DC Updates:
Software and Firmware

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CLAS Collaboration Meeting
03/04/25

Overview

- **DC version 2 calibration and reconstruction updates**
- **DC Readout updates**

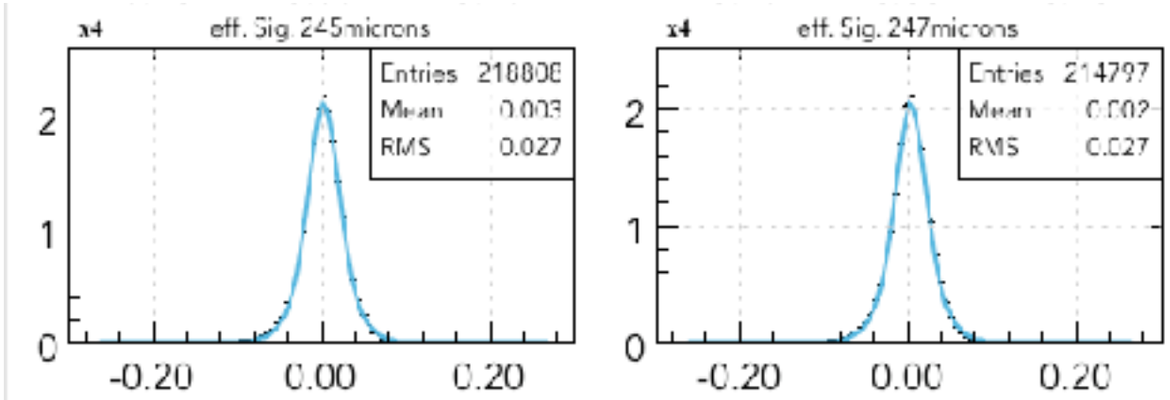
Not covered here:

- **GEMC matching improvements**
- **General tracking improvements by Tongtong**

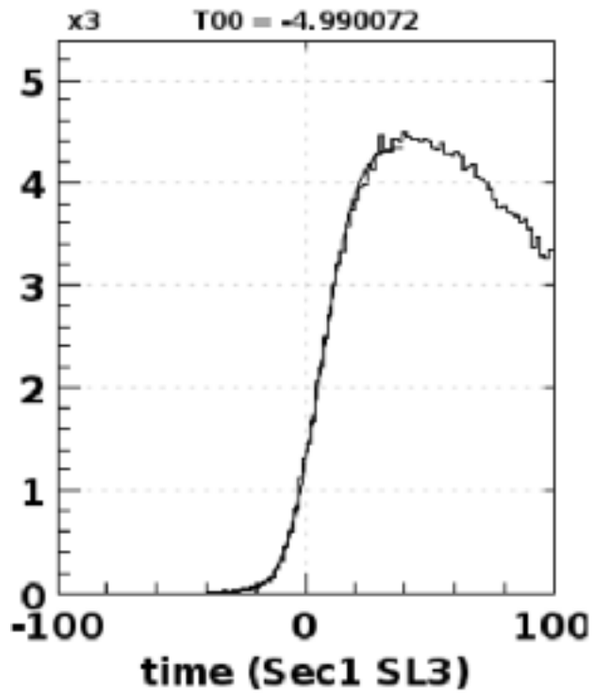
DC V2

What does DC calibration mean

- **Time to distance calibration (T2D)**
  - various parameters, calibration follows specific protocol
  - done per superlayer (6 total)
  - control observable: time residuals = doca difference (track - hit)



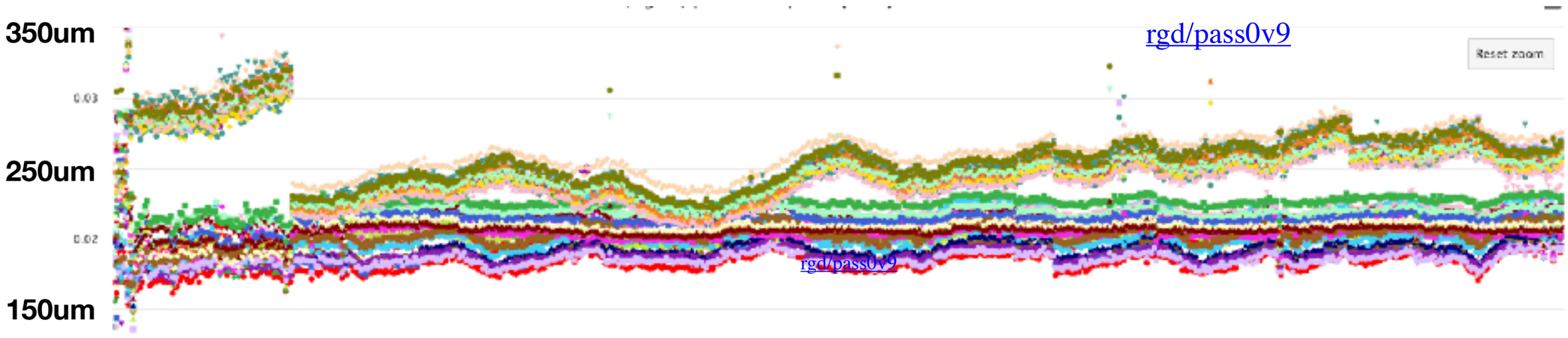
- **T_0/T_{00} calibration:**
  - start point of time spectra
  - account for shifts of wires (T_0)
  - shift of sectors/superlayers (T_{00})

