SoLID Test Beam Preparation

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College of William & Mary

Hall C Winter Collaboration Meeting,
January 27th 2026

WILLIAM & MARY
CHARTERED 1693

Jefferson Lab

Outline

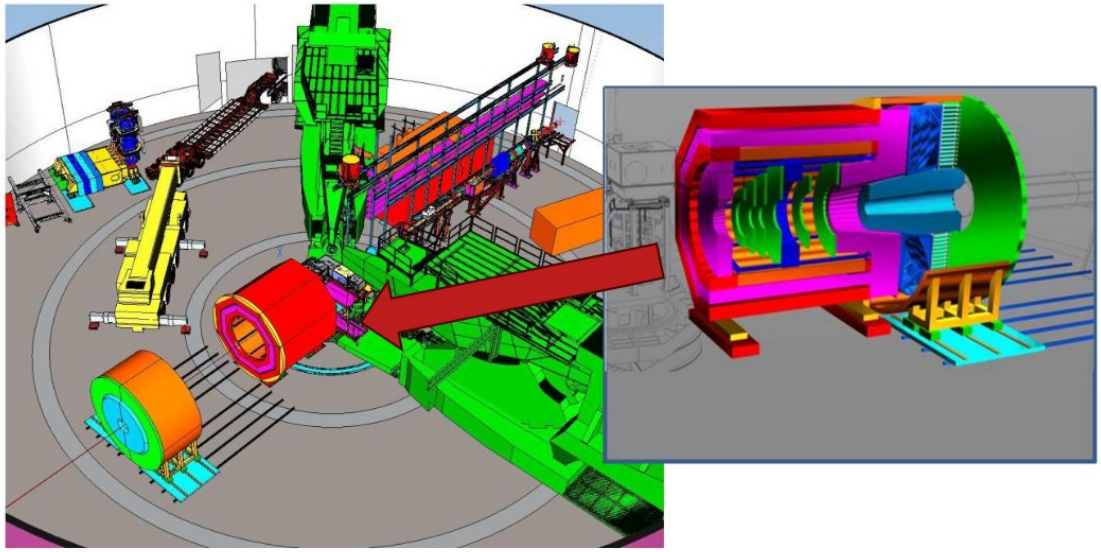
- SoLID test beam goals
- Test beam setup
  - Detectors
  - Magnet and shielding
  - Support and platform
  - DAQ and software
- Test beam plan and schedule
  - layout in the hall
  - Current status
  - Timeline:
    - assembly
    - data taking
- Manpower and responsibilities

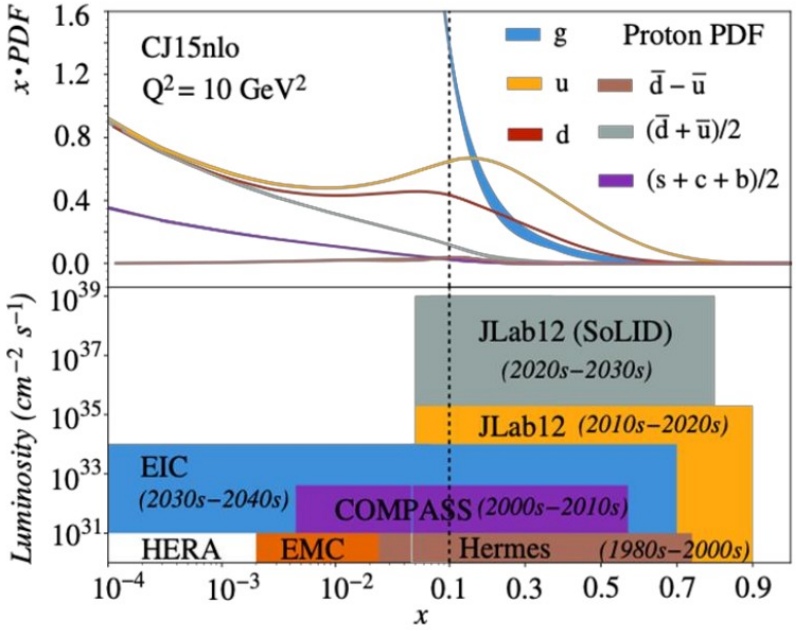
SoLID test beam goals

- SoLID: Physics overview in *Xiaochao's Hall A meeting talk*
  - Combines high luminosity with large acceptance
  - Detectors (especially trackers) need to work in high particle flux

SoLID : Solenoidal **L**arge **I**ntensity **D**evice

- A series of SIDIS experiments will probe the confined motions (3-D imaging) of partons inside protons and neutrons including orbital motion, and uncover the rich QCD dynamics such as spin-orbital correlations.
- Parity Violating Deep Inelastic Scattering (PVDIS) to search for new interactions beyond the Standard Model.
- J/Ψ production near threshold will provide information on the pure gluonic component of QCD





- SoLID in recommendation #4 of the NSAC Long Range Plan

  "We recommend capitalizing on the unique ways in which nuclear physics can advance discovery science and applications for society by investing in additional projects and new strategic opportunities"… which include "the Solenoidal Large Intensity Device (SoLID) at Jefferson Lab".

(Slide credit: Mark Jones)

SoLID test beam goals

- SoLID test beam goals:

  ◘ Test the performance of SoLID detectors prototypes in beam conditions: and especially tracker detectors i.e. GEM, uRwell, uRgroove

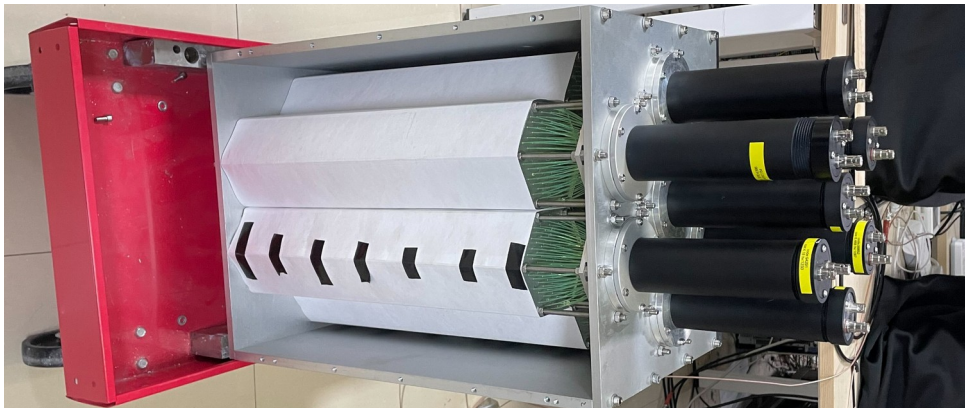
  ◘ Take data with a “mock up spectrometer” parasitically, at relatively low angle, parasitically in Hall C during the pion-CT experiment

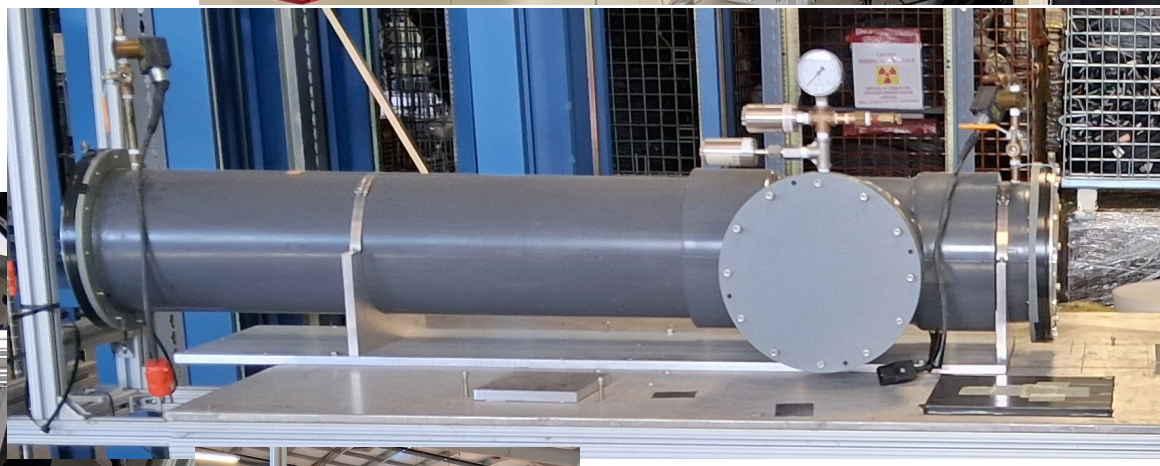
  ◘ A similar test was run in 2022 to test SoLID ECal module prototype, a cherenkov, scintillator paddles for trigger, and a few GEM trackers;

