

MVTX Overview (WBS 3.2)

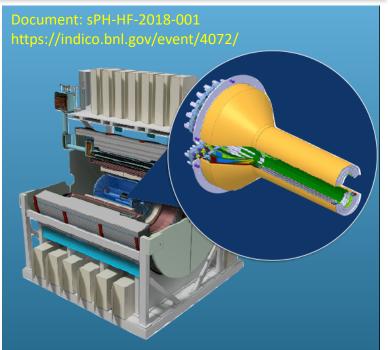
Ming Liu, LANL April 9-11, 2019 BNL Director's Review

Outline



- MVTX science & technology
- MVTX scope
- Cost & schedule
- Status & highlights
- Issues and concerns

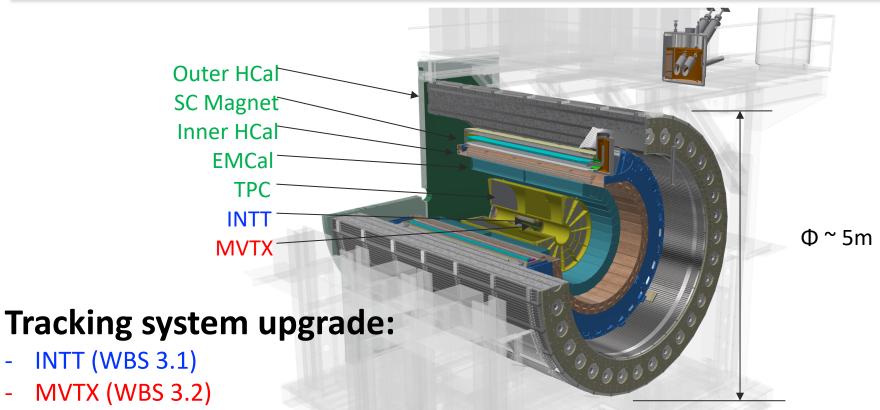
MVTX: Monolithic-active-pixel-sensor based VerTeX detector



A Monolithic Active Pixel Sensor Detector for the sPHENIX Experiment

The sPHENIX Detectors

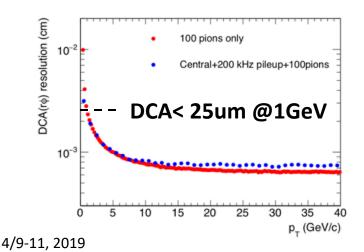


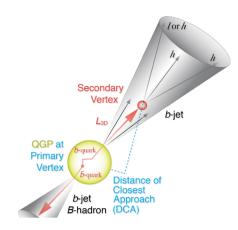


MVTX Enables the 3rd Science Pillar



- 1. Jets
- 2. Upsilons
- 3. Open Heavy Flavor
- Bottom quarks are heavy (4.2 GeV)
- Produced in initial collision, probe QGP evolution
- Well controlled in pQCD
- Access fundamental transport properties of QGP







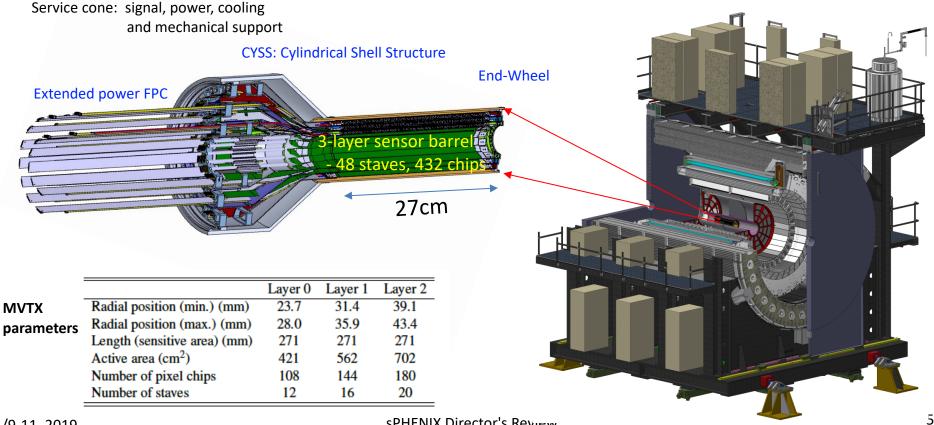
- Precision tracker + High rate capability
 → Precision bottom observables over wide scales in p+p, p+A and A+A
- Initial observables:
 - *B*-meson @ *p*_τ <10 GeV/c
 - *b*-jet @ 15< *p*_T<50 GeV/c

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MVTX Technical Overview



Ross & Yuan's talks



4/9-11, 2019

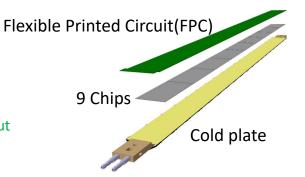
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Monolithic Active Pixel Sensors (MAPS)

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

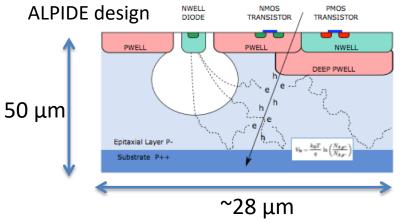
Advantages of ALICE PIxel DEtector (ALPIDE) sensor:

- 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 μs, 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



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

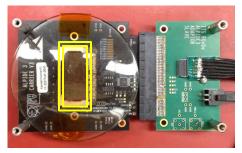
An ideal detector for QGP physics!



Tower Jazz 0.18 µm CMOS

- feature size 180 nm
- metal layers 6
- gate oxide 3nm

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

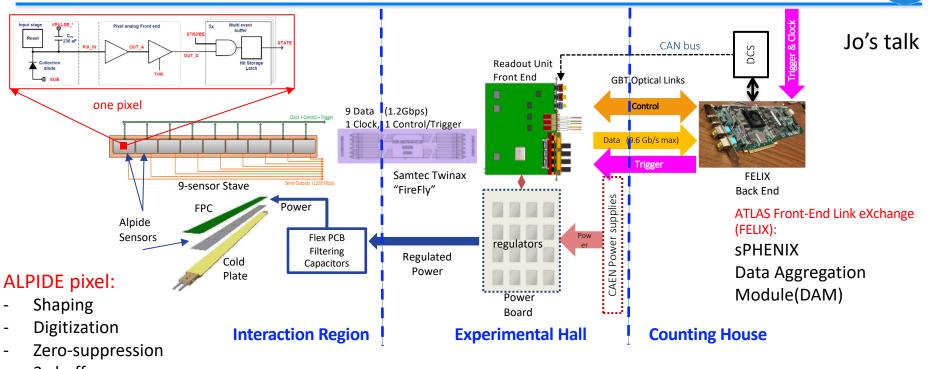


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SPHENIX

MVTX Readout, Power and Controls



- 3x buffer

MVTX Detector Electronics consists of three parts

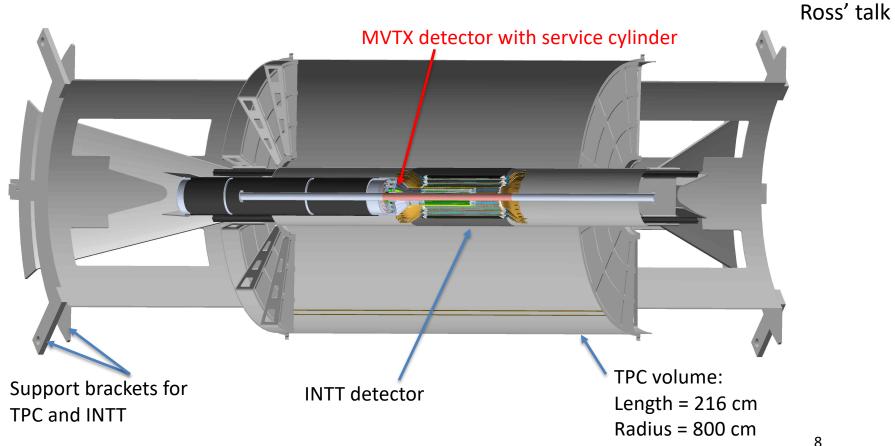
Sensor-Stave (9 ALPIDE chips) | Front End-Readout Unit | Back End-FELIX/DAM

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SPHENIX

MVTX Detector in sPHENIX





MVTX Scope



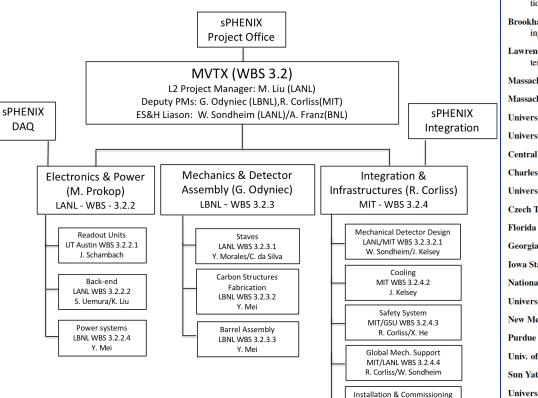
- Mechanical structure design
 - Design & FEA, LANL/MIT
 - End Wheels
 - Cylindrical structure shells
 - Detector service half barrels
 - Service patch panels
 - Global interface
- Mechanical structure fabrication
 - Composite structures, LBNL
 - Non-composite structures, MIT
 - Installation tooling etc., MIT/LANL/LBNL/BNL
- Ancillary systems "adopt" ALICE/ITS
 - Cooling plant, MIT/BNL
 - Slow control & monitoring etc., MIT/GSU

- MVTX electronics
 - Backend FELIX and cables
 - Integration into sPHENIX DAQ
 - Power system
- Detector assembly & test
 - Stave QA & half detector assembly @LBNL
 - System test & integration @LBNL/BNL
- Installation & commissioning, by all
 - Pre-installation commissioning @BNL
 - Installation @IR

Early generic R&D accomplished through LANL LDRD

- Readout integration
- Detector conceptual design

MVTX Collaborators & Institution Roles



Los Alamos National Laboratory (LANL) : Overall readout electronics and mechanical system integra- tion, project management.
Brookhaven National Laboratory (BNL) : Global system integration and services, safety and monitor- ing, project management.
Lawrence Berkley National Laboratory (LBNL) : Carbon structure production, LV and HV power sys- tem, full detector assembly and test, project management.
Massachusetts Institute of Technology (MIT/Bates) : Global mechanical system integration and cooling.
Massachusetts Institute of Technology (MIT) : Stave assembly and test at CERN.
University of California at Los Angeles (UCLA) : Simulation and readout testing.
University of California at Riverside (UCR) : Detector assembly and test, simulations.
Central China Normal University (CCNU/China): MAPS chip and stave test at CERN and/or CCNU.
Charles University (CU/Czech) : MAPS stave production and QA.
University of Colorado (UCol) : b-jet simulations and future hardware.
Czech Technical University (CTU/Czech) : MAPS stave production and QA at CERN.
Florida State University (FSU) : Offline software and simulations.
Georgia State University (GSU) : Online software and trigger development.
Iowa State University (ISU) : Detector assembly and test, simulations.
National Central University (NCU/Taiwan)* : Stave assembly and test, simulations.
University of New Mexico (UNM) : Cabling & connectors.
New Mexico State University (NMSU) : Tracking algorithm and physics simulations.
Purdue University (PU): Detector assembly and test, simulations.
Univ. of Science and Technology of China (USTC/China) : MAPS chip and stave test, simulations.
Sun Yat-Sen University (SYSU/China) : MVTX detector and physics simulations.
University of Texas at Austin (UTA) : MVTX readout electronics integration, Readout Units production and test.