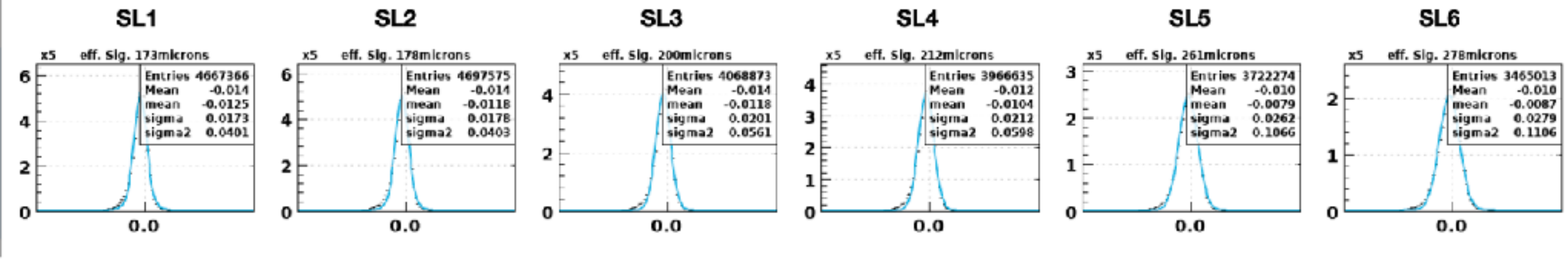


Why Calibration Updates

- **Pass2 T2D calibrations for RGA/B/K sometimes cumbersome (convergence problems, manual adjustments required)**
- **ToF correction calculation for DC hits with a bug (shifted T0)**
- **Non-monotonic T2D behavior for R2 at large docas due to B-field dependent term**
- **Calibration with pass2 software and protocol didn't work for newer HV settings**

RGD residuals





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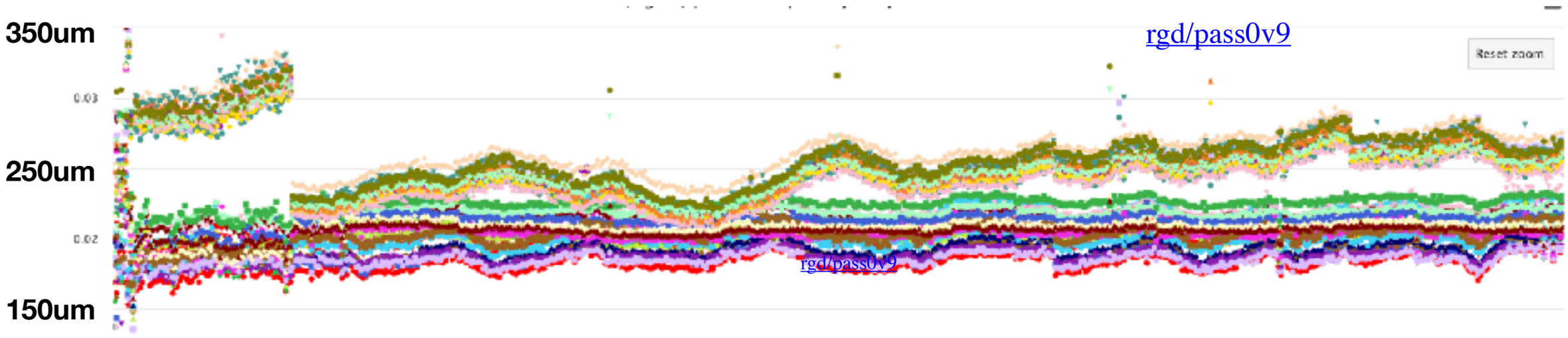
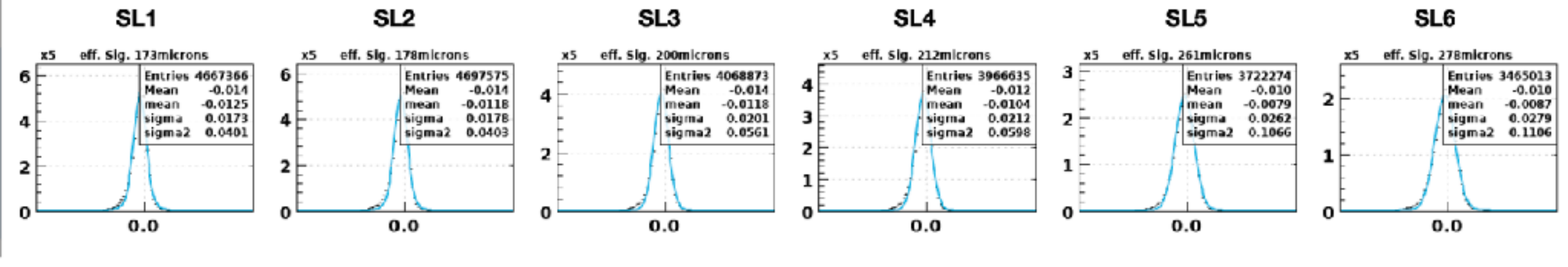
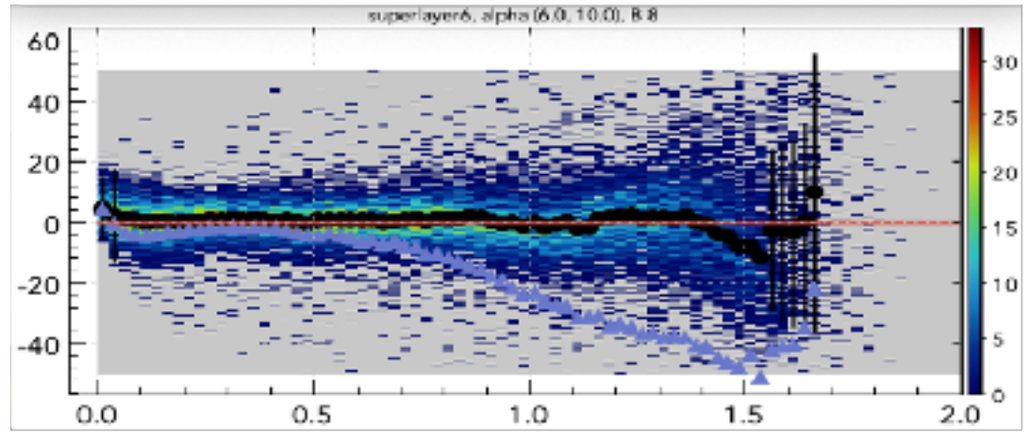




—> Updates to calibration software and methods which break backward compatibility!!!!

