# BigBite optics and background study for transversity experiment
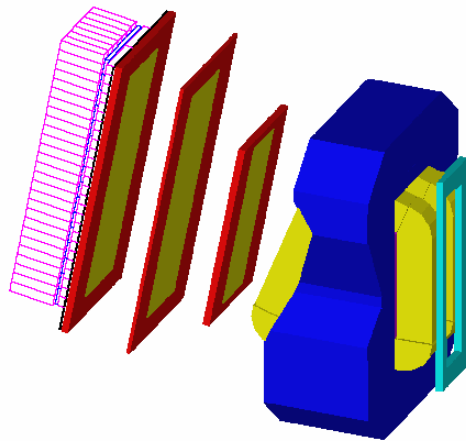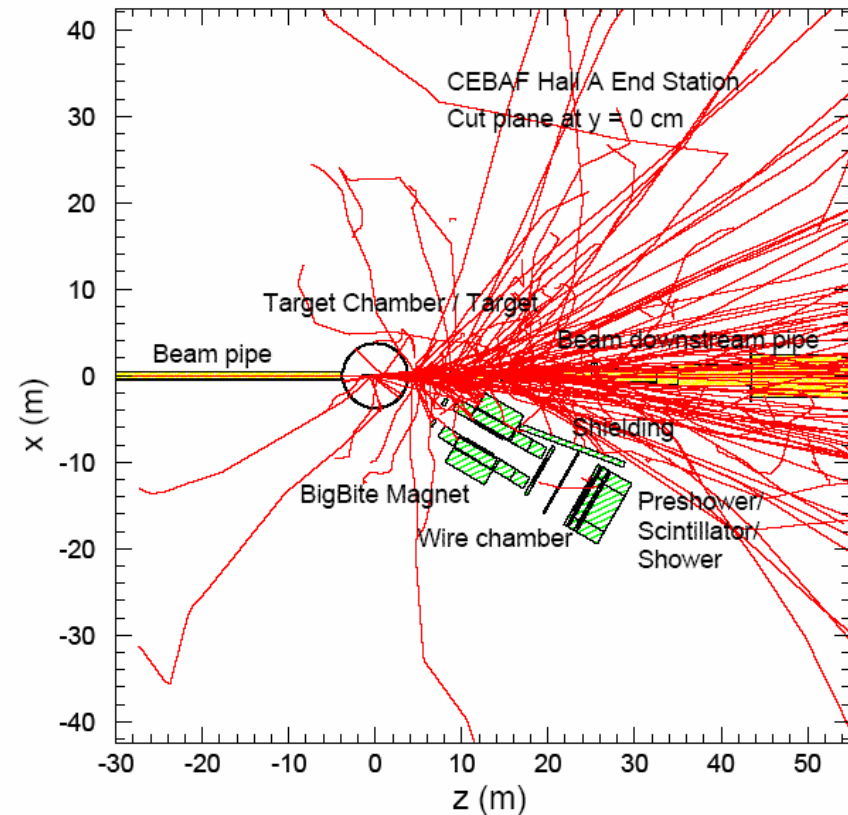
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# Simulation (from Pavel Degtiarenko)

- ☐ GEANT3 with modified physics.
- ☐ Modified Physics:
    - ■ Use exclusive event generator: photon-nuclear fragmentation package DINREG in GEANT substitutes old 'PFIS' mechanism.
    - ■ Electron-nuclear interactions are modeled using equivalent photon representation of an electron.
- ☐ Geometry: target, BigBite magnet, detector, beam pipe, beam dump and Hall.
- ☐ Output: histogram, and Ntuple.
- ☐ Version: interactive, batch.

# Background study summary

☐ Comparisons were performed for transversity test run, Neutron N20 test run, SRC data, bare wire chamber test run, GEN (three kinematics).
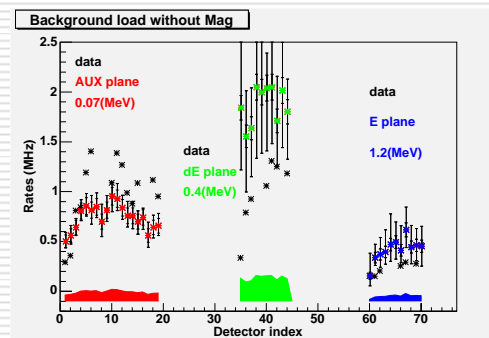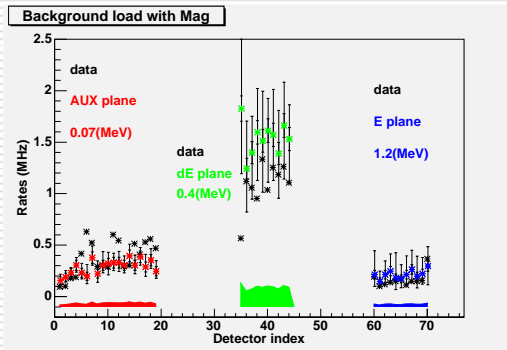


