In collaboration with
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CORRELATION OF HEAVY AND LIGHT FLAVOURS IN SIMULATIONS

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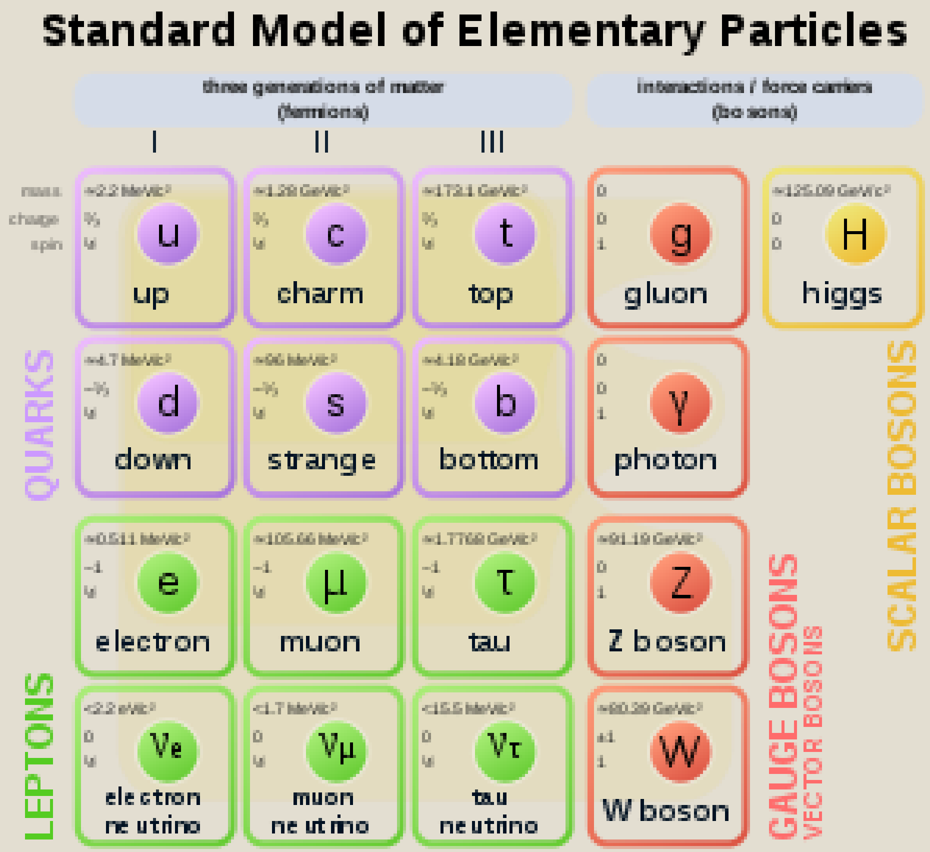
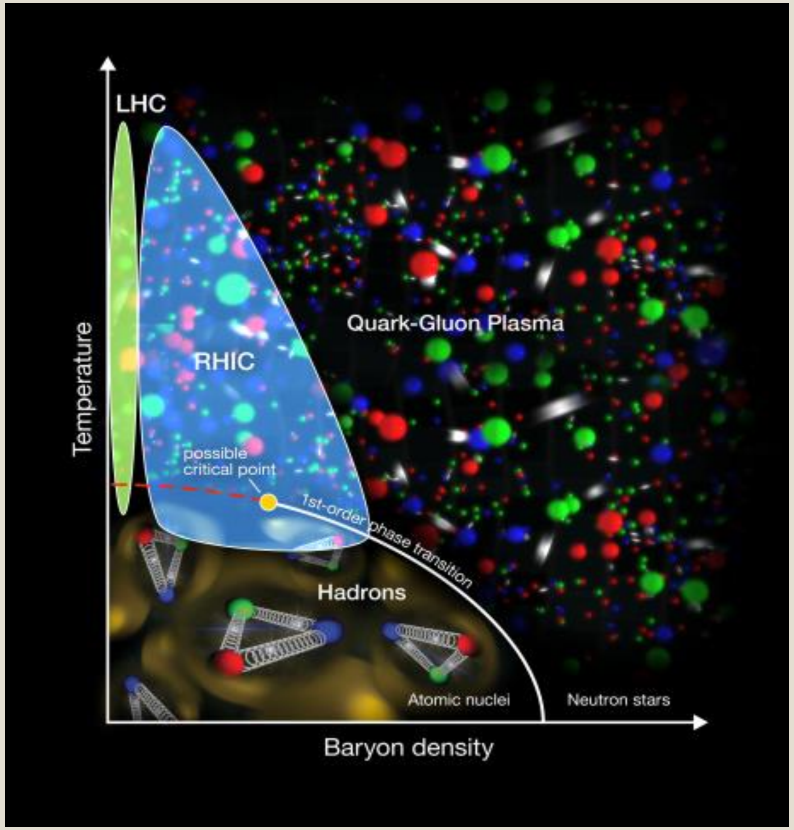
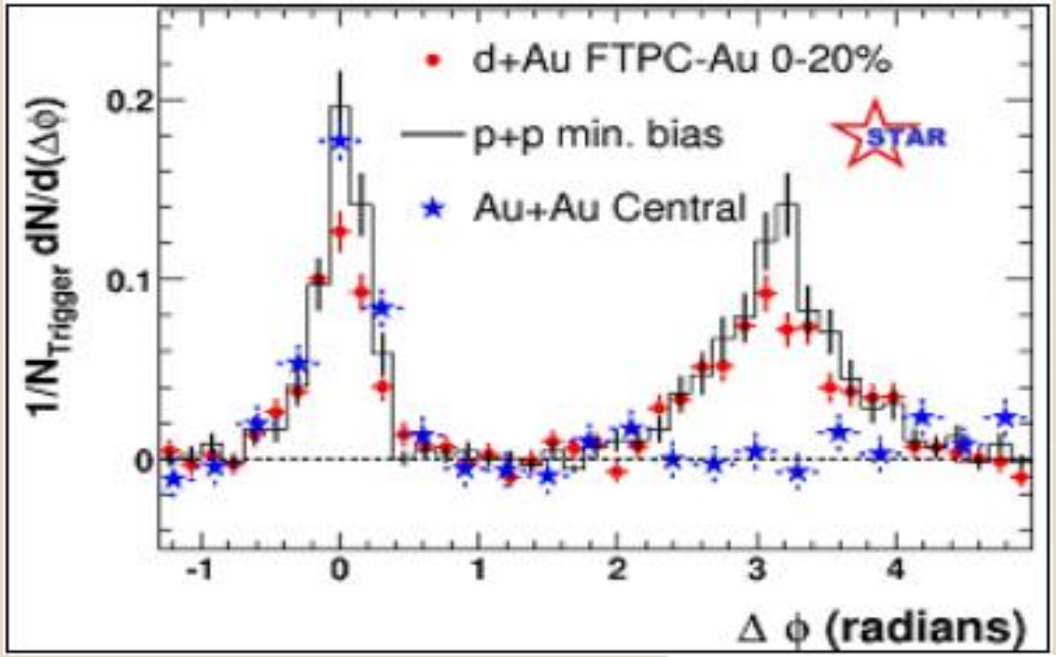
Fundamentals of high-energy physics





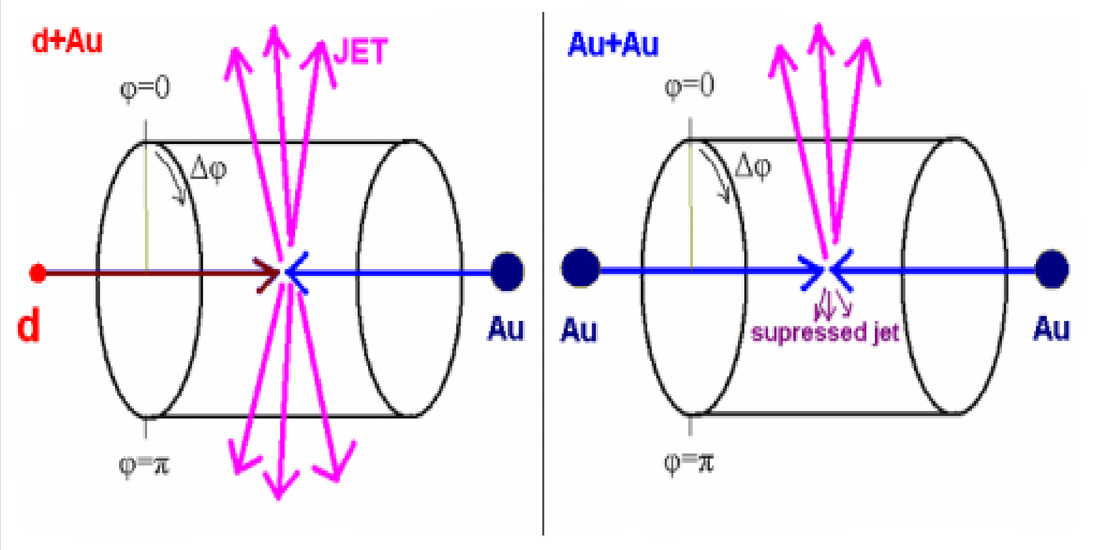
- QGP can be recreated in the lab in heavy ion collisions

Two-particle correlations



It was the first convincing evidence of hot and dense strongly interacting nuclear matter in the final state.

