



# CLAS12 reconstruction: latest improvements and plans

V.Ziegler

CLAS12 Collaboration meeting

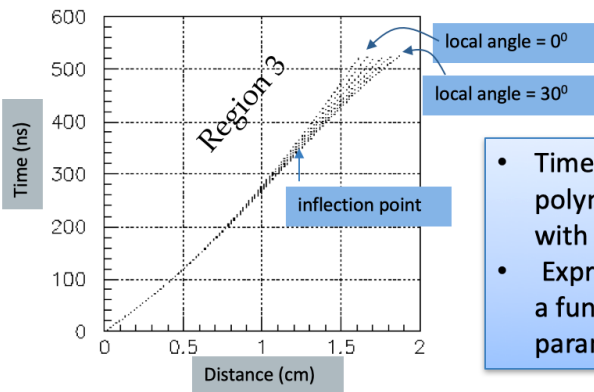
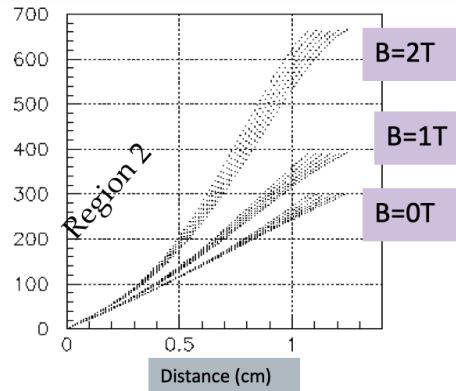
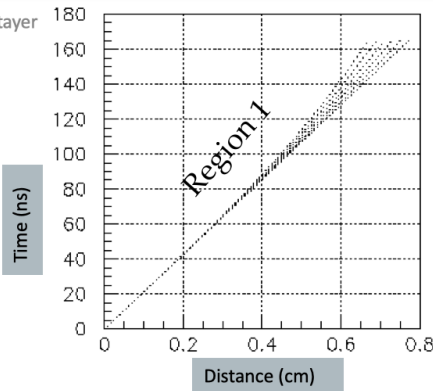
June 18, 2019

# Reconstruction Developments Overview

- Central Tracking (see Maxime's talk)
  - Efficiency studies and improvements in development
  - Use of alignment in tracking in development
- Forward Tracking
  - KF Smoothing
  - Track swimming failures analysis and fix using state propagation method.
  - Beam offset parameters used in recalculation of track at doca to plane containing the beam line.
  - Swim to Beam line significantly improves vertex reconstruction
  - Time-to-Distance function: polynomial functional form in development
- DC Geometry & Alignment (see Mac and Raffaella's slides)
  - DC alignment parameters used in tracking (spring and fall variations)
- ECAL Updates
  - Logarithmic weighting in cluster position
  - Validation of moments calculation
  - Edge distance calculation for fiducial cuts
  - Improved timing with new TW corrections implemented by Cole (see Dan's talk)
- LTCC PID (see Harut's talk)
- EB Updates (see Nathan's talk)
  - track hit matching to allow many-to-one relations
  - REC::Scintillator banks
  - FT-based start time

# New DC Time to Distance Function (in development)

Mac Mestayer



Simulations (GARFIELD)

- Time to distance lineshapes look polynomial-like  $\rightarrow$  parametrize with function  $t = \sum_i a^i d^i$ ;  $i=0 \dots 4$ .
- Express polynomial coefficients as a function of calibration parameters.

- T2D functions (exponential or polynomial form) accessible to calibration suite
- Beta corrections accessible to calibration suite
- Unique source for function
- Revisiting beta-dependent correction.

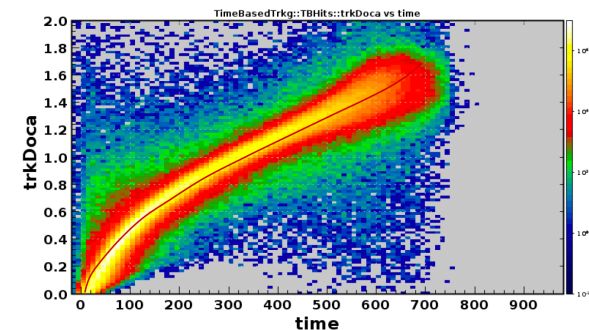
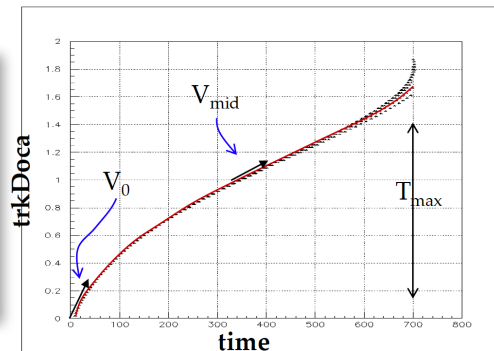
4th order polynomial

data

$$T = a x^4 + b x^3 + c x^2 + d x \quad (x = \text{trkDoca})$$

Solve for a, b, c, d using 4 constraints:

- 1) Velocity at  $x = 0 \Rightarrow$  parameter  $v_0 \rightarrow d = 1/v_0$
- 2) Inflection point at  $x = r \cdot d_{\text{Max}} \rightarrow$  parameter  $r$
- 3) Velocity at inflection point  $\Rightarrow$  parameter  $v_m$
- 4)  $T_{\text{max}}$  at  $d_{\text{Max}} \cdot \cos(30 - \alpha)$

