Reconstruction of η mesons and dielectron spectra: progress report

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Outline

- Dielectrons:
  - ✓ PHSD vs. UrQMD for dielectron input
  - ✓ new Monte Carlo request and expected results
- Reconstruction of η mesons with embedded simulations

(Di)electrons

Simulated signals for dielectron studies

- Results of dielectron studies depend on the simulated signals

i	Dilepton channels	
1	Dalitz decay of π^0:	$\pi^0 \to \gamma e^+ e^-$
2	Dalitz decay of η:	$\eta \to \gamma l^+ l^-$
3	Dalitz decay of ω:	$\omega \to \pi^0 l^+ l^-$
4	Dalitz decay of Δ:	$\Delta \to N l^+ l^-$
5	Direct decay of ω:	$\omega \to l^+ l^-$
6	Direct decay of ρ:	$\rho \to l^+ l^-$
7	Direct decay of ϕ:	$\phi \to l^+ l^-$
8	Direct decay of J/Ψ:	$J/\Psi \to l^+ l^-$
9	Direct decay of Ψ':	$\Psi' \to l^+ l^-$
10	Dalitz decay of η':	$\eta' \to \gamma l^+ l^-$
11	pn bremsstrahlung:	$pn \to pnl^+ l^-$
12	$\pi^\pm N$ bremsstrahlung:	$\pi^\pm N \to \pi N l^+ l^-$

- The main hadronic contributors are decays of π^0 and η:
  - ✓ direct contamination by e^+e^- pairs from Dalitz decays
  - ✓ main sources of photons → control conversion conversion
- Most of event generators are consistent for π^0 and η yields within ± 20%
  → can not count on anything better
- Kinematics of Dalitz decays and (hopefully) conversion is mostly under control

Simulated signals for dielectron studies

- Situation with predictions for LVMs and heavier hadrons is much more complicated:
  - ✓ predictions of event generators for these particles significantly differ from each other
  - ✓ there is no simple way to extract LVM/h $\rightarrow$ ee yields from the event generators
    - o particles are decayed in hadronic channels, low-BR decays are ignored
    - o if particles are forced to be stable their yields are strongly over predicted due to hadron recombination in the hadronic phase, which is not compensated by hadron rescattering (by up to a factor of 10 for ρ in UrQMD)

- There is only a small number of event generators, which are suitable for simulation of di-electron signals:
  - ✓ UrQMD with reweighting and extra steps/efforts
  - ✓ PHSD as a guideline for the simulated signals, M_{ee} continuum which can not be injected directly
  - ✓ PLUTO: ???, input from Sudhir
  - ✓ private input ???

