SoLID Recoil Detector Ideas and MVTX

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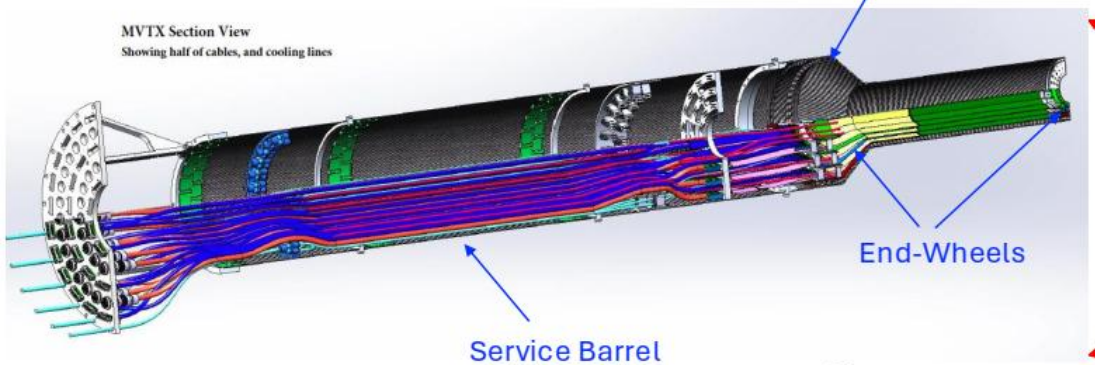
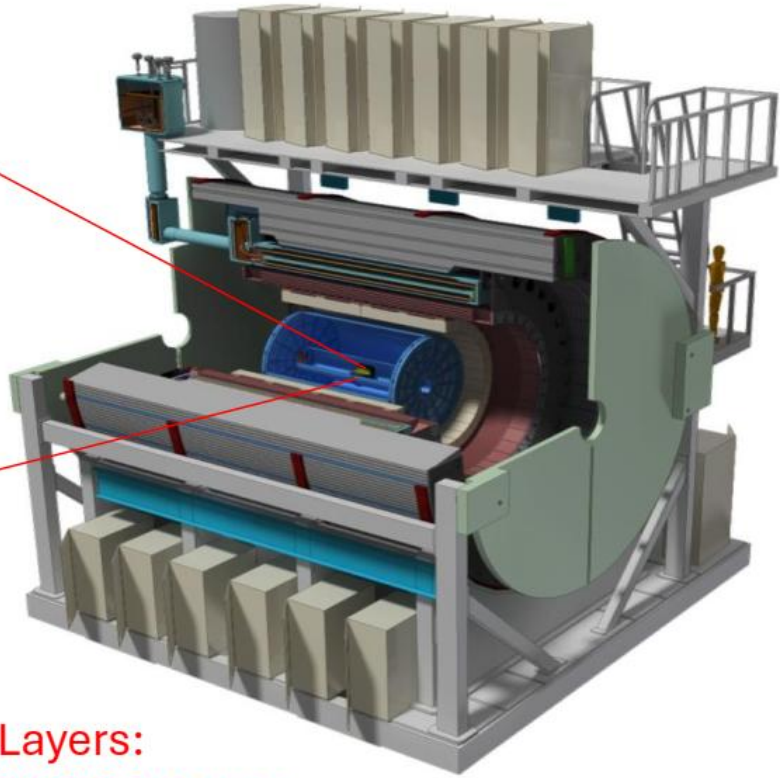
SoLID Collaboration Meeting
Feb 19-20, 2026

Outline

- sPHEHIX MVTX detector
- SoLID Recoil detector ideas
  - Deep Exclusive Meson Production
  - u-channel pion electroproduction
  - Tagged DIS
  - Dilepton production (JPsi, TCS, DDVCS)
  - DVCS

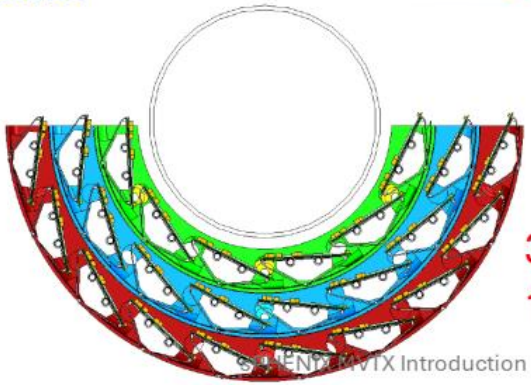
MVTX Detector in sPHENIX





MVTX parameters: L = 271 mm

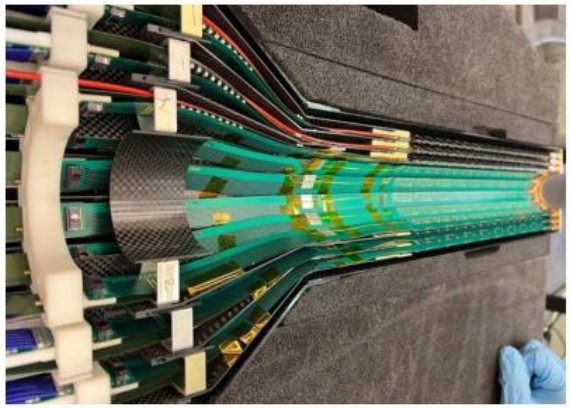
	R_min (mm)
Layer 0	24.61
Layer 1	31.98
Layer 2	39.93

