CLAS12 Reconstruction Status

V.Ziegler

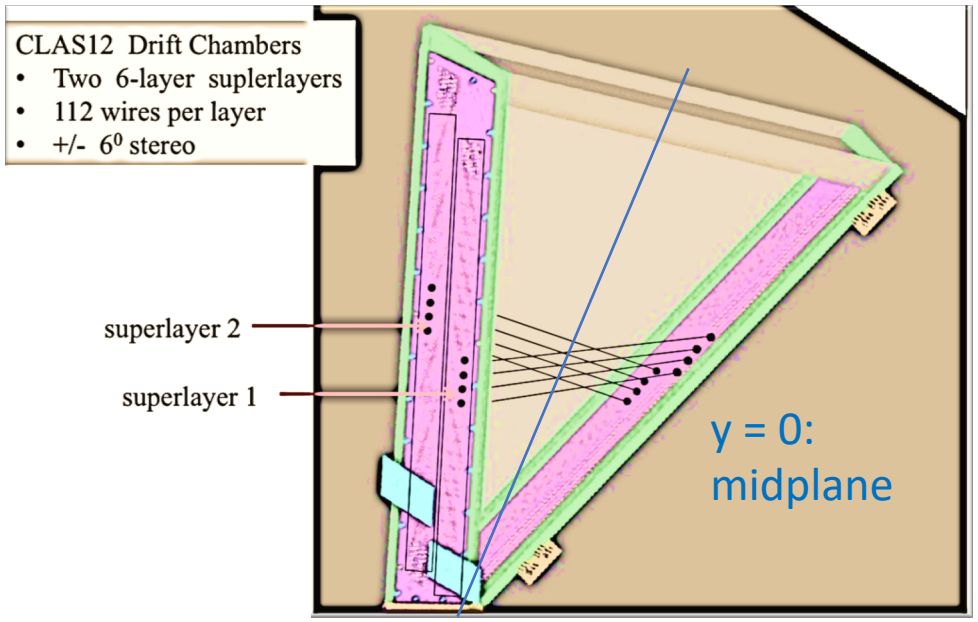
CLAS12 Collaboration meeting

November 12, 2019

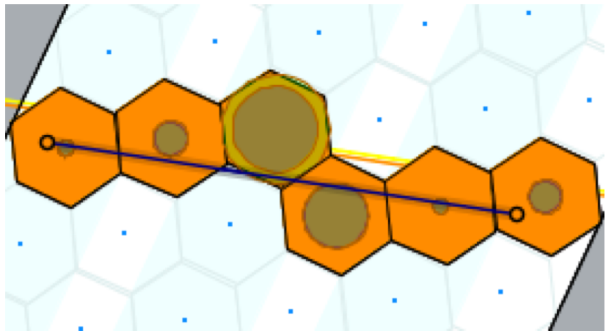
Reconstruction Developments Overview

- Central Tracking (see Francesco's talk tomorrow)
  - Development of code with alignment functionality
  - Update on tracking algorithms
- Forward Tracking
  - New track fitting algorithm
  - Updates to Time-to-Distance function
  - Swimming updates
  - API updated for AI-assisted tracking capability
- DC Geometry & Alignment
  - DC alignment parameters used in tracking (spring and fall variations)
- ECAL Updates
  - PCAL projection yielding non-centered residuals resolved
  - Logarithmic weighting in cluster position validated
  - Validation of moments calculation done
- RICH
  - Reconstruction service included in the service chain
- CND
  - Updated cluster definition for trajectory compatibility
- ALERT
  - Reconstruction effort started
- RTPC (see David's talk)
  - Reconstruction algorithms in place
  - Reconstruction included in service chain
- EB Updates (see Nathan's talk)
  - Vertex-corrected start time
  - Delayed helicity correction improvement
  - Get charged tracks beta from non-TOF outer detectors if TOF info. unavailable
  - REC particle bank for FT update
  - Easier timestamp-based lookup for scalers/helicity

DC TRACKING: New Fitting Algorithm



MC docas at midplane



- **Previous algorithm:**
  - Get a position at midplane = wire + lr*doca_corr
  - Use position as measurement
  - Project state vector onto measurement (i.e. midplane) at site z = z of wire plane in TSC system.
  - Filter using delta(meas – projected)

- **New algorithm:**
  - Get a signed doca: lr*doca
    - Lr → floated parameter of doca_m < 5 mm
  - Use signed doca as measurement
  - Project state vector onto measurement at site z = z of wire plane in TSC system.
  - For now compute projector matrix numerically (del_h/del_a; a = state vector)
  - Filter using delta(meas – projected) as before

DC TRACKING: Reconstruction Improvements

- Reinitialize the track from last Hit-Based state vector in KF → avoid frame transformation.
- Use of custom 5-d matrix used in KF: faster matrix operation compared to JAMA (matrix library used in development). [Implemented by Gagik in jnp package].
- More efficient track segment overlap finder.
- More efficient code to recompose clusters at Time-Based level using Hit-Based H.O.T.s.
- AI assisted tracking: potentially ~ 5x faster Hit-Based tracking (see my next talk).

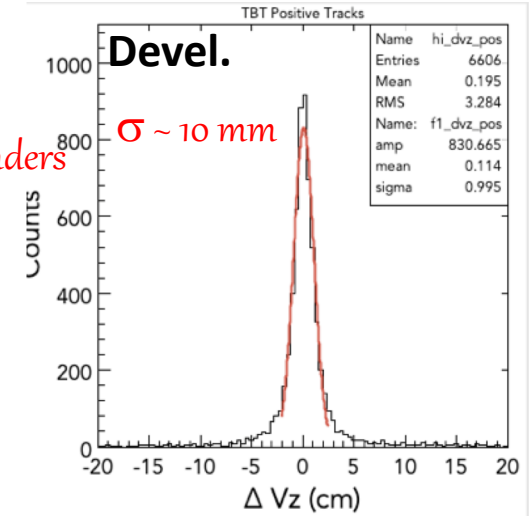
- Outer detector matching using ECAL if no TOF hit matches (see Nathan's talk).
  - Preliminary studies: yields about 8% more tracks in MC → Testing with data ongoing.

