Momentum Calibration with GEM Resolution and Multiple Scattering

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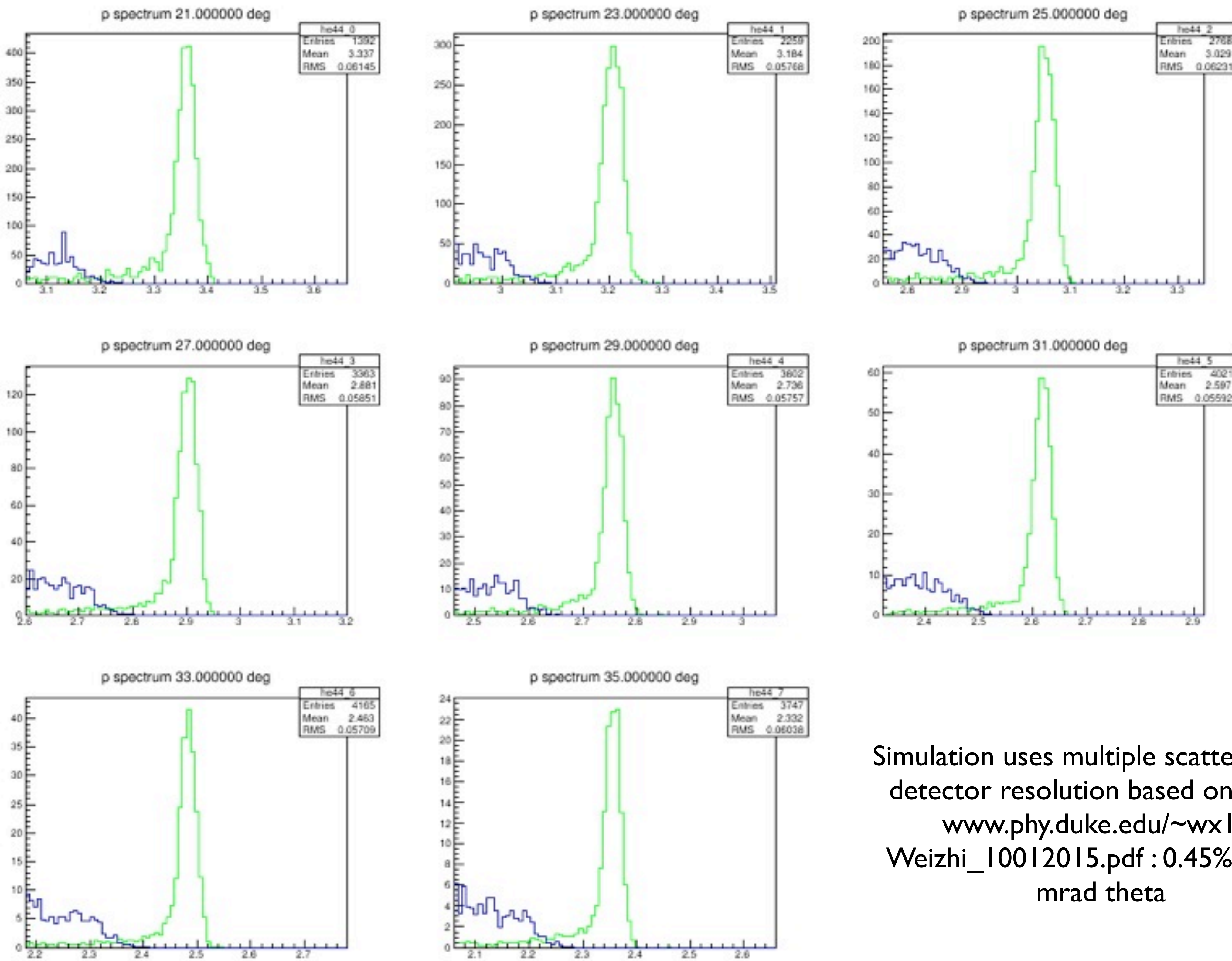
- Trajectory determined by vertex ($x_v \approx 0$, $y_v \approx 0$, z_v) and momentum (p, θ_p, ϕ_p).
- Hits in 2 GEM chambers give 4 quantities x_1, y_1, x_2, y_2 or r_1, ϕ_1, r_2, ϕ_2
- Invert the mapping.
- Cylindrical symmetry => Use variables independent of ϕ_p:
  - $R \equiv (r_1 + r_2) / 2$; $\Delta\phi \equiv \phi_2 - \phi_1$, $\Delta r \equiv r_2 - r_1$
- $\Delta\phi$ is strongly correlated with $1/p$; Δr is correlated with $\tan \theta_p$; $\Delta r/R$ is correlated with z_v
- For easier comparison between plane pairs, R is normalized by $(z_1+z_2)/2$, and $\Delta\phi$, Δr are normalized by $z_2 - z_1$
- For elastics, angle-energy correlation => use 2 variables

Calibration procedure:

