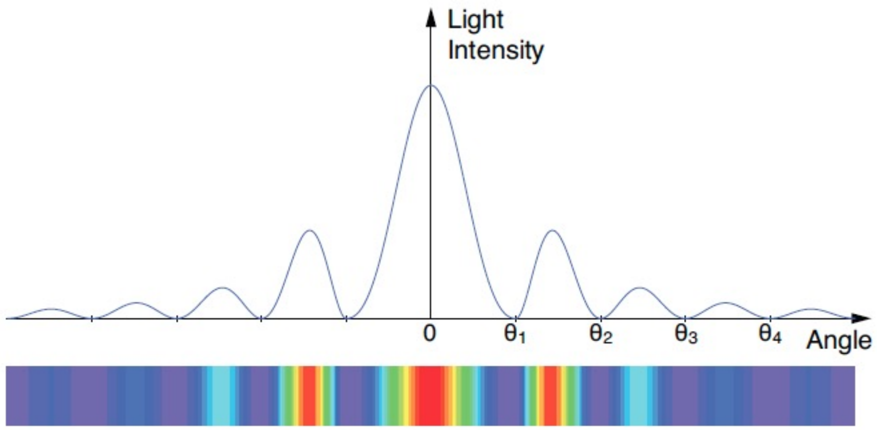
VM program in *eA* at the EIC – ATHENA



Series of study

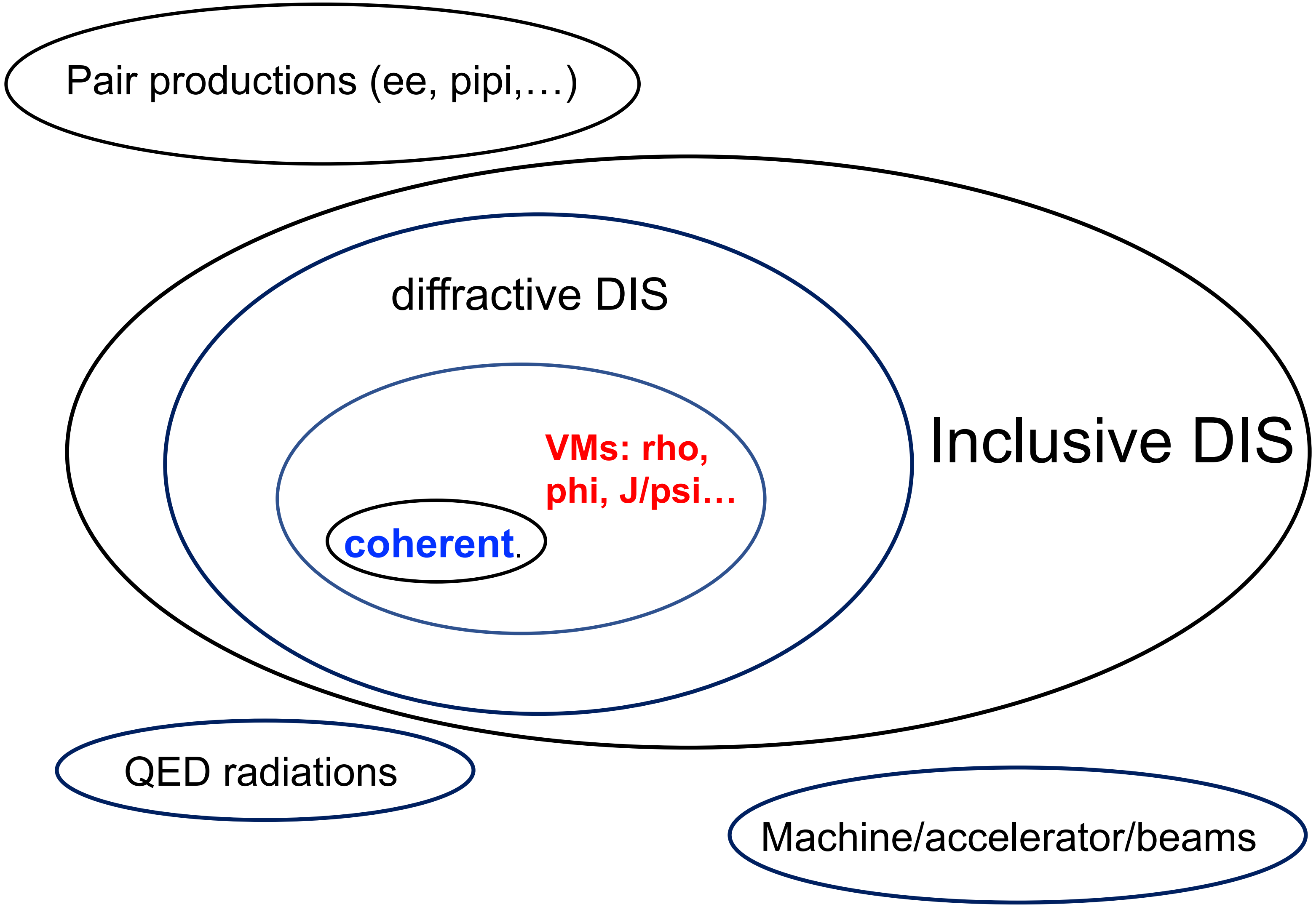
I. Baselines and setups
II. …

Kong Tu and Thomas Ullrich

BNL

08. 13. 2021

Structure of this problem



Backgrounds:

- Every process that is “more” inclusive than exclusive VM production can be a physics background.
- Some backgrounds contaminates in *cross section*, while other backgrounds smear the distributions (like QED).

Questions:

- How much can we veto and how much we cannot?
- How to correct the data? How well the detector needs to be?

Samples

- Sartre 20% of 100M for each VMs are used,

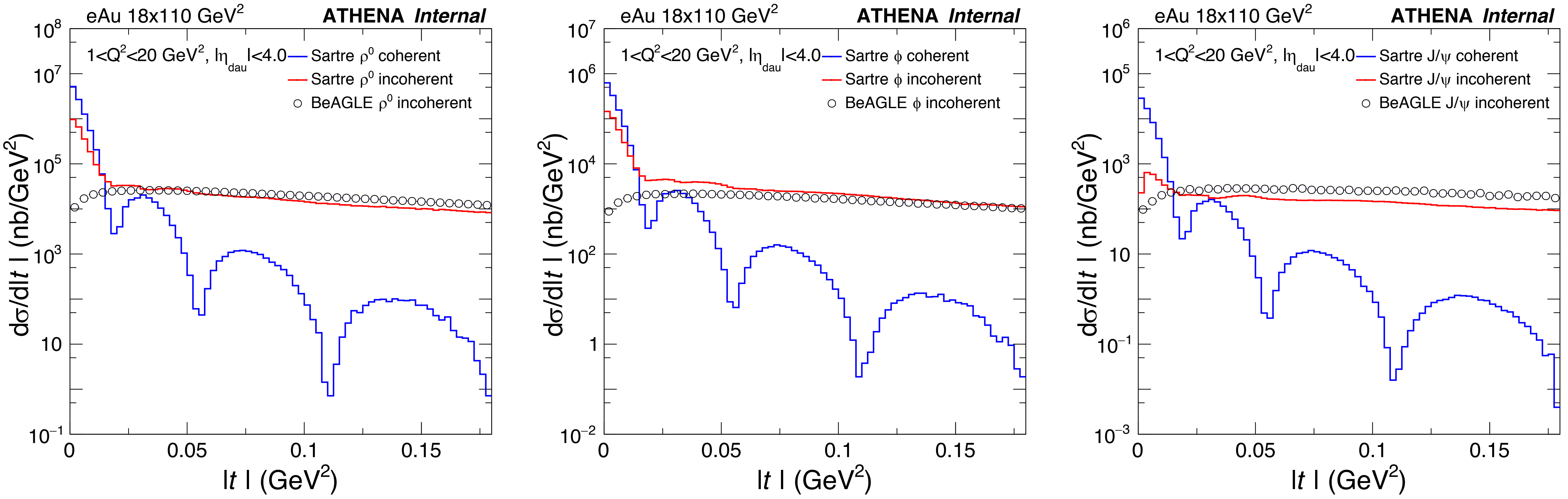
/gpfs02/eic/DATA/sartre/data/*

- BeAGLE 20M out of 100M for all VMs are used,

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

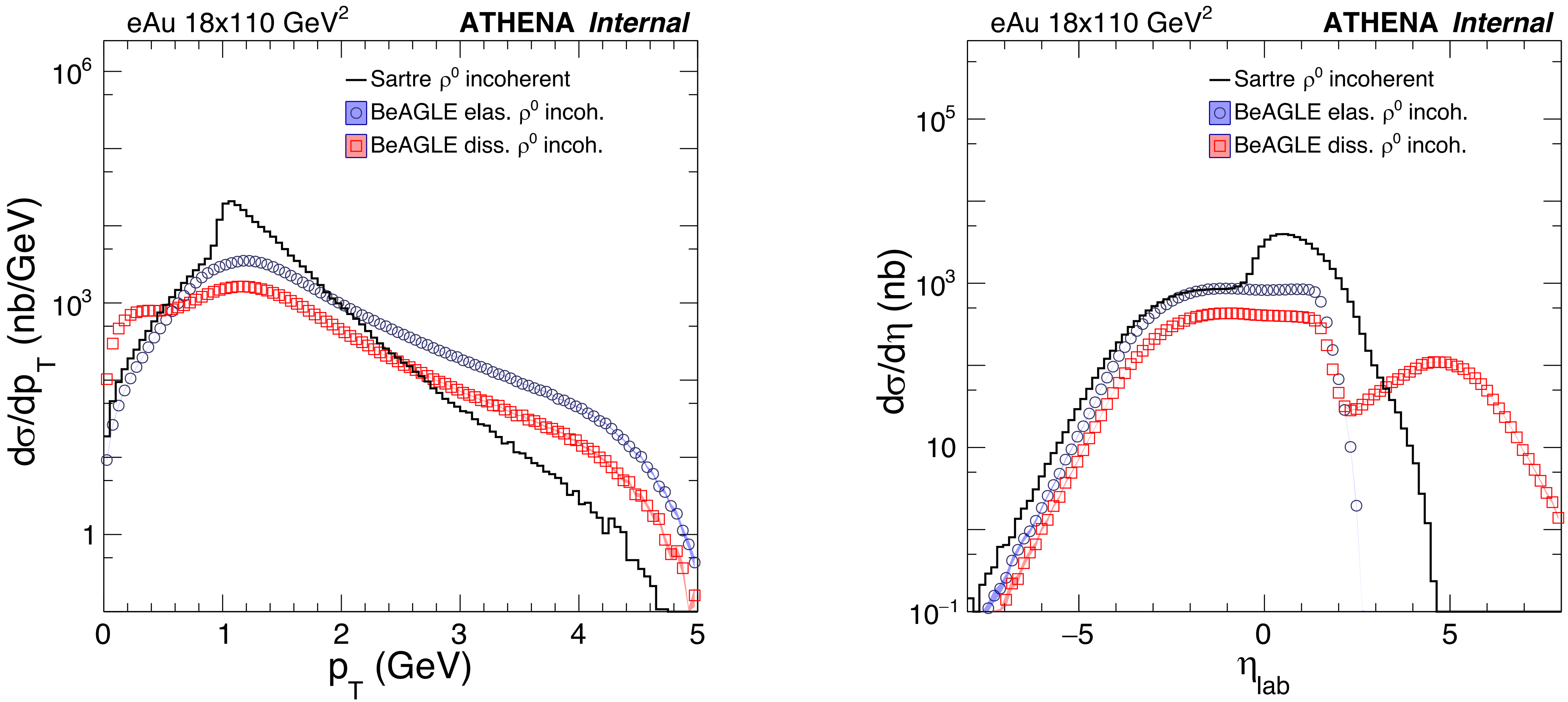
- Two MC models are cut on the same phase space,
  - $1<Q^2<20$ GeV^2
  - $1.95<W<89$ GeV
  - * daughter |eta| < 4.0