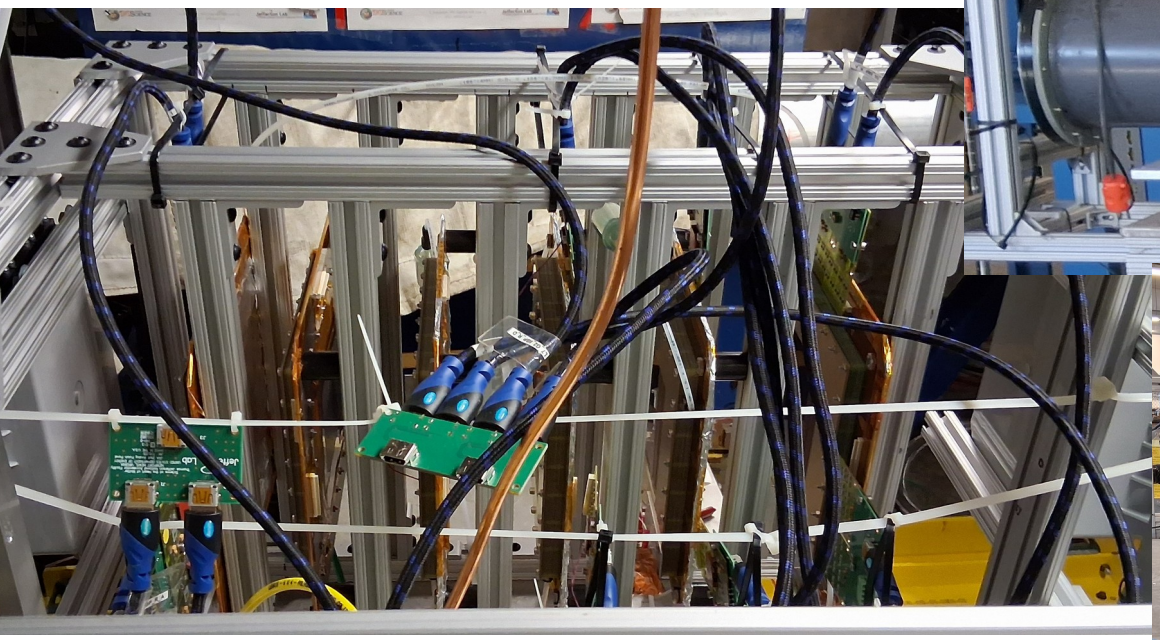
  ◘ with the exception of scintillators paddles and the Cherenkov, all other detectors will be new wrt to the 2022 test

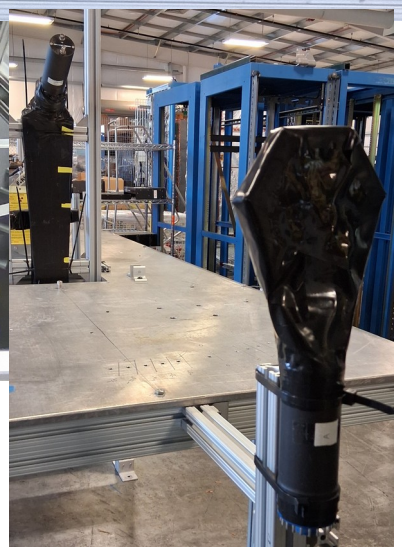
SoLID test beam setup

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





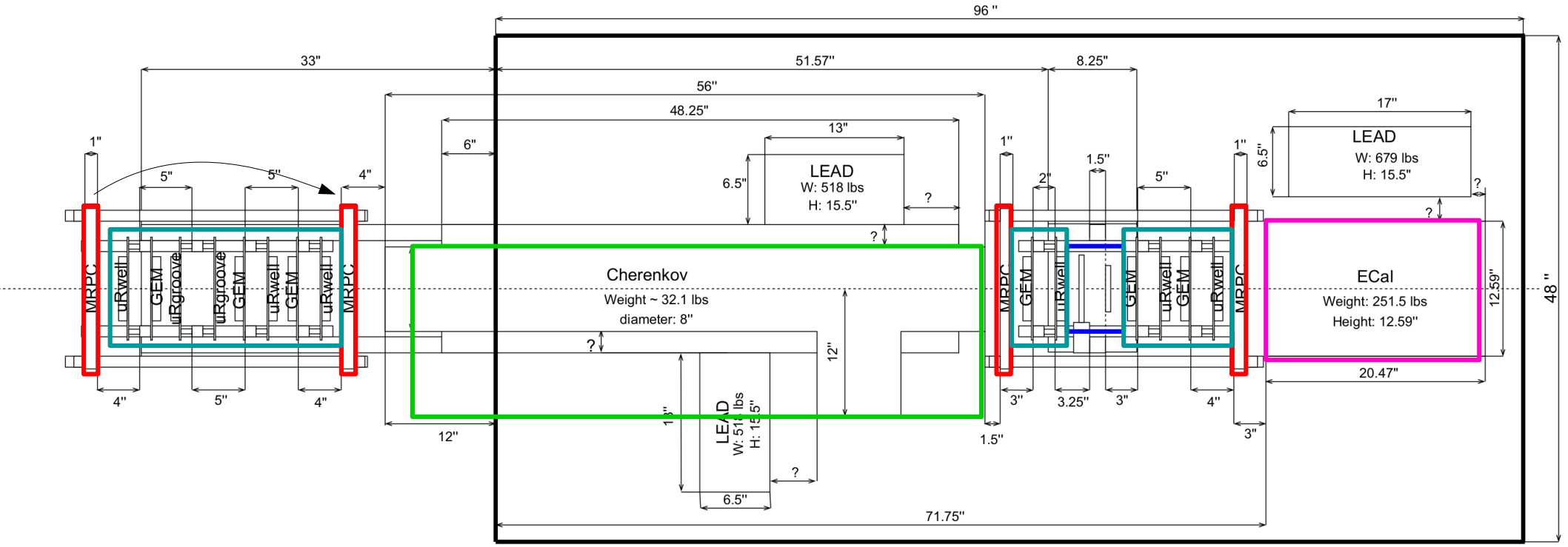




SoLID test beam setup

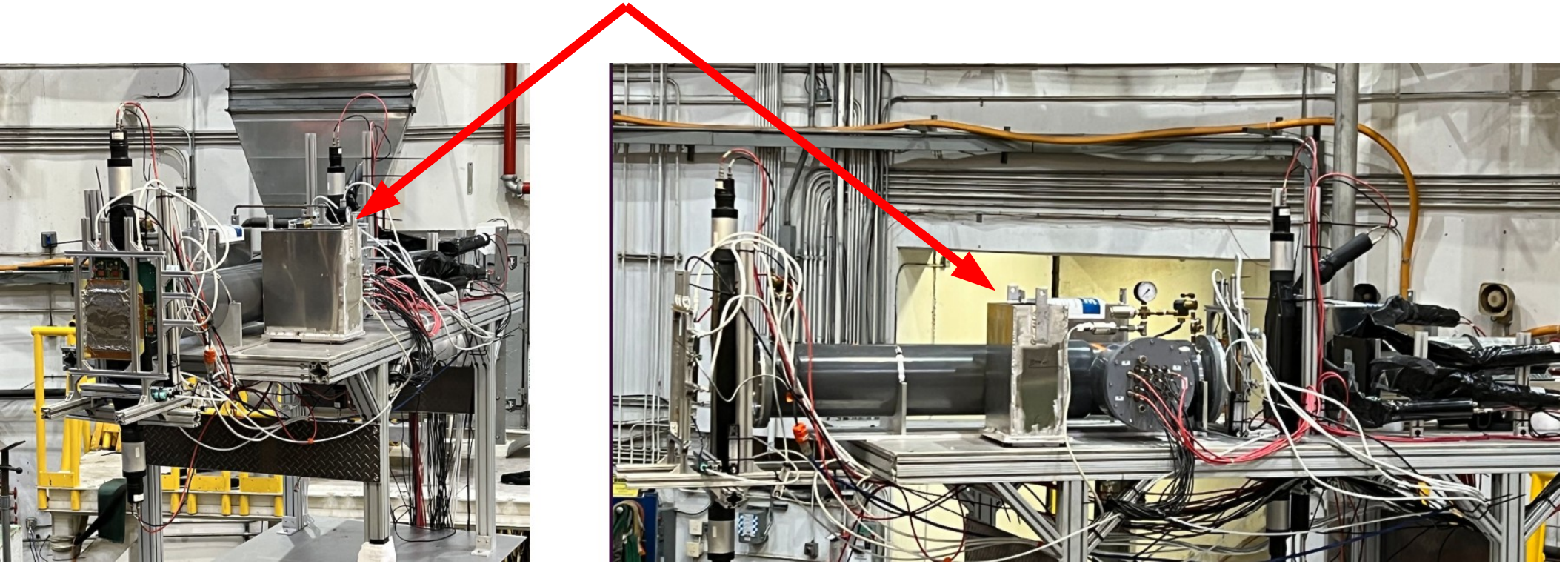
- Test beam setup detectors:
  - ◘ Ecal “supermodule” (assembly of 7);
  - ◘ Cherenkov;
  - ◘ Scintillator paddles;
  - ◘ 4 MRPCs;

◘ Tracking detectors:
- ♦ 6 GEMs;
- ♦ 5 uRwells;
- ♦ 2 uRgrooves;



