RECENT UPC RESULTS FROM STAR

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U.S. DEPARTMENT OF ENERGY

STAR

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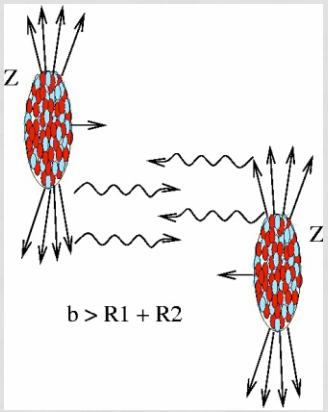
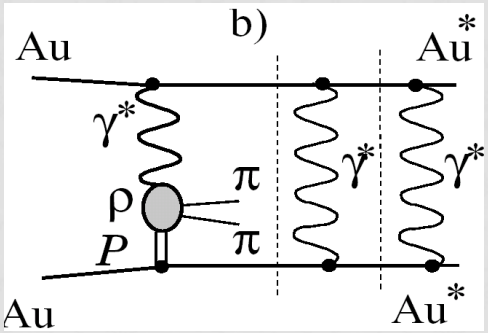
Ultraperipheral Collisions

- Intense electromagnetic fields act for very short time
- Weizsacker-Williams model
  - Photon flux ~ Z^2
- Photon emitted by projectile nucleus fluctuates into $q\bar{q}$ pair, which then scatters from target nucleus
- Coherent coupling to both nuclei

  → small transverse momentum

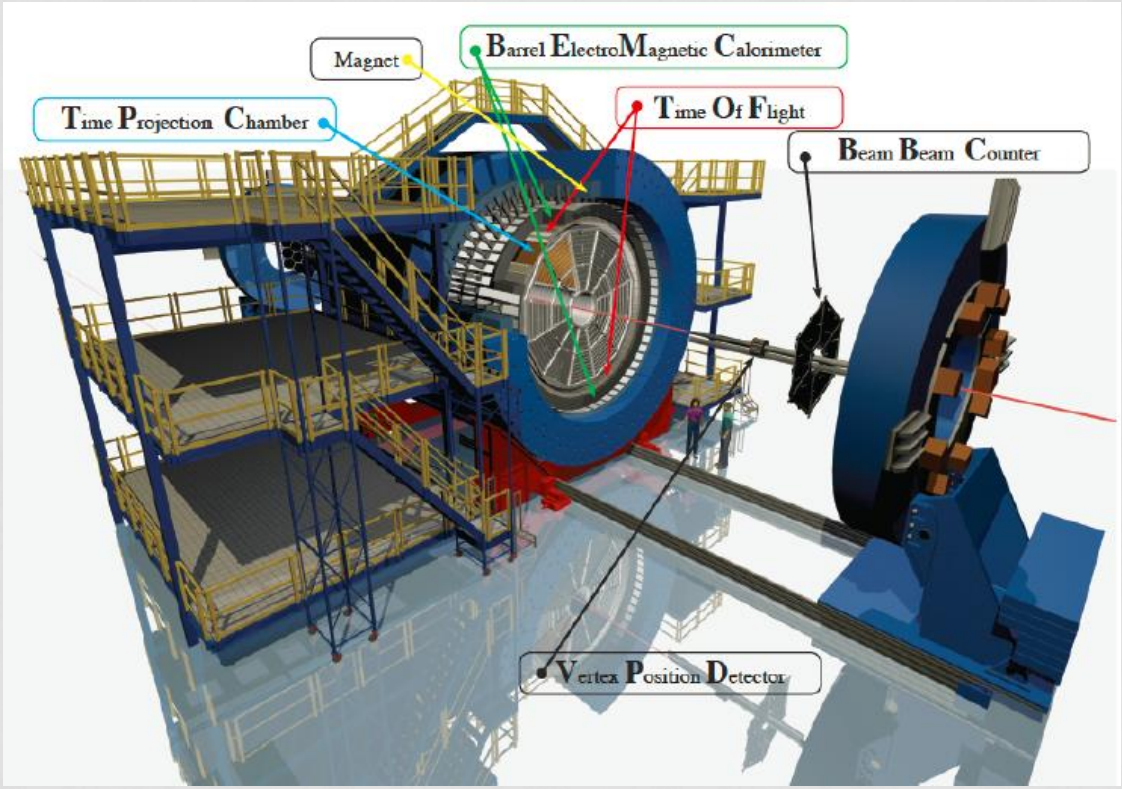
  $p_T \sim \hbar/R_A \sim 30$ MeV/c
  - Max photon energy ~ 3 GeV at RHIC
- Exclusive vector meson production (γ+A → V+A) of interest as a probe of the nuclear gluon distribution g(x,Q^2) and GPDs





Klein & Nystrand, PRC60 014903
Baltz et al PRL89 012301(2002)
Bauer et al NP A729 787 2003

