



# L-HRS Optics & Coinc Timing Check

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M.I.T.

For Transversity Collaboration Meeting  
Sept 24, 2009 @ JLab

# Content

## Identification of Raster Problem

## HRS Optics

- Calibration
- Stability
- Cuts

## Fixing LHRS retiming

- Further check from last meeting

## Coinc Timing Check

## Definition of target spin

# HRS Optics

## A Mathematical Review



# Mathematical review of Spectrometer Optics

- ▶ Blah Blah Blah ...
- ▶ Since it will be dry and boring, let's skip this part

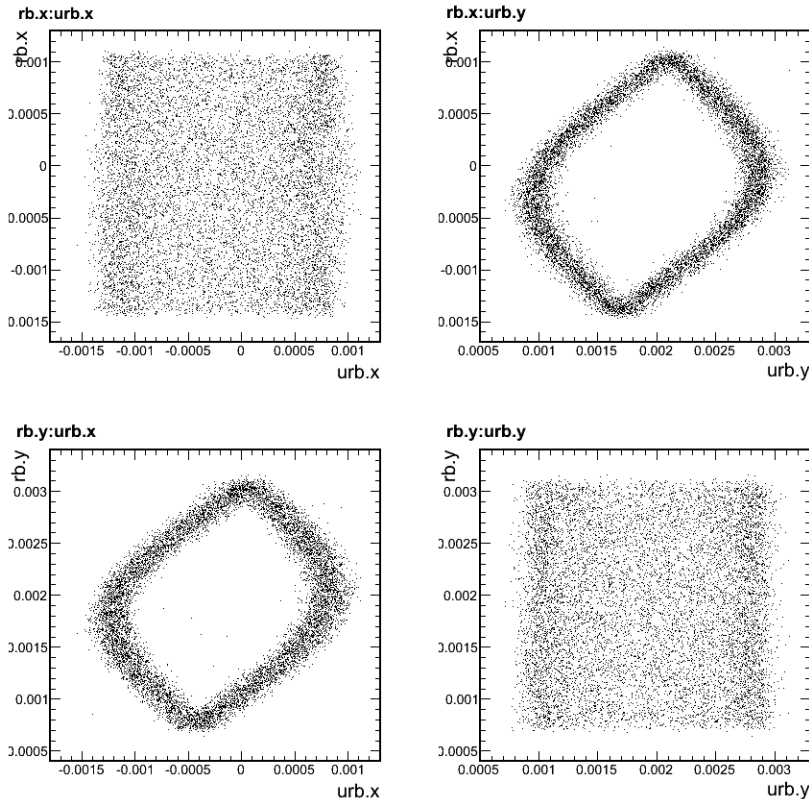
# Raster Channel Identification

- » Introduction
- Identifying Raster Direction
- Solution

# Introduction

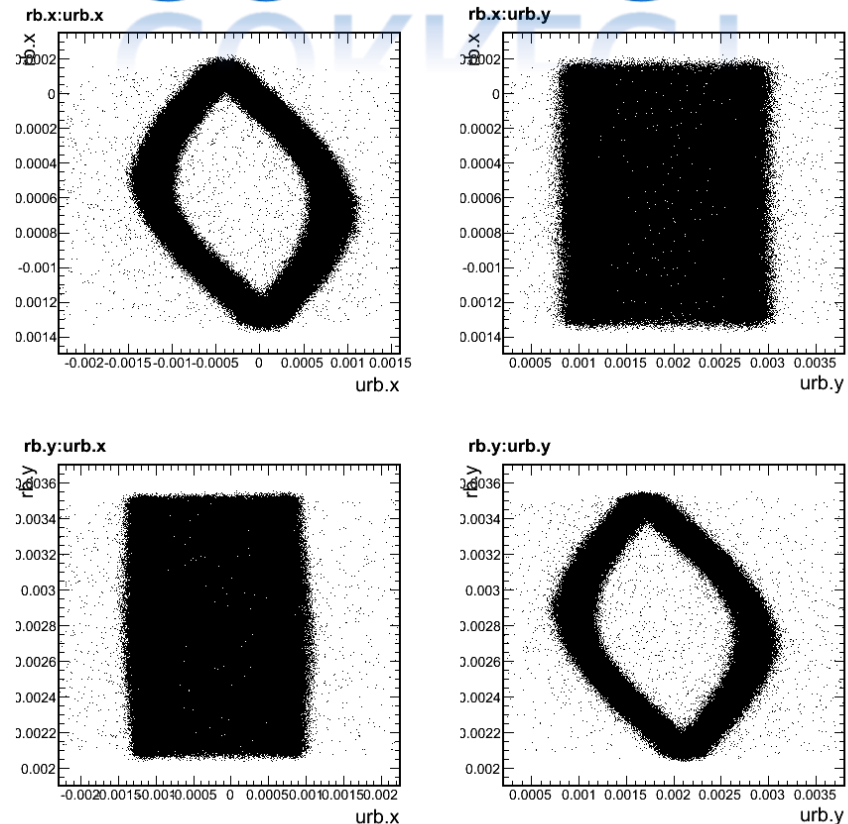
- ▶ Coordinate convention in Hall A Analyzer
  - Raster beam X is to beam left
  - Raster beam Y is to vertical up
  - Beam position affects HRS optics reconstructions
- ▶ In Analyzer Raster beam X–Y is calculated by
  - An offset term  $\sim$  mean BPM position
  - + An correction term  $\sim$  raster current ADC signal (called rawcurx/rawcury in root files)
  - By default database
    - +rawcurx  $\rightarrow$  +X
    - + rawcury  $\rightarrow$  -Y
- ▶ We found during Transversity
  - +rawcury  $\rightarrow$  +X
  - + rawcurx  $\rightarrow$  -Y
- ▶ Suspecting raster cable swapped Some time before

# Identifying the problem / Raster BPM correlation



**X WRONG**

**CORRECT**





# Identifying the problem / Special Target Run

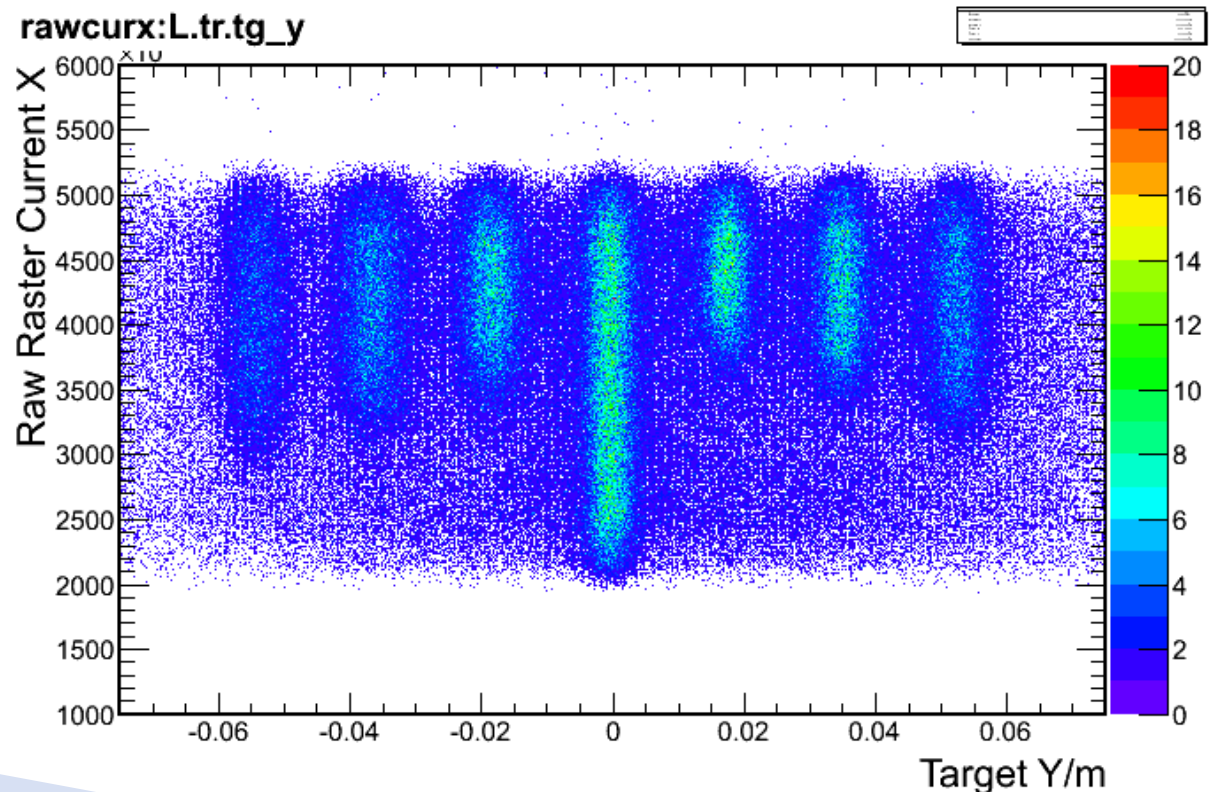


a run with beam  
hit on top of  
carbon foils



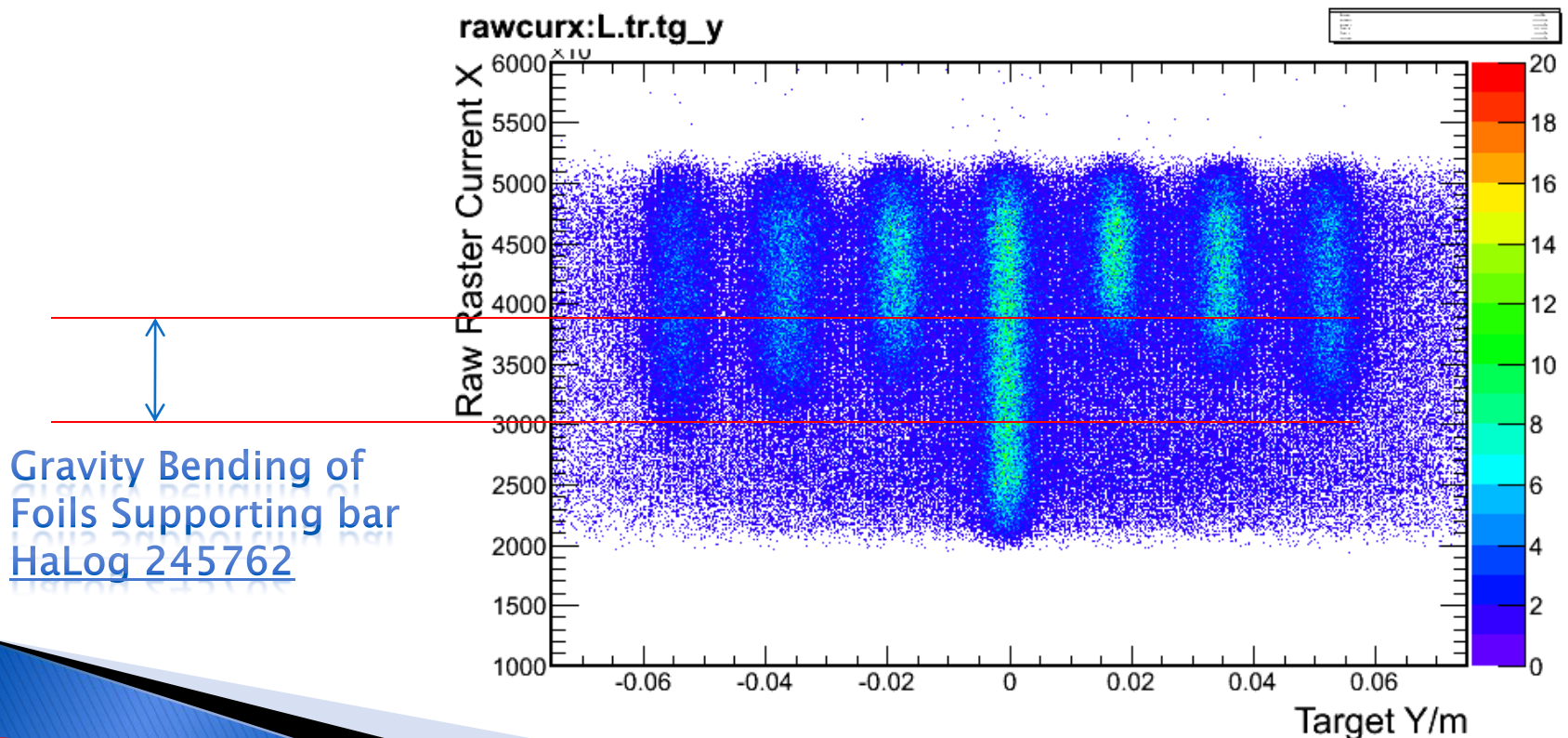
# Identifying the problem / Special Targets

- ▶ From top edge of carbon foils  
+rawcurx (**should be rawcury**) is toward vertical down  
=  $-Y$  in Hall Coordinate System



# Identifying the problem / Special Targets

- ▶ From top edge of carbon foils  
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=  $-Y$  in Hall Coordinate System



# Fixing Raster Cable Map

- ▶ fixing the raster cable map
- 1. Downloading Newest Analyzer from CVS
  - Thanks to Ole fixing the THaRaster
- 2. Change Raster Cable map from

```
[Raster_detmap]
      1      4      1      21      24 27      1881
     -1      0      0      0      0 0      0
```

TO

```
[Raster_detmap]
      1      4      1      21      25 25      1881
      1      4      1      21      24 24      1881
      1      4      1      21      26 27      1881
     -1      0      0      0      0 0      0
```

- ▶ Thanks to Kalyan, all raster for transversity is re-calibrated

# HRS Optics Calibration/Statbility/Cuts



# Optics For Transversity

- ▶ LHRS, as hadron arm, it's optics is useful for
  - Angular reconstruction will go into calculation of  $\theta_h$ . Its resolution would be magnified by 5 times as that of  $\theta_h$
  - Vertex reconstruction is used to form vertex coincidence with BigBite
  - Momentum resolution is not sensitive for us. It's still going to be checked
- ▶ SRC optics has been used as online analysis
- ▶ I have calibrated HRS optics to an unnecessary high precision