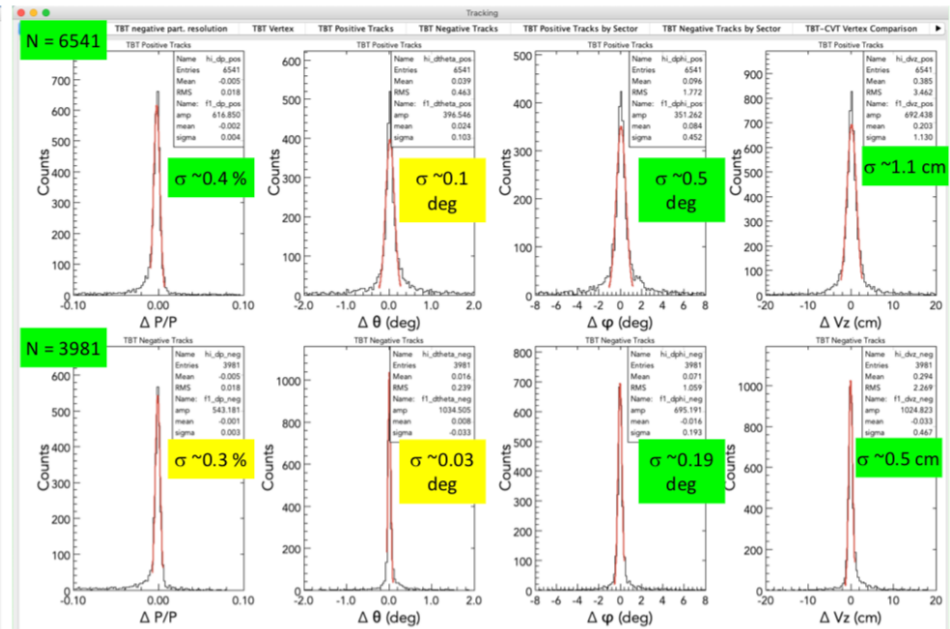
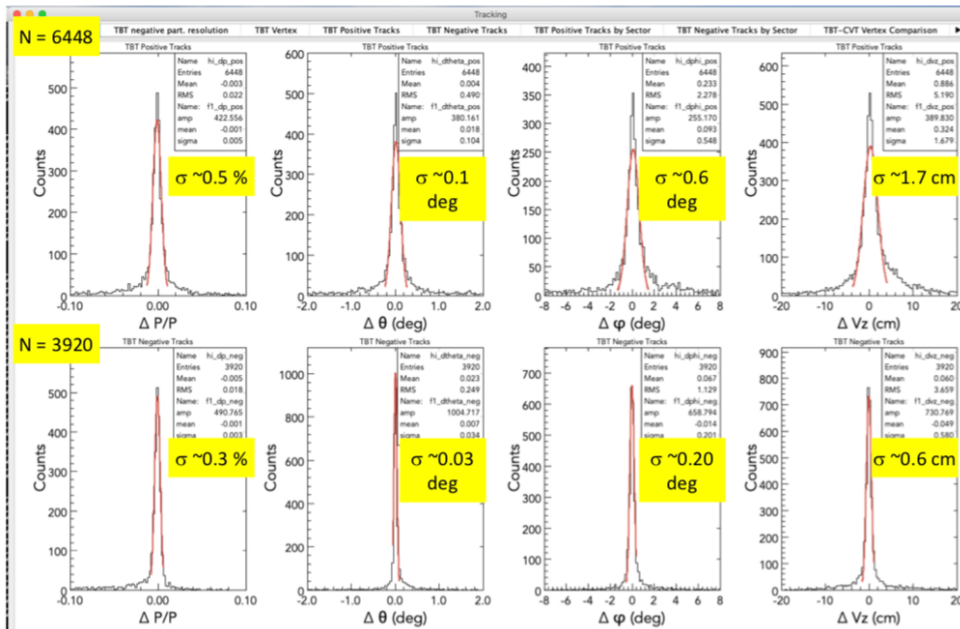


# Swim failures recovery & KF smoothing

## Fitting Improvements

- Smoothing (swim inward)
- State vector initialization for TBT using HBT state vector (output to bank)  
→ more robust
- Improves phi and vertex resolution

## SIDIS events





# Swimming Updates

## (D. Heddle, CNU)

### (A new) Adaptive Step-size Swimmer In development (test branch)

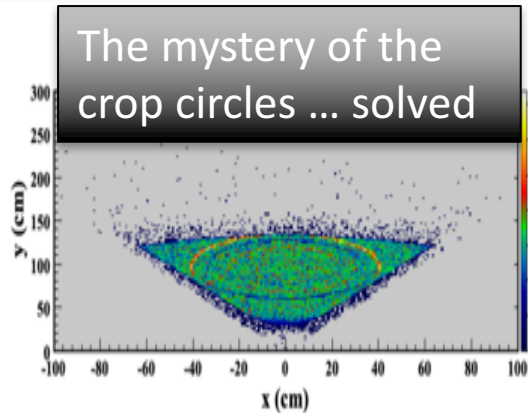
Not yet tagged/used in reconstruction

- Easier to use
- Faster (about 1.5 times faster)
- Old swimmer:
  - standard 4th order Runge-Kutta (with a 5th order correction) stepper with a (boring) half- step adapter.
- New swimmer: **Butcher Tableau** stepper
  - best tableau seems to be **Cash-Karp\***
  - several are available for your selection
- Appears to be more robust → “step-size too small” exceptions not observed in tests
- The new package is **adaptive only**. No uniform step-size option.
- Old swimmer still available.

