SRC Weekly Meeting
June 12, 2012

Optics for HRSs,
HRS Detector Efficiencies,
HRS Timing,
BigBite Scintillator- PID & Timing

Jefferson Lab
Thomas Jefferson National Accelerator Facility

LEFT & RIGHT HRS OPTICS

Navaphon Muangma (Tai)
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Optics Overview

Optics calibration is the calibration of the transport matrix. The transport matrix translates the focal plan information to the target information, i.e.,

$(x_{fp}, y_{fp}, \theta_{fp}, \Phi_{fp})$ to

$(dp, y_{tg}, \theta_{tg}, \Phi_{tg})$

Where each target variable can be expressed as the series expansion of the focal plan variables.

i.e. $y_{tg} = Y_{jki}\,\theta^j * y^k * \Phi^l$

where $Y_{jki} = C_i * x^i$

Navaphon Muangma (Tai)

Optics Overview

The optic runs with known target variables are required as follow:

Optimized variable	Required
Vertex	Multiple-foil target. [known separations and locations]
Theta & Phi	Multiple-foil target with Sieve inserted. [know holes separation, Sieve location]
dp	Various dp scan for the same central_p, i.e., +/-4% +/-2% and 0%. For carbon target and Hydrogen target

Left Optic Run-list

Calibration	Run	Target	Beam Energy (GeV)	Central Momentum (GeV)	Central Theta (degree)	Sieve	Comment
Vertex	1237	C-Optics	2.25776	2.05494	16.5026	Out	Known miss-pointing information
Theta & Phi	1238	C-Optics	2.25776	2.05494	16.5026	In	Sieve Location from 2009 survey
Dp	1228, 1229, 1231, 1243, 1241	LH2	2.25776	2.13707, 2.09598, 2.05496, 2.02001, 1.97291	16.5026	Out	Single Elastic strip but strongly dependent on the scattered angle
Dp	1884, 1888, 1892, 1995, 2005	C-Optics	1.1601	1.14002, 1.118, 1.09597, 1.074, 1.05498	17.4997	In	Multiple peaks from Carbon excitation state
Dp	2871, 3,5,6	C-Optics	4.45629	3.60145	20.3008	In	Exact momentum for the production kinematics

Right Optic Run-list

Calibration	Run	Target	Beam Energy (GeV)	Central Momentum (GeV)	Central Theta (degree)	Sieve	Comment
Vertex, Theta & Phi	2017, 2018, 2019	BeO, 4cm Al Dummy, 15 cm Al	?	?	12.5	In	Known miss-pointing information

Outline

- **Vertex**
  - Vertex calibration
  - Target y resolution
  - Solid Target vs. Cryo Target offset
  - Miss pointing Calculation (ongoing)

Outline

- **Theta & Phi**
  - Sieve Location
  - Hole Location

Outline

- **Dp**
  - Energy lost
  - Exact momentum setting for each point in delta scan

LEFT OPTICS

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Left Vertex (16.5 deg)

The resolution is range from 2.86 to 3.48 mm.

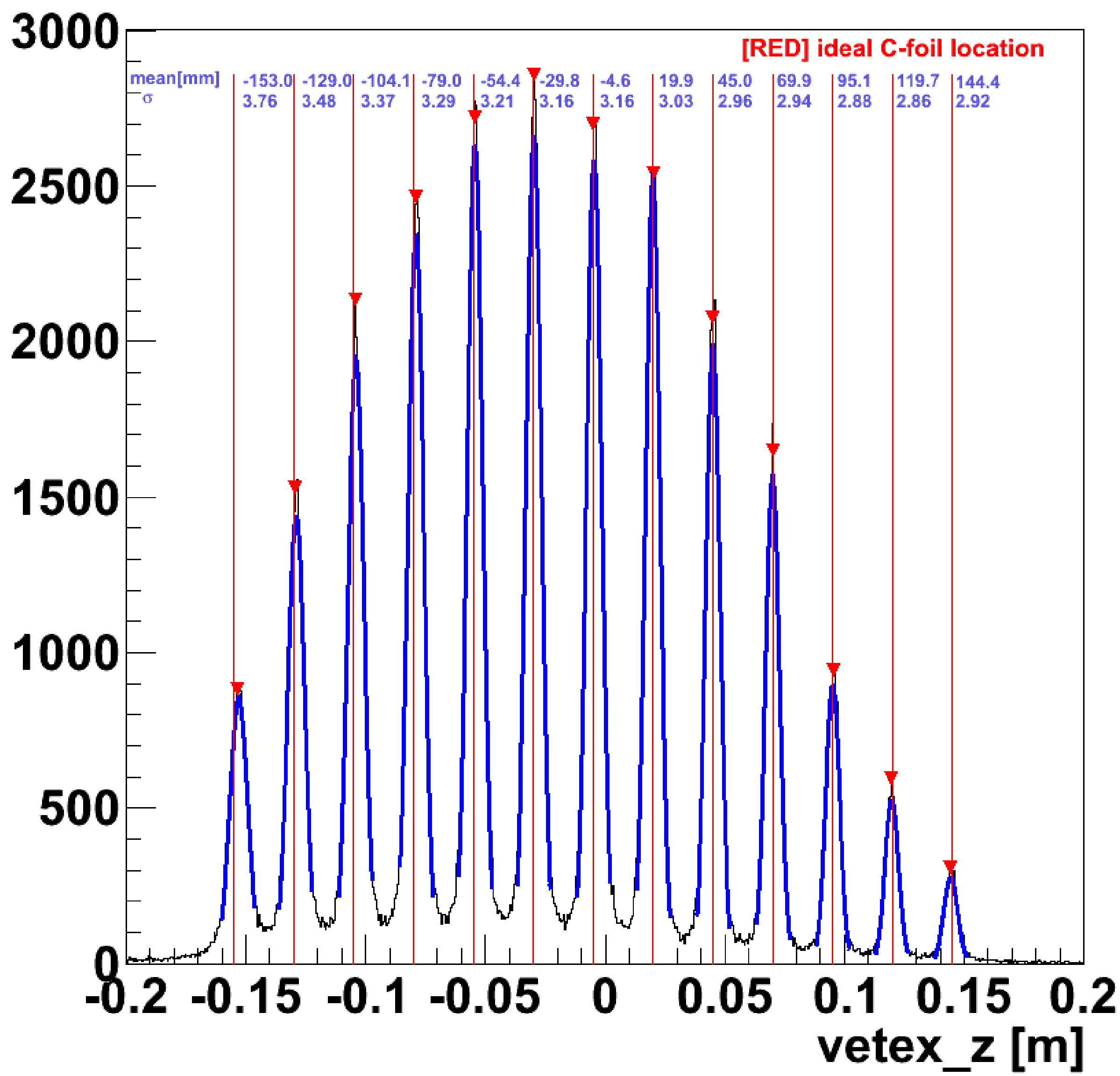
Each foil is 25 mm apart from one another.

The red line shows the ideal location.

Run 1237

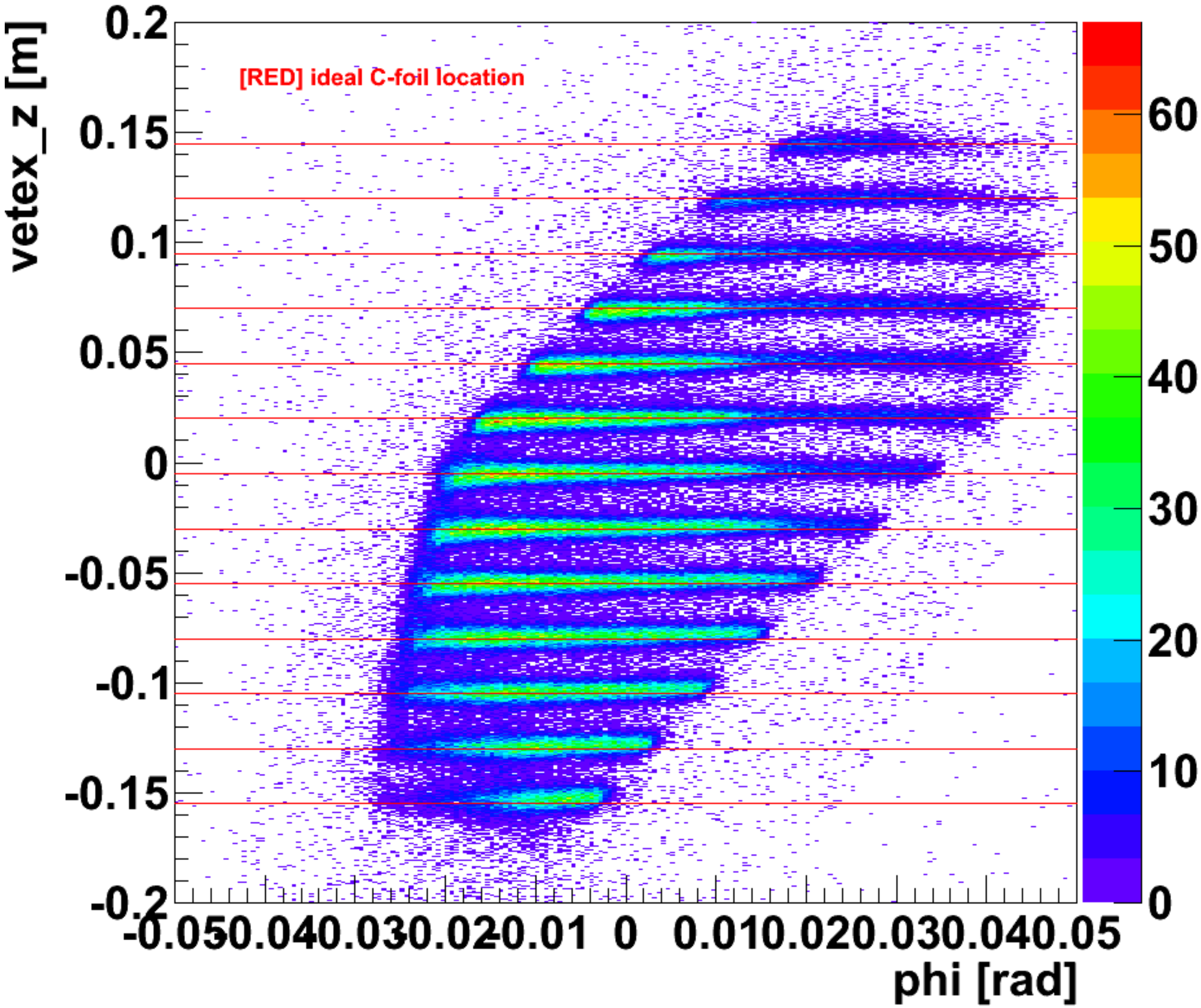
Angle 16.5 degree

With miss-pointing offset imposed.



Left Vertex

Vertex Z is ideally independent of the target phi. This show the final result after removing those dependence.



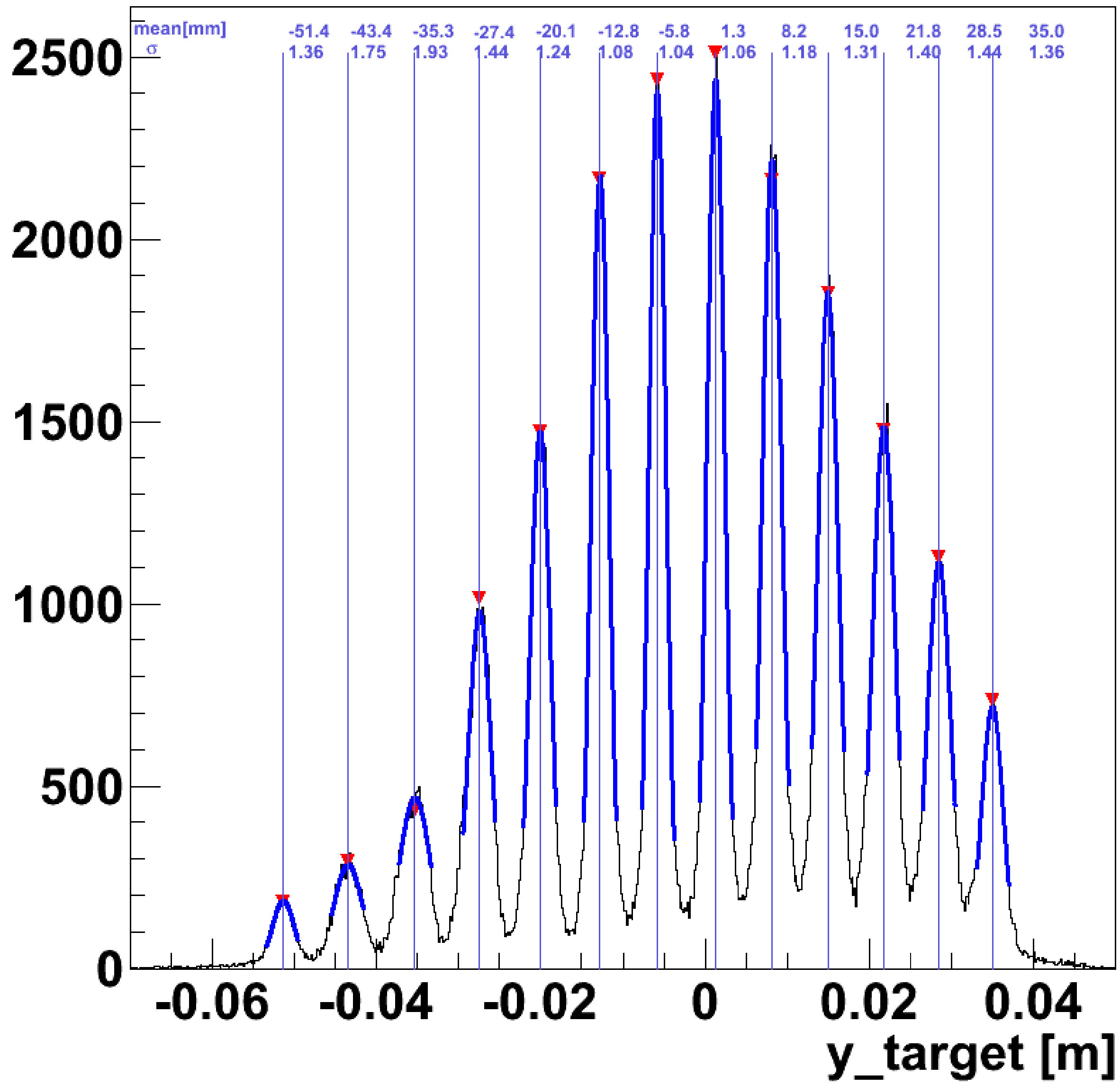
Run 1237

Angle 16.5 degree

With miss-pointing offset imposed.

Left Target Y

The target Y resolution will not change when the HRS angle change. This shows the resolution of the target Y which range from 1.04 to 1.93 mm.



Run 1237

Angle 16.5 degree

With miss-pointing offset imposed.

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Sieve X Y

After Vertex calibration, the theta and phi are next.

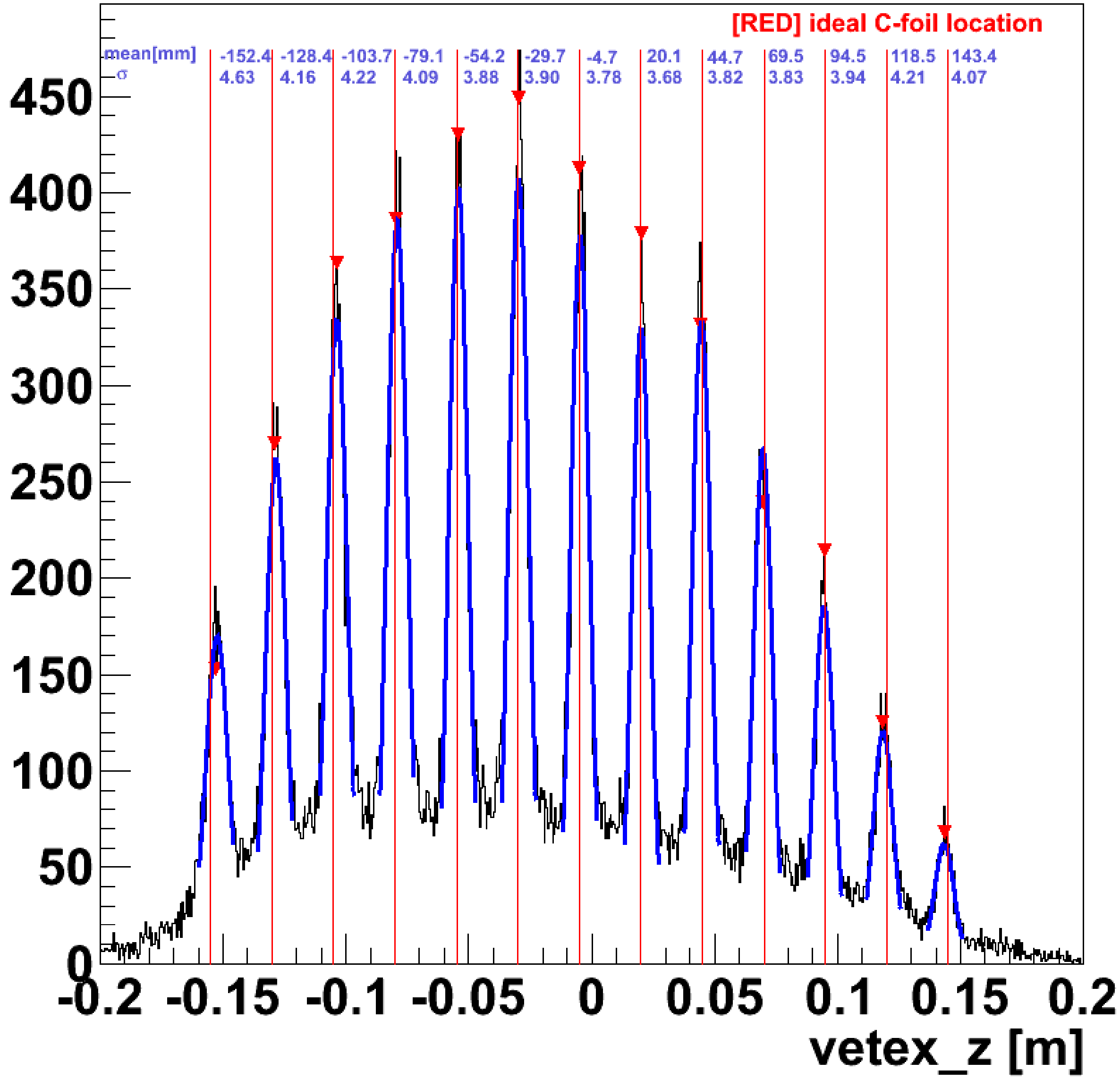
This show the vertex reconstruction for the C12-Optics with the Sieve inserted. The resolution is worse as the Sieve blocked and scattered some particle.

