Drift Chamber Tracking for CLAS12

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October 5, 2017 1 / 30

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Outline

- DC for CLAS12
- OC Specifications and Geometry
- OC Tracking
- OC Calibration
- Time to Distance Relation
- **6** Summary

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Drift Chamber for CLAS12

 The CLAS12 DC will measure trajectories (path length) and hence the momentum of the charged particle emerging from the target.





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Specifications and Geometry

- Includes 18 wire chambers, each with 2 superlayers of 6 layers and 112 wires \rightarrow a total of 24,192 sense wires.
- Each cell will give a spacial resolution of \sim 250 350 $\mu m.$
- Small cells and fast drift velocity to meet the luminosity requirement of 10³⁵ cm⁻²s⁻¹.

DC – Tracking Specifications			
PARAMETER	SPECIFICATION		
Angular coverage	5° – 40° (50% φ-coverage at 5°)		
Momentum resolution	dp/p < 1%		
θ Resolution	1 mrad		
φ Resolution	1 mrad/sinθ		
Luminosity	10 ³⁵ cm ⁻² s ⁻¹		

DC – Design Summary		
Cell type	Hexagonal cell	
Wire layout	6 sectors, 3 regions, 2 sl's / region	
Stereo	+/- 6 ⁰ stereo	
Position	Regions at ~2, 3, 4m. From target	
Granularity	112 wires/ layer (24192 total)	
Gas Choice	90/10 Argon / CO ₂	

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Specifications and Geometry





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CED Cross-sectional view



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CED Cross-sectional view



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Signal From Drift Chamber



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DC Tracking

- With the time information and wire index, two separate tracking are implemented:
- Hit-Based tracking: Uses hit position information
- Time-Based tracking: Uses timing information

Several hits \rightarrow Each cluster, Cluster \rightarrow Segment, Two segments (from both SL) \rightarrow Cross, Three Crosses \rightarrow Track

- 10

DC Tracking: Hits



(Hit Based)



(Time Based)

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October 5, 2017 10 / 30

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DC Tracking: Segments and Crosses

- Hits within each cluster is fitted to form segment.
- Segments from adjacent superlayers are used to construct cross.
- This is done both for hit-based and time-based tracking.



DC Tracking: Out-of-time-hits Rejection

$$\sum_{i:hit in segment} Doca \sim \sum_i cell - size$$

(Slide courtesy of V. Ziegler)

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DC Tracking: Kalman Filter

• Start process by propagating the state vector from the first measurement plane using the pattern recognition estimates (swim back from point at first cross to first plane).

(Slide courtesy of V. Ziegler)

DC Tracking: Tracks

DC Calibration

Motivation:

- We want to improve the resolution of DC Tracking by utilizing the timing information.
- This requires extraction of distance (Distance Of Closest Approach Doca) from the timing information.
- However the challenge is the exact relation between time and distance is not known.
- The time-to-distance relation might evolve over different run periods.

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DC Calibration

Solution:

- Constrain the time to distance relation by invoking
 - Symmetry
 - Physics constraints
 - Other studies like Garfield simulations
- Express time-to-distance relation in terms of adjustable calibration constants.
- Calibrate the adjustable constants through iterative procedure.
- Achieve convergence on time-residual, where

Time residual = Distance from T2D function (calcDoca) - Distance from the fitted track (trkDoca)

3

Time to Distance Relation: Functional Form

The total drift time t has three contributions,

- i) The main drift time
- ii) Beta-dependent timewalk correction
- iii) The B field dependent contribution

Thus

$$t(\mathbf{x}) = t_d + \Delta t_\beta + \Delta t_B \tag{1}$$

i)The main drift time contribution:

$$t_d(x) = \frac{x}{v_0} + a\hat{x}^n_\alpha + b_\alpha \hat{x}^m_\alpha$$
(2)

where

$$\hat{x}_{lpha} = rac{x}{x^{lpha}_{max}} = rac{x}{x_{max}\cos(30-lpha)}$$

ii) Beta-dependent time-walk correction:

$$\Delta t_eta = rac{\sqrt{x^2+(x_etaeta^2)^2}-x}{v_0}$$

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(3)

