

# SoLID Test Beam Preparation

**Eric Fuchey**  
**College of William & Mary**

**SOLID** Collaboration Meeting,  
**February 19<sup>th</sup> 2026**



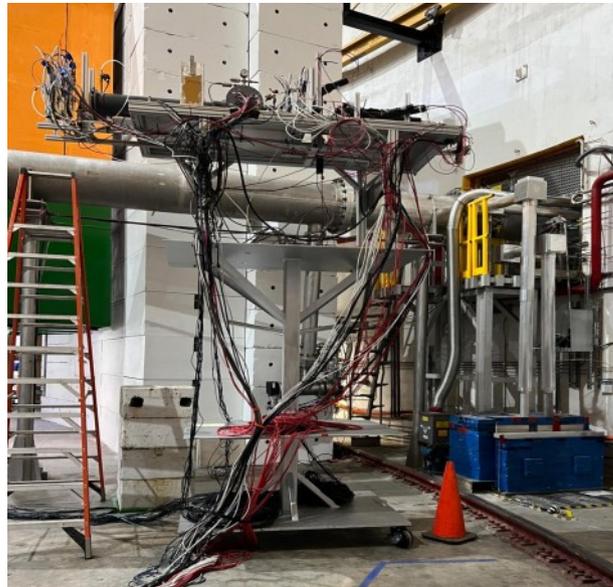
# Outline

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- SoLID test beam goals
- Test beam setup
  - Detectors
  - Magnet and shielding
  - Support and platform
  - DAQ and software
- Test beam plan and schedule
  - Run plan
  - layout in the hall
  - Current status
  - Timeline:
    - ◆ assembly
    - ◆ data taking
- Workforce and responsibilities
- Summary

# SoLID test beam goals

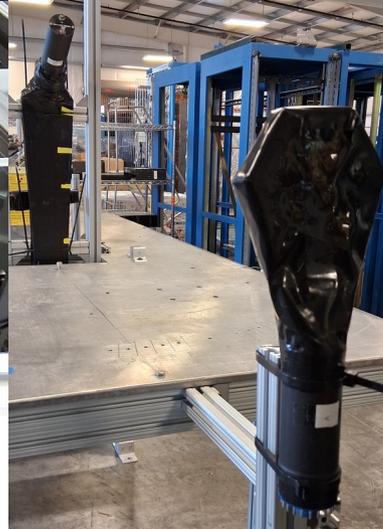
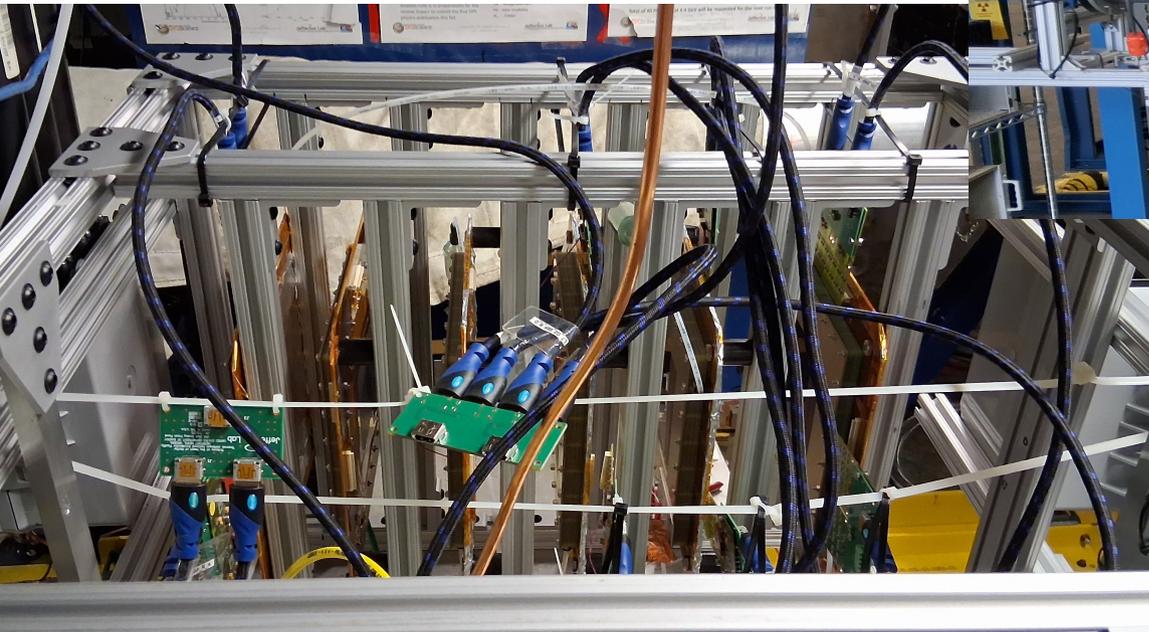
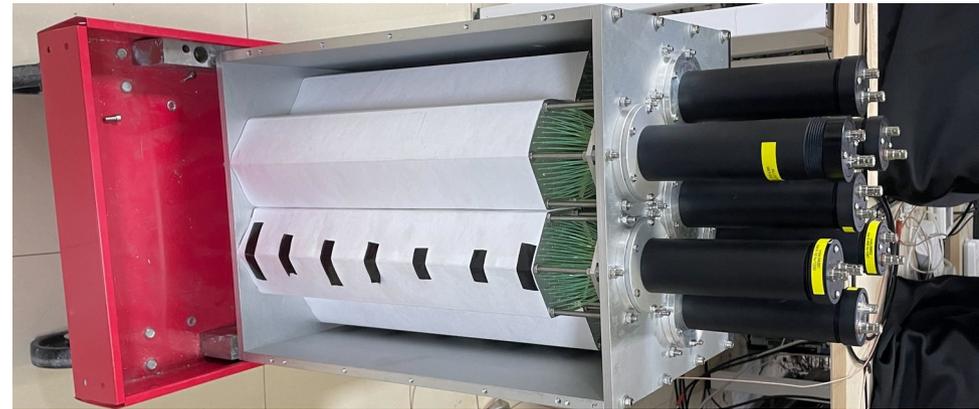
- SoLID test beam goals:
  - *Key goal:* assess the performance of tracking with GEMs,  $\mu$ Rwell,  $\mu$ Rgrooves in high background conditions;
  - assess the energy (and time) resolution of the ECAL supermodule assembly prototype;
  - assess the time resolution of the MRPC prototype;
  - test the gain of performance of the VMM chip over the APV.
- To achieve those goals:
  - build a “mock up spectrometer” to take data parasitically in Hall C at large (80 degrees) and low angles (18, 15 degrees)



- A similar test was run in 2022 to test SoLID ECal module prototype, a cherenkov, scintillator paddles for trigger, and a few GEM trackers;

# SoLID test beam setup

- Test beam setup detectors:
  - Ecal “supermodule” (assembly of 7);  
(Old ECAL 3 module for backup);
  - Cherenkov;
  - Scintillator paddles;
  - 4 MRPCs;
  - Tracking detectors:
    - ◆ 6 GEMs;
    - ◆ 5 uRwells;
    - ◆ 2 uRgrooves;



# SoLID test beam setup

- Test beam setup detectors:

- Ecal “supermodule” (assembly of 7);

- Cherenkov;

- Scintillator paddles;