Yonsei University (YSU/Korea) : MAPS chip production QA, readout electronics test and simulations

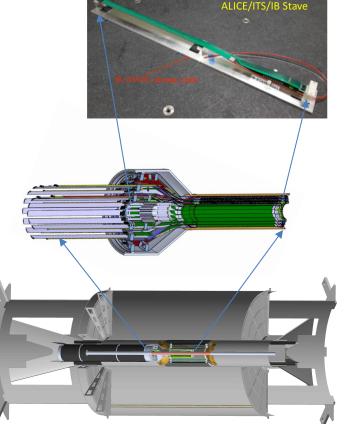
BNL/all WBS 3.2.4.6

SPHENIX

Schedule Drivers

- Budget availability
 - Final engineering design of the mechanical system
 - Production of support structures
- Mechanical structures
 - Detector and interface system design
 - Carbon structure fabrication
- Detector assembly and test
 - Assembly jigs design and fabrication
 - Detector assembly & QA
 - Metrology
- Final installation in IR
 - Last detector to be installed





Cost Drivers



MVTX Bu	udget by L3 in AYk\$	Burdened /Esc.							
WBS	Level 2 WBS Description	OPC	TEC	Total					
3.2.01	Project Management	\$0	\$642	\$642					
3.2.02	Electronics	\$0	\$665	\$665					
3.2.03	Mechanics and Assembly	\$0	\$2,001	\$2,001					
3.2.04	Integration and Installation	\$0	\$1,023	\$1,023					
	Sub-total	\$0	\$4,331	\$4,331					
	Contingency	\$0		\$0					
	Total Project Cost	\$0	\$4,331	\$4,331					

Mechanical design and fabrication

- CYSS
- End wheels
- Service barrel
- Global interface

Basis of Estimate & Resource-Loaded Schedules PHE

- Electronics: production
 - FELIX: ATLAS/sPHENIX production, LANL/LDRD
 - RU services, cables: ALICE/ITS production, LANL/LDRD
 - Power boards: ALICE/ITS production , LANL/LDRD
 - CAEN bulk PS: Quotes from CAEN, ALICE/ITS production, LANL/LDRD
- Mechanics & Integration: design and production
 - CYSS, End wheels, Service barrel: ALICE/ITS
 - Integrations: Recent experience at RHIC, HFT/STAR, FVTX/PHENIX

WBS Number: 3.2.2.3 Backend Electronics - FELIX

MVTX BoE Doc

This item contains all the backend readout electronics FELIX boards required for MVT2 readout.

Work statement:

Technical scope:

Produce 8 FELIX boards to integrate MVTX readout electronics into the sPHENIX DAQ system.

Assumptions used in developing estimate:

We will use the ATLAS FELIX v2.0 PCIe board developed by the BNL group for the ATLAS upgrade. The FELIX board production quote for sPHENIX was obtained in 2018, about \$8K per board. A total of 8 FELIX boards (6 + 2 spares) are required for MVTX.

Cost Summary:

Total (K)	M&S	Labor	Contingency (average)
122	103	19	25%

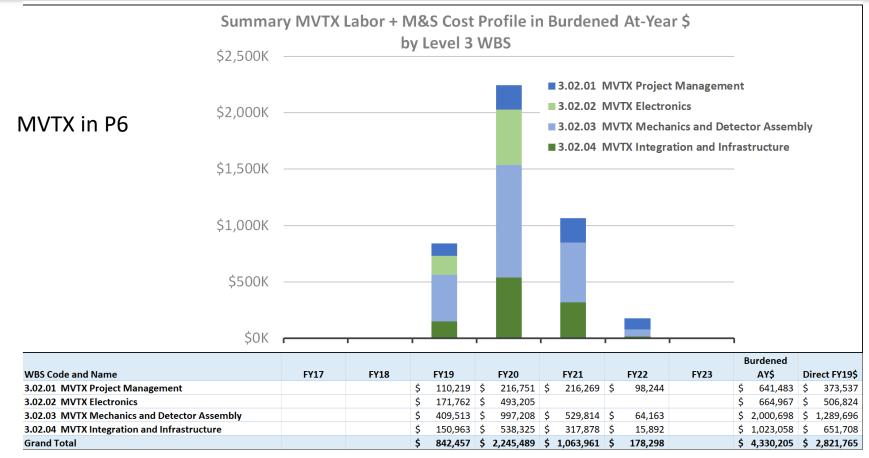
												_											
											POM02B_	3.02.3.02.02.02 FELIX 2.0	FIIX		254	01-Apr-19	03-Apr-20	392	186	88400	\$18,588	\$103,640	\$122,229
											\$103000	Produce Felix 2.0 first productio	n unit - Labor	Liu, Ming	57	01-Apr-19	19-Jun-19	218	16	0	Labor,	M&S	\$3,073
											\$103100	Procure Optical Fiber - Labor		Liu, Ming	121	01-Apr-19	19-Sep-19	414	2	0	\$307	\$0	\$307
1											\$103200	Produce Felix 2.0 first productio	n unit - M&S	Liu, Ming	57	01-Apr-19	19-Jun-19	218	0	20000	\$0	\$22,778	\$22,778
BROOKHAVEN					sPHEN			t Detailed			\$103300	Procure Optical Fiber - M&S		Liu, Ming	121	01-Apr-19	19-Sep-19	414	0	50	\$0	\$63	\$63
NATIONAL LABORATORY								blished: 02-				Test/QA 1st Felix Unit and Fiber	s	Liu, Ming	10	20-Sep-19	03-Oct-19	414	40	0	\$0	\$0	\$0
Activity ID Activity Name	CAM	At Compl. Duration	. Start	Finish	Total Float	Hours	Direct FY19\$ - M&S	- Burd AY\$ -	Burd AY\$ - M&S	Burd AY\$ - Total	\$103500	Procure 7 Felix 2.0 Remaining U	Jnits -Provide	Liu, Ming	5	06-Nov-19	13-Nov-19	392	6	0	\$1,187	\$0	\$1,187
S110400 ship from CERN to LBNL - Batch 1	Liu, Ming	7	7 27-Jun-19	08-Jul-19	318	0	600	\$0	\$7,500	\$7,500	-	Requirements to Procurement									T -7		· · ·
S110500 ship from CERN to LBNL - Batch 2	Liu, Ming	7	7 25-Sep-19	03-Oct-19	268	0	6000	\$0	\$7,564	\$7,564	\$103600	Procure 57 Optical Fiber Sets - I	abor	Liu, Ming	20	06-Nov-19	06-Dec-19	462	2	0	\$396	\$0	\$396
S110600 ship from CERN to LBNL - Batch 3	Liu, Ming	7	7 27-Dec-19	07-Jan-20	219	0	600)	\$0	\$7,650	\$7,650	S103700	Procure 57 Optical Fiber Sets M	&S	Liu, Ming	20	06-Nov-19	06-Dec-19	462	0	2850	\$0	\$3,634	\$3,634
Ciaro pristo Con press Struc	ture	es '	7 27-Mar-20			0	6000		\$7,650	\$7,650													
POM02B_3.02.3.02.03.02 Carbon Structures			01-Apr-19			5774		1 \$910,025	\$472,154														
POM028_3.02.3.02.03.02.01 Mechanics Detector Design S110800 Develop MAPS inner tracker mechanical model	Liu, Ming		0 01-Apr-19 0 01-Apr-19			640 640		abor.	M&S	\$167,952 \$167,952		-											
POM028_3.02.3.02.03.02.02 End Wheels		277	7 24-Jul-19	28-Aug-20	54	502		\$73,964	\$90,875	\$164,839													
S110900 Design End-wheels	Liu, Ming	15	24-Jul-19	13-Aug-19	54	120	0	\$36,658	\$0	\$36,658		ſ	3										
S111000 Prototype End-wheels - M&S	Liu, Ming	30	0 14-Aug-19	25-Sep-19	54	0	10000	\$0	\$12,500	\$12,500													
S111100 Prototype End-wheels - Labor	Liu. Mine	30	14-Aug-19	25-Sep-19	54	12	0	\$2.305	\$0	\$2.305				I									

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Resource Distribution

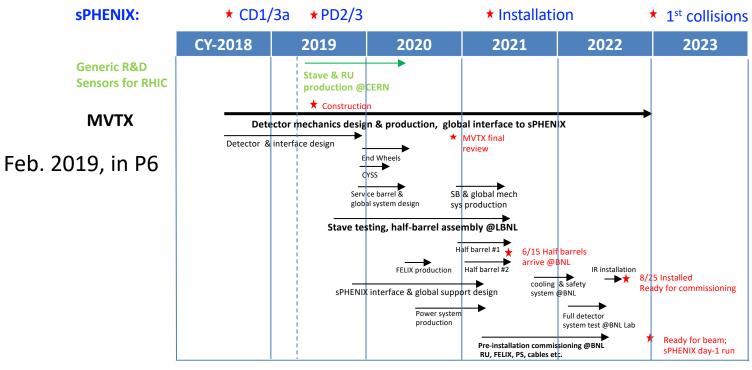




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MVTX Schedules and Milestones **BPHE**