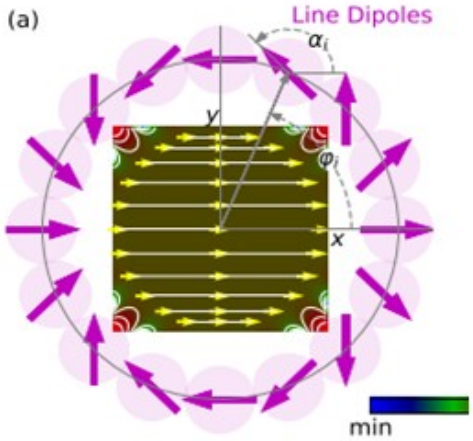
SoLID test beam setup

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

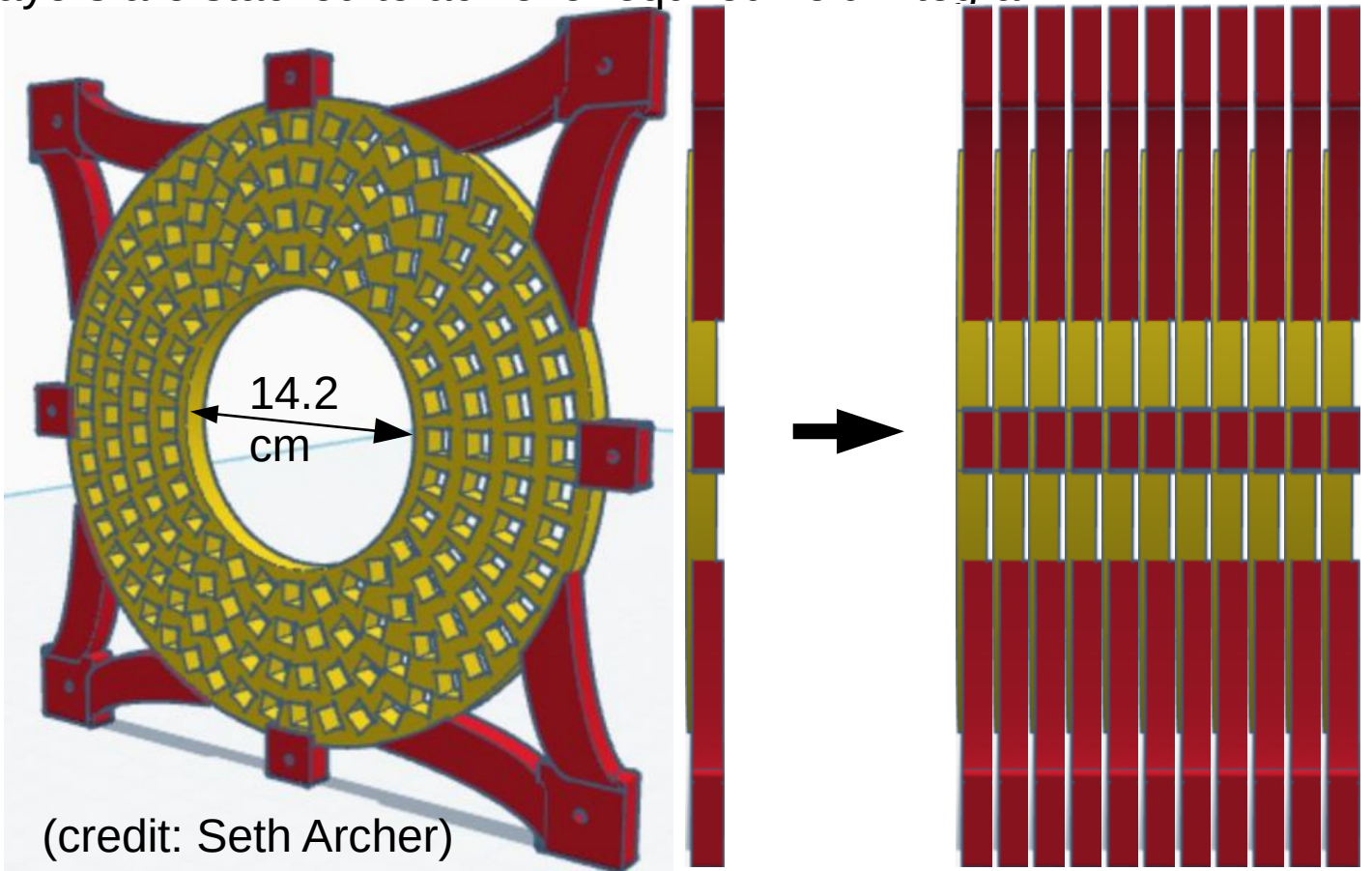


SoLID test beam setup

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



(credit: Klaus Dehmelt)

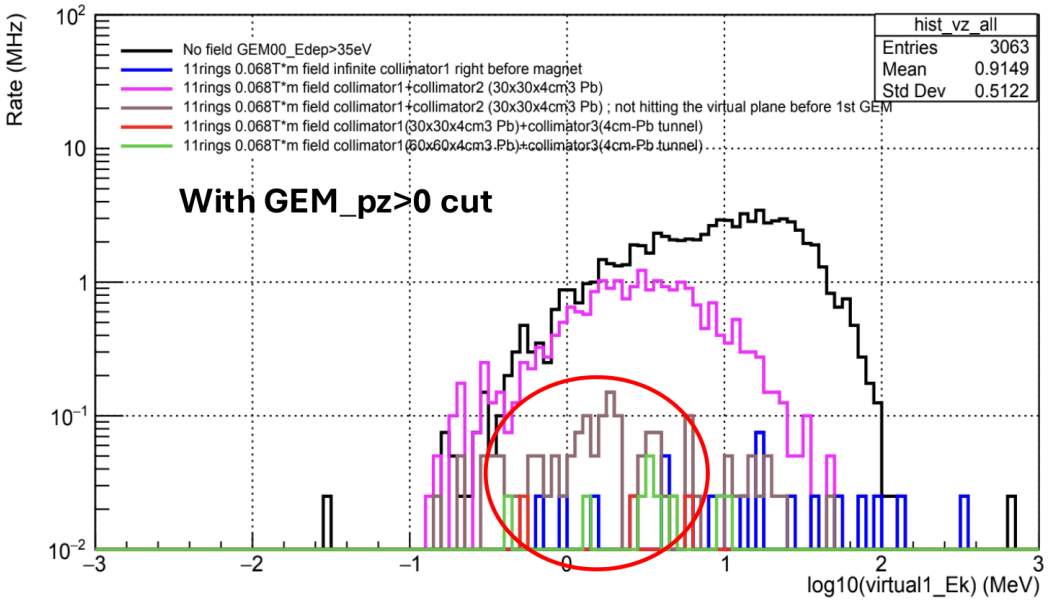


(credit: Seth Archer)

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 Tian)

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 collimato material.
- The remaining background is dominated by low energy particles (E < 5 MeV), which are easier to handle.

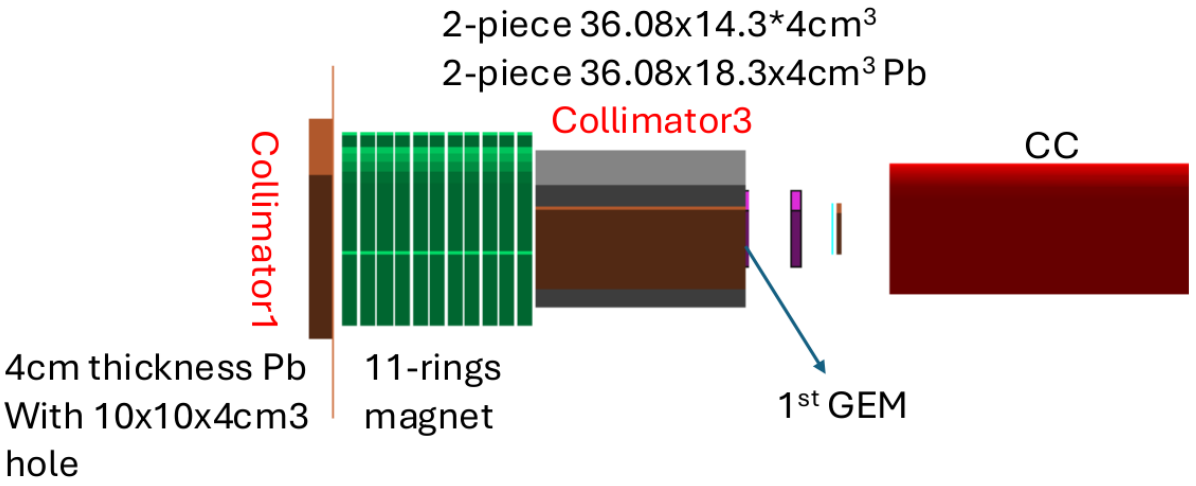
- Collimator 1 (30x30x4cm^3 Pb with a $\pm 5cm$ hole)+ Collimator 2 (30x30x4cm^3 Pb with a $\pm 5cm$ hole)
- Infinite collimator 1
- Collimator 1 (30x30x4cm^3 Pb with a $\pm 5cm$ hole)+ Collimator 2 (30x30x4cm^3 Pb with a $\pm 5cm$ hole)+Collimator 3 cut (cylinder with a r=7.1cm hole)
- Collimator 1 (30x30x4cm^3 Pb with a $\pm 5cm$ hole)+Collimator 3 (4cm thickness Pb tunnel)
- Collimator 1 (60x60x4cm^3 Pb with a $\pm 5cm$ hole)+Collimator 3 (4cm thickness Pb tunnel)

(slide and study credit: Ye Tian)

