SHMS forward transport and acceptance studies from focal plane studies

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Hall C collaboration meetings

Outline

- Introduction
- Focal plane distributions comparison with MC

  -Forward transport acceptance studies

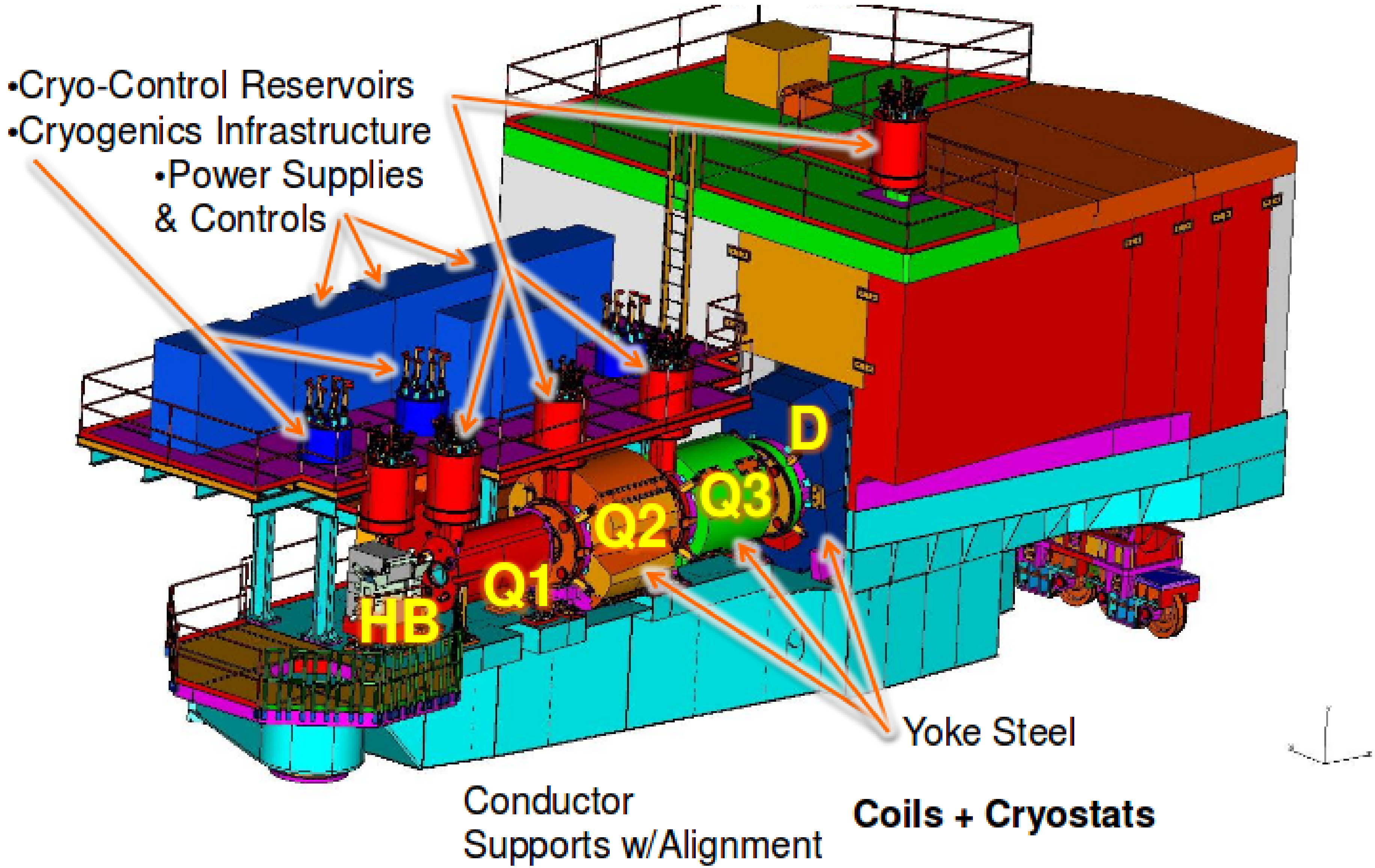
  -Momentum dependence studies on focal plane distributions.

  -Aperture acceptance studies
- Momentum dependence studies on Y target.
- Summary and future work

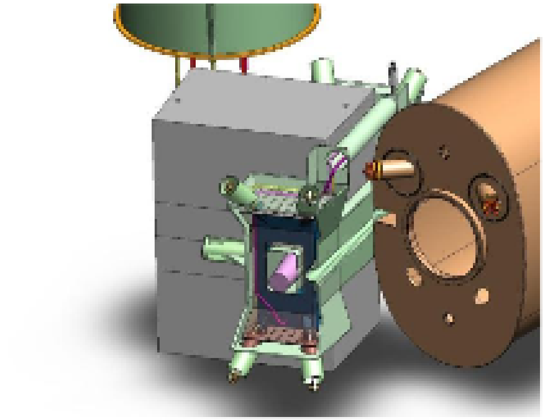
Purpose of the study

- To understand the focal plane distributions of data and correctly model the SHMS forward transport and acceptance defined by apertures.
- To understand the Y_{tar} dependence on momentum using HB.

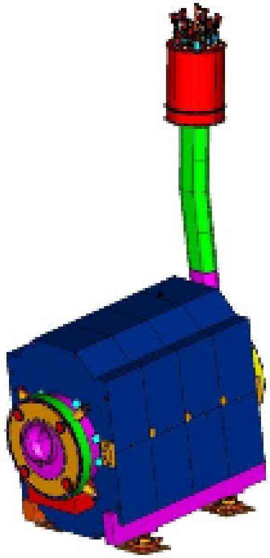
SHMS and magnet systems



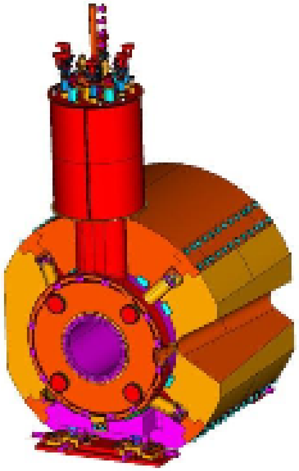
SHMS magnets



HB (Horizontal-Bend Dipole)
- Superferric "C" magnet
- 2.6 Tesla
- 21 cm x 25 cm warm bore
- 0.75 m EFL
- 1.93 Tm
- 19 % design margin
- 220 kJ stored Energy
- SC is SSC outer cable



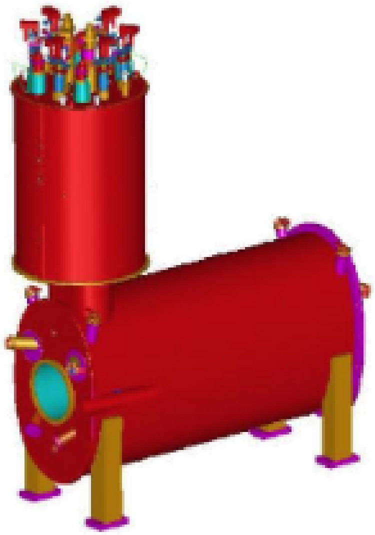
Dipole
- 3.86 Tesla Cosine(Θ) dipole
- 60 cm warm bore
- 2.85 m EFL
- 11.2 Tm Integral B.dL
- 10 % Test margin
- 13.7 MJ stored Energy
- 4800 A/cm^2
- 11 GeV/c
- Iron Yoke: 126 Tons



Q2 11.8 T/m cos(2Θ) Quad
- 60 cm. warm bore
- 1.64 m EFL
- 10 % Test margin
- 7.6 MJ stored Energy
- Iron Yoke: 72 Tons

Q3 identical to Q2 but runs at 7.9 T/m
- Iron Yoke: 18 Tons

Both use same conductor as dipole (Cu + SSC outer)



Q1 Quadrupole
- JLab Cold Iron Design
- Clone of HMS Q1
- 11 GeV/c performance
- 7.9 T/m Gradient
- 40 cm warm bore
- 1.86 m EFL
- 14.75 (T/m)m Int. Grad.
- 398 kJ Stored Energy
- 25 % design margin
- SC is SSC outer

Utilize the Monte Carlo

- To understand the forward transport of the SHMS (ie. the magnetic field integrals)

  By adjusting field integrals check for the best comparison of data to MC at focal plane distribution.

- To correct the Y_{tar} dependence on the momentum Using HB.
- To understand and correctly model the SHMS forward transport and acceptance defined by aperture sizes / positions.

  Edge of the focal plane distributions are not determined by optics. It determined by aperture. By changing aperture sizes/positions the focal plane distributions of MC and data compared.

Single arm Monte Carlos

- Hall C uses two flavors of Monte Carlos.

  Single arm Monte Carlos (mc_shms_single)

- Intended for use with inclusive (single arm) experiments.
- Single arm Monte Carlos used to determine/simulate spectrometer acceptance and resolution only.
- Event generation based on spectrometer phase space (ztarget, x',y', delta)
- Includes multiple scattering at target and in spectrometer

  → No radiative effects.

