FDC Status

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JLAB

- Material issues
- Lorentz effect

Material Issues

- DC review (March '07):

"[p]riority should be given to studying design modifications that would significantly reduce the amount of material in the GlueX tracking chambers"

- Our response
  - Reduce thickness of Kapton from 50 microns to 25 microns
  - Reduce thickness of Copper from 5 microns to 2 microns
  - Reduce or eliminate Rohacell backing for cathode planes
  - Replace solid G10 frames with G10/foam laminates

Active Area, no foam

Material	Number of layers	Thickness per layer (g/cm^2)	Radiation Length (g/cm^2)	X/X_0
Kapton	48	0.003550	40.56	0.004201
Copper	48	0.001792	12.86	0.006689
Mylar	48	0.000876	39.95	0.001052
Argon	24	0.000660	19.55	0.000810
CO_2	24	0.001110	36.20	0.000736
Air	48	0.000603	36.60	0.000790
Total (2 μm Cu)			All 4 packages	0.0143

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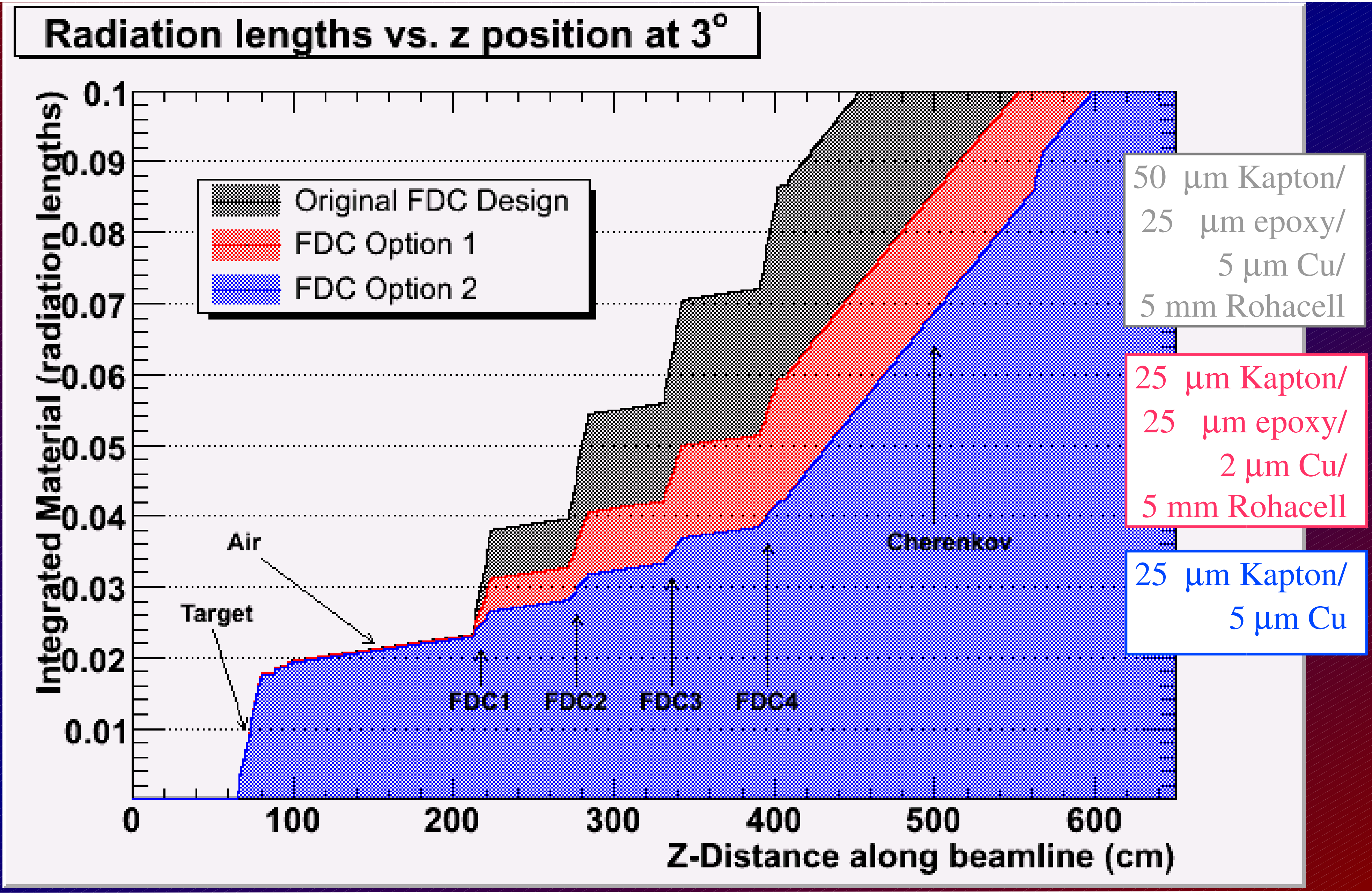
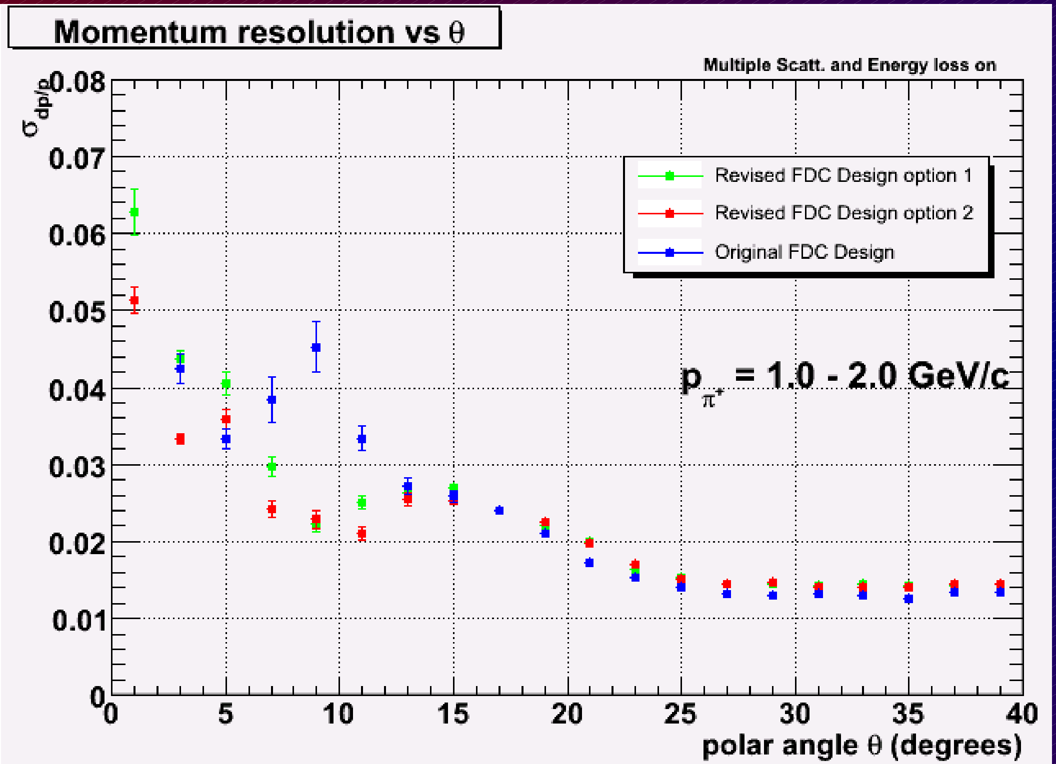
was 5.6%!

