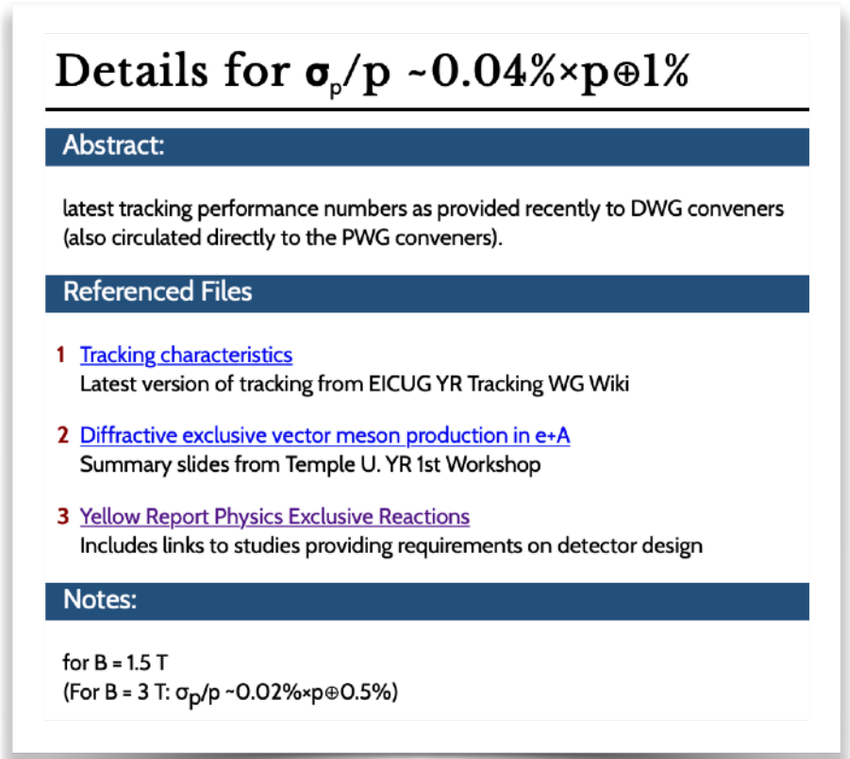
first look at exclusive $e+A \rightarrow J/\psi \rightarrow \mu^+\mu^-$

Special thanks to Jin for continuous help!

Peter Steinberg, BNL/ 3rd ECCE simulation workshop / 7 July 2021

Introduction

- **Assess performance of ECCE to measure |t| in <u>coherent</u> J/ψ→μμ using Sartre 1.35**
  - Coherent diffractive process is sensitive to spatial distributions of gluon in nucleus
  - Saturation physics requires larger dipole separation (i.e. ρ,ϕ)
  - J/ψ is an important channel, covered extensively in YR (but without G4), motivating choice of 3T magnet
  - Incoherent is important but measures spatial fluctuations, and must be rejected to perform the imaging studies