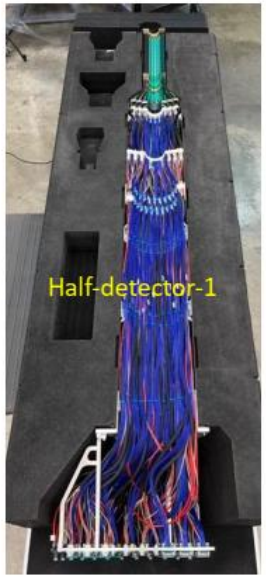


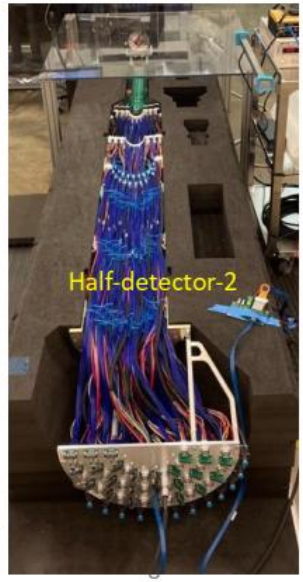
3 Layers:
12/16/20 staves

sPHENIX MVTX Detectors

- **Construction completed in 2022**
  - ➢ 84 staves available, 48 used in MVTX, rest as spares
- **Installed in sPHENIX IR in 2023**
  - ➢ Short commission run in 2023, Au+Au collisions
- **Long 1-year 2024 p+p run**
  - ➢ Triger-less full streaming readout
- **Long 1-year 2025 Au+Au run**
  - ➢ in progress, triggered readout mode
- Available in 2026 for other experiments
  - ➢ Full detectors, readout and control



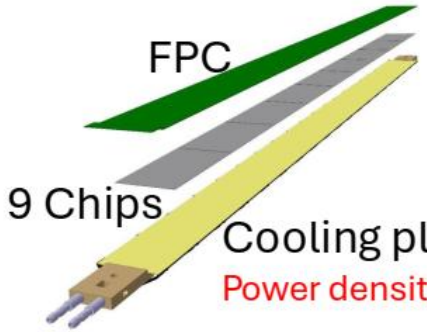




Monolithic-Active-Pixel-Sensors (MAPS)

A State of the Art Pixel Tracker

- Advantages of ALICE MAPS/ALPIDE:
  - Very fine pitch (27x29 μm), 5um tracking resolution
  - High efficiency (>99%) and low noise (<10^{-6})
  - Time resolution, ~5 μs
  - Ultra-thin/low mass, 50μm (~0.3% X_0)
  - On-pixel digitization, low power dissipation
  - Full streaming readout (trigger less) and trigger mode
  - Rad hard, >2.7MRad

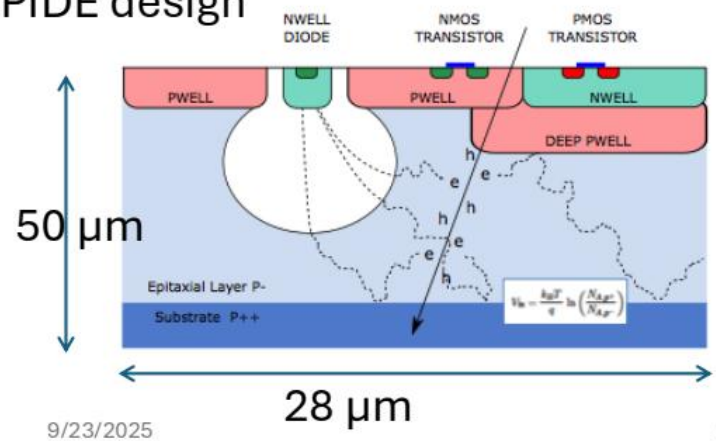


Chip:
1.5 x3 cm^2

Power density < 40 mW/cm^2

A 9-chip MAPS stave, (1.5 x 3)x9cm^2

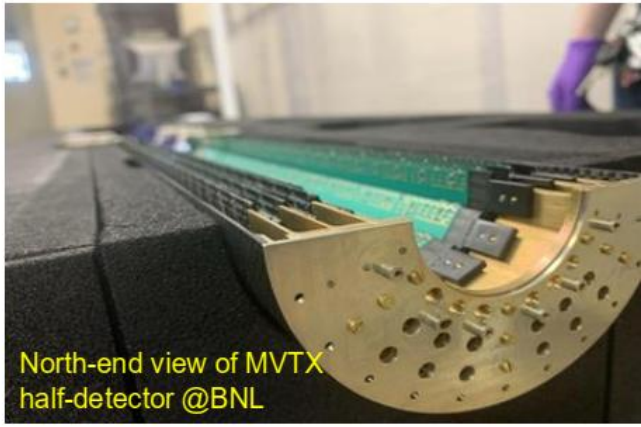
ALPIDE design



Tower Jazz 0.18 μm CMOS

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

substrate: $N_A \sim 10^{18}$
epitaxial layer: $N_A \sim 10^{13}$
deep p-well: $N_A \sim 10^{16}$