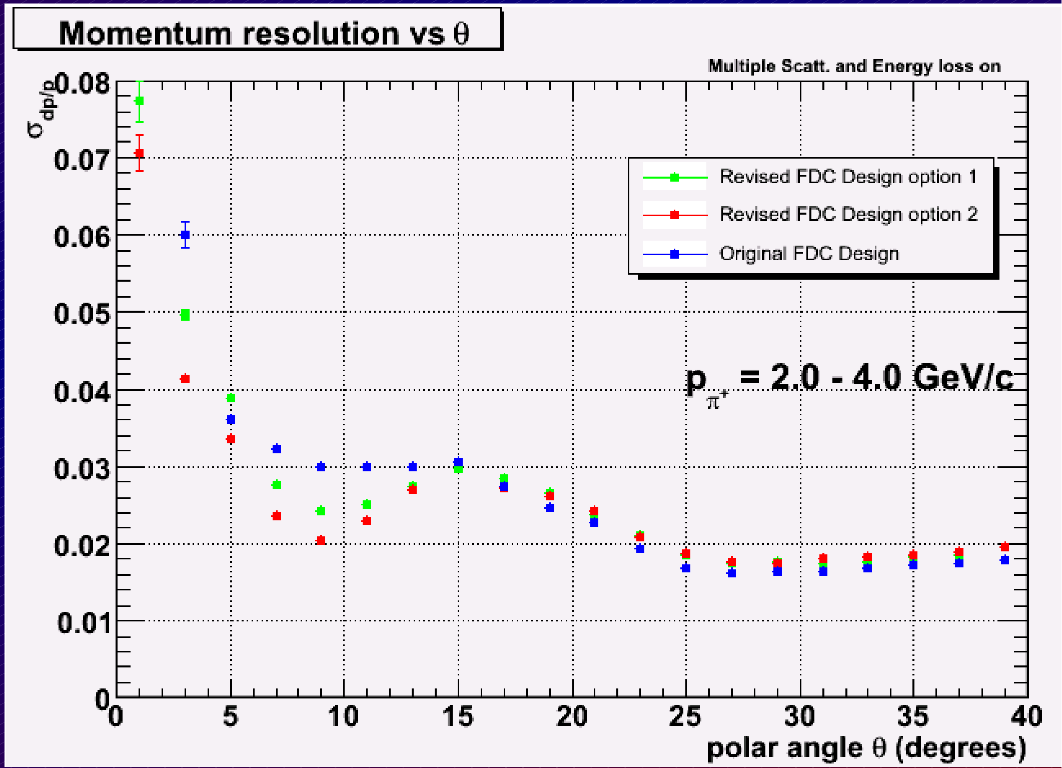
Radiation Length Scan



Effect of Reduced Material on δp/p

- Reduction of Copper/Kapton thickness → significant improvement 5º-13º
- Reduction of foam backing → further improvement possible...



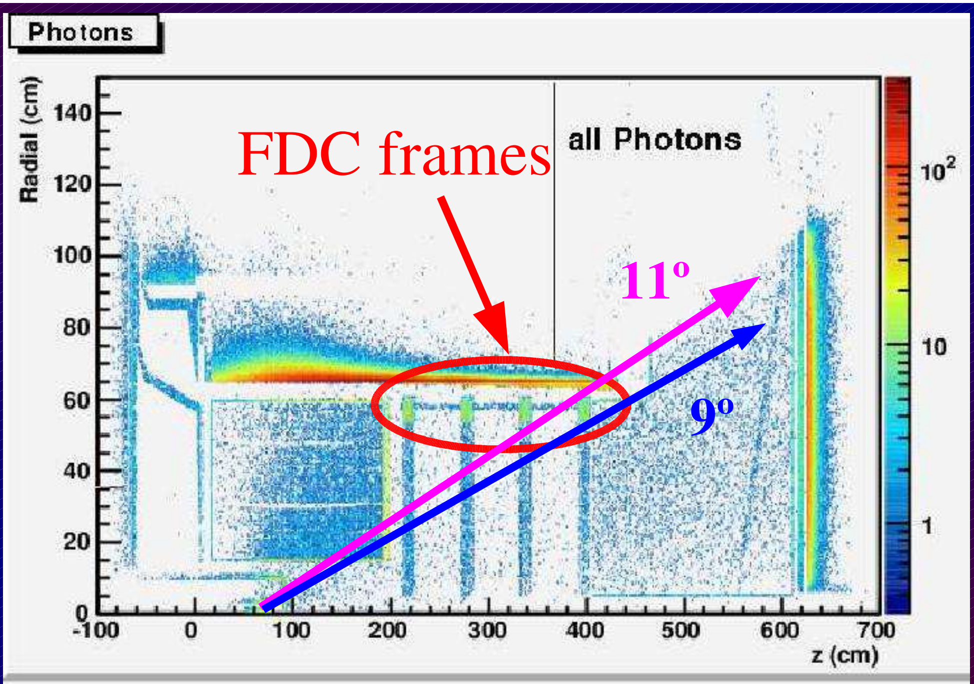


Original Design
5mm foam backing
No foam backing

Intermediate foam thickness: 2 mm → 2.2% X/X_0

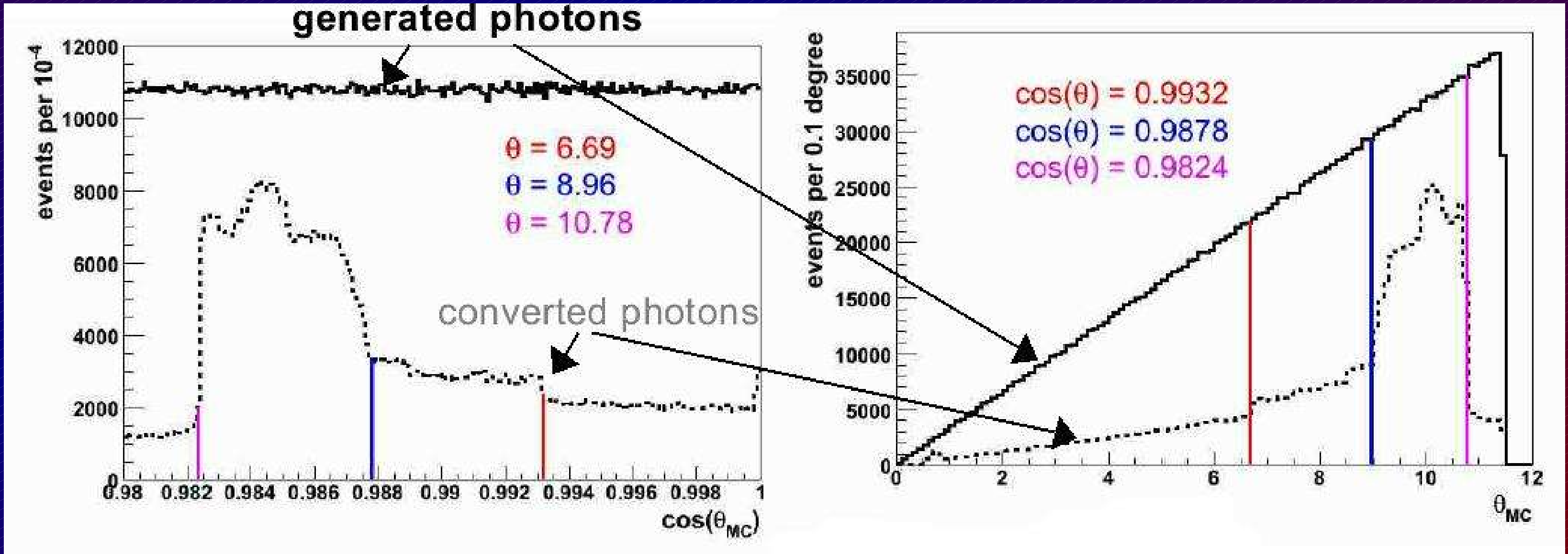
Inactive Area

- Issue: photon conversions in the frame material lead to reconstruction problems



Original design:

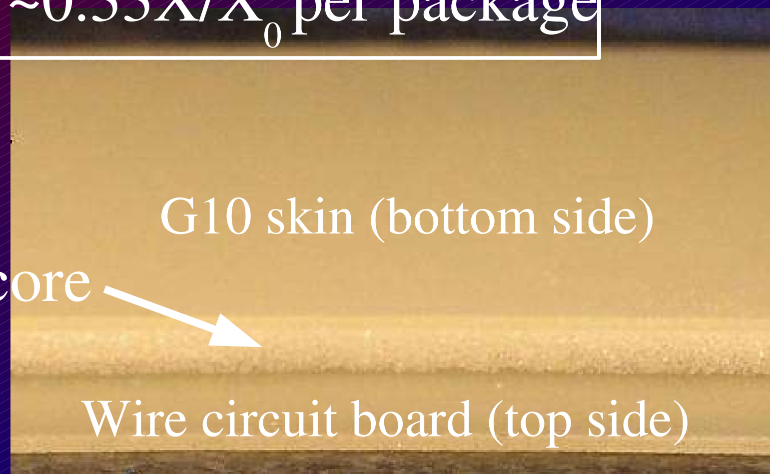
More than 60% of generated photons convert in frames of last package...