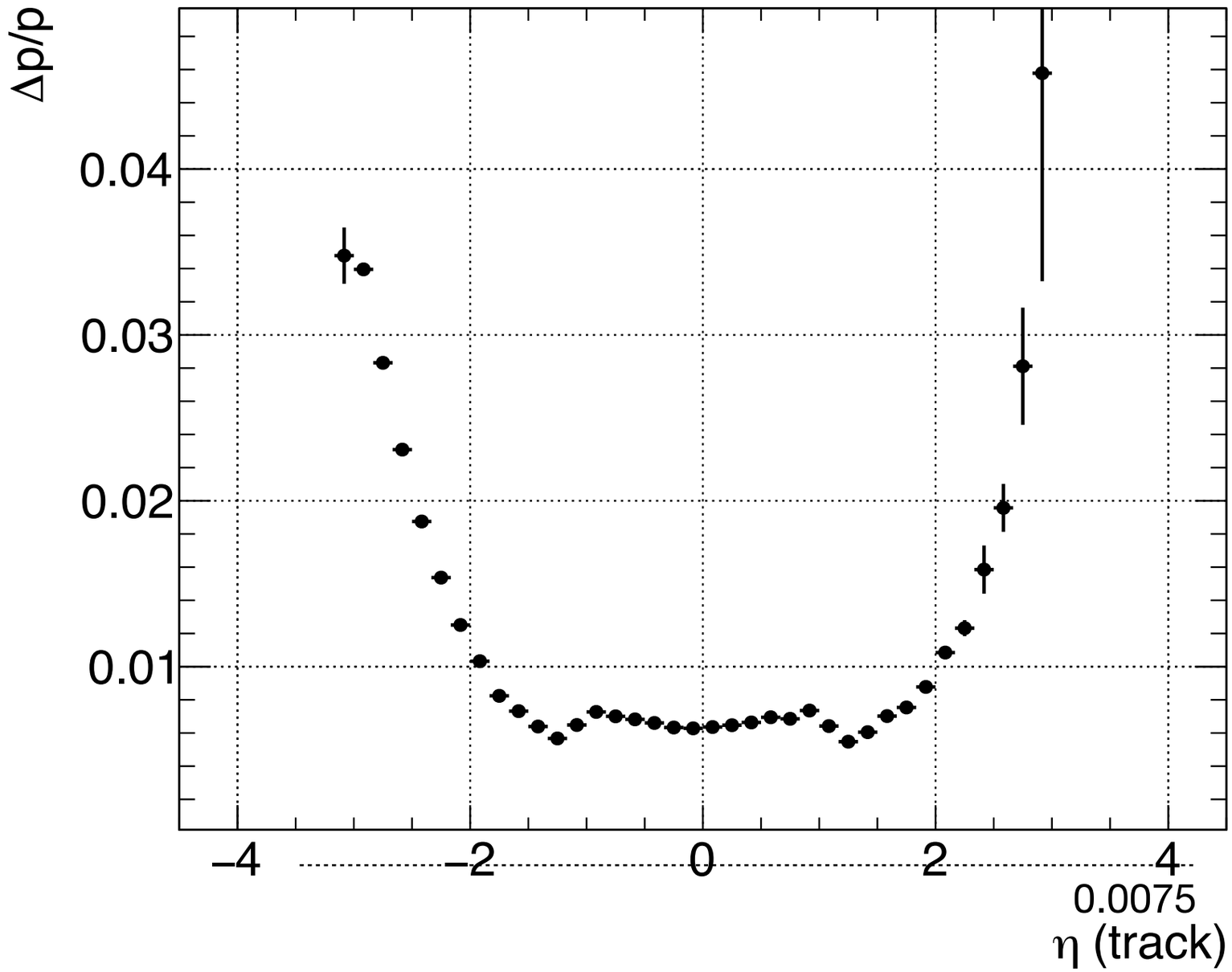
https://physdiv.jlab.org/DetectorMatrix/

- **Using Sartre 1.35 standalone (DIS, 1<Q²<10 GeV²)**
  - J/ψ to μμ, to avoid complexities from electron bremsstrahlung
  - Produces text files for EIC smear → EIC smear ntuples
  - My executable producing text file scales outgoing nuclear momentum vector by $A(m_N/m_p)$
    - *Still needs work - seeing lots of forward showering in fun4all*

- **Moved to new fun4all macros two weeks ago**
  - Using new Si tracker
  - Handmade samples - running ~75k events overnight - need ~5M to populate diffractive peaks

- **Calculating |t| at 4 levels (using EventEvaluator as primary analysis tool - thanks!)**
  - HEPMC - input generator level
  - g4 (“mcpart”) level - after crossing angle & beam divergence applied
  - reconstructed - from event_tree
  - smeared - g4 level particles convolved with Δp/p=0.75% (crude first look, but OK!)

