g_2^p HRS Optics with Septum

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On Behalf of the E08-027 g2p collaboration

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E08-027
g_2^p & the LT Spin Polarizability

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  - Don Crabb (UVA)
  - Karl Slifer (UNH)
- Pos Docs
  - Kalyan Allada
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  - Vince Sulkosky
  - Jixie Zhang
- Graduate Students
  - Toby Badman
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  - Chao Gu
  - Min Huang
  - Jie Liu
  - Pengjia Zhu
  - Ryan Zielinski

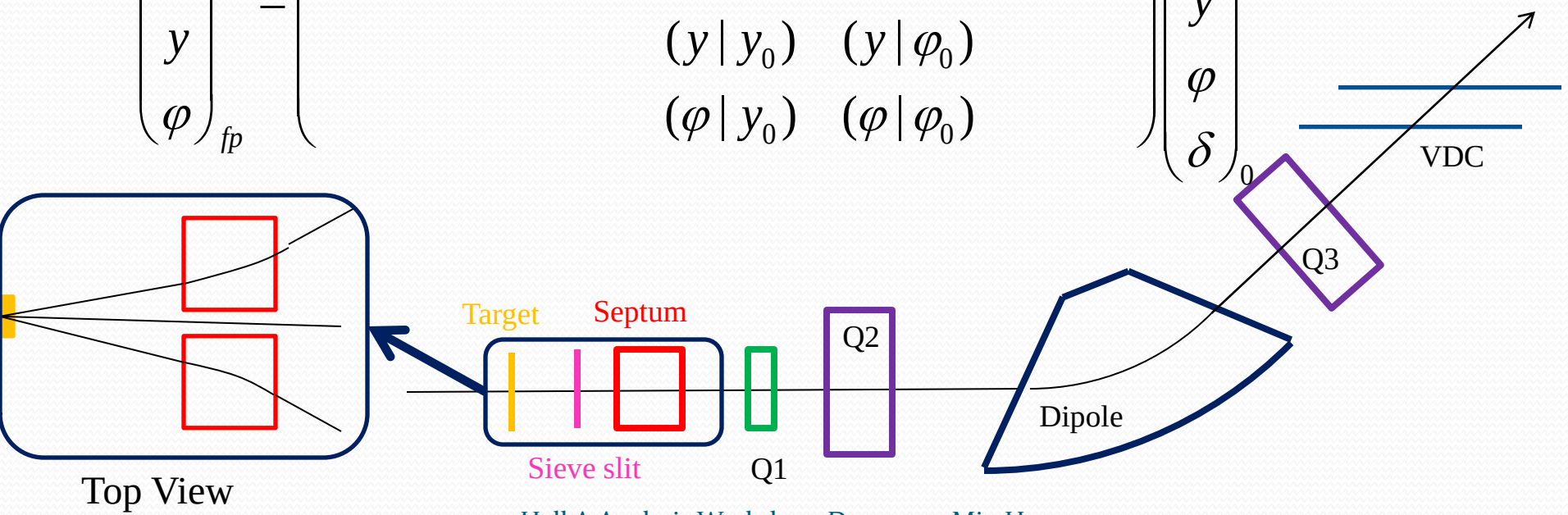
Outline

- General HRS Optics
- Intro of g2p Optics
  - Goals and design
  - Septa and target
  - Data taken
- Status of Optics data calibration

HRS Optics with Septum

- Target plane info ← Focal plane info (VDC tracking)
- Multi-dimensional polynomials
- First order matrix

$$\text{Focal plane} \begin{pmatrix} x \\ \theta \\ y \\ \varphi \end{pmatrix}_{fp} = \begin{pmatrix} (x|x_0) & (x|\theta_0) & & & (x|\delta) \\ (\theta|x_0) & (\theta|\theta_0) & & & (\theta|\delta) \\ & & (y|y_0) & (y|\varphi_0) & \\ & & (\varphi|y_0) & (\varphi|\varphi_0) & \end{pmatrix} \begin{pmatrix} x \\ \theta \\ y \\ \varphi \\ \delta \end{pmatrix}_0 \text{Target plane}$$



g2p Optics

- What is a good first order matrix for g2p?
  - $(x|\theta_o)$ very small ← point to point HRS focusing
- Understand the goal of g2p optics
- g2p goal: syst. uncertainty of cross section 5%
- Optics goal
  - Syst. uncertainty of θ: 0.5%
  - Contribution to cross section uncertainty: 2%
  - Requires good uncertainty of angle (horizontal) reconstruction
  - Momentum uncertainty not sensitive, but not hard to achieve 10^{-4} level

g2p Optics

- First order matrix
  - Matrix elements can be adjusted by tuning quarupole fields

Focal plane

$$\begin{pmatrix} x \\ \theta \\ y \\ \varphi \end{pmatrix}_{fp} = \begin{pmatrix} (x|x_0) & (x|\theta_0) & (x|y_0) & (x|\varphi_0) & (x|\delta) \\ (\theta|x_0) & (\theta|\theta_0) & (\theta|y_0) & (\theta|\varphi_0) & (\theta|\delta) \\ (y|x_0) & (y|\theta_0) & (y|y_0) & (y|\varphi_0) & (y|\delta) \\ (\varphi|x_0) & (\varphi|\theta_0) & (\varphi|y_0) & (\varphi|\varphi_0) & (\varphi|\delta) \end{pmatrix} \begin{pmatrix} x \\ \theta \\ y \\ \varphi \\ \delta \end{pmatrix}_0$$

Target plane

- Optics design
  - Tuned Quadrupole fields in SNAKE to satisfy the goals
  - New I vs P_0 setting of HRS Quads for g2p experiment
  - Online database from SNAKE model

Thanks to John Lerose for his help!

g2p Optics

--Septa

- Designed symmetric left and right septum
- Each septum has top and bottom 3 pairs of coils each
- 48-48-16
  1st good septum

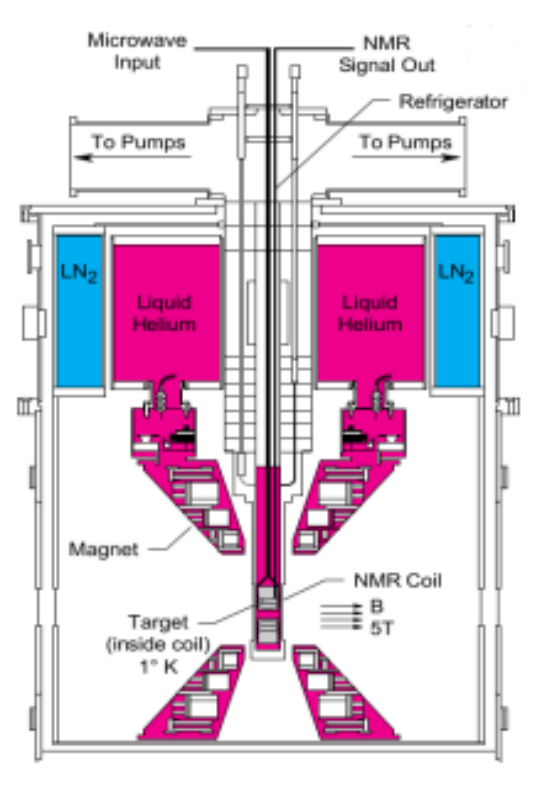
Courtesy Jixie Zhang

g2p Optics
--Septa

- Right septum caught on fire twice
- 1st accident
  - happened after 3 weeks running
  - right top 40-32-16 (2nd bad septum), bottom no change
- 2nd accident
  - Two weeks later
  - Right top 40-00-16 (3rd very bad septum), bottom no change
- Left coils remained the same
- Right septum field changed a lot, while left one field also got impacted
- Optics data on each situations

