Identified two-particle correlation studies of the proposed VHMPID detector for ALICE

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VHMPID Collaboration

VHMPID LoI (arXiv:1309.5880 [nucl-ex])

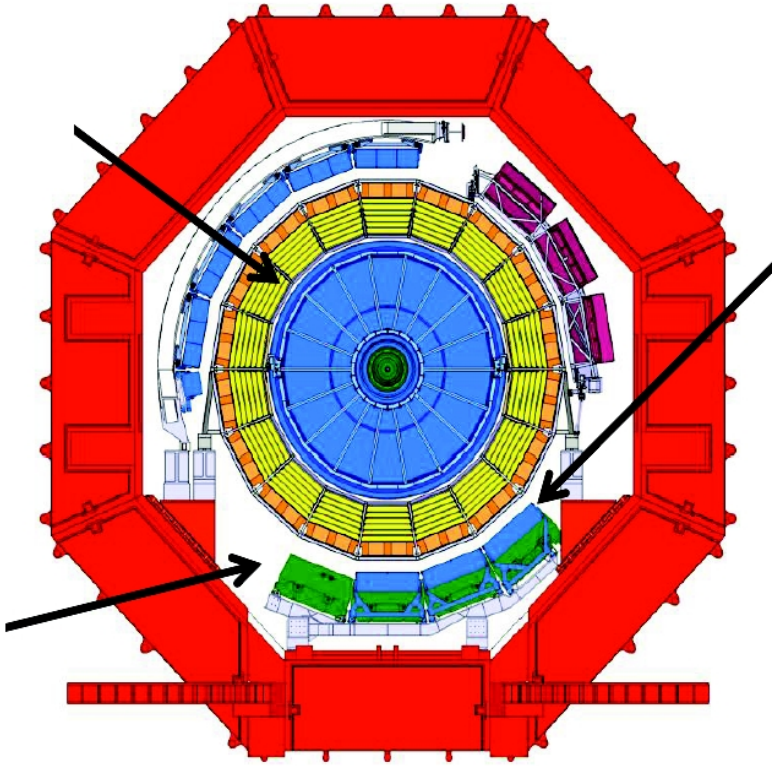
Outline

- VHMPID proposal
- Particle correlations at high-pT
- Monte Carlo study of identified two-particle azimuthal correlations in p-p and Pb-Pb collisions
- Outlook: measurement of the interesting phenomena that we see in MC with existing PID detectors in ALICE

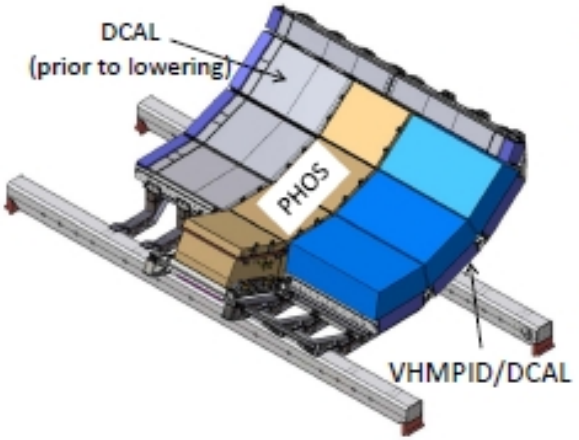
VHMPID proposal

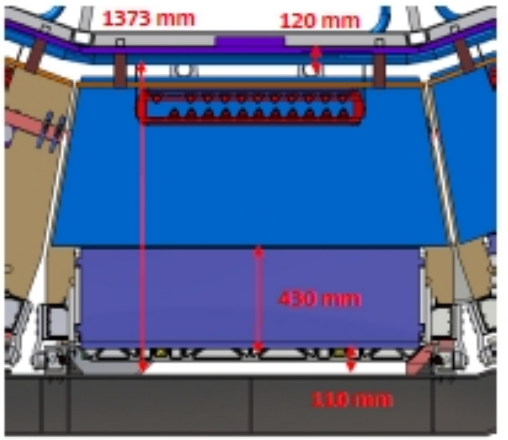
- The **V**ery **H**igh **M**omentum **P**article **I**dentification **D**etector was proposed as a possible upgrade option for ALICE
- The VHMPID provides track-by-track PID in the momentum range of **5-25 GeV/c** (pi, k, p)
- VHMPID is a specialized detector located at mid-rapidity with limited acceptance
- The VHMPID upgrade proposal is not pursued by ALICE

Proposed location in ALICE



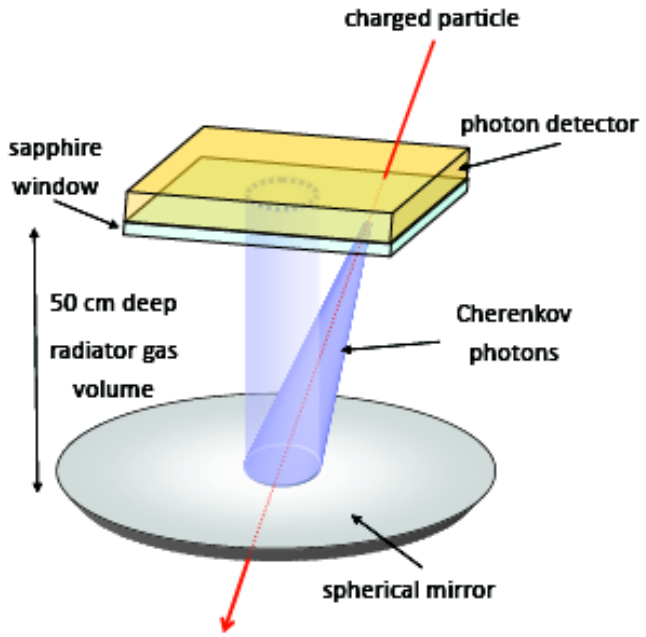
- Proposed layout as DCAL + VHMPID sandwich opposite to the existing EMCAL
- This layout allows PID in the calorimeter's accepatance for jet-like and (di-)jets measurements

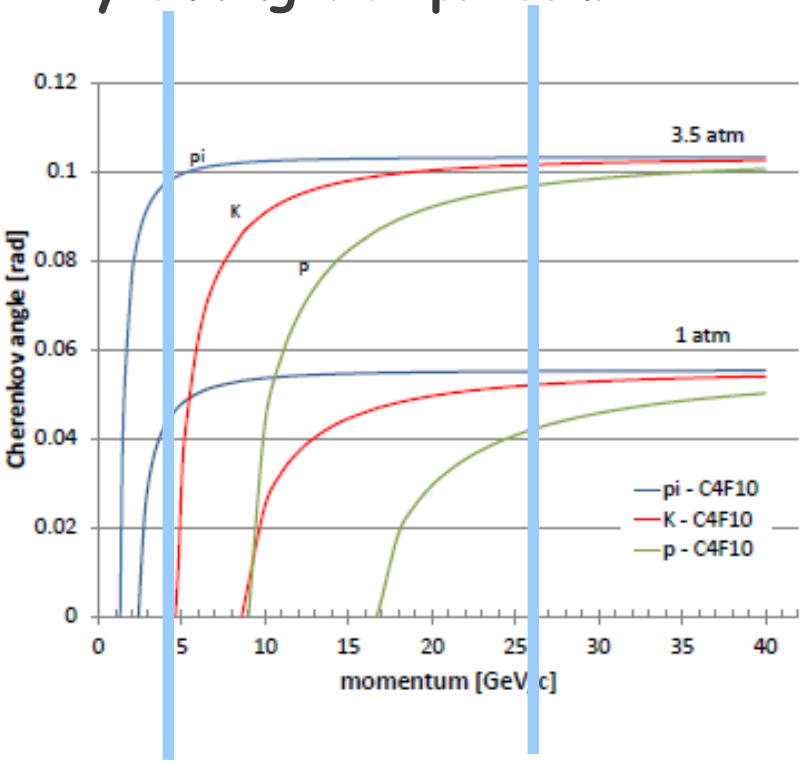




VHMPID Detector

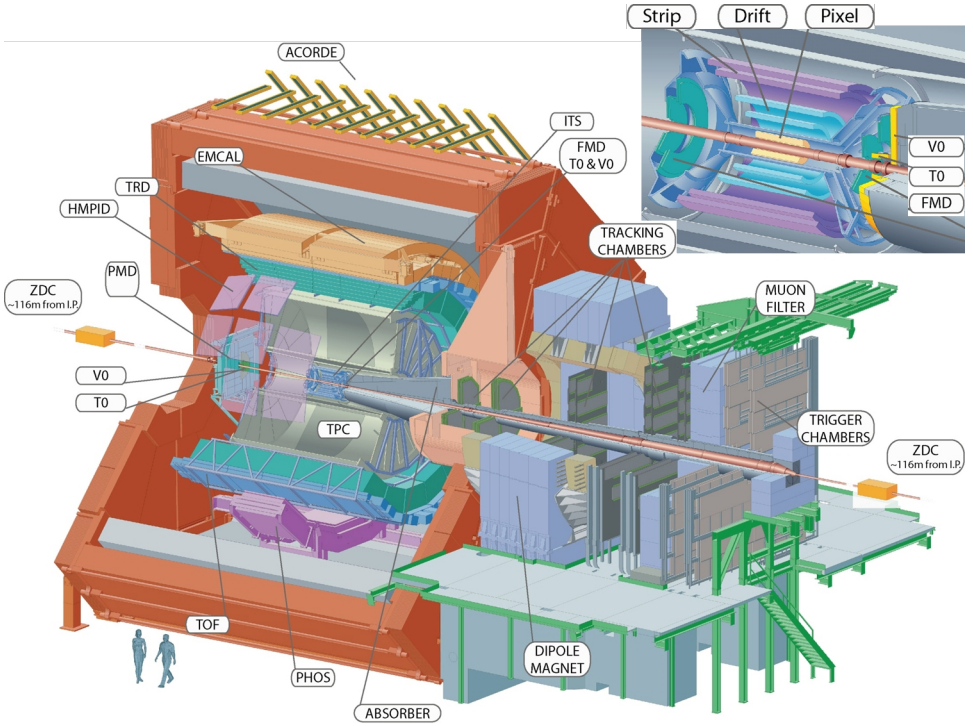
- Ring Imaging CHerenkov Detector (RICH)
- Pressurized with C4F8O gas radiator
  → The PID range can be selected by tuning the pressure