Sartre vs BeAGLE



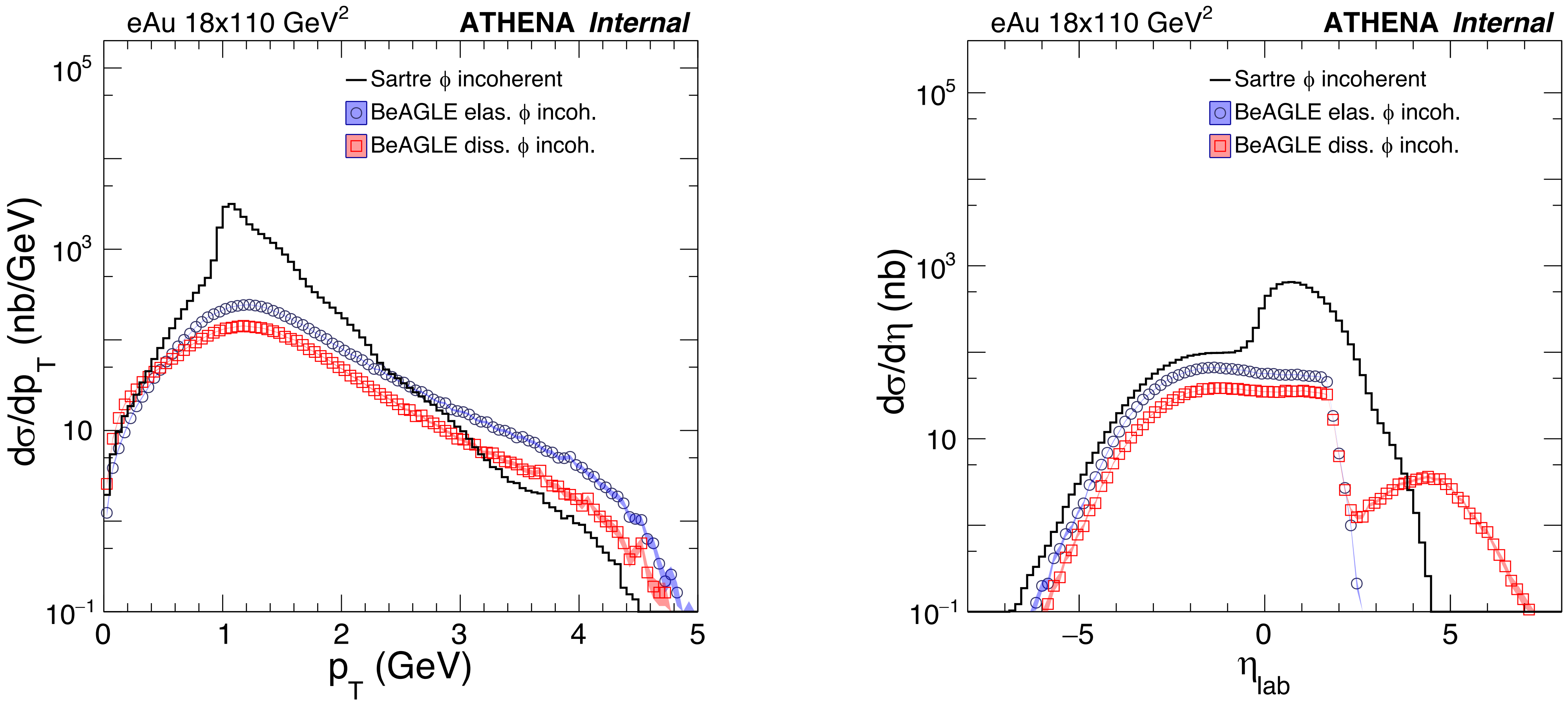
- Both models include photon flux. (similar formulism? See backup)
- Breakup mechanism very different. (see low t and later slides)
- BeAGLE assumes cross section ep/n * A
- Sartre without saturation

Sartre vs BeAGLE (incoherent) ρ^0 meson



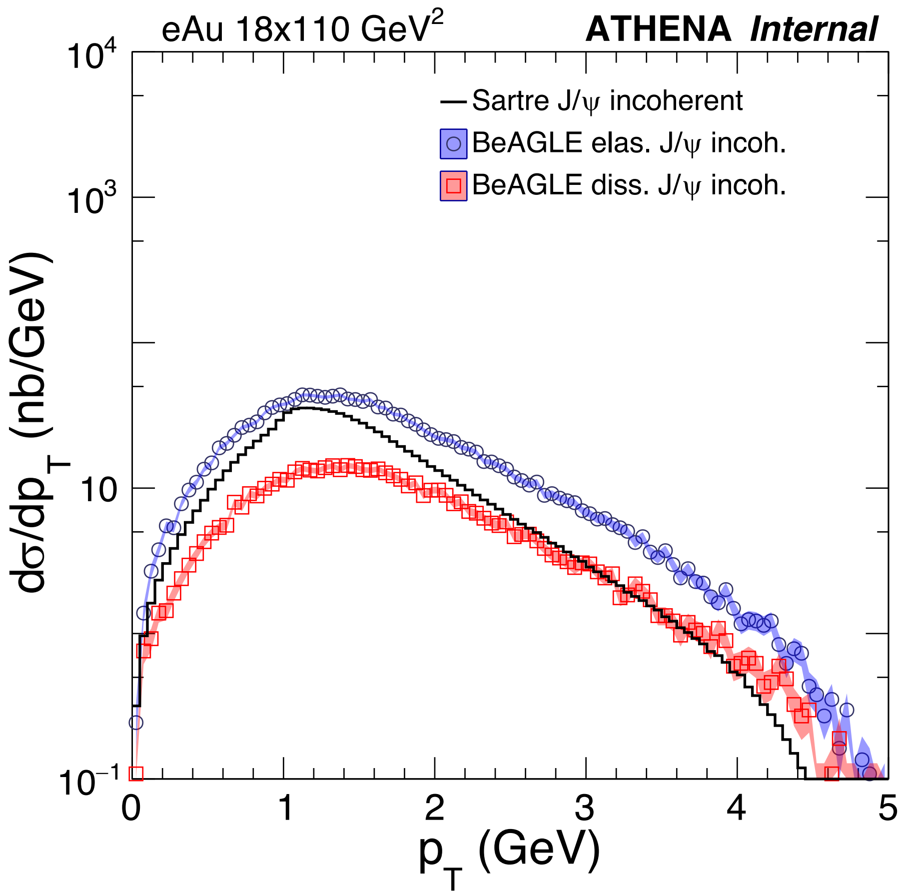
BeAGLE separates incoherent to elastic and dissociative (nucleon breakup)

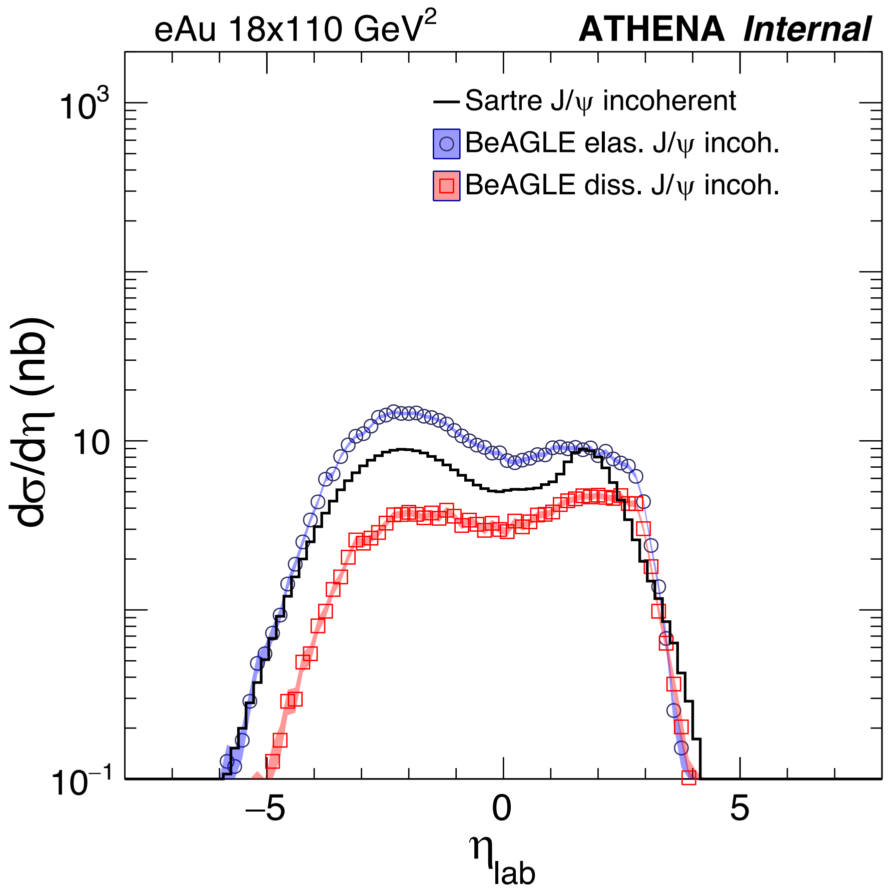
Sartre vs BeAGLE (incoherent) ϕ meson



BeAGLE separates incoherent to elastic and dissociative (nucleon breakup)

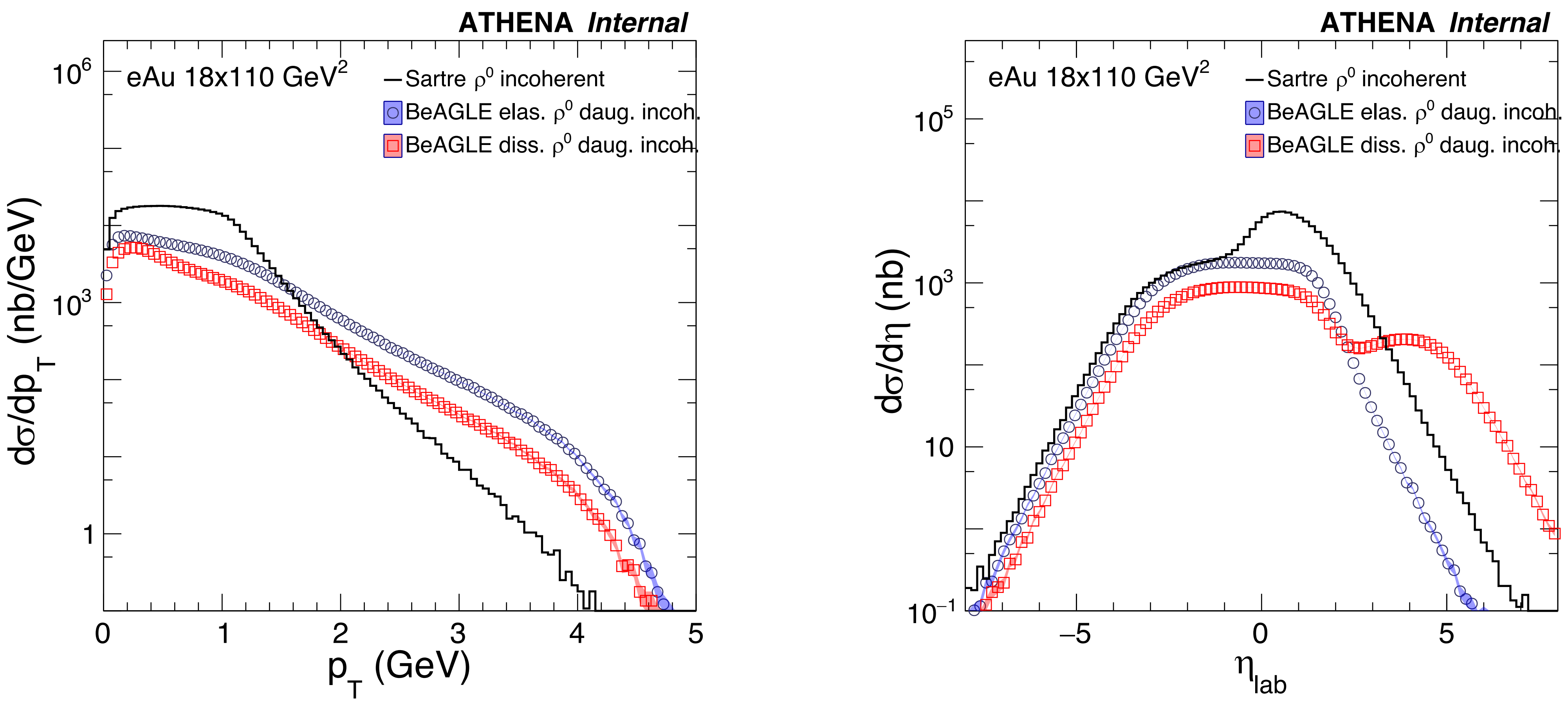
Sartre vs BeAGLE (incoherent) J/ψ meson





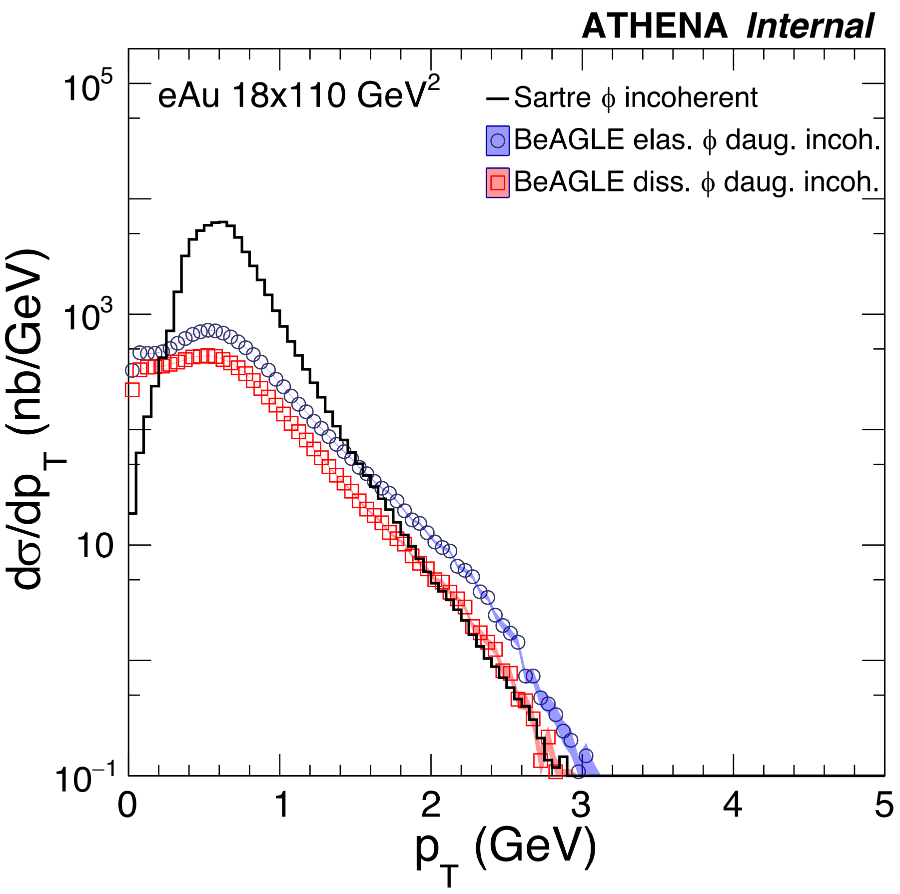
BeAGLE separates incoherent to elastic and dissociative (nucleon breakup)