g2p Optics

--Target Configuration



NH_3

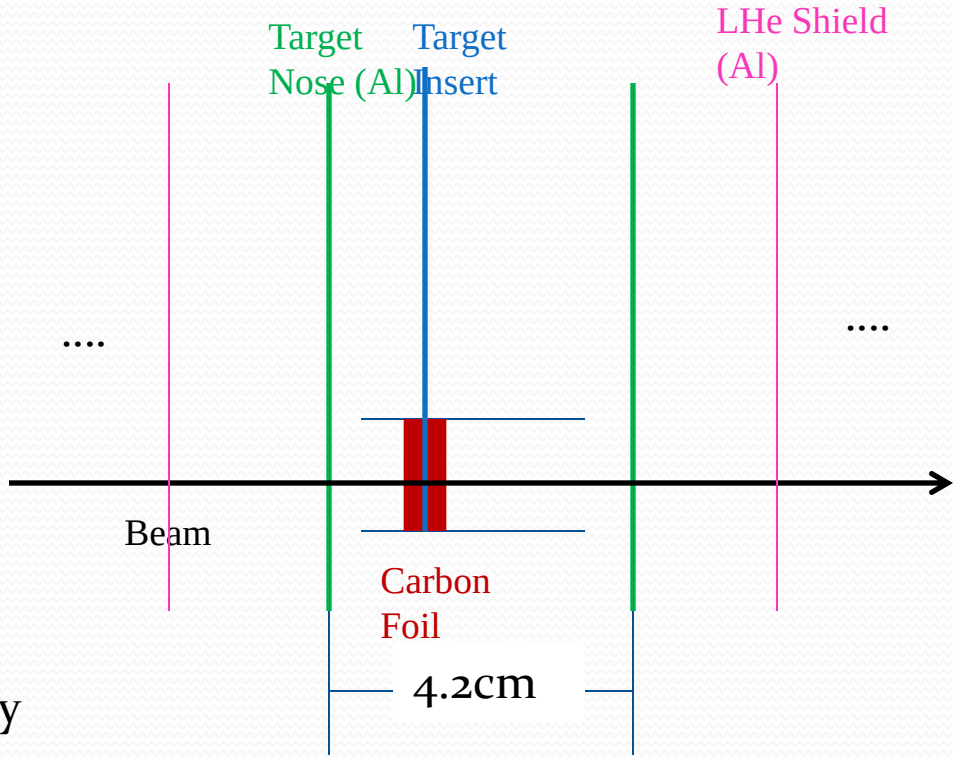
CH_2

Carbon

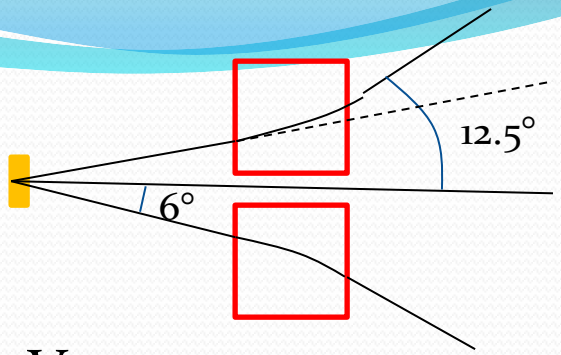
NH_3

Dummy

Carbon



g2p Optics Data



- 11 sets of data
  - Beam energy: 2.254GeV, 1.706 GeV, 1.158 GeV
  - Target field: 0, 2.5T, 5T
  - 3 different septa situations
- 2 sets of no target field data: 48-48-16 (1^{st}), 40-00-16 (3^{rd})

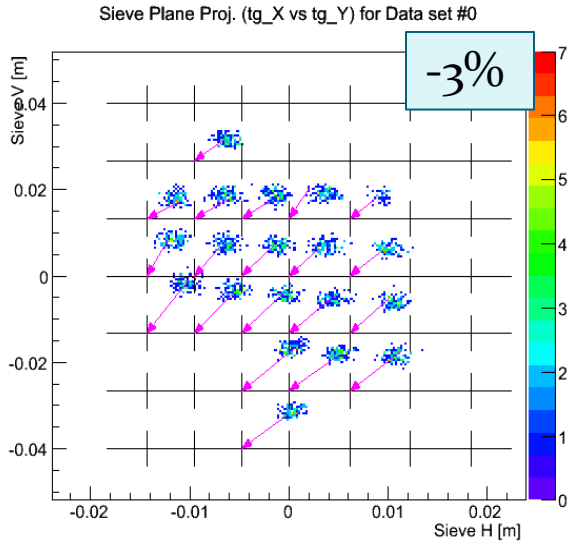
- Delta scan with sieve in, C foil: matrix calibration
- Pointing, C foil in LHe or CH_2 foil: central scattering angle determination
- Beam position scan , C foil: small angle ~6°, short production target ~3cm, high target field
- Fast & slow rasters, C foil: acceptance calibration

