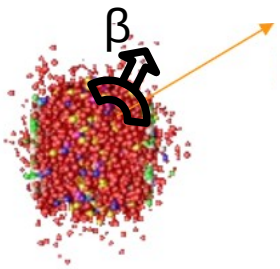
Updates in PWG4
Electromagnetic signals

D.Peresunko and C. Yang for the PWG4

PWG4: goals and organization

- Conveners: Chi Yang, Dmitri Peresunko
- Physics objectives
  - Neutral meson rapidity, spectra, flow
  - Direct photon rapidity, spectra, flow, interferometry
  - Dileptons: mass distributions, spectra
  - Antineutrons in calorimeter
  - Neutral pion interferometry
  - Fluctuations in relative yield
- Talk overview
  - Software development
  - Neutral meson analysis
  - Collective flow

Real and virtual photons



$$E_\gamma \frac{\mathrm{d}^3 N_\gamma}{\mathrm{d}^3 p_\gamma} \propto e^{-E_\gamma / T_{\mathrm{eff}}}$$

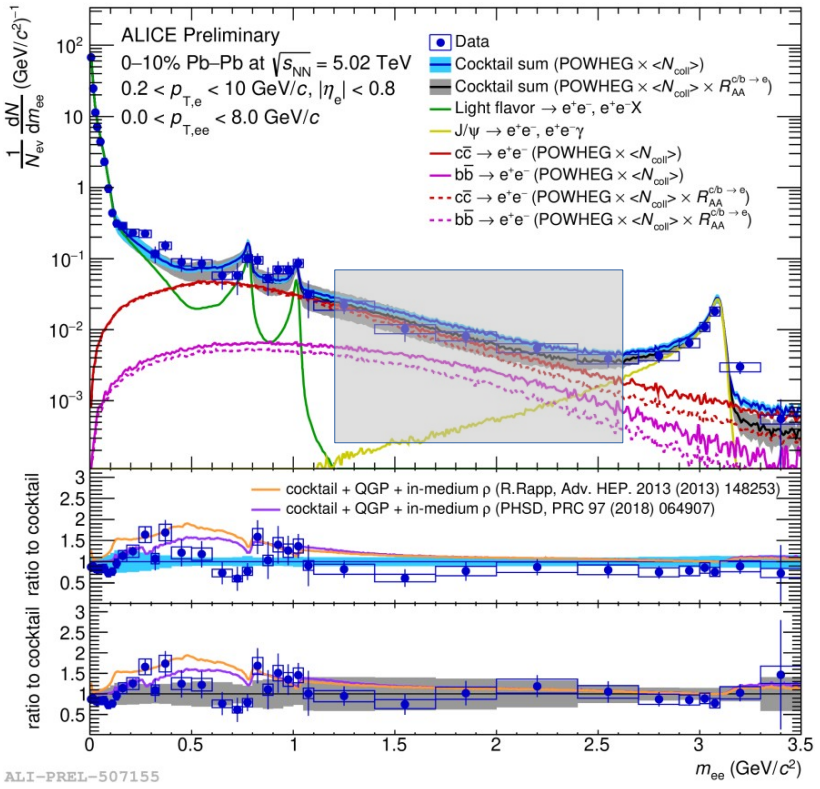
$$T_{\mathrm{eff}} = \sqrt{\frac{1+\beta_{\mathrm{flow}}}{1-\beta_{\mathrm{flow}}}} \times T$$

Real photons:

- Thermal contribution significant at p_T<3-5 GeV/c
- Slope strongly affected by collective flow
- Integrate contributions from pre-equilibrium phase till hadronic gas freeze-out

Virtual photons:

- Intermediate mass region provides true temperature
- May contain pre-equlibrium contribution

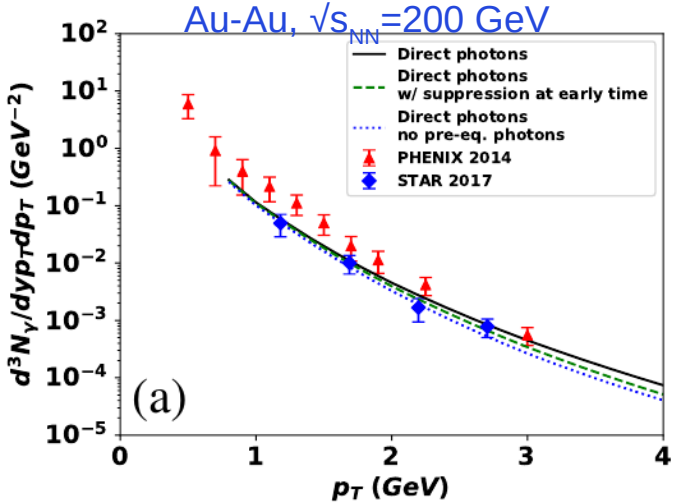


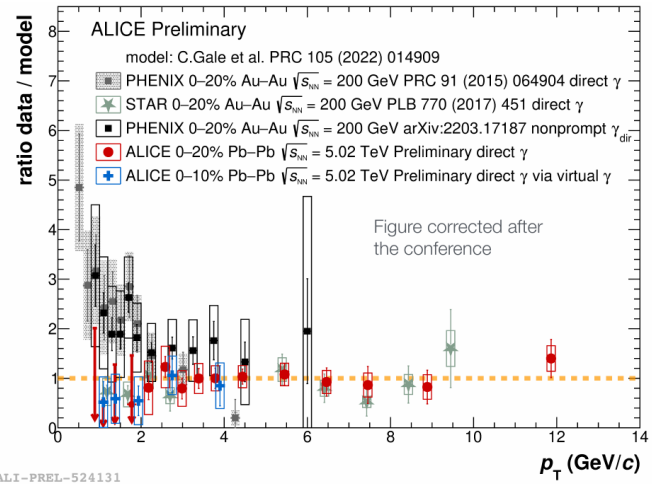
$$\frac{dN}{dM_{ee}} \propto (M_{ee}\,T)^{3/2} e^{-M_{ee}/T}$$

See Sudhir Rode presentation on dilepton status

Direct photon puzzle

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





ALI-PREL-524131

Spectra:

PHENIX: factor 2-5 higher than predictions

STAR: consistent with predictions

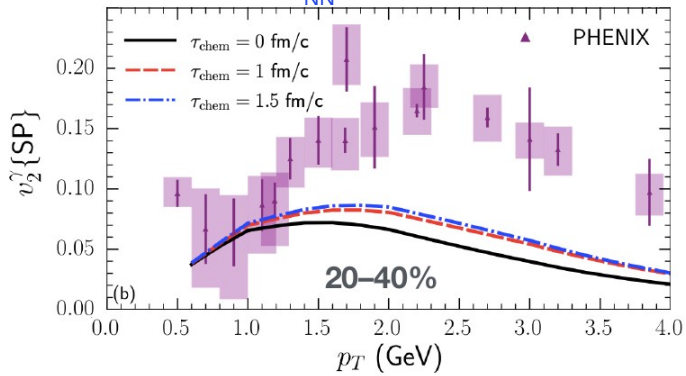
ALICE Pb-Pb 2.76 TeV: up to factor 2 higher, but consistent within uncertainties
5.02 TeV: consistent with predictions

