

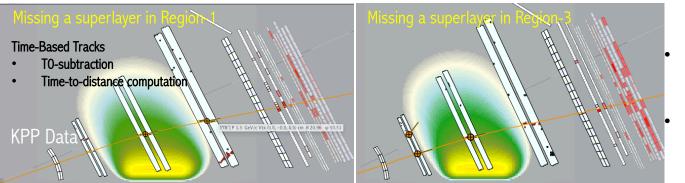
Tracking Status

Veronique Ziegler CLAS12 First Experiment Workshop 06/13/2017



Status at the last meeting DC Tracking Status

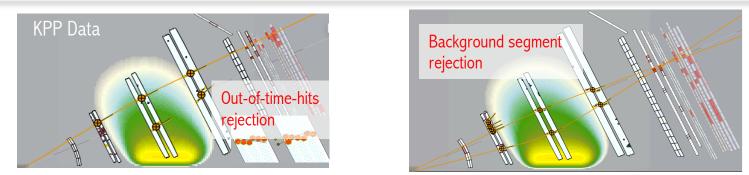
5-Out-Of-6 superlayers tracking



MC Studies

- Loosing a superlayer has a minimal effect on tracking resolutions
- Inefficiencies due to missing SL: 5% for SL1, 10% for SL2, less than 3% for all other SLs

Noise rejection algorithms validation on KPP data

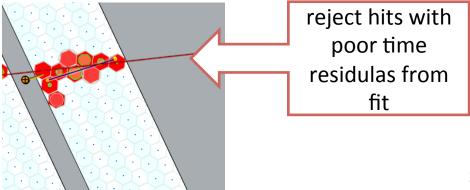


* FMT in simulation (Maxime) \rightarrow after geometry validation use FMT points to refit the track



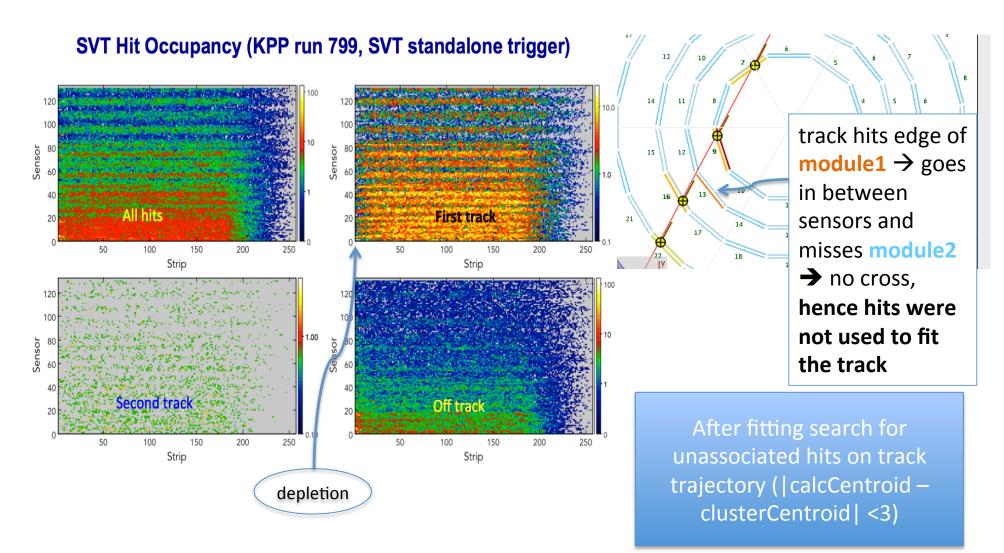
DC Tracking Updates

- Improved Kalman Filter code (significant memory footprint improvements & track parameters propagation calculation speed improvements [c.f. Gagik's talk]
- Ongoing validation using KPP data
 - Understanding tracking inefficiencies and tuning the algorithms





