Extended Target Correction
&
Coincidence Timing for Transversity

Jin Huang
M.I.T.
Hall A Analysis Workshop
Dec 14, 2009 @ JLab

Jefferson Lab

Content

Extended Target Correction

- Origin of the Correction
- Raster Correction
- New Raster Cable Map

Coincidence TOF Calibration for E06010

- Introduction
- LHRS Timing
- BigBite Timing
- Coincidence Timing

Extended Target Correction

- Origin of the Correction
- Raster Correction
- New Raster Cable Map

Extended Target Correction

- HRS Optics Matrix
  - Base on VDC track parameters: t, y, th, ph
  - Target Variables: y, th, ph, dp
- But with one assumption
  - $x_{tg} = 0$
  - Or equal to
    - beam along hall center line
    - HRS at 90°
- How to make it work for real configuration?
- -> Extended Target Correction
  THaExtTargCor in analyzer

Do the math

- To model the correction:
  1. Fix track on VDC
  2. Shift beam location, HRS angle
  3. Look at shift on target variables to produce same track on VDC
- A simple magnet modeling
  - Use 1st order transportation matrix in HallA NIM

$$\text{Focal Plane Variables} = \begin{bmatrix} -2.48 & 0.0 & 0.0 & 0.0 & 12.4 \\ -0.15 & -0.40 & 0.0 & 0.0 & 2.04 \\ 0.0 & 0.0 & -0.40 & -1.30 & 0.0 \\ 0.0 & 0.0 & 0.54 & -0.78 & 0.0 \\ 0.0 & 0.0 & 0.0 & 0.0 & 1.0 \end{bmatrix} \times \text{Target Variables}$$

Say, beam shift vertically

- From the 1st model:

$$\frac{dth_{tg}}{dy_{beam}} = -0.645 - 0.416 y_{tg} \cot\theta_0 + \text{Smaller Second Order Terms}$$

$$\frac{ddp_{tg}}{dy_{beam}} = -0.2 - 0.129 y_{tg} \cot\theta_0 + \text{Smaller Second Order Terms}$$

$$\frac{dph_{tg}}{dy_{beam}} = \frac{dy_{tg}}{dy_{beam}} = 0$$

- In analyzer we apply two corrections believe from fitting of data

$$\frac{dth_{tg}}{d(-x_{tg})} = 0.61$$

$$\frac{ddp_{tg}}{d(-x_{tg})} = 0.19$$

Agree well with Expectation

Beam x, HRS angle…

- Leading correction on beam x (horizontal) is Second order
- Leading correction on HRS angle is Third order
- These two term could be ignored

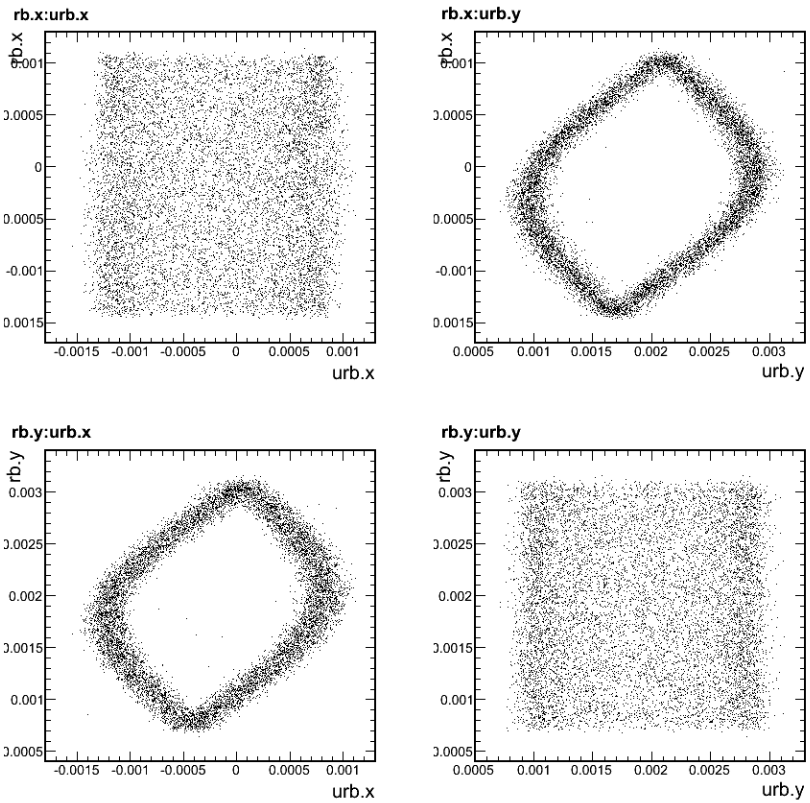
- Detail could be found at http://www.jlab.org/~jinhuang/Meeting/2009.09.25%20Transversity%20Collaboration%20Meeting/173.htm

Therefore Raster is important

- Raster determine beam position
- Two independent raster: x, y
- Two raster cable found swapped long before Transversity
  - New raster cable map
  - Patch on Analyzer (Sept 09, 2009 -> CVS)

