Neutral meson analysis in MPD

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Neutral meson and photons: motivation

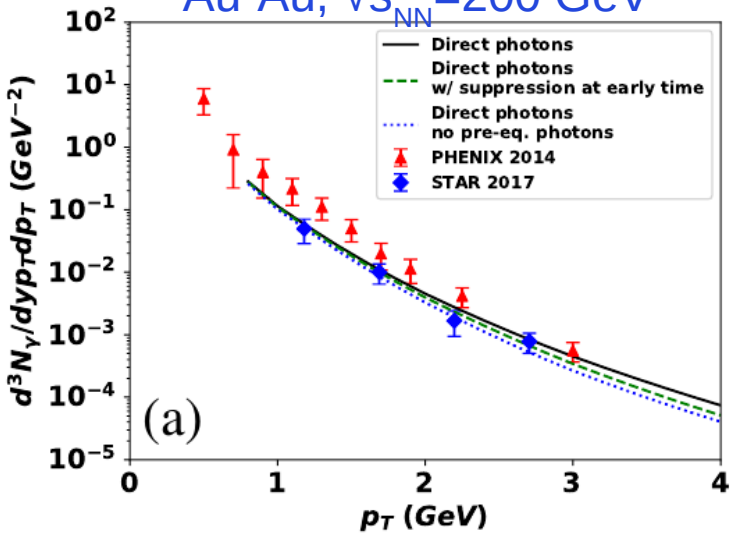
- Spectra, rapidity and flow distributions of identified π^0, η
  - Thermodynamics
  - Collective flow
  - Resonance production
- Spectra, rapidity, flow and BE correlations of direct photons
  - Test of initial state
  - Probe innermost/hottest part of the collision

Direct photon puzzle

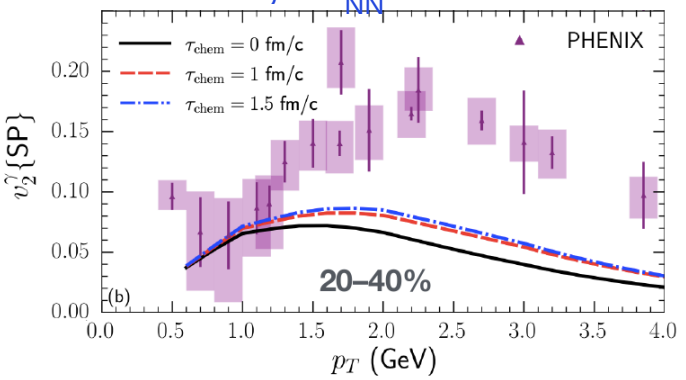
- Spectra
  - PHENIX: factor 2-5 higher than predictions
  - STAR: consistent with predictions
  - ALICE Pb-Pb 2.76 TeV: up to factor 2 higher, but consistent within uncertainties