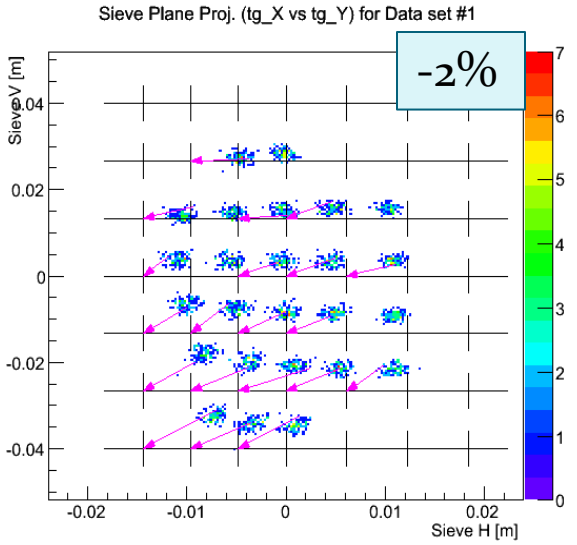
g2p Optics Calibration

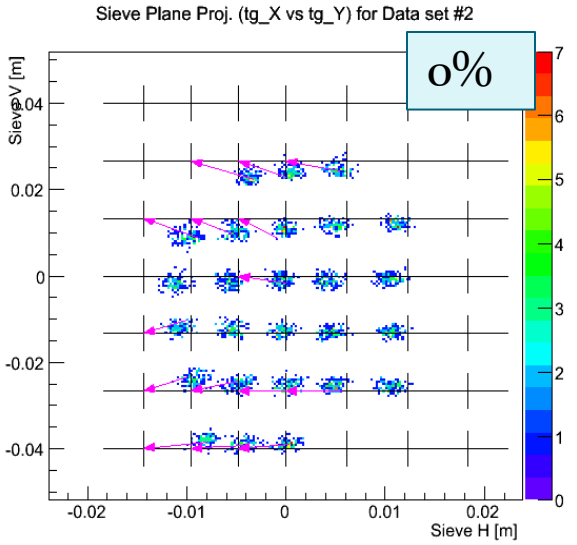
-- 48-48-16 1st Septum

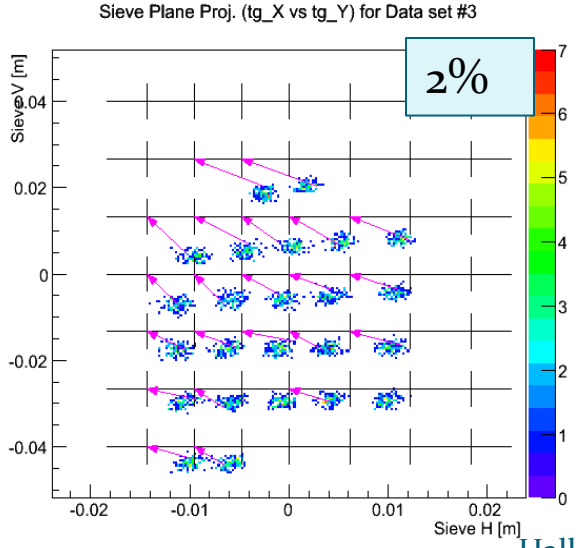
- Settings
  - Beam energy 2.254 GeV
  - No target field
  - Good septum: 48-48-16
- Optics runs
  - Full delta scan on both arms (-3%, -2%, 0, 2%, 3% on LHRS, -3.5%, -1%, 0, 2%, 3.5% on RHRS)

