ECCE exclusive J/ψ

(post-proposal update to DPAP)

Peter Steinberg, BNL / Detector 1 EDT meeting / 27 June 2022

Exclusive J/ψ production

Projections for full physics processes (P):

P-1: diffractive electroproduction of J/Psi on nuclei.
e Pb -> e J/Psi + Pb and e Pb -> e J/Psi + X
Plot of the cross section vs t for the coherent and the incoherent process with the following settings (cf Figures 7.83 in the YR and 3.23 in the WP):

- 1 GeV^2 < Q^2 < 10 GeV^2
- x_V < 0.01 with x_V = (Q^2 + MJPsi^2) / W^2
- integrated luminosity 10 fb^{-1} / A
- beam energies 18 GeV on 110 GeV/A

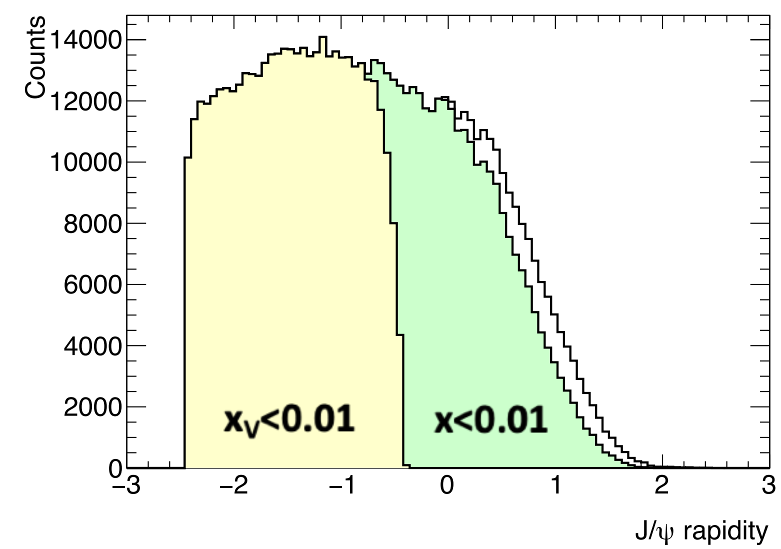
Please indicate statistical and total errors separately. (e.g. by inner bars for statistical errors). If within the possibilities of your detector, provide separate plots for using the e+e- and the mu+mu- decay channels.

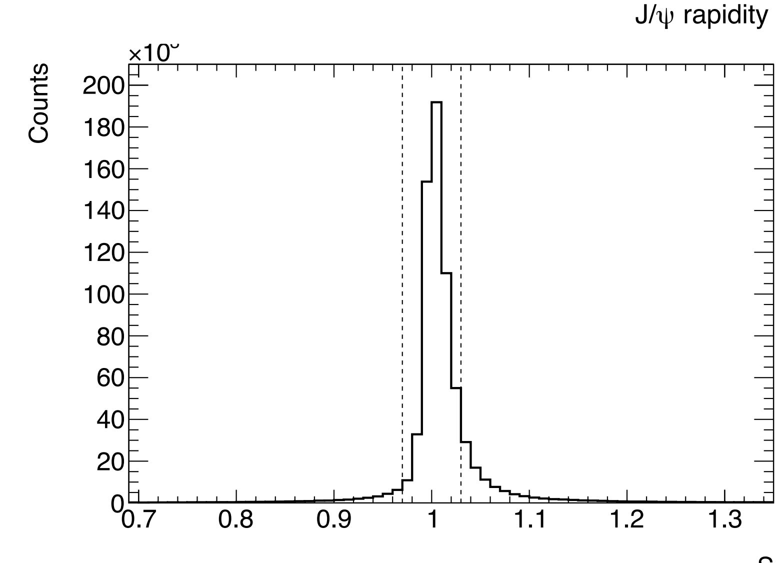
Signal (coherent): Sartre 1.37
Background: Beagle 1.X, normalized to incoherent cross section from Sartre

Only μμ and ee channels simulated. Assuming hadronic background has negligible contribution from exclusive 3 track events, including scattered e'

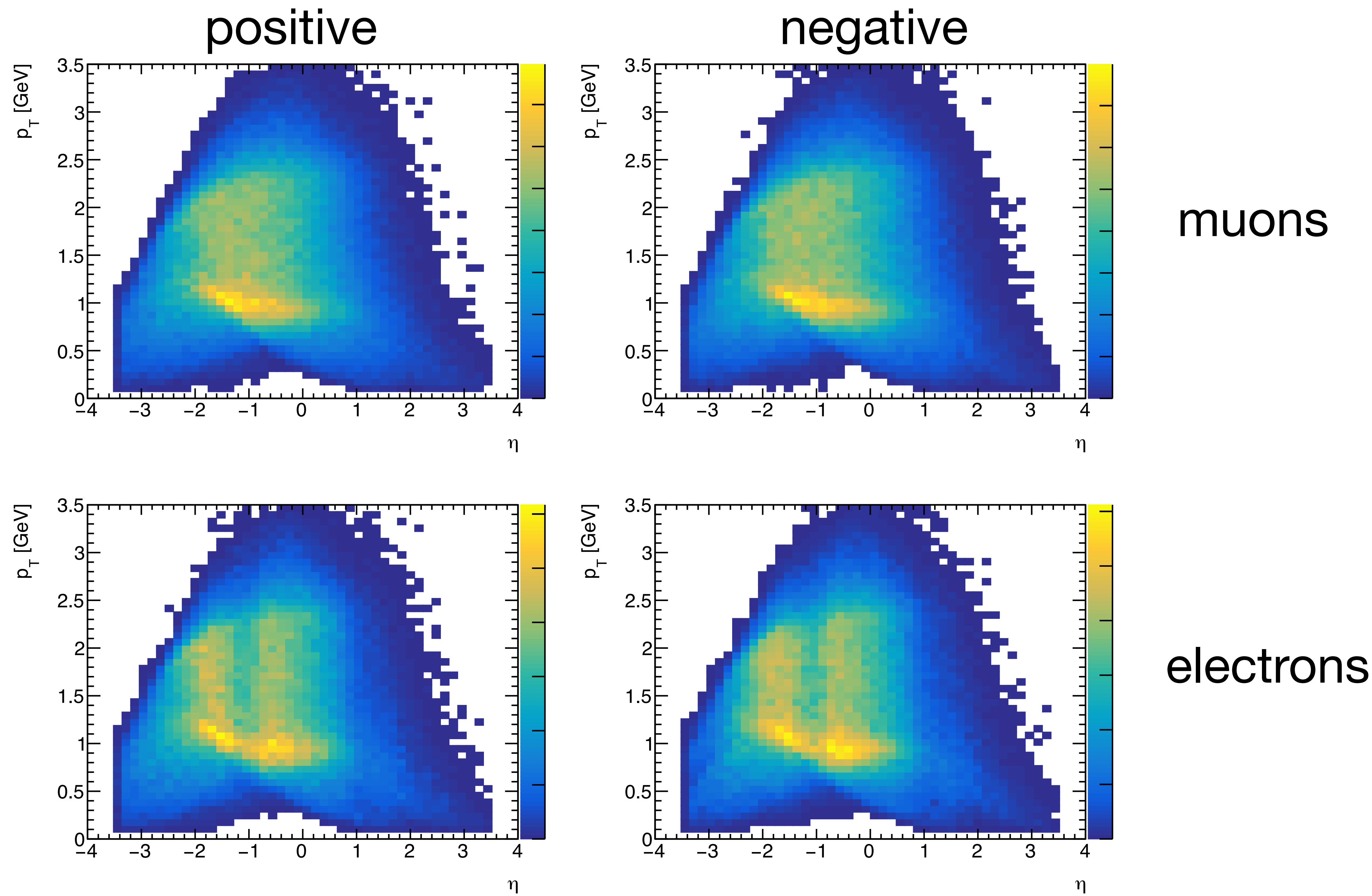
- **Differences w.r.t. ECCE proposal**
  - Use Q^2=1-10 GeV2
  - Move from $x = Q^2/W^2$ to $x_V = (Q^2+M^2)/W^2$
    - *40% signal loss, vs. 5% for x<0.01*
  - 10 fb^{-1}/A (vs. 20 fb^{-1}/A in proposal) - reflected in number of events, not just error bars
  - Full PID for e and μ, based on presence/absence of an EM cluster:
    - *ePID satisfied if $E_{clus}/P_{track}>0.6$, otherwise μPID*
    - *3e events use mass constraint to resolve ambiguity of j/psi with e'*
  - e' energy adjusted to obey kinematic constraint (correct for coherent), similar to "method L" (called "method K" here…)
    - *$e+A = e'+A'+J/\psi \rightarrow M^2_{A'} = (A - (Se'-e) - \psi)^2 = M^2_A$*
    - *Correction required to be small to guarantee well-reconstructed scattered electron*
    - *$|S-1|<0.03$ - requires additional efficiency correction*
  - Simple efficiency corrections to arrive at cross section
    - *Coherent x-sect based on Sartre 1.37*
    - *Incoherent is Beagle normalized to Sartre incoherent.*