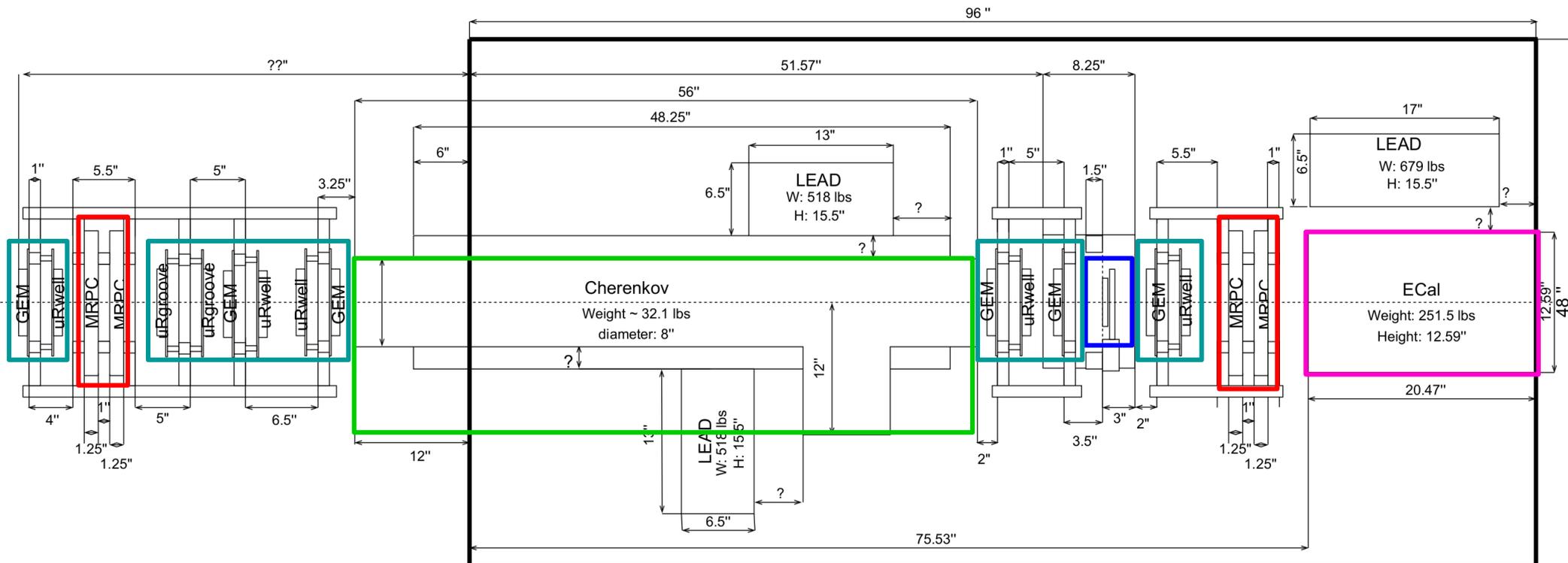
- 4 MRPCs;

- Tracking detectors:

- ◆ 6 GEMs;

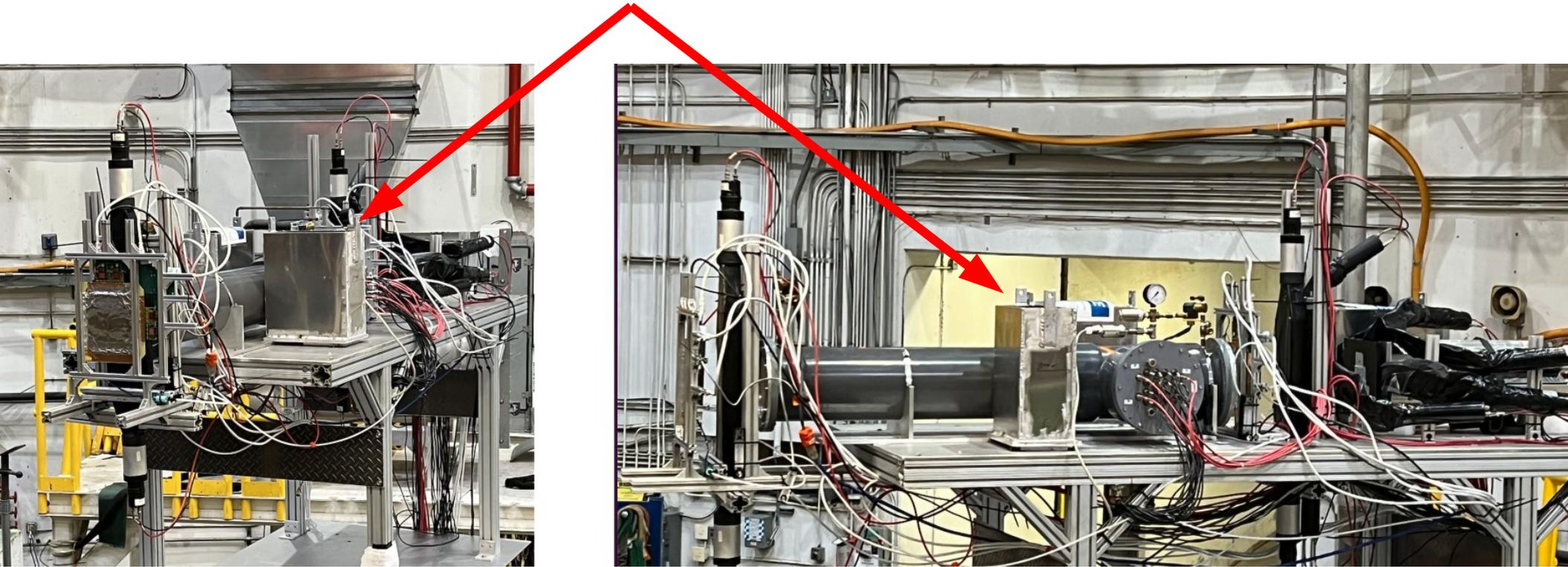
- ◆ 5 uRwells;

- ◆ 2 uRgrooves;



# SoLID test beam setup

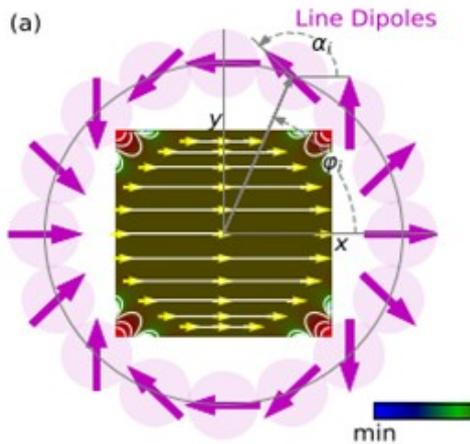
- Magnets and shielding:
  - Preexisting lead shielding to protect ECal and Cherenkov PMTs