Based on the angular correlation data of STAR, jet-quenching can be observed.



Previous measurements in heavy ion collisions

Variables determining the particle movement

- Rapidity

$$y = \frac{1}{2} ln \frac{E + p_z}{E - p_z}$$

- Pseudorapidity

$$\eta = \frac{1}{2} \ln \frac{p + p_z}{p - p_z} = -\ln(\tanh\left(\frac{\theta}{2}\right))$$

- Transverse momentum

$$p_T = \sqrt{p_x^2 + p_y^2}$$

- Azimuthal angle

$$\Phi = \frac{p_y}{p_x}$$

Applications of correlation measurements

- Understanding jet structure by correlation
  - Interaction of partons with QGP can be studied by full jet reconstruction
  - The background size makes it difficult to reconstruct the jet under a certain momentum
  - Solution: measuring the angular correlation of particles

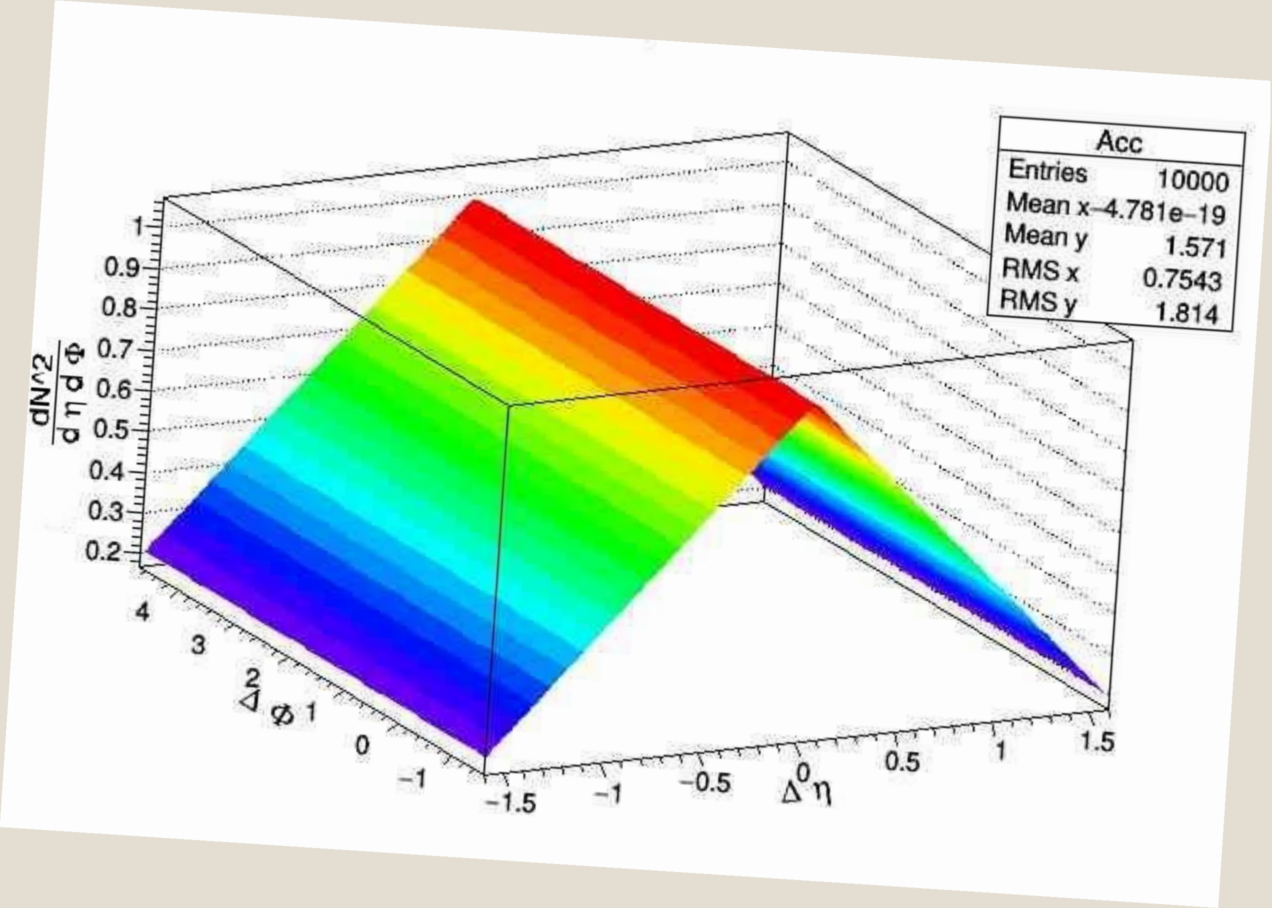
- Identify the characteristic correlation images of heavy quarks
  - Compare near- and away-side peaks associated with hadrons from different heavy quarks from a given pT
  - Which probes are sensitive to heavy quarks?

- Parameterization of correlation images by fitting

Simulation settings

- Event generator based on Monte Carlo method: PYTHIA 8.1
- Hard QCD events were created in PYTHIA using the default Monash 2013 settings for LHC p + p data.
- The phase space has been reduced so that the leading hard process has at least 5 GeV / c momentum.
- In the case of heavy quark samples, the renormalization scales were set based on the STAR Heavy Flavor tune (from which we expect the corresponding result in the examined momentum range) and only the following two processes are allowed: $gg \to b\bar{b}$, $qq \to b\bar{b}$ and $gg \to c\bar{c}$, $qq \to c\bar{c}$.

