Management Plan for a Micromegas Outer Tracker detector in sPHENIX

Hugo Pereira Da Costa, for the team *
Université Paris-Saclay/LANL

sPHENIX General Meeting, October 30, 2020

* The team: Maxence Vandenbroucke, Stephan Aune, Takao Sakaguchi, Christof Rolland, Ross Curliss, Hugo Pereira Da Costa

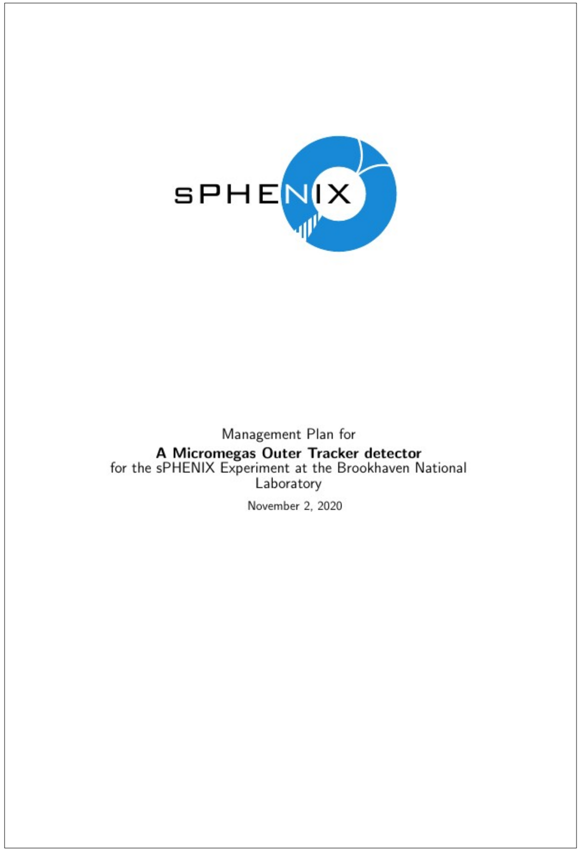
Introduction

Following the recommendations from the Calibration Task Force concerning the need for an Outer Tracker to monitor the space charge distortions in the TPC [1], sPHENIX management has asked a “Management Plan for the Outer Tracker” to the team, based on the MVTX proposal, to discuss schedule, costs, project organisation, etc.

Will serve as a basis to ask for funding

Deadline to submit a first draft: Nov. 2 (Next Monday)

Today: status report on document advancement [2]


sPHENIX

Management Plan for
A Micromegas Outer Tracker detector
for the sPHENIX Experiment at the Brookhaven National Laboratory

November 2, 2020

(1) https://indico.bnl.gov/event/9722/contributions/41867/attachments/30710/48214/CalibTF_Genmeeting_201002_v1.pdf

(2) https://www.overleaf.com/project/5f89ce6e89df1e0001cdefcd

Motivation for the project

Distortions in the TPC:

Source	Length scale	Time scale
E and B inhomogeneity, field alignment	O(1cm)	Static (one year data taking)
Beam induced, due to space charge, time averaged	O(1mm)	half hour
Event-by-event fluctuations around the mean	O(100um)	10ms

Correcting for all these distortions to an accuracy < 100um is mandatory for the TPC to meet its requirements in terms of momentum (Jet program) and invariant mass (Upsilon program) resolution

Means of monitoring and correcting for the distortions:

- anode currents + model
- directed laser system
- diffuse laser system
- tracks

Current strategy:

- static distortions: directed laser system
- time averaged beam induced distortions: diffuse laser and tracks
- event-by-event fluctuations: anode currents + model

Motivation for the project

Distortions in the TPC:

Source	Length scale	Time scale
E and B inhomogeneity, field alignment	O(1cm)	Static (one year data taking)
Beam induced, due to space charge, time averaged	O(1mm)	half hour
Event-by-event fluctuations around the mean	O(100um)	10ms

Correcting for all these distortions to an accuracy < 100um is mandatory for the TPC to meet its requirements in terms of momentum (Jet program) and invariant mass (Upsilon program) resolution

Means of monitoring and correcting for the distortions:

- anode currents + model
- directed laser system
- diffuse laser system
- tracks

Outer tracker is critical to be able to use tracks on a time scale of < half hour