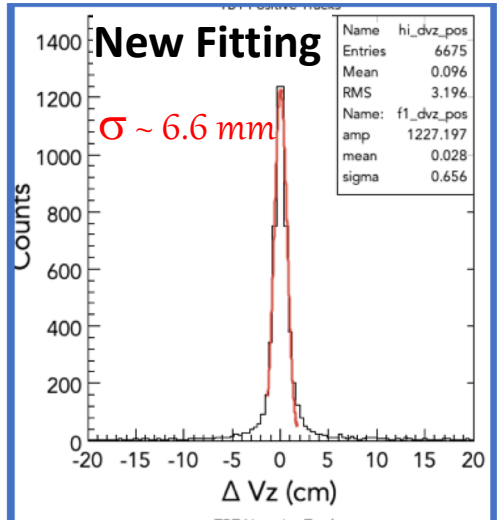
DC TRACKING: New Fitting Algorithm

- Vertex resolution improvement

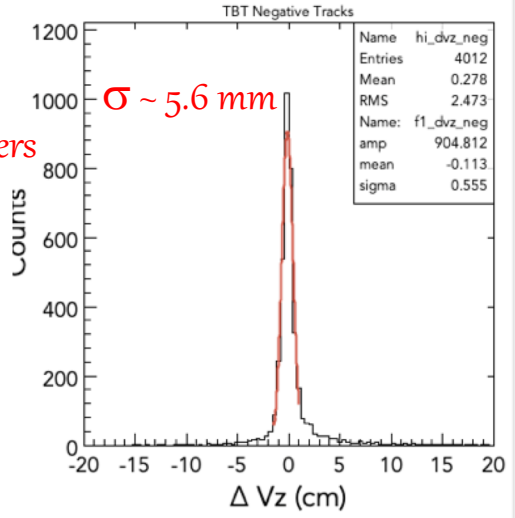
SIDIS MC events

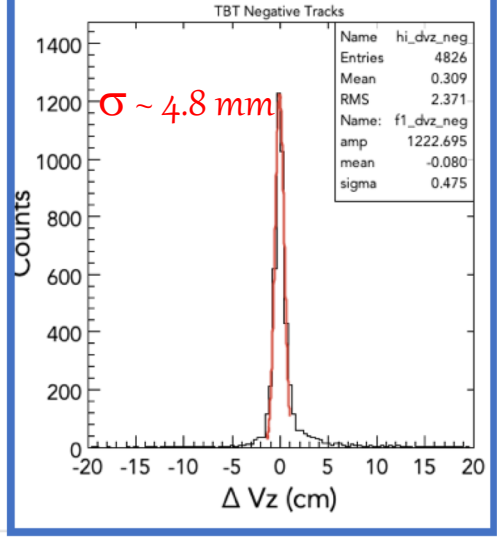
outbenders





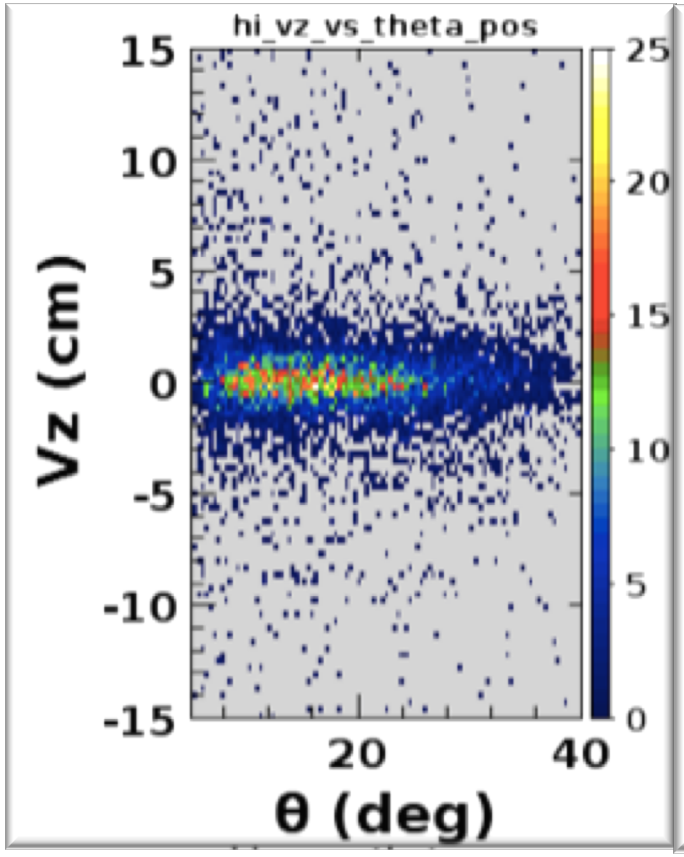
inbenders



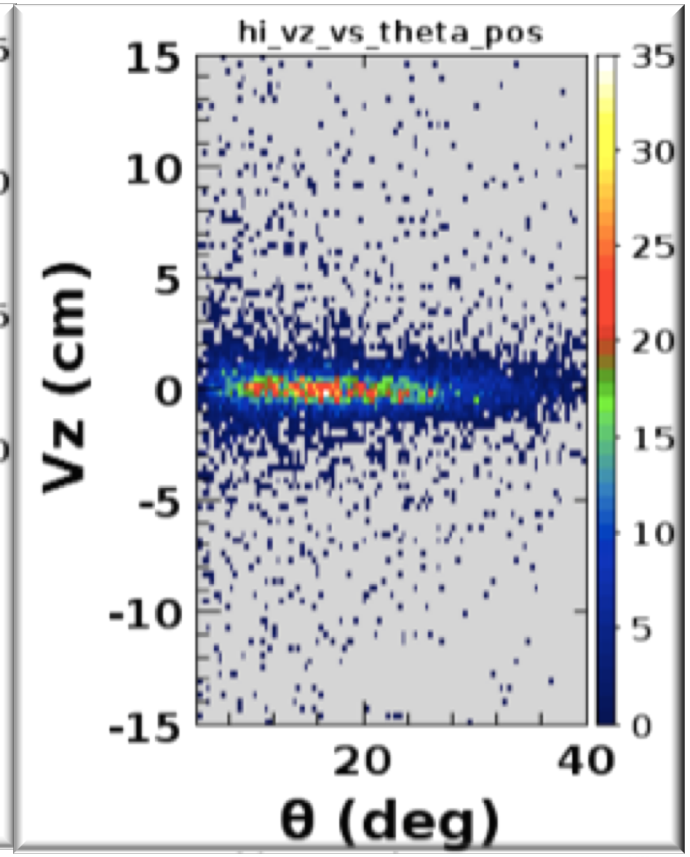


- 0.1% better resolution in $\Delta p/p$ for outbenders
- Vertex resolution as a function of θ

Devel.



