Hall C Spectrometer Optics

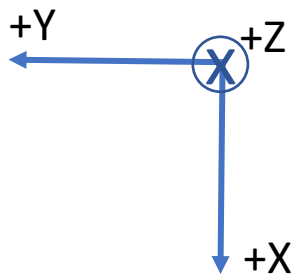
Jpsi-007 Collaboration Meeting

Oct 26, 2018

Holly Szumila-Vance

Coordinate Systems

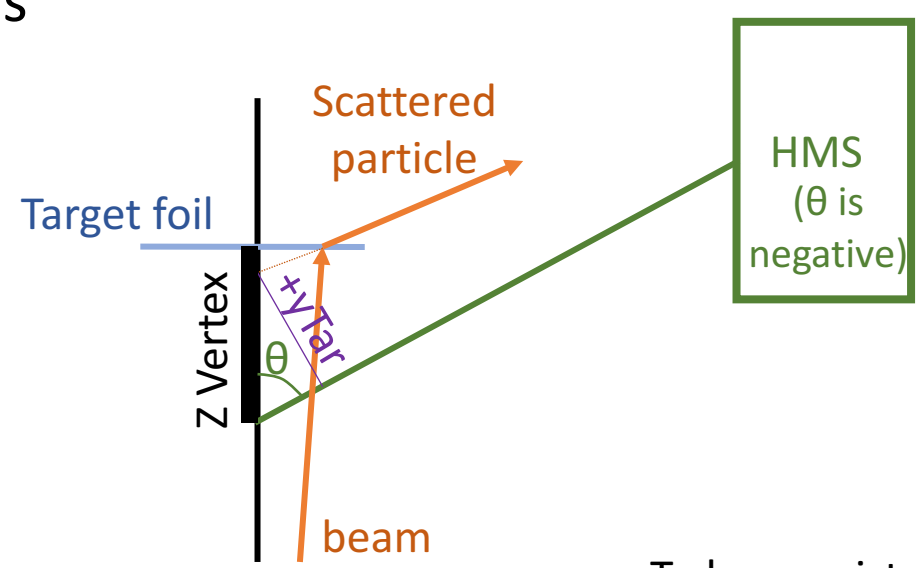
Transport:



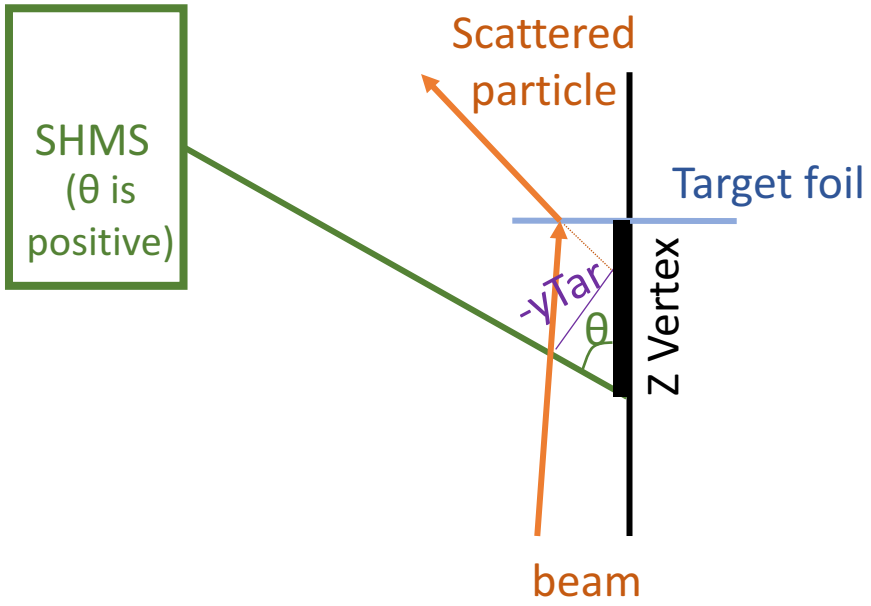
+X: down/vertical/dispersive

+Y: beam left/horizontal/non-dispersive

+Z: Along central ray/into spectrometer/downstream



To be consistent, implies +yTar is downstream for HMS and upstream for SHMS!



Variables in replayed ROOT files

- Focal plane quantities are from drift chamber variables:

P.dc.x_fp	$x_{\text{focal plane}}$
P.dc.y_fp	$y_{\text{focal plane}}$
P.dc.xp_fp	$x'_{\text{focal plane}}$
P.dc.yp_fp	$y'_{\text{focal plane}}$

- Target reconstructed quantities are golden track variables:

P.gtr.dp	delta
P.gtr.x	x_{target}
P.gtr.y	y_{target}
P.gtr.ph	y'_{target}
P.gtr.th	x'_{target}

- Raster

P.react.x	raster x position, cm
P.react.y	raster y position, cm

Technically, tangents of the angles:

$$x' = \frac{\mathrm{d}x}{\mathrm{d}z}$$
$$y' = \frac{\mathrm{d}y}{\mathrm{d}z}$$

Small approx, same as angle in radians

DATFILES has a README to explain the various recon Matrix Elements

Point to your desired ME for recon in here:

PARAM/SHMS/GEN/pcana.param

Offsets, noted in the README and/or header file of ME are put here:

PARAM/SHMS/GEN/shmsflags.param:

From 0^{th} order ME, put in X'_{target} offset (labeled as *phi_offset*...)

```
! reconstruction matrix elements for SHMS, 23 Mar 2018
! <theta y phi delta | nmpq>;(x**n xp**m y**p yp**q)
! as of 03/23/18, no z offset included
! created: 03/23/18
! zeroth order matrix elements from fitting:
! <theta|> 0.000483 rad
! <y|> 5.613501015e-04 m
! <phi|>  6.628772870e-04 rad
! <p|> 0.0 %
! <theta y phi delta | nmpq>;(x**n xp**m y**p yp**q)
```

pphi_offset here = 0.000483

From actual SHMS offsets found this past spring, we shifted the $y_{focal\ plane}$ (in *pdc_geom.param*) by -0.429871 cm.