NB: no beam energy spread effect





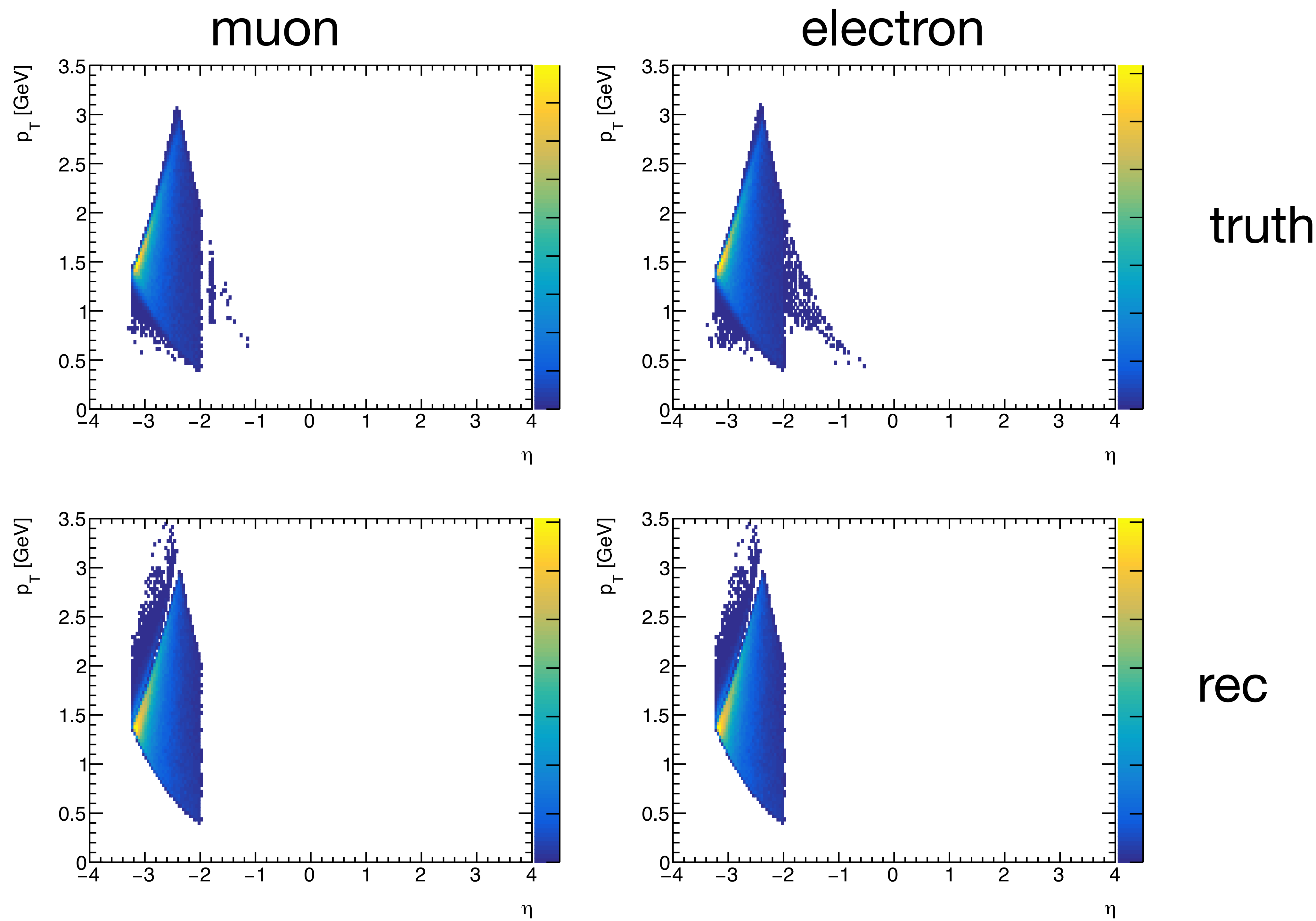
J/ψ kinematics



Tracks accepted within $|\eta|<3.4$ and $p_T>0.1$ GeV

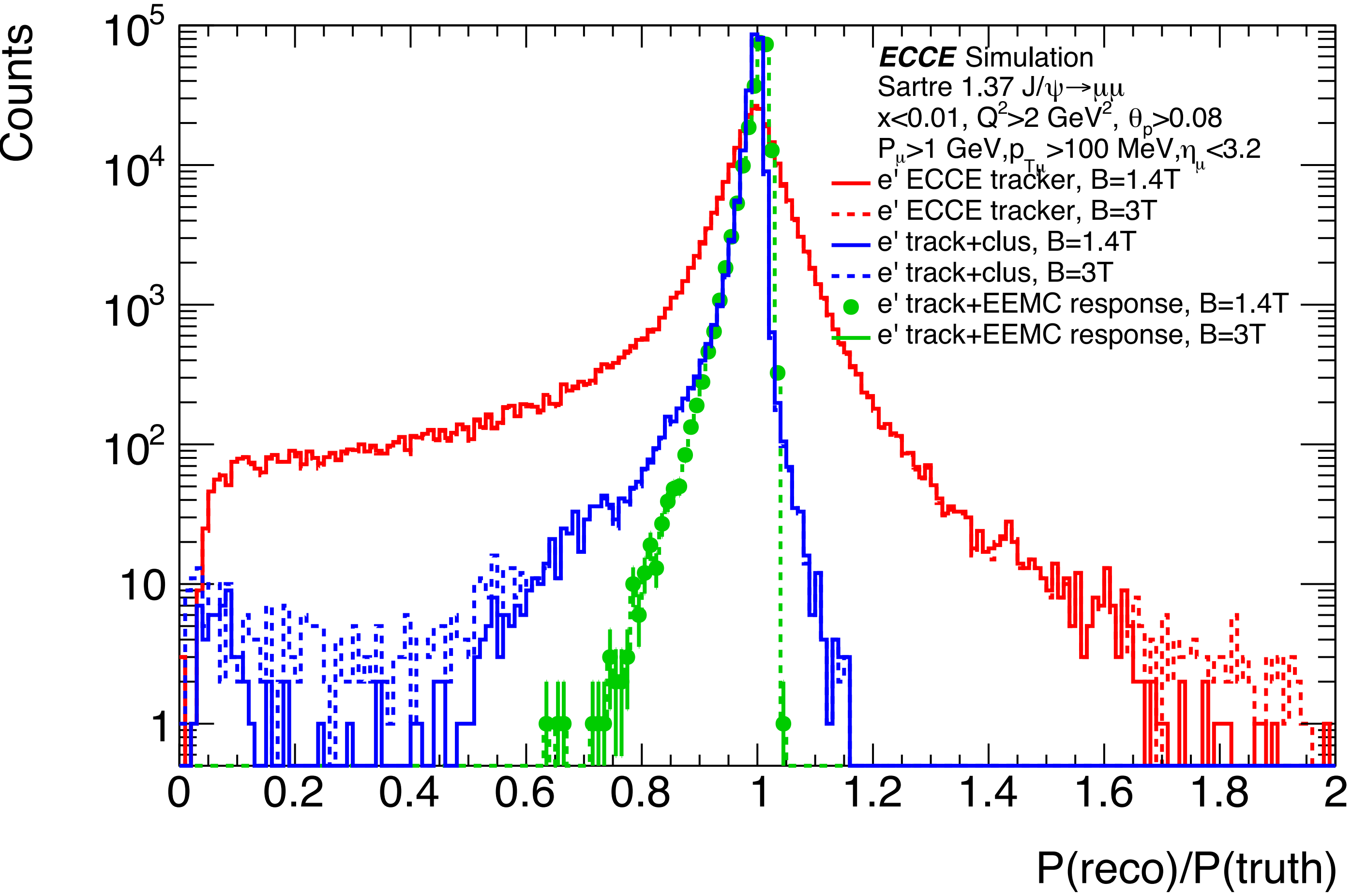