- No physics generators - to get realistic yields, need a separate model with which to weight the output

Variables in replayed ROOT files

- Focal plane quantities are from SHMS drift chamber variables:

  P.dc.x_fp $x_{\text{focal plane}}$

  P.dc.y_fp $Y_{\text{focal plane}}$

  P.dc.xp_fp $x'_{\text{focal plane}}$

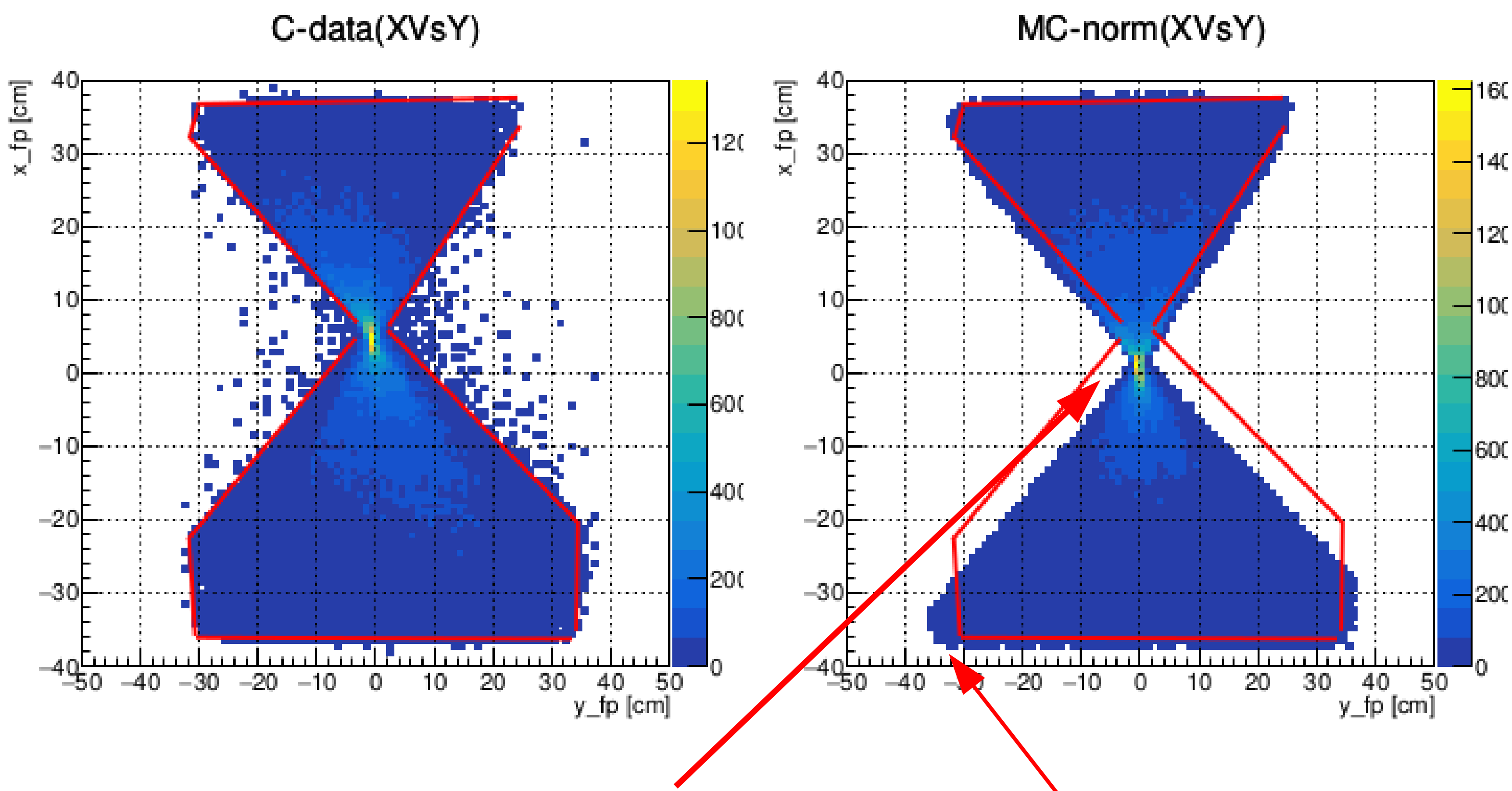
  P.dc.yp_fp $Y'_{\text{focal plane}}$

- Technically, tangents of the angles

$$x' = \frac{dx}{dz} \qquad y' = \frac{dy}{dz}$$

FP comparison data to MC before any tuning

X focal plane Vs Y focal plane

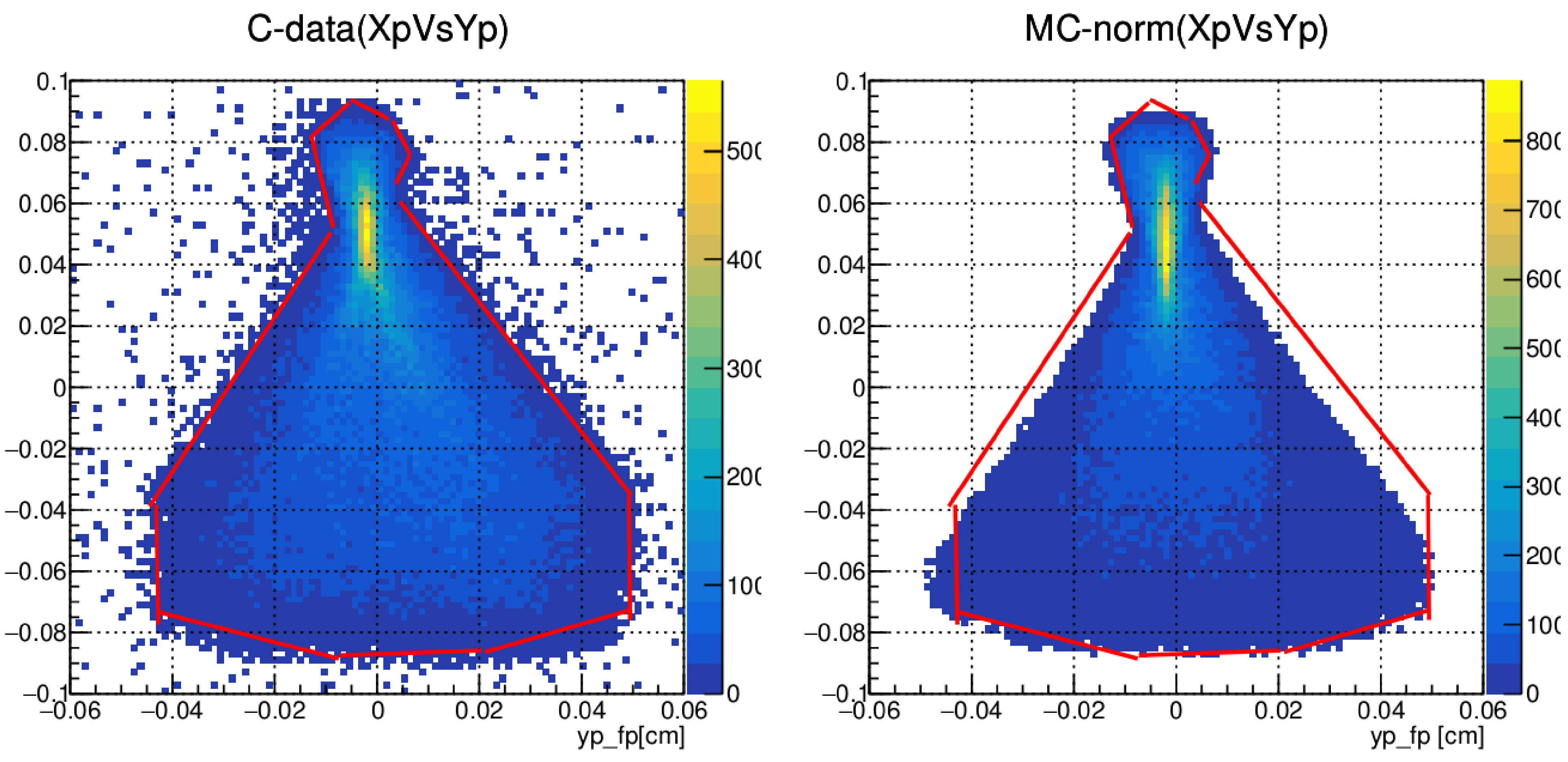


Focusing point is different

Distribution edges are different

X’ focal plane Vs Y’ focal plane

Focusing point is different and the distribution edges are different



1.Forward transport studies

What changed in MC?

- To correct the focusing issue

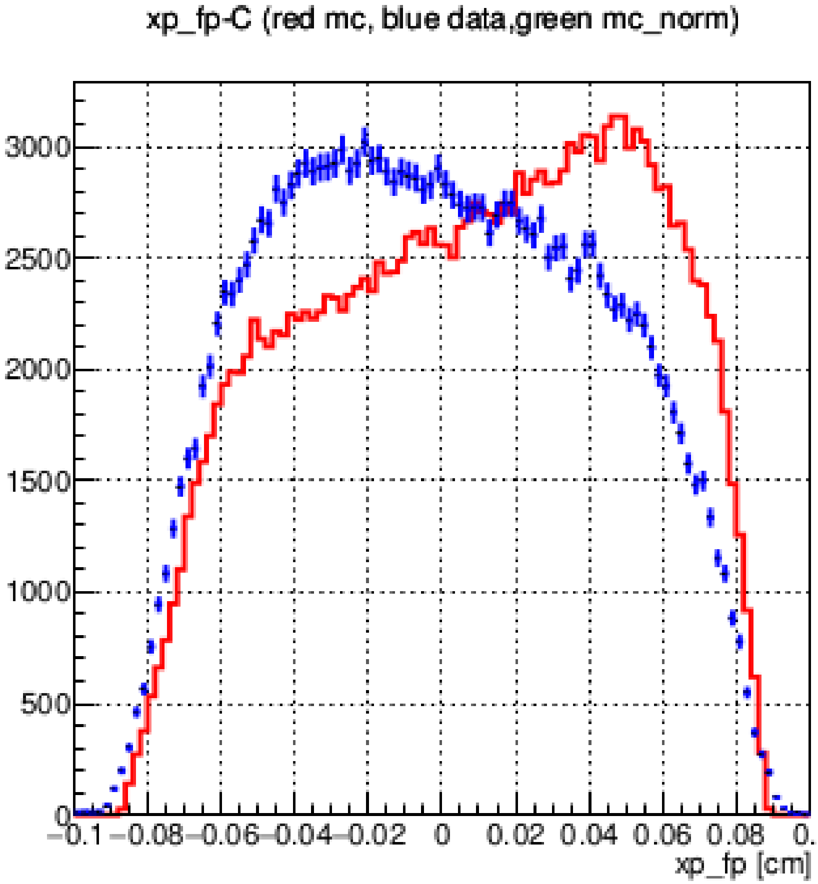
  -Generate the forward and reconstruct matrix elements by tuning magnetic fields in COSY .

