MAPS Cost, Schedule and Resources Plan

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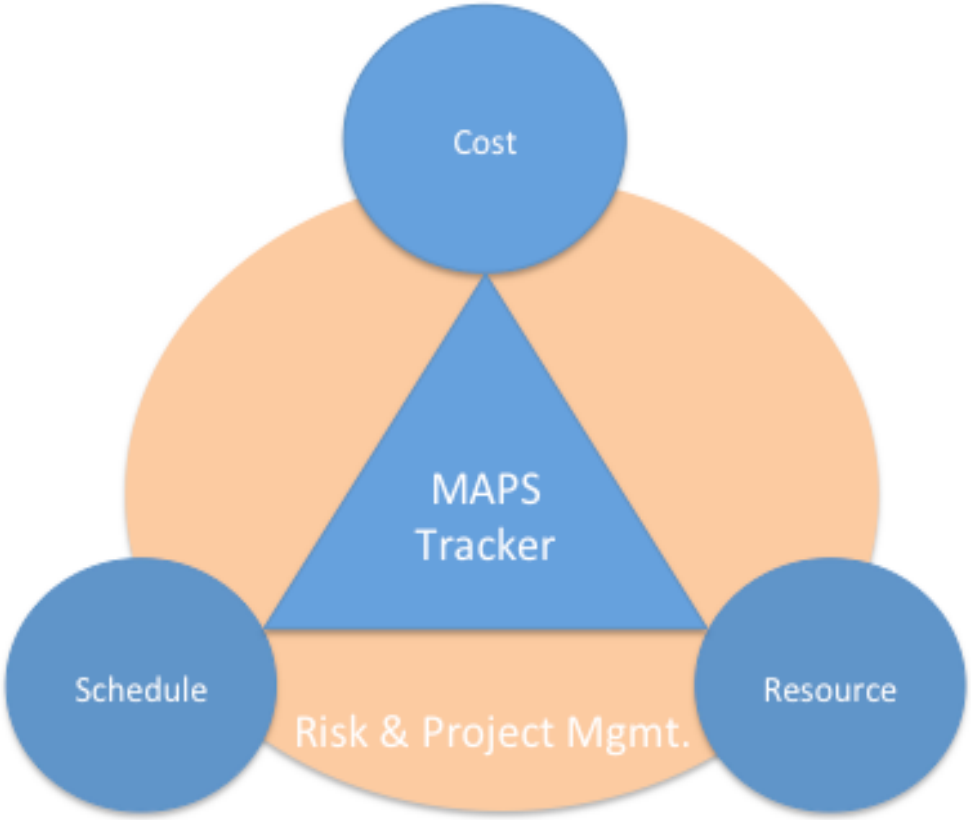
Los Alamos National Laboratory

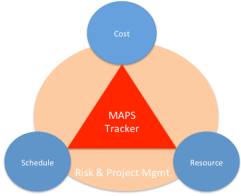
Outline

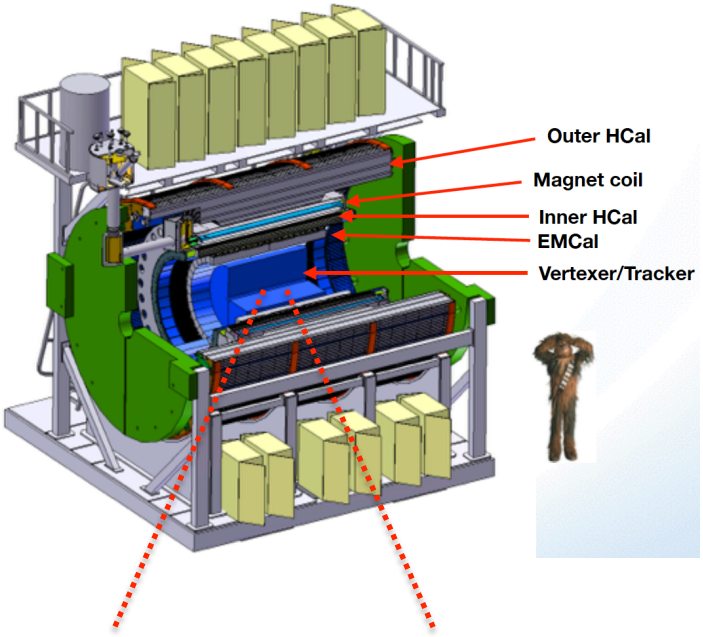
- Scope of project
  - MAPS inner tracker
  - Cost and Schedule Basis
- Cost
  - R&D
  - Production
- Schedule
  - R&D
  - Production
- Resources



- Risk and project management

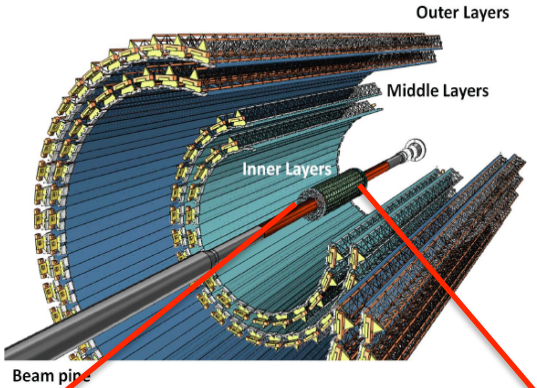
sPHENIX MAPS Inner Tracker

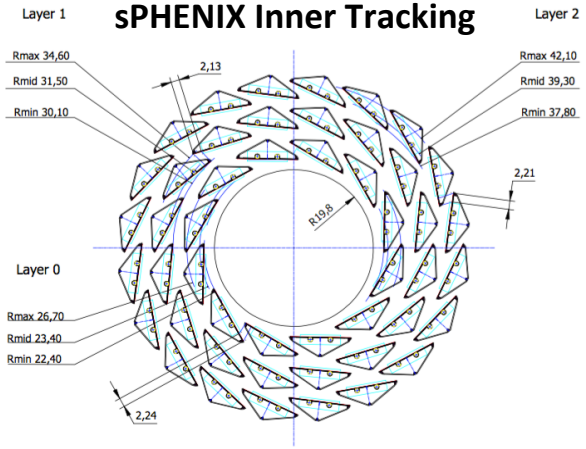


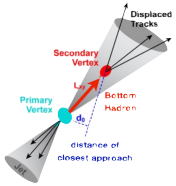


Key issues:
- Readout
- Mechanics

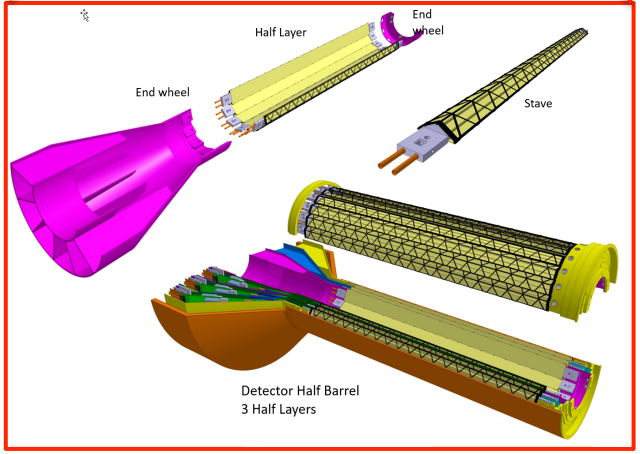
ALICE ITS;
Inner Tracker System



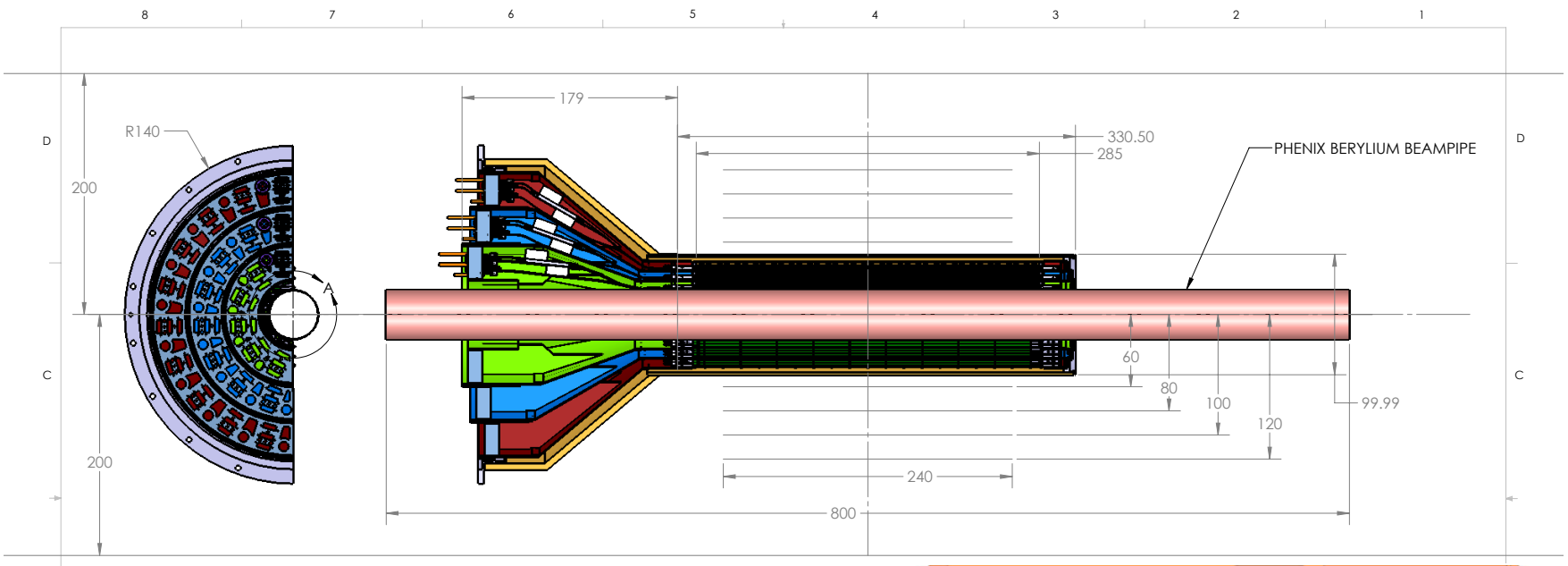


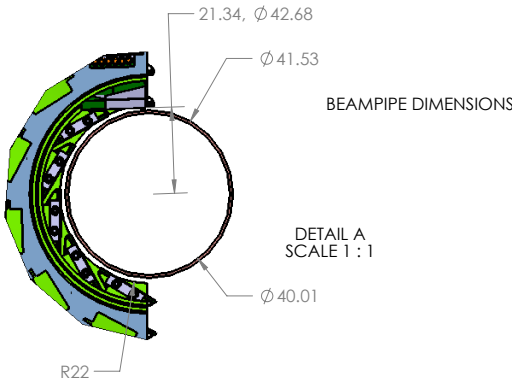


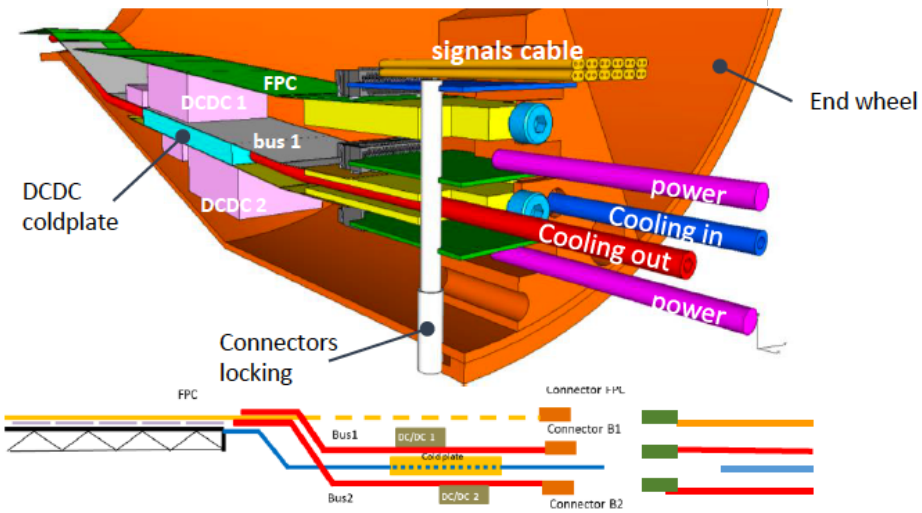
Copy of ITS
Inner Tracker



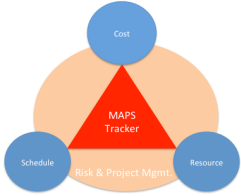
sPHENIX MAPS Inner Tracker





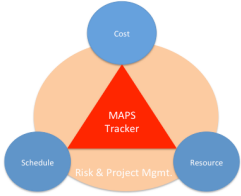


Scope of the Project



- 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
    - Conceptual design by LANL LDRD
    - Prototype by sPHENIX R&D
    - Design integration frames
    - Cage etc.
    - Installation tooling etc.
  - Copy ALICE cooling plant design
    - Minor modification to fit sPHENIX
    - Smaller heat load than ALICE ITS
  - Metrology and Survey

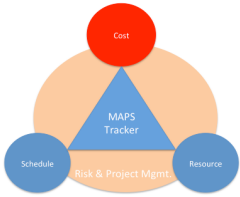
Assumptions



- Copy ALICE 3-layer MAPS Inner Tracker
- Extend ALICE ITS production
- Follow proposed sPHENIX CD process
- Critical R&D 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
- Labor 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 40% cost & schedule contingency (pre CD-0)
- Initial cost and manpower allocation, w/o funding profile

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



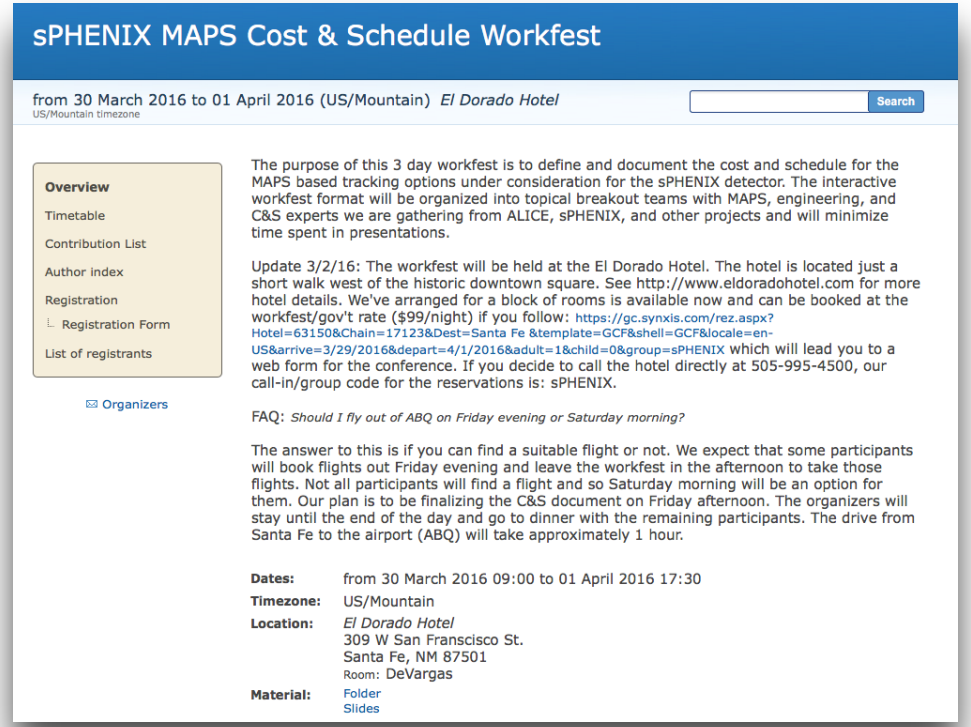
https://indico.bnl.gov/conferenceDisplay.py?confId=1741

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

Overview
Timetable
Contribution List
Author index
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.