C.Gale, J-F. Paquet, B. Schenke, C. Shen, Quark Matter 2019, arxiv 2002.05191

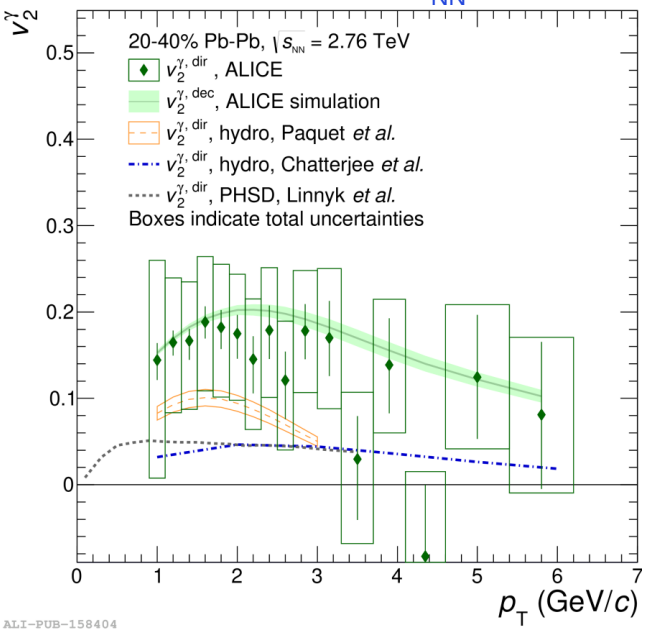
Au-Au, $\sqrt{s_{NN}}$=200 GeV



Au-Au, $\sqrt{s_{NN}}$=200 GeV



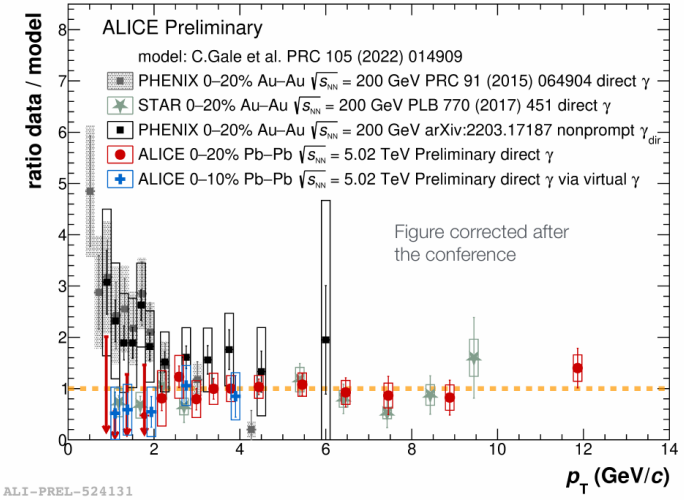
ALICE: Pb-Pb, $\sqrt{s_{NN}}$=2.76 TeV

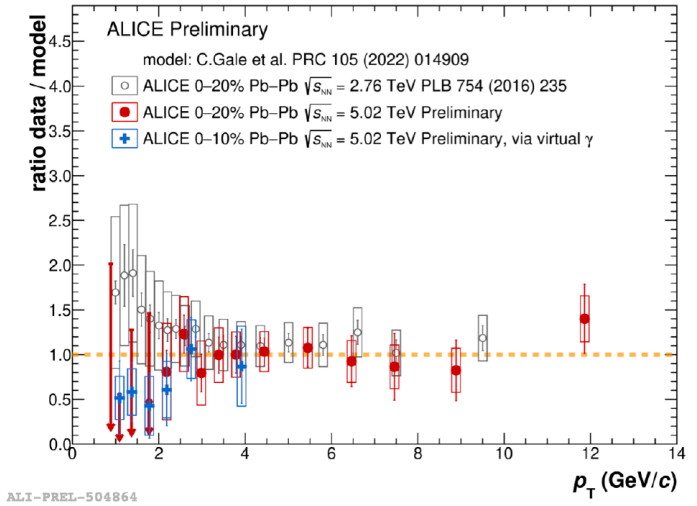


- Flow
  - PHENIX: $v_2^\gamma \sim v_2^\pi$ and much larger than theory predictions
  - ALICE: $v_2^\gamma \sim v_2^\pi$, statistically consistent with predictions

Photon puzzle at LHC

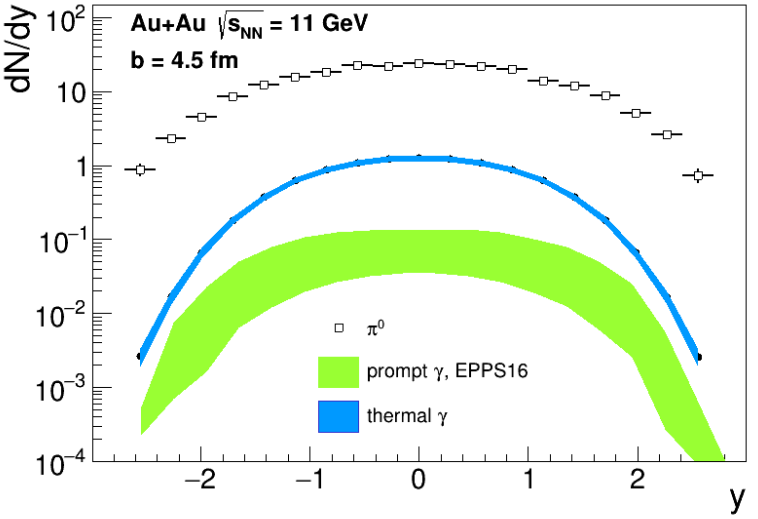
- New ALICE 5.02 TeV data consistent with theory predictions
- Conversion method now uses self-normalized material budget estimate what considerably decreased uncertainties, see arXiv:2303.15317

