MVTX Production Readiness Review Overview

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For the MVTX Team

MVTX Production Readiness Review (Remote Meeting)
12/15/2020

Outline

- MVTX detector design
  - **Design updates**
- Review questions
  - **MVTX status**
- Recommendations from previous FDR
  - **All implemented**
- Mechanical structure production and detector assembly plan
  - **Updated schedule**

A Production Readiness Review (PRR) for MVTX components will be held Dec 15th, 2020 as a virtual meeting. The purpose of the PRR is to address design updates and actions items from the FDR and approve readiness for fabrication of the MVTX Cylindrical Support Structure (CYSS), End Wheels, and Service Barrel and the MVTX "X-Wing" support structure. The review will also cover assembly fixtures, assembly procedures, and planning for the integrated support and insertion system in the core of sPHENIX.

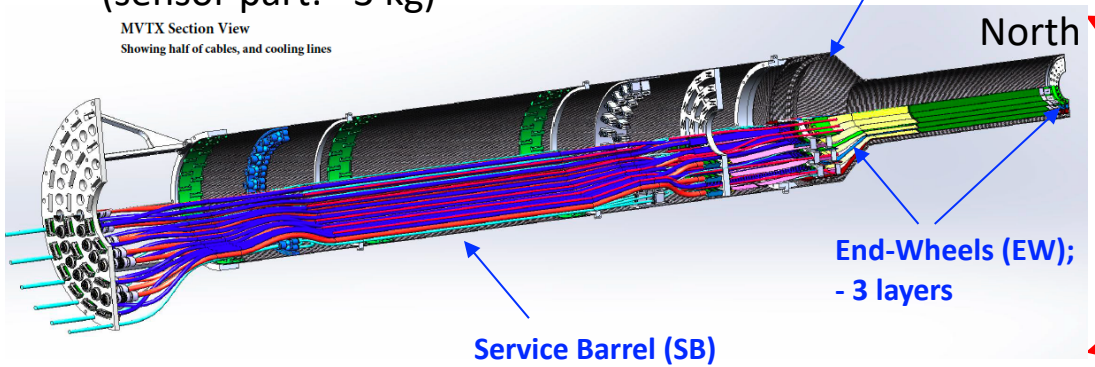
In general a ***Production Readiness Review (PRR)*** addresses the following questions and topics:

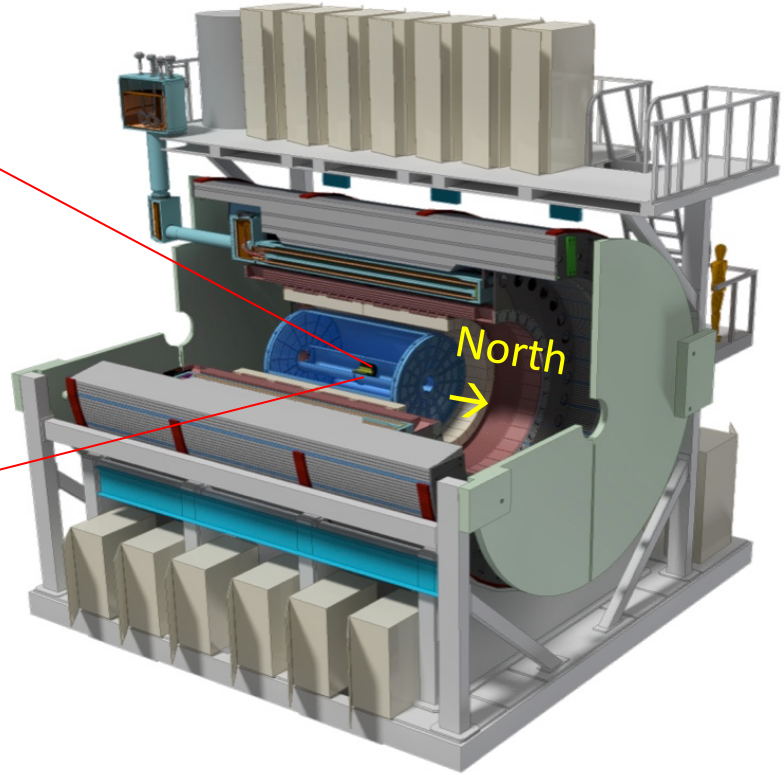
1. **Engineering and Design** – Are the drawings complete? Have they been reviewed , approved, and released following guidelines? Are the drawings now under configuration control? Has there been an appropriate independent review of the design? If there have been changes to the documents since the Final Design Review, have these changes been vetted properly? Are the changes still consistent with the Requirements? Has appropriate parts lists been generated for all subsystem assemblies? Have all components been identified?
2. **Management** - Is the schedule for procurement, including internal signatures and approvals, bid duration, material procurement, and fabrication been correctly estimated? Are they consistent with the Resource Loaded Schedule? Have all recommendations from prior reviews been properly addressed and approved?
3. **Fabrication** – Have potential vendors been identified? Will assembly be required? Who will perform the assembly? What are the acceptance criteria for parts? Is this documented and part of the procurement package? Who will do the acceptance inspection and testing? Is shipping included in the procurement? Where will equipment be stored upon arrival at BNL?
4. **Quality** - What are the quality assurance requirements for this procurement? Are material certifications required? Are there intermediate inspection steps required during fabrication that will require BNL involvement? Are they clearly spelled out in the procurement documentation?
5. **Safety** – Have all safety requirements been satisfied and closed out?