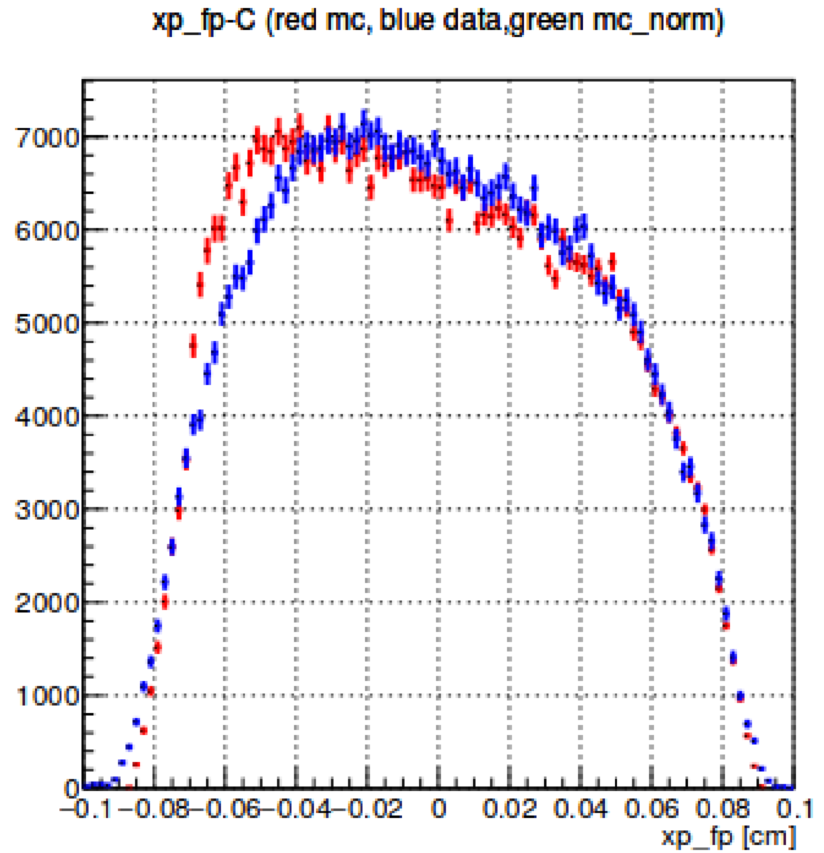
  -Change one magnet at a time and generate the forward and reconstruct matrix elements.

  - Run the simulation using single arm.

  -Compare the MC simulation with data.

Requirement of physics weighting





Before Physics weighting

After Physics weighting

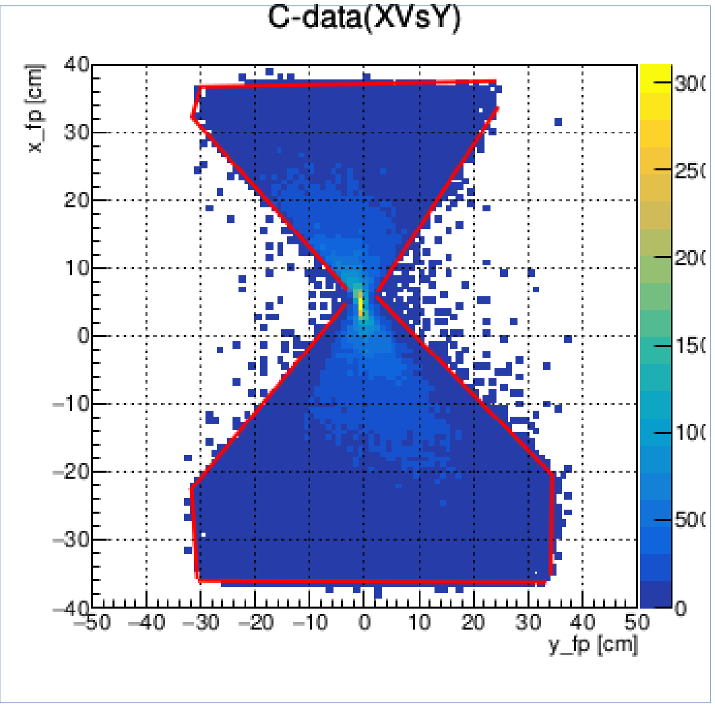
2D plots are insensitive to physics weighting. So 1-D plots should check to obtain correct model

For improvements in comparison

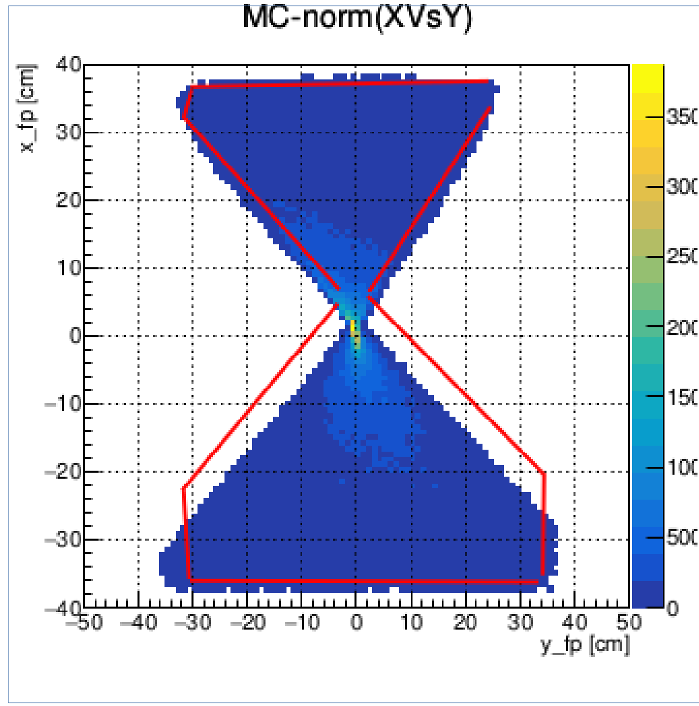
- Radiative contributions include from rc-externals
- Born cross section has complete using MC-re weight
- After using above two codes still the Q2+1.8% tune is the best magnetic tune.

X focal plane Vs Y focal plane

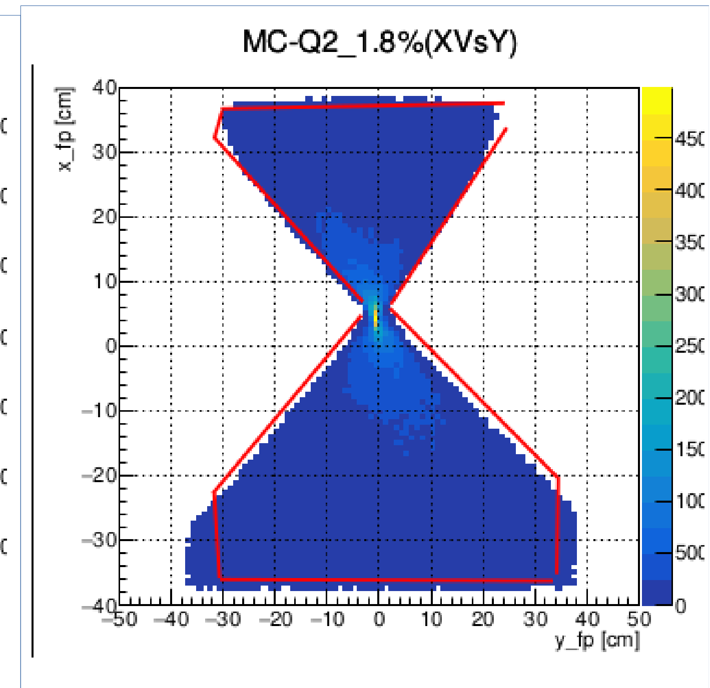
Data Run# 2548



Before tuning the magnets



After tuning the magnets



After physics weighting still the Q2+1.8% tune is the best magnetic tune.

Since the dipole is off by 1.8%

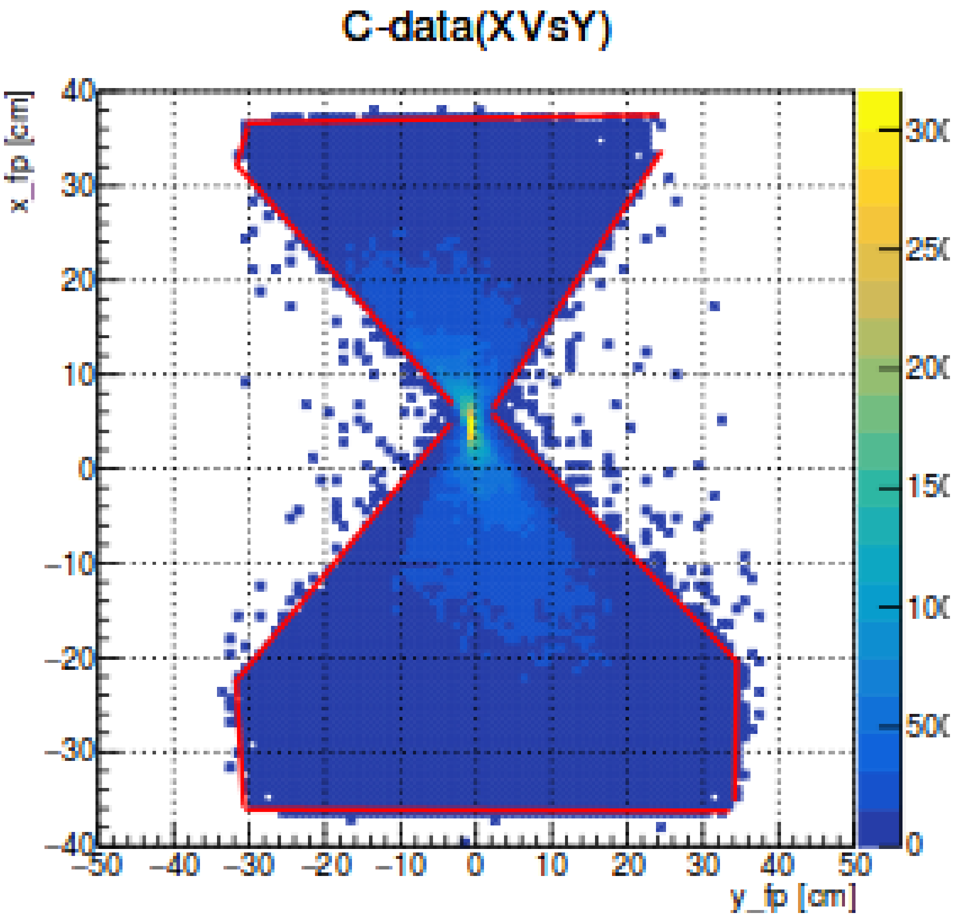
- We should correct it in Q1,Q2 and Q3.(Ratio of D/Q should be same)
- So the real nominal is

