A_T Progress

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Transverse Beam Asymmetry (A_T)

- Non PV, transverse asymmetry sensitive to the imaginary part of 2-γ exchange amplitude

- For lead predicted to be large ~ few ppm

- Potential systematic error

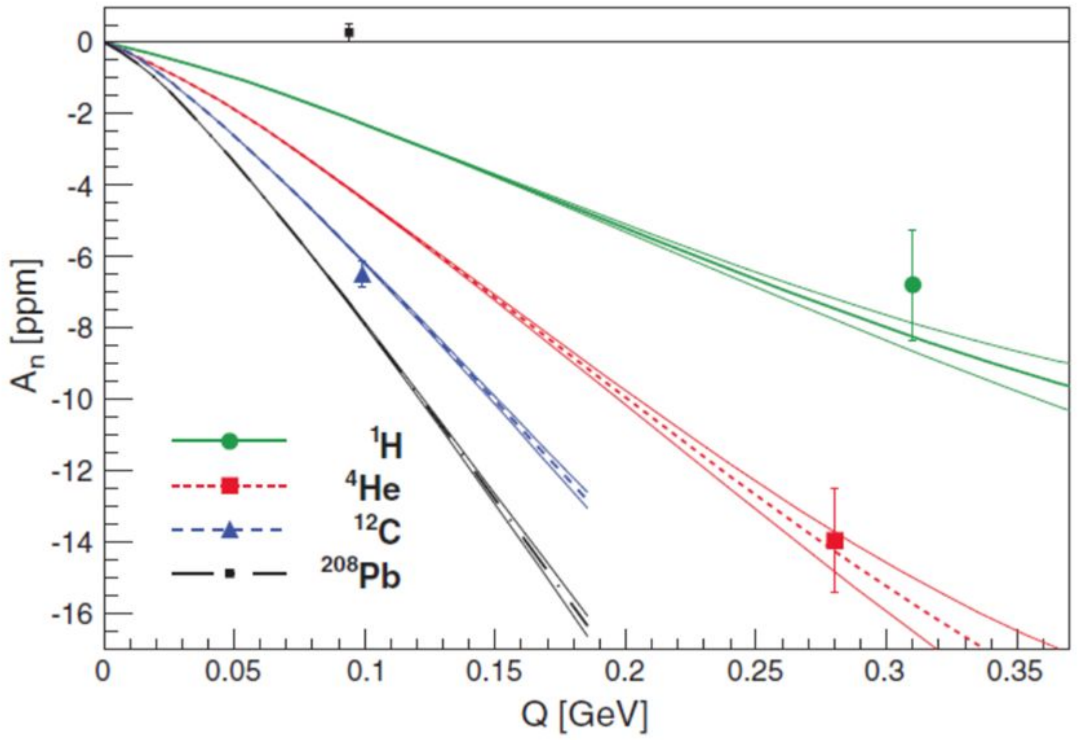
<u>A_T result</u>

$A_{n,\,^{208}Pb} = 0.13 \pm 0.19 \pm 0.36$ ppm

- Lead A_T ~ 0 (Missing Coulomb distortions)

- Coulomb distortions grow with Z

- Motivation for more calculations and measurements at intermediate Z (e.g. ^{48}Ca)

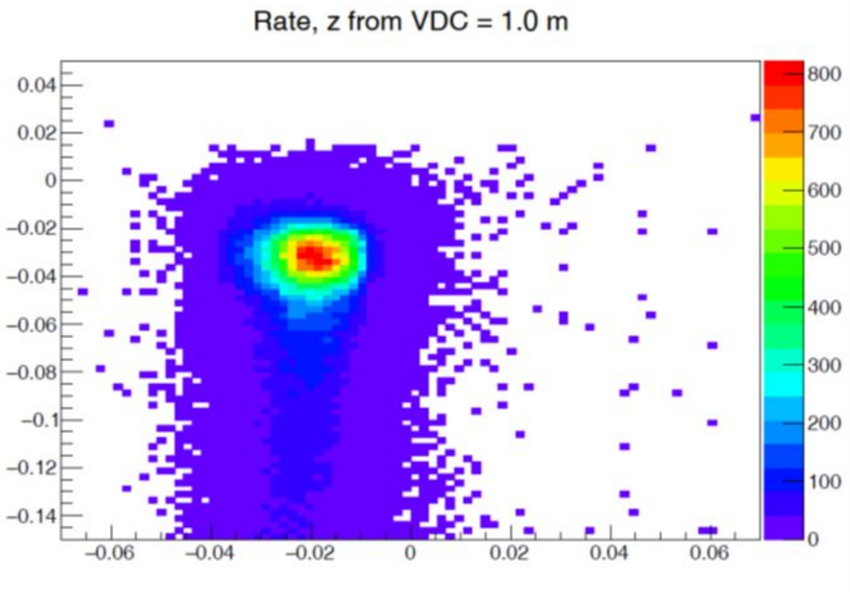


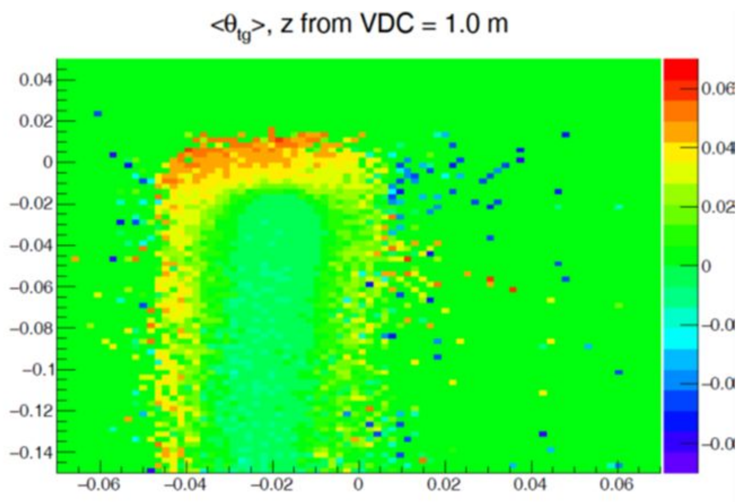
Exploring A_T Data (Focal Plane)

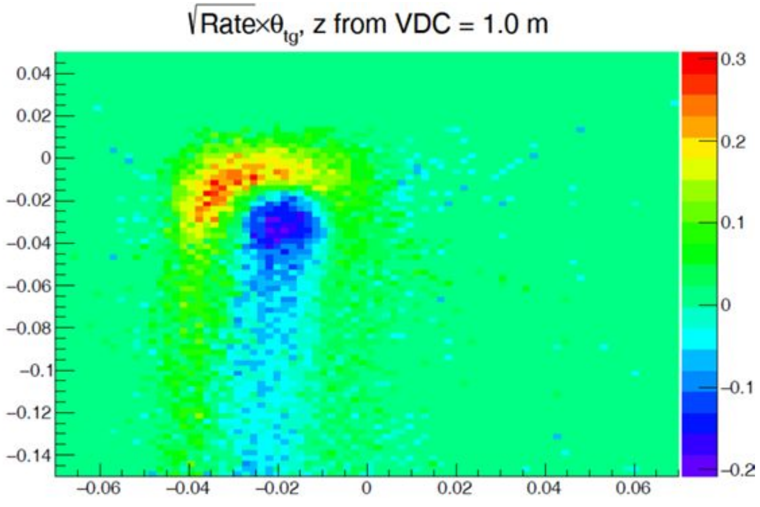
Question

Can we predict where the A_T enhancement shows up using optics principles?

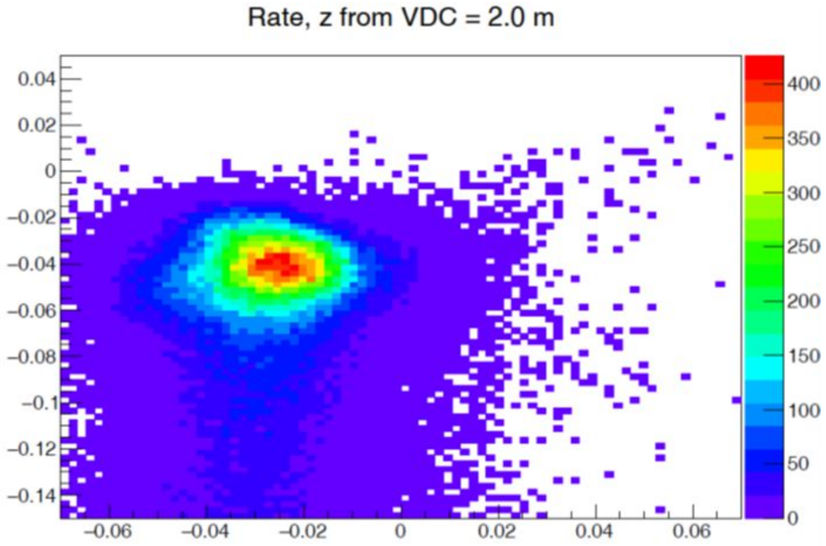
- A_T is proportional to θ_{tg} , ϕ
- Requires transverse component of polarization

