

Measurements of F_2 and $R=\sigma_L/\sigma_T$ on Deuteron and Nuclei in the Nucleon Resonance Region

E02-109/E04-001 (Jan05) Analysis
Update

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On behalf of the Jan05 Collaboration

Experiment: Details

- Ran in Hall C for ~2 weeks in January 2005
- E02-109: Measurements of F_2 and R on Deuterium
- E04-001: Measurements of F_2 and R on Carbon, Iron, and Aluminum
- Beam energies used were: 4.6, 3.5, 2.3, and 1.2 GeV
- Coverage: $0.05 < Q^2 < 2 \text{ GeV}^2$
 $0.5 < W^2 < 4.25 \text{ GeV}^2$

Kinematic Coverage

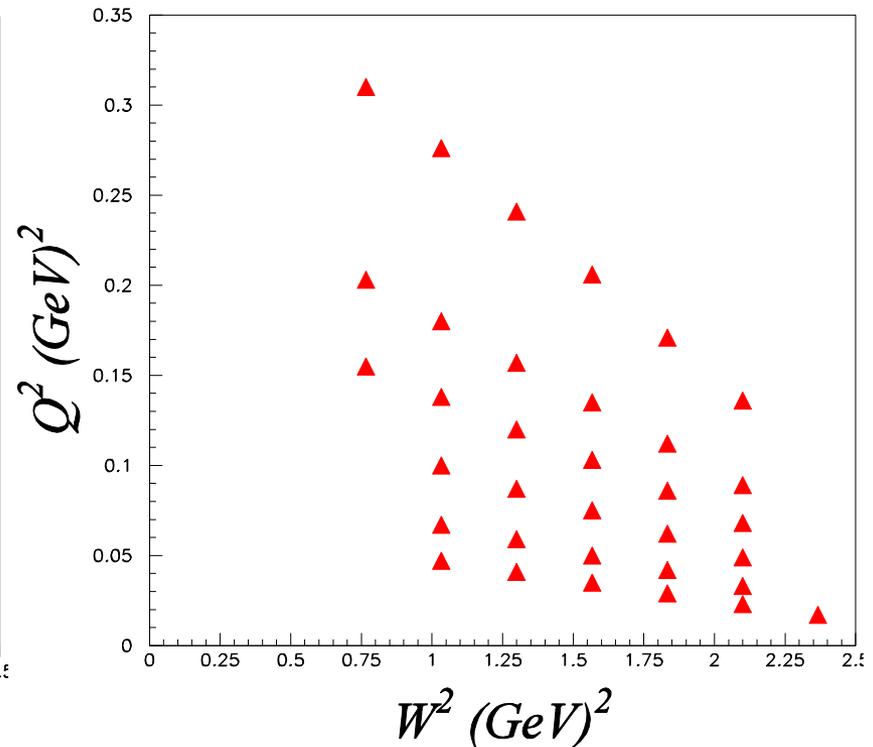
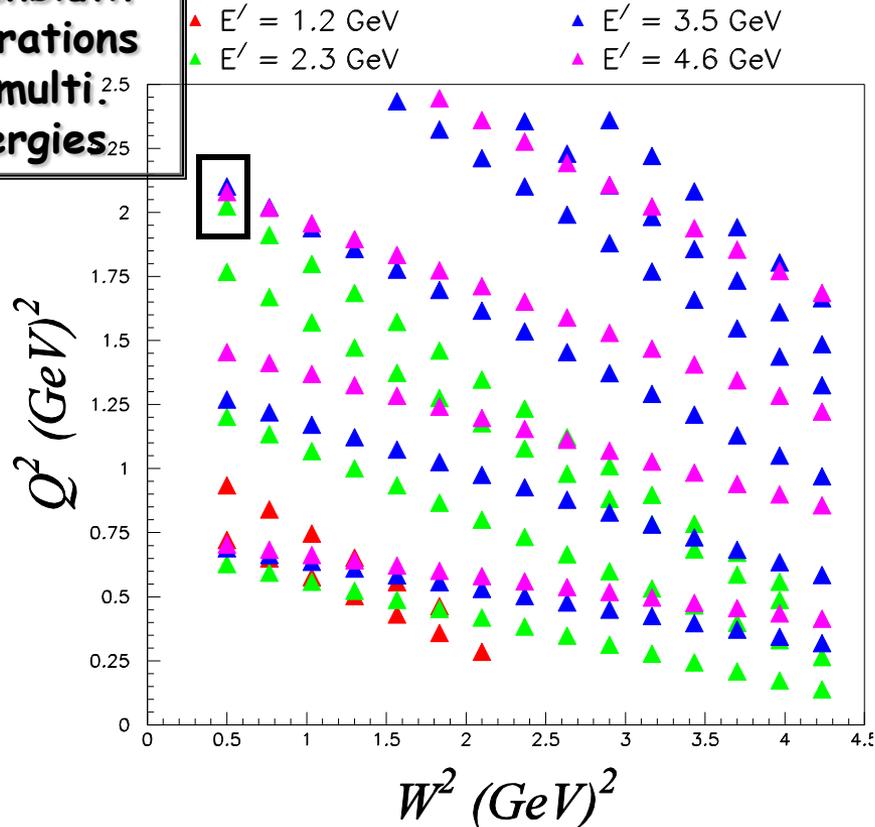
Rosenbluth Separation Data

- Targets: D, C, Al, Fe, and some H
- Final Uncertainties estimated at $\sim 1.6\%$ pt-pt in e (2% normalization).

Low Q^2 data for ν modeling

- Targets: H, D, C, Al
- Final Uncertainties estimated at $\sim 3 - 8\%$ (Much larger RCs and rates)

Rosenbluth separations at multi-energies



From Ya Li's talk

Analysis Status as of Jan 2009: *from* *Ya Li's talk at the Jan09 Hall C meeting*

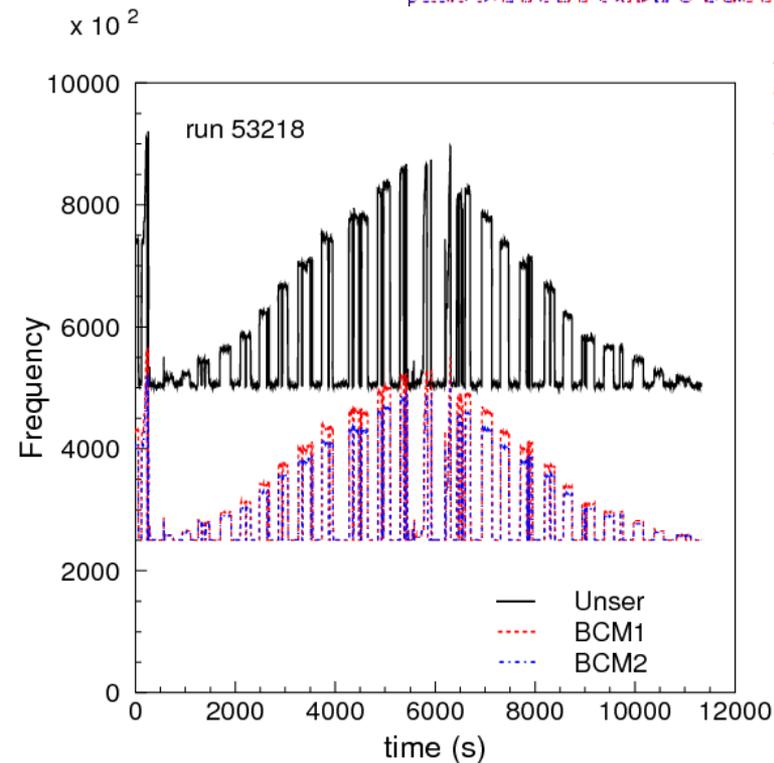
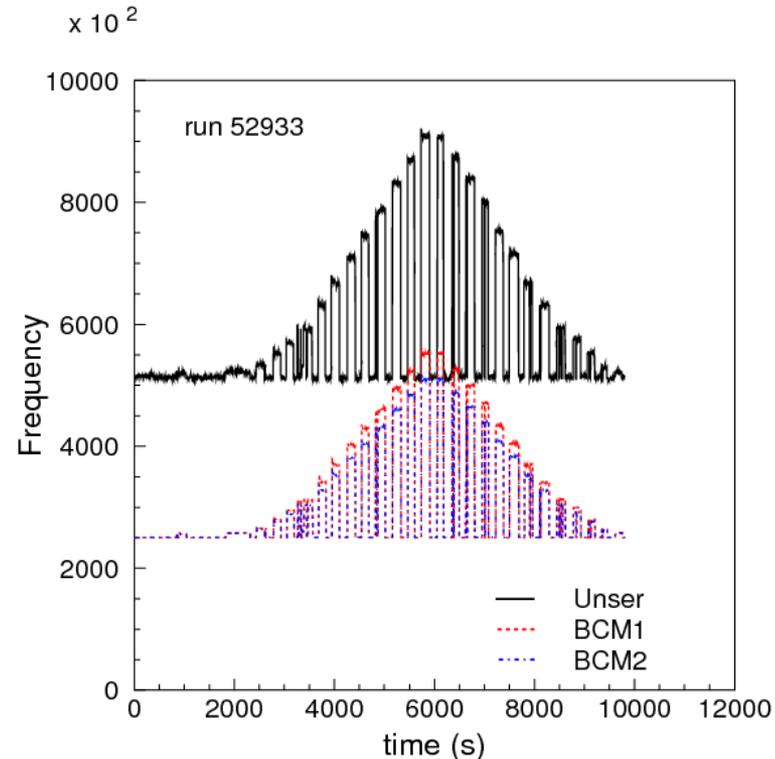
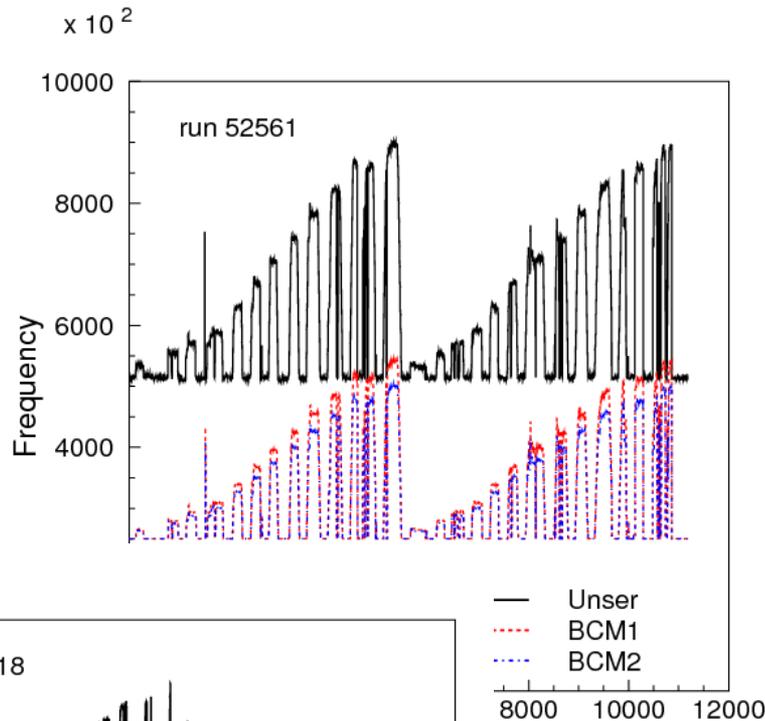
- Detector Calibration completed
- Calorimeter Eff. completed
- Cerenkov Eff. completed
- Tracking Eff. completed
- Trigger Eff. problem
- Computer Dead Time completed
- Acceptance Corrections completed
- Beam Position Stability Study completed
- Beam Position Offsets completed
- Target Position Offsets completed
- Optics Checks Preliminary Sieve Slit
- Charge Symmetric Background completed
- Radiative Corrections iterating
- Cross Sections iterating

My Analysis Update

- Cross-checked calibrations for **HMS electron runs**:
 - BCM
 - Cerenkov
 - Scintillator (looking at beta for electrons)
 - Drift chambers
 - Calorimeter

- Checked calibration for **positron SOS data**
 - Cerenkov
 - Calorimeter
 - Drift chamber
- Scanned through the positron cross section extraction from SOS data
- May need to re-do some drift chamber calibrations and re-extract the SOS positron cross sections

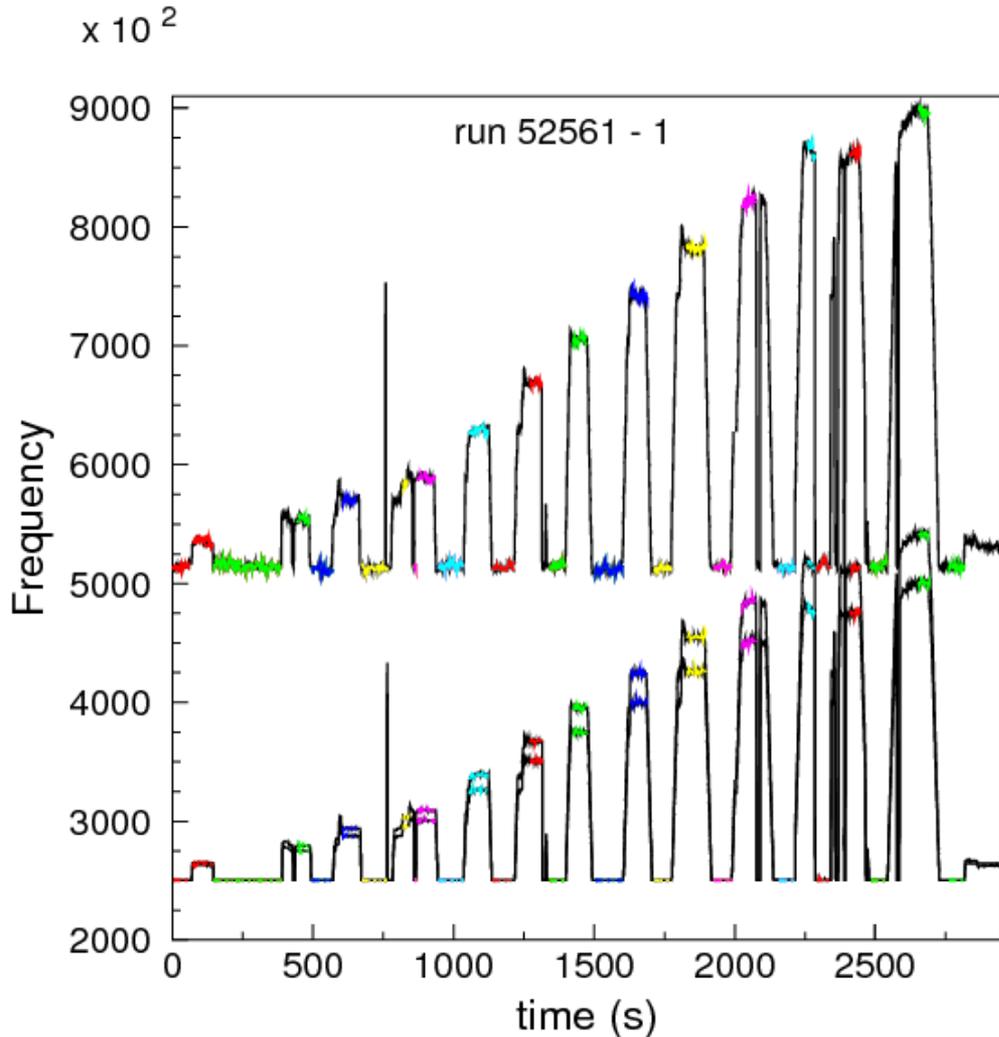
Calibrations Checks: BCM



Three BCM calibration runs taken for Jan05

Purpose: calibrated the 2 BCMs used for current measurement during the experiment

Calibrations Checks: BCM



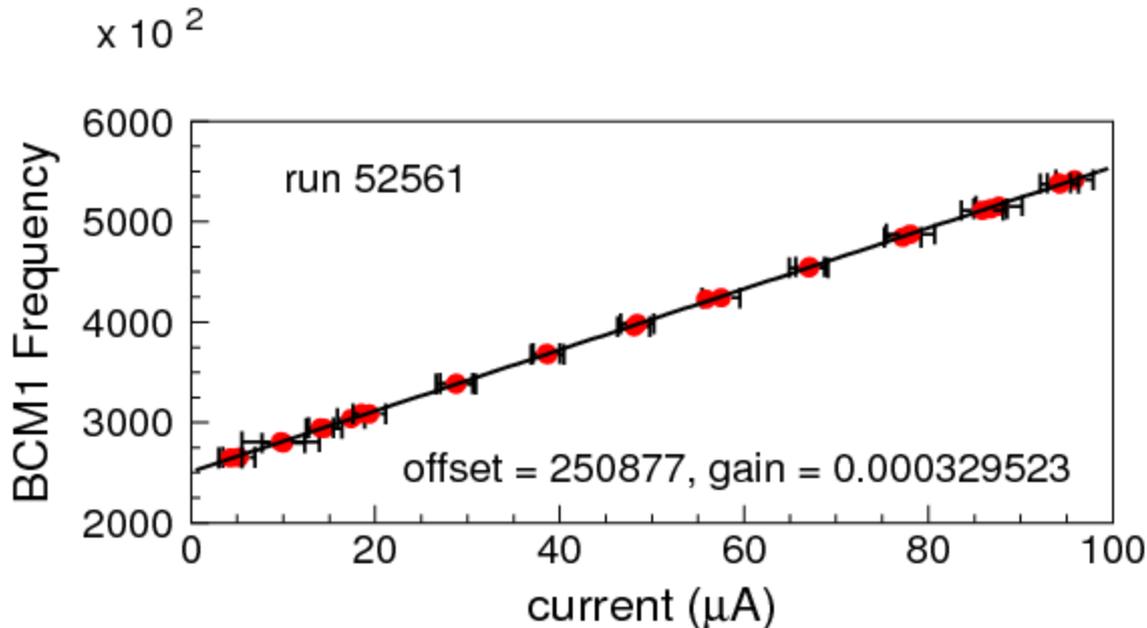
The Unser has very stable gain but unstable offset

Instabilities in the Unser offset are “canceled” by averaging over the beam off periods surrounding the beam on period

$$I^{unser} = \left(v_{beam-on} - \frac{v_{beam-off}^{before} + v_{beam-off}^{after}}{2} \right) * gain$$

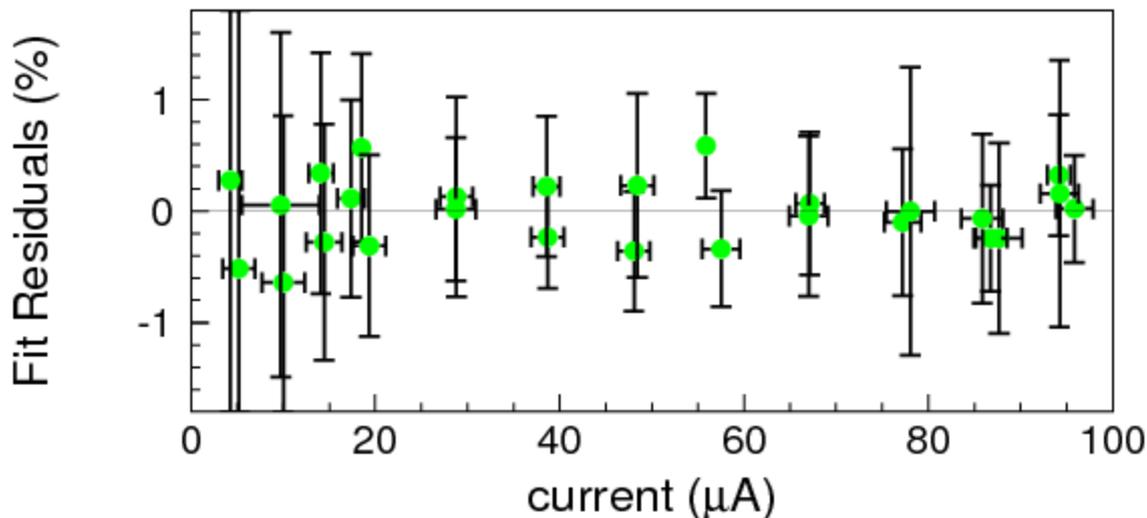
The current during the calibration run is then calculated based on the Unser output

Calibrations Checks: BCM



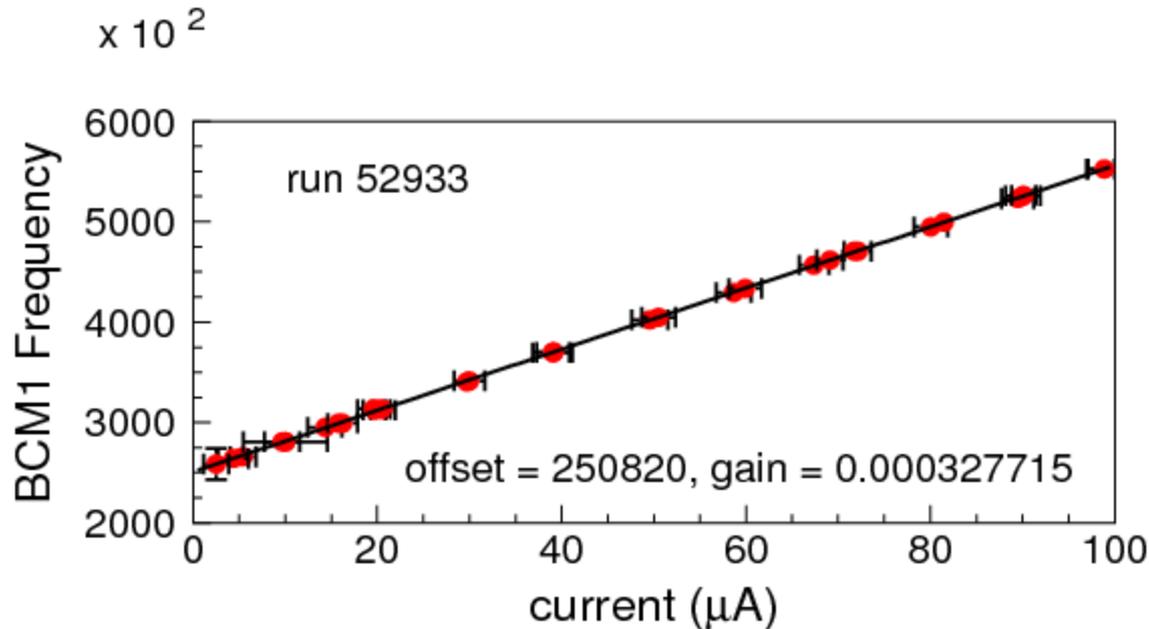
The BCMs have stable offset but unstable gain

The BCMs offset and gain are fitted by using the current as measured by the Unser and the beam of frequency



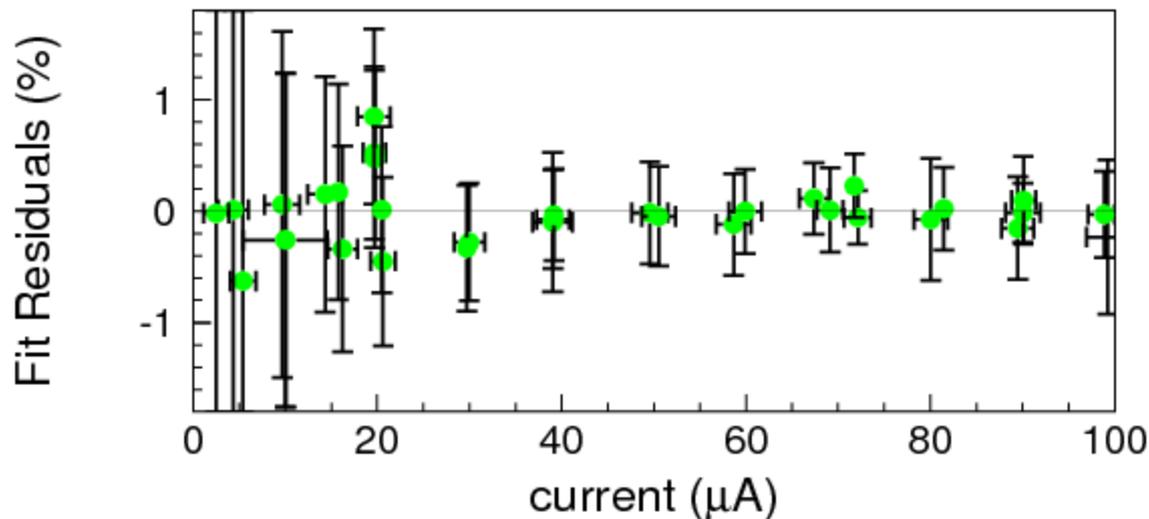
$$V_{beam-on} = offset + \frac{I_{Unser}}{gain}$$

Calibrations Checks: BCM



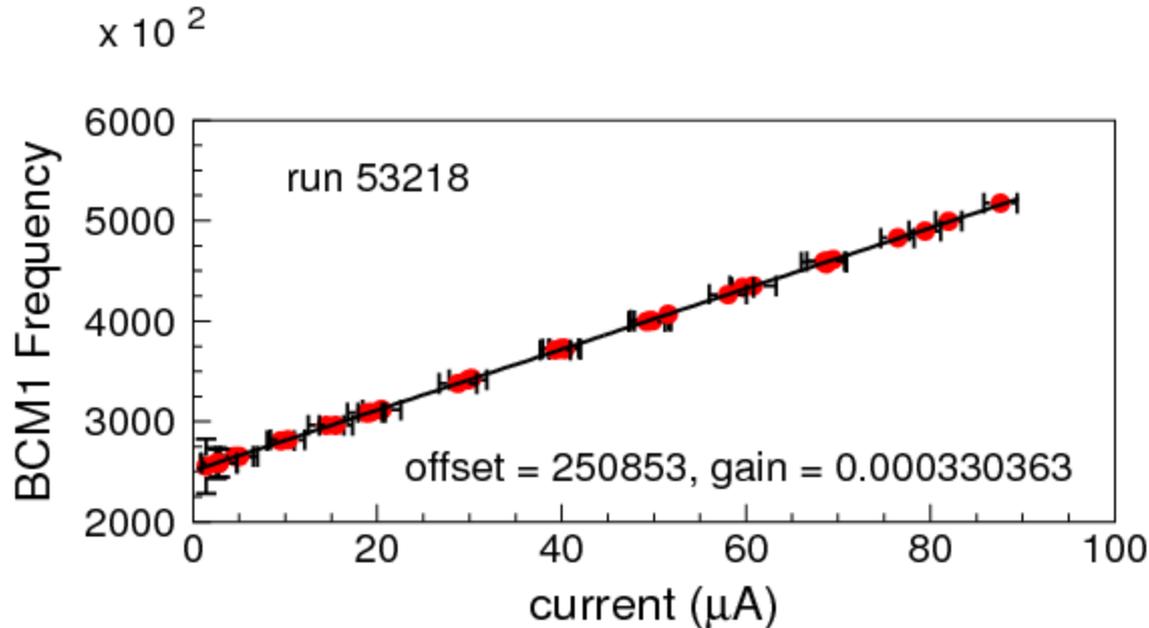
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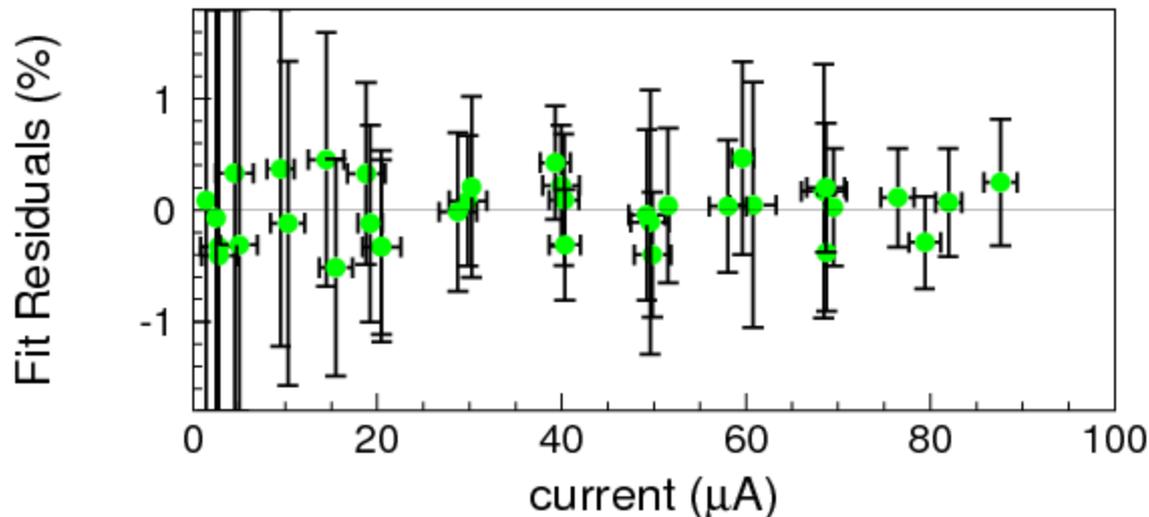
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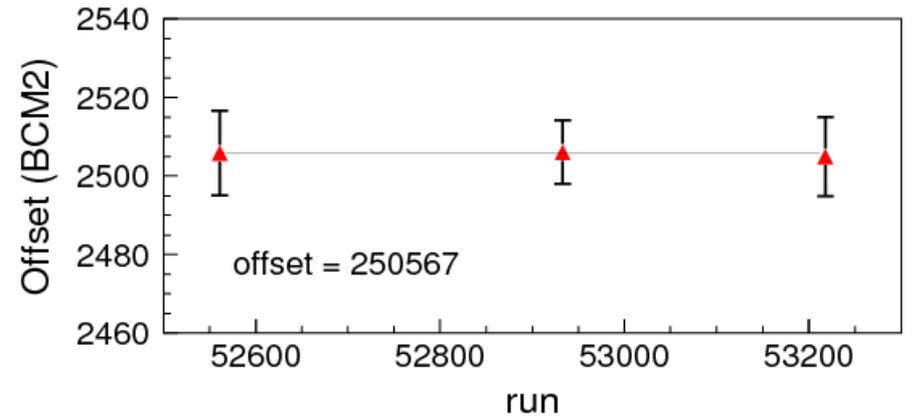
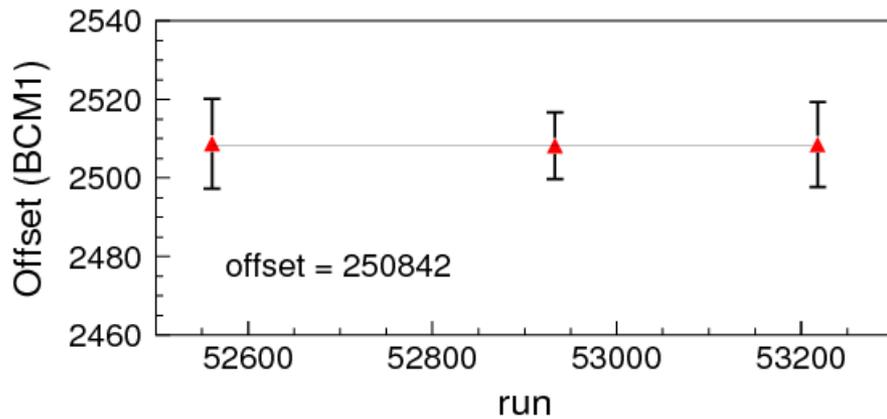
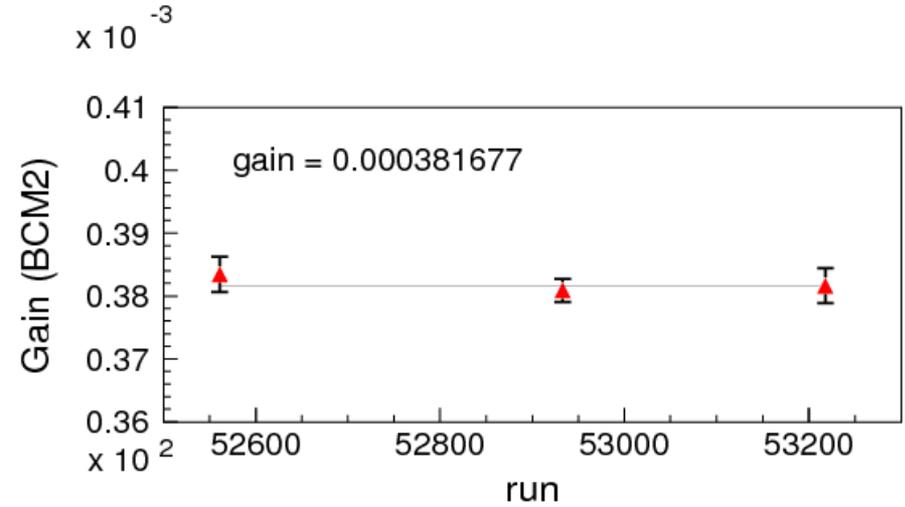
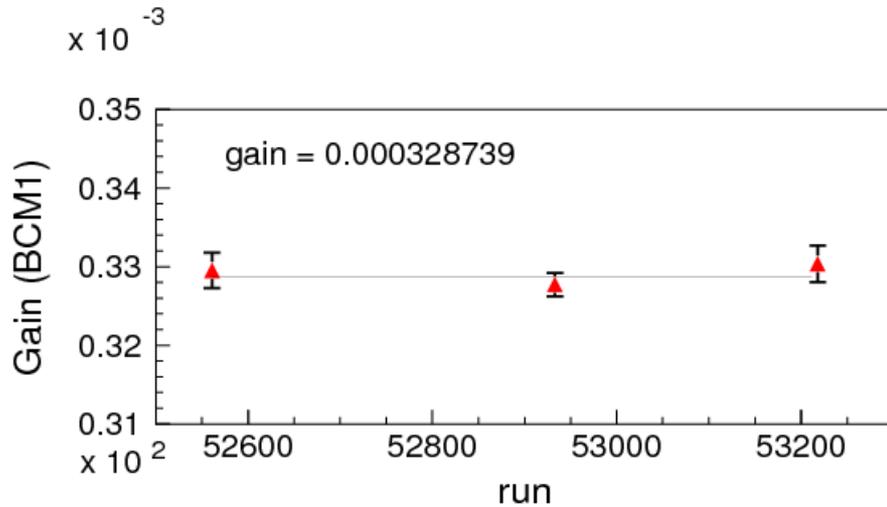
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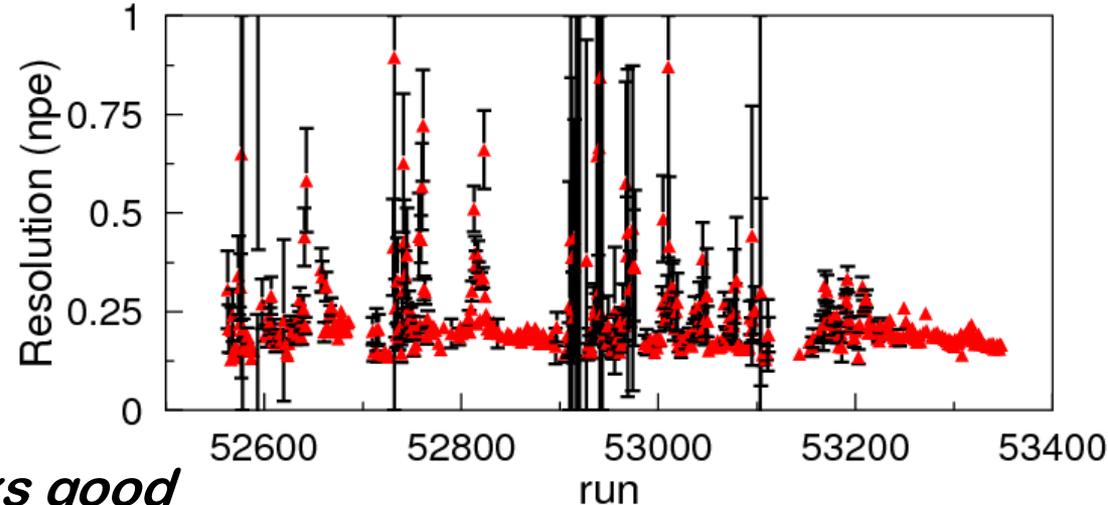
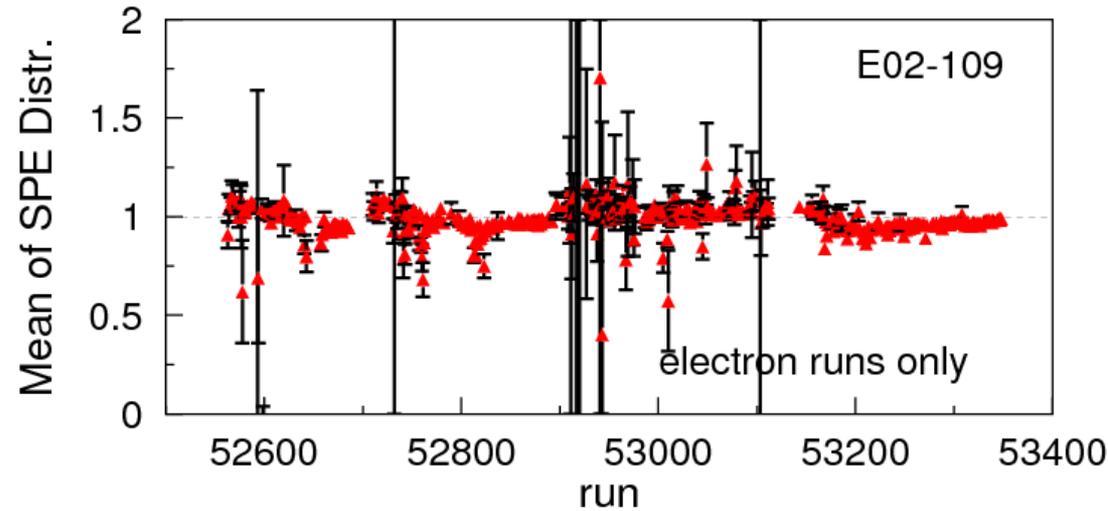
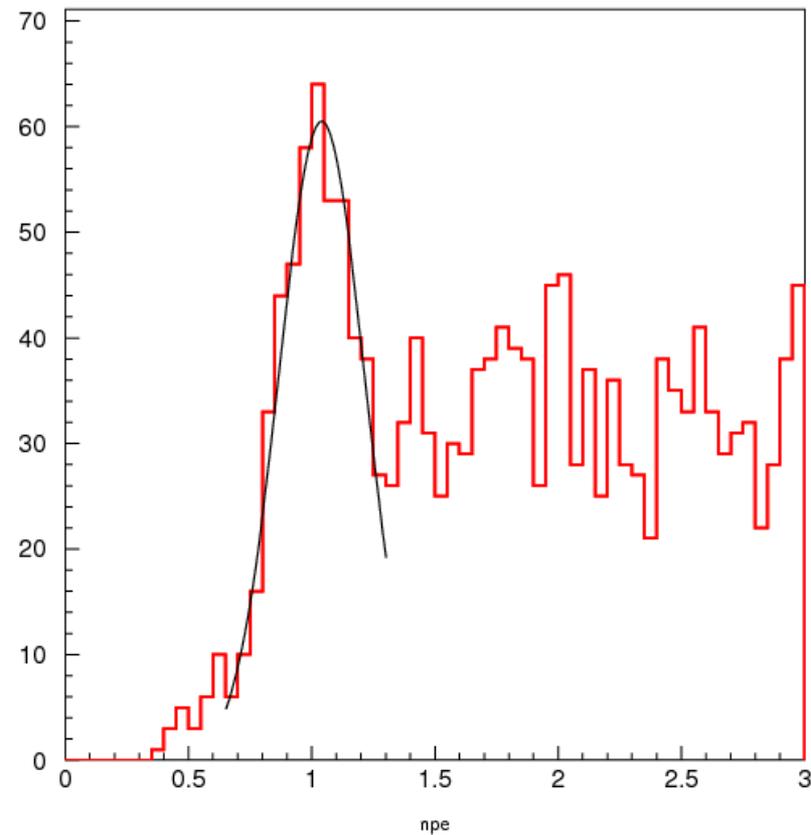
Fit results from the three calibration runs are then combined to give an overall gain and offset for each of the 2 BCMs (BCMs performance stable during the experiment)