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 Tian)

Weight Estimation

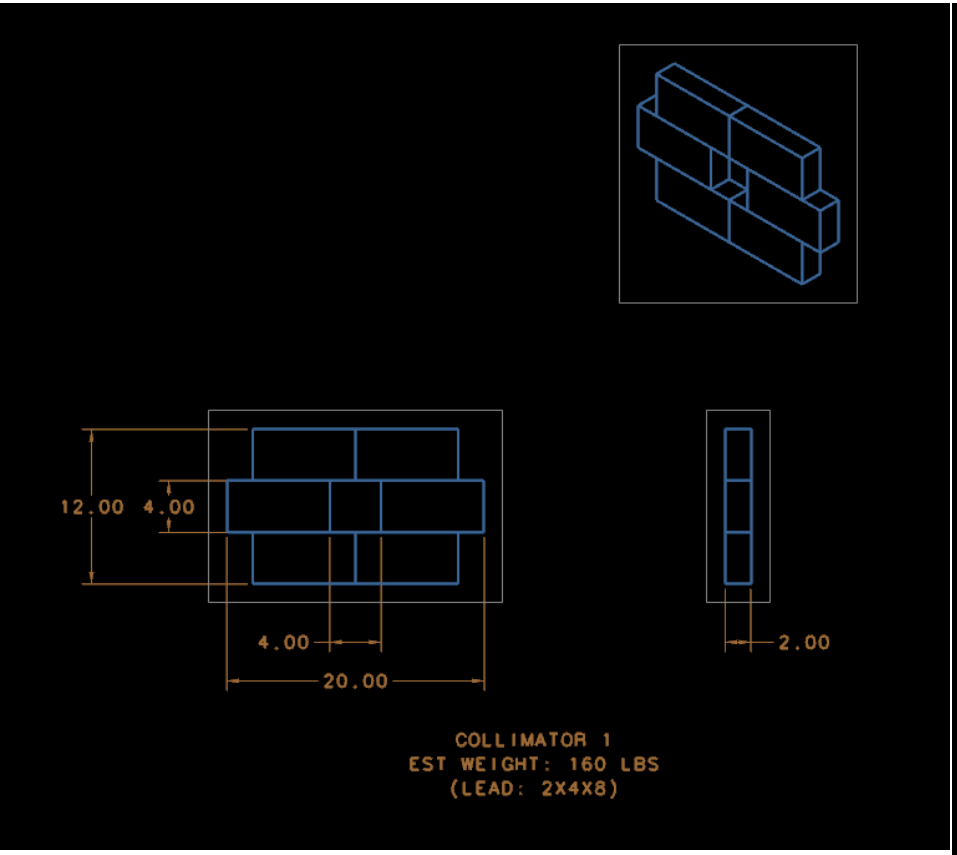


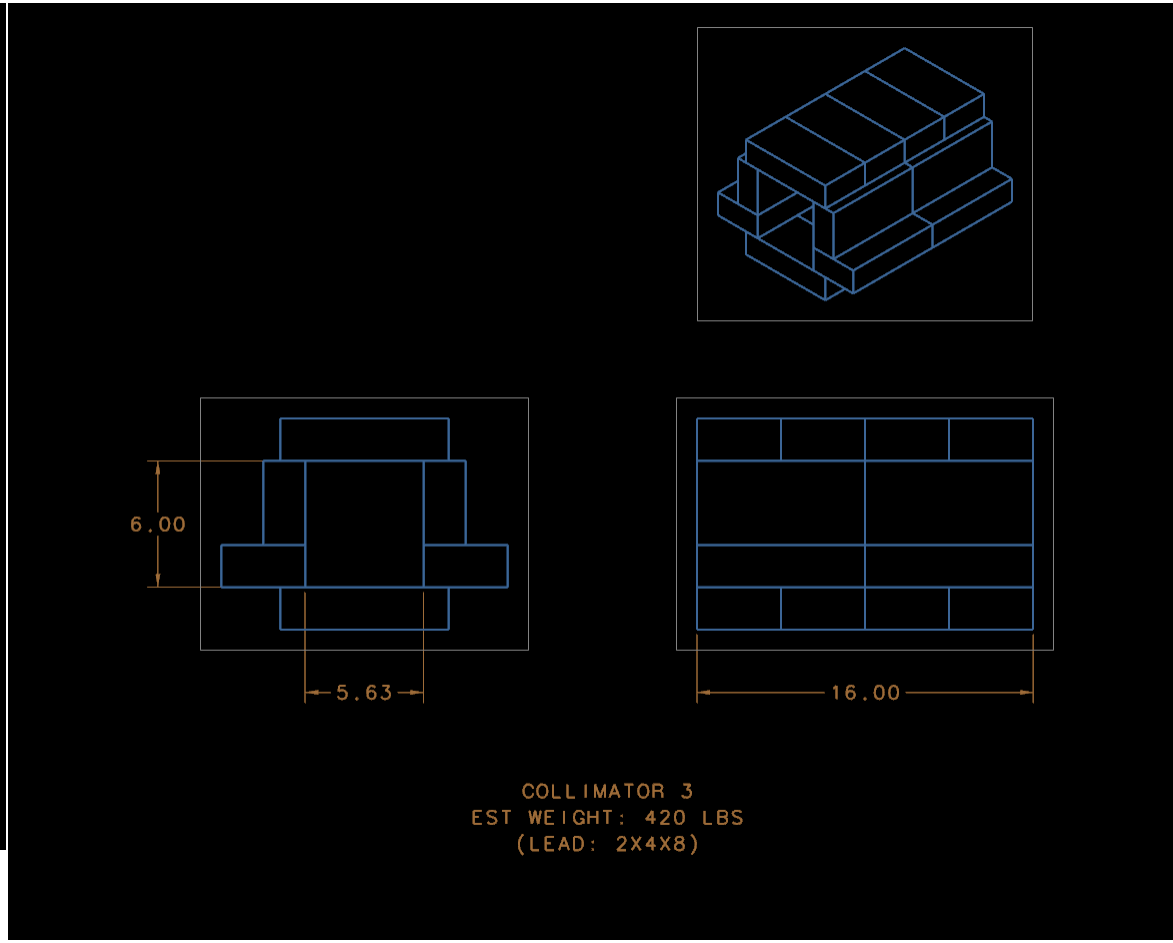
Collimators for 11-rings (magnet weight 155 lb) (2*36.08x14.3*4cm^3+2*36.08x18.3x4cm^3)Pb tunnel collimator 3)	Reduction factor		**Total collimator weight lb**	**Colli+magnet lb**
	Pz>0	No cut		
+60x60x4cm^3 Pb Collimator 1 with 10x10x4cm^3 hole	153	48	103.4+132.1+350= **586**	**741**
+30x30x4cm^3 Pb Collimator 1 with 10x10x4cm^3 hole	190	60	103.4+132.1+80=**316**	**471**

(slide and study credit: Ye Tian)

SoLID test beam setup

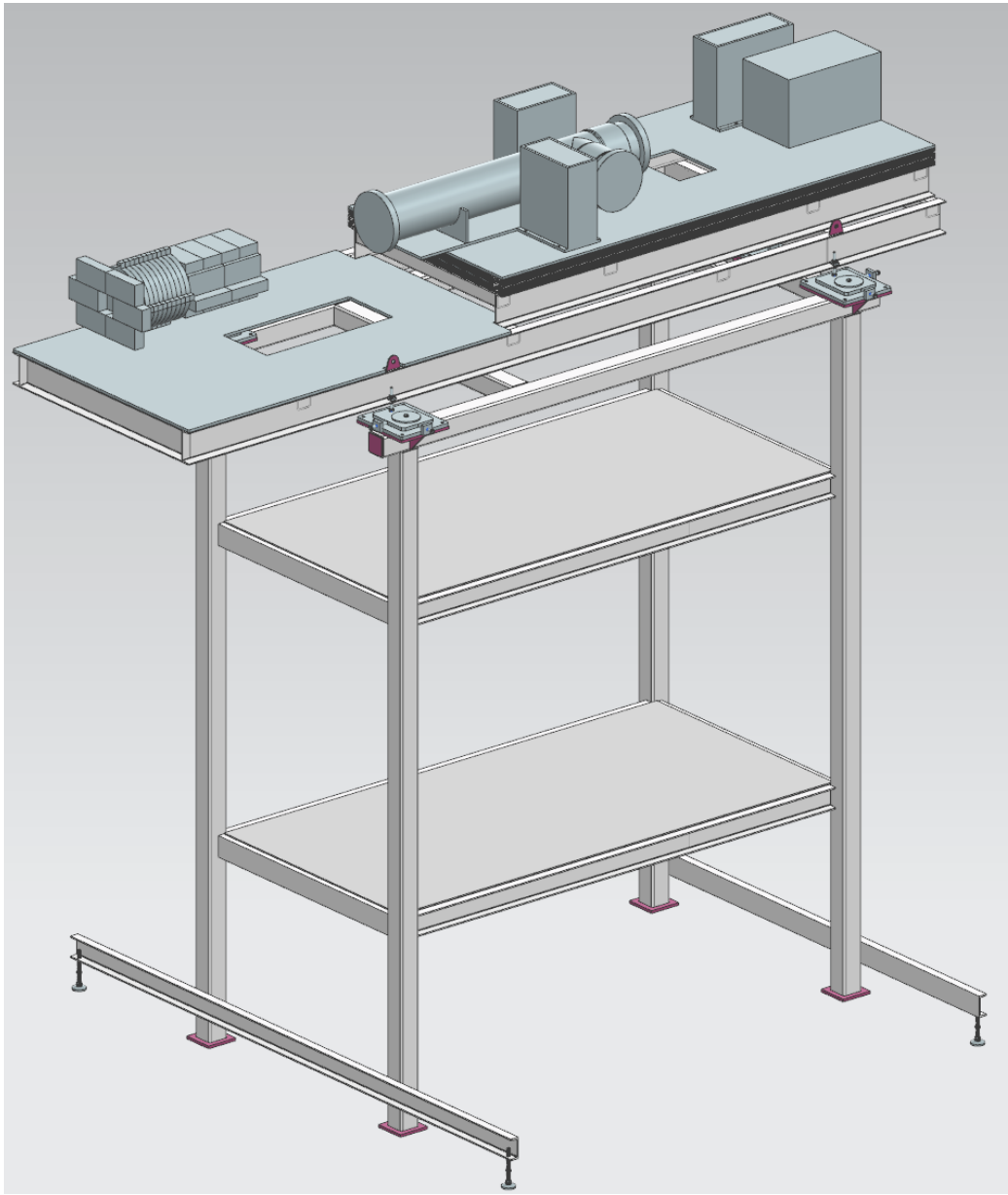
- Magnets and shielding:
  - Preexisting lead shielding to protect ECal and Cherenkov PMTs
  - Magnet for deflection of < 30 MeV electrons away from trackers:
  - New shielding optimized with MC by Ye Tian
  - Shielding “adapted” to use standard 2x4x8 lead bricks