Run 1238

C12- 13foils

At 16.5 degree

Sieve In



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Sieve X Y

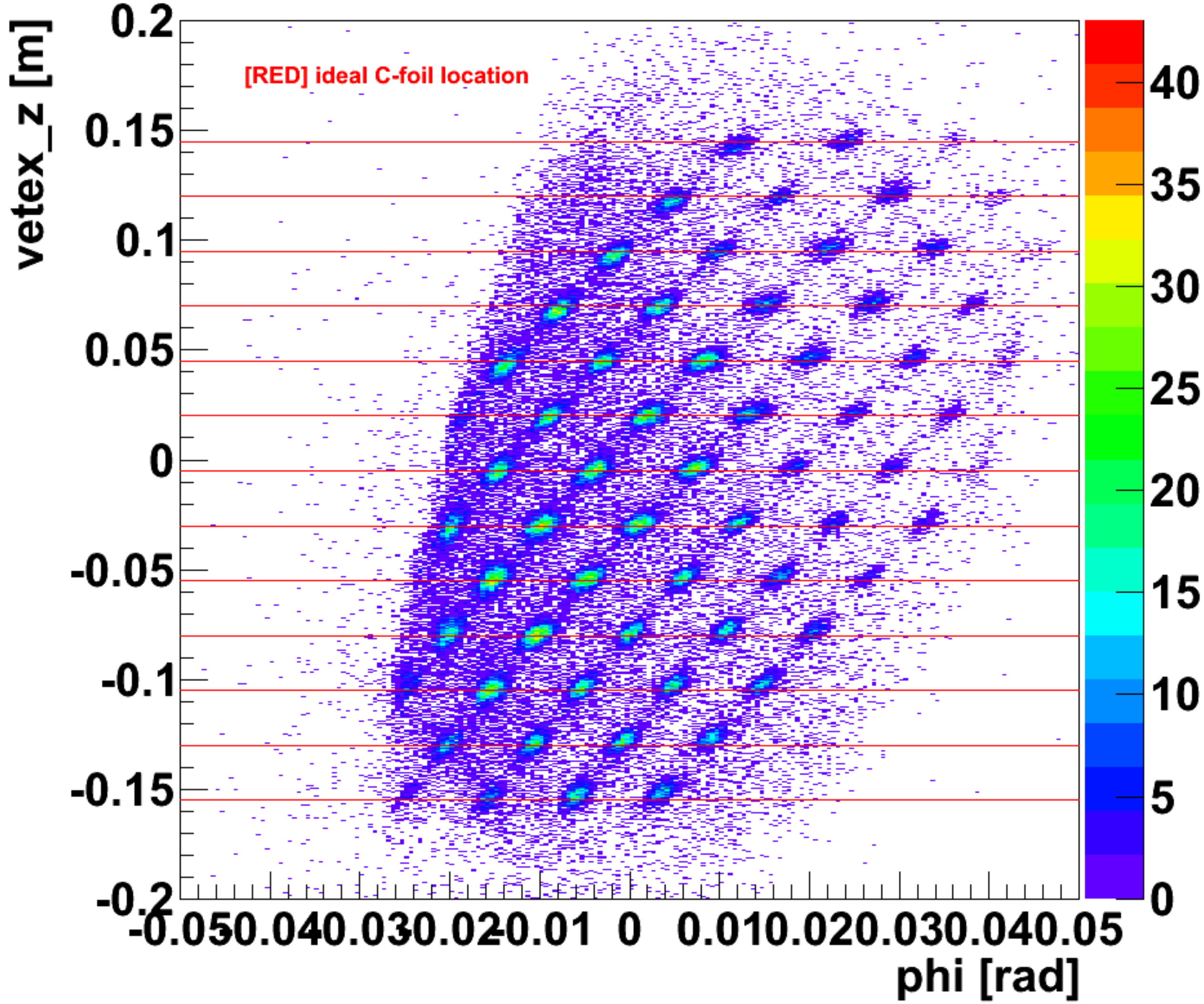
After Vertex calibration, the theta and phi are next.

This show the vertex reconstruction for the C12-Optics with the Sieve inserted.

Run 1238

C12- 13foils

At 16.5 degree

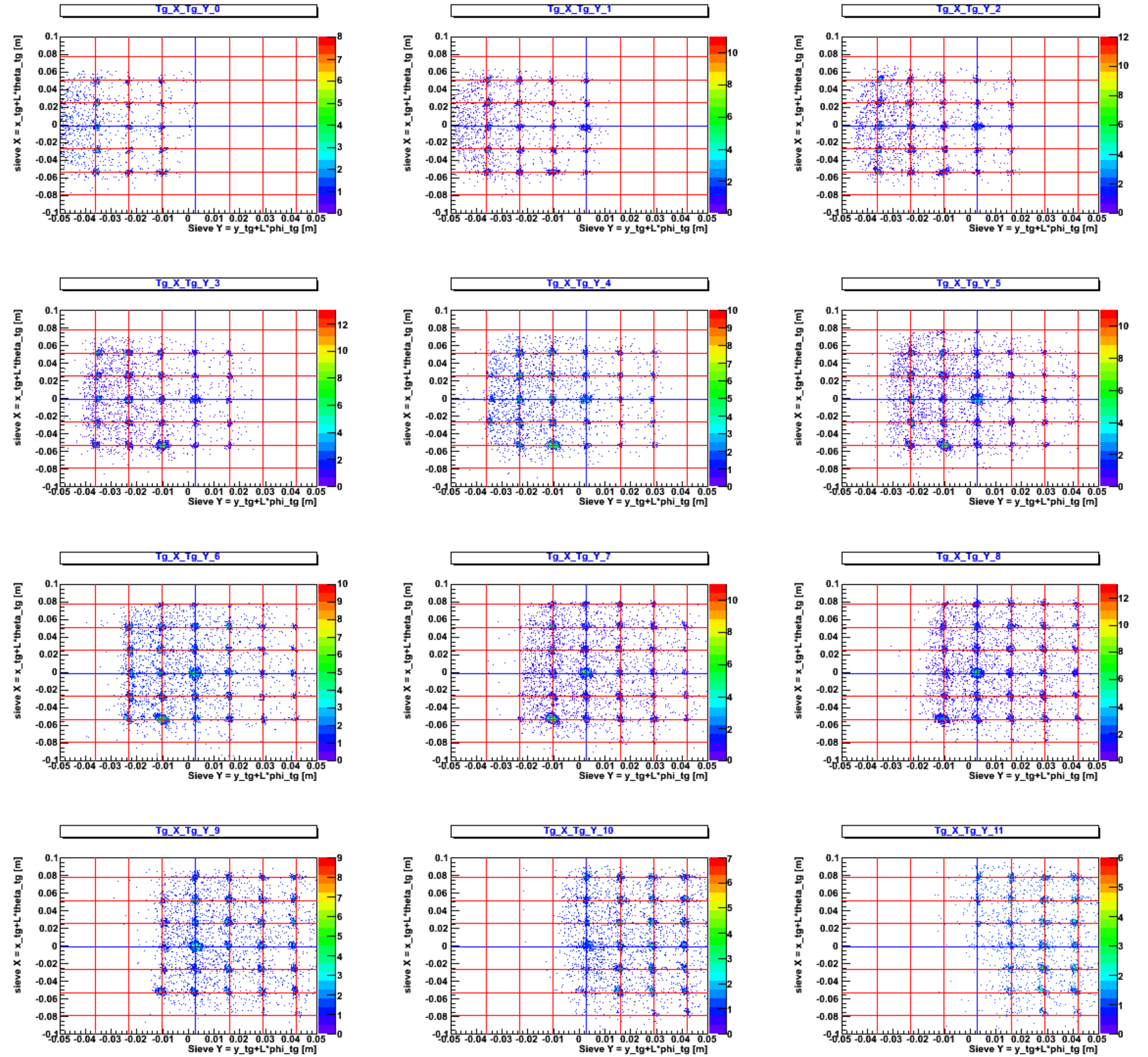


Sieve X Y

Each foil

Run 1238

C12- 13foils



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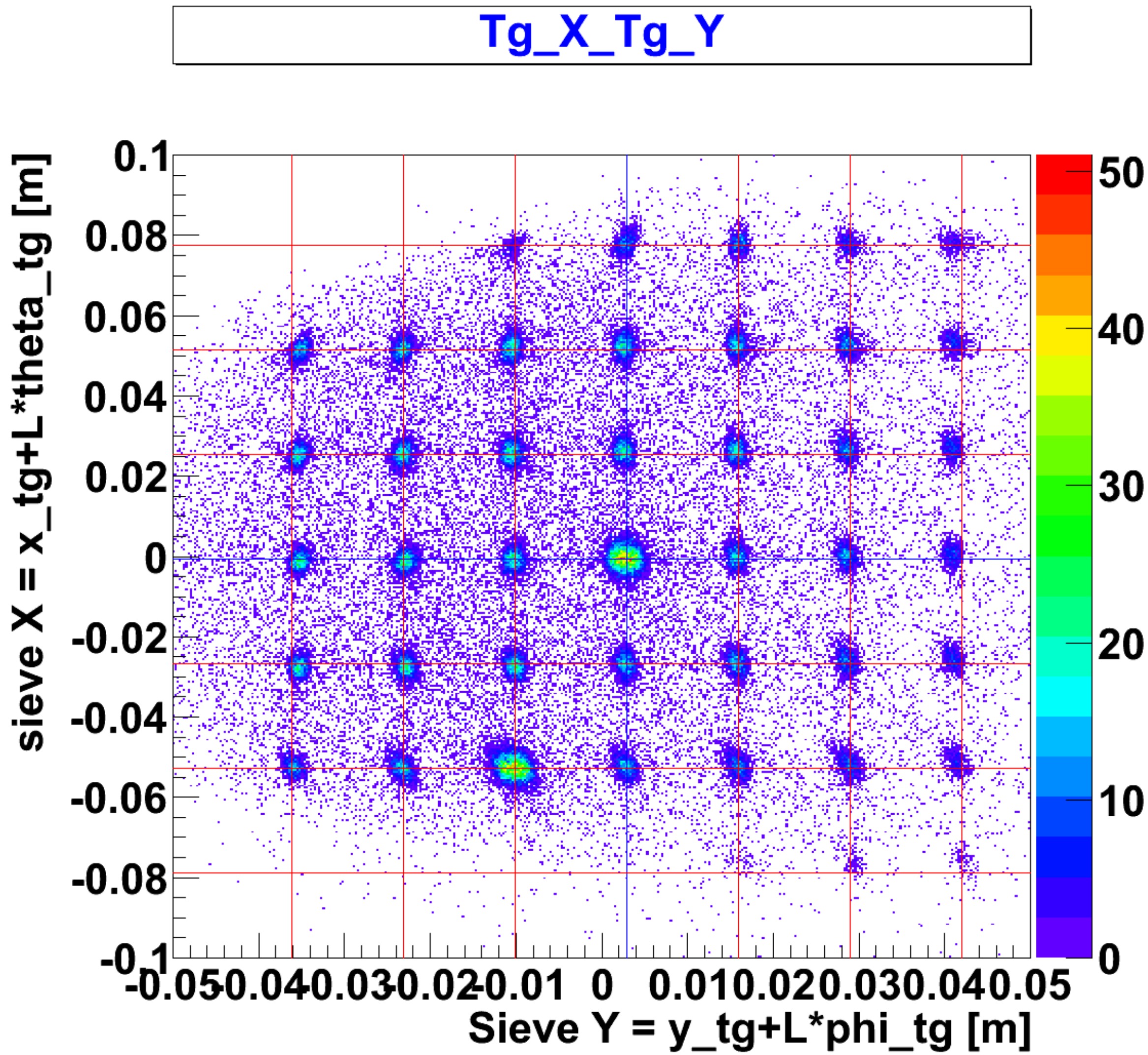
Sieve X Y

All foils

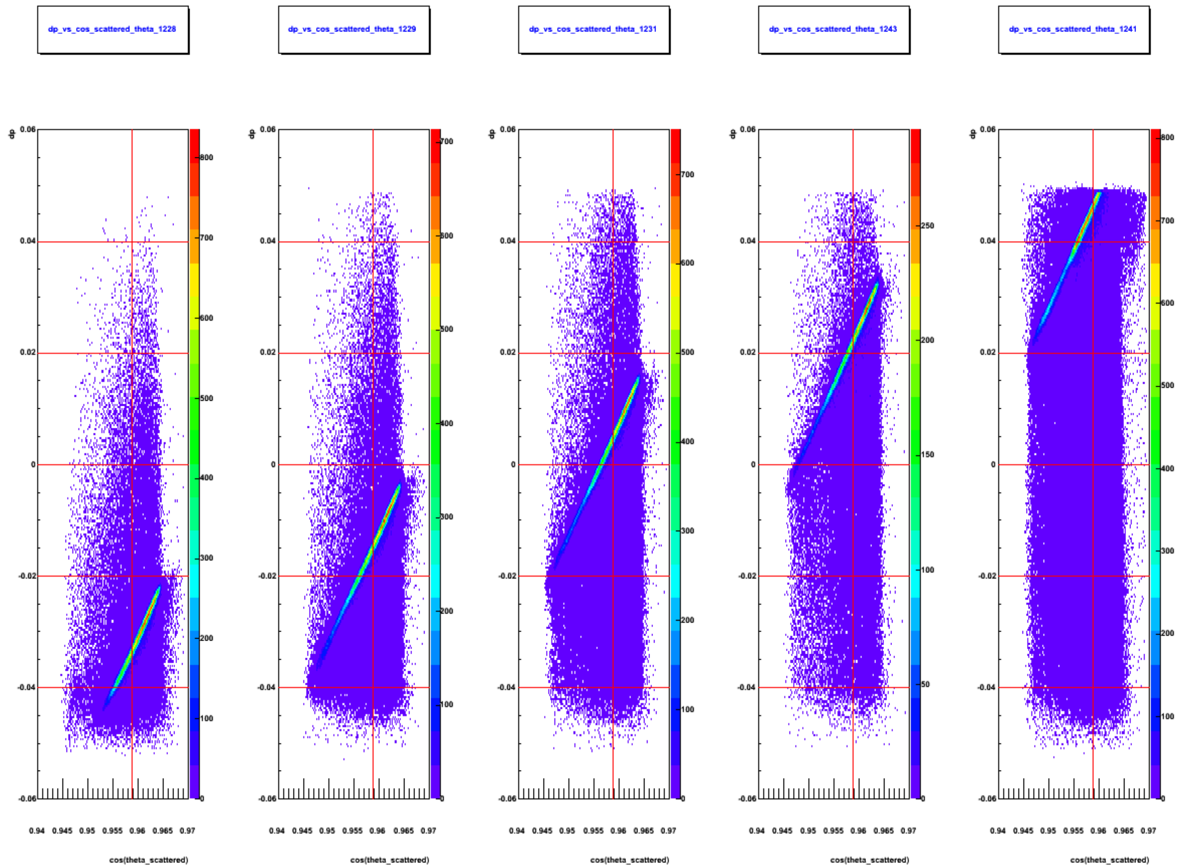
The reconstructed Sieve holes are at their ideal location shown by the crossing of the red/blue lines.