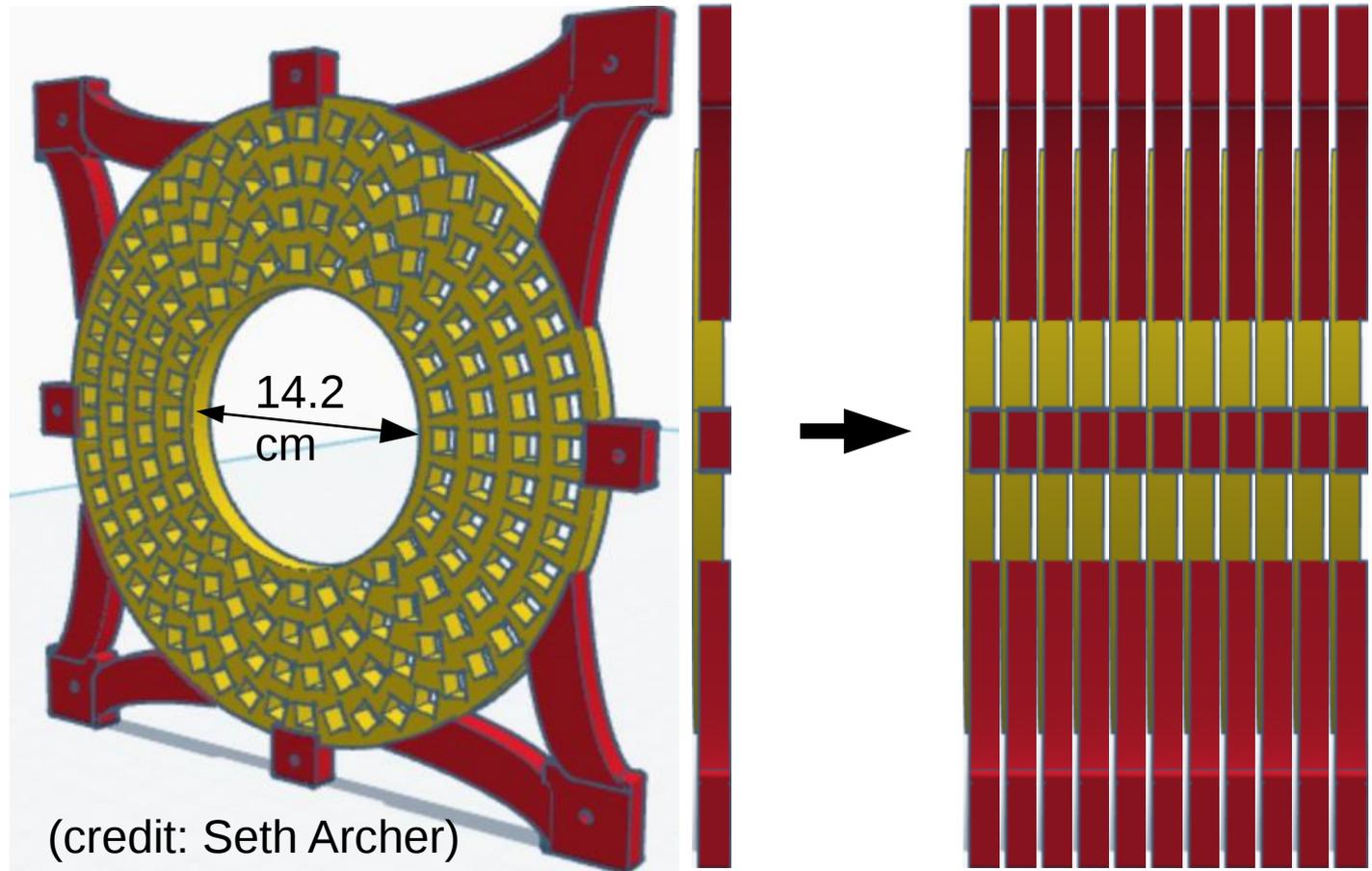
- One of the shielding elements may need to be moved around, new holes to be drilled on the table

# SoLID test beam setup

- Magnets and shielding:
  - Preexisting lead shielding to protect ECal and Cherenkov PMTs
  - Magnet for deflection of  $\sim 30$  MeV electrons away from trackers:
    - ◆ design started by Klaus, continued by Seth
    - ◆ uses permanent magnets inserted in a 3D printed support
    - ◆ contributions from all magnets  $\Rightarrow$  0.2 T field in magnet bore
    - ◆ ring layers are stacked to achieve required field integral



(credit: Klaus Dehmelt)

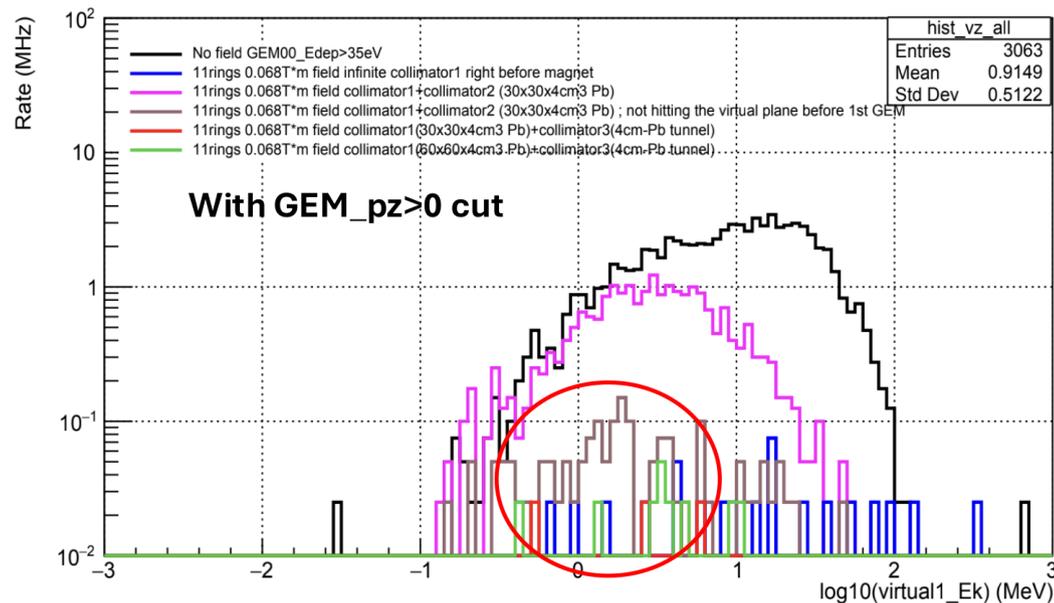


(credit: Seth Archer)

# SoLID test beam setup

- Magnets and shielding:
  - Preexisting lead shielding to protect ECal and Cherenkov PMTs
  - Magnet for deflection of  $< 30$  MeV electrons away from trackers
  - New shielding to reduce background in trackers (optimized by Ye)

