Hall A Optics Optimization

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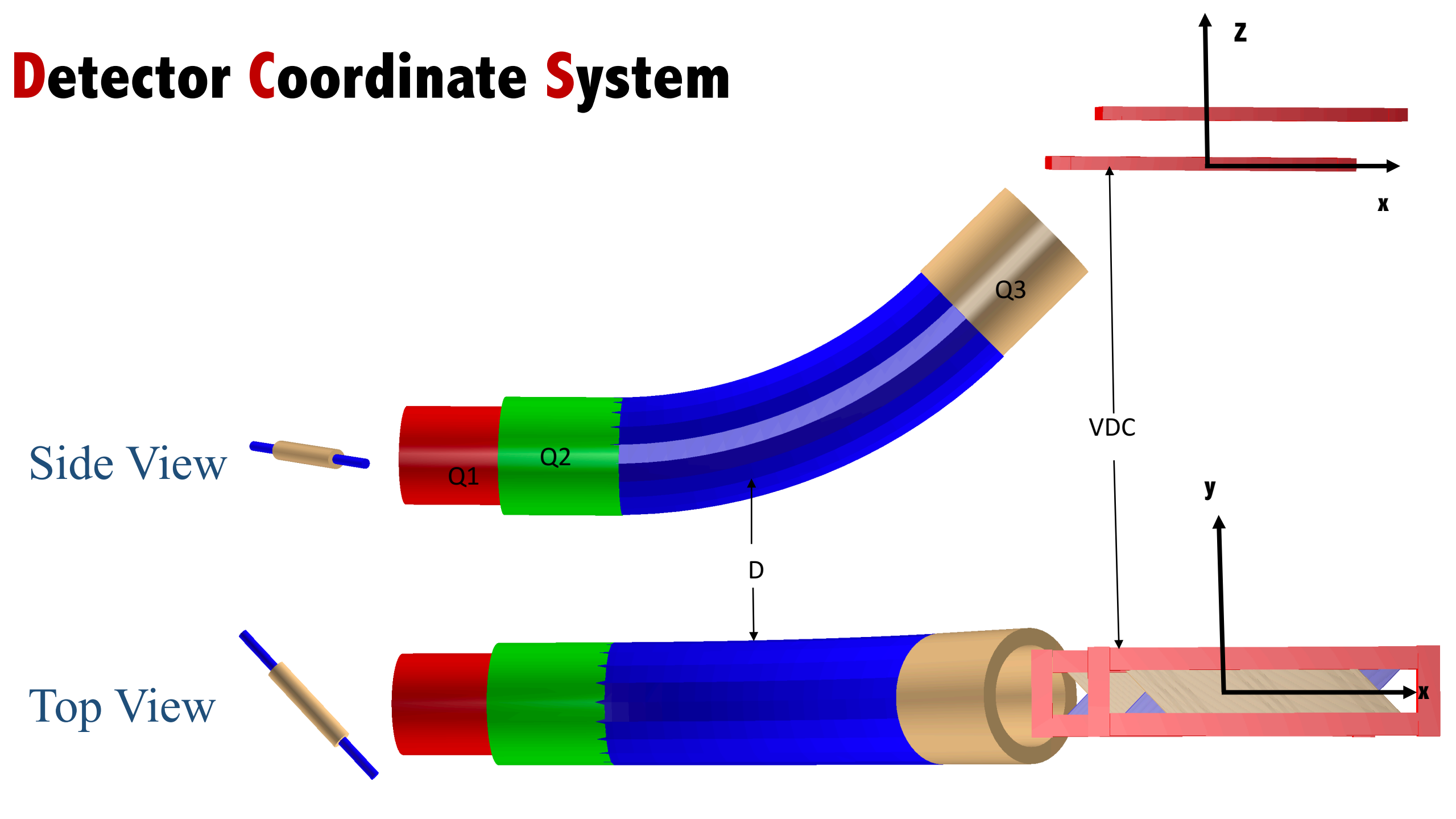
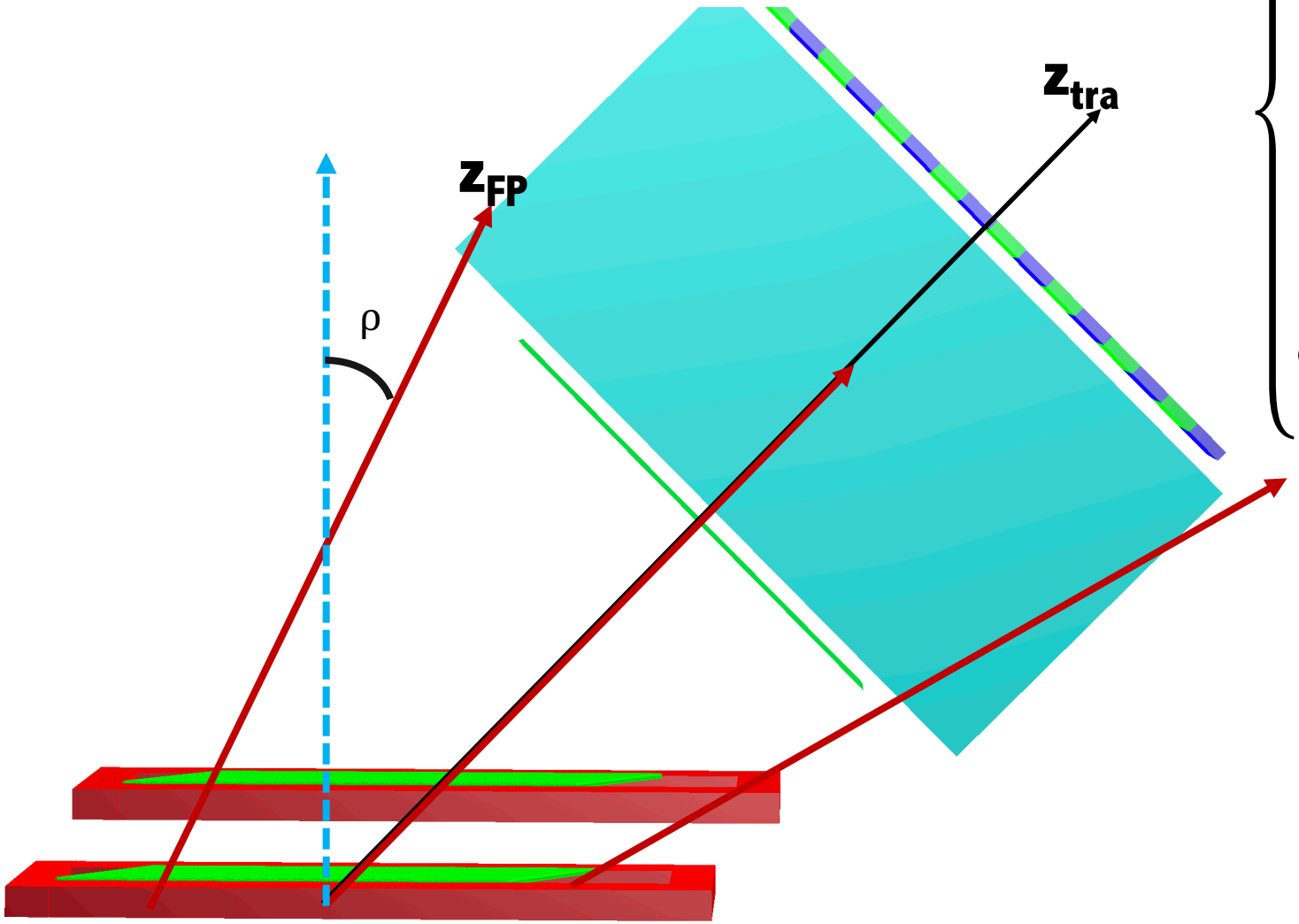
Detector Coordinate System