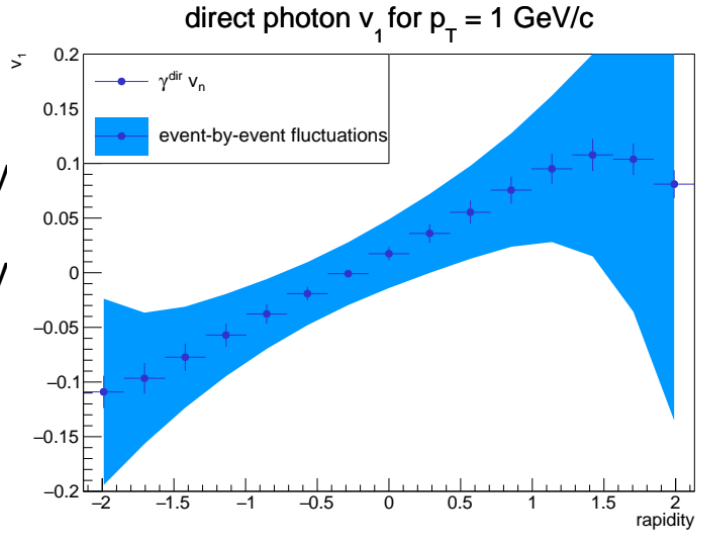


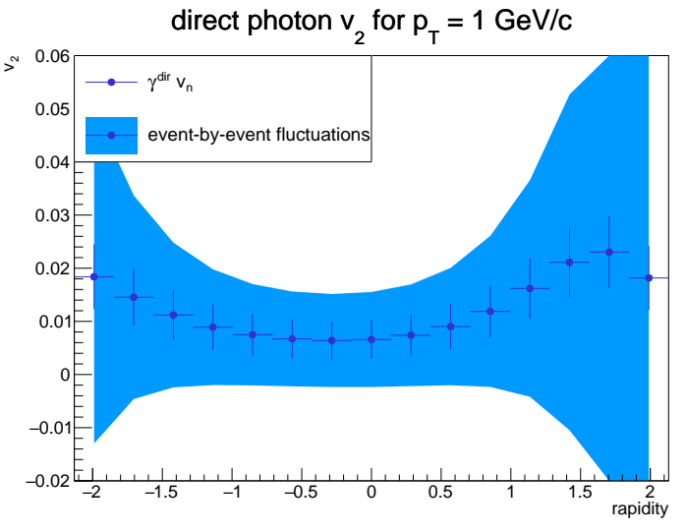


MPD advantages

- New colliding energy
- Large rapidity coverage:
  - Can be even further increased with large dz of primary vertex
  - first time look for rapidity dependence
- Look at correlation between direct photon and final hadron flow
- TODO: estimate possibility of analysis of events with large Z to increase rapidity coverage







Goals of EM wagons

- Spectra and collective flow of inclusive photons
  - Centrality dependence
  - Rapidity dependence
  - Systematic uncertainties calculation: cut variation (within one vagon or in several wagons?)
  - Calorimeter photons and conversion photons
- Spectra and collective flow of neutral pions, eta-, omega-mesons
  - Centrality dependence
  - Rapidity dependence
  - Systematic uncertainties calculation: cut variation (within one wagon or in several wagons?)
  - Calorimeter photons, conversion photons and hybrid
  - To analyze pi0 flow measure both yield vs phi-Psi and inv. mass vs phi-Psi
- Provide possibility to analyze MC data
  - Tag primary and secondary particles
  - Estimate purity, efficiency and feed-down
- Dileptons

Wagons

- MpdV0Maker: Calculate list of V0
  - Task common for several analyses
  - Need to assume track PID for V0 construction (electrons for conversion, K_s^0, Λ,...)
  - How sensitive result for this assumption? Can be improved later in analysis of existing V0?
  - Improved algorithms?
- MpdConvPi0: Use prepared list of V0s and clusters

New class MpdV0

```
class MpdV0 : public TLorentzVector {
public:

   void setMatched1(int matched);  // First matched track index
   void setMatched2(int matched); // Second matched track index

   int getCommonParent(); // Index of matched particles parent (-1 for fake V0)

   void getArmenteros(float &alpha, float &qt) const;  // Armenteros-Podolansky parameters

   void getAsymmetry(float &asym1, float &asym2) const;

   float getChi2() const { return mChi2; } // chi2 provided by Kalman fit

   float getDaughterDCA() const ; // Minimal distance between daughters

   float getMass() const ; // calculated mass of the pair
   float getPA() const ; // angle between momentum and direction from primary vertex to creation point
   float getCospsi() const; // Pair orientation vrt mag field
   float getRconv() const; // Conversion radius

   int  getTr1(); // First track index
   int  getTr2(); // Second track index

   void getVertex(float &x, float &y, float &z);  // Conversion position

};
```

New class MpdV0Maker

- Originated from very first version provided by A.Zinchenko
- Combines all track pairs with opposite charges and attempts to create a pair with MpdParticle::BuildMother()
- CPU consumption not negligible and can be improved by pre-selecting pairs with some kinematic cuts