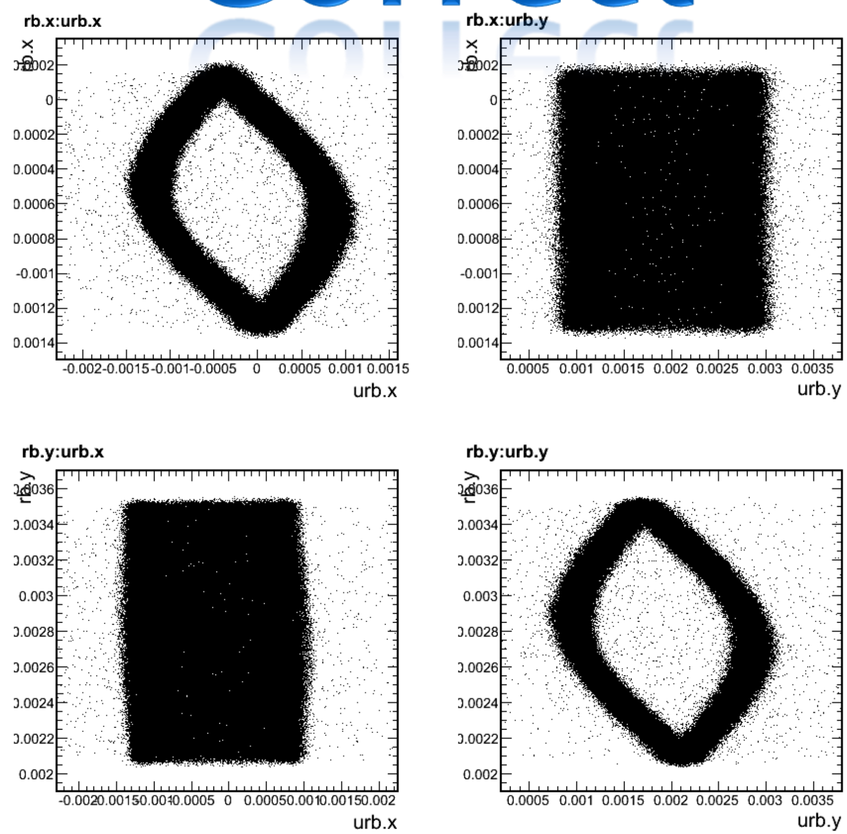
- Suggested check for your experiment

Identifying the problem / Raster BPM correlation



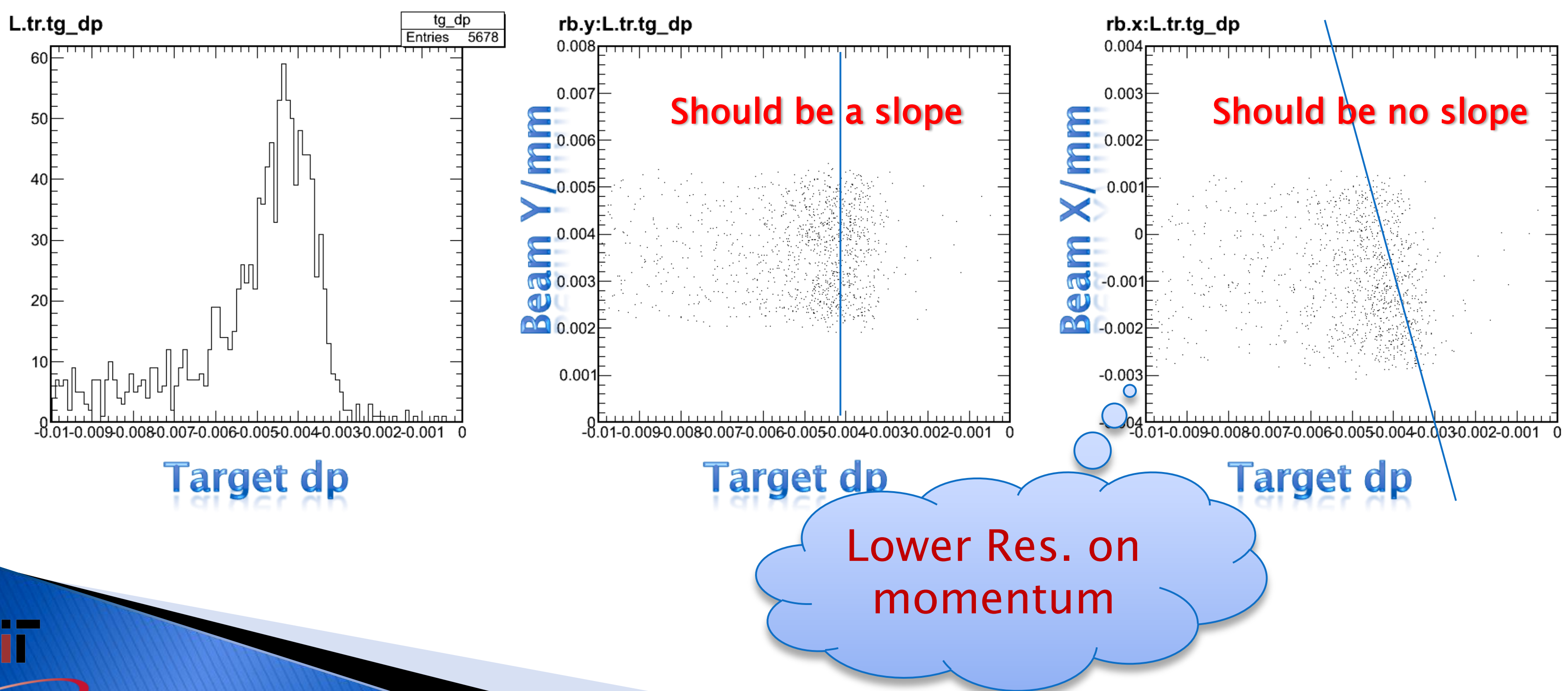
X Wrong

Correct



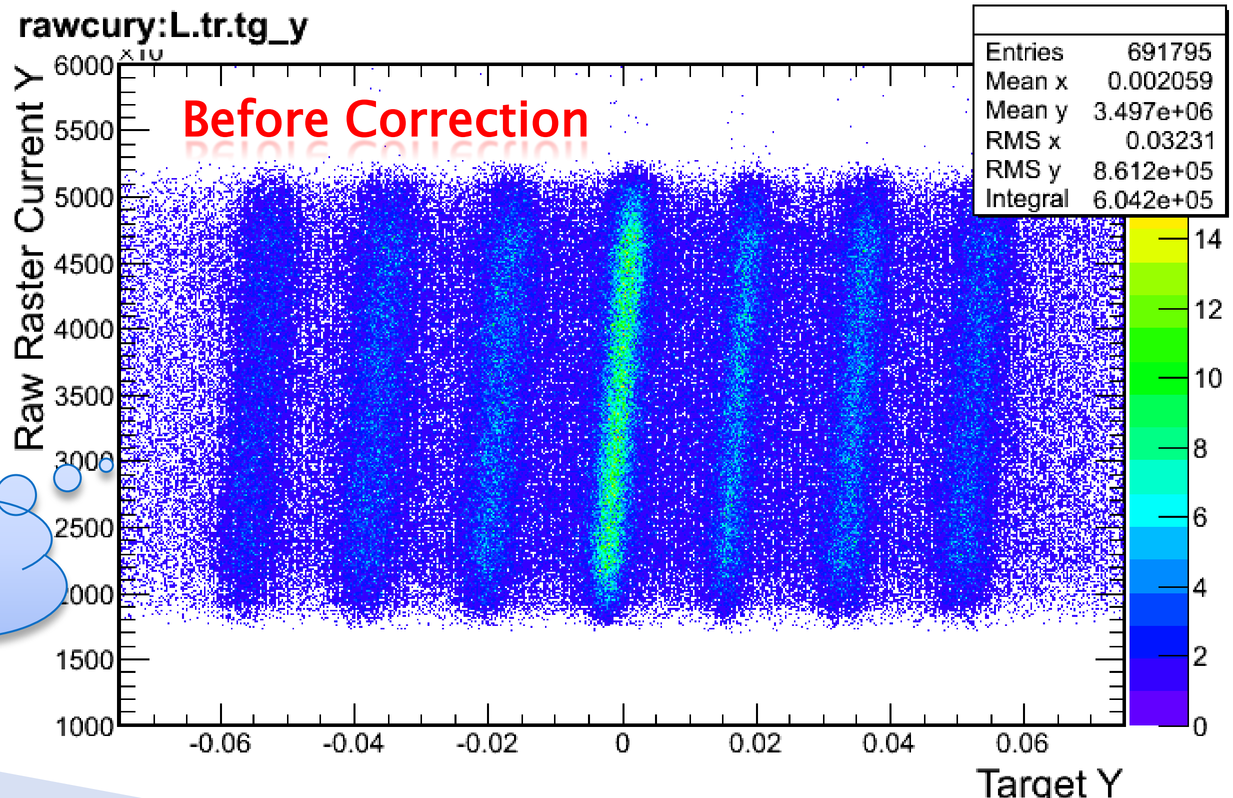
Identifying the problem / dp

- Check L.tr.tg_dp dependency
  - Cutting central ray into spectrometer
  - A peak structure should be correlated with Beam Y



Identifying the problem / Carbon Targets

- Positive slope on raster current VS target Y -> +rawcury (should be rawcurx) is toward beam left = +X in Hall Coordinate System

