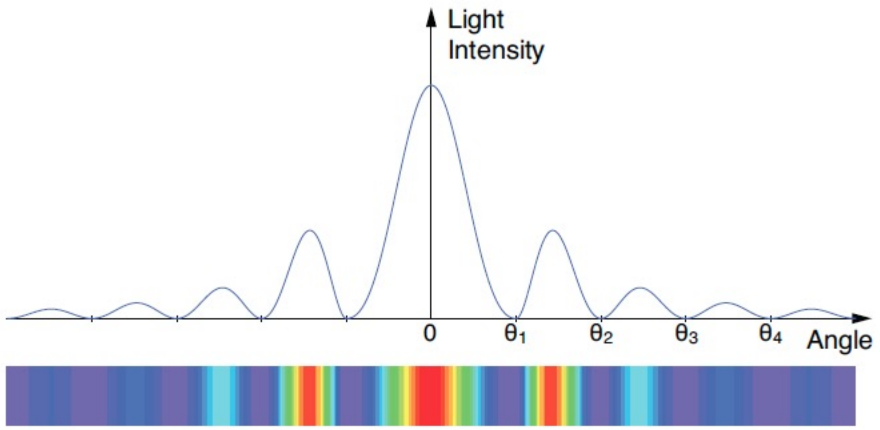
VM program in *eA* at the EIC – ATHENA



Series of study

I. Baselines and setups
II. PHP, ***t*** reco, and mass

Kong Tu, Thomas Ullrich, and Zhangbu Xu

BNL

08. 20. 2021

Comments from the last meeting (Aug.13)

- Dissoc. process in BeAGLE with forward producing rho/phi, what happens?

Response: BeAGLE/pythia-6 indeed has diffractive-n/p states where struck nucleon fragments into a rho/phi, which has significant nucleon beam momentum (~50 GeV).

- Spectral function in BeAGLE, compared with Sartre.

Response: similar but different. Sartre uses the formula learned from STAR (see Zhangbu's slides July.16), while BeAGLE(pythia-6) uses relativistic Breit-Wigner distributions. See later slides.

- Send MC samples to ATHENA simulation team.

Reponses: did a small conversion for BeAGLE, not yet for Sartre. Dmitry Romanov is looking into it.

- Photoproduction of phi and others.

Response: one of today's focuses.

Samples

- Sartre 20% of 100M for each VMs are used, both elect & php

/gpfs02/eic/DATA/sartre/data/*

- BeAGLE 20M out of 100M for all VMs are used, both elect & php

/gpfs02/eic/DATA/BeAGLE/eAu/VM/18x110_Q2_1_20/EICTree/18x110_Q2_1_20_batch_3_20M

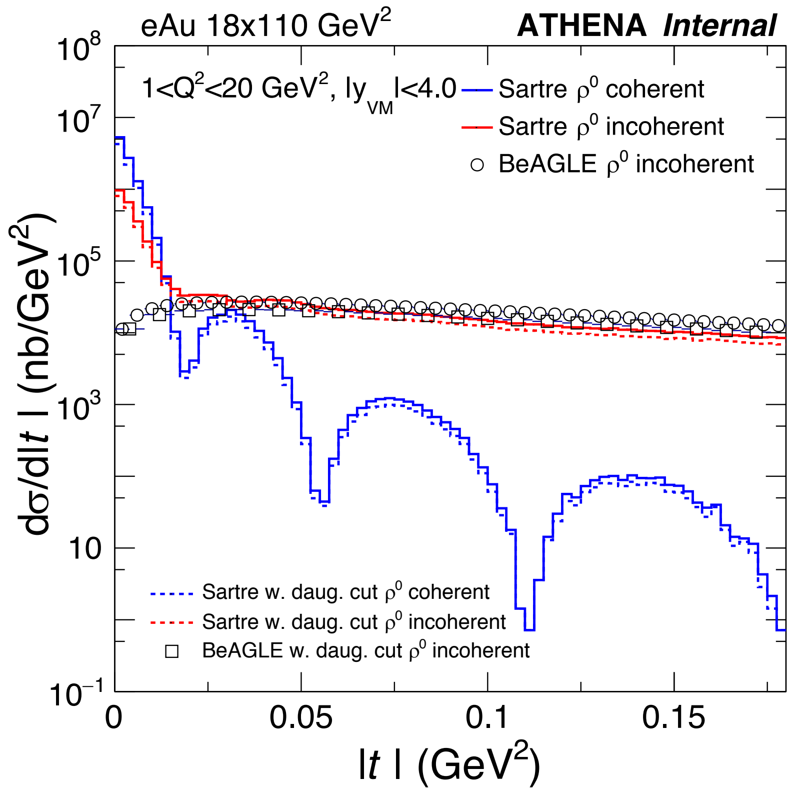
/gpfs02/eic/DATA/BeAGLE/eAu/VM/18x110_Q2_0/EICTree/18x110_Q2_0_batch_1_80M

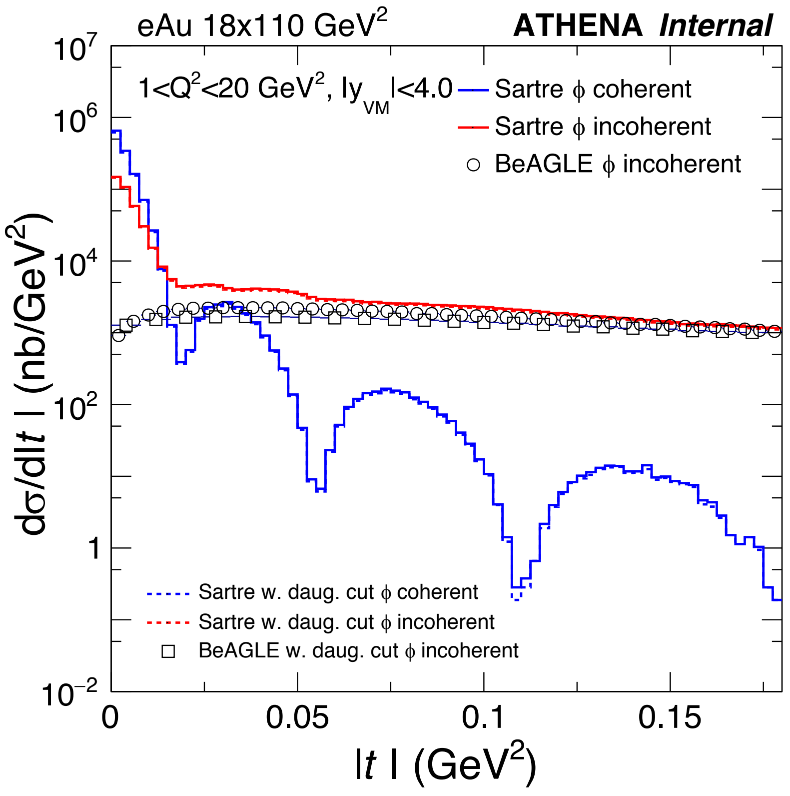
- Two MC models are cut on the same phase space,
  - $1<Q^2<20$ GeV^2 (both), $0.1<Q^2<0.2$ (Sartre)* , 1e-7$<Q^2<0.2$ (BeAGLE)
  - $1.95<W<89$ GeV
  - We will look at cross section for $|y_{VM}| < 4.0$ *(what we want to measure)*, vs $|y_{VM}| < 4.0 + |eta_{daug.}|<4.0 + pt_{daug.}>0.15$ *(what we can measure)*

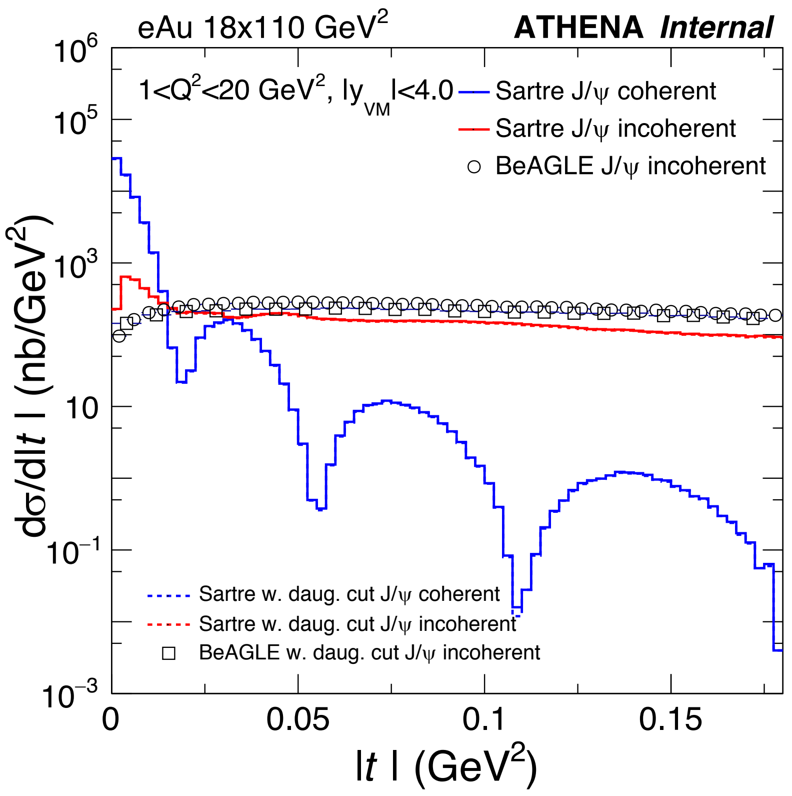
* Sartre found lower the lower Q^2 limit doesn't change much.

Sartre vs BeAGLE (electro-)

Reminder:
Daug. Phase Space
1. |eta|<4.0
2. Pt>0.15



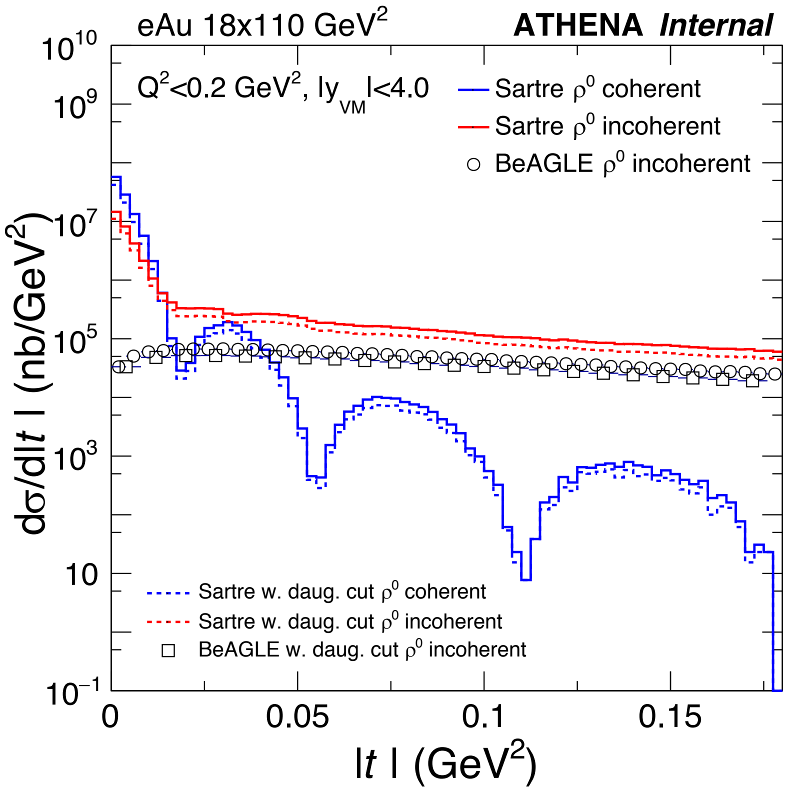




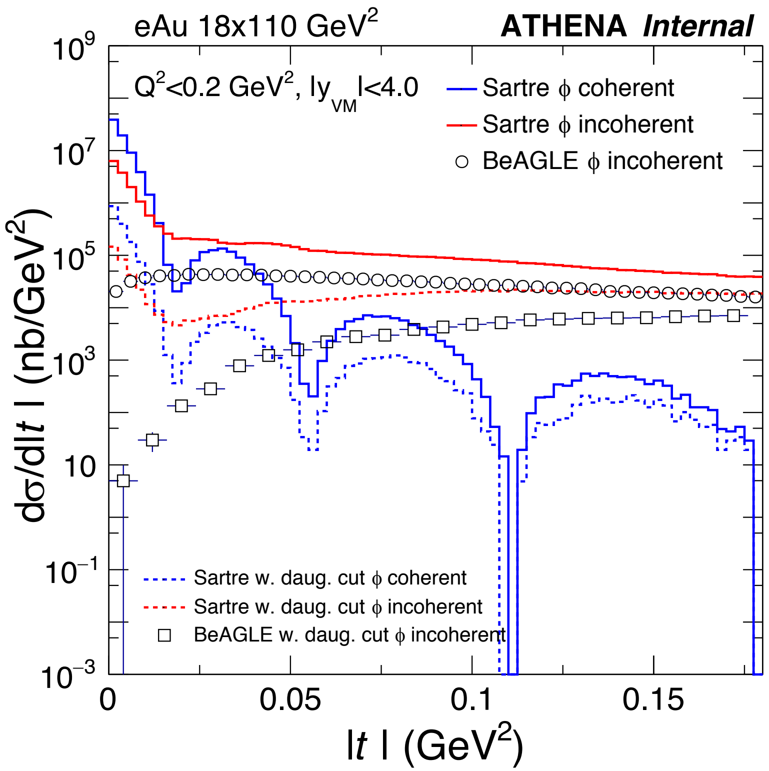
- Similar plots as last week for electroproduction (1<Q^2<20 GeV^2)
- Separate into phase space of VM, and phase space of VM daughters.
- Our acceptance is great for electroproduction.