Run 1238

C12- 13foils

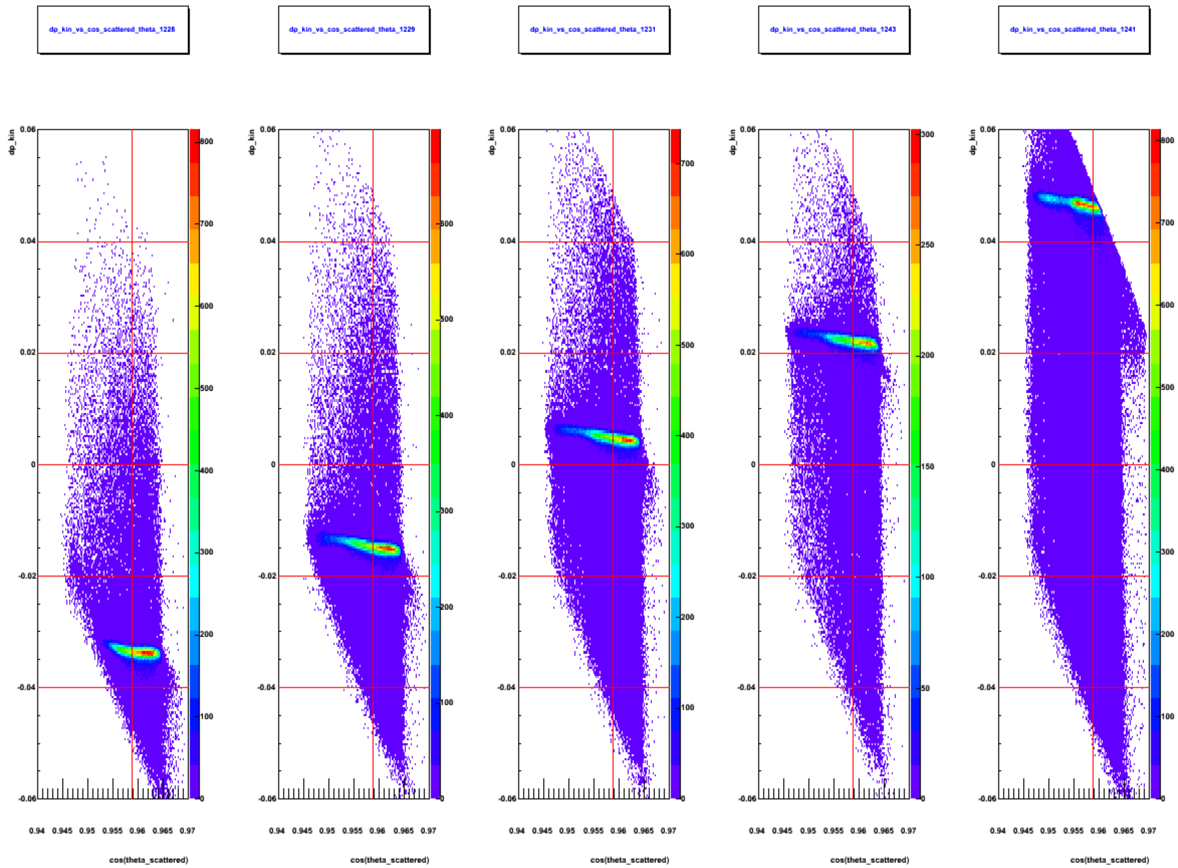


Momentum scan: LH2: dp vs. cos(scattered angle)



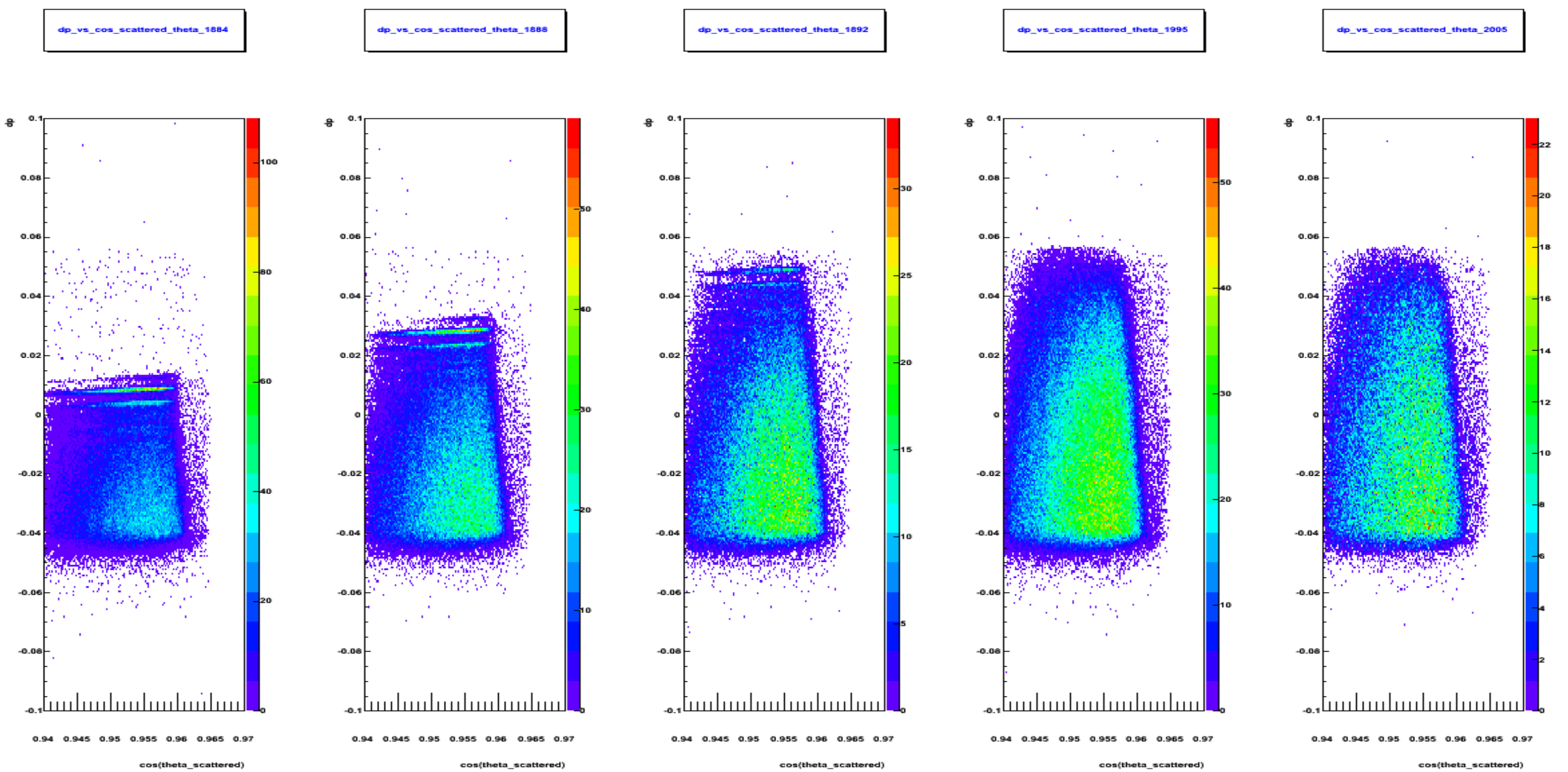
Cos(scattered angle) = [cos(theta0) – phi_tg*sin(theta0)]/sqrt(1+theta_tg^2+phi_tg^2)

Momentum scan: LH2: dp_kin vs. cos(scattered angle)
Dp_kin = dp – [P(M,theta) – P(M, theta0)]/p0



LH2 at the second pass data at 16.5 deg, dp_kin vs cos(scattered angle)

Momentum scan: C12: dp vs. cos(scattered angle)



Less dependent on the scattered angle but not completely independent.

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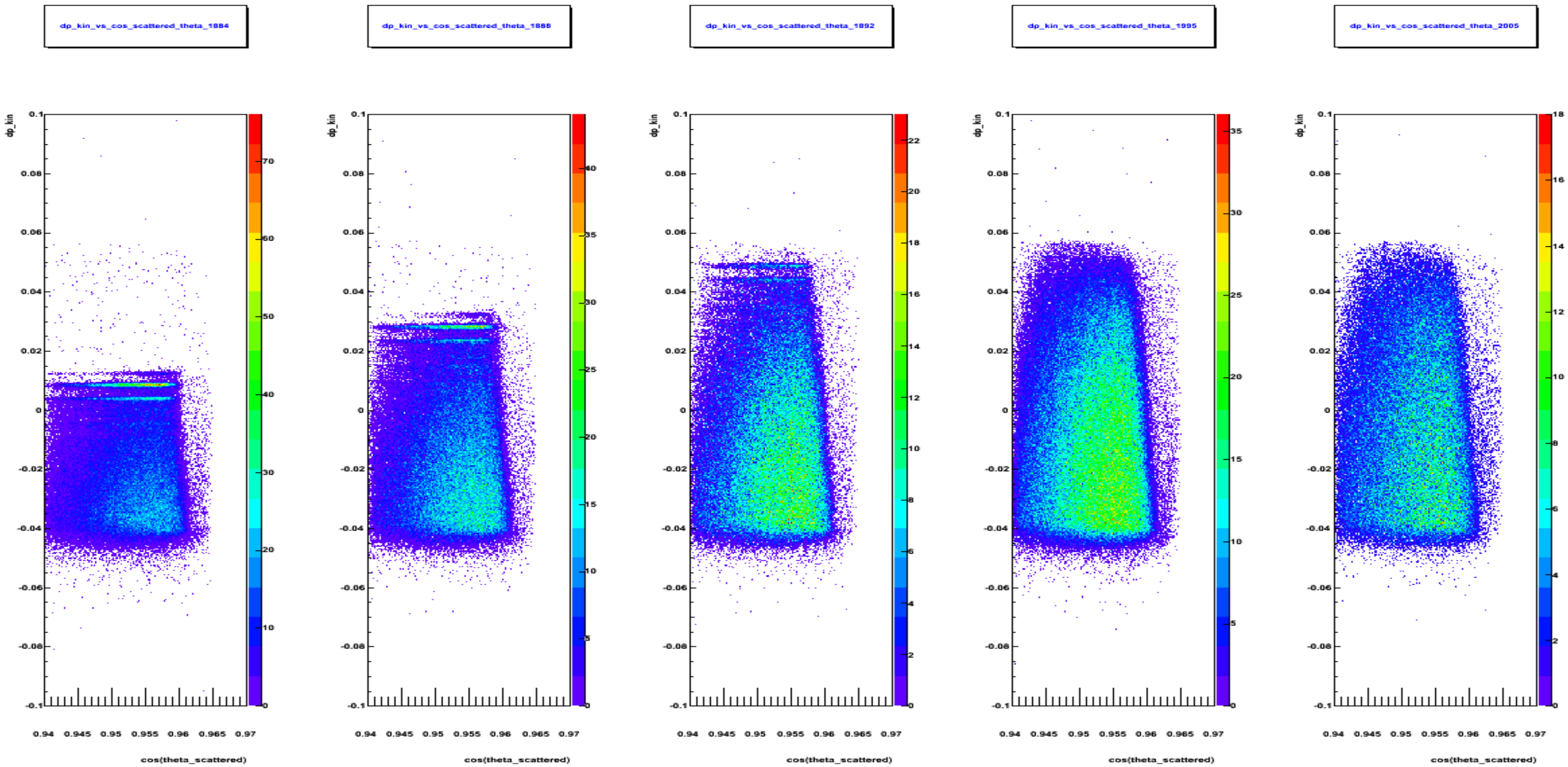
Momentum scan : C12: dp_kin vs. cos(scattered angle)



Problem: only have half of the kinematics cover…. Need to go back and modify the code for LH2

Timing

- Define
  - TOF = s2.time - path_length /(beta *c)
- Using the high relativistic electron run to eliminate the beta.
- Controversial for this method.
- Good for making a coincidence time with other spectrometers.

Timing

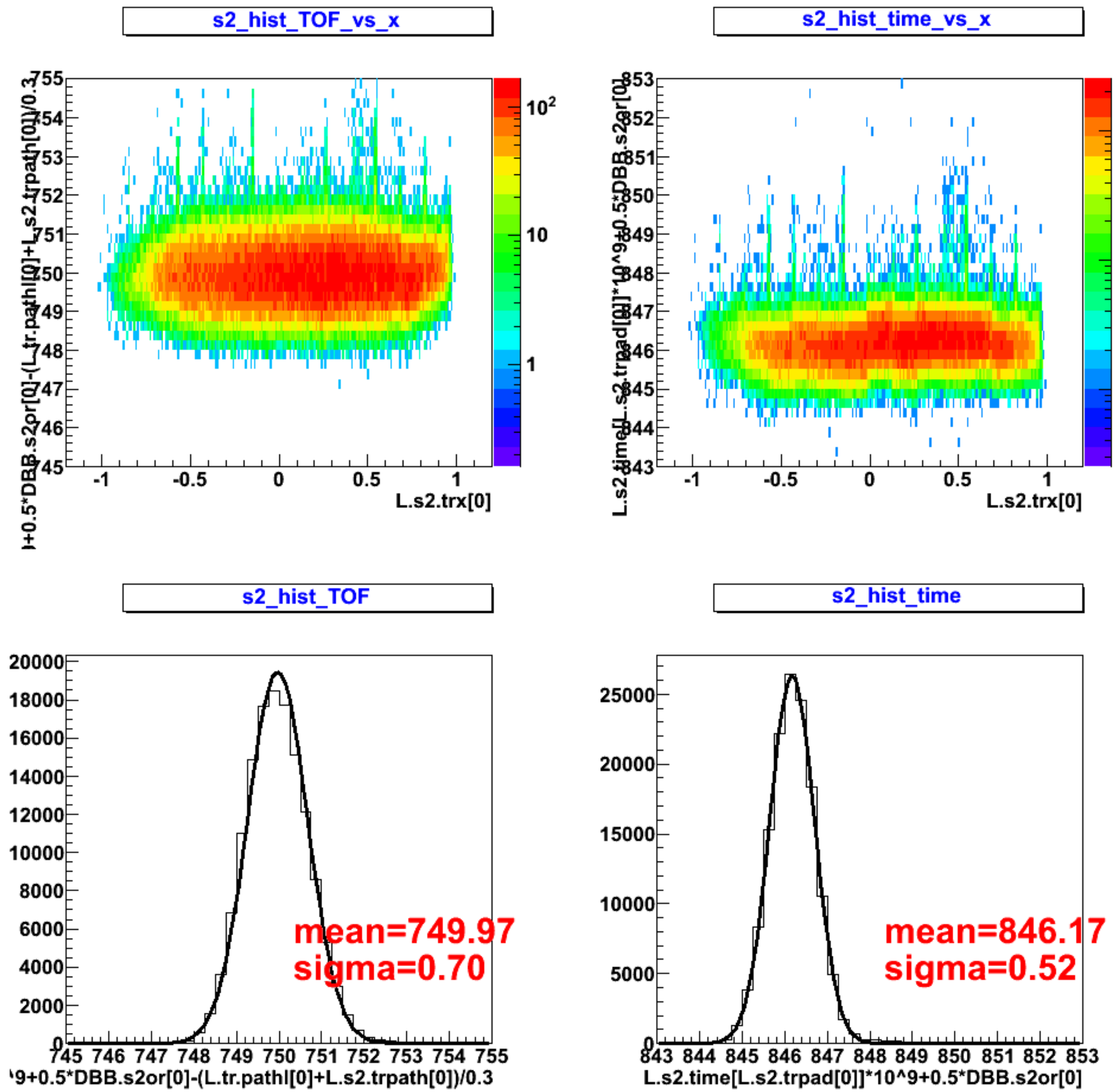
Top left : S2 TOF vs x

Top right: S2 time vs x

Bottom left: s2 TOF

Bottom right: s2 time

All units are in ns and meter



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PID: Pion Rejecter Efficiency

- In general, we can use either Pion Rejecter or Cherenkov or both to make electron selection.
- However, we only have the Cherenkov fixed for the overflow in the kinematic 3 only.
- Thus, we can only use Pion Rejecter for the electron-PID.
- The efficiency of the pion rejecter can only be studied at the kinematic 3.

Pion Rejecter Efficiency

All plots has cut on abs(vertex) < 0.8 m ,

abs(theta)<0.07,

abs(phi)<0.04,

abs(dp)<0.05

No edtm, and Trigger 3

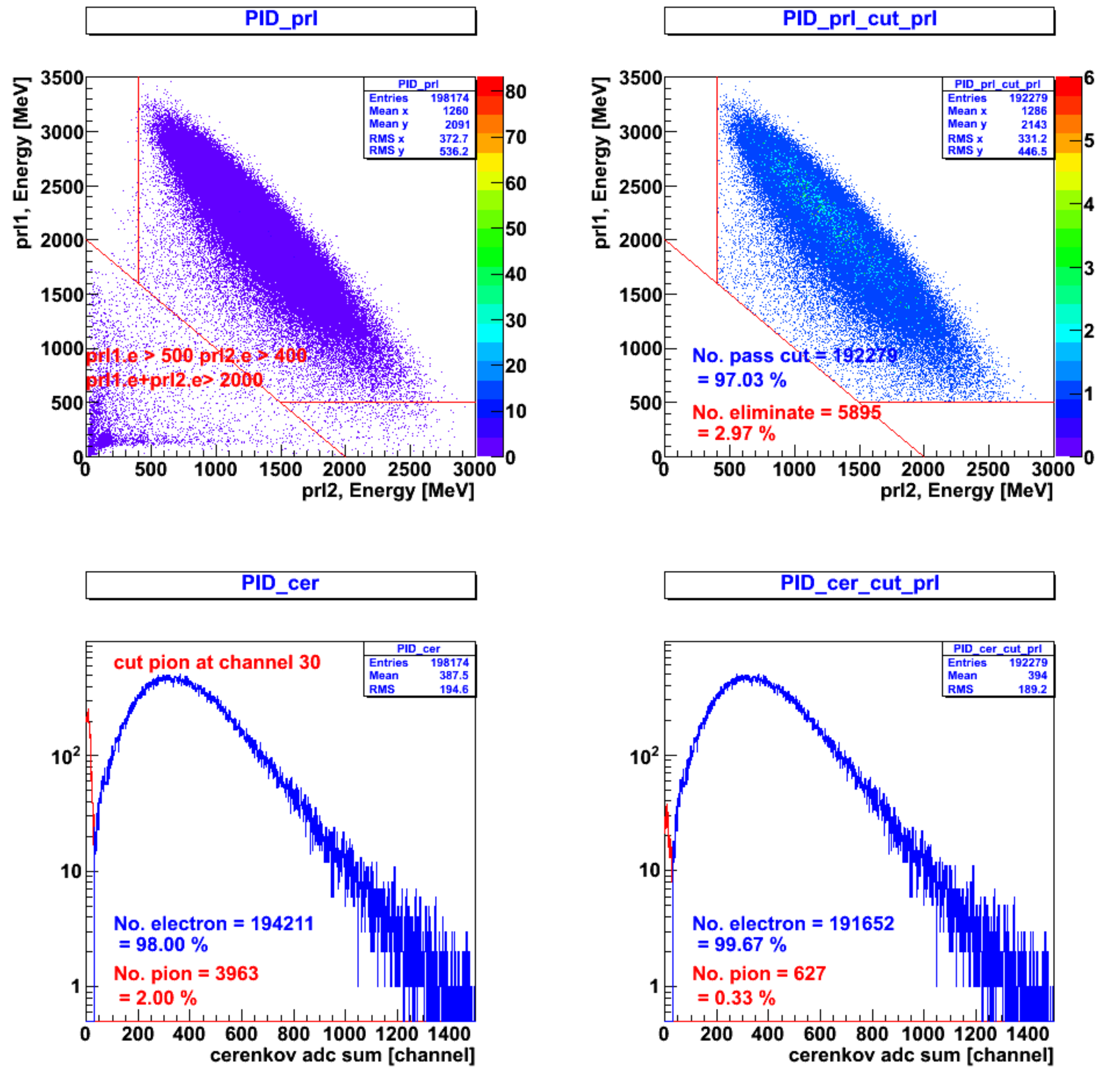
Top left: prl1 vs prl2

Bottom left: cer with identify pion and electron

Top right: prl1 vs prl2 with cut on prl1 > 500, prl2>400 & **prl1+prl2> 2000**

Bottom right: cer with all prl cut.