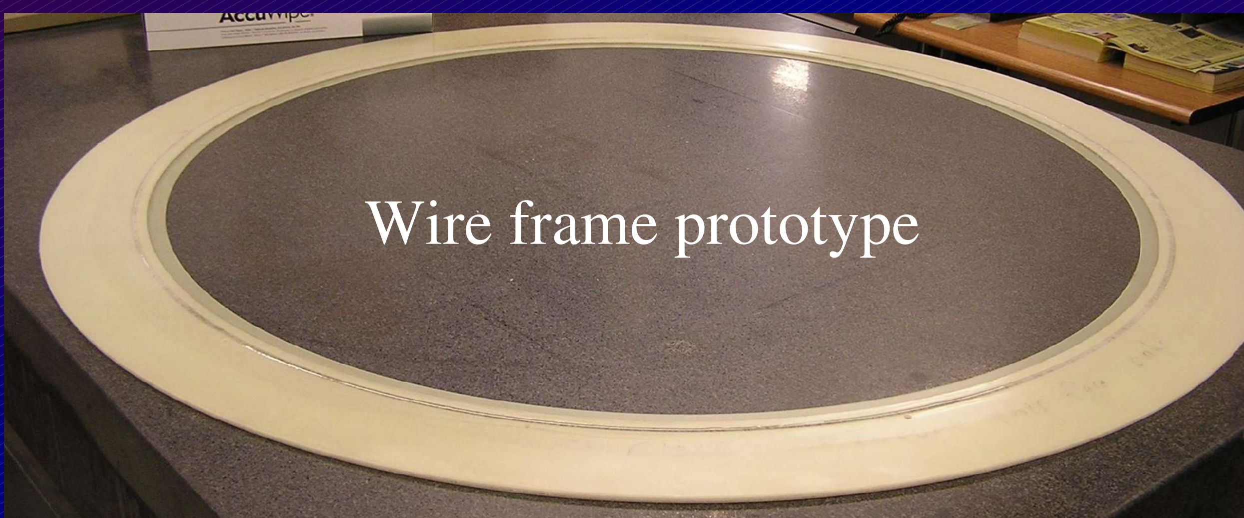


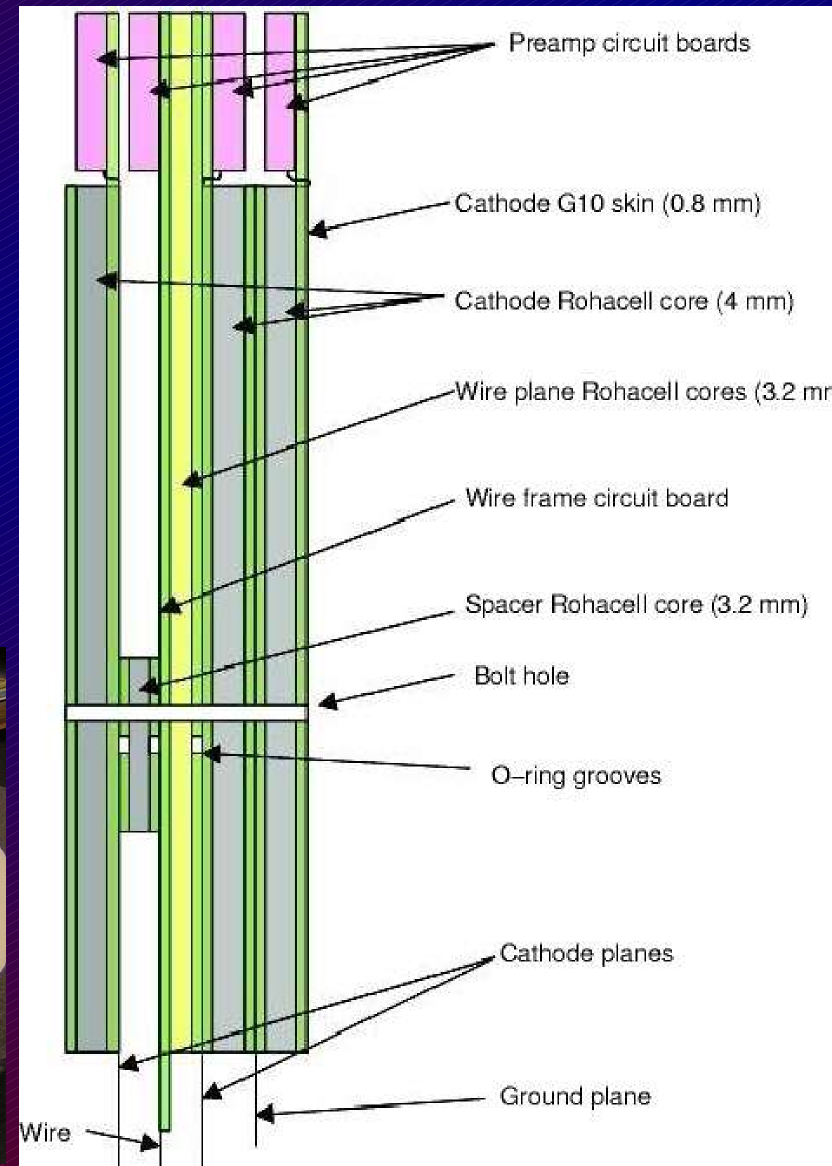
Inactive Area Redesign

- Solution: G10/Rohacell/G10 composite frames

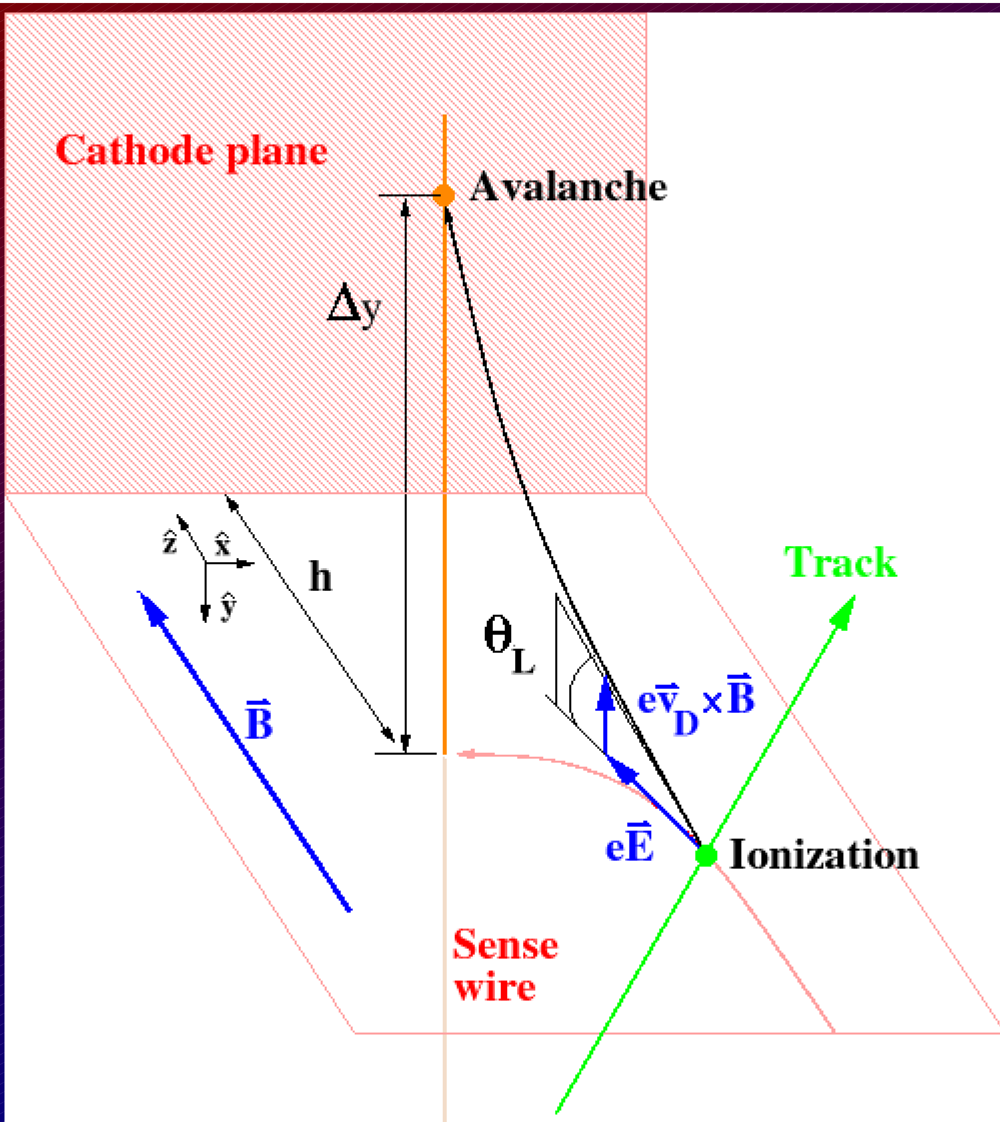
Reduced thickness:
$\sim 0.76 X/X_0 \rightarrow \sim 0.33 X/X_0$ per package