Acceptance correction

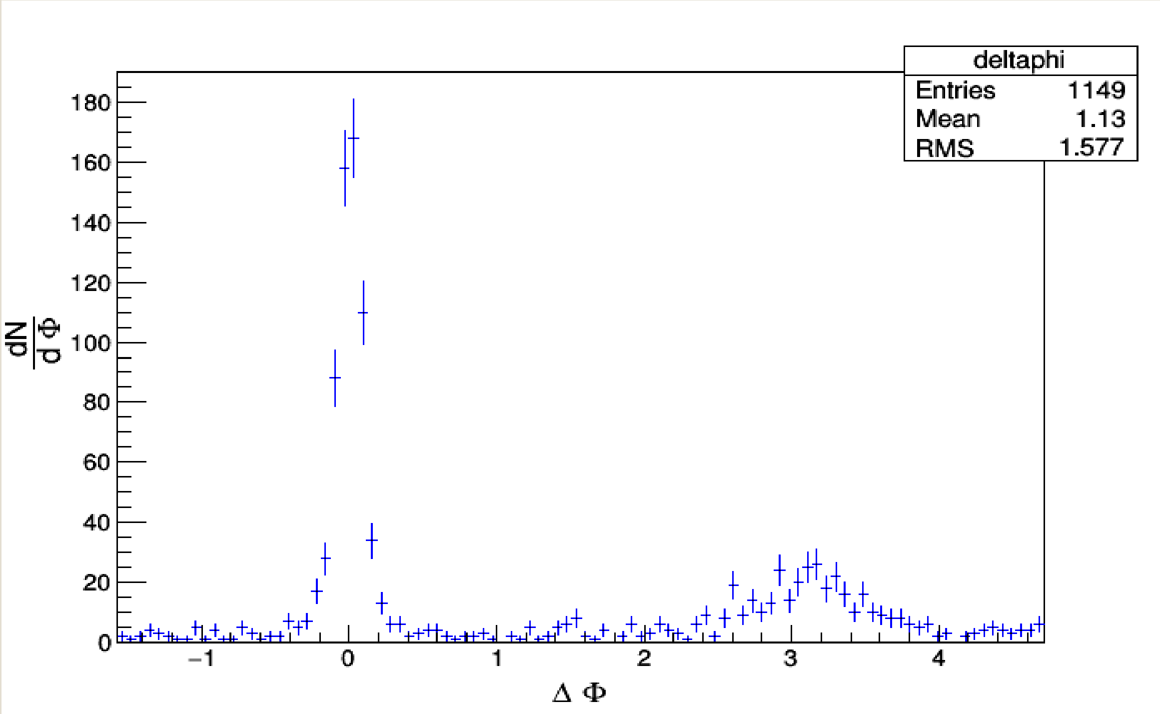


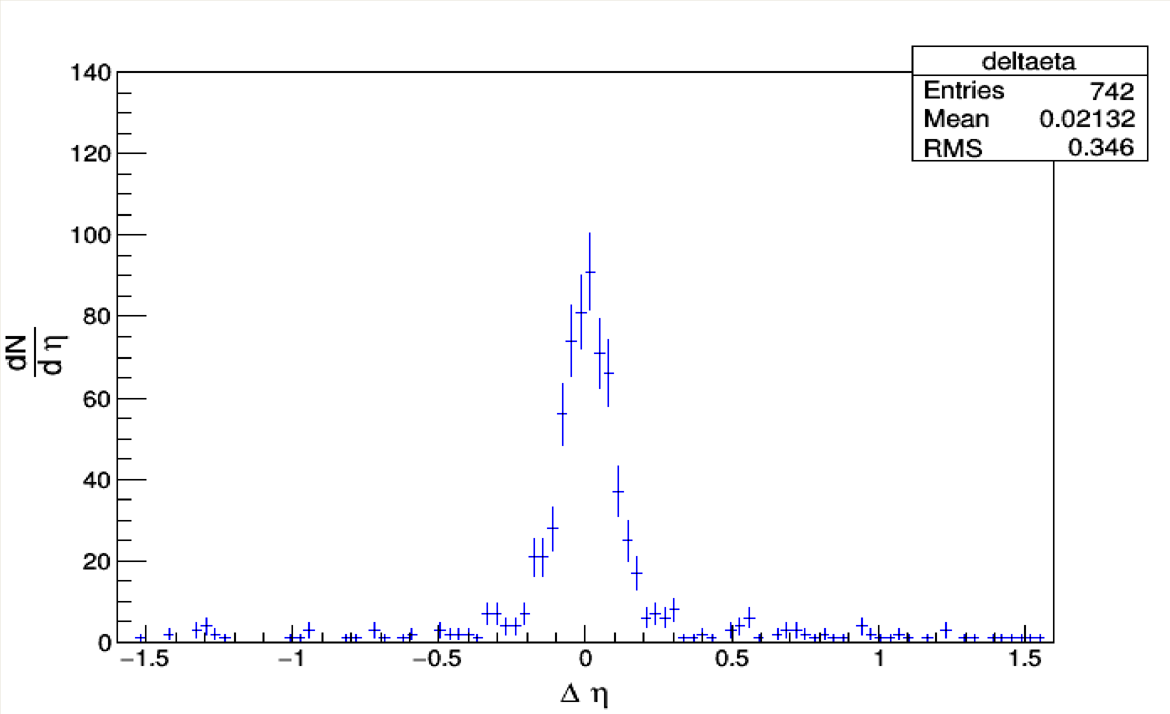
$$\frac{dN}{d\Delta\eta} = \frac{1}{2A} - \frac{1}{4A^2}|\Delta\eta|$$

To correct the finite size of the detector we divide the correlation in the $\Delta\eta - \Delta\varphi$ plane with this tent-shaped function.

Two-particle correlations

- select a trigger particle from a given momentum (p_T) range
- then in a lower momentum (p_T) window examine all the other particles from the same event (associated particles)
- near-side and away-side peak





Determining the peak's parameters by function fitting

Gauss

$$N \cdot \frac{1}{\sqrt{2\pi}\,\sigma_\eta} \cdot e^{-\left(\frac{\Delta\eta^2}{2{\sigma_\eta}^2}\right)}$$

$$N \cdot \frac{1}{\sqrt{2\pi}\,\sigma_\Phi} \cdot e^{-\left(\frac{\Delta\eta^2}{2{\sigma_\Phi}^2}\right)}$$

Generalized Gauss

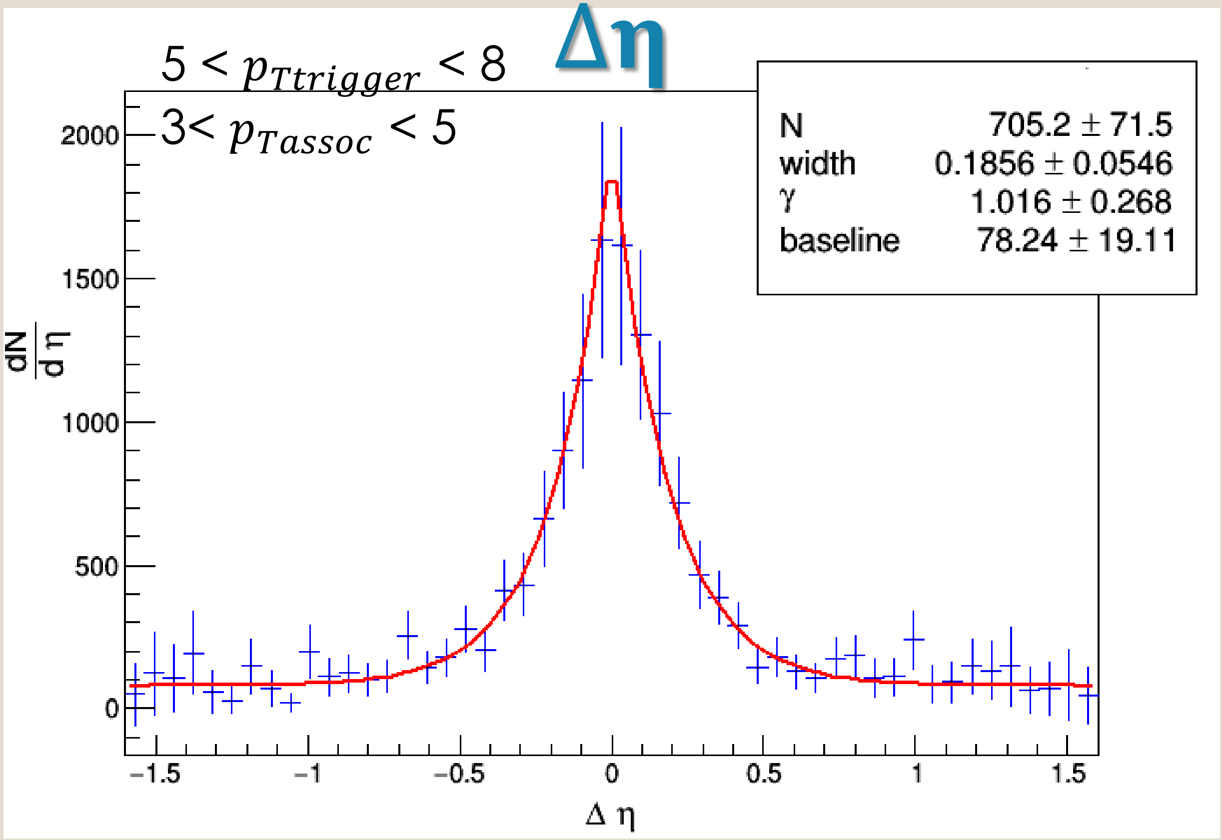
If $\gamma = 2$, it can be identified with a simple gaussian function

$$N \cdot \frac{\gamma_\eta}{2\omega_\eta \Gamma(\frac{1}{\gamma_\eta})} \cdot e^{-}\left(\frac{|\Delta\eta|}{\omega_\eta}\right)^{\gamma_\eta}$$

