



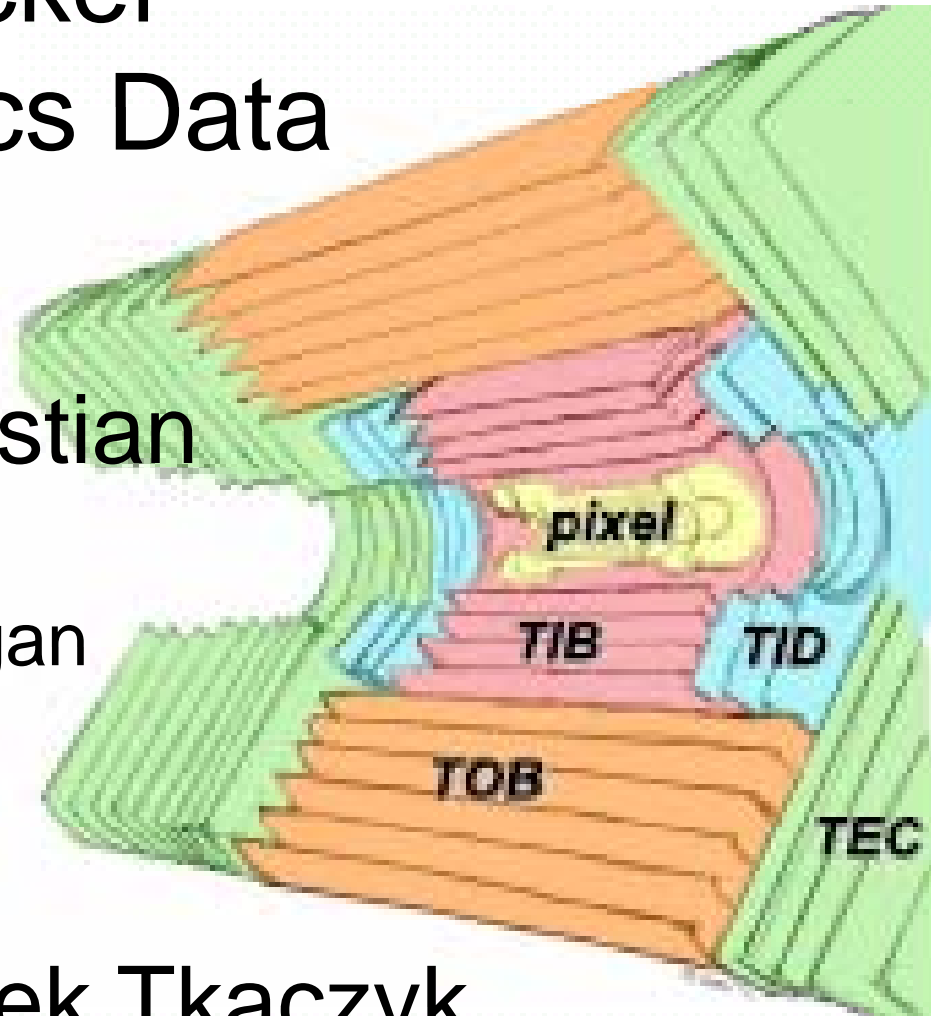
Multiple Scattering Resolution in CMS Tracker from Cosmics Data