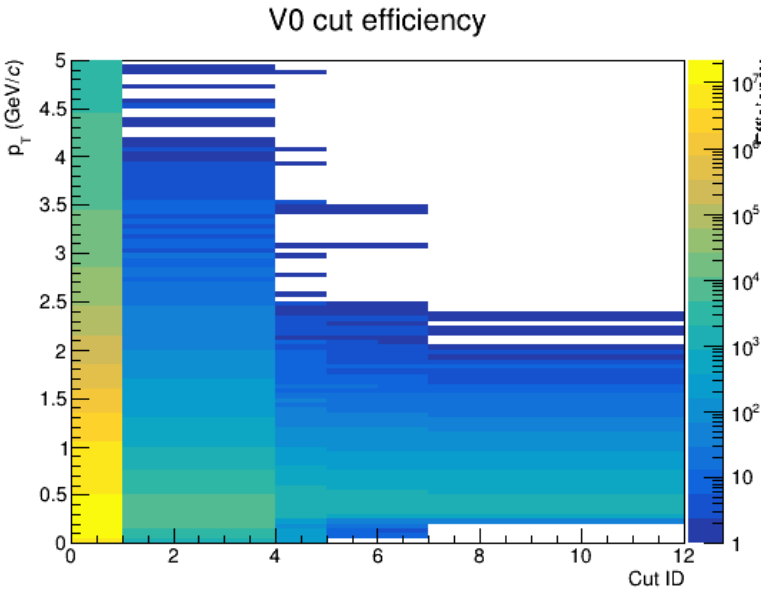
Code status

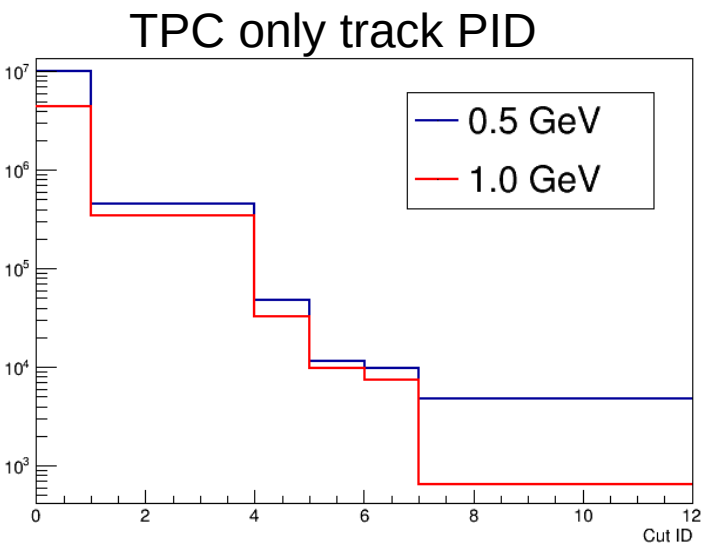
- First version committed
  - Included in official train
- Some bug fixes to be committed
- “Partisan” analysis while preparing for official train

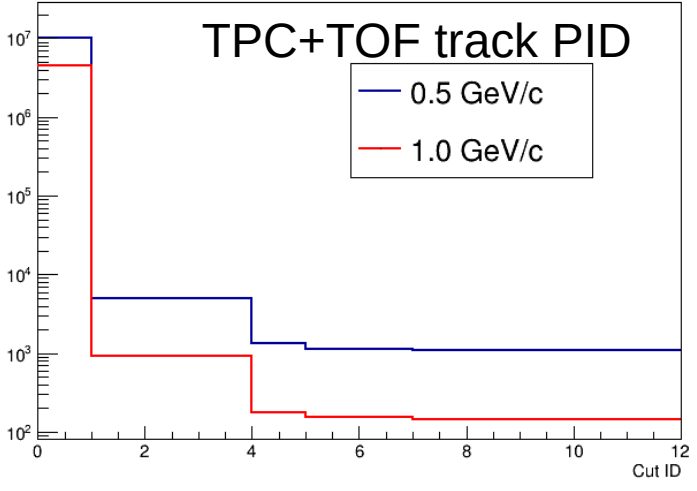
V0 selection

- Cut efficiency

V0 cuts
0: All
1: p_T>5 MeV/c
2: χ^2<10
3: 1<R_{conv}<150 cm
4: CPA<0.1
5: Daughter DCA<10 cm
6: m_{ee}<100 MeV/c
7: Armenteros
8: Asymmetry
9: cos(Ψ_{ee}) <1