Sartre vs BeAGLE (photo-)

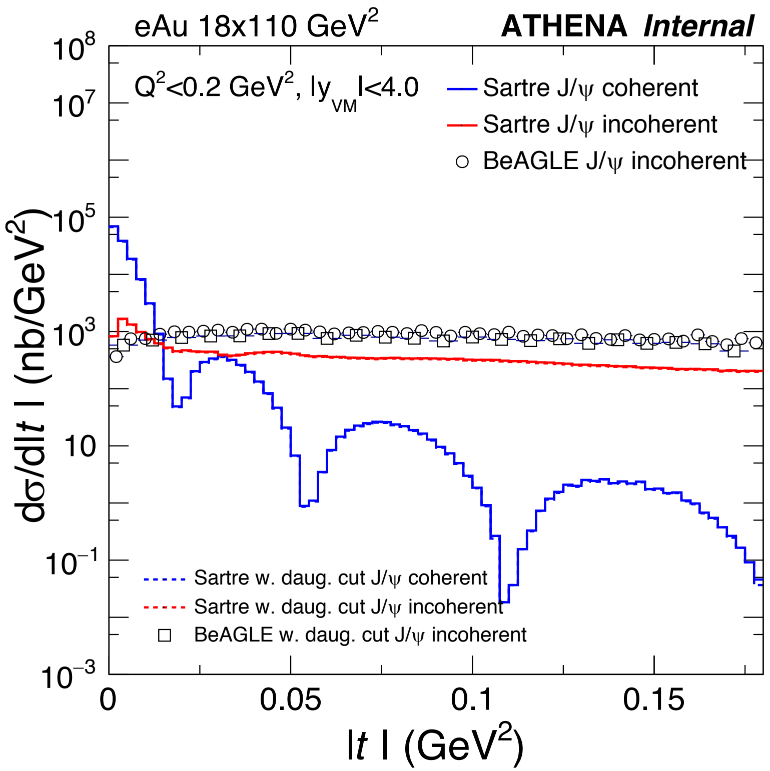
Reminder:
Daug. Phase Space
1. |eta|<4.0
2. Pt>0.15



0.1 < Q2 < 0.2



0.0001 < Q2 < 0.01

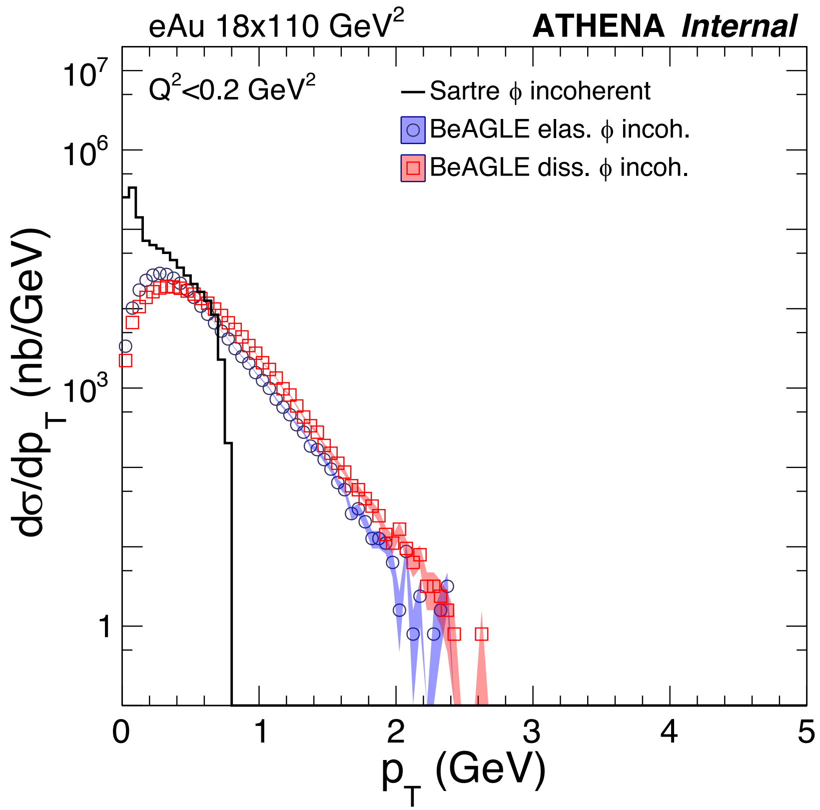


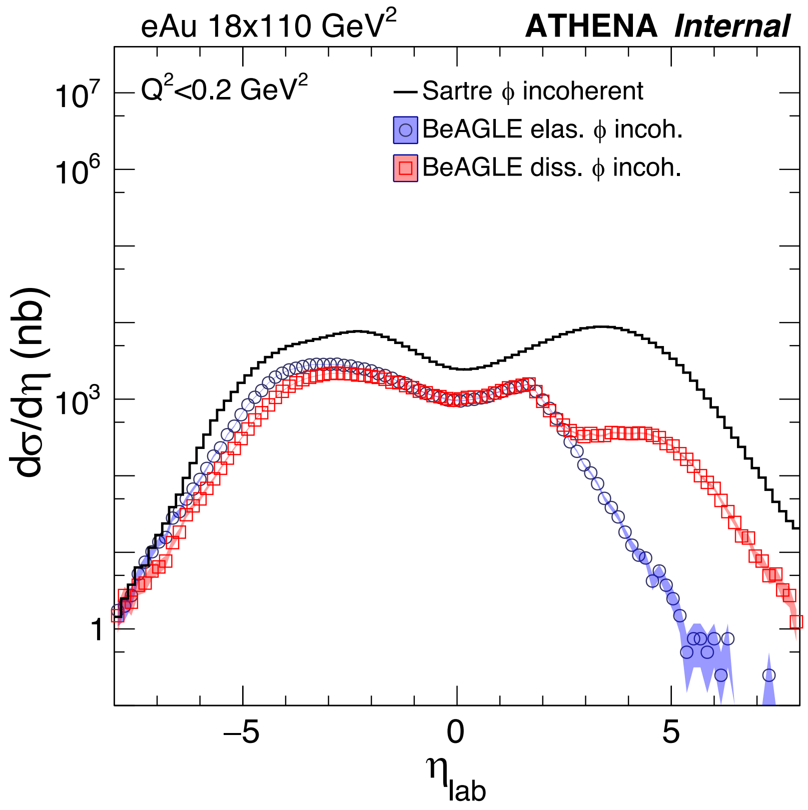
0.0001 < Q2 < 0.01

- Our acceptance is great for Jpsi and rho, but not phi.
- Incoherent phi won't be a problem, see later slides. But mostly coherent phi.
- Cross sections ok for both models? (e.g., Phi in photo-Sartre seems too large? BeAGLE could be generally too large?)

Photoproduction

Sartre vs BeAGLE (incoherent) ϕ meson

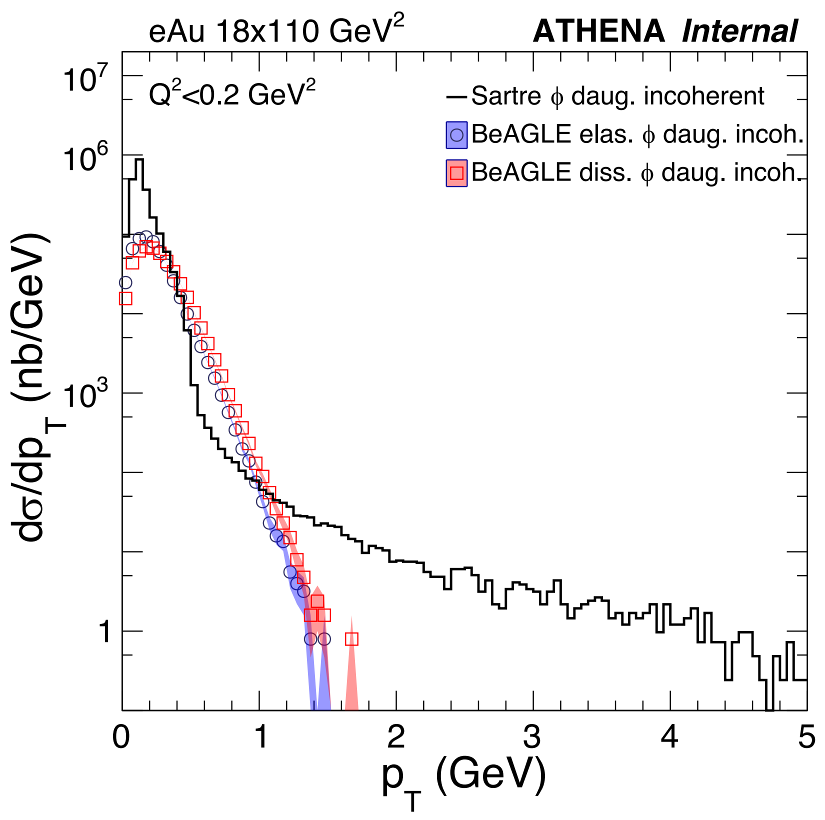


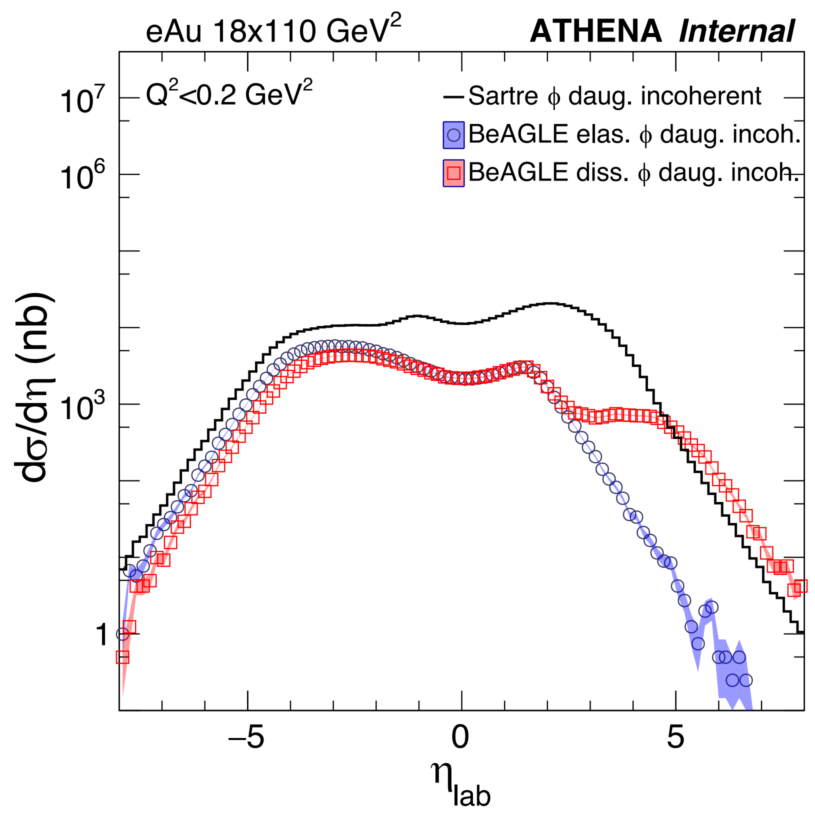


BeAGLE separates incoherent to elastic and dissociative (nucleon breakup)

Photoproduction

Sartre vs BeAGLE (incoherent) ϕ meson decay

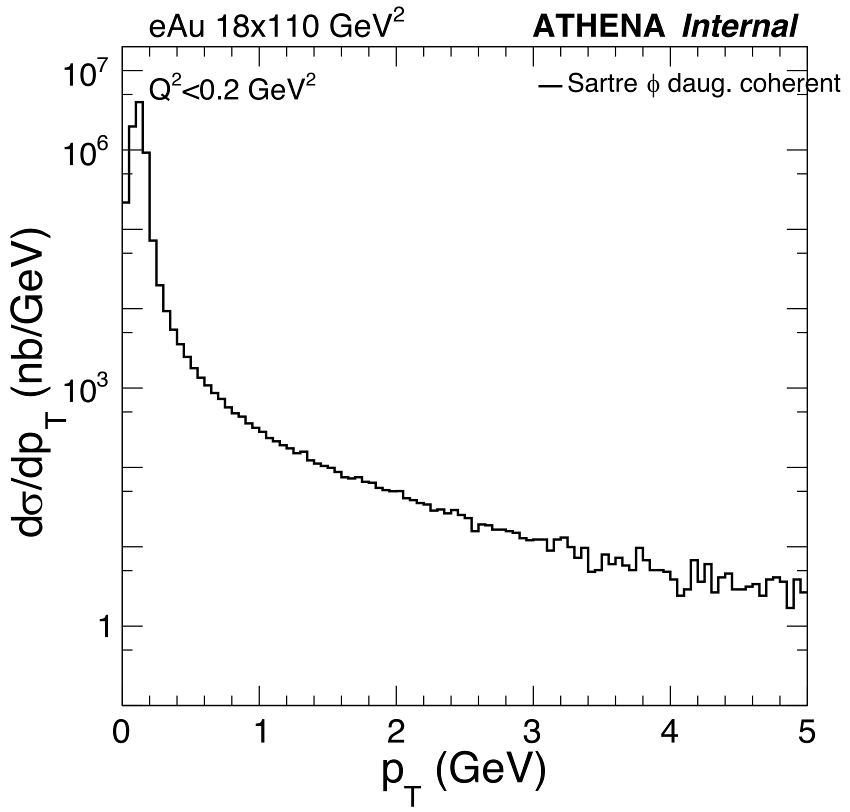


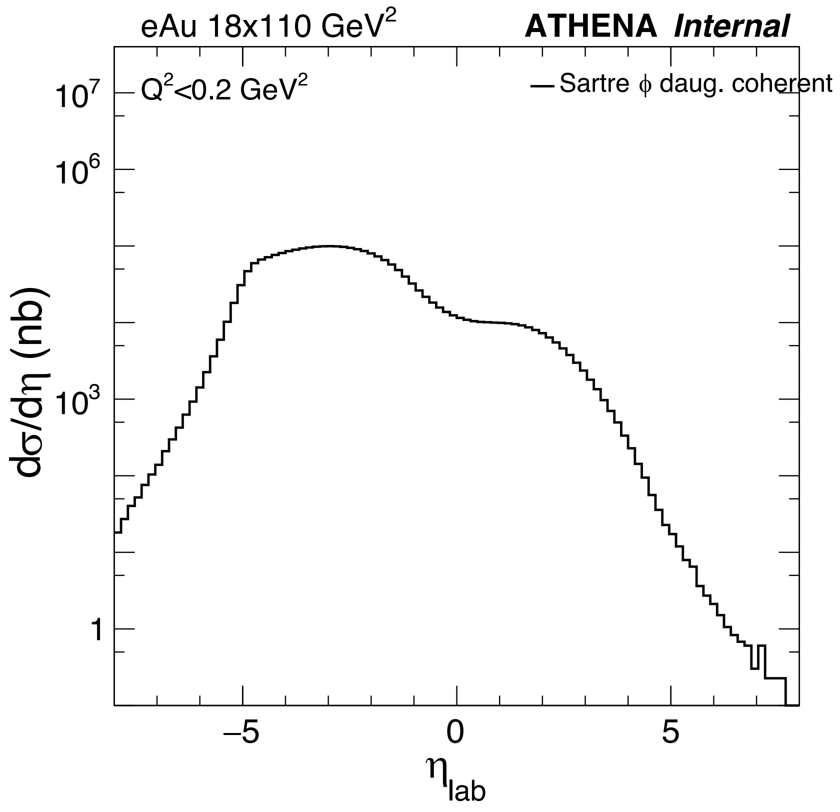


Decay is forced to be kaon in Sartre (BR~49.8%)

Sartre (coherent)