SRC data: 70 kHz, Simulation: 142.8 +- 5.8 (stat) +- 24.8 (sys) kHz.
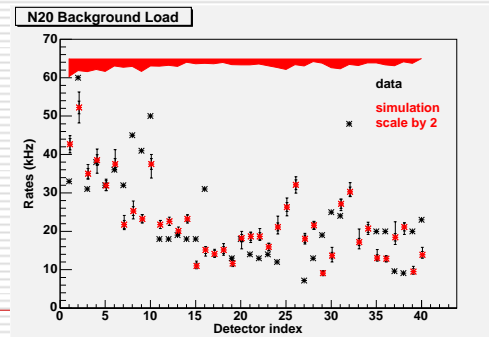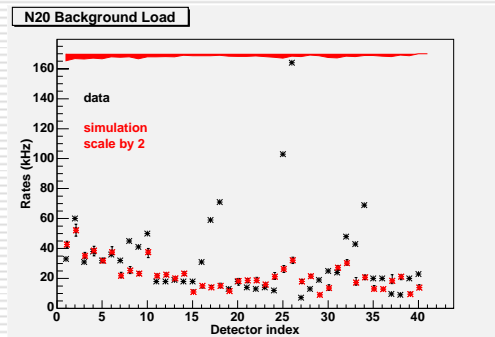
Data: rate per wire: 1.8 kHz.
Simulation with 5.0 keV cut: 1.76 +- 0.12 (stat.) +- 0.57 (sys.) kHz.

# Background study summary

- GEN: data (simulation) MHz
  - 1st: 14 (12) , 7 (4.07) , 5 (3.41)
  - 2nd: 10.5 (7.2), 12.2 (12.7), 11.6 (11.0)
  - 3rd: 15.0 (8.5), 16.7 (16.6), 11.6 (12.72)
- In general, the difference between the simulation result and the data is within 2.
- In particular, for BigBite low energy background during GEN experiment, the difference is within 30%.

# Background study summary

- ☐ Transversity situation:

TRAN 10uA, 6GeV, 30 degree, with thick shielding wall.

|  | BD1(MHz) | BD2(MHz) | BD3(MHz) |
|---|---|---|---|
| GEN: | 19.2 | 22.0 | 19.3 |
| TRAN: | 10.6 | 23.0 | 23.0 |

With more shielding, collimator, improvement in tracking algorithim, we may go back to 15 uA (in proposal).

Note: wire chamber should stand background at 15 uA, tracking is the major concern.