MVTX main information

- 84 staves of 27cm long and 1.5cm wide, total area 3804cm2
- Good position resolution 5um
- Time resolution 5us, need another fast detector for timing
- Rad hard
- Better use MAPS as it is

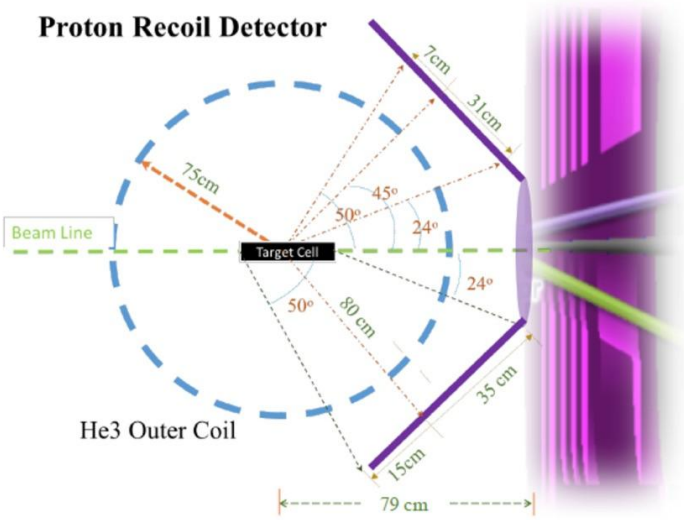
DEMP Recoil

Original idea

Proton Recoil Detector

- A Conceptual Design:

  - ✓ Cover angles of 24° to 50°
    2π on the azimuthal angle
  - ✓ Inner Radius=32 cm
    Outer Radis = 67 cm
    Detector Length = 50 cm
  - ✓ Distance from Target = 79cm
    (far end touches the magnet)



- Need good timing resolution (<60~ps)
- Need fine segments due to huge low energy backgrounds
  (An aluminum foil cover can block most of low energy electrons)
- Need to provide angle information for offline background suppression
- Photon-Detectors need to work in strong magnetic fields from target & solenoid
- A good candidate: Scintillating Fiber Tracker
- Geant4 Simulation is undergoing

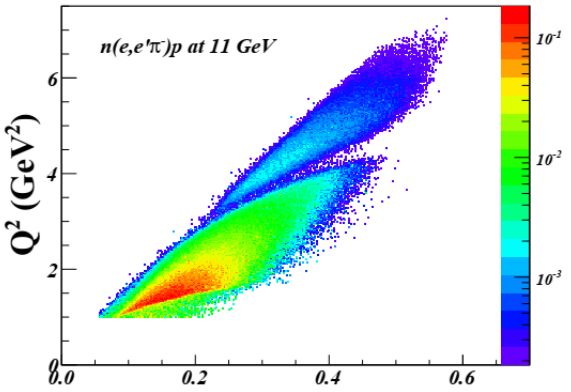
DEMP

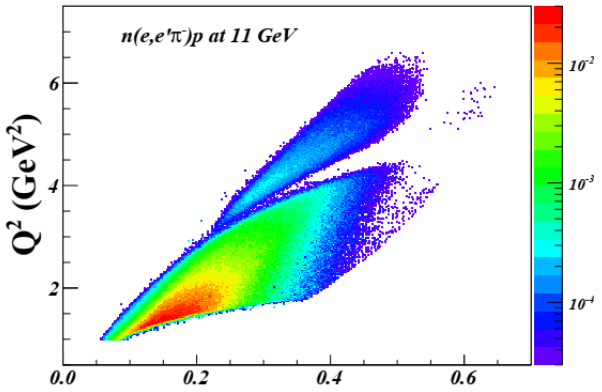
$1< Q^2 <4$ GeV^2	$Q^2 >4$ GeV^2	Total
DEMP: $\vec{n}(e,e'\pi^- p)$ Triple-Coincidence (Hz)		
25.59 (6.11)	0.54 (0.26)	26.13 (6.37)
SIDIS: $\vec{n}(e,e'\pi^-)X$ Double-Coincidence (Hz)		
1388.85	35.77	1424.62

