

SPHE



Hugo Pereira Da Costa (LANL) TPOT technical review - July 20, 2022

Introduction

TPOT = TPc Outer Tracker

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)

Concept:

- 8 identical modules of Micromegas detectors (2x1D detectors each),
- Located at the bottom of the TPC, above the EMCAL,
- Attached to picture frames mounted on the I-HCAL

Outline:

- TPOT highlights since last ALD review (Jan. 2022)
- Cost and schedule
- Summary





INTT

MVTX

TPOT

TPC

Work force



Saclay	LANL	MIT	BNL
Maxence Vandenbroucke Stephan Aune Arnaud Bonenfant Audrey Francisco Cyril Goblin Aude Grabas Irakli Mandjavidize Ana Wills	Walter Sondheim Eric Renner Hubert van Hecke Dave Lee Bade Sayki H.P.	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)

Micromegas production at Saclay (1/3) SPHENCE















Micromegas production at Saclay (2/3) SPHENCE

- 9 out of 10 Micromegas modules produced
- 8 out of 10 modules are validated
- one module available at BNL since May 2022, all other modules at Saclay

<mark>Work to go</mark>:

- finish last module (module 10)
- validate the last two modules
- · assemble modules on detector trays
- metrology
- ship to BNL (exp. by July 25, if the detectors are hand-carried)





See presentation by Audrey

Micromegas detectors - performances

TPOT Key Performance Parameters

Radiation length (bare detector)	<10% x ₀	~
Active strips	> 90 %	~
Hit efficiency	>90 %	~
Hit resolution	< 200 μm (Φ layer), < 300μm (z layer)	~



See presentation by Audrey

July 20, 2022

TPOT ALD review



SPHENIX



Hit resoluton measurement, limited by large contribution from tracks

6

Electronics

SPHENIX

All parts at hand at BNL. Needed performance fully achieved

- All FEE boards needed for TPOT are available and tested
- Being assembled to support structure at BNL, together with gap pad and cooling plate (60% done)
- FEE-to-detector transition cables (SAMTEC) received and tested





Assembled FEE boards (5 modules)

July 20, 2022

Electronics (cont.)

- June 2022: successful test of TPOT Module 1 + final electronics at BNL
- July 2022: First complete module assembly with FEE board, cooling plates mechanics





SPHE



Mechanical integration and installation



See presentation by Walter

TPOT support structure

- Design finalized. FDR on May 18
- All parts ordered. Expected lead time: August 12 at BNL Assembly has already begun:
- detectors on tray (at Saclay)
- FEE + Gap pad + cooling plate on support (BNL)

TPOT transportation cart

Will be built at MIT/Bates Lead time: mid August

TPOT lifting

- Lifting fixtures will be built at MIT/Bates
- Lead time: mid September

Lifting/installation plan is being finalized with Russ Feder and sPHENIX Technical coordination





Cables and services

High Voltage

- HV Power Supply received and tested
- Work to go: HV cable definition and order

Low Voltage

- all cables ordered
- LV Power Supply follow sPHENIX schedule (will use free slots in TPC LV-PS)

Fibers

- ordered fibers from sort-out box to patch panel
- work to go: define and order fibers from patch panel to detector

Cooling:

- FEE cooling plates received and tested
- will use same chiller as TPC
- work to go: tubing from chiller to detector





SPHE



July 20, 2022

TPOT ALD review

10

Cables and services (cont.)

