Beam Monitoring

Toroids and MI DCCT
Target BPMs
Target Multiwire

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A bit of history

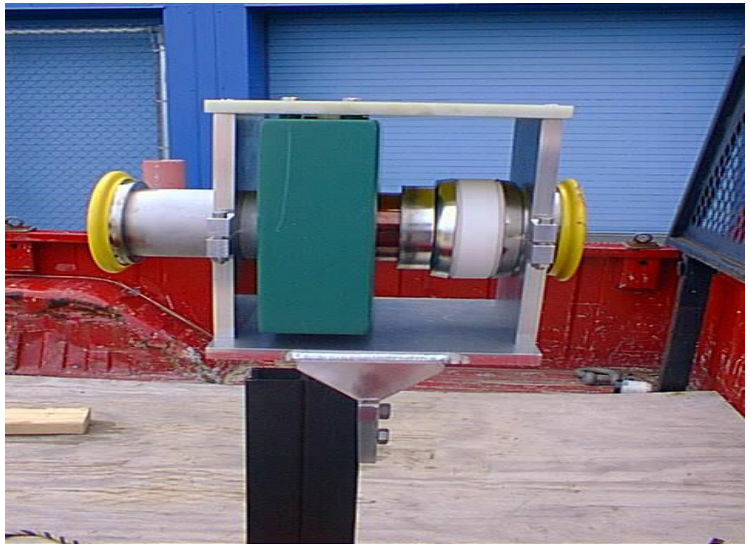
- Started with the first spill delivered. (before this run, all data saved)
- So techniques a bit old*:
- Toroids are multiply logged. Considerable agony in VAX days
- Now differences of a few spills. Was ~ 1% at times !
- Gather Lumberjack data using dataview2 or ACL - day by day
- Do some processing using Fortran (or C)
- Results saved in a spreadsheet (Gordon Koizumi)
- Has been run automatically using a cron job, E-Mail results daily
- Things like offsets and resolutions have varied over the years. **More Below**

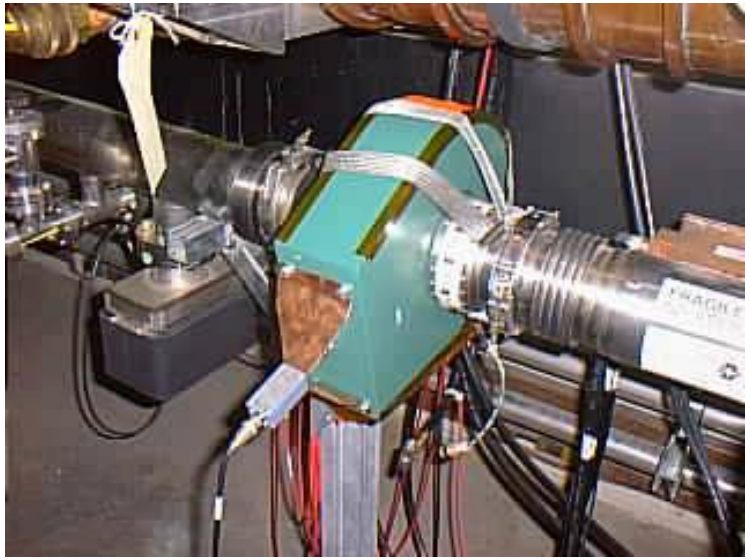
- *Now – Java and Python more commonly used.

The Toroids

- Calibration maintained by Aisha Ibrahim and Dallas Heikkinen
- Calibration – Send an appropriately shaped known pulse of current through the NuMI toroids and MI DCCT
- Most recent message: calibrated to 0.05 %

- TRTGTD is THE NvMI reference intensity





Figures from Aisha Paper

Lumberjack in NOT a DAQ system

- Just because data is requested does not mean it will be delivered.
- NOT a real time system.
- Number of spills is not the same from logger to logger – see below
- Spills from I:BEAM 57158, Spills from E:TRTGTD 57154
- The problem was much worse in the ‘Old Days’ !

- Data available in the Gordon Koizumi Spread Sheets

Sample of Daily Analysis

- Logged start and stop : Start time 12-Jan-2016:00:00:00
- Logged start and stop : Stop time 13-Jan-2016:00:00:00
- Gordon stuff 1 1499155.250 i_beam.tmp
- Gordon stuff 2 1500567.250 e_tr101d.tmp
- Gordon stuff 3 1494279.375 e_trtgtd.tmp
- Gordon stuff 4 1494251.000 d_trtgtd.tmp
- Gordon stuff 5 7219.676 e_tlmpt.tmp
- Gordon stuff 6 842.644 e_tlmctd.tmp
- Gordon stuff 7 81.132 e_tlmctu.tmp
- Gordon stuff 8 1282.425 e_tlmns.tmp
- Gordon stuff 9 922254.000 e_tlmnsh.tmp
- Gordon stuff 10 64021.000 Number of E: $ADs
- Gordon stuff 11 57154.000 Number of E: $ADs with Beam
- Gordon stuff 12 64022.000 Number of I: $ADs
- Gordon stuff 13 57158.000 Number of I: $ADs with beam

Other checks of data logging with Lumberjack

- Things like successive time stamps equal >> and data equal
- Experience suggests possible issues for monitoring

```
 Number of cases repeat gt  5 =     0
            ( see dcheck.txt for details
          maximum length of repeat sequence =    2
           that sequence ends at sample no   13967

          Number of time lockups
              (see tcheck.txt for details)        0
```

Ratios of Intensity Monitors

Note Widths:

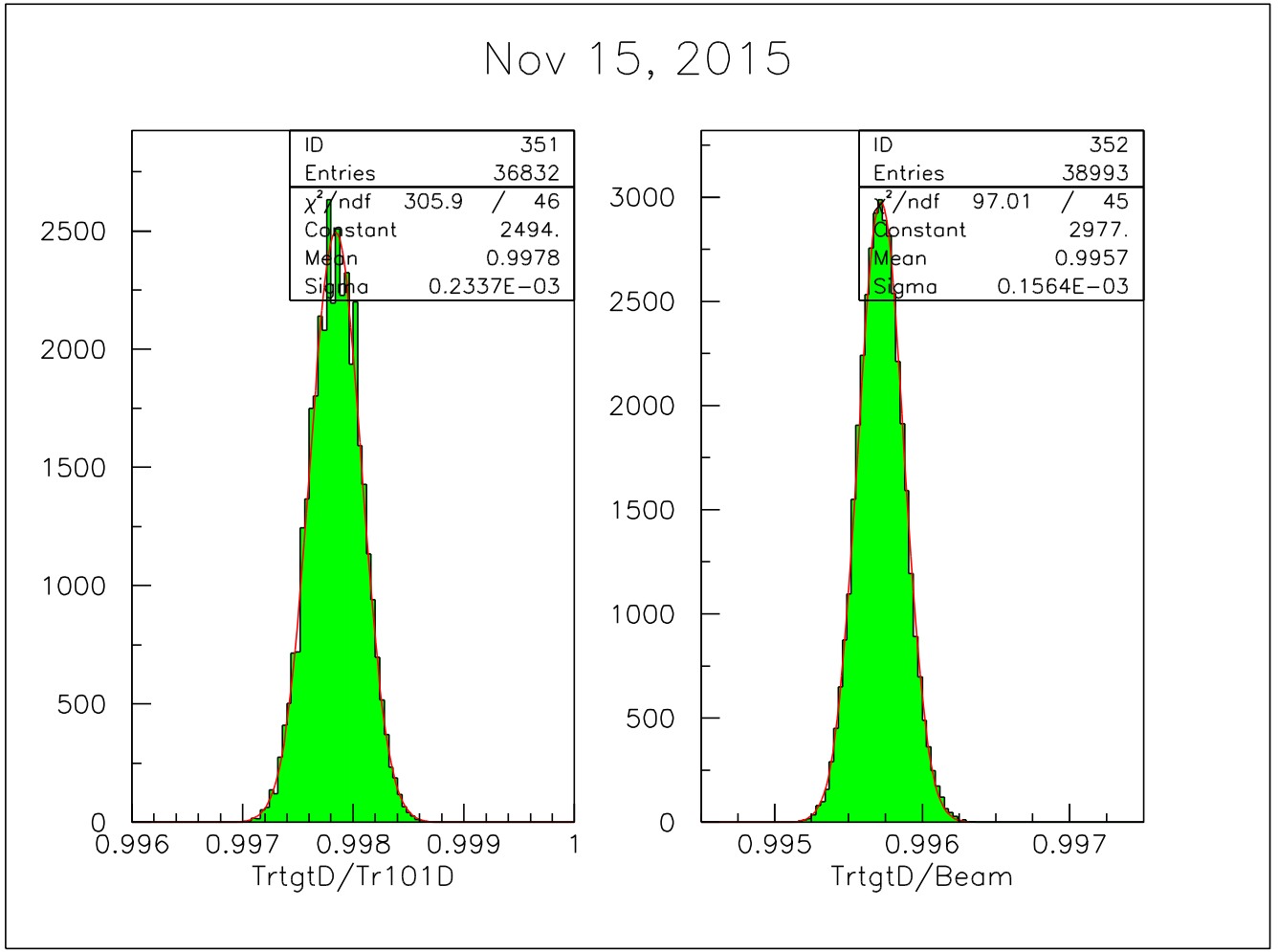
Trtgtd/Tr101D 0.00023

Trtgtd/Beam 0.00016

That is: **σ ~ 2 x 10^{-4}**

Widths may depend on intensity.
These plots at 23 x 10^{12}
At 32 x 1012, s = .00014, .00016
Widths also subject to machine operation.

