Special Considerations for SIDIS

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Caltech

Special Considerations

- Uniformity:
  - E.g. Design of Detector Support Structure to minimize holes in acceptance (especially in azimuthal angle)
- Background in Detectors
- Radiation:
  - Design of Detector front end electronics and calorimeter
    - Minimize radiation damage
    - Maximize radiation hardness of design.
- Multiple New Detectors:
  - Need dedicated time to commission detectors and system integration.
  - Multiple/Staged beam tests needed for detector R&D.
  - Detailed Integration Plan.
- Mechanical Design:
  - Compact
  - Detector maintenance
  - Cable layout
  - Switch plan among different configurations:
    - Transverse vs. Longitudinal
    - SIDIS vs. PVDIS
  - Require Strong Engineering Support
- Procedure of quick establishment of detector performance.
  - Position of Tracking detectors
  - Energy response in Calorimeter
  - Background/Gain in Gas Cerenkov.
  - Physics asymmetry in single hadron, and zero PV will help in this.

Requirement of SIDIS

- Kinematics Coverage:
  - **0.05 ~ 0.6 in x (valence)**
  - **0.3 ~ 0.7 in z (factorization region)**
  - **P_T up to ~ 1 GeV (TMD Physics)**
  - **Fixed target → Q^2 coverage 1-8 GeV^2 (~ 2 GeV^2 in ΔQ^2 at fixed x)**
- Luminoisity:
  - **Unpolarized ~ 10^{37} $N/cm^2/s$**
- Polarized ^{3}He Target:
  - **~ 60% higher polarization**
  - **Fast spin flip (<20 mins)**
- Electron PID:
  - **<1% Pion contamination (asymmetry point of view)**
- Pion PID:
  - **<1% Kaons and Protons**
  - **<1% electron contamination**
- Optics of Reconstruction:
  - **< a few % in δP/P.**
  - **< 1 mr in polar angle.**
  - **< 10 mr in azimuthal angle**
  - **~ 1-2 cm vertex resolution**
  - **Similar precision required.**
  - **A factor of 2-3 better already achieved in MC.**
- DAQ:
  - **~ 3kHz Physics Coincidence**
  - ~ 200 kHz Single electron
  - ~ 50 kHz Coincidence
  - **Limits: 300 MB/s to tape.**

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Mainly Determined by Magnet.

Mainly Determined by Detector Capability. R&D

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Requirement on GEMs

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Requirement on funding?

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Requirement on GEMs

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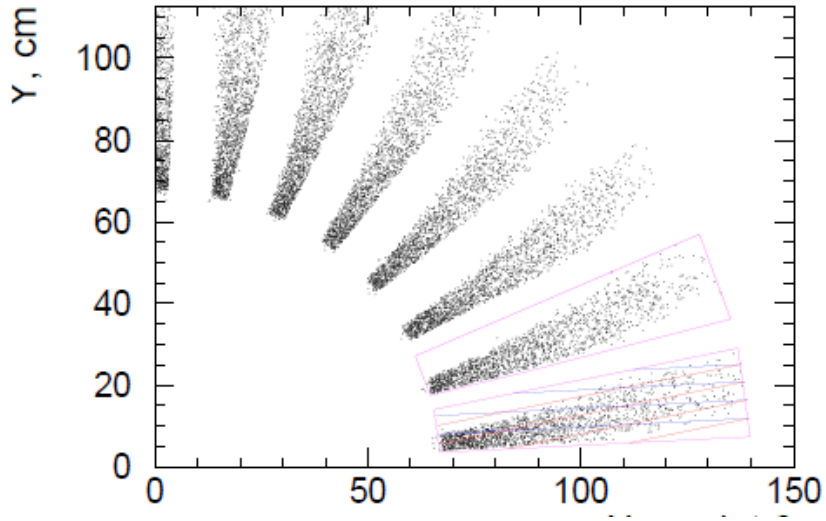
Requirement on funding

Current Design



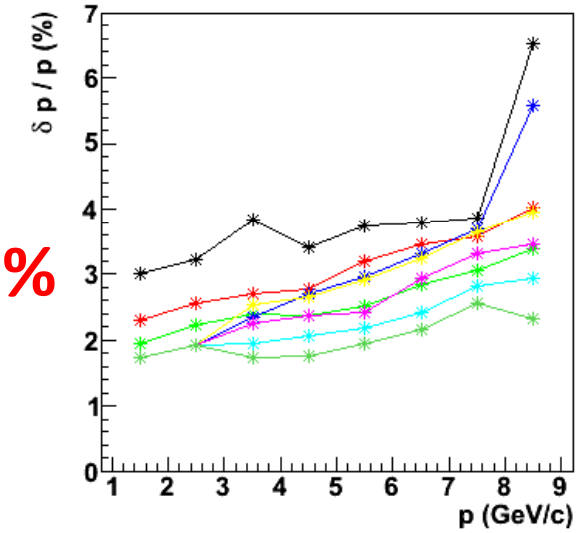
- Strip pitches are 0.4 mm and 0.6 mm (Design from Eugene)
  - Nilanga:
    - Best condition 1-sigma resolution is about 70 um.
    - Expected safe realistic estimate for possible resolution is about 150 →200 um in field?
      - but the field is perpendicular to the GEMs
- Question:
  - What is the impact of current design on detector resolution?
  - How will these compare to our requirements?

