MAPS Cost and Schedule Document

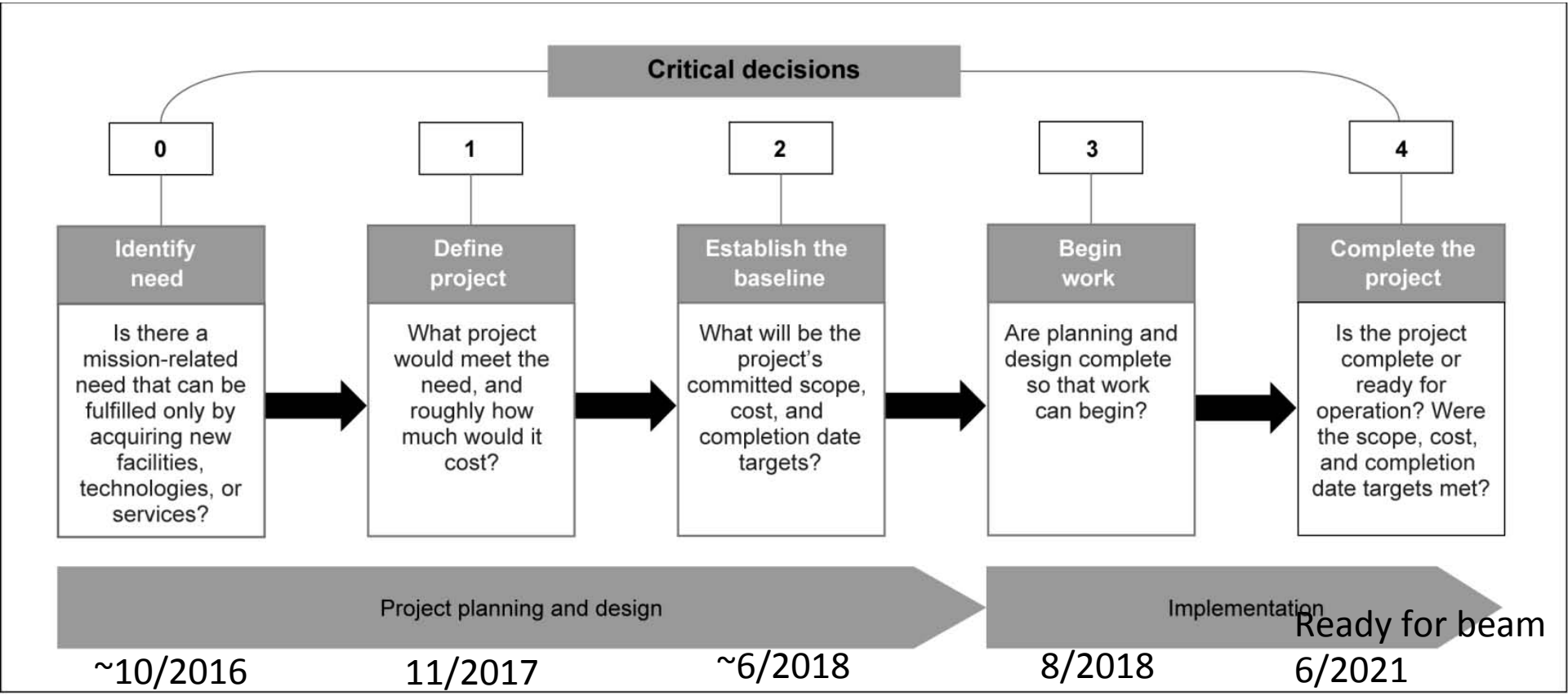
Ming Liu

LANL

Assumptions

- Copy of ALICE 3-layer MAPS Inner Tracker
- Extend ALICE ITS production
- Follow proposed sPHENIX CD process
- Critical R&D by LANL LDRD
- 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
- Duration from ALICE where available and previous FVTX/PHENIX experience
- Work in progress manpower smoothing
- Work in progress schedule contingency (MoU w/ ALICE)
- Applied 30% cost & schedule contingency

sPHENIX DOE Critical Decision Process



Subsystem dependent

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

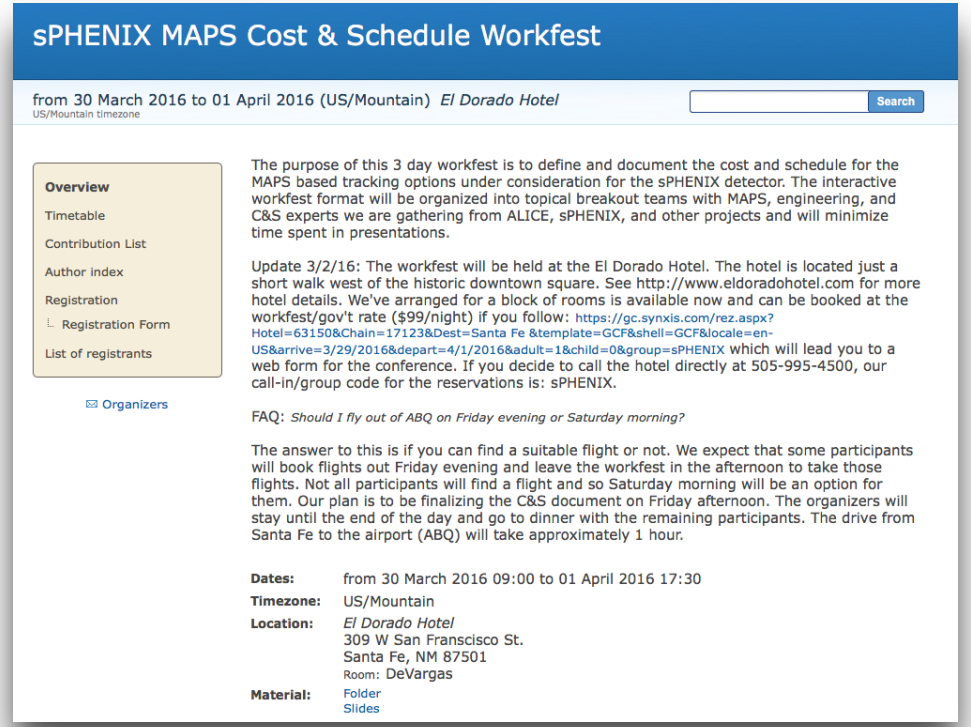
https://indico.bnl.gov/conferenceDisplay.py?confId=1741

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

Overview of the Project Schedule

Key dates:

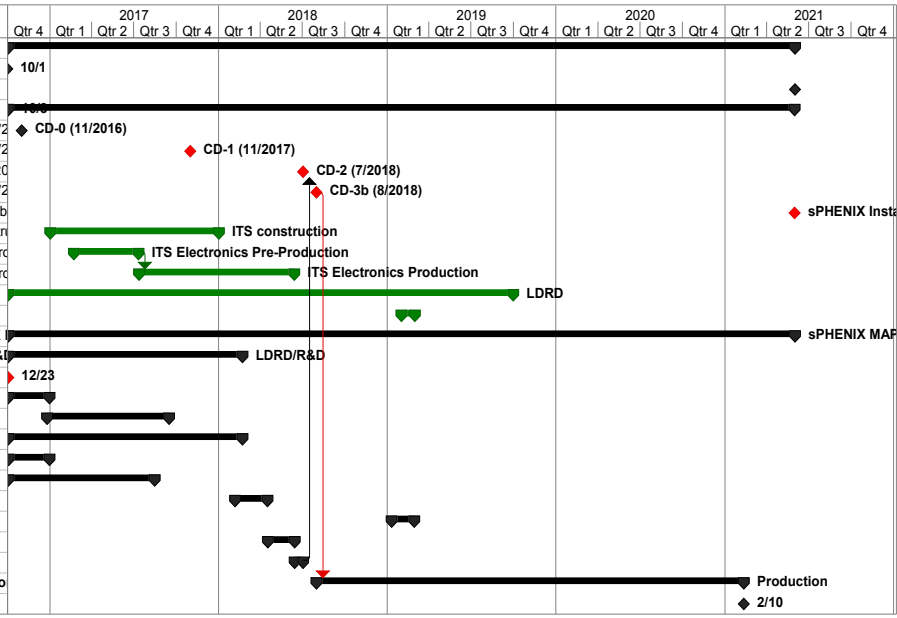
MoU btw LANL/sPHENIX and ITS/ALICE: ~12/2016
Meet CD-1: 11/2017
- MAPS Electronics R&D completed: ~3/2018
- MAPS design completed: ~8/2018

Meet CD-3b: 8/2018
- MAPS final design/CD-2: 7/2/2018

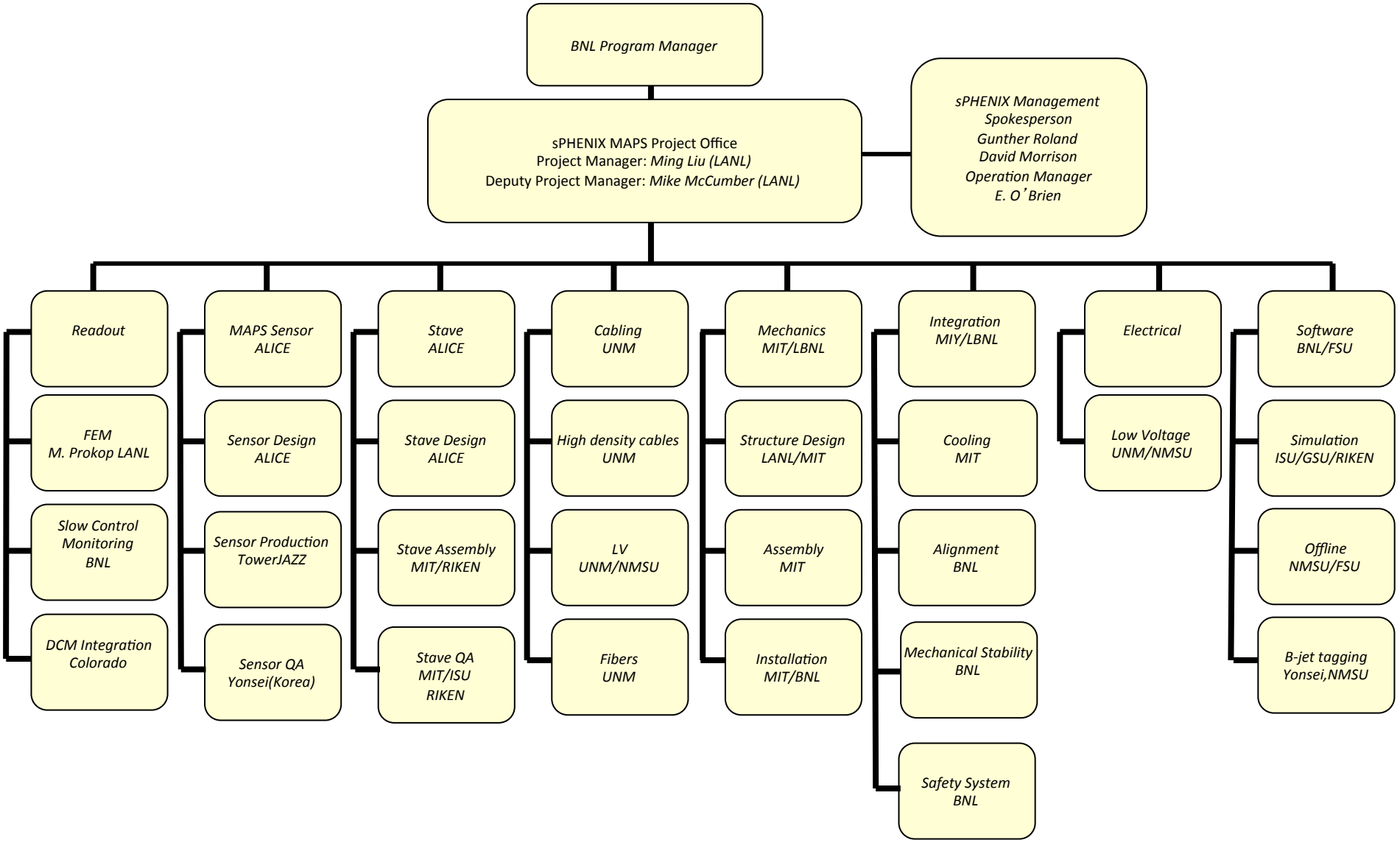
Ready for beam: 6/1/2021

Sun 8/21/16

ID	WBS	Task Name	Duration	Start	Finish	Cost Center	Fixed Cost	Cost	Text10
1	**1**	**MAPS Inner Barrel**	**1217 days**	**Mon 10/3/16**	**Tue 6/1/21**		**$0.00**	**$4,835,948.24**	
2	1.11	MAPS Inner Barrel Starts	0 days	Sat 10/1/16	Sat 10/1/16		$0.00	$0.00	
3	1.10	MAPS Inner Barrel Ends	0 days	Tue 6/1/21	Tue 6/1/21		$0.00	$0.00	
4	**1.1**	**Milestones of sPHENIX**	**1216 days**	**Mon 10/3/16**	**Tue 6/1/21**		**$0.00**	**$0.00**	
5	1.1.1	sPHENIX Technical Design CD-0	0 days	Tue 11/1/16	Tue 11/1/16		$0.00	$0.00	CD-0 (11/2
6	1.1.2	sPHENIX Technical Design (CD-1/CD-3a)	0 days	Wed 11/1/17	Wed 11/1/17		$0.00	$0.00	CD-1 (11/2
7	1.1.3	sPHENIX Technical Dewsgin (CD-2)	0 days	Mon 7/2/18	Mon 7/2/18		$0.00	$0.00	CD-2 (7/20
8	1.1.4	sPHENIX Start Construction (CD-3b)	0 days	Wed 8/1/18	Wed 8/1/18		$0.00	$0.00	CD-3b (8/2
9	1.1.5	sPHENIX Installation	0 days	Tue 6/1/21	Tue 6/1/21		$0.00	$0.00	ready for b
10	1.1.6	ALICE ITS Inner Barrel Construction	261 days	Mon 1/2/17	Mon 1/1/18		$0.00	$0.00	ITS constr
11	1.1.9	ALICE ITS Electronics Pre-Production	100 days	Wed 2/22/17	Tue 7/11/17		$0.00	$0.00	ITS Electro
12	1.1.8	ALICE ITS Electronics Production	240 days	Thu 7/13/17	Wed 6/13/18		$0.00	$0.00	ITS Electro
13	1.1.7	LANL LDRD	781 days	Mon 10/3/16	Mon 9/30/19	LDRD	$0.00	$0.00	LDRD
14	1.1.11	sPHENIX Test Beam	21 days	Fri 2/1/19	Fri 3/1/19	LDRD	$0.00	$0.00	
15	**1.2**	**Project Management**	**1217 days**	**Mon 10/3/16**	**Tue 6/1/21**		**$0.00**	**$671,784.00**	**sPHENIX I**
19	**1.3**	**Design & Prototyping**	**363 days?**	**Mon 10/3/16**	**Wed 2/21/18**	**LDRD**	**$0.00**	**$980,090.91**	**LDRD/R&D**
20	1.3.1	MOU btw LANL/sPHENIX and ALICE	60 days?	Mon 10/3/16	Fri 12/23/16	LDRD	$0.00	$0.00	
21	**1.3.2**	**Readout Test Stand**	**65 days**	**Mon 10/3/16**	**Fri 12/30/16**	**LDRD**	**$0.00**	**$45,600.00**	
25	**1.3.3**	**Detector Staves**	**190 days?**	**Mon 12/26/16**	**Fri 9/15/17**	**LDRD**	**$0.00**	**$147,000.00**	
29	**1.3.4**	**Electronics**	**363 days**	**Mon 10/3/16**	**Wed 2/21/18**	**LDRD**	**$0.00**	**$360,890.91**	
62	**1.3.5**	**Ancillaries**	**64 days**	**Tue 10/4/16**	**Fri 12/30/16**	**LDRD**	**$0.00**	**$56,200.00**	
66	**1.3.6**	**Mechanics**	**227 days**	**Mon 10/3/16**	**Tue 8/15/17**	**LDRD**	**$0.00**	**$370,400.00**	
92	**1.4**	**Prototype Assembly**	**50 days**	**Tue 2/6/18**	**Mon 4/16/18**	**LDRD**	**$0.00**	**$72,000.00**	
96	**1.5**	**Test Beam Operation**	**35 days**	**Fri 1/11/19**	**Thu 2/28/19**	**LDRD**	**$0.00**	**$30,800.00**	
100	**1.6**	**sPHENIX Mechanics Integration**	**42 days?**	**Wed 4/18/18**	**Thu 6/14/18**		**$0.00**	**$50,000.00**	
106	**1.7**	**MAPS Inner Barrel Review**	**12 days**	**Fri 6/15/18**	**Mon 7/2/18**		**$0.00**	**$28,000.00**	
110	**1.8**	**Productions**	**661 days?**	**Wed 8/1/18**	**Wed 2/10/21**		**$0.00**	**$3,003,273.33**	**Productio**
144	1.9	Ready for beam	0 days	Wed 2/10/21	Wed 2/10/21		$0.00	$0.00	



