Λ^0 hyperons yields in 4.0 and 4.5 AGeV carbon-nucleus interactions

(status report)

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Baryonic Matter at Nuclotron

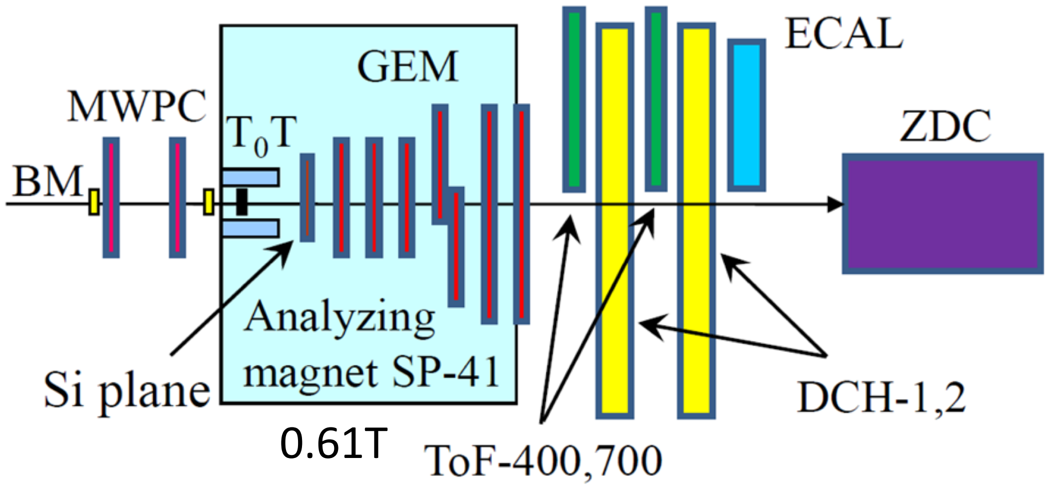
10th Collaboration Meeting of the BM@N Experiment at the NICA Facility

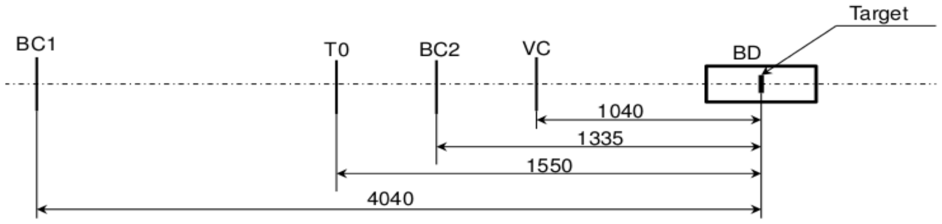
14-19 May 2023

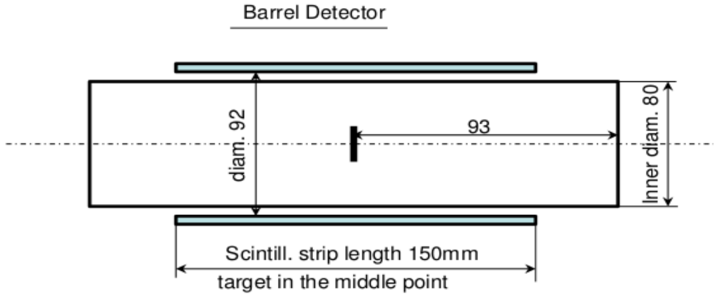
BM@N configuration in Run6

- Central tracker
  - One plane of a forward Si detector
  - 6 GEM stations
    - 5 GEM detectors (66x41 cm2)
    - 2 GEM detectors (163x45 cm2)
- Triggers: BD, BC1, BC2, T0, VETO
- Beam Ekin=4.0 and 4.5 GeV
  - Intensity 10^5 per spill
  - Spill duration 2-2.5 sec.
- <u>Physics</u>: measure inelastic reactions C+A→X
  - Targets: C, Al, Cu, Pb

March 2017





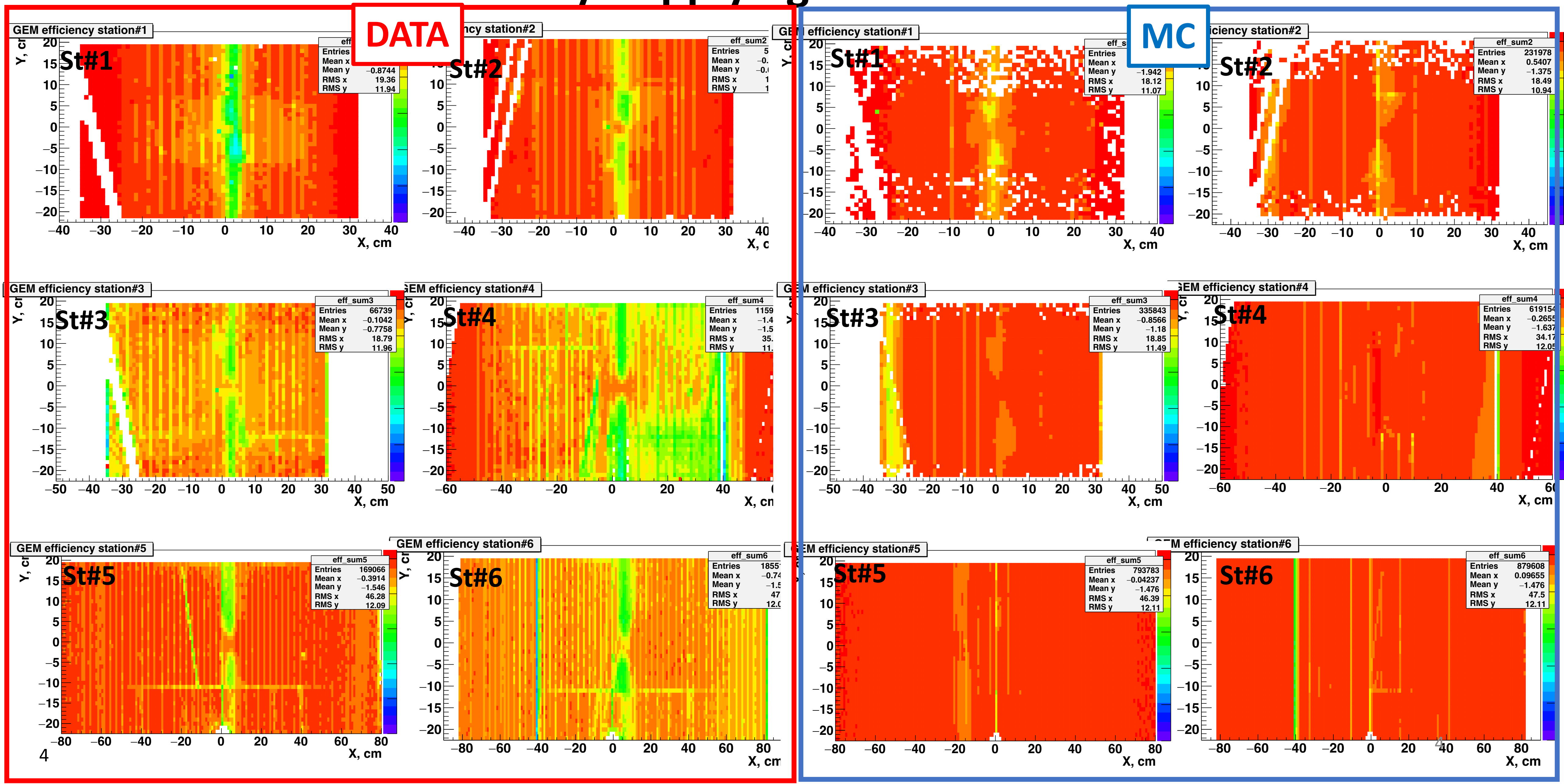


Analysis current status

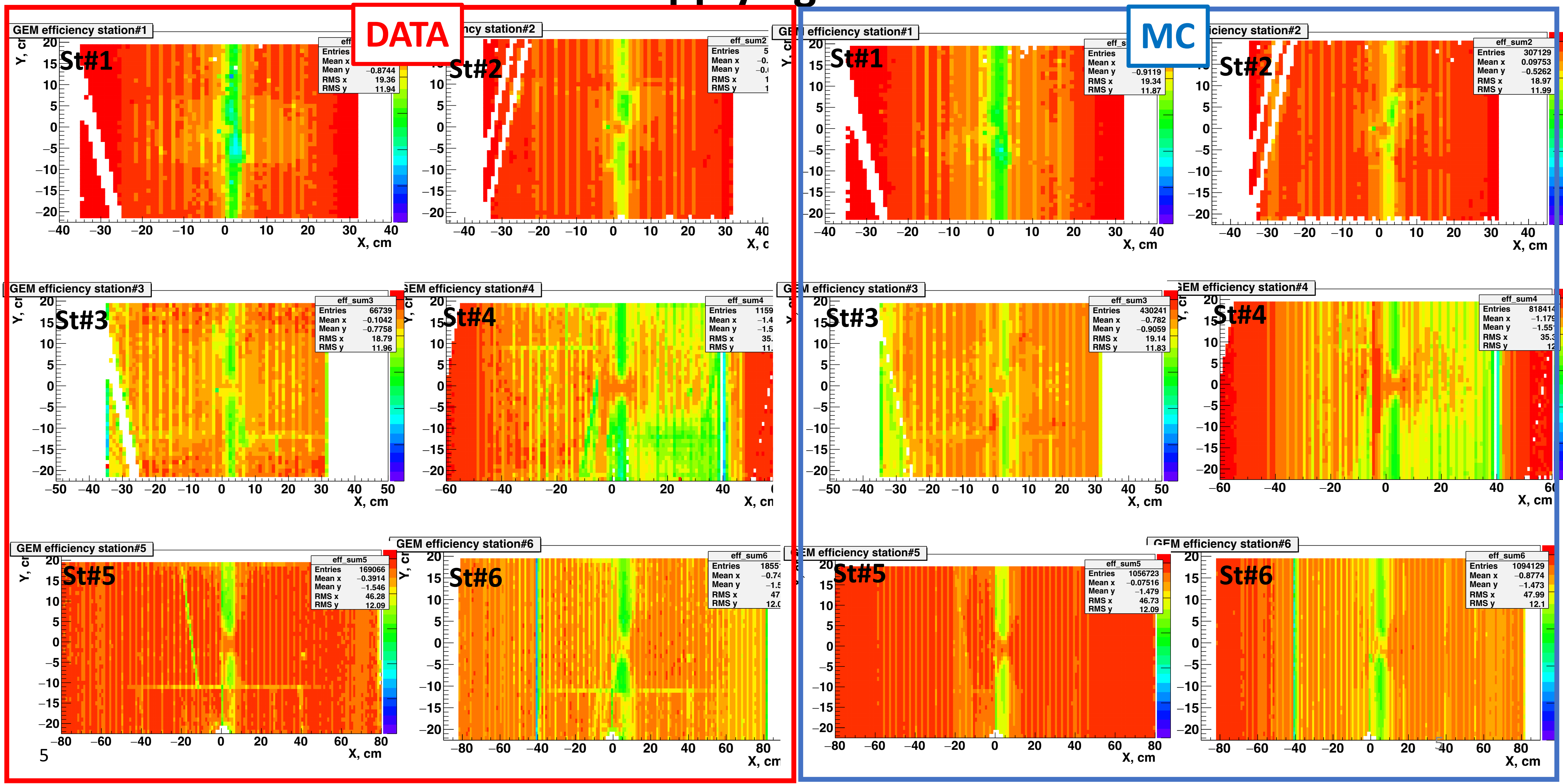
- **Main goal of current analysis** – cross-check with previous analysis 2020 (was performed by Gleb Pokatashkin)
- **From previous analysis status:**
  - Check GEM efficiencies for MC & Data
    - Apply efficiencies for MC simulation
  - Check residuals for MC & Data
    - Make corrections for residuals in Data & MC
    - Momentum smearing procedure for MC simulation
    - Make corrections for sigma dx/dy in MC simulation
- **Analysis:** compare distributions MC/Data for pt/momentum/etc.
- **Measure cross-sections of the Λ^0's hyperon** (**we are near finish**)

All distributions will be for C+Cu 4.0 GeV sample

GEM efficiencies comparison Data/MC (4.0GeV C+Cu) w/o applying effs to MC

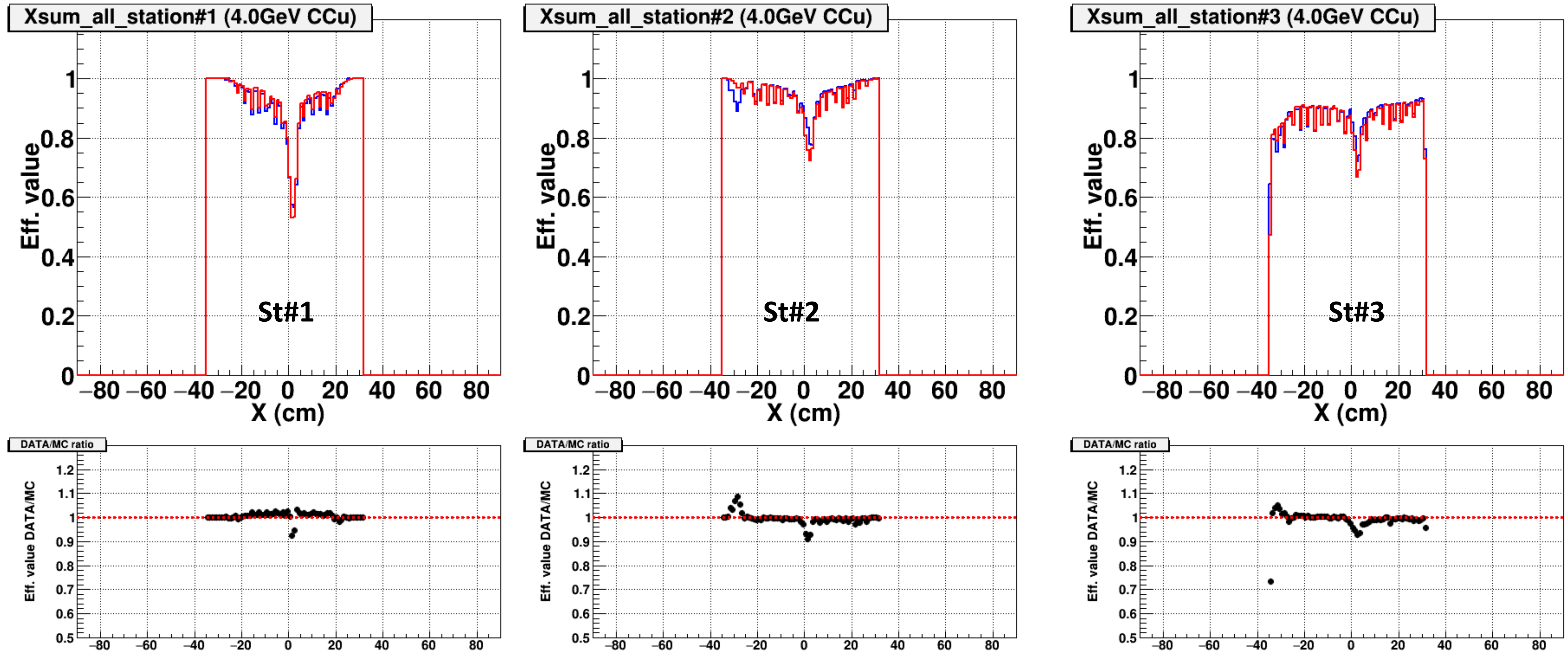


GEM efficiencies comparison Data/MC (4.0GeV C+Cu) after applying effs to MC



GEM efficiencies C+Cu 4.0GeV SumEff over X

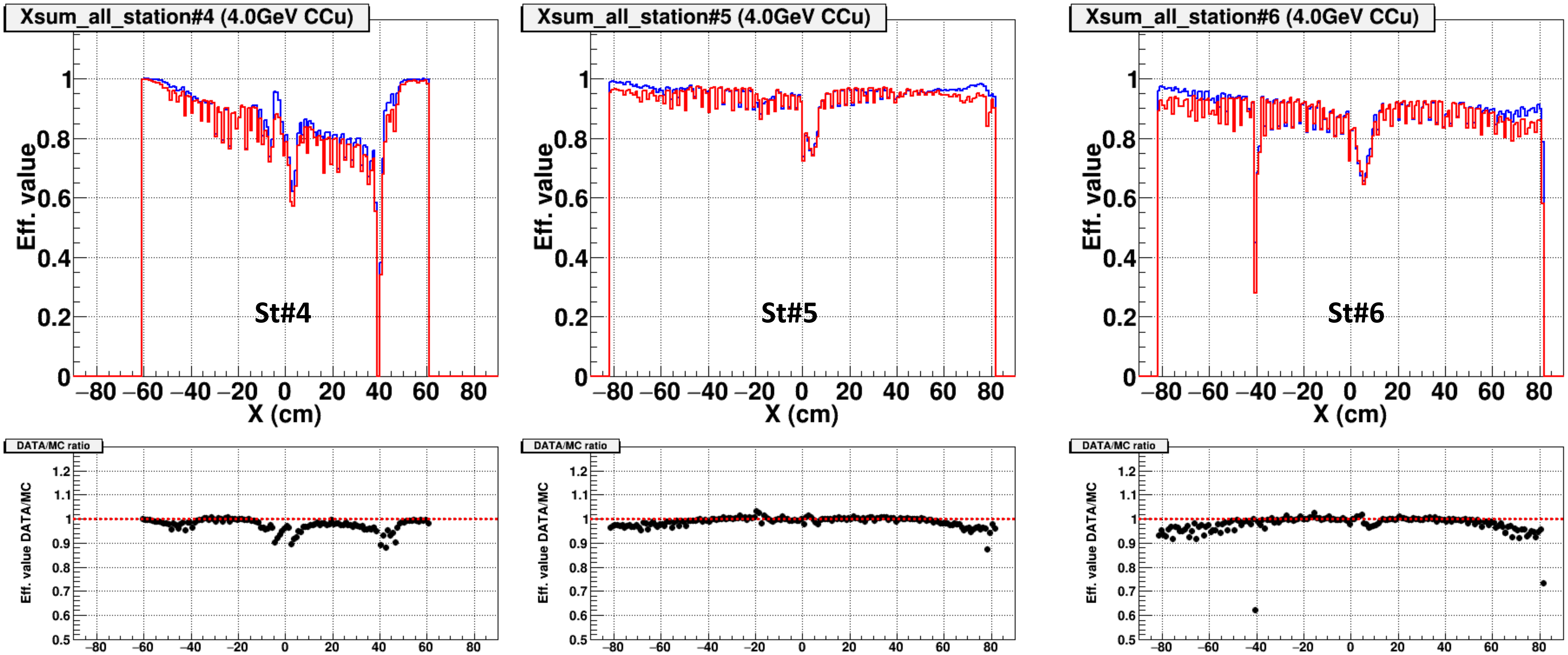
Red: Data; Blue: MC;



X, cm

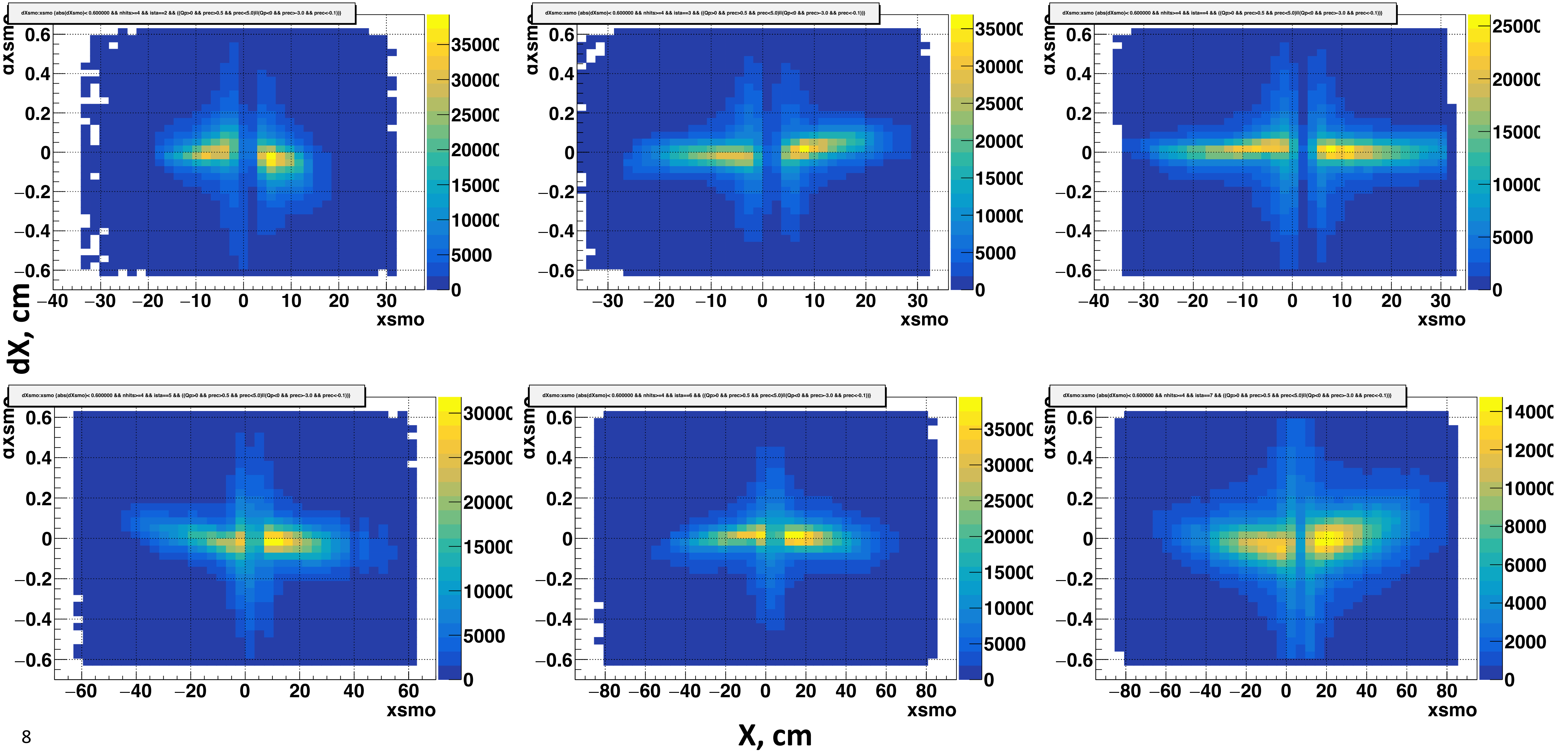
GEM efficiencies C+Cu 4.0GeV SumEff over X