Theresa Christian

MIT

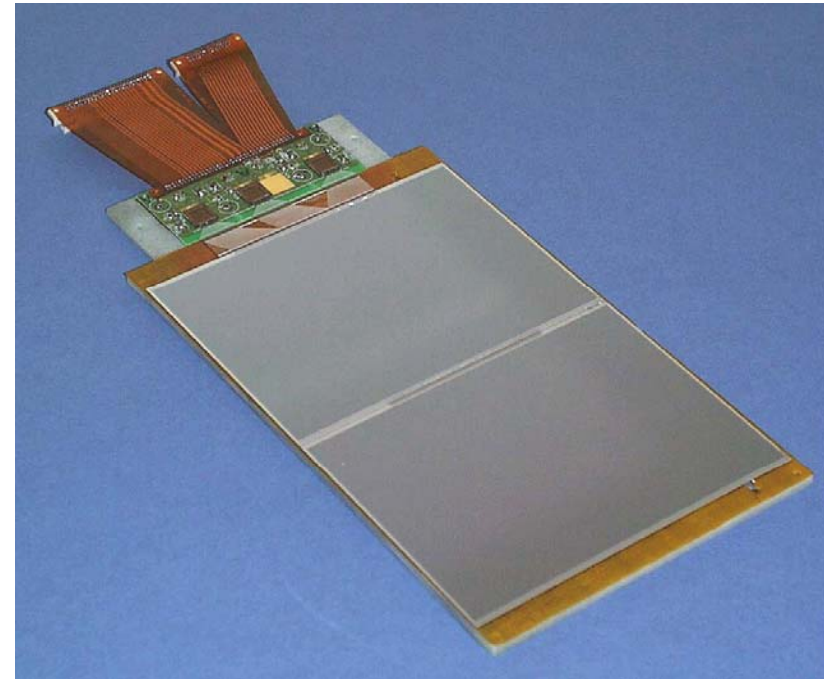
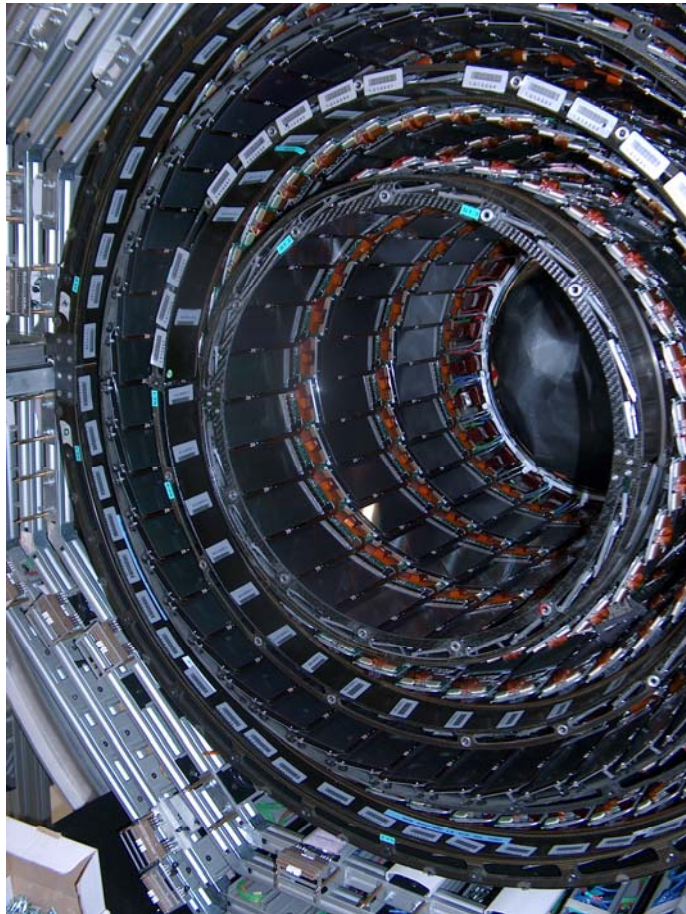
CERN / U Michigan

