MAPS Cost, Schedule and Resources Plan

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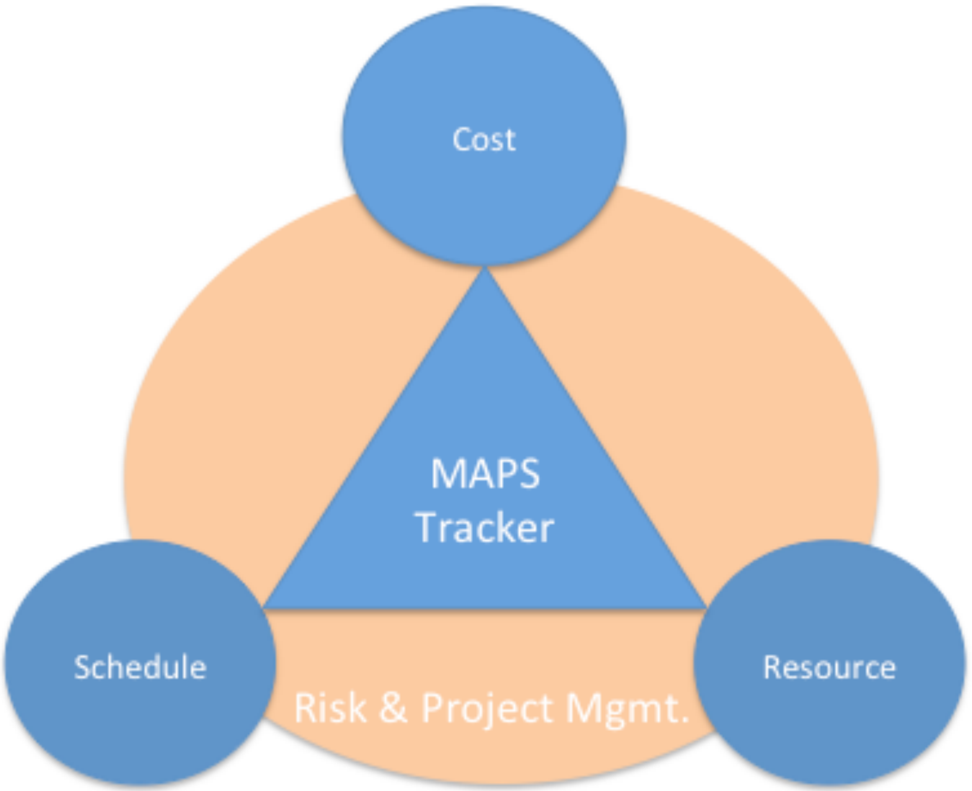
Los Alamos National Laboratory

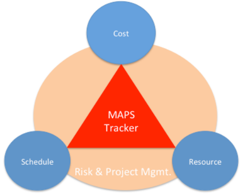
Outline

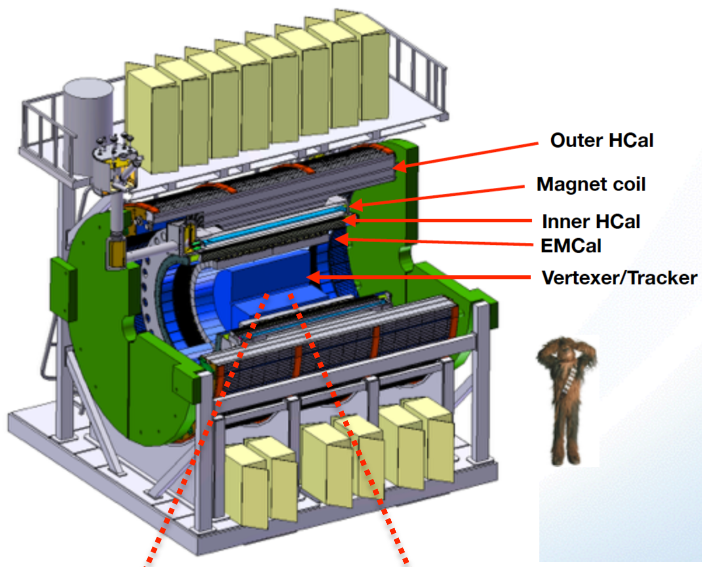
- Scope of Project
  - MAPS inner tracker
  - Cost and Schedule Basis
- Cost
  - R&D
  - Production
- Schedule
  - R&D
  - Production
- Resources



- Risk and project management

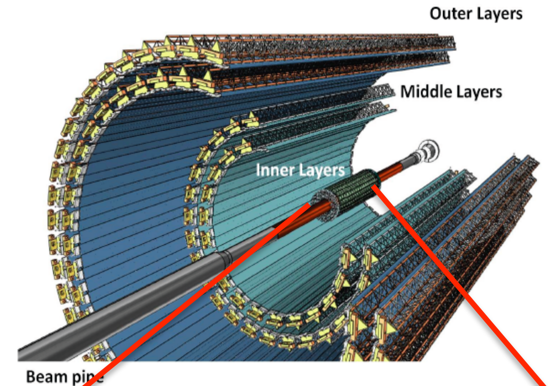
sPHENIX MAPS Inner Tracker



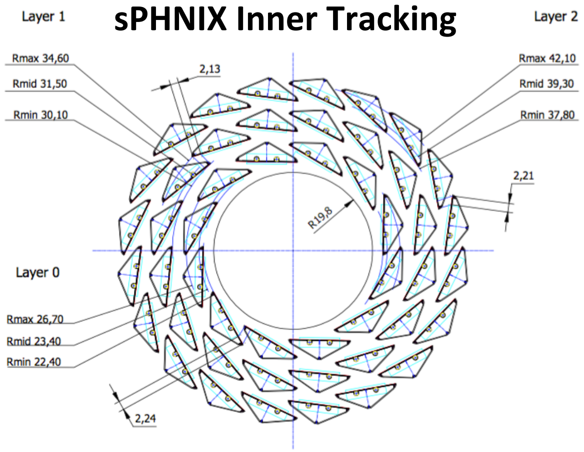


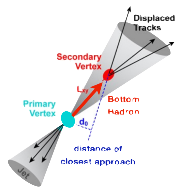
Key issues: Integration of Readout & Mechanics

ALICE ITS;
Inner Tracker System

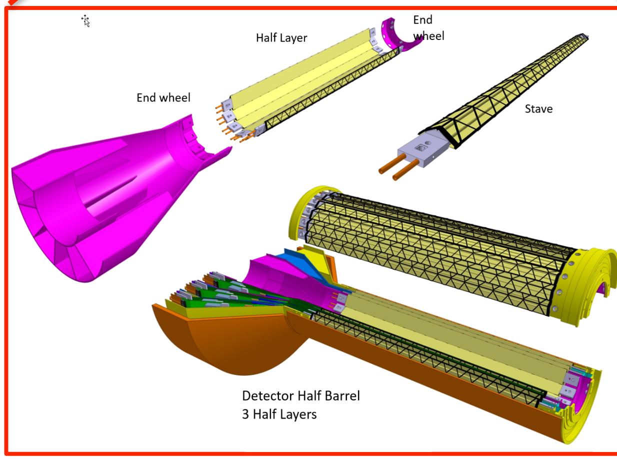


sPHNIX Inner Tracking

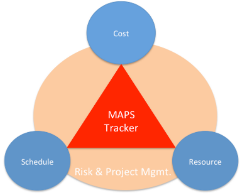


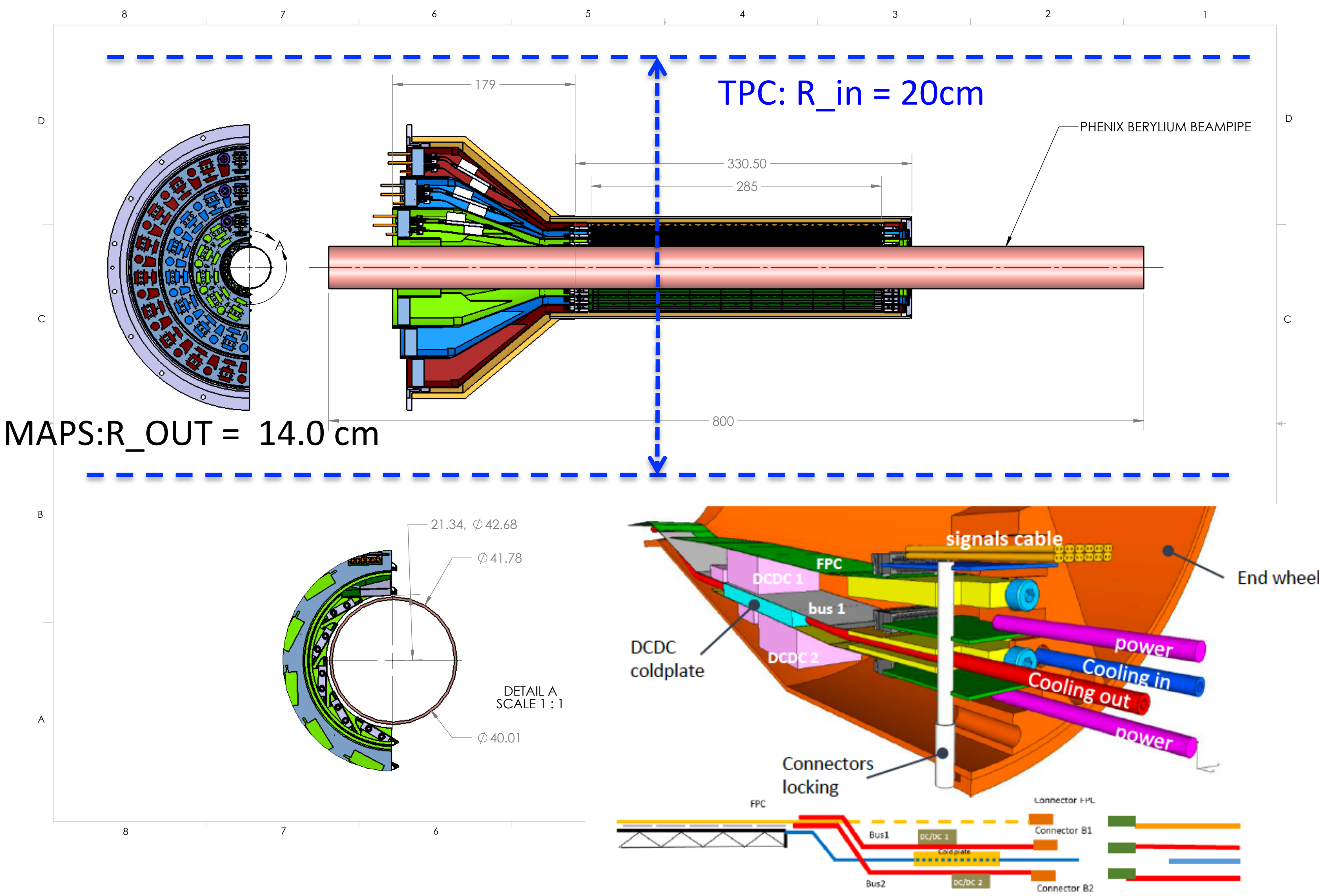


Copy of ITS Inner Tracker

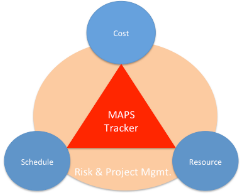


sPHENIX MAPS Inner Tracker



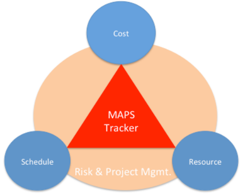


Scope of the Project



- MAPS & Electronics
  - MAPS Detectors
    - MoU to build 68 ITS MAPS staves
    - No modification
  - Readout Electronics
    - Use ALICE/ITS, RDO + CRU
    - Modify/reprogram CRU for sPHENIX
      - Plan-B: build a custom board to convert ALICE/ITS into sPHENIX DAQ format
    - R&D by LANL LDRD
  - Production
    - Extend ALICE/ITS MAPS stave production
    - Train sPHENIX personnel for assembly and testing staves at CERN
    - Reproduce additional ALICE RDO+CRU for sPHENIX
  - Ancillary systems
    - LV, cables, crates, racks etc.
    - Slow control, safety and monitoring

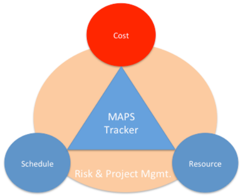
- Mechanics & Cooling
  - No/minor changes to ALICE/ITS inner tracker mechanical structures
    - End Wheels
    - Cylindrical structure shells
    - Detector half barrels
    - Service half barrels
    - Detector and Service half barrels
    - Half support structures
  - Mechanics Integration into sPHENIX system
    - Conceptual design by LANL LDRD
    - Prototype by BNL sPHENIX R&D
    - Design integration frames
    - Cage
    - Installation tooling etc.
  - ALICE cooling plant
    - Minor modification to fit sPHENIX
    - Smaller heat load than ALICE ITS
  - Metrology and Survey



Assumptions

- Copy ALICE 3-layer MAPS Inner Tracker
- Extend ALICE ITS production
- Follow proposed sPHENIX CD process
- Critical R&D for CD-1 and CD-2/3 by LANL LDRD
- Mechanical Integration R&D fund available for CD-2/3
- Production starts at CD-3b

- Initial cost and schedule from ALICE ITS documents
- Other cost from recent experiments, FVTX/PHENIX, HFT/STAR
- Manpower costs from Lab Engineers and Techs
- Durations from ALICE C&S where available, FVTX/PHENIX experience
- Schedule contingency in progress (MoU w/ ALICE, mortgage etc.)
- Apply 30% cost & schedule contingency (prorated from ITS C&S)
- Initial cost and manpower allocation, w/o funding profile



MAPS Cost and Schedule Workshop
3/30-4/1, 2016, Santa Fe, NM

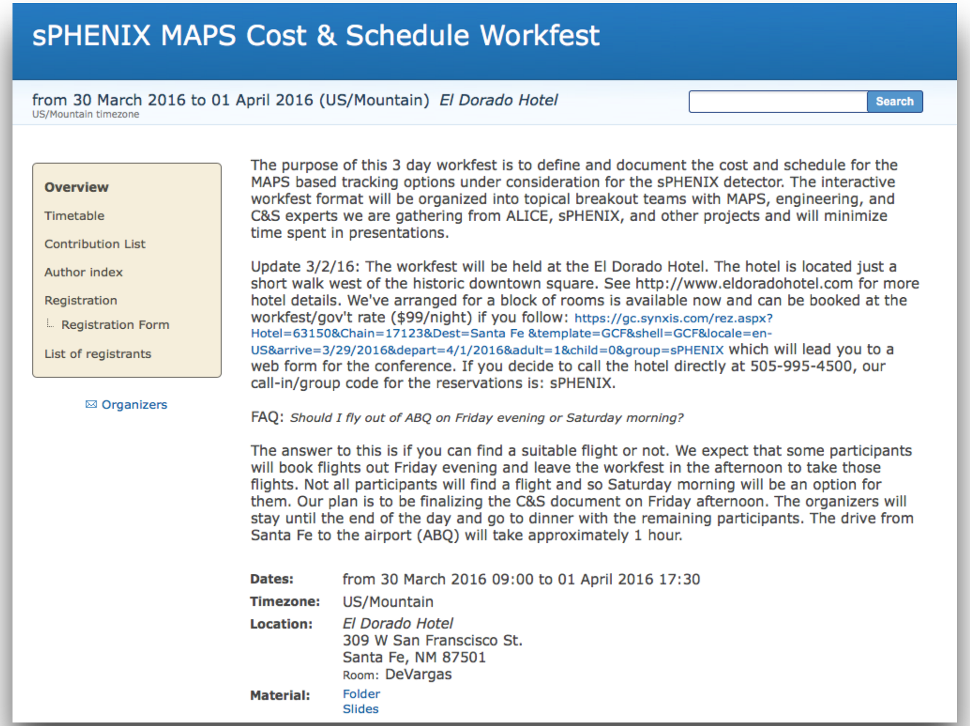
https://indico.bnl.gov/conferenceDisplay.py?confId=1741

Well attended by experts from:
sPHENIX, ITS/ALICE,
HFT/STAR, FVTX/PHENIX, EIC

LANL, CERN, LBNL, BNL, MIT, FSU, UColorado
Yonsei/Korea, and several other US institutions

Take Home:

- **Extension of ALICE production possible**
- **Inner tracker cost <$5M inc. contingency**
- **Can meet sPHENIX CD schedule**



sPHENIX MAPS Cost & Schedule Workfest

from 30 March 2016 to 01 April 2016 (US/Mountain) *El Dorado Hotel*
US/Mountain timezone

Search

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Registration
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List of registrants

Organizers

The purpose of this 3 day workfest is to define and document the cost and schedule for the MAPS based tracking options under consideration for the sPHENIX detector. The interactive workfest format will be organized into topical breakout teams with MAPS, engineering, and C&S experts we are gathering from ALICE, sPHENIX, and other projects and will minimize time spent in presentations.

Update 3/2/16: The workfest will be held at the El Dorado Hotel. The hotel is located just a short walk west of the historic downtown square. See http://www.eldoradohotel.com for more hotel details. We've arranged for a block of rooms is available now and can be booked at the workfest/gov't rate ($99/night) if you follow: https://gc.synxis.com/rez.aspx?Hotel=63150&Chain=17123&Dest=Santa Fe &template=GCF&shell=GCF&locale=en-US&arrive=3/29/2016&depart=4/1/2016&adult=1&child=0&group=sPHENIX which will lead you to a web form for the conference. If you decide to call the hotel directly at 505-995-4500, our call-in/group code for the reservations is: sPHENIX.

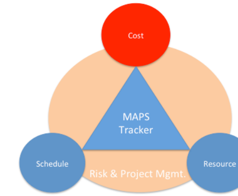
FAQ: *Should I fly out of ABQ on Friday evening or Saturday morning?*

The answer to this is if you can find a suitable flight or not. We expect that some participants will book flights out Friday evening and leave the workfest in the afternoon to take those flights. Not all participants will find a flight and so Saturday morning will be an option for them. Our plan is to be finalizing the C&S document on Friday afternoon. The organizers will stay until the end of the day and go to dinner with the remaining participants. The drive from Santa Fe to the airport (ABQ) will take approximately 1 hour.

Dates:	from 30 March 2016 09:00 to 01 April 2016 17:30
Timezone:	US/Mountain
Location:	*El Dorado Hotel* 309 W San Franscisco St. Santa Fe, NM 87501 Room: DeVargas
Material:	Folder Slides

- First draft Cost and Schedule project was produced based on inputs from Santa Fe Workshop
- Further inputs from BNL 6/30 MAPS mini review

Project Task and Time Line



FY2016 FY2017 FY2018 FY2019 FY2020 FY2021

CD-0
11/1

CD-1
11/1

CD-2/3
8/1

Ready for
Beam
6/1

Key R&D

Readout R&D
Mech. design
@LANL/ALICE

Mech. Integr.
& Prototype
@BNL/LANL

Production

MAPS Prod. & QA
@ALICE

→

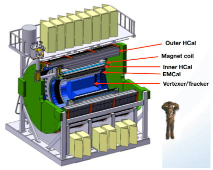
Stave Prod.&Test
@CERN;
FEM Prod. @US

→

Det. Assembly & Test
@BNL

→

Det. Install.
@BNL

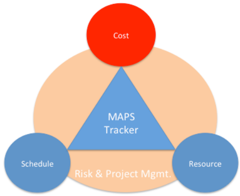


+2%

+50%

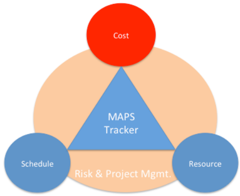
MoU w/ ALICE: 12/2016
To produce staves, frames and FEMs

Major Item Cost Estimate w/ Contingency

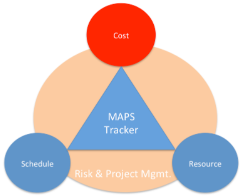


sPHENIX MAPS Inner Tracker Cost Estimate							
3 MAPS layers	Updated: 8/27/2016						
FY16 dollars							
							Funding Profile
	R&D LANL (k$)	R&D BNL (k$)	Production (k$)	Comments	Total Contingency	Cost with Contingengy (k$)	FY17-FY21
MAPS Staves	128		1064	Alice production	0.3	1383.2	
						0	
RDO boards	7.4		354	Alice production	0.3	460.2	
CRU boards	11		183.3	Alice production	0.3	238.29	
sPHENIX readout R&D (+Plan-B)	178						
DAQ integration	82.2						
						0	
ALICE Readout Teststand	40			Alice production		0	
SamTec cables	2.4		28	Alice production	0.3	36.4	
Optical links	0.6		43.2	Alice production	0.3	56.16	
						0	
LVPS etc	27.4		61.6	Alice production	0.3	80.08	
Racks	7.4					0	
Chiller & Cooling Plant	52	51	118.6	Alice production; may need to modify them to fit sPHENIX	0.3	154.18	
Safety system	29.2	56					
Mechnical integration	182	158.6			0	0	
Mechnical Prototype		50					
Assembly Jigs	34.4	41.4	101	Alice production; may need to modify them to fit sPHENIX	0.3	131.3	
Test beam							
						0	
End wheels			35.6	Alice production	0.3	46.28	
Cylindrical Structure Shells			12.6	Alice production	0.3	16.38	
Detector half barrels			14.6	Alice production	0.3	18.98	
Service half barrels			121.6	Alice production	0.3	158.08	
Detector and Service Half Barrels			22.6	Alice production	0.3	29.38	
Two Half Support Structures			51.6	Alice production; may need to modify them to fit sPHENIX	0.3	67.08	
Total	782	357	2212.3			2875.99	

Cost Basis – Major Items



- MAPS and Staves
  - ALICE ITS production
- Readout
  - ALICE ITS RDO and CRU production
- Electronics Interface to sPHENIX/DAQ
  - FVTX/PHENIX experience
- Slow control, DCM-II etc.
  - FVTX/PHENIX experience
- Mechanical structures and cooling
  - ALICE ITS inner tracker desgin
  - FVTX/PHENIX experience

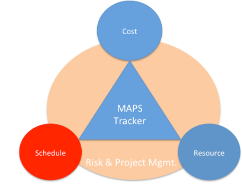


Major Item R&D Costs

- LANL LDRD-DR: $780K
  - – $1.1M/year for 3 years (FTE's and M&S)
    - DAQ Interface: $540K
    - Mechanics: $240K

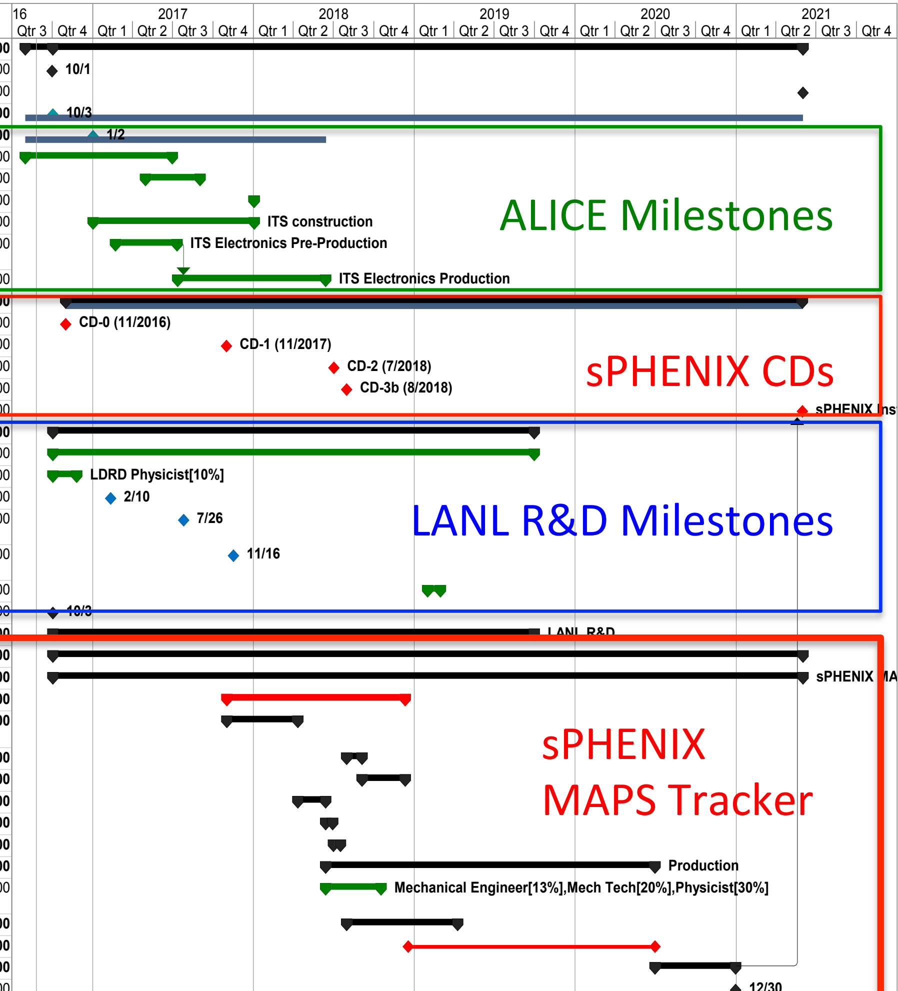
- BNL sPHENIX R&D: $360K
  - – Mechanical design and integration: $310K
  - – Mechanical prototype: $50K