See presentations by Takao, John

- Gas
- ESRC review on June 21st
- will use pre-mix Ar/iC4H10 95/5 rather than doing the mix ourselves
- No additional flammable gas detection needed
- will use modified PHENIX TOFW gas system





Software (cont.)

sPHENIC reconstruction workflow (S&C review, 05/16)

Calibration needs

TPOT is but a small addition in scope wrt to TPC. It has very little calibration needs: pedestal and threshold, alignment

Code for pedestal and threshold easily adaptable from what is used for existing tests

TPOT geometrical implementation in sPHENIX is ready for sPHENIX alignment implementation (ACTS+millepede, ongoing)

SPHE

TPOT ability to reconstruct SC distortions in the TPC

Reconstruction readiness

TPOT fully integrated in sPHENIX reconstruction software and in the TPC distortion reconstruction chain since 2021

Job 0 **TPC clustering** MVTX Clustering **TPOT Clustering INTT** Clustering 5 0.3 CM meta-clustering CM residual calculations ă _{0.1}∲ Job C 30.03 Job A 02 0.02 **TPC** cluster cleaning ACTS silicon track seeding @= 1.833 rad @ = 1.833 rad φ = 1.833 rad Static distortion correction TPC track seeding z = 5.00 cm z = 5.00 cm z = 5.00 cm Static distortion correction TPC seed beamline propagation Input track seeds and -0.0 correction maps from Remove duplicate TPC seeds pass 1 -0.02 -0.03 TPC TOF z correction to raw clusters Static+average+fluctuat ACTS track fit on distortion corrections Silicon-TPC tracklet matching Move to surface for fit 30 30 70 Ghost track removal r (cm Static distortion correction **TPOT-TPC tracklet matching** Collision vertexing Silicon+TPOT ACTS track fit ACTS propagation to z=0 correction reco from CM vertex TPC residual calculation CM correction averaging z±0 reco from tracks extrapolate using CM z=0 Job B July 20, 2022 12 **TPOT ALD review**



Cost, Schedule, testing and installation plans



	Projected (\$)	Projected + contingency (\$)	Spent (\$)	Remaining (\$)	Remaining
Production Contract with Saclay	291,000	349,200	337,500	0	
FEE transition board	16,000	19,200	20,880	0	
HV Power Supply and cables	22,000	26,400	37,300	17,000	HV cables
LV Power Supply and cables	1,700	2,040	0	0	
FEE boards + Fibers	5,608	6,910	0	3,000	Fibers patch-panel to detector
FEE cooling plates	6,400	8,960	3,600	0	
FEE Backend (FELIX, EBDC, mighty-JACK,	14,000	16,800	0	0	
sort-out box)					
Mechanics	75,000	115,000	66,000	20,000	hardware, installation mechanics
Gas system	10,000	13,000	0	5,000	tubing
Cooling system	10,000	13,000	0	5,000	tubing
Total	451,708	570 <mark>,510</mark>	465,280	50,000	

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

Spending are under control, consistent with projections. We have spent ~90% of what we need.