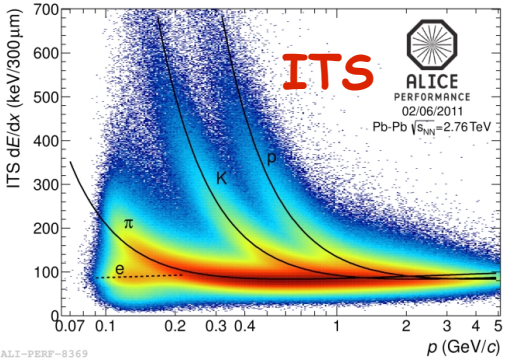


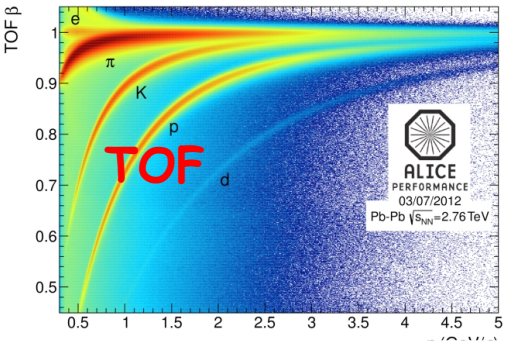


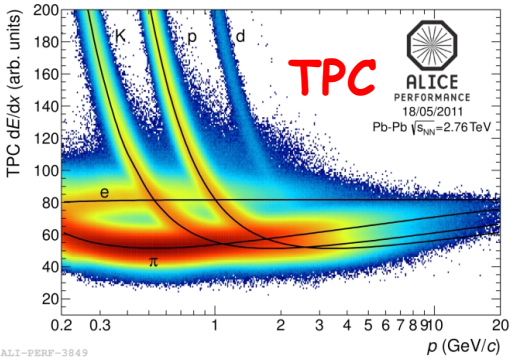
P = 5 – 25 GeV/c

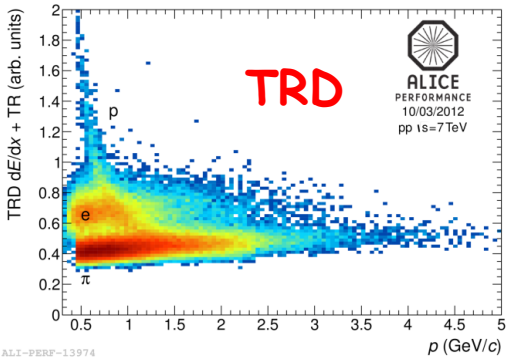
PID in ALICE

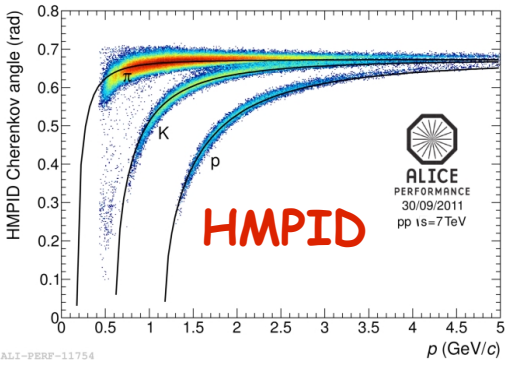






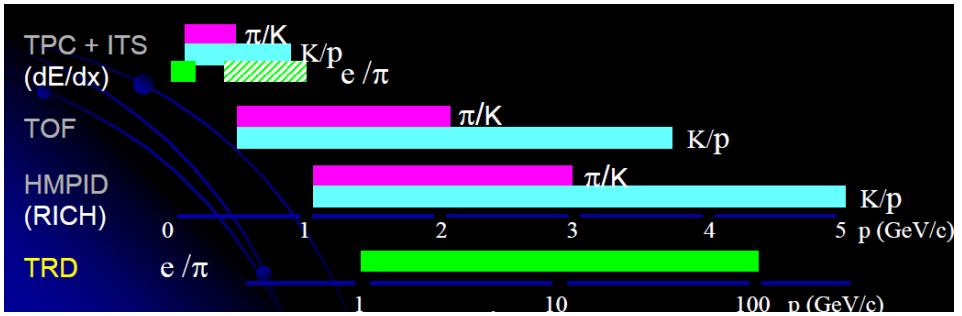






- **The strenght of the ALICE is PID (practically with all known techniques)**

The VMHPID would extend the PID range up to high-pT, p = 5-25 GeV/c, not accessible in ALICE



VHMPID extended physics

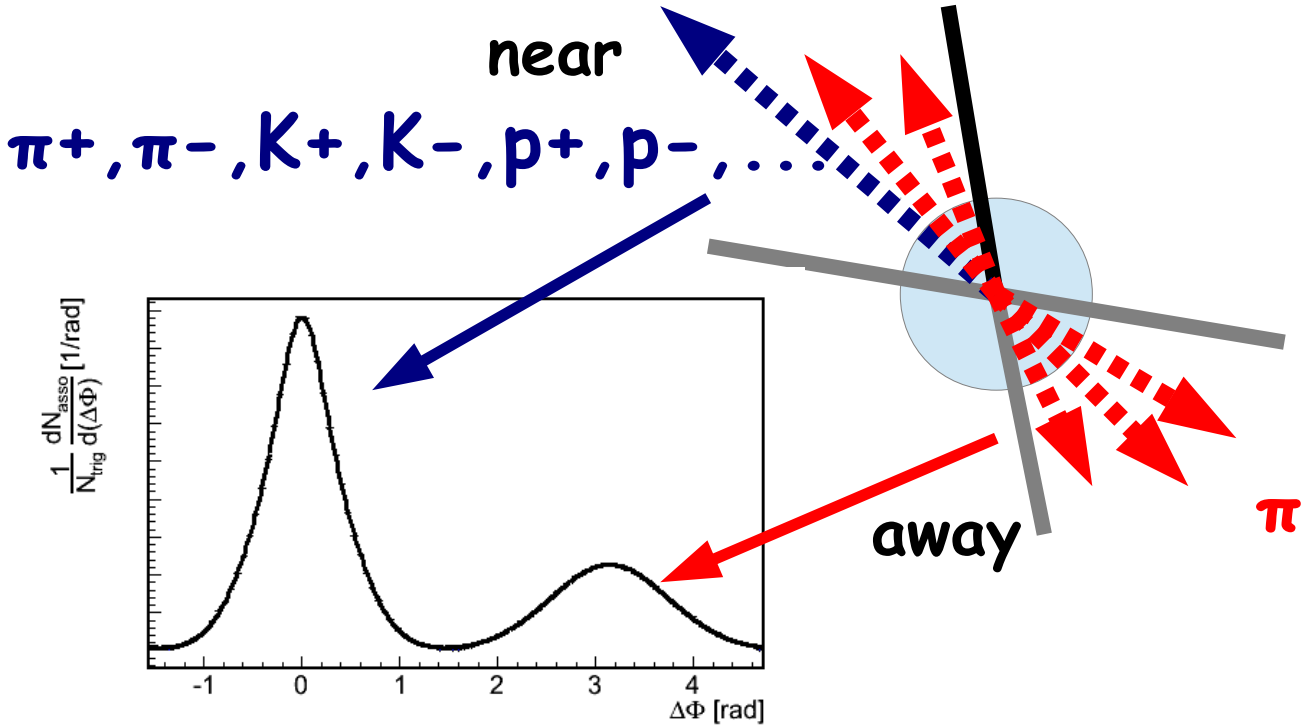
- In conjunction with the central barrel tracking and the calorimeter jet trigger, the VHMPID gives access to …
- **Pb-Pb**
  - Determination of cause of baryon enhancement at intermediate to high pT through measurement of hadro-chemistry in tagged jets.
  - Detailed mapping of gluon splitting process (energy loss in medium) through measurement of hadro-chemistry in tagged jets.
  - Determination of baryon/anti-baryon imbalance through momentum dependent proton/anti-proton measurement in tagged jets in medium
- **p-p**
  - Determination of baryon fragmentation functions via protons and anti-protons in jets
  - Determination of charmonium production process via PID characteristics in subleading heavy quark jet
  - Determination of quark vs. gluon fragmentation by measuring hadro-chemistry in tagged jet

Further details in VHMPID LoI (arXiv:1309.5880 [nucl-ex])

Next: Focus on hadron-hadron correlation

Identified two-particle azimuthal correlations

- Identified **triggers**, identified **associateds** integrated in mid-rapidity region



- Trigger p_T > Assoc p_T
- |Trigger, Assoc eta η| < 1
- Trigger, Associated species selection both on near and away sides

π+,π−,K+,K−,p+,p−,...