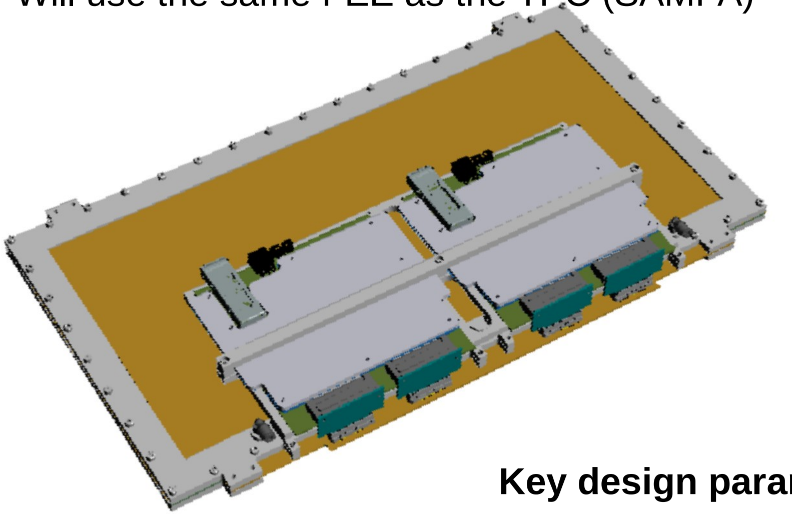
Current strategy:

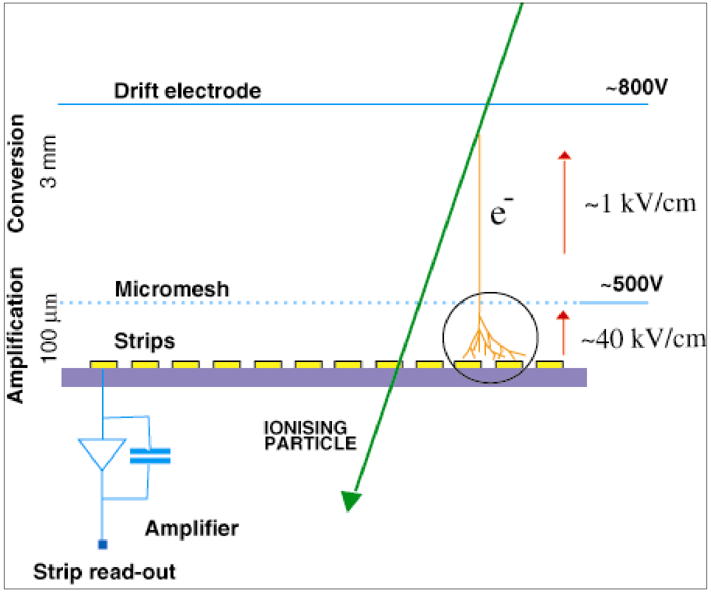
- static distortions: directed laser system
- time averaged beam induced distortions: diffuse laser and tracks
- event-by-event fluctuations: anode currents + model

Detector Technology

Modular design consisting of identical Micromegas-based “tiles” (= module), with two detector by module each providing a 1D measurement along z (longitudinal) or phi (azimuth)

Will use the same FEE as the TPC (SAMPA)





Key design parameters:

	z layer	phi layer
detector dimension (sensitive area) (mm^2)	250x500	200x500
number of strips	256	256 (512) (*)
strip length (mm)	250	500 (250) (*)
Strip pitch (mm)	1.95	0.98
Gas	Ar/iC4H10 90/10	

(*): Two options are considered for the phi layer segmentation because of high occupancy

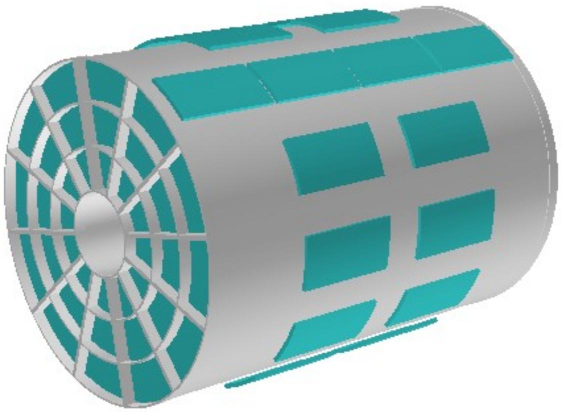
Estimates for the FEE are based on the ‘maximum’ option (512 channels in phi layer)

Detector Configuration and performance parameters

It is unrealistic to cover the full TPC acceptance with Micromegas tiles

Will need to extrapolate the reconstruction to the regions not covered by the OT based on model, diffuse laser. Need to keep the extrapolation distance short

- One module for each sector of the TPC on each side, due to sector-to-sector variations of IBF
- One sector of the TPC fully equiped with Micromegas to validate the extrapolation along z used in the other sectors and quantify systematic uncertainties



Radiation length	$< 10\%$ of x_0
Active strips	$> 90\%$
Hit efficiency	$> 90\%$
Hit resolution	$< 200\ \mu m$ (ϕ layer), $< 300\ \mu m$ (z layer)
Noise hits per detector	N/A
LVL1 latency	4 μs
LVL1 Multi-Event buffer depth	5 events
Read-out trigger rate	> 15 kHz