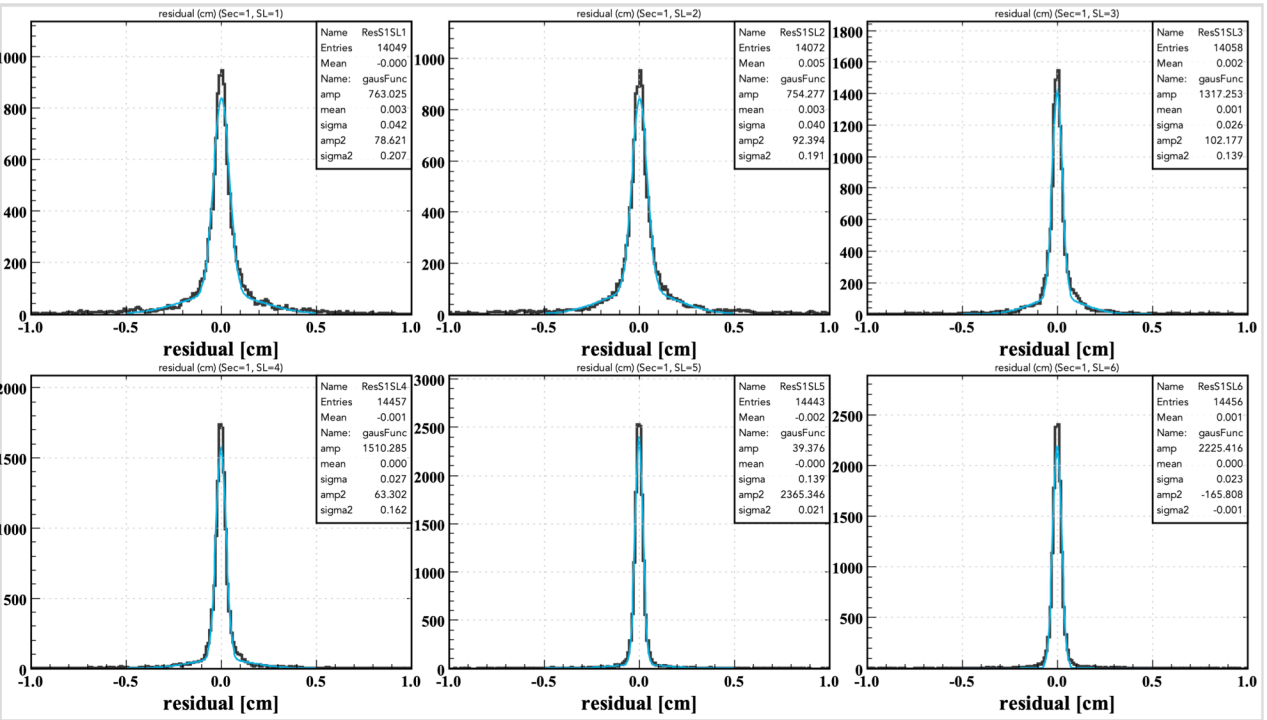
New Fitting



New Fitting Algorithm: Improvements in Fit Residuals

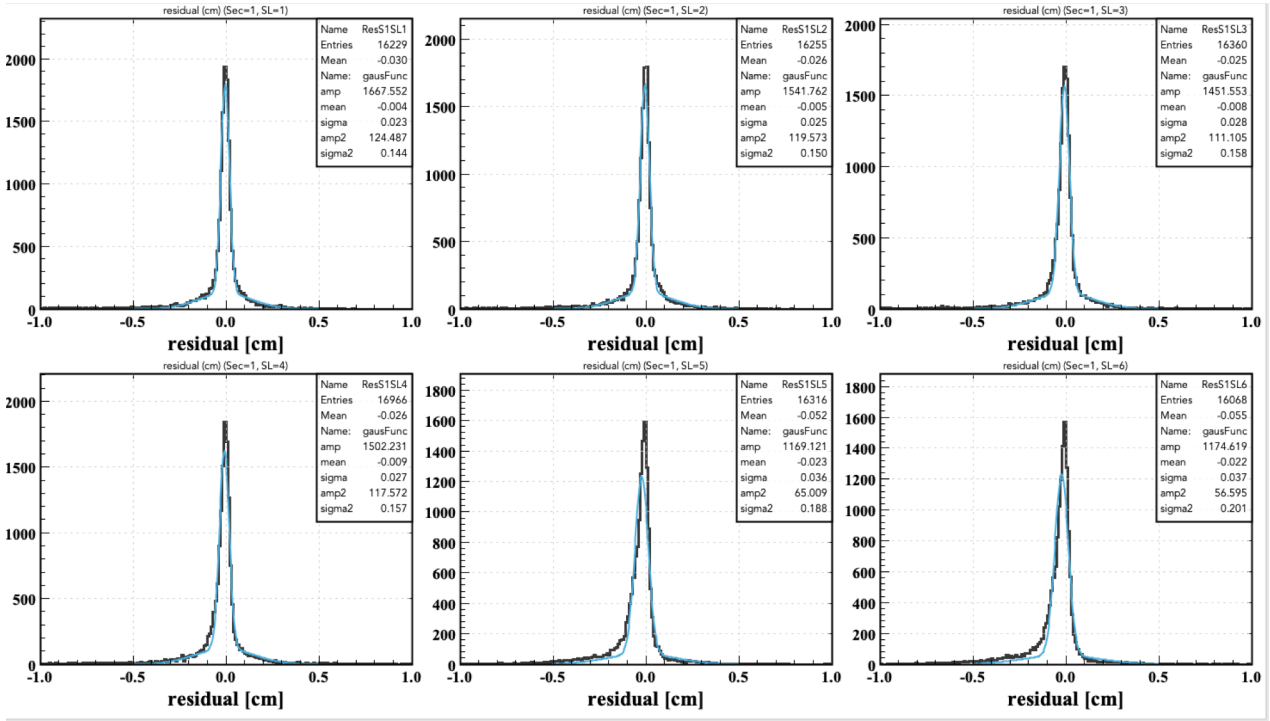
- Previous algorithm had fit bias in DC R-3 → pulling fit