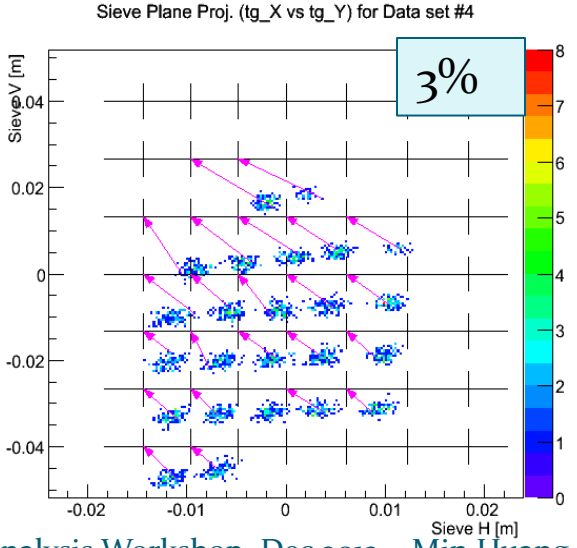
LHRS Before Calibration







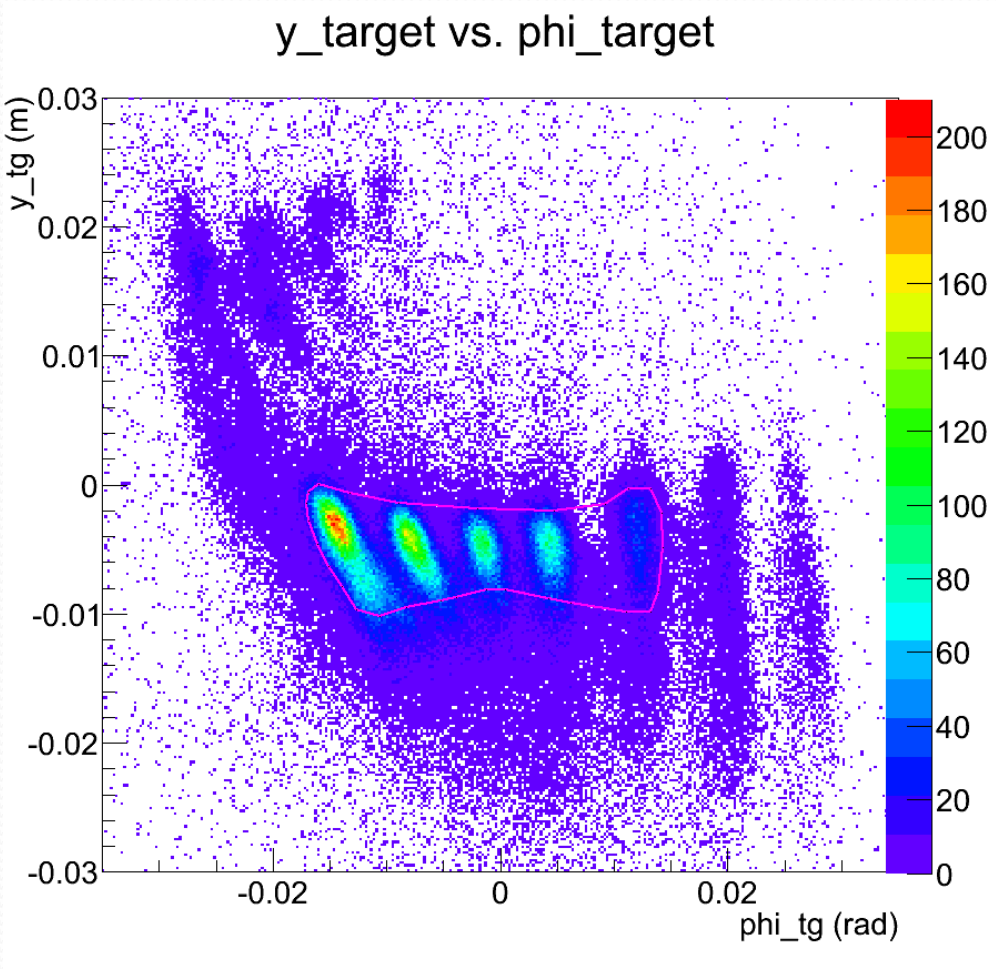




With data base from SNAKE model

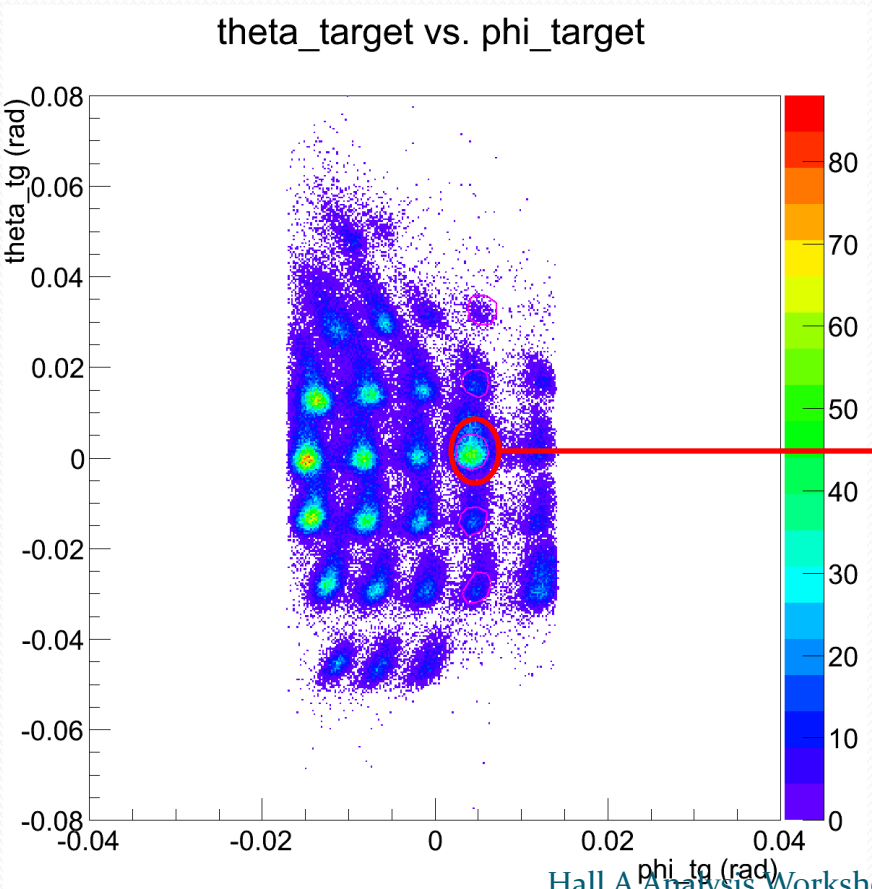
Calibration Steps

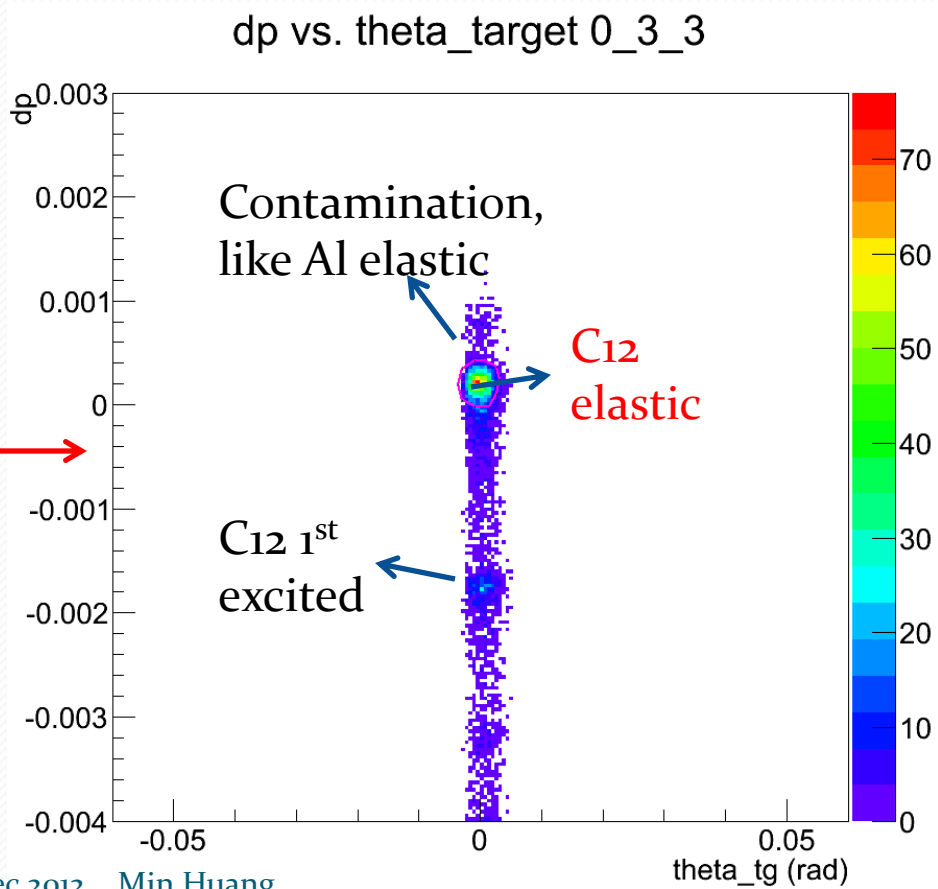
1. Tg_y vs. Tg_ph vetex cut for the whole run



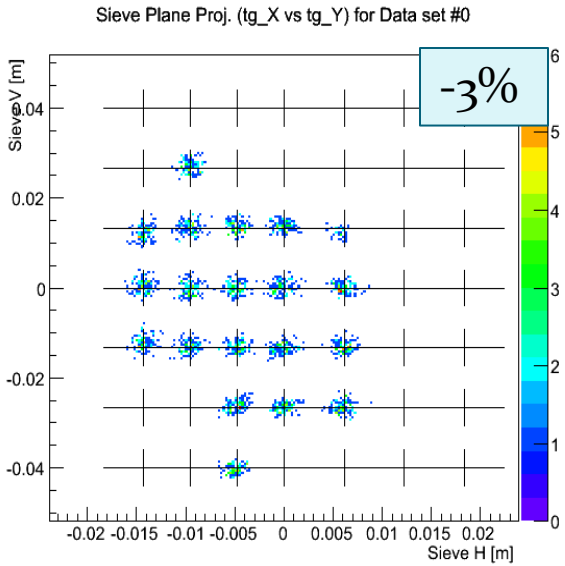
Calibration Steps

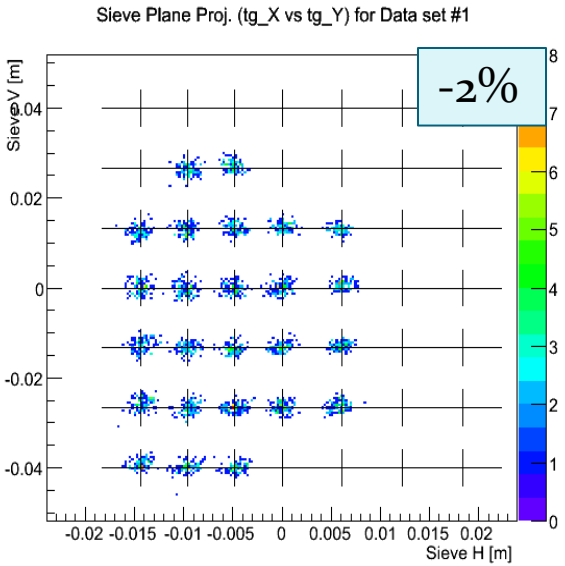
2. Cut on each hole
3. Cut carbon elastic for each hole

