Kinematics and detector needs for eRHIC

Matt Lamont

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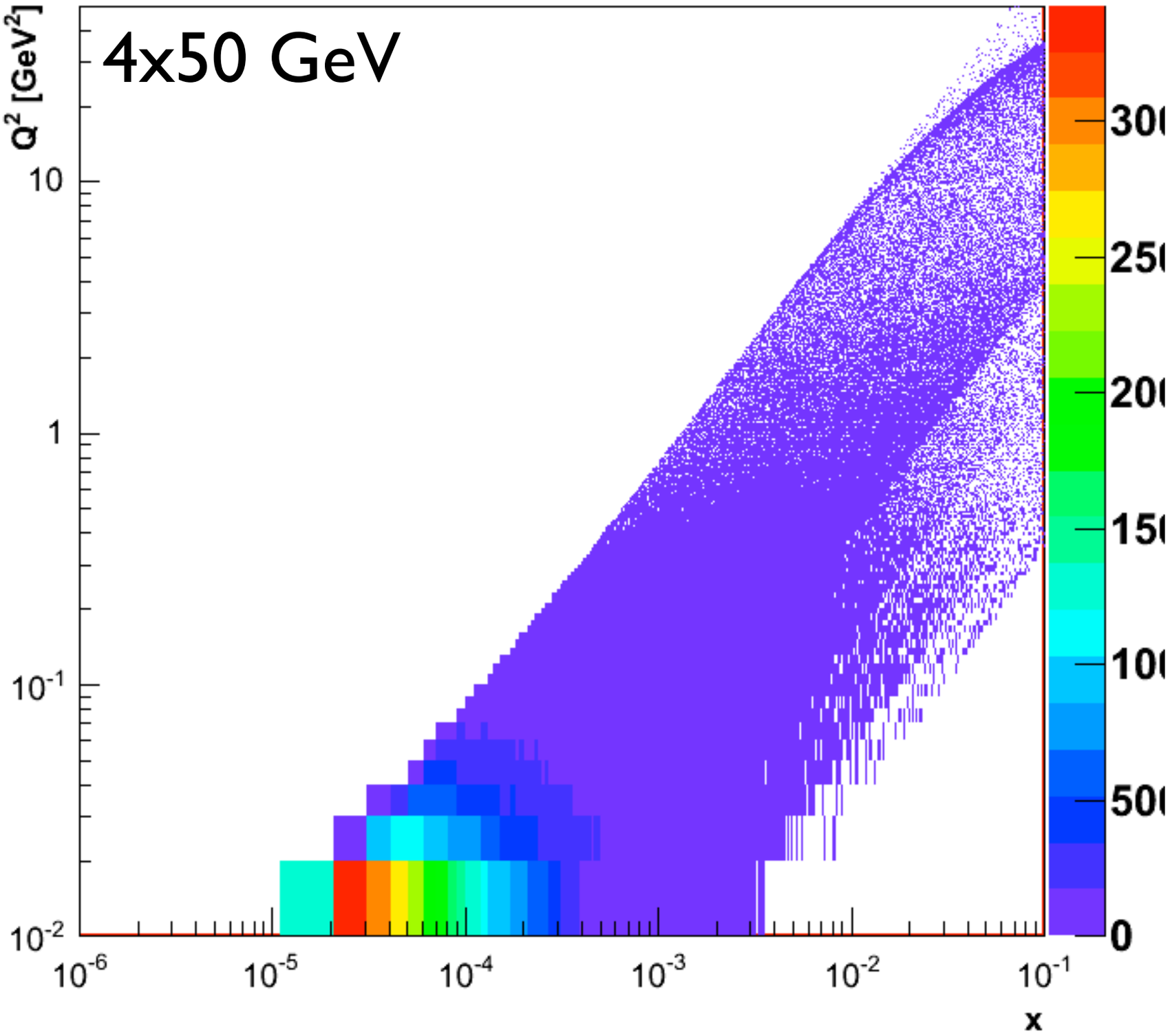
x-Q^2 acceptance vs energy



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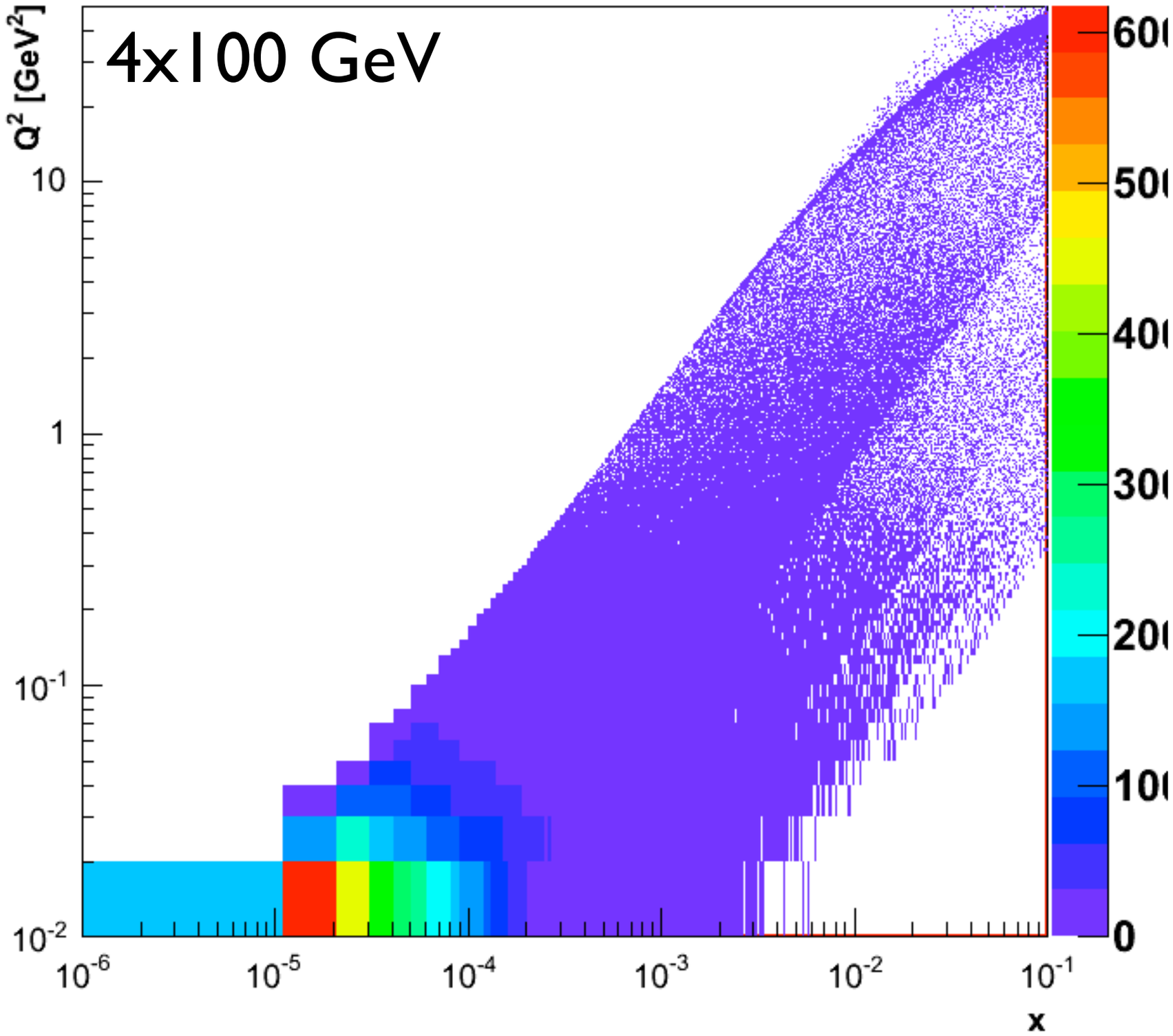

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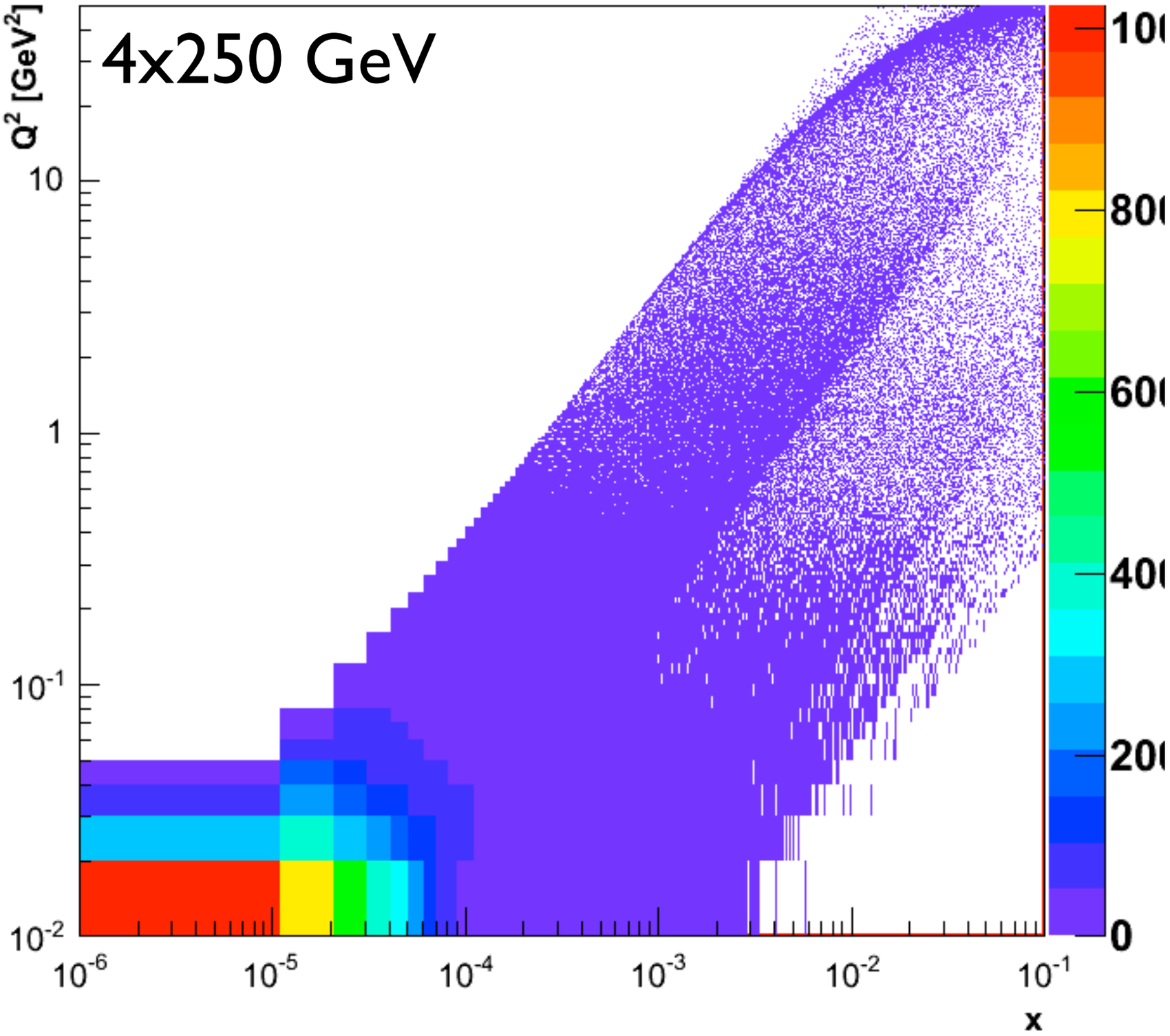

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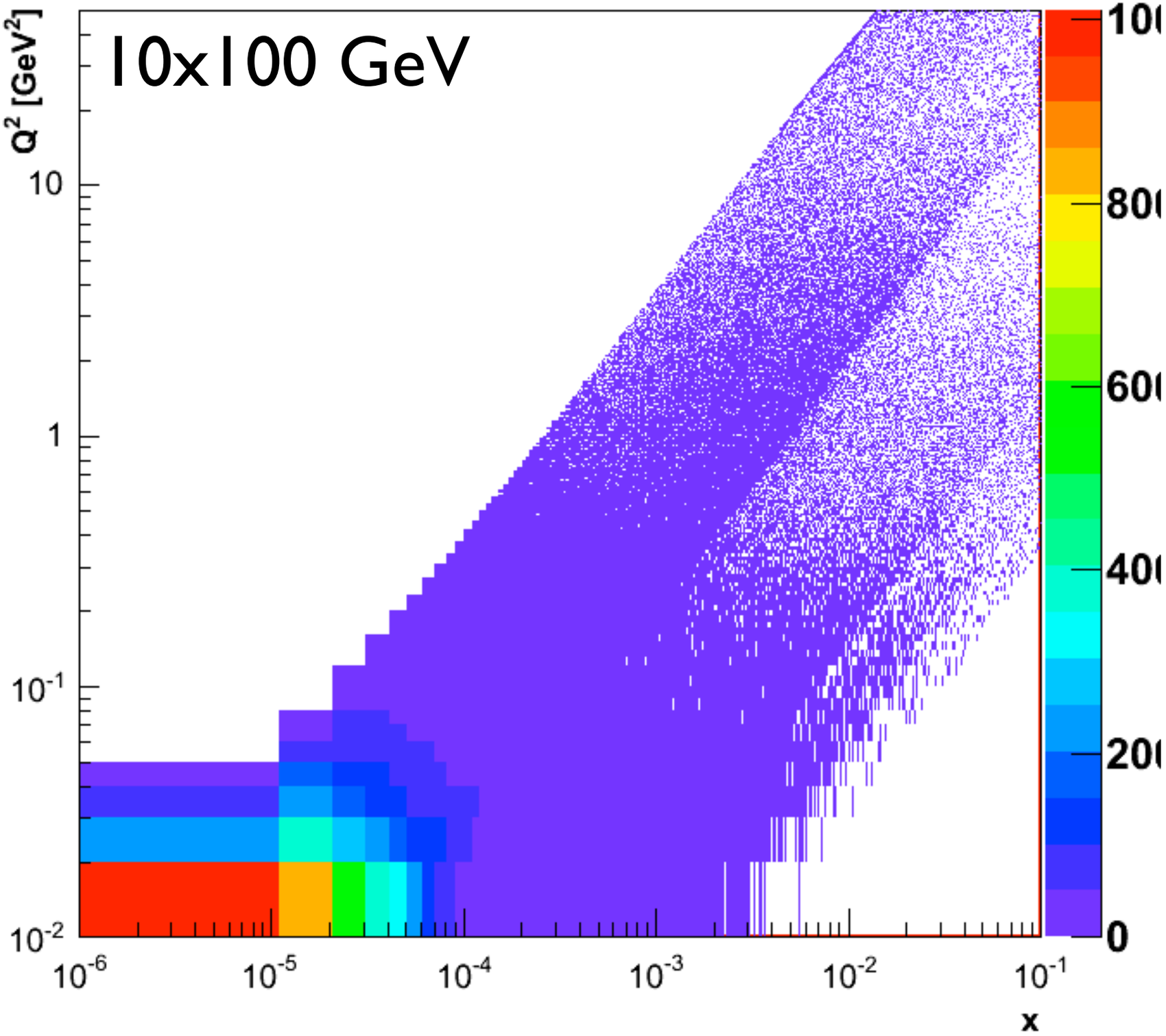

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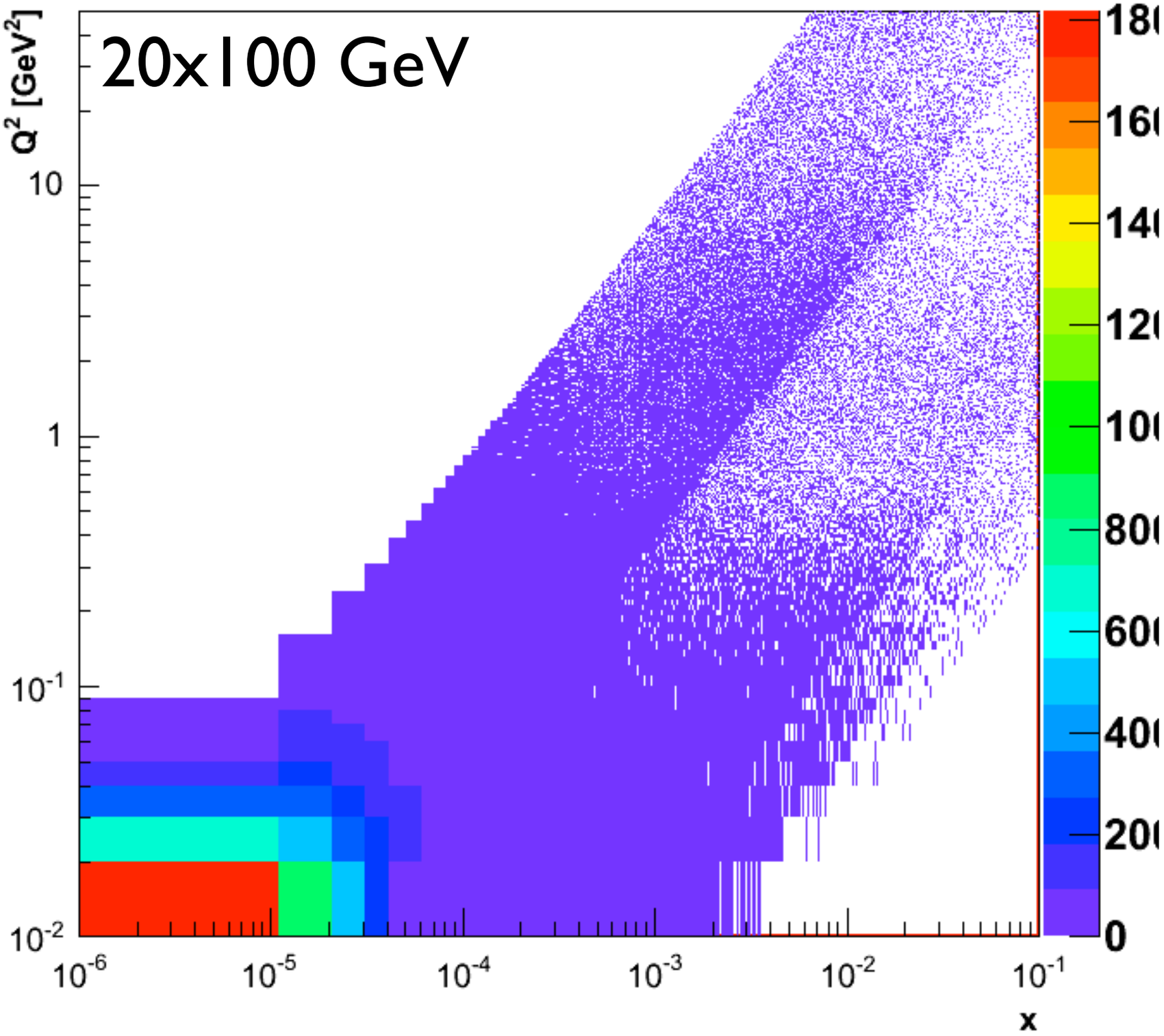
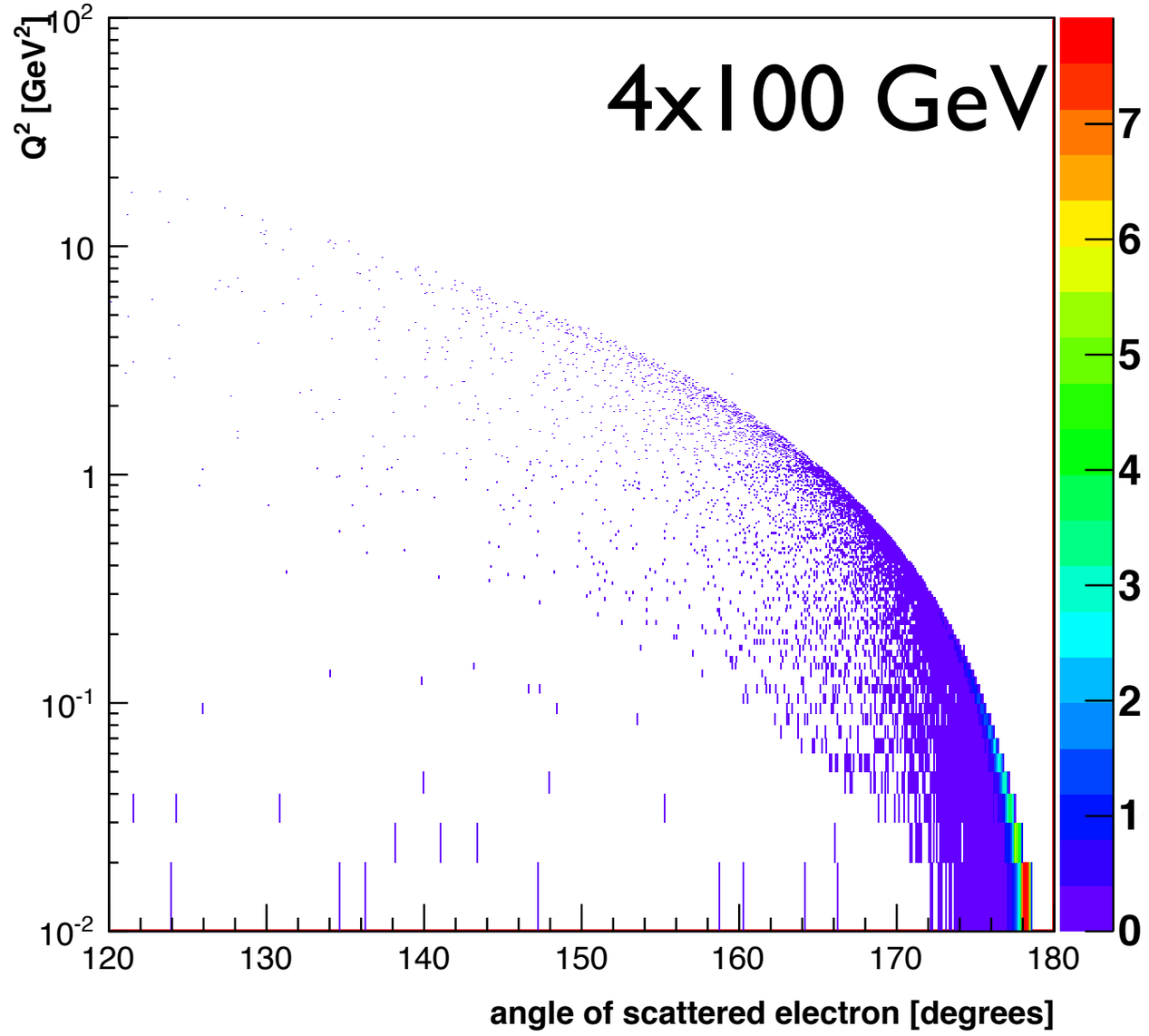
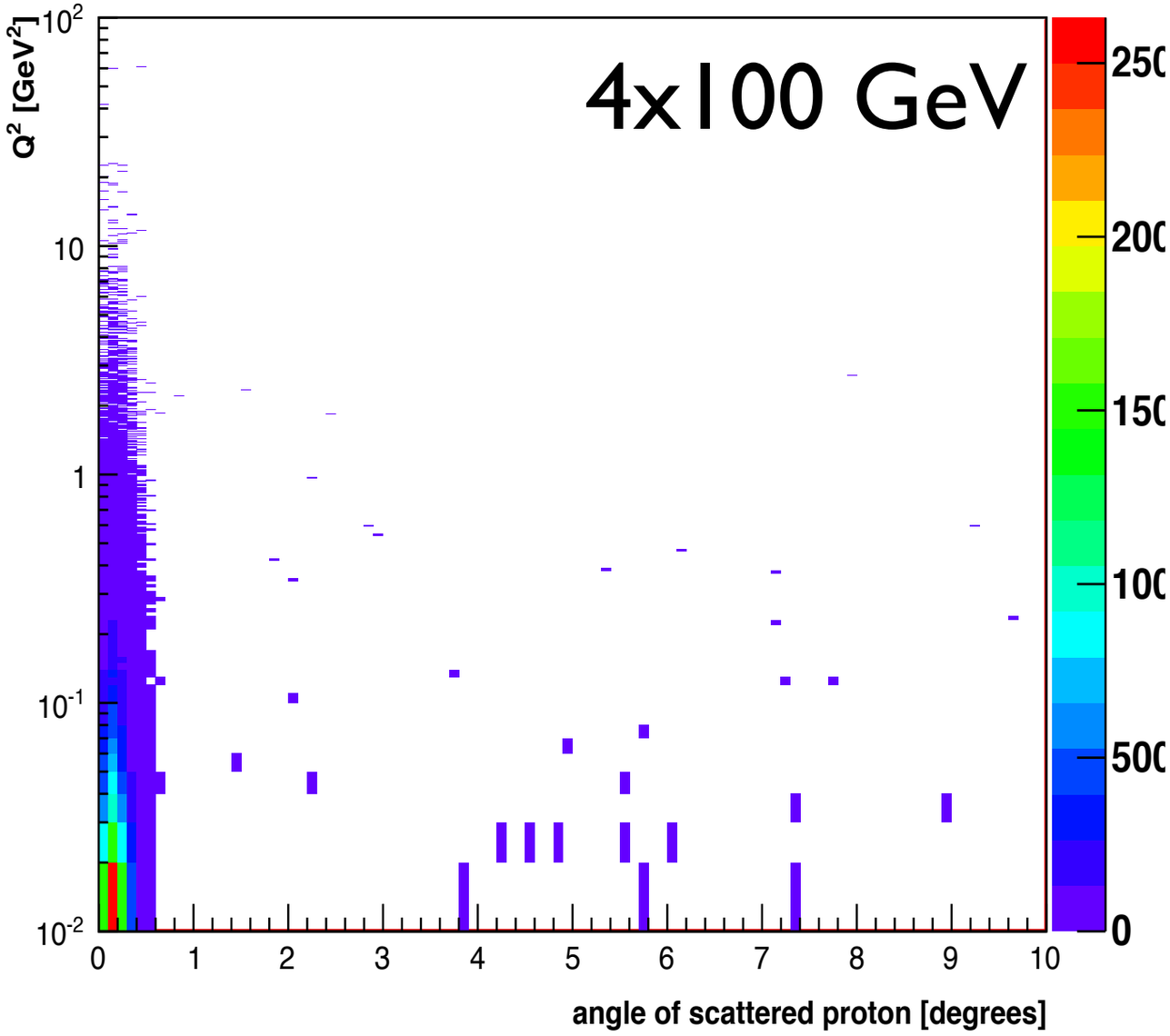