e’ kinematics

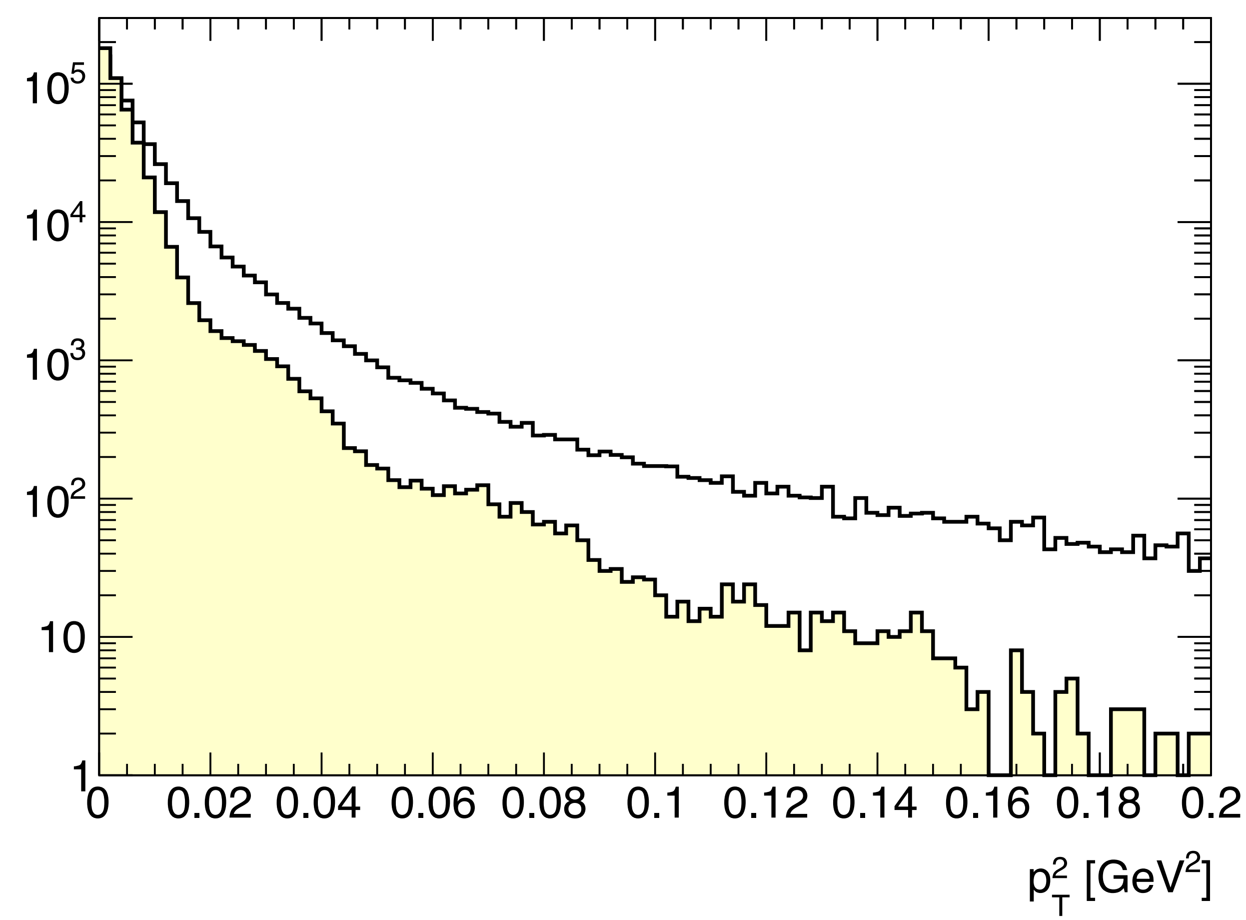
$1<Q^2<10$ GeV^2, $x<0.01$



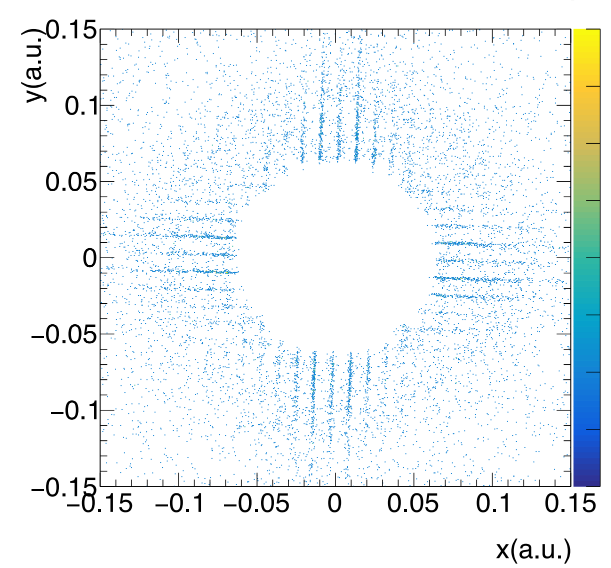
some artifacts visible of my algorithm in picking the scattered e’