4cm-Pb collimator1+36.1cm-long collimator 3+no poly



## 11 rings magnet

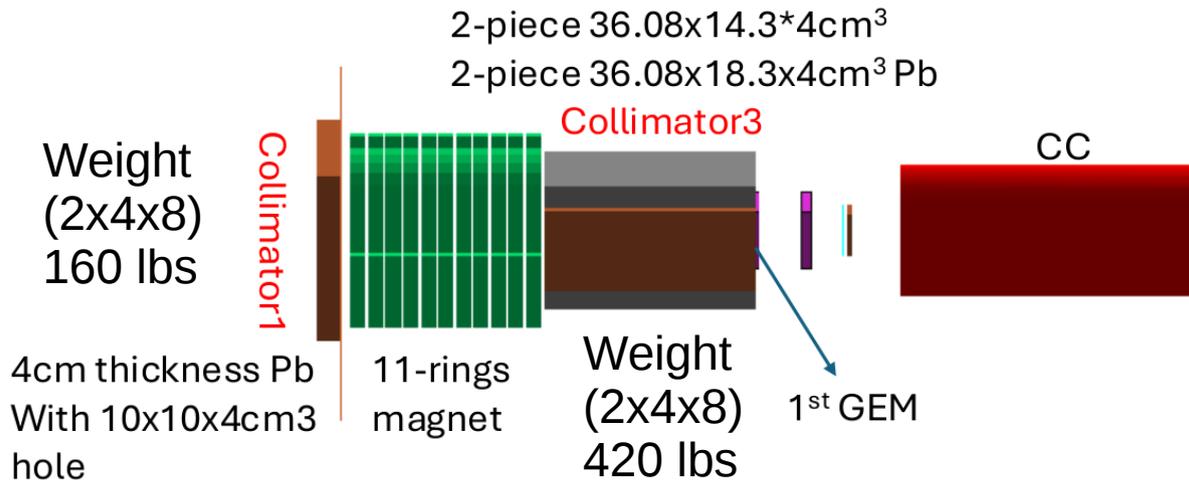
- The magnet bends the high energy background away.
- There is no high energy punch through the Pb collimator material.
- The remaining background is dominated by low energy particles ( $E < 5$  MeV), which are easier to handle.

- Collimator 1 ( $30 \times 30 \times 4 \text{ cm}^3$  Pb with a  $\pm 5 \text{ cm}$  hole )+ Collimator 2 ( $30 \times 30 \times 4 \text{ cm}^3$  Pb with a  $\pm 5 \text{ cm}$  hole)
- Infinite collimator 1
- Collimator 1 ( $30 \times 30 \times 4 \text{ cm}^3$  Pb with a  $\pm 5 \text{ cm}$  hole )+ Collimator 2 ( $30 \times 30 \times 4 \text{ cm}^3$  Pb with a  $\pm 5 \text{ cm}$  hole)+Collimator 3 cut (cylinder with a  $r=7.1 \text{ cm}$  hole)
- Collimator 1 ( $30 \times 30 \times 4 \text{ cm}^3$  Pb with a  $\pm 5 \text{ cm}$  hole)+Collimator 3 (4cm thickness Pb tunnel)
- Collimator 1 ( $60 \times 60 \times 4 \text{ cm}^3$  Pb with a  $\pm 5 \text{ cm}$  hole)+Collimator 3 (4cm thickness Pb tunnel)

# SoLID test beam setup

- Magnets and shielding:
  - Preexisting lead shielding to protect ECal and Cherenkov PMTs
  - Magnet for deflection of  $< 30$  MeV electrons away from trackers:
  - New shielding to reduce background in trackers (optimized by Ye)

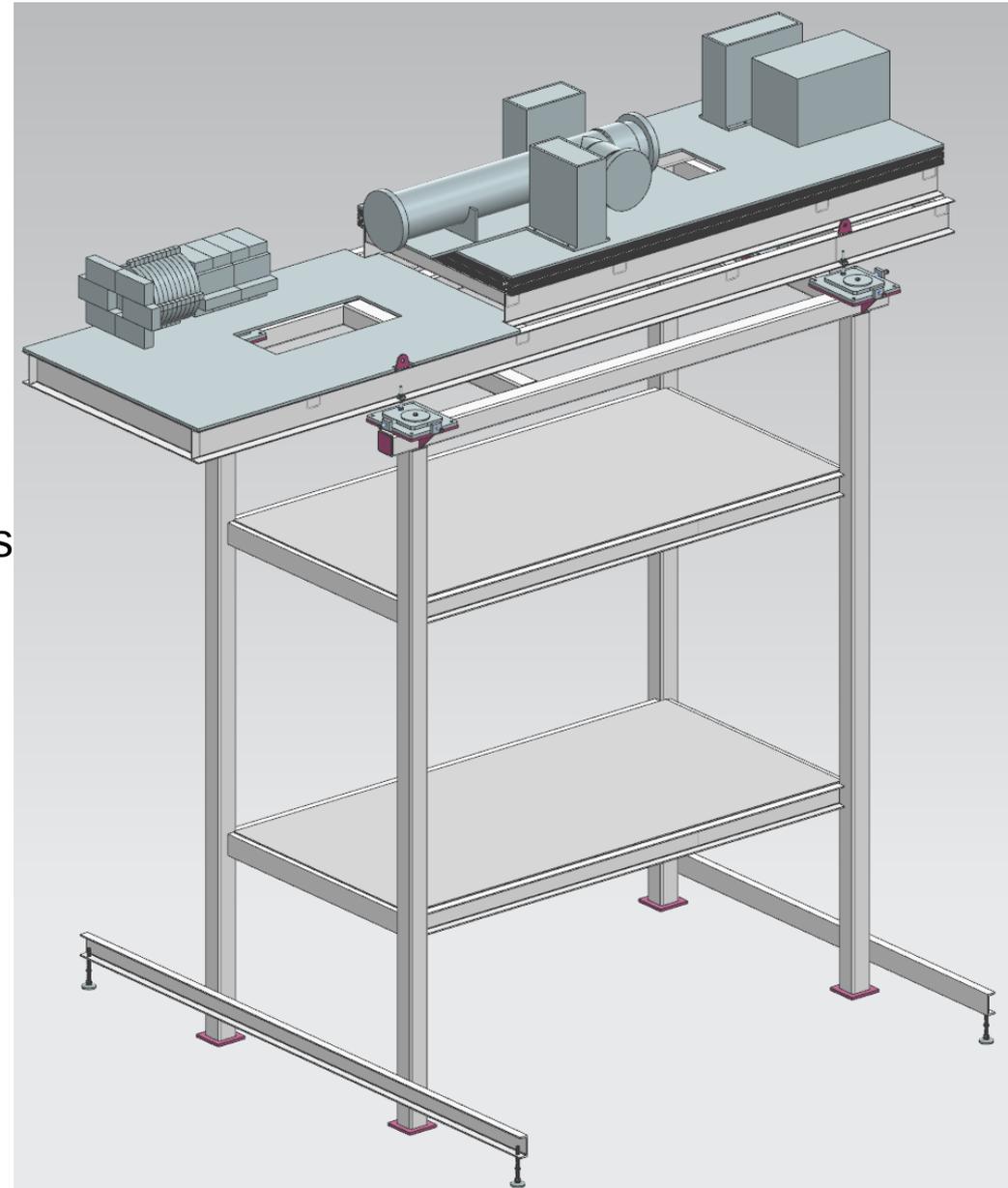
## Weight Estimation



Collimators for 11-rings (magnet weight 155 lb) ( $2 \times 36.08 \times 14.3 \times 4 \text{ cm}^3 + 2 \times 36.08 \times 18.3 \times 4 \text{ cm}^3$ ) Pb tunnel collimator 3 )	Reduction factor		Total collimator weight lb	Colli+magnet lb
	Pz>0	No cut		
+60x60x4cm <sup>3</sup> Pb Collimator 1 with 10x10x4cm <sup>3</sup> hole	153	48	$103.4 + 132.1 + 350 = 586$	741
+30x30x4cm <sup>3</sup> Pb Collimator 1 with 10x10x4cm <sup>3</sup> hole	190	60	$103.4 + 132.1 + 80 = 316$	471