Calibration Code Updates (Veronique)

- **Code refactoring**
  - **utility classes for various tasks**
  - **cleanup and optimization**
- **Better debug functionalities**
- **New plots for visualization of fit quality**
- **Bug fixes (LR ambiguity failures)**

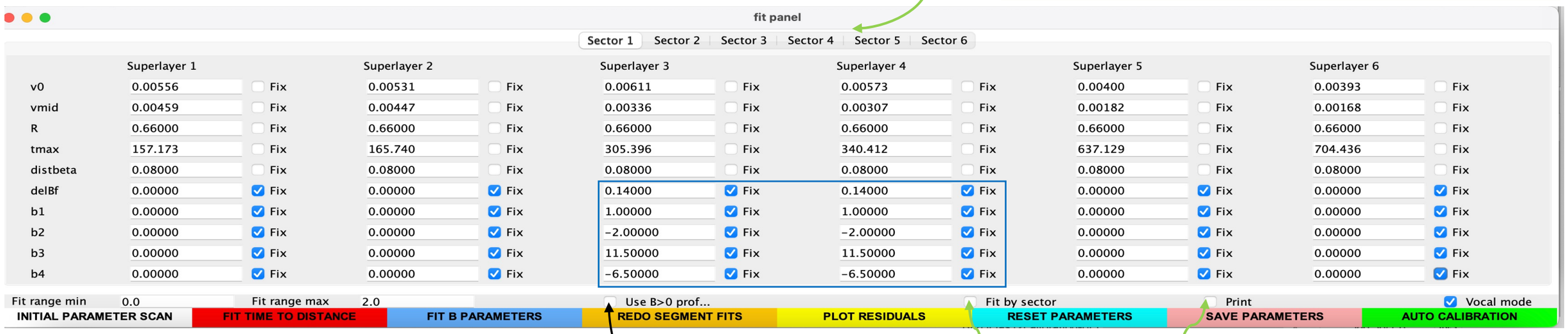


- **B-field parameters fit functionality**
- **Beta dependent correction term part of the T2D function (no adhoc correction anymore) —> this requires also changes to reconstruction!**
- **New features (still more testing to do)**
  - **Sector-dependent T2D calibration (will be done first for RGK)**
  - **Automated calibration**

T2D Calibration Features

DC4 new features

Sector-by-sector calibration parameters displays
- Each calibration procedure (scan, segment fits, parameter fits) run for each sector
- Scan, fits for each sector run on a separate thread



Sector-by-sector calibration (scan, fit)

Prints fit results and status to screen

Vocal mode reports calibration status and fit failures

INITIAL PARAMETER SCAN
Runs initial parameter scan over fixed values of R and distbeta parameters to improve fit stability and handle parameters correlations

FIT TIME TO DISTANCE
Parameter fits for fixed values of R and distbeta parameters

FIT B PARAMETERS
Fit B-field-dependent Parameters (refits only for R2, fitting one B-field parameter at a time)

REDO SEGMENT FITS
Reprocesses the segment fits with option to include R2 profiles with all B-field values

PLOT RESIDUALS
Plots time residuals after the segments fits have been done

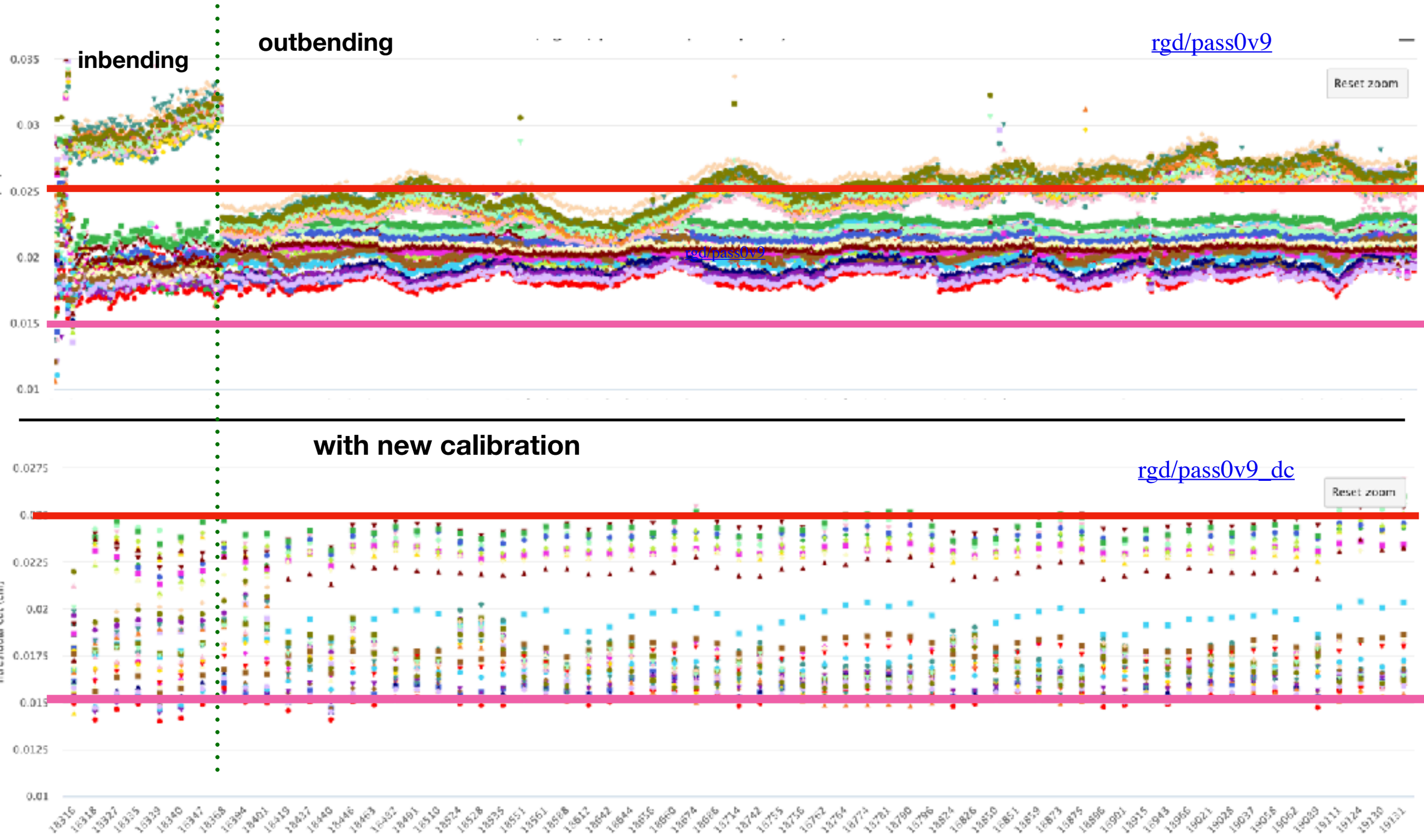
RESET PARAMETERS
Resets parameters to ccdb values

