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Beauty production via semi-electronic decay channel in Pb-Pb collisions at 5.02 TeV

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koALICE national workshop - Jeongseon
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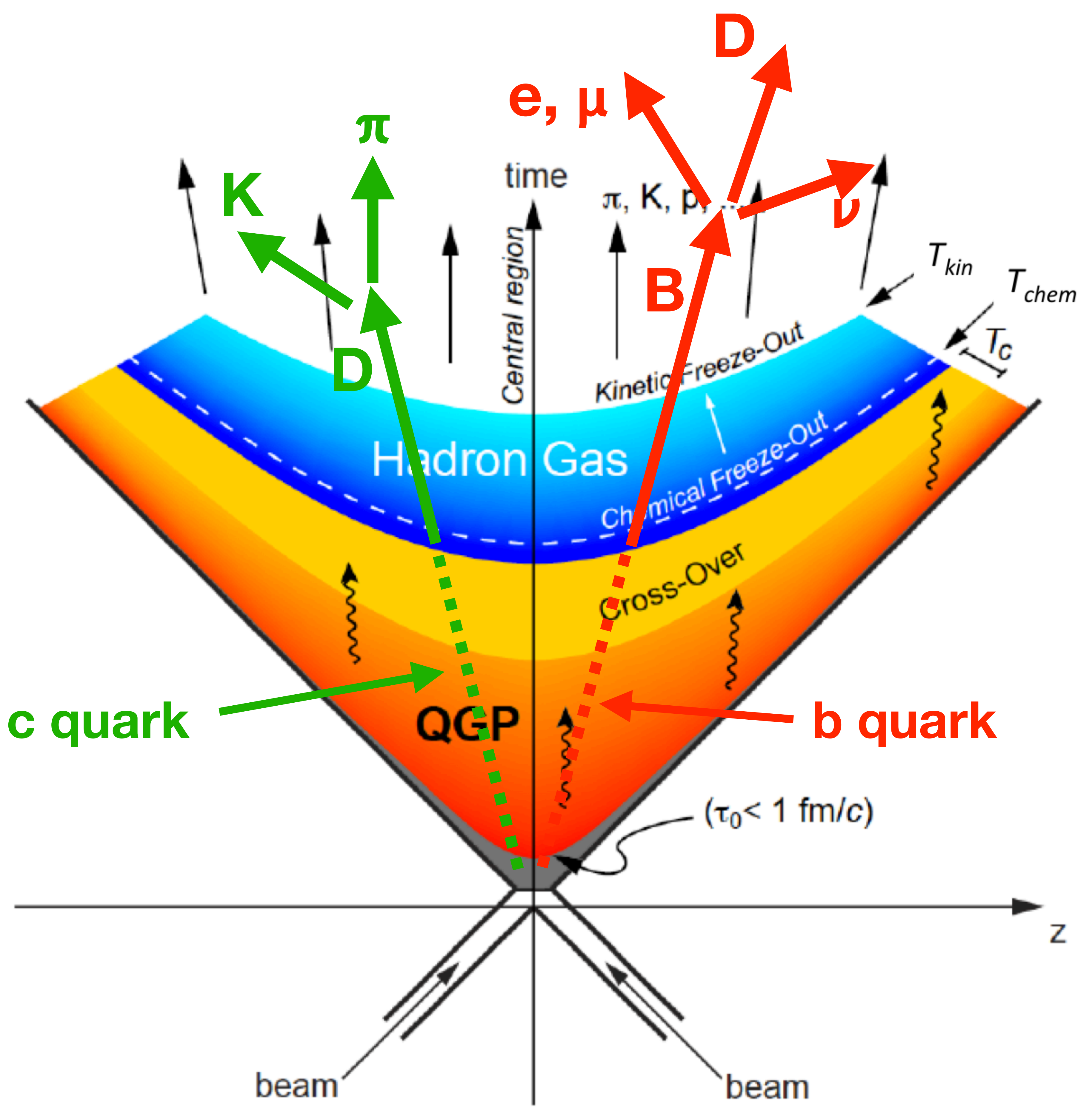
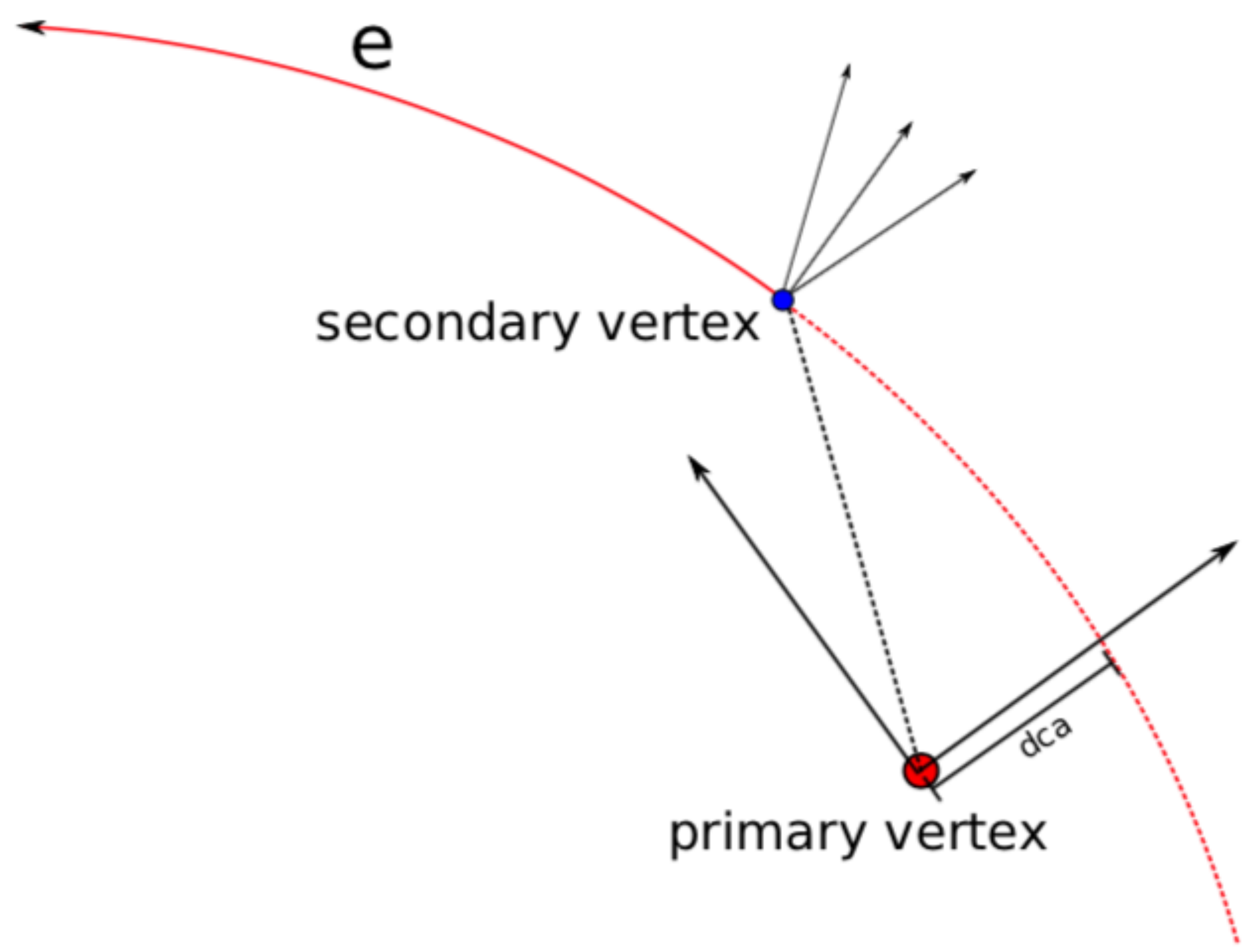
Physics Motivation

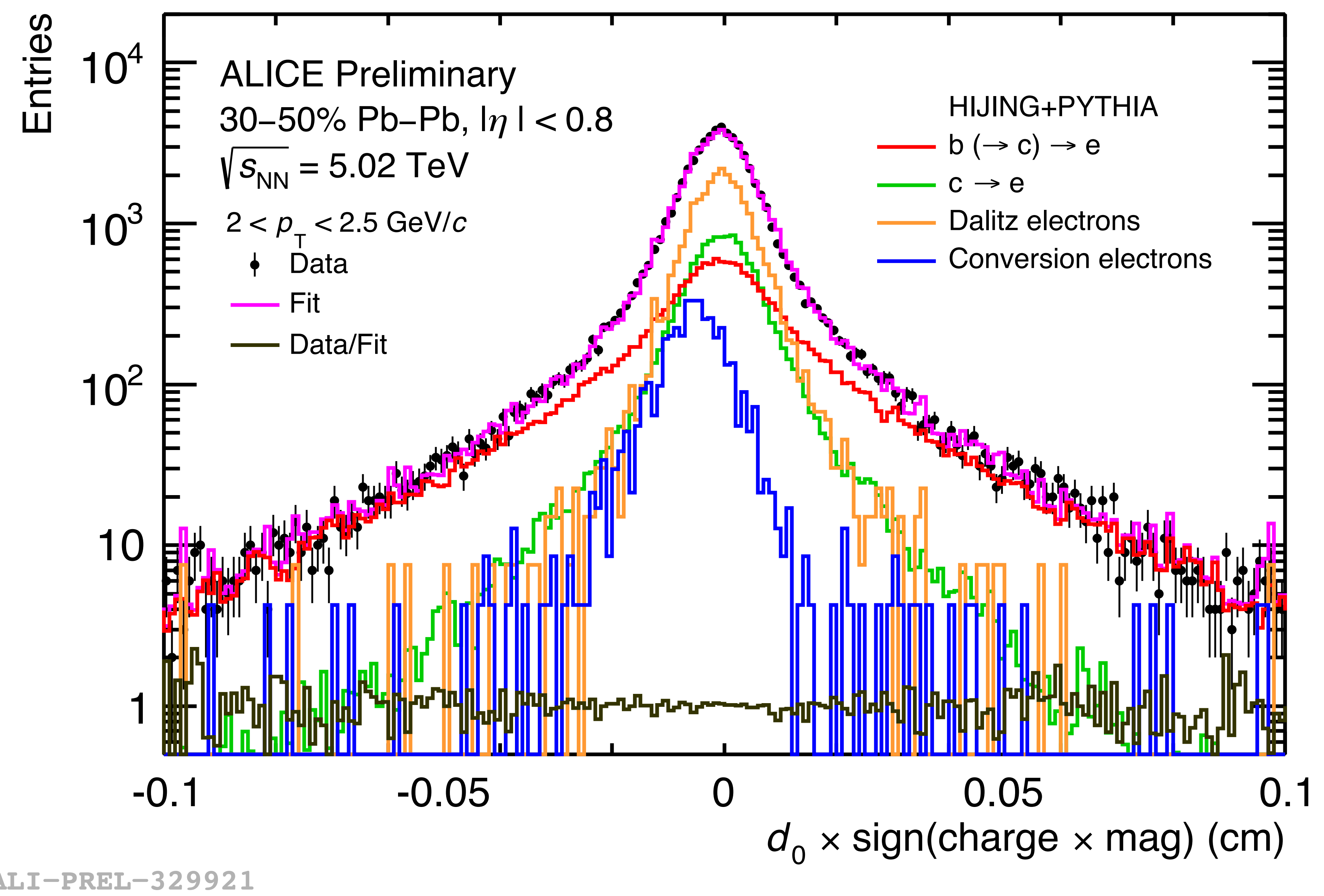
- Heavy flavors
  - Produced in hard scattering processes in the initial stage of the collisions
- In-medium parton energy loss
  - Undergo both elastic (collisional) and inelastic (radiational) collisions
  - Expect to be mass and color charge dependences
    - Color charge effect : $\Delta E_g > \Delta E_q$ due to stronger coupling
    - Mass effect : $M_{u,d,s} < M_c < M_b \longleftrightarrow \Delta E_{u,d,s} > \Delta E_c > \Delta E_b$
- Provide a hint of mass dependence of the in-medium parton energy loss model by comparing between charm and beauty productions



Analysis Procedure

- Separate beauty contribution via impact parameter (IP) from electron candidates
  - IP : Distance of Closest Approach to the primary vertex in xy plane
  - Beauty hadrons have larger decay length → lead to larger IP than other sources
- Fit the inclusive electron DCA distribution using templates obtained from MC with corrections