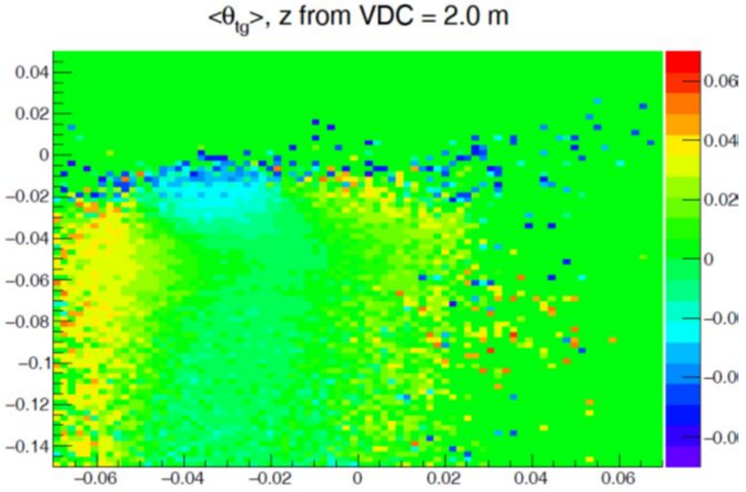


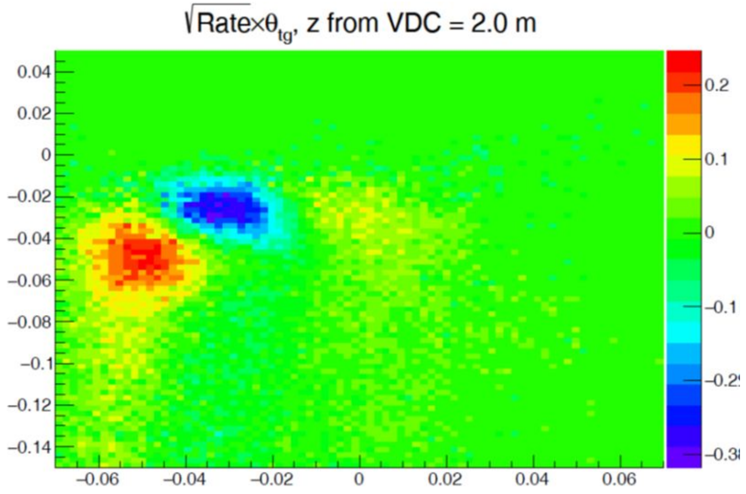




Data (A_T Plane)







Should be able to predict where the A_T enhancement shows up using second order optics matrix elements
Idea is put A_T detector where the red spot
Sits on the fringe of the acceptance

Is it possible that the enhancement is outside the calibration region?

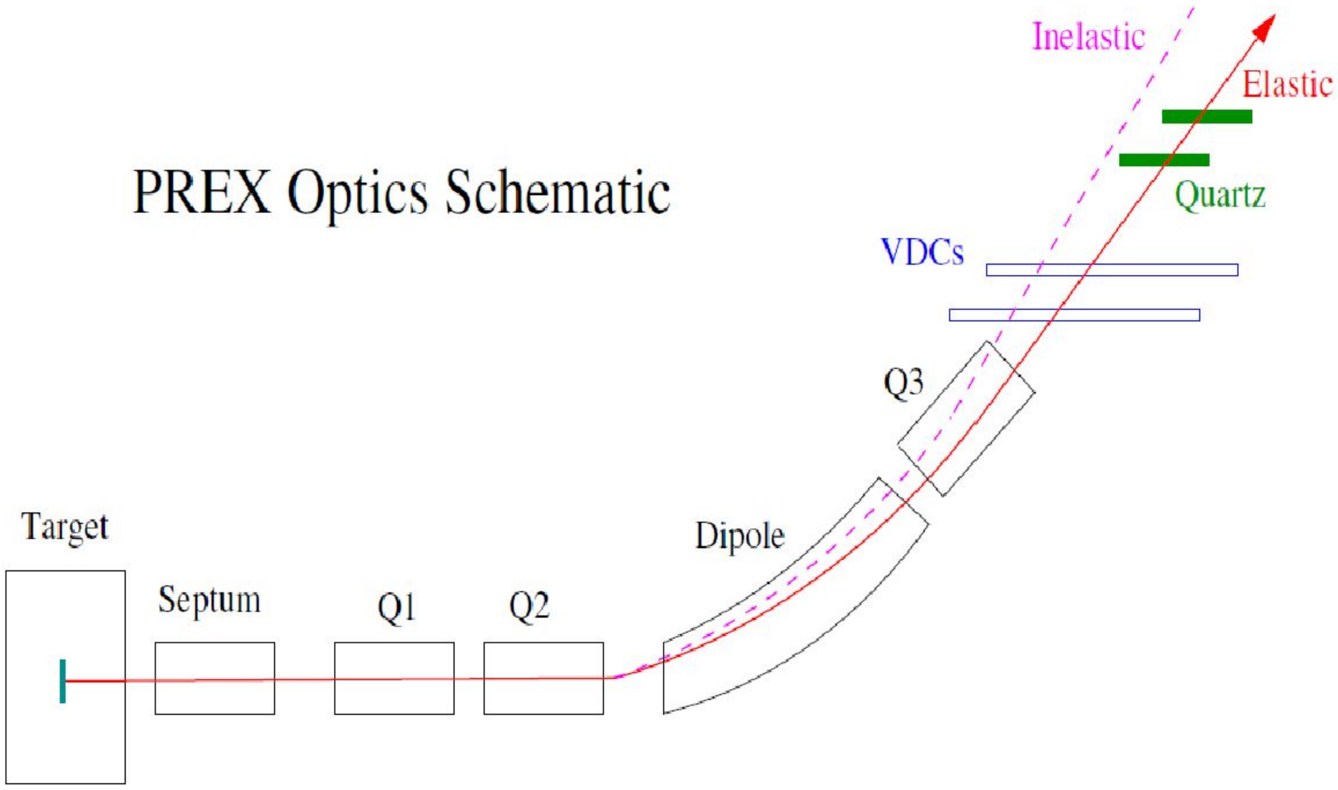
Optics

- Would like a way to relate focal plane variables to target variables (Optics Matrix Formalism)

- Taylor expansion around central trajectory (1^{st} order expansion 5D vector, 2^{nd} order expansion 20D vector

$$\begin{bmatrix} x_{tg} \\ \theta_{tg} \\ y_{tg} \\ \phi_{tg} \\ \delta \end{bmatrix}$$

2^{nd} order includes cross terms (e.g, $x\theta$, $y\varphi$, δ^2 etc.)



PREX = $SQQD_nQ$

Beam Transport (1st Order)

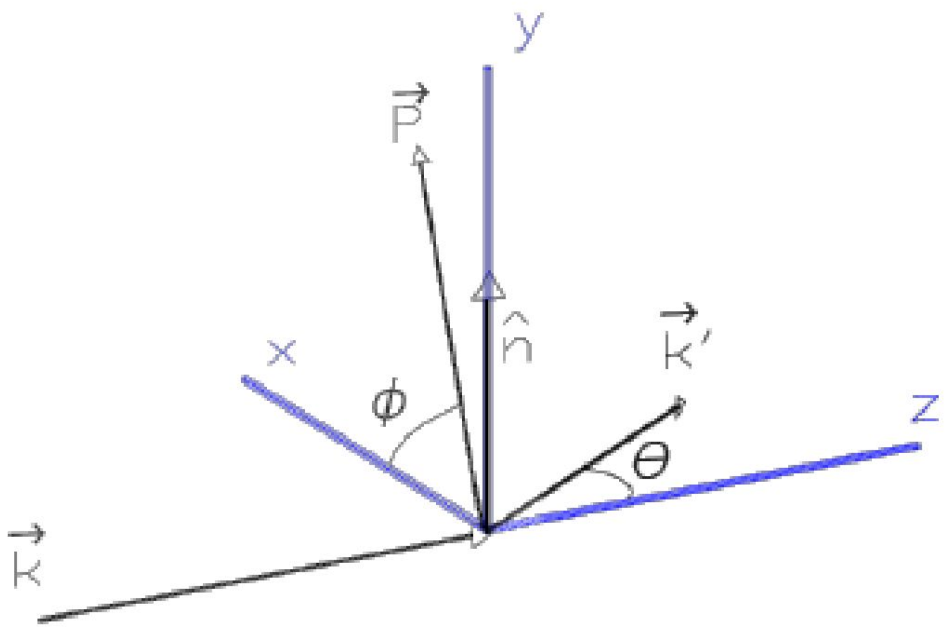
$$\begin{bmatrix} x_{fp} \\ \theta_{fp} \\ y_{fp} \\ \phi_{fp} \\ \delta_{fp} \end{bmatrix} = \text{[matrix below]} \begin{bmatrix} x_{tg} \\ \theta_{tg} \\ y_{tg} \\ \phi_{tg} \\ \delta \end{bmatrix}$$

$(x\|x_{tg})$	$(x\|\theta_{tg})$	$(x\|y_{tg})$	$(x\|\varphi_{tg})$	$(x\|\delta_{tg})$
$(\theta\|x_{tg})$	$(\theta\|\theta_{tg})$	$(\theta\|y_{tg})$	$(\theta\|\varphi_{tg})$	$(\theta\|\delta_{tg})$
$(y\|x_{tg})$	$(y\|\theta_{tg})$	$(y\|y_{tg})$	$(y\|\varphi_{tg})$	$(y\|\delta_{tg})$
$(\varphi\|x_{tg})$	$(\varphi\|\theta_{tg})$	$(\varphi\|y_{tg})$	$(\varphi\|\varphi_{tg})$	$(\varphi\|\delta_{tg})$
$(\delta\|x_{tg})$	$(\delta\|\theta_{tg})$	$(\delta\|y_{tg})$	$(\delta\|\varphi_{tg})$	$(\delta\|\delta_{tg})$