Table 2.2: Outer Tracker Key Performance Parameters (KPP)

Ultimate Performance Parameter:

provide a correction of the space-charge distortions in the TPC of accuracy < 100 μm in the azimuthal direction [...] over timescales of < 30 minutes, and in each TPC volume element of sufficiently small dimensions in which there are tracks

Deliverables

Item	Quantity	Spares
Micromegas detectors	52 (26 z layer, 26 ϕ layer)	8 (4 z layer, 4 ϕ layer)
Support structures	26	0
HV Power lines	260 input channels	40 input channels
	(208 pos. polarity, 52 neg. polarity)	(32+, 8-)
HV Power supplies	6 (5 pos. polarity, 1 neg. polarity)	1
Gas system	1	0
Front-end electronic	26 $\times$ 3 SAMPA FE boards	3 $\times$ 3 FE boards
LV power supply	1 MegaPak (10 DC-DC mods)	TBD
Cooling for electronic	78 Cooling plates	TBD
Back-end electronics	3 FELIX boards	TBD
TPC-EBDC computers	3 Commodity server	TBD

Table 2.1: Outer Tracker deliverables

Cost breakdown

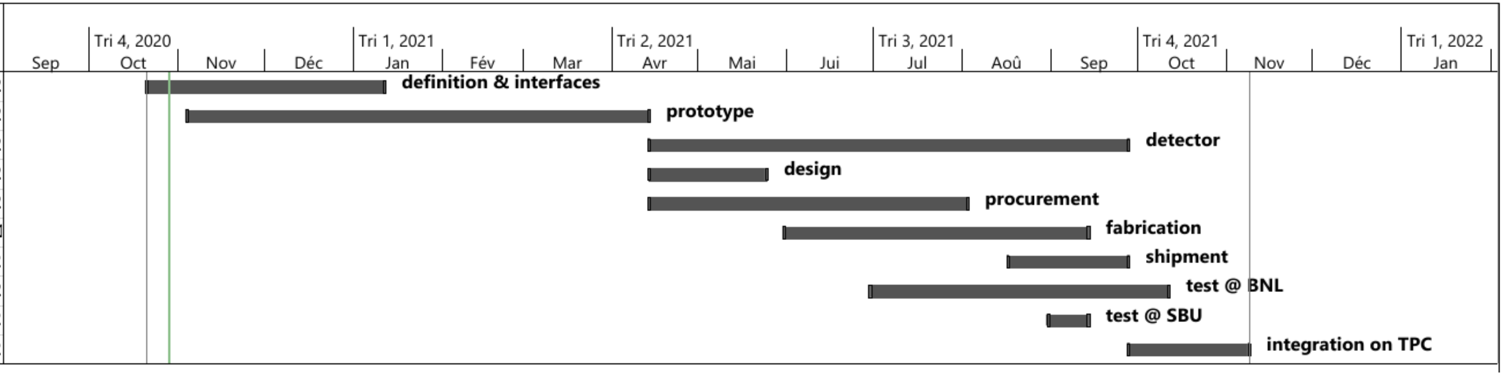
PBS	Cost
Prototypes	N/A
Detector ϕ	N/A
Detector z	N/A
Tooling	N/A
Support structure	N/A
High Voltage (cables + HV units)	\$64k
Gas System (Mixing Chamber and piping)	\$26k
FEE to detector Flex	\$47k
FEE housing	\$61k
FEE	\$132k
Cooling	N/A

Table 2.4: Cost estimate for the main products of the Outer Tracker project

- Cost estimate for the Micromegas detector will be communicated as soon as validated by CEA/Saclay management. Planing for two contract: one early contract for the prototyping, a second for the full detectors
- Cost estimate for the FEE based on the TPC estimates, large fraction of it might be covered from TPC spares
- Cost estimate for gas system are indicative, based on past experiments
- Support structure, Cooling, still need to be estimated

Schedule

N°		Mode Tâche	Nom de la tâche	Durée	Début
1			definition & interfaces	49 jours	Mer 21/10/2
6			prototype	100 jours	Mer 04/11/2
34			detector	94 jours	Mer 14/04/2
35			design	24 jours	Mer 14/04/2
44			procurement	54 jours	Mer 14/04/2
55			fabrication	56 jours	Lun 31/05/21
72			shipment	30 jours	Mar 17/08/2
77			test @ BNL	54 jours	Mer 30/06/2
82			test @ SBU	10 jours	Mar 31/08/2
84			integration on TPC	30 jours	Mar 28/09/2



Detector:

Prototyping end in Apr. 2021

Final detector design+building ends in Sep. 2021

Shipping and testing at BNL starts in Aug. 2021

Integration to the TPC could start in Sep. 2021

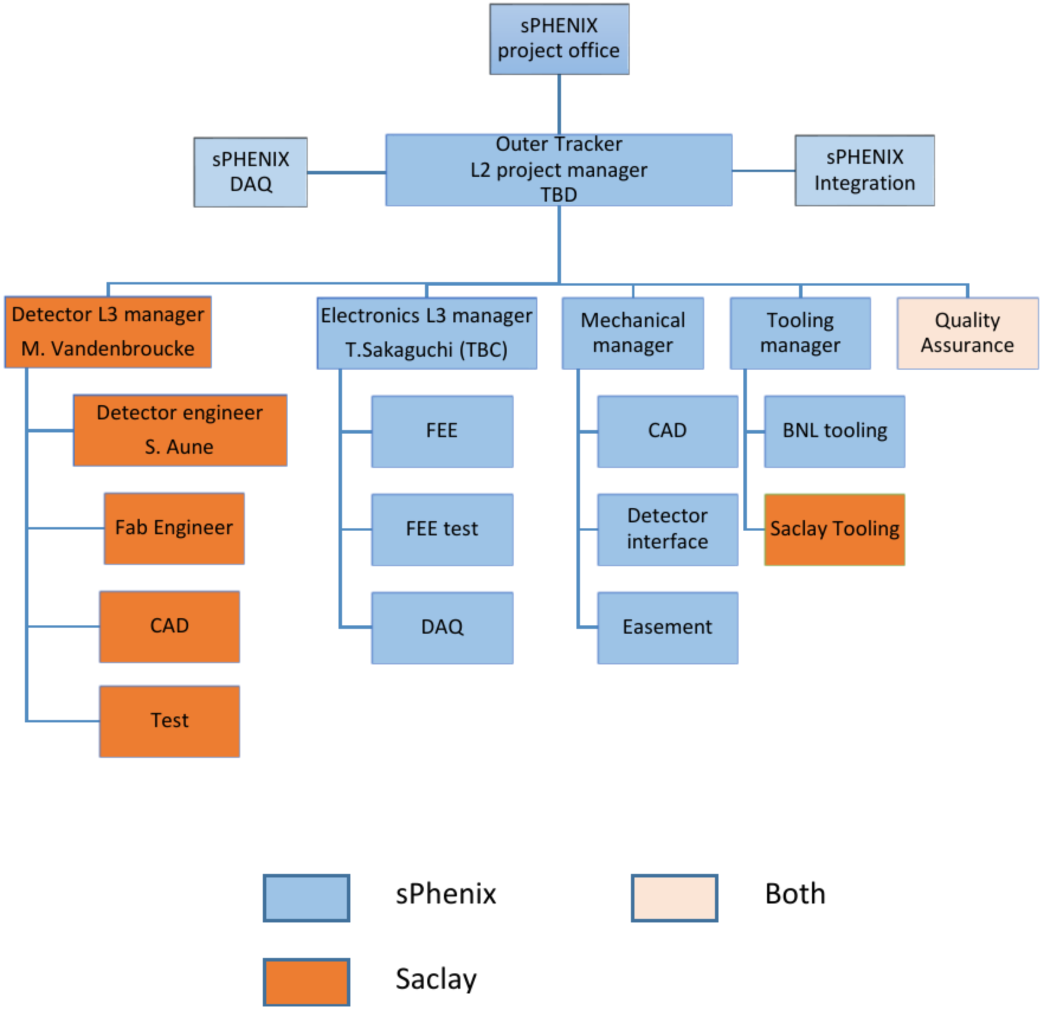
Electronics:

Detailed schedule to be defined. Will follow the schedule of the detector development/production.

(no additional development needed)

Schedule for mechanical integration and gas system still to be defined

Management structure



Management structure at Saclay is well defined

Many missing names for the other tasks

In particular L2 Project leader is TBD

Saclay insists that it should be provided by sPHENIX, and US based (preferentially BNL based), to ease the coordination and integration of the project to sPHENIX

Participating Institutions

Commissariat a l’énergie atomique et aux énergies alternatives (CEA): Conception, Design, building, testing and characterization of the Micromegas tiles, detector simulations, tracking software, project management

Brookhaven National Laboratory (BNL): Global system integration and services, HV, LV, Front-End electronics, gas system, project management

Stonybrook University (SBU): (TBC) Mechanical support, integration to the TPC, simulations, distortion reconstruction

Outlook

Main ingredients are in place and in a good shape (IMHO), especially for the detector part and FEE

Will need to wait for CEA validation on detector cost estimates to update the document

Other weak points include: support structure, gas system, integration to TPC and project management

Will also need input from sPHENIX management on

- baseline change control
- management responsibilities
- risk management
- project reporting
- QA and document management
- ESSH

(all are sections of the original MVTX document for which we have no experience)