Take 175 um and 12 Degree Readout as an Example.

- 5 GEM planes
- Smear the positions in perpendicular to the strip direction.
- Recombine to get the final position.
- Use the new positions to calculate optics and compare it with the true kinematics variable.

New Resolution 175 um

3%



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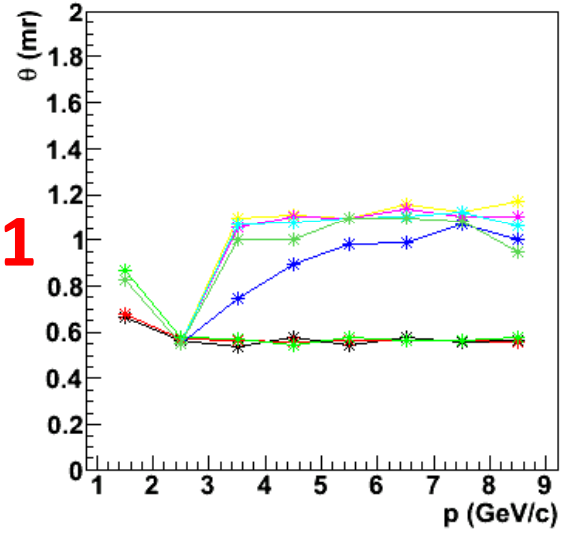

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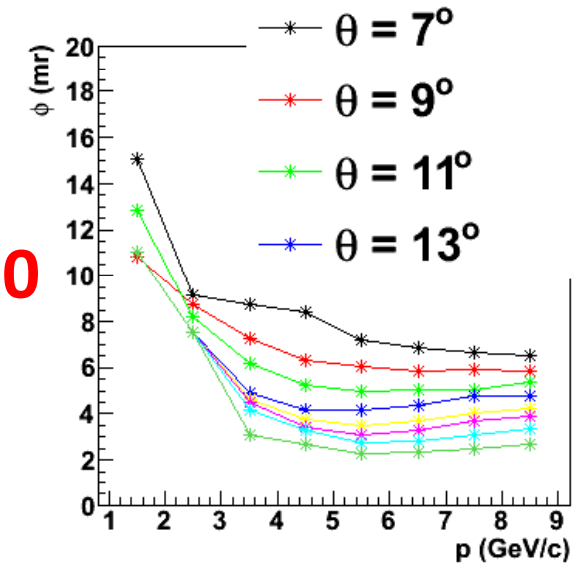

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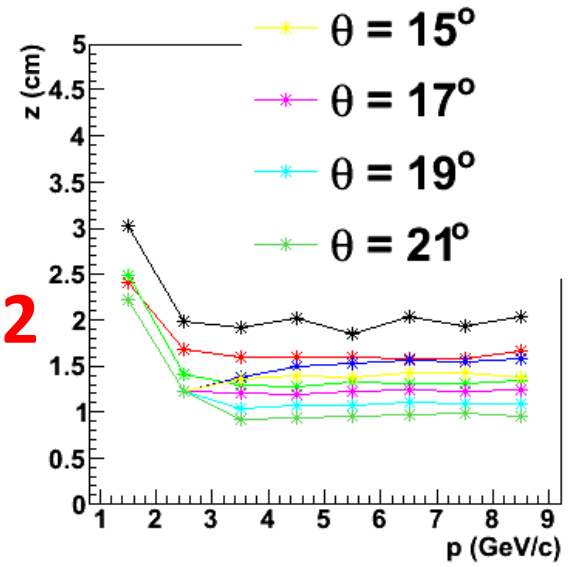


