

TOF Calibration and Development

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Outline

- 1: Introduction
- 2: Time Calibration
- 3: Coo Calibration
- 4: Software Development
- 5: Summary and Outlook

Geometry

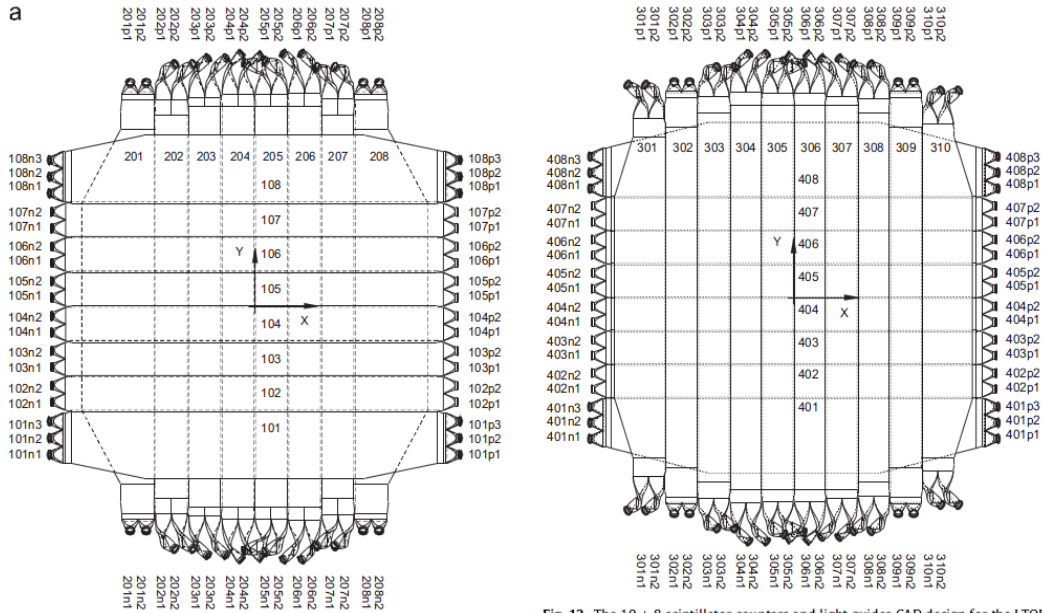
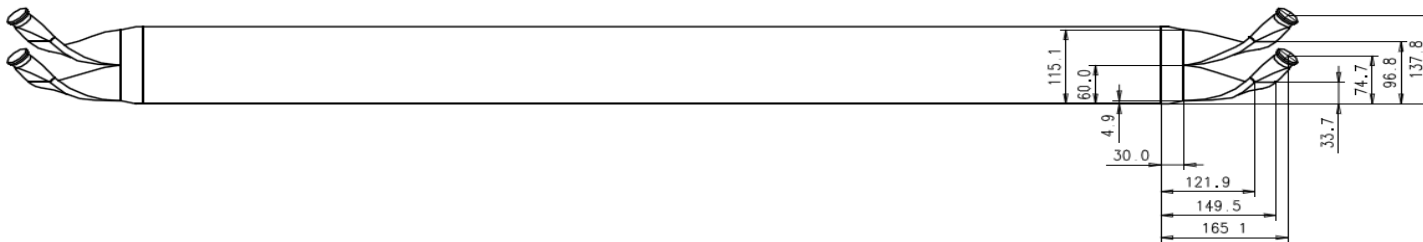
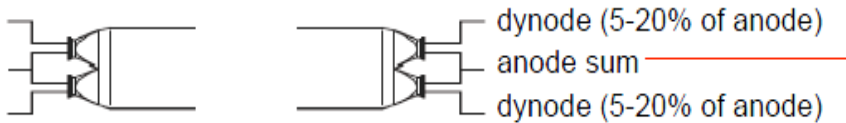


Fig. 12. The 10 & 8 scintillator counters and light guide CAD design for the LTOF

- 1: TOF 4 Planes
- 2 UTOF+LTOF 8 8 10 8 Counters
- 3 UTOF Z 61~66cm LTOF Z -66~-61cm
- 4 Counters Length 110~135cm
- 5 Counters Width 12cm(18~26cm)
- 6 0.5cm overlap with nearby Counters



TOF Readout

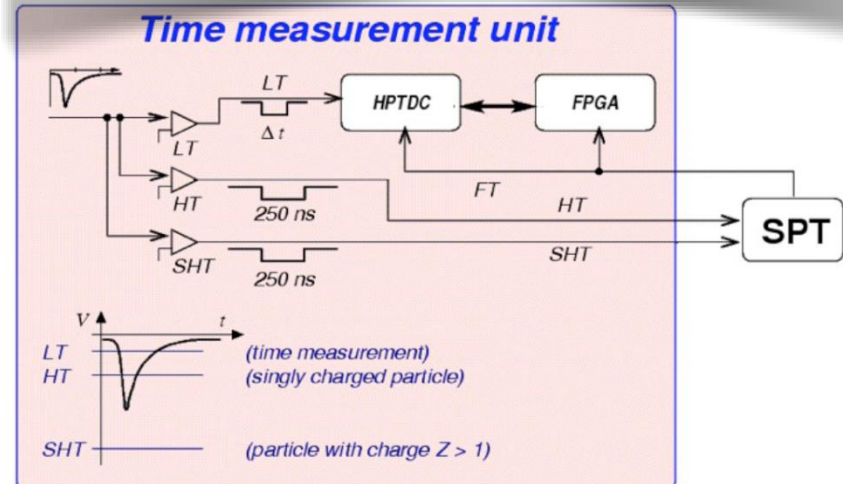
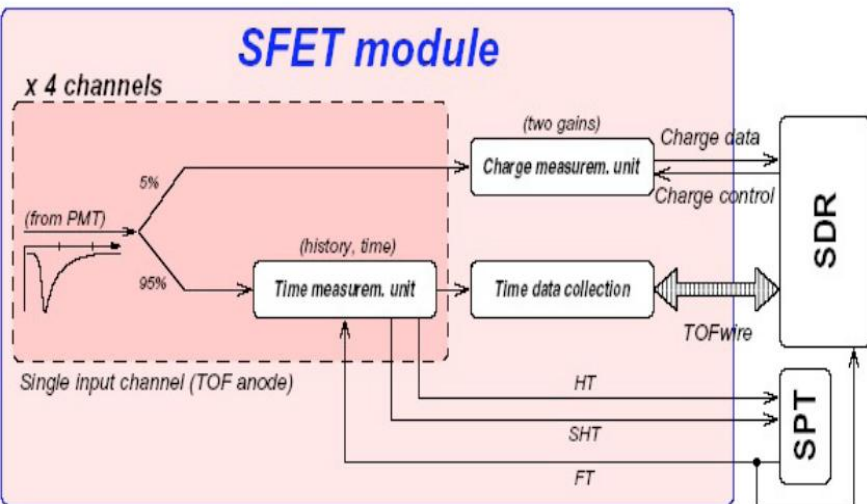


1: each side combine 2(3)PMTs to get anode signal .

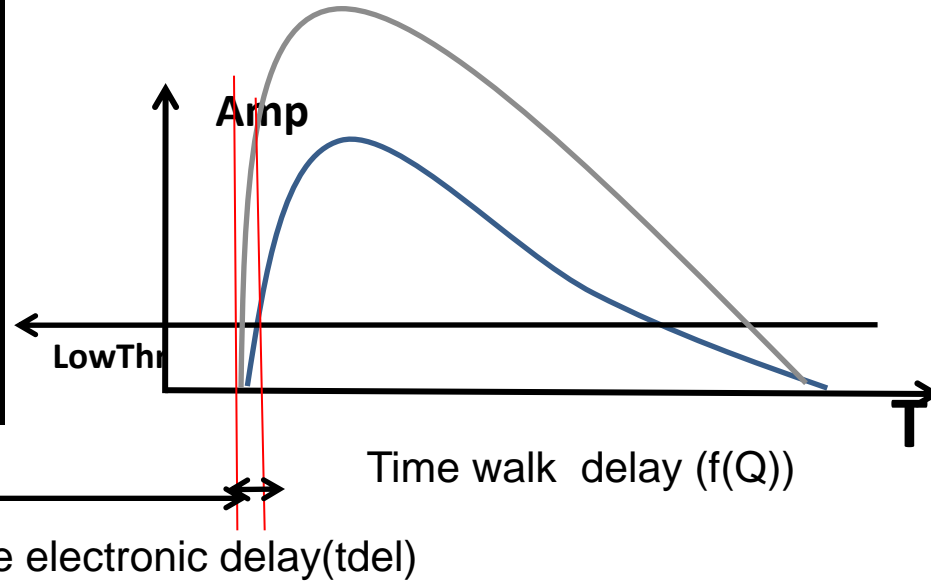
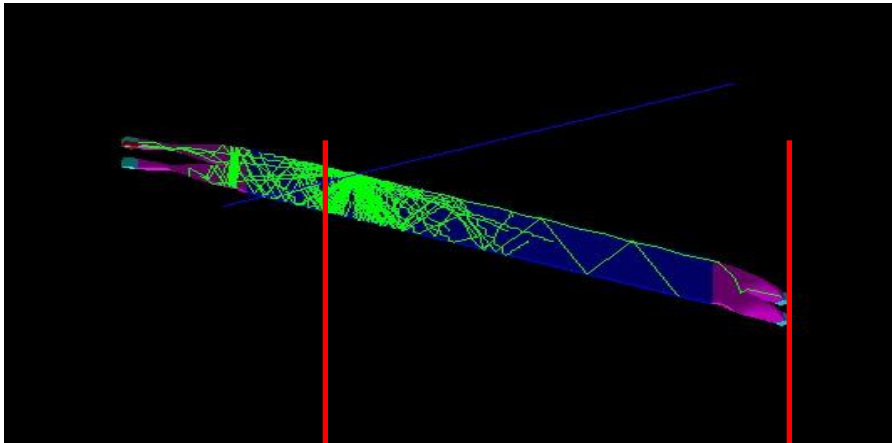
95% for Time measurement,
5% for charge measurement