Overview of Schedules



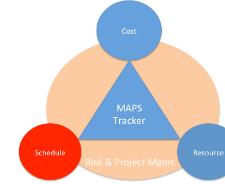
Fri 8/26/16

ID	WBS	Task Name	Duration	Start	Finish	Cost Center	Fixed Cost	Cost	Activi	Cost per Unit
1	1	**MAPS Inner Barrel**	**1217 days**	**Mon 10/3/16**	**Tue 6/1/21**		**$0.00**	**$5,305,297.33**		**$0.00**
2	1.1	MAPS Inner Barrel Starts	0 days	Sat 10/1/16	Sat 10/1/16		$0.00	$0.00		$0.00
3	1.2	MAPS Inner Barrel Ends	0 days	Tue 6/1/21	Tue 6/1/21		$0.00	$0.00		$0.00
4	**1.3**	**Milestones & Key Tasks**	**0 days**	**Mon 10/3/16**	**Mon 10/3/16**		**$0.00**	**$6,400.00**		**$0.00**
5	**1.3.1**	**ALICE ITS Key Tasks**	**0 days**	**Mon 1/2/17**	**Mon 1/2/17**		**$0.00**	**$0.00**		**$0.00**
6	1.3.1.1	ALICE MAPS Production (7/17)	240 days?	Mon 8/1/16	Fri 6/30/17		$0.00	$0.00		$0.00
7	1.3.1.2	ALICE ITS IB FPC Production (9/17)	90 days	Mon 5/1/17	Fri 9/1/17		$0.00	$0.00		$0.00
8	1.3.1.3	ALICE ITS IB Stave Production (1/18)	1 day?	Tue 1/2/18	Tue 1/2/18		$0.00	$0.00		$0.00
9	1.3.1.4	ALICE ITS IB Stave Assembly (3/18)	262 days	Mon 1/2/17	Tue 1/2/18		$0.00	$0.00	ITS c	$0.00
10	1.3.1.5	ALICE ITS Electronics Pre-Production (7/17)	100 days	Wed 2/22/17	Tue 7/11/17		$0.00	$0.00	ITS Electi	$0.00
11	1.3.1.6	ALICE ITS Electronics Production (6/18)	240 days	Thu 7/13/17	Wed 6/13/18		$0.00	$0.00	ITS E	$0.00
12	**1.3.2**	**sPHENIX Milestones**	**1195 days**	**Tue 11/1/16**	**Tue 6/1/21**		**$0.00**	**$0.00**		**$0.00**
13	1.3.2.1	sPHENIX Technical Design CD-0	0 days	Tue 11/1/16	Tue 11/1/16		$0.00	$0.00	CD-0	$0.00
14	1.3.2.2	sPHENIX Technical Design (CD-1/CD-3a)	0 days	Wed 11/1/17	Wed 11/1/17		$0.00	$0.00	CD-1	$0.00
15	1.3.2.3	sPHENIX Technical Dewsgin (CD-2)	0 days	Mon 7/2/18	Mon 7/2/18		$0.00	$0.00	CD-2	$0.00
16	1.3.2.4	sPHENIX Start Construction (CD-3b)	0 days	Wed 8/1/18	Wed 8/1/18		$0.00	$0.00	CD-3	$0.00
17	1.3.2.5	sPHENIX Installed and Ready for Beam	0 days	Tue 6/1/21	Tue 6/1/21		$0.00	$0.00	ready	$0.00
18	**1.3.3**	**LDRD Milestones & Critical Tasks**	**781 days**	**Mon 10/3/16**	**Mon 9/30/19**		**$0.00**	**$6,400.00**		**$0.00**
19	1.3.3.1	LDRD Start and End	781 days	Mon 10/3/16	Mon 9/30/19		$0.00	$0.00		$0.00
20	1.3.3.2	MOU btw LANL and ALICE for R&D	40 days	Mon 10/3/16	Fri 11/25/16	LDRD	$0.00	$6,400.00		$0.00
21	1.3.3.3	Setup ALICE Readout Test Stands	0 days	Fri 2/10/17	Fri 2/10/17		$0.00	$0.00		$0.00
22	1.3.3.4	Complete final sPHENIX Readout Design Review	0 days	Wed 7/26/17	Wed 7/26/17		$0.00	$0.00		$0.00
23	1.3.3.5	Complete Final MAPS Detector Design (CD-1)	0 days	Thu 11/16/17	Thu 11/16/17		$0.00	$0.00		$0.00
24	1.3.3.6	sPHENIX Test Beam	21 days	Fri 2/1/19	Fri 3/1/19	LDRD	$0.00	$0.00		$0.00
25	1.3.3.7	MAPS Final Design (CD-2/CD-3)?	0 days	Mon 10/3/16	Mon 10/3/16		$0.00	$0.00		$0.00
26	**1.4**	**LANL LDRD**	**781 days**	**Mon 10/3/16**	**Mon 9/30/19**	**LDRD**	**$0.00**	**$1,372,560.00**	**LANL**	**$0.00**
11	**1.5**	**sPHENIX Project**	**1217 days?**	**Mon 10/3/16**	**Tue 6/1/21**		**$0.00**	**$3,926,337.33**		**$0.00**
12	**1.5.1**	**sPHENIX Project Management**	**1217 days**	**Mon 10/3/16**	**Tue 6/1/21**		**$0.00**	**$671,784.00**	**sPHE**	**$0.00**
16	**1.5.2**	**sPHENIX Mechanics Integration**	**289 days**	**Thu 11/2/17**	**Tue 12/11/18**		**$0.00**	**$307,000.00**		**$0.00**
17	**1.5.2.1**	**Stave Support Frame & Global Interface to sPHENIX**	**115 days**	**Thu 11/2/17**	**Wed 4/11/18**		**$0.00**	**$158,600.00**		**$0.00**
22	**1.5.2.2**	**Cooling System**	**25 days**	**Wed 8/1/18**	**Tue 9/4/18**		**$0.00**	**$51,000.00**		**$0.00**
26	**1.5.2.3**	**Safety Systems**	**70 days**	**Wed 9/5/18**	**Tue 12/11/18**		**$0.00**	**$56,000.00**		**$0.00**
30	**1.5.2.4**	**Stave Assembly Tooling**	**45 days**	**Thu 4/12/18**	**Wed 6/13/18**		**$0.00**	**$41,400.00**		**$0.00**
34	**1.5.3**	Mechanics Final Design Review	**12 days**	**Thu 6/14/18**	**Fri 6/29/18**		**$0.00**	**$11,000.00**		**$0.00**
38	**1.5.4**	**MAPS Inner Barrel Review (CD-2/CD-3)**	**12 days**	**Mon 7/2/18**	**Tue 7/17/18**		**$0.00**	**$28,000.00**		**$0.00**
42	**1.5.5**	**Productions**	**534 days?**	**Thu 6/14/18**	**Tue 6/30/20**		**$0.00**	**$2,660,153.33**	**Prod**	**$0.00**
43	1.5.5.1	Full Pre-Production-Mechnical System Mock Up Test	90 days	Thu 6/14/18	Wed 10/17/18		$0.00	$52,800.00		$0.00
44	**1.5.5.2**	**Procurements**	**180 days?**	**Wed 8/1/18**	**Tue 4/9/19**		**$0.00**	**$2,246,020.00**		**$0.00**
62	**1.5.5.3**	**Assembly and Testing at BNL**	**400 days**	**Wed 12/19/18**	**Tue 6/30/20**		**$0.00**	**$361,333.33**		**$0.00**
71	**1.5.6**	**Installation**	**131 days**	**Wed 7/1/20**	**Wed 12/30/20**		**$0.00**	**$248,400.00**		**$0.00**
76	1.5.7	Ready for beam	0 days	Wed 12/30/20	Wed 12/30/20		$0.00	$0.00		$0.00



About 6 months on schedule contingency

LANL R&D Schedule



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11	1.3.1.6	ALICE ITS Electronics Production (6/18)	240 days	Thu 7/13/17	Wed 6/13/18		$0.00	$0.00	ITS E	$0.00
12	1.3.2	sPHENIX Milestones	1195 days	Tue 11/1/16	Tue 6/1/21		$0.00	$0.00		$0.00
18	1.3.3	LDRD Milestones & Critical Tasks	781 days	Mon 10/3/16	Mon 9/30/19		$0.00	$6,400.00		$0.00
19	1.3.3.1	LDRD Start and End	781 days	Mon 10/3/16	Mon 9/30/19		$0.00	$0.00		$0.00
20	1.3.3.2	MOU btw LANL and ALICE for R&D	40 days	Mon 10/3/16	Fri 11/25/16	LDRD	$0.00	$6,400.00		$0.00
21	1.3.3.3	Setup ALICE Readout Test Stands	0 days	Fri 2/10/17	Fri 2/10/17		$0.00	$0.00		$0.00
22	1.3.3.4	Complete final sPHENIX Readout Design Review	0 days	Wed 7/26/17	Wed 7/26/17		$0.00	$0.00		$0.00
23	1.3.3.5	Complete Final MAPS Detector Design (CD-1)	0 days	Thu 11/16/17	Thu 11/16/17		$0.00	$0.00		$0.00
24	1.3.3.6	sPHENIX Test Beam	21 days	Fri 2/1/19	Fri 3/1/19	LDRD	$0.00	$0.00		$0.00
25	1.3.3.7	MAPS Final Design (CD-2/CD-3)?	0 days	Mon 10/3/16	Mon 10/3/16		$0.00	$0.00		$0.00
26	1.4	LANL LDRD	781 days	Mon 10/3/16	Mon 9/30/19	LDRD	$0.00	$1,372,560.00	LANL	$0.00
27	1.4.1	Obtain Designs from ALICE	1 day	Mon 10/3/16	Mon 10/3/16		$0.00	$960.00		$0.00
31	1.4.2	Setup Alice Readout Test Stand	95 days	Mon 10/3/16	Fri 2/10/17	LDRD	$0.00	$44,000.00		$0.00
34	1.4.3	Procure R&D ALICE Staves	180 days	Mon 11/28/16	Fri 8/4/17	LDRD	$0.00	$154,200.00		$0.00
35	1.4.3.1	Procure and Produce 4 Staves	60 days	Mon 11/28/16	Fri 2/17/17	LDRD	$55,000.00	$127,000.00		$13,750.00
36	1.4.3.2	Test Staves	5 days	Mon 2/13/17	Fri 2/17/17	LDRD	$0.00	$7,200.00		$0.00
37	1.4.3.3	Travel and Per Diem Support	180 days	Mon 11/28/16	Fri 8/4/17	LDRD	$20,000.00	$20,000.00		$0.00
38	1.4.4	Procure ALICE Electronics & Cabels	107 days	Mon 10/3/16	Tue 2/28/17	LDRD	$0.00	$81,360.00		$0.00
39	1.4.4.1	ALICE Readout Electronics Boards	65 days	Wed 11/30/16	Tue 2/28/17		$0.00	$31,160.00		$0.00
40	1.4.4.1.1	Readout Units (RDOs)	65 days	Wed 11/30/16	Tue 2/28/17		$0.00	$15,400.00		$0.00
41	.4.4.1.1.1	Procure 4 RDOs	60 days	Wed 11/30/16	Tue 2/21/17	LDRD	$5,000.00	$7,400.00		$1,250.00
42	.4.4.1.1.2	Test RDOs	10 days	Wed 2/15/17	Tue 2/28/17	LDRD	$0.00	$8,000.00		$0.00
43	1.4.4.1.2	Common Readout Units (CRUs)	65 days	Wed 11/30/16	Tue 2/28/17		$0.00	$15,760.00		$0.00
44	.4.4.1.2.1	Procure 2 CRUs	60 days	Wed 11/30/16	Tue 2/21/17	LDRD	$10,000.00	$10,960.00		$5,000.00
45	.4.4.1.2.2	Test CRUs	5 days	Wed 2/22/17	Tue 2/28/17	LDRD	$0.00	$4,800.00		$0.00
46	1.4.4.2	SamTec Cables	11 days	Mon 10/3/16	Mon 10/17/16		$0.00	$2,800.00		$0.00
47	1.4.4.2.1	Procure 7 SamTec Cables	10 days	Mon 10/3/16	Fri 10/14/16	LDRD	$2,000.00	$2,400.00		$235.00
48	1.4.4.2.2	Test Cables	1 day	Mon 10/17/16	Mon 10/17/16	LDRD	$0.00	$400.00		$0.00
49	1.4.4.3	Optical Cables	11 days	Tue 10/4/16	Tue 10/18/16		$0.00	$800.00		$0.00
50	1.4.4.3.1	Procure 4 Optical Cables	10 days	Tue 10/4/16	Mon 10/17/16	LDRD	$400.00	$560.00		$100.00
51	1.4.4.3.2	Test Optical Cables	1 day	Tue 10/18/16	Tue 10/18/16	LDRD	$0.00	$240.00		$0.00
52	1.4.4.4	Procure Ancillaries	64 days	Tue 10/4/16	Fri 12/30/16	LDRD	$0.00	$46,600.00		$0.00
53	1.4.4.4.1	Procure LV,HV,etc	60 days	Tue 10/4/16	Mon 12/26/16	LDRD	$25,000.00	$27,400.00		$0.00
54	1.4.4.4.2	Procure Racks	60 days	Thu 10/6/16	Wed 12/28/16	LDRD	$5,000.00	$7,400.00		$0.00
55	1.4.4.4.3	Procure Chiller	60 days	Mon 10/10/16	Fri 12/30/16	LDRD	$7,000.00	$11,800.00		$0.00
56	1.4.5	sPHENIX Readout Electronics Integration	270 days	Tue 10/4/16	Mon 10/16/17		$0.00	$178,000.00		$0.00
57	1.4.5.1	Initial FEM Design (modify ALICE)	40 days	Tue 10/4/16	Mon 11/28/16	LDRD	$0.00	$38,400.00		$0.00
58	1.4.5.2	Prototype FEM	60 days	Tue 11/29/16	Mon 2/20/17	LDRD	$5,000.00	$38,600.00		$0.00
59	1.4.5.3	FEM test-I	5 days	Tue 2/21/17	Mon 2/27/17	LDRD	$0.00	$7,600.00		$0.00
60	1.4.5.4	Revised FEM Design	20 days	Tue 2/28/17	Mon 3/27/17	LDRD	$0.00	$19,200.00		$0.00
61	1.4.5.5	Prototype FEM-II	60 days	Tue 3/28/17	Mon 6/19/17	LDRD	$5,000.00	$24,200.00		$0.00
62	1.4.5.6	FEM test-II	5 days	Tue 6/20/17	Mon 6/26/17	LDRD	$0.00	$4,400.00		$0.00

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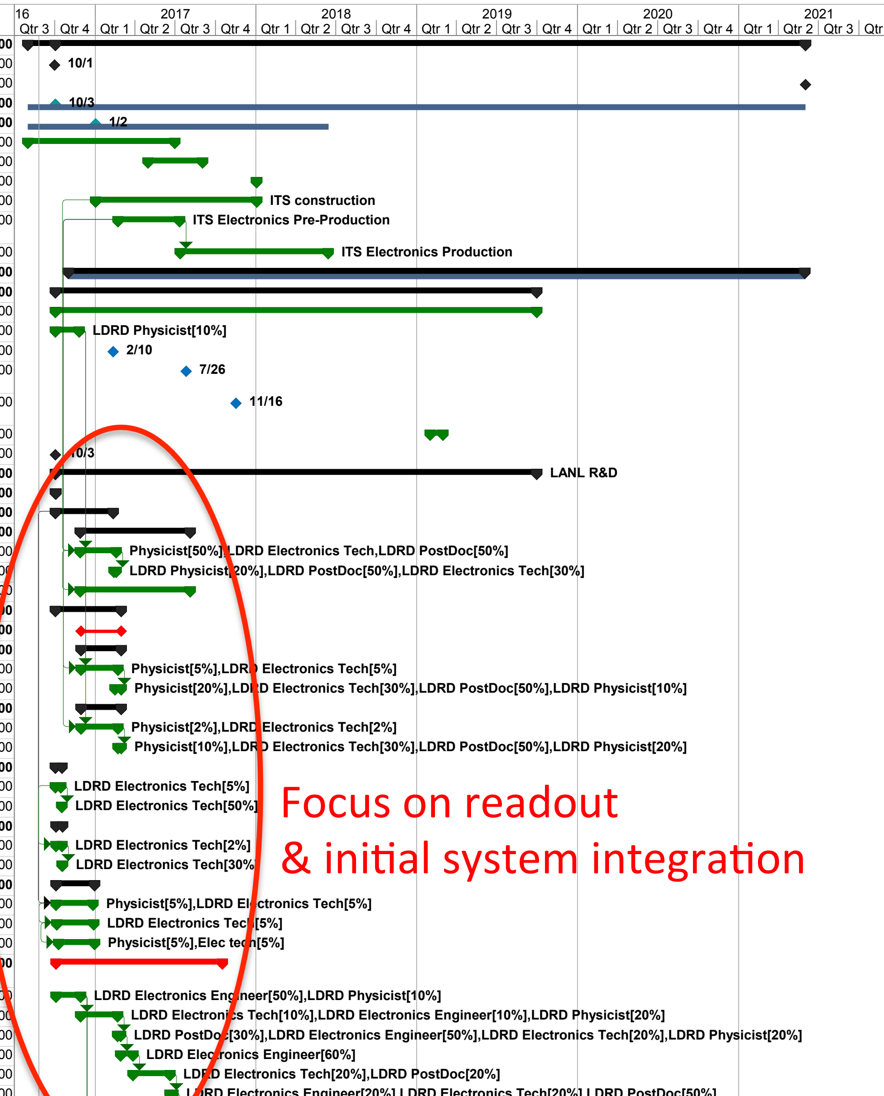
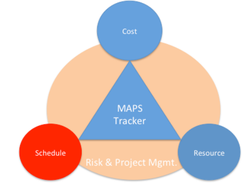


Focus on readout
& initial system integration

Production



Fri 8/26/16

ID	WBS	Task Name	Duration	Start	Finish	Cost Center	Fixed Cost	Cost	Activi	Cost per Unit
1	1	**MAPS Inner Barrel**	**1217 days**	**Mon 10/3/16**	**Tue 6/1/21**		**$0.00**	**$5,305,297.33**		**$0.00**
2	1.1	MAPS Inner Barrel Starts	0 days	Sat 10/1/16	Sat 10/1/16		$0.00	$0.00		$0.00
3	1.2	MAPS Inner Barrel Ends	0 days	Tue 6/1/21	Tue 6/1/21		$0.00	$0.00		$0.00
4	**1.3**	**Milestones & Key Tasks**	**0 days**	**Mon 10/3/16**	**Mon 10/3/16**		**$0.00**	**$6,400.00**		**$0.00**
5	**1.3.1**	**ALICE ITS Key Tasks**	**0 days**	**Mon 1/2/17**	**Mon 1/2/17**		**$0.00**	**$0.00**		**$0.00**
6	1.3.1.1	ALICE MAPS Production (7/17)	240 days?	Mon 8/1/16	Fri 6/30/17		$0.00	$0.00		$0.00
7	1.3.1.2	ALICE ITS IB FPC Production (9/17)	90 days	Mon 5/1/17	Fri 9/1/17		$0.00	$0.00		$0.00
8	1.3.1.3	ALICE ITS IB Stave Production (1/18)	1 day?	Tue 1/2/18	Tue 1/2/18		$0.00	$0.00		$0.00
9	1.3.1.4	ALICE ITS IB Stave Assembly (3/18)	262 days	Mon 1/2/17	Tue 1/2/18		$0.00	$0.00	ITS c	$0.00
10	1.3.1.5	ALICE ITS Electronics Pre-Production (7/17)	100 days	Wed 2/22/17	Tue 7/11/17		$0.00	$0.00	ITS Electi	$0.00
11	1.3.1.6	ALICE ITS Electronics Production (6/18)	240 days	Thu 7/13/17	Wed 6/13/18		$0.00	$0.00	ITS E	$0.00
12	**1.3.2**	**sPHENIX Milestones**	**1195 days**	**Tue 11/1/16**	**Tue 6/1/21**		**$0.00**	**$0.00**		**$0.00**
18	**1.3.3**	**LDRD Milestones & Critical Tasks**	**781 days**	**Mon 10/3/16**	**Mon 9/30/19**		**$0.00**	**$6,400.00**		**$0.00**
19	1.3.3.1	LDRD Start and End	781 days	Mon 10/3/16	Mon 9/30/19		$0.00	$0.00		$0.00
20	1.3.3.2	MOU btw LANL and ALICE for R&D	40 days	Mon 10/3/16	Fri 11/25/16	LDRD	$0.00	$6,400.00		$0.00
21	1.3.3.3	Setup ALICE Readout Test Stands	0 days	Fri 2/10/17	Fri 2/10/17		$0.00	$0.00		$0.00
22	1.3.3.4	Complete final sPHENIX Readout Design Review	0 days	Wed 7/26/17	Wed 7/26/17		$0.00	$0.00		$0.00
23	1.3.3.5	Complete Final MAPS Detector Design (CD-1)	0 days	Thu 11/16/17	Thu 11/16/17		$0.00	$0.00		$0.00
24	1.3.3.6	sPHENIX Test Beam	21 days	Fri 2/1/19	Fri 3/1/19	LDRD	$0.00	$0.00		$0.00
25	1.3.3.7	MAPS Final Design (CD-2/CD-3)?	0 days	Mon 10/3/16	Mon 10/3/16		$0.00	$0.00		$0.00
26	**1.4**	**LANL LDRD**	**781 days**	**Mon 10/3/16**	**Mon 9/30/19**	**LDRD**	**$0.00**	**$1,372,560.00**	**LANL**	**$0.00**
111	**1.5**	**sPHENIX Project**	**1217 days?**	**Mon 10/3/16**	**Tue 6/1/21**		**$0.00**	**$3,926,337.33**		**$0.00**
112	**1.5.1**	**sPHENIX Project Management**	**1217 days**	**Mon 10/3/16**	**Tue 6/1/21**		**$0.00**	**$671,784.00**	**sPHE**	**$0.00**
116	**1.5.2**	**sPHENIX Mechanics Integration**	**289 days**	**Thu 11/2/17**	**Tue 12/11/18**		**$0.00**	**$307,000.00**		**$0.00**
117	**1.5.2.1**	**Stave Support Frame & Global Interface to sPHENIX**	**115 days**	**Thu 11/2/17**	**Wed 4/11/18**		**$0.00**	**$158,600.00**		**$0.00**
122	**1.5.2.2**	**Cooling System**	**25 days**	**Wed 8/1/18**	**Tue 9/4/18**		**$0.00**	**$51,000.00**		**$0.00**
126	**1.5.2.3**	**Safety Systems**	**70 days**	**Wed 9/5/18**	**Tue 12/11/18**		**$0.00**	**$56,000.00**		**$0.00**
130	**1.5.2.4**	**Stave Assembly Tooling**	**45 days**	**Thu 4/12/18**	**Wed 6/13/18**		**$0.00**	**$41,400.00**		**$0.00**
134	**1.5.3**	Mechanics Final Design Review	**12 days**	**Thu 6/14/18**	**Fri 6/29/18**		**$0.00**	**$11,000.00**		**$0.00**
138	**1.5.4**	**MAPS Inner Barrel Review (CD-2/CD-3)**	**12 days**	**Mon 7/2/18**	**Tue 7/17/18**		**$0.00**	**$28,000.00**		**$0.00**
142	**1.5.5**	**Productions**	**534 days?**	**Thu 6/14/18**	**Tue 6/30/20**		**$0.00**	**$2,660,153.33**	**Prod**	**$0.00**
143	1.5.5.1	Full Pre-Production-Mechnical System Mock Up Test	90 days	Thu 6/14/18	Wed 10/17/18		$0.00	$52,800.00		$0.00
144	**1.5.5.2**	**Procurements**	**180 days?**	**Wed 8/1/18**	**Tue 4/9/19**		**$0.00**	**$2,246,020.00**		**$0.00**
145	**1.5.5.2.1**	**CERN Procuments**	**180 days?**	**Wed 8/1/18**	**Tue 4/9/19**		**$0.00**	**$1,097,840.00**		**$0.00**
146	.5.5.2.1.1	Produce 68 Inner Staves	180 days	Wed 8/1/18	Tue 4/9/19		$920,000.00	$1,064,000.00		$13,530.00
147	.5.5.2.1.2	Other ITS/CERN items	120 days	Wed 8/1/18	Tue 1/15/19		$10,000.00	$13,840.00		$0.00
148	.5.5.2.1.3	Travel and Per Diem at CERN	180 days?	Wed 8/1/18	Tue 4/9/19		$20,000.00	$20,000.00		$0.00
149	1.5.5.2.2	Procure 68 Readout / FEM Units	100 days	Wed 8/1/18	Tue 12/18/18		$322,000.00	$354,000.00		$4,700.00
150	1.5.5.2.3	Procure Optical Links 68	60 days	Thu 8/2/18	Wed 10/24/18		$42,200.00	$43,160.00		$620.00
151	1.5.5.2.4	Procure 34 Common Readout Units	100 days	Fri 8/3/18	Thu 12/20/18		$181,700.00	$183,300.00		$5,300.00
152	1.5.5.2.5	Procure 400 SamTec Cables	60 days	Mon 8/6/18	Fri 10/26/18		$27,000.00	$27,960.00		$270.00
153	1.5.5.2.6	Procure Ancillary Materials (LVPS and cables etc)	100 days	Tue 8/7/18	Mon 12/24/18		$60,000.00	$61,600.00		$0.00
154	1.5.5.2.7	Procure Cooling Plant	100 days	Wed 8/1/18	Tue 12/18/18		$117,000.00	$118,600.00		$0.00
155	1.5.5.2.8	Procure Assembly Fixtures & Jigs	60 days	Thu 8/2/18	Wed 10/24/18		$100,000.00	$100,960.00		$0.00
156	1.5.5.2.9	Procure End Wheels	100 days	Fri 8/3/18	Thu 12/20/18		$34,000.00	$35,600.00		$0.00
157	.5.5.2.10	Procure Cylindrical Structural Shells	100 days	Mon 8/6/18	Fri 12/21/18		$11,000.00	$12,600.00		$0.00
158	.5.5.2.11	Procure Detector Half Barrels	100 days	Tue 8/7/18	Mon 12/24/18		$13,000.00	$14,600.00		$0.00
159	.5.5.2.12	Procure Service Half Barrels	100 days	Wed 8/8/18	Tue 12/25/18		$120,000.00	$121,600.00		$0.00
160	.5.5.2.13	Procure Detector and Service Half Barrels	100 days	Thu 8/9/18	Wed 12/26/18		$21,000.00	$22,600.00		$0.00
161	.5.5.2.14	Procure Two Half Support Structures	100 days	Fri 8/10/18	Thu 12/27/18		$50,000.00	$51,600.00		$0.00

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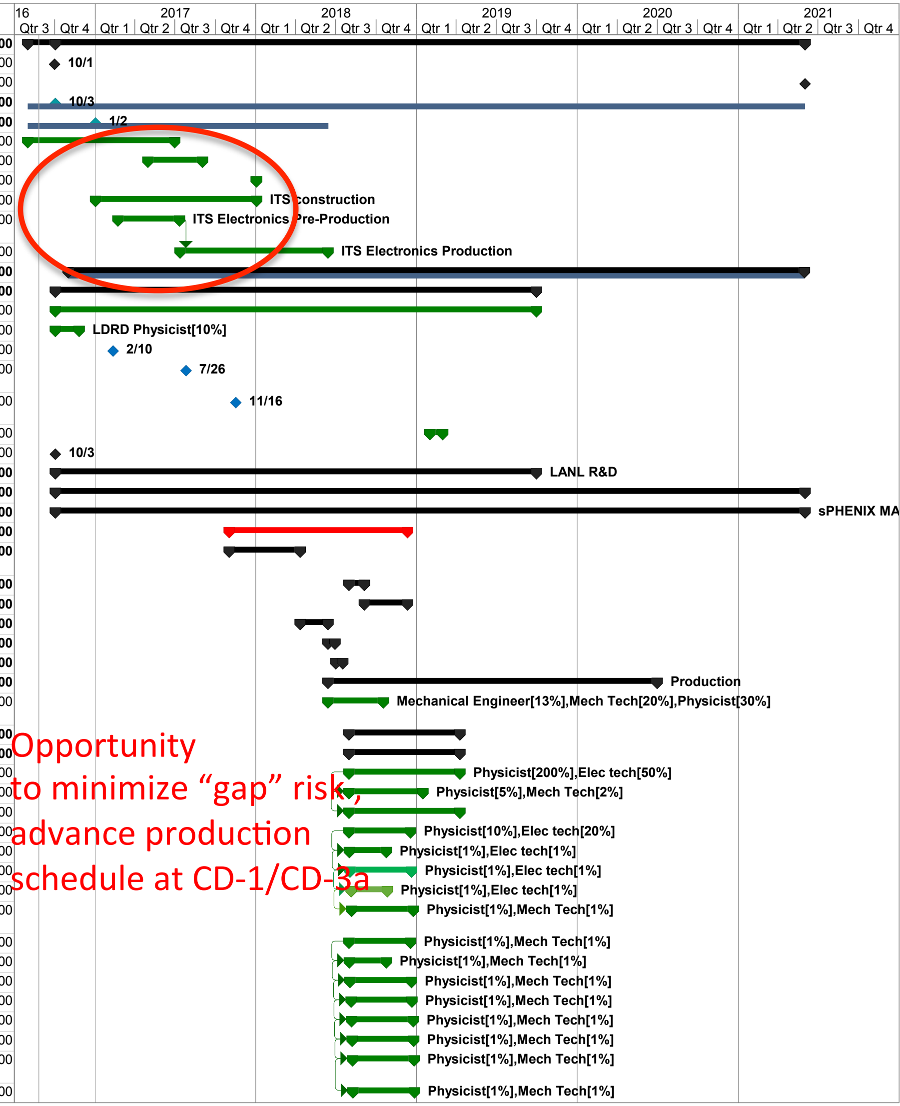
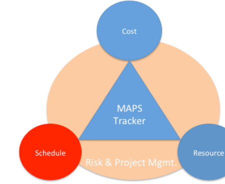