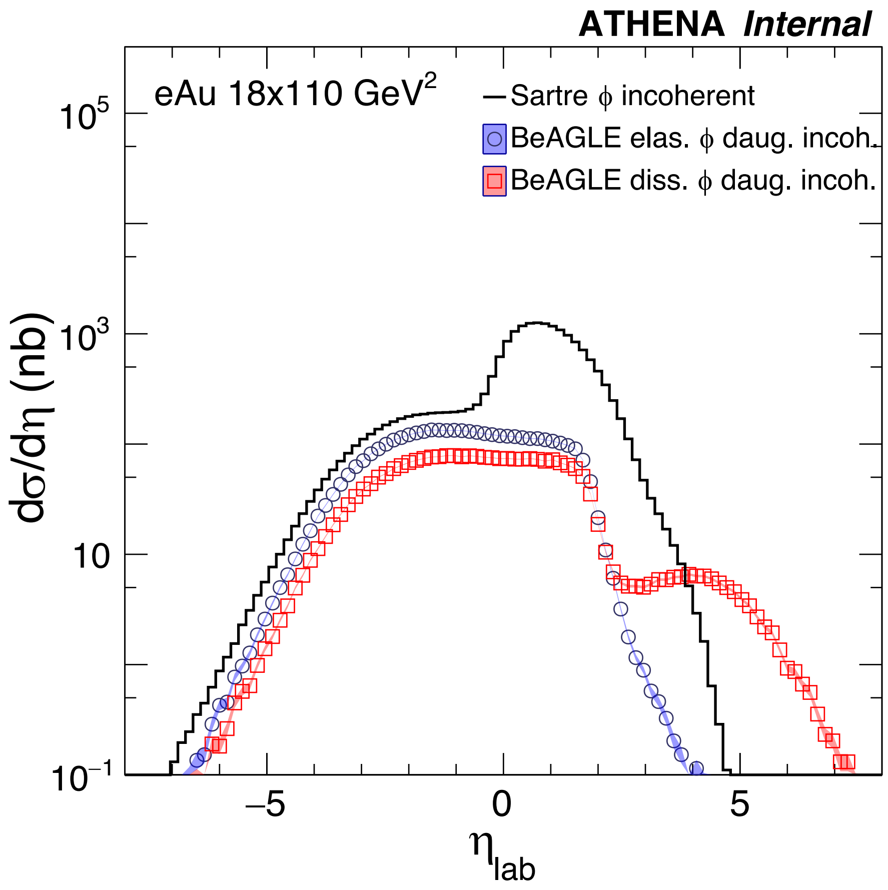
Sartre vs BeAGLE (incoherent) ρ^0 meson decay



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

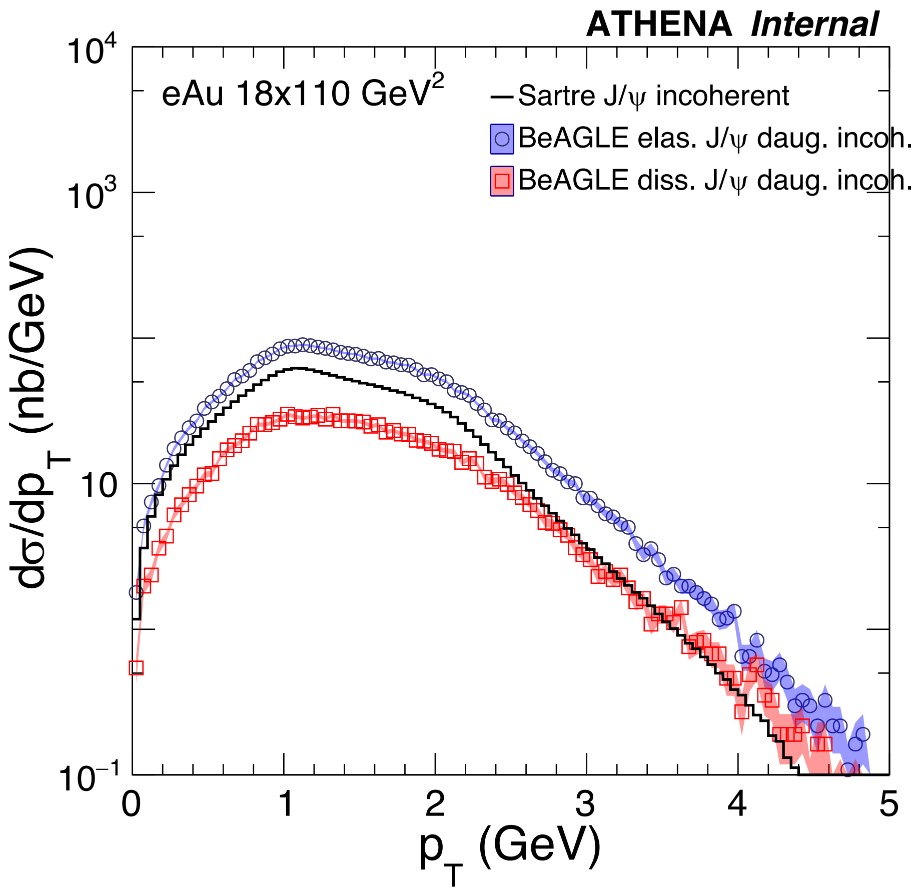
Sartre vs BeAGLE (incoherent) ϕ meson decay

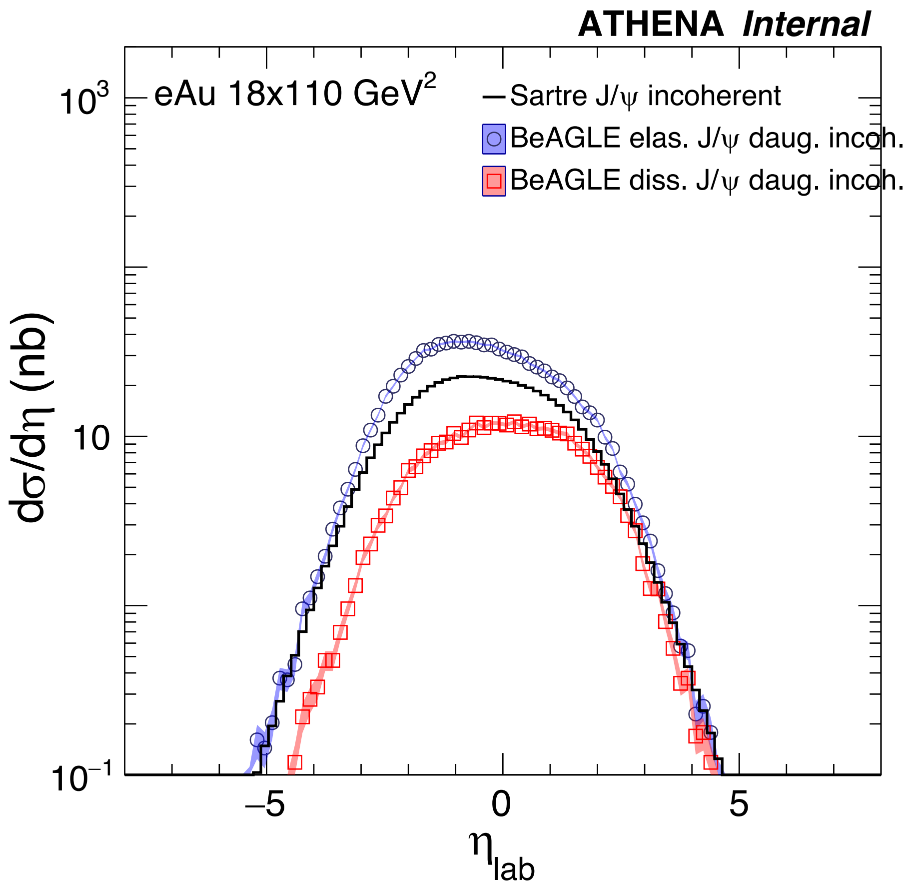




Decay is forced to be kaon in Sartre (BR~49.8%)

Sartre vs BeAGLE (incoherent) J/ψ meson decay

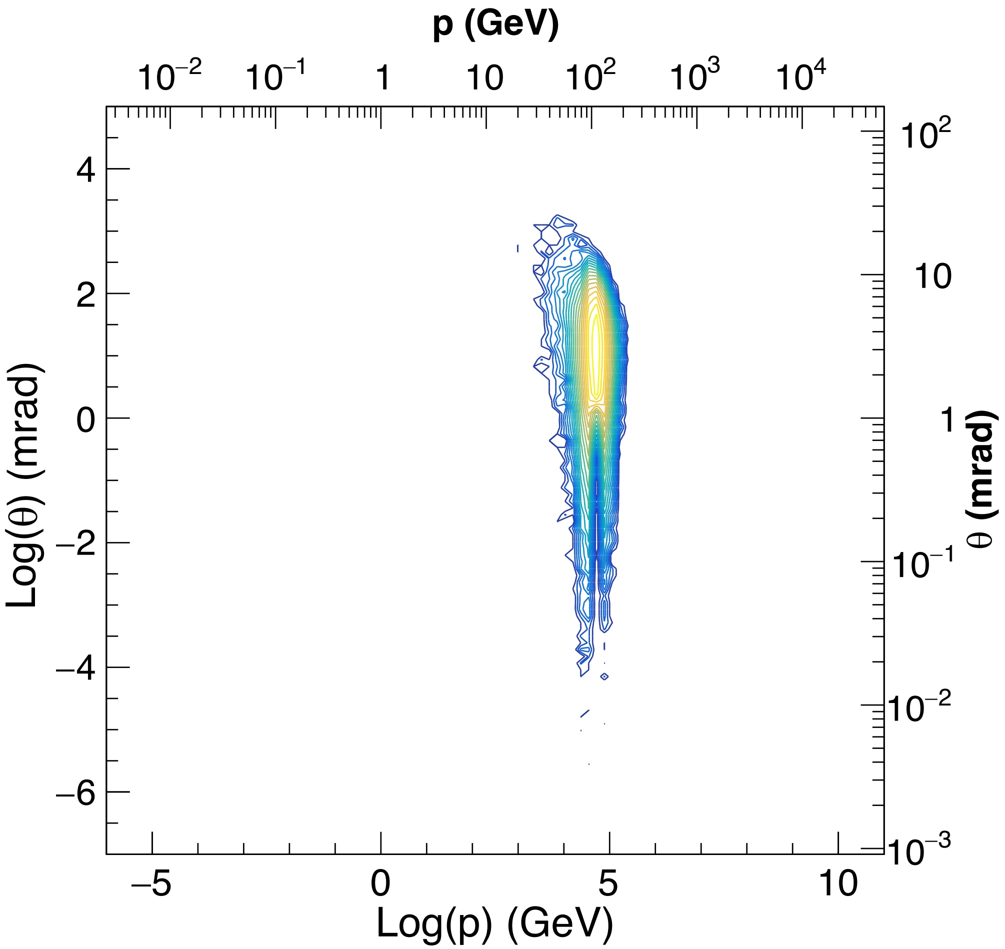




Decay is forced to be electron or muon, but only electrons selected. (BR~5.9%)

ρ^0 meson

- Breakup particles BeAGLE (incoherent)
- Separate them into protons, neutrons, photons, pions, kaons, electrons, muons, nuclei.