SVT Tracking on cosmics



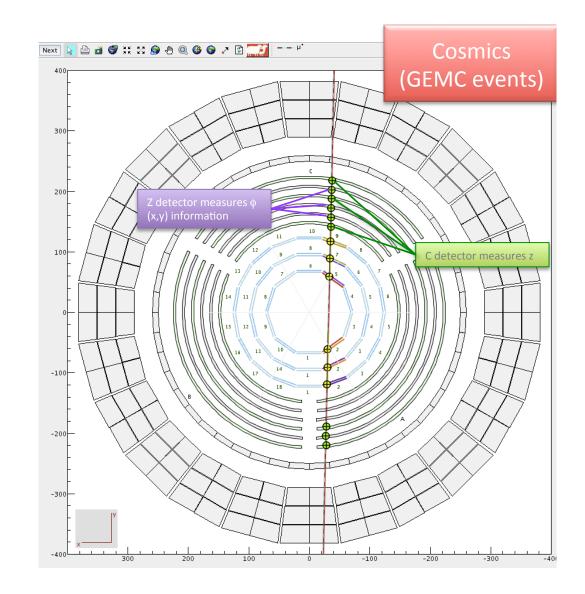


CVT Reconstruction

- New package includes Barrel Micromegas Tracker (BMT).
- BMT digitization in GEMC (Maxime).
 - Geometry constants accessed from ccdb (in simulation & reco.)
- Validation of agreement of digitization & dedigitization, geometry, Lorentz angle correction between simulation and reconstruction.



- 1. Pattern recognition in BMT
 - Reconstruct clusters of strip (todo: energy-weighted centroid)
 - 2. Obtain pseudo crosses
 - Z detectors P=(x,y), C detector P=(r,z)
- 2. Store information in fit arrays:
 - 1. extract helix parameters (2step fit: 1. x,y projection fit to extract \mathbf{d}_0 , ϕ_0 , ρ ; 2. r,z projection fit to extract \mathbf{z}_0 , tan λ)
 - HT to select straight track candidate (use XY projection, check coincidence in r.z projection)





Validation & geometry checks using simulated cosmics (Y. Gotra)

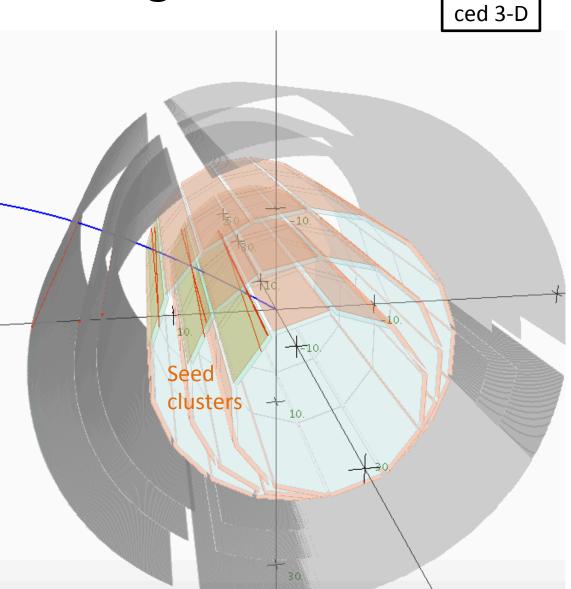
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CVT (SVT+BMT) Reconstruction



- 1. Use SVT as a track seeder
 - Reconstruct clusters of strip and compute energyweighted centroid
 - 2. Obtain position of these centroid wrt lab frame
 - Fit cluster endpoints (upstream side) XY projection to a circle after HT-type selection to select clusters belonging to a track candidate.
 - 4. Find crosses and refit to match to BMT crosses
 - 5. Refit using all SVT and BMT crosses
 - Todo: recheck SVT clusters to verify matching
- This is the track *seed*, it contains SVT clusters + BMT pseudocrosses

