

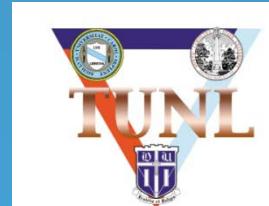
# $g_2^p$ HRS Optics with Septum

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On Behalf of the E08-027  $g_2^p$  collaboration

Hall A Analysis Workshop, 12/12/12



E08-027

# $g_2^p$ & the LT Spin Polarizability

- Spokespeople
  - Alexandre Camsonne (JLab)
  - Jian-Ping Chen (JLab)
  - Don Crabb (UVA)
  - Karl Slifer (UNH)
- Post Docs
  - Kalyan Allada
  - James Maxwell
  - Vince Sulkosky
  - Jixie Zhang
- Graduate Students
  - Toby Badman
  - Melissa Cummings
  - Chao Gu
  - Min Huang
  - Jie Liu
  - Pengjia Zhu
  - Ryan Zielinski

# Outline

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

# HRS Optics with Septum

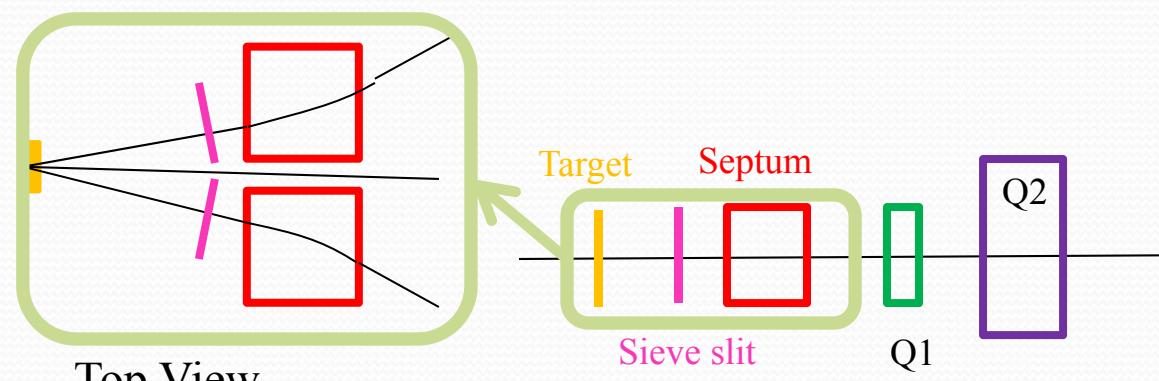
- Target plane info  $\leftarrow$  Focal plane info (VDC tracking)
- Multi-dimensional polynomials
- First order approximation

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

$$(y|y_0) \quad (y|\varphi_0) \\ (\varphi|y_0) \quad (\varphi|\varphi_0)$$

$$(x|\delta) \quad \begin{pmatrix} x \\ \theta \\ y \\ \varphi \\ \delta \end{pmatrix} \\ (\theta|\delta) \quad \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}$$

Target plane



# g2p Optics

- What is a good first order matrix for g2p?
  - $(x|\theta_0)$  very small  $\leftarrow$  point to point HRS focusing
- g2p goal: syst. uncertainty of cross section **5%**
- Optics goal
  - Syst. uncertainty of  $\theta$ : **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**

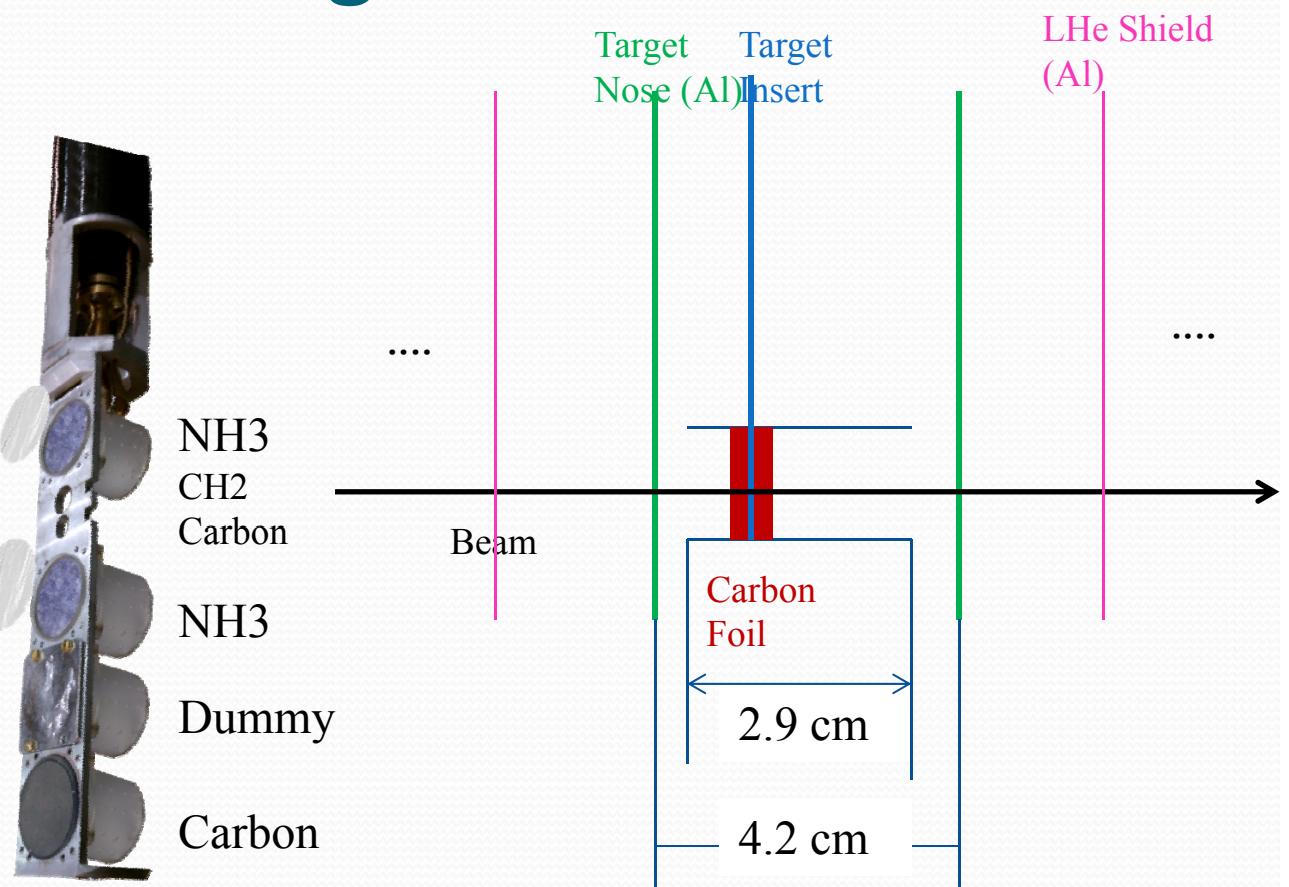
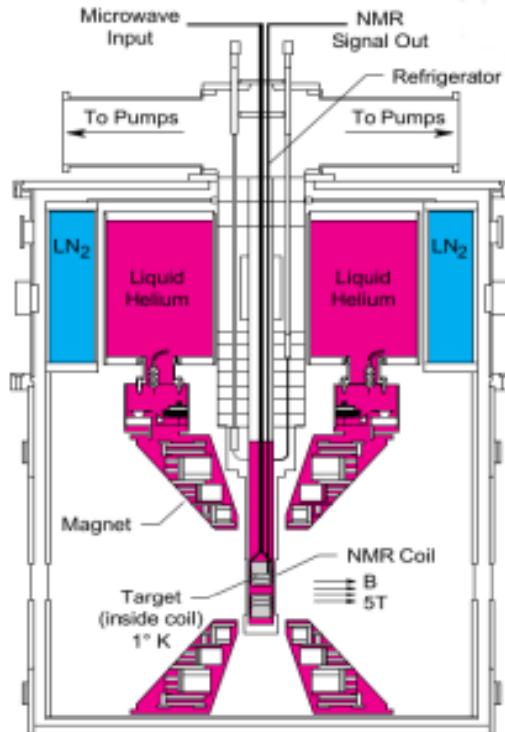
$$\begin{array}{l}
 \text{Focal plane} \\
 \left( \begin{array}{c} x \\ \theta \\ y \\ \phi \end{array} \right)_{fp} = \left( \begin{array}{cc} (x|x_0) & (x|\theta_0) \\ (\theta|x_0) & (\theta|\theta_0) \end{array} \right) \left( \begin{array}{cc} (y|y_0) & (y|\varphi_0) \\ (\varphi|y_0) & (\varphi|\varphi_0) \end{array} \right) \left( \begin{array}{c} x \\ \theta \\ y \\ \phi \end{array} \right)_{tg} \\
 \text{Target plane}
 \end{array}$$