Also 0^{th} order Matrix Element
Offsets: X', Y'

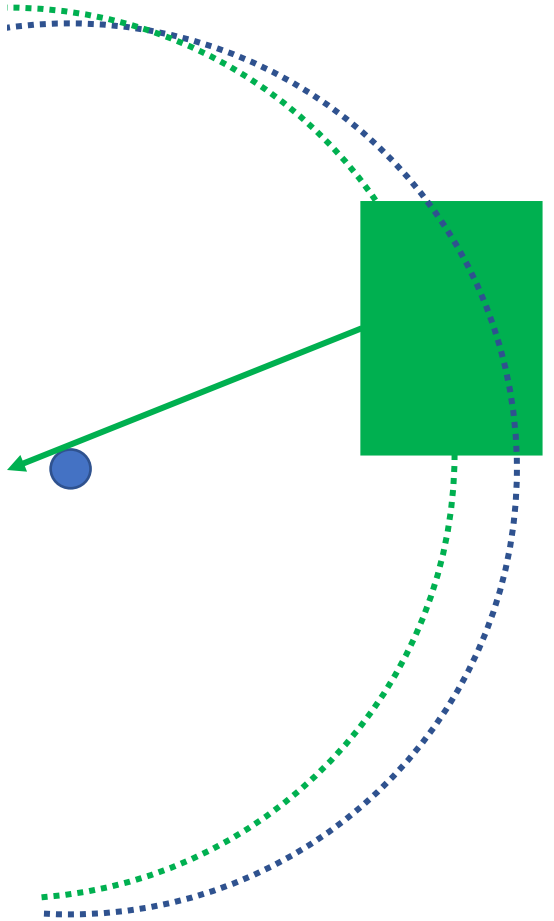
Offsets

Beam offsets:
X, Y, X', Y'

From BPMs in Fall17/Spring18 runs, this was all 0

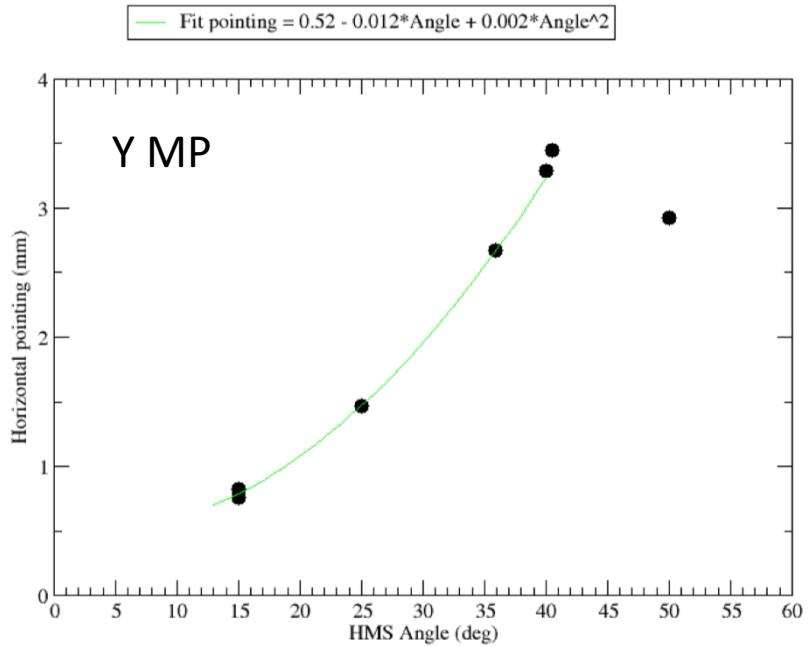
Mis-pointing:
X, Y

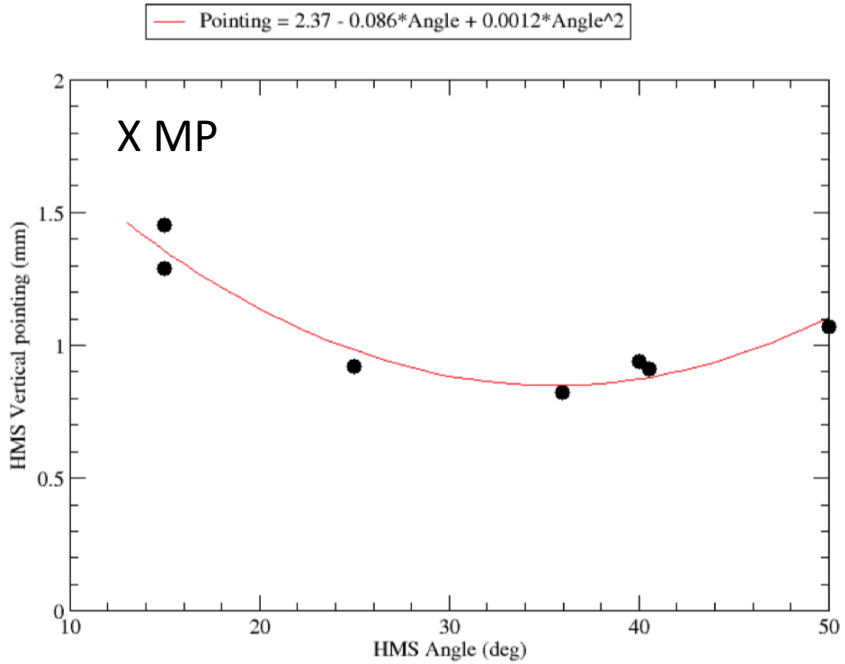
Mis-pointings from survey. Vary with angle, could also vary with other spectrometer angle!