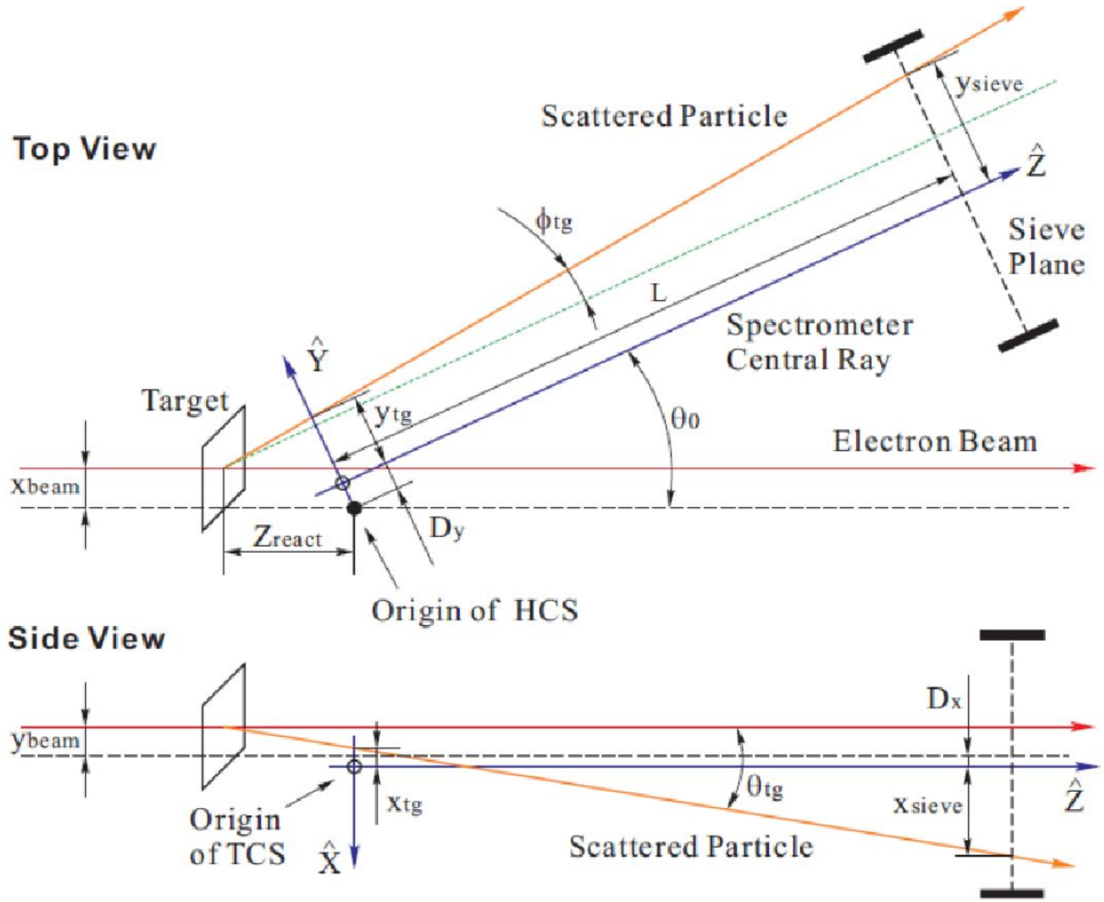
Fractional momentum deviation from central trajectory ($\delta = 0$)

Express focal plane variables as a Taylor expansion of the target variables (1st order optics matrix is 5 x 5)

Coordinate Systems



Hall Coordinate System



Target Coordinate System

PREX Tune B (1st Order Matrix Elements)

Heavy coupling between δ and x

Focal Plane Coordinates

$$\begin{bmatrix} x_{fp} \\ \theta_{fp} \\ y_{fp} \\ \phi_{fp} \\ \delta_{fp} \end{bmatrix} = M \begin{bmatrix} x_{tg} \\ \theta_{tg} \\ y_{tg} \\ \phi_{tg} \\ \delta \end{bmatrix}$$

-3.09	-0.02	0	0	16.73
-0.31	-0.32	0	0	2.5
0	0	2.11	0.01	-0.48
0	0	1.1	0.48	-0.19
0	0	0	0	1

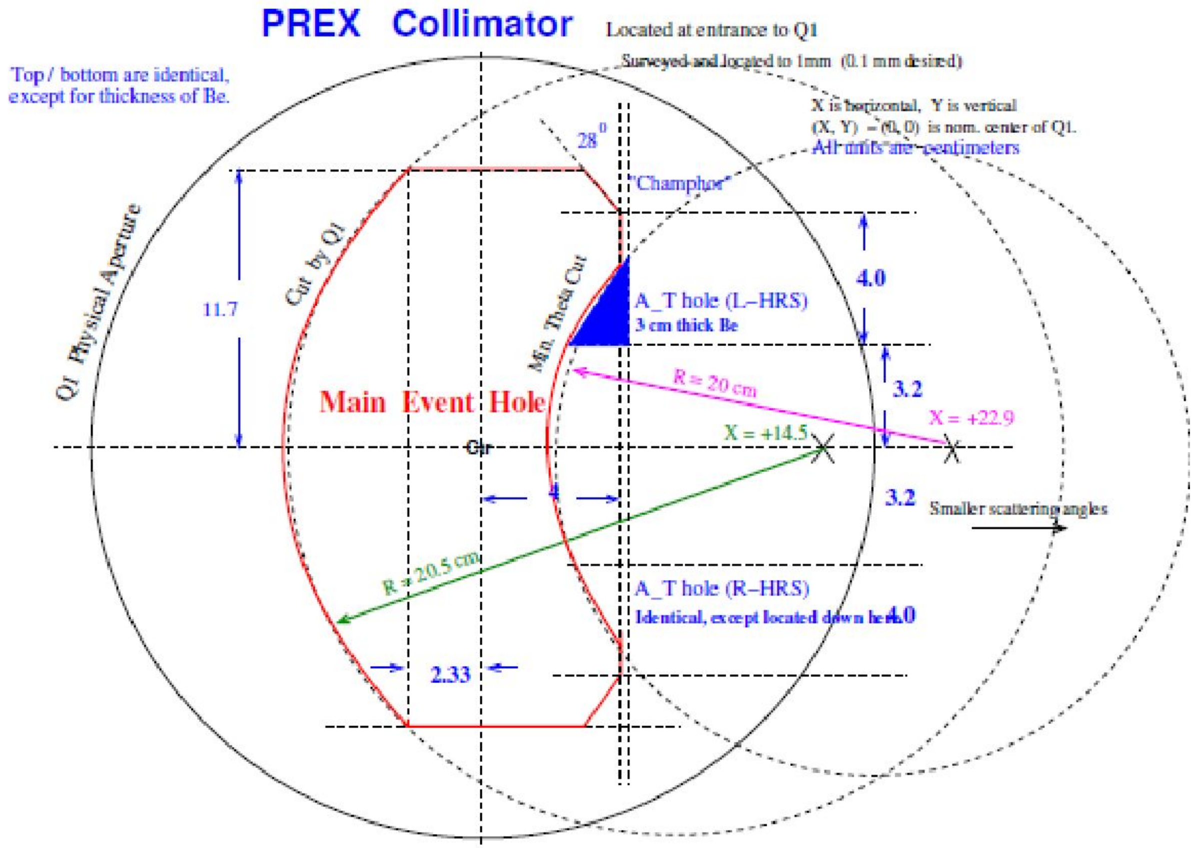
Target Coordinates

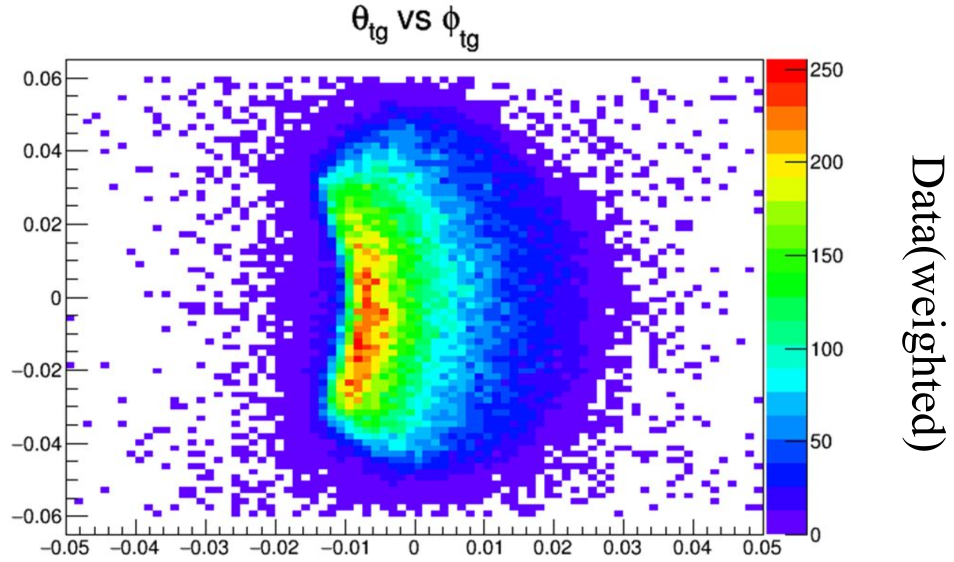
Field values q1 = 0.099950, q2 = -0.132890 q3 = -0.171751