Red: Data; Blue: MC;

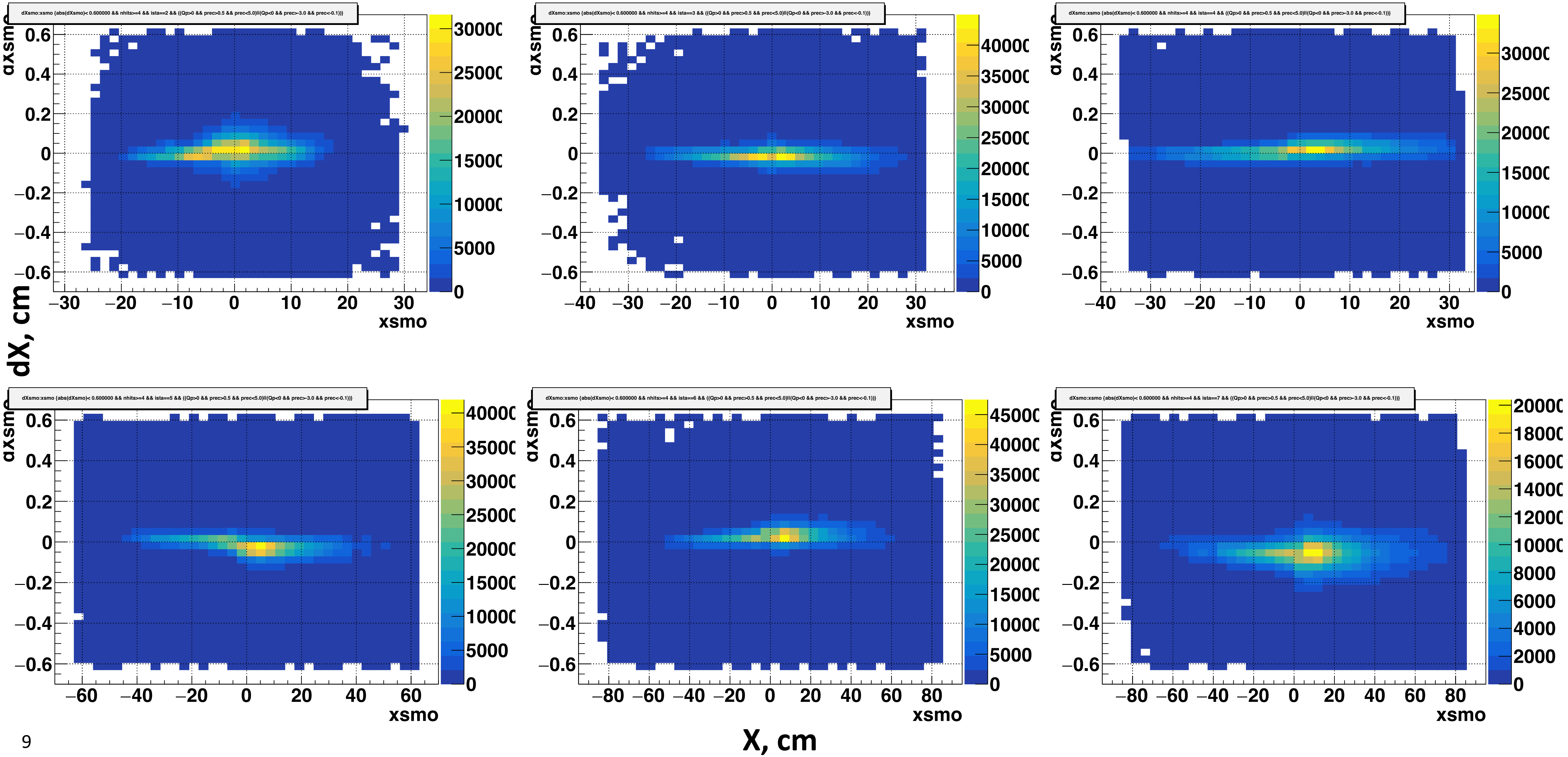


X, cm

Check residuals Data DX vs.X (4.0GeV CCu)



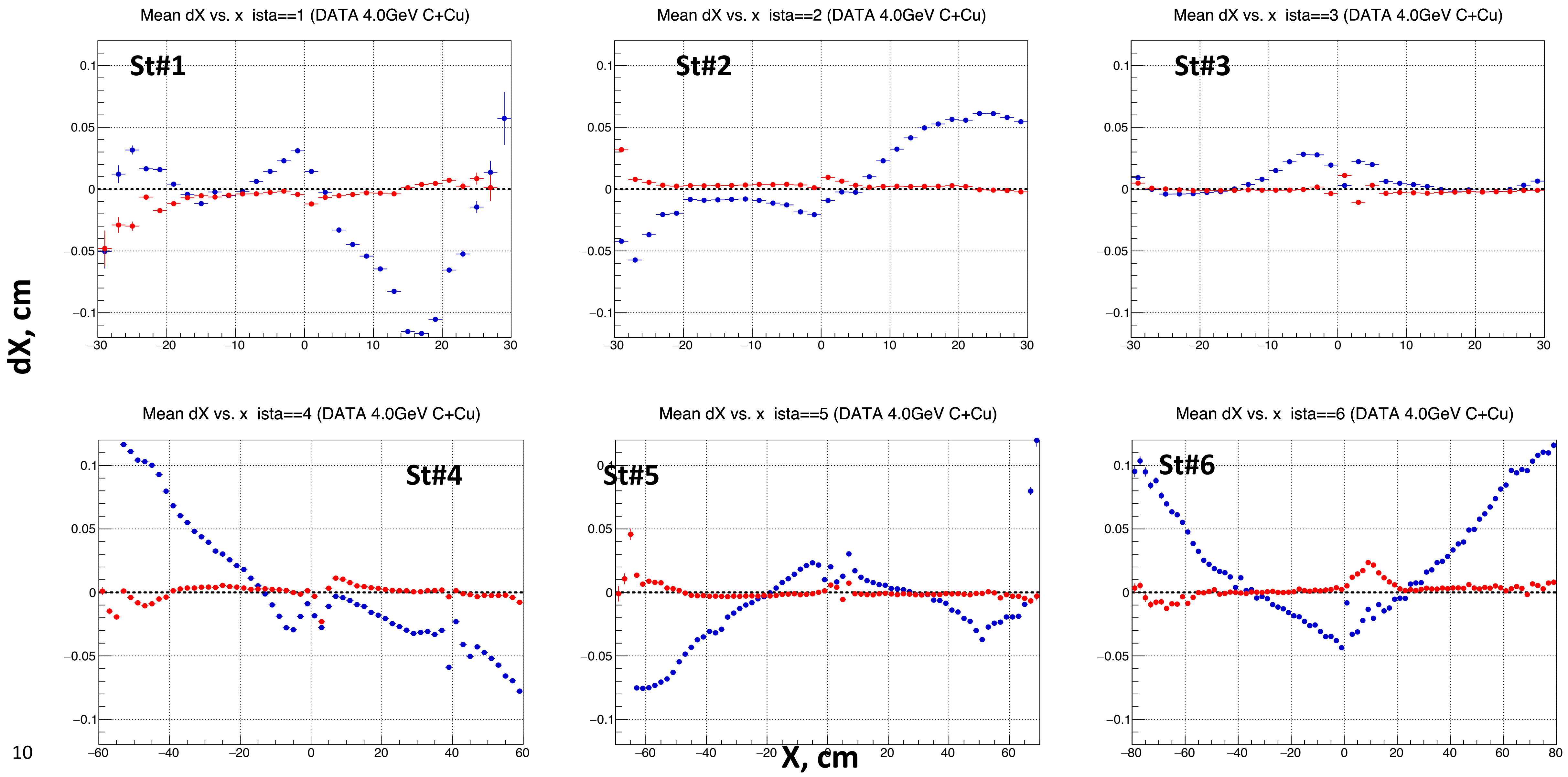
Check residuals MC DX vs.X (4.0GeV CCu)



Blue: before corrections

Red: after corrections

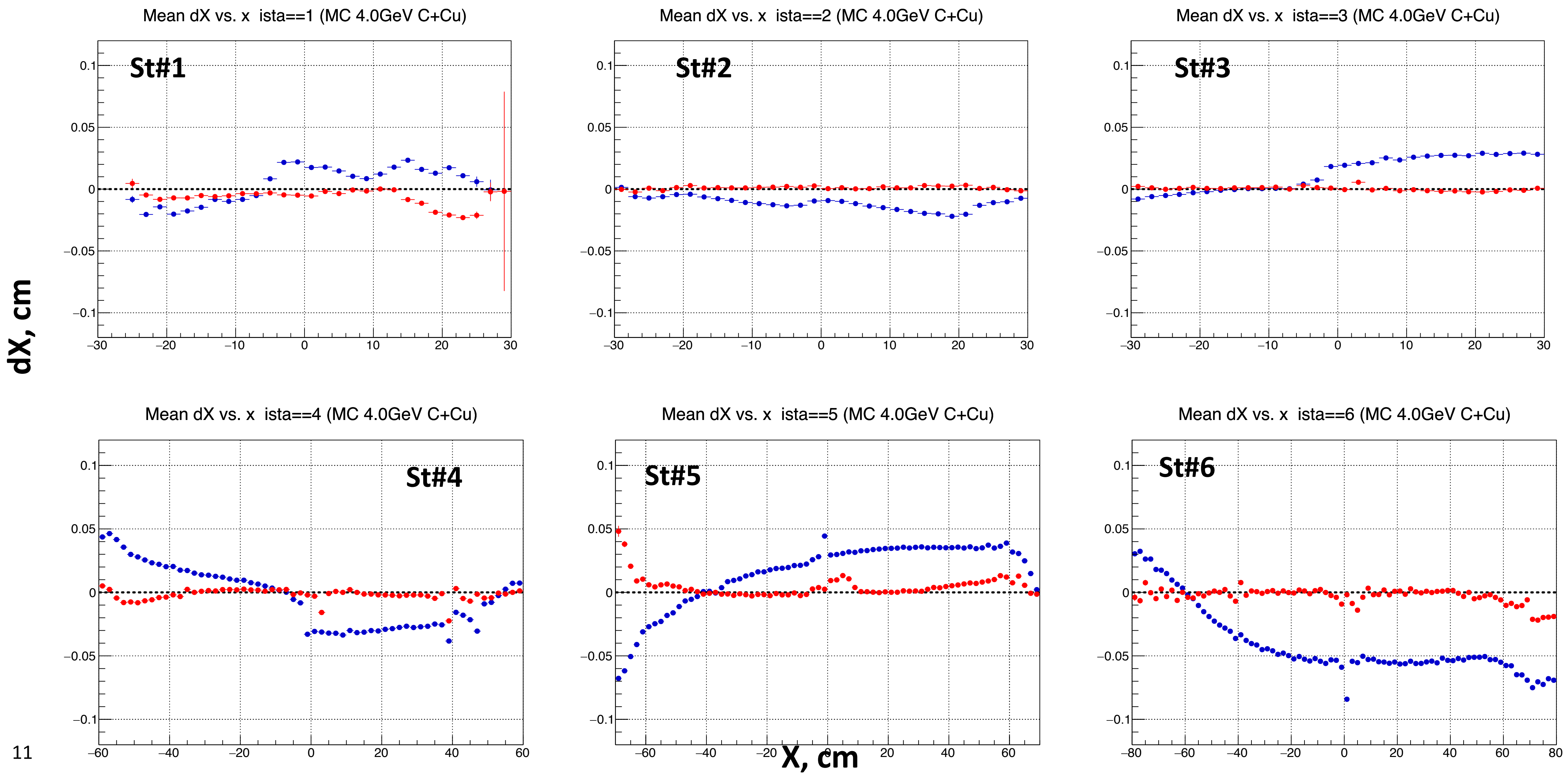
Mean Dx vs x (DATA 4.0GeV C+Cu)



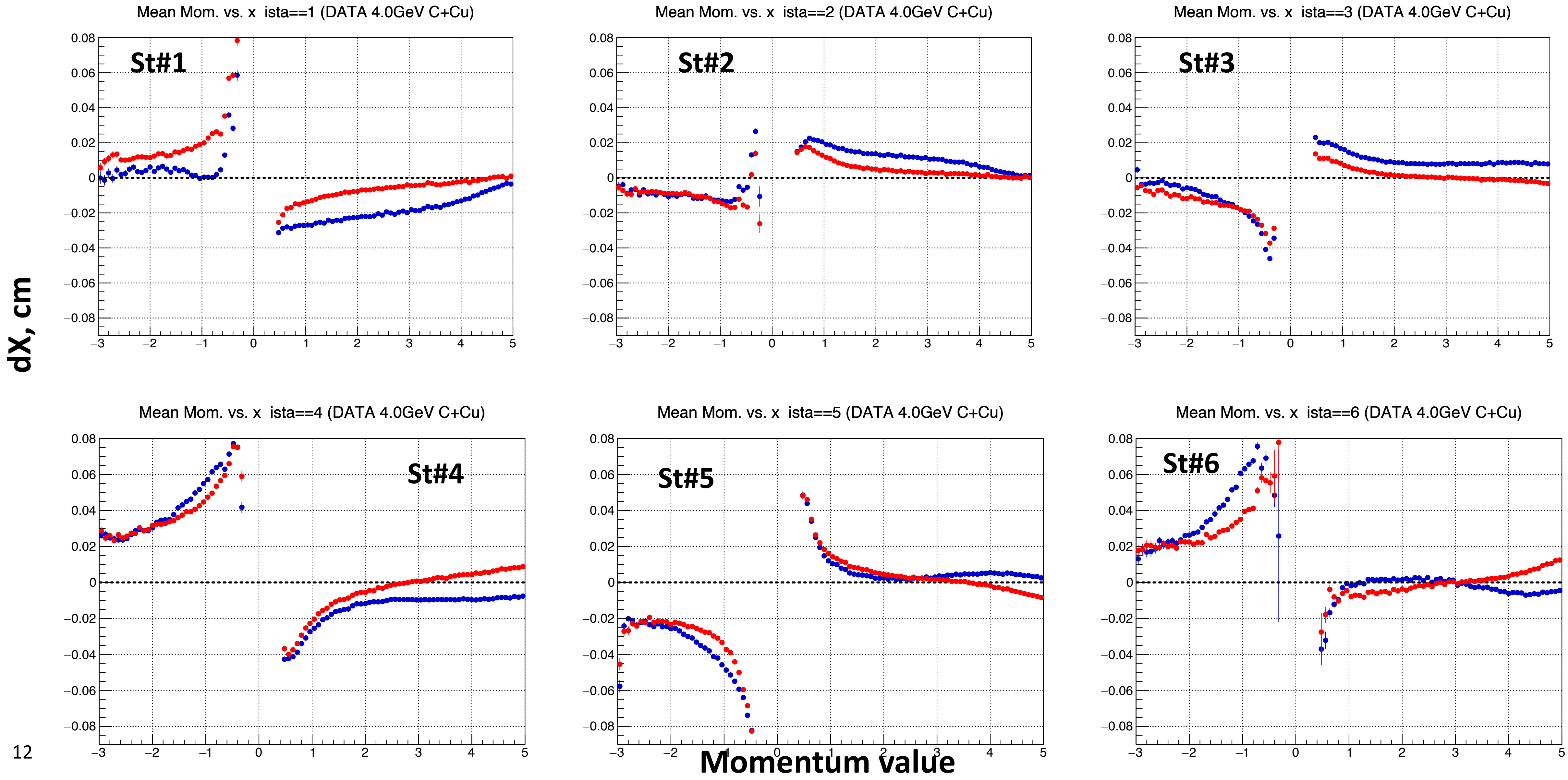
Blue: before corrections

Red: after corrections

Mean Dx vs x (MC 4.0GeV C+Cu)

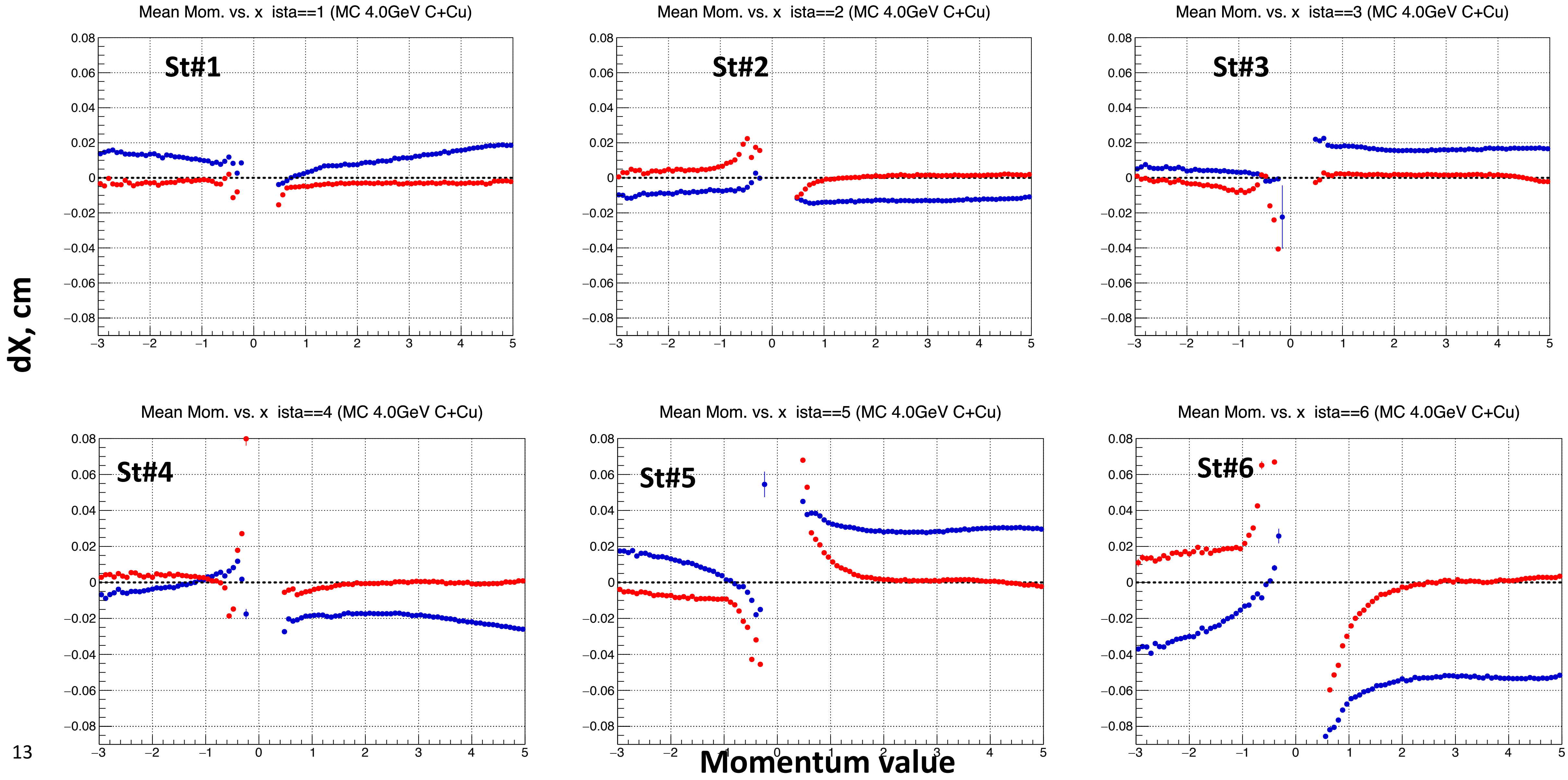


Mean Dx vs Momentum (DATA 4.0GeV C+Cu)