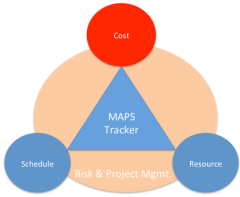
FAQ: *Should I fly out of ABQ on Friday evening or Saturday morning?*

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

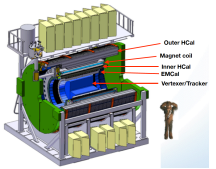
Readout R&D
Mech. design
@LANL/ALICE

Key R&D

Mech. Integr. & Prototype @BNL/LANL

Production

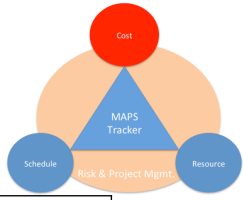
MAPS Prod. & QA @ALICE → Stave Prod.&Test @CERN; FEM Prod. @US → Det. Assembly & Test @BNL → Det. Install. @BNL



+2% +50%

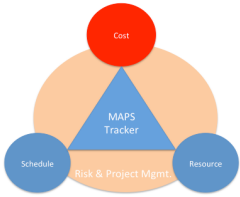
MoU w/ ALICE: 12/2016
To produce staves, frames and FEMs

Major Item Cost Estimate

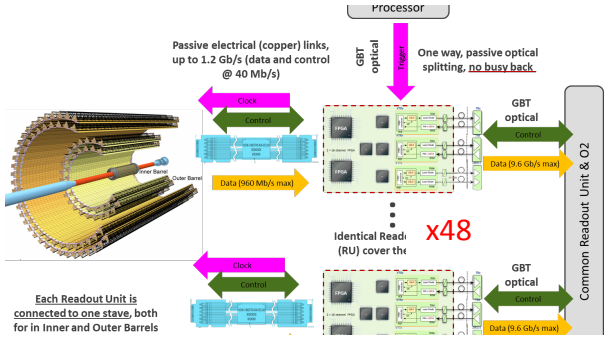


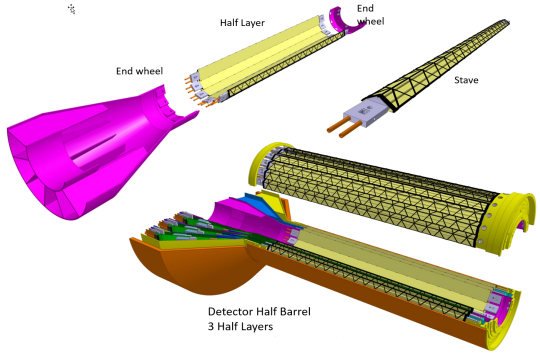
sPHENIX MAPS Inner Tracker Cost Estimate									
3 MAPS layers	Updated: 9/2/2016		LANL STD Labor Rates w/ o OH		LANL STD Labor Rates w/o OH				
FY16 dollars			No Funding Profile						
	R&D	R&D		Construction (k$)		Comments	Contingency	M&S OH	Full M&S Cost with Contingengy (k$)
	LANL (k$)	Collaboration (k$)							
		M&S	Labor Cost w/o Cont. & OH	M&S	Labor Cost w/o Cont.				
Produce & Test MAPS Staves at CERN	205.4			945.7	139.7	Alice production	0.4	0.25	1654.975
							0.4	0.25	0
Procure and Test RDO boards	17.6			265.7	15.5	Alice production	0.4	0.25	464.975
Procure and Test CRU boards	16.9			271.7	1.6	Alice production	0.4	0.25	475.475
sPHENIX readout R&D	203.4						0.4	0.25	0
DAQ integration	104.5						0.4	0.25	0
							0.4	0.25	0
Setup 2 ALICE Readout Teststand	52.9					Alice production	0.4	0.25	0
Procure and Test SamTec cables	3.2			27	0.3	Alice production cost	0.4	0.25	47.25
Procure and Test Optical links	1			81.6	0.6	Alice production cost	0.4	0.25	142.8
							0.4	0.25	0
Procure and Test LV, Cables etc	28.6			100	1.6	Alice production cost	0.4	0.25	175
Racks	8.6						0.4	0.25	0
Chiller & Cooling Plant	41.8	20	23.4	40	1.6	Alice production; may need to modify them to fit sPHENIX	0.4	0.25	105
Safety system	35.4	20	36.4				0.4	0.25	35
Mechnical integration	65.1	50	78.5				0.4	0.25	87.5
Assembly Jigs	48.37	20	24.6	100	0.9	Alice production; may need to modify them to fit sPHENIX	0.4	0.25	210
Test beam	99.6						0.4	0.25	0
							0.4	0.25	0
End wheels				34	1.6	Alice production	0.4	0.25	59.5
Cylindrical Structure Shells				11	1.6	Alice production	0.4	0.25	19.25
Detector half barrels				13	1.6	Alice production	0.4	0.25	22.75
Service half barrels				120	1.6	Alice production	0.4	0.25	210
Detector and Service Half Barrels				21	1.6	Alice production	0.4	0.25	36.75
Two Half Support Structures				50	1.6	Alice production; may need to modify them to fit sPHENIX	0.4	0.25	87.5
Total	932.37	110	162.9	2080.7	171.4				3833.725
	LDRD fully burdened	R&D M&S	R&D Labor	Prod. M&S	Prod. Labor				Pod. M&S wirh Cont. & OH

Cost Basis – Major Items

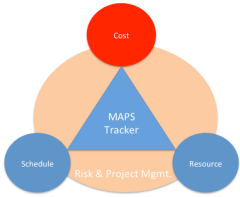


- MAPS and Staves
  - ALICE ITS production
- Readout
  - ALICE ITS RDO and CRU production
- Electronics Interface to sPHENIX/DAQ
  - FVTX/PHENIX experience
- Slow control, DCM-II etc.
  - FVTX/PHENIX experience
- Mechanical structures and cooling
  - ALICE ITS inner tracker desgin
  - FVTX/PHENIX experience





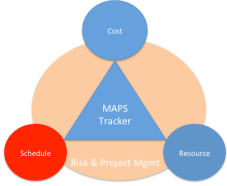
Major Item Prototype Costs



- LANL LDRD-DR: $932K
  - $1.1M/year for 3 years (FTE's and M&S)
    - DAQ Interface: $605K
    - Mechanics: $228K
    - Test beam: $99K

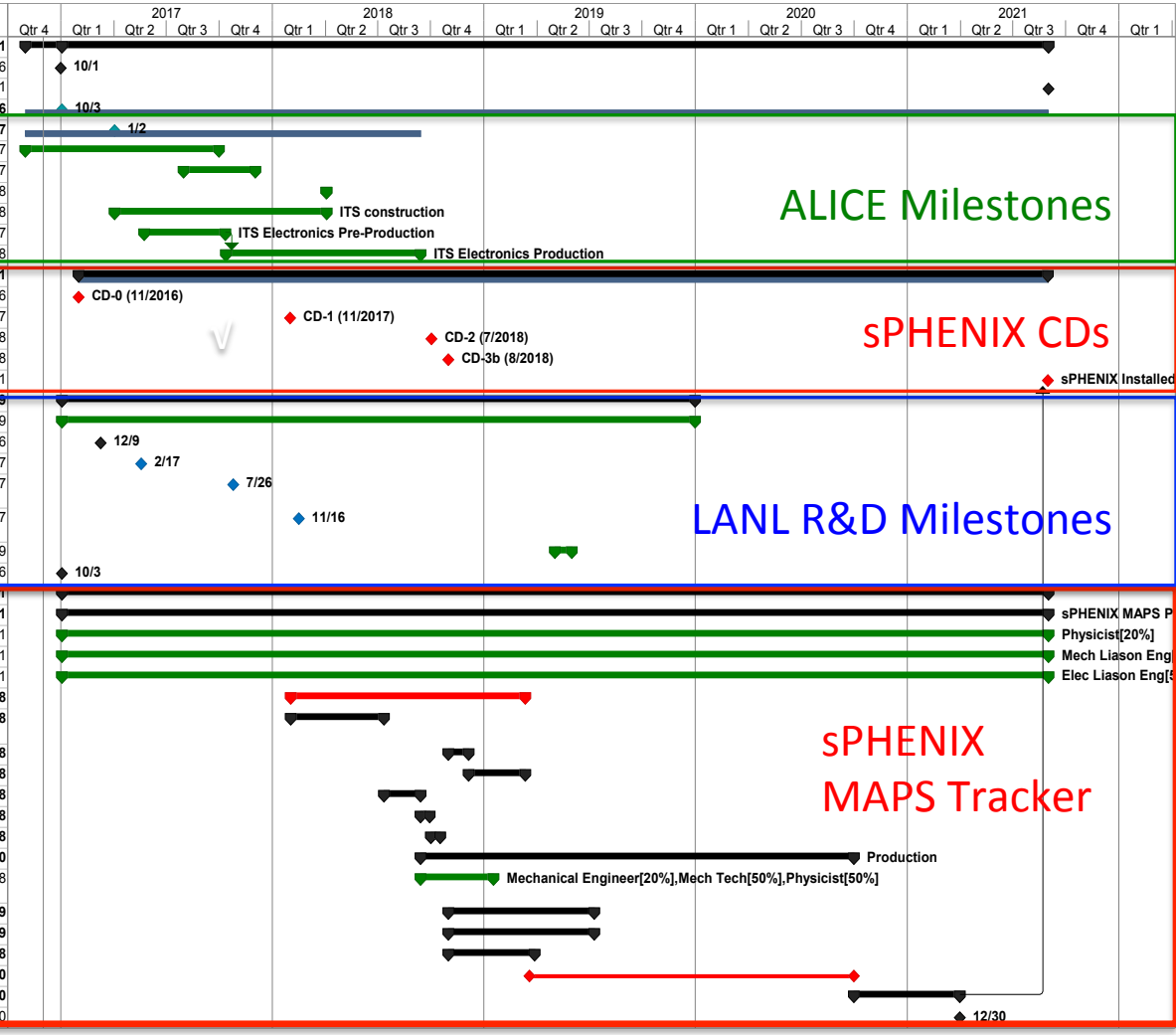
- sPHENIX Prototype: $273K
  - Mechanical design and integration: $223K
  - Mechanical prototype: $50K

Overview of Schedules



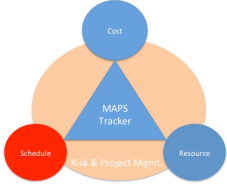
Thu 9/1/16

ID	WBS	Task Name	Duration	Start	Finish
1	1	**MAPS Inner Barrel**	**1217 days**	**Mon 10/3/16**	**Tue 6/1/21**
2	1.1	MAPS Inner Barrel Starts	0 days	Sat 10/1/16	Sat 10/1/16
3	1.2	MAPS Inner Barrel Ends	0 days	Tue 6/1/21	Tue 6/1/21
4	1.3	**Milestones & Key Tasks**	**0 days**	**Mon 10/3/16**	**Mon 10/3/16**
5	1.3.1	**ALICE ITS Key Tasks**	**0 days**	**Mon 1/2/17**	**Mon 1/2/17**
6	1.3.1.1	ALICE MAPS Production (7/17)	240 days?	Mon 8/1/16	Fri 6/30/17
7	1.3.1.2	ALICE ITS IB FPC Production (9/17)	90 days	Mon 5/1/17	Fri 9/1/17
8	1.3.1.3	ALICE ITS IB Stave Production (1/18)	1 day?	Tue 1/2/18	Tue 1/2/18
9	1.3.1.4	ALICE ITS IB Stave Assembly (3/18)	262 days	Mon 1/2/17	Tue 1/2/18
10	1.3.1.5	ALICE ITS Electronics Pre-Production (7/17)	100 days	Wed 2/22/17	Tue 7/11/17
11	1.3.1.6	ALICE ITS Electronics Production (6/18)	240 days	Thu 7/13/17	Wed 6/13/18
12	1.3.2	**sPHENIX Milestones**	**1195 days**	**Tue 11/1/16**	**Tue 6/1/21**
13	1.3.2.1	sPHENIX Technical Design CD-0	0 days	Tue 11/1/16	Tue 11/1/16
14	1.3.2.2	sPHENIX Technical Design (CD-1/CD-3a)	0 days	Wed 11/1/17	Wed 11/1/17
15	1.3.2.3	sPHENIX Technical Dewsgin (CD-2)	0 days	Mon 7/2/18	Mon 7/2/18
16	1.3.2.4	sPHENIX Start Construction (CD-3b)	0 days	Wed 8/1/18	Wed 8/1/18
17	1.3.2.5	sPHENIX Installed and Ready for Beam	0 days	Tue 6/1/21	Tue 6/1/21
18	1.3.3	**LDRD Milestones & Critical Tasks**	**781 days**	**Mon 10/3/16**	**Mon 9/30/19**
19	1.3.3.1	LDRD Start and End	781 days	Mon 10/3/16	Mon 9/30/19
20	1.3.3.8	Complete MoU LANL-ALICE	0 days	Fri 12/9/16	Fri 12/9/16
21	1.3.3.3	Setup ALICE Readout Test Stands	0 days	Fri 2/17/17	Fri 2/17/17
22	1.3.3.4	Complete final sPHENIX Readout Design Review	0 days	Wed 7/26/17	Wed 7/26/17
23	1.3.3.5	Complete Final MAPS Detector Design (CD-1)	0 days	Thu 11/16/17	Thu 11/16/17
24	1.3.3.6	sPHENIX Test Beam	21 days	Fri 2/1/19	Fri 3/1/19
25	1.3.3.7	MAPS Final Design (CD-2/CD-3)?	0 days	Mon 10/3/16	Mon 10/3/16
26	1.5	**sPHENIX Project**	**1217 days?**	**Mon 10/3/16**	**Tue 6/1/21**
27	1.5.1	**sPHENIX Project Management**	**1217 days**	**Mon 10/3/16**	**Tue 6/1/21**
28	1.5.1.1	Level 3 Project Manager	1217 days	Mon 10/3/16	Tue 6/1/21
29	1.5.1.2	Mechanical Liason Engineer	1217 days	Mon 10/3/16	Tue 6/1/21
30	1.5.1.3	Electronics Liason Engineer	1217 days	Mon 10/3/16	Tue 6/1/21
31	1.5.2	**sPHENIX Mechanics Integration**	**289 days**	**Thu 11/2/17**	**Tue 12/11/18**
32	1.5.2.1	**Stave Support Frame & Global Interface to sPHENIX**	**115 days**	**Thu 11/2/17**	**Wed 4/11/18**
37	1.5.2.2	**Cooling System**	**25 days**	**Wed 8/1/18**	**Tue 9/4/18**
41	1.5.2.3	**Safety Systems**	**70 days**	**Wed 9/5/18**	**Tue 12/11/18**
45	1.5.2.4	**Stave Assembly Tooling**	**45 days**	**Thu 4/12/18**	**Wed 6/13/18**
49	1.5.3	Mechanics Final Design Review	12 days	Thu 6/14/18	Fri 6/29/18
53	1.5.4	**MAPS Inner Barrel Review (CD-2/3)**	**12 days**	**Mon 7/2/18**	**Tue 7/17/18**
57	1.5.5	**Productions**	**534 days?**	**Thu 6/14/18**	**Tue 6/30/20**
58	1.5.5.1	Full Pre-Production-Mechnical System Mock Up Test	90 days	Thu 6/14/18	Wed 10/17/18
59	1.5.5.2	**Procurements**	**180 days?**	**Wed 8/1/18**	**Tue 4/9/19**
60	1.5.5.2.1	**CERN Procurements**	**180 days?**	**Wed 8/1/18**	**Tue 4/9/19**
65	1.5.5.2.2	**Non-CERN Procurements**	**107 days**	**Wed 8/1/18**	**Thu 12/27/18**
80	1.5.5.3	**Assembly and Testing at BNL**	**400 days**	**Wed 12/19/18**	**Tue 6/30/20**
89	1.5.6	**Installation**	**131 days**	**Wed 7/1/20**	**Wed 12/30/20**
94	1.5.7	Ready for beam	0 days	Wed 12/30/20	Wed 12/30/20