2: Pulse go to different Threshold LT HT SHT.
LT mainly for Time measurement

3: TDC chip ~25ps count resolution



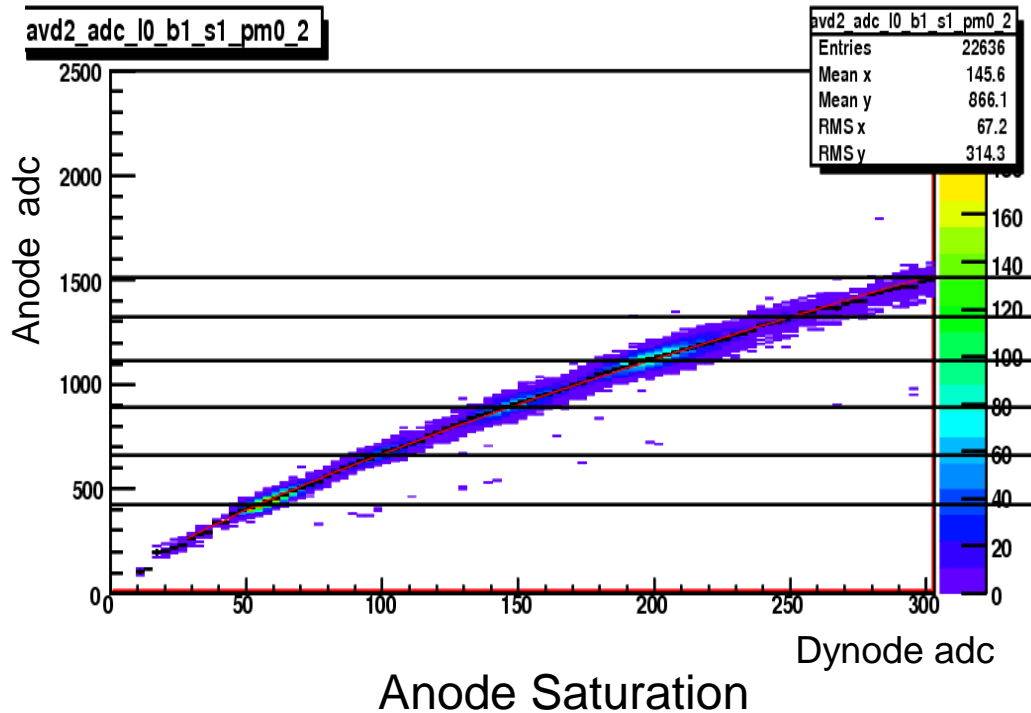
Time Measurement



$$T_{mes} = FT - LT = -(T_{raw} + x/v + t_{del} + f(Q)) + T_{Trig}$$

Time Calibration

Time walk delay



- 1: Different pulse has different Time Delay $f(Q)$, need ADC correction.
- 2: Anode ADC behave strange. Non-linear saturation come very soon.
- 3 Assume saturation due to ADC electronic. Integral Time measurement pulse will not proportion to charge ADC
- 4 This saturation can be describe by $Anode = (Dynode)^a$

$$T_{mes} = FT - LT = -(T_{raw} + x/v + t_{del} + f(Q)) + T_{Trig}$$

$$f(Q) = S/\sqrt{Q} \Rightarrow f(Q) = S/Q^p \text{ (According to saturation curve)}$$

Calibration Algorithm

$$-T_{mes} = T_{raw} + x/v + t_{del} + S/Q^p - T_{rig}$$

How to calibrate TDC readout $34PMT \times 2Side \Rightarrow v \ t_{del} \ S \ p \ ??$

Procedure of Chi2:

1: Mean Time of Same Counter Two Side (Assuming two side $v_0=v_1=v$ $p_0=p_1=p$)

$$-T_{m0} = T_{raw} + (L-x)/v_0 + t_{del0} + S_0/Q^{p0} - T_{trig}$$

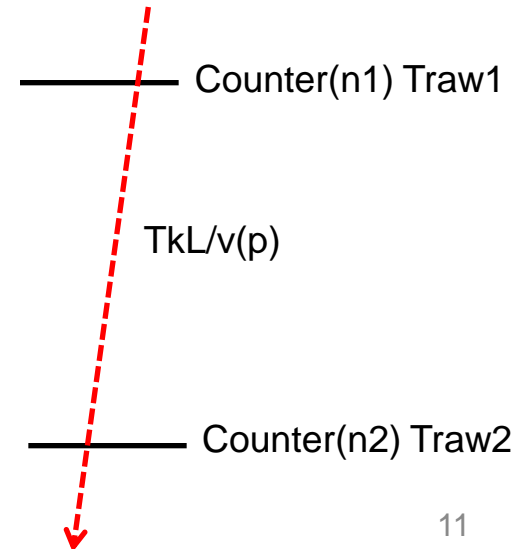
$$-T_{m1} = T_{raw} + x/v_1 + t_{del1} + S_1/Q^{p1} - T_{trig}$$

$$-T_{raw} = ((T_{0m} + T_{1m}) + L/v + (S_0/Q^p + S_1/Q^p))/2 - T_{trig} + T_{del}$$

2: For 2 Layer Counter $n_1 \ n_2$ (Fixed):

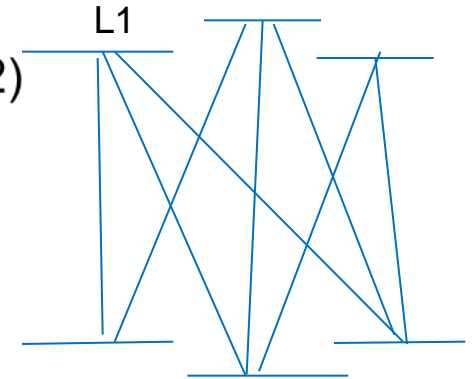
$$(T_{raw2} - T_{raw1}) = f(2T_{del}, 4S, p) = T_{kL}/v(p) \quad (\text{expect dt})$$

$$X_{|n_1 n_2}^2 = \sum_{n_1 n_2} (T_{raw|n_2} - T_{raw|n_1} - T_{kL}|_{n_1 n_2}/v(p))^2$$



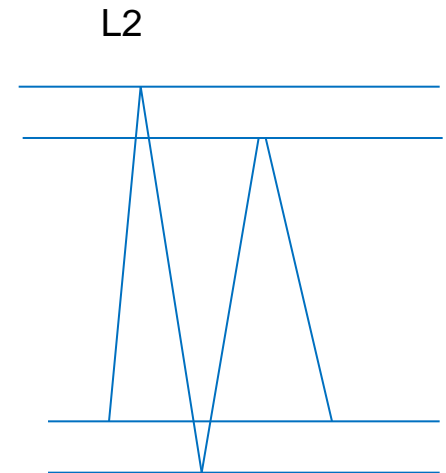
3: For Fixed 2 Layer: L1 L2 (sum all 2 bars pattern $A_{n1}^1 A_{n2}^1$ Chi2)

$$X|_{l1l2}^2 = \sum_{Cn1n2} X_{l1n1l2n2}^2$$



4: For 4 Layers (pattern $C_4^2 - 2$)

$$X|_{global}^2 = X^2|_{l0l2} + X^2|_{l0l3} + X^2|_{l1l3} + X^2|_{l1l4}$$

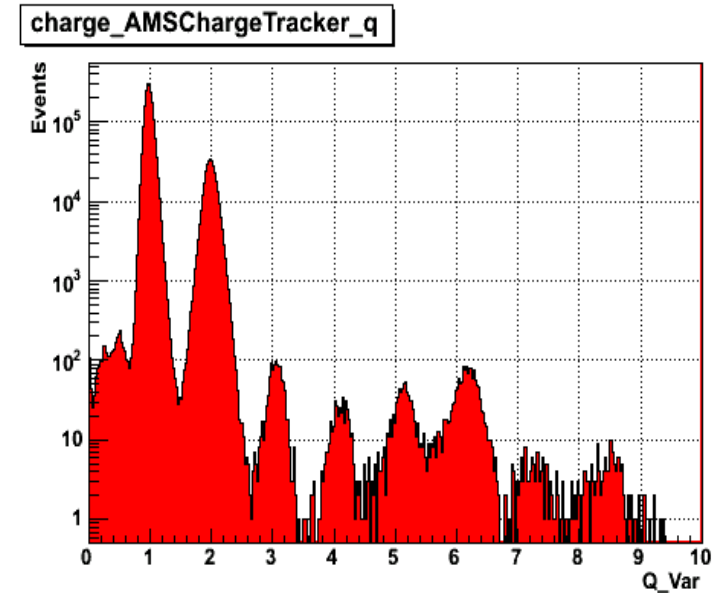


5: Final Minimization (68 S+ 34C +1p-1=102 Par)

Minimize this complicate $X|_{global}^2$ to do all Calibration once

Calibration Events Selection

- 1 : 1 Track && 1 Particle && 1 TrdTrack
- 2: Track $\text{ChisX} < 50$ $\text{ChisY} < 10$ && $\text{YHit} \geq 5$ $\text{XHit} \geq 4$
- 3 : 4 TOF Cluster && all used by Beta
- 4 : no glue TOFRawCluster && both sides are has signal
- 5: $\text{Rigidity} > 20 \text{ GeV}$
proton $\text{beta} > 0.998$ ($Z/m=1$) nucleus $\text{beta} > 0.995$ ($Z/m=0.5$)



Data: B550+B584(Comparesion): 2011/05/19->2012/05/16

Pulse Shape Tracing and Data Sample

1 : Time walk delay relate to pulse shape

$$-T_{mes} = T_{raw} + x/v + t_{del} + S/Q^p - Trig$$

p and S → Relate to pulse shape (saturation)

2: Should select proper sample to do calibration, to follow unknown pulse shape for different charge

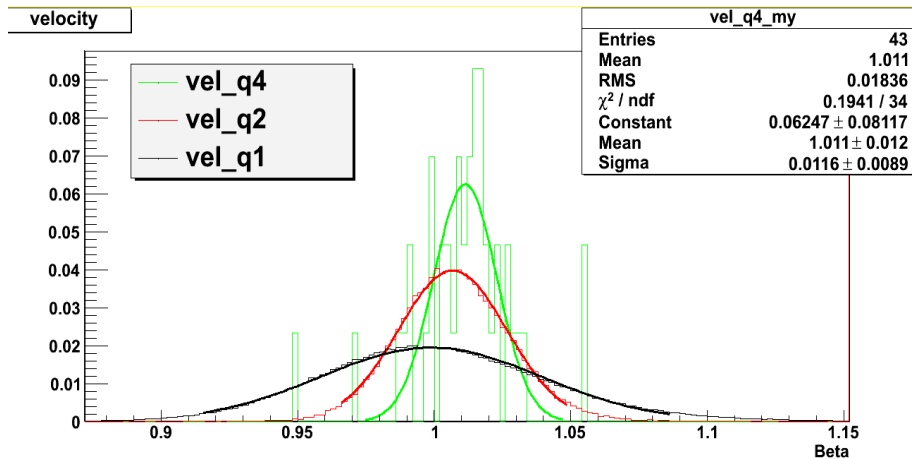
3: Most Cosmic ray is proton, very low pulse. However high rigidity nucleus is too rare to do dynamic calibration