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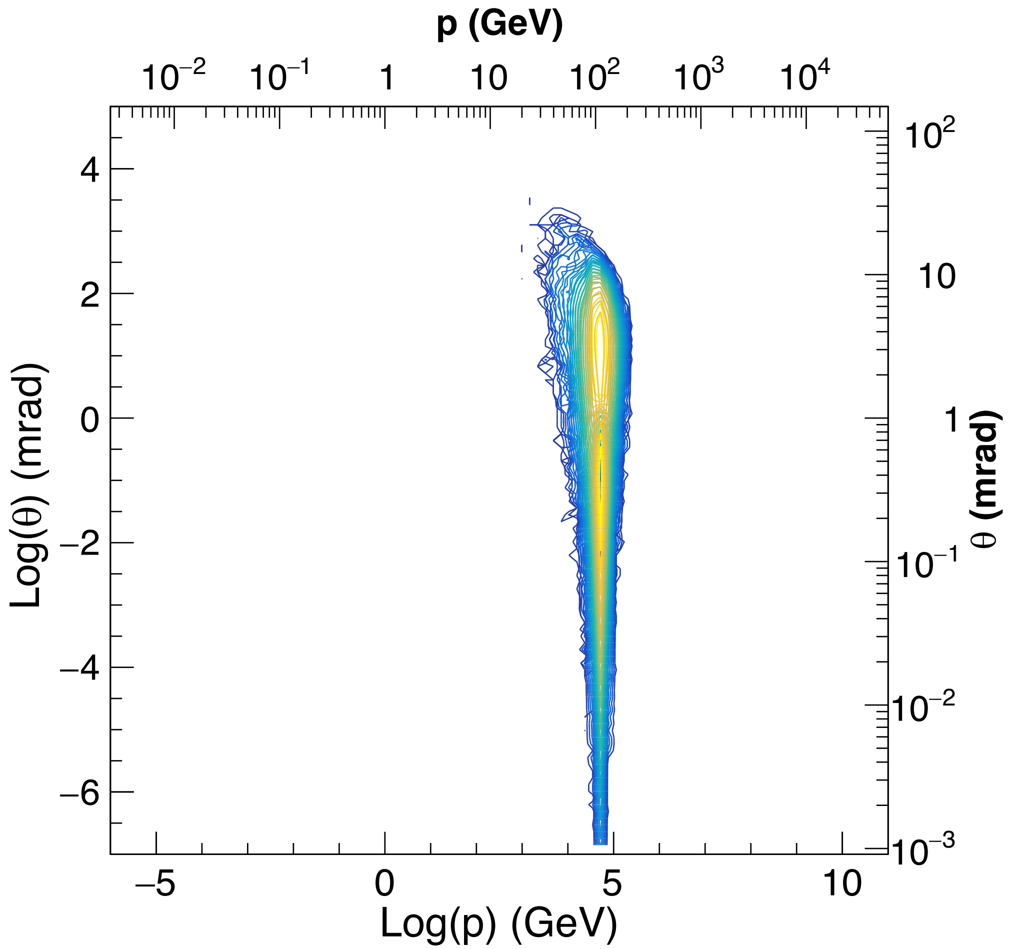

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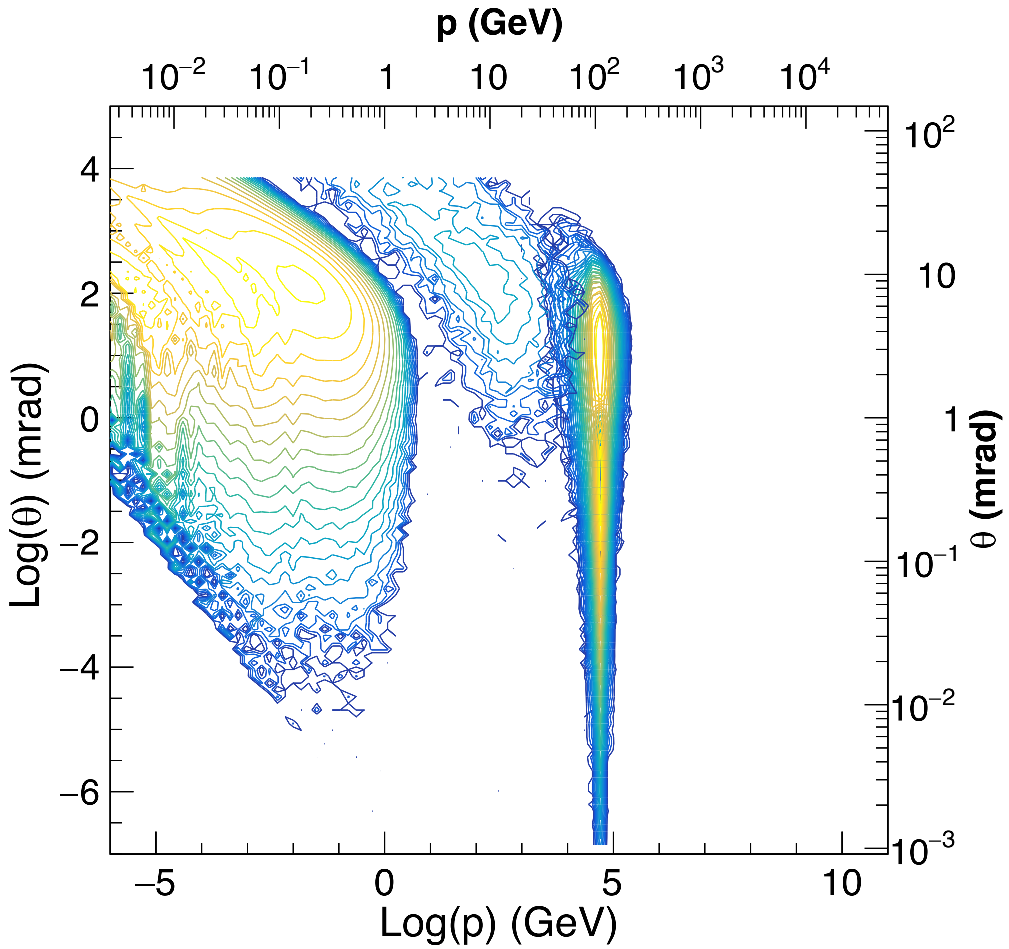

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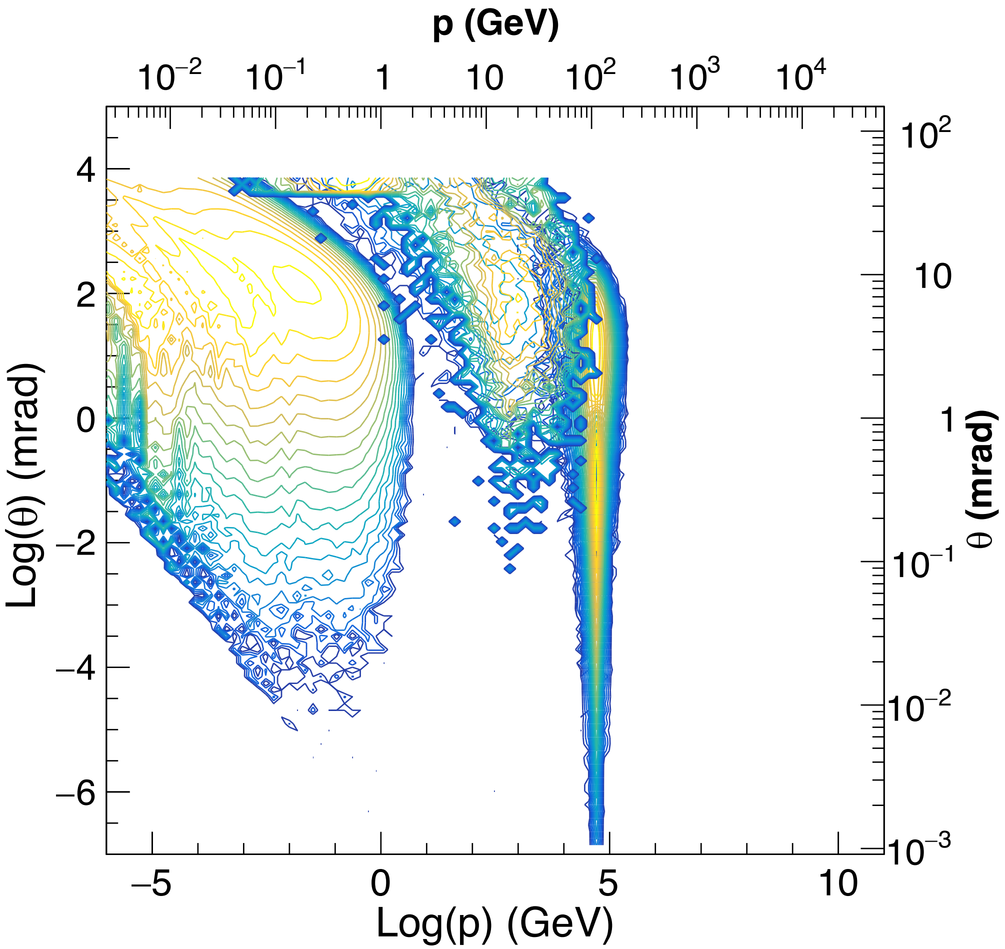

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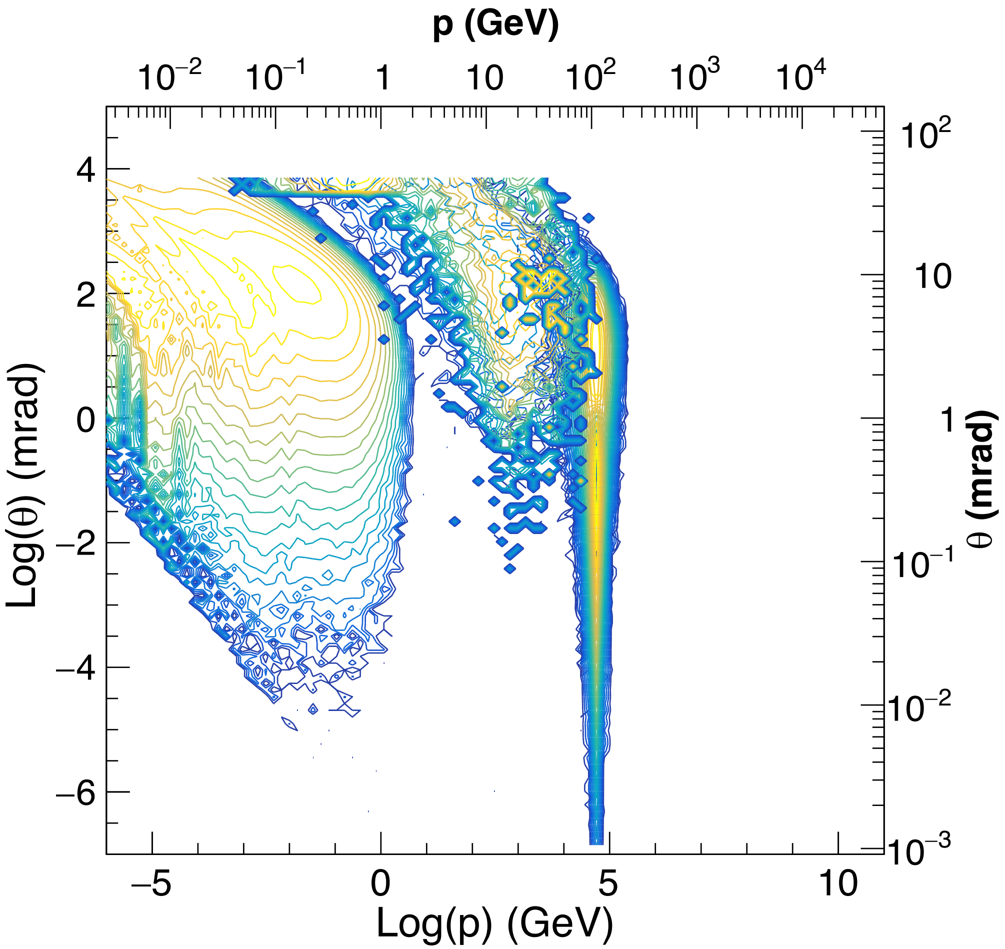

