TPOT overview

Hugo Pereira Da Costa (CEA Saclay/LANL)

TPOT technical review - January 26, 2022

Content

- Detector concept, mission and merit
- TPOT highlights since last C&S review (Sept 2021)
- Work force, cost and schedule
- Summary

Context

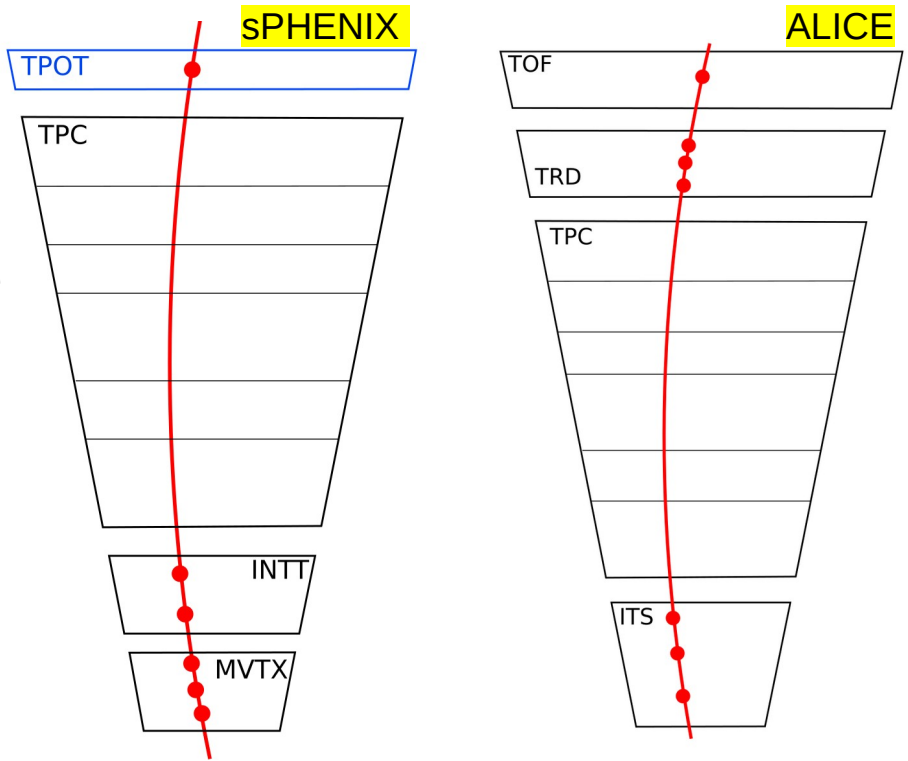
TPOT = TPc Outer Tracker

Located on the outside of the sPHENIX TPC

Mission:

provide an additional space point on the outside of the sPHENIX TPC, in a fraction of the acceptance, to calibrate the TPC (i.e. beam-induced space charge distortions)

Similar role as TOF and TRD for ALICE, albeit in a fraction of the total acceptance



Adapted from EPJ. Web Conf. 245 (2020) 01003
Not to scale

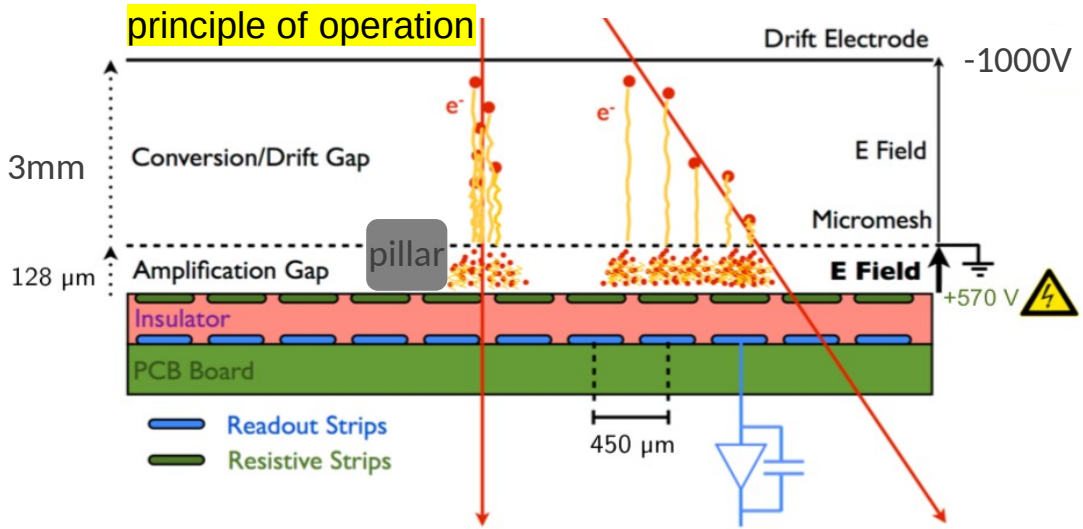
Detector technology

Use modular design to cover key sections of the TPC acceptance

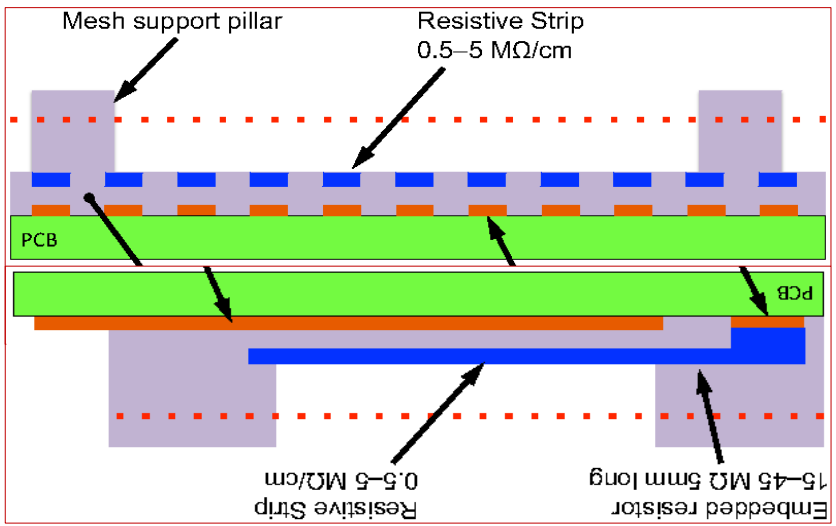
Each module consists of two back-to-back 1D bulk, resistive Micromegas detectors

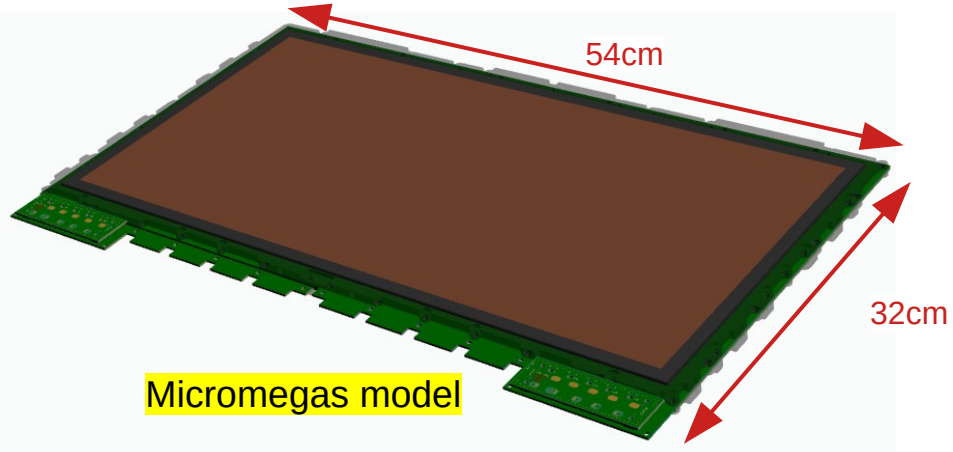
See presentation by Maxence

principle of operation



Micromegas module early design





Micromegas model

Detector configuration

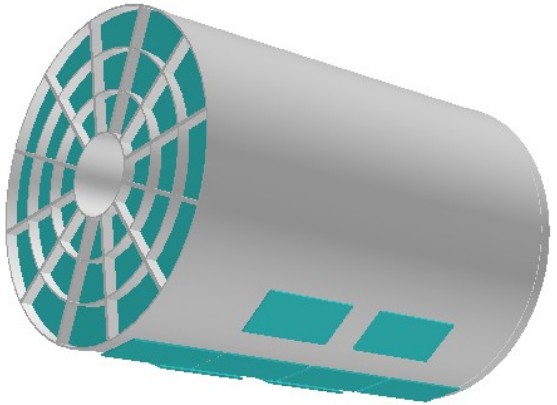
Following C&S review recommendations, consider year-1 configuration only:

- 8 modules (16 detectors) located at the bottom of the TPC
- Bottom-most sector has 4 modules to have full longitudinal coverage
- Immediate neighbor sectors have 2 modules each to validate extrapolation procedure to sectors which do not have Micromegas modules
- Calibration provided by TPOT in limited acceptance extrapolated to full acceptance using well established procedure

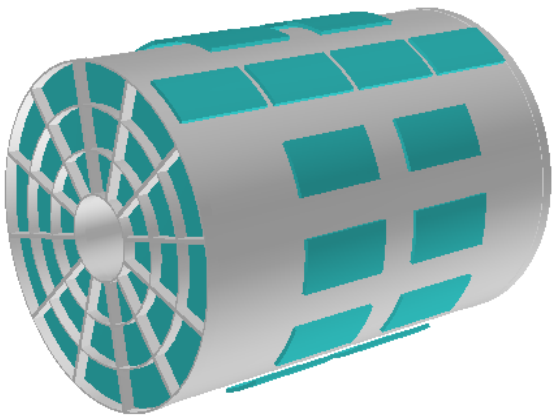
Reasons for the reduction of scope:

- Cost, schedule
- Impossibility to install anything after sPHENIX start of operation