In order to balance this unbalance, Introduce some trick

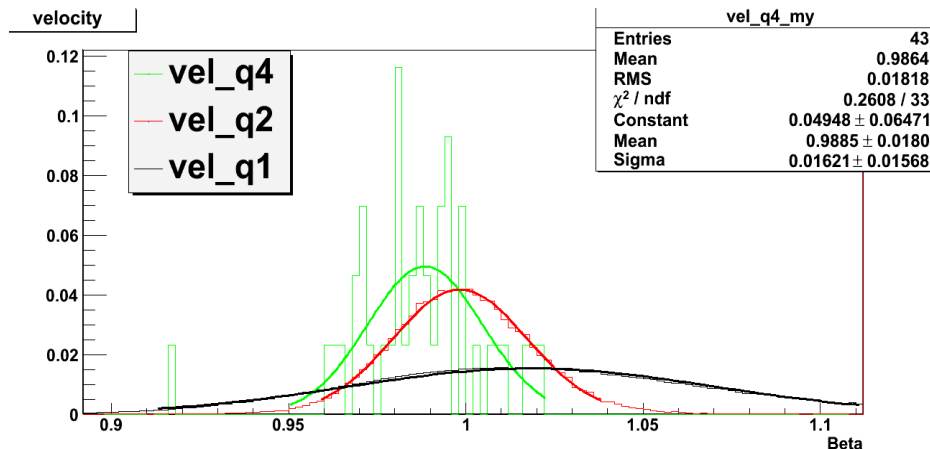
Calibration Sample and Testing

Natural Cosmic ray sample(8 days data for testing)

- 1: Proton+Helium+Nucleus($Z>2$): =>nucleus beta shift (proton dominate)