About 6 months of schedule float

LANL R&D Schedule



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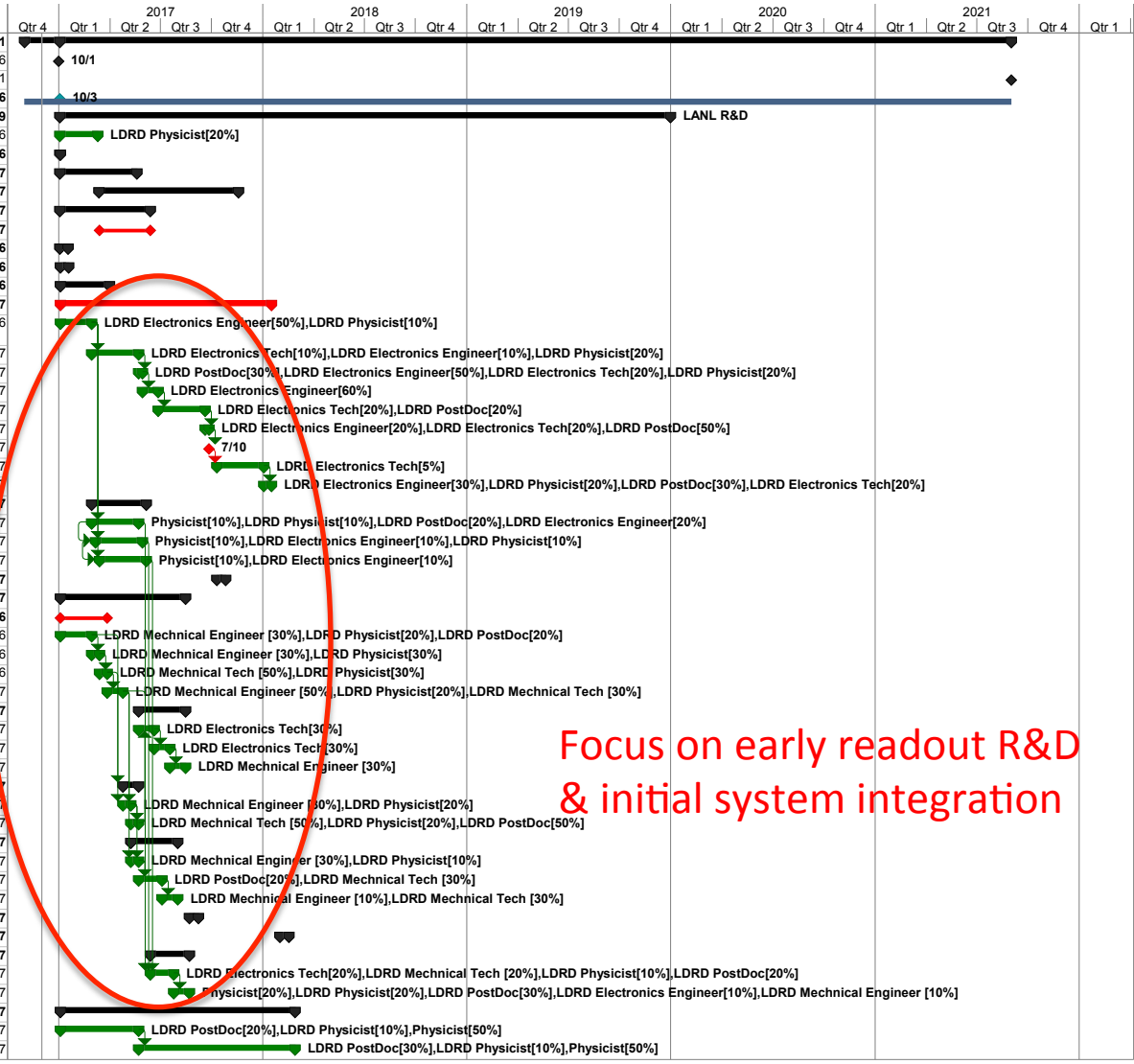
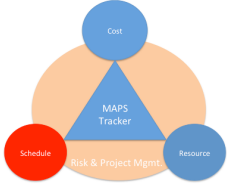
4	**1.3**	**Milestones & Key Tasks**	**0 days**	**Mon 10/3/16**	**Mon 10/3/16**
26	**1.4**	**LANL LDRD**	**781 days**	**Mon 10/3/16**	**Mon 9/30/19**
27	1.4.1	MOU btw LANL and ALICE for R&D	50 days	Mon 10/3/16	Fri 12/9/16
28	**1.4.2**	**Obtain Designs from ALICE**	**1 day**	**Mon 10/3/16**	**Mon 10/3/16**
32	**1.4.3**	**Setup Alice Readout Test Stand**	**100 days**	**Mon 10/3/16**	**Fri 2/17/17**
35	**1.4.4**	**Procure R&D ALICE Staves**	**180 days**	**Mon 12/12/16**	**Fri 8/18/17**
39	**1.4.5**	**Procure ALICE Electronics & Cabels**	**116 days**	**Mon 10/3/16**	**Mon 3/13/17**
40	**1.4.5.1**	**ALICE Readout Electronics Boards**	**65 days**	**Tue 12/13/16**	**Mon 3/13/17**
47	**1.4.5.2**	**SamTec Cables**	**11 days**	**Mon 10/3/16**	**Mon 10/17/16**
50	**1.4.5.3**	**Optical Cables**	**11 days**	**Tue 10/4/16**	**Tue 10/18/16**
53	**1.4.5.4**	**Procure Ancillaries**	**64 days**	**Tue 10/4/16**	**Fri 12/30/16**
57	**1.4.6**	**sPHENIX Readout Electronics Integration**	**270 days**	**Tue 10/4/16**	**Mon 10/16/17**
58	1.4.6.1	Initial sPHENIX Readout Design (sCRU, modified from ALICE)	40 days	Tue 10/4/16	Mon 11/28/16
59	1.4.6.2	Prototype sCRU	60 days	Tue 11/29/16	Mon 2/20/17
60	1.4.6.3	sCRU test-I	5 days	Tue 2/21/17	Mon 2/27/17
61	1.4.6.4	Revised sCRU Design	20 days	Tue 2/28/17	Mon 3/27/17
62	1.4.6.5	Prototype sCRU-II	60 days	Tue 3/28/17	Mon 6/19/17
63	1.4.6.6	sCRU test-II	5 days	Tue 6/20/17	Mon 6/26/17
64	1.4.6.7	Final sPHENIX Readout Design (CD-1)	10 days	Mon 6/26/17	Mon 7/10/17
65	1.4.6.8	Procure 4 sCRUs	60 days	Tue 7/11/17	Mon 10/2/17
66	1.4.6.9	Final sCRU Test	10 days	Tue 10/3/17	Mon 10/16/17
67	**1.4.7**	**sPHENIX DAQ System Integration**	**70 days**	**Tue 11/29/16**	**Mon 3/6/17**
68	1.4.7.1	Slow Control Design	60 days	Tue 11/29/16	Mon 2/20/17
69	1.4.7.2	Trigger Interface Design	60 days	Tue 12/6/16	Mon 2/27/17
70	1.4.7.3	DAQ Interface Design	60 days	Tue 12/13/16	Mon 3/6/17
71	**1.4.8**	**Electronics Final Design Review**	**12 days**	**Tue 7/11/17**	**Wed 7/26/17**
75	**1.4.9**	**Mechanical Support and Cooling**	**160 days**	**Tue 10/4/16**	**Mon 5/15/17**
76	**1.4.9.1**	Specifications	**60 days**	**Tue 10/4/16**	**Mon 12/26/16**
77	1.4.9.1.1	Review & Simulate Heat Load	40 days	Tue 10/4/16	Mon 11/28/16
78	1.4.9.1.2	review mechanical tolerances/distortions	10 days	Tue 11/29/16	Mon 12/12/16
79	1.4.9.1.3	review disassembly/repair options	10 days	Tue 12/13/16	Mon 12/26/16
80	1.4.9.2	Prototype Stave Frame Design	20 days	Tue 12/27/16	Mon 1/23/17
81	**1.4.9.3**	**Safety Systems**	**60 days**	**Tue 2/21/17**	**Mon 5/15/17**
82	1.4.9.3.1	review sensors & interlocks	20 days	Tue 2/21/17	Mon 3/20/17
83	1.4.9.3.2	electrical interlock design	20 days	Tue 3/21/17	Mon 4/17/17
84	1.4.9.3.3	cooling interlocks design	20 days	Tue 4/18/17	Mon 5/15/17
85	**1.4.9.4**	**Cooling System**	**20 days**	**Tue 1/24/17**	**Mon 2/20/17**
86	1.4.9.4.1	Prototype Design (modify ALICE)	10 days	Tue 1/24/17	Mon 2/6/17
87	1.4.9.4.2	Mock up Testing	10 days	Tue 2/7/17	Mon 2/20/17
88	**1.4.9.5**	**Stave Assembly Tooling**	**60 days**	**Tue 2/7/17**	**Mon 5/1/17**
89	1.4.9.5.1	Jig Design (modify ALICE)	10 days	Tue 2/7/17	Mon 2/20/17
90	1.4.9.5.2	Prototype Jigs	30 days	Tue 2/21/17	Mon 4/3/17
91	1.4.9.5.3	Final Jigs Design and Production	20 days	Tue 4/4/17	Mon 5/1/17
92	**1.4.10**	Mechanical Coneptual Design Review	**12 days**	**Tue 5/23/17**	**Wed 6/7/17**
96	**1.4.11**	**MAPS Inner Barrel Review (CD-1)**	**12 days**	**Wed 11/1/17**	**Thu 11/16/17**
100	**1.4.12**	**Prototype Assembly and Test**	**50 days**	**Tue 3/14/17**	**Mon 5/22/17**
101	1.4.12.1	Assemble prototype	30 days	Tue 3/14/17	Mon 4/24/17
102	1.4.12.2	Prototype Full System Test	20 days	Tue 4/25/17	Mon 5/22/17
103	**1.4.13**	**Softrware Development**	**300 days**	**Tue 10/4/16**	**Mon 11/27/17**
104	1.4.13.1	Online Monitoring and Contorls	100 days	Tue 10/4/16	Mon 2/20/17
105	1.4.13.2	Offline Software and Analysis	200 days	Tue 2/21/17	Mon 11/27/17