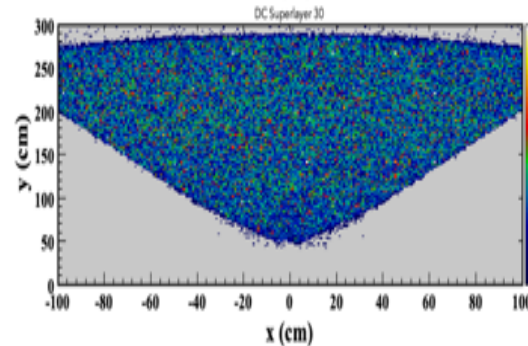
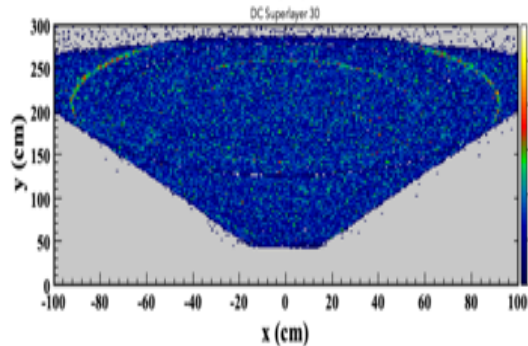
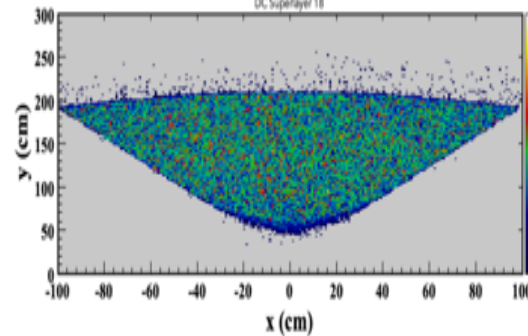
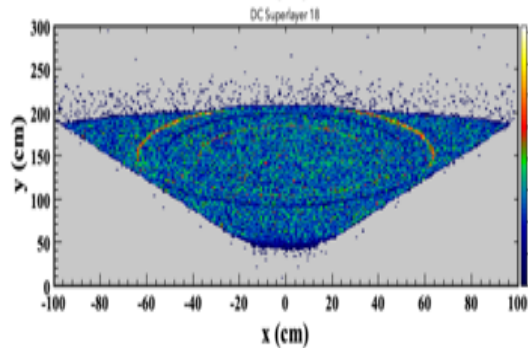
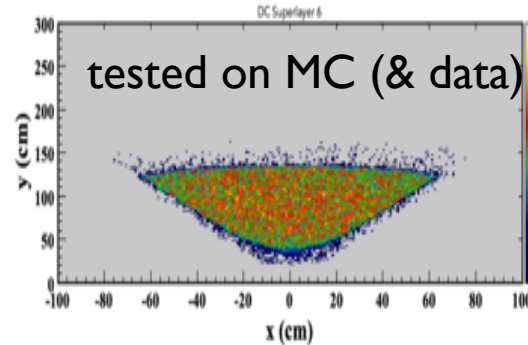
\* Method uses 6 function evaluations to calculate 4<sup>th</sup> and 5<sup>th</sup> -order solutions, taking the difference between these to be the error of the 4<sup>th</sup>-order solution, employed for **adaptive stepsize** integration.

# Trajectory Bank Structure

The mystery of the  
crop circles ... solved

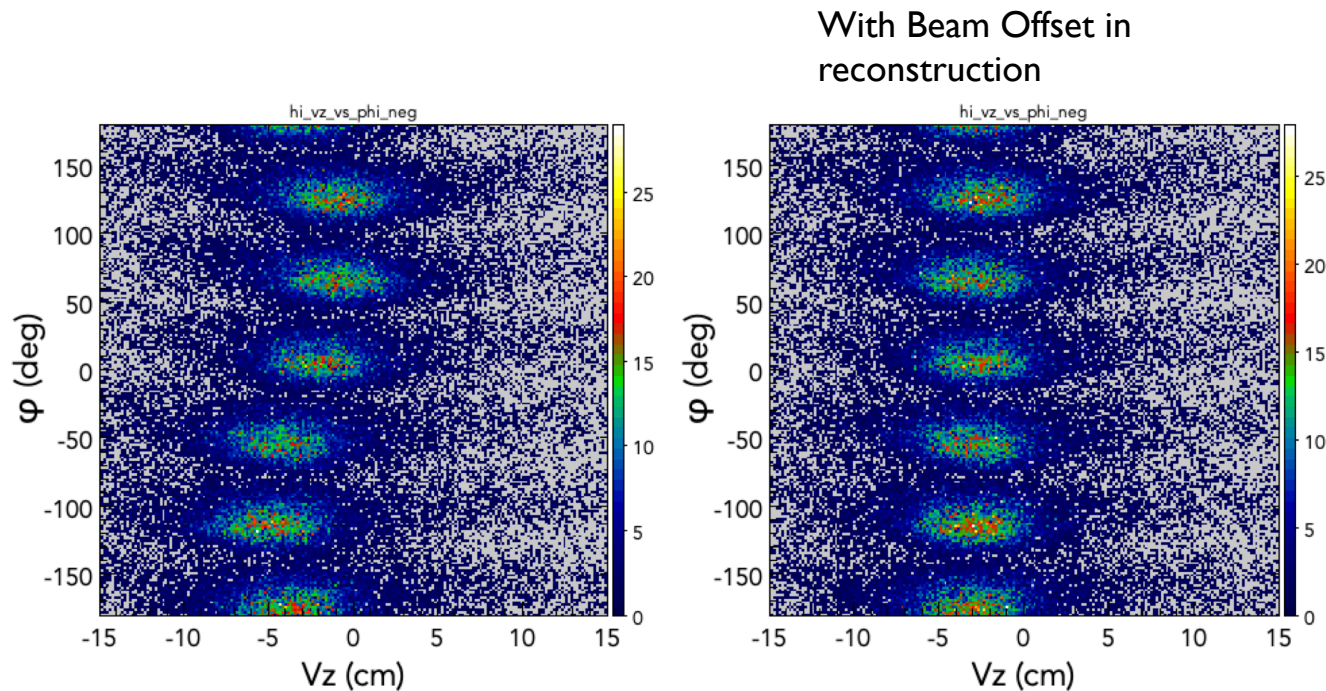


tested on MC (& data)



- Bank structure modified to use detector/layer indexes
- Trajectory surfaces redefined to best match what needed by the EB to match tracks to detector hits, e.g. FTOF planes correspond now to midplane of the panel where hits are reported by FTOF reconstruction
- Debugging and fixes of reported issues (disconnected planes → crop circles)
- Forward Detectors trajectory planes now include:
  - Target center and downstream window
  - FM T planes
  - HTCC sphere
  - DC layers 6, 12, 18, 24, 30, 36
  - LTCC plane
  - FTOF panels,
  - ECAL V strip planes
  - RICH will use planes and spheres

