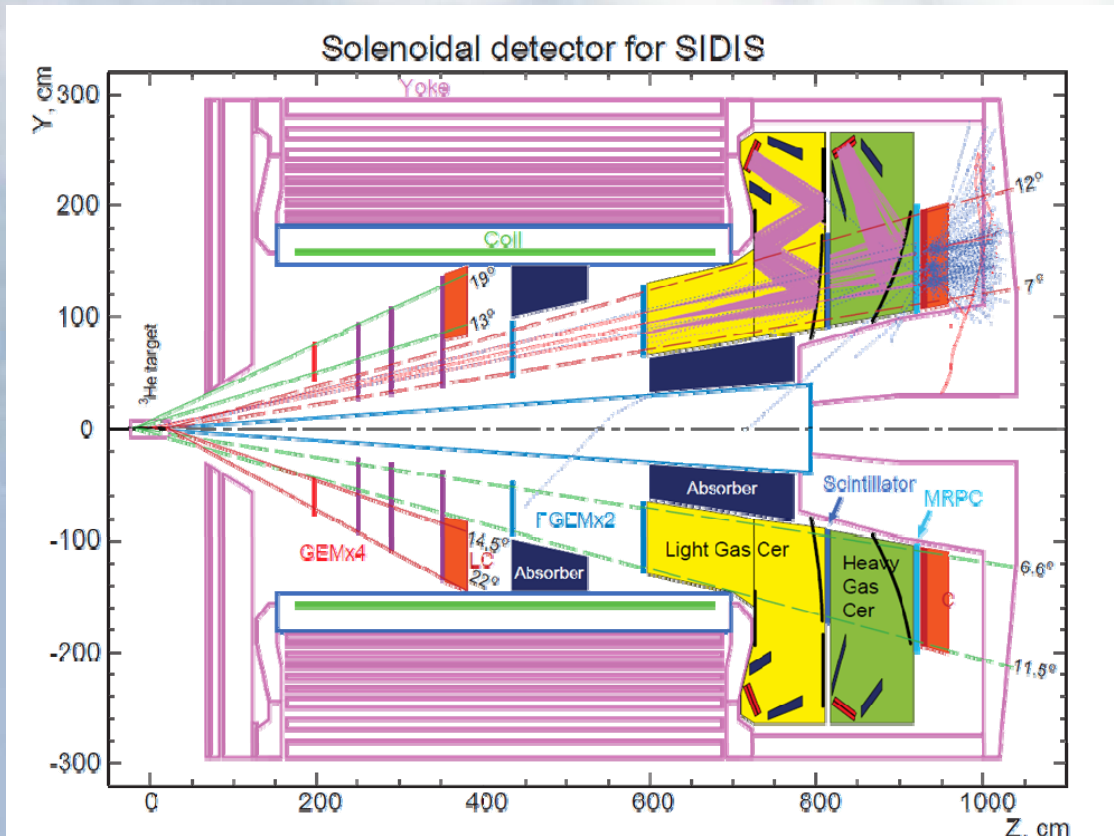
Optics, Tracking, and TOF Status/Update/Roadmap



Xin Qian

KRL

Caltech

Optics

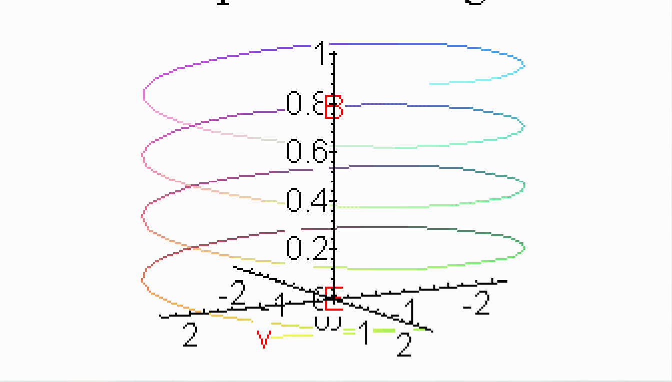
- Current Optics
  - Is build based on COMGEANT Simulation with magnetic field generated by Poisson.
  - is used to study the detector resolution.
  - Is used in progressive tracking, as one needs to predict the hitting locations from the known knowledge.
- 200 um GEM position resolution with u/v orientation 10^o separation.
  - 1% momentum resolution.
  - Polar angular resolution 0.3 mr.
  - Azimuthal angular resolution is 5 mr.
  - 0.8 cm vertex resolution.

Starting Model:

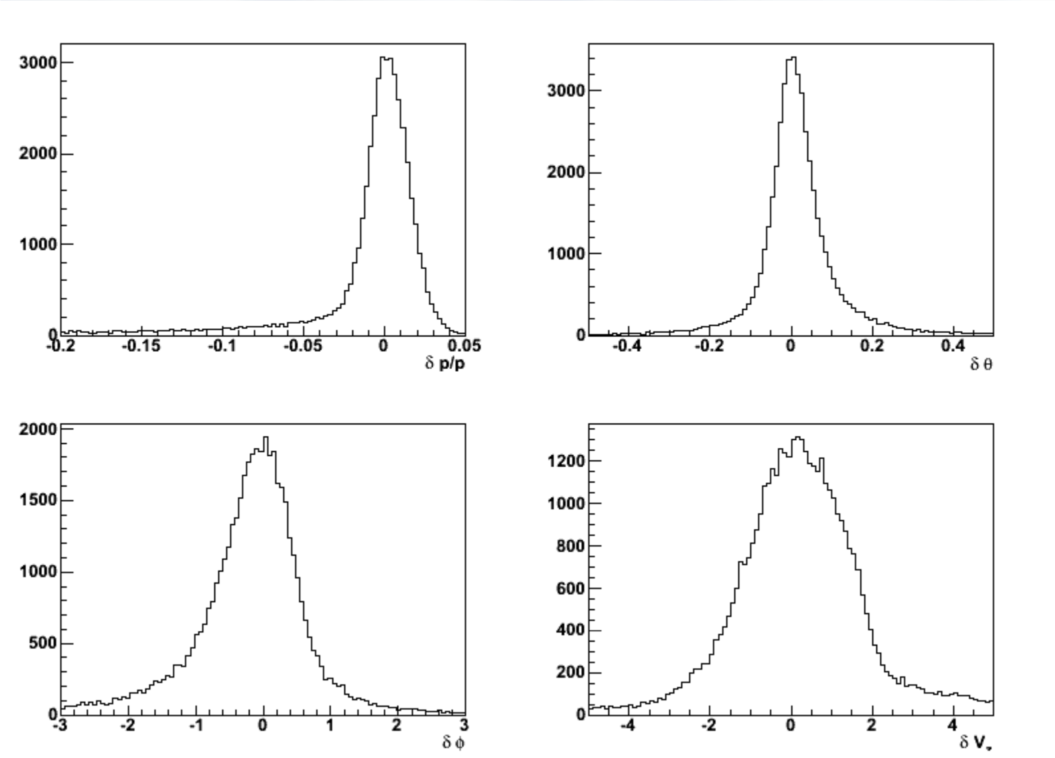
$$BqR = P_T$$
$$R \cdot \theta \sim P_T$$
$$z \sim P_L$$