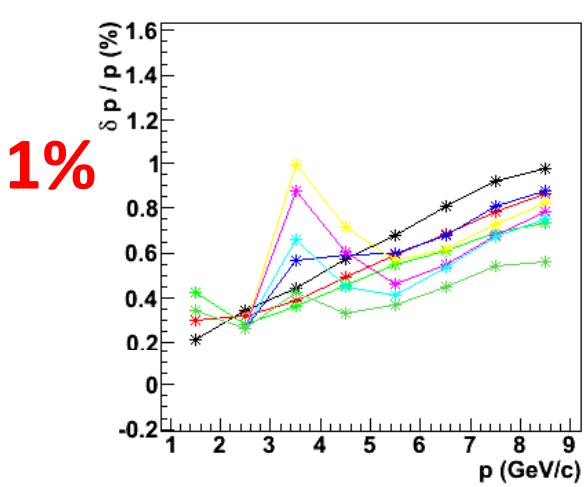
3% in delta P/P

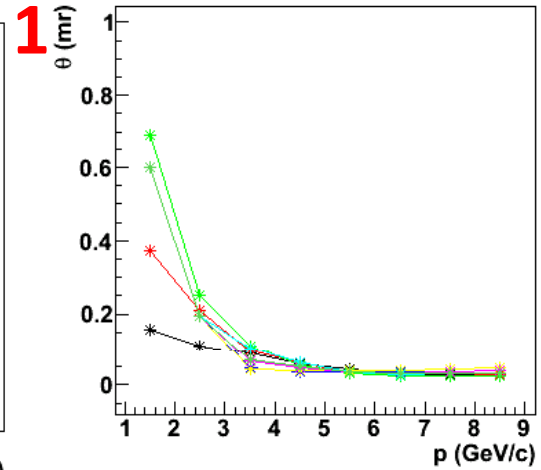
0.8 mr in polar angle

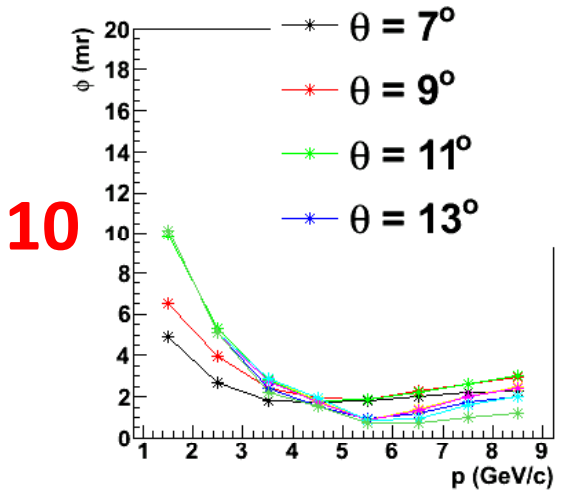
6 mr in azimuthal angle

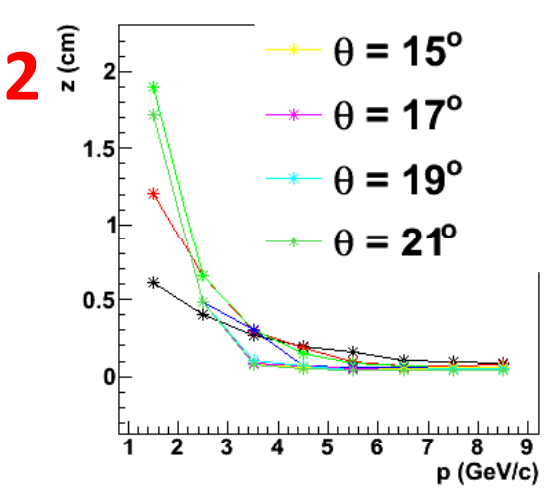
1.5 cm in vertex

Sanity Check: Zero Position Resolution









0.5% in delta P/P

0.1 mr in polar angle

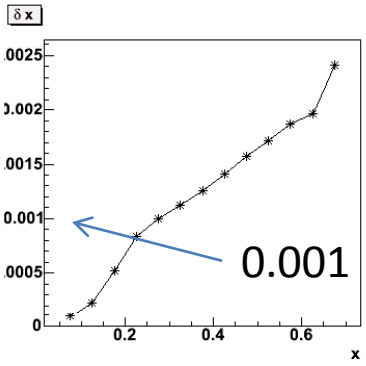
3 mr in azimuthal angle

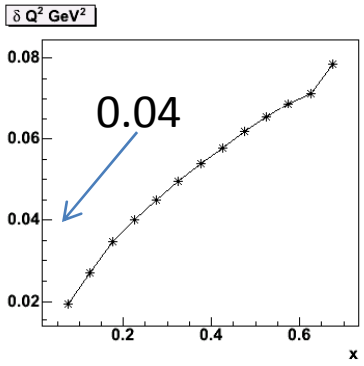
0.3 cm in vertex

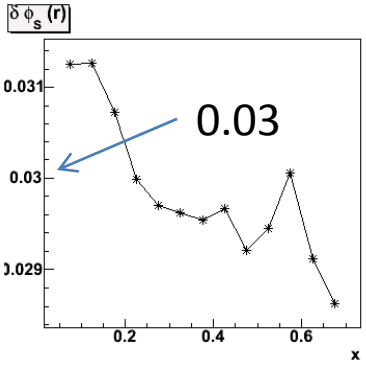
These are intrinsic resolution from the current optics model

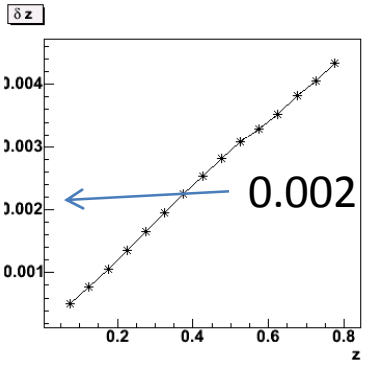
What are the impact on kinematics variables?

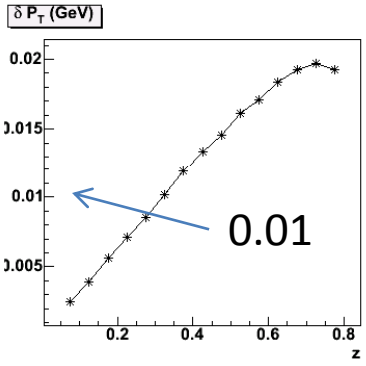
Based on 0.5% deltap/P
0.1 mr in polar angle
3 mr in azimuthal angle.