Systematic error from calibration: $0.34 \mu\text{A}$

HMS electron runs

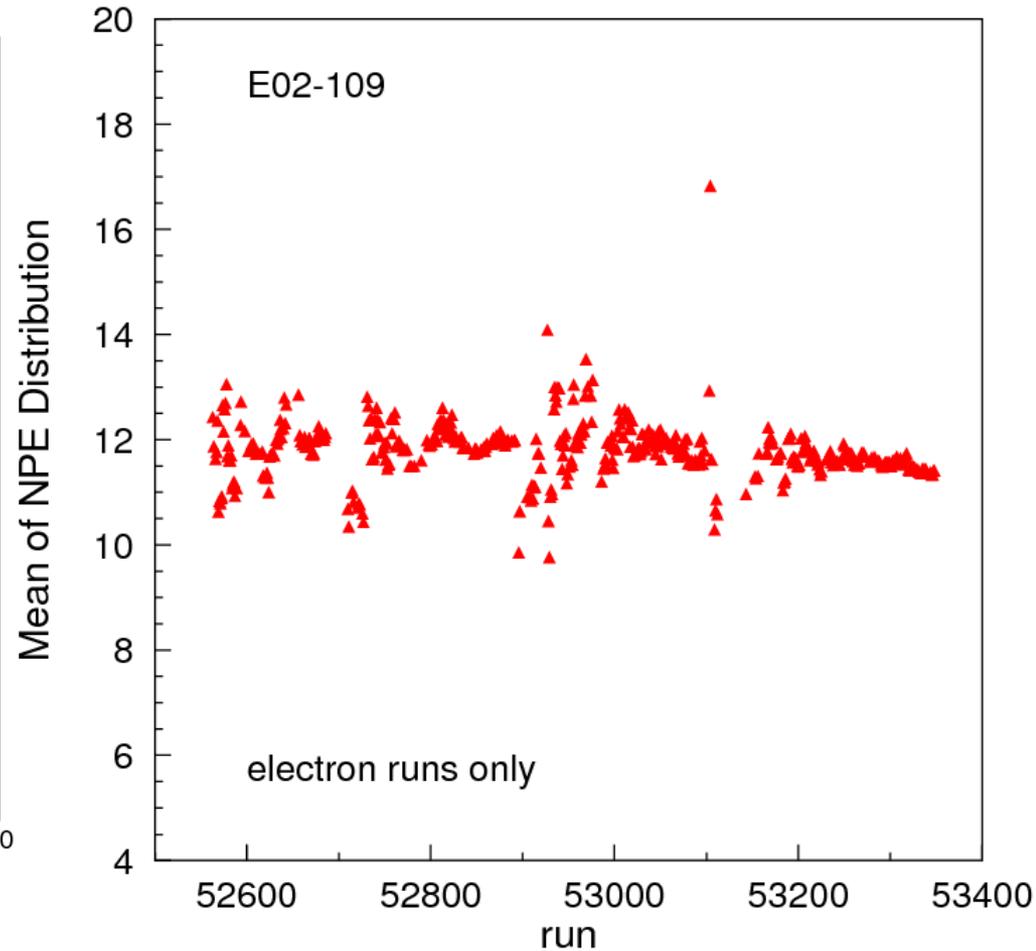
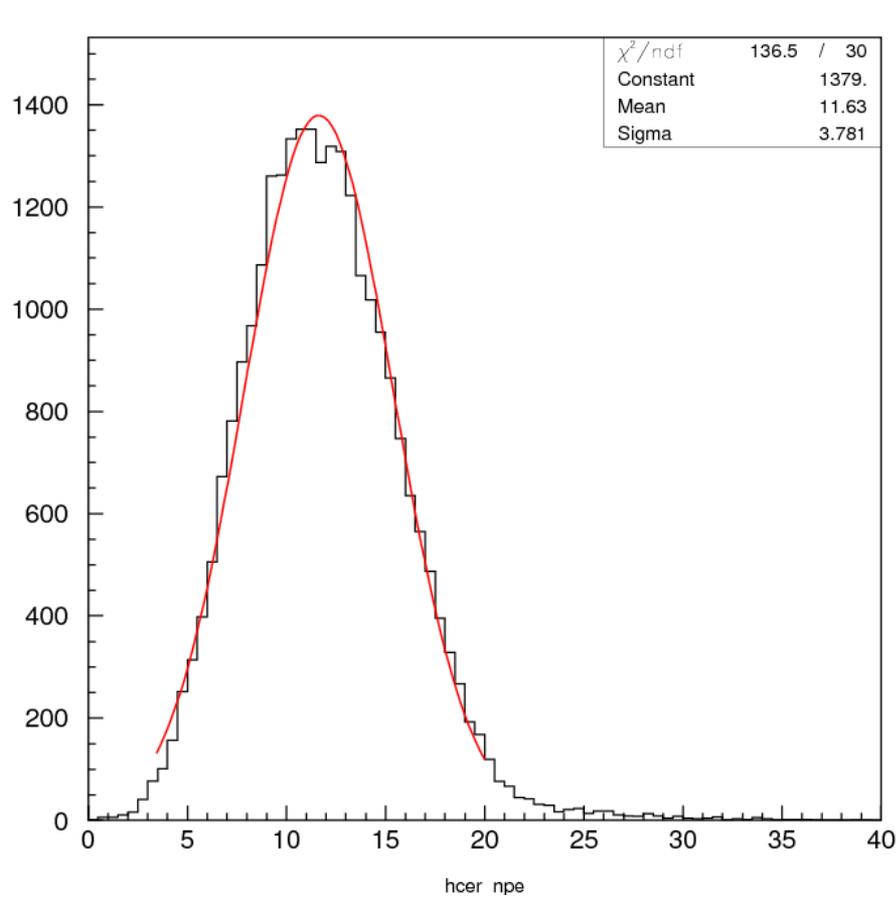
Calibrations Checks: Cerenkov

Check quality of the Cerenkov detector calibration by **identifying the single-photoelectron** peak for each run (use appropriate cuts)



The Cerenkov calibration looks good

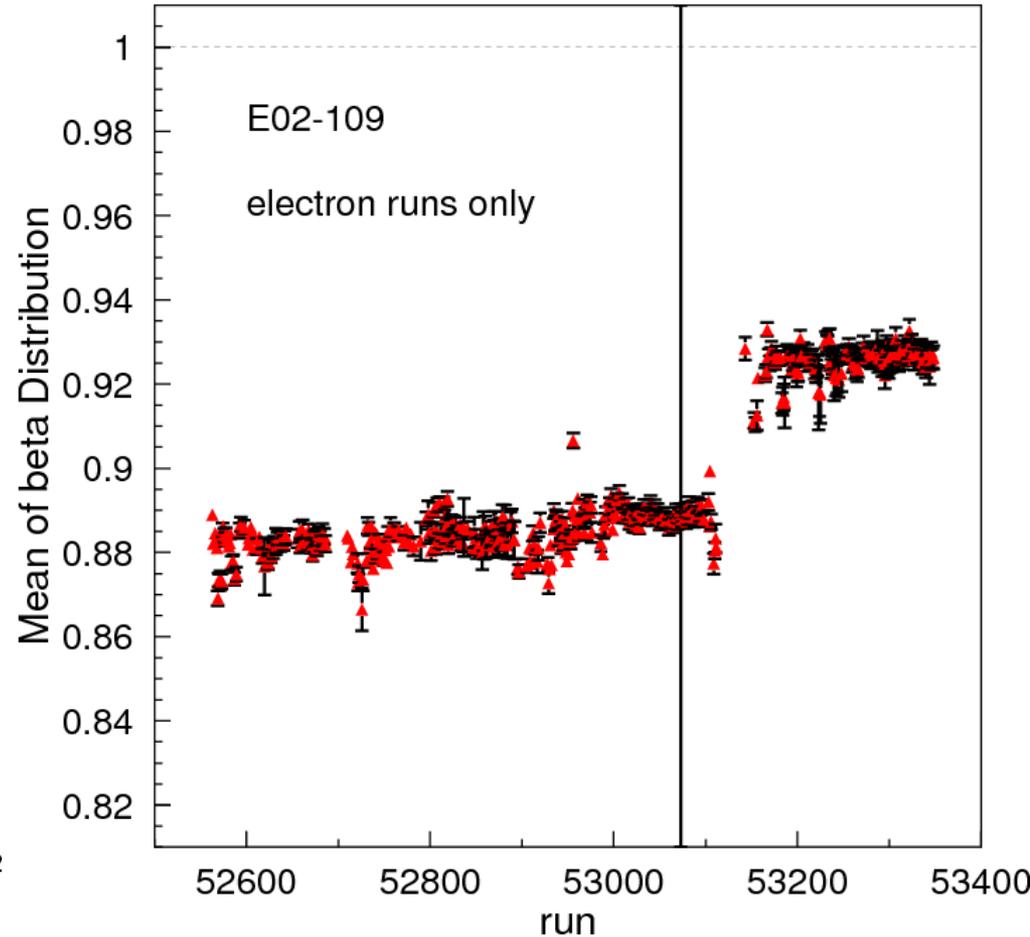
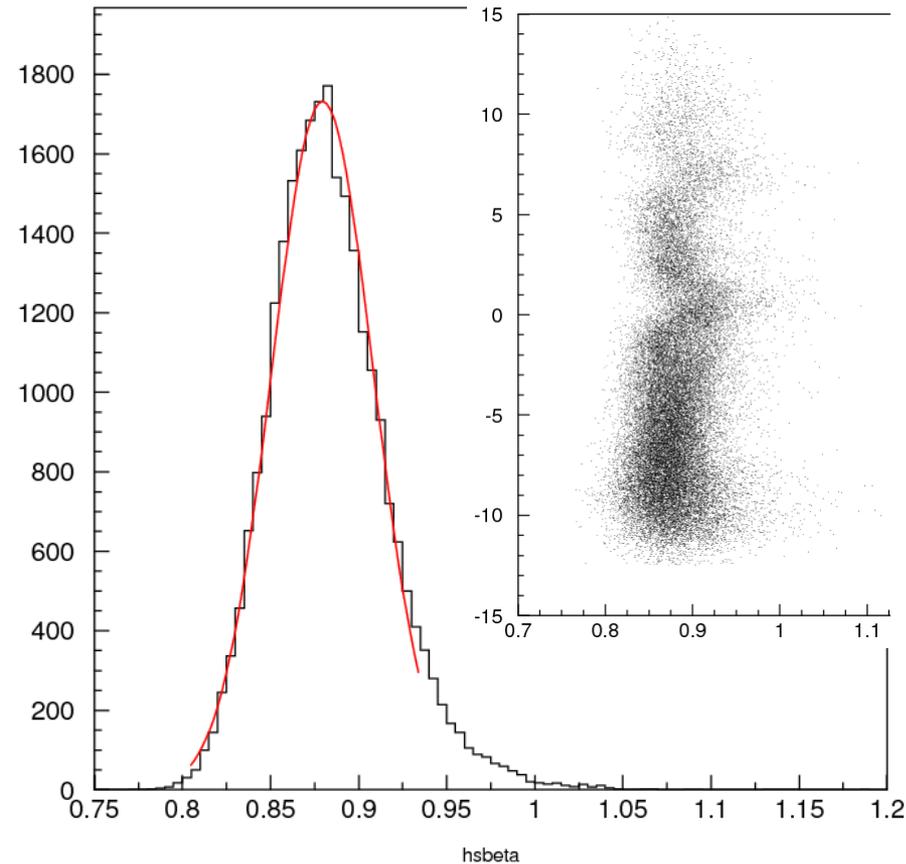
Calibrations Checks: Cerenkov



Electrons produce, on average, 11-12 photoelectrons in the Cerenkov

Calibrations Checks: Scintillators

Check scintillator timing calibration by looking at the beta distribution for electrons

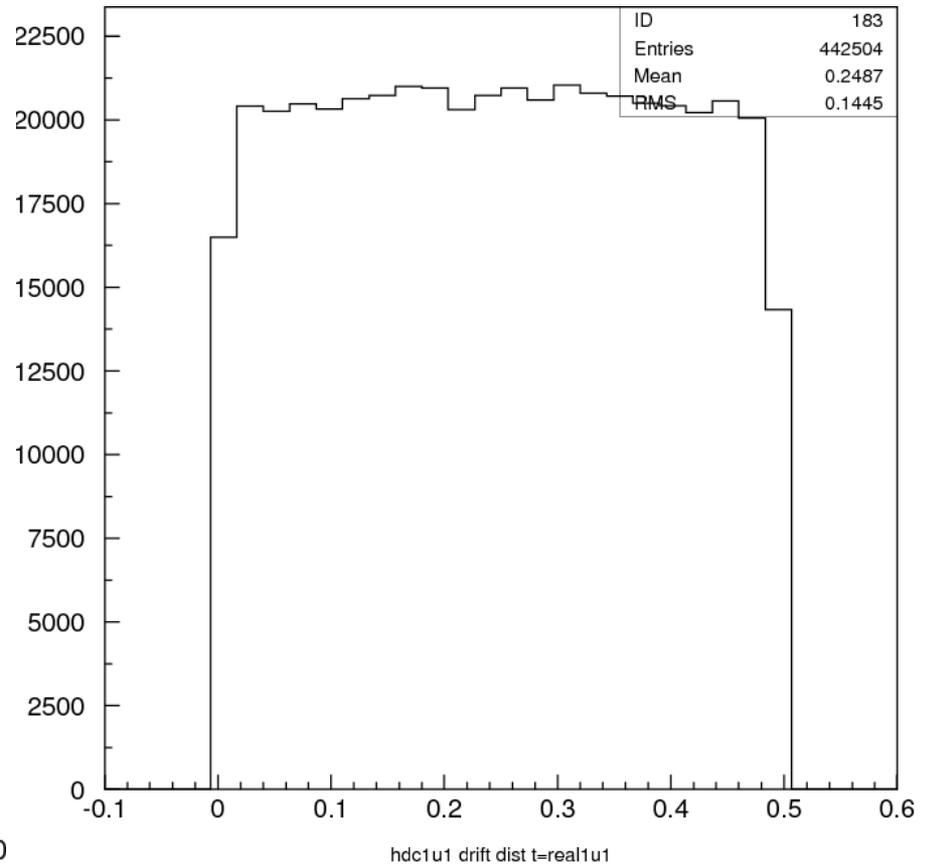
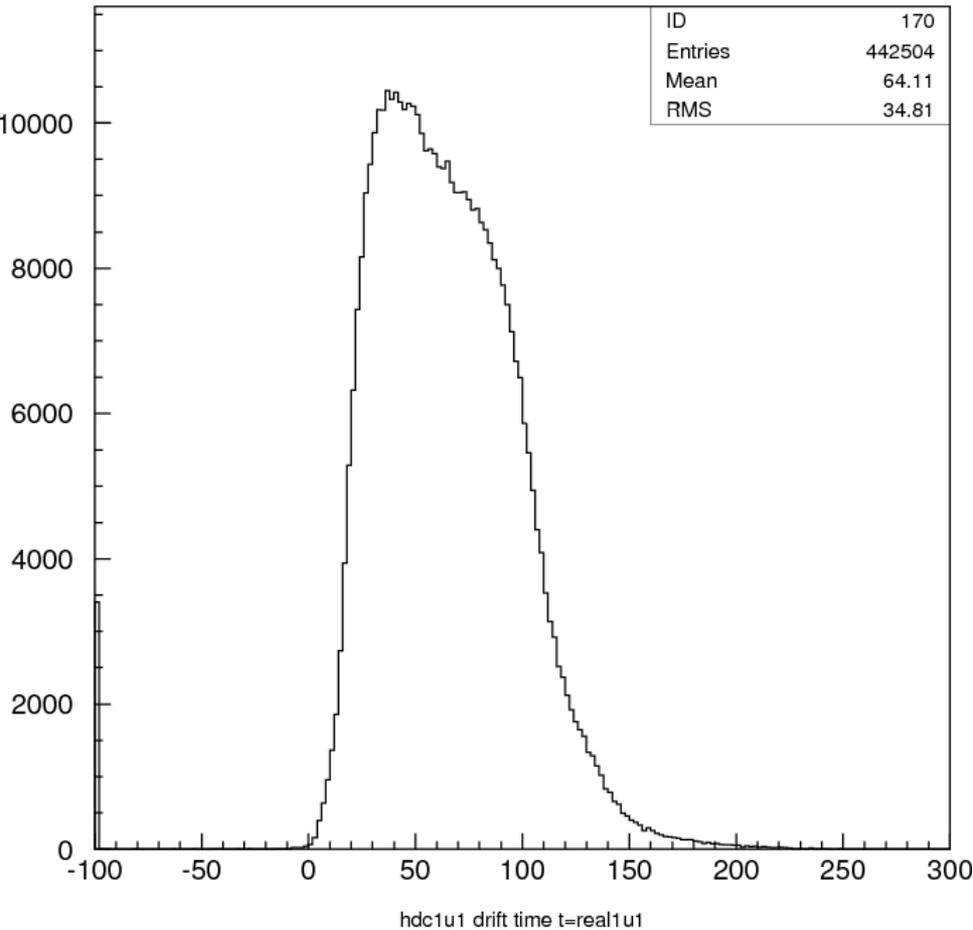


There is an offset of ~ 0.1 w.r.t. 1 in the beta distribution for electrons
→ miscalibration (~ 1 ns)

It is *very unlikely* that it will affect drastically the drift chamber calibration

Calibrations Checks: Drift Chambers

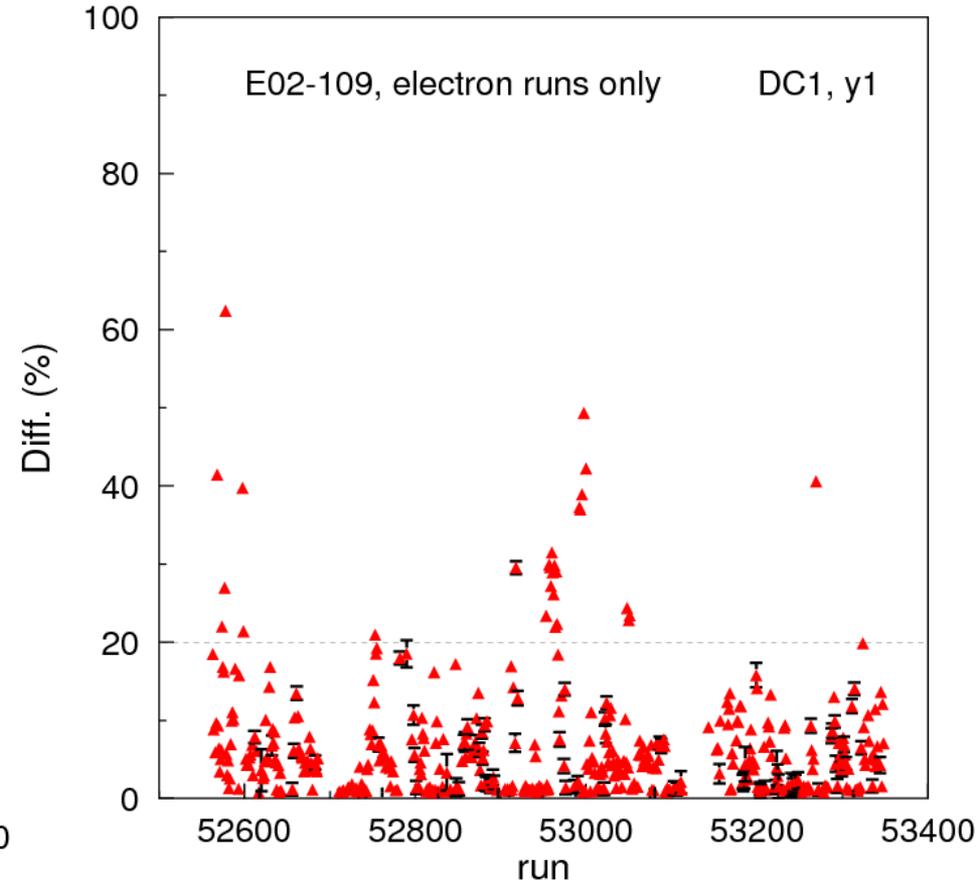
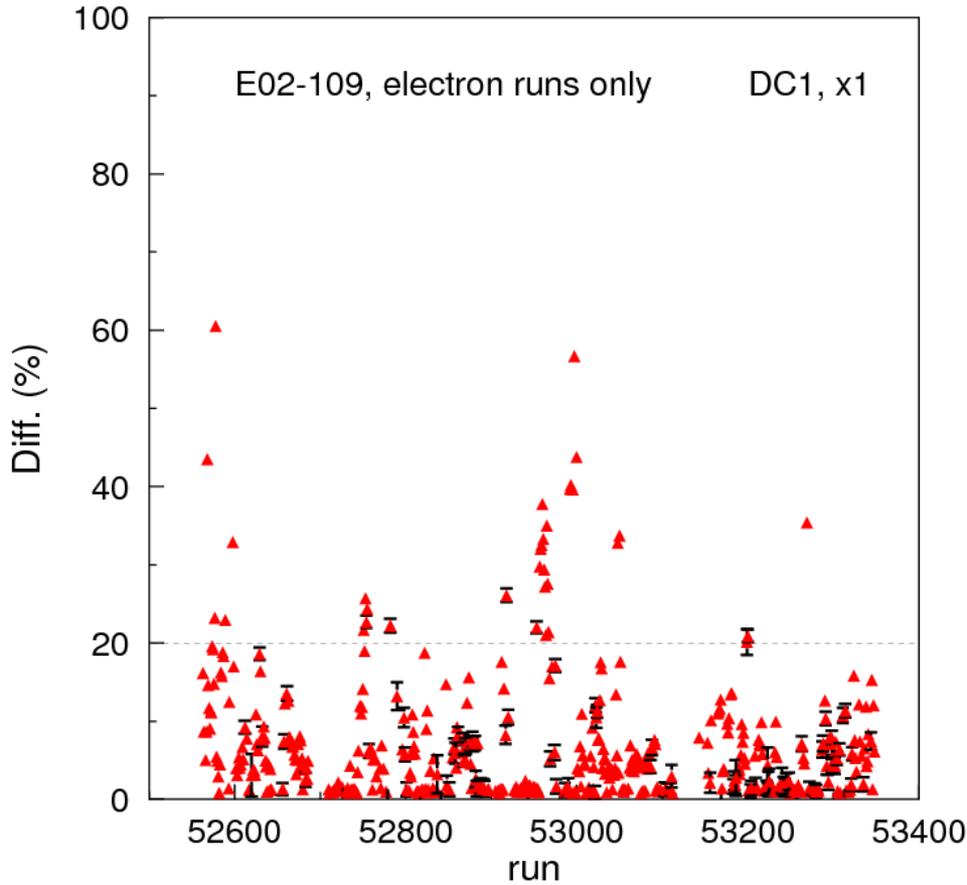
Drift distance calculated from the drift time and added to the wire coordinate to improve the resolution of the chamber



The drift cell is populated uniformly so we expect an uniform distribution of the drift distance after calibration

Calibrations Checks: Drift Chambers

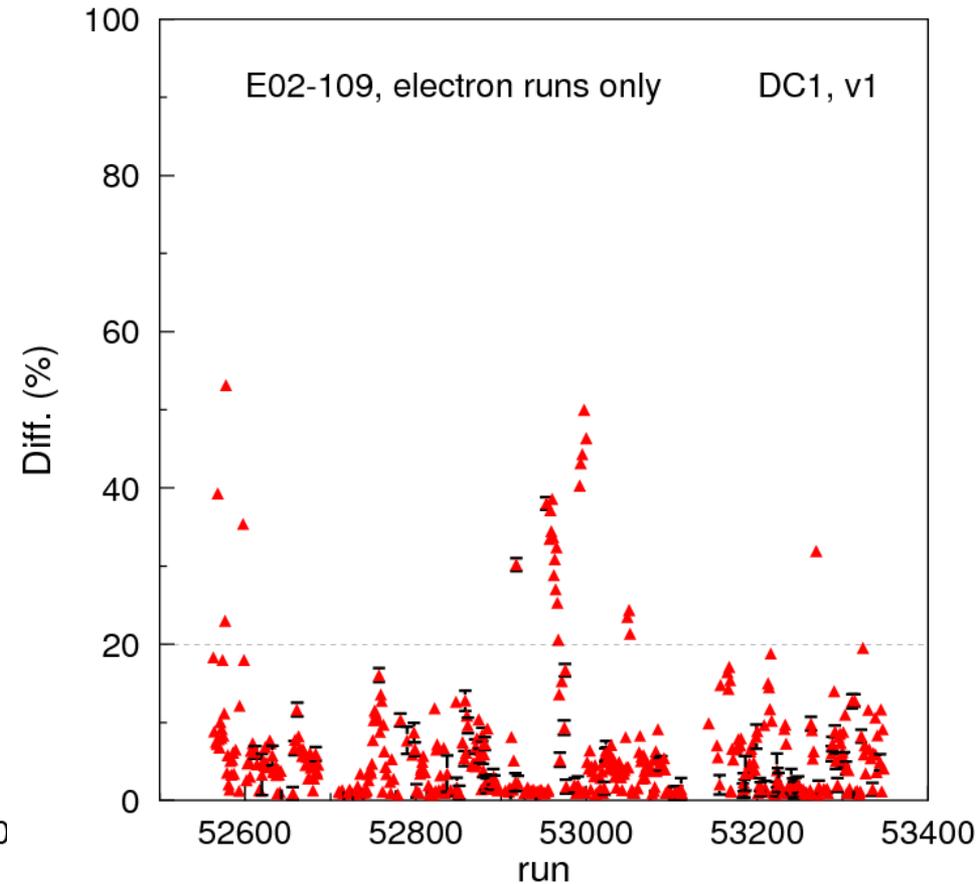
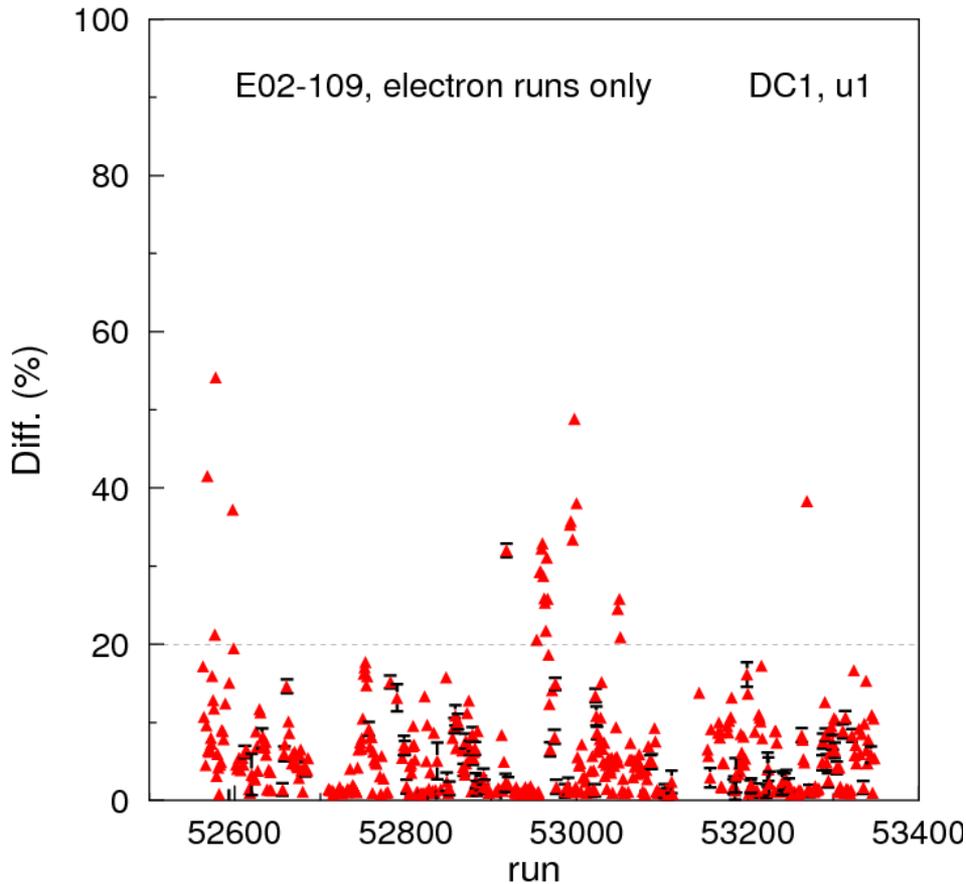
The difference plotted is a measure of the drift distance distribution uniformity within a drift cell after calibration