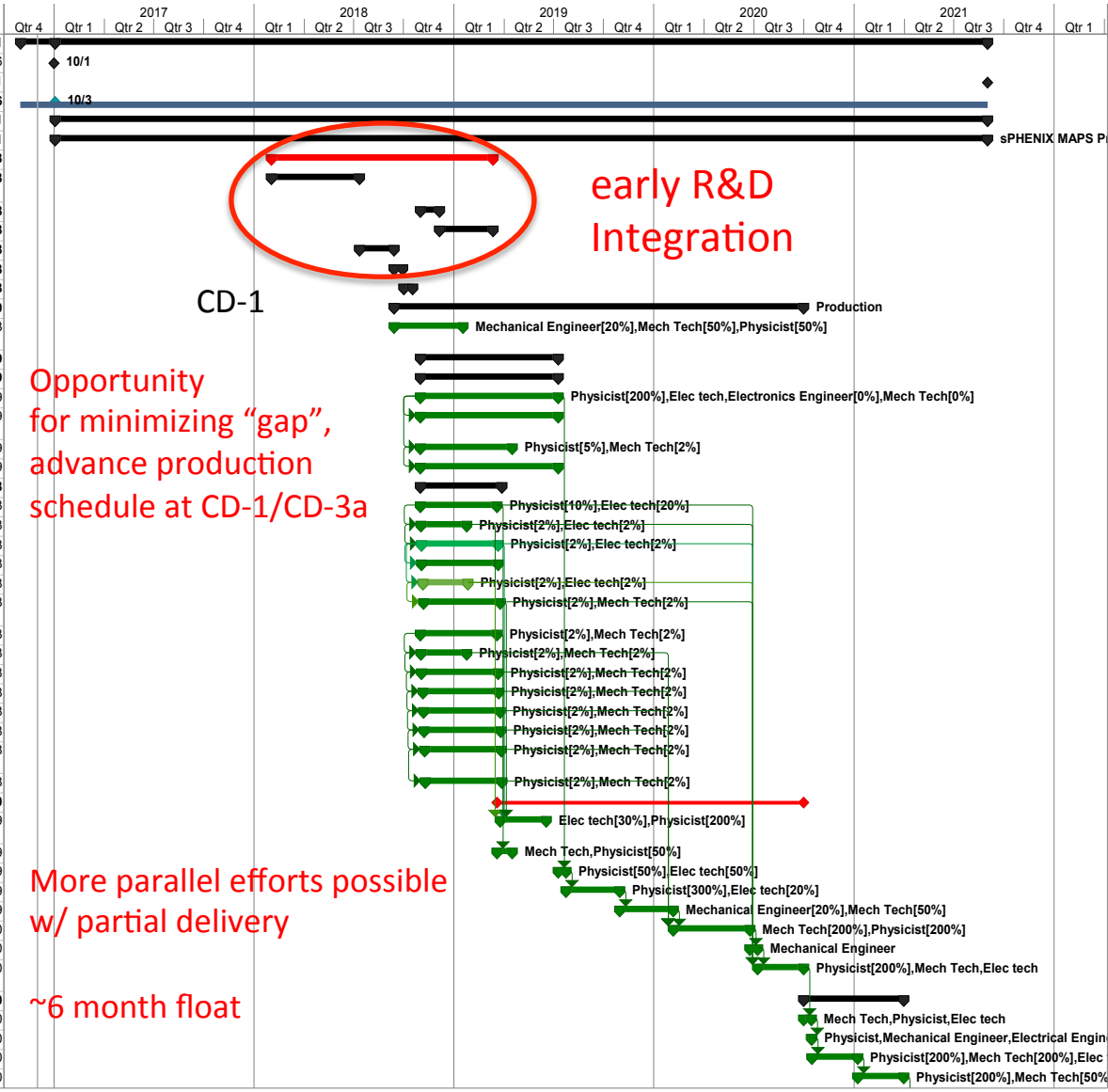


Focus on early readout R&D & initial system integration

Production, Assembly & Installation

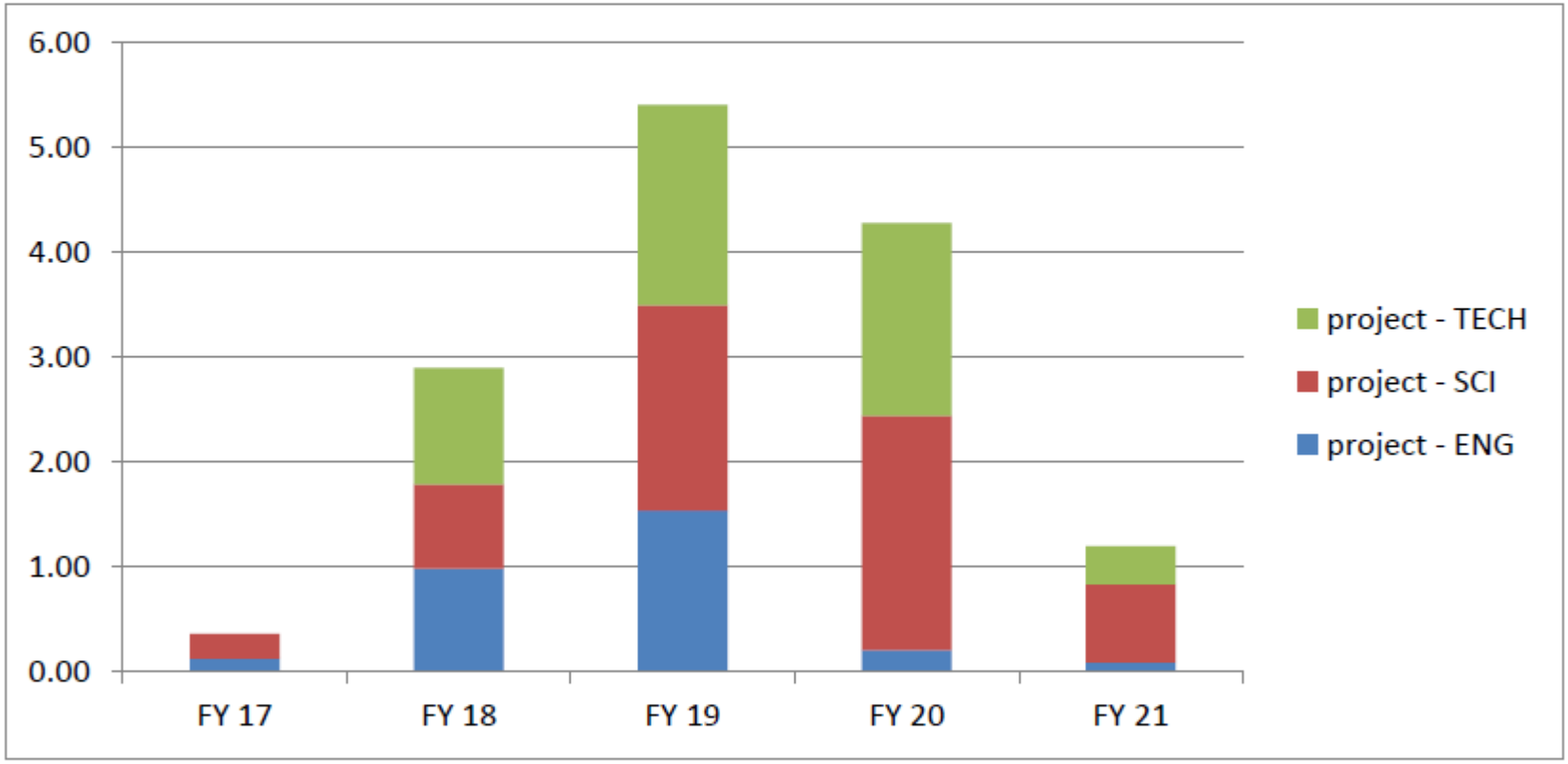


ID	WBS	Task Name	Duration	Start	Finish
1	1	**MAPS Inner Barrel**	**1217 days**	**Mon 10/3/16**	**Tue 6/1/21**
2	1.1	MAPS Inner Barrel Starts	0 days	Sat 10/1/16	Sat 10/1/16
3	1.2	MAPS Inner Barrel Ends	0 days	Tue 6/1/21	Tue 6/1/21
4	1.3	**Milestones & Key Tasks**	**0 days**	**Mon 10/3/16**	**Mon 10/3/16**
26	1.5	**sPHENIX Project**	**1217 days?**	**Mon 10/3/16**	**Tue 6/1/21**
27	1.5.1	**sPHENIX Project Management**	**1217 days**	**Mon 10/3/16**	**Tue 6/1/21**
31	1.5.2	**sPHENIX Mechanics Integration**	**289 days**	**Thu 11/2/17**	**Tue 12/11/18**
32	1.5.2.1	Stave Support Frame & Global Interface to sPHENIX	**115 days**	**Thu 11/2/17**	**Wed 4/11/18**
37	1.5.2.2	**Cooling System**	**25 days**	**Wed 8/1/18**	**Tue 9/4/18**
41	1.5.2.3	**Safety Systems**	**70 days**	**Wed 9/5/18**	**Tue 12/11/18**
45	1.5.2.4	**Stave Assembly Tooling**	**45 days**	**Thu 4/12/18**	**Wed 6/13/18**
49	1.5.3	Mechanics Final Design Review	**12 days**	**Thu 6/14/18**	**Fri 6/29/18**
53	1.5.4	**MAPS Inner Barrel Review (CD-2/3)**	**12 days**	**Mon 7/2/18**	**Tue 7/17/18**
57	1.5.5	**Productions**	**534 days?**	**Thu 6/14/18**	**Tue 6/30/20**
58	1.5.5.1	Full Pre-Production-Mechnical System Mock Up Test	90 days	Thu 6/14/18	Wed 10/17/18
59	1.5.5.2	**Procurements**	**180 days?**	**Wed 8/1/18**	**Tue 4/9/19**
60	1.5.5.2.1	**CERN Procurements**	**80 days?**	**Wed 8/1/18**	**Tue 4/9/19**
61	1.5.5.2.1.1	Produce 68 Inner Staves	180 days	Wed 8/1/18	Tue 4/9/19
62	1.5.5.2.1.2	Stave Production Full Cost Recovery of CERN Manpower	180 days	Wed 8/1/18	Tue 4/9/19
63	1.5.5.2.1.3	Other ITS/CERN Test Equiptment Items	120 days	Wed 8/1/18	Tue 1/15/19
64	1.5.5.2.1.4	Travel and Per Diem at CERN	180 days?	Wed 8/1/18	Tue 4/9/19
65	1.5.5.2.2	**Non-CERN Procurements**	**107 days**	**Wed 8/1/18**	**Thu 12/27/18**
66	1.5.5.2.2.1	Procure 68 Readout /RDO Units	100 days	Wed 8/1/18	Tue 12/18/18
67	1.5.5.2.2.2	Procure Optical Links 68	60 days	Thu 8/2/18	Wed 10/24/18
68	1.5.5.2.2.3	Procure 34 Common Readout Units	100 days	Fri 8/3/18	Thu 12/20/18
69	1.5.5.2.2.4	sPHENIX CRU Production Contingency	100 days	Fri 8/3/18	Thu 12/20/18
70	1.5.5.2.2.5	Procure 100 SamTec Cables	60 days	Mon 8/6/18	Fri 10/26/18
71	1.5.5.2.2.6	Procure Ancillary Materials (LVPS and cables etc)	100 days	Tue 8/7/18	Mon 12/24/18
72	1.5.5.2.2.7	Procure Cooling Plant	100 days	Wed 8/1/18	Tue 12/18/18
73	1.5.5.2.2.8	Procure Assembly Fixtures & Jigs	60 days	Thu 8/2/18	Wed 10/24/18
74	1.5.5.2.2.9	Procure End Wheels	100 days	Fri 8/3/18	Thu 12/20/18
75	1.5.5.2.2.10	Procure Cylindrical Structural Shells	100 days	Mon 8/6/18	Fri 12/21/18
76	1.5.5.2.2.11	Procure Detector Half Barrels	100 days	Tue 8/7/18	Mon 12/24/18
77	1.5.5.2.2.12	Procure Service Half Barrels	100 days	Wed 8/8/18	Tue 12/25/18
78	1.5.5.2.2.13	Procure Detector and Service Half Barrels	100 days	Thu 8/9/18	Wed 12/26/18
79	1.5.5.2.2.14	Procure Two Half Support Structures	100 days	Fri 8/10/18	Thu 12/27/18
80	1.5.5.3	**Assembly and Testing at BNL**	**400 days**	**Wed 12/19/18**	**Tue 6/30/20**
81	1.5.5.3.1	Test Production FEMS, e-Links, CRU, LV, Optical Links	60 days	Tue 12/25/18	Mon 3/18/19
82	1.5.5.3.2	Assemble & Test Cooling System	20 days	Wed 12/19/18	Tue 1/15/19
83	1.5.5.3.3	Stave Reciept Inspection	10 days	Wed 4/10/19	Tue 4/23/19
84	1.5.5.3.4	Individual Stave Readout Test	70 days	Wed 4/24/19	Tue 7/30/19
85	1.5.5.3.5	Metrology on Stave Assemblies	70 days	Wed 7/31/19	Tue 11/5/19
86	1.5.5.3.6	Assemble full Ladders into Half support	100 days	Wed 11/6/19	Tue 3/24/20
87	1.5.5.3.7	Metrology on Final Assembly	10 days	Wed 3/25/20	Tue 4/7/20
88	1.5.5.3.8	Half detector Assembly Readout and Cooling Test	60 days	Wed 4/8/20	Tue 6/30/20
89	1.5.6	**Installation**	**131 days**	**Wed 7/1/20**	**Wed 12/30/20**
90	1.5.6.1	Installation Prep	10 days	Wed 7/1/20	Tue 7/14/20
91	1.5.6.2	Installation Review	1 day	Wed 7/15/20	Wed 7/15/20
92	1.5.6.3	Installation	60 days	Thu 7/16/20	Wed 10/7/20
93	1.5.6.4	Commissioning	60 days	Thu 10/8/20	Wed 12/30/20

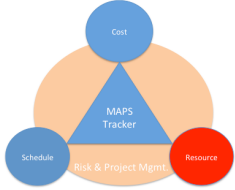


MAPS Labor Profile

MAPS Labor profile from resource – loaded schedule sorted by FY and job category



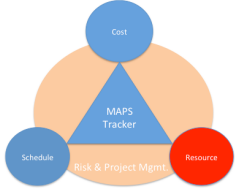
Participating and Interested Institutions



- 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

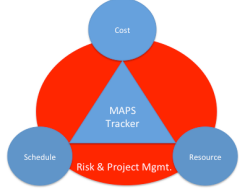
Potential collaboration

Organization Chart



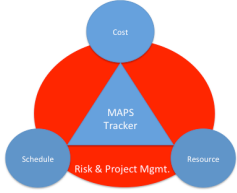
- *BNL Program Manager*
  - *sPHENIX Project Office*
    Manager: Ed O'Brien
    - sPHENIX MAPS Project Office
      Project Manager: *Ming Liu (LANL)*
      Deputy Project Manager: *Mike McCumber (LANL)*
      Electrical Engineer:TBD
      Mechanical Engineer: Walt Sondheim
      - *sPHENIX Management*
        Spokespersons
        Gunther Roland
        David Morrison
      - *Readout*
        UT/LANL
        - *FEM*
          M. Prokop LANL
        - *Slow Control & Monitoring*
          BNL
        - *DCM Integration*
          Colorado
      - *MAPS Sensor*
        ALICE
        - *Sensor Design*
          ALICE
        - *Sensor Production*
          TowerJAZZ
        - *Sensor QA*
          Yonsei(Korea)
      - *Stave*
        ALICE
        - *Stave Design*
          ALICE
        - *Stave Assembly*
          MIT/UIC/LANL
        - *Stave QA*
          MIT/ISU
      - *Cabling*
        UNM
        - *High density cables*
          UNM
        - *LV*
          UNM/NMSU
        - *Fibers*
          UNM
      - *Mechanics*
        MIT/LBNL
        - *Structure Design*
          LANL/MIT
        - *Assembly*
          BNL/MIT
        - *Installation*
          BNL/MIT
      - *Integration*
        MIT
        - *Cooling*
          MIT
        - *Alignment*
          BNL/UIC
        - *Mechanical Stability*
          BNL
        - *Safety System*
          BNL
      - *Electrical*
        BNL
        - *Low Voltage*
          UNM/NMSU
      - *Software*
        UIC/FSU
        - *Simulation*
          ISU/GSU/
        - *Offline*
          NMSU/FSU
        - *B-jet tagging*
          LANL,NMSU

Risk Mitigation



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

Plans and Issues

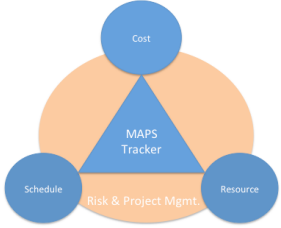


- MoU with ALICE/CERN: by ~12/2016
  - Prototype and final stave production and delivery
  - Obtain ALICE readout test stand and electronics for early R&D
  - Obtain design files, electronics and mechanics
  - Training sPHENIX personnel, available manpower
  - R&D collaboration and schedule
  - Availability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