May of course create a third (redundant) ratio – not shown

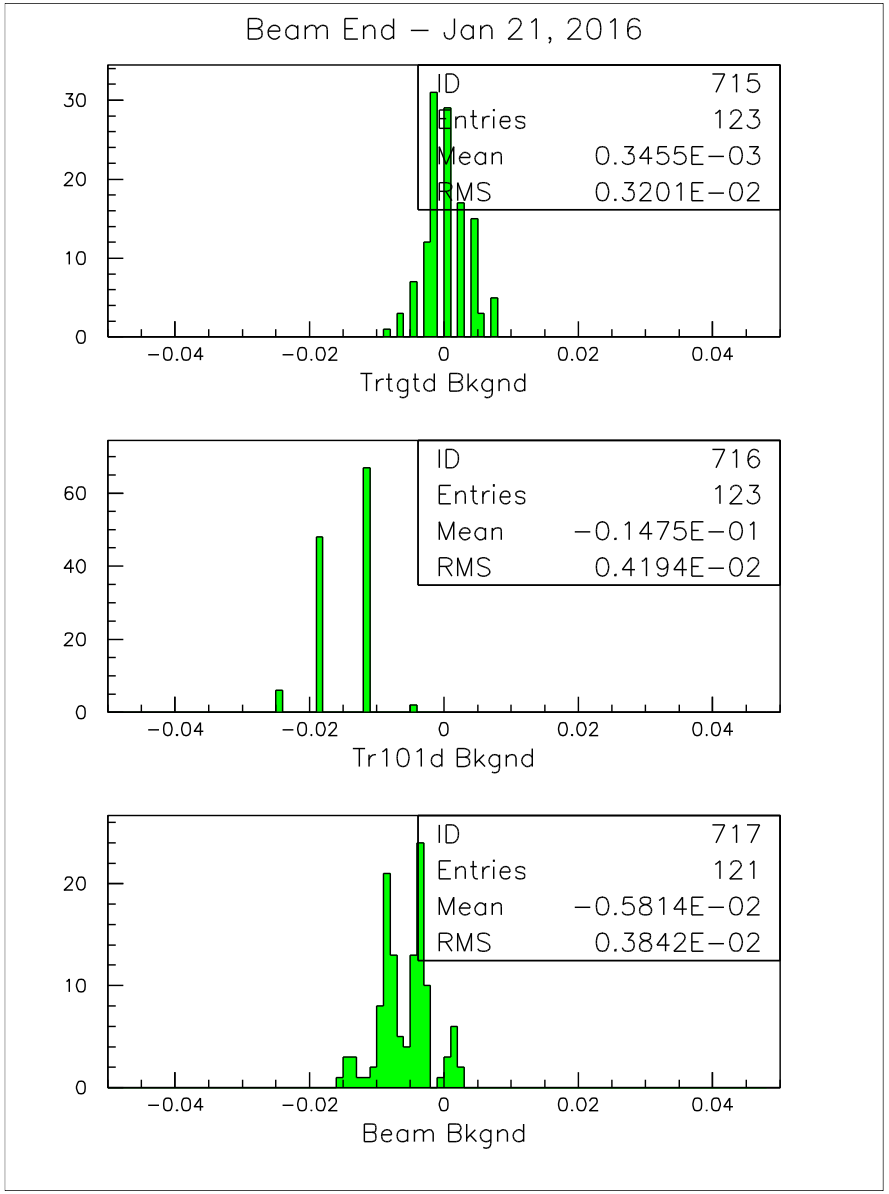


Toroid Backgrounds / Offsets

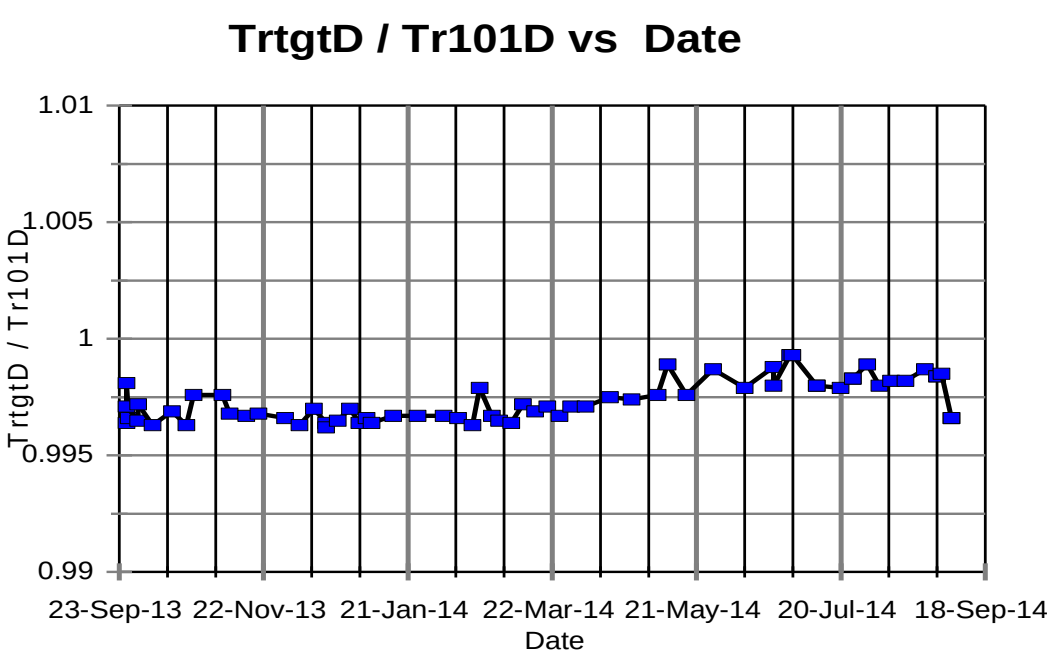
Toroids have small offsets and noise
Scale is ~ .01

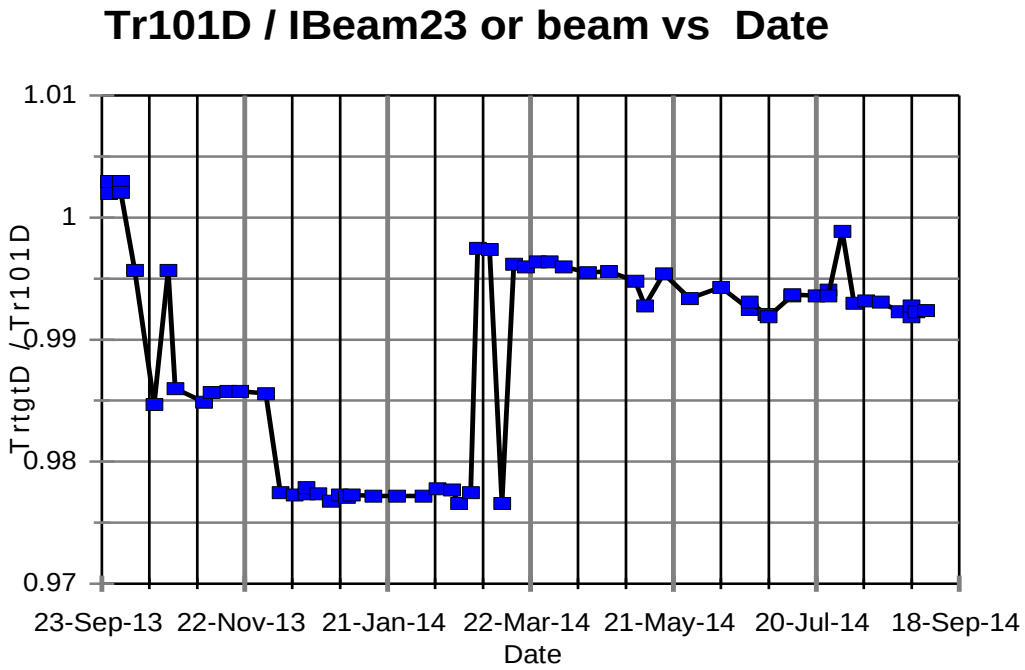
Nominal Signal ~ 20 to 40

Noise/Signal ~ < 0.001



Monitoring a Full Run Period



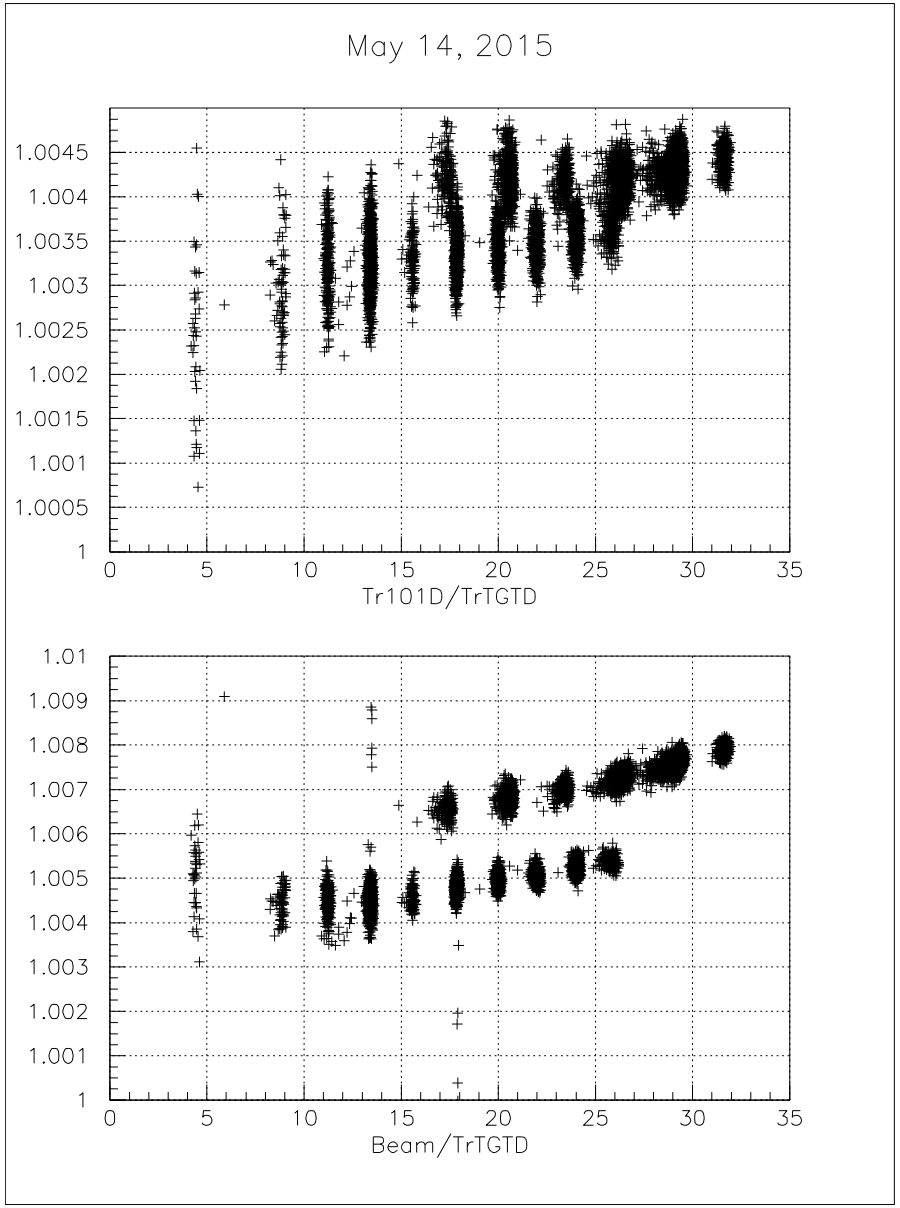


- Numi Got more protons than AD delivered this cycle !
- Now these ratios are monitored daily in Gordon Plots

Ratios vs Intensity

Horizontal Axis is TRTGTD Intensity

Data collected when the machine was started slowly increasing the intensity



Conclusions:

Beam Intensity monitoring is very stable and has minimal background/offset

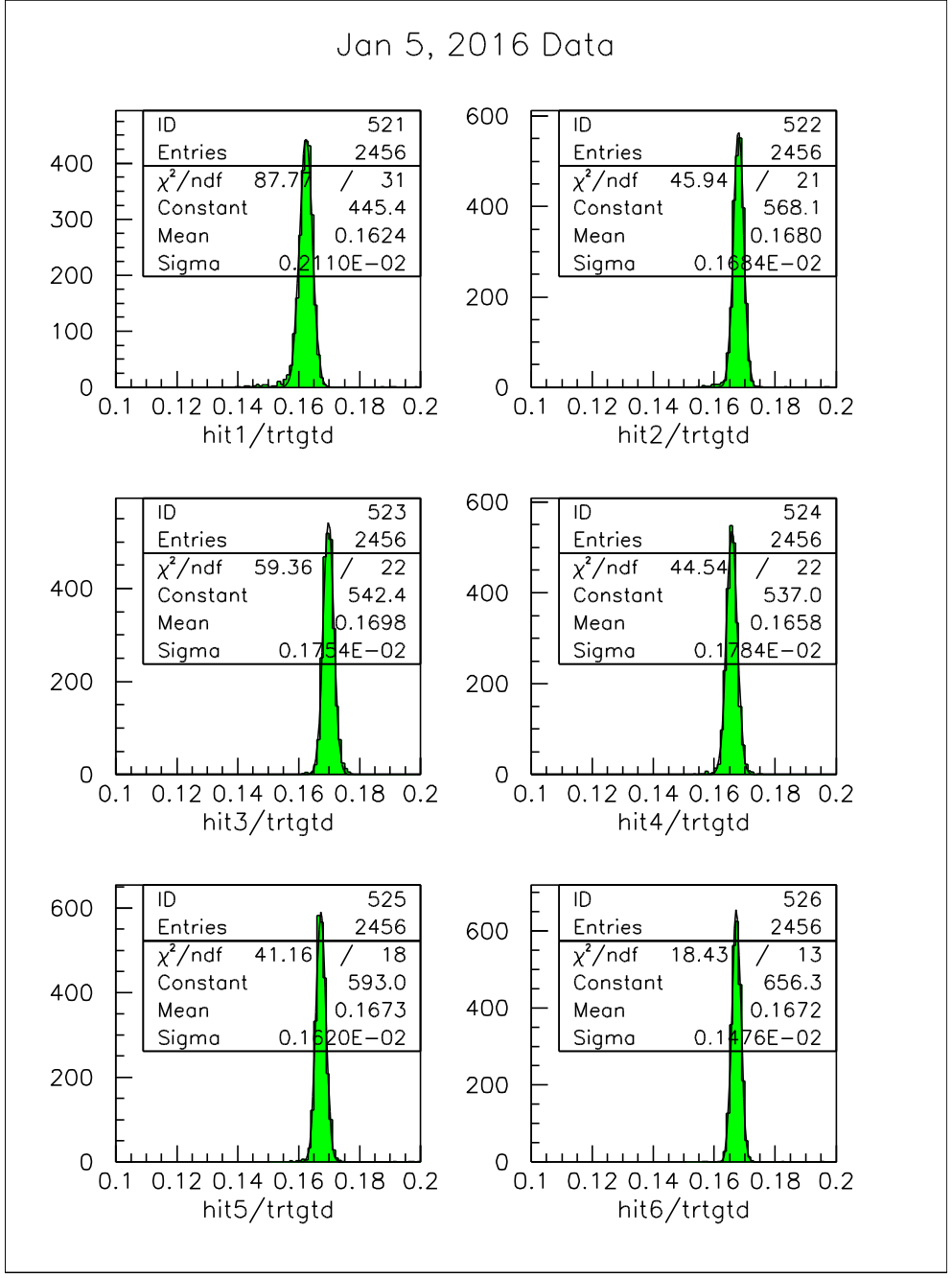
TRTGTD is a very stable and accurate monitor of the beam intensity.

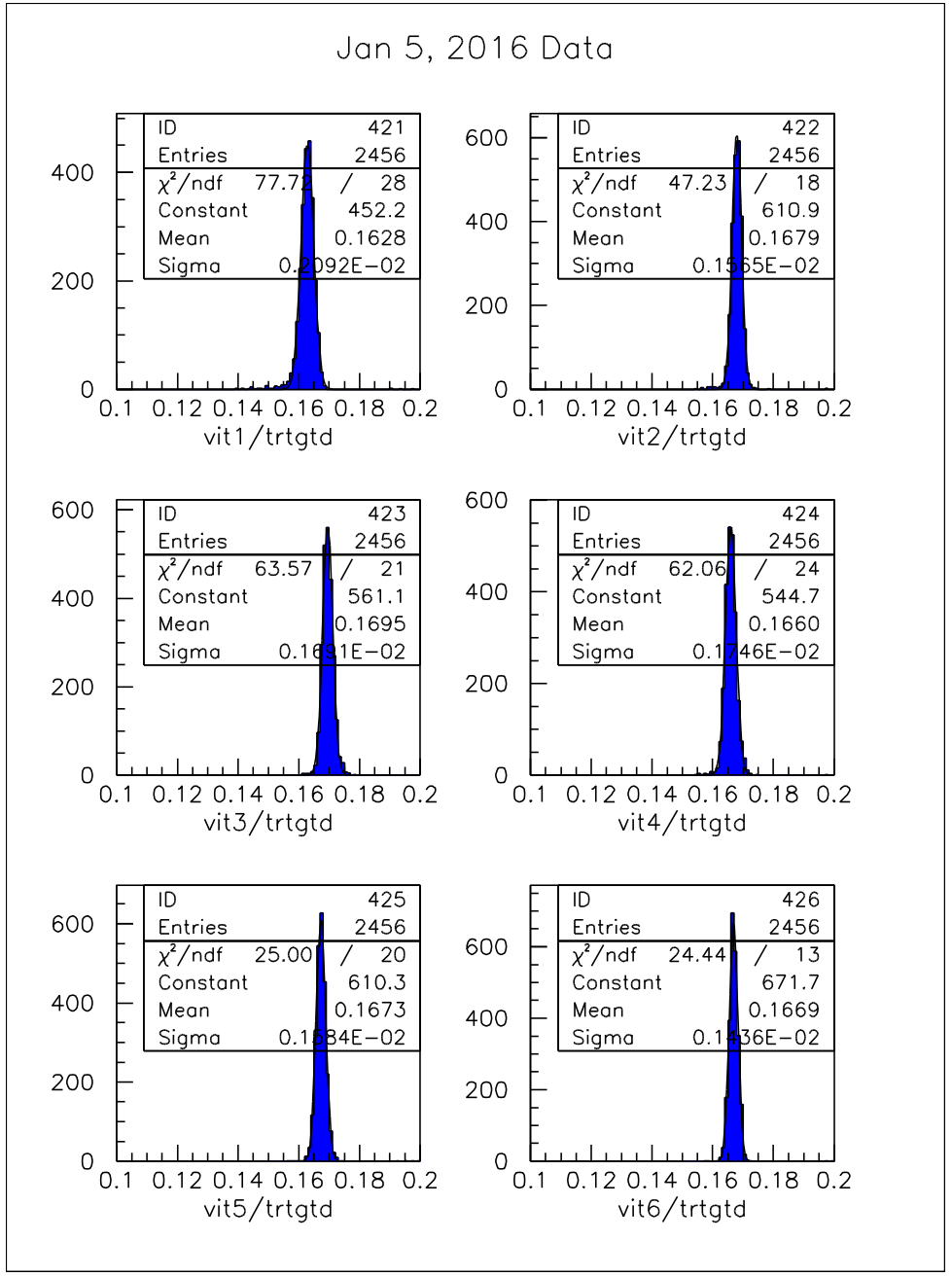
The intensity is well monitored and available via the Gordon Spreadsheet.

Use BPMs to monitor Intensity Bunch by Bunch

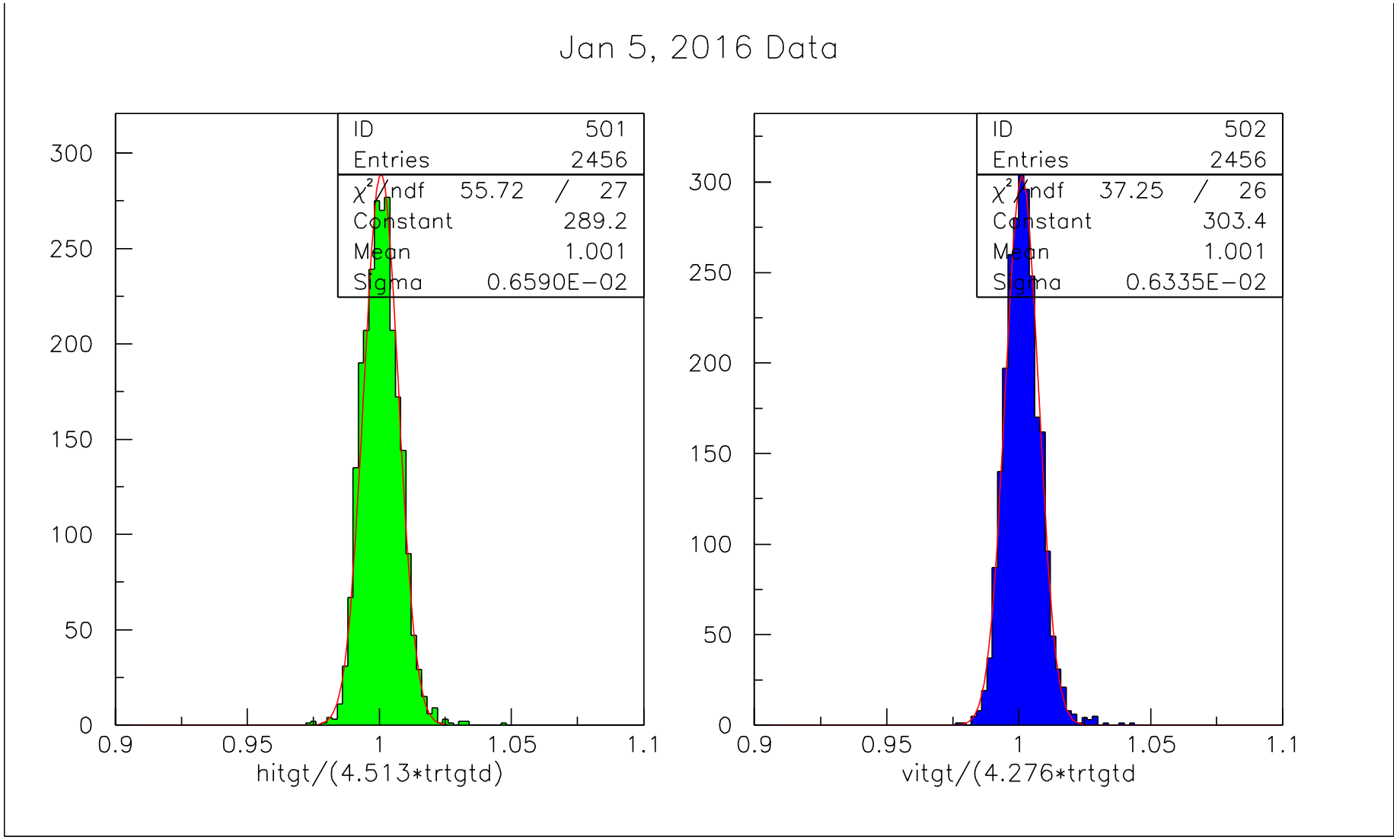
- Toroids do not have the time resolution to see individual bunches
- The BPMs do have the time resolution to see the individual bunches
- BUT – the intensities are not calibrated
- for example hitgt, and sum(hitgt[1] … hitgt[6]) have different normalizations
- Two Sets of plots, Without, then With Slipstacking