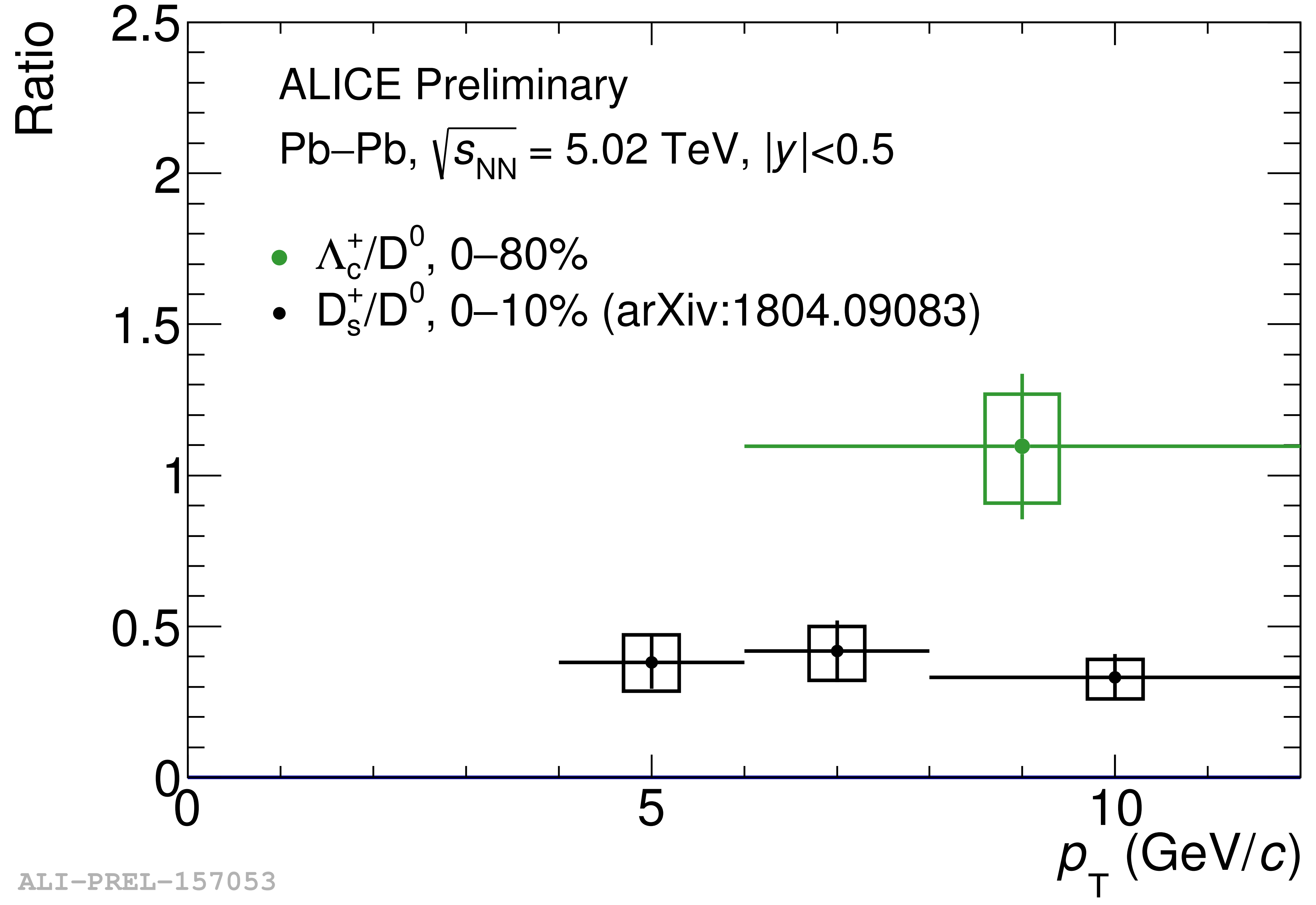


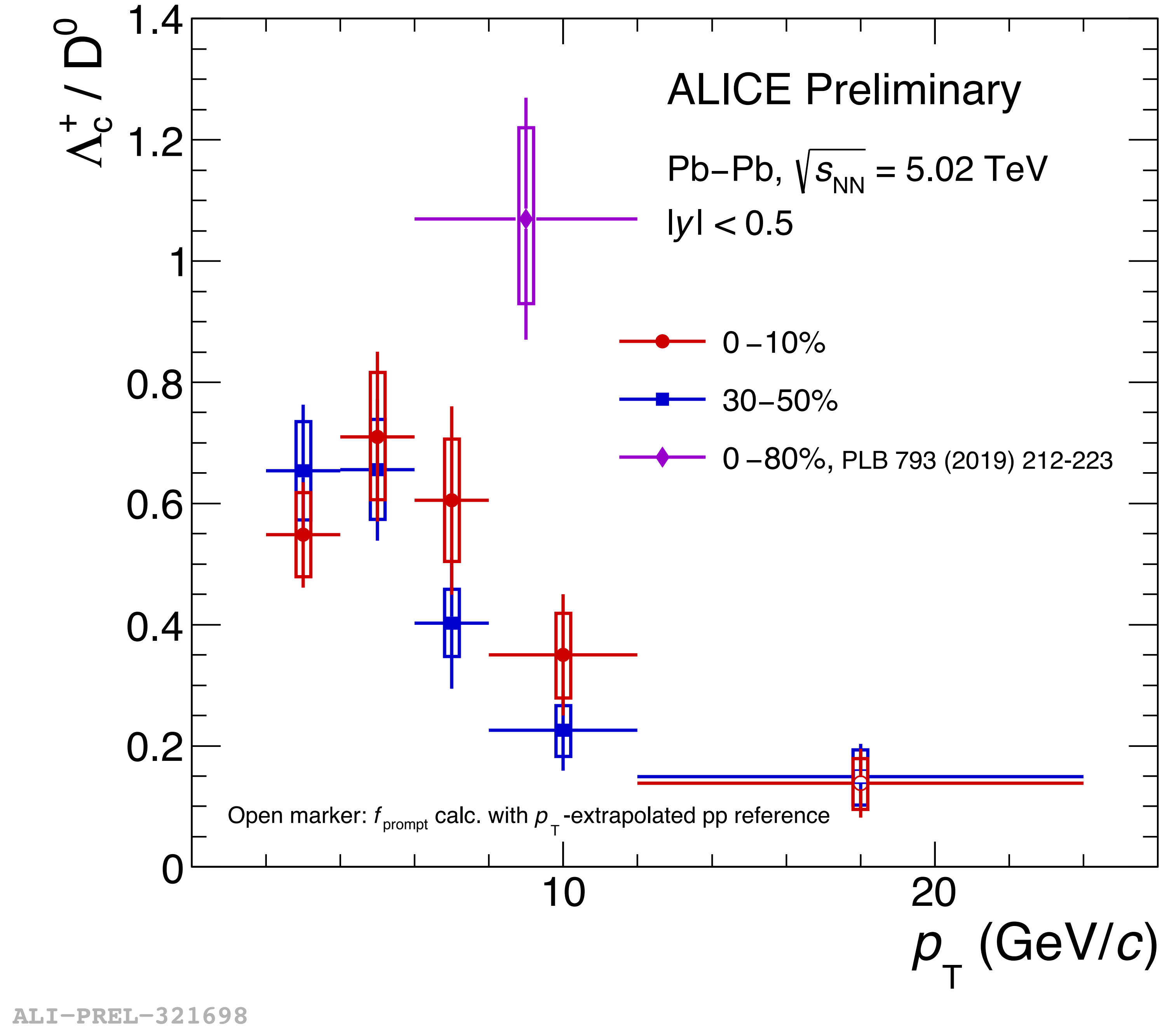


Updates since last workshop
- New Λ_c correction
- Correction of different charm species fraction
- Remake 0-10% result with all the recent updates

New Λ_c Correction

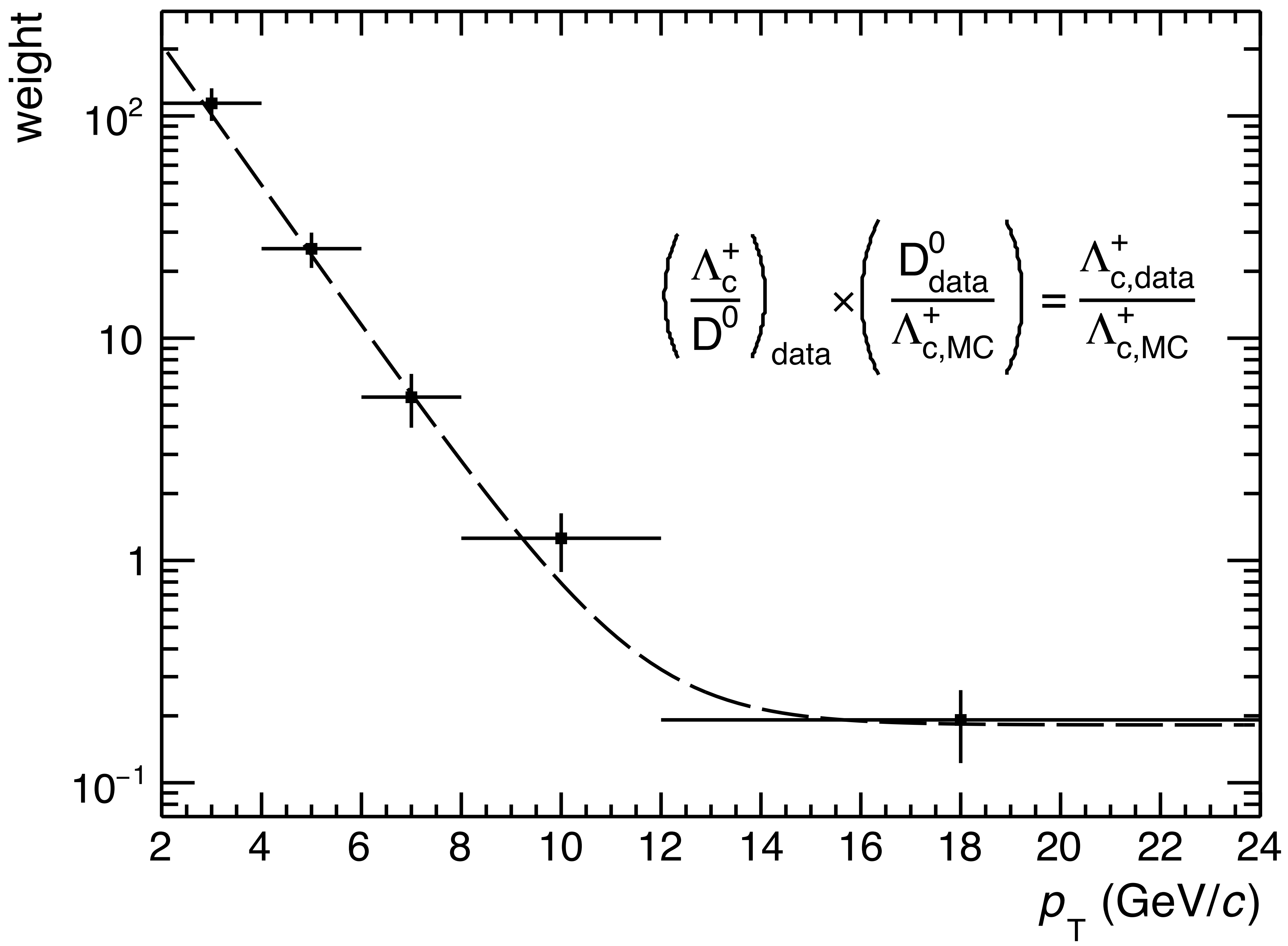
- Not correct Λ_c p_T, just correct Λ_c/D^0 ratio
  - With 2015 sample, one data point at high p_T with wide centrality range → constant ratio was assumed for all p_T range and all centrality cases
- Adding 2018 sample, newly measured Λ_c/D^0 ratio
  - Possible to separate centralities → 0-10% and 30-50%
  - The ratio has p_T dependence → need to correct Λ_c p_T shape