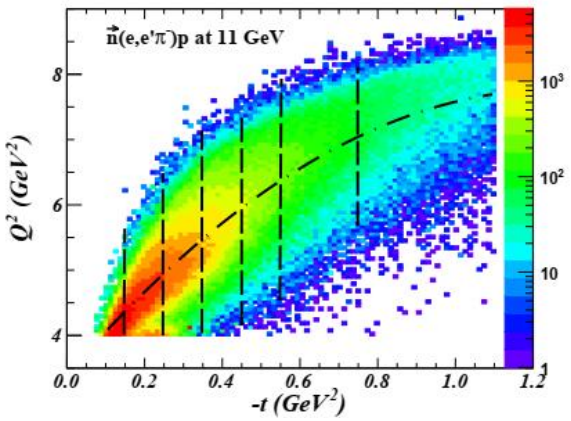
with (w/o) recoil proton detection at least double the counts

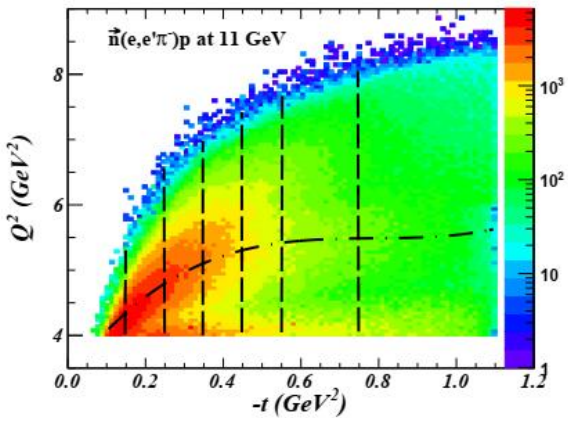
without recoil

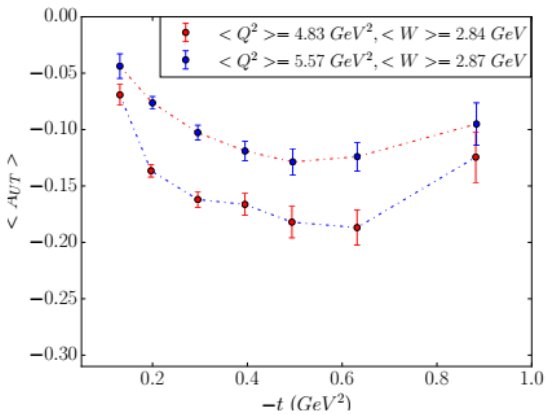
with recoil

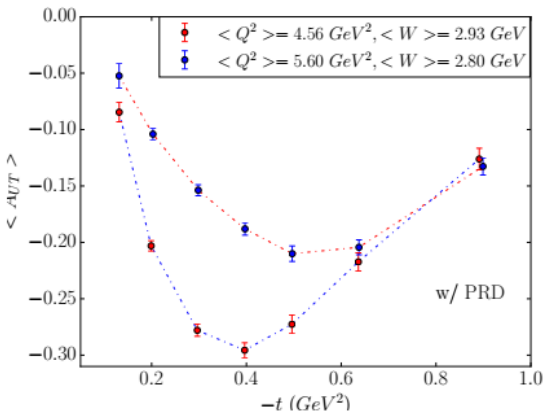






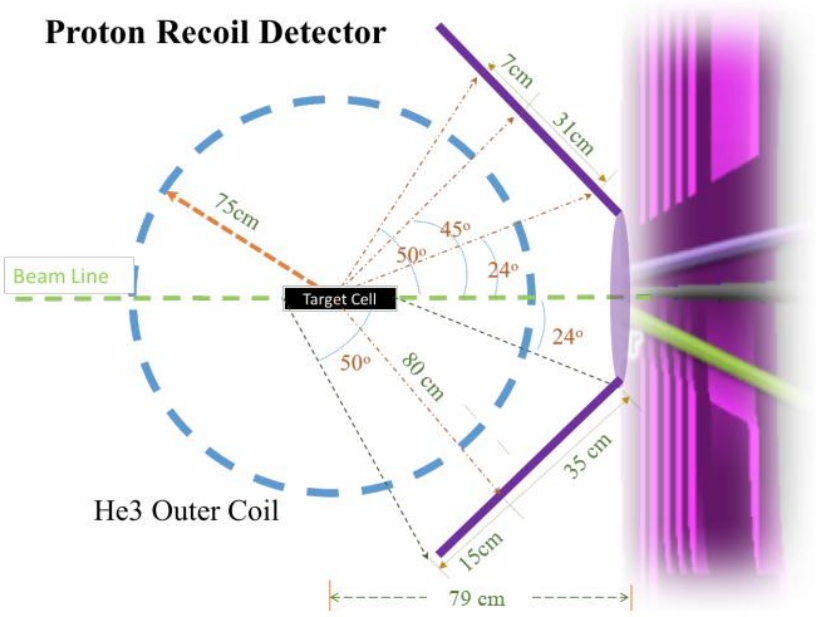


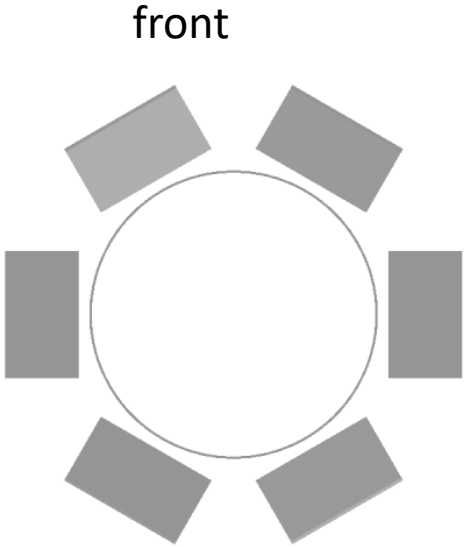




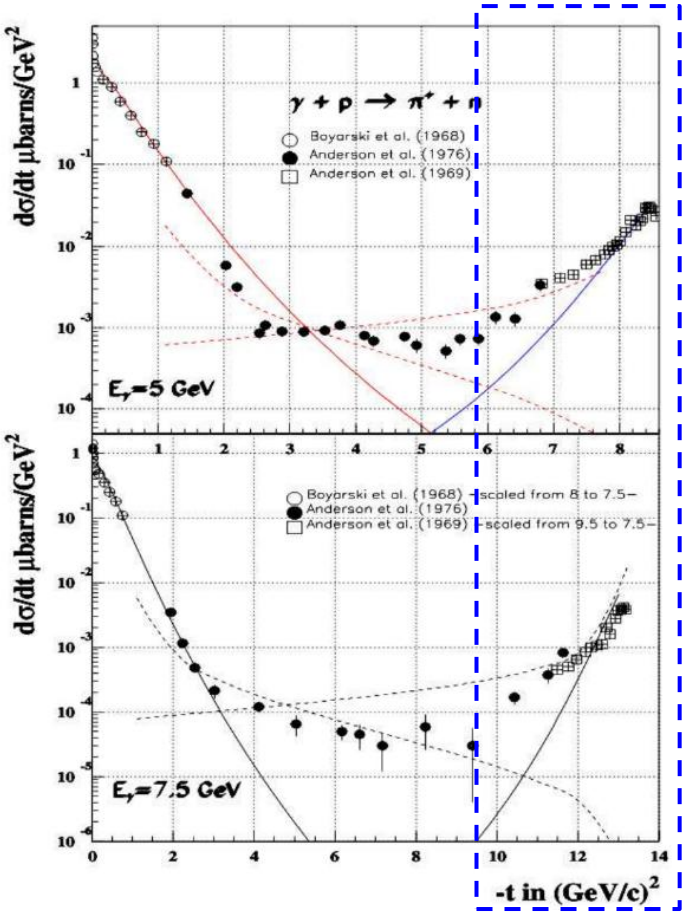
MVTX as DEMP recoil tracker

- 6 sectors in phi to cover about half of the solid angle between polar angle range of 24-50deg
- Each sector has 14 staves in 27*21cm as tracker