electron and proton angles vs Q^2

electron



proton



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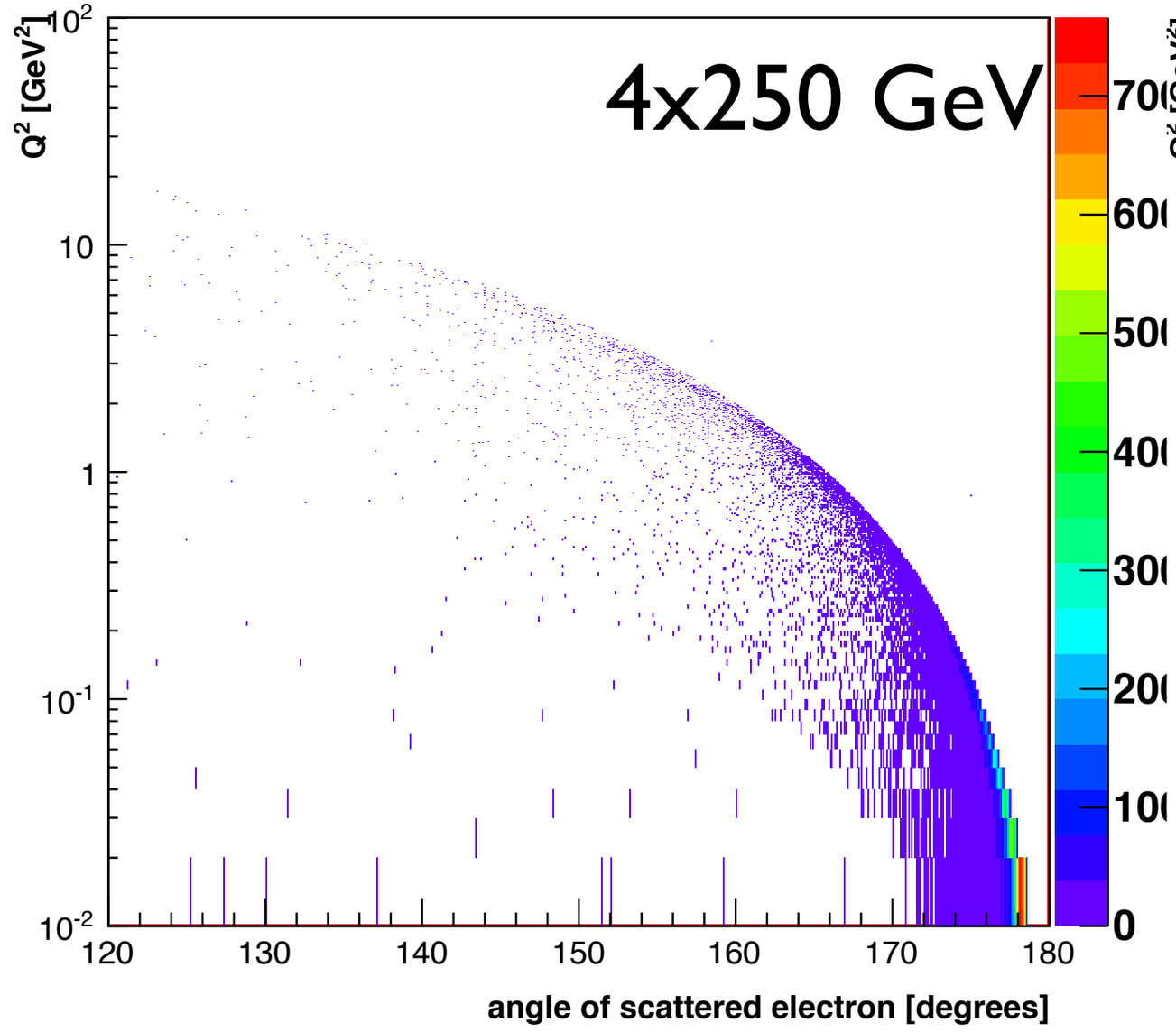

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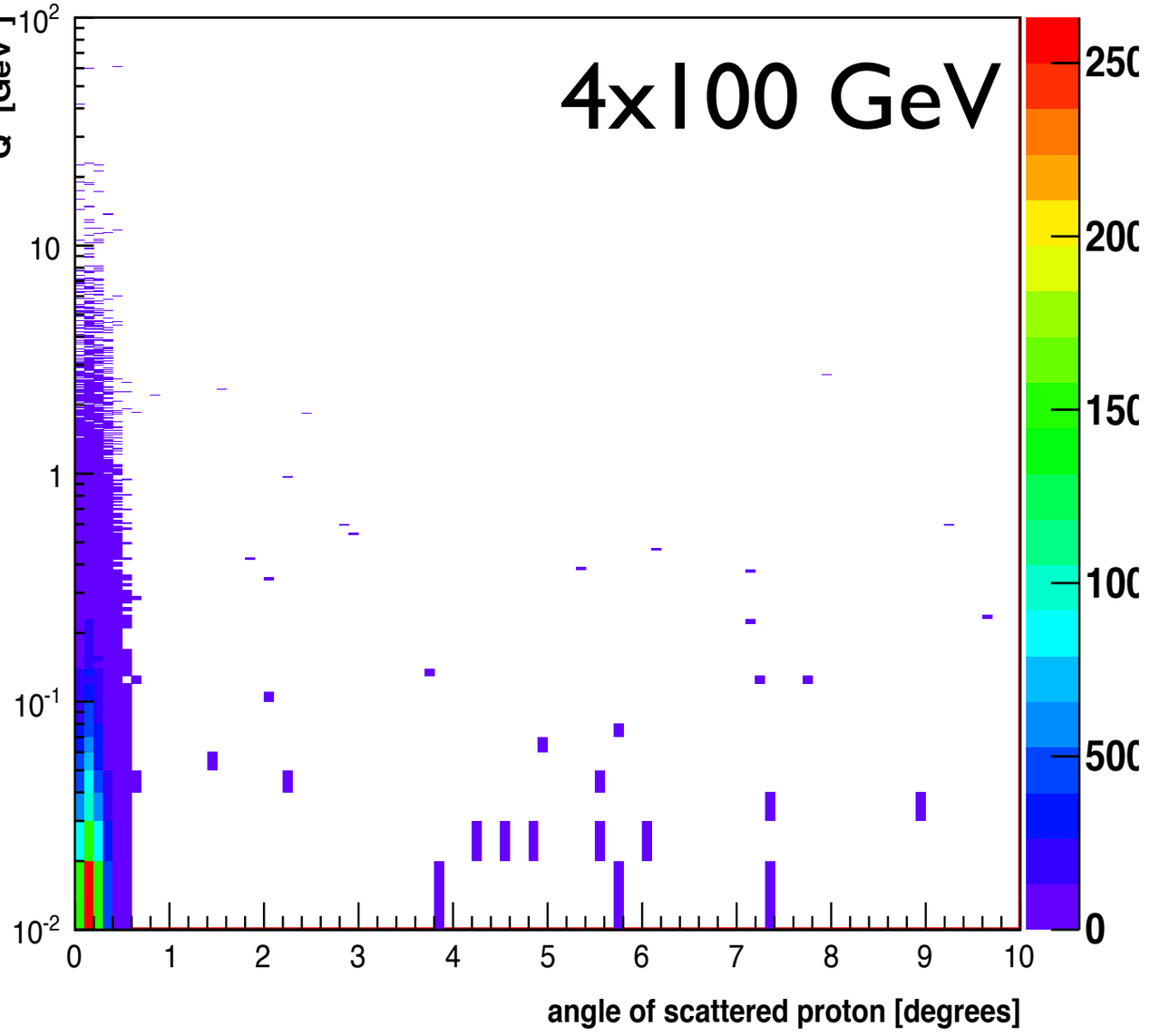

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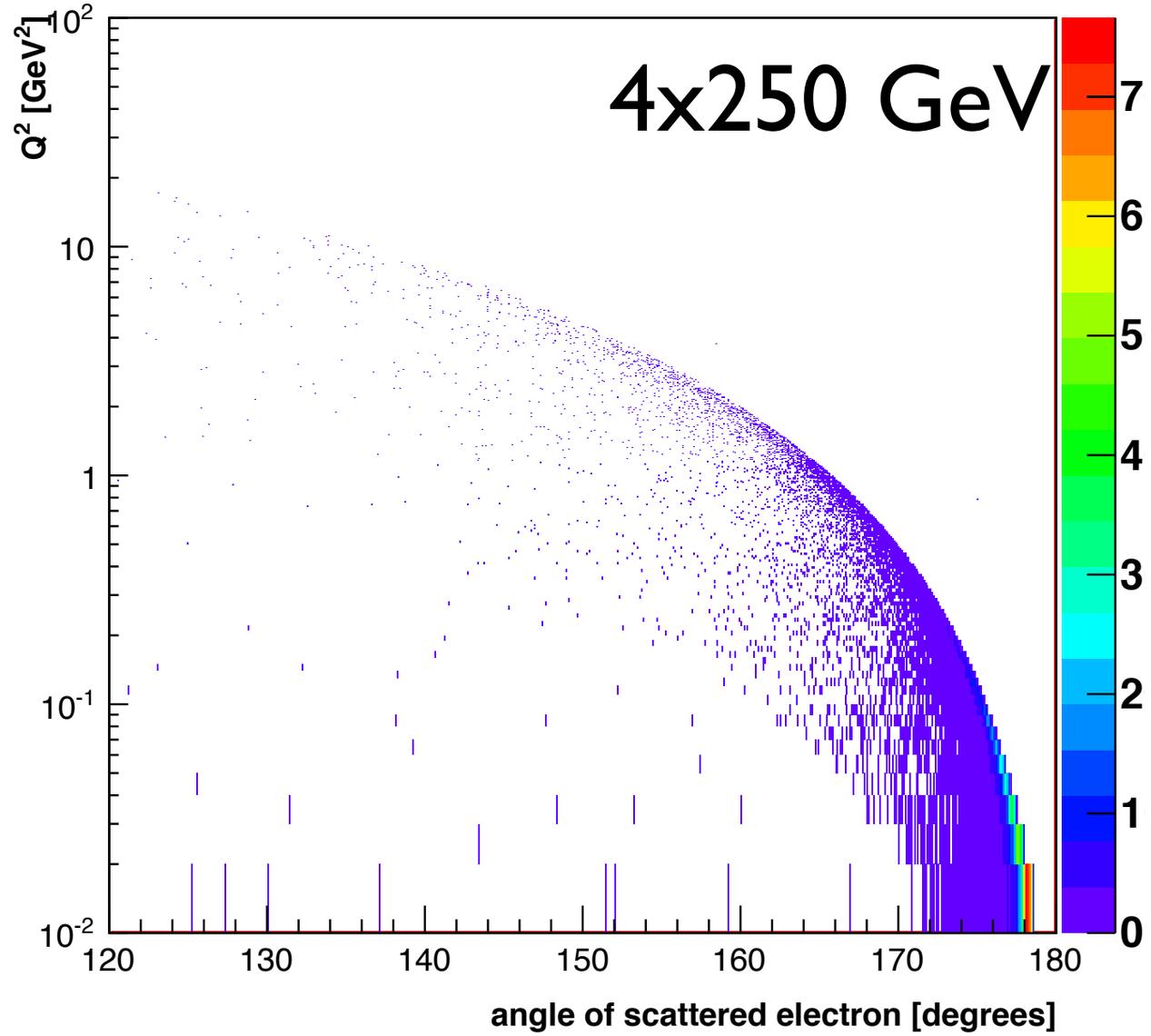

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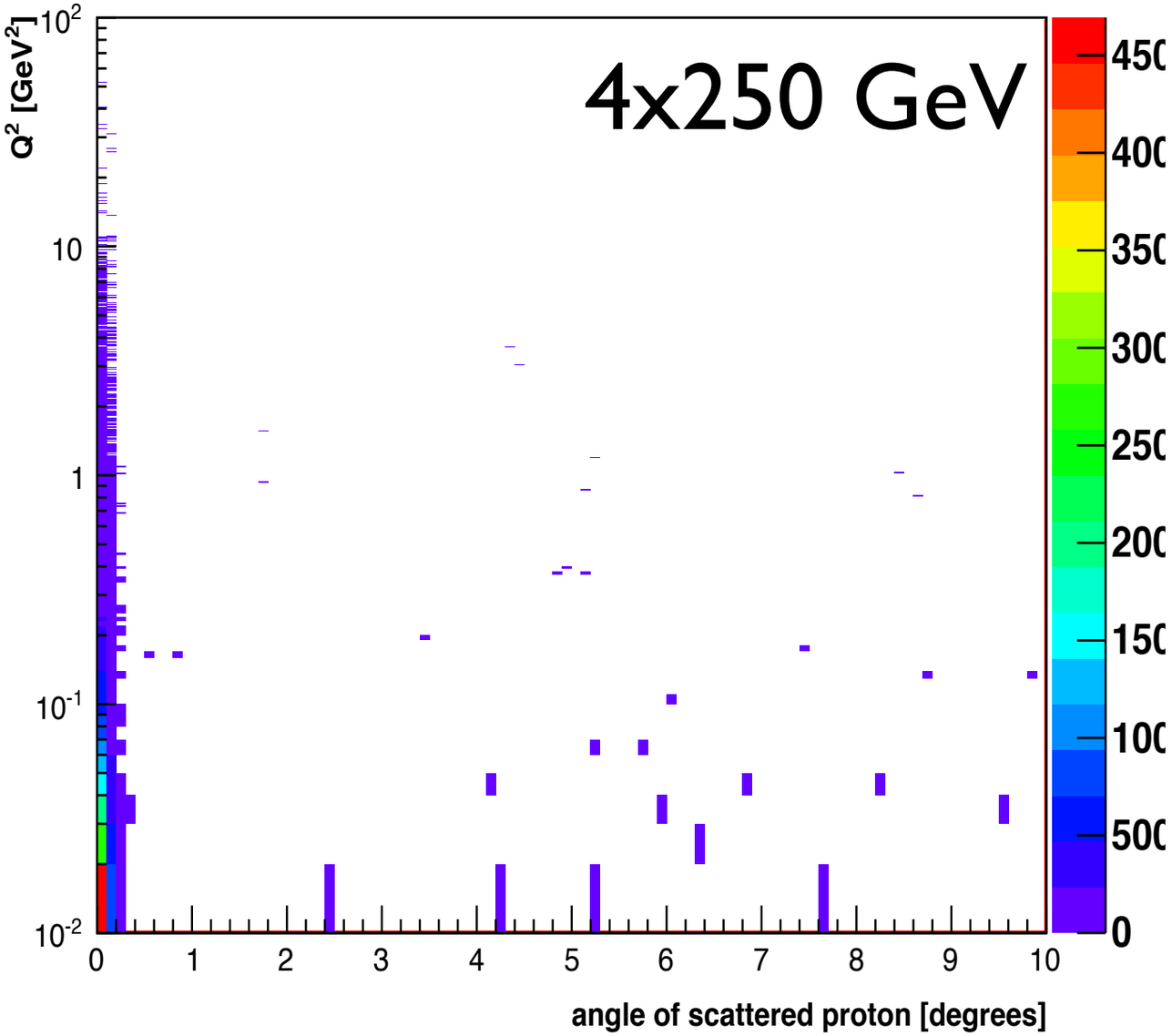

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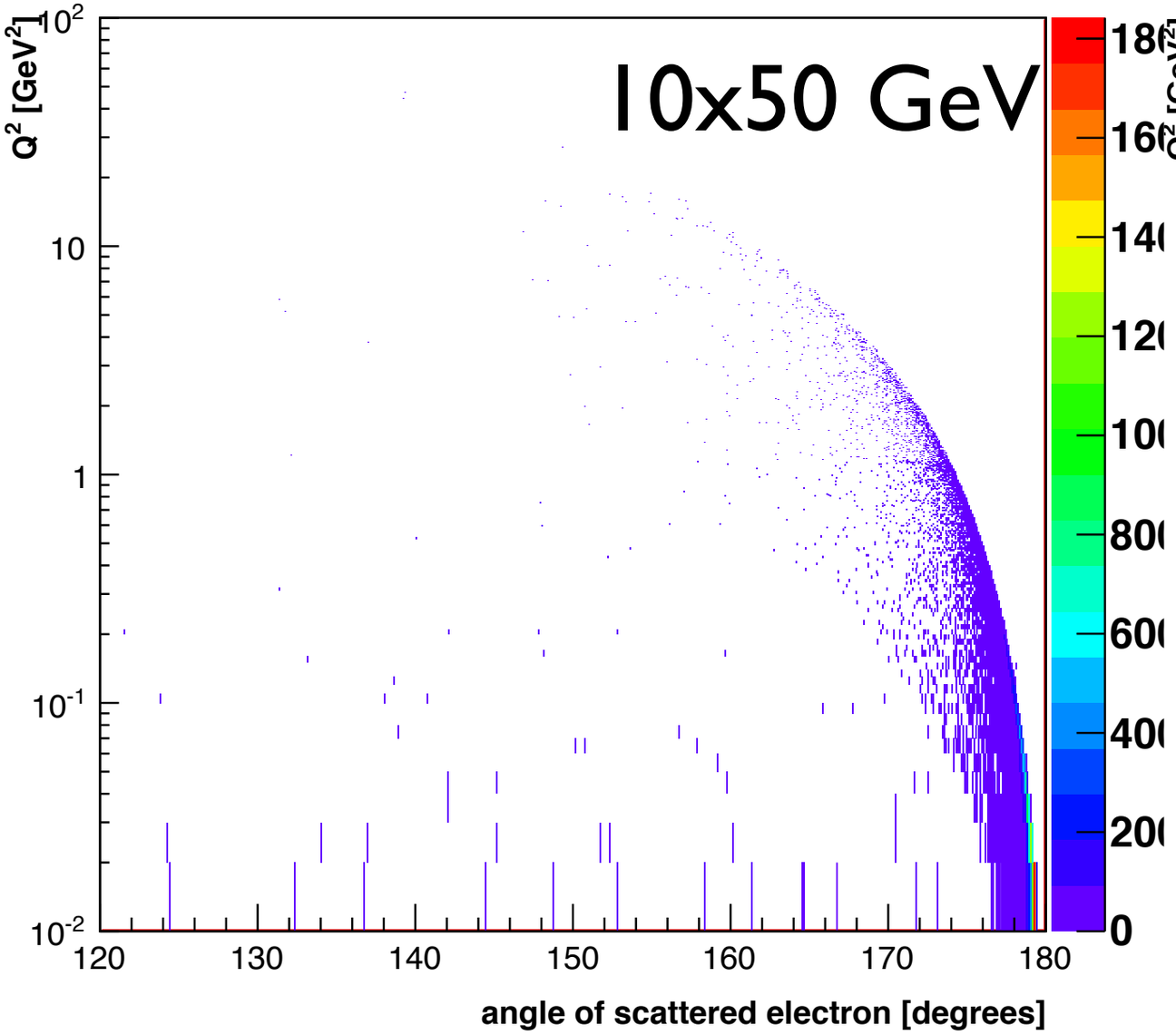

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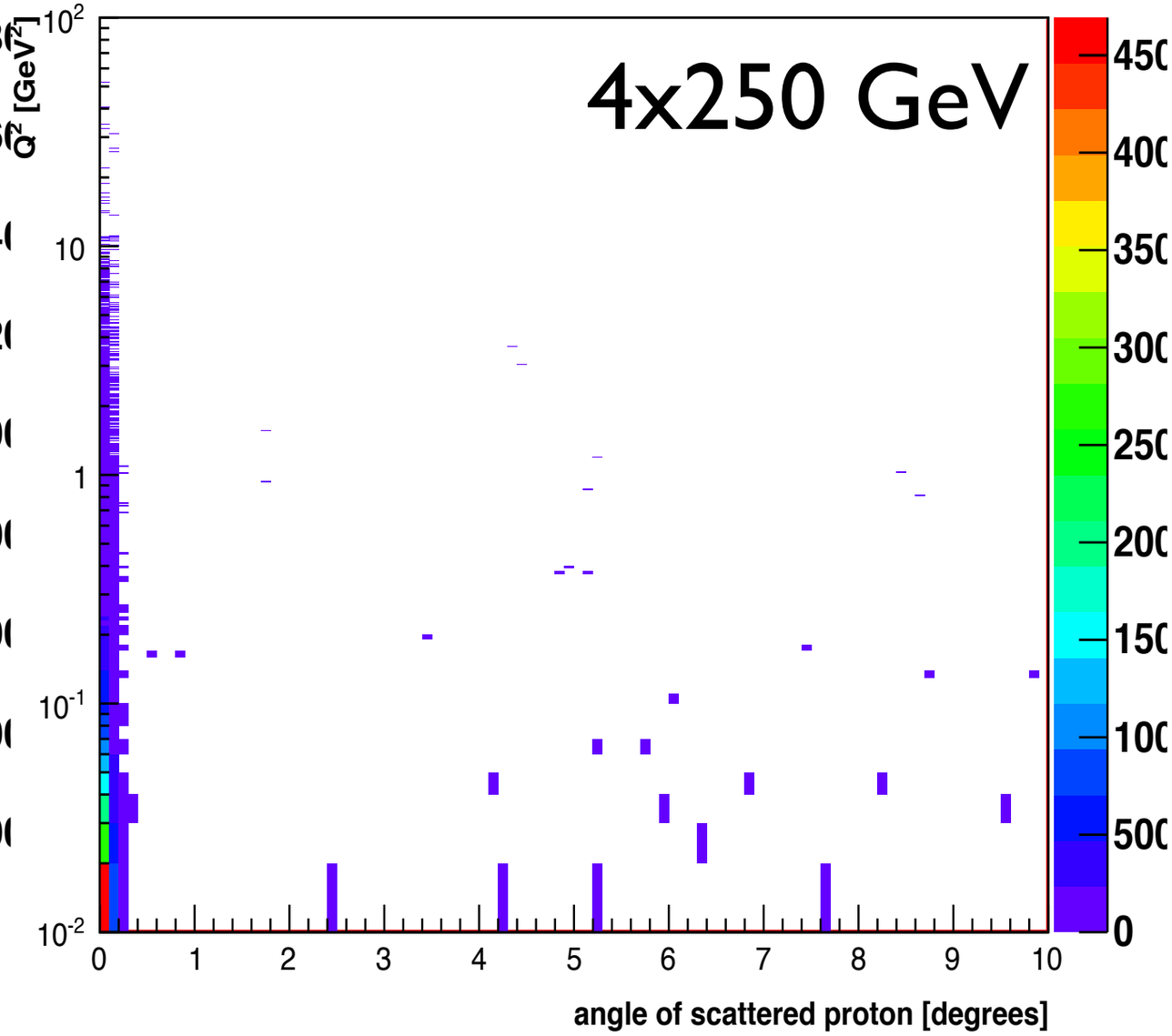

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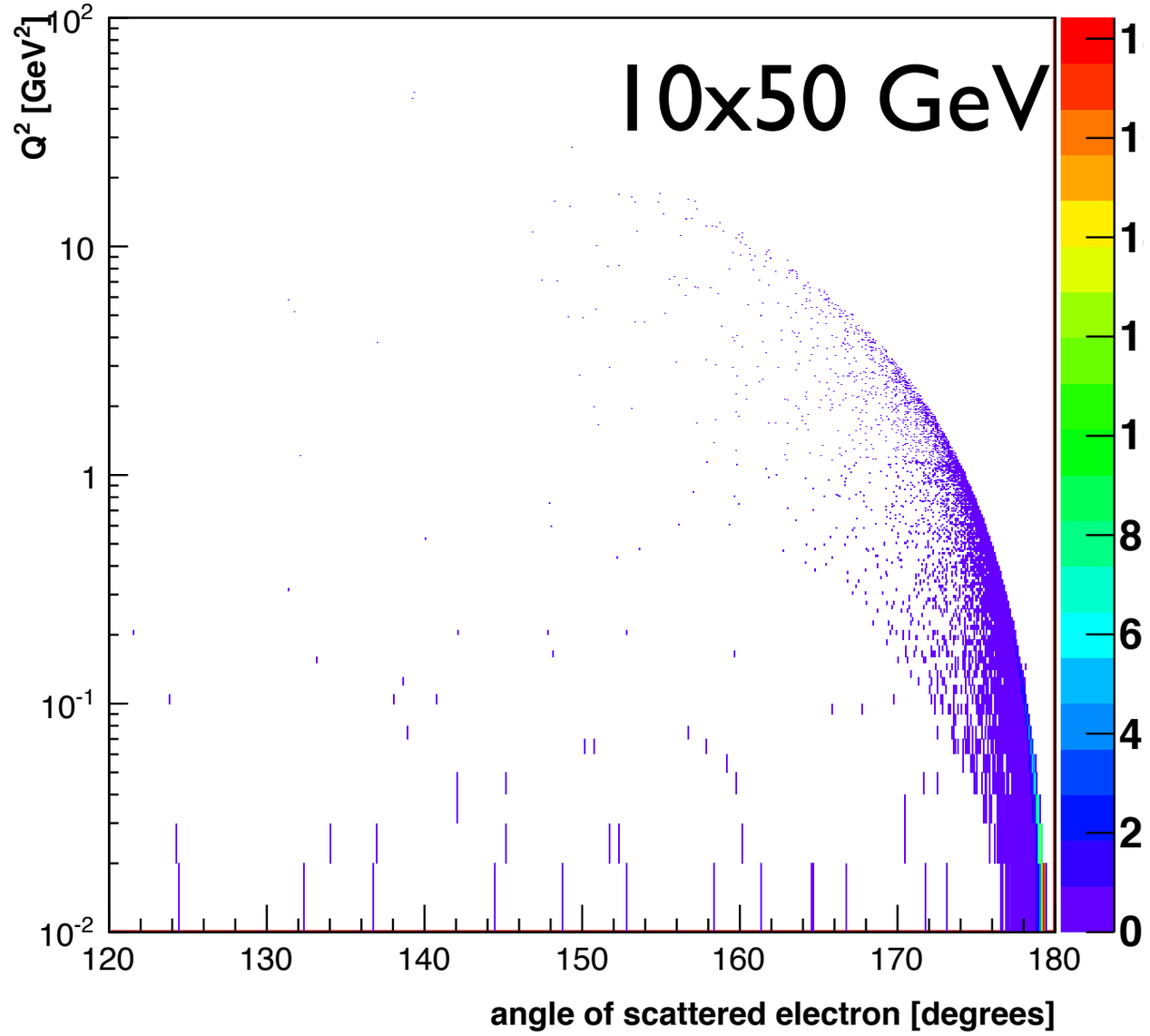