- Schedule/funding gap of stave productions
  - ITS/IB production: ~1/2017 - Mid/2018
  - sPHENIX CD-3b: 8/2018
  - Risk Mitigation:
    1. Early training through LDRD effort, maintain activity at low level
    2. Possible mortgage for sPHENIX production from ALICE/CERN with MoU
    3. 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

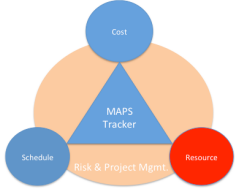
Summary

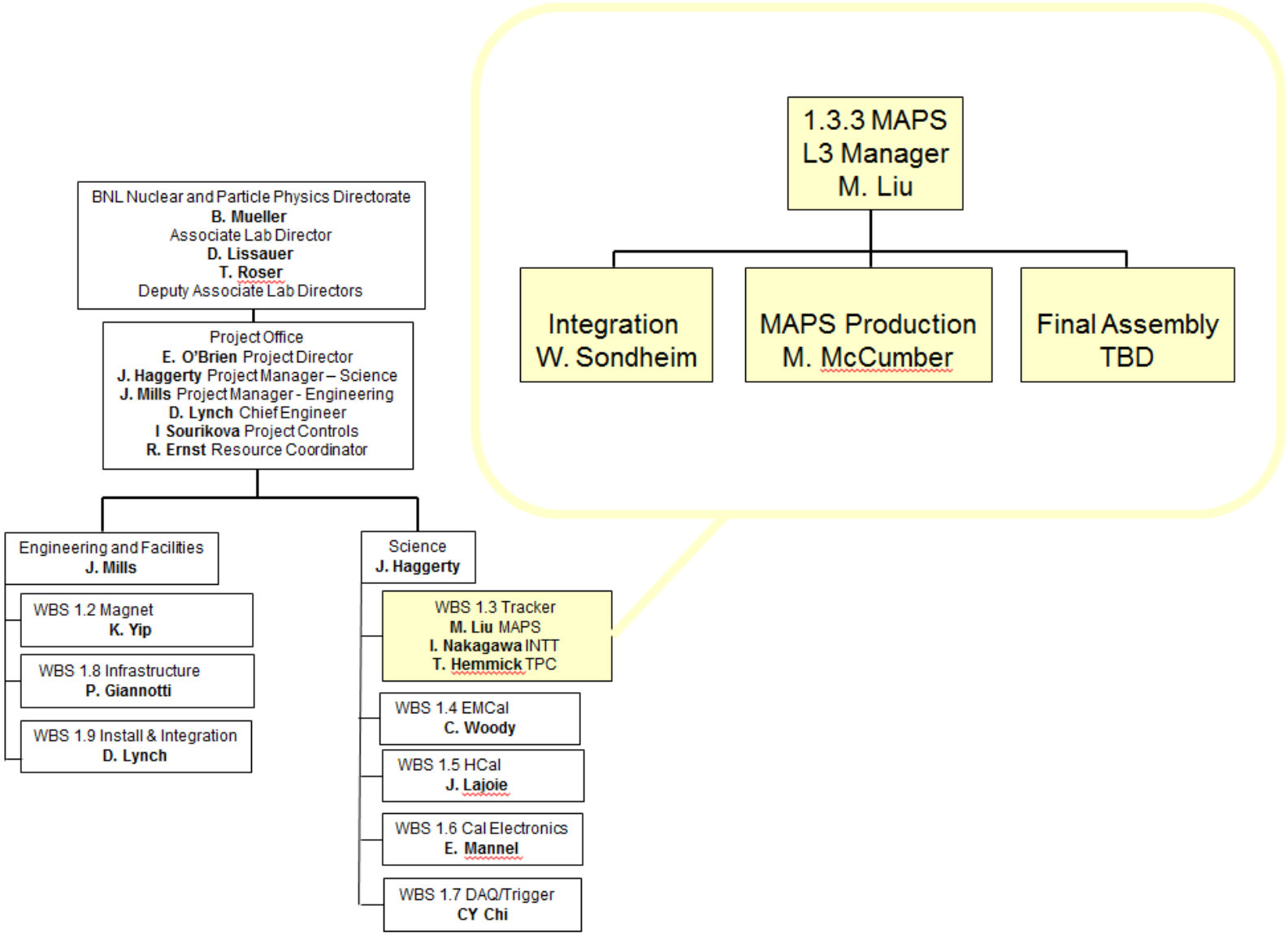


- No high risk R&D necessary
- Early MoU with ALICE critical
- LANL LDRD very important
- Early mechanical integration R&D important
- Cost basis is in reasonable shape
- Management plan is in progress
- Installed and ready for beam ~1/2021
- Project has ~6 months float

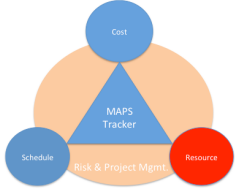
Backup Slides

MAPS Org Chart





MAPS Labor Profile

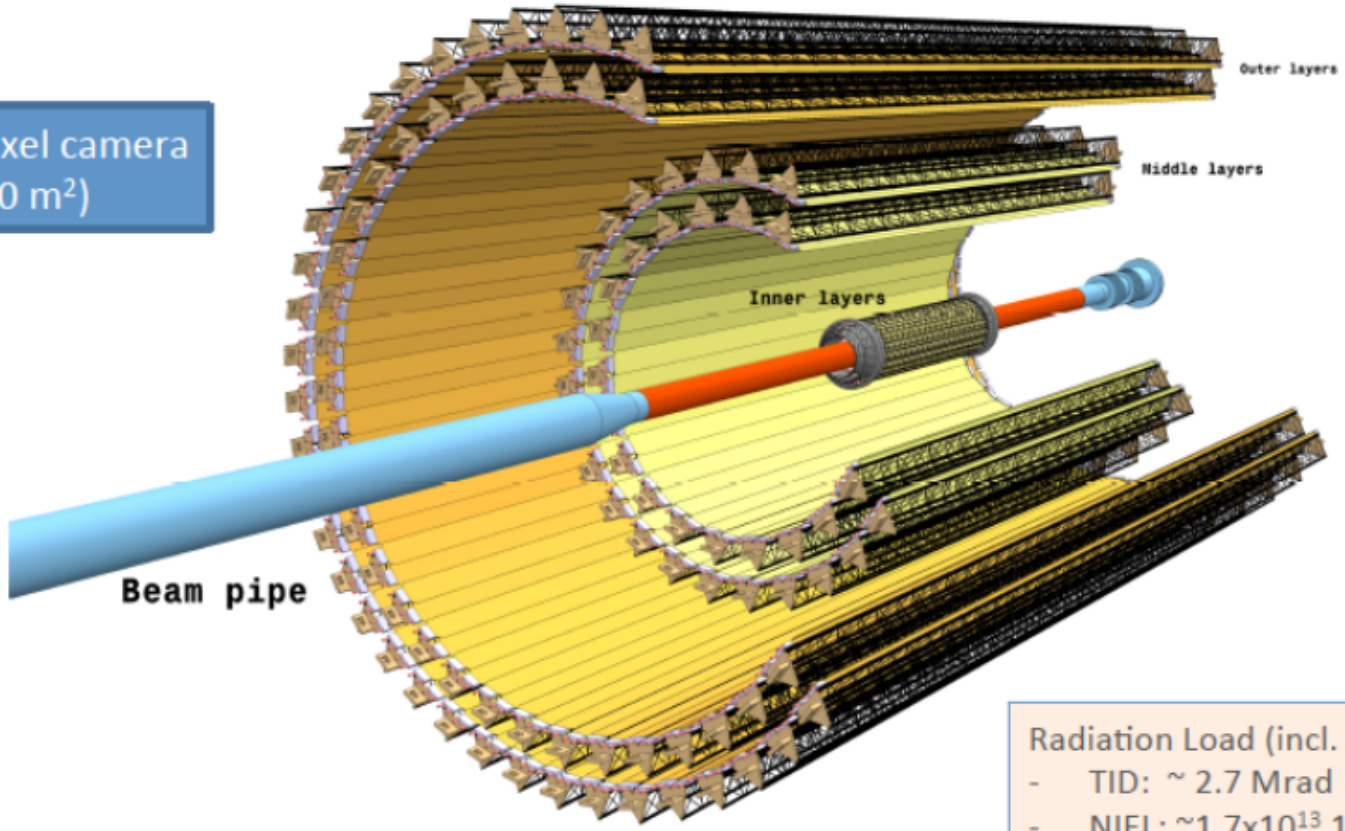


MAPS Labor profile from resource – loaded schedule sorted by FY and job category

Row Labels	FY 17	FY 18	FY 19	FY 20	FY 21
project	**0.35**	**2.90**	**5.41**	**4.28**	**1.19**
ENG	**0.12**	**0.98**	**1.53**	**0.20**	**0.08**
Elec Liason Eng	0.06	0.06	0.06	0.06	0.04
Electrical Engineer	0.00	0.04	0.05	0.00	0.00
Electronics Engineer	0.00	0.42	1.25	0.00	0.00
Mech Liason Eng	0.06	0.06	0.06	0.06	0.04
Mechanical Engineer	0.00	0.40	0.12	0.07	0.00
SCI	**0.24**	**0.81**	**1.96**	**2.24**	**0.75**
Physicist	0.24	0.81	1.96	2.24	0.75
TECH	**0.00**	**1.11**	**1.91**	**1.84**	**0.36**
Elec tech	0.00	0.12	0.44	0.82	0.18
Mech Tech	0.00	0.99	1.47	1.02	0.18
Grand Total	**0.35**	**2.90**	**5.41**	**4.28**	**1.19**

Source of Labor is LANL + MIT with numerous additional institutions expressing interest in participating. Anticipate additional firm institutional commitments over the next few months.

New ITS Layout



12.5 G-pixel camera
(~10 m²)

Radiation Load (incl. safety factor 10)
- TID: ~ 2.7 Mrad
- NIEL: ~1.7x10^{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

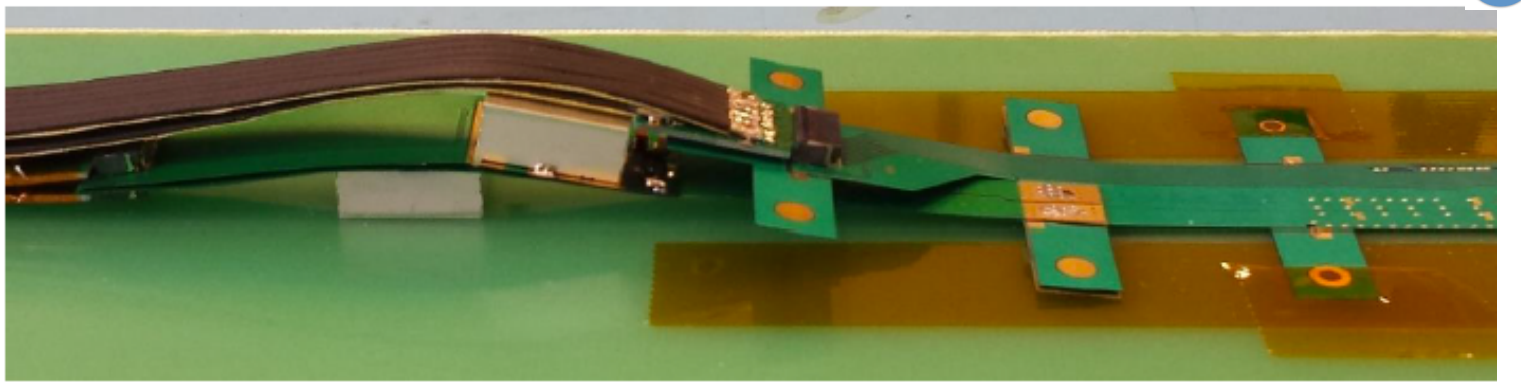
3 Inner Barrel layers (**IB**)

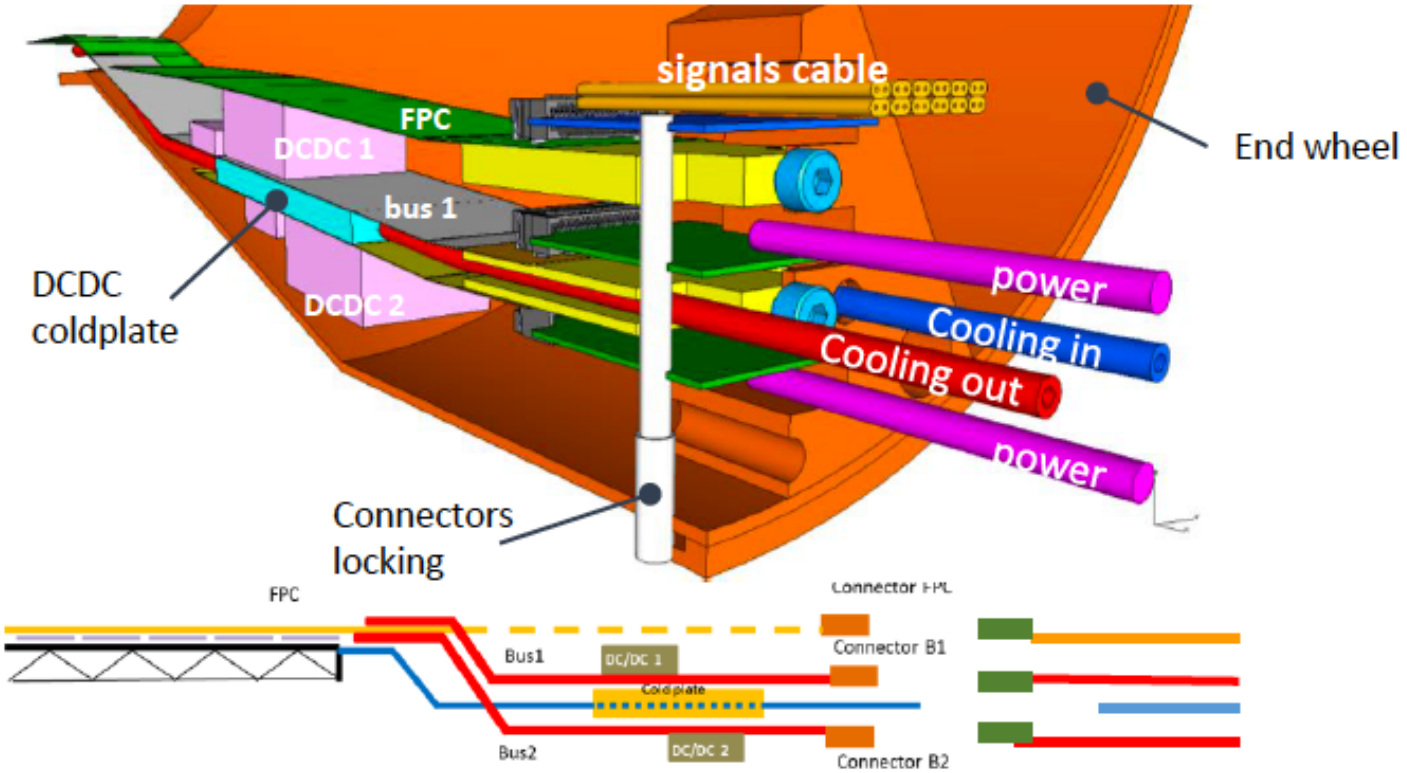
4 Outer Barrel layers (**OB**)

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

sPHENIX

MAPS Service Lines





3-Layer vs 2-Layer

- Cost reduction
  - Stave and electronics cost and schedule
    - Saving $661K
  - Labor: testing/assembly, installation and commissioning
    - Saving ~ 28/68x(206+186+47) = $180K

    Total saving ~ $661+$180 = $842K

- 3 Layers: total $1,681K
  - (12+16+20)+20 = 68 staves
    - Cost: $945+$164 = $1,109K
    - Schedule: 180 days
  - 68 RDOs:
    - Cost: $266+$32 =$298K
  - 34 CRUs:
    - Cost: $272+$2 = $274K

- 2 Inner Layers: total = $1020K
  - (12+16)+12 ALICE layers 0 & 1= 40 staves
    - Cost: 40/68 x $1,109K = $652K
    - Schedule: 106 days
  - 40 RDOs
    - 40/68x $298K = $175K
  - 24CRU:
    - 24/34x$274K = $193K

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
  - 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.