ϕ meson decay

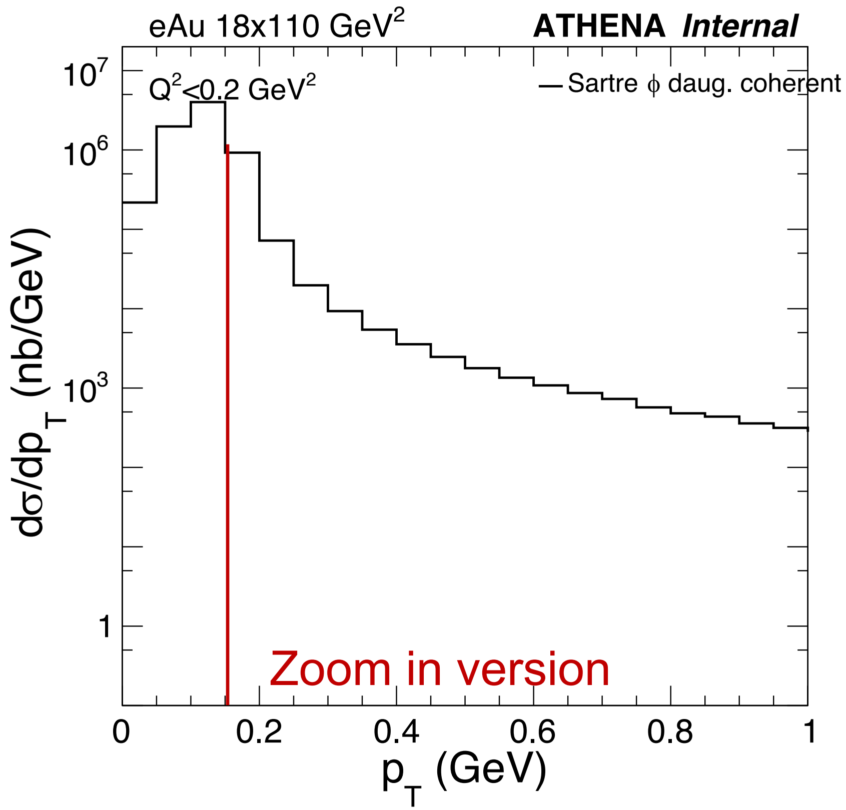


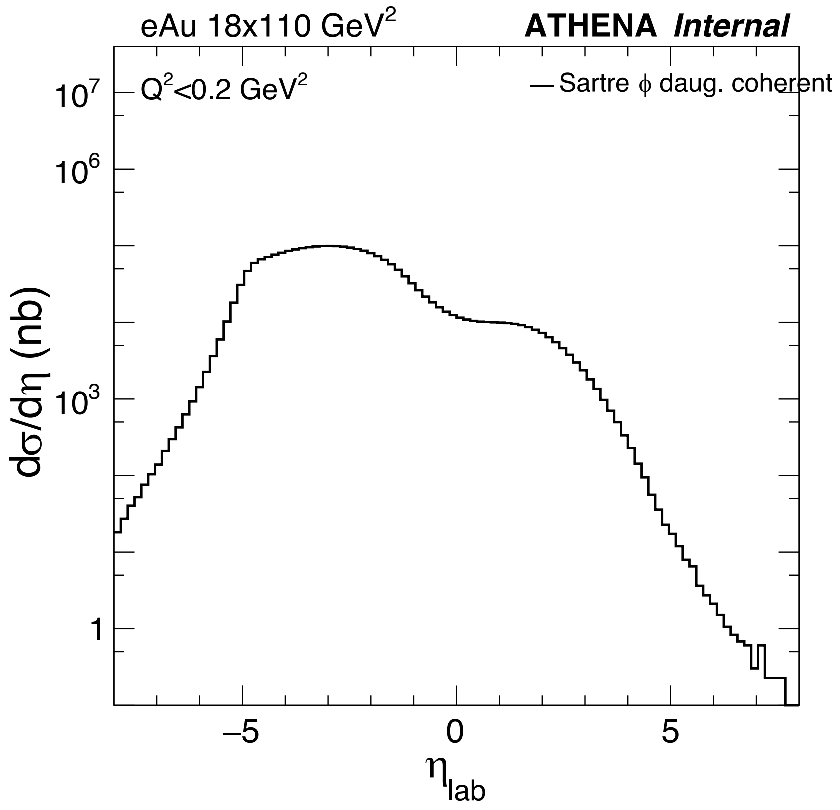


Decay is forced to be kaon in Sartre (BR~49.8%)

Sartre (coherent)

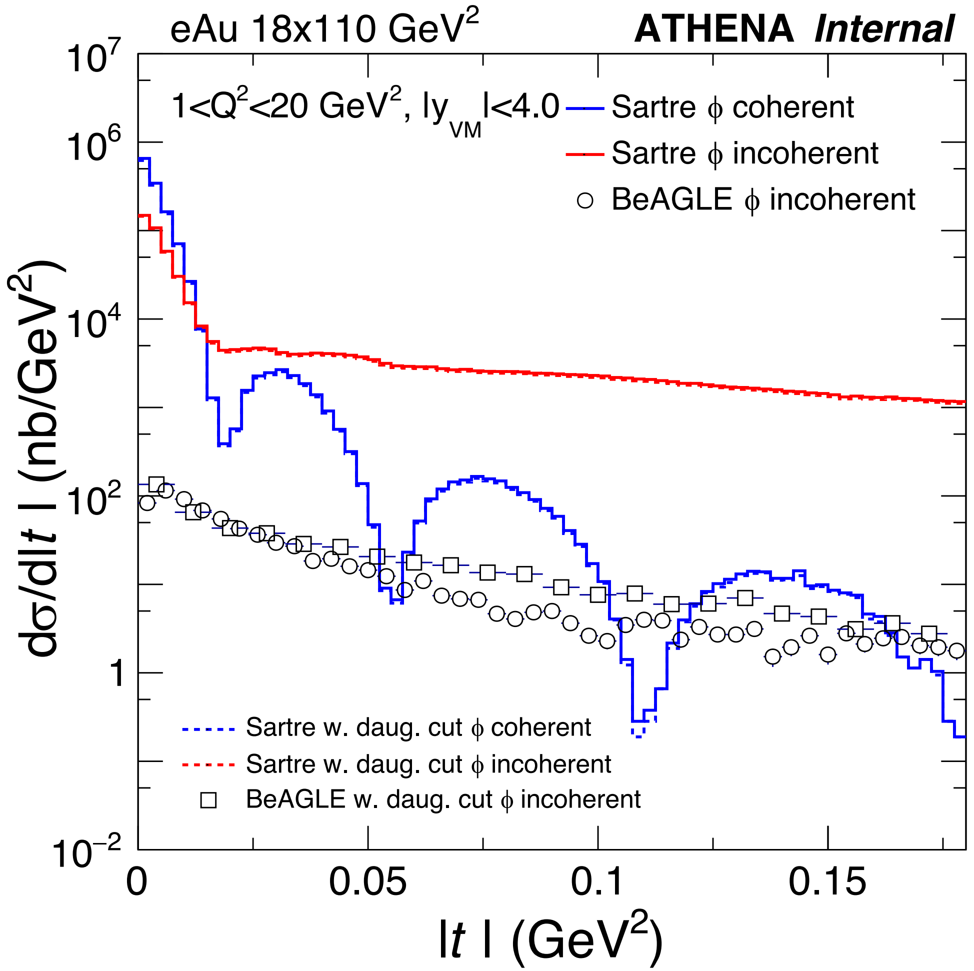
ϕ meson decay

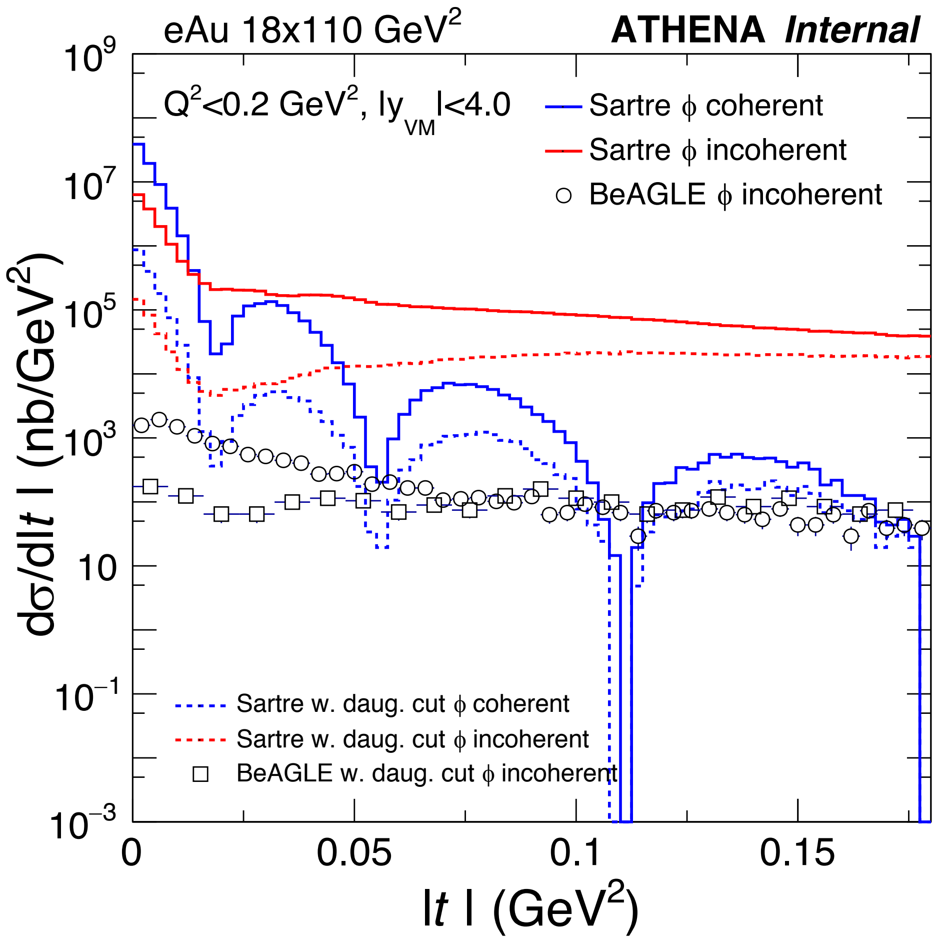




Decay is forced to be kaon in Sartre (BR~49.8%)

After veto. (Toy veto.)

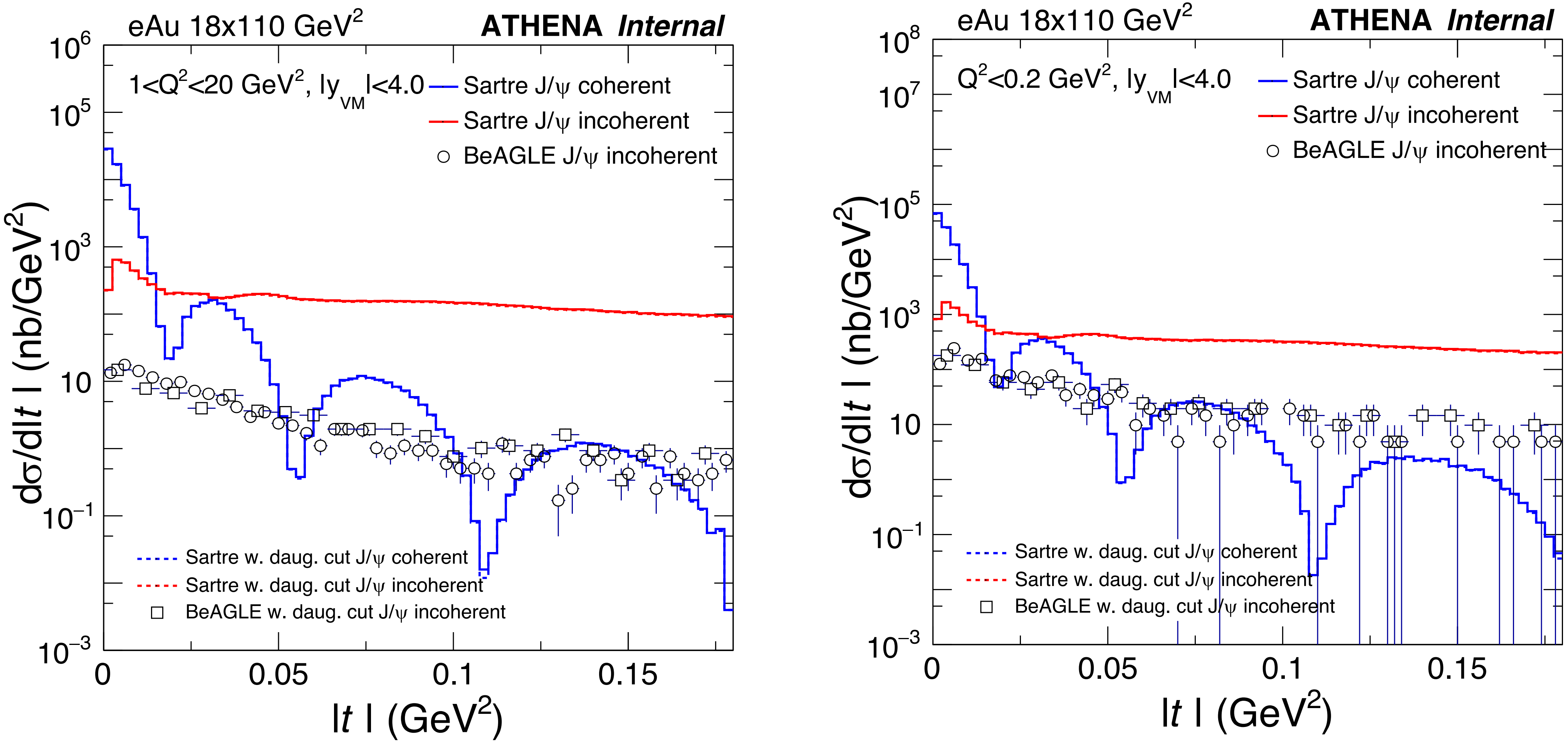




After veto. (Toy veto.)

A digression

J/ψ meson



Where we are now

- Good acceptance for all 3 VMs, except Phi in photoproduction.
- Good vetoing (at least Toy) in photoproduction for phi and J/psi.

Two points so far:

1. Photoproduction of J/psi is easy and achievable (baseline).
2. Phi is challenging, one suffers from incoherent, while the other from acceptance. (our ATHENA advantage, if overcomes the challenge? Like lower the field even lower than 1.5T?)