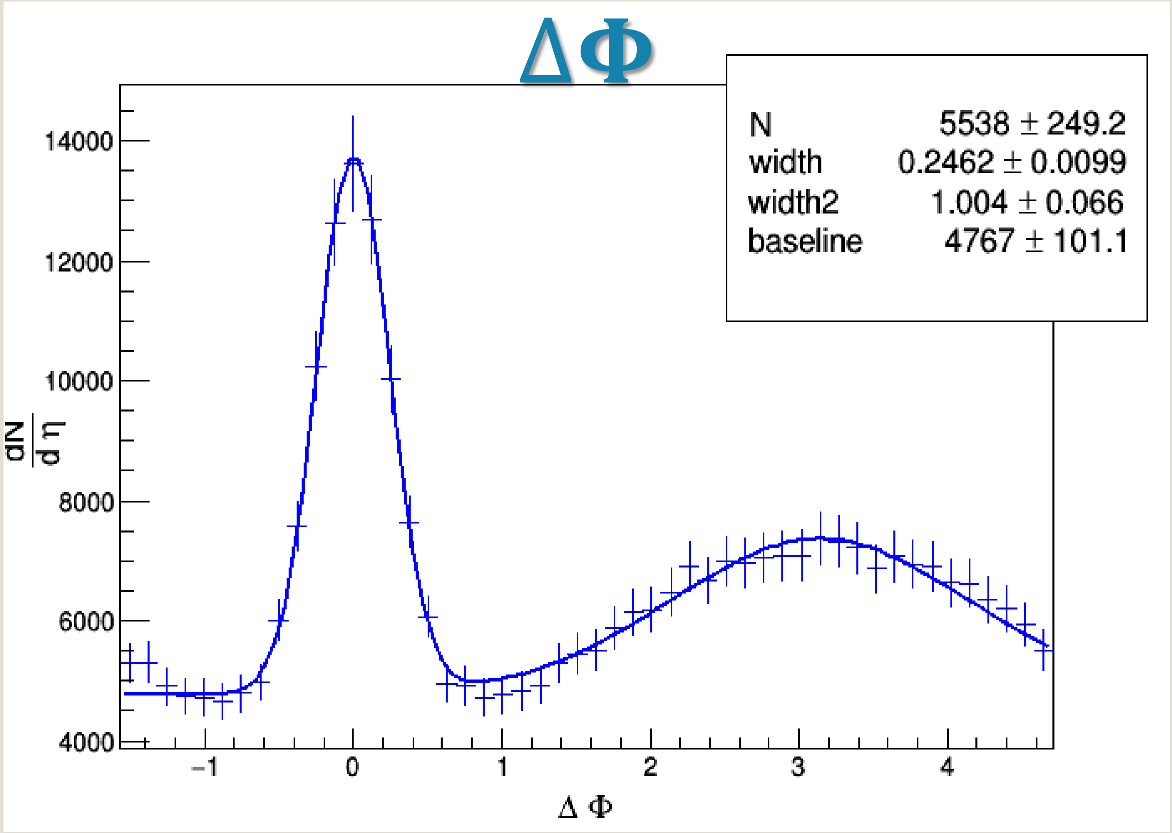
$$N \cdot \frac{\gamma_\Phi}{2\omega_\Phi \Gamma(\frac{1}{\gamma_\Phi})} \cdot e^{-}\left(\frac{|\Delta\Phi|}{\omega_\Phi}\right)^{\gamma_\Phi}$$

RESULTS

Correlations of light charged hadrons

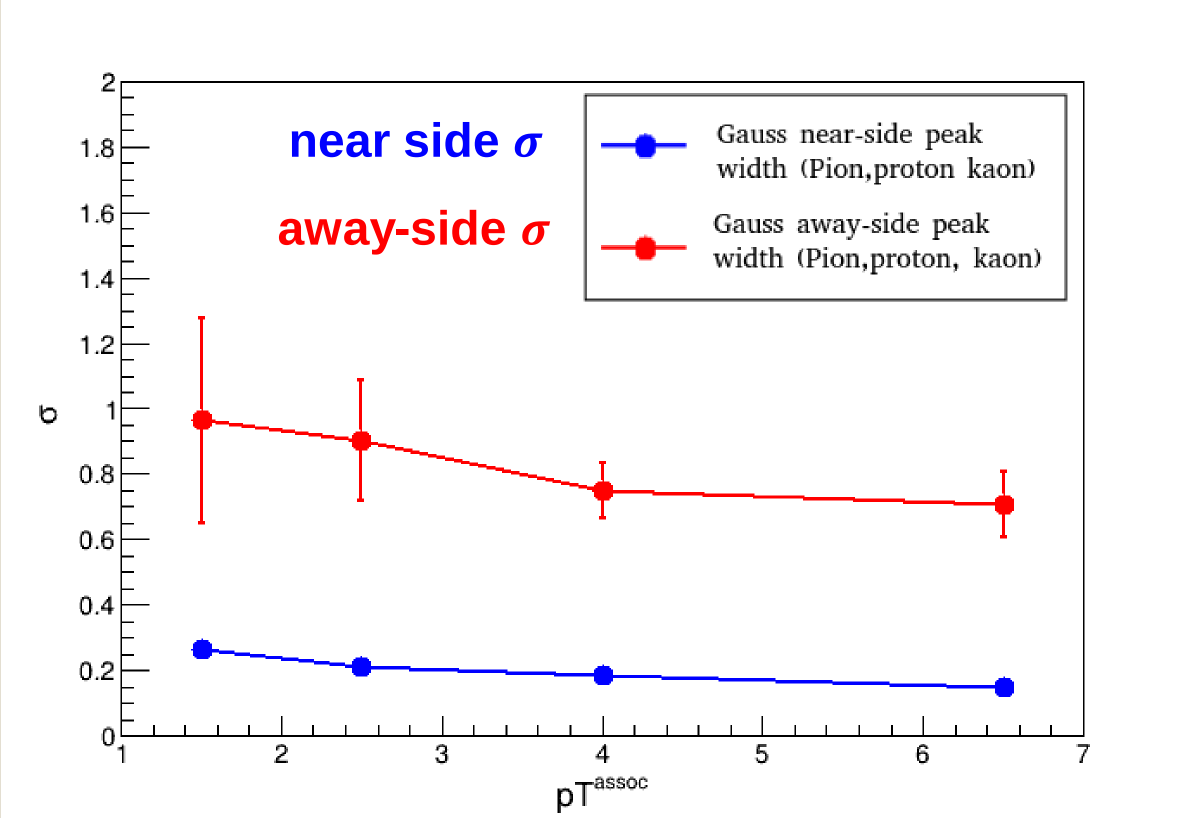


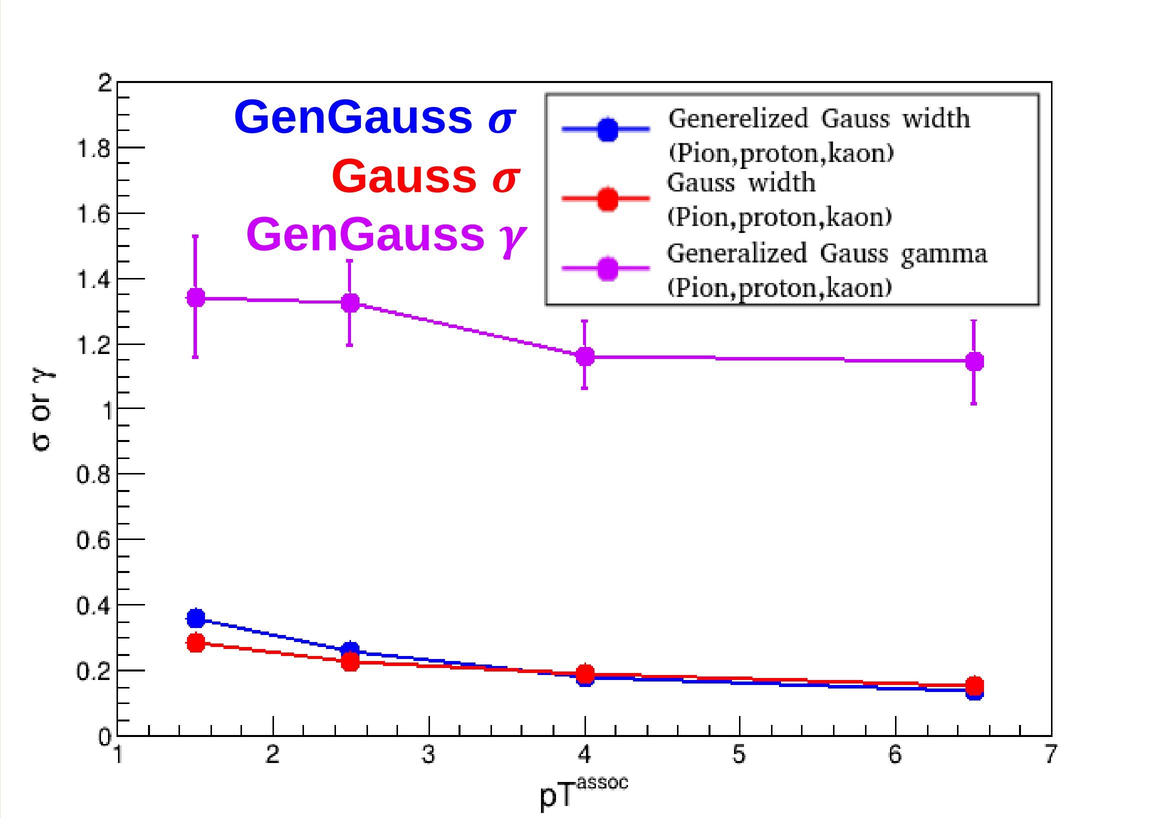
The near-side peak is significantly "peakier" than a Gaussian, γ~1.016.