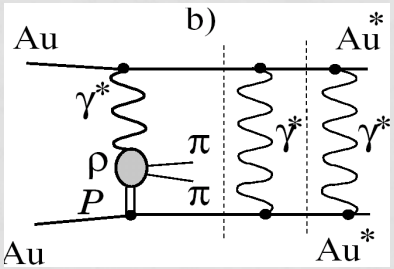
STAR Experiment

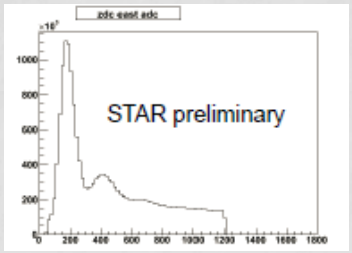


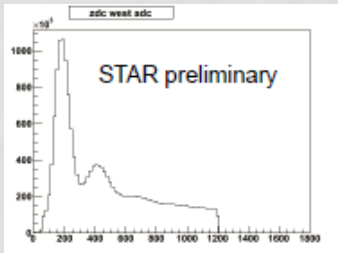
- TPC and TOF provide tracking and PID for $\eta < 1.2$
  - TOF also used for triggering
- Beam-beam counters cover $2 < \eta < 5$
  - Used as veto to define rapidity gap
- Zero degree calorimeters 18 m from interaction point
  - used for triggering

STAR UPC triggers

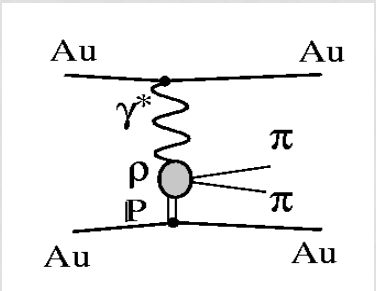
- UPC_Main
  - Low multiplicity in TOF
    - 2 < # of TOF hits < 6
  - Veto on small-tile BBCs ($3 < \eta < 5$)
  - Signal in both ZDCs
    - 1 < beam neutrons < 6 in each ZDC





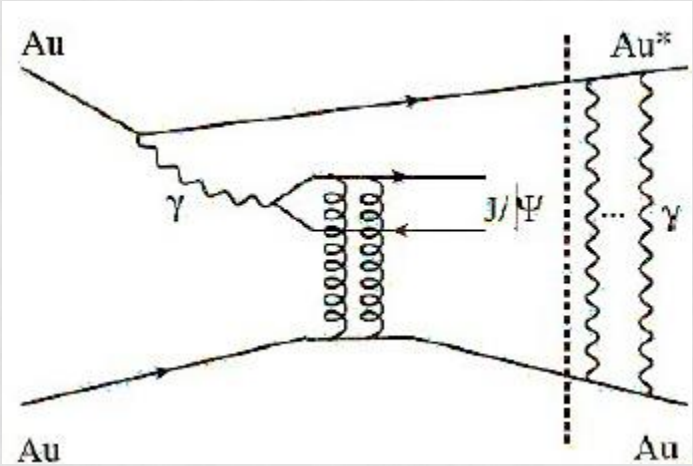


- UPC_Topo (small sample)
  - Low multiplicity in TOF
    - 2 < # of TOF hits < 6
  - Veto on small-tile BBCs ($3 < \eta < 5$)
  - Back-to-back tracks in TPC, with veto for up-down tracks in TOF to reduce cosmic rays



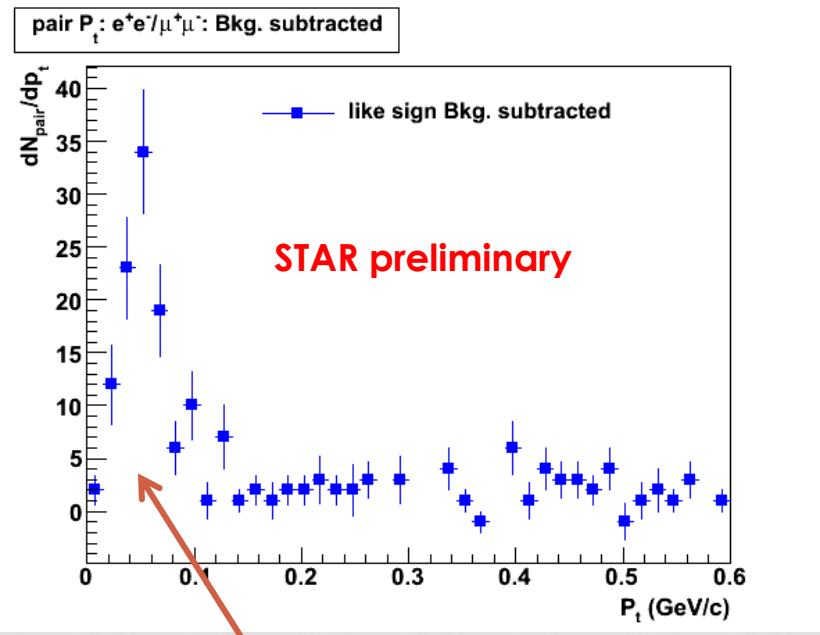
J/Ψ Photoproduction

- 2- gluon interaction
- Data Selection
  - |Zvertex| < 100 cm
  - # of tracks/ event =2
  - Connect vertex to TOF trigger to eliminate pile-up events
  - # of TPC hits ≥ 14
  - Pair p_T < 0.15 GeV/c
  - Vector meson rapidity: |y| < 1
- Backgrounds:
  - Cosmic Rays
    - Rejected by ZDC trigger requirement
  - Beam gas interactions
    - Rejected with multiplicity, vertex cuts
  - Peripheral AA collisions
    - Reduced with multiplicity, p_T cuts