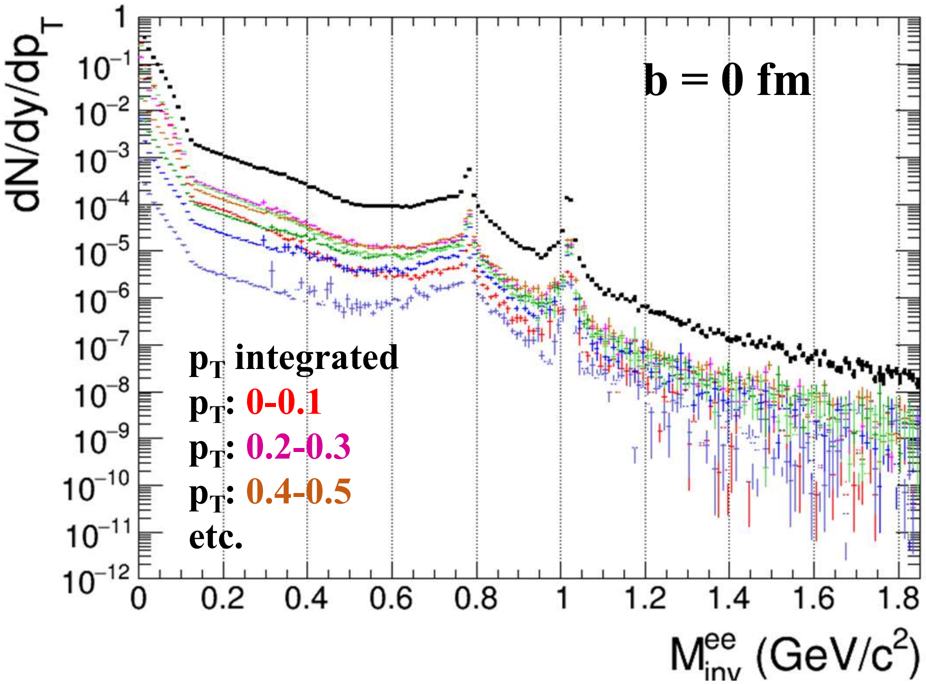
UrQMD and PHSD

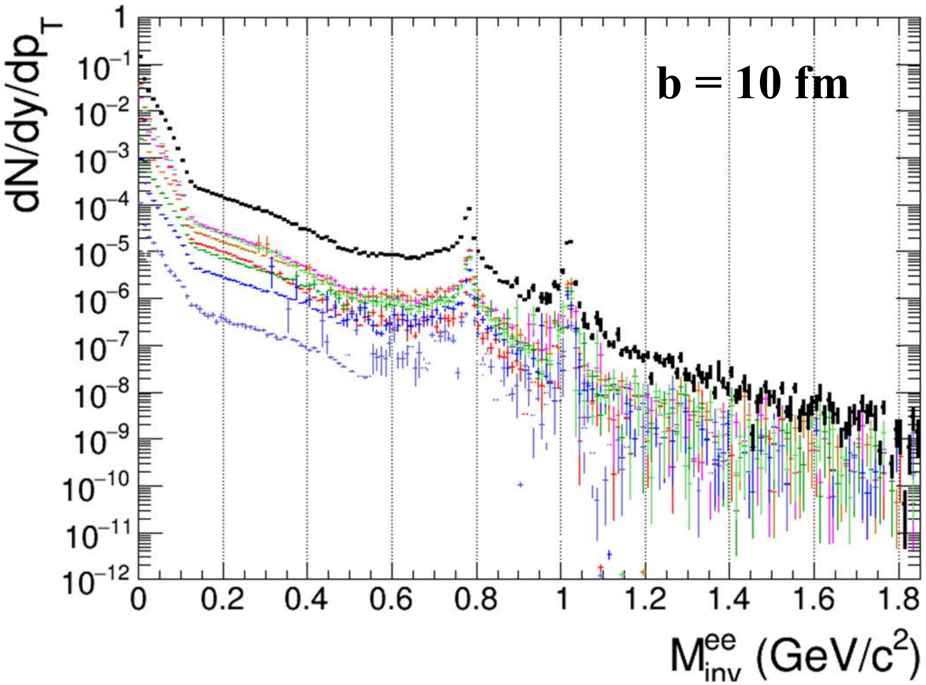
- We have seen what UrQMD has to offer for dielectron signals. Very convenient but reliability of simulations is questionable and depends on the scheme used (no direct use is possible for dielectrons)

- PHSD:
  - ✓ generates background, decays hadrons in the main decay channels and ignores low-BR decays → very similar to UrQMD
  - ✓ predictions for π^0 and η yields vs. p_T and rapidity are consistent with UrQMD
  - ✓ unlike UrQMD, the PHSD has an option to generate M_{ee} continuum alone (with no background) as a sum of all possible contributions
  - ✓ generated M_{ee} continuum can not be directly injected for tracking but it can be used to reweight the UrQMD input

PHSD

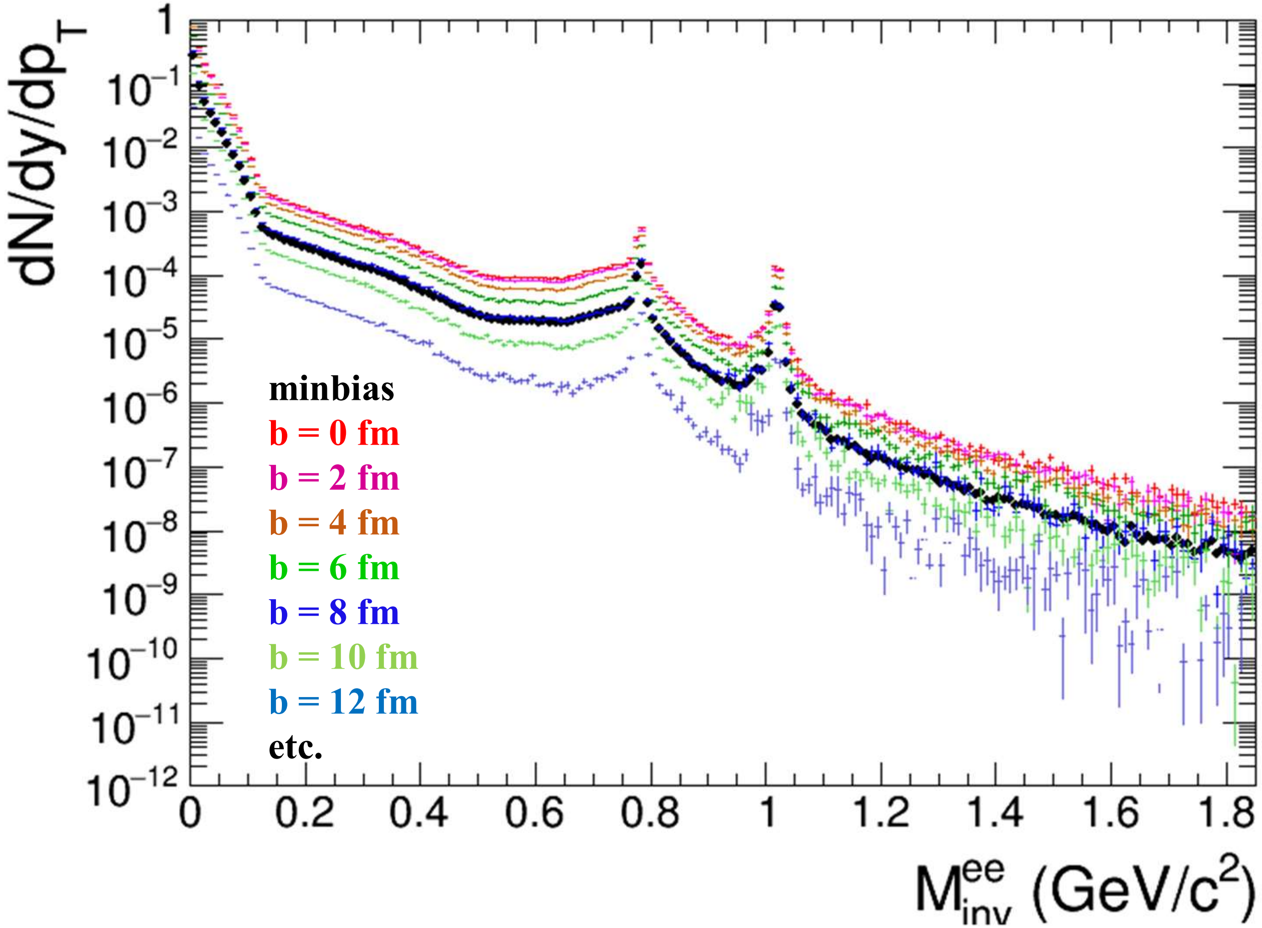
- PHSD prints out the simulated M_{ee} continuum spectra in huge 50+ Mb ASCII files
- Yield (total and for each contribution) as a function of p_T, y and mass with fine binning; differential for different values of impact parameter
- Some reprocessing & averaging of the data points is needed in order to compile a needed M_{ee} spectrum
- Examples for AuAu@11: p_T integration at $|y| < 0.5$ for different impact parameter values