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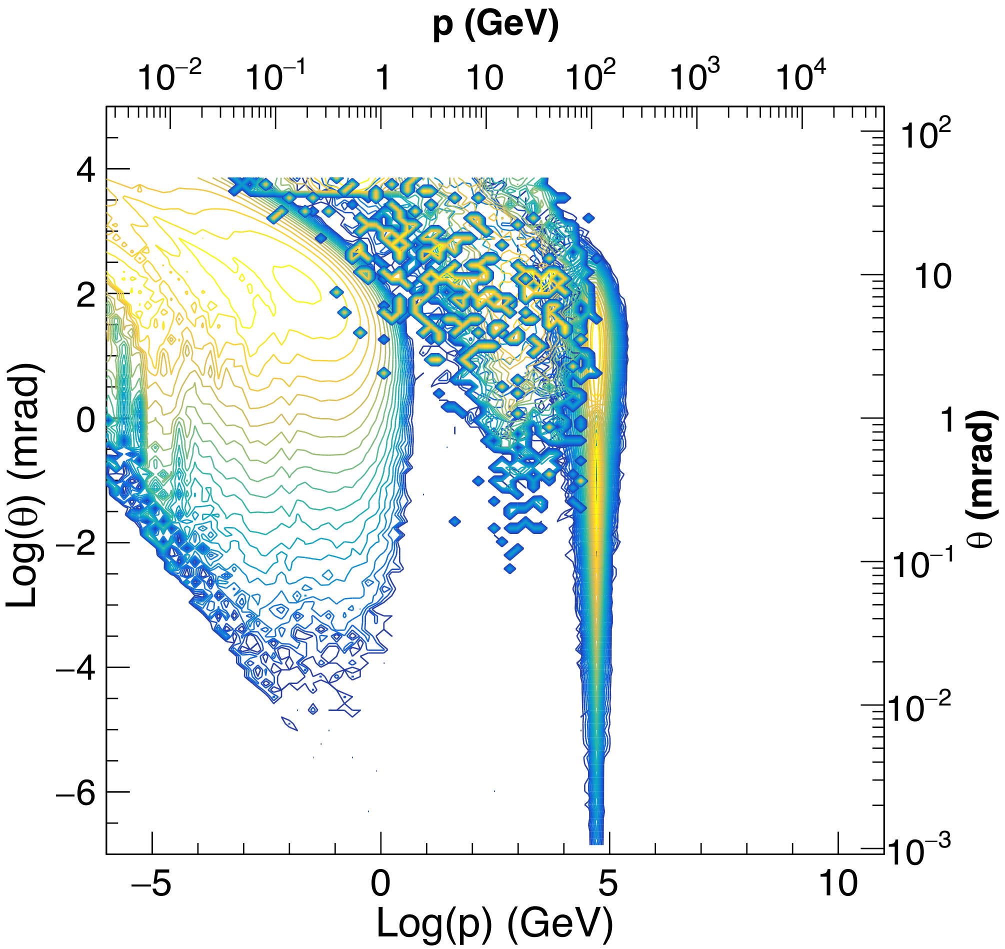

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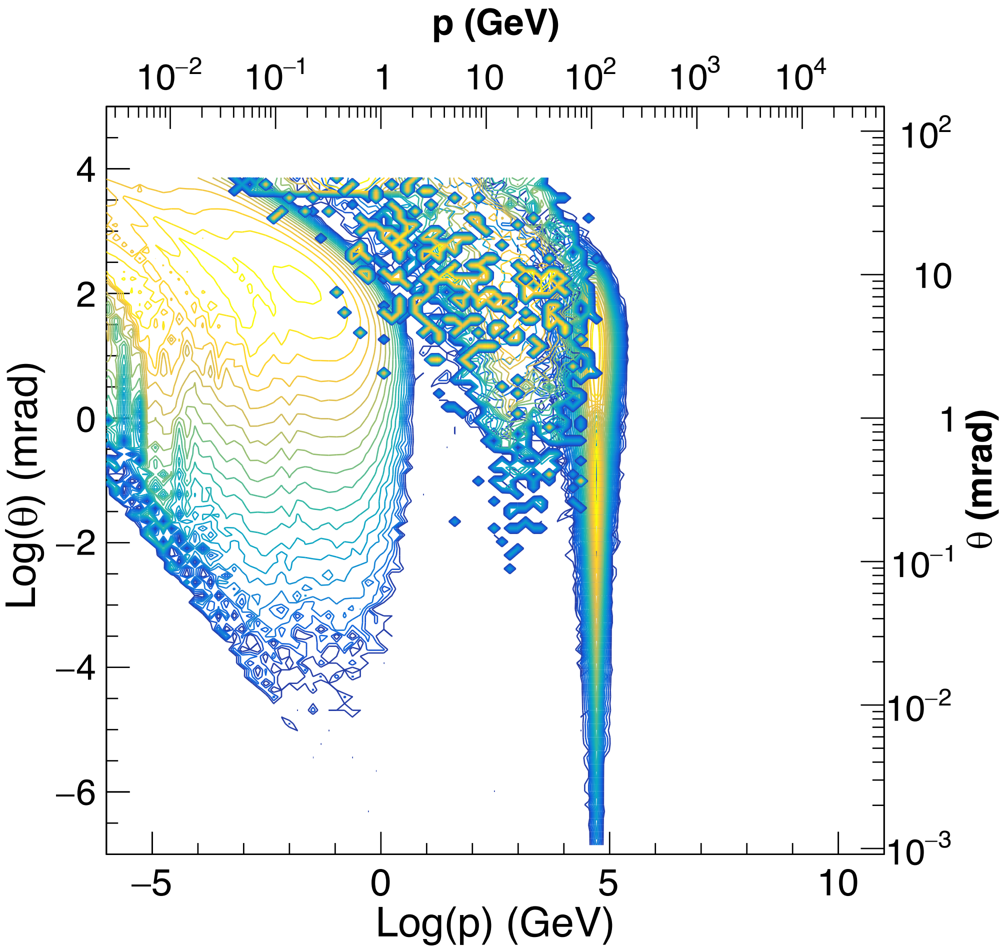

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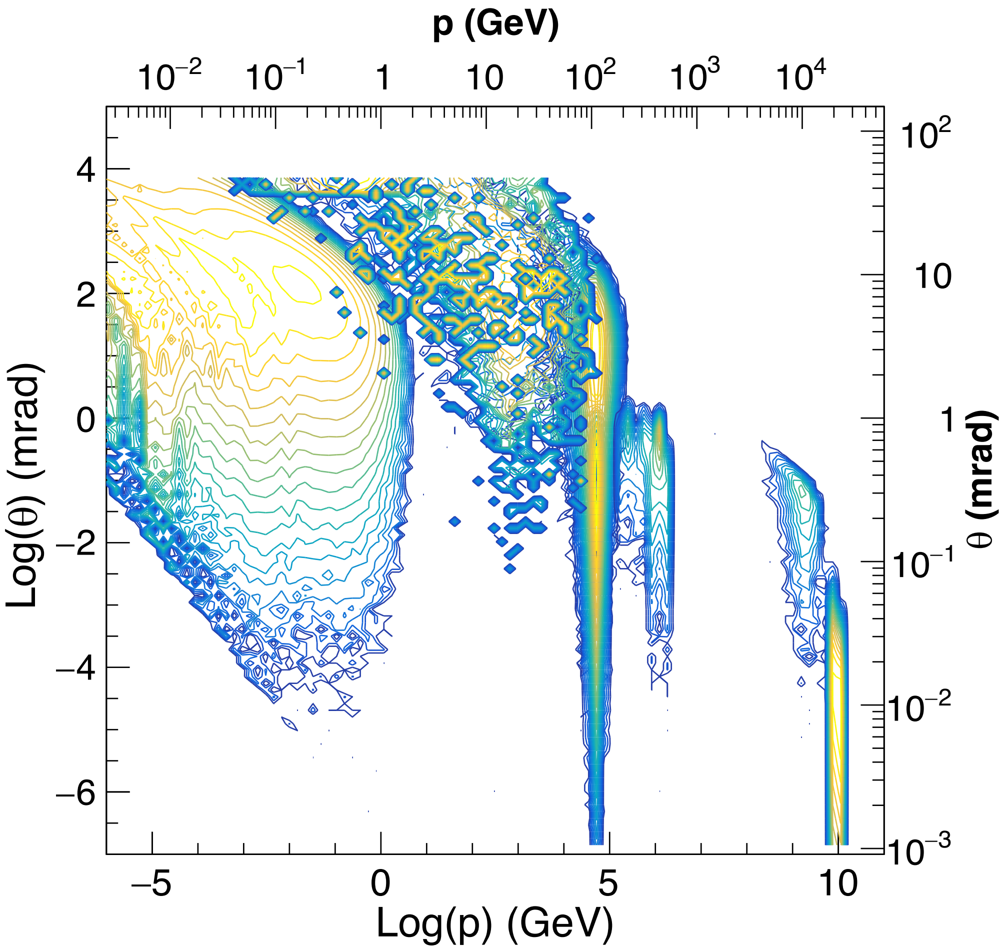

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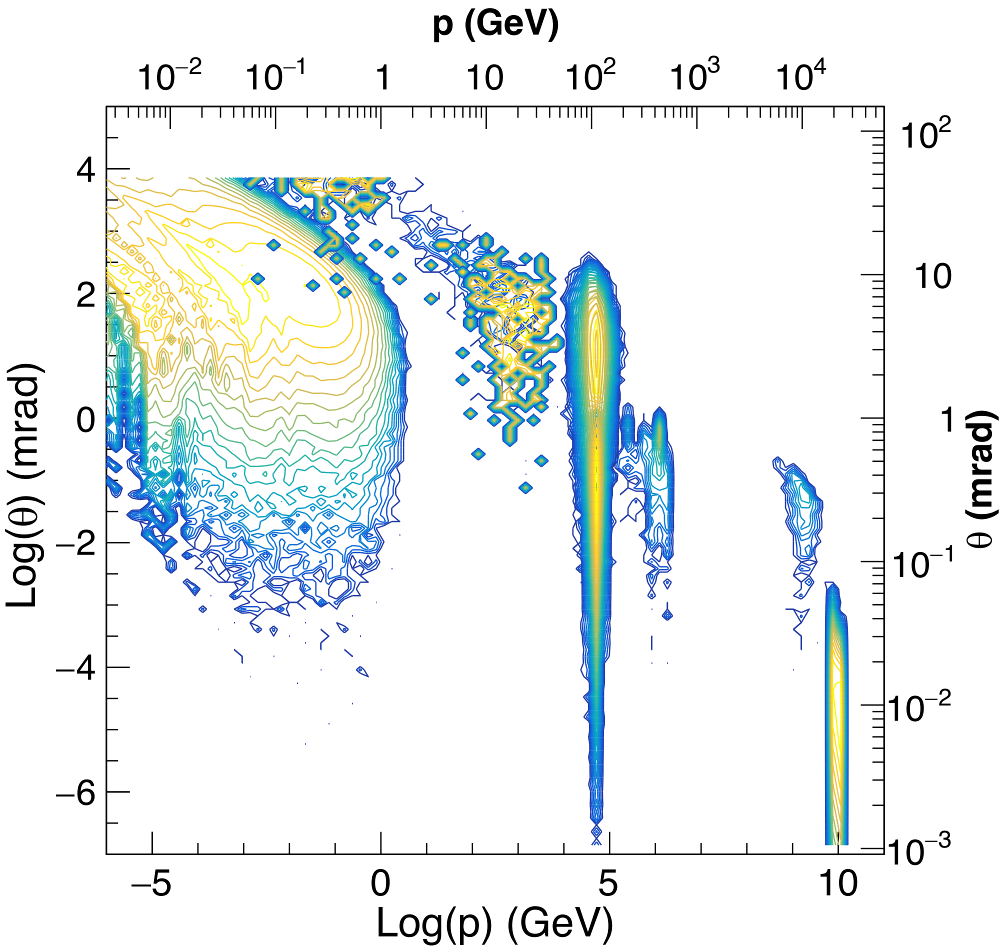

J/ψ meson

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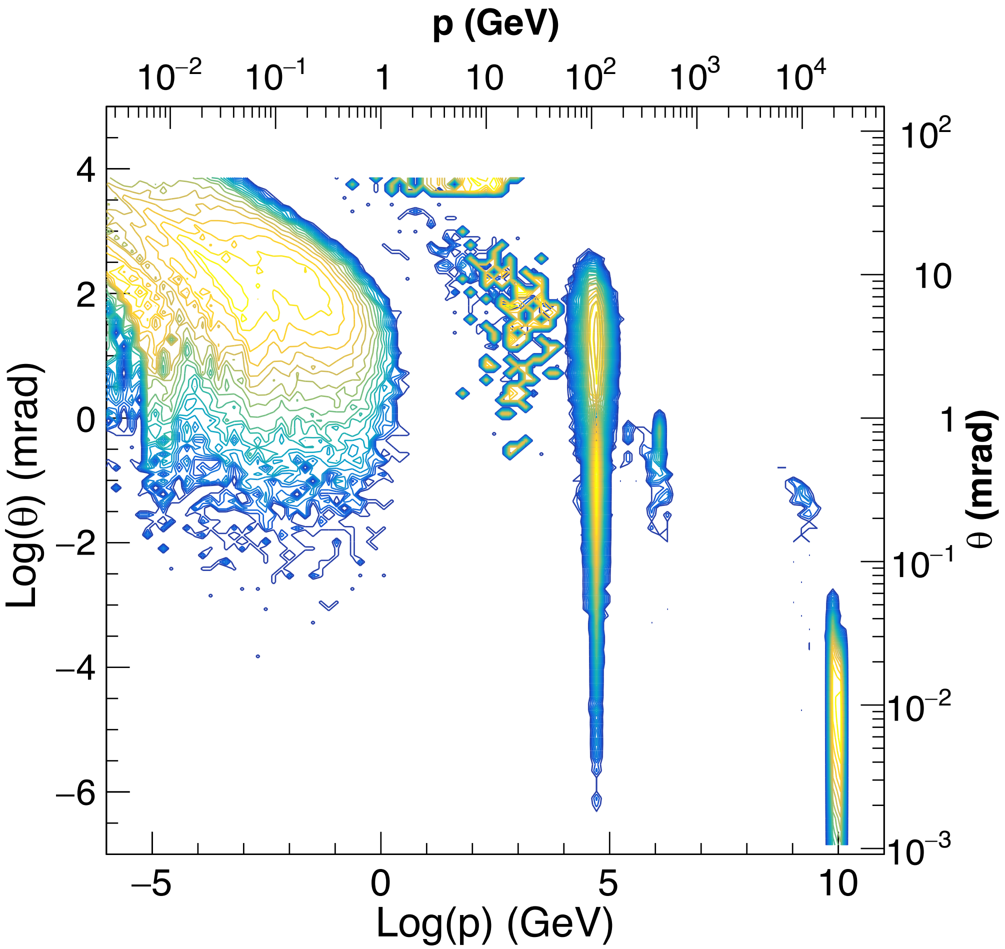