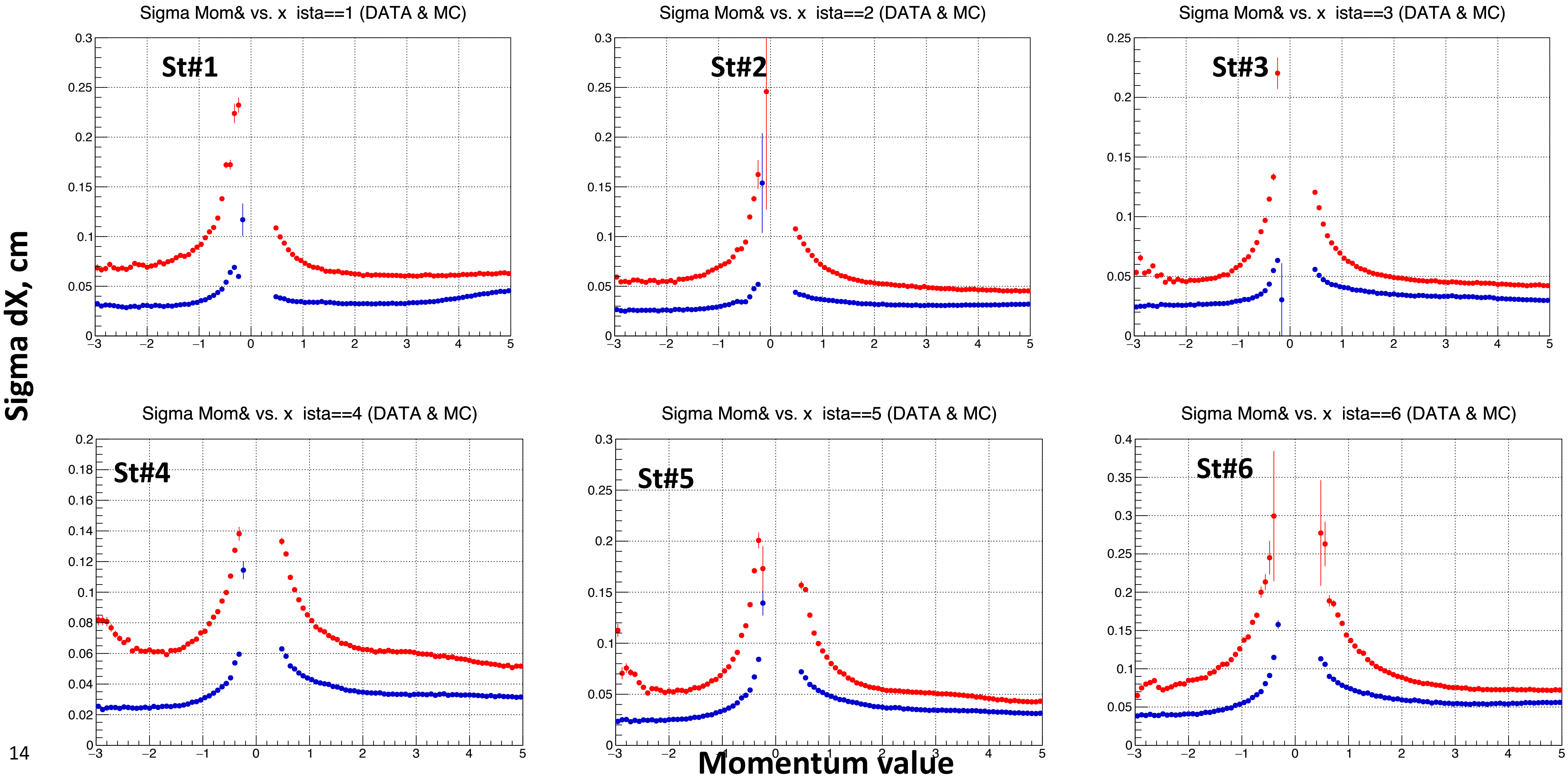
Blue: before corrections
Red: after corrections

Mean Dx vs Momentum (MC 4.0GeV C+Cu)

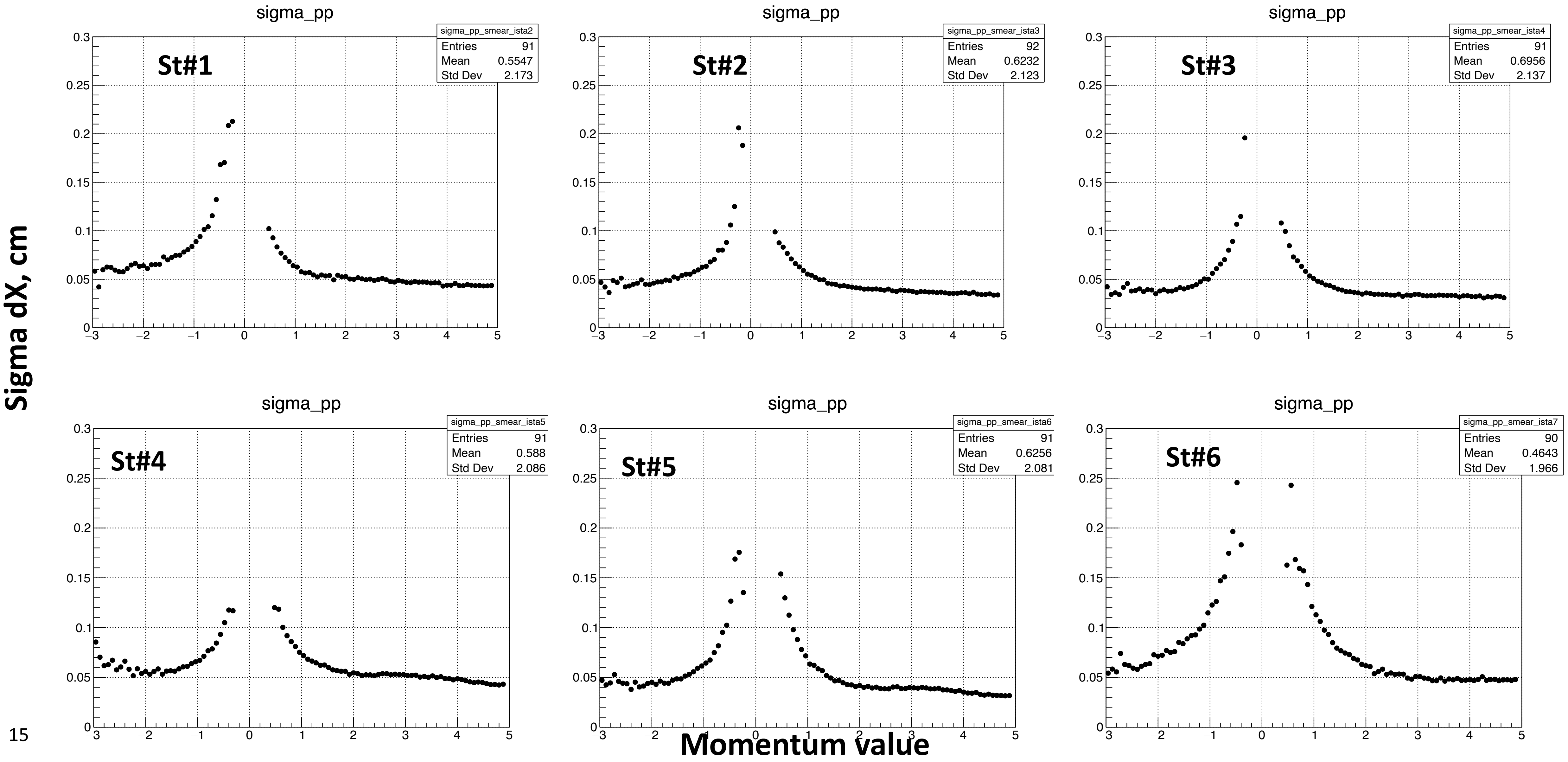


Blue: MC
Red: DATA

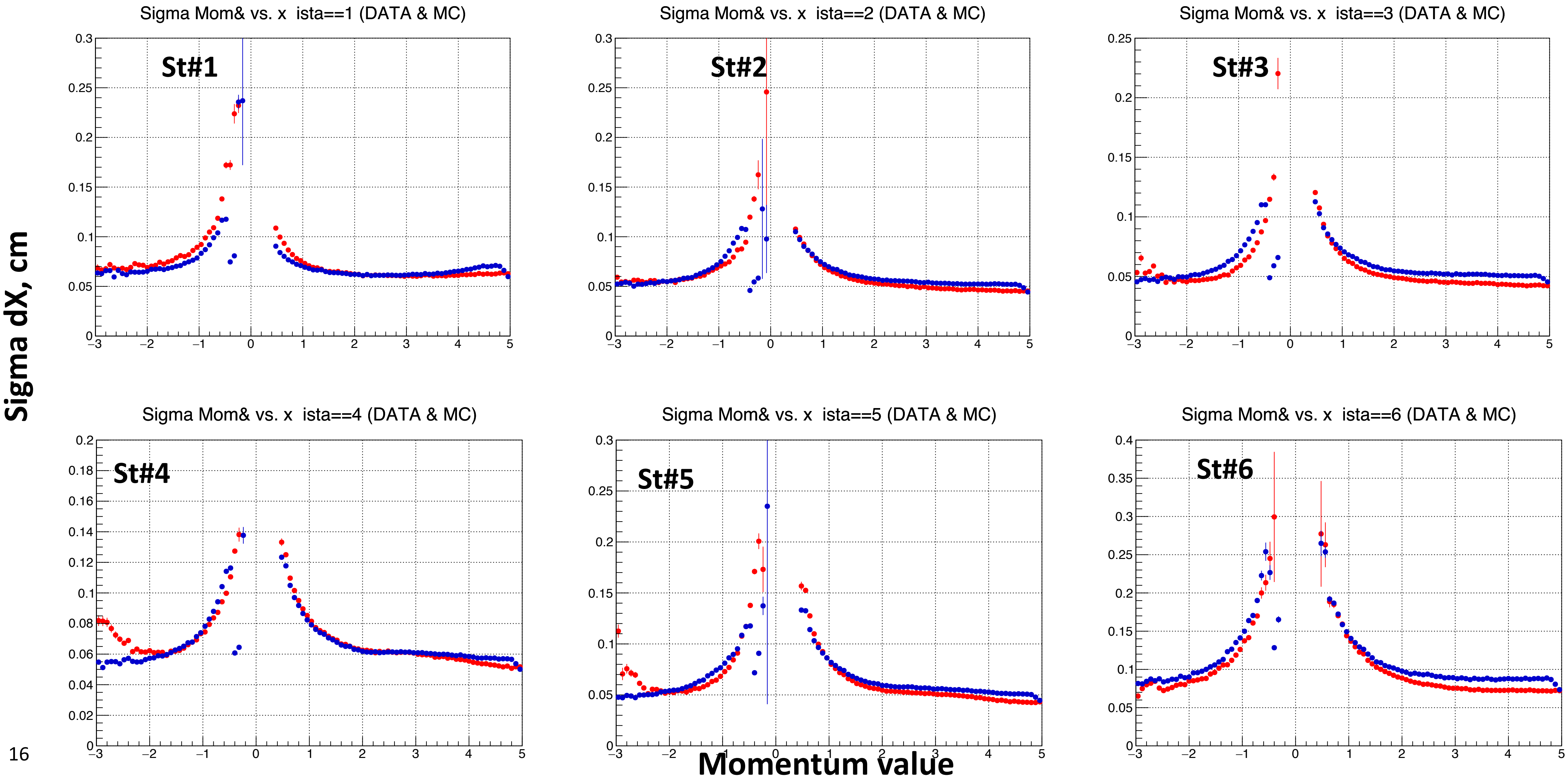
Sigma Dx vs Momentum (MC & Data 4.0GeV C+Cu)



MC Smearing functions (Sigma Dx vs Momentum): $\sigma_{SMEAR} = \sqrt{\sigma^2_{DATA} - \sigma^2_{MC}}$

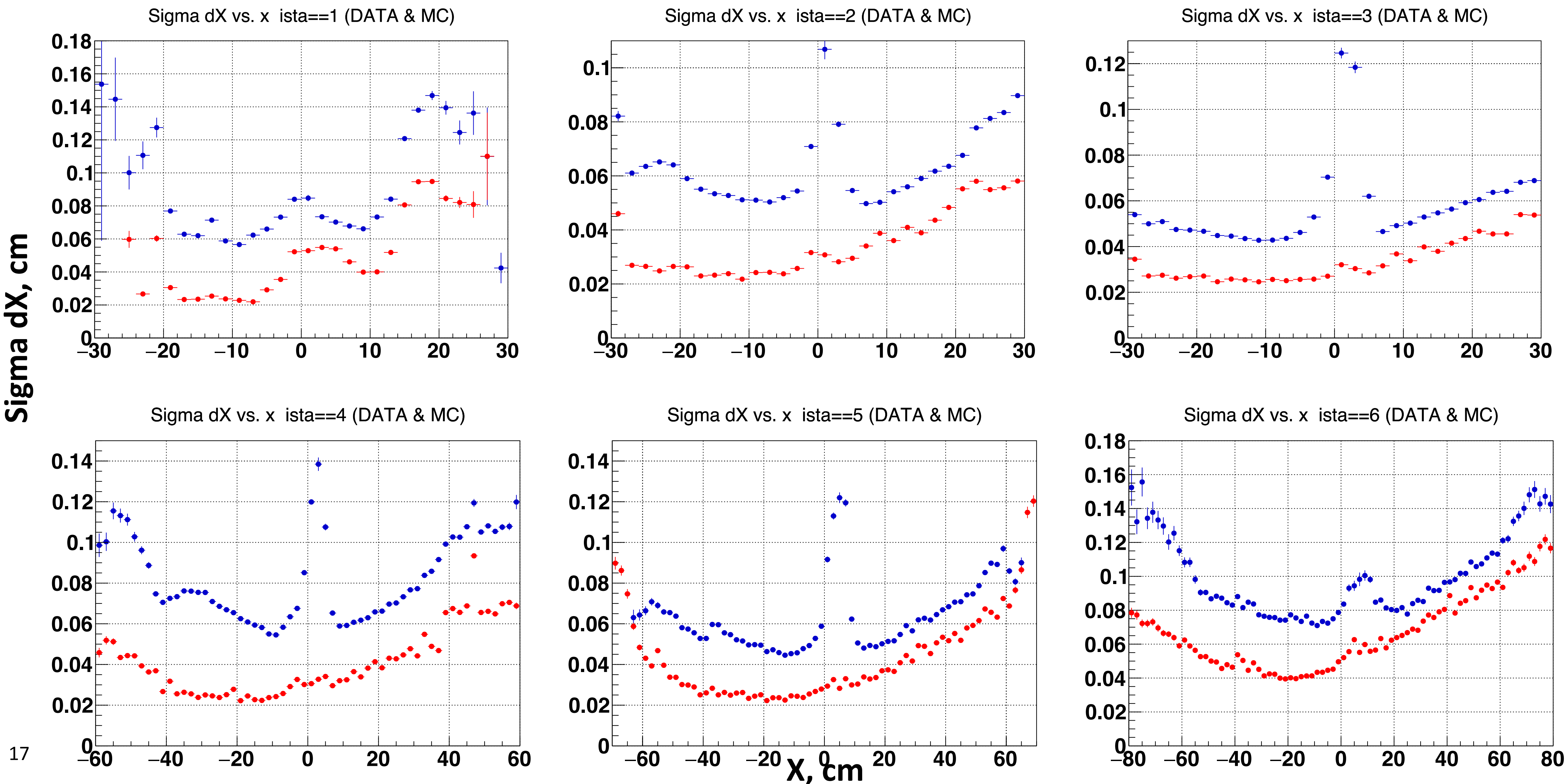


Sigma Dx vs Momentum after smearing (DATA & MC 4.0GeV C+Cu)



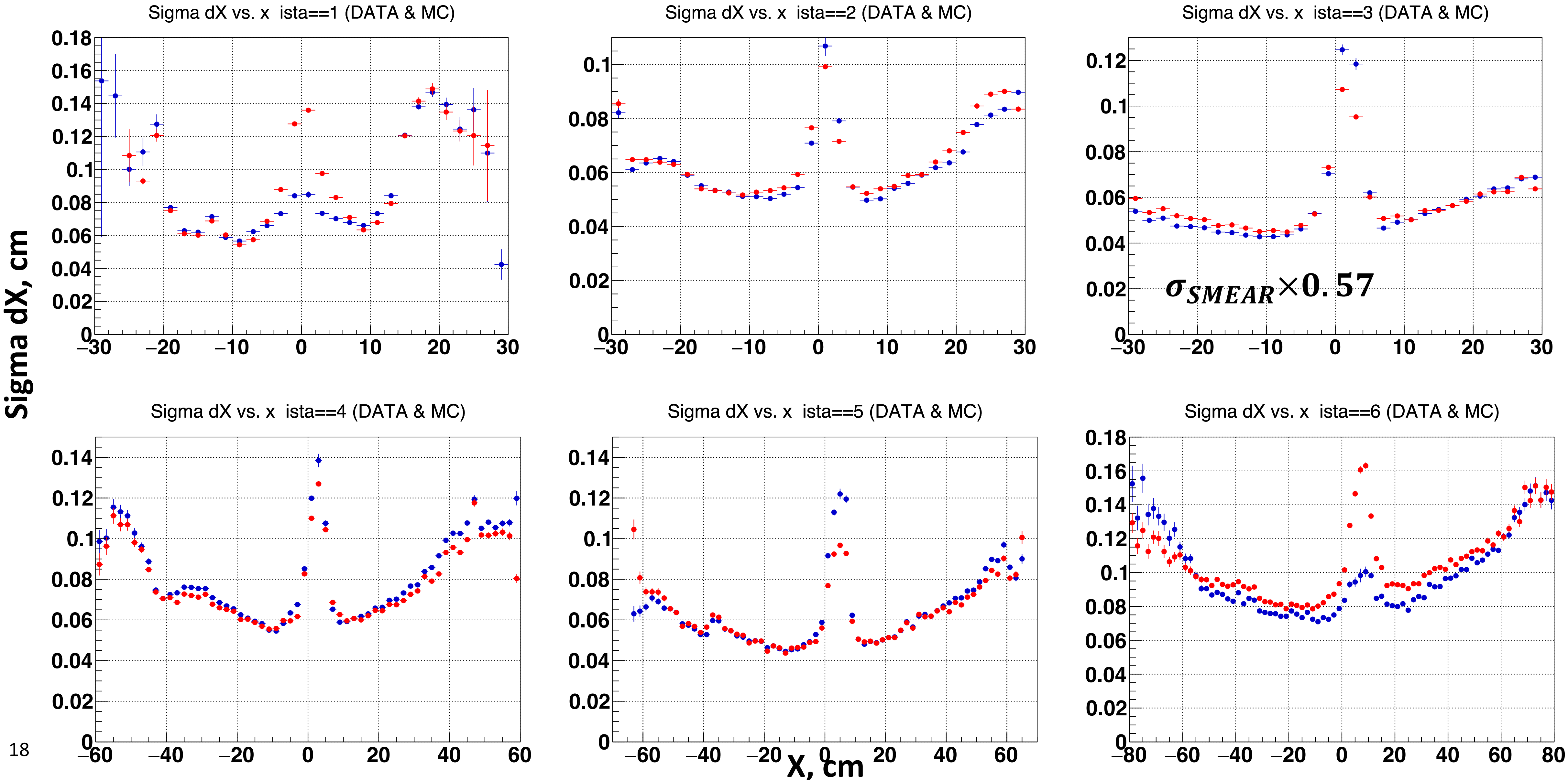
Sigma Dx vs X comparison (DATA & MC 4.0GeV C+Cu)