The near-side and away-side peaks in $\Delta\phi$ are well described by a Gaussian.

Correlations of light charged hadrons

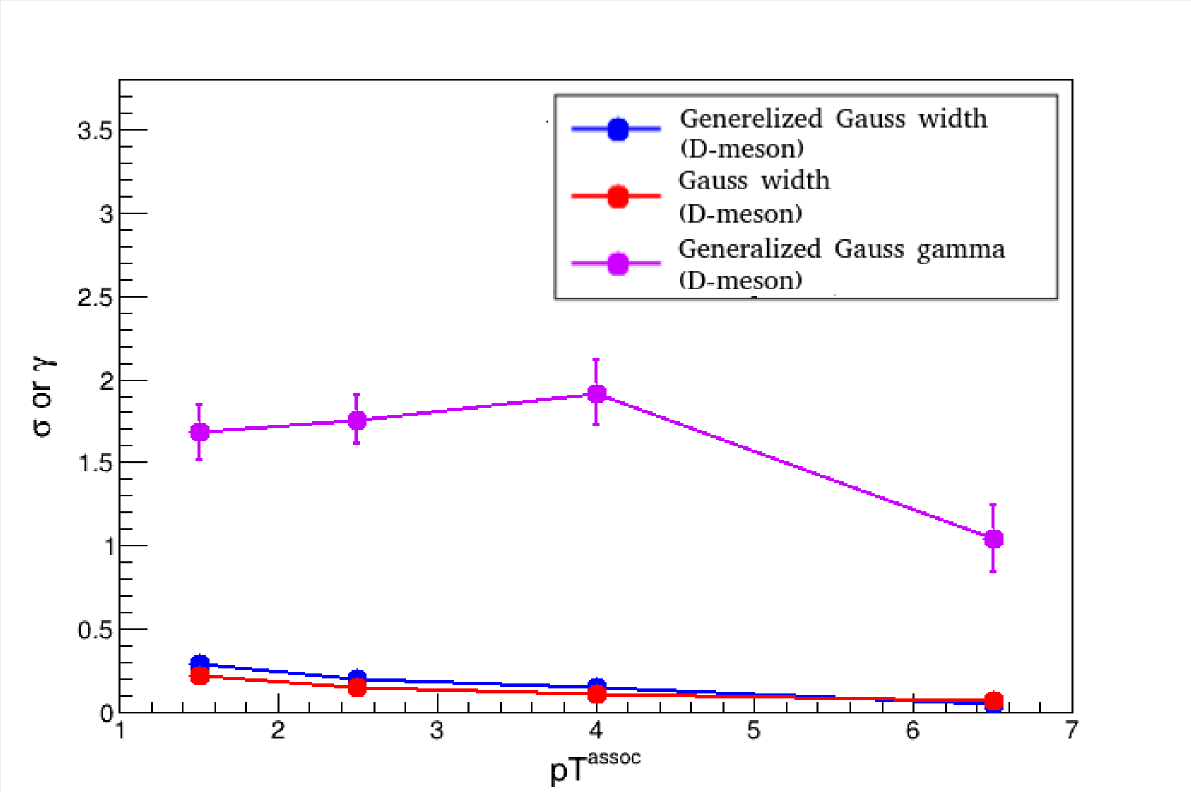




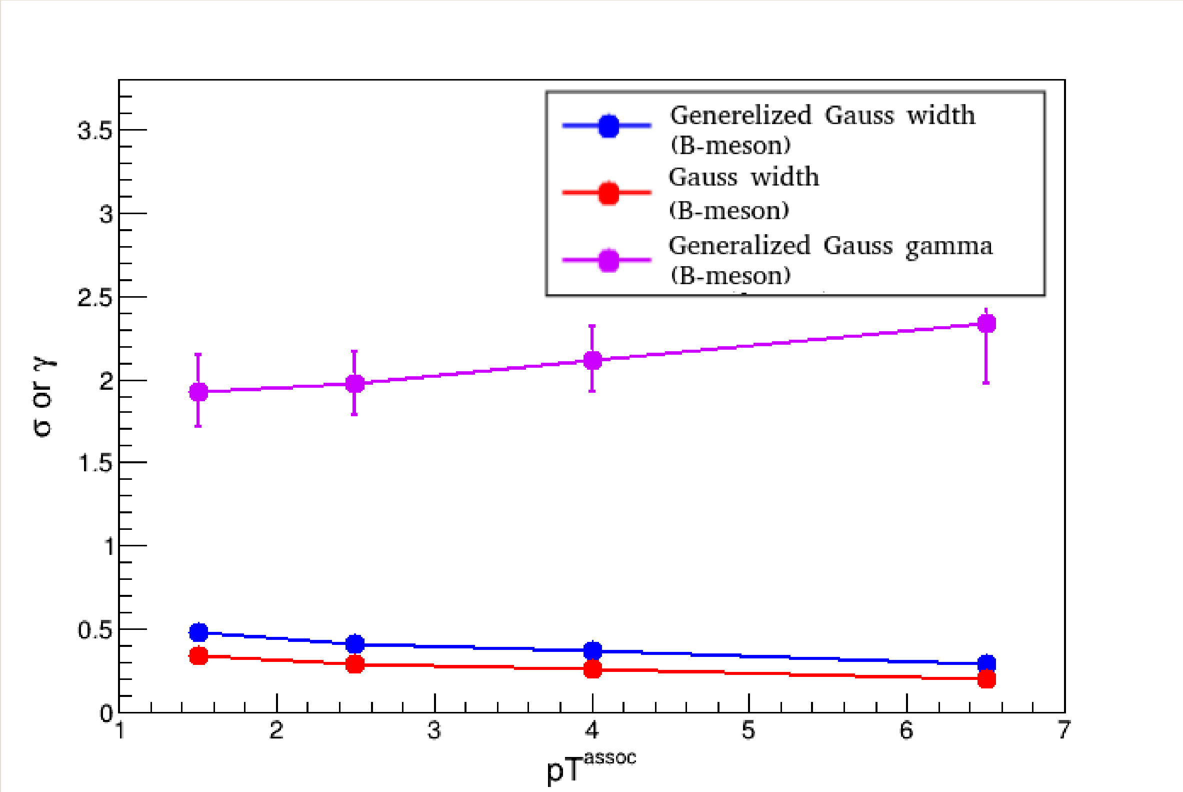
Peaks are getting narrower towards higher p_T (Lorentz-boost).
GenGauss parameter γ is constant within error.