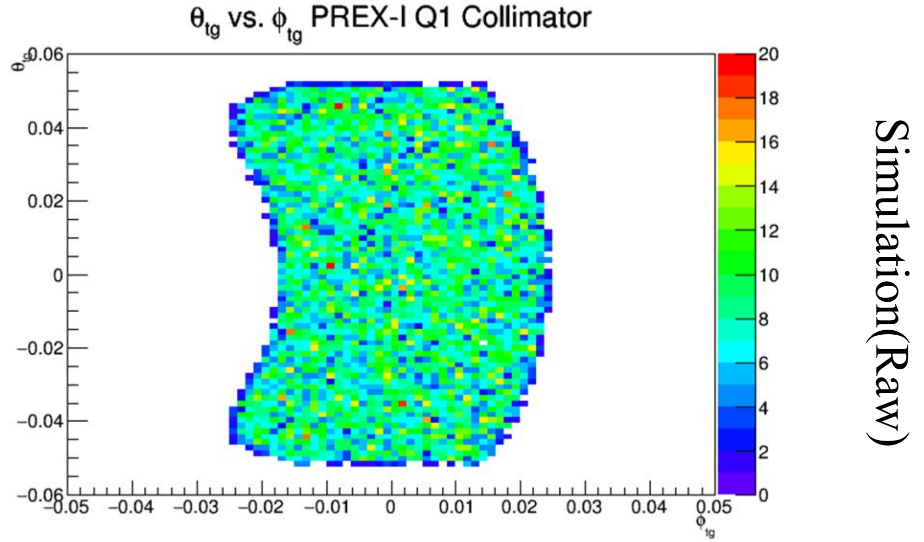
(x|θ) and (y|φ) ~ 0 - Point to point imaging in x,y at focal plane detector (Focused to a point)

https://github.com/sbujlab/hrstrans

Collimator







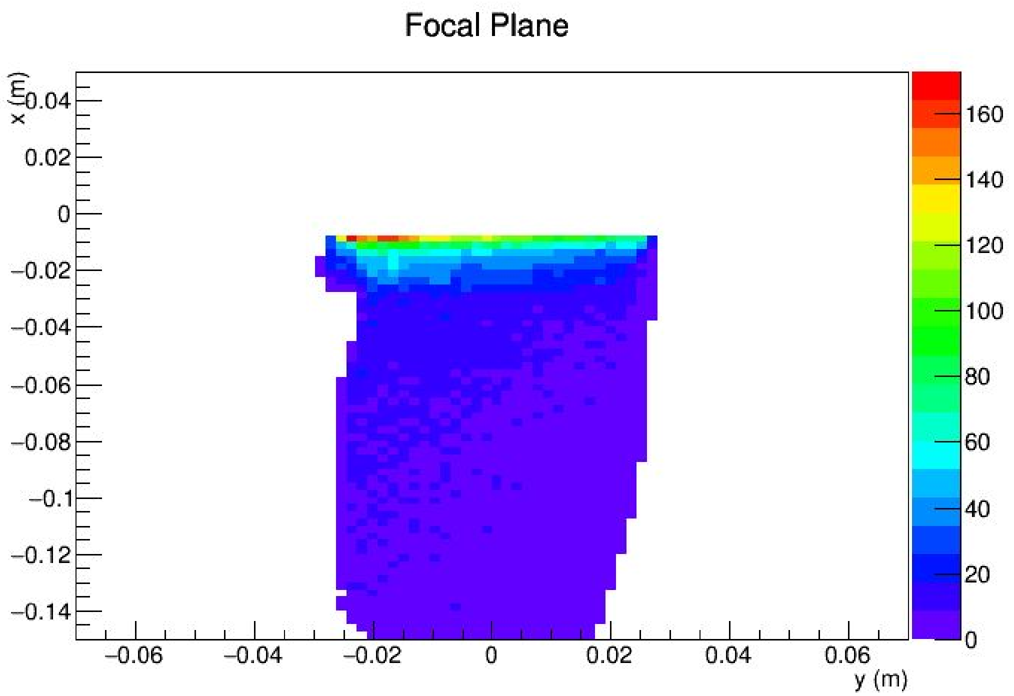
- Enforce collimator cut before looking at detector plane distributions
  $(x|x) = 0.91$, $(x|\theta) = 2.28$, $(y|y) = 0.98$, $(y|\varphi) = 2.39$

Optics model Inputs

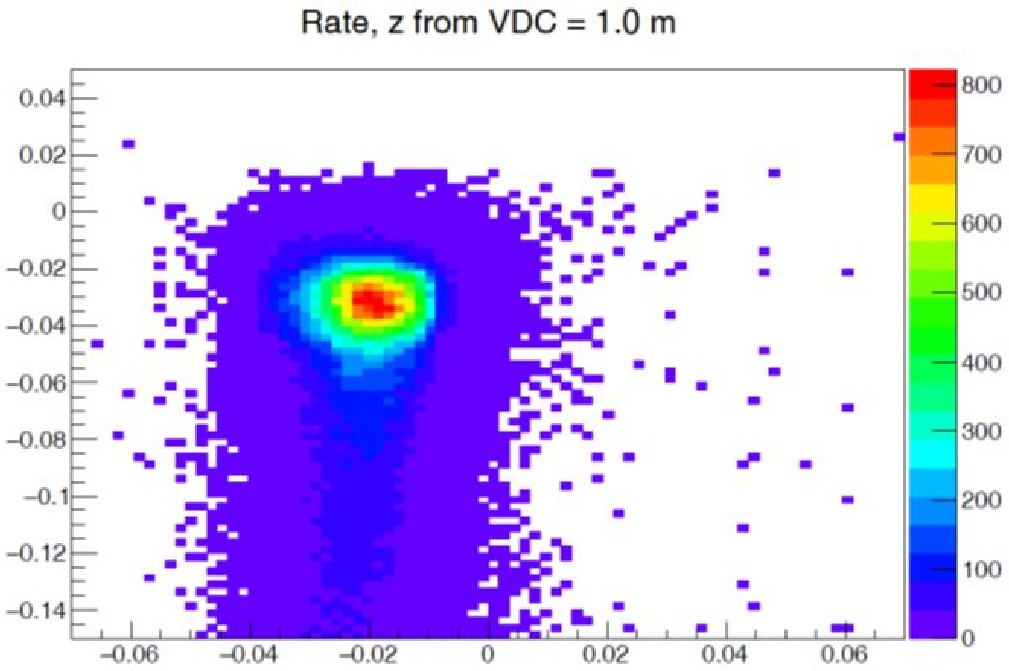
- Want our optics model to be an accurate representation of the data
- Requires septum mistune
- Requires weighted sampling
- Includes Mott cross section
- Requires identifying calibration region (BPM info, target thickness etc.)

Focal Plane (Rates)