SAVE PARAMETERS
Saves parameters to file
- Opens panel with view of parameters for all sectors (in development)

AUTO CALIBRATION
Runs all calibration steps
- Initial parameter scan
- Segment fits
- Parameter fits
- B-f parameter fits

from Veronique's CALCOM slides Jan 09, 2025 3

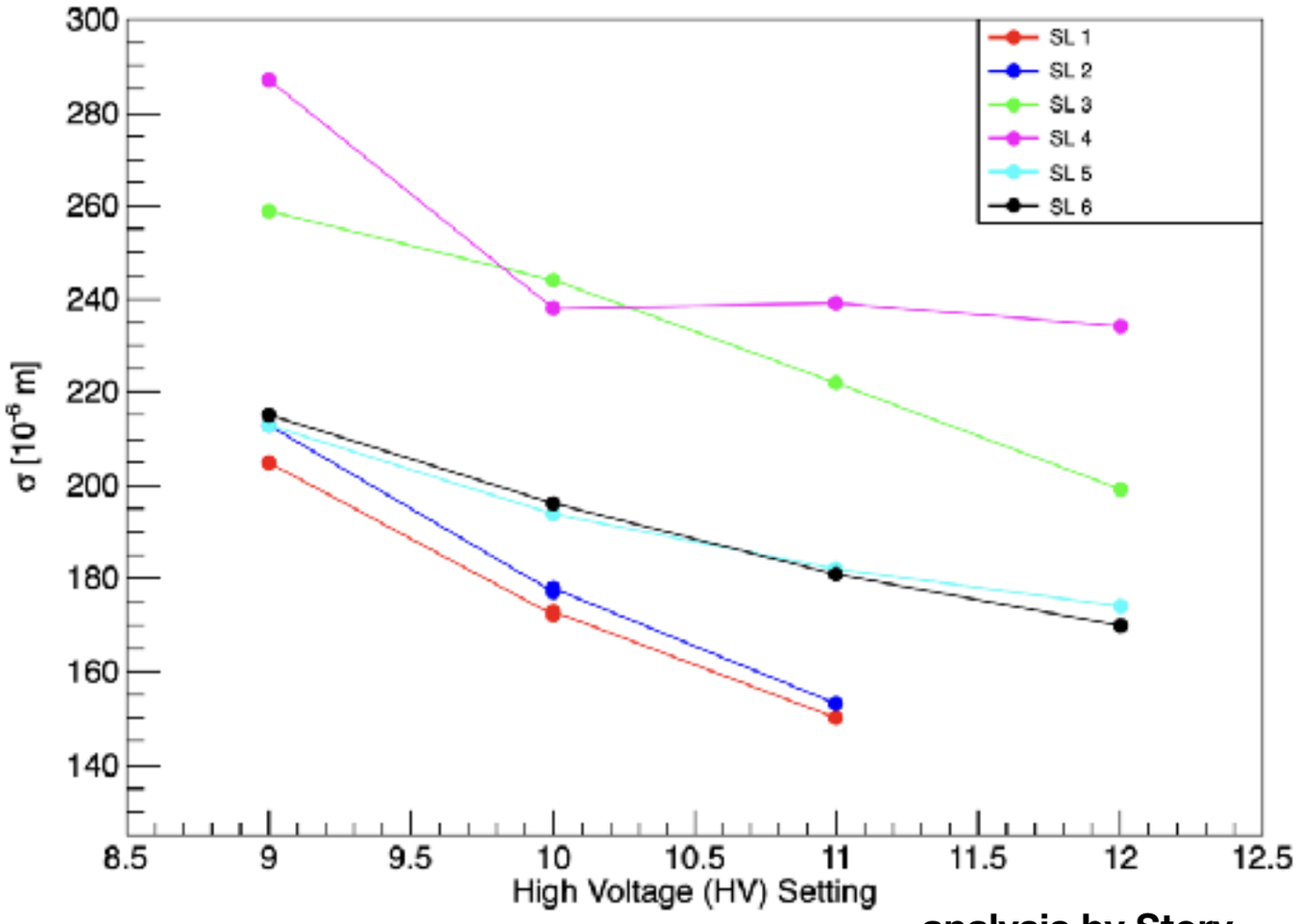
Results of new calibration (w/o sector dependence) for RGD