# Physics background study

- ☐ Naïve pion rejection study for shower system gives ~ 100:1 pion rejection.
- ☐ Single pion/e ratio estimation 370-100-30-10:1.
- ☐ Random coincidence R=0.01 Hz (worst case) with 10 ns coincident window, factor of 5 due to vertex cut, 50 pion rejection.
- ☐ Physics rate R~ 0.5 Hz.
- ☐ Two pion coincident background for positive pion detection:
  - ■ Dipangkar Dutta gives an estimation of 0.1 Hz using photon nulcean exclusive two pion production.
  - ■ Peter Bosted is using HALL B Eg1b data to give ratio of these two reaction channel.
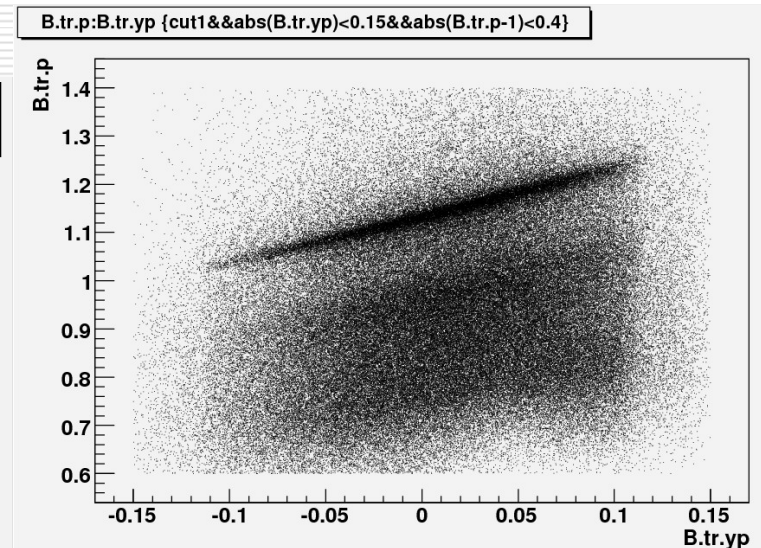- ☐ Gas Cherenkov can definitely increase our PID ability in electron arm.
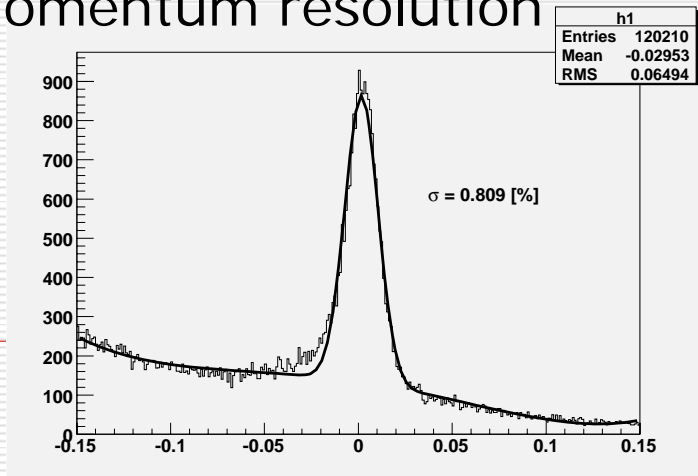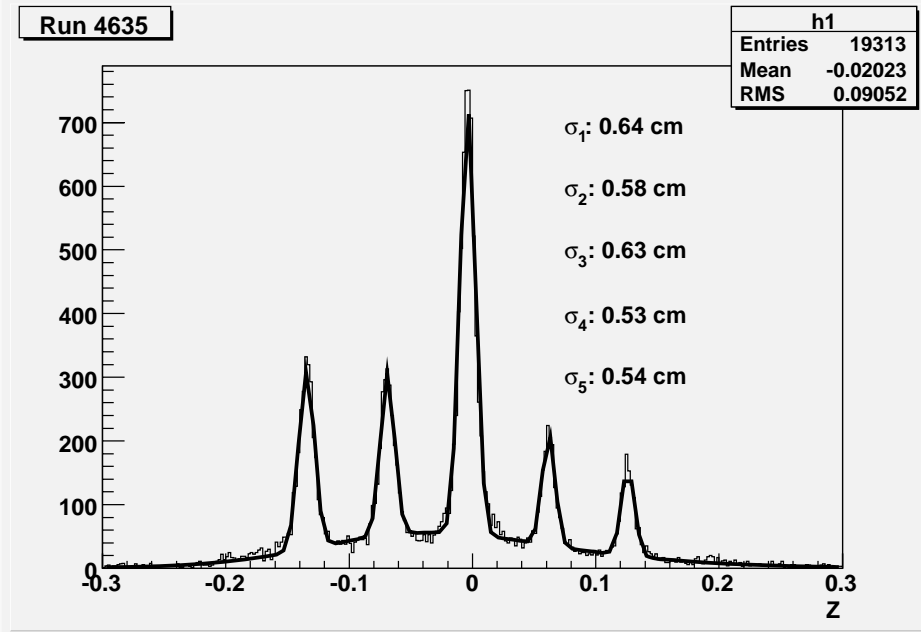
# Optics study