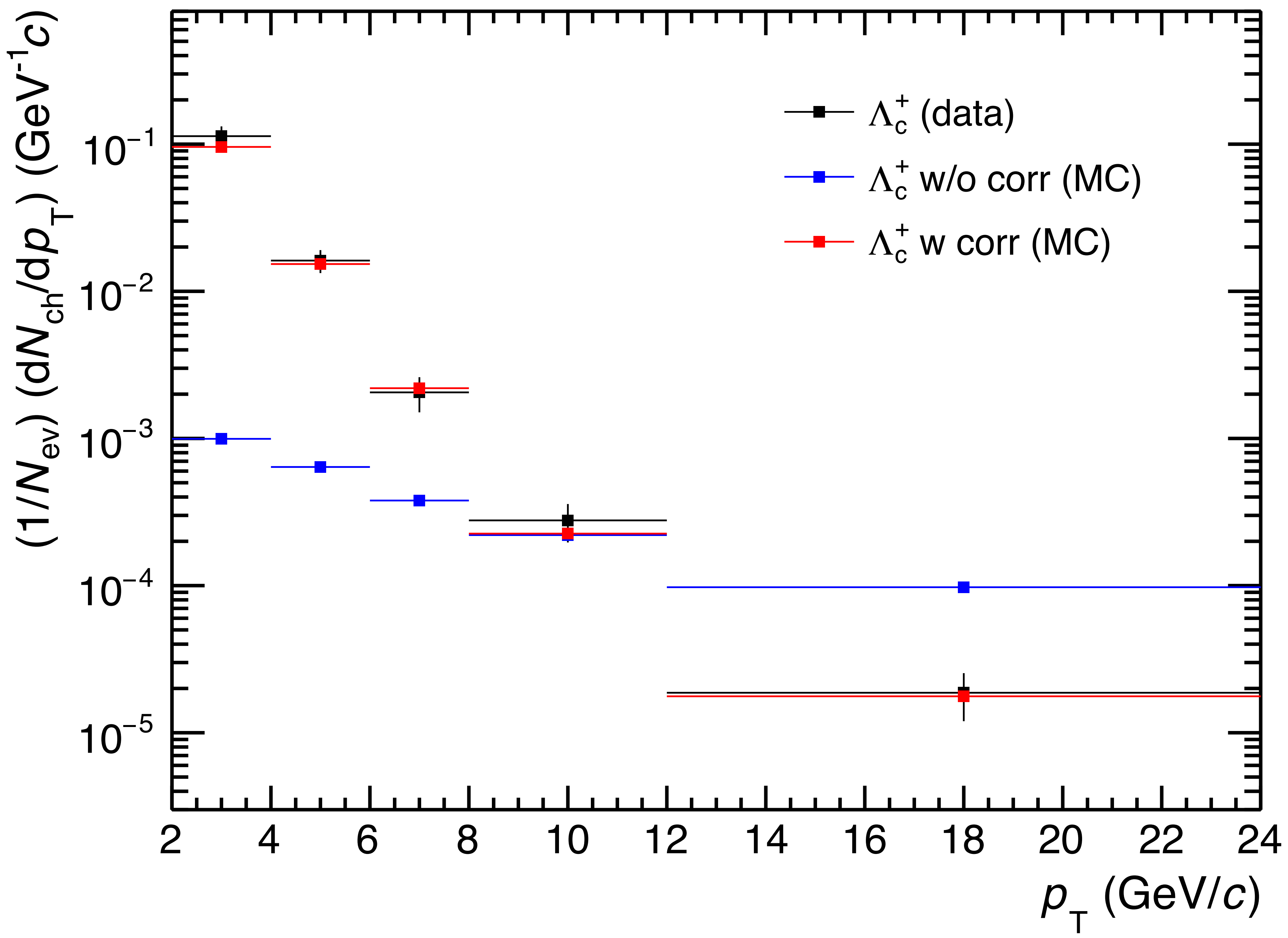




Λ_c p_T Correction

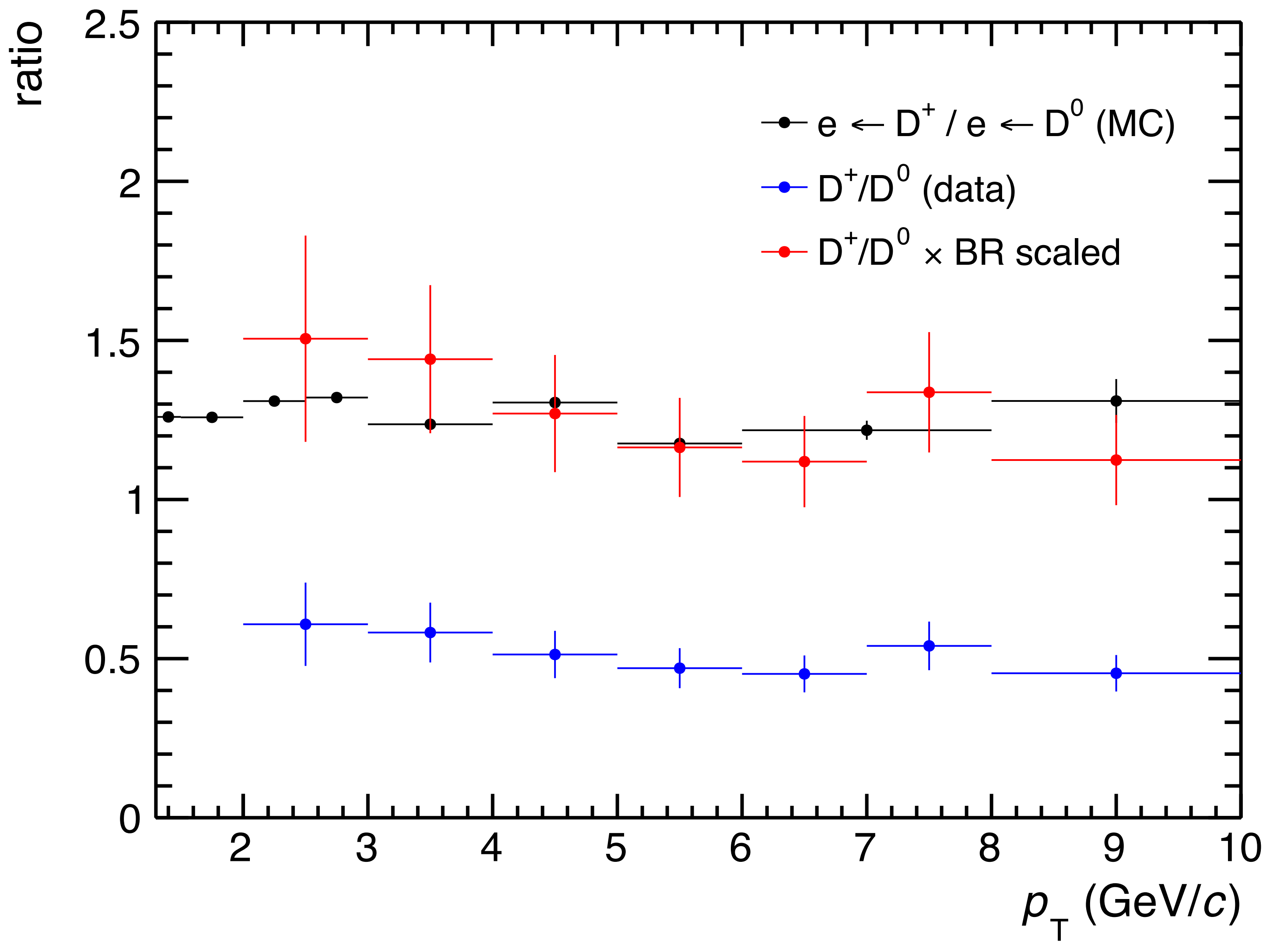
- Weighting factor is calculated as $\Lambda_{c,data}/\Lambda_{c,MC}$
  - Interpolate a ratio of $\Lambda_{c,data}/\Lambda_{c,MC}$ using exponential function
- Λ_c spectrum in MC after correction agrees with data
- Need to check different charm species fraction

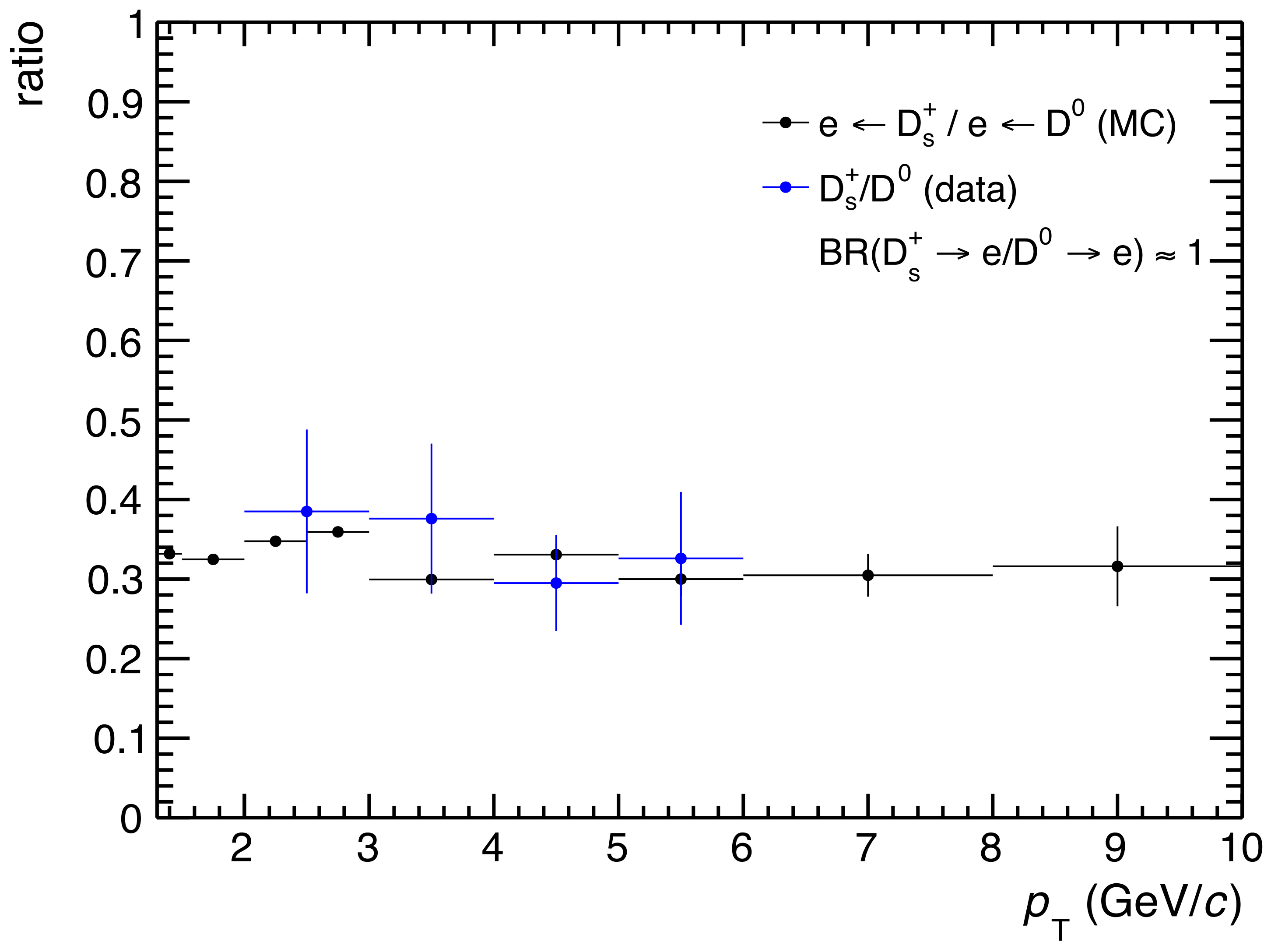


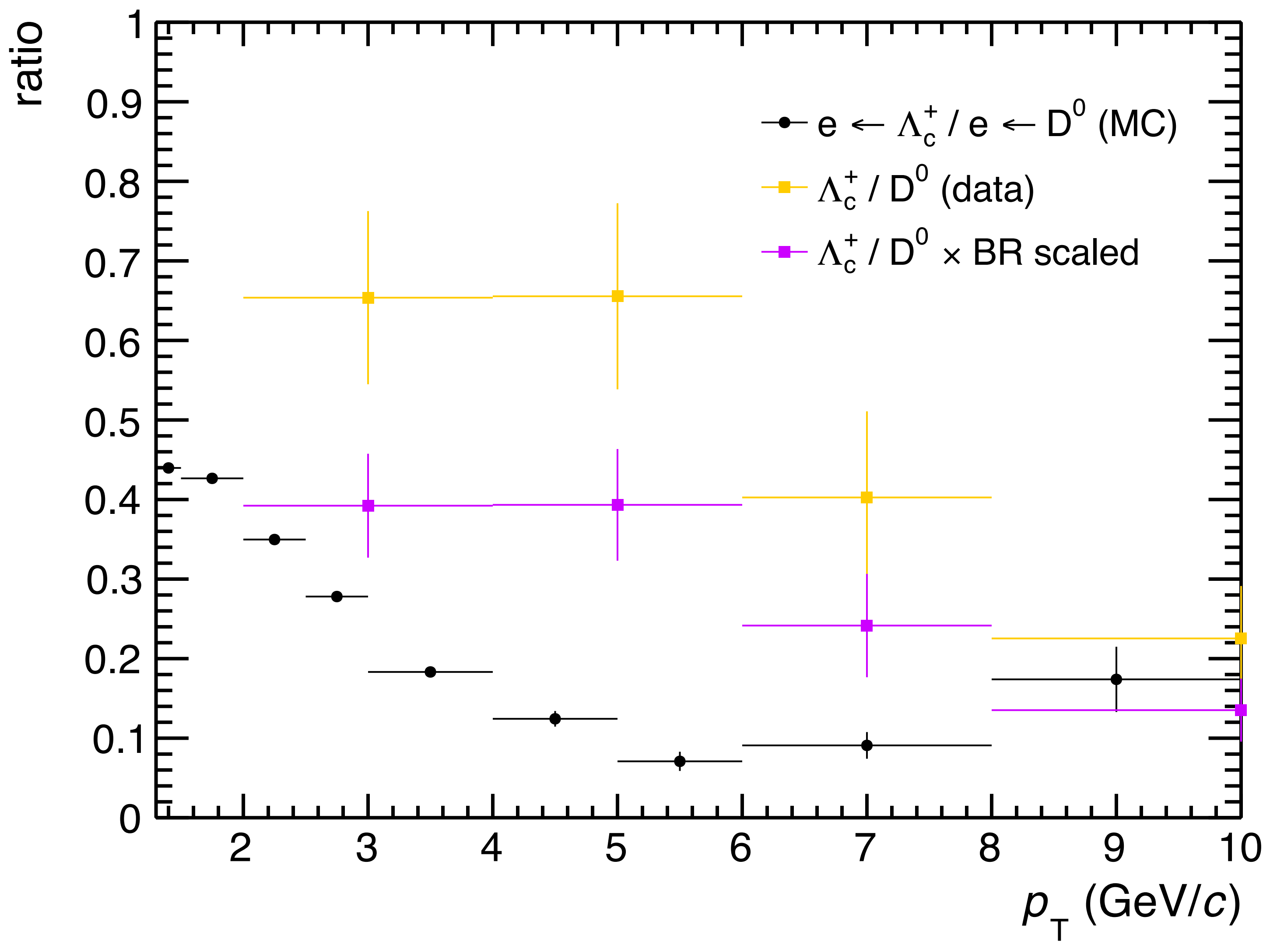


Correction of Different Charm Species Fraction

- Check the relative fraction of different charm species w.r.t D^0
  - Different charm species have different decay length → different IP distribution (D^0 : 120 μm, D^+ : 300 μm, D_s : 300 μm, Λ_c : 50 μm)
  - The measured ratio is scaled by branching ratio (since D_s and D^0 have almost similar branching ratio, no scaling on D_s/D^0)
- All fractions are in agreement with the measured results