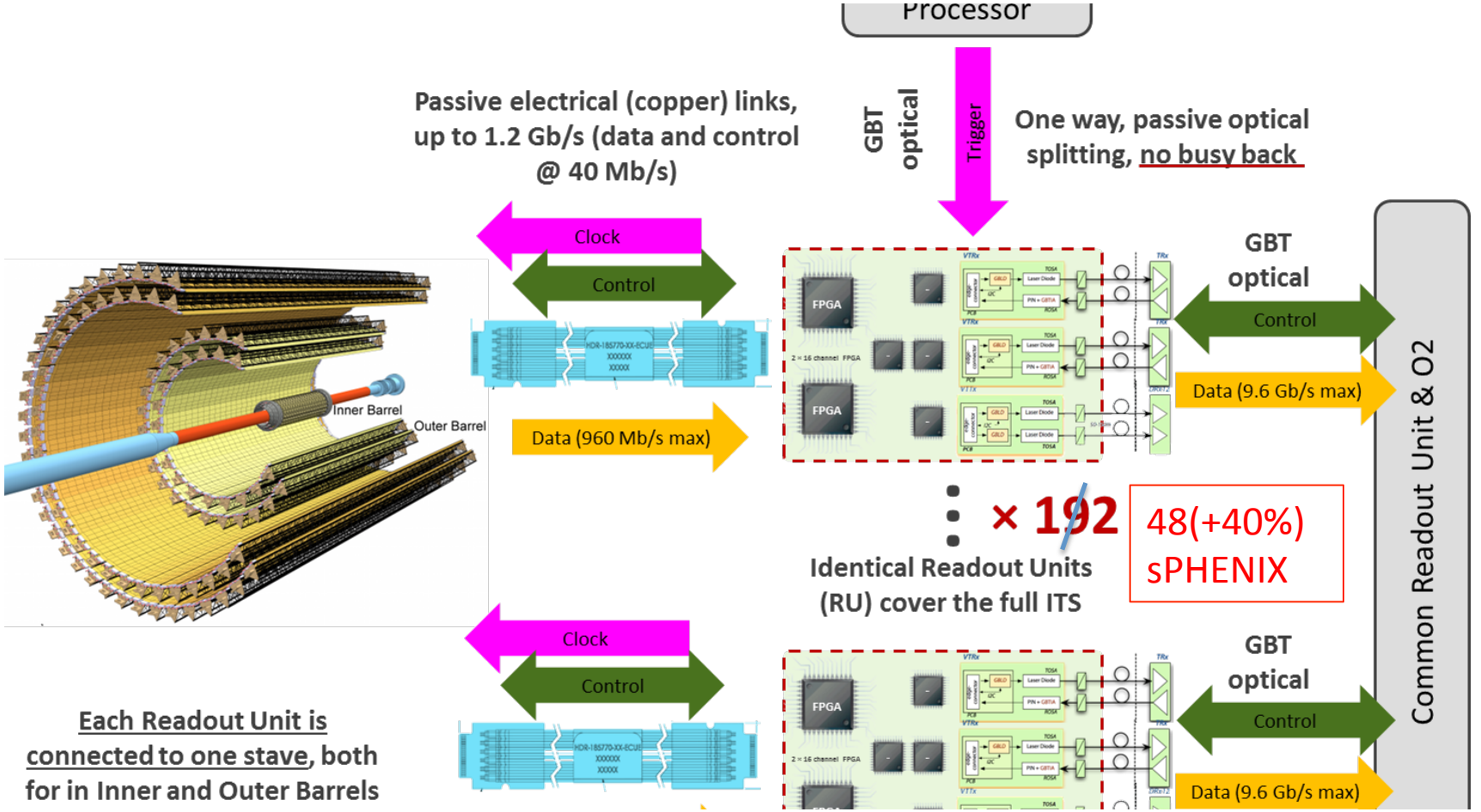
A possible timeline is presentation of your request at the MB of 1st September and at the CB of 11th November.

Kind Regards,
Luciano

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

Cost Basis For Electronics

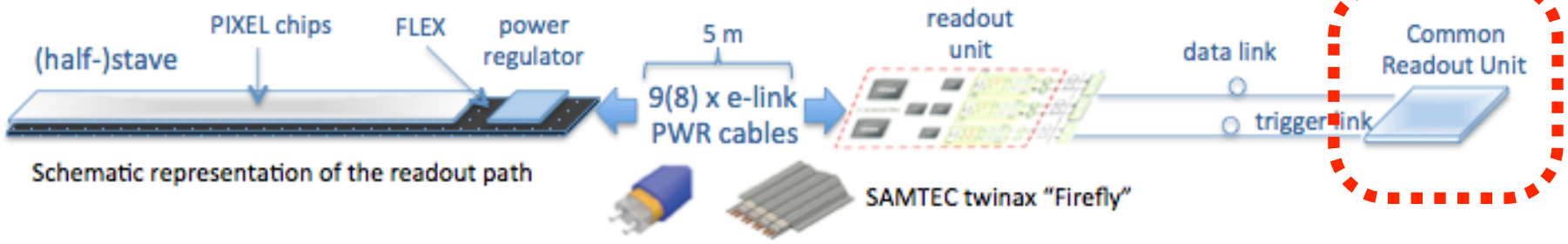
J. Phys. G: Nucl. Part. Phys. **41** (2014) 087002



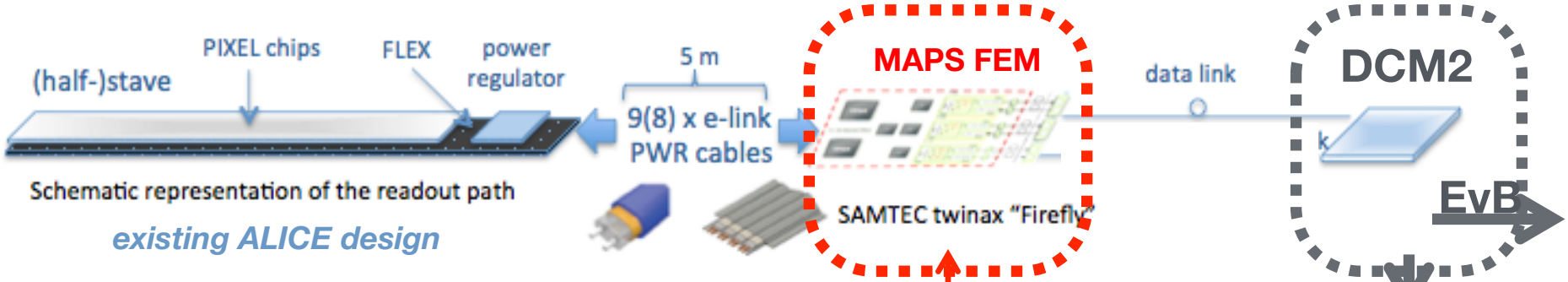
MAPS Electronics

ALICE readout path

Plan A: reprogram



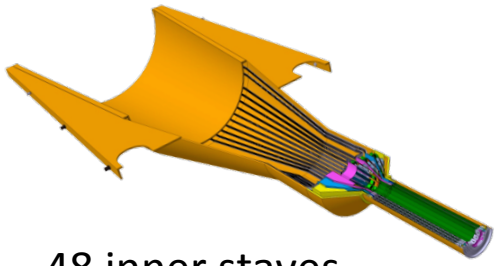
Plan B: sPHENIX readout path (held as contingency)



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

ITS IB:
Produce 120 staves in one year

120% contingency

sPHENIX: 48 +40% = 68

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**

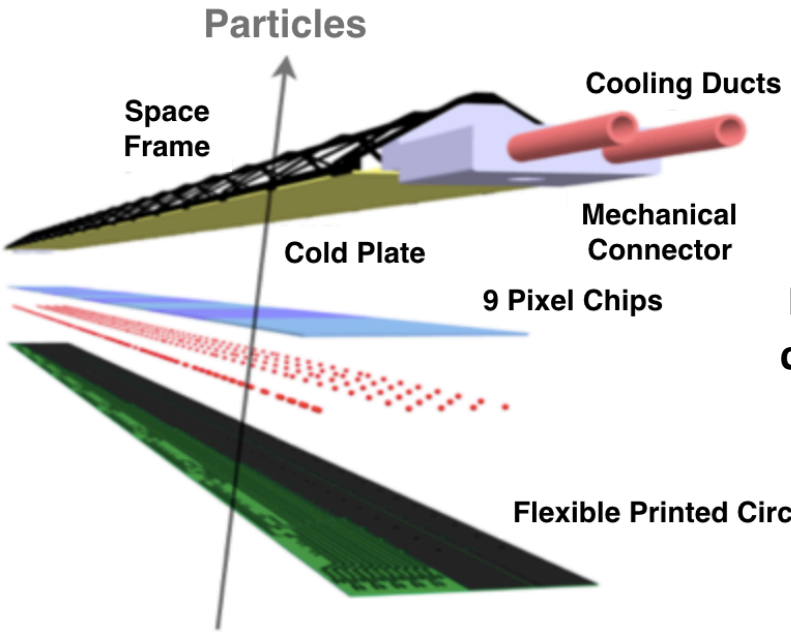
LBNL R&D expert visited LANL May 2-4th

Mike's expertise on DCM-II

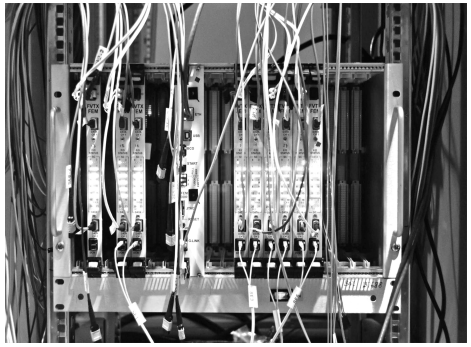
LANL R&D Deliverable: a Prototype Tracker

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

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



MAPS stave construction

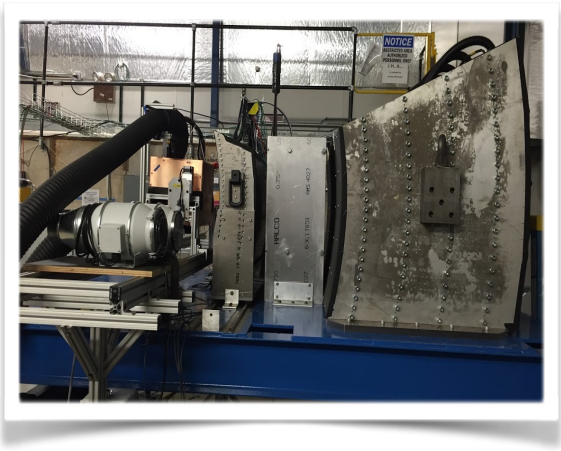


Custom front end, integrate into sPHENIX readout (FVTX expertise)

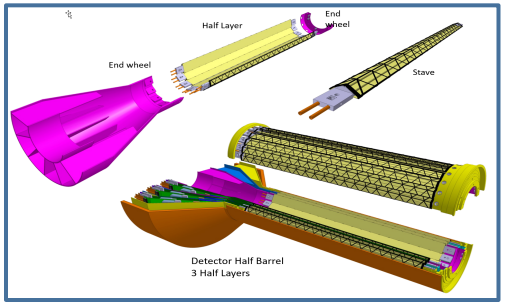
Annual Fermilab Test beam

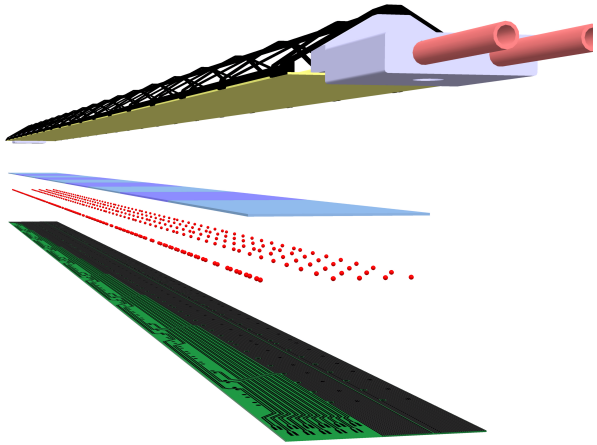
Test prototype tracker

Validate tracking and reconstruction

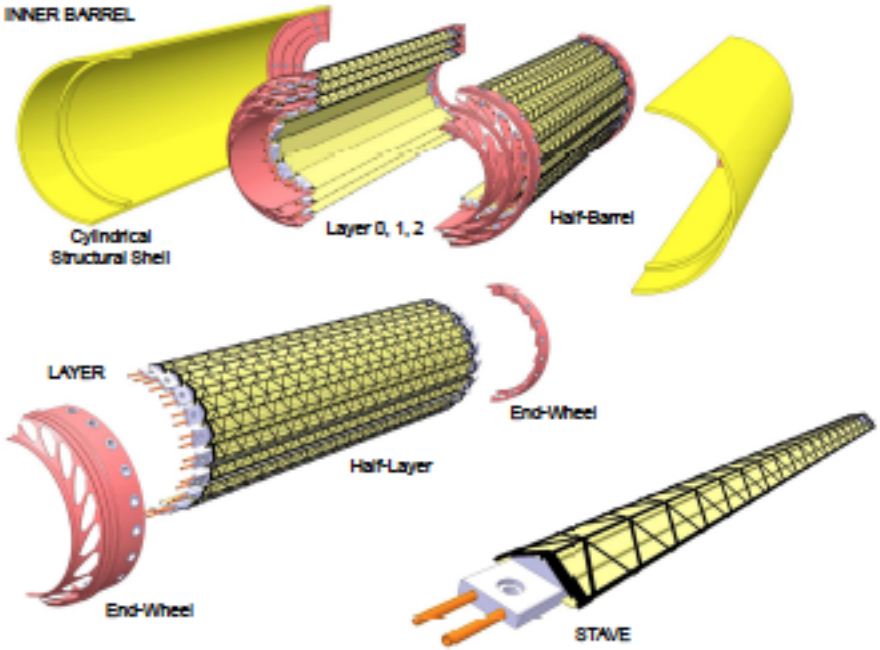


ALICE Stave and Global Support Structure Cost and Schedule Basis





ALICE Stave



(a) ITS Inner Barrel design.