# Intro Optics Calibration

## ▶ Data

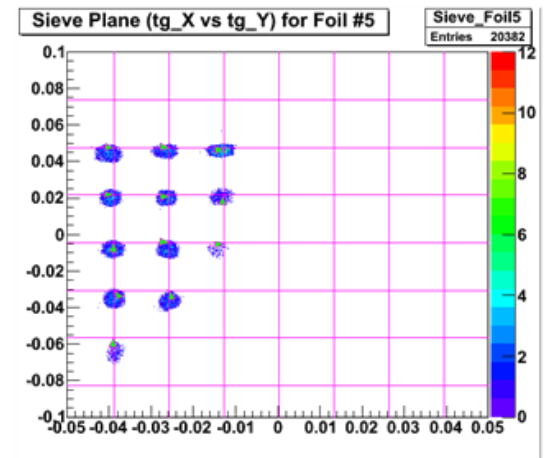
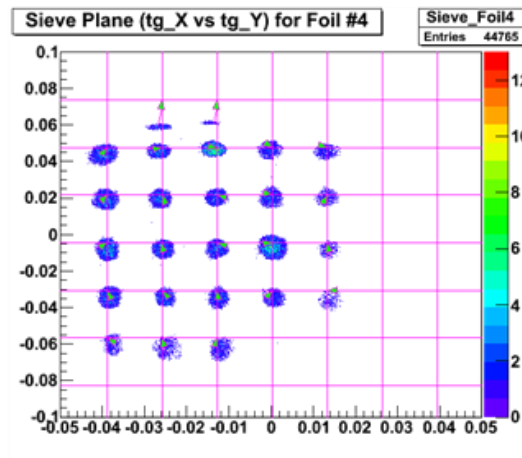
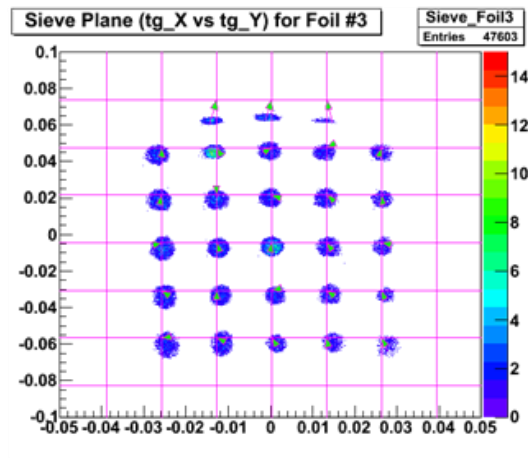
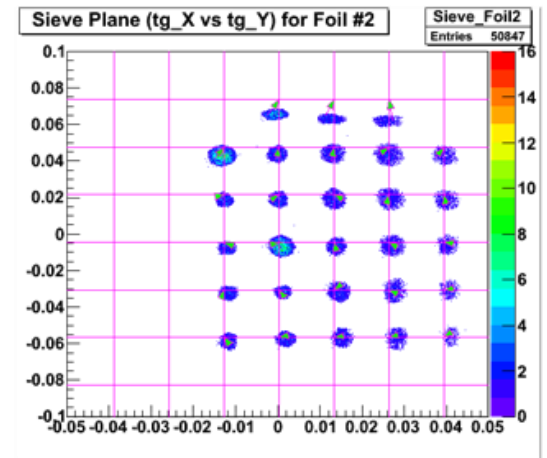
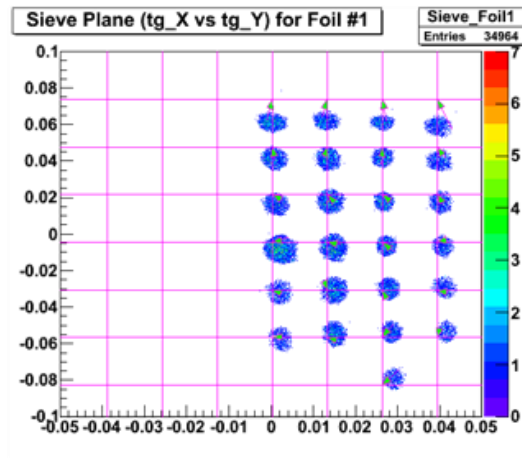
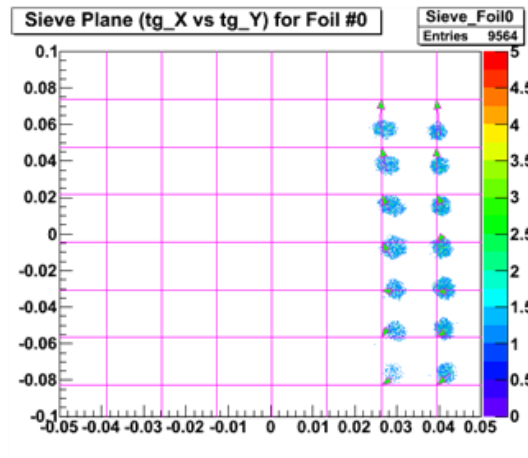
- Delta Scan on Carbon Foils (1 Pass , Low Momentum Setting)
- H2 Optics Runs (1 Pass, Low Momentum Setting)
- Lots of 5Pass Optics Target Runs
- Material Thickness from Xiaodong and Chiranjib

## ▶ New Tools Invented

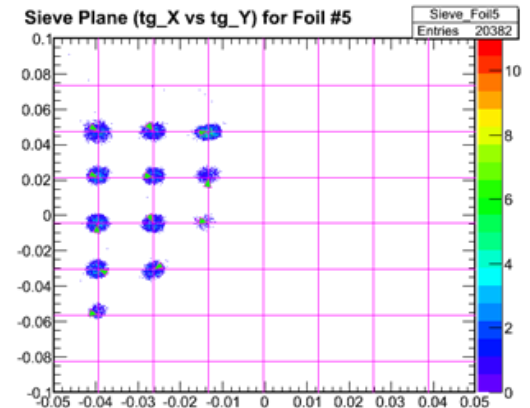
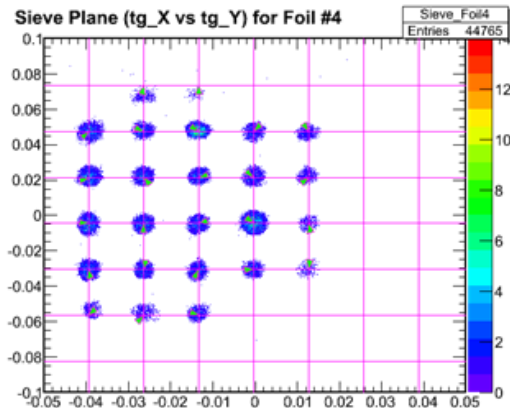
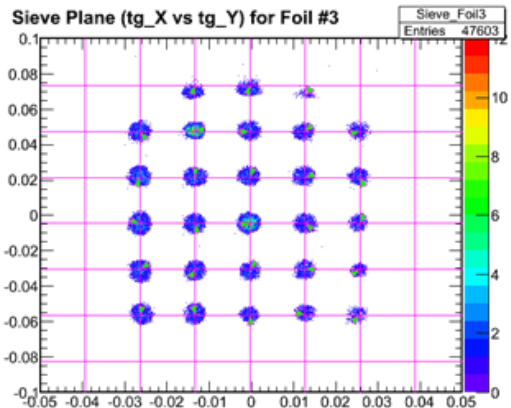
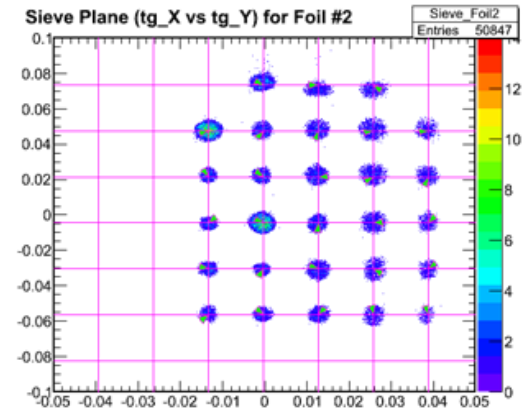
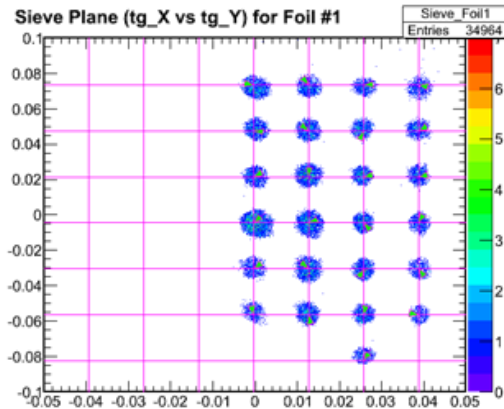
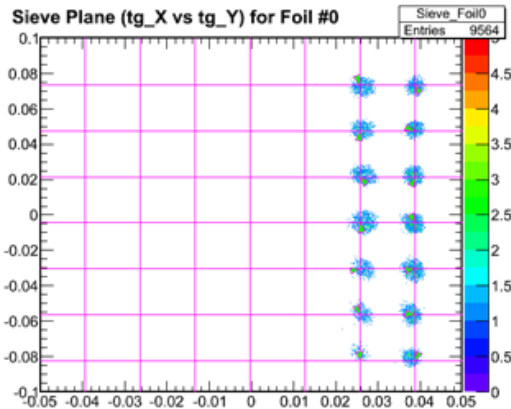
- A new optimization tool replacing Optimizer++
  - Base on THaVDC, same code for replay
  - Specialized Algorithm for our optics data
- <http://www.jlab.org/~jinhuang/HRSOptics/>