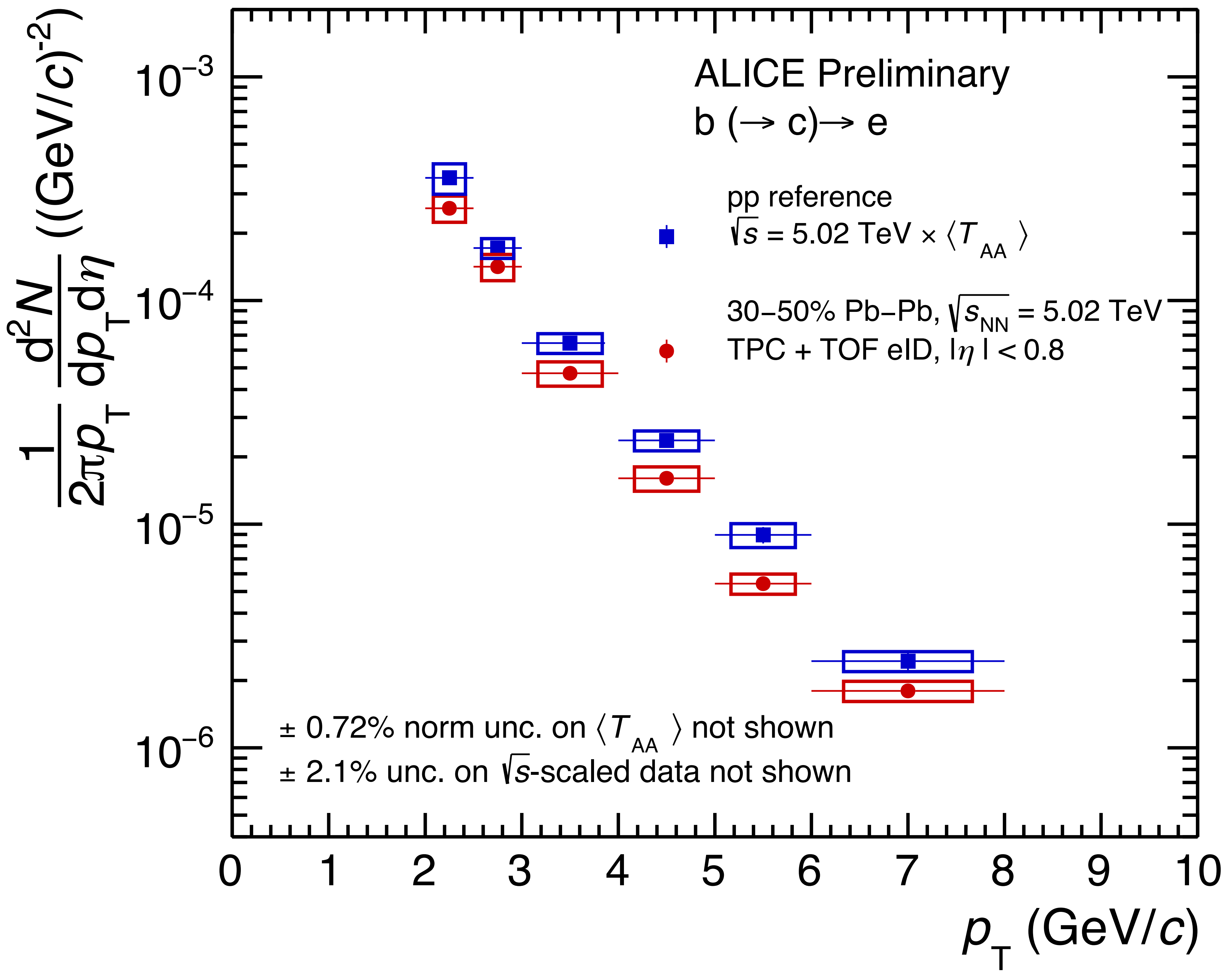






Results

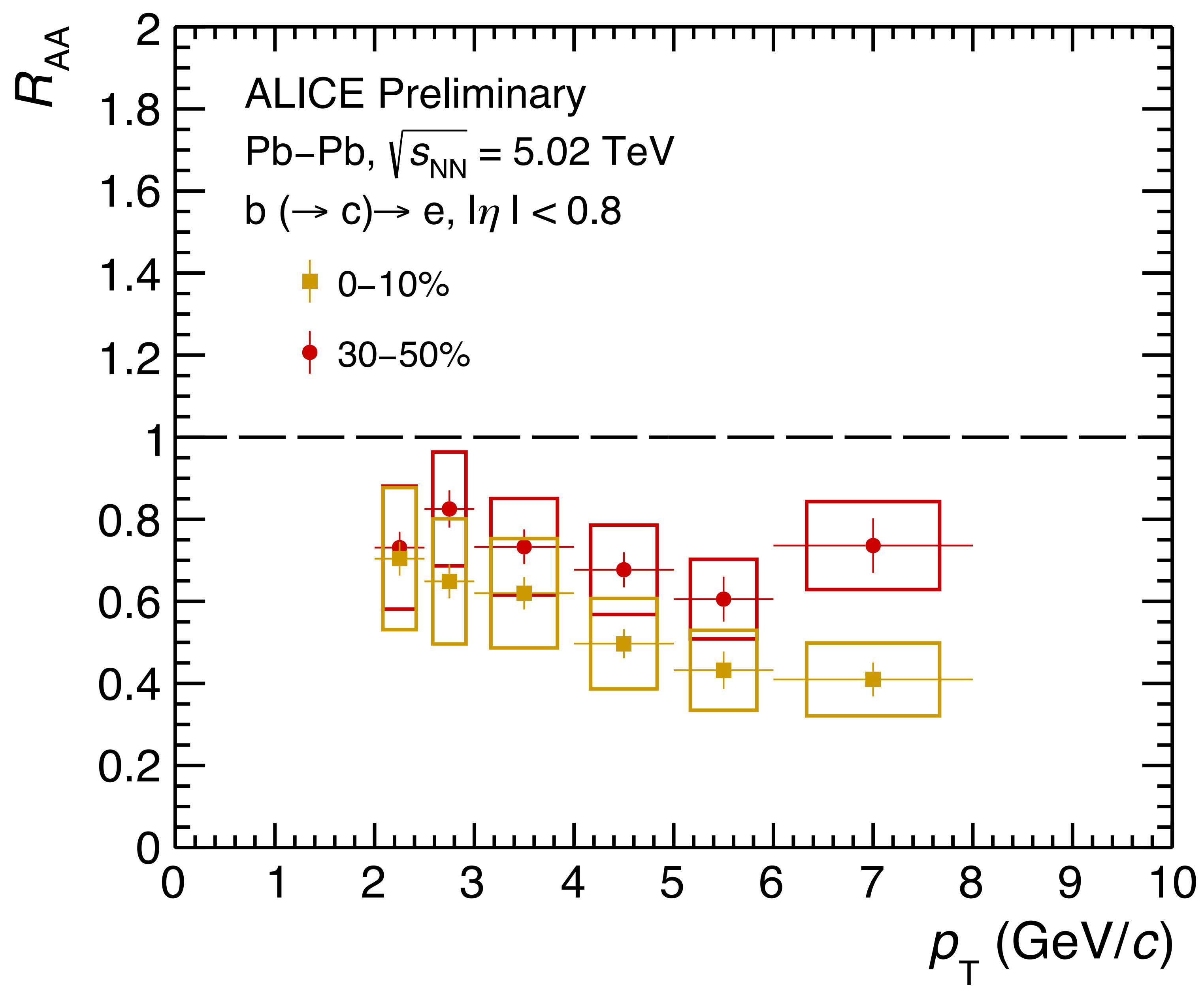
- Invariant yield of electrons from beauty-hadron decays in 30-50% Pb-Pb collisions at 5.02 TeV - RED
- Compare with pp reference measured at 5.02 TeV with ⟨ T_{AA} ⟩ scaling - BLUE

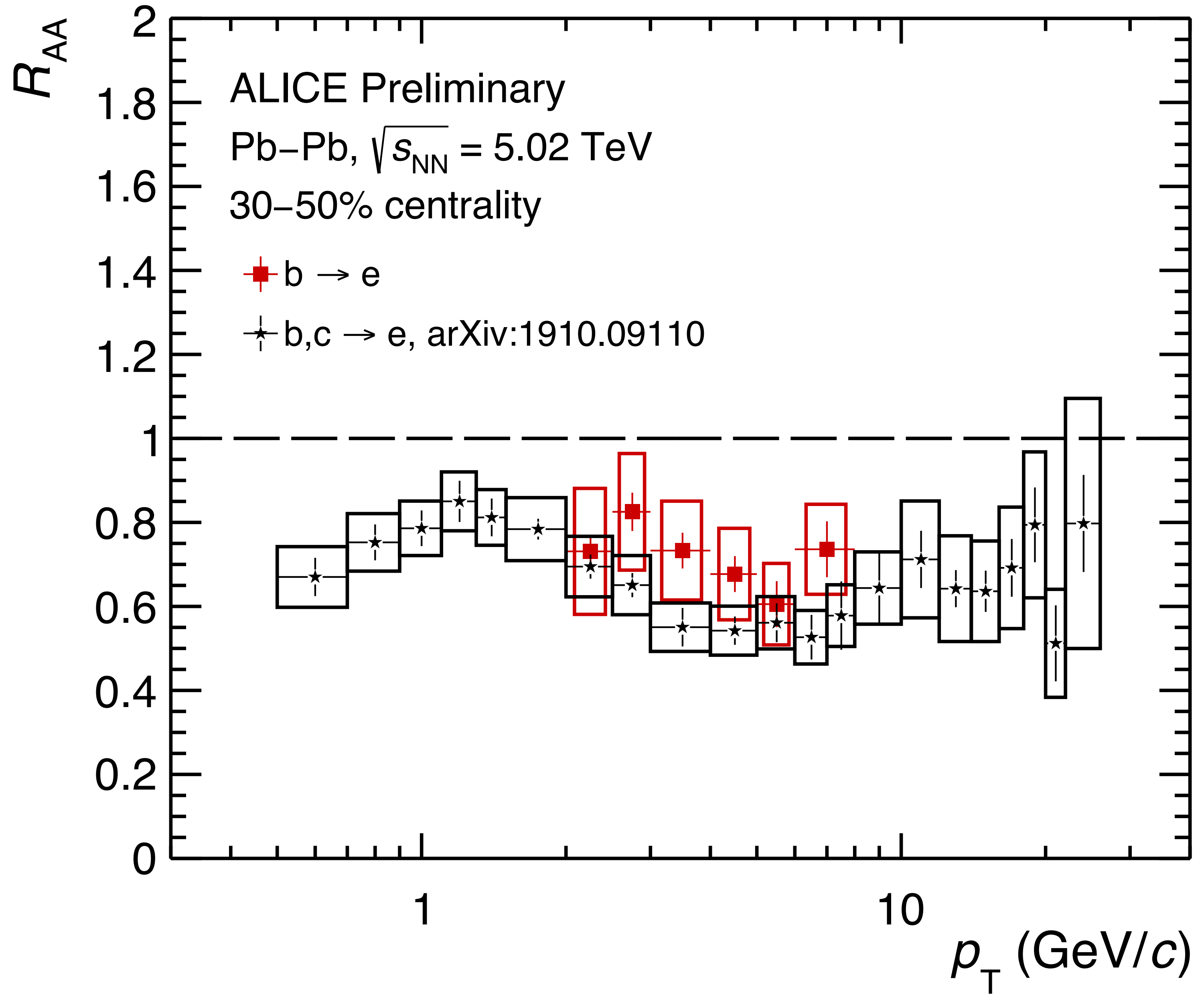


Results

- R_{AA} of beauty-decay electrons in Pb-Pb collisions at 5.02 TeV
- Comparison between different centralities
  - R_{AA} (0-10%) < R_{AA} (30-50%) for 4 < p_T < 8 GeV/c
- Comparison of b→e with c,b→e
  - Hint of beauty quarks undergoing less energy loss than charm quarks at low p_T

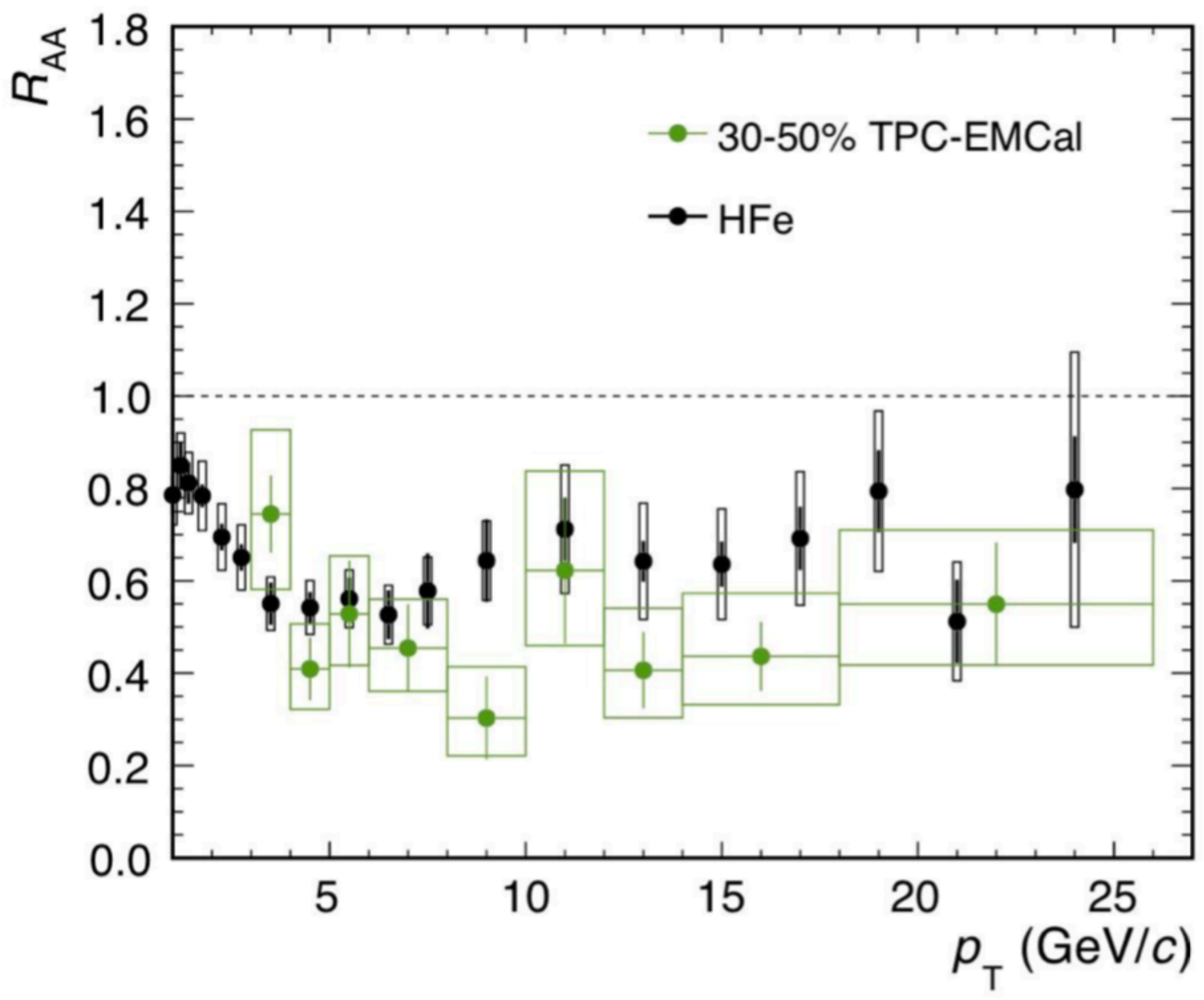
$$R_{AA} = \frac{dN_{AA}/dp_T}{\langle T_{AA}\rangle d\sigma_{pp}/dp_T}$$