# SoLID test beam setup

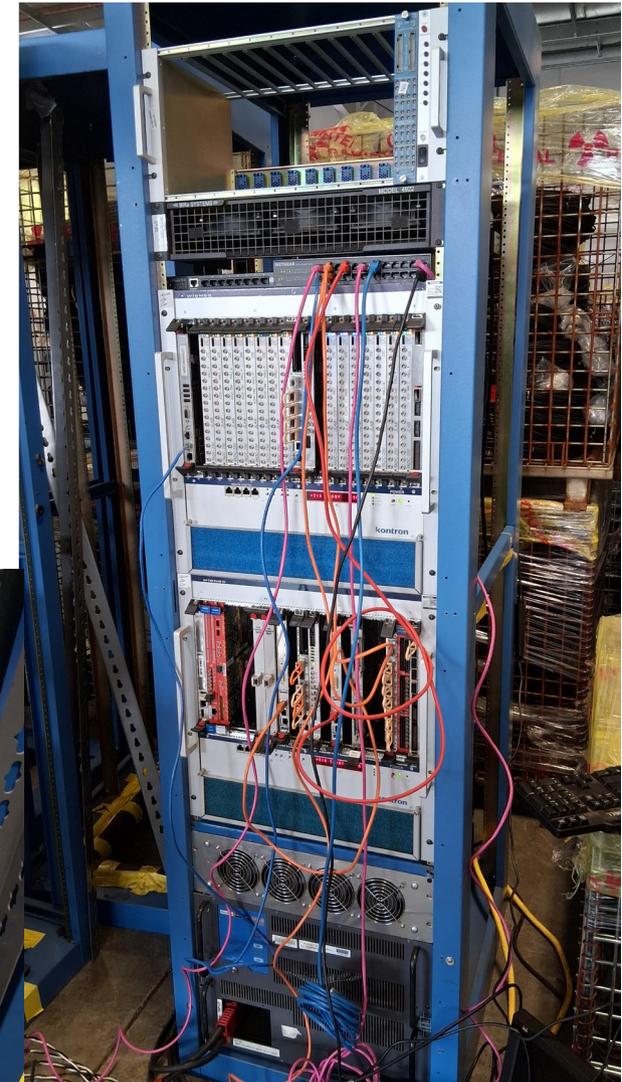
- Support and Platform
  - designed by the Hall C engineers and designers: Hunter Garrett, Paul Medeiros, Jason Clark, Jamie Shiflett (many thanks to them)
  - requirements:
    - ◆ sturdy enough to safely carry the weight of all the shielding
    - ◆ ability to adjust height and angle of the table top to point the detectors towards the target
  - Construction ETA March 13
  - Magnet support design to be finalized
    - ▶ *magnet design to be finalized*;
    - ▶ PR for prototype
    - ▶ build one ring to validate design;



# SoLID test beam setup

- DAQ:
  - DAQ setup in ESB;
  - FADC for ECal/Cherenkov/scintillators;
  - VTP for tracking detectors;
  - Front-end for tracking detector:
    - ▶ MPD crate, GEM LV PS, NIM fanout
  - TDCs for MRPC
- Plans for trigger:
  - Ecal+Cherenkov coincidence in VTP for electrons;
  - Special triggers with scintillator paddles for pions;

System	Channels	HV Channels
ECAL	7	7
Cherenkov	4	4
Scintillators	5	5
GEMs	3072	6
uRwell	1280	5
uRgroove	1280	4
MRPC	512	4



# SoLID test beam setup

- Software
  - Requires working decoding and basic reconstruction for all detectors especially trackers, to be able to perform calibrations and monitoring
  - Using SBS-offline:
    - ▶ [https://github.com/JeffersonLab/SBS-offline\\_SOLIDtestbeam](https://github.com/JeffersonLab/SBS-offline_SOLIDtestbeam)
    - ▶ [https://github.com/JeffersonLab/SBS-replay\\_SOLIDtestbeam](https://github.com/JeffersonLab/SBS-replay_SOLIDtestbeam)
- Task list:
  - Databases being written (responsibles Ching Him Leung, Alexandre)
  - replay script written – need testing (responsible Eric)
  - No high priority code modifications:
    - ▶ VMM decoder: lower priority;
    - ▶ MRPC reconstruction: lower priority;
    - ▶ 3-layer uRwell reconstruction: lower priority;
    - ▶ Cherenkov: *Possible* modifications to exploit readout granularity (lower priority);
  - MC simulation sample: Responsibles Ye, Zhiwen

# SoLID test beam plan and schedule

- Test beam assembly in ESB



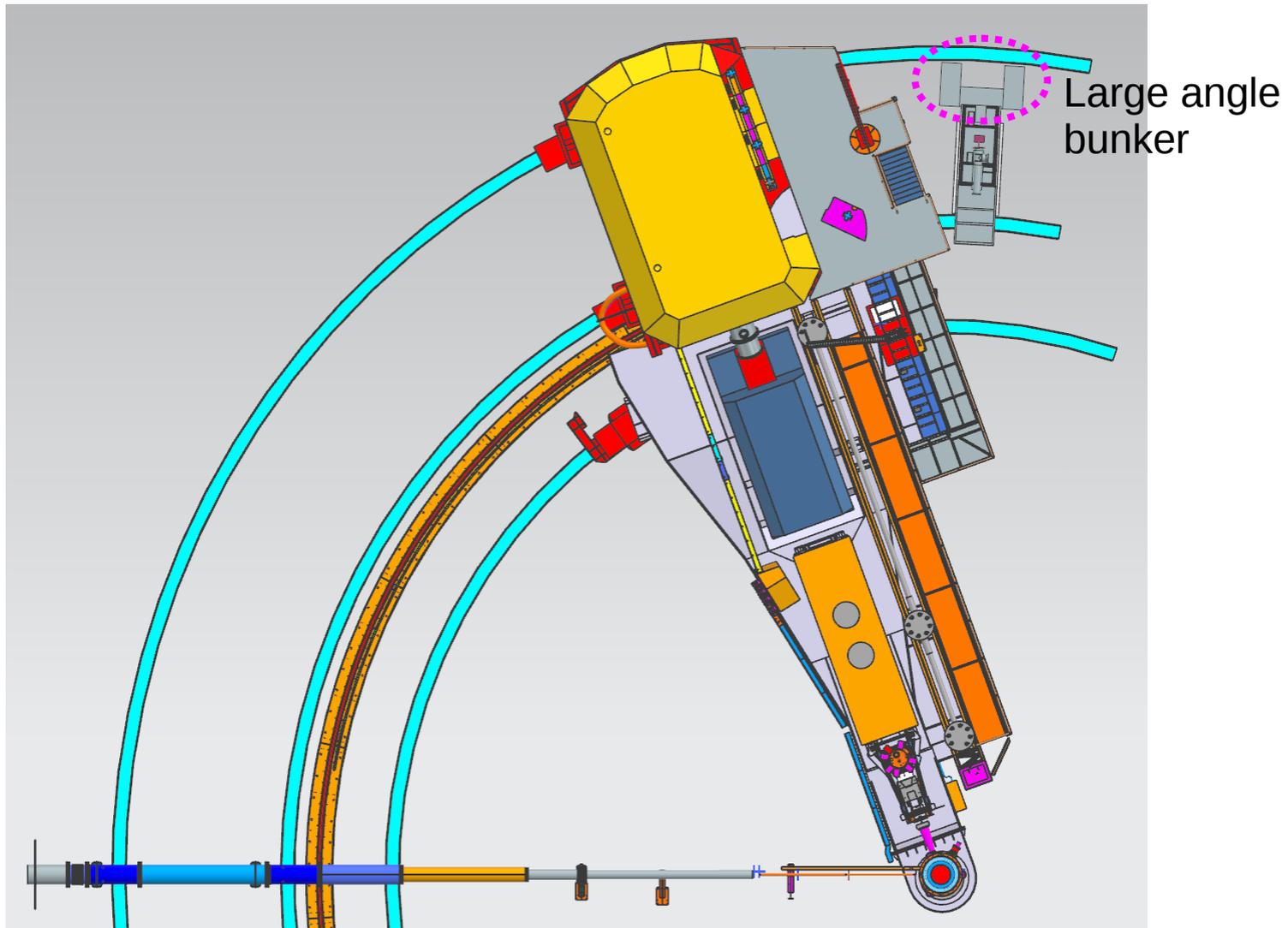
- Test beam setup moved in Hall C *during the accelerator reconfiguration*:
  - Large angle (~80 degrees) during R-SIDIS, part of pion-CT;
  - 18 degrees on HMS side during pion-CT Q2 8.5 GeV<sup>2</sup> (HMS 36 degrees)
  - 15 degrees during pion-CT Q2 7.5 GeV<sup>2</sup> (HMS 29 degrees)