- **Usually X (horizontal) is in Green**
- **Usually Y (vertical) is in Blue**

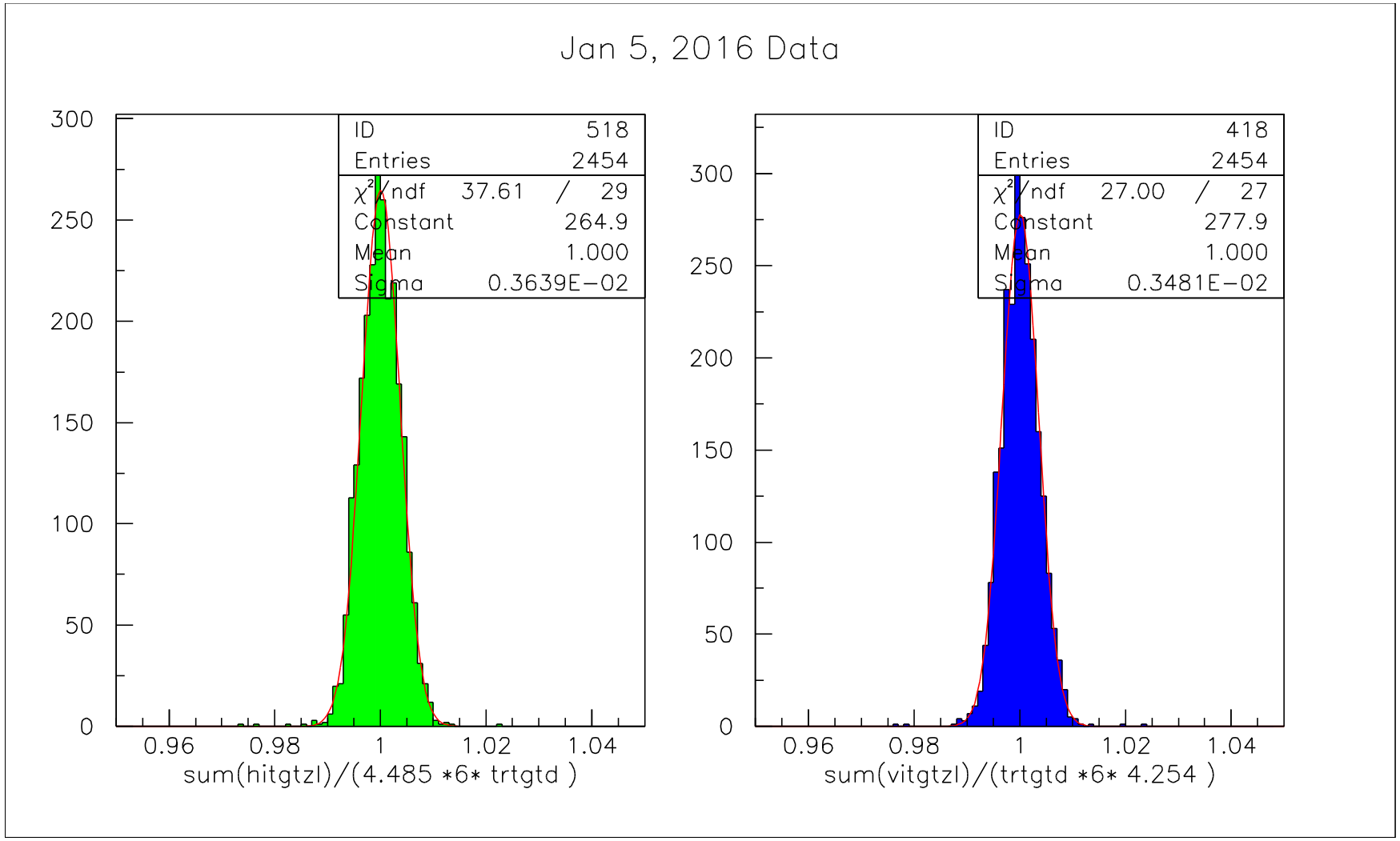

Jan 5, 2016 Data
ID 521
Entries 2456
χ²/ndf 87.77 / 31
Constant 445.4
Mean 0.1624
Sigma 0.2110E−02
hit1/trtgtd
ID 522
Entries 2456
χ²/ndf 45.94 / 21
Constant 568.1
Mean 0.1680
Sigma 0.1684E−02
hit2/trtgtd
ID 523
Entries 2456
χ²/ndf 59.36 / 22
Constant 542.4
Mean 0.1698
Sigma 0.1754E−02
hit3/trtgtd
ID 524
Entries 2456
χ²/ndf 44.54 / 22
Constant 537.0
Mean 0.1658
Sigma 0.1784E−02
hit4/trtgtd
ID 525
Entries 2456
χ²/ndf 41.16 / 18
Constant 593.0
Mean 0.1673
Sigma 0.1520E−02
hit5/trtgtd
ID 526
Entries 2456
χ²/ndf 18.43 / 13
Constant 656.3
Mean 0.1672
Sigma 0.1476E−02
hit6/trtgtd


Jan 5, 2016 Data
ID 421
Entries 2456
χ²/ndf 77.77 / 28
Constant 452.2
Mean 0.1628
Sigma 0.2092E−02
vit1/trtgtd
ID 422
Entries 2456
χ²/ndf 47.23 / 18
Constant 610.9
Mean 0.1679
Sigma 0.1565E−02
vit2/trtgtd
ID 423
Entries 2456
χ²/ndf 63.57 / 21
Constant 561.1
Mean 0.1695
Sigma 0.1691E−02
vit3/trtgtd
ID 424
Entries 2456
χ²/ndf 62.06 / 24
Constant 544.7
Mean 0.1660
Sigma 0.1746E−02
vit4/trtgtd
ID 425
Entries 2456
χ²/ndf 25.00 / 20
Constant 610.3
Mean 0.1673
Sigma 0.1584E−02
vit5/trtgtd
ID 426
Entries 2456
χ²/ndf 24.44 / 13
Constant 671.7
Mean 0.1669
Sigma 0.1436E−02
vit6/trtgtd

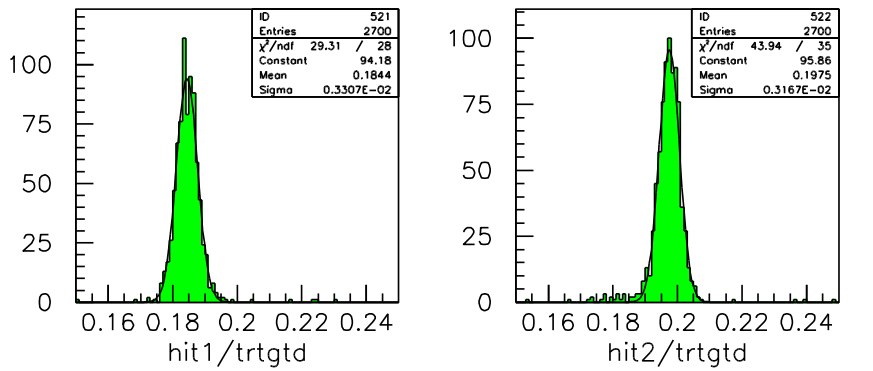
Normalized Ratio of {hi,vi}bpm/trtgtd No Slipstacking

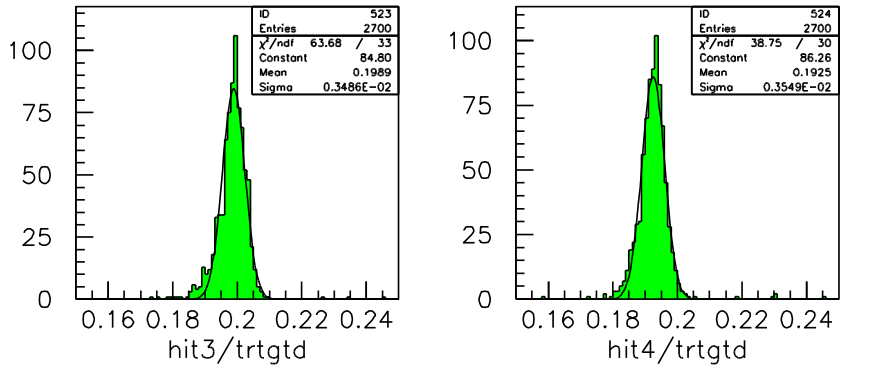


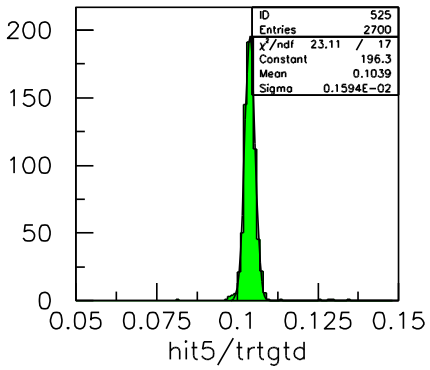
Normalized Sum({h,v}ibpm[i]/trtgtd) No Slipstack