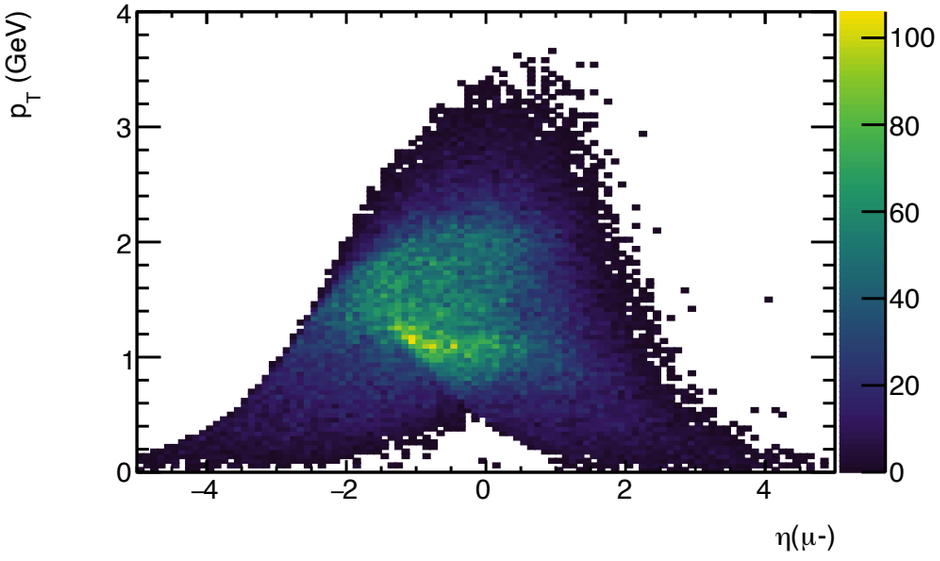
Tracking resolution

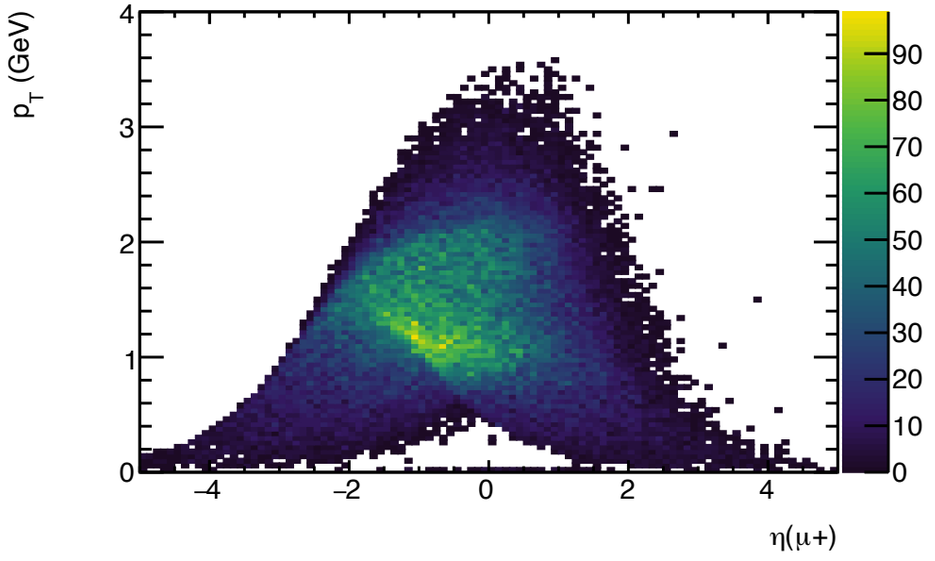


taken straight from tracking evaluator output

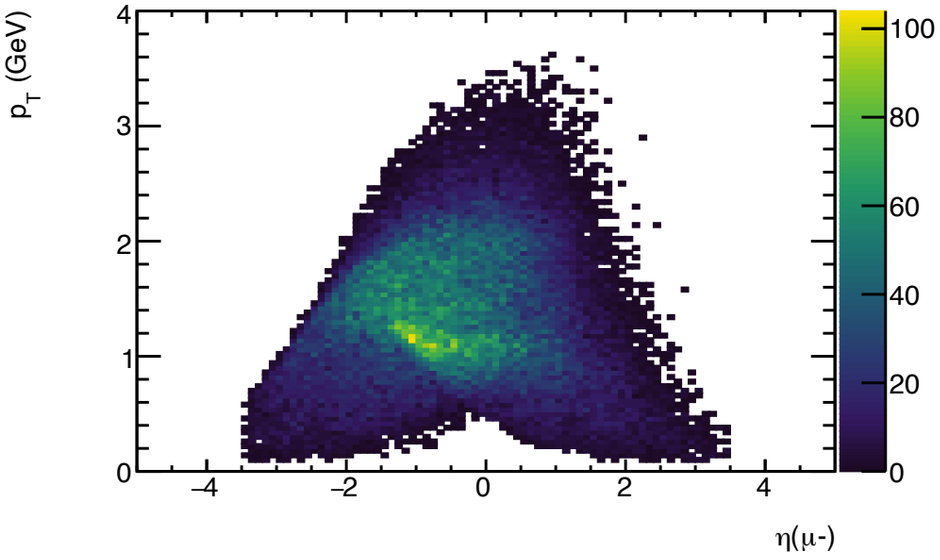
ECCE acceptance for J/ψ

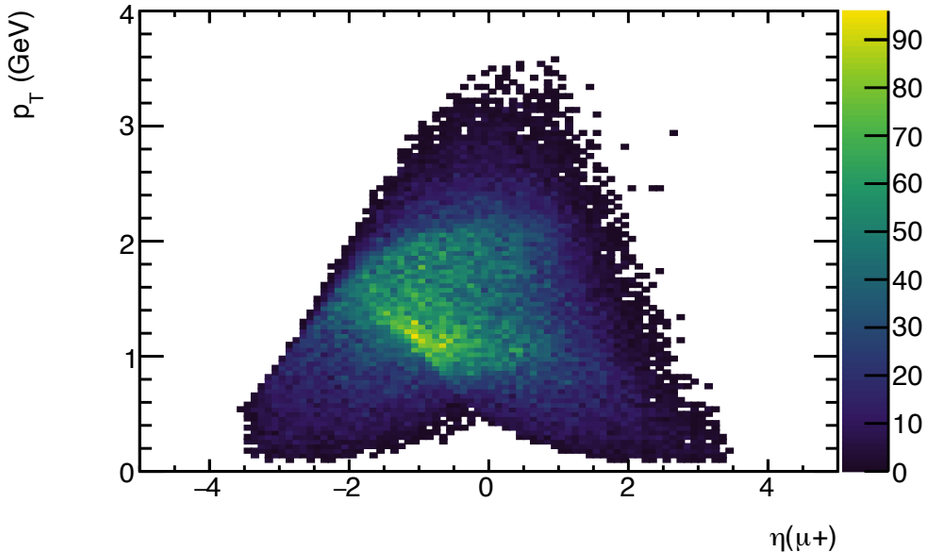
Truth





ECCE





$p_T > 0.1$ GeV applied here

μ-

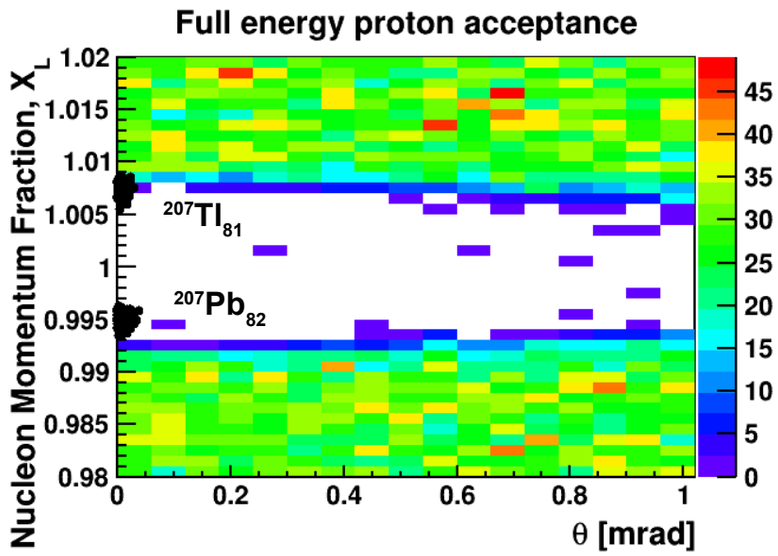
μ+

t reconstruction

- **In principle straightforward**
  - for e+p, t = (p' - p)^2 using outgoing proton