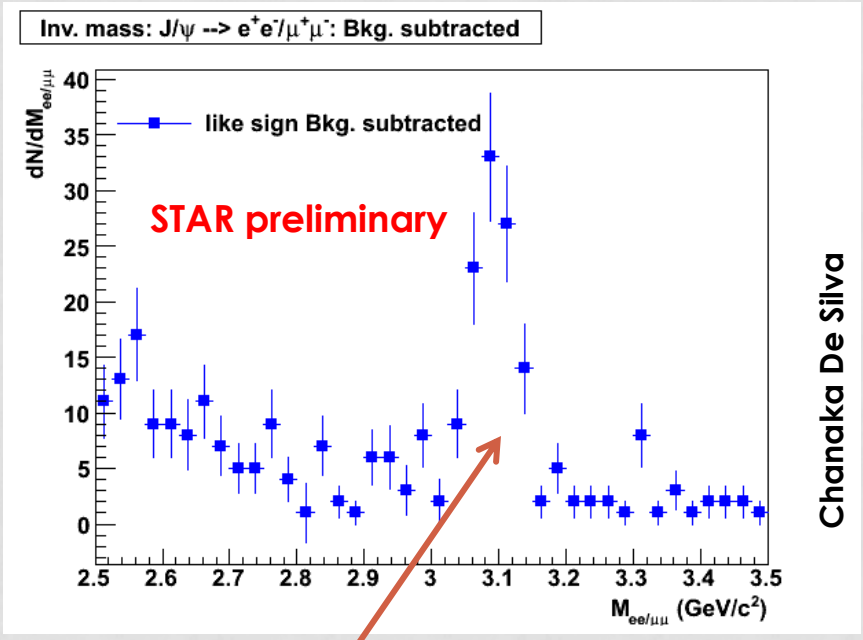
2010 Data (~37M UPC triggers)

Pairs with $3.0 < M_{ee} < 3.2$ GeV/c^2



Peak at low p_T consistent with coherent production

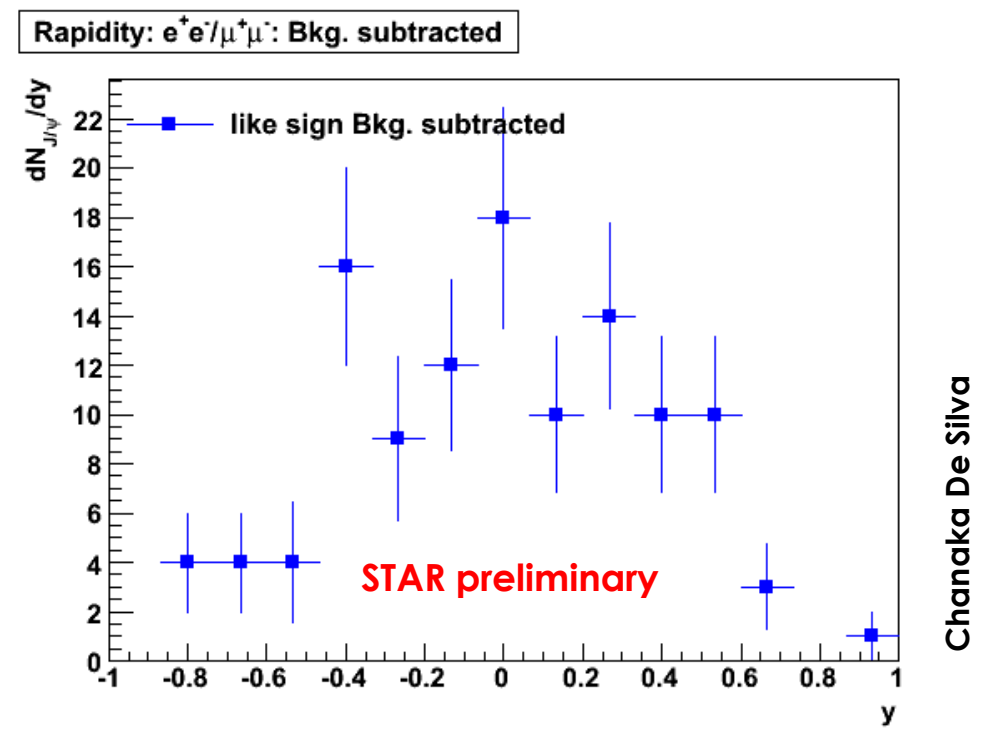
No PID
Electron continuum not subtracted