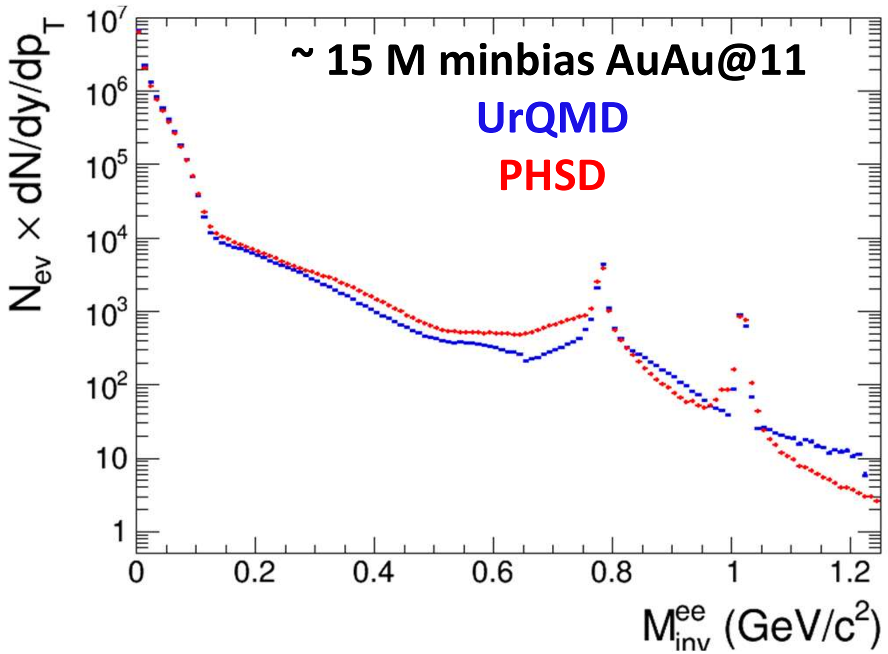
PHSD

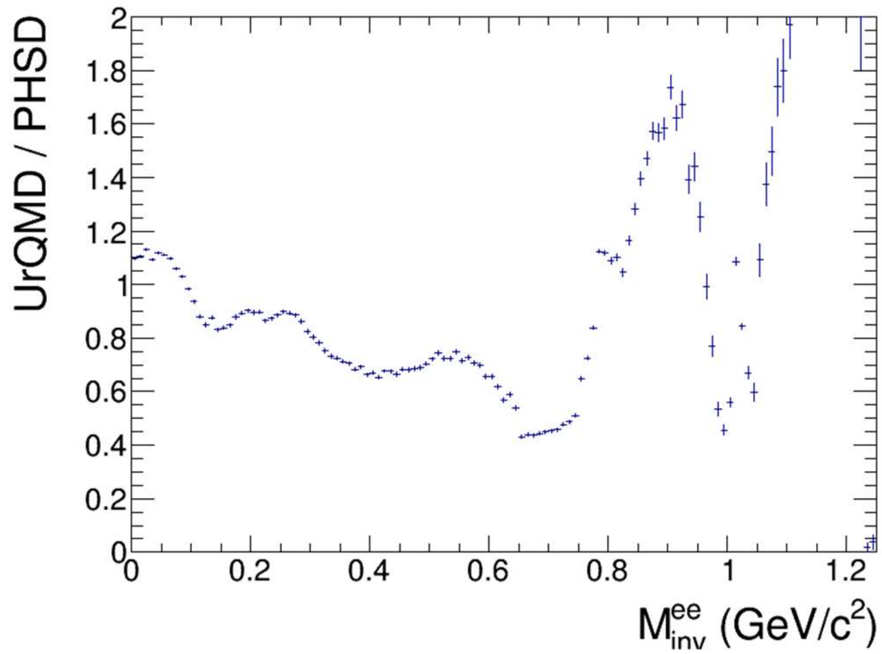
- Examples for AuAu@11: averaging of p_T-integrated spectra by centrality
- The obtained spectrum is to be compared to the UrQMD one.



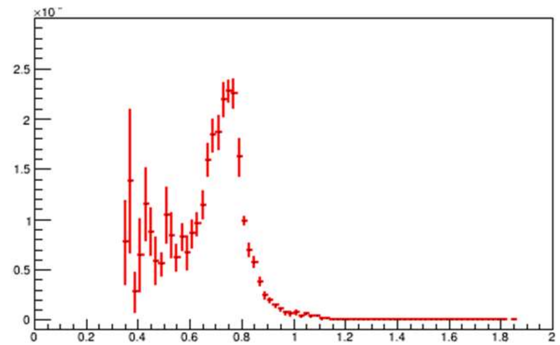
Generated dielectron continuum: UrQMD vs. PHSD