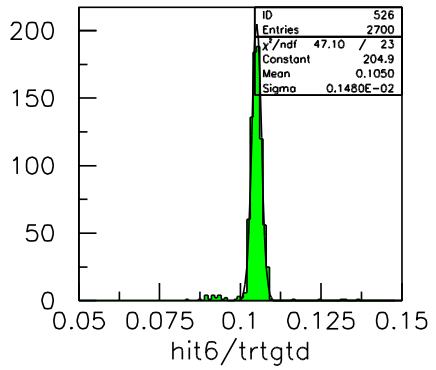


Jan 7, 2016 Slip Stack

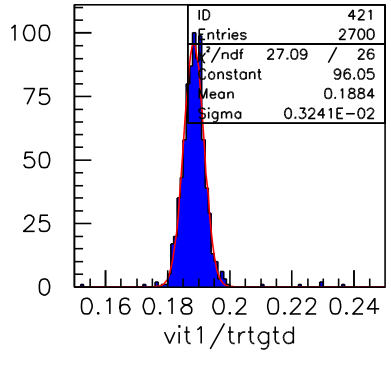


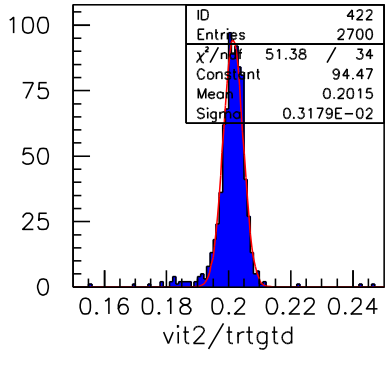


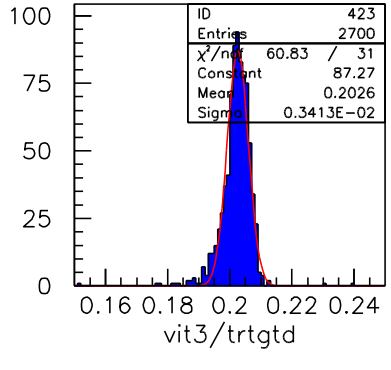


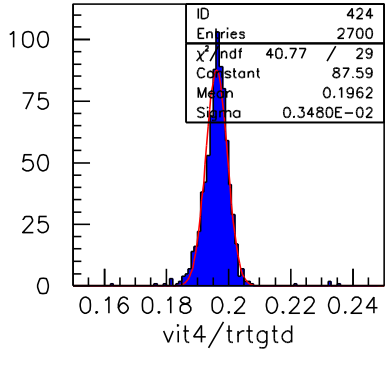


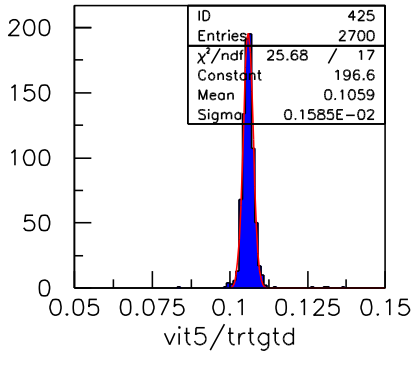
Jan 7, 2016 Slip Stack

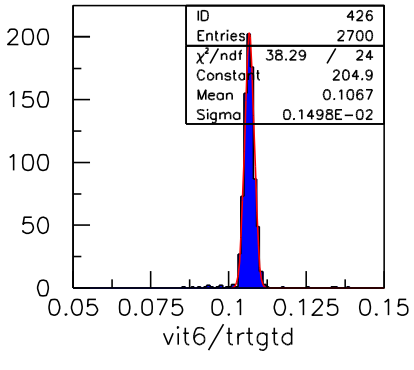




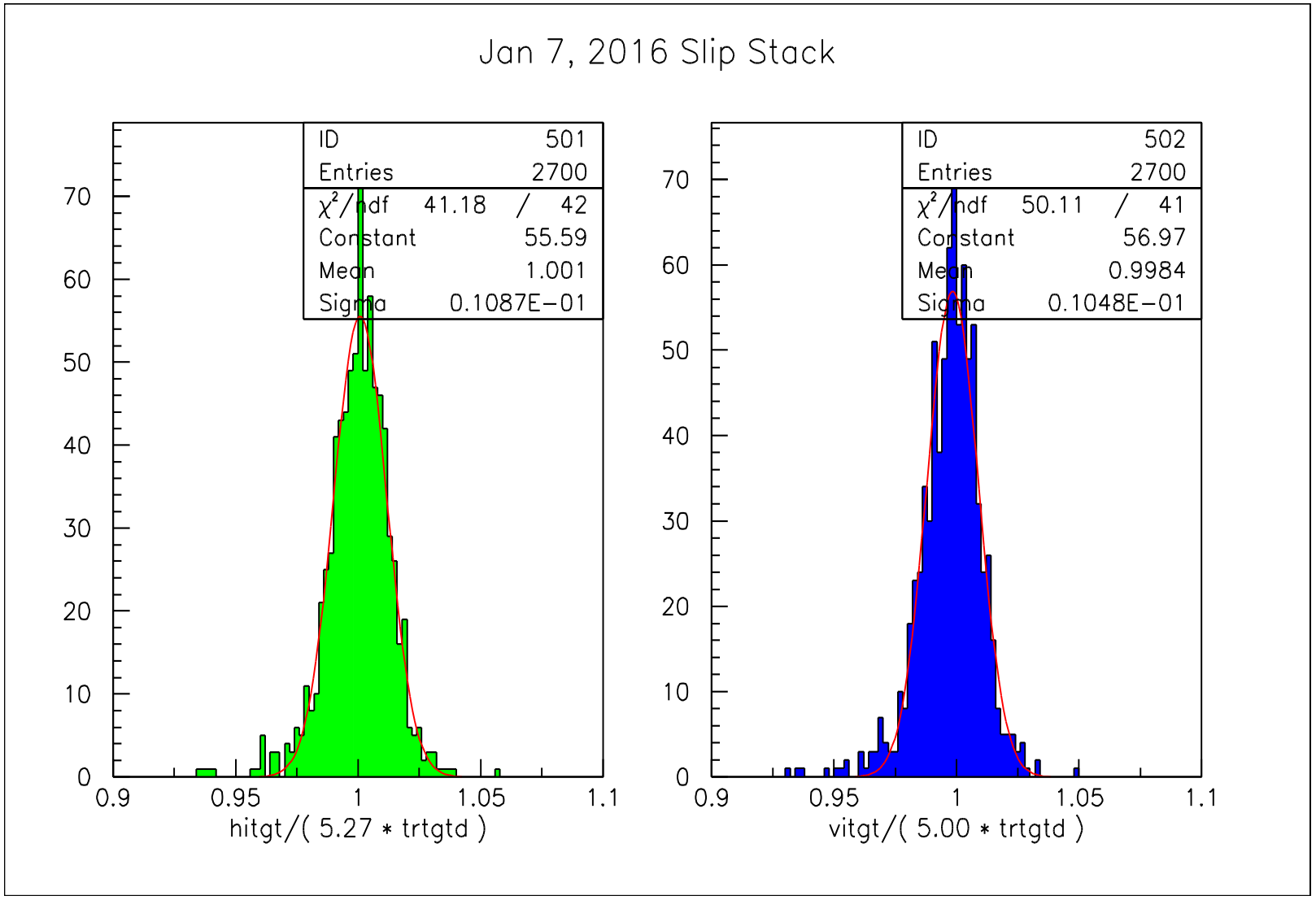




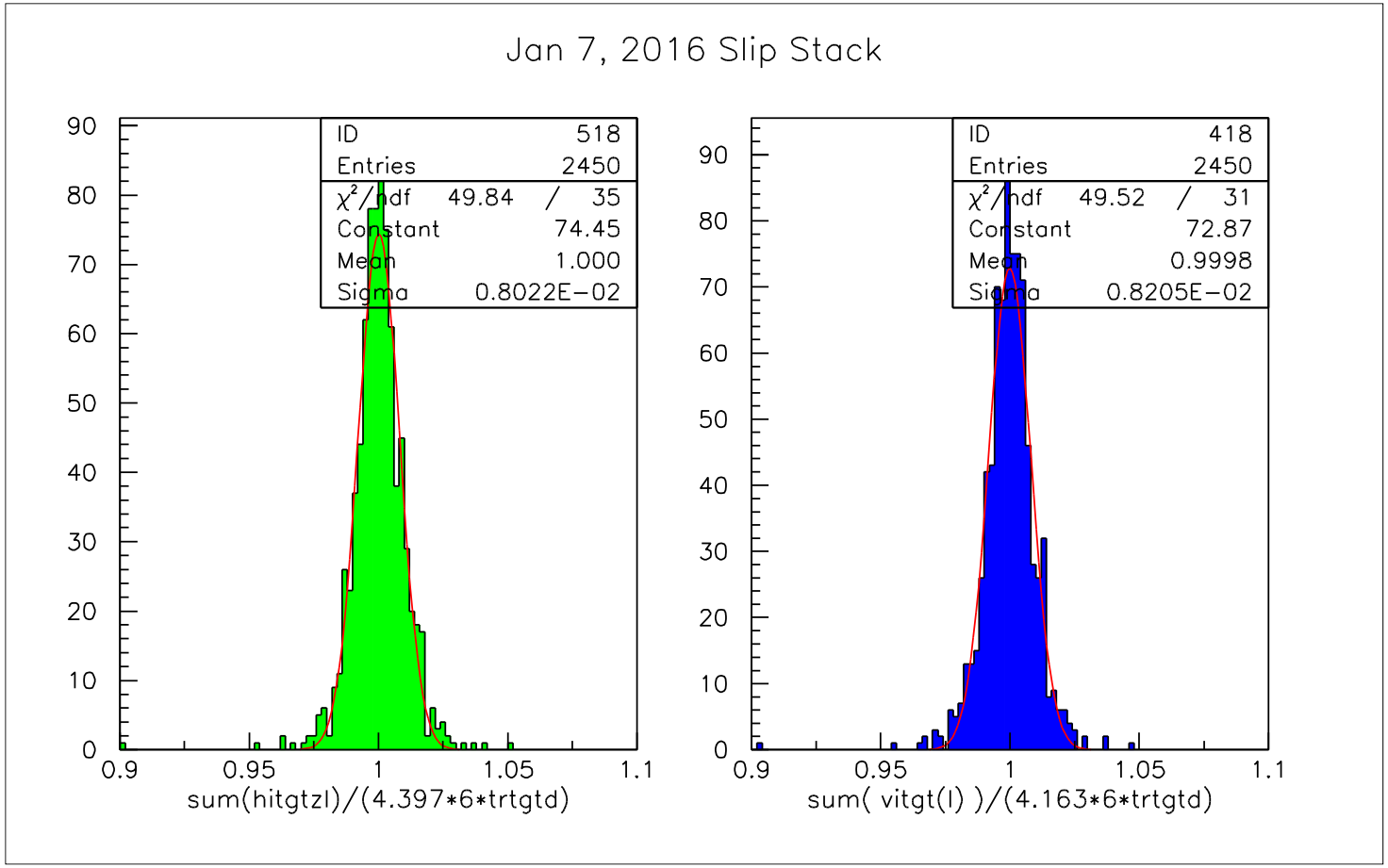




Normalizing HITGT and VITGT to TRTGTD



Normalizing Sum{hitgt_i, vitgt_i} to TRTGTD



Summary of BPM normalizations

σ = width of BPM/TrtgtD distribution

• No Slipstack	H	4.51	
•	V	4.28	σ = .0066
	H sum	4.48	
	V sum	4.25	σ = .0036
With Slipstack	H	5.27	
	V	5.00	σ = .011
	H sum	4.40	
	V sum	4.16	σ = .008

Long term stability of these calibration has not been studied.