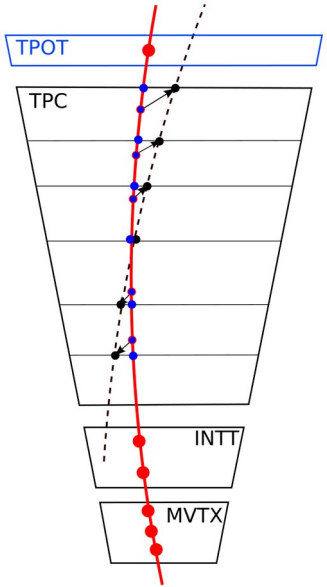
Current (**final**) TPOT configuration

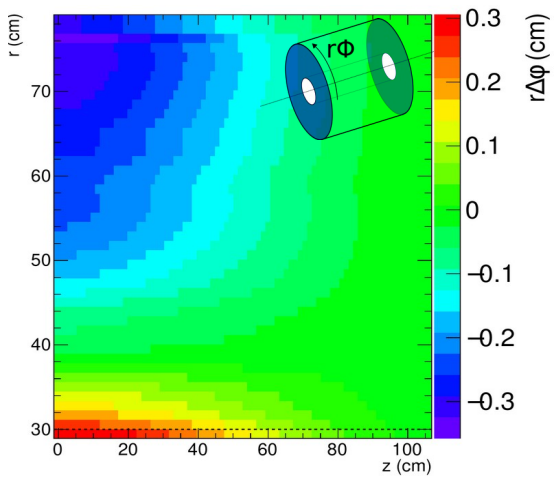


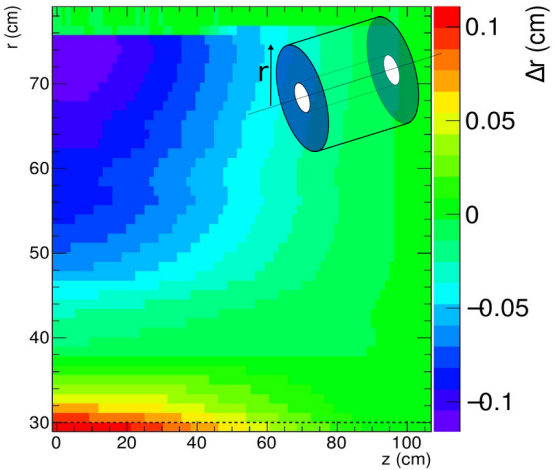
Full configuration at C&S review

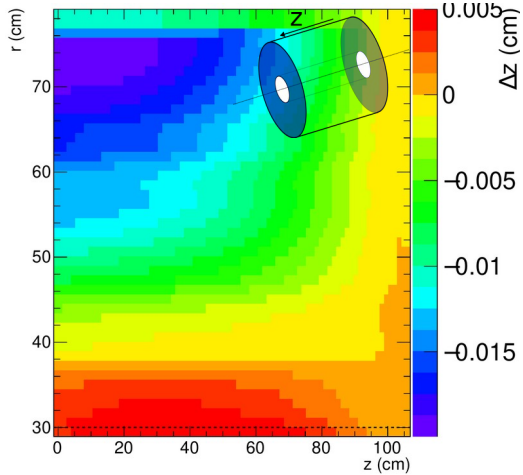


Merit









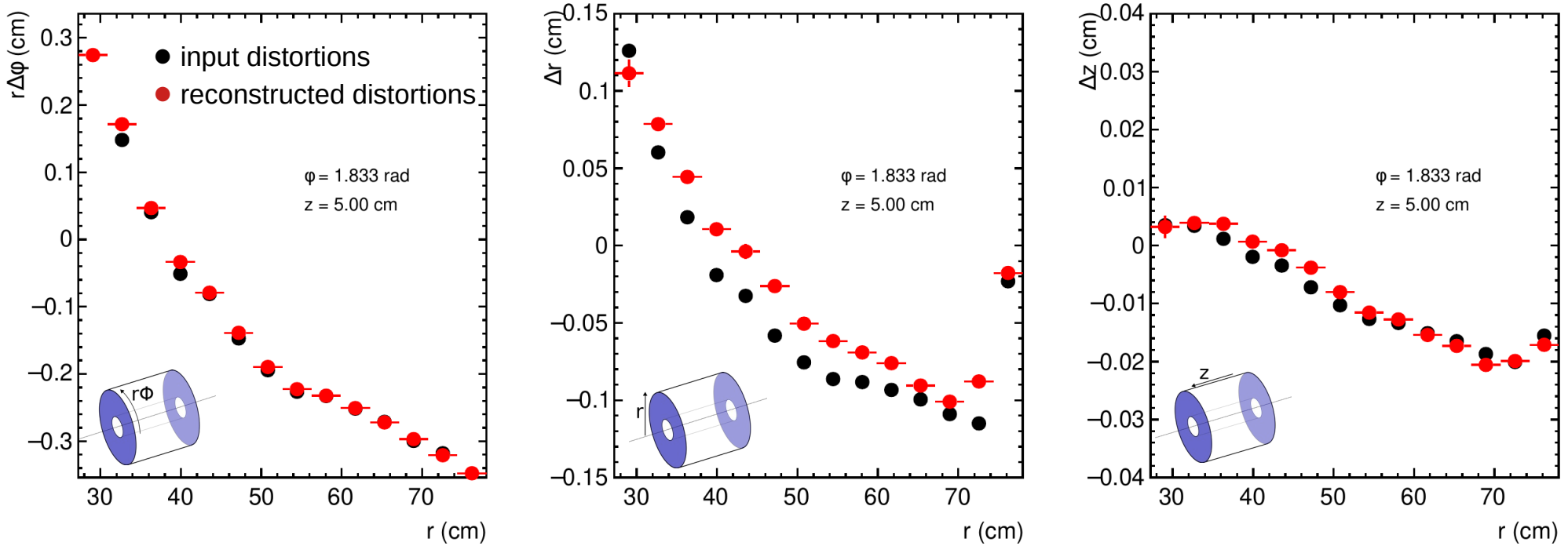
Expected time averaged beam-induced space charge distortions in the TPC

Magnitude of the expected distortions:

- up to 3mm along Φ
- up to 1.2 mm along r
- up to 200 μm along z

Typical timescale before significant variations: 1/2h

Merit (cont.)



Ability for TPOT to reconstruct time-averaged beam induced distortions in the TPC

- Remaining difference in |Δr| < 200um being investigated (likely tracking artifacts)
- Procedure to extrapolate the measured distortions in the rest of the acceptance uses diffuse laser central membrane data (see backups)

TPOT Highlights

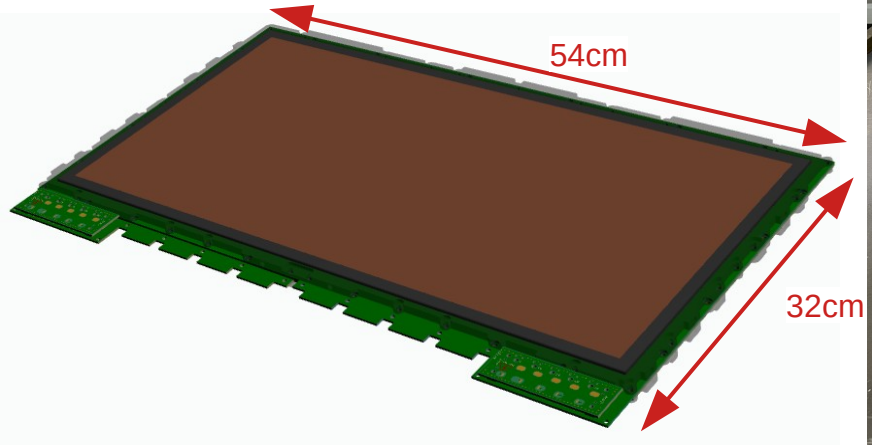
General news

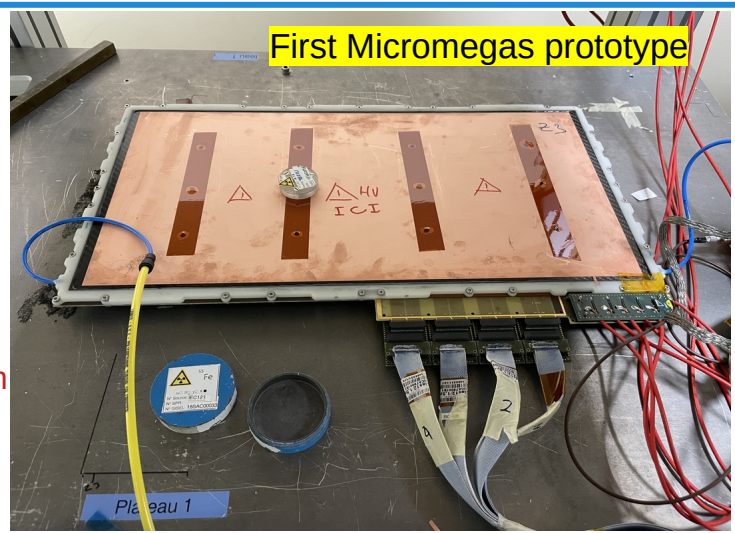
- TPOT received green light to proceed from BNL NPP ALD, Haiyan Gao, on November 9 2021
- Project funded by BNL + in-kind contributions from Saclay, MIT and LANL

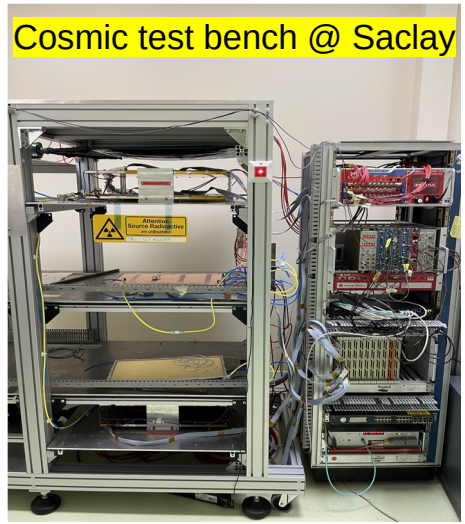
  in-kind contributions have been decisive for getting the green light from BNL
- Contract BNL-Saclay for producing 20 Micromegas detectors ($337.5k) is being finalized
- TPOT dedicated budget line opened at BNL early January 2022 and first purchase orders placed
- We have weekly meetings to discuss progress on detector, mechanics, electronics, etc.

Micromegas detectors

Micromegas model



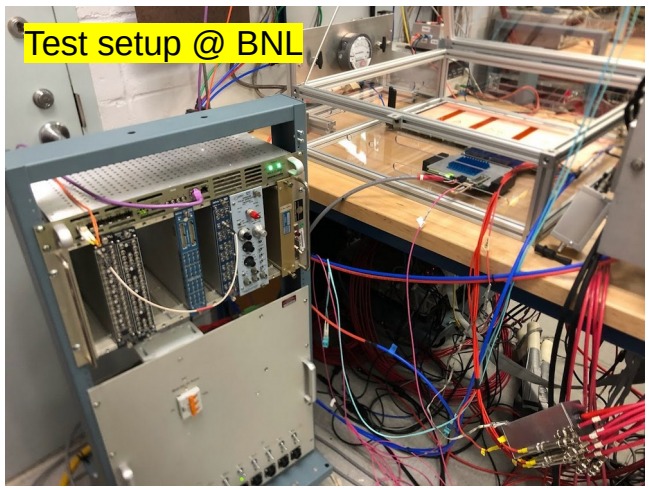




- First Micromegas prototype build at Saclay

  (z-view, 2mm pitch, straight strips, Ar/iC4H10 95/5)
- Tested at Saclay with FE55 source and cosmic test bench using in-house electronics (DREAM)
- Sent to BNL late Dec. 2021 for testing with final electronics (SAMPA)

See presentations by Maxence, Takao

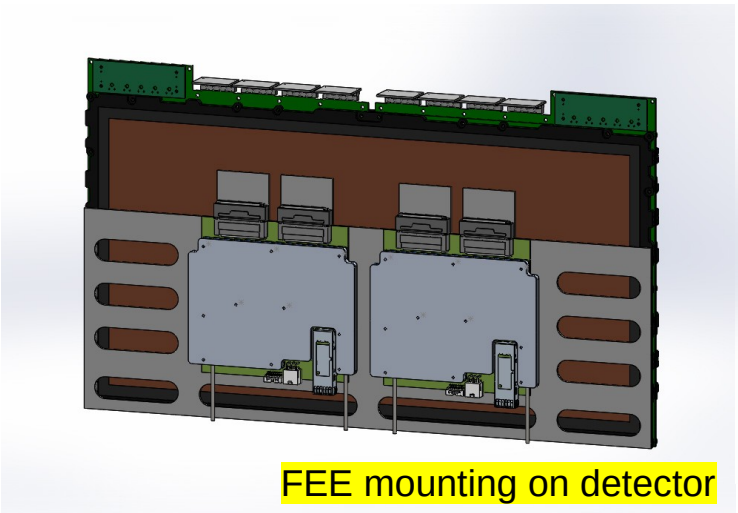


Electronics

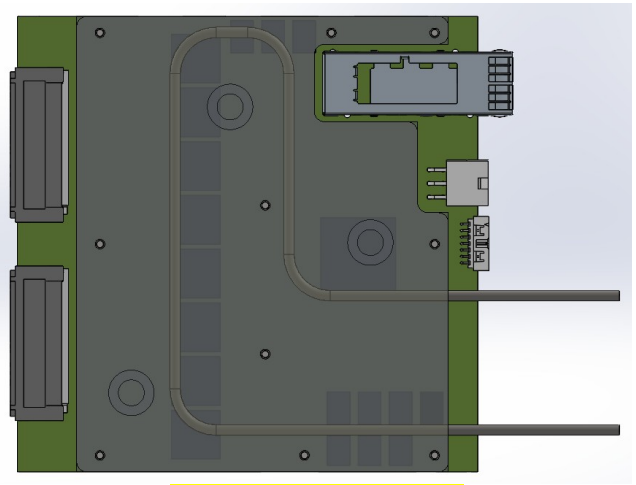
TPOT uses same electronics and back-end as TPC (SAMPA, FELIX, EBDC)

Developments specific to TPOT:

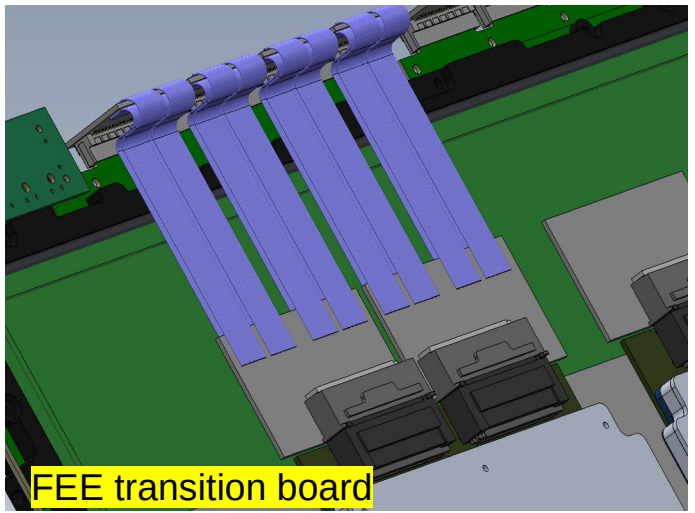
- mounting of the FEE boards on the detector
- FEE cooling plates
- FEE-to-detector transition boards



