

MVTX Overview

Ming Liu LANL sPHENIX Collaboration Meeting July 8-9, 2019, Lehigh University, PA

MVTX Detector – Modified from ALICE/ITS Design





Scope of the MVTX Project

- MAPS Staves & Electronics
 - Readout Integration
 - Frontend: ALICE/ITS RU
 - Backend: ATLAS FELIX
 - Production & Assembly @US: ~\$5M
 - QA & assembly
 - RU boards @UT-A
 - Half detectors @LBNL
 - FELIX boards @LANL/BNL, 6+spares(2)
 - Ancillary systems "adopt" ALICE ITS system
 - Power, slow control & monitoring etc.

Production @CERN: \$1.36M, a separate project

84 ALICE/ITS-IB staves from CERN Acceptance test @LBNL, 48+spares(2-inner layers+)
60 ALICE/ITS-RU from CERN Acceptance test @UT-Austin, 48+spares(12)

- Mechanical system
 - Modify ALICE/ITS mechanical structures
 - End Wheels
 - Cylindrical structure shells
 - Service half barrels
 - Mechanical system integration,
 - Design & simulations, MIT/LANL
 - Composite structure production, LBNL
 - Non-composite structure, MIT
 - Installation tooling etc., BNL/LANL/MIT/LBNL
 - Adopt ALICE cooling plant design
 - Modifications to fit sPHENIX, MIT/BNL





- 3x buffer

MVTX Detector Electronics consists of three parts

Sensor-Stave (9 ALPIDE chips) | Front End-Readout Unit | Back End-FELIX/DAM

MVTX Overview



MVTX Global Mechanical System Integration

- MVTX system preliminary design, with two parts:
 - Part-1: from MVTX to PP-1b, all power PCB, 40cm
 - Part-2: length TBD later, from PP-1b to PP-2





Ross' talk



Wednesday Jul 10, 2019, 9:00 AM → 4:00 PM US/Eastern

https://indico.bnl.gov/event/6377/

- MVTX, INTT, TPC ...

MVTX Overview



Project Status

- Confirmed long SamTec readout cables recently last key integration R&D
 - 11.4m long cables, > 10m desired length
- MVTX mechanical design: excellent progress
 - Asked for quotes from outside companies based on preliminary designs
 - sPHENIX integration workfest scheduled 7/10 @BNL, MVTX/INTT/TPC...
- Release of early R&D fund in progress
 - MVTX mechanical engineering design, MIT/LANL
 - Preparation for Stave and RU acceptance test, LBNL, UT-Austin
- MVTX Cost & Schedule Review we are ready for full production
 - July 29-30 @BNL
 - WBS, PMP, Risk Registry, P6 being updated

Stave and RU production at CERN

- DOE Fund arrived at UTK
- Procurement paperwork in progress (any day from now if not done yet)
- CERN is ready to proceed with stave production





2019 MVTX Test Setup



Stave housing sits on a motion table which can be moved in (x, y) plane perpendicular to the nominal beam direction. It can also be rotated (+40, -40) degrees (see photo on right). Operation was done at counting house. $\frac{7/8}{19}$







IVIVIX Overview

Detector Misalignment, Hit Spatial Resolution





Offline analysis in progress: all TB data in RCF https://wiki.bnl.gov/sPHENIX/index.php/MAPS-based_Vertex_Detector_(MVTX)

Beam angle: 0

Run 907, Number of Events: 37055

(eta ~0)









Offline Analysis: Cluster size vs Angle Run , angle = 40



SPHENES Confirmed New MVTX Long SamTec Readout Cables 8.8m + 2.6m = 11.4m (10m desired for sPHENIX; ALICE 8m cables)





MVTX Readout and Power Cable Route



ALICE ITS/IB final readout cables: ~8m



sPHENIX MVTX: 7.9+m Cable-A: 1.4 m Cable-B: 6.5+ m Power cable:4.7+ m Desired ~10m



MVTX Goals – the 2nd TB, 6/17-22, 2019

- Test and confirm optimal MVTX operation parameters for sPHENIX
 - Threshold scan, analogy shaping time etc.
 - Study chip hit efficiency vs trigger(strobe) latency
 - dT = 1 ~ 10 uS
- Parameters predetermined from laser scan at LANL, in good progress
 - Single chip readout with MOSAIC with pulsed laser (~MIP)
 - Threshold and noise
 - Analogy shaping time
 - Strobe delay and length





"Stretched Settings" for sPHENIX trigger study

"ALICE Default Settings"

MAX: 64 cells x 106nS = 6.8uS

Strobe Delay



Study MAPS Performance with Pulsed Laser @LANL

- Inject "MIP" signal, focused laser beam
 - 850 nm laser, 4ns wide pulse, ~1 MIP
 - 50kHz trigger
 - Find optimal MAPS operating parameters







N Pixels / Event



Run Types – Details being documented in MVTX wiki



SPHENIX

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MVTX Schedules and Milestones in progress (3/2019)



MVTX experts help ALICE/ITS – to help us!