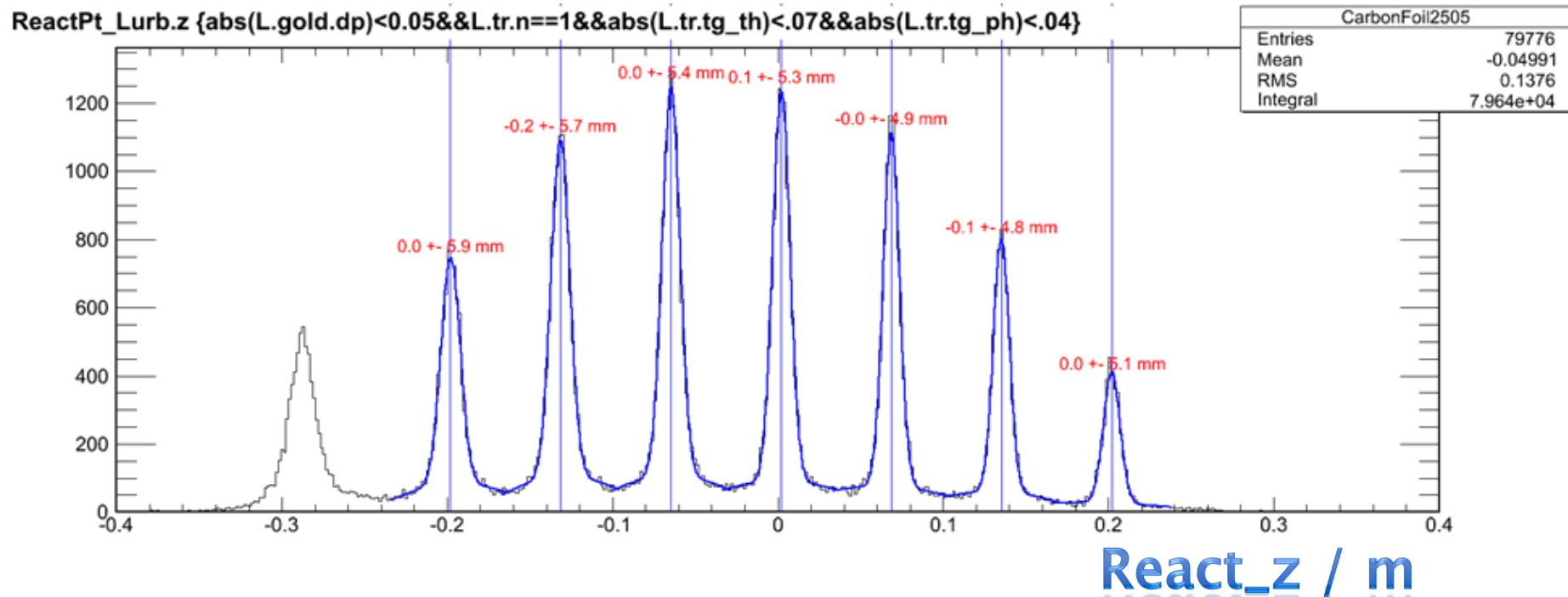
# Sieve : Before Calibration



# Sieve : After Calibration



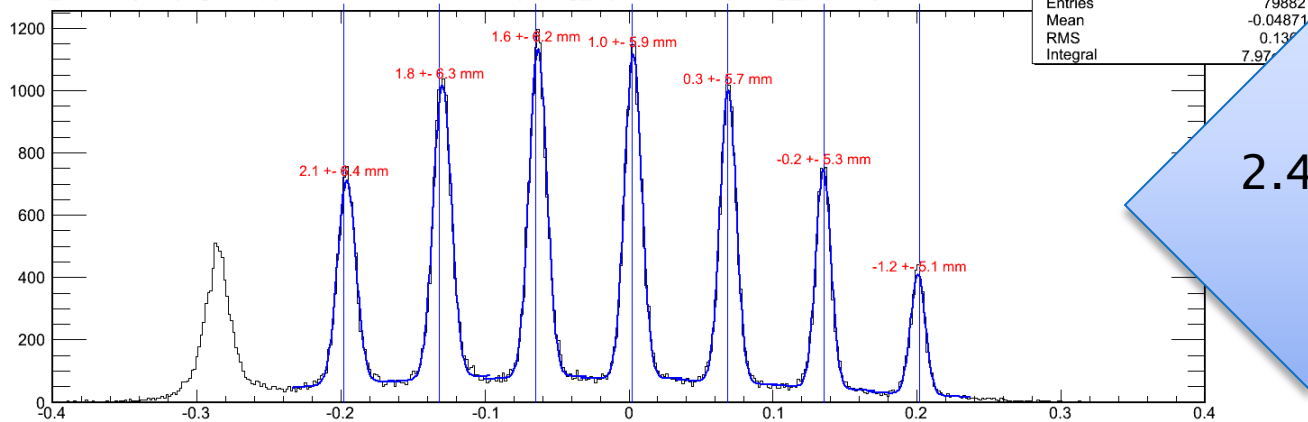
# Vertex / Target Y Reconstruction



# Fun Part : 1.2GeV 2.4GeV Vertex Comparison

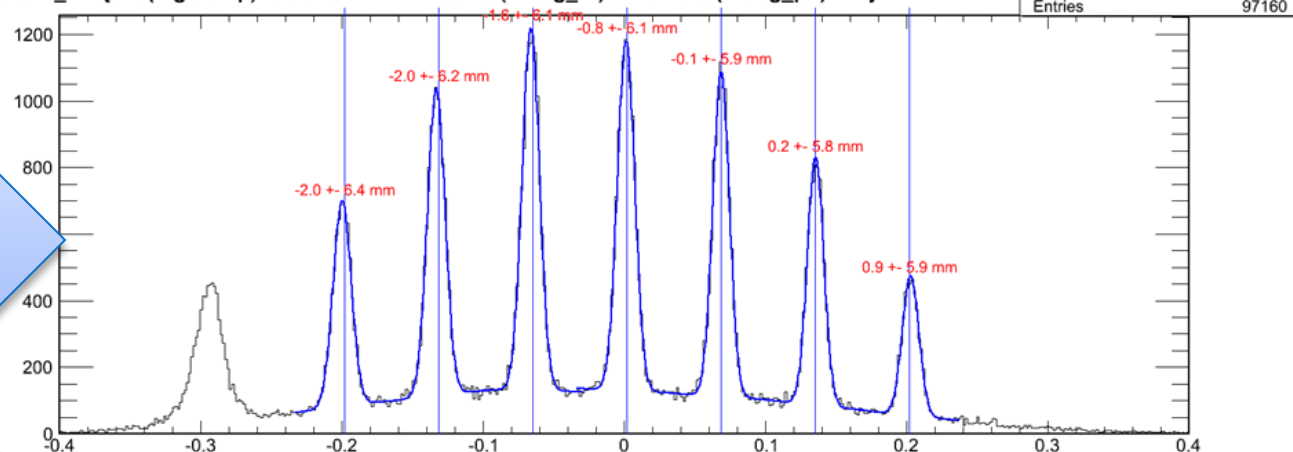
- ▶ There is 1~2mm/20cm scaling effect

ReactPt\_Lurb.z {abs(L.gold.dp)<0.05&&L.tr.n==1&&abs(L.tr.tg\_th)<.07&&abs(L.tr.tg\_ph)<.04}



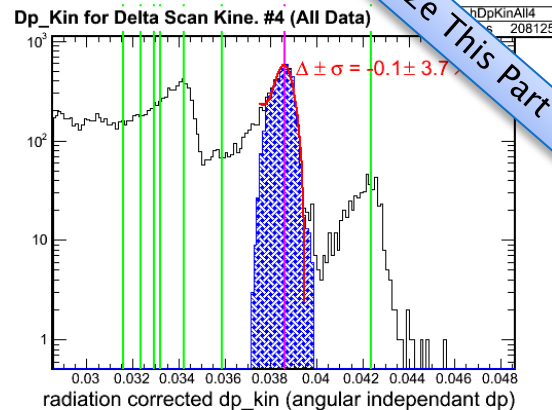
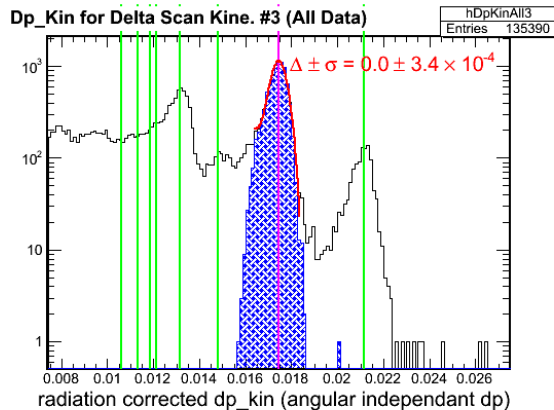
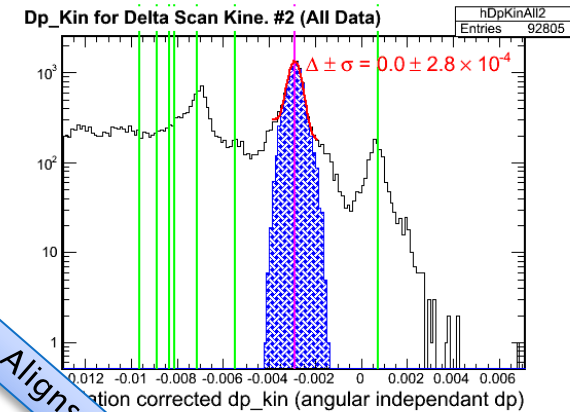
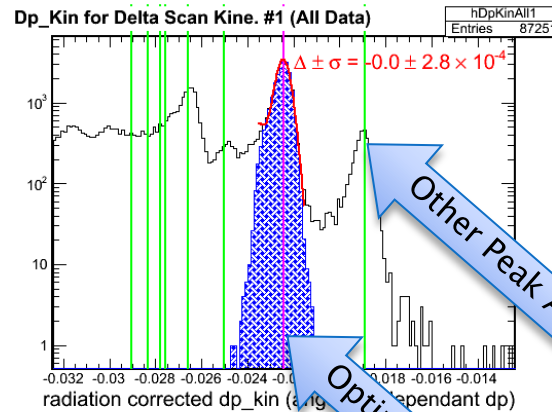
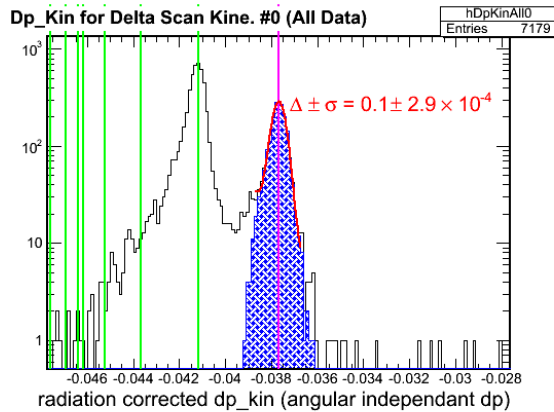
2.4GeV Optics on  
1.2Gev Run

ReactPt\_L.z {abs(L.gold.dp)<0.05&&L.tr.n==1&&abs(L.tr.tg\_th)<.07&&abs(L.tr.tg\_ph)<.04}



1.2GeV Optics  
on 2.4Gev Run

# Dp Reconstruction

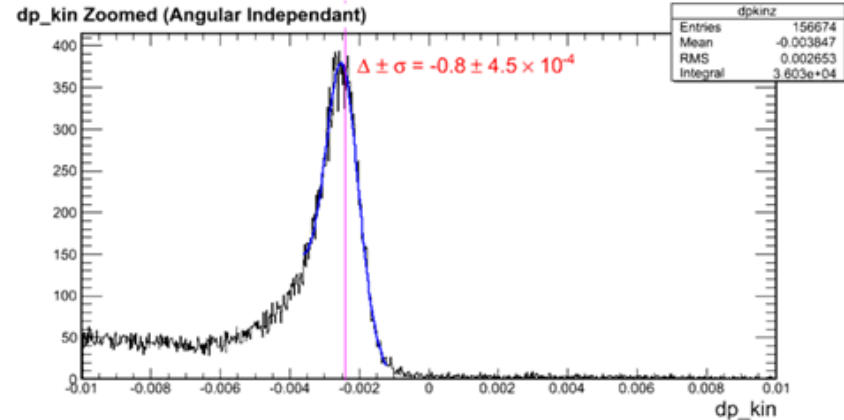
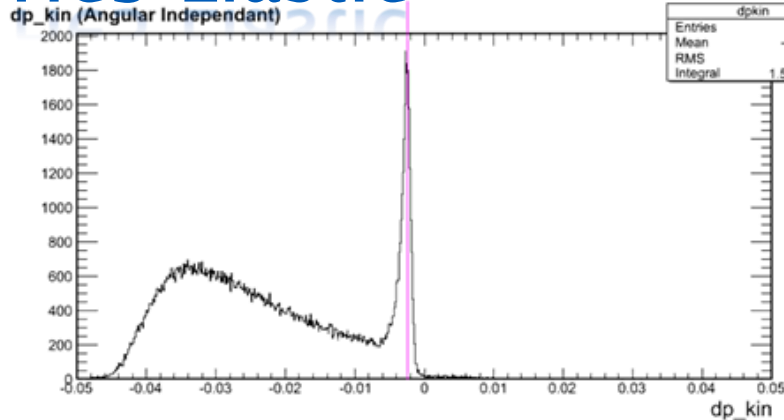


Other Peak Auto Aligns

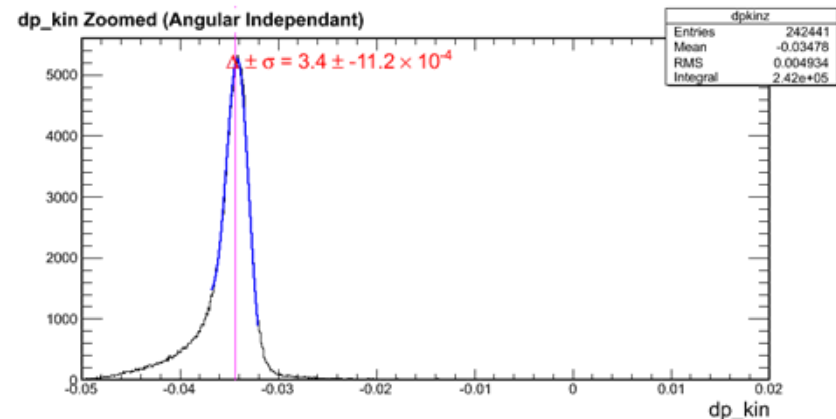
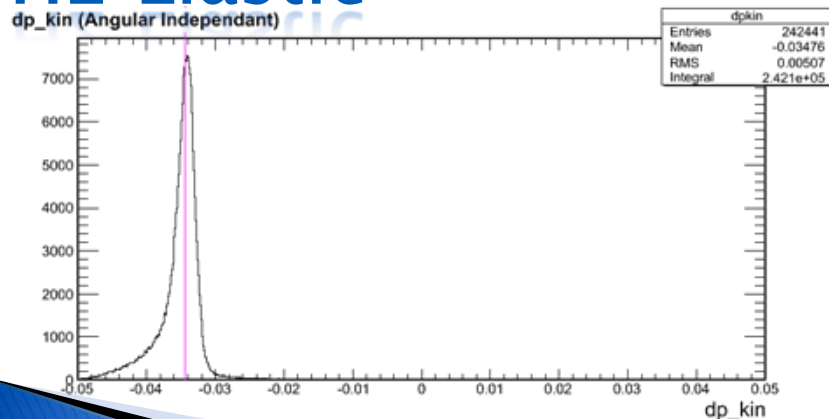
Optimize This Part Only