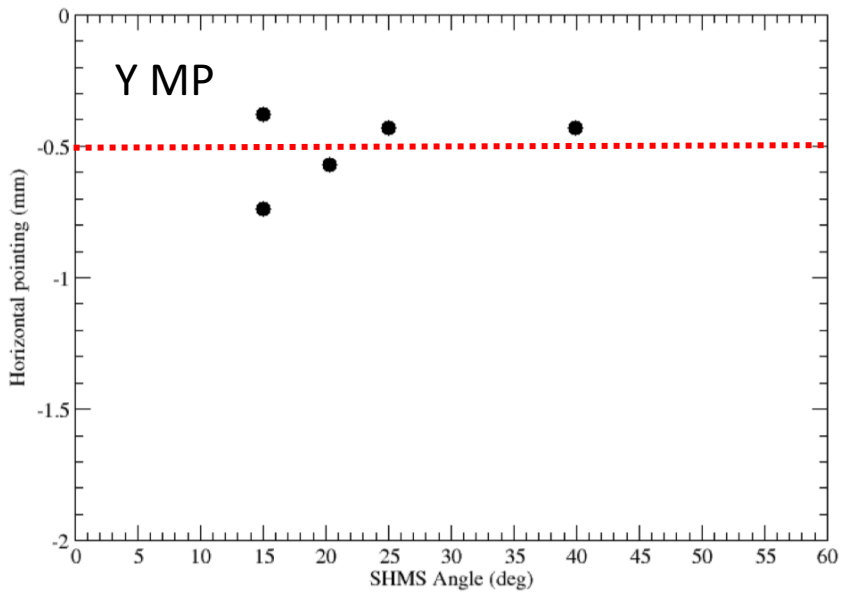
During optimization, HMS MP were offset. SHMS MP flat for all runs.

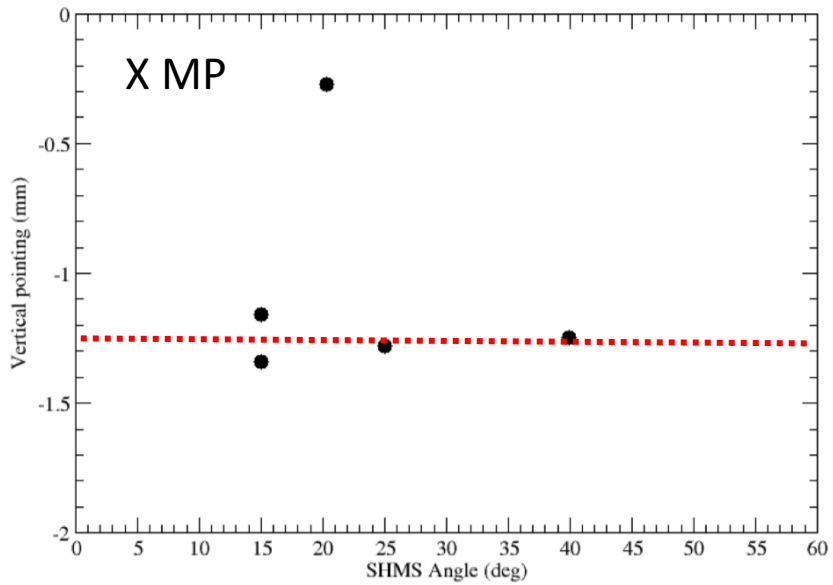
HMS surveys: HMS mis-pointing in X and Y as a function of HMS angle





SHMS surveys: HMS mis-pointing in X and Y as a function of HMS angle





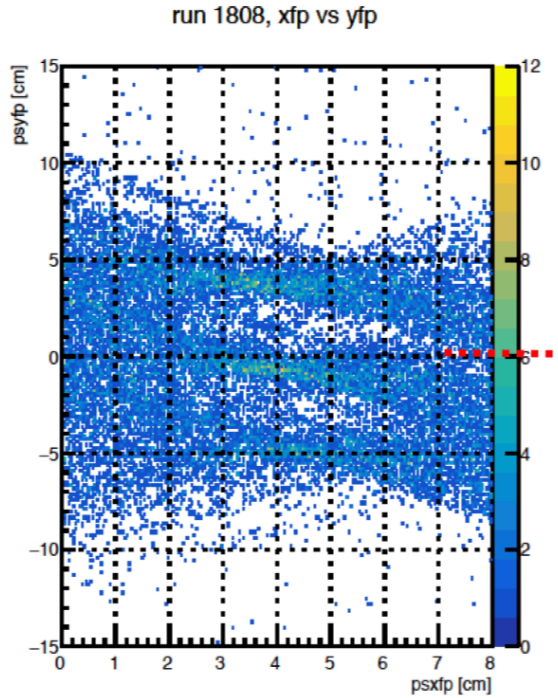
https://hallcweb.jlab.org/elogs/Commissioning+Experiments+Analysis/180221_141950/survey-summary.pdf

Matrix Optimization codes:

https://github.com/hszumila/HMS_optics (detailed README to run on ifarm)
https://github.com/hszumila/SHMS_optics

Adapted from:
https://github.com/brash99/HMS_optics

Good note from Jure:
https://hallcweb.jlab.org/DocDB/0008/000849/001/HMS_optics_notes.pdf



Notice: yfp of center foil is low

Features:

- Mis-pointings can be input run by run
- Flag in SHMS for sieve or shifted sieve
- Optimized matrix currently in use **spans 15-30deg angles and 2-4 GeV central P**

Matrix Optimization

We begin with the focal plane quantities from the drift chambers: yfp, xfp, ypfp, xpfp

We ultimately want to reconstruct the events at the interaction point.