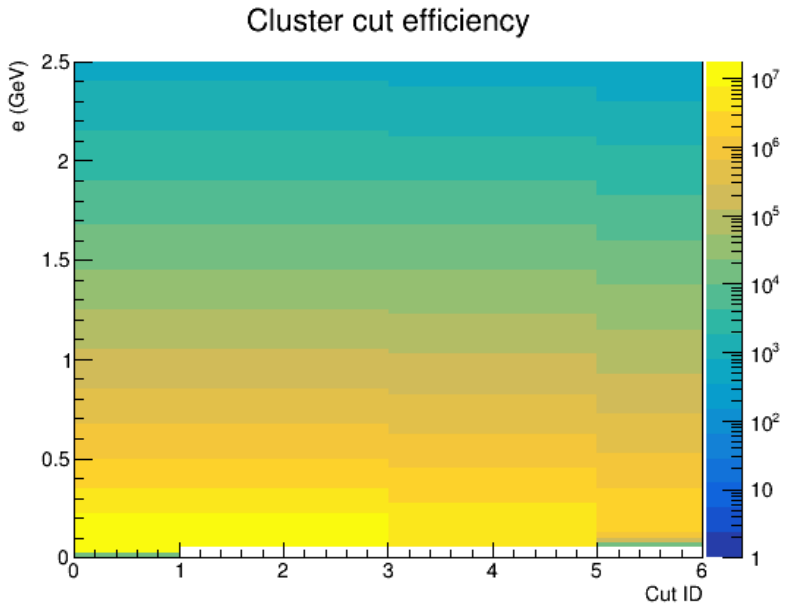


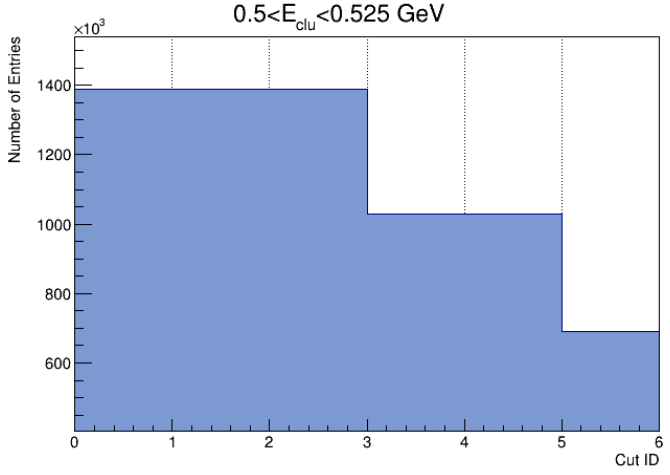


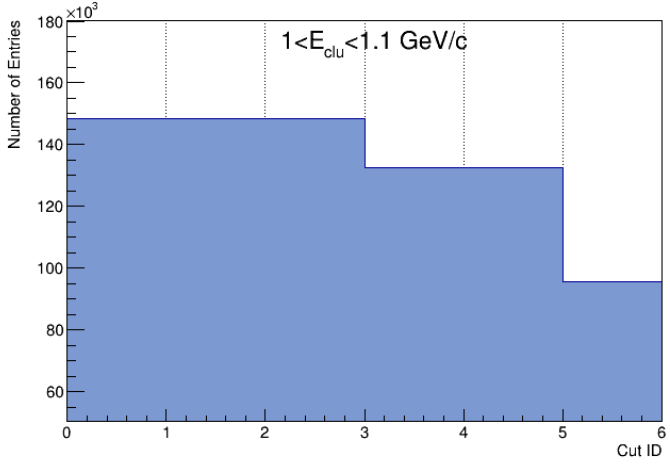
Cluster cut efficiency

Cluster cut ID:

- 0: All
- 1: E>50 MeV
- 2: $N_{cell}>2$
- 3: $|t-t_y|<3\sigma$
- 4: Disp<2.5σ (*not used*)
- 5: $R_{CPV}>2\sigma$