  - Main focus of tagging effort for DVCS, etc.

- **In practice, difficult for e+A**
  - t values are very small - tiny deflection of A even in incoherent events
    - *Mark Baker showed acceptance of IP8 for 207Tl and 207Pb*
  - Nucleus can also break up easily, so t can't be defined for incoherent events using nuclear fragments)

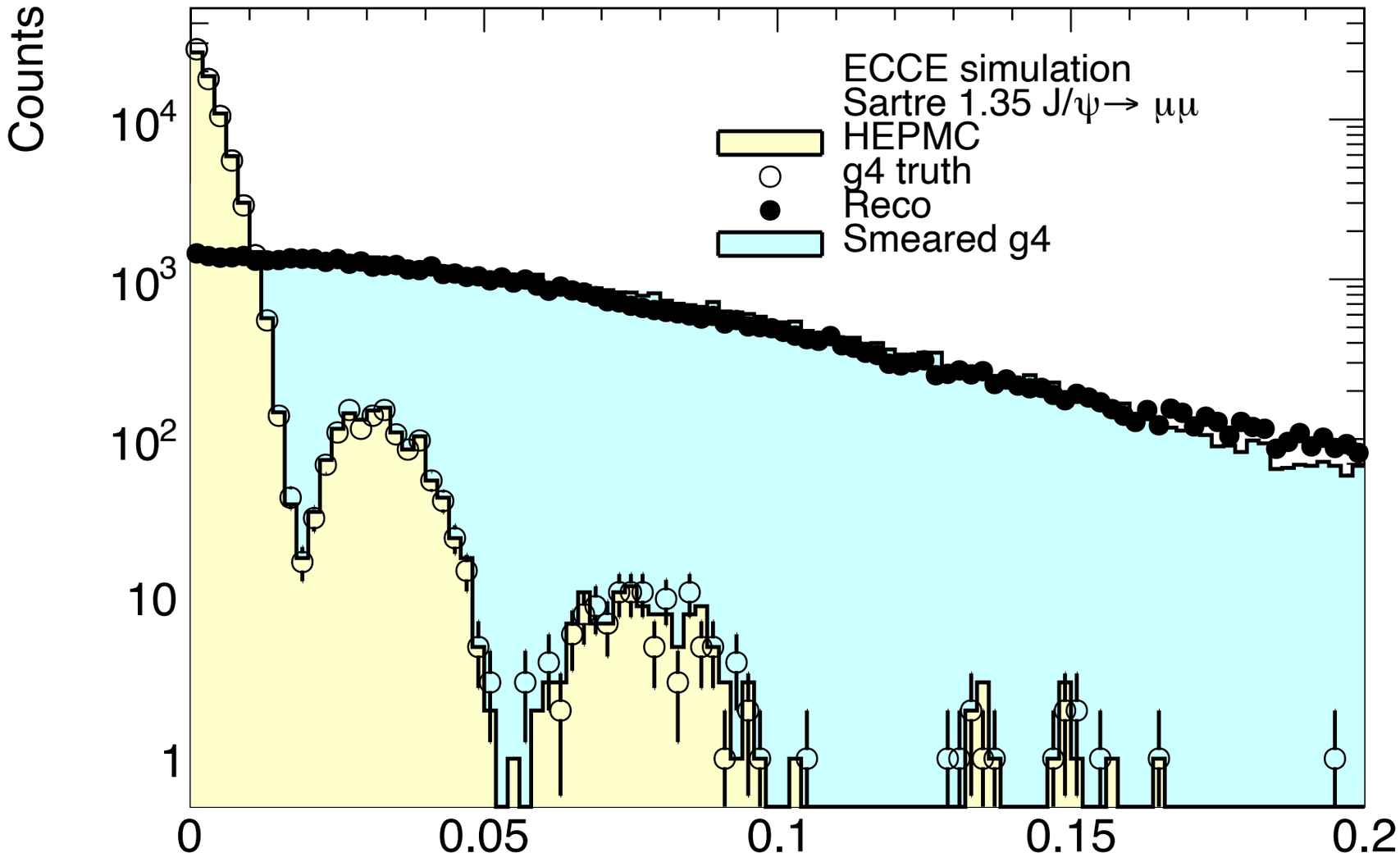
A-1 particles from e+^{208}Pb J/ψ diffraction