Focal Plane Variable



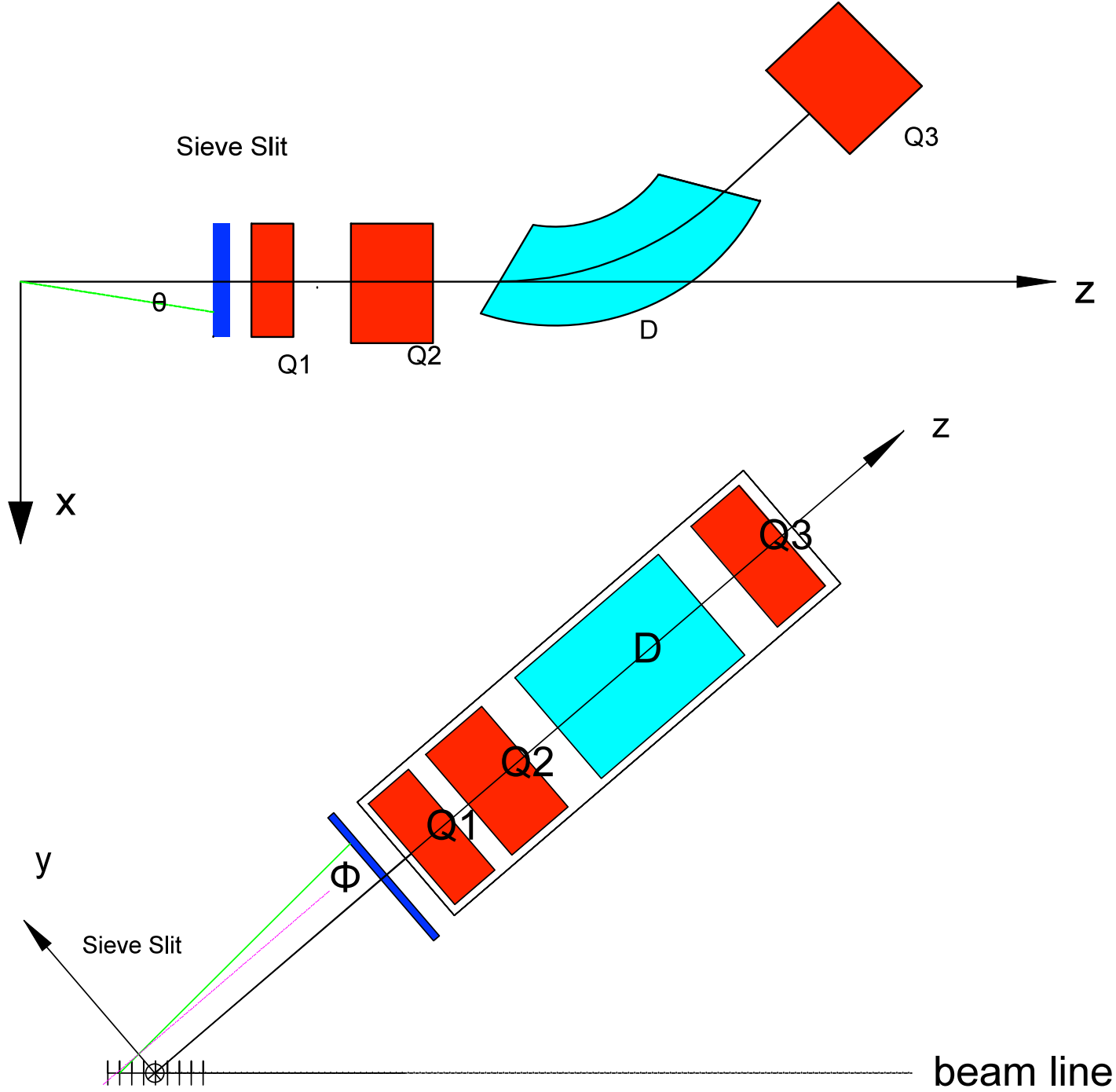
$$\begin{cases} y_{fp} = y_{tra} - \sum y_{i000} x_{fp}^{i} \\ x_{fp} = x_{tra} \\ \theta_{fp} = \dfrac{\theta_{det} + tan\rho}{1 - \theta_{det} tan\rho} \\ \varphi_{fp} = \dfrac{\varphi_{det} - \sum p_{i000} x_{fp}^{i}}{cos\rho - \theta_{det} sinp} \end{cases}$$

$$tan\rho = \sum t_{i000} x_{fp}^{i}$$

Target Variable

Side View

Top View



HRS Optics

- 4 **Focal Plane Variable** from tracking → 4 **Target Variable**
- 4 sets of up to 5th order polynomials to fit the expected target variables