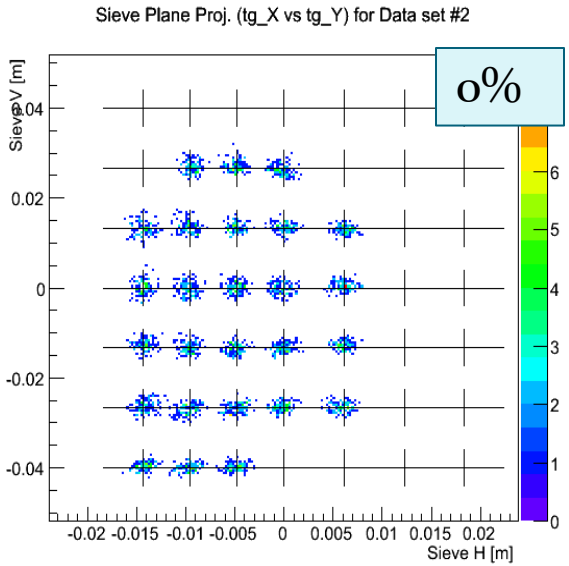


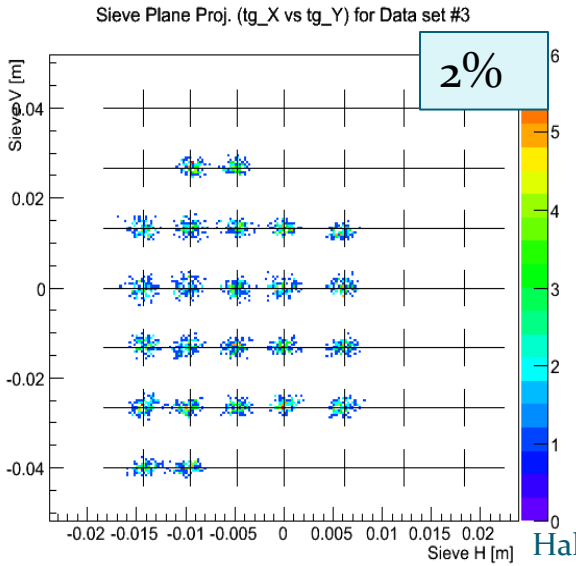


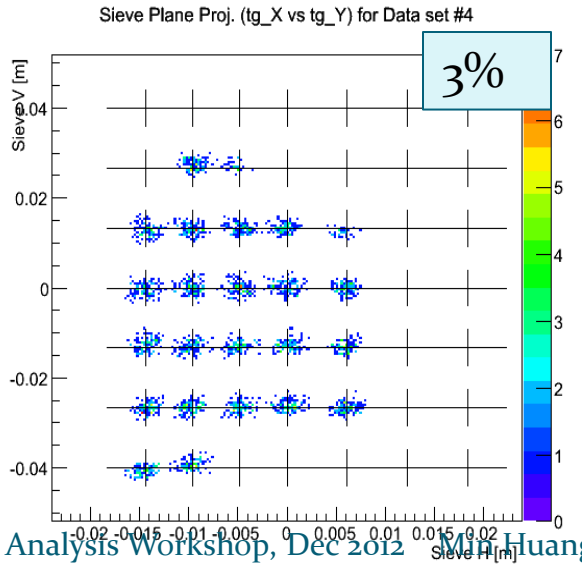
LHRS Matrix Angle Calibration



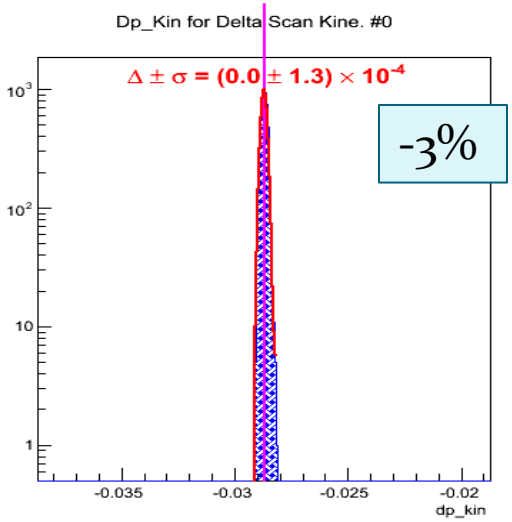


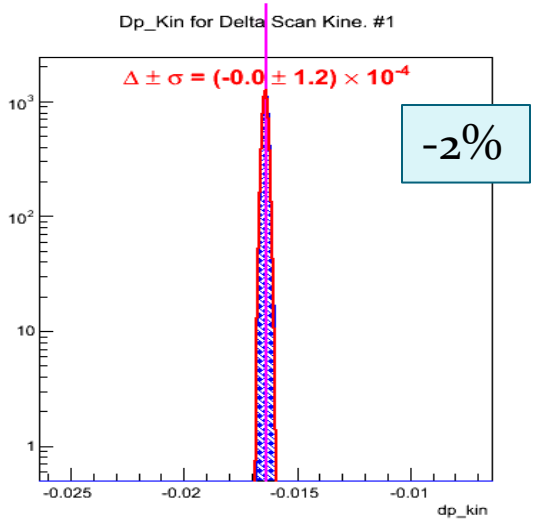


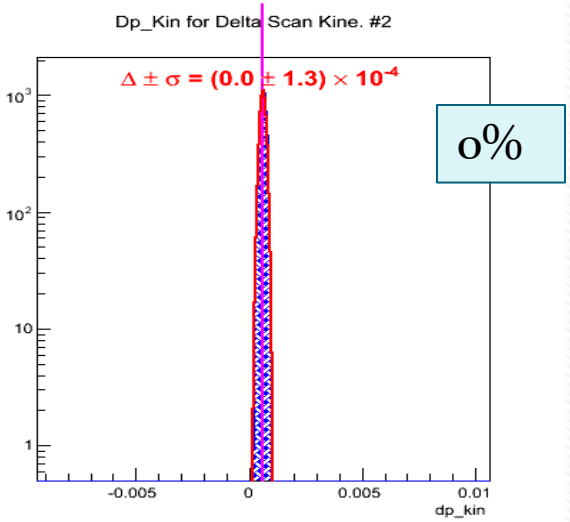


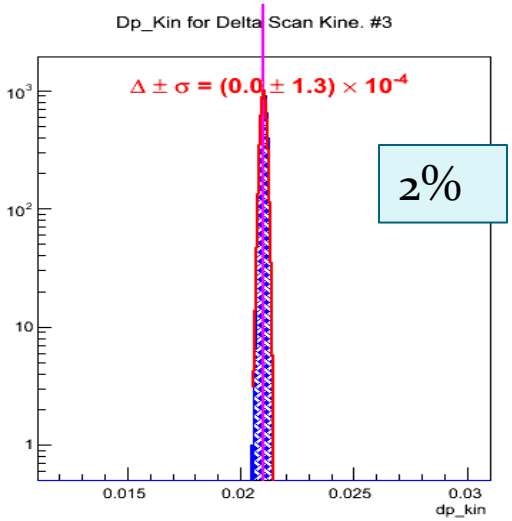


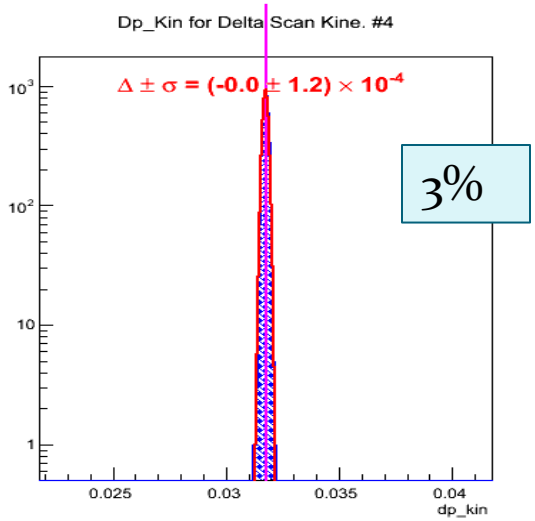
LHRS Matrix Dp calibration



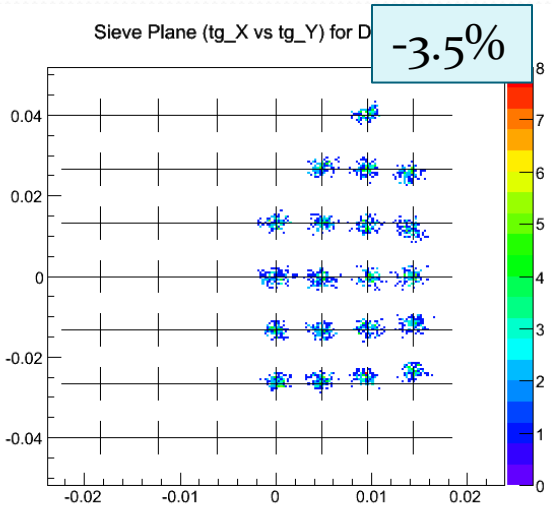


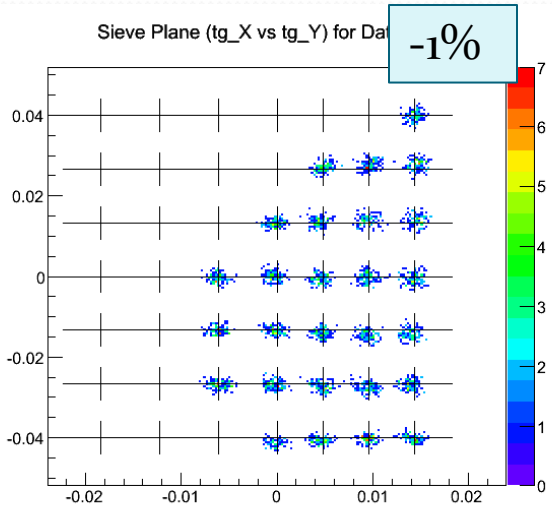


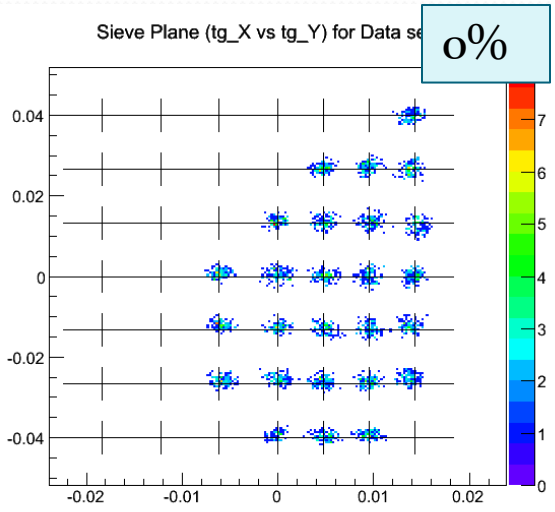


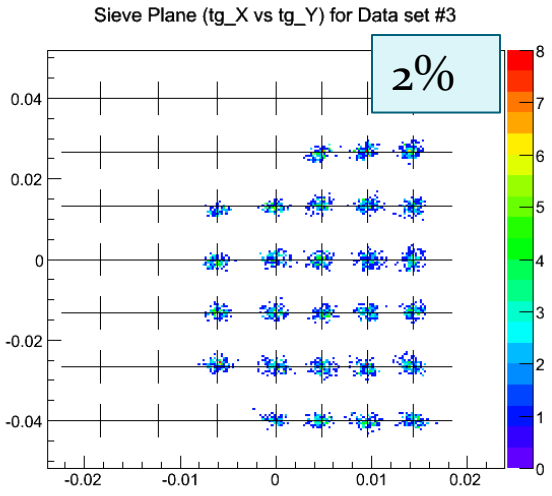


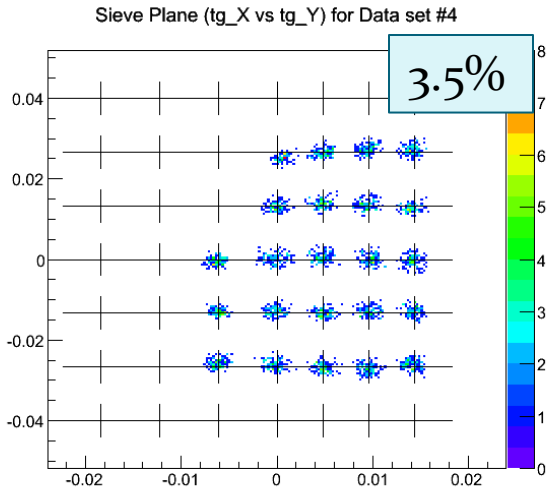
RHRS Matrix Calibration