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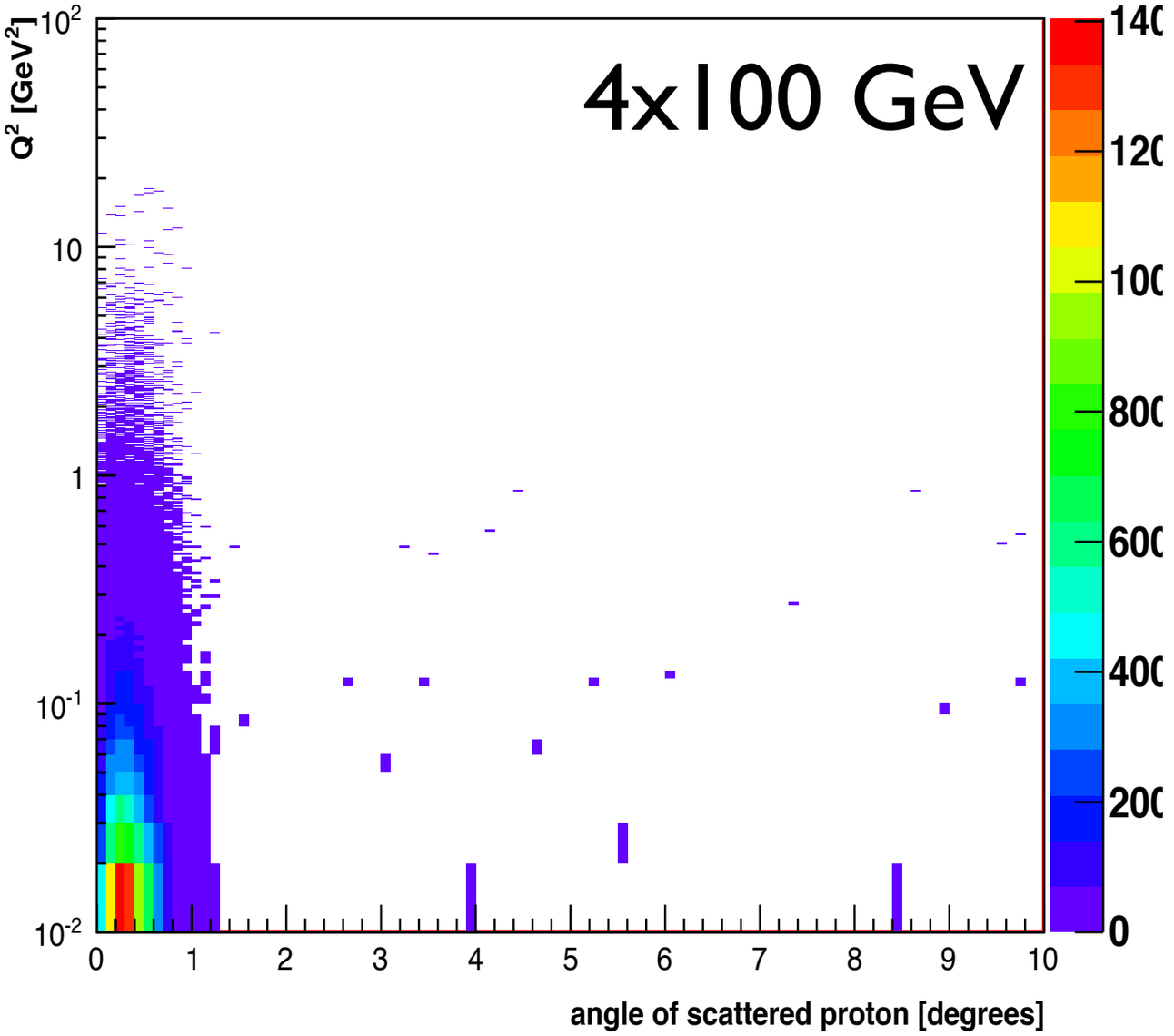

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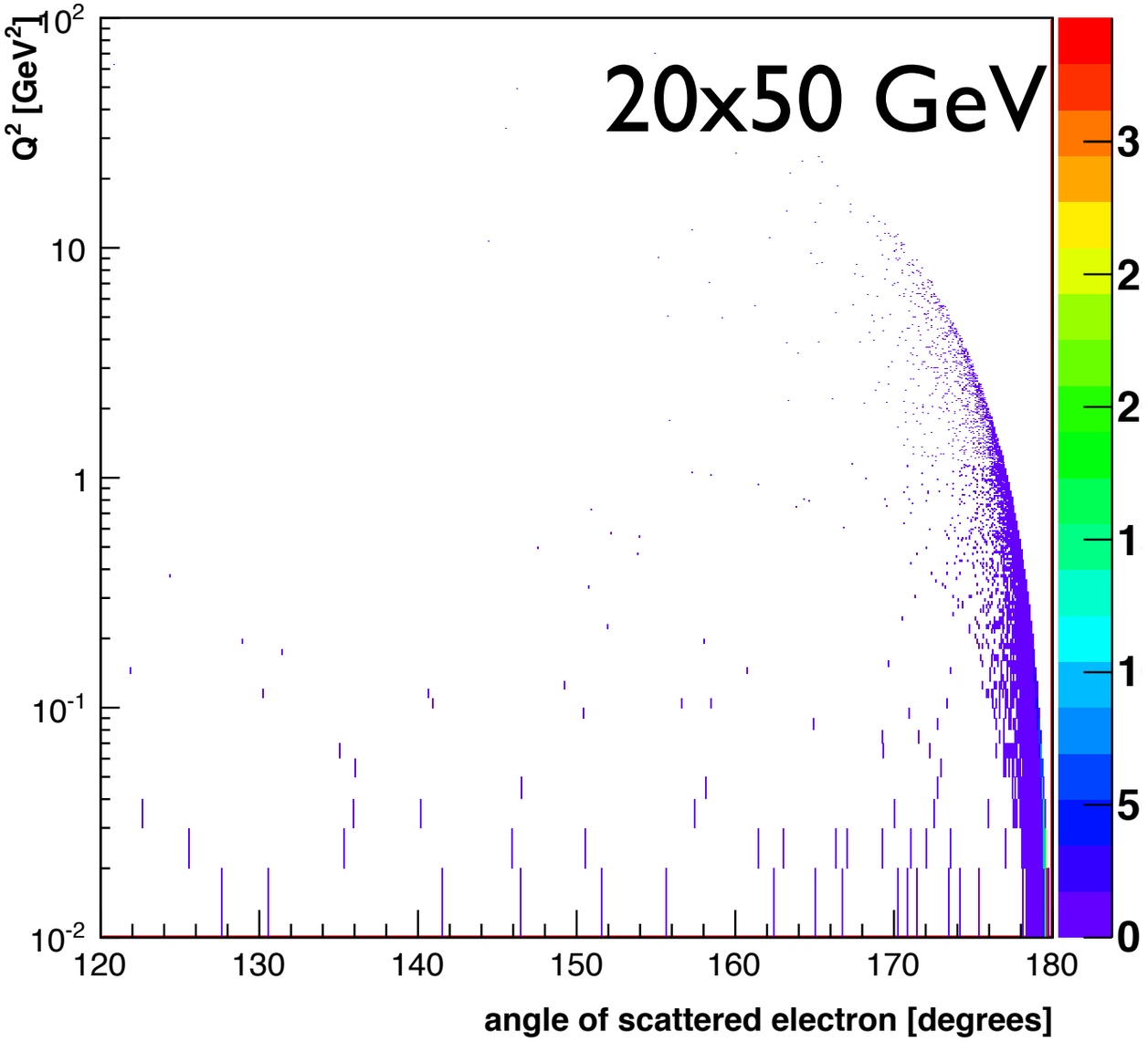

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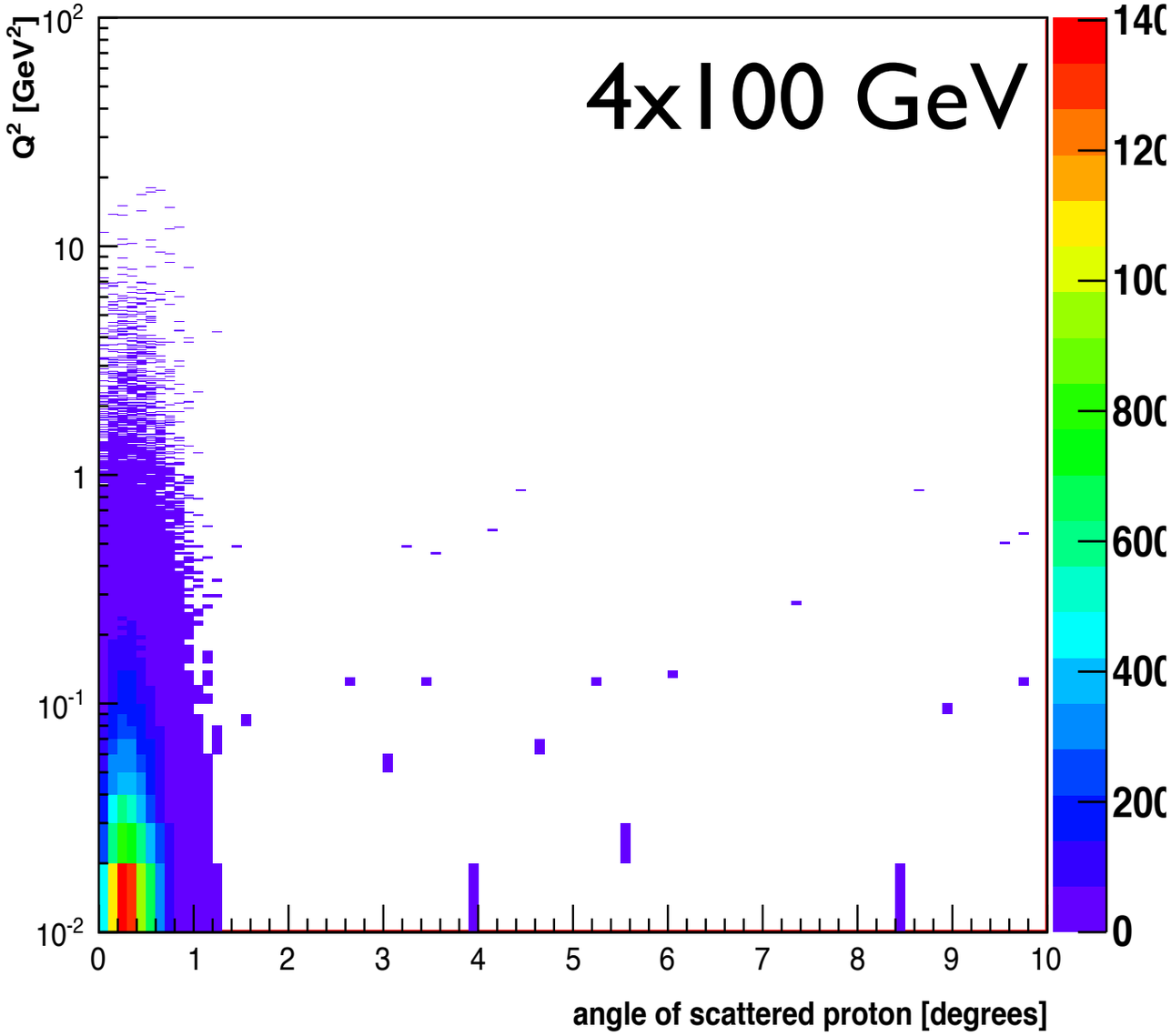

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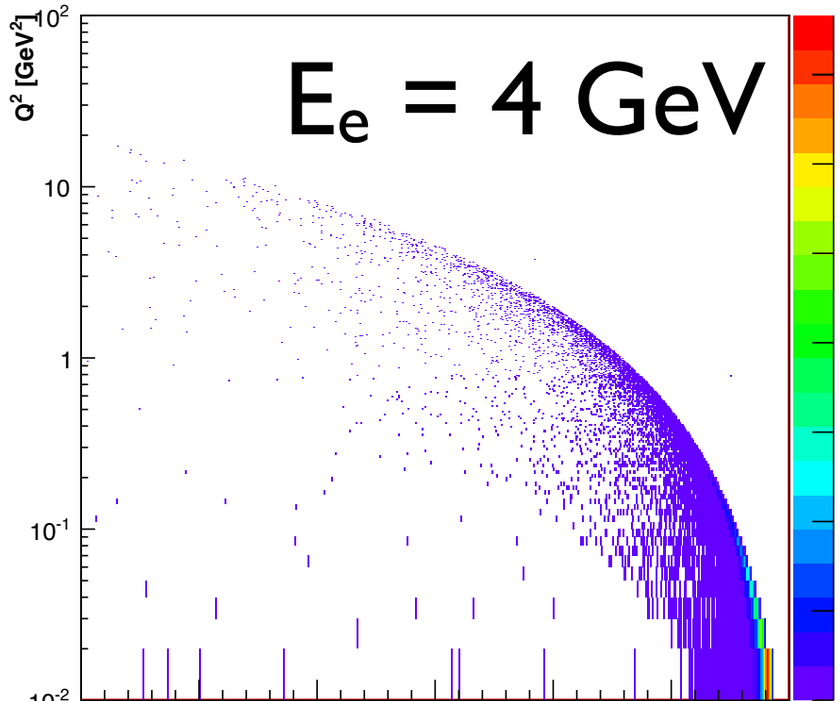

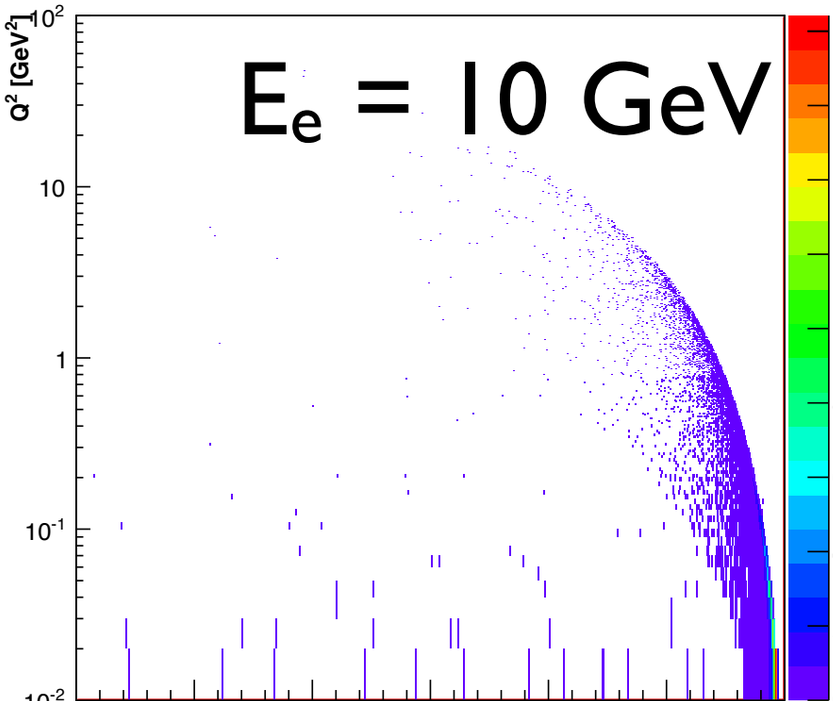

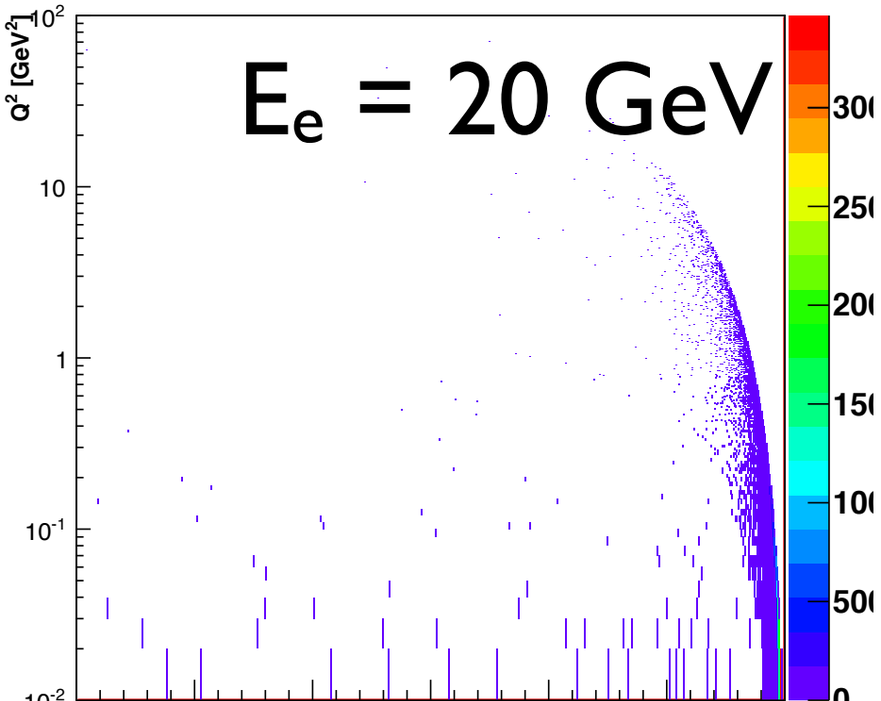

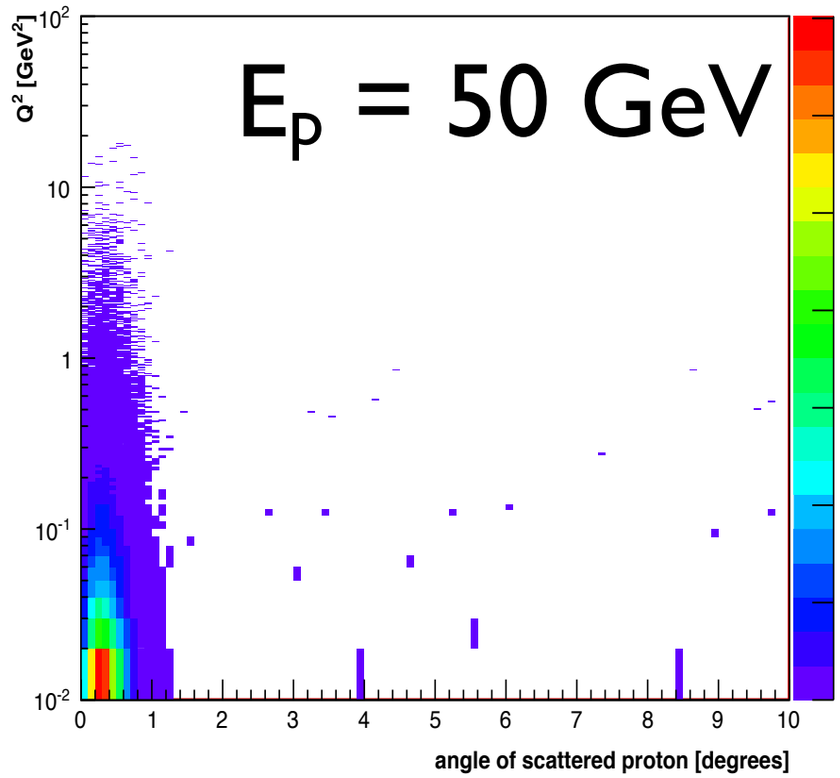

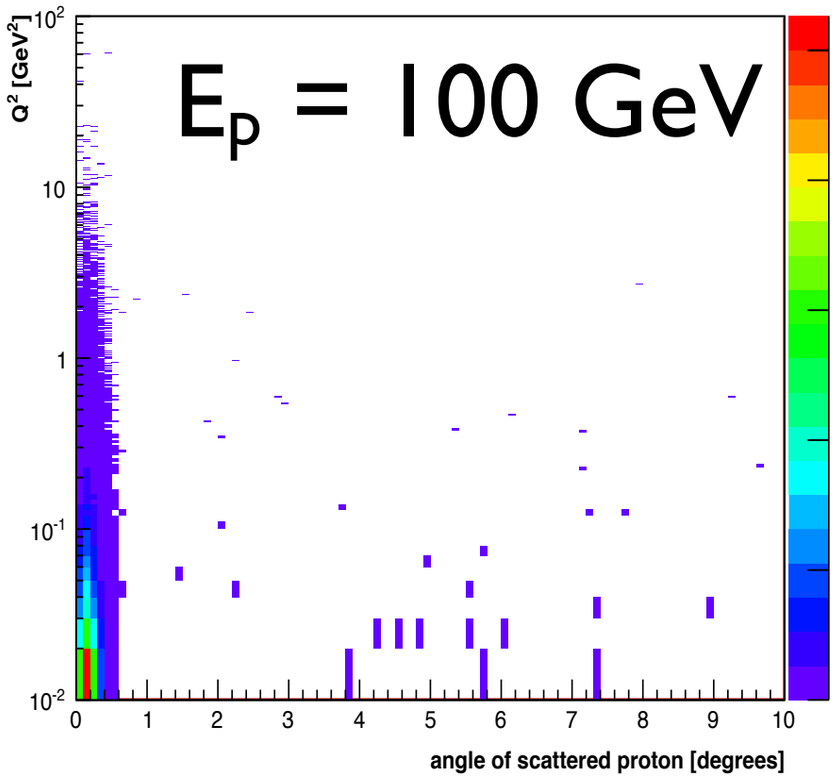

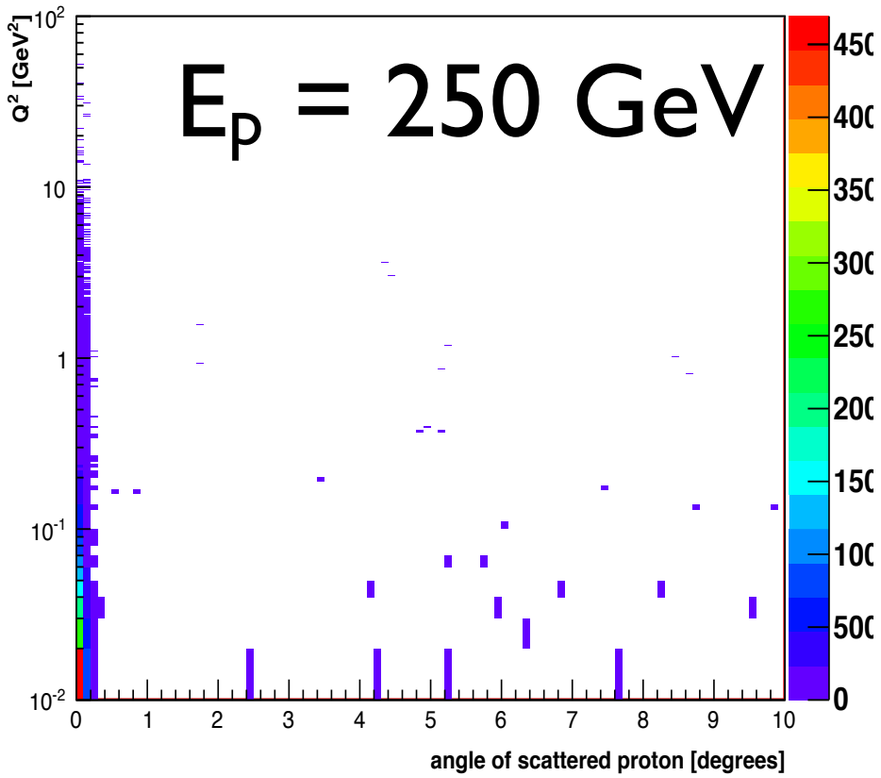

How to measure coherent diffraction in e+A ?