- **R1 and R3 under 200um, R2 around 250um**
- **Calibration works very well!**

Residuals: Dependence on HV

RGD HV scans



analysis by Story

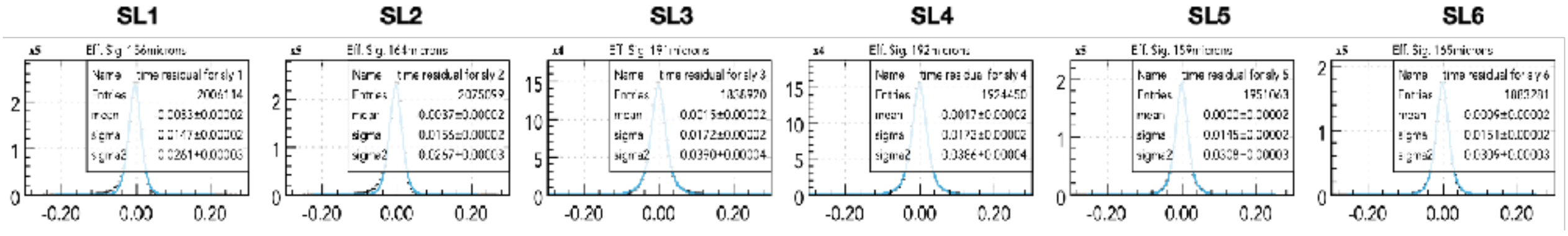
- **Each run separately calibrated**
- **Results averaged over sectors**
- **Decrease of residuals for each SL as expected**
- **Lower sigma for R1/R3 compared to R2**

- **More studies with RGK 2023/24 runs soon**

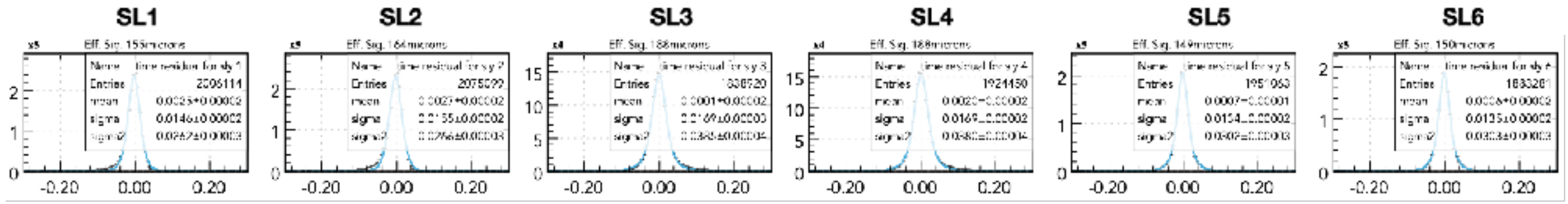
Sector-Dependent Tests (Veronique)

- **Test with RGK run 19220 (HV Setting 10,11,11 - same as RGD/E)**

Sector averaged



Sectors separately



- **Small improvements in SL5 and SL6 on residuals**
- **Consistent with older studies which showed ~ 15-20% sector dependence of parameters**

Summary: Calibration Updates

- **New suite and methods work very well on all HV settings**
- **Calibration routines more reliable - less prone to errors**
- **Beta dependent correction now part of T2D table**
- **Updated B-field dependence to ensure monotonic T2D function in R2**

- **Constants for v2 updates in new CCDB tables under /calibration/dc/v2/***

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Main Caveat: No Backward Compatibility!!!!

- New calibration requires new coatjava version and vice versa
- New coatjava release with v2 soon (final tests in progress)
- New coatjava used for RGD/K/E/L calibration/cooking
- For older run groups, we need to redo DC calibration! The v2 release will fail with runs < 18000 (besides runs 0-1000)

DC Readout Updates

Current Limits of DCRB Firmware

- **No information about trailing edge of signals —> no Time-over-threshold which could be used to cut noise hits**
- **No more than one hit per wire per event —> an early noise hit in the readout window could block a real hit from being recorded**
- **No monitoring/correction of single event upsets (SEU) which recently showed up more often**

—> new firmware without these limits was developed by Ben Raydo and tested during RGE
—> data with the new firmware requires also software updates (storage of trailing edge in DC banks and multi-hit per wire capabilities)
—> ToT cuts to suppress noise in DC