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

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

Full cost recover
for CERN labor
-$500K
(cover in produc
labor cost)
"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

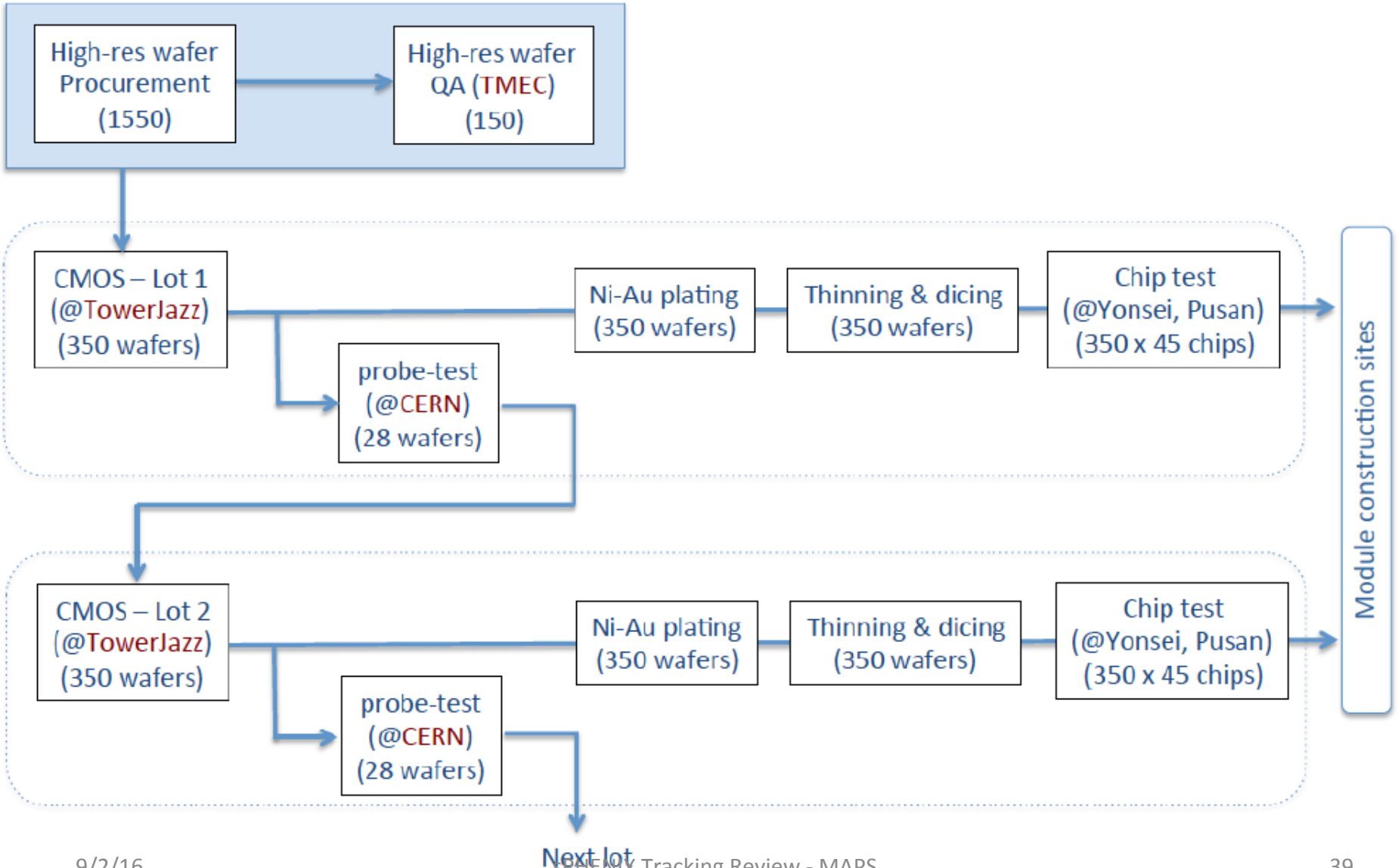
Cost breakdown

A Large Ion Collider Experiment

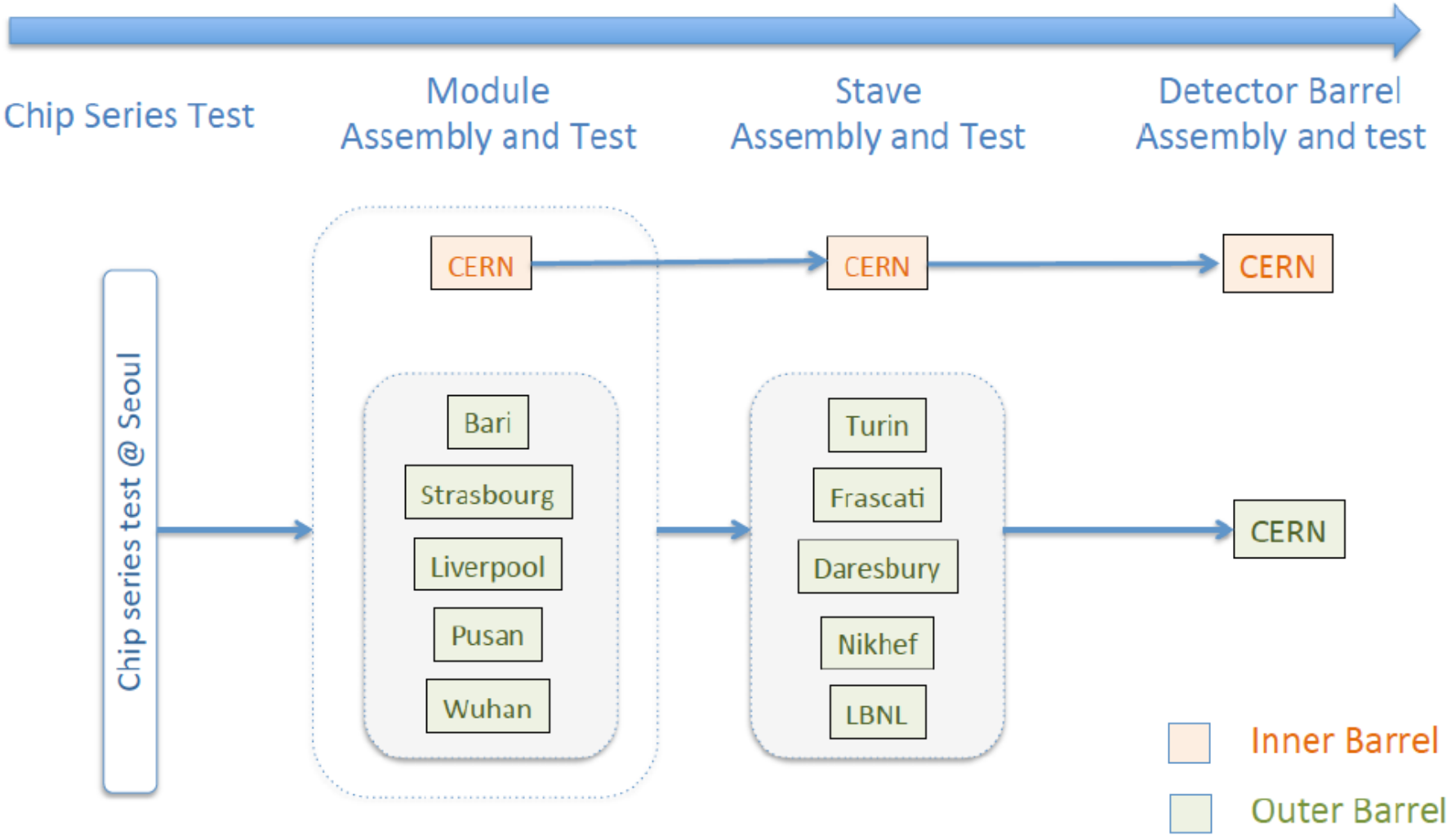
ALICE

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

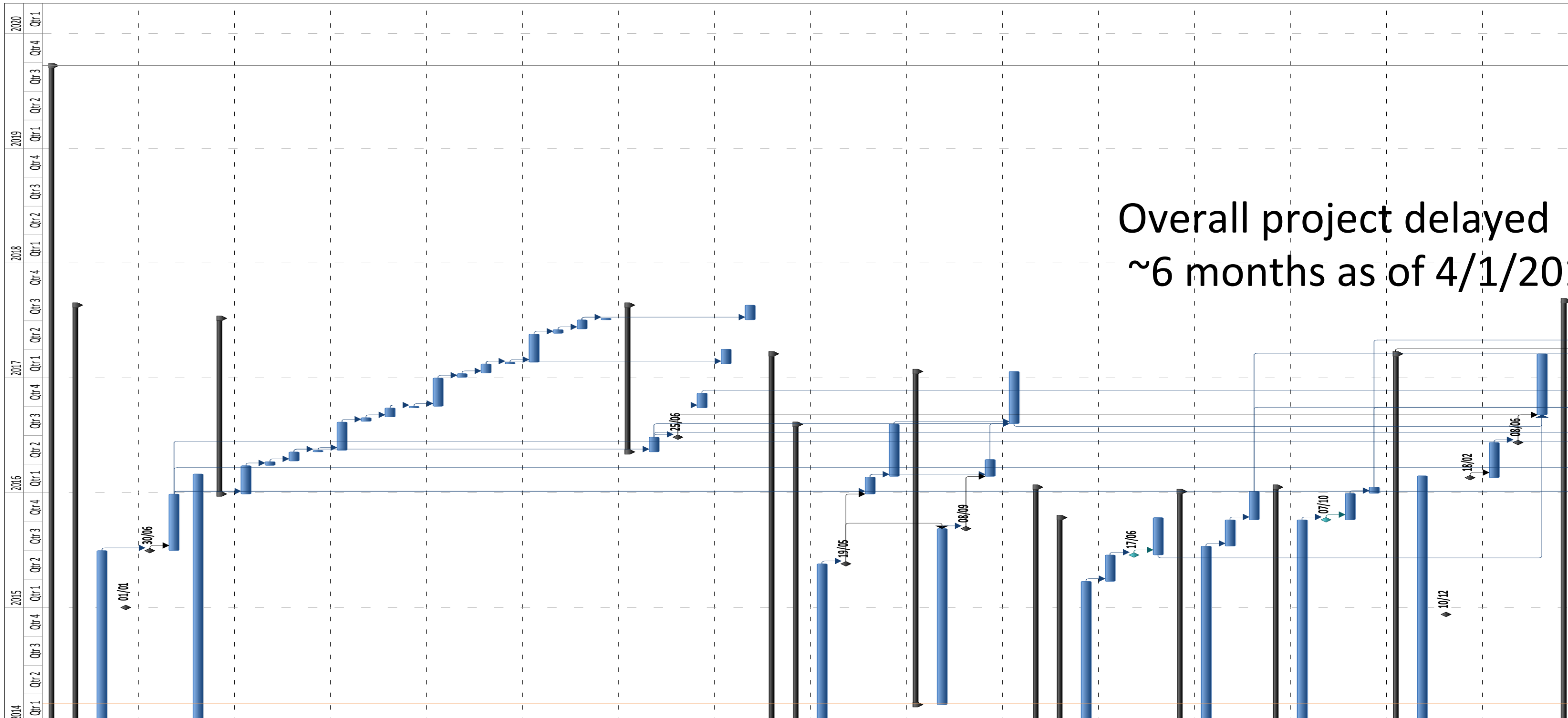
Pixel chip production flow chart



Module and Stave production flow chart



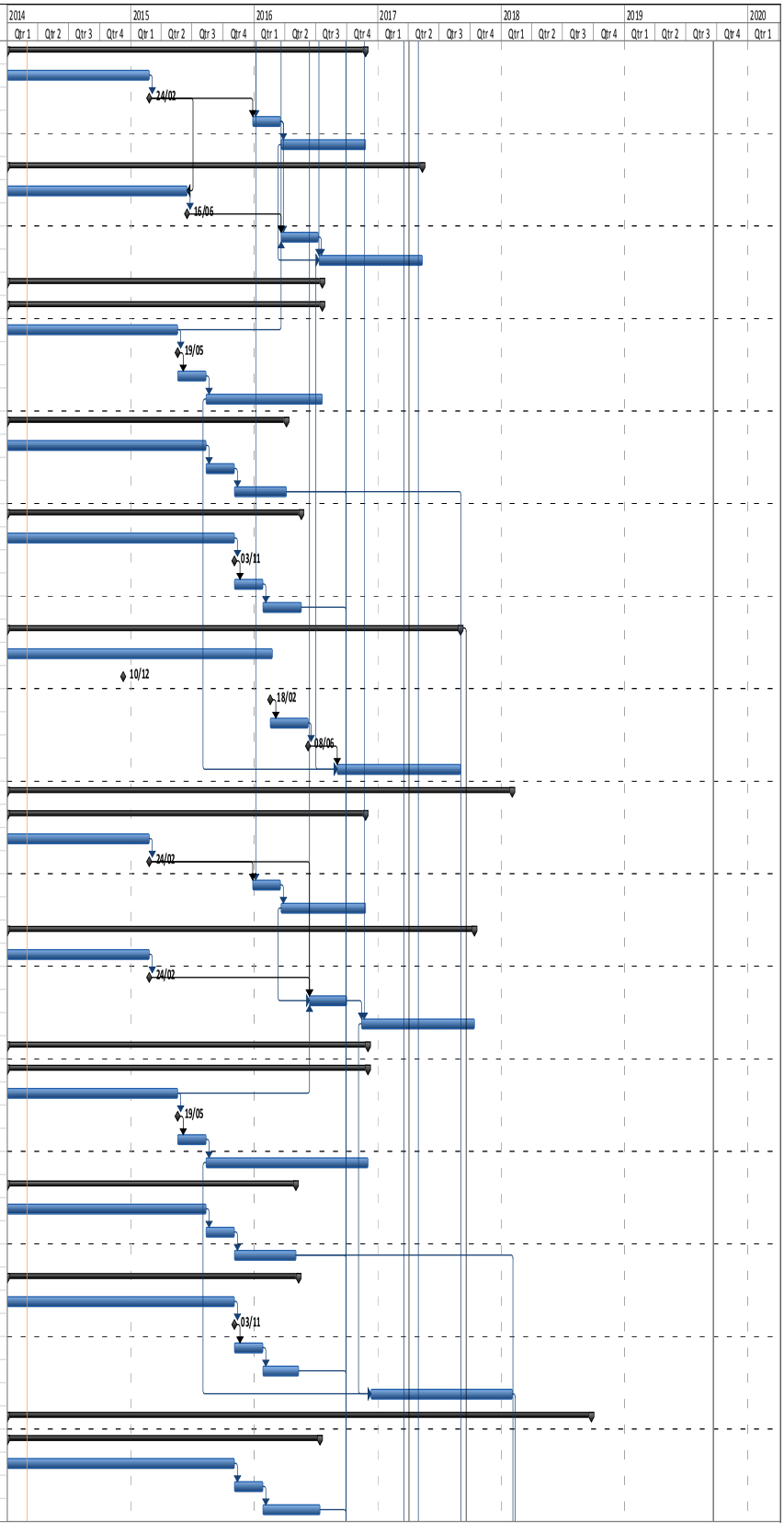
ID	WBS	Task Name	Duration	Start	Finish
1	**1**	**ITS UPGRADE**	**74.65 mons**	**Wed 01/01/14**	**Fri 20/09/19**
2	**1.1**	**Pixel Sensor**	**47.4 mons**	**Wed 01/01/14**	**Sat 19/08/17**
3	1.1.1	Design	19.5 mons	Wed 01/01/14	Tue 30/06/15
4	1.1.2	Design review and architecture selection	0 days	Thu 01/01/15	Thu 01/01/15
5	1.1.3	Production Readines Review	0 mons	Tue 30/06/15	Tue 30/06/15
6	1.1.4	Engineering Run - final design	6 emons	Wed 01/07/15	Mon 28/12/15
7	1.1.5	Characterization of prototype circuits	28.2 mons	Wed 01/01/14	Mon 29/02/16
8	**1.1.6**	**Production**	**20 mons**	**Mon 28/12/15**	**Sat 08/07/17**
9	1.1.6.1	Lot 1	90 edays	Mon 28/12/15	Sun 27/03/16
10	1.1.6.2	Wafer Post-processing Lot 1	10 days	Mon 28/03/16	Fri 08/04/16
11	1.1.6.3	Thinning&Dicing Lot 1	21 days	Mon 11/04/16	Mon 09/05/16
12	1.1.6.4	Test Lot 1	5 edays	Mon 09/05/16	Sat 14/05/16
13	1.1.6.5	Lot 2	90 edays	Sat 14/05/16	Fri 12/08/16
14	1.1.6.6	Wafer Post-processing Lot 2	10 days	Mon 15/08/16	Fri 26/08/16
15	1.1.6.7	Thinning&Dicing Lot 2	21 days	Mon 29/08/16	Mon 26/09/16
16	1.1.6.8	Test Lot 2	5 edays	Mon 26/09/16	Sat 01/10/16
17	1.1.6.9	Lot 3	90 edays	Sat 01/10/16	Fri 30/12/16
18	1.1.6.10	Wafer Post-processing Lot 3	10 days	Mon 02/01/17	Fri 13/01/17
19	1.1.6.11	Thinning&Dicing Lot 3	21 days	Mon 16/01/17	Mon 13/02/17
20	1.1.6.12	Test Lot 3	5 edays	Mon 13/02/17	Sat 18/02/17
21	1.1.6.13	Lot 4	90 edays	Sat 18/02/17	Fri 19/05/17
22	1.1.6.14	Wafer Post-processing Lot 4	10 days	Mon 22/05/17	Fri 02/06/17
23	1.1.6.15	Thinning&Dicing Lot 4	21 days	Mon 05/06/17	Mon 03/07/17
24	1.1.6.16	Test Lot 4	5 edays	Mon 03/07/17	Sat 08/07/17
25	**1.1.7**	**Pixel Chip Testing**	**16.7 mons**	**Mon 09/05/16**	**Sat 19/08/17**
26	1.1.7.1	Test Lot 1	47 edays	Mon 09/05/16	Sat 25/06/16
27	1.1.7.2	First Lot Ready for Assembly	0 mons	Sat 25/06/16	Sat 25/06/16
28	1.1.7.3	Test Lot 2	47 edays	Mon 26/09/16	Sat 12/11/16
29	1.1.7.4	Test Lot 3	47 edays	Mon 13/02/17	Sat 01/04/17
30	1.1.7.5	Test Lot 4	47 edays	Mon 03/07/17	Sat 19/08/17
31	**1.2**	**Inner Layer**	**41.9 mons**	**Wed 01/01/14**	**Fri 17/03/17**
32	**1.2.1**	**Flexible Printed Circuit (FPC)**	**33.9 mons**	**Wed 01/01/14**	**Fri 05/08/16**
33	1.2.1.1	FPC R&D	18 mons	Wed 01/01/14	Tue 19/05/15
34	1.2.1.2	FPC Final Design Review	0 mons	Tue 19/05/15	Tue 19/05/15