FEE mounting on detector



FEE cooling plate



FEE transition board

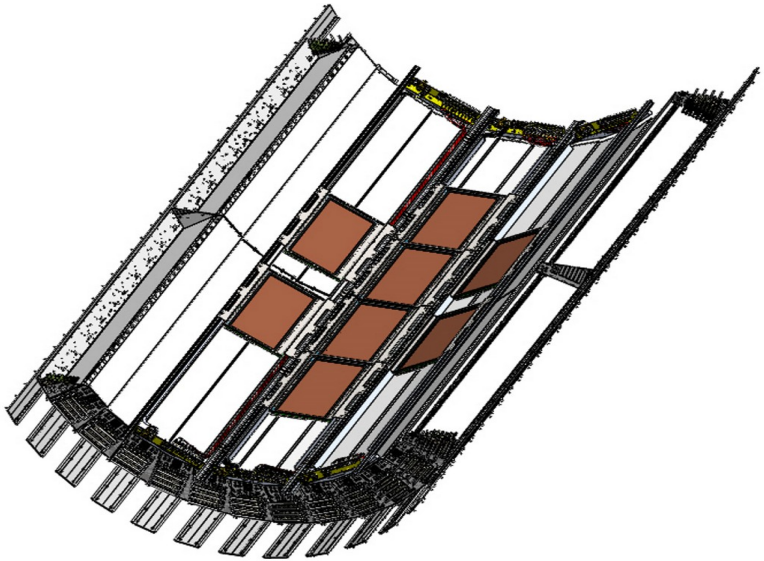
Test of SAMPA electronics + Micromegas prototype at BNL is ongoing

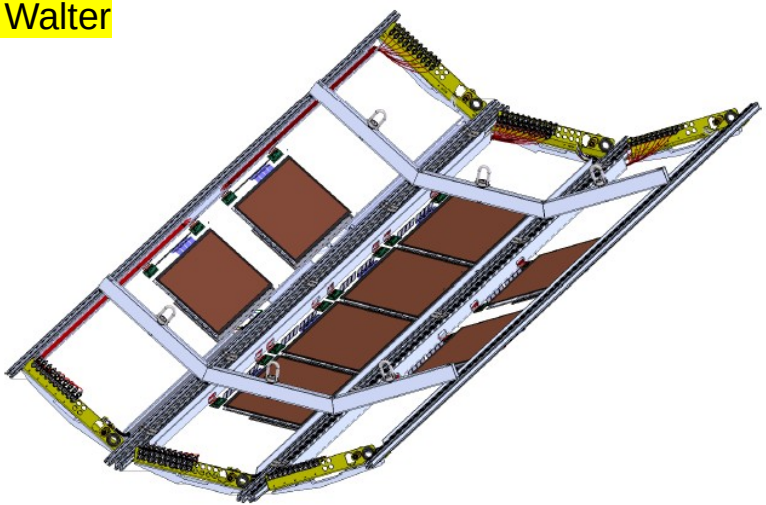
See presentations by Walter, Takao

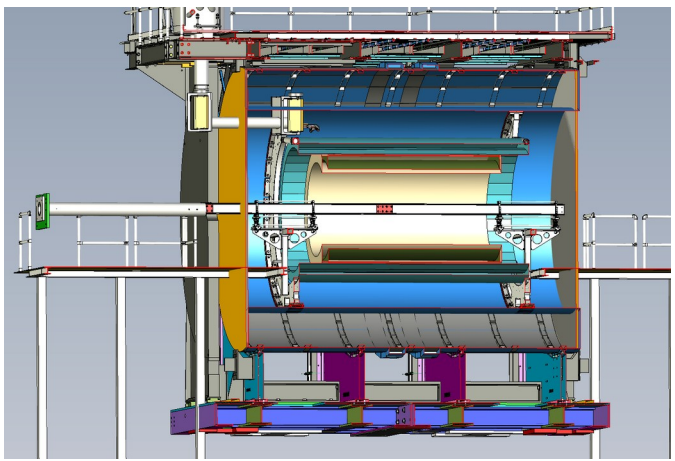
Mechanical integration and installation

- Detectors are assembled, face down, on three *ladders*, one in front of each relevant sector at the bottom of the TPC, and connected to patch panels, at each end of the ladder
- Each ladder can be assembled, connected and tested independently from sPHENIX
- Ladders are mounted between EMCAL and TPC, at the bottom of the TPC, on “picture frames” attached to iHCAL
- Three ladders will be installed at once as a *cradle* using the same I-Beam as that used to insert the TPC

See presentation by Walter





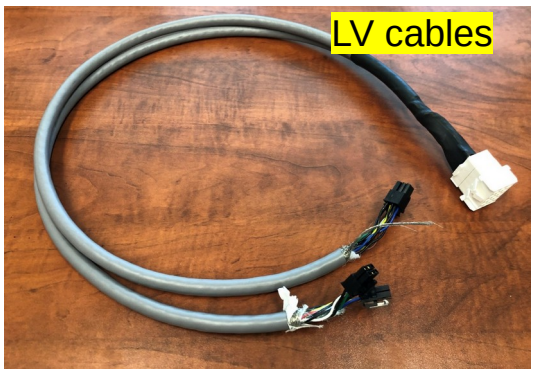


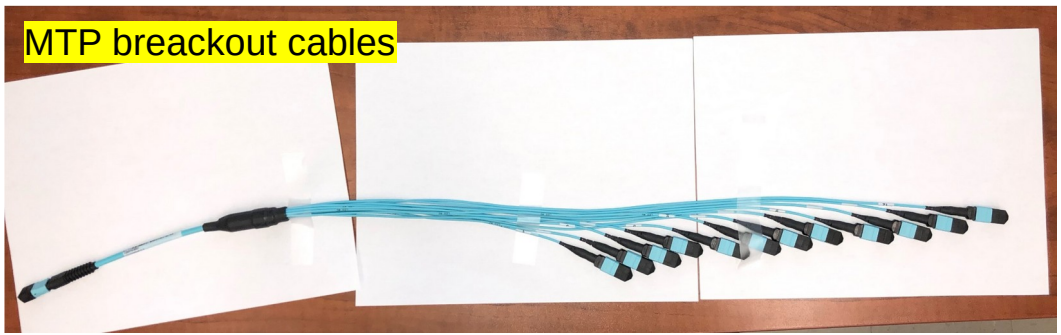
Cables and services

- Services to TPOT are:
  - Low Voltage for FEE power
  - Cooling for the electronics
  - High Voltage for detector operation
  - Gas for detector operation (Ar/iC4H10 95/5)
  - Fibers for data transfer and FEE configuration
- We filled the sPHENIX Interface Control Document

  First step towards defining needed rack space and cable routing
- Cable and power supply definition is ongoing
- Gas system and flammable gas detection under study

HV power supply and mainframe





See presentations by Takao, John, Rob

Work force, cost and schedule

Work force

Saclay	LANL	MIT	BNL
Maxence Vandenbroucke Stephan Aune Arnaud Bonenfant Audrey Francisco Cyril Goblin Aude Grabas Irakli Mandjavidize Ana Wills H.P.	Walter Sondheim Eric Renner Hubert van Hecke Dave Lee Bade Sayki	Jim Kelsey, Christopher Vidal	John Haggerty Takao Sakaguchi Bob Azmoun John Kuczewski Rob Pisani consulting from: Dan Cacace Connor Miraval Rich Ruggiero, etc.
12 FTE.month (engineering) 15 FTE.month (technician)	4 FTE.month (engineering)	4 FTE.month (engineering)	2 FTE.month (all)

All physicist and engineering resources provided as in-kind by Saclay, LANL, MIT, BNL

Work force (cont.)

Project Management	H. Pereira Da Costa, J. Haggerty
Micromegas detector	M. Vandenbroucke, S. Aune, A. Francisco, I. Mandjavidize, A. Grabas, C. Goblin, Ana Wills, B. Azmoun
Electronics	T. Sakagushi, J. Kuczewski, B. Azmoun, I. Mandjavidize, A. Grabas
Mechanics (support and Installation)	W. Sondheim, C. Vidal, E. Renner, S. Aune, D. Cacace, C. Mirraval, R. Ruggiero
Services, Gas, ES&H, interface to BNL	J. Haggerty, T. Sakaguchi, R. Pisani
Software and simulations	H. Pereira Da Costa, A. Francisco, B. Sayki

Several names appear multiple times, but all aspect are covered

Additional resources for installation, commissioning will come from

- Saclay, provided that travel restrictions allow it
- BNL, benefiting from fact that most installation can happen at the same time as for the TPC (i.e. cabling, gas tubing, etc.)
- SBU (undergraduate students). Verbal agreement with Tom Hemmick (TPC L2 manager)

Cost breakdown

	projected ($)	projected+ contingency ($)	current ($)	current+ contingency ($)
Production Contract with Saclay	291,000	349,200	**337,500**	**337,500**
FEE transition board	16,000	19,200	**20,880**	**20,880**
HV Power Supply	22,000	26,400	**37,300**	**37,300**
HV Cables			1,500	2,100
LV cables	1,700	2,040	2,400	2,880
FEE boards* + Fibers	5,608	6,910	8,620	10,530
FEE cooling plates	6,400	8,960	**3,600**	**3,600**
FEE Backend (FELIX, EBDC, mighty-JACK, sort-out box) *	14,000	16,800	14,000	16,800
FEE Mechanics	25,000	35,000	25,000	35,000
Mechanical Support	50,000	80,000	50,000	80,000
Flammable gas detection	10,000	13,000	**11,150**	**11,150**
Gas system parts (gas purity analyzer)			**6,950**	**6,950**
Cooling system	10,000	13,000	10,000	13,000
Total ($)	451,700	570,500	528,900	577,700

BNL agreed to cover all TPOT fixed costs, including production contract, up to $600k

Spending are under control, consistent with projections. Carefully monitored

(*) might drop to zero if using available items from TPC production. See presentation by Takao

Cost breakdown (cont.)