Organization Chart



Management & Collaboration

- 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
  - Establish collaboration with ALICE ITS groups
- MAPS Detector Group Kickoff Meeting 8/19/2016
  - Institutions and interest
  - resources and plan
- US institutions
  - MIT ME group
    - 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
- Other international collaborators
  - RIKEN/RBRC – readout and simulations
  - CCNU

Working on MOU with ITS/ALICE

- Initial discussion with ITS Management
- ITS/ALICE Associate members

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

MOU agreement: 12/2016

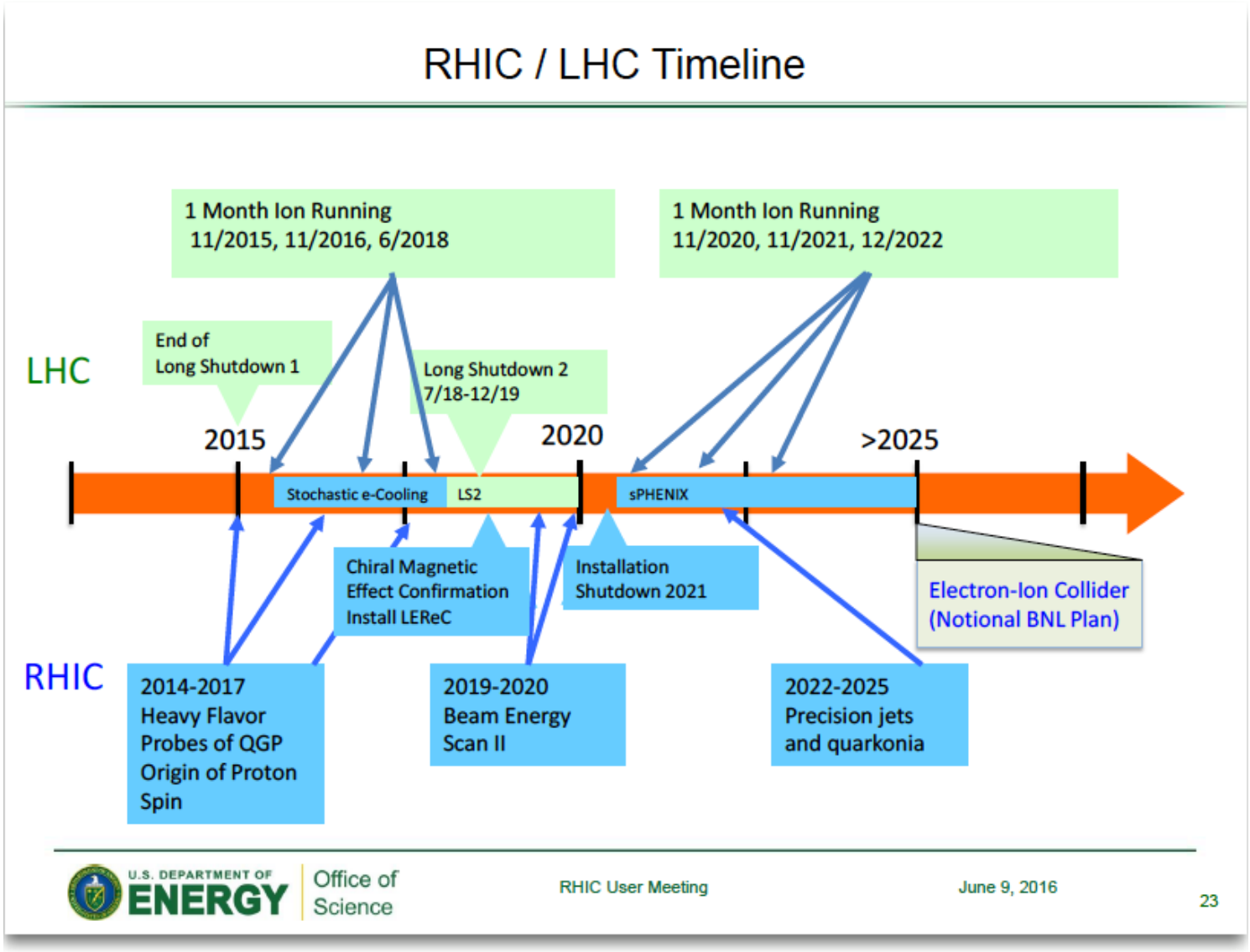
Projected Future sPHENIX Schedule

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

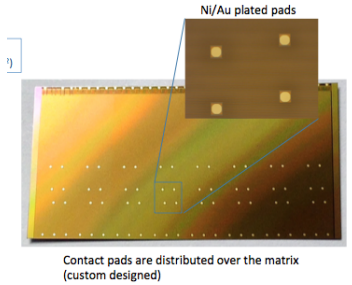
DOE's View on sPHENIX and other Long Term NP



from Tim Hallman's talk at RHIC Users' Meeting, June 2016

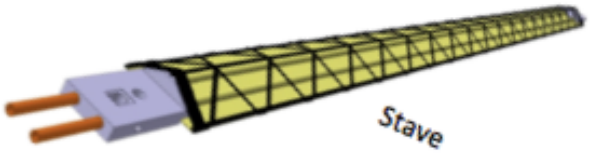
Critical R&D through LDRD

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



2x525 c

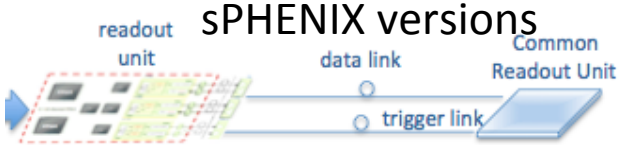
Test Beam Prototype:
4 full inner ALICE ITS Staves
ALICE readout + common readout boards
small scale power & cooling, jigs, etc



4 ct.

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

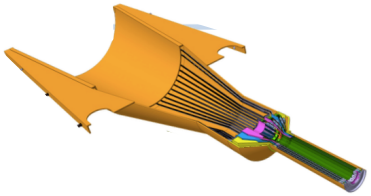
sPHENIX versions



4 ct.

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!

Open Issues

- MoU with ALICE/CERN: by 12/2016?
  - Prototype and production stave productions and delivery
  - Training sPHENIX personnel etc.
  - R&D collaboration and schedule
  - Availability of CERN facilities after ITS production

- Schedule/funding gap of stave productions
  - ITS production: ~1/2017-1/2018
  - sPHENIX CD-3b: 8/2018
  - Risk Mitigation:
    1. early training through LDRD effort, maintain activity at low level
    2. Possible mortgage sPHENIX production from ALICE/CERN, 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 R&D in collaboration with ALICE as associate members

More details

Electronics R&D (I)

Sun 8/21/16

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7	1.1.3	sPHENIX Technical Dewsgin (CD-2)	0 days	Mon 7/2/18	Mon 7/2/18		$0.00	$0.00	CD-2 (7/20
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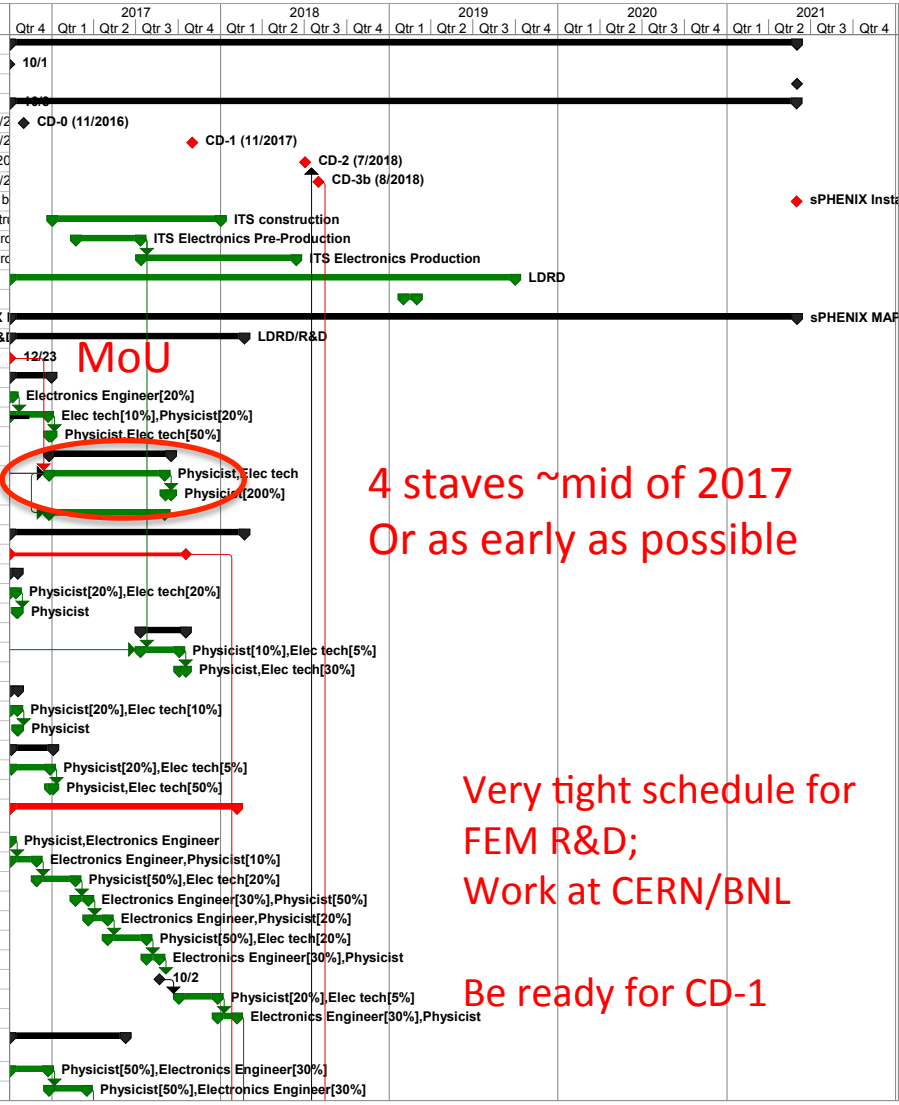
21	**1.3.2**	**Readout Test Stand**	**65 days**	**Mon 10/3/16**	**Fri 12/30/16**	**LDRD**	**$0.00**	**$45,600.00**	
22	1.3.2.1	Obtain Design from CERN	5 days	Mon 10/3/16	Fri 10/7/16	LDRD	$0.00	$2,000.00	
23	1.3.2.2	Procure 2 Test Stands	60 days	Mon 10/3/16	Fri 12/23/16	LDRD	$30,000.00	$39,600.00	
24	1.3.2.3	Setup Test Stands	5 days	Mon 12/26/16	Fri 12/30/16	LDRD	$0.00	$4,000.00	
25	**1.3.3**	**Detector Staves**	**190 days?**	**Mon 12/26/16**	**Fri 9/15/17**	**LDRD**	**$0.00**	**$147,000.00**	
26	1.3.3.1	Procure and Produce 4 Staves	180 days	Mon 12/26/16	Fri 9/1/17	LDRD	$55,000.00	$127,000.00	
27	1.3.3.2	Test Staves	10 days	Mon 9/4/17	Fri 9/15/17	LDRD	$0.00	$0.00	
28	1.3.3.3	Travel and Per Diem Support	180 days?	Mon 12/26/16	Fri 9/1/17	LDRD	$20,000.00	$20,000.00	
29	**1.3.4**	**Electronics**	**363 days**	**Mon 10/3/16**	**Wed 2/21/18**	**LDRD**	**$0.00**	**$360,890.91**	
30	**1.3.4.1**	**ALICE Readout Electronics**	**272 days**	**Mon 10/3/16**	**Tue 10/17/17**		**$0.00**	**$39,600.00**	
31	**1.3.4.1.1**	**SamTec Cables**	**12 days**	**Mon 10/3/16**	**Tue 10/18/16**		**$0.00**	**$5,200.00**	
32	1.3.4.1.1.1	Procure 7 SamTec Cables	10 days	Mon 10/3/16	Fri 10/14/16	LDRD	$2,000.00	$5,200.00	
33	1.3.4.1.1.2	Test Cables	2 days	Mon 10/17/16	Tue 10/18/16	LDRD	$0.00	$0.00	
34	**1.3.4.1.2**	**Readout Units (RDOs)**	**70 days**	**Wed 7/12/17**	**Tue 10/17/17**		**$0.00**	**$13,000.00**	
35	1.3.4.1.2.1	Procure 4 RDOs	60 days	Wed 7/12/17	Tue 10/3/17	LDRD	$5,000.00	$8,200.00	
36	1.3.4.1.2.2	Test RDOs	10 days	Wed 10/4/17	Tue 10/17/17	LDRD	$0.00	$4,800.00	
37	**1.3.4.1.3**	**Optical Cables**	**12 days**	**Tue 10/4/16**	**Wed 10/19/16**		**$0.00**	**$2,600.00**	
38	1.3.4.1.3.1	Procure 4 Optical Cables	10 days	Tue 10/4/16	Mon 10/17/16	LDRD	$1,000.00	$2,600.00	
39	1.3.4.1.3.2	Test Optical Cables	2 days	Tue 10/18/16	Wed 10/19/16	LDRD	$0.00	$0.00	
40	**1.3.4.1.4**	**Common Readout Units (CRUs)**	**65 days**	**Wed 10/5/16**	**Tue 1/3/17**		**$0.00**	**$18,800.00**	
41	1.3.4.1.4.1	Procure 2 CRUs	60 days	Wed 10/5/16	Tue 12/27/16	LDRD	$10,000.00	$14,800.00	
42	1.3.4.1.4.2	Test CRUs	5 days	Wed 12/28/16	Tue 1/3/17	LDRD	$0.00	$4,000.00	
43	**1.3.4.2**	**sPHENIX Readout Electronics Integration (FEM)**	**351 days**	**Mon 10/3/16**	**Mon 2/5/18**		**$0.00**	**$309,290.91**	
44	1.3.4.2.1	obtain ALICE Readout Unit design	1 day	Mon 10/3/16	Mon 10/3/16	LDRD	$0.00	$2,000.00	
45	1.3.4.2.2	initial design	40 days	Tue 10/4/16	Mon 11/28/16	LDRD	$0.00	$40,000.00	
46	1.3.4.2.3	prototype	60 days	Tue 11/29/16	Mon 2/20/17	LDRD	$5,000.00	$24,200.00	
47	1.3.4.2.4	test-I	20 days	Tue 2/21/17	Mon 3/20/17	LDRD	$0.00	$2,545.45	
48	1.3.4.2.5	revised design	30 days	Tue 3/21/17	Mon 5/1/17	LDRD	$0.00	$30,000.00	
49	1.3.4.2.6	prototype	60 days	Tue 5/2/17	Mon 7/24/17	LDRD	$5,000.00	$24,200.00	
50	1.3.4.2.7	test-II	20 days	Tue 7/25/17	Mon 8/21/17	LDRD	$0.00	$2,545.45	
51	1.3.4.2.8	final design	30 days	Tue 8/22/17	Mon 10/2/17	LDRD	$0.00	$30,000.00	
52	1.3.4.2.9	Procure 4 FEMs	60 days	Tue 10/3/17	Mon 12/25/17	LDRD	$20,000.00	$24,800.00	
53	1.3.4.2.10	System Test	30 days	Tue 12/26/17	Mon 2/5/18	LDRD	$0.00	$6,000.00	
54	**1.3.4.2.11**	**sPHENIX DAQ System Integration**	**180 days**	**Mon 10/3/16**	**Fri 6/9/17**		**$0.00**	**$123,000.00**	
55	1.3.4.2.11.4	Slow Control Design	60 days	Mon 10/3/16	Fri 12/23/16	LDRD	$5,000.00	$41,000.00	
56	1.3.4.2.11.5	Trigger Interface Design	60 days	Mon 12/26/16	Fri 3/17/17	LDRD	$5,000.00	$41,000.00	



4 staves ~mid of 2017
Or as early as possible

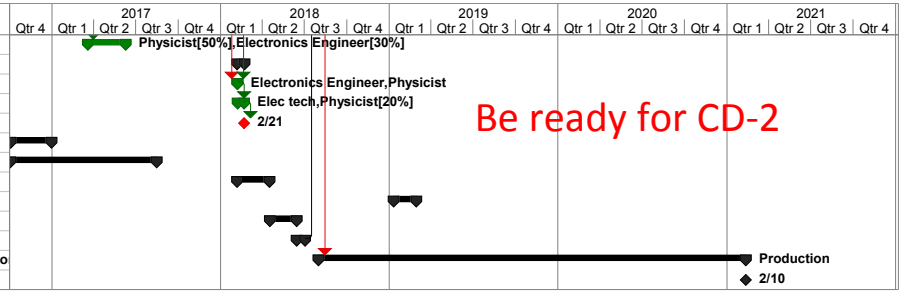
Very tight schedule for FEM R&D;
Work at CERN/BNL