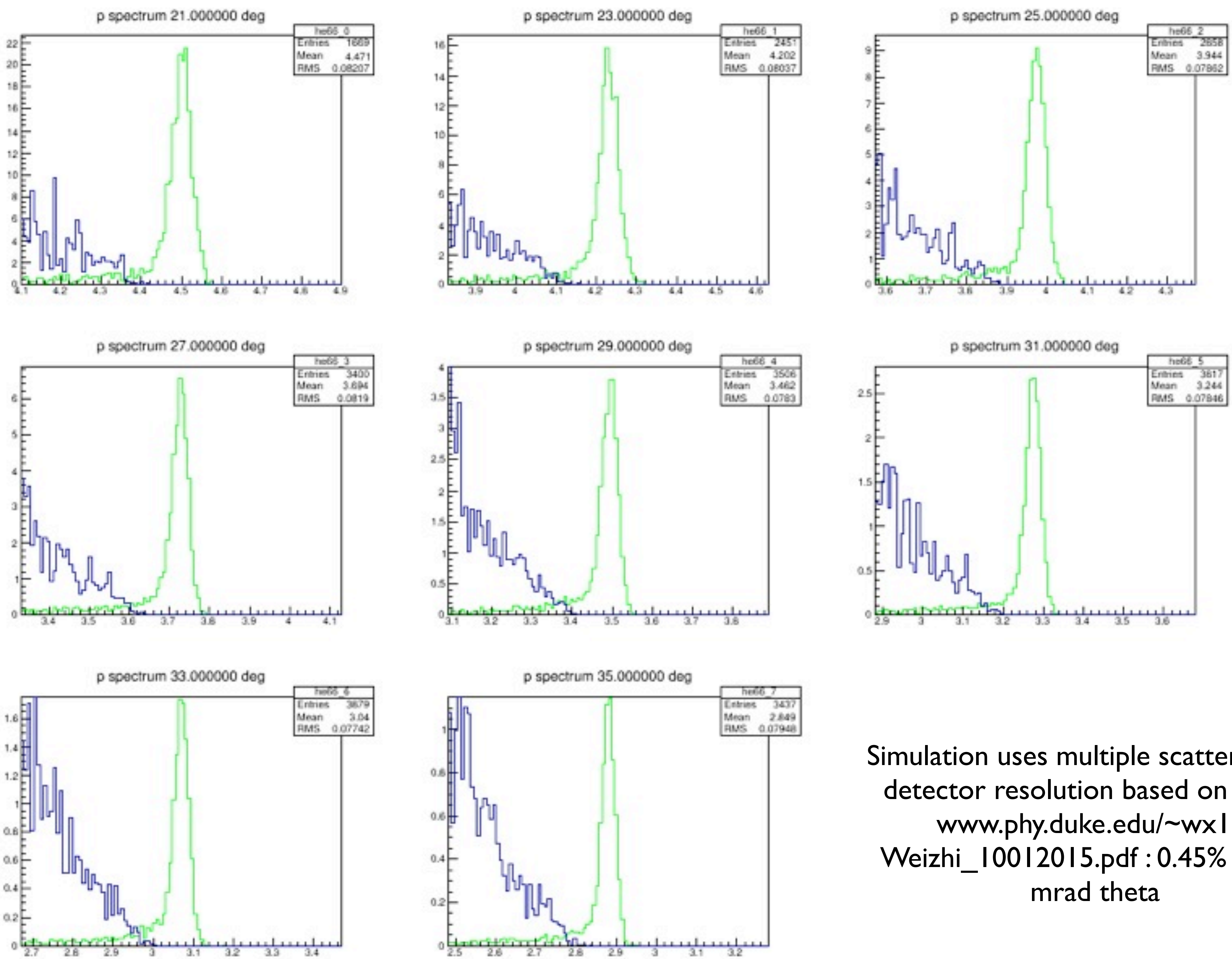
- For elastics at two energies (4.4, 6.6 GeV) get 2-d response functions $P(\Delta r, \Delta r/R)$, $\Theta(\Delta r, \Delta r/R)$ using simulation data, truth values of p, θp
- For combined 4.4, 6.6 GeV elastics get 3-d response functions $P(\Delta r, \Delta r/R, \Delta\phi)$, $\Theta(\Delta r, \Delta r/R, \Delta\phi)$ using real data, $p = P(\Delta r, \Delta r/R)$, $\theta p = \Theta(\Delta r, \Delta r/R)$
- For inelastics, use $P(\Delta r, \Delta r/R, \Delta\phi)$, $\Theta(\Delta r, \Delta r/R, \Delta\phi)$ to extract p, θp

Separation of elastics, inelastics: 4.4 GeV



Simulation uses multiple scattering and detector resolution based on http://www.phy.duke.edu/~wx19/Weizhi_10012015.pdf : 0.45% p, 0.35 mrad theta