Current BPM Positions

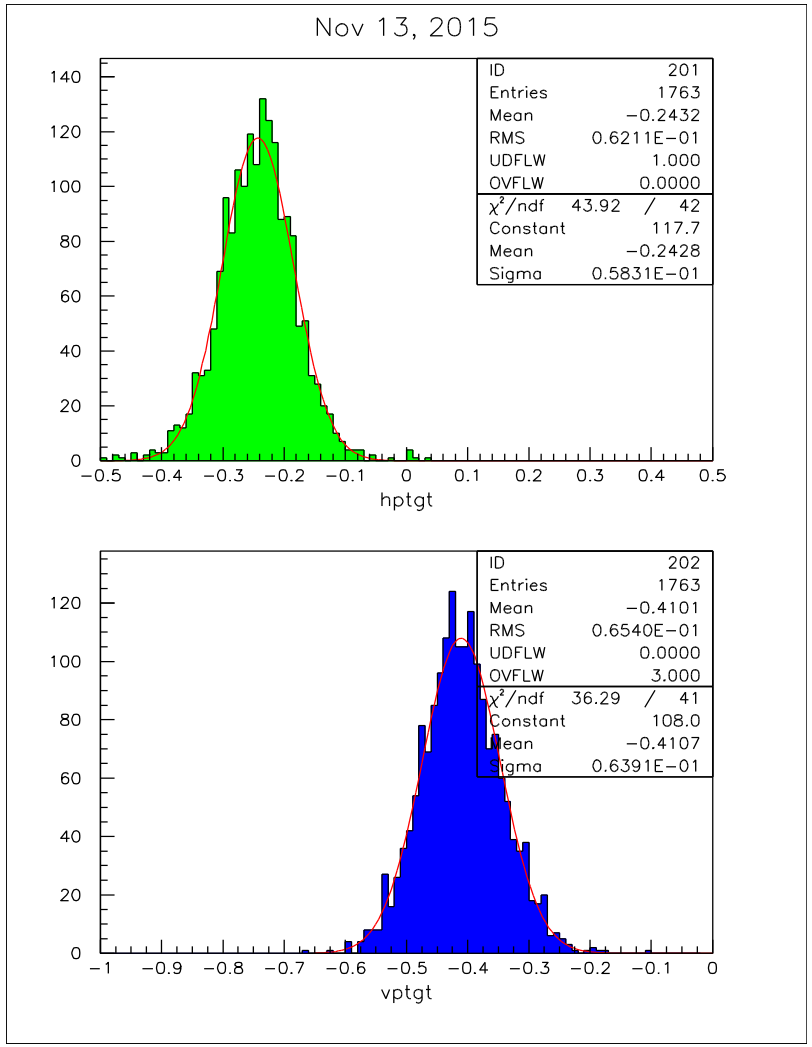
Current raw BPM positions

X: -0.24 mm, σ = 0.058

Y: -0.41 mm, σ = 0.064

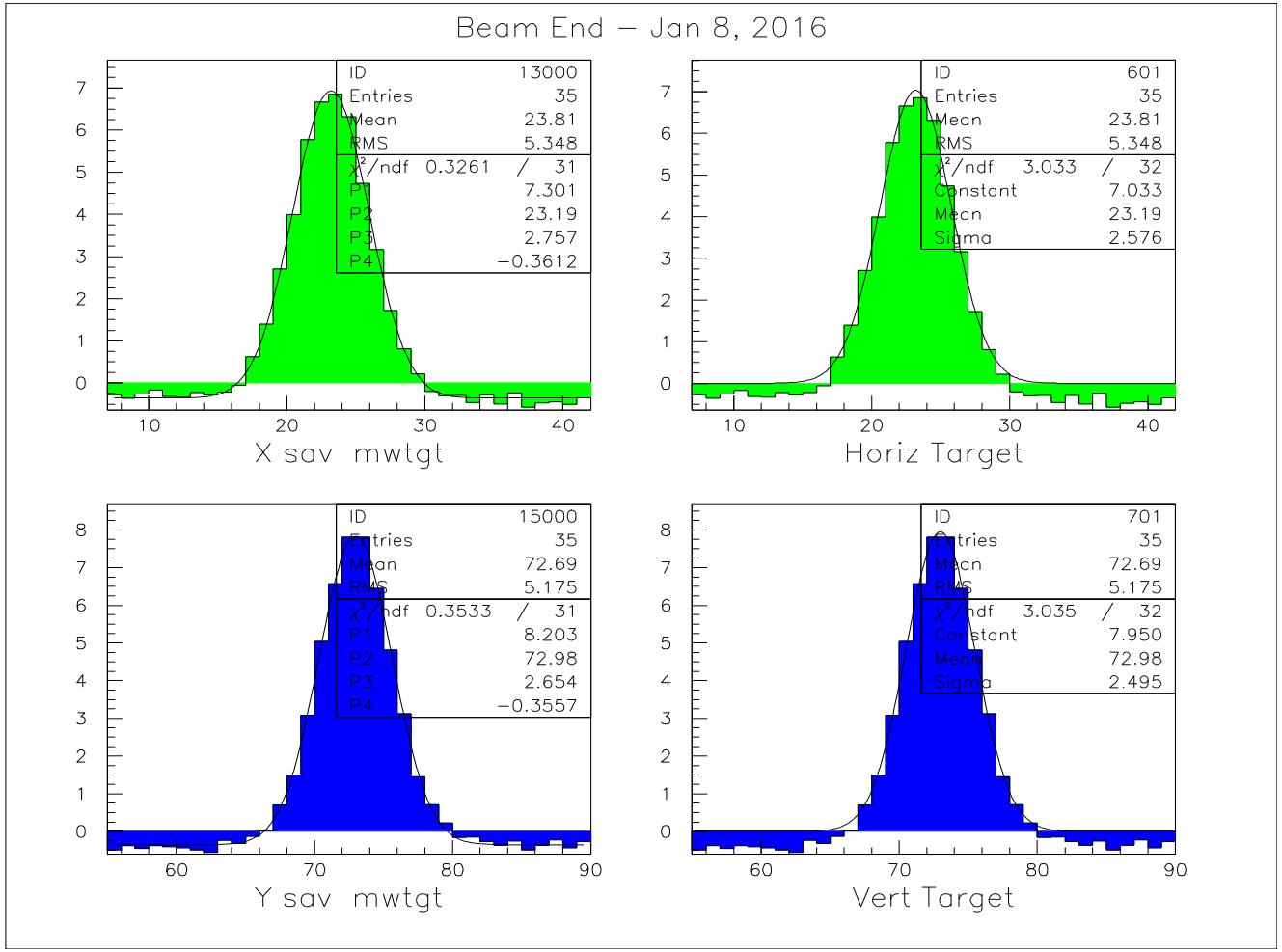
Reminder:

Last year, both of the BPM raw positions were at +1 mm



The raw SEM data, with a fit to a Gaussian + bkgnd.

- Target SEM wire spacing is 0.5 mm.
- Fits are in ‘wire space’
- The wire spacing for the target SEM is 0.5 mm



Compare BPM, SEM position measurement

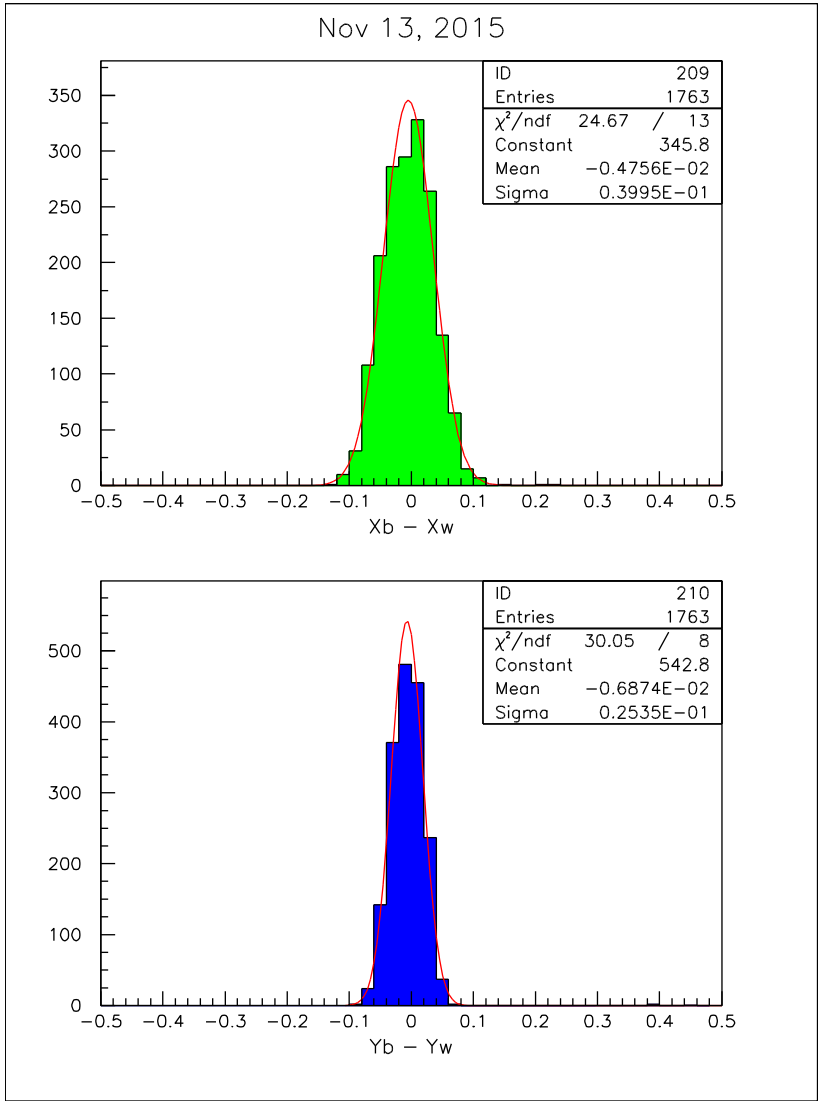
Subtract offsets from the BPM and SEM (multiwire) positions.

Calculate pos(BPM)-pos(SEM)

X: σ = 0.040 mm

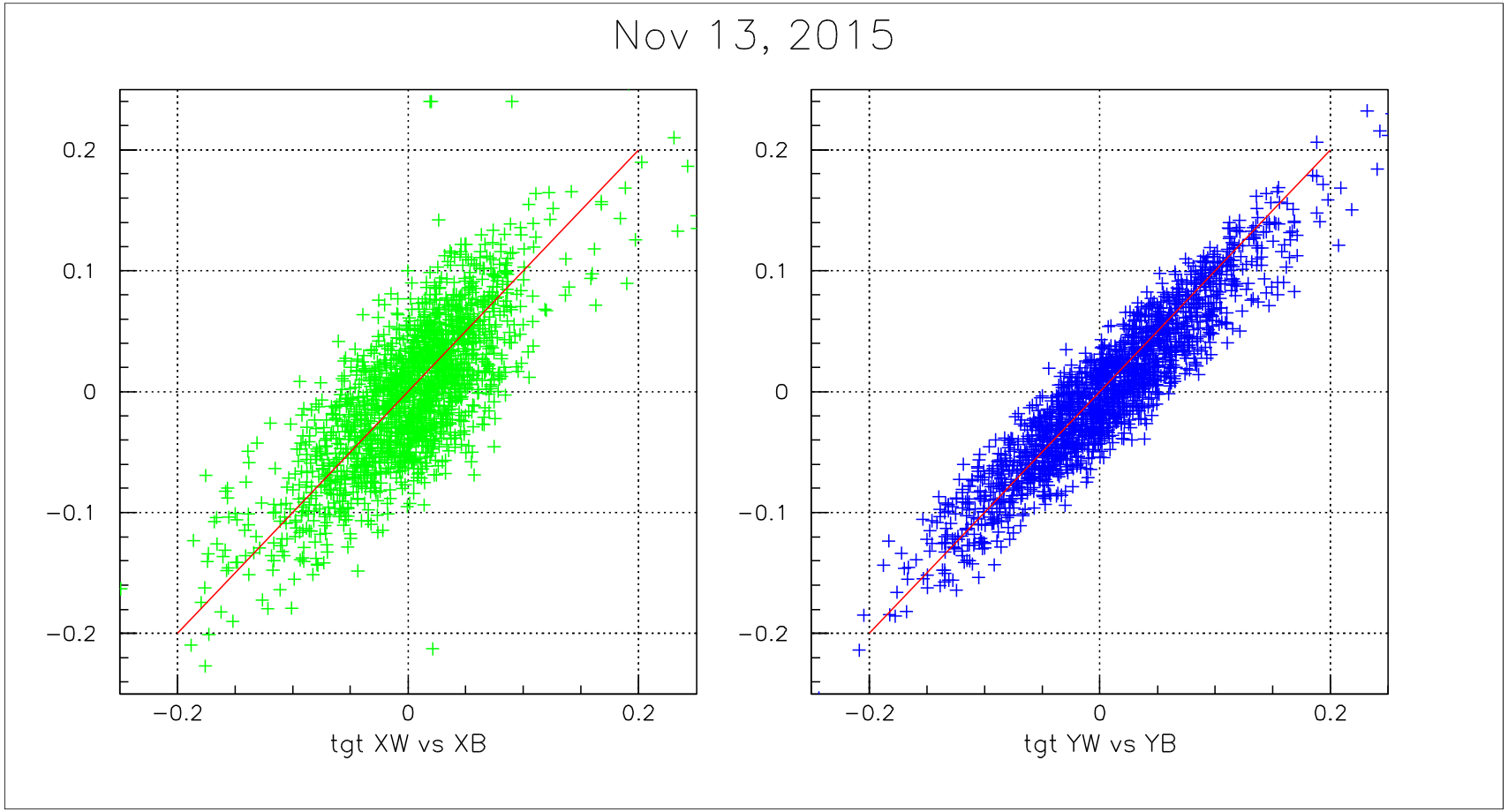
Y: σ = 0.025 mm

When comparing detectors (even SEM wire by wire) – Validate via Time Stamps



Position measured by BPM vs SEM

First time both views have agreed on 'which way is up' !



Multiwires provide beam size (Projections)

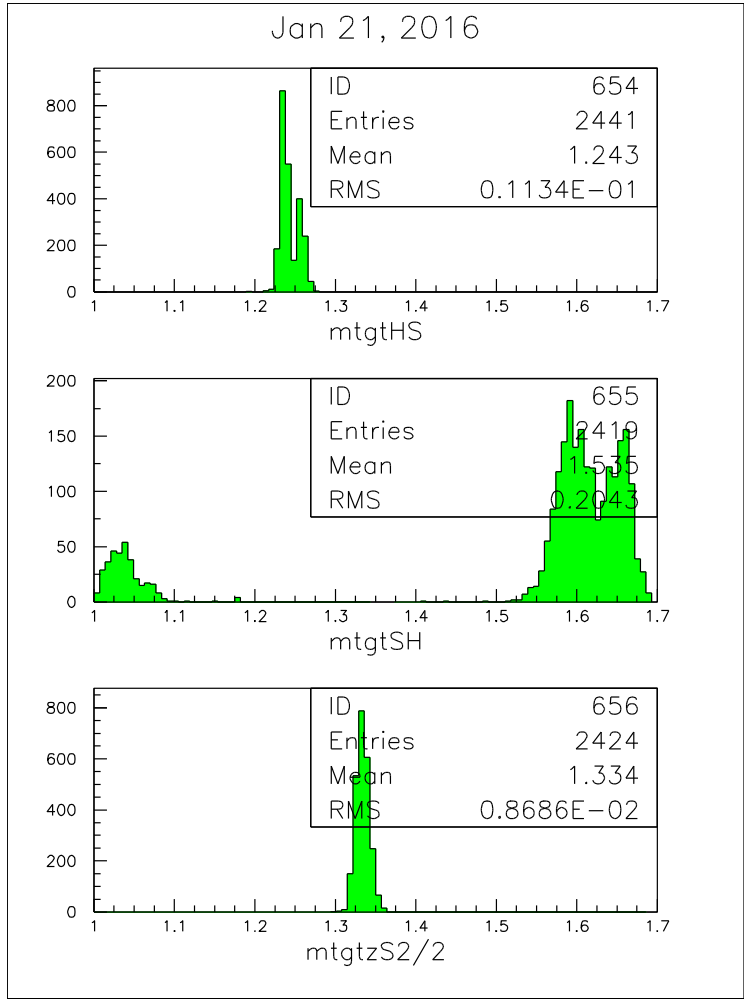
Experimentally – can not distinguish between a circle and an elipse