Today

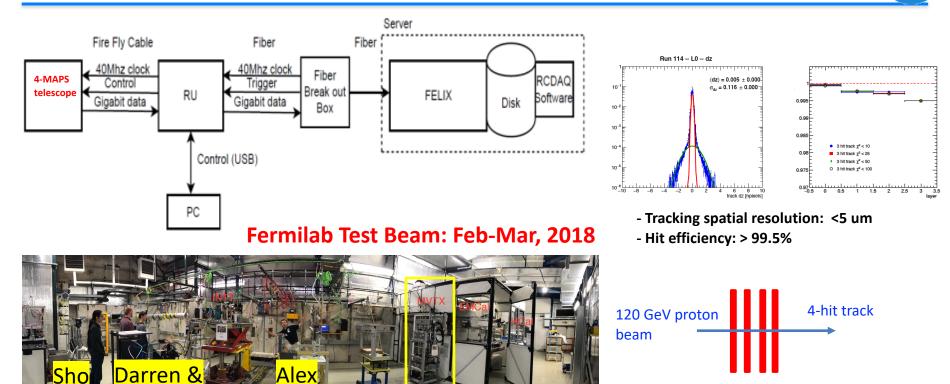
Status and Highlights

- Full readout chain demonstrated through LANL LDRD
 - Successful Fermilab Test Beam run in 2018
- Modified stave certified through LANL LDRD
 - Successfully tested at CERN
 - Radiation hardness verified at CERN
- Mechanical system integration MVTX+INTT
 - sPHENIX tracking optimized with 2-layer INTT configuration
 - Mechanical design being updated and 3-D mockup demonstrated
- Readout cables
 - BNL approved the use of SamTec non-Halogen-free cables
 - Electrically better & mechanically compact
 - ALICE confirmed performance with 8m long Halogen-free cables
 - For MVTX, ~10m very likely work (30AWG/sPHENIX vs 32AWG/ALICE)
 - Samples (6.5 ~ 11.5m long) ordered for R&D test at LANL
 - To be tested in coming months



SPHE

MVTX Full Readout Chain Demonstrated (3/2018) ■PHE



4/9-11, 2019

Sanghoon

4-MAPS telescope

Confirmed HIC with Extended 40(60)cm Power FPC

- Built and tested two HICs at CERN in 9/2018
 - No change in sensor performance (noise, threshold) observed, as expected;



Followed identical ALICE IB QA test procedure, with a 8m SamTec cable!

Sensor Irradiation Test – OK at 2.7MRad



- Continuous effort by ALICE (@NPI, Czech)
- BNL Director's review recommendation:
 - Test sensors up to 1MRad

ALICE/ITS report: 2.7 MRad https://indico.cern.ch/event/758048/ Conclusion

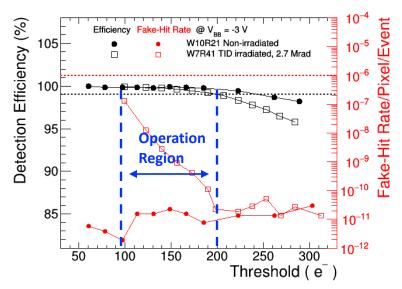
Irradiated ALPIDE sensor (2700 krad) over a large range of threshold settings

has :

1) good efficiency up to threshold ~190 e (Ithr = 100 DAC units) at Vbb = - 3 V, Vcasn = 90, Vcasn2 = 102

2) fake hit rate remains orders of magnitude smaller than the requirement (<< $10^{\text{-6}})$

Irradiated chip#41 (2.7Mrad) : efficiency & fake hit rate



red line - fake hit rate- sensitivity limit of ALPIDE black line - efficiency - the project goal (99%)

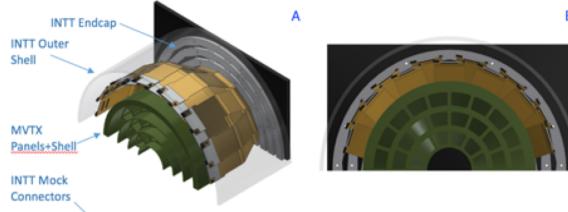
For non irradiated 2 noisy pixels were masked out. No pixel was masked out for the 2.7Mrad chip.

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MVTX + INTT 3-D Mockup (11/2018)

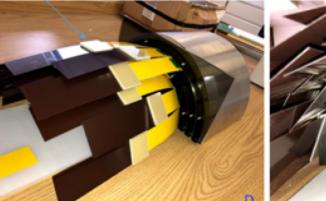




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Office of System Integration – led by Mickey & Bob, a team of engineers and physicists

MVTX and INTT Space conflict resolved!

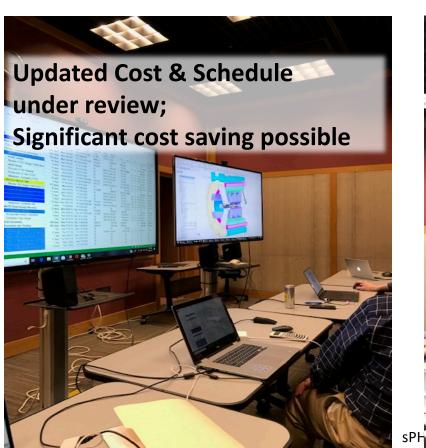






Latest Project Update: MVTX Workshop SPHE

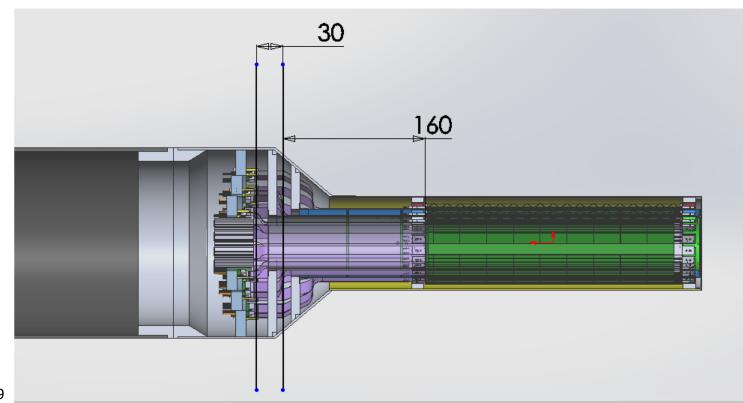
Feb. 28 – Mar. 2, 2019, MVTX/HF Workshop @LBNL



Discussed major carbon structures' design & production cost, line by line; Also LBNL production schedule

Carbon Structures – Work in Progress

- Conical sectors are expensive!
- A new design under development to avoid the conical structures, MIT/LANL





Ross' talk

Issues and Concerns



- Budget availability
 - Funding for final mechanical system design work
 - Early R&D to reduce high production contingency
 - Preparation for Stave acceptance test/QA/storage at LBNL (3 months lead time)
 - Schedule is closely tied to the funding level
- Carbon structures
 - Cost and schedule, high contingency in cost
 - Window of opportunity at LBNL before ATLAS production
 - Other possible production sites (Italy, France, Korea ...)
- Mechanical system integration
 - sPHENIX beam pipe modification, under discussion with CAD
 - Readout cables, cooling etc.
 - MVTX+INTT+TPC... global support structure design

Summary



- MVTX enables the 3rd science pillar
- MVTX detector design & construction
 - As a separate upgrade project from the baseline sPHENIX MIE
 - Engineering design work in progress, MIT/LANL/LBNL et al
 - Need budget now for the final engineering design work
 - Construction and assembly work planned for late 2019
- Project integrated into the sPHENIX P6
 - Latest Cost & Schedule under review, significant cost saving possible
 - To be implemented in P6 after this review
- Successful generic R&D through LANL LDRD support
 - Readout integration
 - Stave modification
 - Mechanical system conceptual design
- MVTX is ready to receive project funding

backup



Address July 2018 Review Recommendations

Stave and RU procurement readiness

- Completed sensor/HIC/stave evaluations at CERN
 - Built, tested and confirmed two HICs with 40cm and 60cm long power FPC
 - Sensors irradiated up to 2.7MRad, no issues (updated 9/18/2018).
- Addressed all recommendations on stave/sensor R&D

https://docs.google.com/document/d/1vsm_G7ZLgqv-kBZqK0jF69T_Nx2Uwk0Zxv86jRVxybw/edit?usp=sharing

Cost are set for staves & RUs, procurement through US-ALICE/UTK

- Technical specs document completed for production, BNL/DOE agreed
- sPHENIX RU and stave production starts ~May 2019
- MVTX/INTT mechanical integration
 - Mechanical design being updated and 3-D mockup demonstrated
 - Inner tracking task force completed evaluation, preferred INTT-layers =2
- Readout cables
 - BNL approved the use of SamTec blue cables
 - Electrically better & mechanically compact
 - ALICE confirmed signal performance with 8m long readout cables. For MVTX, 10m very likely works (30AWG/sPHENIX vs 32AWG/ALICE), to be confirmed by on-going R&D at LANL
 - Samples ordered for system integration mockup and test

Stave and RU Production QA Plan Documents Available

https://indico.bnl.gov/event/4729/

Staves

- Purchase 84 staves from ALICE/CERN
 - 48 + 28(spares for 2 inner layers) + 8 spares
 - Production following the completion of ALICE ITS/IB
 - Starting ~Oct. 2018, will last 6-12 months
 - Fully tested at CERN before shipping to US
 - All Gold/Silver staves (same as ALICE IB)
 - A LANL postdoc (Dr. Yasser Morales) oversees production QA at CERN
- Acceptance QA at LBNL
 - Full test and QA
 - Electrical
 - Mechanical
 - Detector assembly at LBNL

Readout Units

- Purchase 60 RUs from ALICE/CERN
 - 48 + 12 spares(20%)
 - To be part of ALICE production
 - Cost saving
 - Minimize technical risks
 - Initial test at CERN
- Acceptance QA at UT-Austin
 - Full test
 - LANL as the 2nd test site

MVTX in P6 (fully Burd. & Esca.)

