

Risk assessment and mitigation

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TPOT technical review - July 20, 2022

- Methodology
- Risks relevant to TPOT construction
- Risks relevant to TPOT operation
- Risks relevant to sPHENIX (question 4 of the charge)

- Based on [sPHENIX risk management plan](#)
- Each risk relevant to TPOT construction gets a probability, a cost and a schedule impact
- Overall impact score calculated using matrix below:

	Low	Moderate	High
Cost	≤ \$100k	≤ \$225k	> \$225k
Schedule	≤ 3 months delay	≤ 6 months delay	> 6 months delay
Very Likely (>50%)	Moderate	High	High
Possible (≤50%)	Low	Moderate	High
Unlikely (≤10%)	Low	Low	Moderate
Rare (≤2%)	Low	Low	Low

- Risks relevant to TPOT operations and risks relevant to sPHENIX (installation and operation) only get an overall impact score

Overview



Risk Title	Mitigation	Residual risk likelihood	Residual schedule impact	Residual technical impact	Low cost impact (k\$)	Likely cost impact (k\$)	High cost impact (k\$)	Low Schedule impact	Likely Schedule impact	High Schedule impact	Overall impact score (residual)
Micromegas Parts Delivery Delay (e.g PCB)	Contacted different suppliers and ordered first PCBs for inspection										Happened
Micromegas Detector Delivery Delay	Choose robust, well tested Micromegas design. No R&D required.	Possible	Moderate		0	0	0	0.5	1	1	Moderate
FEE											
FEE/DAQ parts (boards, FELIX, fibers, EDBC) are late	Use same as TPC										Not realized
LV Power Supply, distribution, cables) are late	Use same as TPC	Unlikely	Low		0	0	0	1	3	6	Low
FEE to detector transition board	Close collaboration with SAMTEC to design custom PCB+FLEX										Not realized
FEE Cooling plates R&D and delivery is delayed	New design needed. Build on TPC studies. Expect simpler design as for TPC										Not realized
FEE Housing R&D and procurement is delayed											Not realized
Detector, FEE to DAQ Chain test	Same as TPC. Participate to TPC FEE to DAQ chain tests. Have plan B to decouple electronics from detector.										Not realized
Detector + FEE + Housing assembly test is not successful	Have the same team design Detector, FEE transition board and FEE housing (CEA)										Not realized
Other services											
Gas Mixing Chamber design and construction is delayed	Refurbish PHENIX TOF-W mixing chamber	Unlikely	Low		0	0	0	2	3	4	Low
Gas Monitoring design is delayed	Gas mixture considered non flammable	Unlikely	Low		50	100	200	2	4	6	Low
Detector + Gas system test is not successful		Unlikely	Low		0	0	0	2	3	4	Low
HV Power Supply availability is delayed	Use same HV PS as for ATLAS NSW. Use standard cables, have them assembled at SBU workshop										Not realized
HV distribution cables availability is delayed	Use same HV PS as for ATLAS NSW. Use standard cables, have them assembled at SBU workshop	Possible	Moderate		0	0	0	2	4	6	Moderate
HV Monitoring	Use same HV PS and monitoring as ATLAS NSW	Unlikely	Low		0	0	0	0	1	1	Low
Detector + HV test is not successful	Use same HV PS and monitoring as ATLAS NSW	Unlikely	Low		0	0	0	1	2	3	Low
Cooling System Monitoring	Use same as TPC	Unlikely	Low		0	0	0	0	1	1	Low
Mechanical Integration											
Mechanical Support Structures R&D and delivery is delayed	Have engineer team familiar with SPHENIX apparatus, in close contact with BNL team	Possible	Moderate		100	200	250	4	6	10	Moderate
Detector to support structure assembly test	Practice dry run with prototypes or dummy detectors										Not realized
Support structure to EMCAL integration test	Keep close collaboration with EMCAL and TPC teams. Have them validate our design as early as possible	Possible	Moderate		0	0	0	2	4	6	Moderate
Installation											
EMCAL readiness for TPOT installation	Monitor EMCAL assembly and installation schedule	Unlikely	Low		0	0	0	1	2	3	Low
TPOT readiness for installation	Monitor TPOT assembly and installation schedule	Possible	Moderate		0	0	0	2	4	6	Moderate
Detector is broken during installation	Have spare detectors available, practice dry run with prototypes or dummy detectors	Rare	Low		0	0	0	0	3	6	Low