Next issue – ***t*** reconstruction

- So far, we use the true ***t*** in both generator

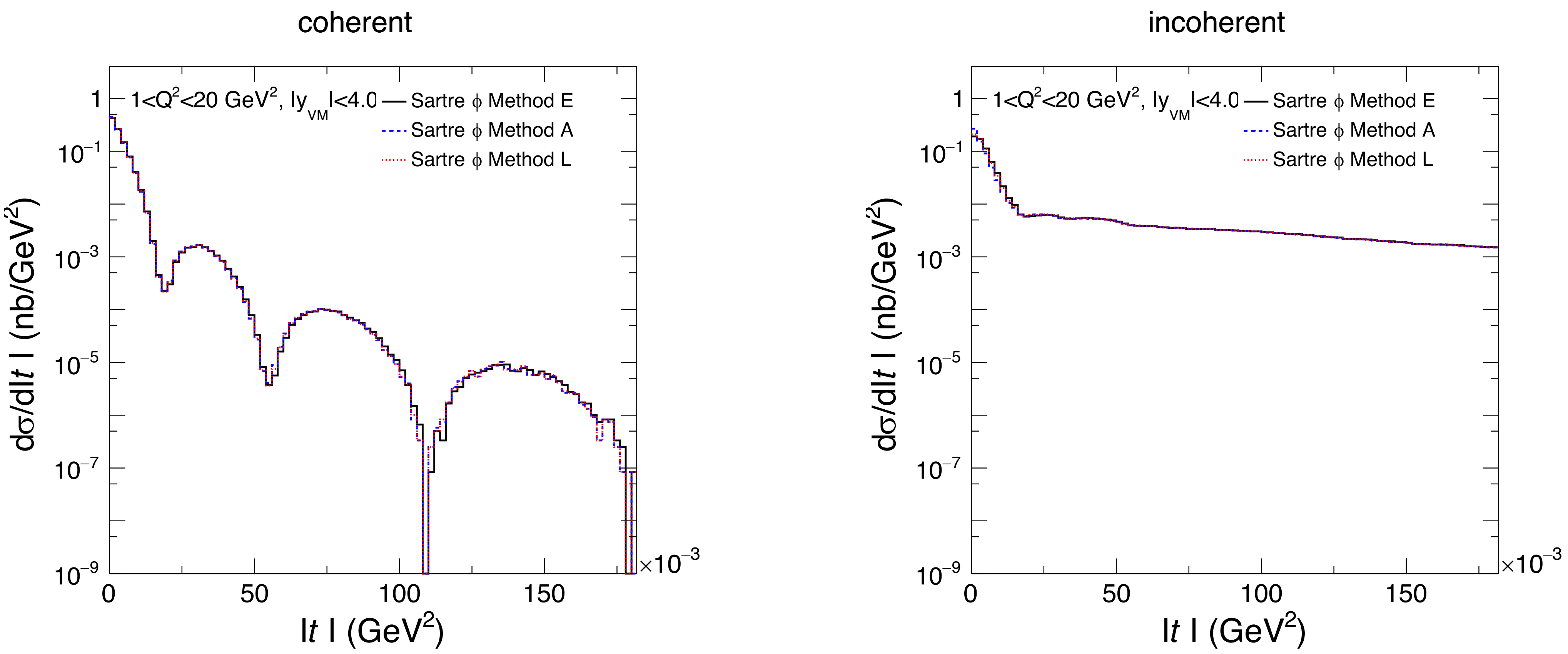
(although, as mentioned before, determination of ***t*** in incoherent production is tricky and NOT without model uncertainty)

- 3 methods established in YR (taken from T. Ullrich's summary)

1. Method. E(xact): $(e\text{-}e'\text{-}V)^2$
2. Method. A(pproximate): $(p_{T,e'} \ +_{vector\_sum} \ p_{T,V})^2$
3. Method. L(appi): $(A'_{corr} - A)^2$ (best against det/beam effects)

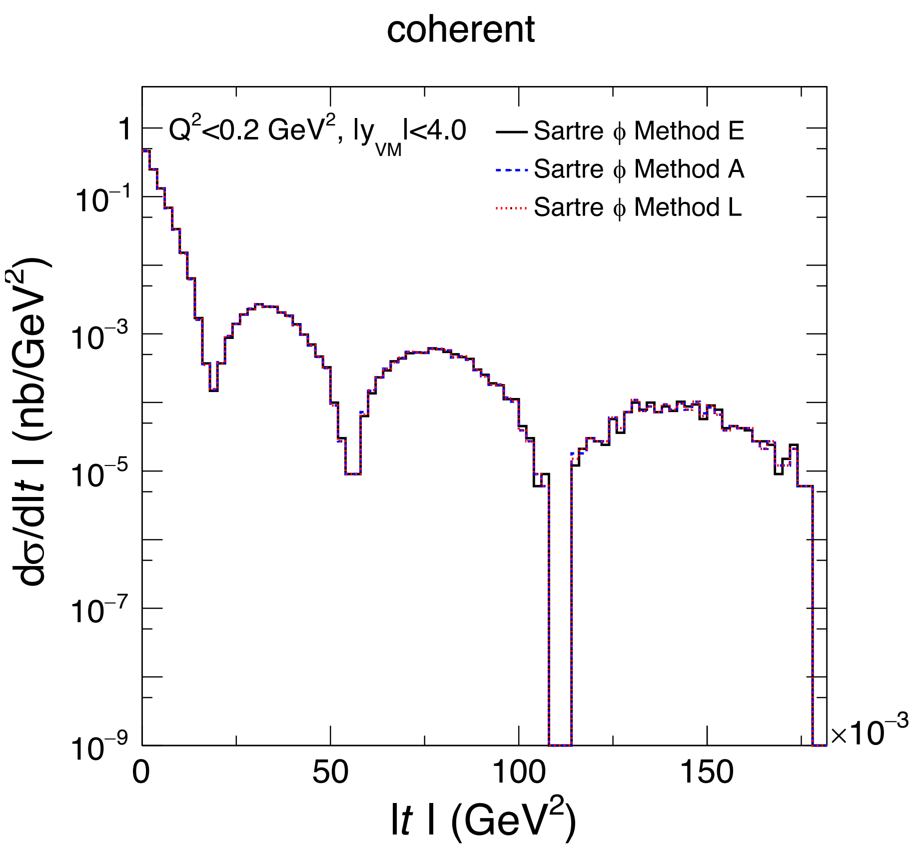
(all results shown beyond will be within daughter phase space.)

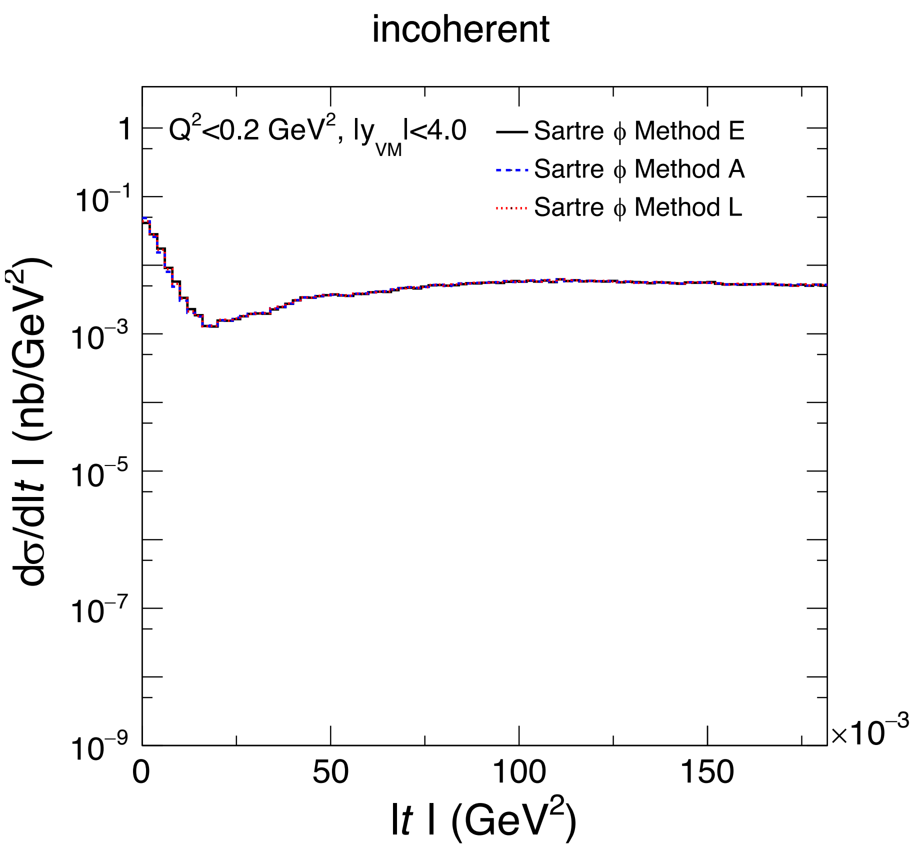
Ideal scenario (electro-Sartre) ϕ meson



Differences are small for phi.

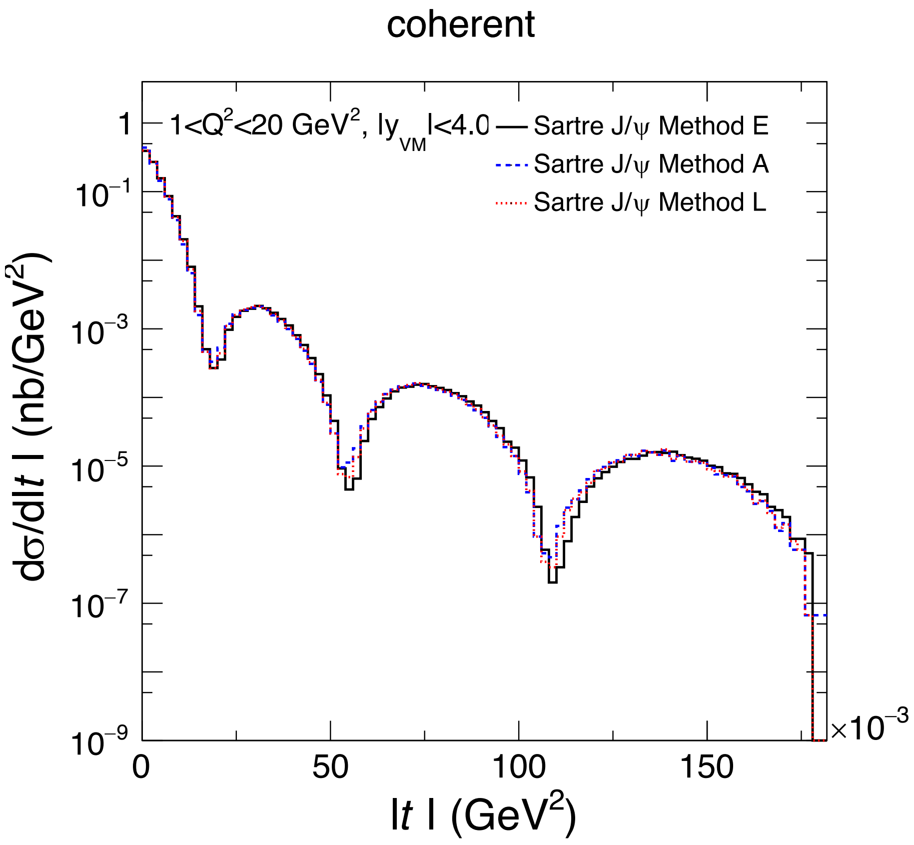
Ideal scenario (photo-Sartre) ϕ meson

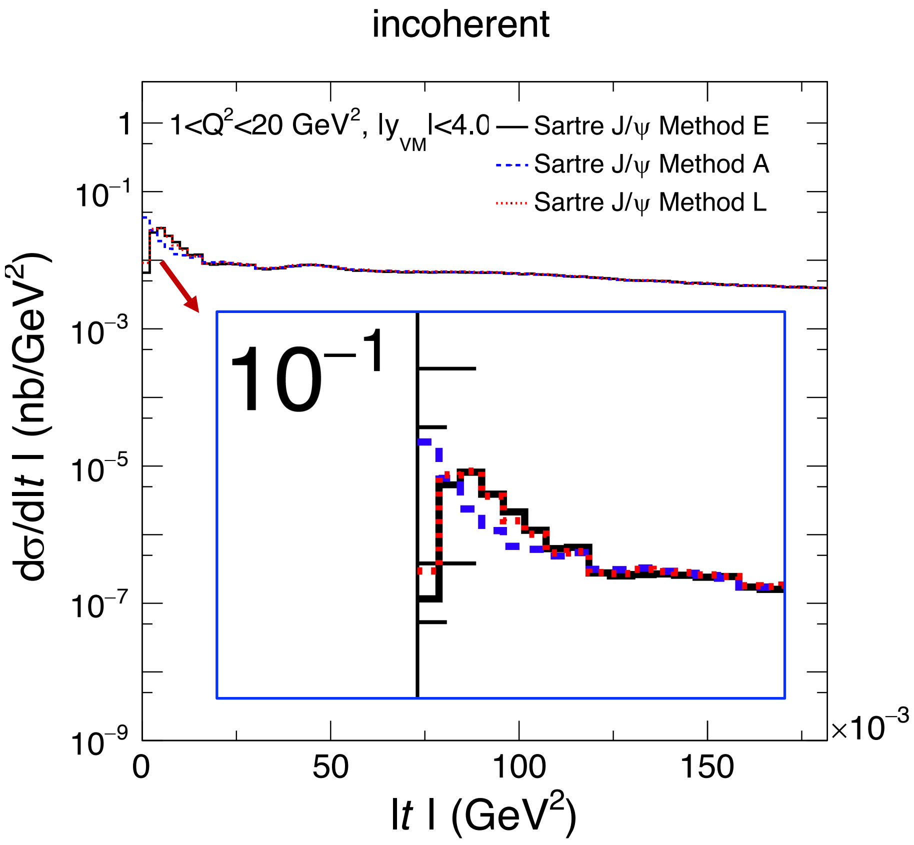




Differences are small for phi.