Flow

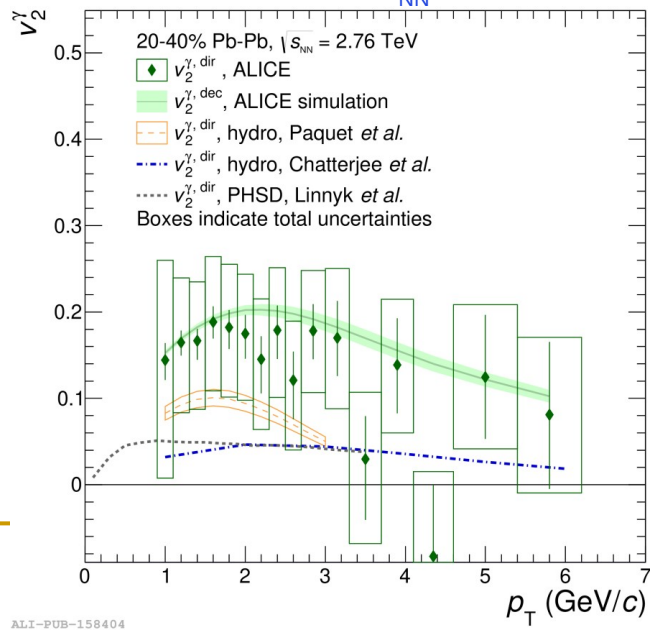
PHENIX: $v_2^\gamma \sim v_2^\pi$ and much larger than theory predictions

ALICE: $v_2^\gamma \sim v_2^\pi$, statistically consistent with predictions

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



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

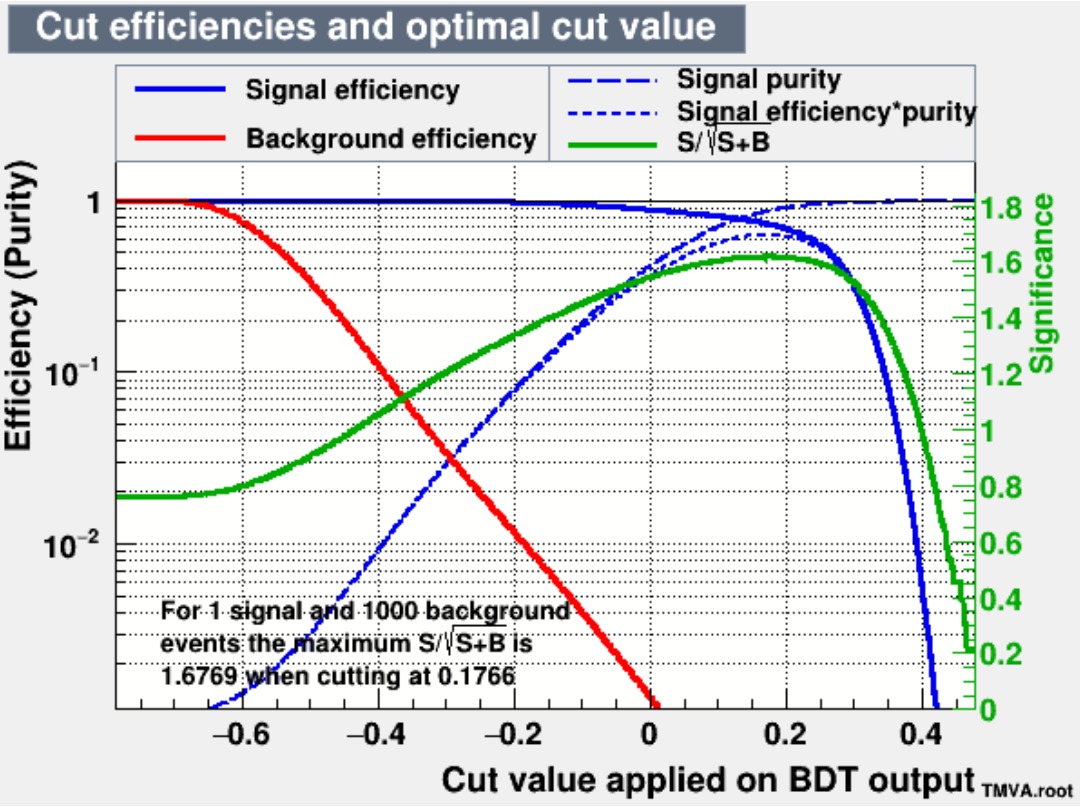


ALI-PUB-158404

Software status: wagons

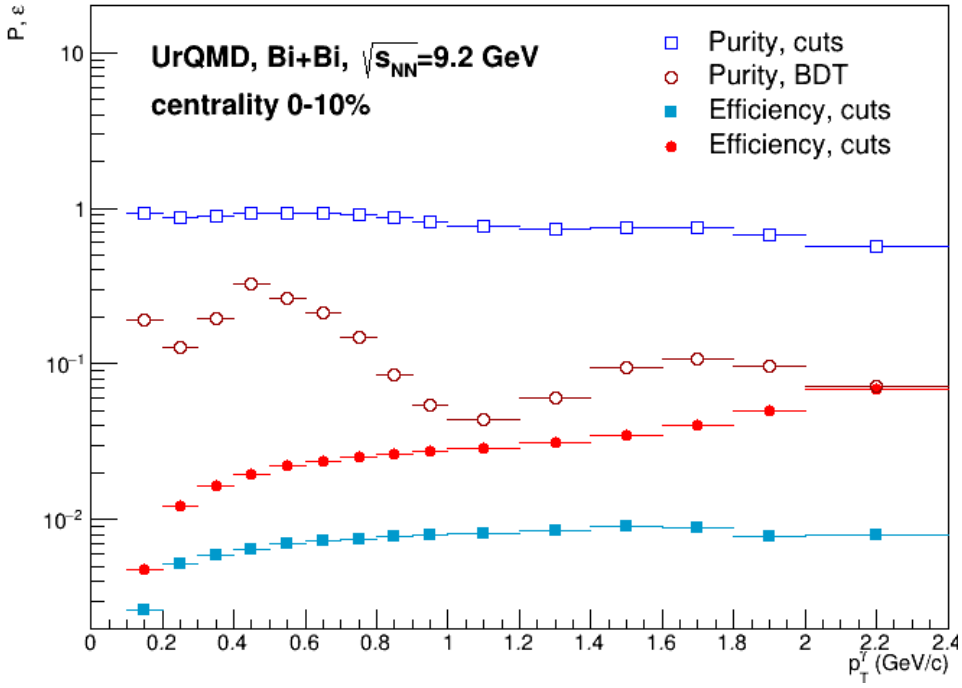
- **MpdV0Maker**: fills container (**MpdV0**) with V0 found per event for subsequent analysis
  - Uses either traditional cuts or ML approach
- **MpdConvPi0**: fills histos for spectrum and flow analysis
  - Consumes outputs of MpdV0Maker
  - Uses all combinations: Calorimeter, Conversion, Hybrid
- Di-lepton analysis: still private code