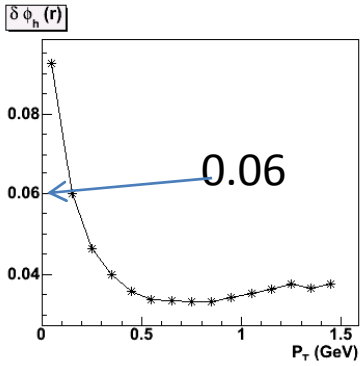




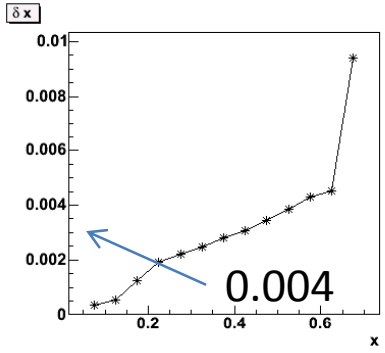


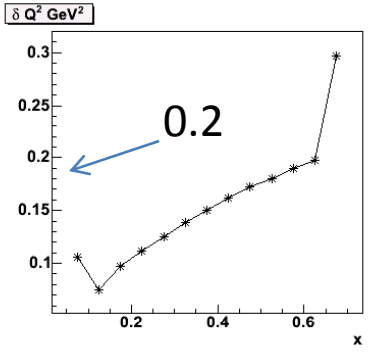


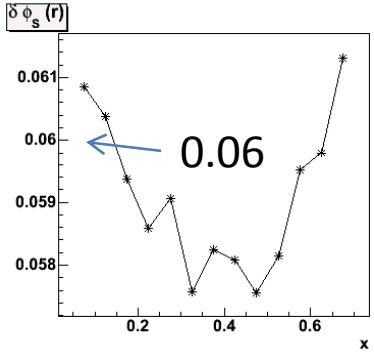


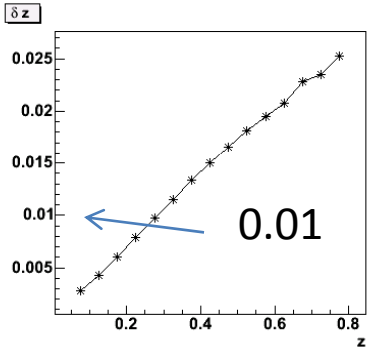


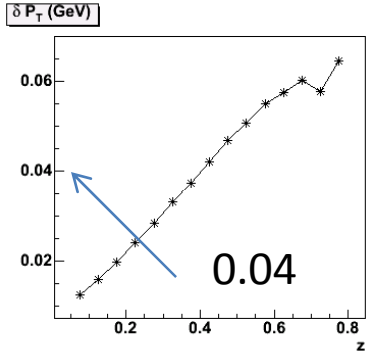
Based on 3% deltap/P
0.8 mr in polar angle
6 mr in azimuthal angle.