- 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 Leroose for his help!*

# g2p Optics

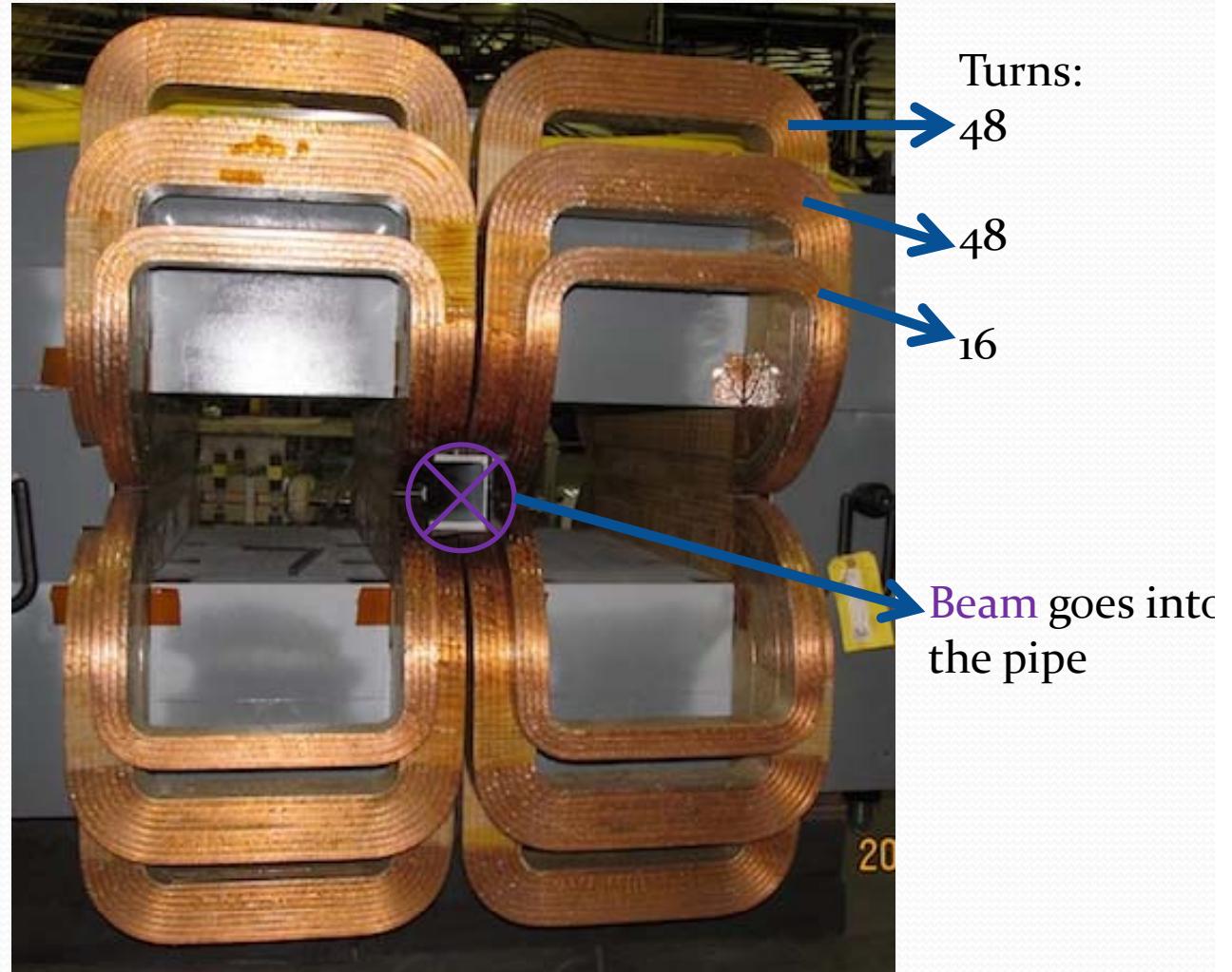
## --Target Configuration



# g2p Optics

## --Septa

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



Courtesy Jixie Zhang

# g2p Optics

## --Septa

- Right septum caught on fire twice

Only right top coils changed		
1) Good	2) Bad	3) Very Bad
48-48-16	40-32-16	40-00-16

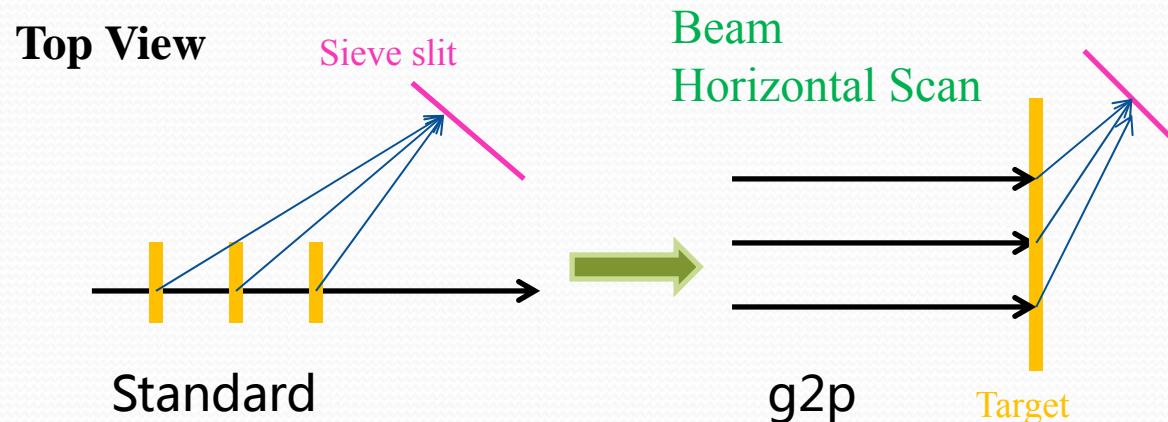
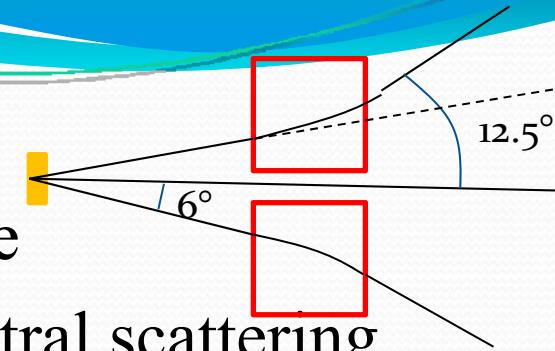


Talk by Melissa  
Cummings in Hall A  
Collaboration Meeting

- Right septum field changed a lot, while left one field also got impacted
- Optics data on each situations