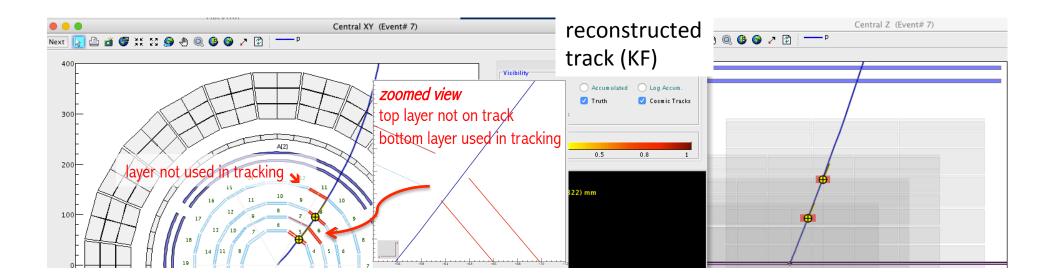
Algorithms





CVT Seeding

- Track seeding... require 2 SVT crosses (4 out of 6 layers using MM)
 - use all SVT clusters + (if available C & Z BMT detector infomations) as measurements for subsequent Kalman Fit
 - Initialize Kalman fit parameters with the result of a global fit to the combined system crosses

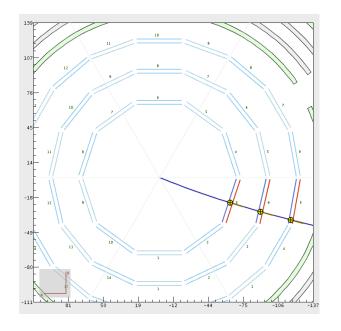


Tracking in CLAS12 CVT

 $a_k =$

1) The State Vector

Track parameters and Covariance matrix estimated from Global Fitting method prior to starting Kalman Filter



 $B \sim B_z \sim 5 T$

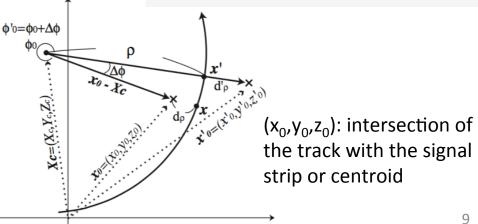
Event display of reconstructed tracks in CLAS12 SVT



- <u>site</u>: SVT module layer where a strip or cluster of strip fired (k = 1...8)
- <u>state</u>: 5-parameter helical track representation

 d_{ρ} : distance between the helix and the site ref. point (x_0, y_0, z_0) in x-y plane ϕ_0 : azimuthal angle of the ref. wrt helix center

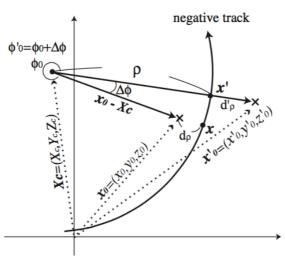
 λ / k dz: distance between helix and reference point in the z direction tan λ :dip angle, i.e., the angle of the helix to the x-y plane.



Tracking in CLAS12 CVT



2) The Propagator



(x₀,y₀,z₀): intersection of the track with the signal strip or centroid

- Propagate from initial state estimated at DOCA to beam line to outermost SVT layer
- <u>state propagator</u>: follows equations of motion for helical track $\mathbf{a}' \equiv \mathbf{a}_k^{k-1} = (d'_{\rho}, \phi'_0, \kappa', d'_z, \tan \lambda')^T = \mathbf{f}_{k-1}(\mathbf{a}_{k-1})$

$$egin{array}{rcl} d'_
ho&=&(X_c-x'_0)\cos\phi'_0+(Y_c-y'_0)\sin\phi'_0-rac{lpha}{\kappa}\ \phi'_0&=&\left\{egin{array}{ll} an^{-1}\left(rac{Y_c-y'_0}{X_c-x'_0}
ight)&(\kappa>0)\ an^{-1}\left(rac{y'_0-Y_c}{x'_0-X_c}
ight)&(\kappa<0)\ \kappa'&=&\kappa\ d'_z&=&z_0-z'_0+d_z-\left(rac{lpha}{\kappa}
ight)(\phi'_0-\phi_0) an\lambda\ an\lambda'&=& an\lambda, \end{array}
ight.$$

$$\begin{cases} X_c \equiv x_0 + (d\rho + \frac{\alpha}{\kappa})\cos\phi_0 \\ Y_c \equiv y_0 + (d\rho + \frac{\alpha}{\kappa})\sin\phi_0 \,. \end{cases}$$