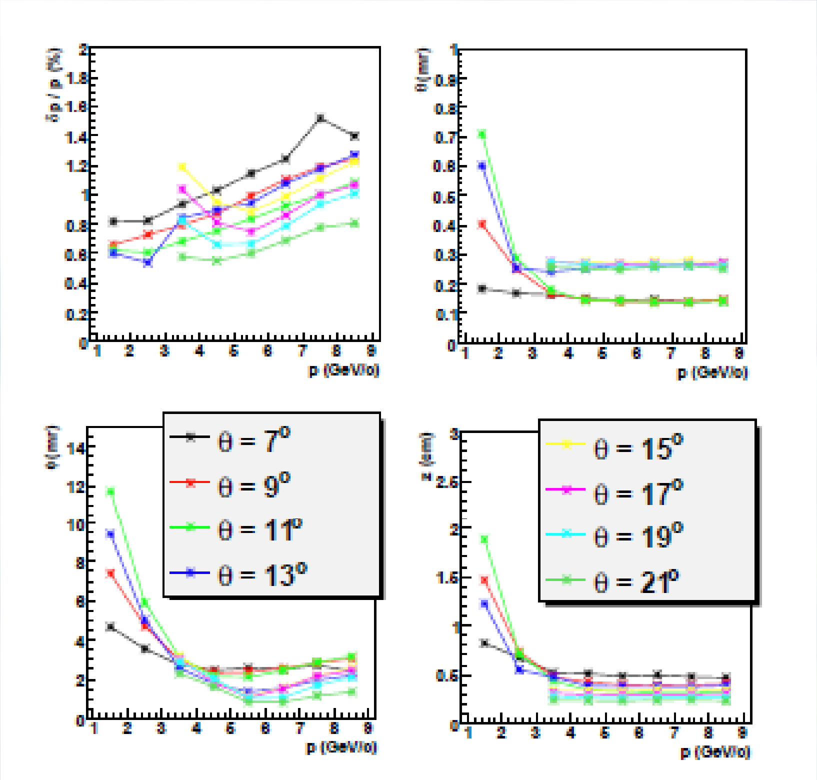
- Along z, the trajectory is a circle.
- With Radius R, and distance along z
  - One can get P_T/P_L -> polar angle
  - Combine R and Magnetic field, one can get P_T -> Momentum
  - Azimuthal angle can be determined at the point when the particles enter magnetic field + theta angle
  - Vertex can be determined by unfolding the trajectory + polar angle + hit positions.

Motion of particle through B field



Quality of Optics



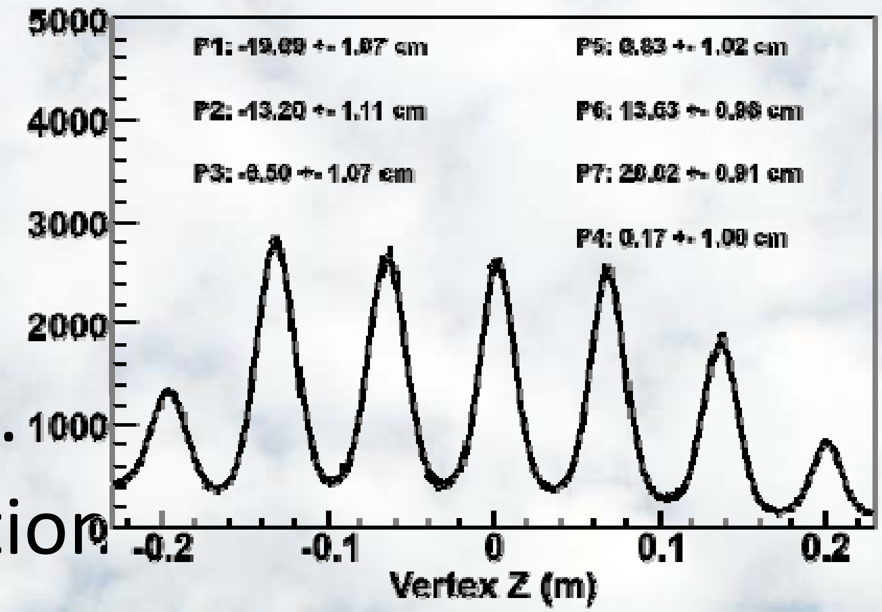


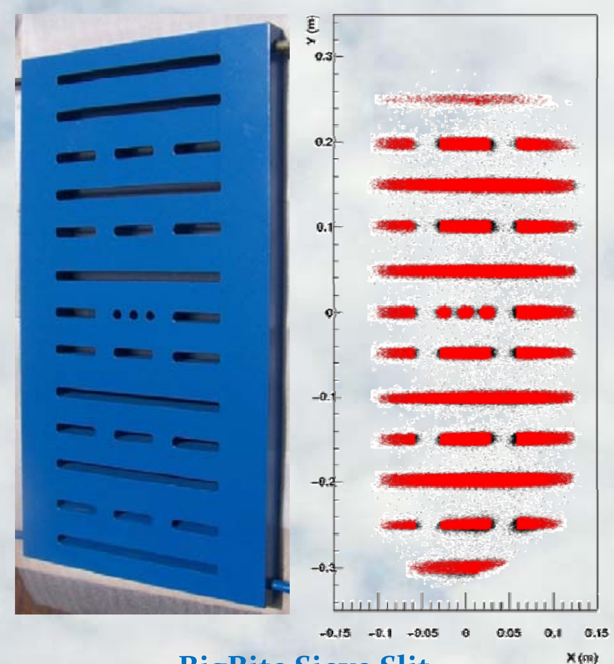
All momentum, no resolution (example)
Show that we can do reconstruction.
We know both input and output

Resolution included, optics is performed at each momentum/angle separately.

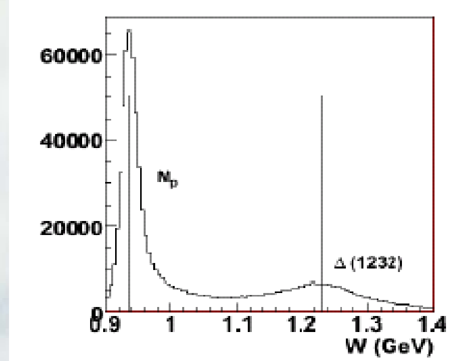
Initial Idea of Optics Calibration

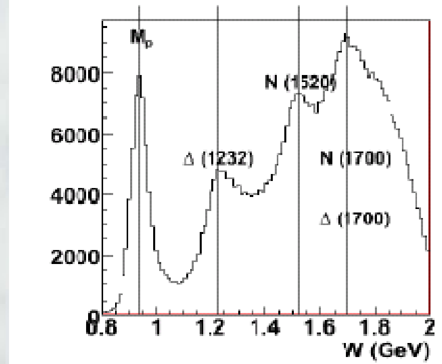
- Similar to BigBite: Multi-Carbon foils for vertex reconstruction.
- Sieve for Angular calibration
- e-p elastic scattering for momentum calibration at 1 and 2 pass.
- Need lower mag. field setting for SoLID
- Other ideas?