35	1.2.1.3	FPC - Pre-series with Final Design	2 mons	Mon 28/12/15	Fri 19/02/16
36	1.2.1.4	FPC PRODUCTION	6 mons	Mon 22/02/16	Fri 05/08/16
37	**1.2.2**	**Hybrid Integrated Circuit (HIC)**	**37.9 mons**	**Wed 26/02/14**	**Fri 20/01/17**
38	1.2.2.1	HIC R&D	20 mons	Wed 26/02/14	Tue 08/09/15
39	1.2.2.2	HIC Final Design Review	0 mons	Tue 08/09/15	Tue 08/09/15
40	1.2.2.3	HIC Final Module Building	2 mons	Mon 22/02/16	Fri 15/04/16
41	1.2.2.4	HIC Production and Test	120 days	Mon 08/08/16	Fri 20/01/17
42	**1.2.3**	**Inner Layer mechanics & Cooling**	**26.7 mons**	**Wed 01/01/14**	**Mon 18/01/16**
43	**1.2.3.1**	**Space Frame and Cold Plate**	**23.25 mons**	**Wed 01/01/14**	**Tue 13/10/15**
44	1.2.3.1.1	R&D	16 mons	Wed 01/01/14	Tue 24/03/15
45	1.2.3.1.2	Pre-Series	3 mons	Wed 25/03/15	Tue 16/06/15
46	1.2.3.1.3	Production Readiness Review	0 mons	Wed 17/06/15	Wed 17/06/15
47	1.2.3.1.4	Production & Test	85 days	Wed 17/06/15	Tue 13/10/15
48	**1.2.3.2**	**Endwheels**	**26.2 mons**	**Wed 01/01/14**	**Mon 04/01/16**
49	1.2.3.2.1	R&D	20 mons	Wed 01/01/14	Tue 14/07/15
50	1.2.3.2.2	Pre-Series	3 mons	Wed 15/07/15	Tue 06/10/15
51	1.2.3.2.3	Production & Test	64 days	Wed 07/10/15	Mon 04/01/16
52	**1.2.3.3**	**Inner Cylindrical Structural Shell**	**26.7 mons**	**Wed 01/01/14**	**Mon 18/01/16**
53	1.2.3.3.1	R&D	23 mons	Wed 01/01/14	Tue 06/10/15
54	1.2.3.3.2	Design Review	0 mons	Wed 07/10/15	Wed 07/10/15
55	1.2.3.3.3	Qualification Module	3 mons	Wed 07/10/15	Tue 29/12/15
56	1.2.3.3.4	Production & Test	14 days	Wed 30/12/15	Mon 18/01/16
57	1.2.4	Stave Assembly & test	41.9 mons	Wed 01/01/14	Fri 17/03/17
58	1.2.4.1	R&D	28 mons	Wed 01/01/14	Tue 23/02/16
59	1.2.4.2	Full-scale prototype 1	0 mons	Wed 10/12/14	Wed 10/12/14
60	1.2.4.3	Full-Scale Prototype with Final Components	0 mons	Thu 18/02/16	Thu 18/02/16
61	1.2.4.4	Final Desfin and Prototype	4 mons	Thu 18/02/16	Wed 08/06/16
62	1.2.4.5	Production Readiness Review	0 mons	Wed 08/06/16	Wed 08/06/16
63	1.2.4.6	Production and Test (120 staves)	7 mons	Mon 05/09/16	Fri 17/03/17
64	**1.3**	**Middle Layer**	**47.9 mons**	**Wed 01/01/14**	**Sat 02/09/17**



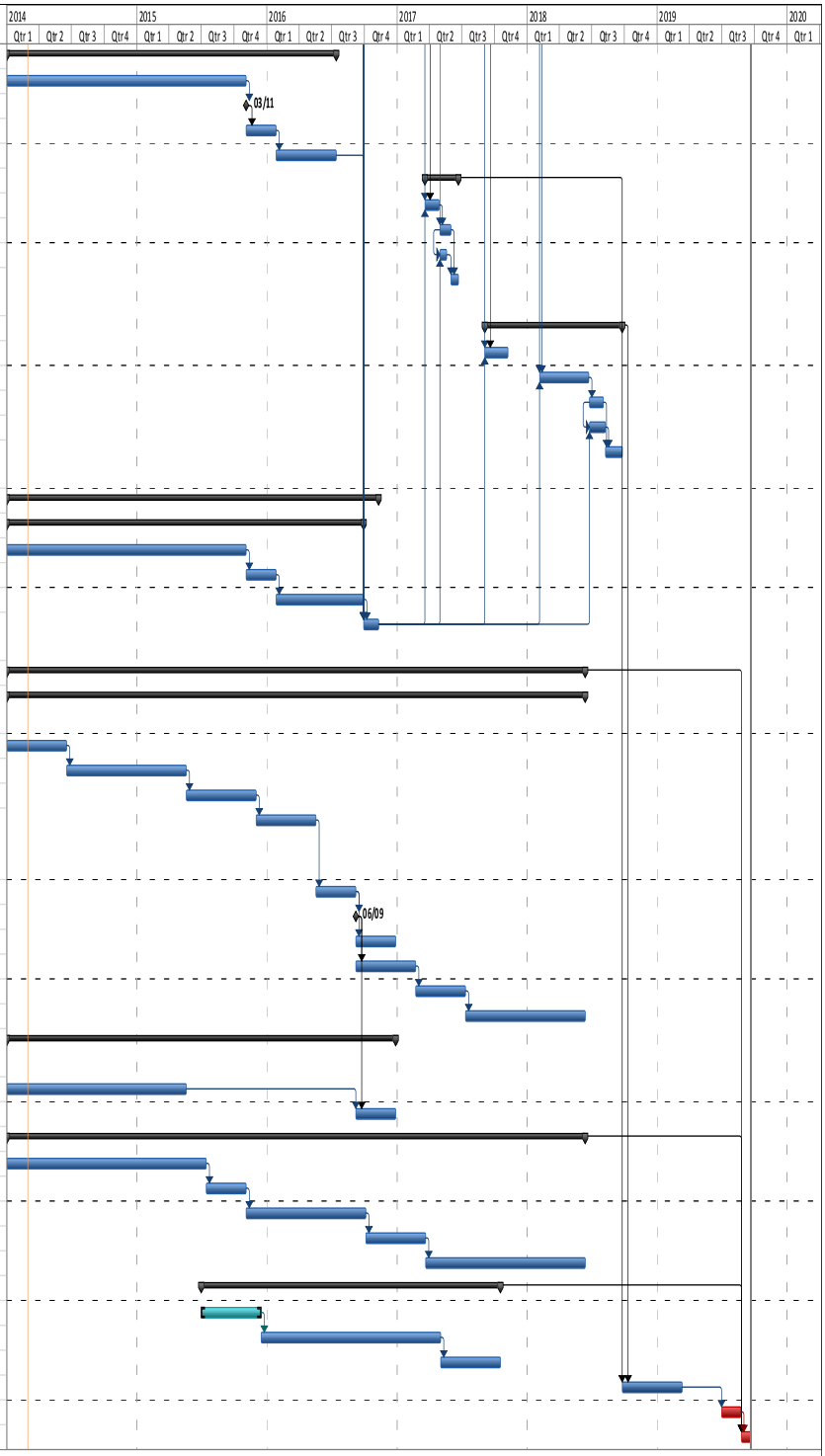
Overall project delayed ~6 months as of 4/1/2016

Page 1

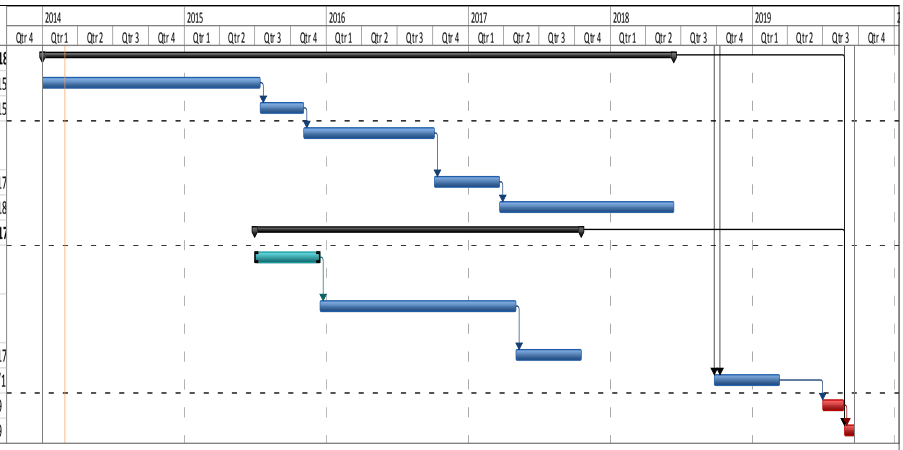
	WBS	Task Name	Duration	Start	Finish
65	**1.3.1**	**Flexible Printed Circuit (FPC)**	**37.9 mons**	**Wed 01/01/14**	**Fri 25/11/16**
66	1.3.1.1	FPC R&D	15 mons	Wed 01/01/14	Tue 24/02/15
67	1.3.1.2	Design Review	0 mons	Tue 24/02/15	Tue 24/02/15
68	1.3.1.3	FPC Pre-Series with Final Design	3 mons	Mon 28/12/15	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



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



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



Forming the Collaboration

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

- **Potential:**
  LBNL, UIC, UCR, UC Davis, 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.