Aug 8, 2007



Advisor: Slawek Tkaczyk

Silicon Strip Tracker



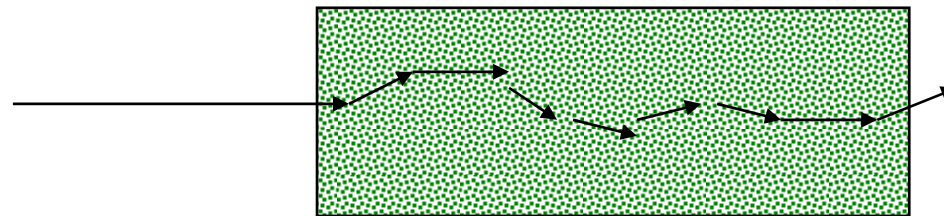
Silicon strips: 320 μm / 500 μm thick

Front-end electronics: printed circuit board

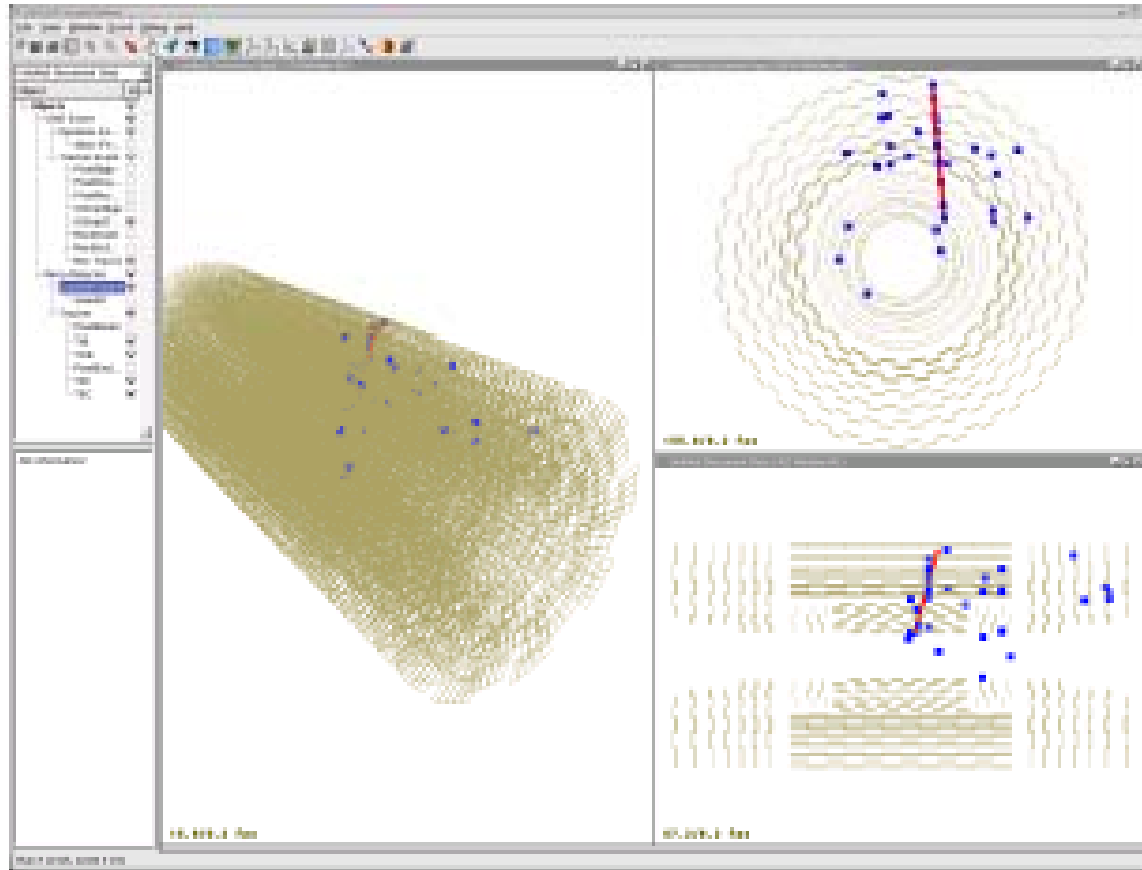
Cu cables, C fiber support structure, etc.

Multiple scattering

- High-energy particles passing through matter are scattered by interactions with nuclei (Rutherford scattering)
- Multiple (independent, small-angle) scattering events => **approximately Gaussian distribution in deflection angle**



- Limits detector resolution



IGUANA online track visualization

Find hits, i.e. clusters

Identify hits that lie approximately along a straight line, i.e. belong to a track