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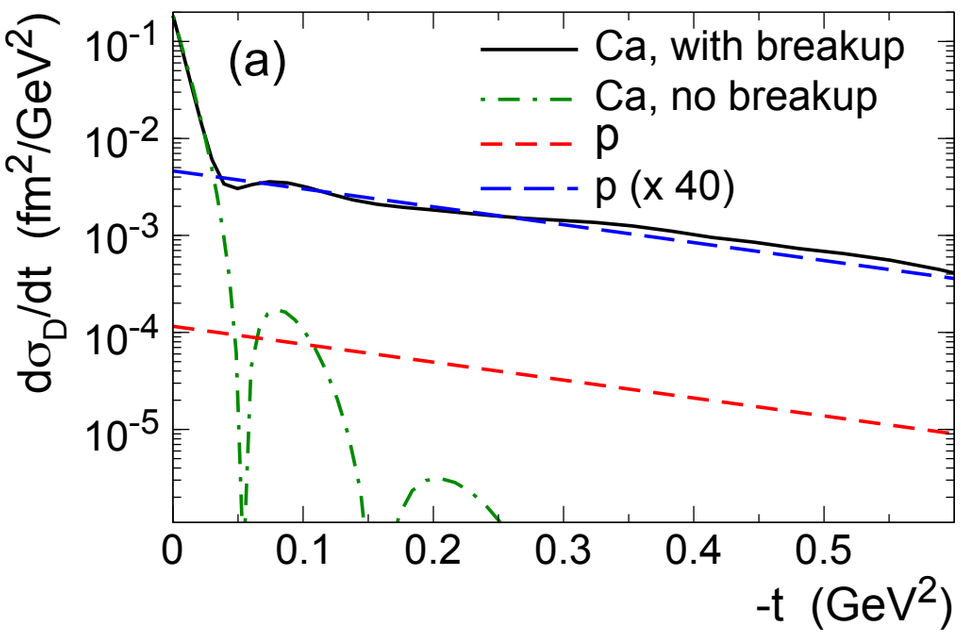

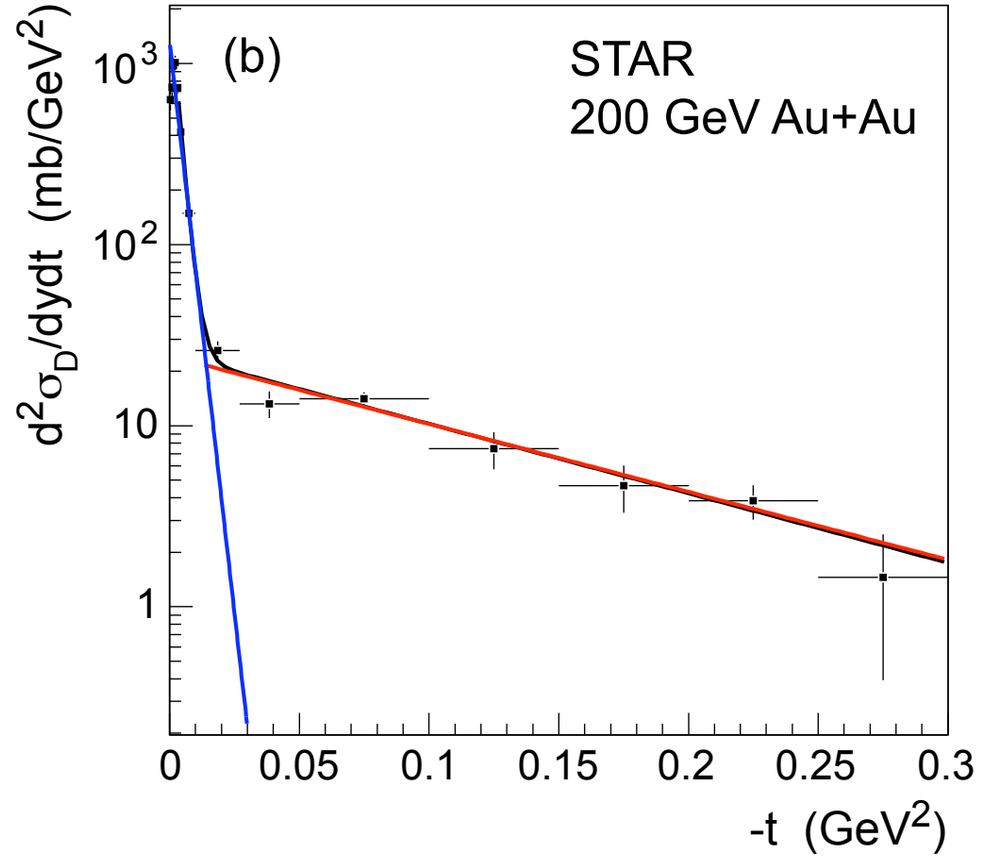

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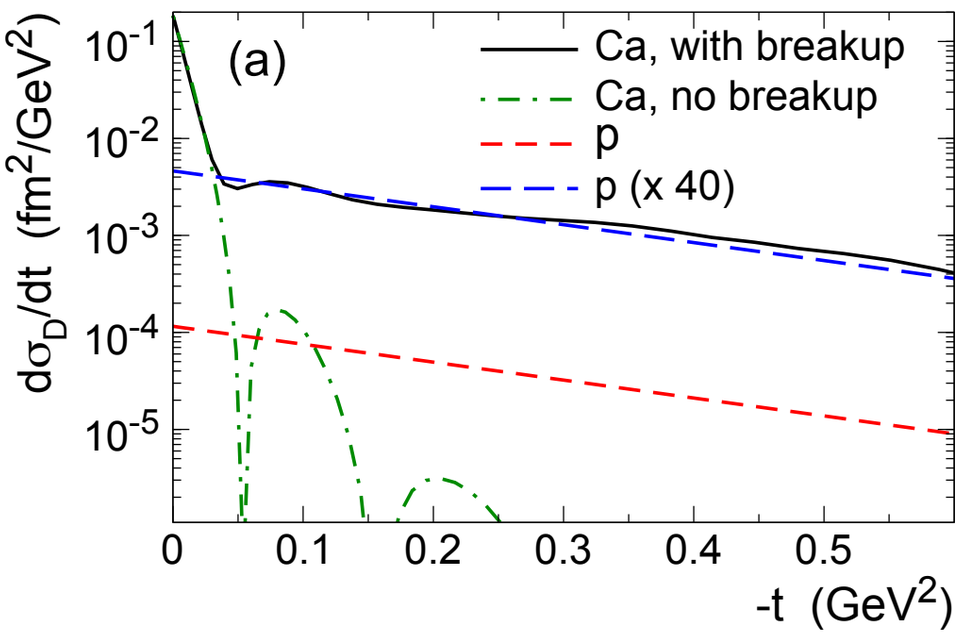

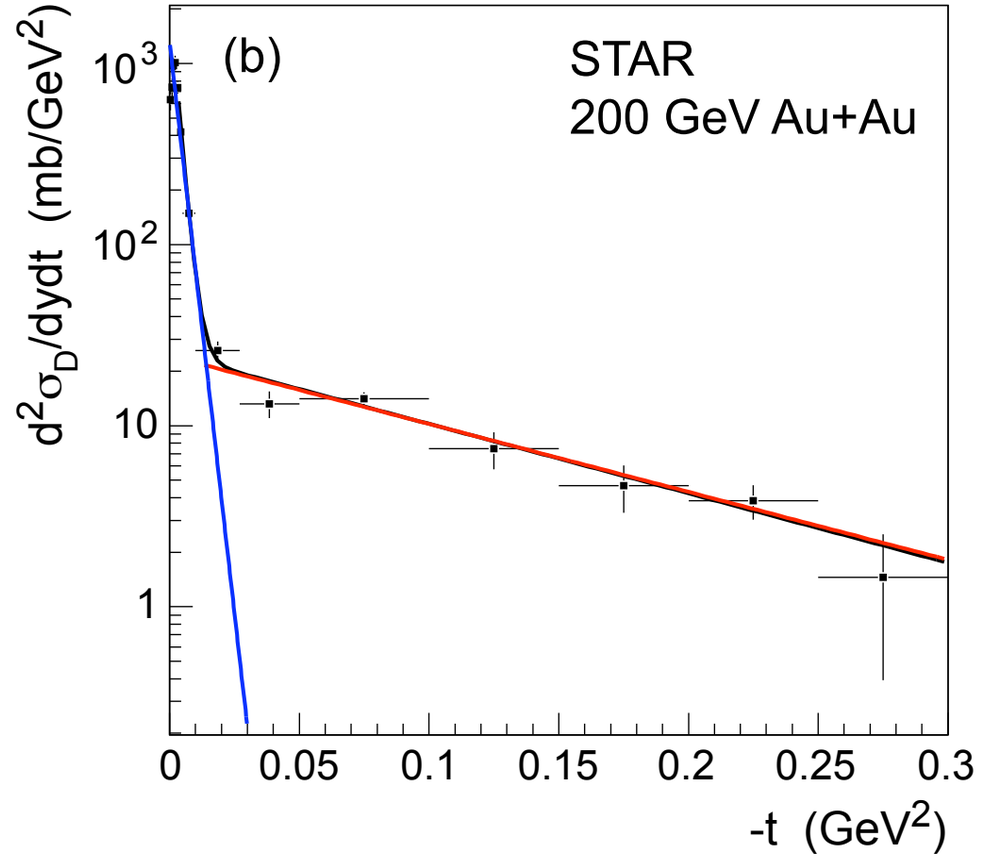

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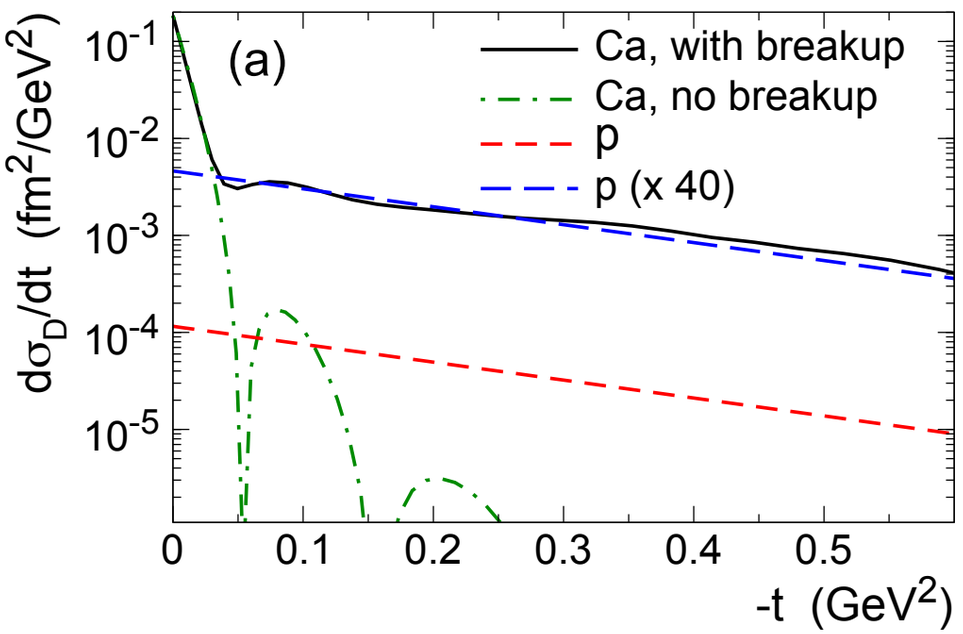

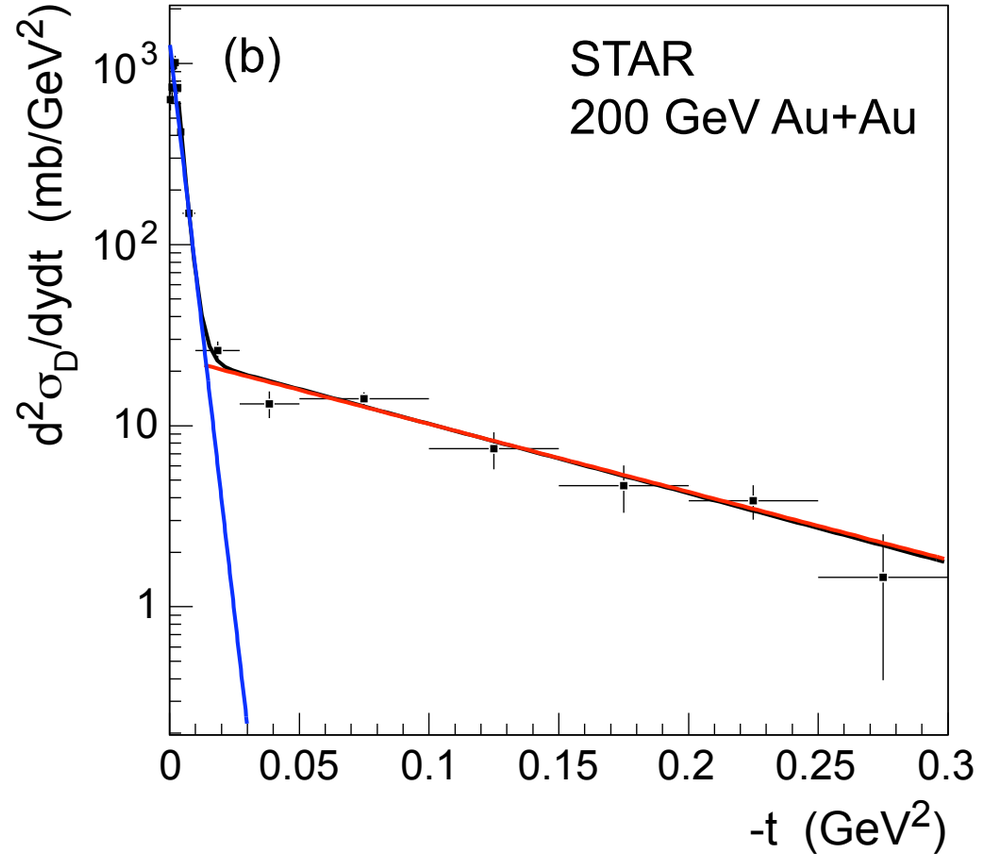

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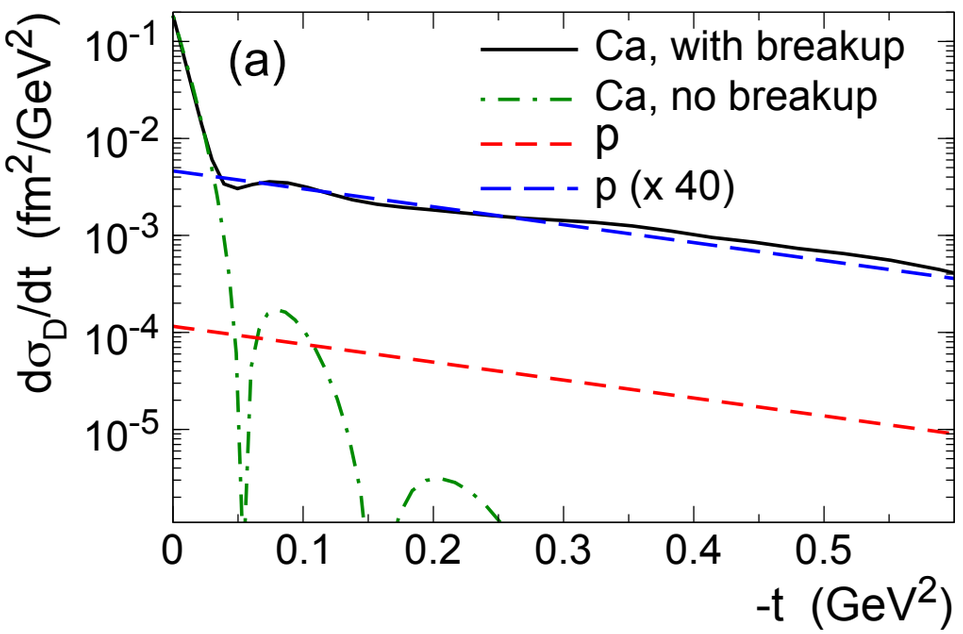

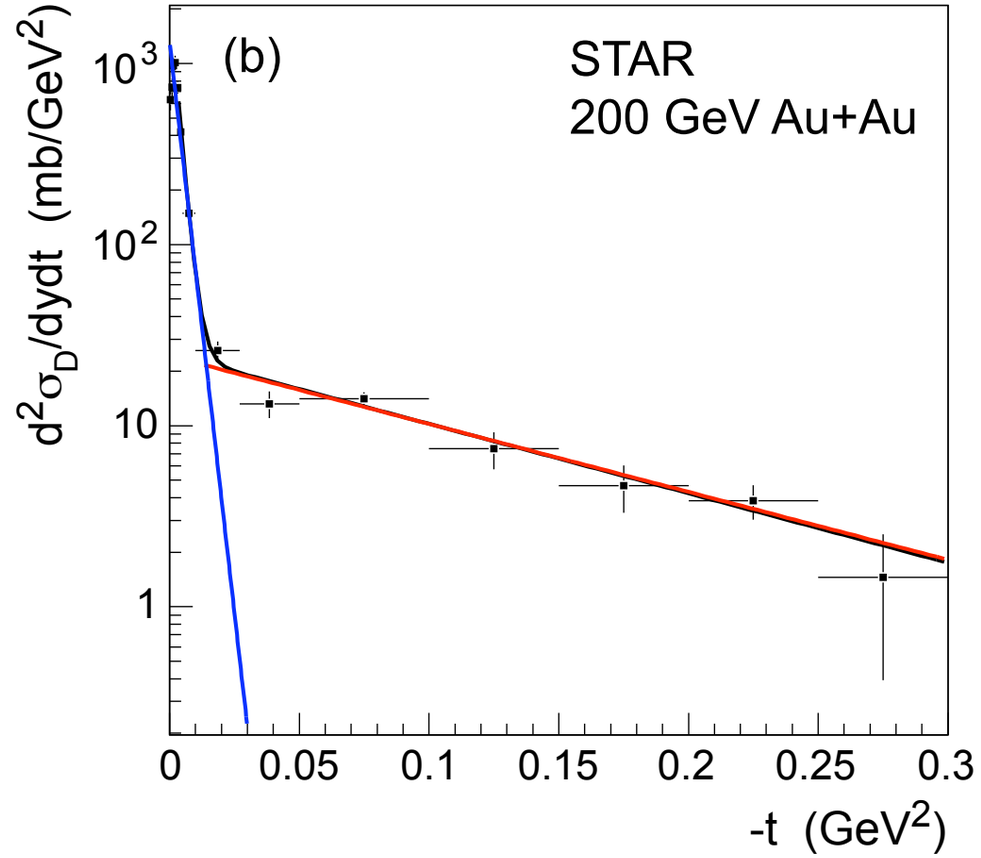

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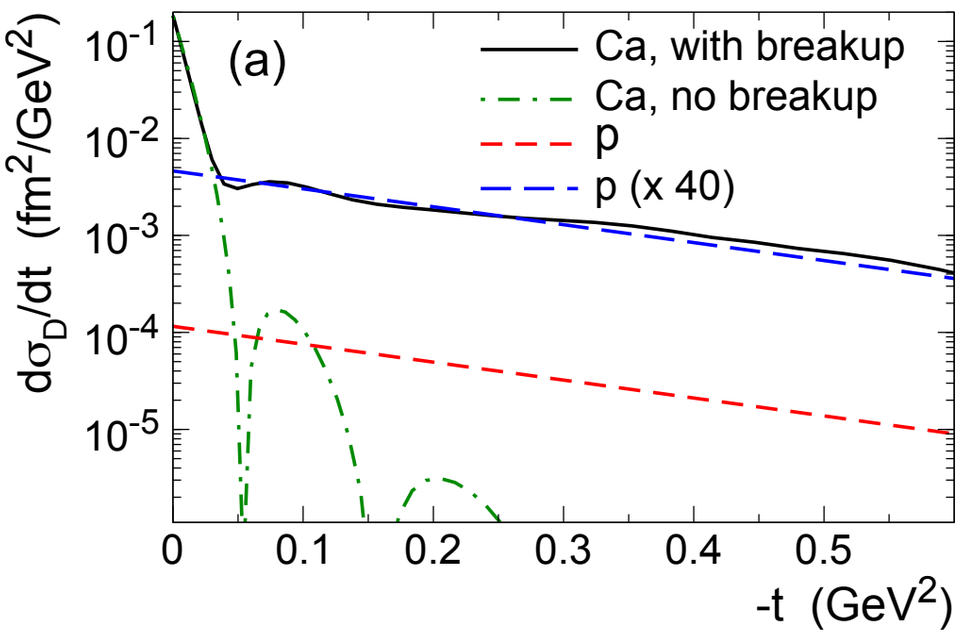

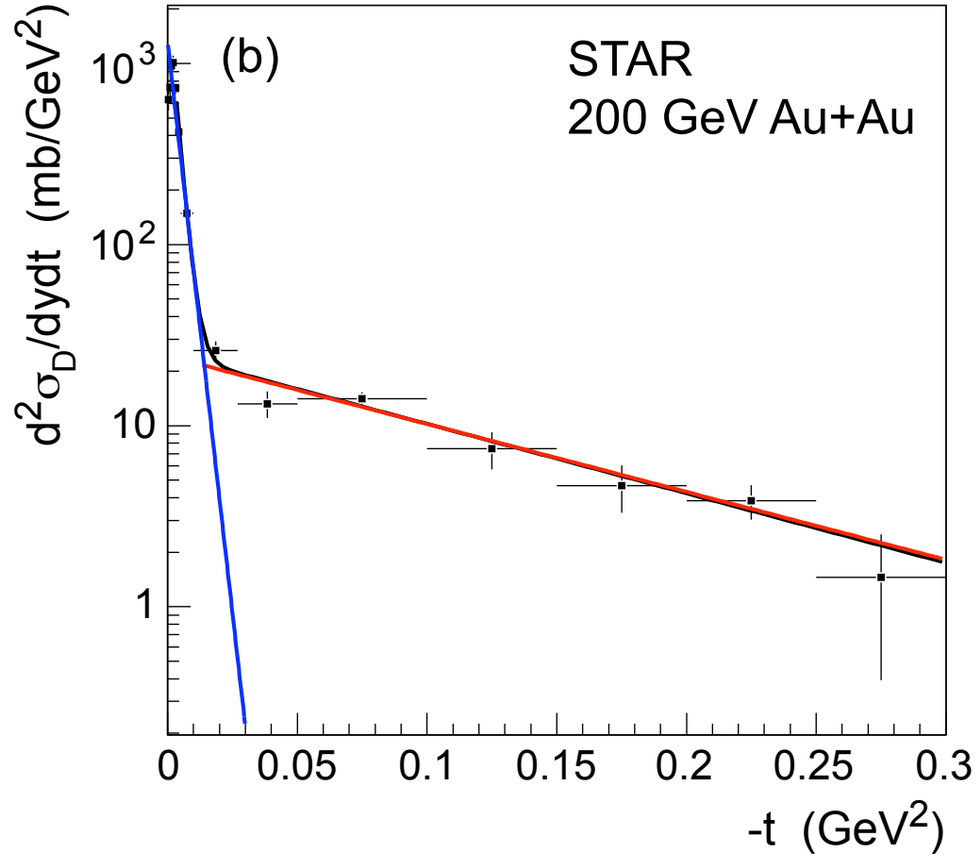

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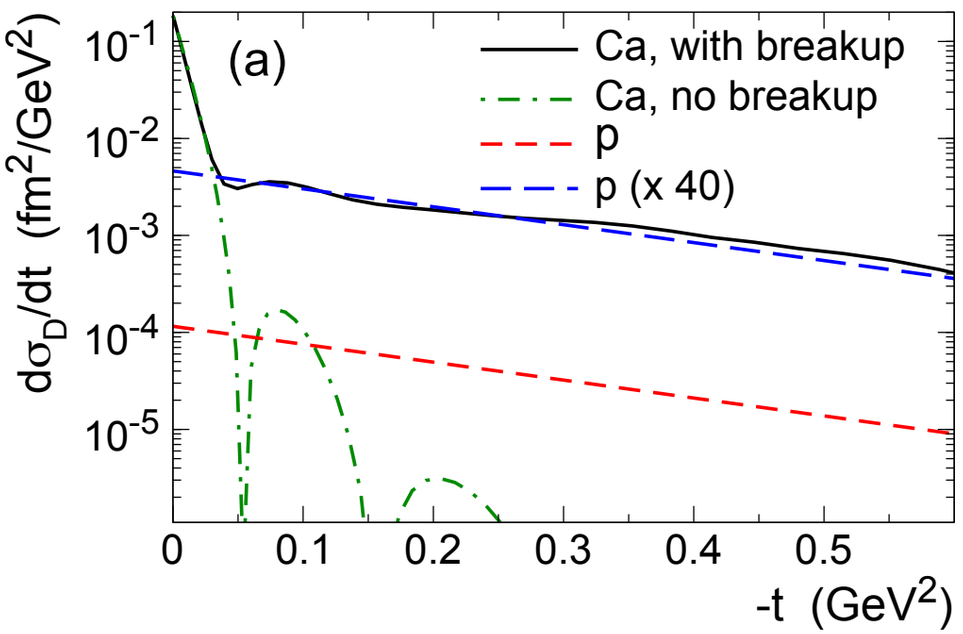