BigBite Sieve Slit





Optics Working Plan (With Future Manpower)

- Current Optics Model is good for director review etc.
- Future working plan includes:
  - Work out a **single unified optics** model for several baseline design (magnetic field, angle etc)
  - Design the **detailed optics working plan** (beam energies/current, beam time, target, settings, and checks)
  - Generate **simulated data** to demonstrate optics reconstruction according to optics working plan.
  - <u>We MUST achieve this before data taking, since tracking needs this information as input (online).</u>

Tracking: Progressive Method

1. Start with one seed in the first plane.
2. Loop over hit in the second plane
3. Predict/Check hit in the next plane (combining the optics information)

3.1 If succeed, predict/check hit in the next plane with better optics information.

3.2 If not succeeded, go to second step.

Use the optics information, trajectories are closely related momentum angle etc.

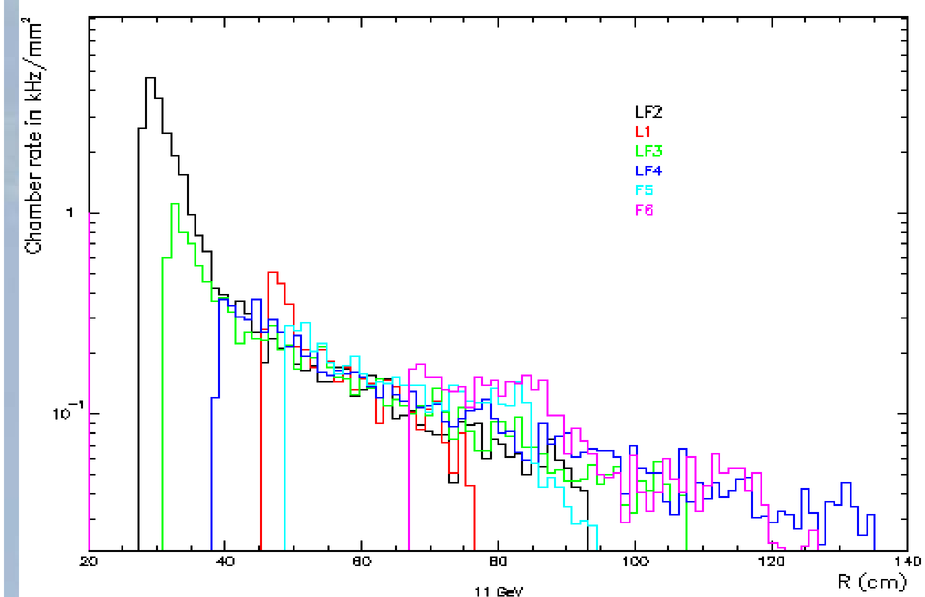
Tracking Algorithm

- 5 planes in forward angle + 4 planes in large angle:
  - Require 4/5 and 3/4 to increase tracking efficiency gives 6+5=11 different combinations
    - separate treatments.
  - Sort all the found tracks by quality of fit (can be improved):
  - Ensure no hits were used twice to deghost the false track.
  - Still need to connect final track with optics and also for TOF.

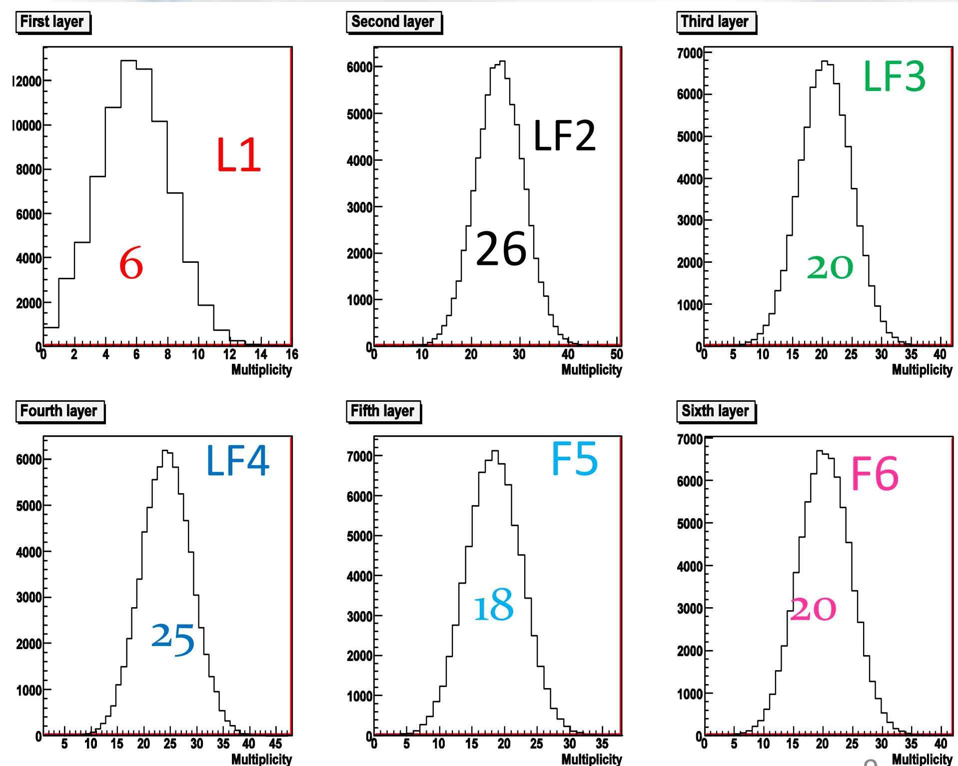
Configuration	Background level	single-track	multi-track	zero-track
large-angle	1	99.4%	0.28%	0.31%
Forward-angle	1	99.2%	0.32%	0.49%
Large-angle	2	95.4%	4.2%	0.32%
Forward-angle	2	95.6%	3.9%	0.44%

Table 2: 3 out of 4 planes (4 out of 5 planes) are required to fire for large-angle (forward-angle) tracking detector for a valid track. When the "Background level" is labeled as 2, we assume the background rates are twice of the simulated rates from GEANT.