With this cut, we have **99.67% electron 0.33% pion contamination. Lost 2.97% of data**



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Pion Rejecter Efficiency

All plots has cut on abs(vertex) < 0.8 m ,
abs(theta)<0.07,
abs(phi)<0.04,
abs(dp)<0.05
No edtm, and Trigger 3

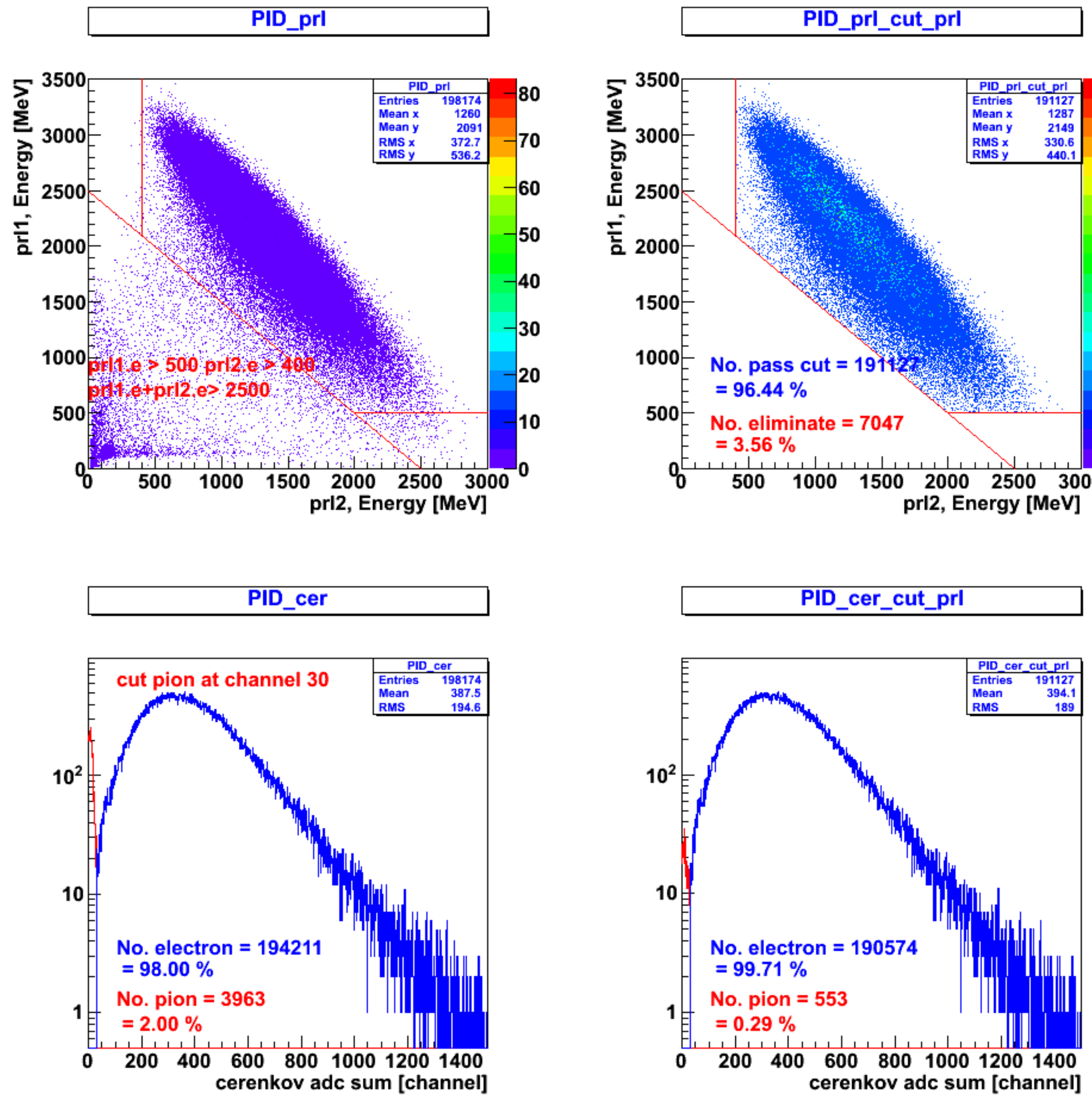
Top left: prl1 vs prl2

Bottom left: cer with identify pion and electron

Top right: prl1 vs prl2 with cut on prl1 > 500, prl2>400 & **prl1+prl2> 2500**

Bottom right: cer with all prl cut.

With this cut, we have **99.71% electron 0.29% pion contamination. Lost 3.56% of data**



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Pion Rejecter Efficiency

All plots has cut on abs(vertex) < 0.8 m , abs(theta)<0.07, abs(phi)<0.04, abs(dp)<0.05

No edtm, and Trigger 3

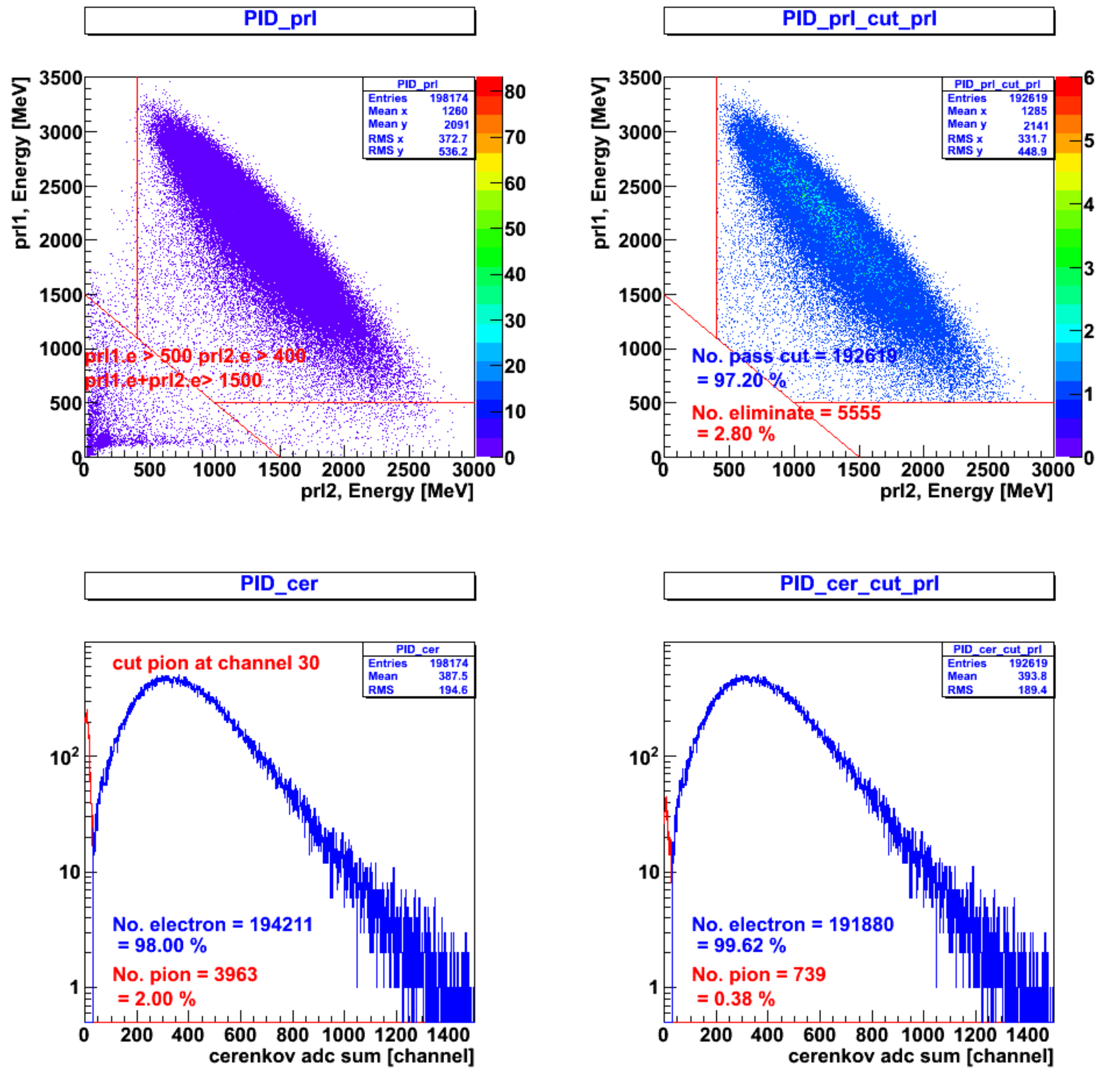
Top left: prl1 vs prl2

Bottom left: cer with identify pion and electron

Top right: prl1 vs prl2 with cut on prl1 > 500, prl2>400 & **prl1+prl2> 1500**

Bottom right: cer with all prl cut.

With this cut, we have **99.62% electron 0.38% pion contamination. Lost 2.80% of data**



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Pion Rejector Efficiency

Comparison table

Prl sum cut (with prl sum peak at 3500 MeV)	Prl Data lost %	Cer Electron %	Cer Pion contamination %
1500	2.80%	99.62%	0.38%
2000	2.97%	99.67%	0.33%
2500	3.56%	99.71%	0.29%

RIGHT OPTICS

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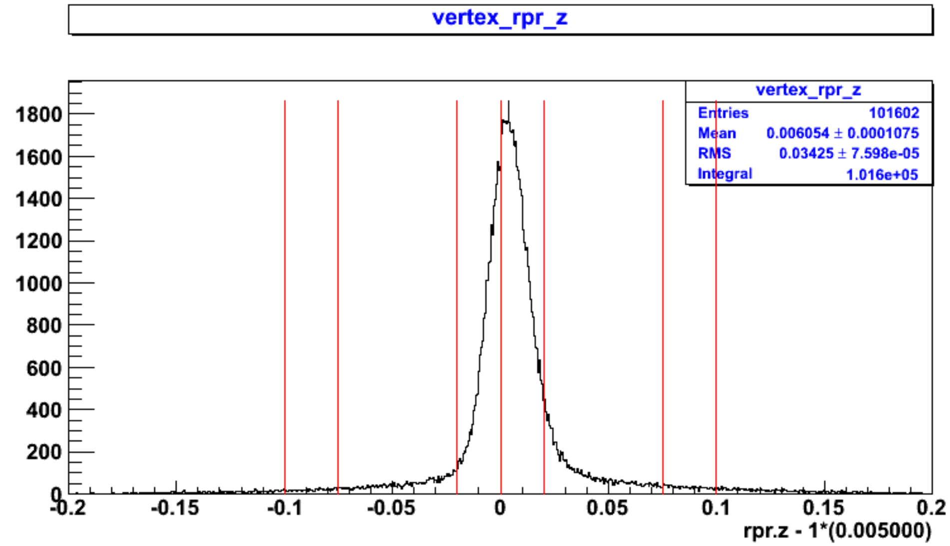
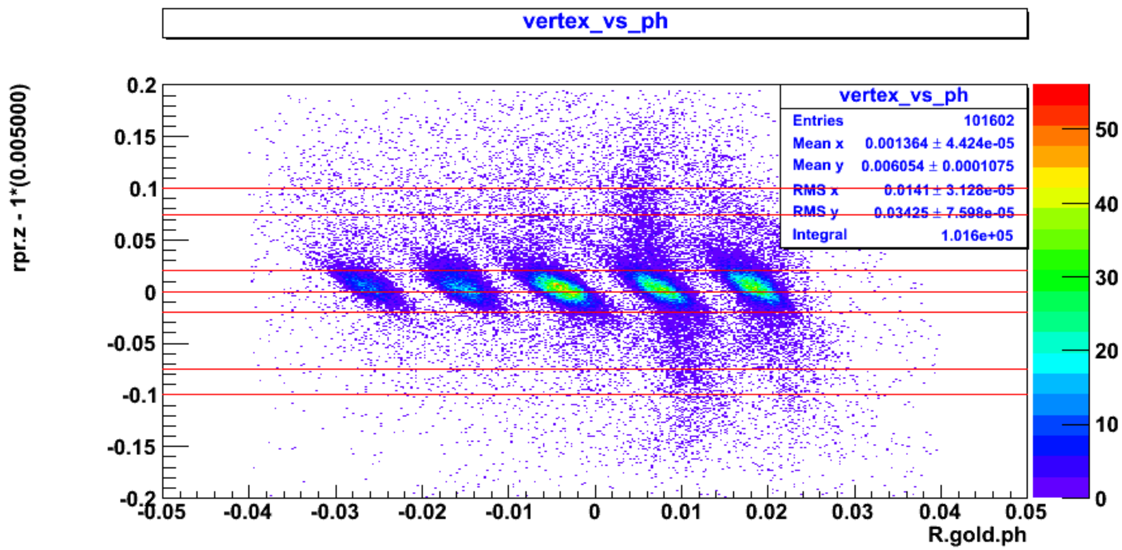
Right Vertex

Miss-pointing survey at 12.5 degree. Try to do the vertex calibration at that angle.

Run 2017

BeO target



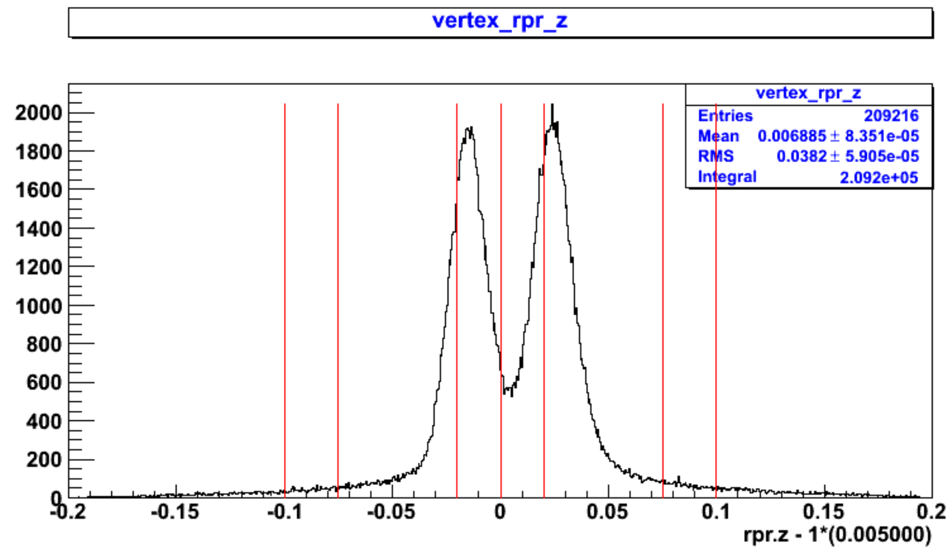


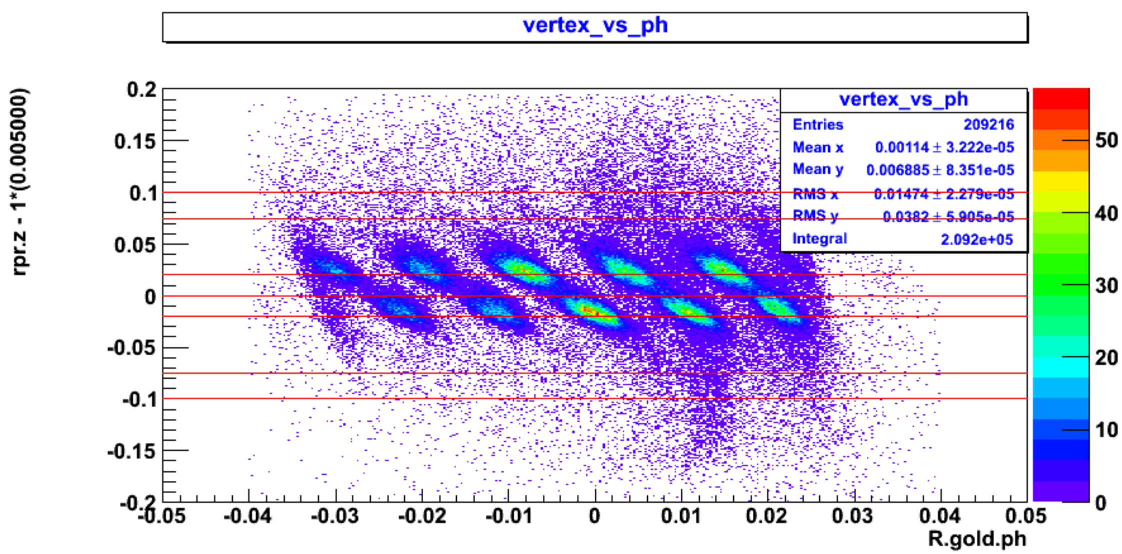
Right Vertex

Combine BeO (previous figure), Dummy 4cm (current), Dummy 15 cm(next)