- p_T-integrated M_{ee} distributions



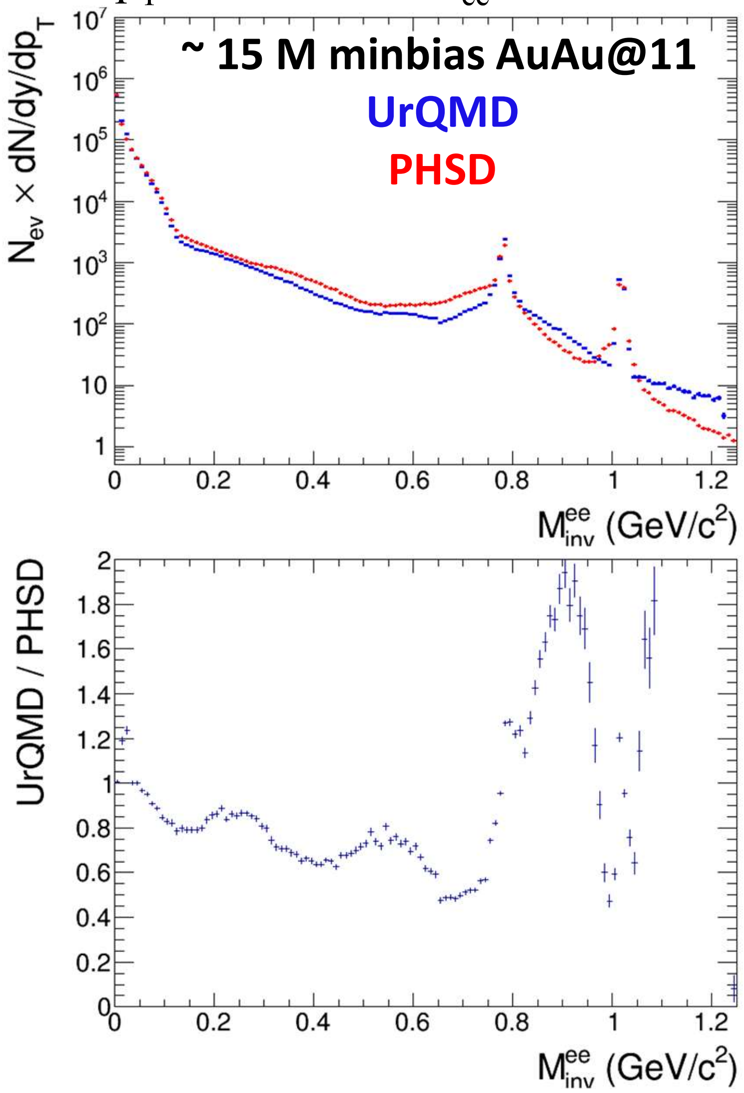


- Relatively good agreement within ± 20-30%
- Most of disagreement is for ρ(770); it is not a (r)BW in PHSD

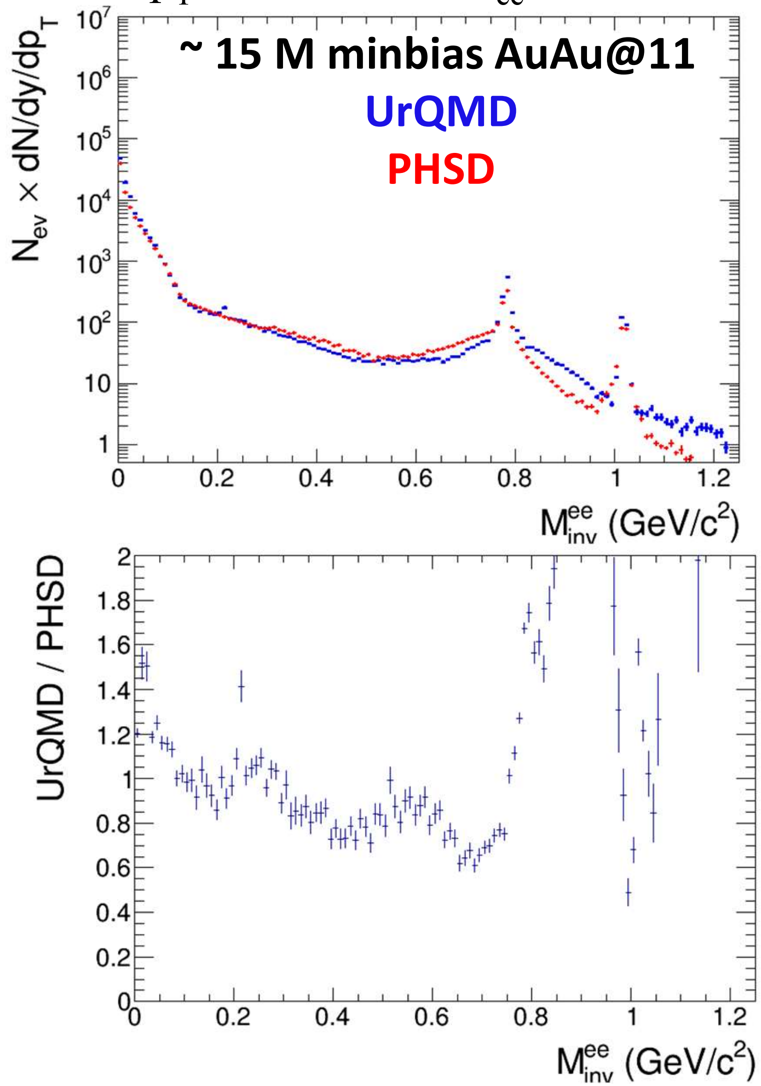


Generated dielectron continuum: UrQMD vs. PHSD

- $p_T > 0.5$ GeV/c M_{ee} distributions



- $p_T > 1.0$ GeV/c M_{ee} distributions



- Agreement gets better at higher momentum, ± 20%; ρ(770) remains to be different