General procedure:

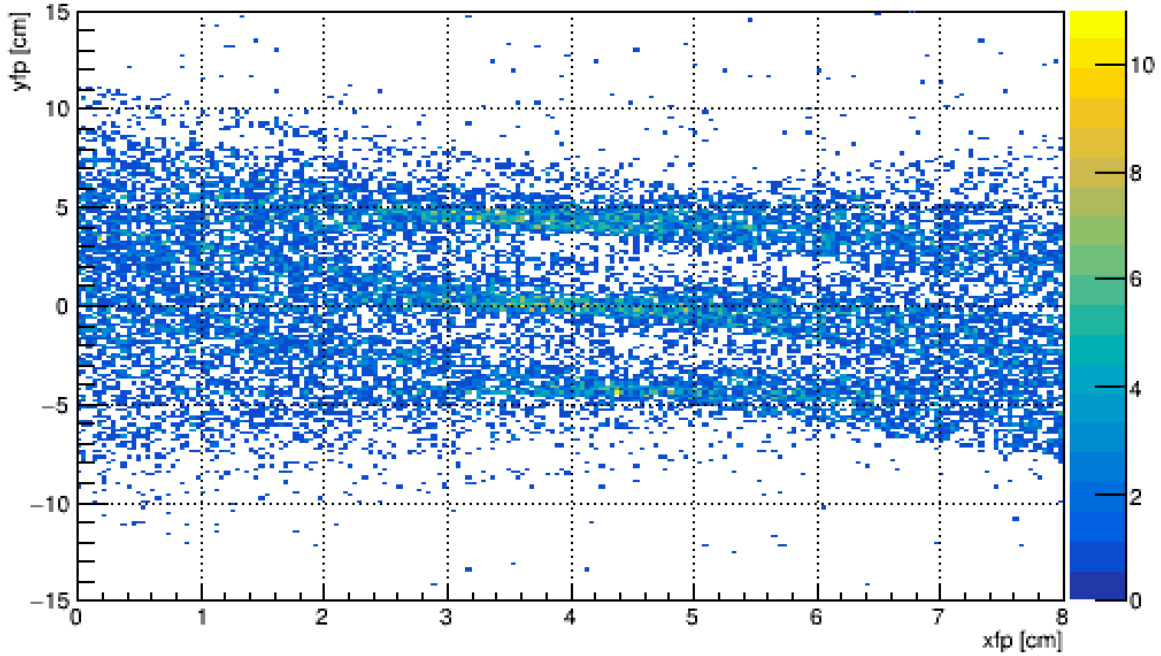
1. Reconstruct events using the best reconstruction matrix we have (from COSY)
2. Determine the true values (events passing through sieve)
3. Minimization of difference between reconstructed variables with true values
4. Calculate optimized matrix

$$x'_{\mathrm{tar}} = \sum_{i,j,k,l,m} X'_{i,j,k,l,m} \cdot x_{\mathrm{fp}}^{i}\, x'^{j}_{\mathrm{fp}}\, y_{\mathrm{fp}}^{k}\, y'^{l}_{\mathrm{fp}}\, x_{\mathrm{tar}}^{m}$$

$$y_{\mathrm{tar}}^{\mathrm{rec}} = \sum_{i,j,k,l,m} Y_{i,j,k,l,m} \cdot x_{\mathrm{fp}}^{i}\, x'^{j}_{\mathrm{fp}}\, y_{\mathrm{fp}}^{k}\, y'^{l}_{\mathrm{fp}}\, x_{\mathrm{tar}}^{m}$$

$$y'_{\mathrm{tar}} = \sum_{i,j,k,l,m} Y'_{i,j,k,l,m} \cdot x_{\mathrm{fp}}^{i}\, x'^{j}_{\mathrm{fp}}\, y_{\mathrm{fp}}^{k}\, y'^{l}_{\mathrm{fp}}\, x_{\mathrm{tar}}^{m}$$

$$\delta_{\mathrm{tar}} = \sum_{i,j,k,l,m} D_{i,j,k,l,m} \cdot x_{\mathrm{fp}}^{i}\, x'^{j}_{\mathrm{fp}}\, y_{\mathrm{fp}}^{k}\, y'^{l}_{\mathrm{fp}}\, x_{\mathrm{tar}}^{m}$$