MVTX Detector Design

Carb. Fib. Comp./CFC = EW, CYSS, SB

Total Weight: ~24 kg
(sensor part: ~3 kg)

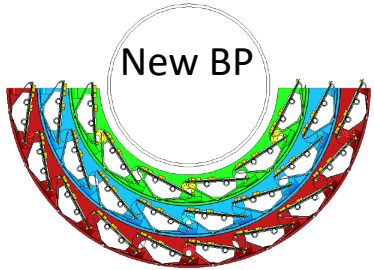




MVTX parameters: L = 271 mm

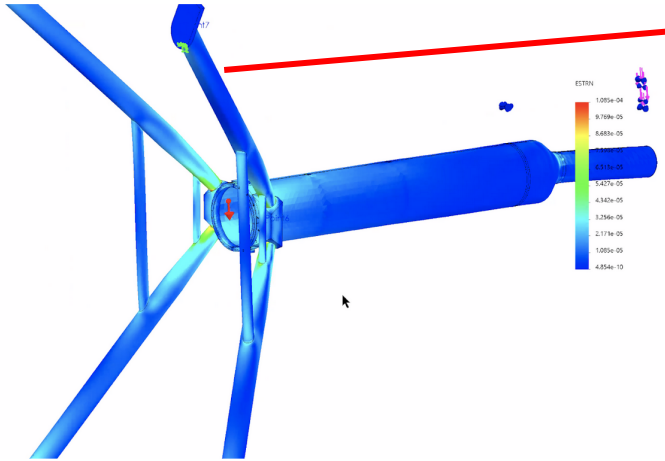
R (mm)	min	mid	max
Layer 0	24.61	25.23	27.93
Layer 1	31.98	33.35	36.25
Layer 2	39.93	41.48	44.26