Find track parameters to minimize χ^2 for hits on the track

Residual = distance between hit position and extrapolated track position



TIF Cosmics Data



<http://home.fnal.gov/~noeding/TIFCosmicRunList.html>

TIB+TOB

Scintillator Position A

Date	Run	Events	FNAL Reco	VR/ZS	DB Tag	Temperature	Pseudolatitude	Good Run	Remarks
9-Mar-07	6203	5,020	0	VR	TIBTOB_v1	Room	48.8		
9-Mar-07	6210	305	305	VR	TIBTOB_v1	Room	48.8		
9-Mar-07	6215	158,948	158,745	VR	TIBTOB_v1	Room	48.8	YES	
10-Mar-07	6217	52,320	52,318	VR	TIBTOB_v1	Room	48.8	YES	
10-Mar-07	6219	14,220	14,220	VR	TIBTOB_v1	Room	48.8	YES	
14-Mar-07	6346	18,160	18,160	VR	TIBTOB_v1	Room	48.8	YES	
14-Mar-07	6354	12,727	12,726	VR	TIBTOB_v1	Room	48.8	YES	
16-Mar-07	6462	3,609	3,609	VR	TIBTOB_v1	Room	48.79	YES	
16-Mar-07	6466	3,297	3,297	ZS	TIBTOB_v1	Room	48.79	YES	
16-Mar-07	6467	42,340	42,337	VR	TIBTOB_v1	Room	48.79	YES	
17-Mar-07	6471	15,946	15,946	VR					
17-Mar-07	6474	15,020	15,020	ZS					
17-Mar-07	6478	4,816	4,816	VR					
17-Mar-07	6479	16,520	16,520	VR					
17-Mar-07	6483	9,940	9,940	ZS					
17-Mar-07	6485	8,050	8,049	VR					
18-Mar-07	6493	15,020	15,019	ZS					
18-Mar-07	6502	15,884	15,884	VR					
18-Mar-07	6505	16,194	16,194	ZS					
18-Mar-07	6507	15,038	15,038	VR					
19-Mar-07	6509	10,065	10,065	ZS	TIBTOB_v1	Room	48.79	YES	
20-Mar-07	6557	1,739	1,739	VR	TIBTOB_v1	Room	48.79	NO	BAD: TOB was turned on after start of run
20-Mar-07	6561	11,130	11,129	VR	TIBTOB_v1	Room	48.79	NO	BAD: TOB was turned off before end of run; track distributions look fine
23-Mar-07	6838	4,229	4,229	VR	TIBTOB_v1	Room	48.79	YES	
23-Mar-07	6884	16,620	16,620	VR	TIBTOB_v1	Room	48.79	YES	
23-Mar-07	6886	7,740	7,740	VR	TIBTOB_v1	Room	50.79	NO	BAD: Wrong latency
23-Mar-07	6893	88	0	VR	TIBTOB_v1	Room	49.84	NO	BAD: Wrong latency; tracks reconstructed with low cluster charge
24-Mar-07	6896	23,880	23,880	VR	TIBTOB_v1	Room	48.79	YES	
24-Mar-07	6897	12,102	12,102	ZS	TIBTOB_v1	Room	48.79	NO	BAD: No tracks (unclear what happened)
24-Mar-07	6898	19,820	19,820	VR	TIBTOB_v1	Room	48.79	YES	
24-Mar-07	6901	19,800	19,800	VR	TIBTOB_v1	Room	48.79	YES	
24-Mar-07	6906	10,293	10,293	VR	TIBTOB_v1	Room	48.79	YES	
25-Mar-07	6909	10,080	10,080	ZS	TIBTOB_v1	Room	48.79	YES	
25-Mar-07	6912	15,020	15,020	VR	TIBTOB_v1	Room	48.79	YES	
25-Mar-07	6914	10,020	10,020	ZS	TIBTOB_v1	Room	48.79	YES	
25-Mar-07	6916	11,940	11,939	VR	TIBTOB_v1	Room	48.79	YES	
25-Mar-07	6917	21,739	21,739	ZS	TIBTOB_v1	Room	48.79	YES	
25-Mar-07	6920	17,396	17,396	VR	TIBTOB_v1	Room	48.79	YES	
25-Mar-07	6922	10,754	10,754	ZS	TIBTOB_v1	Room	48.79	YES	
25-Mar-07	6923	14,530	14,530	VR	TIBTOB_v1	Room	48.79	YES	
26-Mar-07	6925	11,386	11,386	ZS	TIBTOB_v1	Room	48.79	YES	
26-Mar-07	6930	50			TIBTOB_v1	Room	48.79	NO	BAD: No information about the run could be found; small number of events
TOTAL		703,996	698,424						

Data taken with TIB + TOB,

Mar. 9 – Mar. 26, 2007

Available on CASTOR

Change in scintillator arrangement:
Pb blocks added at lower scintillator to filter out low-p muons



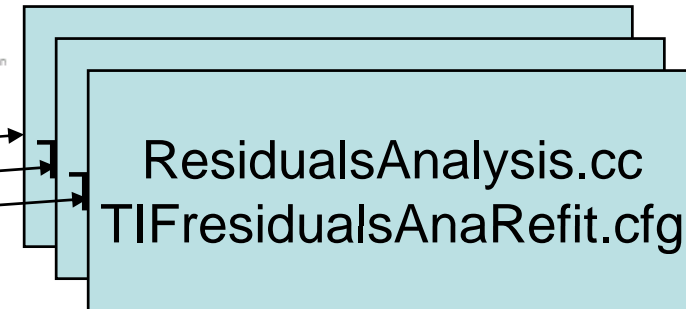
Code Structure

<http://home.fnal.gov/~noeding/TIFCosmicRunList.html>

TIB+TOB

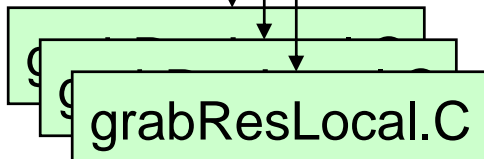
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18-Mar-07	6502	15,884	15,884	VR	TIBTOB_v1	Room	48.79	YES
18-Mar-07	6505	16,195	16,194	ZS	TIBTOB_v1	Room	48.79	YES
18-Mar-07	6507	15,038	15,038	VR	TIBTOB_v1	Room	48.79	YES
19-Mar-07	6509	10,055	10,055	ZS	TIBTOB_v1	Room	48.79	YES
20-Mar-07	6557	1,7						NO
20-Mar-07	6561	11,1						NO
23-Mar-07	6838	4,2						YES
23-Mar-07	6884	16,6						YES
23-Mar-07	6886	7,7						NO
23-Mar-07	6888							BAD: Wrong
23-Mar-07	6893							BAD: Wrong
24-Mar-07	6895	23,8						YES
24-Mar-07	6897	12,1						NO
24-Mar-07	6898	19,8						YES
24-Mar-07	6901	19,8						YES
24-Mar-07	6906	10,2						YES
25-Mar-07	6909	10,0						YES
25-Mar-07	6912	15,0						YES
25-Mar-07	6914	10,0						YES
25-Mar-07	6916	11,5						YES
25-Mar-07	6917	21,7						YES
25-Mar-07	6920	17,3						YES
25-Mar-07	6922	10,7						YES
25-Mar-07	6923	14,5						YES
26-Mar-07	6925	11,5						YES
26-Mar-07	6930							NO
TOTAL		703,5						