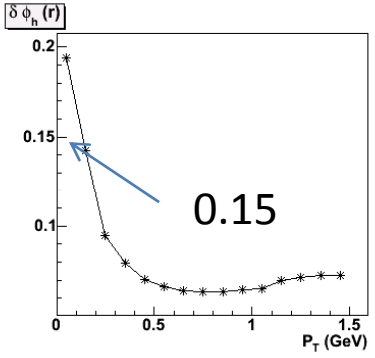








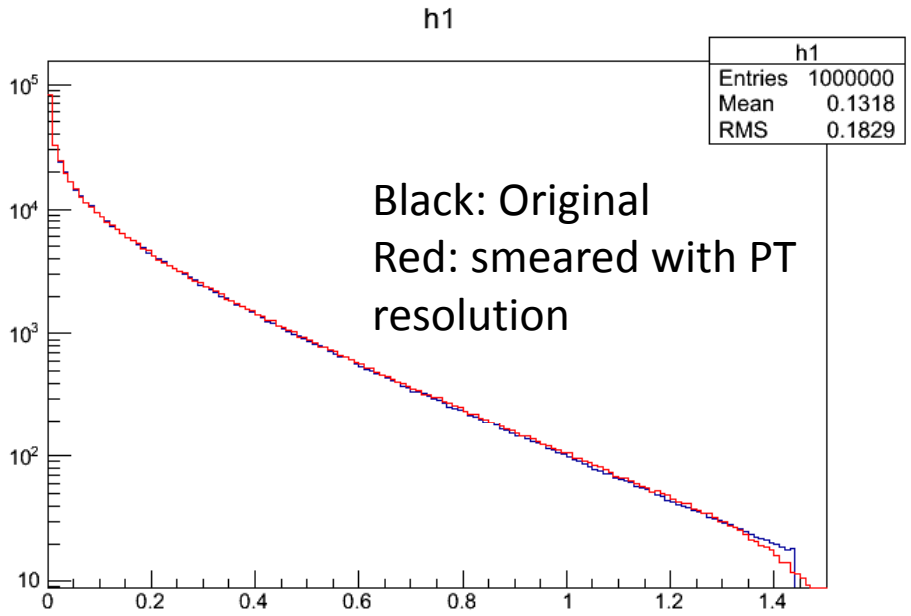




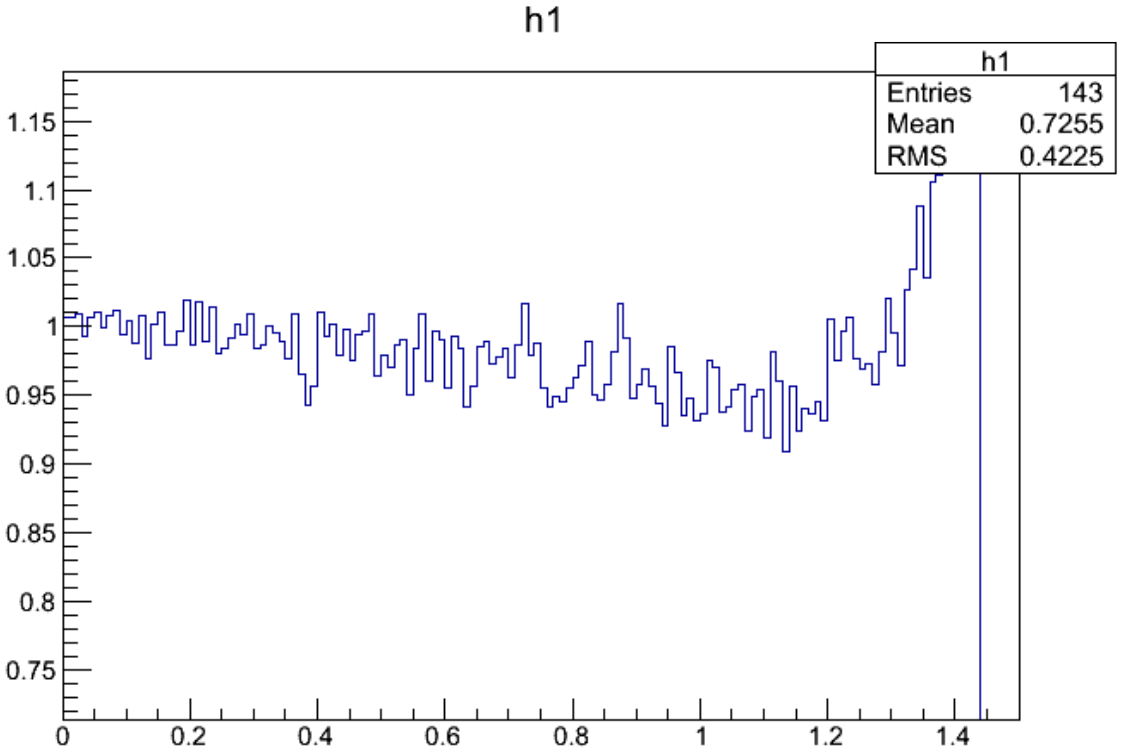
About PT resolution < 0.06 GeV

- PT^2 dependence is about 0.2 + z**2 * 0.25 GeV^2 ~ 0.2625 GeV2.
- Simulation to check change in PT2 distribution.
  - PT_Res = 0.01 + 0.055 * (z-0.1) /0.7
  - Weighted by exp(-PT^2/<PT2>)

distribution

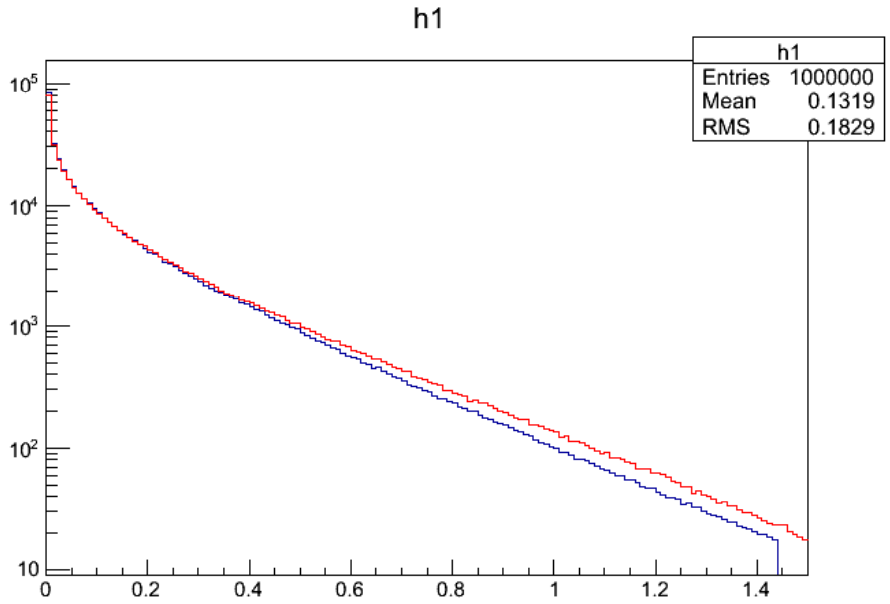


Ratio (Change is negligible with current numbers)