Be ready for CD-1

Electronics R&D (II)

Sun 8/21/16

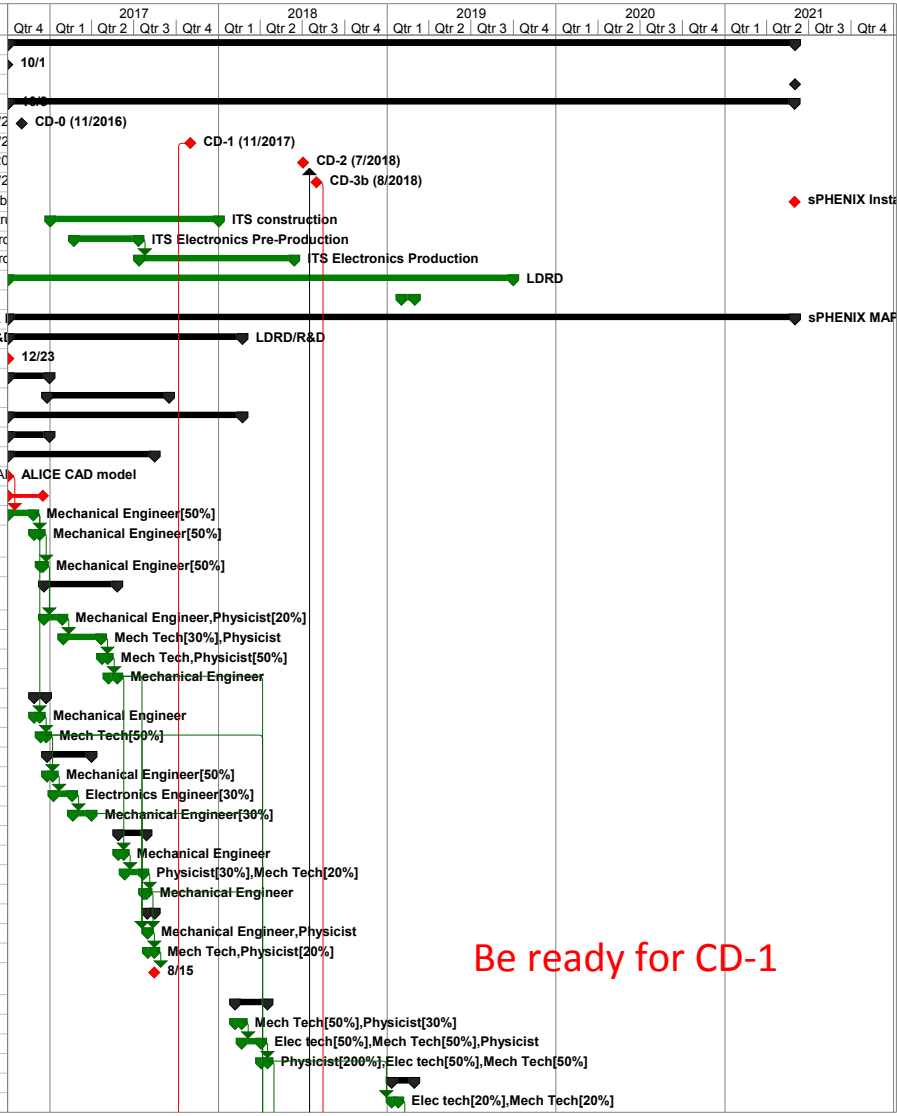
ID	WBS	Task Name	Duration	Start	Finish	Cost Center	Fixed Cost	Cost	Text10
57	1.3.4.2.11.6	DAQ Interface Design	60 days	Mon 3/20/17	Fri 6/9/17	LDRD	$5,000.00	$41,000.00	
58	**1.3.4.4**	**Electronics Final Design Review**	**12 days**	**Tue 2/6/18**	**Wed 2/21/18**		**$0.00**	**$12,000.00**	
59	1.3.4.4.1	Electronics Design Review	1 day	Tue 2/6/18	Tue 2/6/18	LDRD	$0.00	$2,000.00	
60	1.3.4.4.2	Incorporate Review Comments	10 days	Wed 2/7/18	Tue 2/20/18	LDRD	$0.00	$8,000.00	
61	1.3.4.4.3	Complete Final Electronics Design	1 day	Wed 2/21/18	Wed 2/21/18	LDRD	$0.00	$2,000.00	
62	**1.3.5**	**Ancillaries**	**64 days**	**Tue 10/4/16**	**Fri 12/30/16**	**LDRD**	**$0.00**	**$56,200.00**	
66	**1.3.6**	**Mechanics**	**227 days**	**Mon 10/3/16**	**Tue 8/15/17**	**LDRD**	**$0.00**	**$370,400.00**	
92	**1.4**	**Prototype Assembly**	**50 days**	**Tue 2/6/18**	**Mon 4/16/18**	**LDRD**	**$0.00**	**$72,000.00**	
96	**1.5**	**Test Beam Operation**	**35 days**	**Fri 1/11/19**	**Thu 2/28/19**	**LDRD**	**$0.00**	**$30,800.00**	
100	**1.6**	**sPHENIX Mechanics Integration**	**42 days?**	**Wed 4/18/18**	**Thu 6/14/18**		**$0.00**	**$50,000.00**	
106	**1.7**	**MAPS Inner Barrel Review**	**12 days**	**Fri 6/15/18**	**Mon 7/2/18**		**$0.00**	**$28,000.00**	
110	**1.8**	**Productions**	**661 days?**	**Wed 8/1/18**	**Wed 2/10/21**		**$0.00**	**$3,003,273.33**	**Productio**
144	1.9	Ready for beam	0 days	Wed 2/10/21	Wed 2/10/21		$0.00	$0.00	



Mechanics R&D (I)

Sun 8/21/16

ID	WBS	Task Name	Duration	Start	Finish	Cost Center	Fixed Cost	Cost	Text10
1	**1**	**MAPS Inner Barrel**	**1217 days**	**Mon 10/3/16**	**Tue 6/1/21**		**$0.00**	**$4,835,948.24**	
2	1.11	MAPS Inner Barrel Starts	0 days	Sat 10/1/16	Sat 10/1/16		$0.00	$0.00	
3	1.10	MAPS Inner Barrel Ends	0 days	Tue 6/1/21	Tue 6/1/21		$0.00	$0.00	
4	**1.1**	**Milestones of sPHENIX**	**1216 days**	**Mon 10/3/16**	**Tue 6/1/21**		**$0.00**	**$0.00**	
5	1.1.1	sPHENIX Technical Design CD-0	0 days	Tue 11/1/16	Tue 11/1/16		$0.00	$0.00	CD-0 (11/2
6	1.1.2	sPHENIX Technical Design (CD-1/CD-3a)	0 days	Wed 11/1/17	Wed 11/1/17		$0.00	$0.00	CD-1 (11/2
7	1.1.3	sPHENIX Technical Dewsgin (CD-2)	0 days	Mon 7/2/18	Mon 7/2/18		$0.00	$0.00	CD-2 (7/20
8	1.1.4	sPHENIX Start Construction (CD-3b)	0 days	Wed 8/1/18	Wed 8/1/18		$0.00	$0.00	CD-3b (8/2
9	1.1.5	sPHENIX Installation	0 days	Tue 6/1/21	Tue 6/1/21		$0.00	$0.00	ready for b
10	1.1.6	ALICE ITS Inner Barrel Construction	261 days	Mon 1/2/17	Mon 1/1/18		$0.00	$0.00	ITS constr
11	1.1.9	ALICE ITS Electronics Pre-Production	100 days	Wed 2/22/17	Tue 7/11/17		$0.00	$0.00	ITS Electro
12	1.1.8	ALICE ITS Electronics Production	240 days	Thu 7/13/17	Wed 6/13/18		$0.00	$0.00	ITS Electro
13	1.1.7	LANL LDRD	781 days	Mon 10/3/16	Mon 9/30/19	LDRD	$0.00	$0.00	LDRD
14	1.1.11	sPHENIX Test Beam	21 days	Fri 2/1/19	Fri 3/1/19	LDRD	$0.00	$0.00	
15	**1.2**	**Project Management**	**1217 days**	**Mon 10/3/16**	**Tue 6/1/21**		**$0.00**	**$671,784.00**	sPHENIX I
19	**1.3**	**Design & Prototyping**	**363 days?**	**Mon 10/3/16**	**Wed 2/21/18**	**LDRD**	**$0.00**	**$980,090.91**	LDRD/R&D
20	1.3.1	MOU btw LANL/sPHENIX and ALICE	60 days?	Mon 10/3/16	Fri 12/23/16	LDRD	$0.00	$0.00	
21	**1.3.2**	**Readout Test Stand**	**65 days**	**Mon 10/3/16**	**Fri 12/30/16**	**LDRD**	**$0.00**	**$45,600.00**	
25	**1.3.3**	**Detector Staves**	**190 days?**	**Mon 12/26/16**	**Fri 9/15/17**	**LDRD**	**$0.00**	**$147,000.00**	
29	**1.3.4**	**Electronics**	**363 days**	**Mon 10/3/16**	**Wed 2/21/18**	**LDRD**	**$0.00**	**$360,890.91**	
62	**1.3.5**	**Ancillaries**	**64 days**	**Tue 10/4/16**	**Fri 12/30/16**	**LDRD**	**$0.00**	**$56,200.00**	
66	**1.3.6**	**Mechanics**	**227 days**	**Mon 10/3/16**	**Tue 8/15/17**	**LDRD**	**$0.00**	**$370,400.00**	
67	1.3.6.1	obtain ALICE CAD model	0 days	Mon 10/3/16	Mon 10/3/16	LDRD	$0.00	$0.00	ALICE CAI
68	**1.3.6.2**	Specifications	**55 days**	**Mon 10/3/16**	**Fri 12/16/16**		**$0.00**	**$55,000.00**	
69	1.3.6.2.1	review heat load	40 days	Mon 10/3/16	Fri 11/25/16	LDRD	$0.00	$40,000.00	
70	1.3.6.2.2	review mechanical tolerances/distortions	10 days	Mon 11/28/16	Fri 12/9/16	LDRD	$0.00	$10,000.00	
71	1.3.6.2.3	review disassembly/repair options	5 days	Mon 12/12/16	Fri 12/16/16	LDRD	$0.00	$5,000.00	
72	**1.3.6.3**	Stave Support Frame & Global Interface to sPHENIX	**115 days**	**Mon 12/19/16**	**Fri 5/26/17**		**$0.00**	**$159,800.00**	
73	1.3.6.3.1	initial design	30 days	Mon 12/19/16	Fri 1/27/17	LDRD	$0.00	$60,000.00	
74	1.3.6.3.2	prototype	60 days	Mon 1/30/17	Fri 4/21/17	LDRD	$25,000.00	$53,800.00	
75	1.3.6.3.3	test	10 days	Mon 4/24/17	Fri 5/5/17	LDRD	$0.00	$16,000.00	
76	1.3.6.3.4	final design	15 days	Mon 5/8/17	Fri 5/26/17	LDRD	$0.00	$30,000.00	
77	**1.3.6.4**	**Cooling System**	**20 days**	**Mon 11/28/16**	**Fri 12/23/16**		**$0.00**	**$38,000.00**	
78	1.3.6.4.1	Design	10 days	Mon 11/28/16	Fri 12/9/16	LDRD	$0.00	$20,000.00	
79	1.3.6.4.2	Mock up Testing	10 days	Mon 12/12/16	Fri 12/23/16	LDRD	$10,000.00	$18,000.00	
80	**1.3.6.5**	**Safety Systems**	**70 days**	**Mon 12/26/16**	**Fri 3/31/17**		**$0.00**	**$56,000.00**	
81	1.3.6.5.1	review sensors & interlocks	10 days	Mon 12/26/16	Fri 1/6/17	LDRD	$0.00	$10,000.00	
82	1.3.6.5.2	electrical interlock design	30 days	Mon 1/9/17	Fri 2/17/17	LDRD	$5,000.00	$23,000.00	
83	1.3.6.5.3	cooling interlocks design	30 days	Mon 2/20/17	Fri 3/31/17	LDRD	$5,000.00	$23,000.00	
84	**1.3.6.6**	**Stave Assembly Tooling**	**45 days**	**Mon 5/29/17**	**Fri 7/28/17**		**$0.00**	**$41,600.00**	
85	1.3.6.6.1	design	10 days	Mon 5/29/17	Fri 6/9/17	LDRD	$0.00	$20,000.00	
86	1.3.6.6.2	prototype	30 days	Mon 6/12/17	Fri 7/21/17	LDRD	$2,000.00	$11,600.00	
87	1.3.6.6.3	final design	5 days	Mon 7/24/17	Fri 7/28/17	LDRD	$0.00	$10,000.00	
88	**1.3.6.7**	Mechanics Coneptual Design Review	**12 days**	**Mon 7/31/17**	**Tue 8/15/17**		**$0.00**	**$20,000.00**	
89	1.3.6.7.1	Mechanics Design Review	1 day	Mon 7/31/17	Mon 7/31/17	LDRD	$0.00	$2,000.00	
90	1.3.6.7.2	Incorporate Review Comments	10 days	Tue 8/1/17	Mon 8/14/17	LDRD	$0.00	$16,000.00	
91	1.3.6.7.3	Complete Initall Mechanical Design (for CD-1)	1 day	Tue 8/15/17	Tue 8/15/17	LDRD	$0.00	$2,000.00	
92	**1.4**	**Prototype Assembly**	**50 days**	**Tue 2/6/18**	**Mon 4/16/18**	**LDRD**	**$0.00**	**$72,000.00**	
93	1.4.1	Stave Framing Design	10 days	Tue 2/6/18	Mon 2/19/18	LDRD	$0.00	$8,000.00	
94	1.4.2	Assemble prototype	30 days	Tue 2/20/18	Mon 4/2/18	LDRD	$0.00	$48,000.00	
95	1.4.3	Prototype Full System Test	10 days	Tue 4/3/18	Mon 4/16/18	LDRD	$0.00	$16,000.00	
96	**1.5**	**Test Beam Operation**	**35 days**	**Fri 1/11/19**	**Thu 2/28/19**	**LDRD**	**$0.00**	**$30,800.00**	
97	1.5.1	Shipping/Transport	10 days	Fri 1/11/19	Thu 1/24/19	LDRD	$10,000.00	$13,733.33	

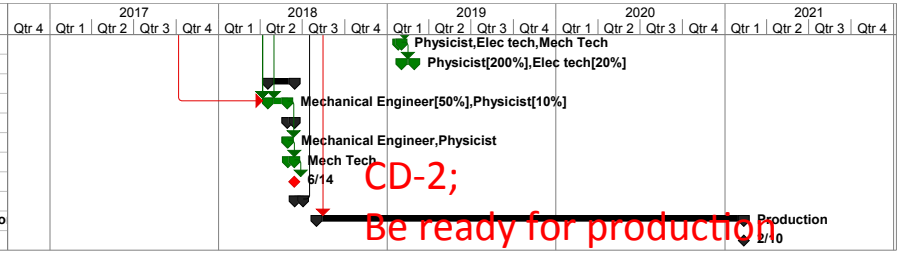


Be ready for CD-1

Mechanics R&D (II)

Sun 8/21/16

ID	WBS	Task Name	Duration	Start	Finish	Cost Center	Fixed Cost	Cost	Text10
98	1.5.2	Setup	5 days	Fri 1/25/19	Thu 1/31/19	LDRD	$0.00	$10,666.67	
99	1.5.3	Operations	20 days	Fri 2/1/19	Thu 2/28/19	LDRD	$0.00	$6,400.00	
100	**1.6**	**sPHENIX Mechanics Integration**	**42 days?**	**Wed 4/18/18**	**Thu 6/14/18**		**$0.00**	**$50,000.00**	
101	1.6.1	Final Mechanics Desgin	30 days?	Wed 4/18/18	Tue 5/29/18	LDRD	$0.00	$30,000.00	
102	**1.6.2**	Mechanics Final Design Review	**12 days**	**Wed 5/30/18**	**Thu 6/14/18**		**$0.00**	**$20,000.00**	
103	1.6.2.4	Mechanics Final Design Review	1 day	Wed 5/30/18	Wed 5/30/18	LDRD	$0.00	$2,000.00	
104	1.6.2.5	Incorporate Review Comments	10 days	Thu 5/31/18	Wed 6/13/18	LDRD	$0.00	$16,000.00	
105	1.6.2.6	Complete Final Mechanical Design	1 day	Thu 6/14/18	Thu 6/14/18	LDRD	$0.00	$2,000.00	
106	**1.7**	**MAPS Inner Barrel Review**	**12 days**	**Fri 6/15/18**	**Mon 7/2/18**		**$0.00**	**$28,000.00**	
110	**1.8**	**Productions**	**661 days?**	**Wed 8/1/18**	**Wed 2/10/21**		**$0.00**	**$3,003,273.33**	Productio
144	1.9	Ready for beam	0 days	Wed 2/10/21	Wed 2/10/21		$0.00	$0.00	