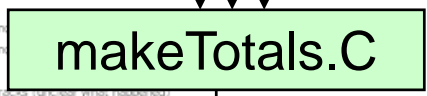


N-tuples

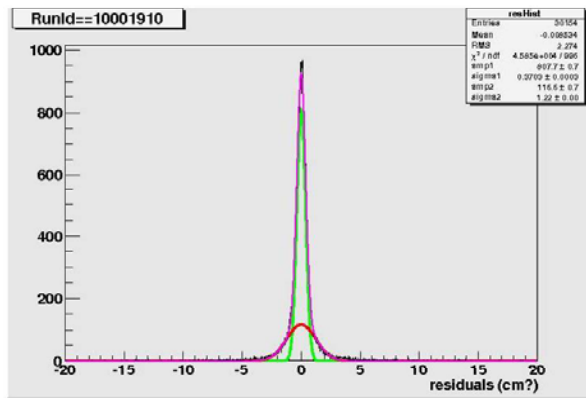
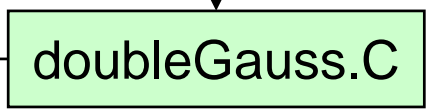
cuts

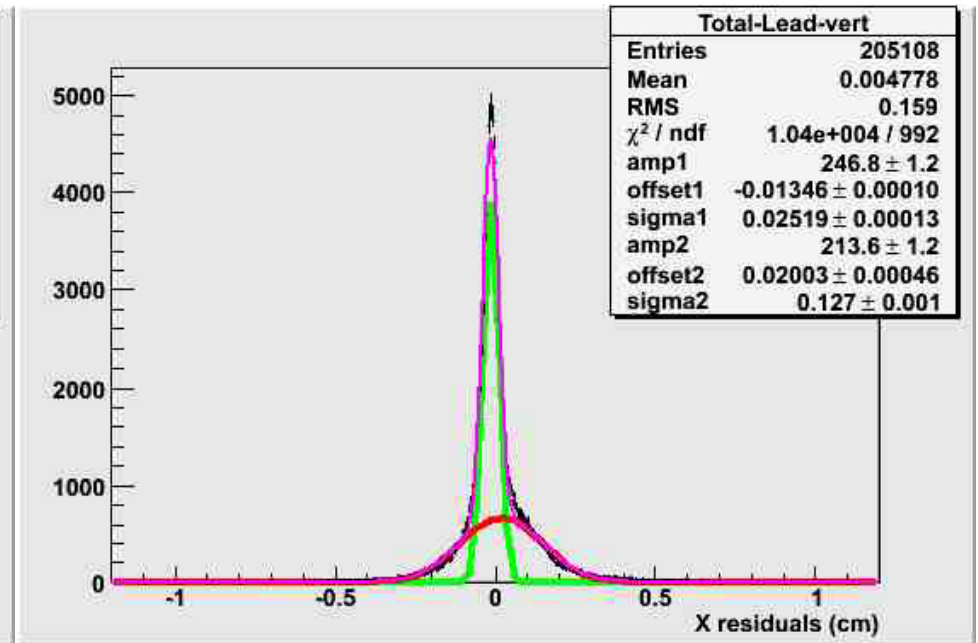
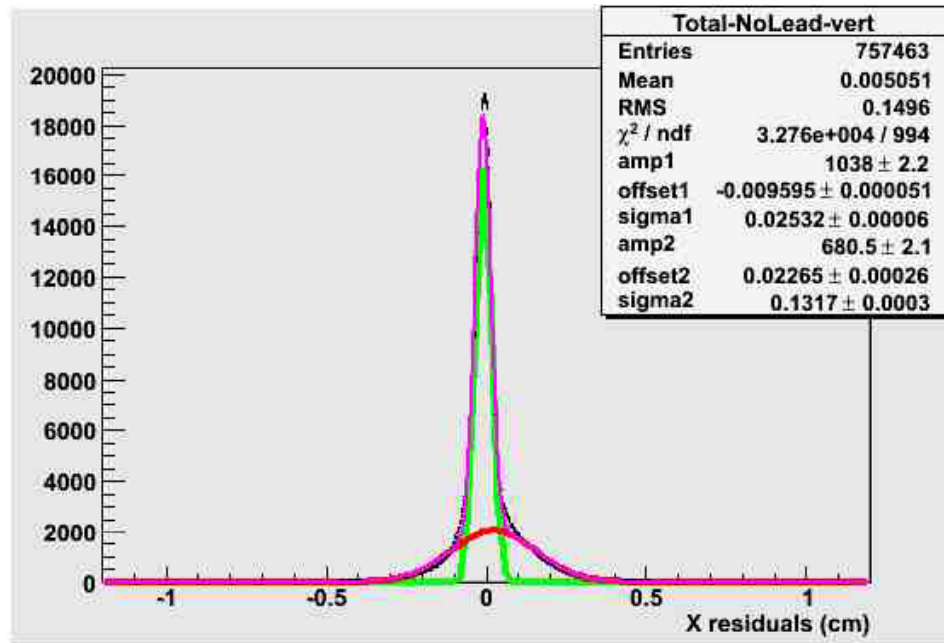