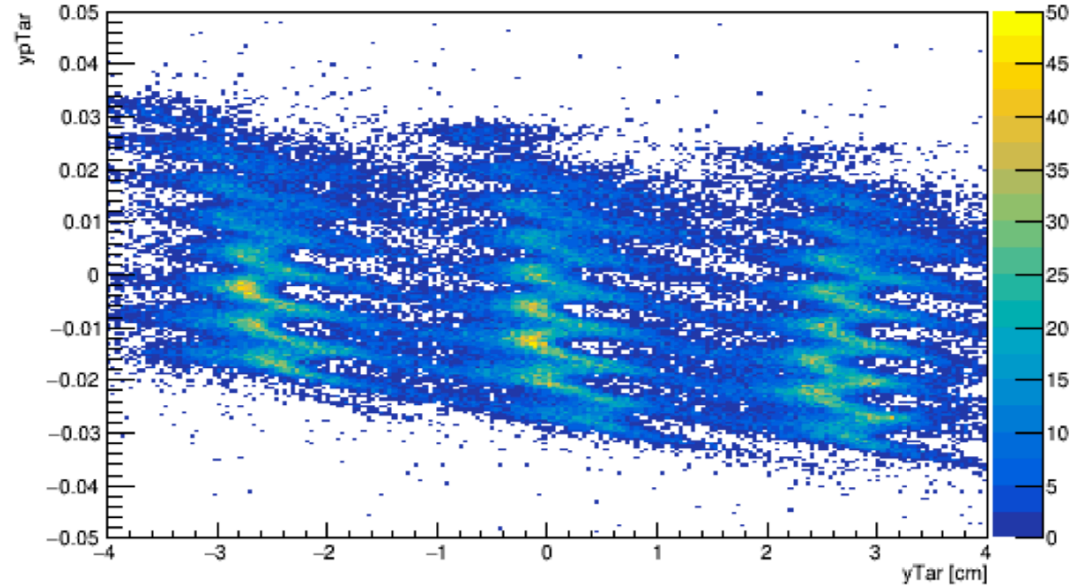


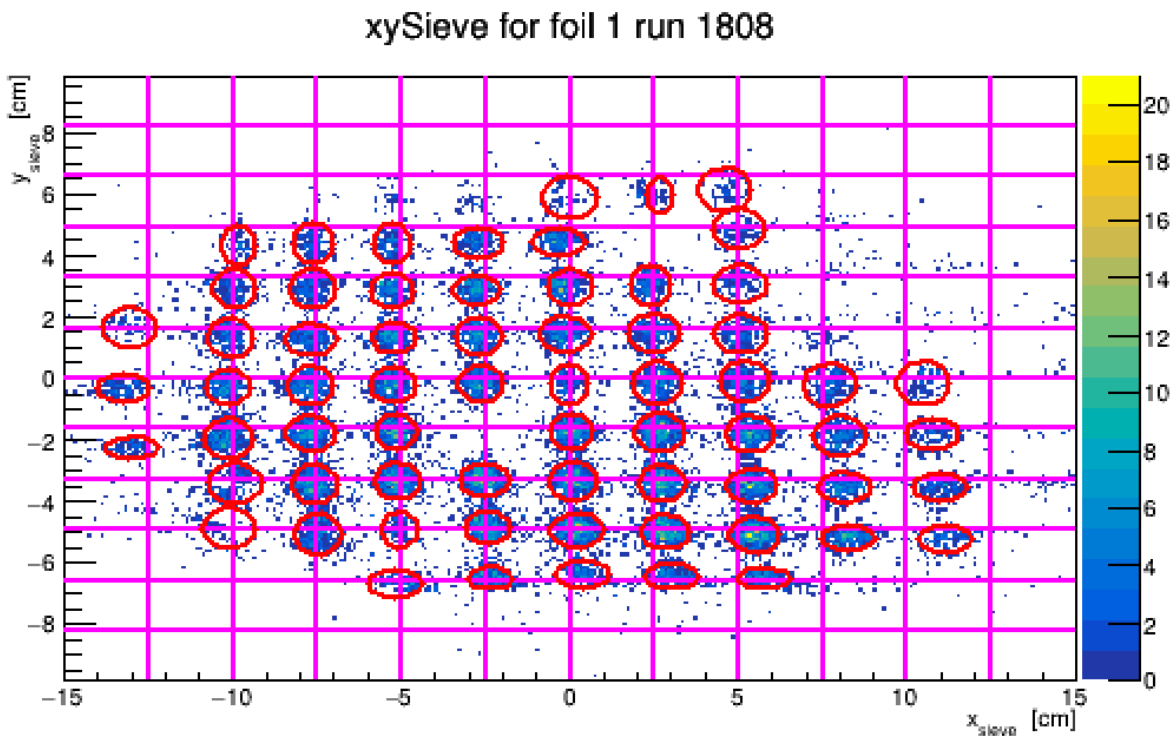
Matrix elements reconstruction file contains the coefficients and powers:

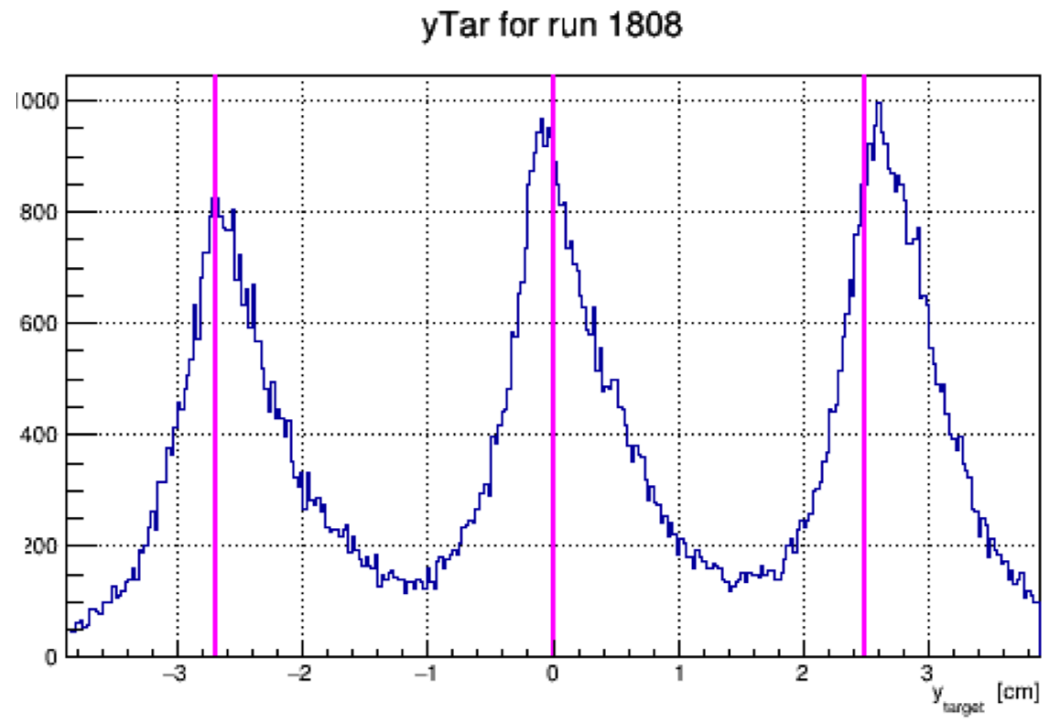
$$X'_{i,j,k,l,m} \quad Y_{i,j,k,l,m} \quad Y'_{i,j,k,l,m} \quad D_{i,j,k,l,m} \quad ijklmn$$

Take runs at various angles and central momenta:

- First pass through data, determine which foil events came from.
- Second pass, selecting events in each foil, plot the x,y sieve distributions. Select events from each sieve hole.
- For the same number of events in each sieve hole, perform Singular Value Decomposition on the difference between data events and real sieve hole position.
- Minimize over yTar, xpTar, ypTar.



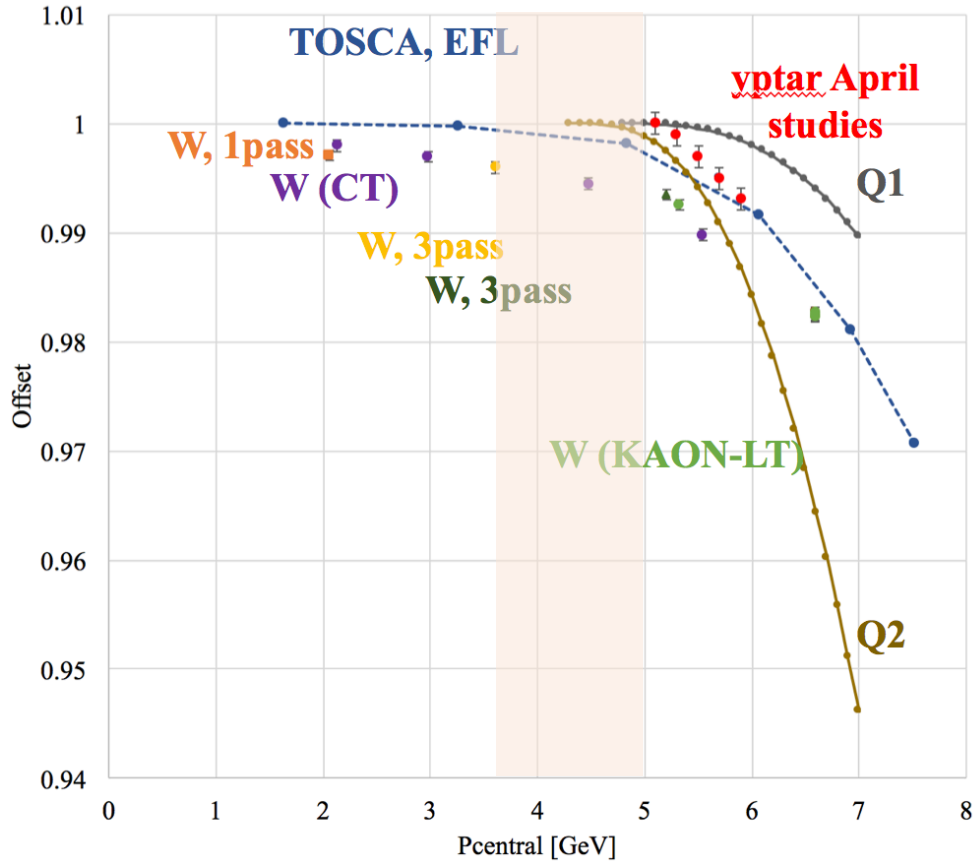




Jspi-007 Settings:

1: P_HMS = -3.45 theta_HMS = 32.8deg. P_SHMS=4.35 theta_SHMS=13.6deg.
2: P_HMS = -4.75 theta_HMS = 20.0deg. P_SHMS=4.25 theta_SHMS=20.0deg.
3: P_HMS = -4.95 theta_HMS = 18.6deg. P_SHMS=4.95 theta_SHMS=16.7deg.