Few outliers but overall looks good

Calibrations Checks: Drift Chambers

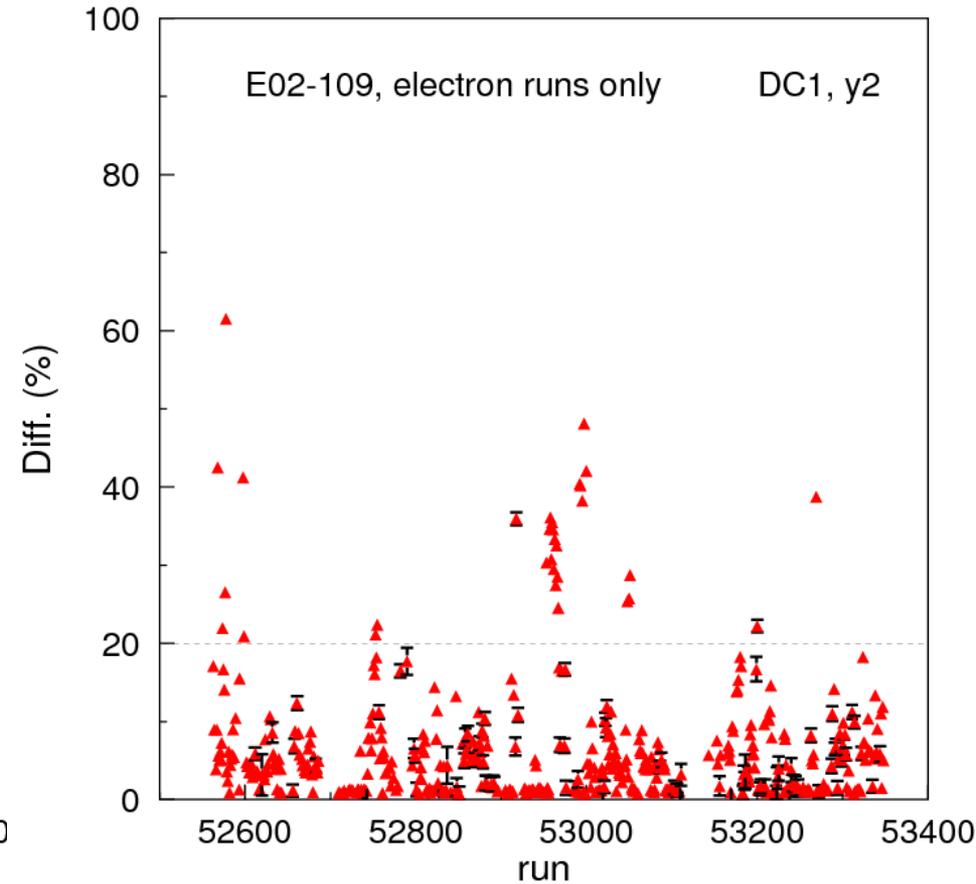
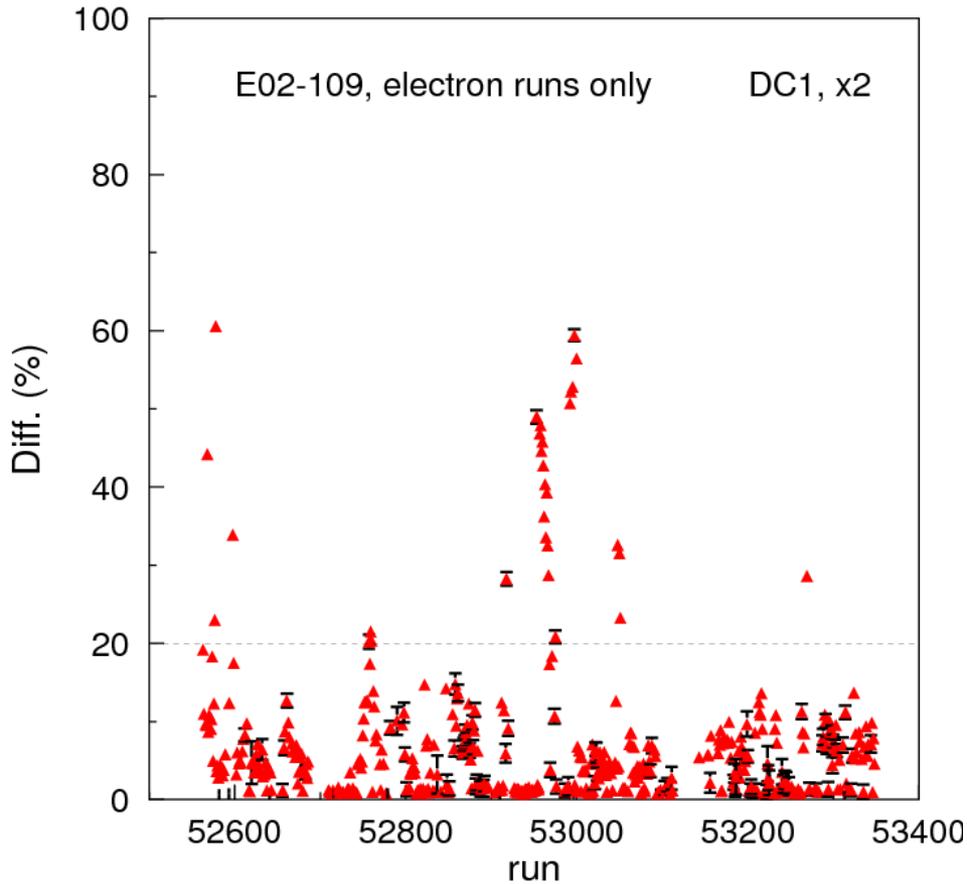
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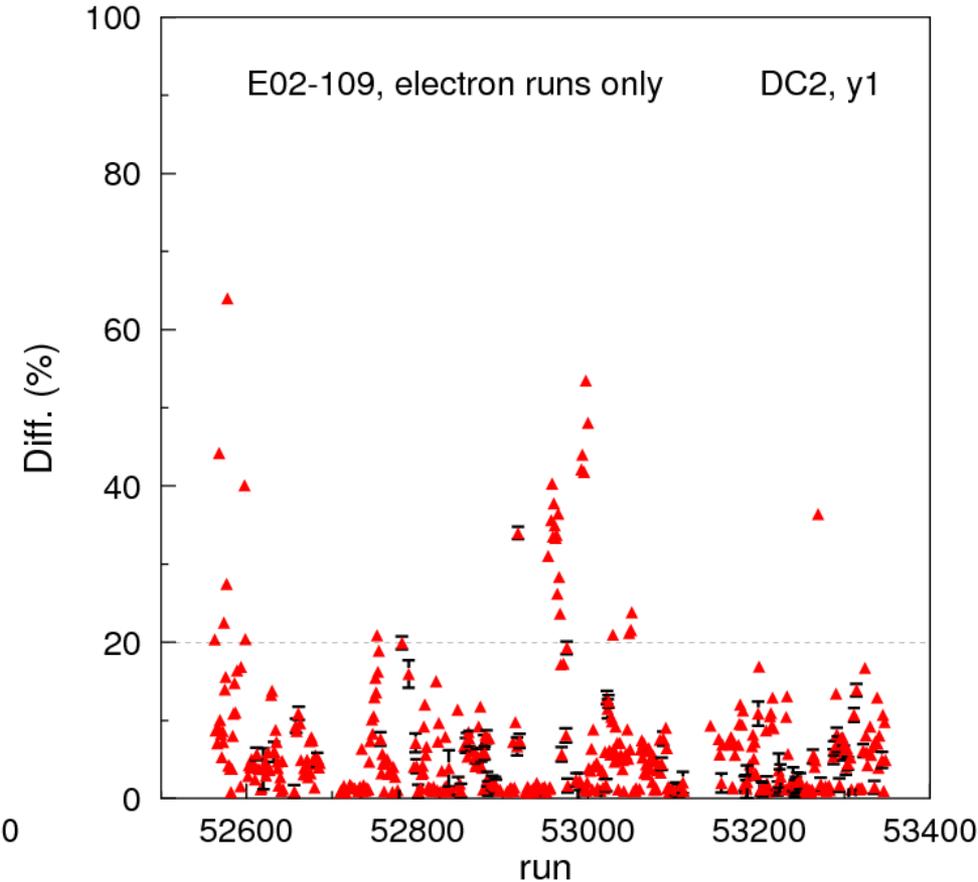
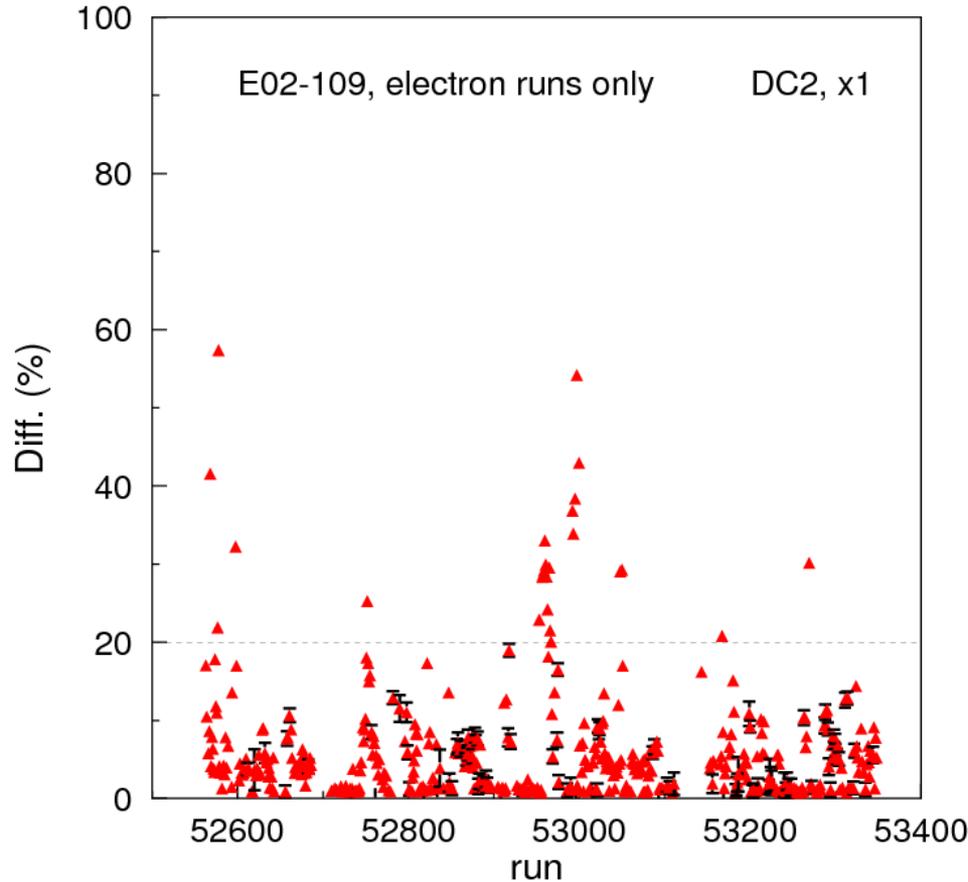
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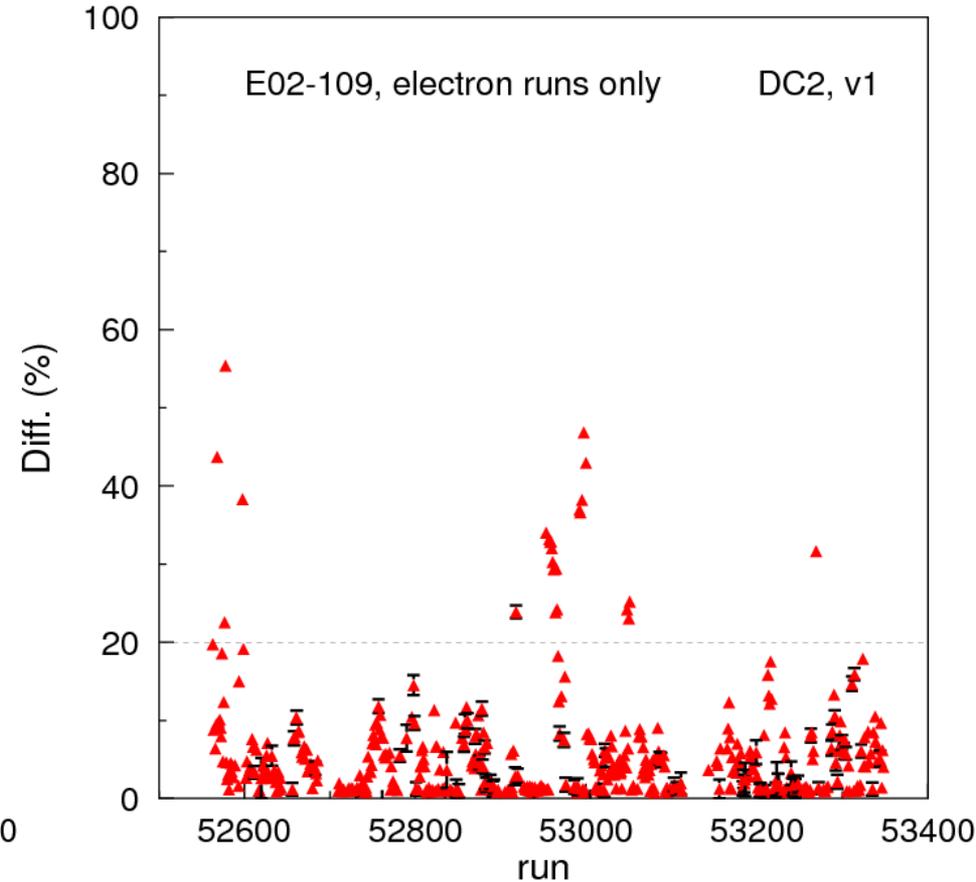
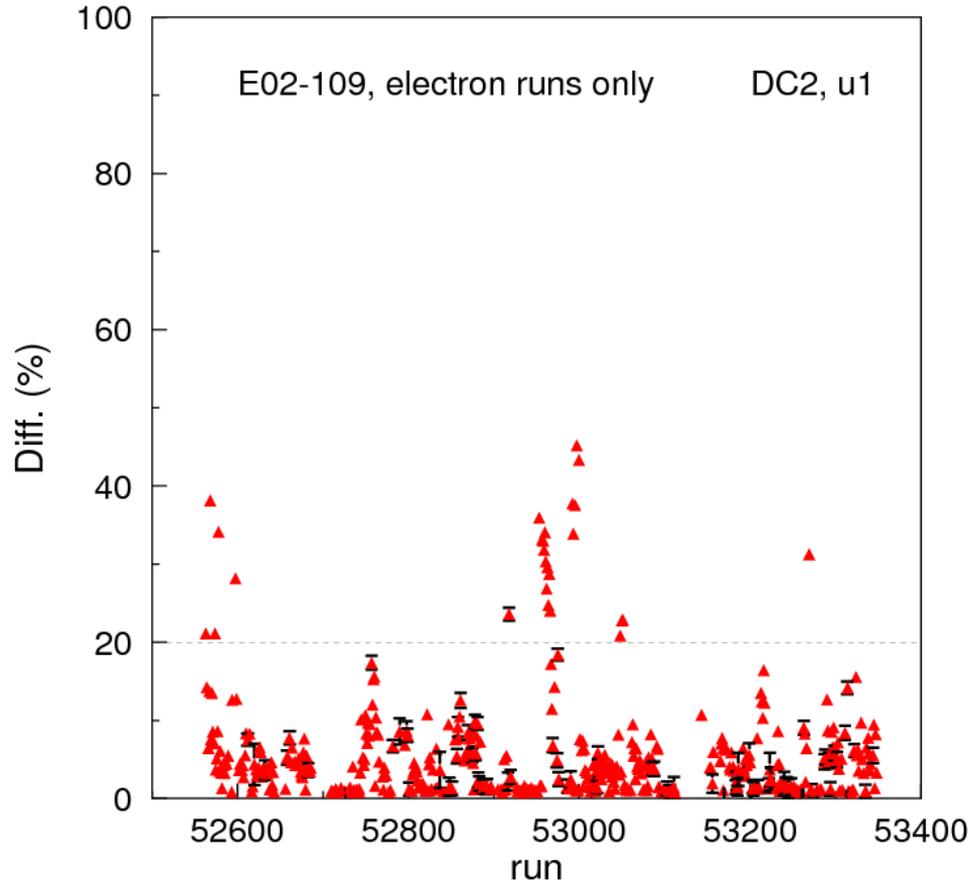
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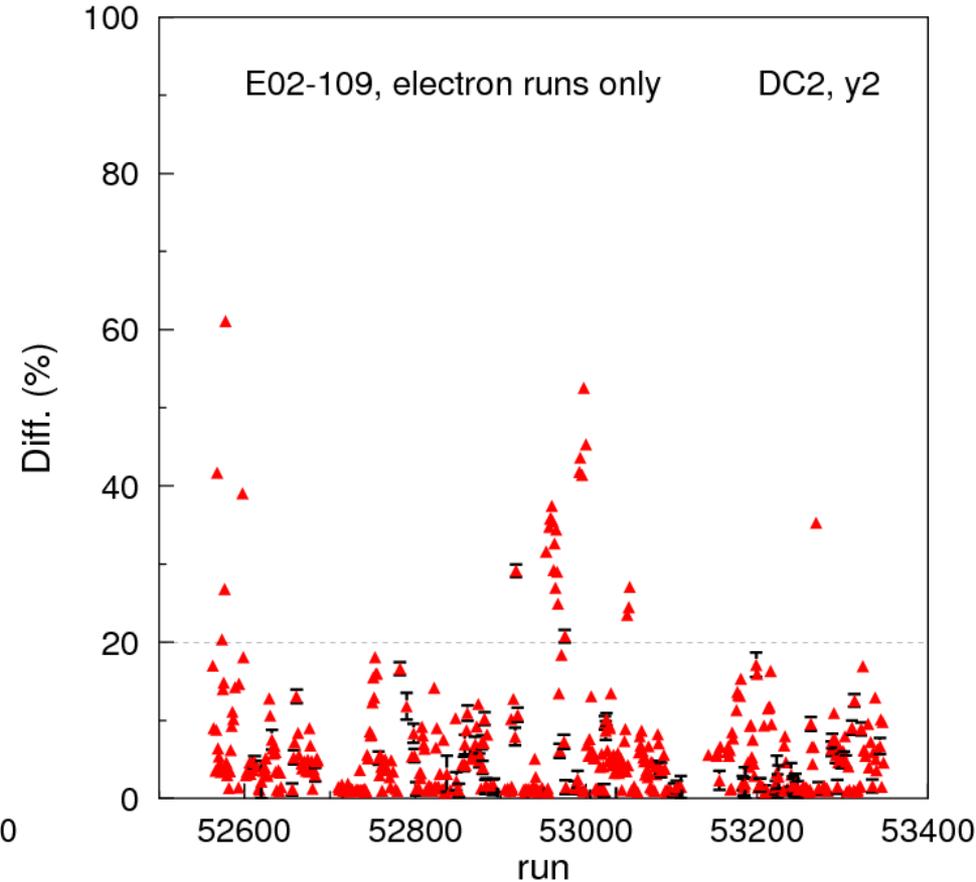
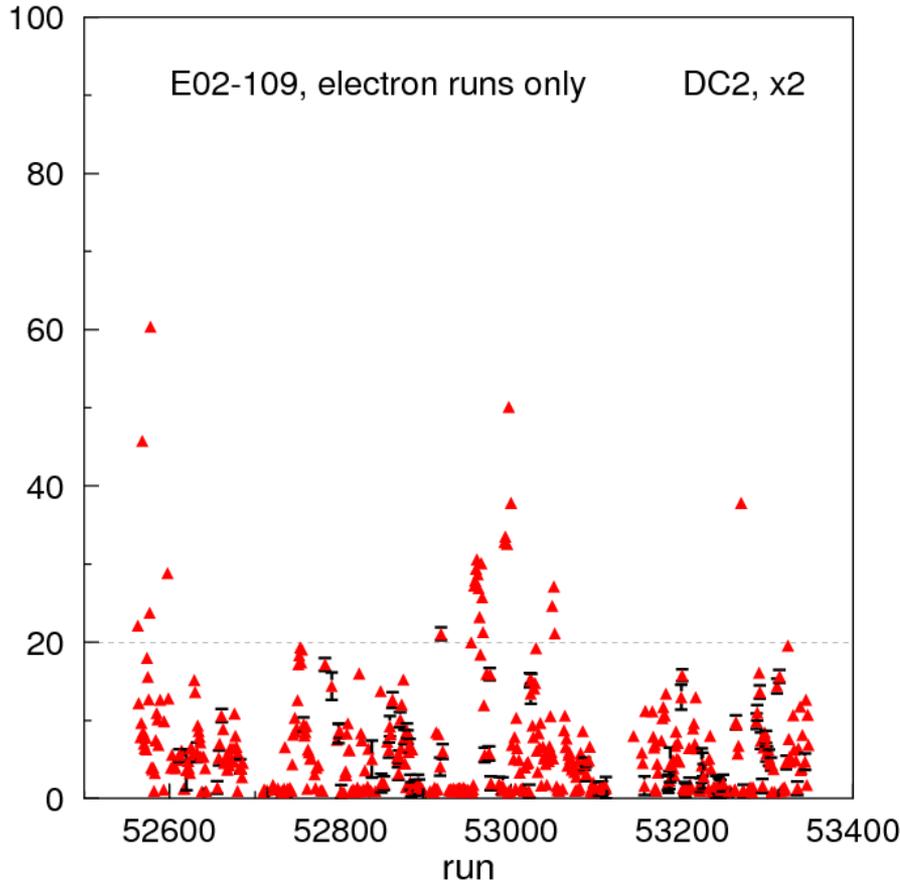
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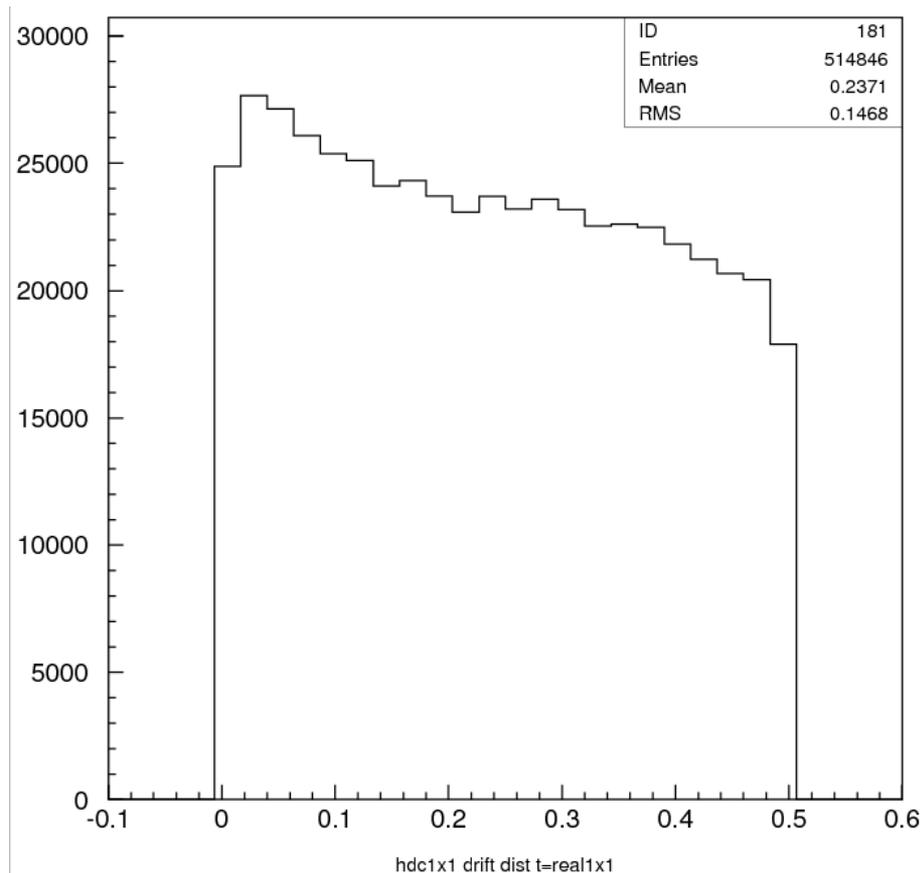
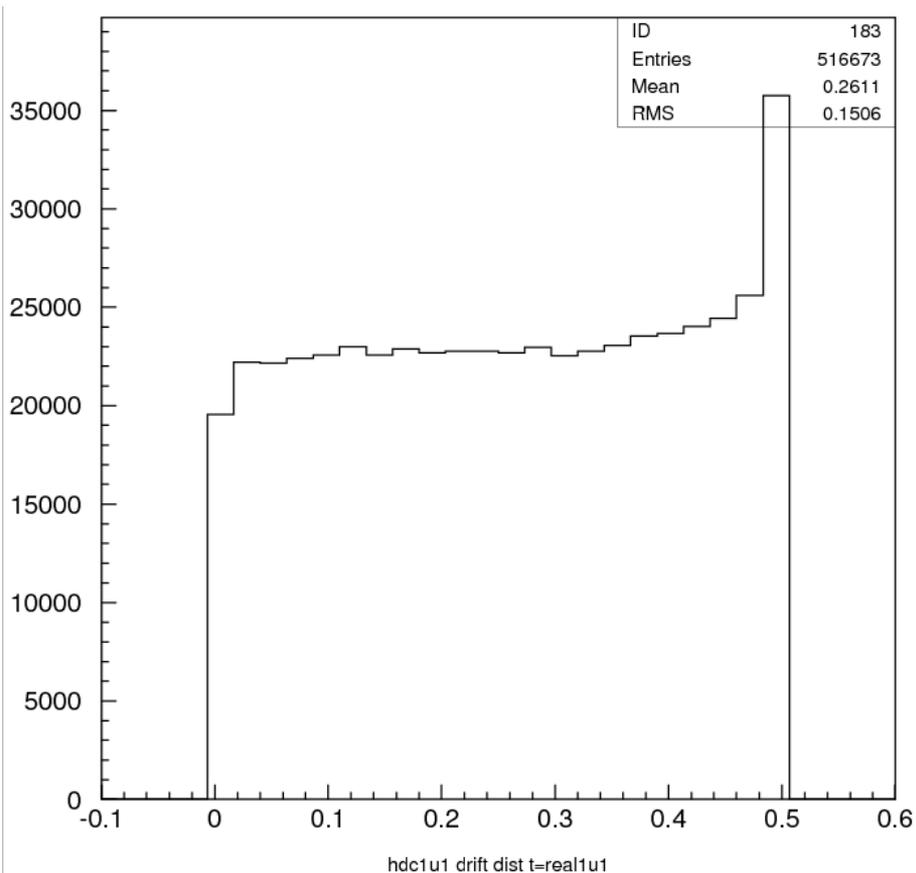


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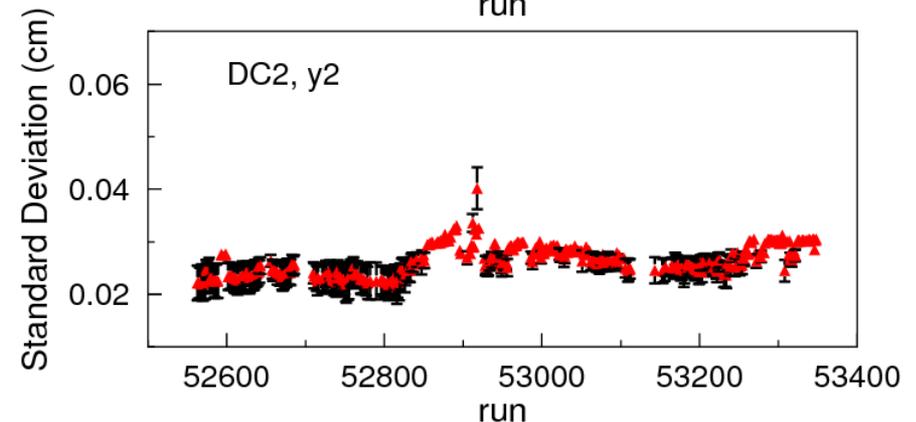
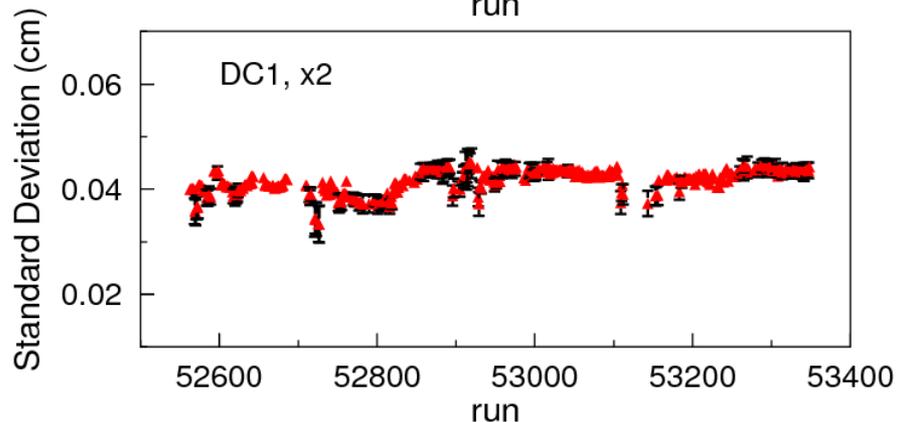
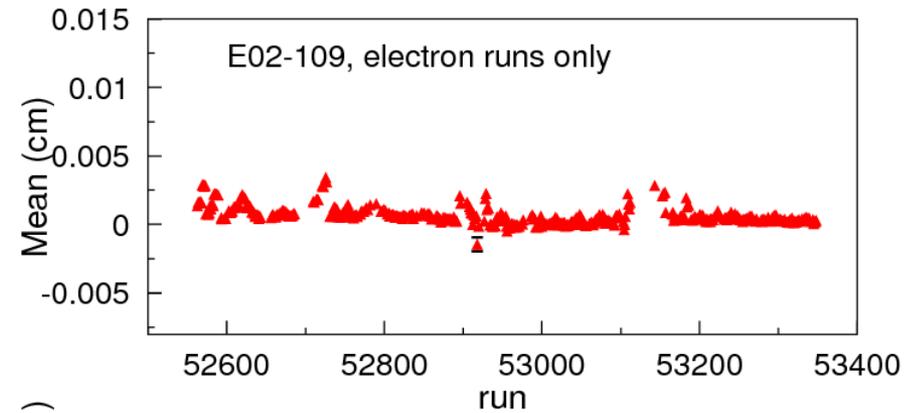
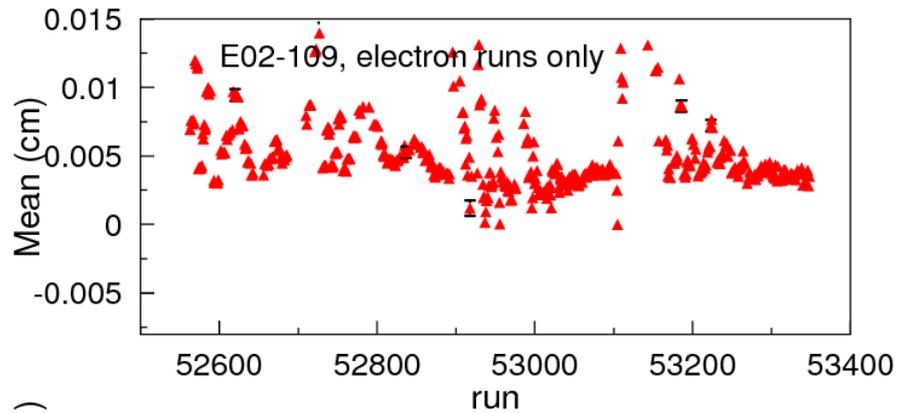
Few runs will need recalibration of the drift time-to-distance map but the calibration looks good for most electron runs