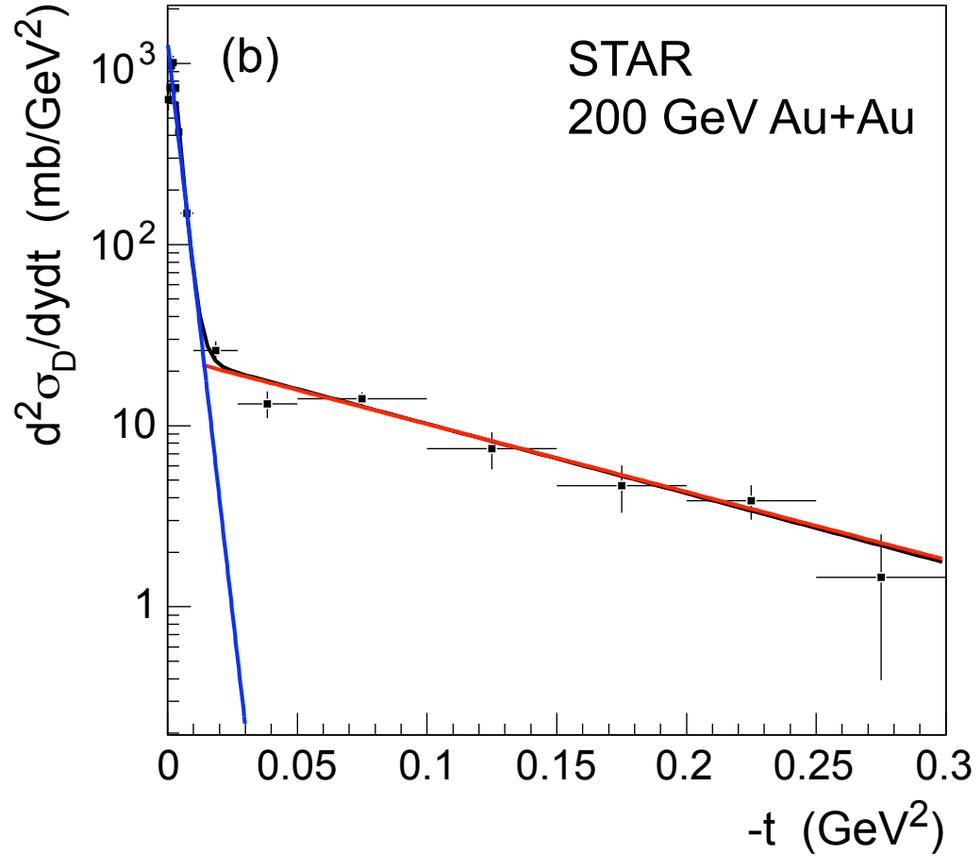

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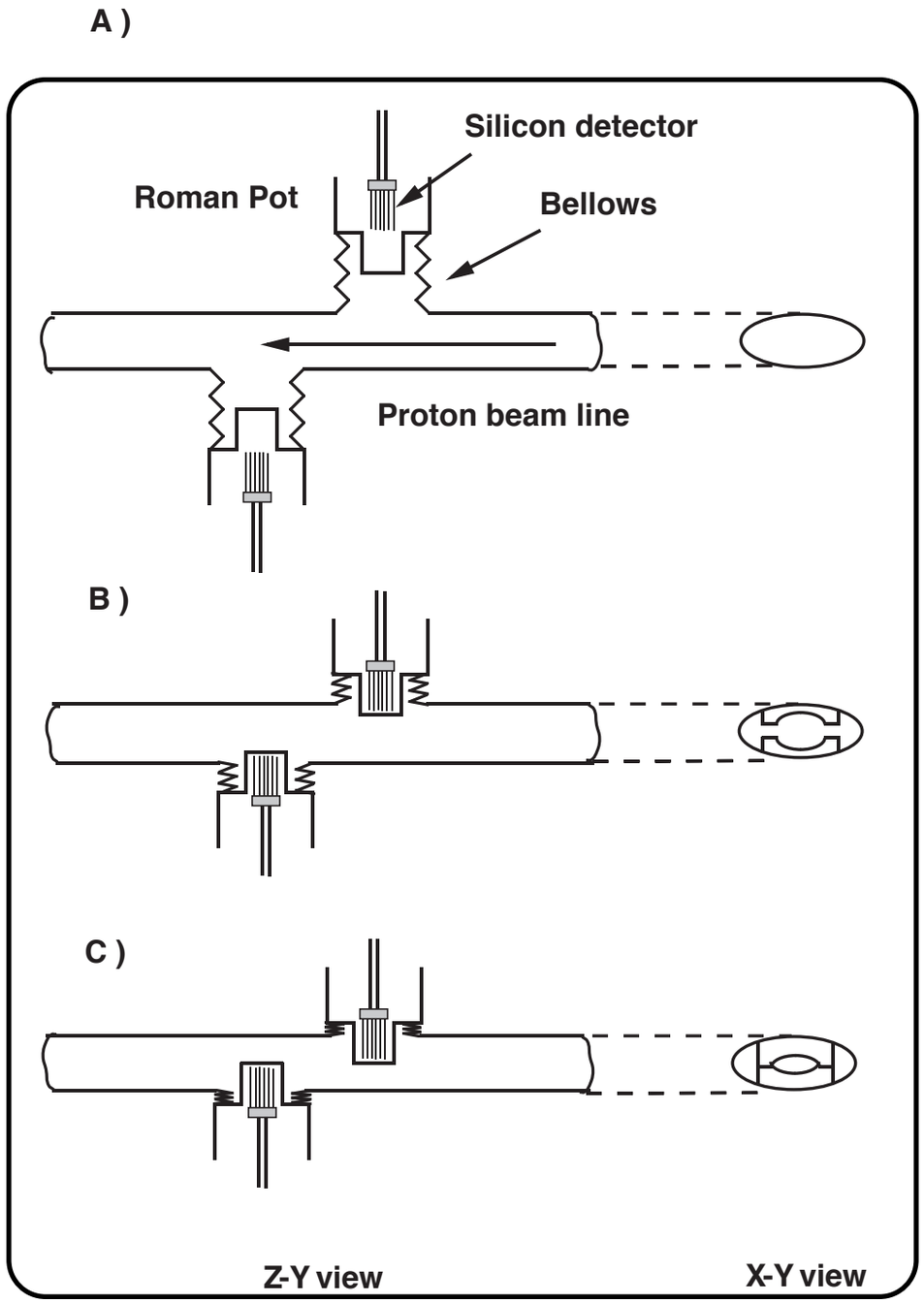

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Cu (63)	0.51
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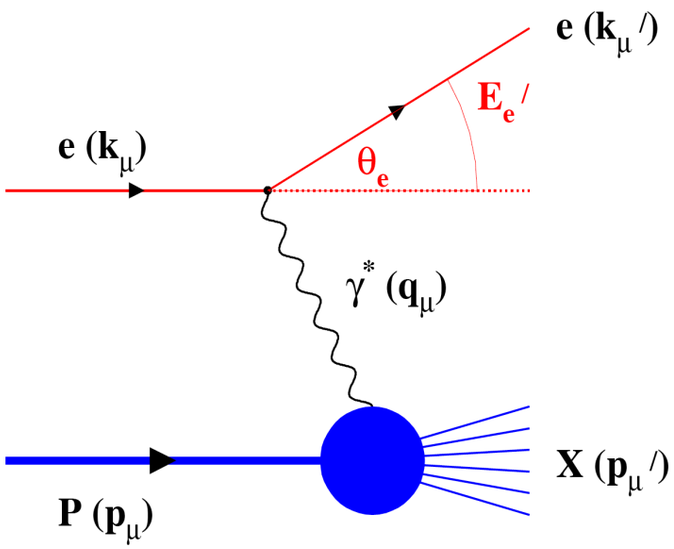
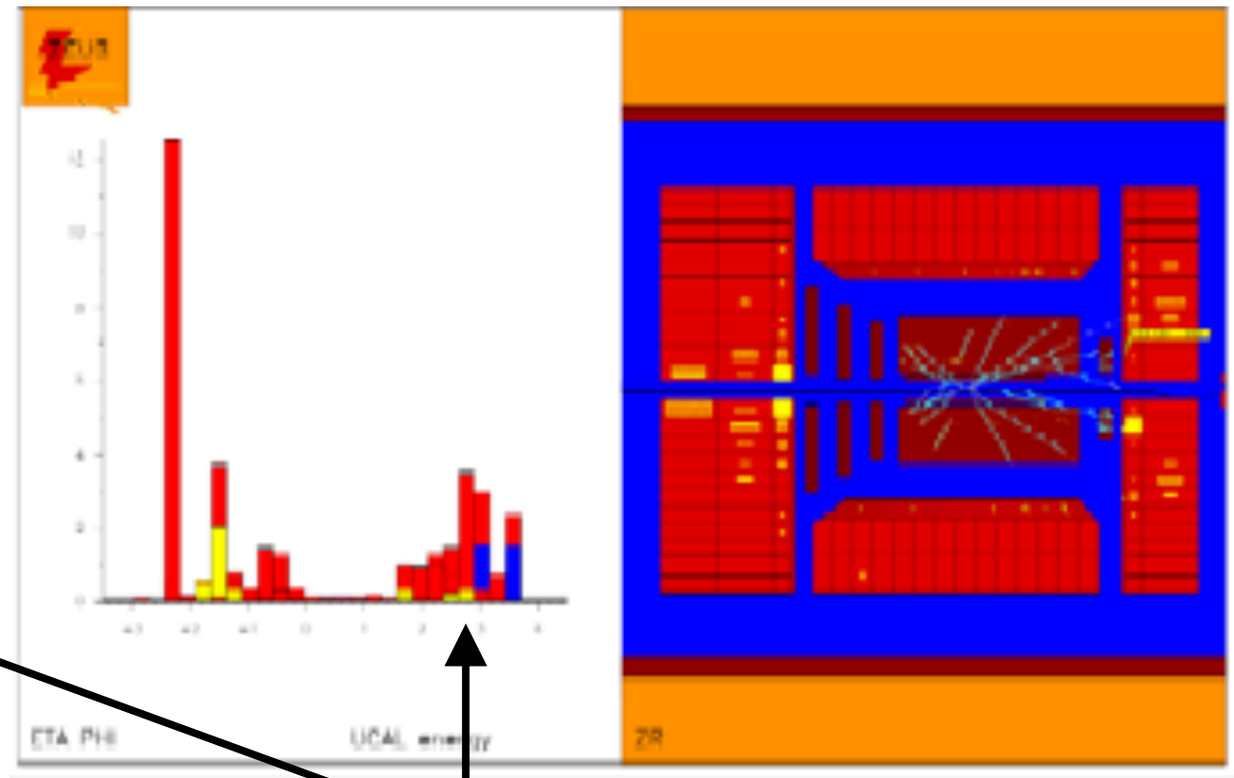
For large A, nucleus cannot be separated from beam without breaking up

Diffractive Physics in e+A

‘Standard DIS event’

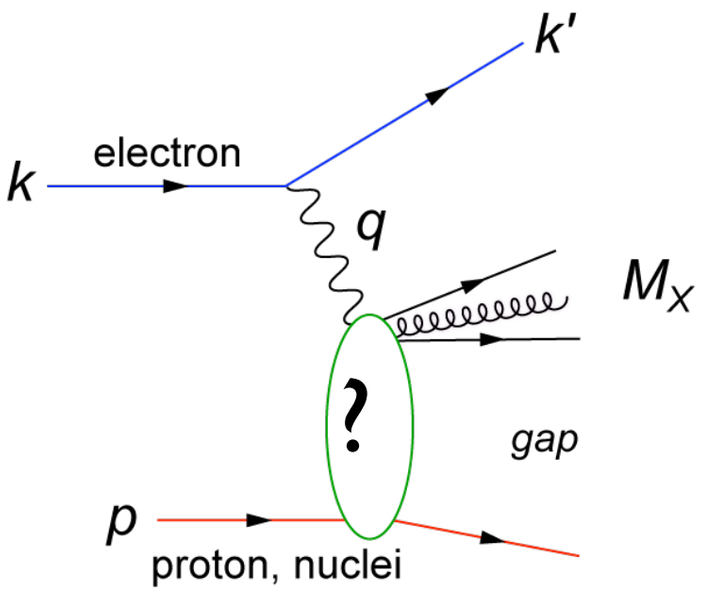


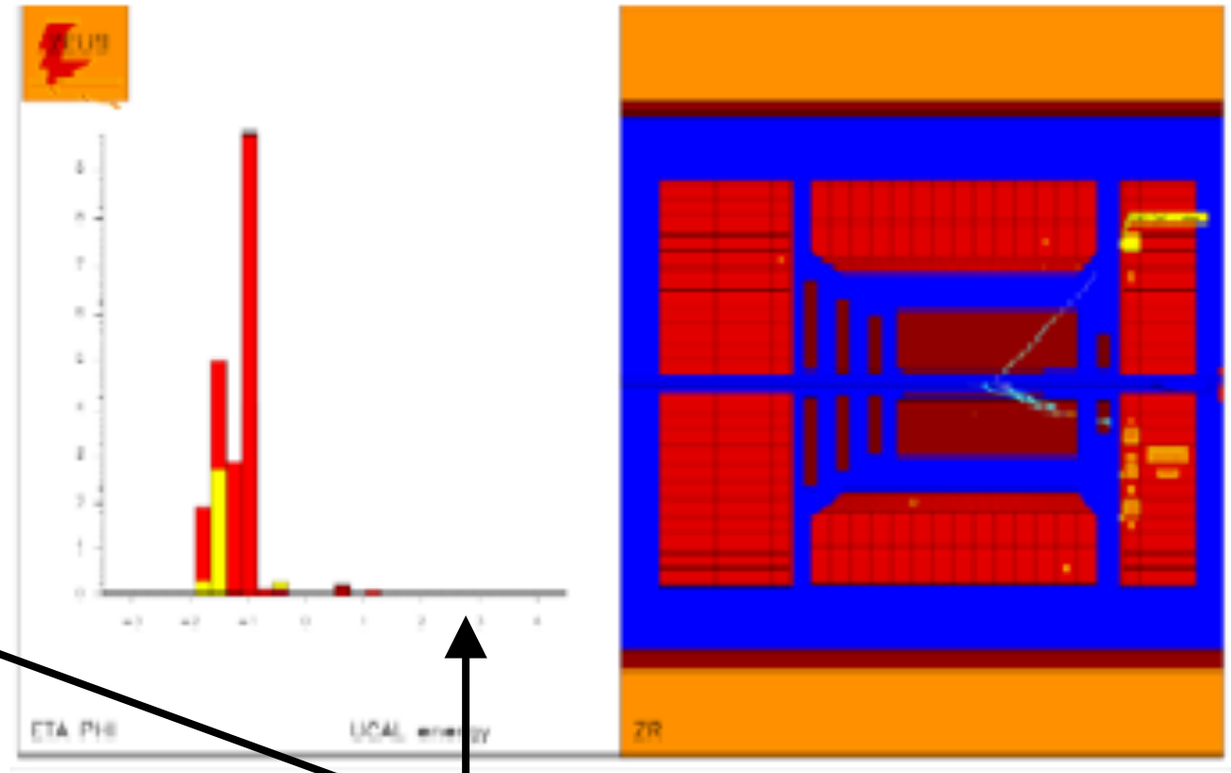


Activity in proton direction

Diffractive Physics in e+A

Diffractive event





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- Diffractive cross-section $\sigma_{diff}/\sigma_{tot}$ in e+A ?
  - ➡ Predictions: ~25-40%?

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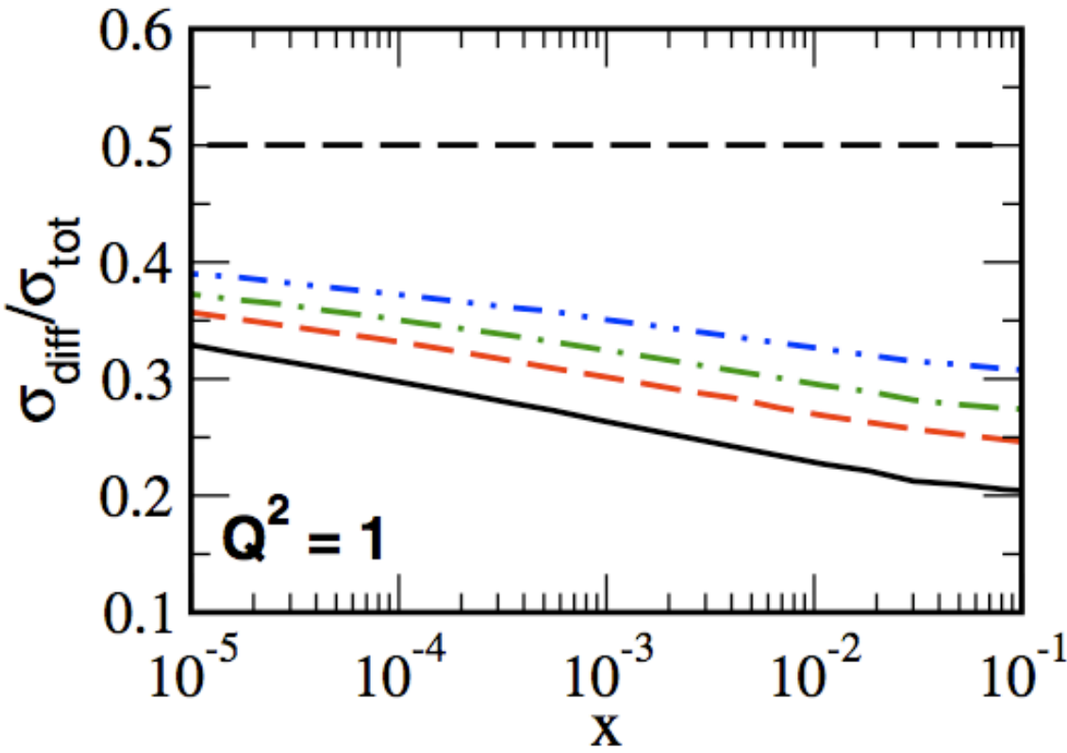
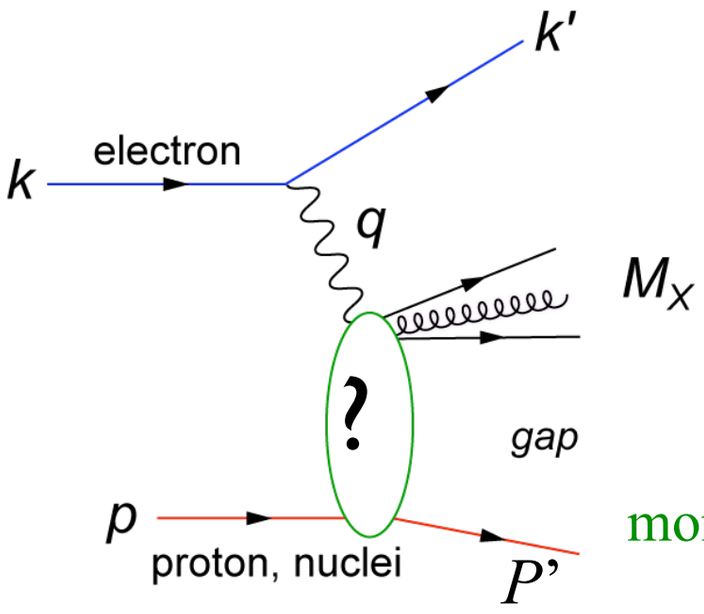


Curves: Kugeratski, Goncalves, Navarra, EPJ C46, 413

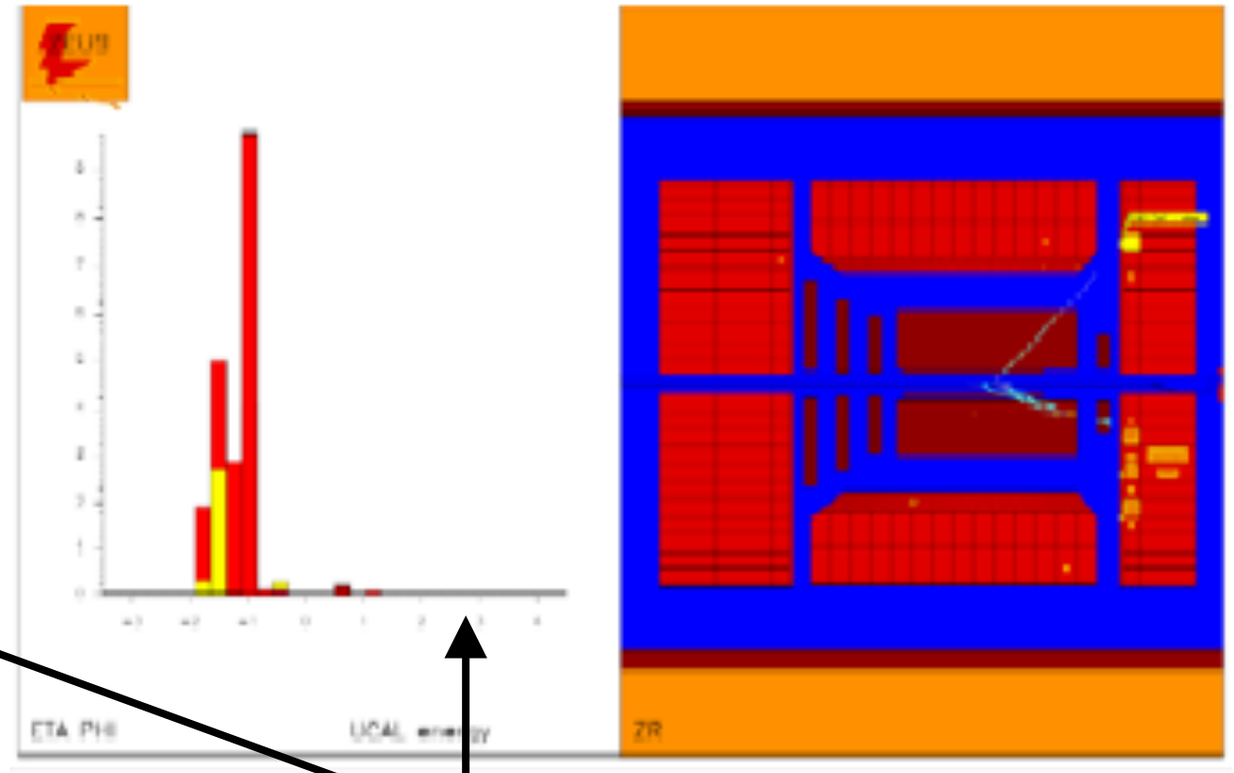
Diffractive Physics in e+A

Diffractive event



M_X

momentum transfer:
$t = (P\text{-}P')^2$



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- Look inside the "Pomeron"
  - ➡ Diffractive structure functions
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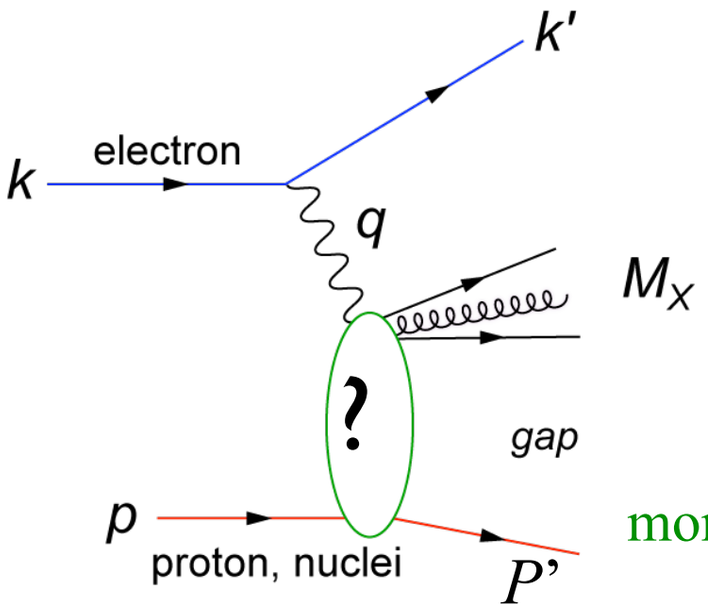
Diffractive Physics in *e*+A

Diffractive event



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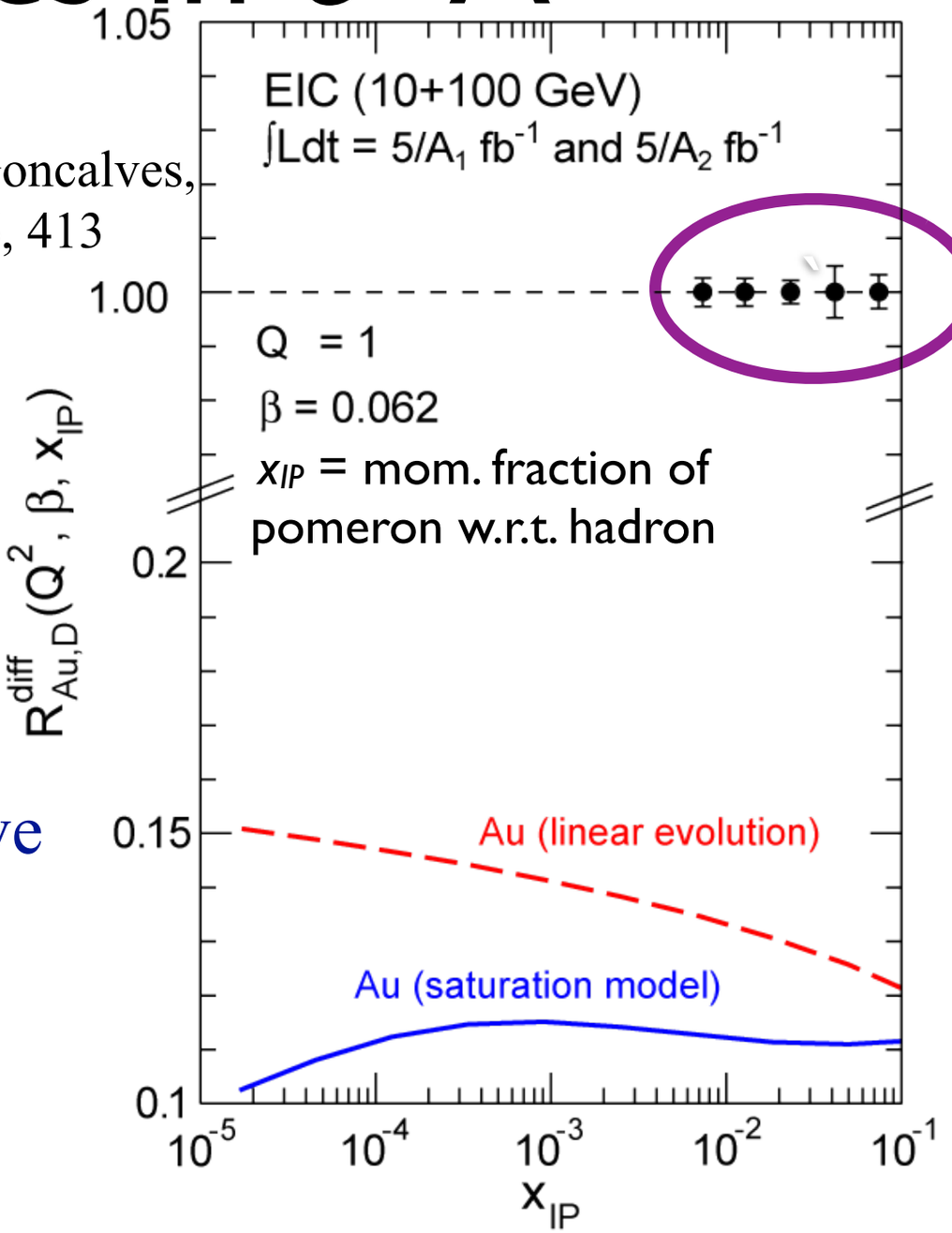

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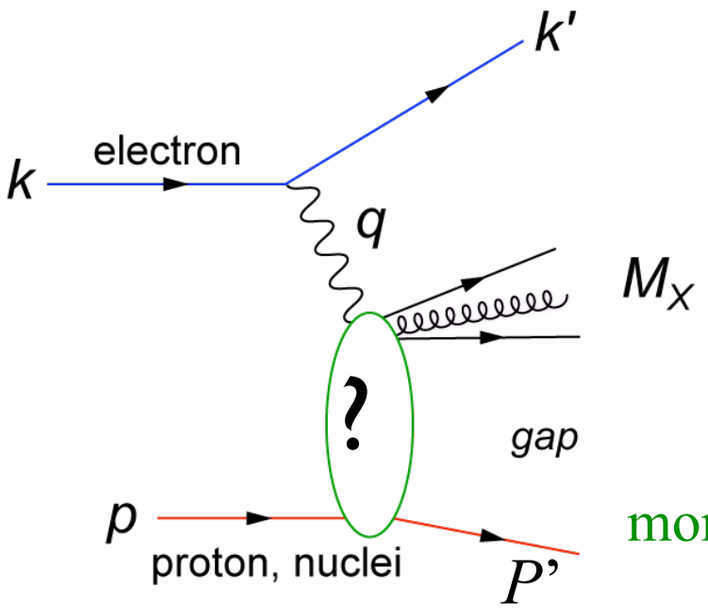