9 risks either in the past or not realized; 9 low risks, 5 moderate risks. Details in the following slides

Risk Title	Mitigation	Residual risk likelihood	Residual schedule impact	Overall impact score (residual)
Micromegas Parts Delivery Delay (e.g PCB)	Contacted different suppliers and ordered first PCBs for inspection	Possible	Moderate	happened
Micromegas Detector Delivery Delay	Choose robust, well tested Micromegas design. No R&D required.	Possible	Moderate	Moderate

Parts delivery delay risk is in the past. Happened (together with difficulties with production), schedule updated accordingly

Risk on detector delivery to Moderate, due to uncertainty on shipping

Risk Title	Mitigation	Residual risk likelihood	Residual schedule impact	Overall impact score (residual)
FEE/DAQ parts (boards, FELIX, fibers, EDBC) are late	Use same as TPC	Unlikely	Low	not realized
LV parts (power supply, distribution, cables) are late	Use same as TPC	Unlikely	Low	Low
FEE to detector transition board	Close collaboration with SAMTEC to design custom PCB+FLEX	Possible	Moderate	not realized
FEE Cooling plates R&D and delivery is delayed	New design needed. Build on TPC studies. Expect simpler design as for TPC	Unlikely	Low	not realized
FEE Housing R&D and procurement is delayed		Unlikely	Low	not realized
Detector, FEE to DAQ Chain test	Same as TPC. Participate to TPC FEE to DAQ chain tests. Have plan B to decouple electronics from detector	Possible	Moderate	not realized
Detector + FEE + Housing assembly test is not succesful	Have the same team design Detector, FEE transition board and FEE housing (CEA)	Unlikely	Low	not realized

All FEE related risks are in the past, not realized, except that of LV cables (ordered, not received yet)

Risk Title	Mitigation	Residual risk likelihood	Residual schedule impact	Overall impact score (residual)
Gas Mixing Chamber design and construction is delayed	Refurbish PHENIX TOF-W mixing chamber	Unlikely	Low	Low
Gas Monitoring design is delayed	Gas mixture considered non flammable	Unlikely	Low	Low
Detector + Gas system test is not succesful		Unlikely	Low	Low
HV Power Supply availability is delayed	Use same HV PS as for ATLAS NSW			Not realized
HV cables availability is delayed	Use standard cables	Possible	Moderate	Moderate
HV Monitoring	Use same HV PS and monitoring as ATLAS NSW	Unlikely	Low	Low
Detector + HV test is not successful	Will test at SBU during module validation	Unlikely	Low	Low
Cooling System Monitoring	Use same as TPC	Unlikely	Low	Low

Mechanical integration



Risk Title	Mitigation	Residual risk likelihood	Residual schedule impact	Overall impact score (residual)
Mechanical Support Structures R&D and delivery is delayed	Have engineer team familiar with sPHENIX apparatus, in close contact with BNL team	Possible	Moderate	Moderate
Detector to support structure assembly test	Practice dry run with prototypes or dummy detectors	Possible	Moderate	Not realized
Support structure to EMCAL integration test	Keep close collaboration with EMCAL and TPC teams. Have them validate our design as early as possible	Possible	Moderate	Moderate

Successful detector-to-support structure assembly test

Other risks remain moderate because not all parts have been received yet

Installation



Risk Title	Mitigation	Residual risk likelihood	Residual schedule impact	Overall impact score (residual)
EMCAL readiness for TPOT installation	Monitor EMCAL assembly and installation schedule	Unlikely	Low	Low
TPOT readiness for installation	Monitor TPOT assembly and installation schedule	Possible	Moderate	Moderate
Detector is broken during installation	Have spare detectors available, practice dry run with prototypes or dummy detectors	Rare	Low	Low