Ideal scenario (electro-Sartre) J/ψ meson

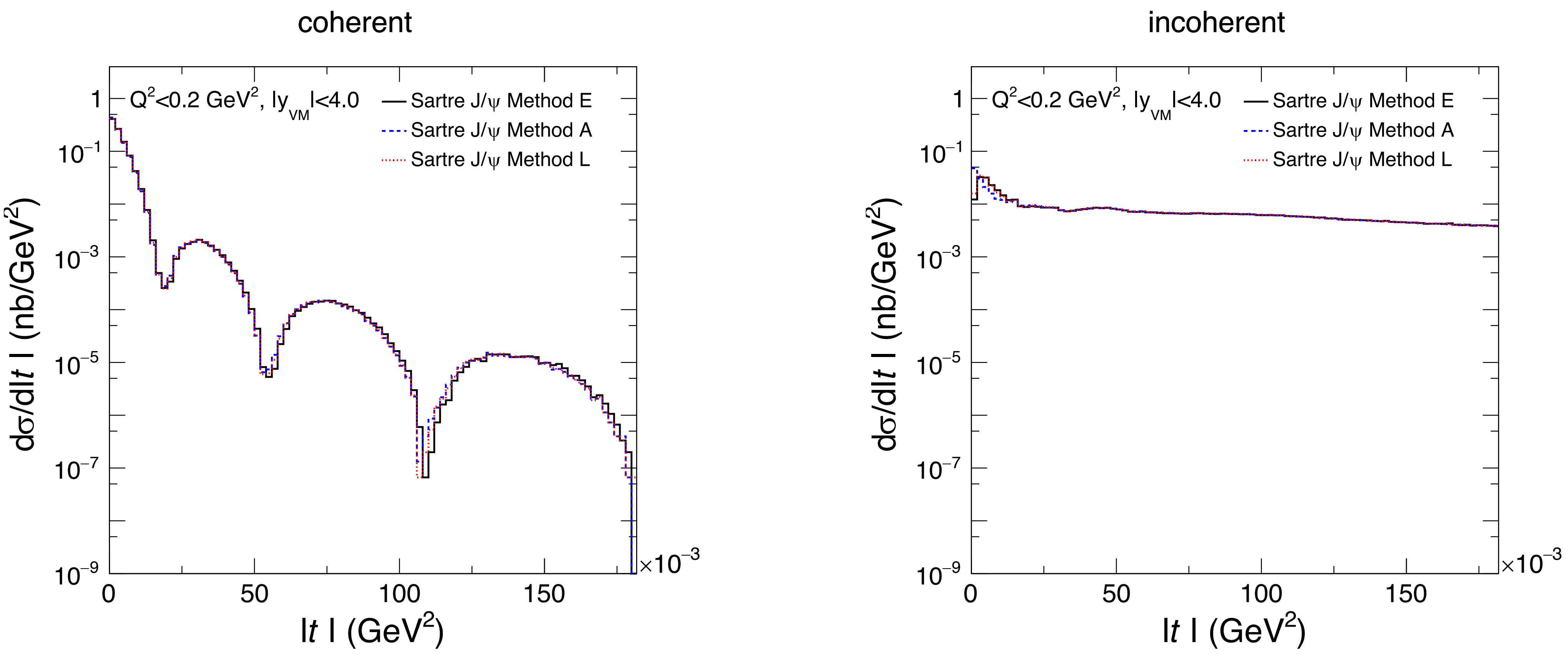




Differences are larger for jpsi.

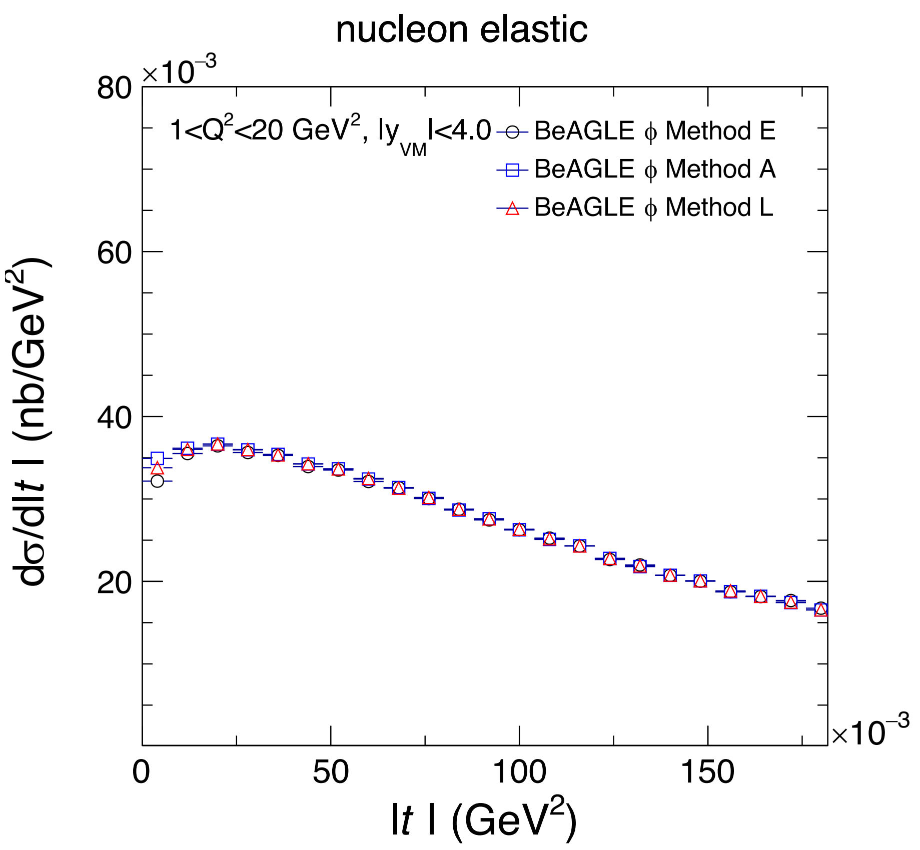
Ideal scenario (photo-Sartre)

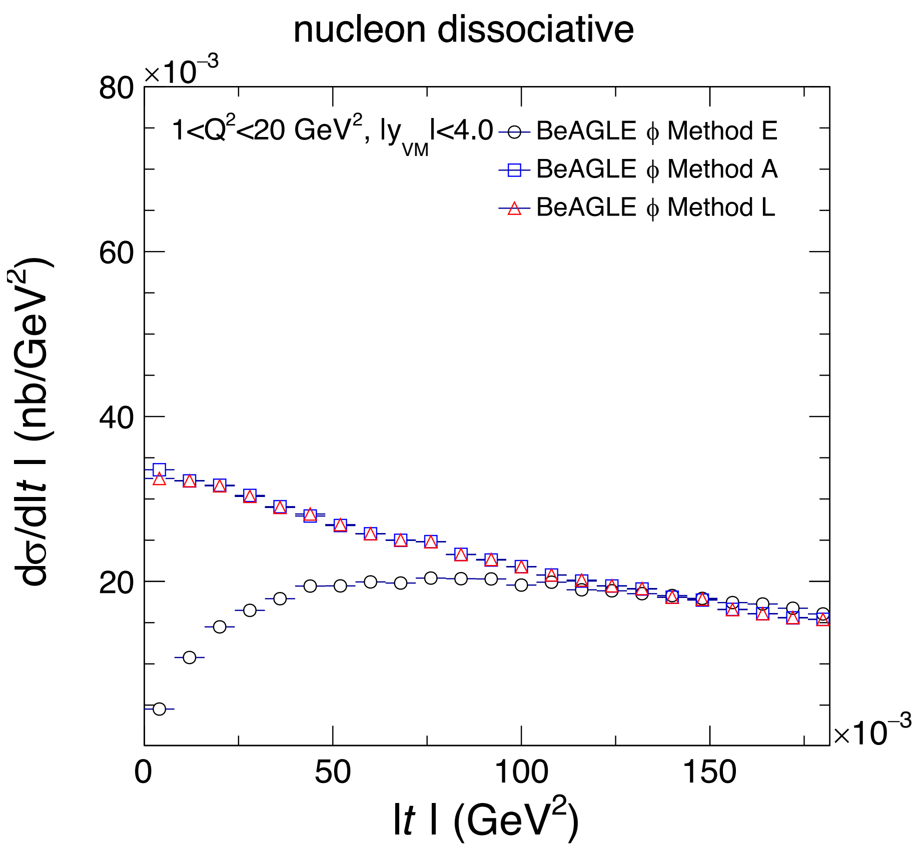
J/ψ meson



Differences are larger for jpsi.

Ideal scenario (electro-BeAGLE) ϕ meson

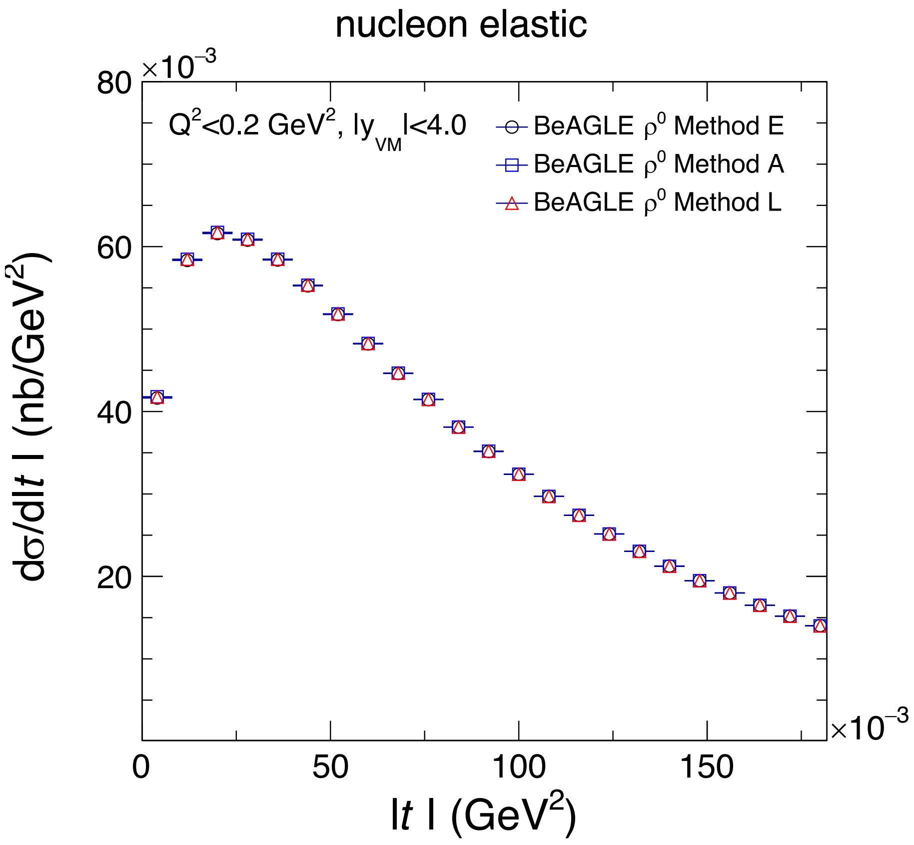


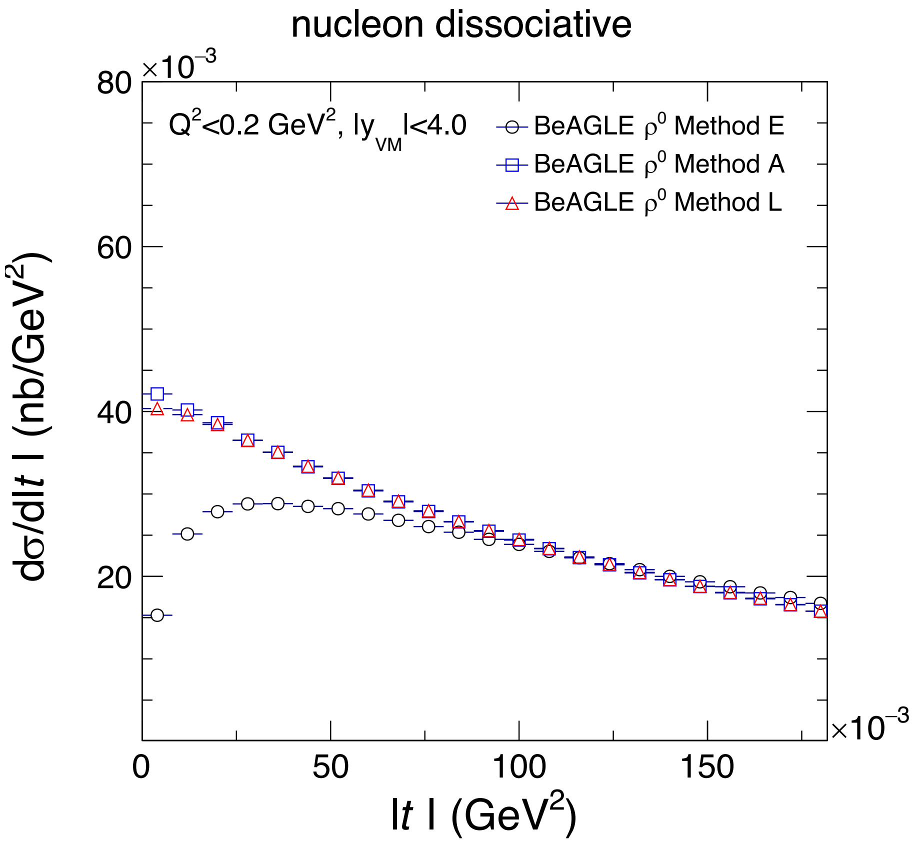


Very different for dissoc. in method E or (A and L)

Ideal scenario (photo-BeAGLE) ϕ meson

Better agreement in photoproduction, as expected!





Very different for dissoc. in method E or (A and L)

Short take-away from *t* reconstructions

- Methods are validated in both models, mostly great!
- (ready for the beam/detector effects!)

- Small difference in incoherent production at low *t* and behaves differently in Beagle and Sartre. Why? Not sure yet. But not critical for now, they will be vetoed anyway;

- Certainly, incoherent breakup is something interesting…but that's more on the models, not for the ATHENA proposal.