Opportunity to minimize "gap" risk, advance production schedule at CD-1/CD-3a

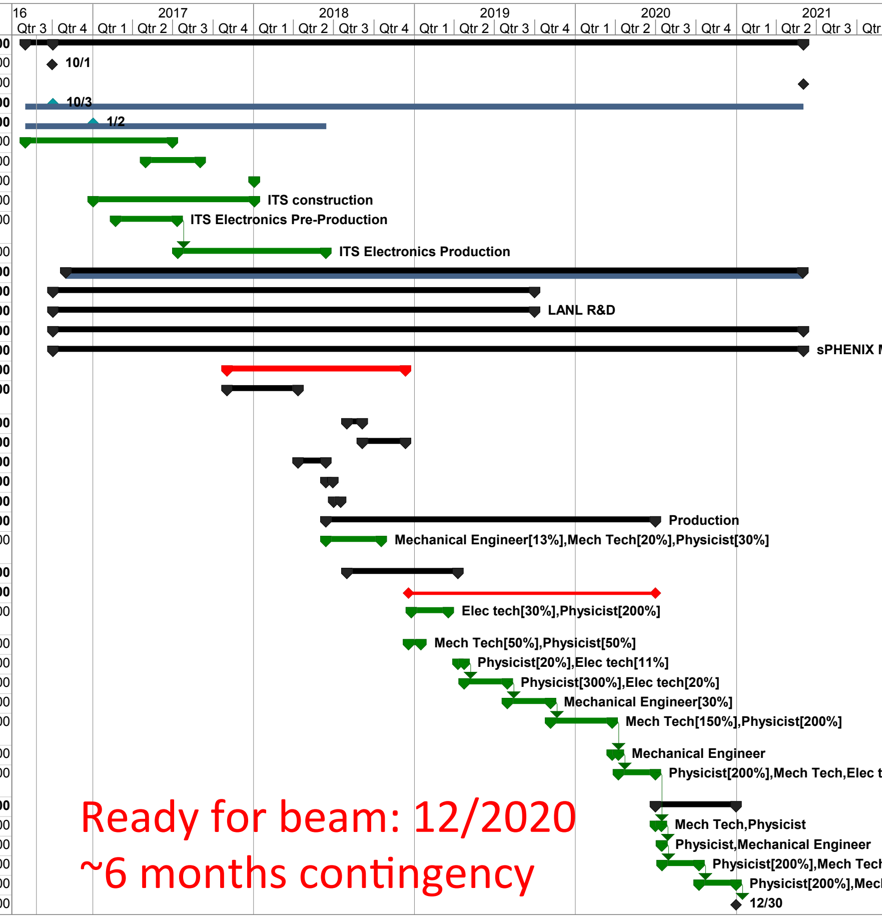
Page 1

Assembly and Installation



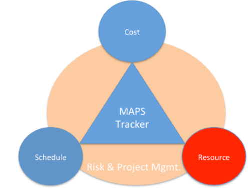
Fri 8/26/16

ID	WBS	Task Name	Duration	Start	Finish	Cost Center	Fixed Cost	Cost	Activi	Cost per Unit
1	1	**MAPS Inner Barrel**	**1217 days**	**Mon 10/3/16**	**Tue 6/1/21**		**$0.00**	**$5,305,297.33**		**$0.00**
2	1.1	MAPS Inner Barrel Starts	0 days	Sat 10/1/16	Sat 10/1/16		$0.00	$0.00		$0.00
3	1.2	MAPS Inner Barrel Ends	0 days	Tue 6/1/21	Tue 6/1/21		$0.00	$0.00		$0.00
4	**1.3**	**Milestones & Key Tasks**	**0 days**	**Mon 10/3/16**	**Mon 10/3/16**		**$0.00**	**$6,400.00**		**$0.00**
5	**1.3.1**	**ALICE ITS Key Tasks**	**0 days**	**Mon 1/2/17**	**Mon 1/2/17**		**$0.00**	**$0.00**		**$0.00**
6	1.3.1.1	ALICE MAPS Production (7/17)	240 days?	Mon 8/1/16	Fri 6/30/17		$0.00	$0.00		$0.00
7	1.3.1.2	ALICE ITS IB FPC Production (9/17)	90 days	Mon 5/1/17	Fri 9/1/17		$0.00	$0.00		$0.00
8	1.3.1.3	ALICE ITS IB Stave Production (1/18)	1 day?	Tue 1/2/18	Tue 1/2/18		$0.00	$0.00		$0.00
9	1.3.1.4	ALICE ITS IB Stave Assembly (3/18)	262 days	Mon 1/2/17	Tue 1/2/18		$0.00	$0.00	ITS c	$0.00
10	1.3.1.5	ALICE ITS Electronics Pre-Production (7/17)	100 days	Wed 2/22/17	Tue 7/11/17		$0.00	$0.00	ITS Electi	$0.00
11	1.3.1.6	ALICE ITS Electronics Production (6/18)	240 days	Thu 7/13/17	Wed 6/13/18		$0.00	$0.00	ITS E	$0.00
12	**1.3.2**	**sPHENIX Milestones**	**1195 days**	**Tue 11/1/16**	**Tue 6/1/21**		**$0.00**	**$0.00**		**$0.00**
18	**1.3.3**	**LDRD Milestones & Critical Tasks**	**781 days**	**Mon 10/3/16**	**Mon 9/30/19**		**$0.00**	**$6,400.00**		**$0.00**
26	**1.4**	**LANL LDRD**	**781 days**	**Mon 10/3/16**	**Mon 9/30/19**	**LDRD**	**$0.00**	**$1,372,560.00**	**LANL**	**$0.00**
111	**1.5**	**sPHENIX Project**	**1217 days?**	**Mon 10/3/16**	**Tue 6/1/21**		**$0.00**	**$3,926,337.33**		**$0.00**
112	**1.5.1**	**sPHENIX Project Management**	**1217 days**	**Mon 10/3/16**	**Tue 6/1/21**		**$0.00**	**$671,784.00**	**sPHE**	**$0.00**
116	**1.5.2**	**sPHENIX Mechanics Integration**	**289 days**	**Thu 11/2/17**	**Tue 12/11/18**		**$0.00**	**$307,000.00**		**$0.00**
117	**1.5.2.1**	Stave Support Frame & Global Interface to sPHENIX	**115 days**	**Thu 11/2/17**	**Wed 4/11/18**		**$0.00**	**$158,600.00**		**$0.00**
122	**1.5.2.2**	**Cooling System**	**25 days**	**Wed 8/1/18**	**Tue 9/4/18**		**$0.00**	**$51,000.00**		**$0.00**
126	**1.5.2.3**	**Safety Systems**	**70 days**	**Wed 9/5/18**	**Tue 12/11/18**		**$0.00**	**$56,000.00**		**$0.00**
130	**1.5.2.4**	**Stave Assembly Tooling**	**45 days**	**Thu 4/12/18**	**Wed 6/13/18**		**$0.00**	**$41,400.00**		**$0.00**
134	**1.5.3**	Mechanics Final Design Review	**12 days**	**Thu 6/14/18**	**Fri 6/29/18**		**$0.00**	**$11,000.00**		**$0.00**
138	**1.5.4**	**MAPS Inner Barrel Review (CD-2/CD-3)**	**12 days**	**Mon 7/2/18**	**Tue 7/17/18**		**$0.00**	**$28,000.00**		**$0.00**
142	**1.5.5**	**Productions**	**534 days?**	**Thu 6/14/18**	**Tue 6/30/20**		**$0.00**	**$2,660,153.33**	**Prod**	**$0.00**
143	1.5.5.1	Full Pre-Production-Mechanical System Mock Up Test	90 days	Thu 6/14/18	Wed 10/17/18		$0.00	$52,800.00		$0.00
144	**1.5.5.2**	**Procurements**	**180 days?**	**Wed 8/1/18**	**Tue 4/9/19**		**$0.00**	**$2,246,020.00**		**$0.00**
162	**1.5.5.3**	**Assembly and Testing at BNL**	**400 days**	**Wed 12/19/18**	**Tue 6/30/20**		**$0.00**	**$361,333.33**		**$0.00**
163	1.5.5.3.1	Test Production FEMS, e-Links, CRU LV, optical links	60 days	Tue 12/25/18	Mon 3/18/19		$0.00	$28,800.00		$0.00
164	1.5.5.3.2	Test Cooling System	20 days	Wed 12/19/18	Tue 1/15/19		$0.00	$16,000.00		$0.00
165	1.5.5.3.3	Stave Reciept Inspection	10 days	Wed 4/10/19	Tue 4/23/19		$0.00	$1,733.33		$0.00
166	1.5.5.3.4	Individual Stave Readout Test	70 days	Wed 4/24/19	Tue 7/30/19		$0.00	$22,400.00		$0.00
167	1.5.5.3.5	Metrology on Stave Assemblies	70 days	Wed 7/31/19	Tue 11/5/19		$0.00	$42,000.00		$0.00
168	1.5.5.3.6	Assemble full Ladders into Half support	100 days	Wed 11/6/19	Tue 3/24/20		$0.00	$38,400.00		$0.00
169	1.5.5.3.7	Metrology on Final Assembly	10 days	Wed 3/25/20	Tue 4/7/20		$0.00	$20,000.00		$0.00
170	1.5.5.3.8	Half detector Assembly Readout and Cooling Test	60 days	Wed 4/8/20	Tue 6/30/20		$0.00	$192,000.00		$0.00
171	**1.5.6**	**Installation**	**131 days**	**Wed 7/1/20**	**Wed 12/30/20**		**$0.00**	**$248,400.00**		**$0.00**
172	1.5.6.1	Installation Prep	10 days	Wed 7/1/20	Tue 7/14/20		$0.00	$16,000.00		$0.00
173	1.5.6.2	Installation Review	1 day	Wed 7/15/20	Wed 7/15/20		$0.00	$2,000.00		$0.00
174	1.5.6.3	Installation	60 days	Thu 7/16/20	Wed 10/7/20		$0.00	$192,000.00		$0.00
175	1.5.6.4	Commissioning	60 days	Thu 10/8/20	Wed 12/30/20		$0.00	$38,400.00		$0.00
176	1.5.7	Ready for beam	0 days	Wed 12/30/20	Wed 12/30/20		$0.00	$0.00		$0.00

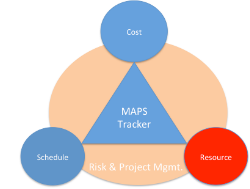


Ready for beam: 12/2020
~6 months contingency

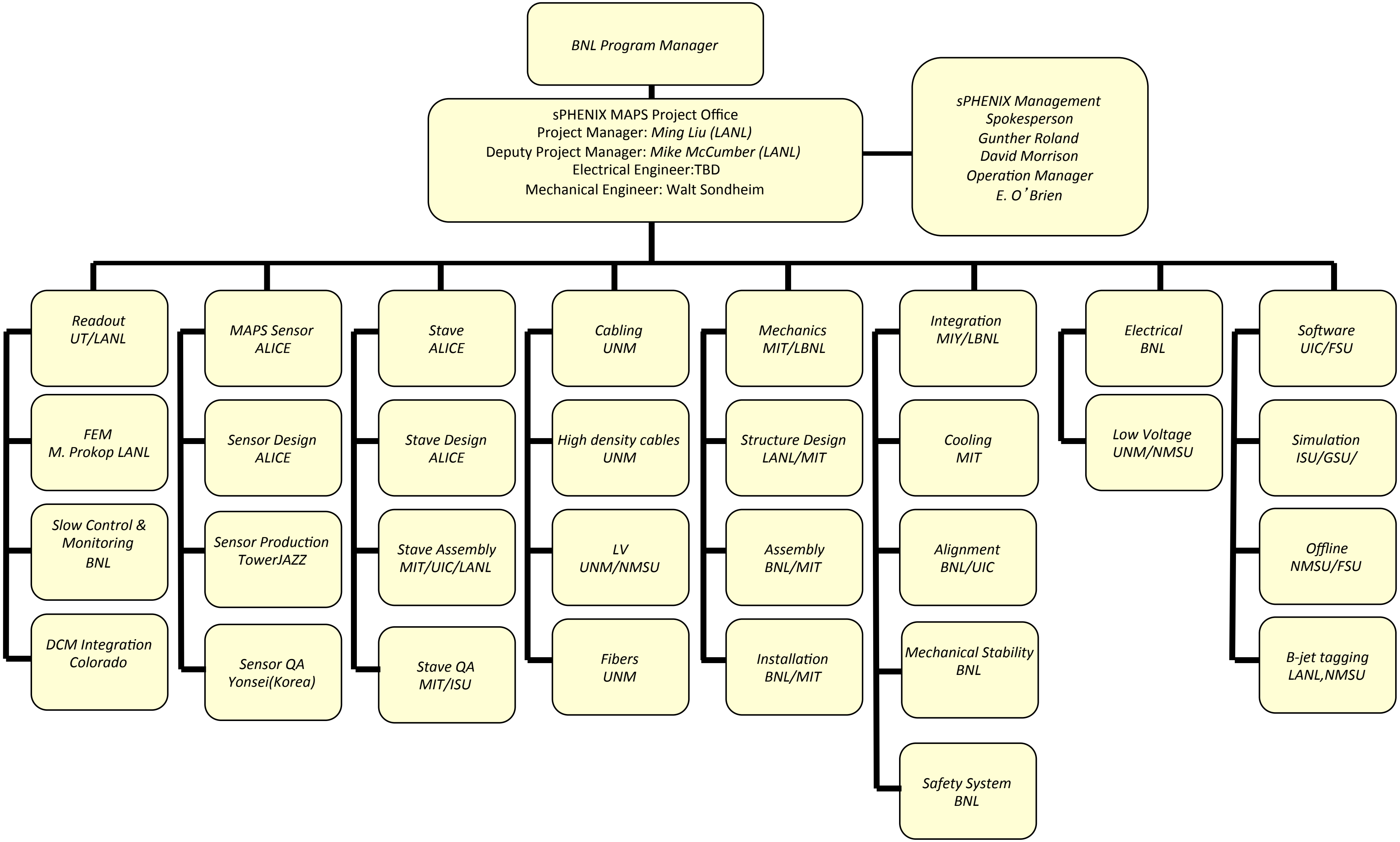
Participating and Interested Institutions



- LANL - Readout & FEMs, Mechanics
- MIT - Assembly and testing, cooling
- LBNL – Mechanical carbon structures, readout
- BNL – Integration and services, safety and monitoring
- UT-Austin – MAPS readout electronics and testing
- Univ. of Colorado – sPHENIX DAQ/DCM-II integration
- Univ. of New Mexico – LV, cabling & connectors
- New Mexico State University – Tracking algorithm and simulations
- Univ. of IL of Chicago – Stave assembly and testing, offline analysis
- Iowa State University – Assembly and testing, simulations
- Georgia State University - Slow control and monitoring
- Florida State University - Offline and simulations
- Univ. of California, Los Angeles – Assembly and testing, simulations
- Univ. of California, Riverside – Assembly and testing, simulations
- RIKEN/RBRC, Japan – Assembly and testing, integration
- Yonsei, Korea – MAPS QA and readout, simulations



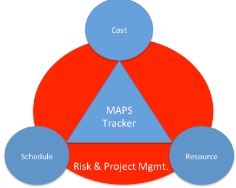
Organization Chart



Risk Based Contingency

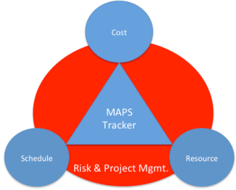
Risk Factor	**Technical**	**Cost**	**Schedule**	**Design**
0	Not used	Not used	Not used	Detail design > 50% done
1	Existing design and off-the-shelf H/W	Off-the-shelf or catalog item	Not used	Not used
2	Minor modifications to an existing design	Vendor quote from established drawings	No schedule impact on any other item	Not used
3	Extensive modifications to an existing design	Vendor quote with some design sketches	Not used	Not used
4	New design; nothing exotic	In-house estimate based on previous similar experience	Delays completion of non-critical subsystem item	Preliminary design >50% done; some analysis done
6	New design; different from established designs or existing technology	In-house estimate for item with minimal experience but related to existing capabilities	Not used	Not used
8	New design; requires some R&D but does not advance the state-of-the-art	In-house estimate for item with minimal experience and minimal in-house capability	Delays completion of critical path subsystem item	Conceptual design phase; some drawings; many sketches
10	New design of new technology; advances state-of-the-art	Top-down estimate from analogous programs	Not used	Not used
15	New design; well beyond current state-of-the-art	Engineering judgment	Not used	Concept only

Risk Management



- Readout electronics R&D to meet CD1 (11/2017)
  - Early procurements of staves and RDO/CRU
  - Joint effort with LBNL/ALICE
- Mechanical & cooling R&D to meet CD2/CD3 (8/2018)
  - Early R&D support at BNL
    - sPHENIX mechanical integration
  - Early joint R&D with BNL/LBNL/MIT
- Production
  - Partial delivery and more parallel efforts

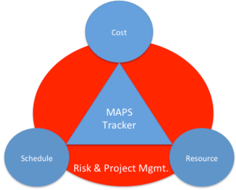
Open Issues



- **MoU with ALICE/CERN: by ~12/2016**
  - Prototype and final stave production and delivery
  - Obtain ALICE readout test stand and electronics for early R&D
  - Obtain design files, electronics and mechanics
  - Training sPHENIX personnel, available manpower
  - R&D collaboration and schedule
  - Availability of CERN facilities after ITS/IB production

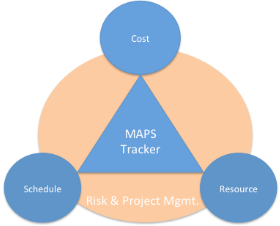
- **Schedule/funding gap of stave productions**
  - ITS/IB production: ~1/2017-1/2018
  - sPHENIX CD-3b: 8/2018
  - Risk Mitigation:
    1. Early procurement of MAPS & staves at CD1/CD-3a
    2. Early training through LDRD effort, maintain activity at low level
    3. Possible mortgage for sPHENIX production from ALICE/CERN, MoU
    4. Seek external foreign funding

- **sPHENIX readout R&D**
  - Possible delay due to unavailability of key elements like staves and readout for R&D
  - Risk mitigation:
    - Early joint R&D with ALICE as associate members
    - Start with prototype RDO and CRU



Risk Registry

- Availability of Stave and Readout Electronics from ALICE for early R&D work
- Availability of R&D fund for Mechanics integration design and prototype for CD2/3
- Funding profile

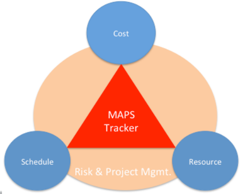


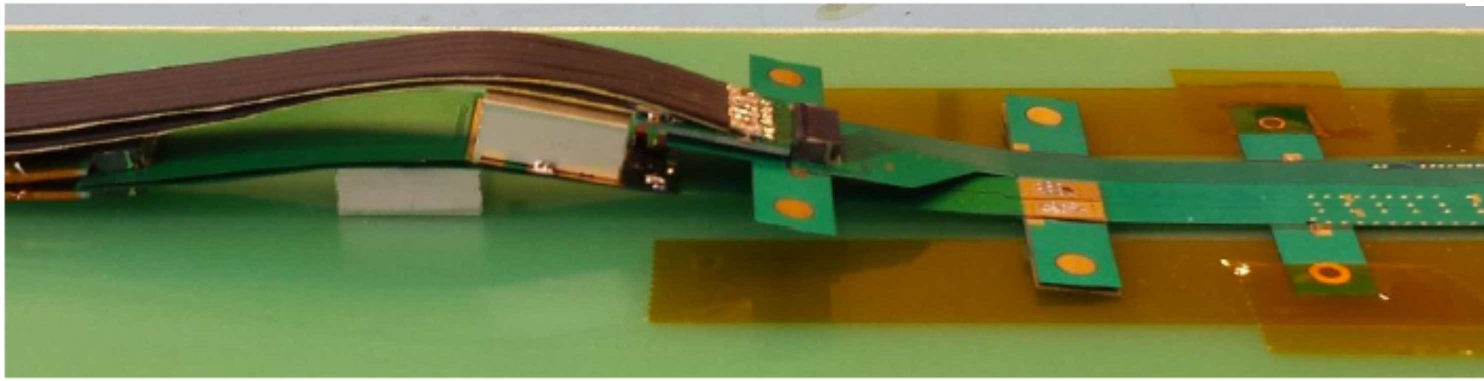
Summary

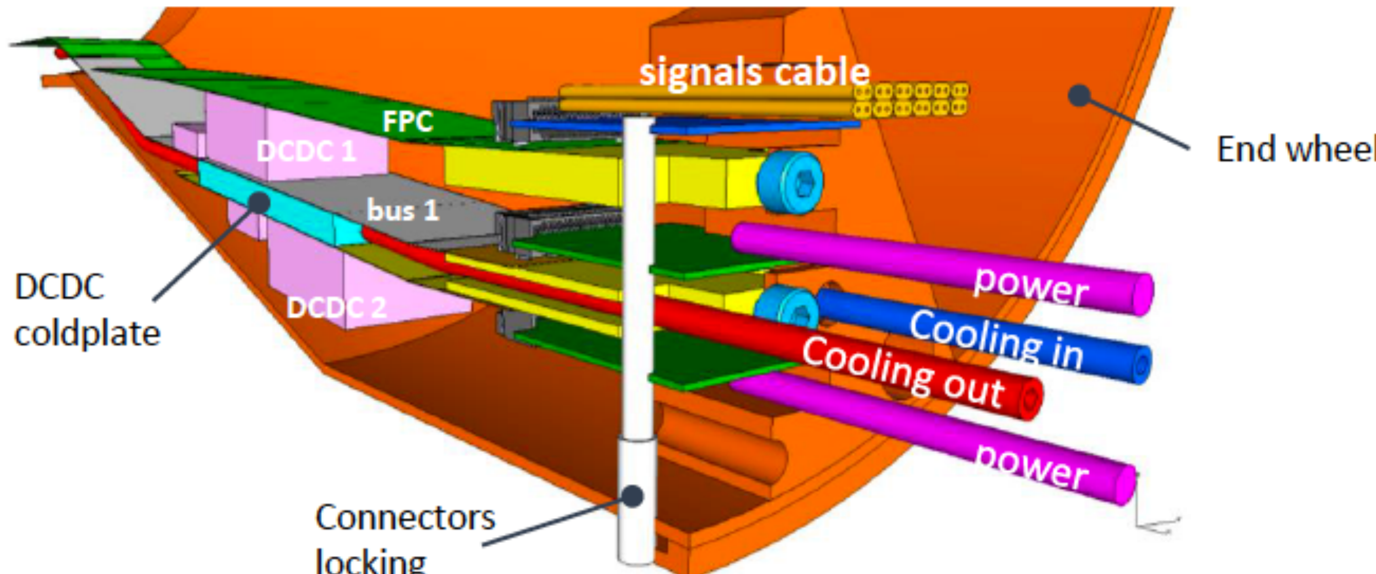
- No high risk R&D necessary
- Early MoU with ALICE critical
- LANL LDRD very important
- Early mechanical integration R&D important
- Cost basis is in reasonable shape
- Management plan is in progress
- Installed and ready for beam ~1/2021
- Schedule has ~6 months contingency

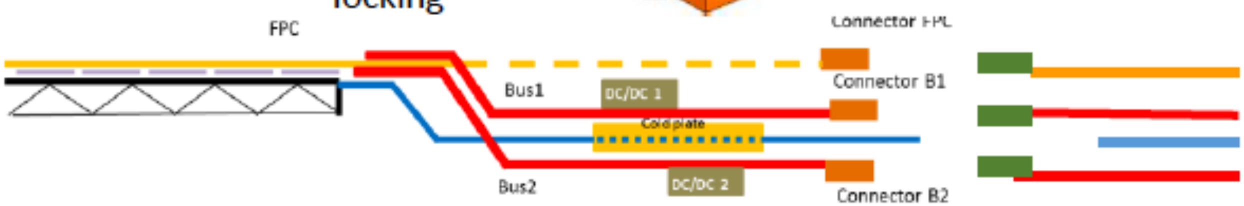
Backup Slides

MAPS Service Lines

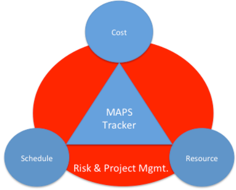








Risk Factors



- Products from ALICE
  - Copies: low risk ~1 (20% Cont.)
  - Some minor modification: medium risk ~2 (30% cont.)
  - New readout board R&D: high risk ~3 (50-100% cont.)