# Run plan

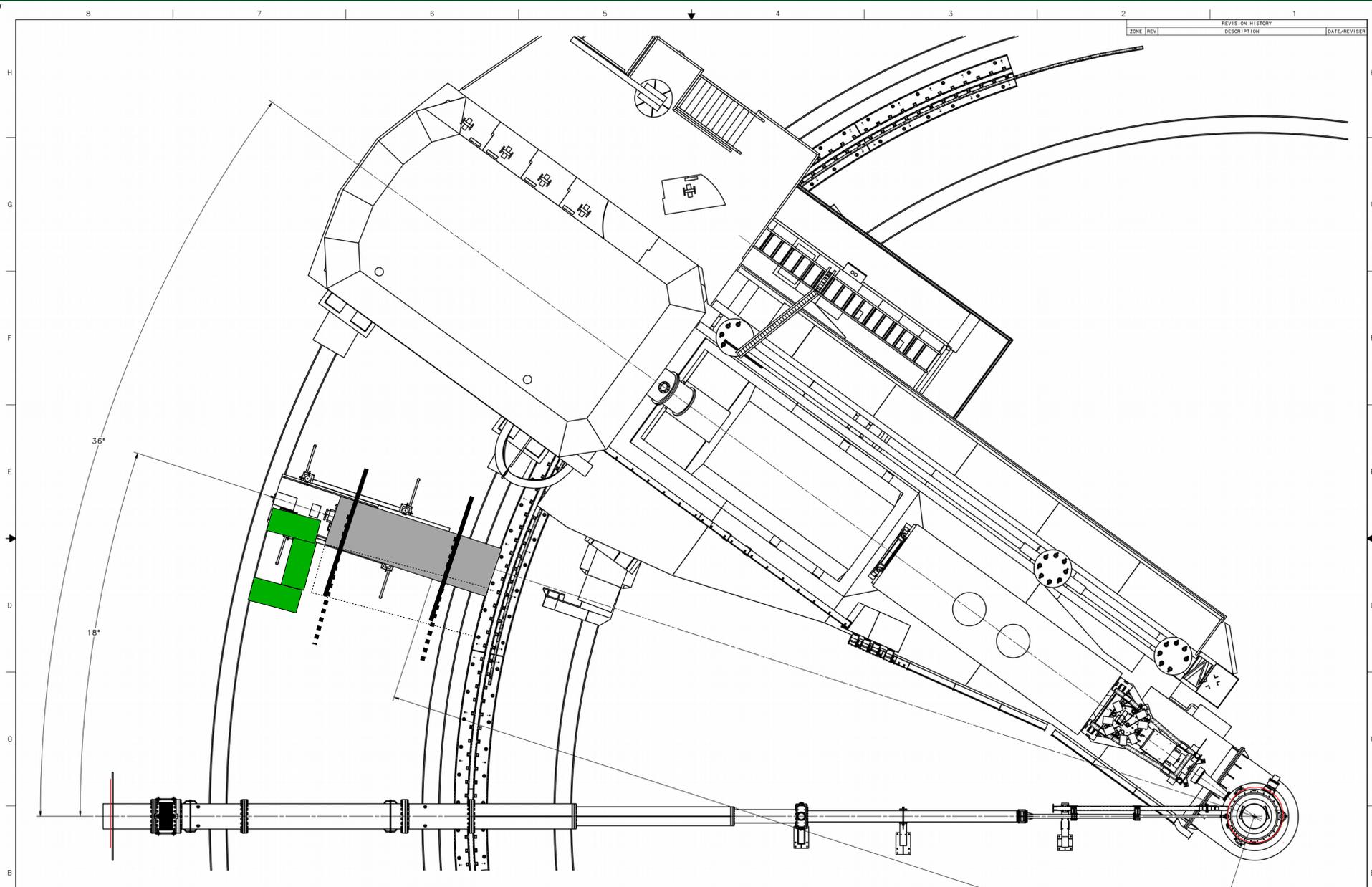
- Test beam installation pushed to May 25 - June 8
  - Commissioning at large angle: June 8 – July 20 (42 days max)
  - Large angle data taking: July 20 – August 5 (16 days)
  - 18 degrees data taking August 5 – August 19 (14 days)
  - 15 degrees data taking August 19 – August 31 (12 days)
- *Change of position during a maintenance day (Wednesday August 5, 19)*
- Commissioning plan
  - tracking detectors flowing with N2
  - June 8 – June 15 ▶ commissioning of calorimeter
  - June 15 – June 22 ▶ commissioning of scintillators
  - June 22 – June 29 ▶ commissioning of Cherenkov
    - ▶ start to flow gas into tracking detectors
  - June 29 – July 6 ▶ commissioning of GEMs
  - July 6 – July 13 ▶ commissioning of uRwell + uRgroove
    - ▶ start to flow gas into MRPC
  - July 13 – July 20 ▶ commissioning of MRPC + uRgroove
- Rest of run plan as exposed above:
  - keep awareness of experiments run plan
  - bookkeeping of beam conditions

# SoLID test beam location

- Large angle (commissioning + data taking):
  - HMS at 70 degrees, platform at 93 degrees, 19.30 m from target
  - moving *after* low energy run: max HMS angle at 50 degrees max  
=> platform at 80 degrees, 19.30 m from target