# Optics Check / He3 / H2 Elastic

## He3 Elastic



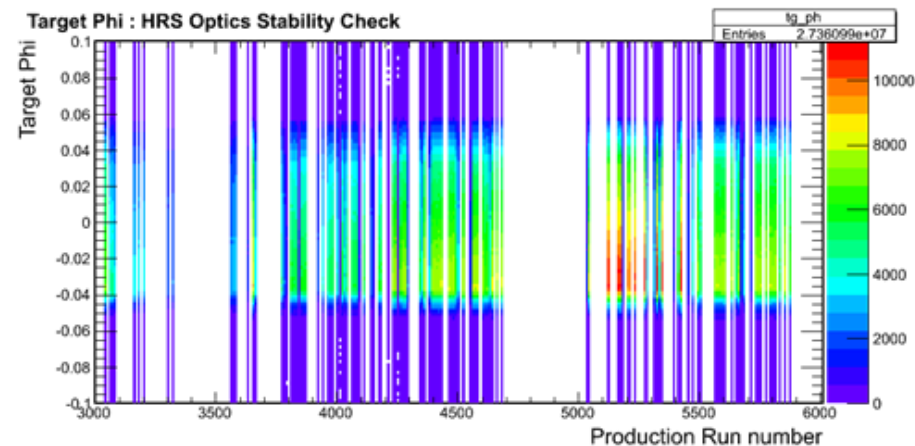
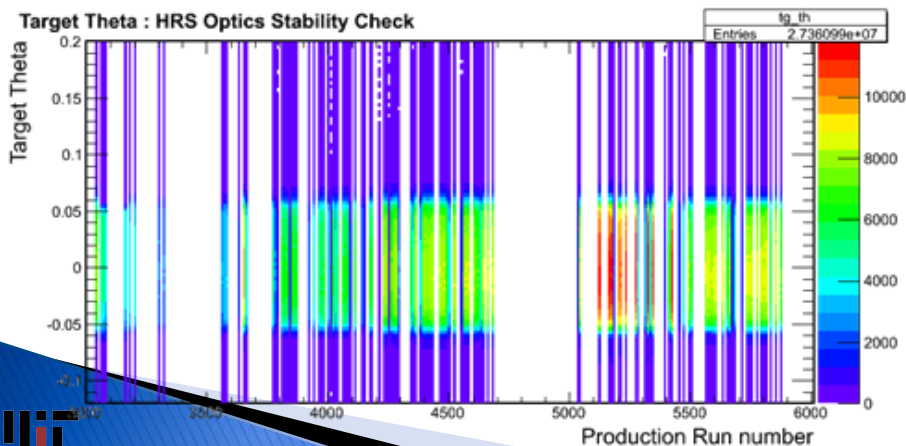
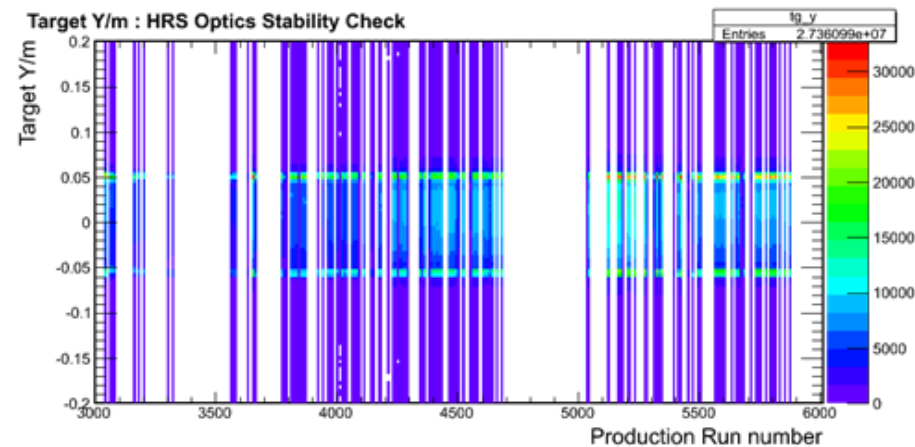
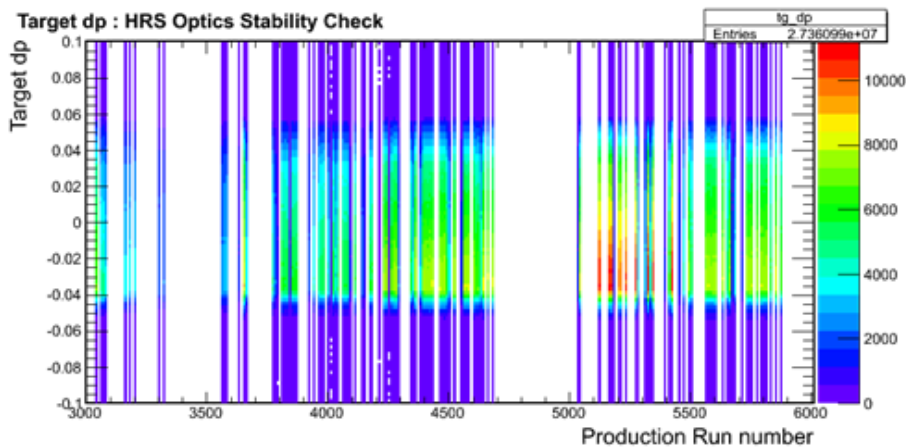
## H2 Elastic





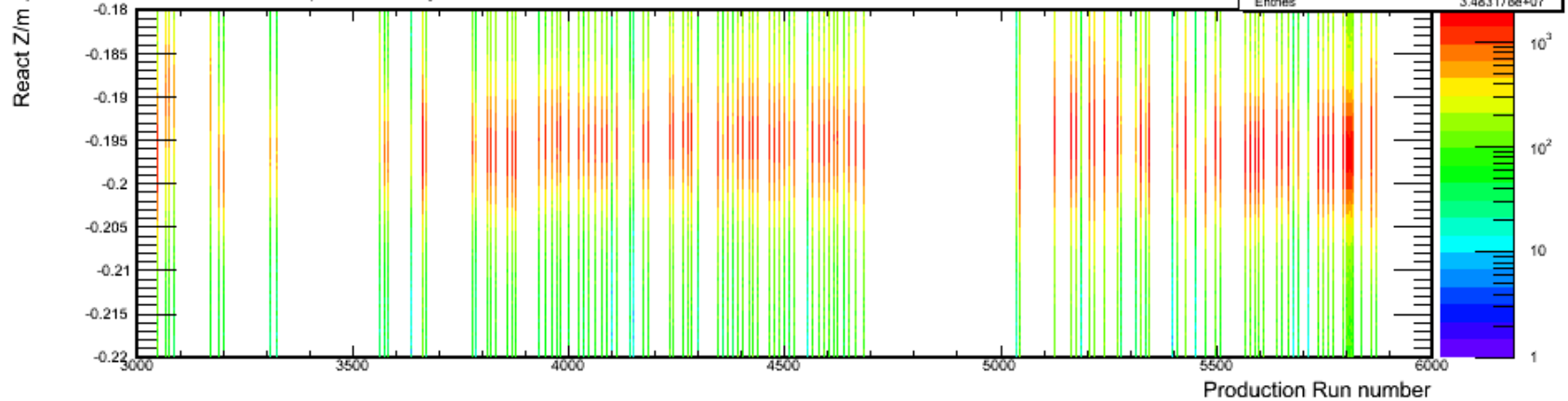
# HRS Optics Stability Check

- Checked with 100 production/ref cell run

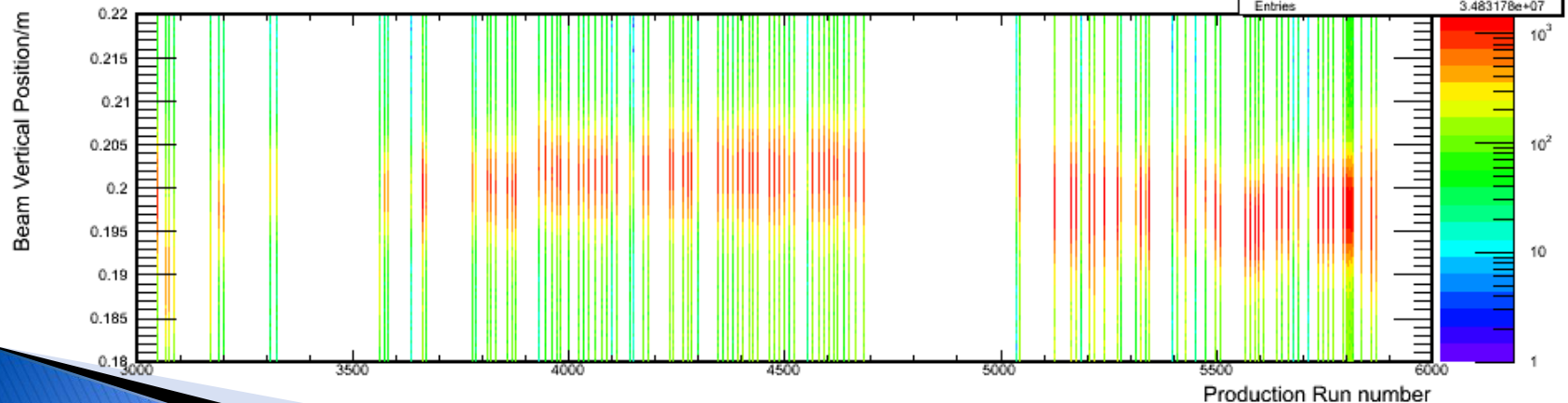


# Cell Window : Close In

UpStream Cell Window : HRS Optics Stability Check



Beam Vertical Position

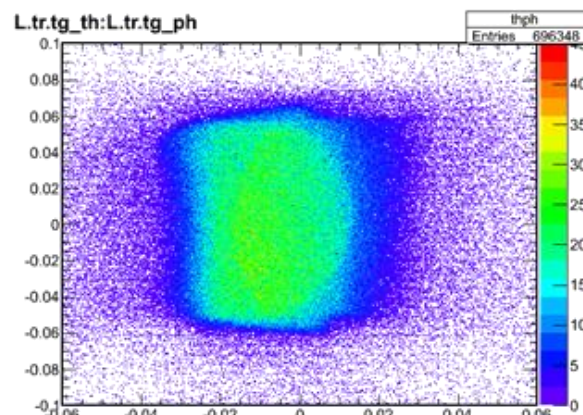
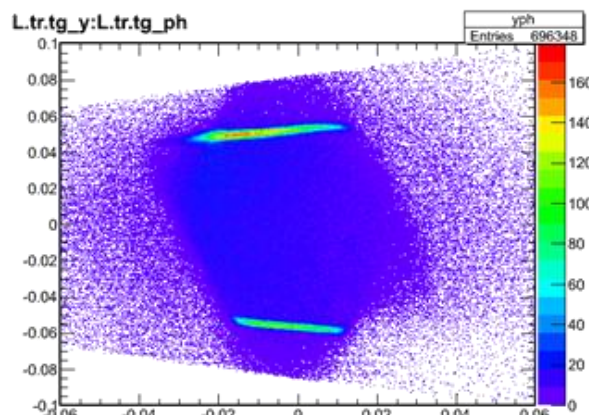
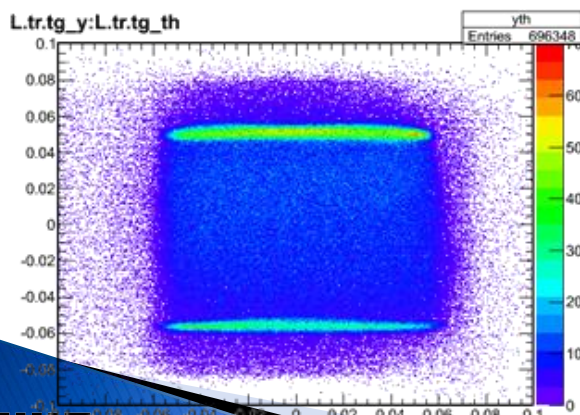
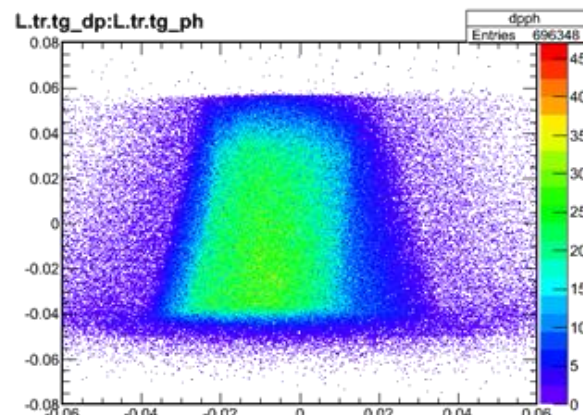
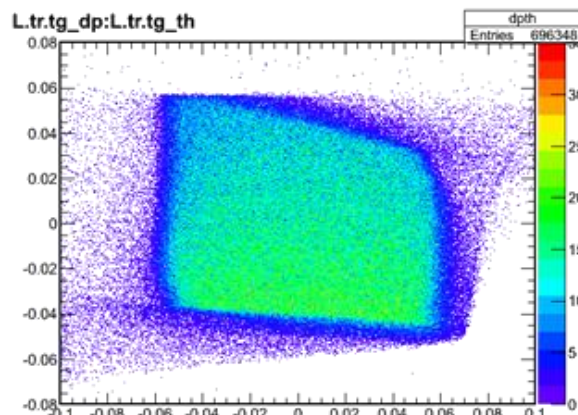
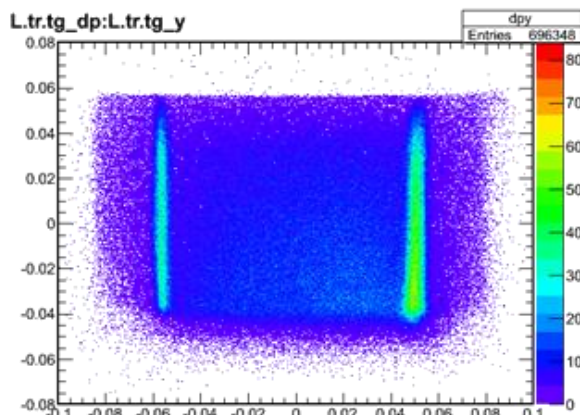


# HRS Acceptance Cut

- ▶ R-Cut
  - 6 sets of 2D graphic Cut on 4 dimensional spectrometer target acceptance space (x th y dp)
  - Acceptance adjustable by change a variable parameter “R”
- ▶ For Transversity:
  - One step back: R Cut with fixed parameter “R”
  - Keep 6 sets 2D graphic Cut