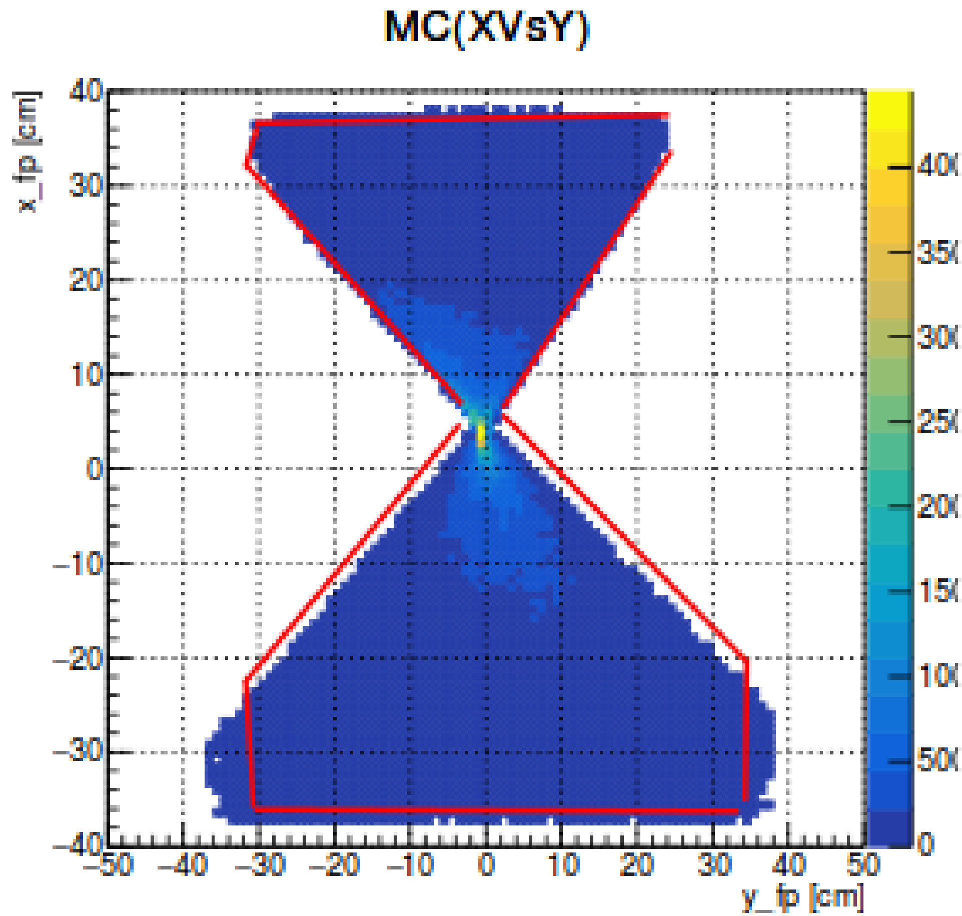
  Q1 norm → 1.018*Q1

  Q2 norm → 1.018*Q2

  Q3 norm → 1.018*Q3
- After we correct this effect the magnetic field again tuned to obtained the best focusing point.

X focal plane Vs Y focal plane (For new nominal values)





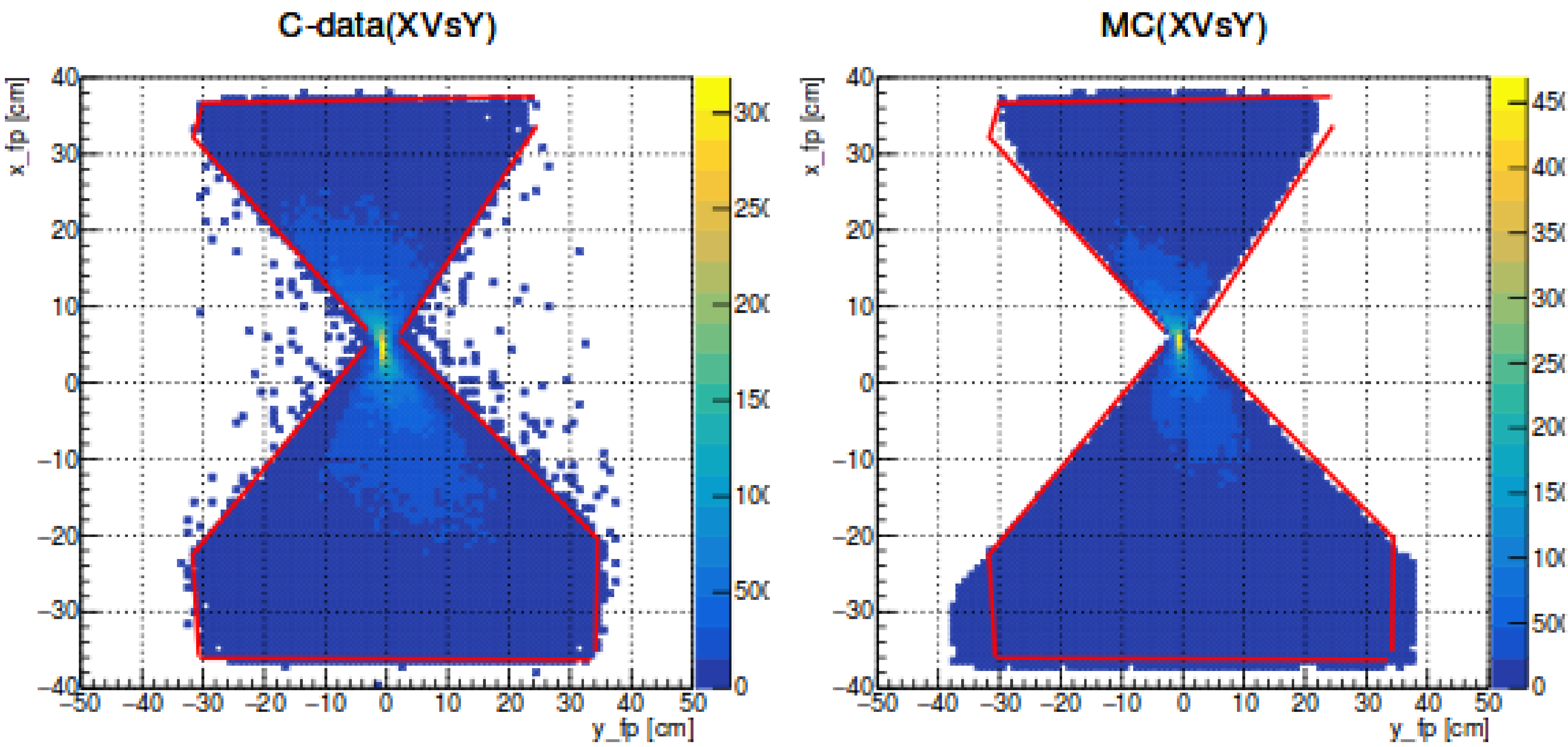
After use of new nominal again the focusing point changed..

Magnetic tuning values for different files

File # mc	Q1	Q2	Q3
180	1.018	1.018	1.018
181	1	1.018	1
182	1	1.02	1
184	0.99	1.02	1.018
185	1.05	1.02	1.018
186	1.018	1.02	0.99
187	1.018	1.02	1.05
188	1	1.025	1
189	1.018	1.025	1.018
190	1.018	1.03	1.018
302	1.018	1.027	1.018

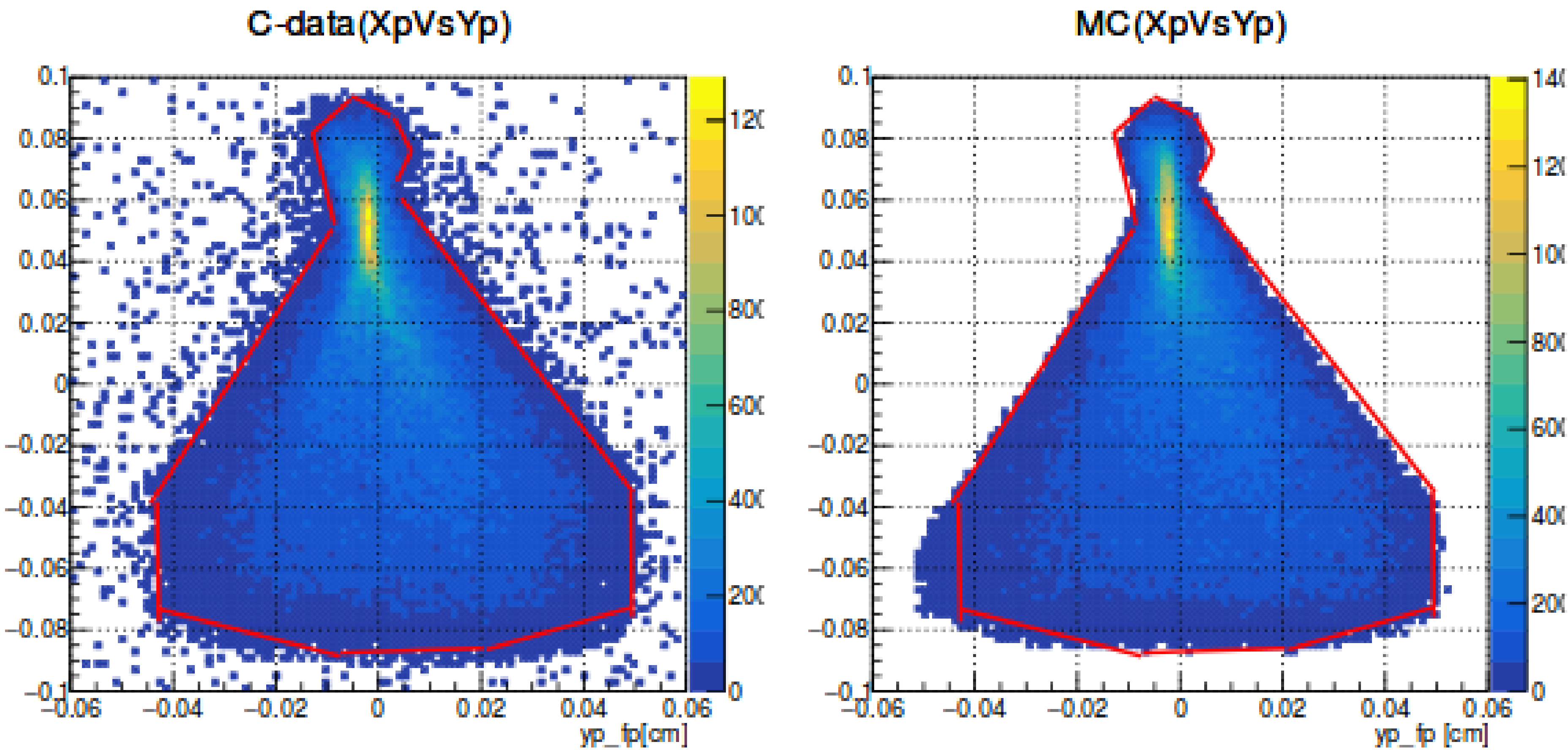
Output files are in the userweb :: https://userweb.jlab.org/~arunin/HALLC/