# g2p Optics Data

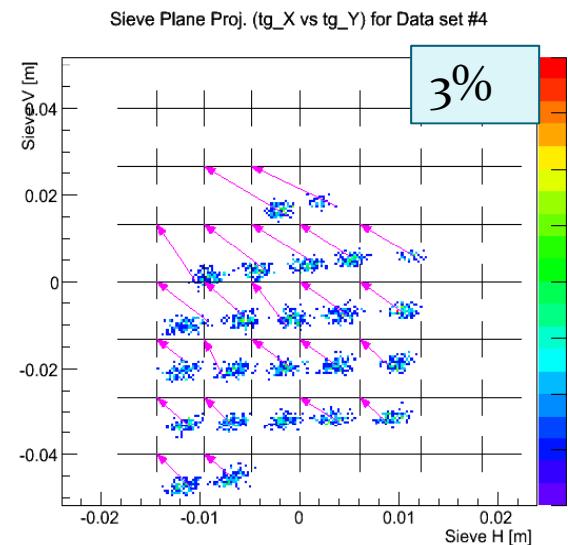
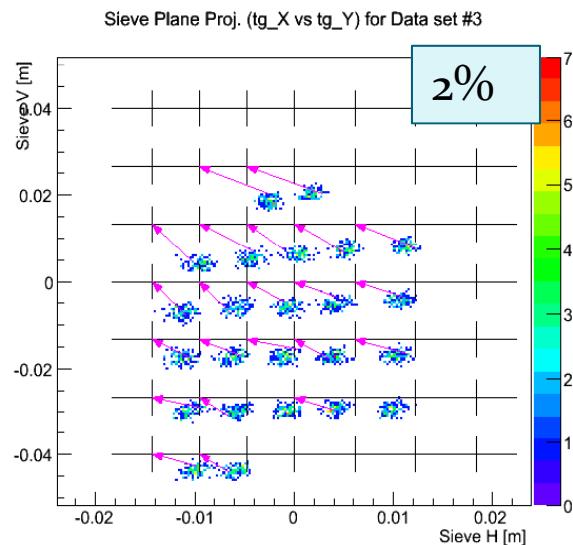
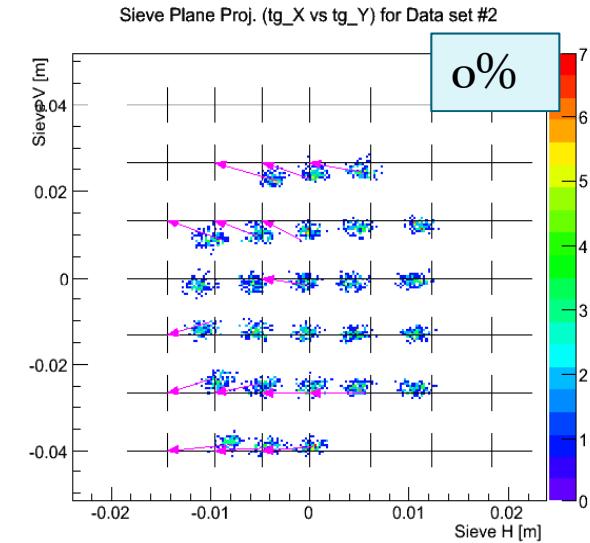
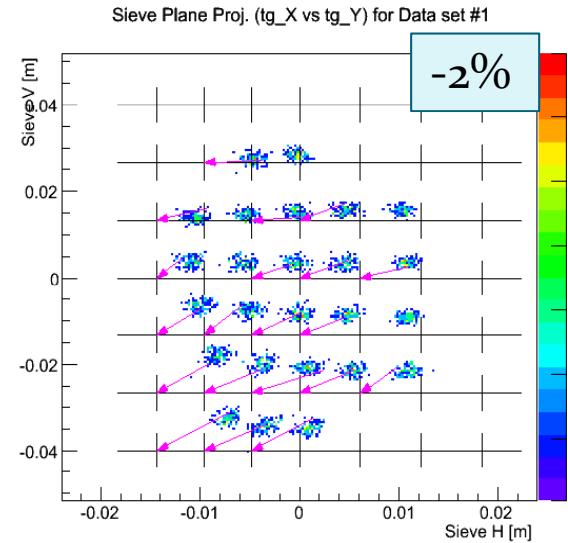
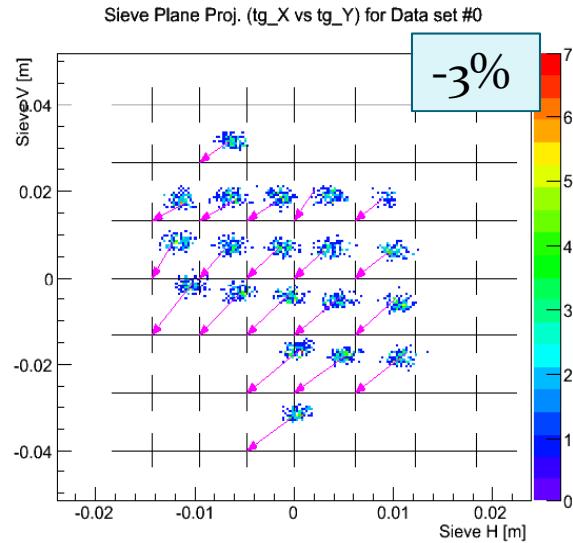
- Delta scan with sieve in, C foil: database
- Pointing, C foil in LHe or CH<sub>2</sub> foil: central scattering angle
- Fast & slow rasters, C foil: acceptance
- Beam position scan, C foil: small angle ~6°, short production target ~3cm



# g2p Optics Data

- 11 total sets of data at  $6^\circ$ 
  - Beam energy: 2.254GeV, 1.706 GeV, 1.158 GeV
  - Target field: 0, 2.5T, 5T
  - 3 different septa situations
- 2 sets of 0 target field data: base for target field on situations
  - Beam energy 2.254 GeV
  - Right septum: 48-48-16 (1), 40-00-16 (3)

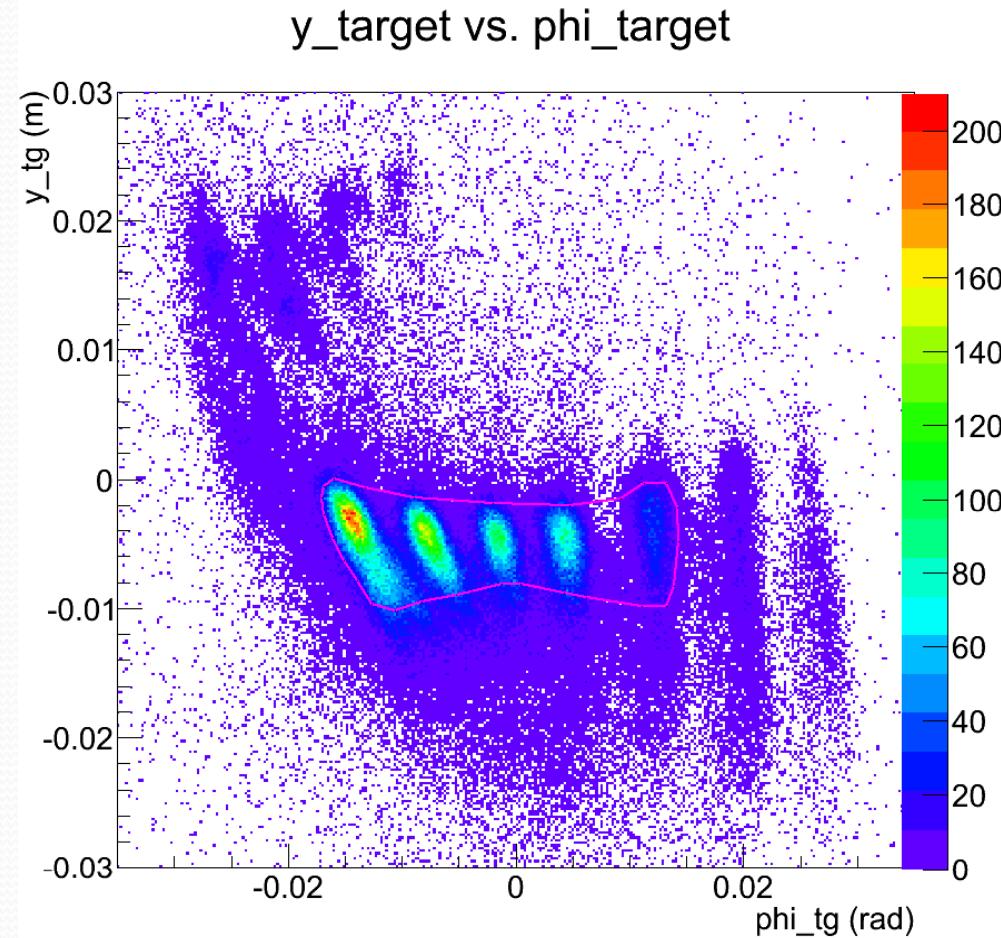
# LHRS Before Calibration (1<sup>st</sup> septum)