SIDIS MC events



- New algorithm yields residuals consistent with cell size

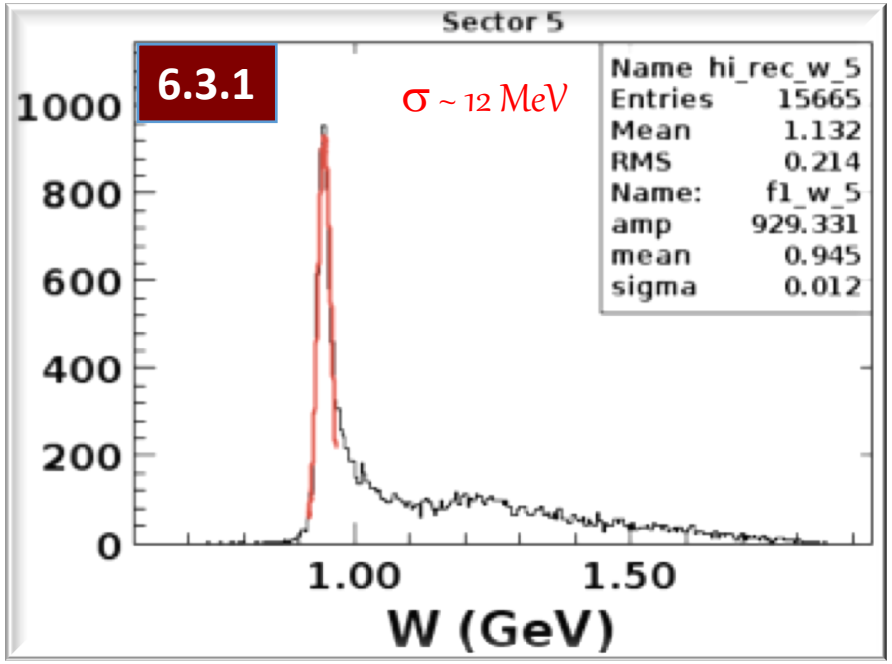
SIDIS MC events

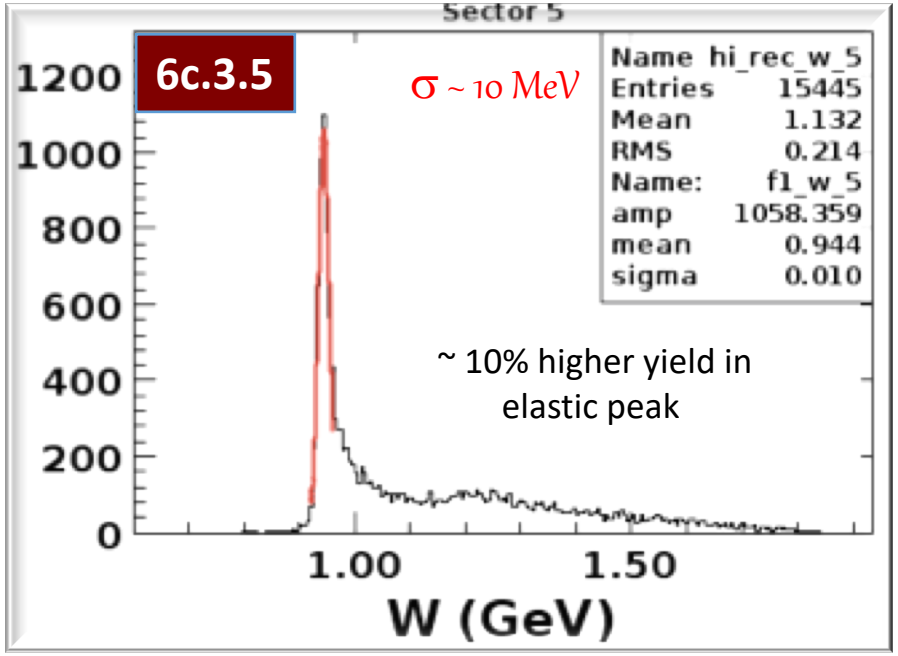


DC TRACKING: New Algorithms

- Validation using data samples
- Comparison between production tag (6.3.1) and c-tag (6c.3.5) with new tracking code
- Elastic peak resolution improvement