Need for kinematic constraint



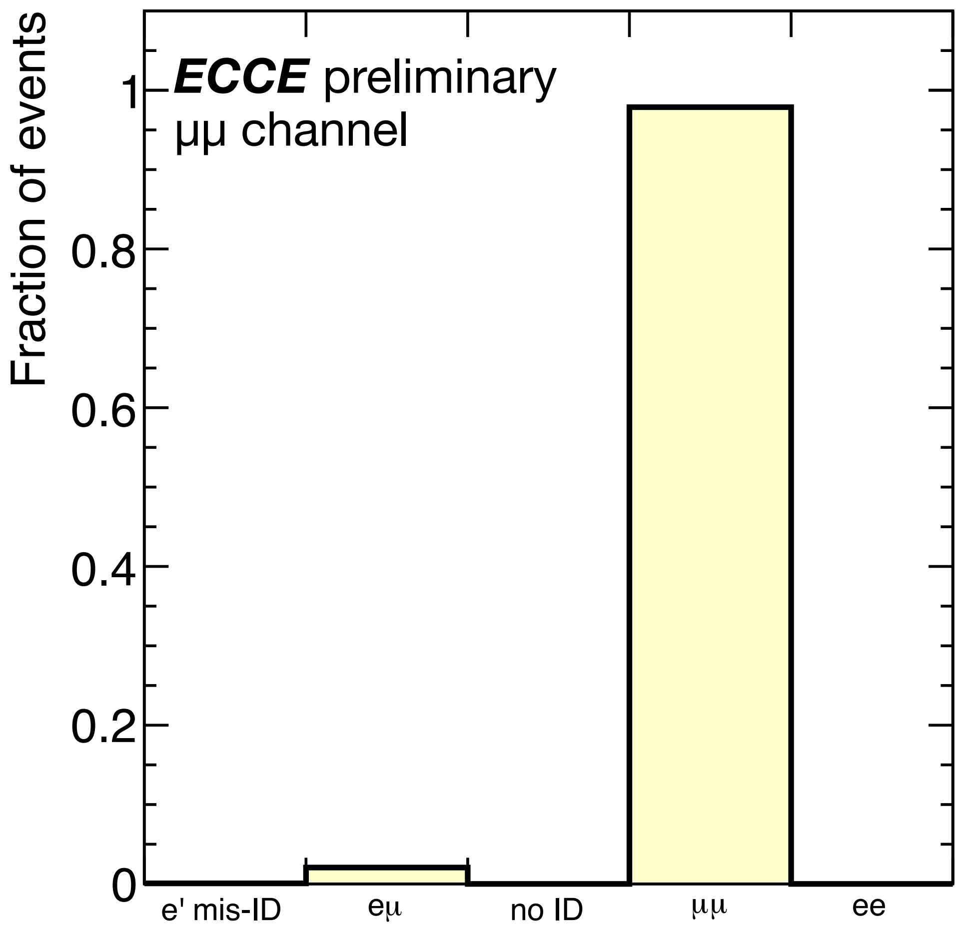


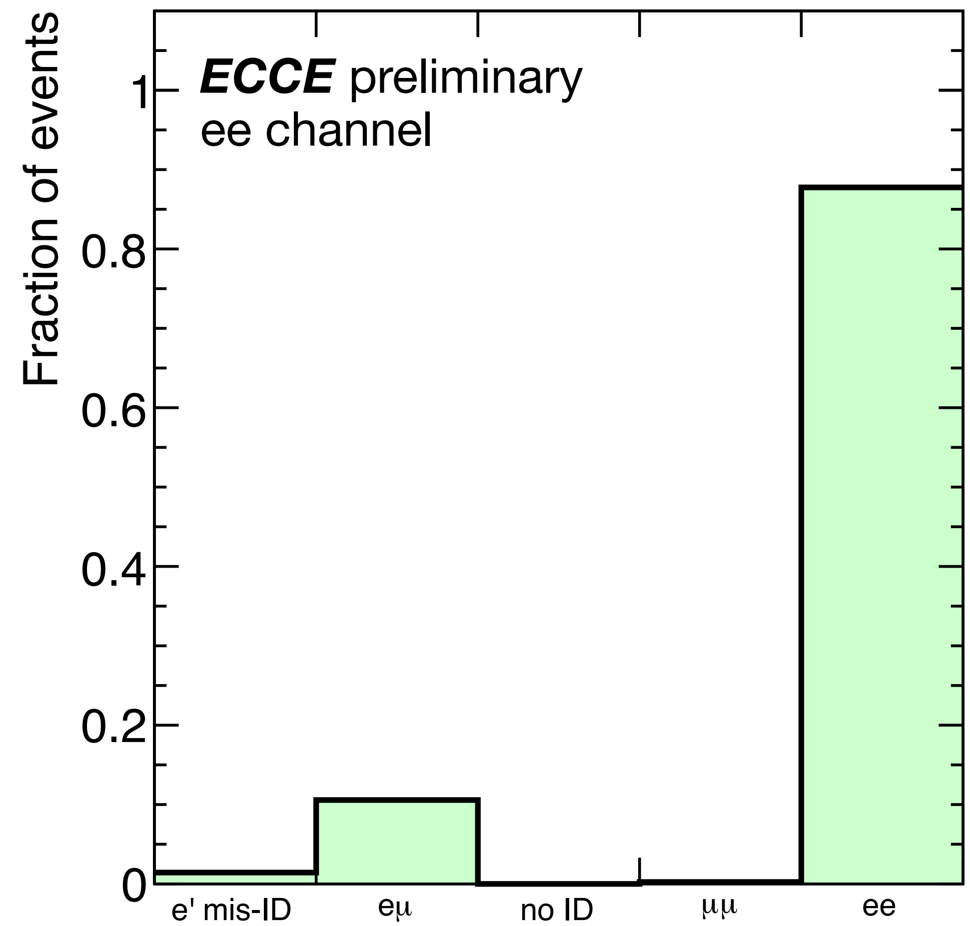
- Primary limitation on this measurement has been the e’ response:
- Tracker alone has too poor a resolution in the far backward region
- EEMC simulation quite close to “ideal” PWO response (crystal ball, based on ECCE sims) but low energy tails induce larger t
- Selections on size of correction control tail contribution, at cost of requiring detailed data/MC agreement
- I implemented Method L from Kong, and so far it doesn’t seem to help as much, but I need more time to assess this



tails (e.g. <0.95) are often associated with cracks in EEMC (simple study, improvements underway…)

PID efficiency

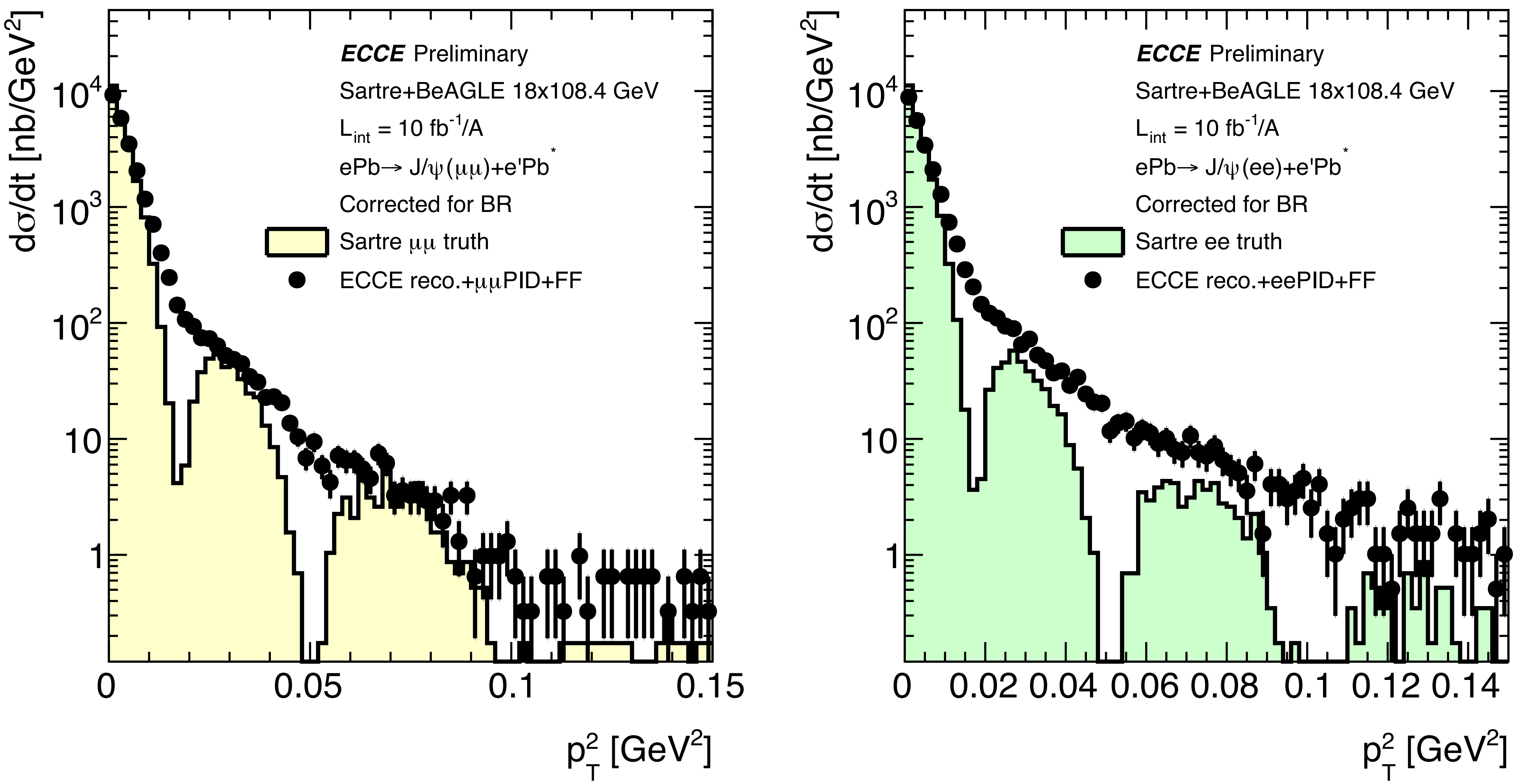




Accepted events require two positive tags on decay products and a confirmation of electron candidate - otherwise event is rejected