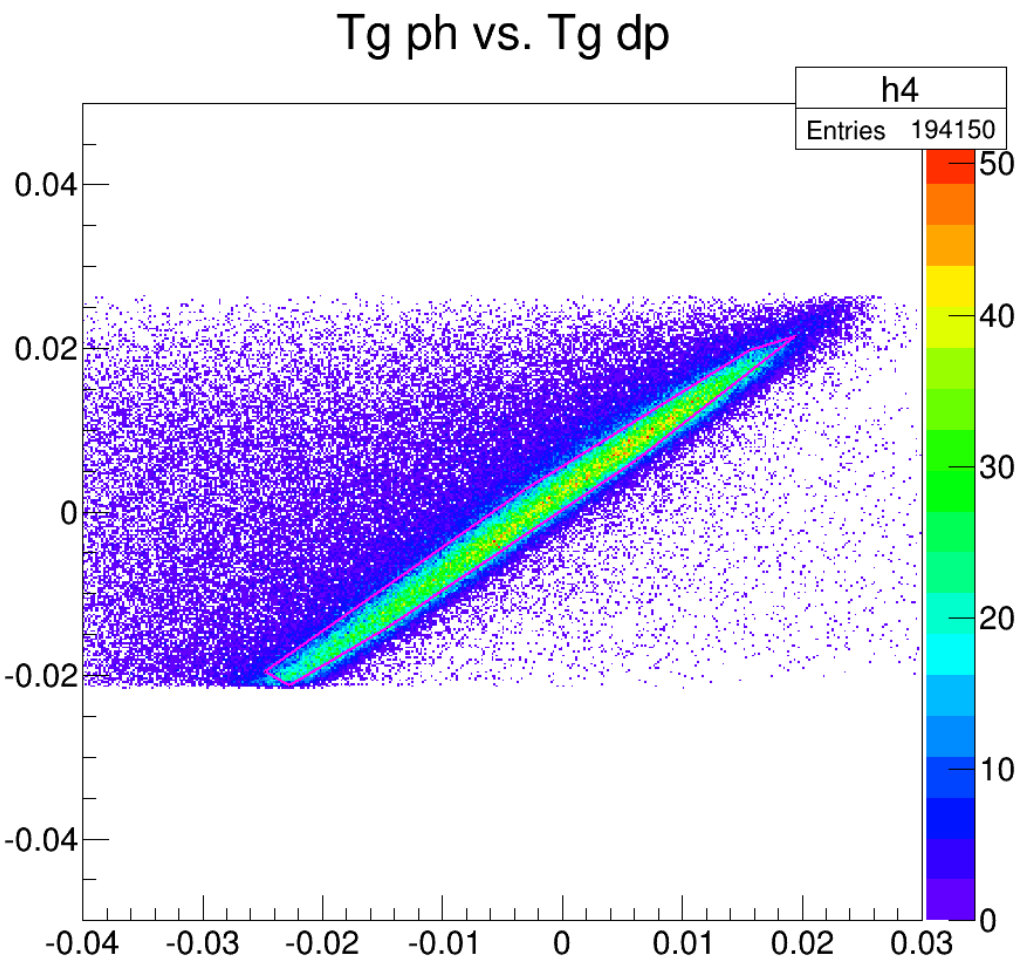
- $$\begin{cases} y_{tg} = \sum_{ljk} Y_{ijk} \theta_{fp}^{l} y_{fp}^{j} \phi_{fp}^{k} \\ \theta_{tg} = \sum_{ljk} T_{ijk} \theta_{fp}^{l} y_{fp}^{j} \phi_{fp}^{k} \\ \phi_{tg} = \sum_{ljk} P_{ijk} \theta_{fp}^{l} y_{fp}^{j} \phi_{fp}^{k} \\ \delta = \sum_{ljk} D_{ijk} \theta_{fp}^{l} y_{fp}^{j} \phi_{fp}^{k} \end{cases}$$
- $$Y/D/T/P = \sum_{i=1}^{m} C_i^{Y/D/T/P} x_{fp}^{i}$$

```
L.vdc.matrixelem =
t 0 0 0  -1.001135e+00 -3.313373e-01 -4.290819e-02  4.470852e-03
y 0 0 0  -8.060915e-03  1.071977e-03  9.019102e-04 -3.239615e-04
p 0 0 0  -2.861912e-03 -2.469069e-03  8.427172e-03  2.274635e-03
D 0 0 0  5.118113E-04 8.522775E-02 6.346834E-03 -4.637195E-03 1.476364E-02
D 1 0 0  -4.247550E-02 2.417700E-01 5.706905E-02 -4.025159E-03
D 2 0 0  -4.331429E+00 5.326924E+00 -7.478135E+00
D 3 0 0  3.167055E+01 9.678060E+01
D 4 0 0  -8.475406E+03
D 0 0 2  1.657123E-01 -8.826997E-01 3.245634E+00
D 0 2 0  8.754870E-01 5.443126E-01 4.792556E+00
D 0 1 1  -1.486998E-01 1.204271E+00 6.101041E-01
D 1 2 0  -6.488178E+01 2.017449E+00
D 1 0 2  6.270685E+00 -6.204080E+01
D 1 1 1  4.413440E+00 -6.221572E+01
D 2 0 2  -1.306661E+01
D 2 1 1  -2.466953E+03
D 2 2 0  -3.635787E+02
D 0 1 3  2.868957E+02
D 0 3 1  1.584274E+03
D 0 0 4  -4.392377E+01
D 0 4 0  -4.708602E+02
D 0 2 2  -1.706259E+03
T 0 1 1  1.783506E-02 1.150902E-02 3.780249E-01
T 1 1 1  -1.273165E+01 1.098221E+00
T 0 0 2  4.859896E-01 2.281832E-01 -2.116492E-01
T 1 0 2  -5.997432E+00
```