Separation of elastics, inelastics: 6.6 GeV

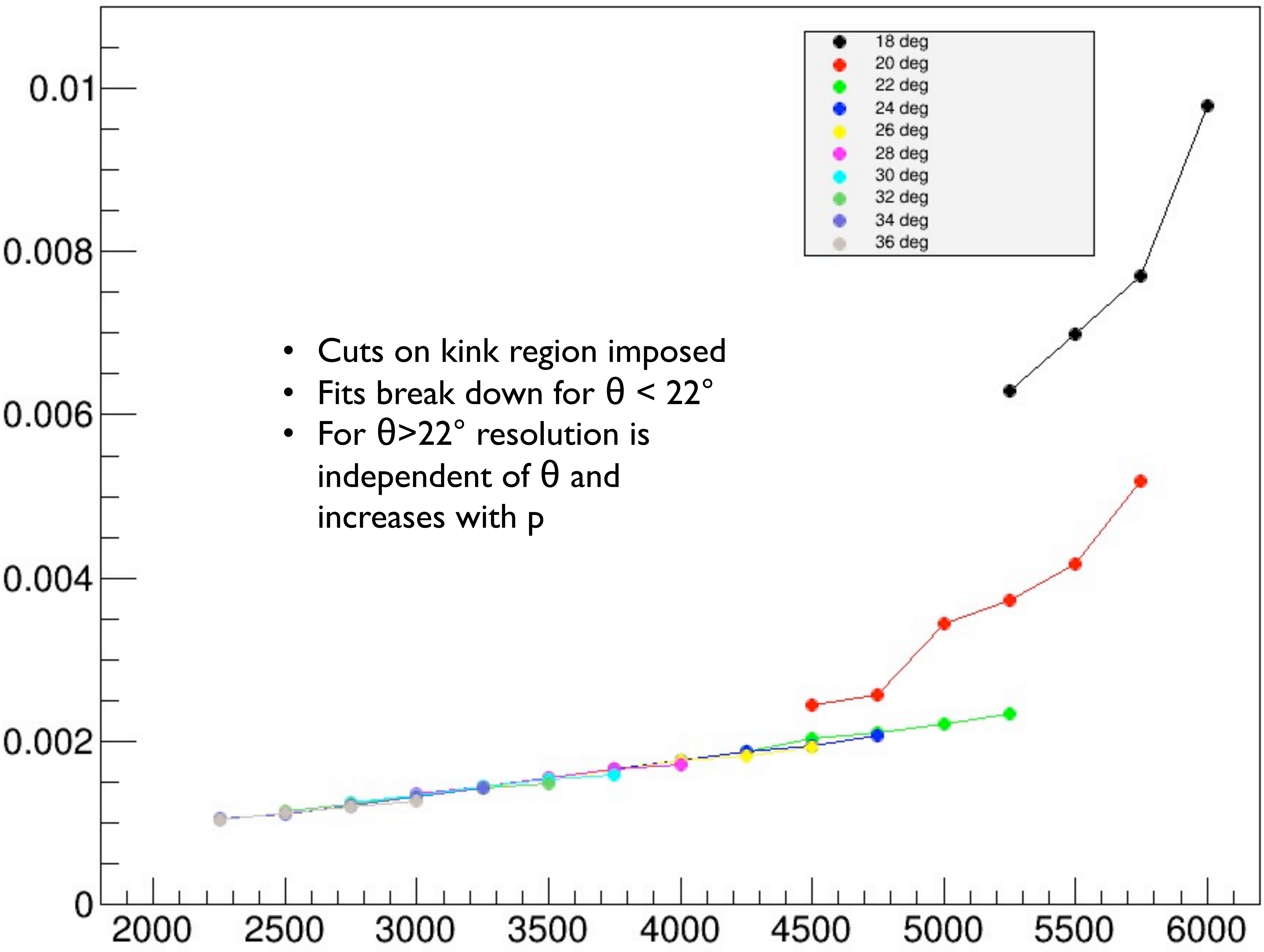


Simulation uses multiple scattering and detector resolution based on http://www.phy.duke.edu/~wx19/Weizhi_10012015.pdf : 0.45% p, 0.35 mrad theta

p, θ_p resolution

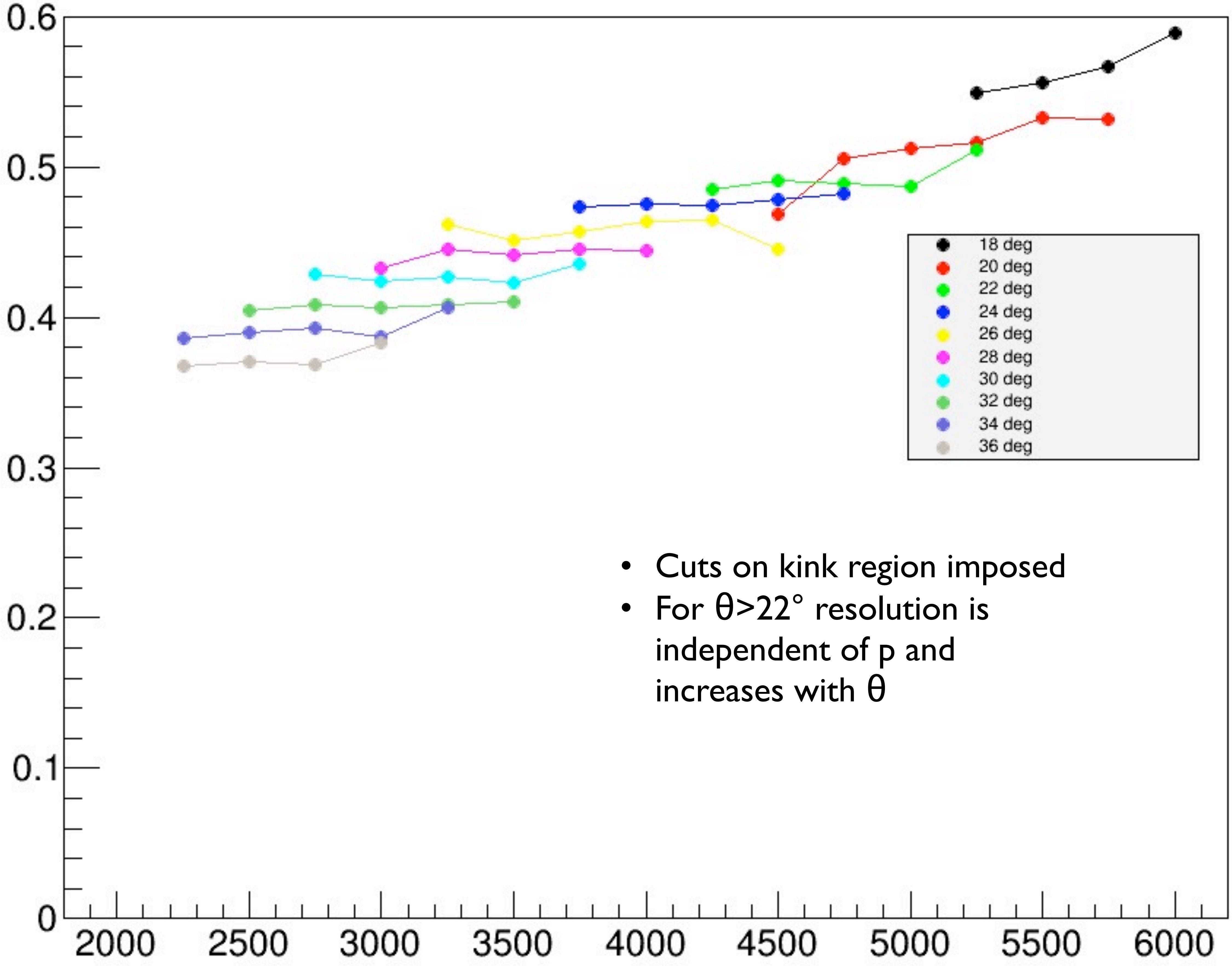
- Use data with simulated detector resolution
- Truth values of r, ϕ are given gaussian smearing
- Using Δu (resolution in strip direction) = 70 μm (for upstream GEMs), get Δr = 470 μm, Δϕ = (0.057/r) rad (r in mm)
- Downstream GEMs 50% larger resolution

p relative width vs. p



- Cuts on kink region imposed
- Fits break down for $\theta < 22°$
- For $\theta > 22°$ resolution is independent of θ and increases with p