Count rate in kHz/mm^2



11 GeV, R(cm)



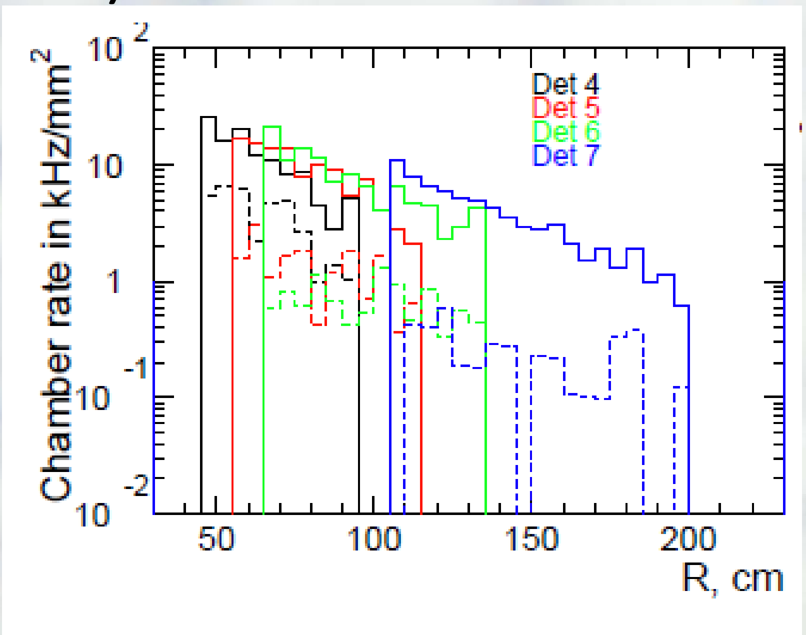
Multiplicity

Tracking Development Plan:

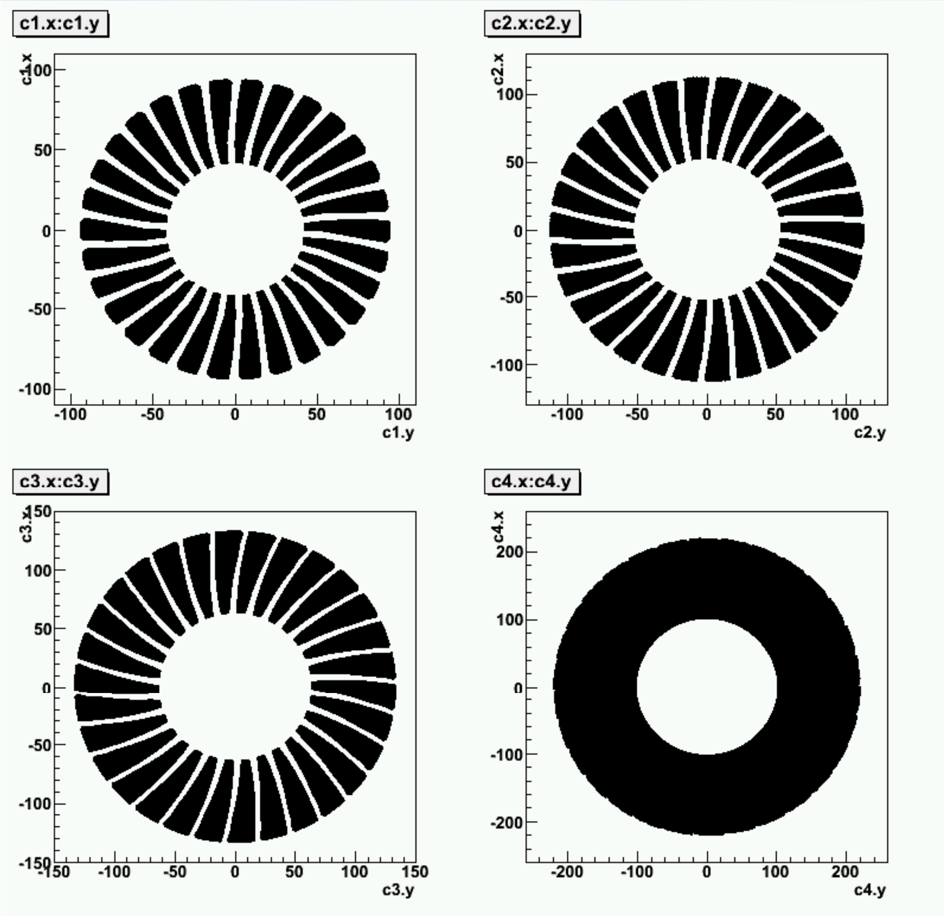
- Major uncertainties: Background on GEM
  - Need further beam test to fully understand background. Impact on
    - Tracking Speed
    - Number of GEM chambers (Currently 5 and 4, also hit efficiency)
  - **<u>Need to work together with SBS GEM test.</u>**
- Online Tracking:
  - Speed: need multi-thread tracking.
  - Need a Good and Quick Optics Model .
    - Also Low luminosity run + event display
  - A good student with great computer skill can help on this part.