Run 2018

4cm Al Dummy





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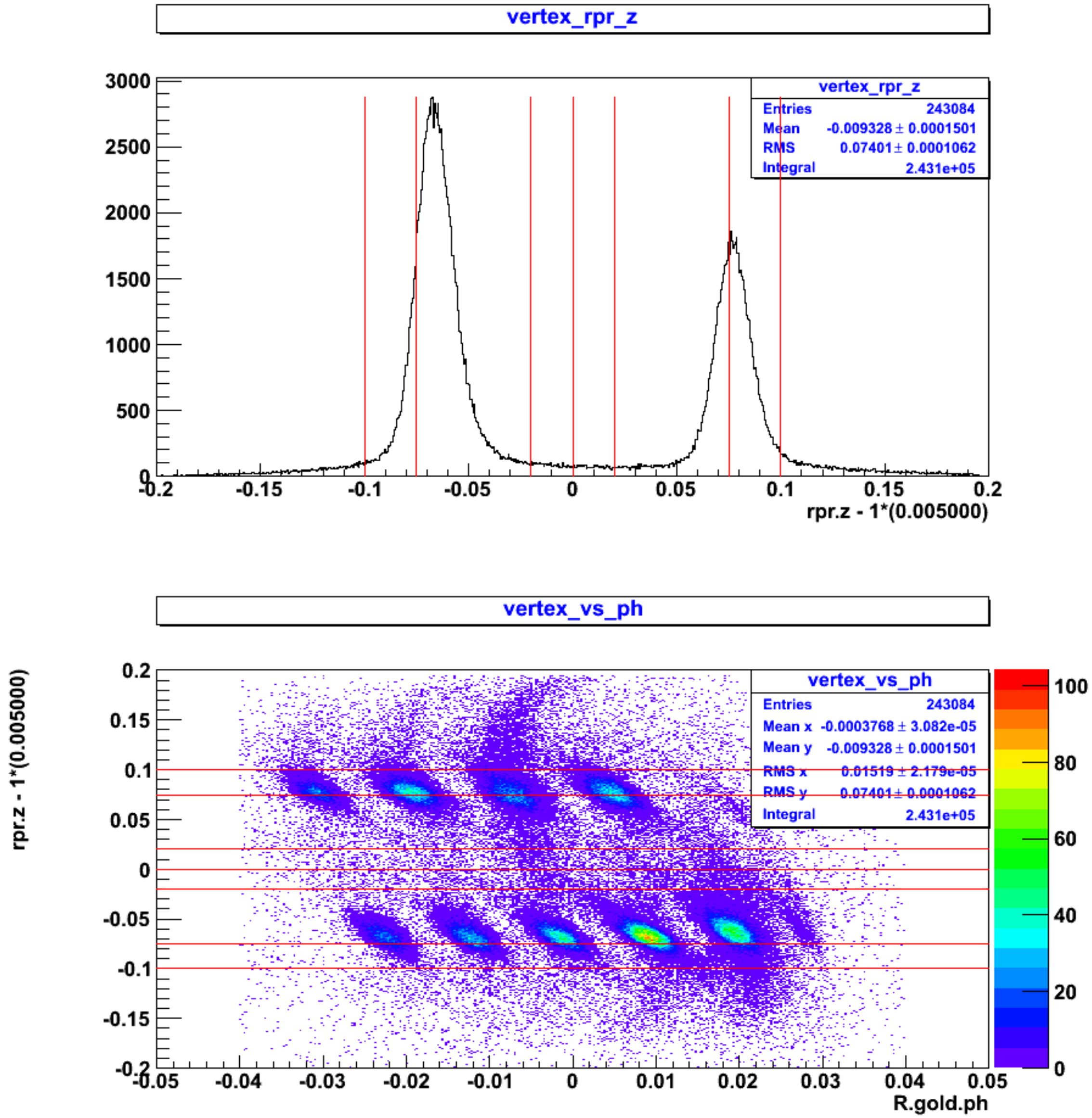
Right Vertex

Dummy 15 cm

Run 2019

15 cm Dummy



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RIGHT, SIEVE XY

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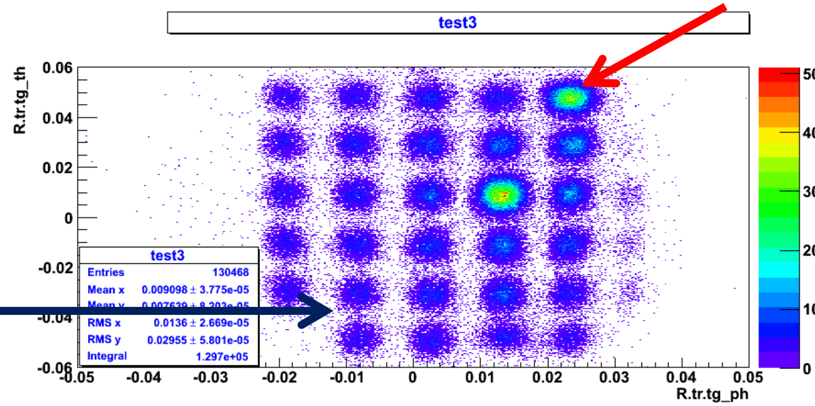
Wrong right optics reconstruction?

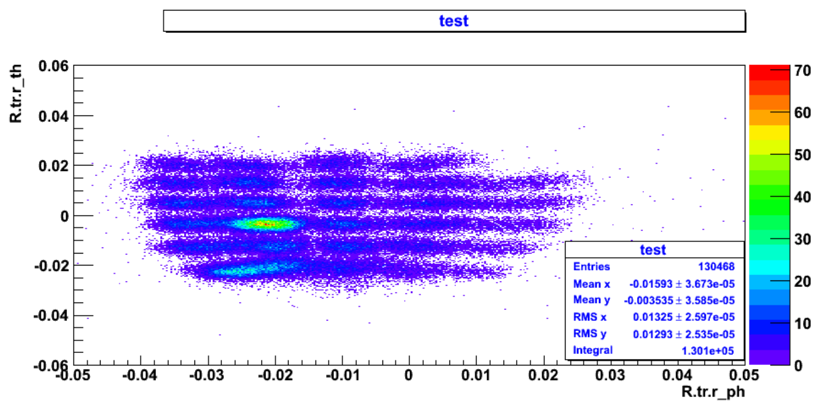
One of the two large holes appears in the unexpected location.

Target
theta vs. phi

Supposed
location



Rotating
(directly
related to focal
plane)
theta vs. phi

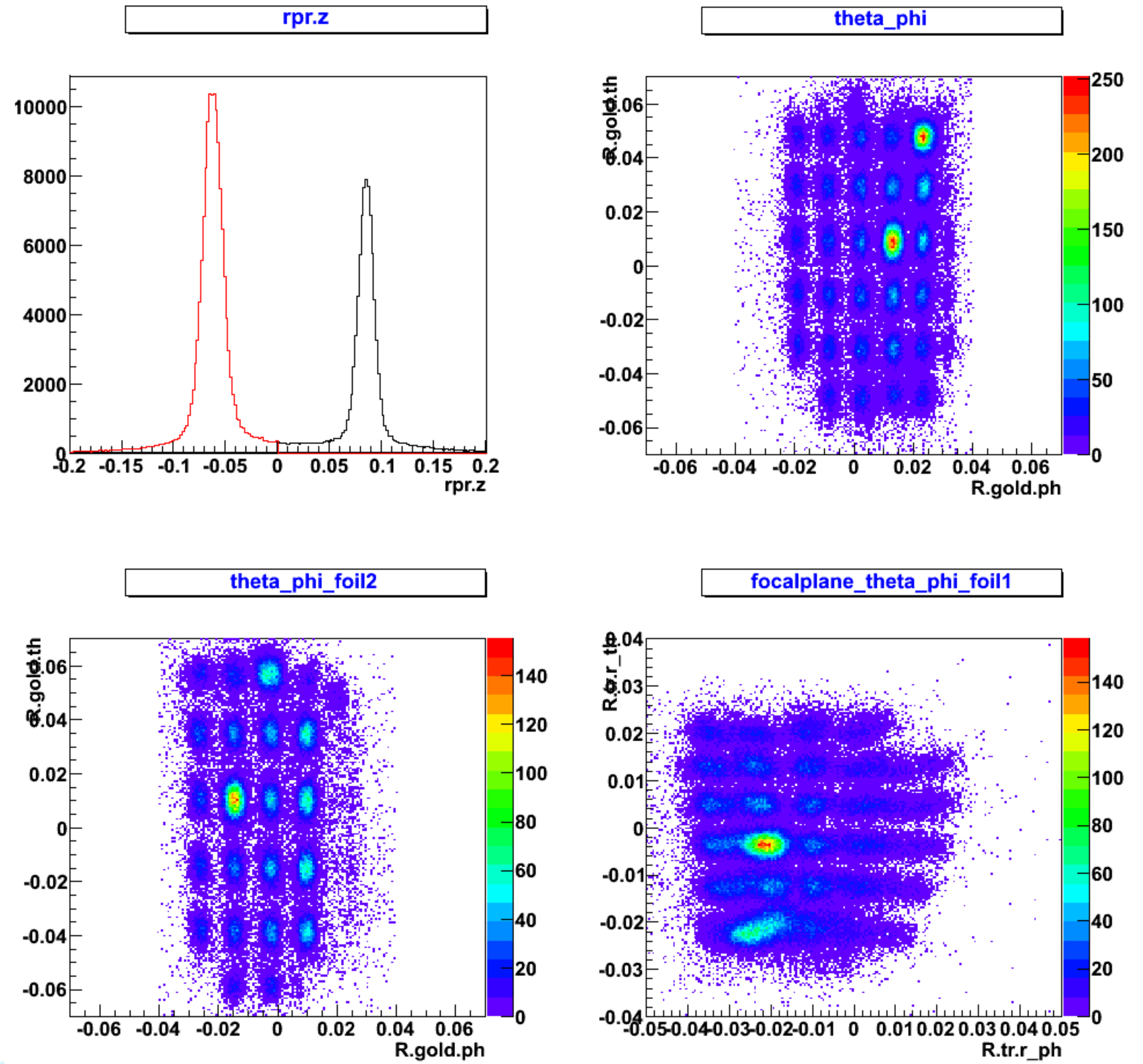


Right Optics?

- **Two possible options**
  - Wrong Optics
  - Wrong Sieve inserted.
- **Wrong Optics Matrix?**
  - Check using the other optics obtain from other experiment.
- **Wrong Sieve Rotation?**
  - Picture? (not available)
  - Data at the focal plane?

Right Optics?

Check with the focal plane variable.



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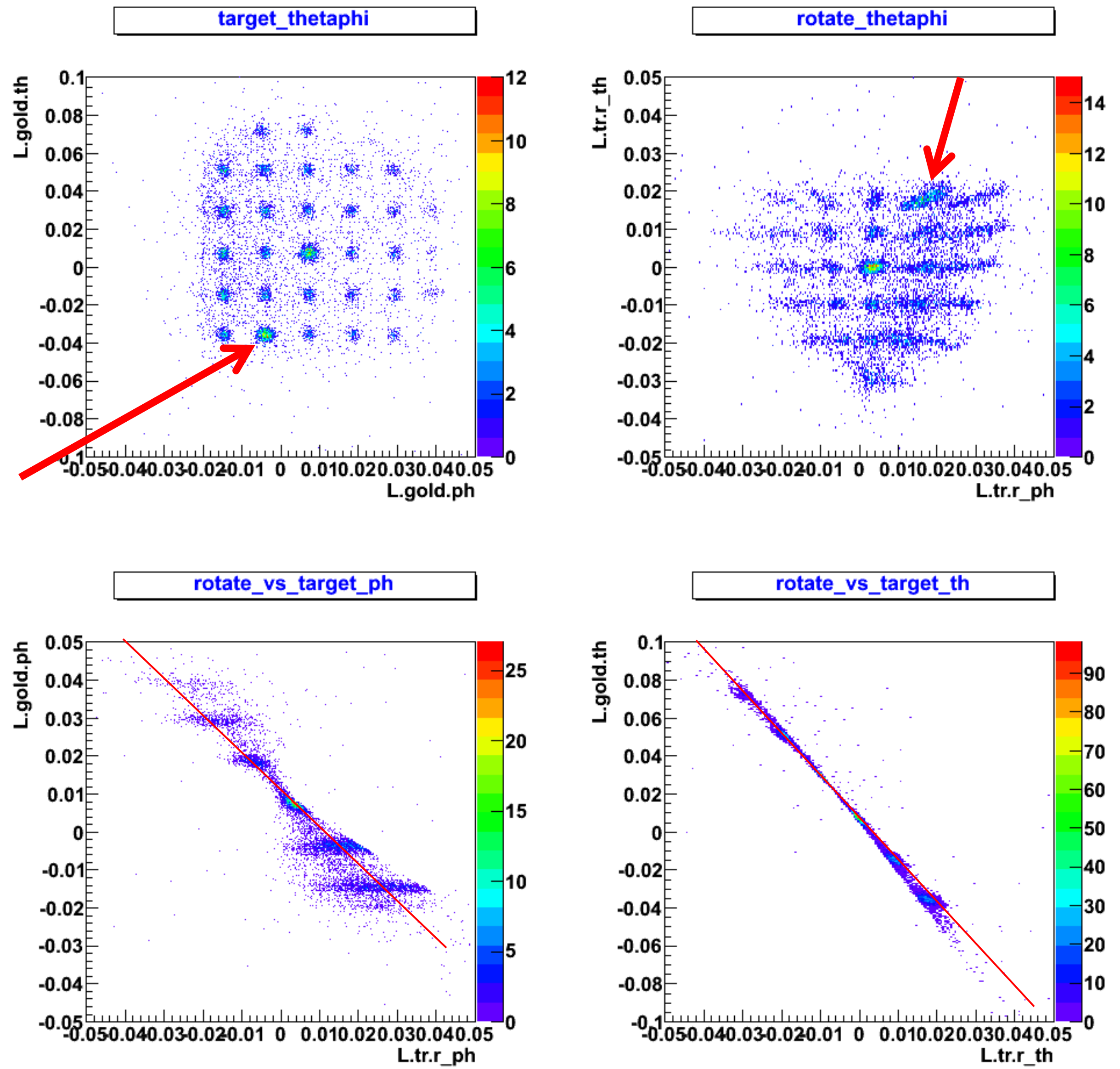
??Matrix??

- **Result**
  - Same sieve orientation appear
- **Sieve Orientation?**
  - Let check against the Left HRS
  - the Sieve in the Left Arm are fixed. Only able to move Up & Down. No Rotated.

Left theta & phi

Actually the target theta & phi are -45 degree of the focal plane variable: anti-correlation.

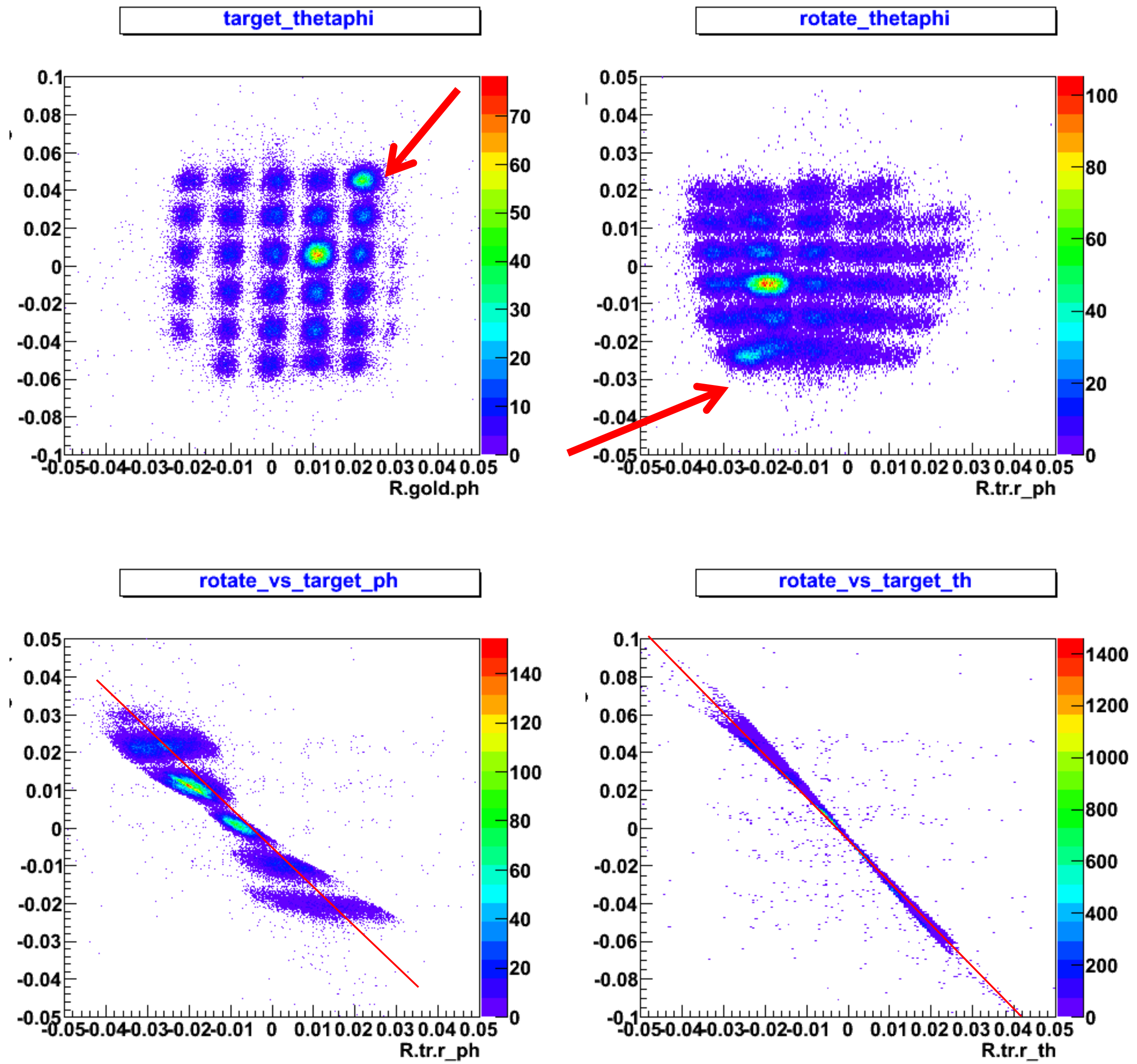


Right Theta & Phi

So… we do have the same relation of target to focal plane theta & phi.