histos



histos





No Pb:

$$\sigma_1 = 253 \text{ um}$$

$$\sigma_{MS} = 1317 \text{ um}$$

With Pb filter:

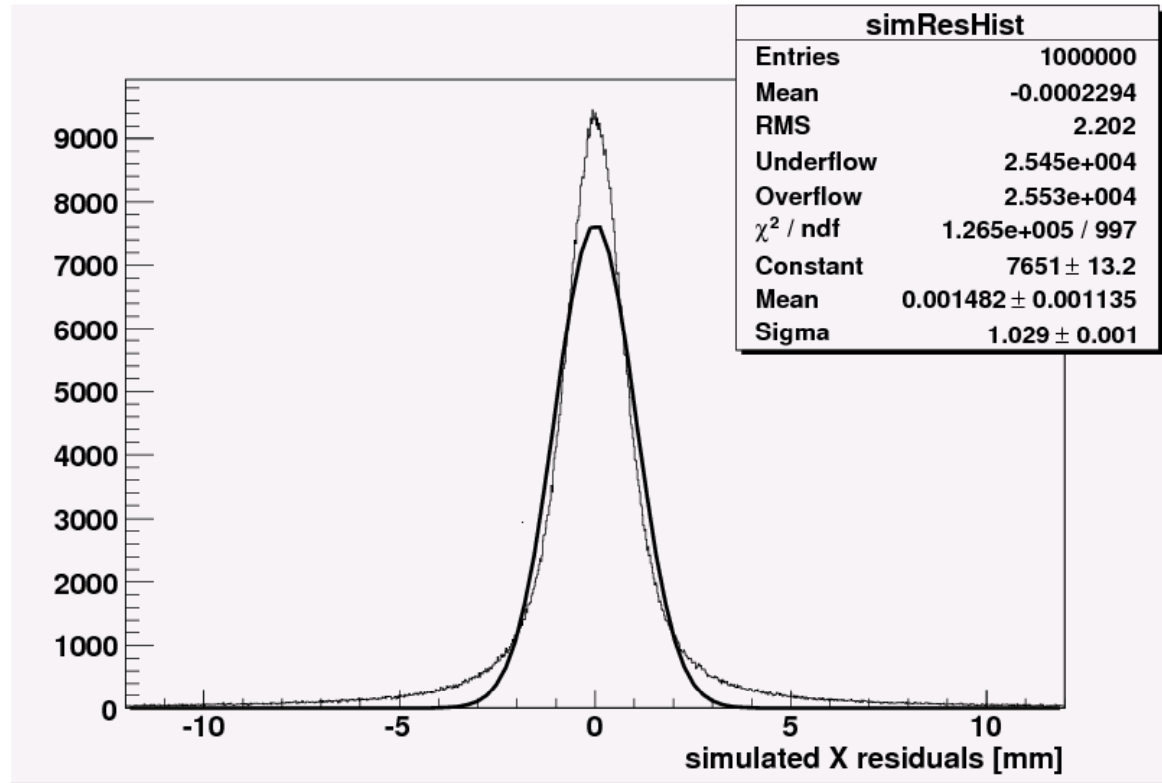
$$\sigma_1 = 252 \text{ um}$$

$$\sigma_{MS} = 1270 \text{ um}$$

Vertical filter: $\phi = -\pi / 2 \pm 0.3$, $-0.3 < \eta < 0.3$



MS scattering simulation