- sPHENIX and ITS/ALICE schedules
  - R&D
  - Production
  - CERN facilities
  - Funding profile

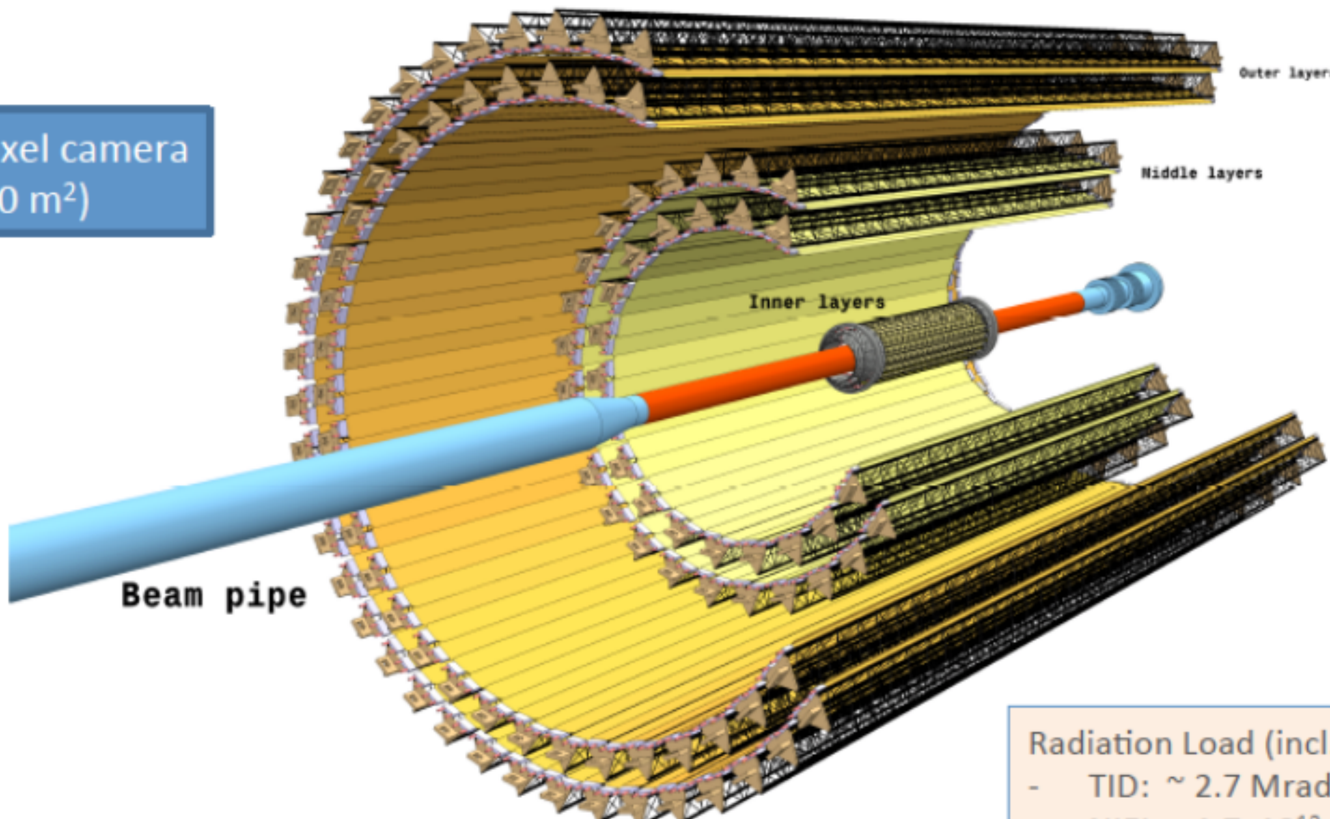
- Long development time for readout boards etc.

New ITS Layout

A Large Ion Collider Experiment

ALICE

12.5 G-pixel camera
(~10 m²)



Radiation Load (incl. safety factor 10)
- TID: ~ 2.7 Mrad
- NIEL: ~1.7×10^{13} 1MeV n_{eq} / cm^2

7-layer barrel geometry based on CMOS Sensors

r coverage: 23 – 400 mm

η coverage: $|\eta| \leq 1.22$
for tracks from 90% most luminous region

3 Inner Barrel layers (IB)

sPHENIX

4 Outer Barrel layers (OB)

Material /layer : 0.3% X_0 (IB), 1% X_0 (OB)

3-Layer vs 2-Layer

- Cost reduction
  - Stave and electronics cost and schedule
    - Saving $626K

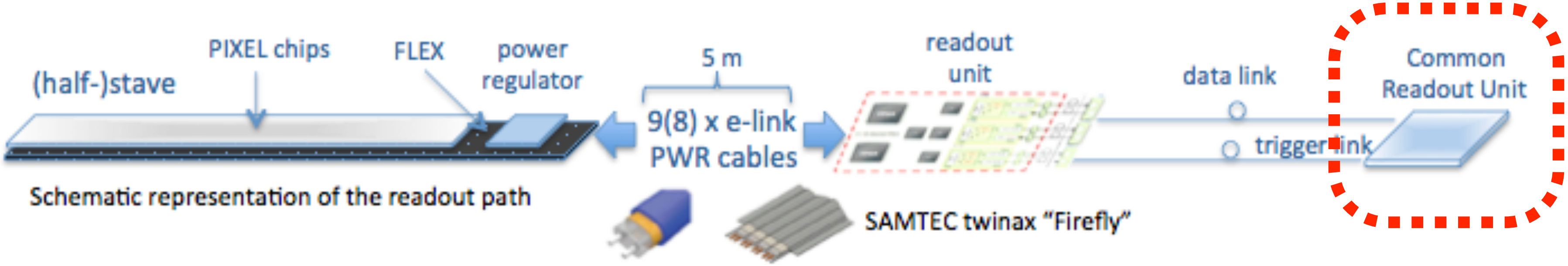
- 3 Layers: total $1,602K
  - (12+16+20)+20 = 68 staves
    - Cost: $920+$144 = $1,064K
    - Schedule: 180 days
  - 68 RDOs:
    - Cost: $322+$32 =$354K
  - 34 CRUs:
    - Cost: $182+$2 = $184K

- 2 Inner Layers: total = $964K
  - (12+16)+12 ALICE layers 0 & 1= 40 staves
    - Cost: 40/68 x $1,064K = $626K
    - Schedule: 106 days
  - 40 RDOs
    - 40/68x $354K = $208K
  - 24CRU:
    - 24/34x$184K = $130K

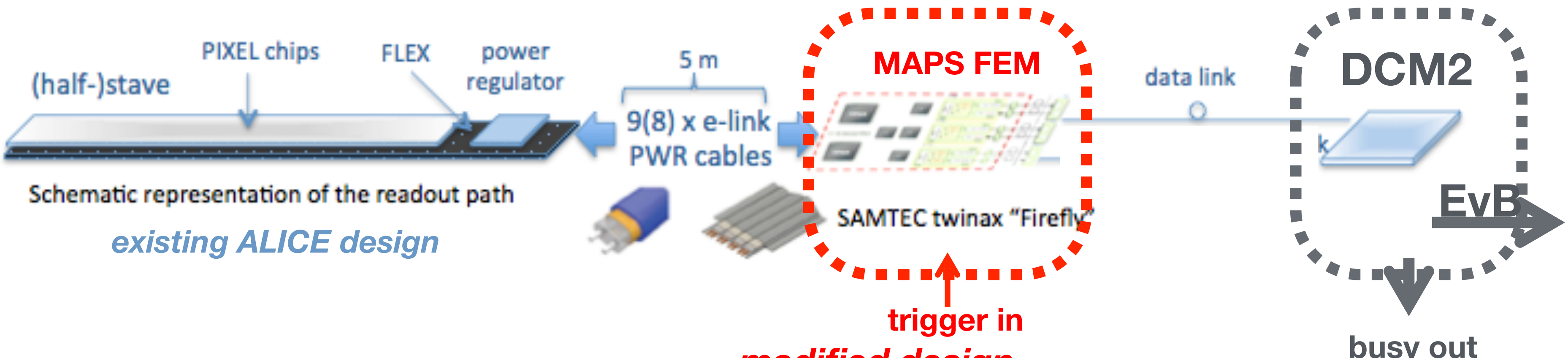
MAPS Electronics

ALICE readout path

Plan A: reprogram



Plan B: sPHENIX readout path (held as contingency)



existing ALICE design

modified design, starting with ALICE boards

existing sPHENIX design

Collaboration & Management

- Workshops organized in Santa Fe, 4/2016
  - Strong support from ITS/ALICE and other groups
    - LBNL, BNL STAR/HFT group
    - MIT, Yonsei / Korean Institutions
  - Produced 1st draft of Cost and Schedule project file
  - Established collaboration with ALICE ITS groups
- MAPS Detector Group Kickoff Meeting 8/19/2016
  - Institutions and their interest
  - Resources and plan
- US institutions
  - MIT HI and ME groups
    - Stave assembly and test at CERN & BNL, cooling, integration etc.
  - LBNL
    - mechanical carbon frame etc
  - BNL
    - Services, DAQ, safety, tech support etc
  - UNM and NMSU
    - Cabling, assembly, simulations and physics analysis
  - U Colorado
    - DAQ and DCM-II integration, simulations and analysis
  - ISU
    - Simulations and analysis, assembly and test
  - GSU
    - Simulations, small controls
  - FSU
    - Offline
  - U California, Riverside/LA/Davis etc
    - Local mechanical and electronics shops, simulations, assembly and test
  - UT Austin
    - Readout electronics
  - UIC
    - Assembly and test, offline
- Other international collaborators
  - RIKEN/RBRC – assembly, test and simulations
  - CCNU/ALICE/ITS
  - Yonsei/ALICE/ITS

Working on MOU with ITS/ALICE

- Initial discussion with ITS Management
- Associate Membership on ITS/ALICE project
- Obtain 4 staves & readout for R&D ASAP
- Stave production extension, schedule and "mortgage"
- Obtain readout design files
- Mechanical design files
- sPHENIX manpower at CERN

- 2 presentations planned
  - 9/1/2016: ALICE Management Board meeting
  - 11/11/2016: ALICE Collaboration Board meeting

Expect MOU agreement: 12/2016

LANL/sPHENIX – ALICE Collaboration

From: Luciano Musa <luciano.musa@cern.ch>
Date: Saturday, August 6, 2016 at 9:25 PM
To: "Ming Liu (LANL)" <ming@bnl.gov>
Subject: Re: ALICE ITS MAPS project and sPHENIX - ALICE Associate Membership?

Dear Ming,

sorry for the late reply to your previous e-mail. We had two Engineering Design Reviews (mechanics and cooling) and then I was in Jakarta for one week for an ITS Asian Meeting.

I am glad to learn that you succeed obtaining a $5M grant (congratulations!!) and your plans to become an ALICE associate member to work in the ITS project. This will require a detailed discussion between the two of us for the preparation of an MoU.
I am leaving today for two weeks of vacation and will be back to CERN on August 22nd. I would propose we get in touch on the 22nd or 23rd August, if this is fine for you.

A possible timeline is presentation of your request at the MB of 1st September and at the CB of 11th November.

Kind Regards,
Luciano

Plan: ITS/ALICE associate members by the end of 2016

TPC

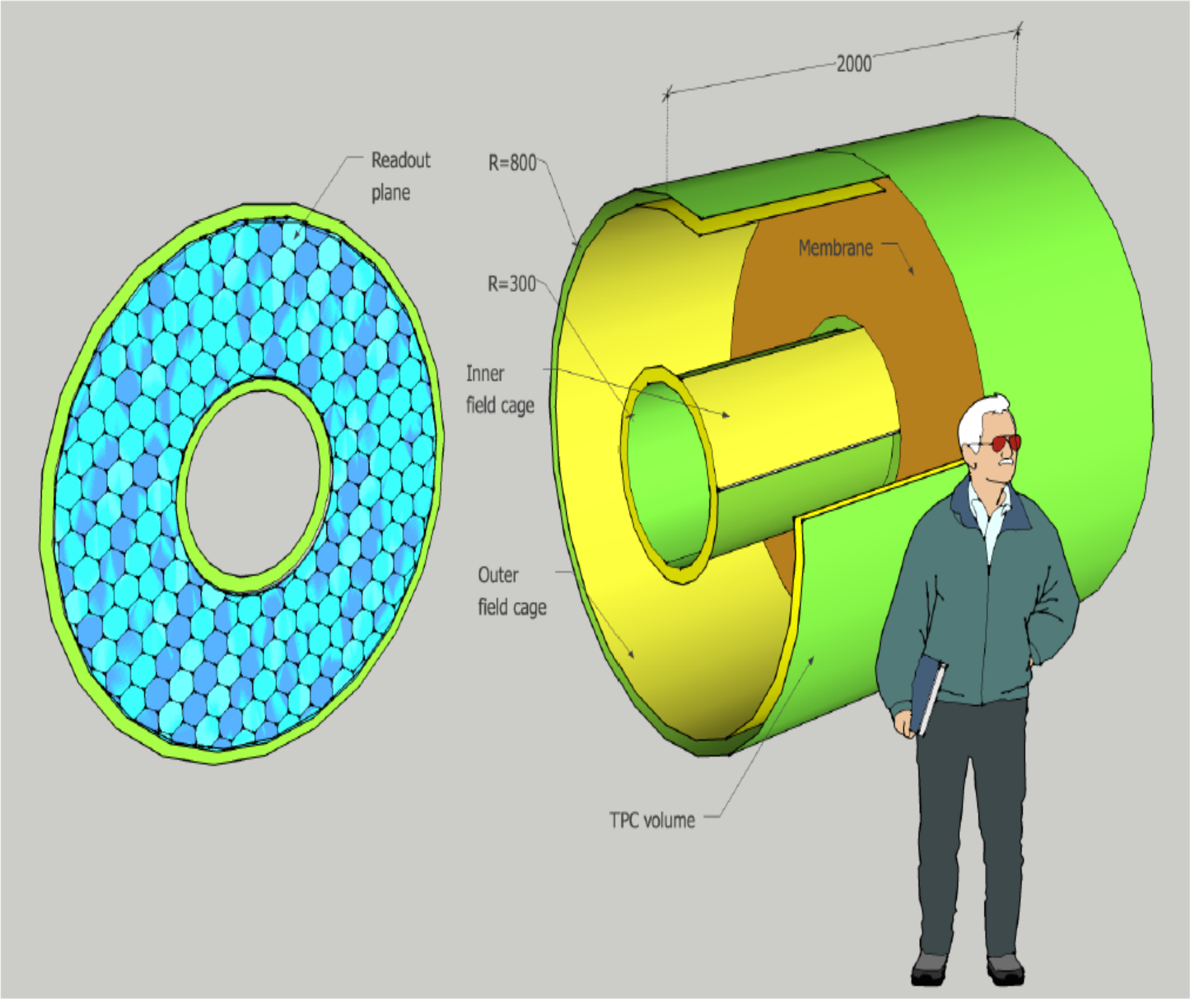
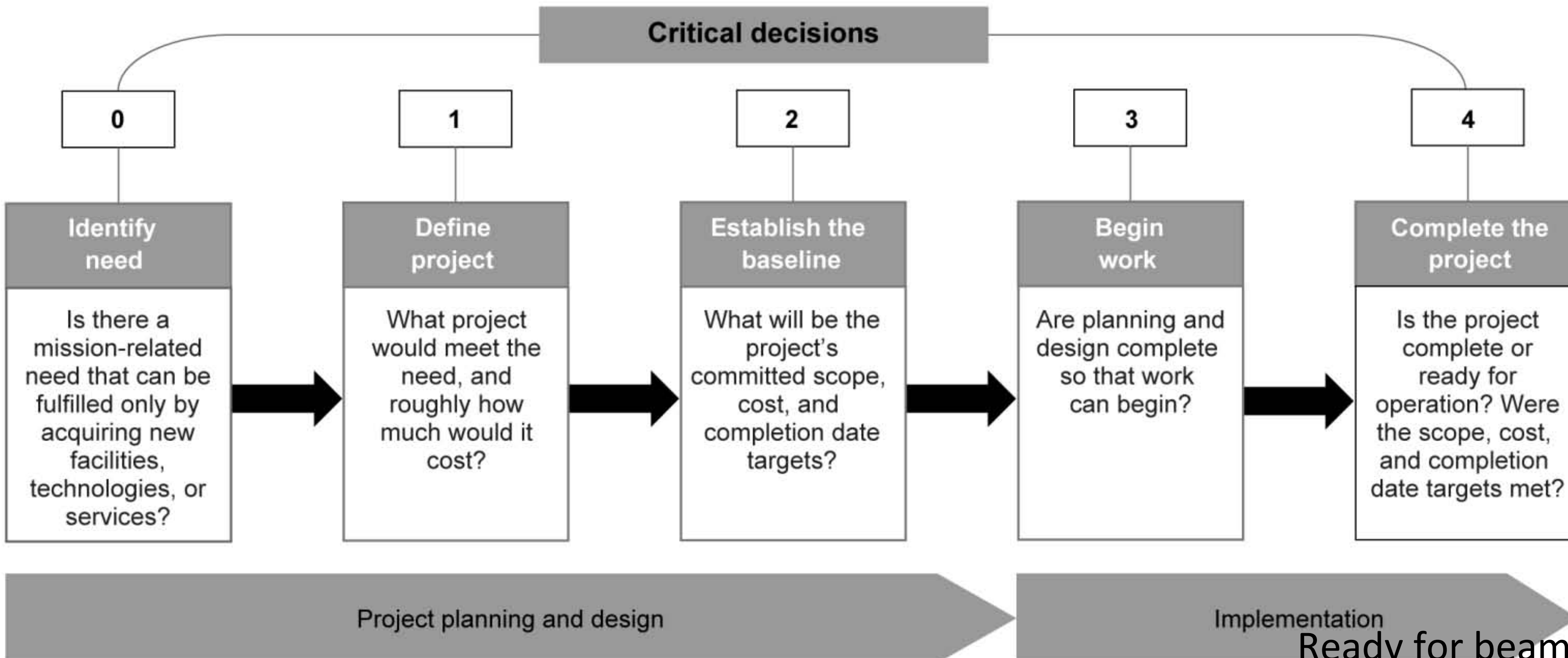


Figure 4.26: Schematic layout of TPC main elements.

Breakout Session Discussion

Details of Cost & Schedule

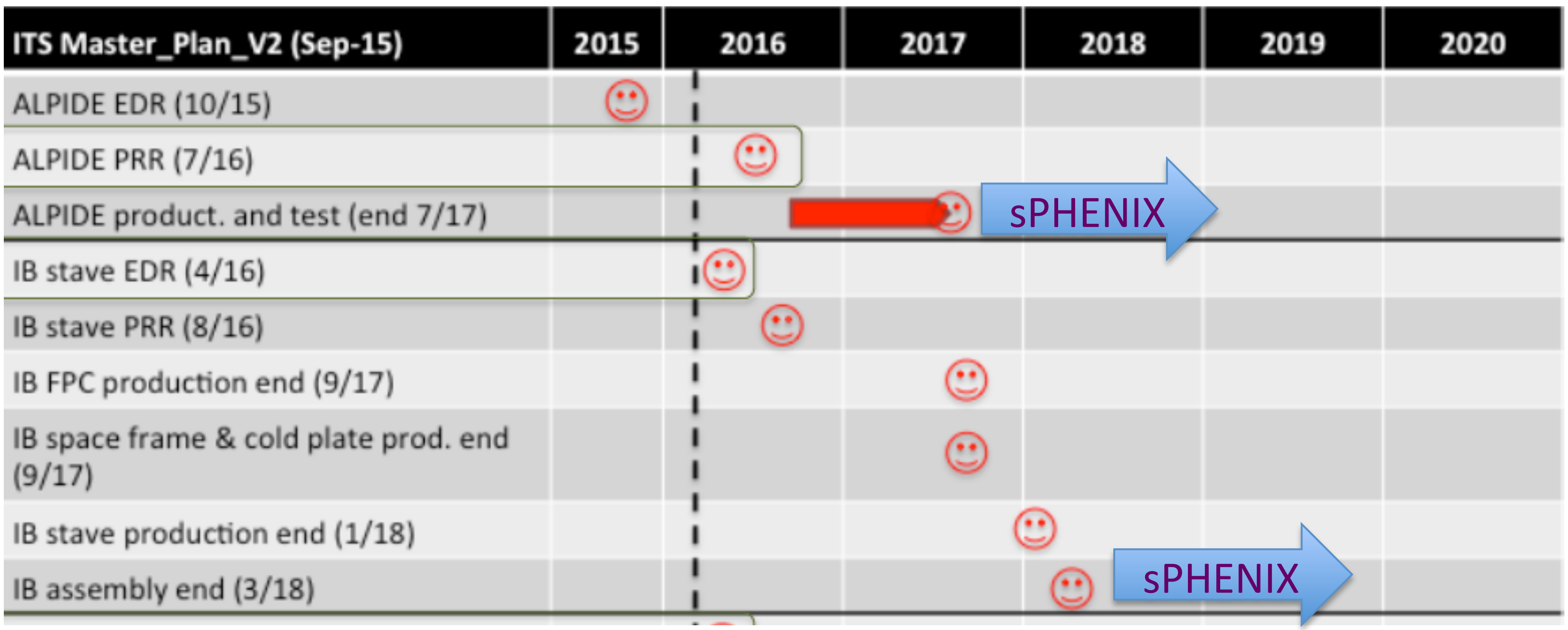
sPHENIX DOE Critical Decision Process



~10/2016 11/2017 CD2: ~6/2018 8/2018

Ready for beam 6/2021
Installation: 2/1
Commissioning: 4/1

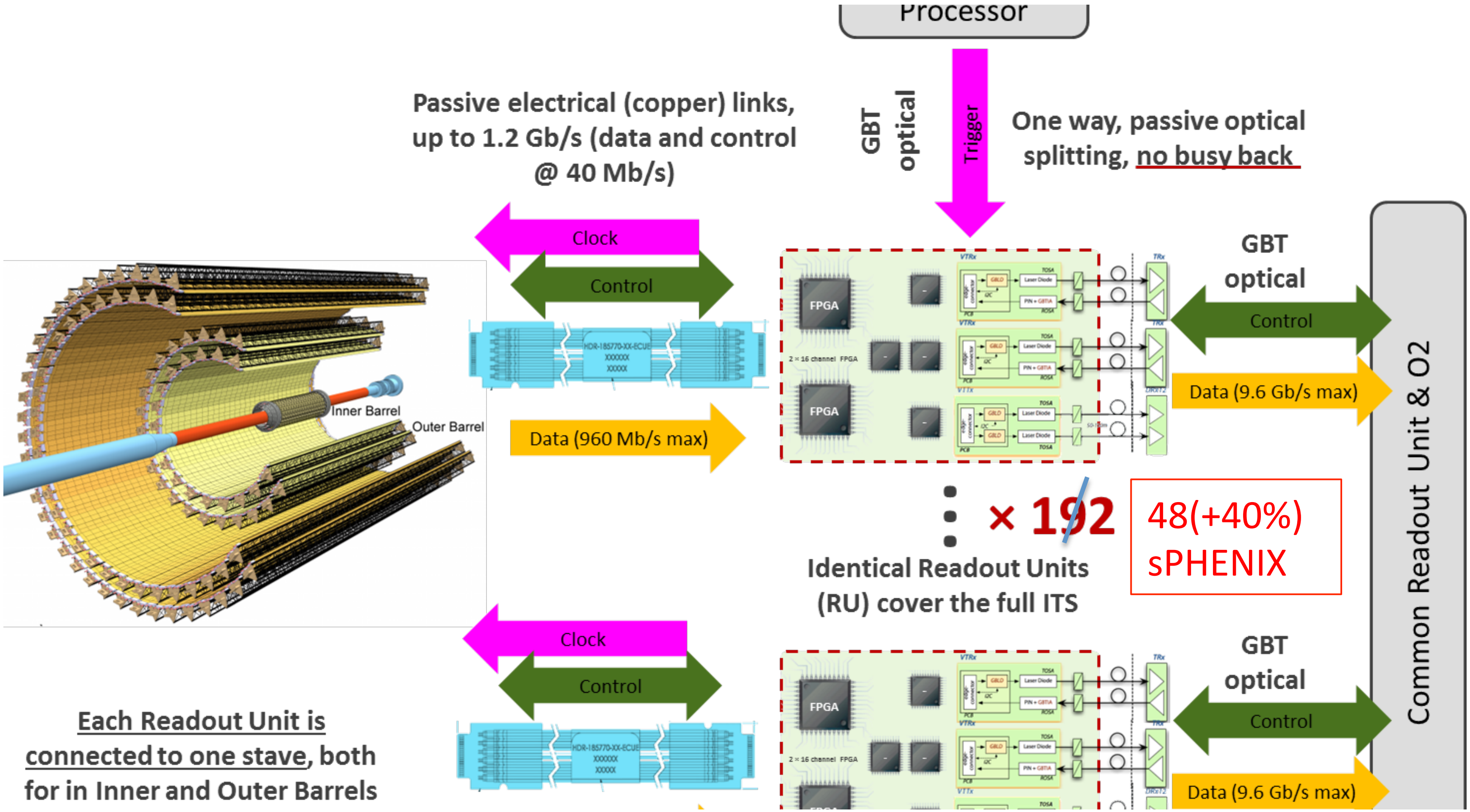
How to mate ALICE and sPHENIX schedules ?



Important to have MoU with ALICE to produce staves for sPHENIX

Cost Basis For Electronics

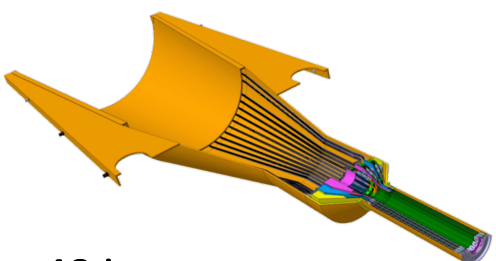
J. Phys. G: Nucl. Part. Phys. **41** (2014) 087002



Readout Units Required for ITS & sPHENIX

Readout Units and GBT links for maximum design rates

Layer	Staves	Copper assemblies	Copper capacity	RUs per stave	RUs per layer	VTRx count	VTTx count	Data fibers	Control fibers	Data fibers capacity	Data fibers usage
			[Gb/s]							[Gb/s]	[%]
0	12	12	103.7	1	12	24	12	36	12	115.2	90.0
1	16	16	138.2	1	16	32	16	48	16	153.6	90.0
2	20	20	172.8	1	20	40	20	60	20	192	90.0
3	24	48	122.9	1	24	48	24	48	24	153.2	80.0
4	30	60	153.6	1	30	60	30	60	30	192	80.0
5	42	168	376.3	1	42	84	42	126	42	403.2	93.3
6	48	196	430.1	1	48	96	48	144	48	460.8	93.3
Total		520	1497.6		192	384	192	576	192	1670	



48 inner staves

48 RDO boards

sPHENIX: 48 +40% = 68

ITS IB:
Produce 120 staves in one year

120% contingency

Key Electronics Readout R&D

- Mostly carried out by LANL LDRD
  - Complete readout electronics design and test by CD-1 (8/1/1017)
- Modify ALICE ITS readout data format to meet sPHENIX DAQ requirements
  - Plan-A:
    - Reprogram CRU to send data directly to PCI/sPHENIX Evt-Builder
  - Plan-B:
    - Build a custom board to convert ALICE data format into sPHENIX DAQ/DCM-II format

Assigned large contingency in both cost and schedule for the readout R&D

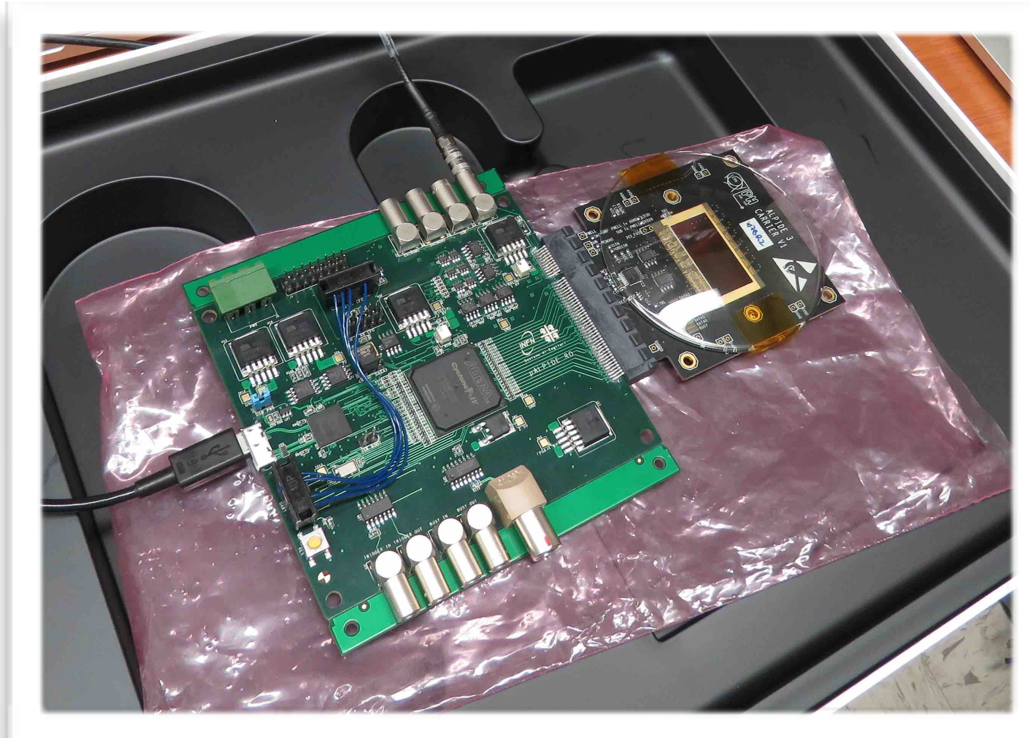
Electronics R&D @LANL

- Obtained MAPS v3 at LANL
- R&D lab setup through LANL fund
  - To setup sPHENIX DAQ/DCM-II
  - MAPS readout integration
  - Reuse FVTX FEMS?