I believe this is good enough to clear the discrepancy.

Someone ~~might~~ put the sieve in wrong.



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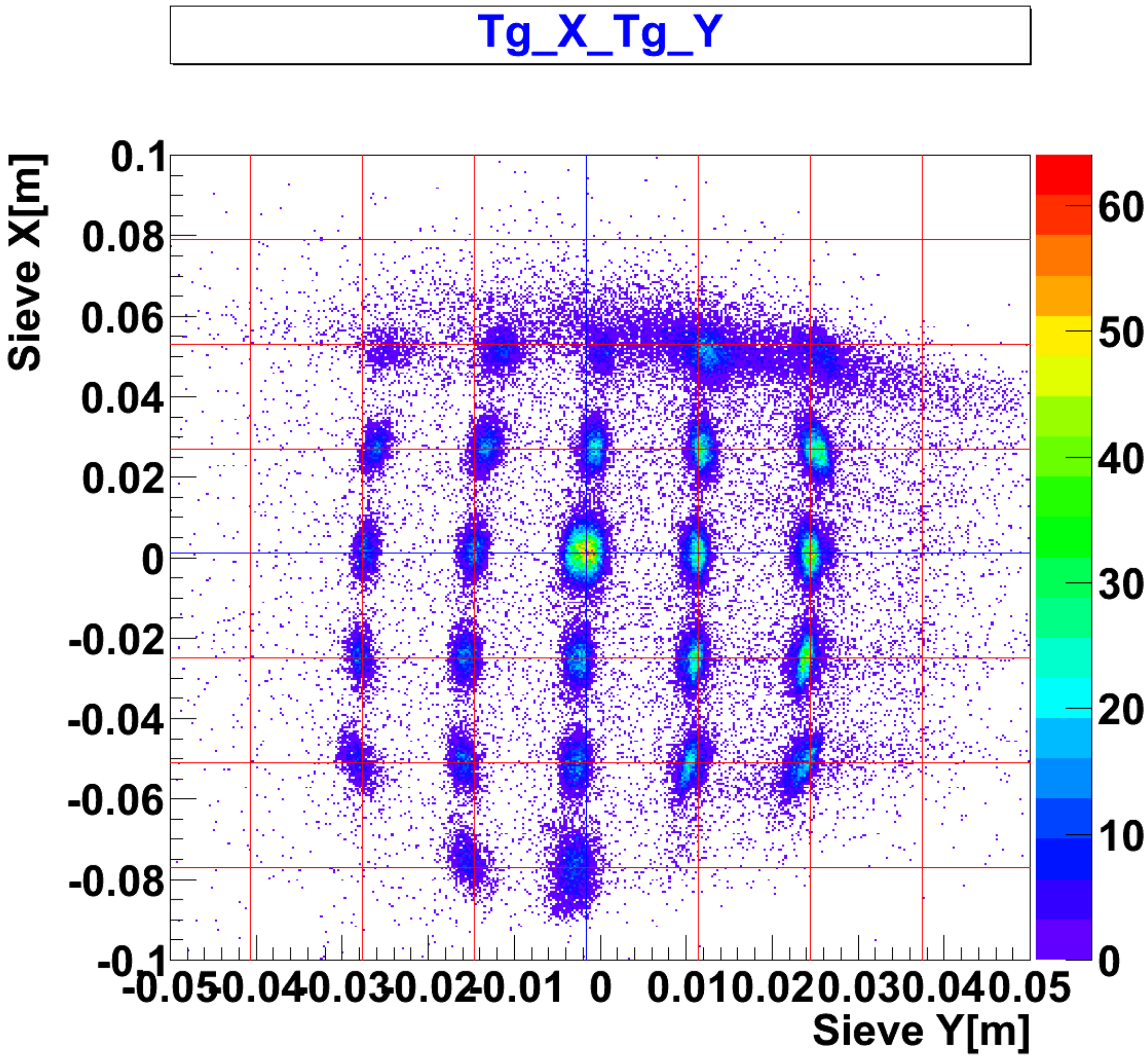
Right
Sieve X Y

Not quite as good as expected

Run 2017 BeO

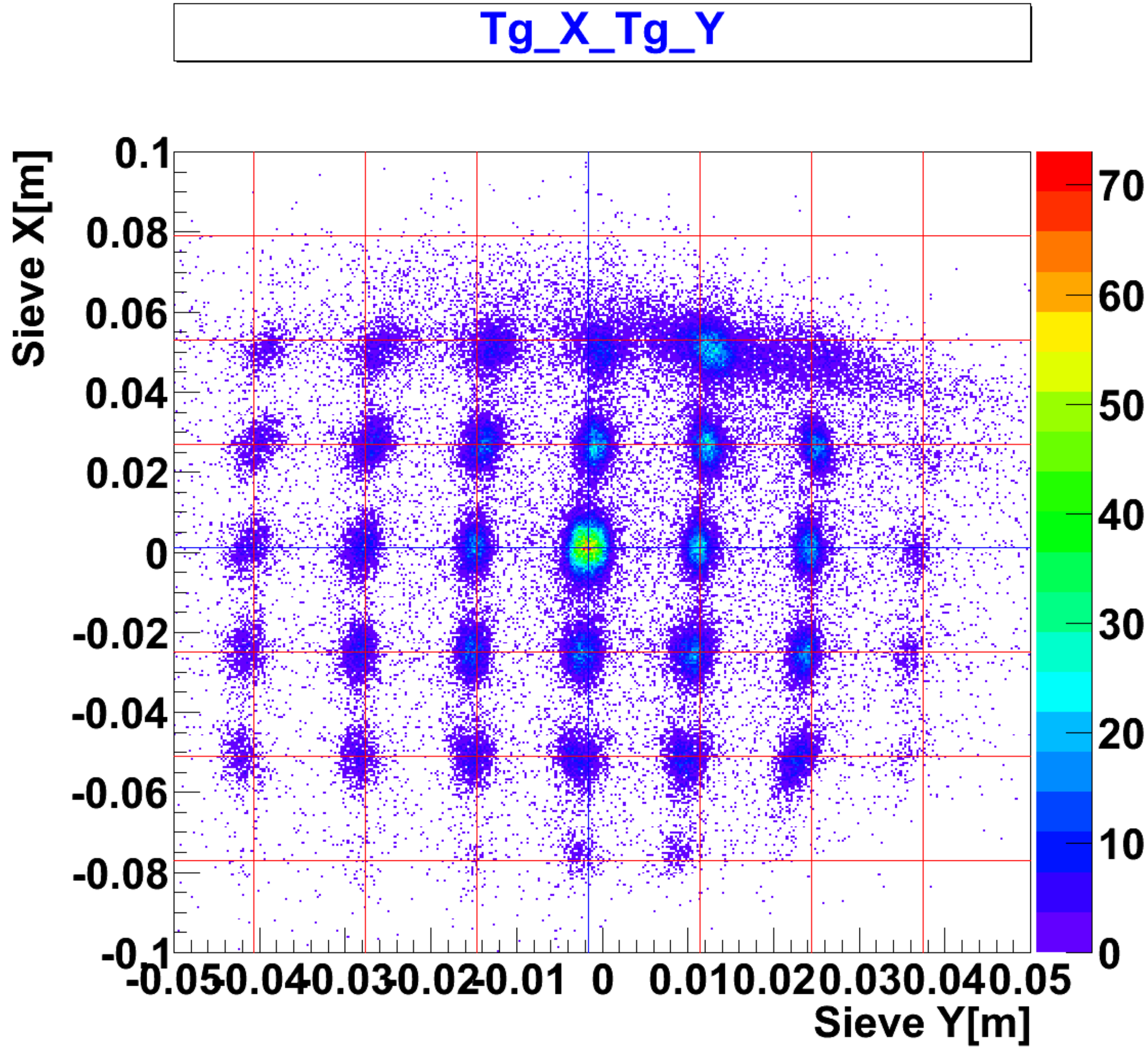


Right
Sieve X Y

Run 2020

C12-optics

The phi calibration is not good enough… need to go for a new angle.



Improvement

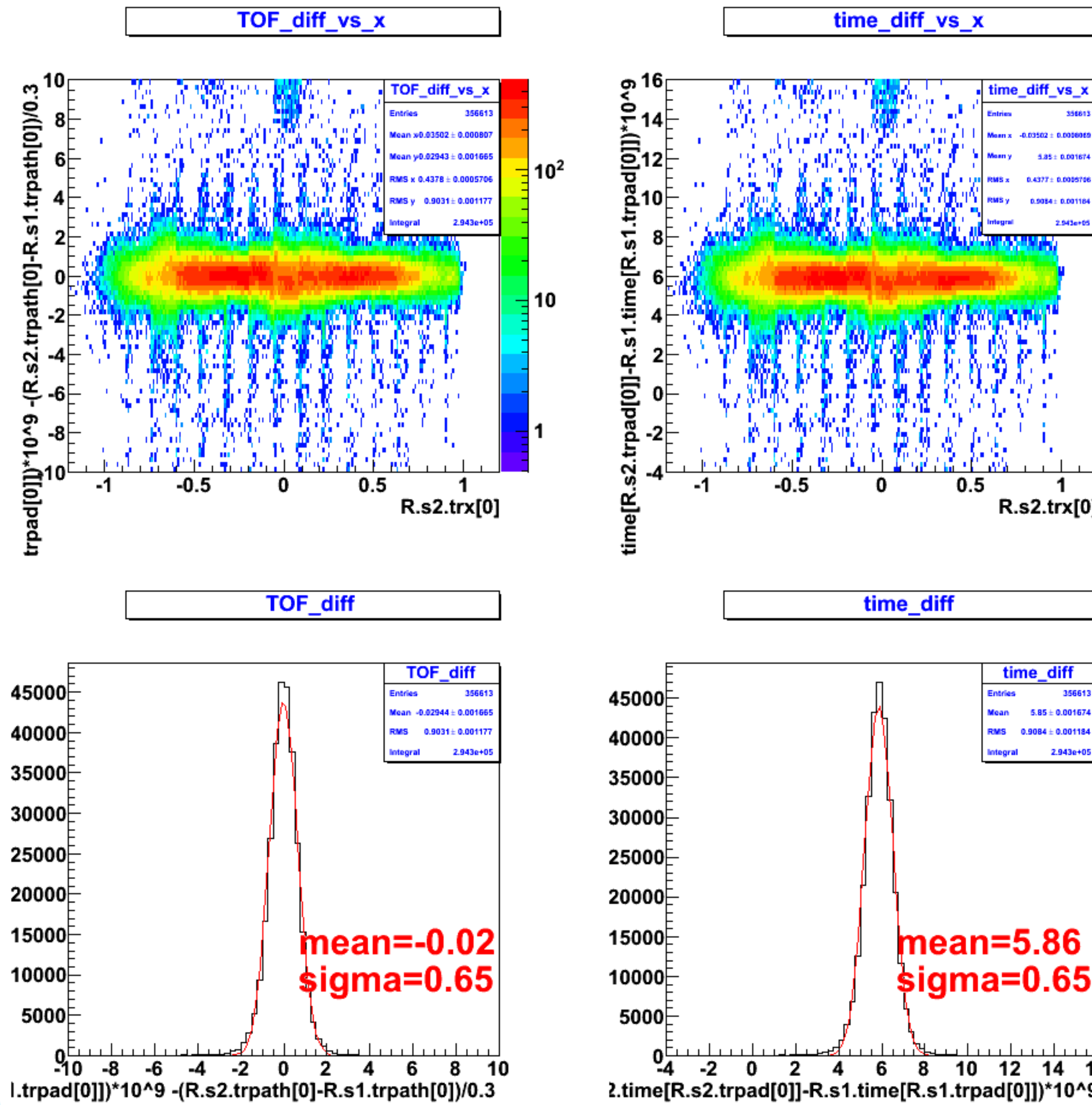
- The theta and Phi reconstructed matrices can be further improved.
- This require more carefully & evenly distribute of the number of event per hole.
- This is good enough for now?

Right Timing

Calibrate the time difference between the S1 and S2 time.

TOF = d(time) – d(pathlength)/(beta*c)

Using electron run 1380 & 1400. This eliminate possible beta extraction for each pathlength.



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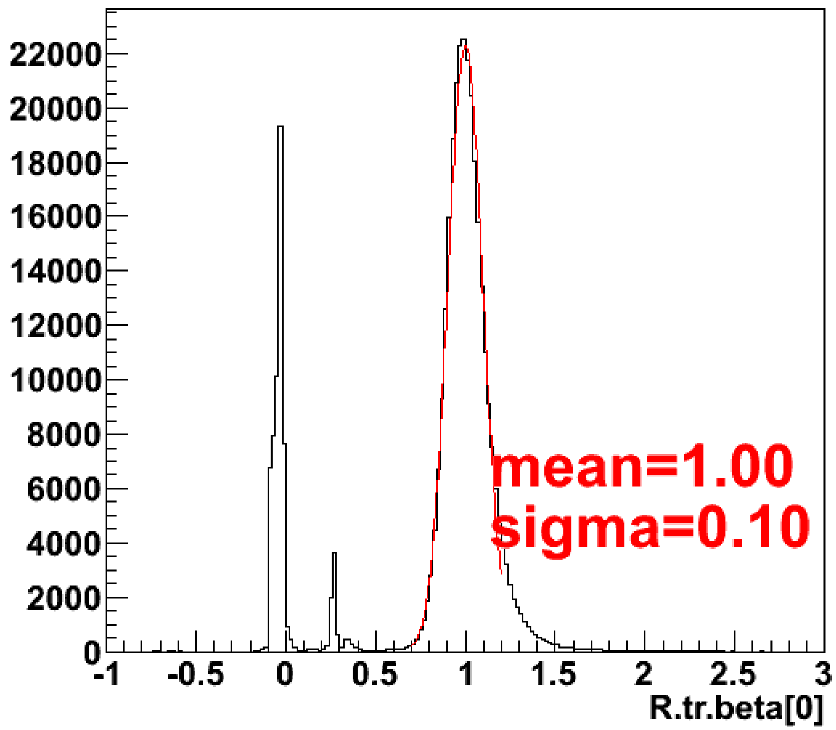
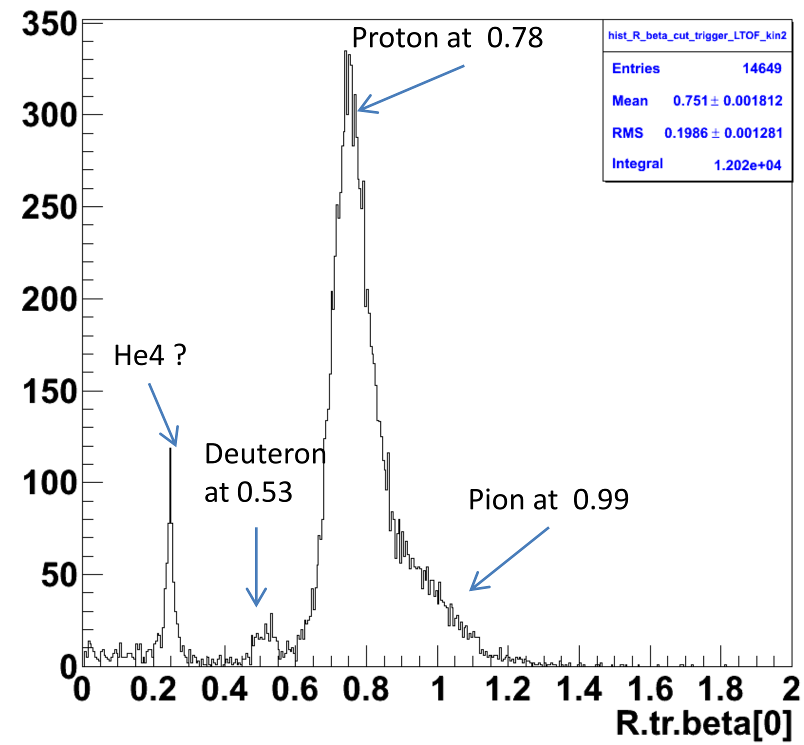
Beta distribution from S1 and S2

Electron beta



Production beta at 1.2 GeV



Right Timing

What do we really want?

- We can only use two detectors in the Right HRS
  - S1 & S2 Scintillator
  - VDC
- The VDC provide the tracking and reconstruction of vertex, theta, phi and dp.

What we have to use?

- Particle Identification (PID) from S1 and S2.
- This mean, the beta reconstruction from the S1 & S2 time difference is not good enough.
- Need to calibrate the S2 alone for the TOF to the full path-length (target to S2).