Simulation

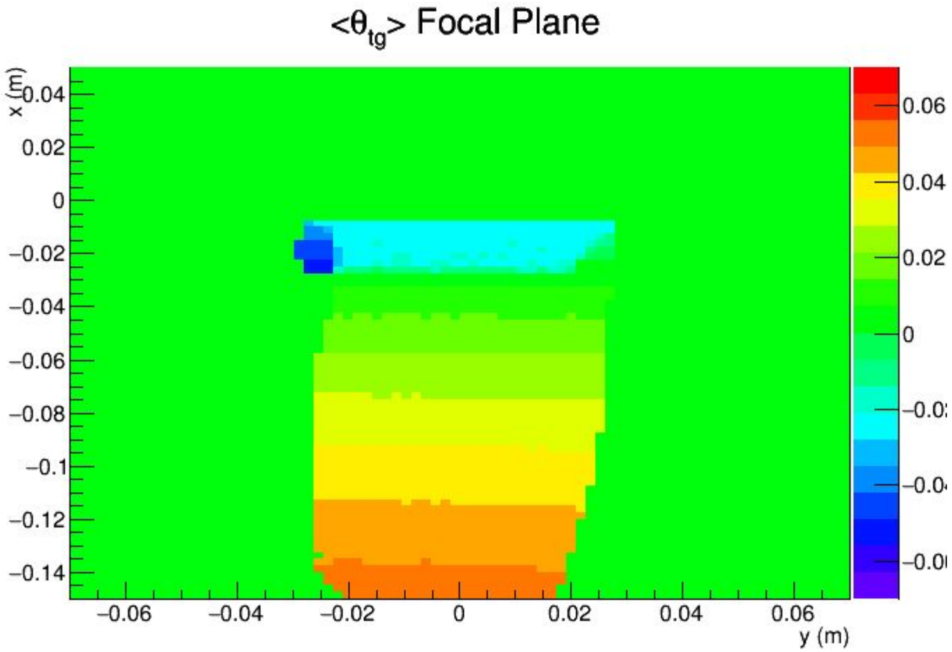


Data

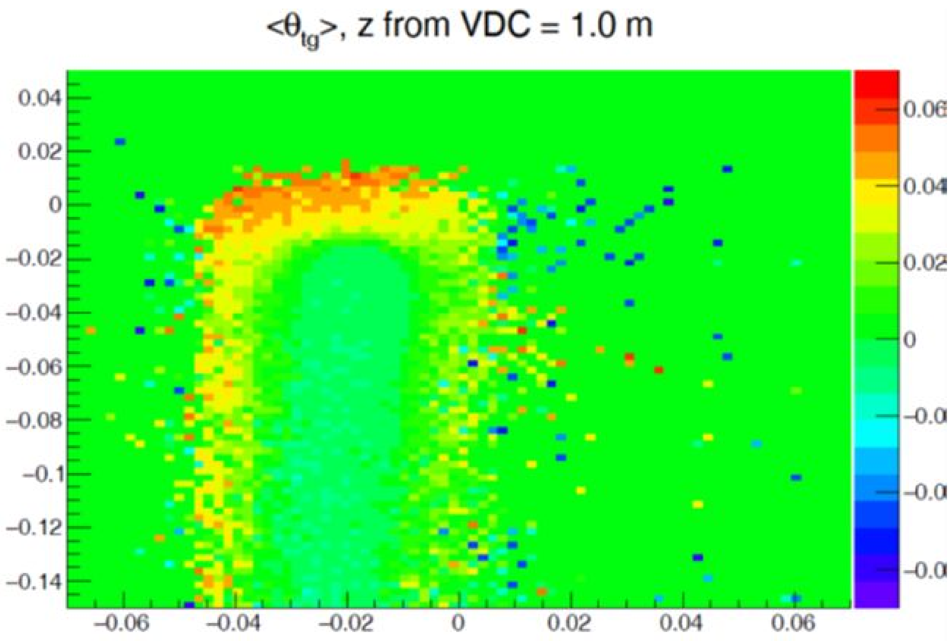


Focal Plane (Analyzing Power)

Simulation

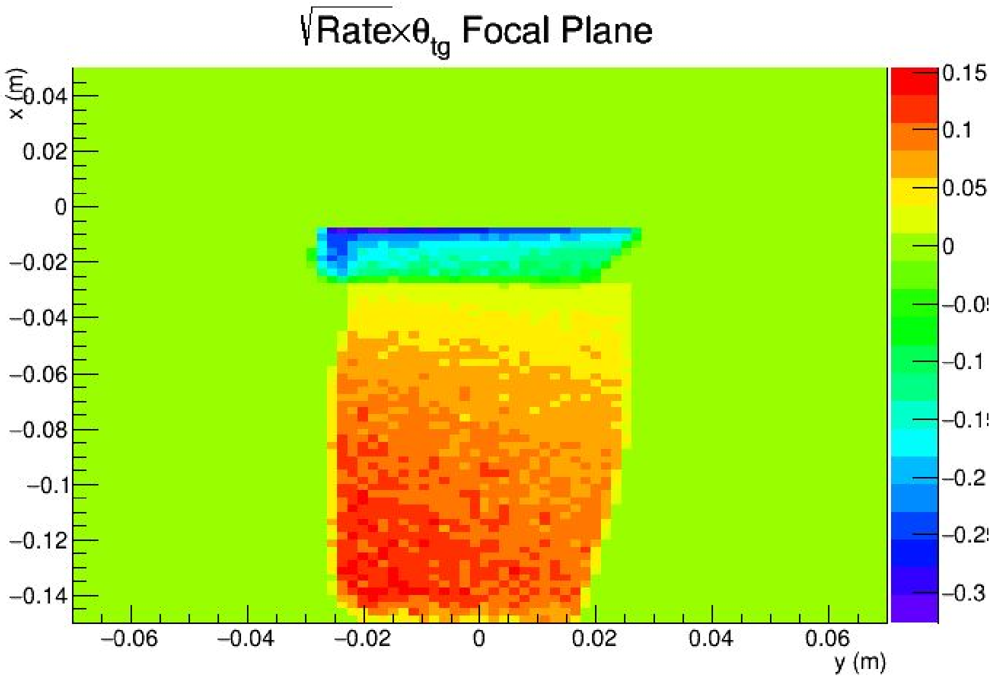


Data

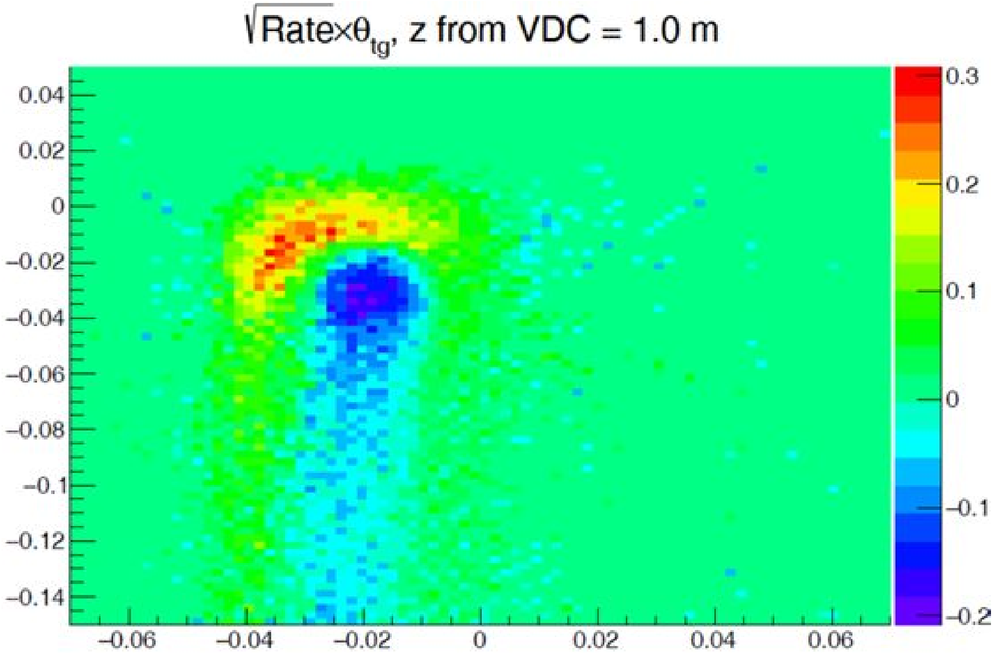


Focal Plane (Figure of Merit)