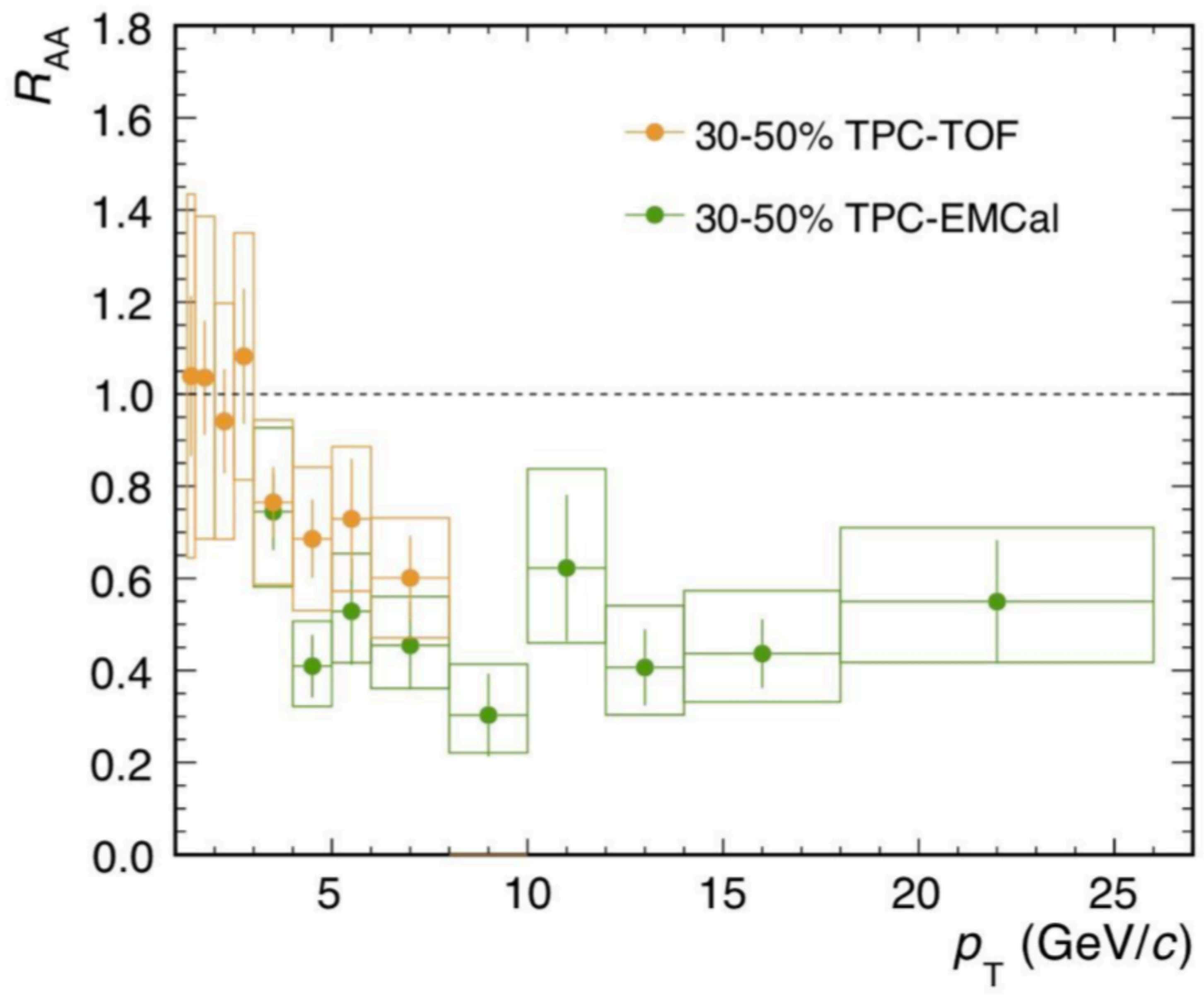




Issue in 30-50%

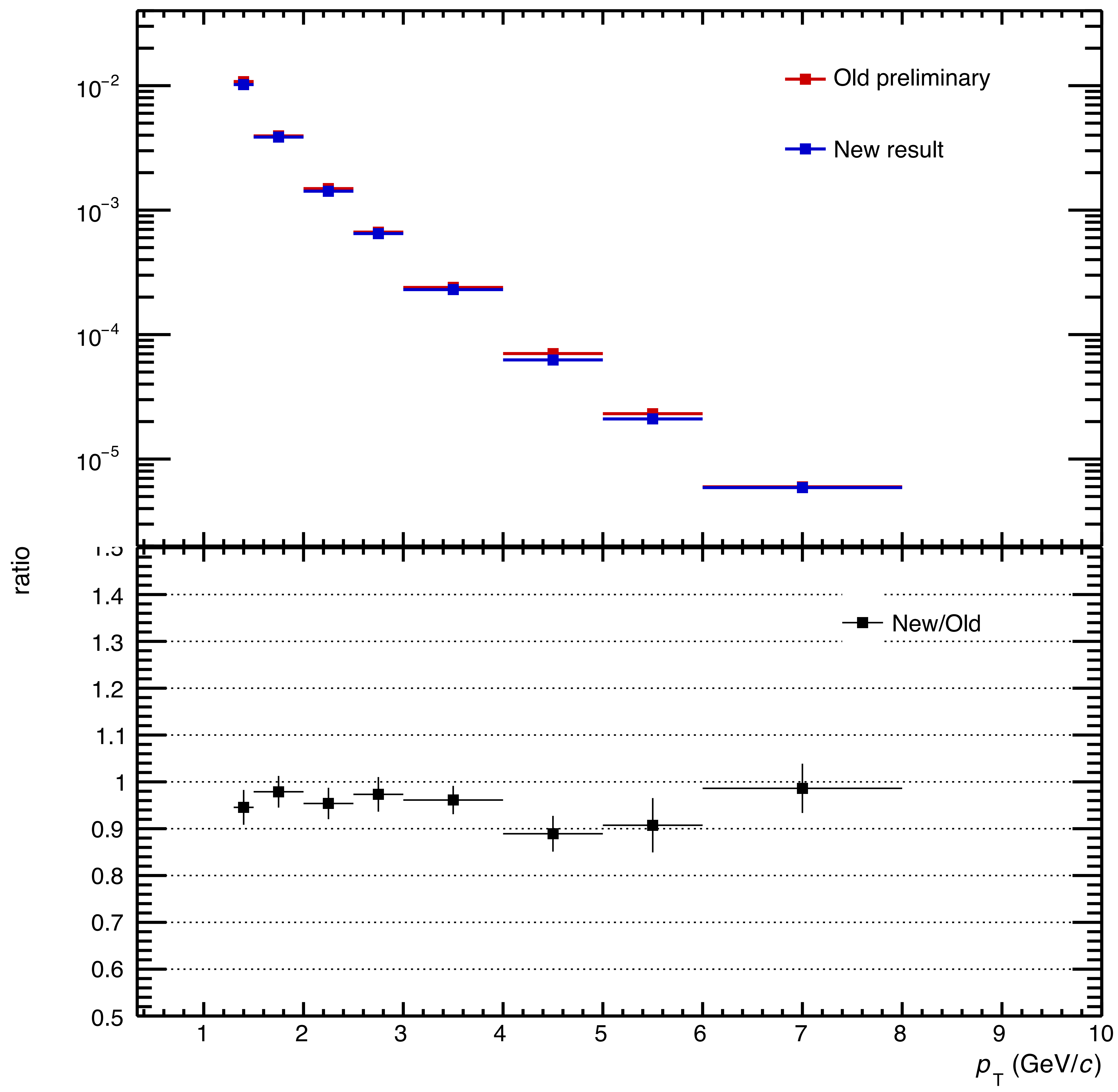
- Crucial issue on beauty analysis in 30-50%
  - TPC-TOF and TPC-EMCal results have large discrepancy in the common p_T region ($4 < p_T < 8$)
  - TPC-EMCal was not accepted at QM approval session
- Have to resolve/understand the discrepancy for paper proposal
- Tried several checks for investigating the problem but not resolved yet





Remake 0-10% result

- Remake 0-10% result with all the recent updates
  - All cuts are the same as before
  - New weight procedure, new fitting routine, adding new correction, etc.
- New result agrees with the old preliminary within 10% deviation



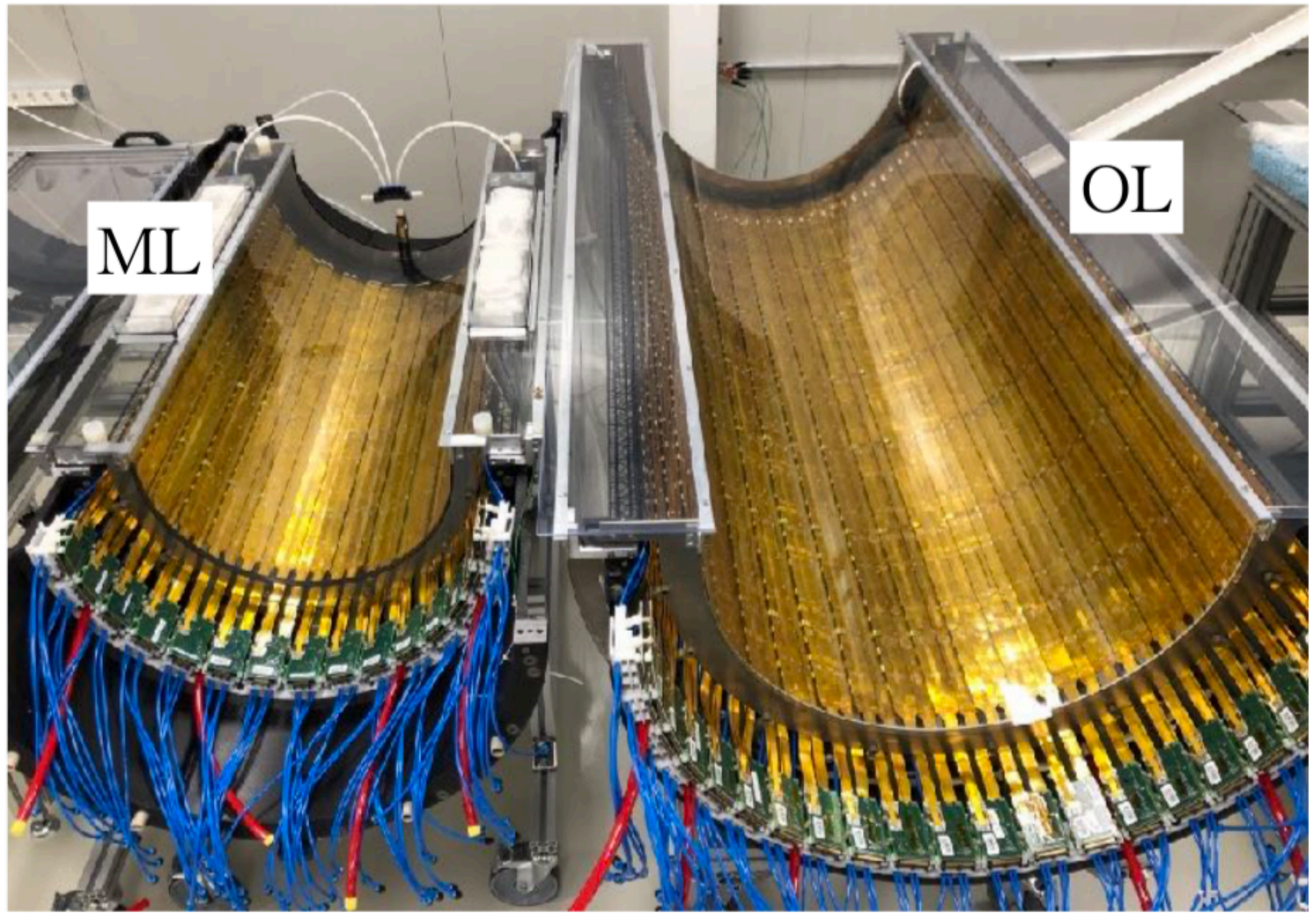
Activities on ITS upgrade

ITS Commissioning Shift

- Participate the ITS commissioning shift since May 2019 and take once per month
- What we do?
  - Do calibration runs for IB (threshold scan, fake-hit rate, readout test, etc.)
  - To monitor the status of power and cooling for the detector safety
  - React immediately in case of problem (communicate with experts)

Reception Test

- Test two different types of staves
  - OL (Outer Layer)
    - 14 HICs per stave and 7 HICs per half-stave
    - Take ~6 hours per half-stave
  - ML (Middle Layer)
    - 8 HICs per stave and 4 HICs per half-stave
    - Take ~4 hours per half-stave
- Test half-stave per setup at a time
- Test single stave → re-do the staves in a layer