Release Release EXT312000 [External Activity] Design/Safety Reviews: Complete, Internal Detector Structural Support Released for Production PP EXT101010 [External Activity] PY20 Funding Available So EXT147100 [External Activity] PY20 Funding Available So EXT147100 [External Activity] PY21 Funding Available So EXT101015 [External Activity] PY21 Funding Available So EXT101016 [External Activity] PY21 Funding Available So POM028_3.02.302.00 Temporary POM028_3.02.302.00 Temporary POM028_3.02.302.00 OI ALICE ITS Key Tasks So S100000 ALICE ITS RU Production Start POM028_3.02.302.00.01 ALICE TO Start S1000100 Stave Production - Batch 1 Stave Production - CERN	[MVTX]	1281 1169 0 0 0 0 0 0 0 0 741 248 0	Start 01-Feb-17 A 01-Feb-17 A 01-Feb-17 A 01-Feb-17 A 01-Feb-17 A 01-Oct-19* 06-Nov-19* 01-Oct-20* 01-Oct-21* 01-Apr-19 01-Apr-19 01-Apr-19	Finish 17-Mar-22 17-Mar-22 01-Oct-21 19-Jul-19* 17-Mar-22 26-Mar-20 01-Apr-19	Total Float 0 0 112 319 417 392 362 112 0 169 255	Hours 26695 26695 0 0 0 0 0 0 0 0 26695 0	Direct FY19\$- M&S 1266751 1266751 0 0 0 0 0 0 0 0 0 0 0 1266751	\$2,760,452 \$0 \$0 \$0 \$0 \$0 \$0 \$0 \$0 \$0 \$0 \$0	\$0 \$0 \$0 \$0 \$0 \$0 \$0 \$0	Total S4,330,205 S0 S0	2015 2016 5 PY16 01-Feb-17 A,	2017 FY17	2018 FY18	2015 FY19 19-Jul-19* • 01-Oct-19*, 06-Nov-19*	FY20 ►	FY21
OM028_3.02.3 Silicon Detectors OM028_3.02.3 O (Temporary) External Placeholder Milestone CM028_3.02.3 O (Temporary) External Placeholder Milestone So Release So EXT13020 (External Activity) Initial Project Funding So EXT31200 (External Activity) Program Fermal Activity) Ervoure Tec Data Felix 2.0 EXT147000 (External Activity) Prozer Tec DAM Felix 2.0 He Boards - Contract Award(s) So EXT101016 (External Activity) Prozer Tec DAM Felix 2.0 He Boards - Contract Award(s) So EXT101016 (External Activity) Prozer Tec DAM Felix 2.0 He Boards - Contract Award(s) So POM028_3.02.3.02.00 Temporary POM028_3.02.3.02.00 Temporary POM028_3.02.3.02.00 O TAULE ITS Key Tasks So Sol00000 ALICE ITS RU Production Start POM028_3.02.3.02.00.02.01 ALICE ITS Rev Production at CERN Sl00010 Stave Production - Batch 1 Si	ees in WBS 3x iourikova, Irina Pontieri, Chris Iourikova, Irina Hemmick, Tom Iourikova, Irina	1281 1169 0 0 0 0 0 0 0 0 741 248 0	01-Feb-17 A 01-Feb-17 A 01-Feb-17 A 01-Oct-19* 06-Nov-19* 01-Oct-20* 01-Oct-21* 01-Apr-19 01-Apr-19 01-Apr-19	17-Mar-22 01-Oct-21 19-Jul-19* 19-Jul-19*	0 112 319 417 392 362 112 0 169	26695 0 0 0 0 0 0 0 0 0 0 0 26695	1266751 0 0 0 0 0 0 0 1266751	\$2,760,452 \$0 \$0 \$0 \$0 \$0 \$0 \$0 \$0 \$0 \$0 \$0 \$0 \$0	\$1,569,754 \$0 \$0 \$0 \$0 \$0 \$0 \$0 \$0 \$0 \$0	\$4,330,205 \$4,330,205 \$0 \$0 \$0 \$0 \$0 \$0 \$0 \$0 \$0 \$0	01-feb-17 A,	•		01-Oct-19*,	, •	
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XT103000 [External Activity] Initial Project Funding Release Sori Release XT317000 [External Activity] Design/Safety Reviews Complete, Internal Detector Structural Support Released for Production Petersity XT101010 [External Activity] Procure Tec DuM Felix 2.0 Boods - contract Award(s) He Boods - contract Award(s) Sori XT101010 [External Activity] Procure TPC DuM Felix 2.0 Boods - contract Award(s) Sori Sori XT101010 [External Activity] FY21 Funding Available Sori XT101010 [External Activity] FY22 Funding Available Sori XT010101 [External Activity] FY22 Funding Available Sori XT010102 [External Activity] FY22 Funding Available Sori XT010105 [External Activity] FY22 Funding Available Sori XT010106 [External Activity] FY22 Funding Available Sori XT010107 [External Activity] FY22 Funding Available Sori XT010108 3.02.30.20 Sori Contract Contract Available Sori XT010109 Auard Contract Tract Available Sori Contract Available Sori Contract Available XT0101010 [External Activity] FY22 Funding Available Sori Contract Available Sori Contract Available XT0101010 [External Activity] FY22 Funding Available Sori Contract Ava	iourikova, Irina Pontieri, Chris iourikova, Irina Hemmick, Tom iourikova, Irina iourikova, Irina	0 0 0 0 0 0 0 741 248 0	01-Feb-17 A 01-Oct-19* 06-Nov-19* 01-Oct-20* 01-Oct-21* 01-Apr-19 01-Apr-19 01-Apr-19	19-Jul-19*	319 417 392 362 112 0 169	0 0 0 0 0 26695	0 0 0 0 0 0 1266751	\$0 \$0 \$0 \$0 \$0 \$0 \$0	\$0 \$0 \$0 \$0 \$0 \$0	\$0 \$0 \$0 \$0 \$0 \$0 \$0	01-Feb-17 A,	•		01-Oct-19*,	, •	
Release Release XT317000 [External Activity] Design/Safety Reviews Pc Complete, Internal Activity] Proceed for Productor Pc XT11700 [External Activity] PY20 Funding Available So XT11700 [External Activity] PY20 Funding Available So XT147100 [External Activity] PY20 Funding Available So XT147100 [External Activity] PY20 Funding Available So XT101015 [External Activity] PY21 Funding Available So XT101016 [External Activity] FY22 Funding Available So M002B_3.02.3.02 MVTX V0002B_3.02.3.02 MVTX V0002B_3.02.3.02 ON 1 ALICE ITS Key Tasks So S100000 ALICE ITS RU Production Start P S0002B_3.02.3.02.00.02 MVTX Stave Production at CERN Si S100000 Stave Production - Batch 1 P	Pontieri, Chris iourikova, Irina Hemmick, Tom iourikova, Irina	0 0 0 0 0 741 248 0	01-Oct-19* 06-Nov-19* 01-Oct-20* 01-Oct-21* 01-Apr-19 01-Apr-19 01-Apr-19	17-Mar-22 26-Mar-20	417 392 362 112 0 169	0 0 0 0 0 26695	0 0 0 0 0 1266751	\$0 \$0 \$0 \$0 \$0 \$0	\$0 \$0 \$0 \$0 \$0	\$0 \$0 \$0 \$0 \$0 \$0	01-Feb-17 A,	•		01-Oct-19*,	, •	
Complete, Internal Detector Structural Support Released for Production XT101010 [External Activity] PY20 Funding Available Son XT101010 [External Activity] PY20 Funding Available Son Boards - Contract Award(s) XT101015 [External Activity] FY22 Funding Available Son XT101016 [External Activity] FY22 Funding Available Son MO28_3.02.3.02 MVTX MOM28_3.02.3.02 MVTX S100000 ALICE ITS RU Production Start S100000 ALICE ITS RU Production Start S00028_3.02.3.02.00.02 MVTX Stave Production at CERN S100100 [Stave Production - Batch 1	iourikova, Irina Hemmick, Tom iourikova, Irina iourikova, Irina	0 0 0 0 741 248 0	01-Oct-19* 06-Nov-19* 01-Oct-20* 01-Oct-21* 01-Apr-19 01-Apr-19 01-Apr-19	17-Mar-22 26-Mar-20	417 392 362 112 0 169	0 0 0 0 26695	0 0 0 0 1266751	\$0 \$0 \$0 \$0 \$0	\$0 \$0 \$0 \$0	\$0 \$0 \$0 \$0 \$0	<u>``</u>			01-Oct-19*,	, •	
XT147100 [External Activity] Procure TFC DAM Felix 2.0 He Boards - Contract Award(s) So XT101015 [External Activity] FY21 Funding Available So XT101016 [External Activity] FY22 Funding Available So DM028_3023.02 MVTX OM028_3023.02 MVTX OM028_3023.02 0.00 T AUCE ITS Key Tasks So S100000 ALICE ITS RU Production Start POM028_302.302.00.01 ALICE ITS Key Tasks S100000 Stave Production - Batch 1 So	Hemmick, Tom Sourikova, Irina	0 0 0 741 248 0	06-Nov-19* 01-Oct-20* 01-Oct-21* 01-Apr-19 01-Apr-19 01-Apr-19	26-Mar-20	392 362 112 0 169	0 0 26695	0 0 1266751	\$0 \$0 \$0 \$0	\$0 \$0 \$0	\$0 \$0 \$0					, •	
Boards - Contract Award(s) KT101015 [External Activity] FY21 Funding Available So KT101016 [External Activity] FY22 Funding Available So M0028_3.02.302 MVTX M0028_3.02.302.00.01 Fungorary M0028_3.02.302.00.01 ALICE ITS Key Tasks S100000 ALICE ITS RU Production Start POM028_3.02.30.2.00.02 MVTX Stave Production at CERN S100100 Stave Production - Batch 1	Sourikova, Irina	0 0 741 248 0	01-Oct-20* 01-Oct-21* 01-Apr-19 01-Apr-19 01-Apr-19	26-Mar-20	362 112 0 169	0 0 26695	0 0 1266751	\$0 \$0	\$0 \$0	\$0 \$0	>			06-Nov-19*		
XT101016 [External Activity] FY22 Funding Available Soi DM028_3.02.3.02 MVTX WOM028_3.02.3.02 MVTX POM028_3.02.3.02.00 Temporary POM028_3.02.3.02.00.01 ALICE ITS Key Tasks S100000 ALICE ITS RU Production Start POM028_3.02.3.02.00.02 MVTX Stave Production at CERN S100100 S100100 Stave Production - Batch 1	iourikova, Irina	0 741 248 0	01-Oct-21* 01-Apr-19 01-Apr-19 01-Apr-19	26-Mar-20	112 0 169	0 26695	0	\$0	\$0	\$0	>				01-Oct-20*,	
DM02B_3.02.3.02.0VTX OM02B_3.02.3.02.00 Temporary POM02B_3.02.3.02.00.01 ALICE ITS Key Tasks S100000 ALICE ITS RU Production Start POM02B_3.02.3.02.00.02 MVTX Stave Production at CERN S100100 Stave Production - Batch 1		741 248 0	01-Apr-19 01-Apr-19 01-Apr-19	26-Mar-20	0 169	26695	1266751									01-Oct-21*, ♦
OM02a 3.02.3.02.00 Temporary OM02a 3.02.3.02.00.01 ALICE ITS Key Tasks ALICE ITS Key Tasks S100000 ALICE ITS RU Production Start Production Start OM02a 3.02.3.02.00.02 MVTX Stave Production at CERN S100100 Stave Production - Batch 1 Production - Batch 1	Liu, Ming	248 0	01-Apr-19 01-Apr-19	26-Mar-20	169			\$2,760,452	\$1,569, 54	A	,					
POM02B_3.02.3.02.00.01 ALICE ITS Key Tasks S100000 ALICE ITS RU Production Start POM02B_3.02.3.02.00.02 MVTX Sawe Production at CERN S100100 Stave Production - Batch 1	Liu, Ming	0	01-Apr-19			0	0			\$4,330,205						
100000 ALICE ITS RU Production Start DM02B_3.02.3.02.00.02 MVTX Stave Production at CERN 100100 Stave Production - Batch 1	Liu, Ming			01-Apr- 19	255			\$0	\$0	\$0						
DM028_3.02.3.02.00.02 MVTX Stave Production at CERN 100100 Stave Production - Batch 1	Liu, Ming	0	01-Apr-19*		255	0	0	\$0	\$0	\$0						
5100100 Stave Production - Batch 1					255	0	0	\$0	\$0	\$0			01-Apr	±19*, ♦		
		248	01-Apr-19	26-Mar-20	169	0	0	\$0	\$0	\$0						
100200 Stave Production - Batch 2	Liu, Ming	62	01-Apr-19	26-Jun-19	169	0	0	\$0	\$0	\$0						
	Liu, Ming	62	27-Jun-19	24-Sep-19	169	0	0	\$0	\$0	\$0						
S100300 Stave Production - Batch 3	Liu, Ming	62	25-Sep-19	26-Dec-19	169	0	0	\$0	\$0	\$0						
S100400 Stave Production - Batch 4	Liu, Ming	62	27-Dec-19	26-Mar-20	169	0	0	\$0	\$0	\$0						
OM02B_3.02.3.02.00.03 sPHENIX Milestones		0			0	0	0	\$0	\$0	\$0						
M02B_3.02.3.02.01 MVTX Project Management		741	01-Apr-19	17-Mar-22	0	1858	37762	\$592,839	\$48,644	\$641,483						
100500 Milestone Start MVTX	Liu, Ming	0	01-Apr-19		0	0	0	\$0	\$0	\$0			01-A	r-19, 🔸		
	Liu, Ming	741		17-Mar-22	0	1238	0		\$0	\$395,226						
	Liu, Ming	741		17-Mar-22	0	310	0		\$0	\$98,806						
	Liu, Ming	741		17-Mar-22	0	310	0		\$0	\$98,806					_	
	Liu, Ming		01-Apr-19	30-Sep-19	112	0	6250	\$0	\$7,813	\$7,813						
	Liu, Ming		01-Apr-19*		0	0	0	\$0	\$0	\$0			01-Apr	19*, •		_
	Liu, Ming	251		30-Sep-20	112	0	12500	\$0	\$15,938	\$15,938						
	Liu, Ming	250		30-Sep-21	112	0	12500	\$0	\$16,256	\$16,256						
	Liu, Ming Liu, Ming	112 0		17-Mar-22 17-Mar-22	0	0	6512 0	\$0 \$0	\$8,638 \$0	\$8,638 \$0						17-Ma
DM02B 3.02.3.02.02 MVTX Electronics		286	01-Apr-19	19-May-20	363	3863	395448	\$195,007	\$469,960	\$664,967						
POM02B 3.02.3.02.02 IN TX Electronics POM02B 3.02.3.02.02 IN TX Electronics			01-Apr-19	07-Jan-20	453	1137	82428	\$85,282	\$100,435	\$185,717						