Expectation: conservation of quantum numbers

π,K,p – momentum p, charge Q (+K strangeness, +p baryon number)

Fragmentation / hadronization for different particle flavours

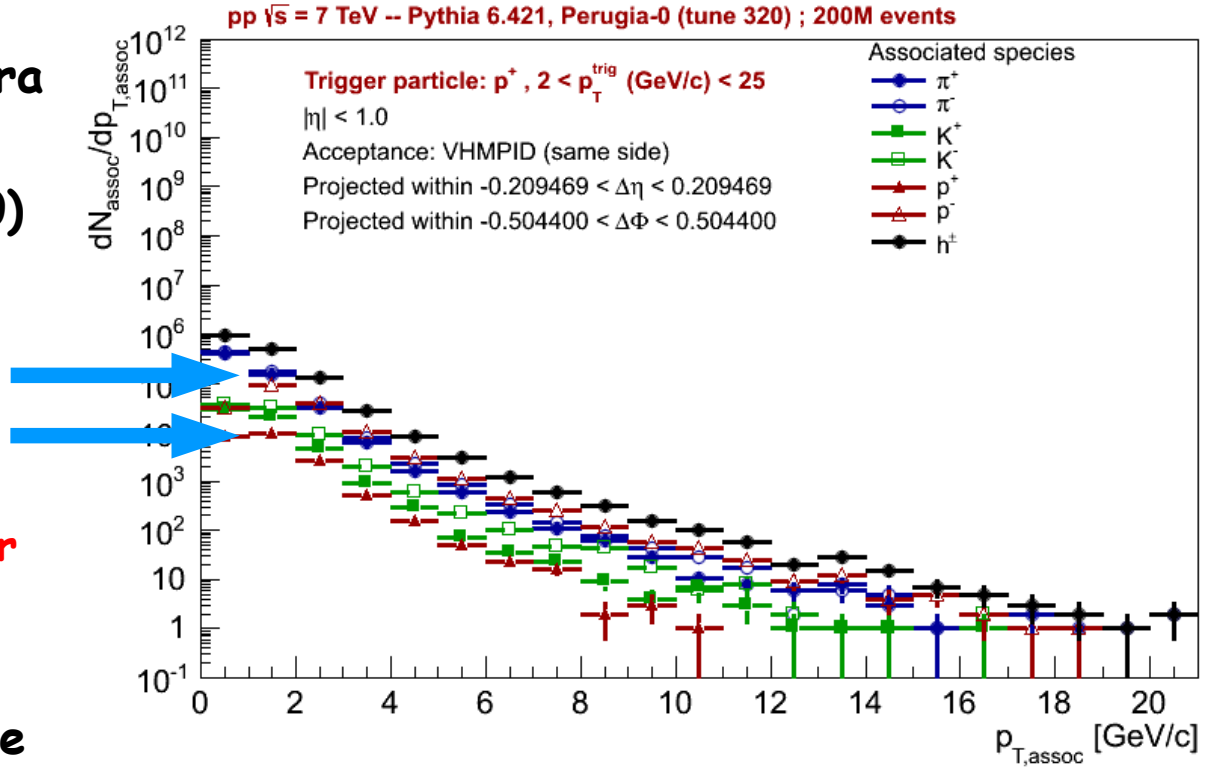
Identified two-particle azimuthal correlations

- **Simulation settings**
- **Pseudorapidity:** trigger particles |eta| < 0.5 , associated particles |eta| < 1.0, ALICE TPC acceptance
- **Azimuthal angle:** ALICE TPC acceptance
- **Azimuthal and pseudorapidity difference**: **Δφ, Δη in TPC/VHMPID acceptance**
- **Identified particles:** π+,π-,K+,K-,p,p_bar
  - **pp** : pythia 6.4 perugia0, tune 320
    - **200M** events generated
  - **PbPb** : Hijing (with quenching)
    - Focusing on centralitiy: **0-10% (4M)**

PID associated spectra

- PID-PID associated pT spectra up to high-pT
- p-p @ 7TeV, Pythia (tune320)
- Same side
- $|\Delta\varphi|$ = 0.21, $|\Delta\eta|$ = 0.50
- Trigger particle: proton
  - in 2<p_T (GeV/c)<25
- Associateds: π+, π-, K+, K-, p, pbar
- Acceptance: VHMPID

- Observation: difference in the proton, anti-proton yields

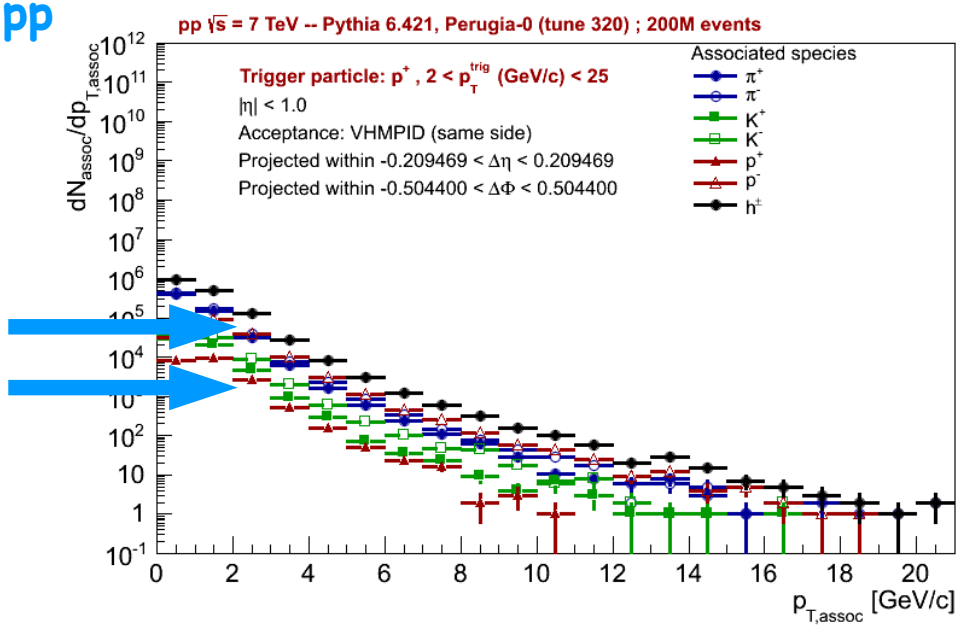


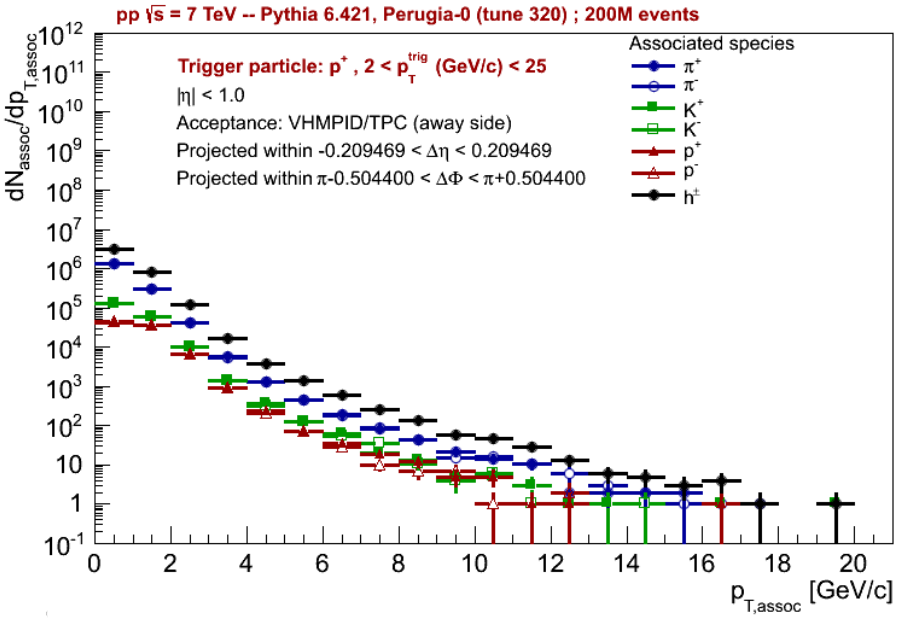
PID associated spectra (p trigger)