• state covariance matrix propagator: Jacobian of state

$$F_{k-1} \equiv \left(\frac{\partial a'}{\partial a}\right) = \begin{pmatrix} \frac{\partial d'_{\rho}}{\partial a} \\ \frac{\partial \phi'_{0}}{\partial a} \\ \frac{\partial k'}{\partial a} \\ \frac{\partial k'}{\partial a} \\ \frac{\partial d'_{a}}{\partial a} \\ \frac{\partial d'_{a}}{\partial a} \\ \frac{\partial \tan \lambda'}{\partial a} \end{pmatrix}$$

$$F_{k-1} \equiv \left(\frac{\partial a'}{\partial a}\right) = \begin{pmatrix} \frac{\partial d'_{\rho}}{\partial a} \\ \frac{\partial \phi'_{0}}{\partial a} \\ \frac{\partial a'}{\partial a} \\ \frac{\partial \tan \lambda'}{\partial a} \end{pmatrix}$$

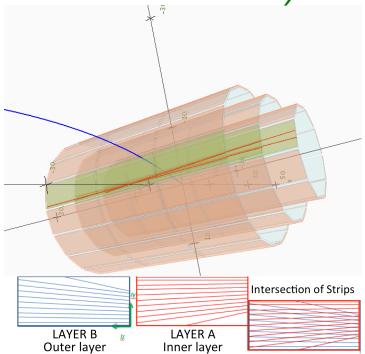
$$F_{k-1} \equiv \left(\frac{\partial a'}{\partial a}\right) = \begin{pmatrix} \frac{\partial d'_{\rho}}{\partial a} \\ \frac{\partial \phi'_{0}}{\partial a} \\ \frac{\partial a'}{\partial a} \\ \frac{\partial \tan \lambda'}{\partial a} \end{pmatrix}$$

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Tracking in CLAS12 SVT



3) The Measurement

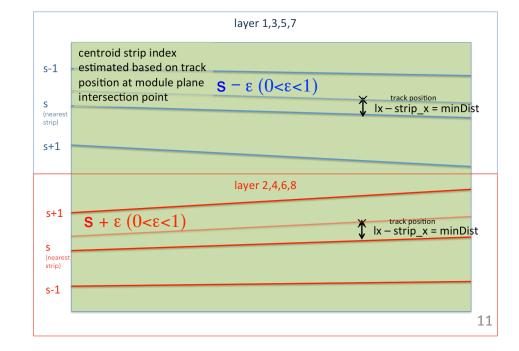


SVT Geometry:

256 strips at 156 μm pitch oriented at graded angle from 0 to 3 deg.

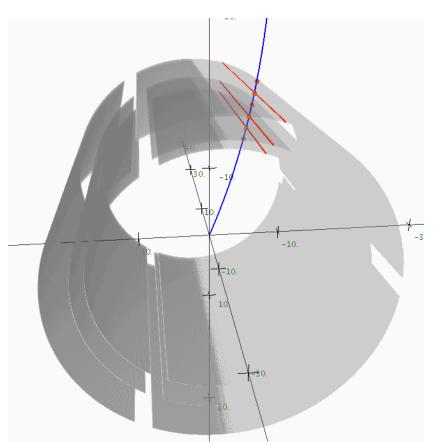
- Measurement: strip or cluster of strips centroid; error: strip/cluster resolution
- Projector $(h_k(a))$ = estimated centroid value based on track parameters at measurement site:

$$\begin{cases} x = x_0 + d_{\rho} \cos \phi_0 + \frac{\alpha}{\kappa} (\cos \phi_0 - \cos(\phi_0 + \phi)) \\ y = y_0 + d_{\rho} \sin \phi_0 + \frac{\alpha}{\kappa} (\sin \phi_0 - \sin(\phi_0 + \phi)) \\ z = z_0 + d_z - \frac{\alpha}{\kappa} \tan \lambda \cdot \phi, \end{cases}$$



Tracking in CLAS12 BMT 3) The Measurement





- Measurement: φ (Z-det), z (C-det)
 - error: phi, z resolution
- Projector (*h_k(a)*) = estimated value based on track parameters at measurement site (i.e atan2(y,x); z):

$$\left(egin{array}{rcl} x &=& x_0 &+& d_
ho\cos\phi_0 &+& rac{lpha}{\kappa}\left(\cos\phi_0-\cos(\phi_0+\phi)
ight) \ y &=& y_0 &+& d_
ho\sin\phi_0 &+& rac{lpha}{\kappa}\left(\sin\phi_0-\sin(\phi_0+\phi)
ight) \ z &=& z_0 &+& d_z &-& rac{lpha}{\kappa} an\lambda\cdot\phi, \end{array}
ight.$$