HMS



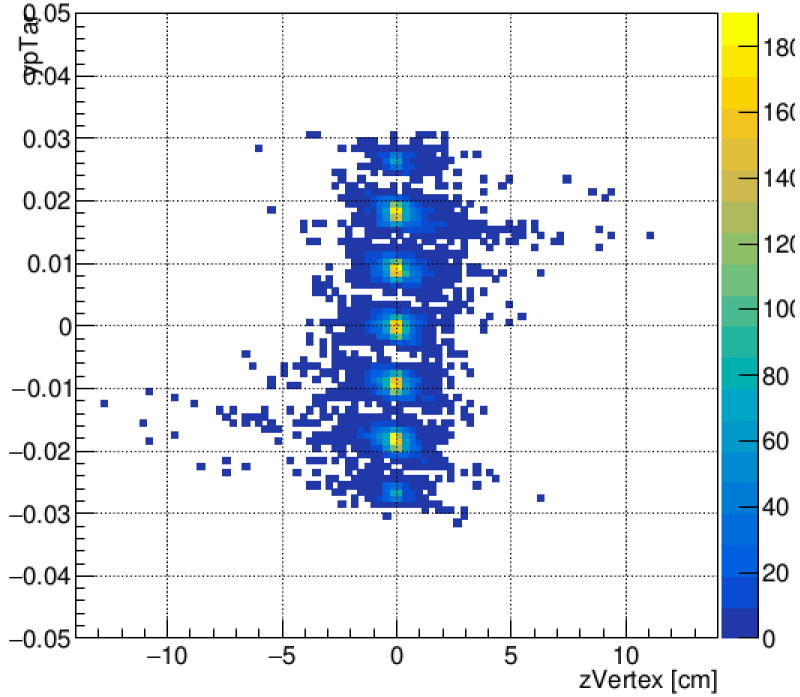
HMS:

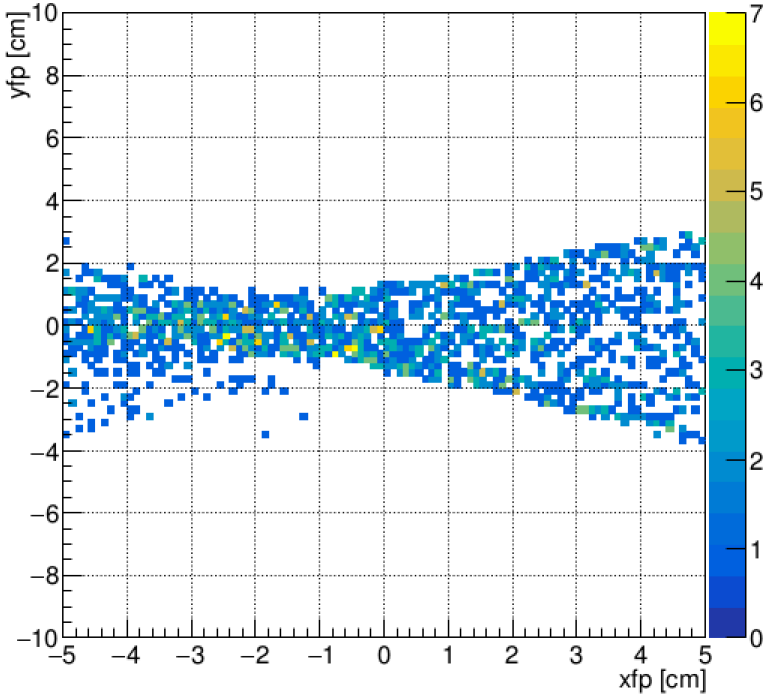
- consistent MP data at these angles
- optics (yptar vs zvertex) look good in this range
- W offset seen in H data that is still being studied (possible quad effect?)

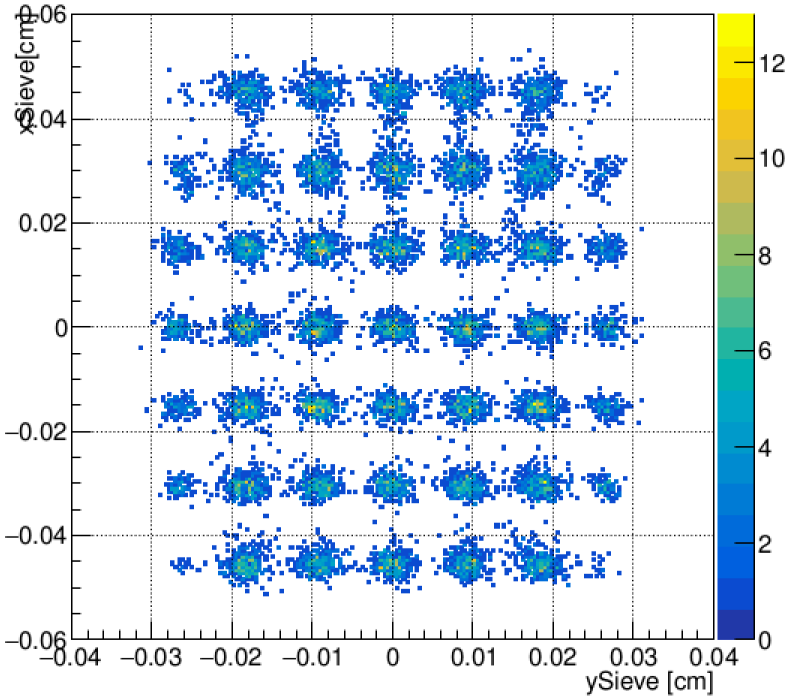
SHMS:

- optimized over these angles
- HB and Q1 seem to have reliable/consistent effects in this range