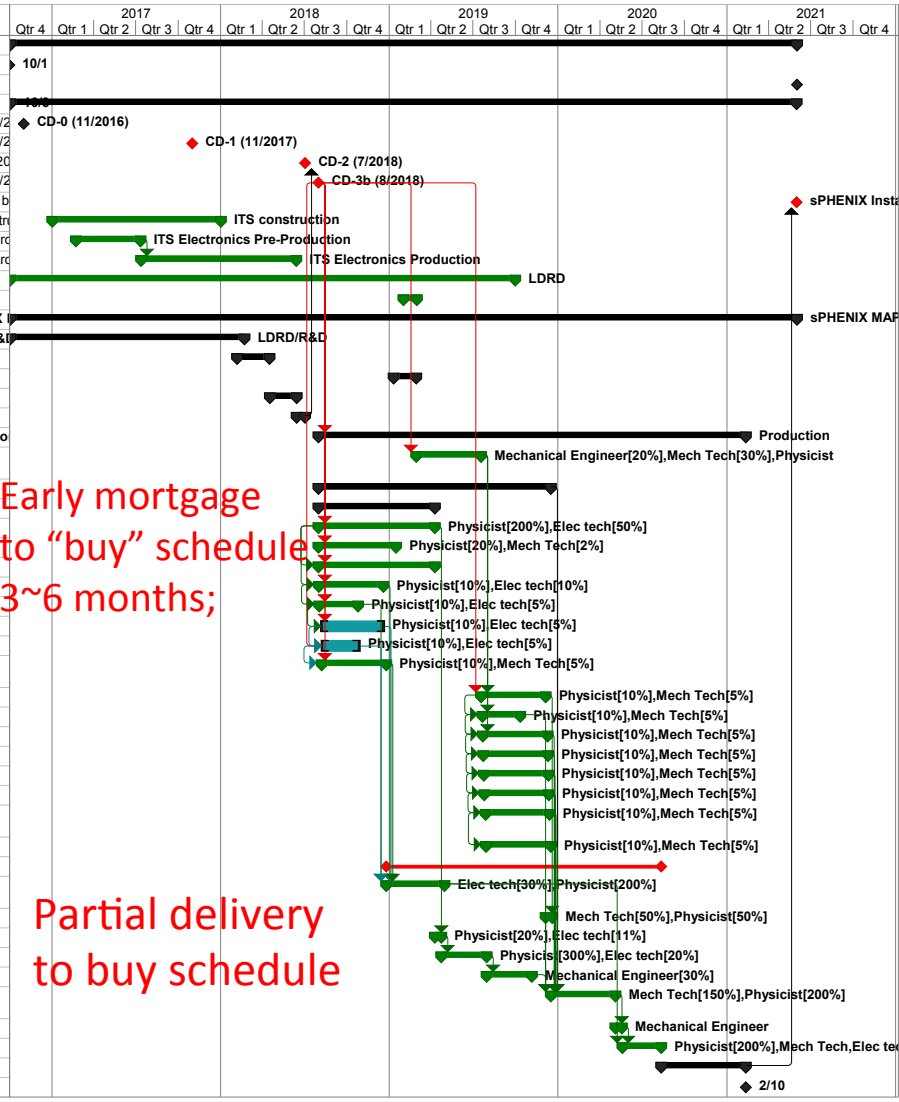


CD-2;
Be ready for production w/CD-3b

Production & Assembly

Sun 8/21/16

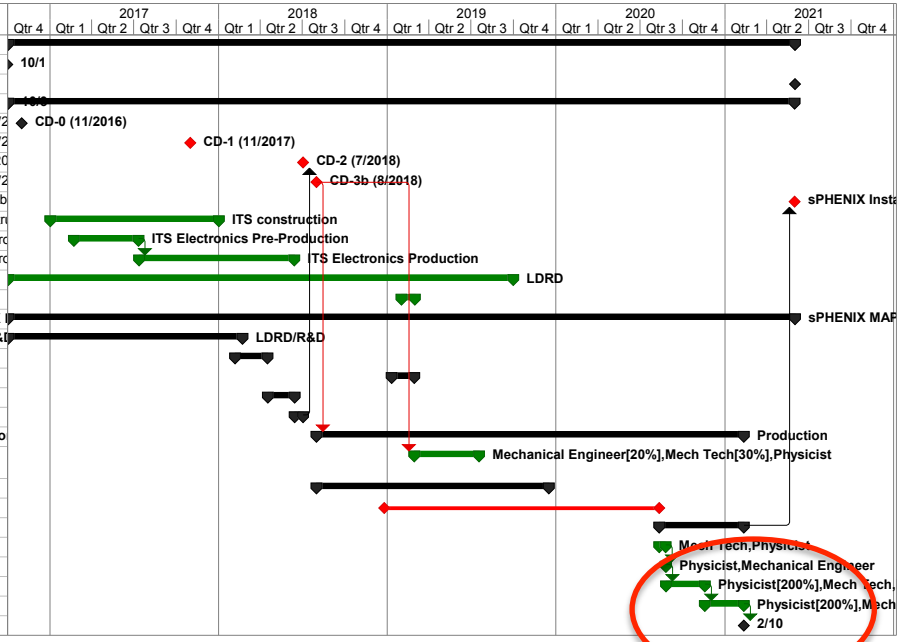
ID	WBS	Task Name	Duration	Start	Finish	Cost Center	Fixed Cost	Cost	Text10
1	**1**	**MAPS Inner Barrel**	**1217 days**	**Mon 10/3/16**	**Tue 6/1/21**		**$0.00**	**$4,835,948.24**	
2	1.11	MAPS Inner Barrel Starts	0 days	Sat 10/1/16	Sat 10/1/16		$0.00	$0.00	
3	1.10	MAPS Inner Barrel Ends	0 days	Tue 6/1/21	Tue 6/1/21		$0.00	$0.00	
4	**1.1**	**Milestones of sPHENIX**	**1216 days**	**Mon 10/3/16**	**Tue 6/1/21**		**$0.00**	**$0.00**	
5	1.1.1	sPHENIX Technical Design CD-0	0 days	Tue 11/1/16	Tue 11/1/16		$0.00	$0.00	CD-0 (11/2
6	1.1.2	sPHENIX Technical Design (CD-1/CD-3a)	0 days	Wed 11/1/17	Wed 11/1/17		$0.00	$0.00	CD-1 (11/2
7	1.1.3	sPHENIX Technical Dewsgin (CD-2)	0 days	Mon 7/2/18	Mon 7/2/18		$0.00	$0.00	CD-2 (7/20
8	1.1.4	sPHENIX Start Construction (CD-3b)	0 days	Wed 8/1/18	Wed 8/1/18		$0.00	$0.00	CD-3b (8/2
9	1.1.5	sPHENIX Installation	0 days	Tue 6/1/21	Tue 6/1/21		$0.00	$0.00	ready for b
10	1.1.6	ALICE ITS Inner Barrel Construction	261 days	Mon 1/2/17	Mon 1/1/18		$0.00	$0.00	ITS constr
11	1.1.9	ALICE ITS Electronics Pre-Production	100 days	Wed 2/22/17	Tue 7/11/17		$0.00	$0.00	ITS Electro
12	1.1.8	ALICE ITS Electronics Production	240 days	Thu 7/13/17	Wed 6/13/18		$0.00	$0.00	ITS Electro
13	1.1.7	LANL LDRD	781 days	Mon 10/3/16	Mon 9/30/19	LDRD	$0.00	$0.00	LDRD
14	1.1.11	sPHENIX Test Beam	21 days	Fri 2/1/19	Fri 3/1/19	LDRD	$0.00	$0.00	
15	**1.2**	**Project Management**	**1217 days**	**Mon 10/3/16**	**Tue 6/1/21**		**$0.00**	**$671,784.00**	sPHENIX I
19	**1.3**	**Design & Prototyping**	**363 days?**	**Mon 10/3/16**	**Wed 2/21/18**	**LDRD**	**$0.00**	**$980,090.91**	LDRD/R&D
92	**1.4**	**Prototype Assembly**	**50 days**	**Tue 2/6/18**	**Mon 4/16/18**	**LDRD**	**$0.00**	**$72,000.00**	
96	**1.5**	**Test Beam Operation**	**35 days**	**Fri 1/11/19**	**Thu 2/28/19**	**LDRD**	**$0.00**	**$30,800.00**	
100	**1.6**	**sPHENIX Mechanics Integration**	**42 days?**	**Wed 4/18/18**	**Thu 6/14/18**		**$0.00**	**$50,000.00**	
106	**1.7**	**MAPS Inner Barrel Review**	**12 days**	**Fri 6/15/18**	**Mon 7/2/18**		**$0.00**	**$28,000.00**	
110	**1.8**	**Productions**	**661 days?**	**Wed 8/1/18**	**Wed 2/10/21**		**$0.00**	**$3,003,273.33**	Productio
111	1.8.1	Full Mechnicas System pre-Production Mock Up and Test Beam Analysis	100 days	Fri 3/1/19	Thu 7/18/19		$0.00	$88,000.00	
112	**1.8.2**	**Procurements**	**359 days?**	**Wed 8/1/18**	**Mon 12/16/19**		**$0.00**	**$2,299,140.00**	
113	**1.8.2.1**	**CERN Procuments**	**180 days?**	**Wed 8/1/18**	**Tue 4/9/19**		**$0.00**	**$1,097,840.00**	
114	1.8.2.1.1	Produce 68 Inner Staves	180 days	Wed 8/1/18	Tue 4/9/19		$920,000.00	$1,064,000.00	
115	1.8.2.1.2	Other ITS/CERN items	120 days	Wed 8/1/18	Tue 1/15/19		$10,000.00	$13,840.00	
116	1.8.2.1.3	Travel and Per Diem at CERN	180 days?	Wed 8/1/18	Tue 4/9/19		$20,000.00	$20,000.00	
117	1.8.2.2	Procure 68 Readout / FEM Units	100 days	Thu 8/2/18	Wed 12/19/18		$322,000.00	$338,000.00	
118	1.8.2.3	Procure Optical Links 68	60 days	Fri 8/3/18	Thu 10/25/18		$42,200.00	$47,000.00	
119	1.8.2.4	Procure 34 Common Readout Units	100 days	Mon 8/6/18	Fri 12/21/18		$181,700.00	$189,700.00	
120	1.8.2.5	Procure 100 SamTec Cables	60 days	Tue 8/7/18	Mon 10/29/18		$27,000.00	$31,800.00	
121	1.8.2.6	Procure Ancillary Materials (LVPS and cables etc)	100 days	Wed 8/8/18	Tue 12/25/18		$60,000.00	$68,000.00	
122	1.8.2.7	Procure Cooling Plant	100 days	Fri 7/19/19	Thu 12/5/19		$117,000.00	$125,000.00	
123	1.8.2.8	Procure Assembly Fixtures & Jigs	60 days	Mon 7/22/19	Fri 10/11/19		$100,000.00	$104,800.00	
124	1.8.2.9	Procure End Wheels	100 days	Tue 7/23/19	Mon 12/9/19		$34,000.00	$42,000.00	
125	1.8.2.10	Procure Cylindrical Structural Shells	100 days	Wed 7/24/19	Tue 12/10/19		$11,000.00	$19,000.00	
126	1.8.2.11	Procure Detector Half Barrels	100 days	Thu 7/25/19	Wed 12/11/19		$13,000.00	$21,000.00	
127	1.8.2.12	Procure Service Half Barrels	100 days	Fri 7/26/19	Thu 12/12/19		$120,000.00	$128,000.00	
128	1.8.2.13	Procure Detector and Service Half Barrels	100 days	Mon 7/29/19	Fri 12/13/19		$21,000.00	$29,000.00	
129	1.8.2.14	Procure Two Half Support Structures	100 days	Tue 7/30/19	Mon 12/16/19		$50,000.00	$58,000.00	
130	**1.8.3**	**Assembly and Testing at BNL**	**425 days**	**Wed 12/26/18**	**Tue 8/11/20**		**$0.00**	**$367,733.33**	
131	1.8.3.1	Test Production FEMS, e-Links, CRU, LV, optical links	90 days	Wed 12/26/18	Tue 4/30/19		$0.00	$43,200.00	
132	1.8.3.2	Test Cooling System	10 days	Fri 12/6/19	Thu 12/19/19		$0.00	$8,000.00	
133	1.8.3.3	Stave Reciept Inspection	10 days	Wed 4/10/19	Tue 4/23/19		$0.00	$1,733.33	
134	1.8.3.4	Individual Stave Readout Test	70 days	Wed 4/24/19	Tue 7/30/19		$0.00	$22,400.00	
135	1.8.3.5	Metrology on Stave Assemblies	70 days	Wed 7/31/19	Tue 11/5/19		$0.00	$42,000.00	
136	1.8.3.6	Assemble full Ladders into Half support	100 days	Tue 12/17/19	Mon 5/4/20		$0.00	$38,400.00	
137	1.8.3.7	Metrology on Final Assembly	10 days	Tue 5/5/20	Mon 5/18/20		$0.00	$20,000.00	
138	1.8.3.8	Test Half detector Assembly	60 days	Wed 5/20/20	Tue 8/11/20		$0.00	$192,000.00	
139	**1.8.4**	**Installation**	**131 days**	**Wed 8/12/20**	**Wed 2/10/21**		**$0.00**	**$248,400.00**	
144	1.9	Ready for beam	0 days	Wed 2/10/21	Wed 2/10/21		$0.00	$0.00	



Installation and Commissining

Sun 8/21/16

ID	WBS	Task Name	Duration	Start	Finish	Cost Center	Fixed Cost	Cost	Text10
1	1	**MAPS Inner Barrel**	**1217 days**	**Mon 10/3/16**	**Tue 6/1/21**		**$0.00**	**$4,835,948.24**	
2	1.11	MAPS Inner Barrel Starts	0 days	Sat 10/1/16	Sat 10/1/16		$0.00	$0.00	
3	1.10	MAPS Inner Barrel Ends	0 days	Tue 6/1/21	Tue 6/1/21		$0.00	$0.00	
4	**1.1**	**Milestones of sPHENIX**	**1216 days**	**Mon 10/3/16**	**Tue 6/1/21**		**$0.00**	**$0.00**	
5	1.1.1	sPHENIX Technical Design CD-0	0 days	Tue 11/1/16	Tue 11/1/16		$0.00	$0.00	CD-0 (11/2
6	1.1.2	sPHENIX Technical Design (CD-1/CD-3a)	0 days	Wed 11/1/17	Wed 11/1/17		$0.00	$0.00	CD-1 (11/2
7	1.1.3	sPHENIX Technical Dewsgin (CD-2)	0 days	Mon 7/2/18	Mon 7/2/18		$0.00	$0.00	CD-2 (7/20
8	1.1.4	sPHENIX Start Construction (CD-3b)	0 days	Wed 8/1/18	Wed 8/1/18		$0.00	$0.00	CD-3b (8/2
9	1.1.5	sPHENIX Installation	0 days	Tue 6/1/21	Tue 6/1/21		$0.00	$0.00	ready for b
10	1.1.6	ALICE ITS Inner Barrel Construction	261 days	Mon 1/2/17	Mon 1/1/18		$0.00	$0.00	ITS constr
11	1.1.9	ALICE ITS Electronics Pre-Production	100 days	Wed 2/22/17	Tue 7/11/17		$0.00	$0.00	ITS Electro
12	1.1.8	ALICE ITS Electronics Production	240 days	Thu 7/13/17	Wed 6/13/18		$0.00	$0.00	ITS Electro
13	1.1.7	LANL LDRD	781 days	Mon 10/3/16	Mon 9/30/19	LDRD	$0.00	$0.00	LDRD
14	1.1.11	sPHENIX Test Beam	21 days	Fri 2/1/19	Fri 3/1/19	LDRD	$0.00	$0.00	
15	**1.2**	**Project Management**	**1217 days**	**Mon 10/3/16**	**Tue 6/1/21**		**$0.00**	**$671,784.00**	**sPHENIX I**
19	**1.3**	**Design & Prototyping**	**363 days?**	**Mon 10/3/16**	**Wed 2/21/18**	**LDRD**	**$0.00**	**$980,090.91**	**LDRD/R&D**
92	**1.4**	**Prototype Assembly**	**50 days**	**Tue 2/6/18**	**Mon 4/16/18**	**LDRD**	**$0.00**	**$72,000.00**	
96	**1.5**	**Test Beam Operation**	**35 days**	**Fri 1/11/19**	**Thu 2/28/19**	**LDRD**	**$0.00**	**$30,800.00**	
100	**1.6**	**sPHENIX Mechanics Integration**	**42 days?**	**Wed 4/18/18**	**Thu 6/14/18**		**$0.00**	**$50,000.00**	
106	**1.7**	**MAPS Inner Barrel Review**	**12 days**	**Fri 6/15/18**	**Mon 7/2/18**		**$0.00**	**$28,000.00**	
110	**1.8**	**Productions**	**661 days?**	**Wed 8/1/18**	**Wed 2/10/21**		**$0.00**	**$3,003,273.33**	**Productio**
111	1.8.1	Full Mechnicas System pre-Production Mock Up and Test Beam Analysis	100 days	Fri 3/1/19	Thu 7/18/19		$0.00	$88,000.00	
112	**1.8.2**	**Procurements**	**359 days?**	**Wed 8/1/18**	**Mon 12/16/19**		**$0.00**	**$2,299,140.00**	
130	**1.8.3**	**Assembly and Testing at BNL**	**425 days**	**Wed 12/26/18**	**Tue 8/11/20**		**$0.00**	**$367,733.33**	
139	**1.8.4**	**Installation**	**131 days**	**Wed 8/12/20**	**Wed 2/10/21**		**$0.00**	**$248,400.00**	
140	1.8.4.1	Installation Prep	10 days	Wed 8/12/20	Tue 8/25/20		$0.00	$16,000.00	
141	1.8.4.2	Installation Review	1 day	Wed 8/26/20	Wed 8/26/20		$0.00	$2,000.00	
142	1.8.4.3	Installation	60 days	Thu 8/27/20	Wed 11/18/20		$0.00	$192,000.00	
143	1.8.4.4	Commissioning	60 days	Thu 11/19/20	Wed 2/10/21		$0.00	$38,400.00	
144	1.9	Ready for beam	0 days	Wed 2/10/21	Wed 2/10/21		$0.00	$0.00	