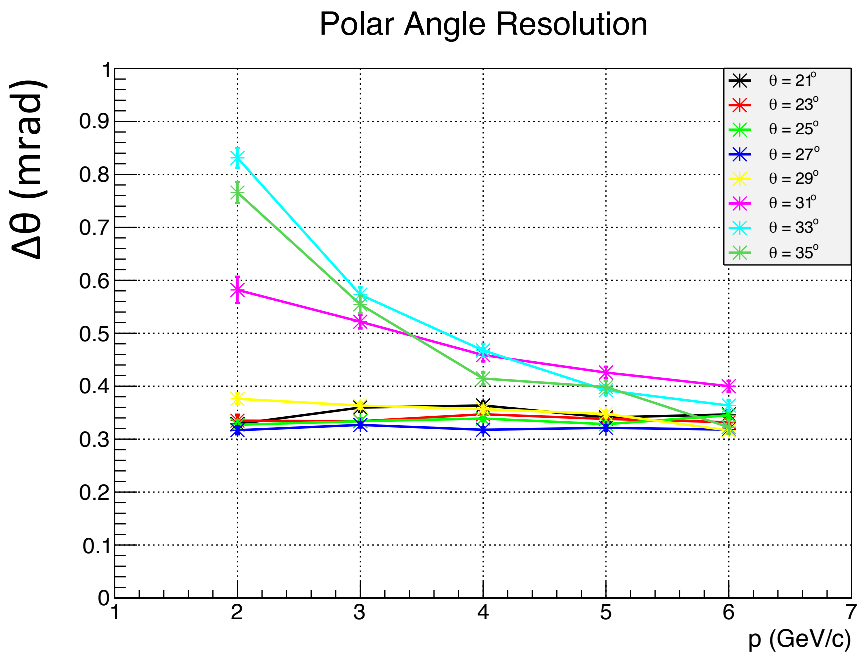
theta width (mrad) vs. p

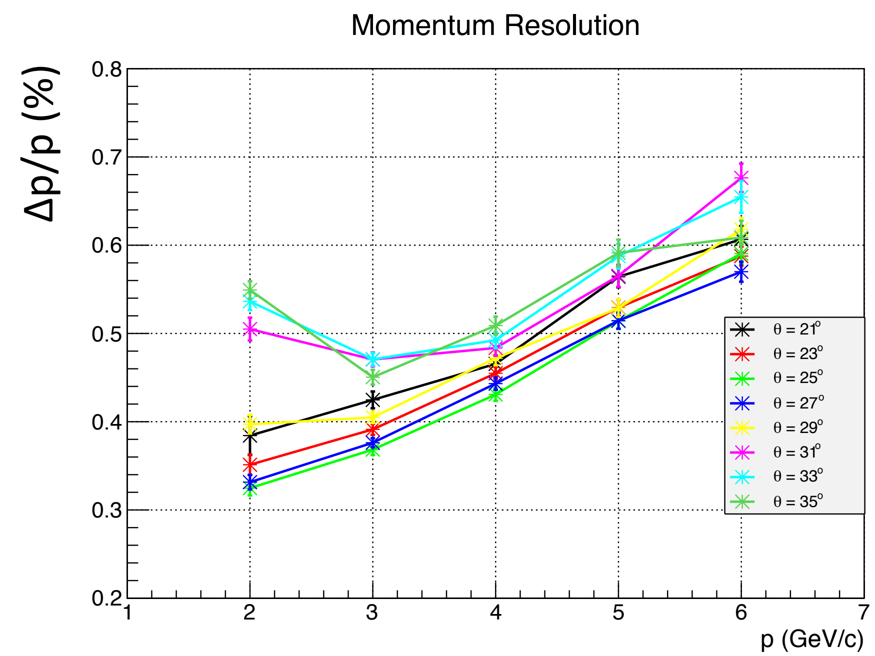


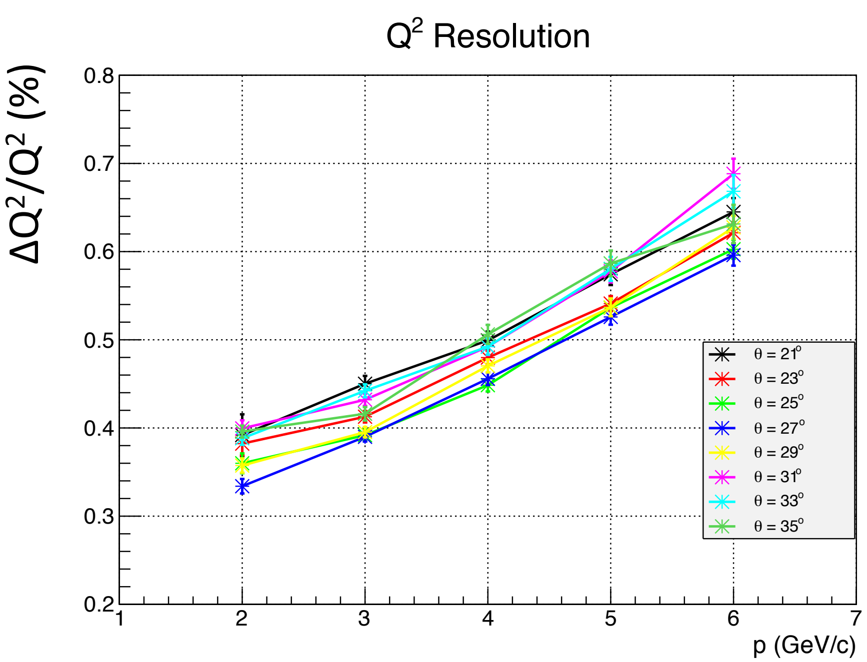
- Cuts on kink region imposed
- For θ>22° resolution is independent of p and increases with θ