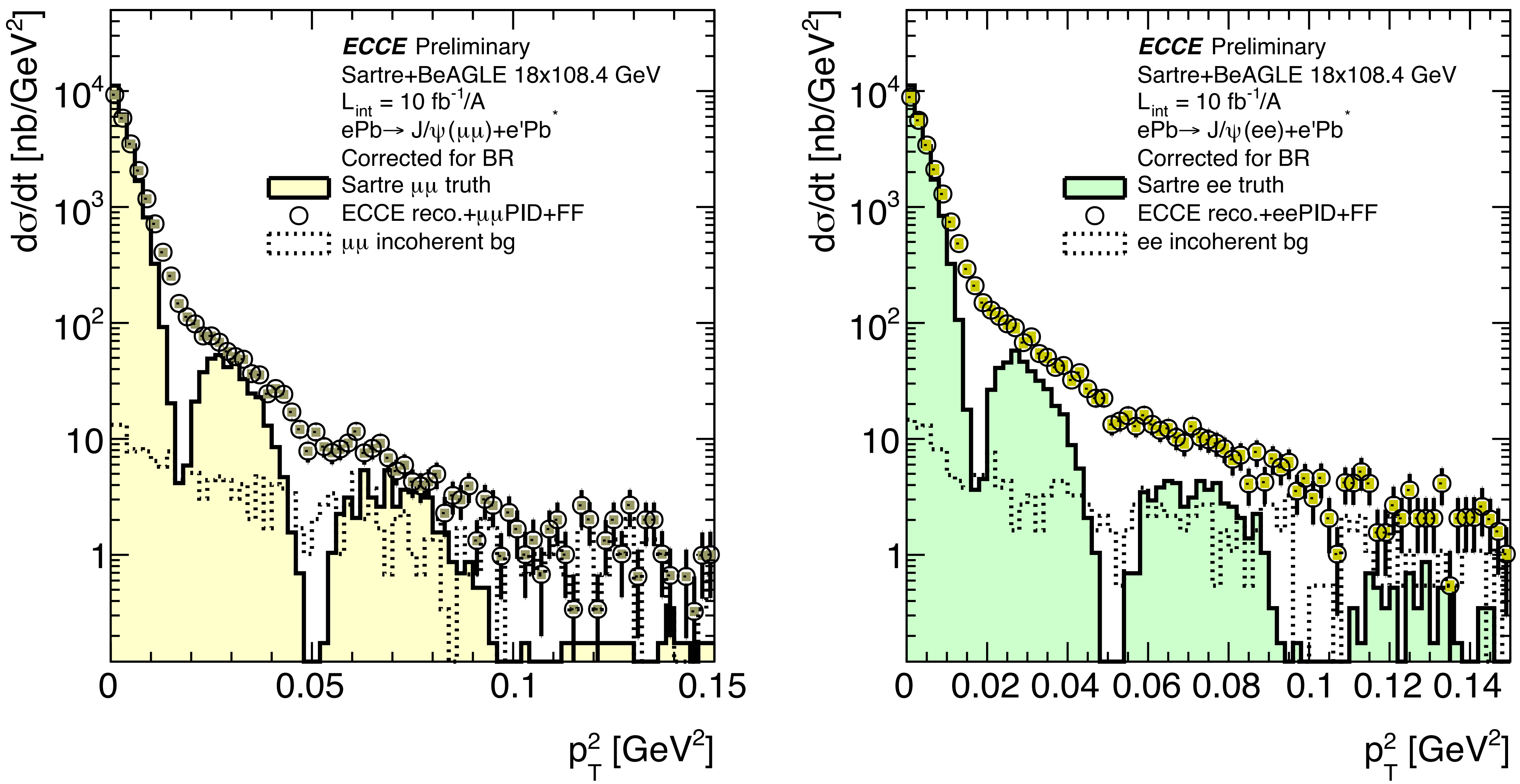
95% PID efficiency for μμ and 85% for ee (gaps in calo acceptance)
Electron/muon contamination after tagging both leptons found to be negligible.

Coherent cross section



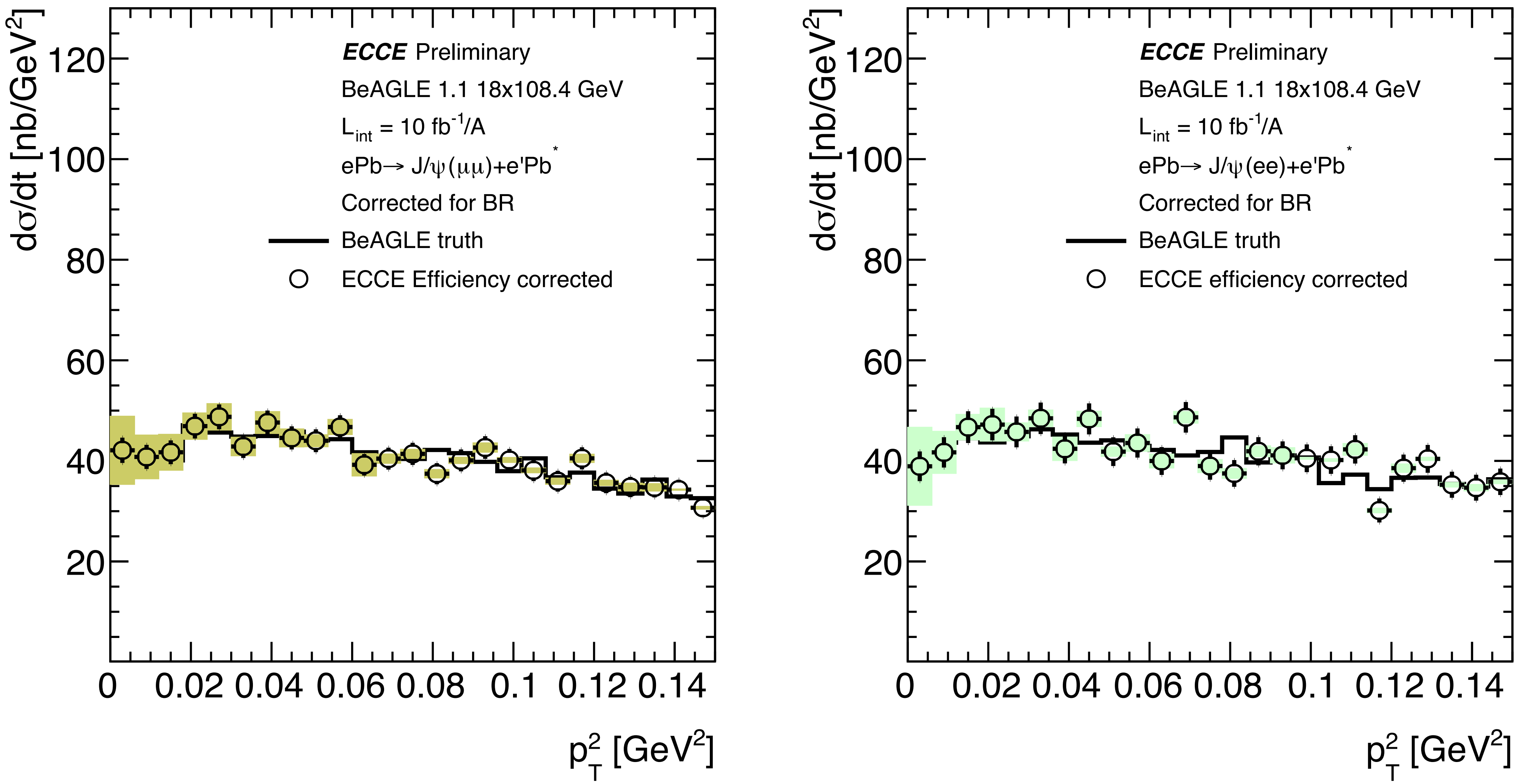
- pT2 is used as proxy for t
- Correction is just simple integral of reconstructed counts over truth
- Efficiency vs Q2 is mostly constant but composed of many parts: e’ efficiency (track & cluster), charged decay products, PID cuts, kinematic constraints, etc.
- Aggregate efficiency is 40% for ee, 60% for μμ. Expect 15% systematics or better, as many efficiencies should be measurable in data using tag & probe.
- Tracking resolution sufficient for observation of “kinks” in the μμ channel - weaker for ee

Coherent & incoherent background



- To estimate incoherent background, selections made on ZDC, Roman Pots, OMD and B0 detectors.
    - *Expect improvements with further optimization of detector design (e.g. B0 EMCal) and analysis methodology*
- Backgrounds modest up to second diffractive peak
    - *Cut more effective at larger t, but signal distribution drops rapidly*

Incoherent cross section only



Events selected using “anti-veto” of the selections used for coherent x-sect.