Schedule Contingency

- Electronics R&D
  - Early procuments
  - Join effort with LBNL/ALICE
- Production
  - Partial delivery

Risk Registry

- sPHENIX and ITS/ALICE schedules

- Long development time for Readout boards

Backup slides

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: become ITS/ALICE associate member by 2016

Proposed Path Forward

- Take advantage of ALICE/ITS production
  - Obtain fully tested staves + 40% spares, right after the end of ITS production (~1/2018)
- Setup an initial MOU with ALICE to proceed with the collaborative effort(10/2016)
  - engage LANL/sPHENIX personnel from the beginning on Stave assembly and testing etc.

Tracker Review Charge - revised

Expect a sentence to be added to the charge asking for an evaluation of whether the Tracker design and performance parameters will enable the sPHENIX Physics program to be successfully carried out.

The review will include an examination of the following specific items:

1. **Technical Design**: Have the physics requirements driving the design specifications of the sPHENIX tracking detector been properly addressed in the detector design and planning? Are the tracking scope and specifications sufficiently well defined to support the preliminary cost and schedule estimates? Has a viable process and schedule for any anticipated significant technology down-selects been put forward? If so, does it realistically conform to the project's schedule constraints?

2. **Cost and Funding**: Are the cost estimates for each of the sub-detectors reasonable? Have the various funding sources and institutional resources been identified in each of the cases, and have any necessary assumptions been properly incorporated into the planning and presented? Do the estimates in the initial resource loaded schedules contain all of the staffing and other resources needed in order to execute the subprojects?

3**. Schedule:** Are the schedules realistic and achievable? If not, how can this be remedied or addressed? Does the project schedule for each of the sub-detectors properly take into consideration all necessary activities associated with detector realization – i.e., design, R&D, prototyping, beam tests and analysis requirements, feedback to the design, and final design and construction?

4**. Management:** Is there a viable plan for the roles and responsibilities of the institutions involved in the different subprojects? Has the staffing at these institutions been identified? Do the proposed institutions/detector collaborations have the expertise and sufficient available research time to execute the projects on the envisioned time scales? Can viable subproject collaborations be assembled in the time available?

5. **Risk:** Have the principal risks been identified and associated mitigation plans been developed? If not, where are the most notable deficiencies and vulnerabilities? Are there modifications to the design and/or R&D campaigns that might significantly reduce the principal risks?

6**. Open Issues:** Are there any unidentified open design or fabrication issues that require additional attention?

Inputs from ALICE ITS Project 4/1/2016

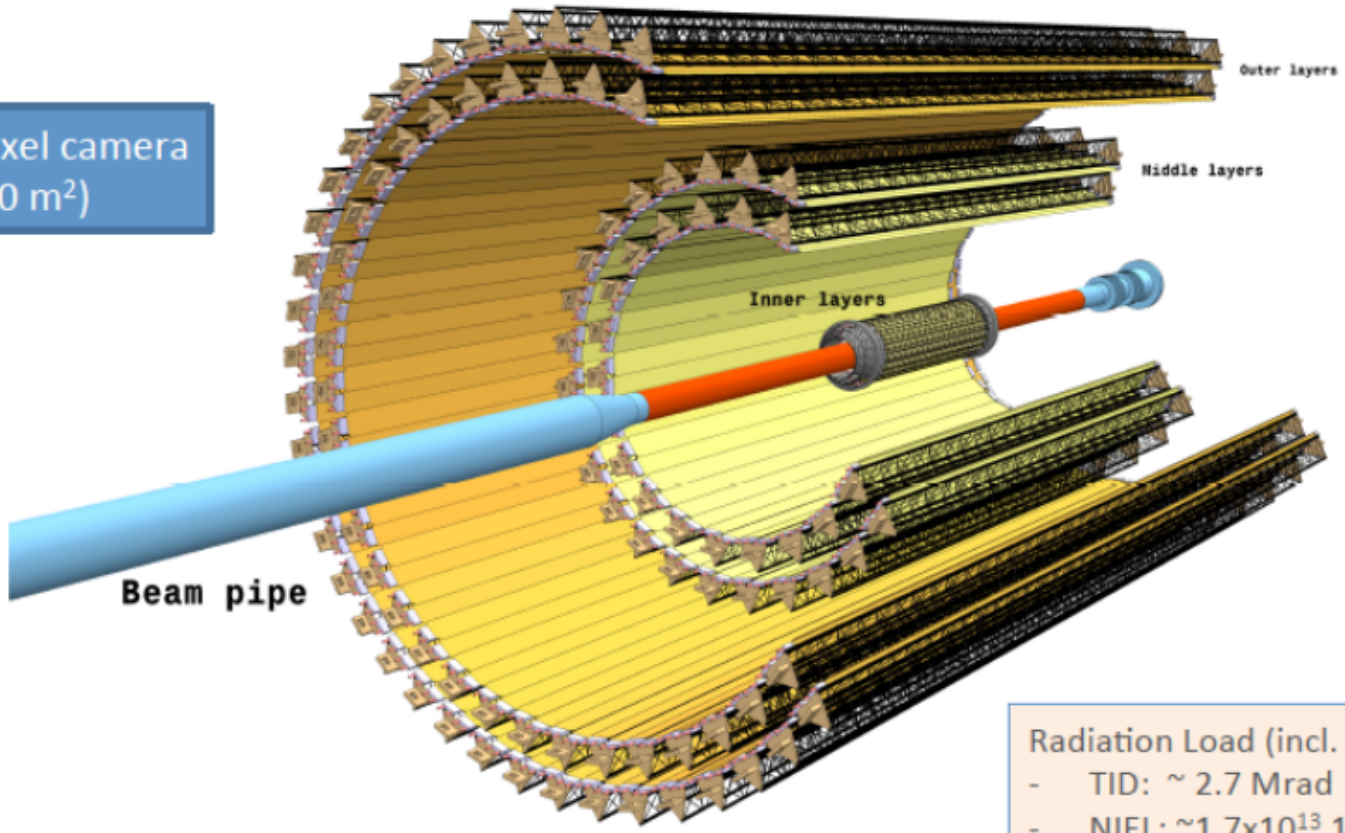
1) Project Schedule, add 6 months delay
2) Cost and FTEs

New ITS Layout

A Large Ion Collider Experiment

ALICE

12.5 G-pixel camera
(~10 m^2)



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**)

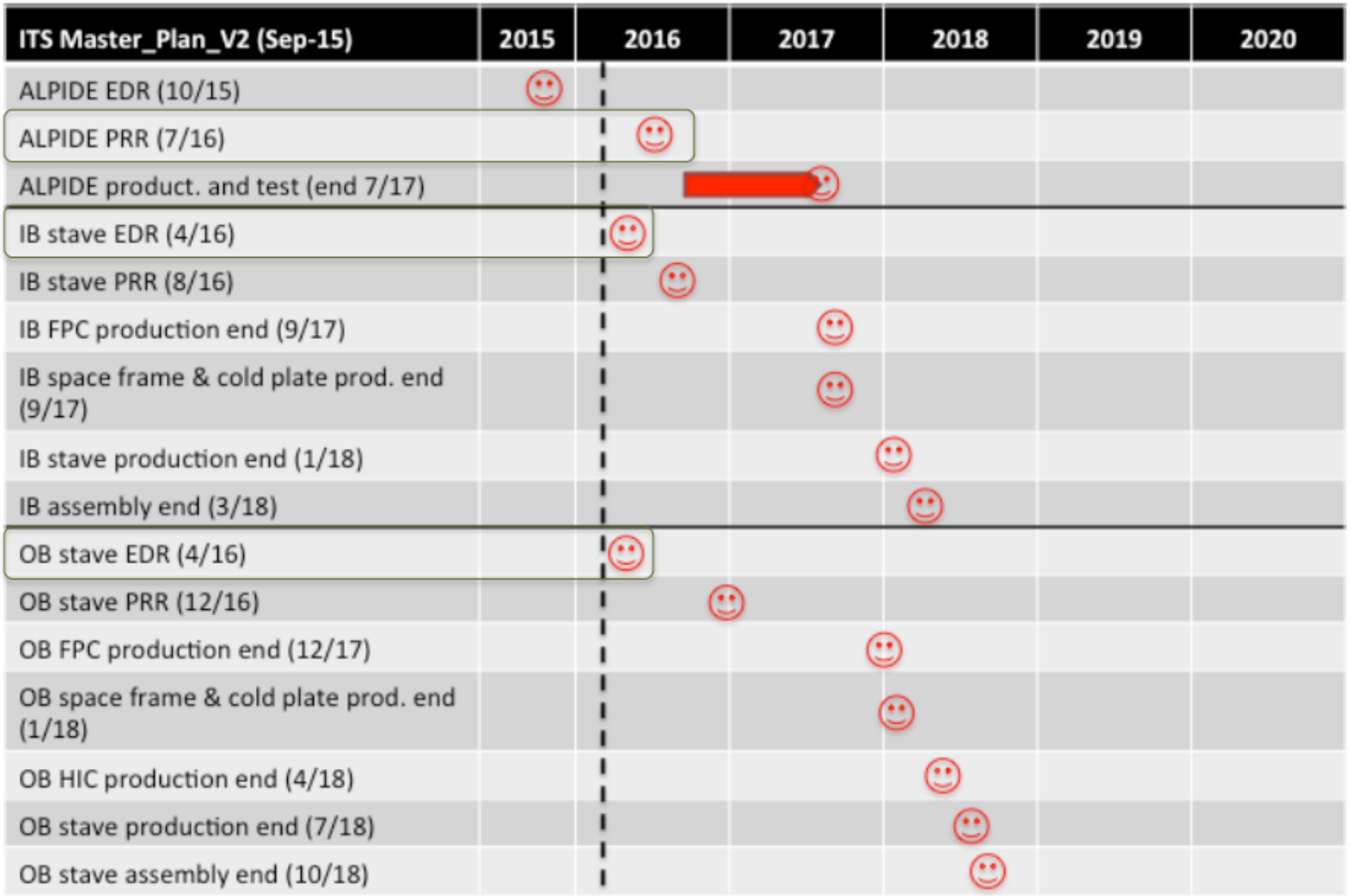
4 Outer Barrel layers (**OB**)

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

Milestones – ALPIDE, IB & OB Staves

A Large Ion Collider Experiment

ALICE



Cost breakdown

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

Cost breakdown

ALICE

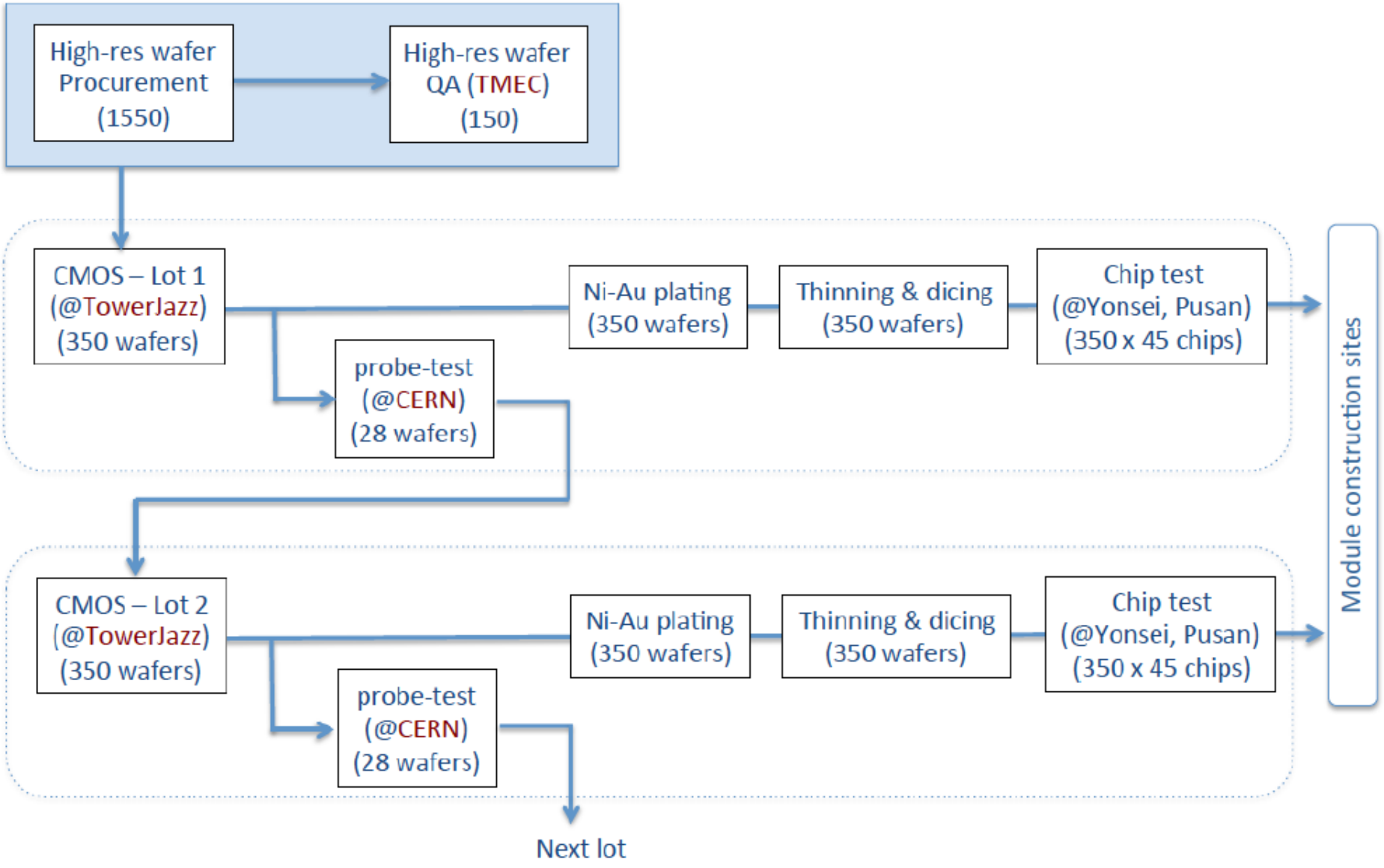
Activity	Material Costs	Manpower Costs	TOTAL COST / ITEM
6 Inner Barrel Global Assembly	70	156	227
6.1 End-Wheels (E-W)	4	30	34
6.2 Assembly of Staves on E-W	16	12	28
6.3 Cylindrical Structural Shell	1	10	11
6.4 Detector Half-Barrels	6	7	13
6.5 Service Half-Barrels	36	84	120
6.6 Detector + Service Half-Barrels	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