3-layer sensor barrel
- 48 staves, 432 chips

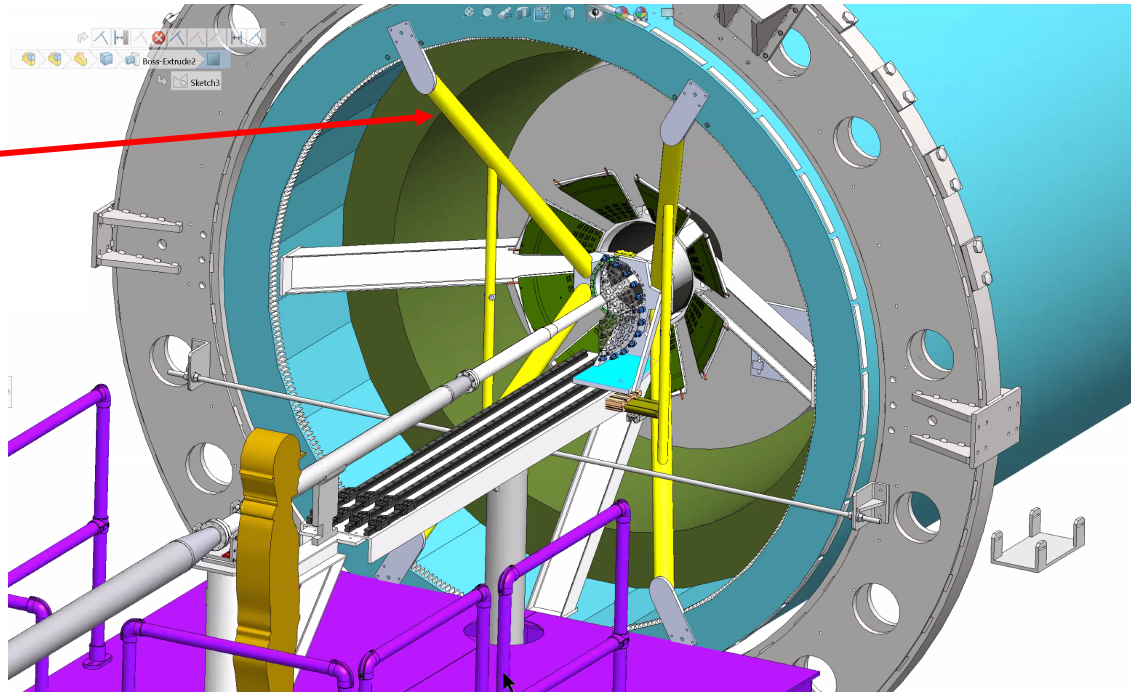


Detector Support Structure: X-Wing

Jason's talk

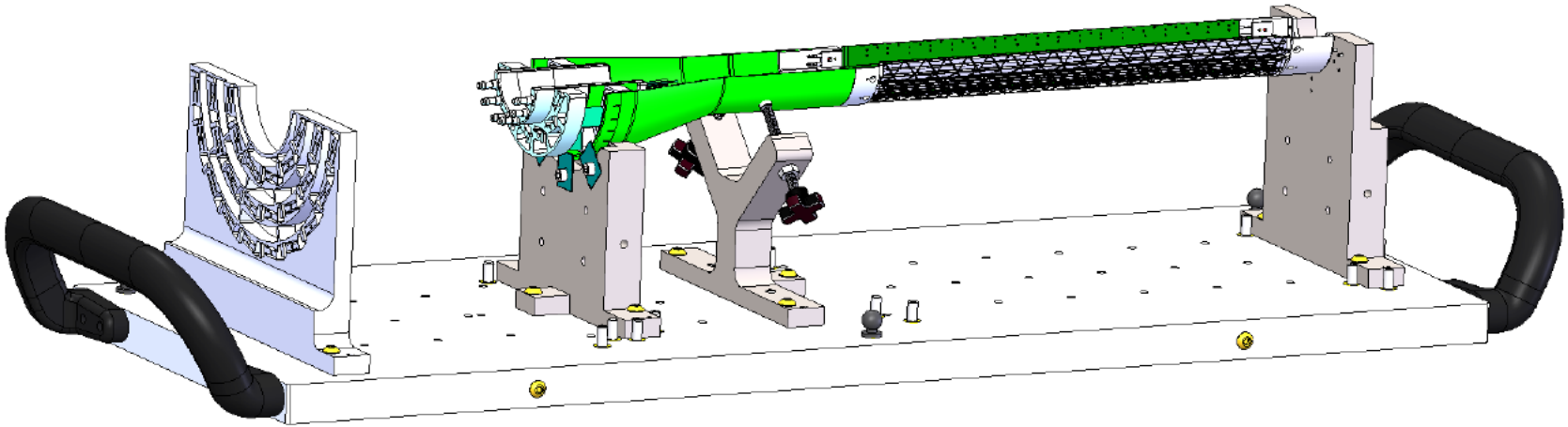


X-Wing



Detector Assembly Fixtures

Joe's talk



1. Engineering and Design

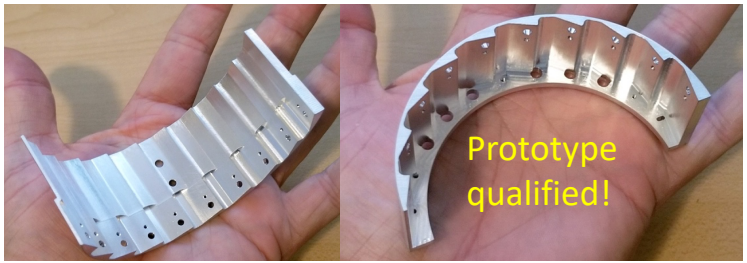
NOTE: all these covered in detail in Jason's presentation.

- Are the drawings complete? - **Yes**
  - Have they been reviewed , approved, and released following guidelines?
  - Are the drawings now under configuration control?
- Has there been an appropriate independent review of the design?
  Yes, LBNL (while updating the LBNL production cost)
  Here is the link to the summary

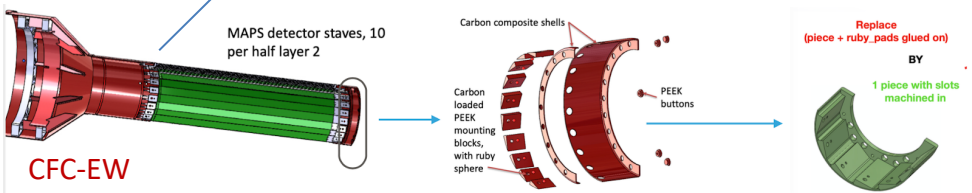
- If there have been changes to the documents since the Final Design Review, have these changes been vetted properly?
  Yes, meetings/reviews with LBNL+CERN, LINK to discussions

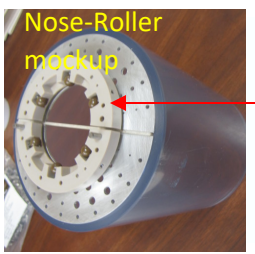
  2 design changes:
  - End-Wheels: a simple 1-piece design, made of Al, ~$10K/pair
  - Lock-and-roll (nose roller) system on the nose of detector to protect against crushing into the Beam Pipe

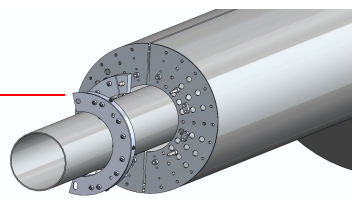
  Are the changes still consistent with the Requirements?
  Yes (link to the EW discussions)



1-piece Al End-Wheel







Nose roller

- Has appropriate parts list been generated for all subsystem assemblies?
  - Yes
- Have all components been identified?
  - Yes

2. Management

- Is the schedule for procurement, including internal signatures and approvals, bid duration, material procurement, and fabrication been correctly estimated?
  - Yes.
  - Prepreg carbon fiber fabrication long lead time: 6-8 weeks
    - for test article, small amount in stock.
    - for the production work: order placed in advance (October)
      --> expected ready to go for full production in Dec/early January