# Beam Offset Position in Forward Tracking



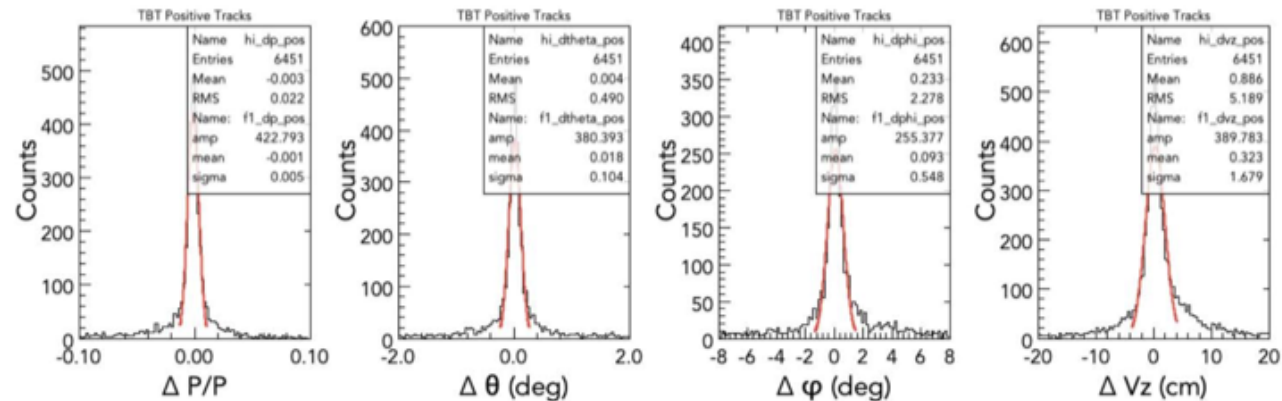
- Beam position correction tested on one file of **run 4013**, using alignment parameters with beam offset  $X = -0.14$  cm,  $Y = -0.4$  cm
- Reconstruct without and with offset

- Reconstruct without and with offset
  - Plots produced with code swimming to plane
  - **Swimming to line improves vertex (next slides)**

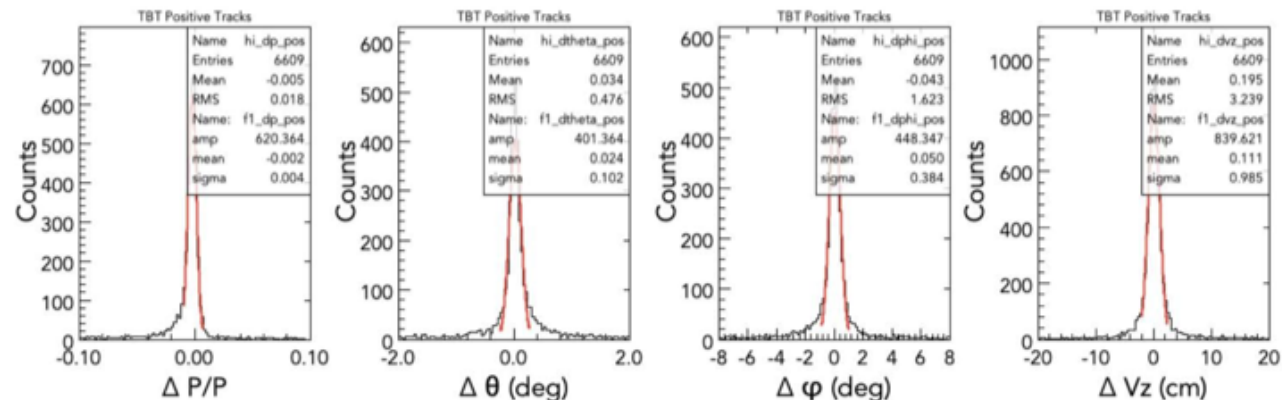
# Swim to Beam Line implementation in Forward Tracking

- Implementation of stopper in Swimmer to stop the track at DOCA to line (fixed step swimming → speed can be improved by going to adaptive step size (in test branch, under validation))

SIDIS MC:  
6b.1.1



SIDIS MC:  
6b.2.0

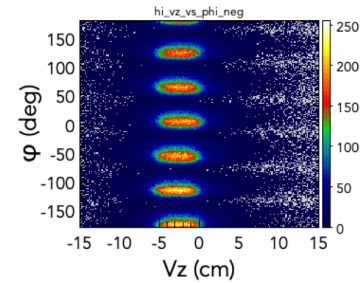
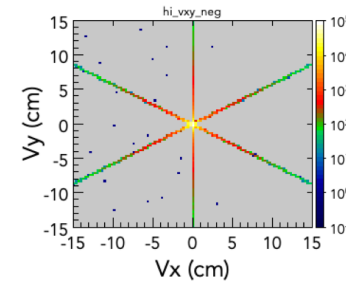
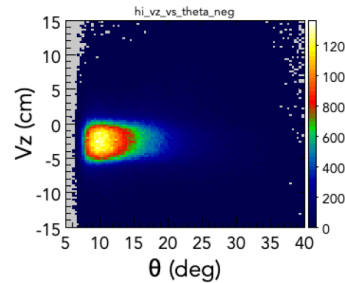
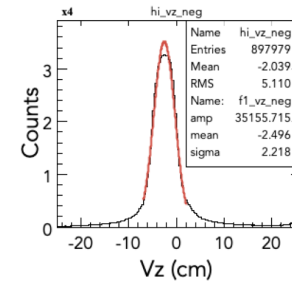
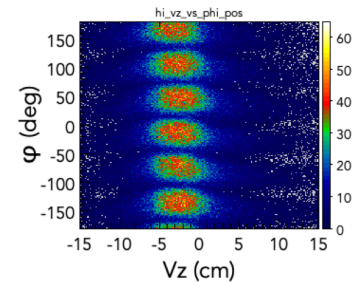
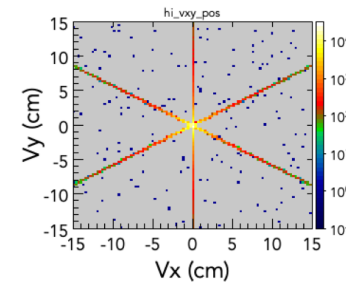
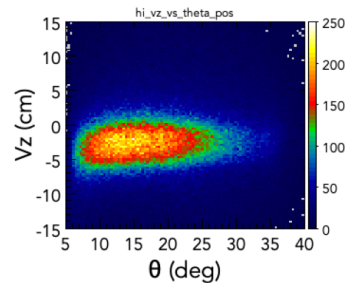
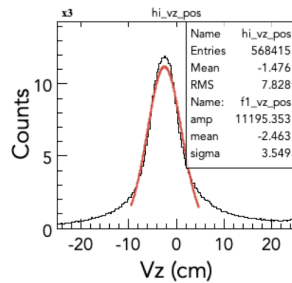