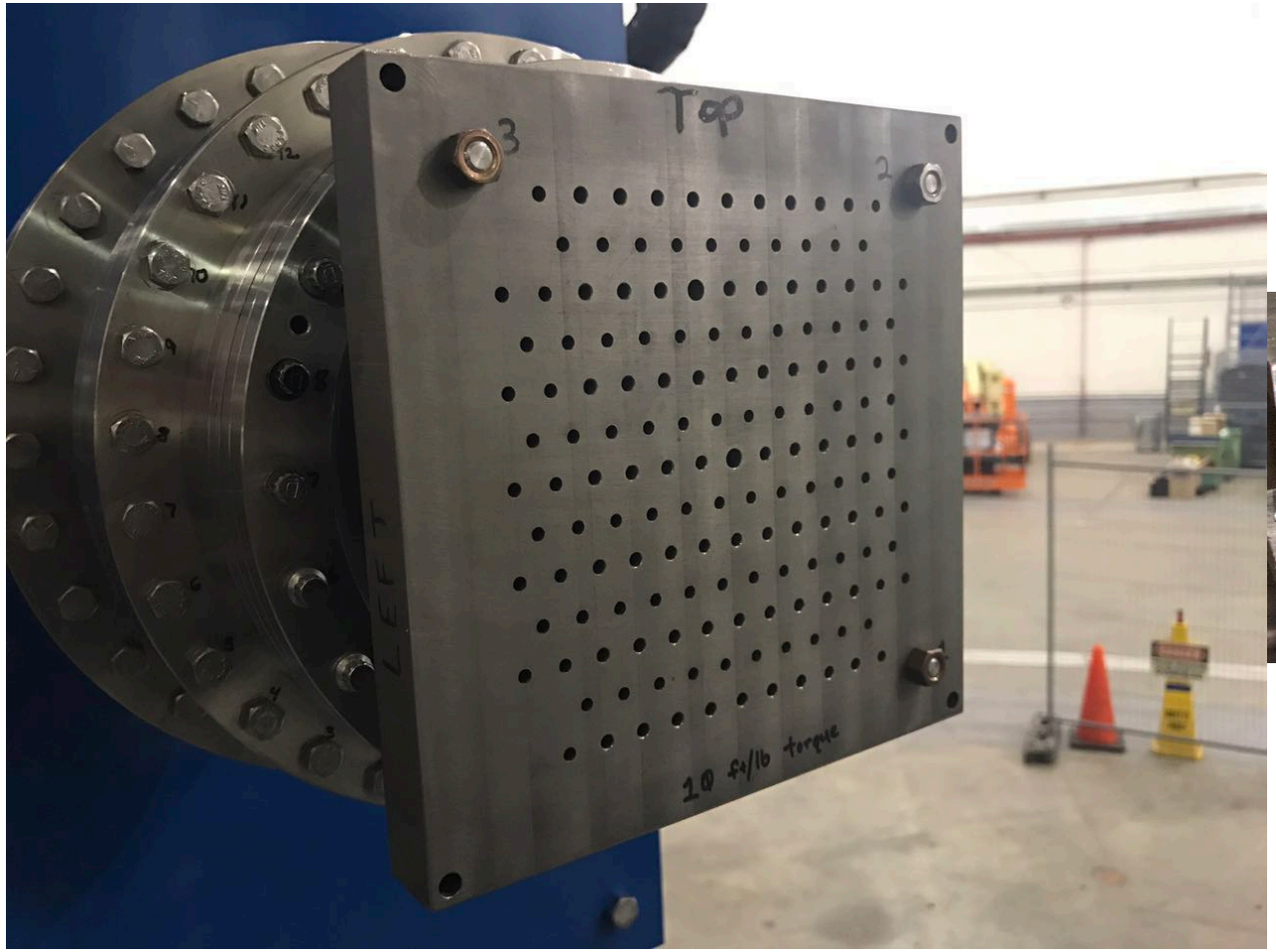
HRS Optics Optimization – Data taking

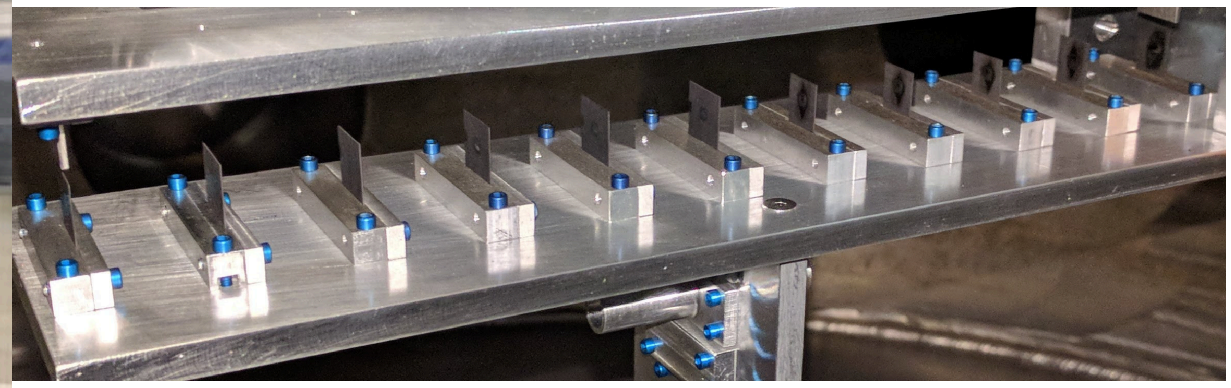
- For $\theta_{tg}, y_{tg}, \varphi_{tg}$
  - Sieve Slit + Mutifoils data which can cover the full acceptance of $\theta_{tg}, y_{tg}, \varphi_{tg}$
  - Sieve Slit : 6×27
  - Mutifoils Target : 11 carbon foil with 2.5cm separation
- For δ
  - Known scattering momentum data
  - Scan the momentum peak at different position within the momentum acceptance

Elastic Scatterting Data(2016 Fall,GMP)