- **So standard approach (again from YR)**
  - Measure t using 4-vector conservation, only using J/ψ & scattered electron
    - $k+p = k'+p'+v \rightarrow (p-p') = (k'-k)+v \rightarrow t = v + q$
  - For now, use *truth* electron kinematics, to focus only on ECCE tracking
  - Also, since t is primarily transverse, use only transverse components of (v+q)

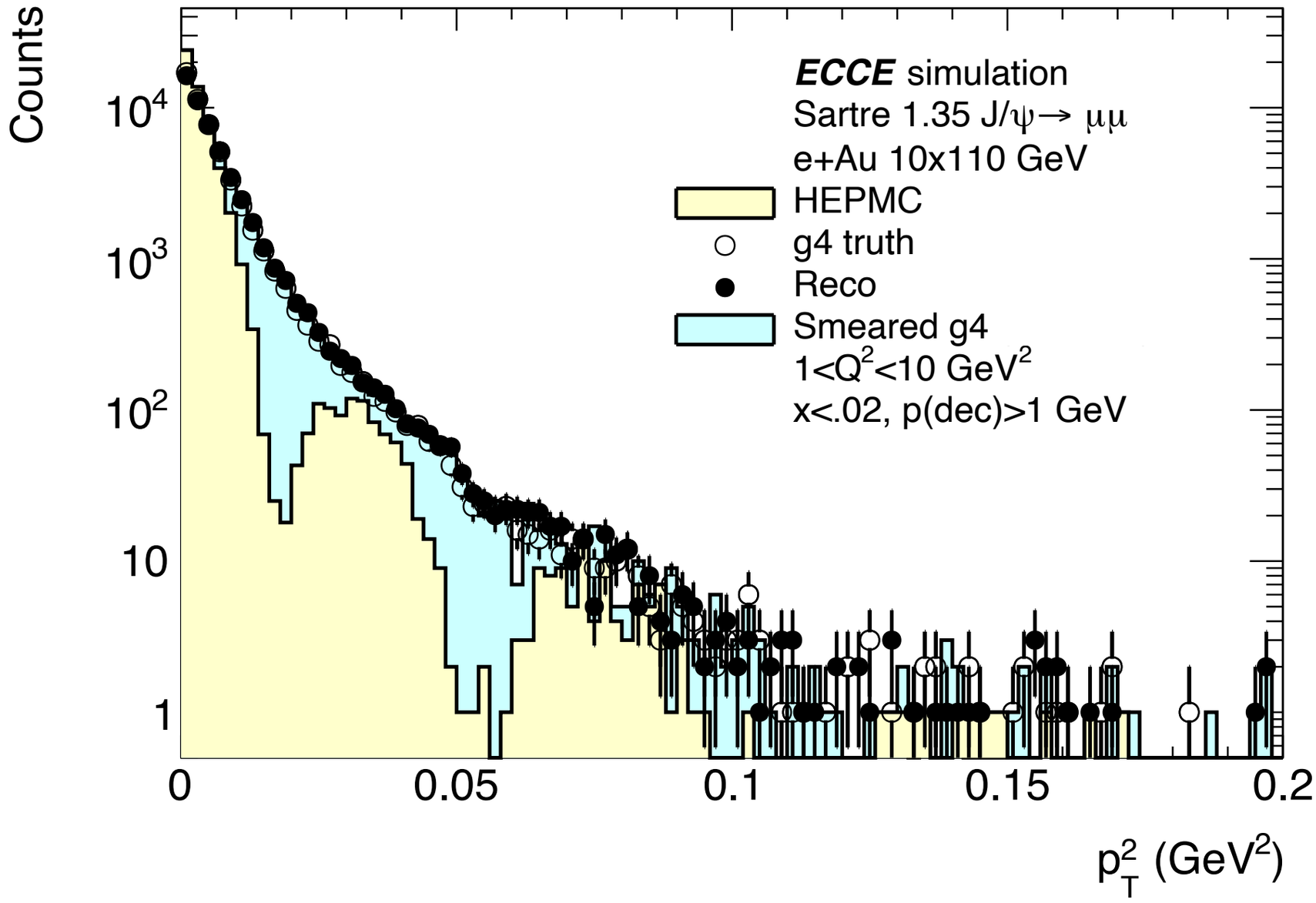
- **The catch**
  - t is very small and very sensitive to crossing angle and beam divergence!