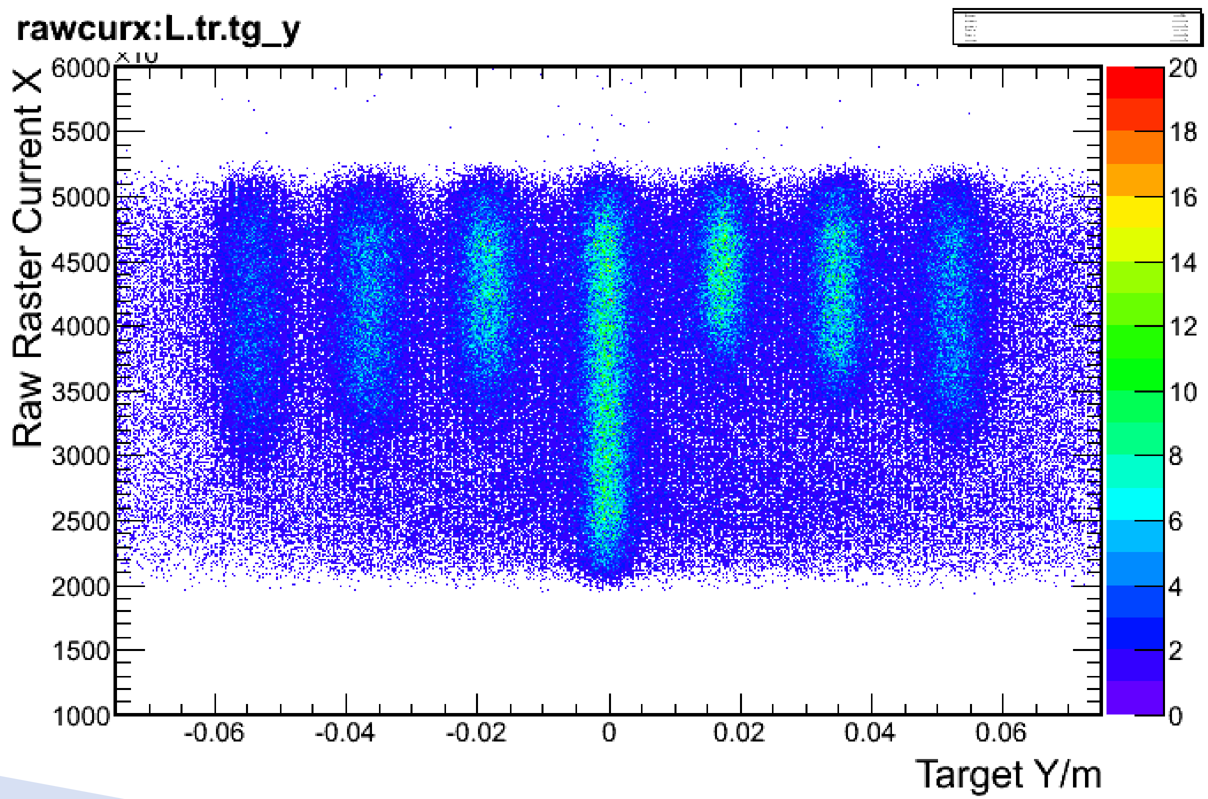


React z Res. destroyed a lot

Identifying the problem / Special Target Run

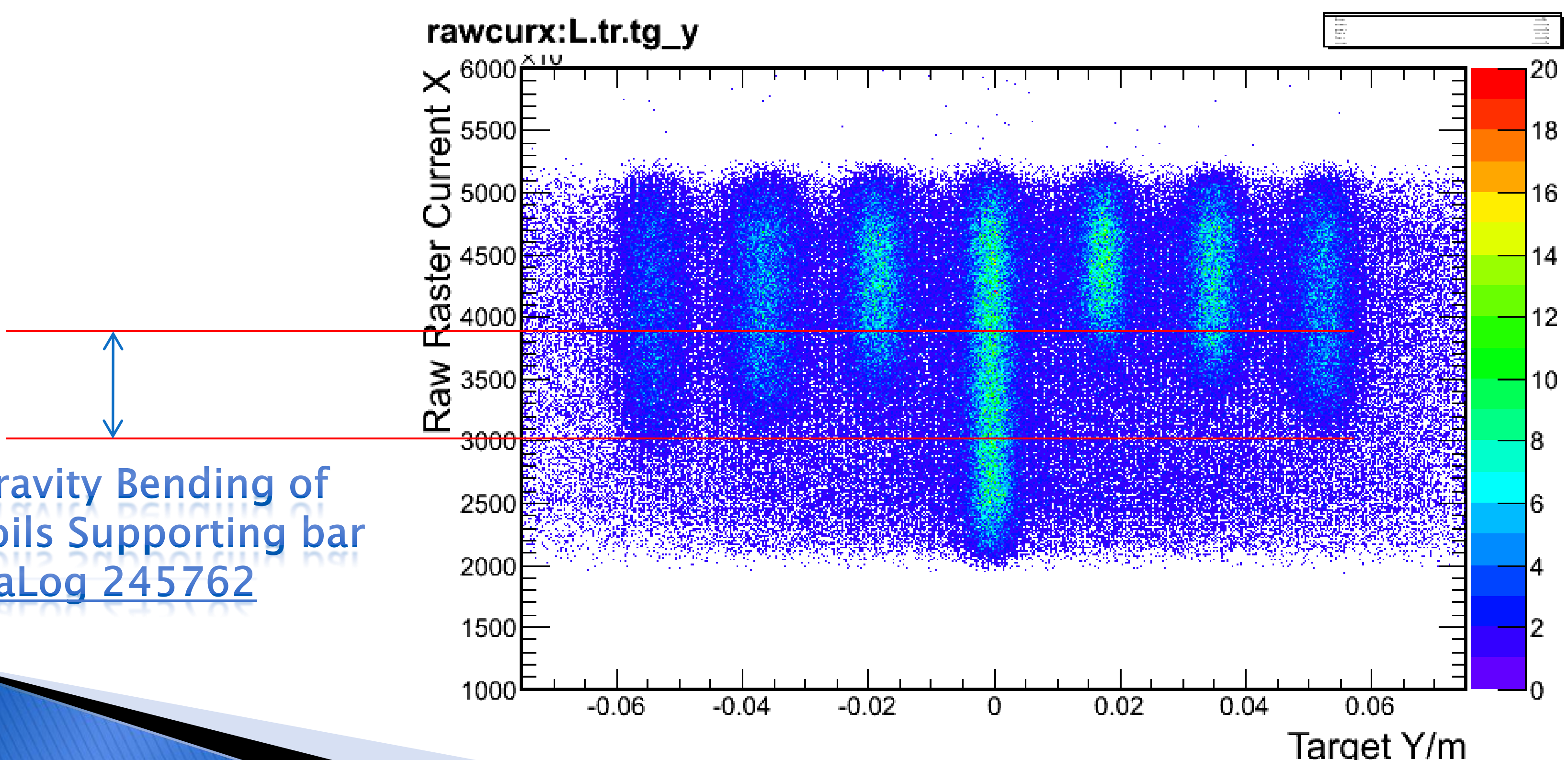
Identifying the problem / Special Targets

- 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 +rawcurx (should be rawcury) is toward vertical down = -Y in Hall Coordinate System