Example of the drift distance distribution for runs that need recalibration



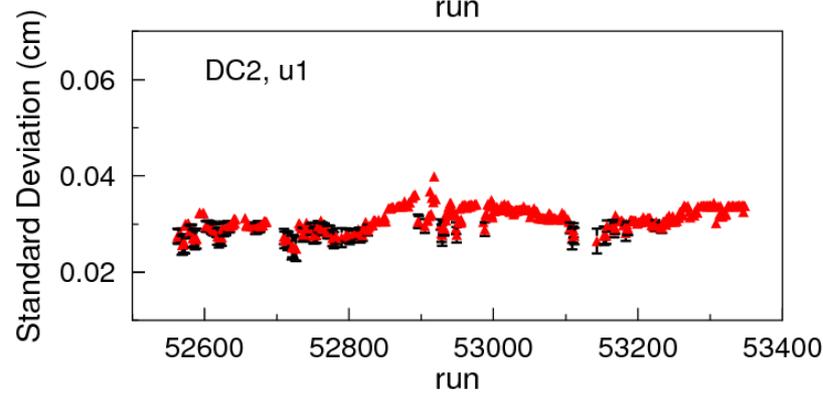
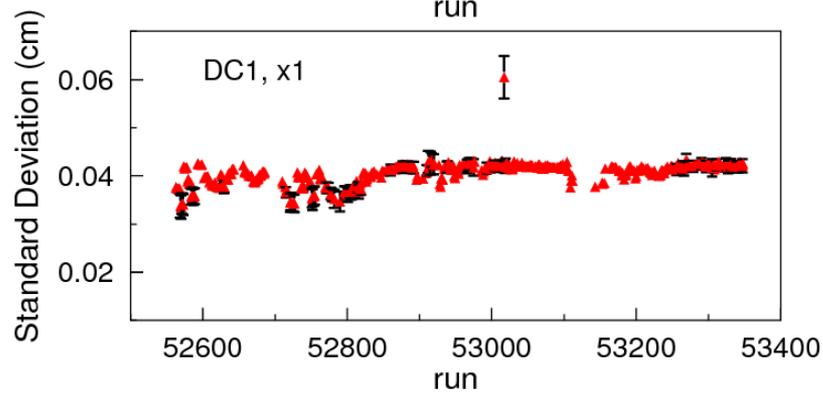
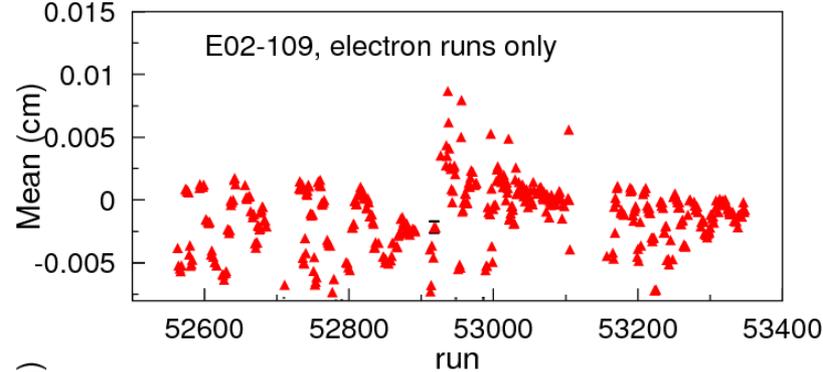
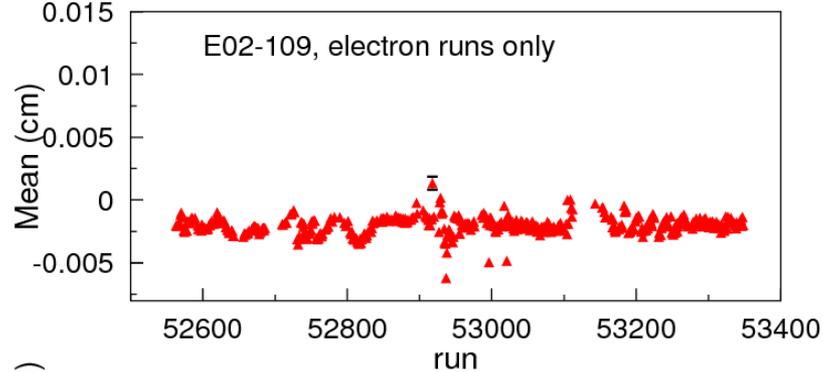
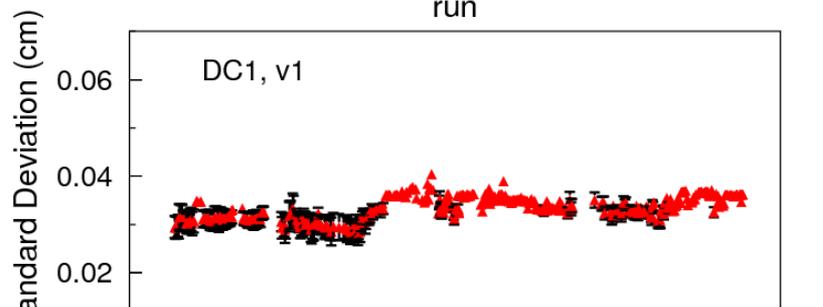
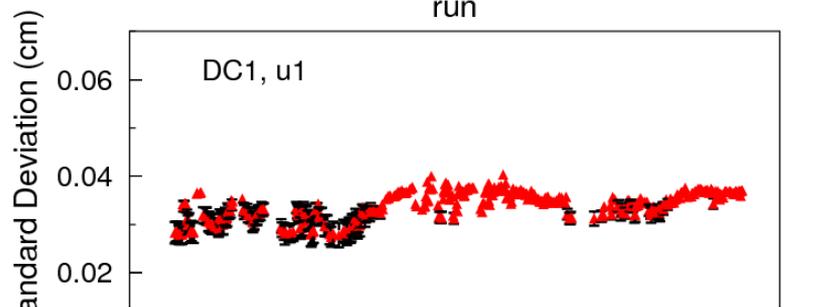
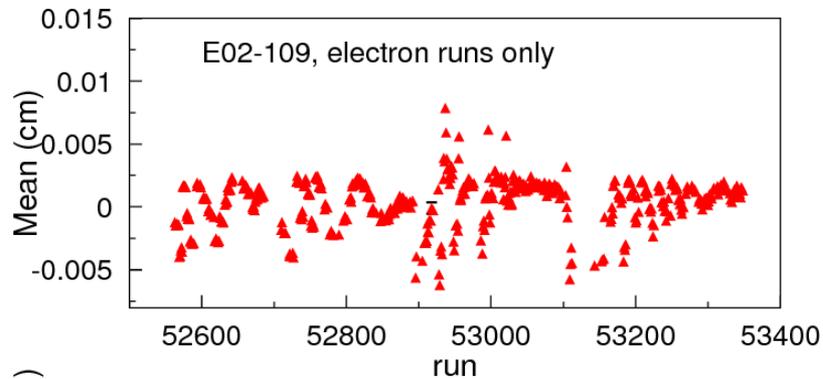
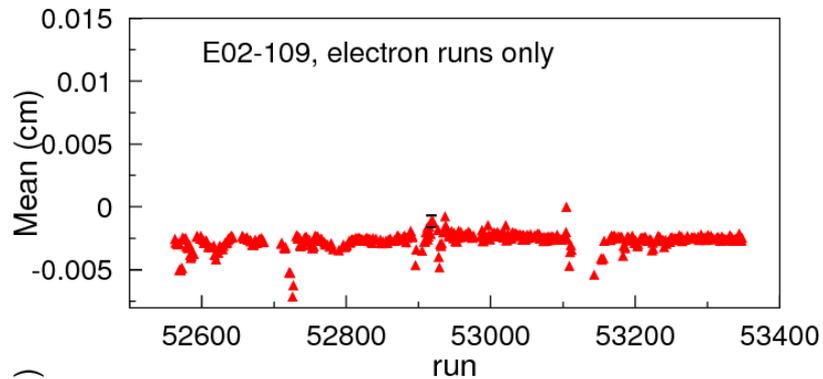
Calibrations Checks: Drift Chambers

Looked at the resolution of the chambers (combination of chamber performance, calibration and tracking) by fitting the residuals for each of the 12 planes (residuals are defined as the difference between where the particle hit the plane –after the drift distance correction- and the projection of the track on the plane)

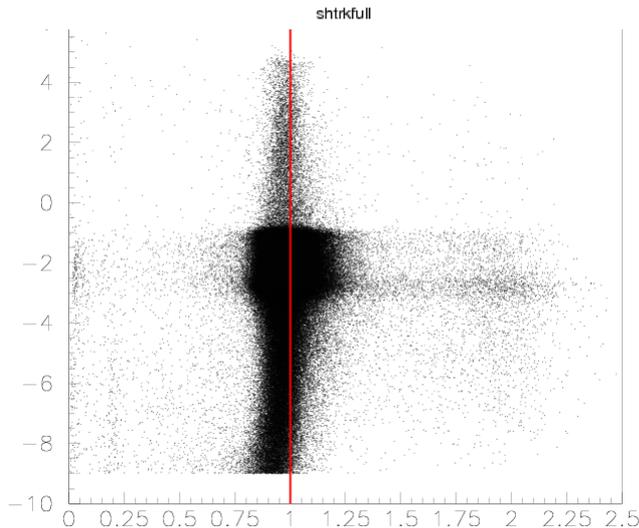
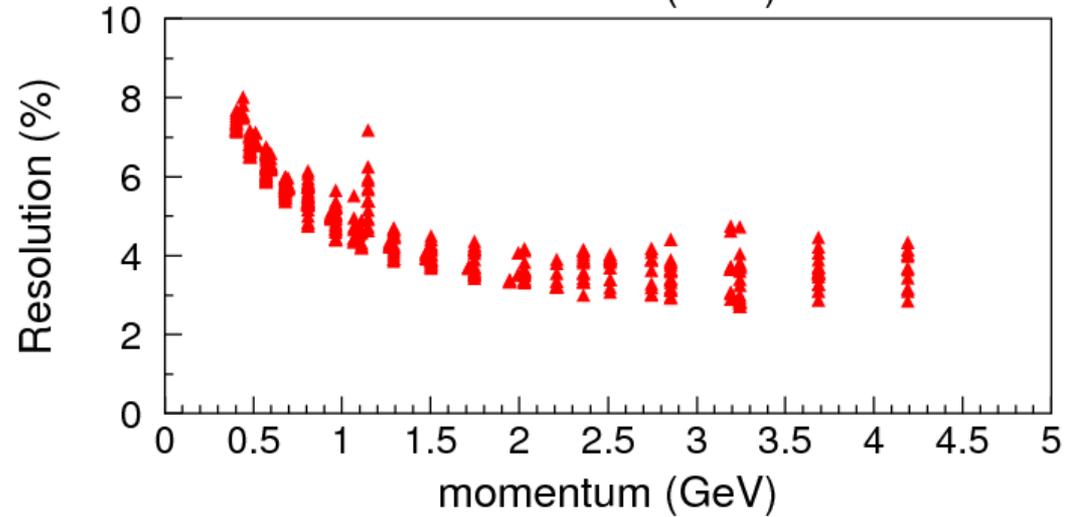
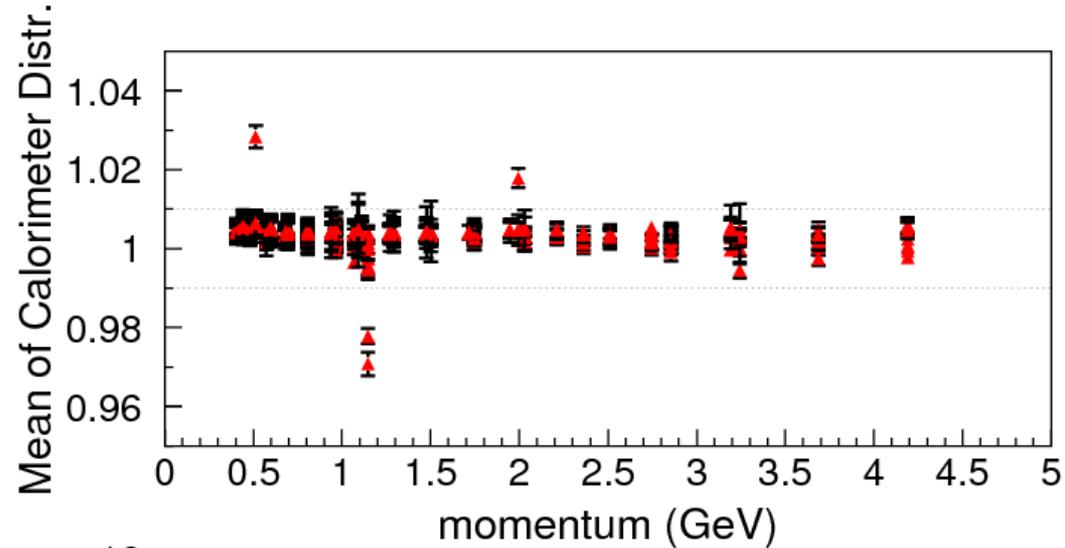
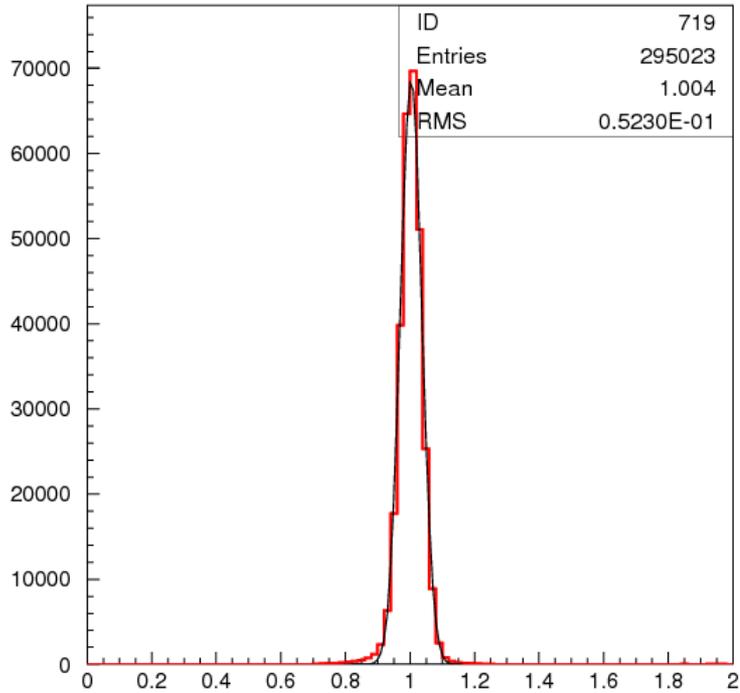


Worst plane resolution: 400 μm

Best plane resolution: 250 μm



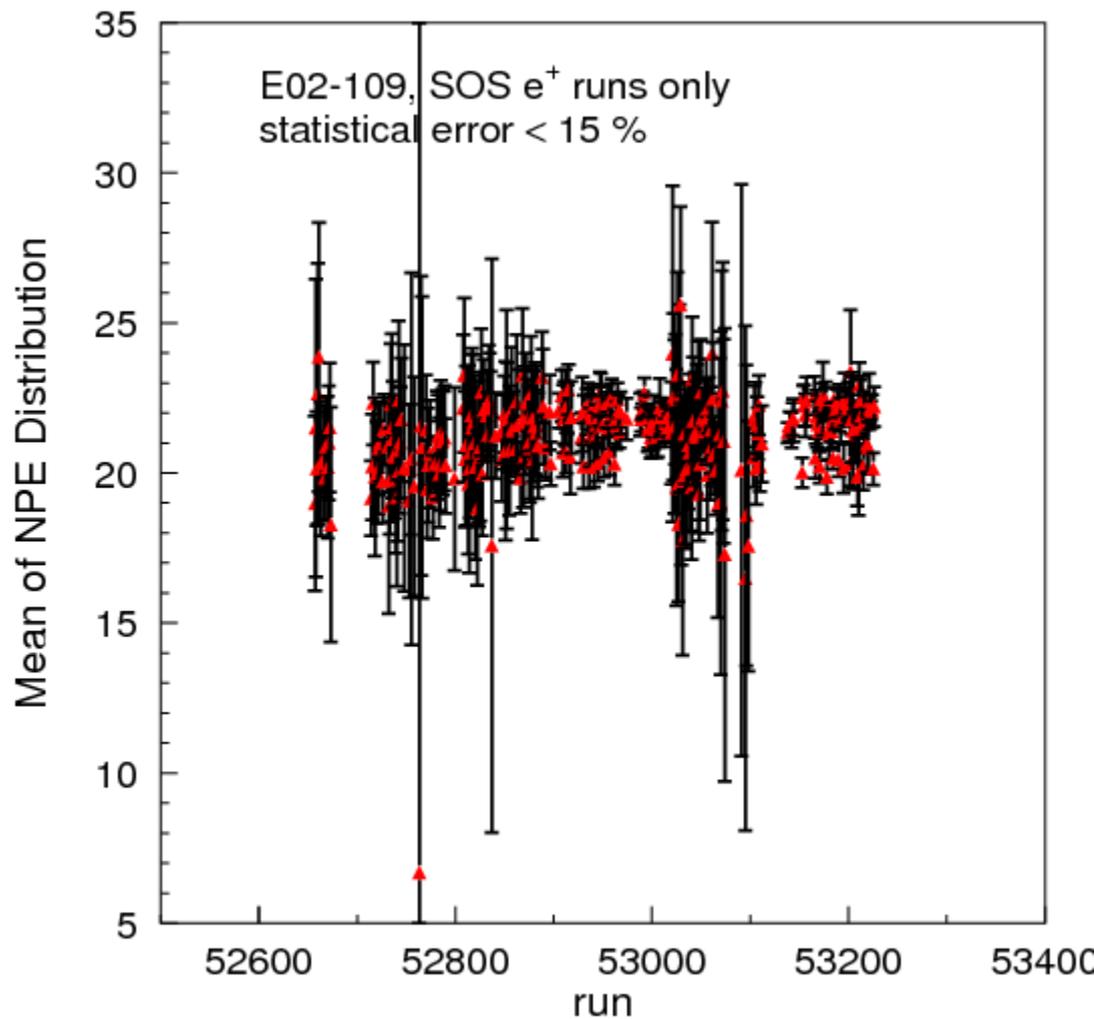
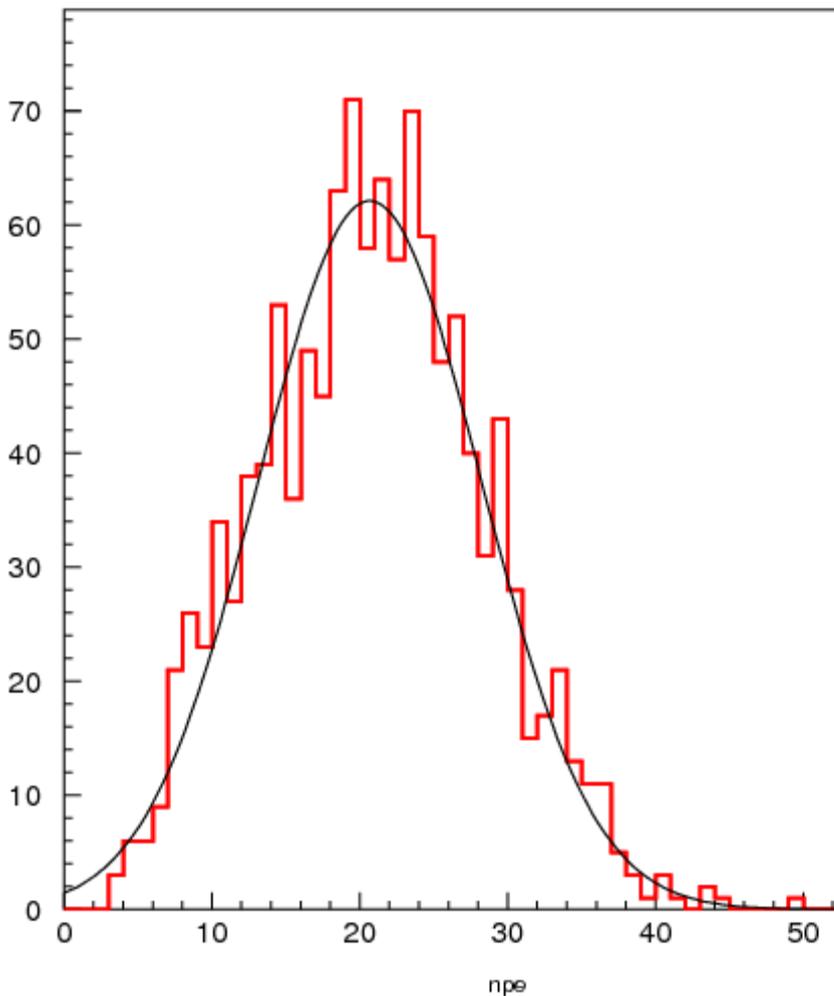
Calibrations Checks: Calorimeter



The Calorimeter calibration for electron runs looks good

SOS positron runs

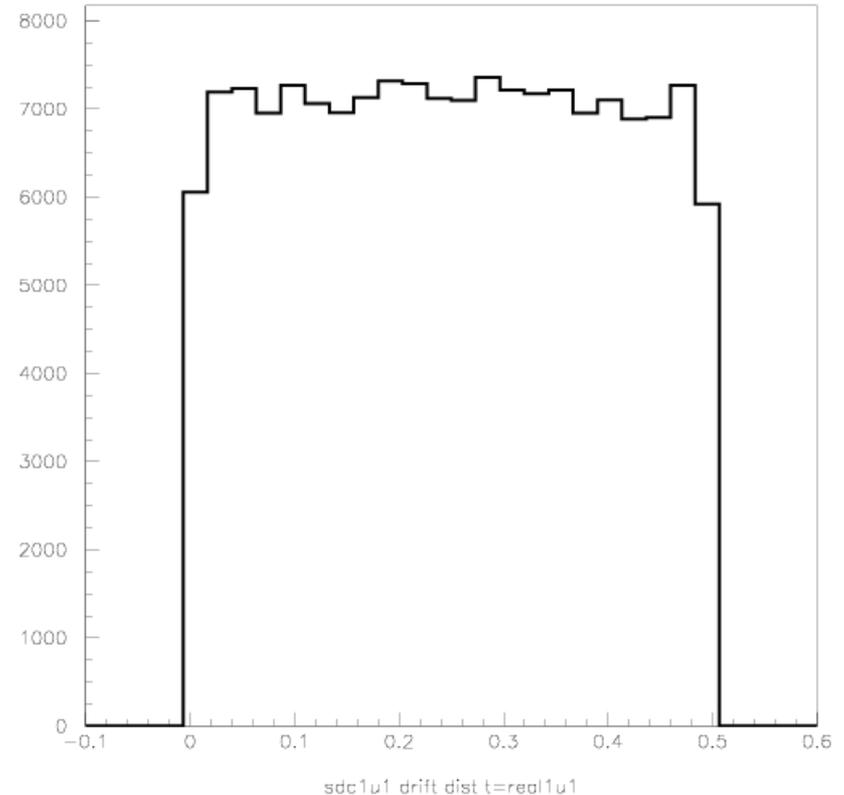
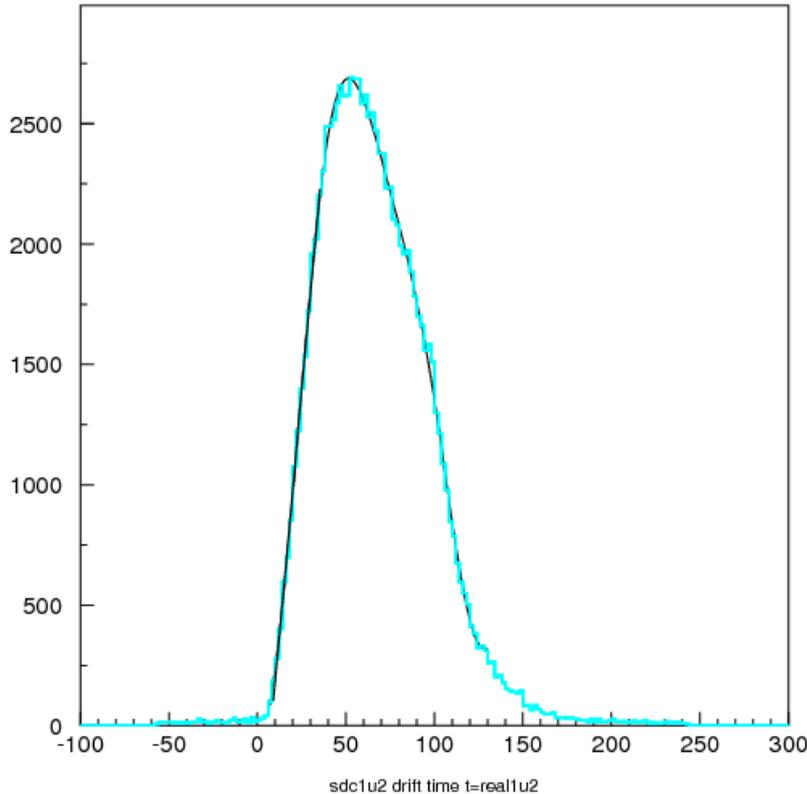
Calibrations Checks: Cerenkov



Positrons produce, on average, 21-22 photoelectrons in the SOS Cerenkov (C₄F₁₀ – 1 m -- at 1.4 atm)

Calibrations Checks: Drift Chambers

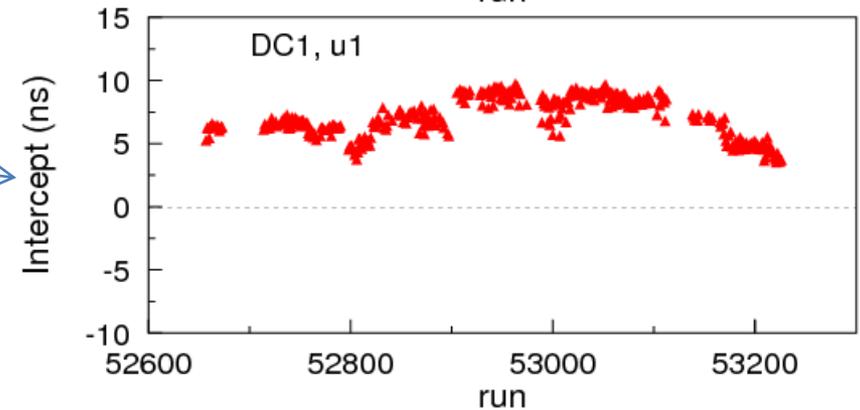
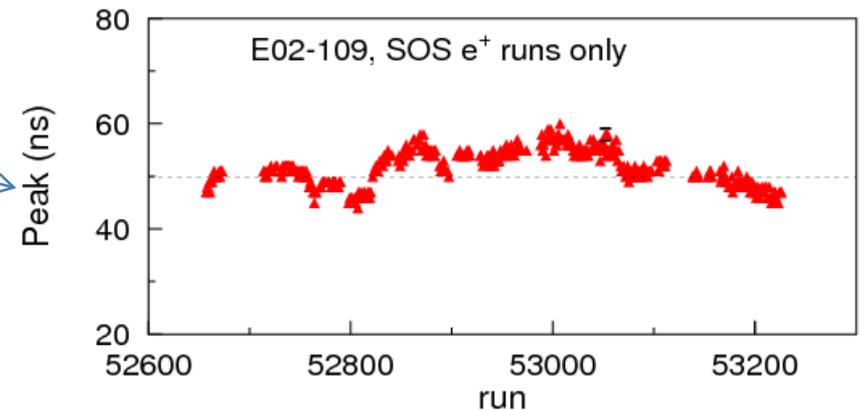
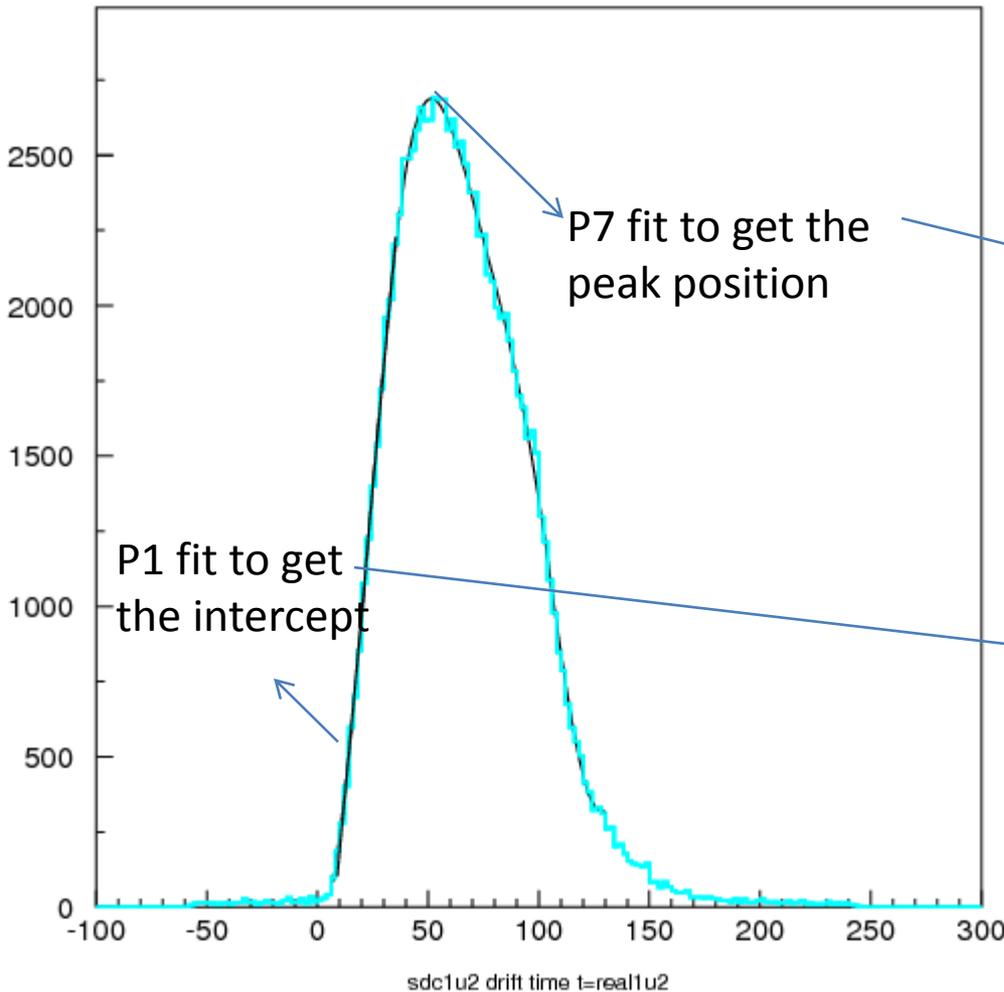
Drift distance calculated from the drift time and added to the wire coordinate to improve the resolution of the chamber



The drift cell is populated uniformly so we expect an uniform distribution of the drift distance after calibration

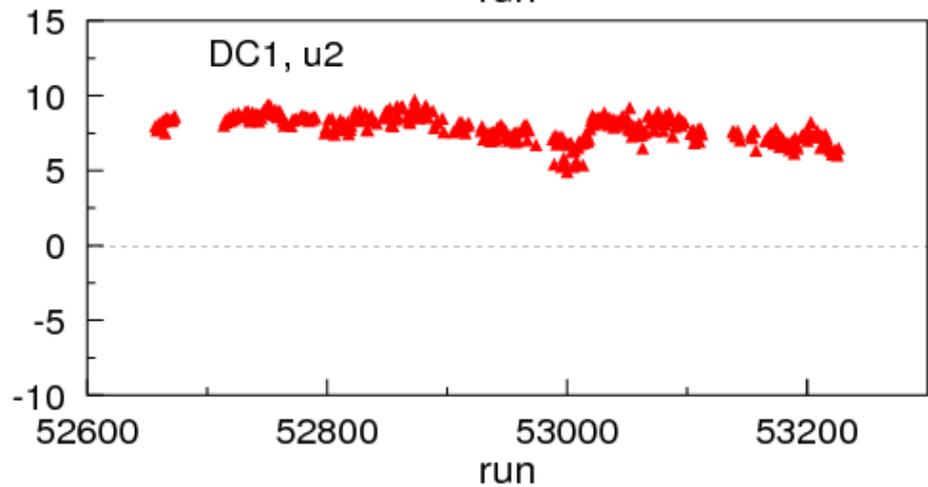
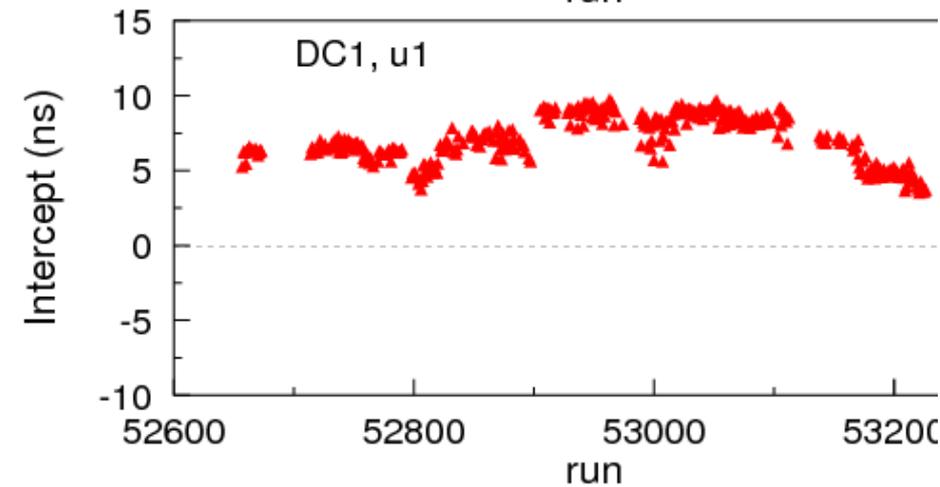
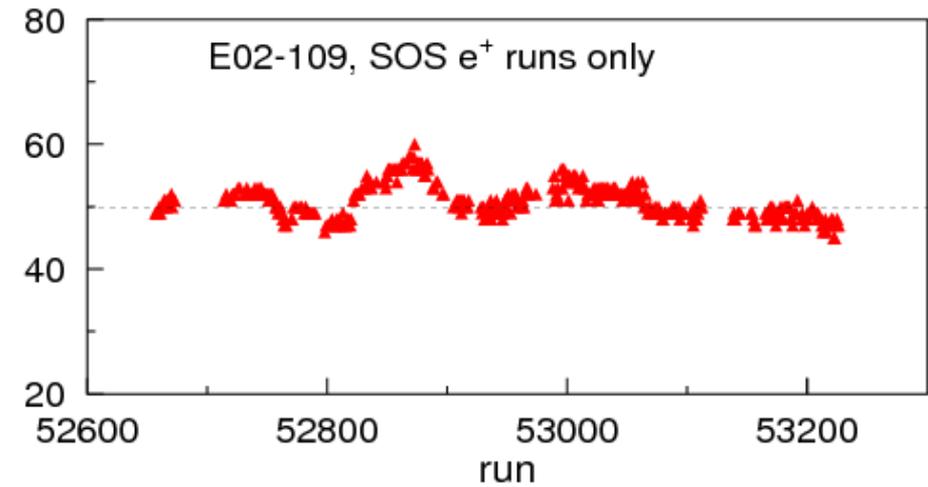
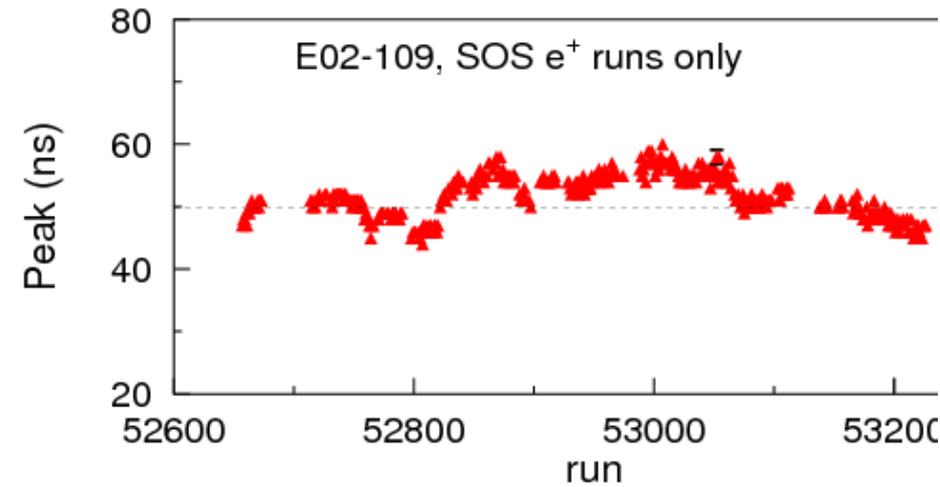
Calibrations Checks: Drift Time