- ☐ Phase space
- ☐ 4 bins in x
- ☐ Loose requirement for momentum (Goal: 1~2%)
- ☐ Vertex resolution can reduce random coincident background. (Goal: 7.5 cm overall cut, 0.7 cm for BigBite vertex resolution)
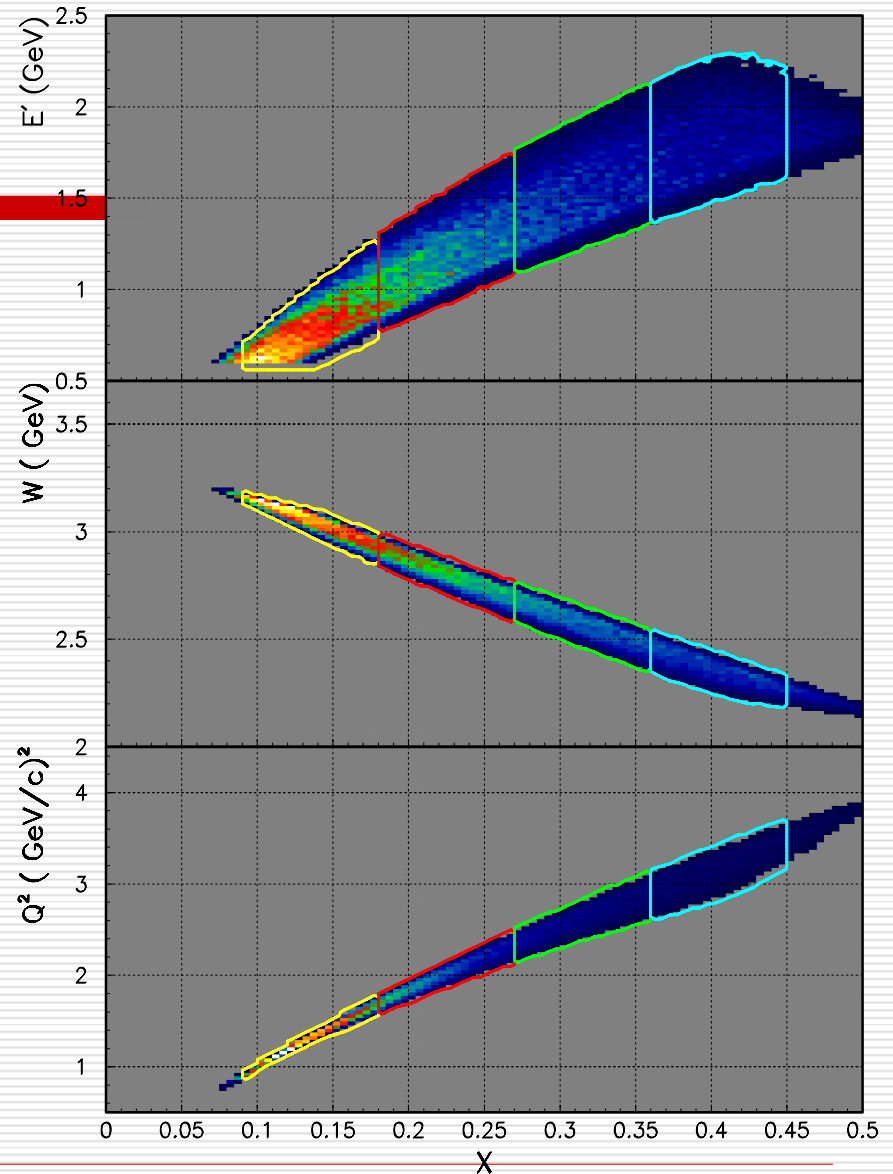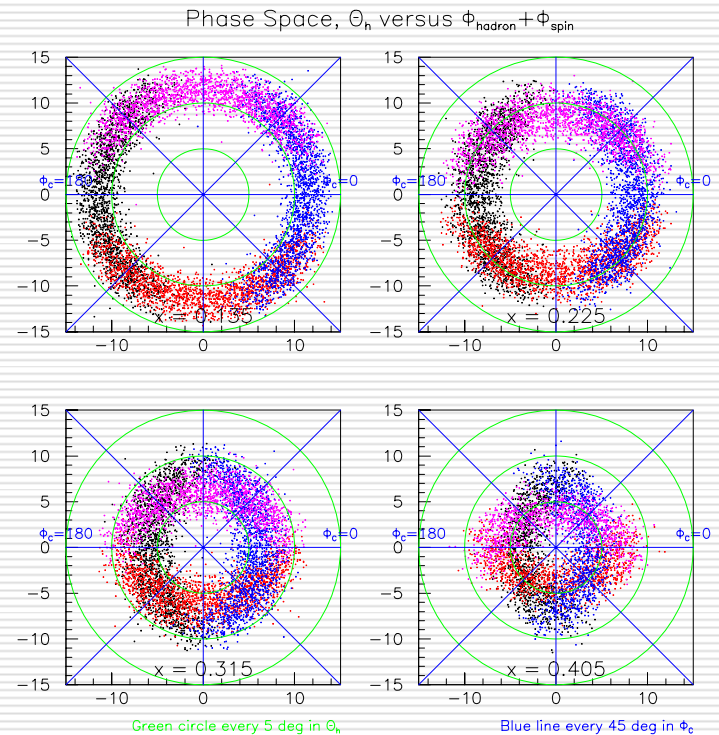
# Result from TRANSVERSITY optics test run