Prompt production of heavy flavour mesons

D-meson from c-quarks



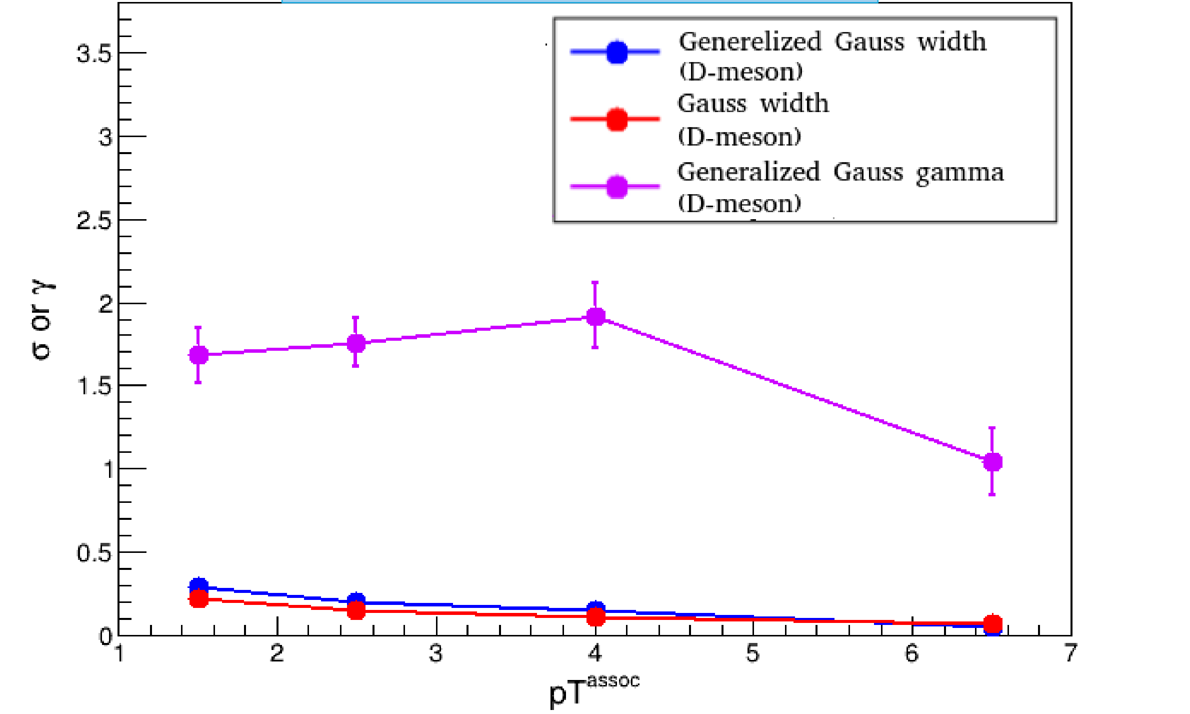
B-meson from b-quarks



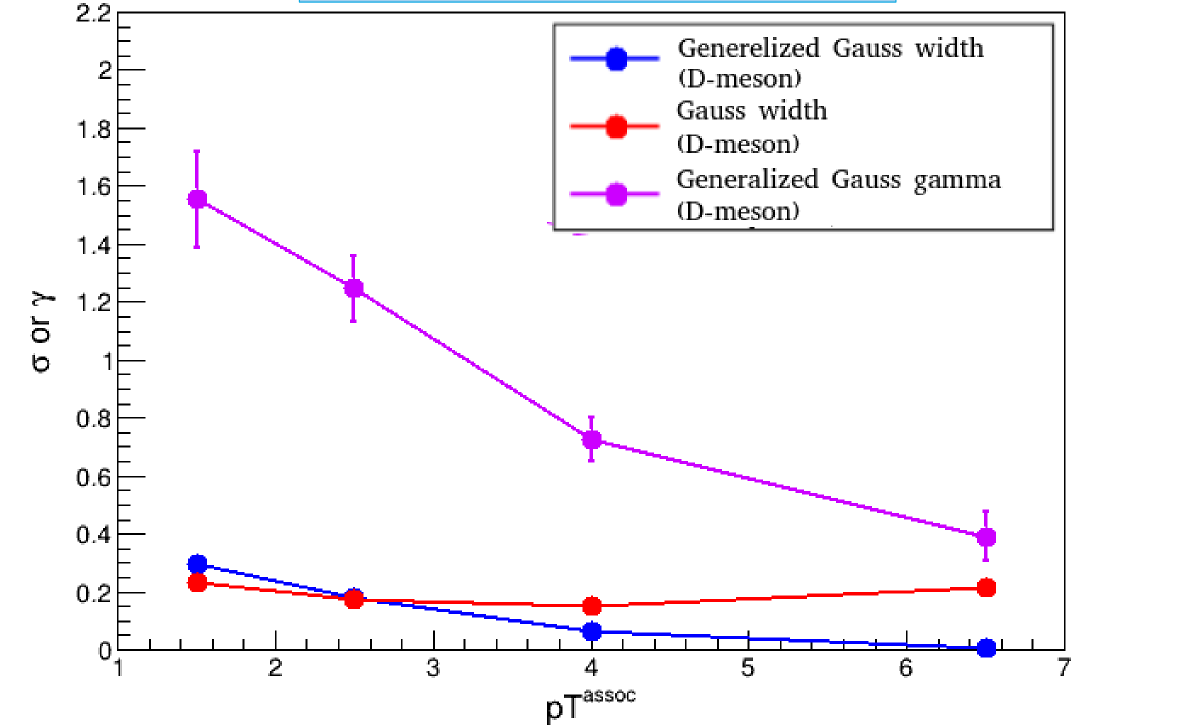
Peaks are mostly consistent with Gaussian.