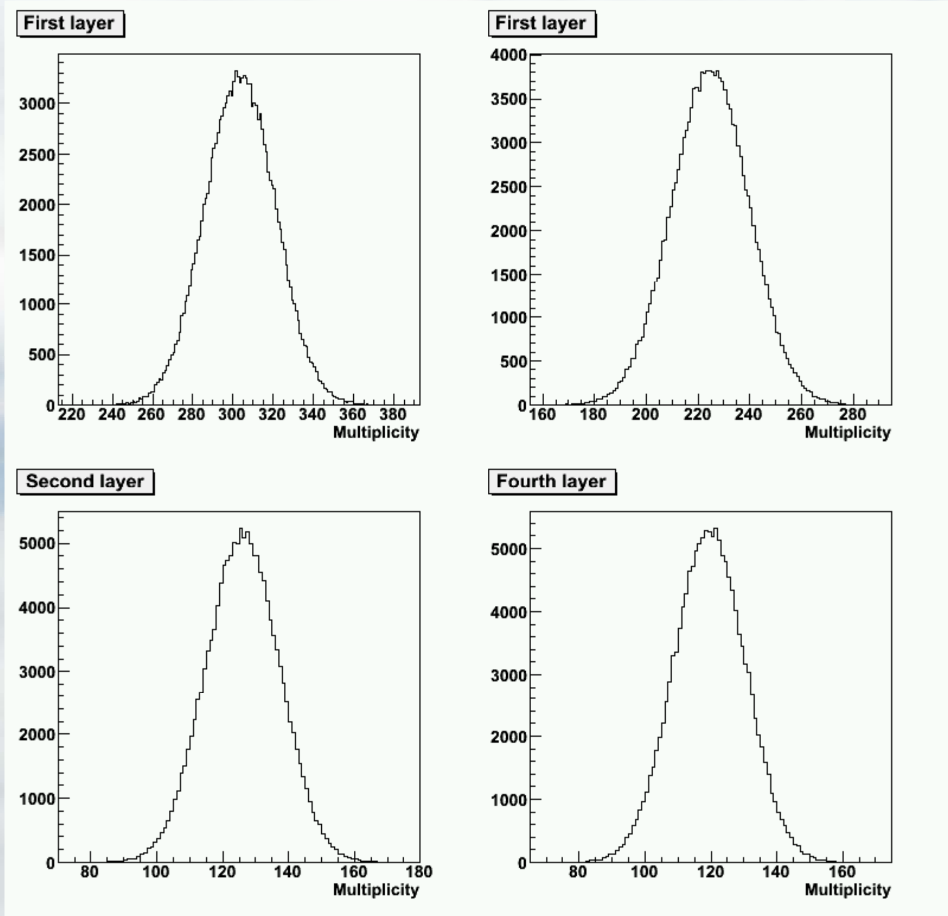
PVDIS Tracking

- Condition:
  - COMGEANT simulation based on realistic magnetic field simulation (energy loss included)
  - 200 um smearing of position in GEMs
  - Background added from simulation. (50 ns TDC window)
  - Add in false hit based on 10 degree strip separation.
  - Factor of 4 reduction assumed for false hits.
  - 98% hitting efficiency

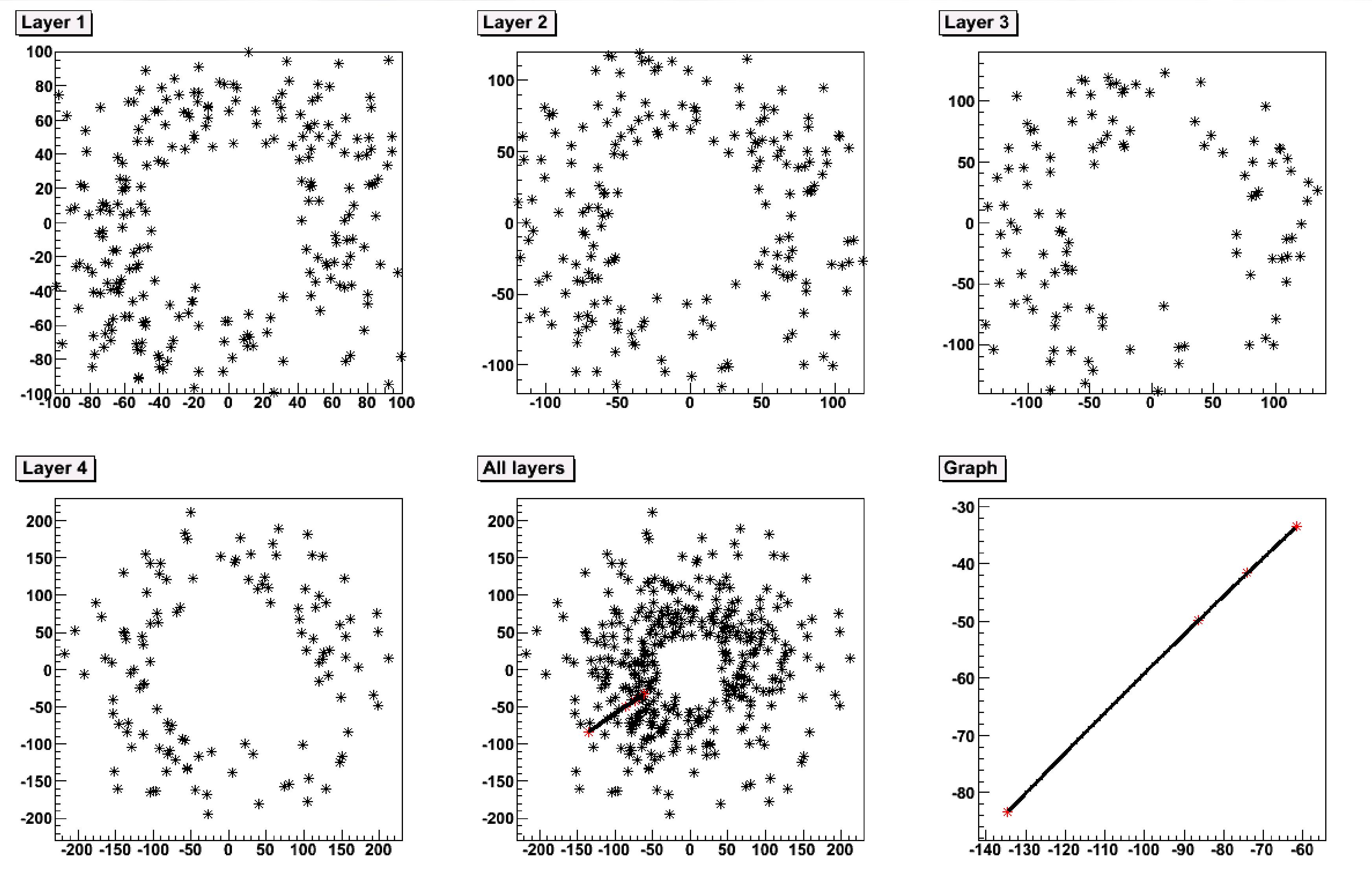


Illustration





Event Display



Tracking Algorithm

- Similar to that of SIDIS
  - Progressive Search (coarse search)
  - Four planes: require ¾ or 4/4 to compare (5 methods)
  - Use optics information to reduce false track (fine search)
  - Final step to de-ghost the tracks
  - total 50000 tracks
  - **No fine tuning yet due to limited time.**
  - Code available @ /w/work5602/transversity/xqian/PVDIS_tracking @ central disk.