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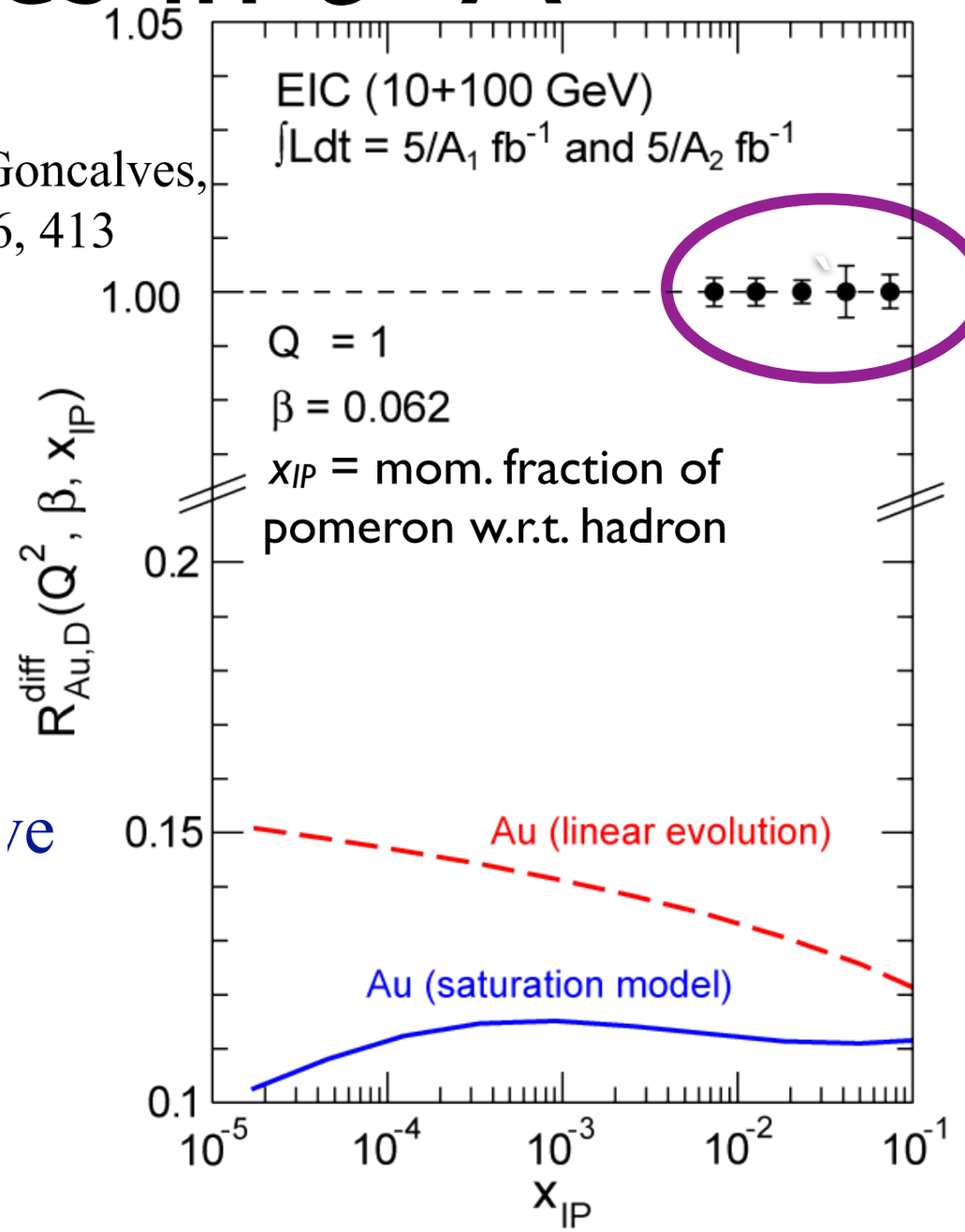
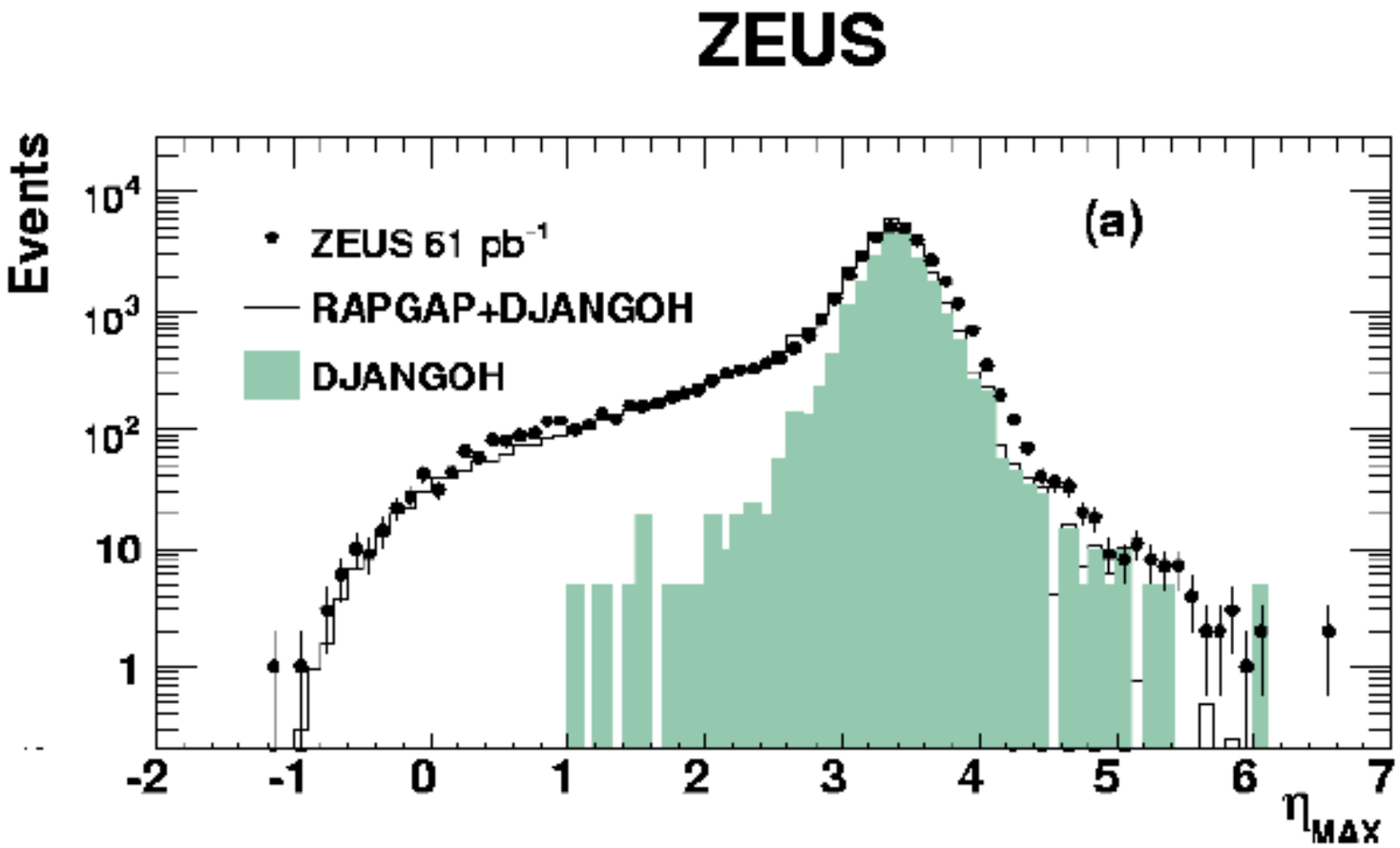
$t = (P\text{-}P')^2$

Curves: Kugeratski, Goncalves, Navarra, EPJ C46, 413





/e

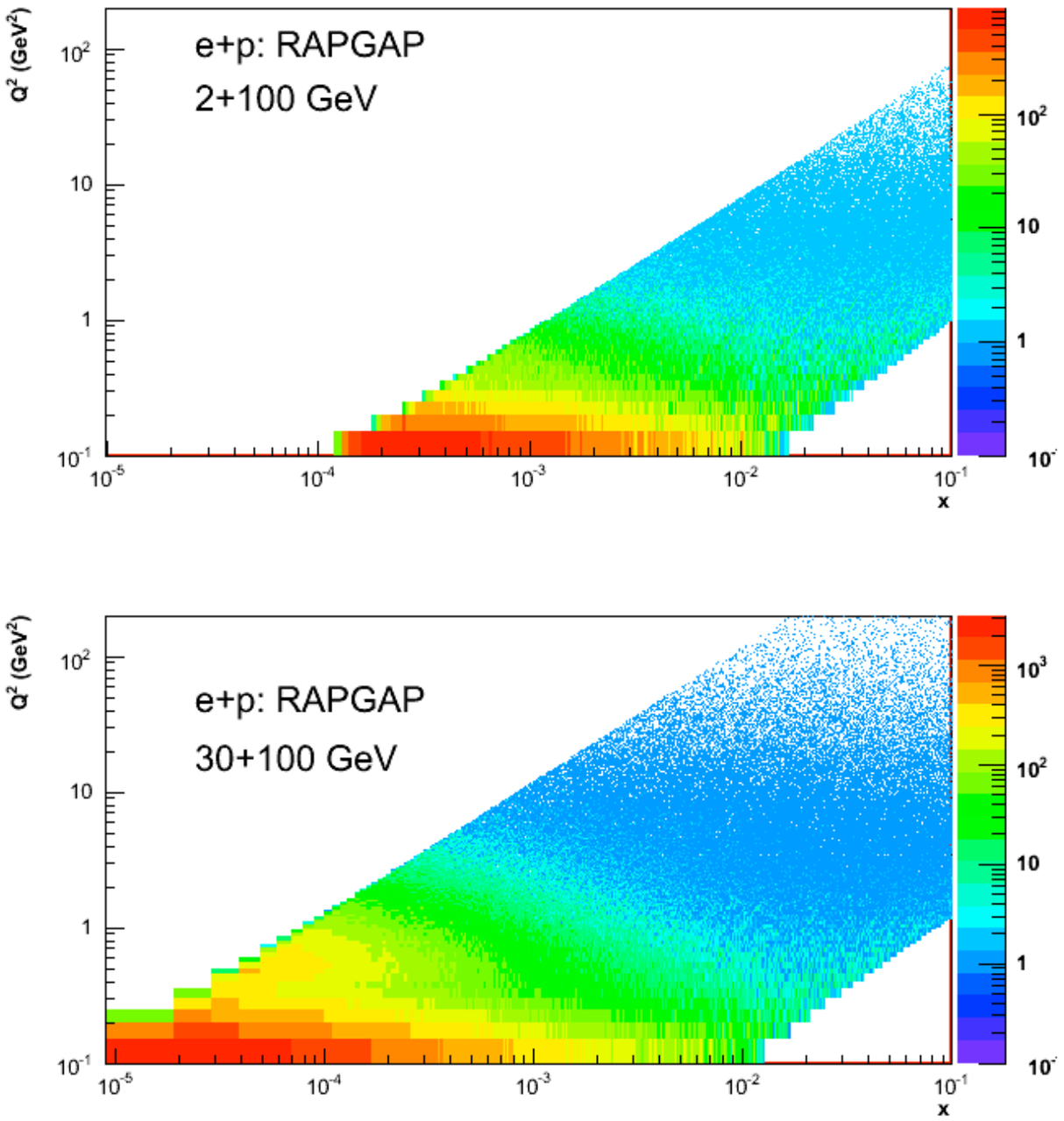
: $d\sigma/dt \sim [xG(x,Q^2)]^2$!!

ation models

Diffractive Physics at an EIC

- Significant coverage in x-Q^2
  - ➡ increases by ~ order of magnitude over EIC energies
- Plotted the distribution of the Most Forward Particle in the event for DIS and Diffractive events
  - ➡ significant gap between two classes of events
- Reproduce the "ZEUS" plot?
- Important - plot the efficiency vs purity
  - ➡ Can place a cut in rapidity for ~90% efficiency and ~90% purity !!

Generated 10^6 e+p events using RAPGAP for a variety of proposed EIC energies



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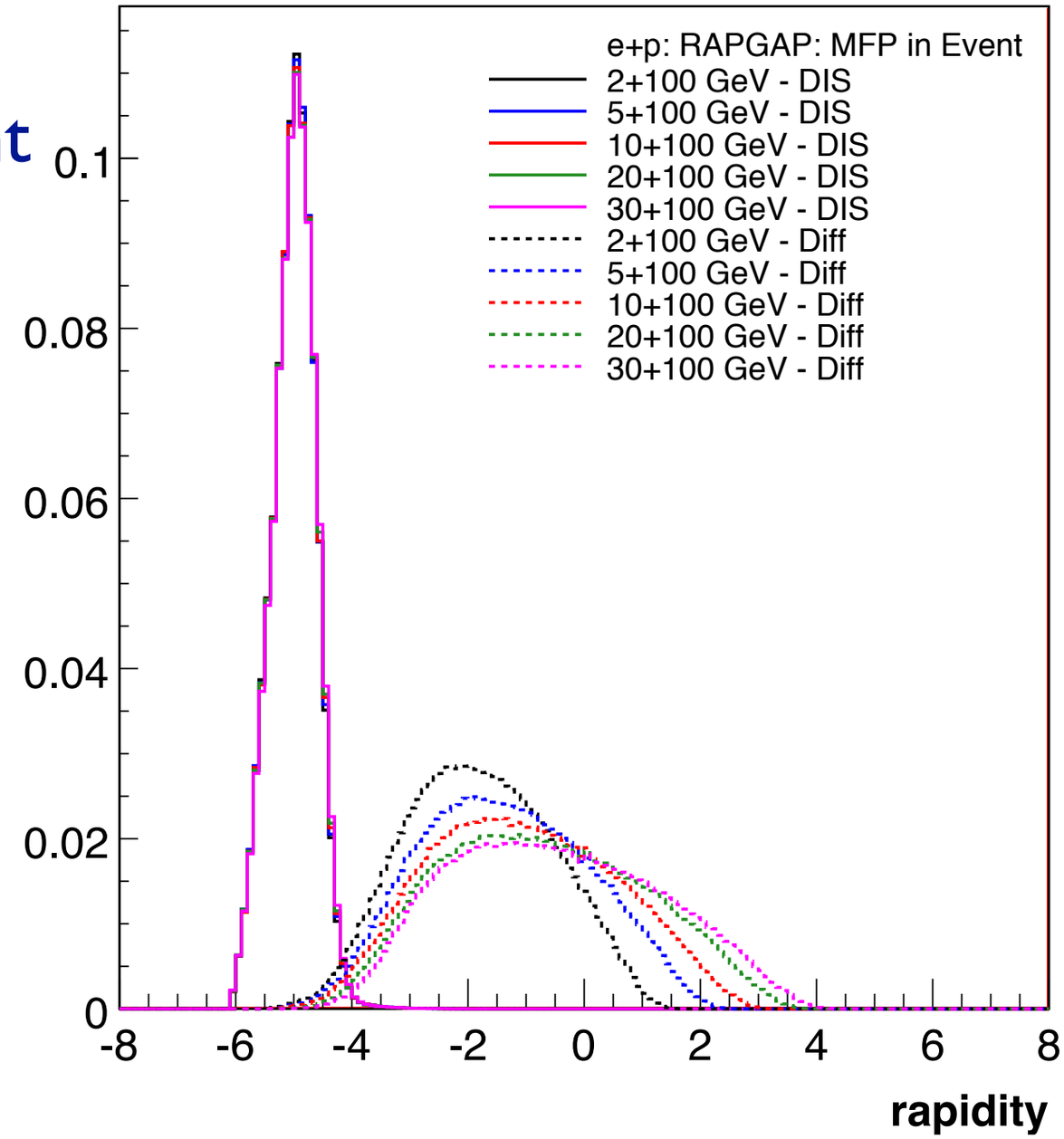

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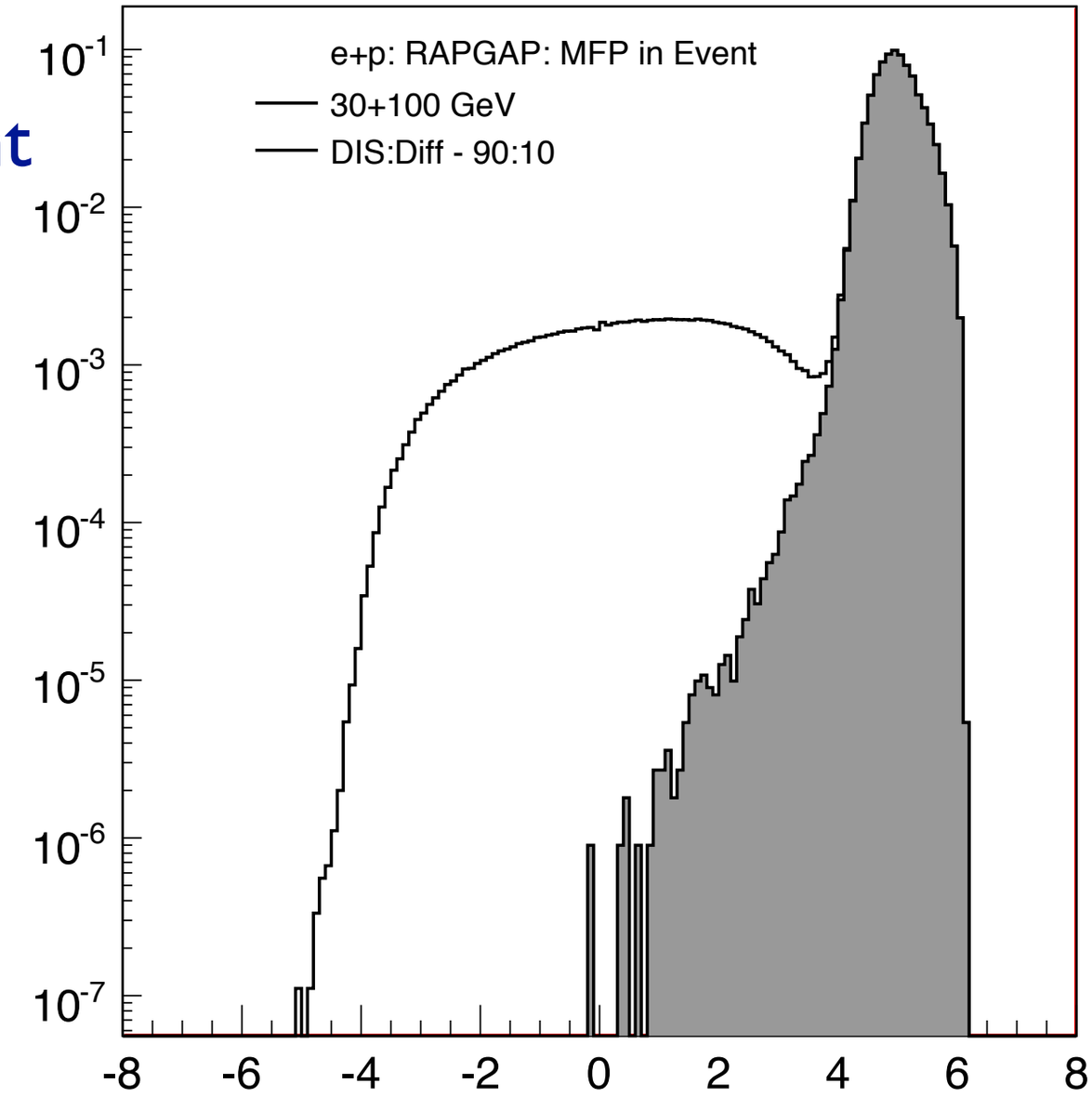

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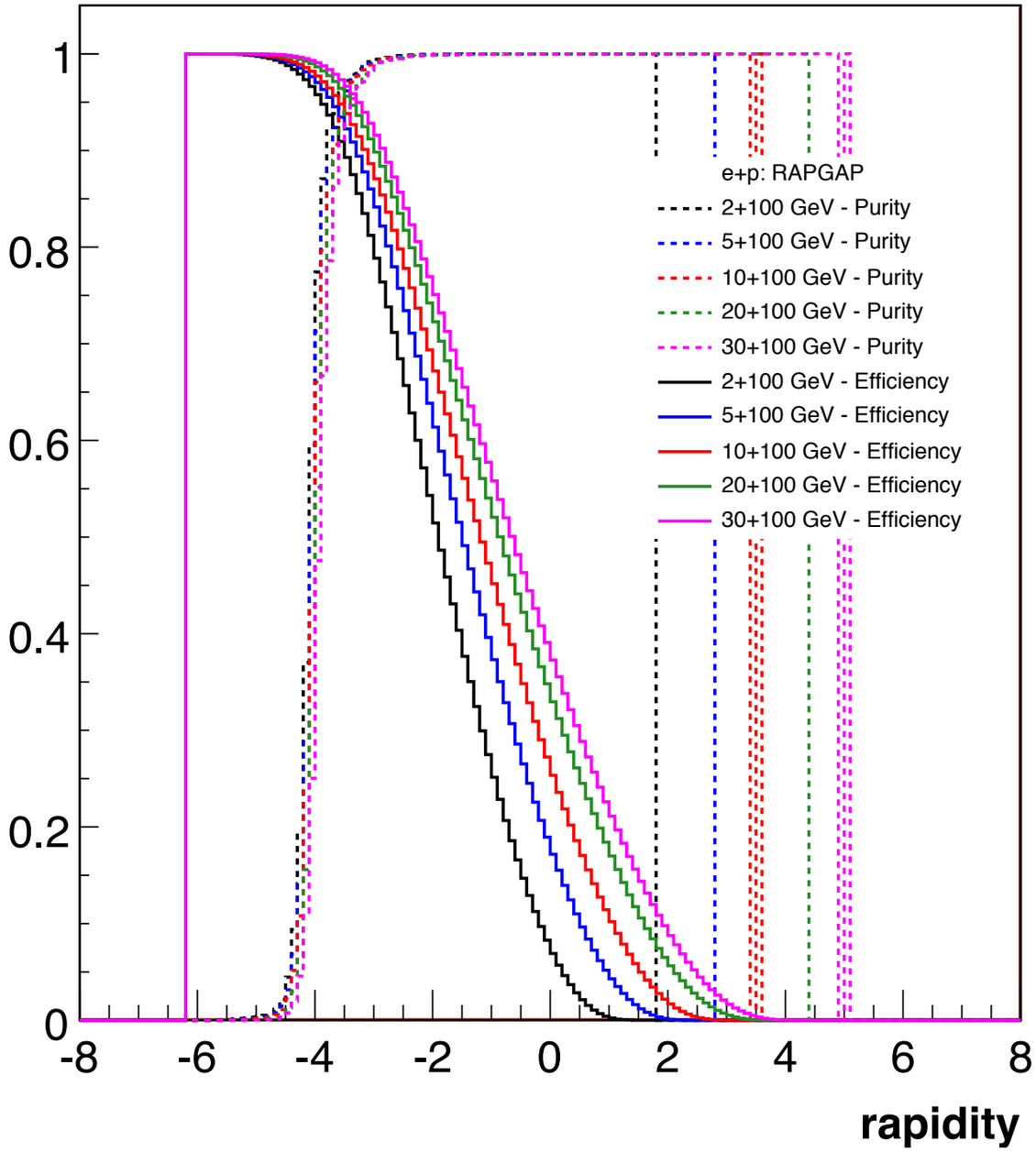

Diffractive Physics at an EIC - Acceptance

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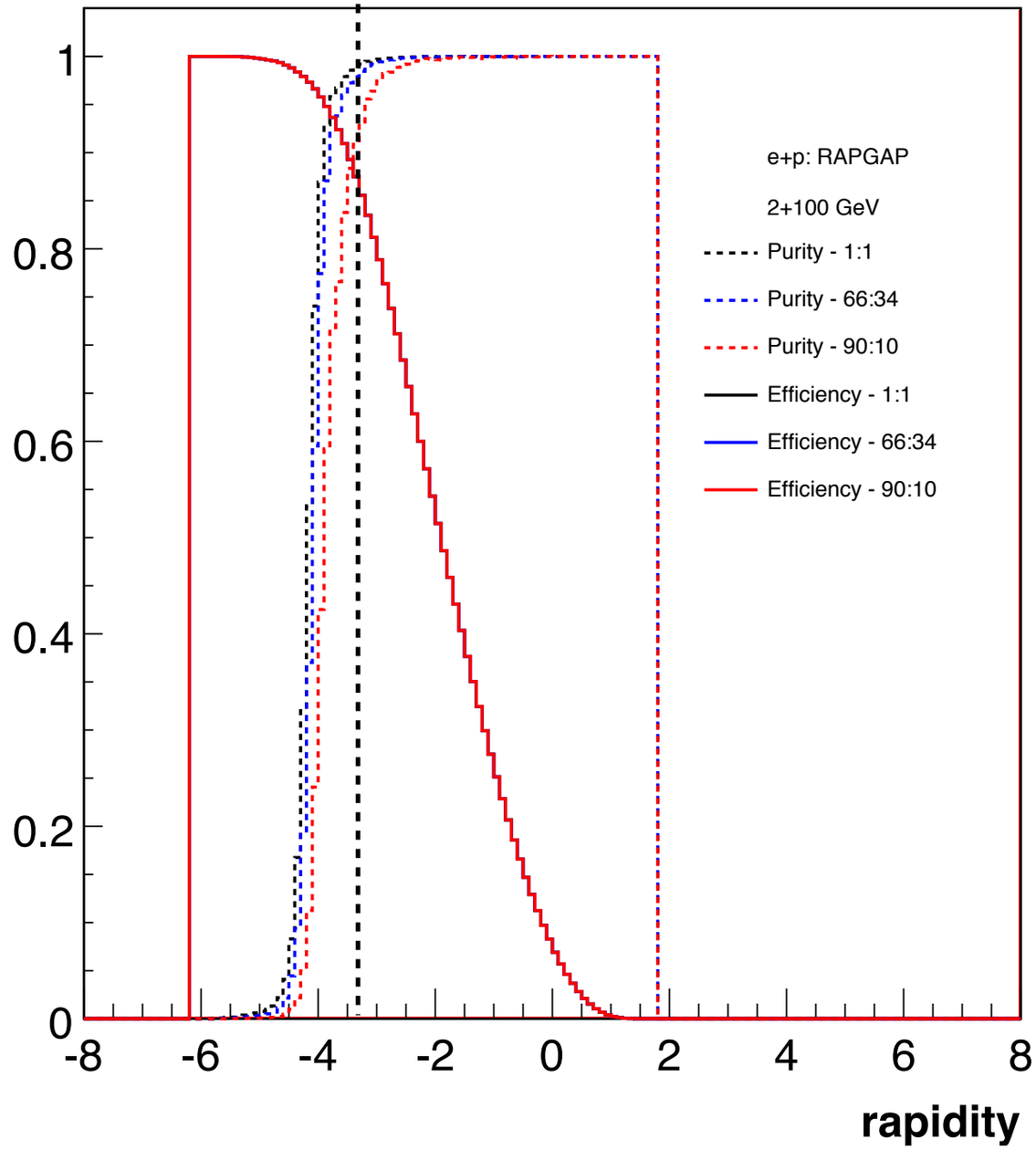