# Raw Target Variable Space

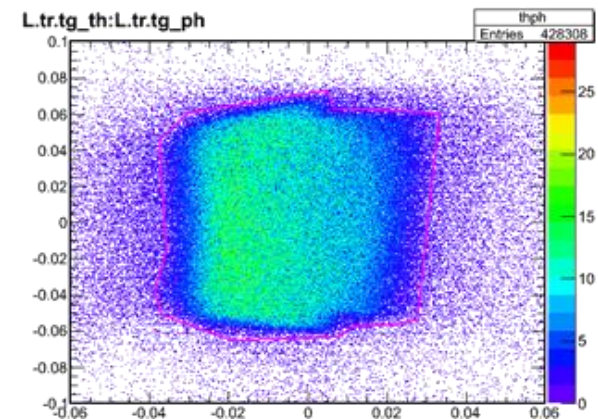
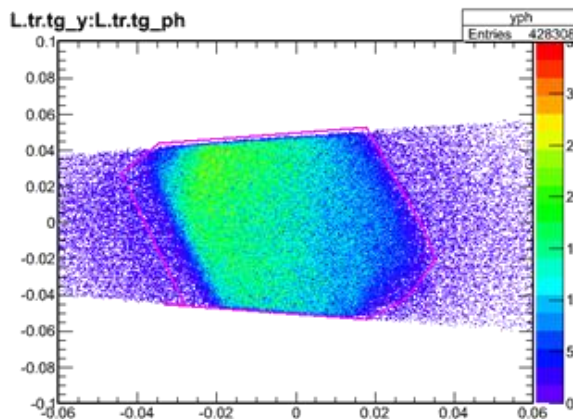
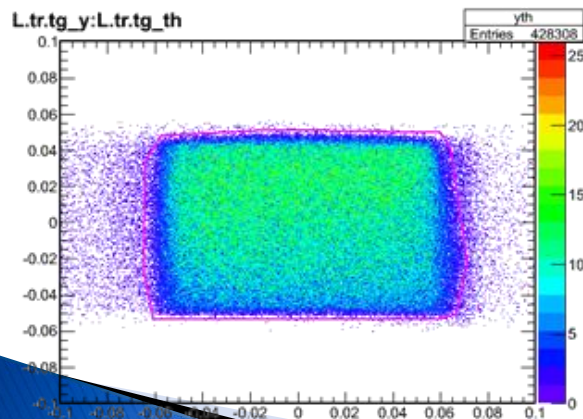
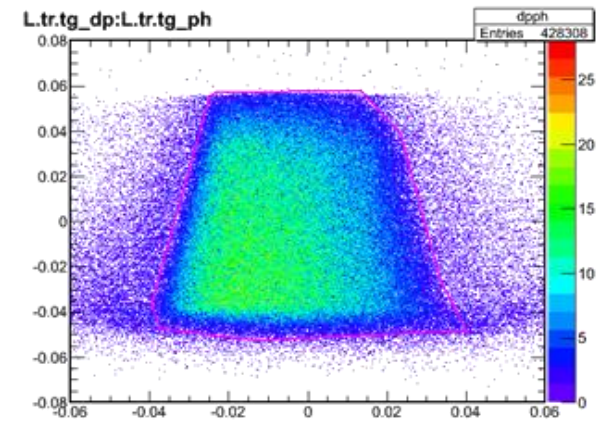
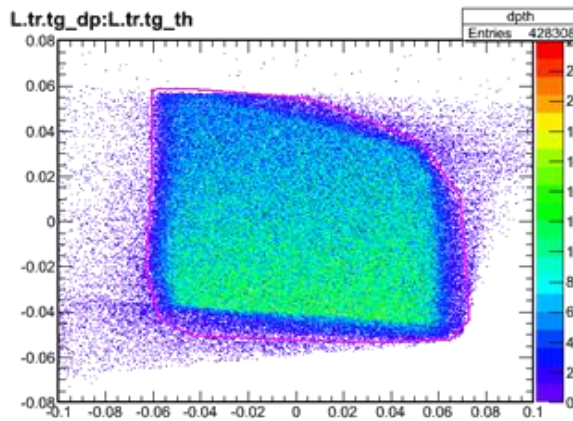
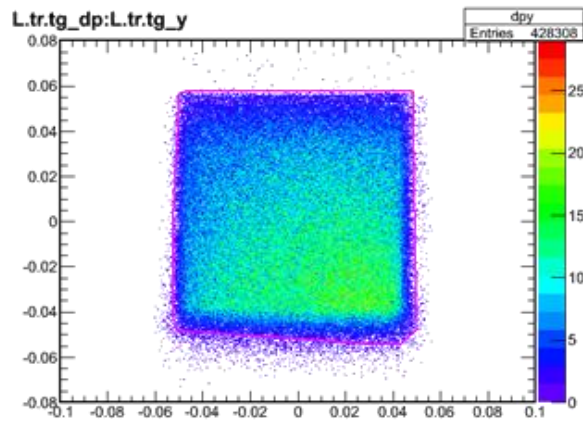
## ► Production DIS, “-” Polarity



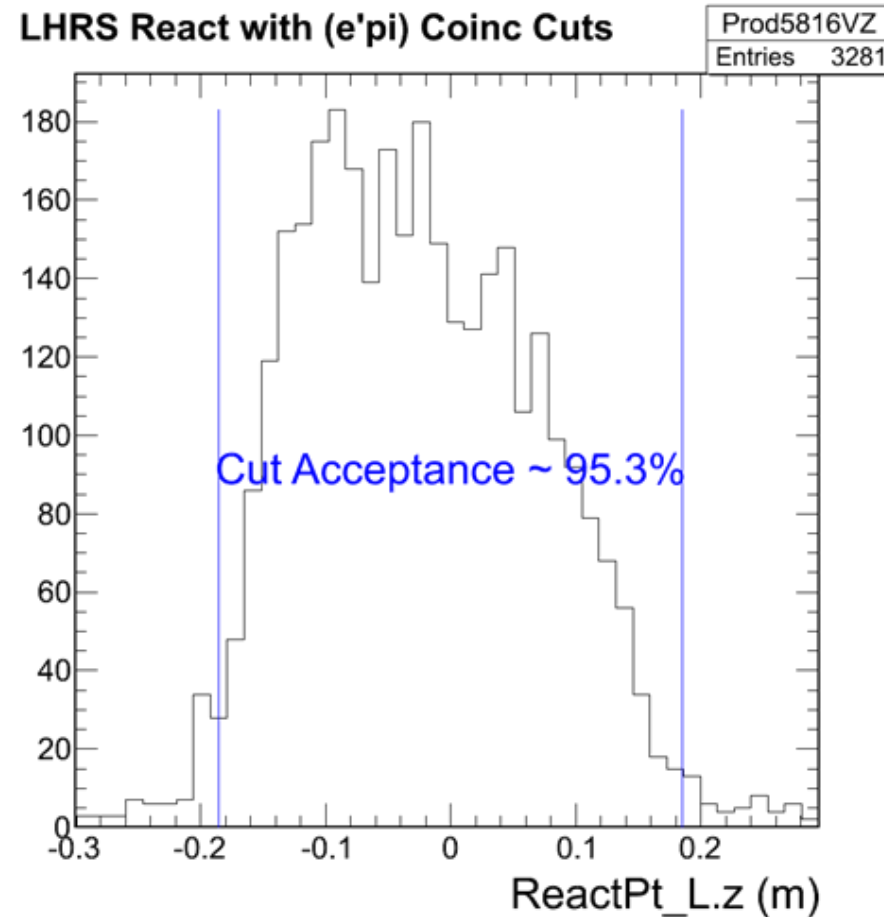
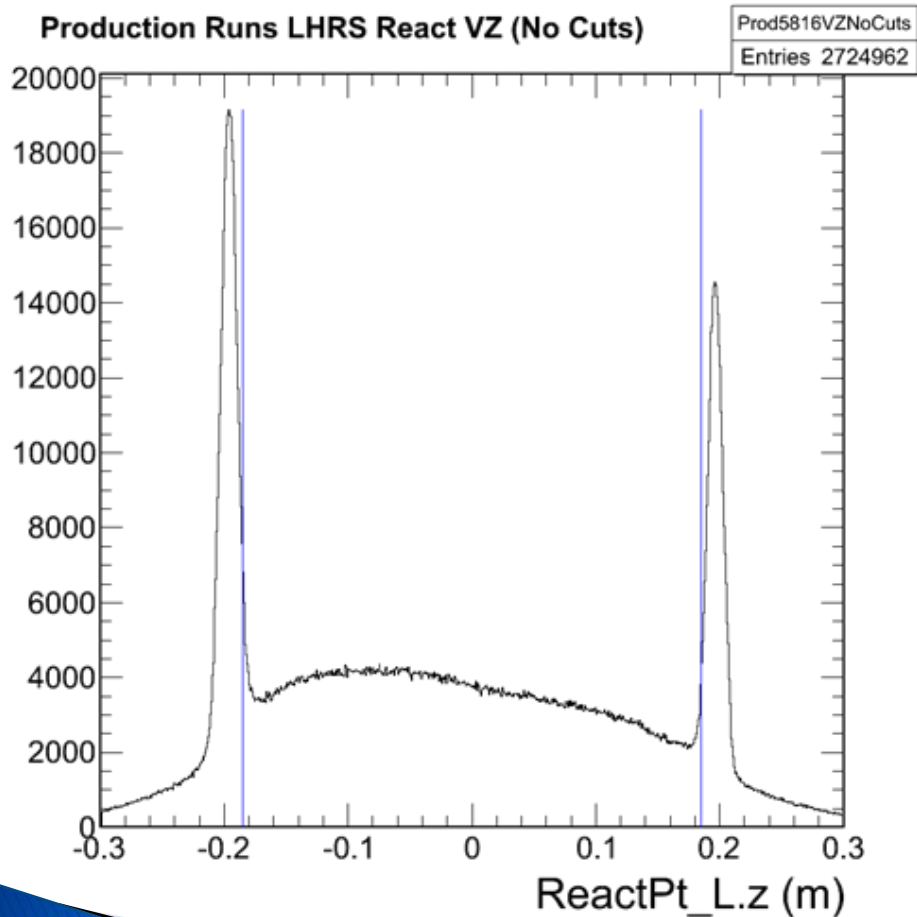


# R Cuts in Target Variable Space

- ▶ Cuts (pink lines) shown on data with Cell Window Removed

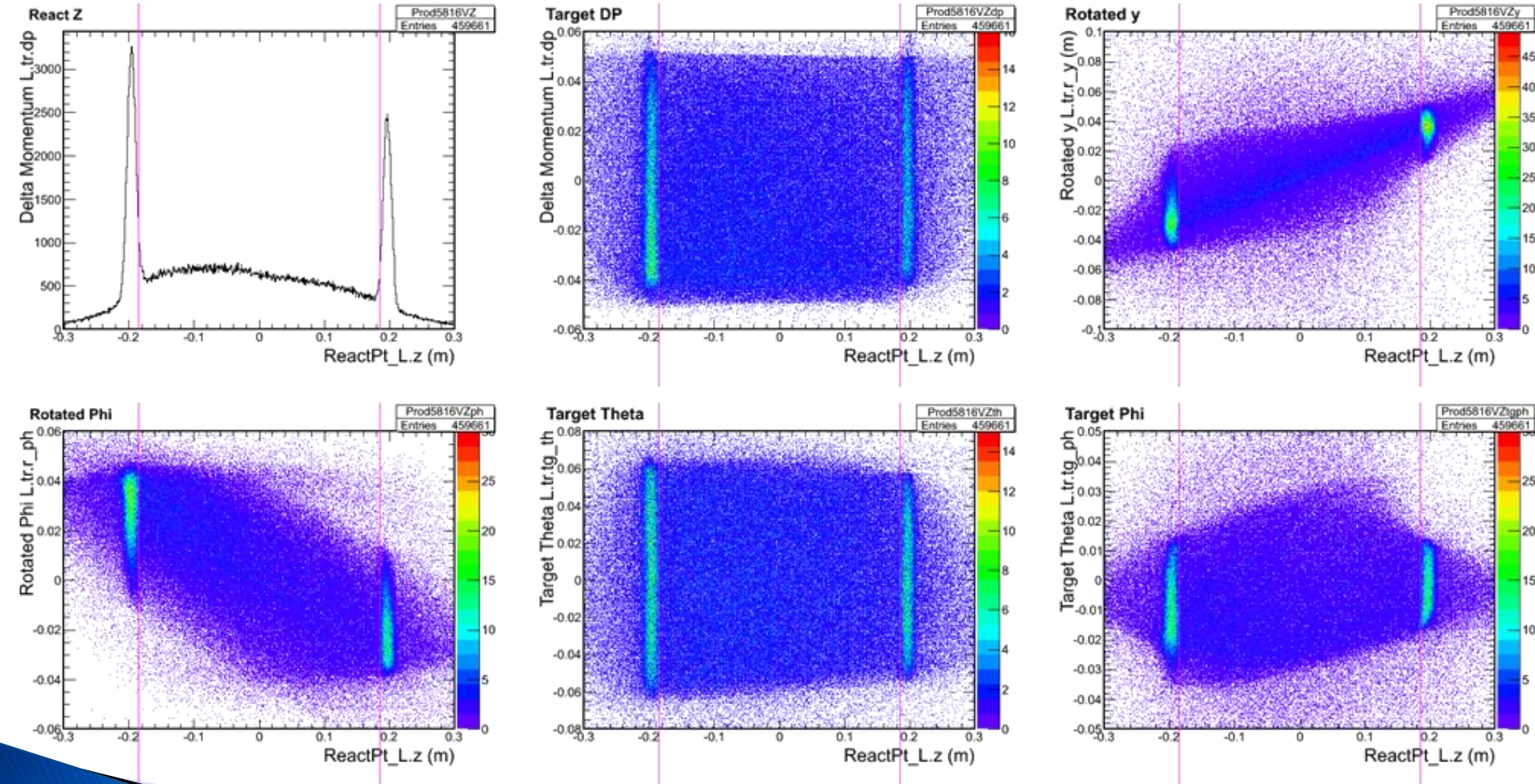


# Plus One: Vertex Acceptance / Absolute VZ



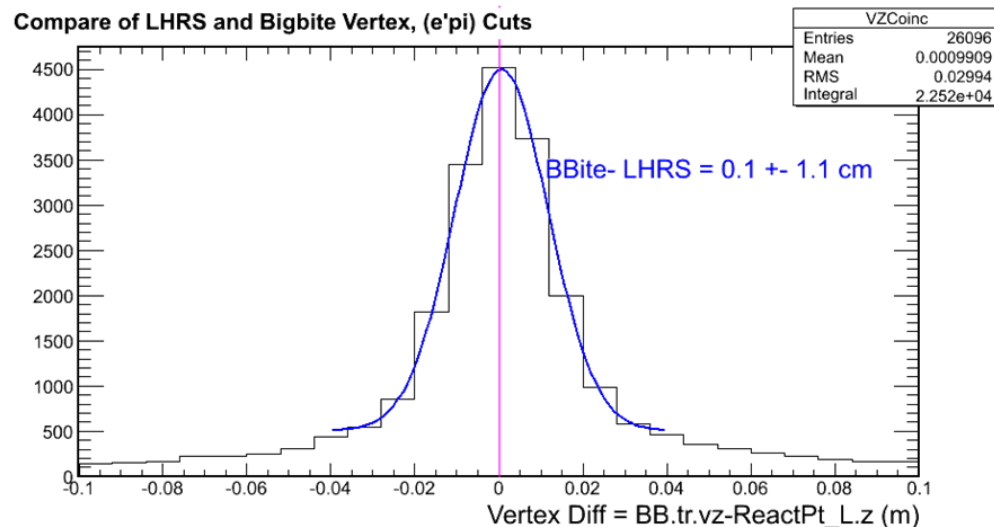
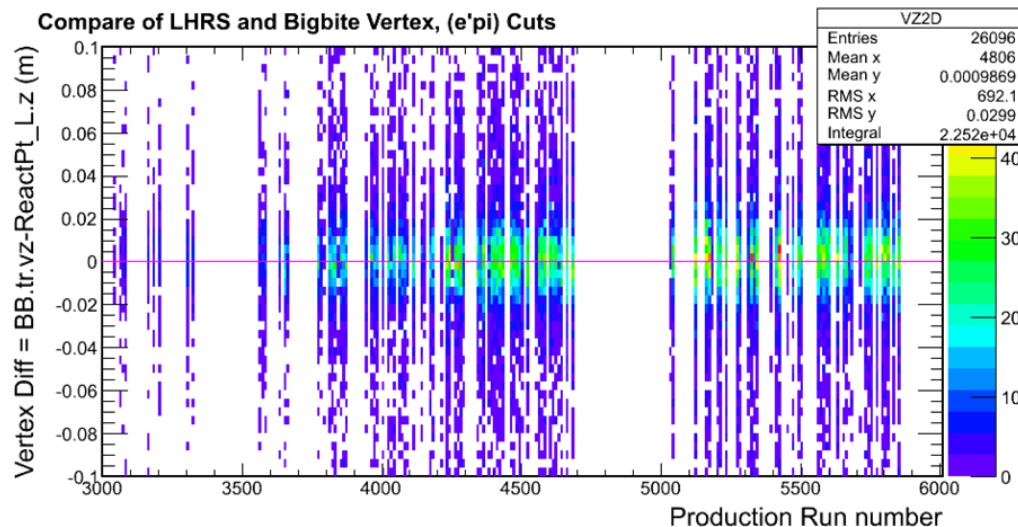