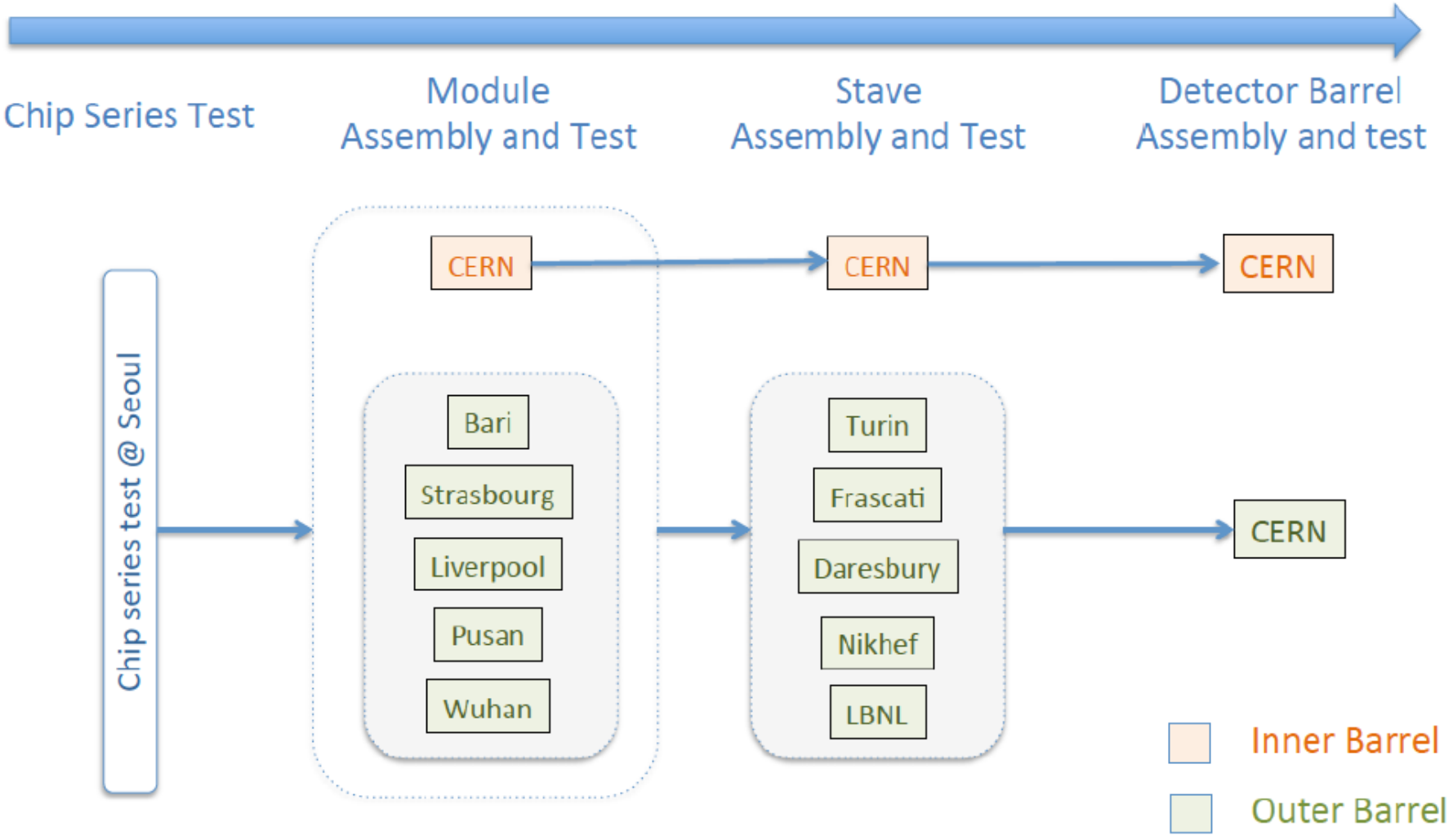
ALICE

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

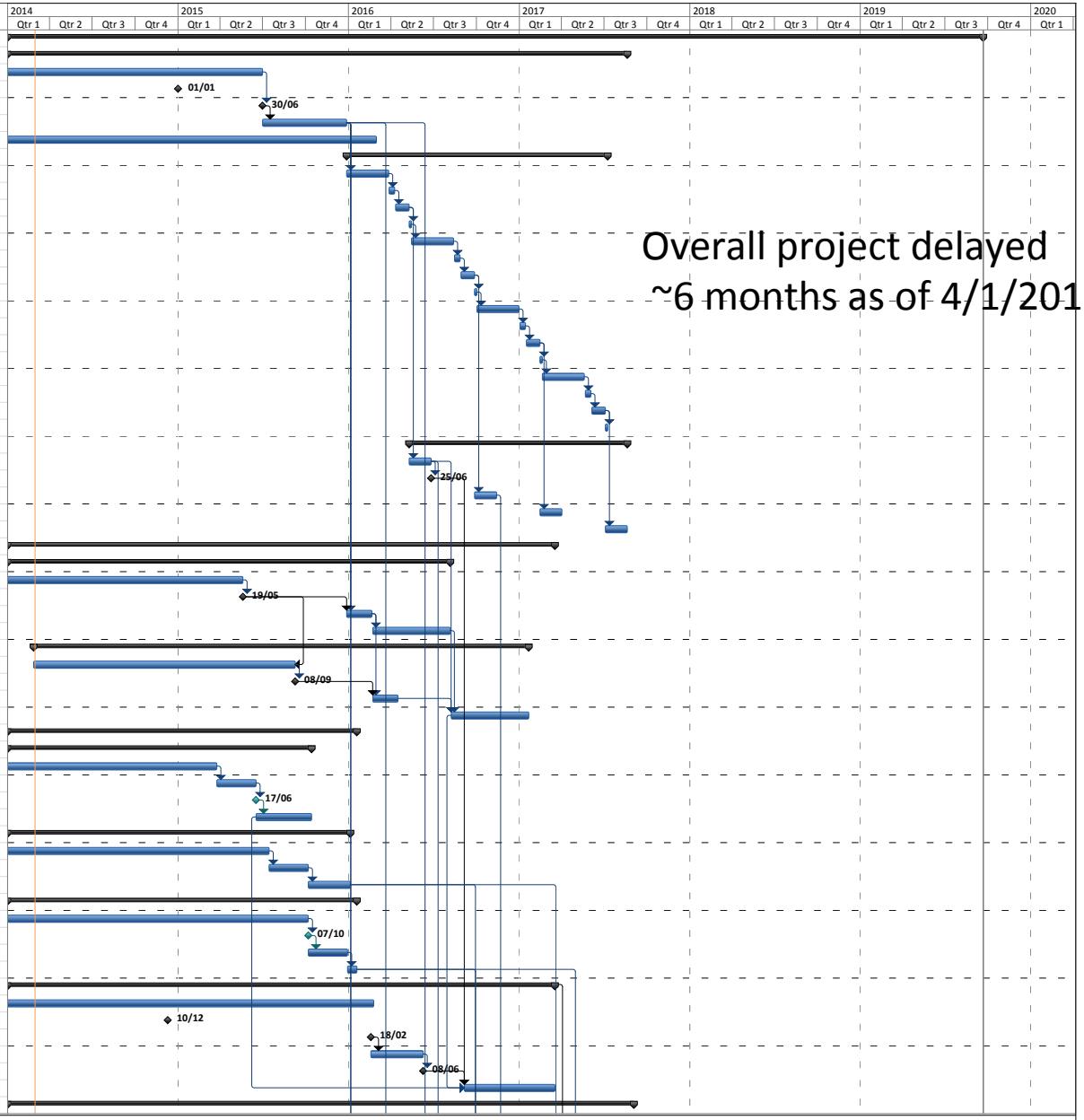
Pixel chip production flow chart



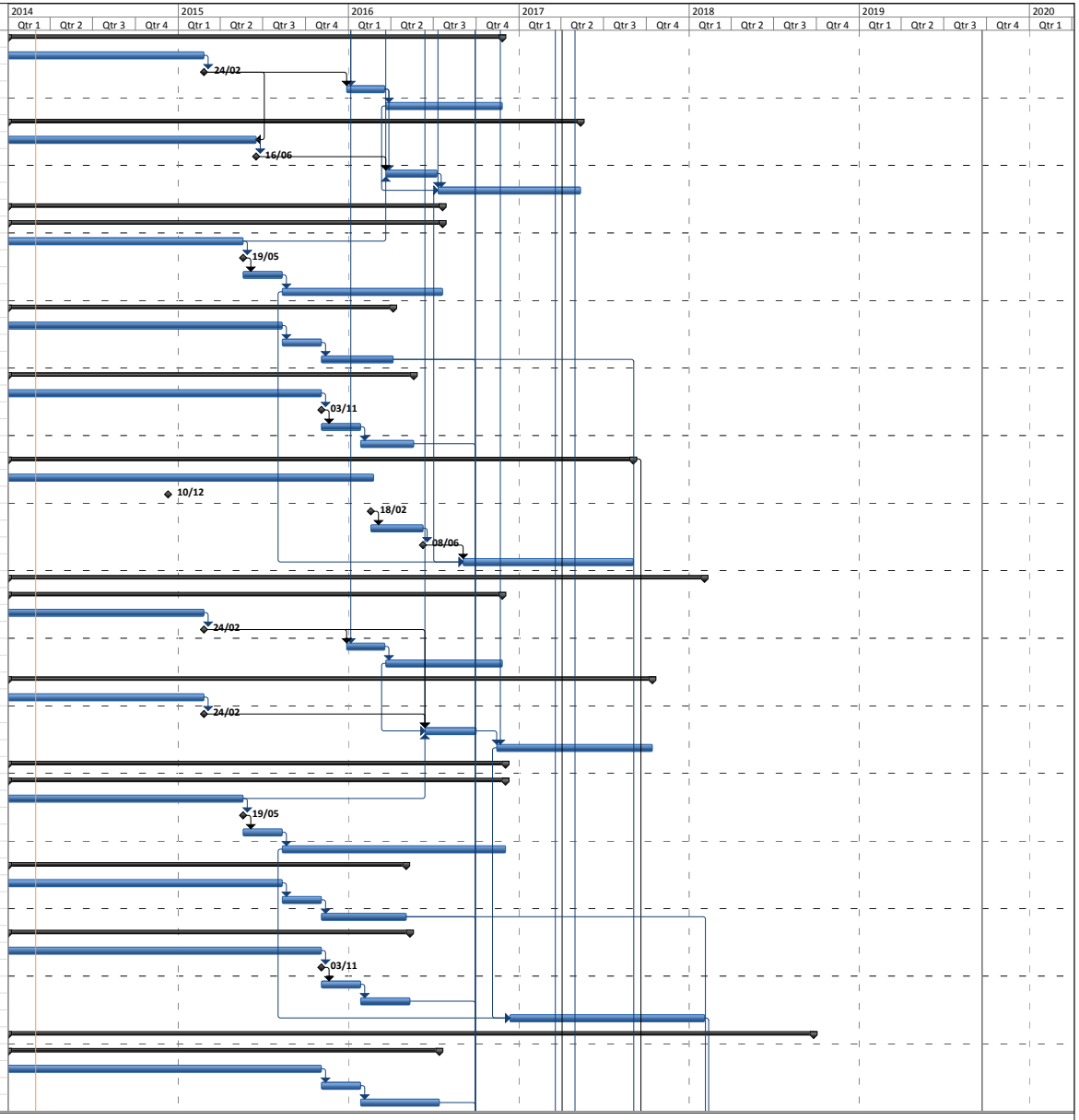
Module and Stave production flow chart



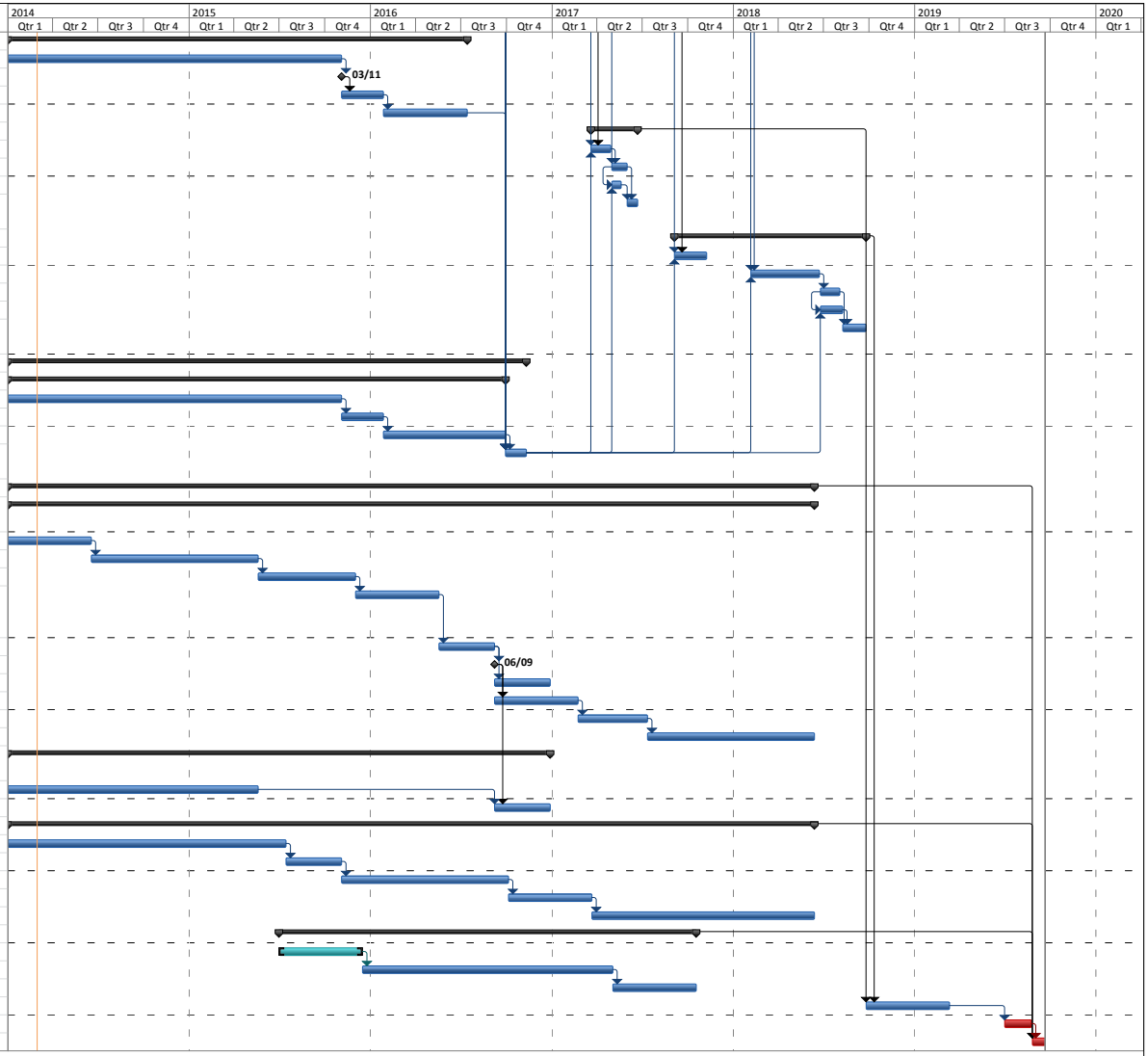
ID	WBS	Task Name	Duration	Start	Finish
1	**1**	**ITS UPGRADE**	**74.65 mons**	**Wed 01/01/14**	**Fri 20/09/19**
2	**1.1**	**Pixel Sensor**	**47.4 mons**	**Wed 01/01/14**	**Sat 19/08/17**
3	1.1.1	Design	19.5 mons	Wed 01/01/14	Tue 30/06/15
4	1.1.2	Design review and architecture selection	0 days	Thu 01/01/15	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**