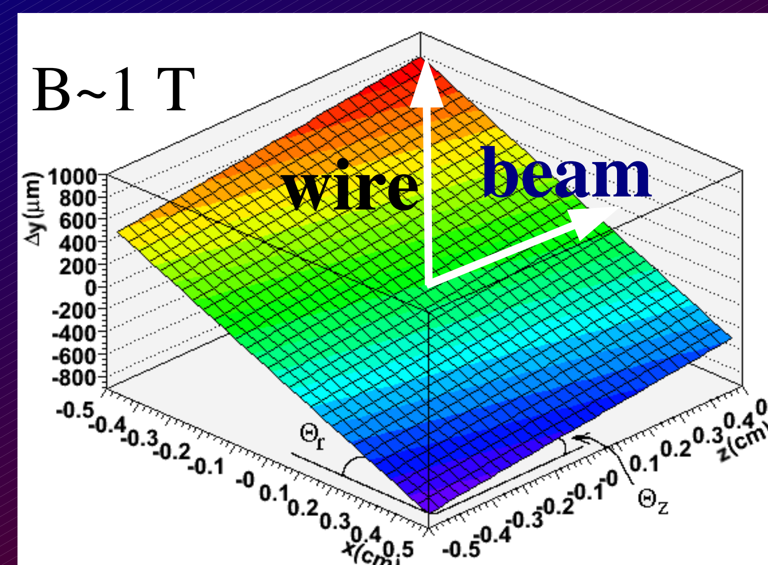
The Lorentz Effect



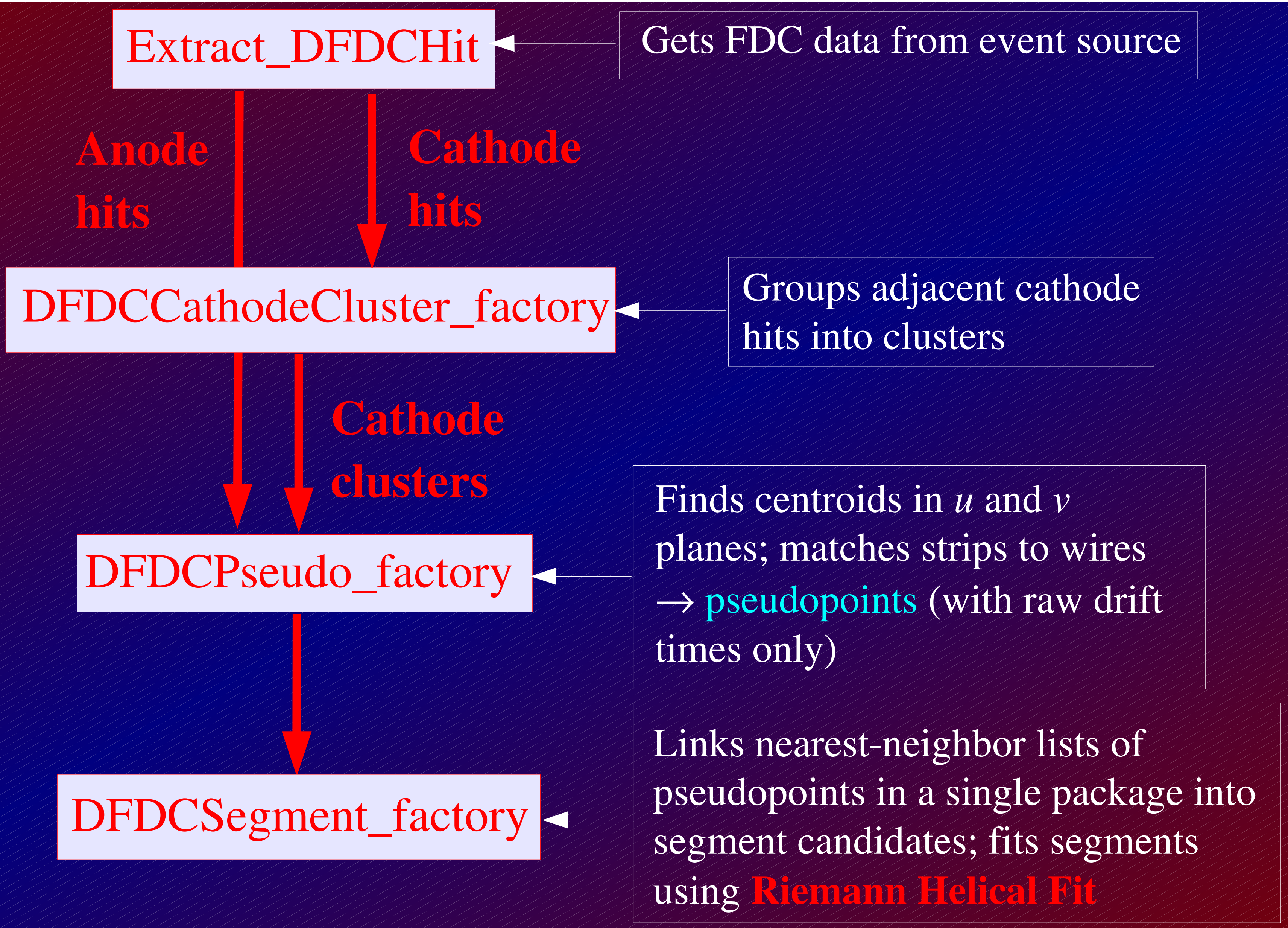
- FDC packages in high magnetic field
- Drifting electrons deflected away from plane for B=0 case → Lorentz angle θ_L

Avalanche position is shifted from track position at measurement plane → need to apply correction...