Carefully monitored

Schedule



ID	Task Name	Start	Finish	Sen	Qtr 1, 2022	Qtr 2, 2022	Qtr 3, 2022	Qtr 4, 2022	Qtr 1, 2023	Dec	Jan
1	ТРОТ	Fri 10/21/05	Fri 2/10/23	000							- Can
2	CEA SACLAY KEY TASKS	Fri 10/21/05	Mon 8/8/22								
3	Prototypes	Wed 3/31/21	Tue 9/7/21								
10	Production Detectors	Fri 10/21/05	Mon 8/8/22								
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				Micron	nedas Dete	ector test at SBU		
21	Procure parts	Tue 1/11/22	Fri 3/18/22			¥ T	· · · · ·				
31	Build Micromegas detectors	Fri 2/11/22	Fri 6/24/22			-	(2w. 7/	26/2022 -	8/8/2022)		
45	Test detectors	Mon 4/25/22	Fri 7/8/22				• <u> </u>		0/0/2022)		
50	Ship to BNL	Fri 10/21/05	Mon 7/25/22								
54	Test production detectors	Tue 7/26/22	Mon 8/8/22								
55	Modules 1-10	Tue 7/26/22	Mon 8/8/22								
56	All detectors built, tested, sent to BNL,	Mon 8/8/22	Mon 8/8/22					•			
	tested at BNL										
57	TPOT Project	Fri 10/1/21	Thu 12/1/22		-				4		
58	TPOT Project Management	Fri 10/1/21	Thu 12/1/22								
59	Milestone Start TPOT	Fri 10/1/21	Fri 10/1/21		u 1						
60	Project Manager	Fri 10/1/21	Thu 12/1/22		9				M C	GR_Institution_L	LANL[10%]
61	Mechanical Integration Engineer	Fri 10/1/21	Thu 12/1/22		9				2 Ph	tor4_institution_	_LANL[5%]
62	Electronics Integration Engineer(sPHENIX)	Fri 10/1/21	Thu 12/1/22] Ph	tor4_institution_	LANL[5%]
63	Travel	Fri 10/1/21	Thu 12/1/22		Ž				1		
64	Electronics	Fri 10/1/21	Fri 8/12/22		•						
65	Fee to Detector Transition	Wed 11/17/21	Mon 7/18/22		t						
66	Design	Wed 11/17/21	Tue 12/7/21			+					
67	Procure FEE to Detector Transition	Fri 2/18/22	Thu 6/16/22			× *		— III			
68	Test	Tue 7/12/22	Mon 7/18/22								
69	HV	Fri 10/1/21	Fri 8/12/22								
70	Identify HV PS	Fri 10/1/21	Thu 10/7/21		*						
71	Procure HV PS	Mon 12/27/21	Fri 3/11/22		1						
72	Define HV cables (count, type, length, connectors)	Tue 2/1/22	Mon 2/28/22								
73	Procure HV Cables	Mon 8/1/22	Fri 8/12/22								
74	Test HV PS	Mon 5/30/22	Eri 6/3/22				│				
75	Detector + HV test	Tue 7/26/22	Mon 8/1/22								
76	LV	Fri 10/1/21	Thu 6/23/22								
77	Identify LV PS	Fri 10/1/21	Thu 10/7/21		¥						
78	Define LV cables (count, type, length,	Tue 2/1/22	Mon 2/28/22			×					
	connectors)										
79	Procure LV PS and cables	Fri 5/20/22	Thu 6/16/22								
80	Test LV PS	Fri 6/17/22	Thu 6/23/22								
81	Fee Boards(SAMPA) 16	Fri 10/1/21	Fri 7/15/22	· · ·							
82	Fabricate FEE Boards	Fri 10/1/21	Thu 10/28/21				<u>+</u>				
83	Test FEE Boards	Mon 6/20/22	Fri 7/15/22								
84	FEE optical	Tue 2/1/22	Mon 2/28/22								
85	FEE Cooling Plates	Fri 10/1/21	Mon 5/23/22		1		-				
86	Design FFF Cooling Plates	Fri 10/1/21	Thu 10/7/21			+					