Reconstruction of full t



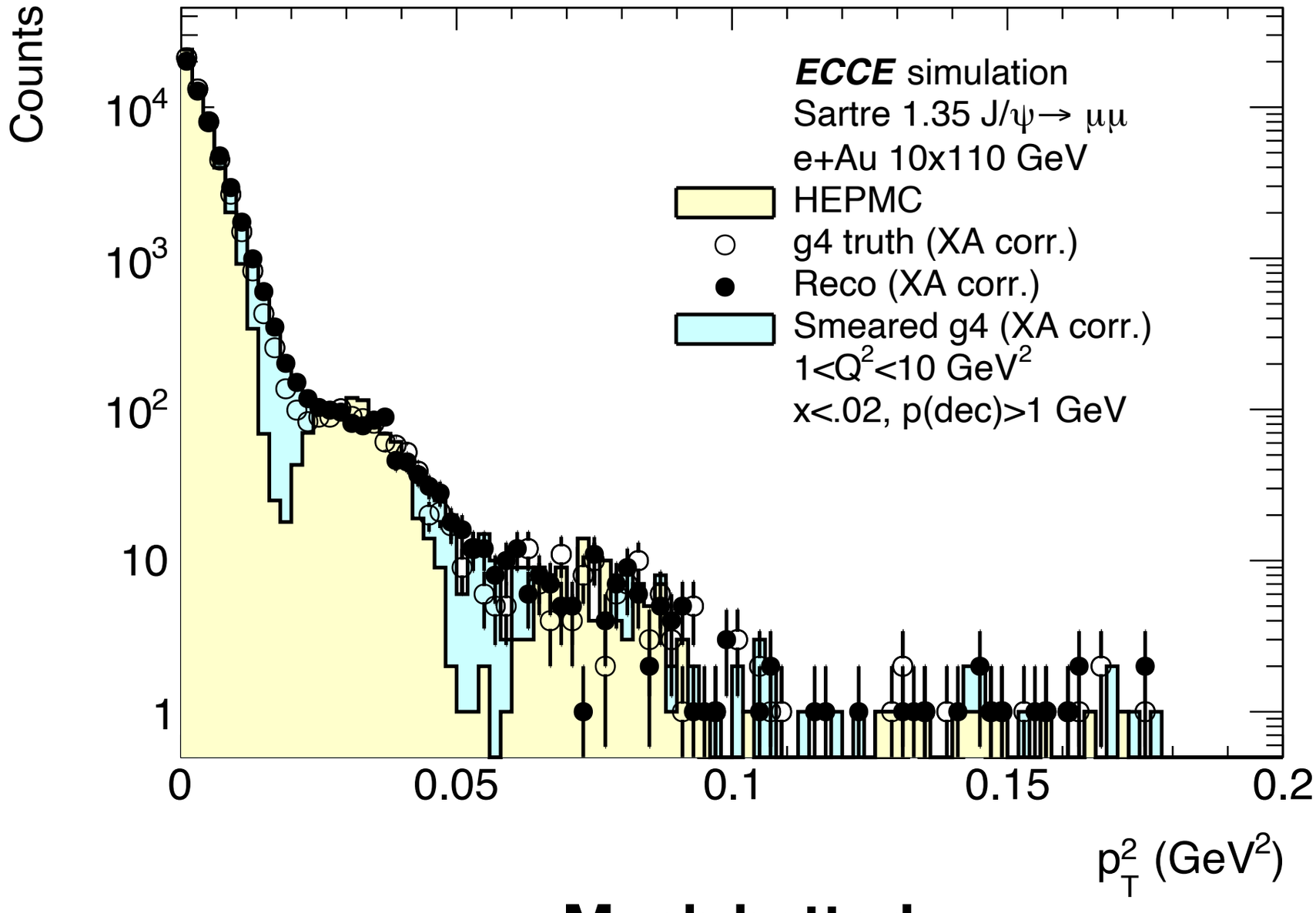
"Hell is other people, and this…"

“transverse t” (t_{pT} or p_T^2)



Much better - but still haven’t corrected for crossing angle: huge distortion seen even at g4 input level!