- Are they consistent with the Resource Loaded Schedule in P6? - Yes
  - Mechanical structure fabrication costs: well within the budget :
    - 3-layer CFC-EW: $197K → in P6 $311K + 60% (contingency)
      One-piece Al-EW: ~$50K
    - CYSS: $54K → in P6 $201K + 40%
    - SB: $53K → in P6 $266K + 40%
  - Manpower cost/schedule:
    - 4~5 months delay, still within cost & schedule contingencies

- Have all recommendations from prior reviews been properly addressed and approved?
  - yes
    - only 1 suggested design modification from the January FDR: the lock-and-roll (nose roller) system

3. Fabrication

- Have potential vendors been identified? -Yes. **-> see Jason's talk**
  - Carbon Fiber: CYSS, SB, EW Layers
    - CAD designs completed in July 2020
    - Design package (drawings + SOW) sent to 4 potential vendors on July 27th (WorkShape in France, 3 in CA, including LBNL)
    - Received feedbacks and revised the drawings accordingly: v2 of the package sent out Aug. 13th, 2020
    - Received 3 responses by the end of August deadline (see back-up for price/schedule comparison)
  - One-piece End-Wheels: Carbon loaded PEEK -> Aluminum -- mostly affected by the pandemic (schedule wise)
    - CAD design finalized early April, 2020
    - Prototype-1 ready end of April: made by Xometry -- failed → weeks to get scheduled for CMM due to COVID shutdown
    - Prorotype-2 sent in August to a 2nd shop in MA → delivered mid-Oct. → (other weeks to schedule CMM) CMM failed
    - Prototype-3 (present): made of Al, sent to MIT shop in end of Oct. → back in November→ CMM acceptable
- Will assembly be required?
  - Yes. Fixtures and assembly steps designed by MIT/Bates, LANL and LBNL → **see Joe's talk**
- Who will perform the assembly?
  - LBNL will do it.
- What are the acceptance criteria for parts? Is this documented and part of the procurement package?
  - All specified in Sec .2. of the SOW here
- Who will do the acceptance inspection and testing?
  - Shops in US (MIT for test articles; LBNL for production parts)
- Is shipping included in the procurement?
  - Yes. Costs from vendor include shipping to US, and there are money allocated for transport from LBNL to BNL
- Where will equipment be stored upon arrival at BNL?
  - Setup a clean tent at BNL in late 2021 for receiving & commissioning
  - The shipping box will also act as a storage cradle, before the detector put on the insertion rails in the IR

4. Quality

- What are the quality assurance requirements for this procurement?
  - Mechanical dimensions and tolerances
- Are material certifications required?
  - No. The prepreg carbon fiber change, from the originally design (ITS) to a better (and more expensive) one, was approved by the MIT/LANL/LBNL engineers.
- Are there intermediate inspection steps required during fabrication that will require BNL involvement?
  - No
- Are they clearly spelled out in the procurement documentation?
  - N/A

5. Safety

- Have all safety requirements been qualified and closed out?
  - Yes.

Requirements ~same for all sPHENIX systems

1. Are there aspects of the MVTX unit design or operation that present a safety hazard like high voltage or flammable gas, etc...?
   - No.
2. Are there aspects of MVTX fabrication, assembly and testing at Bates, LBNL and BNL that present safety hazards?
   - No.
3. Are there aspects of the MVTX installation at BNL that present any unusual hazards like heavy weight, ergonomic issues, etc...?
   - No. → **see Russ and Jason' talks**
   - sPHENIX will also have a design review for the integrated Beam Pipe, MVTX, INTT and MBD installation and tools that will address installation safety, planed for ~early 2021

Addressed all Recommendations from last FDR

Recommendations

1. Before proceeding to finalizing design and drawings:
    a. Finalize discussions with CAD on whether the 40 mm aperture restriction to ±5.6 m is acceptable for all collision species.
2. When the specifications for the composite structures is complete, expected to be in March 2020, confirm feasibility with vendors and/or outside experts soon afterward. Define the specific performance, QA, and dimensional tests that are required. Some balance will be needed between overly tight versus practical and testable specs. The main risk is to schedule, if the specs prove too difficult for vendors to achieve, or too laborious to test.
3. Before final construction:
    a. Complete Interface Control Documents.
    b. Complete plans for interlocks and alarms.