- □ 1.5 m drift distance at 52 degree.
- □ Naïve estimation of In-plane-angle resolution from Y_targ resolution ~ 1.8 mr.
- □ Clean ep elastic strip
  - ■ Less than 1% momentum resolution

**Run 4635**

| h1 | |
|---|---|
| Entries | 19313 |
| Mean | -0.02023 |
| RMS | 0.09052 |

$\sigma_1$: **0.64 cm**

$\sigma_2$: **0.58 cm**

$\sigma_3$: **0.63 cm**

$\sigma_4$: **0.53 cm**

$\sigma_5$: **0.54 cm**

Z

| h1 | |
|---|---|
| Entries | 120210 |
| Mean | -0.02953 |
| RMS | 0.06494 |

$\sigma$ = **0.809 [%]**

B.tr.p:B.tr.yp {cut1&&abs(B.tr.yp)<0.15&&abs(B.tr.p-1)<0.4}
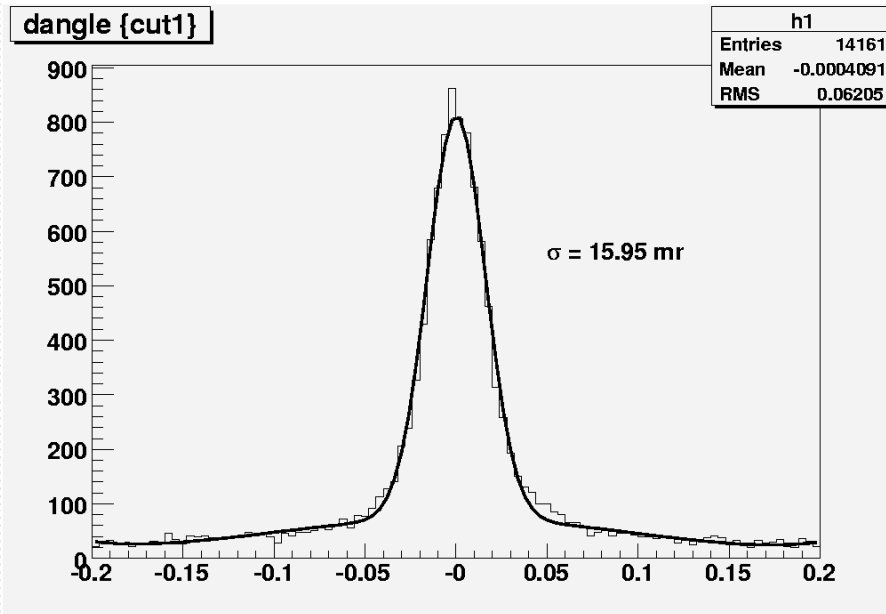
B.tr.p

B.tr.yp

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# Out-of-plane angle requirement