- Correction parameterized using Garfield



FDC Reconstruction Flow Chart



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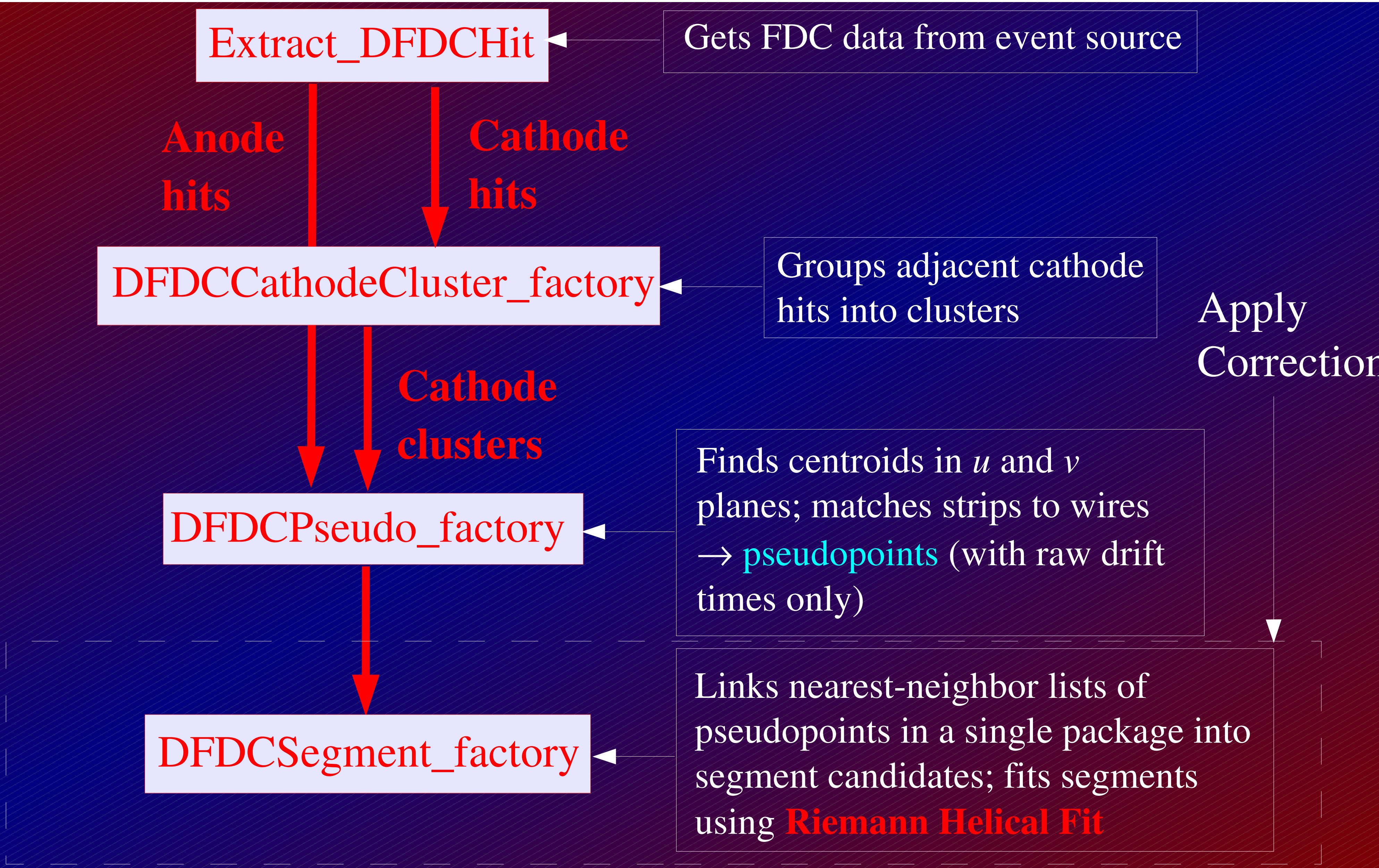
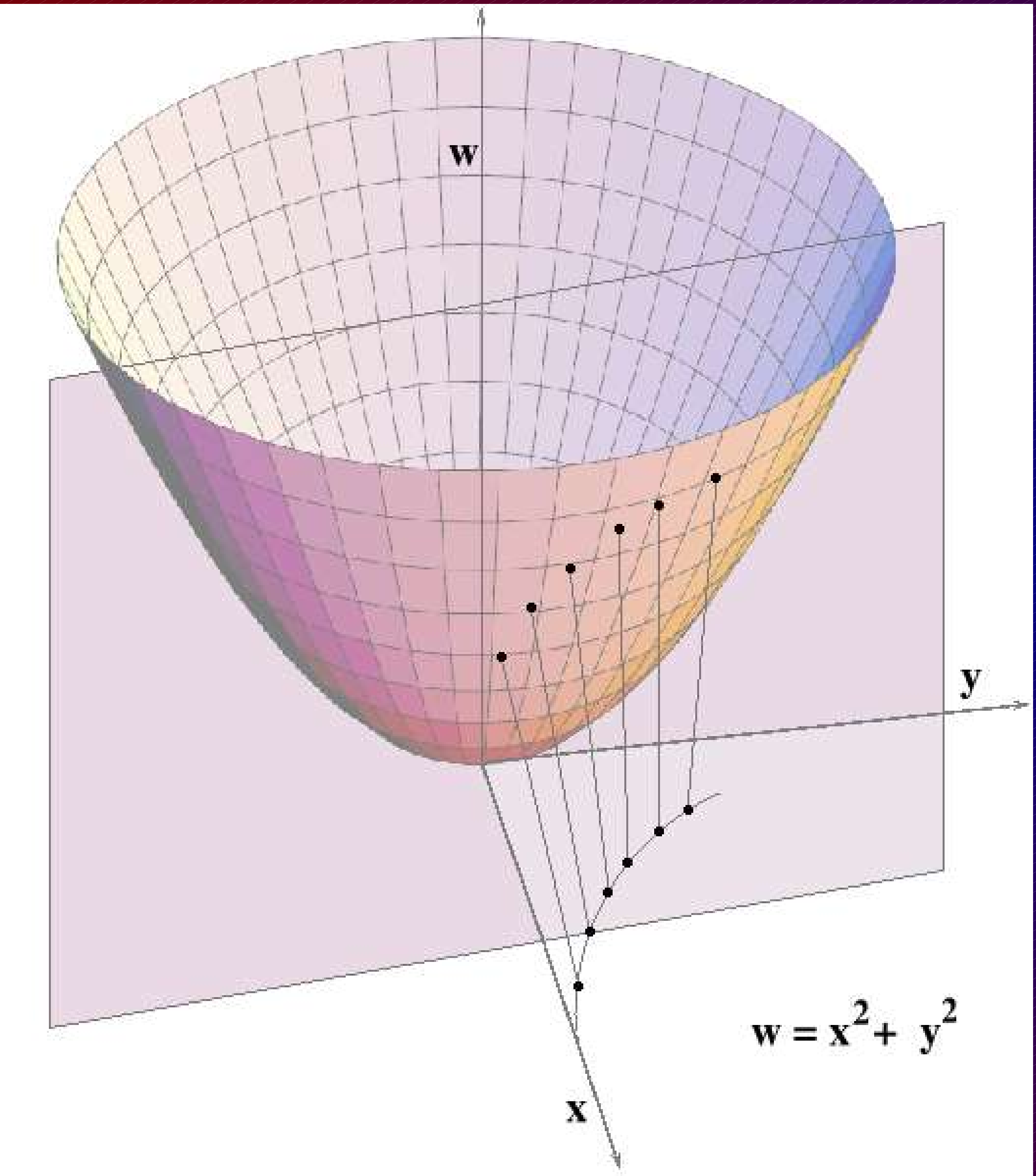
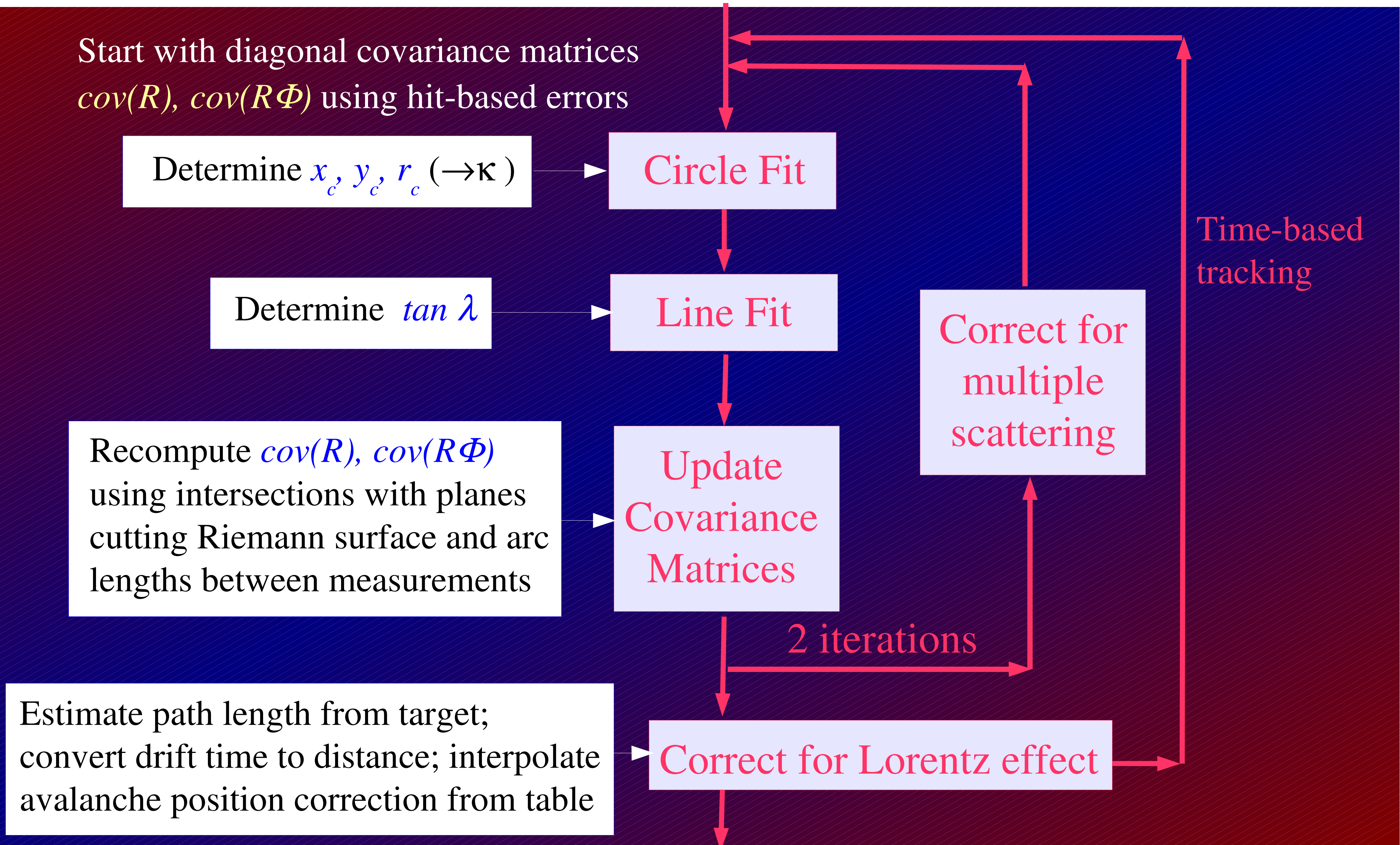