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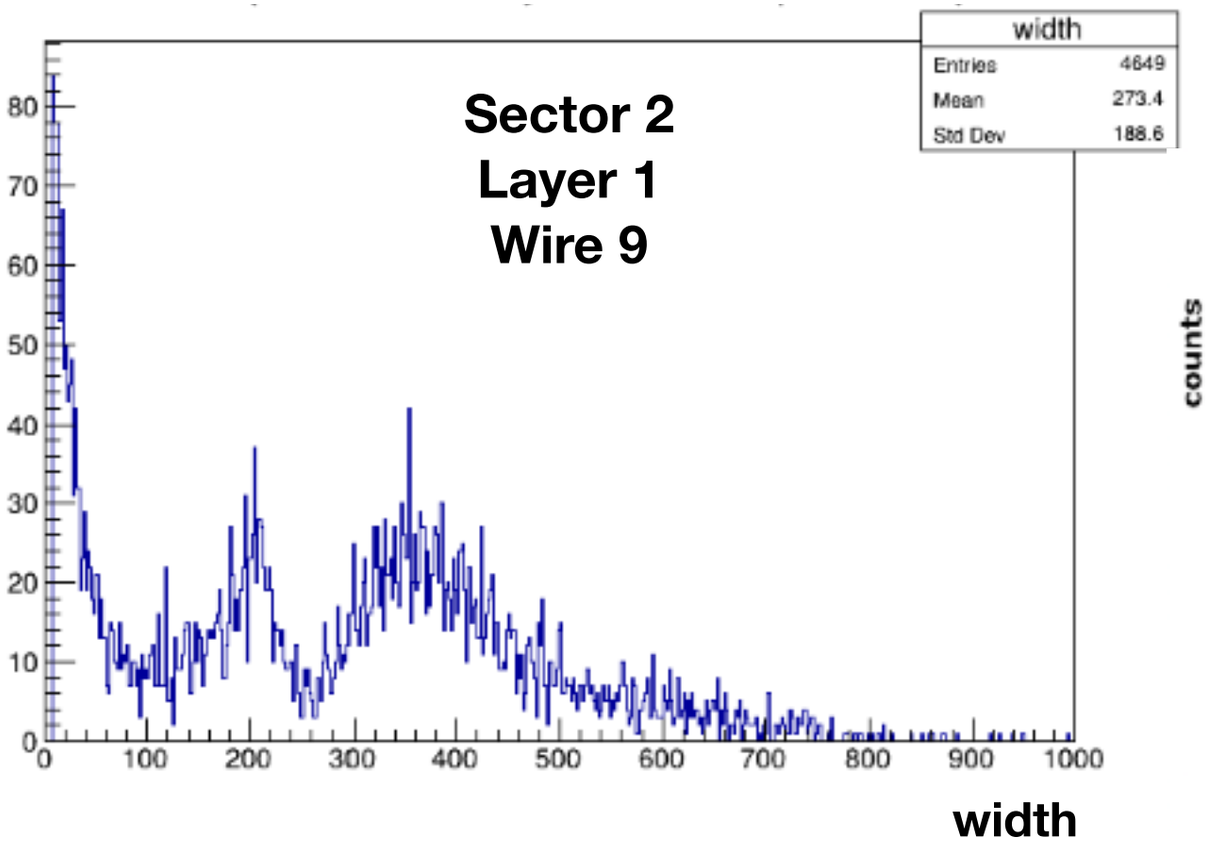
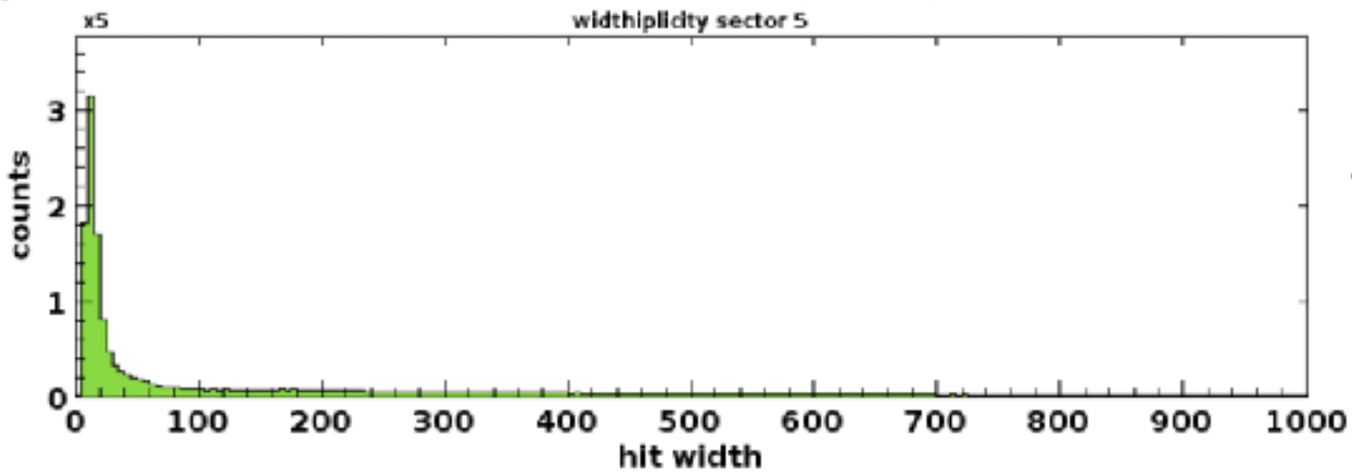
- **RGE test runs: https://logbooks.jlab.org/entry/4288837**
  - **runs with different thresholds (make DC more noisy)**
  - **runs with different beam currents (check under different backgrounds)**
  - **tests done only with Sector 2 and 5**
- **Analysis and studies in progress**

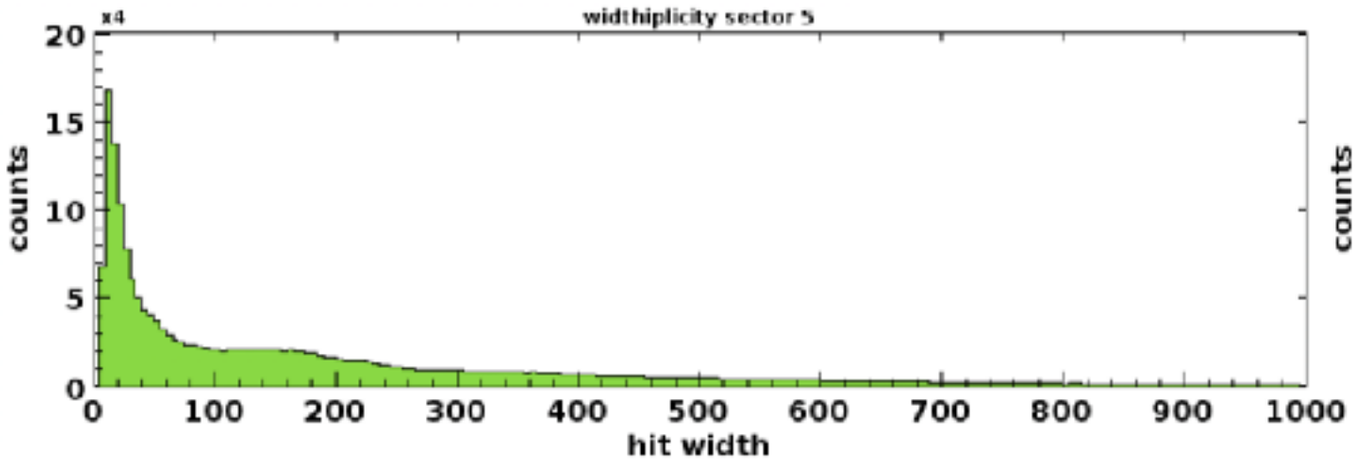
How Does a Width Spectrum looks like?