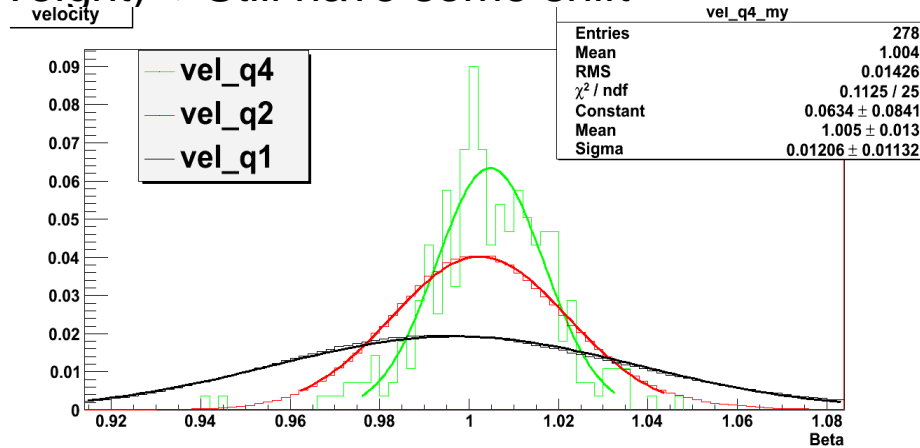


- 2: Helium+Nucleus($Z>2$): =>proton nucleus beta shift

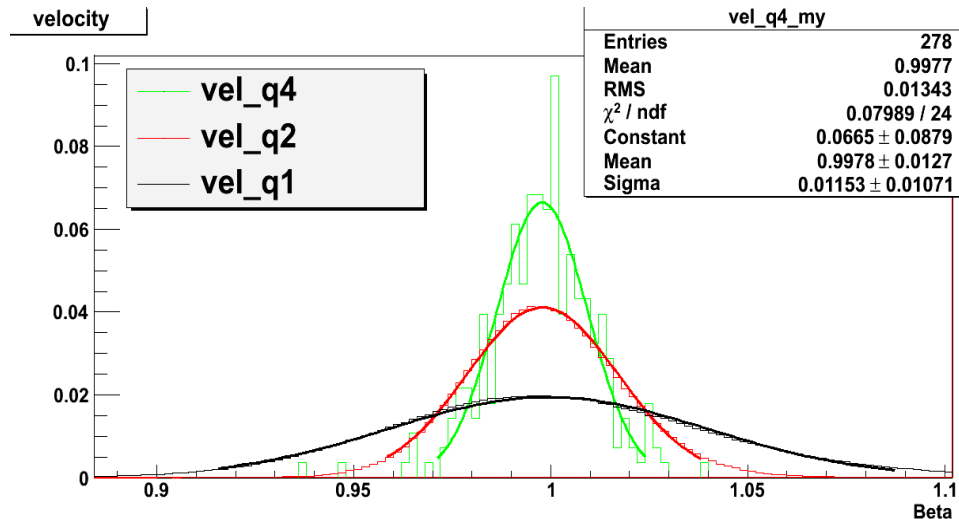


Final Flavoring

3: Proton+Helium(+Weight)=>Still have some shift



4: Proton+Helium(+Weight1)+Nucleus(+Weight2)=>OK

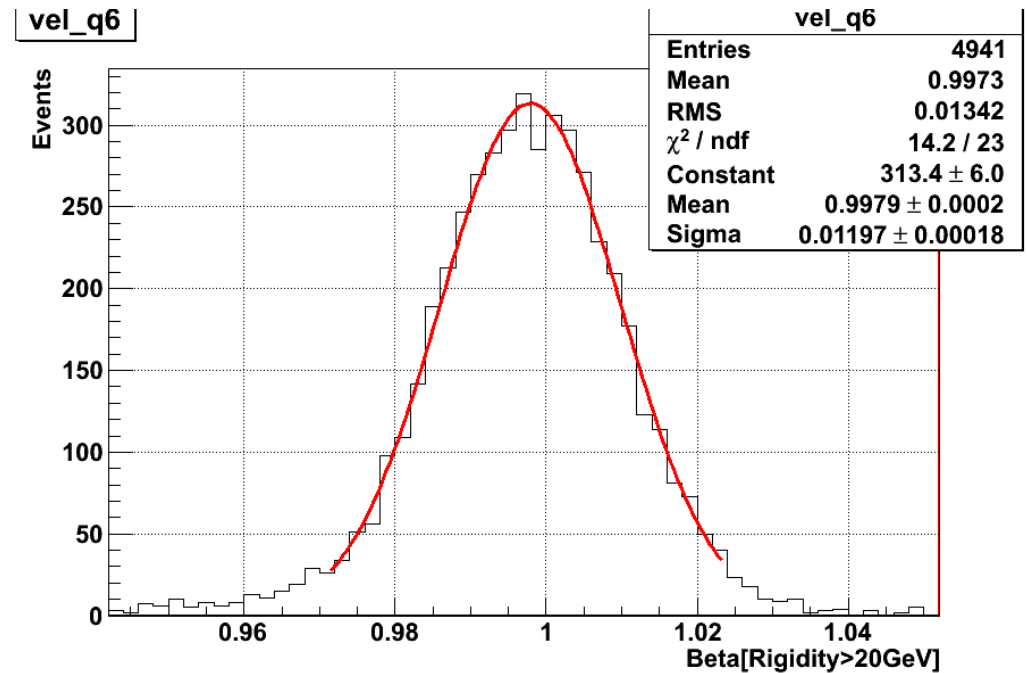


Calibration Time Windows and Result

8days per calibration

15days per calibration

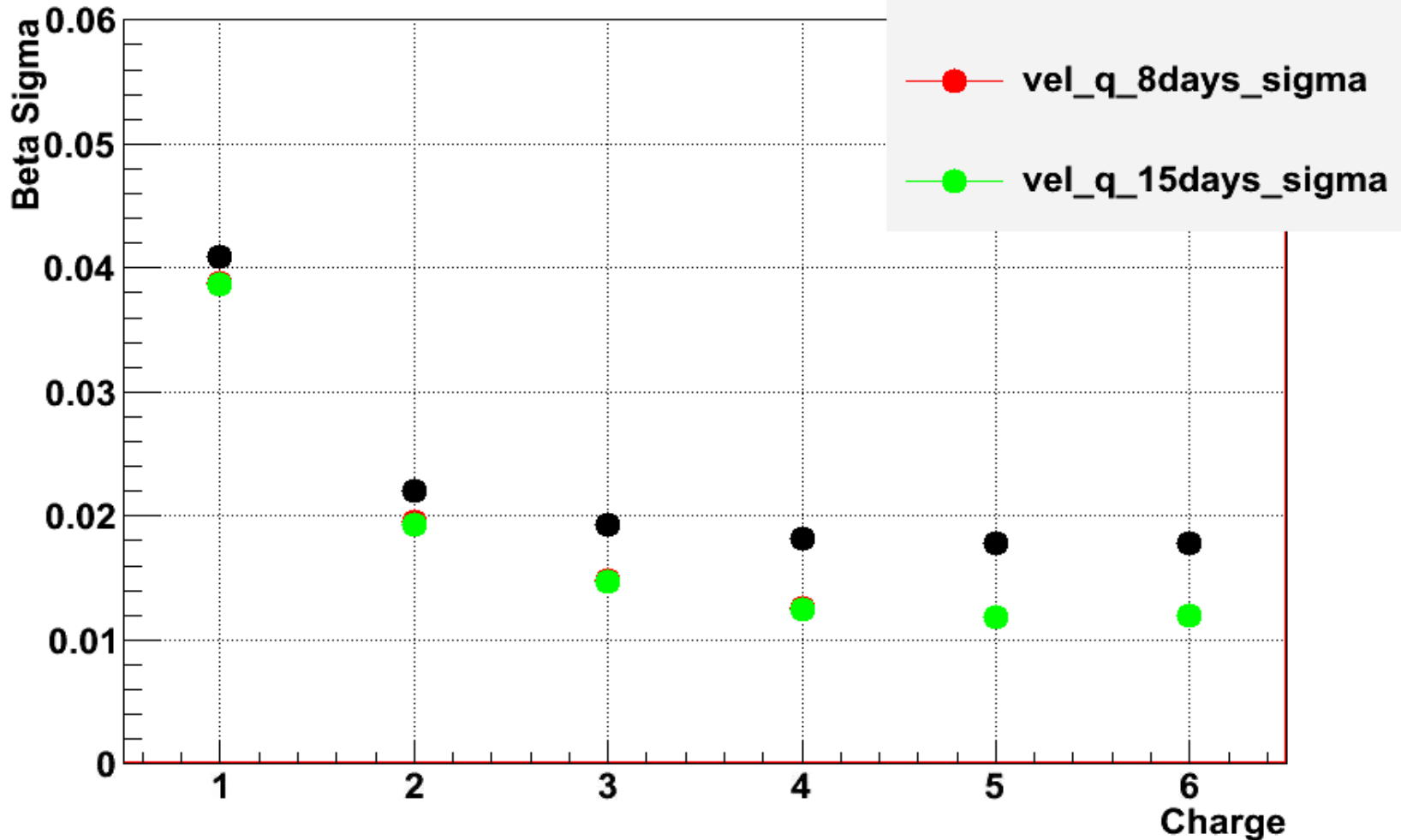
=>2011/05/19->2012/05/16



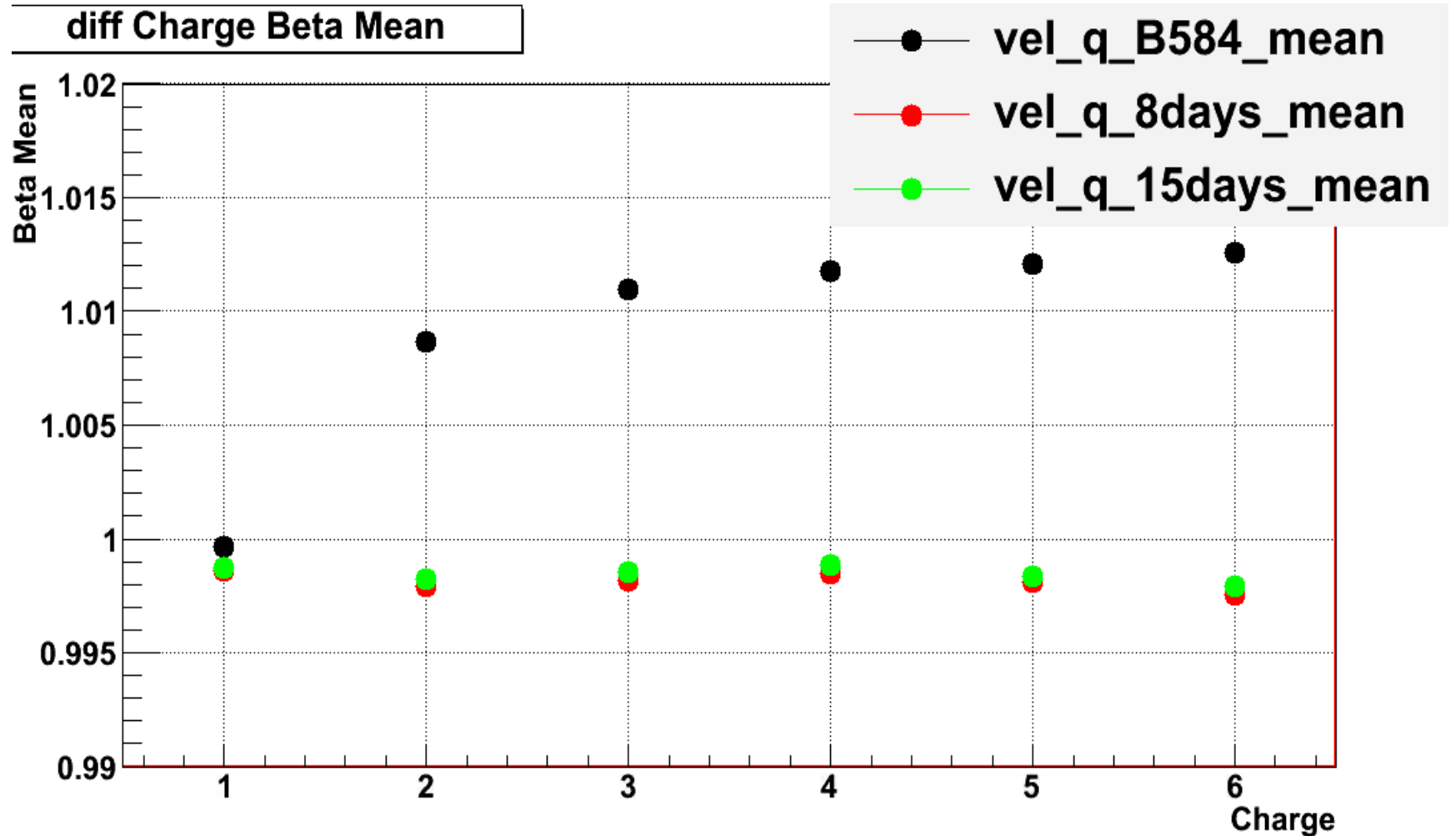
Carbon beta resolution 1.2%~48ns (15days per calibration)

Beta Sigma for Different Charge

diff Charge Beta Sigma

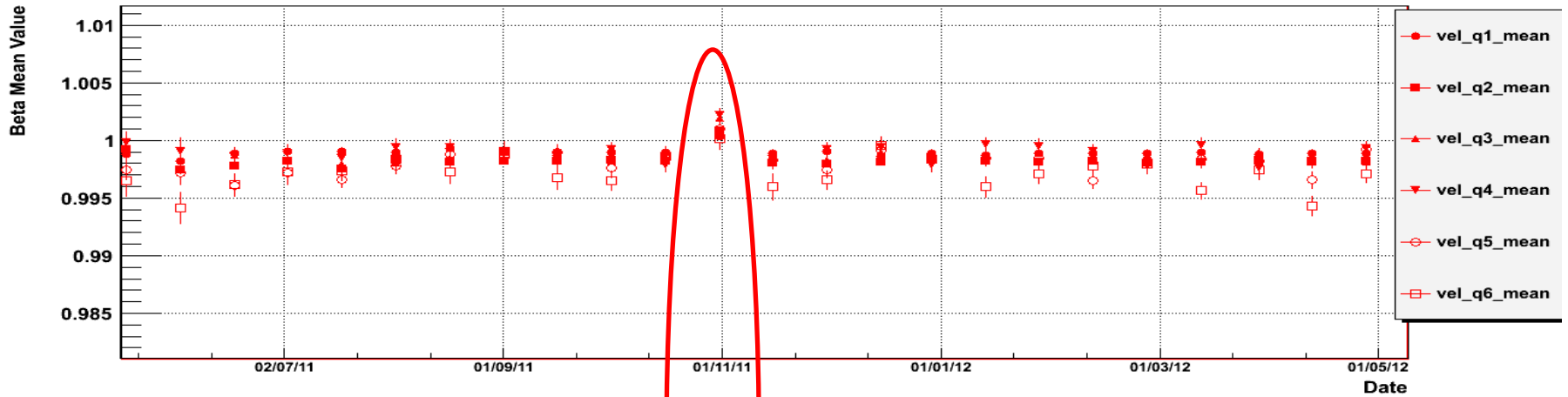


Beta Mean for Different Charge

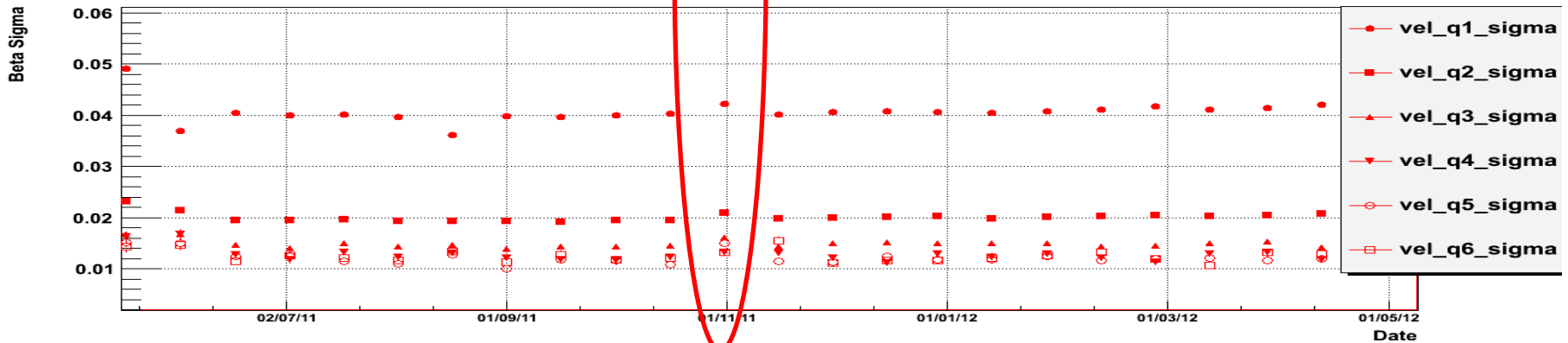


Calibration VS Date (15days per)

diff Charge Beta Mean vs Time

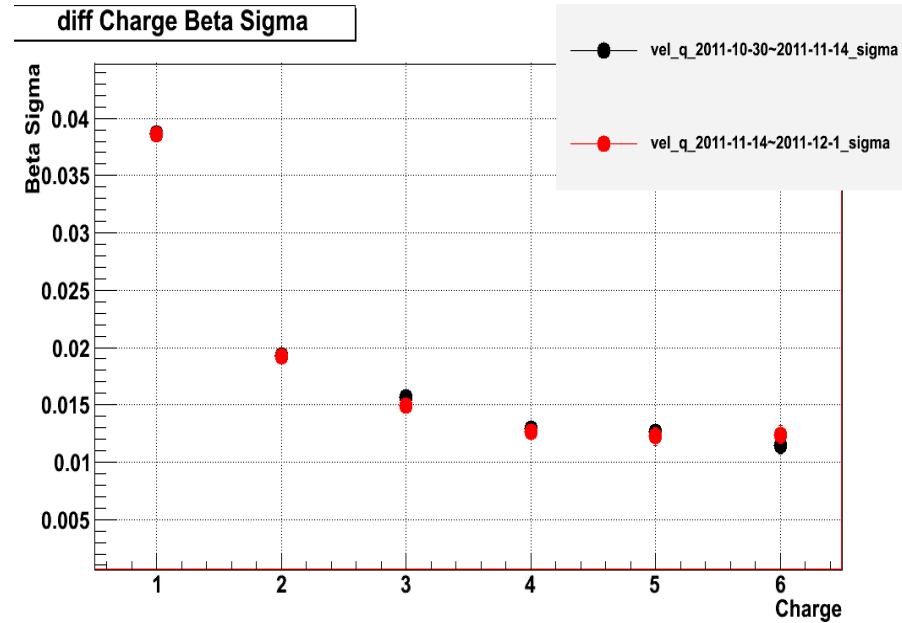
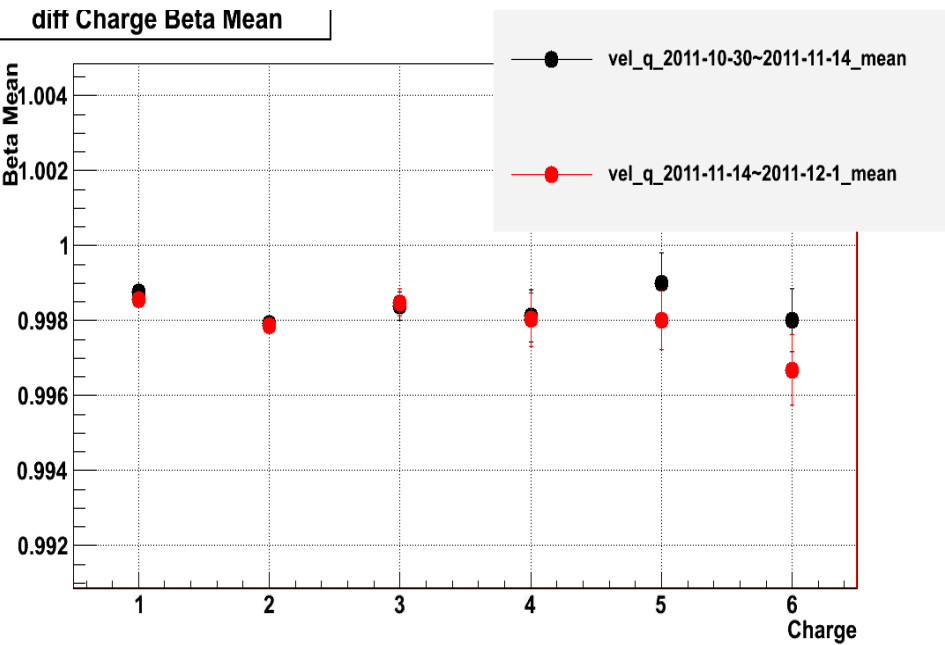