Near side

Away side

pp





PID associated spectra

Near side

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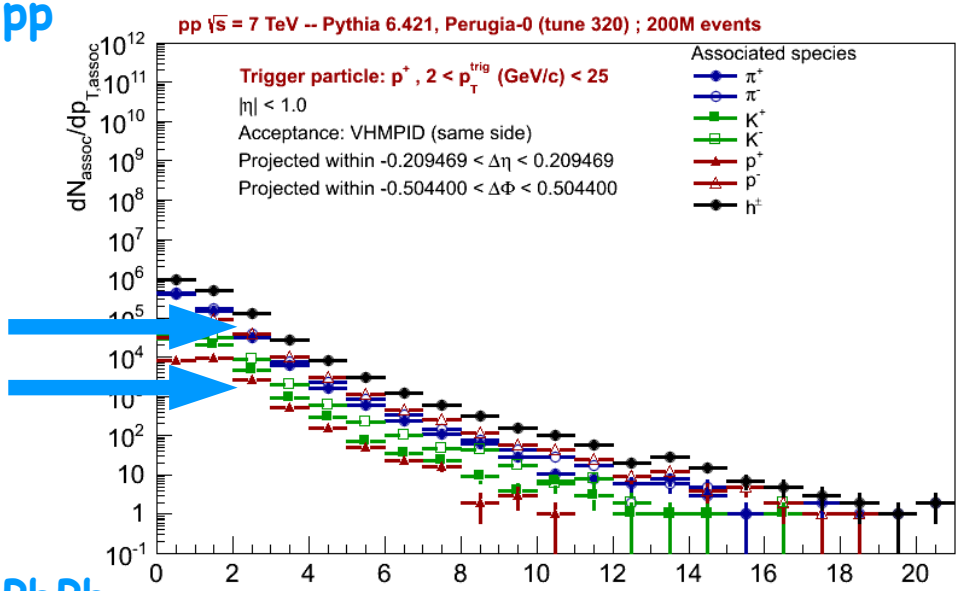
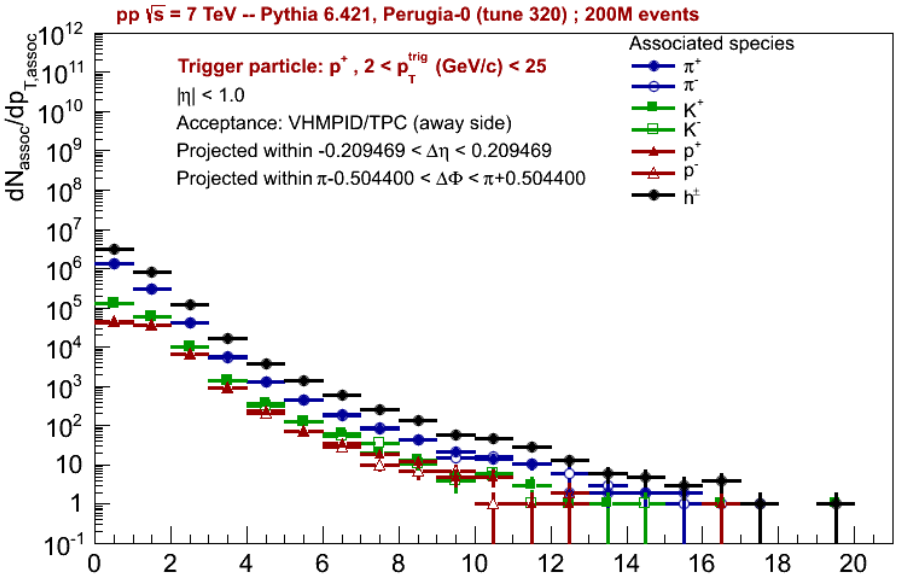
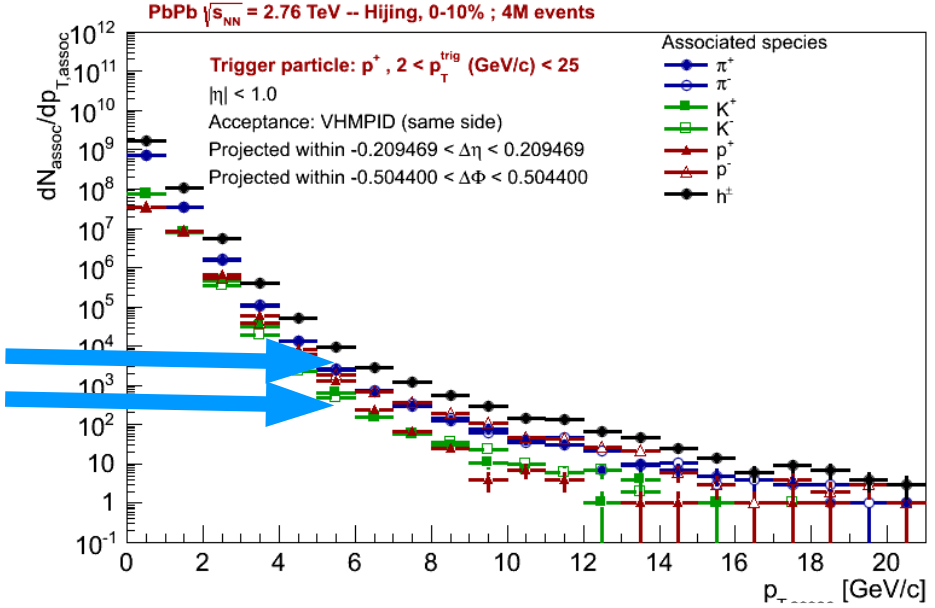
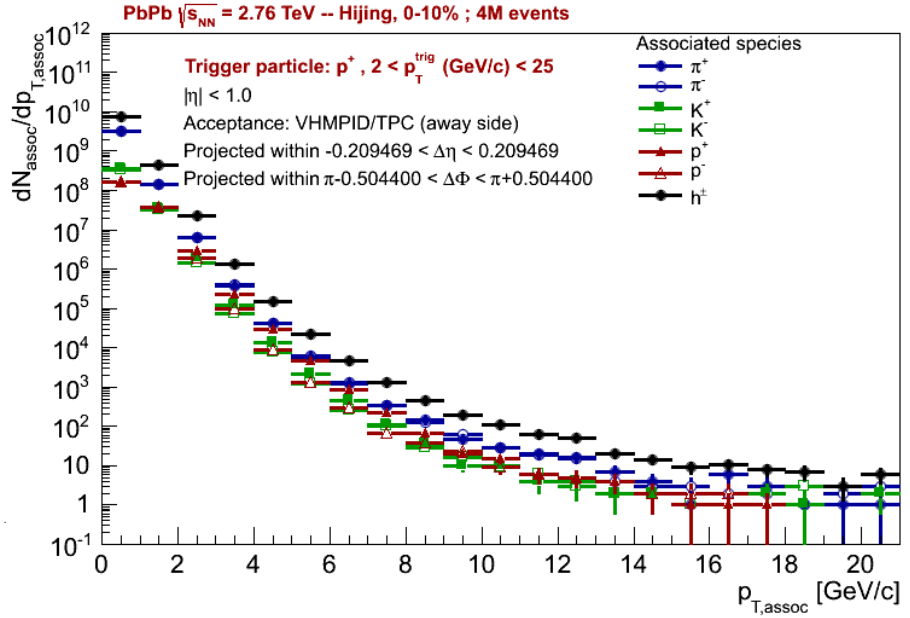




PbPb

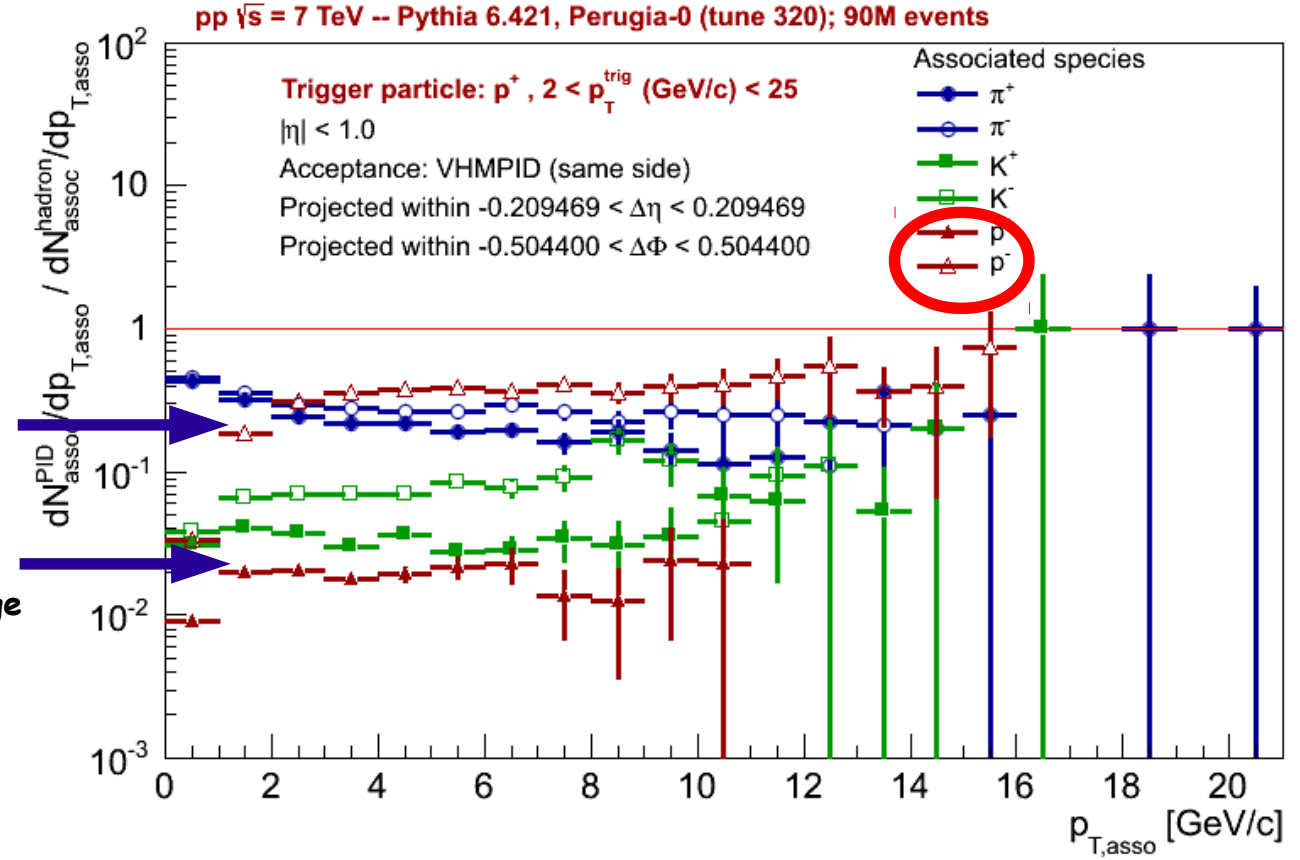




Identified particle ratios (p trigger)