- Swim to line and smoothing improve pathlength resolution and vertex

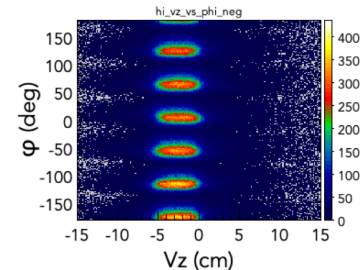
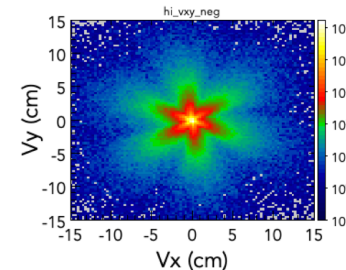
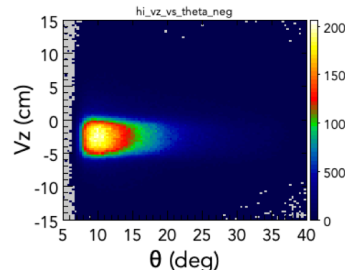
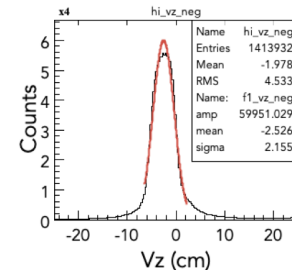
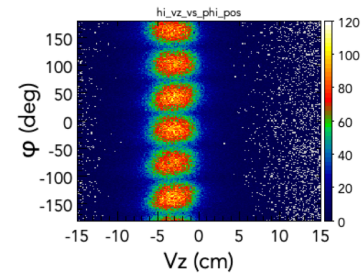
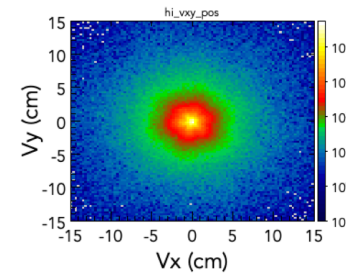
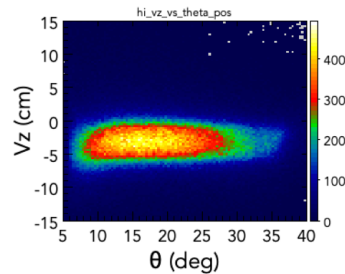
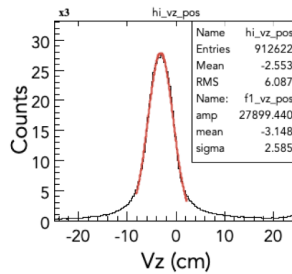


# Vertex Reconstruction Improvements

Vertex  
Reconstruction:  
6b.1.1

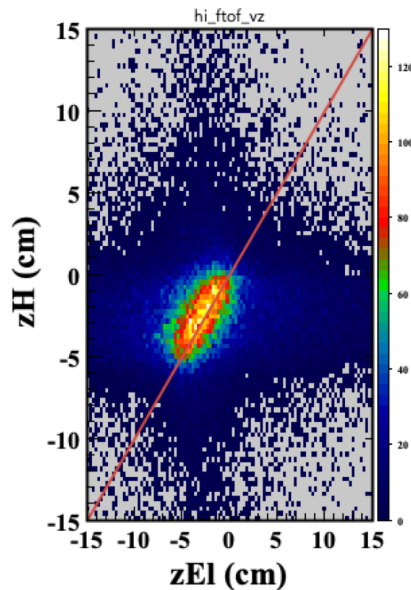


Vertex  
Reconstruction:  
6b.2.0  
(Swim to Beam  
Line)

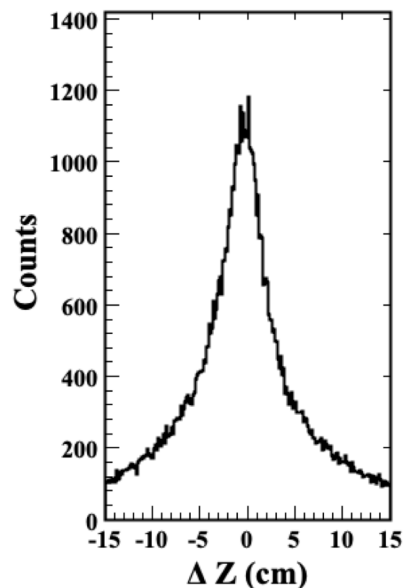
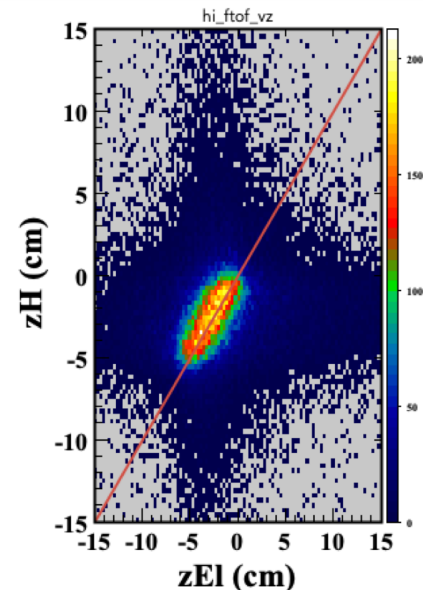