Run 20285 (low DCRB threshold)



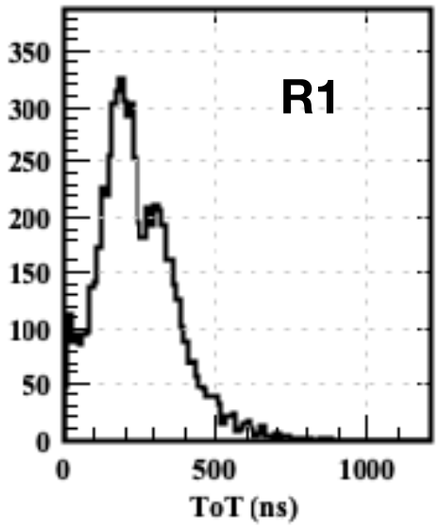
Run 20284 (high DCRB thresholds)

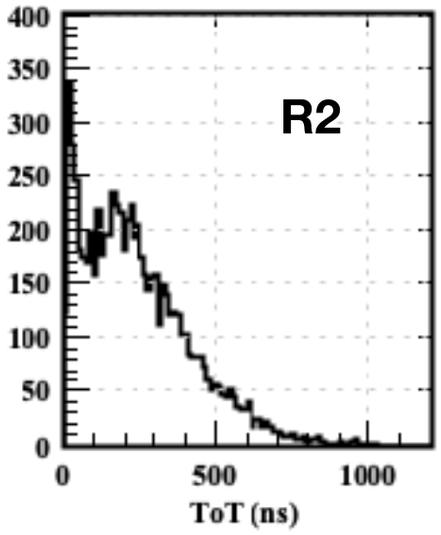


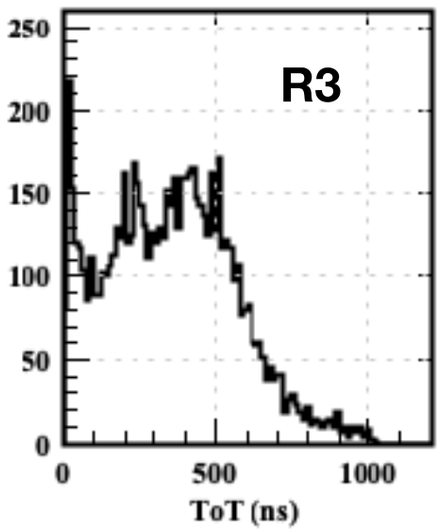
- **Low width correlated with noisy hits**
- **More noisy hits with lower thresholds as expected**

ToT for Reconstructed Hits (Raffaella)