Blue: DATA
Red: MC



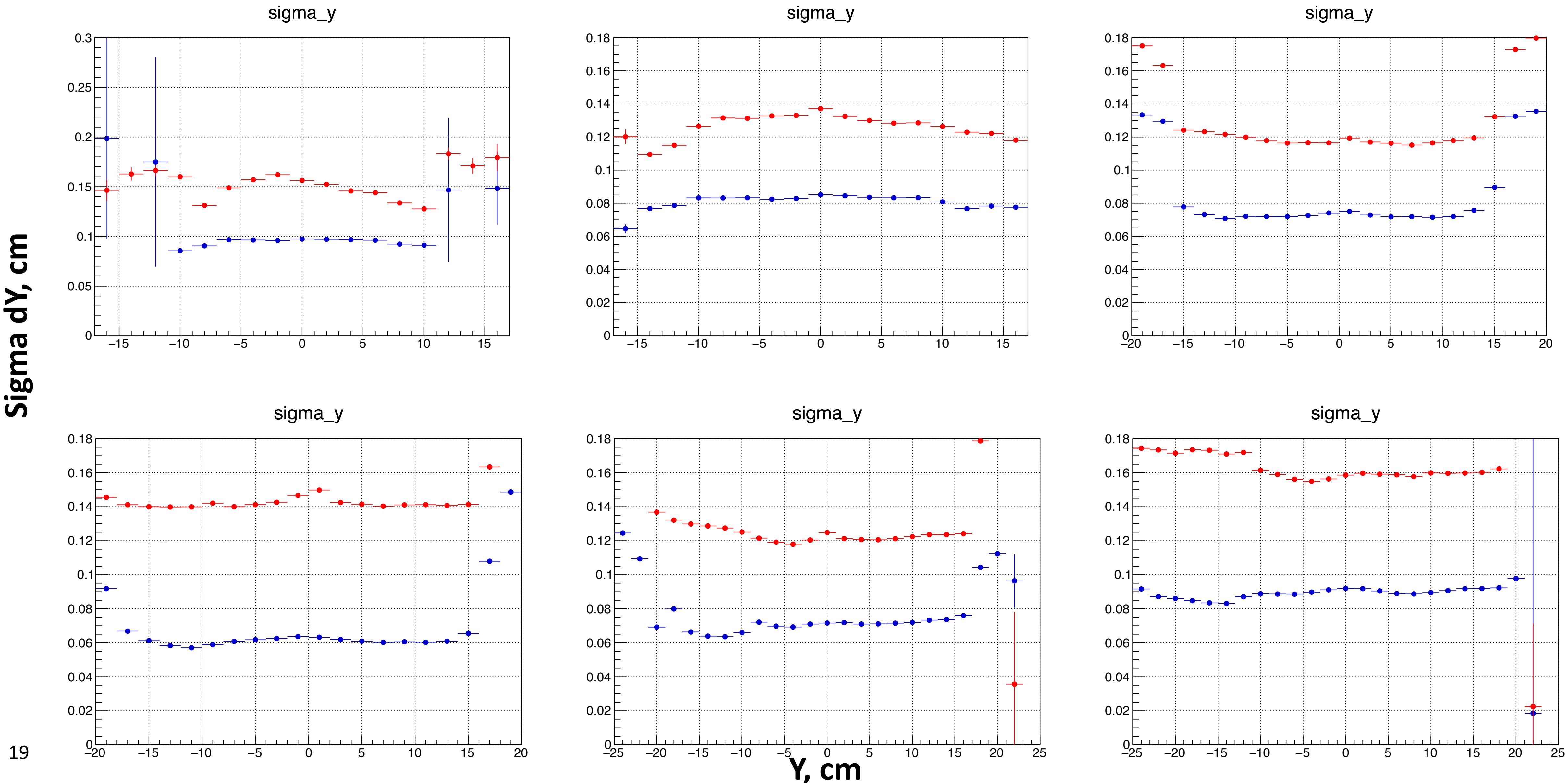
Blue: DATA
Red: MC

Sigma Dx vs X comparison after smearing (DATA & MC 4.0GeV C+Cu)



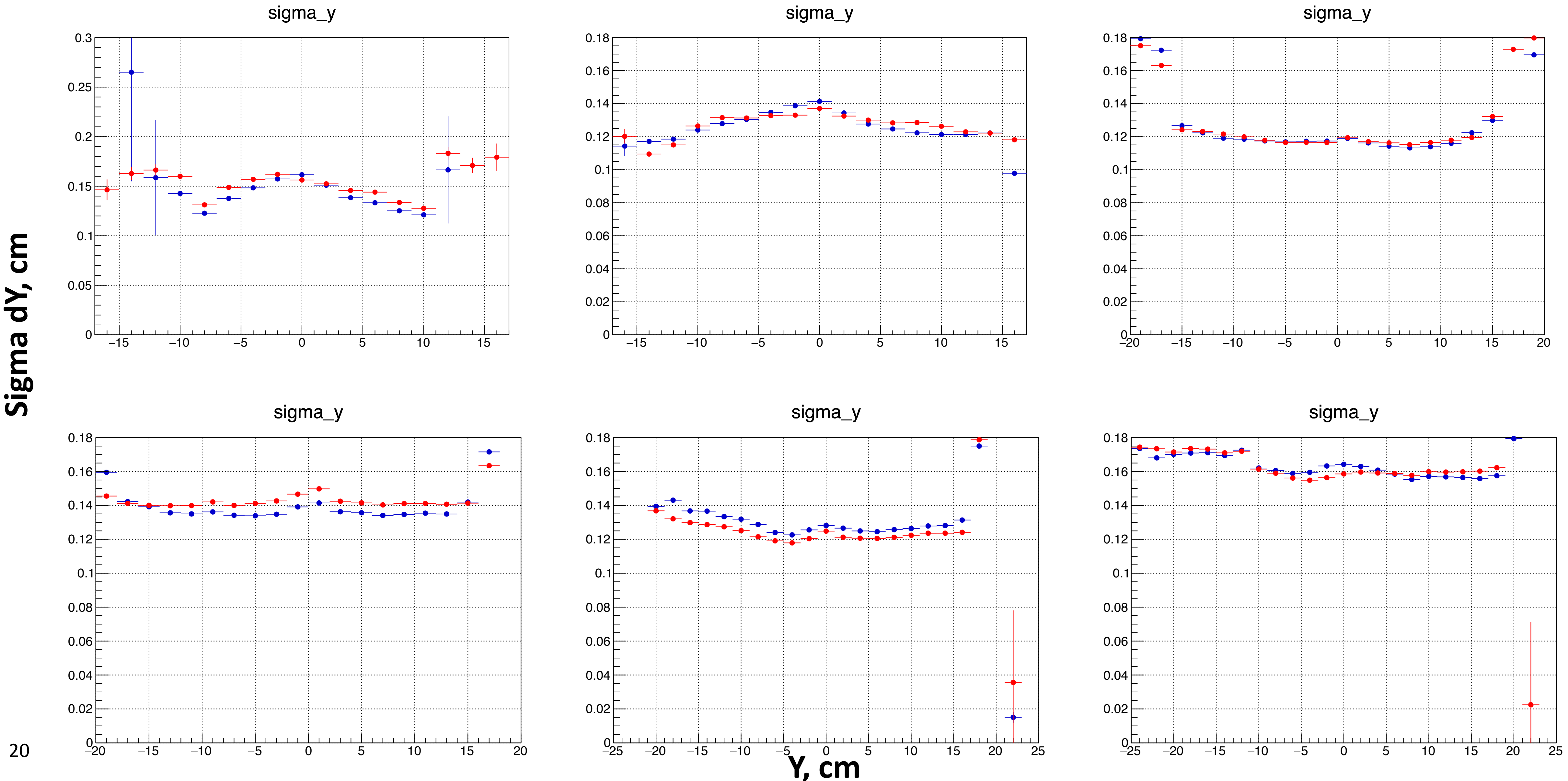
Sigma Dy vs Y comparison (DATA & MC 4.0GeV C+Cu)

Red: DATA
Blue: MC



Sigma Dy vs Y comparison after smearing (DATA & MC 4.0GeV C+Cu)

Red: DATA
Blue: MC

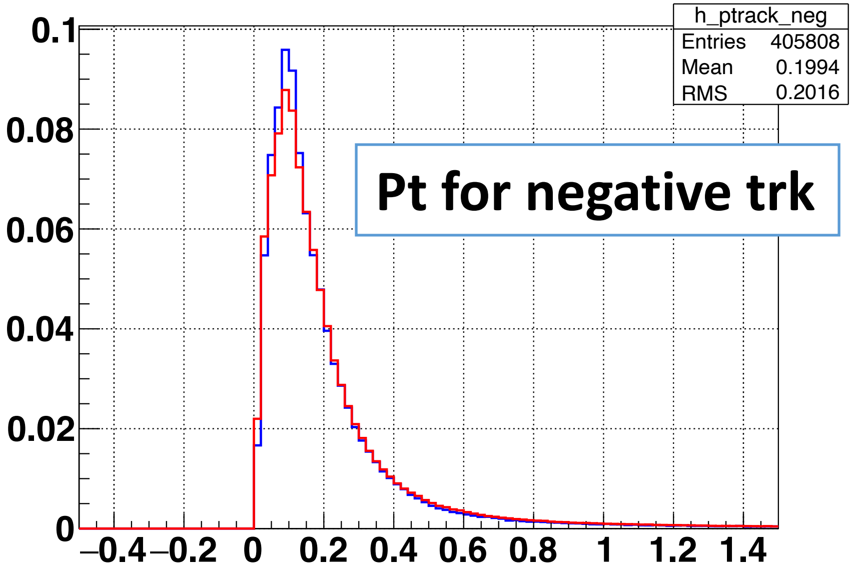


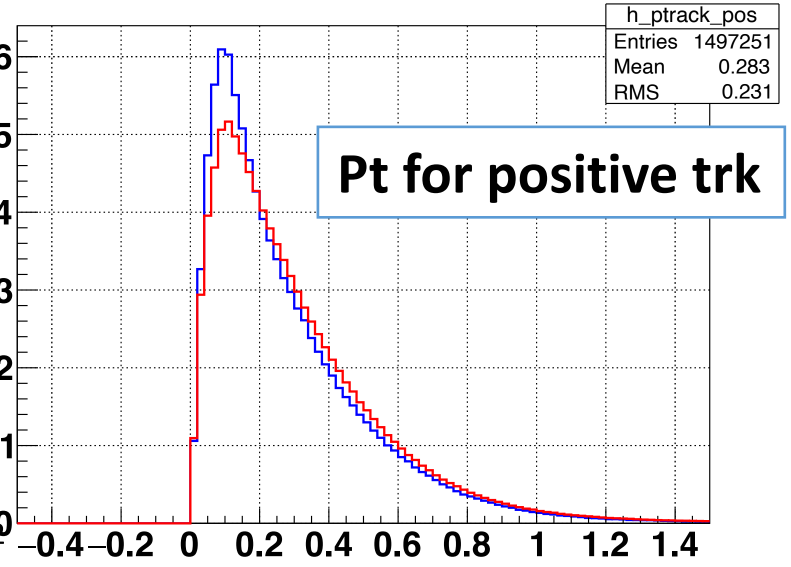
Events preselection cuts for control plots

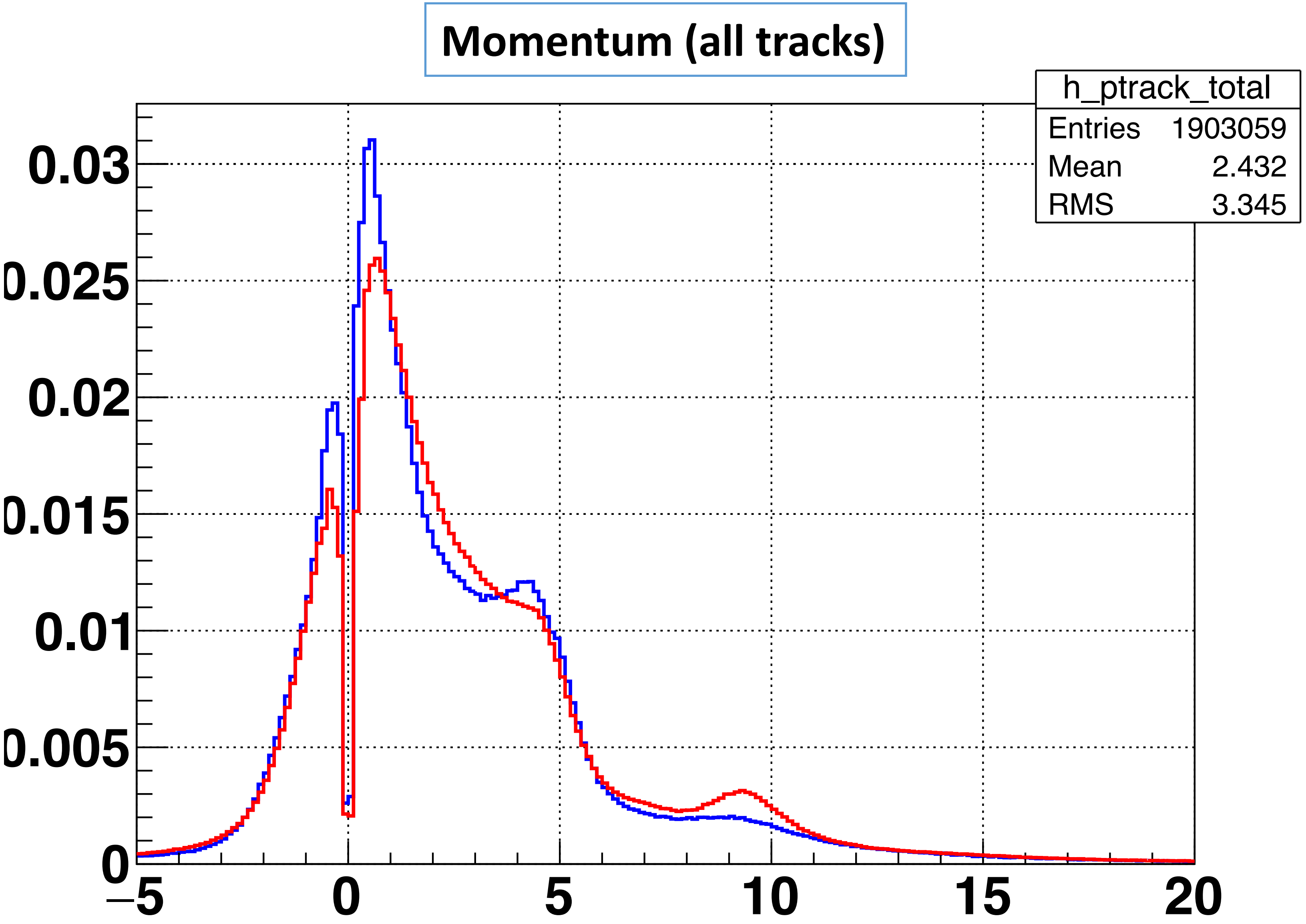
- VETO==0
- BC2Hit==1, Mod==0
- BdHit>=2
- T0Hit==1, Mod==0
- Number tracks in event >= 2
- nHits on Track >=4
- Tracks from Primary Vertex >=2
- Nstrip < 440

C+Cu (4.0 GeV) Control plots (Pt & Momentum of all tracks)

Red: Data; Blue: MC;



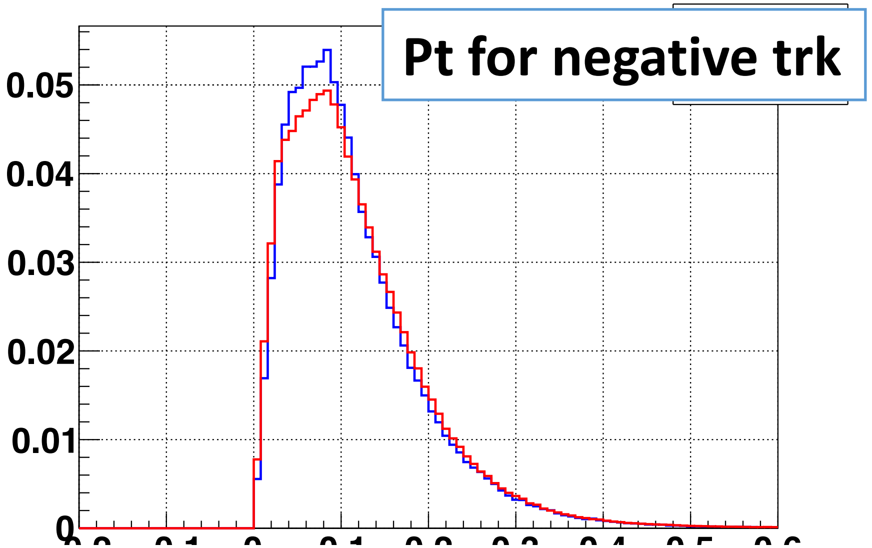


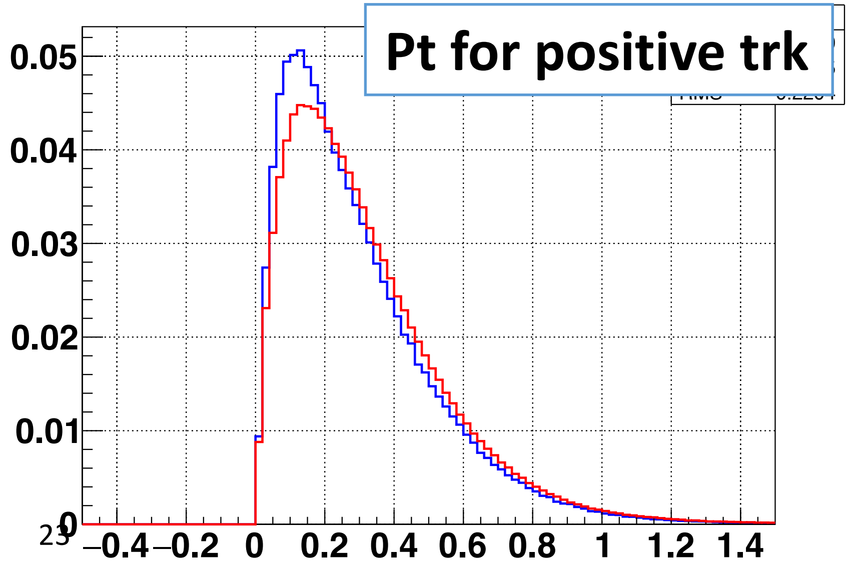


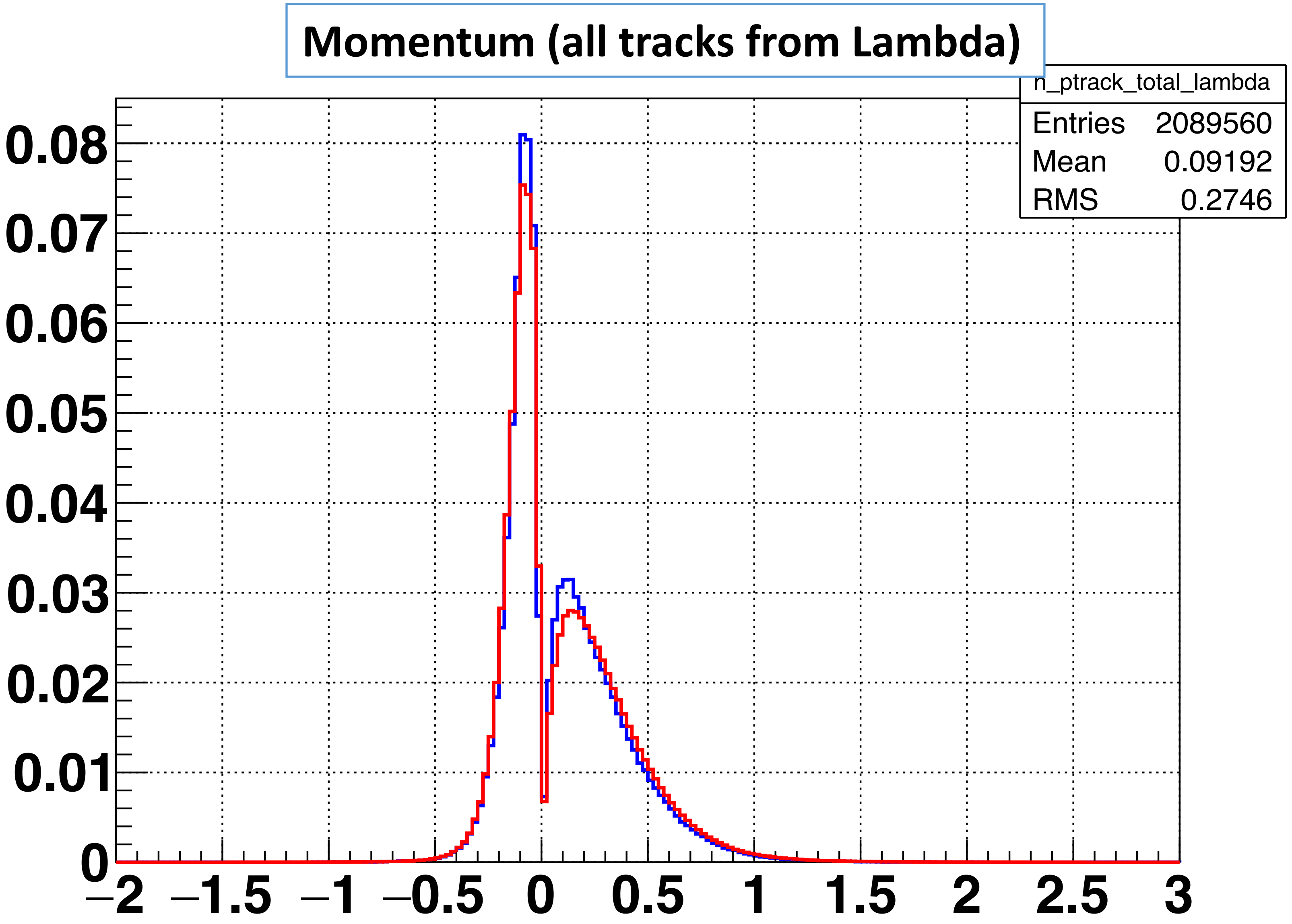
Control plots (Pt & Momentum of traks from Lambda decay)

C+Cu (4.0 GeV)

Red: Data; Blue: MC;