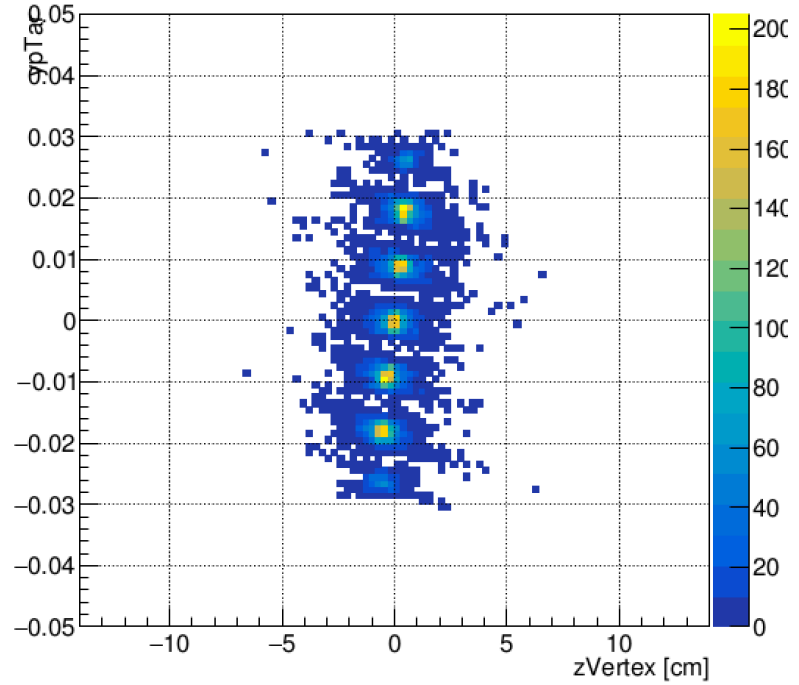
MC: dipole ideal

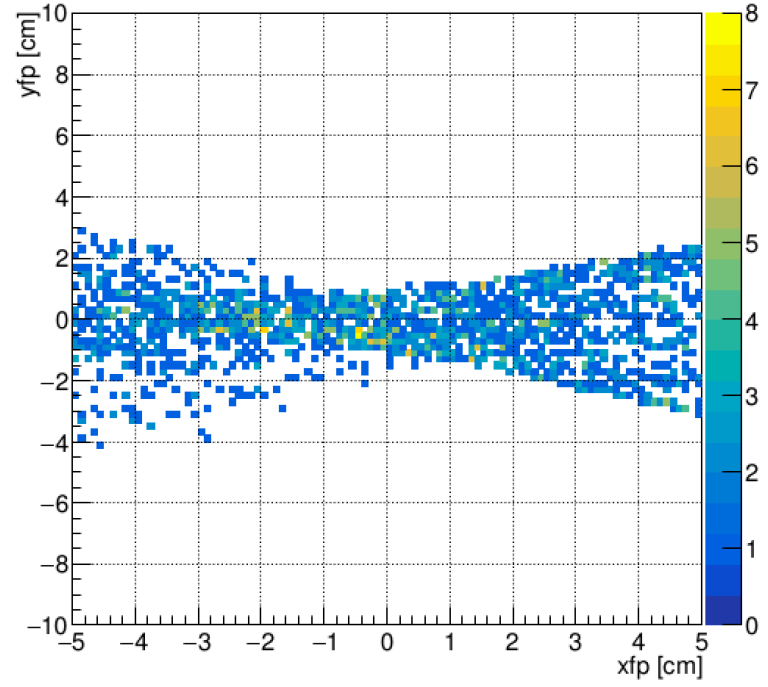


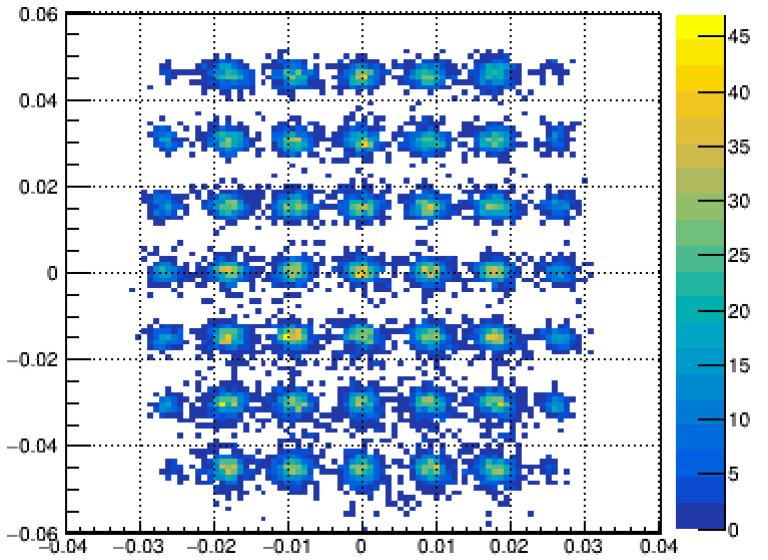




MC: dipole at -0.2%







Setting the magnets:

- Field setting program:
  - https://github.com/hszumila/field17
  - SHMS:
    - Q1 saturation above 6 GeV
    - HB saturation
  - HMS
    - dipole saturation at >5 GeV
    - Q1 & Q2 saturation at 4.5 GeV and above (probably not at high central P)

Summary:

- Check the focal plane distributions
- Check the yptar vs zvertex distributions
- Current matrix elements are sufficient starting points

- For best optics results:
  - H(e,e'p) can show us true dipole offsets by comparing the W peak in data and simulation
  - Carbon+sieve data can show optics distortions, used for re-optimization