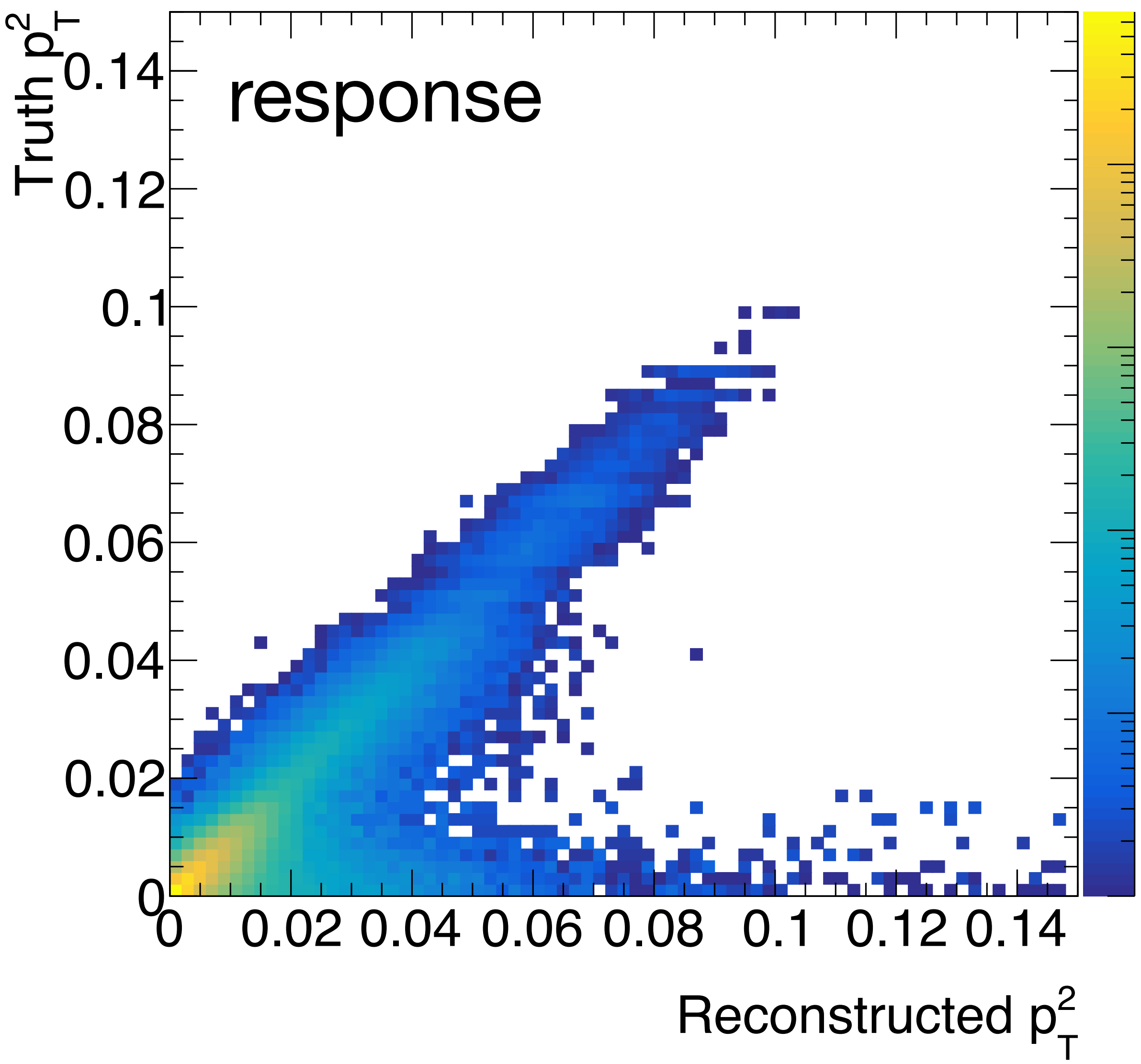
Correction to convert reconstructed to final is a polynomial fit (for smoothing) to truth/reco of yield vs. p_T^2. Uncertainties are identical to coherent case.

Flat distribution in t, so comparable performance for electrons and muons

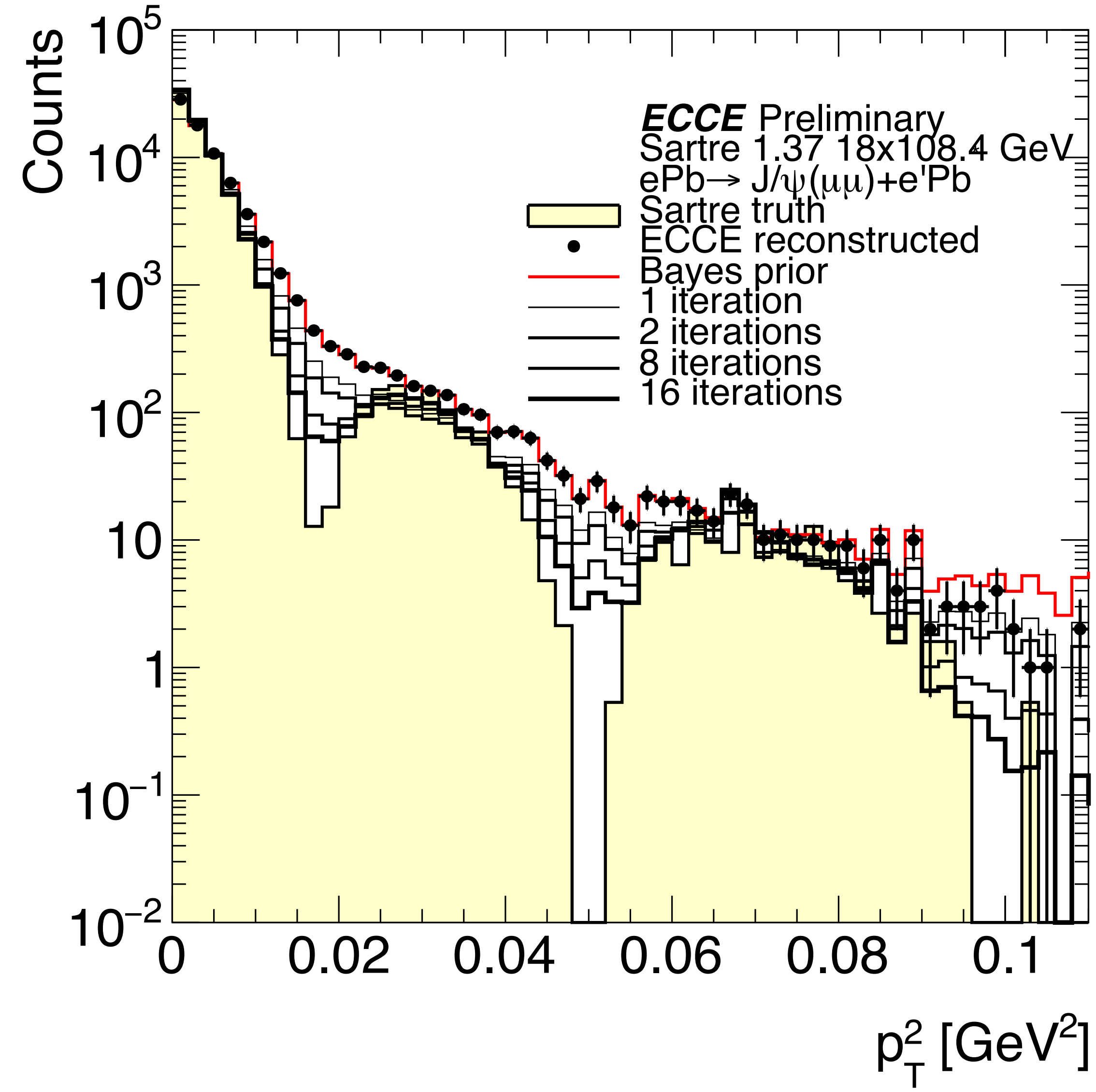
Estimates of systematics

- General
  - Luminosity: 1%
  - Tracking efficiency: 2% (limited by tag & probe statistics)
  - e' PID (cluster matching): 2% (EEMC spatial variations, gaps in calo system)
  - J/psi mass window: 2% for μμ, 5% for ee (variation on window size)
  - J/psi PID – 3% in ee (gaps in calo system)
  - Kinematic constraint to remove long tails from t=0 – 7% (variation of window)
- Incoherent process tagging
  - 10% on total cross section (from larger inefficiency at t=0), 5% on t dependence
  - Large O(50%) impact on cross sections at "high" t (~0.1 GeV^2) where residual incoherent backgrounds are similar in magnitude to coherent signal