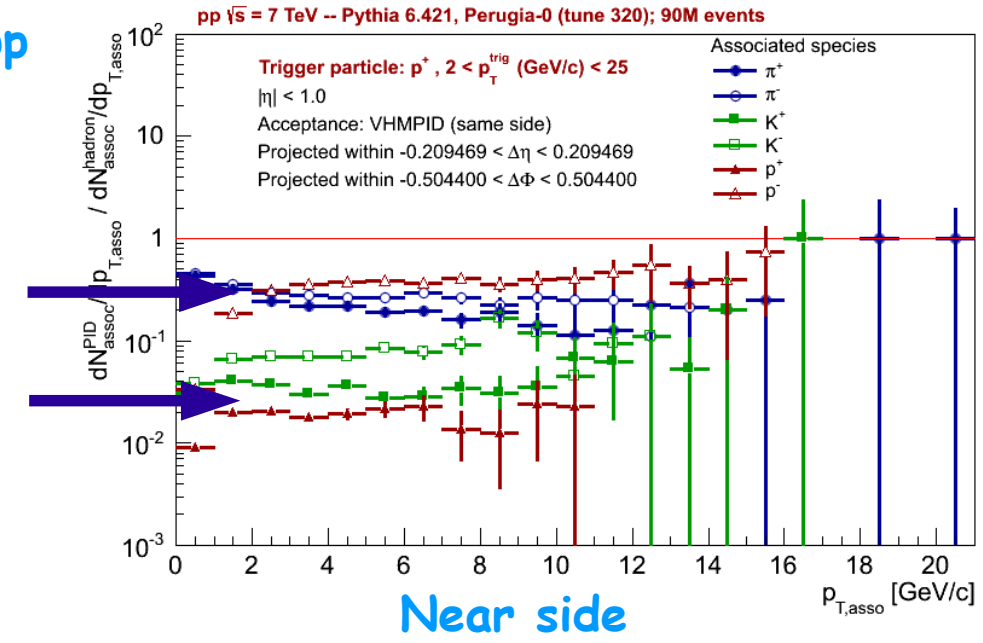
$$R := \frac{\frac{1}{N^{i}_{trig}} \times \frac{dN_{assoc}}{dp_{T,assoc}}}{\frac{1}{N^{j}_{trig}} \times \frac{dN_{assoc}}{dp_{T,assoc}}}, \qquad i \in \{\pi^{\pm}, K^{\pm}, p^{\pm}, h^{\pm}\}, \qquad j \in \{h^{\pm}\}$$

- Pp @ 7TeV, Pythia (tune 320)
- $|\Delta\varphi| = 0.21$, $|\Delta\eta| = 0.50$
- Trigger particle: proton
  - in 2<p_T (GeV/c)<25
- Associateds: π+, π-, K+, K-, p, pbar
- Acceptance: VHMPID
- In an unmodified fragmentation process the baryon number and charge is conserved and leads to highly correlated distributions in the same phase space
- Observation: splitting above 2GeV/c for the triggered protons

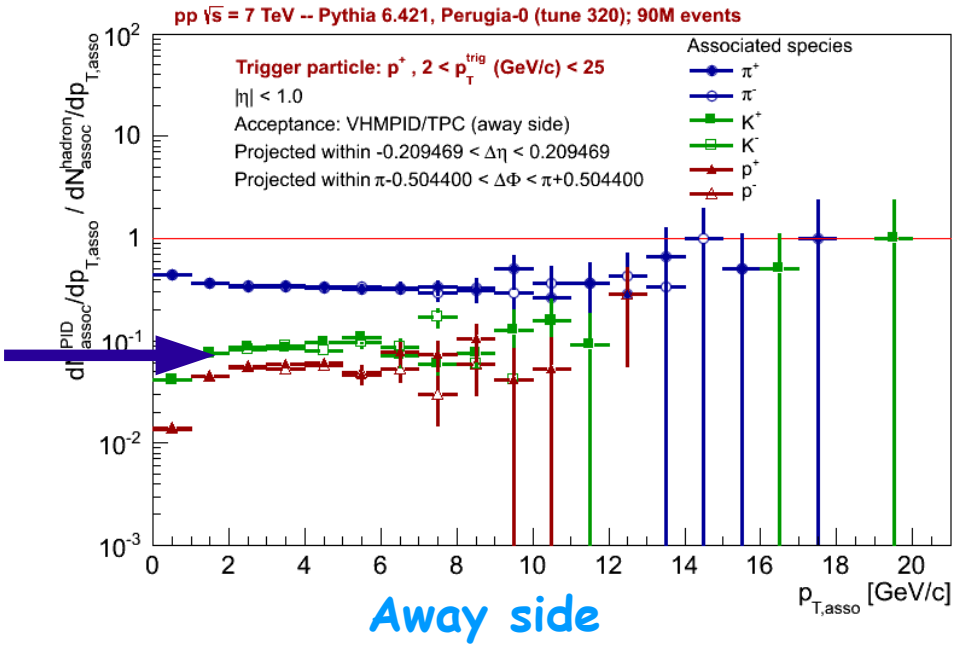


Identified particle ratios (p trigger)

pp



Near side



Away side

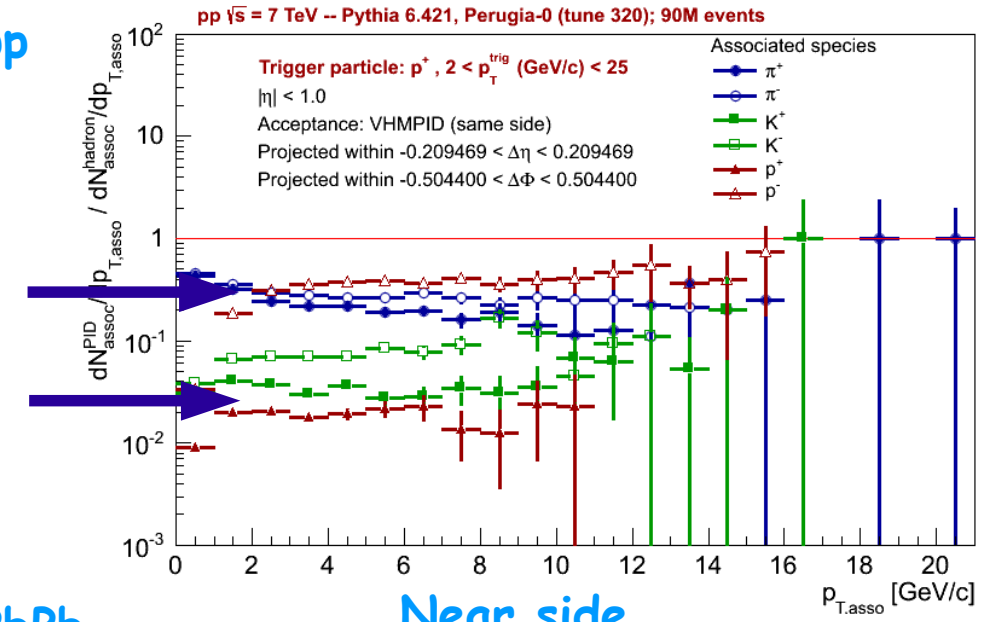
Identified particle ratios (p trigger)