D-mesons from c-quarks and the decay of the B-meson

D-meson from c-quarks



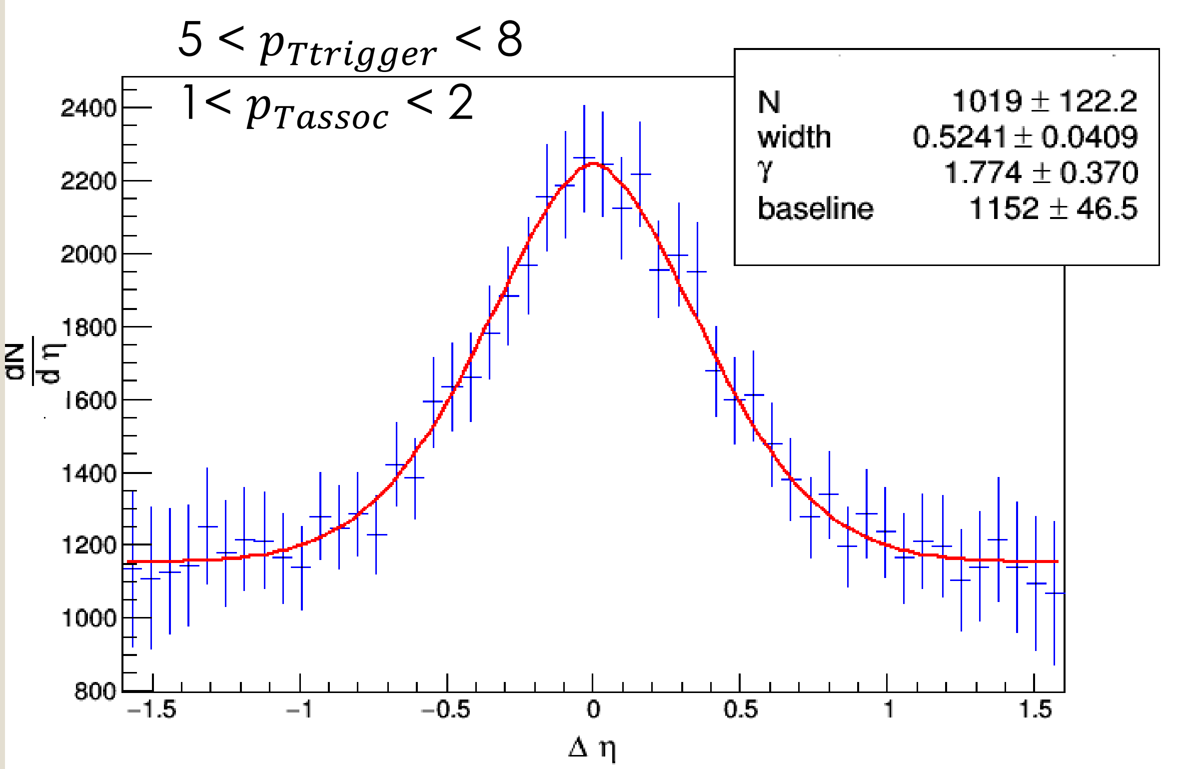
D-meson from B-meson

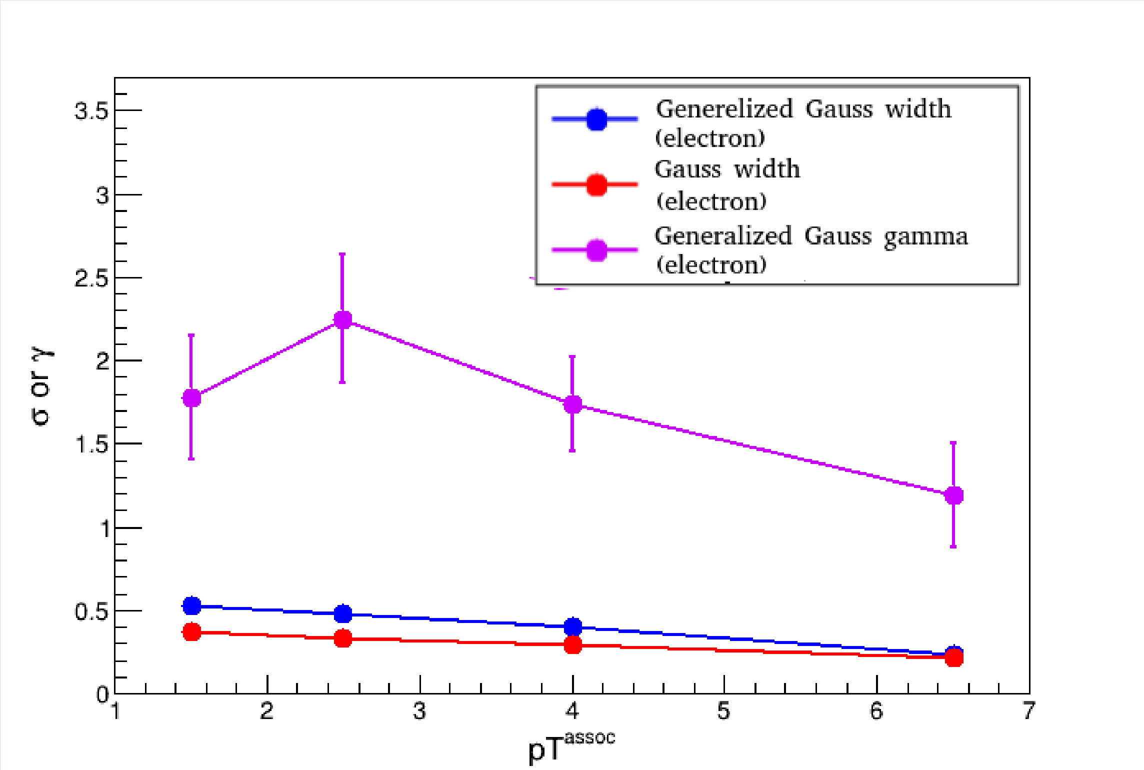


Peaks are mostly consistent with Gaussian

GenGauss parameter γ decreases with pT, together with σ . (Peaks are getting both narrower and "peakier" towards high pT)

Investigation of electrons from B-mesons



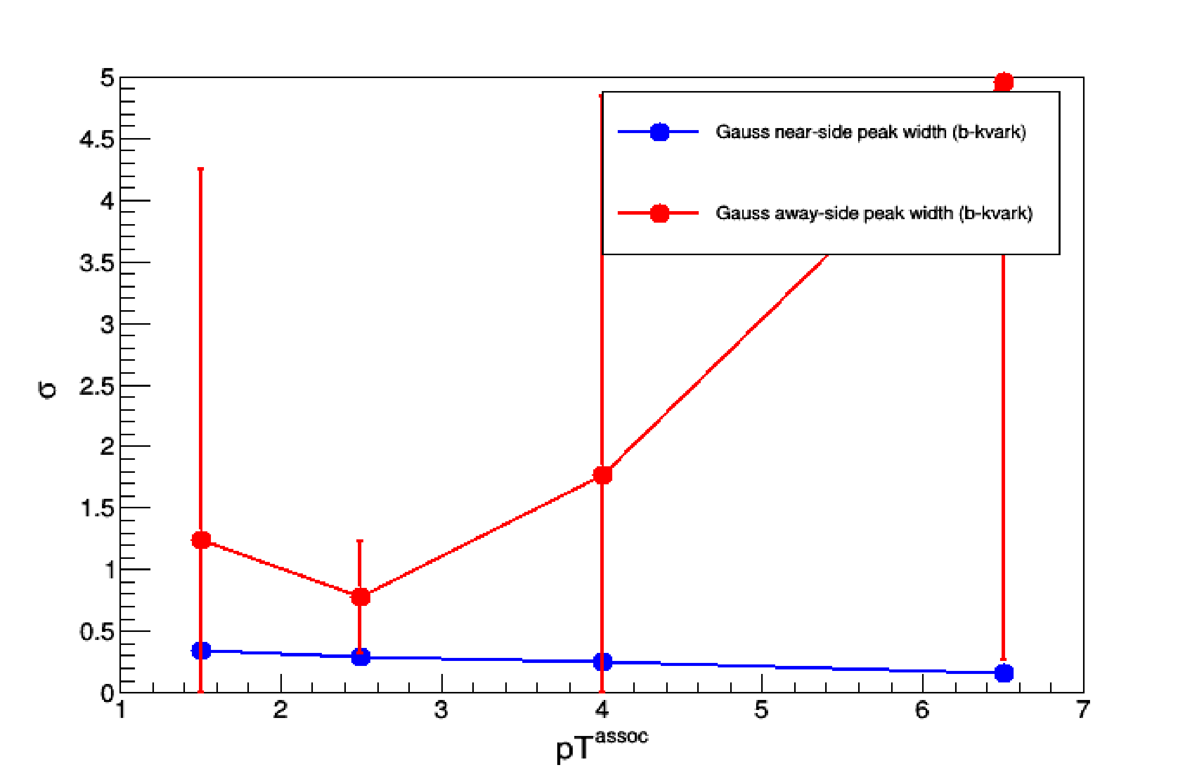


Wide correlation pictures compared to hadrons due to the momentum smearing effect of semileptonic decays.

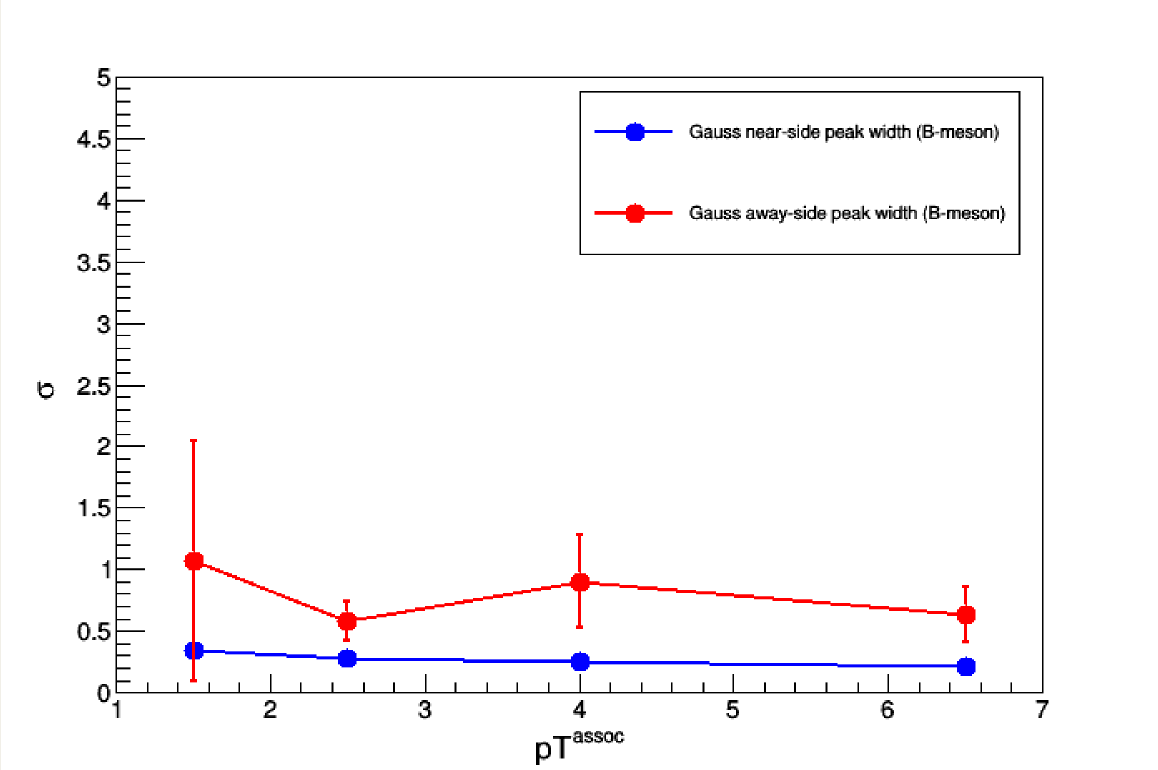
No significant dependence of γ on p_T.