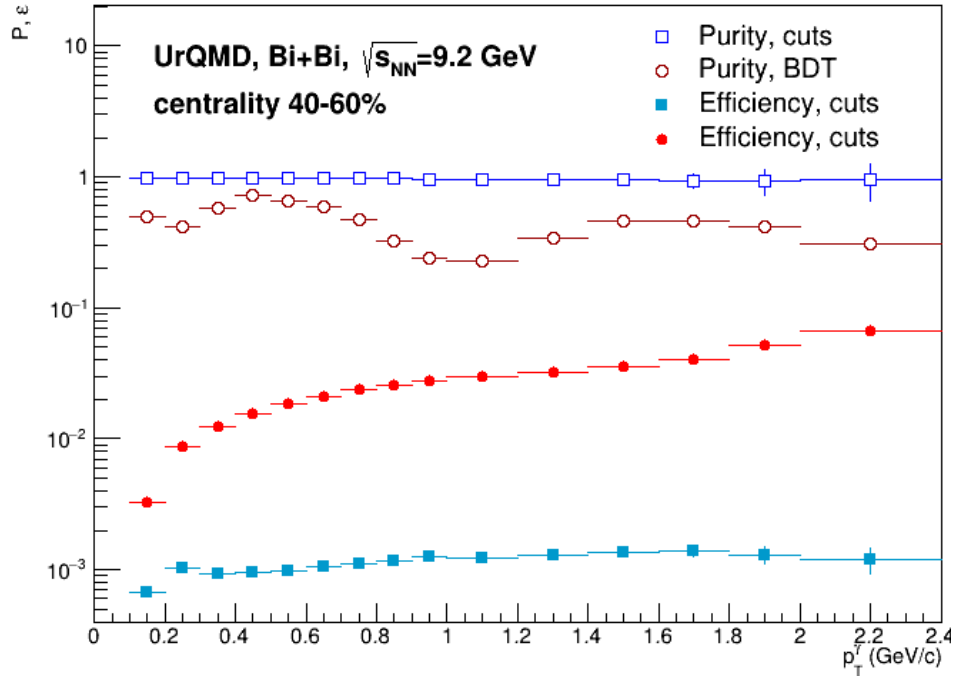
ML V0 identification



- BDT-based algorithm of the conversion V0 identification was implemnted
- Detaild comparison of efficiency and puruty cut and BDT-based approaches was done

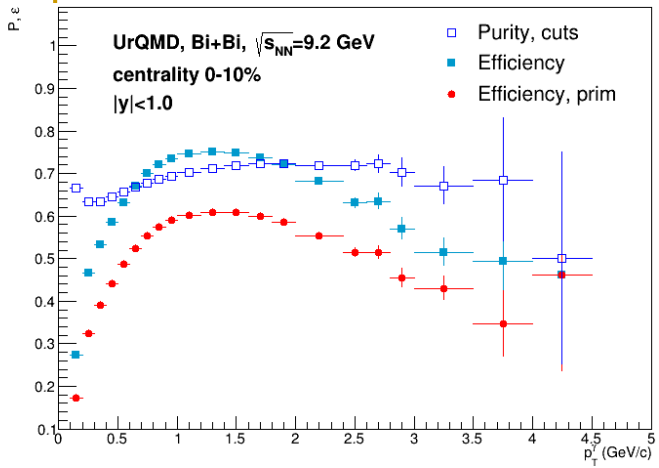
V0 efficiency and purity

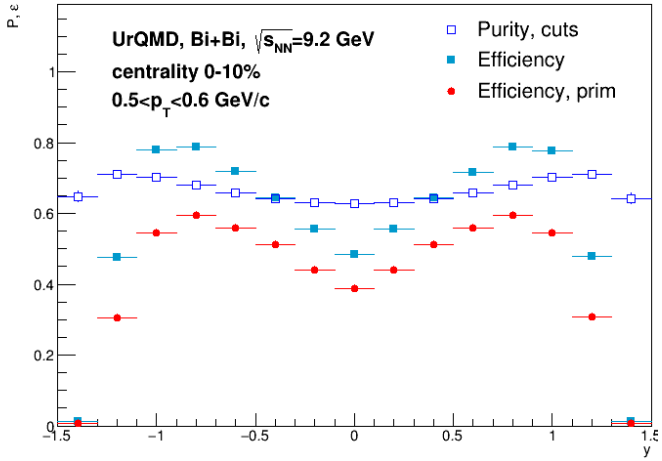


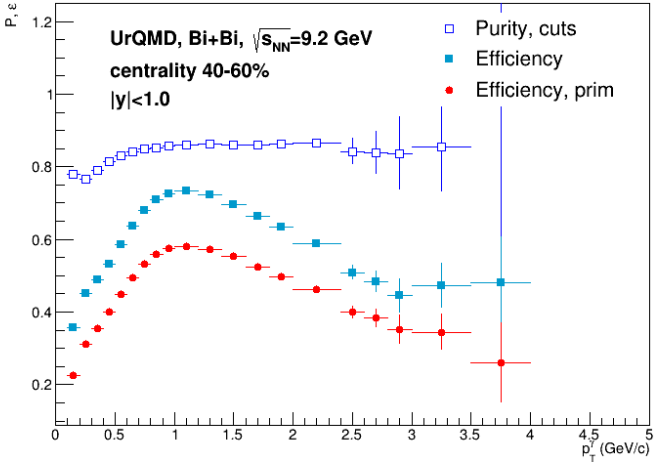


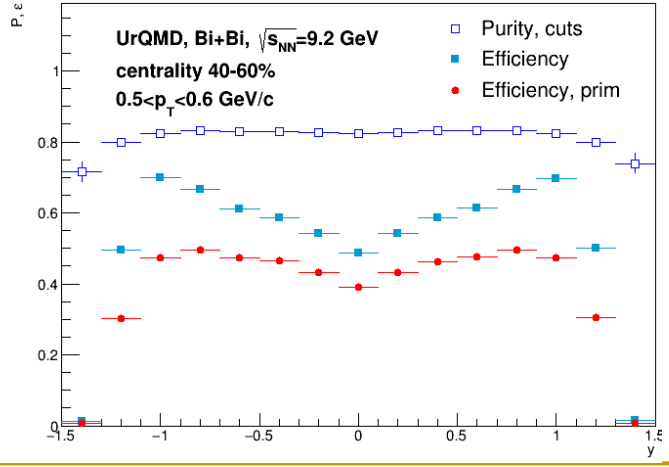
- Cuts provide purity~1, but very low efficiency
- BDT provides higher effieincy, but poorly constrained Purity
  - To be optimized