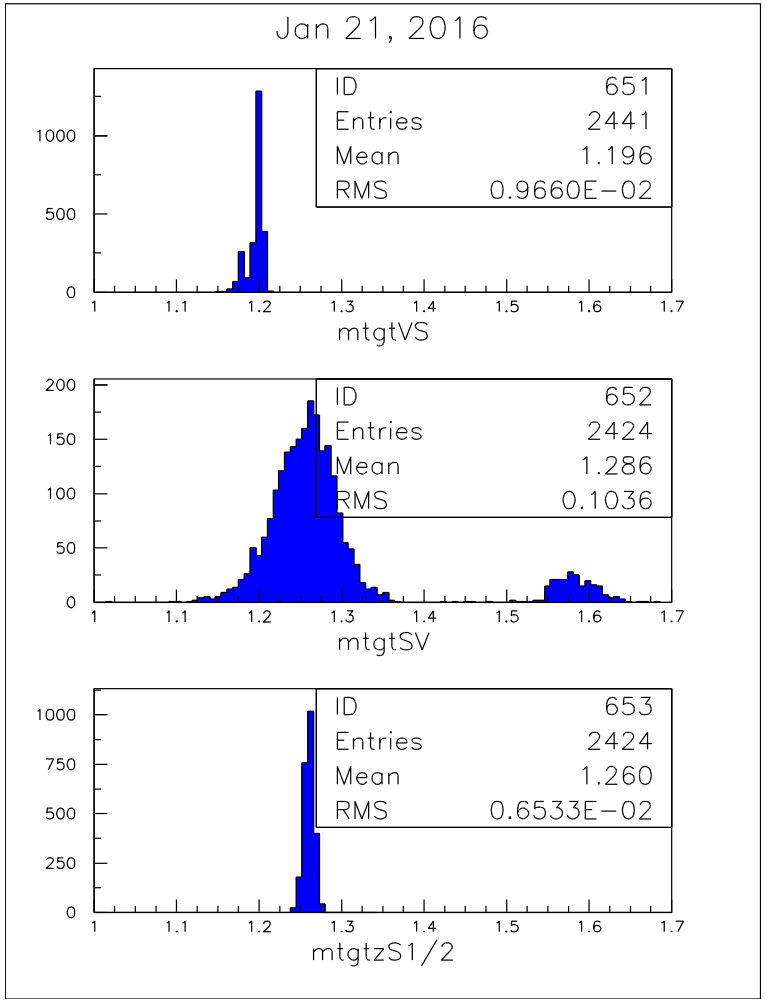
- Spill by Spill – data is saved in Lumberjack
- But some issues:
- Accuracy issues – methods of calculation

  Particularly at low intensity
- Multivalued On Line ??
- Compare to offline calculation – varies !

- I am confused about what happened when !

There are 3 σ parameters for each view. Currently on lumberjack mtgt{sv,vs} and mtgt{sh,hs} and fit mtgt_{s1,s2}/2



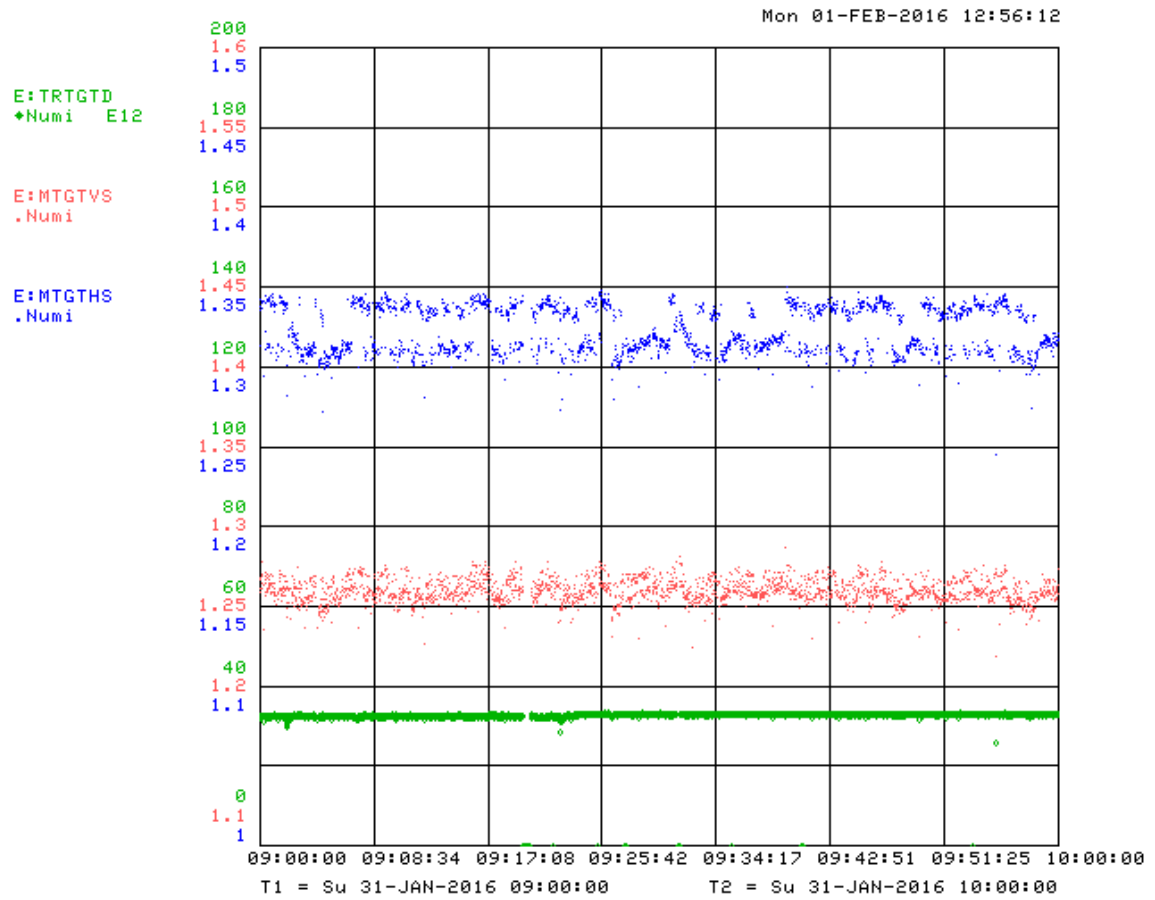


<<SH, SV Clearly not useful

Problem: mtgtHS and mtgtVS are multi-valued

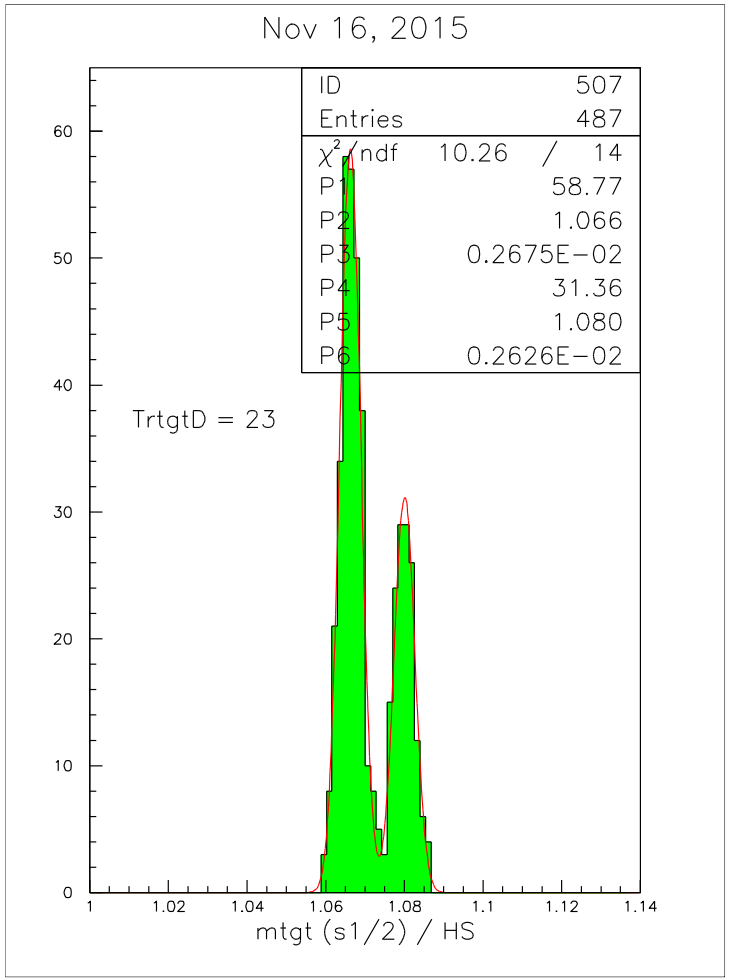
This is a long standing problem. Can not see the problem in downloaded data !

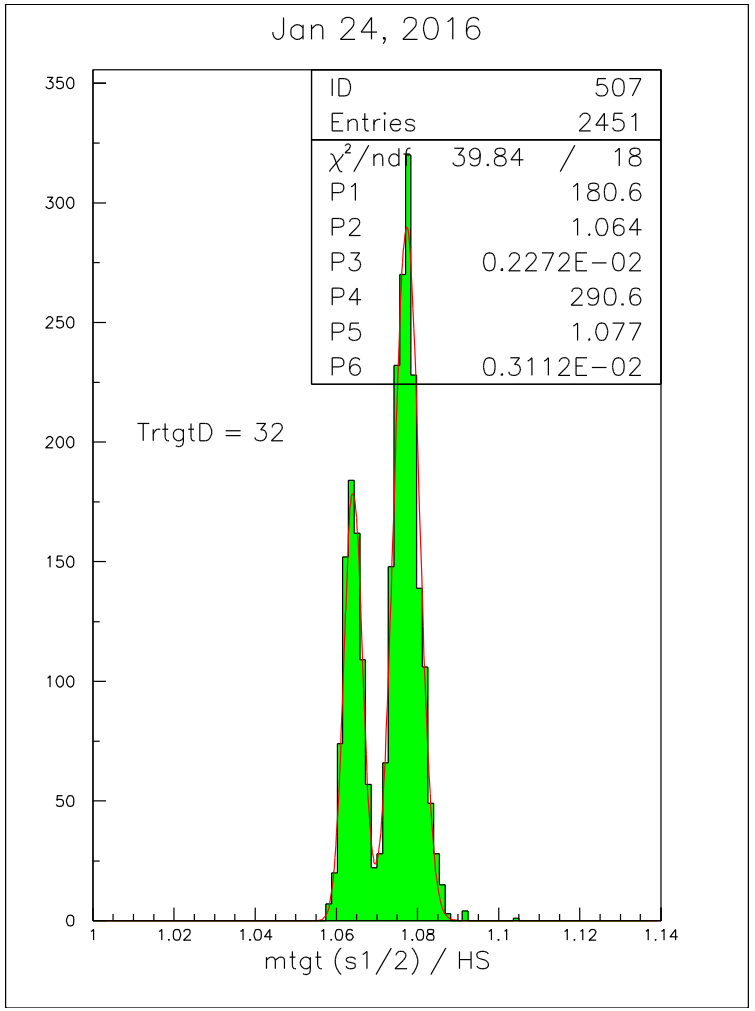
In spite of several efforts, no sign of this multiple valued data can be found in the downloaded SEM data !