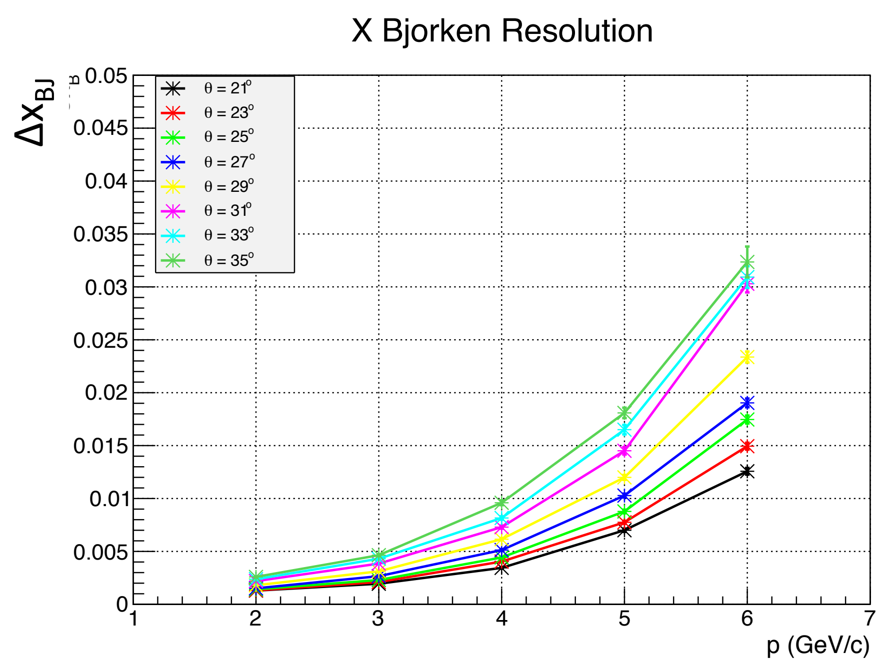
Weizhi:

PVDIS Vertex Reconstruction Resolution









Comparison:

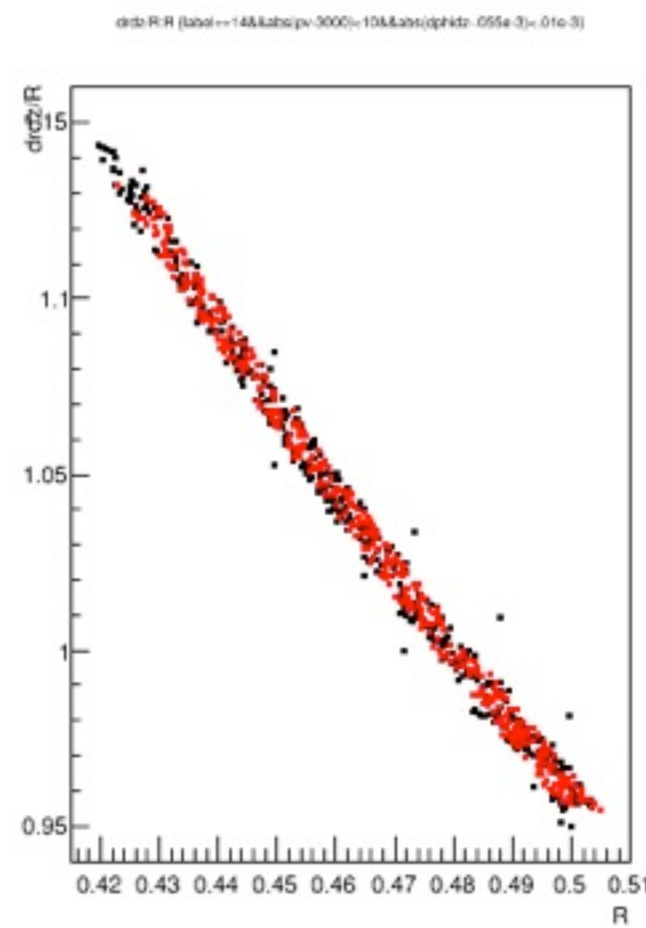
- $\Delta\theta$ comparable at low p, low θ
- 3x larger value for $\Delta p/p$
- Odd behavior for $\theta > 29°$
- For $\theta < 29°$, θ resolution independent of θ

Multiple scattering — in progress

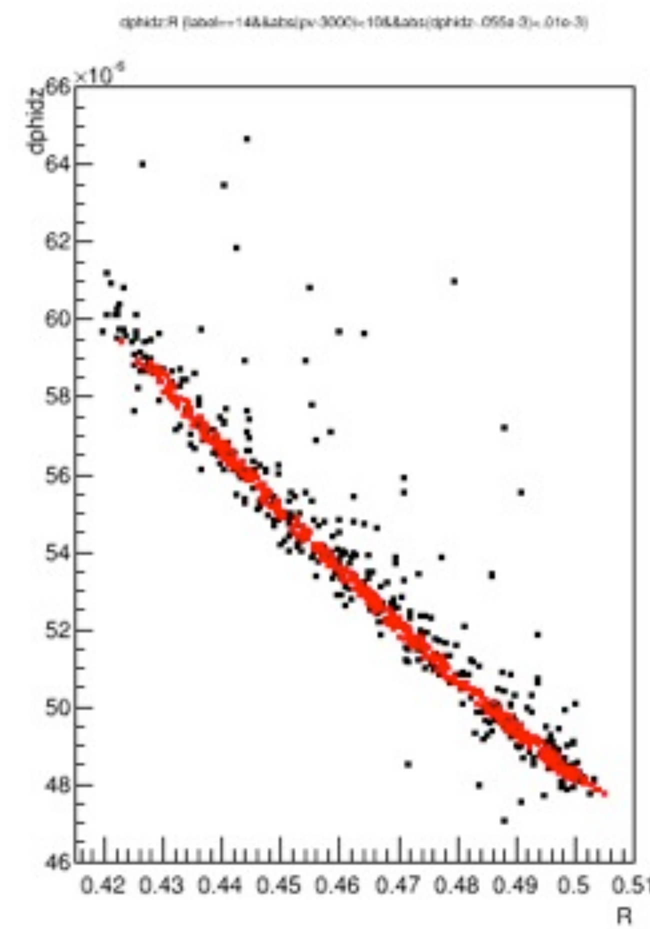
- Resolution much worse ($\Delta p/p$ ~ several %) using 3-d functions
- Using 2-d functions (with elastic data) resolution is good
- Reason: $\Delta\phi$ (not used in 2-d functions) is much more sensitive to multiple scattering
- Possible solutions: cleanup cuts to get rid of events with large motion; iterative procedure cutting events that reconstruct to tails