SPHENIX

MVTX MS Project 1/4(for estimation)

Thu 4/4/19								MVTX-Barrel-1	20718-040	042019											
ID Task Mode	WBS	fask Name	Duration	Start	Finish		Calculated Fixed Cost	Resource Resource Names Costs	Cost												
												2019		1	2020		1	2021		2022	
1 -			4500 4	Mar 44/20/40	E-14/07/00	£0.	64 202 025	62,002,427	* A ACE OF	Н	1	H2		H1	H2	H	11	H2	- F	1 H2	
1 =		MVTX Inner Barrel ALICE ITS Key Tasks		Mon 11/28/16 Mon 11/28/16			\$1,263,825 \$0	\$2,902,127 \$0	\$4,165,954	2											
14	3.1			Mon 5/8/17			\$0	\$0	s	0				•							
21 🛼		MVTX Project		Wed 8/1/18			\$1,263,825	\$2,902,127	\$4,165,952	2											
22 🔫	3.2.1	MVTX Project Management	774 days	Mon 4/1/19		\$0	\$50,000	\$591,621	\$641,621	1										sPHENIX M/	APS Pi
23 🛼	3.2.1.1	Milestone Start MVTX	0 days				\$0	\$0	\$0	D	. •	4/1	1 1		1						
24 🔩	3.2.1.2	lead Coordinator	774 days		Thu 3/17/22		\$0	\$0		Dead Coor	dinator (1									
25 = 26 =	3.2.1.3 3.2.1.4	Project Manager Mechanical Integration Engineer	774 days 774 days		Thu 3/17/22 Thu 3/17/22		\$0 \$0	MGR_Ins\$394,478 PROF4 i\$98,572	\$394,478	8 2 gration Er	nineer .									MGR_Institute PROF4 inst	
27	3.2.1.4	Electronics Integration Engineer	774 days		Thu 3/17/22		\$0	PROF4 i\$98,572		2 pration Er		1								PROF4 inst	
28	3.2.1.6	Travel	342 days		Tue 7/21/20		\$50.000	50	\$50,000			ł			<u> </u>					•	
29 🛋	3.2.2	Electronics	703 days	Wed 8/1/18	Fri 4/9/21	\$0	\$395,448	\$203,311	\$598,759	9		·									
30 🔫	3.2.2.1	Stave Extension Cable	182 days	Wed 8/1/18	Thu 4/11/19		\$0	\$0	\$0	0		+									
31 🛶	3.2.2.1.1	design	4 mons		Tue 11/20/18		\$0	\$0	\$0	•		1			1						
32 =, 33 =,	3.2.2.1.2 3.2.2.1.3	prototype review		Wed 11/21/18			\$0 \$0	\$0 \$0		Dype 👗 D review	1	1			1						
33 =, 34 =,	3.2.2.1.3	procure	2 days 2 mons	Wed 1/16/19 Fri 1/18/19	Thu 3/14/19		\$0 \$0	50		D review D procure	1	1									
35 -	3.2.2.1.4	test	20 days		Thu 3/14/19 Thu 4/11/19		\$0 \$0	SCI3 Ins\$0	50		test	SCI3_Institut	ion LAN		1						
36 -	3.2.2.2	RU	162.63 days		Wed 11/13/19		\$82,428	\$89,994	\$172.422												
37 🛋	3.2.2.2.2	Cold Plate	4 wks	Mon 4/1/19	Fri 4/26/19	\$12,104	\$12,104	ElectTecl\$5,472	\$17,576			ElectTech_	nstitution	UTAustin[38%	1						
38 🛼	3.2.2.2.8	Transition board for RU		Mon 4/29/19	Fri 5/10/19		\$8,716	\$0		6sition bo											
39 🛋	3.2.2.2.9	Power Mezzanine for RU		Mon 5/13/19			\$22,108	\$0		8 er Mezza											
40 🛼	3.2.2.2.3	Test/QA RU		Mon 5/27/19			\$7,500	SCI3_Ins\$3,600	\$11,100			RU 🚝 SCI3_		LANL[50%],EI		tution_0	Austin				
41 =	3.2.2.2.5	Procure 60 SamTec Cables Test/QA		Wed 6/19/19 Wed 9/11/19			\$30,000 \$0	TECH4_1\$922 SCI3 Ins\$80,000	\$30,922		sam rec (Test/QA		113 Institution_LA		ch Inett	ution UTAu	etin Electrica	l Engineer I	TAustin	
42 🛶	3.2.2.2.0	TesuqA	40 days	wed 5/11/15	wed 11/0/15	3 0	30	Engineer	\$00,000			Testiga		.is_insutution_	LANL, LIECTIE	cn_msu	ution_orad	suii,Liecuica	i Liigineer (TAusun	
43 🛼	3.2.2.2.7	Ship to UT Austin	1 wk	Wed 11/6/19	Wed 11/13/19	\$2,000	\$2,000	\$0	\$2,000	D		Ship to UT A	stin 🐗								
44 🔫	3.2.2.3	FELIX	70.33 days		Wed 7/8/20		\$88,400	\$20,275	\$108,675					-							
45 =	3.2.2.3.1	Produce first production unit	4 wks		Tue 4/28/20		\$20,000	TECH4_1\$3,152	\$23,152					tion unit ge cal fiber ⊁ge T							
46 =	3.2.2.3.2 3.2.2.3.3	Procure Optical fiber Test/QA	2 wks	Wed 4/1/20 Wed 4/15/20	Tue 4/14/20		\$50 \$0	TECH4_1\$315 SCI3 Ins\$0	\$365			P	cure Opti	Test/QA							
47	3.2.2.3.3	Procure 7 Remaining Units		Wed 4/15/20 Wed 4/29/20			\$56,000	TECH4 1\$1,261	\$57,261			Procu	re 7 Rema	ining Unite 🖼	TECHA	Institutio	D 1 ANI 12%	1			
49	3.2.2.3.5	Procure 57 optical fibers		Wed 4/29/20			\$2.850	TECH4 I\$315	\$3,165			Pro	cure 57 o	otical fibers 🐳	TECH4 Insti	itution L	ANL[2%]				
50 🛼	3.2.2.3.6	test/QA	5.33 days	Wed 6/24/20	Wed 7/1/20	\$7,500	\$7,500	SCI3_Ins\$15,232	\$22,732	2								H4_Institution	n_LANL,Ele	ctrical Engineer UTAu	ustin
64	3.2.2.3.7	Ship to BNL				eo 000	\$2,000	Engineer \$0	\$2.000					Ship to B	L 🕹						
51 =, 52 =,	3.2.2.3.1	MAPS Power System	1 wk 225 davs	Wed 7/1/20 Mon 6/1/20	Fri 4/9/21		\$2,000	\$93.042	\$2,000					Ship to B							
53	3.2.2.4	Power Boards	175 days				\$117.320	\$80,958	\$198.278								_				
54 =	3.2.2.4.1.1	Review ALICE PB Design	30 days				\$0	ELENG3 \$19,800	\$19,800				eview AL	ICE PB Design	ELENG	G3 Institu	ution LBNL	[35%],MECHE	NG3 Institu	tion LBNL[10%],POS	STD In
55 🛼	3.2.2.4.1.2	Fabricate PB Prototype	40 days	Mon 7/13/20	Fri 9/4/20	\$5,750	\$5,750	ELENG3 \$12,637	\$18,387	7			Fab	icate PB Proto	type 🖡 🛶 E	LENG3	Institution	LBNL[13%],E	LTECH4_Ins	titution_LBNL[13%],F	POSTD
56 🖡	3.2.2.4.1.3	Procure Power Distribution	20 days				\$1,000	POSTD_\$0	\$1,000			1		ocure Power Di							
57 🔫	3.2.2.4.1.4	Test PB Prototype and Distributi		Mon 10/5/20			\$1,150	ELENG3 \$12,960	\$14,110			1	Test PB							14_Institution_LBNL[2	
58 =, 59 =,	3.2.2.4.1.5	Design Production PB Hold Power system Review		Mon 11/2/20 Mon 11/30/20			\$2,000 \$0	ELENG3 \$20,800 ELENG3 \$3,136	\$22,800			1								TD_Institution_LBNL, FFPHYS Institution I	
60	3.2.2.4.1.6	Fabricate Break Out Boards		Mon 11/30/20 Mon 12/7/20		\$0 \$15,000		ELENG3 \$3,136 \$0	\$3,130			1			Break Out Bo			acation_LDN	-[40%],91A		conc,r
61	3.2.2.4.1.8	Fabricate PB to Stave Cables		Mon 12/7/20	Fri 1/1/21		\$5,000	50	\$5,000			1			PB to Stave Ca						
	3.2.2.4.1.10	Fabricate cold (cooling) plates		Mon 12/7/20			\$3,420	MECHTE\$2,288	\$5,708			1		Fabricate co	old (cooling) p	lates 🏟	MECHTECH				
63 🛋	3.2.2.4.1.9	Fabricate Production PB		Mon 12/7/20	Fri 1/29/21		\$84,000	ELENG3 \$9,337	\$93,337			1		Fabric	ate Productio	n PB 🐗	ELENG	63_Institution	_LBNL[13%	,POSTD_Institution_	LBNL
64 🛶	3.2.2.4.2	Power Supplies		Mon 12/7/20	Fri 4/9/21		\$107,300	\$12,084	\$119,384			1		_		-					
65 -	3.2.2.4.2.1	Procure and Integrate Power		Mon 12/7/20	Fri 4/9/21		\$94,800	ELENG3 \$4,234	\$99,034			1			nd Integrate P					NL[3%],STAFFPHYS_I	
66 ==	3.2.2.4.2.2 3.2.2.4.2.3	Procure and terminate PS-to-Pb test PB with power supplies		Mon 12/7/20 Mon 1/18/21	Fri 1/15/21 Fri 1/22/21		\$10,500 \$0	ELTECH \$2,048 ELTECH \$5,120	\$12,548			1			terminate PS-t PB with power					,STAFFPHYS_Institut	uon_LI
68	3.2.2.4.2.3	Document		Mon 1/25/21			\$0 \$0	ELTECH-\$683	\$683			1		testr	5 mar power	Documen	T ELTECI	H4 Institution	n L BNI (50%	6],STAFFPHYS Institu	ution 1
69	3.2.2.4.2.5	ship to BNL		Tue 1/26/21			\$2,000	\$0	\$2,000			1				nip to BN					
70 -	3.2.3	Mechanics and Detector Assembly	1000 days				\$544,177	\$1,258,945	\$1,803,122	2			 	-							
71 🔫	3.2.3.1	Staves	517 days		Tue 3/23/21		\$146,852	\$126,403	\$273,255				+	-							
72 🛼	3.2.3.1.1	Production	245 days		Fri 3/6/20		\$57,360	\$72	\$57,432			arou.				. I					
73	3.2.3.1.1.2	Tests and QA at CERN	160 days		Fri 2/7/20		\$0 \$7.260	SCI3_Ins\$0	\$(CERN	ution D		stitution_LAN		STAFEDUS	S Institution	1 DNI (200		
74 =	3.2.3.1.1.3 3.2.3.1.1.4	CERN Test System Travel and Per Diem at CERN	1 day 1 day		Mon 4/1/19 Mon 4/1/19		\$7,360	ELENG3 \$72 \$0		2 KN Test Der Diem a			udon_tB	nc[5%],POSID	_msutuuon_L	Durlag	g, starri'h		-CONC[30%	0]	
15 ->	0.6.0.1.1.4	Taver and Fel Dielit at CLRN	ruay	10014/1/13	4/1/13	\$30,000	430,000	30	\$30,000	op. Diem a	COLINI I	N									