With database  
from SNAKE  
model

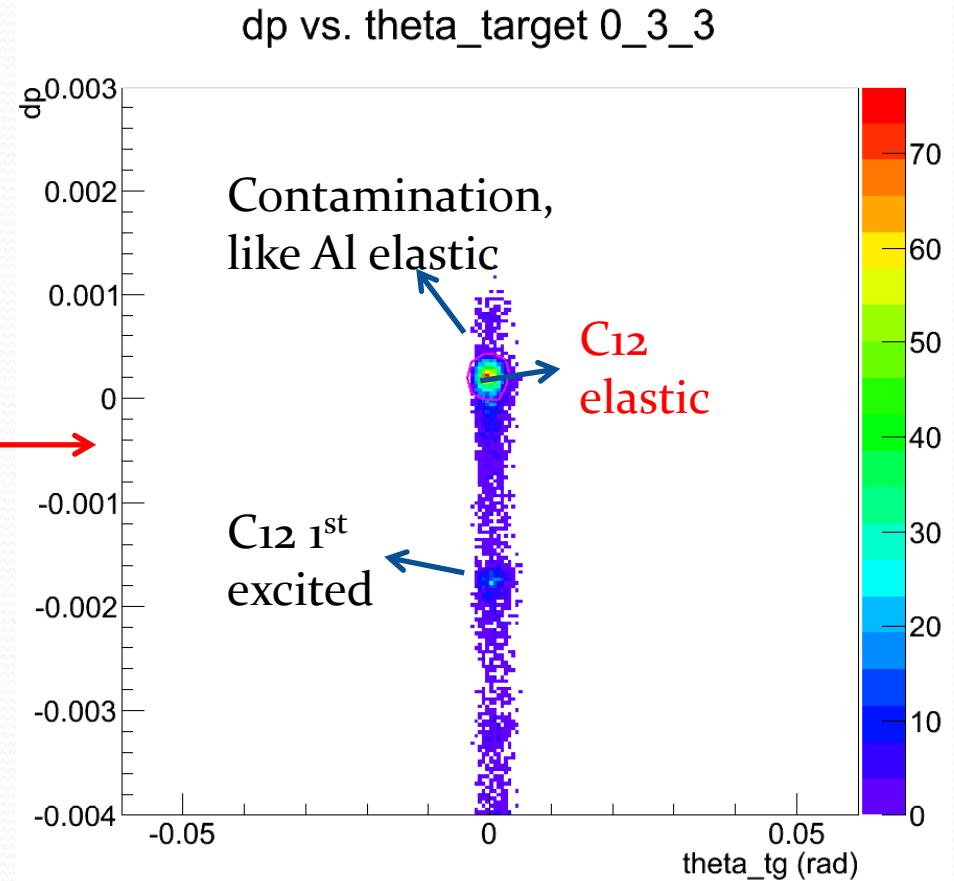
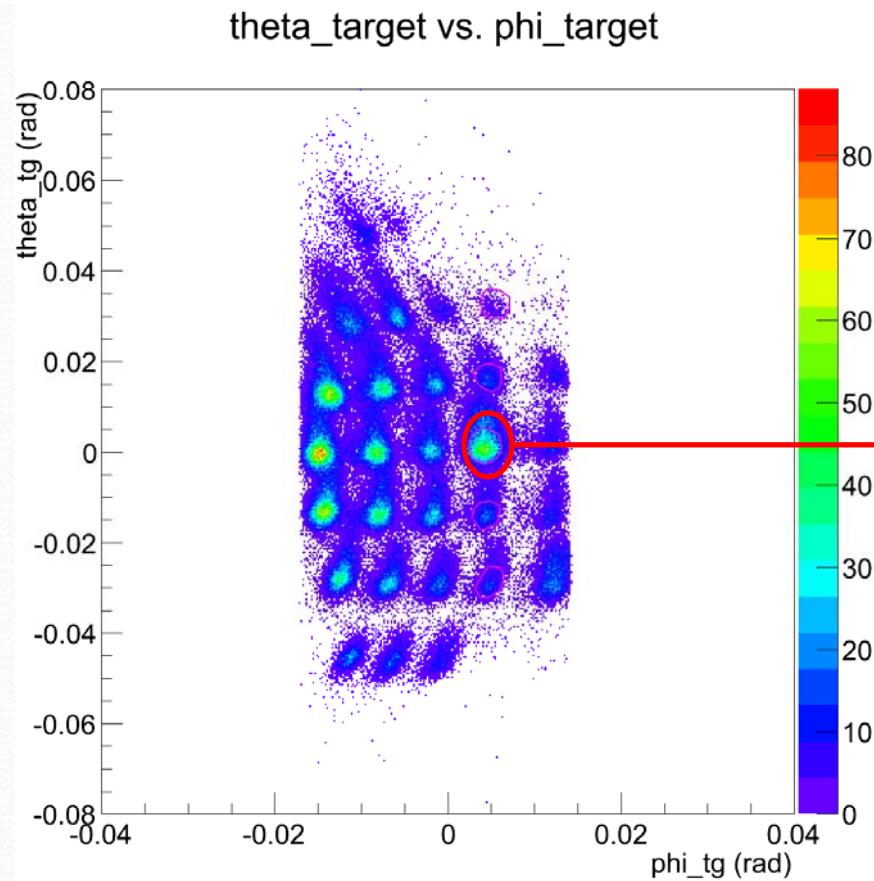
# Calibration Steps