Comparison of B-meson and b-quark

b-quark



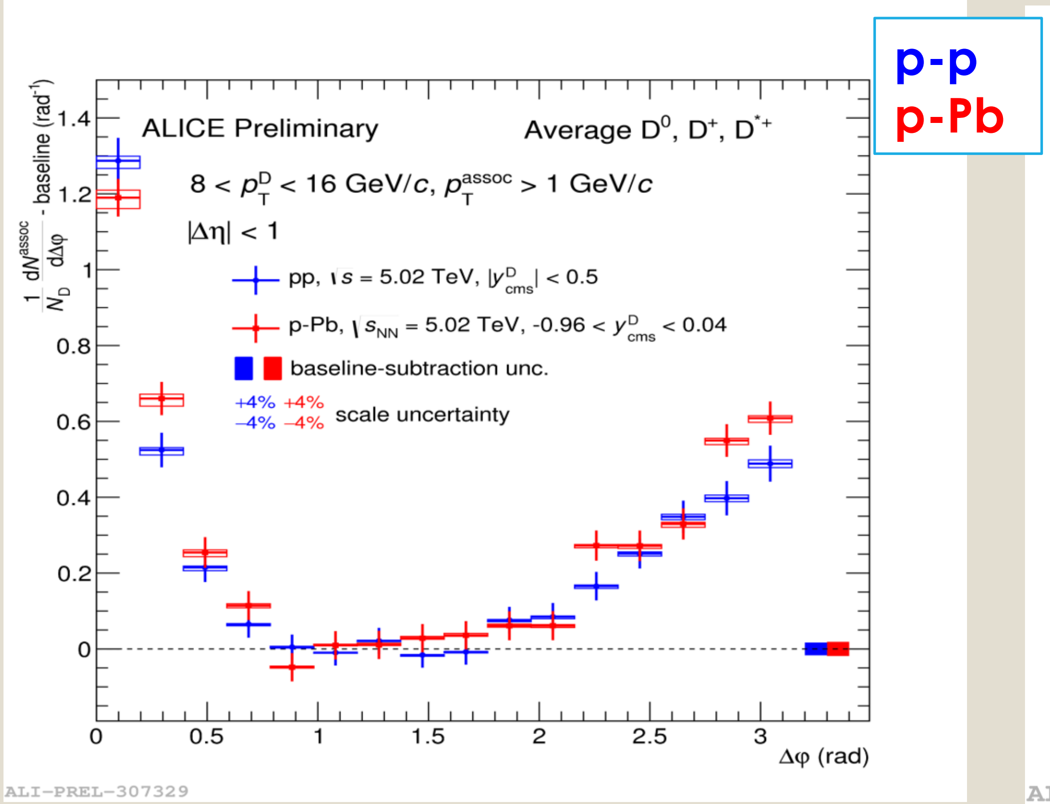
B-meson

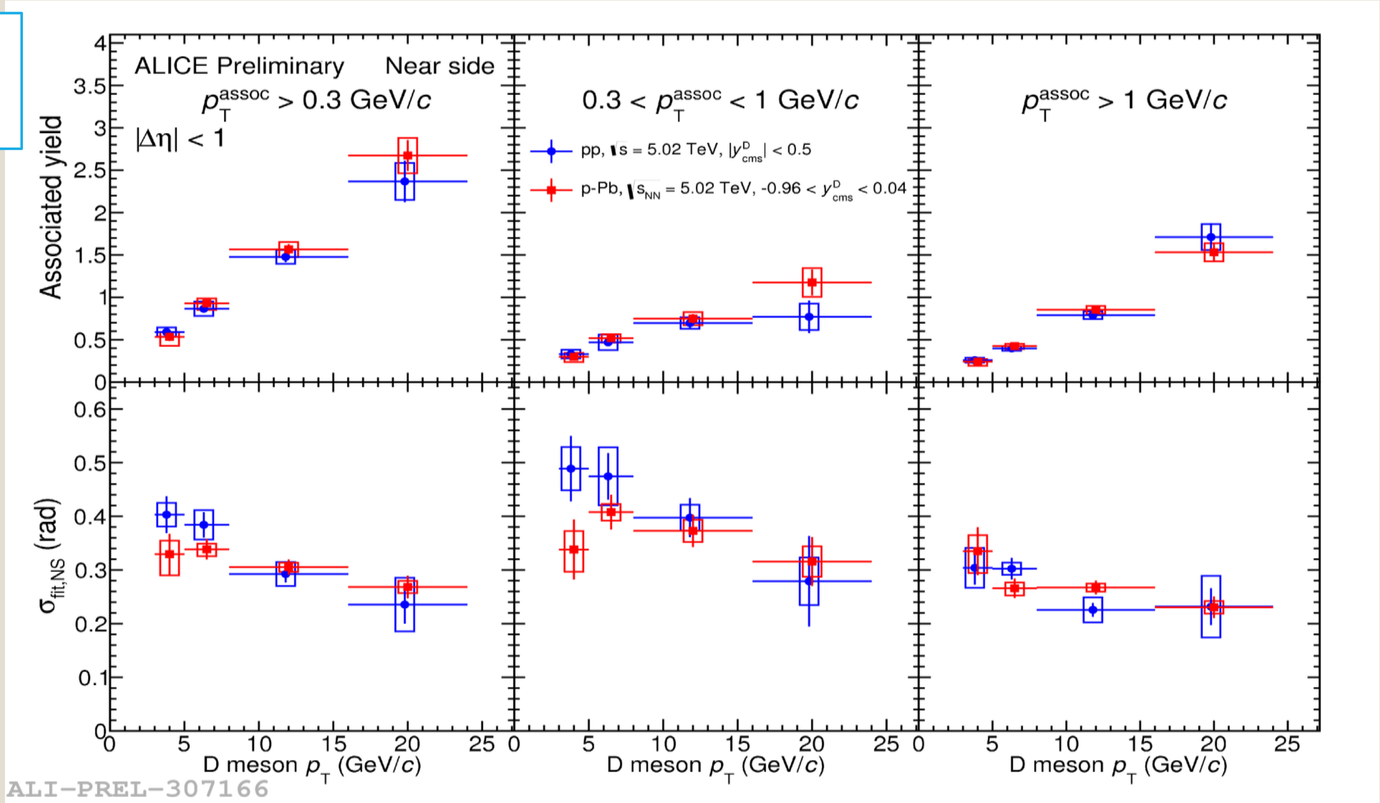


Evolution of correlation pictures match within uncertainties.
B meson is a good proxy for the b quark.

EXPERIMENT

D-h correlations in ALICE 5.02 TeV pp and p-Pb events





Near-side yields and widths consistent between pp and p-Pb.

Similar correlation pattern in pp and p-Pb collisions at $0.3 < p_T(\text{assoc}) < 3$ GeV/c.

No evidence for CNM effects.
Baseline for the upcoming Pb-Pb measurement.

In progress

- Simulations in the ALICE framework to understand parton shower and fragmentation of charm
- Gluon splitting and 2-to-2 processes, comparison of LO and NLO models
- Use different tunes and models for parton shower and fragmentation
- Study the effect of multi-parton iteraction and color reconnection

...stay tuned

SUMMARY

- ❖The shape of the correlation peaks can be used to separate the electrons coming from b-quark decays. This could be a method of identification that, combined with ITS identification, may provide a much better sample purity for examining the secondary vertex shift.
- ❖Correlation images are sensitive to the distribution of secondary vertex in heavy quarks, and these processes can be statistically separated from light quarks.
- ❖It is possible to distinguish which D-meson comes directly and which later decay. This allows the measurement to be used for statistical separation of prompt and late D-mesons.
- ❖We also have a characteristic b-correlation image, which is present in both b-quarks and B-mesons. B-mesons can be used to study b-quarks.
- ❖D-h correlation measurement study in progress.

THANKS FOR YOUR ATTENTION!