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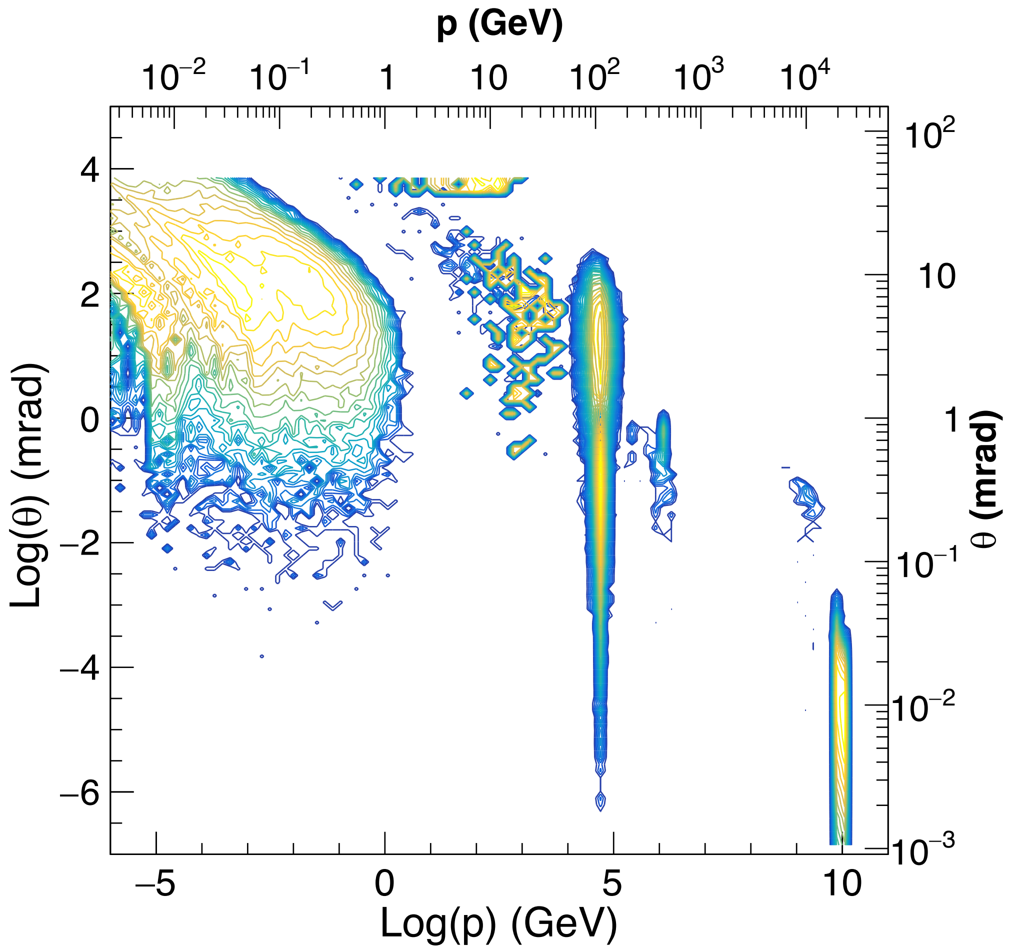


The FF region is very busy!

Veto on the *same* VM incoherent

arXiv:2108.01694
arXiv:2108.xxxxx

"Magnetic rigidity ratio"

Detectors	θ accep. (mrad)	ζ accep.
B0 tracker	[5.5, 20.0]	N/A
Off-Momentum	[0.0, 5.0]	0.45 - 0.65
Roman Pots	[0.0, 5.0]	0.7 - 0.95*
ZDC	[0.0, 4.5]	N/A

Table. 1

Toy vetoing algorithm based on Table. 1

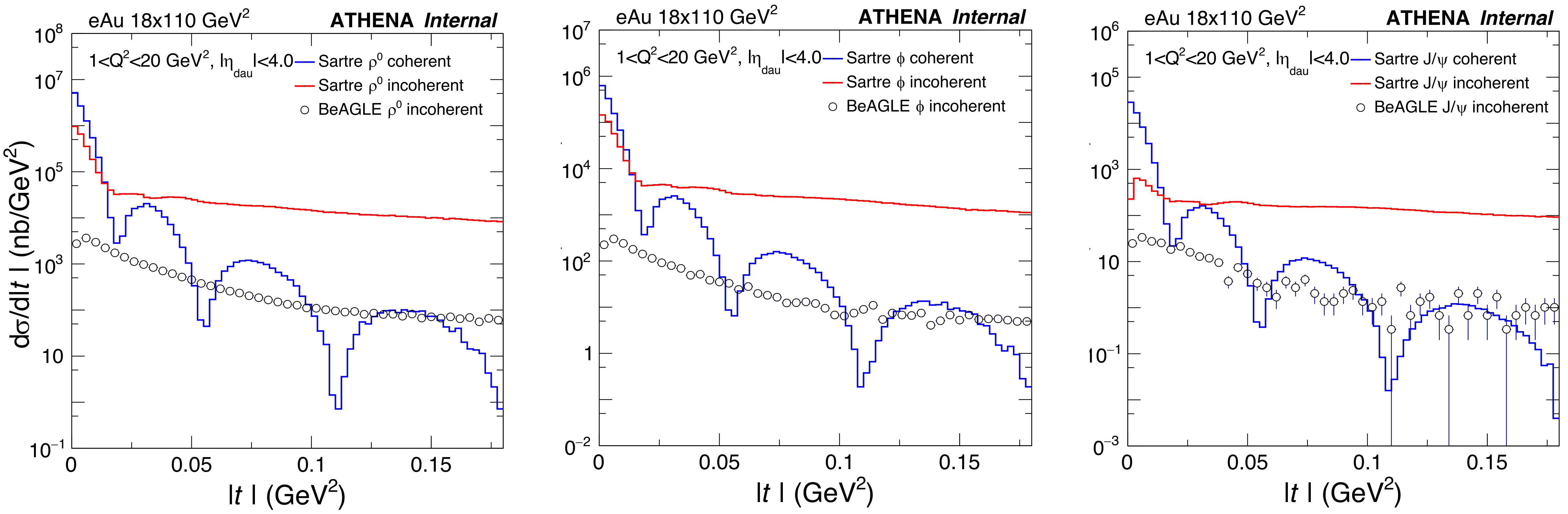
Veto conditions

1. Neutral particles > 50 MeV in ZDC or B0
2. Charged particles
   1. calculate the magnetic rigidity, e.g., [($M_{particle}$ /$M_{nucleon}$) / charge] ~ A/Z, and the ratio to 2.5 (Au~197./79)
   2. If it's between 0.45-0.65 or 0.7-0.95, and the theta < 5.0 mrad.

- ***NO beam pipe or inefficiency is assumed.***
- All these vetos are done independently of VM species.

The real simulations will be handled centrally at ATHENA
[we are building our expectations here…]

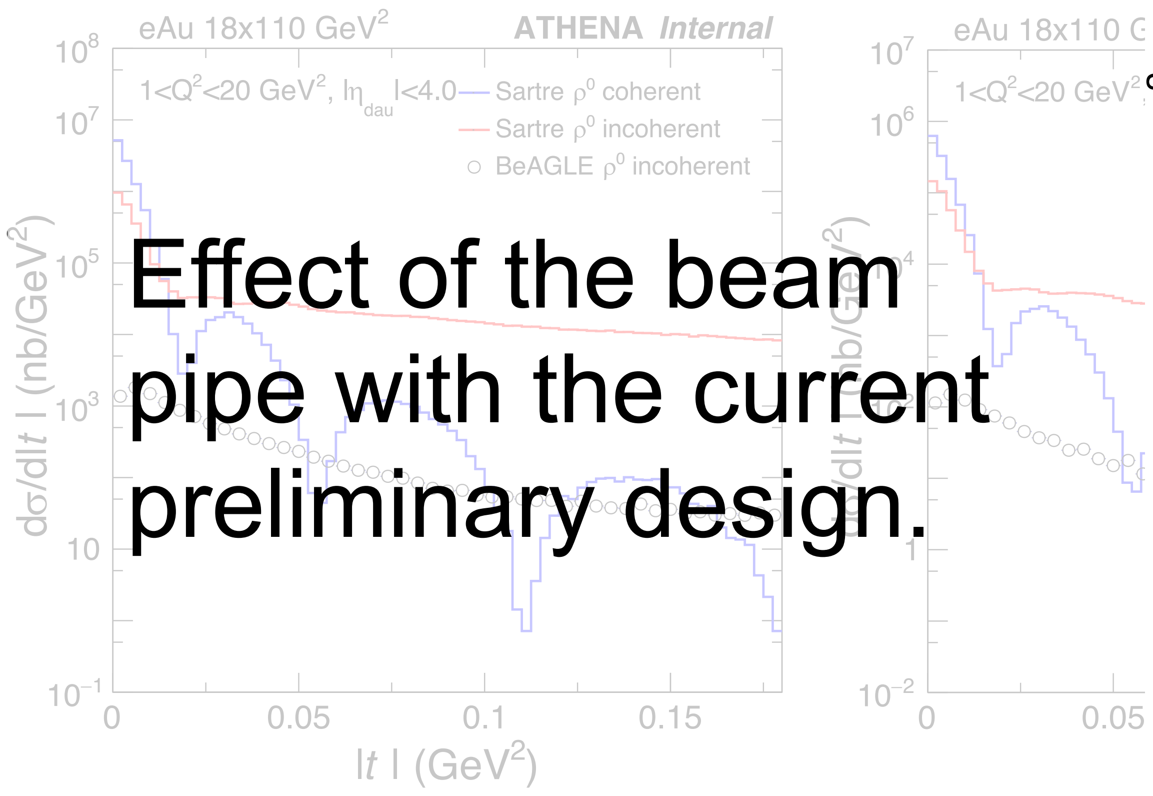
Sartre vs BeAGLE



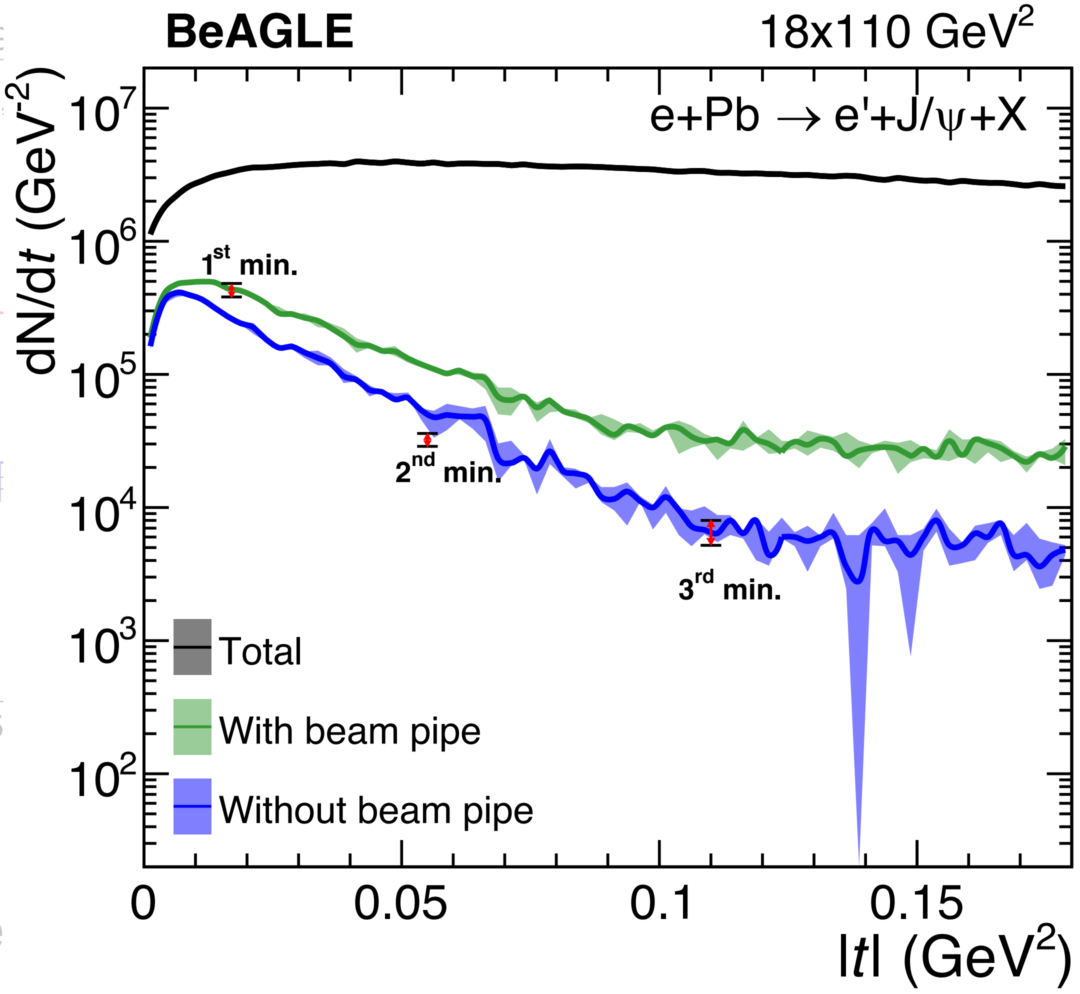
Remember, this is the ideal scenario, e.g., without beam pipes, etc…