1.  $Tg_y$  vs.  $Tg_{ph}$  vetex cut for the whole run



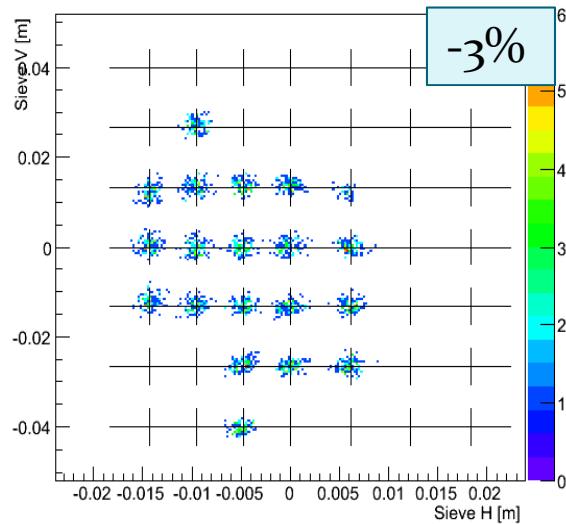
# Calibration Steps

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

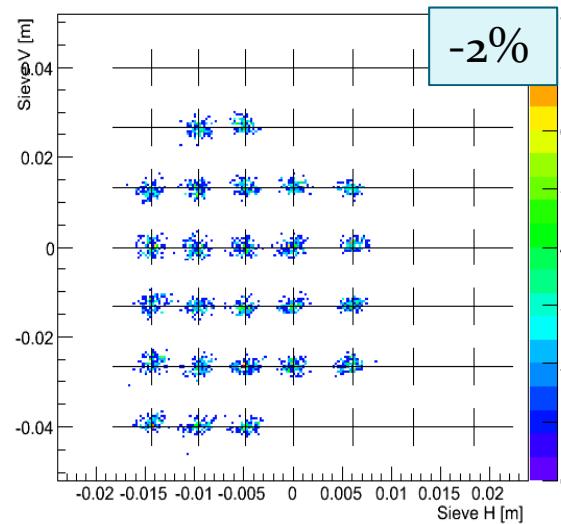


# LHRS Angle (1st septum)

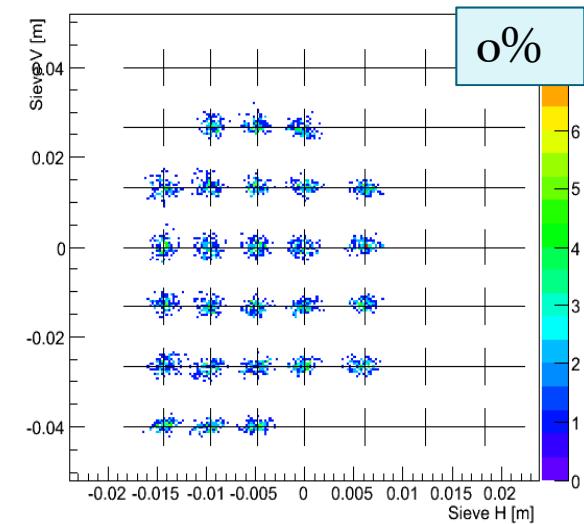
Sieve Plane Proj. ( $\text{tg}_X$  vs  $\text{tg}_Y$ ) for Data set #0



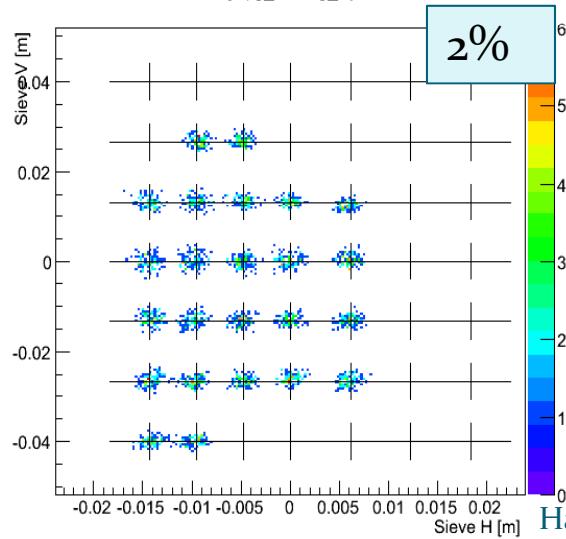
Sieve Plane Proj. ( $\text{tg}_X$  vs  $\text{tg}_Y$ ) for Data set #1



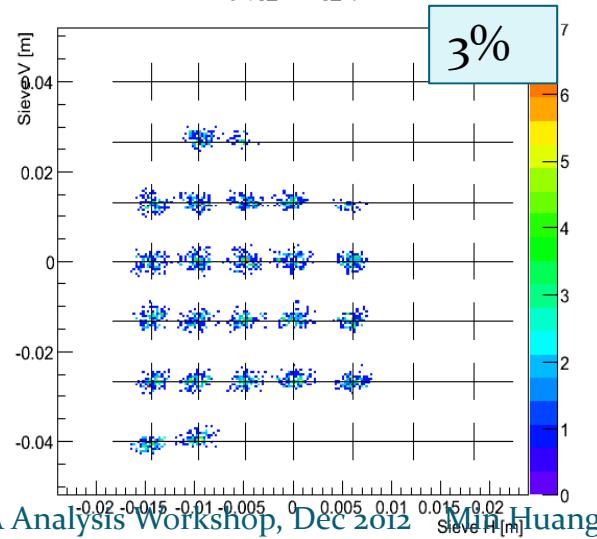
Sieve Plane Proj. ( $\text{tg}_X$  vs  $\text{tg}_Y$ ) for Data set #2