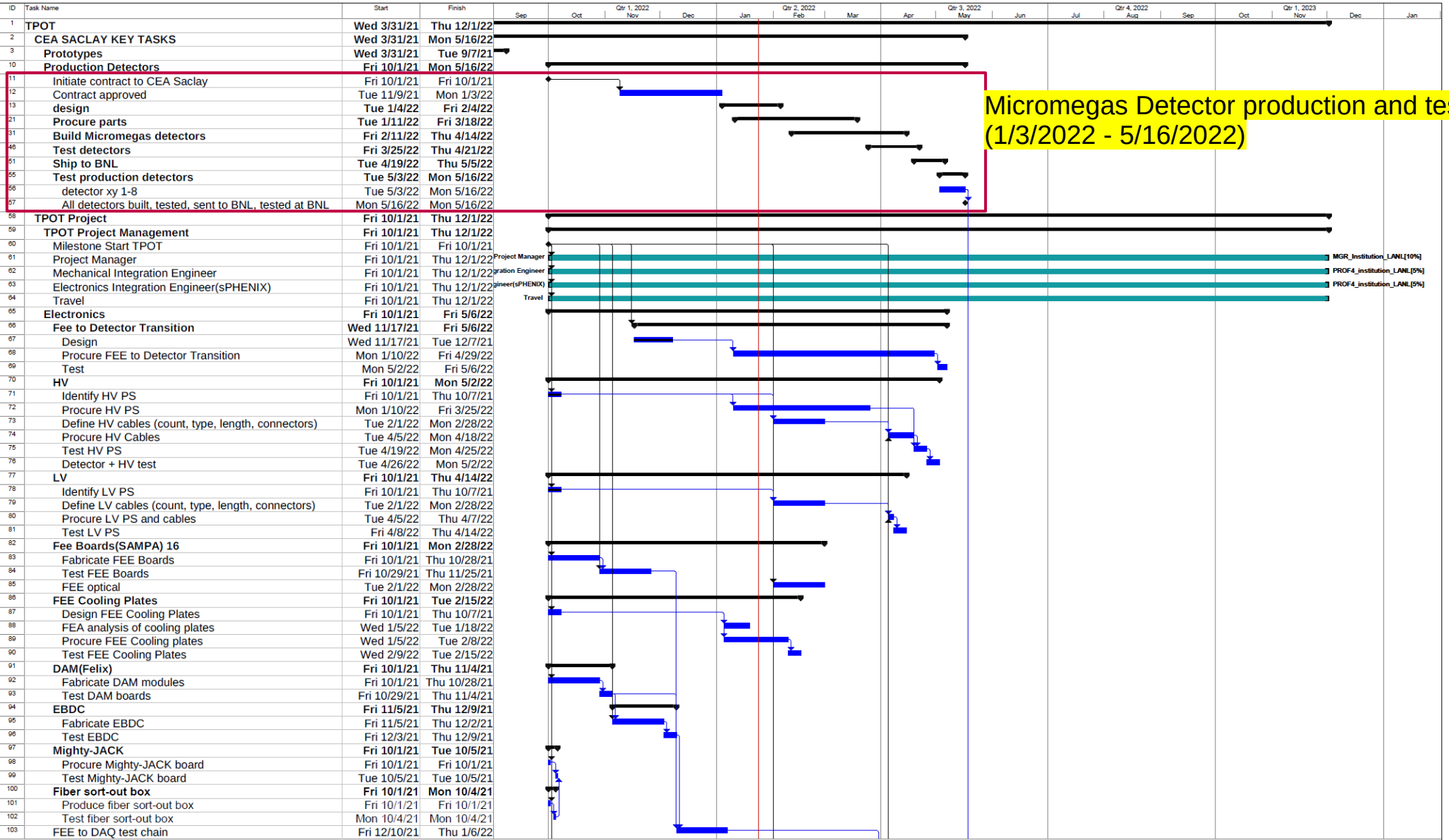
Details of contract with SACLAY for building 20 Micromegas detectors

All person power (physicist, engineer, technician) considered as in-kind, except for dedicated fixed-term contract

Hardware			
	price	quantity	total (Euro)
PCB	1,068	20	21,360
Resistive Layer	1068	20	21,360
bulk	1,023.5	20	20,470
Drift	445	20	8,900
Mechanics	1,780	20	35,600
HV boards	534	20	10,680
Consumable	26,700	1	26,700
Shipment	4,450	2	8,900
Installation	26,130	1	26,030
Total Hardware			**180,000**
Human Resources			
Fixed term contract			90,000
Total (Euro)			**270,000**
Total ($)			**337,500**

Schedule

- Original schedule presented at ALD's C&S TPOT Review (1-2 Sept 2021)
- Modified to account for descoping, (8 modules instead of 26)
- Assumes start of project on October 1st
- Assumes Micromegas production contract signed on Jan. 10 2021



ID	Task Name	Start	Finish
1	**TPOT**	**Wed 3/31/21**	**Thu 12/1/22**
2	**CEA SACLAY KEY TASKS**	**Wed 3/31/21**	**Mon 5/16/22**
3	**Prototypes**	**Wed 3/31/21**	**Tue 9/7/21**
10	**Production Detectors**	**Fri 10/1/21**	**Mon 5/16/22**
11	Initiate contract to CEA Saclay	Fri 10/1/21	Fri 10/1/21
12	Contract approved	Tue 11/9/21	Mon 1/3/22
13	**design**	**Tue 1/4/22**	**Fri 2/4/22**
21	**Procure parts**	**Tue 1/11/22**	**Fri 3/18/22**
31	**Build Micromegas detectors**	**Fri 2/11/22**	**Thu 4/14/22**
46	**Test detectors**	**Fri 3/25/22**	**Thu 4/21/22**
51	**Ship to BNL**	**Tue 4/19/22**	**Thu 5/5/22**
55	**Test production detectors**	**Tue 5/3/22**	**Mon 5/16/22**
56	detector xy 1-8	Tue 5/3/22	Mon 5/16/22
57	All detectors built, tested, sent to BNL, tested at BNL	Mon 5/16/22	Mon 5/16/22
58	**TPOT Project**	**Fri 10/1/21**	**Thu 12/1/22**
59	**TPOT Project Management**	**Fri 10/1/21**	**Thu 12/1/22**
60	Milestone Start TPOT	Fri 10/1/21	Fri 10/1/21
61	Project Manager	Fri 10/1/21	Thu 12/1/22
62	Mechanical Integration Engineer	Fri 10/1/21	Thu 12/1/22
63	Electronics Integration Engineer(sPHENIX)	Fri 10/1/21	Thu 12/1/22
64	Travel	Fri 10/1/21	Thu 12/1/22
65	**Electronics**	**Fri 10/1/21**	**Fri 5/6/22**
66	**Fee to Detector Transition**	**Wed 11/17/21**	**Fri 5/6/22**
67	Design	Wed 11/17/21	Tue 12/7/21
68	Procure FEE to Detector Transition	Mon 1/10/22	Fri 4/29/22
69	Test	Mon 5/2/22	Fri 5/6/22
70	**HV**	**Fri 10/1/21**	**Mon 5/2/22**
71	Identify HV PS	Fri 10/1/21	Thu 10/7/21
72	Procure HV PS	Mon 1/10/22	Fri 3/25/22
73	Define HV cables (count, type, length, connectors)	Tue 2/1/22	Mon 2/28/22
74	Procure HV Cables	Tue 4/5/22	Mon 4/18/22
75	Test HV PS	Tue 4/19/22	Mon 4/25/22
76	Detector + HV test	Tue 4/26/22	Mon 5/2/22
77	**LV**	**Fri 10/1/21**	**Thu 4/14/22**
78	Identify LV PS	Fri 10/1/21	Thu 10/7/21
79	Define LV cables (count, type, length, connectors)	Tue 2/1/22	Mon 2/28/22
80	Procure LV PS and cables	Tue 4/5/22	Thu 4/7/22
81	Test LV PS	Fri 4/8/22	Thu 4/14/22
82	**Fee Boards(SAMPA) 16**	**Fri 10/1/21**	**Mon 2/28/22**
83	Fabricate FEE Boards	Fri 10/1/21	Thu 10/28/21
84	Test FEE Boards	Fri 10/29/21	Thu 11/25/21
85	FEE optical	Tue 2/1/22	Mon 2/28/22
86	**FEE Cooling Plates**	**Fri 10/1/21**	**Tue 2/15/22**
87	Design FEE Cooling Plates	Fri 10/1/21	Thu 10/7/21
88	FEA analysis of cooling plates	Wed 1/5/22	Tue 1/18/22
89	Procure FEE Cooling plates	Wed 1/5/22	Tue 2/8/22
90	Test FEE Cooling Plates	Wed 2/9/22	Tue 2/15/22
91	**DAM(Felix)**	**Fri 10/1/21**	**Thu 11/4/21**
92	Fabricate DAM modules	Fri 10/1/21	Thu 10/28/21
93	Test DAM boards	Fri 10/29/21	Thu 11/4/21
94	**EBDC**	**Fri 11/5/21**	**Thu 12/9/21**
95	Fabricate EBDC	Fri 11/5/21	Thu 12/2/21
96	Test EBDC	Fri 12/3/21	Thu 12/9/21
97	**Mighty-JACK**	**Fri 10/1/21**	**Tue 10/5/21**
98	Procure Mighty-JACK board	Fri 10/1/21	Fri 10/1/21
99	Test Mighty-JACK board	Tue 10/5/21	Tue 10/5/21
100	**Fiber sort-out box**	**Fri 10/1/21**	**Mon 10/4/21**
101	Produce fiber sort-out box	Fri 10/1/21	Fri 10/1/21
102	Test fiber sort-out box	Mon 10/4/21	Mon 10/4/21
103	FEE to DAQ test chain	Fri 12/10/21	Thu 1/6/22