July 20, 2022

Schedule



D	Task Name	Start	Finish	-		Qtr 1, 2022			Qtr 2, 2022			Qtr 3, 2022	1 .		Qtr 4, 2022			Qtr 1, 2023	-	
100	Produce fiber sort-out box	Eri 10/1/21	Fri 10/1/21	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Auq	Sep	Oct	Nov	Dec	Jan
101	Test fiber sort-out box	Mon 10/4/21	Mon 10/4/21		¥															
102	FFF to DAO test chain	Mon 5/23/22	Fri 6/3/22																	
103	FEE Mechanics	Fri 10/1/21	Mon 5/23/22																	
104	Design FEE support	Fri 10/1/21	Thu 10/14/21		*															
105	Procurement	Tue 4/19/22	Mon 5/16/22								•									<u></u>
105	Test	Tue 5/17/22	Mon 5/23/22								Me	char	nical s	unno	rt nrc	ocuren	ient a	and a	ssem	ibly
107	Mechanical Support	Fri 10/1/21	Eri 8/19/22										noai c	appo	it pic	Joaron			50011	
108	Develon Mechanical Model	Fri 10/1/21	Thu 11/25/21		+						<mark>(5</mark>)	v 7/1	8/202	22 - 8	/19/2	(022)				
109	Design detector Module support	Fri 11/26/21	Thu 2/3/22			*			_			v , <i>i i</i> <u>i</u>	.0/202	<u></u>		.022)				
110	EFA Analysis of support	Eri 2/4/22	Thu 3/31/22						*			~								
111	Procure support structures	Mon 7/18/22	Fri 8/12/22											*						
112	Assemble Support Structures	Mon 8/15/22	Fri 8/19/22											T T	* ,					
113	Integration and Infrastructure	Fri 10/1/21	Tue 8/16/22													'				
114	Slow Controls	Fri 10/1/21	Tue 7/26/22	•																
115	design gas monitors	Fri 10/1/21	Thu 10/14/21		*															
116	Integrate HV Monitoring	Fri 10/15/21	Thu 10/21/21		i 🎽															
117	Design Cooling system monitor	Fri 10/22/21	Thu 11/4/21																	
118	Review with BNL ESH	Wed 6/22/22	Tue 6/28/22										1							
119	procure monitors	Wed 6/29/22	Tue 7/26/22																	
120	Gas System	Fri 10/1/21	Tue 8/16/22	•																
121	Design gas system	Fri 10/1/21	Thu 10/28/21		*															
122	Review with BNL ESH	Wed 6/22/22	Tue 6/28/22										1							
123	Procure gas system parts	Wed 6/29/22	Tue 7/26/22																	
124	Install gas system parts	Wed 7/27/22	Tue 8/9/22											L 1						
125	insert gas system into interlocks	Wed 8/10/22	Tue 8/16/22												—					
126	cooling system	Tue 2/1/22	Thu 6/23/22						•				•							
127	Design cooling	Tue 2/1/22	Mon 2/14/22																	
128	procure parts	Fri 5/20/22	Thu 6/16/22									1								
129	assemble system	Fri 6/17/22	Thu 6/23/22										—							
130	Final Design Review	Wed 5/18/22	Thu 5/19/22									*	1		,					
131	ESRC review	Tue 6/21/22	Tue 6/21/22										P							
132	Detector Assembly	Fri 8/19/22	Fri 9/30/22												-					
133	Final integration begins	Fri 8/19/22	Fri 8/19/22												<u> </u>					
134	Assemble modules on support structures	Mon 8/22/22	Fri 8/26/22													4				
135	Attach electronics	Mon 8/29/22	Fri 9/2/22													<u> </u>				
136	Attach cabling	Mon 9/5/22	Fri 9/9/22													- 1				
137	Attach cooling	Mon 9/12/22	Fri 9/16/22													<u> </u>				
138	Test support assembly	Mon 9/19/22	Fri 9/30/22													Terrare 1				
139	Detector ready for integration in sPHENIX	Fri 9/30/22	Fri 9/30/22													•				
140	sPHENIX integration and commissioning	Mon 10/3/22	Fri 2/10/23																	
141	Assemble detector structures on EMCAL	Mon 10/3/22	Fri 10/7/22																	
142	Detector ready for commissioning	Fri 10/7/22	Fri 10/7/22														1			
143	Commissioning for year 1	Mon 10/10/22	Fri 2/10/23																	(