Dave's talk from Monday

The ALICE ITS lab at CERN



- Great opportunity to learn about ITS/MVTX detectors
- Training on technical details
- Developing tools
- Build up operation experience



sPHENIX collaborators – MIT students and postdocs – at CERN developing detector control and quality monitoring software for the ALICE ITS. Part of sPHENIX contribution to ITS production, validates appropriateness of sPHENIX as CERN recog. exp't.



Funds from BNL sent to CERN to build add'I staves of ITS IB design, to be shipped to BNL.

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- Completed essential R&D for readout integration
 - Full 9-chip stave readout per RU
 - Multi-RU readout per FELIX
 - Long readout cables
 - sPHENIX GTM
- Completed preliminary mechanical design
- Improve MC detector response, clustering in progress
 - Calibration data with incident angles, 0, 10,20,30,40,45
- Stave and RU production at CERN in good progress
- MVTX Cost & Schedule review, July 29-30 @BNL

We are ready for the full production and the physics!











- Very successful TB at Fermilab, 5/13-25, 2019
 - Confirmed the long 11.4m SamTec readout cable
 - Confirmed the full stave readout
 - Confirmed multi-RU readout per FELIX
 - Confirmed sPHENIX GTM with FELIX
- A 2nd TB, study optimal MAPS operation points
 - Parasitic with INTT+TPC, 6/17-21
- Preliminary mechanical design developed
 - To prototype CYSS and Layer-2 End-Wheel this summer
 - France, Italy, CERN, contacted and under discussion
- Improve MC detector response, clustering in progress
 - Took calibration data with incident angles, 0, 10,20,30,40,45
- TB later at LBNL/LANL in preparation
 - Scan stave material budget with 50MeV p-beam
 - 8-stave + 8-RU +1-PU + 1-FELIX + 1-GTM + RCDAQ, the full complete readout chain
 - Hardware will be available soon







Monolithic Active Pixel Sensors (MAPS)

The Next-Generation, State-of-the-Art Pixel Tracker

Advantages of ALICE PIxel DEtector (ALPIDE) sensor:

SPHENIX

- Very fine pitch (27μm x 29μm), for superb spatial resolution
- High efficiency (>99%) and low noise (<10⁻⁶), for excellent tracking
- Time resolution, as low as ~5 μ s, for less pileup
- Ultra-thin/low mass, 50μm (~0.3% X₀), for less multiple scatterings
- 0.5M channels with on-pixel digitization, for zero-suppression and fast readout
- Low power dissipation, 40mW/cm², for minimal service materials

An ideal detector for QGP physics!





A 9-chip MAPS stave, 1.5cm x 27cm

ALPIDE sensor: 1.5cm x 3.0cm, 0.5M pixels



MVTX Overview

epitaxial layer: N_A ~ 10¹³

Tower Jazz 0.18 µm CMOS

180 nm

6

N_A ~ 10¹⁸

N_A~10¹⁶

3nm

feature size

metal layers

gate oxide

substrate:

deep p-well:

MVTX Full Readout Chain Demonstrated (3/2018)













Data taking shift in the evenings: 7PM – 7AM Beam: every other Monday –Friday 8:00AM – 8AM

Matt, Hubert, Cameron, Gerd, Zongze, Xuan, Xiaochun, photo by Ming Sho, AlexT Not shown: Sanghoon, Yasser, Martin, Walt, Abel. Chris ...

7/8/19





First Collision Signals

sPHENIX GTM







Staves, RUs, PU etc.









When MAPS parameters off the optimal point, less hits collected





No hits seen when MAPS parameters faroff the optimal point





Installation







3-D event Display: p+Pb collision



Offline Analysis: Cluster size vs Angle Run 877, angle – 30 dgr





MVTX – Half Detector