Unfolding

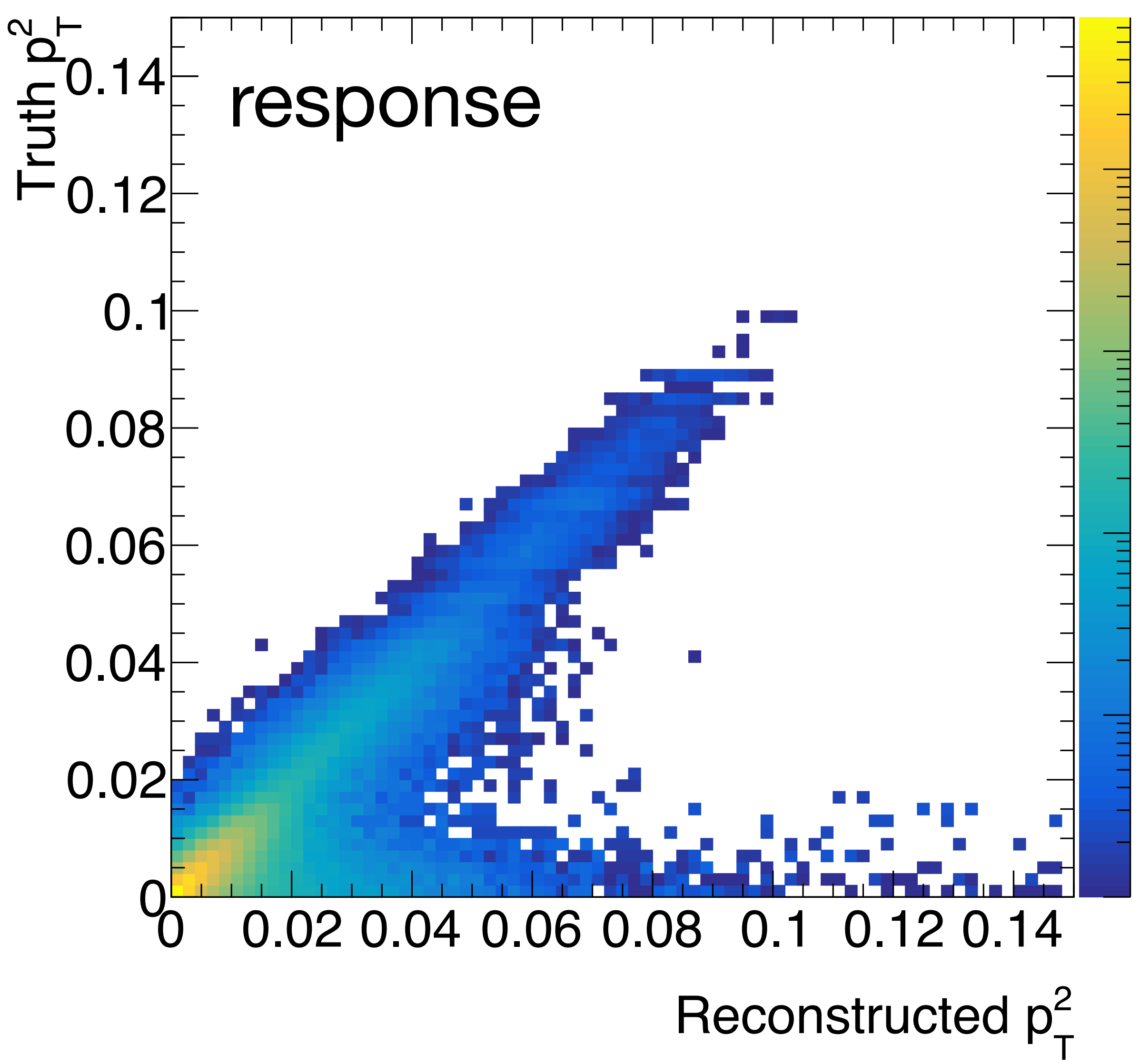


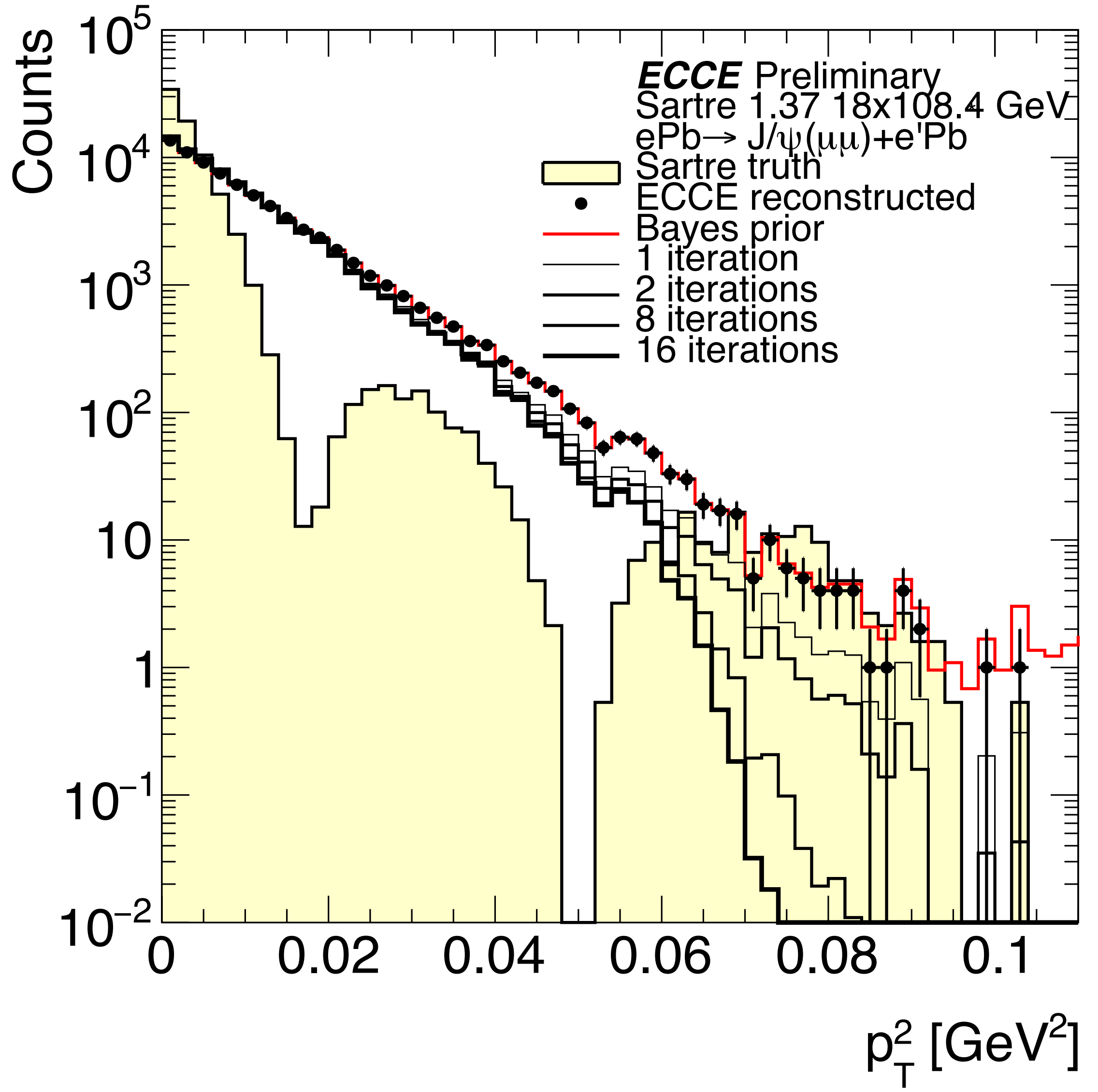
Sartre+BEAGLE, just to build response which populates both branches: reweighed to signal