X focal plane Vs Y focal plane



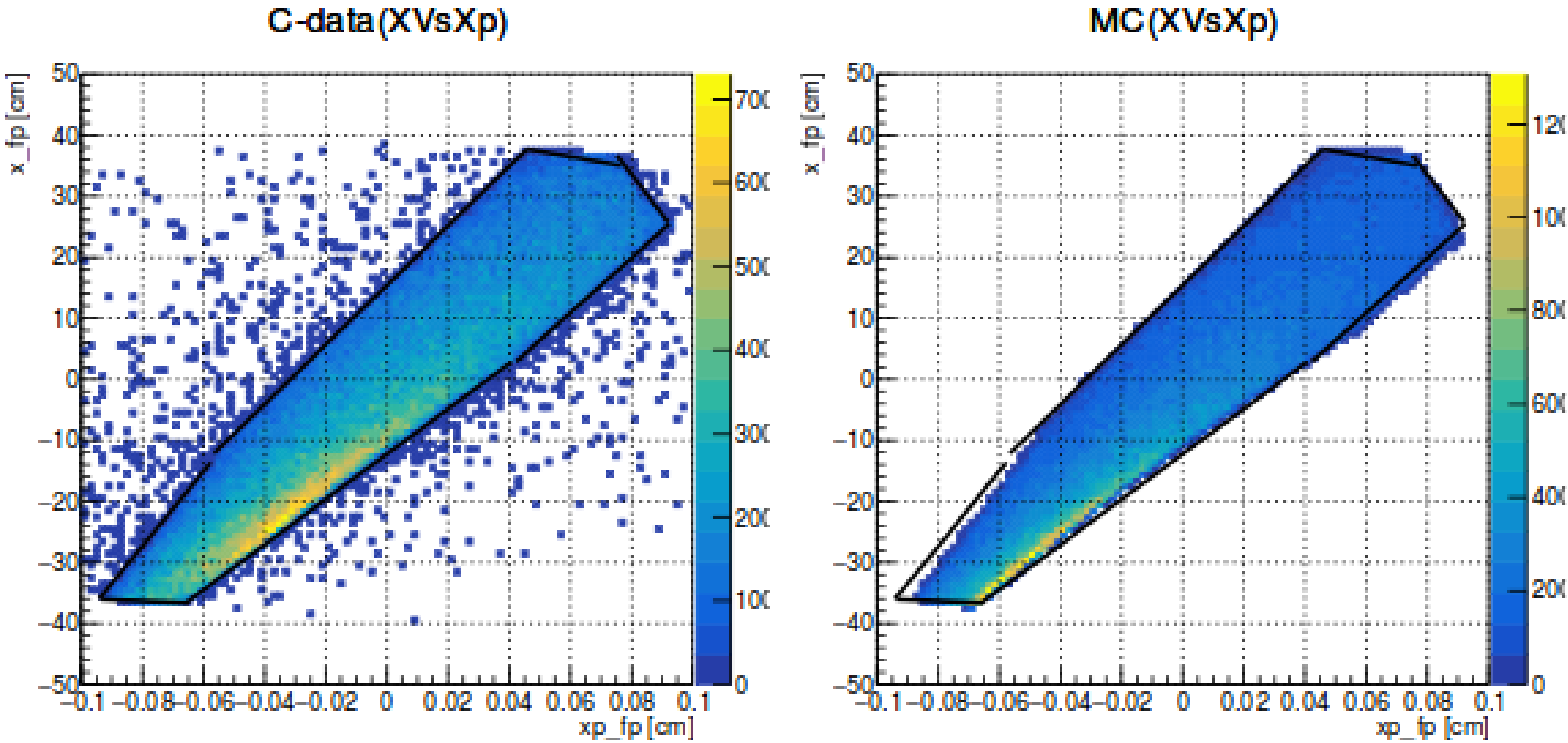
With new nominal the Q2+0.9% tune is the best magnetic tune.

Xp focal plane Vs Yp focal plane



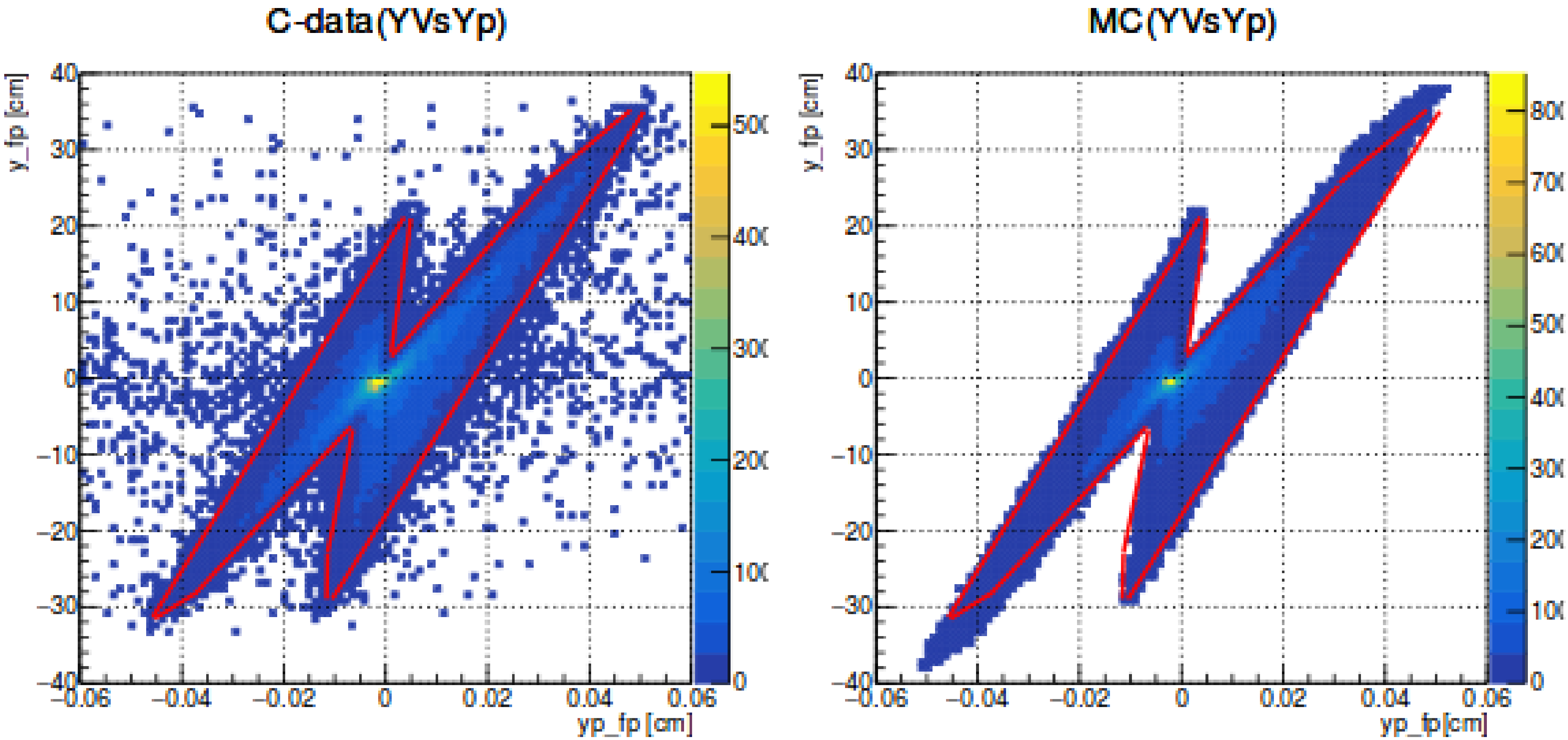
With new nominal the Q2+0.9% tune is the best magnetic tune.

X focal plane Vs Xp focal plane



With new nominal the Q2+0.9% tune is the best magnetic tune.

Y focal plane Vs Yp focal plane



With new nominal the Q2+0.9% tune is the best magnetic tune.

2.Momentum dependence studies on focal plane distributions

To study the dependence of the momentum on focal plane studies

Generate the forward and reconstruct matrix elements by tuning magnetic fields in COSY for the best assumed magnetic field .