New Monte-Carlo request

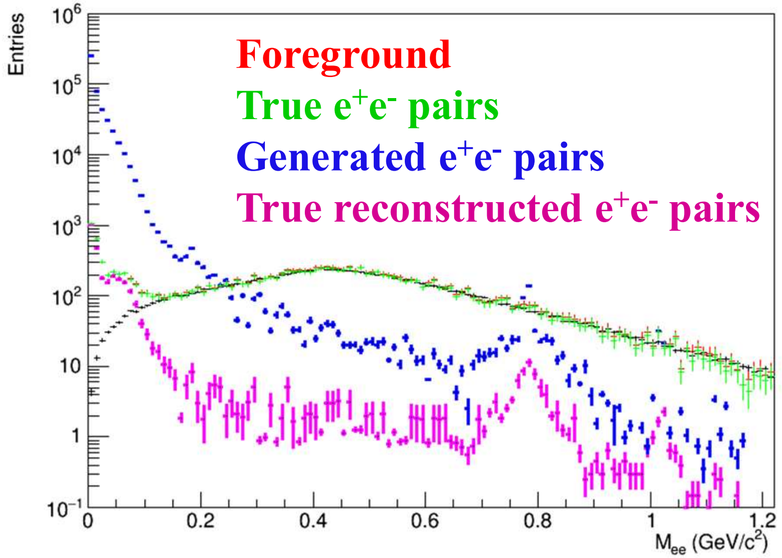
- New Monte Carlo request has been submitted https://mpdforum.jinr.ru/t/request5-pwg4-dielectrons-in-bibi-9-46/235
- Aims at dielectron studies but good for most of other analyses
- The main changes:
  - ✓ new collision system – BiBi@9.46, most probable first beams
  - ✓ fixed problem with zero width of resonances, unstable particles are decayed by Pythia6
  - ✓ fixed problem with Dalitz decay of η (treated by Pythia6 as for unstable particles)

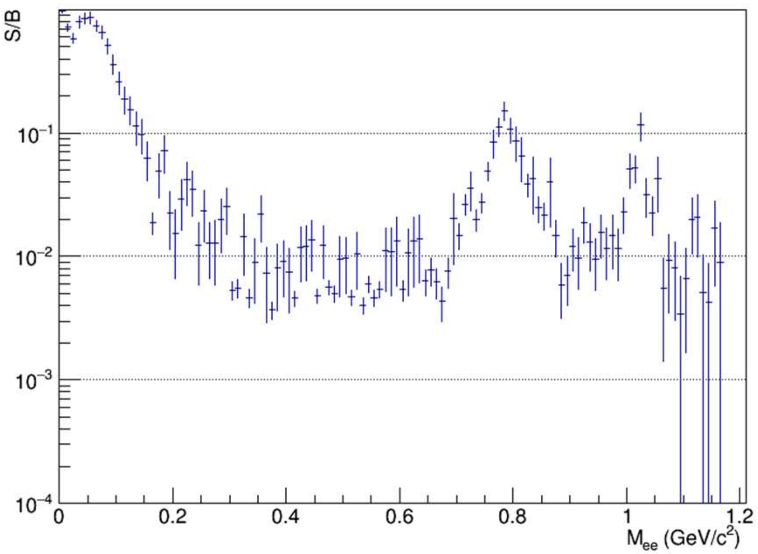
- Remaining issues:
  - ✓ Dalitz decays of ω … Pythia6 does not know such decays → decayed as 3-body decays

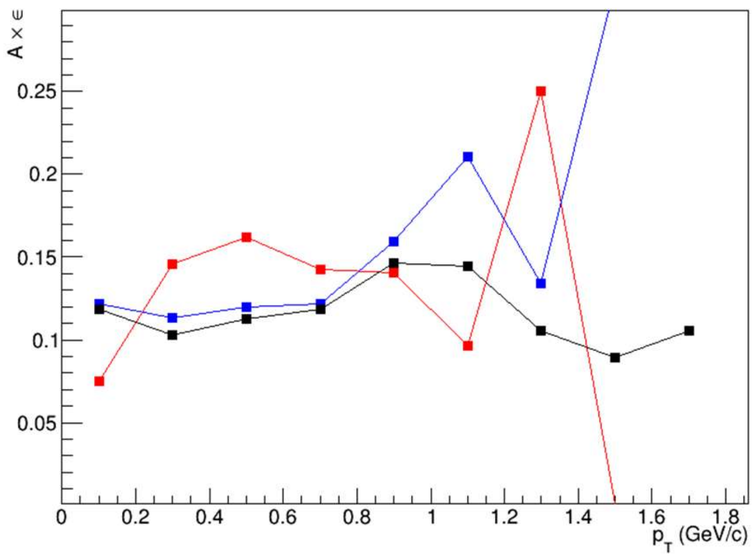
- Production properties:
  - ✓ LVM decays to e^+e^- are enhanced by x20 for smaller fluctuations
  - ✓ production is still usable for most of general purpose analyses

Expected BiBi@9.46 simulation results

- QA test production, ~ 100,000 events
- Downscaled the e+e- BR and reweigted omega Dalitz distribution by shape







- Results look similar to AuAu@11 case
- Generated signal has large fluctuations not covered by statistical uncertainties → need o be ubderstood