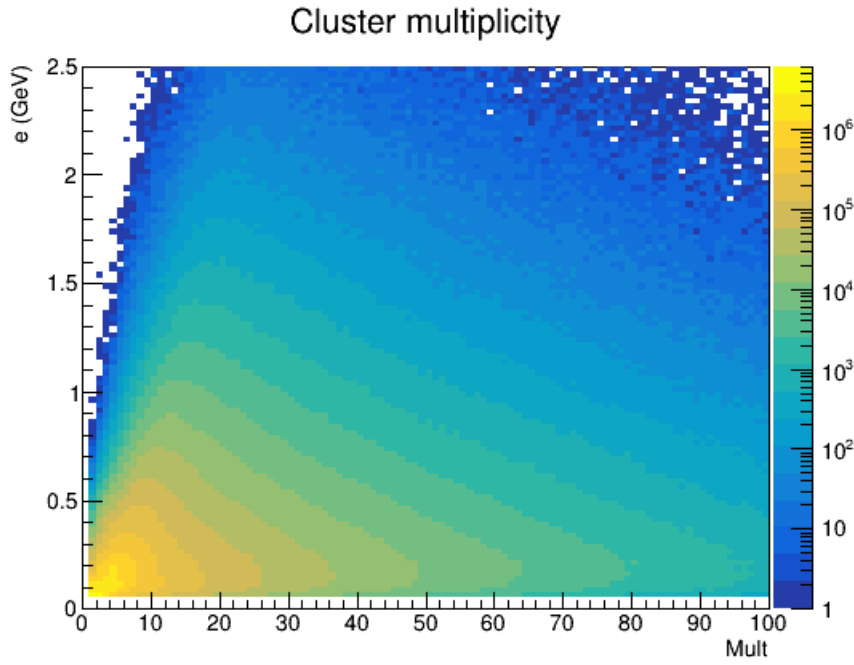


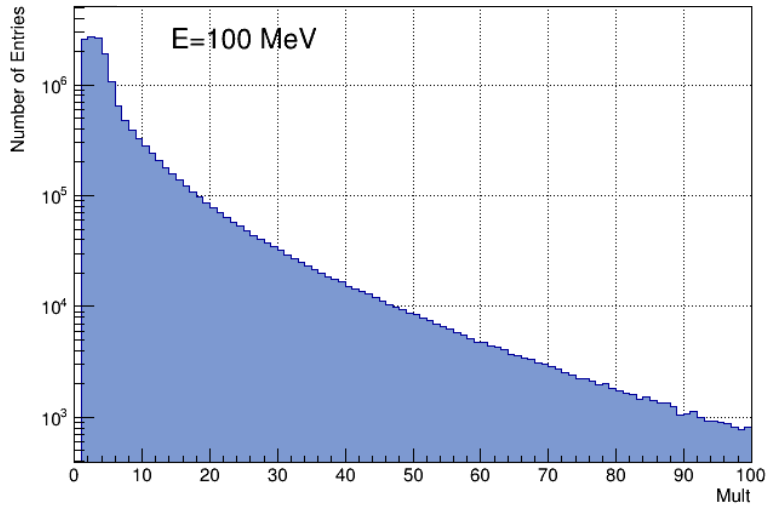




Calorimeter cluster multiplicity

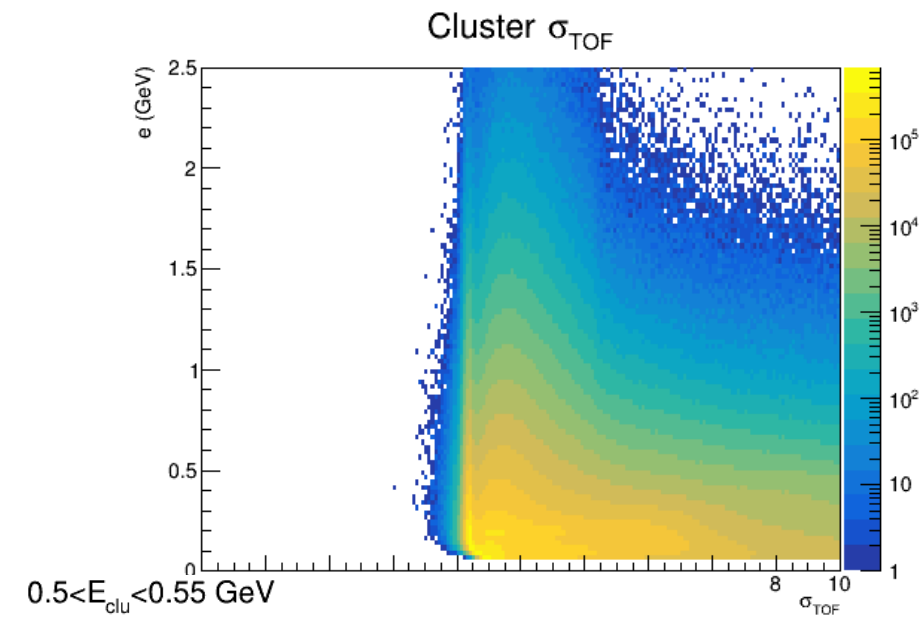
- Number of cells even in small energy clusters can reach 100
  - Percolation of noisy cells?
- Thresholds should be adjusted
- Test alternative clusterizers?