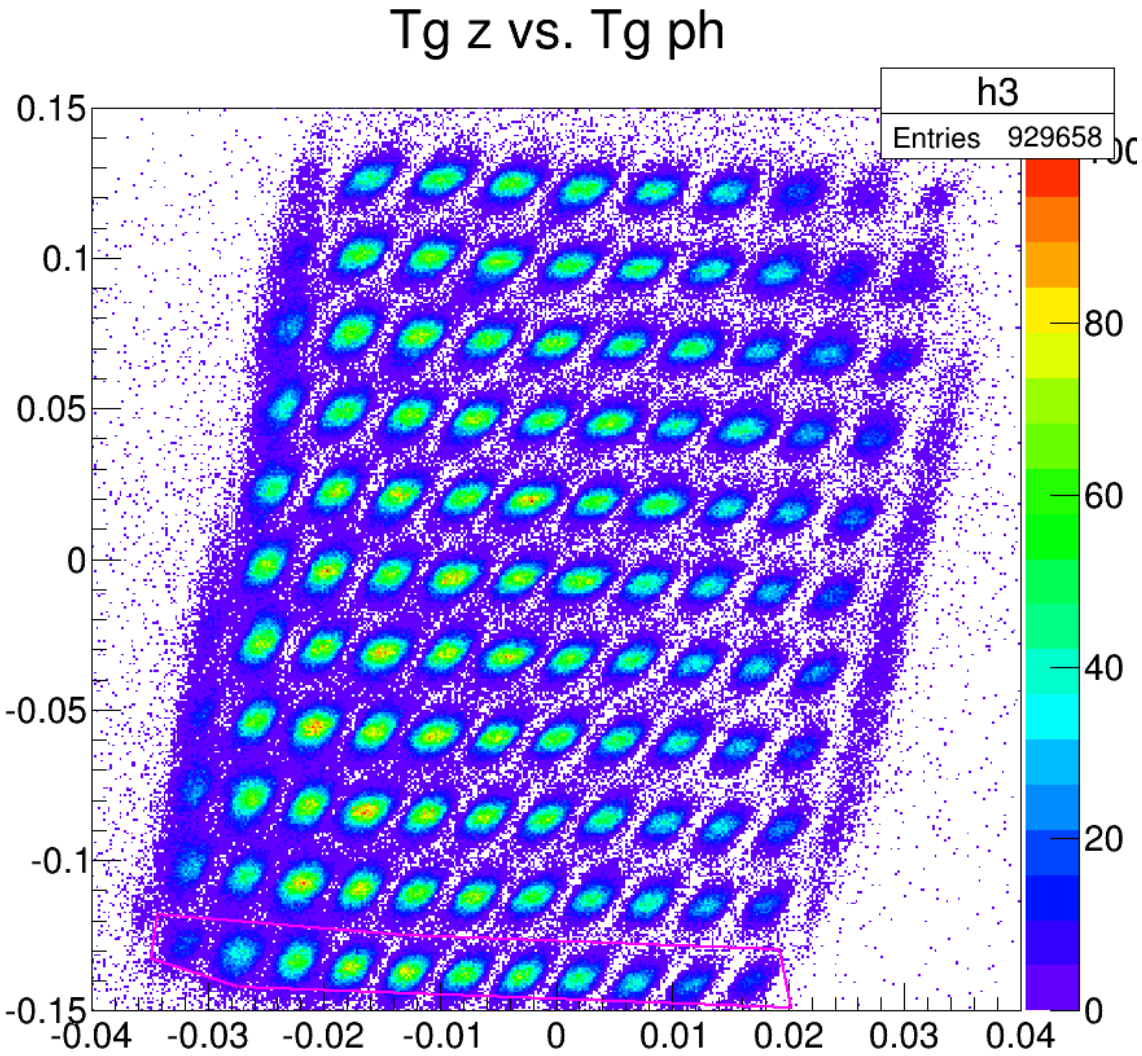


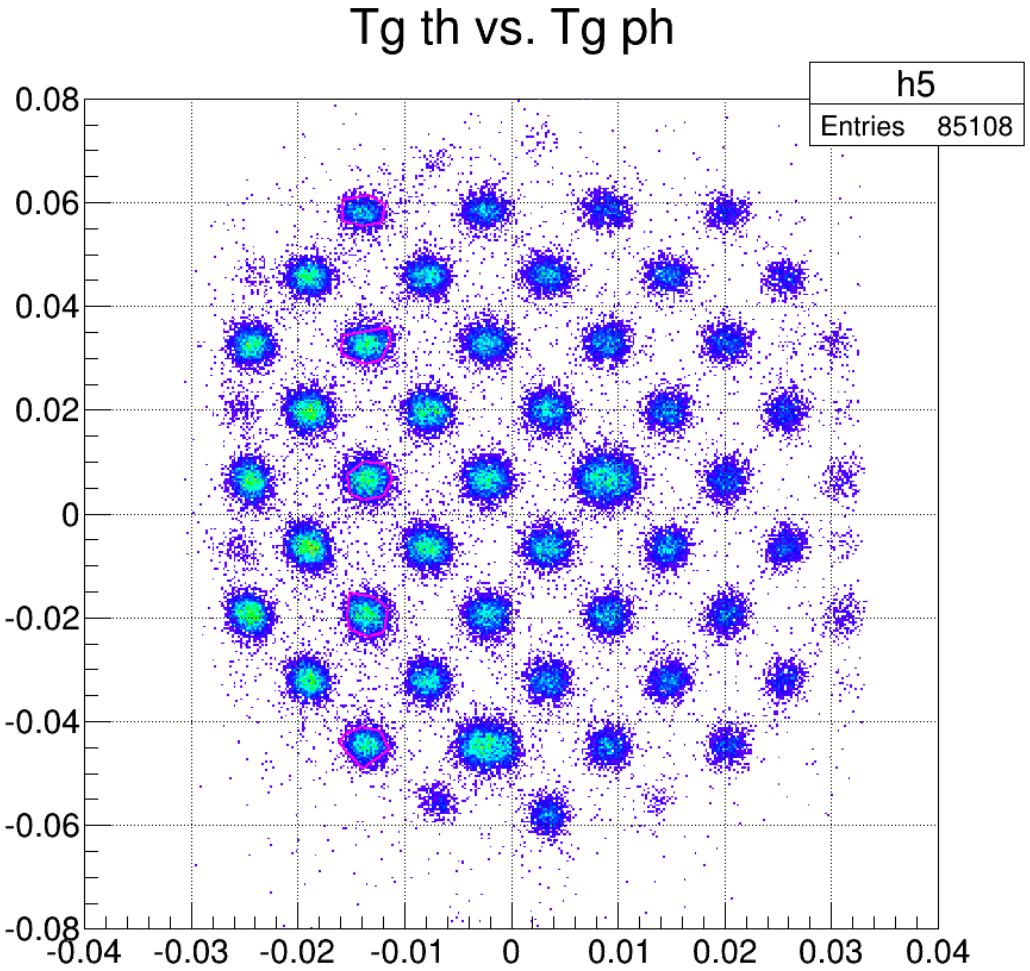
Sieve Slit and Muti-foils Target



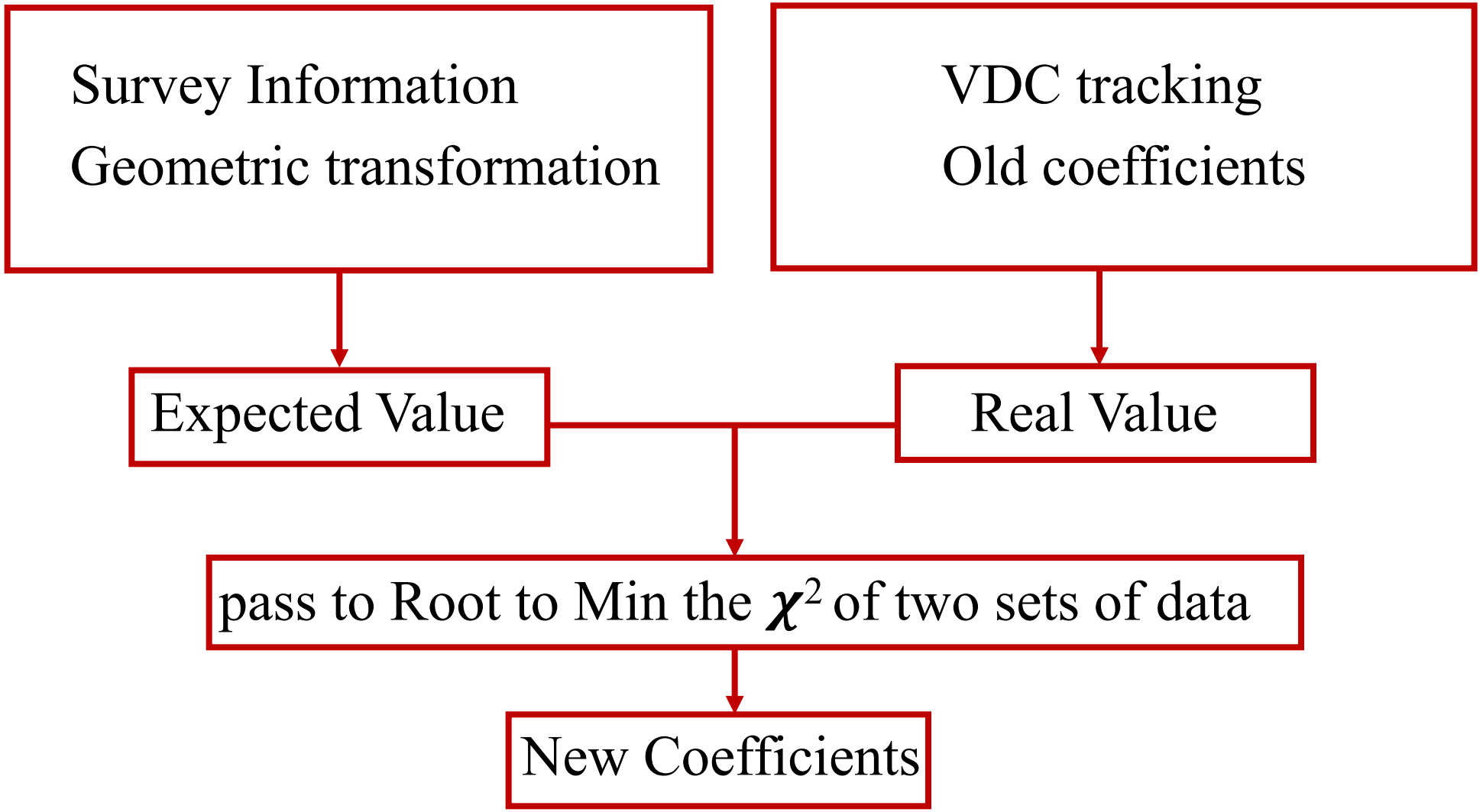