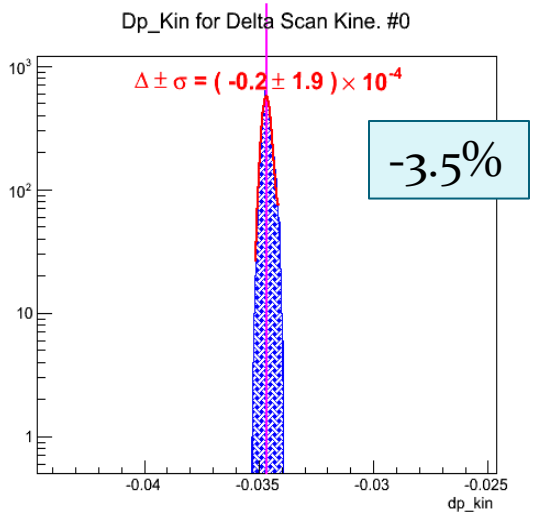


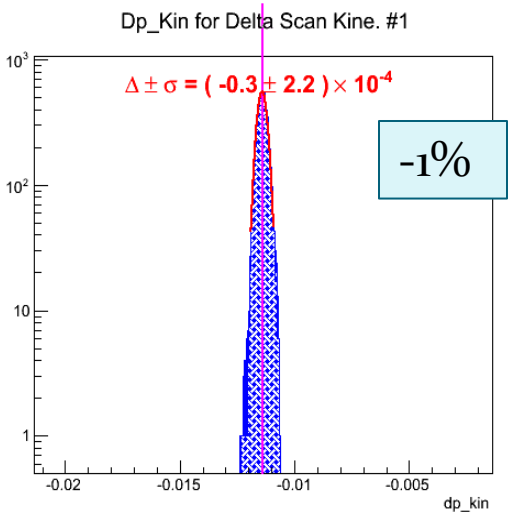


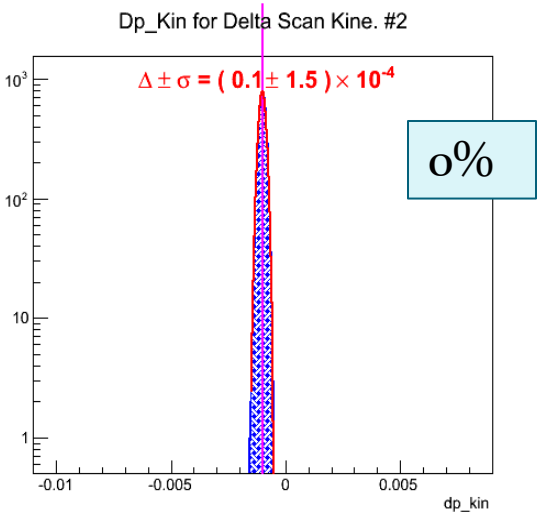


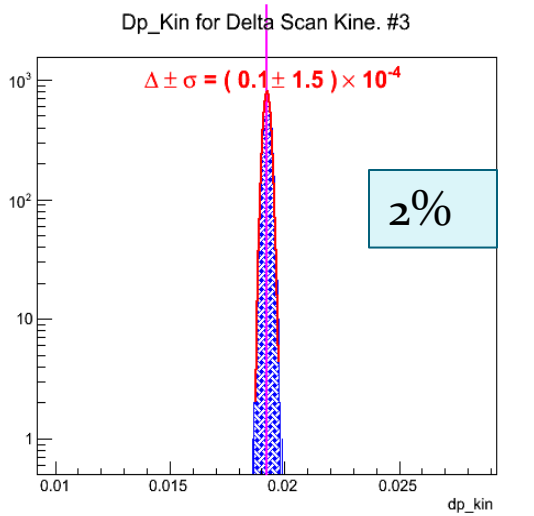


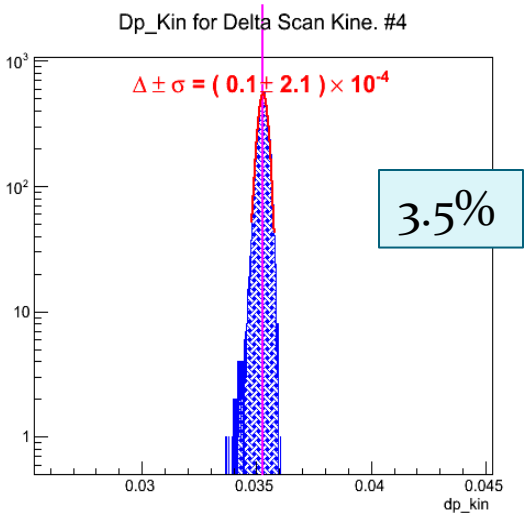
RHRS Matrix Dp calibration











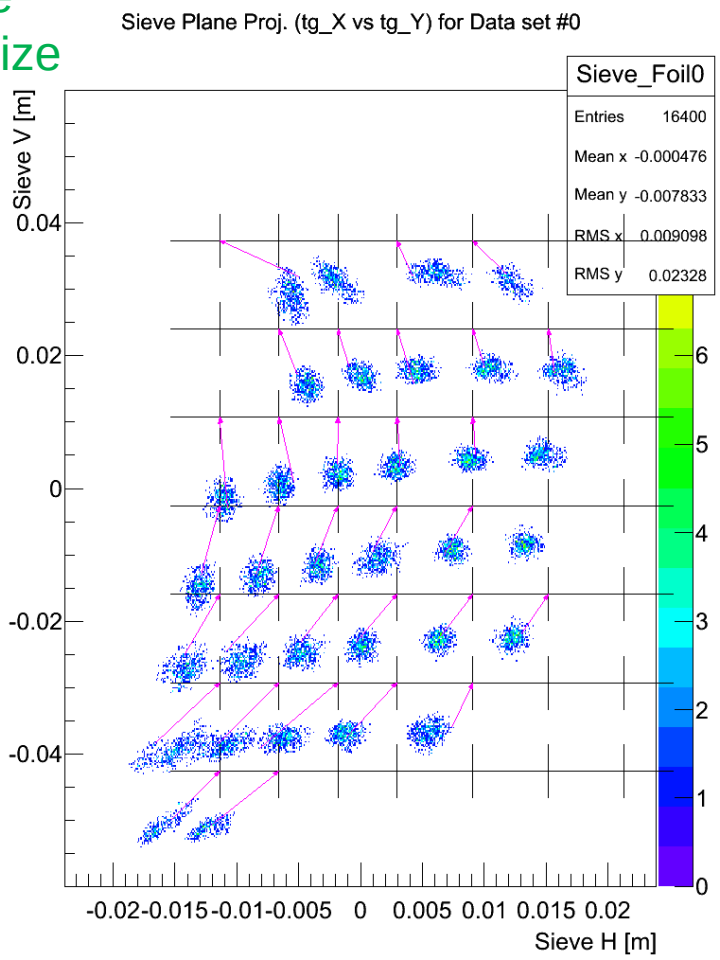
g2p Optics Calibration

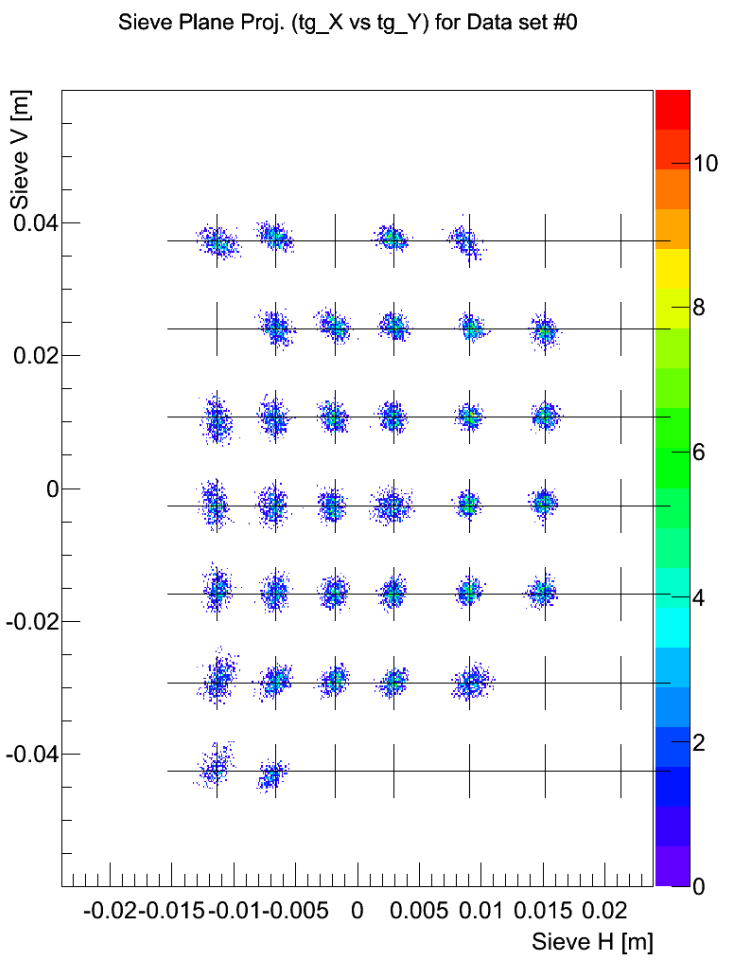
-- 40-00-16 3rd Septum

- Settings:
  - Beam energy 2.254GeV
  - 5T Target Field at 0 deg (view as no target field for now)
  - Septum coil turns 40-00-16
- Optics settings:
  - Full delta scan on left arm (-3%, -1%, 0%, 1%, 3%)
  - Only have 0% on right arm
- Start from good septum optimized matrix