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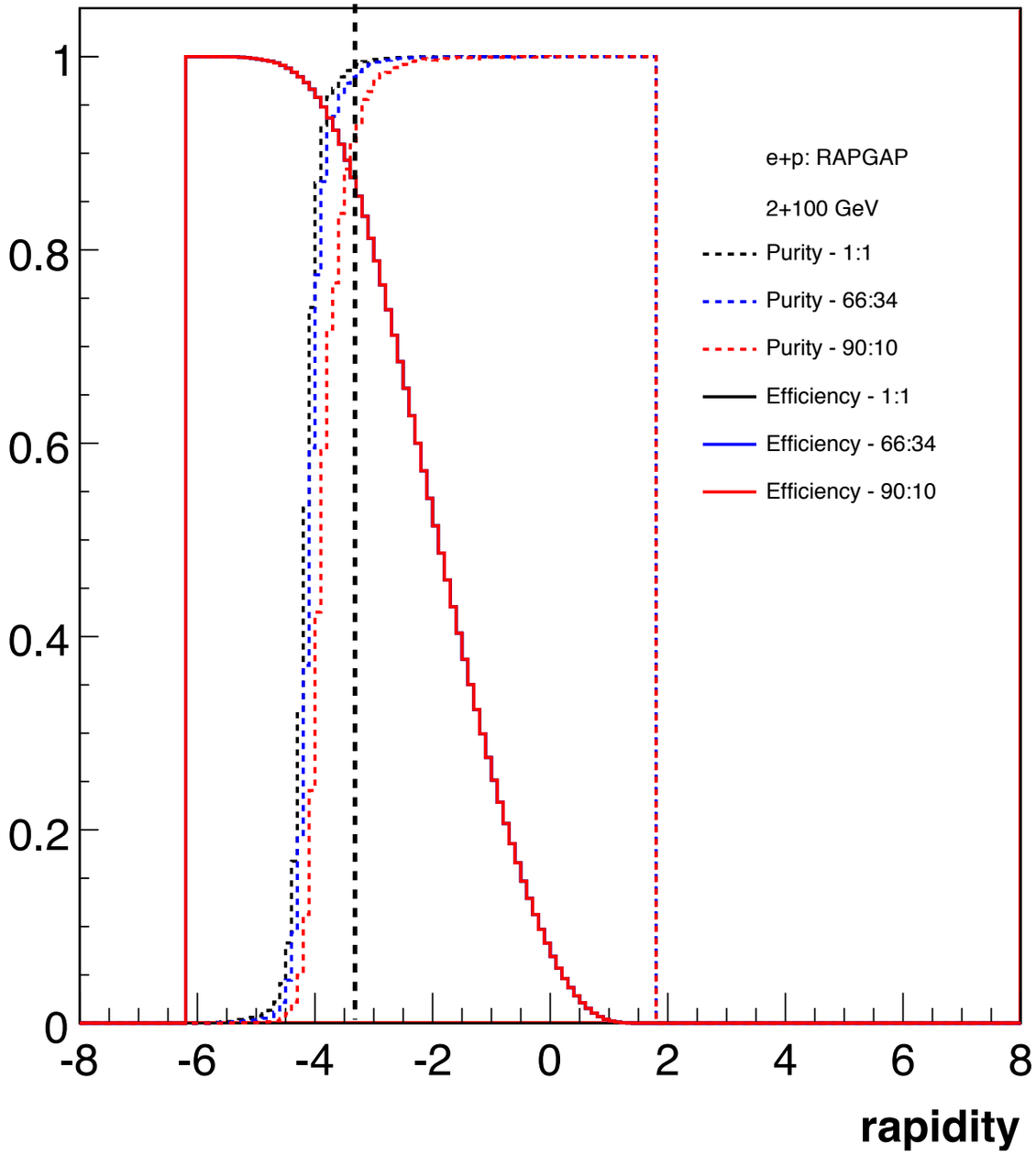

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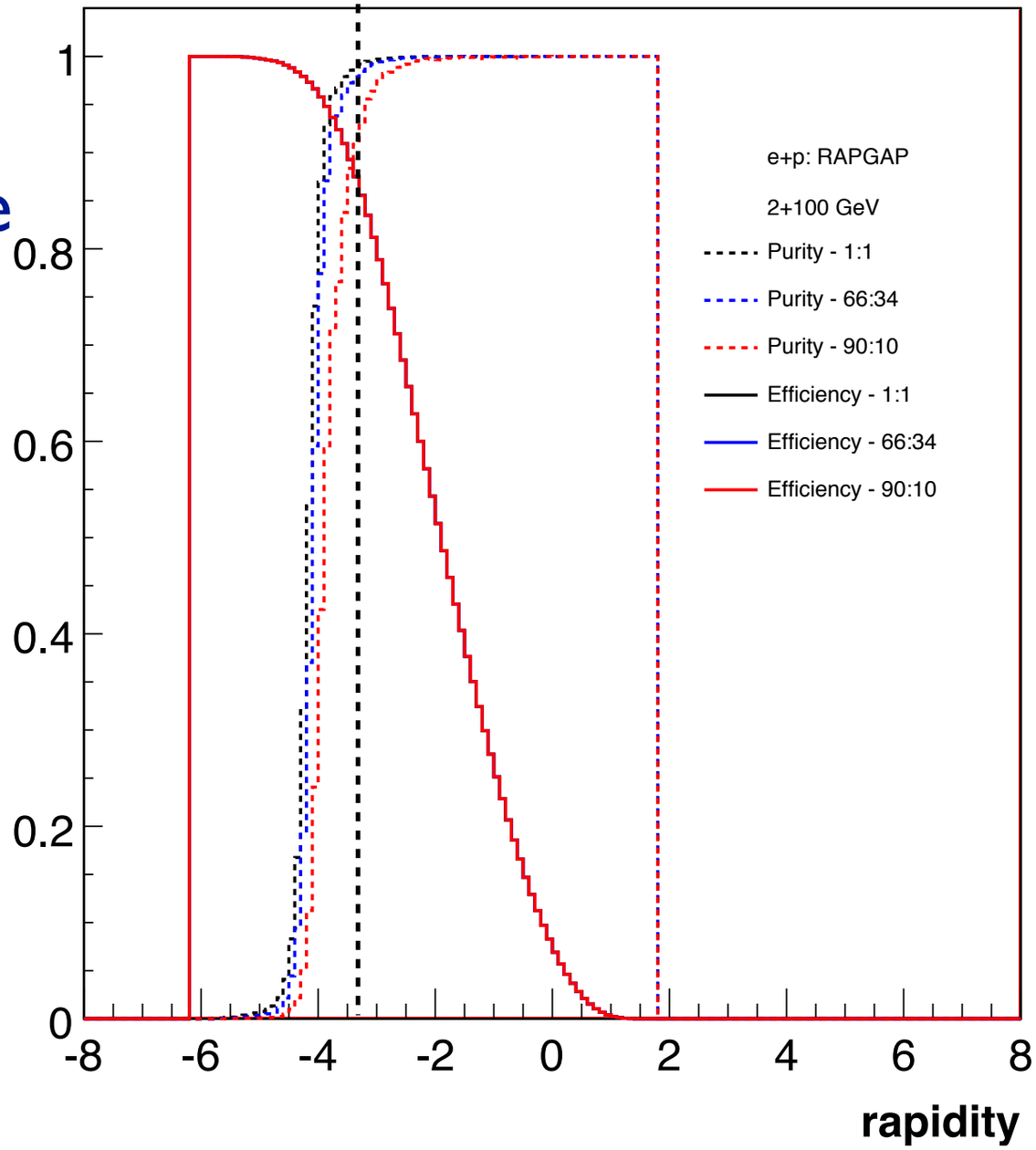

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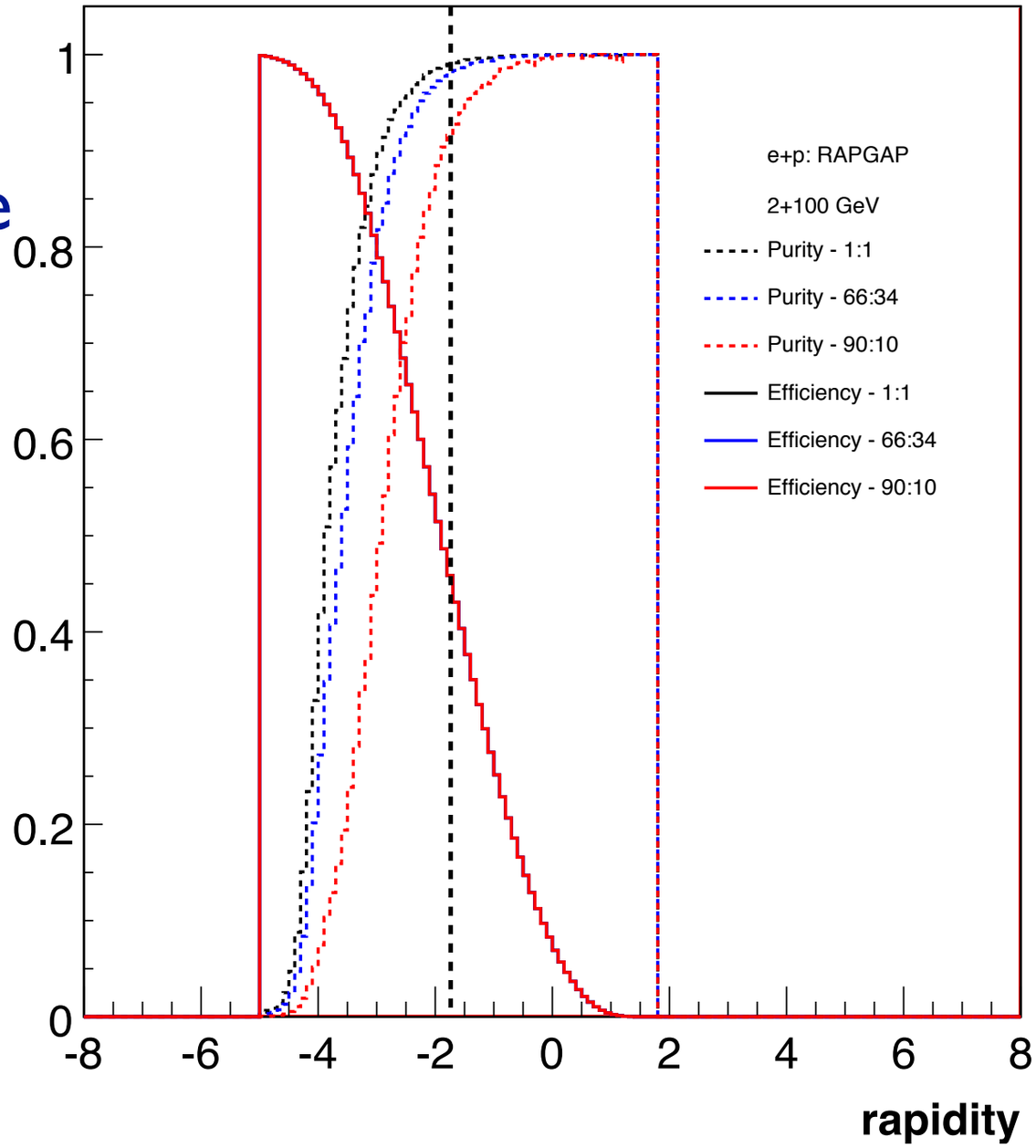

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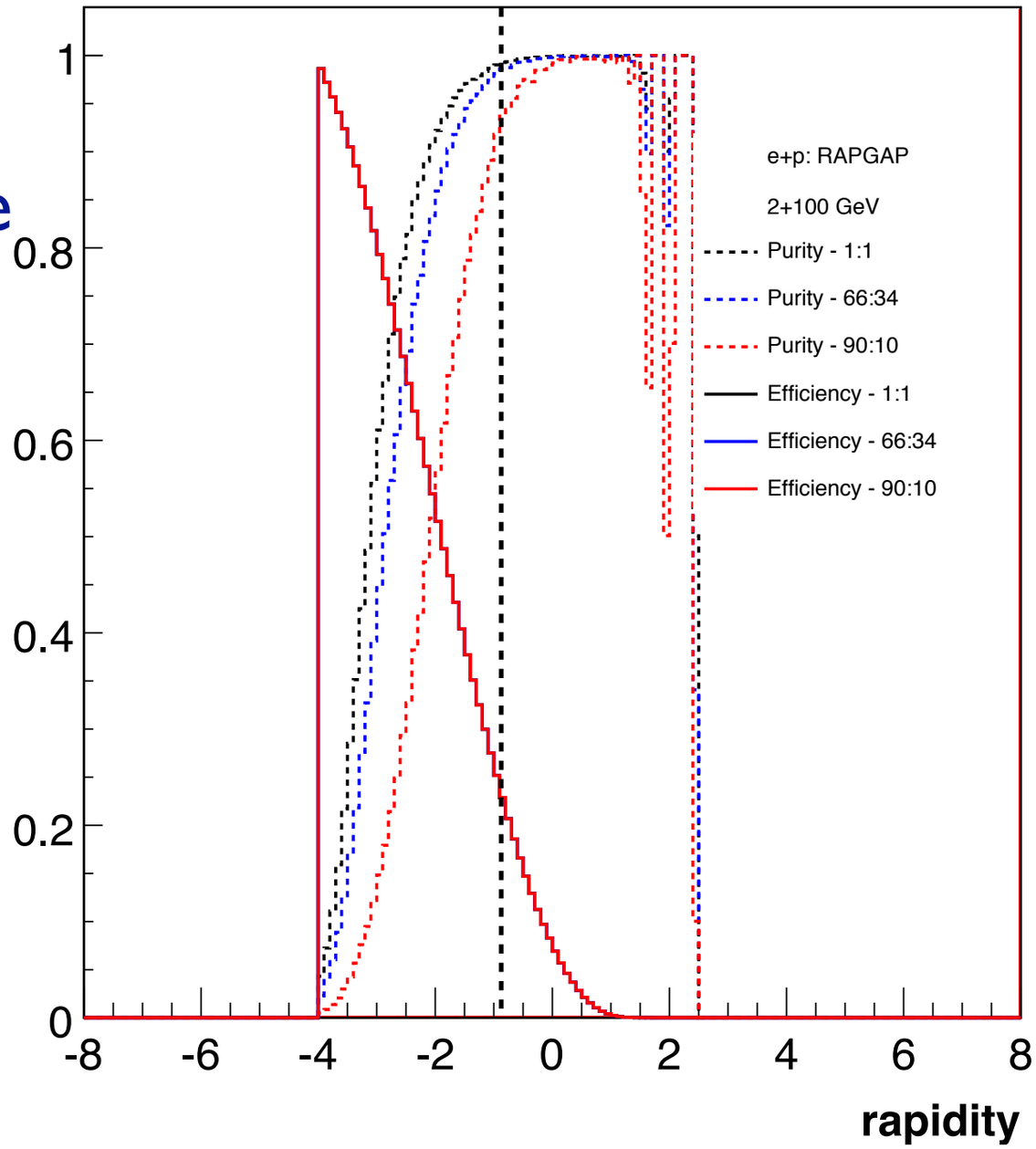

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  - ➡ Efficiency falls by a factor of 4, rapidity cut moves farther to right !!
- When designing a detector, it is essential to be as hermetic as possible !!!

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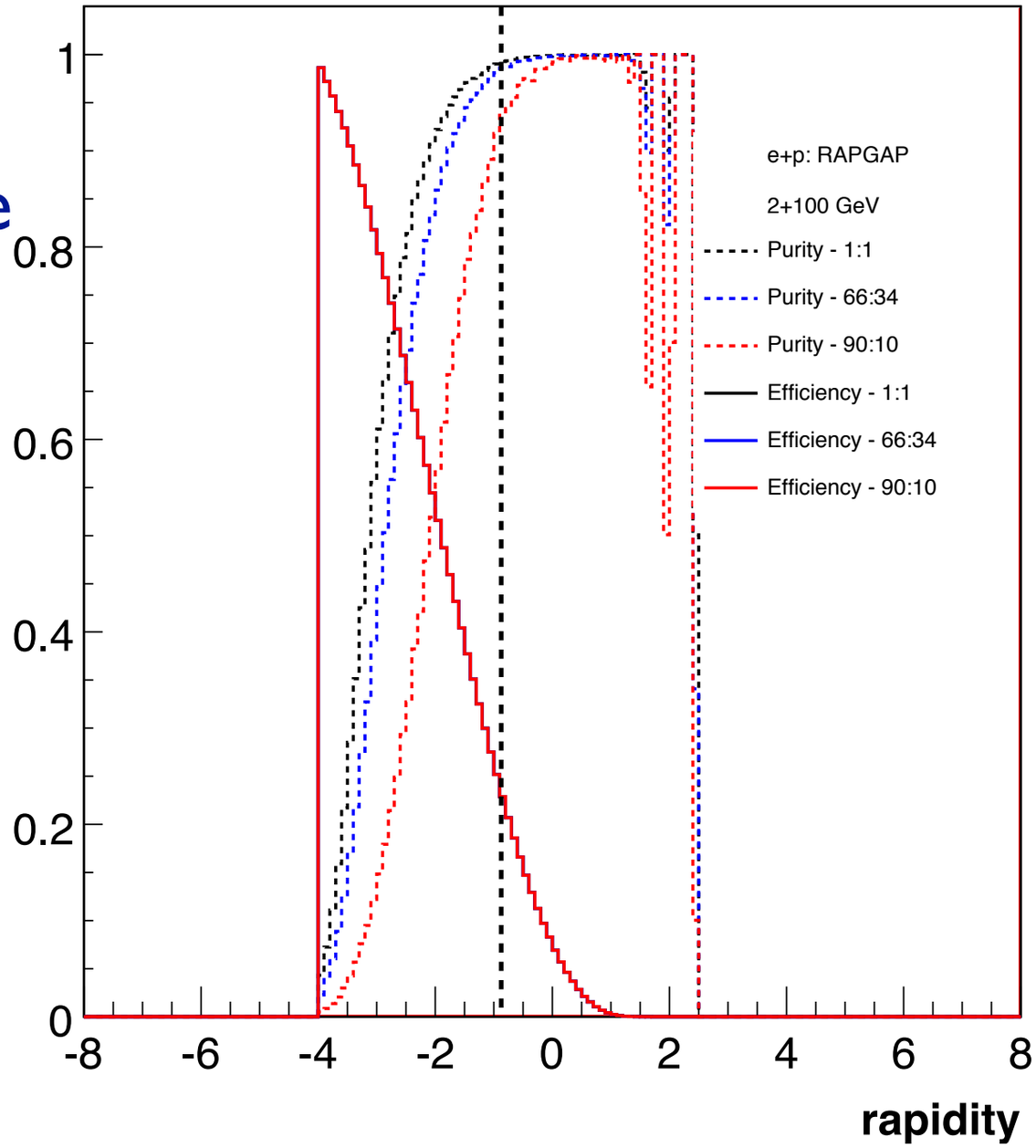
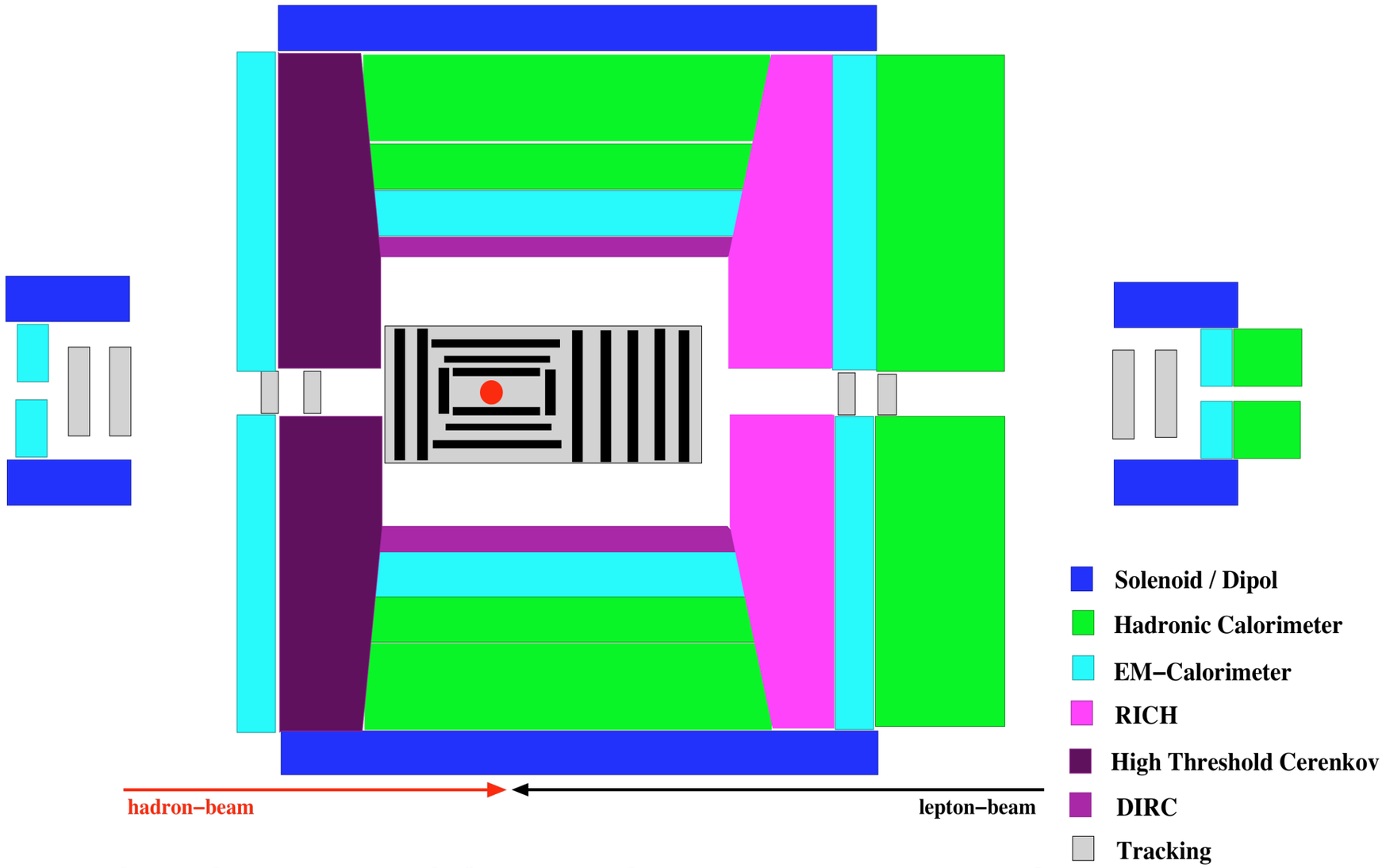


Detector requirements from physics

- e+p physics
  - ➡ Need the same detector for inclusive (ep → e'X), semi-inclusive (ep → e'X + hadrons) and exclusive (ep → e'p+π) reactions
    - Need to have a large acceptance (*both* mid- and forward-rapidity)
    - Crucial to have particle identification
      - e, π, K, p, n over wide momentum range and scattering angles
      - excellent secondary vertex resolution (charm)
    - small systematic uncertainty for e/p polarisation measurements
    - small systematic uncertainty for luminosity measurements
- e+A physics
  - ➡ most requirements similar to e+p guidelines
  - ➡ additional complication arises from the need to tag the struck nucleus in exclusive and diffractive reactions
- Also, important to have the same detector for all energies