- Add a layer of scintillators behind tracker for timing





u-channel pion electroproduction pion recoil at backward angle

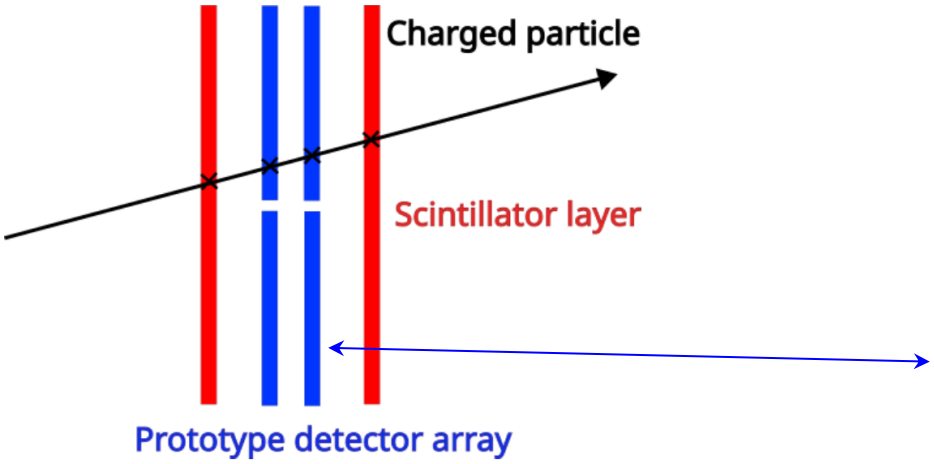


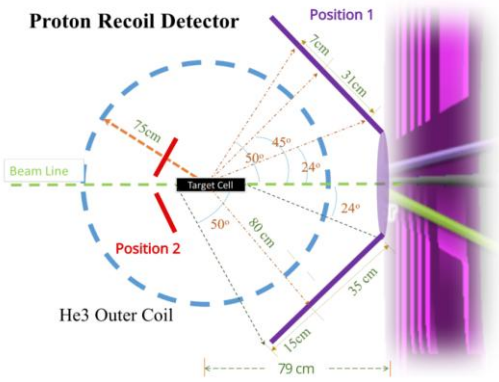
- **Exclusive pi- production via D target**
  - **e+n -> e' +p' + pi-**
  - **Signature includes: scattered electron (e'), an energetic high momentum proton, and backward scattered pi-**
  - **Backward tracker to cover 130–150 degree from the beam line upstream of the target**
  - **Two layer configuration**
  - **The backward pi- momentum ranges between 200-500 MeV, depending on the kinematics**