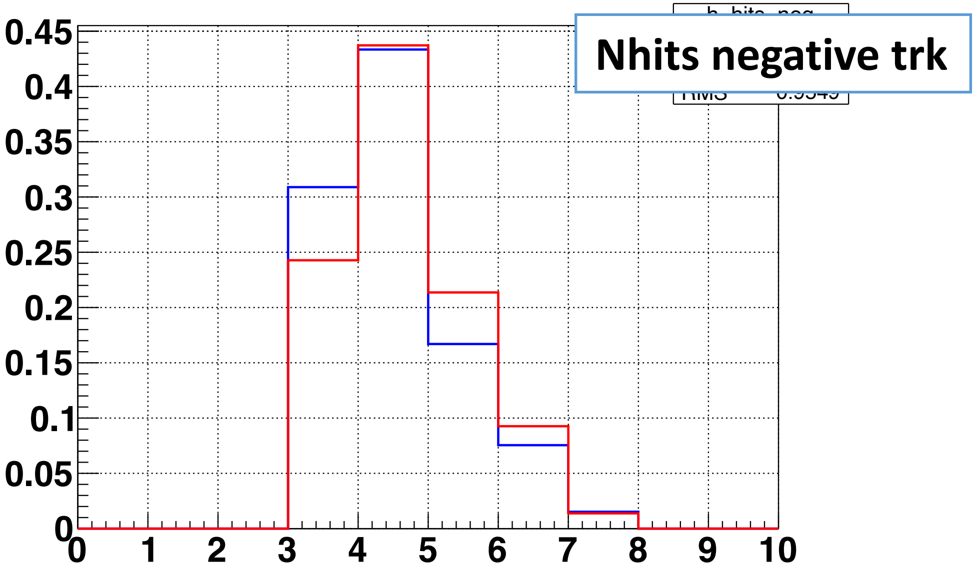


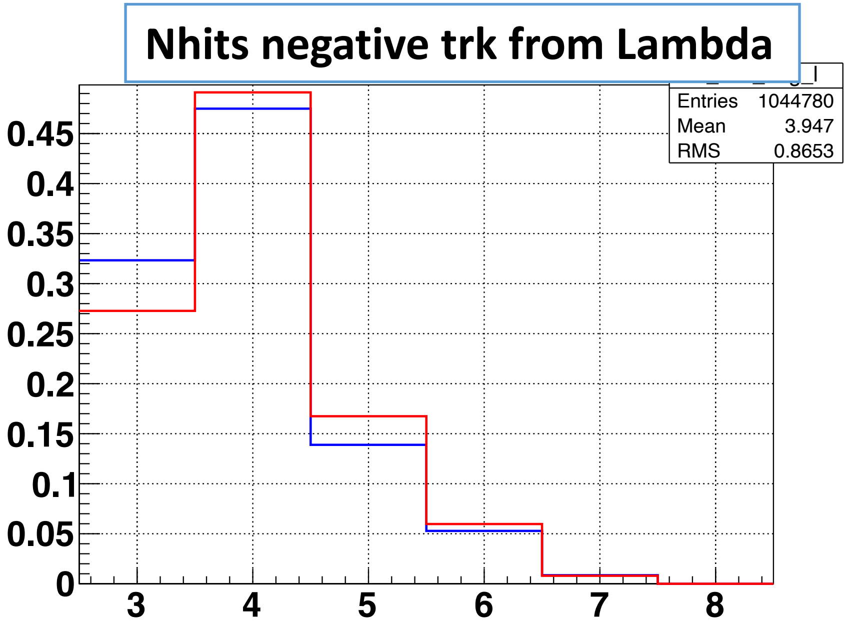


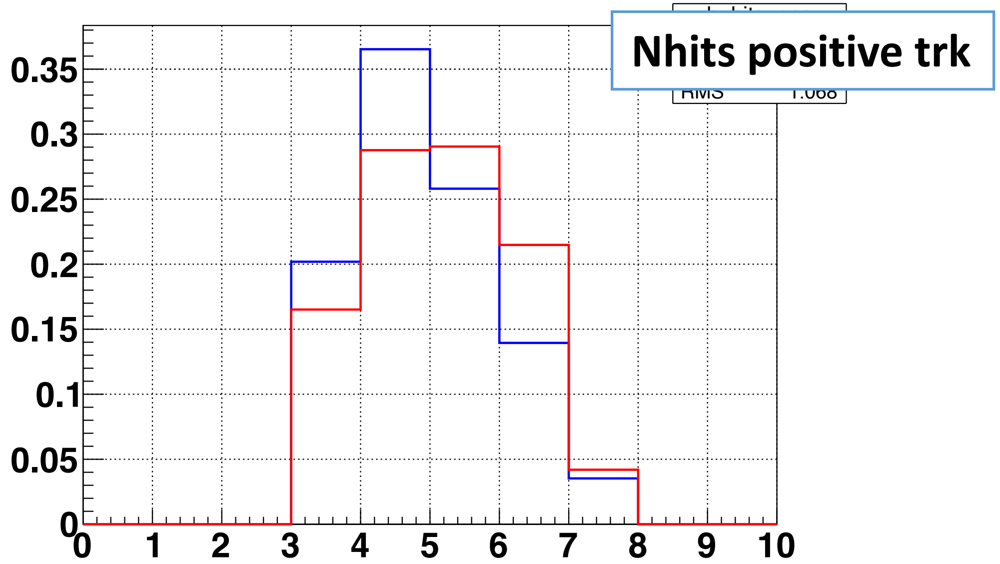
Control plots (Nhits for track)

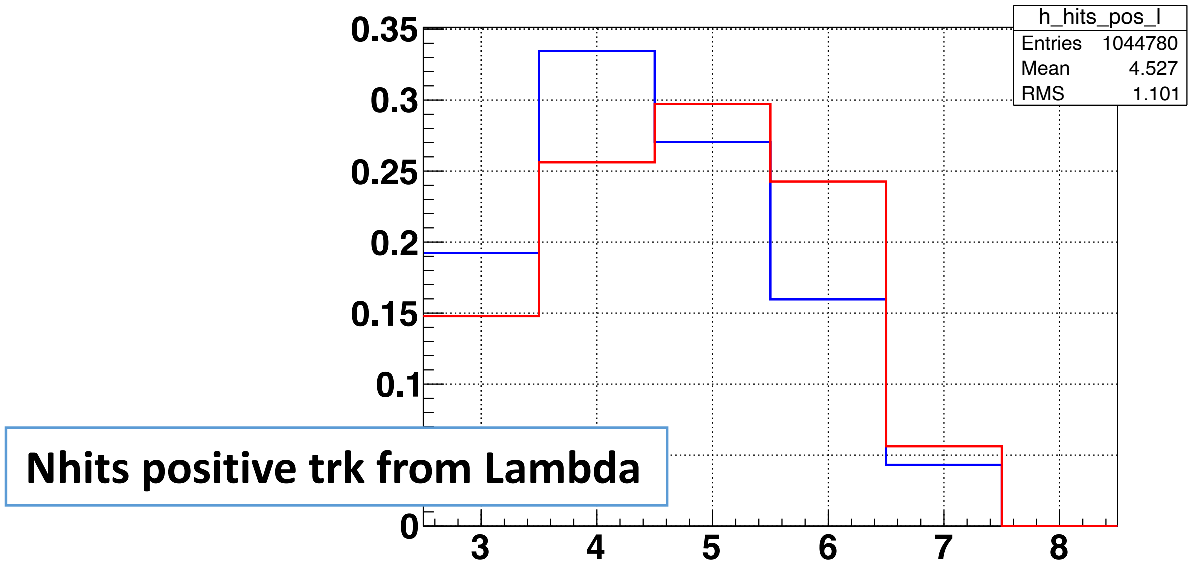
C+Cu (4.0 GeV)

Red: Data; Blue: MC;







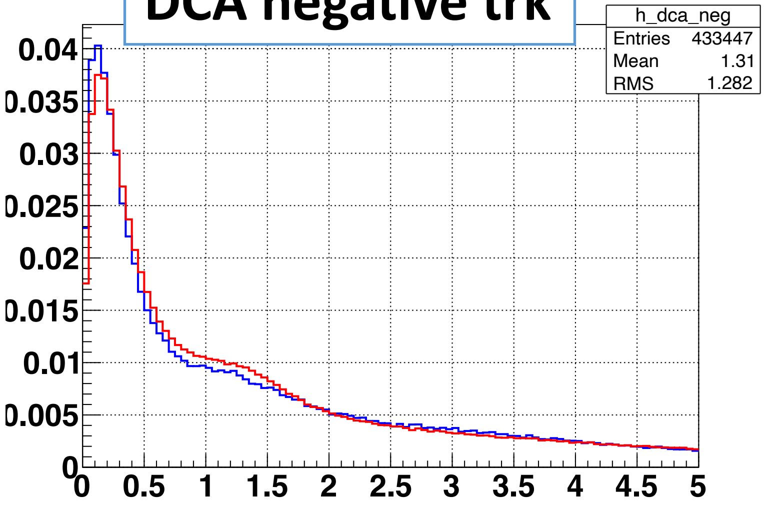


C+Cu (4.0 GeV)

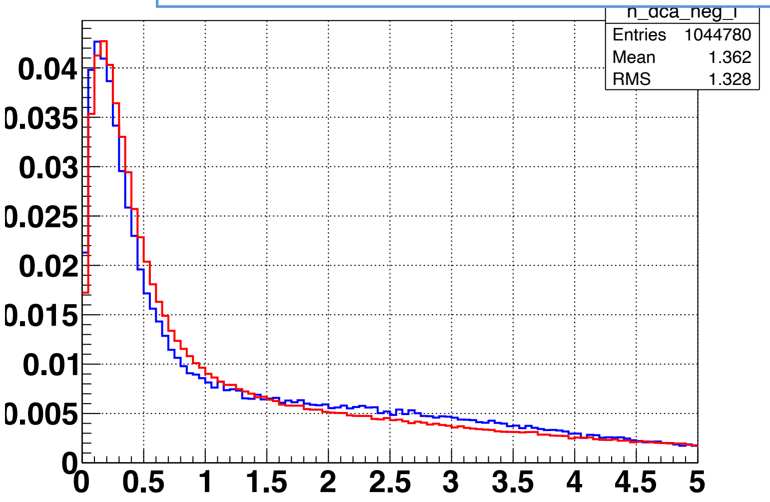
Control plots (DCA tracks to PrimVtx)

Red: Data; Blue: MC;

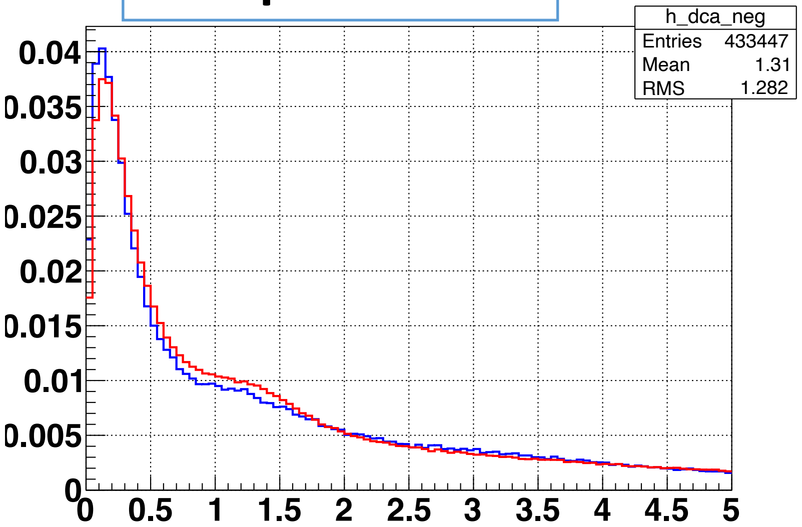
DCA negative trk



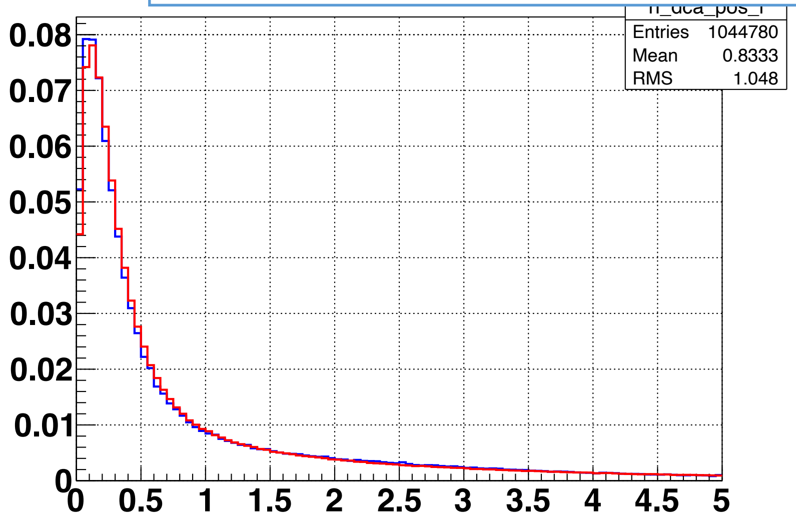
DCA negative trk from Lambda



DCA positive trk



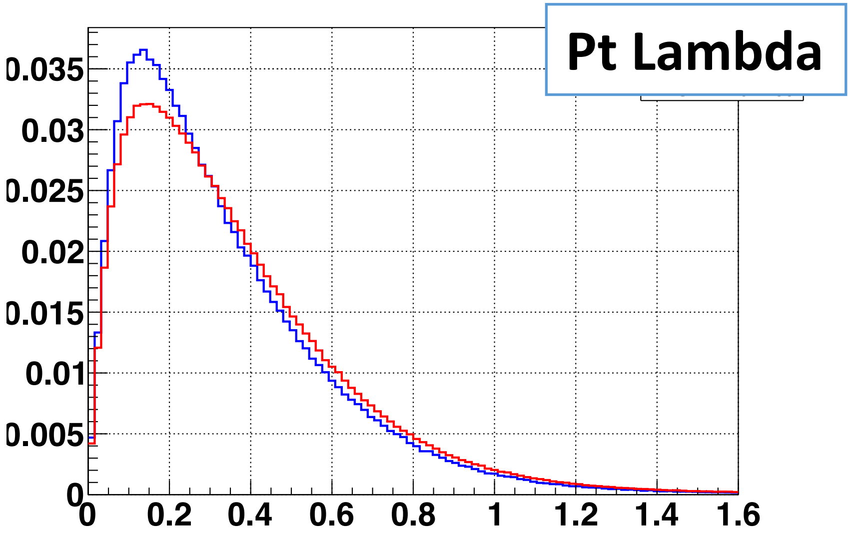
DCA positive trk from Lambda

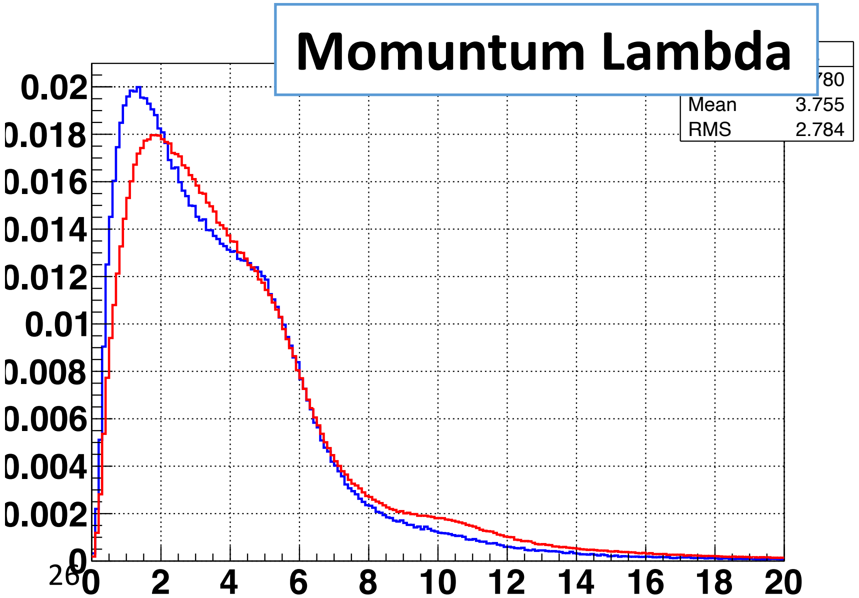


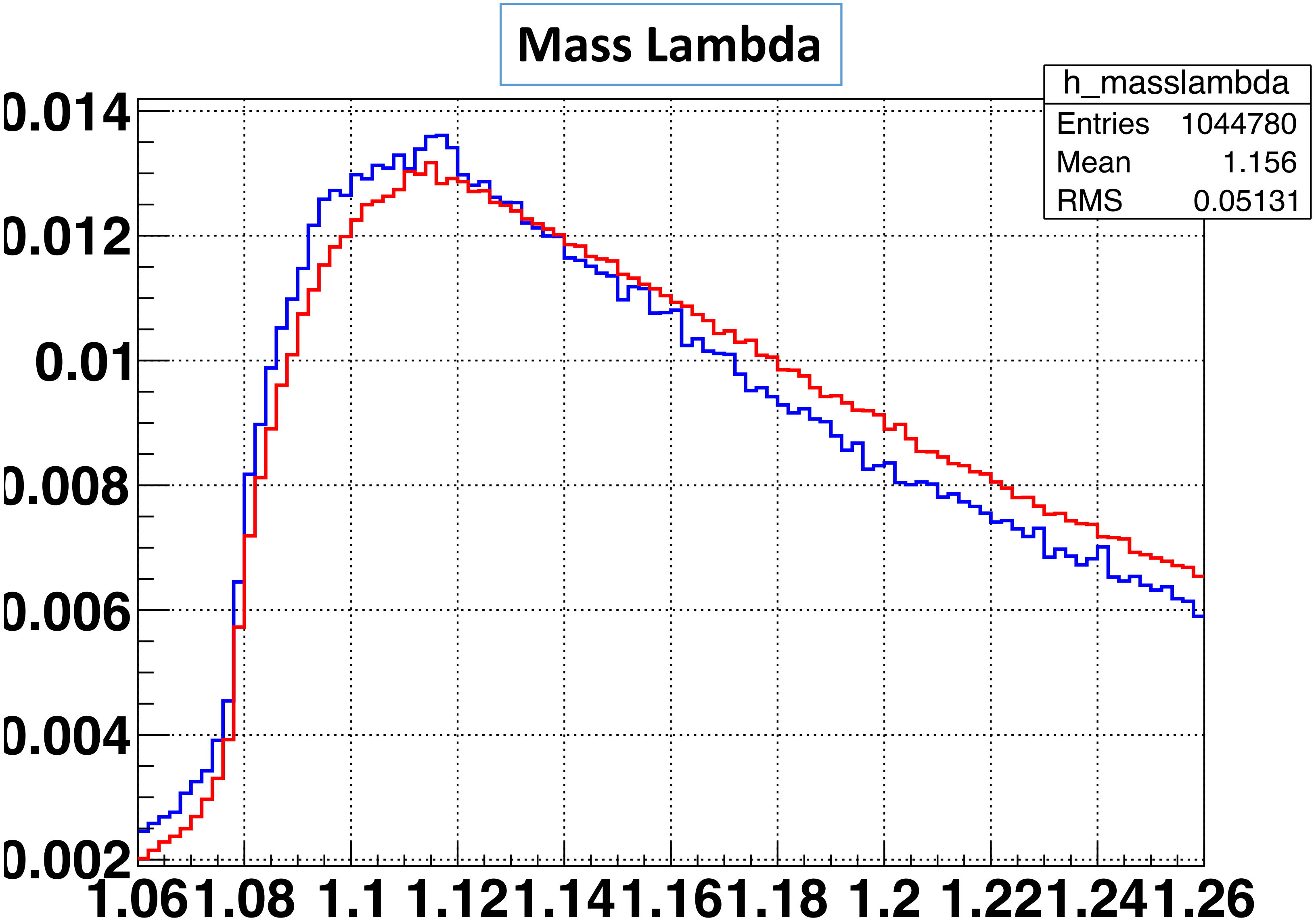
Control plots (Pt, Momentum & Mass of Lambda)

C+Cu (4.0 GeV)

Red: Data; Blue: MC;