No change since last review

Risks relevant to TPOT operation



Risk Title	Mitigation	Overall impact score (residual)
TPOT Performance (resolution, efficiency, HV trips) are poorer than anticipated	Precise in-lab detector characterization before commissioning, have comfortable margins on detector requirements (efficiency, resolution). Have reasonably segmented detector to limit acceptance losses in case of problems	Moderate
Particle rates/multiplicity are higher than anticipated	Detector and DAQ should sustain high rates/occupancy. Have comfortable margins on detector requirements (efficiency, resolution). Detailed simulations to study matching efficiency/purity to TPOT. Possibility to drop most central collisions	Low

No change since last review

Risks relevant to sPHENIX



Risk Title	Mitigation	Overall impact score (residual)
Sphenix installation delay due to TPOT	Agreed with BNL that TPOT must not delay sPHENIX. "If the components are not ready to meet sPHENIX schedule, including meeting milestones for design work, the TPOT will not be installed"	Low
Electronic noise from TPOT	Careful design of ground connections, decoupling from other detectors, EM shielding around FEE board, around detector	Low
Local temperature variations in TPC	Only FEE generate heats. Shielded by detector Need detailed FEE cooling studies, FEA	Low
Degradation of EMCAL performances due to additional material	Detector + FEE rad. length < 10% x_0 Need detailed study including support structure and cables Expected low impact wrt TPC support. Can control online by comparing regions of acceptance w, w/o TPOT	Low

No change since last review. Delay to sPHENIX due to TPOT moved to low, following agreement with BNL:

"If the components are not ready to meet sPHENIX schedule, including meeting milestones for design work, the TPOT will not be installed"

Risks relevant to sPHENIX (cont.)



Risk Title	Mitigation	Overall impact score (residual)
FEE cooling water leaks	Water cooling system identical to TPC. Operated in sub atmospheric pressure	Low
Gas Flammability	Gaz mixture at the detector has low flammable gas fraction. Foresee sniffers around the TPOT detectors. Equip gas barrack to handle flammable gases, based on experience with PHENIX	Low
Data volume	Anticipated data volume is ~2% of that of the TPC	Low
TPOT failure, (detector, FEE)	No impact on current sPHENIX capabilities. Will make calibration of the TPC more difficult, take longer	Low

No change since last review

TPOT construction risks identified and quantified

Moderate risks for TPOT include:

- Micromegas parts (and detector) delivery delay
- FEE-to-detector transition boards delivery delay
- HV power supply delivery delay
- Detector+FEE test (tests are ongoing)
- Mechanical structure readiness and tests (but a lot of progress since last review)
- TPOT readiness for installation

It was agreed with BNL that TPOT should not be installed, would it delay SPHENIX begin of operations in 2023

All risks to SPHENIX operations considered low

Charge

1. Are all the components for TPOT for installation and integration into sPHENIX produced and within specifications? **all presentations**
2. Are the quality control tests, acceptance tests, and characterization of TPOT modules within specifications? **presentation by Audrey**
3. Is the schedule of the TPOT sufficiently well understood and matched to the plan for installation in sPHENIX? **presentation by Hugo**
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? **presentation by Hugo**
5. Are the interfaces and integration with sPHENIX and RHIC well understood?
presentations by Takao, Walter, John
6. Is the gas system properly understood, including safety reviews, as needed for operation in sPHENIX? **presentation by John**
7. Is the ES&H properly managed? **presentation by John**
8. Is the software for calibrations for TPOT and production software for utilizing TPOT for TPC calibrations in place? **presentation by Hugo**

We hope we have convinced you that

- we have addressed all the questions from the charge
- the answer to all questions is positive (details in the backup)