1st MAPS prototype sensor being studied at **LANL**

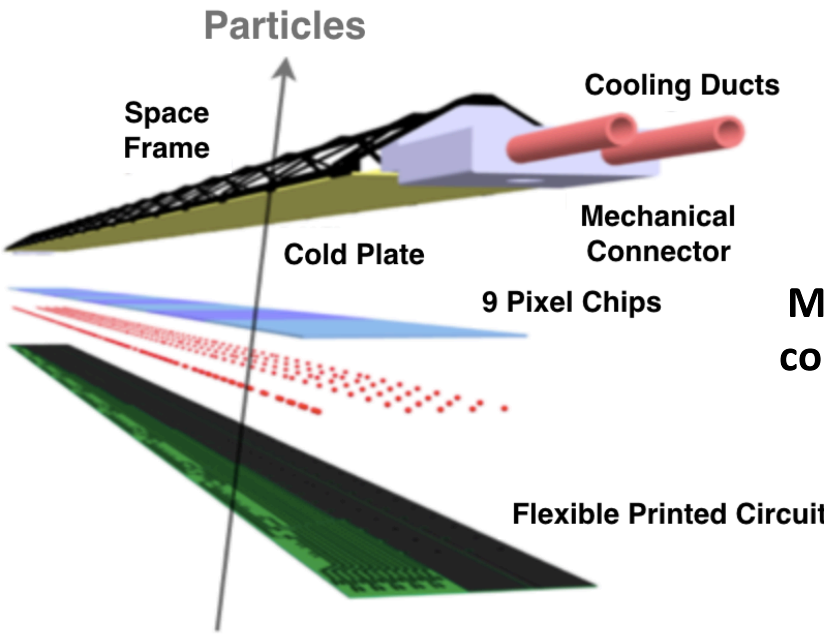
LBNL R&D expert visited LANL May 2-4th

Mike's expertise on DCM-II



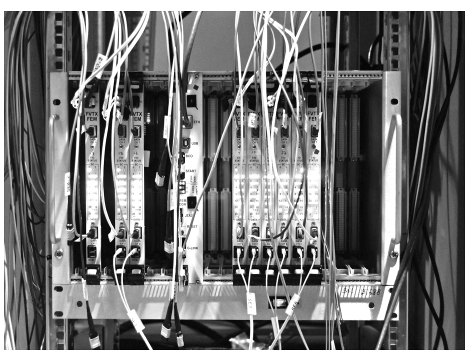
R&D Deliverable: a Prototype Tracker

LDRD Experimental Goal: LANL-built 4-stave prototype tracker at test beam with custom sPHENIX readout



MAPS stave construction

1st MAPS prototype sensor being studied at **LANL**



Custom front end, integrate into sPHENIX readout (FVTX expertise)

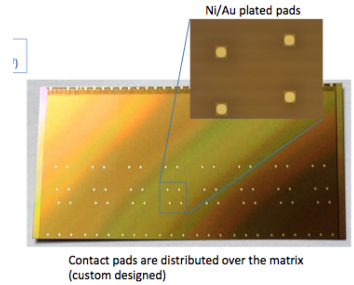
Annual Fermilab Test beam

Test prototype tracker

Validate tracking and reconstruction

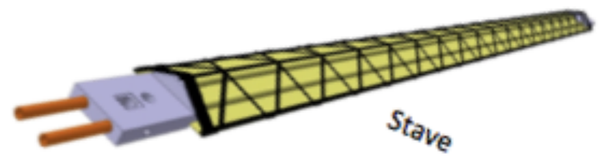
Critical R&D through LDRD

Extend TowerJazz Production:
In-kind contribution
525 ALPIDE-final sensors
(inner 3 layers plus ~20% spares)



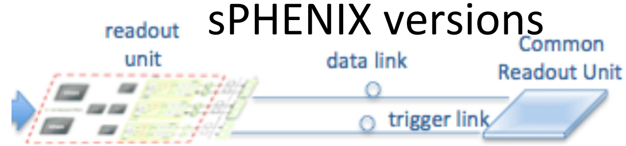
2x525 ct.

Test Beam Prototype:
4 full inner ALICE ITS Staves
ALICE readout + common readout boards
small scale power & cooling, jigs, etc



4 ct.

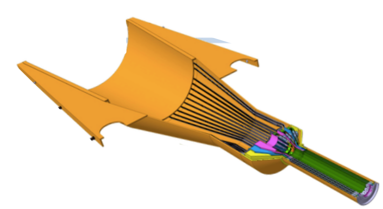
Readout Design:
reprogram CRU for sPHENIX;
or new FEM design for sPHENIX,
replace the ALICE readout board
full-system test with test beam prototype



4 ct.

Initial Half-Barrel Mechanical Design:
adapt ALICE inner 3 layer mechanics to sPHENIX
build 3-layer mounts for full-system test

sPHENIX versions



2 ct.

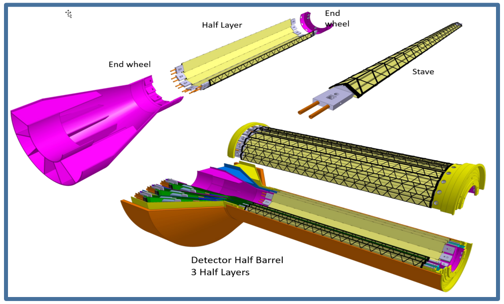
Under LDRD funding:
- Final Detector ~10% populated with staves & readout
- CERN-trained personnel
- Reduce cost of MAPS detector by $2M!

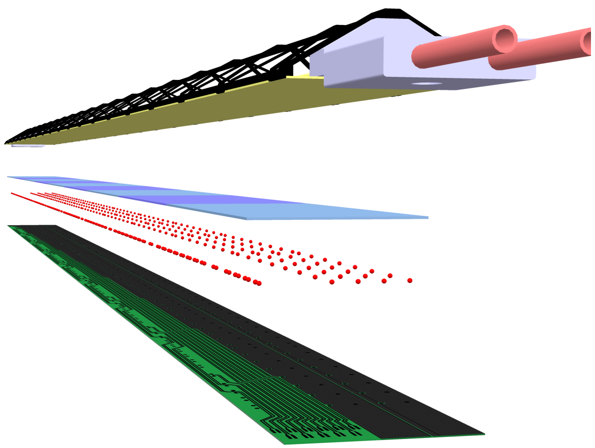
Cost Breakdown - Readout

Activity	M&S ($K)	Manpower ($K)	Total ($K)
68 staves	920	145	1065
68 FEMs	322	32	354
34 CRUs	182	2	184
LVPS, Cables	60	2	62
SamTec cabels, Fibers	70	4	74

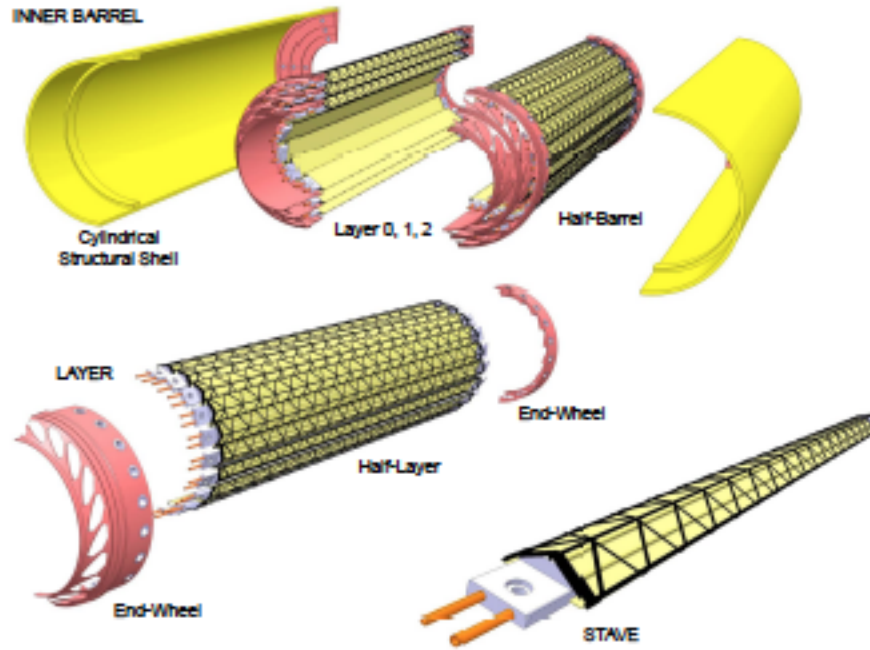
DCM-II: ? $$ TBD
Test bench : $100K

ALICE Stave and Global Support Structure Cost and Schedule Basis





ALICE Stave

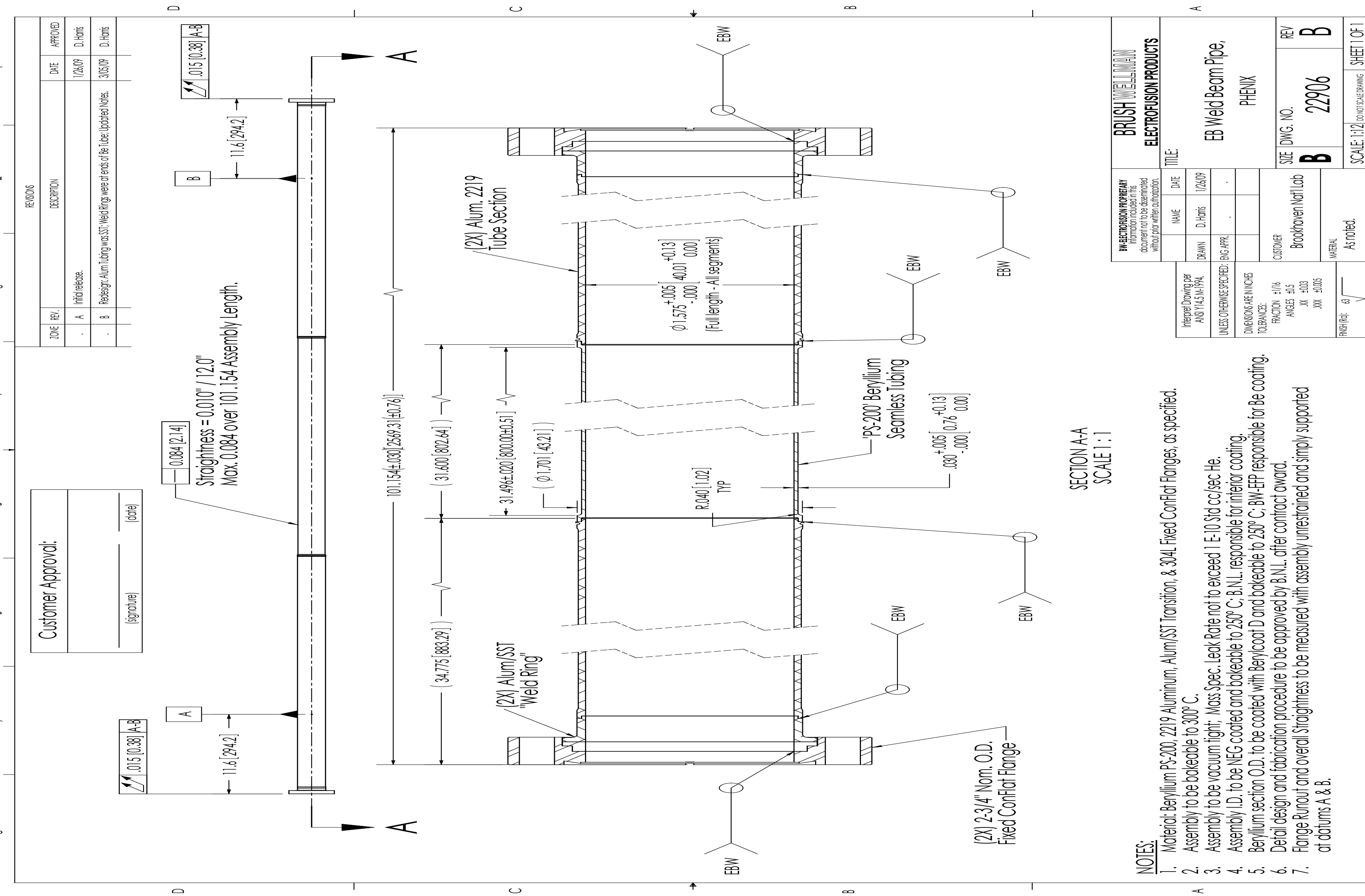


(a) ITS Inner Barrel design.

J. Phys. G: Nucl. Part. Phys. **41** (2014) 087002

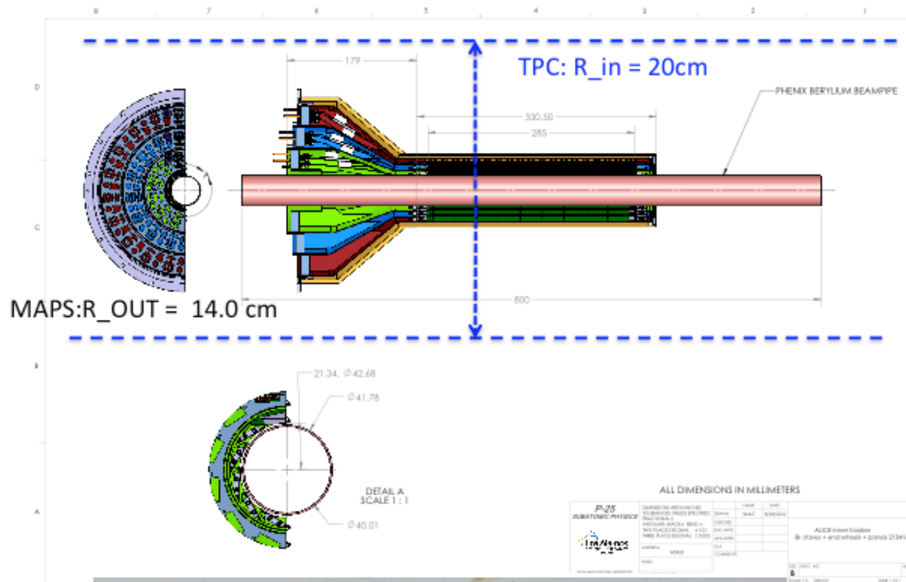
PHENIX Beam Pipe

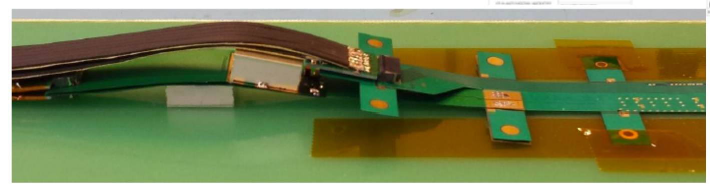
$R_{PHENIX(max)}$ = 20.78 mm
$R_{ALICE\_Frame(min)}$ = 22.00
$R_{ALICE\_MAPS(min)}$ = 22.40

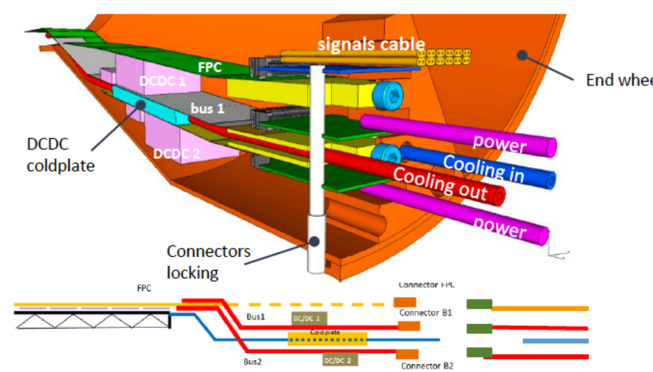


Mechanical Integration

- ALICE ITS can fit sPHENIX
  - PHENIX beam pine:
    - R_out =20.78mm, |Z|<=40cm
    - R_ALICE_frame_min= 22.00 mm
    - R_MAPS_stave_min = 22.40 mm
    - Gap_Beam_pipe_ITS = 1.63mm
  - sPHENIX TPC
    - R_in = 20cm
    - R_ALICE_frame_max=140mm
- Potential modification
  - Extend service structure for cables/cooling lines







Schedule of Mechanics

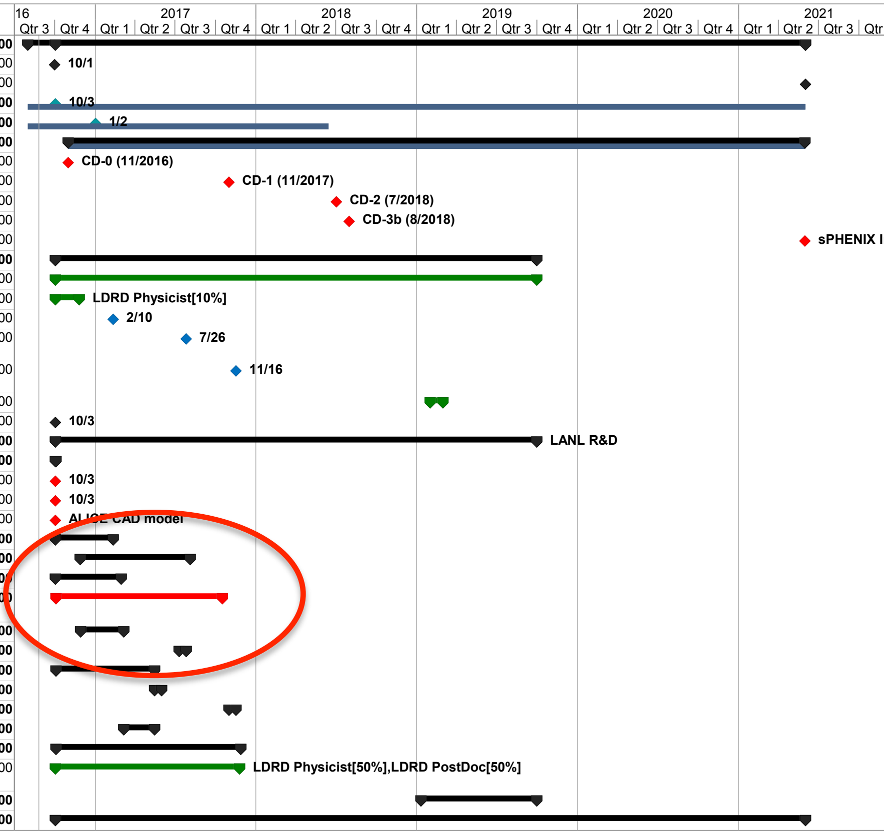
- Early R&D carried out by LANL LDRD
  - Conceptual design for CD-1
  - Cooling system prototyping for CD-2

- DOE Project
  - Carry out final mechanical design and system
    - Stave frames and support structure
    - Cooling
    - Cable layout
  - To meet the CD2/3 schedules, early R&D fund needed for integration design work

LANL R&D

Fri 8/26/16

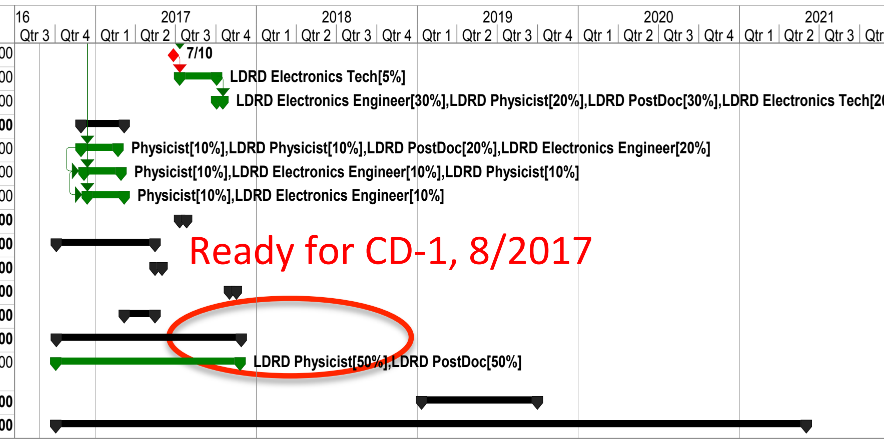
ID	WBS	Task Name	Duration	Start	Finish	Cost Center	Fixed Cost	Cost	Activi	Cost per Unit
1	1	**MAPS Inner Barrel**	**1217 days**	**Mon 10/3/16**	**Tue 6/1/21**		**$0.00**	**$5,305,297.33**		**$0.00**
2	1.1	MAPS Inner Barrel Starts	0 days	Sat 10/1/16	Sat 10/1/16		$0.00	$0.00		$0.00
3	1.2	MAPS Inner Barrel Ends	0 days	Tue 6/1/21	Tue 6/1/21		$0.00	$0.00		$0.00
4	**1.3**	**Milestones & Key Tasks**	**0 days**	**Mon 10/3/16**	**Mon 10/3/16**		**$0.00**	**$6,400.00**		**$0.00**
5	**1.3.1**	**ALICE ITS Key Tasks**	**0 days**	**Mon 1/2/17**	**Mon 1/2/17**		**$0.00**	**$0.00**		**$0.00**
12	**1.3.2**	**sPHENIX Milestones**	**1195 days**	**Tue 11/1/16**	**Tue 6/1/21**		**$0.00**	**$0.00**		**$0.00**
13	1.3.2.1	sPHENIX Technical Design CD-0	0 days	Tue 11/1/16	Tue 11/1/16		$0.00	$0.00	CD-0	$0.00
14	1.3.2.2	sPHENIX Technical Design (CD-1/CD-3a)	0 days	Wed 11/1/17	Wed 11/1/17		$0.00	$0.00	CD-1	$0.00
15	1.3.2.3	sPHENIX Technical Dewsgin (CD-2)	0 days	Mon 7/2/18	Mon 7/2/18		$0.00	$0.00	CD-2	$0.00
16	1.3.2.4	sPHENIX Start Construction (CD-3b)	0 days	Wed 8/1/18	Wed 8/1/18		$0.00	$0.00	CD-3	$0.00
17	1.3.2.5	sPHENIX Installed and Ready for Beam	0 days	Tue 6/1/21	Tue 6/1/21		$0.00	$0.00	ready	$0.00
18	**1.3.3**	**LDRD Milestones & Critical Tasks**	**781 days**	**Mon 10/3/16**	**Mon 9/30/19**		**$0.00**	**$6,400.00**		**$0.00**
19	1.3.3.1	LDRD Start and End	781 days	Mon 10/3/16	Mon 9/30/19		$0.00	$0.00		$0.00
20	1.3.3.2	MOU btw LANL and ALICE for R&D	40 days	Mon 10/3/16	Fri 11/25/16	LDRD	$0.00	$6,400.00		$0.00
21	1.3.3.3	Setup ALICE Readout Test Stands	0 days	Fri 2/10/17	Fri 2/10/17		$0.00	$0.00		$0.00
22	1.3.3.4	Complete final sPHENIX Readout Design Review	0 days	Wed 7/26/17	Wed 7/26/17		$0.00	$0.00		$0.00
23	1.3.3.5	Complete Final MAPS Detector Design (CD-1)	0 days	Thu 11/16/17	Thu 11/16/17		$0.00	$0.00		$0.00
24	1.3.3.6	sPHENIX Test Beam	21 days	Fri 2/1/19	Fri 3/1/19	LDRD	$0.00	$0.00		$0.00
25	1.3.3.7	MAPS Final Design (CD-2/CD-3)?	0 days	Mon 10/3/16	Mon 10/3/16		$0.00	$0.00		$0.00
26	**1.4**	**LANL LDRD**	**781 days**	**Mon 10/3/16**	**Mon 9/30/19**	**LDRD**	**$0.00**	**$1,372,560.00**	**LANL**	**$0.00**
27	**1.4.1**	**Obtain Designs from ALICE**	**1 day**	**Mon 10/3/16**	**Mon 10/3/16**		**$0.00**	**$960.00**		**$0.00**
28	1.4.1.1	Obtain Test Stand Design from CERN	1 day	Mon 10/3/16	Mon 10/3/16	LDRD	$0.00	$320.00		$0.00
29	1.4.1.2	Obtain ALICE Readout Unit Design	1 day	Mon 10/3/16	Mon 10/3/16	LDRD	$0.00	$320.00		$0.00
30	1.4.1.3	obtain ALICE CAD model	1 day	Mon 10/3/16	Mon 10/3/16	LDRD	$0.00	$320.00	ALICI	$0.00
31	**1.4.2**	**Setup Alice Readout Test Stand**	**95 days**	**Mon 10/3/16**	**Fri 2/10/17**	**LDRD**	**$0.00**	**$44,000.00**		**$0.00**
34	**1.4.3**	**Procure R&D ALICE Staves**	**180 days**	**Mon 11/28/16**	**Fri 8/4/17**	**LDRD**	**$0.00**	**$154,200.00**		**$0.00**
38	**1.4.4**	**Procure ALICE Electronics & Cabels**	**107 days**	**Mon 10/3/16**	**Tue 2/28/17**	**LDRD**	**$0.00**	**$81,360.00**		**$0.00**
56	**1.4.5**	**sPHENIX Readout Electronics Integration**	**270 days**	**Tue 10/4/16**	**Mon 10/16/17**		**$0.00**	**$178,000.00**		**$0.00**
66	**1.4.6**	**sPHENIX DAQ System Integration**	**70 days**	**Tue 11/29/16**	**Mon 3/6/17**		**$0.00**	**$82,200.00**		**$0.00**
70	**1.4.7**	**Electronics Final Design Review**	**12 days**	**Tue 7/11/17**	**Wed 7/26/17**		**$0.00**	**$10,720.00**		**$0.00**
74	**1.4.8**	**Mechanical Support and Cooling**	**160 days**	**Tue 10/4/16**	**Mon 5/15/17**		**$0.00**	**$182,400.00**		**$0.00**
91	**1.4.9**	Mechanical Coneptual Design Review	**12 days**	**Tue 5/16/17**	**Wed 5/31/17**		**$0.00**	**$10,720.00**		**$0.00**
95	**1.4.10**	**MAPS Inner Barrel Review (CD-1)**	**12 days**	**Wed 11/1/17**	**Thu 11/16/17**		**$0.00**	**$21,600.00**		**$0.00**
99	**1.4.11**	**Prototype Assembly and Test**	**50 days**	**Tue 3/7/17**	**Mon 5/15/17**	**LDRD**	**$0.00**	**$39,200.00**		**$0.00**
102	**1.4.12**	**Softrware Development**	**300 days**	**Tue 10/4/16**	**Mon 11/27/17**		**$0.00**	**$112,000.00**		**$0.00**
105	1.4.13	Detector Optimizaation and Physics Simulations (CD-1)	300 days	Mon 10/3/16	Fri 11/24/17		$0.00	$360,000.00		$0.00
106	**1.4.14**	**Test Beam Operation**	**187 days**	**Fri 1/11/19**	**Mon 9/30/19**	**LDRD**	**$0.00**	**$95,200.00**		**$0.00**
111	**1.5**	**sPHENIX Project**	**1217 days?**	**Mon 10/3/16**	**Tue 6/1/21**		**$0.00**	**$3,926,337.33**		**$0.00**