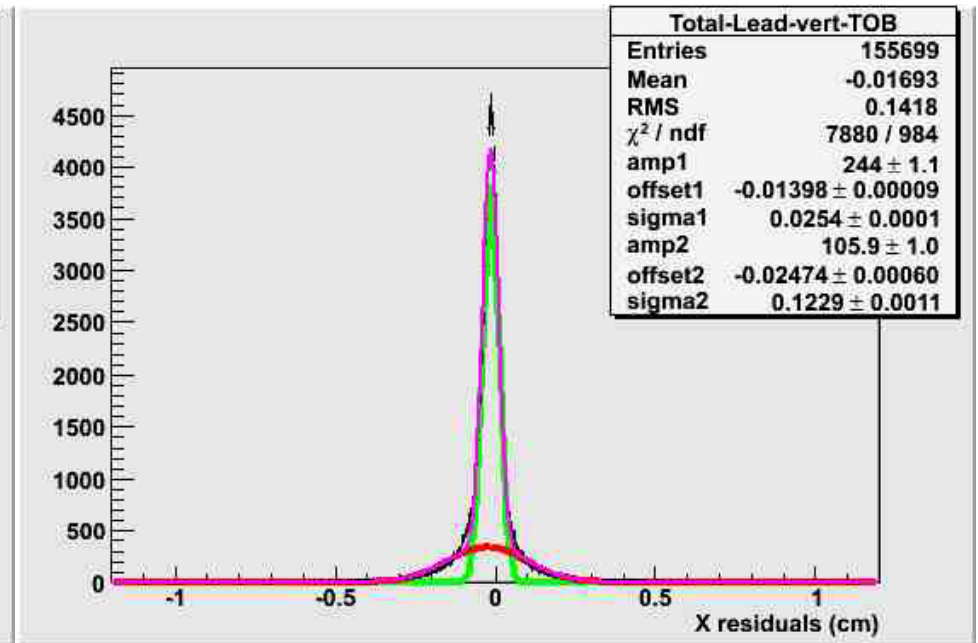
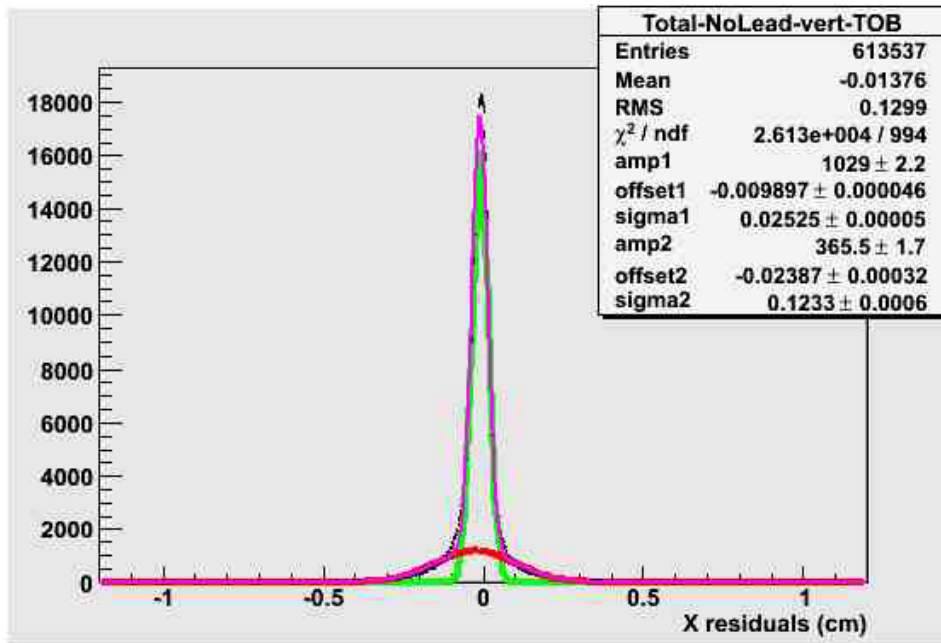


Assume $X/X_0 = 0.3$

Assume uniform p distribution

10 MeV – 1000 MeV	1029 um
100 MeV – 1000 MeV	1008 um

$$\theta_0 = \frac{13.6 \text{ MeV}}{\beta_{cp}} z \sqrt{x/X_0} \left[1 + 0.038 \ln(x/X_0) \right]$$



No Pb:

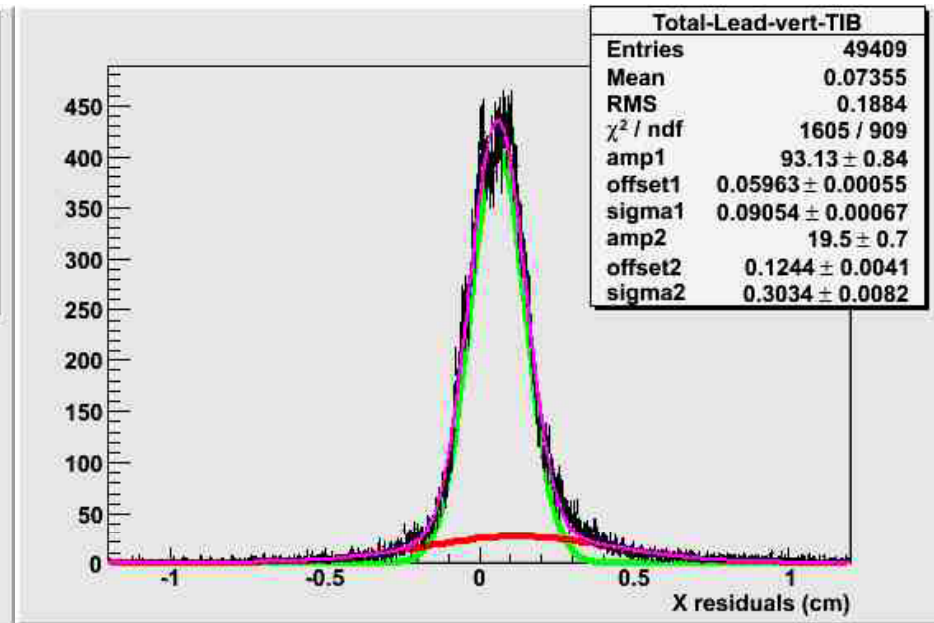
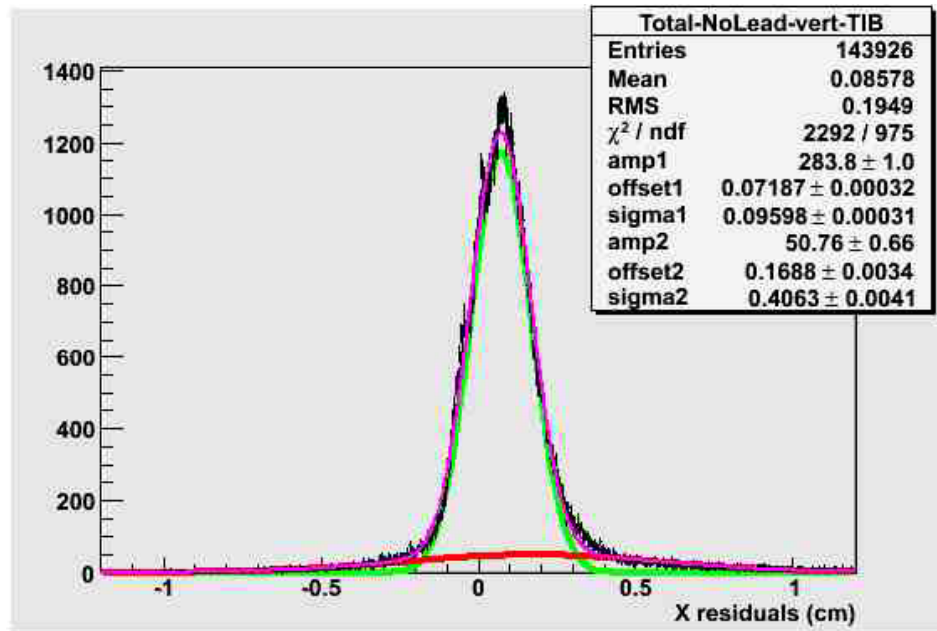
$$\sigma_1 = 252 \text{ um}$$

$$\sigma_{MS} = 1233 \text{ um}$$

With Pb filter:

$$\sigma_1 = 254 \text{ um}$$

$$\sigma_{MS} = 1229 \text{ um}$$



No Pb:

$$\sigma_1 = 960. \text{ um}$$

$$\sigma_{MS} = 4060 \text{ um}$$

With Pb filter:

$$\sigma_1 = 905 \text{ um}$$

$$\sigma_{MS} = 3030 \text{ um}$$



Future Work:

- Refine simulation with more accurate p distribution for cosmic ray muons
- Understand measured resolutions by subdetector and layer
- Process last few skipped runs and add
- Alignment! Similar problems already tackled by D. Stuart; compare notes.



Culture!





Thank you:



Slawek Tkaczyk

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Steve Nahn

Milan Nikolic

**...and all the other
friendly folk in the
TAC!**

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Prof. Homer Neal

Dr. Steven Goldfarb

Jeremy Herr

University of Michigan

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