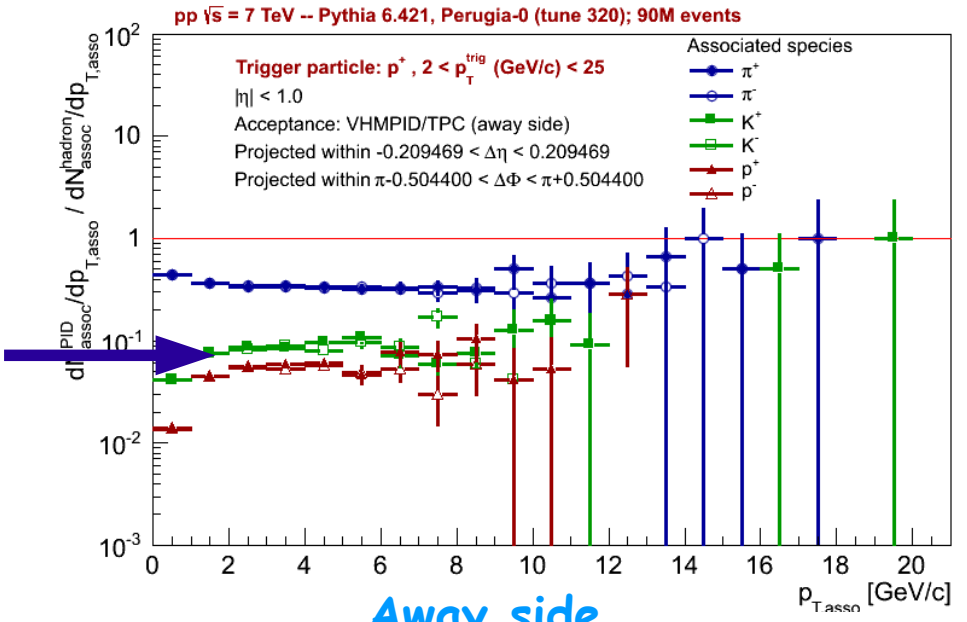
pp

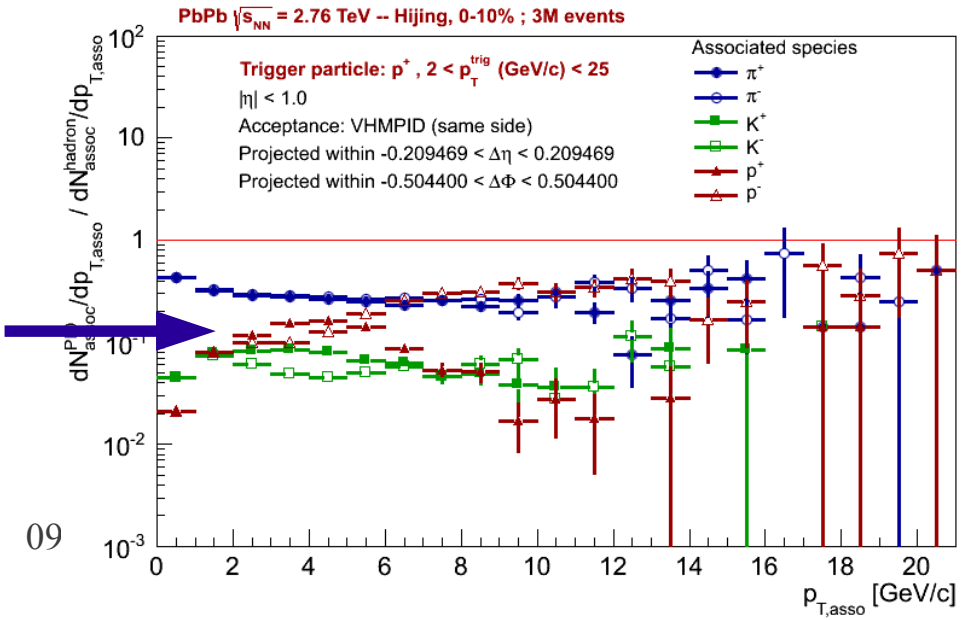
PbPb

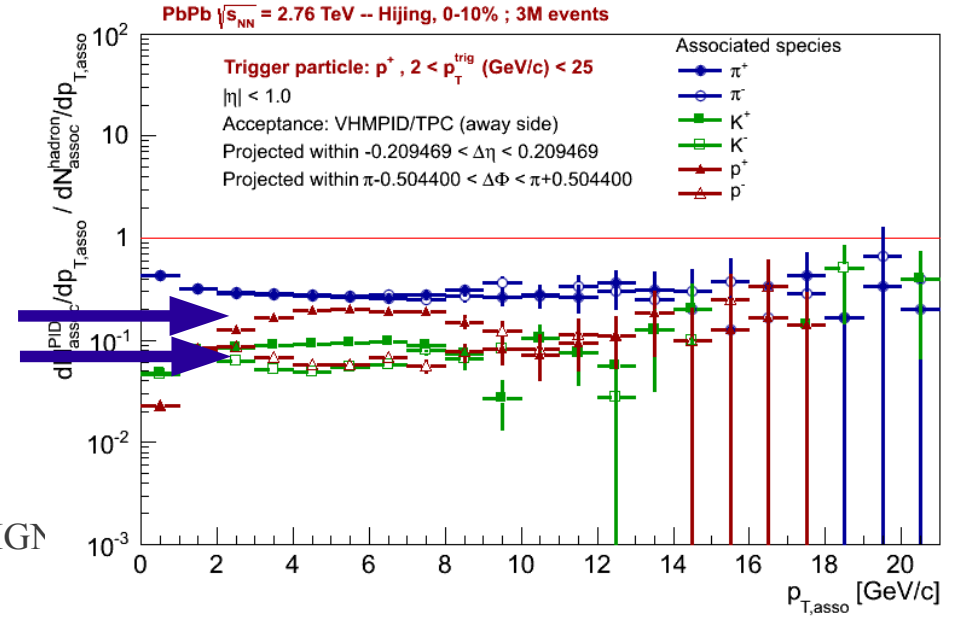
Near side

Away side



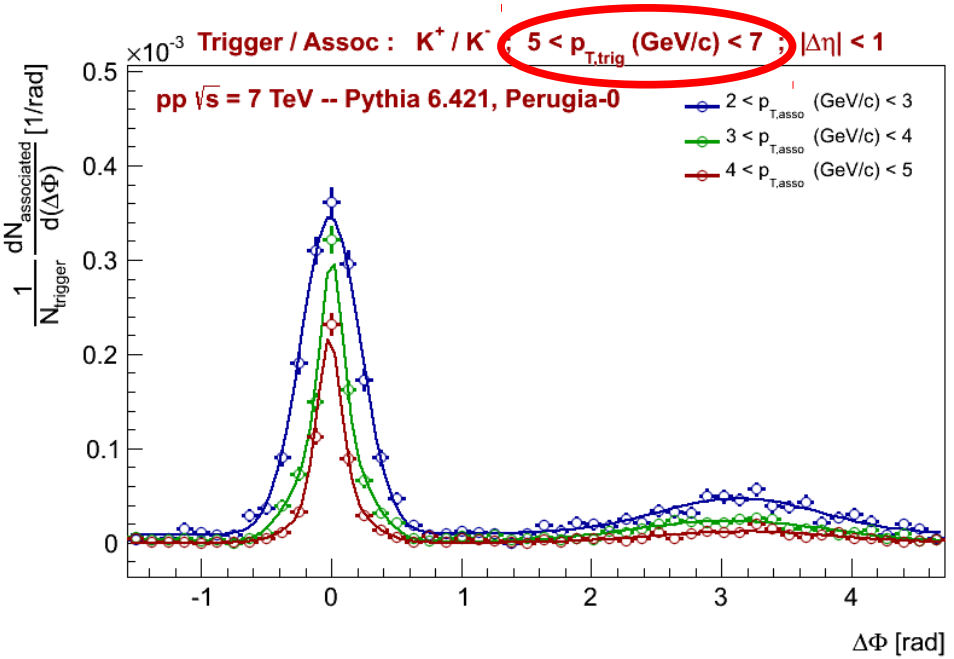


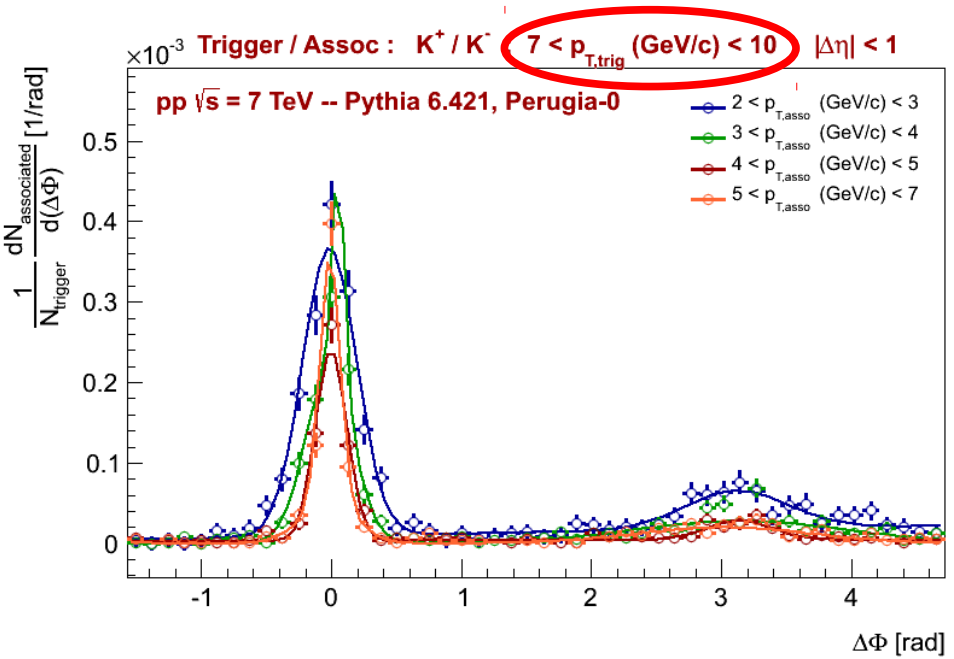




Dphi projections
(flavour conservations, K)