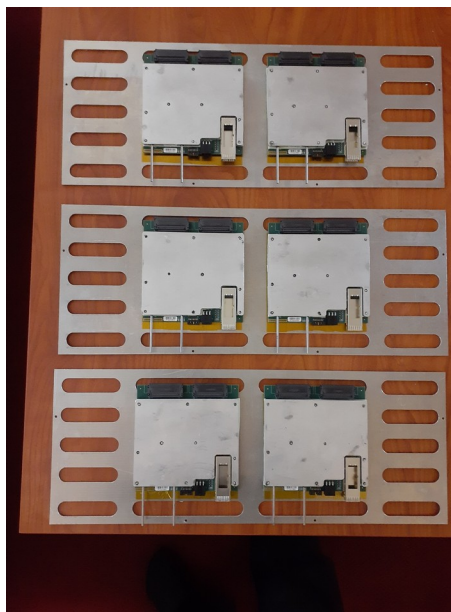
BACKUP

1. Are all the components for TPOT for installation and integration into sPHENIX produced and within specifications?

Partly

All presentations

- FEE, back-end, LV, HV gas and cooling are all available and within specifications to the exception of HV cables and fibers
- Detectors: 90% available, 80% to specifications. Remaining 20% need assembly (10%) and validation
- For the mechanics: 35% available; 45% ordered; 20% to be ordered (mostly insertion mechanics)



2. Are the quality- control tests, acceptance tests, and characterization of TPOT modules within specifications?

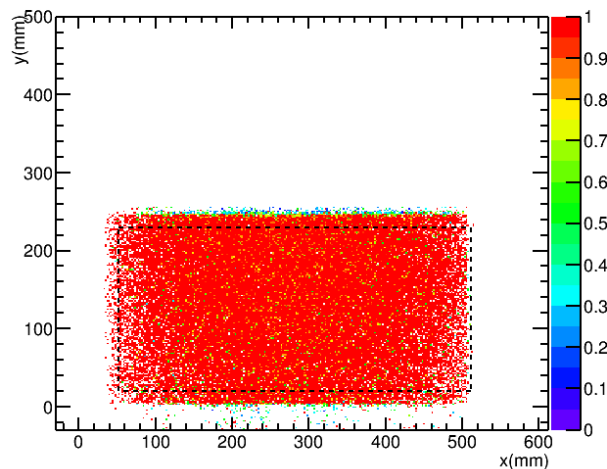
Partly

Presentation by Audrey

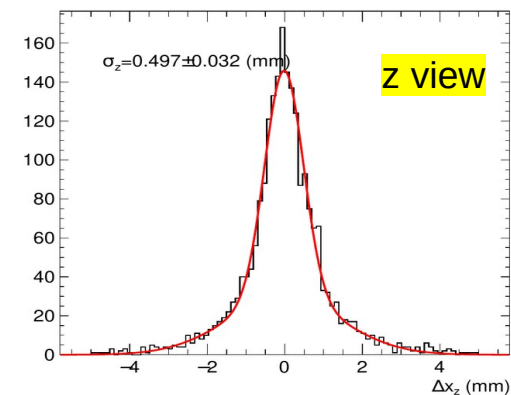
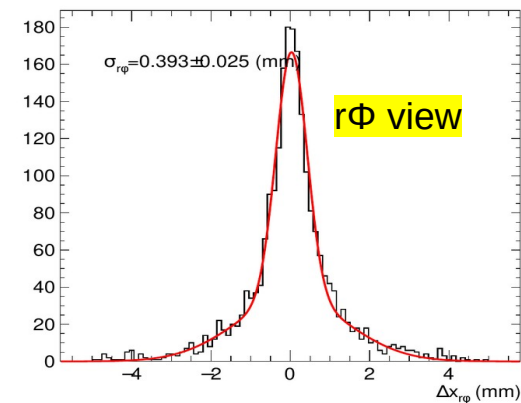
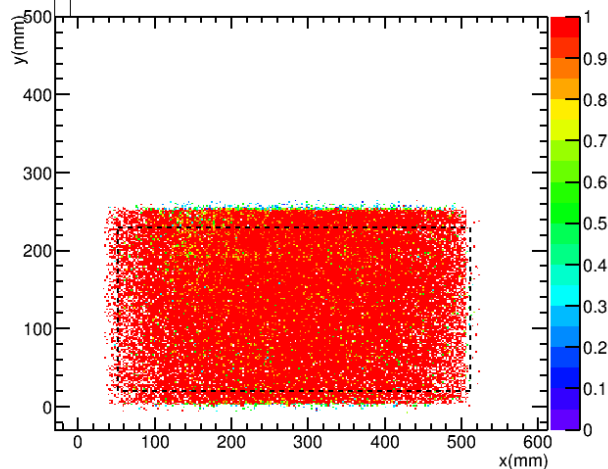
radiation length, efficiency, active strips are up to specification