Riemann Helical Fit



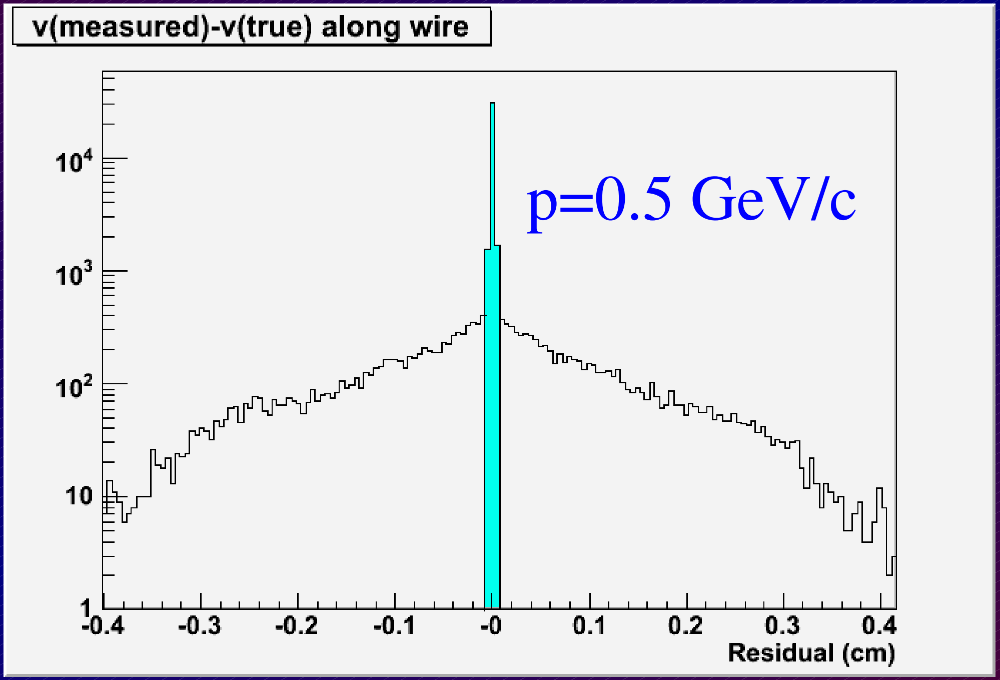
- Map points on circle in *xy*-projection → points on circular paraboloid surface
  - Finding center, radius of circle → fitting plane in *xyw*-space
- Extension to helical path:
  - Compute arc lengths *s* from point to point in *xyz*-space
  - Linear regression of *s* on *z* → tangent of dip angle *tan λ*
- Fitted segment → resolution of left-right ambiguity, correction for flight time

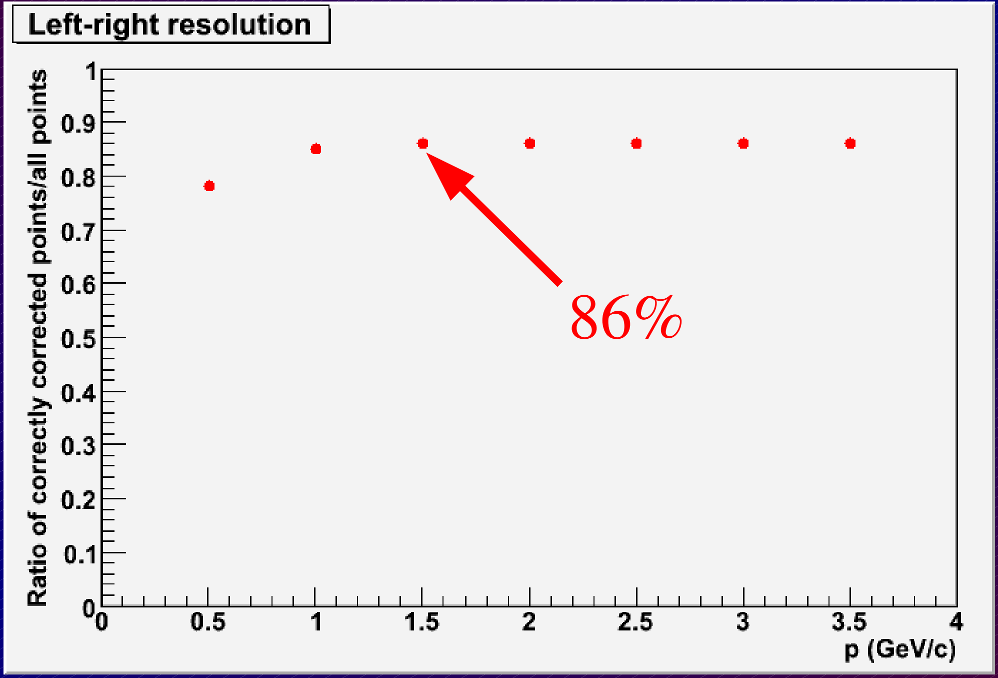
Riemann Fit Algorithm



Efficacy of Lorentz-effect Correction

- Effect implemented in HDGeant
- Threw pion tracks from center of target (no background, no smearing)
  - Compared corrected pseudopoints with truth points



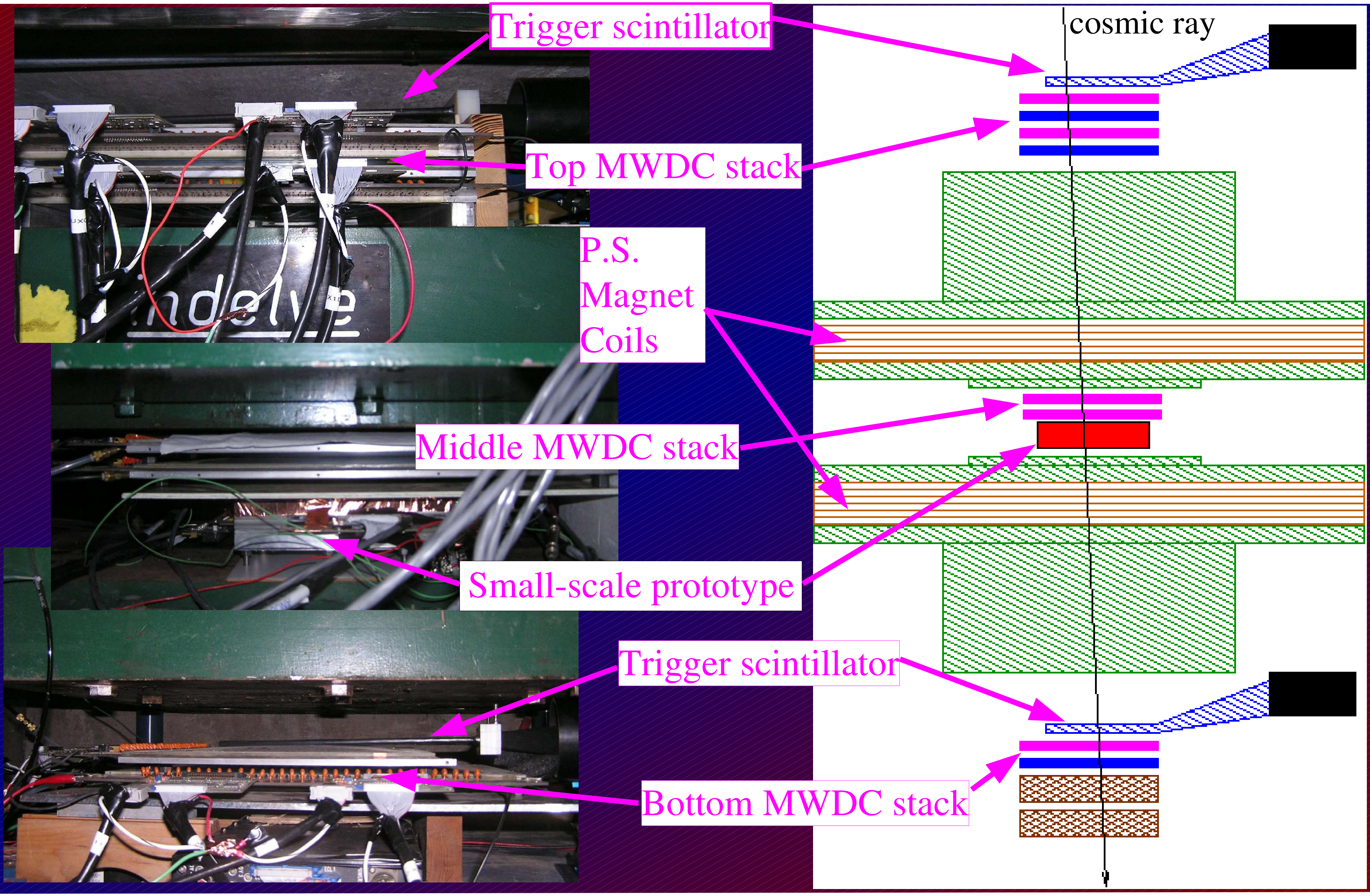


- Technique works equally well for track emerging from other z-positions within target...
- Origin of ~15% failure rate under investigation...