- This will be combined with the next issue - Mass

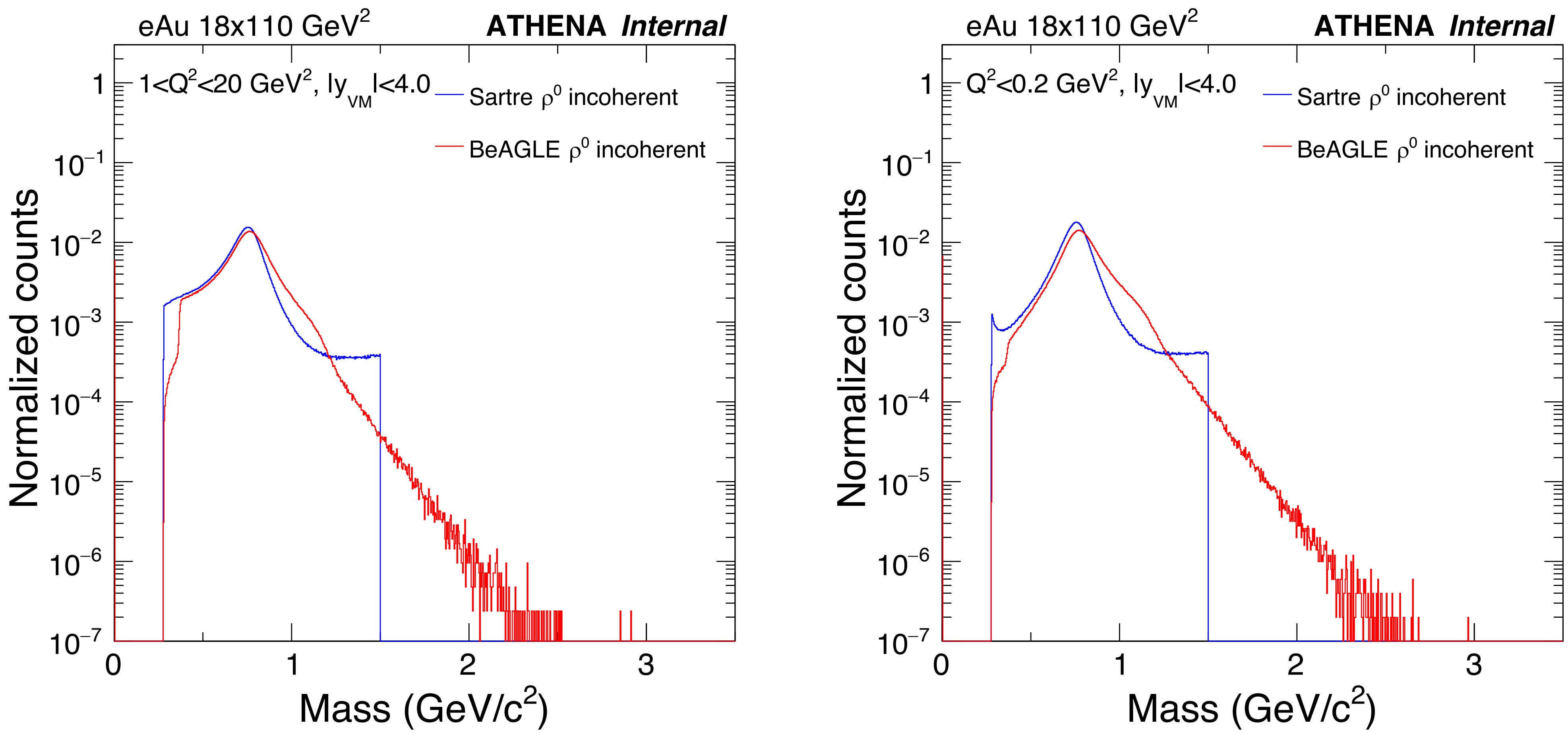
VM mass

- Three scenarios we are considering:

1. Perfect VM identification (daughters. PID)
2. Worst VM identification (no daughters. PID)
3. Good VM identification (with barrel PID |eta|<1.0, 3T field*)

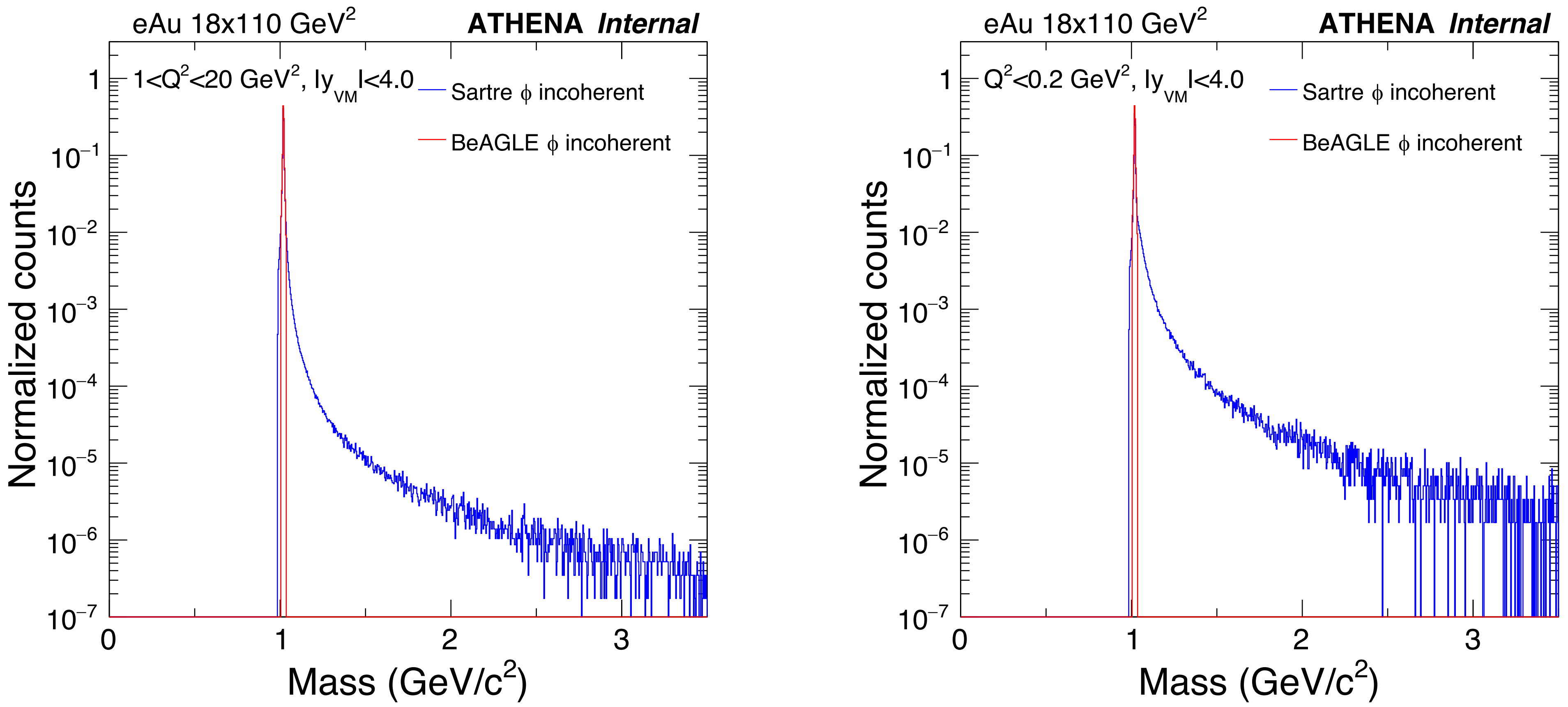
* This is done by Zhangbu initially with 3T field, a little inconsistent with my pt minimum earlier. However, if I made higher pt minimum, it’s only going to be worse for phi meson.

Rho mass



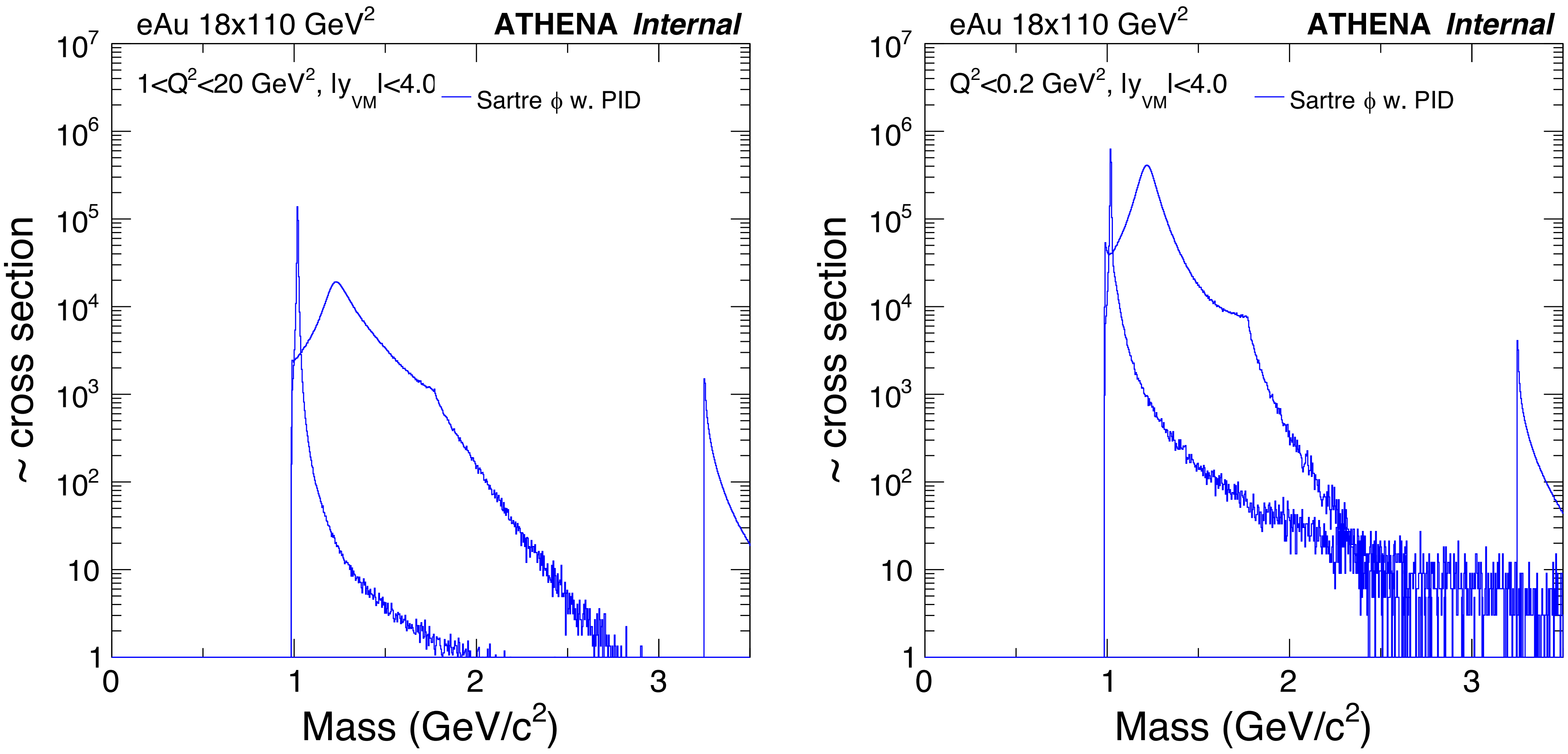
Different spectral functions for rho.

phi mass



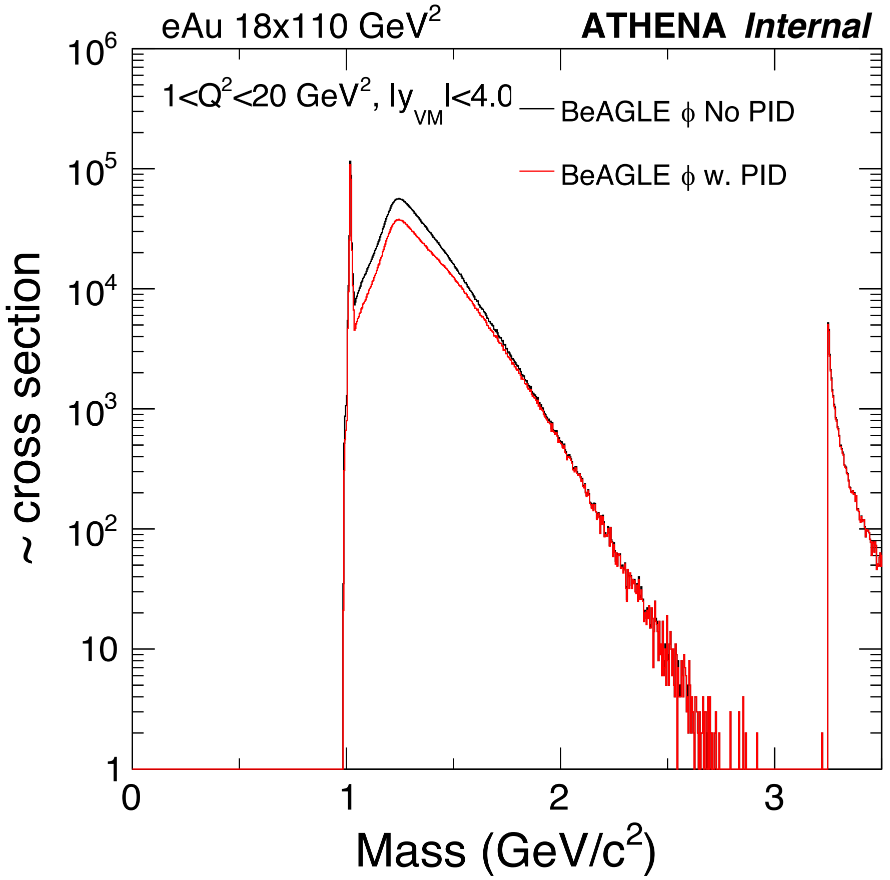
Phi is also different, Sartre has a long tail (problem?)

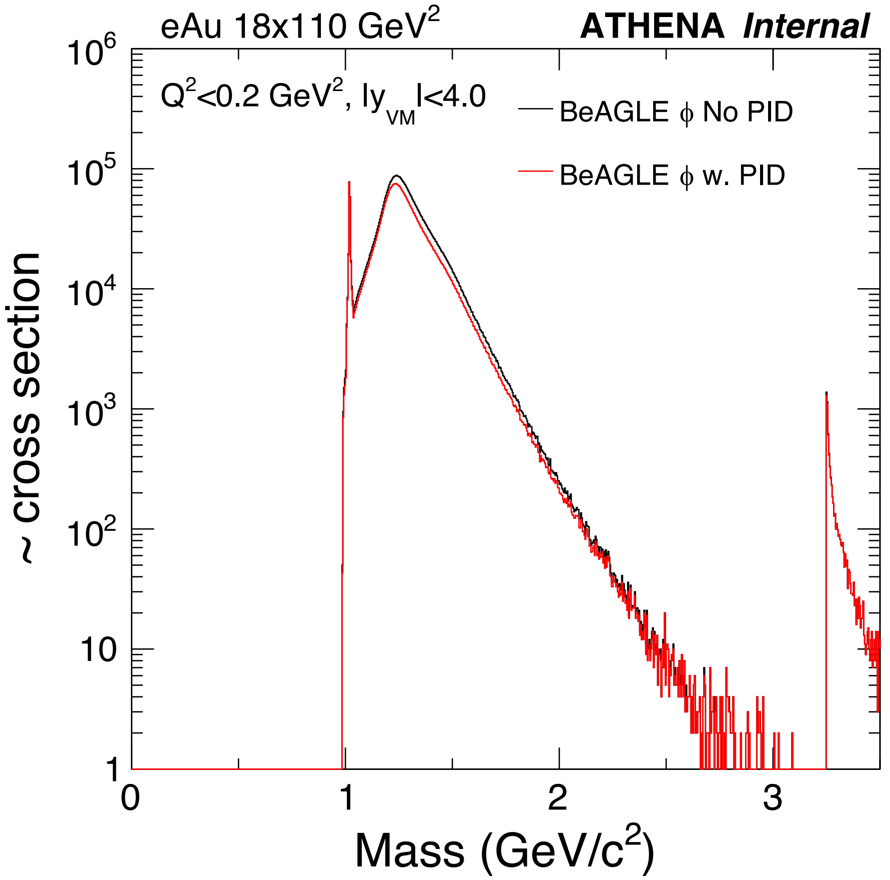
Mixing in Sartre



Sartre VMs weighted by cross sections, where Jpsi->ee and rho->pipi are assumed kaon mass