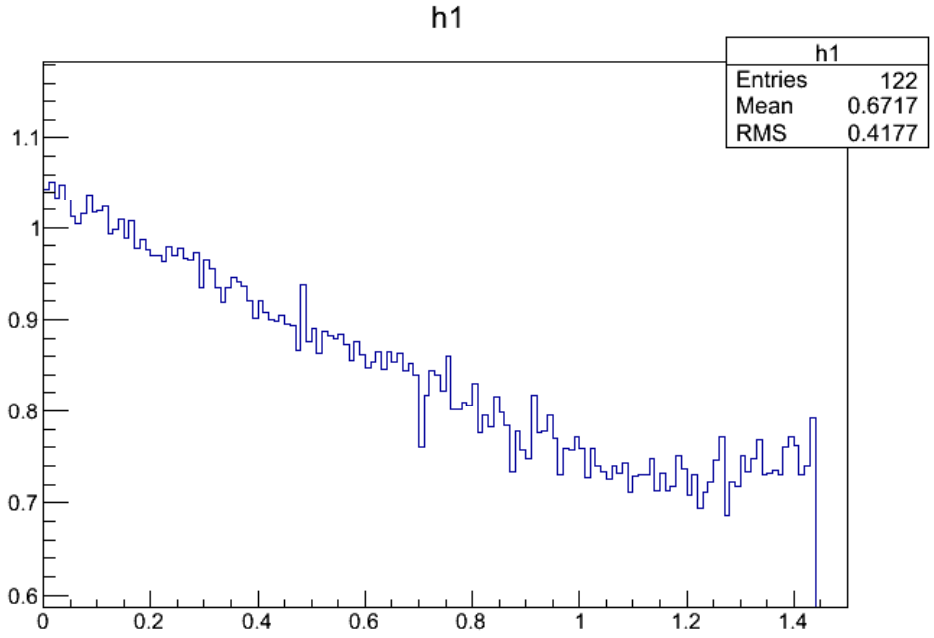
PT2 GeV^2

Sanity Check (with PT resolution worse a factor of 4)



PT2 GeV2

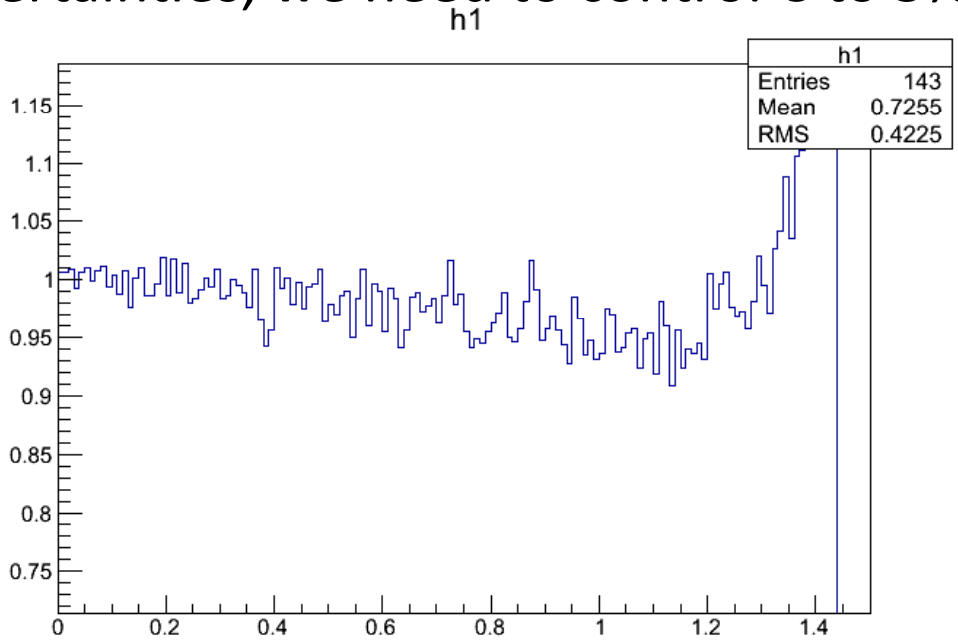
Will lead to up to 30% effect, which is correctable.



PT2 GeV2

Discussion

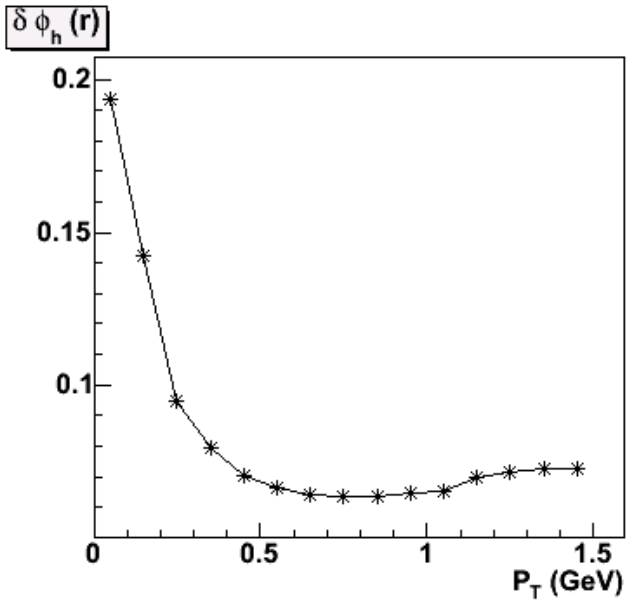
- When there is a resolution, we need to unfold the asymmetry from the measured ones. If we want to control the change to 1% *A
  - Assume contamination is about C (example)
    - C * 2 * A (need to know C to 0.5%), assuming a 10% uncertainties, we need to control C to 5%.