MVTX MS Project 2/4



Thu 4	1/4/19						MVTX-Barrel-	120718-04042019
ID	Task	WBS	Task Name	Duration Start	Finish Fi	xed Calculated	Resource Resource	Cost
	Mode					ost Fixed Cost	Names Costs	
								2019 2020 2021 2022
70	-	323117	Tests and QA at CERN	180 days Mon 7/1/1	9 Fri 3/6/20 \$	50	SCI3 Ins\$0	H1 H2 H1 H2 H1 H2 \$0 Tests and QA at CERN++ Image: CERN++
	- +	3.2.3.1.1.7		257 days Mon 1/13/2			\$44,752	SU Tests and QA at CERNY SUIS_Institution_LAVE
	-+	3.2.3.1.2.1	design	2 wks Wed 12/23/2			PROF4 1\$13,840	sta, sk40 design PROF4 Institution MIT
79	-	3.2.3.1.2.3	final jig design	20 days Mon 1/13/2			PROF4_1\$26,880	\$26,880 final jig design 🖛 PROF4_Institution_MIT
80		3.2.3.1.2.4	procure Assembly Fixtures and t	60 days Mon 2/10/2		\$25,000 \$25,000	PROF4_1\$4,032	\$29,032 procure Assembly Fixtures and tooling
81		3.2.3.1.3	Metrology	65 days Wed 12/23/2			\$59,736 PROF4 \$27,680	\$66,736 \$27,680 Metrology design was PROF4 Institution MIT
82 83		3.2.3.1.3.1 3.2.3.1.3.2	Metrology design Design jigs	1 mon Wed 12/23/2 20 days Wed 1/20/2			PROF4_1\$27,680	S27,680 methology design terms from 4_institution_imit S27,680 Design jest - PROF4_institution_MIT
84		3.2.3.1.3.3		4 wks Wed 2/17/2			TECH4 1\$324	55.324 Procure itas TECH4 Institution MIT[2%]
85		3.2.3.1.3.4		1 wk Wed 3/17/2	1 Tue 3/23/21 \$2	2,000 \$2,000	TECH4_I\$4,052	\$6,052 ship to LBNL 🐳 TECH4_Institution_MIT
86		3.2.3.1.4	Shipping and Storage Container	502 days Mon 4/1/1			\$21,843	\$55,335
87		3.2.3.1.4.1	Design&Fabricate Storage Cabir		Thu 5/23/19 \$		MECHTE\$5,355	S12,347 linets for Staves — MECHTECH4 Institution LBNL[13%],STAFFPHYS Institution LBNL[25%],POSTD Institution LBNL[50%] S17,220 Design&Fabricate Shipping and Storage Containers (Half-Barrels) — MECHTECH4 Institution LBNL[10%],STAFFPHYS Instit
88 89		3.2.3.1.4.2 3.2.3.1.4.3		50 days Wed 12/23/2 1 wk Mon 4/1/1			MECHTE\$5,720 MECHEN\$9,480	\$17,220 Design&Fabricate Shipping and Storage Containers (Half-Barrels) MECHTECH4 Institution_LBNL[10%], STAFFPHYS_Instit \$9,480her for 21 staves W MECHENG4 Institution_LBNL
90		3.2.3.1.4.6		1 day Mon 4/1/1			MECHEN\$1,288	511,288 hipping late 84 w MECHENGS Institution LENL
91		3.2.3.1.4.4	ship to CERN		Mon 5/27/19 \$		\$0	\$5,000 ship to CERN
92		3.2.3.1.5		202 days Mon 7/1/1	Tue 4/7/20 \$	\$24,000	\$0	\$24,000
93		3.2.3.1.5.15		7 days Mon 7/1/1			STAFFPI\$0	\$6,000 CERN to LBNL, Batch #1 w STAFFPHYS_Institution_LBNL
94 95		3.2.3.1.5.16	Shipping staves from CERN to L	7 days Mon 9/30/1			STAFFPI\$0	\$6,000/wes from CERN to LBNL, Batch #2 wy STAFFPHYS_Institution_LBNL \$6,000pping staves from CERN to LBNL, Batch #3 wy STAFFPHYS Institution_LBNL
95		3.2.3.1.5.17 3.2.3.1.5.18	Shipping staves from CERN to L Shipping staves from CERN to L	7 days Mon 12/30/1 7 days Mon 3/30/2			STAFFPI\$0 STAFFPI\$0	36,000 Shipping states from CENN to Lond, patch 3 w STAFFPTTS Institution_Lond. 56,000 Shipping states from CENN to LBNL, Batch 44 w STAFFPHYS Institution LBNL
97		3.2.3.1		1000 days Mon 4/1/1				51,305,0024
98		3.2.3.2.1	Mechanics Detector Design	80 days Mon 4/1/1		\$0	\$195,507	\$195,507
99		3.2.3.2.1.1	Develop MAPS inner tracker me	4 mons Mon 4/1/1			PROF4_i\$195,507	\$195,507 chanical model a PROF4_institution_LANL
) 🔫	3.2.3.2.2	End Wheels	227 days Mon 7/22/1			\$73,810	\$145,810
	4	3.2.3.2.2.1 3.2.3.2.2.2		15 days Mon 7/22/1 30 days Mon 8/12/1			PROF4_i\$36,658 TECH4 I\$2,305	\$36,658 Design Teg-PROF4_Institution_LANL \$12,305 Prototype TEGH4_Institution_LANL[5%]
	3	3.2.3.2.2.7	Experimental tooling for carbon :	4 mons Mon 9/23/1		25,000 \$25,000	MECHEN\$29.059	312,505 Hendel tooling for carbon structure MECHENG3 Institution LBNL/12///MECHTECH4 Institution LBNL/15///MECHENG4 Institution
		3.2.3.2.2.3	Review	2 days Mon 1/13/2			PROF4 i\$5,024	\$5,024 Review # PROF4 institution LANL
	5 🛋	3.2.3.2.2.4	Procure end-wheels	100 days Wed 1/15/2		\$5,000 \$35,000	STAFFPI\$0	\$35,000 Procure end wheels
	5 - 4	3.2.3.2.2.5		1 wk Mon 8/12/1			TECH4_1\$382	\$1,382 Procure A) half disks 🐺 TECH4 Institution_MIT[10%]
	3	3.2.3.2.2.6		1 wk Mon 8/12/1			TECH4_1\$382	\$1,382 Procure Half rings 🕷 TECH4 Institution_MIT[10%]
) -+ 	3.2.3.2.3 3.2.3.2.3.1	Mechanics Fabrication Travel LBNL	1000 days Mon 4/1/1 1000 days Mon 4/1/1		\$286,511 0,000 \$70,000	\$611,612 \$0	\$898,123 \$70,000 Travel LBNL
		3.2.3.2.3.2		195 days Mon 7/22/1			\$342,688	\$445.559
	-	3.2.3.2.3.2.1	Review CYSS Design-Fabrica	40 days Mon 7/22/1	9 Fri 9/13/19 \$		MECHEN\$12,134	\$12,134n-Fabrication Compatibility
	2 🛶	3.2.3.2.3.2.2	modify design	2 mons Mon 9/16/1			PROF4_i\$99,730	\$99,730 modify design - PROF4_institution_LANL
	3 🛶	3.2.3.2.3.2.3 3.2.3.2.3.2.7	Review CYSS Design-Fabrica	15 days Mon 11/11/1			MECHEN\$14,023	S14,023 Review CYSS Design-Fabrication J HECHENG4_Institution_LBNL[25%] MECHENG3_Institution_LBNL[33%],POSTD_Institution_LBNL[20 S20,160 detail design J PROF4 Institution MIT
		3.2.3.2.3.2.1	detail design Procure CYSS Material	15 days Mon 12/2/1 5 days Mon 12/23/1			PROF4_1\$20,160 STAFFP1\$0	\$20,160 detail design ₩ PROF4_Irtstitution_MIT \$15,640 Procure CYSS Material ₩ STAFFPHYS_Institution_LBNL[20%]
		3.2.3.2.3.2.5	Production & Test CYSS	80 days Mon 12/20/1			CMMTEC\$196,640	313,040 Thomas Tas material Stratting Stratting LBNL [20%],MACH4 Institution LBNL[40%],MECHTECH4 Institution 2283,871 Production & Test CVSS CMMTECH4 Institution LBNL [20%],MACH4 Institution LBNL[40%],MECHTECH4 Institution
	-	3.2.3.2.3.2.6	Milestone: Complete CYSS	0 days Fri 4/17/2			\$0	\$0
	3 🛶	3.2.3.2.3.3		387 days Mon 12/2/1			\$268,924	\$382,564
		3.2.3.2.3.3.1	Review SB Design-Fabrication	40 days Mon 12/2/1			MECHEN\$12,646	\$12,646jew SB Design-Fabrication Compatibility MECHENG4 Institution LBN. 18%] STAFFPHYS Institution LBNL[50%], POSTD Institution LBI
		3.2.3.2.3.3.2 3.2.3.2.3.3.3	modify design Hold SB Review (PRR)	1.5 mons Mon 1/27/2 15 days Mon 3/9/2			PROF4_1\$40,320 MECHEN\$12,581	\$40,320 modify design → PROF4 Institution MIT \$12,581 Hold SB Review (PRR) → MECHENG4 Institution LBNL[20%],STAFFPHYS Institution LBNL[20%],POSTD Institutik
	2	3.2.3.2.3.3.4	Procure SB Material	5 days Mon 3/30/2		5,640 \$15,640	STAFFPI\$0	T2.501 Process by the set of the
	- +	3.2.3.2.3.3.5	Production & Test SB	110 days Wed 12/23/2			MACH4 \$203,377	S301.377 Production & Test SE Market MACH4 Institution LBNL[30%],MECHENG3 Ins
	-	3.2.3.2.3.3.6	Milestone: Complete SB	0 days Tue 5/25/2	1 Tue 5/25/21 \$	\$0	\$0	\$0
	5 - 4	3.2.3.2.4	MVTX Final Design Review	12 days Mon 12/7/2			\$55,584	\$65,584
	6 - 4	3.2.3.2.4.1	MVTX Design Review	2 days Mon 12/7/2			MECHEN\$9,264 MECHEN\$41,688	S19,264 MVTX Design Review W MECHENG4_Institution_LBNL,STAFEPHYS_Institution_LBNL,PF S41,688 Incorporate review comments W MECHENG4_Institution_LBNL,PROF4_institution_LANL
		3.2.3.2.4.2 3.2.3.2.4.3	Incorporate review comments Complete Final Design	9 days Wed 12/9/2 1 day Tue 12/22/2			MECHEN\$41,688 MECHEN\$4,632	\$41,688 Incorporate review comments Image: MECHENG4_Institution_LBNL,PROF4_institution_LANL \$4,632 Complete Final Design MECHENG4_Institution_LBNL,PROF4_institution_LANL
		3.2.3.2.4.3	Barrel Assembly	505 days Wed 7/10/1			\$196.029	
) =,	3.2.3.3.1	Assembly and Testing	505 days Wed 7/10/1			\$196,029	\$224,843
131	-	3.2.3.3.1.1	Receive 1st batch Staves from	1 day Wed 7/10/1	9 Wed 7/10/19\$	\$0	\$0	\$0t batch Staves from CERN 💞
130	2 🔩	3.2.3.3.1.2	CERN Test and Rework 1st batch Stav	12 days Thu 7/11/1	Eri 7/26/19 S	\$0	ELENG3 \$5,240	\$5,2401 Rework 1st batch Staves 💑 ELENG3 Institution LBNL[19%] MECHENG3 Institution LBNL[8%] ELTECH4 Institution LBNL[20%],POSTD Inst
	3	3.2.3.3.1.7	Receive 2nd batch Staves from	1 day Wed 10/9/1			\$0	30/240/ Horon is balance from CERN S
	Ŧ		CERN				-	