Muti-Foils Sieve Data(2017 December ,Tritium)





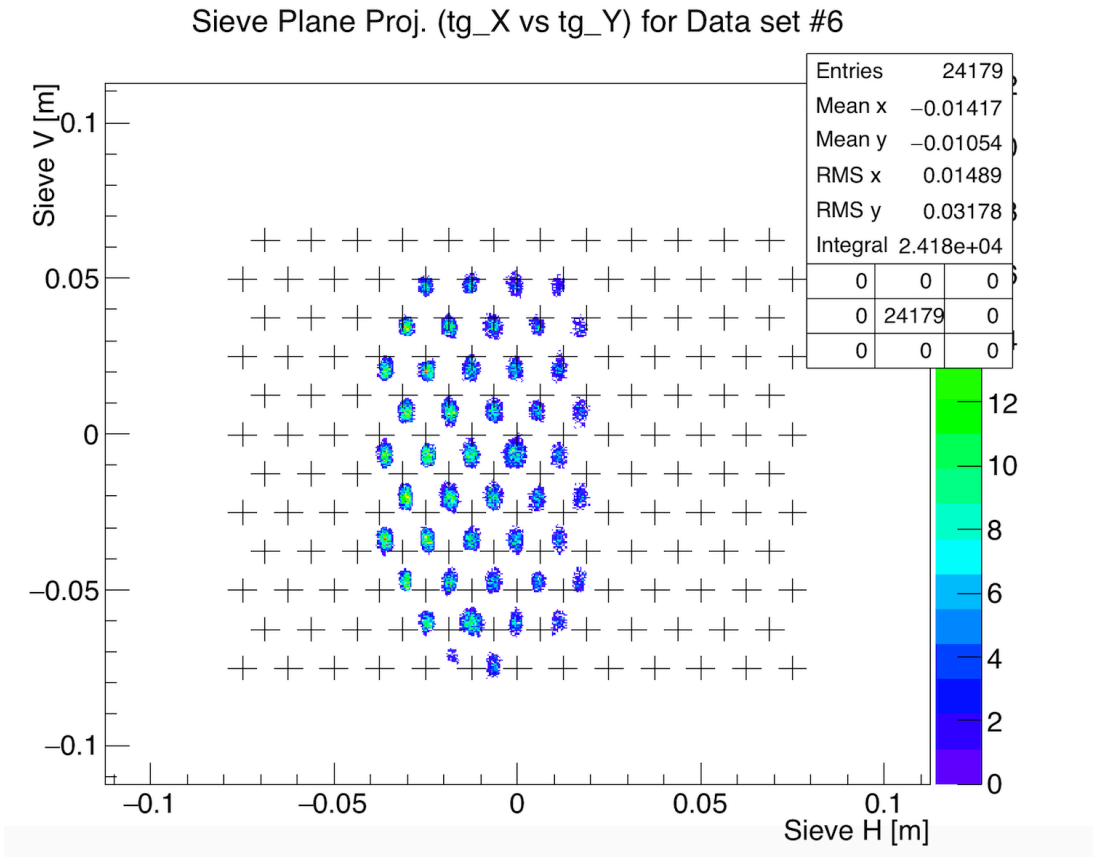
HRS Optics Optimization – Refitting the coefficient