Elastic events (2 nA data, Run 2391): **sector 5**

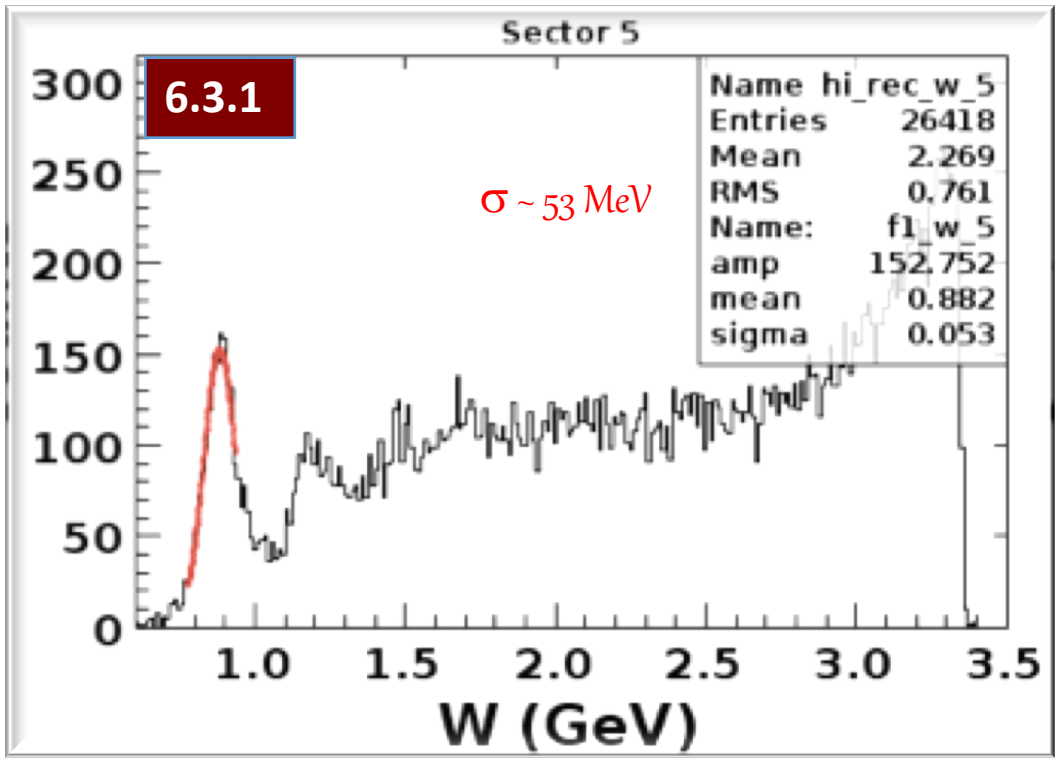


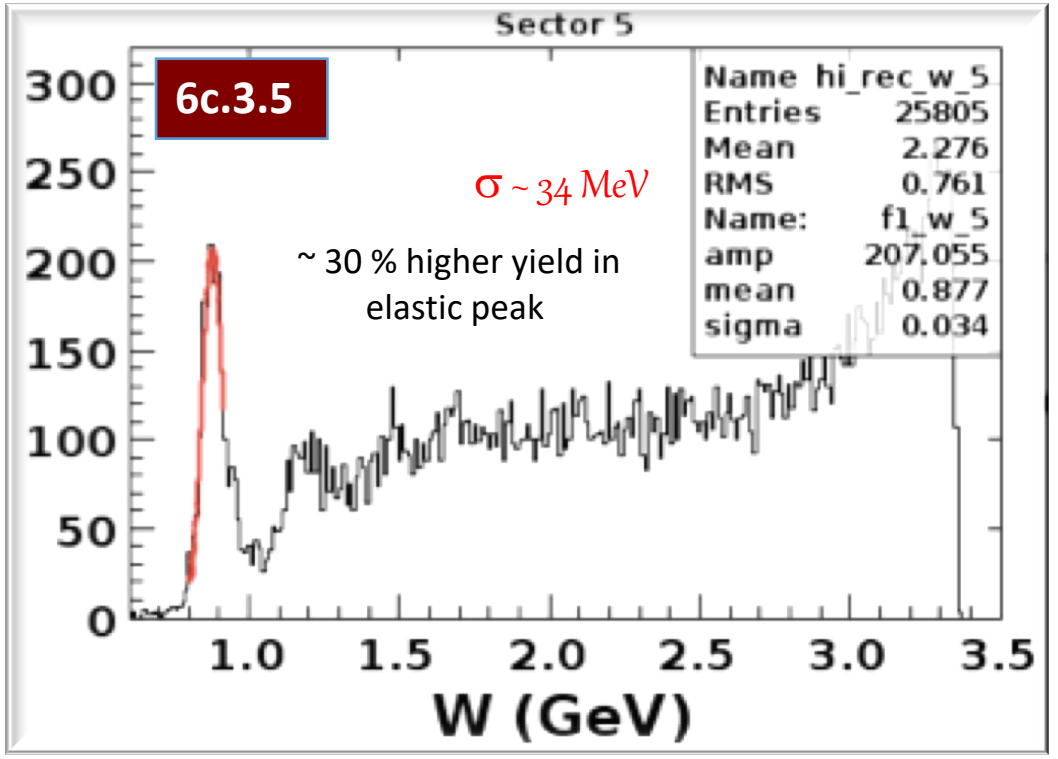


DC TRACKING: New Algorithms

- Elastic peak resolution improvement

Elastic events (6.5 nA data, Run 5990): **sector 5**

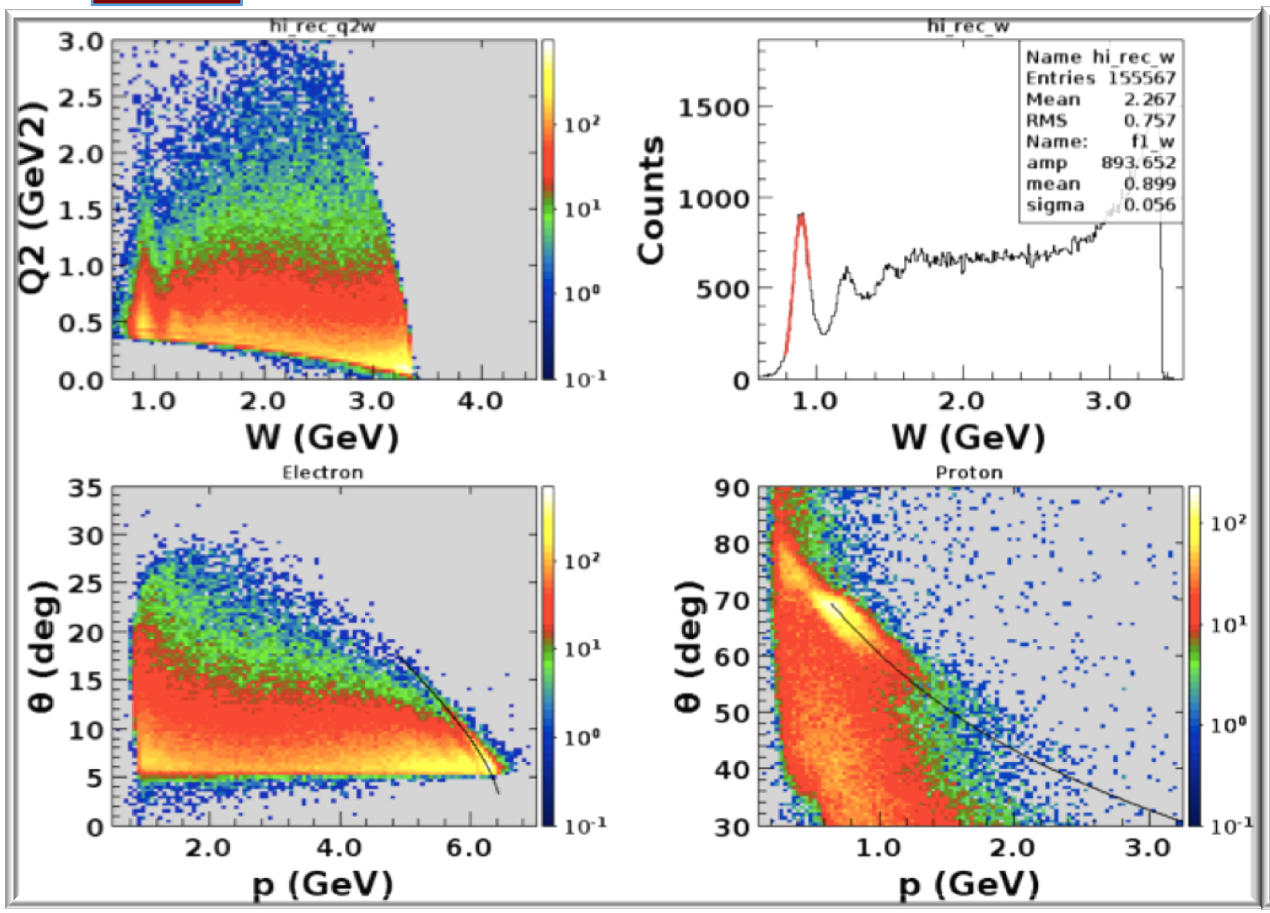




DC TRACKING: New Algorithms

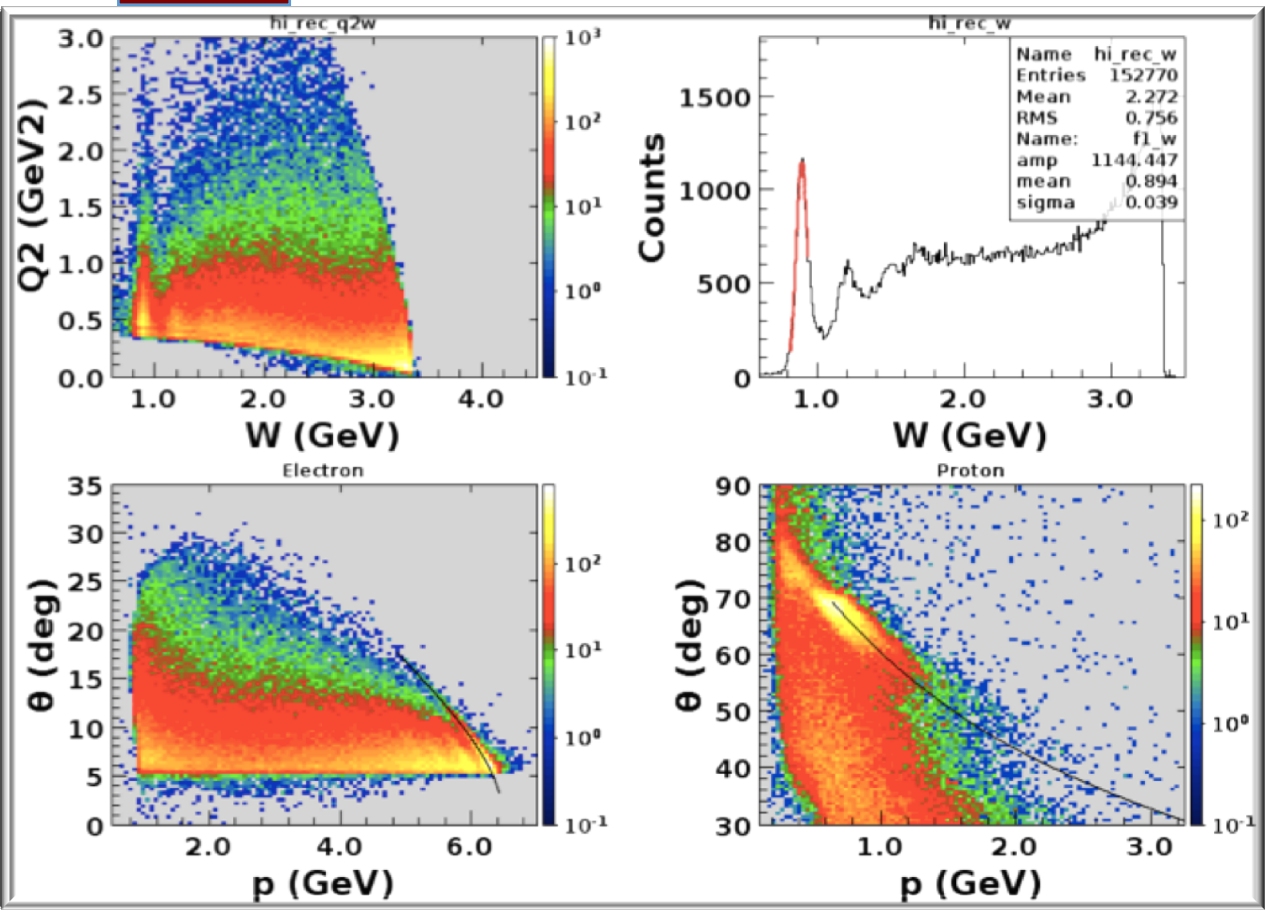
Elastic events (6.5 nA data, Run 5990): **all sectors**

6.3.1



6c.3.5

~ 30 % higher yield in elastic peak



Ongoing Developments

- Validation of DC wire endpoints displacement due to end plates bowing.
  - Implemented in geometry package
  - Currently debugging…

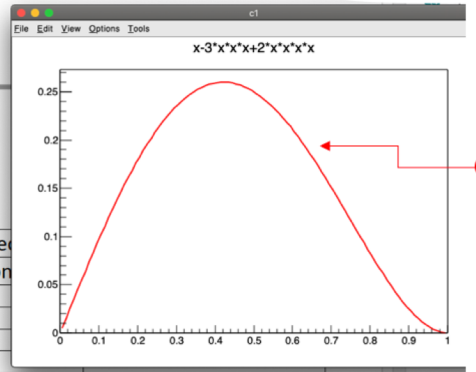
- Testing Time dependent beta correction in Time- to-Distance function
  - Based on CLAS-Note 96-008
  - T_{corr} = TDC – Tflight – Tprop – T0 – TStart
  - $T_{\beta} = [\ c^3 \ .\ T_{corr} / 2.(c^3 + T_{corr}^3)\ ]\ .\ \beta^2$

- Modifies midpoint, endpoints of wire ➔ returns in TSC system to Reconstruction

Functional Form for Endplate Bowing

Equation 3: $Deflection\ (mm) = MaxDef\ (sec, superlayer) * (x - 3 * x^3 + 2 * x^4)$;

where $x = {}^{iwir}/_{112}$.



times Scale Fac.

Magnitude of Endplate Bowing

Survey Data for Endplate Bowing, Region 1

			Region 1 Endplate Defle	
Region	Sector	Side	Maximum Deflection	
1	1	L	2.0**	
1	1	R	2.3**	
1	2	L	2.4**	
1	2	R	2.1**	
1	3	L	2.1*	4.5
1	3	R	2.4*	
1	4	L	2.3*	4.3
1	4	R	2.0*	
1	5	L	2.0*	4.6
1	5	R	2.6*	
1	6	L	2.6**	4.6

Ongoing Developments: New swimmer package

- Testing new adaptive swimmer package (Dave Heddle)
  - 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.

- Modified Swim-tools (V. Ziegler)
  - Simple cut to handle loopers (tracks that will not reach a surface) in stopper.
  - Modified for cylindrical surfaces.

- Ongoing development of Trajectories for Central to be used by the Event Builder.