Tracking in CLAS12 SVT 4) The Projector Matrix

Projector matrix calculation:

$$H = \frac{\partial c_k}{\partial X_k} \frac{\partial X_k}{\partial a_k}$$

 a_k : the state vector at site k

 $X_k = (x, y, z)$: the projected track (i.e. a_k)

intersection point with site k plane

$$\left\{ egin{array}{rcl} x & = & x_0 & + & d_
ho\cos\phi_0 & + & rac{lpha}{\kappa}\left(\cos\phi_0 - \cos(\phi_0 + \phi)
ight) \ y & = & y_0 & + & d_
ho\sin\phi_0 & + & rac{lpha}{\kappa}\left(\sin\phi_0 - \sin(\phi_0 + \phi)
ight) \ z & = & z_0 & + & d_z & - & rac{lpha}{\kappa} an\lambda\cdot\phi, \end{array}
ight.$$

 c_k : the centroid estimated from $X_k = (x, y, z)$





Tracking in CLAS12 BMT 4) The Projector Matrix

Projector matrix calculation:

$$H = \frac{\partial c_k}{\partial X_k} \frac{\partial X_k}{\partial a_k}$$

 a_k : the state vector at site k

 $X_k = (x, y, z)$: the projected track (i.e. a_k)

intersection point with site k plane

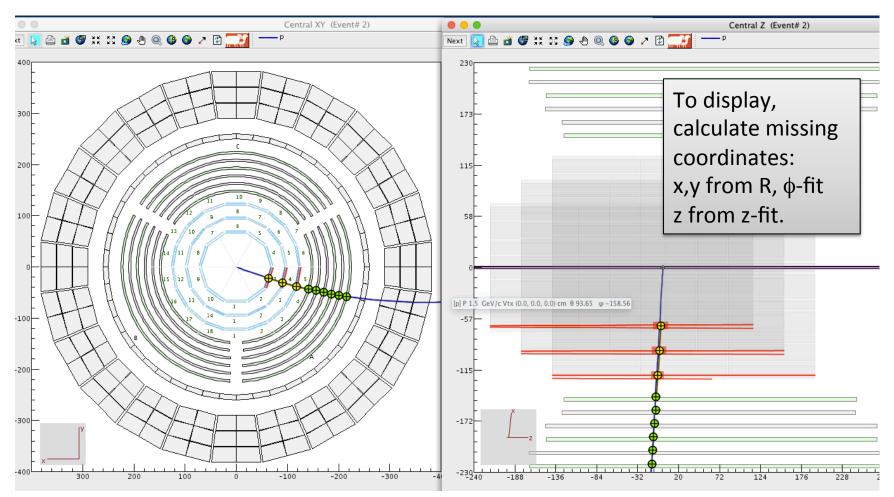
ſ	\boldsymbol{x}	=	x_0	+	$d_ ho \cos \phi_0$	+	$\frac{\alpha}{\kappa} \left(\cos \phi_0 - \cos(\phi_0 + \phi) \right)$
ł	y	=	y_0	+	$d_ ho \sin \phi_0$	+	$\frac{\alpha}{\kappa} \left(\sin \phi_0 - \sin(\phi_0 + \phi) \right)$
l	\boldsymbol{z}	=	z_0	+	d_z	-	$\frac{lpha}{\kappa} an \lambda \cdot \phi,$