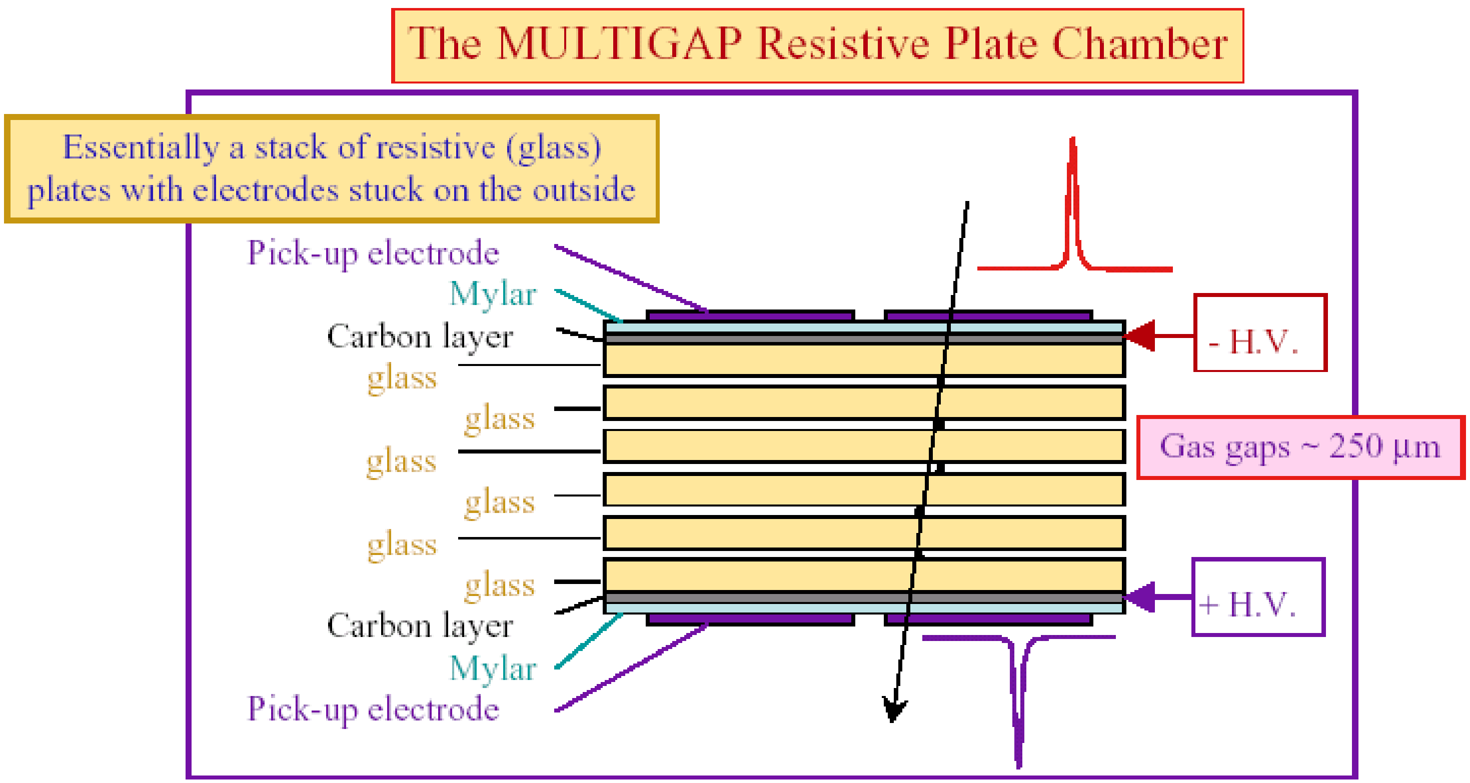
Results (50000 events, 92% for 4/4)

Conf.	Coarse (Single/Multiple)	Fine (Single/Multiple)	4/4 (Coarse) (Single/Multiple)	4/4 (Fine) (Single/Multiple)
No BG 100% eff.	99.30%/-	99.16%/-	95.3%/-	89.0%/-
Track With BG 98% eff PVDIS BG	82.8/16.3% 2532s	86.9/11.6% 2496s	88%/- 797s	82.1%/- 785s
Only BG 98% eff PVDIS BG	14.5/1.5% 2488s	10/0.3% 2520s	-/- 770s	-/- 704s

Discussion

- Motivation:
  - to demonstrate the principle of tracking and give the preliminary requirement for GEM trackers
  - **No fine tuning at this point for optics e**tc
  - Speed is slow
    - Can use multi-thread
    - Can use calorimeter to significantly reduce speed (/30 for sectors) and provide redundancy to eliminate false track.
- Observation:
  - Without Background, tracking efficiency is very high.
  - With Background, need at least 4 planes to reduce multi-tracks.
  - Four GEM planes is not enough (**At least five?**)

Time-of-Flight (TOF)



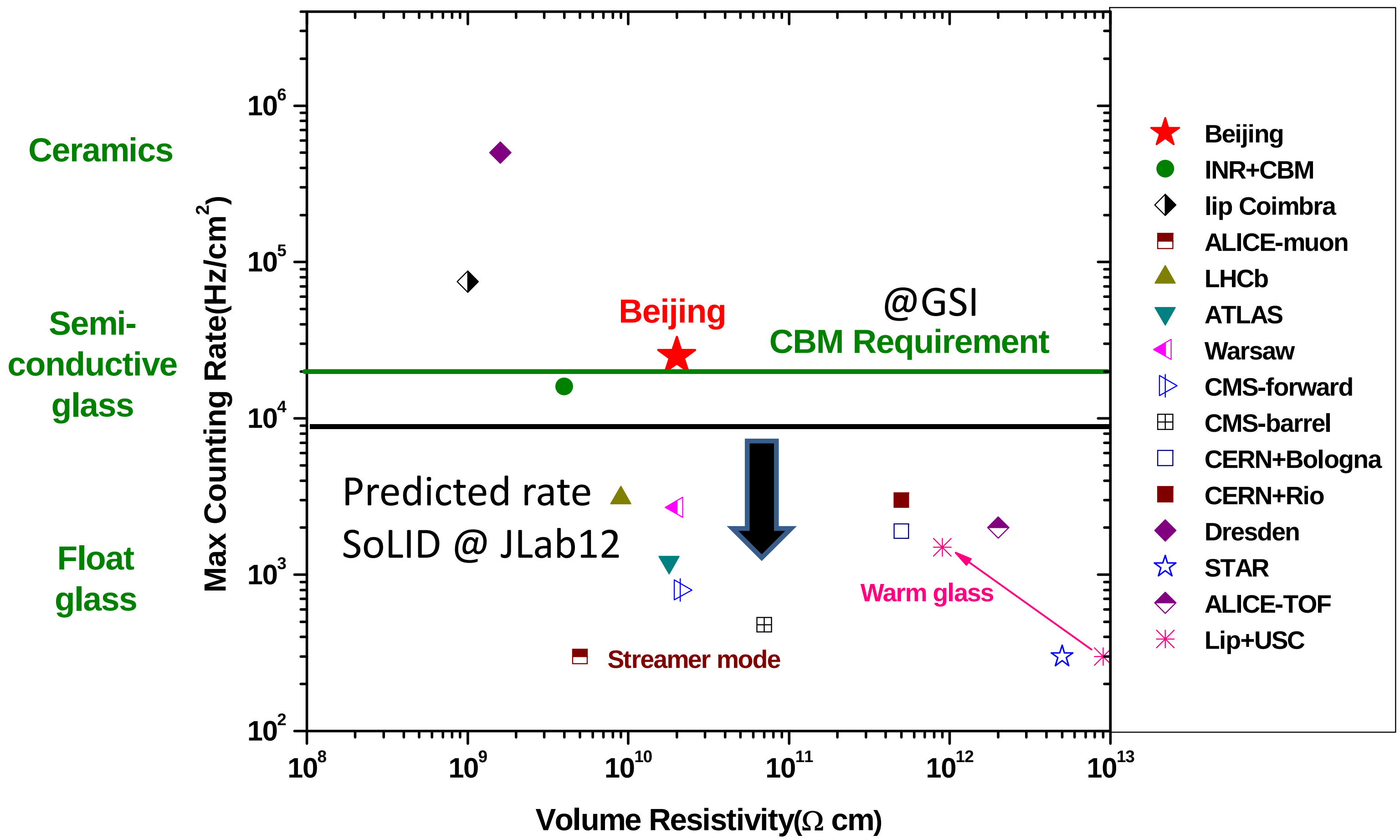
Note 1: internal glass plates electrically floating - take and keep correct voltage by electrostatics and flow of electrons and ions produced in gas avalanches