(4)

Time to Distance Relation: Functional Form

iii) The B field dependent contribution:

The B-field dependent contribution (applicable only for region 2 i.e. super layers 3, 4)

$$\Delta t_B = \delta_B B^2 t_{max} (b_1 \hat{x}_{\alpha} + b_2 \hat{x}_{\alpha}^2 + b_3 \hat{x}_{\alpha}^3 + b_4 \hat{x}_{\alpha}^4)$$
(5)

The physics constraints:

$$t(x = x_0) = t_0,$$

$$\frac{dt}{dx}(x = x_0) = \frac{1}{v_0},$$

$$\frac{d^2t}{dx^2}(x = 0.615x_0) = 0.$$

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Calibration Constants

After removing correlation using physics constraints:

$$p_0 = v_0$$

$$p_1 = \delta_{mn}$$

$$p_2 = t_{max}$$

$$p_3 = x_\beta$$

$$p_4 = \delta_B$$

$$p_5 = b_1$$

$$p_6 = b_2$$

$$p_7 = b_3$$

$$p_8 = b_4$$

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Function form of T2D function: Region 1

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Function form of T2D function: Region 2

October 5, 2017 21 / 30

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Function form of T2D function: Region 3

October 5, 2017 22 / 30

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DC Calibration Flow Chart

DC Calibration Suite

- GUI driven complete calibration suite for DC
- Tested with KPP data for convergence, stability and improved resolution

•••			DC Cel	bration Console	_		
	Estimate TDs	Ban Reconstruction	OC Calibratio	n Suite for CLAS	2 Rus T2D Fitter	Load T2D Parameters to CCDB	
			Instructions: Instructions: 2.8d5 Bettorn is not act 2.8d5 Bettorn is not act 4.6creent Battern was set	Welcome to DC Calif- welcome to DC Calif- vention & here characterized of the con- entity of the content of the content of the content of the content of the content of the	varion Savie for CLAST2		
		(DC cali	bration m	ain GUI)			

Sector 2	Superlayer 1	CCDB variation	for Initial Valu	ies default 💌	
arameter	Lower Limit	Initial Value	Upper Limit	Step Size	Fix it?
0	0.0010	0.0050	0.0100	0.00001	🗌 Fix me
hm	0.3000	1.5000	3.0000	0.00100	🗌 Fix me
пах	32.1916	160.9581	321.9162	0.01000	🗌 Fix me
8	0.0026	0.0128	0.0256	0.00010	🗌 Fix me
1	0.0320	0.1600	0.3200	0.00100	🗌 Fix me
9	0.0800	0.4000	0.8000	0.00100	🗆 Fix me
2	-4.0000	-2.0000	-0.4000	0.00100	🗌 Fix me
9	2.0000	10.0000	20.0000	0.00100	Fix me Fix me
4	-13.0000	-6.5000			
ат ₀	-30.0000	0.0000	30.0000	0.00100	🗌 Fix me
Uncer	tainty xNorm	0.8000 Min xNormMax	elect Angle Bins	Go Fit It	🗌 Fix All
t Results < SL	ν ₀ δ _{nm}	t _{max} x _β δ _B	b ₁ b ₂	b ₃ b ₄	ΔT ₀

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DC Calibration Suite

T0 Correction

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Time to Distance Fit

(A typical fit for time to distance function from SL = 5)

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October 5, 2017 27 / 30

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KPP Data Calibration for Sector = 2 Superlayer = 1

KPP Data Calibration for Sector = 2 Superlayer = 6

Summary

- Drift chamber is one of the core tracking detectors for CLAS12
- DC tracking utilizes both hit-based and time-based tracking to achieve best possible resolution
- DC calibration is an essential part in achieving the desired resolution
- The calibration suite and algorithm are well advanced
- Further fine tuning is in progress

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