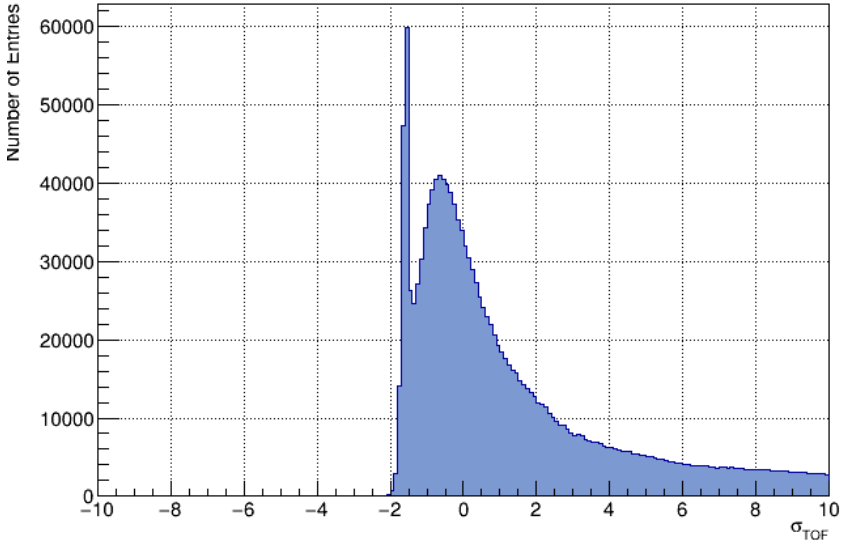




Cluster time distribution

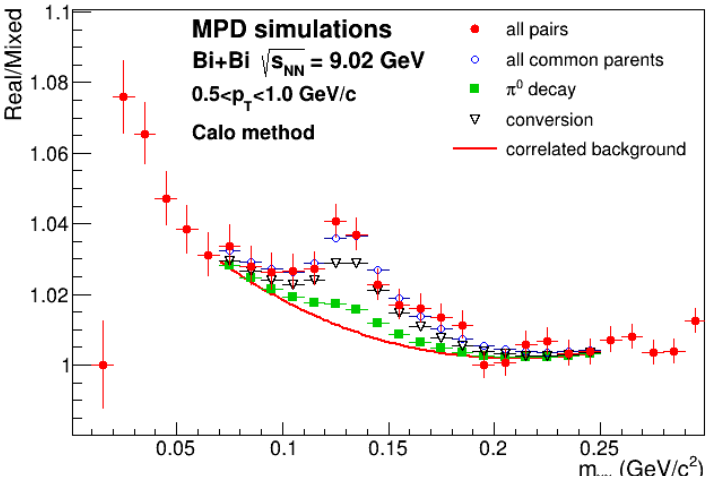
- Time distribution shows offset wrt expected photon arrival
  - Check details of time calculation in MC
  - Check consistency of time modeling in MC and results of beam-test
- Some narrow peak at negative times?