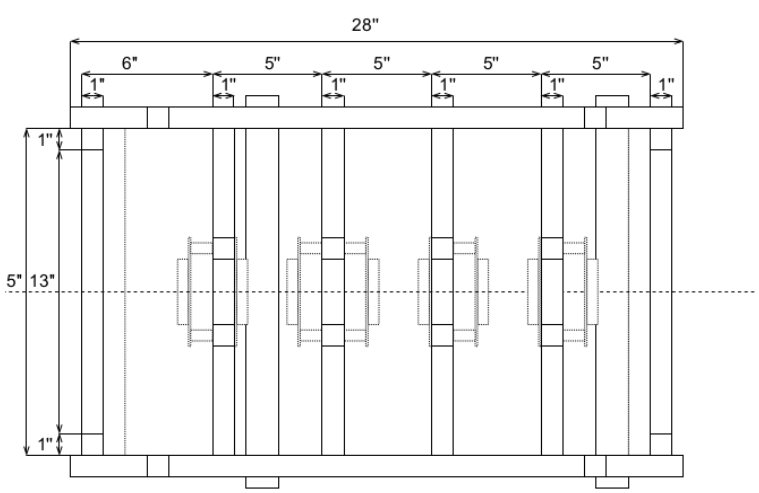
SoLID test beam setup

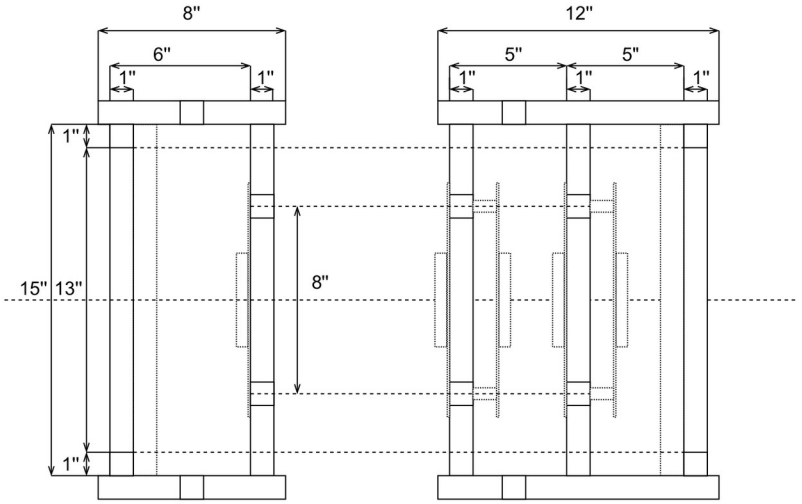
- Support and Platform
  - designed by the Hall C engineers and designers: Hunter Garrett, Paul Medeiros, Jason Clark, Jamie Shiflett (many thanks to them)
  - requirements:
    - sturdy enough to safely carry the weight of all the shielding (prexisting + new)
    - need the ability to adjust the height and angle of the table top to point the detectors towards the target with required accuracy
  - Materials and construction in order to (hopefully) have it ready ahead of beam time.

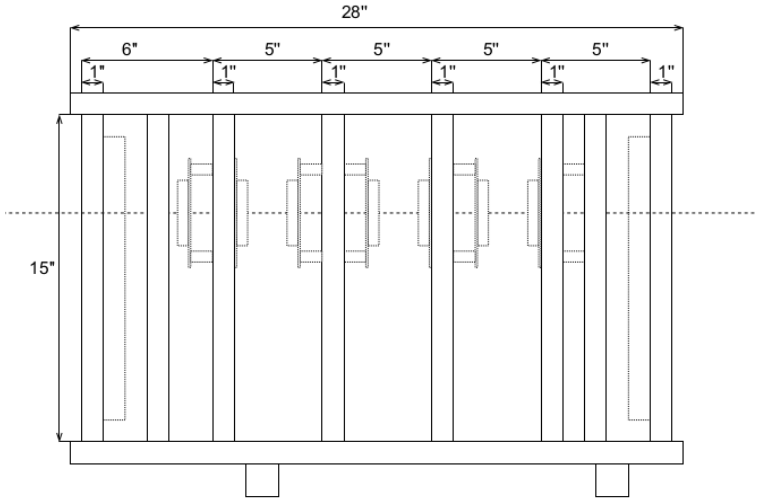


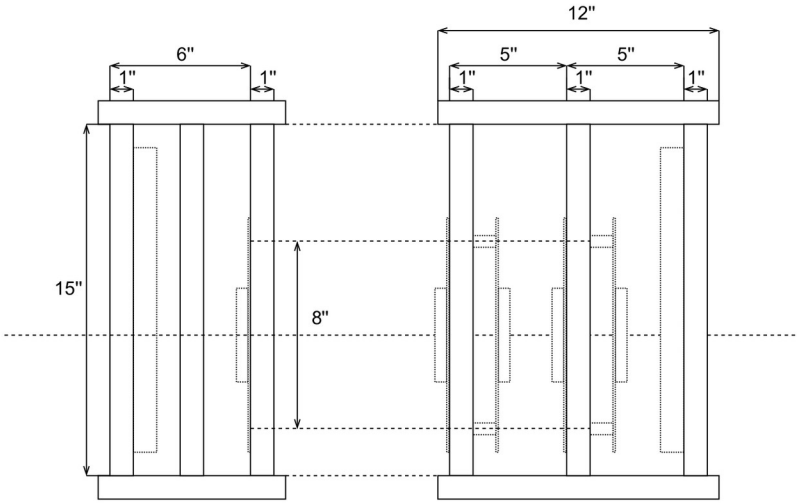
SoLID test beam setup

- GEM/uRwell/uRgroove Tracker supports:
  - Uses 1”x1” 80-20 beams
  - Materials ordered





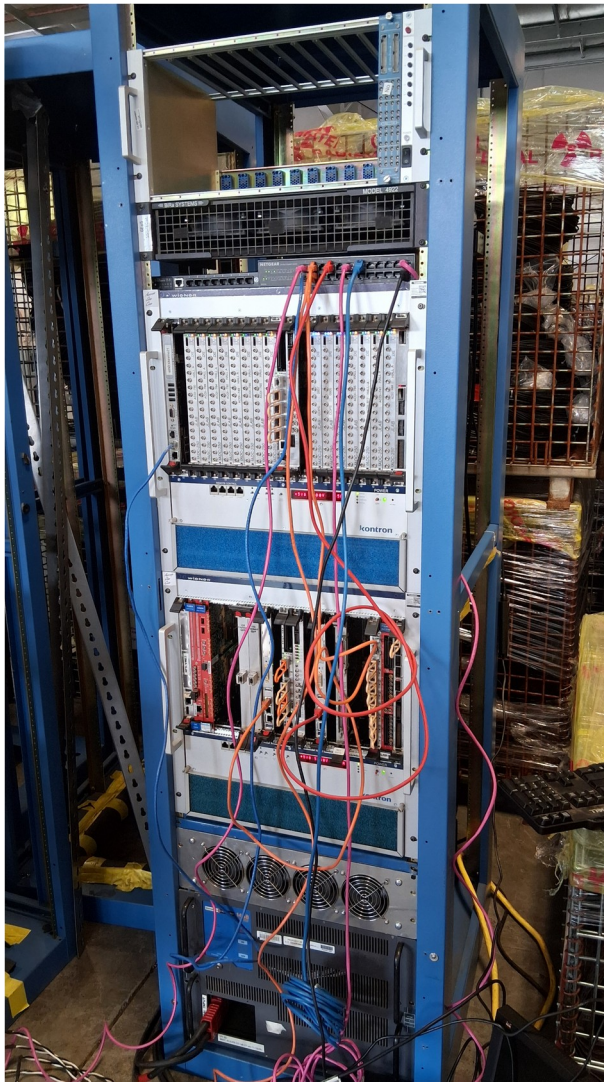




SoLID test beam setup

- DAQ:
  - DAQ setup in ESB;
  - FADC for ECal/Cherenkov/scintillators;
  - VTP and VMM for tracking detectors;
  - Front-end for tracking detector in a different rack;
  - 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	512	2
MRPC	32	4