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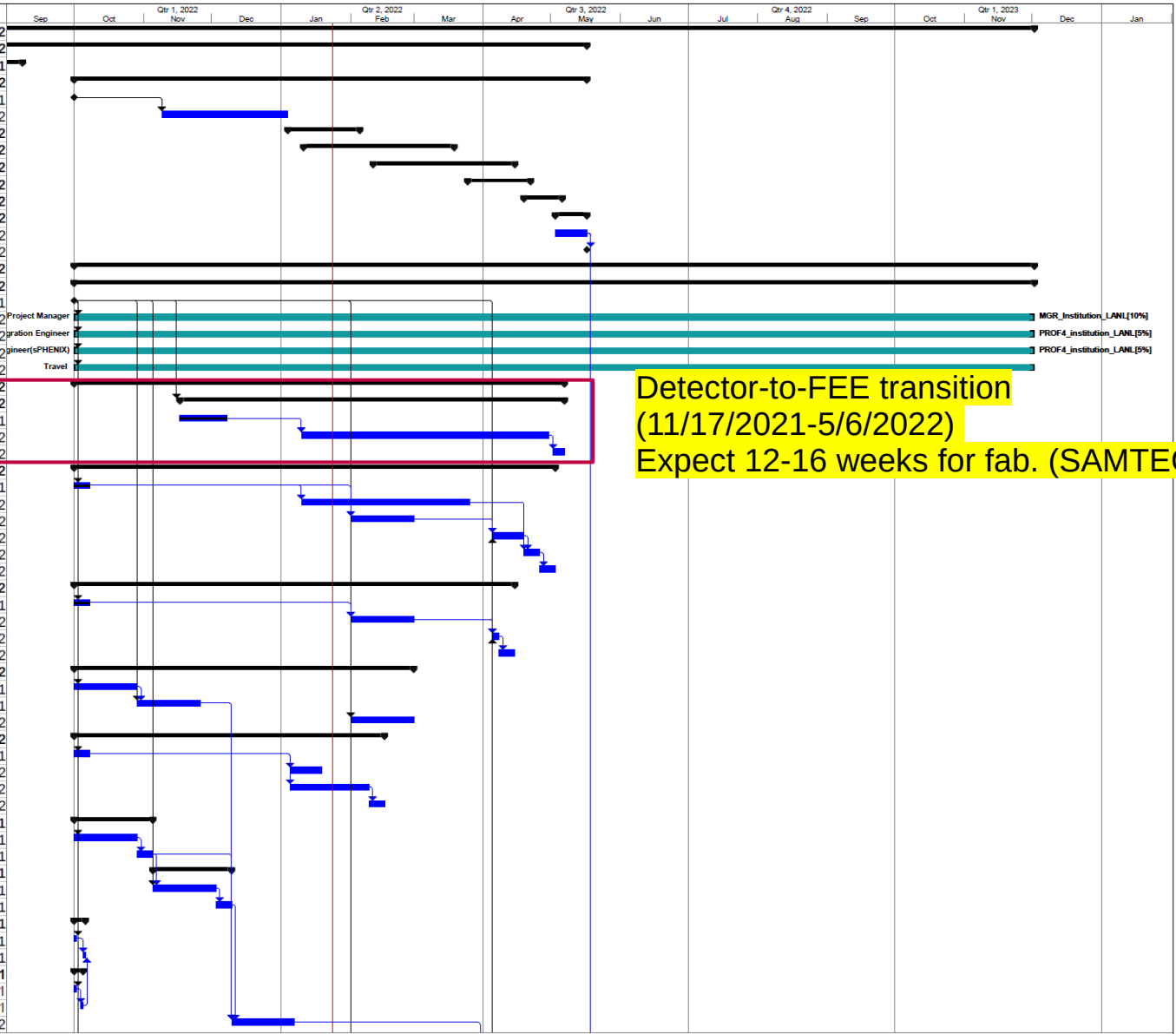
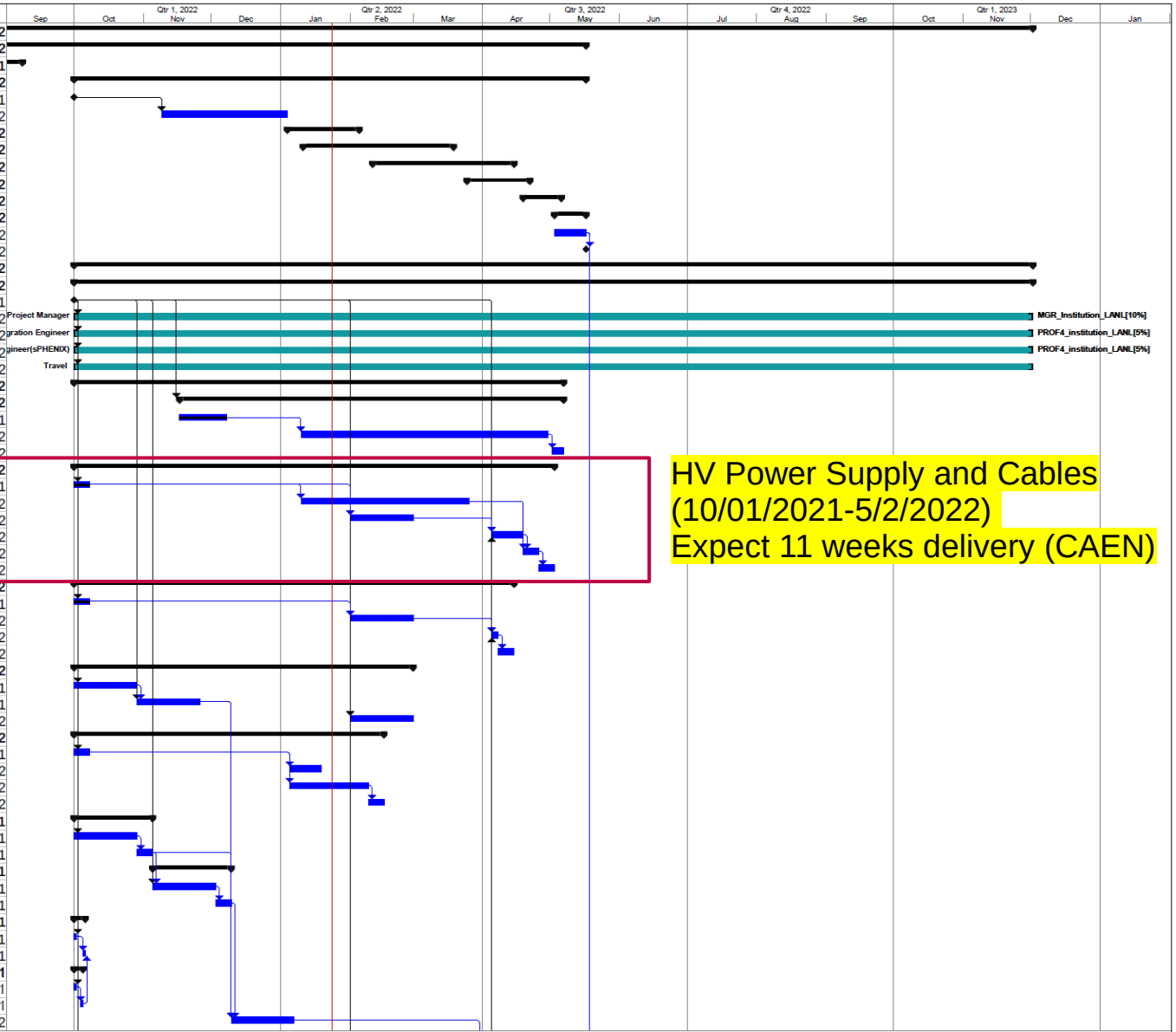
84	Test FEE Boards	Fri 10/29/21	Thu 11/25/21
85	FEE optical	Tue 2/1/22	Mon 2/28/22
86	**FEE Cooling Plates**	**Fri 10/1/21**	**Tue 2/15/22**
87	Design FEE Cooling Plates	Fri 10/1/21	Thu 10/7/21
88	FEA analysis of cooling plates	Wed 1/5/22	Tue 1/18/22
89	Procure FEE Cooling plates	Wed 1/5/22	Tue 2/8/22
90	Test FEE Cooling Plates	Wed 2/9/22	Tue 2/15/22
91	**DAM(Felix)**	**Fri 10/1/21**	**Thu 11/4/21**
92	Fabricate DAM modules	Fri 10/1/21	Thu 10/28/21
93	Test DAM boards	Fri 10/29/21	Thu 11/4/21
94	**EBDC**	**Fri 11/5/21**	**Thu 12/9/21**
95	Fabricate EBDC	Fri 11/5/21	Thu 12/2/21
96	Test EBDC	Fri 12/3/21	Thu 12/9/21
97	**Mighty-JACK**	**Fri 10/1/21**	**Tue 10/5/21**
98	Procure Mighty-JACK board	Fri 10/1/21	Fri 10/1/21
99	Test Mighty-JACK board	Tue 10/5/21	Tue 10/5/21
100	**Fiber sort-out box**	**Fri 10/1/21**	**Mon 10/4/21**
101	Produce fiber sort-out box	Fri 10/1/21	Fri 10/1/21
102	Test fiber sort-out box	Mon 10/4/21	Mon 10/4/21
103	FEE to DAQ test chain	Fri 12/10/21	Thu 1/6/22

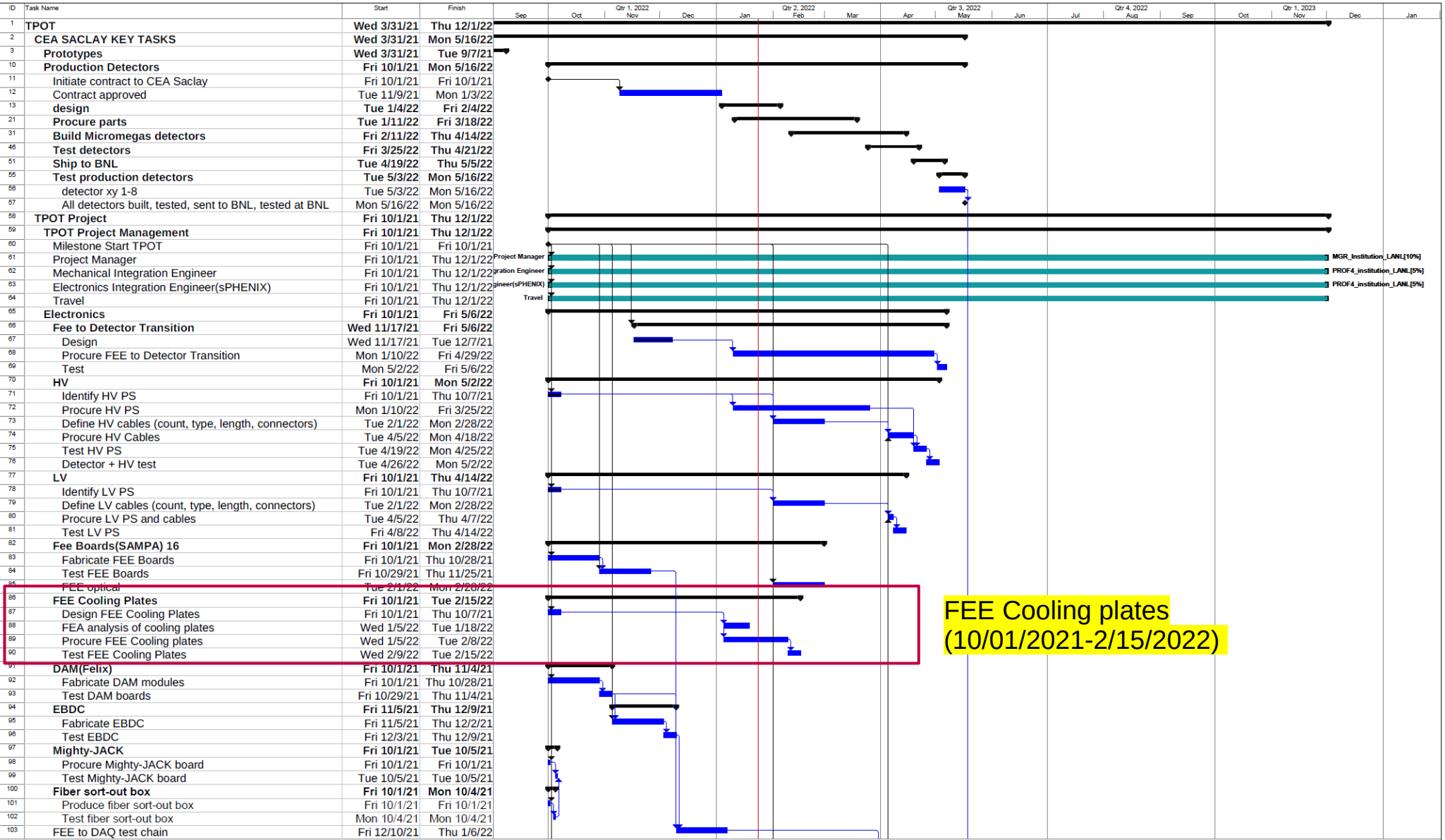


Detector-to-FEE transition (11/17/2021-5/6/2022)
Expect 12-16 weeks for fab. (SAMTEC)

ID	Task Name	Start	Finish
1	**TPOT**	**Wed 3/31/21**	**Thu 12/1/22**
2	**CEA SACLAY KEY TASKS**	**Wed 3/31/21**	**Mon 5/16/22**
3	**Prototypes**	**Wed 3/31/21**	**Tue 9/7/21**
10	**Production Detectors**	**Fri 10/1/21**	**Mon 5/16/22**
11	Initiate contract to CEA Saclay	Fri 10/1/21	Fri 10/1/21
12	Contract approved	Tue 11/9/21	Mon 1/3/22
13	**design**	**Tue 1/4/22**	**Fri 2/4/22**
21	**Procure parts**	**Tue 1/11/22**	**Fri 3/18/22**
31	**Build Micromegas detectors**	**Fri 2/11/22**	**Thu 4/14/22**
46	**Test detectors**	**Fri 3/25/22**	**Thu 4/21/22**
51	**Ship to BNL**	**Tue 4/19/22**	**Thu 5/5/22**
55	**Test production detectors**	**Tue 5/3/22**	**Mon 5/16/22**
56	detector xy 1-8	Tue 5/3/22	Mon 5/16/22
57	All detectors built, tested, sent to BNL, tested at BNL	Mon 5/16/22	Mon 5/16/22
58	**TPOT Project**	**Fri 10/1/21**	**Thu 12/1/22**
59	**TPOT Project Management**	**Fri 10/1/21**	**Thu 12/1/22**
60	Milestone Start TPOT	Fri 10/1/21	Fri 10/1/21
61	Project Manager	Fri 10/1/21	Thu 12/1/22
62	Mechanical Integration Engineer	Fri 10/1/21	Thu 12/1/22
63	Electronics Integration Engineer(sPHENIX)	Fri 10/1/21	Thu 12/1/22
64	Travel	Fri 10/1/21	Thu 12/1/22
65	**Electronics**	**Fri 10/1/21**	**Fri 5/6/22**
66	**Fee to Detector Transition**	**Wed 11/17/21**	**Fri 5/6/22**
67	Design	Wed 11/17/21	Tue 12/7/21
68	Procure FEE to Detector Transition	Mon 1/10/22	Fri 4/29/22
69	Test	Mon 5/2/22	Fri 5/6/22
70	**HV**	**Fri 10/1/21**	**Mon 5/2/22**
71	Identify HV PS	Fri 10/1/21	Thu 10/7/21
72	Procure HV PS	Mon 1/10/22	Fri 3/25/22
73	Define HV cables (count, type, length, connectors)	Tue 2/1/22	Mon 2/28/22
74	Procure HV Cables	Tue 4/5/22	Mon 4/18/22
75	Test HV PS	Tue 4/19/22	Mon 4/25/22
76	Detector + HV test	Tue 4/26/22	Mon 5/2/22
77	**LV**	**Fri 10/1/21**	**Thu 4/14/22**
78	Identify LV PS	Fri 10/1/21	Thu 10/7/21
79	Define LV cables (count, type, length, connectors)	Tue 2/1/22	Mon 2/28/22
80	Procure LV PS and cables	Tue 4/5/22	Thu 4/7/22
81	Test LV PS	Fri 4/8/22	Thu 4/14/22
82	**Fee Boards(SAMPA) 16**	**Fri 10/1/21**	**Mon 2/28/22**
83	Fabricate FEE Boards	Fri 10/1/21	Thu 10/28/21
84	Test FEE Boards	Fri 10/29/21	Thu 11/25/21
85	FEE optical	Tue 2/1/22	Mon 2/28/22
86	**FEE Cooling Plates**	**Fri 10/1/21**	**Tue 2/15/22**
87	Design FEE Cooling Plates	Fri 10/1/21	Thu 10/7/21
88	FEA analysis of cooling plates	Wed 1/5/22	Tue 1/18/22
89	Procure FEE Cooling plates	Wed 1/5/22	Tue 2/8/22
90	Test FEE Cooling Plates	Wed 2/9/22	Tue 2/15/22
91	**DAM(Felix)**	**Fri 10/1/21**	**Thu 11/4/21**
92	Fabricate DAM modules	Fri 10/1/21	Thu 10/28/21
93	Test DAM boards	Fri 10/29/21	Thu 11/4/21
94	**EBDC**	**Fri 11/5/21**	**Thu 12/9/21**
95	Fabricate EBDC	Fri 11/5/21	Thu 12/2/21
96	Test EBDC	Fri 12/3/21	Thu 12/9/21
97	**Mighty-JACK**	**Fri 10/1/21**	**Tue 10/5/21**
98	Procure Mighty-JACK board	Fri 10/1/21	Fri 10/1/21
99	Test Mighty-JACK board	Tue 10/5/21	Tue 10/5/21
100	**Fiber sort-out box**	**Fri 10/1/21**	**Mon 10/4/21**
101	Produce fiber sort-out box	Fri 10/1/21	Fri 10/1/21
102	Test fiber sort-out box	Mon 10/4/21	Mon 10/4/21
103	FEE to DAQ test chain	Fri 12/10/21	Thu 1/6/22