BIGBITE

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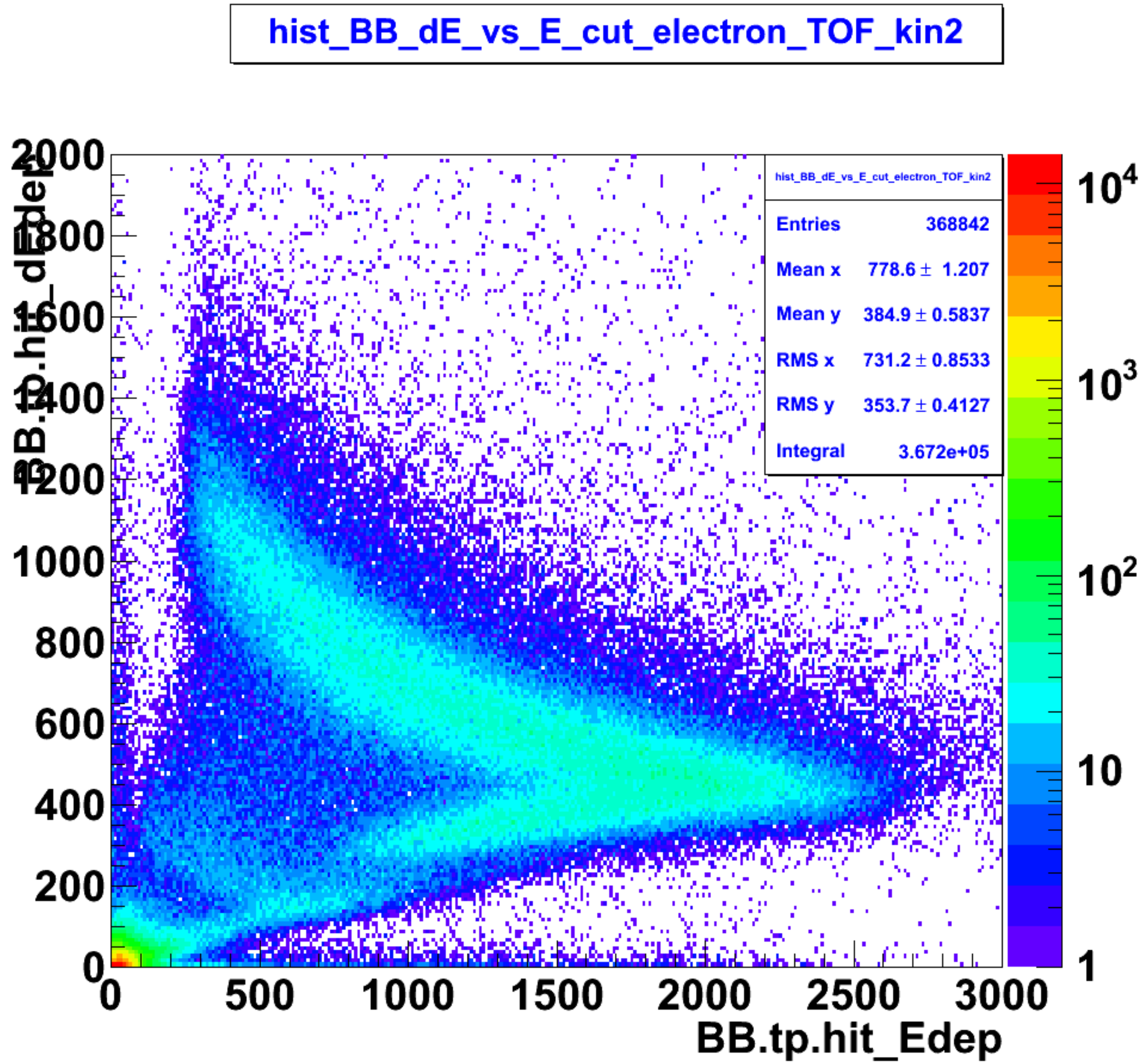
dE vs E
after calibration

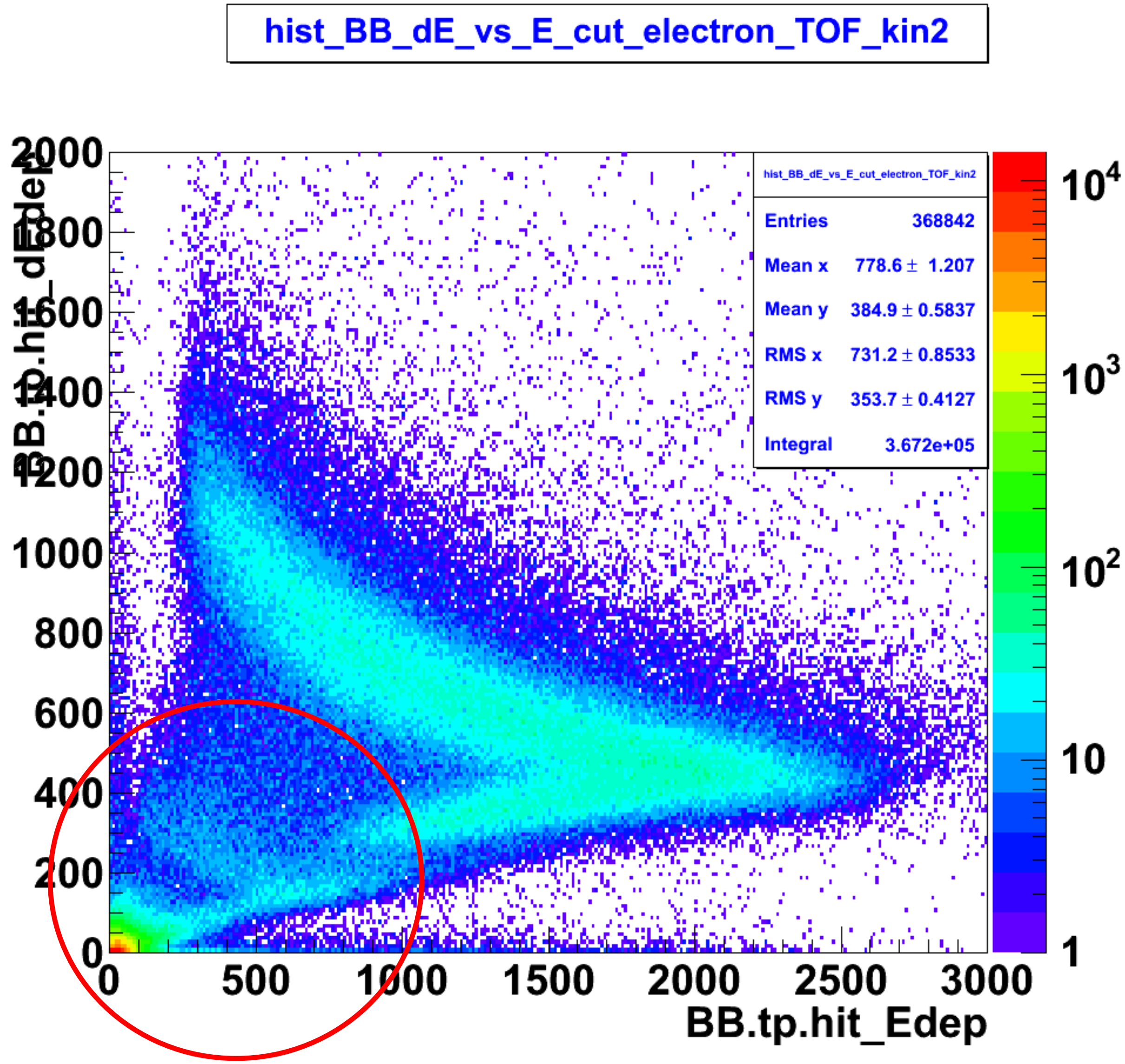
From production data

Within the time window of electron



Pion PID in BB

Within electron tagging we still see the pion in the bigbite.



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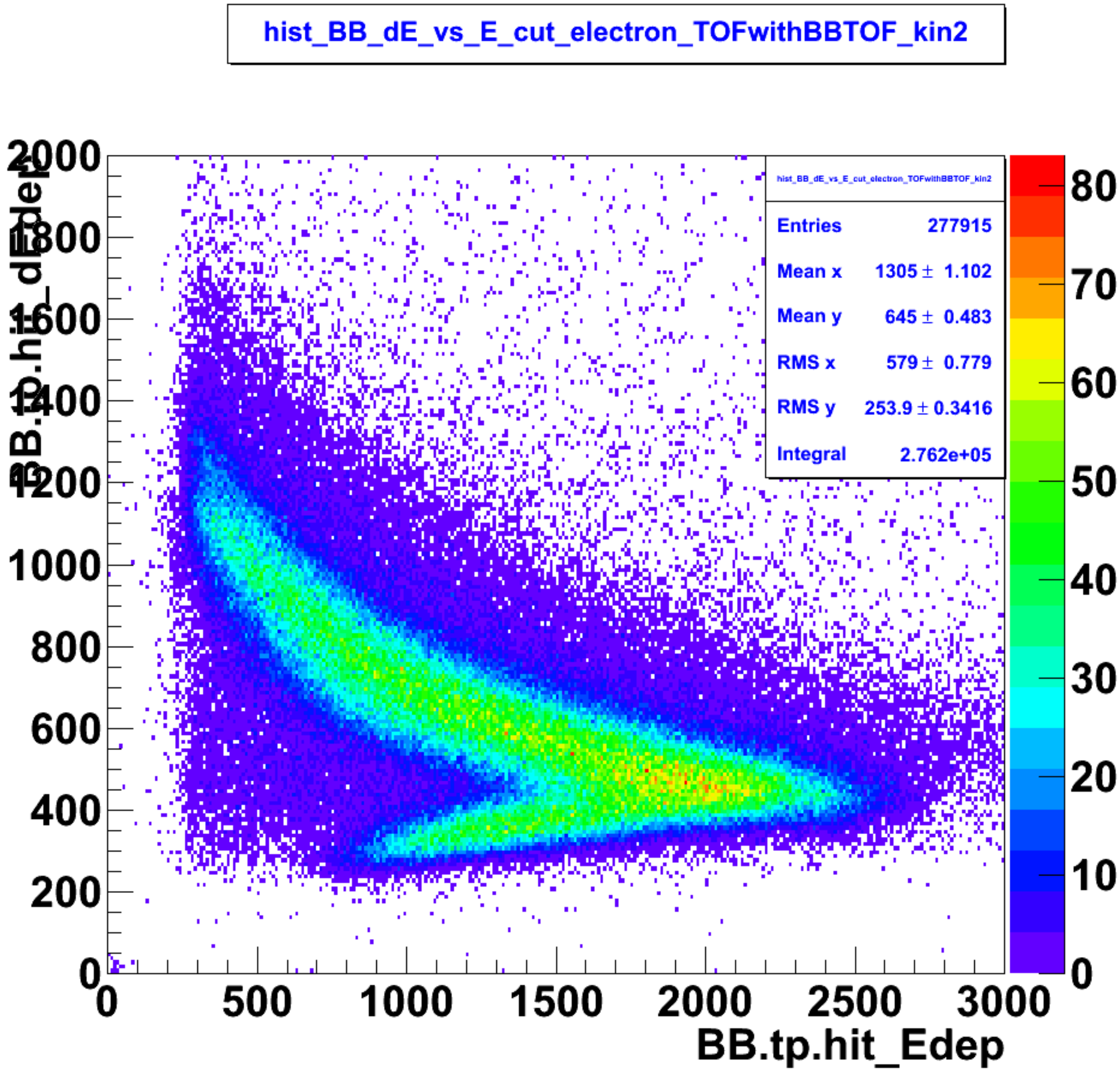
dE vs E

Demand the coincidence time between electron and bigbite.

The MIP is DISAPPEAR.

I think this is the case for the Right arm too if we can make the coincidence time between them after the S2 TOF calibration at full path length to the target.



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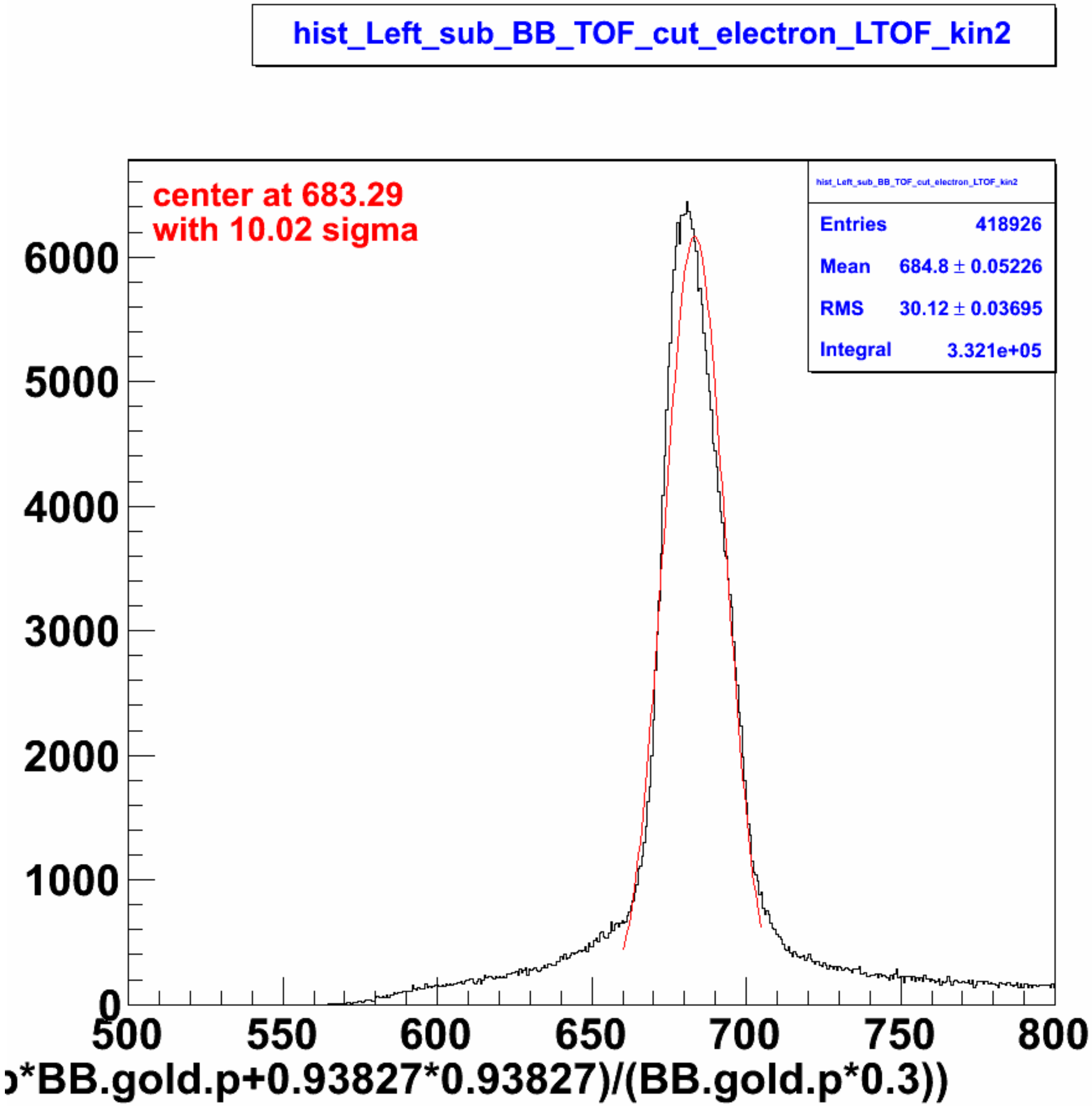
Coincidence time electron & Bigbite

Can be improved with path-length after optics calibration for bigbite.

Unfortunately, I erase all my BigBite timing rootfile. So I don't have my timing for BigBite to show. (Next time).



Momentum from Analytical Model

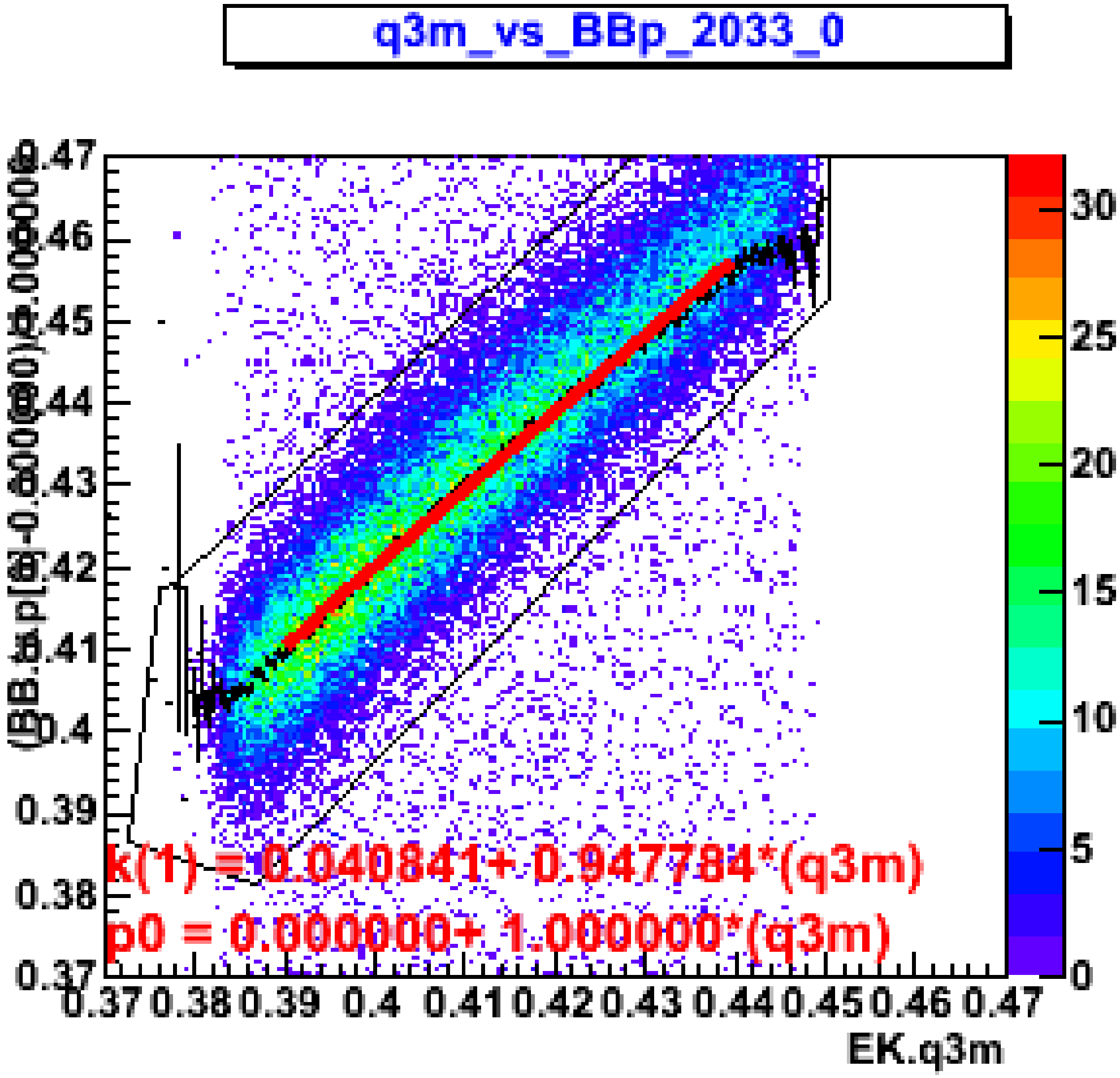
To what error, can we trust this reconstruction?