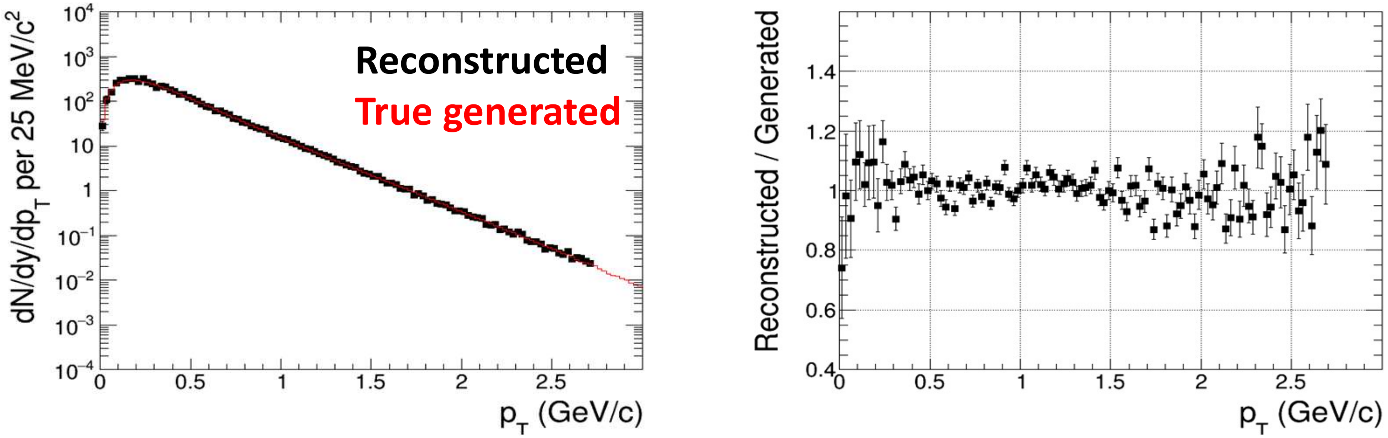
Status & conclusions

- UrQMD & PHSD give similar predictions for background and e^+e^- signals in AuAu@11. Need extra input for the generated e^+e^- signals → Sudhir will report PLUTO simulation results next meeting
- Improve eID with the TOF and TPC for better signal significance
- Improve conversion rejection
- Move to BiBi@9.46 from AuAu@11 → simulations are in progress, minor problems to be resolved

Neutral mesons

Previously … π^0

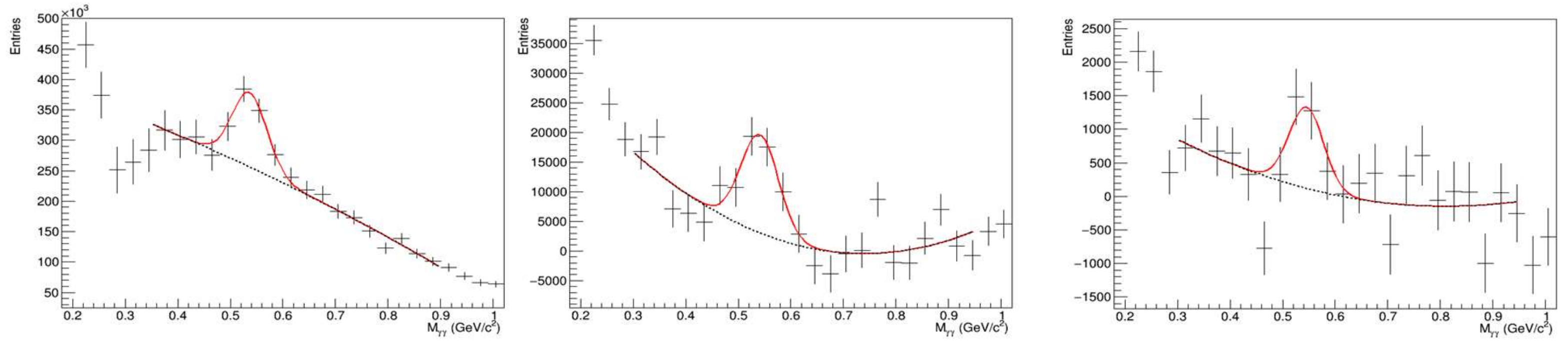
- MC studies for π^0 vs. centrality in AuAu@11, realistic vertex distribution, 15M
  - ✓ mass & width vs. p_T and centrality
  - ✓ reconstruction efficiency vs. p_T and centrality
  - ✓ closure tests vs. p_T and centrality
- Example of the MC closure test for 20% most central AuAu@11 events



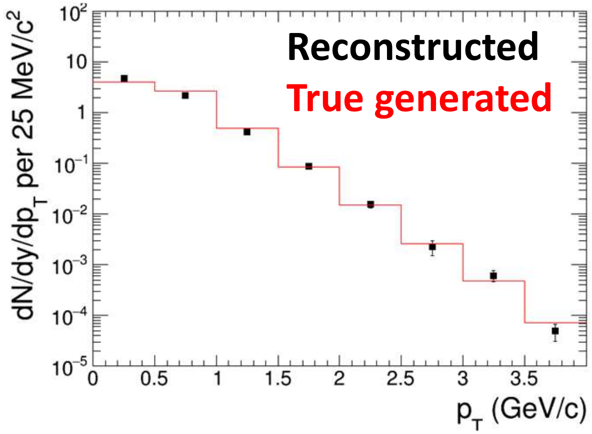
- Main conclusions (full acceptance, same performance) :
  - ✓ measurements are possible with > 10^7 events → achievable in year-1
  - ✓ range of measurements p_T > 50 MeV/c
  - ✓ low-pT uncertainties are driven by signal shape systematic uncertainties, not by statistics
- Remaining tasks for π^0:
  - ✓ better control of the peak shape with different γID selections in the ECAL
  - ✓ BiBi@9.46 for consistency, most probable day-1 beam configuration

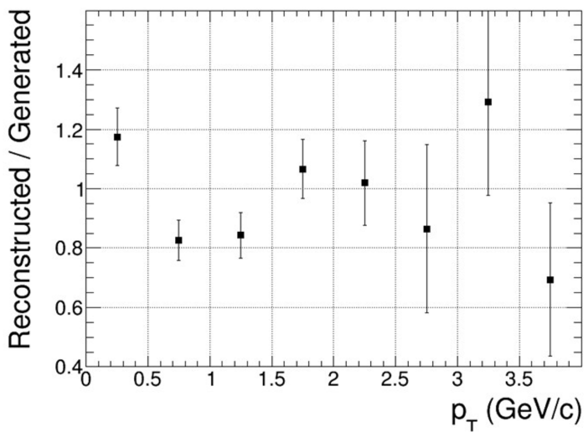
Previously … η

- With 15 M minbias AuAu@11, can observe signals in minbias collisions with coarse p_T bins