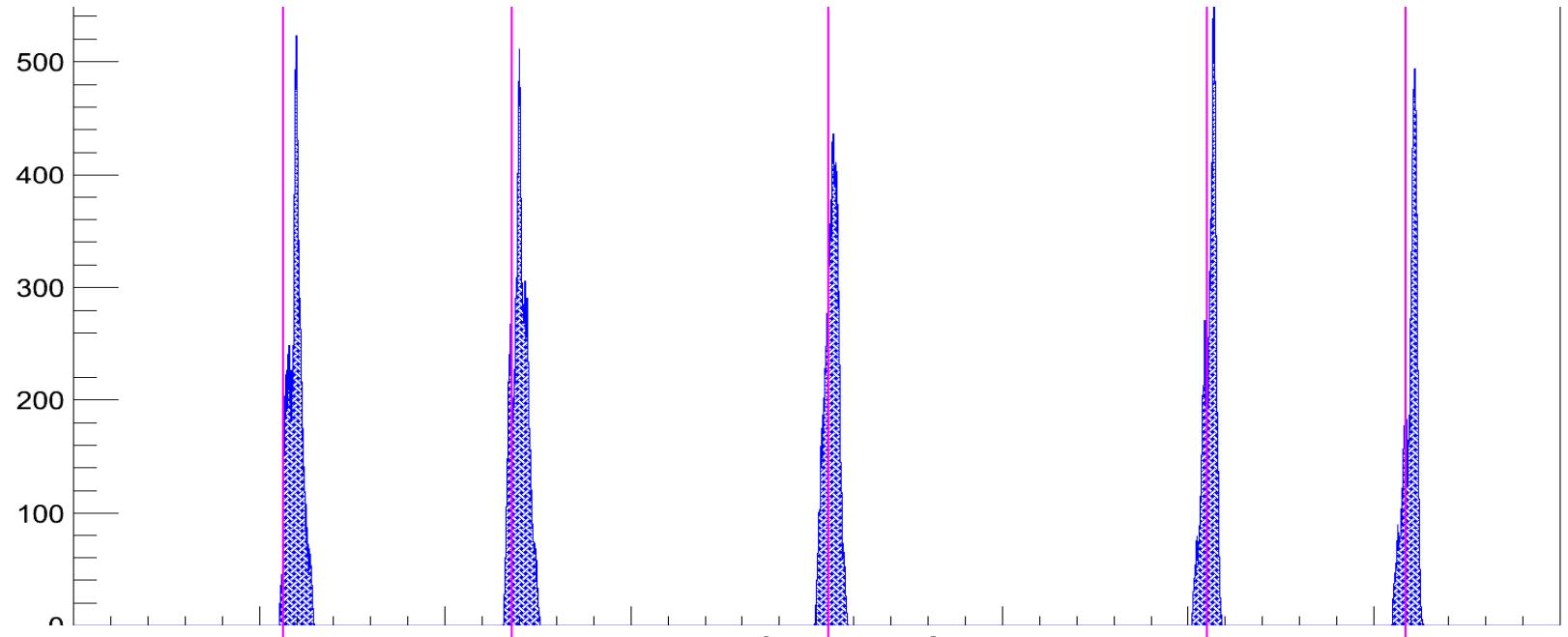


Sieve Plane Proj. ( $\text{tg}_X$  vs  $\text{tg}_Y$ ) for Data set #3



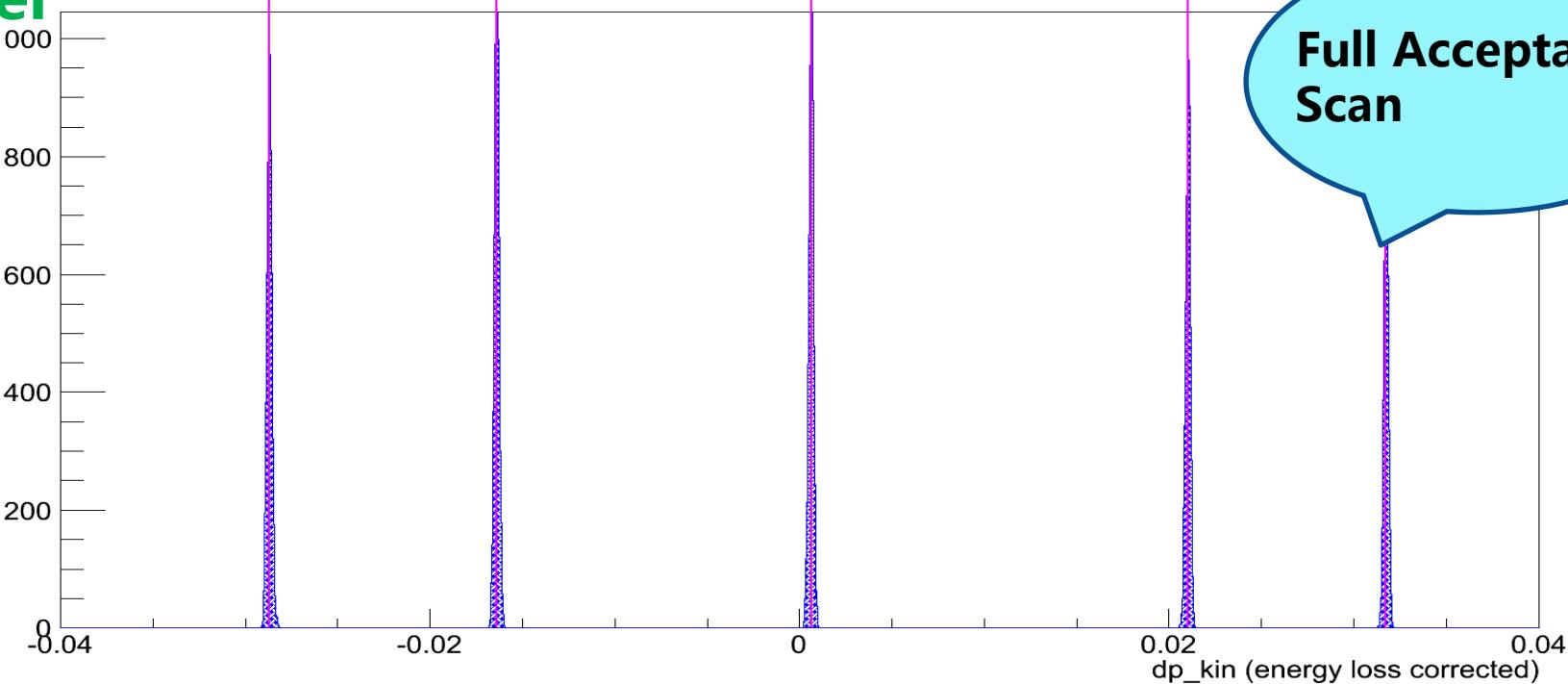
Sieve Plane Proj. ( $\text{tg}_X$  vs  $\text{tg}_Y$ ) for Data set #4





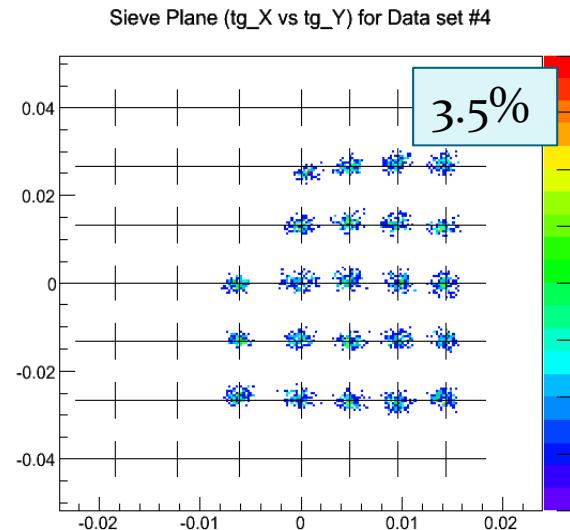
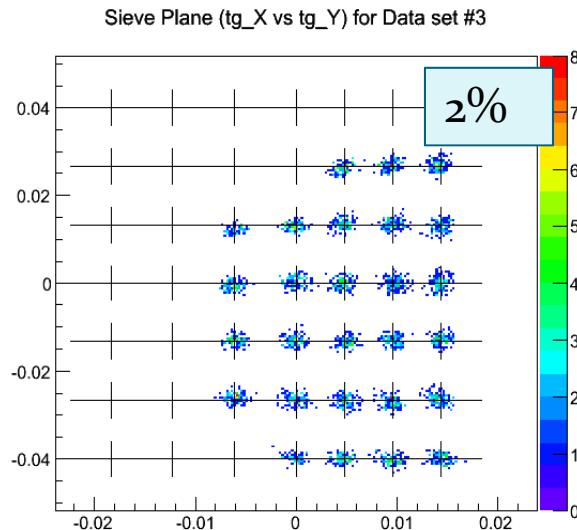
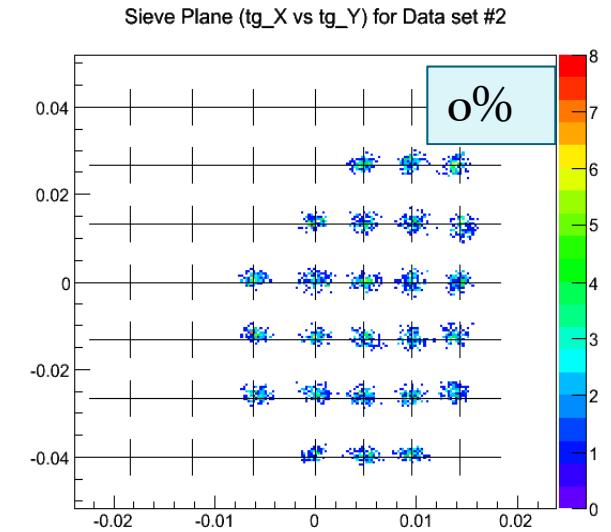
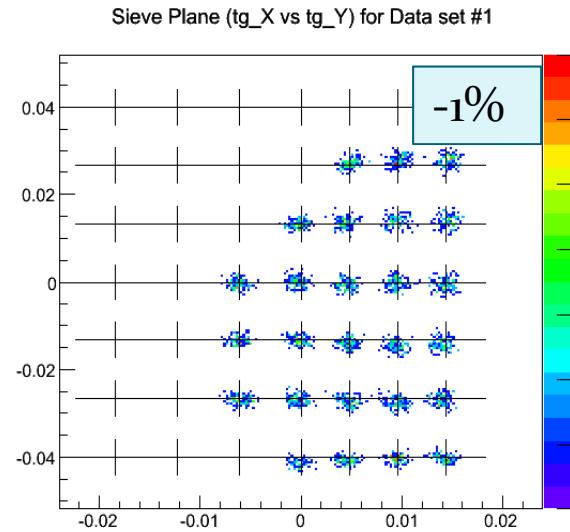
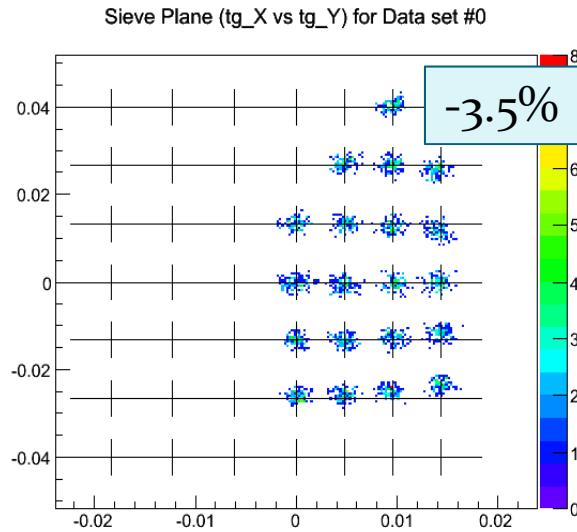
**After**