Kinks in final distributions sufficient to start unfolding in right direction

Unfolding





Sum of Sartre and Beagle samples, to make sure we populate both primary "branches" (from huge peak at t=0)

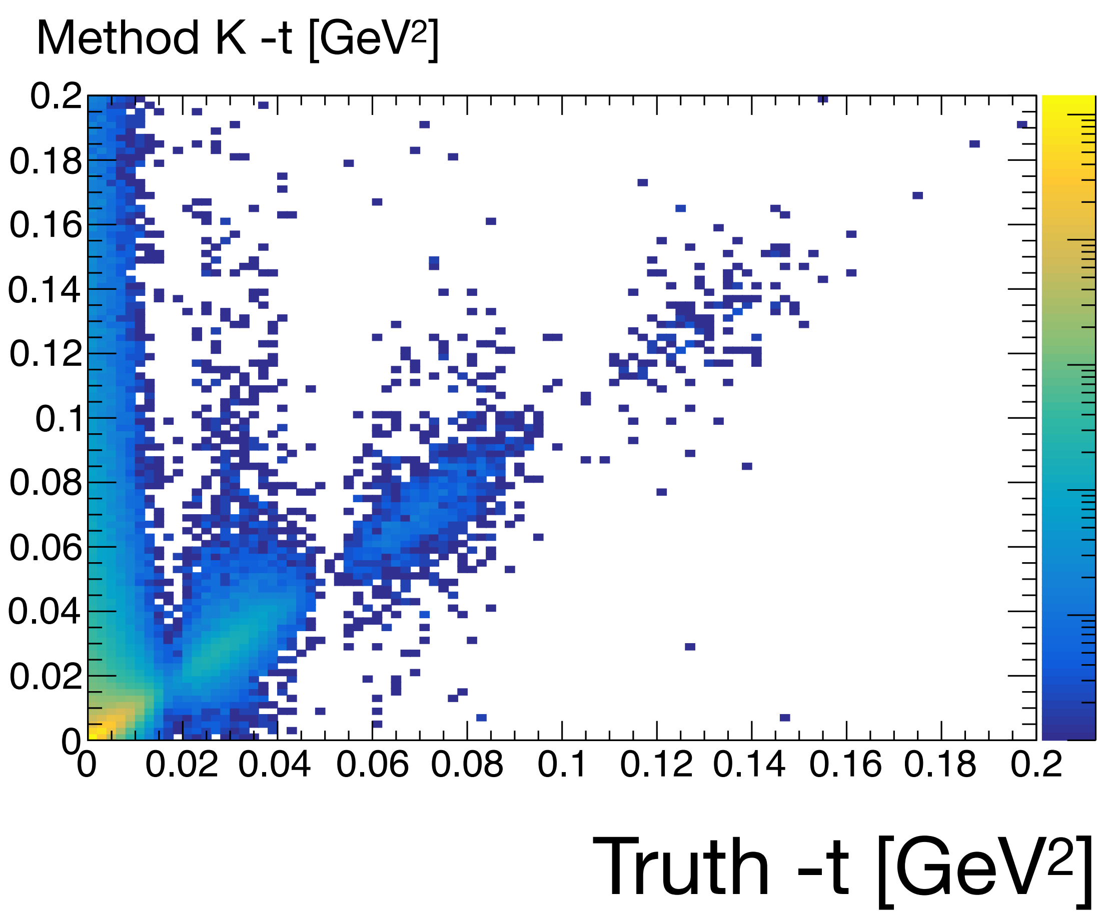
Featureless data does not induce kinks (phew!)

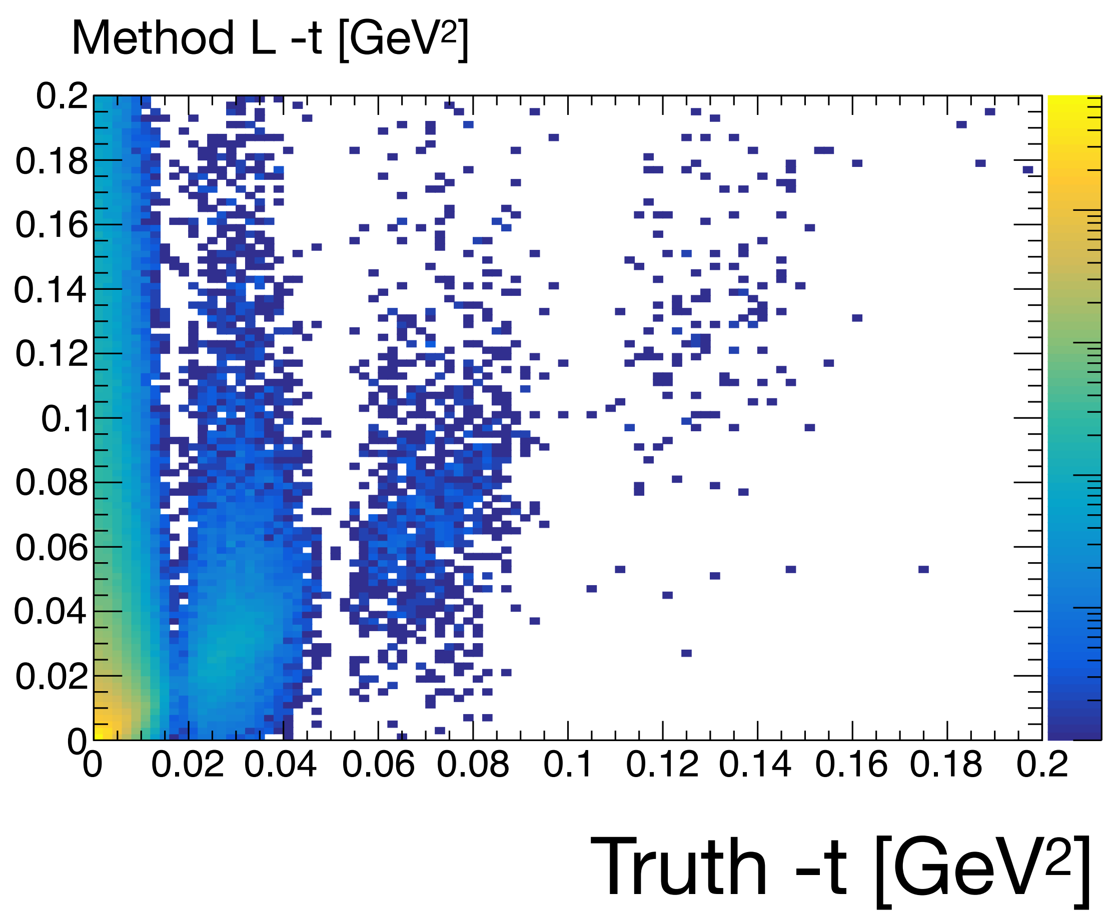
To-do list

- **Writing up baseline analysis for publication**
  - Long overdue! Will also include phi results
- **More detailed study of primary tracking performance**
  - Better material description
  - More detailed study of track properties (e.g. number of hits, goodness of track fit, etc.)
- **More detailed study of EEMC performance**
  - position-dependent energy scale corrections?
- **More detailed studies of incoherent processes**
  - Incorporation of state of the art response of FF detectors
  - However, performance of IR6 will probably always be limited by acceptance of outgoing A (& decay photons, please focus on Pb over Au!)
- **Photoproduction?**
- **Non-Sartre models?**
  - Lots of complaints during this process of the “reality” of the peaks, and constraints imposed on detector based on them…

Method K vs. Method L

- **Implemented as per Kong's email, but perhaps still buggy**





Full magnitude of t, so no impact of crossing angle