LHRS Matrix Angle Calibration

Before Optimize



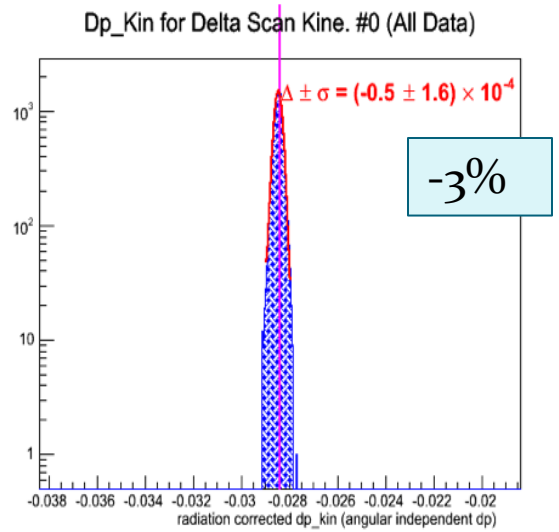


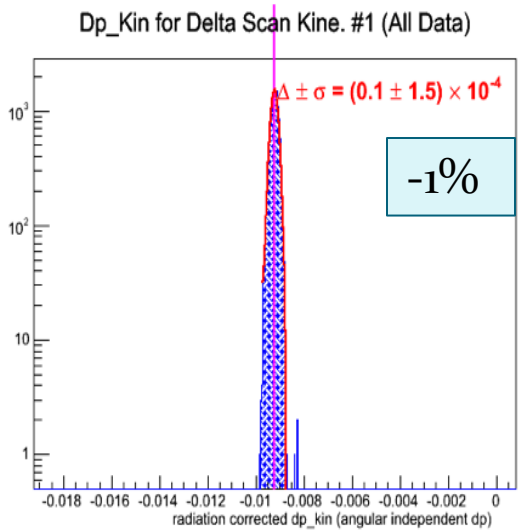
After 1 iteration

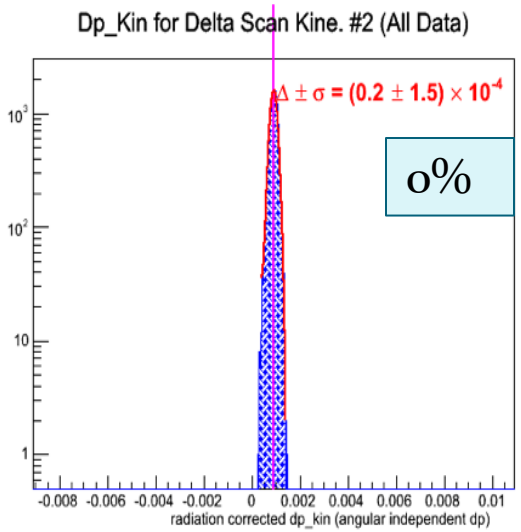
All delta scan combined

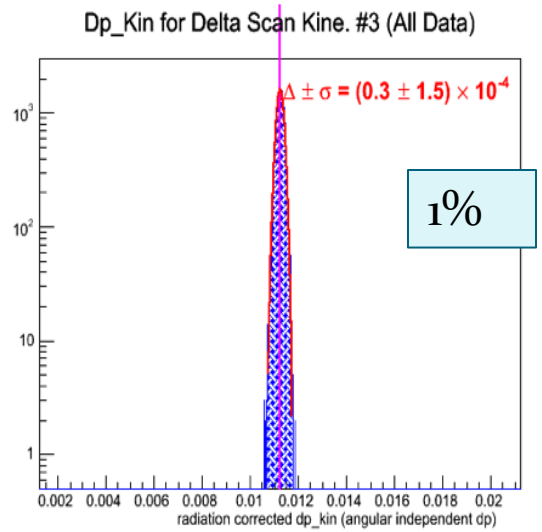
Courtesy Chao Gu

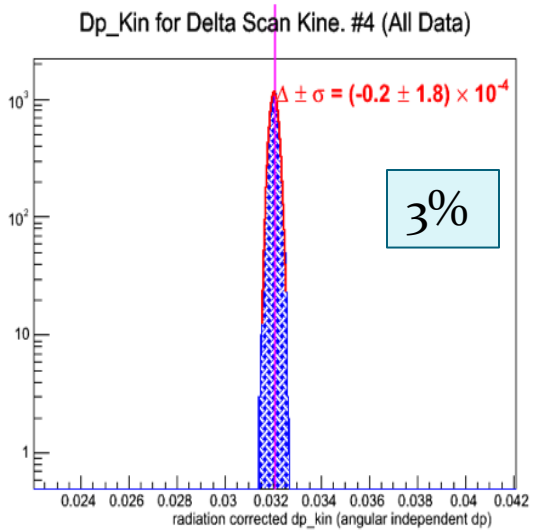
LHRS Matrix Dp calibration











Courtesy Chao Gu

Performance Summary

- Beam energy 2.254 GeV, no target field, 1st & 3rd septum

Root-mean-square	LHRS (1st)	RHRS (1st)	LHRS (3rd)
In-plane Angle [mrad]	0.9	0.9	0.7
Out-of-plane Angle [mrad]	1.5	1.6	1.4
Momentum [(p-po)/po]	1.3×10^{-4}	2.0×10^{-4}	1.8×10^{-4}

- 1st iteration
- Will perform target y calibrations, then work on improving these RMS

What to do

- Target y calibration for each setting
- Pointing: improve the accuracy of central angle
- Work on RHRS 40-00-16 3rd septum setting
- Wrap up no target field results with better accuracy & resolution
- Continue on target field ON situations
  - Jixie Zhang's talk on simulation

Thanks!

- I would like to thank the following people for their guidance and helpful discussions!
  - John Lerose
  - Jian-ping Chen
  - Nilanga Liyanage
  - Jixie Zhang, Vince Sulkosky, Chao Gu
  - Jin Huang, Xin Qian, Yi Qiang, Zhihong Ye, Huan Yao