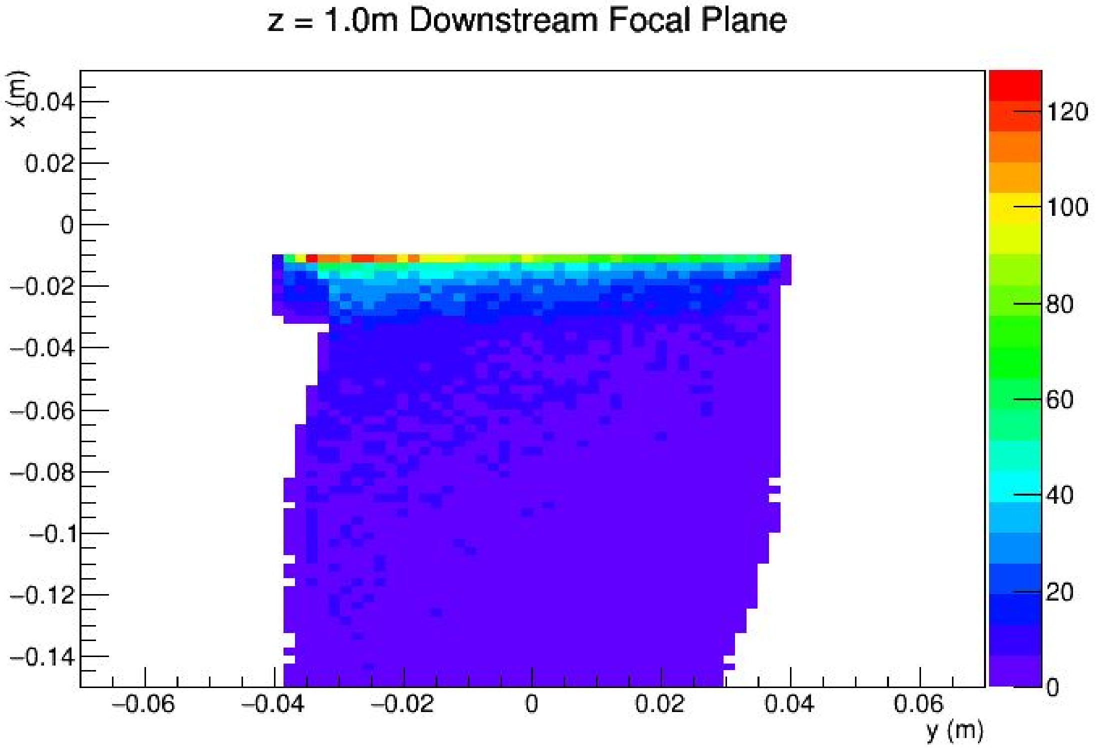
Simulation

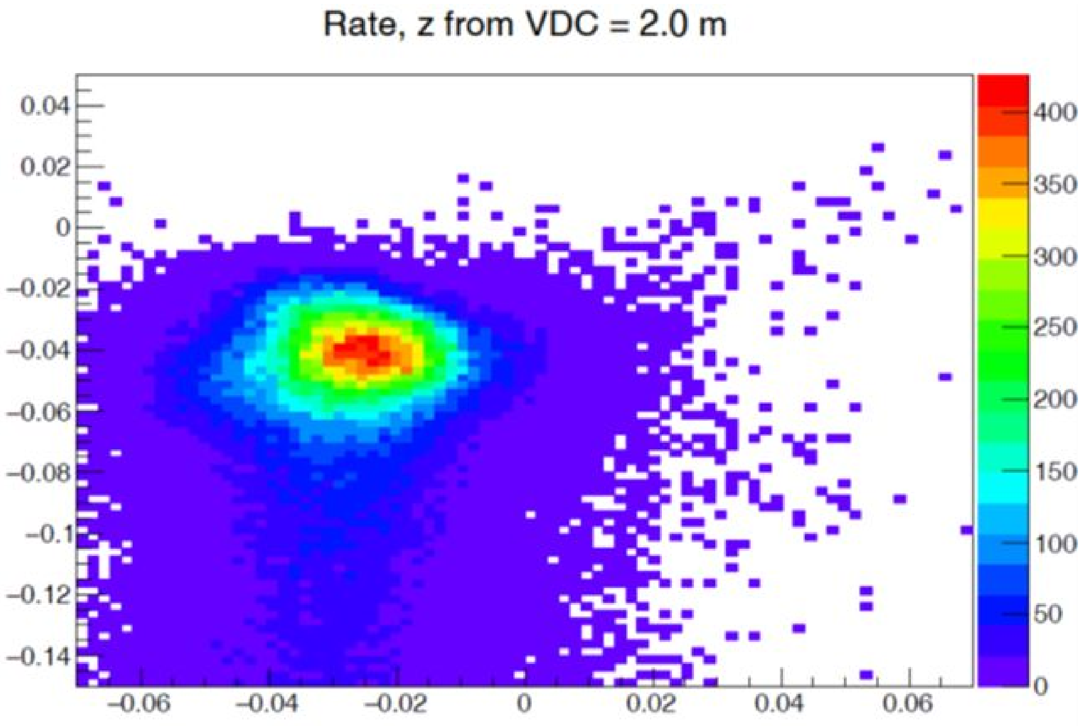


Data

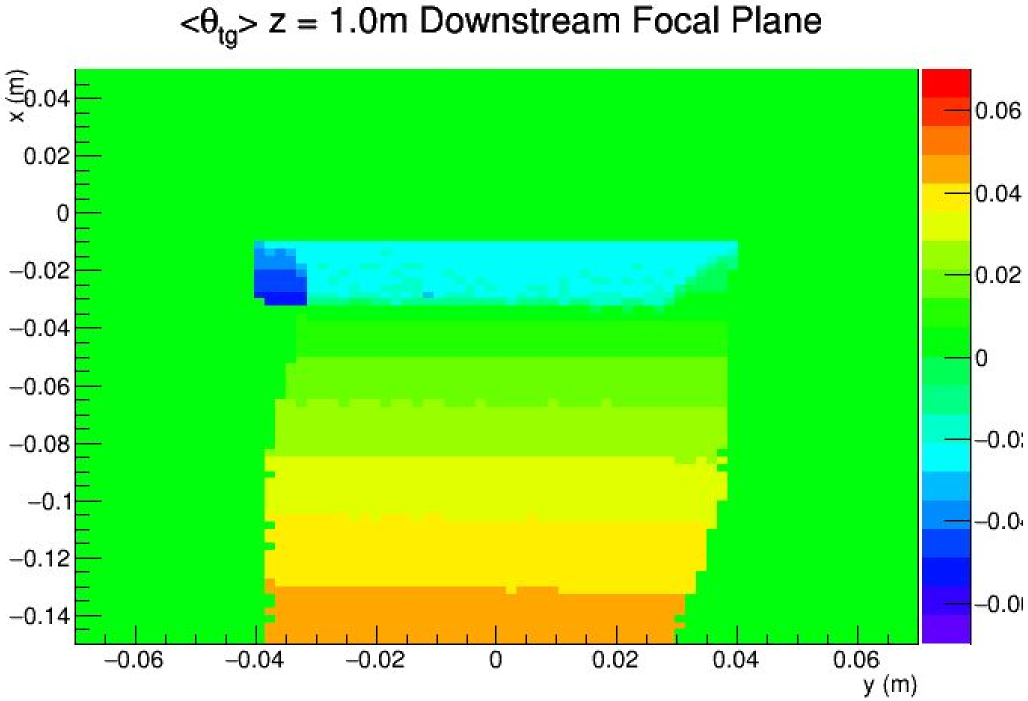


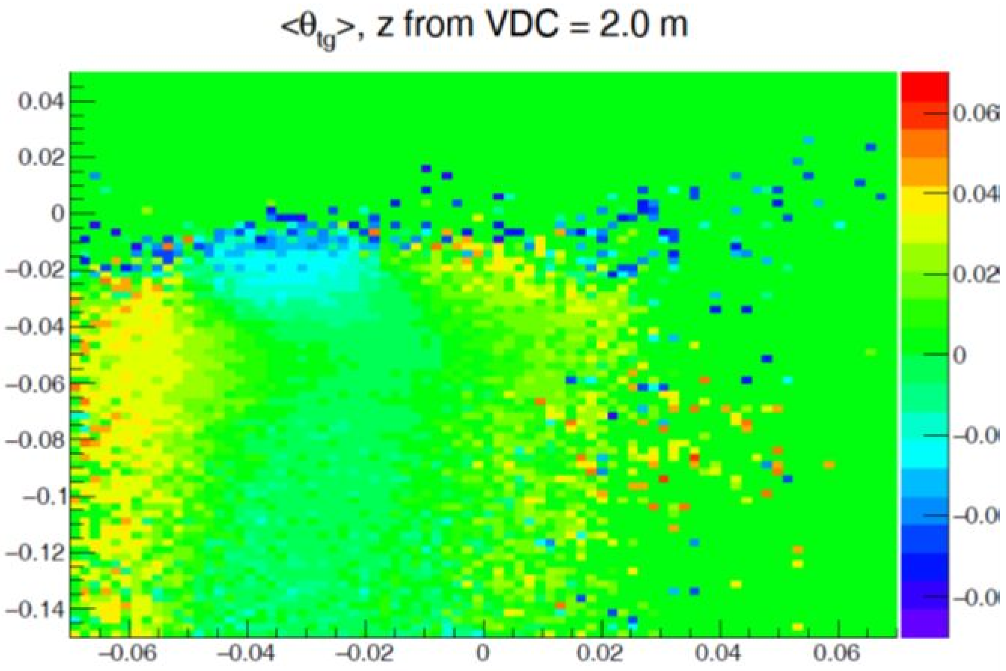
A_T Plane (Rates)