ECAL: photon efficiency and purity







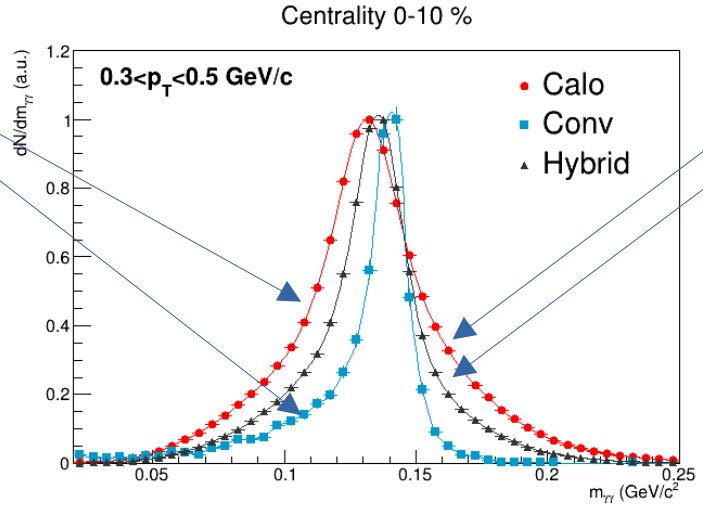


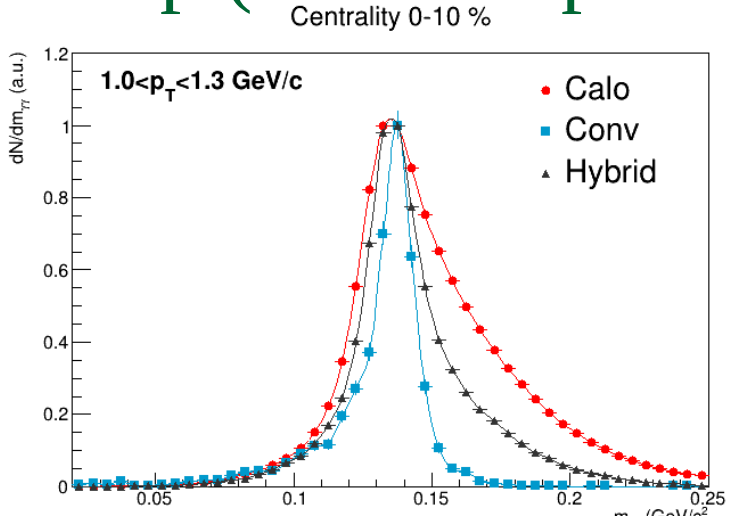
- Central: both purity and efficiency low
  - Photon clusters mis-interpreted as contamination
  - Assigning mother ID to cluster should be revisited
- Large (~20%) difference between photons and primary (non-converted) photons
  - Need precise material budget estimate with real data
  - Need zero-B data
- Rapidity dependence shows deep at y=0 due to minimal digit energy cut

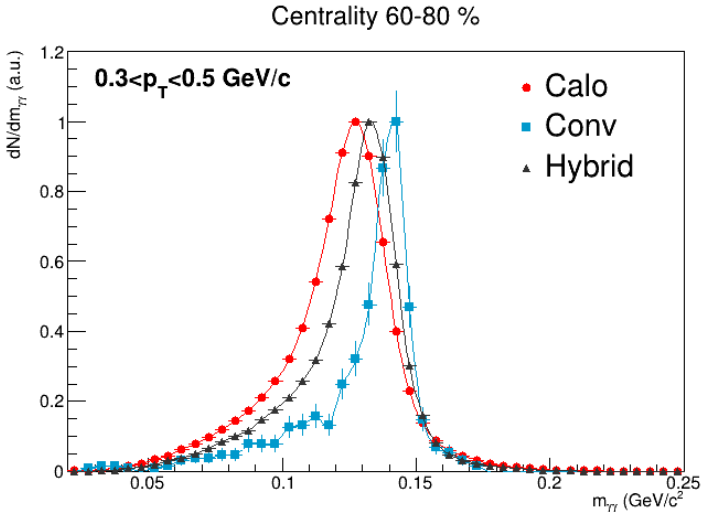
π^0 peak: conversion and cluster overlap (MC true pairs)