Gravity Bending of Foils Supporting bar
HaLog 245762

Fixing Raster Cable Map

To fix the raster cable map in db_rb.Raster.dat

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
```

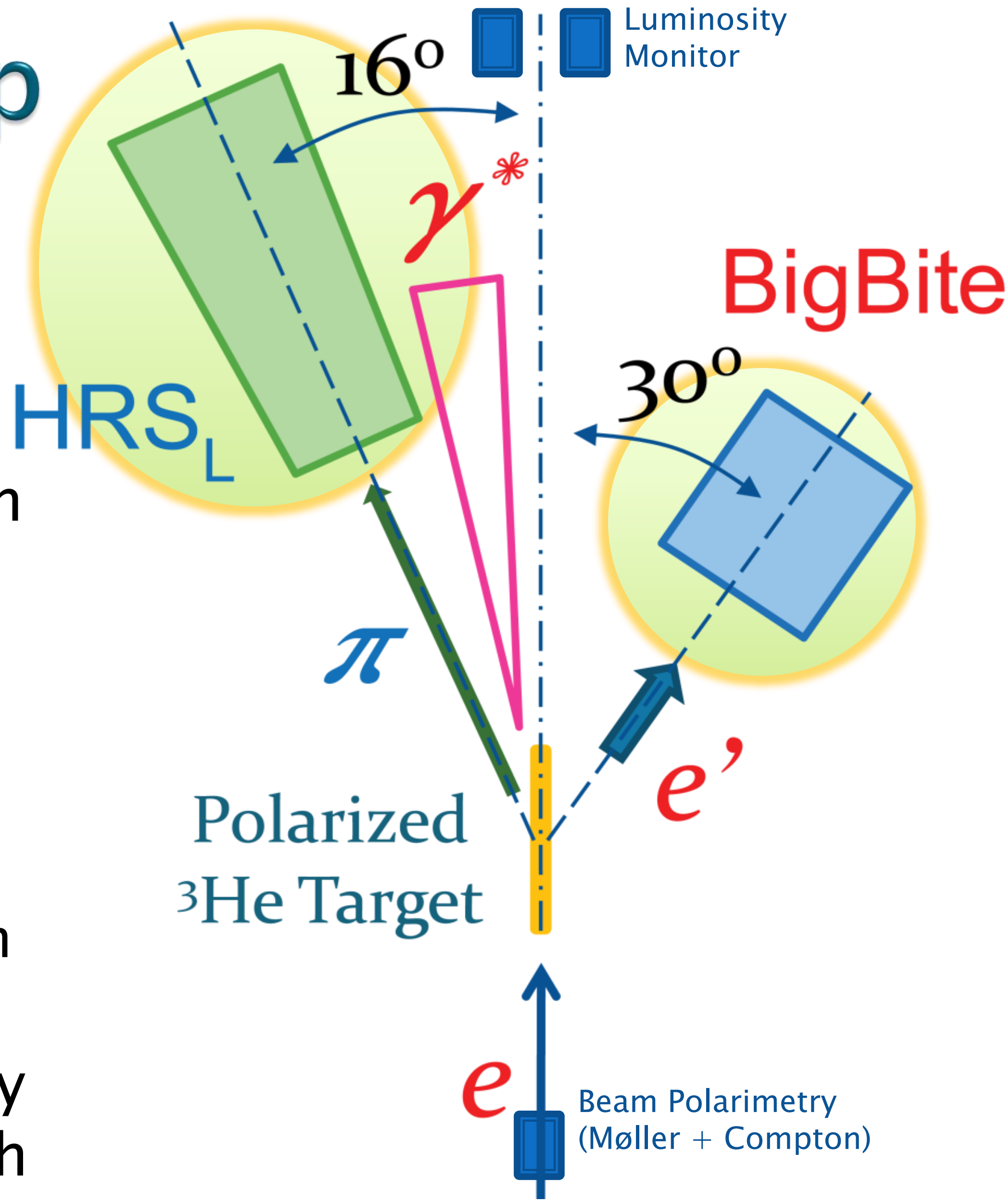
3. Similar for right arm is available

Coincidence TOF Calibration for E06010

- Introduction
- LHRS Timing
- BigBite Timing
- Coincidence Timing

E06-010 Setup

- E0-6010 Setup
  - Two arm coincidence
  - Each arm equipped with a high resolution timing detector
  - LHRS server as hadron arm
    - Detecting pion, kaon and proton
    - Total fly length ~27m
  - BigBite detector electron with short fly path



The idea

- coincidence time (CT) between this two spectrometers are defined as the time difference between when two particles are created in the reaction