Study of Small Prototype in B-field

- Goal: measure the effect of magnetic field on resolution and position along the wire
  - i.e., want to understand the shift due to the Lorentz effect as a function of the magnetic field
  - Compare shift to Garfield calculations and apply corrections
- Method: place prototype within old pair spectrometer magnet in Hall-B alcove
  - Angular range of incidence of tracks ~ 5°
  - Two different gas mixtures: 40% Ar/60% CO_2, 90% Ar/10% $C0_2$
    - 90/10 mixture enhances effect (average Lorentz angle @ 2.2T ~40º)
    - 40/60 mixture is reasonable choice (average Lorentz angle @ 2.2T ~17º)
  - Maximum field ~ 1.2 T → maximum deflection ~ 1 mm for 40%Ar/60% CO_2

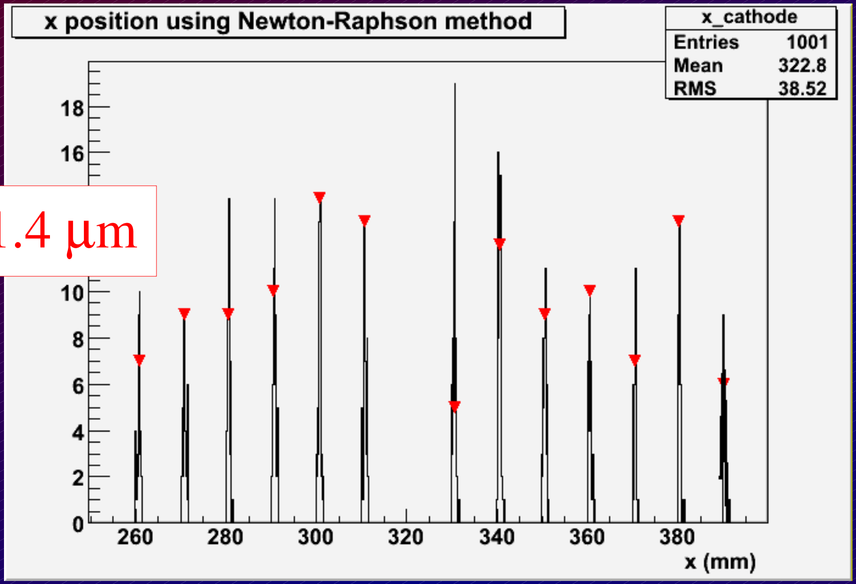
Magnet Test Experimental Setup



Imaging the Wires

B=0 T

$\langle\sigma_x\rangle$=303.5±21.4 μm

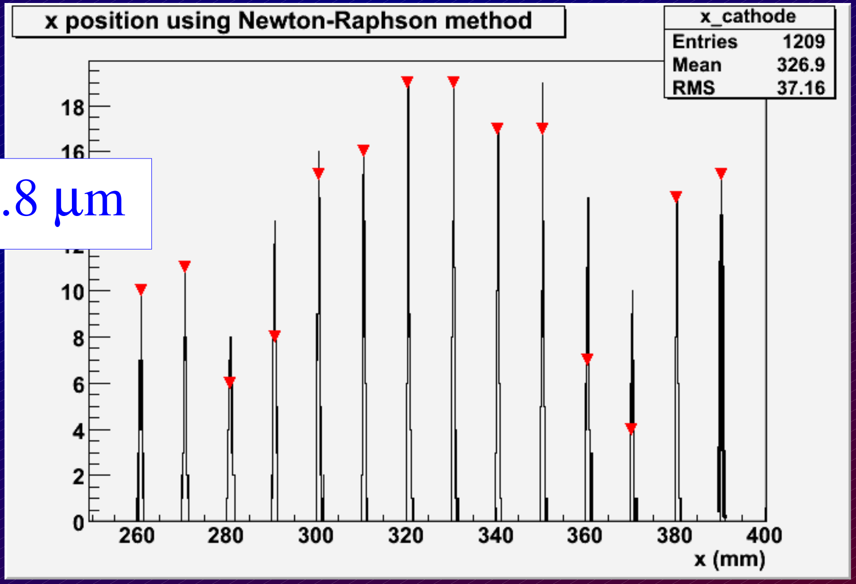


pos(mm)	res(μm)
260.8	258.7
270.6	497.5
280.5	299.6
290.7	290.8
300.7	275.5
310.8	325.6
330.5	300.1
340.6	278.9
350.5	342.6
360.5	291.3
370.6	167.6
380.3	240.3
390.2	376.7

Very preliminary gain calibration!

B=1.2 T

$\langle\sigma_x\rangle$=289.6±17.8 μm

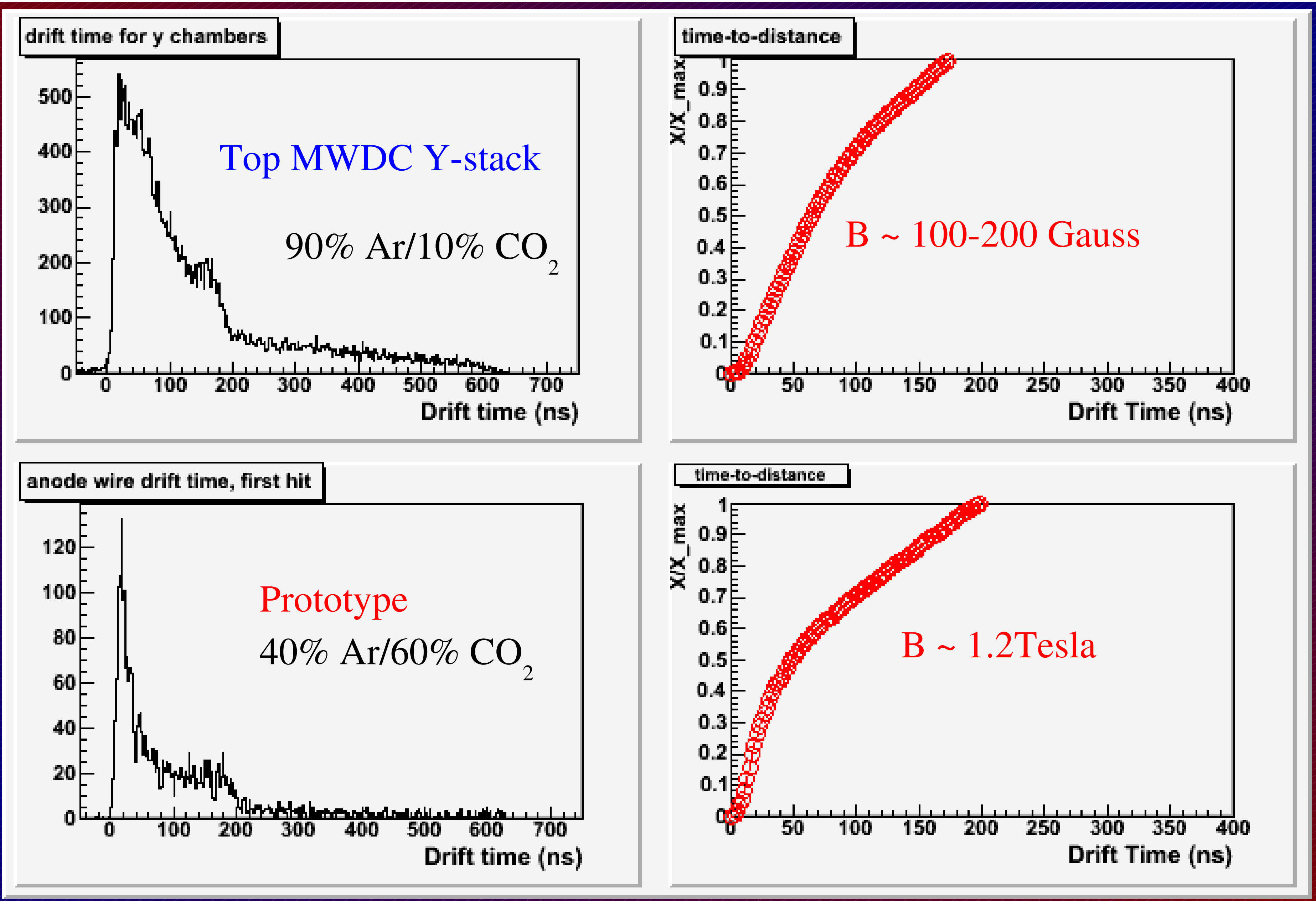


pos(mm)	res(μm)
260.8	271.3
270.7	274.6
280.7	388.4
290.7	262.7
300.5	268.0
310.6	252.4
320.5	321.3
330.5	224.5
340.5	272.2
350.4	286.0
360.5	316.3
370.3	463.4
380.4	213.7
390.3	240.0