PCAL Parallax Correction

Cole Smith (UVA)

Z Tracking Planes in PCAL

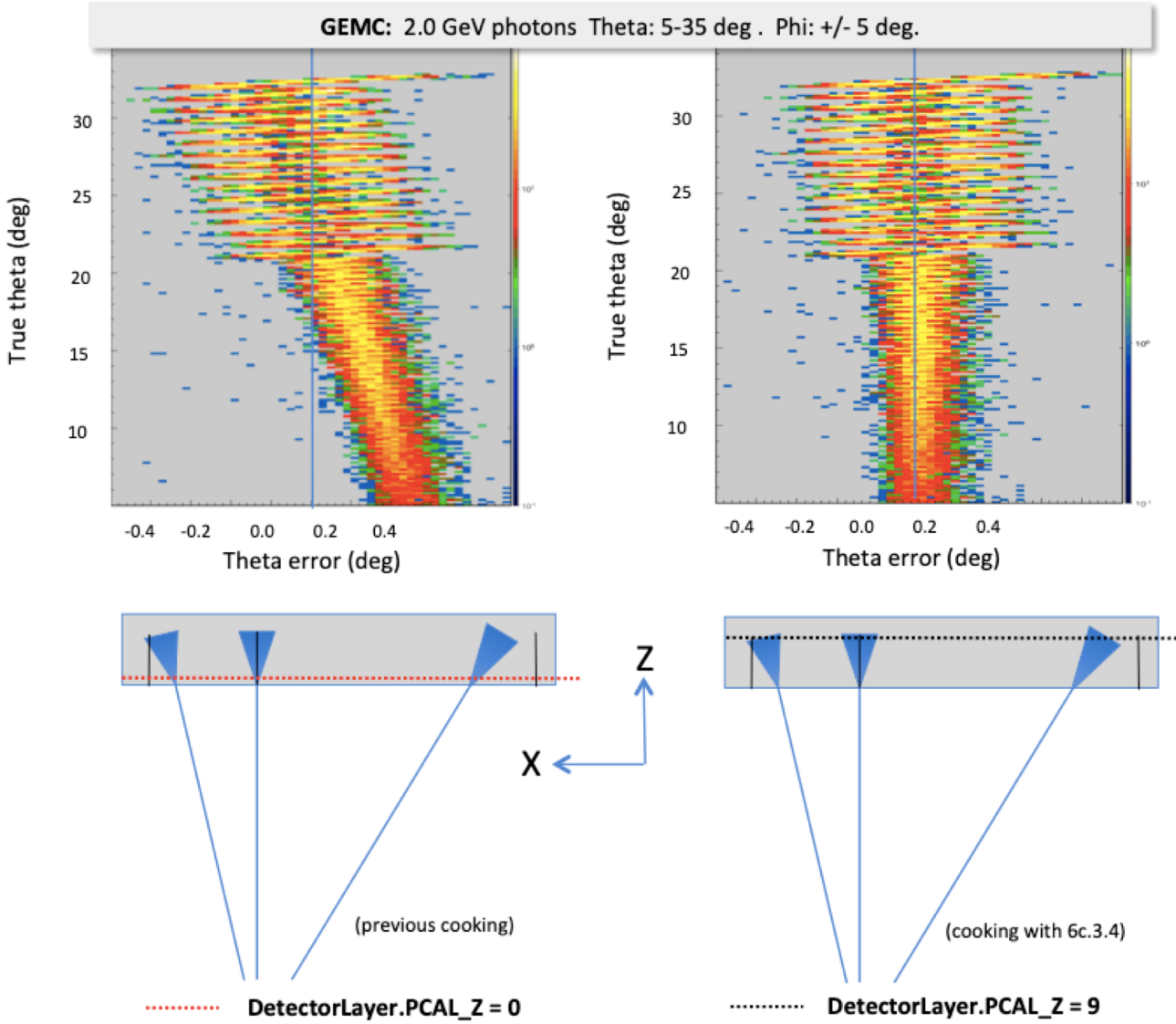
- PCAL and EC reconstruction measures only transverse (x,y) cluster position.
- Cluster z position referenced to user-defined Z tracking plane.
- PCAL Z tracking plane must approximately coincide with depth of shower maximum to avoid parallax errors in theta for off-normal straight tracks (photons,neutrons).
- For EC the scintillator projective geometry compensates for parallax.

Implemented in 6c.3.4

- **ECCommon.java**
- **TrajectorySurfaces.java**
- **DetectorLayer.java**
  - Introduce DetectorLayer.PCAL, EC_INNER, EC_OUTER
  - Set DetectorLayer.PCAL_Z = 9
- **ECFactory.java**
  - Generate scintillator volumes for all ECAL layers

Expected Impact

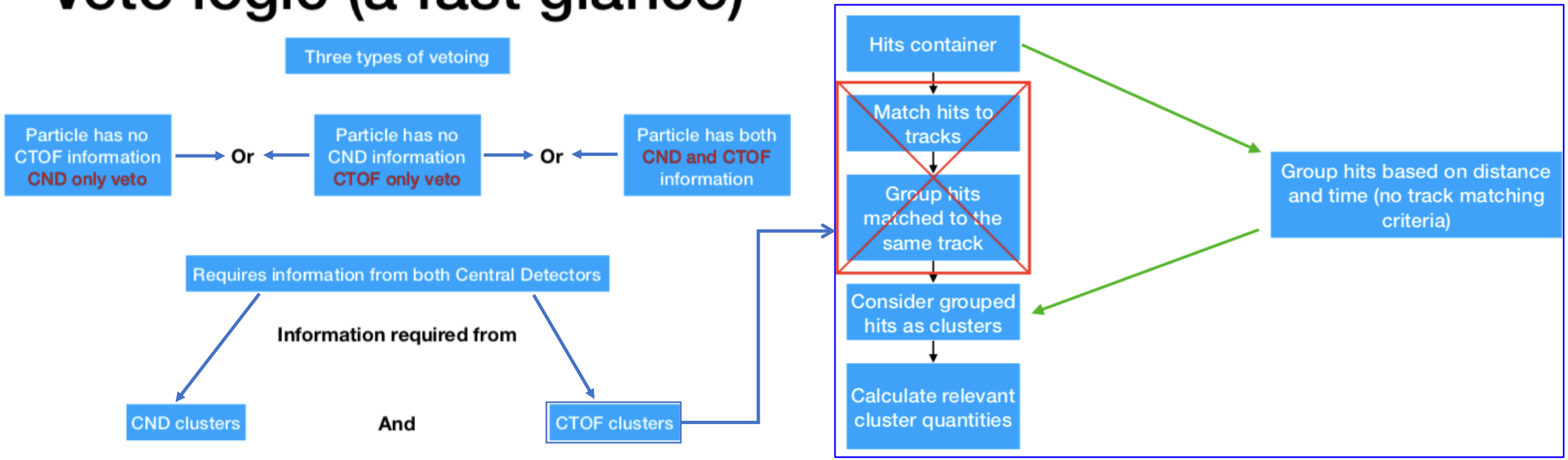
- PCAL-EC cluster matching
- Pathlength for timing calibration
- Neutral meson 4-vector from 2Y decay kinematics
- DC tracking residuals for cluster PID and alignment