Note 2: resistive plates transparent to fast signals - induced signals on external electrodes is sum of signals from all gaps

Large area, high granularity. Good time resolution<100ps

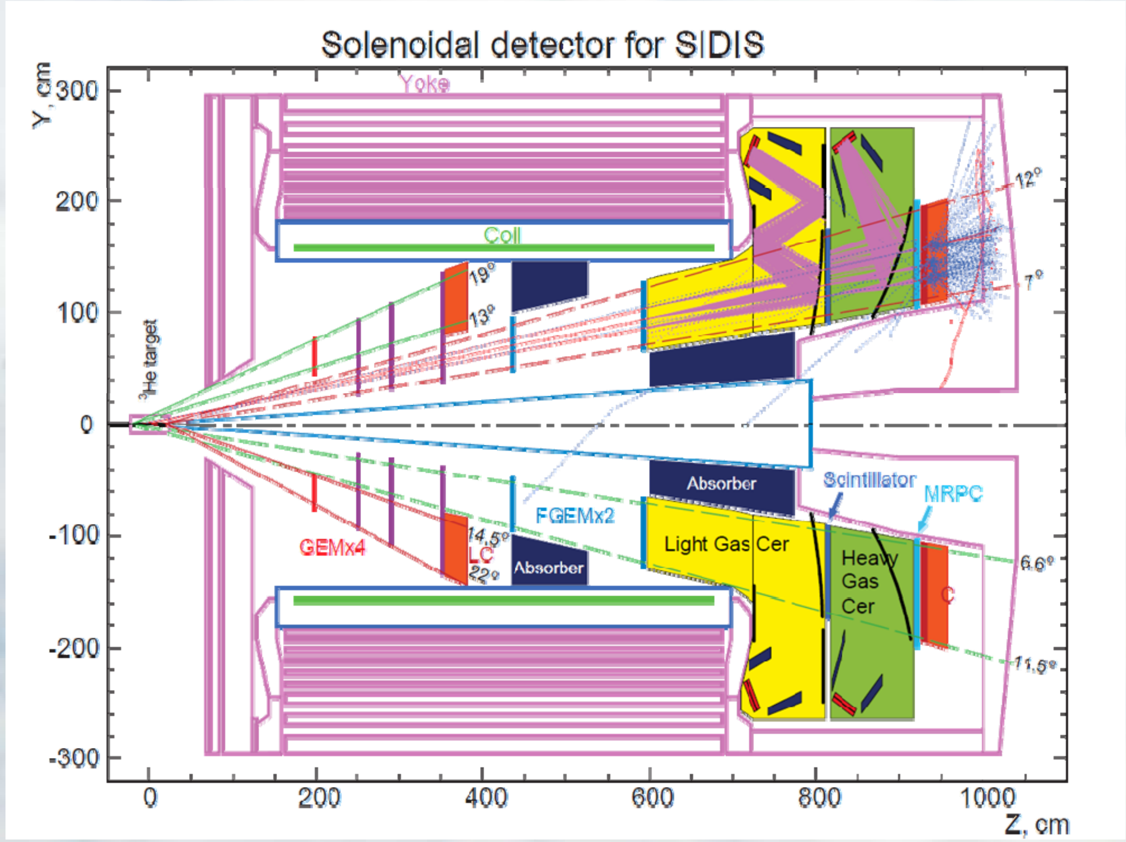
High efficiency> 95% .Low cost

Background Rates



TOF Requirement

- Goal: 20:1 kaon rejection up to 2.5 GeV/c
- ~ 9 m, flight path
  - 0.55 ns separation @ 2.5 GeV/c
  - Considering tail: requiring about 100 ps (200 ps with a gaussain)



BaBar: 7m, with same requirement, need <75 ps (150 ps). Will need to improve the tail with better optics, tighter TOF cut

Naïve Estimation:

- 0.8 cm vertex resolution
- 0.3 mr polar angular resolution
- 5 mr polar angular resolution
- 9 m flight distance
- 4m distance outside field

$$\sqrt{0.8cm^2 + (9m \cdot 0.3mr)^2 + (4m \cdot 5mr)^2} \approx 2.2cm$$

80 ps at c gives 2.4 cm on travel length.

<u>It is possible to reach the desired TOF resolution</u>

TOF Developing Roadmap:

- MRPC Design for SoLID:
  - Beam test on MRPC to demonstrate rate limit.
  - Also beam test for background prediction.
  - How to Eliminate Gap?
  - Electronics integration (DAQ)
- Goal TOF resolution: 100 ps
  - Intrinsic resolution capable of 40~ 60 ps.
    - Determine the cell size
  - <u>Need to study the path length correction in simulation together with optics to determine what is the limit in TOF</u>

Hall D Magnet Study (Preliminary)

- The uniformity of magnetic field is not a big issue for SIDIS
- The strength of the integrated BdL will be related to the momentum resolution.
- Current number: 90 cm radius x 340 cm length
  - Similar ratio of CDF magnet   150 cm radius x 550 cm.
  - Similar size to ZEUS: 86 cm radius x ~ 300 cm length