- Out-of-plane angle is very important to transversity experiment:
  - Separation of Collins (transversity) and Sivers (access to TMD, angular momentum) effect.
  - The large out-of-plane angle mostly came from large acceptance of BigBite:
    - 480 mr for out-of-plane angle coverage and 134 mr for in-plane angle coverage.
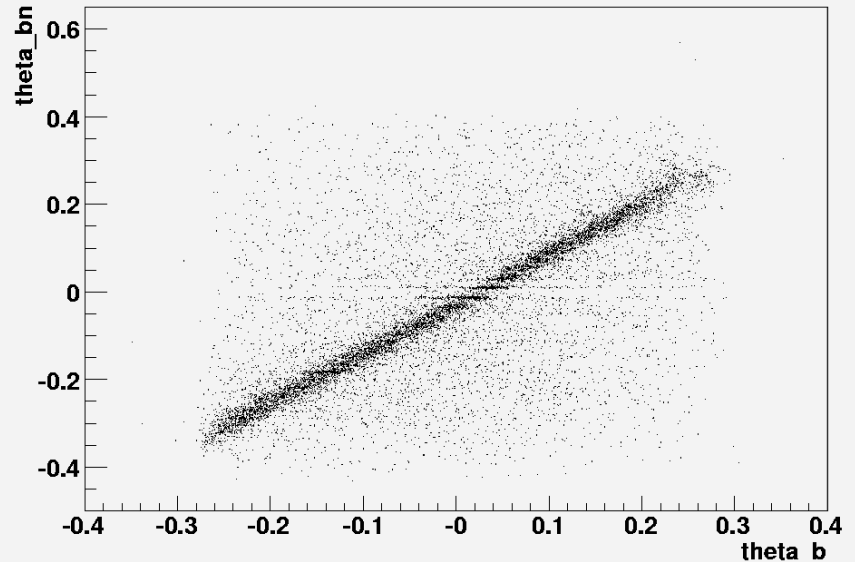  - From HRS, the requirement of BigBite out-of-angle resolution is 10 mr (FWHM).

Phase Space, $\Theta_h$ versus $\phi_{hadron} + \phi_{spin}$

Green circle every 5 deg in $\Theta_h$

Blue line every 45 deg in $\phi_c$

# Result from TRANSVERSITY optics test run

☐ Neutron arm will give a ~ 24.4 mr resolution (15 cm at 9 m).

☐ Need neutron arm information to calibrate.



theta_bn:theta_b {cut1}



dangle {cut1}

| h1 | |
|---|---|
| Entries | 14161 |
| Mean | -0.0004091 |
| RMS | 0.06205 |

$\sigma$ = 15.95 mr
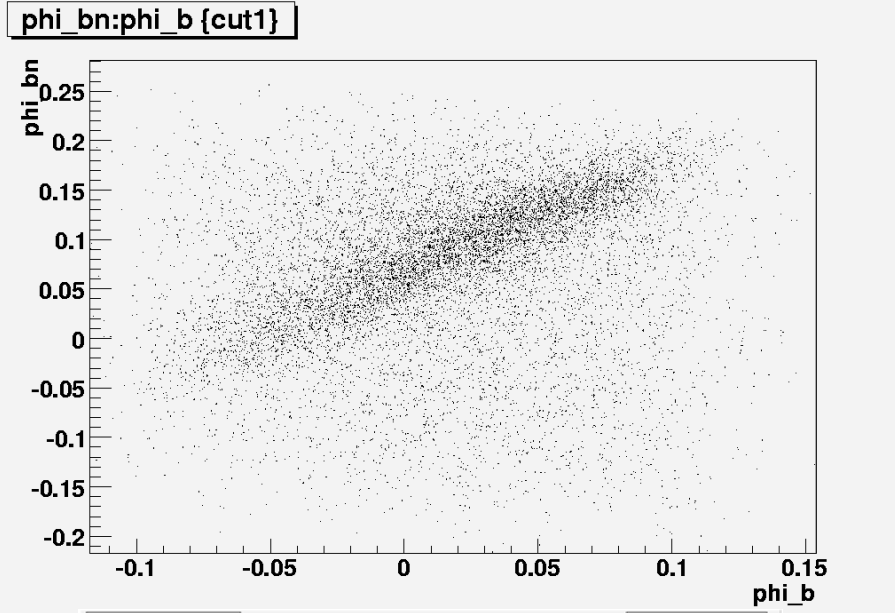
Add first order correction for resolution study purpose.
Naïve estimation of out-of-plane angle resolution is ~ 30. mr (FWHM). (larger than 10 mr requirement)
Maybe enough comparing with 480 mr acceptance.