 ϕ_k : estimated from $X_k = (x, y, z)$ z_k : estimated from $X_k = (x, y, z)$



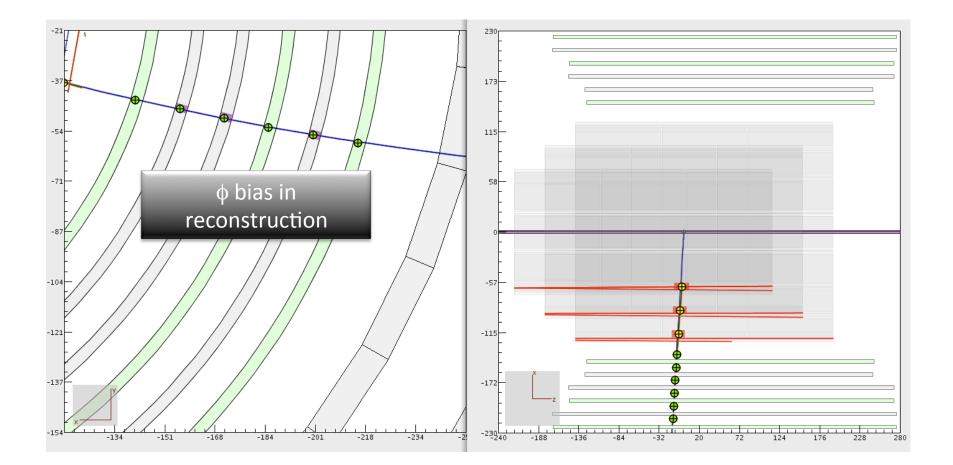


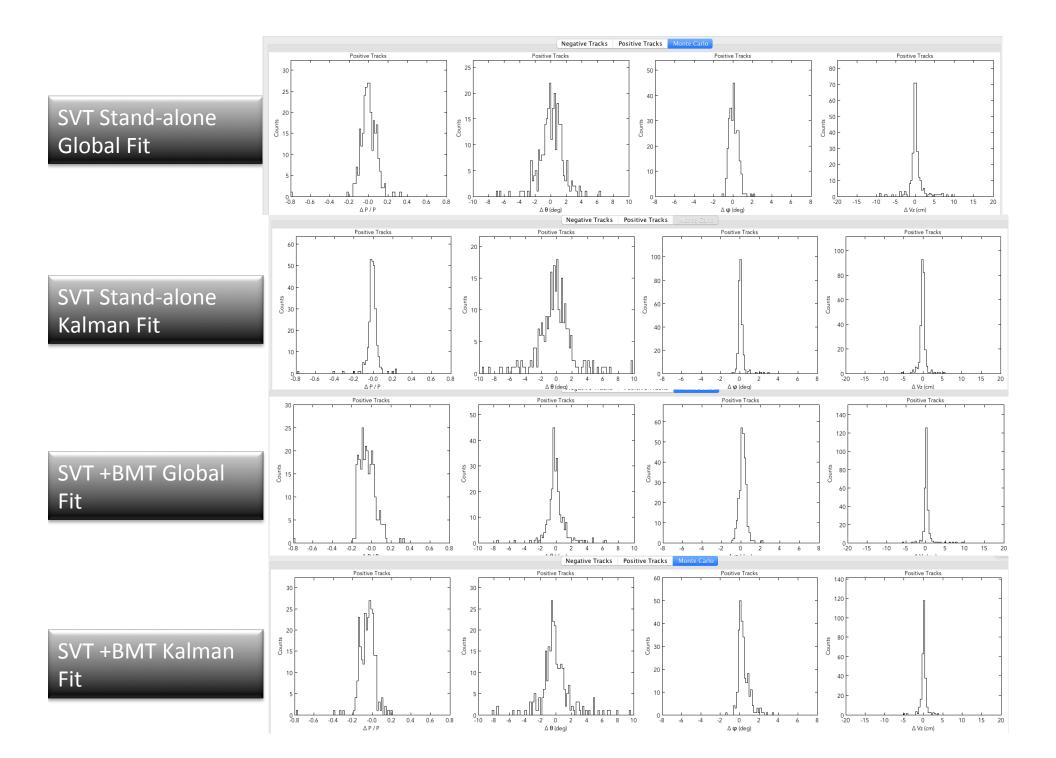
Validation using single track events simulated within acceptance for Central Tracks





Debugging.... 🛞







Next Steps... until the Fall

- Verify MM geometry implementation
- Add ADCs to simulation output (proper centroid calculation in reco.)
- Validate BMT pattern recognition
- Verify proper treatment of errors in KF & determine the cause of lack of convergence of fit
- Write KF fit algorithm to use FMT in forward tracking.

BACKUPS

Resolutions