Monitor the drift time distribution for all SOS positron runs



Calibrations Checks: Drift Time

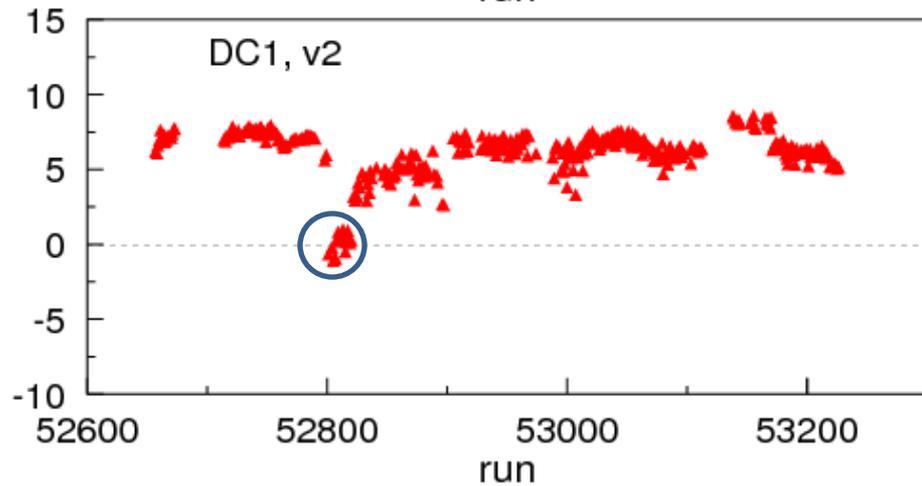
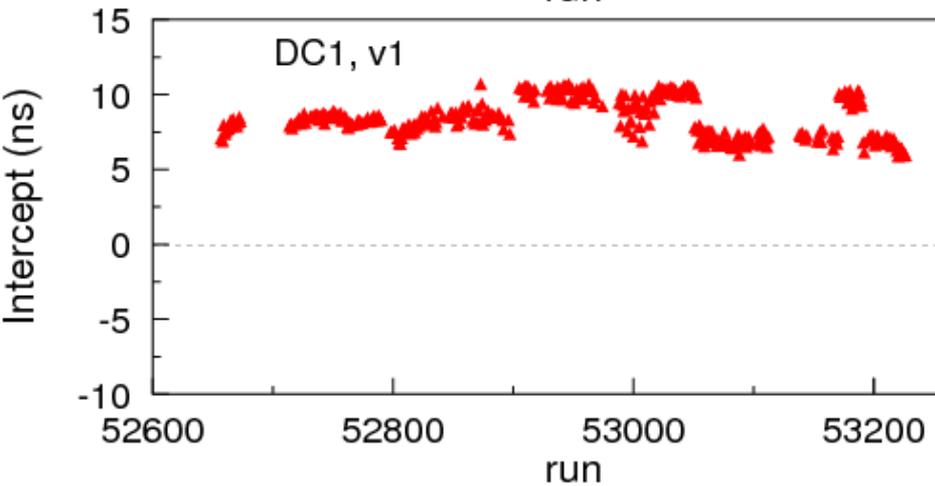
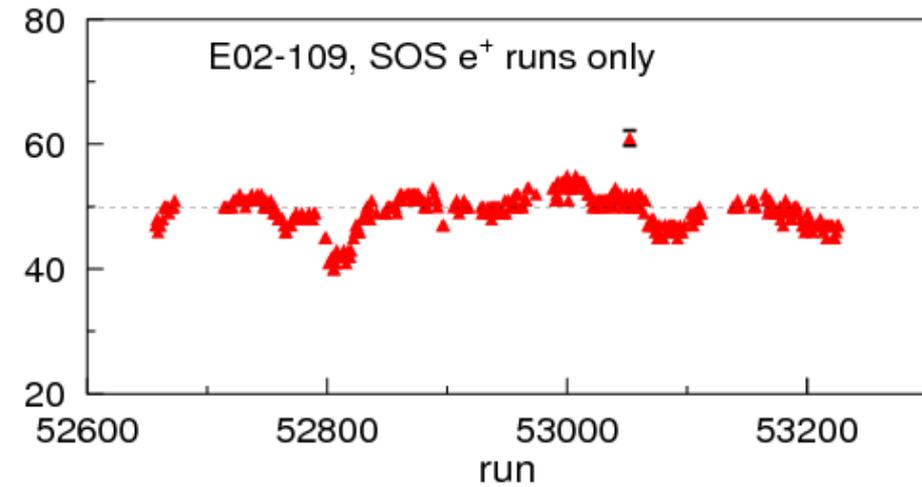
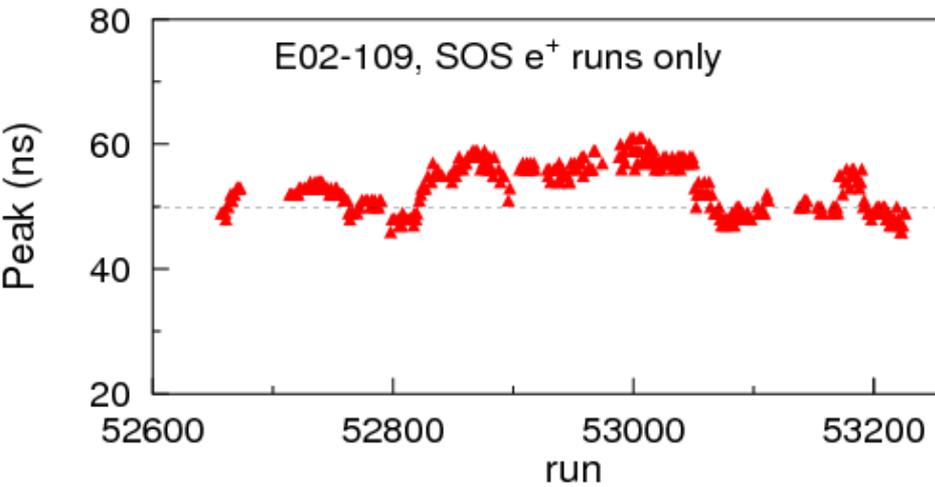
DC1 u1, u2



Looks good

Calibrations Checks: Drift Time

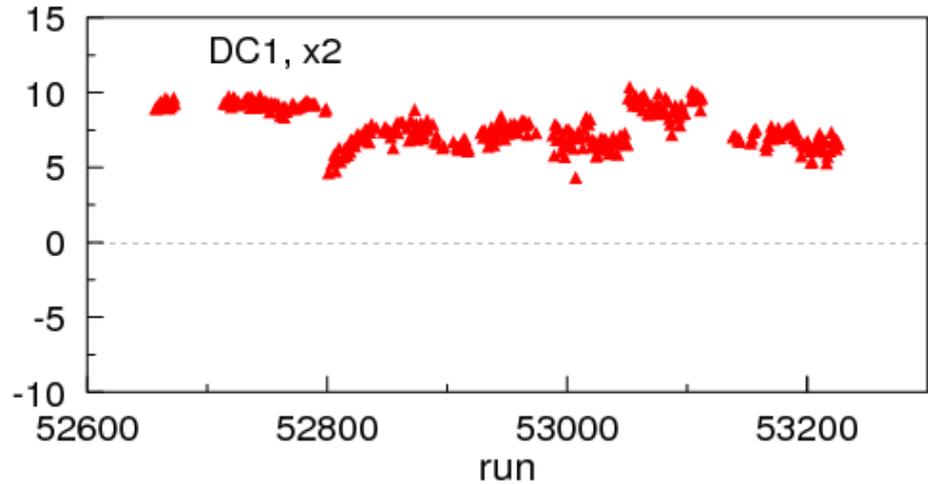
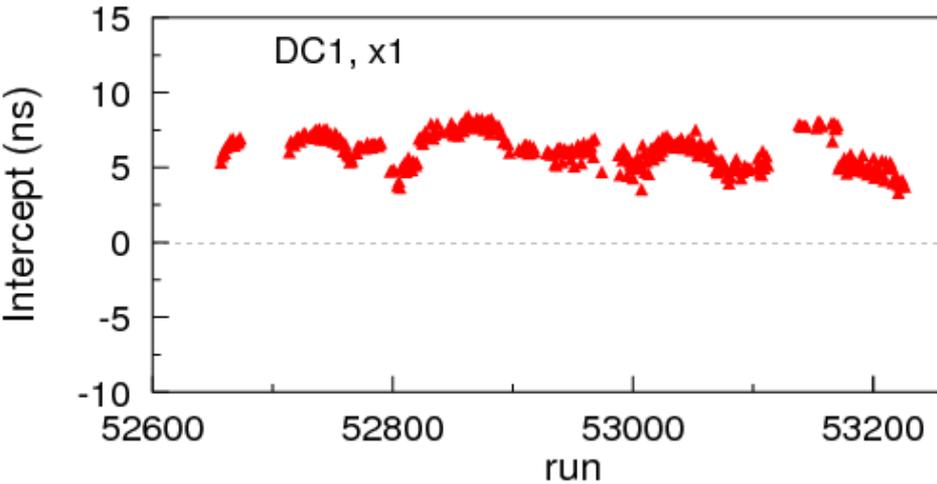
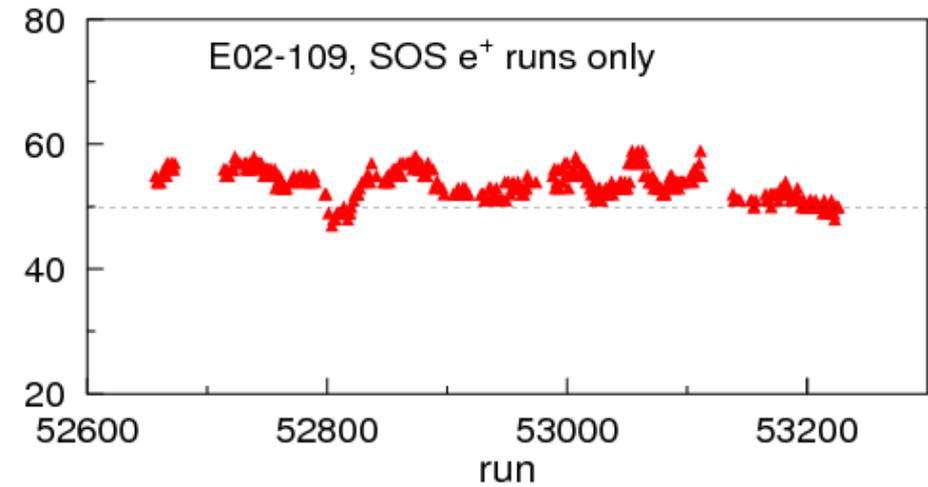
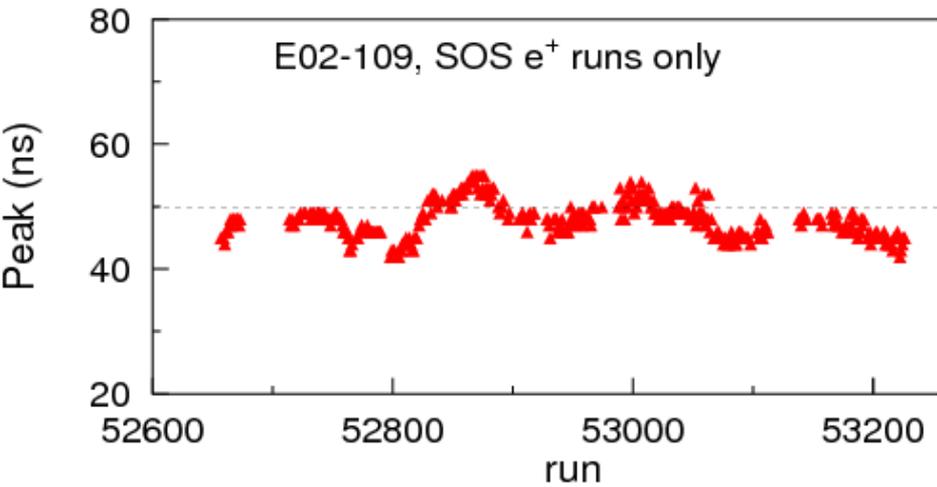
DC1 v1, v2



Looks good

Calibrations Checks: Drift Time

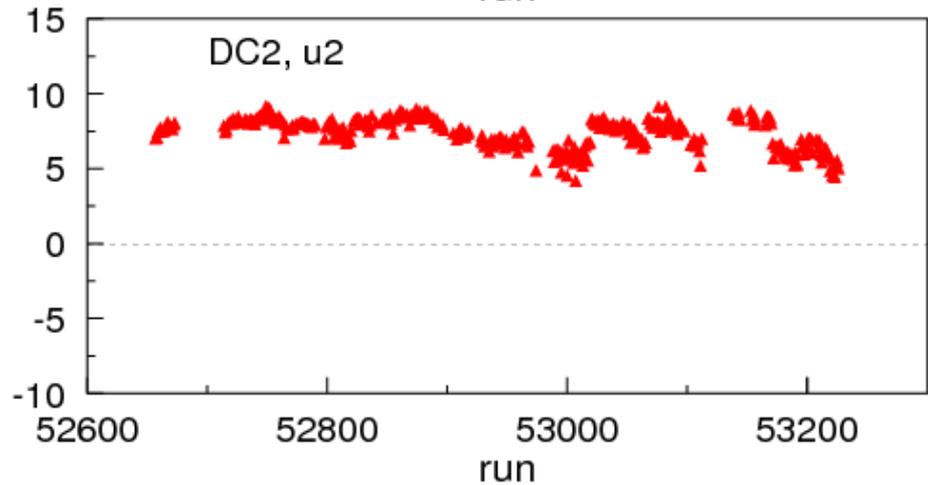
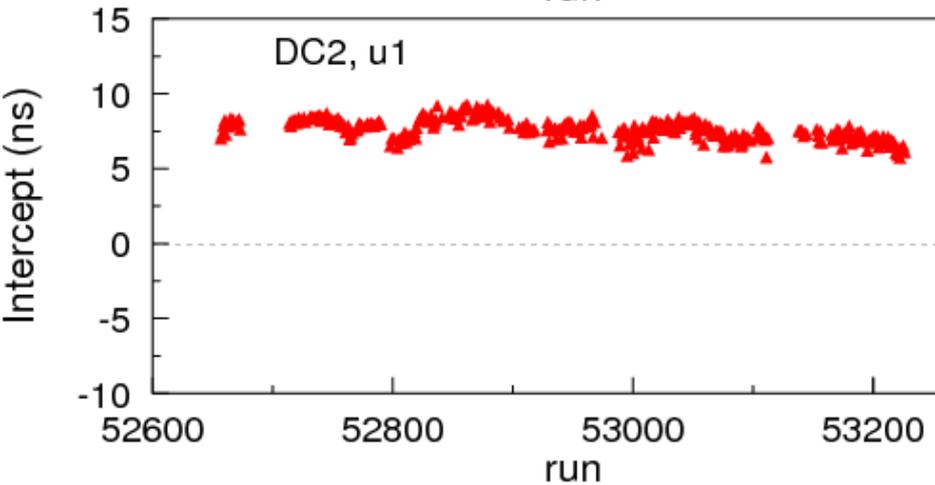
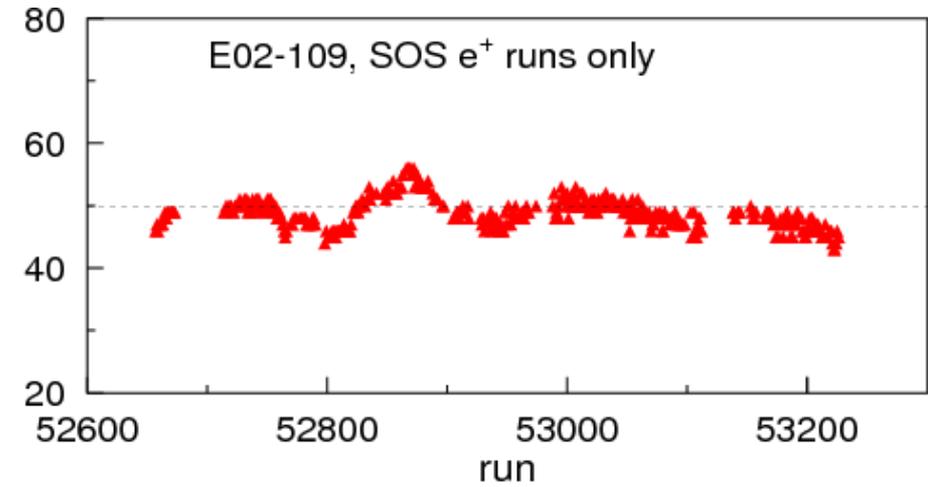
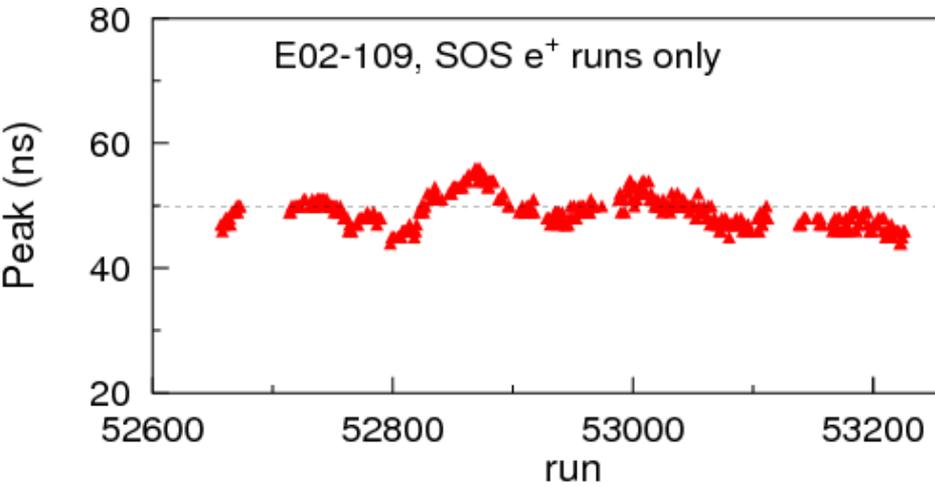
DC1 x1, x2



Looks good

Calibrations Checks: Drift Time

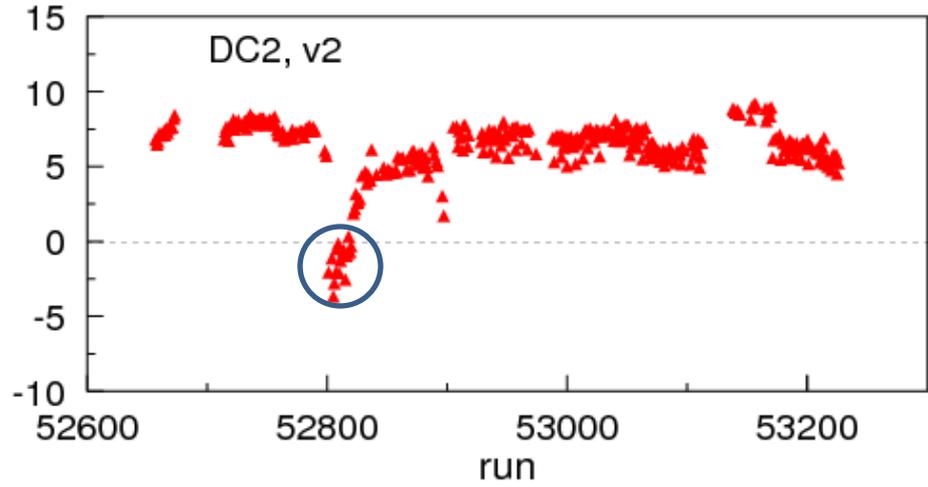
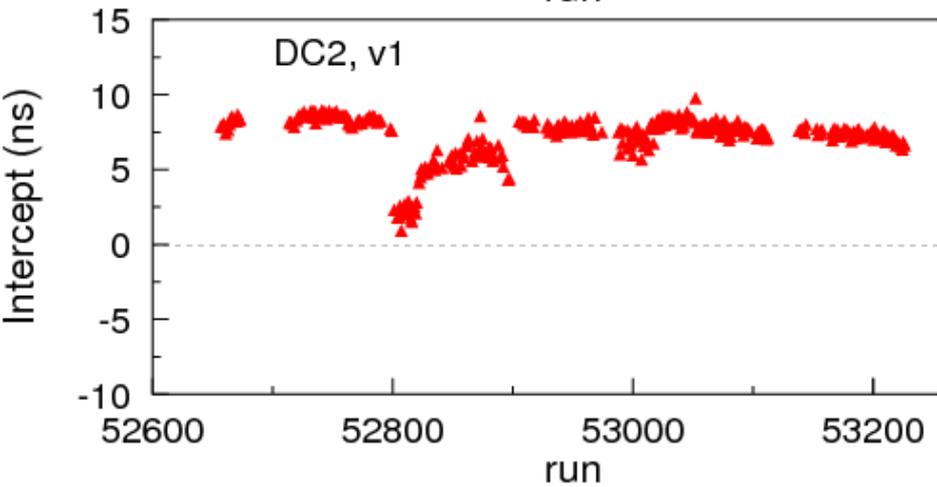
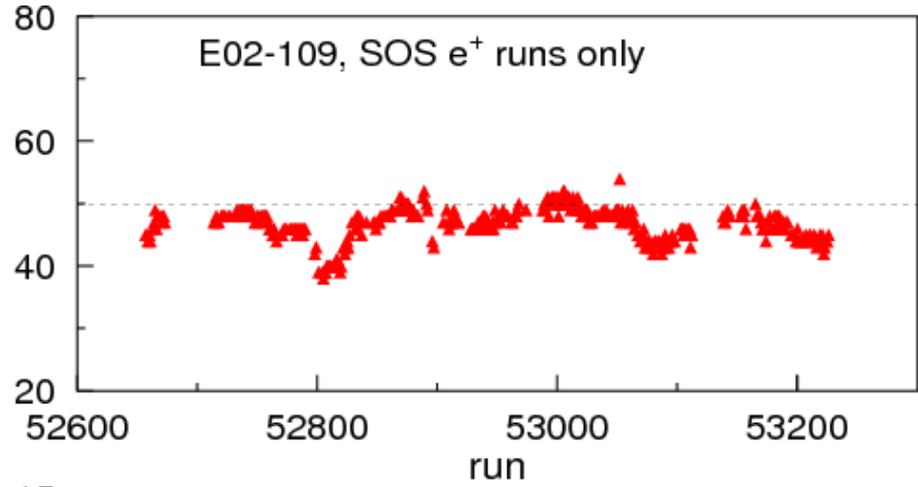
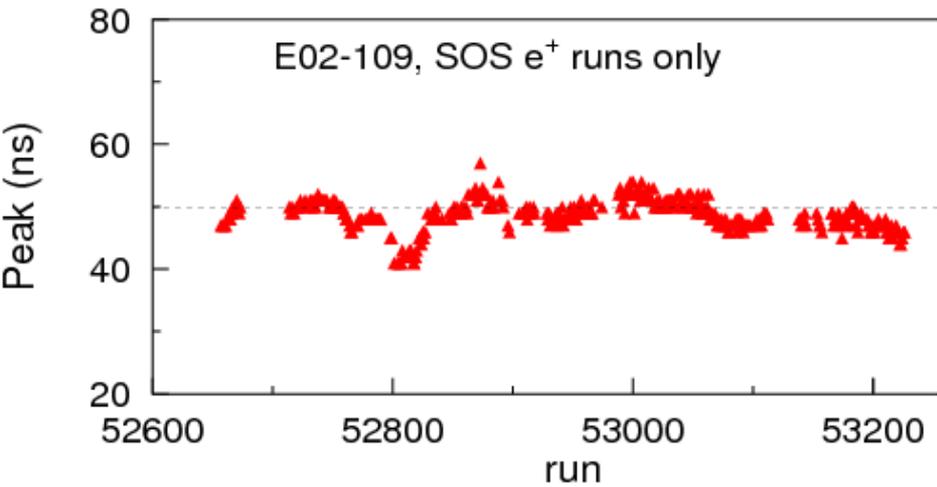
DC2 u1, u2



Looks good

Calibrations Checks: Drift Time

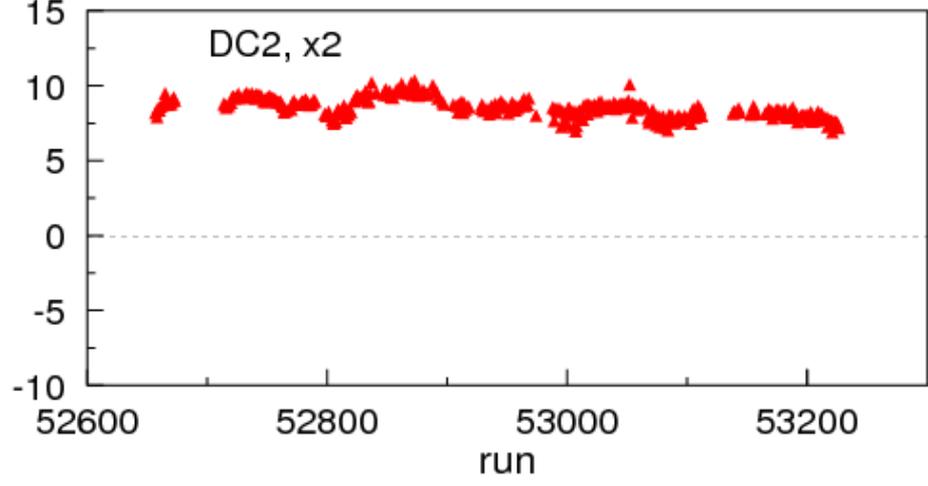
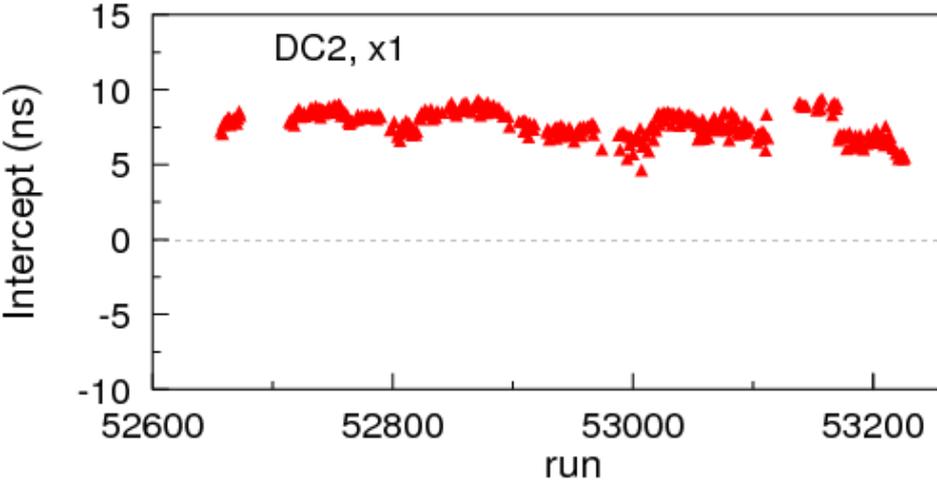
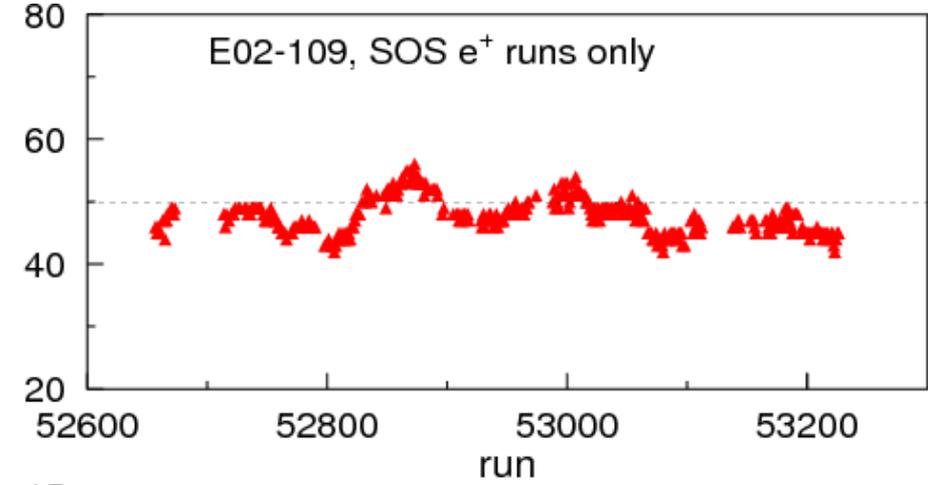
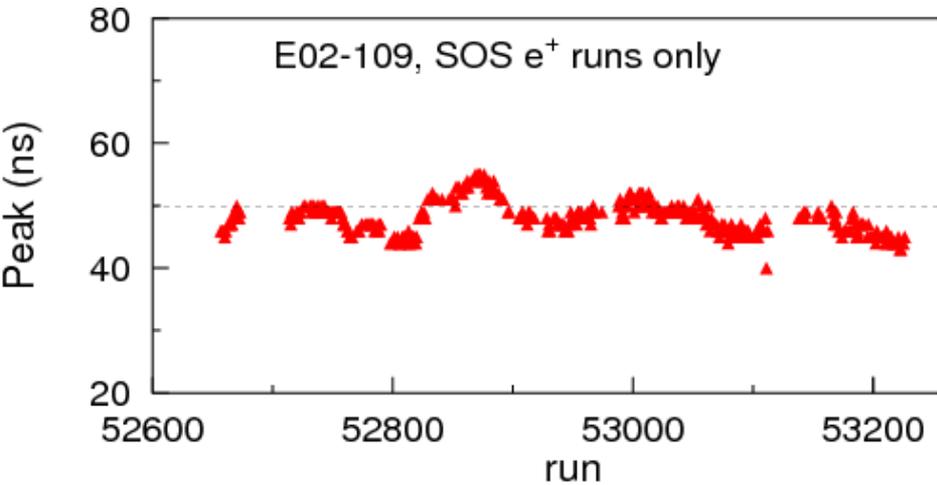
DC2 v1, v2