Summary & Outlook

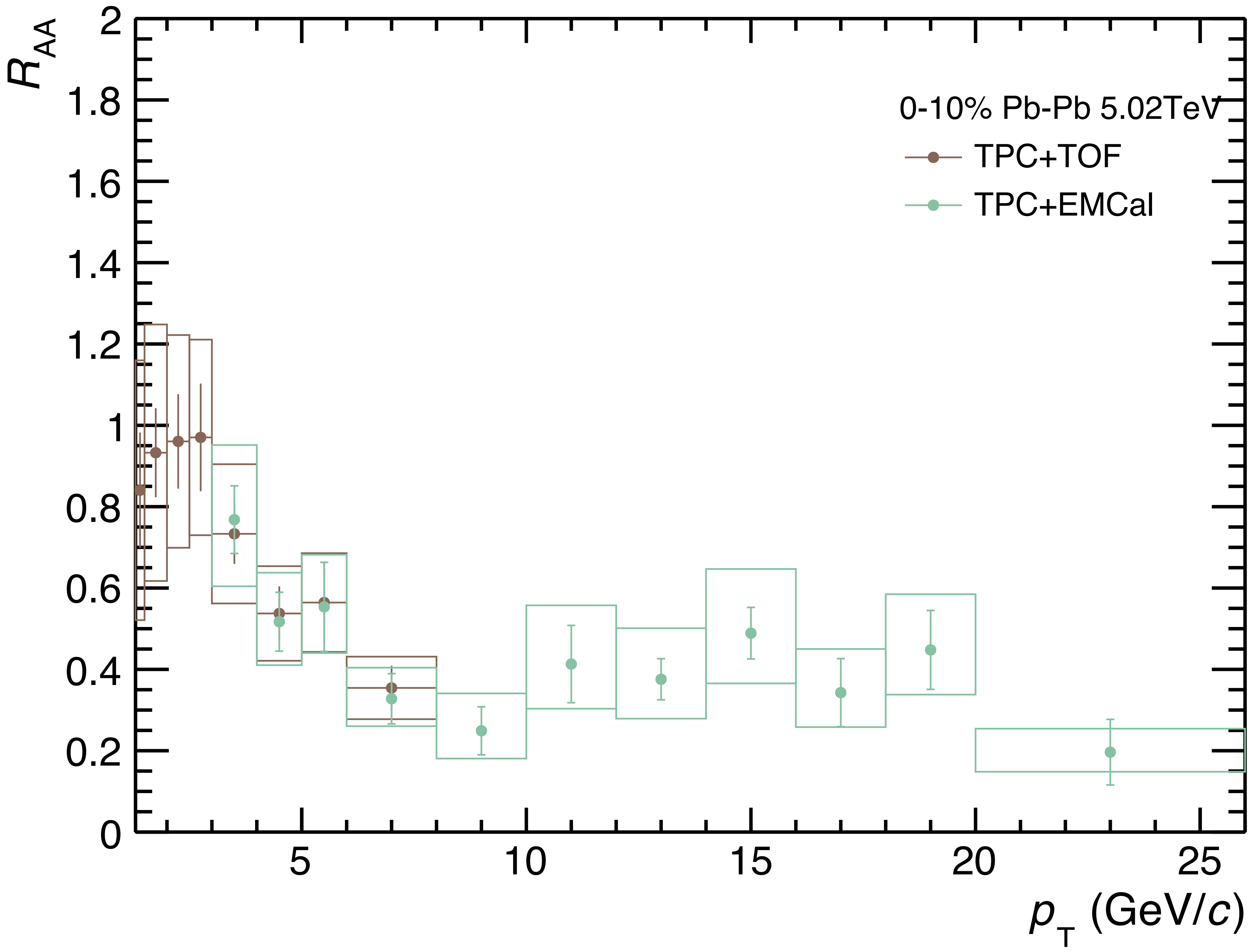
- Study beauty production via semi-electronic decay channel in Pb-Pb at 5.02 TeV
- Participate reception test and detector commissioning shift
  - Finished the reception test
  - Shift will be continued once CERN reopens
- To do list for paper proposal
  - Resolve/understand a discrepancy between TPC-TOF and TPC-EMCal analyses
  - Study the correlated systematic study between 0-10% and 30-50%