SoLID test beam setup

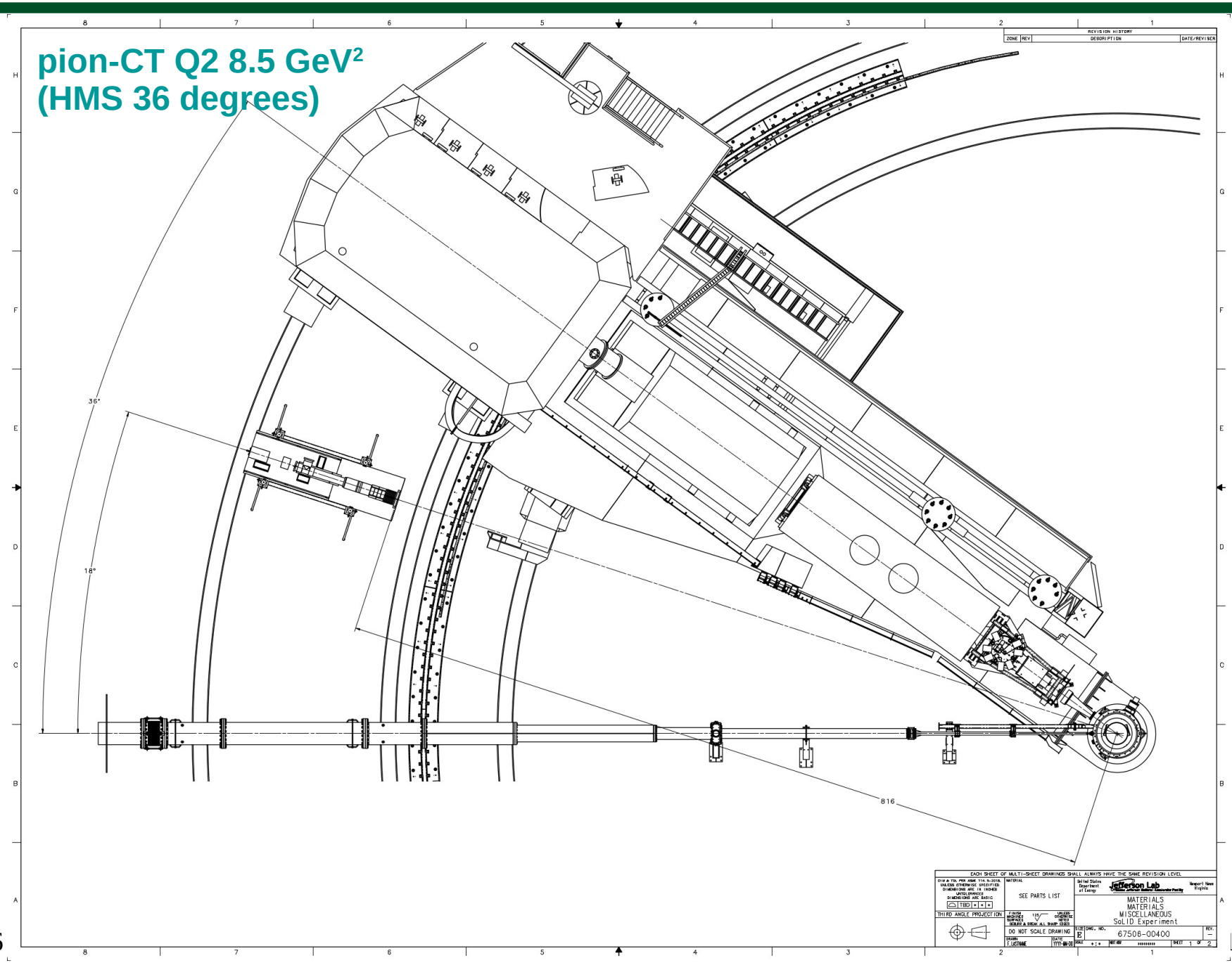
- Software
  - Requires working decoding and basic reconstruction for all detectors especially trackers, to be able to perform calibrations and monitoring
  - Existing software:
    - *https://github.com/JeffersonLab/beamtest_hallc_decoder*
    - adapted from standalone code for SBS by Xinzhan;
    - Needs to includes new decoders for VTP, etc;
  - Proposal to use Jana2:
    - can be interfaced easier with AI;
    - Less favored option short term provided timeline;
    - Can certainly be developed once manpower becomes available

SoLID test beam plan and schedule

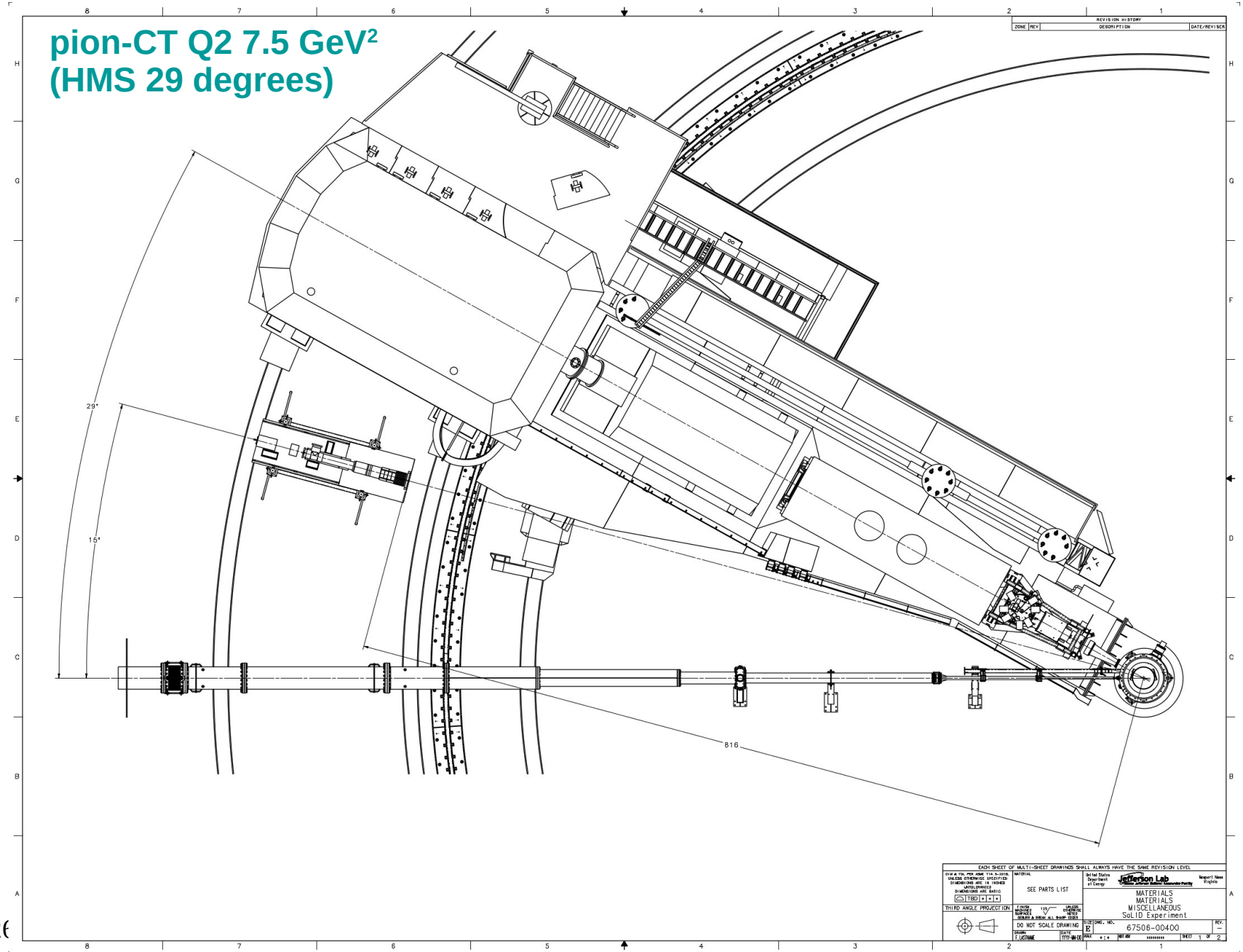
- Test beam assembly in ESB

- Test beam setup in Hall C for the duration of the run:
  - Large angle (80 or 90 degrees) for most of the run;
  - 18 degrees on HMS side during pion-CT Q2 8.5 GeV^2 (HMS 36 degrees)
  - 15 degrees during pion-CT Q2 7.5 GeV^2 (HMS 29 degrees)