# Vertex Reconstruction Improvements

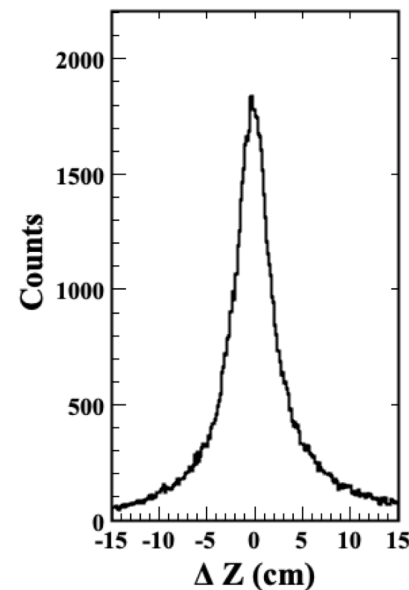
Vertex  
Reconstruction:  
6b.1.1



Vertex  
Reconstruction:  
6b.2.0  
(Swim to Beam  
Line)



Improved  
correlation  
between hadron  
and  
electron vertex

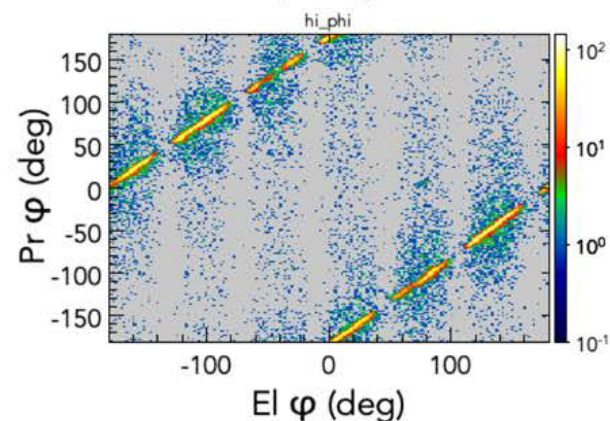
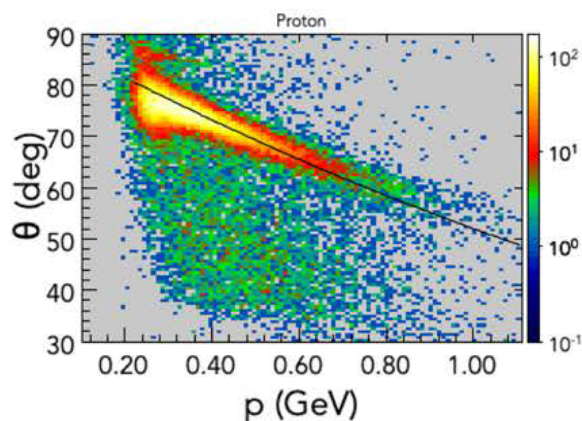
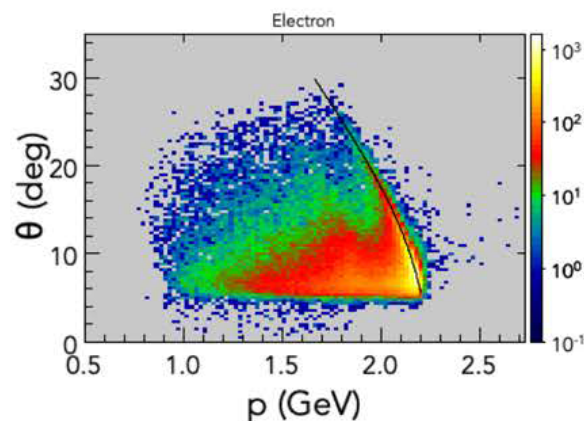
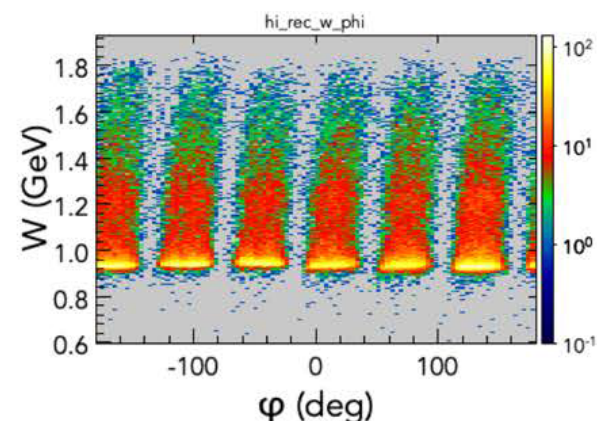
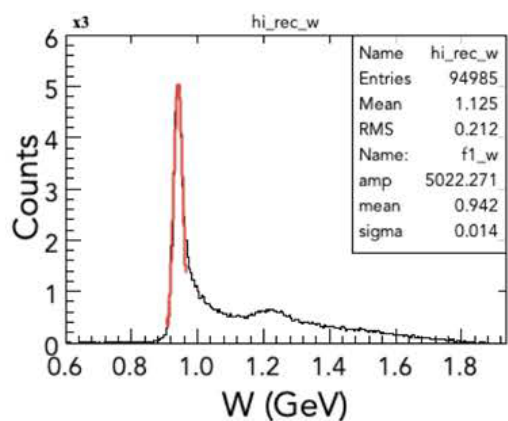
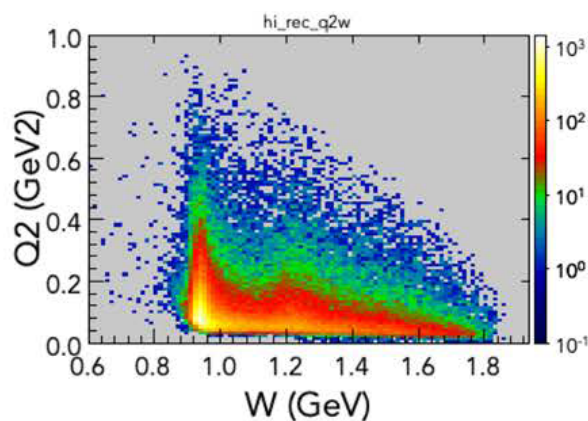