For the hit resolution: telescope not precise enough for definitive answer. Measured residuals (over estimate) are within a factor 2 of required resolution. Impact on ability to reconstruct the SC distortions in the TPC is minor: requires longer integration time

Efficiency Z



Efficiency RPhi



3. Is the schedule of the TPOT sufficiently well understood and matched to the plan for installation in sPHENIX?



Yes

Presentations by Hugo

TPOT ready for installation inside sPHENIX by Sept 30, pending completion of Magnet mapping and all EMCAL sectors
Schedule is tight but carefully monitored

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

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?



Yes

This presentation

Risk Title	Mitigation	Overall impact score (residual)
Sphenix installation delay due to TPOT	Agreed with BNL that TPOT must not delay sPHENIX. "If the components are not ready to meet sPHENIX schedule, including meeting milestones for design work, the TPOT will not be installed"	Low
Electronic noise from TPOT	Careful design of ground connections, decoupling from other detectors, EM shielding around FEE board, around detector	Low
Local temperature variations in TPC	Only FEE generate heats. Shielded by detector Need detailed FEE cooling studies, FEA	Low
Degradation of EMCAL performances due to additional material	Detector + FEE rad. length < 10% x_0 Need detailed study including support structure and cables Expected low impact wrt TPC support. Can control online by comparing regions of acceptance w, w/o TPOT	Low
FEE cooling water leaks	Water cooling system identical to TPC. Operated in sub atmospheric pressure	Low
Gas Flammability	Gaz mixture at the detector has low flammable gas fraction. Foresee sniffers around the TPOT detectors. Equip gas barrack to handle flammable gases, based on experience with PHENIX	Low
Data volume	Anticipated data volume is ~2% of that of the TPC	Low
TPOT failure, (detector, FEE)	No impact on current sPHENIX capabilities. Will make calibration of the TPC more difficult, take longer	Low

5. Are the interfaces and integration with sPHENIX and RHIC well understood?

Yes

Presentations by Takao, Walter, John

TPOT mechanical support is final and ordered. Interface to EMCAL and TPC well understood

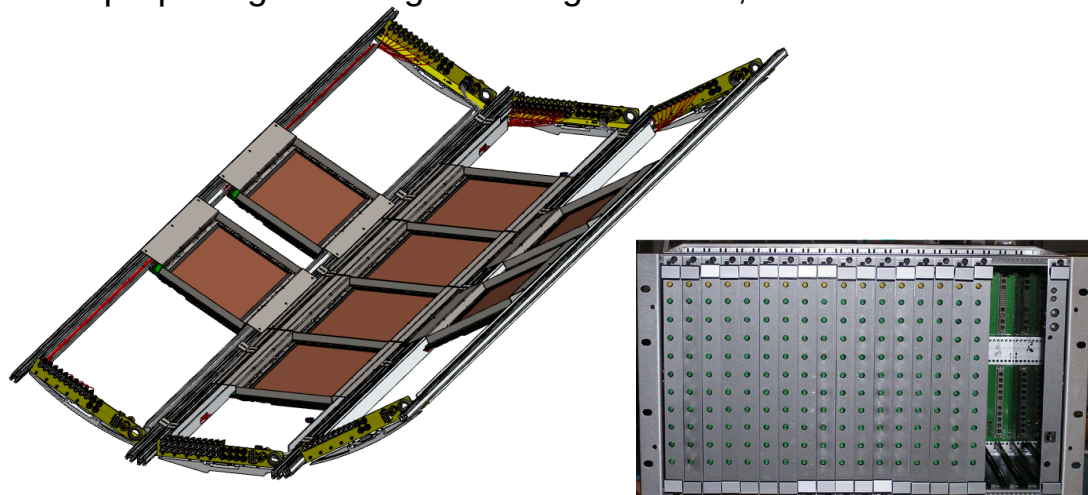
Detailed installation is being finalized with Russ Feder