The plot on the right show the Bigbite Analytical Momentum vs |q3| ,
for the reaction H(e,e'p)

The fit line shows that the analytical momentum

BB.p = 0.9477*|q3|+0.04

For momentum range
0.38 to 0.45 GeV



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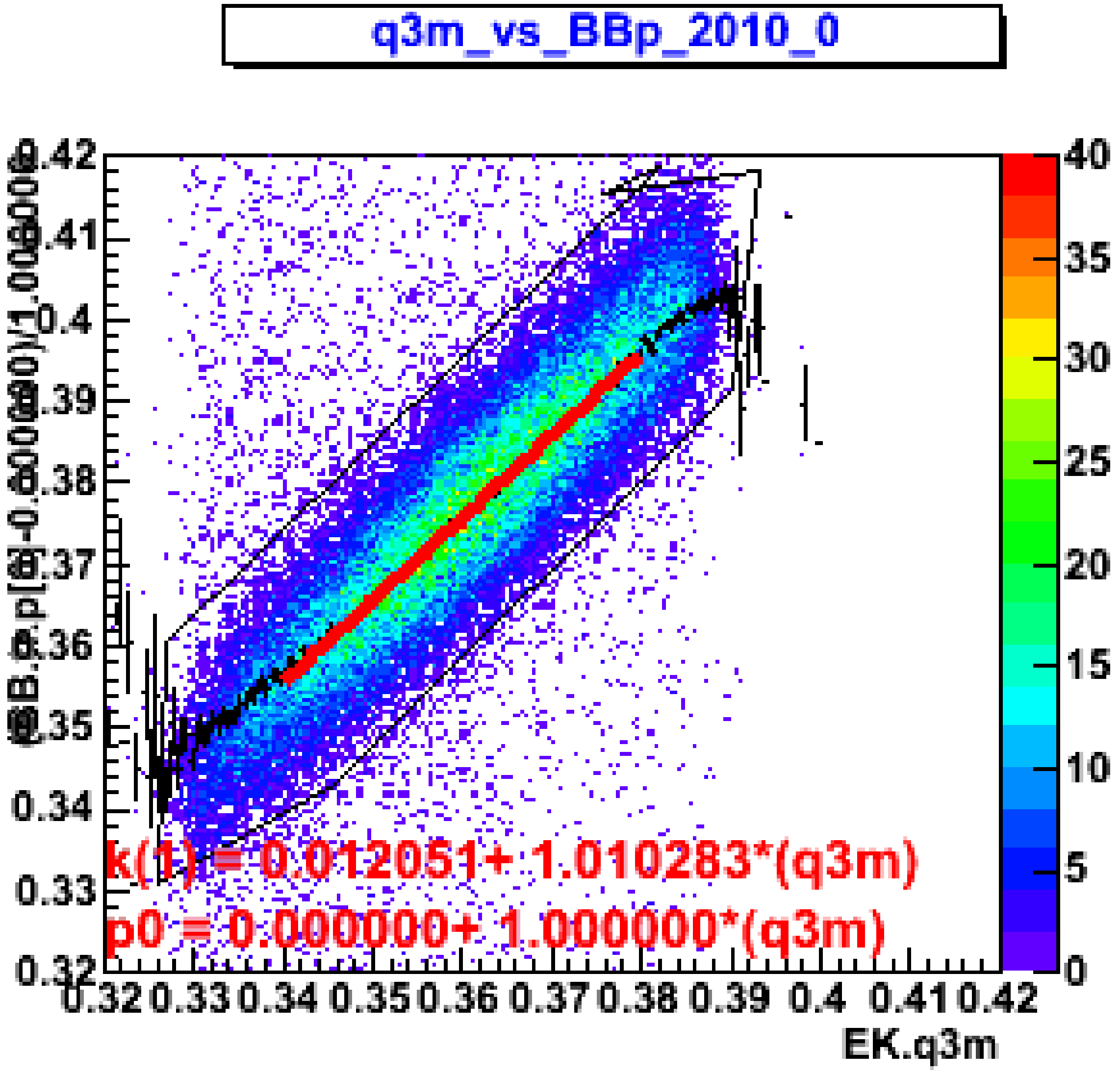
Momentum from Analytical Model

The plot on the right show the Bigbite Analytical Momentum vs |q3| , for the reaction H(e,e'p)

The fit line shows that the analytical momentum

BB.p = 1.010283*|q3|+0.01

For momentum range
0.33 to 0.39 GeV



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Momentum from Analytical Model

The plot on the right show the Bigbite Analytical Momentum vs |q3| ,

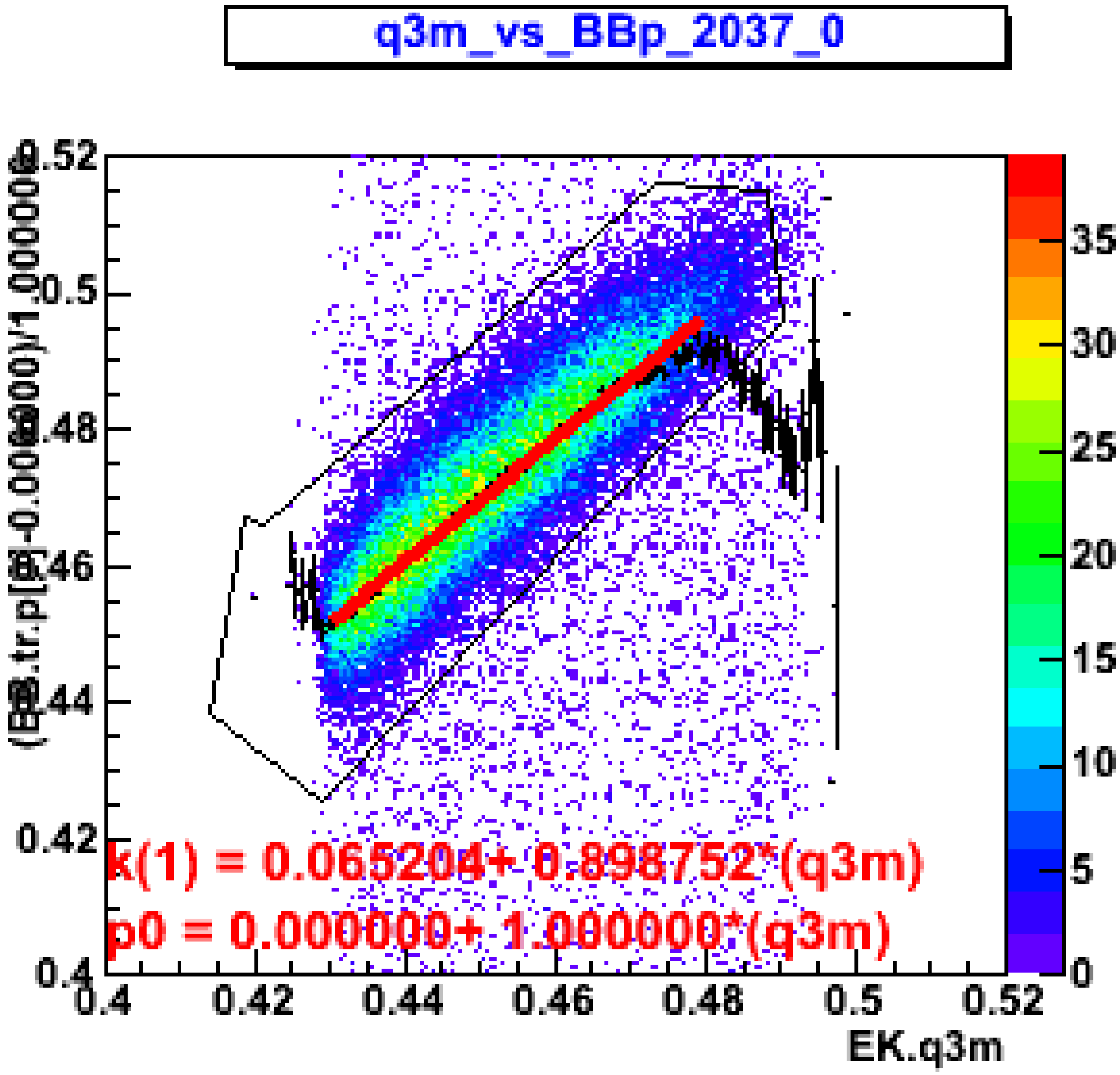
for the reaction H(e,e’p)

The fit line shows that the analytical momentum

BB.p = 0.898752*|q3|+0.06

For momentum range

0.425to 0.48 GeV



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BigBite Analytical Model

The Comparison table

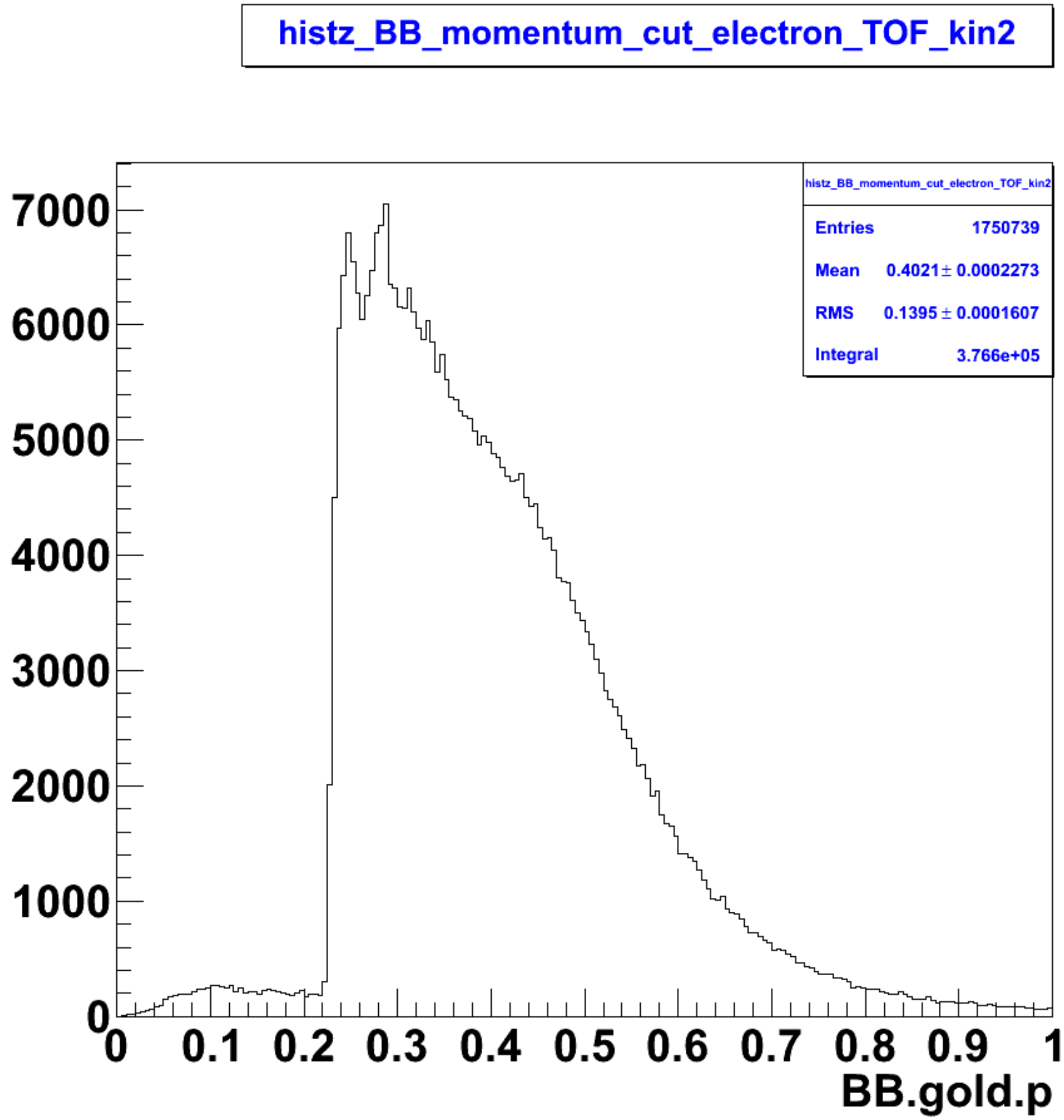
Momentum range (GeV)	Compare to |q3| from electron arm
0.33 to 0.39 GeV	BB.p = 1.010283*|q3|+0.01
0.38 to 0.45 GeV	BB.p = 0.9477*|q3|+0.04
0.425to 0.48 GeV	BB.p = 0.898752*|q3|+0.06

Note that, the energy lost, electron dp error, target cm momentum, and etc. are not take into account.

BB Momentum from Analytical Model

Cut electron TOF window

Kinematics 2



Navaphon Muangma (Tai)

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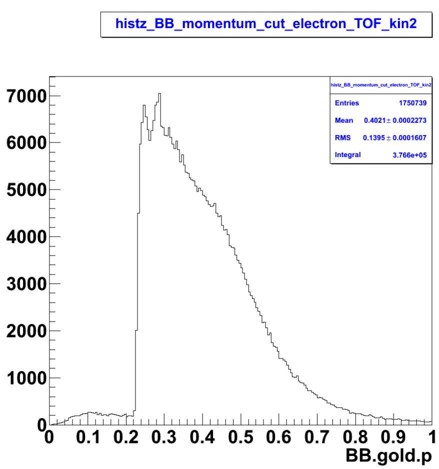
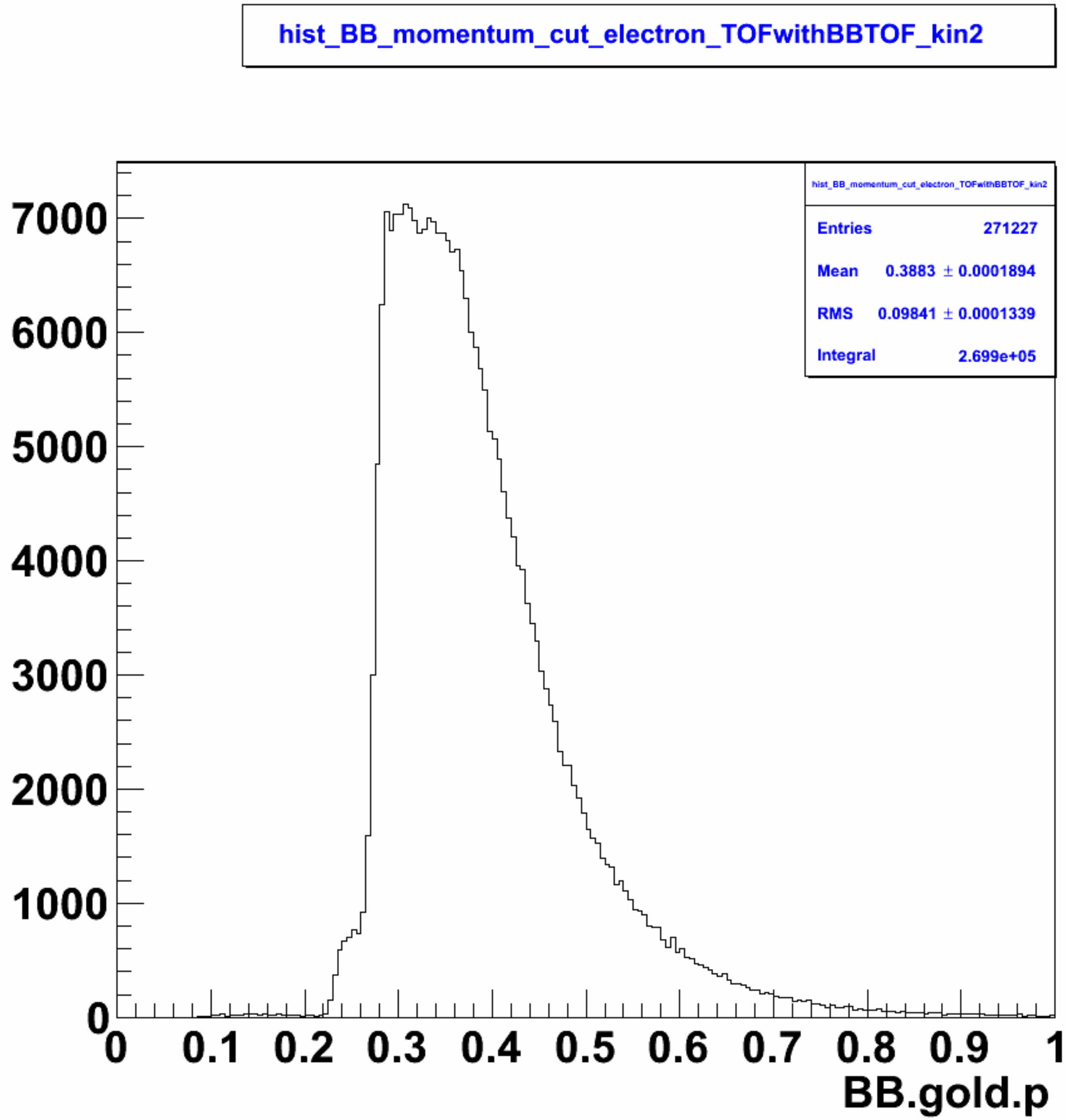
BB Momentum from Analytical Model

With coincidence time between the electron and bigbite

Kinematics 2





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MORE FIGURES …. LET TAKE A LOOK?

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I THINK I WILL SAVE THEM FOR NEXT TIME…

^_______________^

HAVE A NICE DAY…