  - Sharp peak @ 0ns for perfect system
  - Multiple peaks for multi-final state
- Useful for
  - Reducing random coincidence background
  - Help hadron arm PID

General Calibration

- 3 independent piece for calibration

$$\mathrm{CT} = \mathrm{RF\ Time}_{\mathrm{LHRS}} - \mathrm{RF\ Time}_{\mathrm{Bigbite}} - \mathrm{Trigger\ Time\ Difference}$$

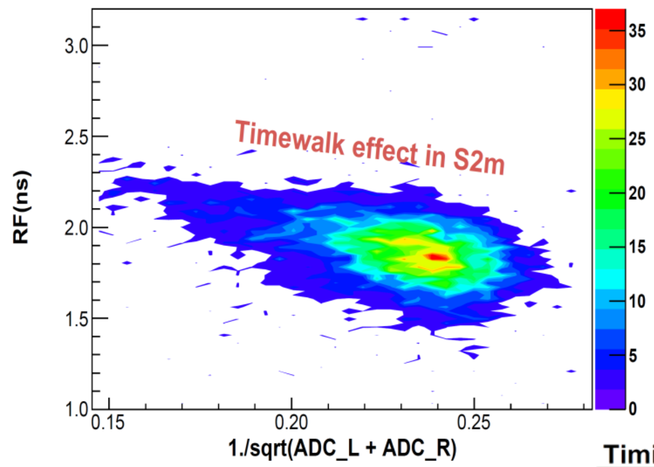
- RF Time$_{\mathrm{Spectrometer}}$ is
  - time cost between
    a vertex reaction and single arm trigger
  - Consist of
    - Time of flight
    - Respond time of timing detector
    - timing detector TDC
- Calibrated VS RF signal
- Only relative timing counts

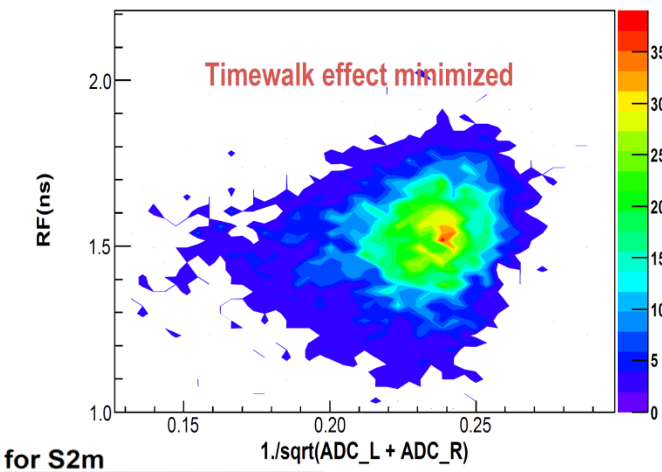
LHRS Timing