# Result from TRANSVERSITY optics test run
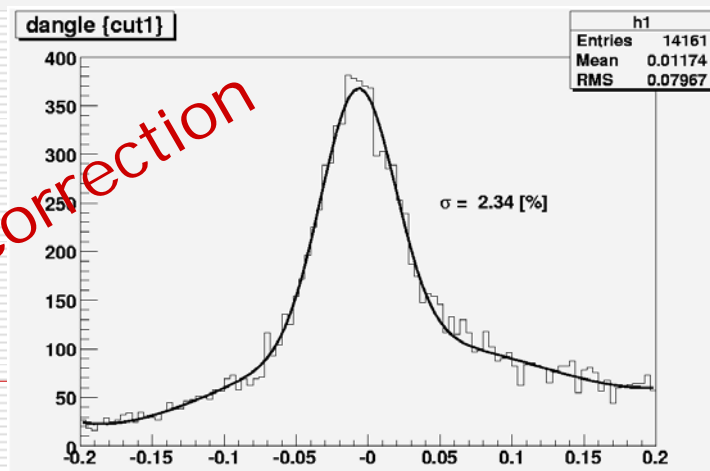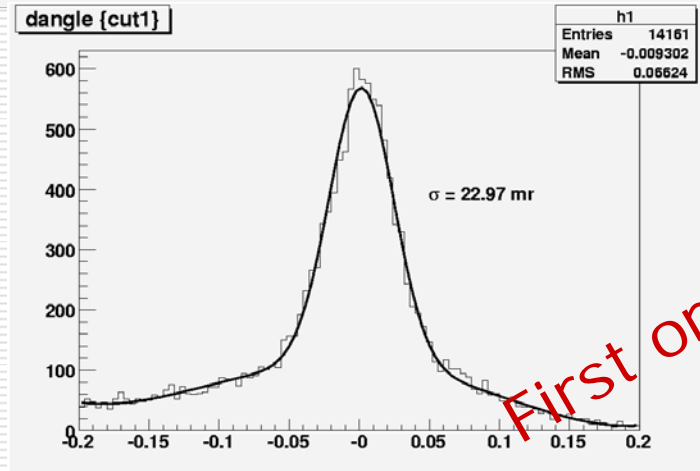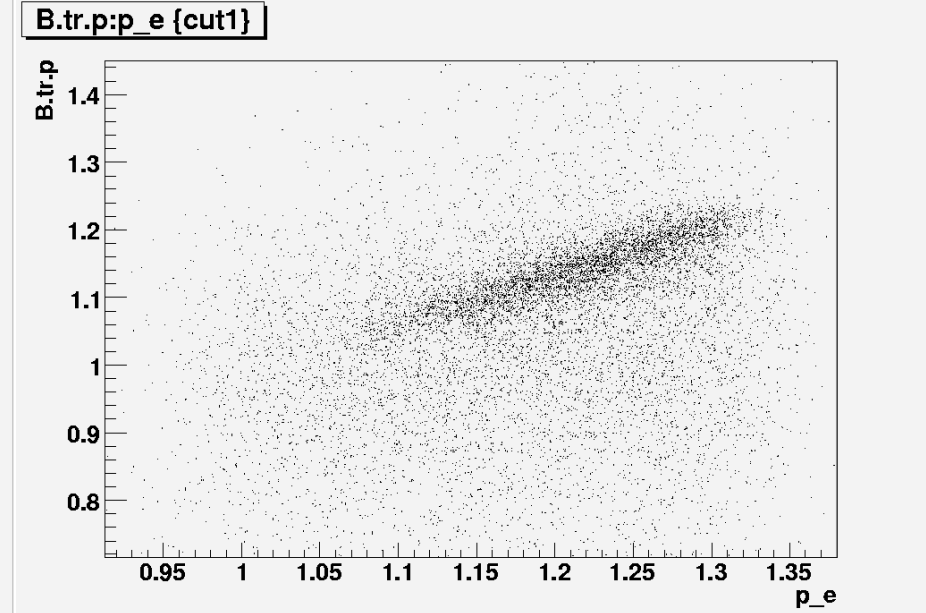


First order correction

# Comments on optics study

- ☐ Neutron arm results do not agree with BigBite tracking reconstruction.

  - ■ Can be geometry problem.
  - ■ Will be used to check BigBite tracking reconstruction after final calibration.

- ☐ Vertex, momentum, in-plane-angle resolution should exceed our requirement.

- ☐ Need more work on out-of-plane-angle resolution (may not be good enough).

# Future work

- TRANSVERSITY experiment need a optics model which can describe particle of momentum range (0.6 GeV/c – 2.0 GeV/c) at 1.5 m drift distance (40 cm target with 30 degree).
- One ep elastic scattering can only cover a limited momentum range. So we need to combine all available optics to generate a optics model.
  - Work out a good optics reconstruction for each kinematics.
  - Select a good sample of ep elastic events for each kinematics.
  - Start building Bigbite magnet model which can describe all five (1.1m and 1.5m drift distance) kinematics.