~ 145 candidates in J/Ψ peak

J/Ψ rapidity distribution

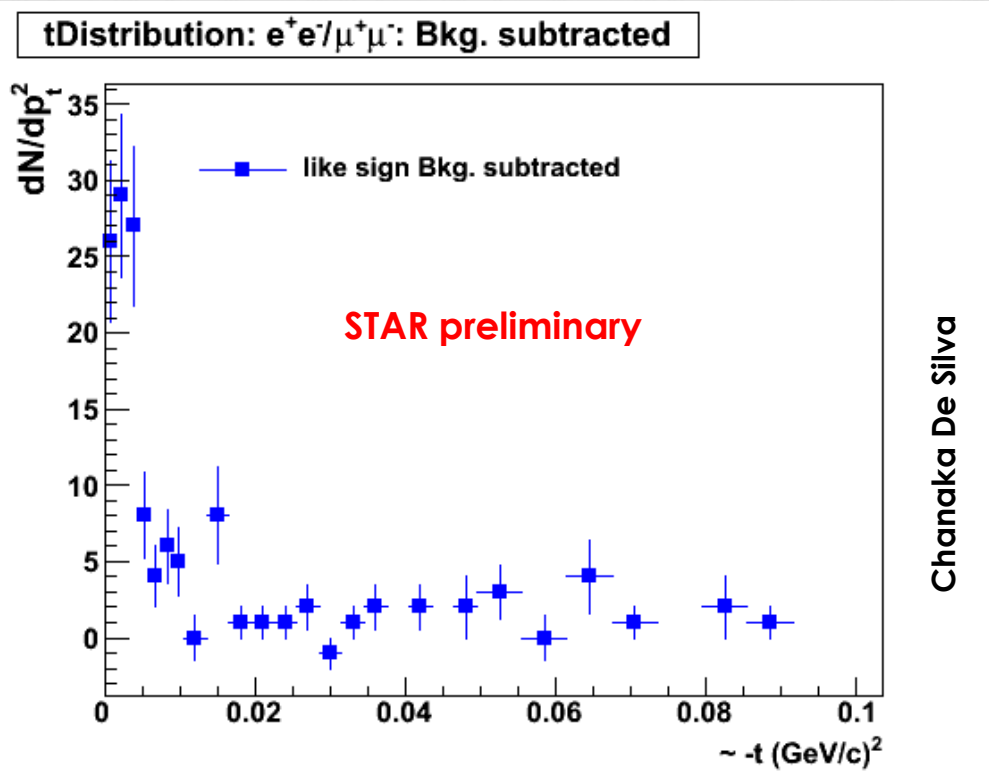
- Cross section for photoproduction of J/Ψ at mid-rapidity can provide insight into nuclear gluon distribution ($d\sigma/dy \sim [g(x,Q^2)]^2$)



- Pairs with $3.0 < M_{ee} < 3.2$ GeV/c^2
- Not efficiency corrected

J/Ψ t- distribution

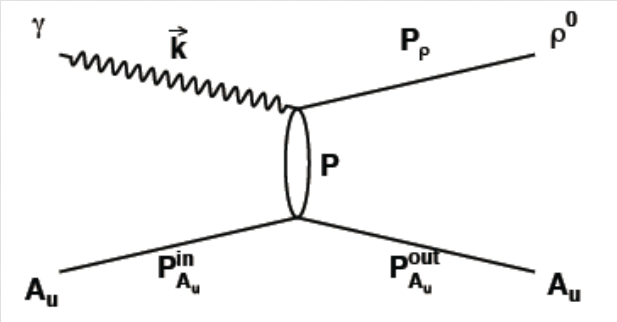
- More statistics needed to observe diffraction pattern