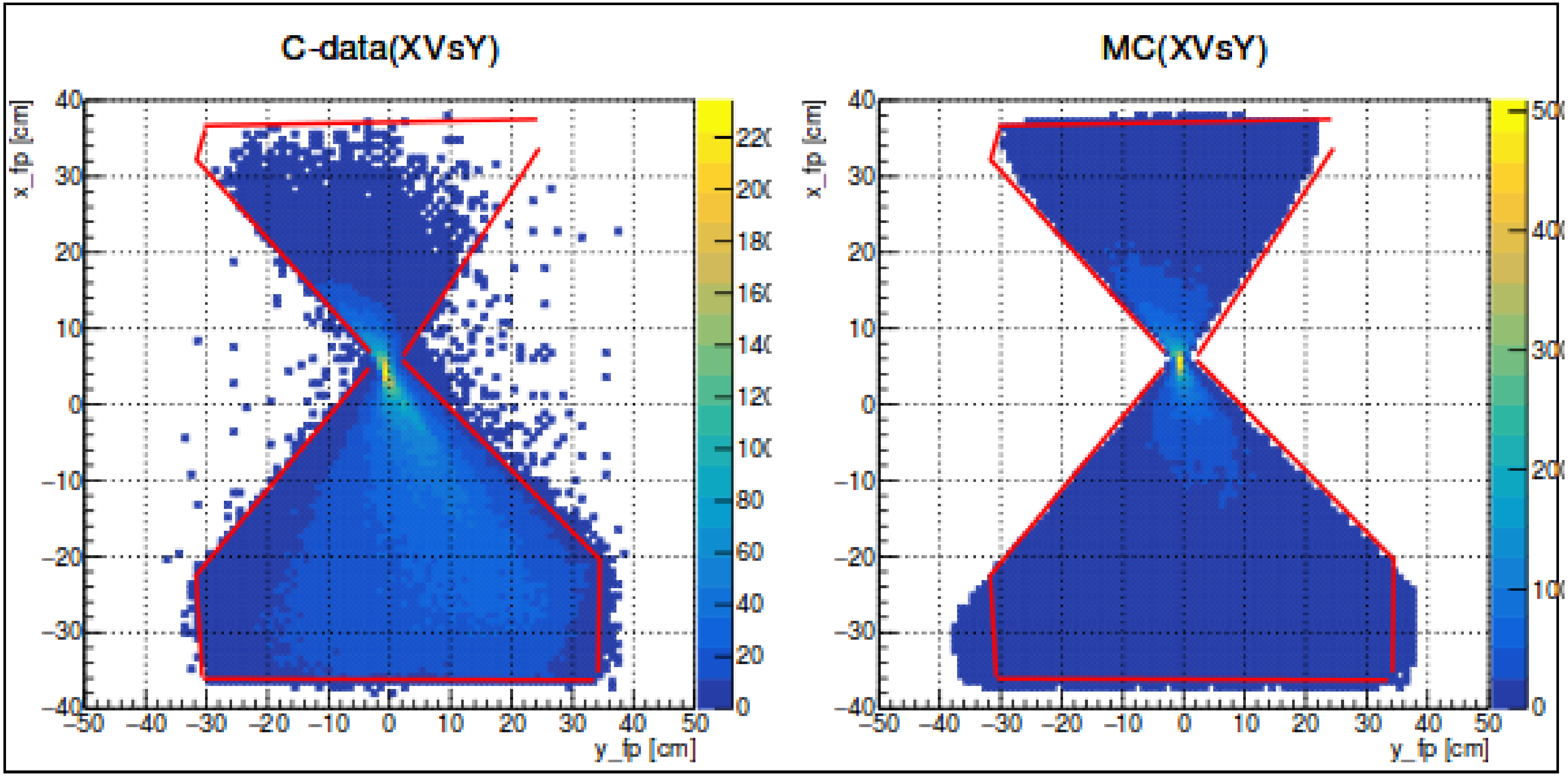
-Use forward and reconstruct matrix elements and compare the MC simulation with data for all C runs.

- https://userweb.jlab.org/~arunin/HALLC/shms-2017-26cm-monte_quads_p18_forward.dat
- https://userweb.jlab.org/~arunin/HALLC/shms-2017-26cm-monte_quads_p18_recon.dat

Kinematic settings for different run numbers used in the study

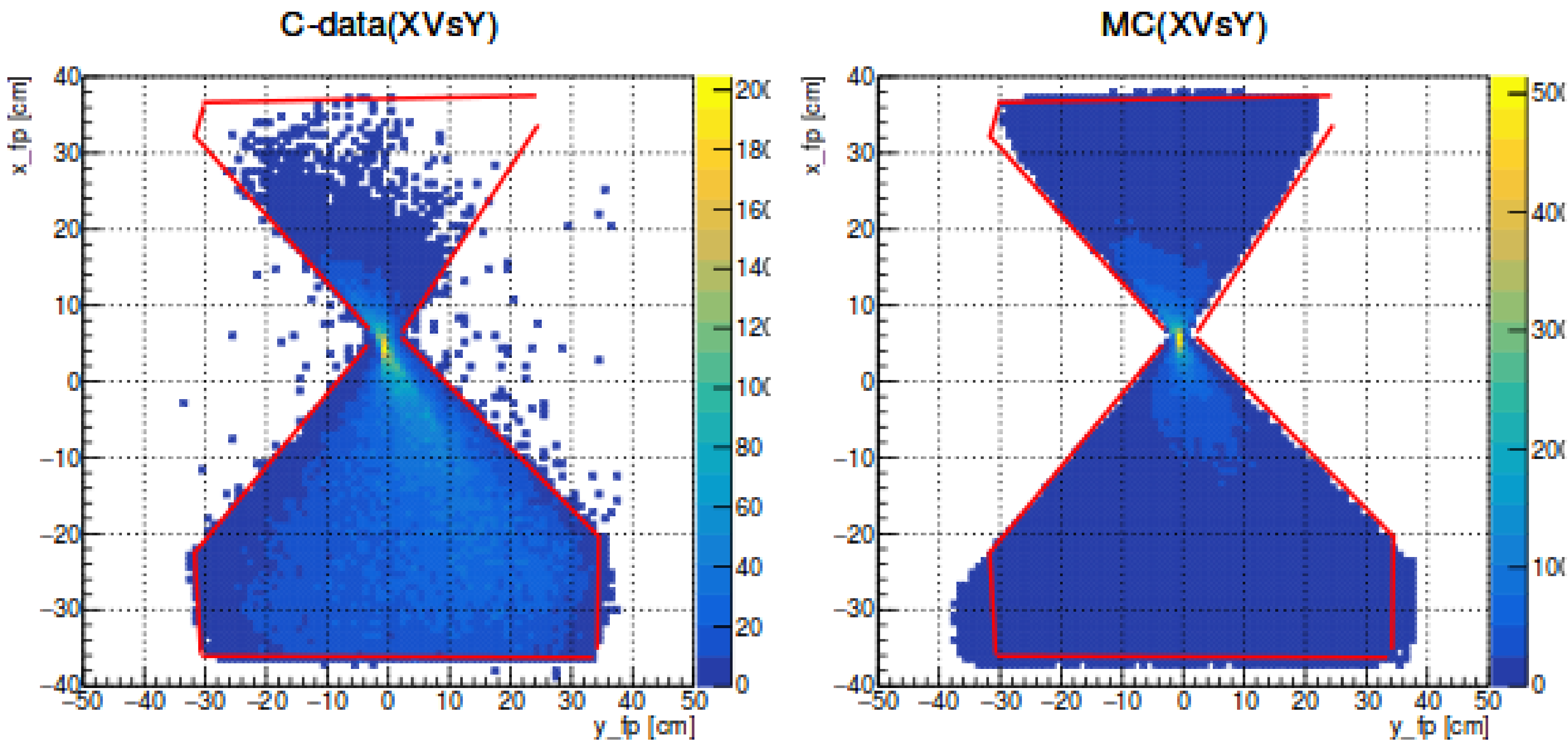
Run #	P(GeV/C)	angle	Mc file	Mc factor *E-03
2508	5.1	21	401	6.85294718
2510	4.0	21	402	6.85372576
2548	2.7	21	403	6.85209315
3035	4.4	25	404	6.85444940
3058	3.5	25	405	6.85246941
3070	3.0	25	406	6.85391715
3084	2.5	25	407	6.84929406
3008	2.0	29	408	6.85171783
2985	2.4	29	409	6.85158139

Run # 2508 P 5.1 GeV/C ,21’



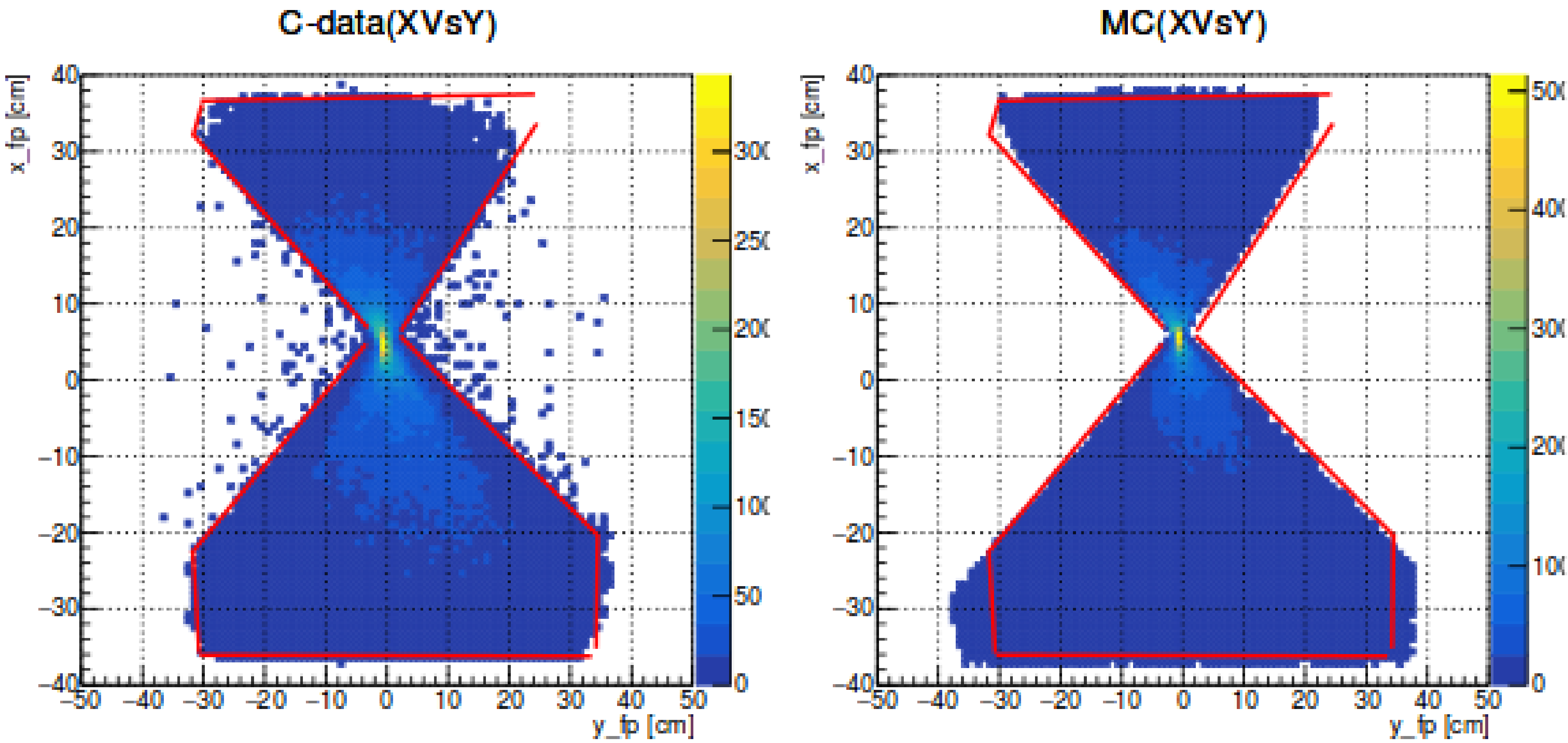
Still the focusing remains same. The Red lines are the edge distributions of Run # 2548 data 2D plots