diff Charge Beta Sigma vs Time



board change point: run1321288304

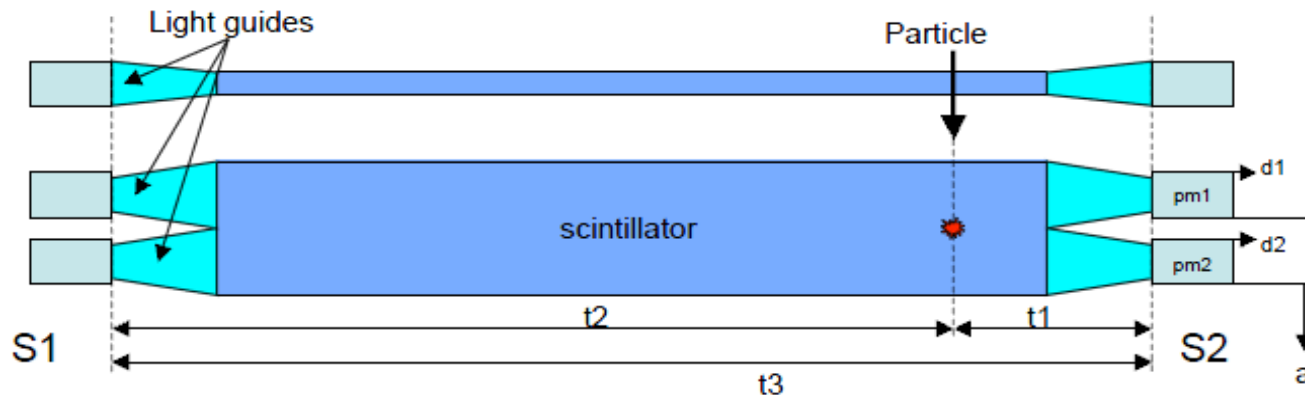
Change Board point has been Fix



Coo Calibration

Time for Longitude Coo Measurement

- 1: TOF Counter 2side Time different can be used for longitude Coo Measurement.
- 2: This measurement can be used for Tracker X identification....
- 3: For Beta measurement, This is also important to match with tracker, This imply two side time coherence measurement quality(Chi2C)
- 4: Can be used for recover bad side information if one side lost, or refind LT if it's Bad (No HT association or wrong LT finding(~30ns dead time) for one side)



Calibration algorithm

One Counter 2 side:

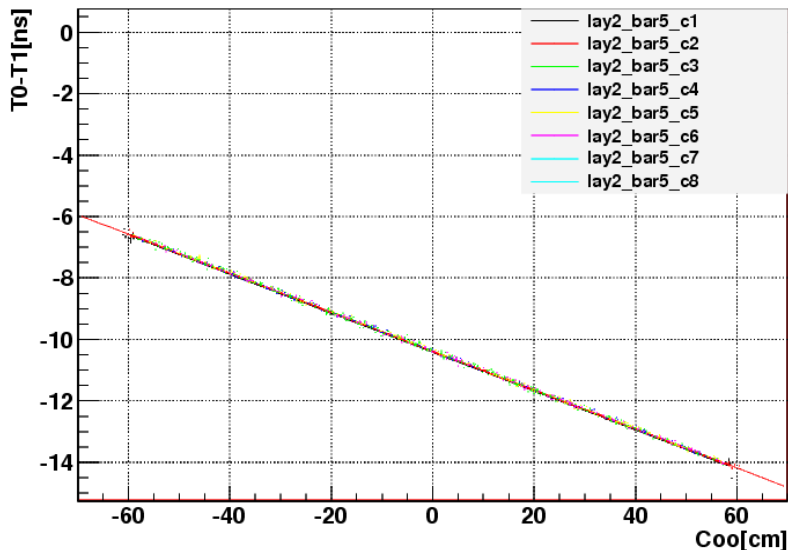
$$-T_{m0} = T_{raw} + (L-x)/v_0 + t_{del0} + S_0/Q^{p_0} - T_{trig}$$

$$-T_{m1} = T_{raw} + x/v_1 + t_{del1} + S_1/Q^{p_1} - T_{trig}$$

$$x = ((t_{m0} + S_0/Q^{p_0} - t_{m1} - S_1/Q^{p_1})/2 + C) * v = vdt + C1 \quad (v = 2 v_0 * v_1 / (v_0 + v_1))$$

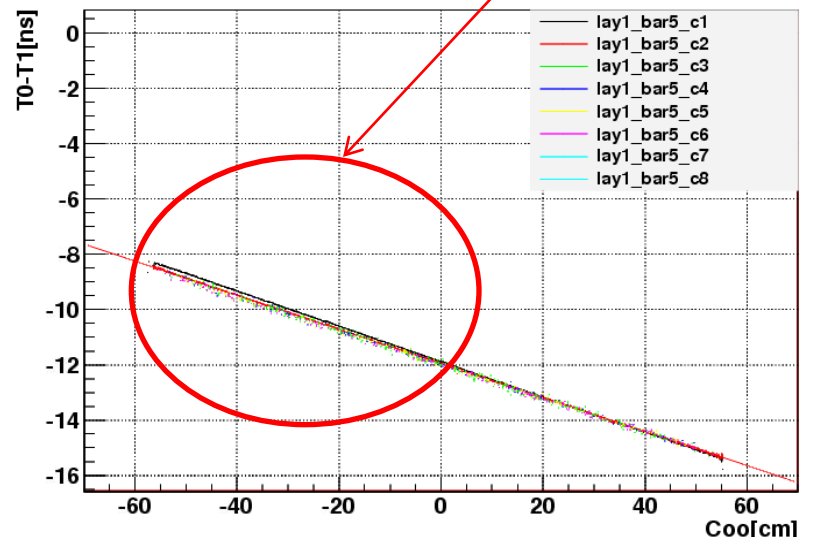
$$\chi^2 = \sum (x/v - (T_{m0} - T_{m1} + S_0/Q^{p_0} - S_1/Q^{p_1})/2 - C)^2 \quad (S_0, S_1, p \text{ from T Calib})$$

Coo vs T0-T1 lay2 bar5

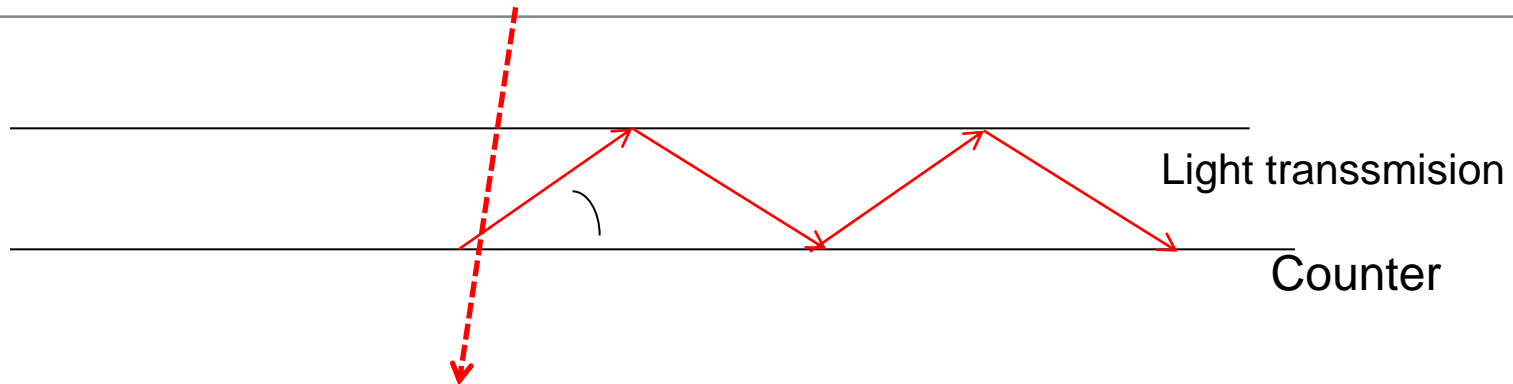


Slope shift a bit with charge

Coo vs T0-T1 lay1 bar5



Adding Compensate Item



Seems Large ADC amplitude More photon has big angle, light speed increase

Charge Fit Function to balance:

$$X^2 = (xv_0 - (Tm_0 - Tm_1 + (S_0 - dS)/Q^{p_0} - (S_1 + dS)/Q^{p_1})/2 - C)^2$$