- Example of the MC closure test for minbias AuAu@11 events





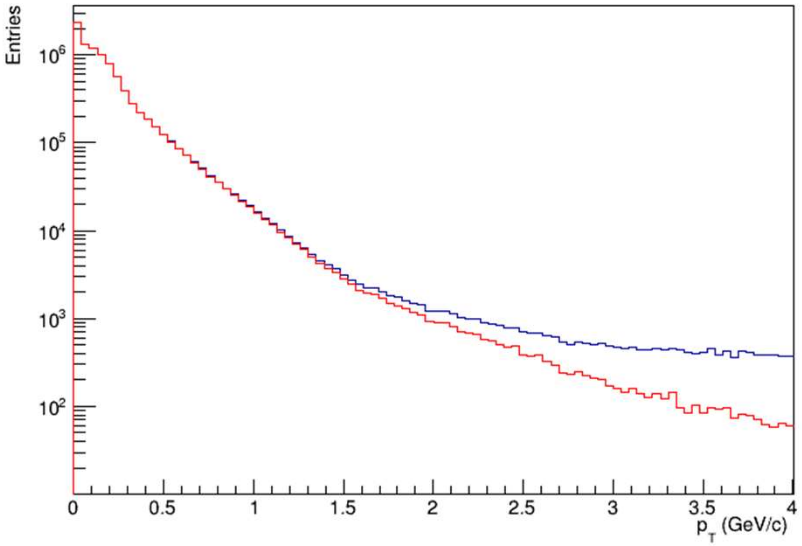
- Main conclusions (full acceptance, same performance) :
  - ✓ first-look measurements are possible with > $2 \cdot 10^7$ events → achievable in year-1
  - ✓ finer p_T bins and/or centrality dependent studies require extra statistics

Embedded simulation for η

- Simulation of > 10-15M events is not effective
- Embedding of extra signals in A+A collisions is the way to increase statistics
- Setup a new MC production :
  - ✓ UrQMD, BiBi@9.46 for consistency
  - ✓ embedded 7 η-mesons per event with flat rapidity (|y|<1) and p_T ($0 < p_T$ (GeV/c) < 5) distributions
  - ✓ run a production for 1.5M events at NICA cluster
- Simulated spectra are distorted by embedded signals:
  - ✓ average multiplicity → vertex, reconstruction efficiency etc.
  - ✓ p_T and rapidity distributions of η → reconstruction efficiency, mass & width
- Started a private production … ongoing

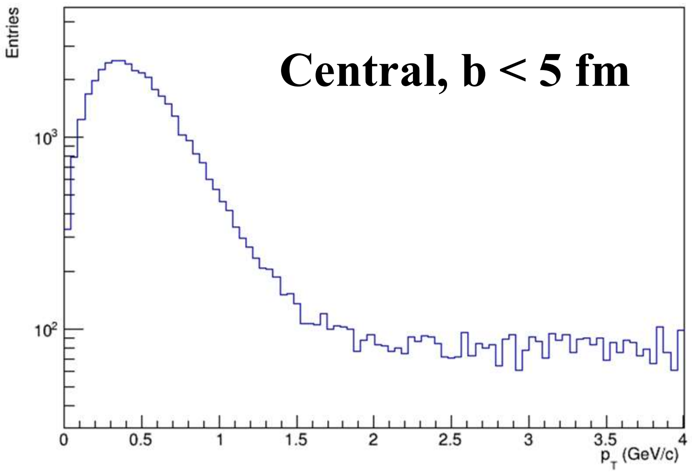
Embedded simulation for η

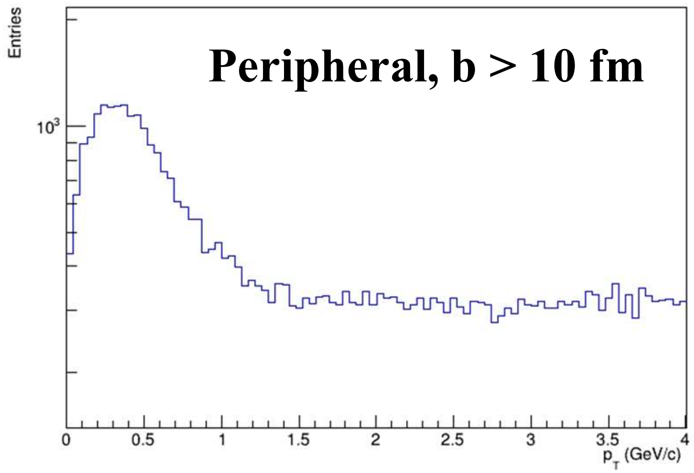
- Average multiplicity is barely affected even in peripheral collisions (b > 10 fm):



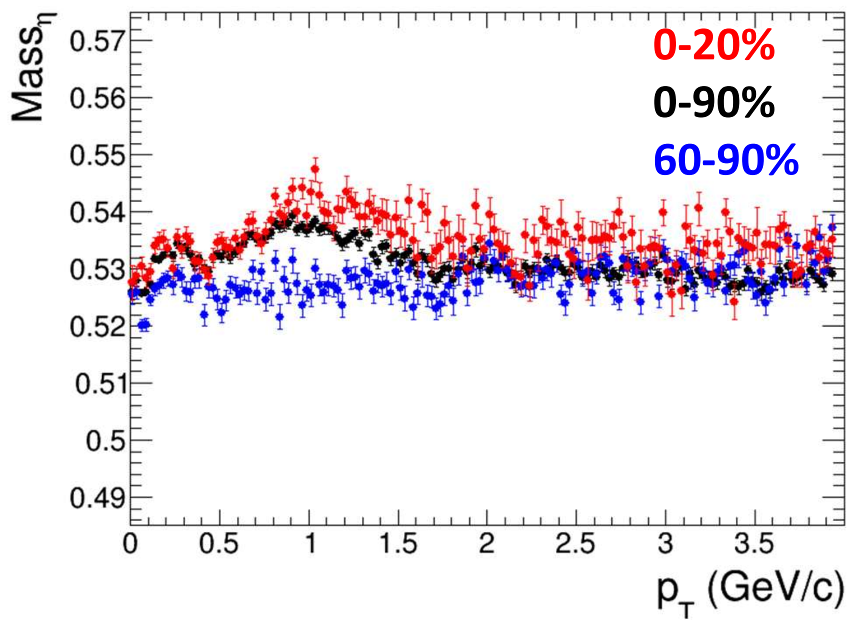
p_T spectrum of all generated particles
p_T spectrum without η mesons (including embedded)