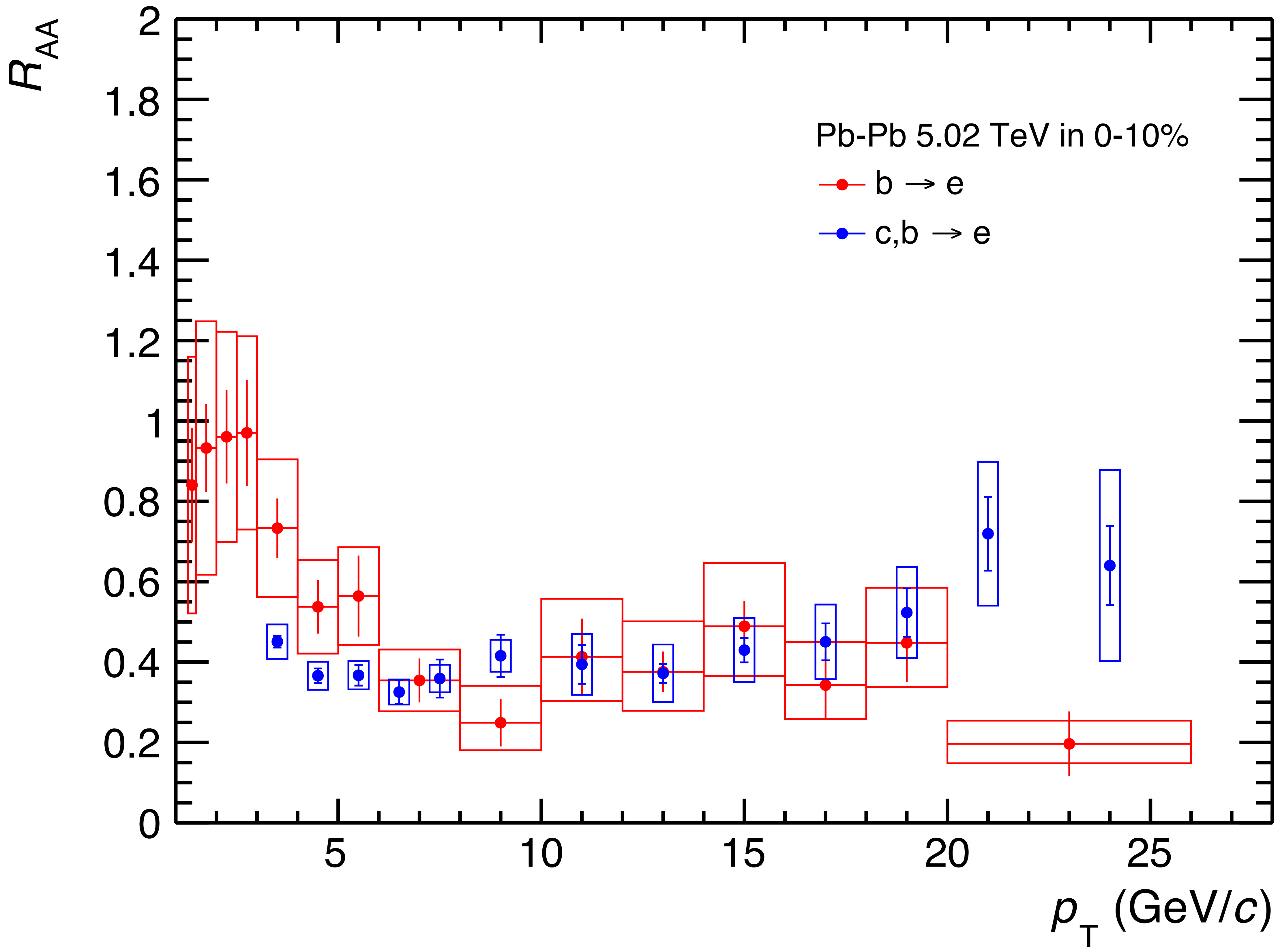
Thanks and

Happy New Year

BACKUP

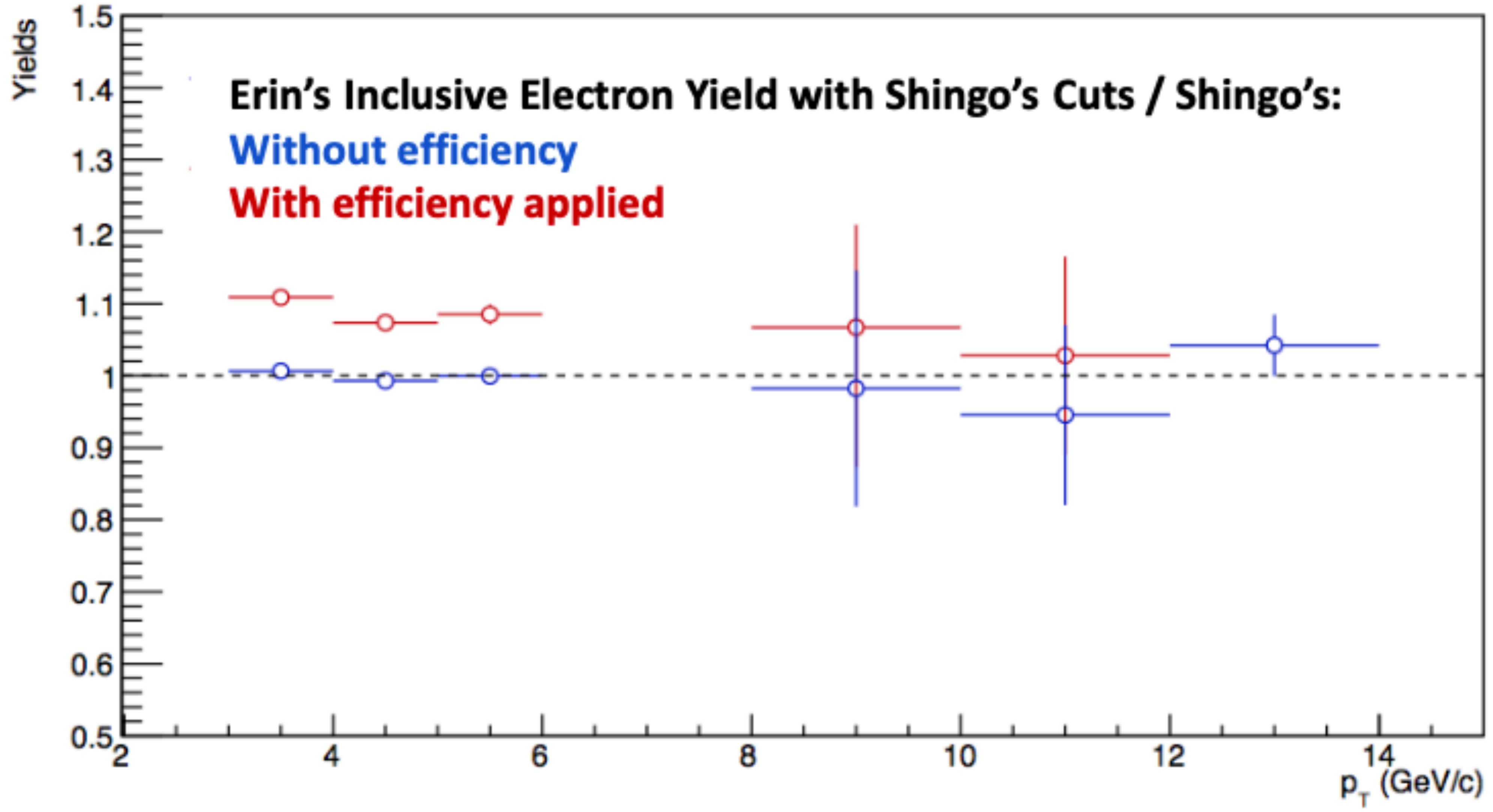
b⟶e in Pb-Pb at 5.02 TeV

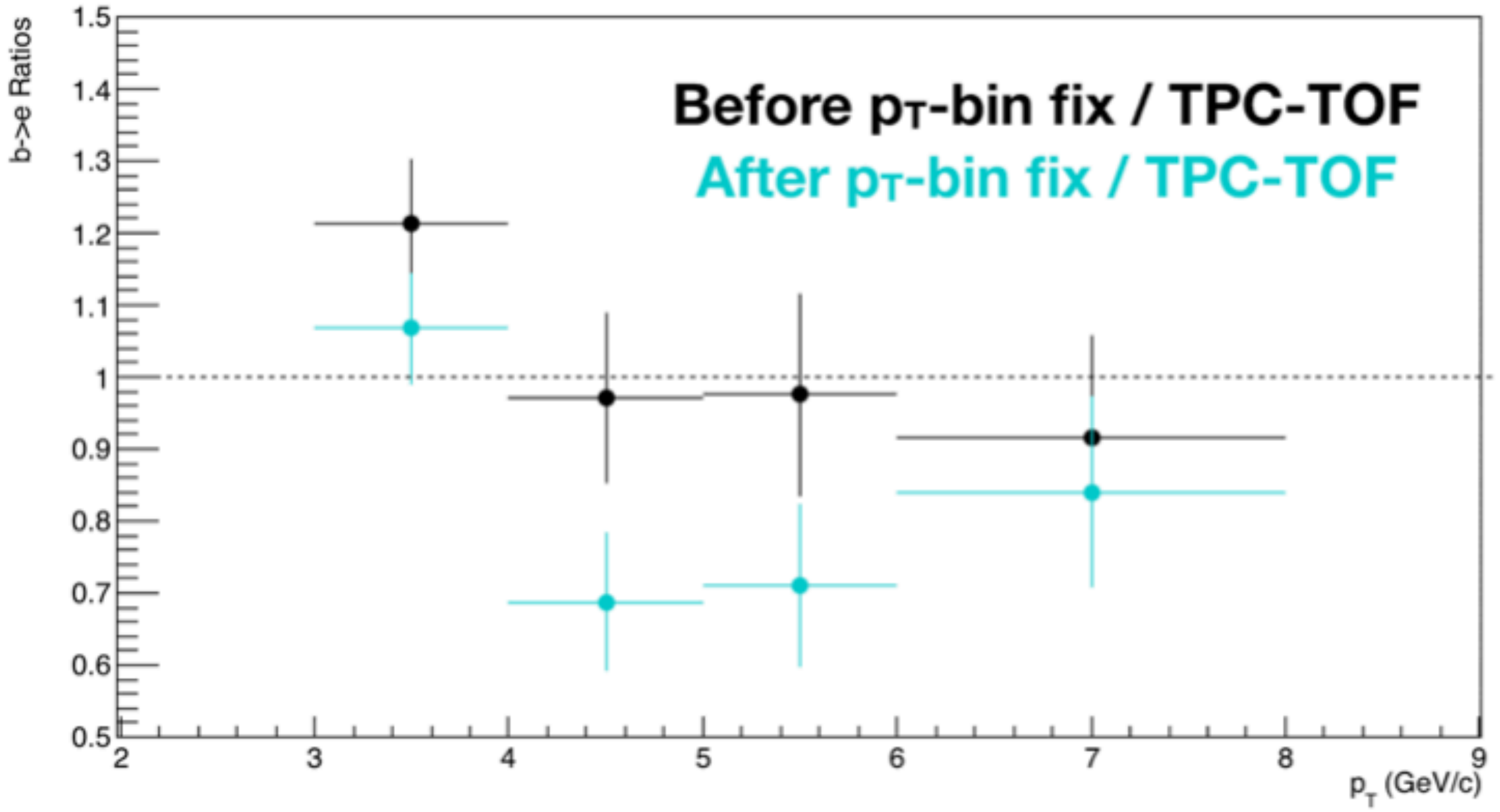




Investigate a discrepancy

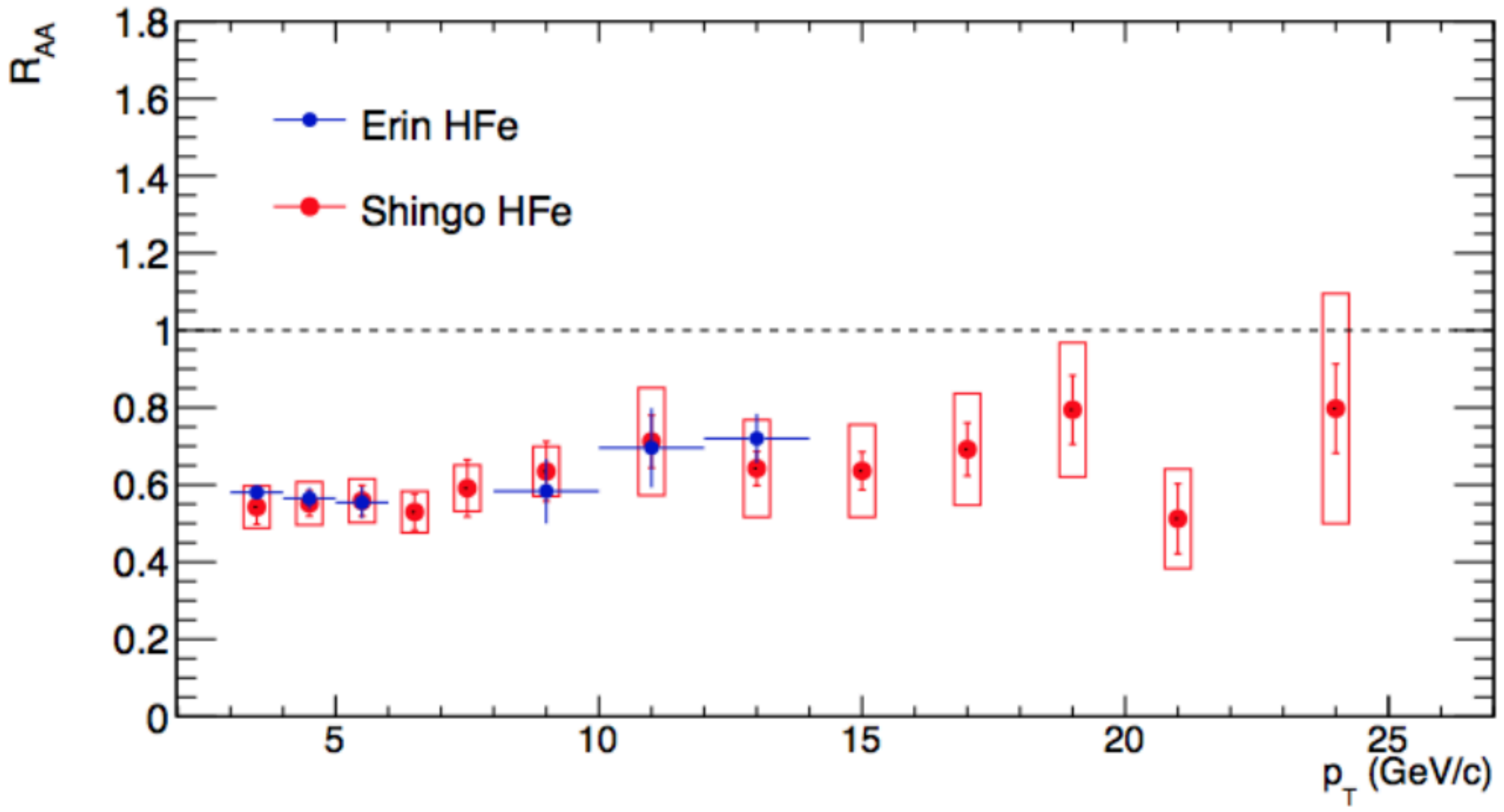
- Resolved p_T binning bug in TPC+EMCal code
  - Fixed yield decreases
- Observed yields between TPC+TOF and TPC+EMCal analyses are different in the common p_T region
- Tried to investigate the discrepancy
  - Look at the yield on HFe level
  - Effect of ITS requirement
  - Fit routine variations
  - Λ_c effect on beauty level
  - Cross-check with TPC-TOF





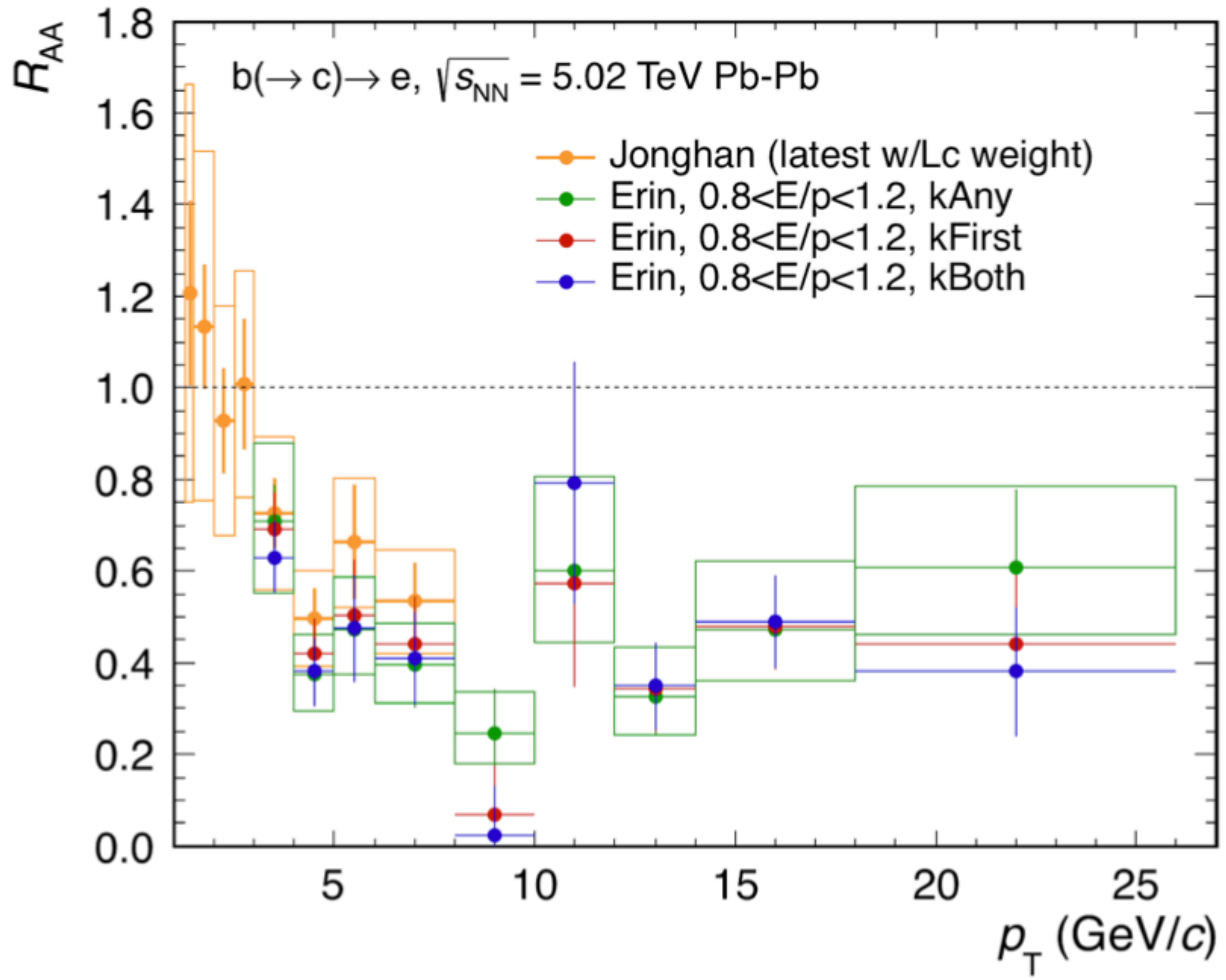
HFe discrepancy solved

- Found a bug in MC efficiency : denominator of the efficiency was filled in a stack loop before event cuts
- Corrected code gives same HFe results



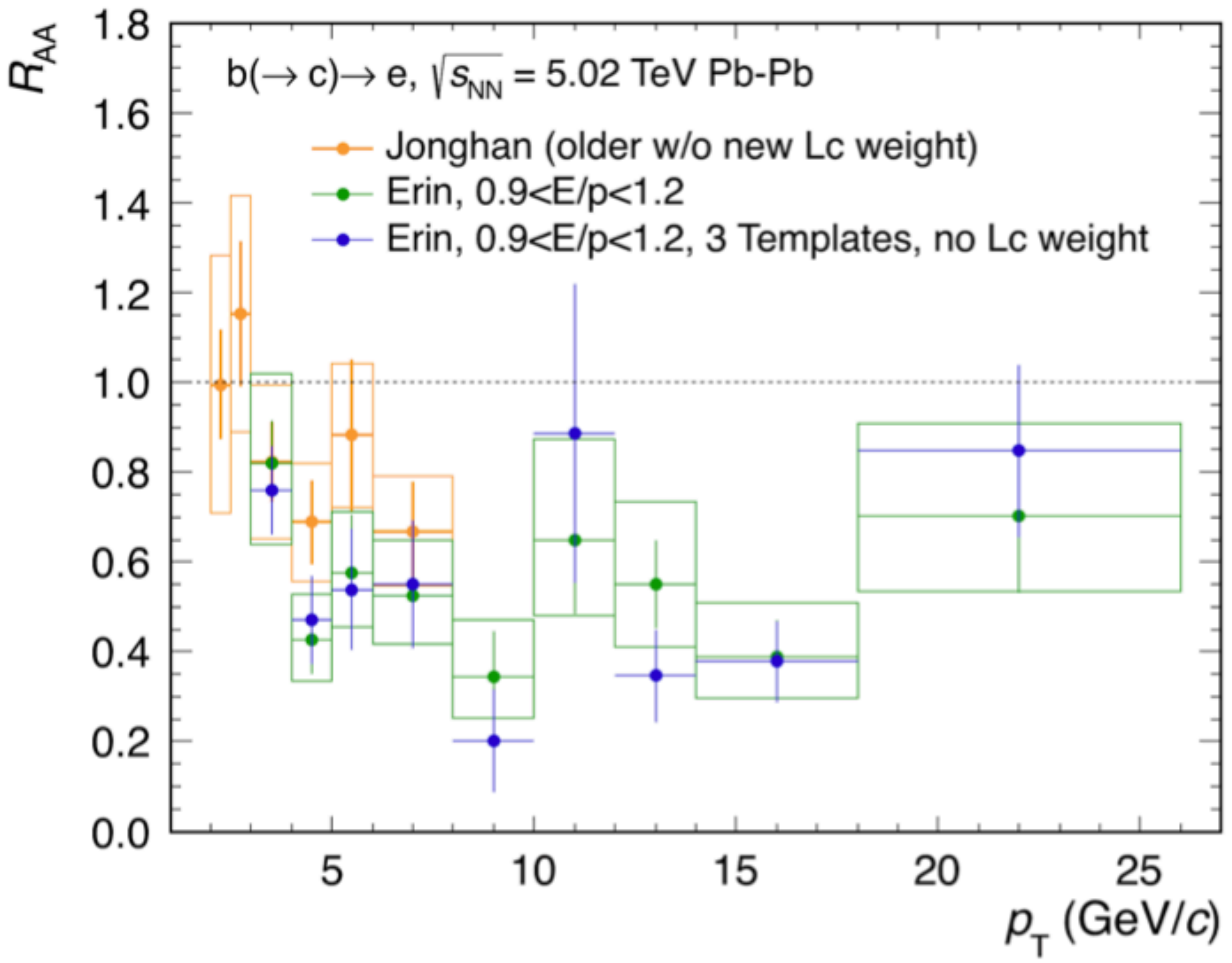
ITS Layer cut tests

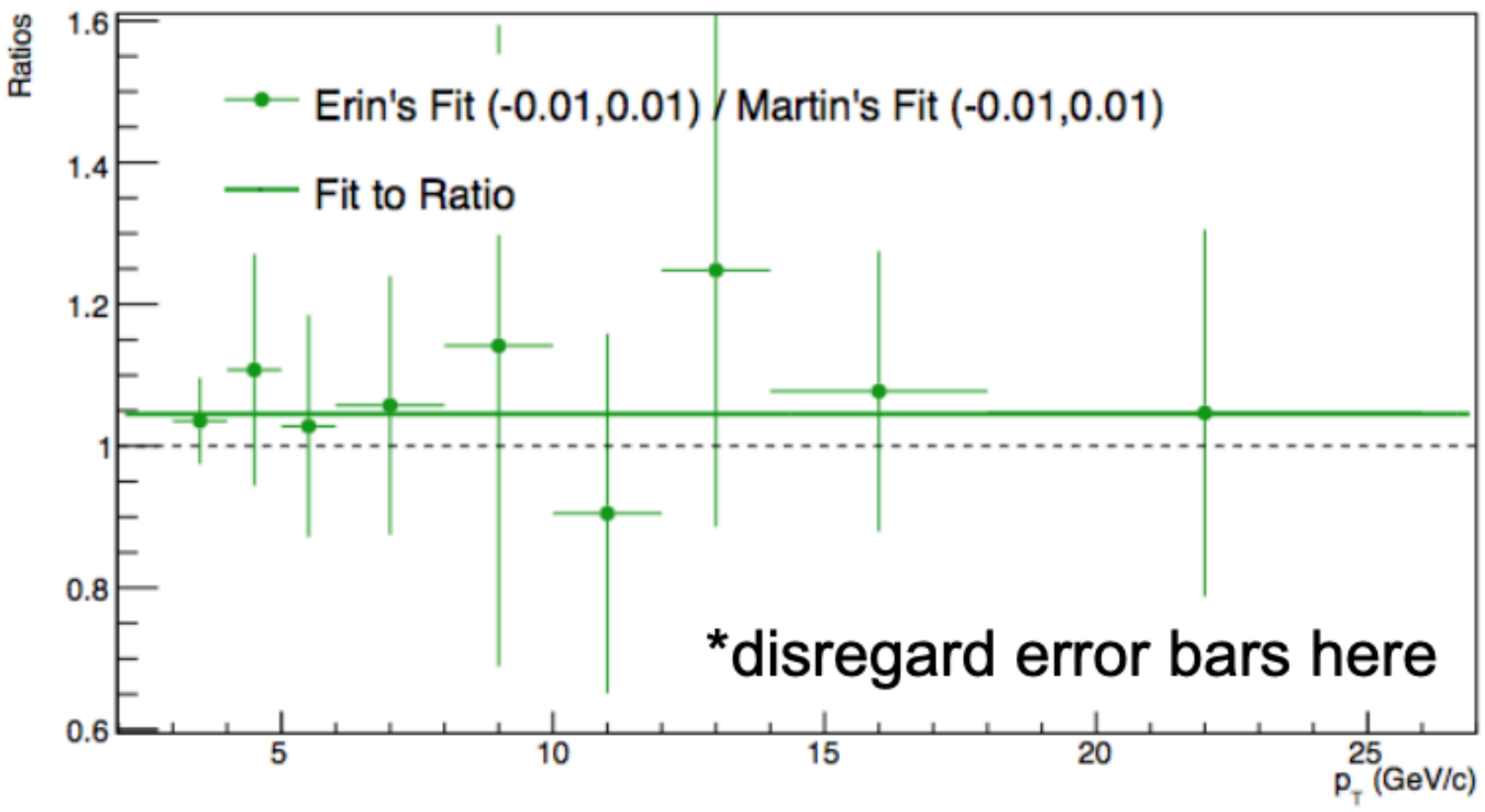
- Test effect of increased resolution by changing the cut on ITS layer requirement
  - Default : kAny, Variations : kFirst and kBoth
  - No major effect (decreases statistics → fluctuation between 8-12 GeV/*c*)