MVTX MS Project 3/4



Thu 4	4/19								MVTX-Barrel-	120718-040	42019						
ID	Task	WBS	Task Name	Duration	Start		Fixed	Calculated	Resource Resource	Cost							
	Mode						Cost	Fixed Cost	Names Costs								
											1	2019	2	020		2021	2022
											HI	H2		H2 H1		2021 H2 H1	2022 H2
134		3.2.3.3.1.6	Test and Rework 2nd batch Stav		Thu 10/10/19			\$0	\$0			2nd batch Staves 🐢					
135	+	3.2.3.3.1.11	Receive 3rd batch Staves from CERN	1 day	Wed 1/8/20	Wed 1/8/20	\$0	\$0	\$0	\$0	Receive 3r	d batch Staves from CE	RN 🖉				
136	-	3.2.3.3.1.10	Test and Rework 3rd batch Stav	12 days	Thu 1/9/20	Fri 1/24/20	\$0	\$0	\$0	\$0	Test an	Rework 3rd batch Sta	rves 🗸				
137	-	3.2.3.3.1.9	Receive 4th batch Staves from	1 day	Wed 4/8/20	Wed 4/8/20	\$0	\$0	\$0	\$0	R	eceive 4th batch Stave	s from CERN 💞				
100	-		CERN		TI (10100	5 . 40 400			\$0								
138 139		3.2.3.3.1.8 3.2.3.3.1.3	Test and Rework 4th batch Stav Layer Assembly and Test	12 days 140 days		Fri 4/24/20 Tue 12/15/20		\$0 \$5,336	\$69,923	\$0 \$75.259		Test and Rework 4th	batch Staves 🗰				
	+	3.2.3.3.1.3.1	Test Installation of Staves onti	20 days		Tue 6/30/20		\$0,336	MECHEN\$7,056	\$75,259	Test Inst	allation of Staves onto	Laver End Wheels	MECHENG3		L[10%],MECHTECH4 Institution L	BNI (20%) POST
		3.2.3.3.1.3.2	Hold Half-Detector Assembly I		Wed 7/1/20			\$0	MECHEN\$2.672	\$2,672						NL[40%],POSTD Institution LBNL,	
	-	3.2.3.3.1.3.3	Install Staves Onto Laver End		Wed 7/8/20			\$2,760	MECHEN\$33,836	\$36,596						tution LBNL[10%],ELENG3 Institut	
143	-	3.2.3.3.1.3.4	Test and Rework Layers After	30 days	Wed 10/14/20	Tue 11/24/20	\$2,576	\$2,576	ELENG3 \$14,875	\$17,451						itution_LBNL[10%],MECHENG3_Ins	
	-4	3.2.3.3.1.3.5	Perform Half-Detector Metrolo		Wed 11/25/20			\$0	CMMTEC\$11,484	\$11,484		Perform	Half-Detector Metrolo			Institution_LBNL[66%],STAFFPH	YS_Institution_LE
	-4	3.2.3.3.1.3.6	Milestone: Complete Layers		Tue 12/15/20			\$0	\$0	\$0					2/15		
146	-4	3.2.3.3.1.4	Half Barrel #1 Assembly and Test	130 days	Wed 12/16/20	Tue 6/15/21	\$0	\$11,739	\$60,433	\$72,172							
147		3.2.3.3.1.4.1	Assemble Lavers and CYSS I	20 days	Wed 12/16/20	Tue 1/12/21	\$2 760	\$2,760	ELENG3 \$14,192	\$16,952		Assemb	e Lavers and CYSS In	to Half-Detector	FI ENG3	Institution LBNL[10%],MECHENG	3 Institution 1 Bt
148		3233142	Test and Rework Half-Detecto		Wed 1/13/21			\$2.576	ELENG3 \$19,200	\$21,776			Test and Re	work Half-Detector	ELE	NG3 Institution LBNL[10%].MECH	ENG3 Institution
149	-	3.2.3.3.1.4.3	Perform Half-Detector Metrolo		Wed 2/24/21			\$0	CMMTEC\$8,120	\$8,120		Perform	Half-Detector Metrol	ogy On Final Assent	y 💑 CM	NG3_Institution_LBNL[10%],MECHI IMTECH4_Institution_LBNL[70%],S	TAFFPHYS_Instit
	-4	3.2.3.3.1.4.4	Validation Of Final Assembly	20 days	Wed 3/10/21	Tue 4/6/21		\$2,576	ELENG3 \$13,976	\$16,552						ELENG3_Institution_LBNL[10%],ME	
	-	3.2.3.3.1.4.5	Pack/Ship Final Assemblies T		Wed 5/26/21			\$3,827	MECHEN\$4,945	\$8,772			Pac	k/Ship Final Assemb	es To BN	L 🗱 MECHENG3_Institution_LBN	NL[13%],MECHTE
152	+	3.2.3.3.1.5	Half Barrel #2 Assembly and	110 days	Wed 1/13/21	Tue 6/15/21	\$0	\$11,739	\$60,433	\$72,172							
153	-	3.2.3.3.1.5.1	Test Assemble Lavers and CYSS I	20 days	Wed 1/13/21	Tue 2/9/21	\$2 760	\$2,760	ELENG3 \$14,192	\$16,952		Asser	ble Lavers and CYSS	Into Half-Detector	EL EN	G3 Institution LBNL[10%],MECHEI	NG3 Institution 1
		3.2.3.3.1.5.2	Test and Rework Half-Detecto		Wed 2/10/21			\$2,576	ELENG3 \$19,200	\$21,776			Test and	Rework Half-Detecto	E E	LENG3_Institution_LBNL[10%],MEC	CHENG3 Instituti
155		3.2.3.3.1.5.3	Perform Half-Detector Metrolo		Wed 3/24/21			\$0	CMMTEC\$8,120	\$8,120		Perf	rm Half-Detector Met	ology On Final Asse	nbly 💑	CMMTECH4_Institution_LBNL[70%]],STAFFPHYS_Ins
156	-	3.2.3.3.1.5.4	Validation Of Final Assembly	20 days	Wed 4/7/21	Tue 5/4/21	\$2,576	\$2,576	ELENG3 \$13,976	\$16,552			Va	lidation Of Final Ass	embly 🖊	ELENG3_Institution_LBNL[10%]	MECHENG3_Inst
157		3.2.3.3.1.5.5	Pack/Ship Final Assemblies T		Wed 5/26/21			\$3,827	MECHEN\$4,945	\$8,772			Pac	k/Ship Final Assemb	ies To BN	L 🏎 MECHENG3_Institution_LBN	NL[13%],MECHTE
158		3.2.3.3.1.5.6	Milestone: Complete Barrel (R		Tue 6/15/21			\$0	\$0	\$0						4 6/15	
	+	3.2.4	Integration and Infrastructure	1000 days		Fri 1/27/23		\$274,200	\$848,250								
	+	3.2.4.1 3.2.4.2	Clean Tent/Room	100 days				\$50,000 \$87,000	\$0 \$19,556	\$50,000 \$106,556	lean Tent/Room	· · · · ·					
	-	3.2.4.2	Cooling System travel	1000 days 1000 days				\$25.000	\$19,556	\$106,556	travel	÷.					
		3.2.4.2.2	Design (modify ALICE)		Wed 12/23/20			\$25,000	PROF4 1\$6,920	\$6,920	uurer		Desig	n (modify ALICE) 📲	PROF4 In	stitution MIT	
	-	3.2.4.2.3	Mock up Testing		Wed 12/30/20			\$20,000	TECH4 1\$4,052	\$24,052				Mock up Testing 🐗	TECH4 II	nstitution MIT	
165	-	3.2.4.2.4	Final Design of Cooling System	5 days	Wed 1/6/21			\$0	PROF4_1\$6,920	\$6,920			Final Design (of Cooling System	PROF4_	Institution_MIT	
	-	3.2.4.2.5	Procure Cooling Plant	100 days		Thu 2/17/22		\$40,000	SCI3_Ins\$1,664	\$41,664					Procure		13_Institution_MIT
	-	3.2.4.2.6	Ship to BNL	1 wk		Thu 2/24/22		\$2,000	\$0	\$2,000						Ship to BNL 🕷	
	-4	3.2.4.3	Safety Systems	724 days				\$35,200	\$100,206	\$135,406 \$25.000				i ii			