# Reconstruction Improvements with Alignment

(see Raffaella's talk)

With tracking improvements and using Forward Detector alignment

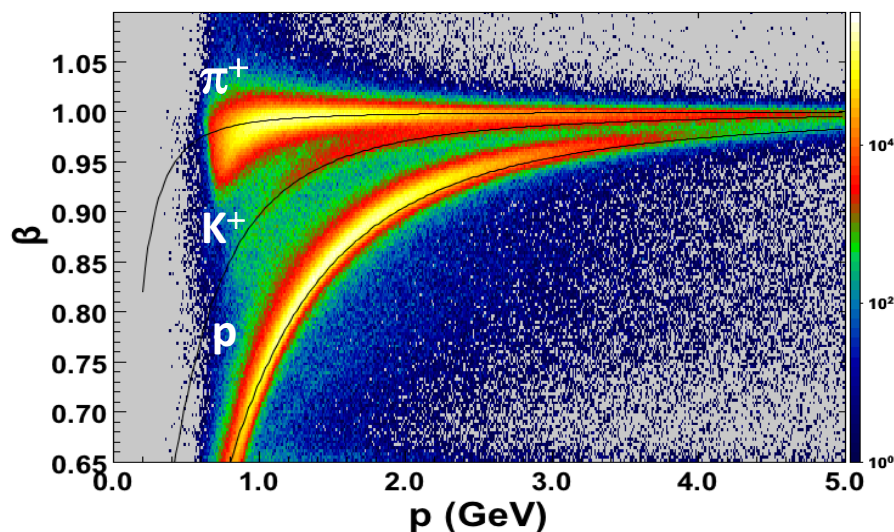
6b.2.0: run 2391, elastic events



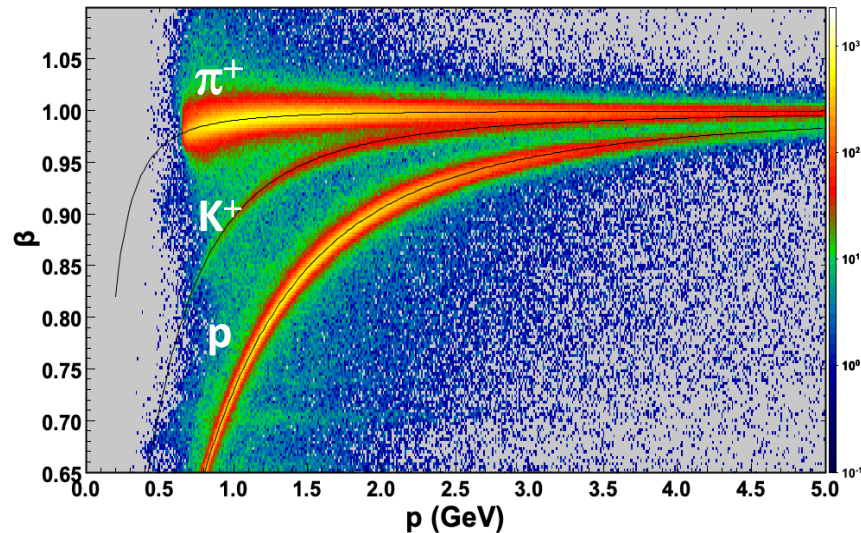


# Reconstruction Improvements

TOF particle  
identification – Oct. 2018



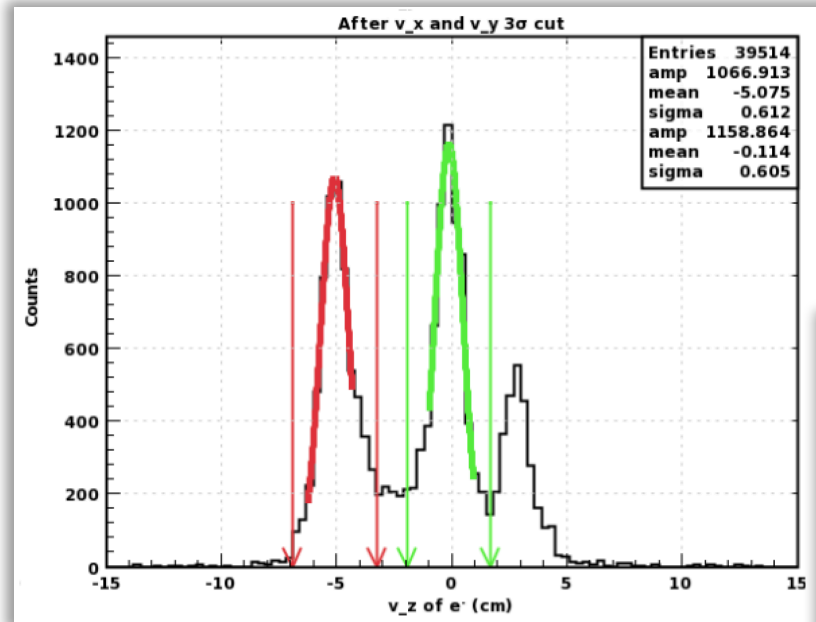
TOF particle  
identification – Now



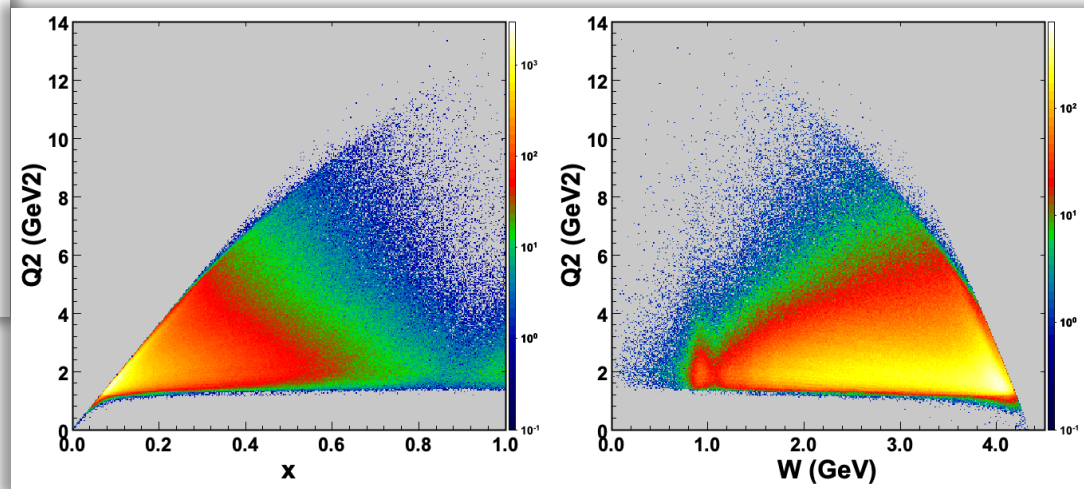


# Reconstruction Improvements

Empty target z vertex  $\sim 6\text{mm}$



Physics reach



# Run Group Dependent Geometries

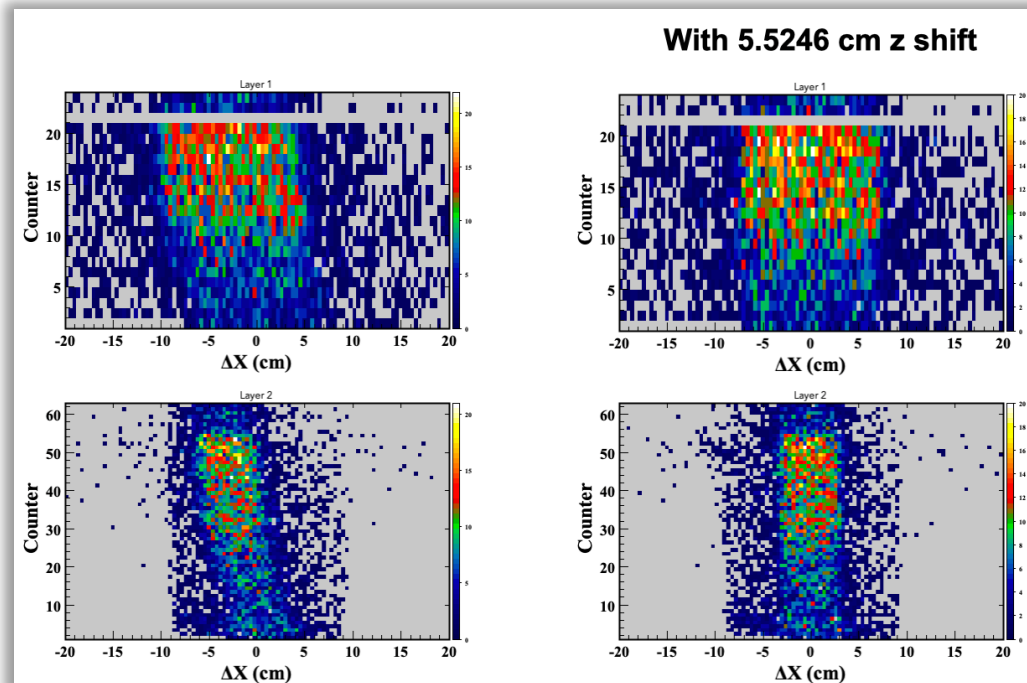
## "rga\_spring2018"

- ✓ Target position from survey set at -1.9 cm
- ✓ Beam position from phi modulation analysis (Stepan) of run 4013
- ✓ DC alignment tables
- ✓ FTOF, EC and PCAL alignment tables set to reproduce a 5.5426 cm z shift of all sectors with no rotations

## "rga\_fall2018"

- ✓ Target position from survey set at -3.0 cm
- ✓ Beam position from phi modulation analysis (Stepan) of run 5036
- ✓ DC alignment tables
- ✓ FTOF, EC and PCAL alignment tables set to reproduce a 5.5246 cm z shift of all sectors with no rotations

FTOF  
residuals  
in tilted  
frame



# New Detector Reconstruction Packages

- Central Neutron Detector completed
- Ring Imaging Detector advanced (see Marco's talk)