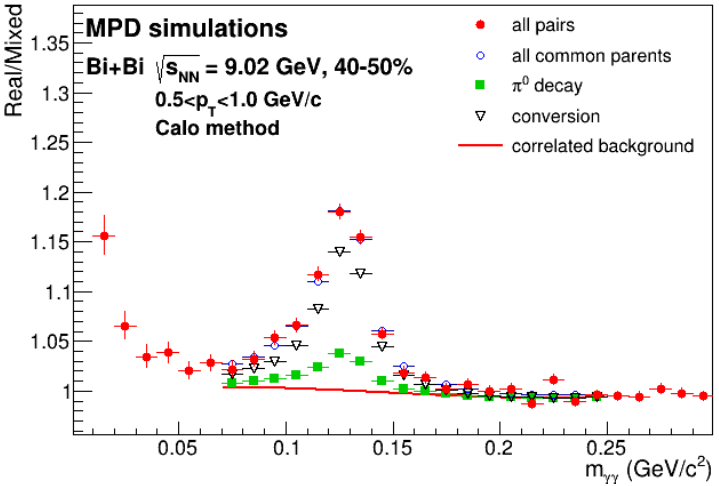


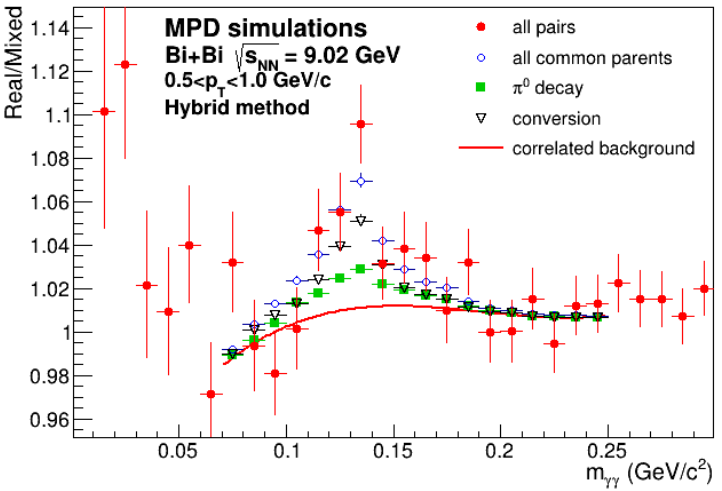


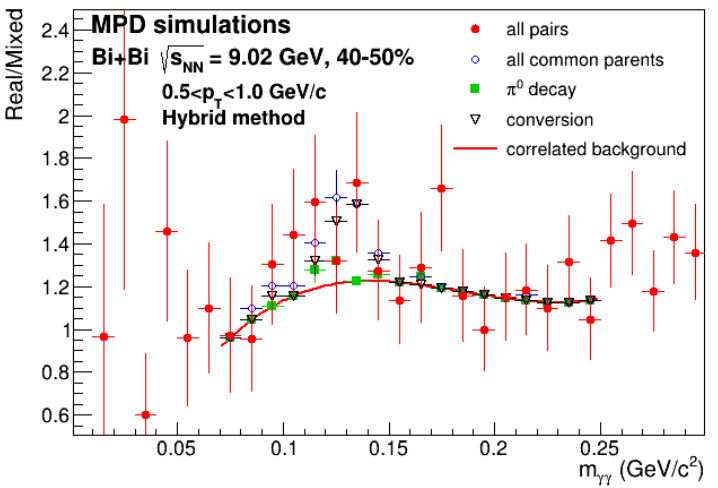
Invariant mass distributions

- 0.78 Mevents analyzed
- Pion peak clearly seen in calorimeter method both in central and mid-central collision
- Some hints in hybrid method
- No statistics in Conversion-Conversion



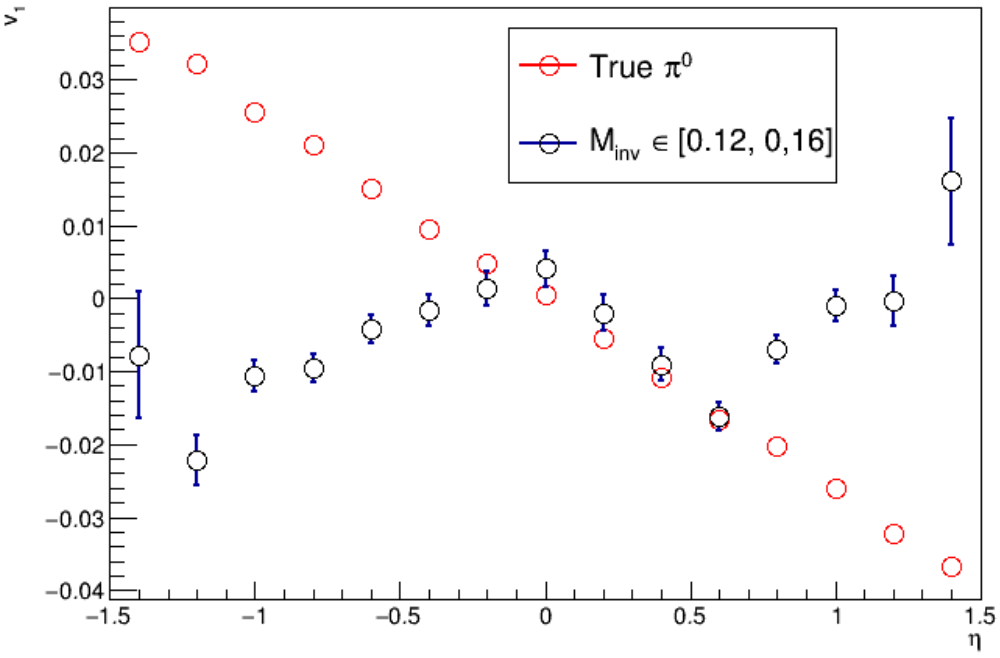






Neutral pion flow

- First look at pion collective flow
- Rapidity dependence of v1 in the region of pion mass similar to expected
- To be checked at larger statistics



Conclusions and open questions

- New class MpdV0Finder is introduced
  - Experts, please have a look
  - Users, please try and test convenience/bugs
- MC simulations to be adjusted
  - Threshold parameters
  - Time response description
  - Alternative clusterizers
- Improve code partormance, CPU and memory consumption