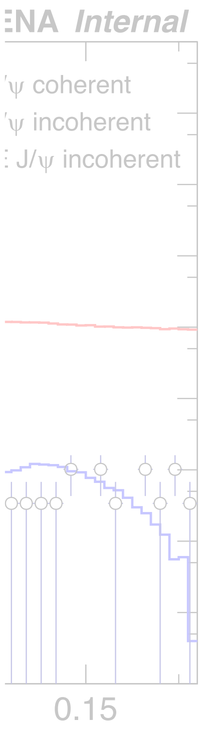
Sartre vs BeAGLE

arXiv:2108.01694, new paper



Effect of the beam pipe with the current preliminary design.





Remember, this is the ideal sce

ρ^0 meson

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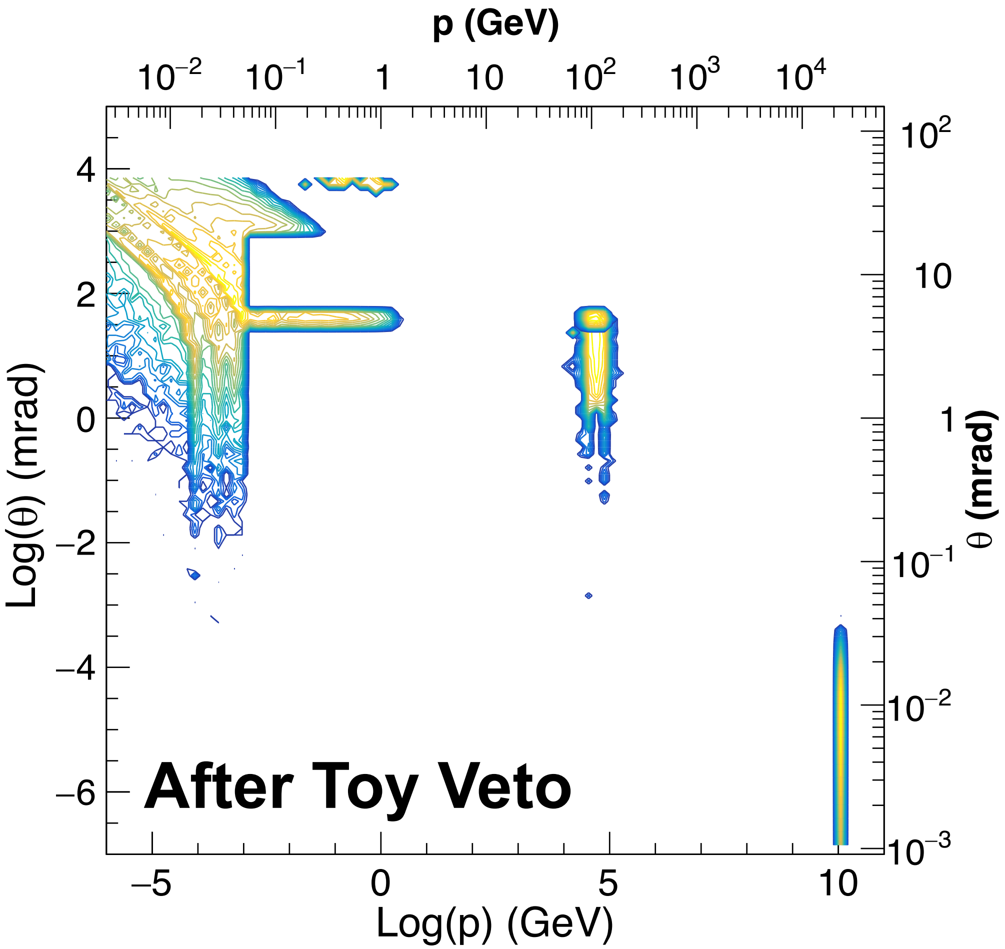

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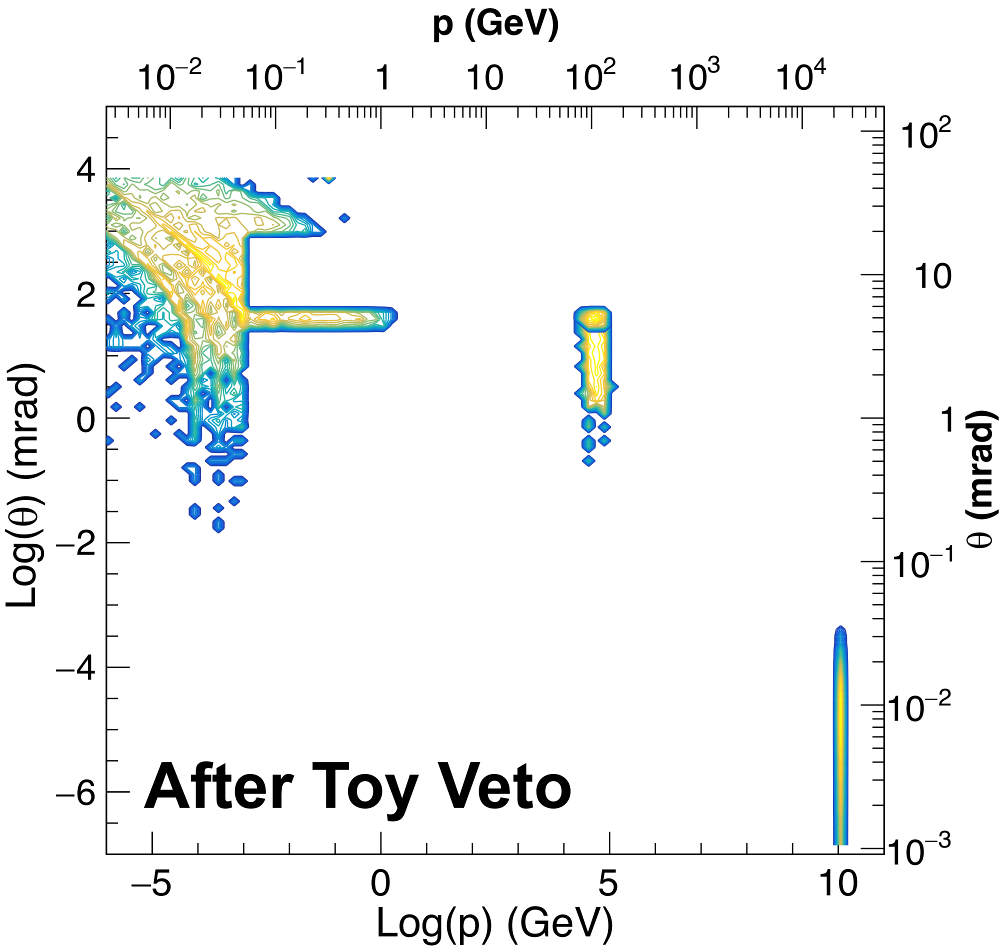

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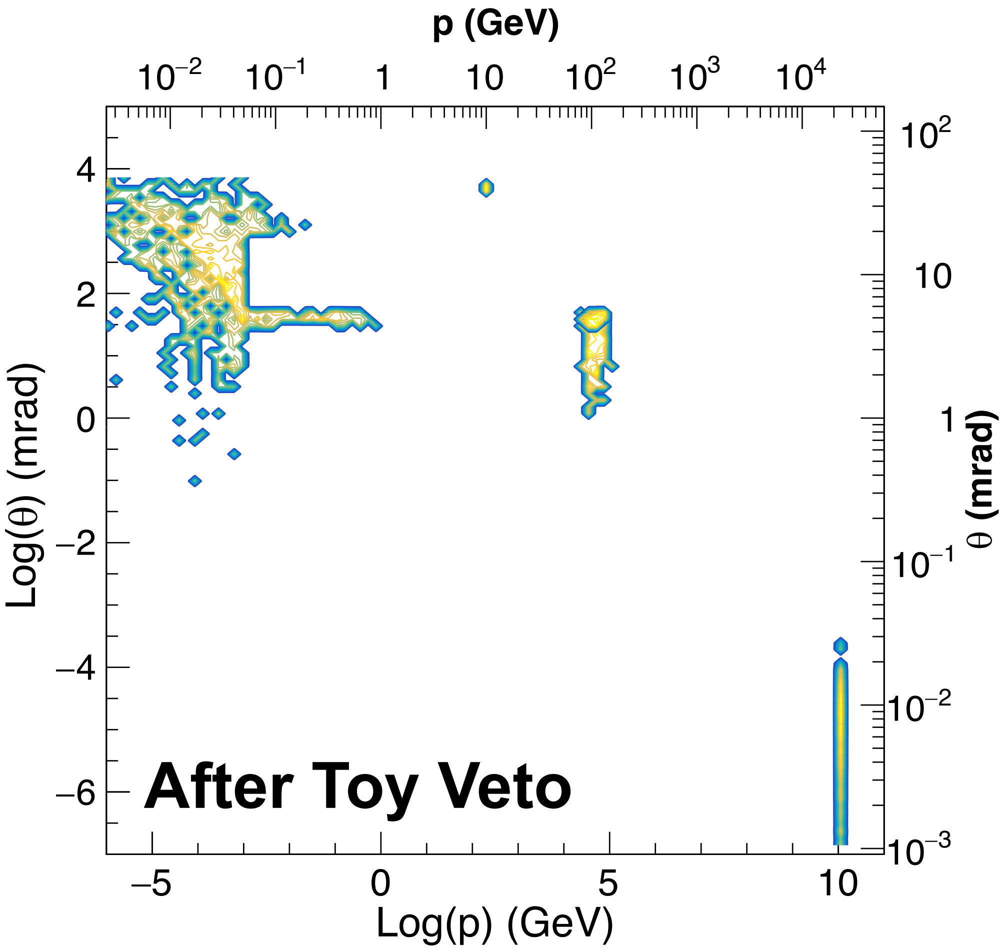


Summary and outlook

1. We should agree on (for now) using Sartre coherent VM + BeAGLE incoherent VM for the proposal. Independently, we should look at why the cross sections are different at low ***t***.
2. *Revisit all ***t*** reconstructions, esp in BeAGLE (incoherent.). Fermi motion?

3. We have only looked at one source of background among many. What we propose next are:
   a) Sartre coherent VM with decays, reconstruct VM mass, reconstruct ***t*** from e' and VM***, and derive dsigma/dt to compare with generated.*** This includes pions, kaons, and electrons final-states. *(Zhangbu et al. PID perspective, smearing, etc..)*
   b) Use the difference as a weight to properly weight BeAGLE *incoherent contributions* on t, after vetos, then combine...