by Chiranjib Dutta

- Timing detector : s2m
- Optimal Calibration Order
  1. Rough offset alignment by looking into two-bar-hit events, with tight ADC cut
     - To precision below 1ns, so possible for next step
  2. Fit for matrix elements for fly path length using RF structure, with tight ADC cut
     - fly path length matrix is similar as optics matrix but independent
     - Up to 2nd order of x_{pf} and th_{pf} is fine for us
  3. Fine bar offset and time walk correction using RF structure

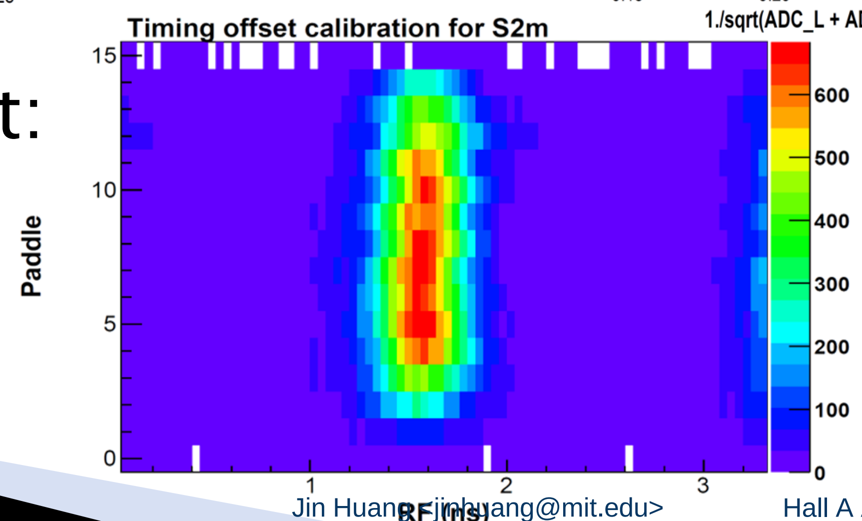
LHRS Timing Calibrations
by Chiranjib Dutta

- Time walk effect contribute to a ~0.5ns long tail, corrected



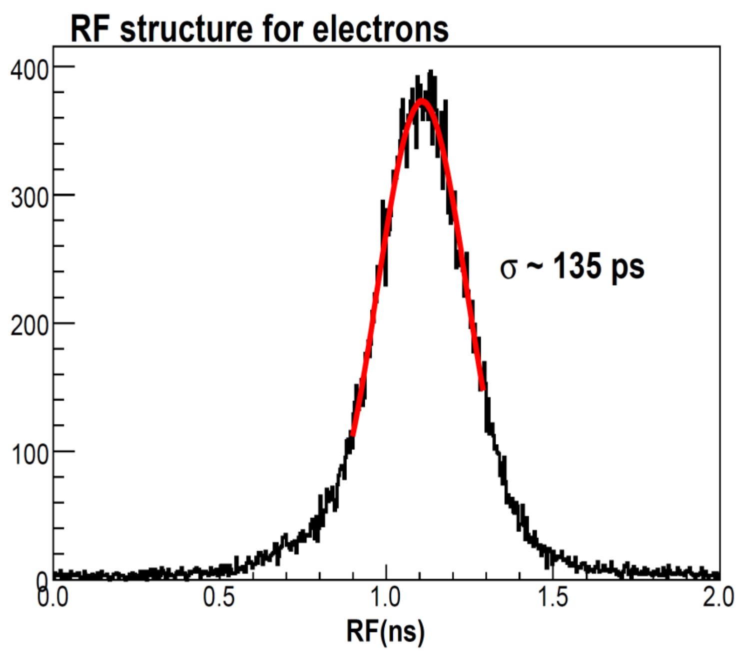


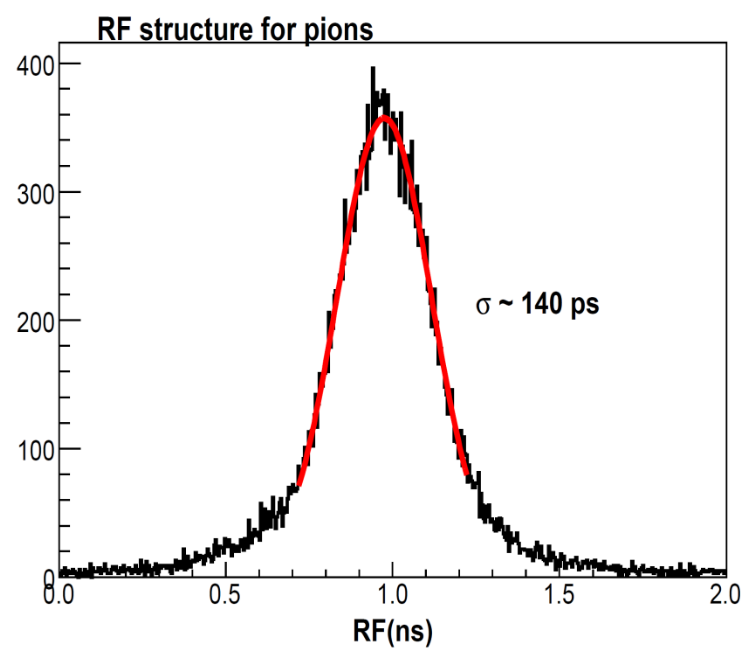
- Bar alignment:



LHRS single arm final
by Chiranjib Dutta

- Reached a 1σ resolution ≤140ps
- Checked with RF Structure $\mathrm{RF\ Time}_{\mathrm{Spectrometer}} - t_{\mathrm{RF}}$



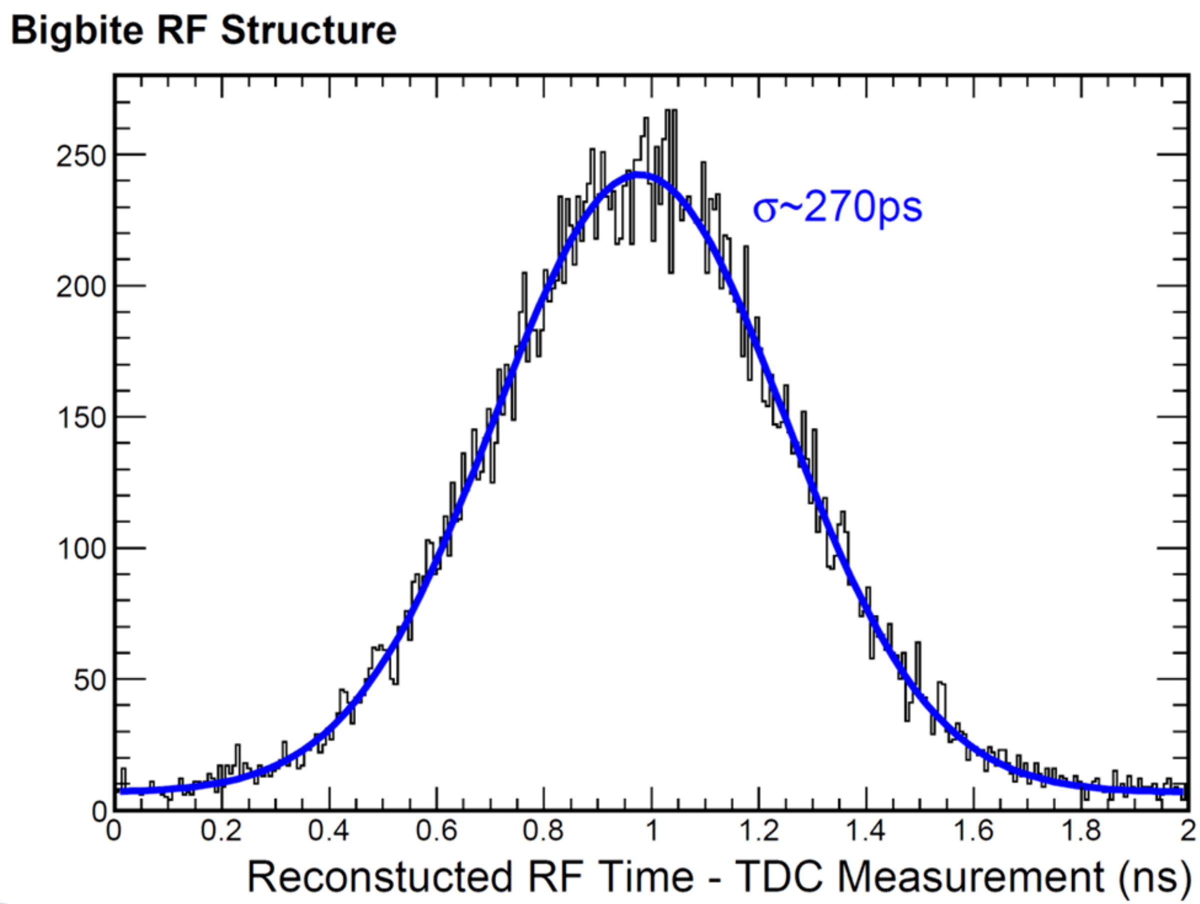


BigBite Timing

- Simpler due to
  - Short flight path, simple described by
    $$\Delta L_{\text{time walk}}/c = 1.4 * \theta_{\text{MWDC}}$$
  - Similarity of particle speed (e & γ)
- Timing detector : BigBite Timing Plane
  - 13 scintillator bar behind shower detector
  - Resolution ~230ps
  - Larger but similar time walk effect for all PMTs
    $$\Delta t_{\text{time walk}} = -17.9(\text{ADC} - \text{pedstal})^{-0.140}\text{ns}$$
  - Calibrated by minimizing timing difference between timing of neighbor bars when both hit