SoLID test beam location

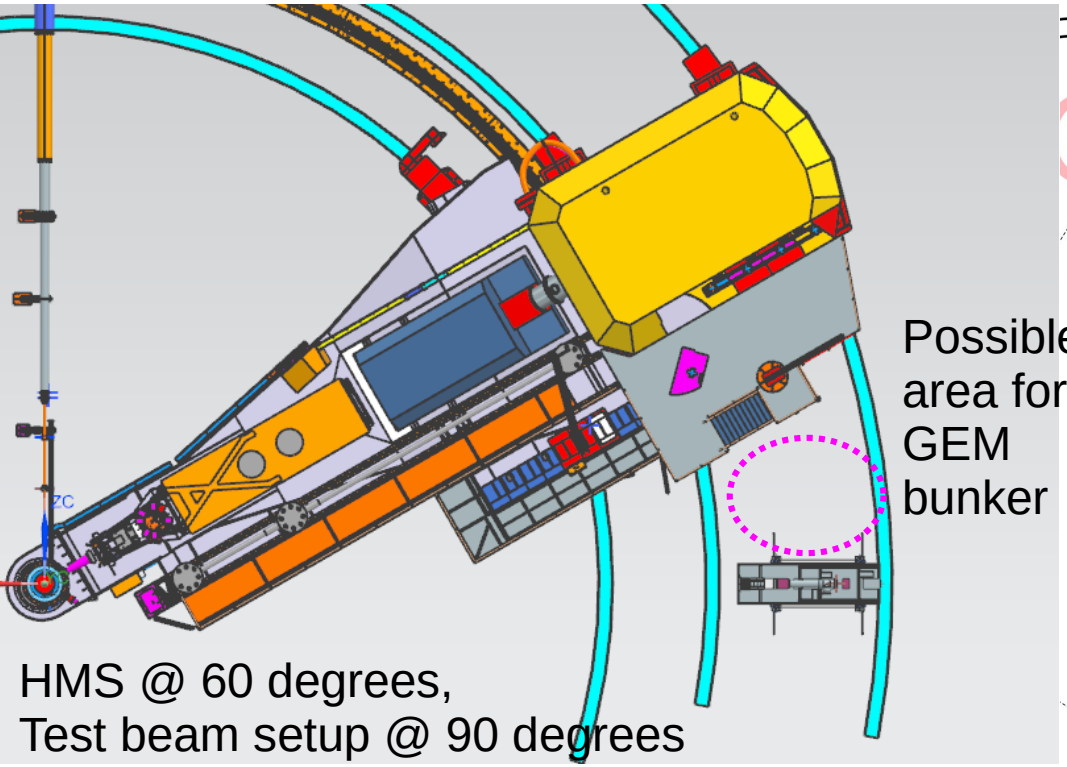


SoLID test beam location



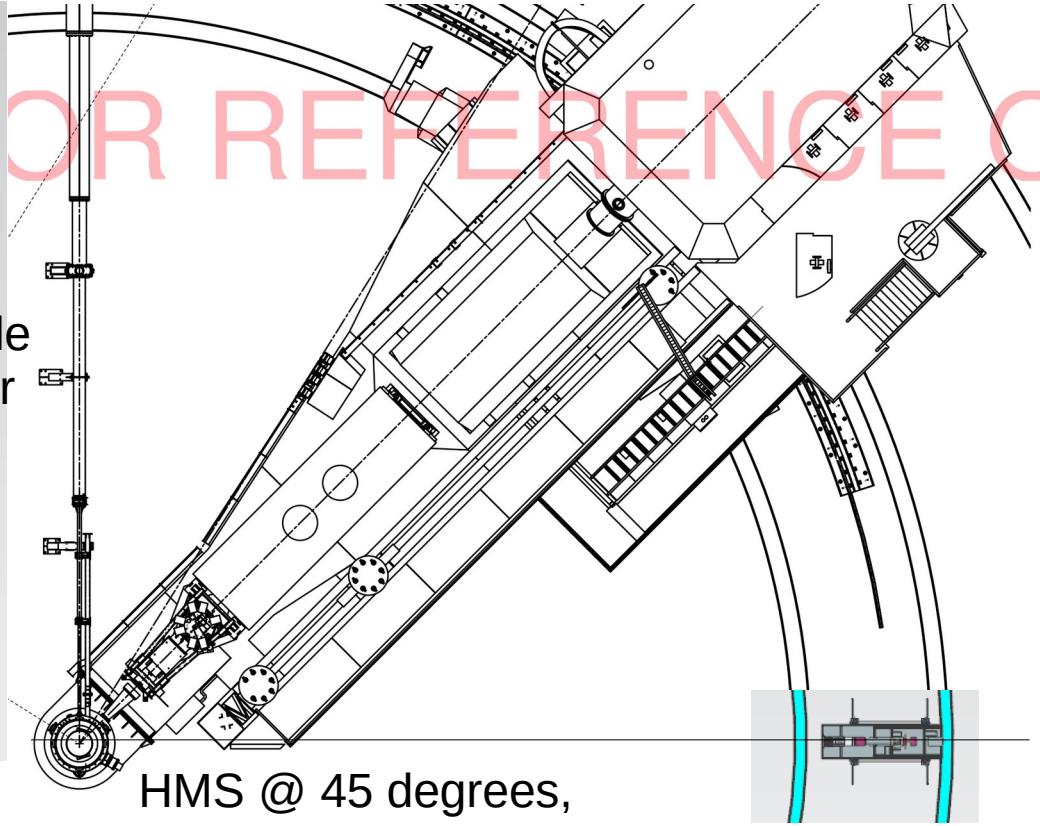
SoLID test beam location

- Large angle setting will remain in place during all of the run in Hall C, including low energy experiments:
  - During R-SIDIS, HMS ≤ 50 deg
  - During Polarizability, HMS ≤ 57 deg
  - During N-delta, HMS ≤ 59 deg (rounded to 60)
  - Angles above are **maximum** angles; most of the time HMS ≤ 45 deg
  - exact location for this setting is still under discussion



Possible area for GEM bunker

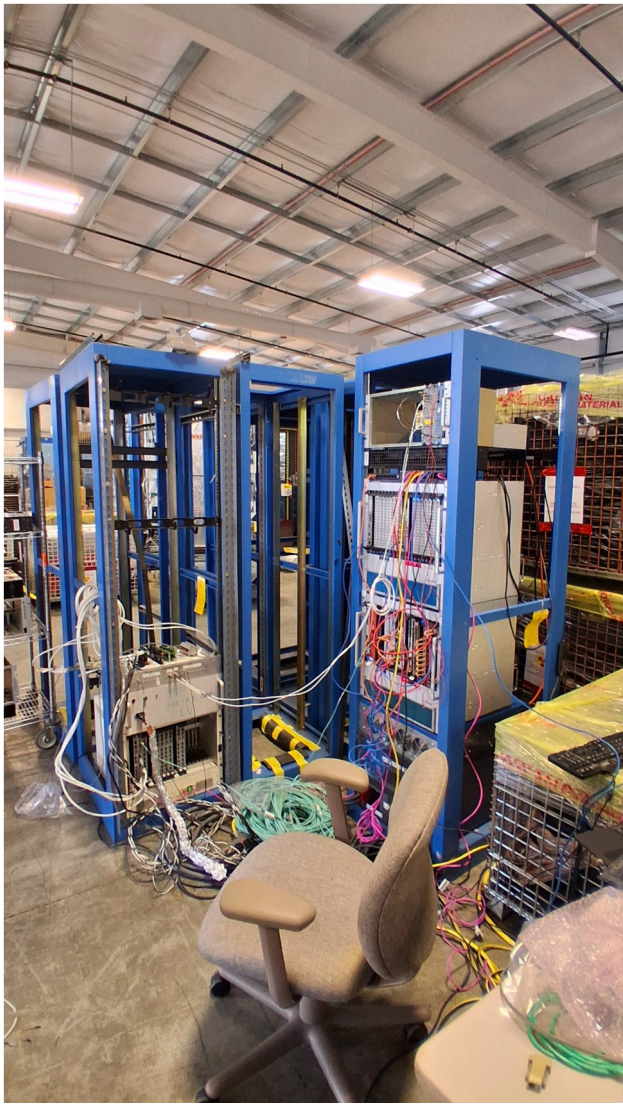
HMS @ 60 degrees,
Test beam setup @ 90 degrees
Test beam view to target blocked



HMS @ 45 degrees,
Test beam setup @ 90 degrees
Test beam view to target clearing

Current status

- Detectors and DAQ being assembled in ESB
  - DAQ assembly (modules, front-end) close to complete
  - Detector assembly planned (see next);
  - Gas for tracking detectors to be ordered soon (thank you Ching Him):
    - Ar/CO2 75/25 for GEMs
    - Ar/CO2/Iso 93/5/2 for uRwell, uRgroove



SoLID test beam assembly timeline

- Test beam assembly timeline

  - Assumptions:
    - Resuming operations Friday, March 13th;
    - Assembly needs to be complete a few weeks ahead, ideally Feb 13th