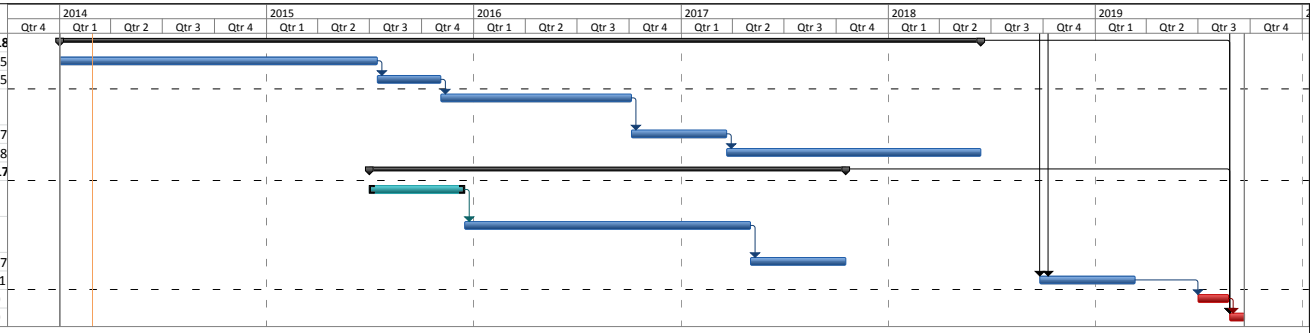
ID	WBS	Task Name	Duration	Start	Finish
65	**1.3.1**	**Flexible Printed Circuit (FPC)**	**37.9 mons**	**Wed 01/01/14**	**Fri 25/11/16**
66	1.3.1.1	FPC R&D	15 mons	Wed 01/01/14	Tue 24/02/15
67	1.3.1.2	Design Review	0 mons	Tue 24/02/15	Tue 24/02/15
68	1.3.1.3	FPC Pre-Series with Final Design	3 mons	Mon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



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

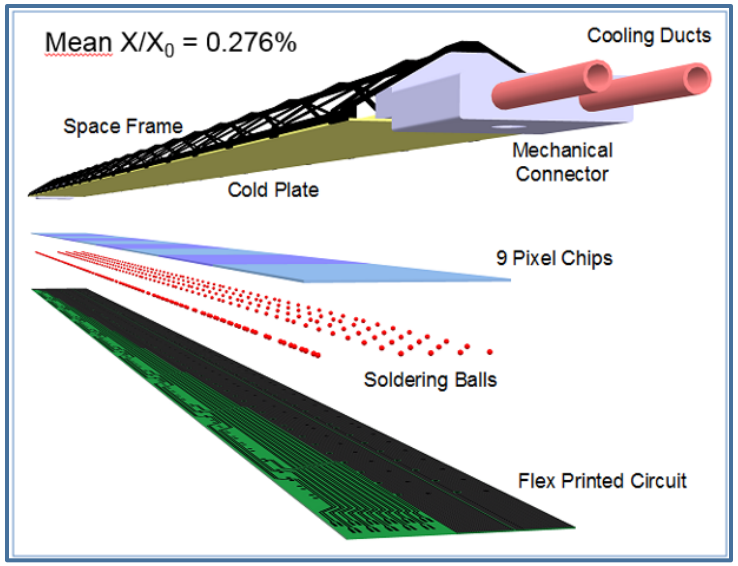


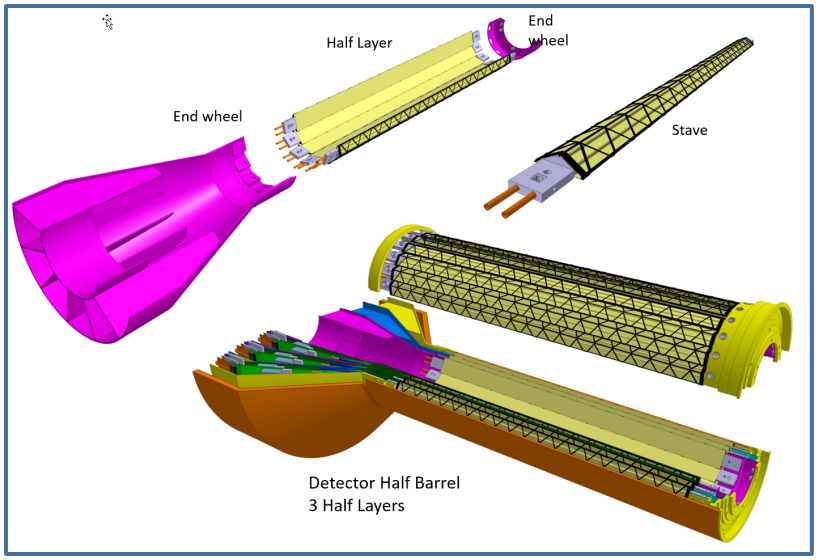
ID	WBS	Task Name	Duration	Start	Finish
166	**1.8**	**Power Distribution**	**58 mons**	**Wed 01/01/1**	**Tue 12/06/18**
167	1.8.1	R&D	20 mons	Wed 01/01/1	Tue 14/07/15
168	1.8.2	Specifications	4 mons	Wed 15/07/1	Tue 03/11/15
169	1.8.3	Qualification of LV Power Delivery Network	12 mons	Wed 04/11/15	Tue 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



Input from STAR/HFT from Leo 4/1/2016

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

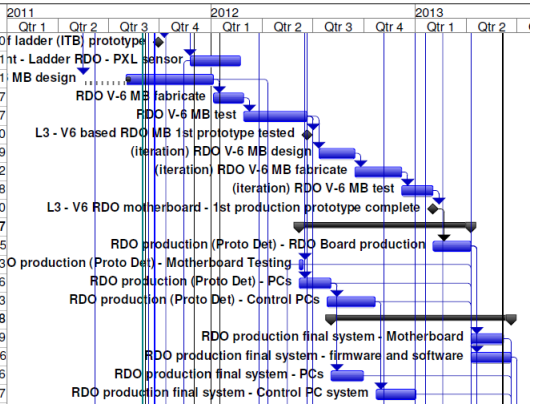
WBS	Task Name	Cost ($K)
1.2	**Pixel Detector (PXL)**	**4,993**
1.2.1	Pixel Mechanics	1,210
1.2.2	Pixel Electronics	3,043
1.2.3	Detector Assembly	225
1.2.4	Infrastructure	515

- 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).

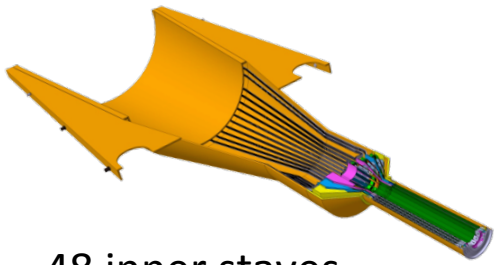
PXL RDO lessons learned

- 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.

Readout Units Required for ITS

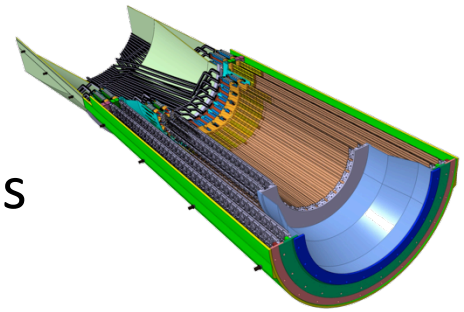
Readout Units and GBT links for maximum design rates

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

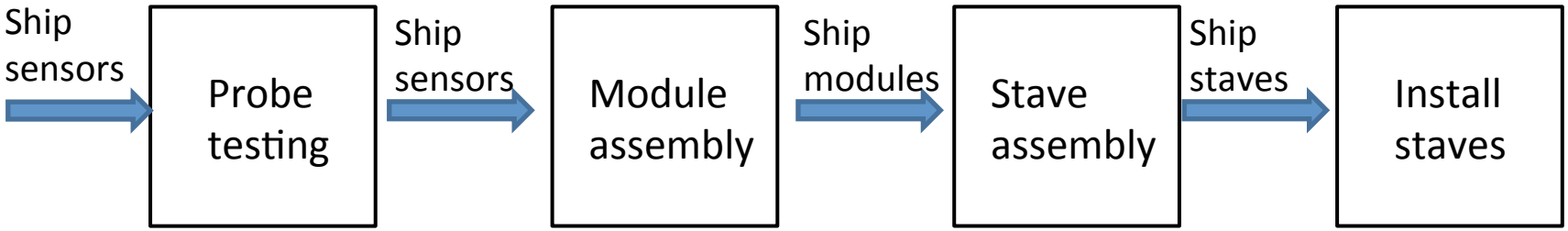


144 RDO boards

54 middle staves
90 outer staves

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.

sPHENIX MAPS Cost & Schedule Workfest

Draft Cost & Schedule Document and Project File

David M Lee

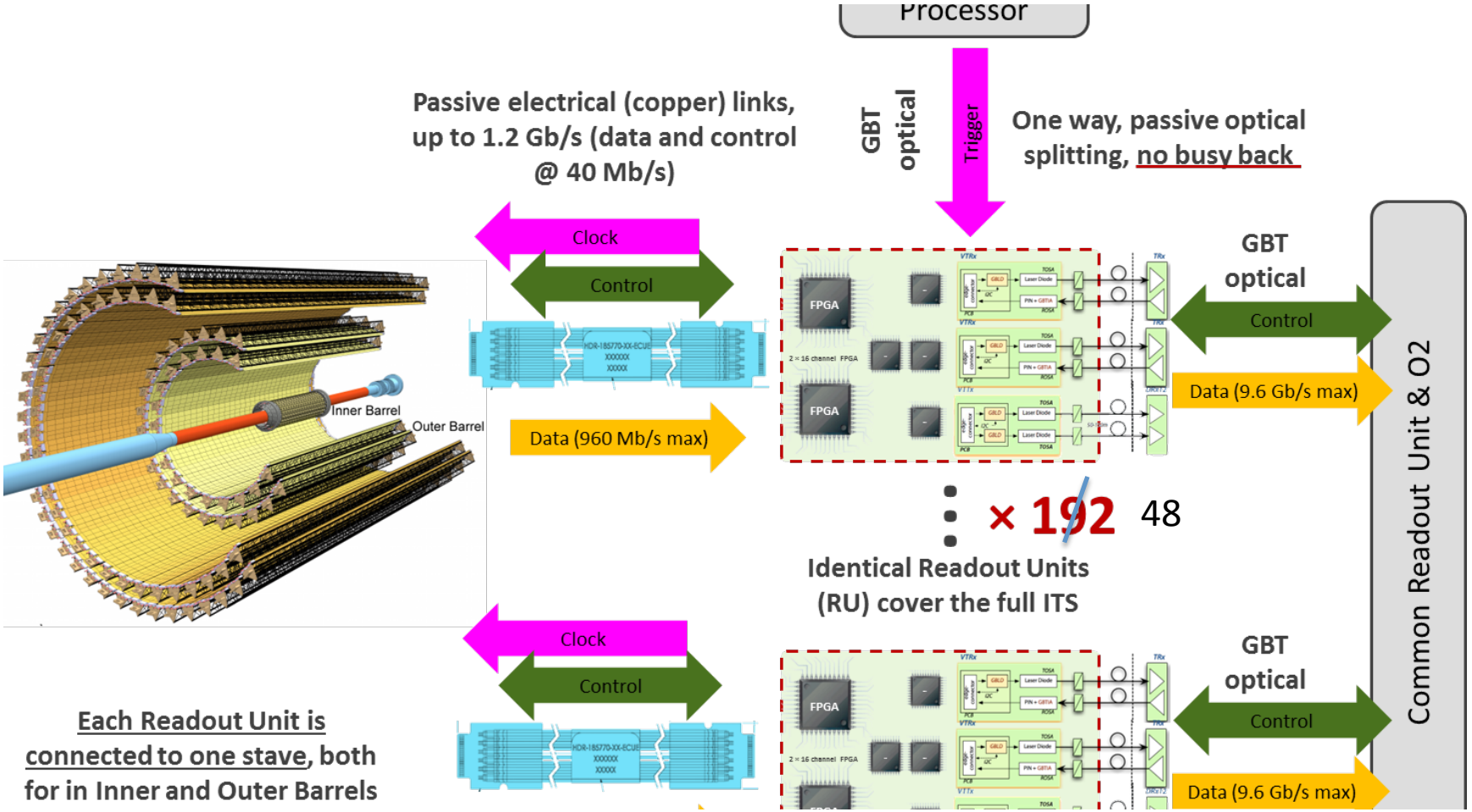
Guest Scientist, Los Alamos National Laboratory

Assumptions

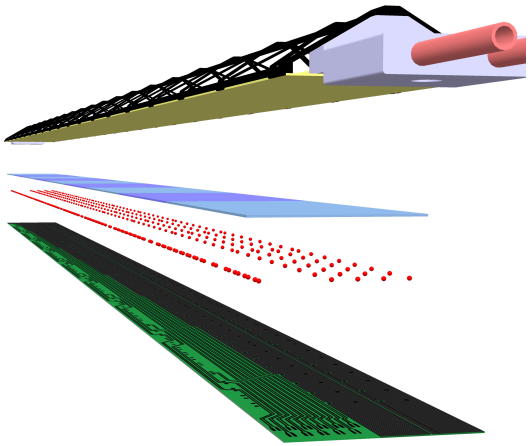
- Copy ALICE Inner Tracker
- Some Initial Costs From ALICE Documents where available
- Other Costs from Previous Experience(Mine)
- Manpower costs from Lab Engineers and Techs
- Durations are My estimates
- No Manpower Smoothing
- No Schedule contingncy
- Applied 30% cost contingency
- Will Follow DOE CD Process

Cost Basis For Electronics

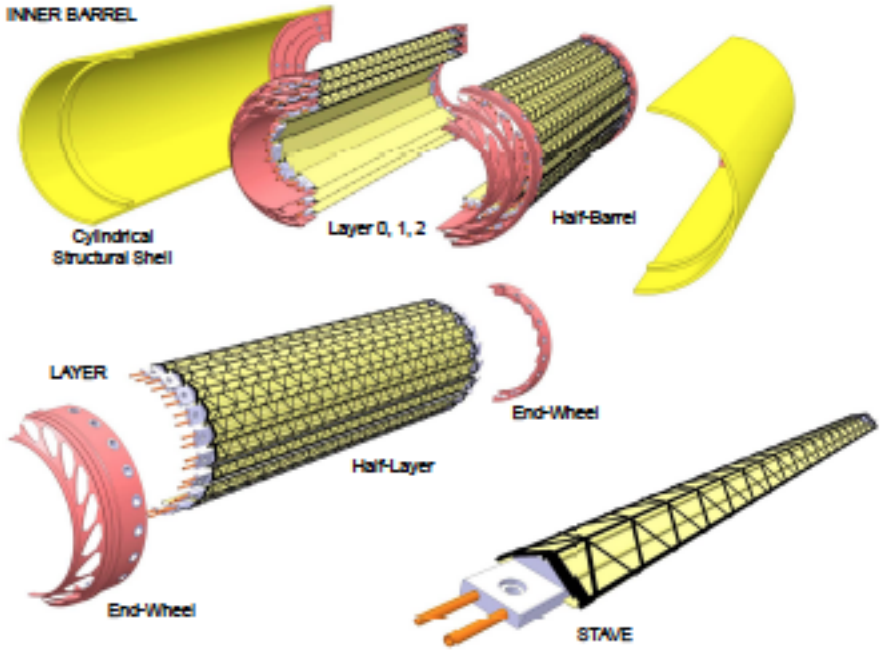
J. Phys. G: Nucl. Part. Phys. **41** (2014) 087002



ALICE Stave and Global Support Structure Cost Basis



ALICE Stave



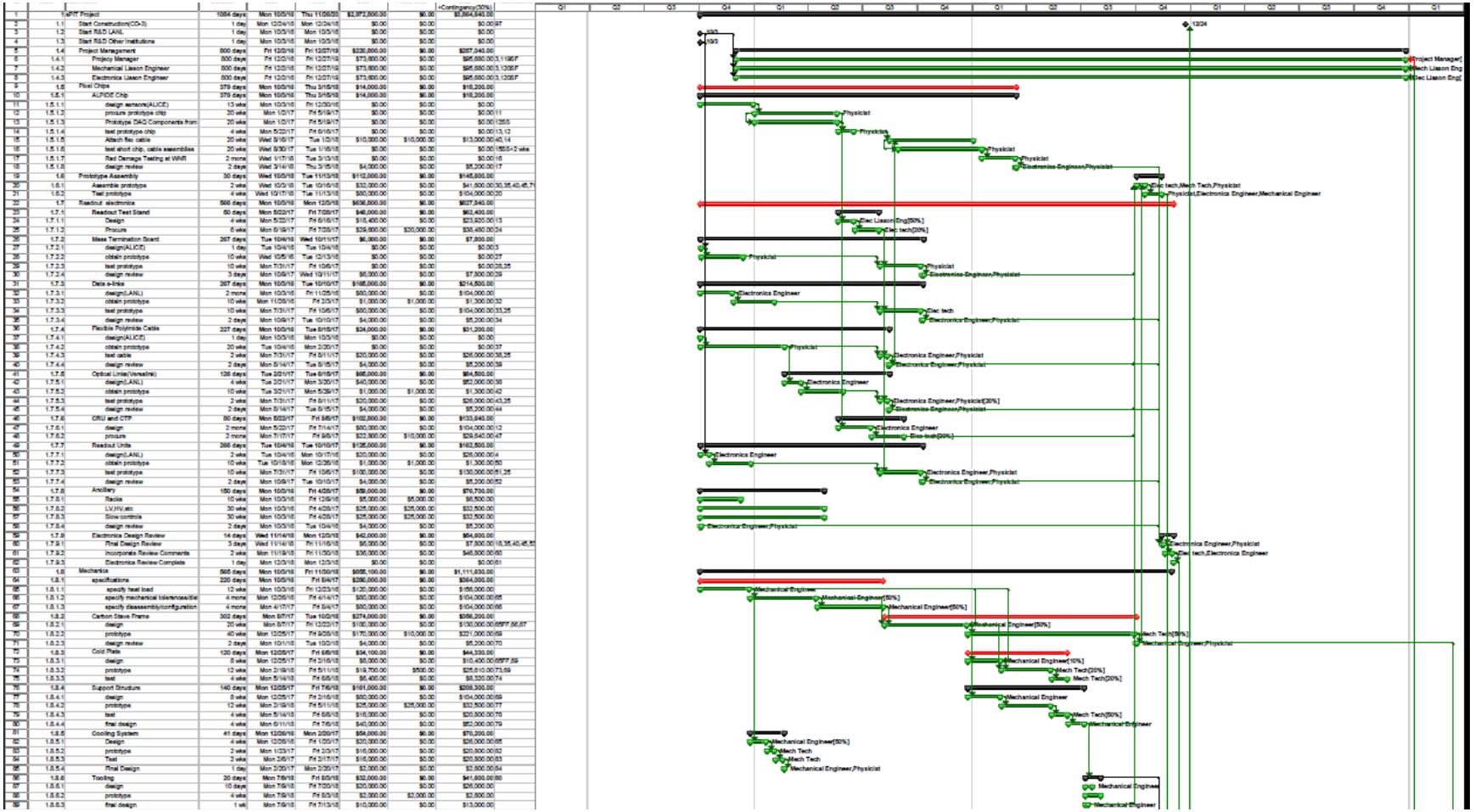
(a) ITS Inner Barrel design.