Mixing in Beagle





Similar was done in BeAGLE – the only contamination is within the phi mass region

Mass vs t

Mass

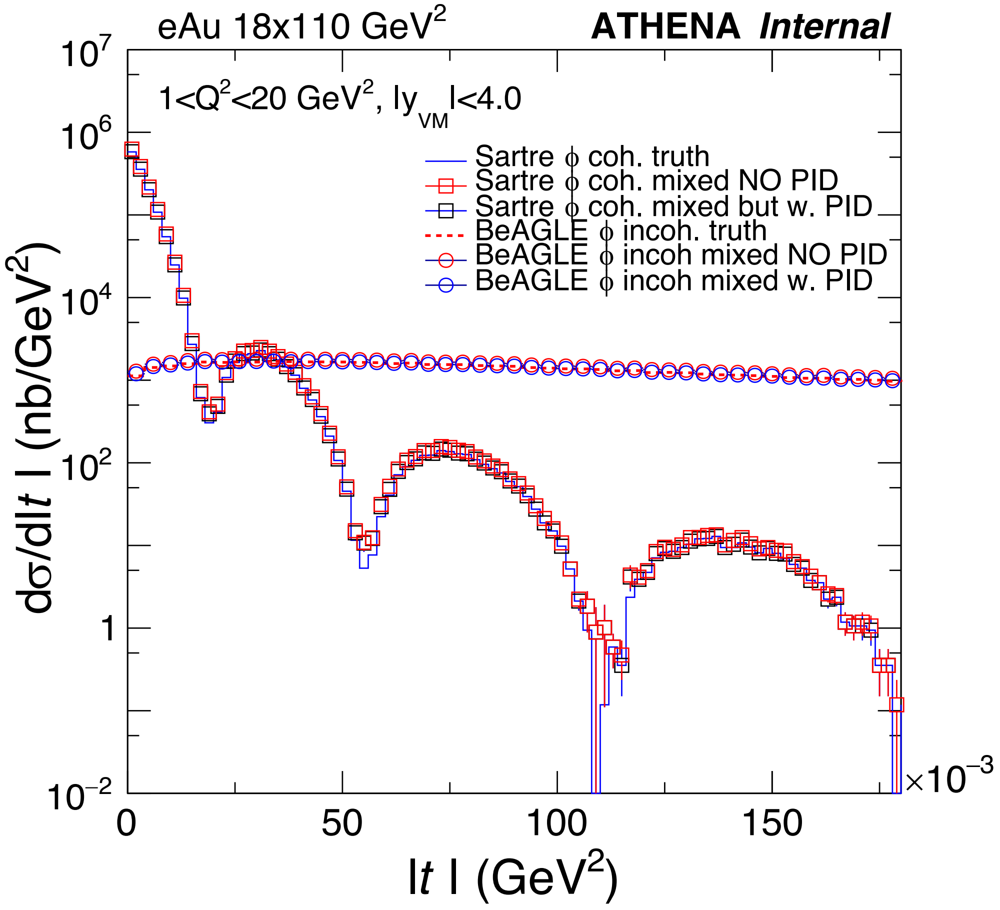
t

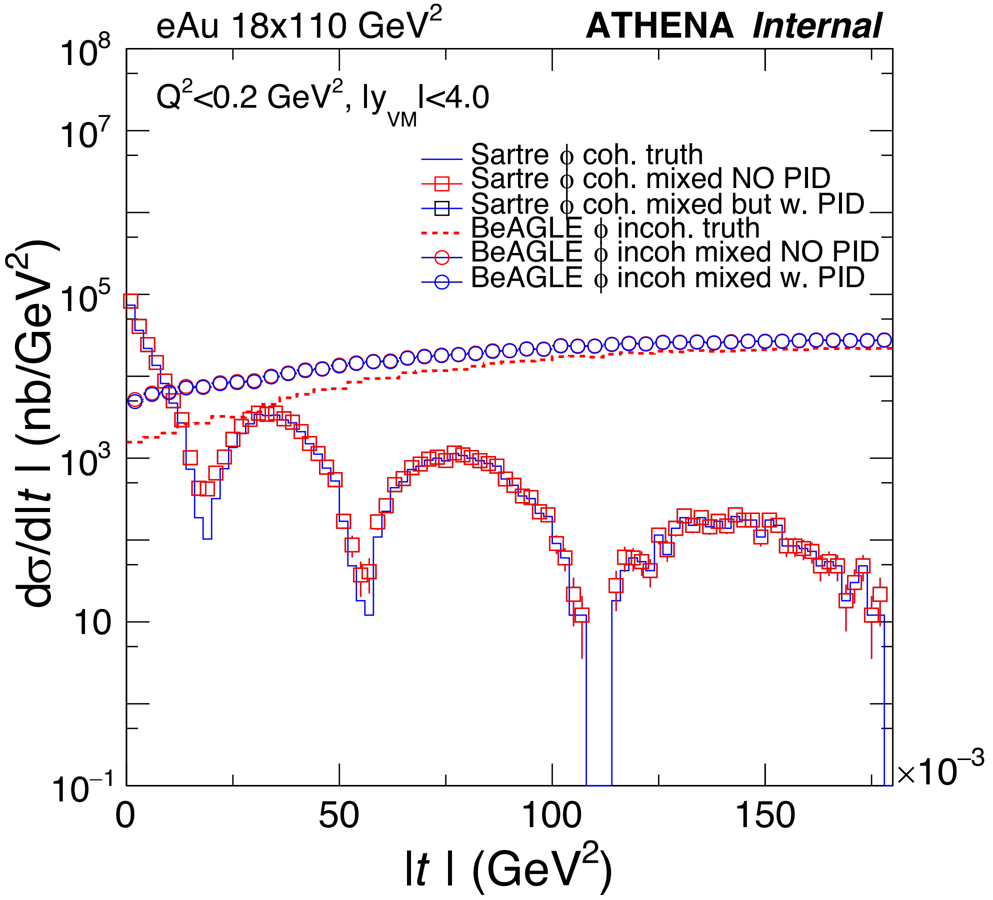
	True mass	**Mixed mass**	**Mixed mass + PID**
Method. E	Next slides	Next slides	Next slides
Method. A	-	-	-
Method. L	-	-	-

- This will be more important when beam/machine/detector effects are turned on;
- For now, let's check Method. E (truth) for different "mass" (phi) scenarios.

- We cut on phi mass 1.019-0.02 < mass < 1.019+0.02

Sartre vs BeAGLE

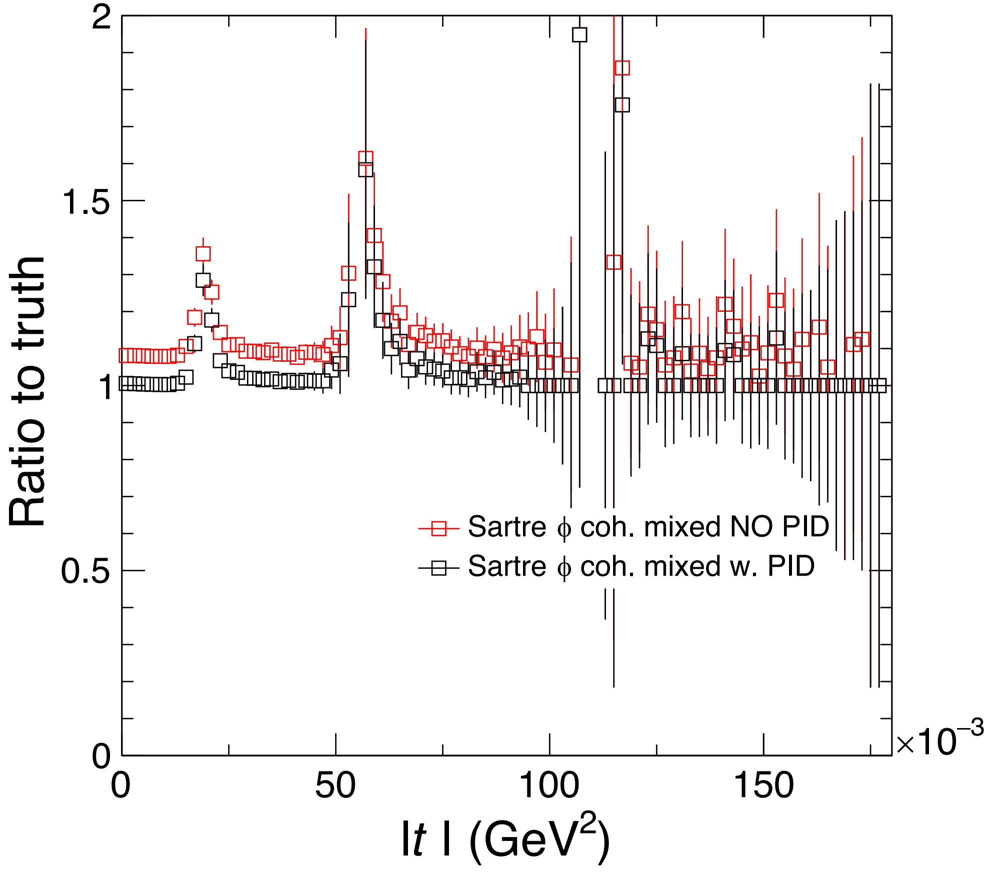




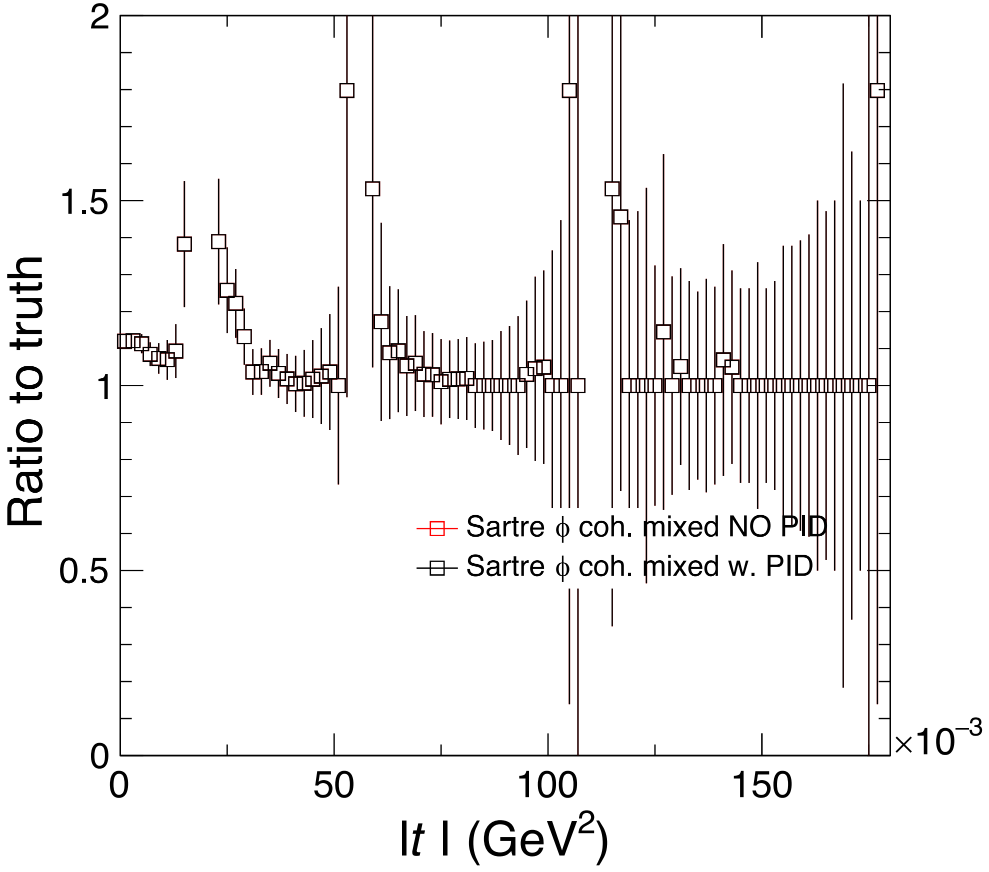
The effect of having PID within |Eta|<1.0 separating pions and kaons, not so dramatic.

Sartre vs BeAGLE ratio

electroproduction



Photoproduction (still 3T setting for PID)



10%-20% is still a big number in precision measurement

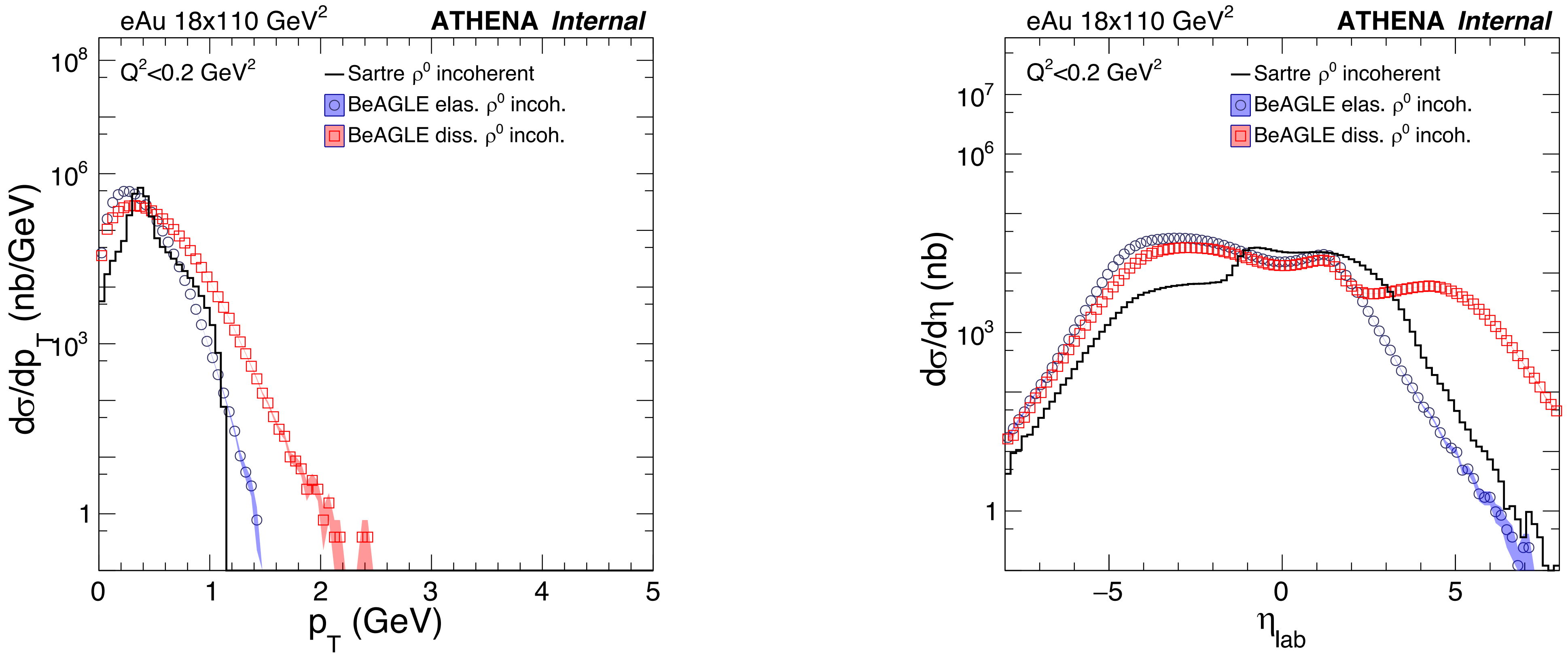
Summary

- Now we have baselines for models (Sartre+BeAGLE), electro- and photoproduction, different t-reconstructions, VM mass and contaminations, and possible PID improvements.
- In parallel, we need to check cross sections for both models (~e.g., slide 5).