Run # 3035 P 4.4 GeV/C 25'



Still the focusing remains same. The Red lines are the edge distributions of Run # 2548 data 2D plots

Run # 3084 P 2.5 GeV/C 25’



Still the focusing remains same. The Red lines are the edge distributions of Run # 2548 data 2D plots

Conclusion for Forward transport studies

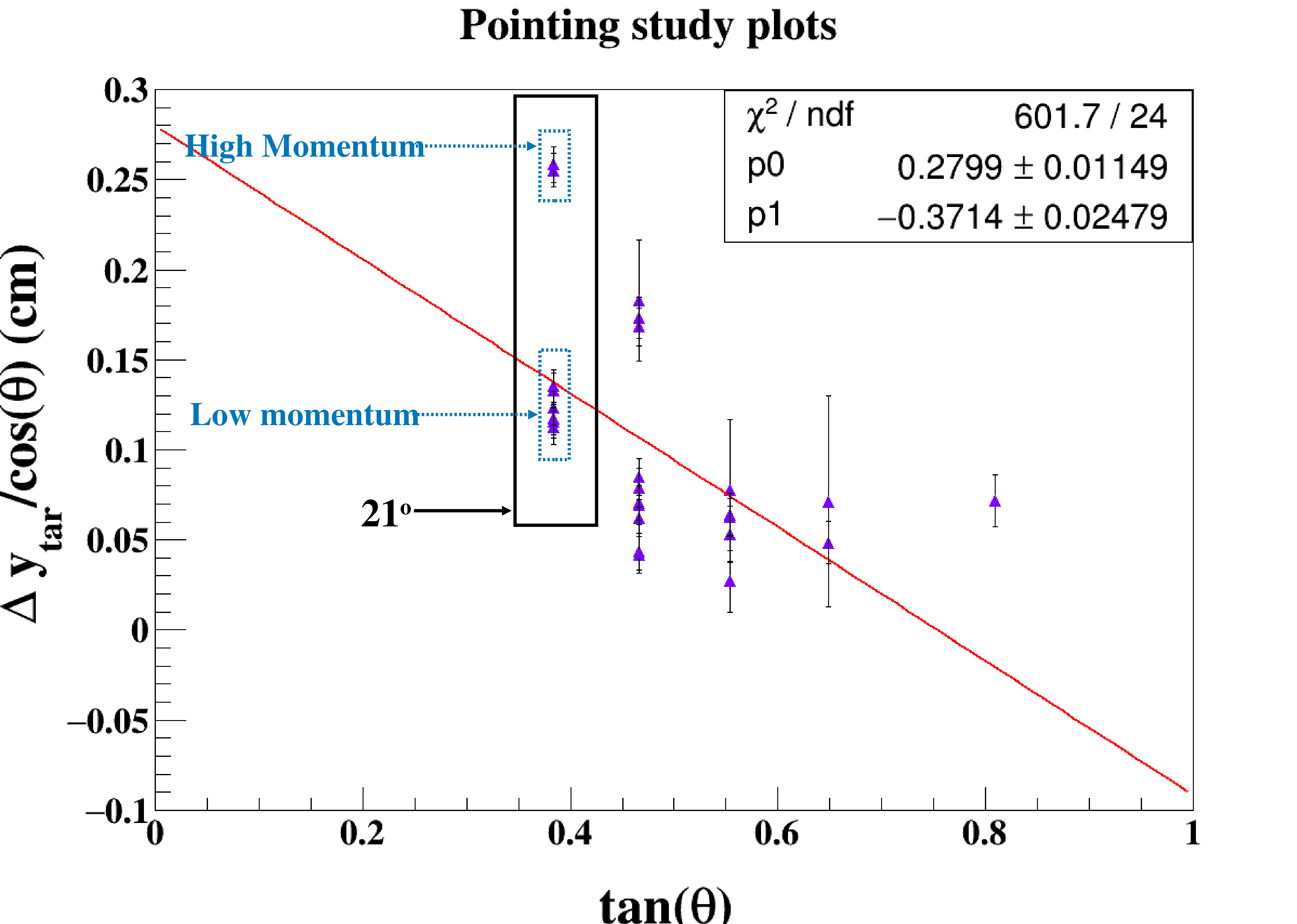
- MC simulation has developed in single arm MC including radiative corrections and cross section.
- The magnetic field tune has completed.

  Q2 should increase by 0.9% to have best focusing properties in the focal plane distributions.
- The focusing of the 2D focal plane distributions are remains same with the change in momentum.
- All out put files are in

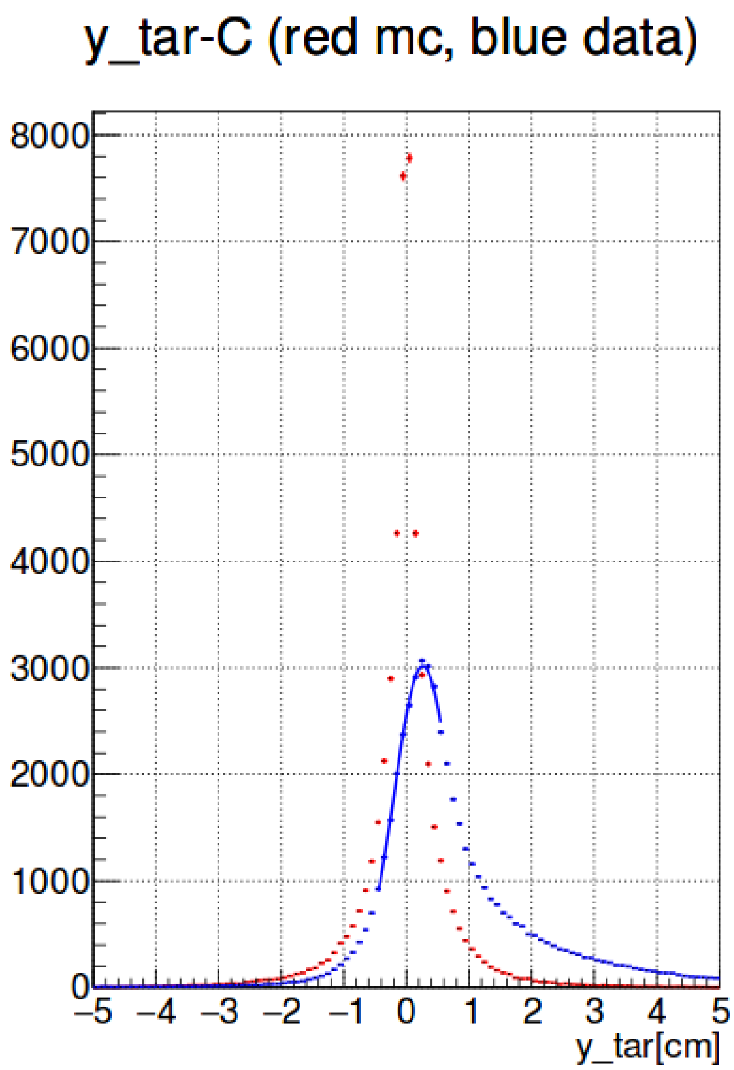
https://userweb.jlab.org/~arunin/HALLC/P_comparison/

3.Studies of HB using Y_{tar}

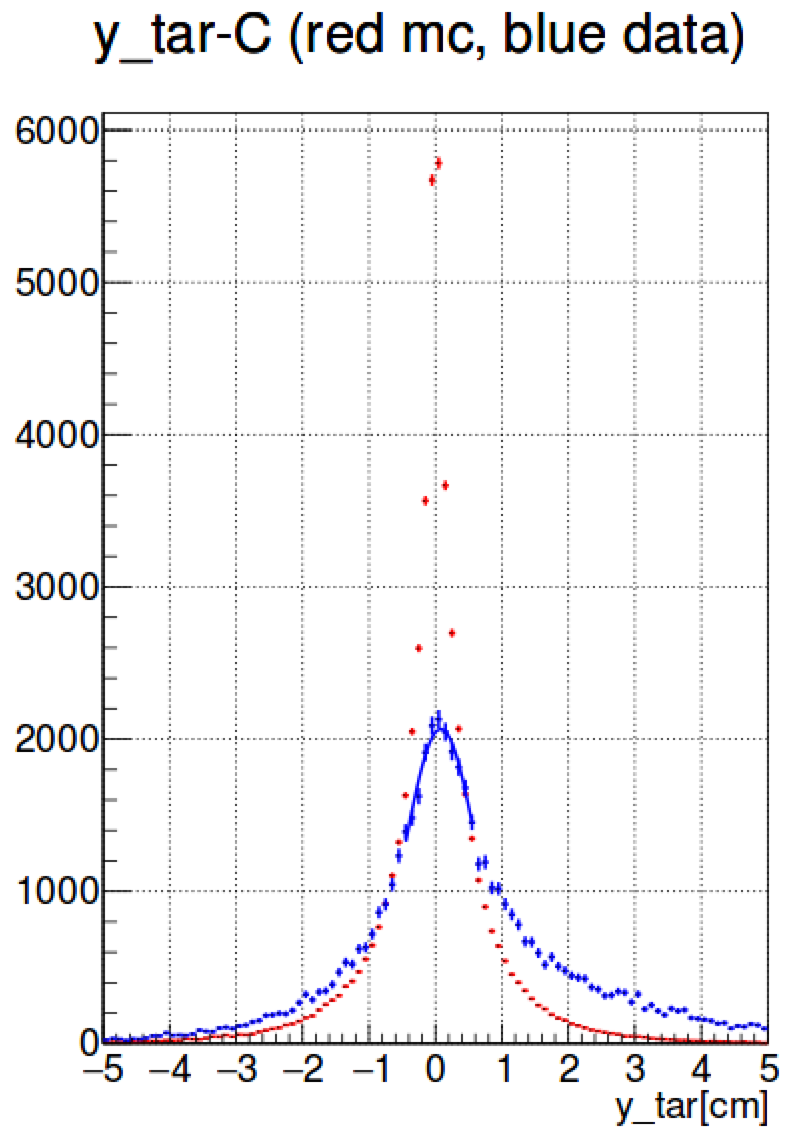
- While doing the beam position offset study -
  - Δy_{tar} / cos(θ) vs tan(θ) for the carbon target runs, where θ is the angle of spectrometer and Δy_{tar} = ((Y target)$_{DATA}$ ~ (Y target)$_{MC}$)
- This plot showed Y_{tar} has a Momentum dependence