LANL R&D (II)

Fri 8/26/16

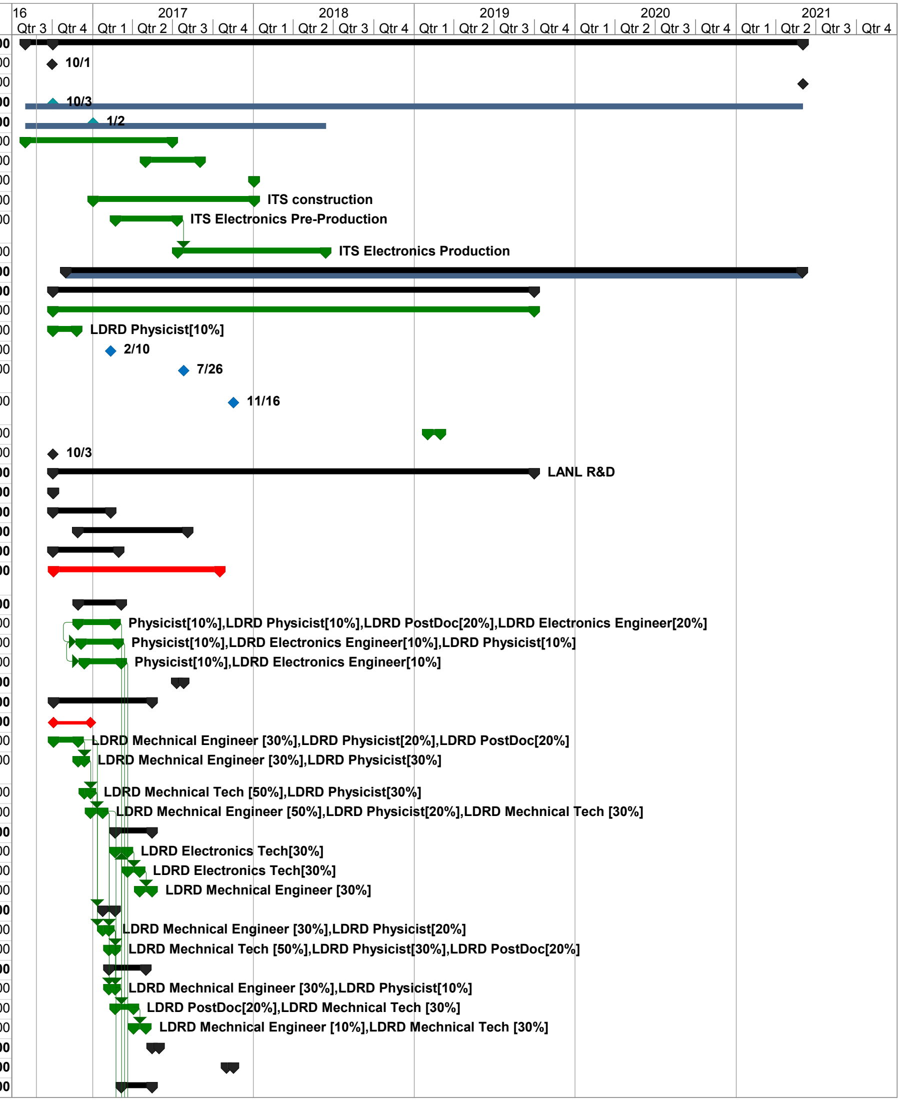
ID	WBS	Task Name	Duration	Start	Finish	Cost Center	Fixed Cost	Cost	Activi	Cost per Unit
63	1.4.5.7	Final FEM design (CD-1)	10 days	Mon 6/26/17	Mon 7/10/17	LDRD	$0.00	$11,200.00		$0.00
64	1.4.5.8	Procure 4 FEMs	60 days	Tue 7/11/17	Mon 10/2/17	LDRD	$20,000.00	$22,400.00		$5,000.00
65	1.4.5.9	Final FEM Test	10 days	Tue 10/3/17	Mon 10/16/17	LDRD	$0.00	$12,000.00		$0.00
66	**1.4.6**	**sPHENIX DAQ System Integration**	**70 days**	**Tue 11/29/16**	**Mon 3/6/17**		**$0.00**	**$82,200.00**		**$0.00**
67	1.4.6.1	Slow Control Design	60 days	Tue 11/29/16	Mon 2/20/17	LDRD	$5,000.00	$43,400.00		$0.00
68	1.4.6.2	Trigger Interface Design	60 days	Tue 12/6/16	Mon 2/27/17	LDRD	$5,000.00	$24,200.00		$0.00
69	1.4.6.3	DAQ Interface Design	60 days	Tue 12/13/16	Mon 3/6/17	LDRD	$5,000.00	$14,600.00		$0.00
70	**1.4.7**	**Electronics Final Design Review**	**12 days**	**Tue 7/11/17**	**Wed 7/26/17**		**$0.00**	**$10,720.00**		**$0.00**
74	**1.4.8**	**Mechanical Support and Cooling**	**160 days**	**Tue 10/4/16**	**Mon 5/15/17**		**$0.00**	**$182,400.00**		**$0.00**
91	**1.4.9**	Mechanical Coneptual Design Review	**12 days**	**Tue 5/16/17**	**Wed 5/31/17**		**$0.00**	**$10,720.00**		**$0.00**
95	**1.4.10**	**MAPS Inner Barrel Review (CD-1)**	**12 days**	**Wed 11/1/17**	**Thu 11/16/17**		**$0.00**	**$21,600.00**		**$0.00**
99	**1.4.11**	**Prototype Assembly and Test**	**50 days**	**Tue 3/7/17**	**Mon 5/15/17**	**LDRD**	**$0.00**	**$39,200.00**		**$0.00**
102	**1.4.12**	**Softrware Development**	**300 days**	**Tue 10/4/16**	**Mon 11/27/17**		**$0.00**	**$112,000.00**		**$0.00**
105	1.4.13	Detector Optimizaation and Physics Simulations (CD-1)	300 days	Mon 10/3/16	Fri 11/24/17		$0.00	$360,000.00		$0.00
106	**1.4.14**	**Test Beam Operation**	**187 days**	**Fri 1/11/19**	**Mon 9/30/19**	**LDRD**	**$0.00**	**$95,200.00**		**$0.00**
111	**1.5**	**sPHENIX Project**	**1217 days?**	**Mon 10/3/16**	**Tue 6/1/21**		**$0.00**	**$3,926,337.33**		**$0.00**



LANL Mechanics R&D (I)

Fri 8/26/16

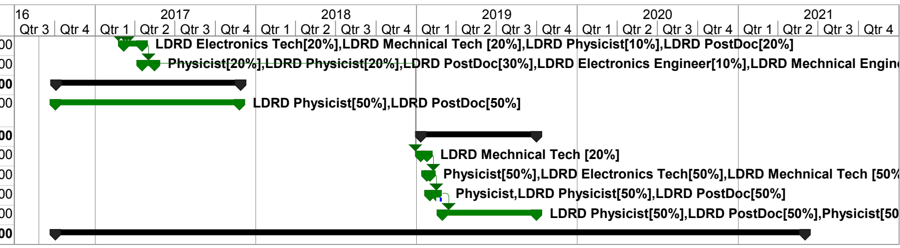
ID	WBS	Task Name	Duration	Start	Finish	Cost Center	Fixed Cost	Cost	Activi	Cost per Unit
1	1	**MAPS Inner Barrel**	**1217 days**	**Mon 10/3/16**	**Tue 6/1/21**		**$0.00**	**$5,305,297.33**		**$0.00**
2	1.1	MAPS Inner Barrel Starts	0 days	Sat 10/1/16	Sat 10/1/16		$0.00	$0.00		$0.00
3	1.2	MAPS Inner Barrel Ends	0 days	Tue 6/1/21	Tue 6/1/21		$0.00	$0.00		$0.00
4	**1.3**	**Milestones & Key Tasks**	**0 days**	**Mon 10/3/16**	**Mon 10/3/16**		**$0.00**	**$6,400.00**		**$0.00**
5	**1.3.1**	**ALICE ITS Key Tasks**	**0 days**	**Mon 1/2/17**	**Mon 1/2/17**		**$0.00**	**$0.00**		**$0.00**
6	1.3.1.1	ALICE MAPS Production (7/17)	240 days?	Mon 8/1/16	Fri 6/30/17		$0.00	$0.00		$0.00
7	1.3.1.2	ALICE ITS IB FPC Production (9/17)	90 days	Mon 5/1/17	Fri 9/1/17		$0.00	$0.00		$0.00
8	1.3.1.3	ALICE ITS IB Stave Production (1/18)	1 day?	Tue 1/2/18	Tue 1/2/18		$0.00	$0.00		$0.00
9	1.3.1.4	ALICE ITS IB Stave Assembly (3/18)	262 days	Mon 1/2/17	Tue 1/2/18		$0.00	$0.00	ITS c	$0.00
10	1.3.1.5	ALICE ITS Electronics Pre-Production (7/17)	100 days	Wed 2/22/17	Tue 7/11/17		$0.00	$0.00	ITS Electi	$0.00
11	1.3.1.6	ALICE ITS Electronics Production (6/18)	240 days	Thu 7/13/17	Wed 6/13/18		$0.00	$0.00	ITS E	$0.00
12	**1.3.2**	**sPHENIX Milestones**	**1195 days**	**Tue 11/1/16**	**Tue 6/1/21**		**$0.00**	**$0.00**		**$0.00**
18	**1.3.3**	**LDRD Milestones & Critical Tasks**	**781 days**	**Mon 10/3/16**	**Mon 9/30/19**		**$0.00**	**$6,400.00**		**$0.00**
19	1.3.3.1	LDRD Start and End	781 days	Mon 10/3/16	Mon 9/30/19		$0.00	$0.00		$0.00
20	1.3.3.2	MOU btw LANL and ALICE for R&D	40 days	Mon 10/3/16	Fri 11/25/16	LDRD	$0.00	$6,400.00		$0.00
21	1.3.3.3	Setup ALICE Readout Test Stands	0 days	Fri 2/10/17	Fri 2/10/17		$0.00	$0.00		$0.00
22	1.3.3.4	Complete final sPHENIX Readout Design Review	0 days	Wed 7/26/17	Wed 7/26/17		$0.00	$0.00		$0.00
23	1.3.3.5	Complete Final MAPS Detector Design (CD-1)	0 days	Thu 11/16/17	Thu 11/16/17		$0.00	$0.00		$0.00
24	1.3.3.6	sPHENIX Test Beam	21 days	Fri 2/1/19	Fri 3/1/19	LDRD	$0.00	$0.00		$0.00
25	1.3.3.7	MAPS Final Design (CD-2/CD-3)?	0 days	Mon 10/3/16	Mon 10/3/16		$0.00	$0.00		$0.00
26	**1.4**	**LANL LDRD**	**781 days**	**Mon 10/3/16**	**Mon 9/30/19**	**LDRD**	**$0.00**	**$1,372,560.00**	**LANL**	**$0.00**
27	**1.4.1**	**Obtain Designs from ALICE**	**1 day**	**Mon 10/3/16**	**Mon 10/3/16**		**$0.00**	**$960.00**		**$0.00**
31	**1.4.2**	**Setup Alice Readout Test Stand**	**95 days**	**Mon 10/3/16**	**Fri 2/10/17**	**LDRD**	**$0.00**	**$44,000.00**		**$0.00**
34	**1.4.3**	**Procure R&D ALICE Staves**	**180 days**	**Mon 11/28/16**	**Fri 8/4/17**	**LDRD**	**$0.00**	**$154,200.00**		**$0.00**
38	**1.4.4**	**Procure ALICE Electronics & Cabels**	**107 days**	**Mon 10/3/16**	**Tue 2/28/17**	**LDRD**	**$0.00**	**$81,360.00**		**$0.00**
56	**1.4.5**	**sPHENIX Readout Electronics Integration**	**270 days**	**Tue 10/4/16**	**Mon 10/16/17**		**$0.00**	**$178,000.00**		**$0.00**
66	**1.4.6**	**sPHENIX DAQ System Integration**	**70 days**	**Tue 11/29/16**	**Mon 3/6/17**		**$0.00**	**$82,200.00**		**$0.00**
67	1.4.6.1	Slow Control Design	60 days	Tue 11/29/16	Mon 2/20/17	LDRD	$5,000.00	$43,400.00		$0.00
68	1.4.6.2	Trigger Interface Design	60 days	Tue 12/6/16	Mon 2/27/17	LDRD	$5,000.00	$24,200.00		$0.00
69	1.4.6.3	DAQ Interface Design	60 days	Tue 12/13/16	Mon 3/6/17	LDRD	$5,000.00	$14,600.00		$0.00
70	**1.4.7**	**Electronics Final Design Review**	**12 days**	**Tue 7/11/17**	**Wed 7/26/17**		**$0.00**	**$10,720.00**		**$0.00**
74	**1.4.8**	**Mechanical Support and Cooling**	**160 days**	**Tue 10/4/16**	**Mon 5/15/17**		**$0.00**	**$182,400.00**		**$0.00**
75	**1.4.8.1**	Specifications	**60 days**	**Tue 10/4/16**	**Mon 12/26/16**		**$0.00**	**$58,800.00**		**$0.00**
76	1.4.8.1.1	Review & Simulate Heat Load	40 days	Tue 10/4/16	Mon 11/28/16	LDRD	$0.00	$38,400.00		$0.00
77	1.4.8.1.2	review mechanical tolerances/distortions	10 days	Tue 11/29/16	Mon 12/12/16	LDRD	$0.00	$9,600.00		$0.00
78	1.4.8.1.3	review disassembly/repair options	10 days	Tue 12/13/16	Mon 12/26/16	LDRD	$0.00	$10,800.00		$0.00
79	1.4.8.2	Prototype Stave Frame Design	20 days	Tue 12/27/16	Mon 1/23/17	LDRD	$0.00	$29,600.00		$0.00
80	**1.4.8.3**	**Safety Systems**	**60 days**	**Tue 2/21/17**	**Mon 5/15/17**		**$0.00**	**$29,200.00**		**$0.00**
81	1.4.8.3.1	review sensors & interlocks	20 days	Tue 2/21/17	Mon 3/20/17	LDRD	$0.00	$4,800.00		$0.00
82	1.4.8.3.2	electrical interlock design	20 days	Tue 3/21/17	Mon 4/17/17	LDRD	$5,000.00	$9,800.00		$0.00
83	1.4.8.3.3	cooling interlocks design	20 days	Tue 4/18/17	Mon 5/15/17	LDRD	$5,000.00	$14,600.00		$0.00
84	**1.4.8.4**	**Cooling System**	**20 days**	**Tue 1/24/17**	**Mon 2/20/17**		**$0.00**	**$30,400.00**		**$0.00**
85	1.4.8.4.1	Prototype Design (modify ALICE)	10 days	Tue 1/24/17	Mon 2/6/17	LDRD	$0.00	$8,000.00		$0.00
86	1.4.8.4.2	Mock up Testing	10 days	Tue 2/7/17	Mon 2/20/17	LDRD	$10,000.00	$22,400.00		$0.00
87	**1.4.8.5**	**Stave Assembly Tooling**	**60 days**	**Tue 2/7/17**	**Mon 5/1/17**		**$0.00**	**$34,400.00**		**$0.00**
88	1.4.8.5.1	Jig Design (modify ALICE)	10 days	Tue 2/7/17	Mon 2/20/17	LDRD	$0.00	$6,400.00		$0.00
89	1.4.8.5.2	Prototype Jigs	30 days	Tue 2/21/17	Mon 4/3/17	LDRD	$2,000.00	$17,600.00		$0.00
90	1.4.8.5.3	Final Jigs Design and Production	20 days	Tue 4/4/17	Mon 5/1/17	LDRD	$0.00	$10,400.00		$0.00
91	**1.4.9**	Mechanical Coneptual Design Review	**12 days**	**Tue 5/16/17**	**Wed 5/31/17**		**$0.00**	**$10,720.00**		**$0.00**
95	**1.4.10**	**MAPS Inner Barrel Review (CD-1)**	**12 days**	**Wed 11/1/17**	**Thu 11/16/17**		**$0.00**	**$21,600.00**		**$0.00**
99	**1.4.11**	**Prototype Assembly and Test**	**50 days**	**Tue 3/7/17**	**Mon 5/15/17**	**LDRD**	**$0.00**	**$39,200.00**		**$0.00**



LANL Mechanics R&D (II)

Fri 8/26/16

ID	WBS	Task Name	Duration	Start	Finish	Cost Center	Fixed Cost	Cost	Activi	Cost per Unit
100	1.4.11.1	Assemble prototype	30 days	Tue 3/7/17	Mon 4/17/17	LDRD	$0.00	$21,600.00		$0.00
101	1.4.11.2	Prototype Full System Test	20 days	Tue 4/18/17	Mon 5/15/17	LDRD	$0.00	$17,600.00		$0.00
102	**1.4.12**	**Softrware Development**	**300 days**	**Tue 10/4/16**	**Mon 11/27/17**		**$0.00**	**$112,000.00**		**$0.00**
105	1.4.13	Detector Optimizaation and Physics Simulations (CD-1)	300 days	Mon 10/3/16	Fri 11/24/17		$0.00	$360,000.00		$0.00
106	**1.4.14**	**Test Beam Operation**	**187 days**	**Fri 1/11/19**	**Mon 9/30/19**	**LDRD**	**$0.00**	**$95,200.00**		**$0.00**
107	1.4.14.1	Shipping/Transport	10 days	Fri 1/11/19	Thu 1/24/19	LDRD	$10,000.00	$12,400.00		$0.00
108	1.4.14.2	Setup	5 days	Fri 1/25/19	Thu 1/31/19	LDRD	$0.00	$7,800.00		$0.00
109	1.4.14.3	Operations	20 days	Fri 2/1/19	Thu 2/28/19	LDRD	$0.00	$12,000.00		$0.00
110	1.4.14.4	Test Beam Data Analysis & Publication	152 days	Fri 3/1/19	Mon 9/30/19		$0.00	$63,000.00		$0.00
111	**1.5**	**sPHENIX Project**	**1217 days?**	**Mon 10/3/16**	**Tue 6/1/21**		**$0.00**	**$3,926,337.33**		**$0.00**



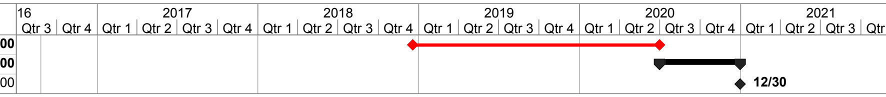
Cost Breakdown - Mechanics

Activity	M&S ($K)	Manpower	Total ($K)
Cooling Plant	117	2	119
Assembly fixtures and Jigs	100	2	102
End Wheels	34	2	36
Cyl. Shells, half barrels etc	24	4	28
Service Half Barrels	141	4	145

sPHENIX Production (II)

Fri 8/26/16

ID	WBS	Task Name	Duration	Start	Finish	Cost Center	Fixed Cost	Cost	Activi	Cost per Unit
162	**1.5.5.3**	**Assembly and Testing at BNL**	**400 days**	**Wed 12/19/18**	**Tue 6/30/20**		**$0.00**	**$361,333.33**		**$0.00**
171	**1.5.6**	**Installation**	**131 days**	**Wed 7/1/20**	**Wed 12/30/20**		**$0.00**	**$248,400.00**		**$0.00**
176	1.5.7	Ready for beam	0 days	Wed 12/30/20	Wed 12/30/20		$0.00	$0.00		$0.00



Cost Breakdown - Assembly

Activity	M&S ($K)	Manpower	Total ($K)
Test FEMs, CRU, LV, etc	0	29	29
Test Cooling sys	0	16	16
Test staves	0	22	22
Metrology of stave assembly	0	42	42
Metrology final detectors	0	20	20
Build half det	**0**	**38**	**38**
Half-det assembly and test; slow control etc		190	190

Cost Breakdown - Installation

Activity	M&S ($K)	Manpower	Total ($K)
Preparation	0	16	16
Installation	0	192	192
Commissioning	0	38	38

Backup slides

Projected Future sPHENIX Schedule

Slide from Ed O'Brien 6/24/2016

CD-0	**Sept-Oct 2016**
Director's Cost and Schedule Review	**Late Fall 2016**
Test Beam at FNAL(2nd round prototyping)	**Jan 2017**
OPA-CD-1/CD-3a Review	**May-Jun 2017**
CD-1/CD-3a authorization	**Nov 2017**
All Preproduction R&D and Design complete	**May-Jun 2018**
OPA- CD-2/CD-3b review	**May-Jun 2018**
CD-2/CD-3b authorization	**Jul-Aug 2018**
sPHENIX Installed, cabled, ready to commission	**Apr 2021**
First RHIC beam for sPHENIX	**Jan 2022**

The current Resource-loaded Schedule contains 8.5 months of float to Jan 2022

Inputs from ALICE ITS Project 4/1/2016

1) Project Schedule, add 6 months delay
2) Cost and FTEs

Cost breakdown

A Large Ion Collider Experiment

ALICE

Activity	Material Costs	Manpower Costs	TOTAL COST / ITEM
1. Pixel Chip	4847	170	5017
1.1 CMOS Wafers	3611		3611
1.2 Thinning & Dicing	800		800
1.3 Series test	436	170	606
2 Inner Barrel	296	262	558
2.1 FPC (construction and test)	23	13	36
2.2 HIC (assembly and test)	250	150	400
2.3 SF & Cold Plate (constr. and test)	3	43	46
2.4 Stave assembly & test	20	56	76
3 Outer Barrel HIC	1447	1118	2565
3.1 FPC (construction and test)	247	88	335
3.2 HIC (assembly and test)	1200	1030	2230
4 Middle Layers Staves	142	322	464
4.1 Powerbus cables	70	3	73
4.2 SF & Cold Plate (constr. and test)	42	113	155
4.3 Stave assembly & test	30	206	236
5 Outer Layers Staves	284	896	1180
5.1 Powerbus cables	127	33	160
5.2 SF & Cold Plate (constr. and test)	97	245	342
5.3 Stave assembly & test	60	618	678

Chips:
1k/50k = 2%
- $100K

Staves:
68/120 = 60%
-$340K

Share R&D cost
-$500K

“Buy staves” and MoU

Total ~$1M

Cost breakdown

A Large Ion Collider Experiment

ALICE

Activity	Material Costs	Manpower Costs	TOTAL COST / ITEM
6 Inner Barrel Global Assembly	70	156	227
6.1 End-Wheels (E-W)	4	30	34
6.2 Assembly of Staves on E-W	16	12	28
6.3 Cylindrical Structural Shell	1	10	11
6.4 Detector Half-Barrels	6	7	13
6.5 Service Half-Barrels	36	84	120
6.6 Detector + Service Half-Barrels	7	14	21
7 Outer Barrel Global Assembly	135	407	542
7.1 ML End-Wheels	13	50	63
7.2 ML Assembly of Staves on E-W	10	21	31
7.3 OL End-Wheels	23	59	82
7.4 OL Assembly of Staves on E-W	12	32	44
7.5 Conycal Structural Shell	8	62	70
7.6 Cylindrical Structural Shell	20	55	75
7.7 Detector Half-Barrels	7	13	20
7.8 Service Half-Barrels	36	85	121
7.9 Detector + Service Half-Barrels	7	30	37
8 Integration in ALICE	91	262	354
8.1 Cage	61	153	215
8.2 Installation Tooling	30	109	139