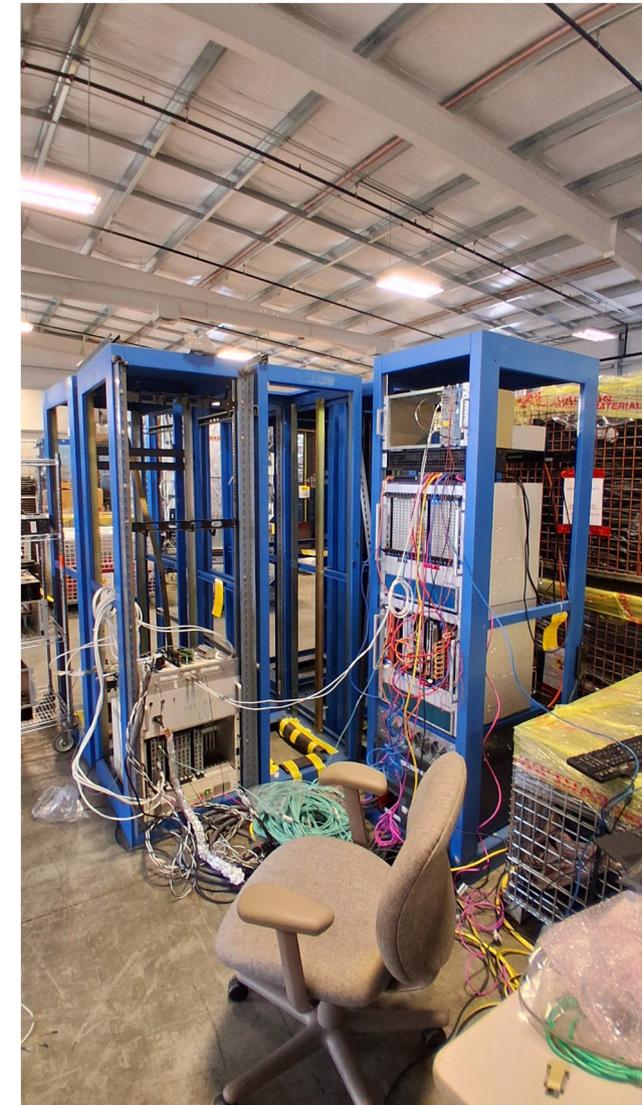


# SoLID test beam location: low angle bunker



# Current status

- Detectors and DAQ being assembled in ESB
  - DAQ assembly (modules, front-end) complete, need debug
  - Detector assembly planned (see next);
  - Gas for tracking detectors ordered (thank you Ching Him):
    - ◆ Ar/CO<sub>2</sub> 75/25 for GEMs
    - ◆ Ar/CO<sub>2</sub>/Iso 93/5/2 for uRwell, uRgroove

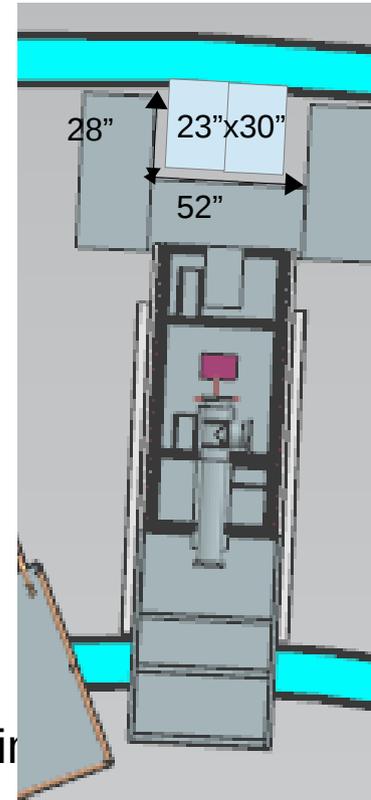


# SoLID test beam installation timeline

- Pushing through detector installation:
  - February 20 timeline will not be reached;
  - Revisiting timeline => March 20
  - Assembly of tracker support material done;
  - TODO: determine the full list of drillings to do on the table:
    - ▶ Ecal fastening
    - ▶ tracker supports fastening
    - ▶ relocation of back lead shielding box
- Availability timeline for detectors:
  - JLab GEMs/uRwell: already on-site, to be assembled this week;
  - Cherenkov: will be assembled this week
  - UVA GEMs/uRwell: request again to get the detectors on site this week;
  - ECal 3 modules: 2 PMTs available, 2 in order (ETA March 6th)
  - ECal 7 modules: to be received in March;
  - Scintillators being tested at W&M: working bases to be retrieved;
  - uRgroove: March 20;
  - MRPCs: on-site; detailed assembly plan still to be discussed.

# SoLID test beam preparation action items

- Things to do *before the hall lock-up*:
  - setup network in Hall C
  - move long cables in Hall C (and setup couple baskets just for us)
  - layout cables *if possible* (i.e. if we don't get on anyone's way)
  - set up marks on the floor for the positions of the platform
    - ▶ determining these positions with designers
  - move the green blocks for the GEM bunkers in the Hall
    - ▶ Make sure we have the number of blocks we need
    - ▶ requires 2 half racks (33.25") "inline if possible".
- Items to be pushed through:
  - *magnet design to be finalized*;
    - ▶ need PR for prototype
    - ▶ need to build one ring to validate the design;
  - setup remote controls for all systems to optimize commissioning time
    - ▶ HV control/monitor;
    - ▶ LV control;
    - ▶ Tracker current monitoring;
    - ▶ Detectors thresholds;
    - ▶ Gas monitoring (via webcam);



# Workforce and responsibilities

- Overall coordination: Eric Fuchey – W&M (alternate: Todd Averett – W&M)
- Detectors:
  - GEMs/uRwell: Florian Hauenstein – JLab / Ching Him Leung – JLab / Huong Nguyen\* – UVA / Xinzhan Bai\* – JLab (\*unavailable during PRad / X-17)
  - uRgroove: Jaydeep Datta – SBU
  - ECal: Xiaochao Zheng – UVA / Michael Nycz – UVA / Zhihong Ye – Tsinghua U
  - Cherenkov: Zhiwen Zhao – Duke U
  - MRPC: Sanghwa Park – JLab
  - Scintillator paddles: Todd Averett – W&M (alternate Eric Fuchey – W&M)
- DAQ: Alexandre Camsonne – JLab / Zhongling Ji – Syracuse U / Hanjie Liu – JLab (interactions with Hall C & Computer Center)
- Magnet: Alexandre Camsonne – JLab (Alternate Klaus Dehmelt – JLab)
- Slow controls: Bill Henry – JLab
- Software/ Simulation: Ching-Him Leung – JLab (alternate Eric Fuchey – W&M)  
Ye Tian – Syracuse U / Zhiwen Zhao – Duke U
- Platform/support design: JLab Hall C engineers/designers: Hunter Garrett, Paul Medeiros, Jason Clark, Jamie Shiflett
- Installation: Jerry Nines and JLab Hall C techs + Chris Gould and JLab Survey/alignment team

Thank you to all the people cited above + the “PIs”: JP Chen – JLab / Klaus Dehmelt – JLab / Xiaochao Zheng – UVA / Todd Averett – W&M / Paul Souder – Syracuse U / Haiyan Gao – Duke U...