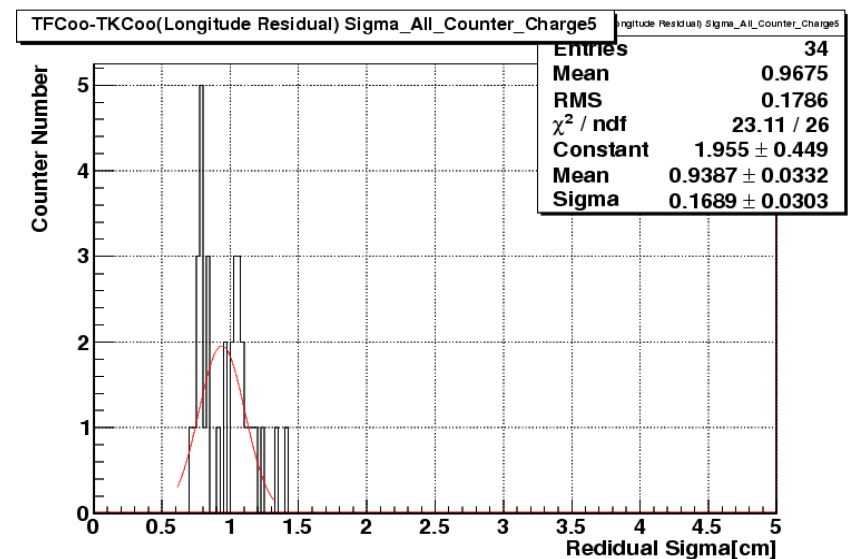
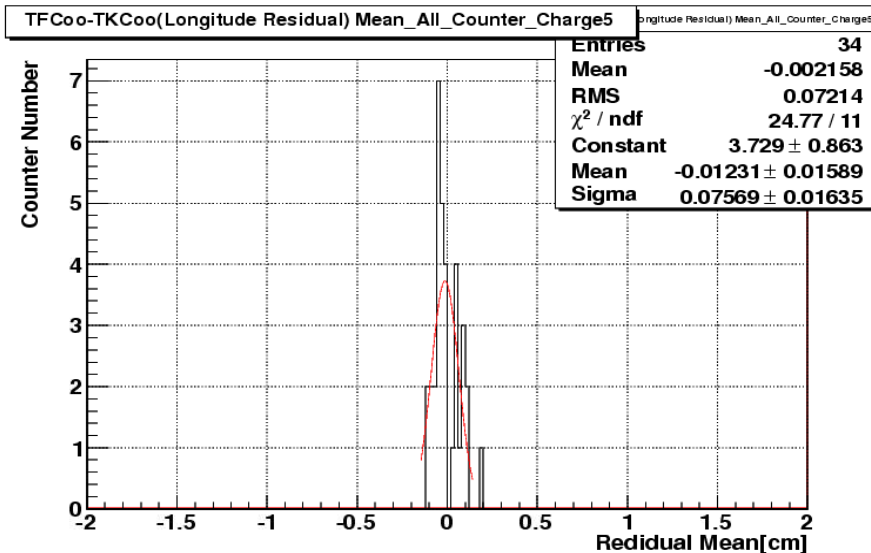
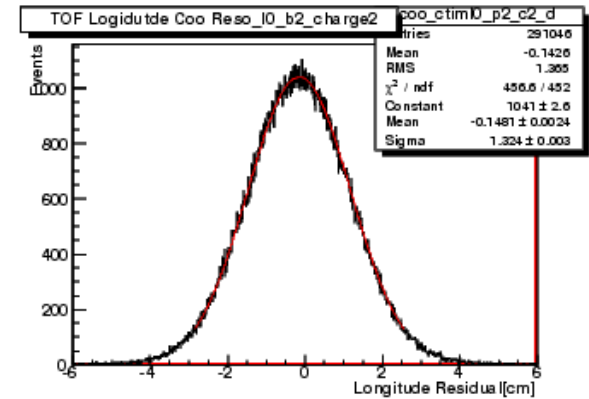
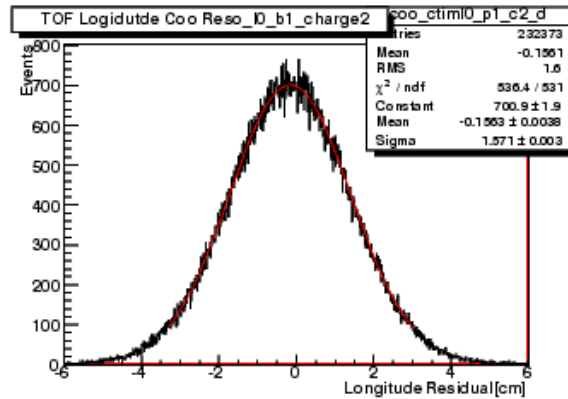
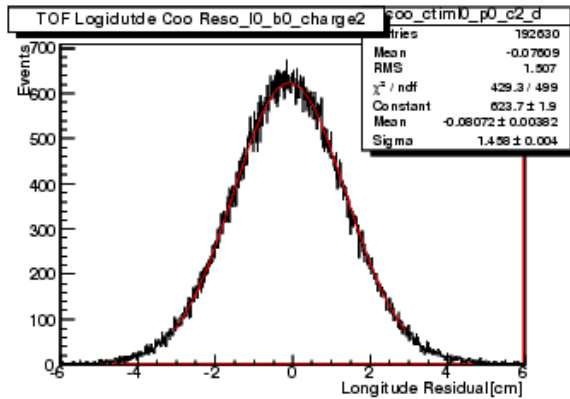
$$\Rightarrow x = ((tm_0 + (S_0 - dS)/Q^{p_0} - (tm_1 - S_1)/Q^{p_1})/2 + C) * v$$

Light Speed compensate item

Sample : Still Use Proton+Helium(+Weight1)+Nucleus(+Weight2)