# Vertex Acceptance / Dependancy



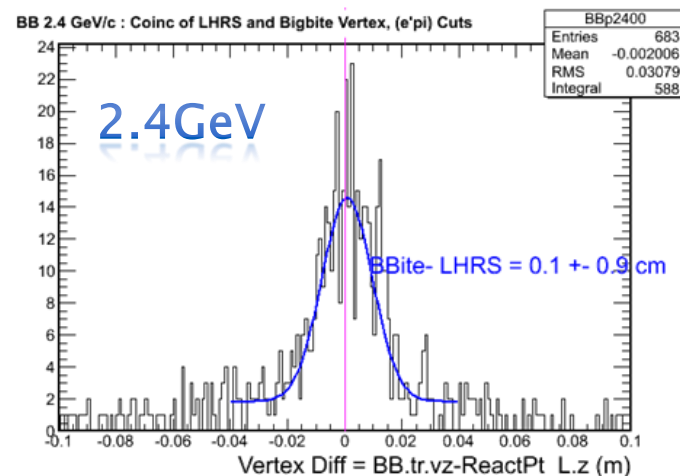
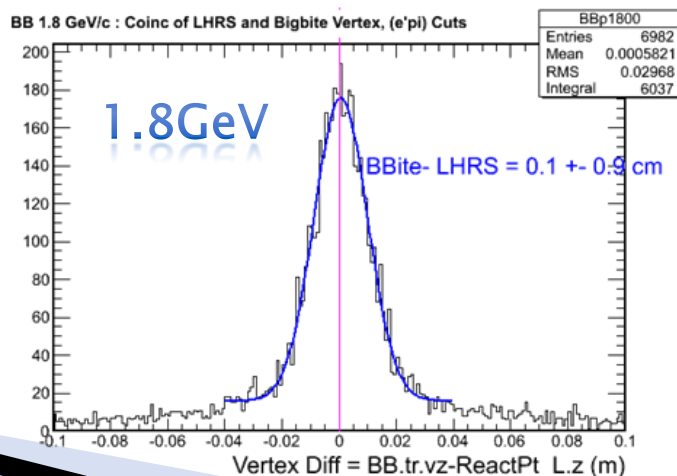
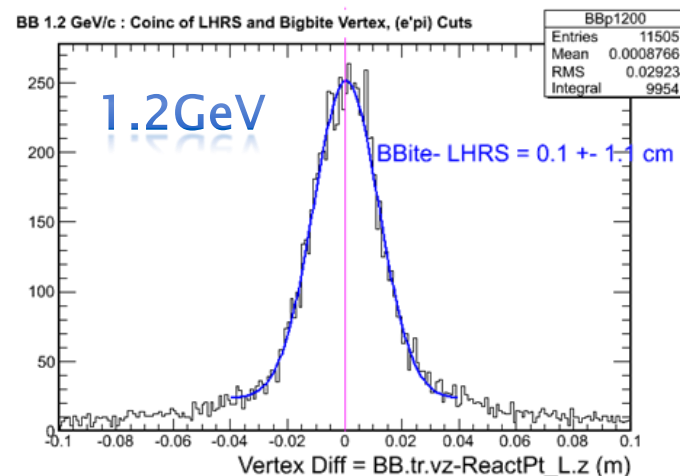
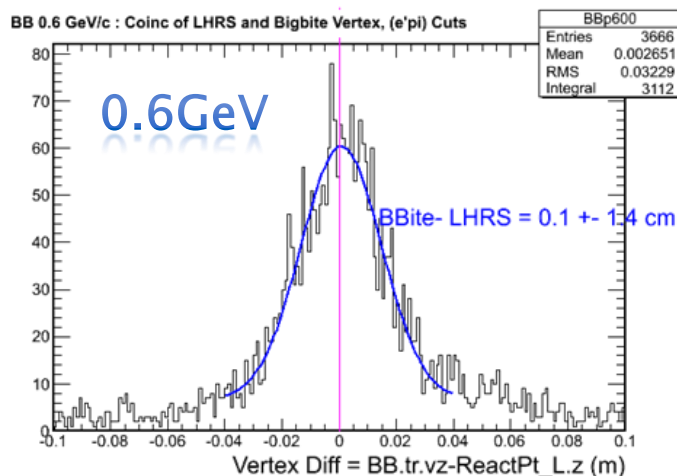
# React Z Match (BB VS LHRS)

- ▶ Good Match
- ▶ Sigma  $\sim 1$  cm



# React Z Match (BB VS LHRS)

- Match precision related to BB Momentum



# Current Status

- ▶ Database Finalized
  - In CVS, ready for your download
  - Two set of optics tg\_y matrix for 1.2/2.4GeV
- ▶ Cuts to be updated in Transversity Elog 149
  - Acceptance Cut to be summarized in a root scripts
  - Other cuts are simple expressions
- ▶ Modified Variables
  - db\_L.vdc.dat, db\_run.dat (spectrometer pointing)
  - L.tr.\*
  - ReactPt\_L.\* / ExtTgtCor\_L.\*
  - Kinematics ...
  - Standard Cuts



# Software Retiming on HRS



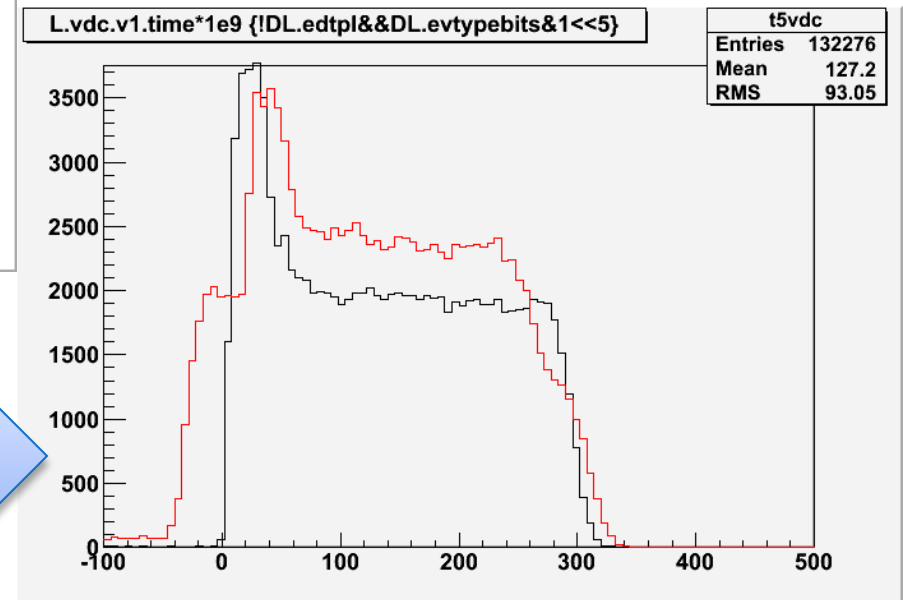
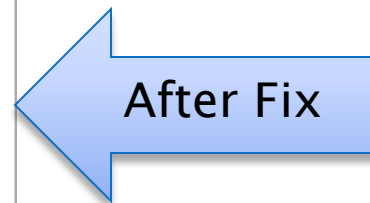
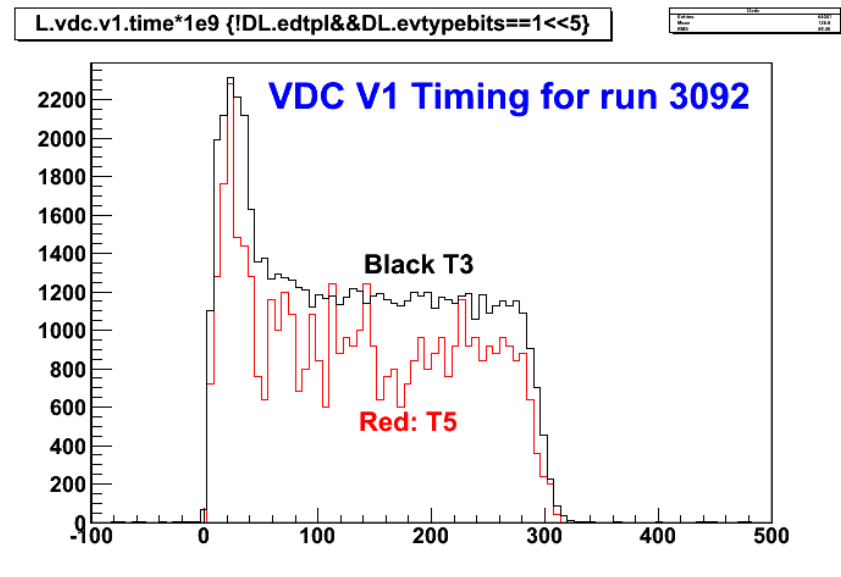
# Continue from last analysis meeting ....

- ▶ Hardware level retiming failed for the first run period
- ▶ Fixed by a software retiming, although the TDC for this calculation is on low res. mod
- ▶ Correction  
=  $DL.TrigT3 - 731\text{ns}$  (T3 Self Timing Peak)
- ▶ New Software module
  - THaHRSE06010
  - THaTriggerTimingE06010
  - Just load THaHRSE06010 instead of THaHRS in replay