169	+	3.2.4.3.1 3.2.4.3.2	travel Define MVTX Safety and Interlock	700 days	Mon 4/1/19 Wed 1/13/21			\$25,000	\$0 STAFFPI\$6.920	\$25,000 \$6,920		Define	MVTV Sefety and Inter	look roguiromonto	- CTAFF	PHYS Institution LBNL[50%],POST	D Institution I P
170		324.3.2	review sensors & interlocks with BI		Wed 1/13/21 Wed 1/27/21			\$0 \$0	PROF4 1\$6,920	\$6,920						4 Institution MIT[50%],STAFFPHY	
172		3.2.4.3.4	Design electronics safety system		Wed 2/10/21			\$0	STAFFPI\$14,234	\$14,234		l				AFFPHYS_Institution_LBNL[50%],	
173		3.2.4.3.5	cooling interlocks design		Wed 3/17/21			\$0	PROF4 1\$20,760	\$20,760				cooling interlocks de	sign 👗	PROF4_Institution_MIT[50%]	
174	+	3.2.4.3.6	Procure Safety Systems	8 wks		Thu 11/25/21			TECH4_1\$9,069	\$19,069				-	Procure S	afety Systems 🗫 TECH4_Insti	
175		3.2.4.3.7	Test		Fri 11/26/21			\$0	TECH4_I\$19,742	\$19,742						Test 📥 TECH4_In	stitution_MIT,PR(
176		3.2.4.3.8	Ship to BNL		Fri 12/17/21			\$200	\$0	\$200						Ship to BNL	
	-+	3.2.4.3.9	Test at BNL		Fri 12/24/21			\$0	TECH4_1\$22,560	\$22,560						Test at BNL 🐳 TECH4_	Institution_MIT,P
178	+	3.2.4.4	Stave Support Frame & MVTX Interface to sPHENIX	1000 days	Mon 4/1/19	Fri 1/27/23	20	\$102,000	\$343,480	\$445,480							
179	-	3.2.4.4.1	travel	1000 davs	Mon 4/1/19	Fri 1/27/23	\$20.000	\$20,000	\$0	\$20,000	travel	<u>+</u>					
		3.2.4.4.2	Design Interface to sPHENIX		Mon 10/7/19			\$0	PROF4_I\$134,400	\$134,400	Design Inte	face to sPHENIX 🗩	PROF4_In	stitution_MIT			
181	-4	3.2.4.4.3	FEA, Thermal, stress analysis		Wed 3/3/21			\$0	PROF4_I\$138,400	\$138,400			FEA,	Thermal,stress analy	is 🐛 🚽	PROF4_Institution_NIT	
	-+	3.2.4.4.4	design interface to rail system		Wed 12/23/20			\$0	PROF4_1\$69,200	\$69,200				ce to rail system 🗰		DF4_Institution_MIT	
	+	3.2.4.4.5	procure support structure		Mon 2/24/20				TECH4_1\$629	\$40,629		procure support s	tructure 🚛 TEC				
184		3.2.4.4.6	Procure rail interface		Wed 3/3/21			\$40,000	TECH4_1\$648	\$40,648						TECH4_Institution_MIT[2%]	
185 186		3.2.4.4.7	ship to BNL Half detector Assembly Readout		Wed 4/28/21			\$2,000 \$0	TECH4_1\$203	\$2,203				shi	to BNL	TECH4_Institution_MIT[50%]	
100	+	3.2.4.5	and Cooling Test at BNL	oro.so uays	Wed 11/13/19	1/10/0/10/22	30	30	\$58,064	\$58,064							
187		3.2.4.5.1	Test Half Barrel #1		Wed 6/16/21			\$0	MECHEN\$6,144	\$6,144						#1 MECHENG4_Institution _LI	
188	+	3.2.4.5.2	Test Half Barrel #2	15 days	Wed 6/16/21	Tue 7/6/21	\$0	\$0	MECHEN\$6,144	\$6,144				Test	lalf Barre	#2 🏹 MECHENG4_Institutio n_LI	BNL[20%],POSTD

MVTX MS Project 4/4



Thu 4/	4/19							MVTX-Barrel-	120718-040	4042019
ID	Task Mode	WBS	Task Name	Duration	Start	Finish	Fixed Calcula Cost Fixed C		Cost	
										2019 2020 2021 2022 H1 H2 H1 H2 H1 H2 H1 H2
189	+	3.2.4.5.3		20 days	Fri 2/25/22	Thu 3/24/22		TECH4_1\$16,640	\$16,640	40 Assemble & Test Cooling System at βNL 💏 TECH4_Institution
190	-	3.2.4.5.8	Complete System Test at BNL	3 mons	Fri 3/25/22	Thu 6/16/22		SCI3_Ins\$0	\$0	\$0 Complete System Test at BNL V SCI3_Ins
191	+	3.2.4.5.4	test RU at BNL	0.8 wks	Wed 11/13/19	Tue 11/19/19	\$0 \$0	SCI3_Ins\$12,608 Engineer	\$12,608	08 test RU at BNL 🗳 SCI3_Institution_LANL,PROF4_institution_LANL,Electrical Engineer UTAustin[50%]
192	+	3.2.4.5.5	test FELIX at BNL	0.8 wks	Wed 7/8/20	Tue 7/14/20	\$0 \$0	SCI3_Ins\$12,608 Engineer	\$12,608	08 test FELIX at BNL 🐺 SCI3_Institution_LANL,PROF4_Institution_LANL,Electrical Engineer UTAustin[:
193	-	3.2.4.5.6	PS tests at BNL	0.5 wks	Tue 2/2/21	Thu 2/4/21	\$0 \$0	POSTD_\$3,920	\$3,920	20 PS tests at BNL # POSTD_Institution_LBNL,ELENG3_Institution_LBNL
194	-	3.2.4.6	Installation and Commissioning	387 days	Wed 7/7/21	Thu 12/29/22		\$326,944	\$326,944	44
195		3.2.4.6.1	Installation Prep	10 days	Wed 7/7/21	Tue 7/20/21	\$0 \$0	Mech \$15,520 Tech,Phy	\$15,520	
196	+	3.2.4.6.2	Installation Review	1 day	Wed 7/21/21	Wed 7/21/21	\$0 \$0	Physicist \$2,320 Engineer	\$2,320	20 Installation Review V Physicist, Mechanical Engineer, E lectrical I
197	-	3.2.4.6.3	Install FELIX	2 days	Thu 7/22/21	Fri 7/23/21	\$0 \$0	SCI3_Ins \$5,168	\$5,168	
198	-+	3.2.4.6.4	Install Optical fibers	1 wk	Mon 7/26/21	Fri 7/30/21	\$0 \$0	TECH4_I\$8,120	\$8,120	20 Install Optical fibers 🕷 TECH4_Institution_LANL
199	+	3.2.4.6.5	Install RU	1 wk	Mon 8/2/21	Fri 8/6/21	\$0 \$0	SCI3_Ins\$19,320 Engineer	\$19,320	20 Install RU 🕷 SC13_Institution_LANL,PROF4_institutio
200	-	3.2.4.6.6	Install Samtec Cables	1 wk	Mon 8/9/21	Fri 8/13/21		TECH4_1\$8,120	\$8,120	20 Install Samtec Cables 🐺 TECH4_Institution_LANL
201	-	3.2.4.6.10	Electronics Integration	6 mons	Mon 8/16/21	Fri 1/28/22		PROF4_i\$158,136	\$158,136	36 Electronics Integration 🗸 PROF4_institution_LAI
202		3.2.4.6.7	Install Half-Barrel 1	1 mon	Fri 7/1/22	Thu 7/28/22	\$0 \$0	MECHTE\$26,320	\$26,320	20 Install Half-Barrel 1 🛶 MEC
203	-	3.2.4.6.8	Install Half-Barrel 2	1 mon	Fri 7/29/22	Thu 8/25/22	\$0 \$0	MECHTE\$26,320	\$26,320	20 Install Half-Barrel 2 🍆 M
204	+	3.2.4.6.9	Commissioning	90 days	Fri 8/26/22	Thu 12/29/22	\$0 \$0	Physicist \$57,600 Engineer	\$57,600	00 Commissioning 📥
205	-	3.2.5	Ready for beam	0 days	Thu 12/29/22	Thu 12/29/22	\$0 \$0	\$0	\$0	\$0