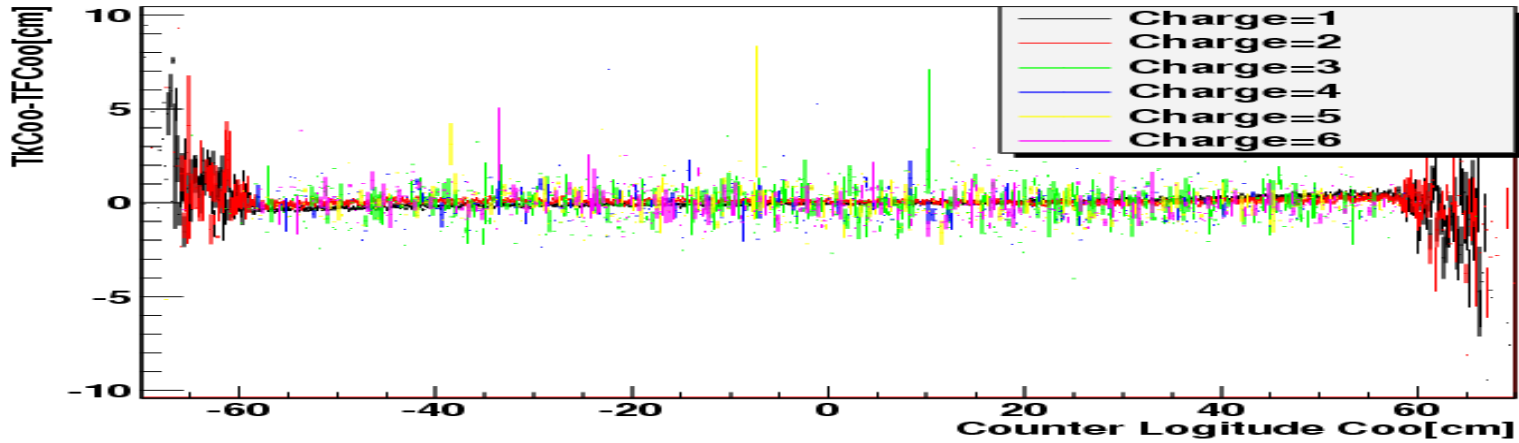
Minimization Chi2 to get parameters

Longitude TCoo Resolution



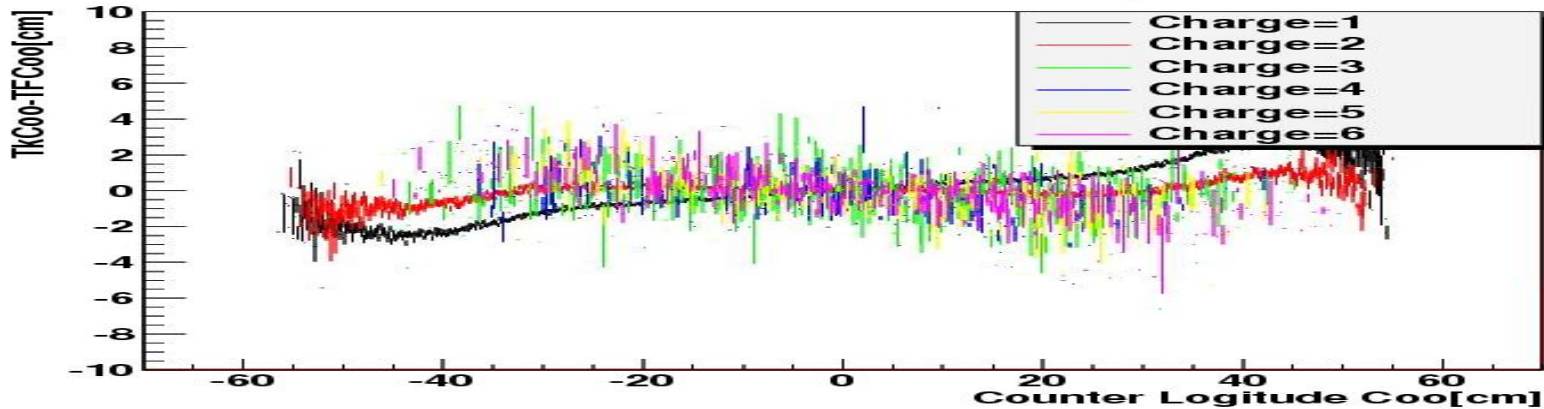
Longitude Coo Residual

TOF Logitude Coo VS Residual Lay2_Bar3



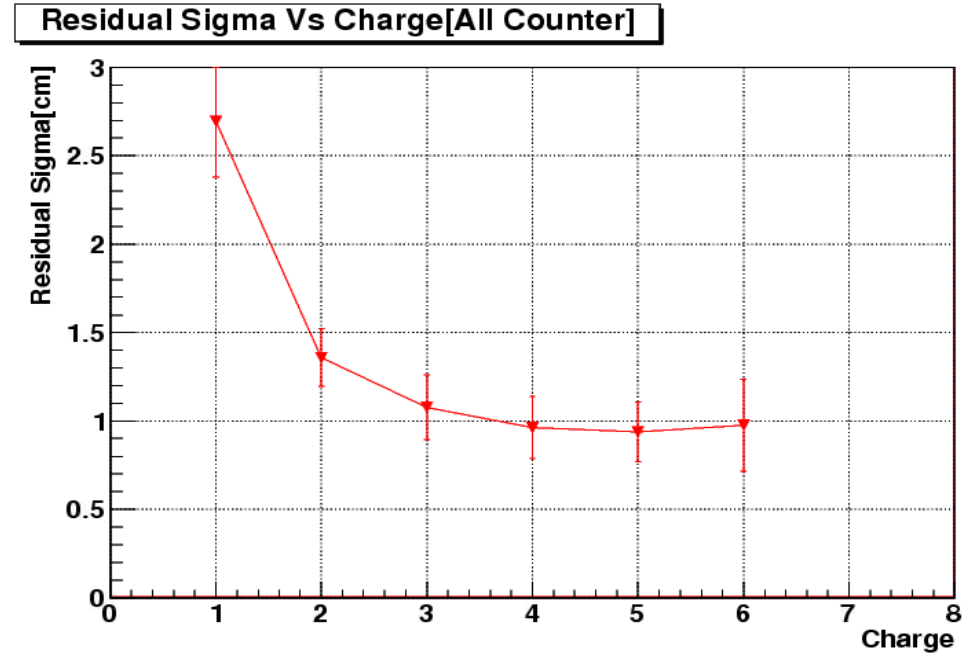
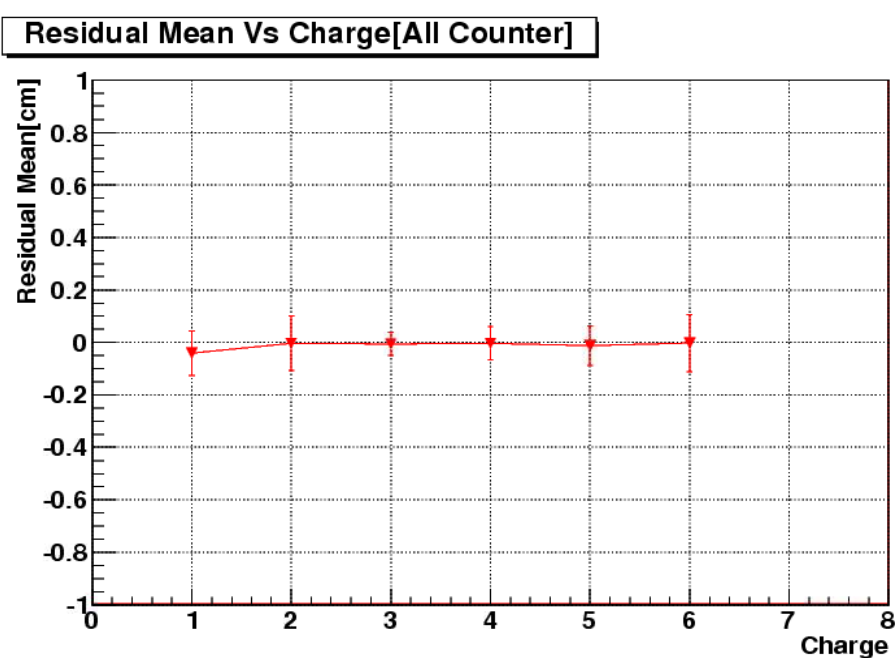
Normal Counter

TOF Logitude Coo VS Residual Lay1_Bar7



Trapezoid Counter

Longitude TCoo Resolution VS Charge



Efficient Light speed in scintillator $\sim 16\text{cm/ns}$ for one counter
Time resolution 160ps (proton) $\sim 48\text{ps}$ (carbon)
 $\Delta s = v\Delta t = 2.6\text{cm}$ (proton) $\sim 0.8\text{cm}$ (carbon) coherent with TCoo resolution

Software Development

New TOF Software Introduction

AMS New TOF Independent Software(BetaH version)

New TOF Software based TOF new calibration and new feature

1: Version 1.2 and TDV 1.0 was released, which already be used for B592 z>1 production for testing. Mainly for Time Calibration

2: Version 1.3 and TDV 1.1 was released, which updated Calibration(Coo+Time)

3: Version 1.3N was released this week, which expand production and lib dynamic rebuild in the same framework. Therefore user can use B584 or much lower version production data to do rebuild with the new software and new calibration.

4: Charge Part calibration and reconstruction will be integrated to the software for the following months.

.

- **Reconstruction Procedure**

- TofRawSide(1side ADC TDC)->TofClusterH(1 Fired Counter Time Edep...)->BetaH (Pattern Finding , Beta Mass...). ParticleR and ChargeR has index to access

New Feature:

1: Provide abundant tool for analysis base on beta measurement. Time interpolate, time recover, Beta refit....

2: Tag many Low Level reconstruction information in ClusterH and BetaH. Those information can be used for different kind of analysis.

4: Include TOF flexible Geometry Interface and TOFLocal-Global conversion

5: Mass calculation module

6: Support dynamic rebuild , which means rebuild can be redone with the newest calibration and newest software development

7: Easy to use

Class Reference

My title - Microsoft Internet Explorer

http://ams.cern.ch/AMS/Analysis/hp13itp1/root02_v5/html/development/html/classTofClusterHR.html

文件(F) 编辑(E) 查看(V) 收藏夹(A) 工具(T) 帮助(H)

收藏夹 MMM Services My title

TrElem

TofClusterHR

[\[legend\]](#)

[List of all members.](#)

Public Member Functions

int	NTofRawSide () <i>access function to TofRawSideR objects used</i>
int	iTofRawSide (unsigned int i) <i>access function to TofRawSideR objects used</i>
TofRawSideR *	pTofRawSide (unsigned int i) <i>access function to TofRawSideR objects used// i=0 NSide i=1 PSide</i>
	TofClusterHR ()
	TofClusterHR (int ilay, int ibar)
	TofClusterHR (unsigned int sstatus[2], unsigned int status, int pattern, int idsoft, double adca[2], double adcd[2][3], double sdtm[2], double times[2], double timer, double etimer, AMSPoint coo, AMSPoint ecoo, double edepa, double edepd, TofRawSideR *tfraws[2])
	TofClusterHR (AMSTOFClusterH *ptr)
virtual	~TofClusterHR ()
bool	IsGoodSide (int is) <i>check Counter Side is good or not //require A+T measure</i>
bool	IsOneLT (int is) <i>check Side whether only 1 LT in FT windows</i>
bool	IsExistHT (int is)

Internet 130%

My title - Microsoft Internet Explorer

http://ams.cern.ch/AMS/Analysis/hpl3itp1/root02_v5/html/development/html/classBetaHR.html

文件(F) 编辑(E) 查看(V) 收藏夹(A) 工具(T) 帮助(H)

收藏夹 MMM Services My title

Home Stop Print Page Setup Security Tools Help

BetaHR

[\[legend\]](#)

[List of all members.](#)

Public Member Functions

	BetaHR ()
	BetaHR (AMSBetaH *ptr)
	BetaHR (TofClusterHR *phith[4], TrTrackR *ptrack, TrdTrackR *trdtrack, TofBetaPar betapar)
virtual	~BetaHR ()
int	iTrTrack () const access function to <i>TrTrackR</i> object used
TrTrackR *	pTrTrack ()
int	iTrdTrack () const access function to <i>TrdTrackR</i> object Matched
TrdTrackR *	pTrdTrack () access function to <i>TrdTrackR</i> object Matched
int	NTofClusterH () const access function to <i>TofClusterHR</i> objects used
int	iTofClusterH (unsigned int i) access function to <i>TofClusterHR</i> objects used
TofClusterHR *	pTofClusterH (unsigned int i) access function to <i>TofClusterHR</i> objects used
TofClusterHR *	GetClusterHL (int ilay) Get pointer to TOF BetaH iLayer(0-3) ClusterH /*return 0 if not exist*/.
bool	TestExistHL (int ilay)

完成 Internet 130%

AMSTwiki Introduction

The screenshot shows a Microsoft Internet Explorer browser window with the address bar displaying <https://twiki.cern.ch/twiki/bin/view/AMS/BetaH>. The browser interface includes a menu bar with options like '文件(F)', '编辑(E)', '查看(V)', '收藏夹(A)', '工具(T)', and '帮助(H)'. The page content is organized into a sidebar and a main area. The sidebar on the left contains a navigation menu under the heading 'AMS', with sub-sections for 'AMS Web' (including 'Create New Topic', 'Index', 'Search', 'Changes', 'Notifications', 'Statistics', 'Preferences') and 'Public webs'. The main content area shows the breadcrumb 'TWiki > AMS Web > TOF > BetaH (10-Jul-2012, QiYan)' and three action buttons: 'Edit', 'Attach', and 'PDF'. The main text begins with the title 'BetaH' and a sub-section 'BetaH Software in AMSsoft'. The 'Author: Qi Yan' is listed. The text describes the IHEP Version TOF software, noting its independent calibration and use for TOF information analysis. A 'Feature' section follows, detailing 'TofClusterHR' (reconstructed from TofRawSide) and 'BetaH' (using Matched with Track or TrdTrack TOF Counters). Both features are noted to have a geometry interface for estimating TOF quality. The page concludes with an 'Example to Use' section and a 'Beta Meaument' heading.

BetaH < AMS < TWiki - Microsoft Internet Explorer

<https://twiki.cern.ch/twiki/bin/view/AMS/BetaH> Live Search

文件(F) 编辑(E) 查看(V) 收藏夹(A) 工具(T) 帮助(H)

收藏夹 MMM Services BetaH < AMS < TWiki

AMS

TWiki > AMS Web > TOF > BetaH (10-Jul-2012, QiYan) Edit Attach PDF

BetaH

BetaH Software in AMSsoft

Author: Qi Yan

IHEP Version [TOF](#) software: [TofRawSide](#)->[TofClusterH](#)->[BetaH](#) was released. This new software contains independent new calibration for [TOF](#), more analysis tool for user to use [TOF](#) information. This software had been implemented to do production of B592 z>1 for testing.

Feature

[TofClusterHR](#)
Reconstructed from [TofRawSide](#), records information of each fired [TOF](#) Counter. Coo, Time...

[BetaH](#)
Using Matched with Track(or [TrdTrack](#)) [TOF](#) Counters to reconstructed [BetaH](#), which mainly for calculating beta, nucleus mass. While Particle and Charge has index to access this class.

Both of them has goemetry interface, also provide some function to estimate [TOF](#) quality.

Example to Use

Beta Meaument

How to Rebuild BetaH(Refit)

1: Software requirement: latest AMSsoft

2: Data requirement: ISS data

3: Build Procedure:

Process each events using this Function:

->TofRech::Rebuild()

->Then relate class will be rebuild, and ParticleR and ChargeR will create index to this class.