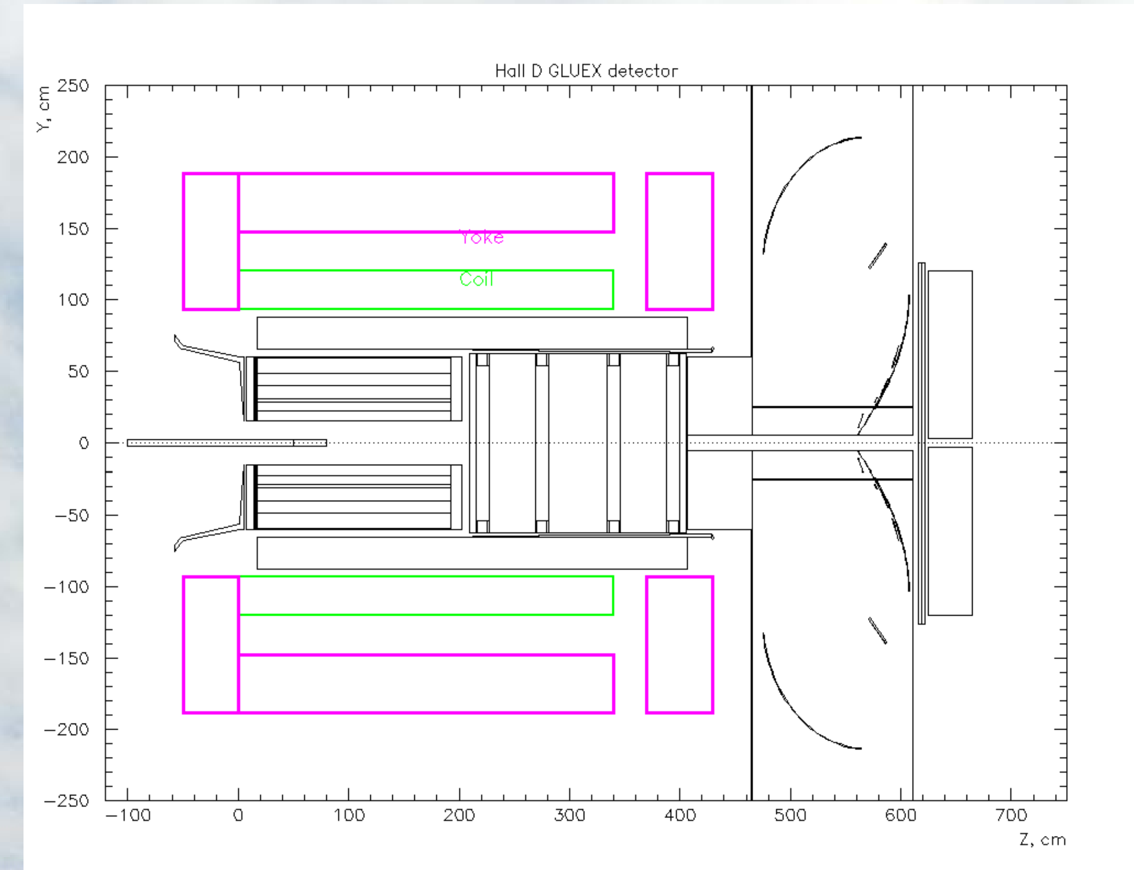
Things not likely to be changed:

1. Distance between target and magnet
2. Length of calorimeter, gas Cerenkov detectors.
3. TOF are needed, so the distance between MRPC and target.

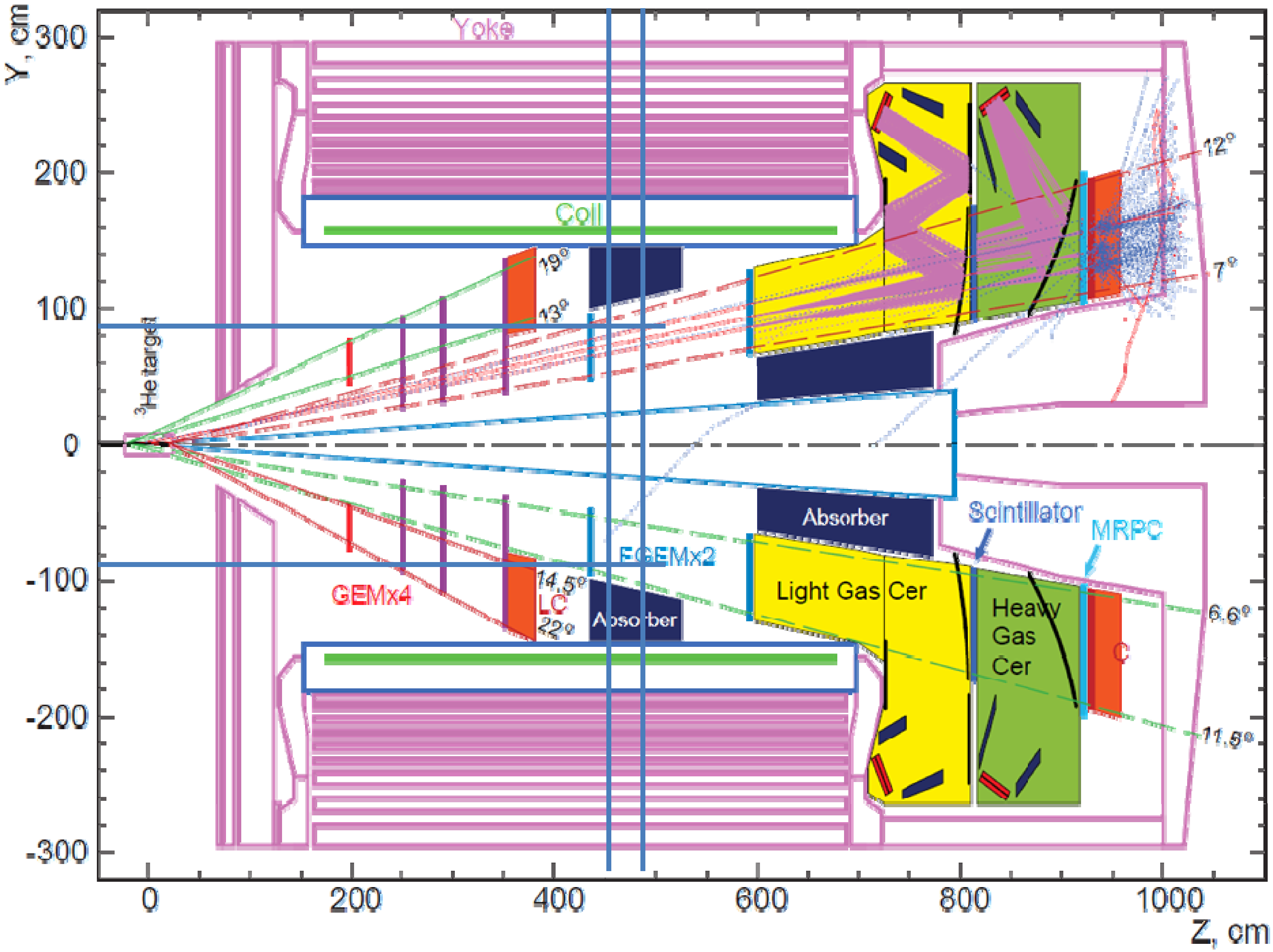
BABAR and CLEO Magnet can work for SIDIS

CDF will give slightly worse phase space, but can work too.

ZEUS and Hall D are similar, Probably ZEUS will give a better phase space



Solenoidal detector for SIDIS



Discussion

- Most of forward angle detectors will be ok.
  - Largest limitation will be on the yoke, need to have enough room to hold the detectors.
  - Background will not change much.
- Will phase space got affected?
  - Depending on the thickness of front york (also back)
  - Shorter target, but higher density to improve the phase space?
  - Slightly shorter magnet possible?
- Current design of large angle detector will not work.
  - Need new design for GEMs and large angle calorimeter (barrel shape for both)