pp

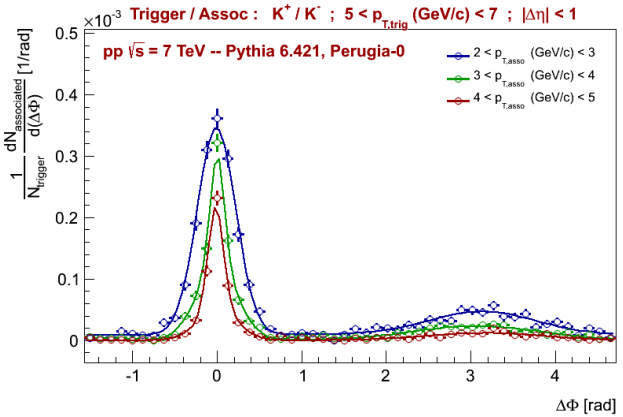


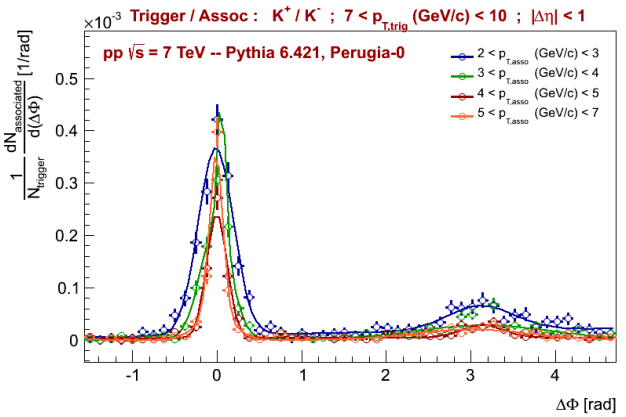


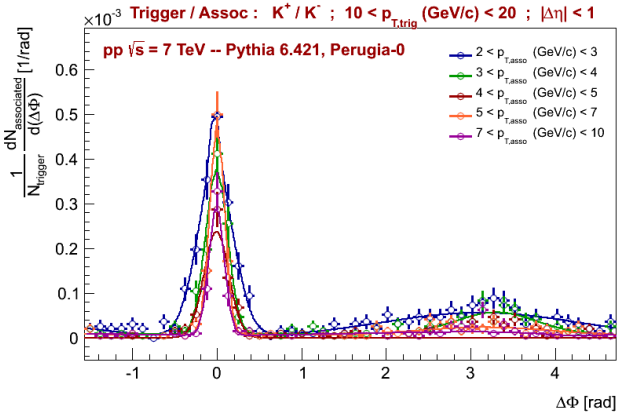
- **Same side flavor and charge correlations decrease as a function of pT;assoc and pT;trig (the width narrows) compared to the away side correlations which stay roughly constant when the trigger particle momentum is raised**

Dphi projections
(flavour conservations, K)

pp



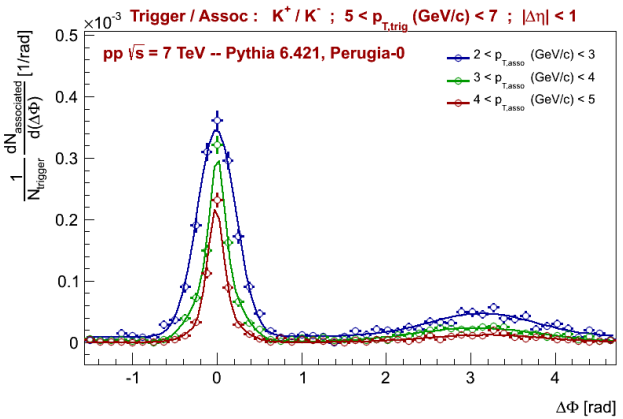


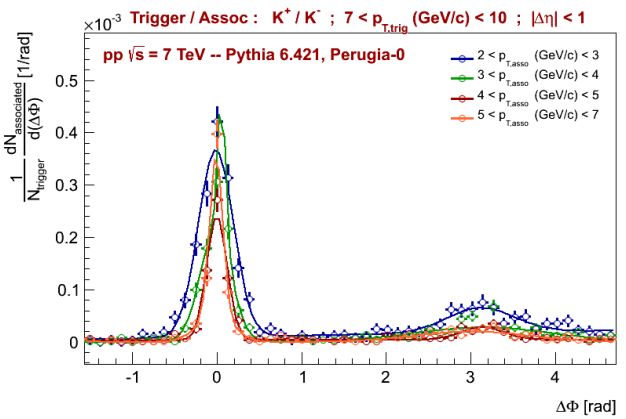


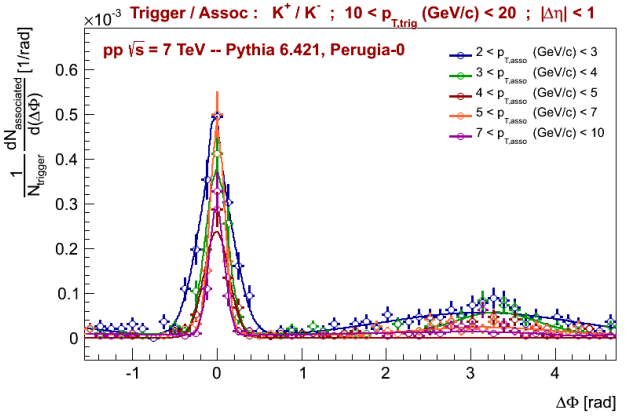
- **Same side flavor and charge correlations decrease as a function of pT;assoc and pT;trig (the width narrows) compared to the away side correlations which stay roughly constant when the trigger particle momentum is raised**
- **The question is whether this effect is unique to the strange flavor particles and whether this kinematic pattern persists when one hadronizes out of an extended thermal medium**

Dphi projections
(flavour conservations, K)

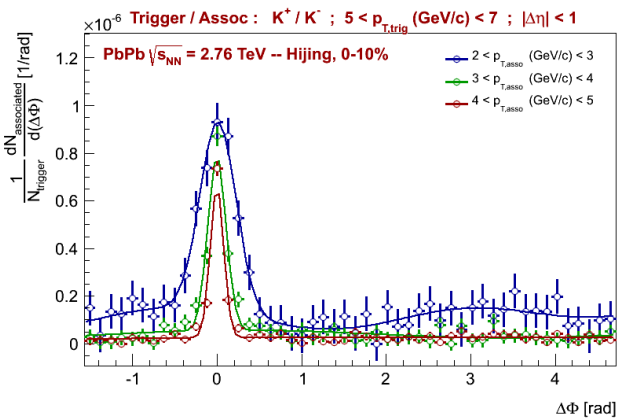
pp

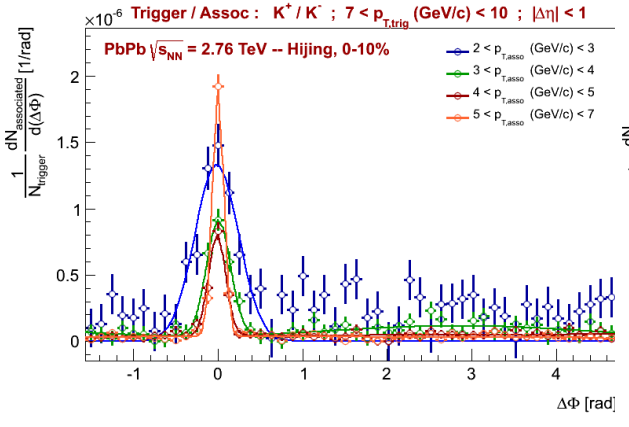


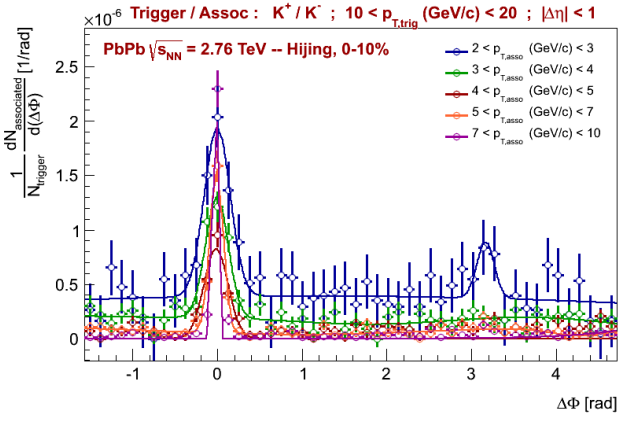




PbPb







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Summary and Outlook

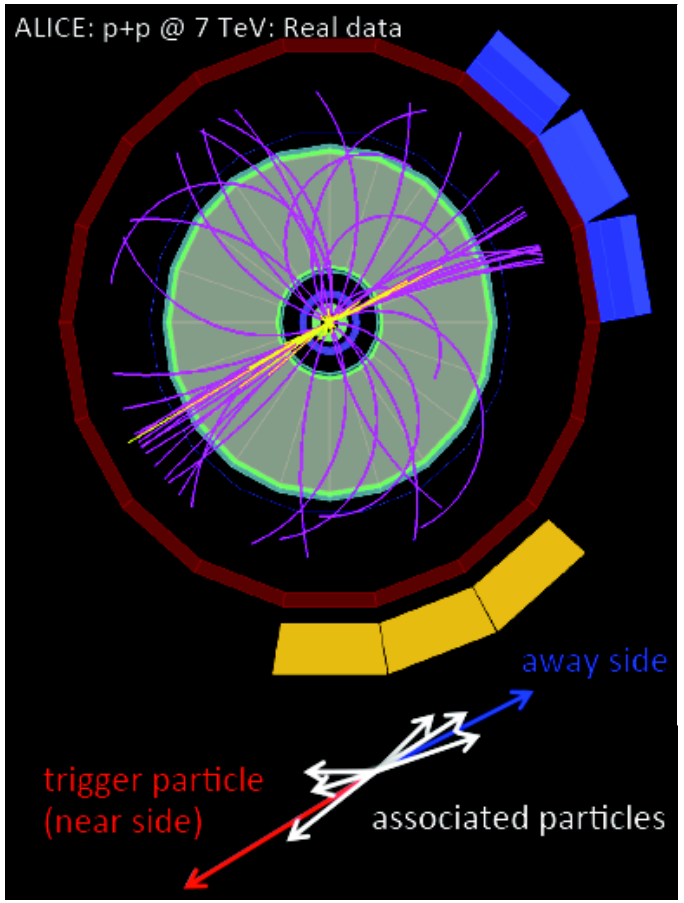
- MC simulations and analysis have been performed to study PID-PID azimuthal correlations in the proposed VHMPID acceptane
- MC shows interesting splitting in associated particle production (p-triggered to hadron-triggered ratios of the yields shows splitting: in pp on the near side and in PbPb on the near and away side as well)
- No experimental measurements to contrast with the observed MC analysis
- Analysis has been started to perform the same analysis exploiting the PID capabilities of ALICE
- The observed interesting patterns can be measured at lower momentum in ALICE
  - In principle this can be done by the TPC, statistical method: relativistic dE/dx
  - Purity PID cuts