~10 degree coverage in phi per sector

u-channel pion electroproduction pion recoil at backward angle

Proposed MVTX Prototype module

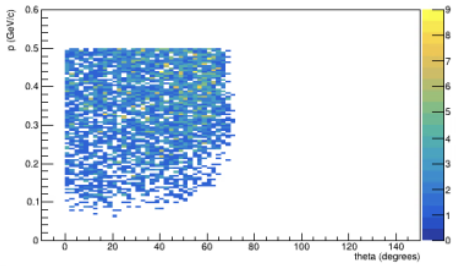




EAch module has 30 staves

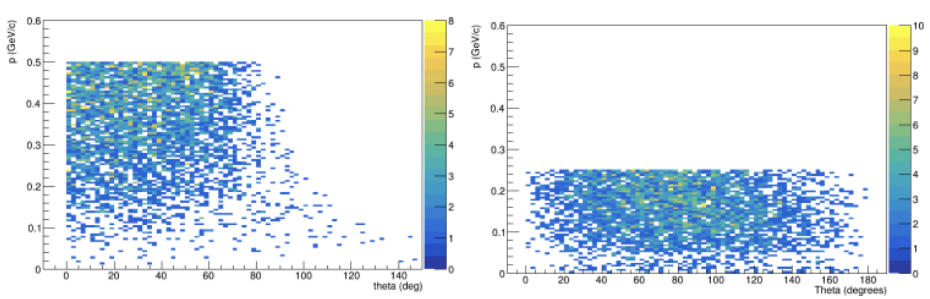
- The effective active area for charged-particle detection is approximately 60 cm × 27 cm

Tagged DIS



- For H target recoil protons are up to ~60deg in polar angle
- For D target and recoil and spectator protons are backward angle with low energy

Figure 10: Recoil (left) and spectator (right) proton momenta versus angle for the TDIS reaction $H(e,e'p_{recoil})$X.



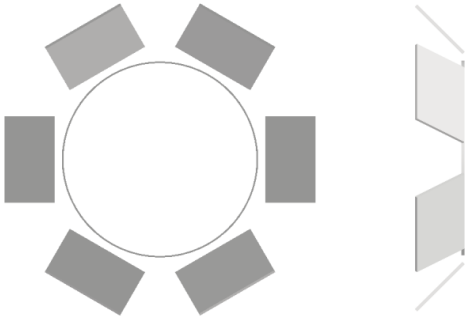
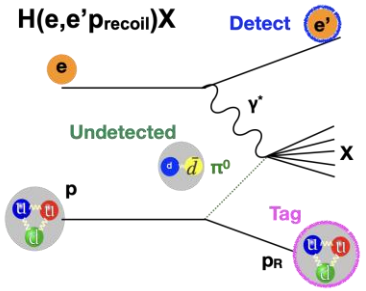
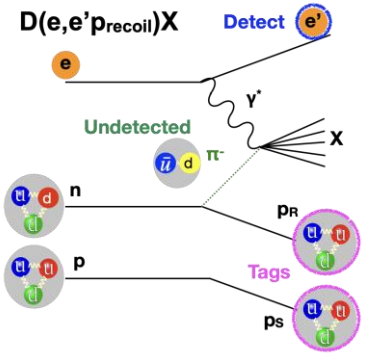


Figure 11: Recoil (left) and spectator (right) proton momenta versus angle for the TDIS reaction $D(e,e'p_{recoil}p_{spectator})$X.