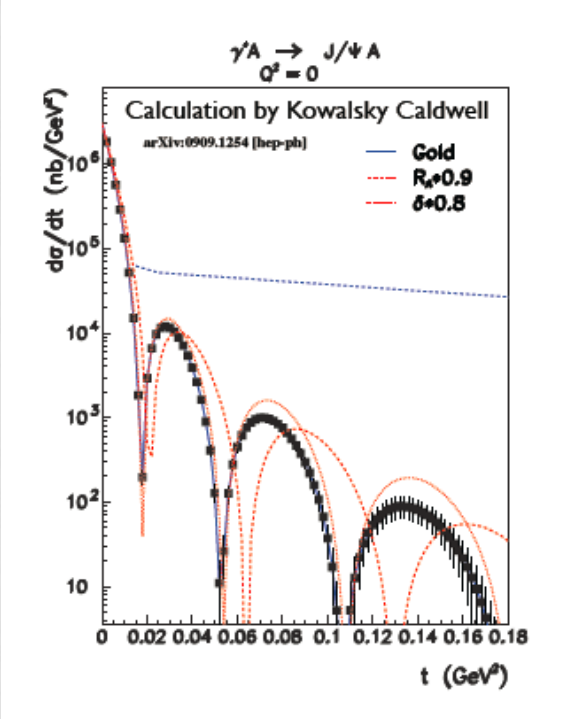


Pairs with
$3.0 < M_{ee} < 3.2$ GeV/c^2

Rho diffraction

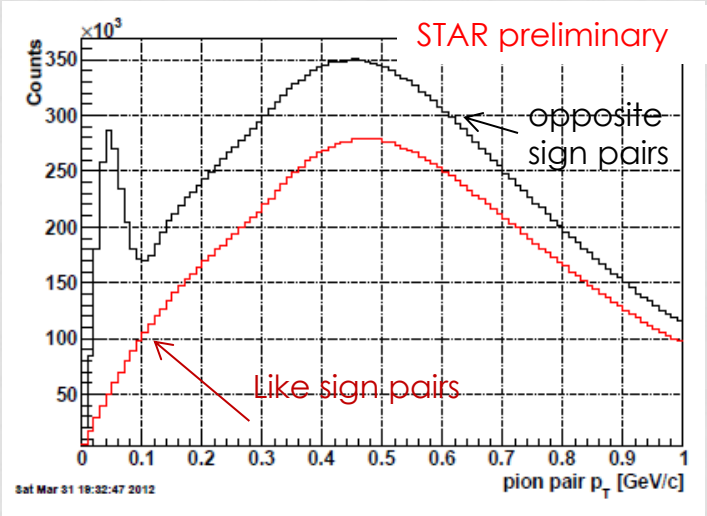
- p_T of photon is very small
  - p_T of ρ approx. balances the p_T of the recoiling gold
- Can expect to see diffraction pattern in t- distribution of coherently produced ρ mesons
- Fourier transform of dσ/dt is related to GPDs

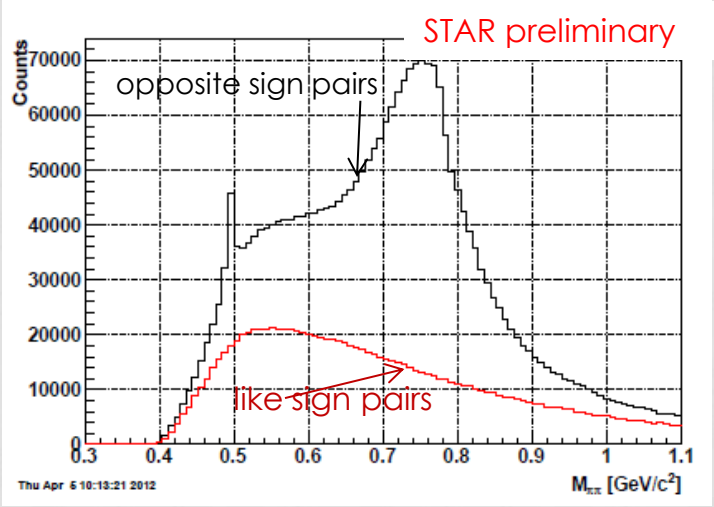




Rho meson photoproduction – 2010 data

- Data Selection
  - Exactly one neutron in each ZDC
  - Connect vertex to TOF trigger to eliminate pile-up events
  - Exactly two tracks out of selected vertex
    →Exclusive production
  - at least 14 hits in TPC
  - Select pions with TPC dE/dx
- 2.82M ρ candidates