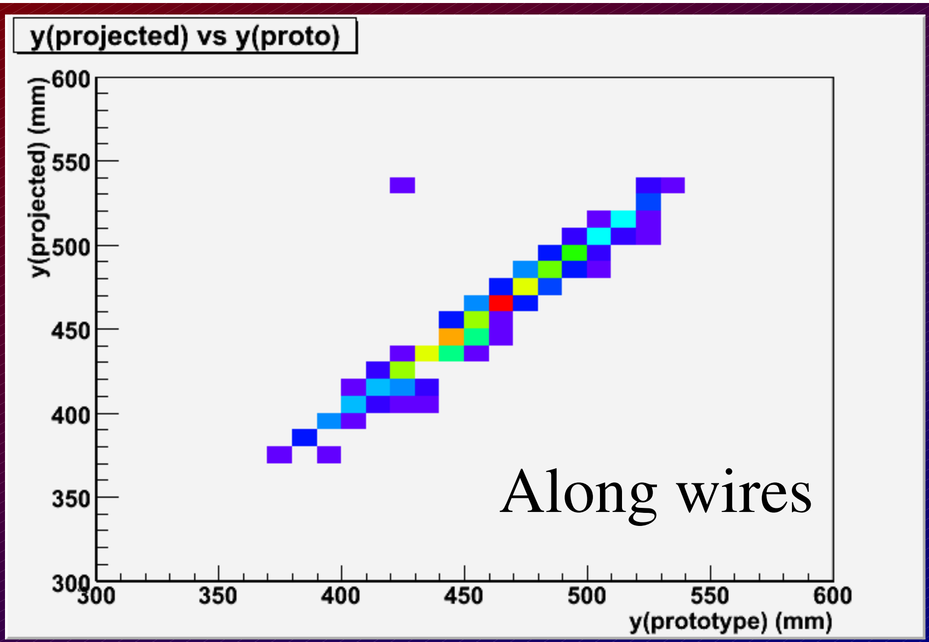
Bench tests in Test Lab:

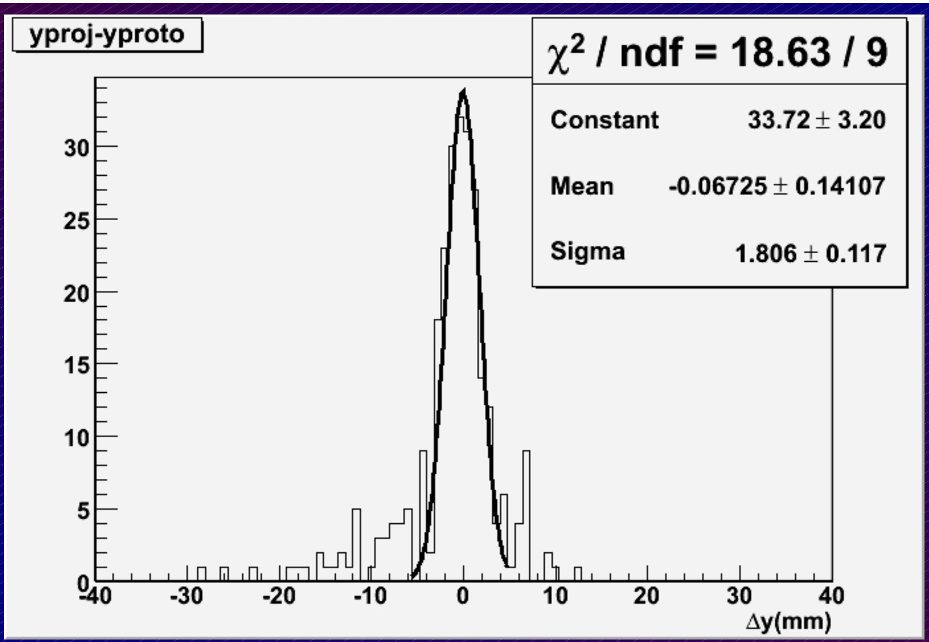
$\langle\sigma_x\rangle$ ~ 160-180 μm

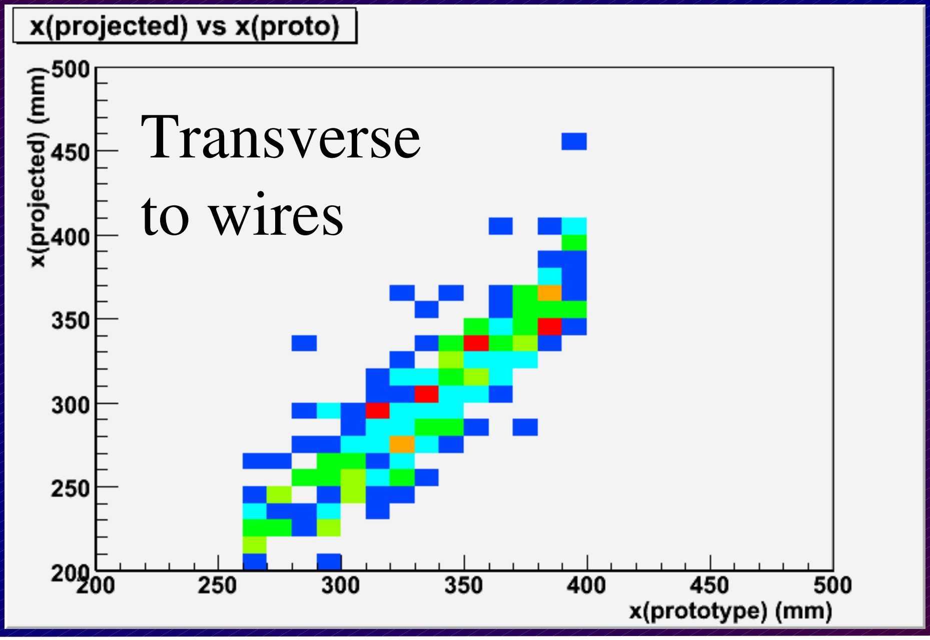
Time-to-distance Calibration



Correlation between MWDCs and prototype



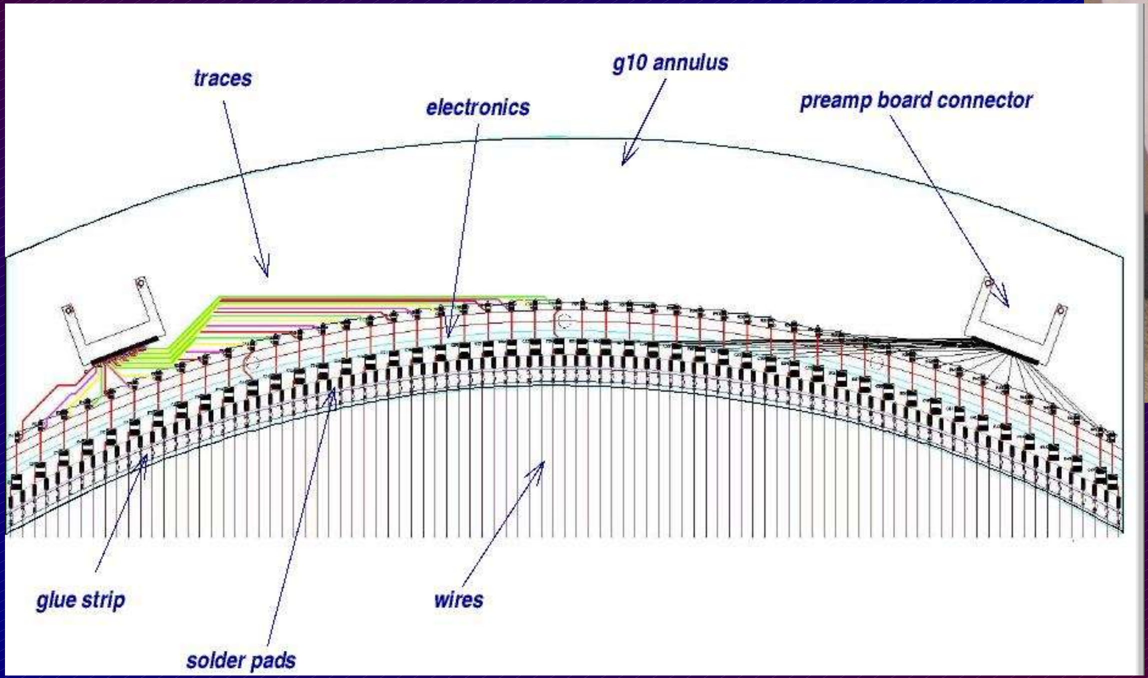




B=1.2 T

Full Scale Prototype

- Design of full-scale prototype underway
- Tentative schedule
  - STB and HVTB design completed this year.
  - Composite frames completed early next year.
  - Wire winding in first quarter of 2008.
  - Cathodes orders in first quarter of 2008.
  - Assembly in second quarter of 2008.



Summary

- Addressed concerns of DC Review Committee regarding material in FDC
  - Reduction of amount of Copper/Kapton/foam in active area
  - Replaced solid G10 frames with composites in inactive area
- Studied effect of magnetic field on chamber performance
  - Simulation with Garfield, implementation in HDGeant
  - Track segment reconstruction using Riemann Helical Fit
  - Test with Pair-Specrometer Magnet in Hall-B, analysis ongoing...
- Future plans: study the performance of the ASICs with small-scale prototype