Looks ~good

Calibrations Checks: Drift Time

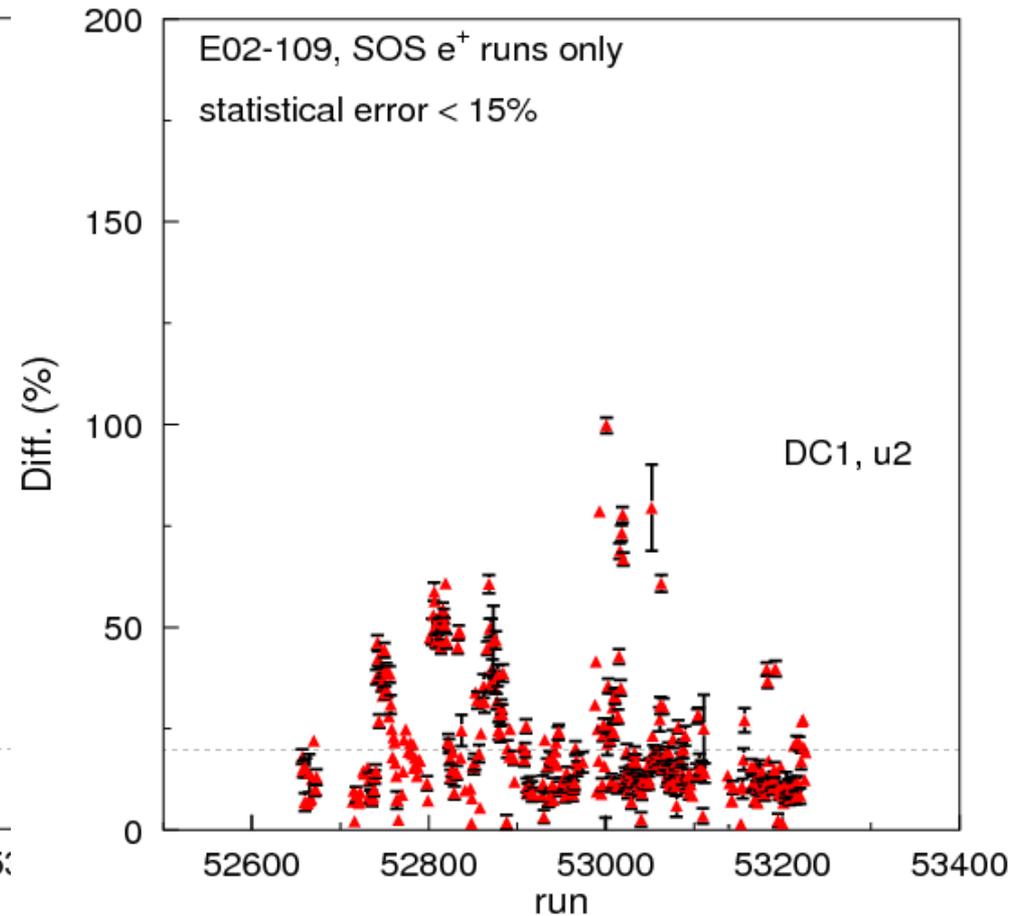
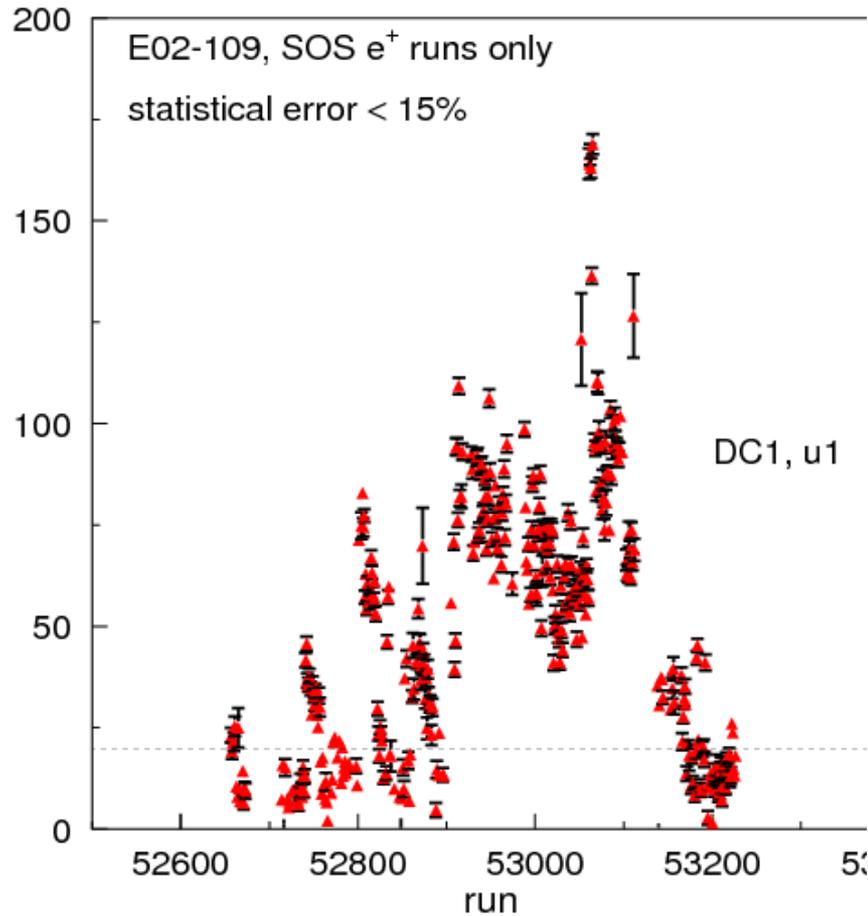
DC2 x1, x2



Looks good

Calibrations Checks: Drift Distance DC1 u1, u2

The difference plotted is a measure of the drift distance distribution uniformity within a drift cell after calibration



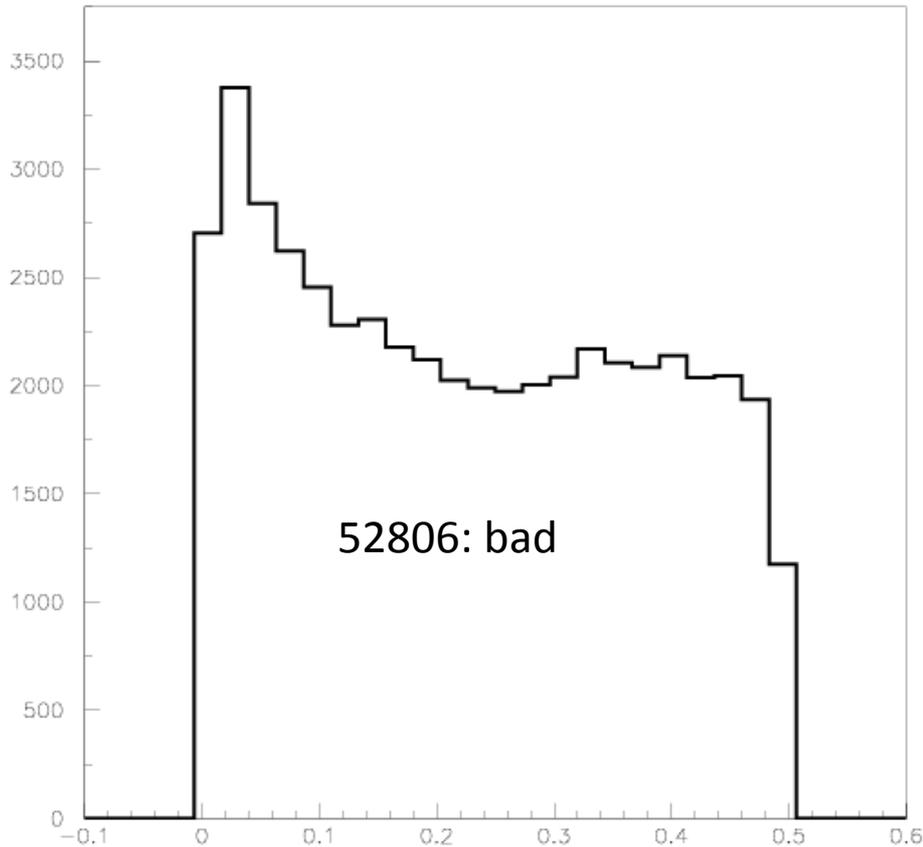
Looks so-so

Calibrations Checks: Drift Chambers

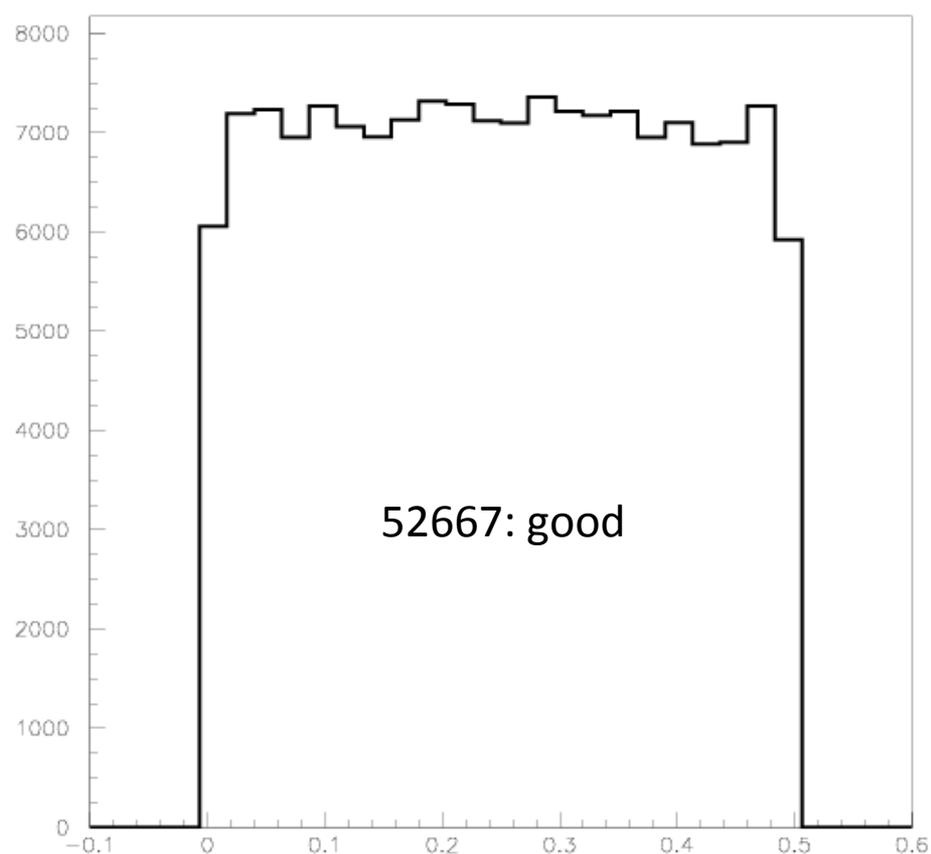
DC1 u1

Some runs will need recalibration of the drift time-to-distance map

DC1, u1



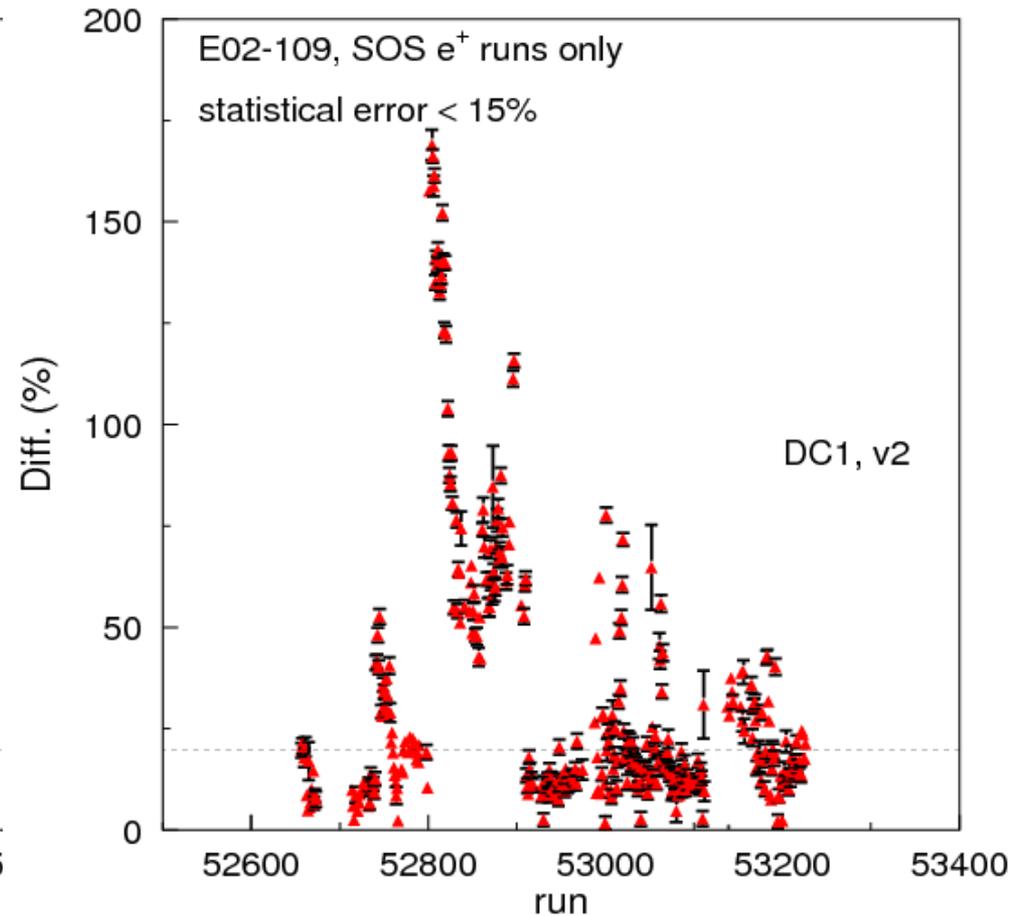
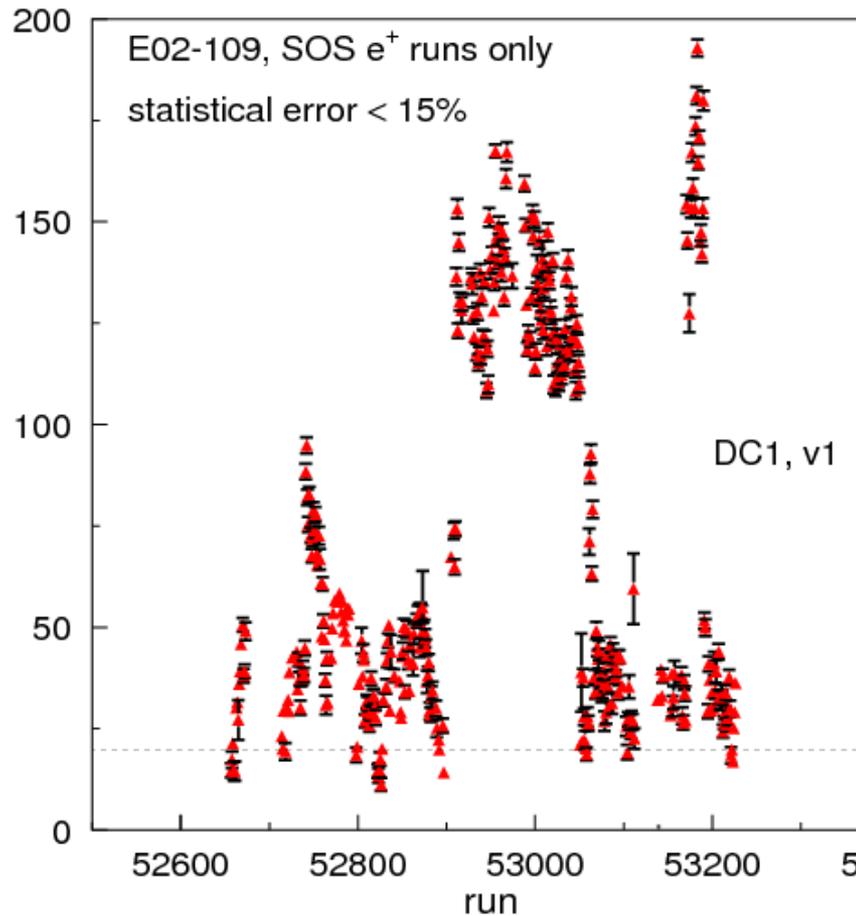
DC1, u1



Calibrations Checks: Drift Chambers

DC1 v1, v2

The difference plotted is a measure of the drift distance distribution uniformity within a drift cell after calibration



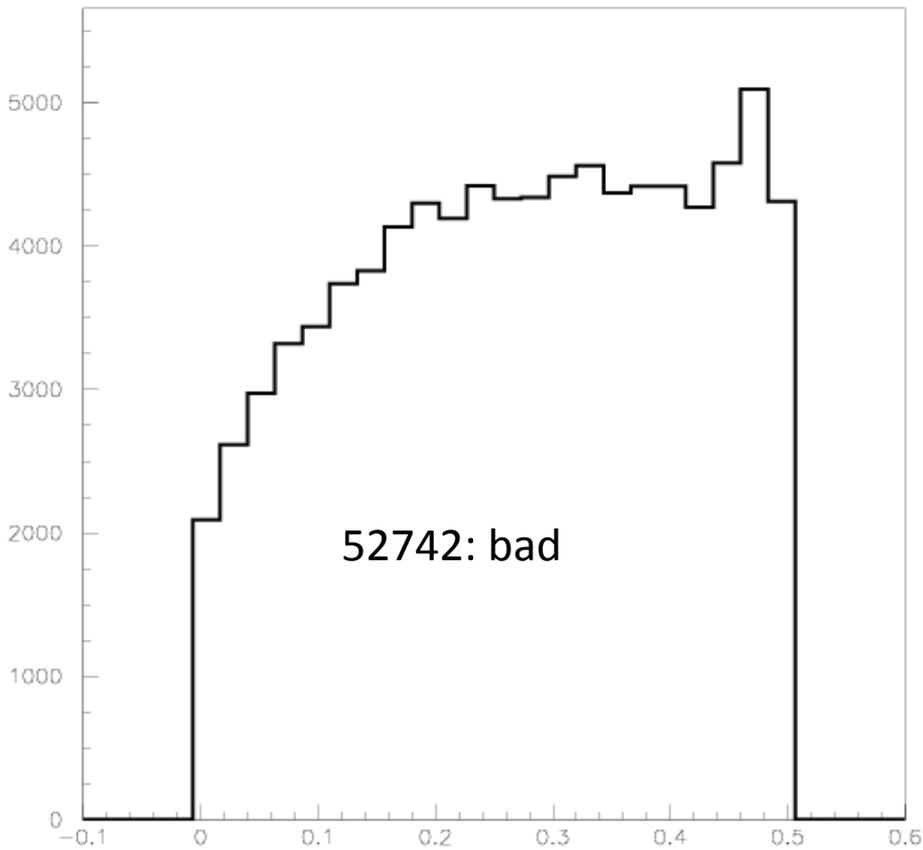
Looks so-so

Calibrations Checks: Drift Chambers

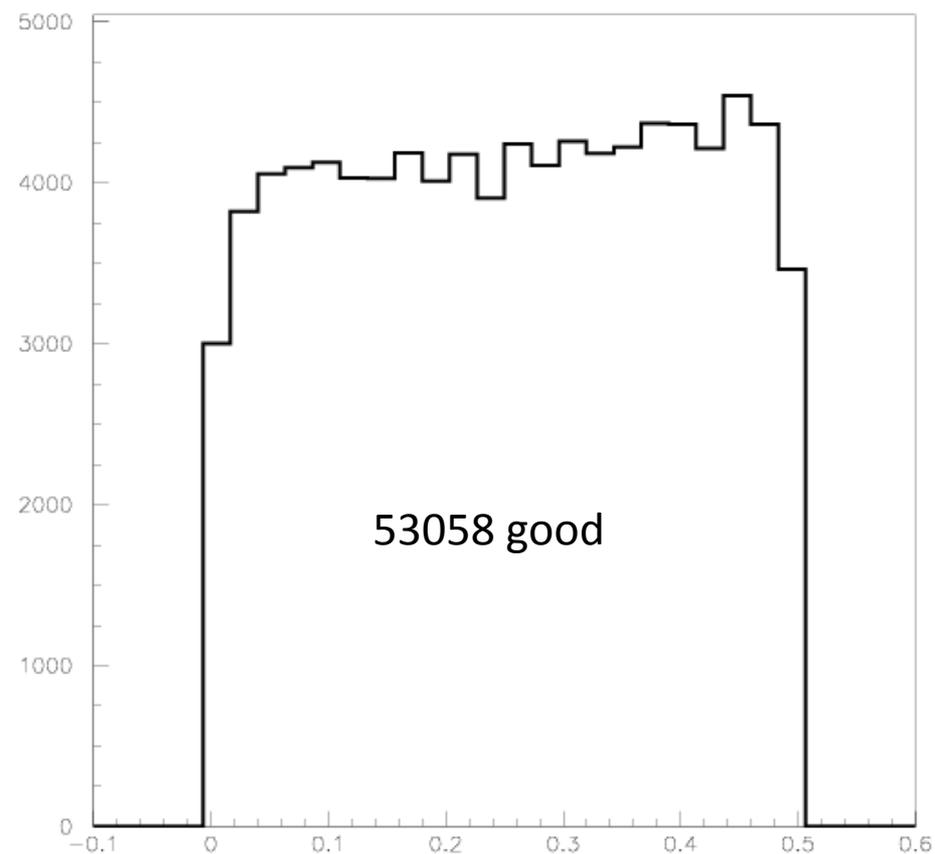
DC1 v1

Some runs will need recalibration of the drift time-to-distance map

DC1, v1



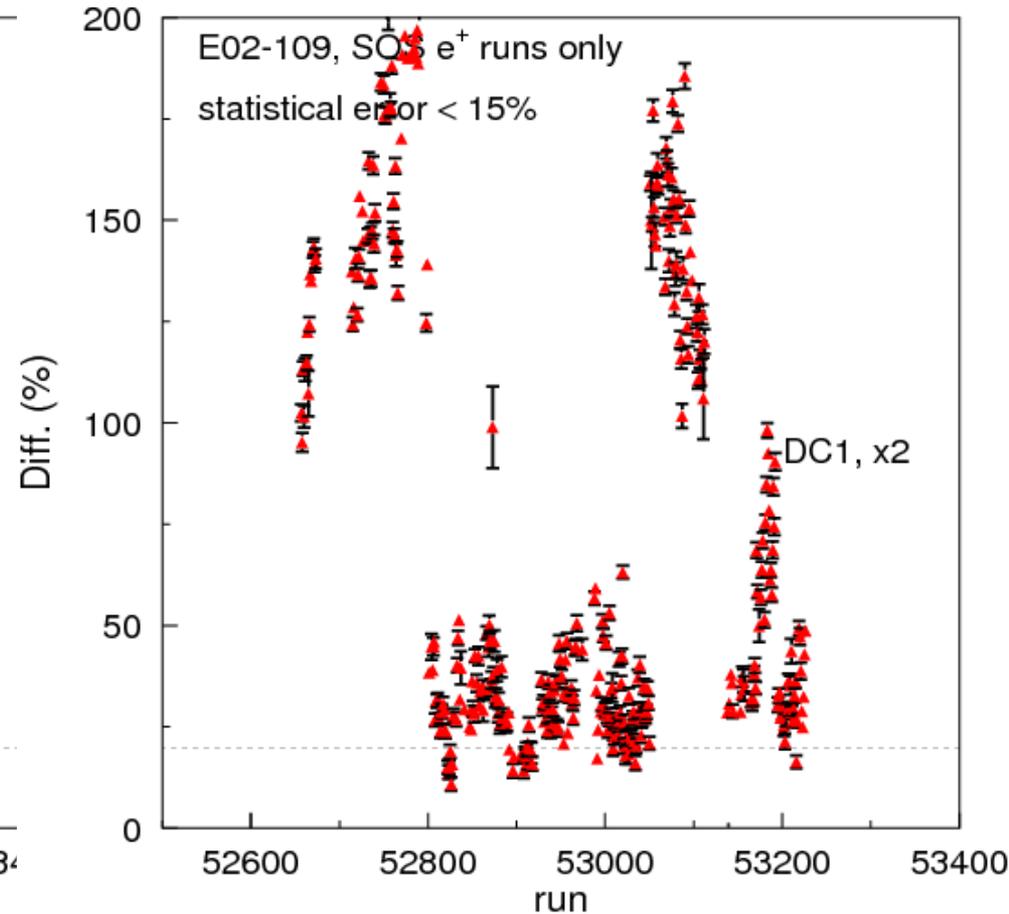
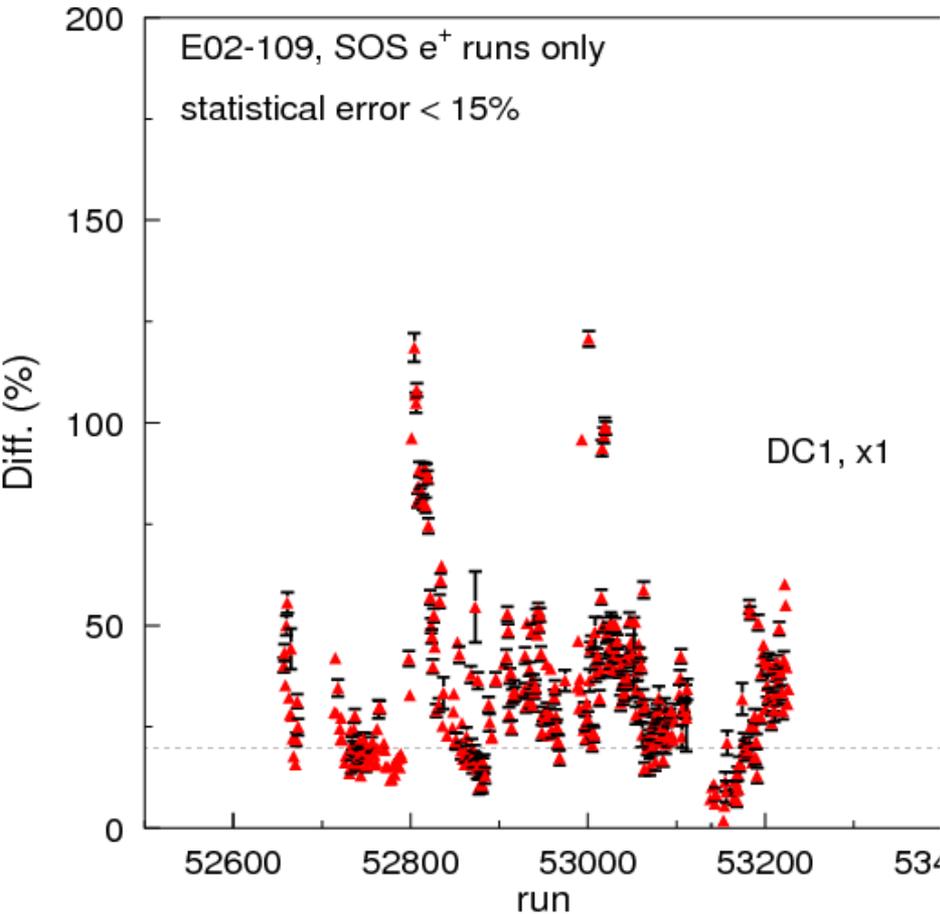
DC1, v1



Calibrations Checks: Drift Chambers

DC1 x1, x2

The difference plotted is a measure of the drift distance distribution uniformity within a drift cell after calibration



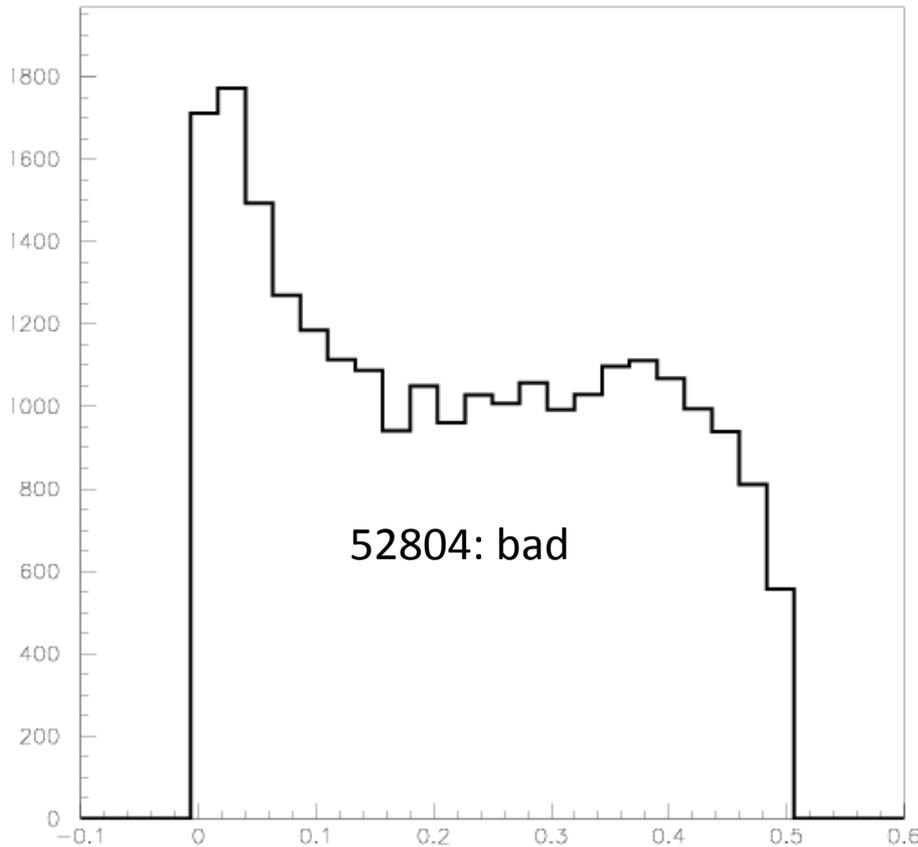
Looks so-so

Calibrations Checks: Drift Chambers

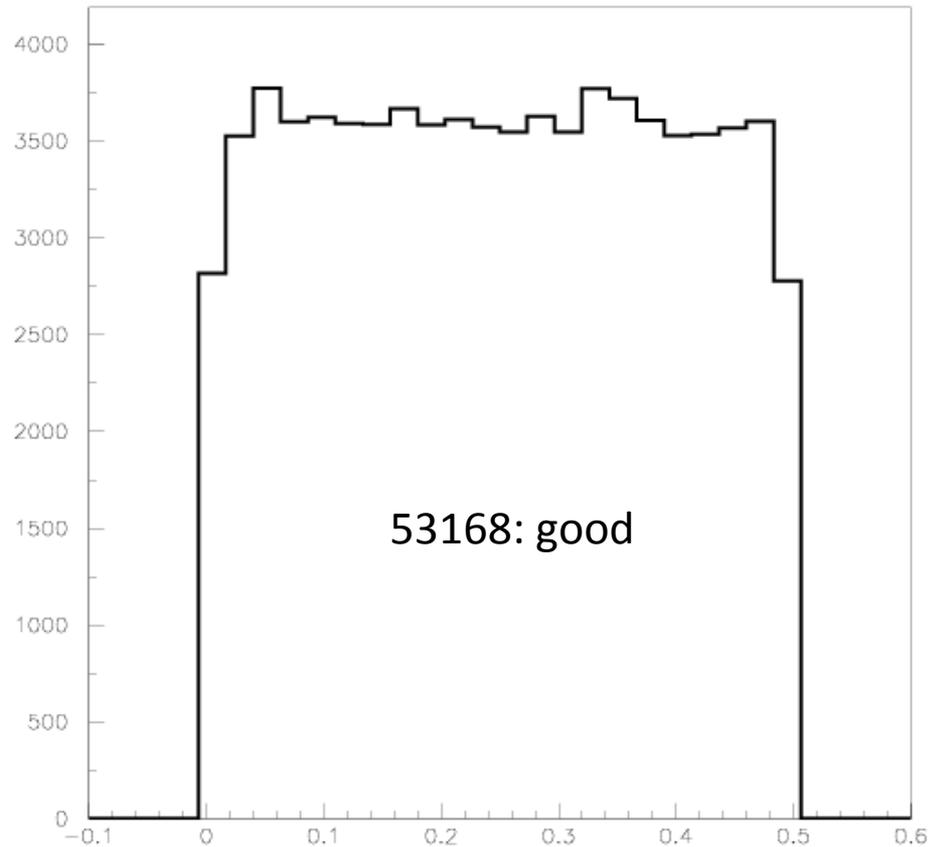
DC1 x1

Some runs will need recalibration of the drift time-to-distance map

DC1, x1



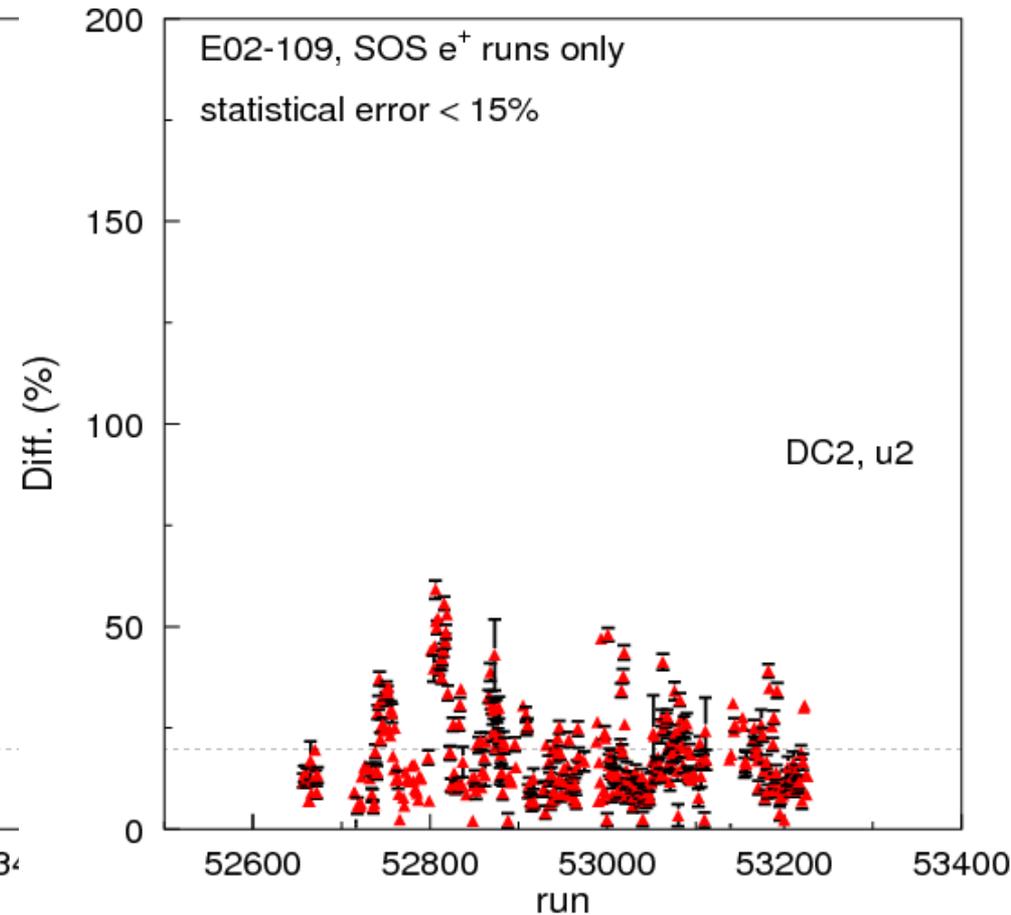
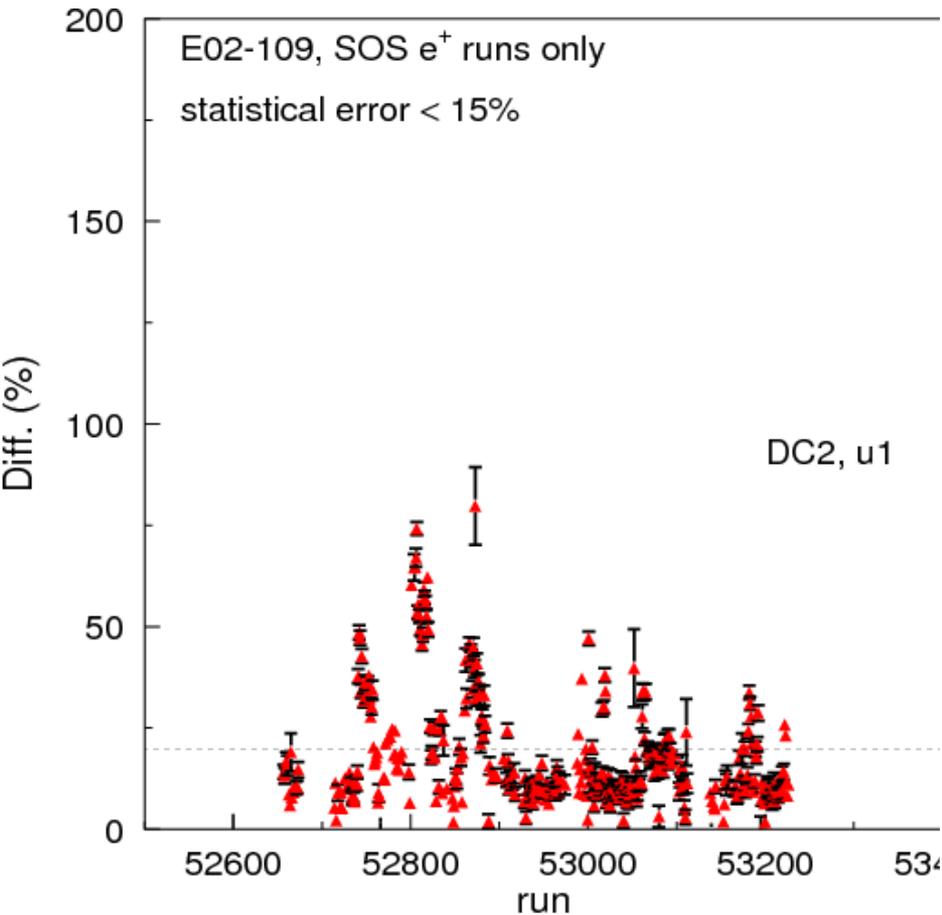
DC1, x1