Schedule



ID T	ask Name	Start	Finish	Seo	Oct	Qtr 1, 2022	Dec	Jan	Qtr 2, 2022 Feb Mar	Apr	tr 3, 2022 May Jun	Jul.	Qtr 4, 2022	Sep	Oct	Qtr 1, 2023	Dec	Jan
100	Produce fiber sort-out box	Fri 10/1/21	Fri 10/1/21		Б													
101	Test fiber sort-out box	Mon 10/4/21	Mon 10/4/21		T I													
102	FEE to DAQ test chain	Mon 5/23/22	Fri 6/3/22								*							
103	FEE Mechanics	Fri 10/1/21	Mon 5/23/22		+													
104	Design FEE support	Fri 10/1/21	Thu 10/14/21		*					<u> </u>								
105	Procurement	Tue 4/19/22	Mon 5/16/22							*	_							
105	Test	Tue 5/17/22	Mon 5/23/22								*							
107	Mechanical Support	Fri 10/1/21	Fri 8/19/22		+													
108	Develop Mechanical Model	Fri 10/1/21	Thu 11/25/21		*													
109	Design detector Module support	Fri 11/26/21	Thu 2/3/22			*												
110	FEA Analysis of support	Fri 2/4/22	Thu 3/31/22						*		1							
111	Procure support structures	Mon 7/18/22	Fri 8/12/22															
112	Assemble Support Structures	Mon 8/15/22	Fri 8/19/22										1					
113	Integration and Infrastructure	Fri 10/1/21	Tue 8/16/22		+													
114	Slow Controls	Fri 10/1/21	Tue 7/26/22		+						-							
115	design gas monitors	Fri 10/1/21	Thu 10/14/21		*)													
116	Integrate HV Monitoring	Fri 10/15/21	Thu 10/21/21		i 🎽													
117	Design Cooling system monitor	Fri 10/22/21	Thu 11/4/21															
118	Review with BNL ESH	Wed 6/22/22	Tue 6/28/22								1 🎽							
119	procure monitors	Wed 6/29/22	Tue 7/26/22								L L							
120	Gas System	Fri 10/1/21	Tue 8/16/22		+						-							
121	Design gas system	Fri 10/1/21	Thu 10/28/21		*													
122	Review with BNL ESH	Wed 6/22/22	Tue 6/28/22								1							
123	Procure gas system parts	Wed 6/29/22	Tue 7/26/22								T.							
124	Install gas system parts	Wed 7/27/22	Tue 8/9/22									T 🕯						
125	insert gas system into interlocks	Wed 8/10/22	Tue 8/16/22															
126	cooling system	Tue 2/1/22	Thu 6/23/22															
127	Design cooling	Tue 2/1/22	Mon 2/14/22								I							
128	procure parts	Fri 5/20/22	Thu 6/16/22				N 4											the sec
129	assemble system	Fri 6/17/22	Thu 6/23/22					iule ir	istallatior	on sub	port, cor	inecti	ons a	and po	dst as	ssemb	IV TESI	and
130	Final Design Review	Wed 5/18/22	Thu 5/19/22				10	0.000	10000			· · · ·	- 11					<u> </u>
131	ESRC review	Tue 6/21/22	Tue 6/21/22				(6W)	8/22	12022 - 9	30/2022	/) 1							
132	Detector Assembly	Fri 8/19/22	Fri 9/30/22				(••••,	0			-/		-	-	•			
133	Final integration begins	Fri 0/19/22	Fri 8/19/22											_				
134	Assemble modules on support structures	Mon 8/22/22	Fri 8/26/22										*	-				
135	Attach electronics	Mon 8/29/22	Fri 9/2/22											1				
136	Attach cabling	Mon 9/5/22	Fri 9/9/22											*				
137	Attach cooling	Mon 9/12/22	Fri 9/16/22											*				
138	Test support assembly	Mon 9/19/22	Fri 9/30/22											*				
139	Detector ready for integration in sPHENIX	Fri 9/30/22	Fri 9/30/22												*			
140	sPHENIX integration and commissioning	Mon 10/3/22	Fri 2/10/23												÷			
141	Assemble detector structures on EMCAL	Mon 10/3/22	Fri 10/7/22												1			
142	Detector ready for commissioning	Fri 10/7/22	Fri 10/7/22												4			
143	Commissioning for year 1	Mon 10/10/22	Fri 2/10/23												+			

(see schedule summary in the backup)