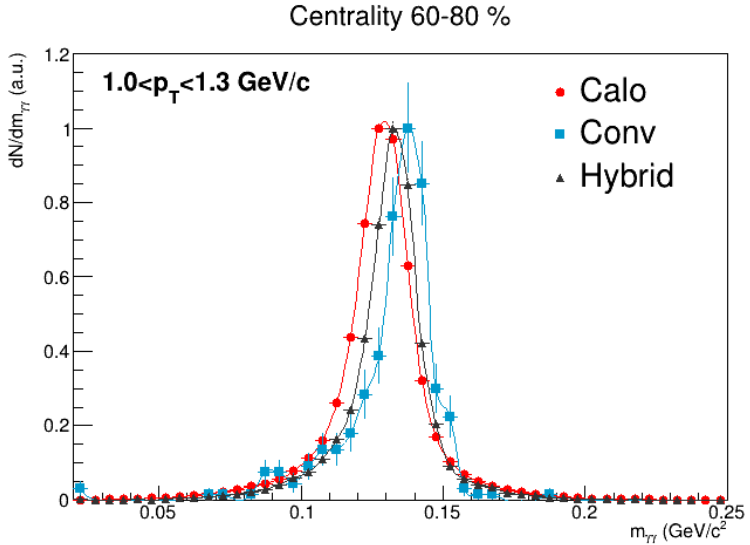
Photon conversion $e^{\pm}$ E loss

Cluster overlap



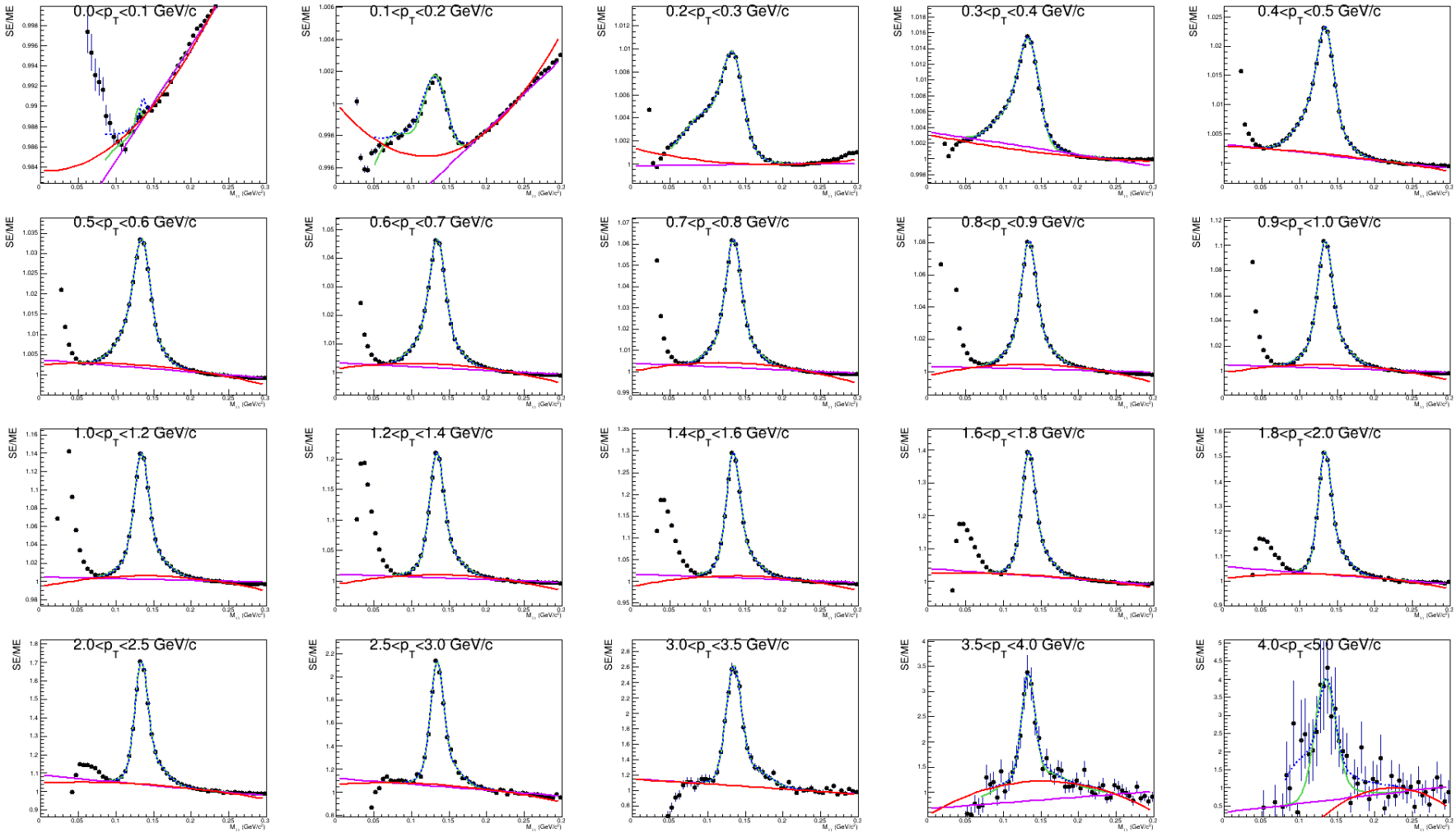




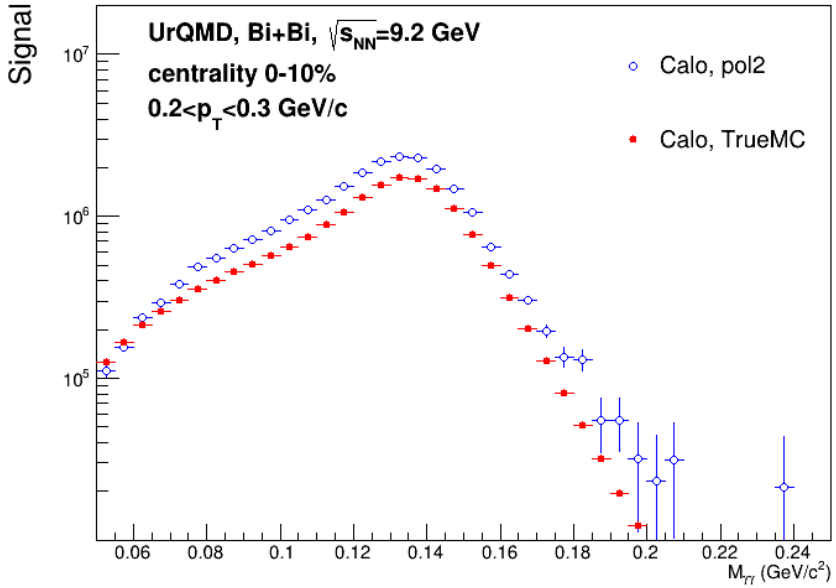


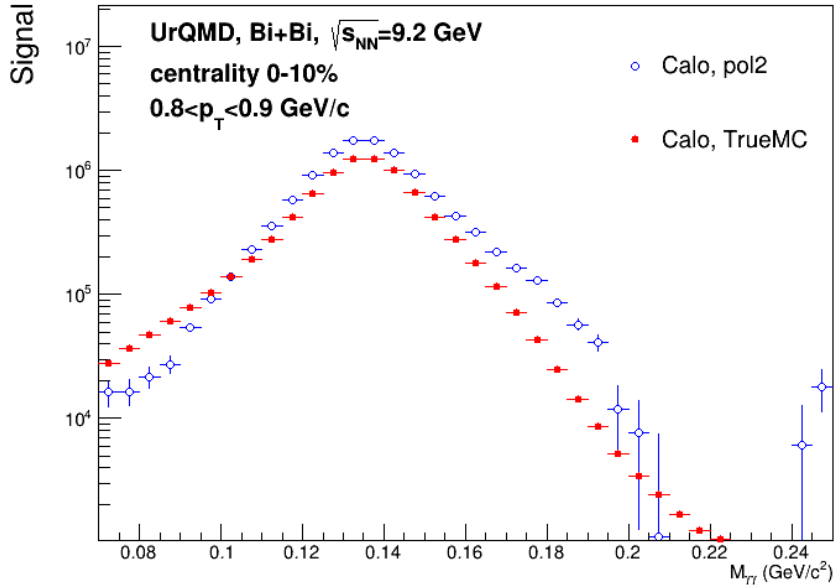
π^0 peak extraction (S/Bg)