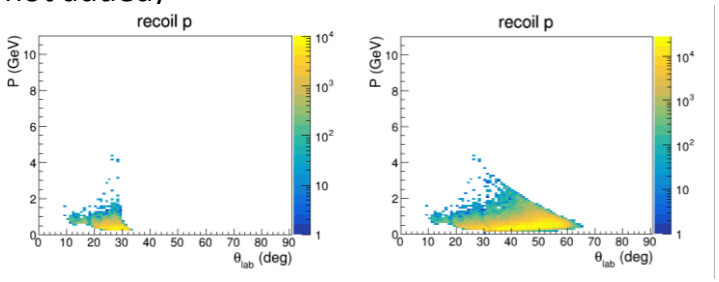


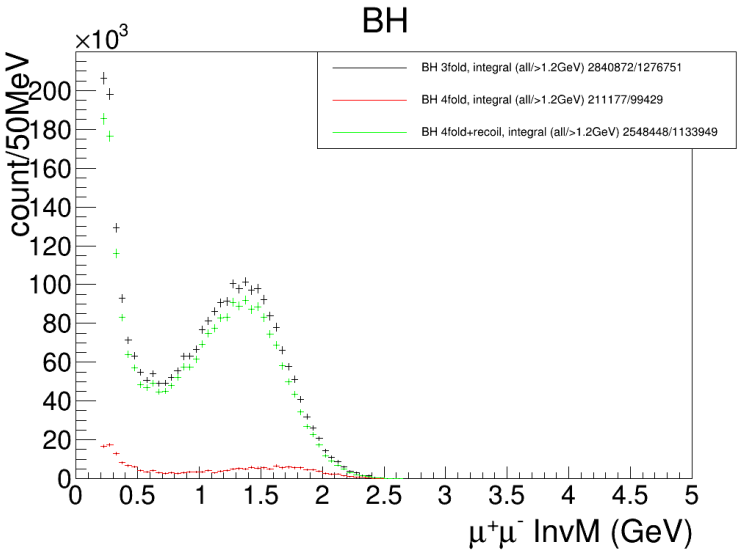


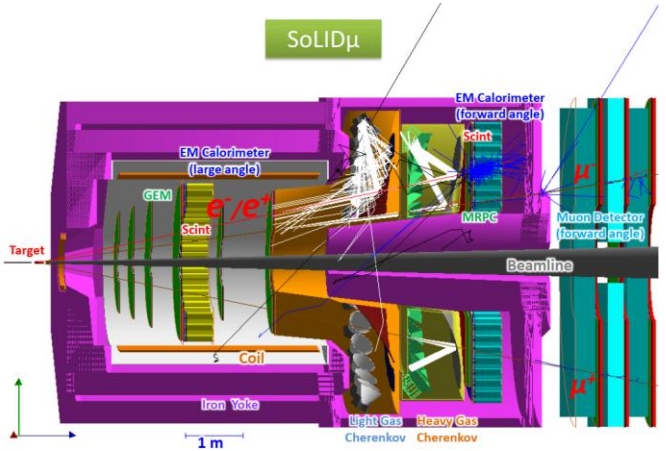
- Similar to DEMP appropriate (if possible) with even fuller polar angle coverage to maximize reach for spectator proton up to and slightly beyond 100 deg
- Likely need a target position further upstream than jpsi LH2 target at z=-315cm, to allow for forward angle detection

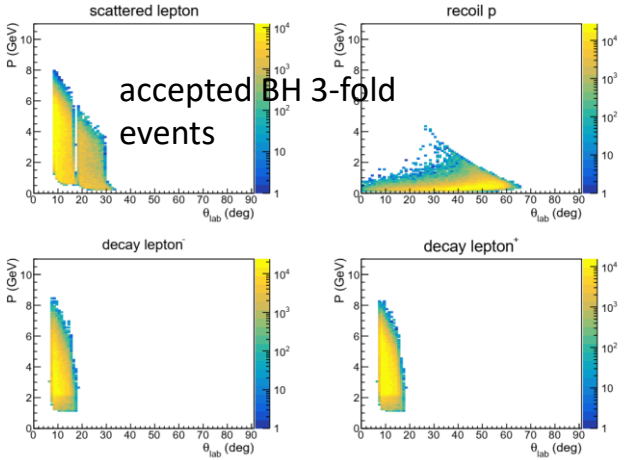
SoLID DDVCS

Before (left) and after (right) adding recoil detector from 30 to 65 deg (field effect not added)









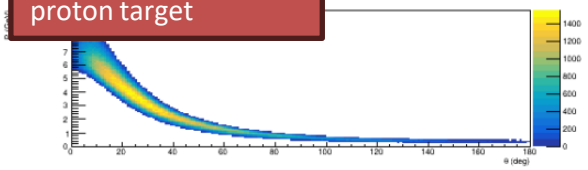
While e,mu+,mu- are detected, recoil proton is below 3GeV and below 65deg

- With a recoil detector at 30-65deg, 4fold events will be the main channel with cleaner background than 3fold events
- But target position is close to solenoid entrance and optimized for dilepton detection and 30-65deg is where entrance iron is and not easy to put recoil detector