1. Beam pipe modification reviewed and approved, work in progress at Materion (BNL, Russ' talk)

2. Worked with vendors on the final designs and tolerances. A test article (most challenging piece, MVTX Layer-0 EW) was produced and qualified with the selected vendor (WorkShape)

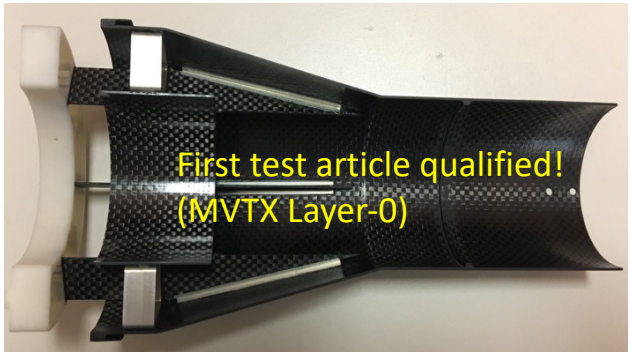
3. a) Completed ICD documents, and
   b) preliminary plans for interlocks and alarms (BNL, Russ' talk)

Summary I: Mechanical Design and Vendor Selection

- **Final designs developed based on ITS/IB concept, with inputs from MIT, LANL, CERN, LBNL and BNL engineers**
  - CAD designs completed in July 2020 and sent to 4 potential vendors with SOW on 7/27/2020
    - modification of EW, with one-piece-EW
    - Lock-and-roll system
  - Received feedbacks and revised the drawings accordingly: final package sent out Aug. 13th
  - Received 3 responses by the end of August deadline

- **Changed vendor selection process for the production cost and COVID-19 schedule challenge**
  - Advise from LBNL CFC production experience: skip the round-1 competition, provide detailed designs & SOW for vendor selection, then work with the selected vendor to fabricate the production CFC

- **WorkShape (France) won the competition**
  - Experience/qualifications, cost and delivery schedule
  - Started fabrication of the test article in September 2020
  - The first test article produced in Nov. and qualified in Dec. at MIT!
    (links to the US CMM measurements and also from WorkShape)
  - Full production and delivery plan developed



Summary II: CFC Production and Detector Assembly Schedule

- **Mechanical support structures**
  - **Test article production and QA**
    - 1st test article, Layer-0 EW qualified
    - **PRR: Dec. 15, 2020 (Today)**
  - **CFC full production starts ~Jan. 2021**
    - 1st half CFC(EW+CYSS+SB) available in ~March 2021
    - 2nd half CFC finish in April 2021
  - **Assembly fixtures designed (Joe's talk)**
  - **Insertion system designed & mockup in progress (Jason's talk)**
    - System integration review: early 2021

- **Stave production in good progress at CERN**
  - Shipping and QA at LBNL, Jan -- Mar in 2021

- **Half-detector assembly at LBNL**
  - Assembly fixture production, ~Jan/Feb 2021
  - CFC CMM & test fitting, March~April, 2021
  - Half-detector assembly review, ~May 2021
  - Complete the 2nd Half-detector by 12/2021 (orig. schedule)

Aim to meet the original MVTX installation dates

- ready to install in sPHENIX IR, ~March, 2022
- IR available for MVTX installation, ~Sept., 2022

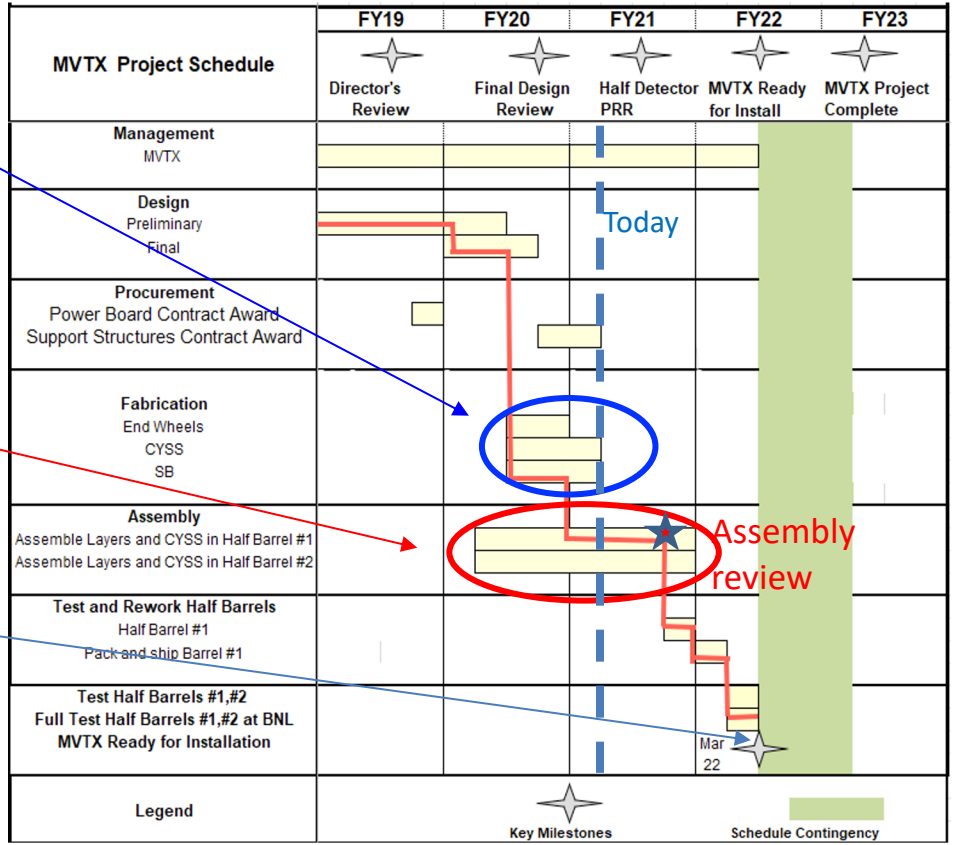
MVTX has ~6 months schedule float

NB:

Original (pre-COVID19) schedule:
- start assembly in Dec 2020

Current schedule:
- start assembly in March/April 2021 (3-4 months delay)

Pre-COVID19 Schedule in MVTX PMP

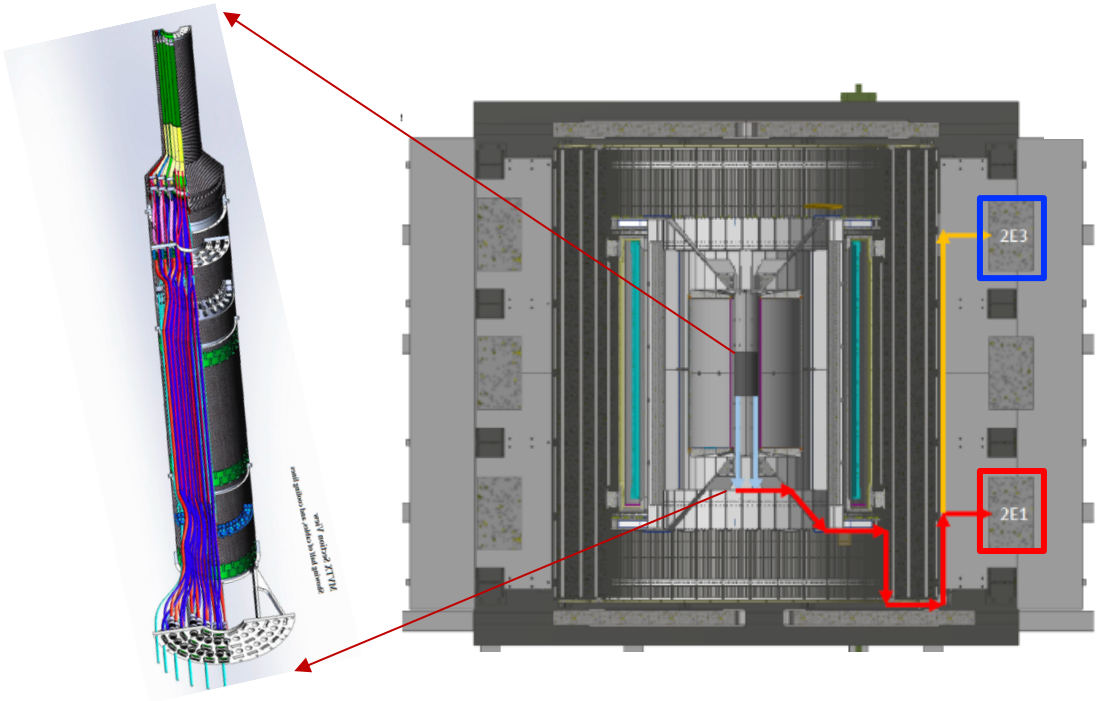


Backup slides

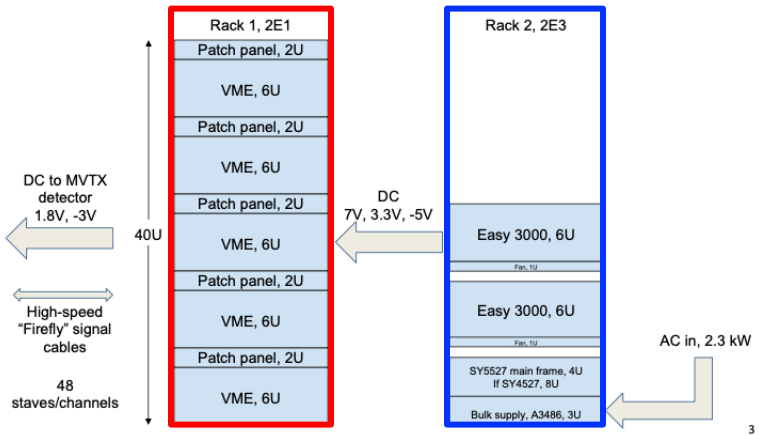
MVTX Detector and Interface

sPHENIX-SE-ICD-042 Document:

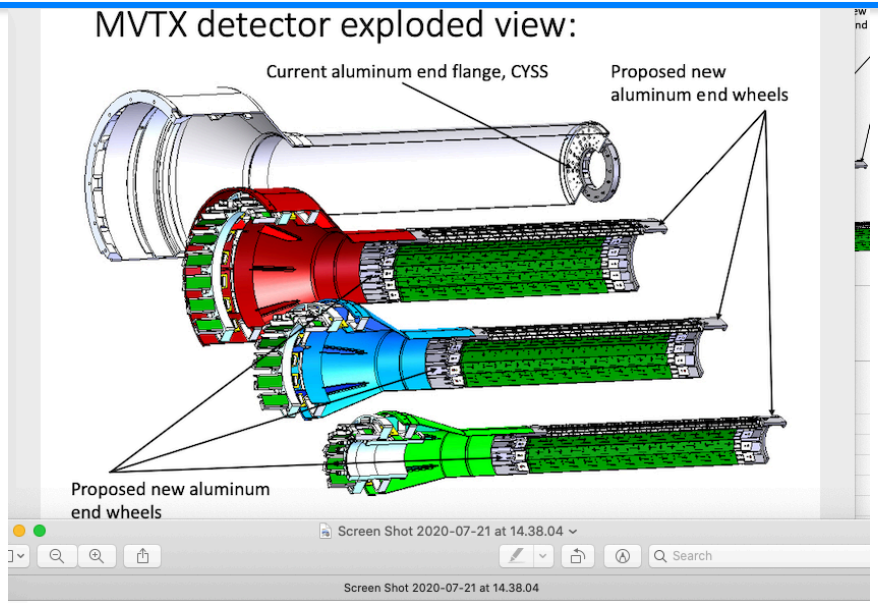
https://docs.google.com/spreadsheets/d/1hHUhxZOZv8WEs3FH361_gN6McVU4Zhy60sGtYotRHMs/edit?usp=sharing

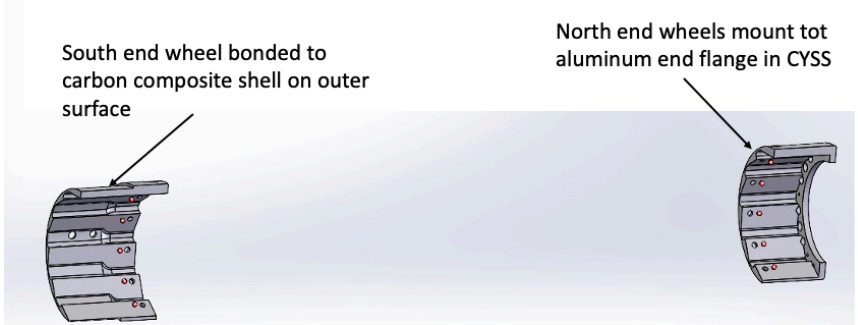


Power and safety interlock



MVTX Detector: End-Wheels





3 Vendors' Bids Received (one didn't responded)

		Workshape	SpencerComposite	LBL
Price	Bulk	270 552 EUR	461 000 USD	~896 000 USD (best case)
	Extra	**options**)	for visit	~1 046 000 USD (worst case)
	TOTAL	314 595 USD	>470 000 USD	
Delivery time	testArticle	12weeks+6weeks (Grenoc)	~26weeks ARO	--
	everything	testArticleApproval+~20weeks ...	(almost 1 year)	--
Impressions		Much experience in very similar projects.	Very Formulaic Reponse	Thoroughly thought out quote, willing to
Proposed changes		Propose to combine cone and cylinder of CYSS		Propose to combine cone and cylinder of
		Propose to use 7075 instead of 6061 Aluminum		Propose to use 7075 instead of 6061

Cost from WorkShape

1 EU$ = 1.2 US$

Total cost = EU$271K x 1.2 = US $325K

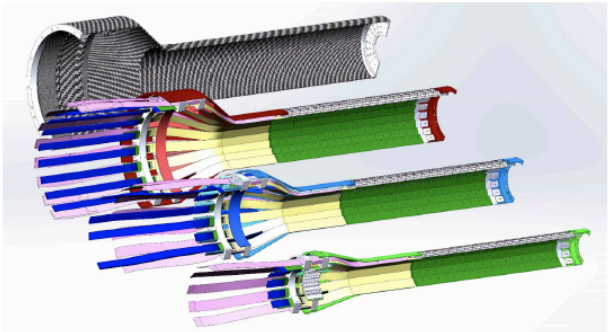
EWs: EU $164.1 => US $197K
CYSS: EU $44.65K => US $54K
SB: EU $44.15K => US $53K

Shipping: US $21K

Summary			
MVTX L0	set		51 256,00
MVTX L1	set		53 774,00
MVTX L2	set		59 084,00
MVTX CYSS	set		44 652,00
MVTX Service Barrel	set		44 146,00
Packing and transport	1		17 640,00
OPTIONS			
Additional CAD/CAM, milling and finishing of the moulds, parts manufacturing in case of springback.	1 to 2	6 640,00	
Prototype MVTX L0 assembly (needs CAD/CAM, as well as the moulds to be manufactured), included all measurements with reports, packing and transport.	1	14 933,00	
MVTX L0 assembly: same as above, with all the documentation and coupons.	1	15 649,00	
Extra work: to gain 2 weeks on the prototype, so 10 weeks instead of 12	1	4 908,00	
Extra work: to gain 4 to 5 weeks on the project, prototype not included (5 weeks on 22 weeks, so 17 weeks for the project after prototype)	1	23 448,00	
Total, no options		270 552,00	

Project Management Plan

- Draft PMP document completed
  - **Project baseline**
    - **Physics**
    - **Functional requirements/KPP**
    - **Technical scope**
    - **Cost breakdown**
    - **Schedule**
    - **Funding profile**
    - **Planned BNL funding**
    - **Baseline change control**
  - **Management structure**
    - **Organization and team**
    - **Management responsibilities**
    - **Participating institutions**
  - **Project management and oversight**
    - **Risk management**
    - **Project reporting**
    - **Engineering and technology readiness**
    - **Quality assurance and configuration/document management**
    - **Operation readiness plan**
    - **ESSH plans and fabrication**
    - **Project closeout**
- Project fully integrated into sPHENIX P6
  - **Costs, schedules and risk register**



Management Plan

for

A Monolithic-Active-Pixel-Sensor-based Vertex Detector (MVTX) Upgrade for the sPHENIX Experiment

at the

Brookhaven National Laboratory

July 22, 2019

Deliver MVTX on schedule/budget for day-1 physics!