HV Power Supply and Cables (10/01/2021-5/2/2022)
Expect 11 weeks delivery (CAEN)


ID
Task Name
Start
Finish
Qtr 1, 2022
Qtr 2, 2022
Qtr 3, 2022
Qtr 4, 2022
Qtr 1, 2023
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
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Sep
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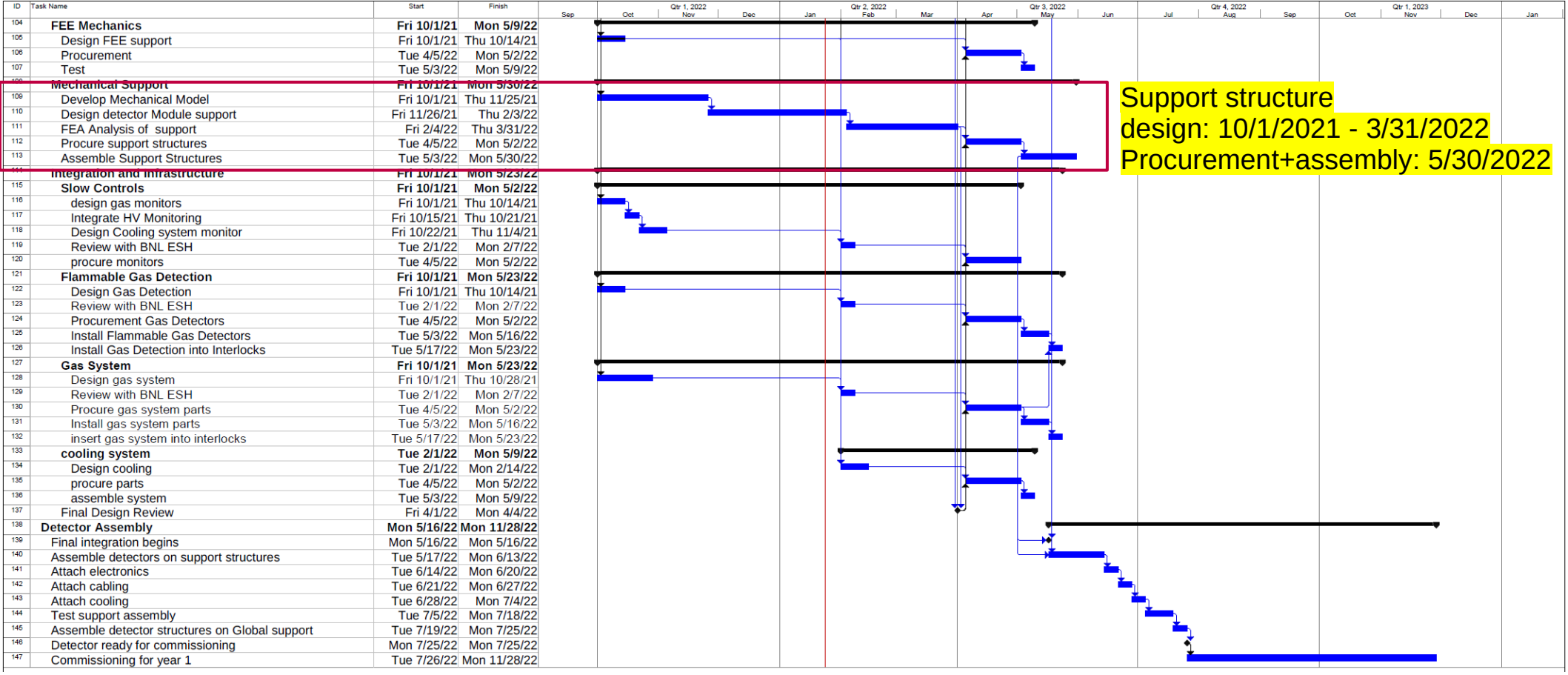
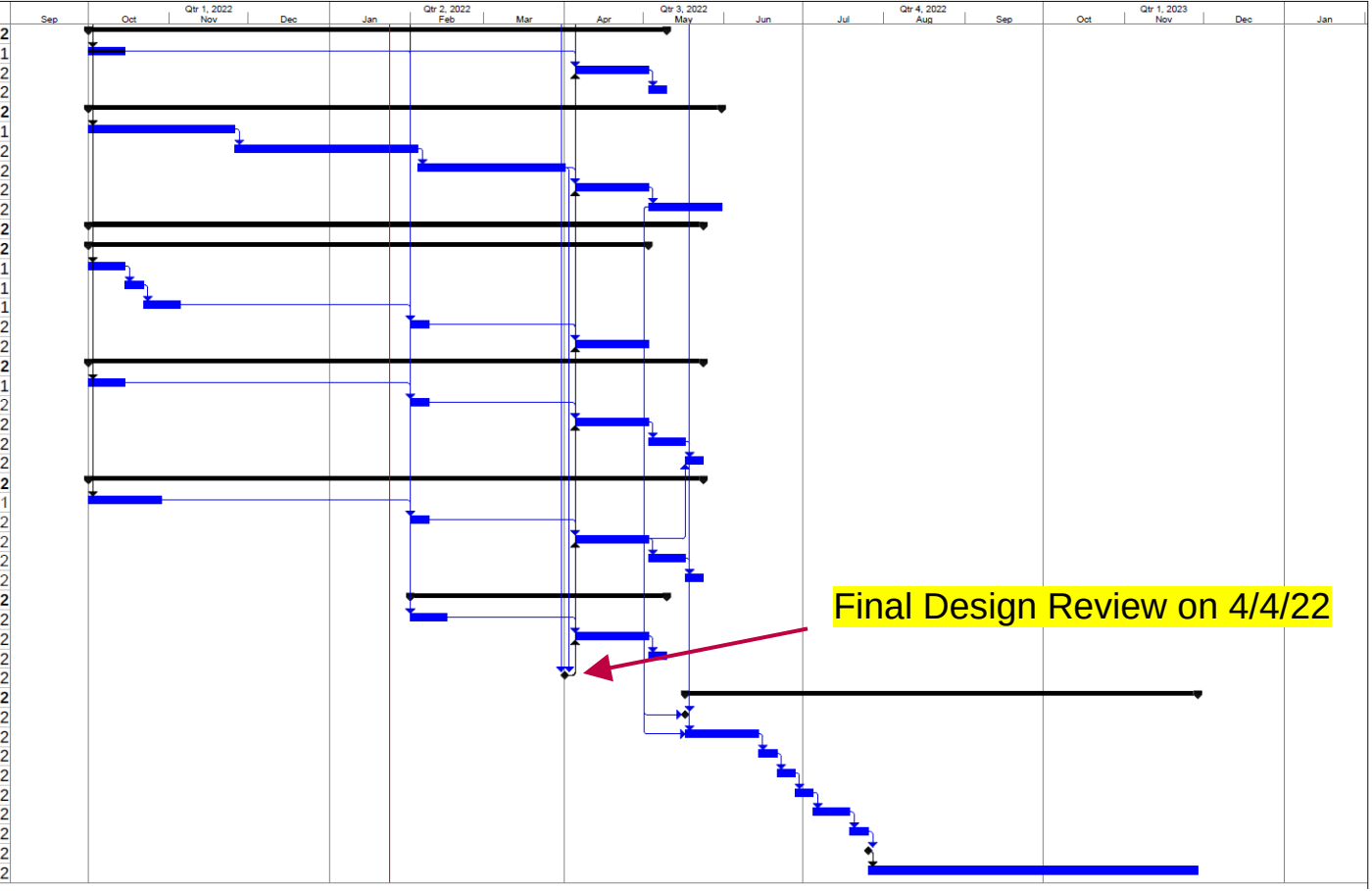
Dec
Jan
1 TPOT Wed 3/31/21 Thu 12/1/22
2 CEA SACLAY KEY TASKS Wed 3/31/21 Mon 5/16/22
3 Prototypes Wed 3/31/21 Tue 9/7/21
10 Production Detectors Fri 10/1/21 Mon 5/16/22
11 Initiate contract to CEA Saclay Fri 10/1/21 Fri 10/1/21
12 Contract approved Tue 11/9/21 Mon 1/3/22
13 design Tue 1/4/22 Fri 2/4/22
21 Procure parts Tue 1/11/22 Fri 3/18/22
31 Build Micromegas detectors Fri 2/11/22 Thu 4/14/22
46 Test detectors Fri 3/25/22 Thu 4/21/22
51 Ship to BNL Tue 4/19/22 Thu 5/5/22
55 Test production detectors Tue 5/3/22 Mon 5/16/22
56 detector xy 1-8 Tue 5/3/22 Mon 5/16/22
57 All detectors built, tested, sent to BNL, tested at BNL Mon 5/16/22 Mon 5/16/22
58 TPOT Project Fri 10/1/21 Thu 12/1/22
59 TPOT Project Management Fri 10/1/21 Thu 12/1/22
60 Milestone Start TPOT Fri 10/1/21 Fri 10/1/21
61 Project Manager Fri 10/1/21 Thu 12/1/22
62 Mechanical Integration Engineer Fri 10/1/21 Thu 12/1/22
63 Electronics Integration Engineer(sPHENIX) Fri 10/1/21 Thu 12/1/22
64 Travel Fri 10/1/21 Thu 12/1/22
65 Electronics Fri 10/1/21 Fri 5/6/22
66 Fee to Detector Transition Wed 11/17/21 Fri 5/6/22
67 Design Wed 11/17/21 Tue 12/7/21
68 Procure FEE to Detector Transition Mon 1/10/22 Fri 4/29/22
69 Test Mon 5/2/22 Fri 5/6/22
70 HV Fri 10/1/21 Mon 5/2/22
71 Identify HV PS Fri 10/1/21 Thu 10/7/21
72 Procure HV PS Mon 1/10/22 Fri 3/25/22
73 Define HV cables (count, type, length, connectors) Tue 2/1/22 Mon 2/28/22
74 Procure HV Cables Tue 4/5/22 Mon 4/18/22
75 Test HV PS Tue 4/19/22 Mon 4/25/22
76 Detector + HV test Tue 4/26/22 Mon 5/2/22
77 LV Fri 10/1/21 Thu 4/14/22
78 Identify LV PS Fri 10/1/21 Thu 10/7/21
79 Define LV cables (count, type, length, connectors) Tue 2/1/22 Mon 2/28/22
80 Procure LV PS and cables Tue 4/5/22 Thu 4/7/22
81 Test LV PS Fri 4/8/22 Thu 4/14/22
82 Fee Boards(SAMPA) 16 Fri 10/1/21 Mon 2/28/22
83 Fabricate FEE Boards Fri 10/1/21 Thu 10/28/21
84 Test FEE Boards Fri 10/29/21 Thu 11/25/21
86 FEE Cooling Plates Fri 10/1/21 Tue 2/15/22
87 Design FEE Cooling Plates Fri 10/1/21 Thu 10/7/21
88 FEA analysis of cooling plates Wed 1/5/22 Tue 1/18/22
89 Procure FEE Cooling plates Wed 1/5/22 Tue 2/8/22
90 Test FEE Cooling Plates Wed 2/9/22 Tue 2/15/22
91 DAM(Felix) Fri 10/1/21 Thu 11/4/21
92 Fabricate DAM modules Fri 10/1/21 Thu 10/28/21
93 Test DAM boards Fri 10/29/21 Thu 11/4/21
94 EBDC Fri 11/5/21 Thu 12/9/21
95 Fabricate EBDC Fri 11/5/21 Thu 12/2/21
96 Test EBDC Fri 12/3/21 Thu 12/9/21
97 Mighty-JACK Fri 10/1/21 Tue 10/5/21
98 Procure Mighty-JACK board Fri 10/1/21 Fri 10/1/21
99 Test Mighty-JACK board Tue 10/5/21 Tue 10/5/21
100 Fiber sort-out box Fri 10/1/21 Mon 10/4/21
101 Produce fiber sort-out box Fri 10/1/21 Fri 10/1/21
102 Test fiber sort-out box Mon 10/4/21 Mon 10/4/21
103 FEE to DAQ test chain Fri 12/10/21 Thu 1/6/22
Project Manager
gration Engineer
gineer(sPHENIX)
Travel
MGR_Institution_LANL[10%]
PROF4_institution_LANL[5%]
PROF4_institution_LANL[5%]
FEE Cooling plates
(10/01/2021-2/15/2022)