- Next, we are going for beam/detector/machine effects, e.g., crossing angles, beam divergence.
- Finally, we will check other backgrounds, most likely subdominant, e.g., low multiplicity diffractive DIS?

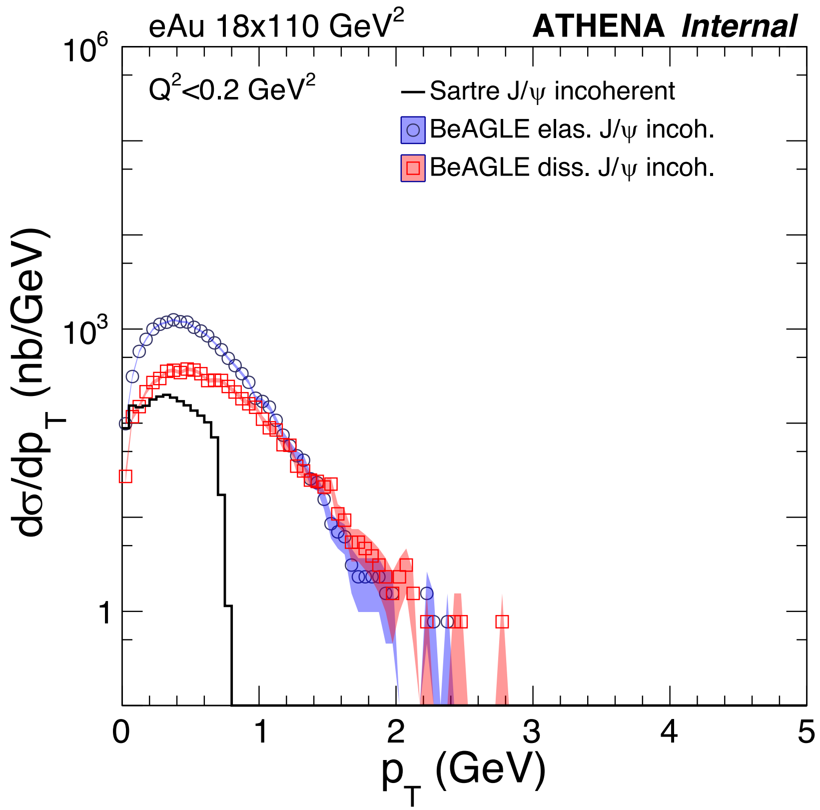
Backup

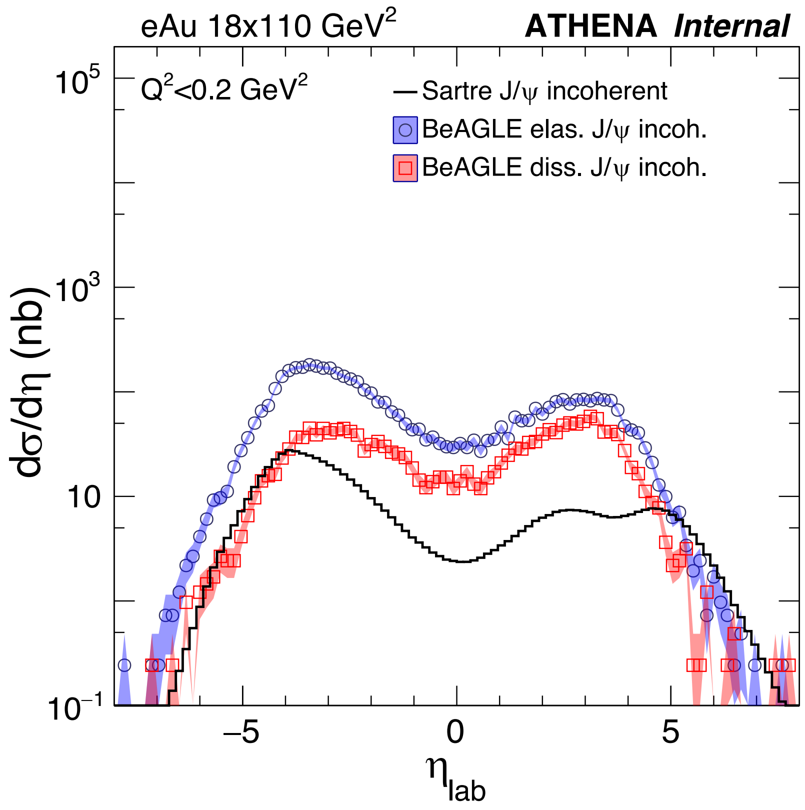
Sartre vs BeAGLE (incoherent) ρ^0 meson



BeAGLE separates incoherent to elastic and dissociative (nucleon breakup)

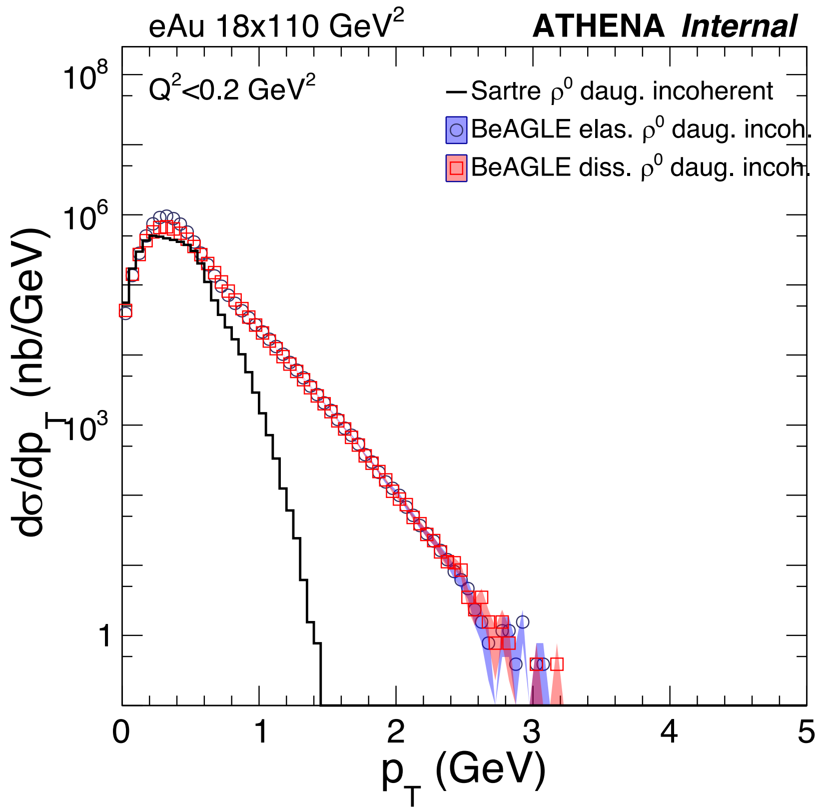
Sartre vs BeAGLE (incoherent) J/ψ meson

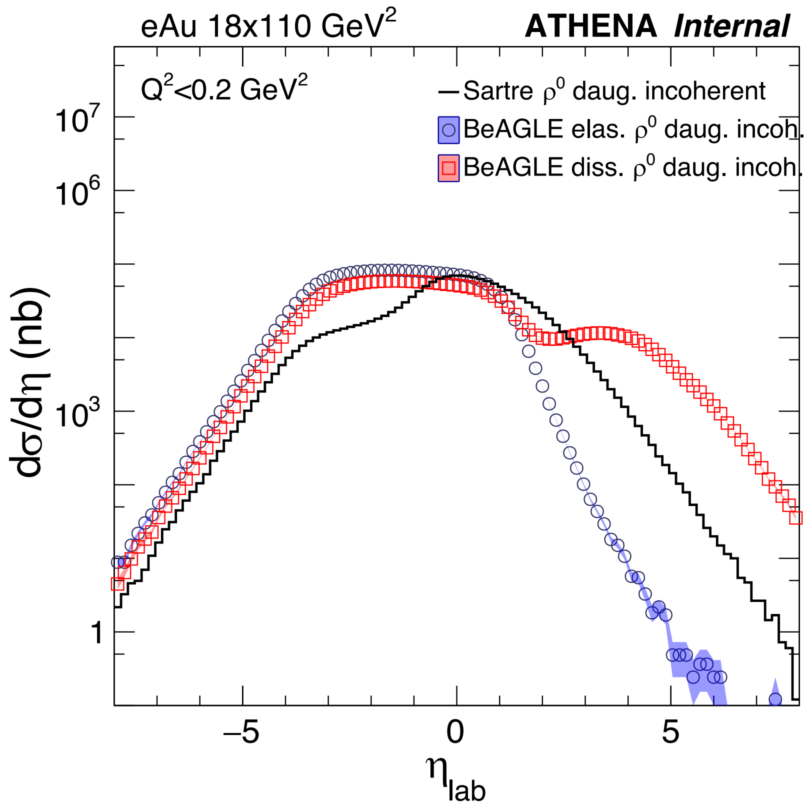




BeAGLE separates incoherent to elastic and dissociative (nucleon breakup)

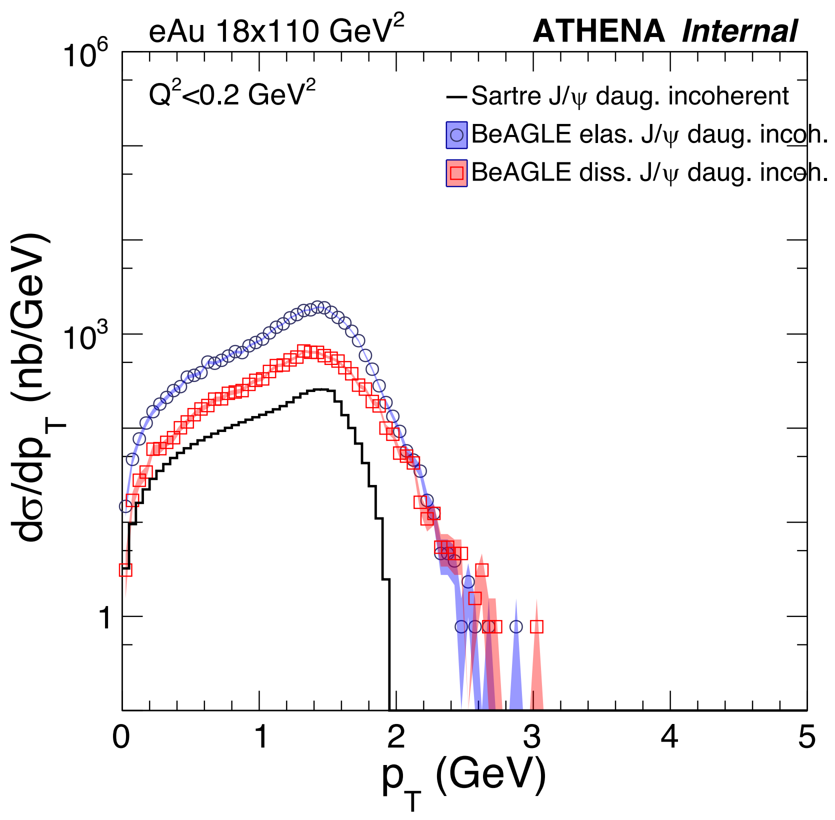
Sartre vs BeAGLE (incoherent) ρ^0 meson decay

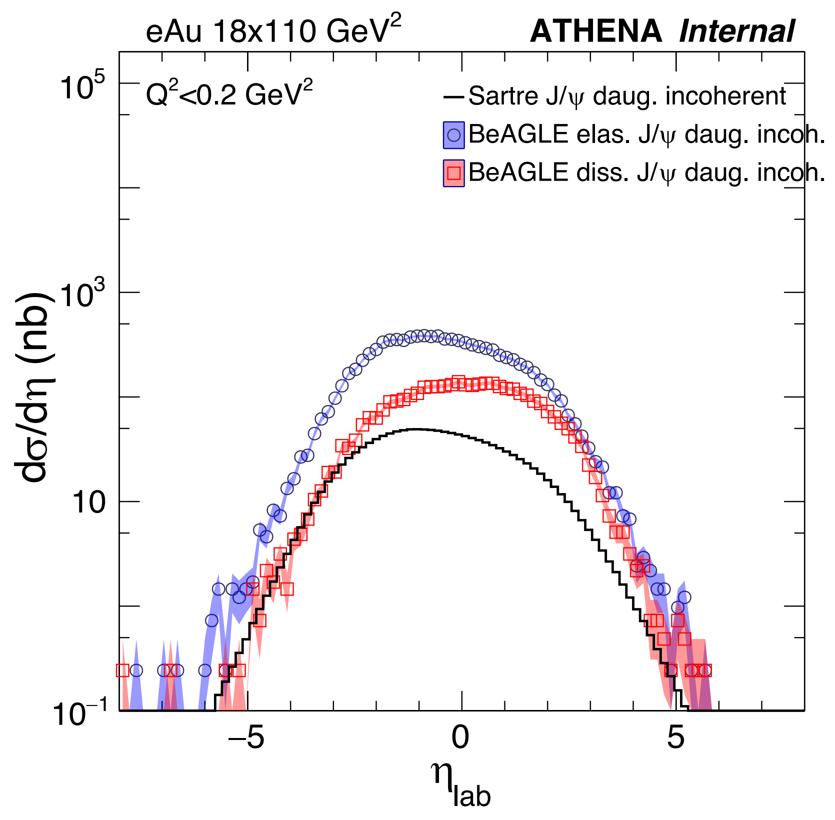




Decay is forced to be pion (BR~100%)

Sartre vs BeAGLE (incoherent) J/ψ meson decay





Decay is forced to be electron or muon, but only electrons selected. (BR~5.9%)

From Zhangbu Xu