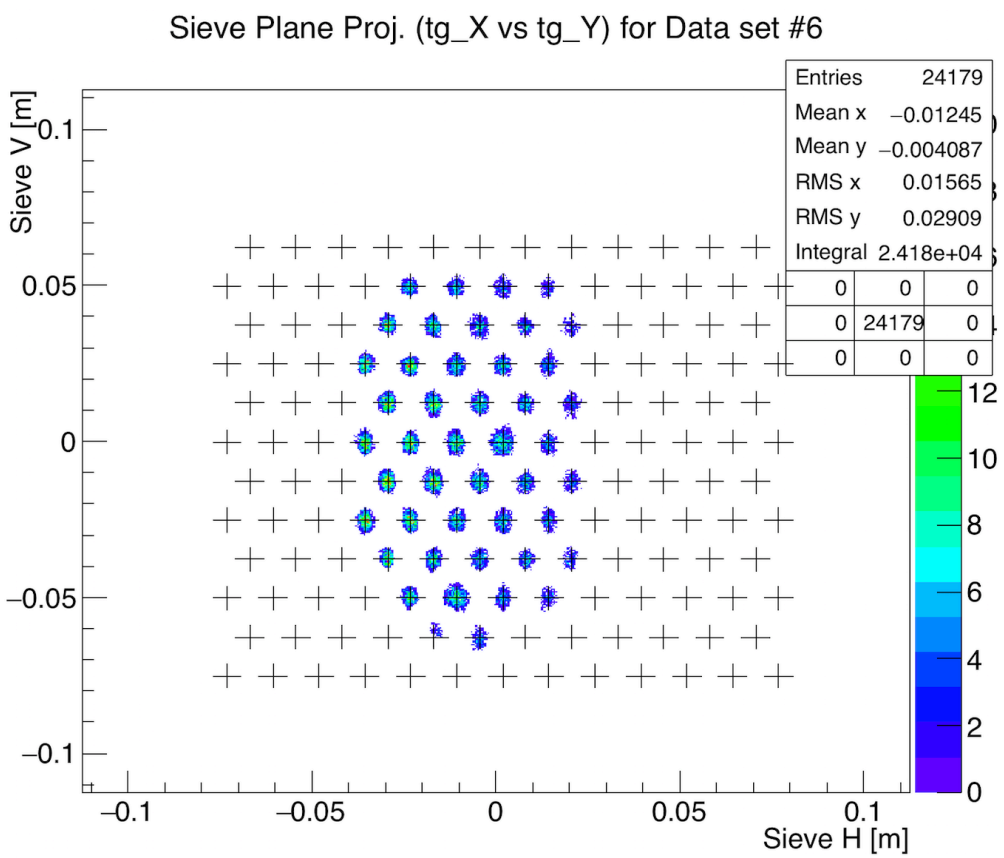


Code to use

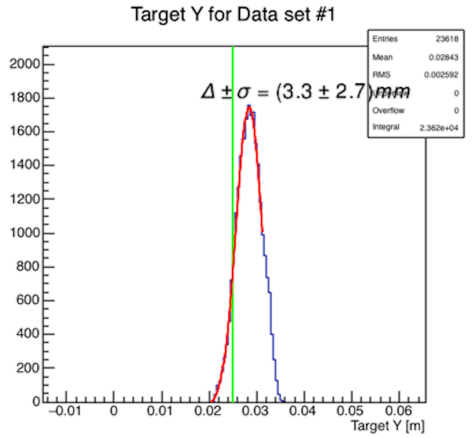
- First developed by Nilanga Liyanage et al. in Fortran and modified by several generations users
- Full C++ version
  - **Cut_L ,Cut_R** : Apply the cut for vertex, foil and momentum peak
    - Author : Jin Huang
    - Modified by Yang Wang for Gmp to update the number of foils and sieve holes
  - **Tree2Ascii** : Extract the data from root tree with the applied cut and generate the .txt data file
    - Author: Ole Hansen, JLab, February 2004
    - Modified by Jin Huang to support additional cuts
  - **OpticsOpt Class** : Main code to optimize the matrix and to check the result
    - Author: Jin Huang
    - Modified by Yang Wang for the LH target energy loss