PT2 GeV2

What about azimuthal Angle?

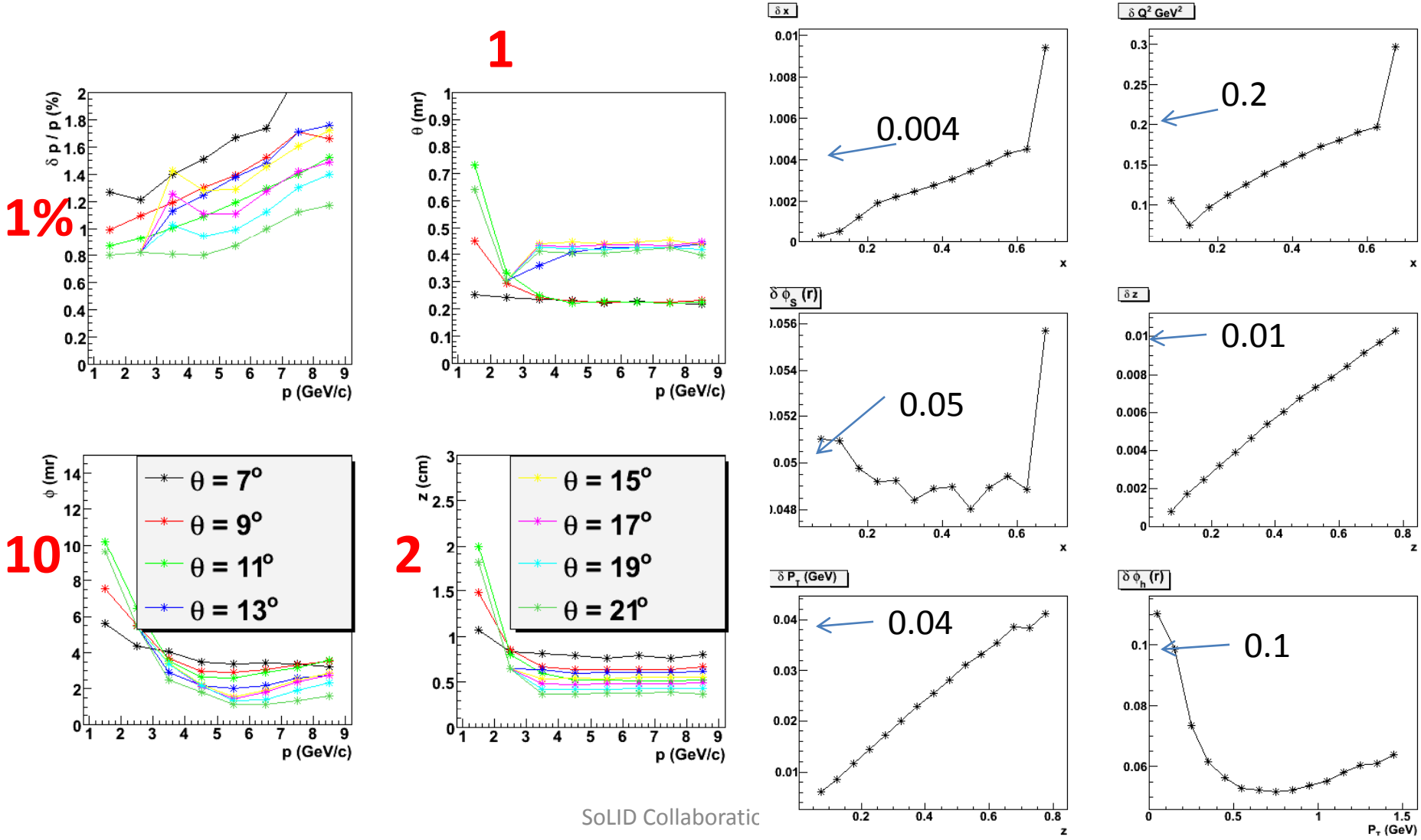
- Azimuthal angle resolution <0.1 rad ~ 5.72 degree (in systematic uncertainties, we considered the case of 8 degrees, 0.14 rad)
  - Low PT part really need better resolution?!



Note: with spectrometer, the we are always focusing at low PT part, so the resolution are bad in this region.

Of coz, we should always have some safety margins.