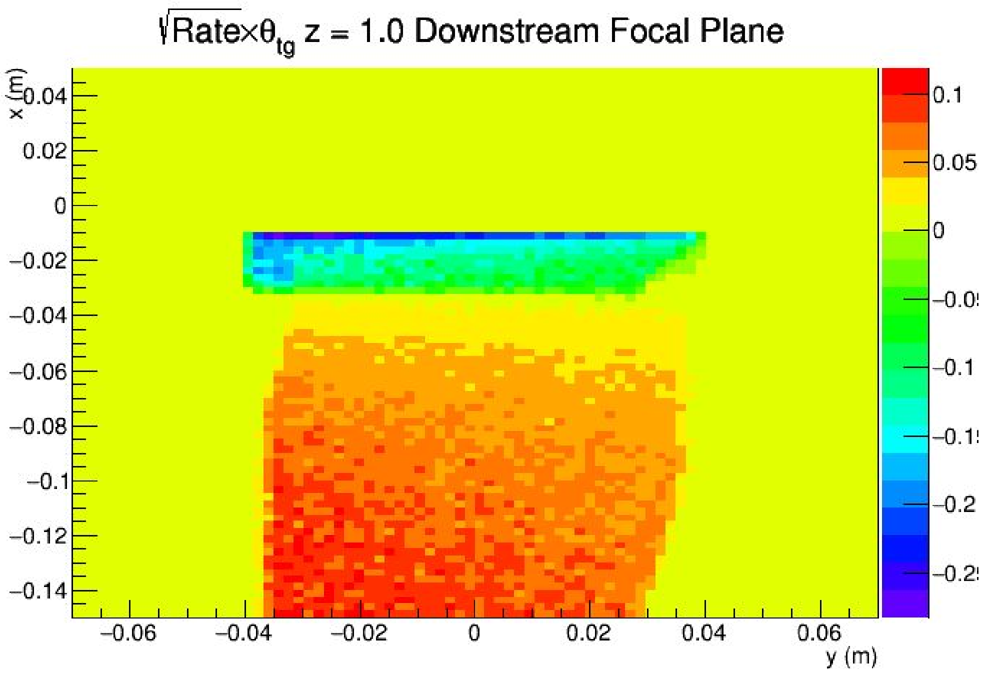


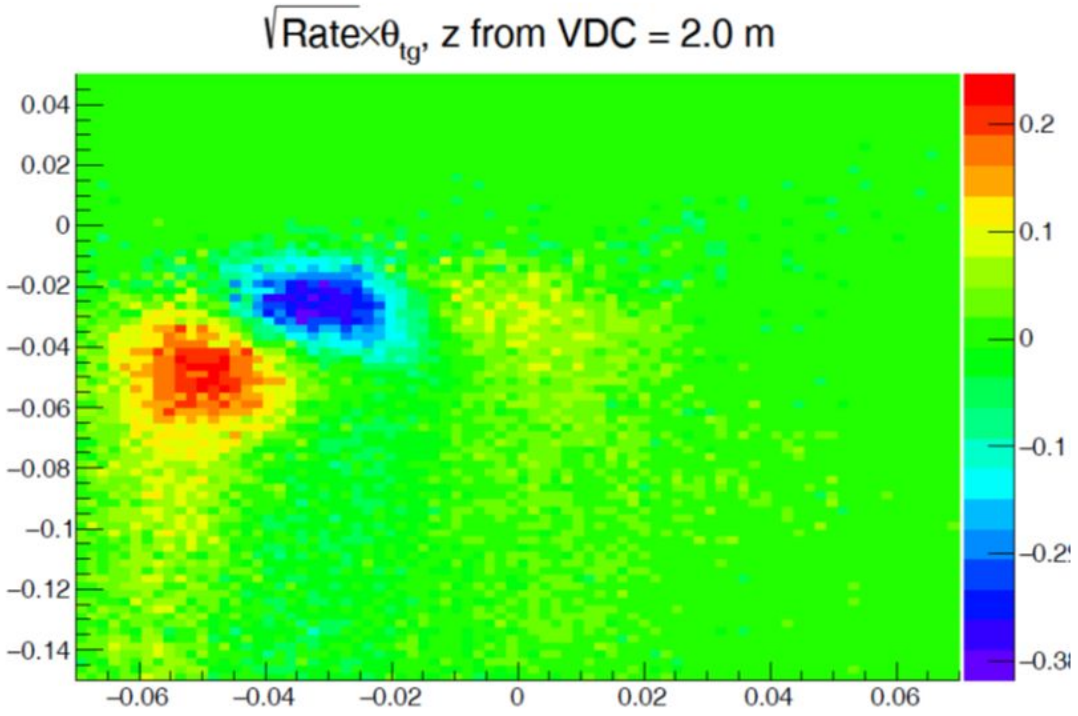
A_T Plane (Analyzing Power)



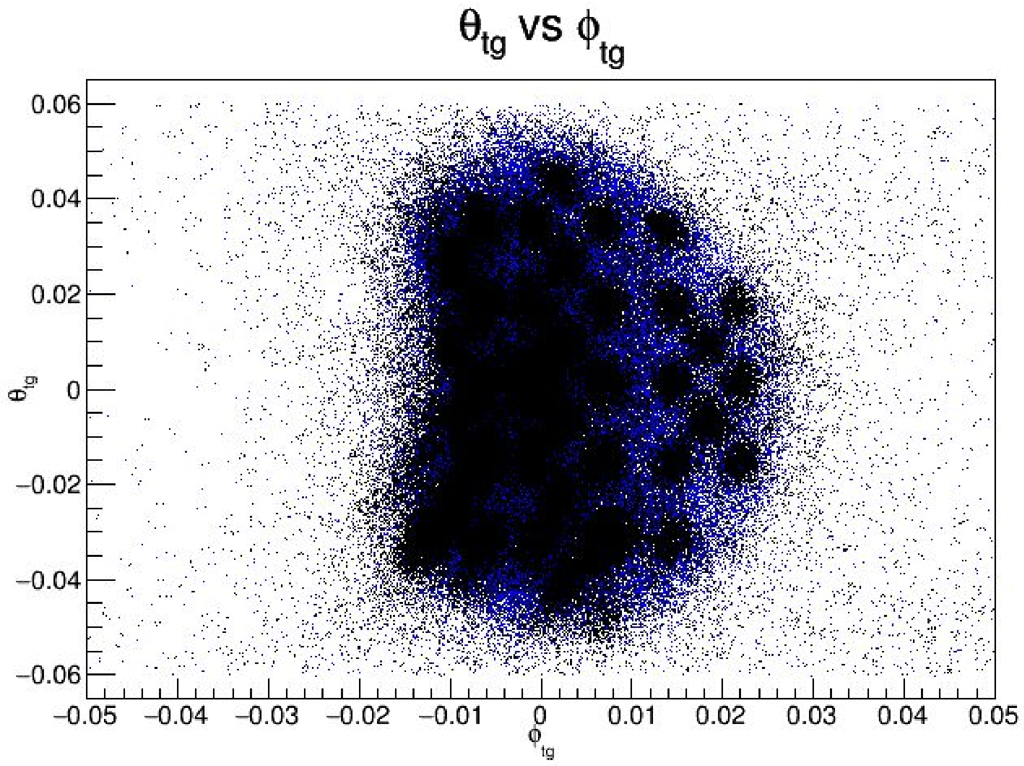


A_T Plane (Figure of Merit)



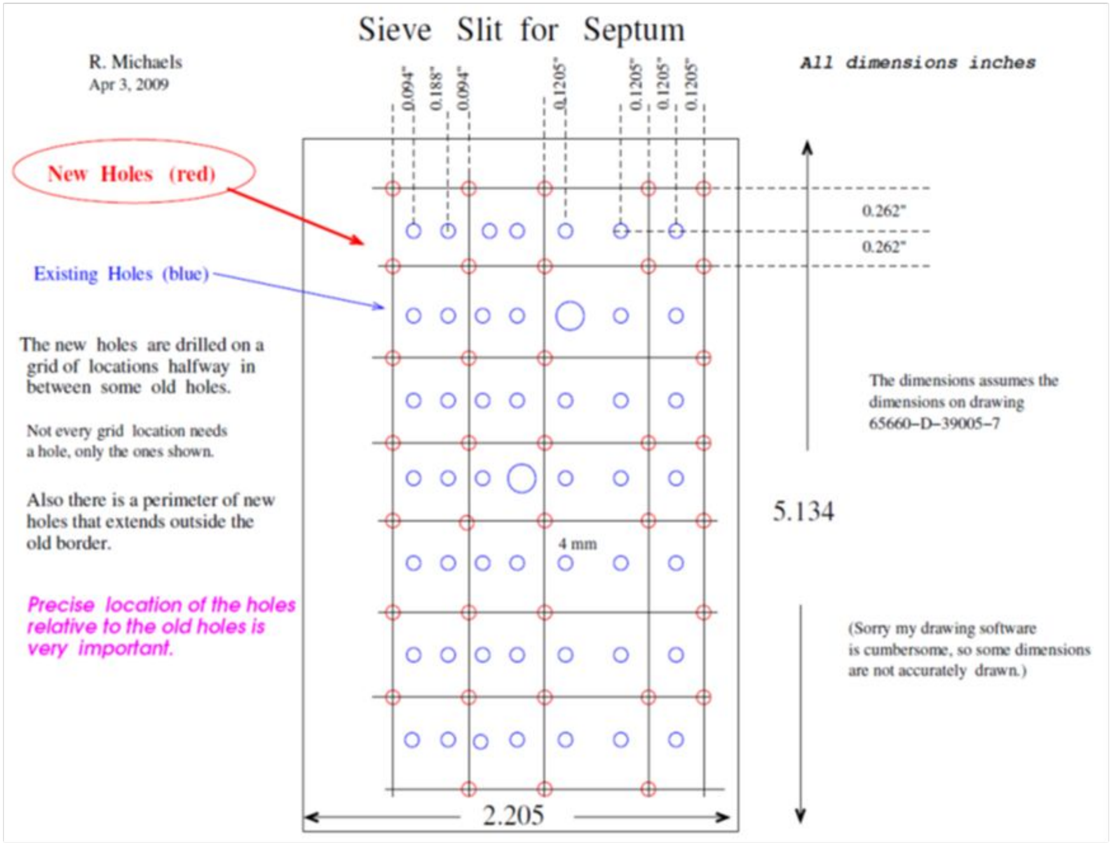


Sieve Data



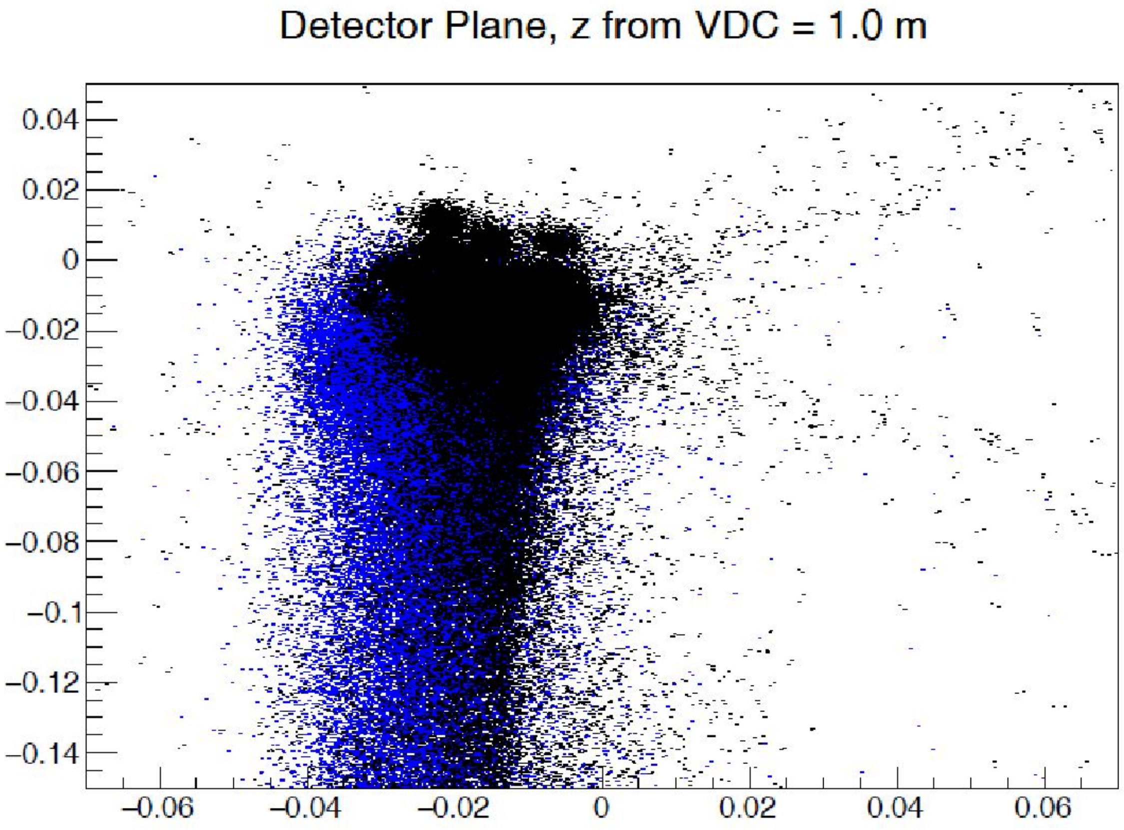
Sieve In(no raster, Super Thin ^{12}C, 0.075 mm thick)