# Summary

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- SoLID test beam is making progress to run concurrently in Hall C during the next run period;
  - installation pushed back during the accelerator reconfiguration time:
    - ▶ **need to keep momentum!**
    - ▶ setup remote controls for all systems to optimize commissioning
  - drafted run and commissioning plan
  - low angle/high background data taking during pion-CT (between two and three weeks);
- Timelines to achieve our objectives are aggressive, but hopefully realistic;
  - platform fabrication is underway;
  - many detectors are already on-site or will be soon, and will be ready to be installed by March
  - DAQ in good progress; software should be ready by end of March
- **Any help is more than welcome :)**

# SoLID test beam installation in the Hall

- Action items for installation:
  - Completion of the platform; (ETA March 13)
  - Installation of all the detectors on the detector table; (March 20)
  - Fiducialization of the detector table by the Survey/Alignment group; (between March 23-27)
  - Move of the platform to Hall C after its construction (ETA end of May)
  - Installation of the platform setup at large angle (ETA end of May);
  - Move of the detector table from ESB to Hall C (ETA early June);
  - Installation of the detector table on top of the platform (ETA early June);
  - Move of the long cables from ESB to Hall C (March 6 – March 13);
  
  - Installation of the long cables in Hall C (*if possible*, before March 20);
  - Move of the DAQ from ESB to Hall C (May 27-28);
  - Installation of the GEM bunker at large angle in Hall C (ETA end of May)

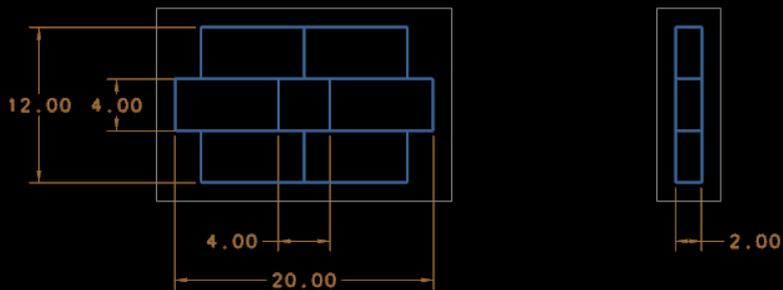
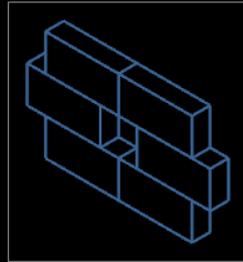
# SoLID test beam moving procedure

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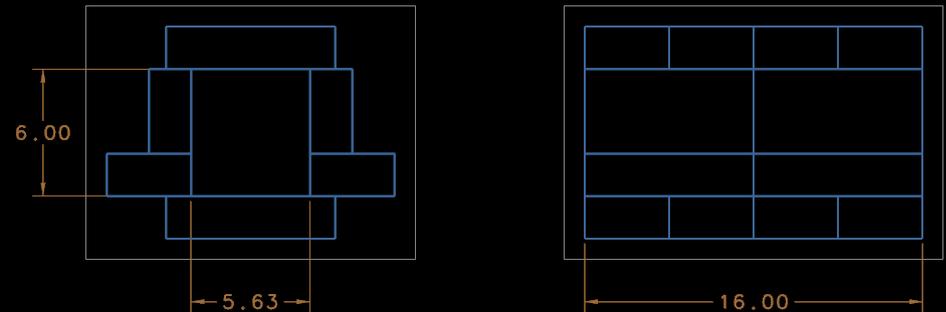
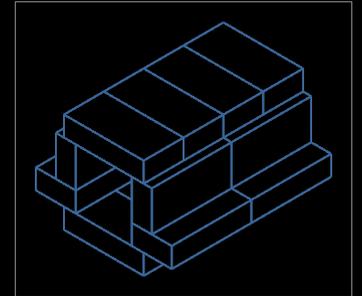
- Prerequisites:
  - HMS must already be at 36 degrees
  - will use an accelerator maintenance day
  - restricted access may have to be considered for this operation
  - GEM bunker must be already installed (or would have to be installed later...)
- Moving procedure from 80 to 18 degrees:
  - setup table craned off of the platform
  - platform craned over HMS, set to the predefined location at 18 degrees
  - setup table craned over HMS, placed on top of platform
  - survey group will adjust the table to point it towards the target with the desired tolerance

# SoLID test beam setup

- Magnets and shielding:
  - Preexisting lead shielding to protect ECal and Cherenkov PMTs
  - Magnet for deflection of  $< 30$  MeV electrons away from trackers:
  - New shielding optimized with MC by Ye Tian
  - Shielding “adapted” to use standard 2x4x8 lead bricks



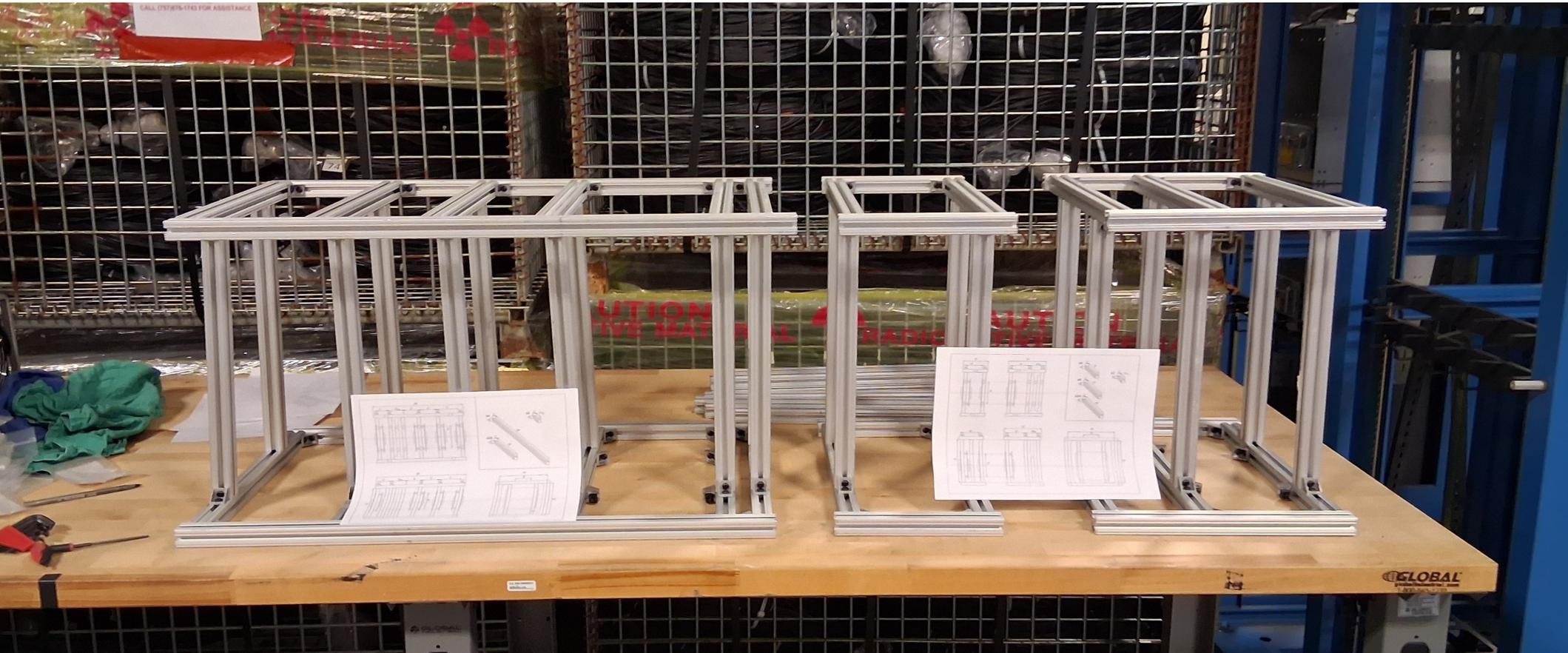
COLLIMATOR 1  
EST WEIGHT: 160 LBS  
(LEAD: 2X4X8)



COLLIMATOR 3  
EST WEIGHT: 420 LBS  
(LEAD: 2X4X8)

# SoLID test beam setup

- GEM/uRwell/uRgroove Tracker supports:



# SoLID test beam location: low angle bunker