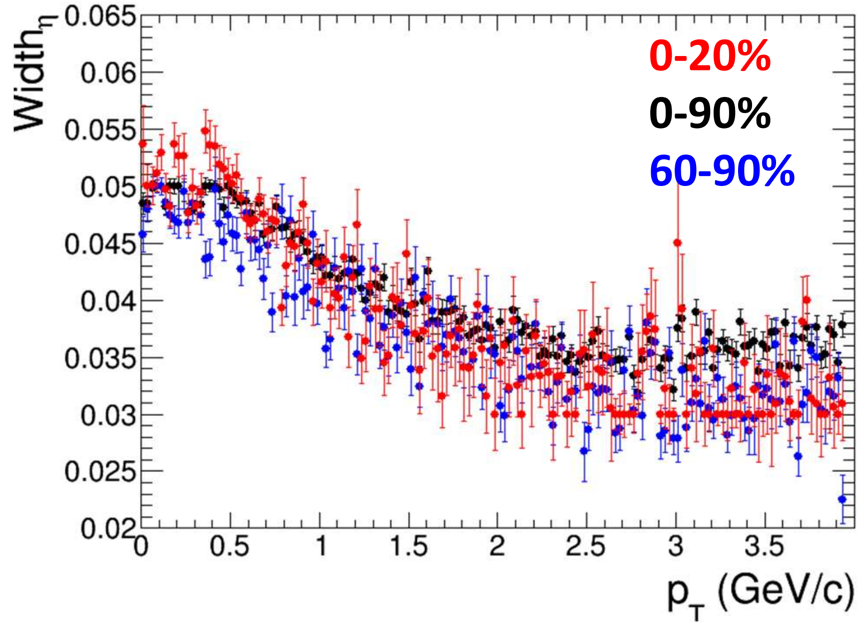
- Distortions of p_T spectra for η are multiplicity dependent → need to be corrected by weights





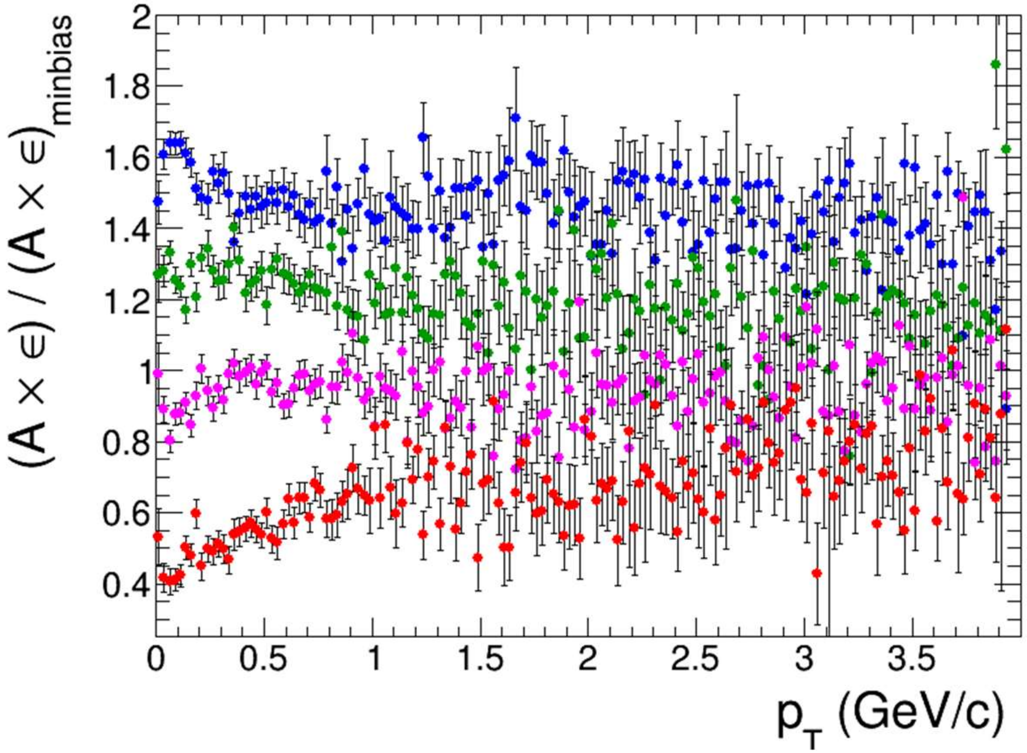
Mass & width of η vs. p_T and centrality





- Reconstructed mass increases with multiplicity:
  - ✓ shower merging at high multiplicity
- Weak dependence of the reconstructed mass on p_T
  - ✓ Relatively high energy photons from η decays
- Reconstructed width decreases with p_T:
  - ✓ energy resolution is multiplicity dependent
- Wek dependence of the reconstructed width on centrality:
  - ✓ large uncertainties

Reconstruction efficiency of η vs. p_T and centrality



- Reconstruction efficiency shows strong multiplicity dependence:
  - ✓ multiplicity dependence of false track matching (false veto)
  - ✓ larger fraction of merged clusters with non-EM shower shapes at high multiplicity

Remaining tasks for η

- Run more simulations to have 3-4 M simulated & embedded events (privately)
- Extraction of η raw yields in fine p_T bins with weights
- Estimation of needed statistics for centrality dependent studies