ID	Task Name	Start	Finish
104	**FEE Mechanics**	**Fri 10/1/21**	**Mon 5/9/22**
105	Design FEE support	Fri 10/1/21	Thu 10/14/21
106	Procurement	Tue 4/5/22	Mon 5/2/22
107	Test	Tue 5/3/22	Mon 5/9/22
108	**Mechanical Support**	**Fri 10/1/21**	**Mon 5/30/22**
109	Develop Mechanical Model	Fri 10/1/21	Thu 11/25/21
110	Design detector Module support	Fri 11/26/21	Thu 2/3/22
111	FEA Analysis of support	Fri 2/4/22	Thu 3/31/22
112	Procure support structures	Tue 4/5/22	Mon 5/2/22
113	Assemble Support Structures	Tue 5/3/22	Mon 5/30/22
114	**Integration and Infrastructure**	**Fri 10/1/21**	**Mon 5/23/22**
115	**Slow Controls**	**Fri 10/1/21**	**Mon 5/2/22**
116	design gas monitors	Fri 10/1/21	Thu 10/14/21
117	Integrate HV Monitoring	Fri 10/15/21	Thu 10/21/21
118	Design Cooling system monitor	Fri 10/22/21	Thu 11/4/21
119	Review with BNL ESH	Tue 2/1/22	Mon 2/7/22
120	procure monitors	Tue 4/5/22	Mon 5/2/22
121	**Flammable Gas Detection**	**Fri 10/1/21**	**Mon 5/23/22**
122	Design Gas Detection	Fri 10/1/21	Thu 10/14/21
123	Review with BNL ESH	Tue 2/1/22	Mon 2/7/22
124	Procurement Gas Detectors	Tue 4/5/22	Mon 5/2/22
125	Install Flammable Gas Detectors	Tue 5/3/22	Mon 5/16/22
126	Install Gas Detection into Interlocks	Tue 5/17/22	Mon 5/23/22
127	**Gas System**	**Fri 10/1/21**	**Mon 5/23/22**
128	Design gas system	Fri 10/1/21	Thu 10/28/21
129	Review with BNL ESH	Tue 2/1/22	Mon 2/7/22
130	Procure gas system parts	Tue 4/5/22	Mon 5/2/22
131	Install gas system parts	Tue 5/3/22	Mon 5/16/22
132	insert gas system into interlocks	Tue 5/17/22	Mon 5/23/22
133	**cooling system**	**Tue 2/1/22**	**Mon 5/9/22**
134	Design cooling	Tue 2/1/22	Mon 2/14/22
135	procure parts	Tue 4/5/22	Mon 5/2/22
136	assemble system	Tue 5/3/22	Mon 5/9/22
137	Final Design Review	Fri 4/1/22	Mon 4/4/22
138	**Detector Assembly**	**Mon 5/16/22**	**Mon 11/28/22**
139	Final integration begins	Mon 5/16/22	Mon 5/16/22
140	Assemble detectors on support structures	Tue 5/17/22	Mon 6/13/22
141	Attach electronics	Tue 6/14/22	Mon 6/20/22
142	Attach cabling	Tue 6/21/22	Mon 6/27/22
143	Attach cooling	Tue 6/28/22	Mon 7/4/22
144	Test support assembly	Tue 7/5/22	Mon 7/18/22
145	Assemble detector structures on Global support	Tue 7/19/22	Mon 7/25/22
146	Detector ready for commissioning	Mon 7/25/22	Mon 7/25/22
147	Commissioning for year 1	Tue 7/26/22	Mon 11/28/22

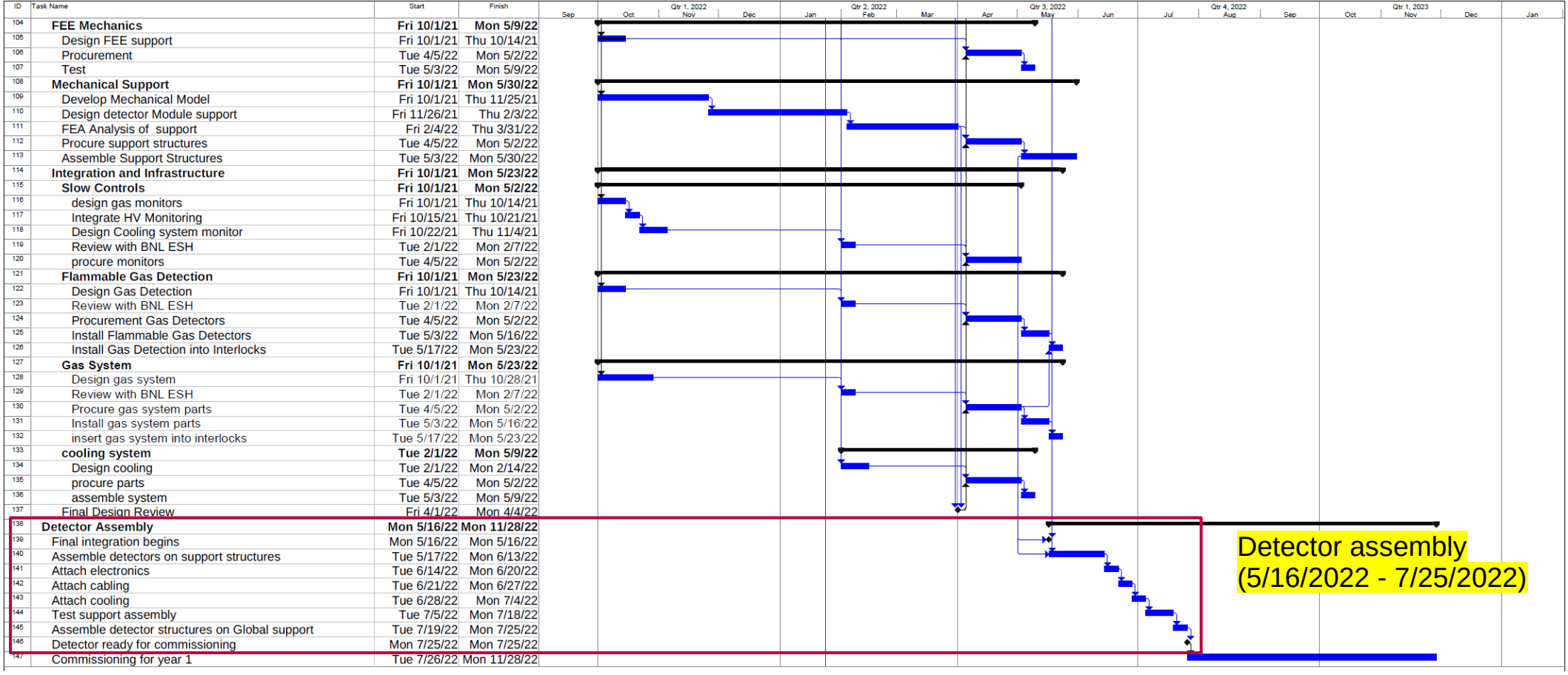


Support structure
design: 10/1/2021 - 3/31/2022
Procurement+assembly: 5/30/2022

ID	Task Name	Start	Finish
104	**FEE Mechanics**	**Fri 10/1/21**	**Mon 5/9/22**
105	Design FEE support	Fri 10/1/21	Thu 10/14/21
106	Procurement	Tue 4/5/22	Mon 5/2/22
107	Test	Tue 5/3/22	Mon 5/9/22
108	**Mechanical Support**	**Fri 10/1/21**	**Mon 5/30/22**
109	Develop Mechanical Model	Fri 10/1/21	Thu 11/25/21
110	Design detector Module support	Fri 11/26/21	Thu 2/3/22
111	FEA Analysis of support	Fri 2/4/22	Thu 3/31/22
112	Procure support structures	Tue 4/5/22	Mon 5/2/22
113	Assemble Support Structures	Tue 5/3/22	Mon 5/30/22
114	**Integration and Infrastructure**	**Fri 10/1/21**	**Mon 5/23/22**
115	**Slow Controls**	**Fri 10/1/21**	**Mon 5/2/22**
116	design gas monitors	Fri 10/1/21	Thu 10/14/21
117	Integrate HV Monitoring	Fri 10/15/21	Thu 10/21/21
118	Design Cooling system monitor	Fri 10/22/21	Thu 11/4/21
119	Review with BNL ESH	Tue 2/1/22	Mon 2/7/22
120	procure monitors	Tue 4/5/22	Mon 5/2/22
121	**Flammable Gas Detection**	**Fri 10/1/21**	**Mon 5/23/22**
122	Design Gas Detection	Fri 10/1/21	Thu 10/14/21
123	Review with BNL ESH	Tue 2/1/22	Mon 2/7/22
124	Procurement Gas Detectors	Tue 4/5/22	Mon 5/2/22
125	Install Flammable Gas Detectors	Tue 5/3/22	Mon 5/16/22
126	Install Gas Detection into Interlocks	Tue 5/17/22	Mon 5/23/22
127	**Gas System**	**Fri 10/1/21**	**Mon 5/23/22**
128	Design gas system	Fri 10/1/21	Thu 10/28/21
129	Review with BNL ESH	Tue 2/1/22	Mon 2/7/22
130	Procure gas system parts	Tue 4/5/22	Mon 5/2/22
131	Install gas system parts	Tue 5/3/22	Mon 5/16/22
132	insert gas system into interlocks	Tue 5/17/22	Mon 5/23/22
133	**cooling system**	**Tue 2/1/22**	**Mon 5/9/22**
134	Design cooling	Tue 2/1/22	Mon 2/14/22
135	procure parts	Tue 4/5/22	Mon 5/2/22
136	assemble system	Tue 5/3/22	Mon 5/9/22
137	Final Design Review	Fri 4/1/22	Mon 4/4/22
138	**Detector Assembly**	**Mon 5/16/22**	**Mon 11/28/22**
139	Final integration begins	Mon 5/16/22	Mon 5/16/22
140	Assemble detectors on support structures	Tue 5/17/22	Mon 6/13/22
141	Attach electronics	Tue 6/14/22	Mon 6/20/22
142	Attach cabling	Tue 6/21/22	Mon 6/27/22
143	Attach cooling	Tue 6/28/22	Mon 7/4/22
144	Test support assembly	Tue 7/5/22	Mon 7/18/22
145	Assemble detector structures on Global support	Tue 7/19/22	Mon 7/25/22
146	Detector ready for commissioning	Mon 7/25/22	Mon 7/25/22
147	Commissioning for year 1	Tue 7/26/22	Mon 11/28/22