Sieve Out (beam raster, ^{208}Pb/Diamond, 0.8 mm thick)



Identify calibration region by looking at sieve data with different targets

Sieve Data



Pb target (sieve out, beam raster)

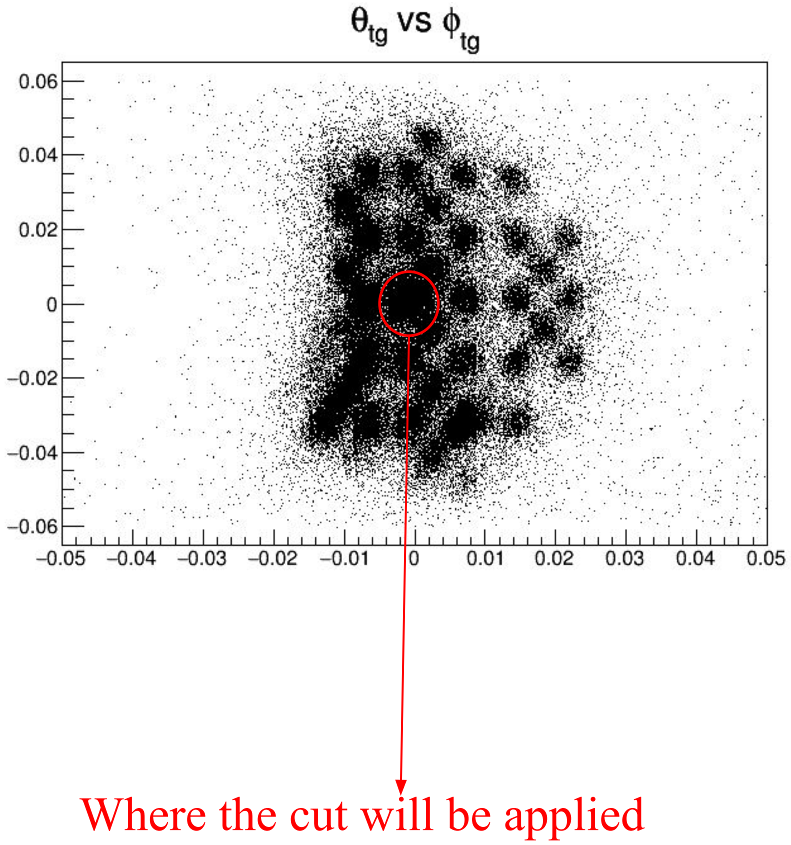
Super thin ^{12}C (sieve in, no beam raster)

<u>Question</u>

Are there sieve holes near where the enhancement shows up?

- Observe the offset between sieve in an sieve out data
- Is that due energy ionization losses, beam off center?
- Make a sieve cut around the center hole and try to isolate the same set of ray bundles (i.e, φ_{tg}, θ_{tg})

Sieve Data (Full Coverage)



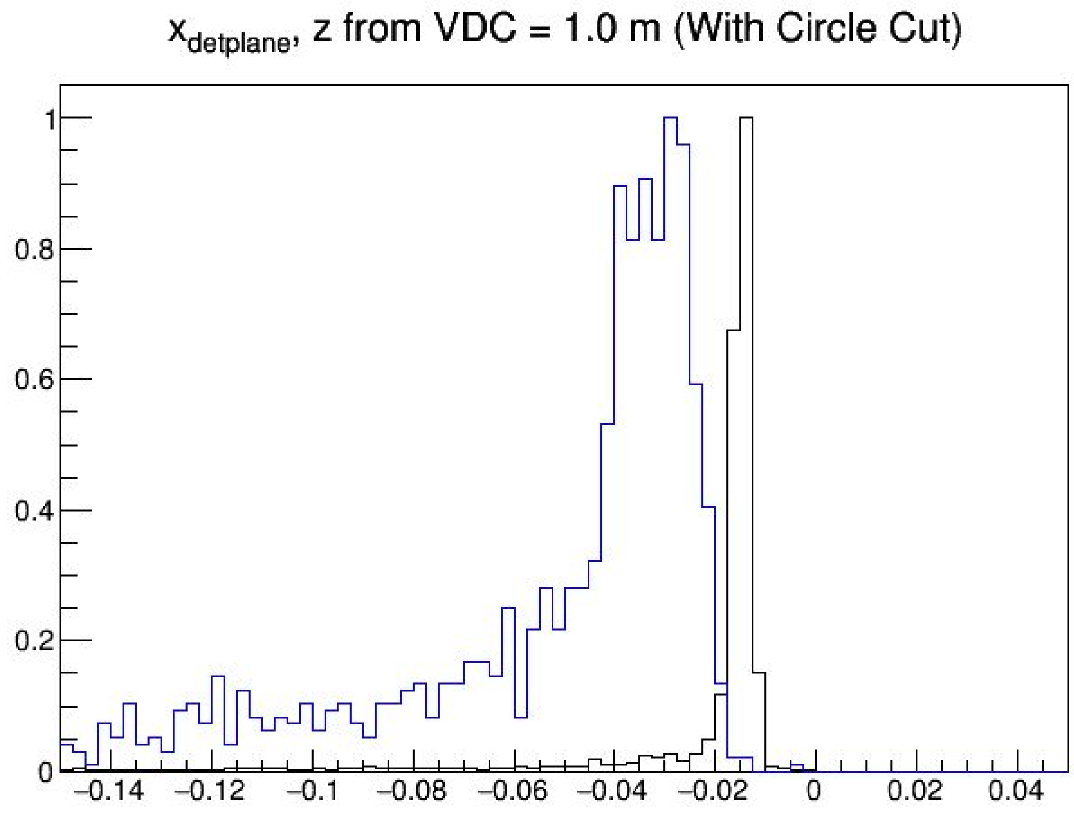
Central Hole Sieve Slit - Survey measurements
Z = 798.02 mm, X = 69.91 mm , Y = -1.50mm
along central spectrometer line

- Distance between target and sieve = 0.8 m
- diameter = 4mm

$$x_{sieve} = 0.8*\theta_{tg}$$
$$y_{sieve} = 0.8*\varphi_{tg}$$

- Center hole cut - $\mathrm{sqrt}(\theta_{tg}^{2} + \varphi^{2}_{tg}) < 0.0025$
- Use this to explore ionization losses

Exploring Calibration Region



Pb target (sieve out, beam raster)
Super thin ^{12}C (sieve in, no beam raster)

- We need to compare these on the same level i.e., compare the data with same set of ray bundles
- Optics calibration data has no raster
- Lead data has beam raster which has to be accounted for
- Crucial to look at beam positions

Beam Postions

- Requires extrapolate BPM central values to the target.
- Use the beam position at the target as to account compare the sieve in and sieve out data.
- Important part of trying to incorporate some radiative corrections in our optics model.

Summary

- Exploring A_T using second order optics
- Included cross section into our optics model
- Simulated septum mistune
- Exploring calibration region using sieve data (looking at BPM info, ionization losses) with different targets

Beam Positions

Run Number	Comment	BPMA.xpos (mm)	BPMA.ypos (mm)	BPMB.xpos (mm)	BPMB.ypos (mm)	Target.xpos (mm)	Target.ypos (mm)
27412 (0.5 µA)	Spot Check (No Target)	-0.0367491	0.280214	-0.0404017	0.974841	-0.0415	1.224
27427 (0.05 µA)	Sieve Out Pb/D	0	0	0	0	0	0
27428 (0.5 µA)	Spot Check (No Target)	-0.0248617	0.2189595	-0.102949	1.20861	-0.119	1.41263
27118 (0.5 µA)	Sieve In Thin Carbon	0.0186223	-0.0398863	-0.0597374	-0.0173224	-0.07589	-0.01267
27119 (0.5 µA)	Sieve In Thin Carbon	0.1598886	0.0253923	0..0796082	0.0304588	0.06306	0.0315
27120 (0.5 µA)	Sieve In Thin Carbon	0.0881368	-0.0146237	0.0215824	0.0280935	0.007862	0.0369