4. Move to the next upper level of backgrounds, e.g., pair productions, diffractive DIS, DIS...

Backup

2. Strategy

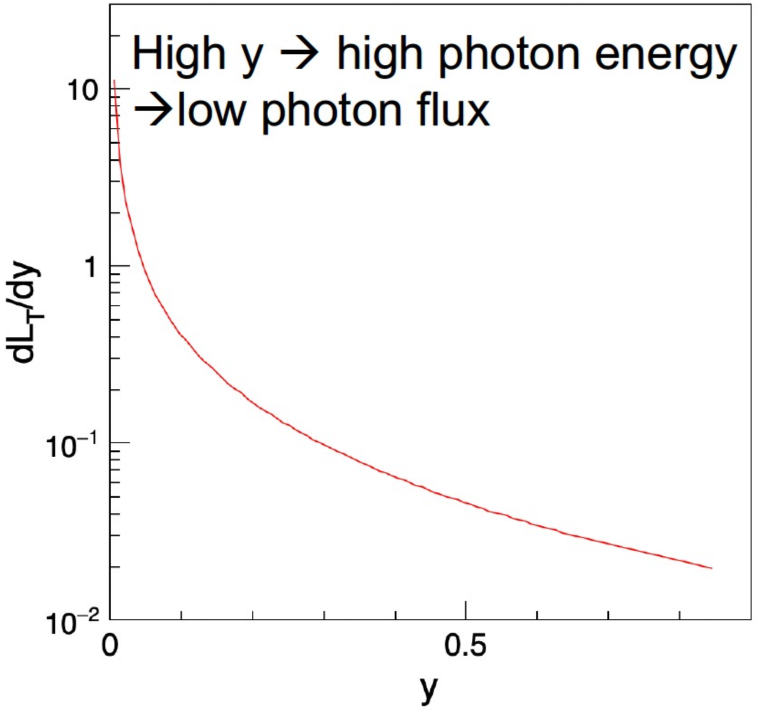
1. Have 3 VMs processes, and their relative cross sections ready. All goes to desired final-states, pipi, kk, and ee.
2. Smear momentum [ATHENA] with acceptance to all final-state particles, including e'.
3. Reconstruct ***t*** and M in a 2D histogram → ***t*** distribution for signal.

- 3* We need to mix all particles and then we try to distinguish them w/o PID.
- 3** [later] Add combinatorial backgrounds.
- 4. Treat incoherent the same way.
- 5. Look at full results.

[One of YR meetings]

Photon flux @ small Q2

$$\frac{dL_T}{dy} \approx \frac{\alpha}{2\pi}\left([1+(1-y)^2]\log\frac{(1-y)Q^2_{max}}{m_e^2y^2} - 2(1-y) + \frac{2m_e^2y^2}{Q^2_{max}}\right)$$

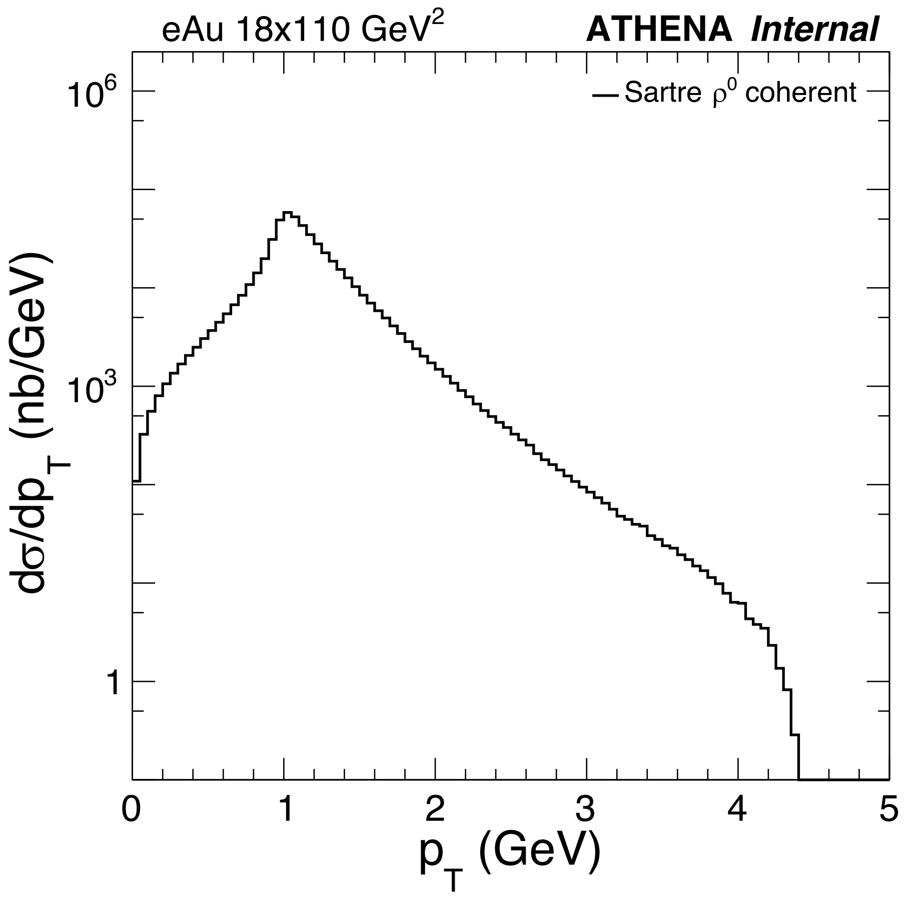


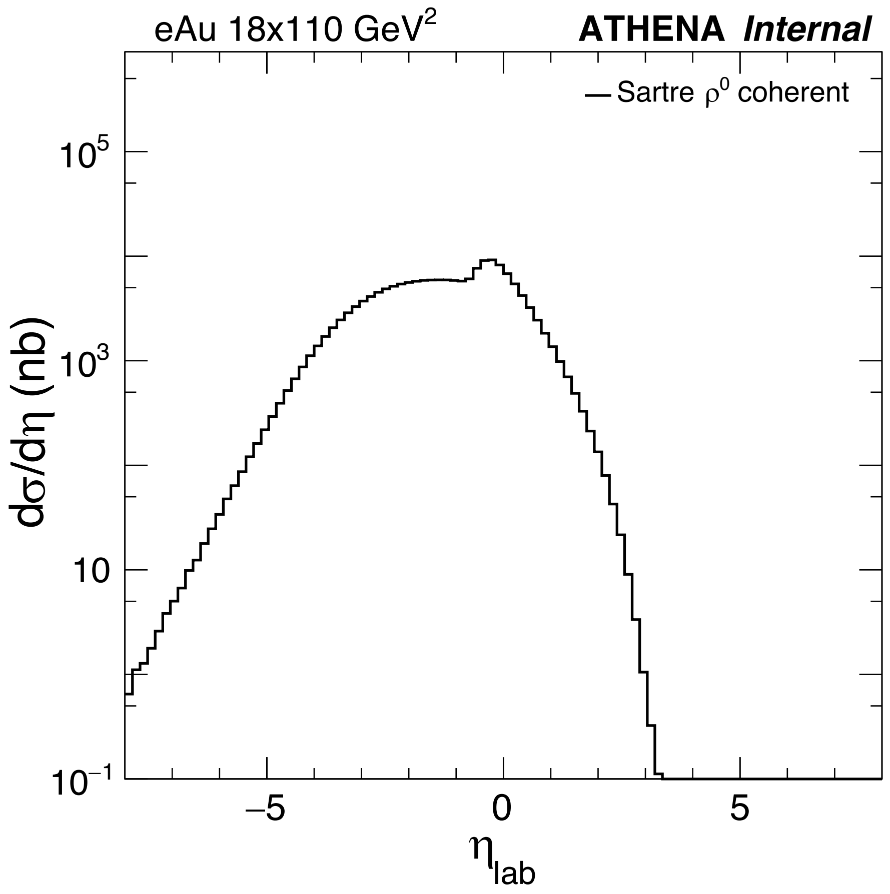
- For small Q2 limit, e.g., photoproduction limit, the energy difference of the electron (18 GeV vs 27 GeV) does not make a difference!

- For very small electron beam energy, when Q2 is not small compared to beam energy, this approximation breaks down. For the EIC energy, this approximation works well.

Photon flux determines the J/psi yield in the experiment, so as statistical precisions!

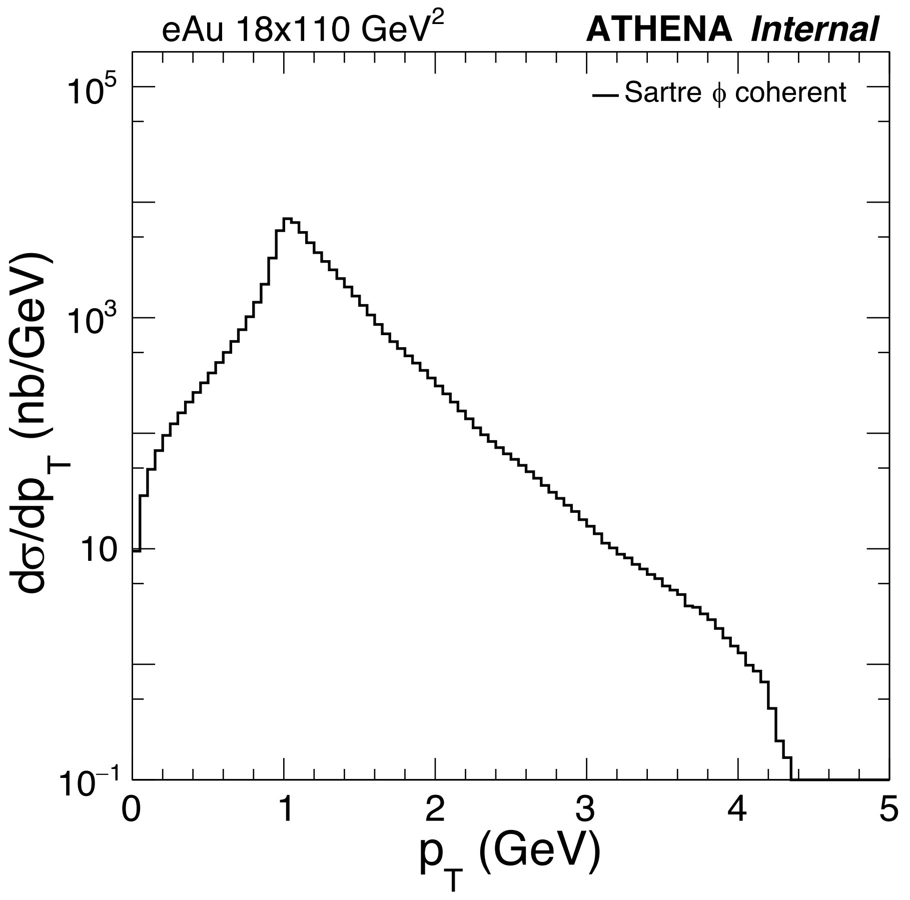
Sartre (coherent) ρ^0 meson

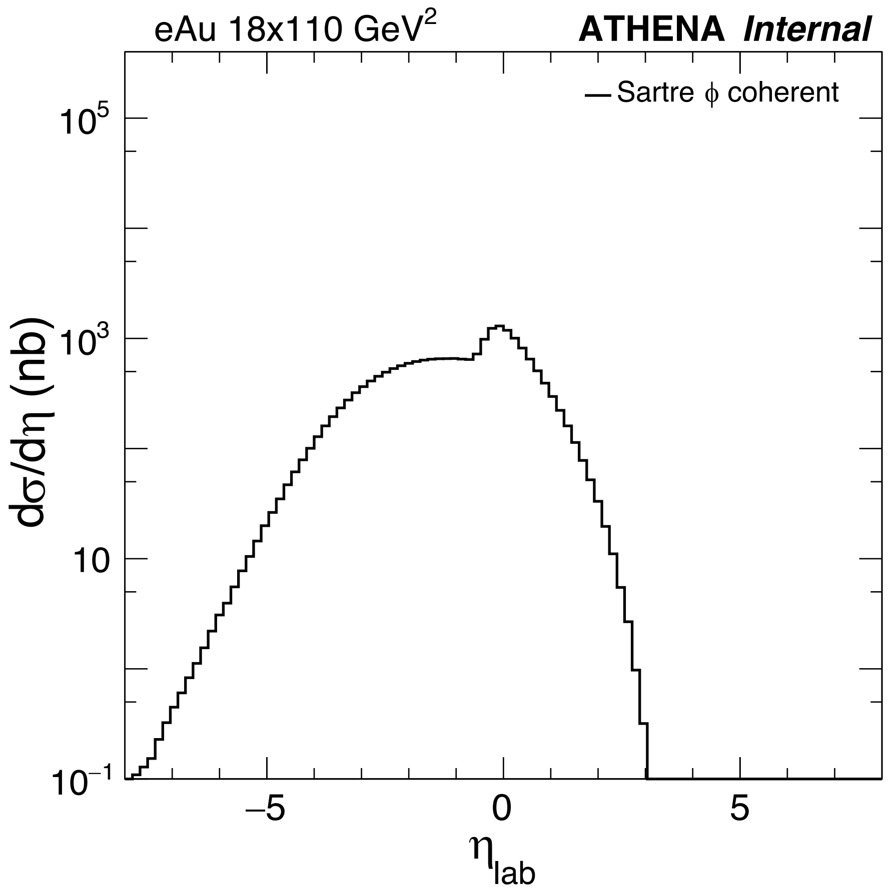




Sartre (coherent)

ϕ meson





Sartre (coherent)

J/ψ meson