Bi+Bi, 9.2 GeV, centrality 0-10%



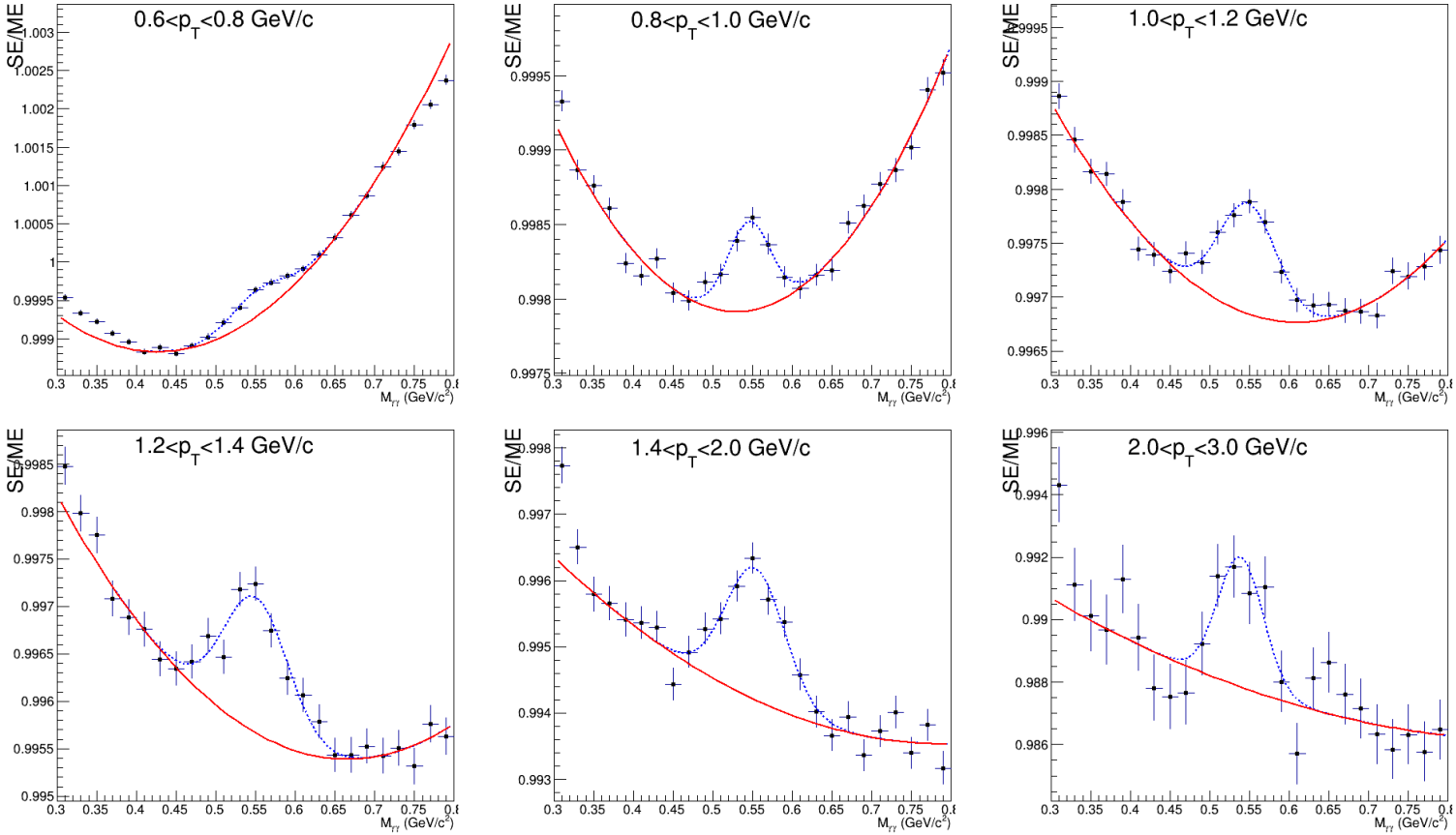
π^0 peak in calorimeter





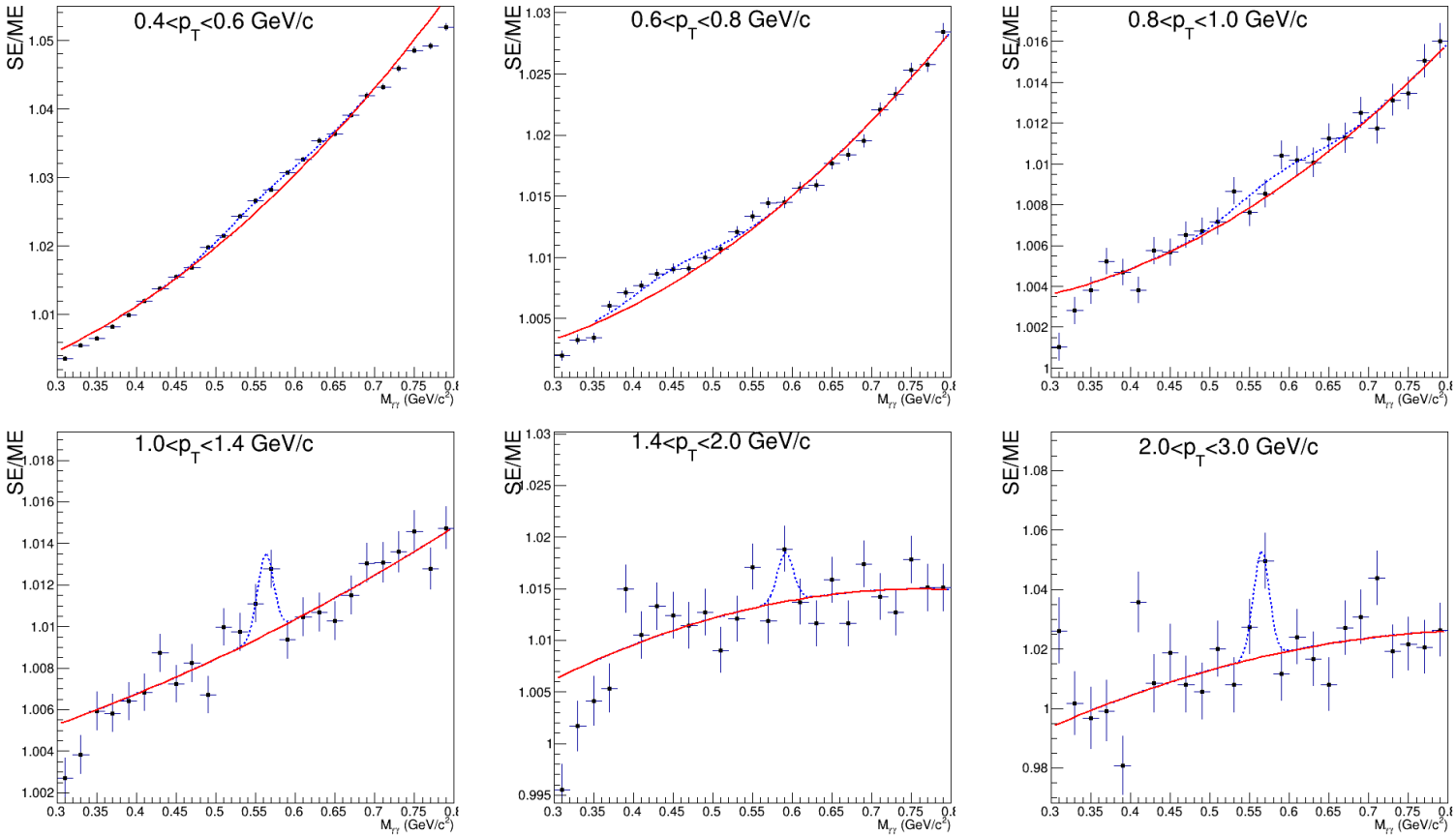
- The shape of the signal is very to one of expected pairs with common π^0 parent (TrueMC)
- However, number of pairs with common parent is smaller than the number of correlated pairs in π^0 peak (~20-30%)
  - primary particles assignment?
  - Consistent with too low photon reconstruction efficiency?

η-meson



- First look at η-meson
- Clearly see peak at p_T>0.6 GeV/c
- Large correlated background
  - Use Event Plane selection for mixing
  - Other selections?

Eta-meson with hybrid method



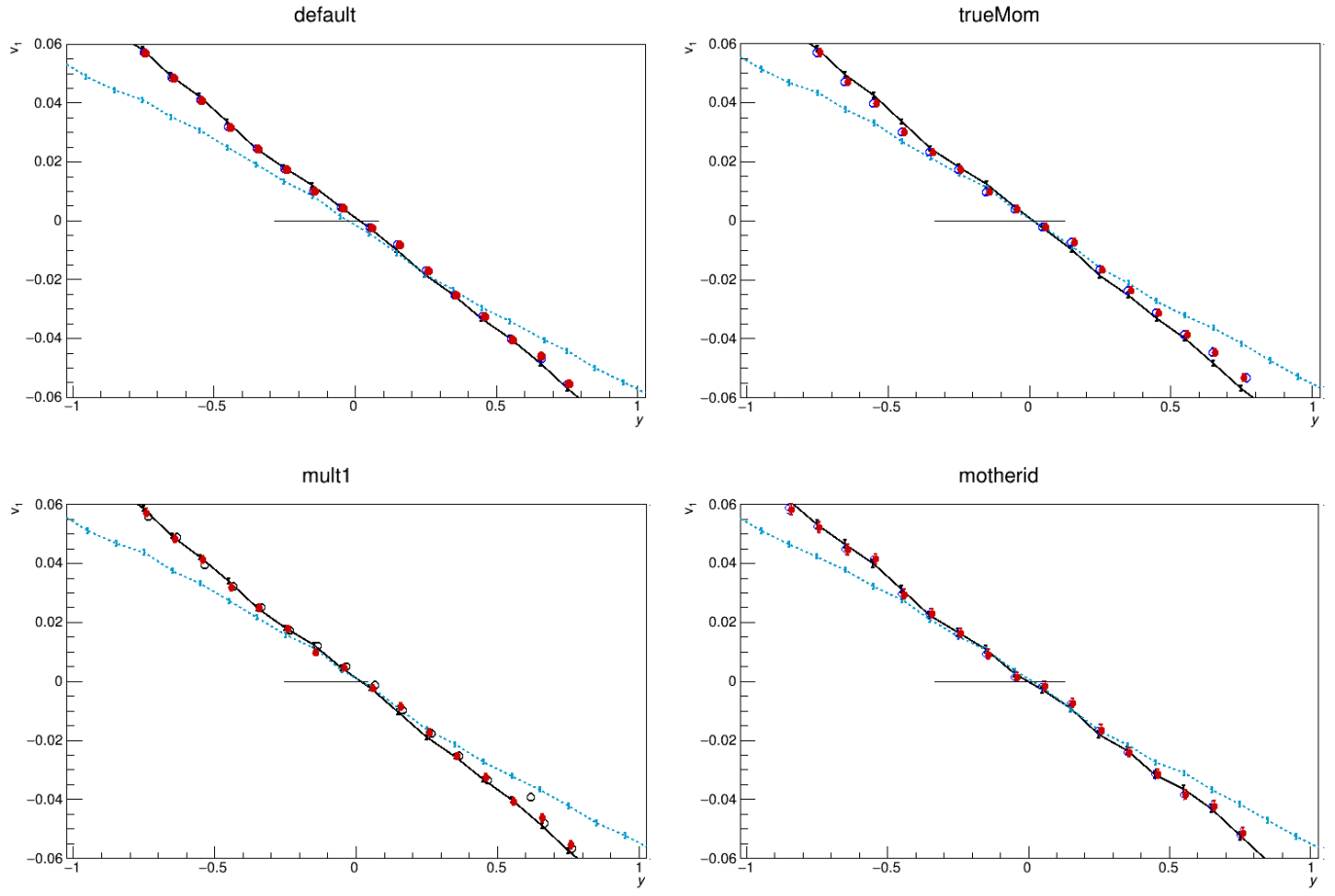
- In Hybrid method a trace of eta is seen
- Shape of background is more reasonable