Dp\_Kin for Delta Scan

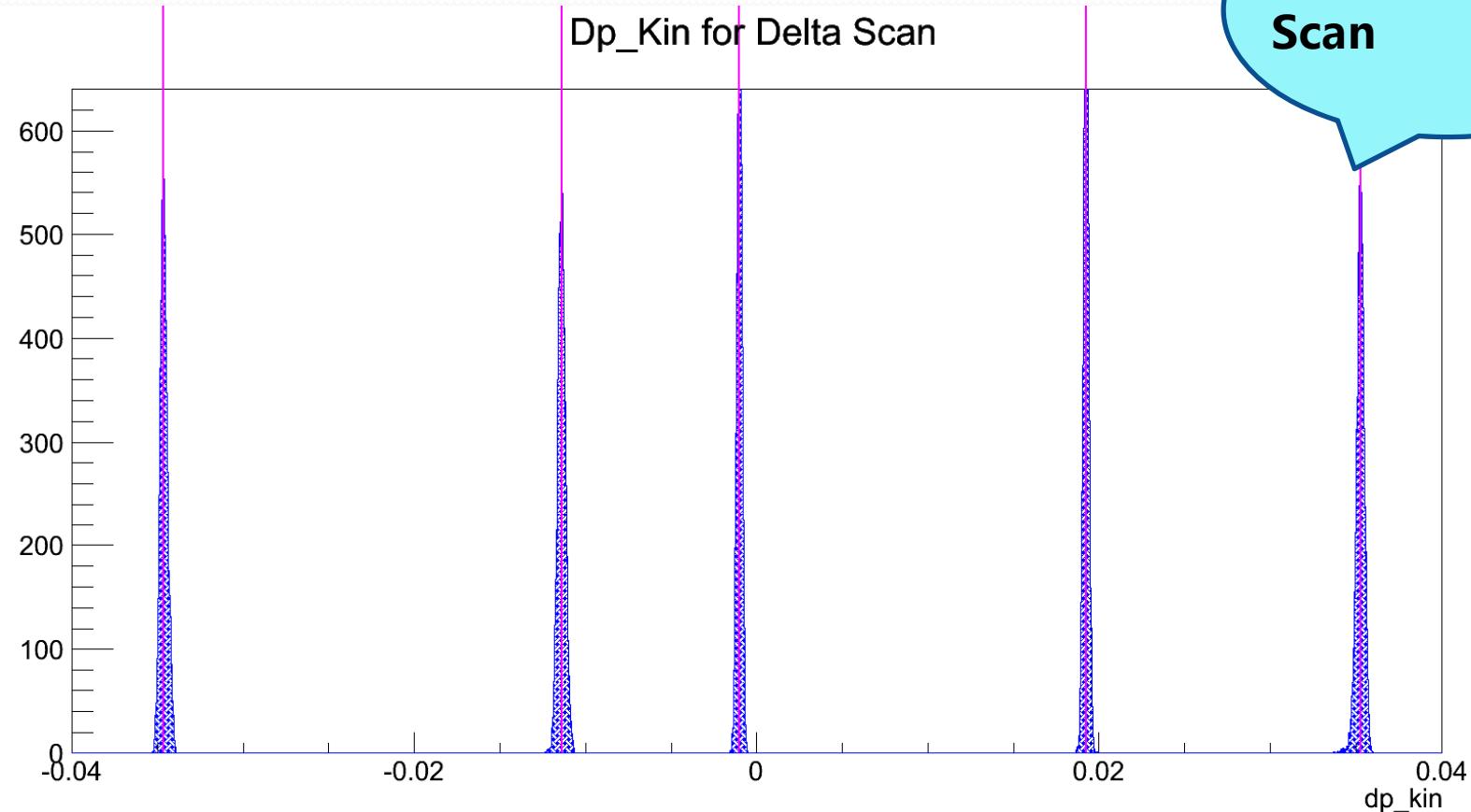


**Full Acceptance  
Scan**

# RHRS Angle (1<sup>st</sup> septum)

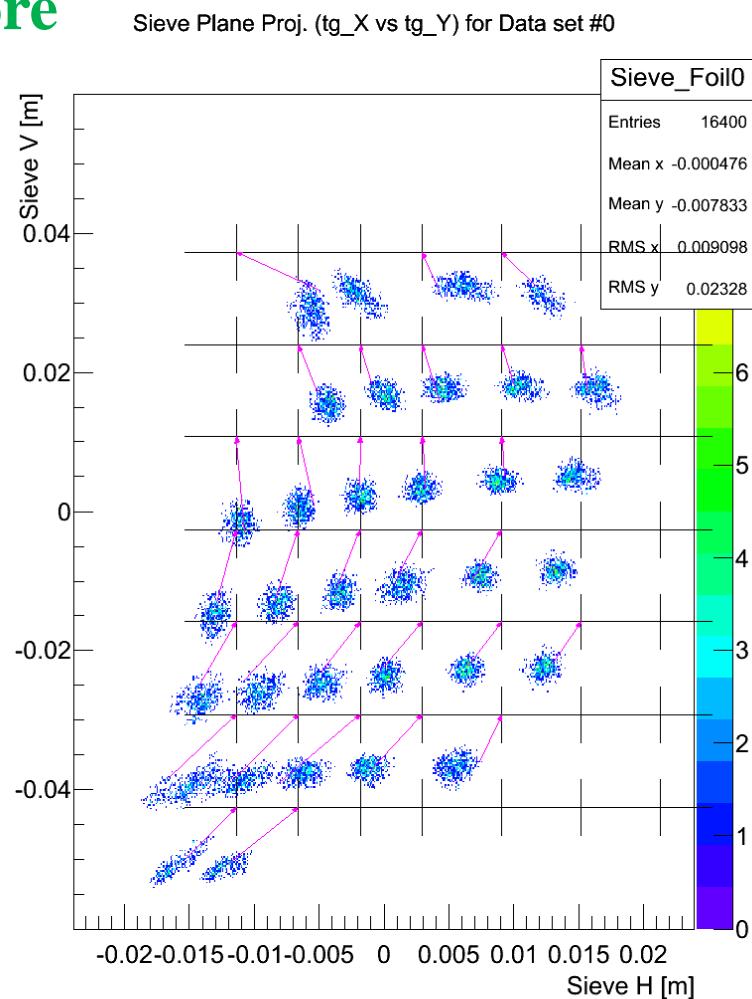


# RHRS Momentum (1<sup>st</sup> septum)

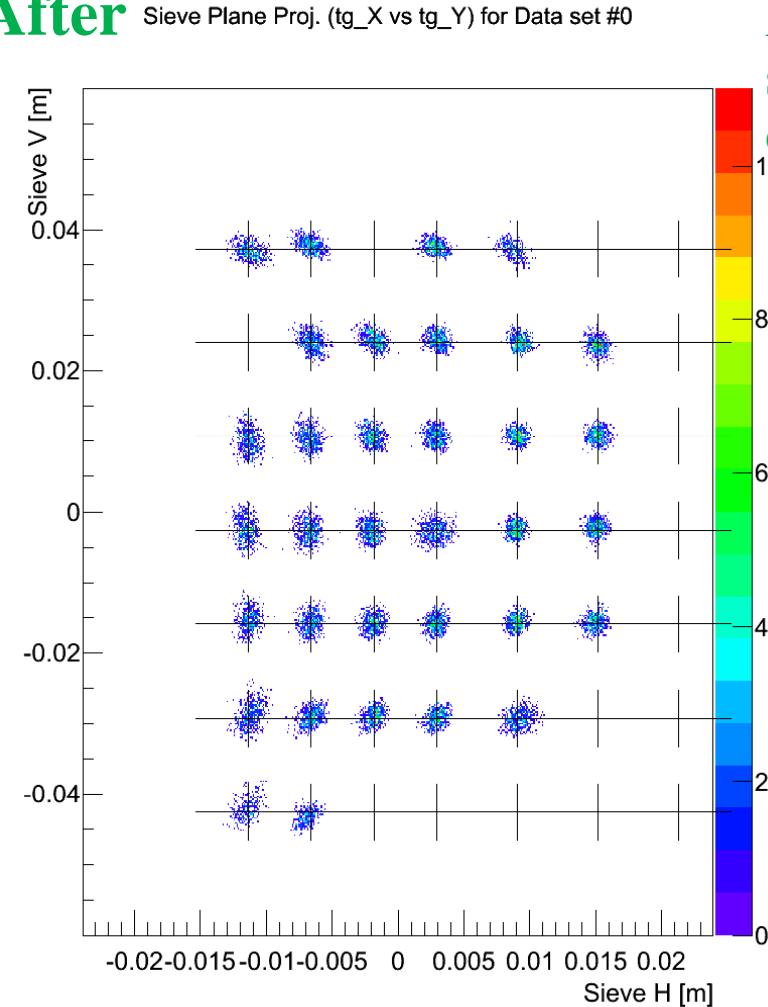


# LHRS Angle (3<sup>rd</sup> septum)

Before

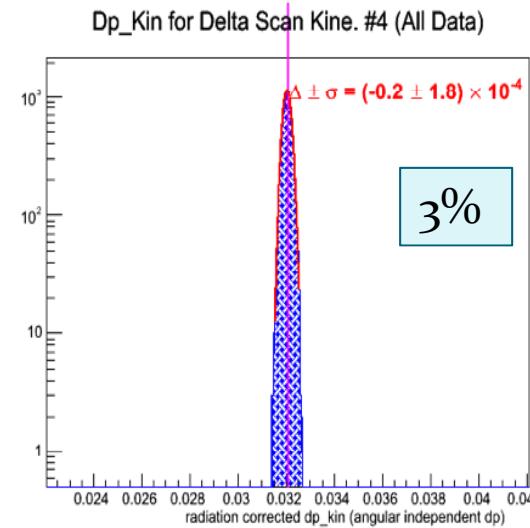
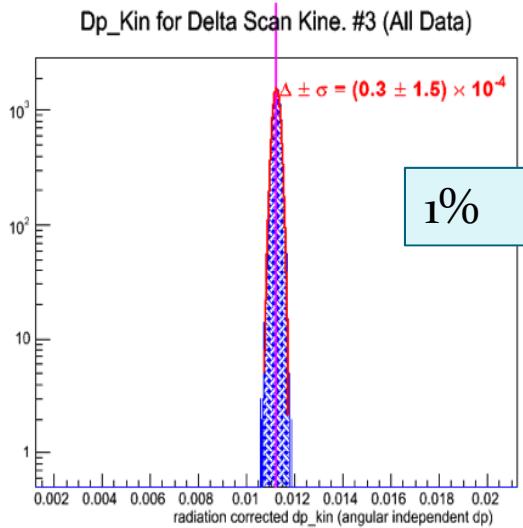
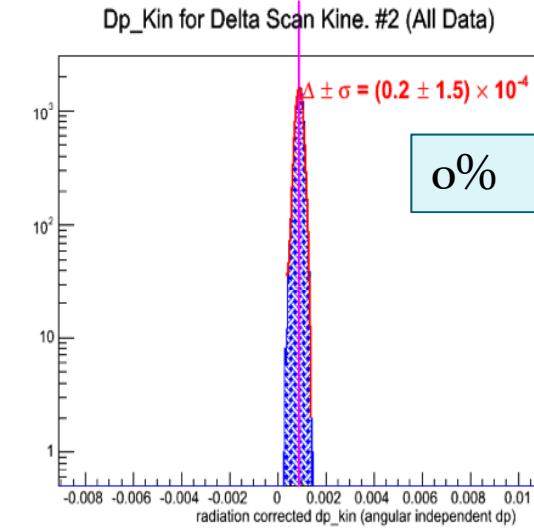
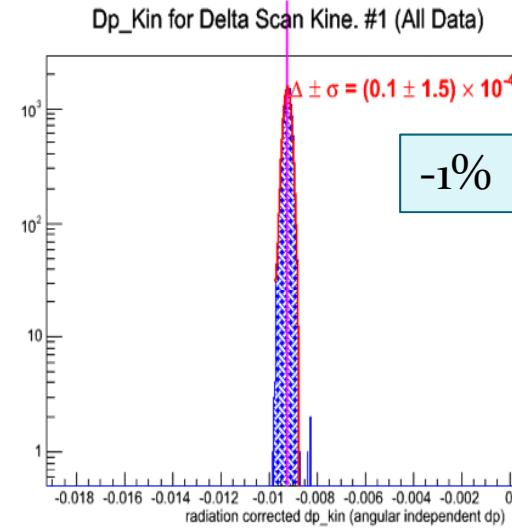
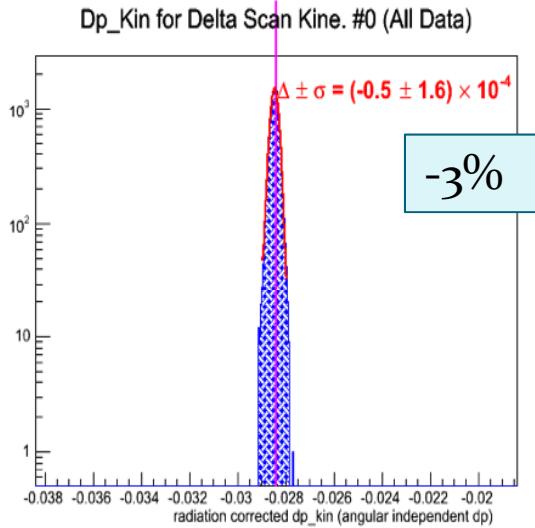


After



All delta  
scan  
combined

# LHRS Momentum (3<sup>rd</sup> septum)



Full Acceptance  
Scan

# Performance Summary

- Beam energy 2.254 GeV, no target field, 1<sup>st</sup> & 3<sup>rd</sup> septum, carbon foil

Resolution (RMS)	LHRS (1 <sup>st</sup> )	RHRS (1 <sup>st</sup> )	LHRS (3 <sup>rd</sup> )
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]	1.3x10 <sup>-4</sup>	2.0x10 <sup>-4</sup>	1.8x10 <sup>-4</sup>

- Reference: beam energy 845 MeV, angle 16°, no septum standard HRS, carbon foil (Hall A NIM)

Resolution (RMS)	
In-plane Angle [mrad]	0.8
Out-of-plane Angle [mrad]	2.5
Momentum [(p-po)/po]	1.1x10 <sup>-4</sup>

$$* \text{FWHM} = 2.3548 * \text{RMS}$$

# What to do

- Target y calibration for each setting
- Pointing: improve the accuracy of central angle
- RHRS 3<sup>rd</sup> septum 40-00-16 setting
- Wrap up 0 target field results with better accuracy & resolution
- Continue on target field ON situations

Talk by Jixie Zhang  
on HRSMC 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, Kiad Saenboonruang, Huan Yao, Zhihong Ye