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

Inner Tracker Properties

- 48 Staves
- 432 Chips
- 27 cm long
- 3 layers: radii = 22mm, 31 mm, 39 mm
- Silicon Wafer: 18 chips/wafer, $2330/wafer
- Dicing: $520/wafer
- Inner Tracker needs (20% spares) 29 wafers

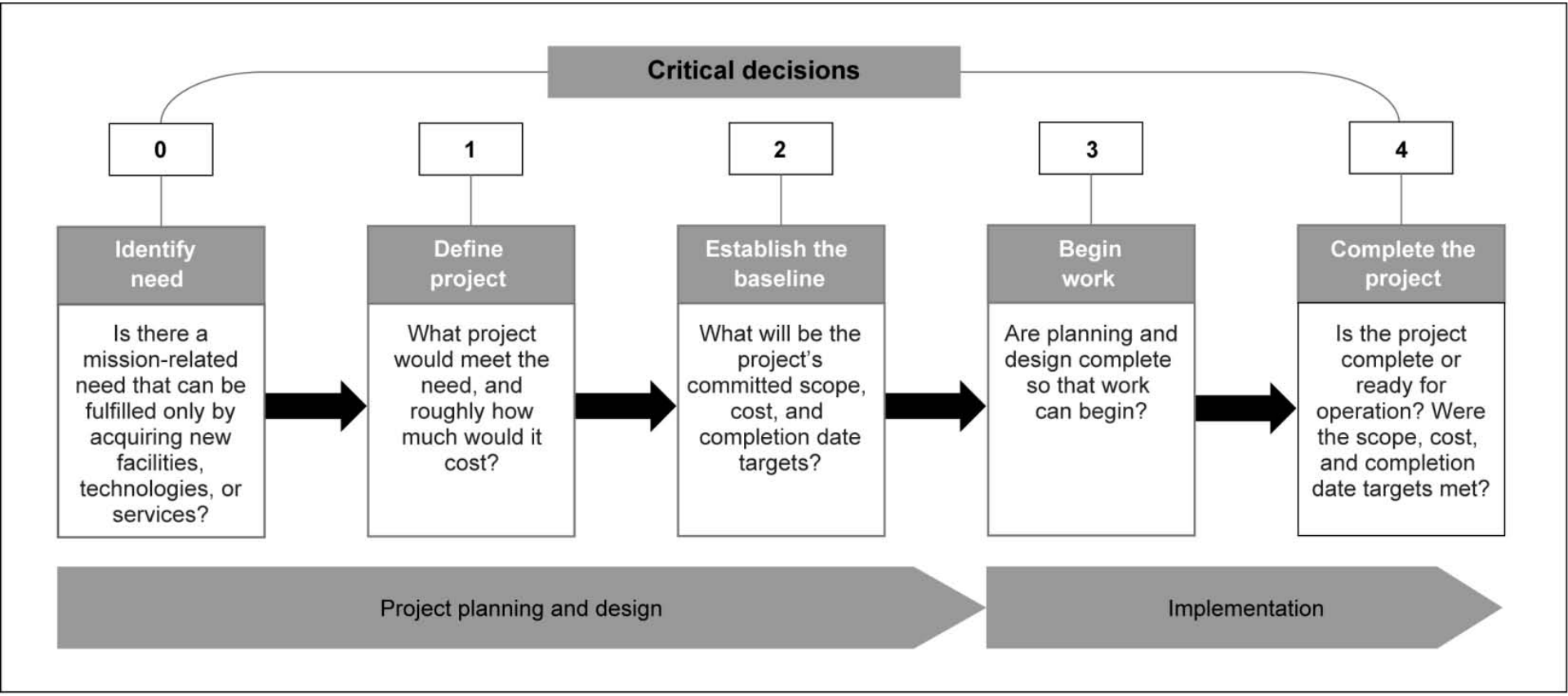
Project File



Sample Electronics Subtasks

ID	WBS	Task Name	Duration	Start	Finish	Cost	Fixed Cost	Cost +Contingency(30%)
1	**1**	sPIT Project	**1084 days**	**Mon 10/3/16**	**Thu 11/26/20**	**$2,972,800.00**	**$0.00**	**$3,864,640.00**
2	1.1	Start Construction(CD-3)	1 day	Mon 12/24/18	Mon 12/24/18	$0.00	$0.00	$0.00
3	1.2	Start R&D LANL	1 day	Mon 10/3/16	Mon 10/3/16	$0.00	$0.00	$0.00
4	1.3	Start R&D Other Institutions	1 day	Mon 10/3/16	Mon 10/3/16	$0.00	$0.00	$0.00
5	**1.4**	Project Management	**800 days**	**Fri 12/2/16**	**Fri 12/27/19**	**$220,800.00**	**$0.00**	**$287,040.00**
9	**1.5**	Pixel Chips	**379 days**	**Mon 10/3/16**	**Thu 3/15/18**	**$14,000.00**	**$0.00**	**$18,200.00**
19	**1.6**	**Prototype Assembly**	**30 days**	**Wed 10/3/18**	**Tue 11/13/18**	**$112,000.00**	**$0.00**	**$145,600.00**
22	**1.7**	Readout electronics	**566 days**	**Mon 10/3/16**	**Mon 12/3/18**	**$636,800.00**	**$0.00**	**$827,840.00**
23	**1.7.1**	**Readout Test Stand**	**50 days**	**Mon 5/22/17**	**Fri 7/28/17**	**$48,000.00**	**$0.00**	**$62,400.00**
24	1.7.1.1	Design	4 wks	Mon 5/22/17	Fri 6/16/17	$18,400.00	$0.00	$23,920.00
25	1.7.1.2	Procure	6 wks	Mon 6/19/17	Fri 7/28/17	$29,600.00	$20,000.00	$38,480.00
26	**1.7.2**	Mass Termination Board	**267 days**	**Tue 10/4/16**	**Wed 10/11/17**	**$6,000.00**	**$0.00**	**$7,800.00**
27	1.7.2.1	design(ALICE)	1 day	Tue 10/4/16	Tue 10/4/16	$0.00	$0.00	$0.00
28	1.7.2.2	obtain prototype	10 wks	Wed 10/5/16	Tue 12/13/16	$0.00	$0.00	$0.00
29	1.7.2.3	test prototype	10 wks	Mon 7/31/17	Fri 10/6/17	$0.00	$0.00	$0.00
30	1.7.2.4	design review	3 days	Mon 10/9/17	Wed 10/11/17	$6,000.00	$0.00	$7,800.00
31	**1.7.3**	Data e-links	**267 days**	**Mon 10/3/16**	**Tue 10/10/17**	**$165,000.00**	**$0.00**	**$214,500.00**
32	1.7.3.1	design(LANL)	2 mons	Mon 10/3/16	Fri 11/25/16	$80,000.00	$0.00	$104,000.00
33	1.7.3.2	obtain prototype	10 wks	Mon 11/28/16	Fri 2/3/17	$1,000.00	$1,000.00	$1,300.00
34	1.7.3.3	test prototype	10 wks	Mon 7/31/17	Fri 10/6/17	$80,000.00	$0.00	$104,000.00
35	1.7.3.4	design review	2 days	Mon 10/9/17	Tue 10/10/17	$4,000.00	$0.00	$5,200.00
36	**1.7.4**	Flexible Polyimide Cable	**227 days**	**Mon 10/3/16**	**Tue 8/15/17**	**$24,000.00**	**$0.00**	**$31,200.00**
37	1.7.4.1	design(ALICE)	1 day	Mon 10/3/16	Mon 10/3/16	$0.00	$0.00	$0.00
38	1.7.4.2	obtain prototype	20 wks	Tue 10/4/16	Mon 2/20/17	$0.00	$0.00	$0.00
39	1.7.4.3	test cable	2 wks	Mon 7/31/17	Fri 8/11/17	$20,000.00	$0.00	$26,000.00
40	1.7.4.4	design review	2 days	Mon 8/14/17	Tue 8/15/17	$4,000.00	$0.00	$5,200.00
41	**1.7.5**	Optical Links(Versalink)	**126 days**	**Tue 2/21/17**	**Tue 8/15/17**	**$65,000.00**	**$0.00**	**$84,500.00**
42	1.7.5.1	design(LANL)	4 wks	Tue 2/21/17	Mon 3/20/17	$40,000.00	$0.00	$52,000.00

DOE Critical Decision Process



Sources: GAO and DOE.

GAO-13-129 DOE Nonmajor Projects

What Needs to Be Done?

- Define Owners of Tasks, i.e. who will do the work?
- Research Costs, Durations, and Resources for Accuracy
- Provide Documentation for the Cost estimates
- Estimate Contingency
- Provide Information to the Project Office
- Develop an Org Chart

Summer Work and Beyond

- LDRD funded!
  - LDRD: 10/2016-9/2019
- MAPS test and integration @LANL
  - Standalone sPHENIX DAQ/DCM-II
  - MAPS readout R&D
- Update C&S for September 7-9 review
- BNL sPHENIX tracker review (Nov. 2016?)
- sPHENIX MAPS full proposal?
  - Build collaboration
  - Simulation and detector optimization
  - Full detector design, CD-1
  - Plan for construction, CD-3b

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?

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.

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.

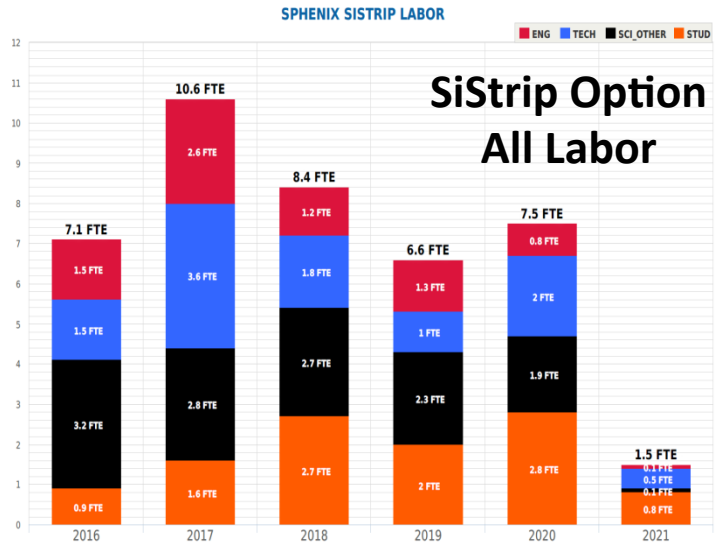
sPHENIX installed commissioned and ready for beam Jun 2021.

First RHIC Beam for sPHENIX Jan 2022

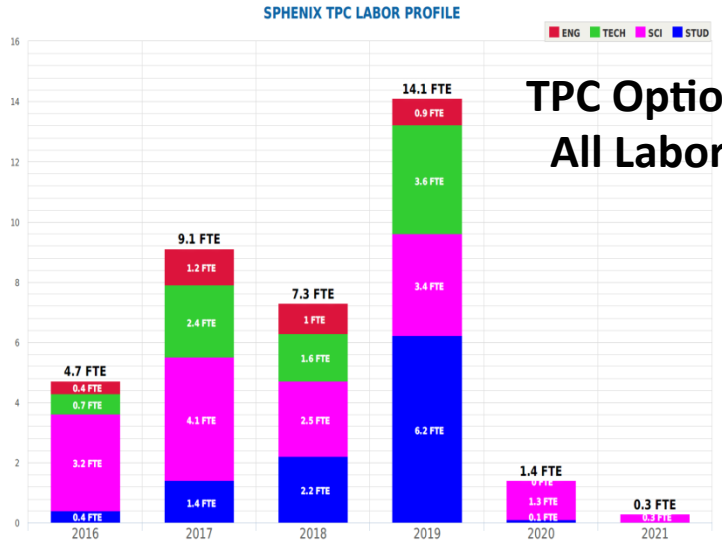
CD-4 **Jan 2023**

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

Tracker Direct Materials and Labor FY16$

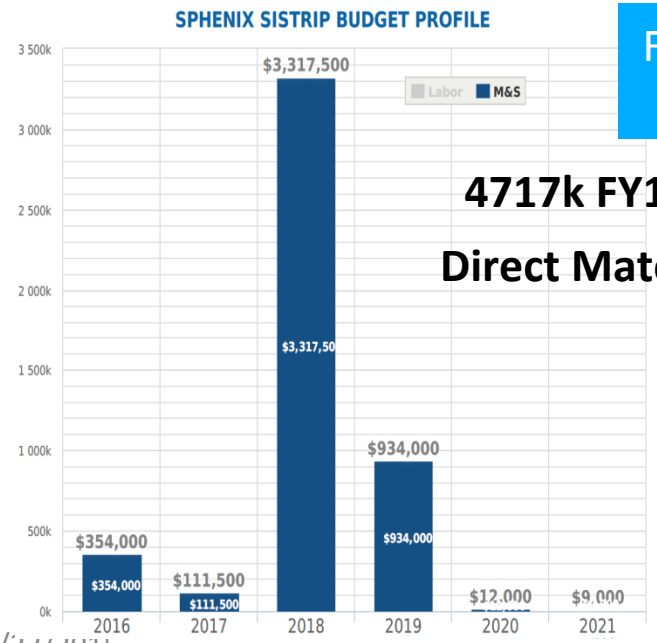


SiStrip Option
All Labor



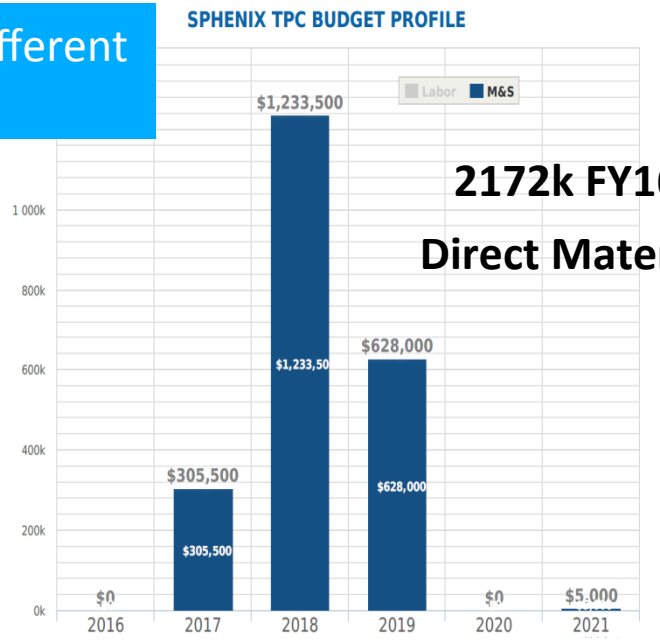
TPC Option
All Labor

Figures have different scales



4717k FY16$

Direct Material



2172k FY16$

Direct Materials