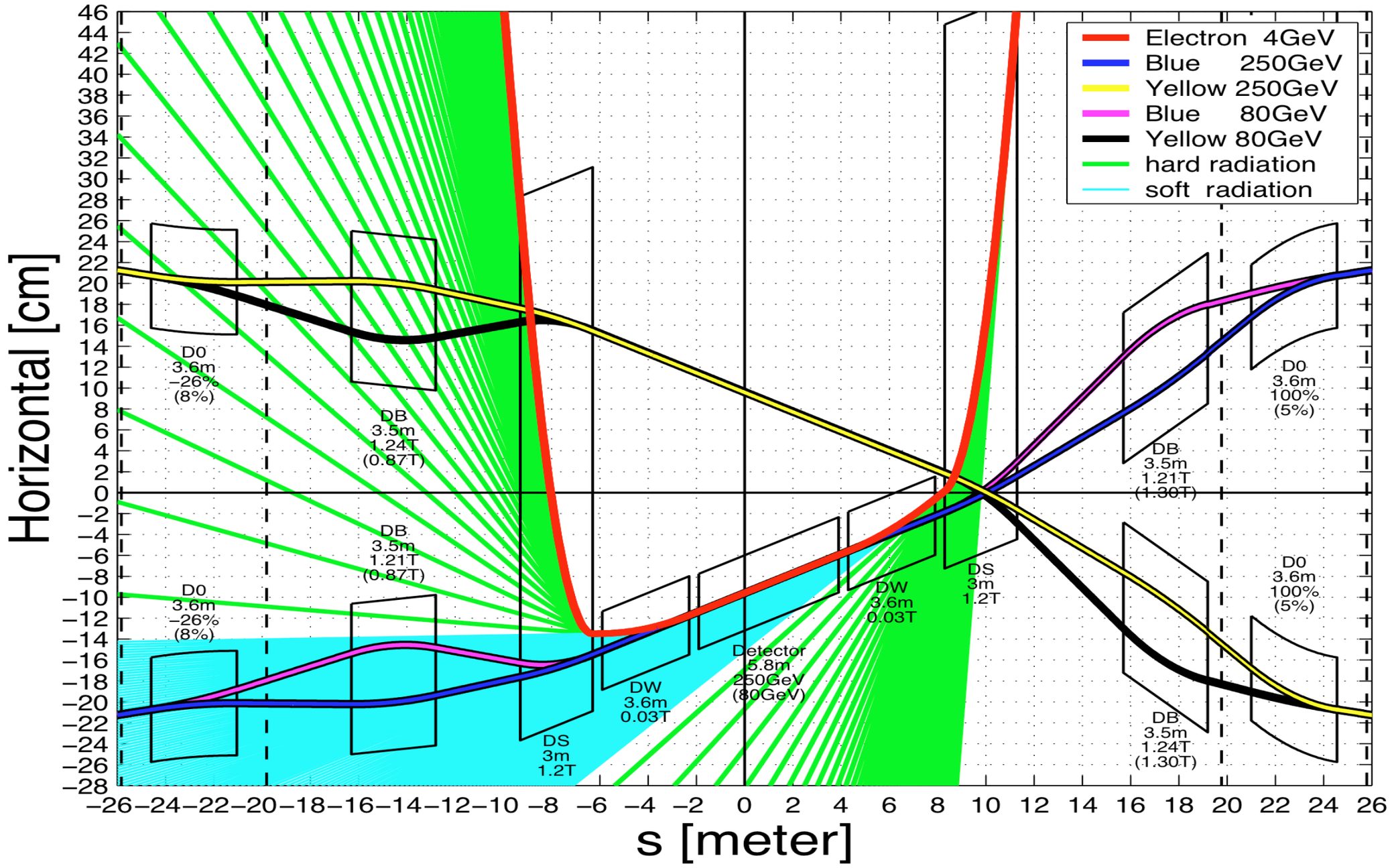
First attempt at detector design



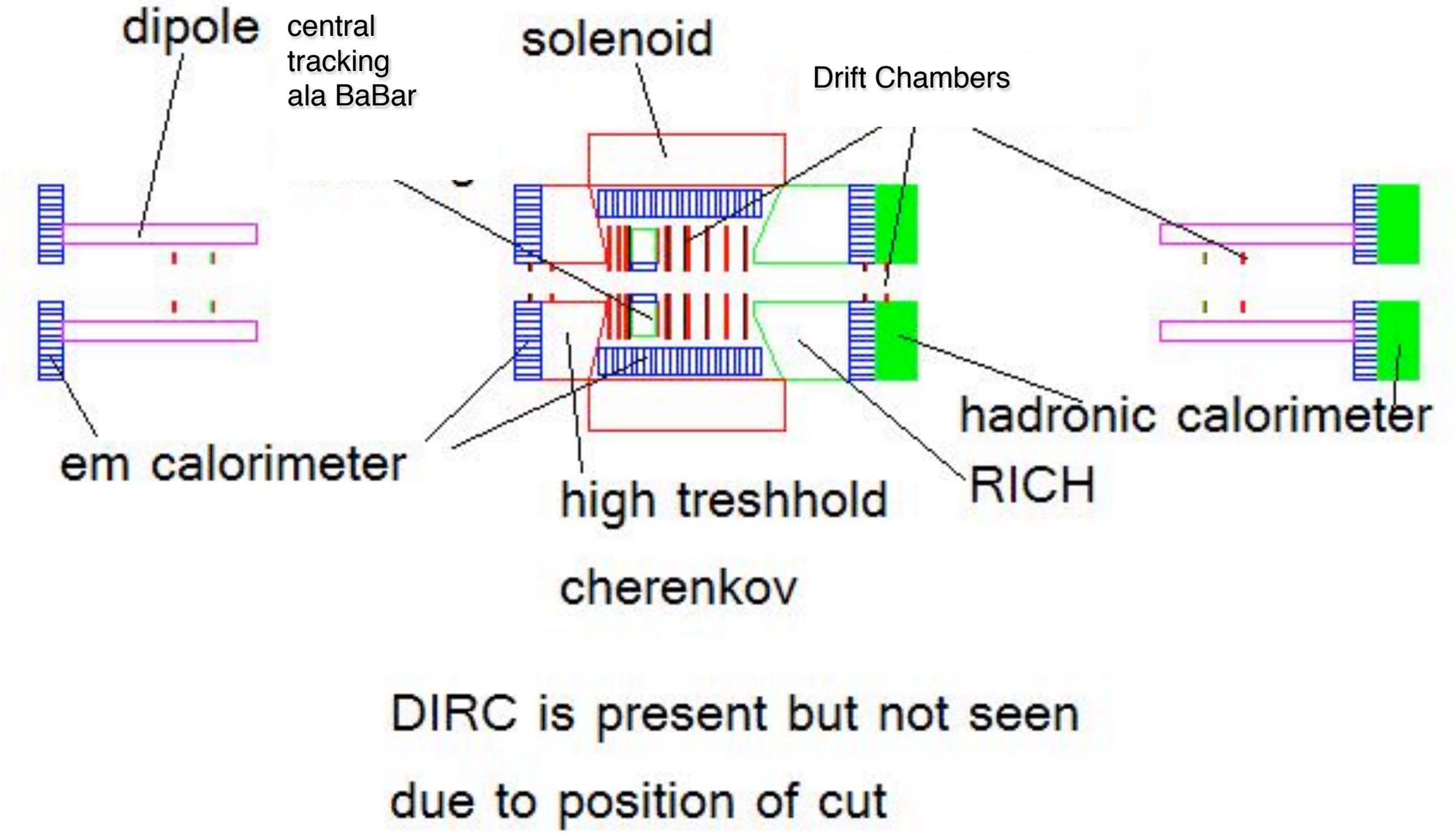
- Dipoles need to have good forward momentum resolution
  - ➡ Solenoid has no magnetic field for r → 0
- RICH, DIRC for hadron pid
- High threshold Cherenkov → fast trigger for scattered lepton
- Radiation length very critical → low lepton energies

Latest IR Design for MeRHIC at IP2

- No DX magnet
- No synchrotron shielding included
- Height of beam from floor ~ 6 feet
- Allows p and A decay product tagging



MeRHIC Detector in Geant 3



- Note - no hadronic barrel calorimeter due to height restrictions at IP2

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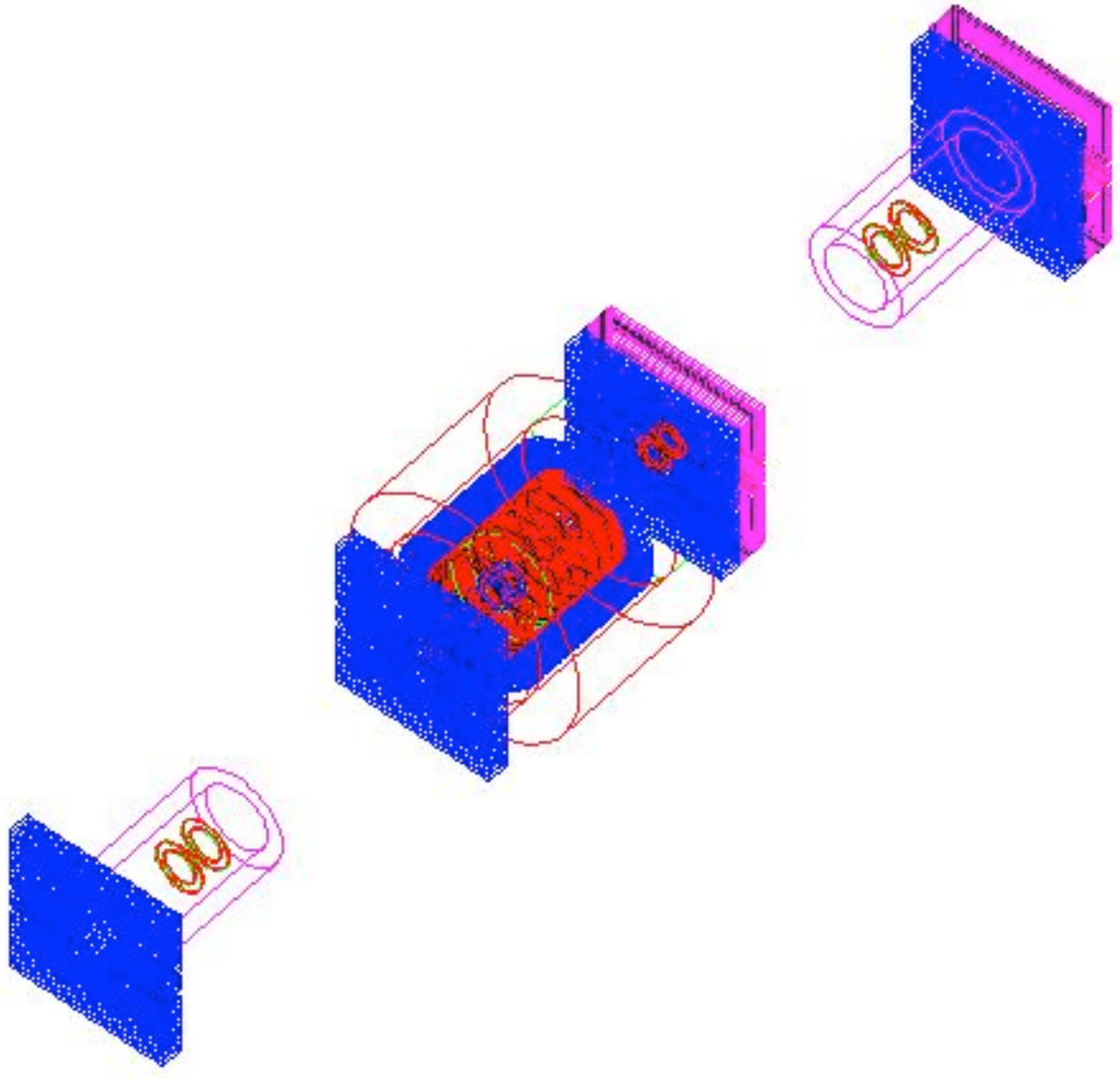

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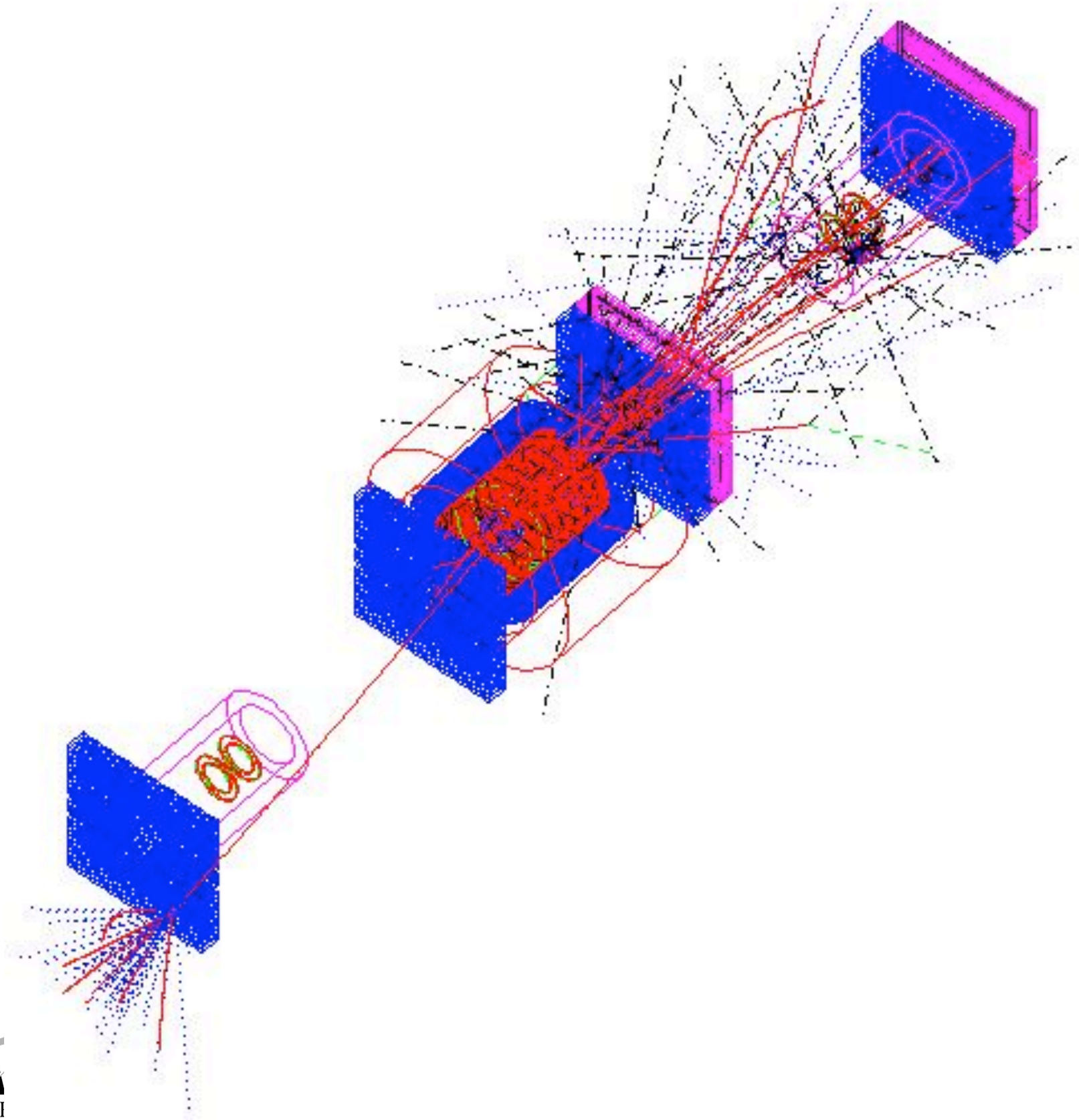

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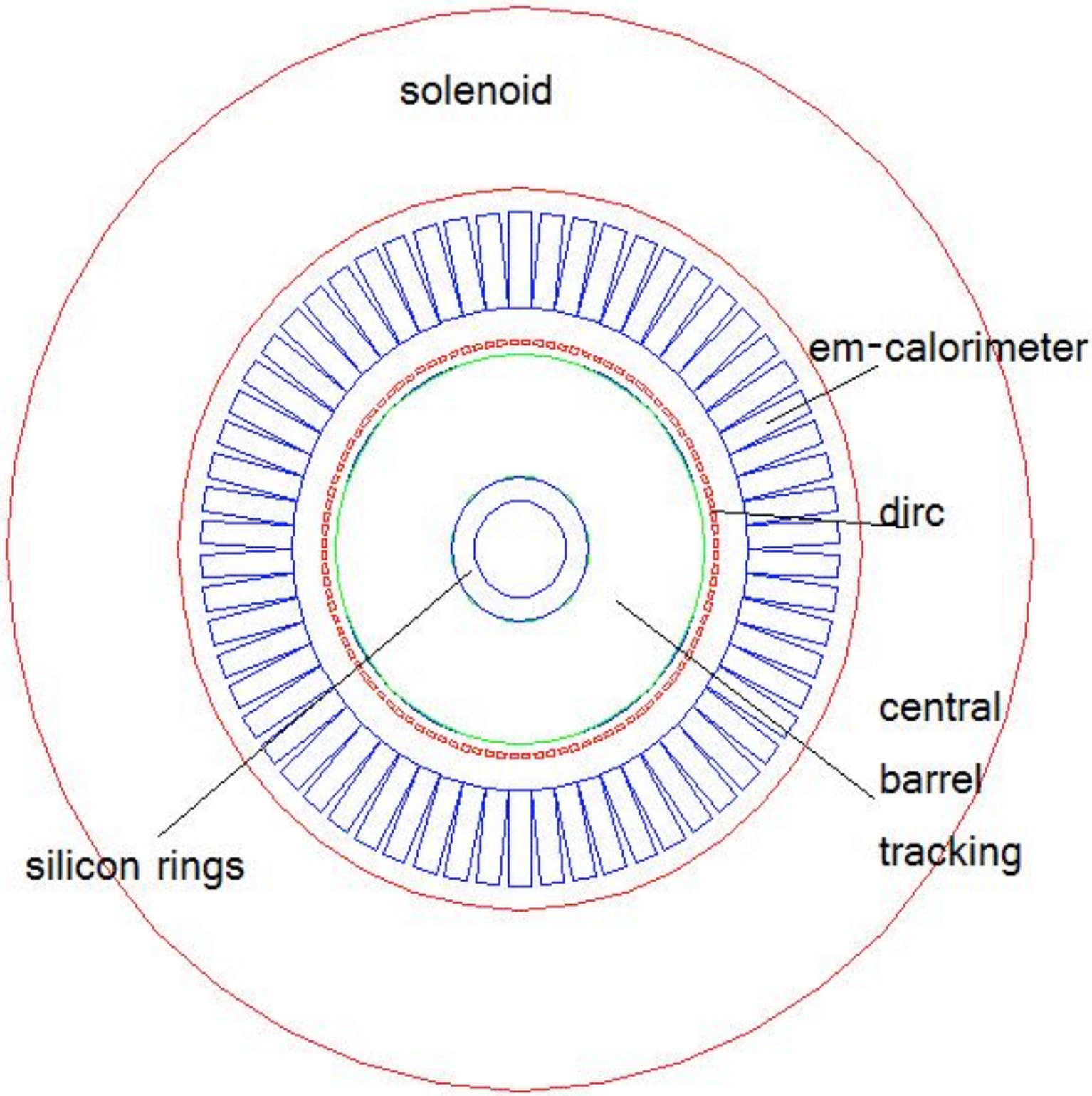

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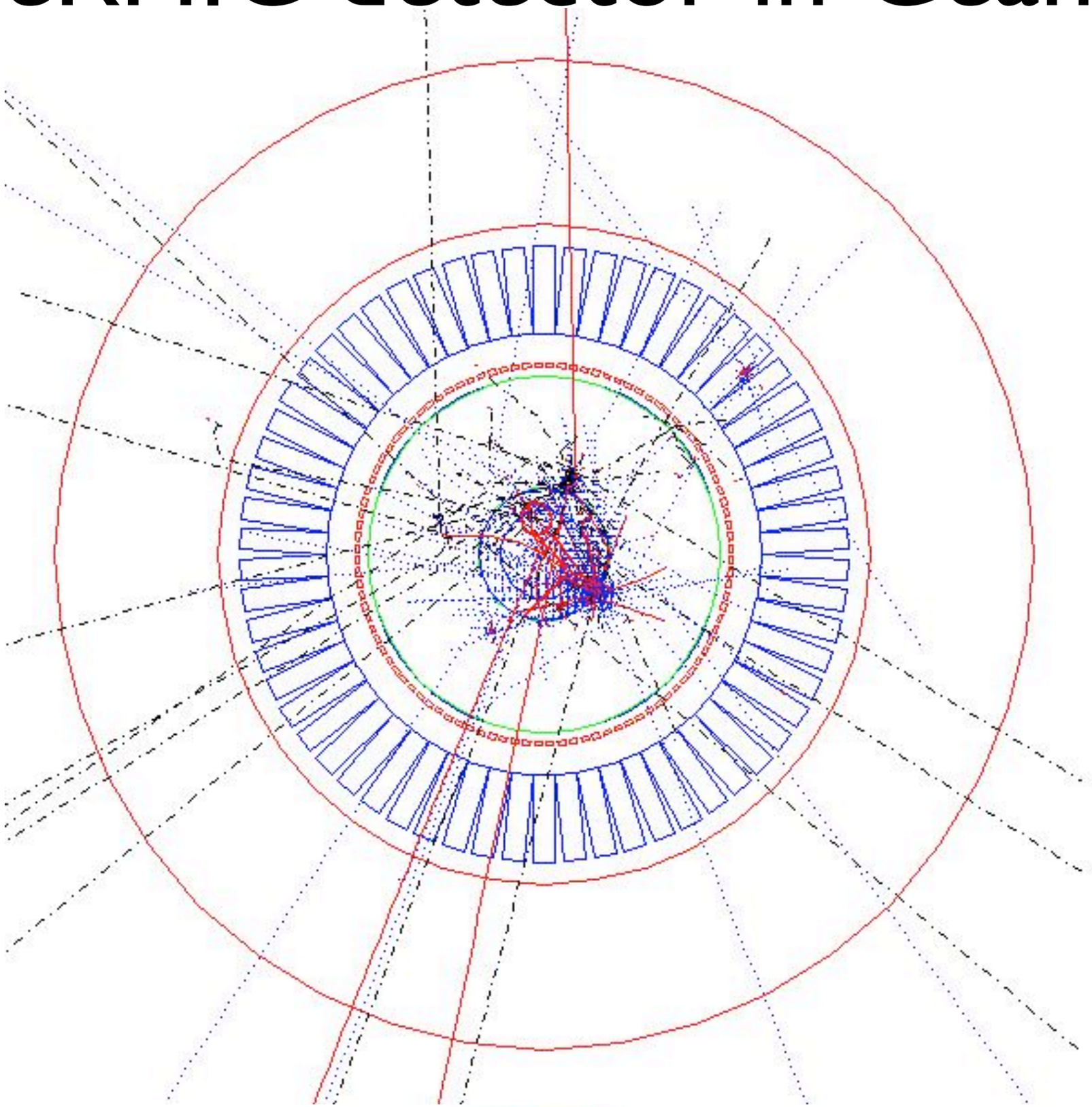
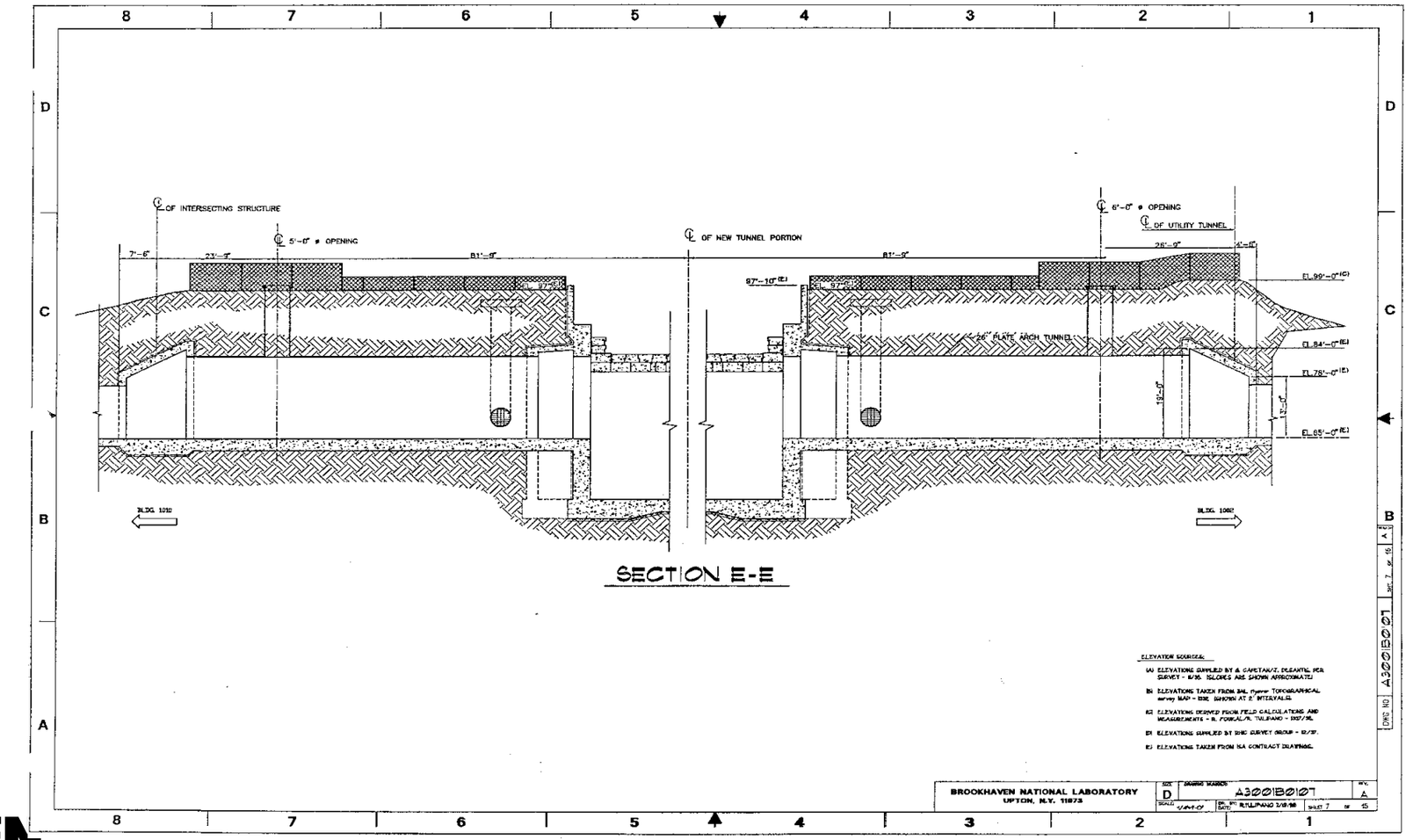


Why 2 o'clock and not 12 o'clock?

- Start at 12 o'clock originally:
  - ➡ Detector cost savings
    - ▸ fully staged detector from MeRHIC to eRHIC
      - vertical stage much bigger
      - need to buy magnets only once
      - can stage detector components (i.e. hadronic calorimeter)
      - no moving of detector



Summary and Outlook

- First steps made on detector design
- Optimisations needed
  - ➡ Do we need 4 T for solenoid and 3 Tm for dipole?
  - ➡ What radiation length can be tolerated for low energy electron?
  - ➡ Optimise the distance from solenoid to dipole
  - ➡ What is the impact of the beam lines through the detector on the physics?
  - ➡ Need to optimise acceptance at low scattering angle
    - Need acceptance down to 1 degree
- Need to add Roman Pots into detector configuration
- Need to include luminosity monitor and lepton polarimeter in IR design