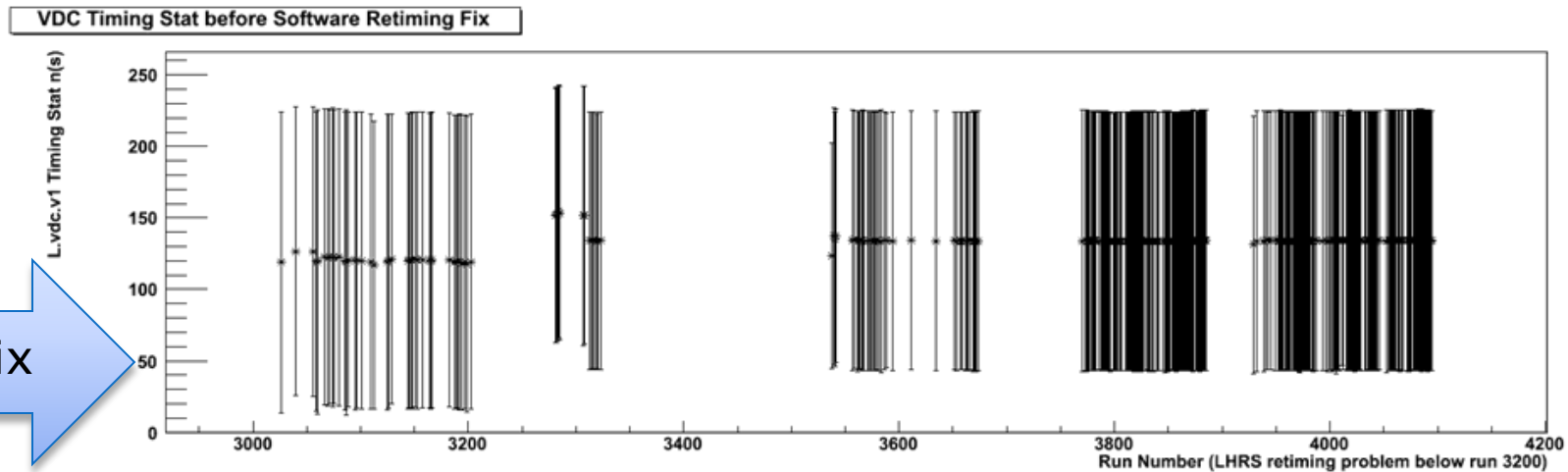
# Continued on Fix Quality Check

## ► VDC Timing Fix (plotted with ns)

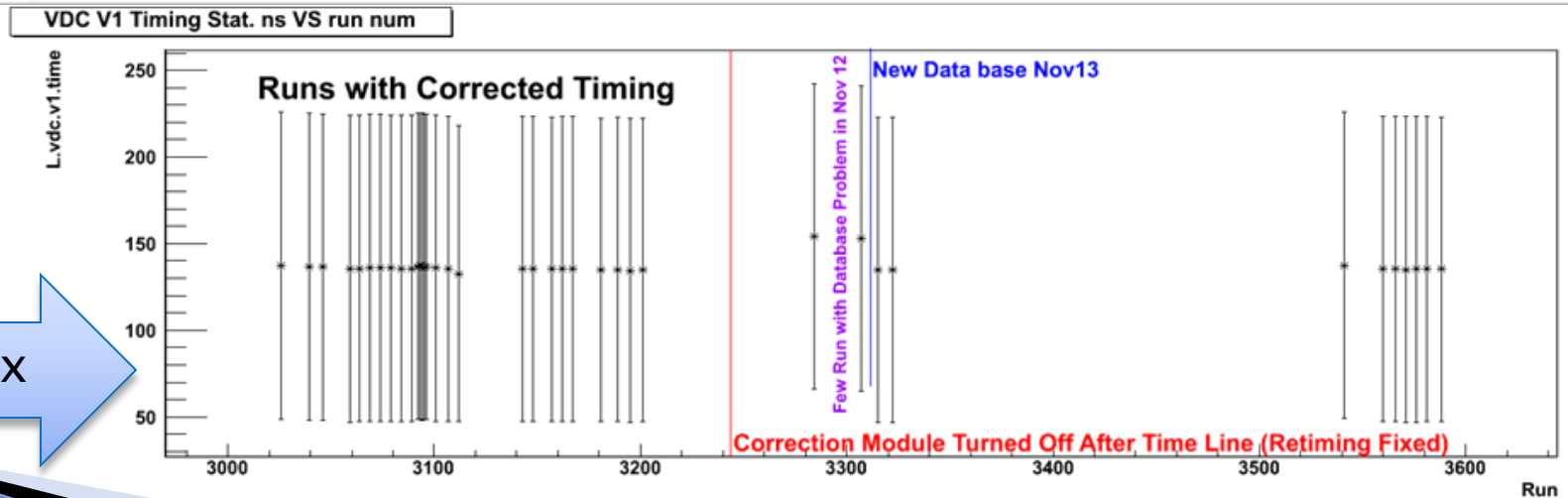


# VDC Timing Fix VS run

Before Fix

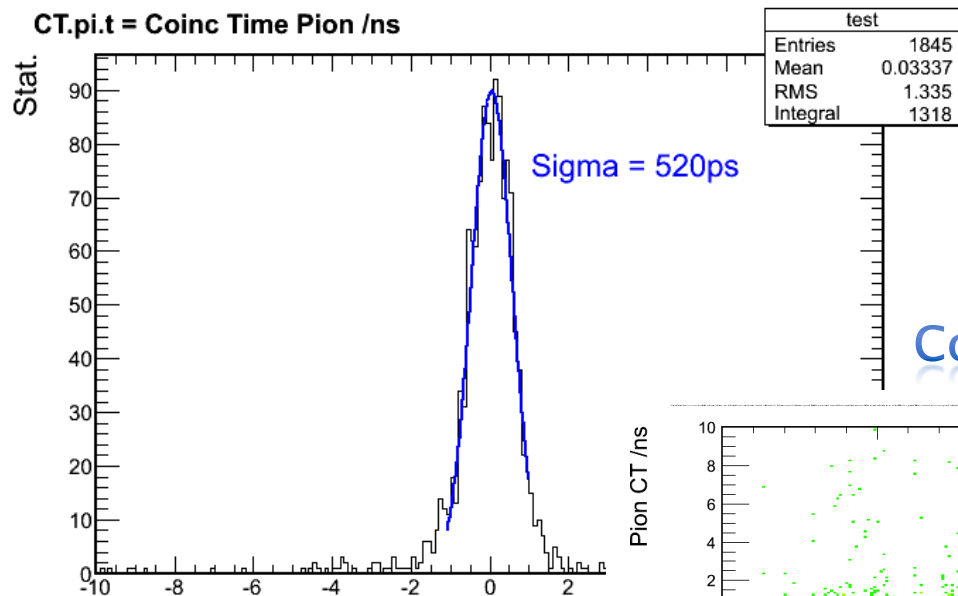


After Fix

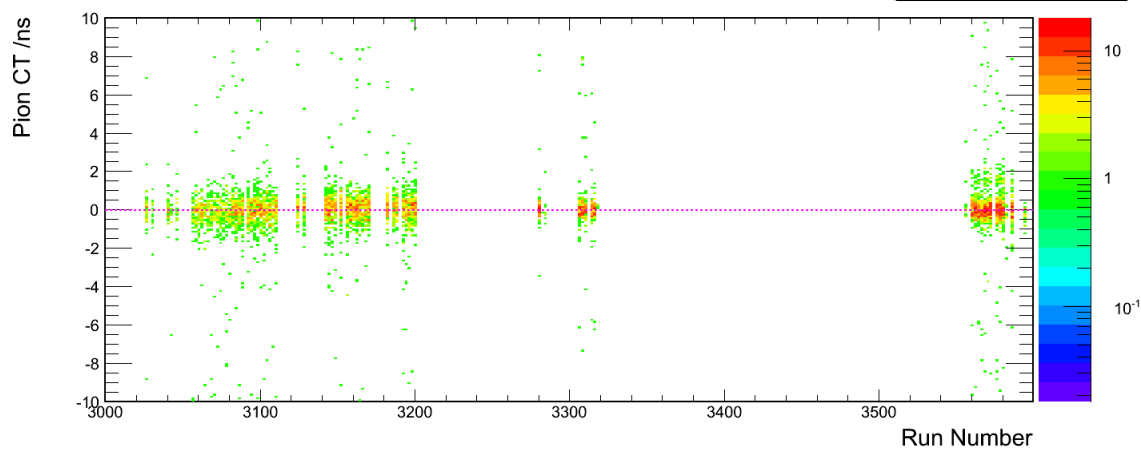


# Coinc Timing After Fix

- ▶ Relative to Normal Run (340ps) Resolution is certainly worse due to lack of High Res. TDC

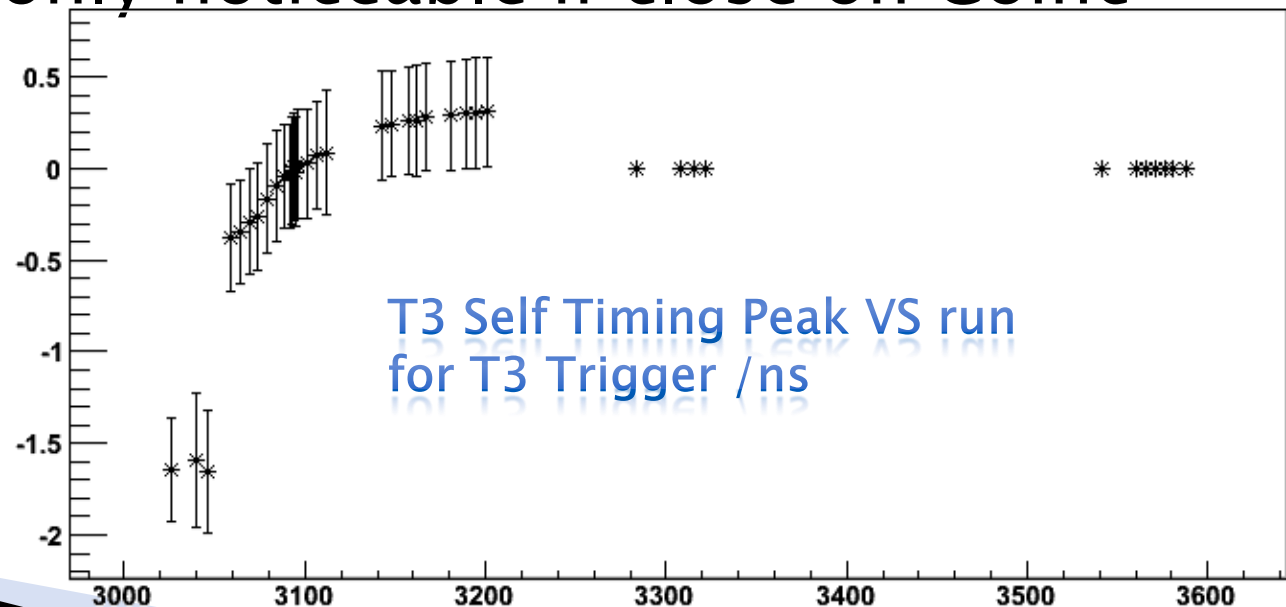


Coinc Time Stable Along Time Now



# Buy one get one free ...

- ▶ T3 Self Timing is drifting Mysteriously
  - This drift go to VDC and s2m timing
- ▶ Automatically fixed after software retiming
- ▶ This effect still remains, but 10 times smaller (0.2ns), only noticeable if close on Coinc Time



# Coinc Timing Stability Check



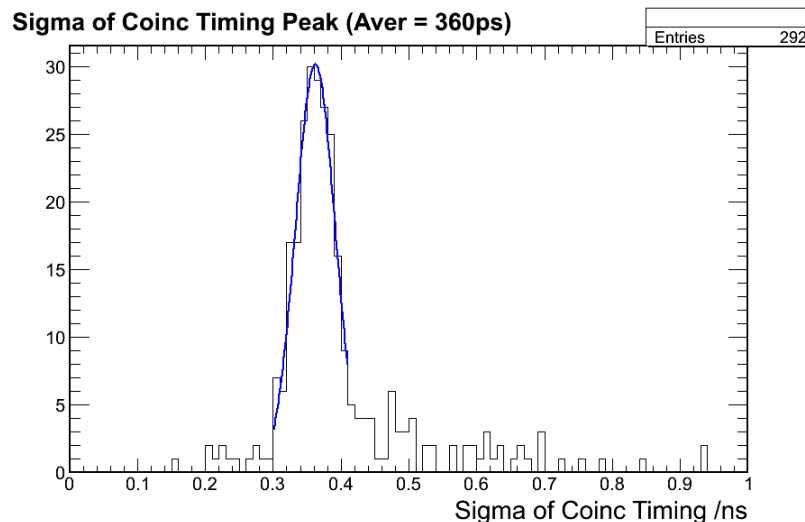


# Coinc Timing Check

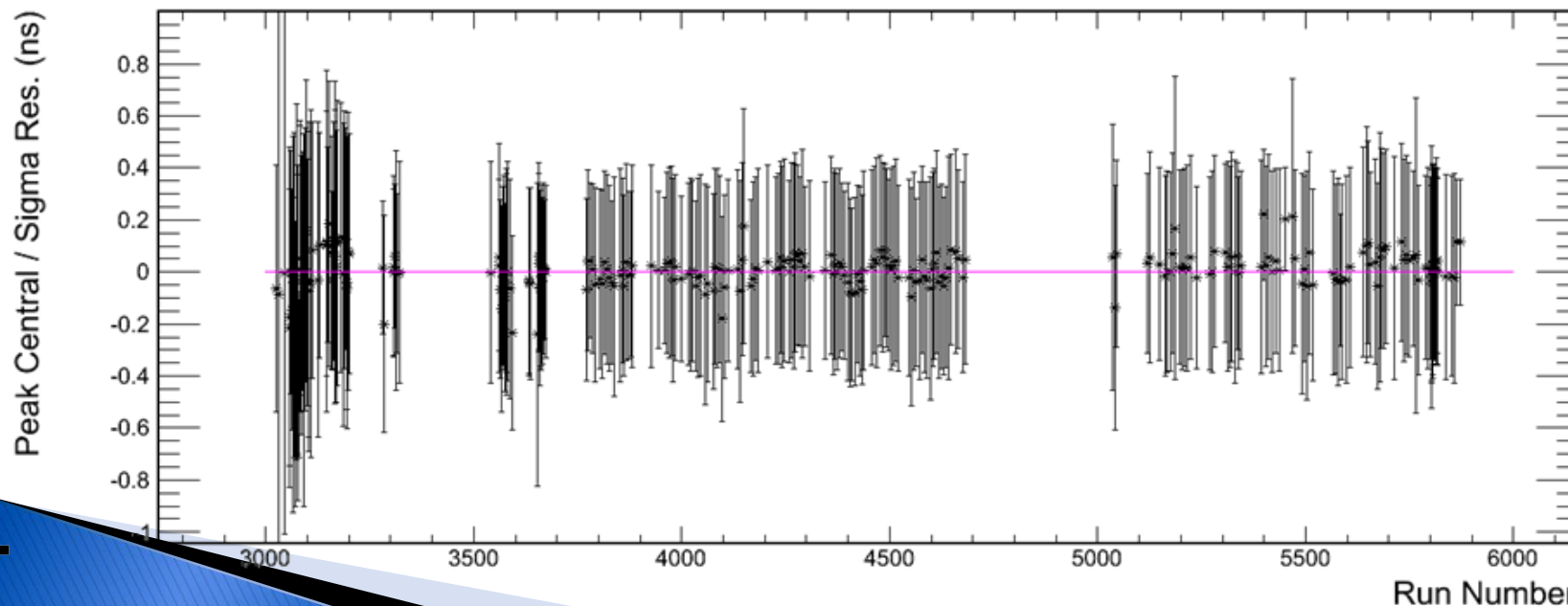


# In another view

- 30% of production / ref cell run
- With PID/Quality Cuts on Elog
- Sigma  $\sim 360$ ps