We also did the study for 68 um resolution with current readout

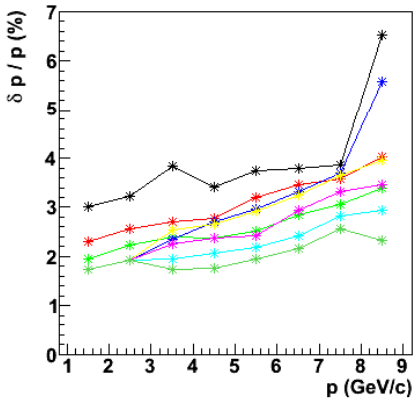


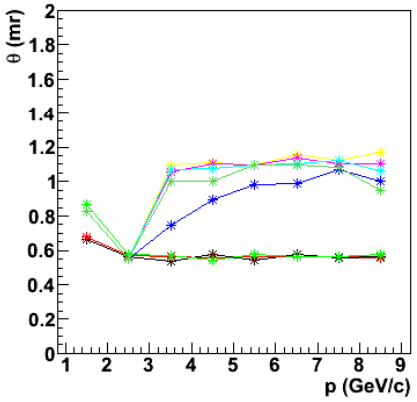
Discussions

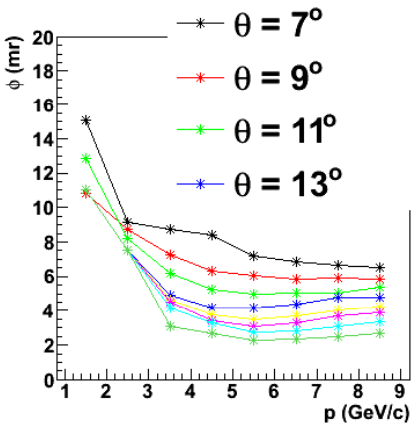
- With current design of readout, we are in a very comfortable situation with 70 um resolution.
- A 170 um resolution is marginal.
- We should set the goal to be **100 um**.
  - Is this a problem?
- What about different readout design?
- Other tricks?

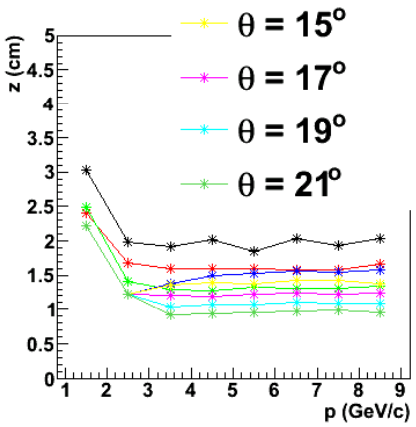
12 degree vs. 90 degrees

- 175 um resolution

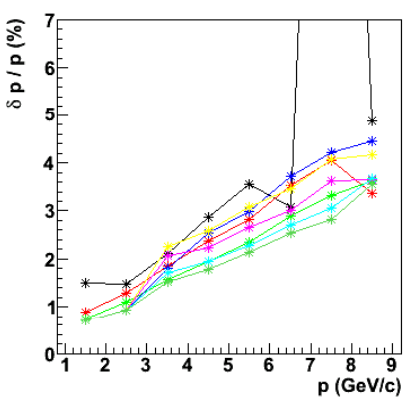


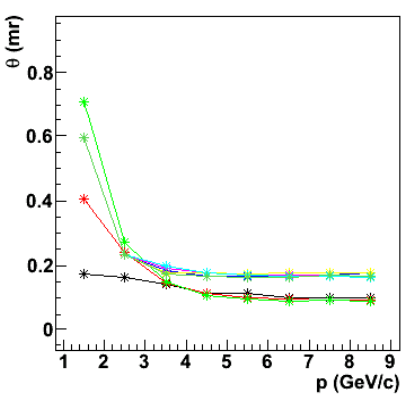


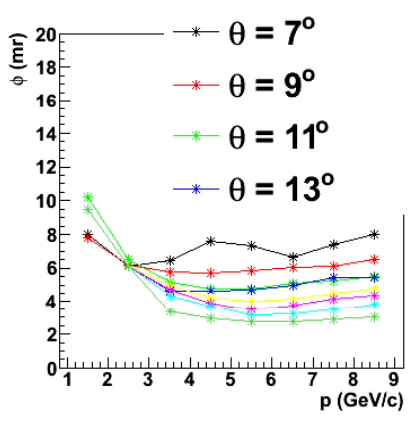


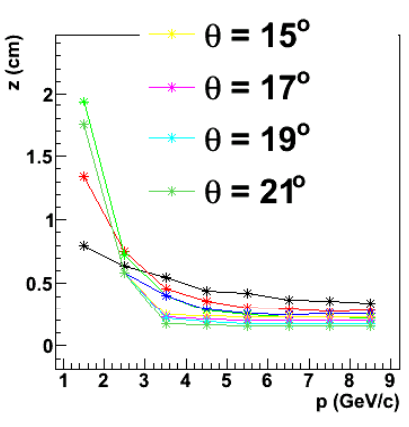


- 175 um resolution









Summary

- We confirm that resolution in transverse momentum is acceptable.
- Azimuthal angle resolution at low transverse momentum is one limiting factor.
- Require a 100 um position resolution with 12 degree readout or equivalent.