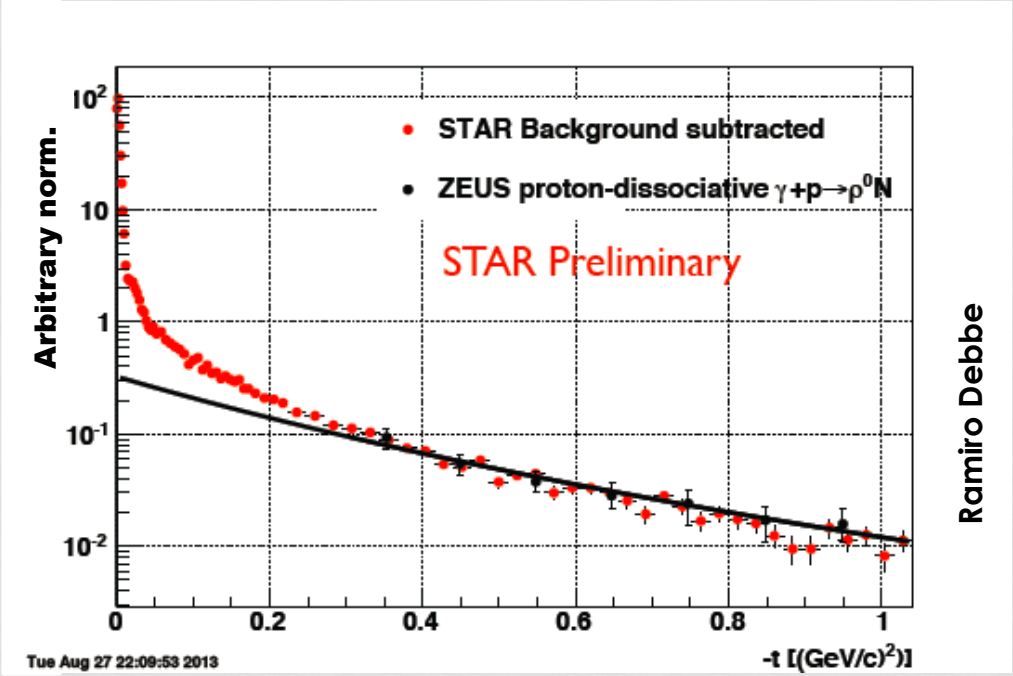




Ramiro Debbe

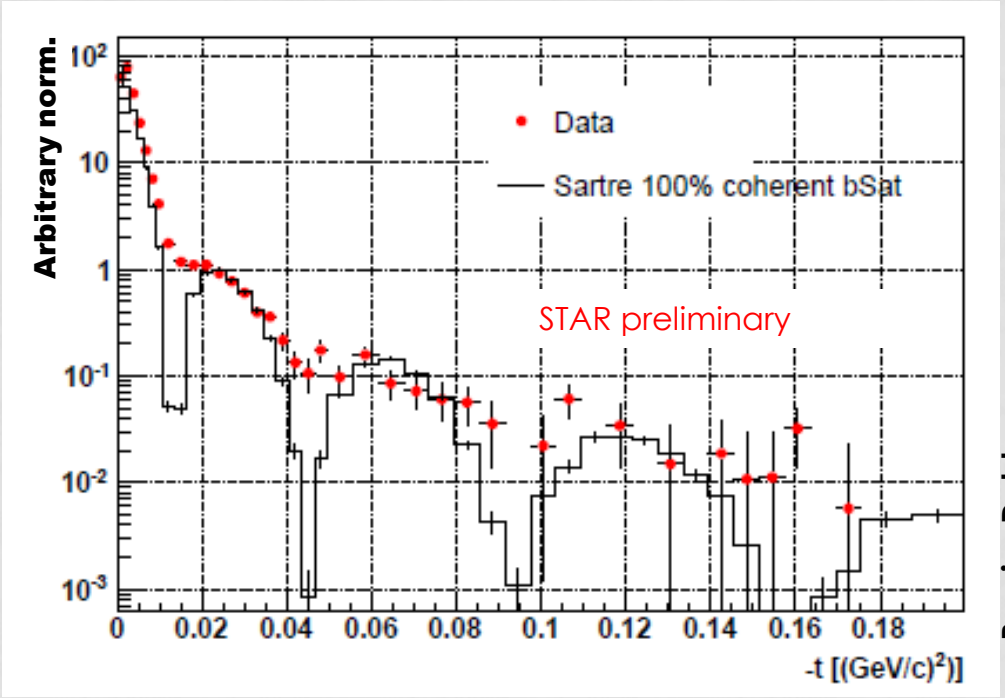
ρ t-distribution

- $t = -p_T^2$
- Like-sign background has been subtracted
- Data normalized using preliminary efficiencies & luminosity
- Incoherent tail is fit to a power law
  - Black line
- This is then subtracted to reveal the coherent distribution



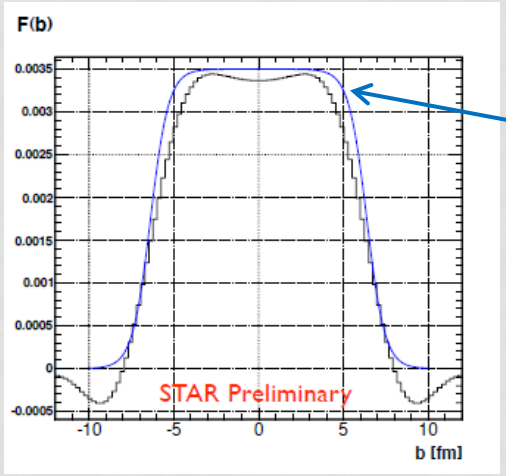
ZEUS results for $\gamma p \rightarrow \rho N$ scaled by 10.6 match the measured tail.