DAQ chain identical to TPC. Ongoing/encouraging test Detector + FEE

LV is same as TPC

HV power supply available, inspected and tested

Gas: repurposing TOF.W gas mixing chamber, control and monitoring



6. Is the gas system properly understood, including safety reviews, as needed for operation in sPHENIX?

Yes

Presentations by John

Gas system and monitoring based on repurposing PHENIX TOF-W

ESRC review happened on June 22. No safety issue identified regarding gas

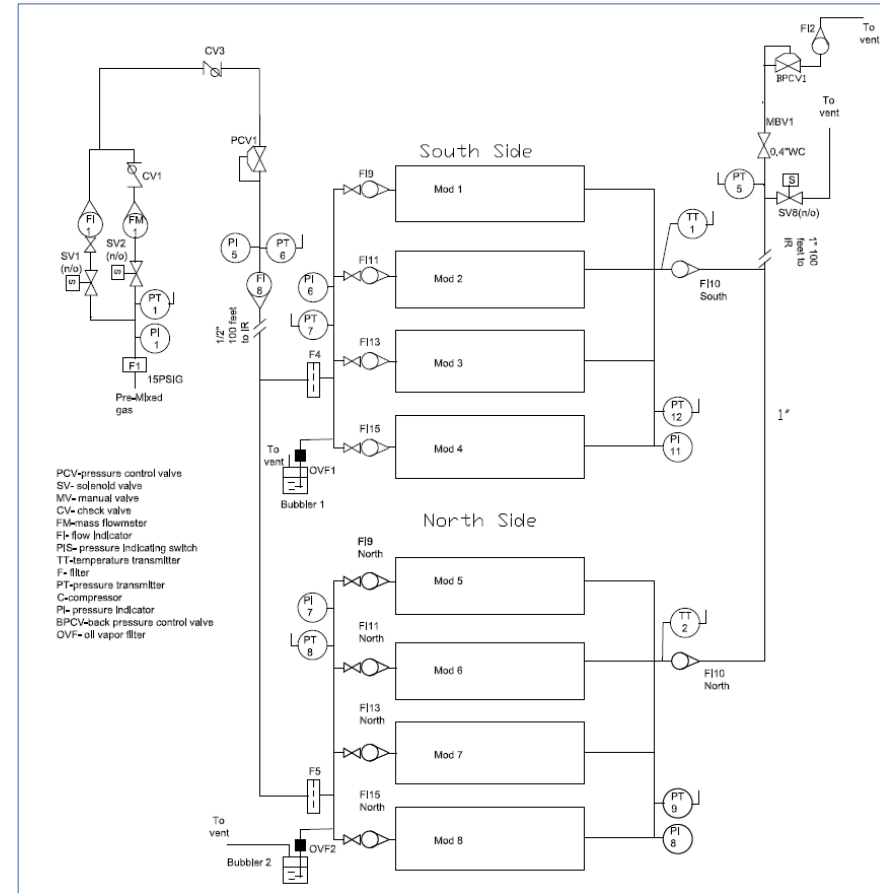
Gas mixture is considered non flammable

We will use Pre-mixed gas from a vendor. The gas in the bottle is not considered flammable

email from Joe Levesque:

While a component of the gas will be flammable (5% isobutane), when diluted in air to increase the oxygen content to above 12% (the normal oxygen level needed to sustain ignition of a gas), the flammable component goes below the lower flammable limit for isobutane (1.8%).

*From the US Bureau of Mines Bulletin 627, it is shown in this chart. **It means the blended gas is inert.***



7. Is the ES&H properly managed?

Yes

Presentation by John

- TPOT has the usual safety issues (fusing, flammability of components, shock hazards from HV and LV)
- All cables, power supply units, tubes are identified
- Consequences of using a gas mixture that contains a small fraction of flammable gas has been evaluated
- ESRC review has happened on June 21st.

8. Is the software for calibrations for TPOT and production software for utilizing TPOT for TPC calibrations in place?

Yes

Presentation by Hugo

TPOT is an integral part of the sPHENIX reconstruction workflow as presented at the fourth sPHENIX S&C review (May 2022)
All needed parts are in place and functional