Calibrations Checks: Drift Chambers

DC2 u1, u2

The difference plotted is a measure of the drift distance distribution uniformity within a drift cell after calibration



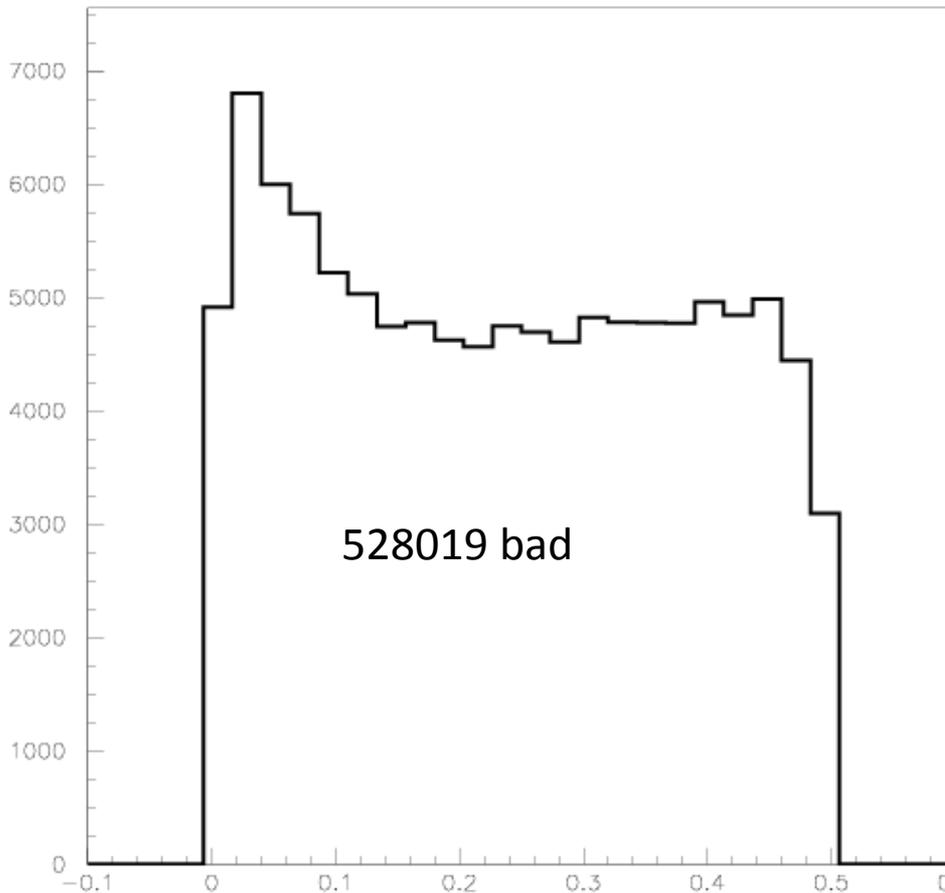
Looks good

Calibrations Checks: Drift Chambers

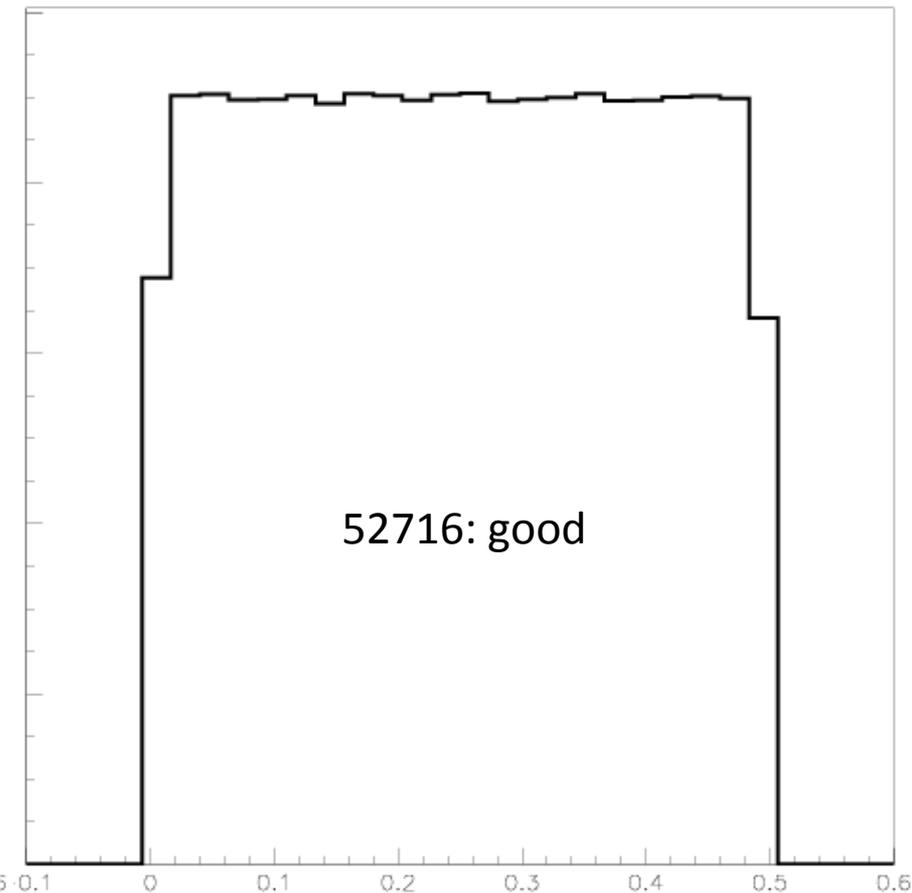
DC2 u2

Some runs will need recalibration of the drift time-to-distance map

DC2, u2



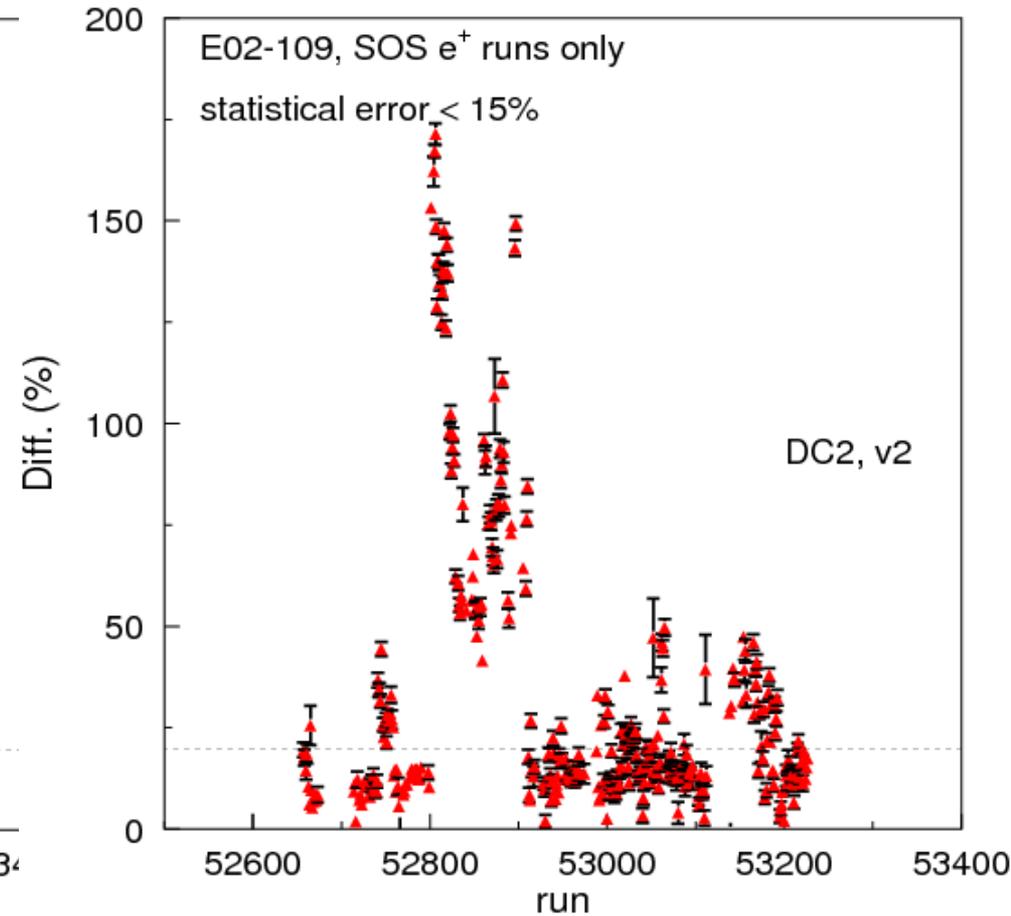
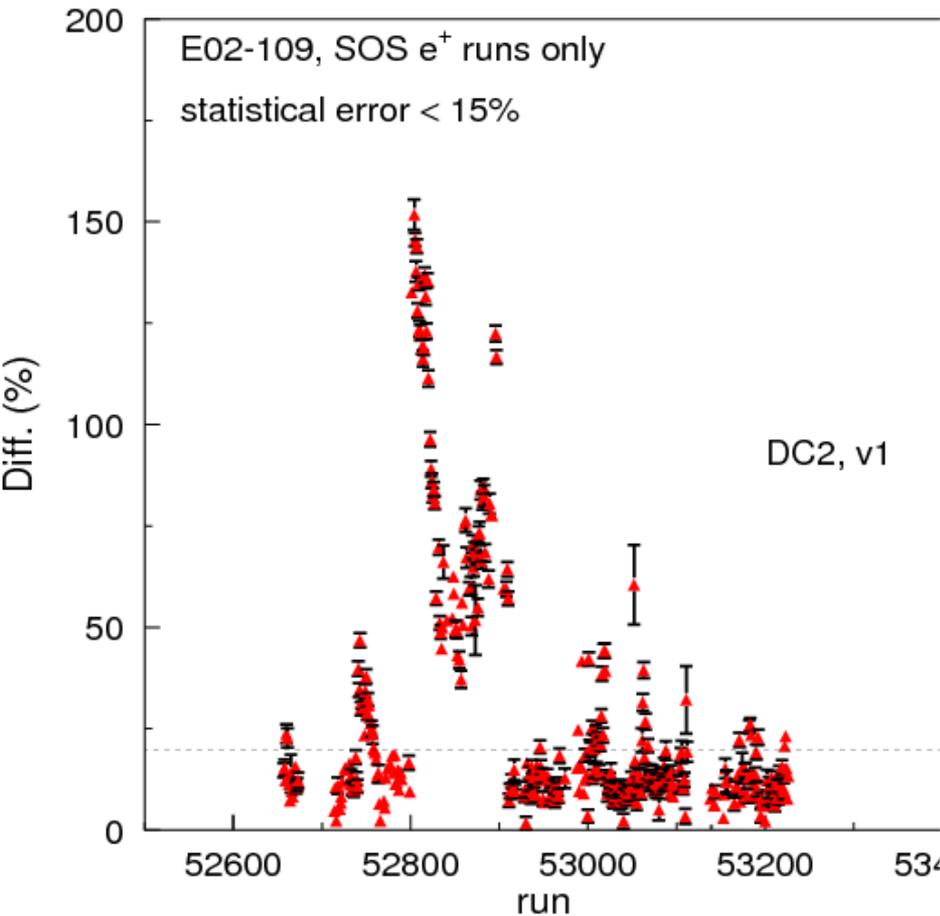
DC2, u2



Calibrations Checks: Drift Chambers

DC2 v1, v2

The difference plotted is a measure of the drift distance distribution uniformity within a drift cell after calibration



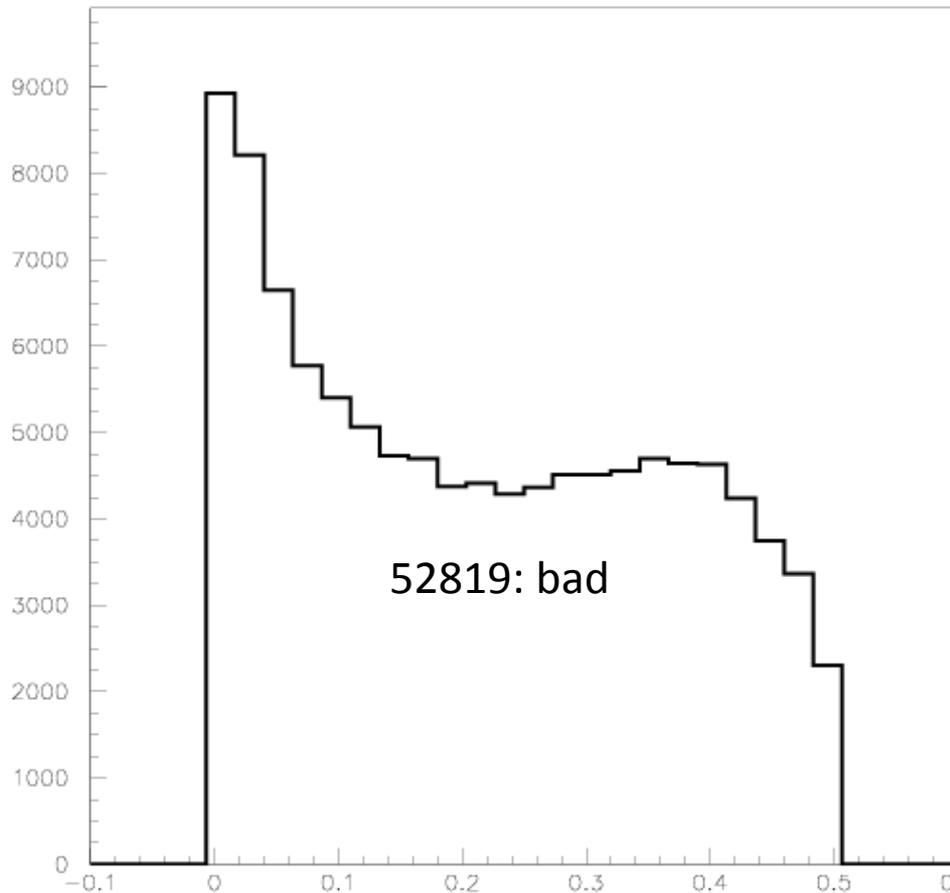
Looks so-so

Calibrations Checks: Drift Chambers

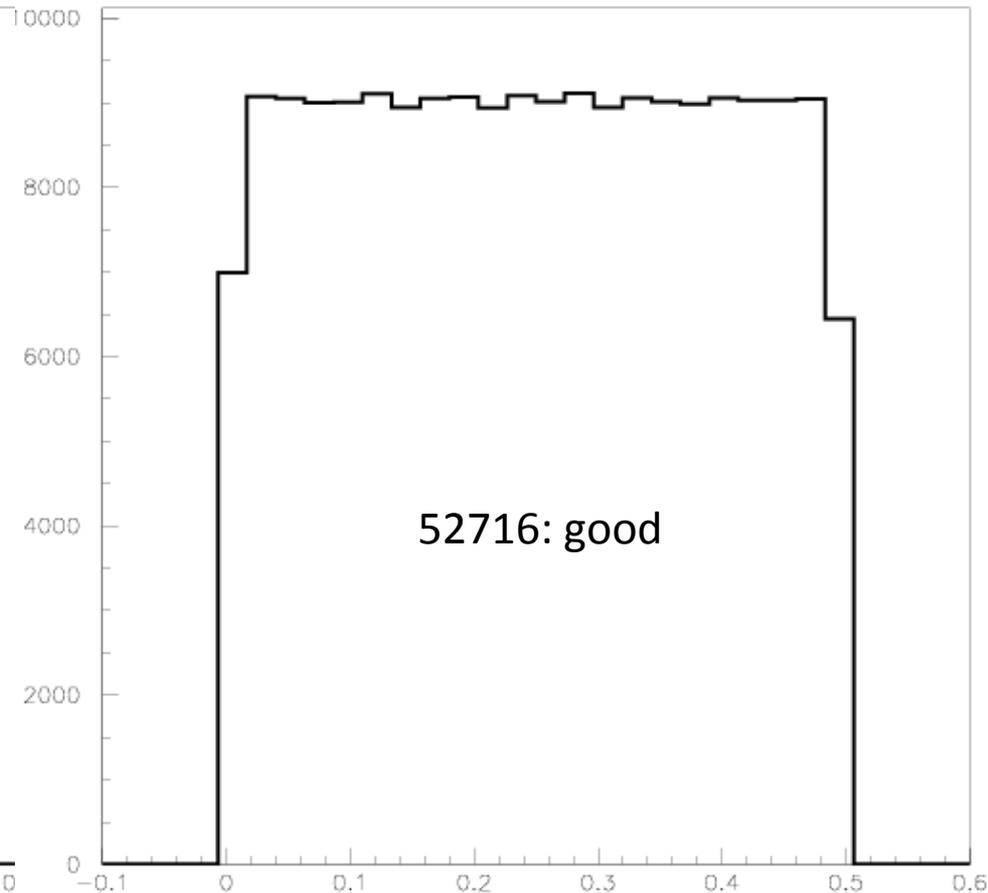
DC2 v2

Some runs will need recalibration of the drift time-to-distance map

DC2, v2



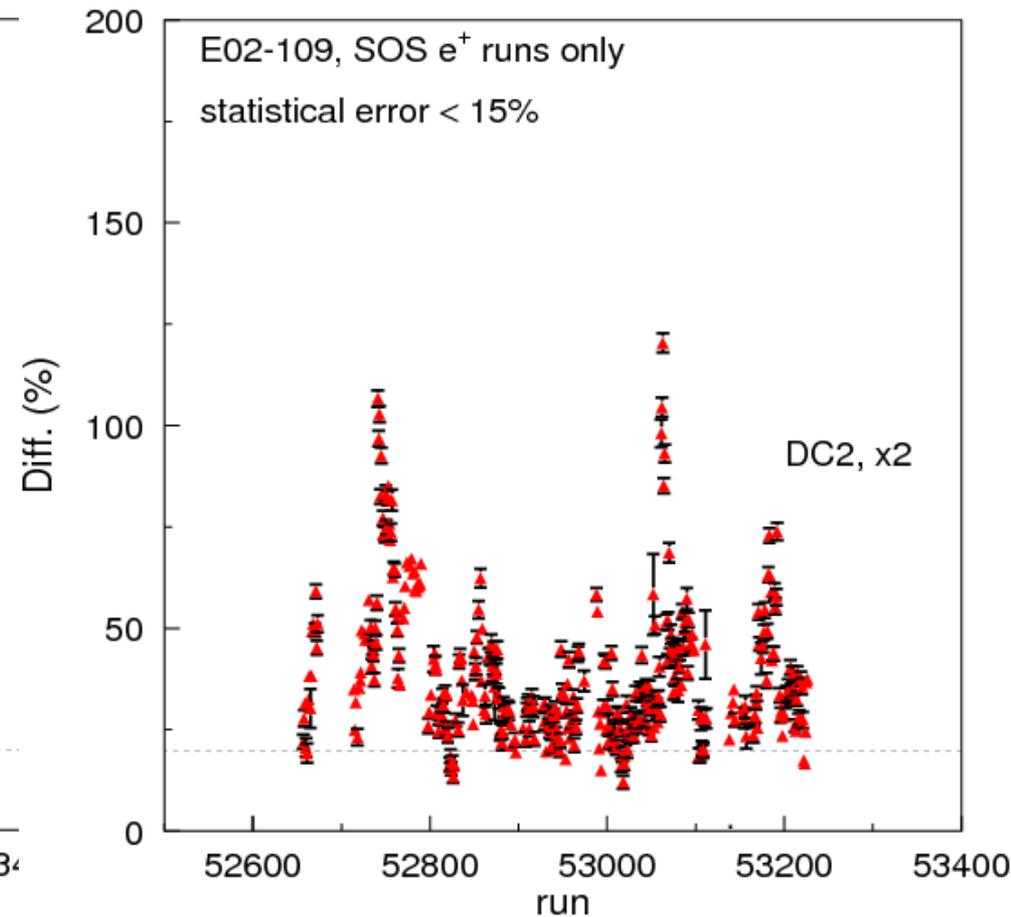
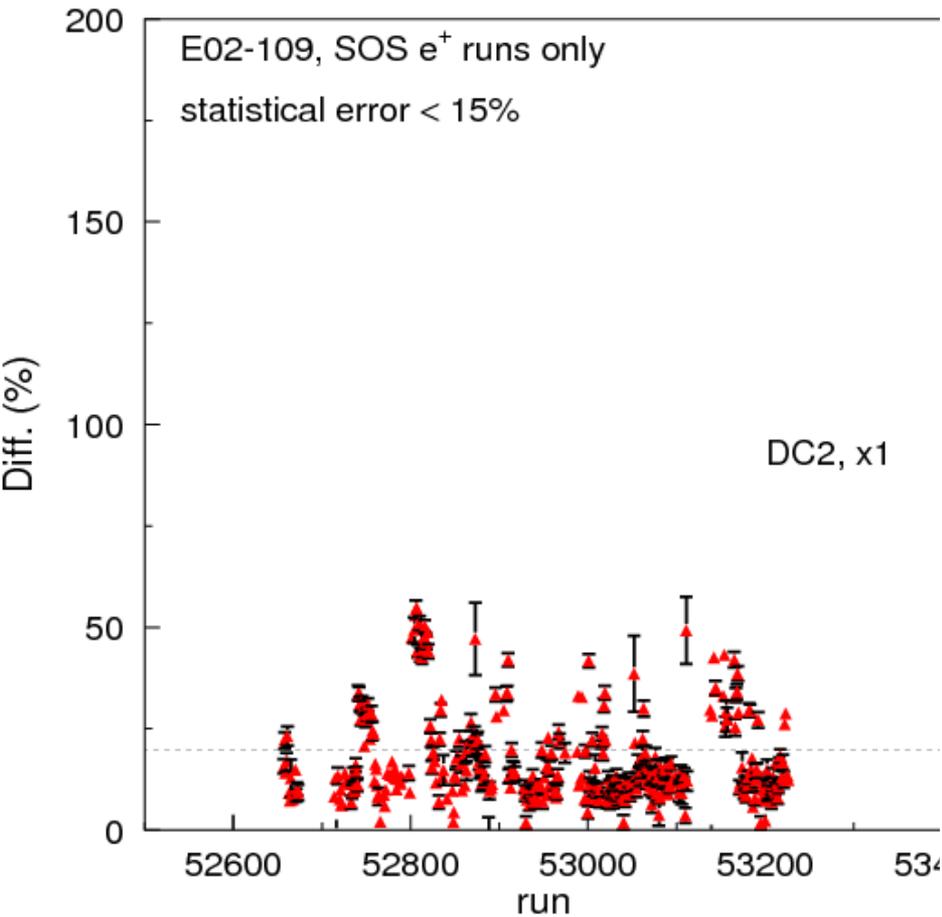
DC2, v2



Calibrations Checks: Drift Chambers

DC2 x1, x2

The difference plotted is a measure of the drift distance distribution uniformity within a drift cell after calibration



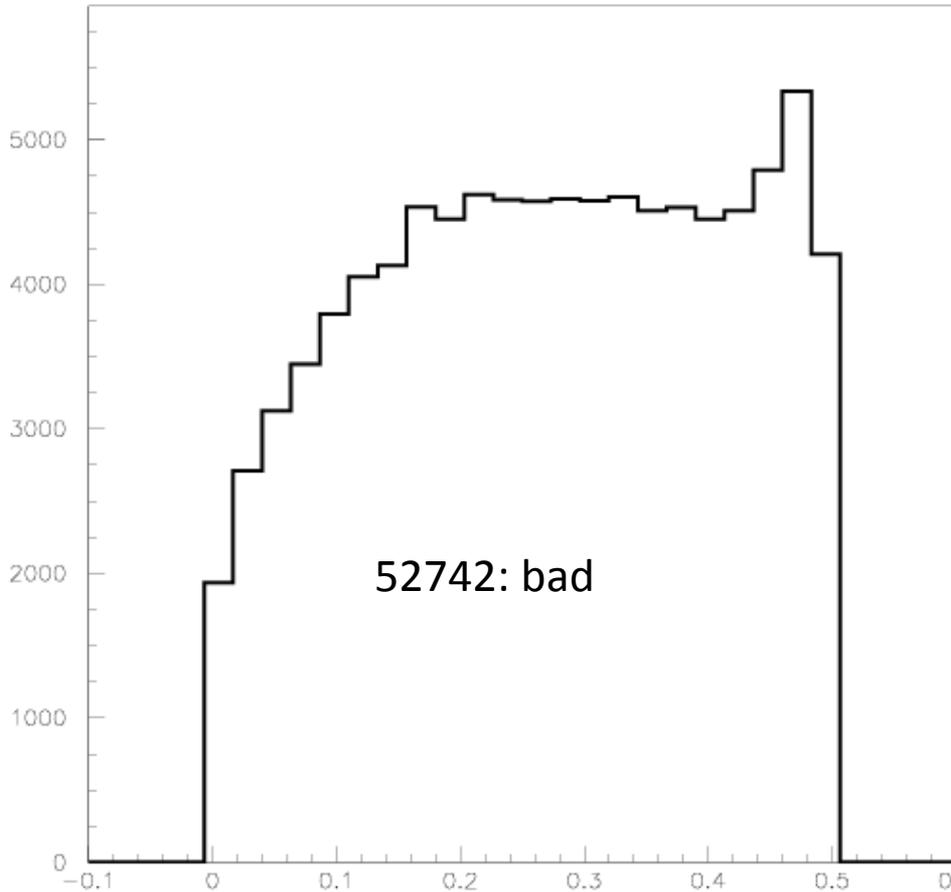
Looks ~good

Calibrations Checks: Drift Chambers

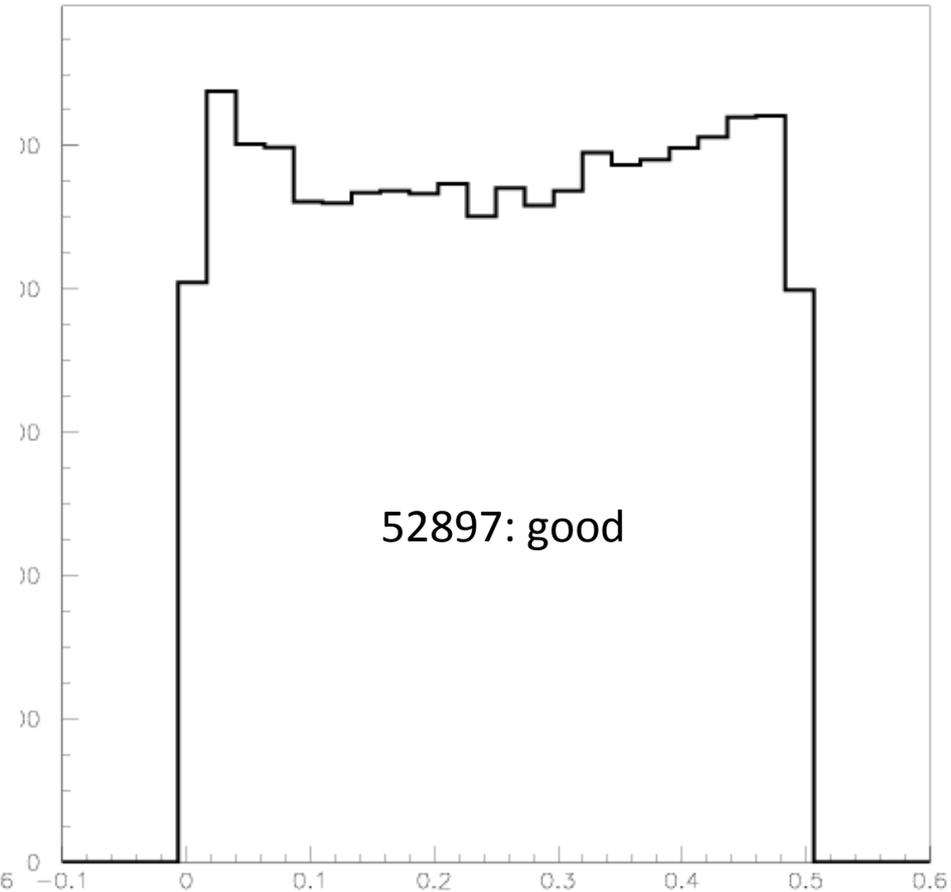
DC2 x2

Some runs will need recalibration of the drift time-to-distance map

DC2, x2



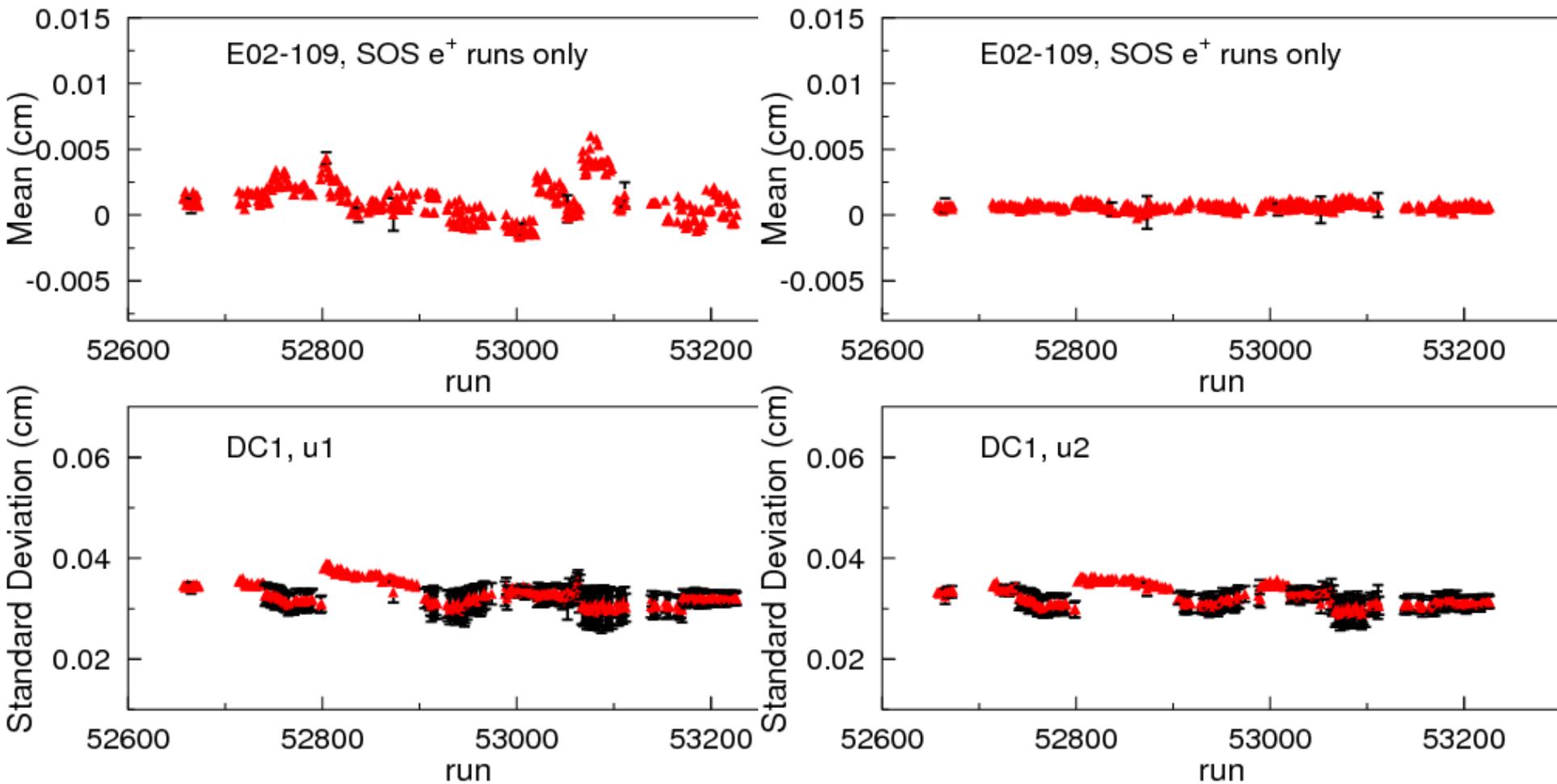
DC2, x2



Calibrations Checks: Drift Chambers

Residuals DC1 u1,u2

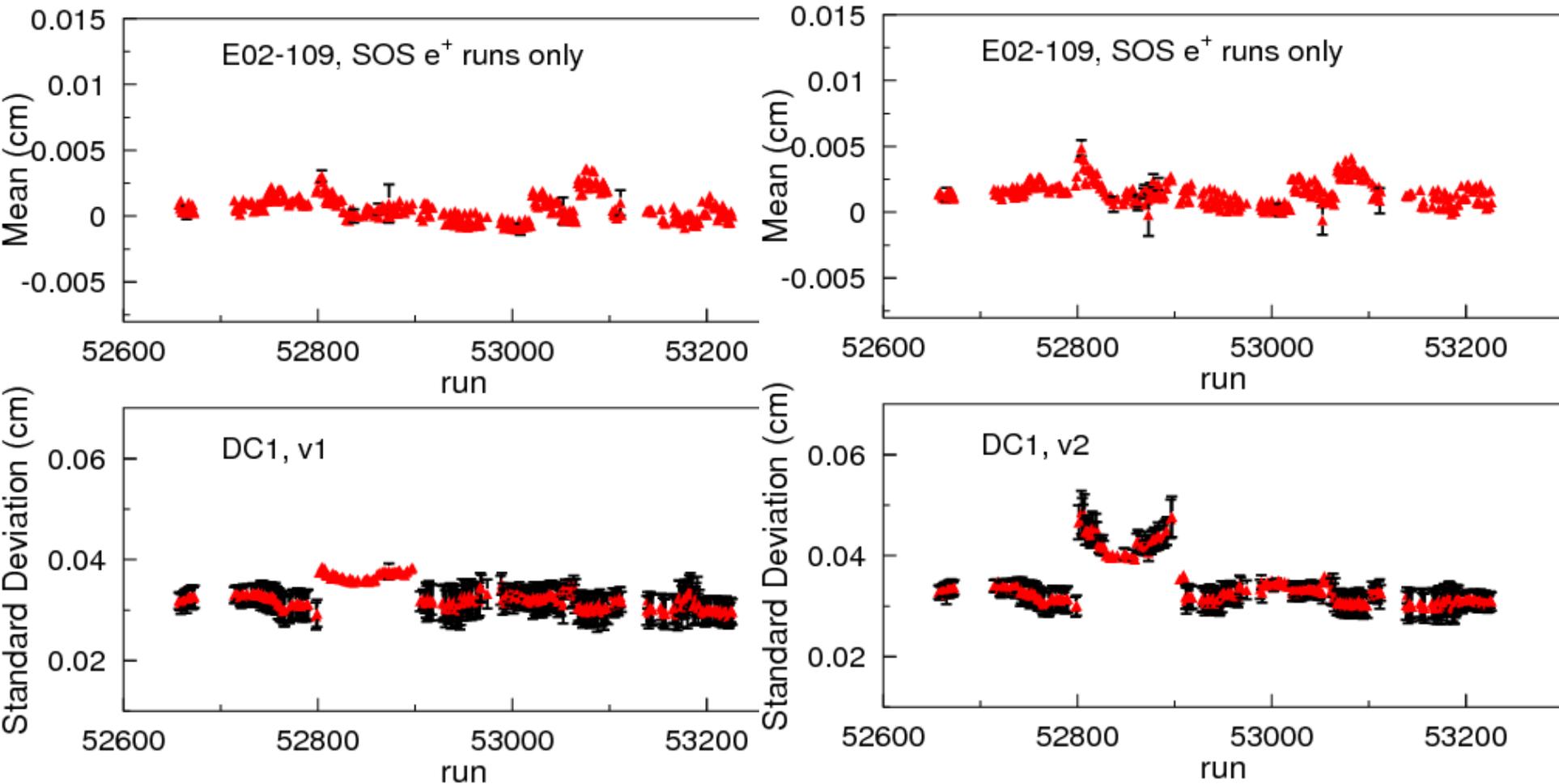
Looked at the resolution of the chambers (combination of chamber performance, calibration and tracking)