“transverse t” - crossing angle

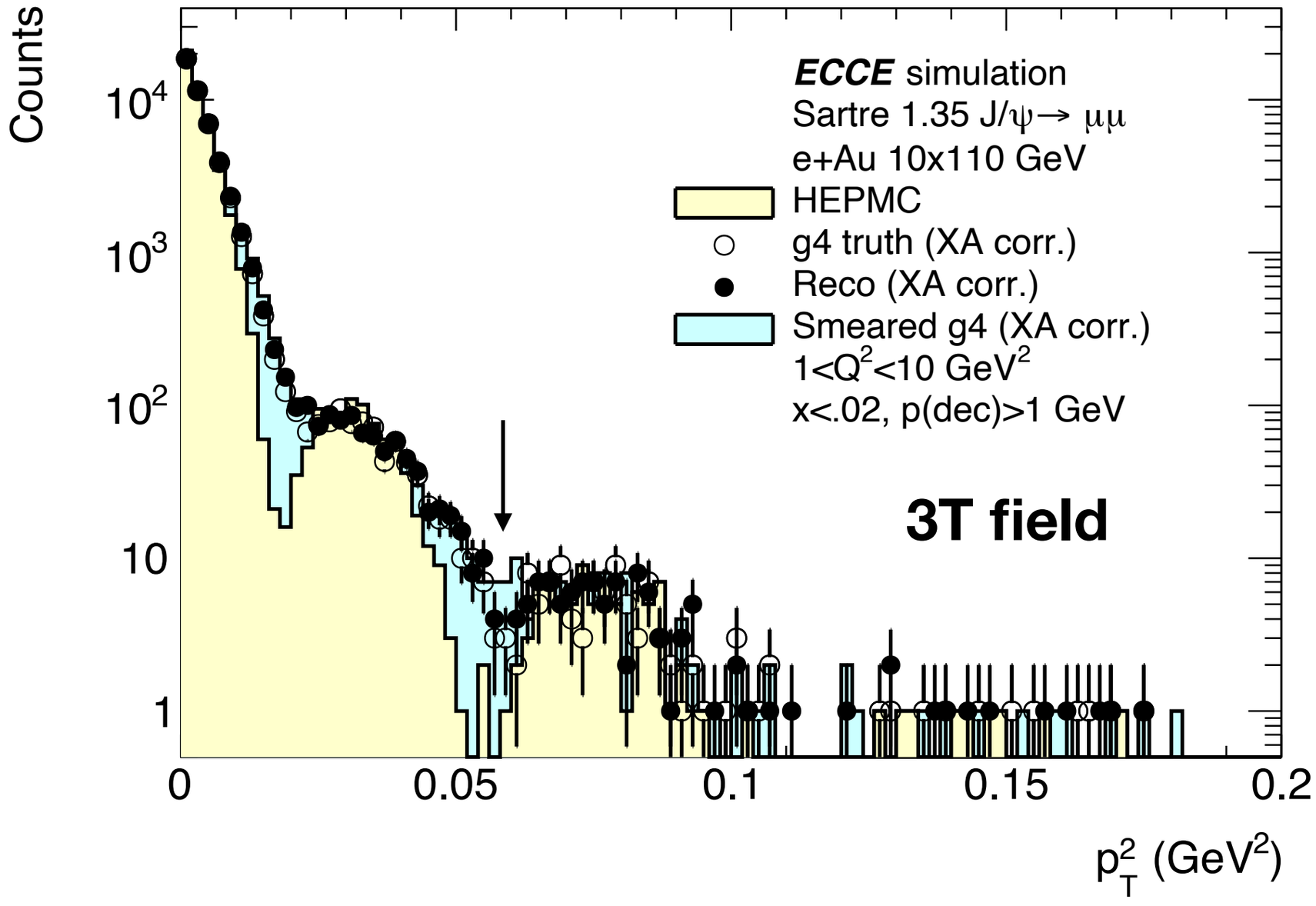


Much better!