Diffraction pattern



- Sartre simulations give t of recoiling gold; data is measured t of ρ^0
  - Data normalized using preliminary efficiencies & luminosity
- Can see diffraction pattern in data up through third dip
- Slope of first peak, and peak location are consistent with coherent interaction with an object with size of Au nucleus

Ramiro Debbe

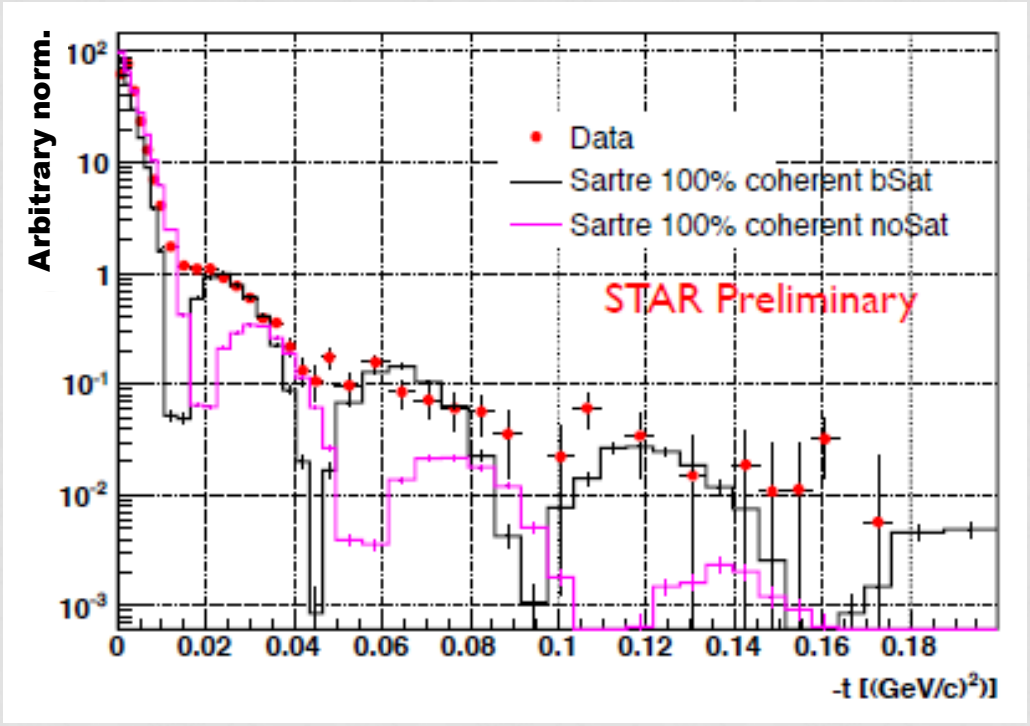


Blue is Wood-Saxon with R_{AU} = 6.38 fm, a = 0.53 fm

Sartre: Monte Carlo event generator based on an impact parameter dependent dipole model

T. Ulrich and T. Toll, arXiv:1108.1713 [nucl-th]
https://code.google.com/p/sartre-mc/

Details of diffraction pattern constrain dipole cross section models



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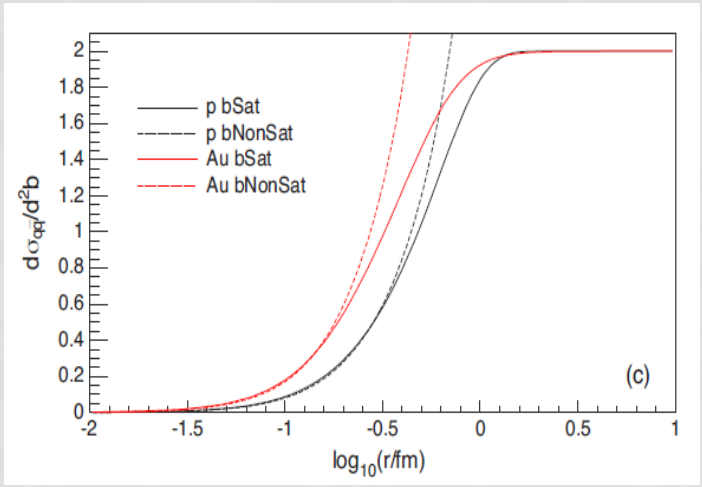
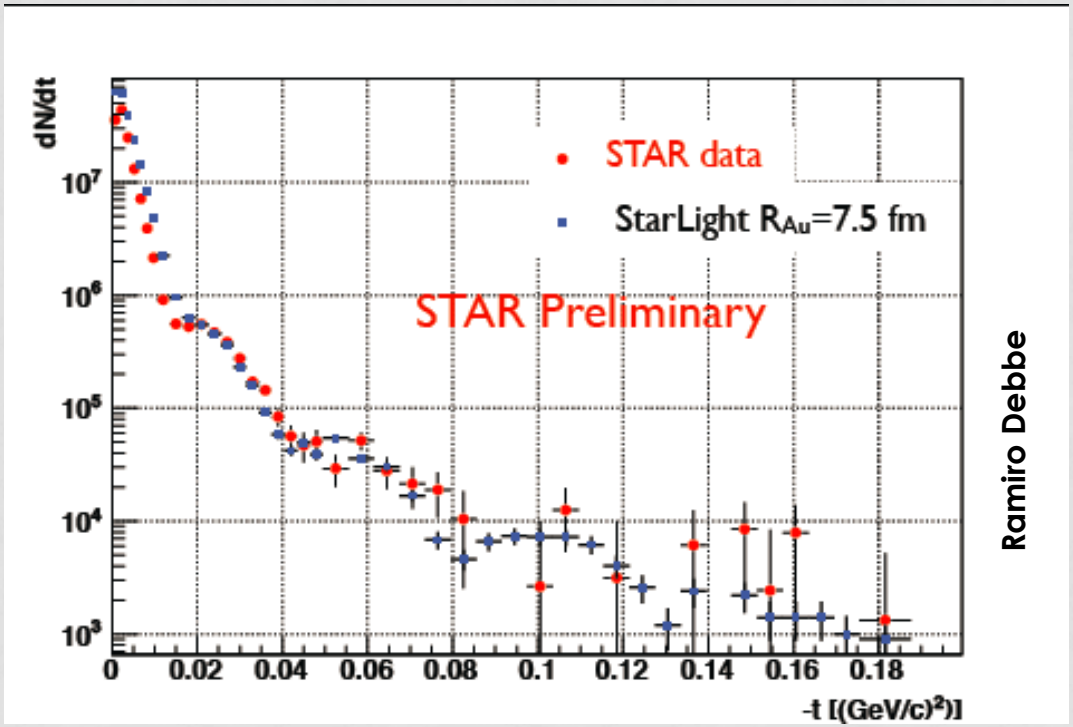