Inclusive photon and pion flow

- Oleg Golosov
  - Cross-PWG 23.01.2024: https://indico.jinr.ru/event/4314/
  - Cross-PWG 28.11.2023: https://indico.jinr.ru/event/4167/

Collective flow of inclusive photons $v_1(y)$

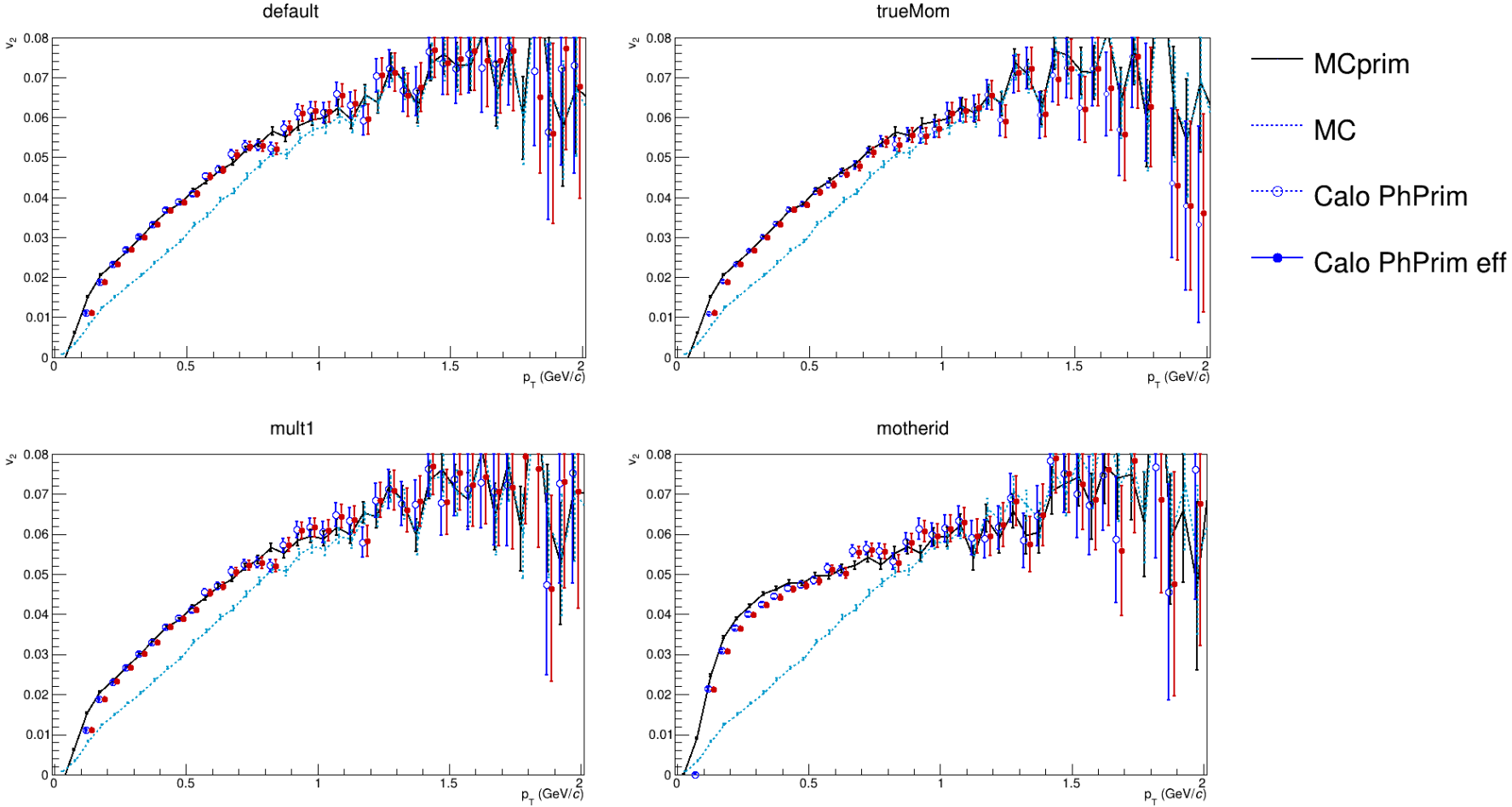
Bi+Bi, $\sqrt{s_{NN}}$=9.2 GeV, centrality 30-40%, photon clusters



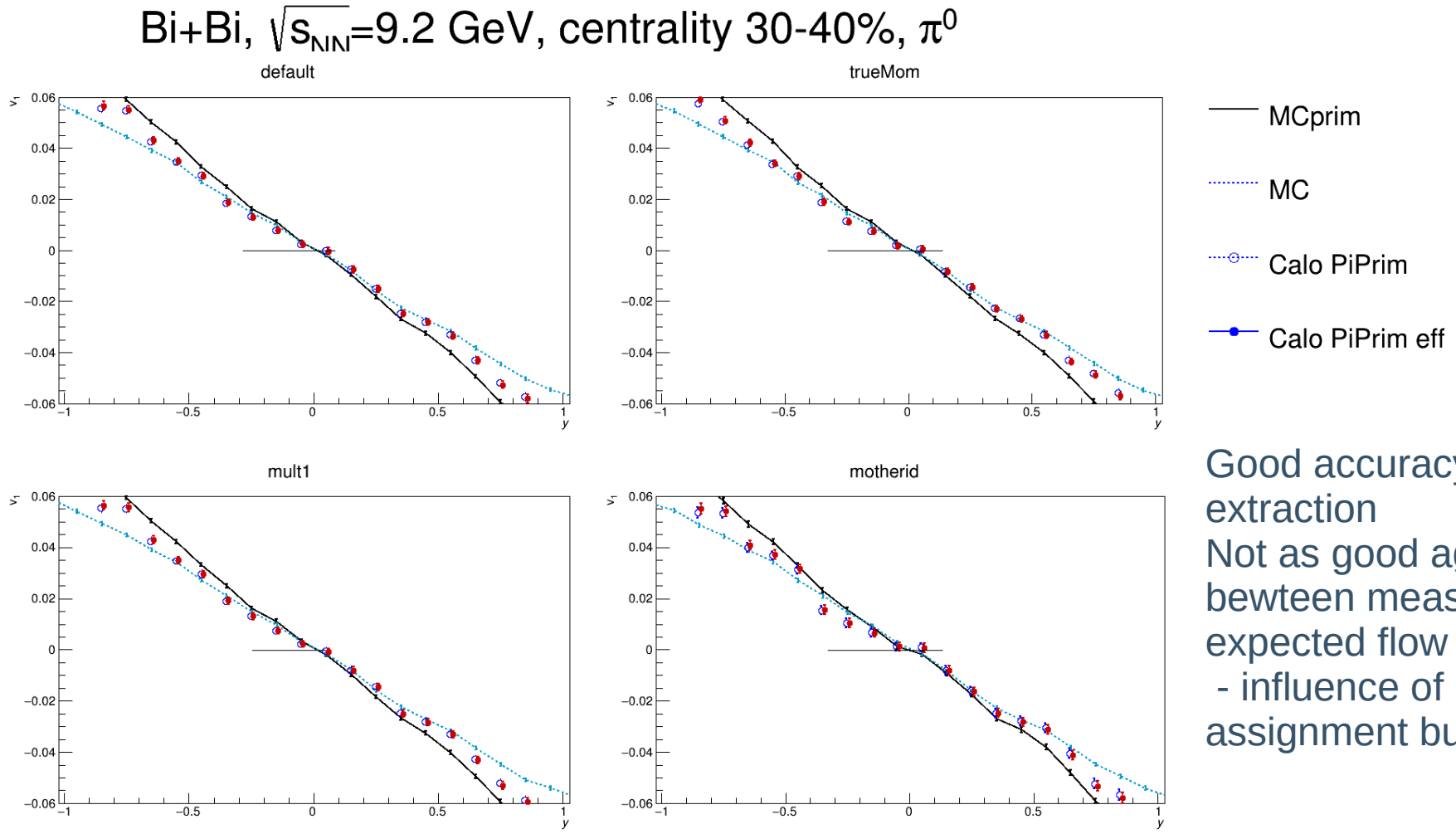
Flow of clusters created by photons agree with expected
- Implement procedure to estimate and remove contamination
- Large difference in flow of primary and secondary photons