High level milestones



Milestone	date	Status	risk
FEA analysis finished and reviewed	18/05/22	FDR happened. more FEA analyses requested. Agreed with Russ Feder to move forward	done
First batch of 5 TPOT Modules assembled & tested (Saclay)	07/06/22	6 modules assembled, test ongoing	done
FEE to detector fabricated and tested	07/18/22	cables/boards received on 6/21	done
HV system tested	06/16/22	happened on Week 21 (May 23)	done
Second batch of 5 TPOT modules assembled & tested (Saclay)	07/22/22		low
Characterization of all TPOT modules at SBU	08/08/22	(modules arrive at BNL on 7/25)	moderate
Gas system designed, ES&H reviewed and tested	07/07/22 → ?	designed and ESRC reviewed on 6/21	low
TPOT mechanical support assembled	08/19/22		moderate
installation of modules 1-4 on support structures	08/26/22		moderate
installation of modules 5-8 on support structures	08/26/22	same date. In parallel to modules 1-4	moderate
End of TPOT assembly	09/30/22		moderate
Installation of TPOT in sPHENIX	10/07/22	(also depends on sPHENIX schedule)	moderate

Detector characterization at SBU

what:

- Duplicate the cosmic setup at BNL
- Make sure detectors have not been damaged during transportation
- check HV and currents, gas tightness
- check noise level and efficiency on cosmics

when: July 25 - August 8 (2w)where: SBU (room S118)

who: Bade, Hugo, Takao, Audrey, Maxence (remotely)





SPHE

TPOT assembly at BNL



What:

Assemble support structure on transportation cart. Assemble detector on support structure. Connect all services from detector to patch pannel

When: Support structure: Aug. 15 to Aug. 19 (1w)

Detector on structure: Aug. 22 to Sept 16 (4w)

Where: Building 912

Who:

Stefan Aune (1w, 10d max), Arnaud Bonenfant, Cyril Goblin, Maxence, Audrey from Saclay Walter Sondheim, Eric Renner (LANL), Hugo, Bade + technical support from BNL

Post-assembly tests at BNL



What:

Test that everything is connected properly and alive once TPOT is assembled and before it is installed in EMCAL

- gas tightness
- FEE cooling tightness
- all LV connected to FEE boards
- all HV connected to detectors
- leakage currents
- all electronic channels responding
- noise levels
- detector survey on structure

When: Sept 19 to Sept 30 (2w), depending on sPHENIX magnet mapping schedule

Where: Building 912 or (more likely) 1008

Who: Hugo, Bade Sayki, Takao, + support from BNL (John H., John K., Rob.) + support from Saclay

Summary



TPOT project is well underway

- Detector production is nearly complete, fulfills KPP
- Everything is ordered to start detector assembly. Some assembly has already begun
- Almost everything ordered for interface to sPHENIX
- Costs are under control
- Schedule is tight, carefully monitored

Summary (cont.)



Charge

- 1. Are all the components for TPOT for installation and integration into sPHENIX produced and within specifications?
- 2. Are the quality control tests, acceptance tests, and characterization of TPOT modules within specifications?
- 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 gas system properly understood, including safety reviews, as needed for operation in sPHENIX?
- 7. Is the ES&H properly managed?
- 8. Is the software for calibrations for TPOT and production software for utilizing TPOT for TPC calibrations in place?

Agenda

- TPOT Overview H.P. #1, 3, 8
- Micromegas detector Audrey Francisco #3,6
- Electronic and LV Takao Sakaguchi #1,3,5
- Mechanical support and installation Walter Sondheim #1,5
- Services, slow control, ES&H John Haggerty #1,5,6, 7
- Risk assessment and mitigation, summary H.P #4

Backup

Simplified schedule



Task	Start date	End date
Micromegas detector test at SBU	7/26/22	8/8/22
TPOT support structure procurement	7/18/22	8/12/22
TPOT support structure assembly	8/15/22	8/19/22
Module installation on support, connection	8/22/22	9/16/22
Post assembly commissioning	9/19/22	9/30/22
TPOT installation on EMCAL	10/3/22	10/7/22



First signal observation with SAMPA