4.4 GeV elastics at p ~ 3 Gev

$\Delta r/r$ vs Δr



$\Delta\phi$ vs Δr



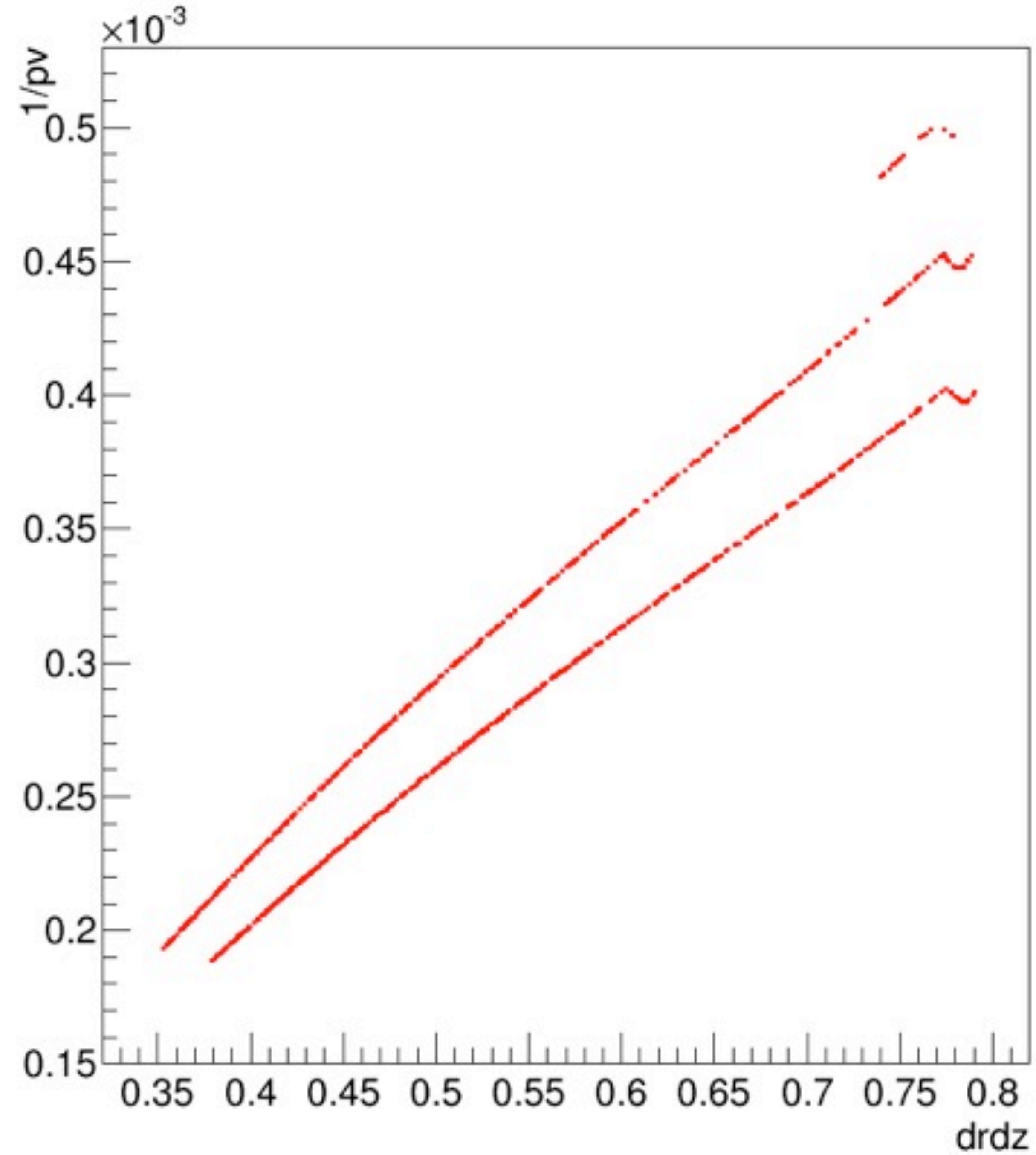
Extra

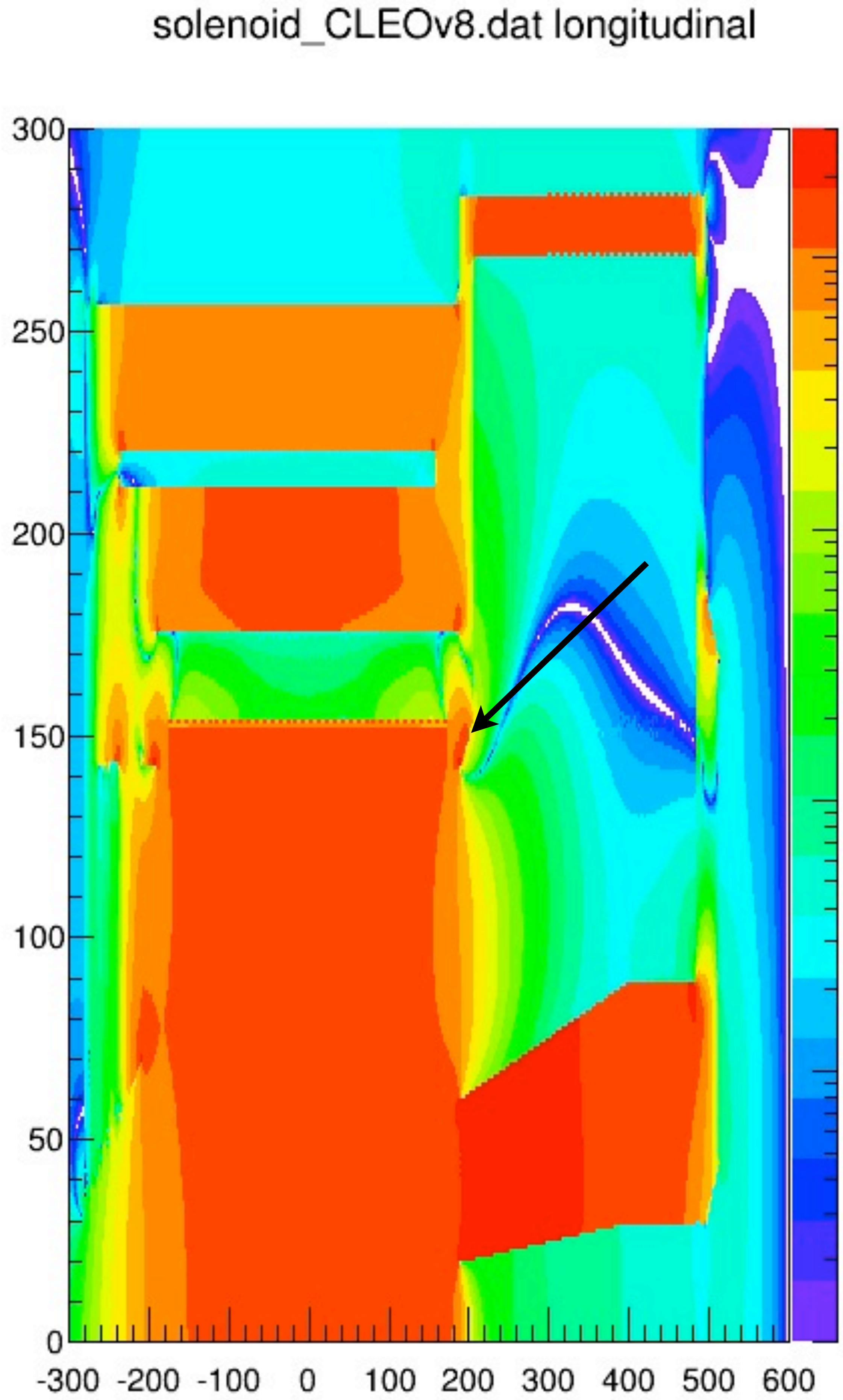
- 3D data (uniform p 2–6 GeV, θ_p 19°–40°, z_v -10–30 cm, with cuts for x_{bj} > .55, W^2 > 4 GeV^2, Q^2 > 6 GeV^2) fit of 1/p to polynomial in **Δϕ**, **Δ**r, **Δ**r/R. Poor results.

- Cause: "kink" in 1/p vs. **Δ**r observed when using downstream GEMs

- Cause of kink not known in detail but associated with passing through z ~ 200 cm, r ~ 150 cm

1/p vs **Δ**r for thin target (z_v=0) and fixed values of **Δϕ**.