Inclusive photons, $v_2(p_T)$ dependence

Bi+Bi, $\sqrt{s_{NN}}$=9.2 GeV, centrality 30-40%, inclusive photons



Neutral pions, $v_1(y)$

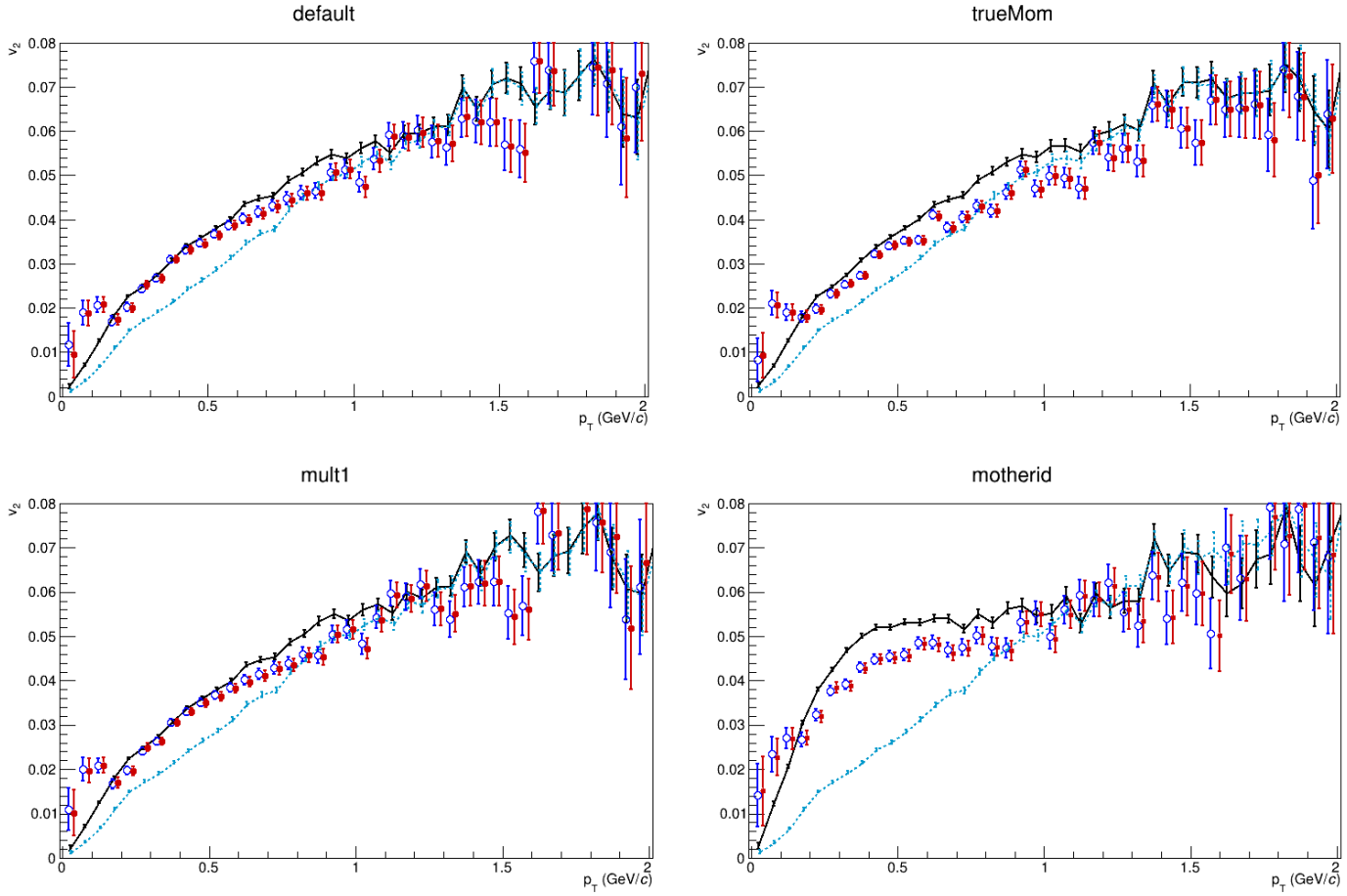


Good accuracy of flow extraction
Not as good agreemen bewteen measured and expected flow
- influence of primary assignment bug???

Neutral pions, $v_2(p_T)$

$$v(m_{\gamma\gamma}) = \frac{N_S(m_{\gamma\gamma})v_S + N_{BG}(m_{\gamma\gamma})v_{BG}}{N_S(m_{\gamma\gamma}) + N_{BG}(m_{\gamma\gamma})}$$

Bi+Bi, $\sqrt{s_{NN}}$=9.2 GeV, centrality 30-40%, π^0



Deviations at low p_T are due to neutrality cut. To be elaborated

Conclusions

- Analysis software continut developing
- Reached accuracy, necessary for direct photon analysis
- Possible bugs/features of simulation/reconstruction algorithms were identified
- Missing parts
  - Tuning of simulation parameters
    - Electronic noise (=> thresholds in reconstruction algorithm)
    - Energy resolution (noise, light collection implemented in MC)
    - Time resolution (can be estimated from data, but need estimate of contamination)
    - Non-linearity (only partially can be inferred from real data, need beam-test results)
    - Shower shape (should be validated vs beam-test results)

Conclusions (2)

- Much more analyses in pipeline
  - $\pi/\eta \to \gamma(e^+e^-)$
  - $K_s^0 \to \pi^0\pi^0$
  - $\pi \to \pi^0\gamma$, $\pi^0\pi^+\pi^-$
  - $\eta' \to \eta\pi^+\pi^-$
  - $\Sigma^0 \to \Lambda\gamma$, $\Sigma^0 \to \Lambda(e^+e^-)$, $\Sigma^+ \to p\pi^0$, $\overline{\Sigma}^{\pm} \to \overline{n}\pi^{\pm}$
  - Dielectron continuum, LVMs
  - Single e_{HF}
  - Fluctuations $<\pi^0,\pi^{\pm}>$
  - ….