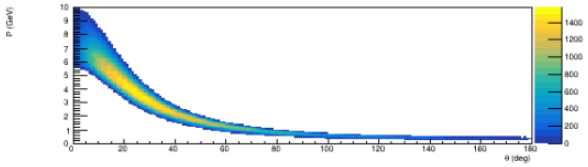
SoLID Jpsi photoproduction

11GeV e- beam, free proton target

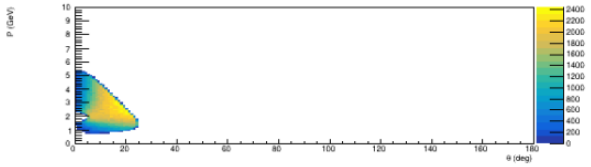
e-



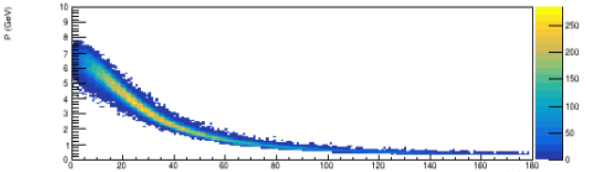
e+

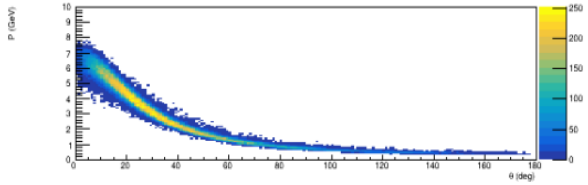


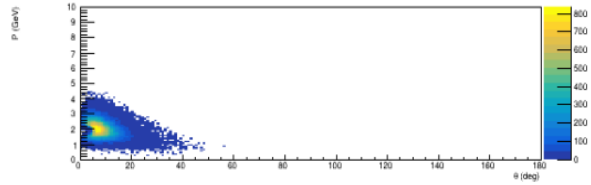
Recoil



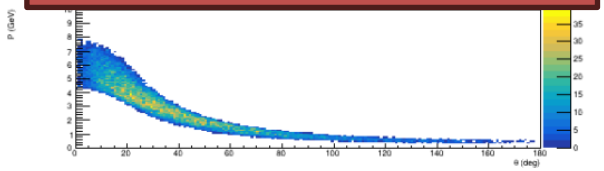
8.5GeV e- beam, proton in d as target

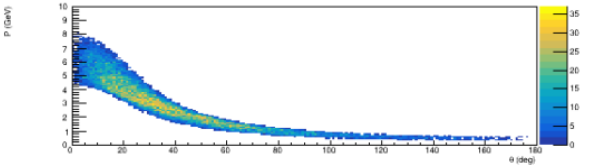


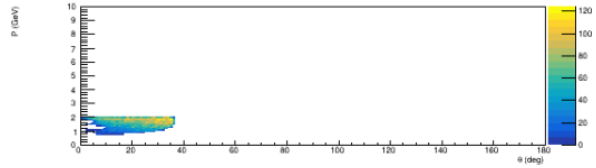




8.5GeV e- beam, deuteron as target





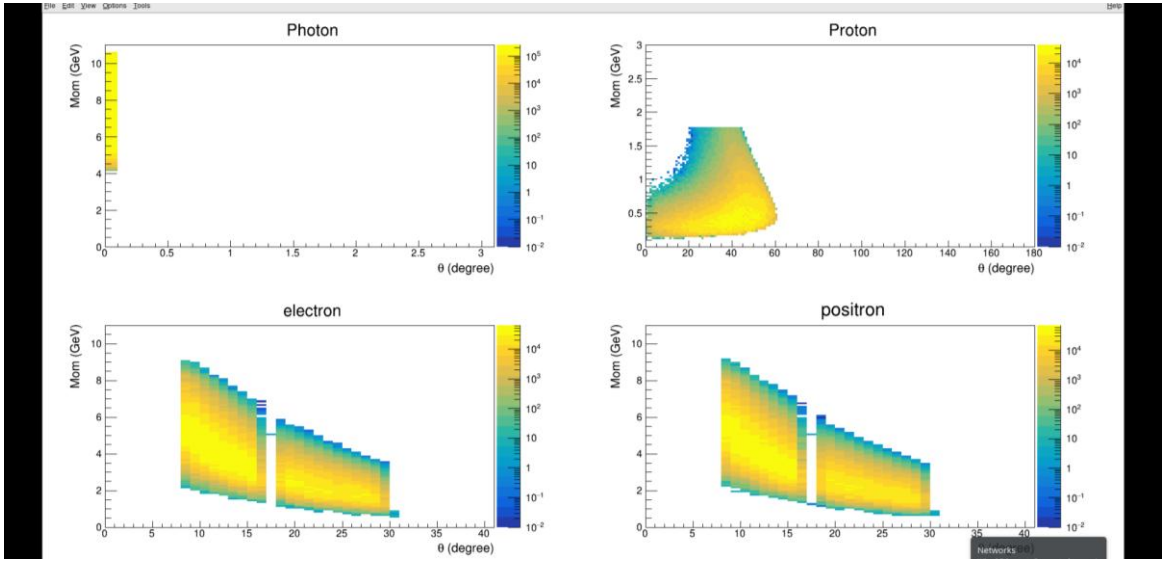


- Recoil particle is below 40deg

SoLID TCS

11GeV e- beam, free proton target

- e- and e+ are accepted by FA and LA, but not both at LA



- Recoil proton is below 60deg

Summary

- MVTX will be uninstalled in May and the group has received several proposals
- SoLID Recoil detector may use its staves as thin trackers without modifying MAPS readout
- More study needed if it moving forward