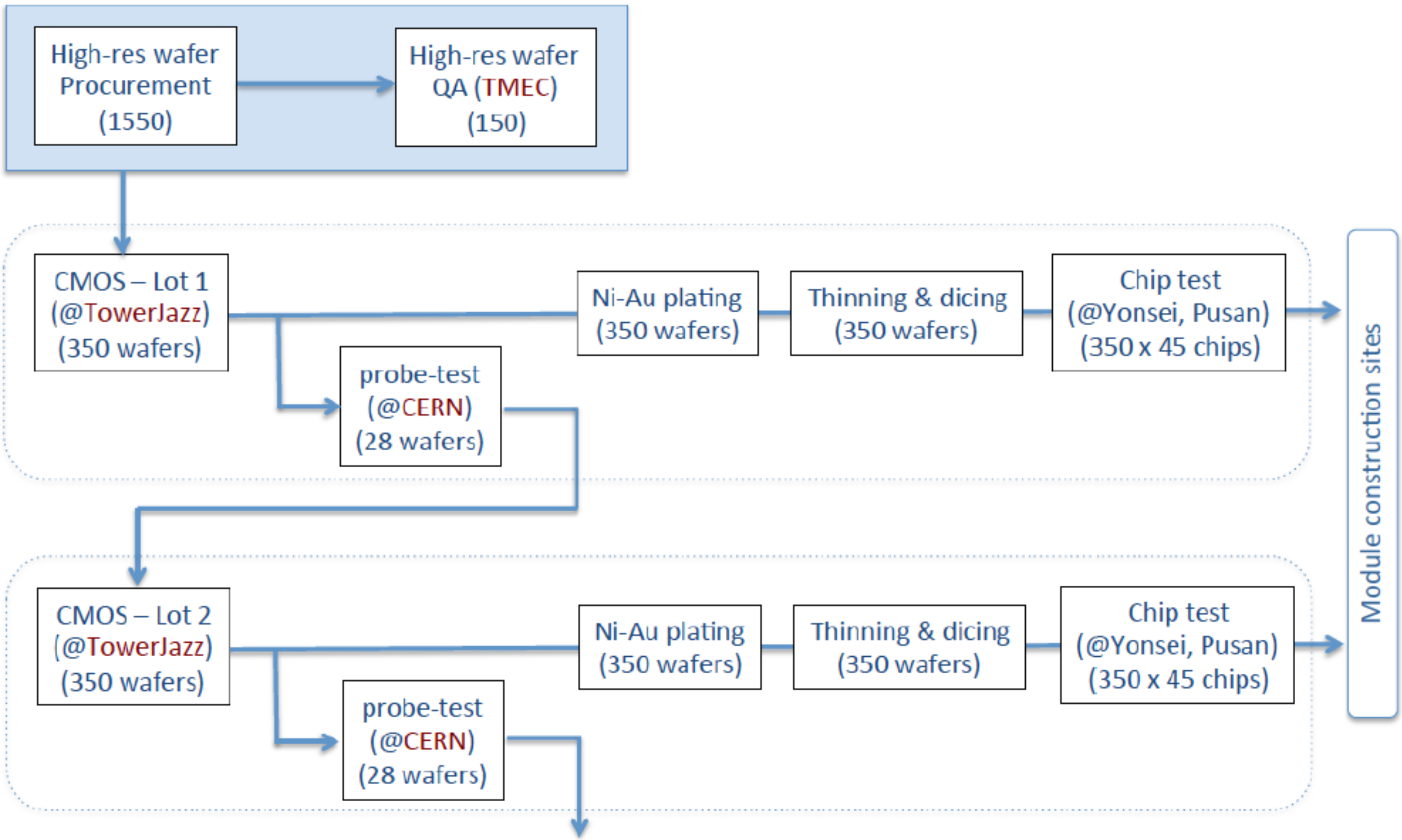
Cost breakdown

A Large Ion Collider Experiment

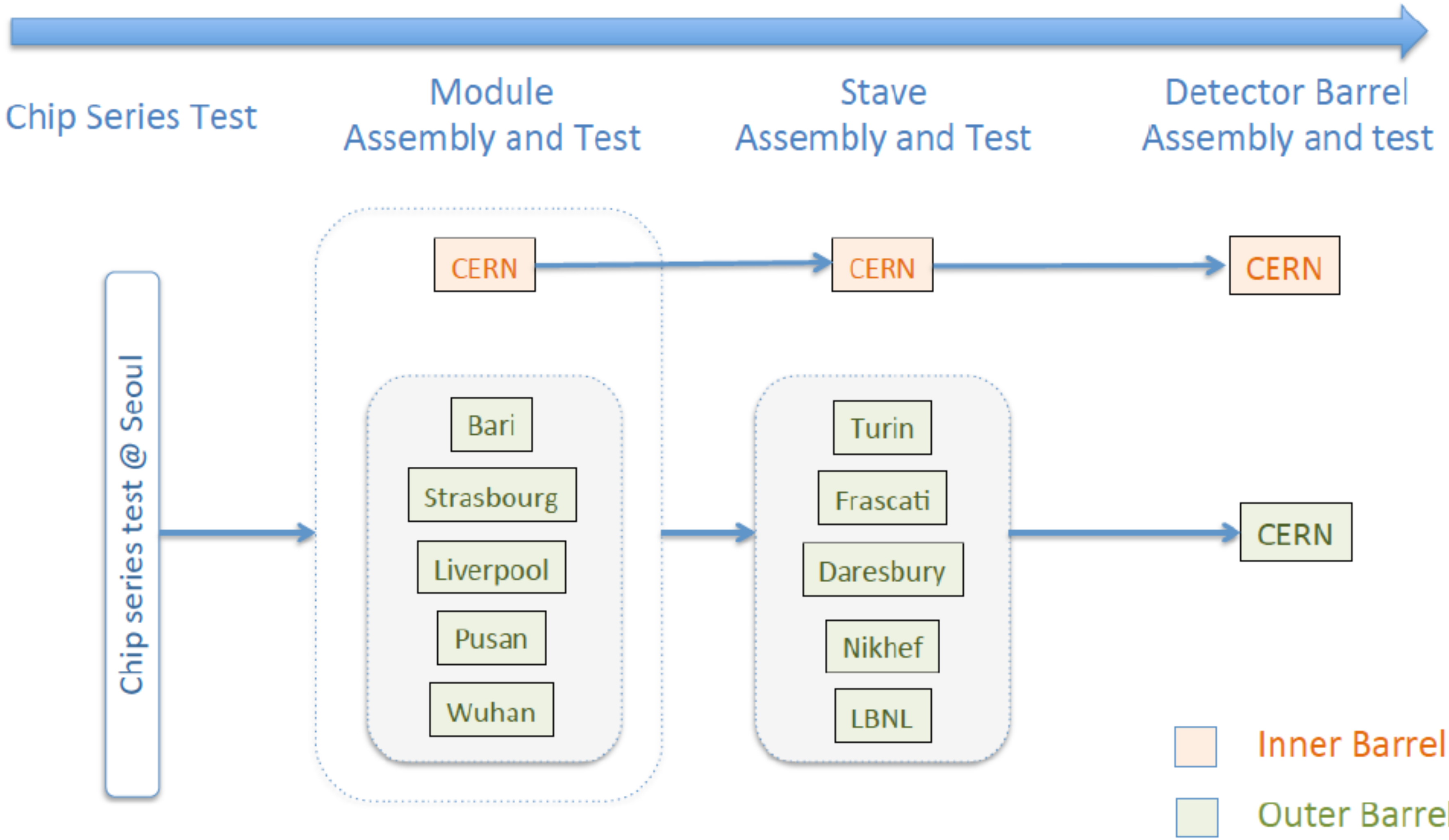
ALICE

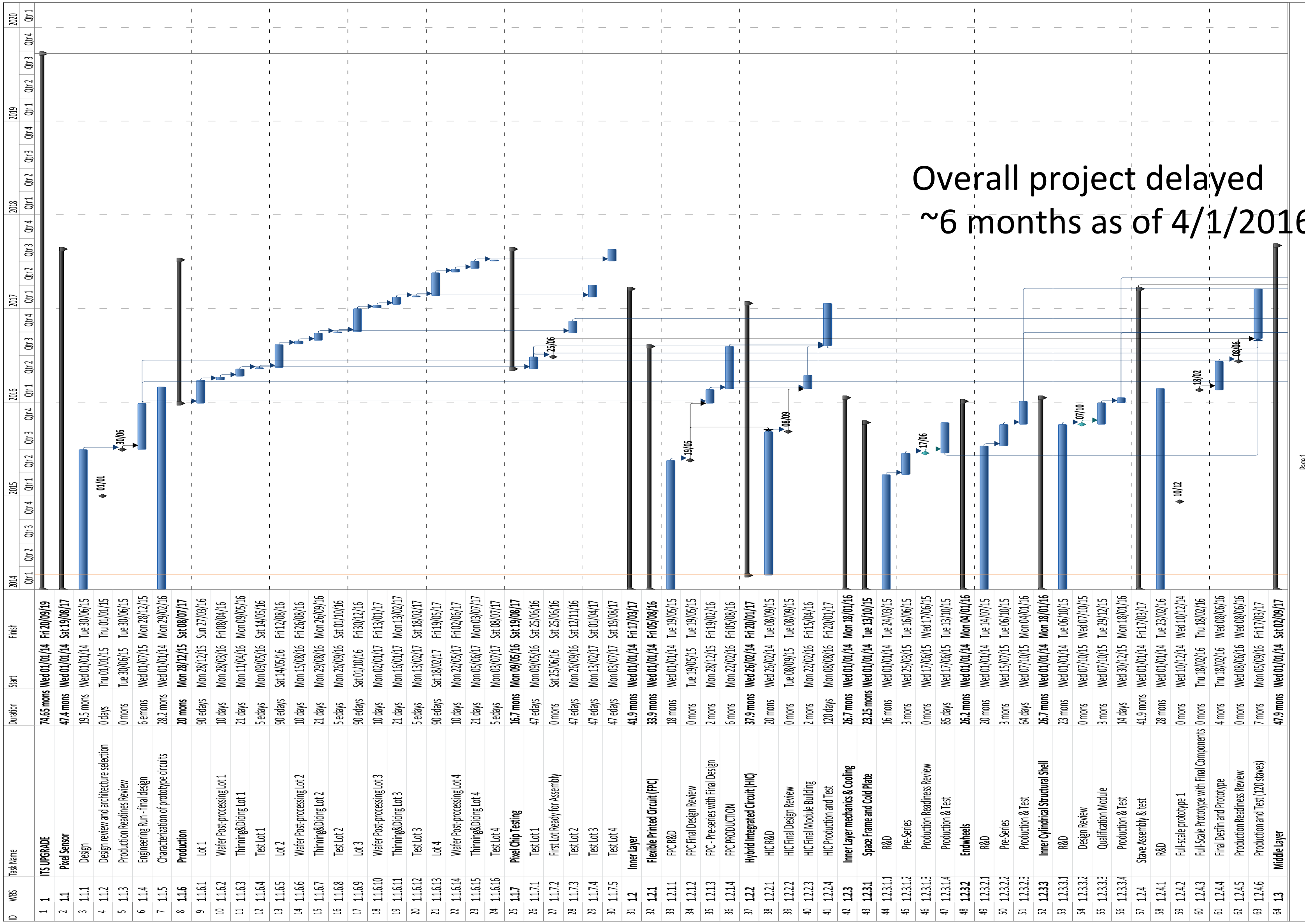
Activity	Material Costs	Manpower Costs	TOTAL COST / ITEM
9 Readout Electronics	715	50	765
9.1 Data e-Links	82	50	132
9.2 Patch-panels	20		20
9.3 Readout Unit	469		469
9.4 Optical Links	144		144
10 Power distribution	1149	50	1199
10.1 Power Supplies	750		750
10.2 Power Distribution	242	50	292
10.3 Power Regulation	157		157
11. DCS	150		150
12. Cooling	620	0	620
12.1 Water Cooling Plant	470		470
12.2 Ventilation Humidity Plant	150		150
GRAND TOTAL	9947	3693	13640

Pixel chip production flow chart



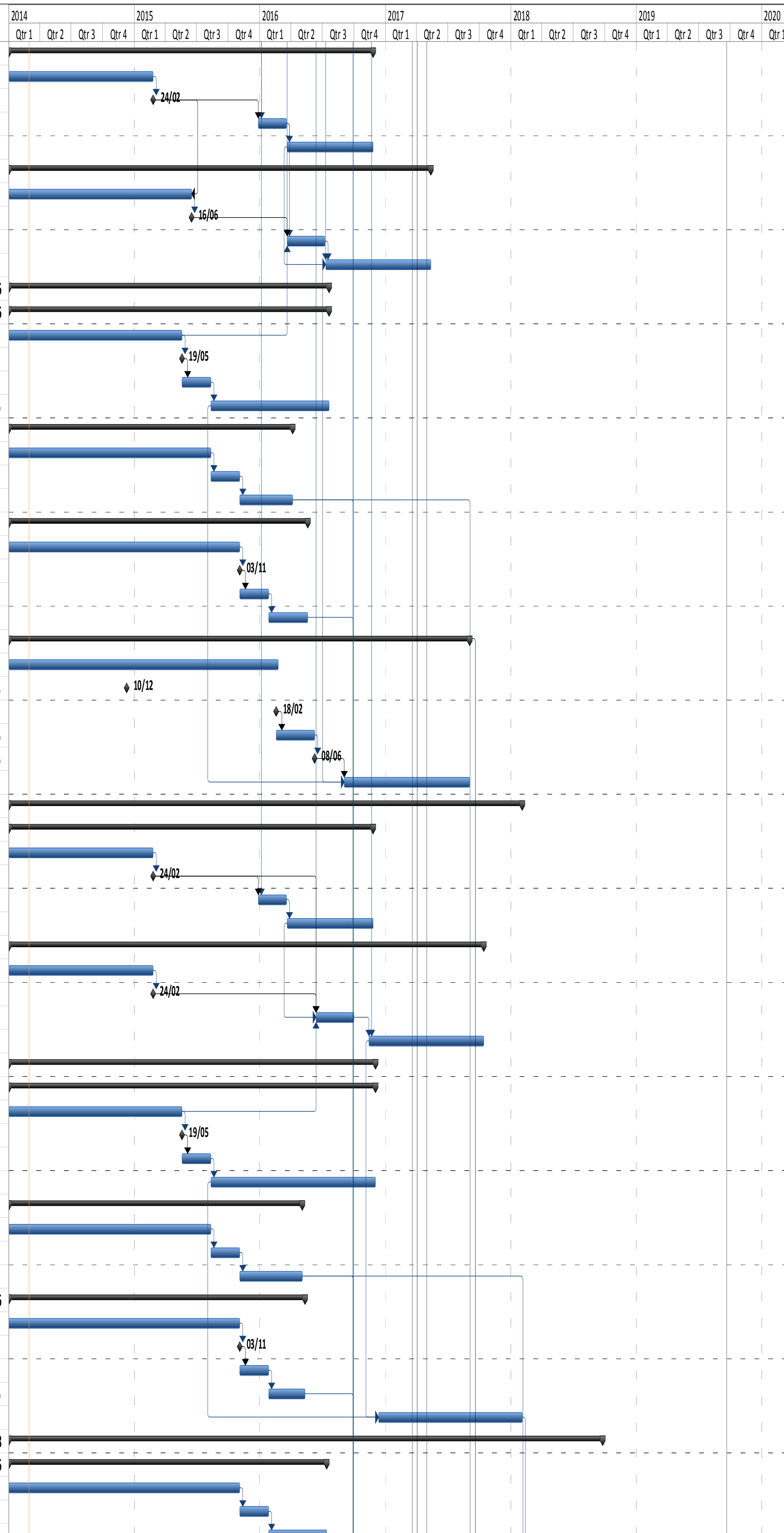
Module and Stave production flow chart





Overall project delayed ~6 months as of 4/1/2016

ID	WBS	Task Name	Duration	Start	Finish
65	1.3.1	Flexible Printed Circuit (FPC)	37.9 mons	Wed 01/01/14	Fri 25/11/16
66	1.3.1.1	FPC R&D	15 mons	Wed 01/01/14	Tue 24/02/15
67	1.3.1.2	Design Review	0 mons	Tue 24/02/15	Tue 24/02/15
68	1.3.1.3	FPC Pre-Series with Final Design	3 mons	Mon 28/12/15	Fri 18/03/16
69	1.3.1.4	FPC Production	9 mons	Mon 21/03/16	Fri 25/11/16
70	1.3.2	Hybrid Integrated Circuit (HIC)	43.9 mons	Wed 01/01/14	Fri 12/05/17
71	1.3.2.1	HIC R&D	19 mons	Wed 01/01/14	Tue 16/06/15
72	1.3.2.2	HIC Final Design Review	0 mons	Tue 16/06/15	Tue 16/06/15
73	1.3.2.3	HIC Final Module Building	4 mons	Mon 21/03/16	Fri 08/07/16
74	1.3.2.4	HIC Production and Test	11 mons	Mon 11/07/16	Fri 12/05/17
75	1.3.3	Middle Layer Mechanics & Cooling	33.3 mons	Wed 01/01/14	Wed 20/07/16
76	1.3.3.1	Spaceframe & Coldplate	33.3 mons	Wed 01/01/14	Wed 20/07/16
77	1.3.3.1.1	R&D	18 mons	Wed 01/01/14	Tue 19/05/15
78	1.3.3.1.2	Production Readiness Review	0 mons	Tue 19/05/15	Tue 19/05/15
79	1.3.3.1.3	Pre-Series	3 mons	Wed 20/05/15	Tue 11/08/15
80	1.3.3.1.4	Production & Test	246 days	Wed 12/08/15	Wed 20/07/16
81	1.3.3.2	End Wheels	29.5 mons	Wed 01/01/14	Tue 05/04/16
82	1.3.3.2.1	R&D	21 mons	Wed 01/01/14	Tue 11/08/15
83	1.3.3.2.2	Qualification Module	3 mons	Wed 12/08/15	Tue 03/11/15
84	1.3.3.2.3	Production & Test	110 days	Wed 04/11/15	Tue 05/04/16
85	1.3.3.3	Conical Structural Shell	31.1 mons	Wed 01/01/14	Thu 19/05/16
86	1.3.3.3.1	R&D	24 mons	Wed 01/01/14	Tue 03/11/15
87	1.3.3.3.2	Design Review	0 mons	Tue 03/11/15	Tue 03/11/15
88	1.3.3.3.3	Qualification Module	3 mons	Wed 04/11/15	Tue 26/01/16
89	1.3.3.3.4	Production & Test	82 days	Wed 27/01/16	Thu 19/05/16
90	1.3.4	Stave Assembly & test	47.9 mons	Wed 01/01/14	Sat 02/09/17
91	1.3.4.1	R&D	28 mons	Wed 01/01/14	Tue 23/02/16
92	1.3.4.2	Full-scale prototype 1	0 mons	Wed 10/12/14	Wed 10/12/14
93	1.3.4.3	Full-Scale Prototype with Final Components	0 mons	Thu 18/02/16	Thu 18/02/16
94	1.3.4.4	Final Desfin and Prototype	4 mons	Thu 18/02/16	Wed 08/06/16
95	1.3.4.5	Production Readiness Review	0 mons	Wed 08/06/16	Wed 08/06/16
96	1.3.4.6	Production and Test (65 staves)	365 edays	Fri 02/09/16	Sat 02/09/17
97	1.4	Outer Layer	53.4 mons	Wed 01/01/14	Fri 02/02/18
98	1.4.1	Flexible Printed Circuit (FPC)	37.9 mons	Wed 01/01/14	Fri 25/11/16
99	1.4.1.1	FPC R&D	15 mons	Wed 01/01/14	Tue 24/02/15
100	1.4.1.2	Design Review	0 mons	Tue 24/02/15	Tue 24/02/15
101	1.4.1.3	FPC Pre-Series with Final Design	3 mons	Mon 28/12/15	Fri 18/03/16
102	1.4.1.4	FPC Production	9 mons	Mon 21/03/16	Fri 25/11/16
103	1.4.2	Hybrid Integrated Circuit (HIC)	49.4 mons	Wed 01/01/14	Fri 13/10/17
104	1.4.2.1	HIC R&D	15 mons	Wed 01/01/14	Tue 24/02/15
105	1.4.2.2	HIC Final Design Review	0 mons	Tue 24/02/15	Tue 24/02/15
106	1.4.2.3	HIC Final Module Building	4 mons	Mon 13/06/16	Fri 30/09/16
107	1.4.2.4	HIC Production and Test	12 mons	Mon 14/11/16	Fri 13/10/17
108	1.4.3	Outer Layer Mechanics & Cooling	38.15 mons	Wed 01/01/14	Fri 02/12/16
109	1.4.3.1	Spaceframe & Coldplate	38.15 mons	Wed 01/01/14	Fri 02/12/16
110	1.4.3.1.1	R&D	18 mons	Wed 01/01/14	Tue 19/05/15
111	1.4.3.1.2	Production Readiness Review	0 mons	Tue 19/05/15	Tue 19/05/15
112	1.4.3.1.3	Pre-Series	3 mons	Wed 20/05/15	Tue 11/08/15
113	1.4.3.1.4	Production & Test	343 days	Wed 12/08/15	Fri 02/12/16
114	1.4.3.2	End Wheels	30.5 mons	Wed 01/01/14	Tue 03/05/16
115	1.4.3.2.1	R&D	21 mons	Wed 01/01/14	Tue 11/08/15
116	1.4.3.2.2	Qualification Module	3 mons	Wed 12/08/15	Tue 03/11/15
117	1.4.3.2.3	Production & Test	130 days	Wed 04/11/15	Tue 03/05/16
118	1.4.3.3	Cylindrical Structural Shell	30.8 mons	Wed 01/01/14	Wed 11/05/16
119	1.4.3.3.1	R&D	24 mons	Wed 01/01/14	Tue 03/11/15
120	1.4.3.3.2	Design Review	0 mons	Tue 03/11/15	Tue 03/11/15
121	1.4.3.3.3	Qualification Module	3 mons	Wed 04/11/15	Tue 26/01/16
122	1.4.3.3.4	Production & Test	76 days	Wed 27/01/16	Wed 11/05/16
123	1.4.4	Outer layers - stave assemby & test	15 mons	Mon 12/12/16	Fri 02/02/18
124	1.5	Global Assembly	61.7 mons	Wed 01/01/14	Mon 24/09/18
125	1.5.1	Inner Service Barrel	33.05 mons	Wed 01/01/14	Wed 13/07/16
126	1.5.1.1	R&D	24 mons	Wed 01/01/14	Tue 03/11/15
127	1.5.1.2	Qualification Module	3 mons	Wed 04/11/15	Tue 26/01/16
128	1.5.1.3	Production & Test	121 days	Wed 27/01/16	Wed 13/07/16



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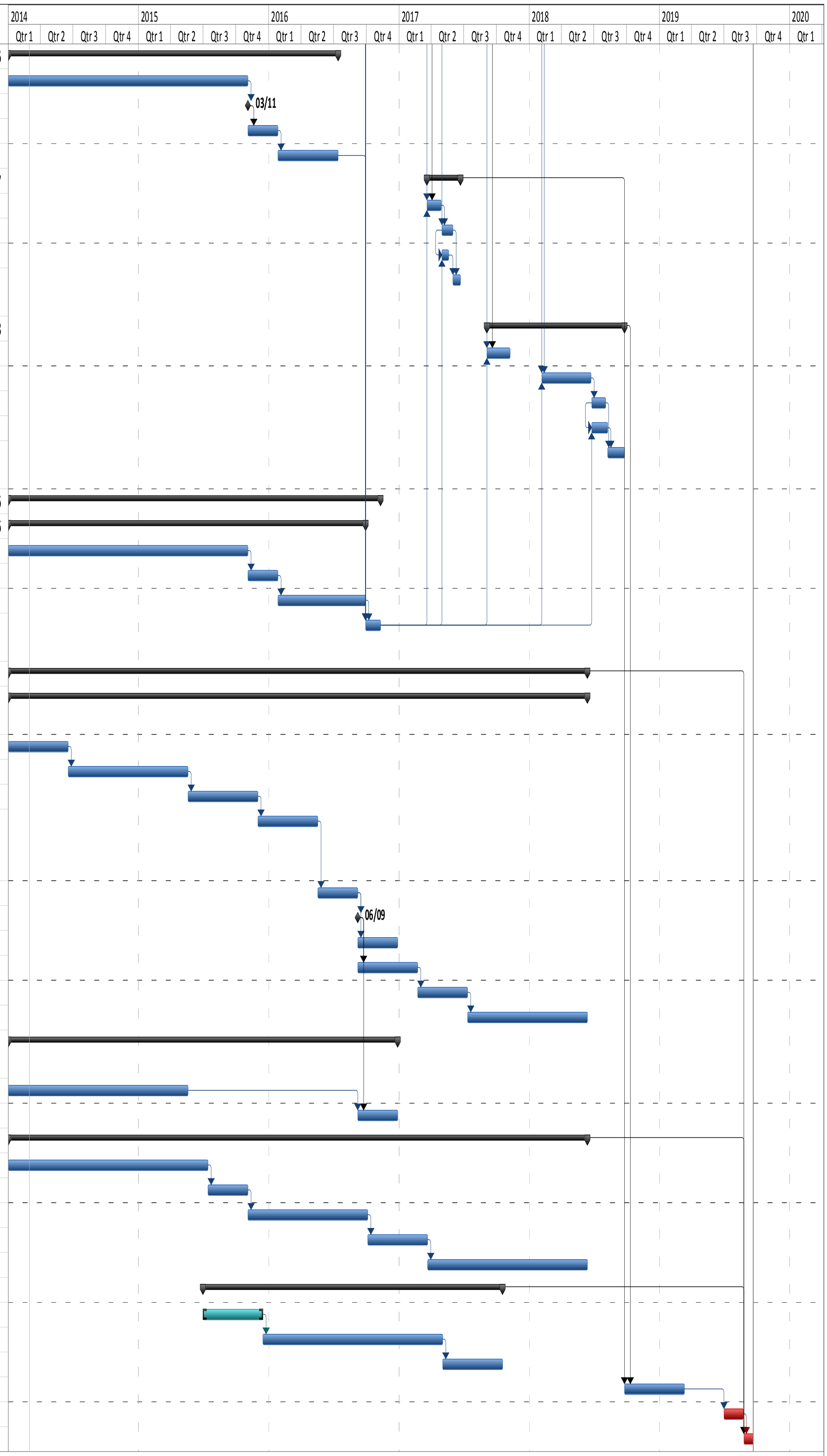
ID	WBS	Task Name	Duration	Start	Finish
129	**1.5.2**	**Outer Service Barrel**	**33.05 mons**	**Wed 01/01/14**	**Wed 13/07/16**
130	1.5.2.1	R&D	24 mons	Wed 01/01/14	Tue 03/11/15
131	1.5.2.2	Design Review	0 mons	Tue 03/11/15	Tue 03/11/15
132	1.5.2.3	Qualification Module	3 mons	Wed 04/11/15	Tue 26/01/16
133	1.5.2.4	Production & Test	121 days	Wed 27/01/16	Wed 13/07/16
134	**1.5.3**	**Inner Barrel**	**3.4 mons**	**Mon 20/03/17**	**Wed 21/06/17**
135	1.5.3.1	Inner Layers Assembly	30 days	Mon 20/03/17	Fri 28/04/17
136	1.5.3.2	Detector Barrel Assembly	23 days	Mon 01/05/17	Wed 31/05/17
137	1.5.3.3	Service Barrel Assembly	15 days	Mon 01/05/17	Fri 19/05/17
138	1.5.3.4	Detector Barrel and Service Barrel Integration	15 days	Thu 01/06/17	Wed 21/06/17
139	**1.5.4**	**Outer Barrel**	**13.8 mons**	**Mon 04/09/17**	**Mon 24/09/18**
140	1.5.4.1	Middle Layers Assembly	47 days	Mon 04/09/17	Tue 07/11/17
141	1.5.4.2	Outer Layers Assembly	100 days	Mon 05/02/18	Fri 22/06/18
142	1.5.4.3	Detector Barrel Assembly	29 days	Mon 25/06/18	Thu 02/08/18
143	1.5.4.4	Service Barrel Assembly	33 days	Mon 25/06/18	Wed 08/08/18
144	1.5.4.5	Detector Barrel and Service Barrel Integration	33 days	Thu 09/08/18	Mon 24/09/18
145	**1.6**	**Integration in ALICE**	**37.3 mons**	**Wed 01/01/14**	**Wed 09/11/16**
146	**1.6.1**	**Cage + Installation Mechanics**	**35.8 mons**	**Wed 01/01/14**	**Wed 28/09/16**
147	1.6.1.1	R&D	24 mons	Wed 01/01/14	Tue 03/11/15
148	1.6.1.2	Qualification Module	3 mons	Wed 04/11/15	Tue 26/01/16
149	1.6.1.3	Production & Test	176 days	Wed 27/01/16	Wed 28/09/16
150	1.6.2	Insertion Test with all Final Support Structures (without detector)	1.5 mons	Thu 29/09/16	Wed 09/11/16
151	**1.7**	**Readout Electronics**	**58 mons**	**Wed 01/01/14**	**Tue 12/06/18**
152	**1.7.1**	**Readout Unit (readout board 5m from detector)**	**58 mons**	**Wed 01/01/14**	**Tue 12/06/18**
153	1.7.1.1	Specifications	6 mons	Wed 01/01/14	Tue 17/06/14
154	1.7.1.2	Readout Unit ver. 1	12 mons	Wed 18/06/14	Tue 19/05/15
155	1.7.1.3	Readout Unit vers. 2	7 mons	Wed 20/05/15	Tue 01/12/15
156	1.7.1.4	Test of complete readout chain (front-end, e-links, readout unit, common readout unit and trigger interface)	6 mons	Wed 02/12/15	Tue 17/05/16
157	1.7.1.5	Readout Unit vers. 3	4 mons	Wed 18/05/16	Tue 06/09/16
158	1.7.1.6	Production Readiness Review	0 mons	Tue 06/09/16	Tue 06/09/16
159	1.7.1.7	Market survey and tendering	4 mons	Wed 07/09/16	Tue 27/12/16
160	1.7.1.8	Readout Unit final version	6 mons	Wed 07/09/16	Tue 21/02/17
161	1.7.1.9	Pre-series production	5 mons	Wed 22/02/17	Tue 11/07/17
162	1.7.1.10	Production and test (220 boards)	12 mons	Wed 12/07/17	Tue 12/06/18
163	**1.7.2**	**E-links (electrical links between detector stave and Readout Unit)**	**39 mons**	**Wed 01/01/14**	**Tue 27/12/16**
164	1.7.2.1	R&D	18 mons	Wed 01/01/14	Tue 19/05/15
165	1.7.2.2	Procurement (336 cables)	4 mons	Wed 07/09/16	Tue 27/12/16
166	**1.8**	**Power Distribution**	**58 mons**	**Wed 01/01/14**	**Tue 12/06/18**
167	1.8.1	R&D	20 mons	Wed 01/01/14	Tue 14/07/15
168	1.8.2	Specifications	4 mons	Wed 15/07/15	Tue 03/11/15
169	1.8.3	Qualification of LV Power Delivery Network	12 mons	Wed 04/11/15	Tue 04/10/16
170	1.8.4	Market survey and Tendering	6 mons	Wed 05/10/16	Tue 21/03/17
171	1.8.5	Procurment	16 mons	Wed 22/03/17	Tue 12/06/18
172	**1.9**	**Cooling Plant**	**30 mons**	**Wed 01/07/15**	**Tue 17/10/17**
173	1.9.1	Conceptual design and specifications	6 mons	Wed 01/07/15	Tue 15/12/15
174	1.9.2	Development and construction	18 mons	Wed 16/12/15	Tue 02/05/17
175	1.9.3	Commissioning	6 mons	Wed 03/05/17	Tue 17/10/17
176	**1.10**	**Commissioning at surface**	**6 mons**	**Tue 25/09/18**	**Mon 11/03/19**
177	**1.11**	**Installation**	**8 wks**	**Mon 01/07/19**	**Fri 23/08/19**
178	**1.12**	**Commissioning in ALICE**	**4 wks**	**Mon 26/08/19**	**Fri 20/09/19**