PhysRevC.87.024913

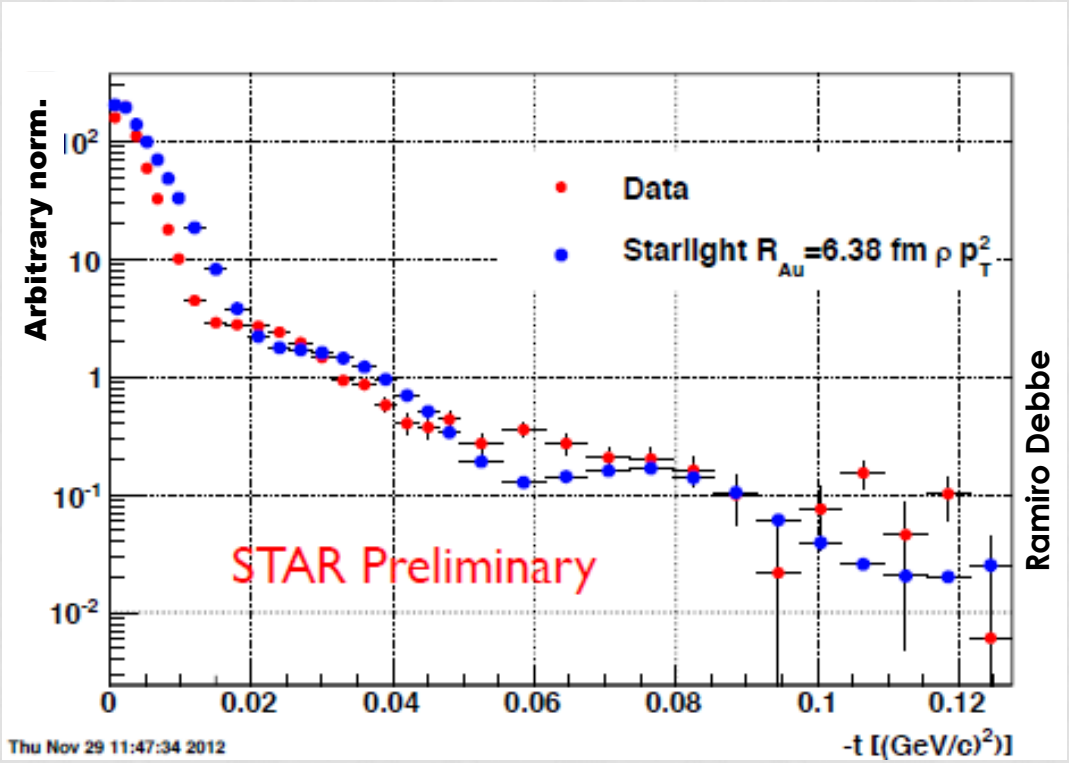
Data normalized using preliminary efficiencies & luminosity

Comparison to Starlight



- To match the locations of the dips, Starlight requires R_{AU} = 7.5 fm
- Starlight allows photon transverse momentum → no sharp valleys in the diffraction pattern

Comparison to Starlight



- With gold radius of 6.38 fm, Starlight systematically shifted to higher p_T than data
  - Data normalized using preliminary efficiencies & luminosity

Summary and Future Prospects

- J/Ψ photoproduction in two units of rapidity around y = 0 observed at RHIC
- Large sample of exclusive ρ photoproduction
  - Able to separate events where ρ scatters coherently off nucleus
  - Diffraction pattern of ρ mesons observed
- Corrections and normalizations need to be finalized
- U+U data at 193 GeV has been collected
- We are preparing for the 2015 p+Au run with the Roman Pots.