Fits to the ratio of off-line fits to on-line mtgtHS

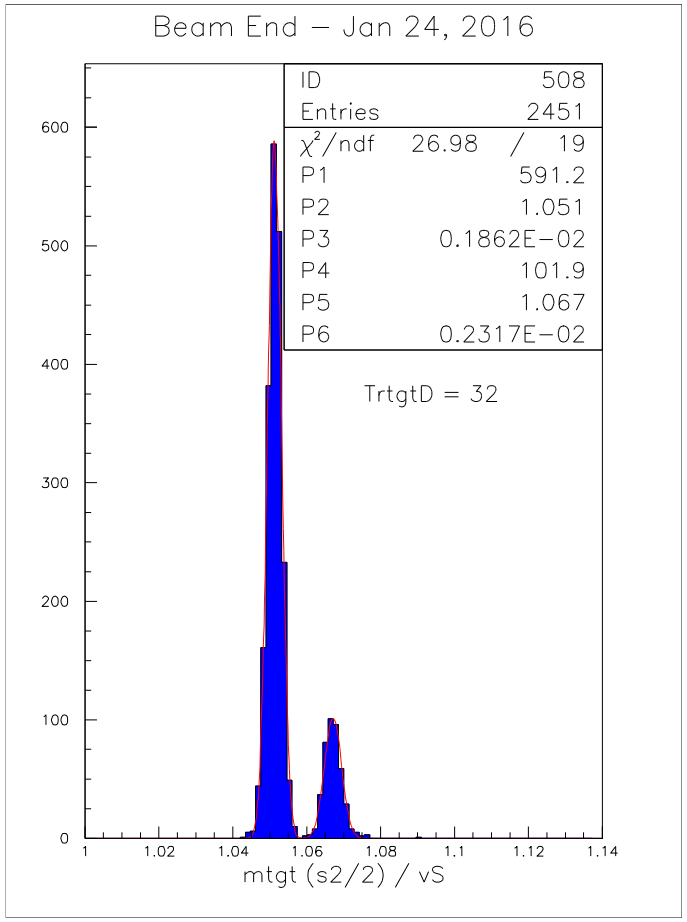
different samples have different peak heights. Ratio = 1.065 or 1.078

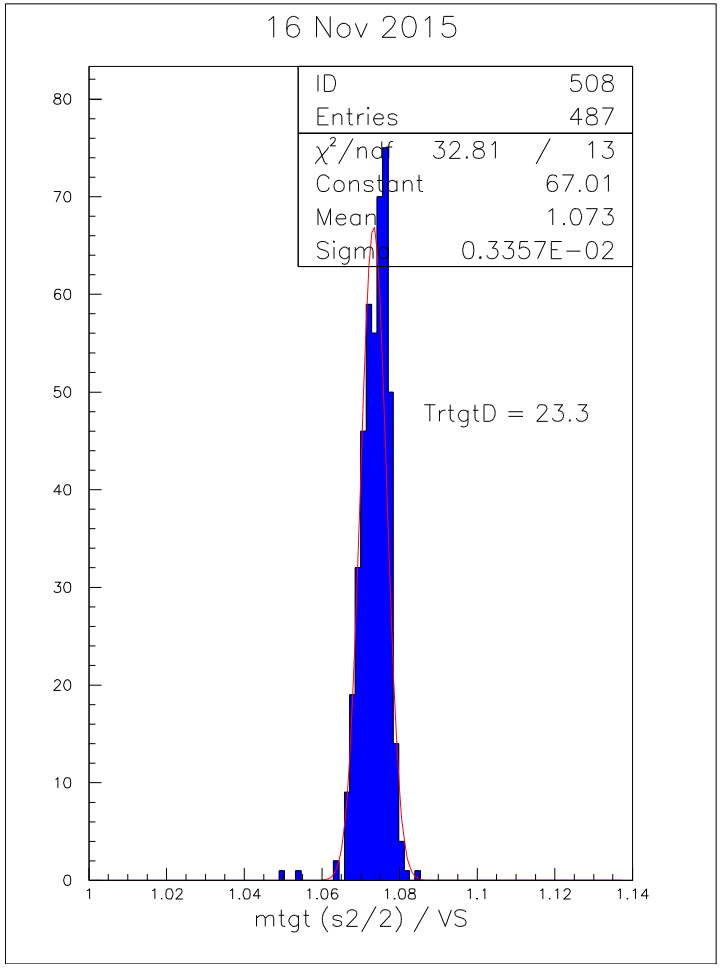


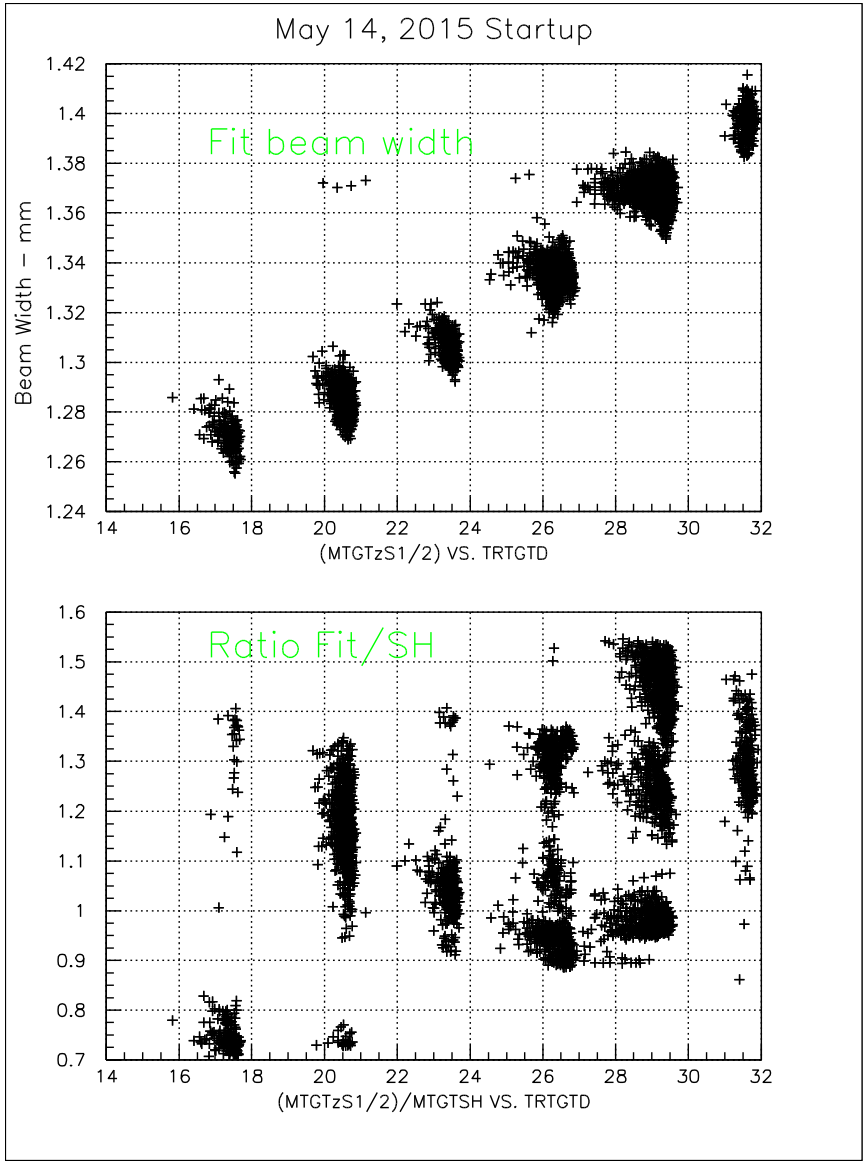


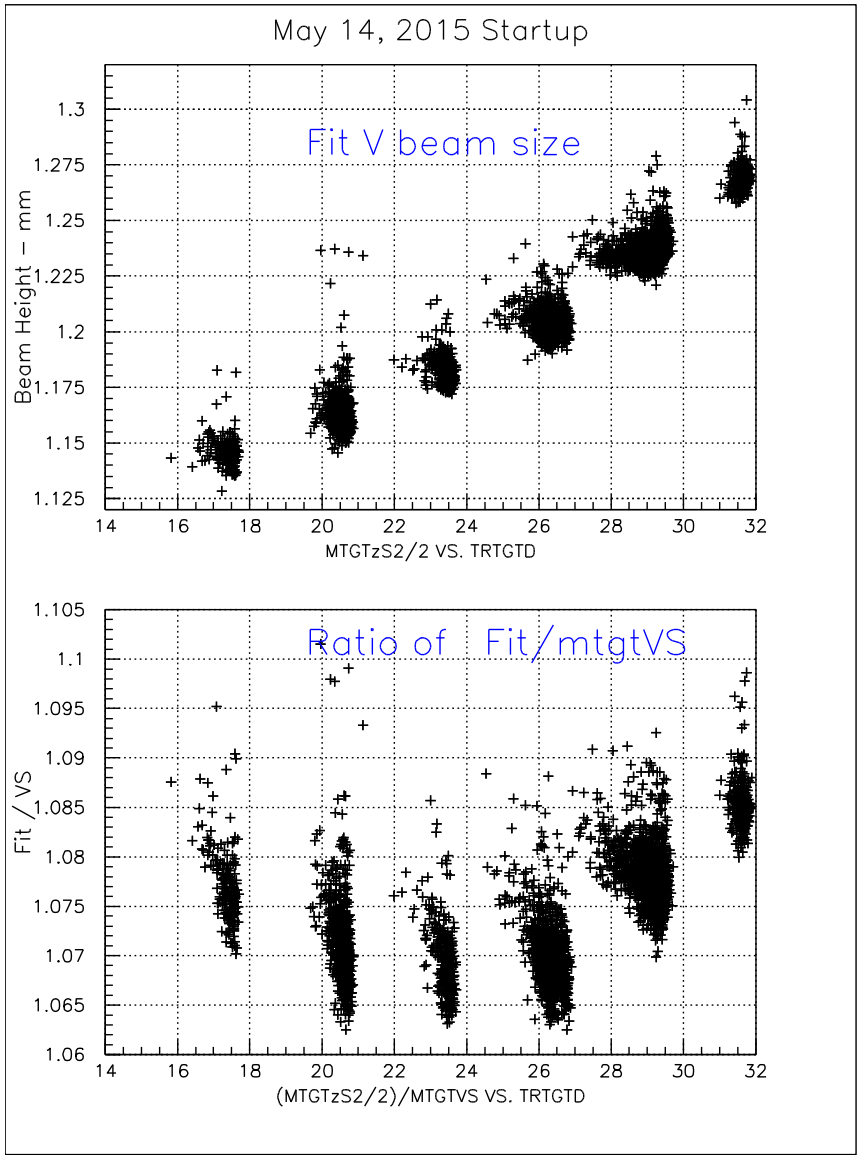
Fits to the ratio of off-line fits to on-line mtgtVS

different samples have different peak heights. Ratio = 1.051 or 1.067; 1.073






May 14, 2015 Startup
Fit beam width
Beam Width – mm
(MTGTzS1/2) VS. TRTGTD
Ratio Fit/SH
(MTGTzS1/2)/MTGTSH VS. TRTGTD


May 14, 2015 Startup
Fit V beam size
Beam Height – mm
MTGTzS2/2 VS. TRTGTD
Ratio of Fit/mtgtVS
Fit /VS
(MTGTzS2/2)/MTGTVS VS. TRTGTD

To summarize HS vs S1/2 ; VS vs S2/2

On the previous page, there is a comparison between the sizes of the beam obtained by fits to a Gaussian + background and the currently available parameters mtgtHS and mtgtVS. There is clearly an issue with these later parameters. I do not know how to resolve the issues.

So I have started rewriting my code for implementation on a clx machine for easy access.