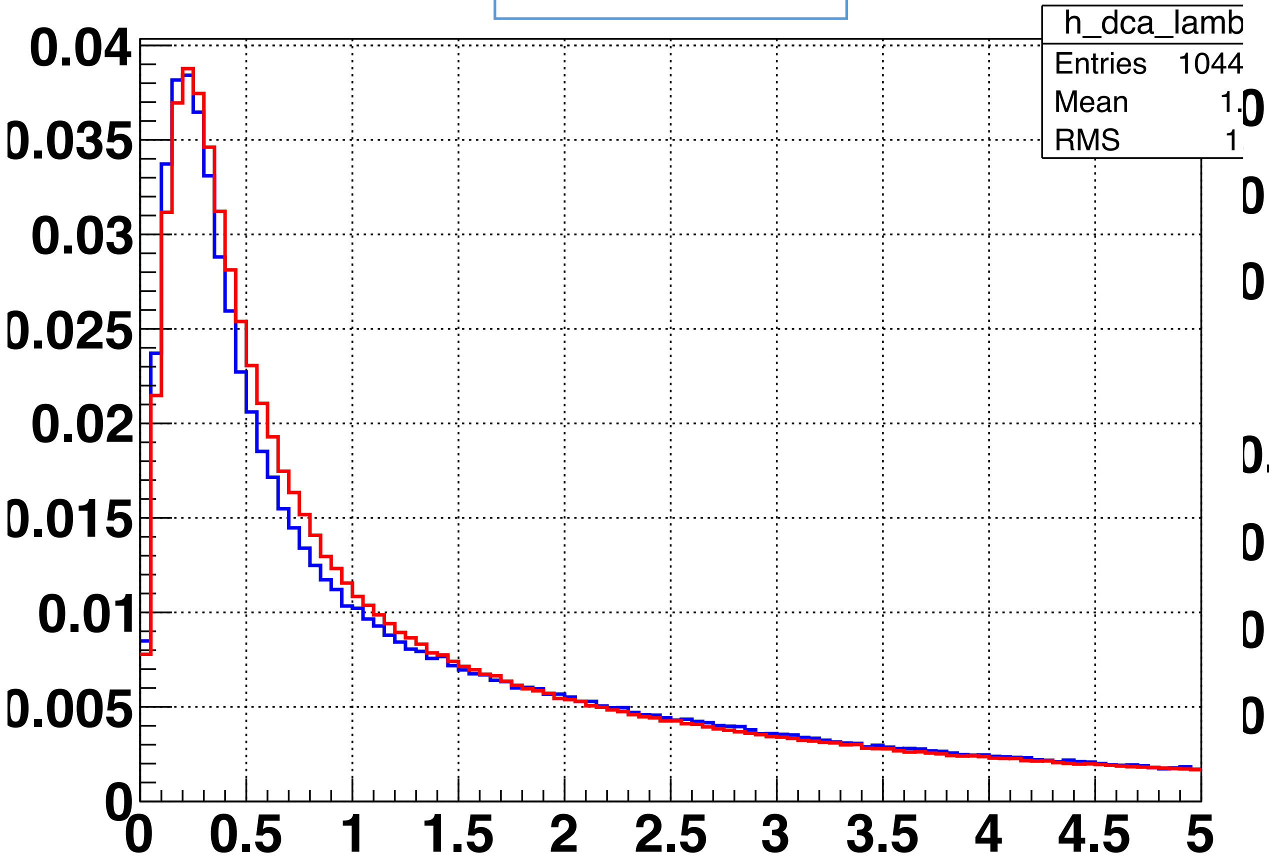


C+Cu (4.0 GeV)

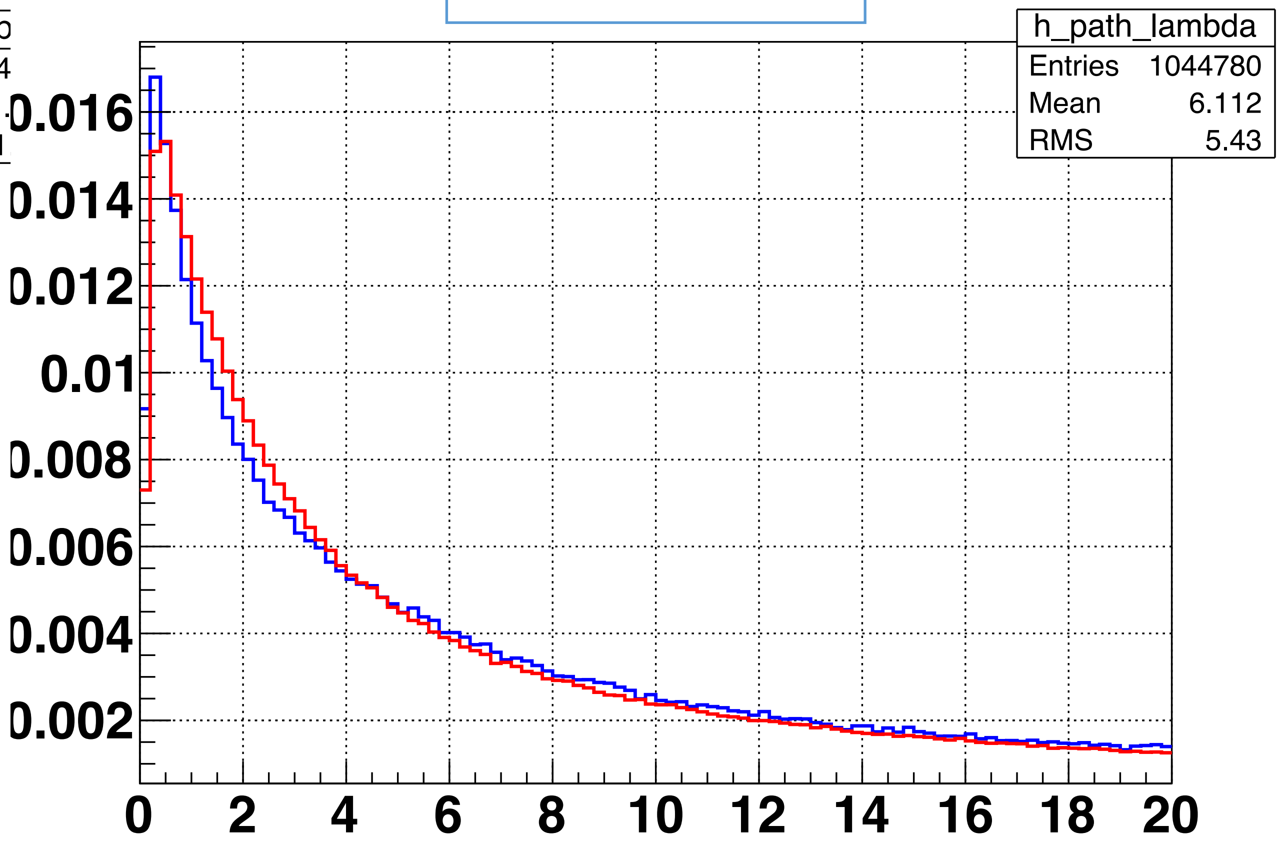
Control plots (DCA & PATH of Lambda)

Red: Data; Blue: MC;

DCA Lambda



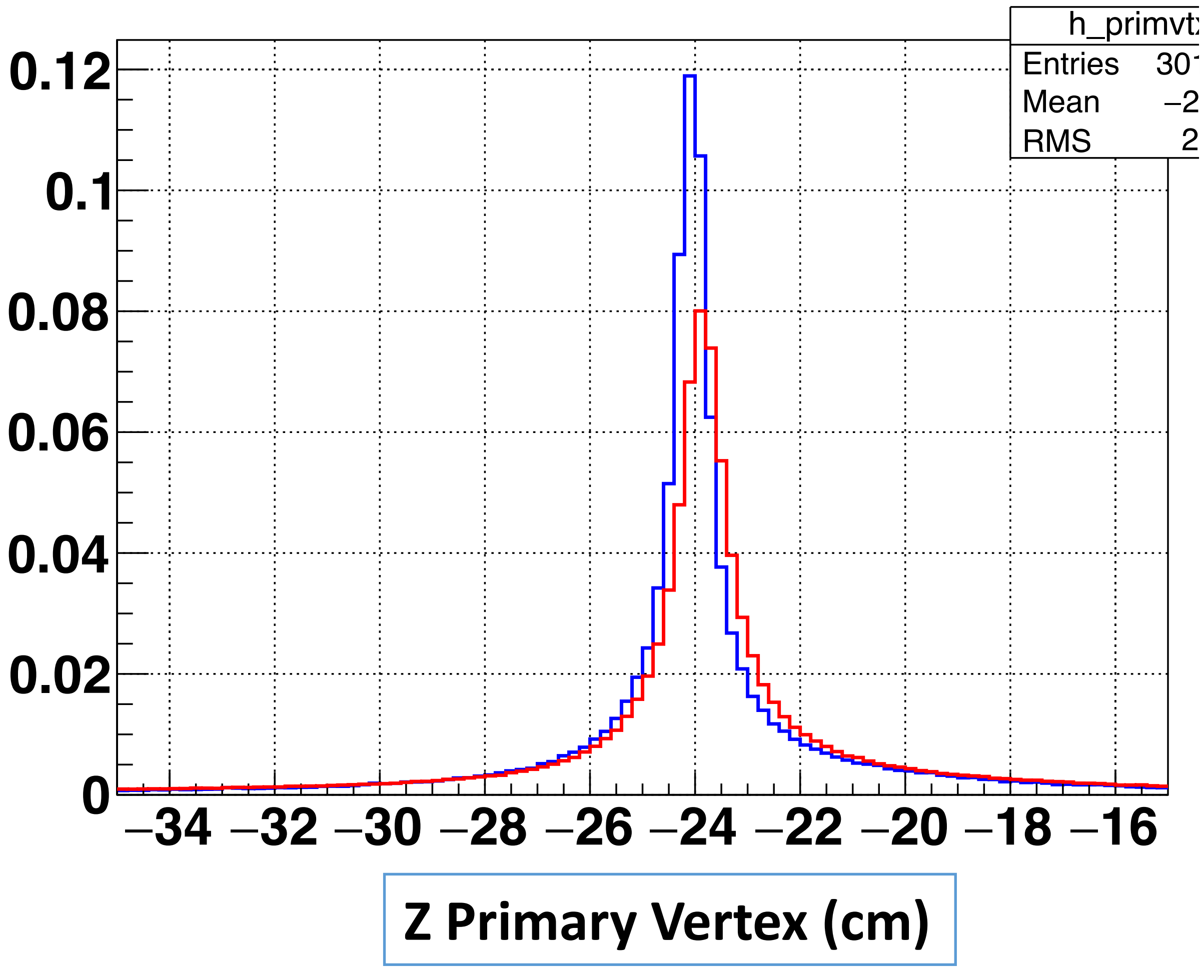
PATH Lambda

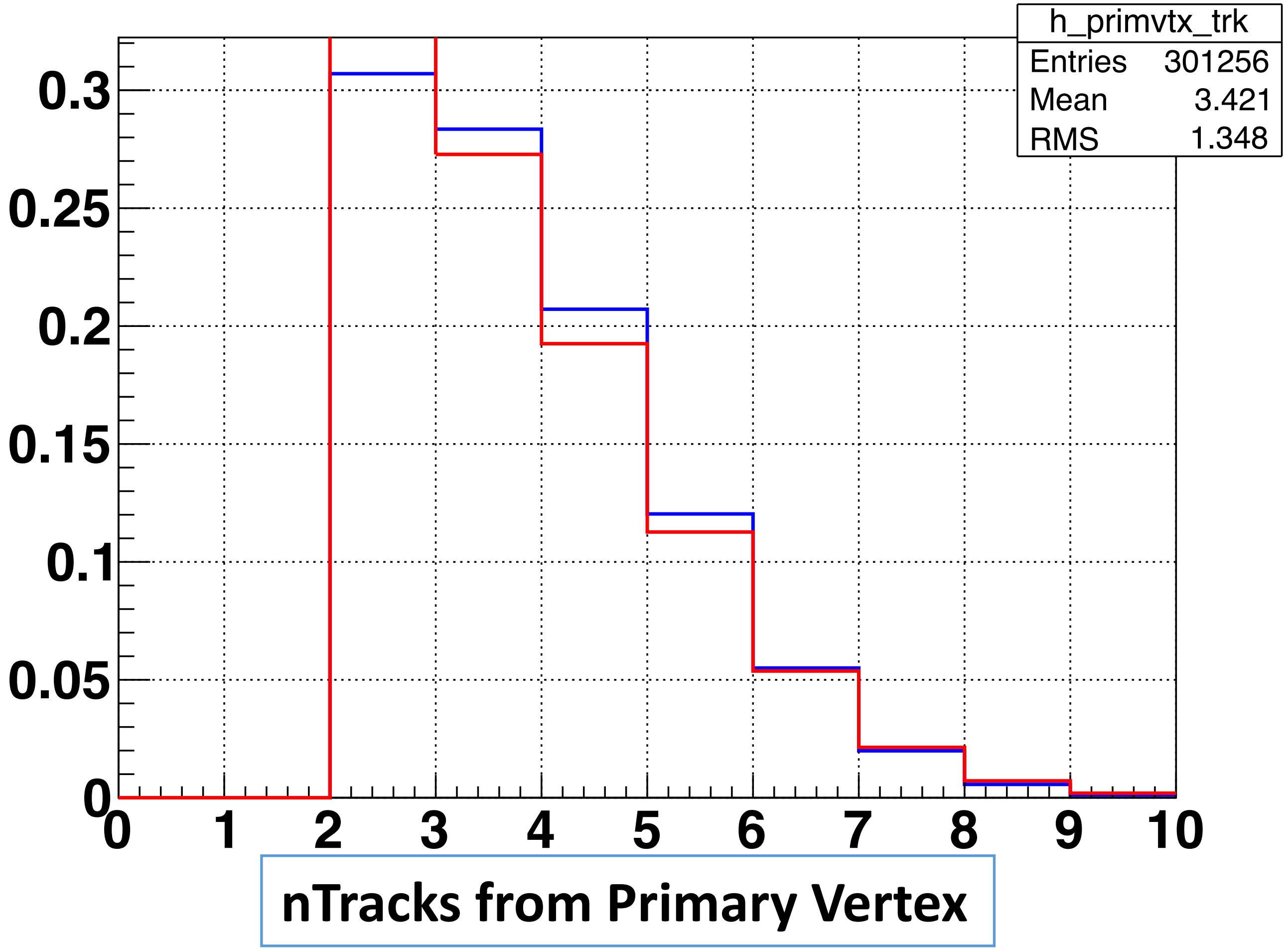


C+Cu (4.0 GeV)

Control plots (Primary Vertex)

Red: Data; Blue: MC;





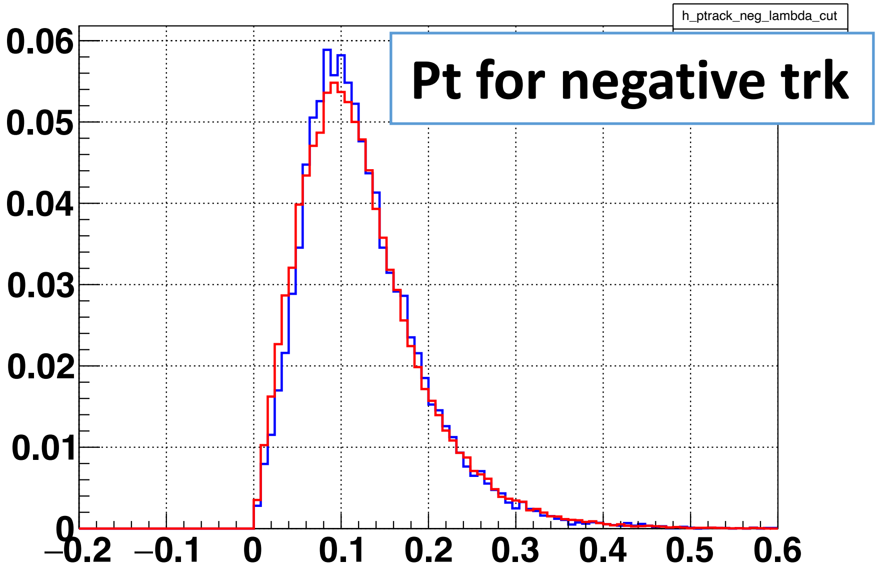
Apply additional cuts for Lambda

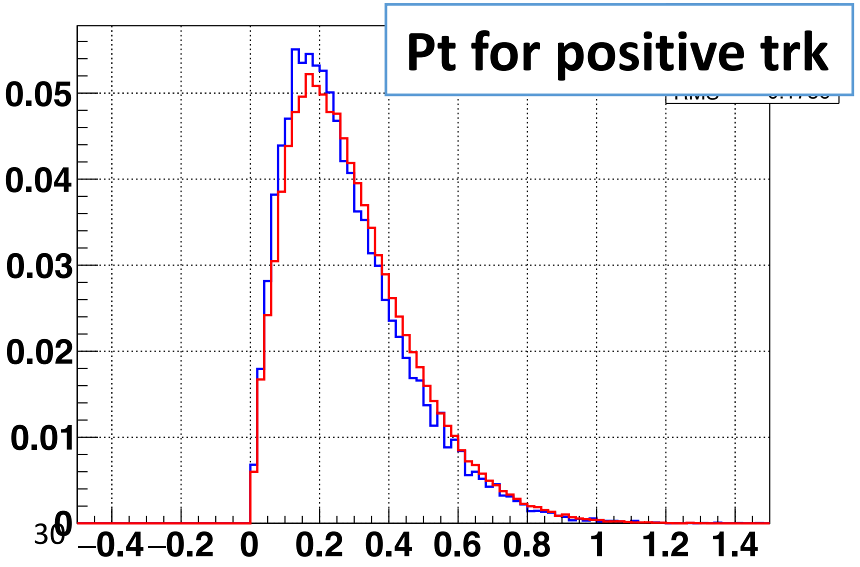
- Momentum proton track < 3.9
- Momentum pion track > 0.3
- Lambda path > 2.5
- Lambda DCA < 1.0

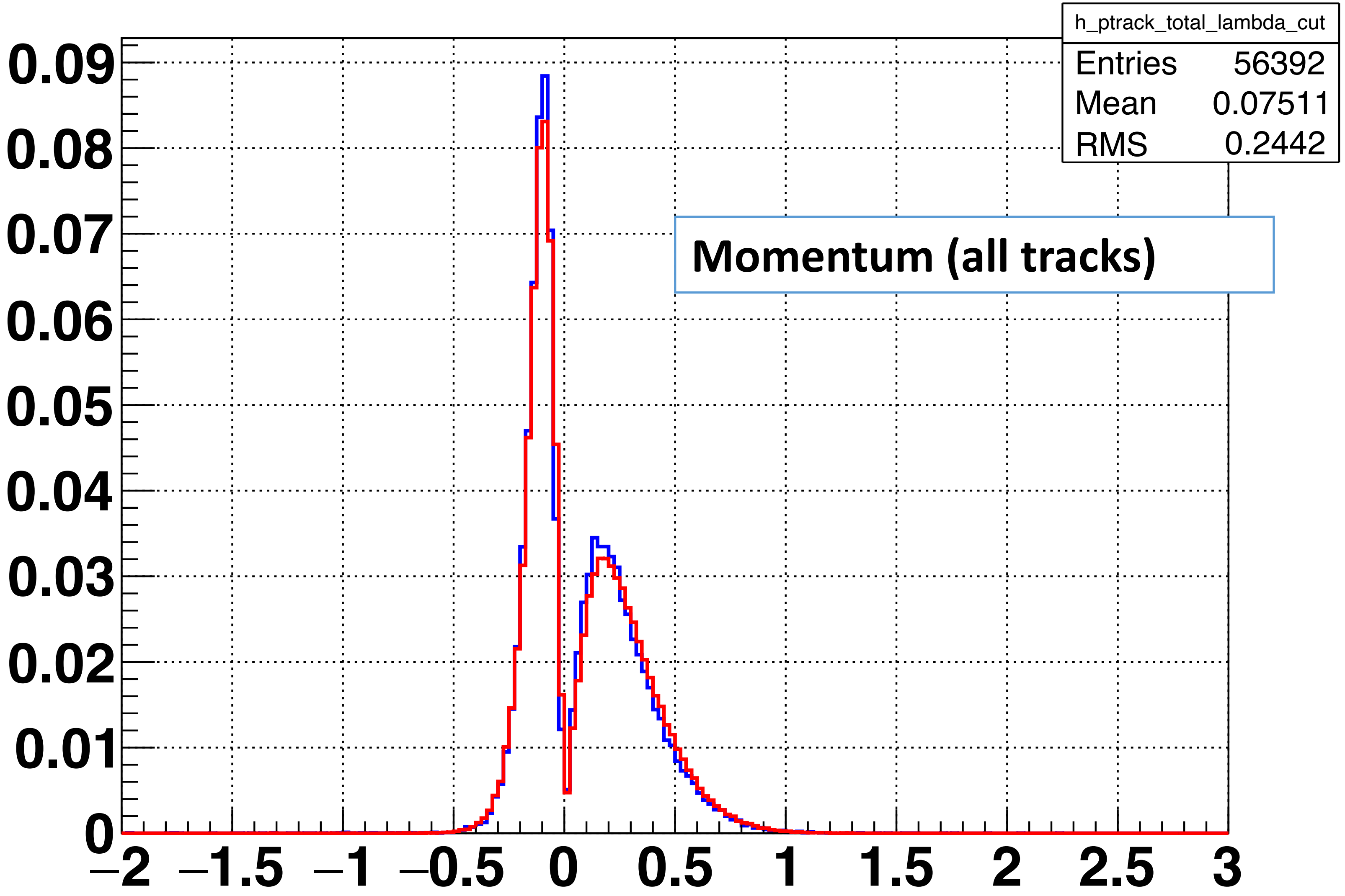
29

C+Cu (4.0 GeV) All cuts applied (Pt & Momentum of all tracks)

Red: Data; Blue: MC;