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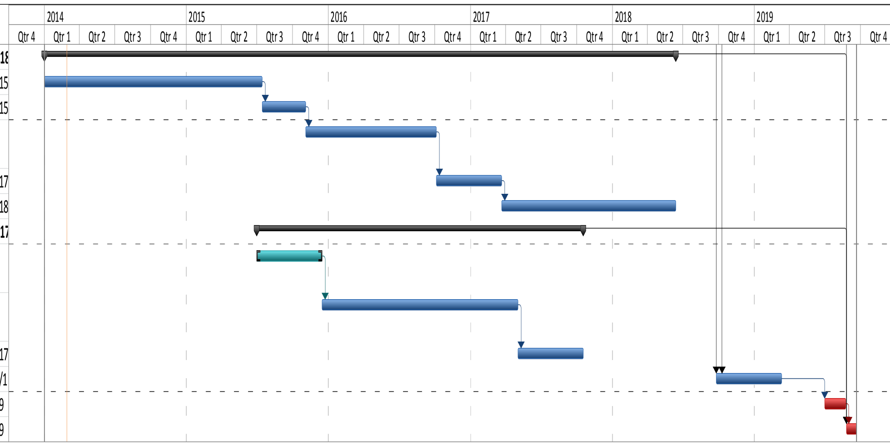
ID	WBS	Task Name	Duration	Start	Finish
166	**1.8**	**Power Distribution**	**58 mons**	**Wed 01/01/1**	**Tue 12/06/18**
167	1.8.1	R&D	20 mons	Wed 01/01/1	Tue 14/07/15
168	1.8.2	Specifications	4 mons	Wed 15/07/1	Tue 03/11/15
169	1.8.3	Qualification of LV Power Delivery Network	12 mons	Wed 04/11/15	Tue 04/10/16
170	1.8.4	Market survey and Tendering	6 mons	Wed 05/10/1	Tue 21/03/17
171	1.8.5	Procurment	16 mons	Wed 22/03/1	Tue 12/06/18
172	**1.9**	**Cooling Plant**	**30 mons**	**Wed 01/07/1**	**Tue 17/10/17**
173	1.9.1	Conceptual design and specifications	6 mons	Wed 01/07/15	Tue 15/12/15
174	1.9.2	Development and construction	18 mons	Wed 16/12/15	Tue 02/05/17
175	1.9.3	Commissioning	6 mons	Wed 03/05/1	Tue 17/10/17
176	1.10	**Commissioning at surface**	6 mons	Tue 25/09/18	Mon 11/03/1
177	1.11	**Installation**	8 wks	Mon 01/07/1	Fri 23/08/19
178	1.12	**Commissioning in ALICE**	4 wks	Mon 26/08/1	Fri 20/09/19



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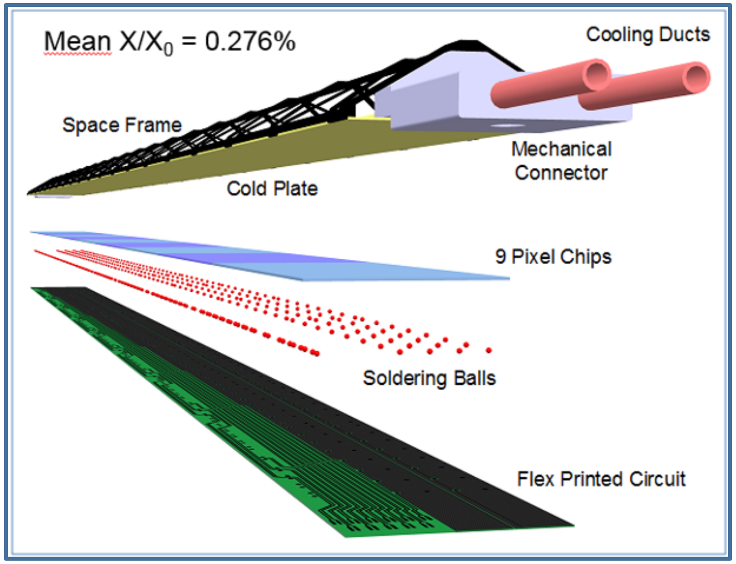
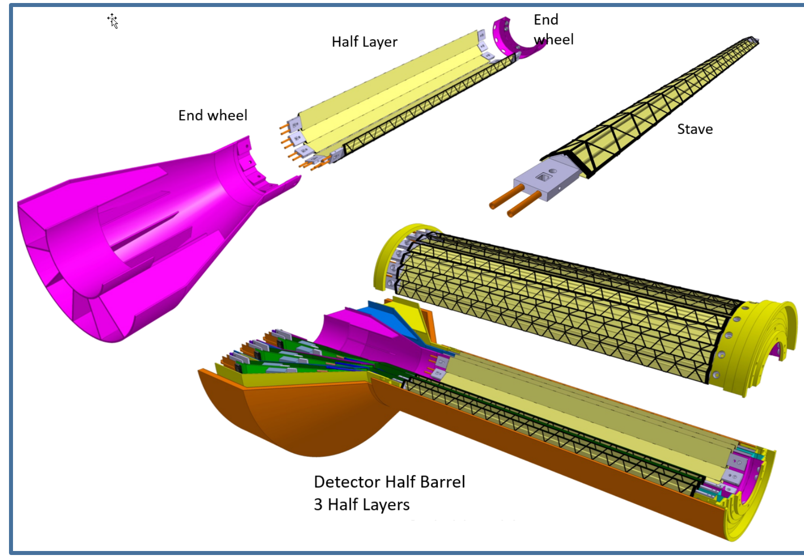
ITS Inner Layers vs PXL/STAR HFT





48 inner staves

Readout for: →

- 432 Sensors
- 226 M pixels
- 0.19 m^2 of silicon

Very comparable to PXL

STAR/HFT PXL Cost and schedule

Taken at CD-3

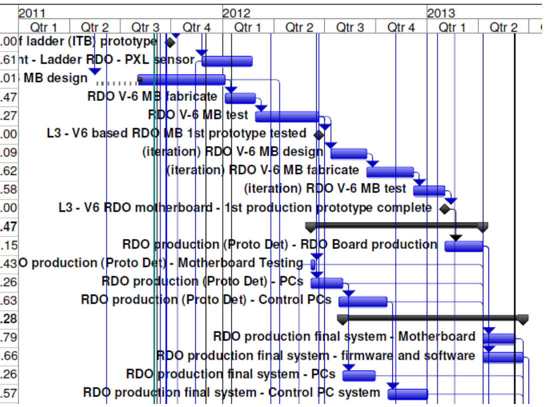
WBS	Task Name	Cost ($K)
1.2	**Pixel Detector (PXL)**	**4,993**
1.2.1	Pixel Mechanics	1,210
1.2.2	Pixel Electronics	3,043
1.2.3	Detector Assembly	225
1.2.4	Infrastructure	515

- The cost for WBS 1.2.2.6 Readout Electronics is $800k
- Production RDO boards are ~$4.9k/board in quantities of 50.
- Most of the firmware and software was done by non-(project)costed people
- Full cost book to show detailed cost is available (distributed with slides in separate file).

PXL Cost and schedule

Taken at CD-3

ID	WBS	Task Name	% Complete	Duration	Start	Finish	Free Slack	Estimate Basis	Cost
223	1.2.2.6.1.5	L3 - Full RDO of ladder (ITB) prototype	0%	0 days	6/28/11	6/28/11	972.75 days		$0.00
224	1.2.2.6.1.6	RDO Development - Ladder RDO - PXL sensor	0%	63 days	8/25/11	11/22/11	91 days	EJ	$108,364.61
225	1.2.2.6.1.7	RDO V-6 MB design	5%	109.58 days	2/15/11	10/5/11	0 days	EJ	$64,399.01
226	1.2.2.6.1.8	RDO V-6 MB fabricate	0%	36 days	10/5/11	11/28/11	0 days	EJ	$77,966.47
227	1.2.2.6.1.9	RDO V-6 MB test	0%	75 days	11/28/11	3/21/12	0 days	EJ	$26,332.27
228	1.2.2.6.1.10	L3 - V6 based RDO MB 1st prototype tested	0%	0 days	3/21/12	3/21/12	793.17 days		$0.00
229	1.2.2.6.1.11	(iteration) RDO V-6 MB design	0%	45 days	4/11/12	6/14/12	0 days	EJ	$8,347.09
230	1.2.2.6.1.12	(iteration) RDO V-6 MB fabricate	0%	58.33 days	6/14/12	9/6/12	0 days	EJ	$45,545.62
231	1.2.2.6.1.13	(iteration) RDO V-6 MB test	0%	40 days	9/6/12	11/1/12	0 days	EJ	$17,249.58
232	1.2.2.6.1.14	L3 - V6 RDO motherboard - 1st production prototype complete	0%	0 days	11/1/12	11/1/12	0 days		$0.00
233	**1.2.2.6.2**	**RDO production (Proto Det)**	**0%**	**207.91 days**	**3/7/12**	**1/8/13**	**184 days**		**$160,776.47**
234	1.2.2.6.2.1	RDO production (Proto Det) - RDO Board production	0%	39 days	11/1/12	1/8/13	0 days	EJ	$112,572.15
235	1.2.2.6.2.2	RDO production (Proto Det) - Motherboard Testing	0%	5 days	3/7/12	3/13/12	0 days	EJ	$1,206.43
236	1.2.2.6.2.3	RDO production (Proto Det) - PCs	0%	41 days	3/7/12	5/2/12	0 days	EJ	$33,864.26
237	1.2.2.6.2.4	RDO production (Proto Det) - Control PCs	0%	60 days	4/26/12	7/20/12	0 days	EJ	$13,133.63
238	**1.2.2.6.3**	**RDO production final system**	**0%**	**216.91 days**	**5/3/12**	**3/21/13**	**72.09 days**		**$155,180.28**
239	1.2.2.6.3.1	RDO production final system - Motherboard	0%	40 days	1/8/13	3/7/13	10 days	EJ	$96,354.79
240	1.2.2.6.3.2	RDO production final system - firmware and software	0%	50 days	1/8/13	3/21/13	0 days	EJ	$11,822.66
241	1.2.2.6.3.3	RDO production final system - PCs	0%	41 days	5/3/12	6/29/12	175.91 days	EJ	$33,864.26
242	1.2.2.6.3.4	RDO production final system - Control PC system	0%	50 days	7/23/12	10/1/12	111.91 days	EJ	$13,138.57



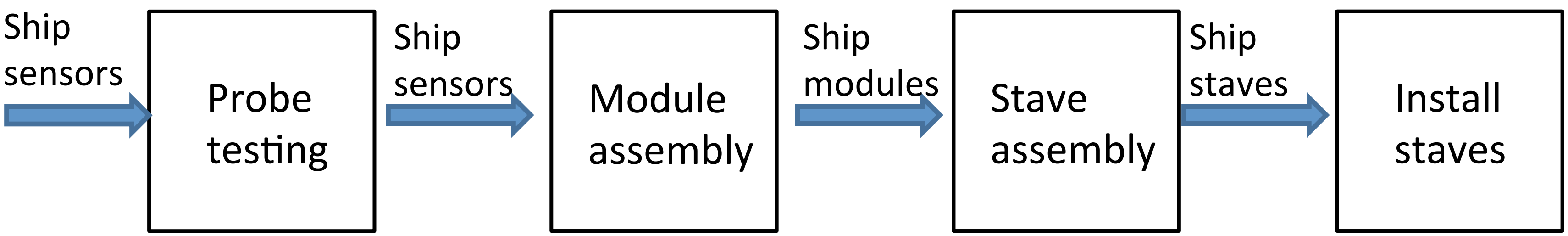
- 22 months - From initial RDO board design to delivery of all production RDO boards.
- We co-developed the earlier generations of sensors with the earlier generations of RDO so the firmware and software modules are often common to generations.
- Contributed resources are not counted in the project schedule document (firmware and software).

PXL RDO lessons learned

- Co-development of sensors and RDO was very useful. The architecture and code base is well tested and vetted with the sensors over generations and less likely to contain surprises.
- The production RDO system was designed to be the base for all testing. Beam tests, probe testing and other production testing. This unified our code base and simplified our hardware needs.
- Close attention should be paid to the interfaces and architecture that you are interfacing to. Allow extra time to find incompatibilities.
- A significant system test (at least a few chains) with beam and interfaced to the rest of the full DAQ, slow controls, etc. is highly desirable to uncover system level problems.
- The cost drivers for us were multiple design iterations of the production RDO boards, the interlock systems, the software and scripts for the interface to the STAR run and experiment control systems.
- Build in flexibility that will allow you to address unforeseen problems. Our LU damage problem was solved with the current limiting threshold and remote voltage adjustment capabilities built into the system.

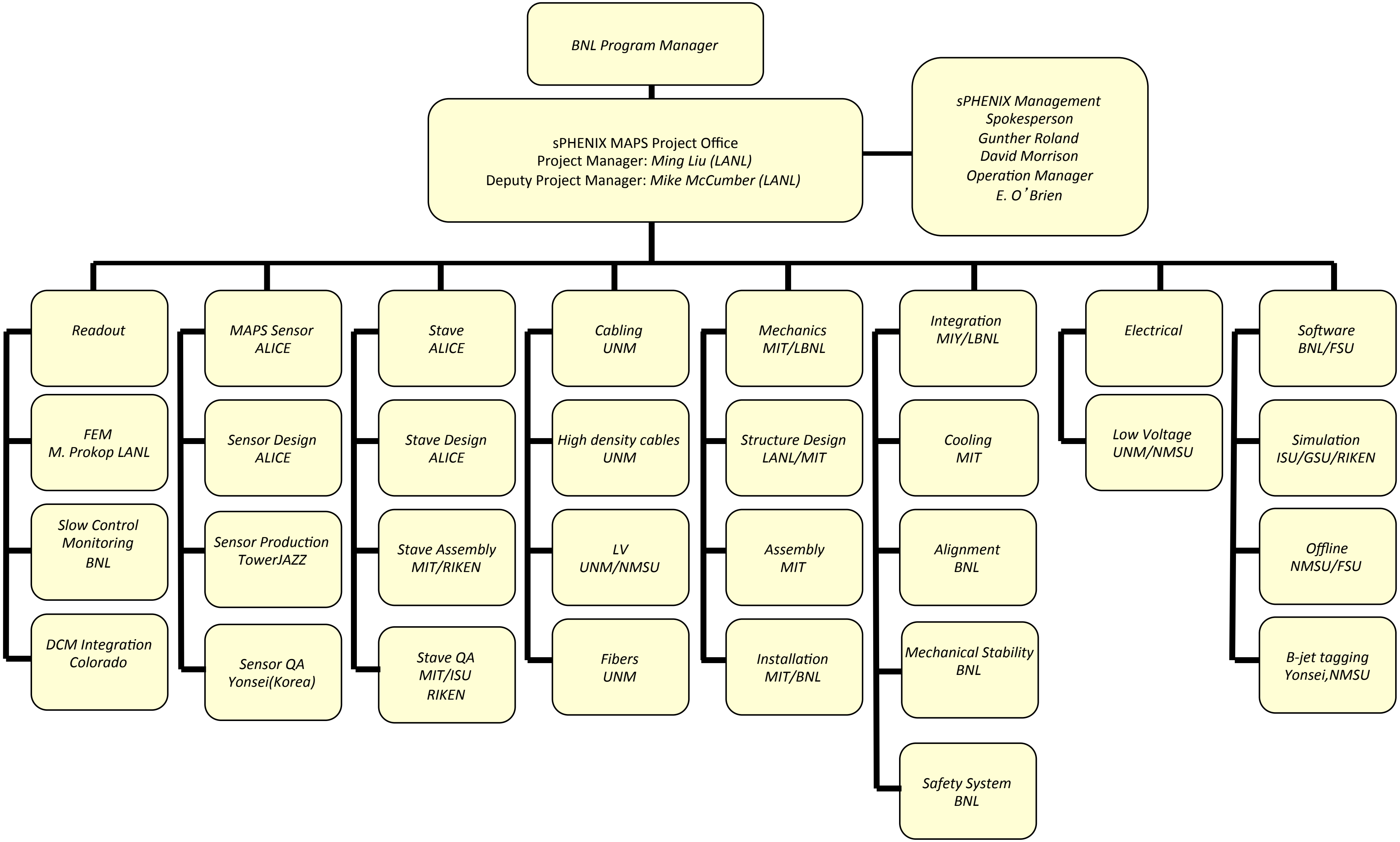
Workflow Overview

Leo's talk



- This is a draft overview of the workflow for building middle and outer layer staves.
- For this draft, we assume wire bonding for the interconnection technology.
- For this draft, we assume the tabbed version of the FPC.
- We are specifying a baseline workflow and will update as the sequences become more developed.
- Not all processes are fully developed.
- In the shipping stages, the barcode information for each item is stored in the database.

Organization Chart



Forming the Collaboration

- **On board:**
  LANL, MIT, UNM, RIKEN, NMSU, BNL, Colorado, ISU, GSU, UT-Austin, UIC

- **Potential:**
  LBNL, UCR, UC Davis, UCLA, Korean Institutes

- **Consulting:**
  ALICE/CERN, Yonsei/Korea, CCNU/China

Resources I

- 1. LANL:
- Supported by LDRD (FY17-19), will develop a 4-stave MAPS prototype to fully test the readout chain from MAPS to sPHENIX DAQ, and also initial mechanical design.
- Provide electronics and mechanical engineering support through LDRD at least.

- 2. MIT:
- Both HI and ME groups are joining the MAPS efforts, strong physics and engineering capabilities (Bates Center); extensive experience on technical integration and cooling system, worked on STAR HFT in collaboration with LBNL.
- already have many students and postdocs working at CERN, could help on MAPS stave assembly and testing at CERN;
- Could lead the stave assembly and testing at CERN and BNL, cooling and mechanical integration effort

- 3. LBNL:
- Extensive experience in mechanical carbon structure and MAPS readout electronics, worked on PHENIX/FVTX carbon frame supporting structure, already have test stand developed for the on-going ALICE MAPS upgrade project, will make a decision soon on joining the sPHENIX project.
- Could lead the mechanical carbon support structure, assembly and testing of staves etc

- 4. BNL:
- Strong technical capabilities in mechanical structure and DAQ, computing, slow control, safety and tech support, could lead the MAPS "Services" tasks;

Resources II

- 5. Univ. of Colorado
- Extensive experience with DAQ electronics, DCM-II and slow controls, close to LANL for collaborative work, excellent physics and simulation capabilities
- Could lead the DAQ DCM-II integration effort and simulation work

- 6. ISU
- Plan to add one postdoc to work on various MAPS related tasks and simulations, have several students
- Could take a major role on simulation effort, and testing MAPS

- 7. FSU
- Could continue to lead the tracking software effort, one graduate student

- 8. UNM
- Extensive experience through PHENIX Muon Tracker and FVTX projects on cabling, LV distribution and high density cables etc.
- Could lead effort on LV and cabling, design, testing and integration

Resources III

- 9. NMSU
- Extensive experience with software and simulations, LV/HV control system etc.
- Could play a major role on simulations, heavy-flavor tagging and physics analysis, provide manpower for testing and assembly work

- 10. GSU
- Strong physics interest in heavy flavor, could play a major role on simulations and analysis, capable to develop small electronics control system

- 11. UCLA
- Interested in MAPS hardware and heavy flavor physics, could play a major role on MAPS prototype R&D work and simulations, will send one student to work on LANL's LDRD project

- 12. UCR/UCDavis
- Interested in MAPS project, heavy flavor physics, have local "very cost effective" machine and electronics shop to fabricate small structures and devices

- 13. Yonsei/Korea
- Leading ALICE MAPS QA, could contribute to the production QA of MAPS chips, simulations and analysis

- 14.RIKEN/RBRC
- Interested in MAPS project, from simulation to stave assembly and testing.

Project Input to sPHENIX Descoping/Cost Reduction Exercise

Scenario A	Δ	FY16 M$ Scenario B	Δ
two-layer MAPS inner barrel	+3.0	one-layer MAPS inner barrel	+2.1
no reuse of VTX	−0.2	no reuse of VTX	−0.2
reduce TPC readout	−0.5	reduce TPC readout	−0.5
reduce EMCal segmentation	−1.8	reduce EMCal segmentation	−1.8
reduce EMCal η acceptance	−2.0	further reduce EMCal η acceptance	−2.2
reduce DAQ refresh	−0.5	reduce DAQ refresh	−0.5
reuse beam-beam trigger counter	−0.5	reuse beam-beam trigger counter	−0.5
Total	−2.5	Total	−3.6

Specifically for Scenario B in the attached document there are 4 main areas of cost reduction:

1. **Reduce TPC readout channels from 200k to 100k - $500k**
2. **Reduce EMCal through 4 to1 ganging of tower output -$1800k**
3. **Reduce EMCal eta coverage to |eta| < 0.7 -$2200k**
4. **Reduce DAQ/Trigger hardware -$500k**

Presume success in $500k savings by obtaining a Trigger detector through an international collaborator or re-use of existing device
Presume the $200k saved by not building VTX external support structure is in the MAPs cost estimate(?)

Could the appropriate L2 and L3 managers analyze the proposed cost savings and answer the following questions for each of the 4 items:

Answer by this Monday Jun 20

- **Based on your best information are the cost savings reasonable?**
- **What is the schedule impact of the cut? It can be positive or negative.**
- **What if any additional technical risk will result from these cuts?**

Specifically for the DAQ/Trigger, excluding the cut Trigger Device, the budget is cut from $1.2M to $0.7M. Could Martin, Eric and Chi answer what would be purchased for $0.7M and what would we have to forego?

Status of sPHENIX Project Preparation

- Defined the subsystem Project scope
- Defined WBS categories (Det:Design, Prototyping, Production, Elec:Design, Prototyping, Production)
- Defined Project approach
  - Software choices: MS-Project for CD-1, Primavera for CD-2/3
  - Use standard CD-1, CD-2/3 approval dates for project planning purposes
  - No final design until CD-1 approval. No production start until CD-3. All R&D MUST be done prior to CD-3.
  - Set number of scheduled reviews (preproduction , safety, post prototype…), include 3 rounds of prototyping in most cases.
- Assign resources and durations to all tasks
  - All L3 manager 20% time just to manage. All L2 managers 50% time.
  - All procurements should have small amount of resources defined to follow orders.
- Procurement tasks
  - Orders < $100k 1 month to place order
  - Orders < $1M 3 month to place orders
  - Orders > $1M 6 months to place orders
- All tasks are linked with predecessors and successors
- Material costs are assigned where appropriate
- Define labor bands are associated with the labor resources
- Analyze labor and budget profiles.

sPHENIX Schedule Summary

Project Schedule and Budget incorporating Review committee recommendations:

CD-0 Apr 2016 (keep for now but it will slip)

DOE approval to decommission PHENIX Apr 2016

Decommissioning starts immediately at the end of Run-16, mid Jun 2016

CD-1/CD-3a Nov 2017

CD-3b Jul 2018

Tracker fully assembled and tested. Ready for installation in 1008 Jan 2021.

sPHENIX installed commissioned and ready for beam Jun 2021.

First RHIC Beam for sPHENIX Jan 2022

CD-4 Jan 2023

The critical path for the project is through the Outer HCal. The schedule has 8.5 months of float to 1st beam Jan 2022.

Responsibilities (FVTX)

The sensors will be a joint responsibility between US and the Prague group from the Czech Republic, with the Prague group doing the bulk of the R&D. A collaboration has been formed with the FNAL Engineering Dept., headed by Ray Yarema, for development of the FPHX chip.
The FNAL group has modified an existing operational FPIX2 chip to our specifications and will produce and test the new FPHX chips. Los Alamos National Laboratory (LANL) will oversee this effort.
The HDI will be a joint US institutional responsibility with University of New Mexico (UNM) leading the effort.
The sensor wedge assemblies are the responsibility of Columbia University. The cooling backplane will be purchased through an engineering firm, HYTEC.