1) rotation of t vector by θ=-0.0125, 2) boost by β=-sin(0.0125)

Unsurprisingly, rotation is dominant effect

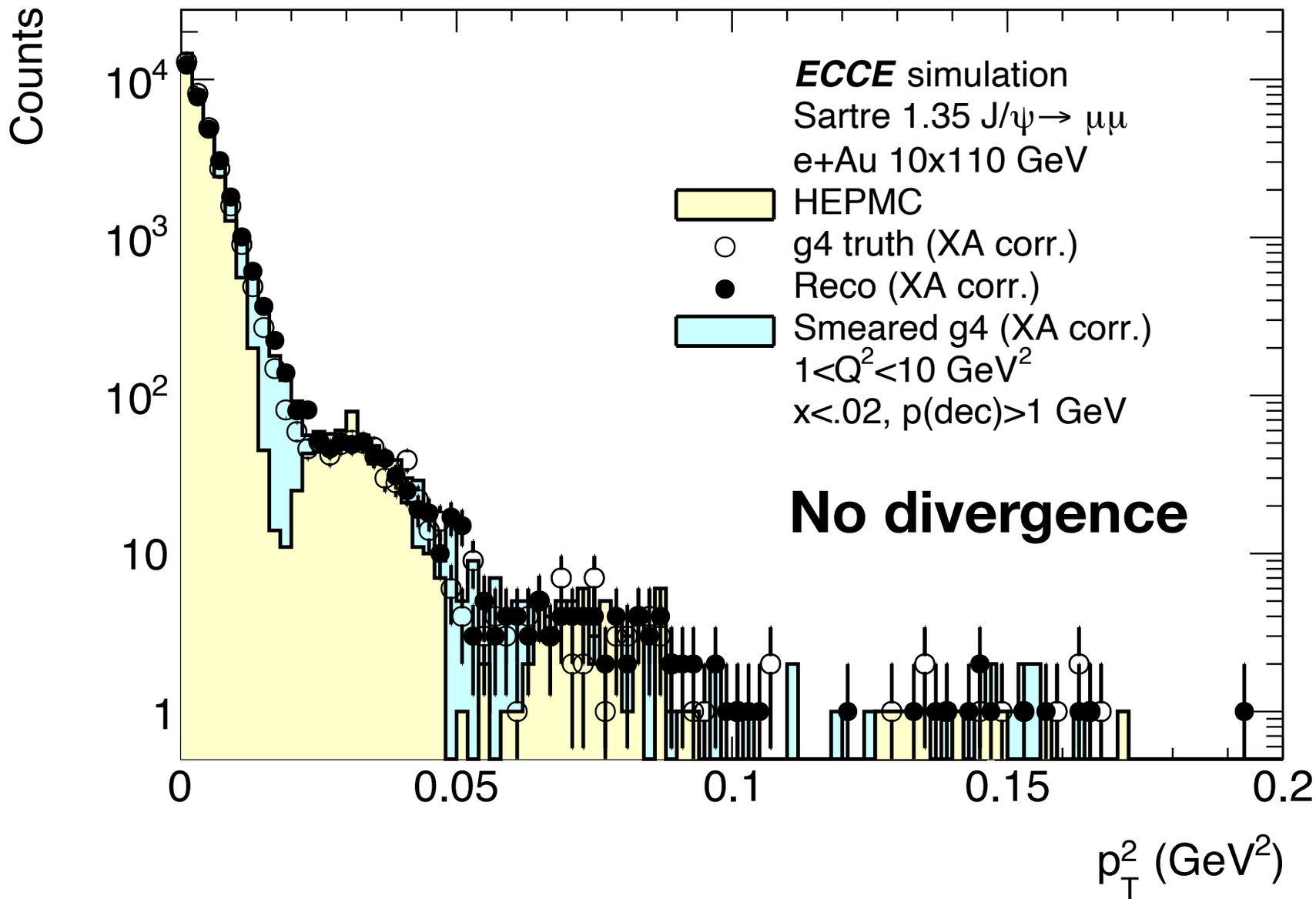
What about 3T?



Visibly better - but worth a new magnet?

Better performance in dip between 2nd & 3rd peaks

Removing beam divergence



Sample run without beam divergence (commenting it out in G4_Input.C):
looks a little better, but does not fully fix differences
between HEPMC & g4 input levels: still need to remove another beam effect!

Conclusions & next steps

- **To first order: ECCE spectrometer is sensitive to structures predicted in Sartre**
  - Still need to remove all beam divergence effects to re-establish parity between HEPMC and g4 input levels

- **Lots of work to establish baseline ECCE performance**
  - Electron channel - impact of radiative tails?
  - Scattered electron reconstruction - impact on |t|
    - *Happy to share this with other groups!*
  - Background contributions - BeAGLE simulations
    - *Measurement stands or falls based on ability to reject incoherent processes*
  - Larger statistics for signal and background
    - *Will participate in Diffraction&tagging MC campaign*
  - Straightforward to correct for crossing angle, but can we unfold beam divergence effects?