Pointing study plots
χ^2 / ndf 601.7 / 24
p0 0.2799 ± 0.01149
p1 −0.3714 ± 0.02479
High Momentum
Low momentum
21°
$\Delta y_{tar}/\cos(\theta)$ (cm)
tan(θ)
0.3
0.25
0.2
0.15
0.1
0.05
0
−0.05
−0.1
0
0.2
0.4
0.6
0.8
1

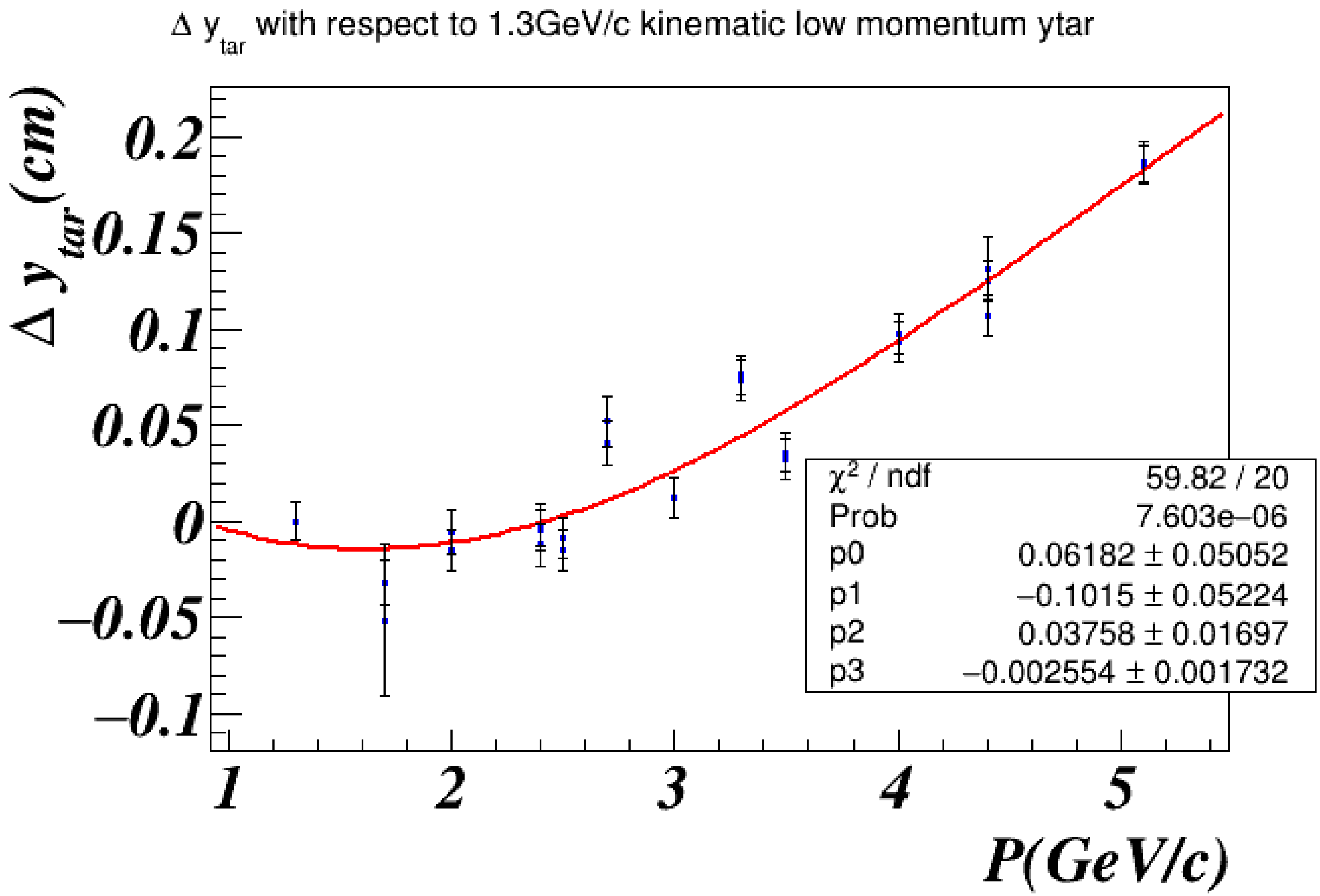
Ytar depend on momentum



Ytar for 5.1 GeV/c



Ytar for 1.3 GeV/c



$\Delta Y_{tar} = Y_{tar}$ at each P $- Y_{tar}$ at 1.3 GeV/c

Change in field in HB in MC

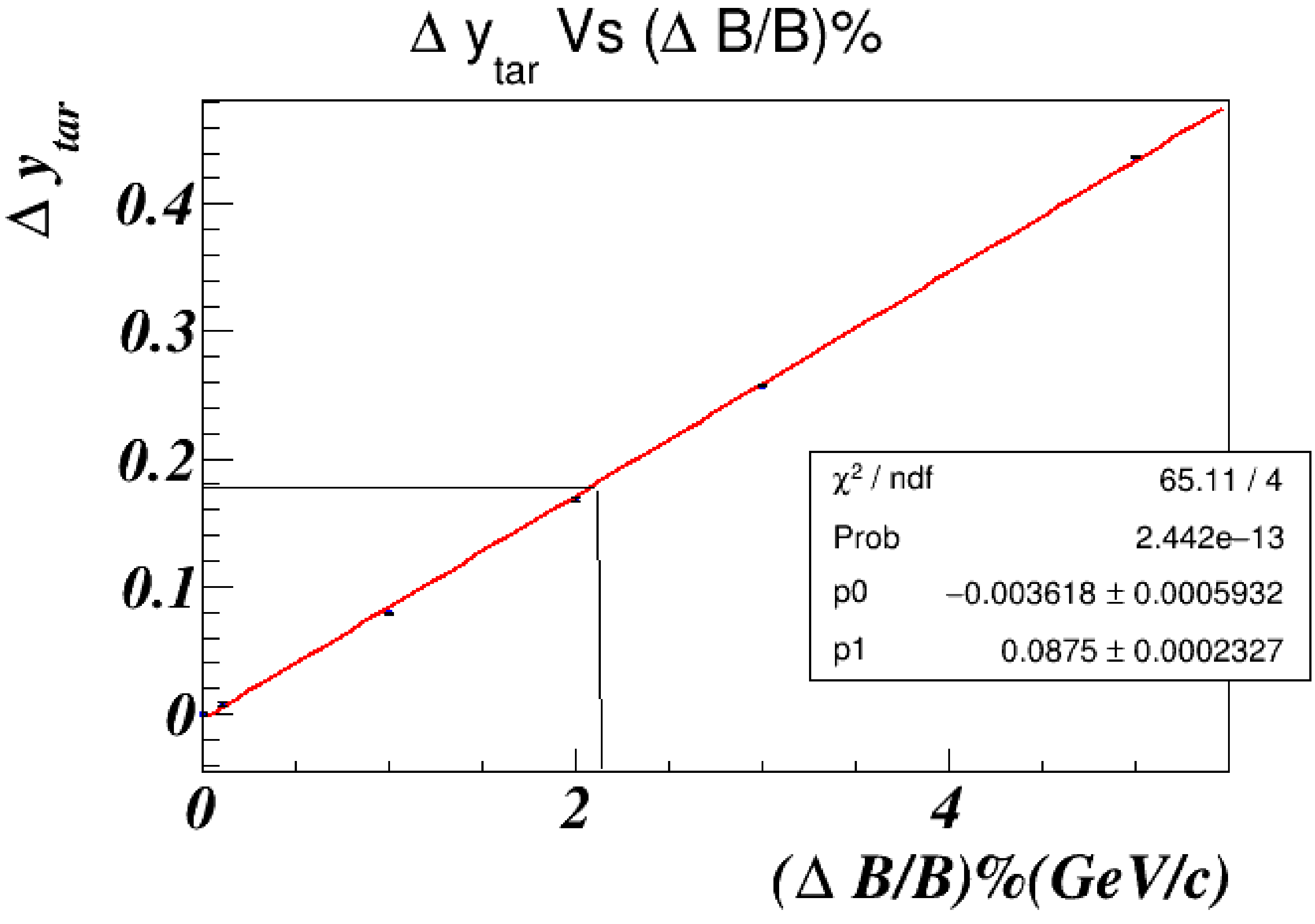
- To correct for the HB field -changed mc_single_arm/src/shms/mc_shms.f
- To study changes in HB field by changing the particle momentum

  cfac=0.999944(change the value)

  dpps=100*(p/(p_spec*cfac)-1)

- Δ cfac $\approx \Delta B/B$ in HB

Y_{tar} variation with HB field



Conclusion

- Y_{tar} depend on the momentum .
- By changing HB field can correct the change in y_{tar} with momentum.

Future work

- Still working on momentum dependence of HB.

  Plot $\Delta B/B$ vs P graph

- Still working on the aperture acceptance studies