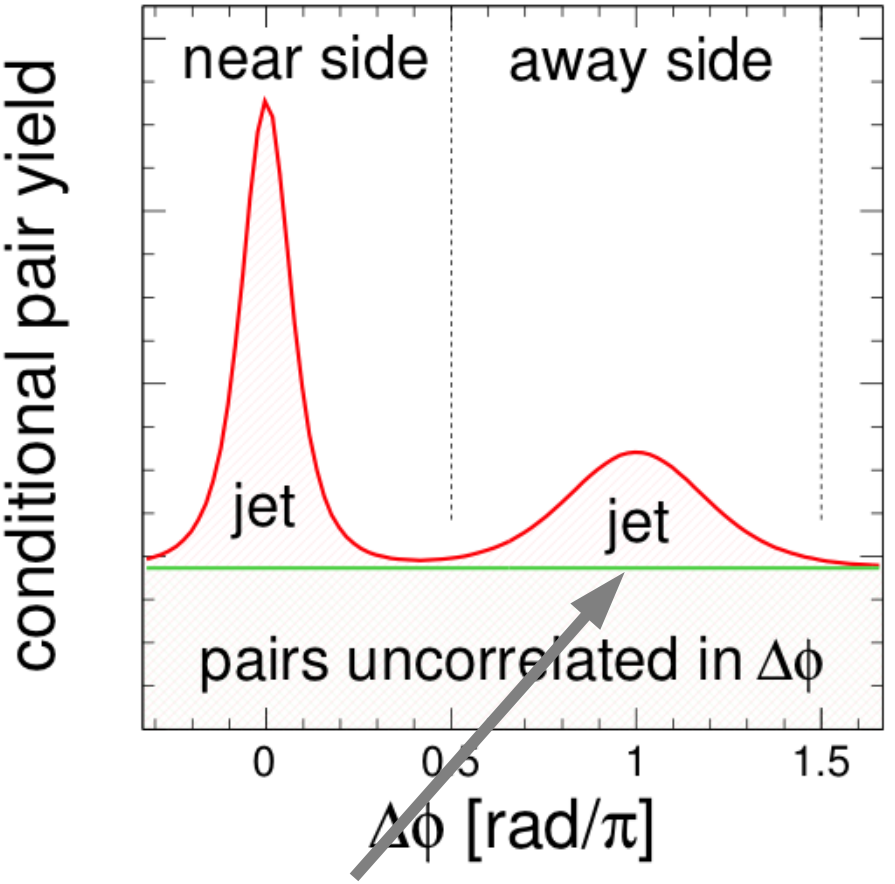
Backup

VHMPID specific measurements

- In intermediate pT the baryon-to-meson ratio enhanced by more than a factor three in Pb-Pb compared to pp.
- PID triggered correlations enable us to distinguish between different underlying mechanisms.
- Quantum number conservations can be studied with the tools of correlations (beyond barion/meson ratio)
- Flavour changing correlations …
- …

Azimuthal correlations

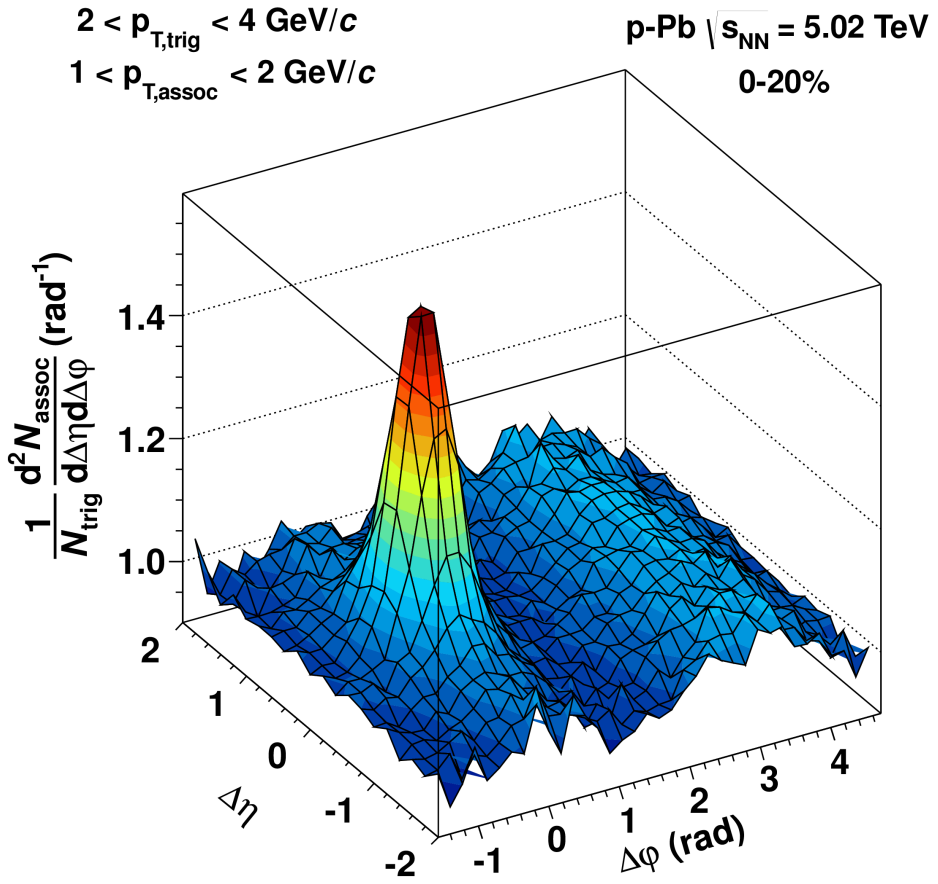




ZYAM: Zero Yield At Minimum

$\Delta\varphi = \varphi_{trigger} - \varphi_{assoc}$, $\Delta\eta = \eta_{trigger} - \eta_{assoc}$

Azimuthal correlations



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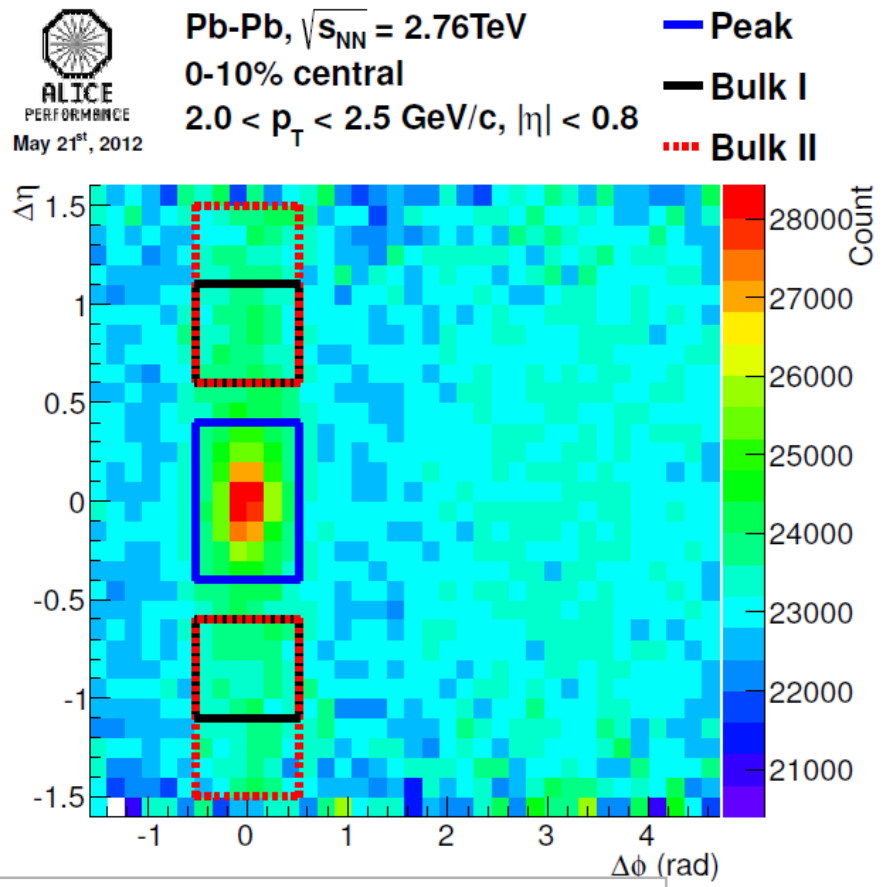

arXiv:1208.1445v1 [nucl-ex] 7 Aug 2012