PID: CND/CTOF Veto

Adam Hobart
(Orsay)

Veto logic (a fast glance)



- For CTOF (and CND) do it in 4 D taking into account detector resolutions

Not a geometric distance ←

$$d^2 = \frac{\Delta x^2}{\sigma x_1 \sigma x_2} + \frac{\Delta y^2}{\sigma y_1 \sigma y_2} + \frac{\Delta z^2}{\sigma z_1 \sigma z_2} + \frac{\Delta t^2}{\sigma t_1 \sigma t_2}$$

< minimum (to be determined)

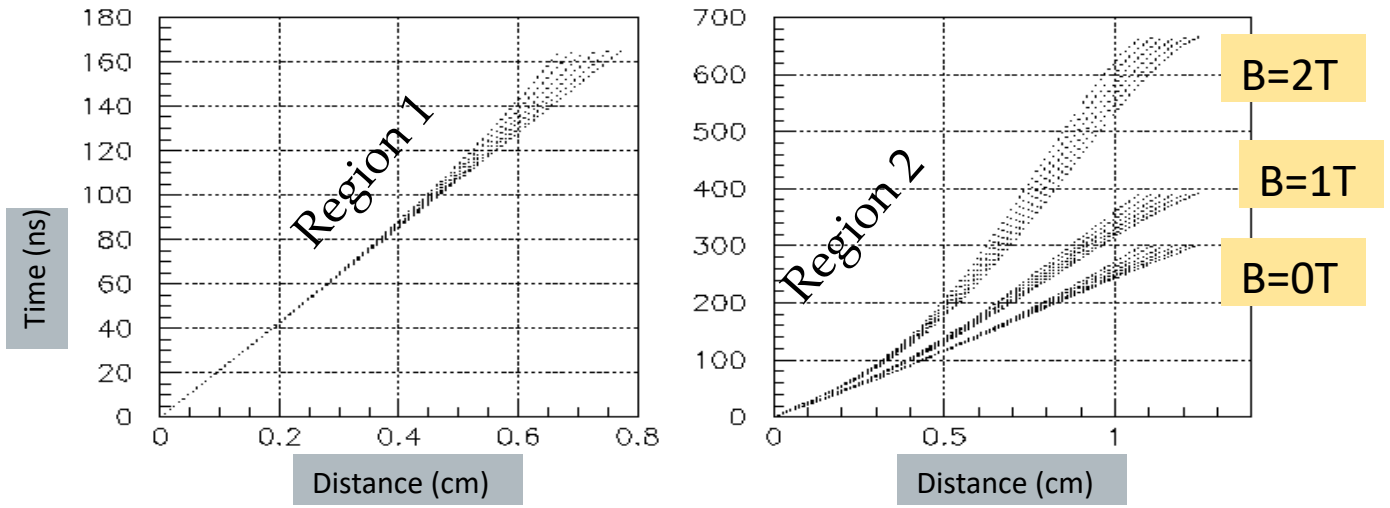
Current Status & Summary

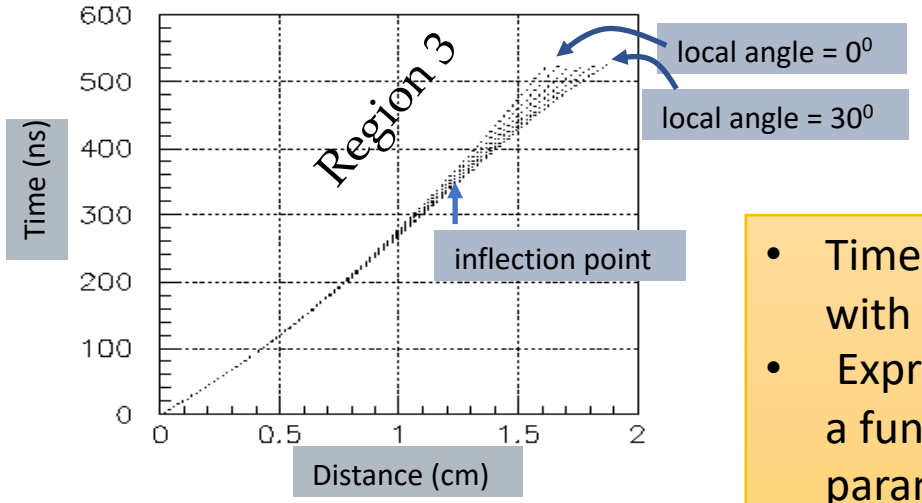
- Validation of new Central Tracking ongoing
- Validation of DC Tracking Efficiency ongoing
- New DC tracking improvements impact on missing masses (physics), matching for PID, alignment
  - Fine tuning in timing calibration
  - DC re-calibration ongoing
- DC Tracking modified to work with Neural-Network-predicted Hits-On-Track. (Done)
- Improvements in matching algorithms
  - EB impact on efficiency
  - ECAL parallax correction & better tracking → improvements in tracking resolution (cluster position) ➔ pathlenth, opening angle for gammas, π^0 invariant mass
- PID: CND/CTOF veto

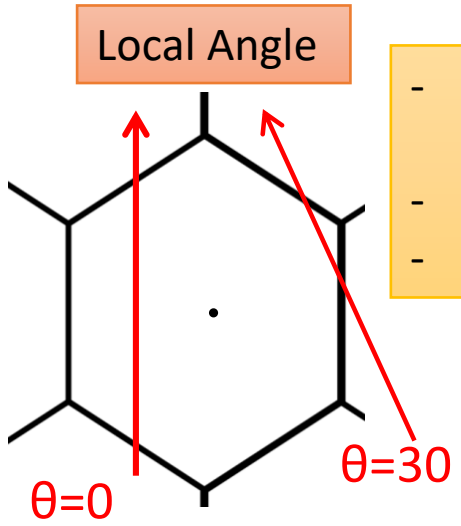
- Next: validation of c-tag using luminosity scan, physics reaction

BACK-UP SLIDES

DC TRACKING: Time To Distance Calculation







- Calculated from segment fits (superlayer) - fix
- Corrected for B-field
- Reduced to 0—30 deg.

- Time to distance → parametrize with function $t = \Sigma_i a^i d^i$; i=0…4.
- Express polynomial coefficients as a function of calibration parameters.

- **Validated interpolation as a function of <u>local angle</u>, B, time to calculate the DOCAS from Times**