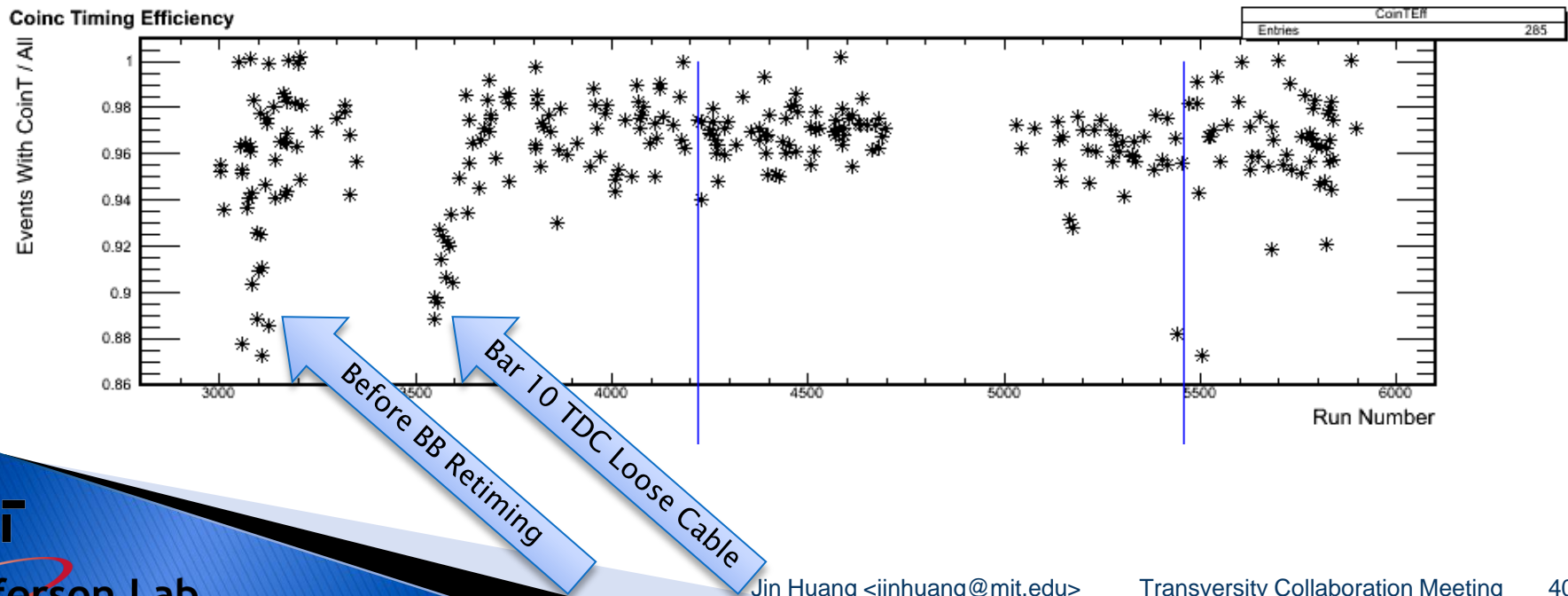


Offset and Sigma Res. of (e'pi) Coinc peak



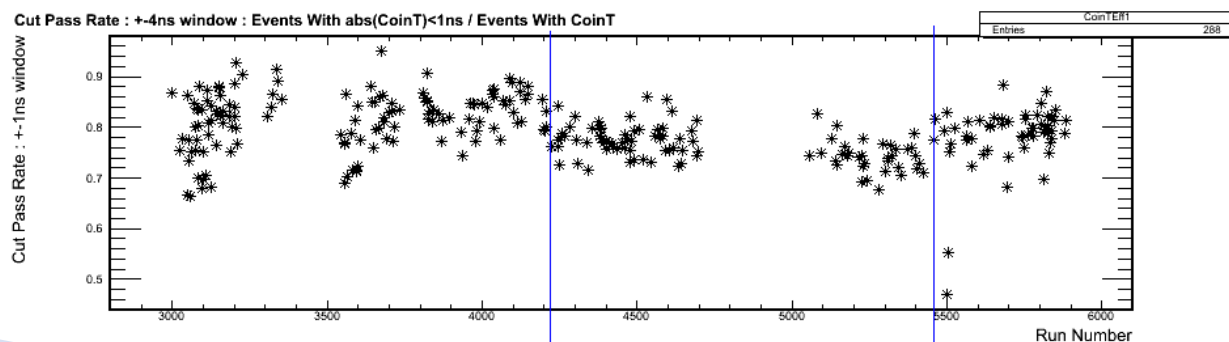
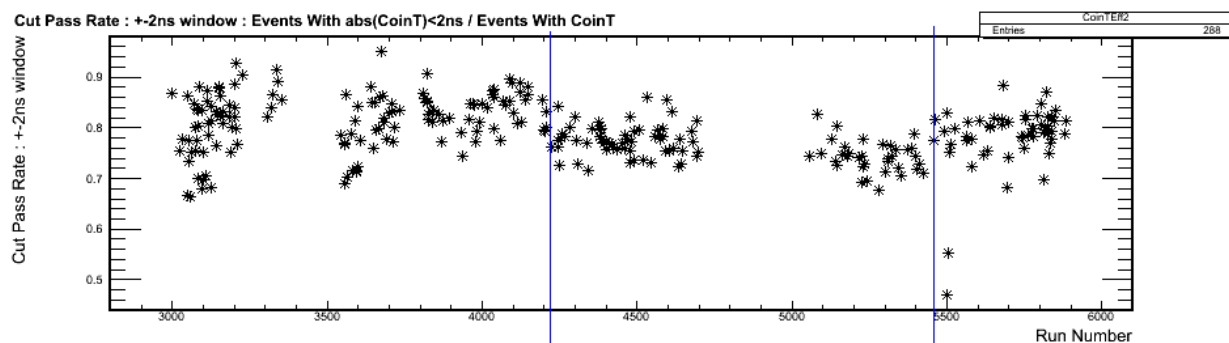
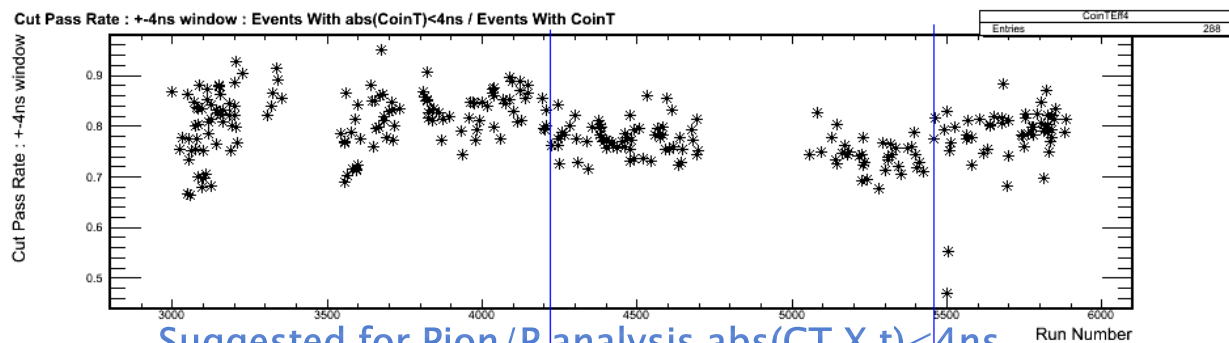
# Coinc Timing Efficiency

- ▶ ~97% of good PID event have coinc time value
- ▶ Most in efficiency come from BB side
  - Missing BB scint hit
  - Missing match of BB scint hit (10 sigma horizontal hit position match)



# Coinc Timing Cut : Pass Ratio

- ▶ With (e'pi) PID cut and VZ match cut, 80% event is in pion coinc peak
- ▶ Not sensitive to cut window width



# Review of Target Spin Definition and implementation

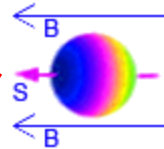




# Target Spin

- ▶ Definition of He3 Spin
  - Following State is same
    - He3 Spin Along Magnetic Field
    - Spin Up/+
    - $\text{he3.spin} = +1$

For Transversity,  
B field is always along  
Vertical Up or  
Beam Right direction

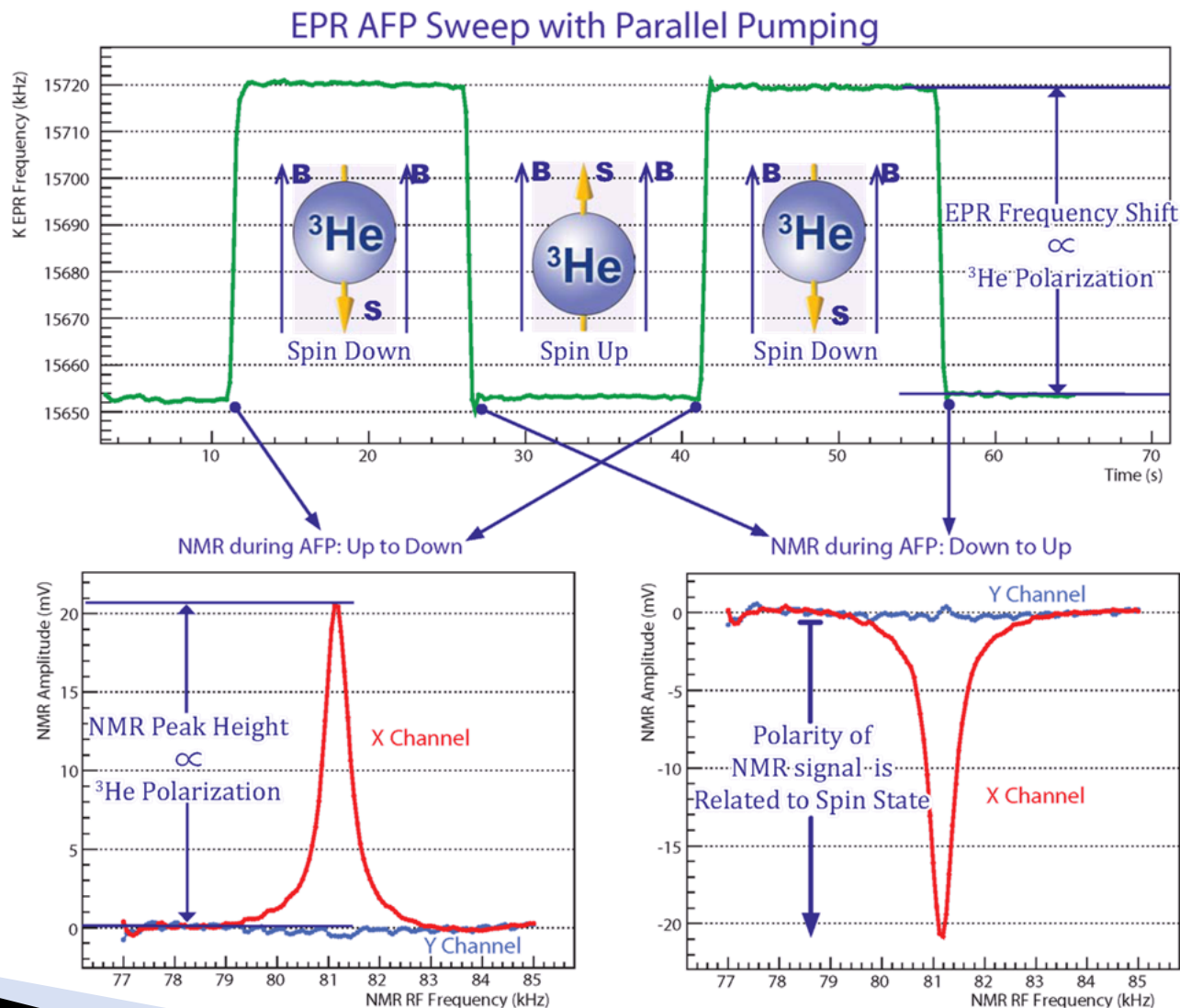


<u>Sys. Ctrl</u>	<u>Sys. Status</u>	<u>Spin</u>	<u>Auto Flip</u>	<u>Functions</u>	<u>Modules</u>
<b>Ready to Flip</b>  Expert Lock <b>Protected Mode</b>  Run Mode <b>Normal</b> <b>Open Manual</b> <b>EXIT</b>	Sequence ID 357 Flip Count 5 Last Reboot At 11:37:38 5/6/2009  Main Heart Beat <span style="color: green;">●</span> Flip Timer Heart Beat <span style="color: green;">●</span> Motor Ctrl Heart Beat <span style="color: green;">●</span> Sync. Heart Beat <span style="color: black;">●</span> EPICS Heart Beat <span style="color: green;">●</span>	 Spin Parallell to Holding Field Pol. %= <b>65.5</b> <b>Flip Now!</b>	Auto Flip Set OFF ON <b>Auto Flip Alive</b> Flip Interval 20 Min 0 Sec Waiting Progress <div style="width: 100%; height: 10px; background-color: blue;"></div> System Time 23:35:50 5/6/2009 Next Flip Expected 23:47:09 5/6/2009 Last Flip Start Time 23:27:02 5/6/2009 Last Flip Finish Time 23:27:09 5/6/2009 <b>Waiting For Flip</b>	<b>Show Status</b> <b>Show Log</b> <b>Open Log File</b> <b>Make HaLog Report</b> <b>Reboot EPICS</b>	<b>Sweep Setup</b> <b>Sweep Status</b> <b>Phase Analysis</b> <b>Laser Pol. Ctrl</b> Changing Pol. <span style="color: green;">●</span> Author: Jin Huang <jinhuang@jlab.org>

# How spin is determined

- ▶ When he3 spin along holding field, its magnetic moment is Antiparallel, therefore a weaker total field.
- ▶ This small shift in field is tested during EPR, which server as an absolute calibration of spin direction
- ▶ Signal polarity would flip for different spin state during NMR. Therefore,
  1. EPR calibrate NMR Phase
  2. For each spin flip, NMR phase is read in to determine spin state

# Typical EPR for spin calibration



# Distribution of Spin signal

- ▶ Spin signal generated by detecting NMR phase at each flip
- ▶ There were two copy of spin signal generator
  - one broadcasts the spin signal to scalars/ADCs
  - The other is for double check only (ADC only)
- ▶ The signal was read back to target computer and compared with expected spin state constantly

# Spin Flip Session

- ▶ Spin flip session is a continuous spin flip sequence with a non-repeating ID. During a single session, following target features remain identical:
  - Target Hardware Setting, including He3 Cell, Set Temperature, Laser Power
  - Target Field Direction
  - Target Polarimetry Parameters
- ▶ All spin flip sessions are summarized on Transversity Elog 131