  - A fraction of trackers already tested standalone, on-site, will be included early February (Than you Florian)
  - the 2 uRgrooves are in testing in Stony Brook and will be shipped to JLab in the first part of February (Thank you Jaydeep)
  - ECal supermodule assembly stuck in China for the time being, most likely not on-site before mid or even end of February: Will reassemble the old ECal module:

  - MRPCs on-site, to be tested during the next 3 weeks (Thank you Sanghwa)
  - Cherenkov on-site, PMTs + gas system tested during the next 3 weeks (Thank you Zhiwen, Michael)
  - Scintillators on-site, will tested during the next 3 weeks

SoLID test beam data taking timeline

- Test beam tentative data taking timeline
  - https://www.overleaf.com/read/qfqvhpjydkby#6a3b5a
  - Assumptions:
    - Resuming operations Friday, March 13th;
    - Machine configuration change May 11th – May 22nd;
    - Pion-CT running **after** R-SIDIS;

Action	**Tentative date**
Assembly and cosmics test of detectors	
Move of setup into the Hall at 90 degrees	March 6 - March 10
Detector commissioning and test at large angle	
Addition of magnet to setup (During accelerator reconfiguration)	May 11 - May 22
Test beam data taking (90 deg)	
Move of setup in Hall C to 18 degrees, 20.8 m	Wed, July 22nd
Test beam data taking (18 deg) - Pion-CT highest Q^2 data taking	
Move of setup to 15 degrees	Wed, August 5th
Continuing Pion-CT and Hall C program	

Table 2: Tentative events timeline according to the current schedule: beginning of operations Friday **March 13th**, and Pion-CT *after* R-SIDIS.

Manpower 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 / Zhihong Ye – Tsinghua U
  - Cherenkov: Zhiwen Zhao – Duke U
  - MRPC: Sanghwa Park – JLab
  - Scintillator paddles: TBD (alternate Eric Fuchey – W&M)

- DAQ: Alexandre Camsonne – JLab / Zhongling Ji – Syracuse U / Hanjie Liu – JLab (interactions with Hall C & Computer Center)

- Software: TBD (alternate Eric Fuchey – W&M)

- Platform/support design: JLab Hall C engineers/designers: Hunter Garrett, Paul Medeiros, Jason Clark, Jamie Shiflett

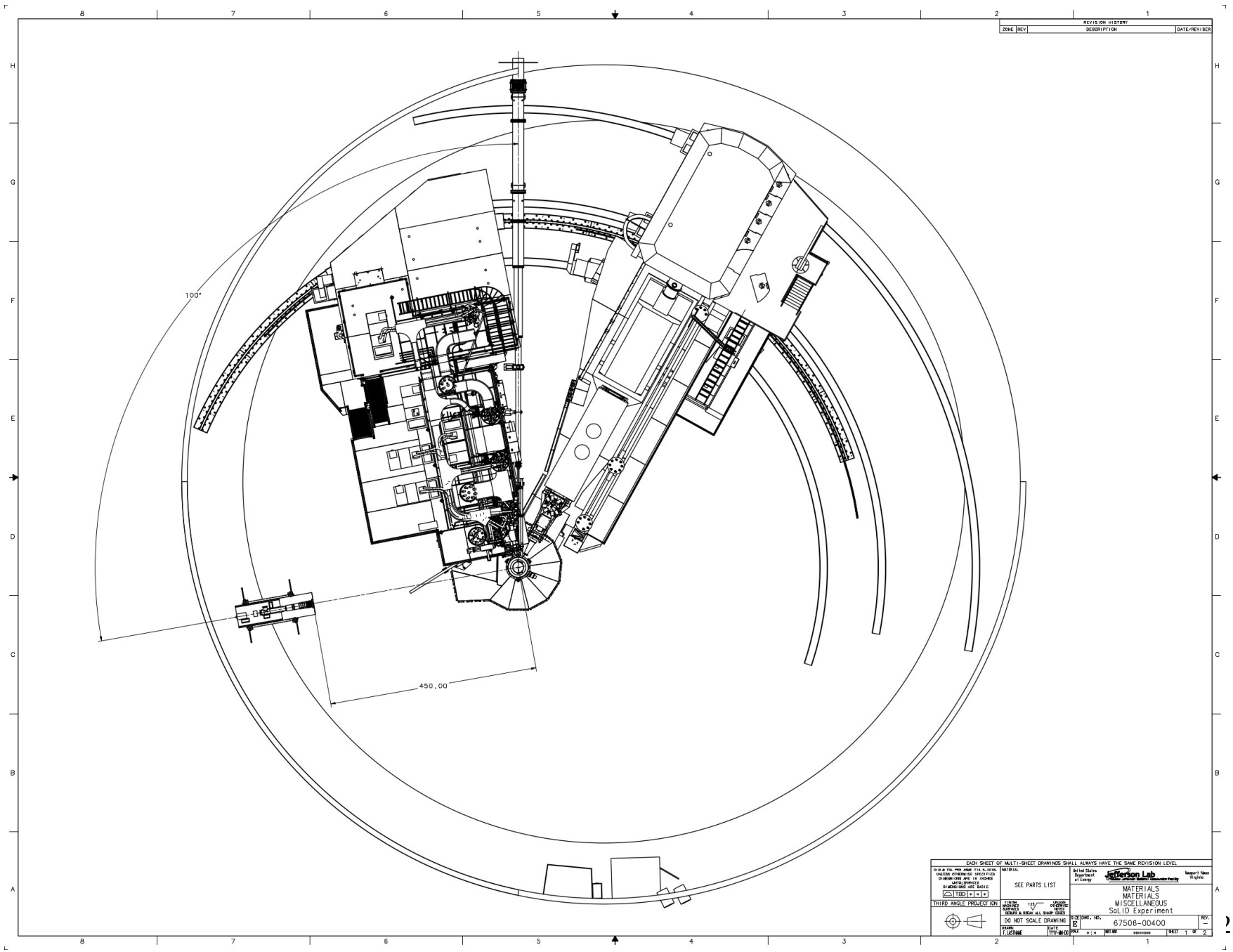
- Installation: Jerry Nines and JLab Hall C techs + Chris Gould and JLab Survey/alignment team

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

Summary

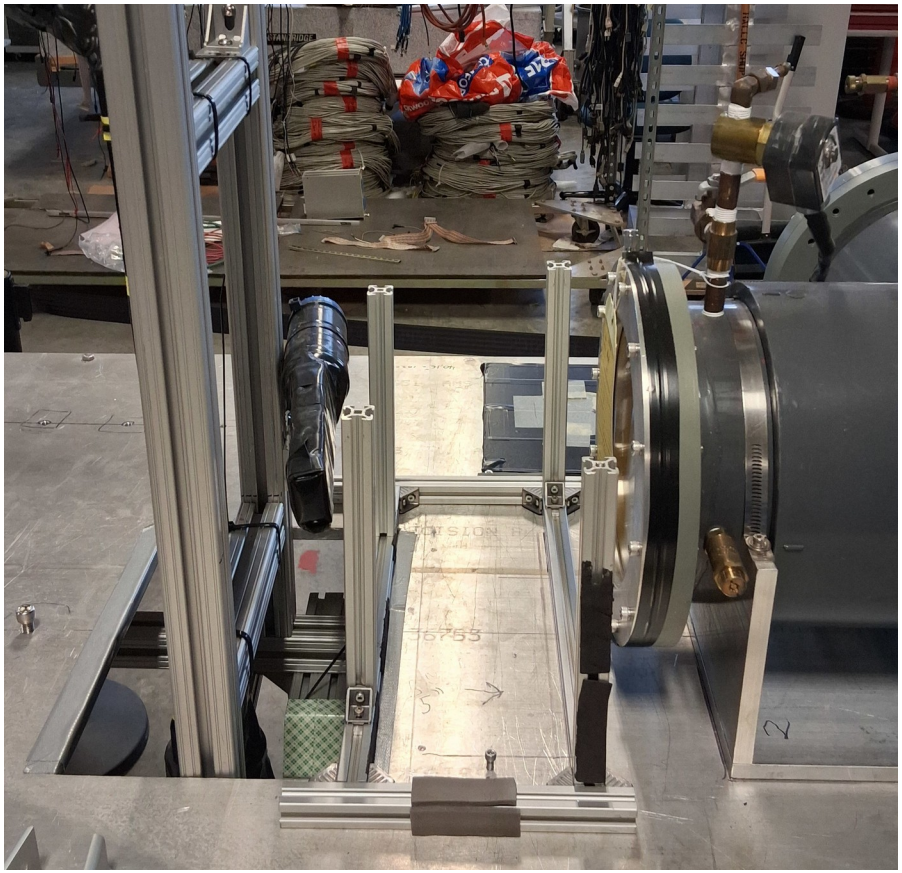
- SoLID test beam is making progress to run concurrently in Hall C during the next run period;
  - most of the run the test beam setup and platform will sit at large angle;
  - low angle/high background data taking during pion-CT (bteween two and three weeks);
- Timelines to achieve our objectives are 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 February (with the exception of the ECal supermodule);
  - DAQ in good progress; software should be ready if we find someone to be responsible for it
- **Any help is more than welcome :)**

SoLID test beam location



SoLID test beam status

- Activities in ESB
  - Tracker supports: built a “prototype” with parts lingering around



  - Adjusted the support design with back tracker support in two parts