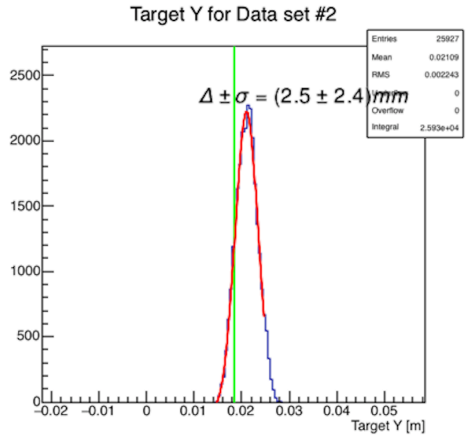
Sieve Optimization

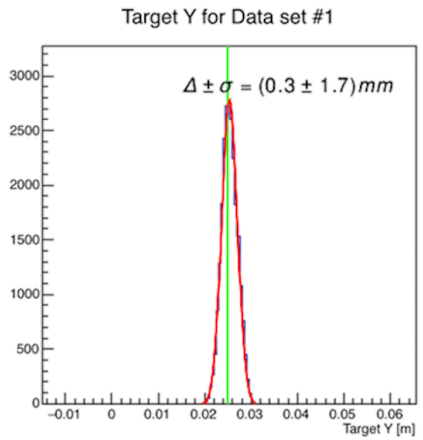


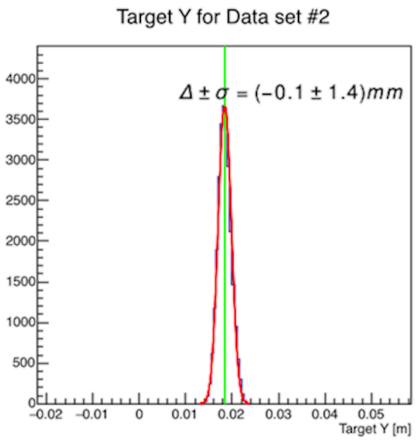


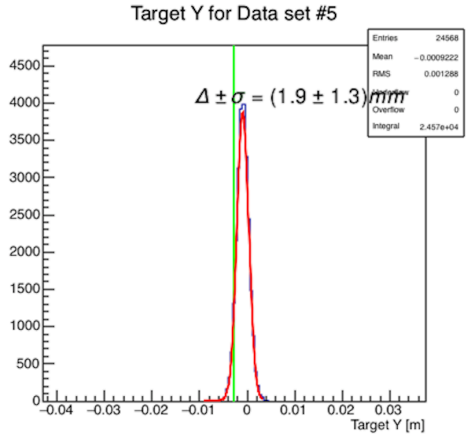
Vertex Optimization

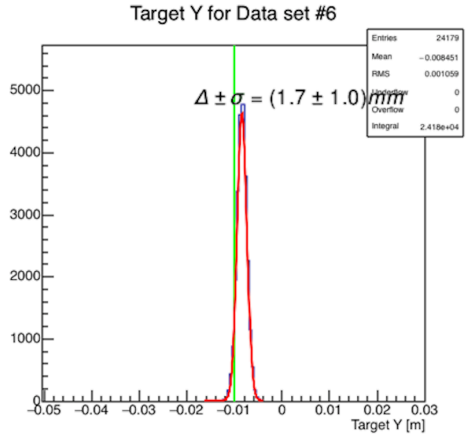


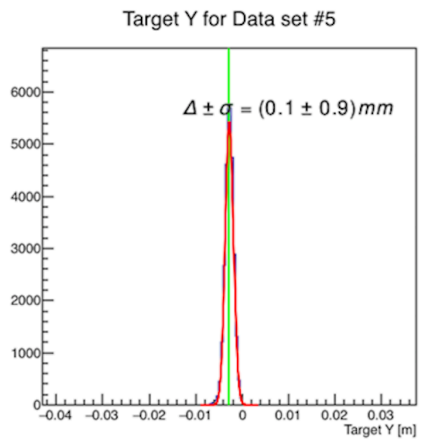


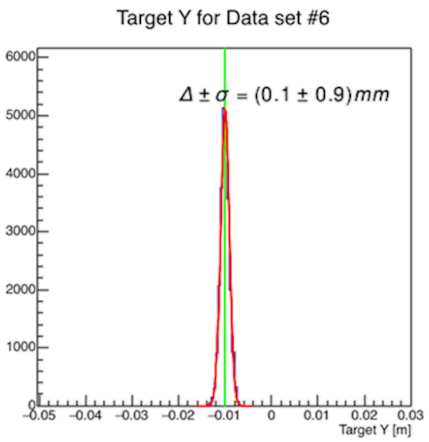






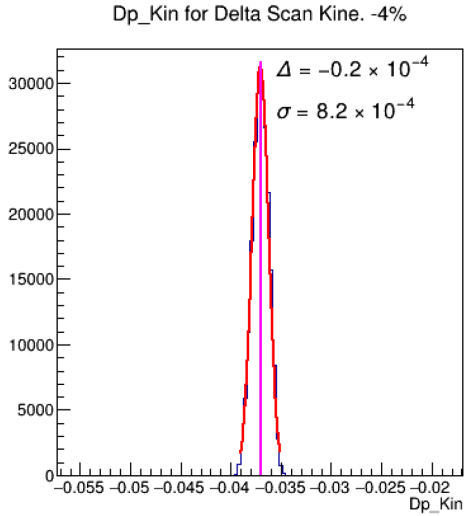


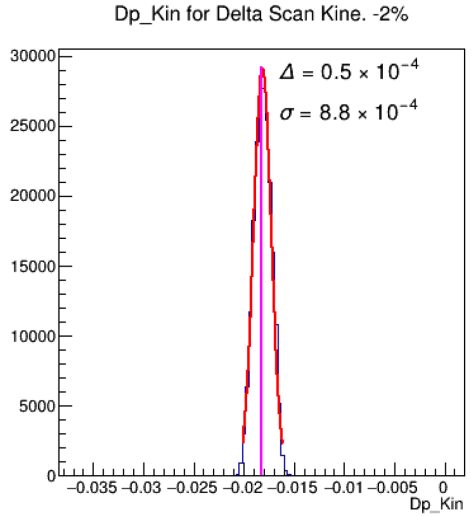


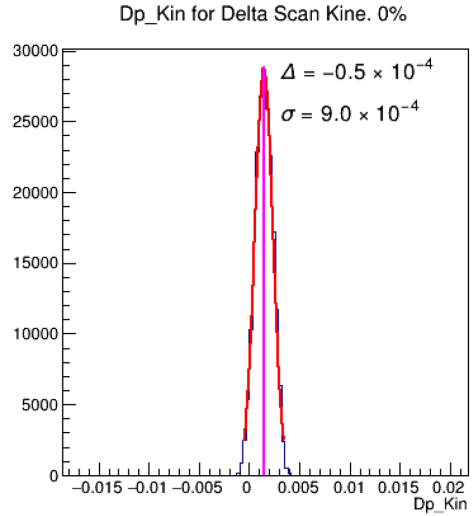


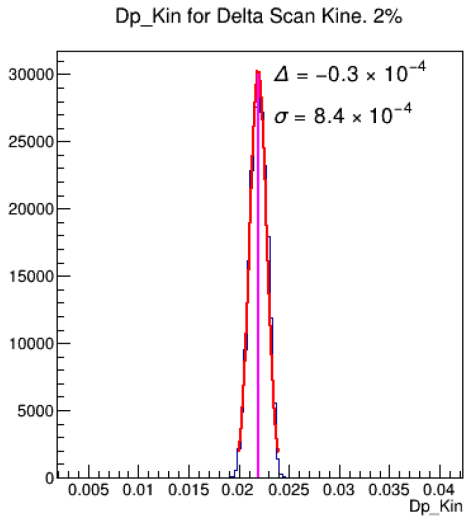
δ Optimization (GMP Data)

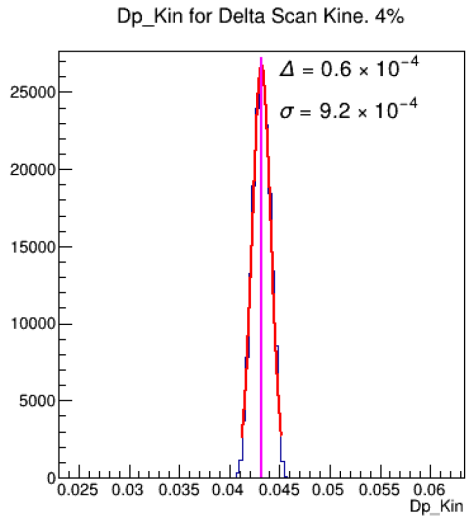
LHRS 17 degrees, dp calibration











$$DpKin_{Real} = \frac{P_{\theta_{HRS}} - P_{Central}}{P_{Central}}$$

$$DpKin = dp - \frac{(P_{\theta} - P_{Loss}) - P_{\theta_{HRS}}}{P_{Central}}$$

$$DpKin - DpKin_{Real} = dp - \frac{(P_{\theta} - P_{Loss}) - P_{Central}}{P_{Central}}$$