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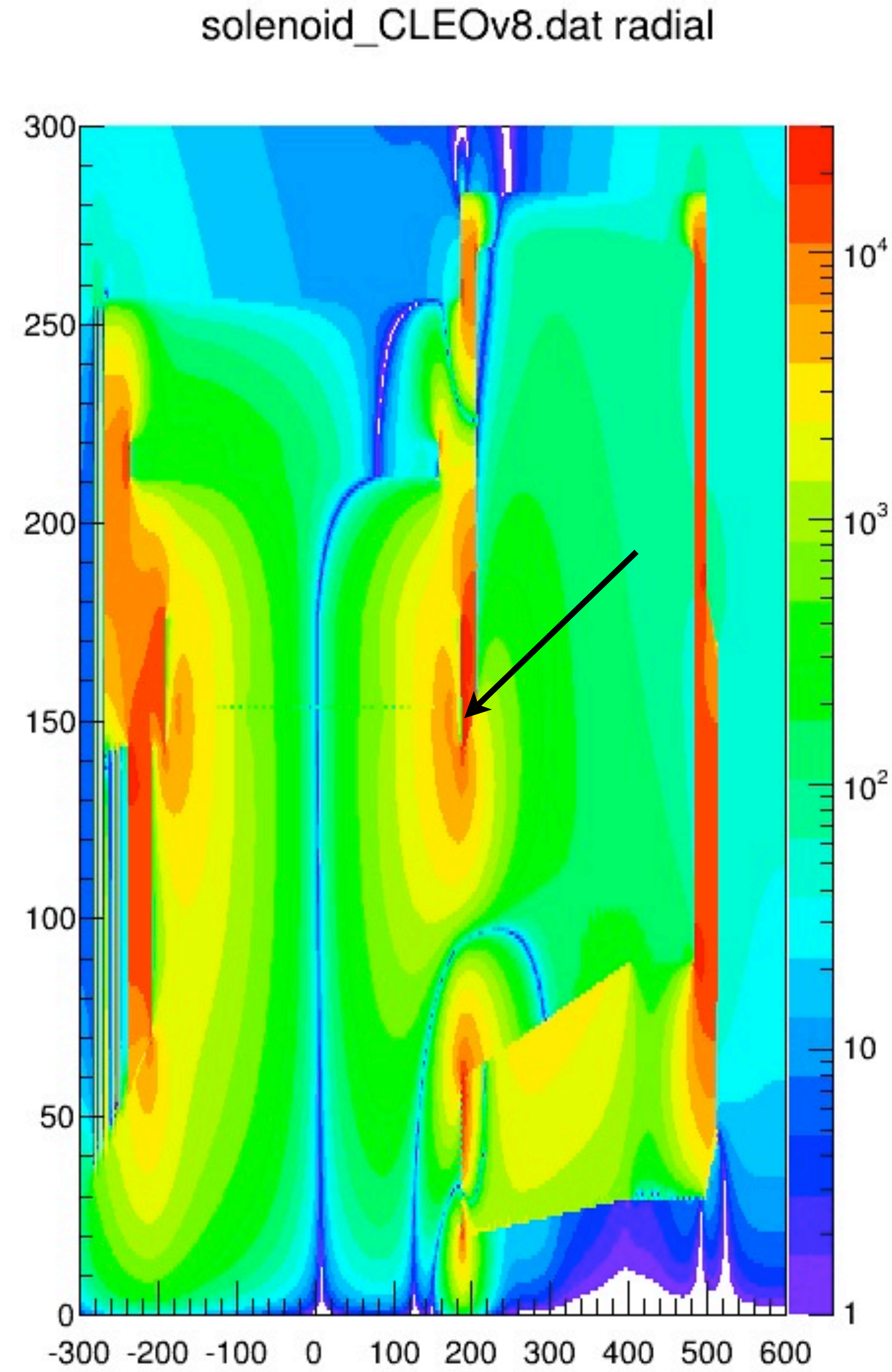
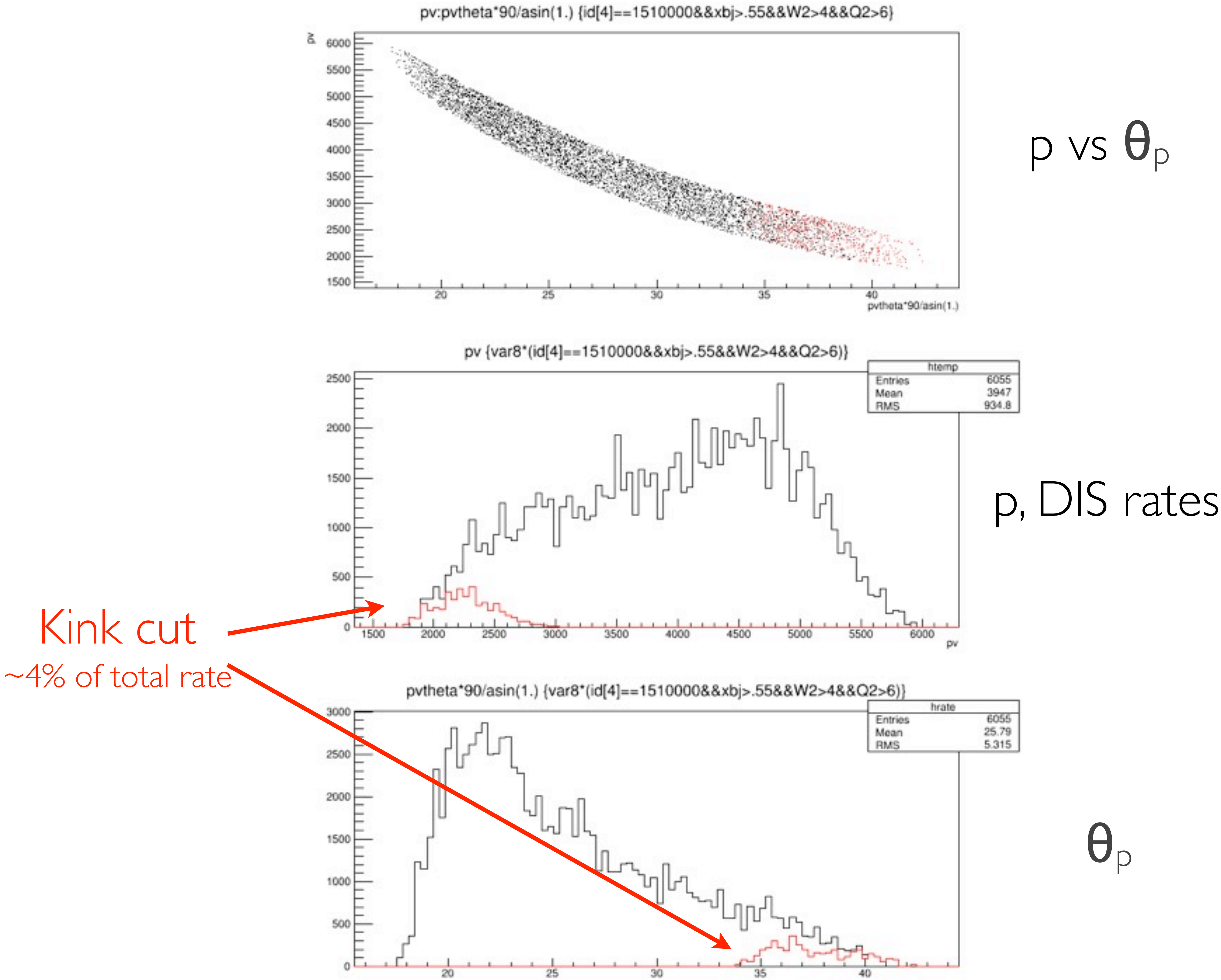
250
200
150
100
50
0
-300 -200 -100 0 100 200 300 400 500 600
10^4
10^3
10^2
10
1


solenoid_CLEOv8.dat radial
300
250
200
150
100
50
0
-300 -200 -100 0 100 200 300 400 500 600
10^4
10^3
10^2
10
1



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pvtheta*90/asin(1.)
pv {var8*(id[4]==1510000&&xbj>.55&&W2>4&&Q2>6)}
htemp
Entries 6055
Mean 3947
RMS 934.8
pv
pvtheta*90/asin(1.) {var8*(id[4]==1510000&&xbj>.55&&W2>4&&Q2>6)}
hrate
Entries 6055
Mean 25.79
RMS 5.315
Kink cut
~4% of total rate
p vs θp
p, DIS rates
θp