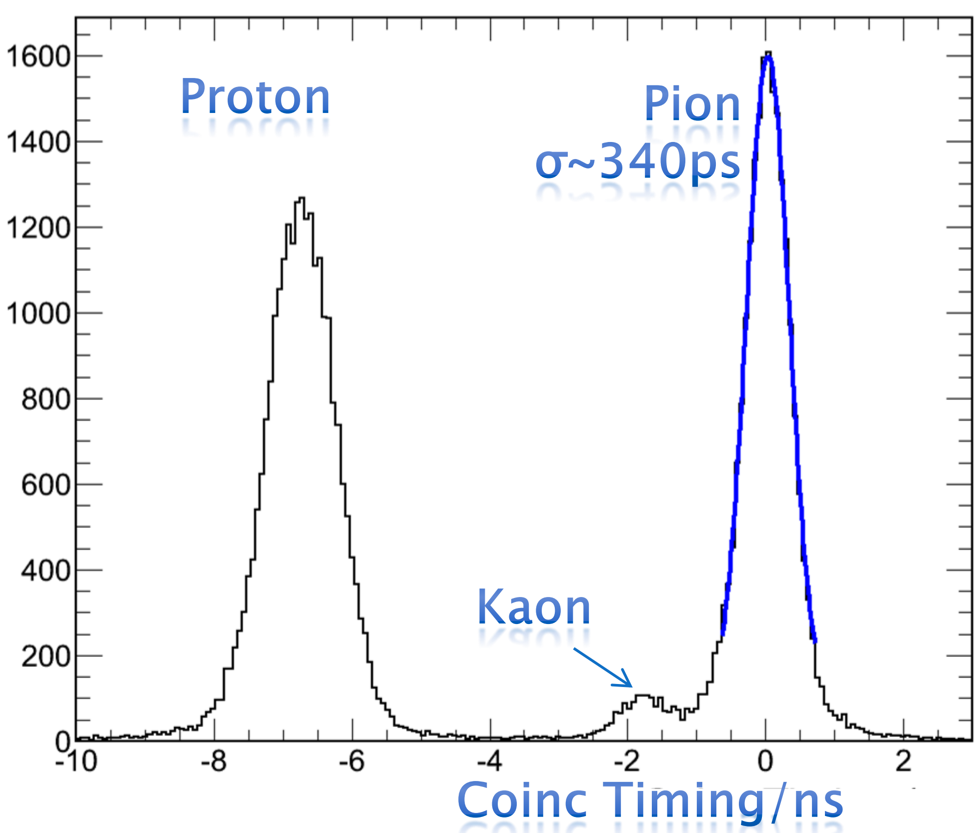
BigBite single arm final

- Final electron timing resolution reached σ~270ps

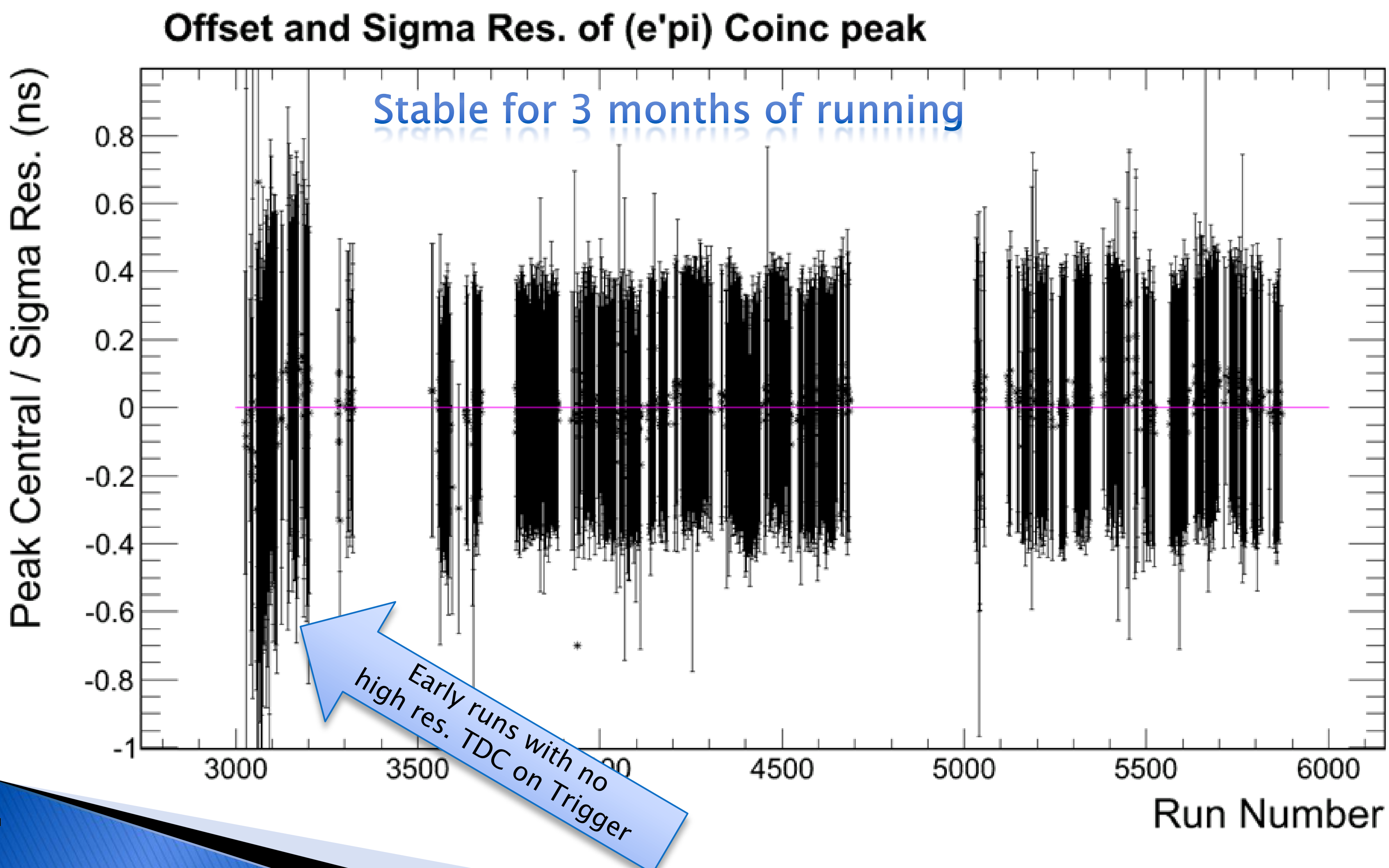


Combing -> CT

- Difference between two single arm trigger is measured by high res. TDC
- Compiling All Pieces:
  - σ~340ps
  - Random Coinc Rej. 100:1
  - Pion Rej. from Kaon >25:1
  - Also for (e,γhadron) σ~400ps

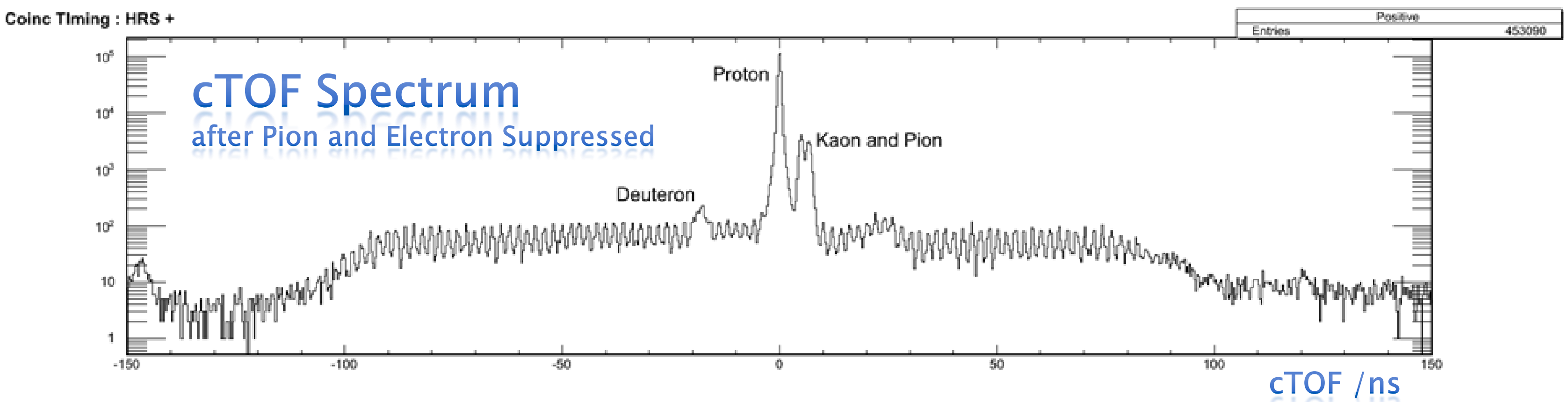


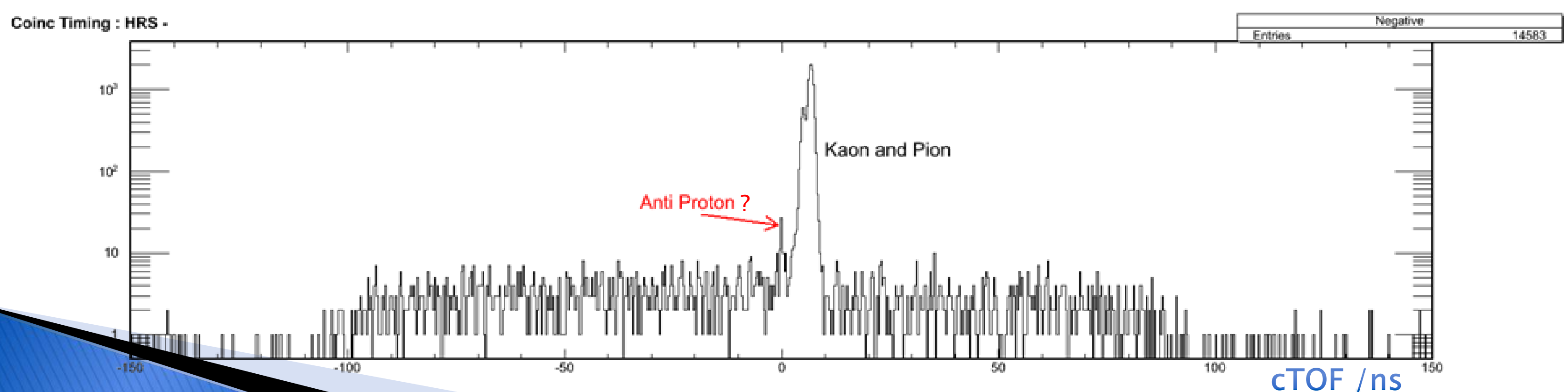
It’s check run by run



Fun part: Identifying more particle with CT?

- We can also identify deuteron and possibly anti-proton? from the (e,e'hadron) CT





Special Thanks to contributors to this talk

- Chiranjib Dutta
- Kalyan Allada
- Yi Qiang, Vincent Sulkosky, Ole Hansen, et al,

THE END

QUESTIONS?