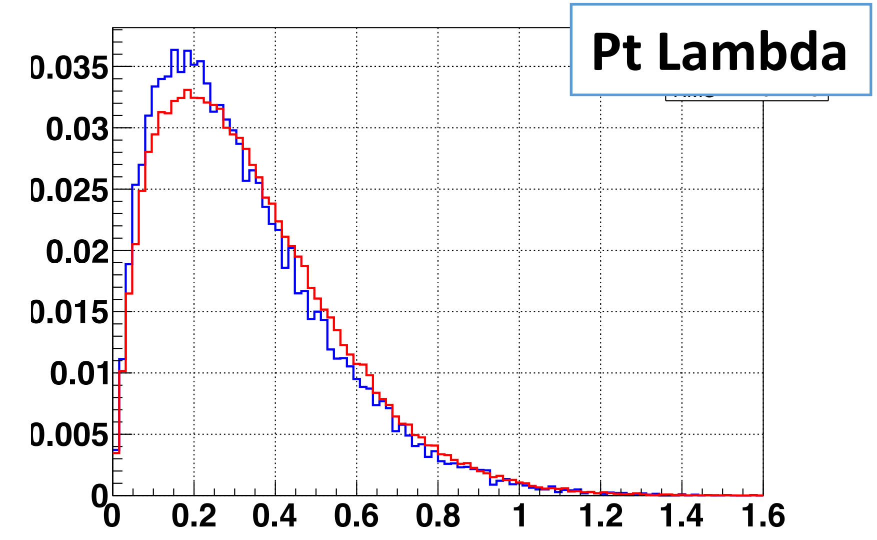


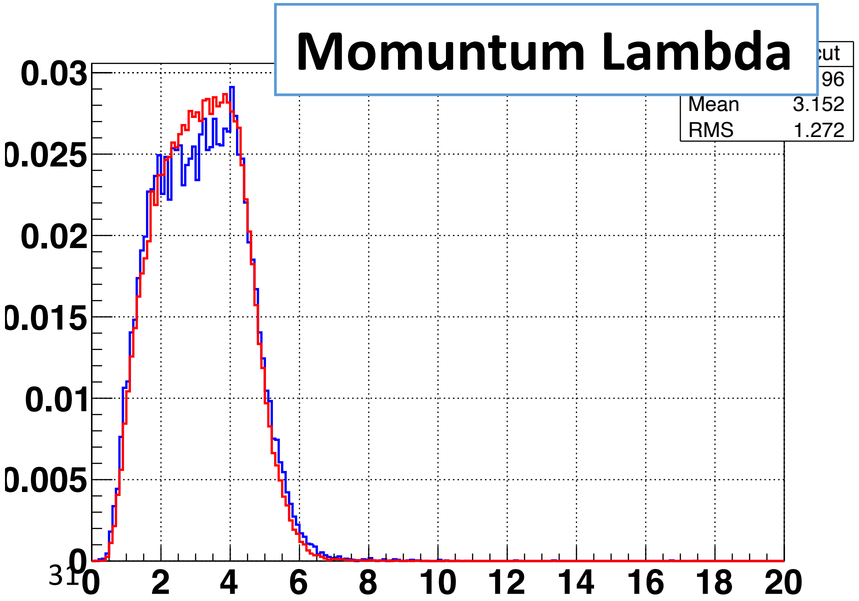


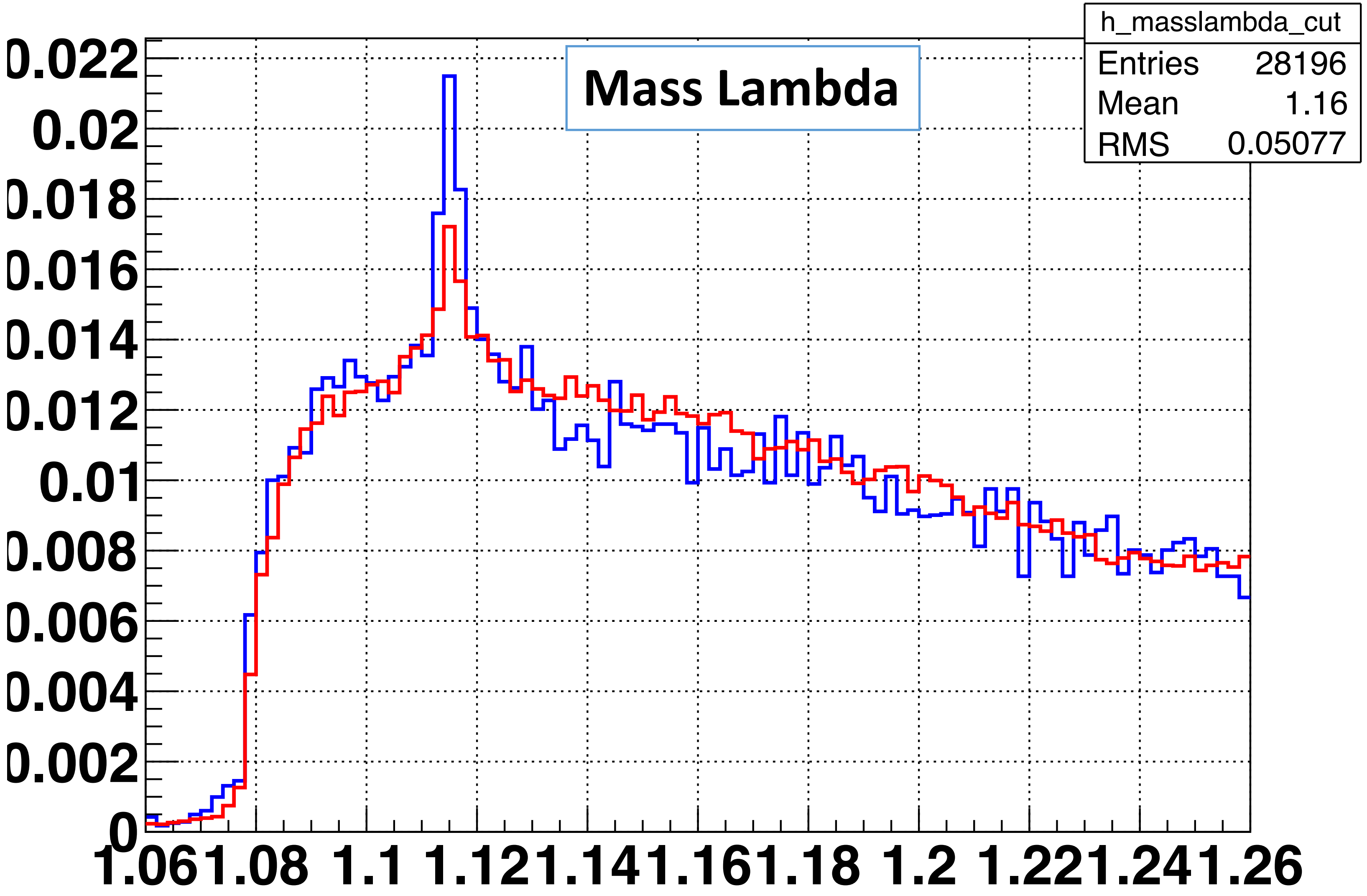
C+Cu (4.0 GeV)

Red: Data; Blue: MC;

All cuts applied (Pt, Momentum & Mass of Lambda)

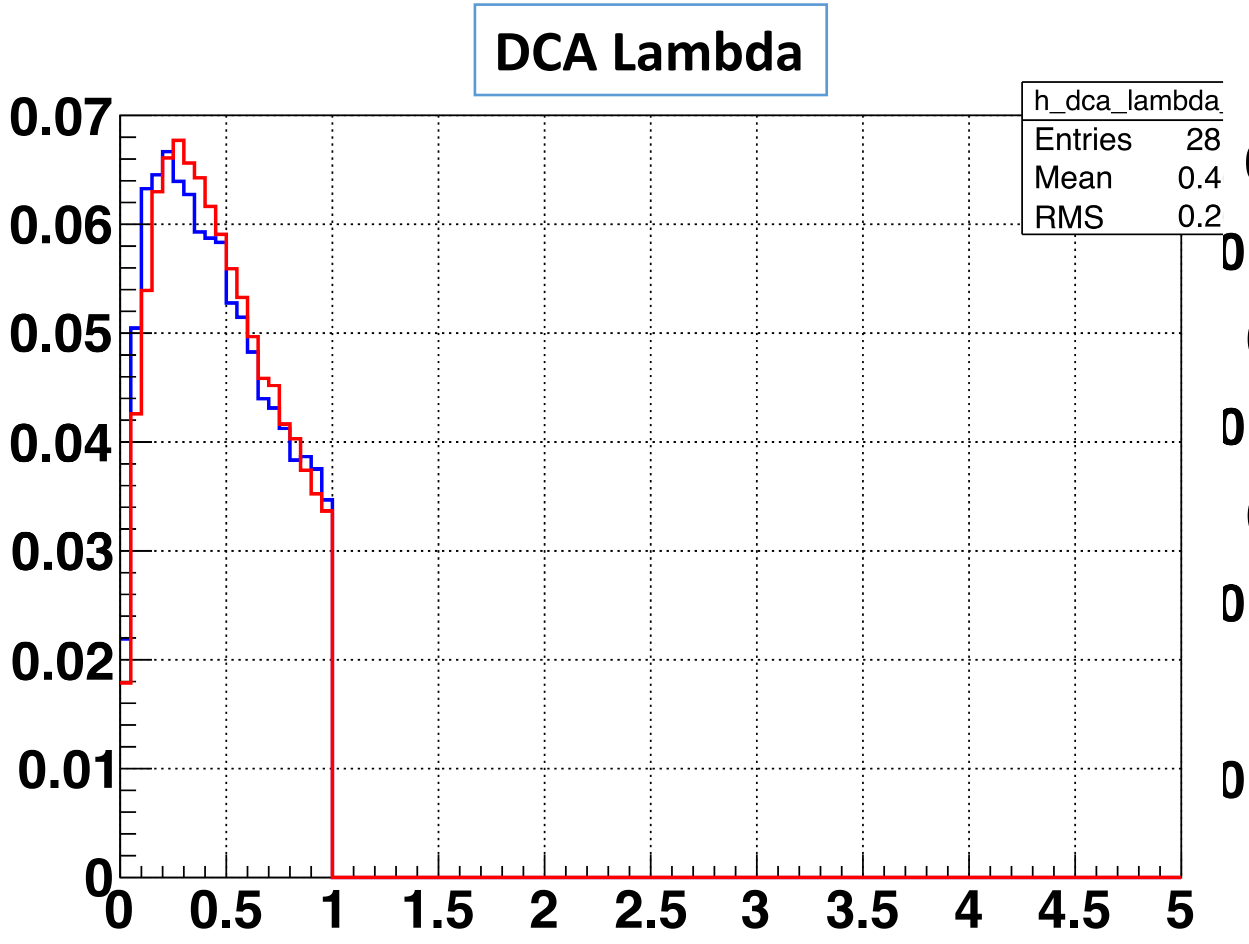


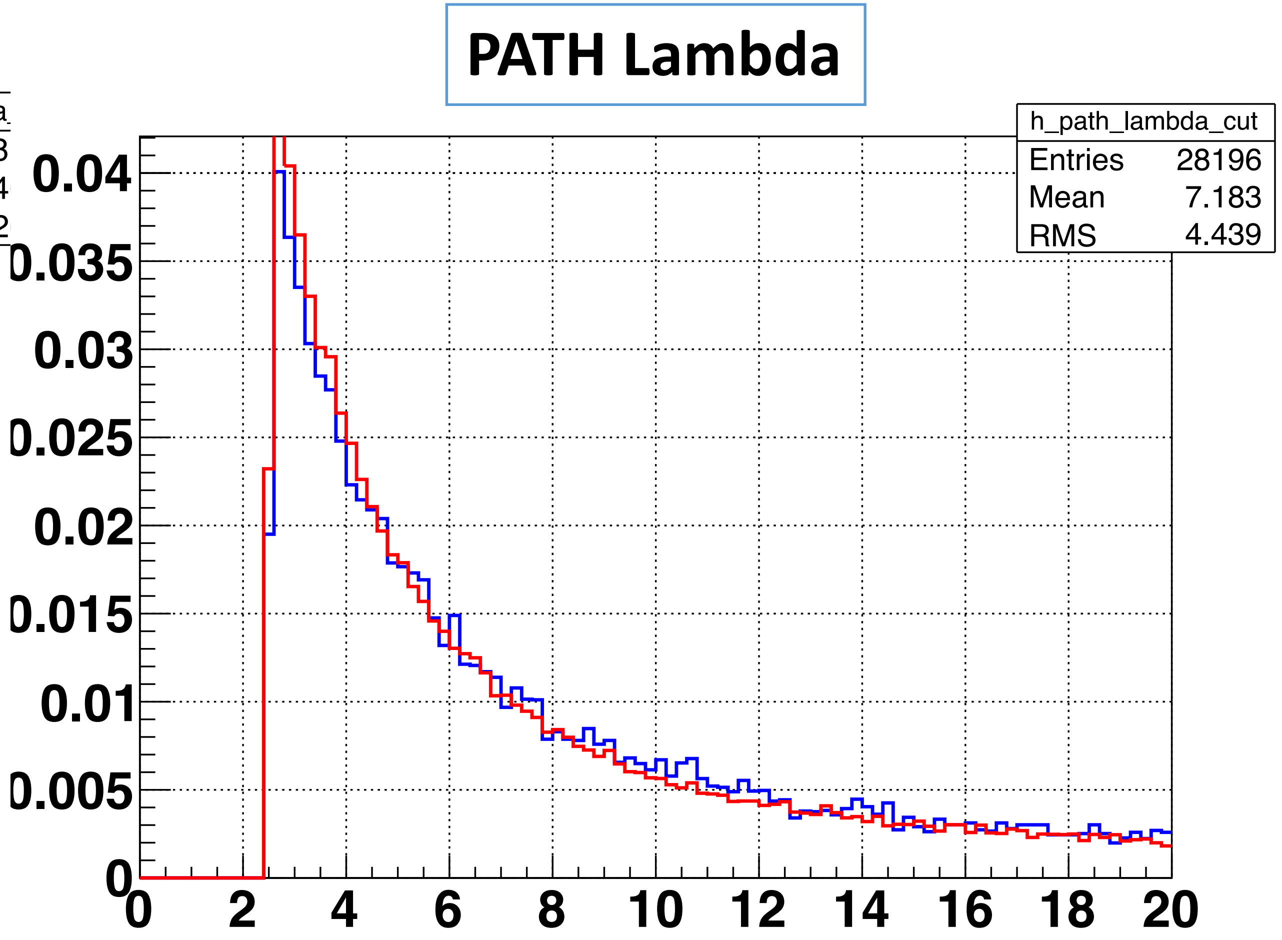




C+Cu (4.0 GeV) **All cuts applied (DCA & PATH of Lambda)**

Red: Data; Blue: MC;

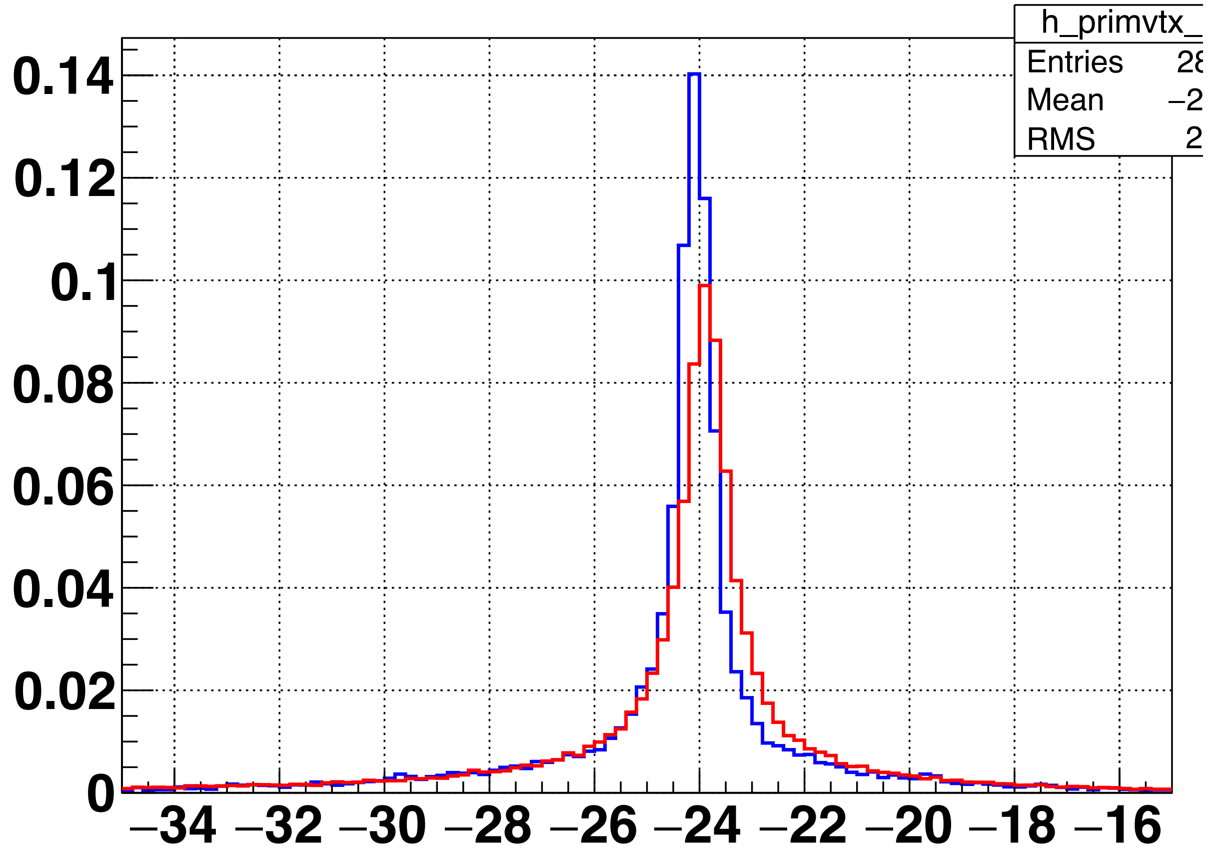




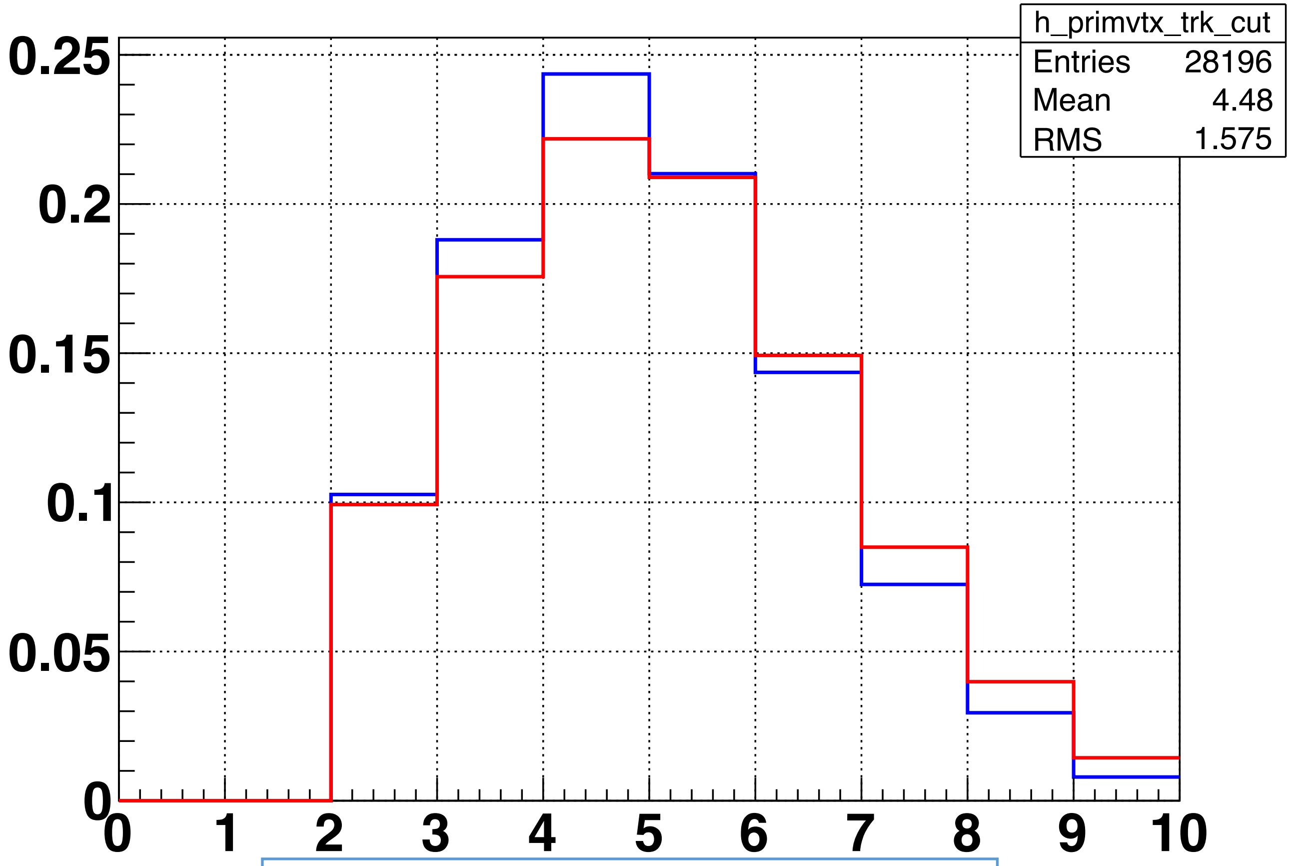
C+Cu (4.0 GeV)