ID	Task Name	Start	Finish
104	**FEE Mechanics**	**Fri 10/1/21**	**Mon 5/9/22**
105	Design FEE support	Fri 10/1/21	Thu 10/14/21
106	Procurement	Tue 4/5/22	Mon 5/2/22
107	Test	Tue 5/3/22	Mon 5/9/22
108	**Mechanical Support**	**Fri 10/1/21**	**Mon 5/30/22**
109	Develop Mechanical Model	Fri 10/1/21	Thu 11/25/21
110	Design detector Module support	Fri 11/26/21	Thu 2/3/22
111	FEA Analysis of support	Fri 2/4/22	Thu 3/31/22
112	Procure support structures	Tue 4/5/22	Mon 5/2/22
113	Assemble Support Structures	Tue 5/3/22	Mon 5/30/22
114	**Integration and Infrastructure**	**Fri 10/1/21**	**Mon 5/23/22**
115	**Slow Controls**	**Fri 10/1/21**	**Mon 5/2/22**
116	design gas monitors	Fri 10/1/21	Thu 10/14/21
117	Integrate HV Monitoring	Fri 10/15/21	Thu 10/21/21
118	Design Cooling system monitor	Fri 10/22/21	Thu 11/4/21
119	Review with BNL ESH	Tue 2/1/22	Mon 2/7/22
120	procure monitors	Tue 4/5/22	Mon 5/2/22
121	**Flammable Gas Detection**	**Fri 10/1/21**	**Mon 5/23/22**
122	Design Gas Detection	Fri 10/1/21	Thu 10/14/21
123	Review with BNL ESH	Tue 2/1/22	Mon 2/7/22
124	Procurement Gas Detectors	Tue 4/5/22	Mon 5/2/22
125	Install Flammable Gas Detectors	Tue 5/3/22	Mon 5/16/22
126	Install Gas Detection into Interlocks	Tue 5/17/22	Mon 5/23/22
127	**Gas System**	**Fri 10/1/21**	**Mon 5/23/22**
128	Design gas system	Fri 10/1/21	Thu 10/28/21
129	Review with BNL ESH	Tue 2/1/22	Mon 2/7/22
130	Procure gas system parts	Tue 4/5/22	Mon 5/2/22
131	Install gas system parts	Tue 5/3/22	Mon 5/16/22
132	insert gas system into interlocks	Tue 5/17/22	Mon 5/23/22
133	**cooling system**	**Tue 2/1/22**	**Mon 5/9/22**
134	Design cooling	Tue 2/1/22	Mon 2/14/22
135	procure parts	Tue 4/5/22	Mon 5/2/22
136	assemble system	Tue 5/3/22	Mon 5/9/22
137	Final Design Review	Fri 4/1/22	Mon 4/4/22
138	**Detector Assembly**	**Mon 5/16/22**	**Mon 11/28/22**
139	Final integration begins	Mon 5/16/22	Mon 5/16/22
140	Assemble detectors on support structures	Tue 5/17/22	Mon 6/13/22
141	Attach electronics	Tue 6/14/22	Mon 6/20/22
142	Attach cabling	Tue 6/21/22	Mon 6/27/22
143	Attach cooling	Tue 6/28/22	Mon 7/4/22
144	Test support assembly	Tue 7/5/22	Mon 7/18/22
145	Assemble detector structures on Global support	Tue 7/19/22	Mon 7/25/22
146	Detector ready for commissioning	Mon 7/25/22	Mon 7/25/22
147	Commissioning for year 1	Tue 7/26/22	Mon 11/28/22



Schedule consistent with TPOT being installed inside EMCAL before TPC insertion, and ready for commissioning on 7/25/2022

Milestones

01/03/2022	Production detector contract with Saclay
01/10/2022	Micromegas detector prototype available at BNL for testing
01/26/2022	Completed FEE+Detector test at BNL
01/26/2022	Technical review
03/24/2022	First Micromegas module constructed at Saclay
03/31/2022	Mechanical support structure design completed
04/04/2022	Final design review
04/05/2022	All Micromegas modules constructed at Saclay *
04/12/2022	Completion of Saclay in-house tests of all 10 Micromegas modules *
05/05/2022	All Micromegas modules built, tested, sent to BNL, tested at BNL *
05/16/2022	Everything (detector, mechanical support, FEE, HV, LV, etc.) ready for final integration into sPHENIX
07/25/2022	Detector assembled and installed inside sPHENIX EMCAL, before TPC insertion. Ready for commissioning

(*) milestones as they appear in contract with BNL.

Current schedule have them ~10 days later due to PCB delivery delays.

Does not affect project completion date. See presentation by Maxence

Summary

- A lot of progress on all fronts since ALD's C&S TPOT Review in Sept. 2021, and official green light to move forward on Nov. 9 2021
- Contract with Saclay finalized
- First purchase orders (HV hardware to CAEN, transition boards and cables to SAMTEC) have been placed
- All engineering and physicist needs for TPOT completion are covered by in-kind contributions from Saclay, LANL, MIT and BNL
- Fixed costs are covered by BNL. Costs details are understood and carefully monitored
- Schedule consistent with TPOT installed inside EMCAL and ready for commissioning on 7/25/2022

Summary (cont.)

Charge

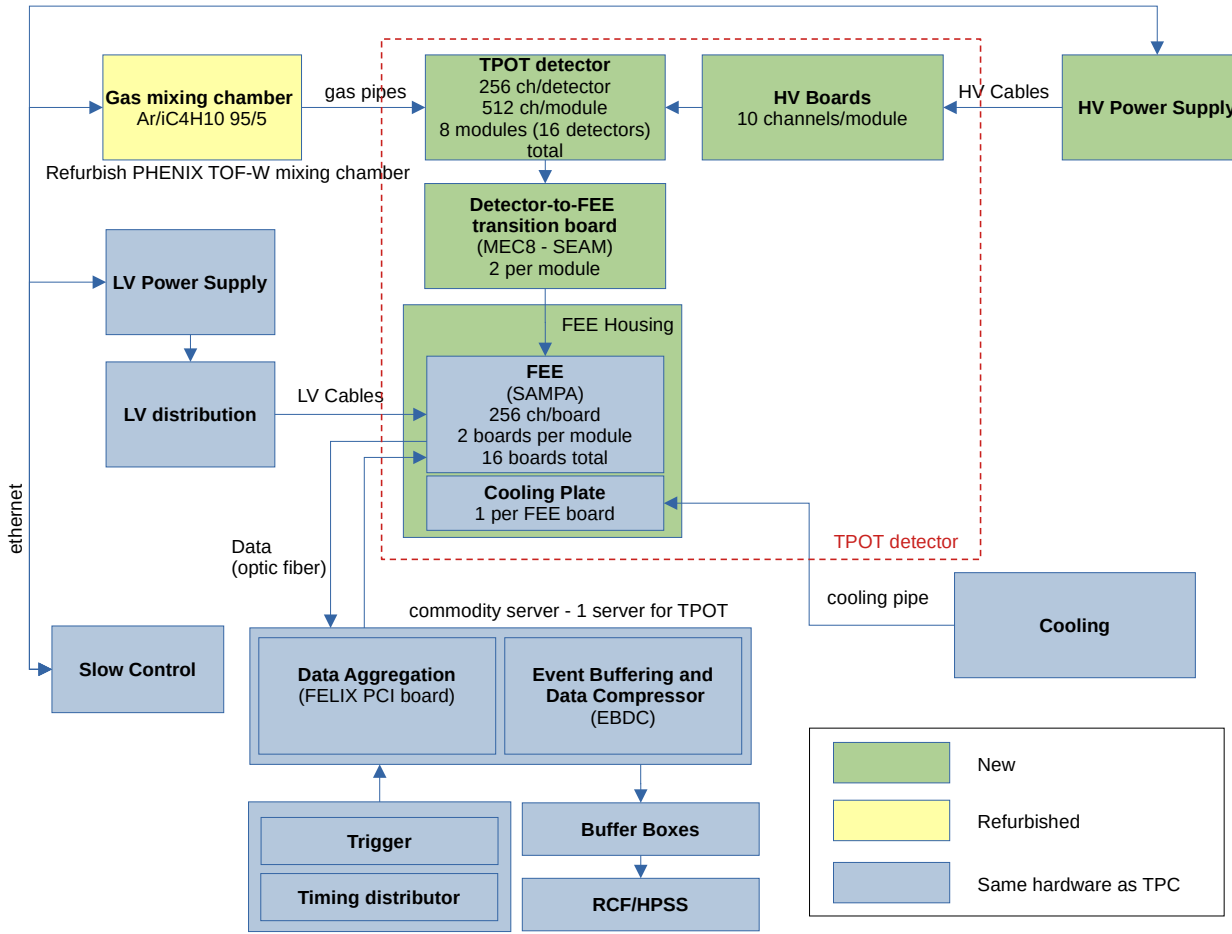
1. Are the technical details of the TPOT for installation and integration in sPHENIX sufficiently mature?
2. Is the gas system properly understood and at a level of maturity that will ensure safe operation of the TPOT and sPHENIX?
3. Is the schedule of the TPOT sufficiently well understood and matched to the plan for installation in sPHENIX?
4. Are the risks introduced by the TPOT upgrade into the successful operation of sPHENIX well understood, and are sufficient plans to mitigate these risks in place?
5. Are the interfaces and integration with sPHENIX and RHIC well understood?
6. Is the ES&H properly managed?
7. Are the costs of the TPOT sufficiently well understood, and are the resource needs required to complete the TPOT upgrade fully identified?

Agenda

- TPOT Overview - H.P. #3, 7
- Micromegas detector - Maxence Vandenbroucke #1,3
- Electronic and LV - Takao Sakaguchi #1,3,5
- Mechanical support and installation - Walter Sondheim #1,5
- Gas system, flammable gas detection - Rob Pisani #2, 5
- Services, slow control, ES&H - John Haggerty #2,5,6
- Risk assessment and mitigation, summary - H.P #4

BACKUP

Block diagram



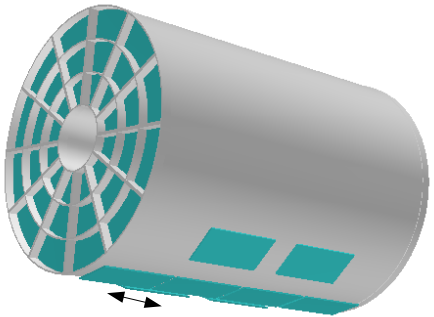
One TPOT module:

- 2 TPOT detectors
- FEE
- FEE transition board
- HV board
- FEE cooling plate
- FEE Housing

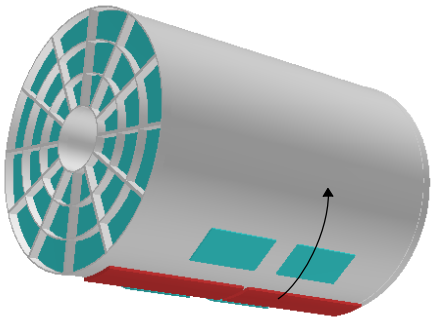
Services:

- FEE LV
- HV
- Gas
- FEE Cooling

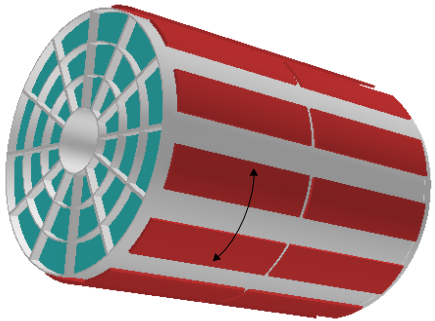
Distortion extrapolation procedure



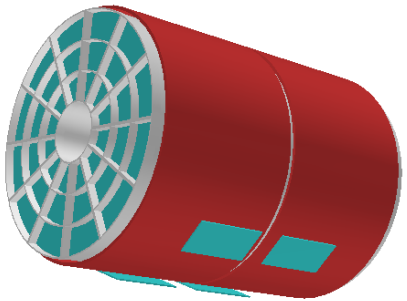
1) small z interpolation between Micromegas modules in fully equipped sector



2) copy z dependence to other sectors of the TPC using Central Membrane data, and analog currents, for normalization



3) Linear interpolation between sectors to cover full acceptance, possibly driven by Central Membrane data/analog currents



4) Compare extrapolated distortions to measurements from Micromegas, to validate the extrapolation and assign systematic uncertainties

Timeline

Jul. 2019:	First quantitative discussions with sPHENIX about an Outer Tracker detector
late 2019-early 2020:	first concrete Micromegas proposal to sPHENIX Institutional Board creation of a taskforce dedicated to optimize detector design and sPHENIX integration
Nov. 2020:	writing of a preliminary “management plan” (project description, deliverable, schedule, cost breakdown)
Dec. 2020:	internal review of the detector proposal with sPHENIX
Feb. 2021:	setup first contract BNL and Saclay for building prototypes
Jun. 2021:	presentation at NPP PAC meeting
Sept. 2021:	Associate Laboratory Director’s Cost & Schedule Review
Nov. 2021:	Green light from BNL NPP ALD, Haiyan Gao, to proceed with the TPOT project
Jan. 2022:	TPOT technical Review

FEE transition board concept drawings