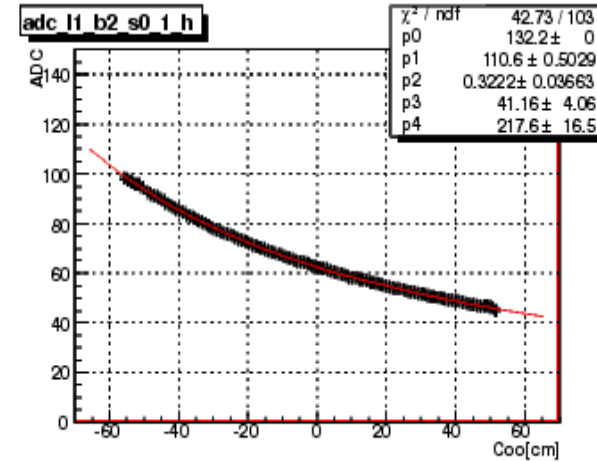
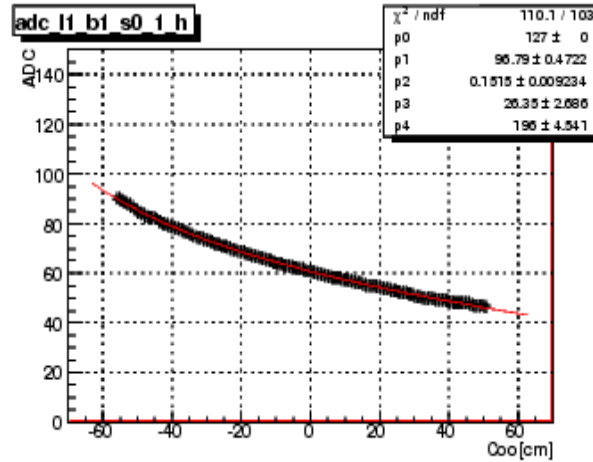
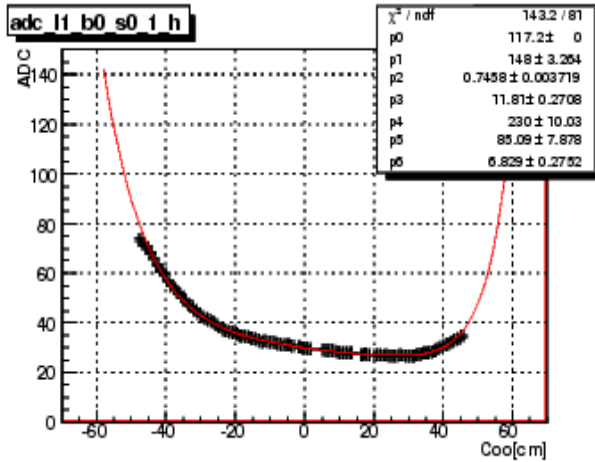
4: Limitation:

Further testing and optimization is on going.

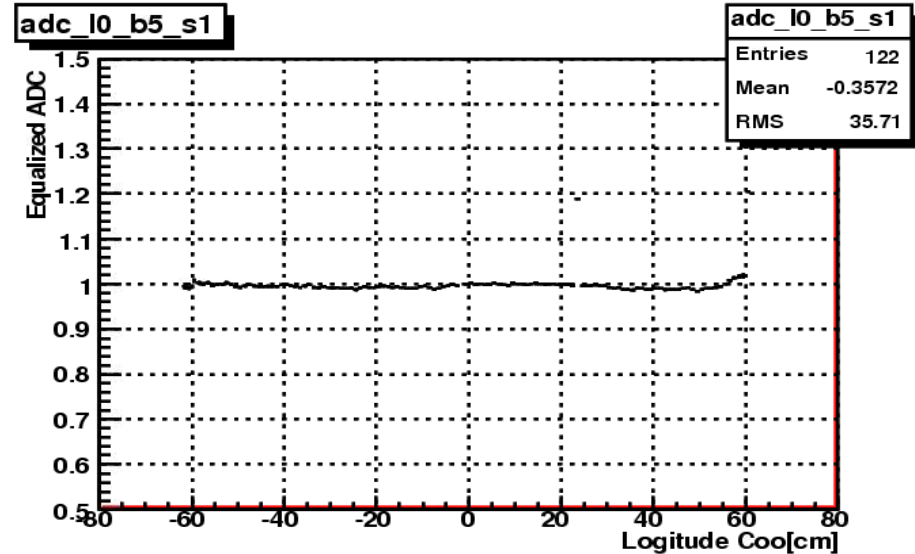
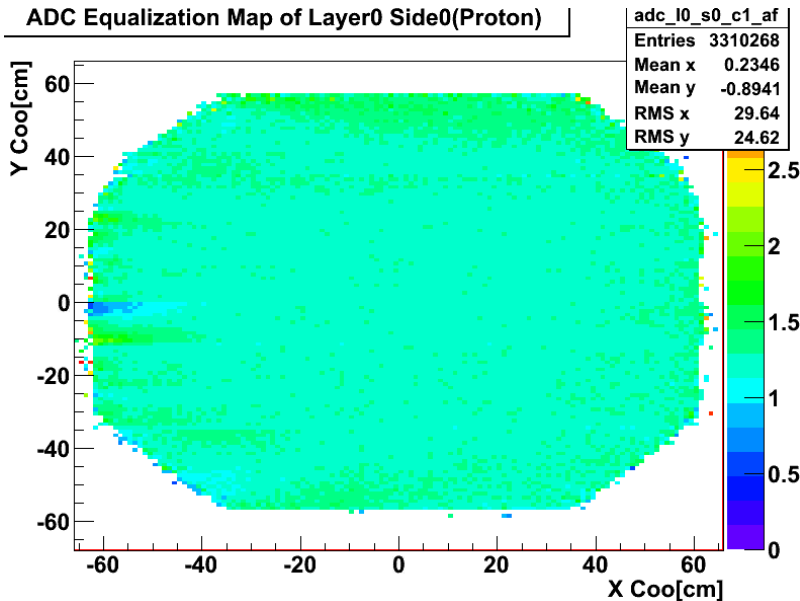
Summary and Outlook

- 1: The TOF new beta and longitude coo calibration of one year data is available with the new software.
- 2: New calibration: TOF beta resolution 4% for proton, ~1.2% for carbon(4Layer Hit). Longitude coo resolution: 2.8cm for proton, 0.9cm for carbon.
- 3: New software has been release with new feature, which is available to user.
- 4: TOF Charge calibration for this software(Hai Chen also take part) is in progress, and also new MC calibration will be done later.

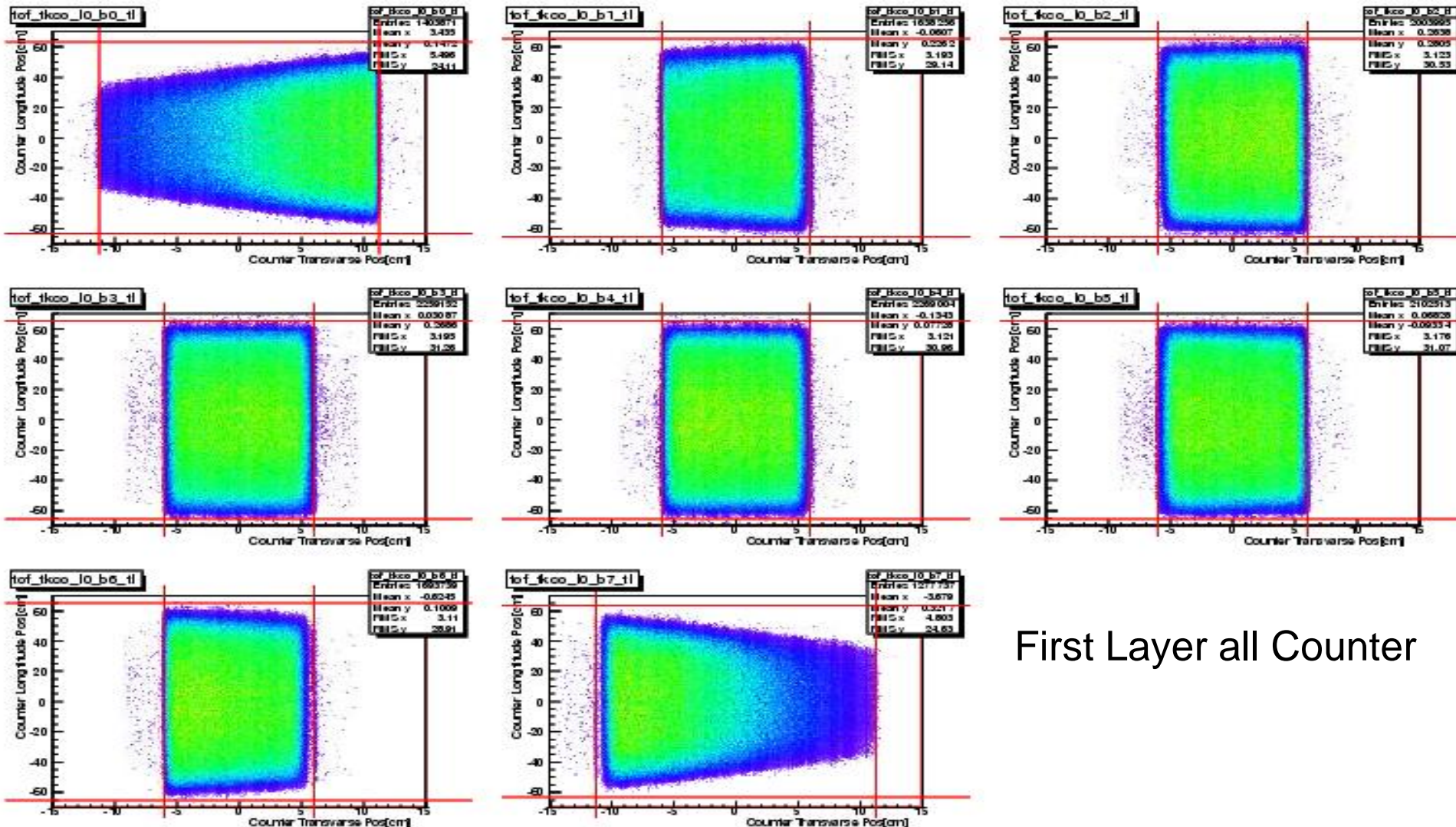
Charge Part Work Introduction



ADC Equalization Map of Layer0 Side0(Proton)



Transverse Coo Shift



First Layer all Counter

Hard to Calibrate Shift due to Boundary Factor