All cuts applied (Primary Vertex)

Red: Data; Blue: MC;



Z Primary Vertex (cm)



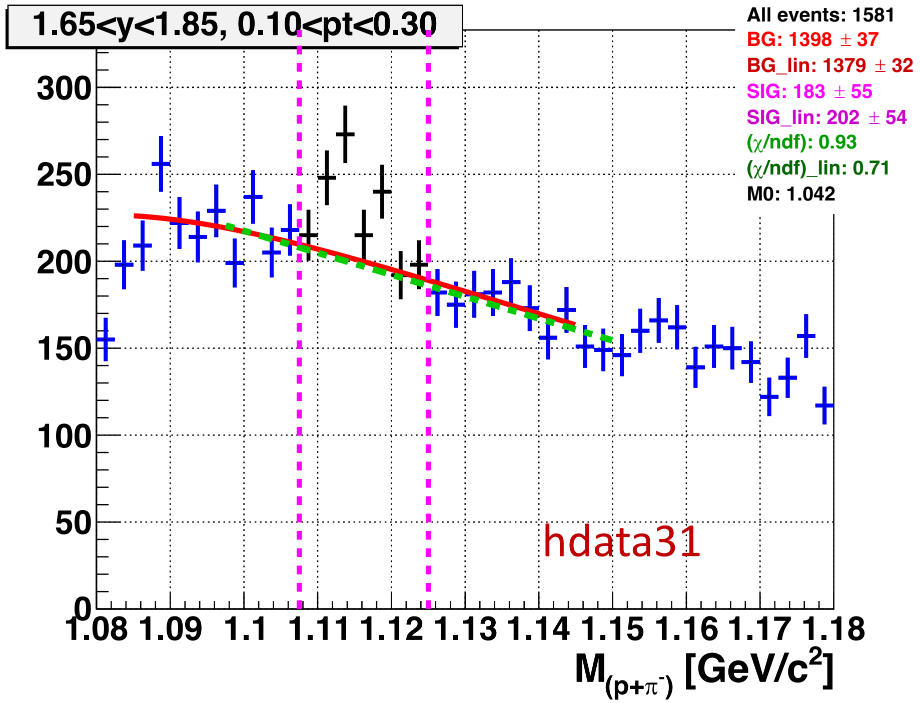
nTracks from Primary Vertex

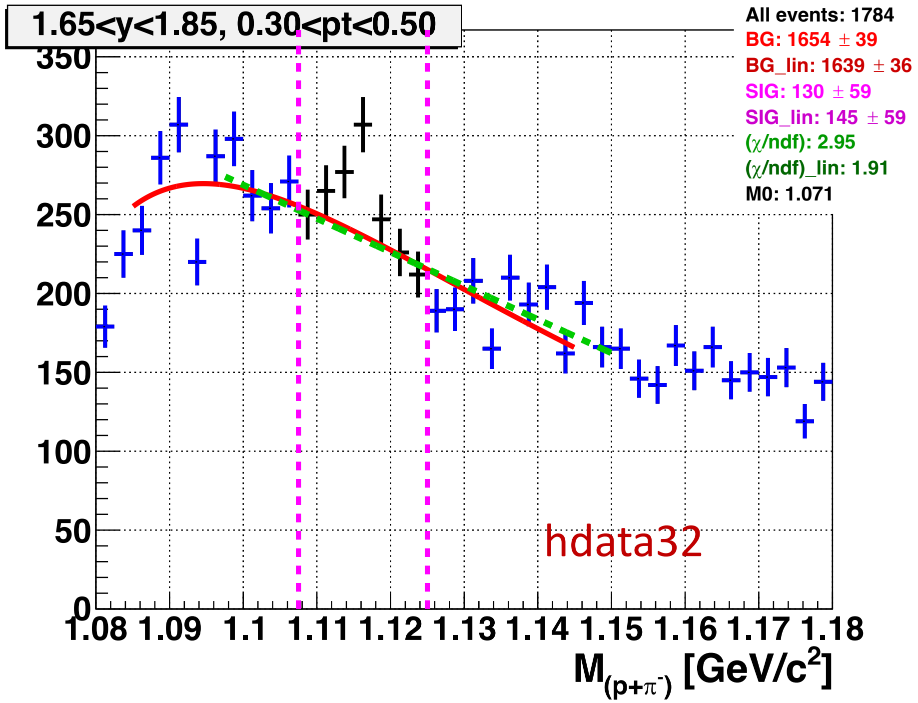
pt & y intervals hists numbering for Lambda signal extraction

pt	y=1.2	y		y=2.1
Pt=1.05	h14	h24	h34	h44
	h13	h23	h33	h43
	h12	h22	h32	h42
Pt=0.1	h11	h21	h31	h41

MC statistics were increased by factor x10

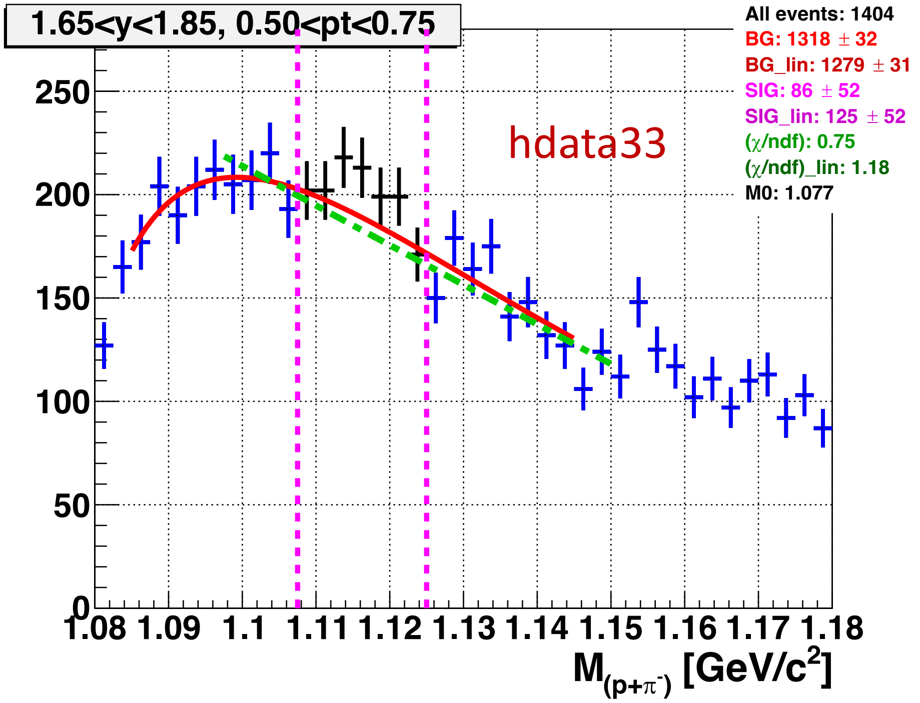
C+Cu 4.0GeV

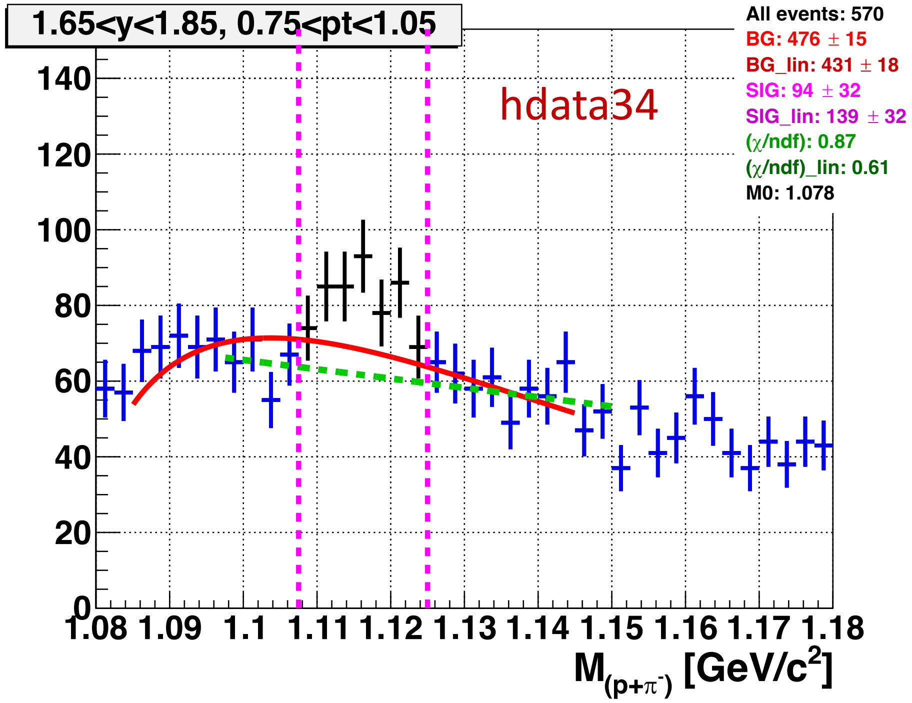




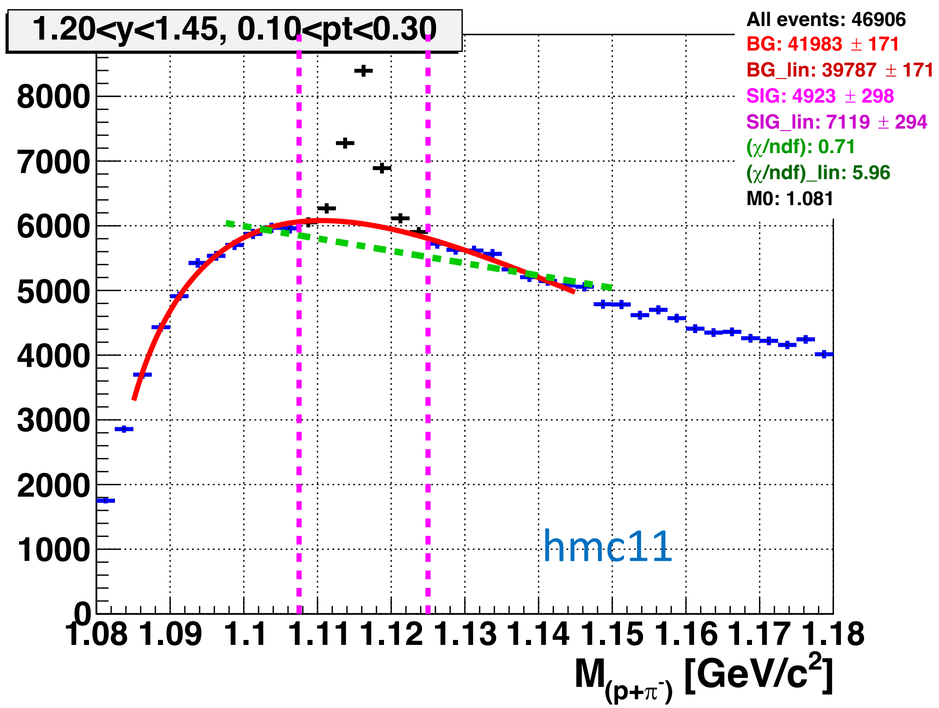
$$BG = A * x + b$$

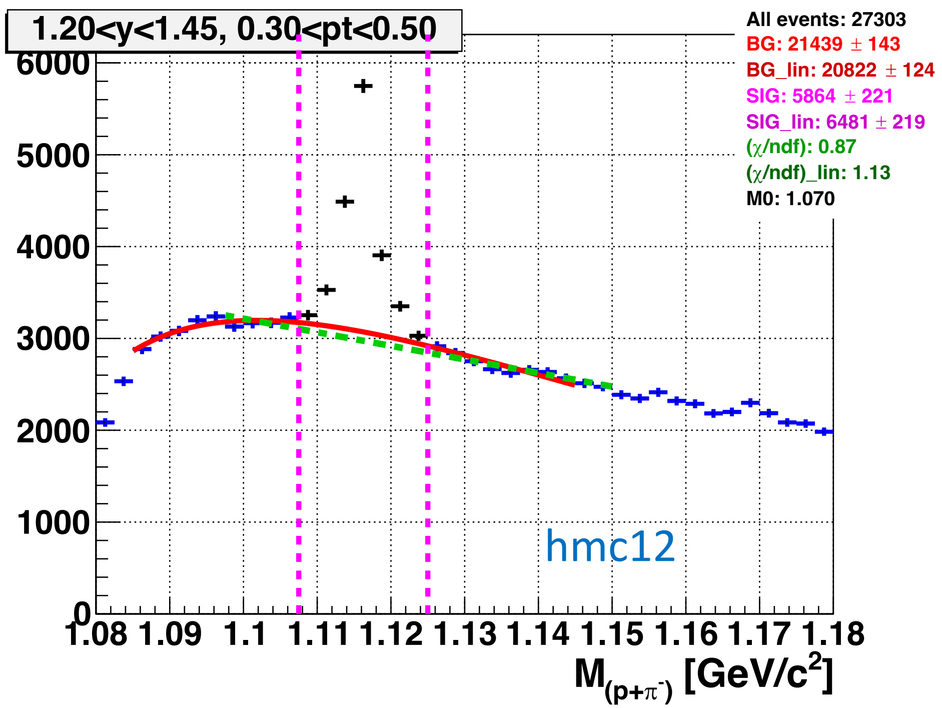
$$BG = N * (x - M_0)^A * \\ * \exp(-B * (x - M_0))$$





FUN	FUN lin
183±55	202±54
130±59	145±59
86±52	125±52
94±32	139±32

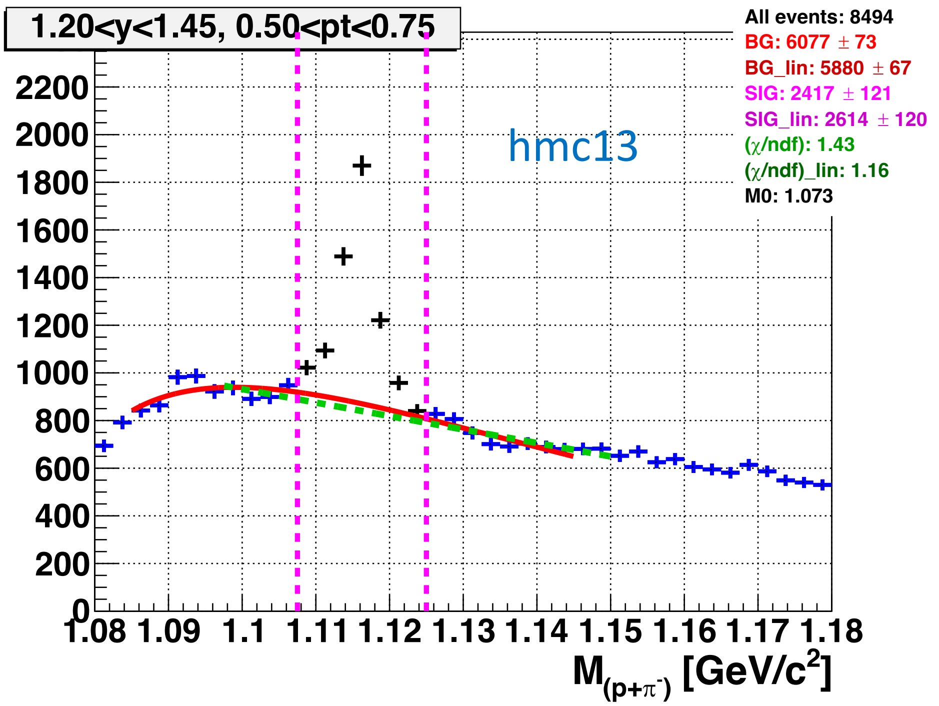


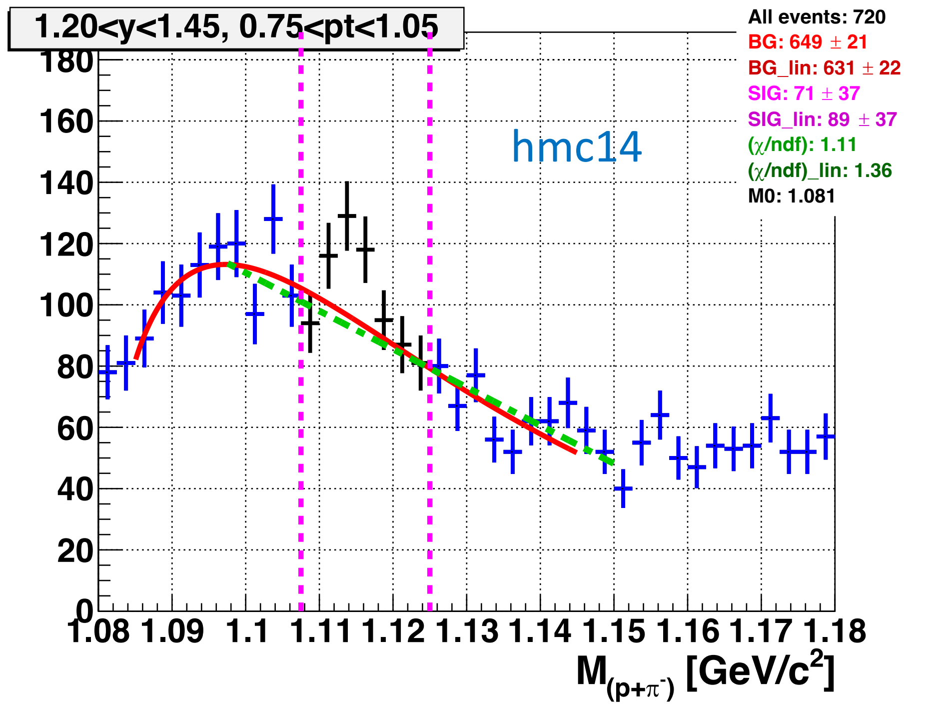


C+Cu 4.0GeV

$$BG = A * x + b$$

$$BG = N * (x - M_0)^A * \\ * \exp(-B * (x - M_0))$$





FUN	FUN lin
4923±298	7119±294
5864±221	6481±219
2417±121	2614±120
71±37	89±37

The inclusive cross section σ_Λ and yield Y_Λ of Λ hyperon production in $C+C$, $C+Al$, $C+Cu$, $C+Pb$ interactions are calculated in bins of y (p_T) according to the formulae:

$$\sigma_\Lambda(y) = \Sigma y\ [N_{rec}^{\Lambda}(y,p_T) / (\varepsilon_{rec}(y,p_T) \cdot \varepsilon_{trig} \cdot \varepsilon_{pileup} \cdot L)] \qquad Y_\Lambda(y) = \sigma_\Lambda(y) / \sigma_{inel}$$

$$\sigma_\Lambda(p_T) = \Sigma p_T\ [N_{rec}^{\Lambda}(y,p_T) / (\varepsilon_{rec}(y,p_T) \cdot \varepsilon_{trig} \cdot \varepsilon_{pileup} \cdot L)] \qquad Y_\Lambda(p_T) = \sigma_\Lambda(p_T) / \sigma_{inel}$$

Yields total 4.0 GeV

Target	C+C	C+Al	C+Cu	C+Pb
Previous analysis	**0,0164±0,0013**	**0,0286±0,0025**	**0,0307±0,0020**	**0,0366±0,0048**
New analysis	**0,0101±0,0028(-38%)**	**0,0322±0,0069 (+12%)**	**0,0315±0,0064(+2.5%)**	**0,0412±0,0061 (+13%)**

Preliminary!

Yields total 4.5 GeV

Target	C+C	C+Al	C+Cu	C+Pb
Previous analysis	**0,0224±0,0026**	**0,0355±0,0034**	**0,0406±0,0032**	**0,040±0,0057**
New analysis	**0,0115±0,0036(-48%)**	**0,024±0,0053(-32%)**	**0,0337±0,0067(-17%)**	**0,0333±0,0108(-18%)**

Next…

BM@N
Baryonic Matter at Nuclotron

- More accurate yields calculations
  - In some cells (4x4) low reconstruction efficiencies due low statistics
  - Extrapolate numbers from MC model
- Another way of yields calculations for cross-check
  - Divide y, pt on more narrowed regions (8x8 cells);
  - Extract MC reconstructed signal (fit procedure)
  - Determinate: $\omega_i = MC_{rec\_i}/MC_{gen\_i}$ for each cell
  - Fill mass histograms for DATA with ω_i
  - Sum data histograms over pt & y (4 hists for pt & 4 hists for y)
  - Fit histograms, extract numbers for yields calculation

In progress now (will be performed by Ksenia Alishina)

Thank you for your attention!