- Backward Angle Neutron Detector (scintillator half-ring) part of service chain
- Radial Time Projection Chamber (BONuS detector for bound nucleus experiment) under development, being tested by developers (ODU)

# New Detector Reconstruction:FTT

(Alessandra Filippi, INFN Torino)

- Hit reconstruction completed
- Pattern recognition (clustering, crosses, layer matching) done, matching improvements in development
- Reconstruction output to banks available
- Validation using FTCal ongoing using MC

# Reconstruction Options

- Configuration options
  - Field Maps
  - Start time
  - DC wire distortions
  - Different YAML files for running data or MC
  - Solenoid can be shifted in z, torus can be shifted in x,y,z; symmetric or non-symmetric torus map selection in YAML.
  - Variations
  - **Support for run dependent geometries including sector-dependent shifts**
  - Additional Tools
  - DC layer efficiency analysis
  - Data bg merger for tracking efficiency studies (used for forward and central tracking efficiency analysis)
  - Tracking Trigger Roads maker
    - \* for online, has duplicate roads counter, dictionary validation code

# Outlook

- Additional tracking efficiency improvements will be ongoing.
- Tracking speed improvements expected from new swimmer.
- Switch to and validate new Time to Distance function.
- Central tracking improvements and alignment (see Maxime's talk).