MVTX Milestones and Key Tasks

Table 5 Milestones and Key Tasks:

Milestone	Date
Project Start	December 2019
Preliminary Design of the MVTX Detector	March 2020
Power Board Production Contract Award	April 2020
End Wheel, CYSS and SB Design Complete	June 2020
Start Test and Rework Staves – Batch 1	July 2020
Insertion Mock-up Ready	August 2020
MVTX Final Design Review	September 2020
Samtec Readout Cable Contract Award	November 2020
Complete End-Wheels Fabrication	January 2021
Complete CYSS Fabrication	February 2021
Complete SB Fabrication	March 2021
Support Structure Production Start	April 2021
Test Installation of Staves onto End-Wheels	May 2021
Half-Detector Assembly Review	July 2021
Perform Half-Detector Metrology on Layers	September 2021
Assemble Layers and CYSS into Half-Barrel #1	October 2021
Assemble Layers and CYSS into Half-Barrel #2	November 2021
Test and Rework Half-Barrel #1	December 2021
1st Half Barrels Assembled	February 2022
2nd Half Barrels Assembled	March 2022
Test Half Barrels at BNL	April 2022
MVTX ready for Installation	June 2022
Approve Project Complete	May 2023

From MVTX PMP 12/2019

MVTX High Level Cost

WBS	Level 2 WBS Description	Burdened AY$ labor	Burdened AY$ M&S	Burdened AY$ Total
3.02.01	MVTX Project Management	$498.8k	$46.8k	$544.6k
3.02.02	MVTX Electronics	$211.2k	$358.4k	$569.6k
3.02.03	MVTX Mechanics and Detector Assembly	$1241.6k	$667.0k	$1908.6k
3.02.04	MVTX Integration and Installation	$456.8k	$416.5k	$873.3k
	Total	$2187.8k	$1500.6k	$3688.5k

MVTX Carbon Structure Cost(July 2019)

	WBS	Cost (K)	Contingency	Basis
End Wheels	03.02.02 Line 143	$311	40% 60%	Previous experience
Cylindrical Structure	03.02.03.01 Line 158	$201	40%	Previous experience
Service Barrel	03.02.03.02 Line 169	$266	40%	Previous experience

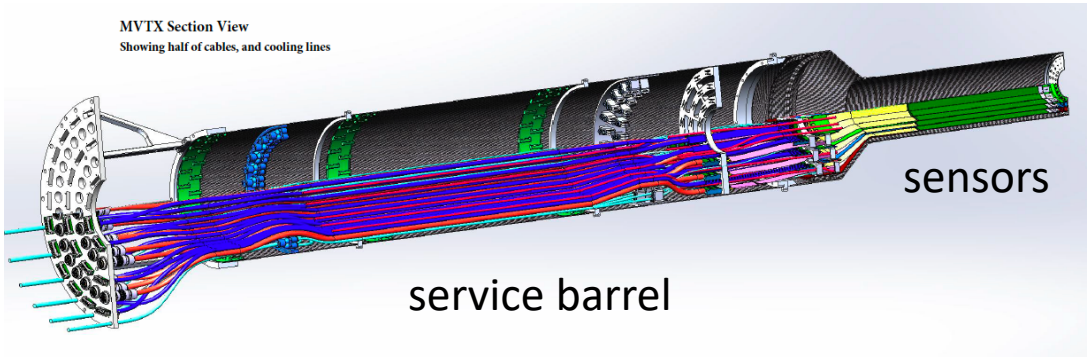
Changed to 60%,
following July 2019 review recommendations

MVTX Material Distribution

Total weight = ~24kg

Sensors parts (CYSS+EWs+Staves+noseroller)= ~3 kg

Cables of detector = ~12kg
Cooling tubes = ~1.1kg



Signal Cables Load	2226 g
Signal Cables Type	Distributed Force, per side
Location	SB inside face
Power Cables	3612.3 g
Type	Distributed Force, per side
Location	SB inside face
L0	261.26 g
Type	Remote mass, per side
Location	CYSS Clamp ring and Nose Plate
L1	312.9 g
Type	Remote mass, per side
Location	CYSS Clamp ring and Nose Plate
L2	418.9 g
Type	Remote mass, per side
Location	CYSS Clamp ring and Nose Plate
Cooling tubes 4mm + Air Tubes	1122.054 g
Type	Distributed Force, per side
Location	SB Inside face
Nose rollers	30 g
Type	Distributed Force, total
Location	Nose Plates