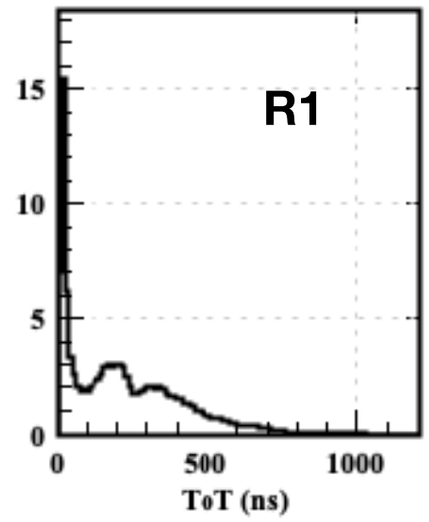
hits on tracks

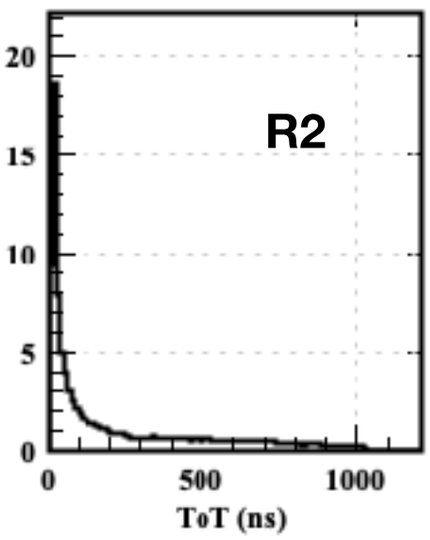


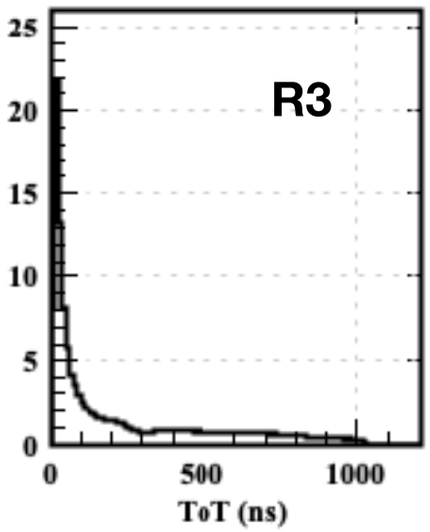




hits not on tracks

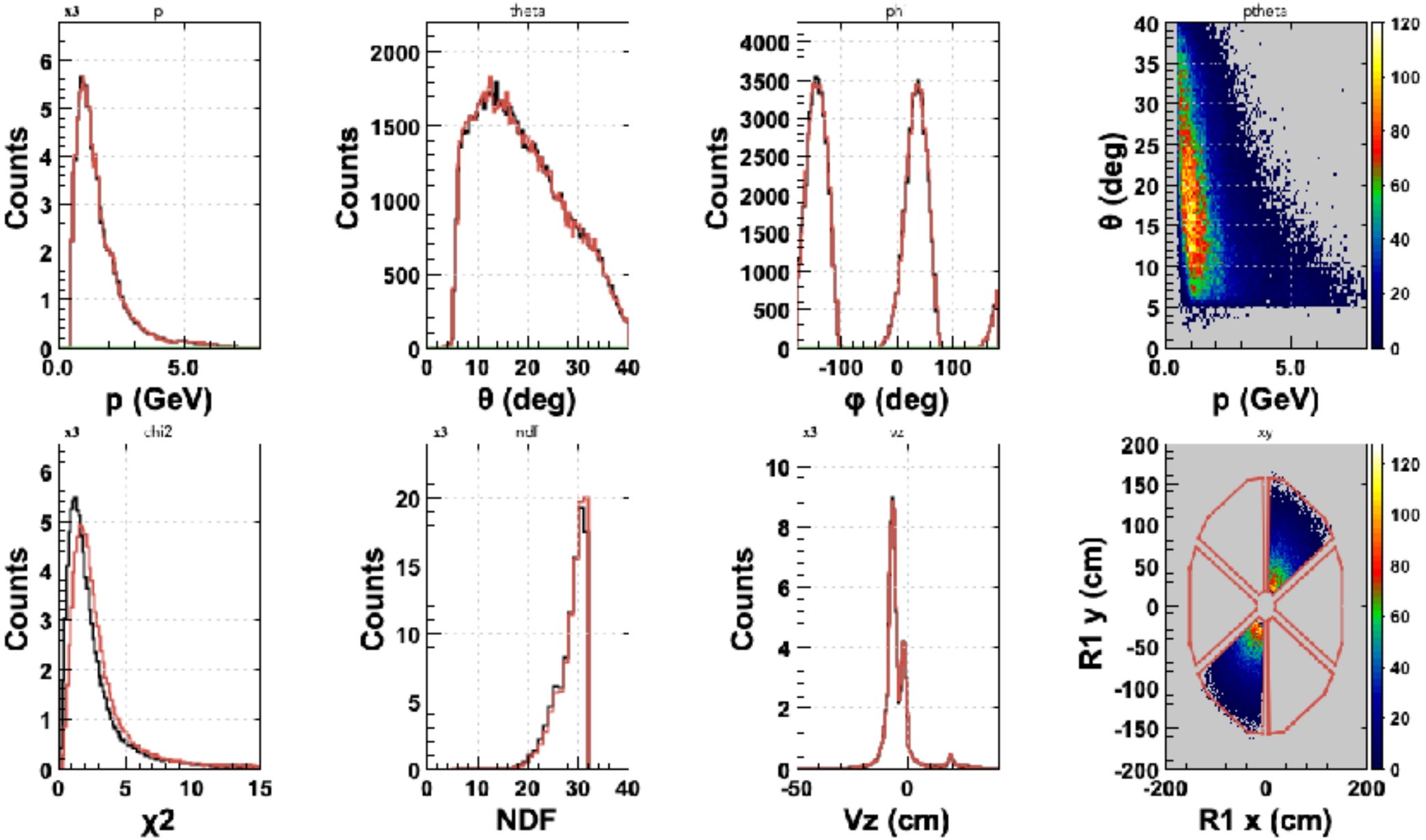






- **Analysis done for run 20287 (35nA, LD2+Pb target), Sector 2 and 5 with new firmware**
- **Modified coatjava version to handle ToT and multiple hits per wire**
- **Kept first hit in time window (no ToT cut)**

Test of Reconstruction with ToT cuts



- **Black - Run 20288, old firmware, 70nA, LD2+Pb**
- **Red - Run 20283, new firmware, 70nA, LD2+Pb, ToT > 50 cut for first hit**

- **Electron kinematic observables and vertex distribution similar**
- **Small difference in $\chi 2$**

Test of reconstruction with ToT cuts

charge	n. sl	run 20288	run 20283	gain
pos	any	97664	97825	1.0016
pos	6	88856	90580	1.0194
pos	5	8673	7125	0.8215

- **Indication of more 6-superlayer tracks with new firmware and ToT cuts —> might indicate regain of hits in new firmware due to multi-hit capabilities**
- **However, decrease of 5-superlayer tracks**
- **More studies underway**

Summary/Outlook: Readout Updates

- **New DCRB firmware gives access to more information from DC during data taking**
- **Initial tests with RGE did not indicate issues with the new firmware**
- **More studies needed to understand possible improvements in reconstruction**
  - **noise suppression**
  - **improvement of efficiency/resolution by recovery of hits blocked currently by noise in readout window**
- **Plan to use the new firmware for RGL**

- **Next steps:**
  - **Add 2D histograms with ToT and hit multiplicity to monitoring plots**
  - **Check again data rates from DC crates (seemed to be okay during RGE)**
  - **Check reconstruction in noisy area of DC (e.g Sec 5, Region 2)**
  - **Dependence on number of hits/tracks on ToT cut**

Backup

Hit Multiplicities

Run 20283, 70nA current, LD2+Pb target