Calibrations Checks: Drift Chambers

Residuals DC1 v1,v2

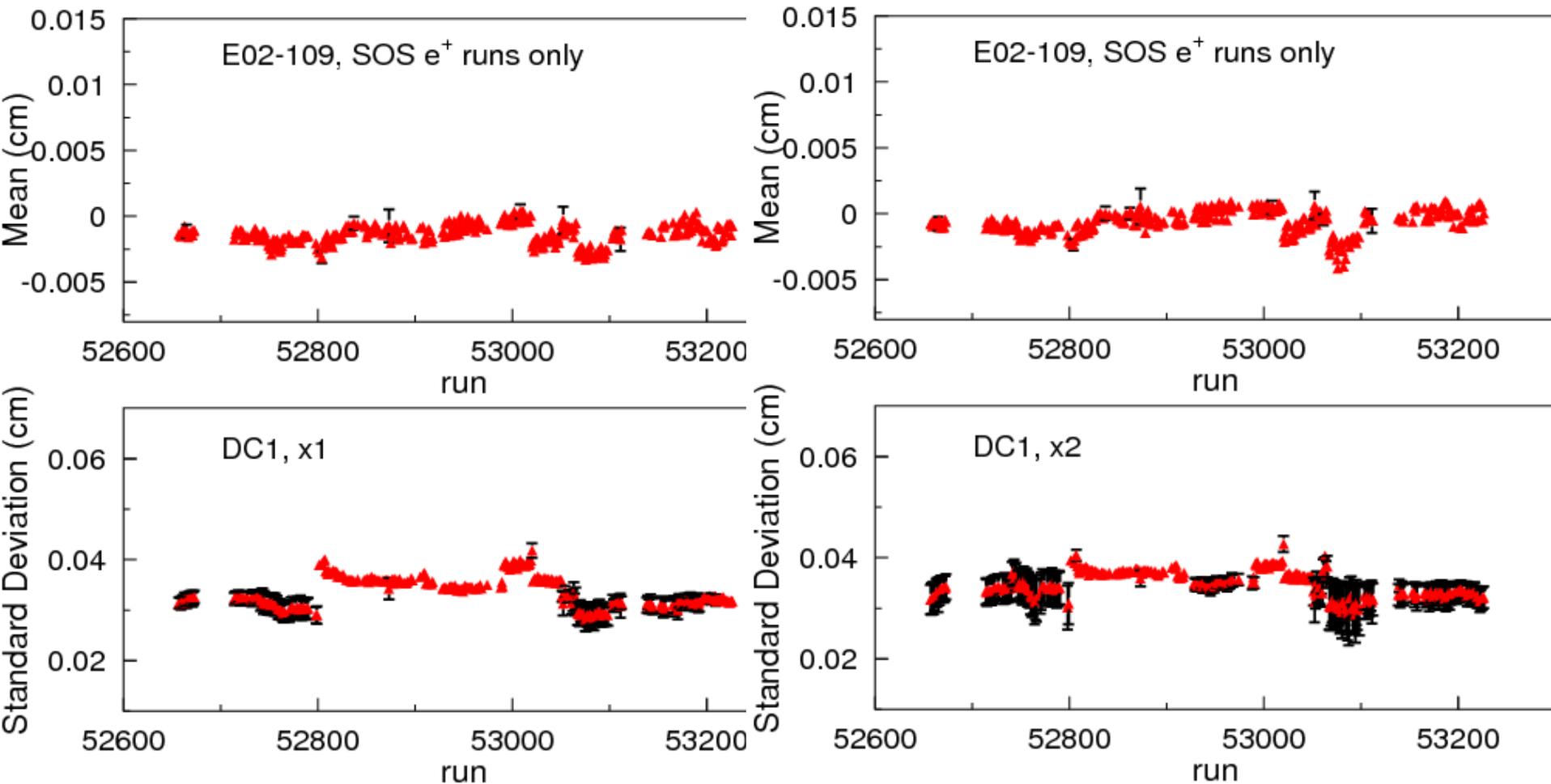
Looked at the resolution of the chambers (combination of chamber performance, calibration and tracking)



Calibrations Checks: Drift Chambers

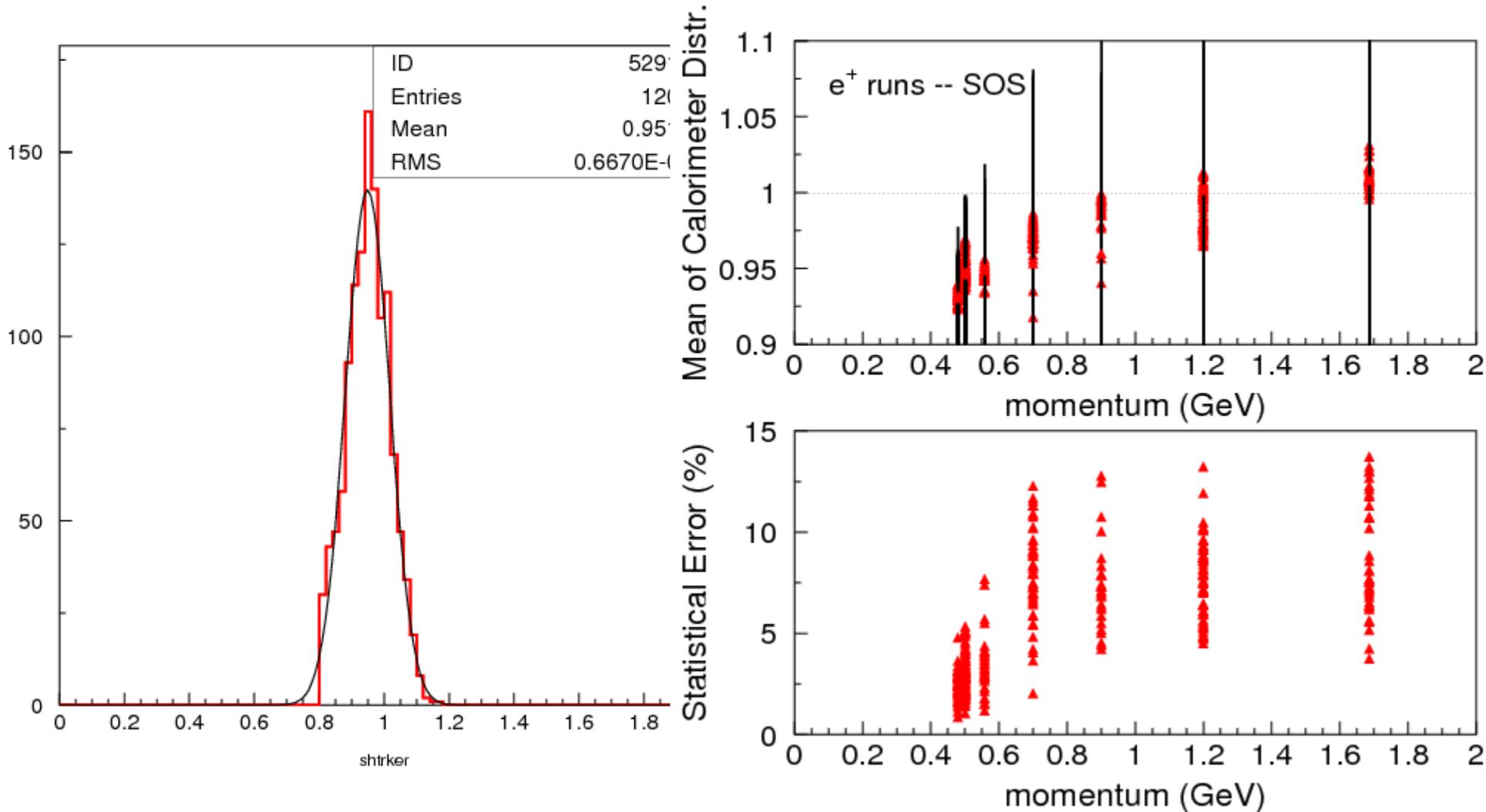
Residuals DC1 x1,x2

Looked at the resolution of the chambers (combination of chamber performance, calibration and tracking)



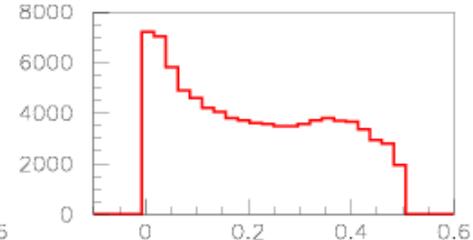
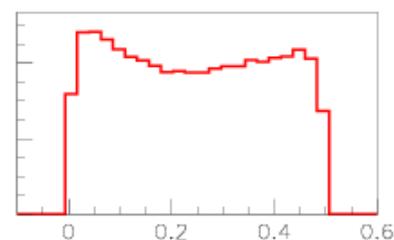
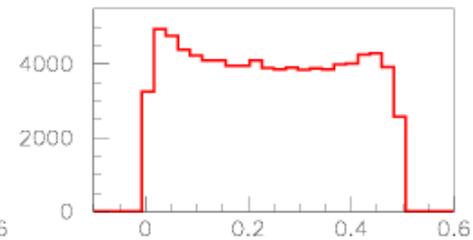
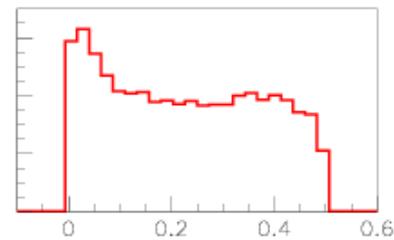
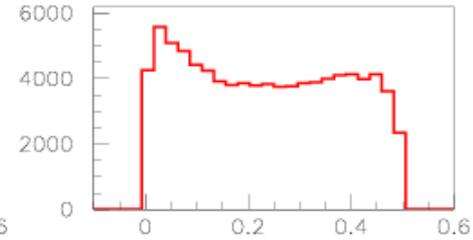
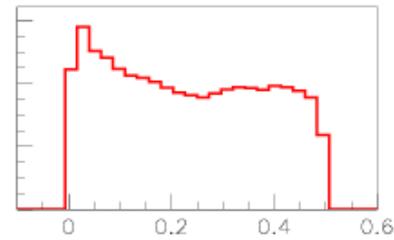
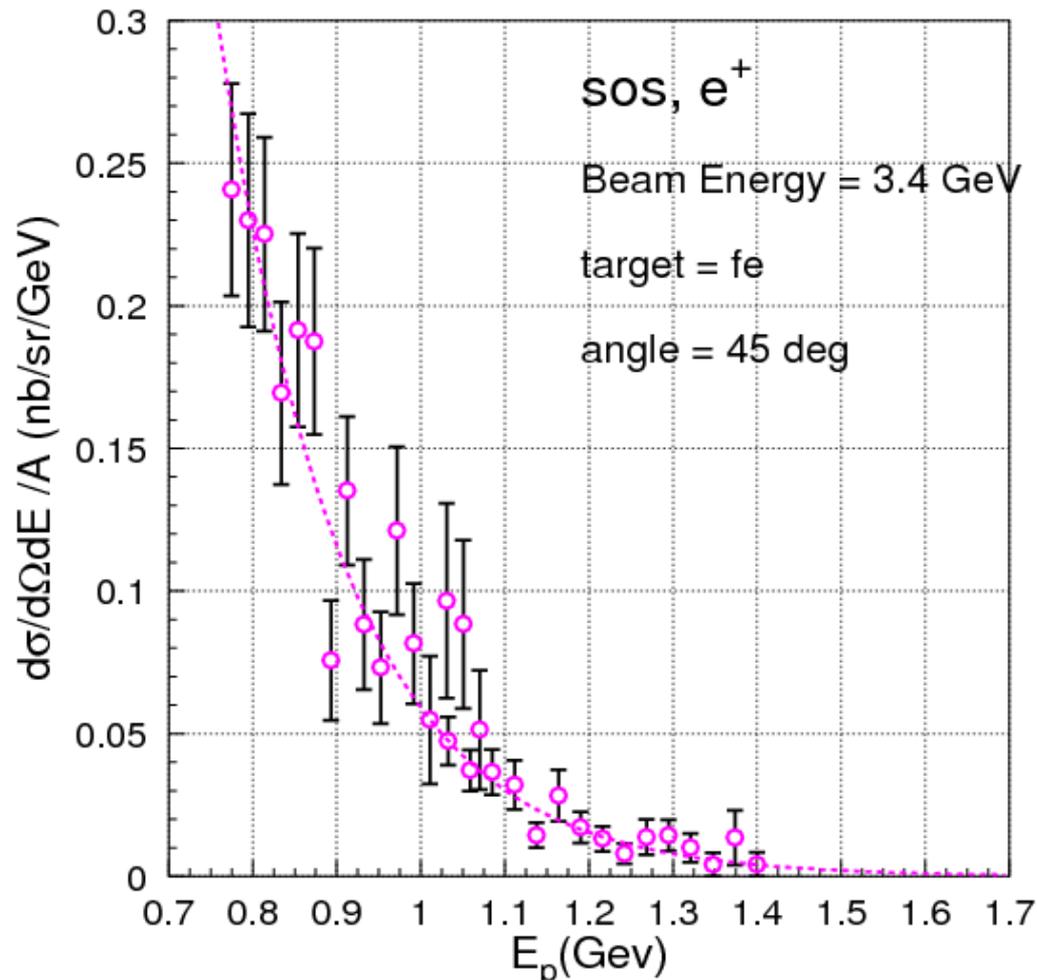
Calibrations Checks: Calorimeter

Given the typically low statistics runs the calorimeter calibration looks good



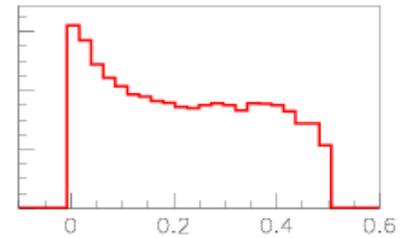
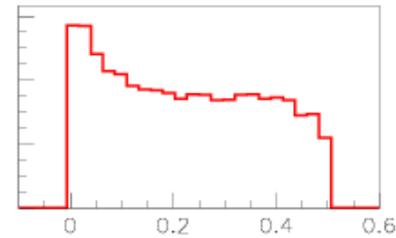
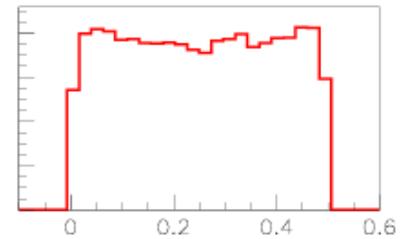
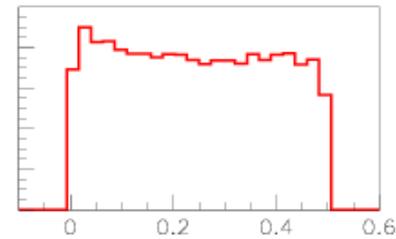
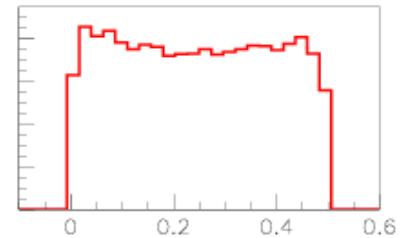
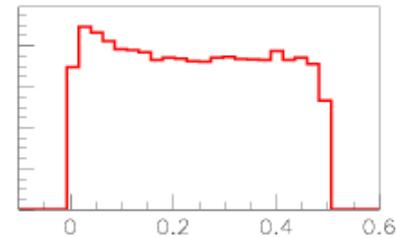
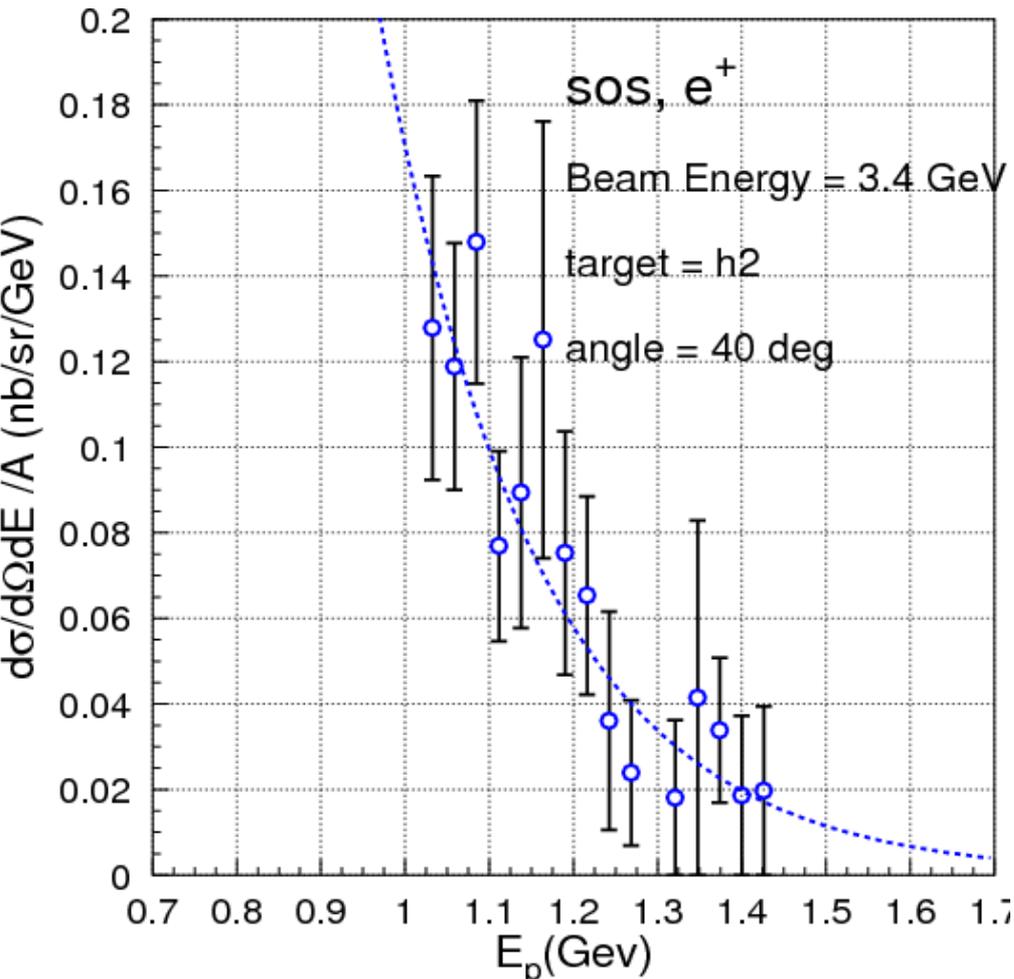
SOS positron Cross Sections: Ya Li

Checked if there is a correlation between the drift chamber miscalibrations and the spread in the positron cross section results



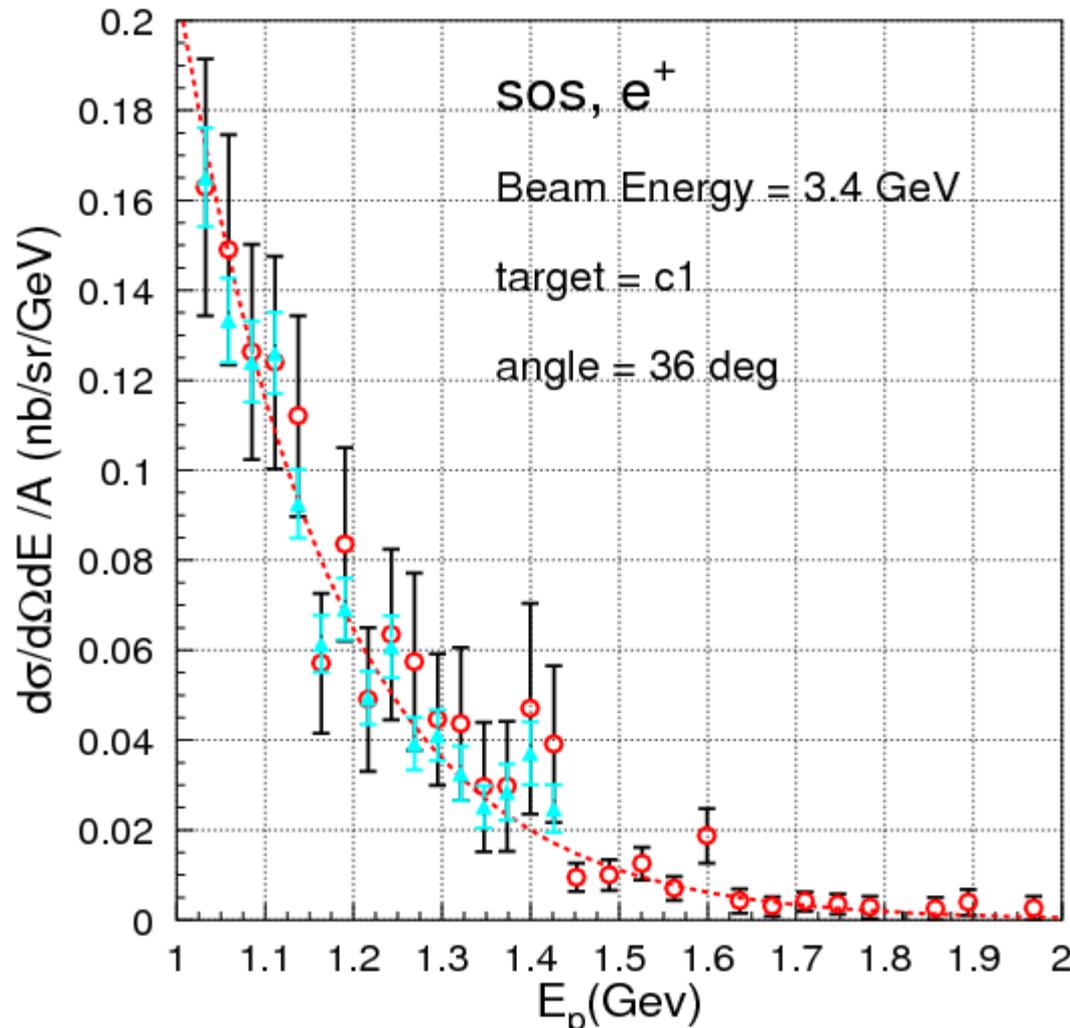
SOS positron Cross Sections: Ya Li

Checked if there is a correlation between the drift chamber miscalibrations and the spread in the positron cross section results



SOS positron Cross Sections: Ya Li

Recurrent problem: not all the statistics is used for positron cross section extraction



20 % stat. error

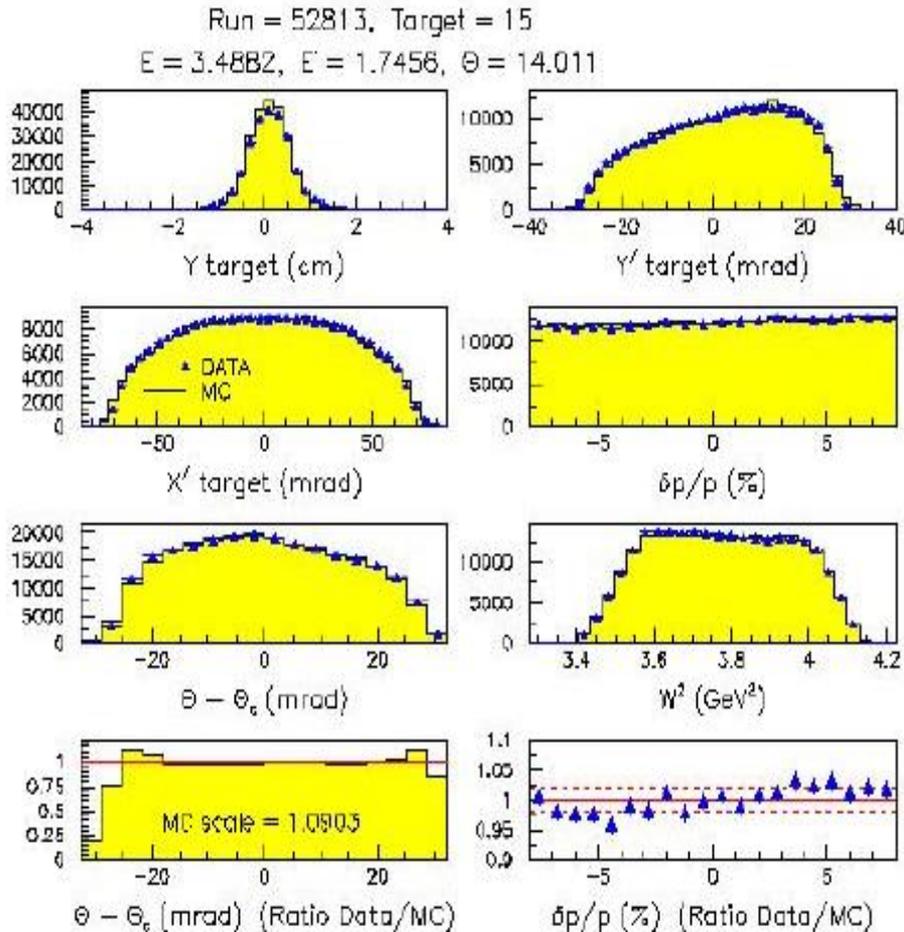
7 % stat. error (all runs)

Summary

- Most calibrations for the electron runs look good
- The positron runs need recalibration of the drift distance map
- Run a final replay
- We will re-extract the positron cross sections (using the full statistics) and re-parameterize the charge symmetric background
- Extract the differential cross sections and do LTs

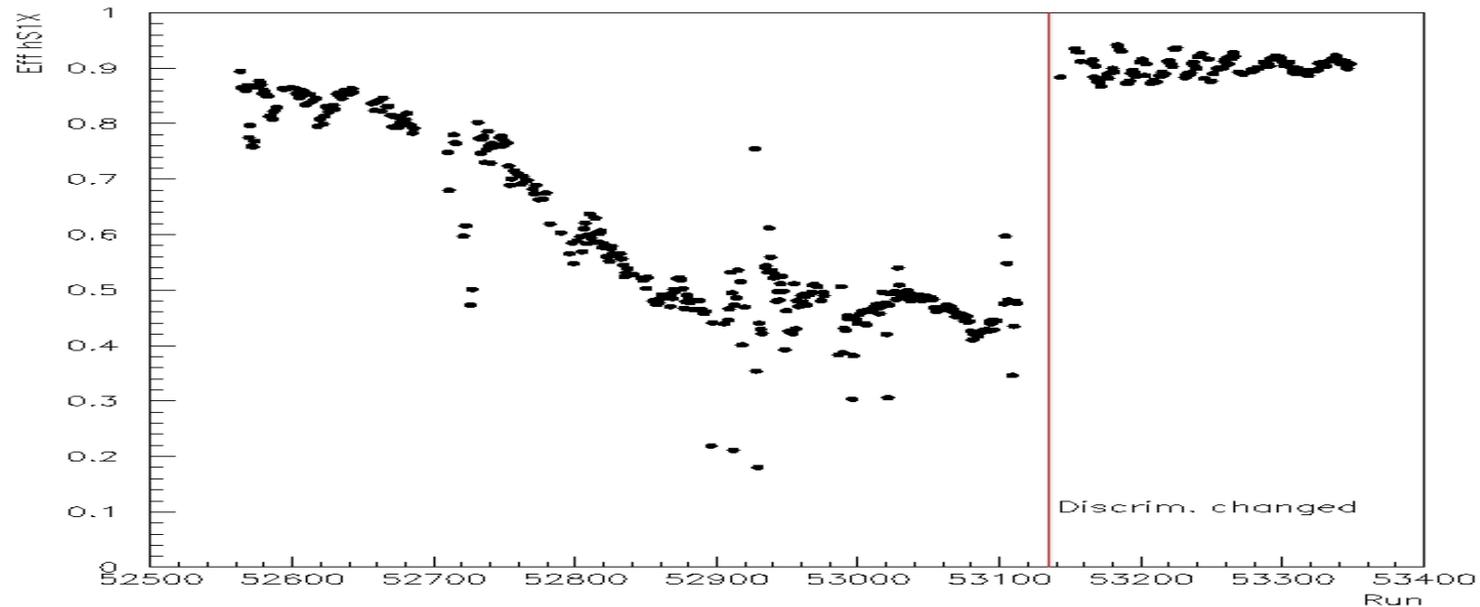
Backup Slides

Monte Carlo Ratio Method: from Ya Li



- (1) Generate MC events with σ model weighting (radiative contributions included).
- (2) Scale the MC yield by $L_{\text{Data}}/L_{\text{MC}}$, where L_{MC} is that needed to produce N_{gen} for the given σ_{mod} and phase space generated into.
- (3) Add background contributions to MC
- (4) $d\sigma(\delta, \theta) = d\sigma_{\text{mod}}(\delta, \theta) * \frac{Y_{\text{data}}}{Y_{\text{MC}}}$
Where Y is the yield for events with any value of θ , i.e. this integrates over θ

Faulty Discriminator: from Ya Li



- Sx1 hodoscopes faulty discriminator caused low efficiency in some channels
- Solution: Implementing Position dependent trigger efficiency ($\Delta p/p$)