Fit routine variations

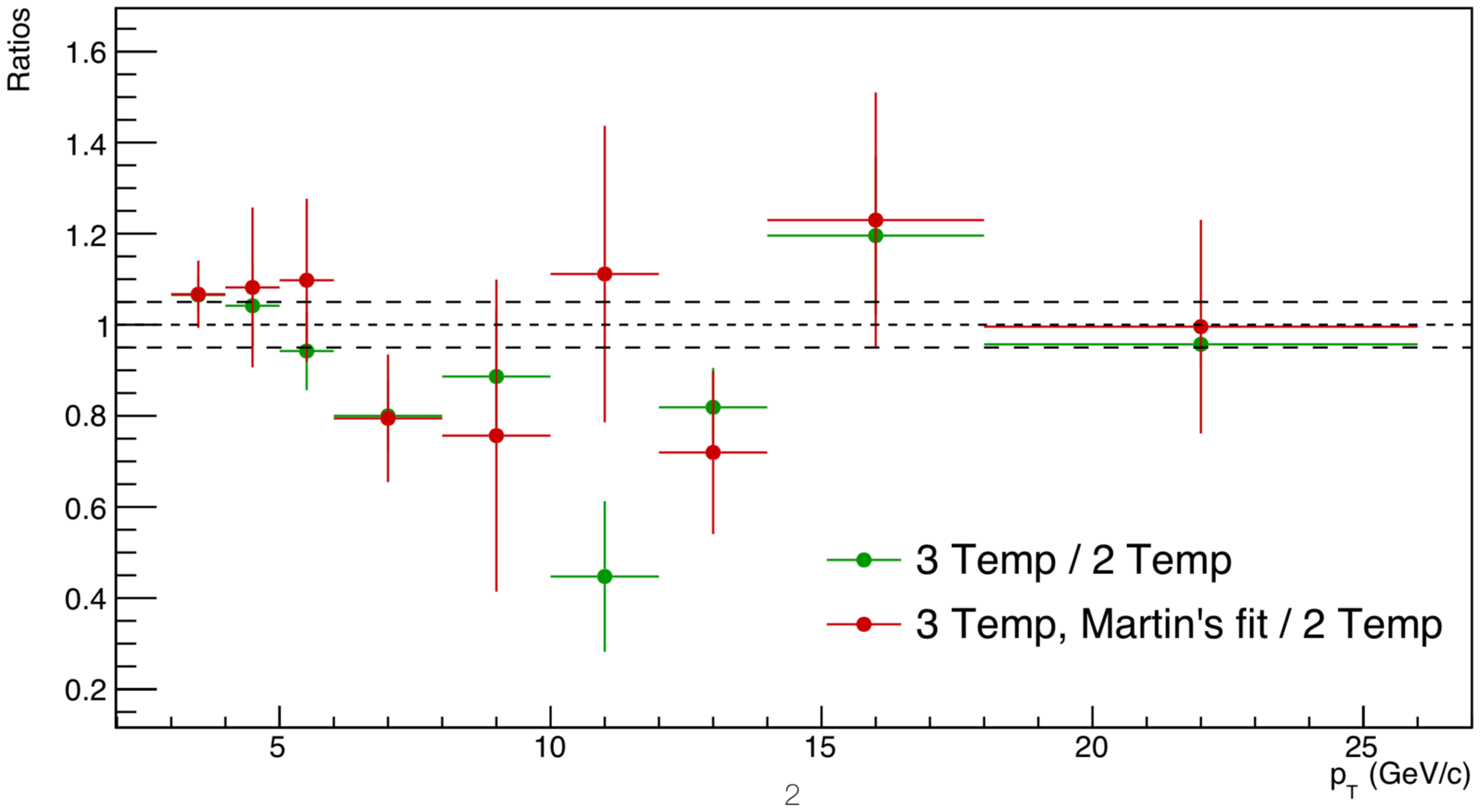
- Varied fitting routine:
  - Three templates ($D \rightarrow e$, $\Lambda_c \rightarrow e$ and $B \rightarrow e$) → no trend, fluctuating
  - Use the weighted template fit method → beauty yield decreases about 5% with the weighted fitting routine





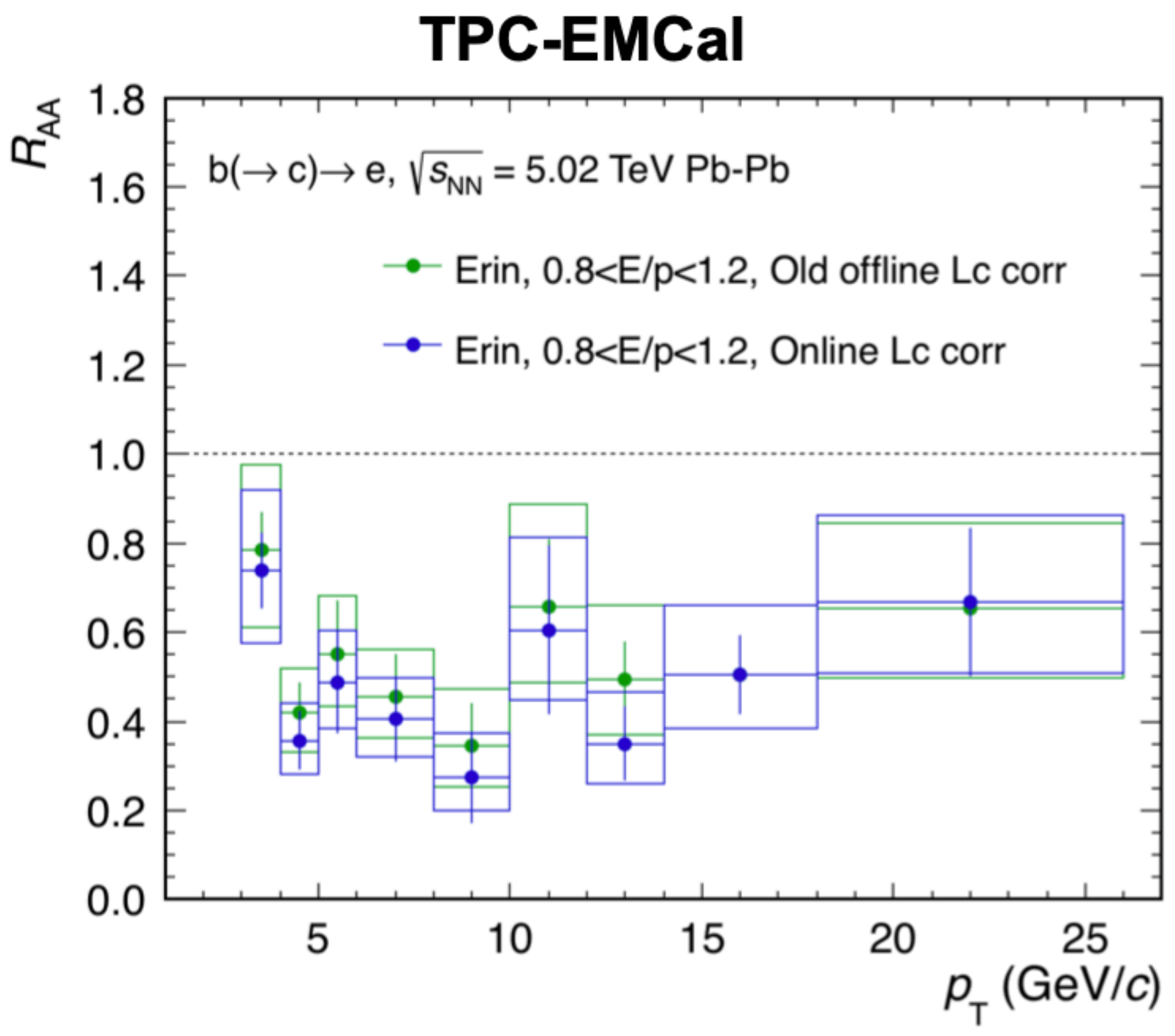
Fit routine variations

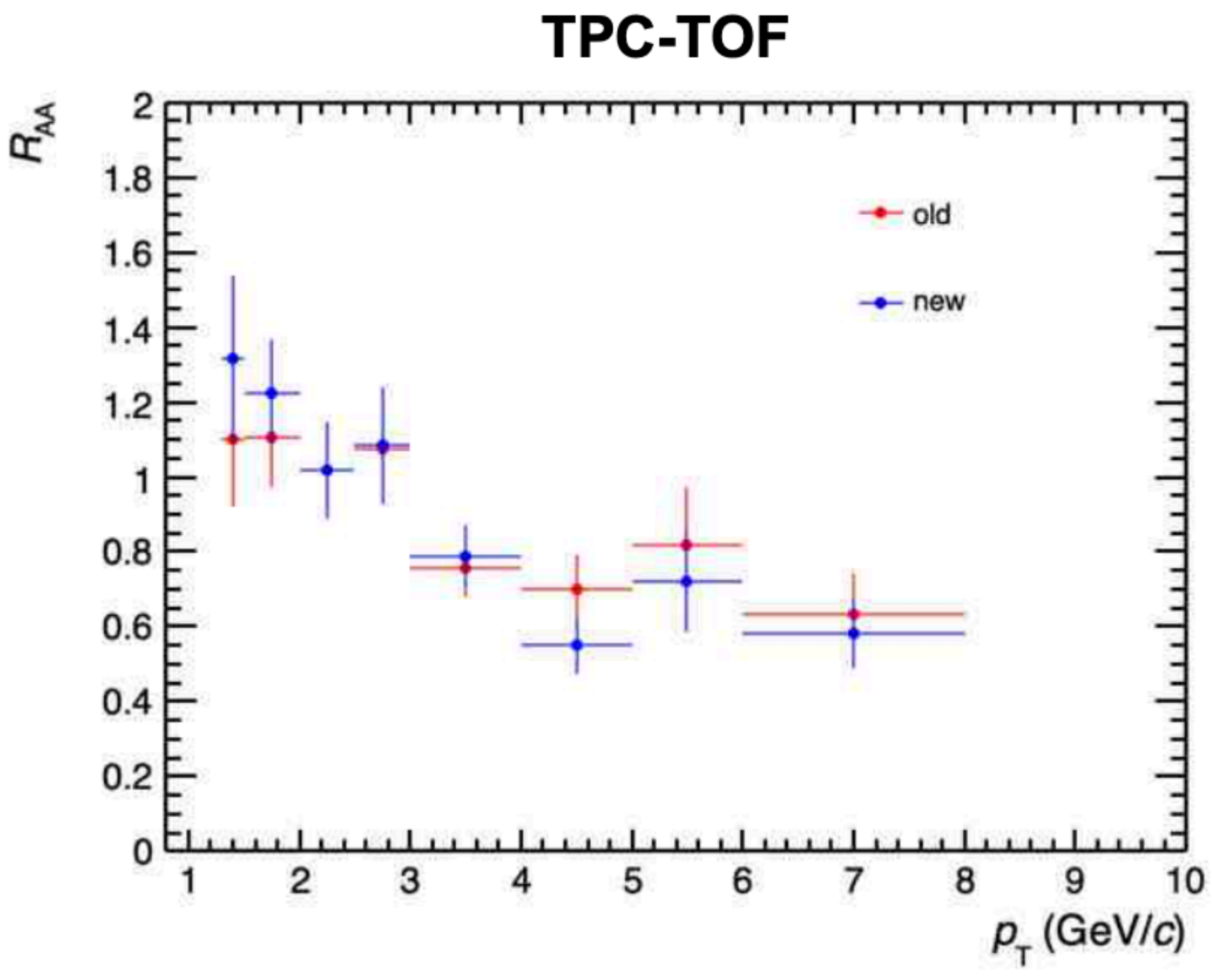
- Varied fitting routine:
  - Three templates ($D+\Lambda_c \rightarrow$e and $B\rightarrow$e from MC and non-HFe from data-driven invariant mass method)
    - Instead of subtracting the non-HFe, add it as a third template
  - Compared between non-weighted template fit method and weight template fit method with tree templates
    - Entries of the templates in the non-weighted template fit should be integer (Poissonian statistics)
  - Ratio plot is rather bumpy → ~5% differences in first few bins with respect to the weighted template fit



Λ_c correction effect

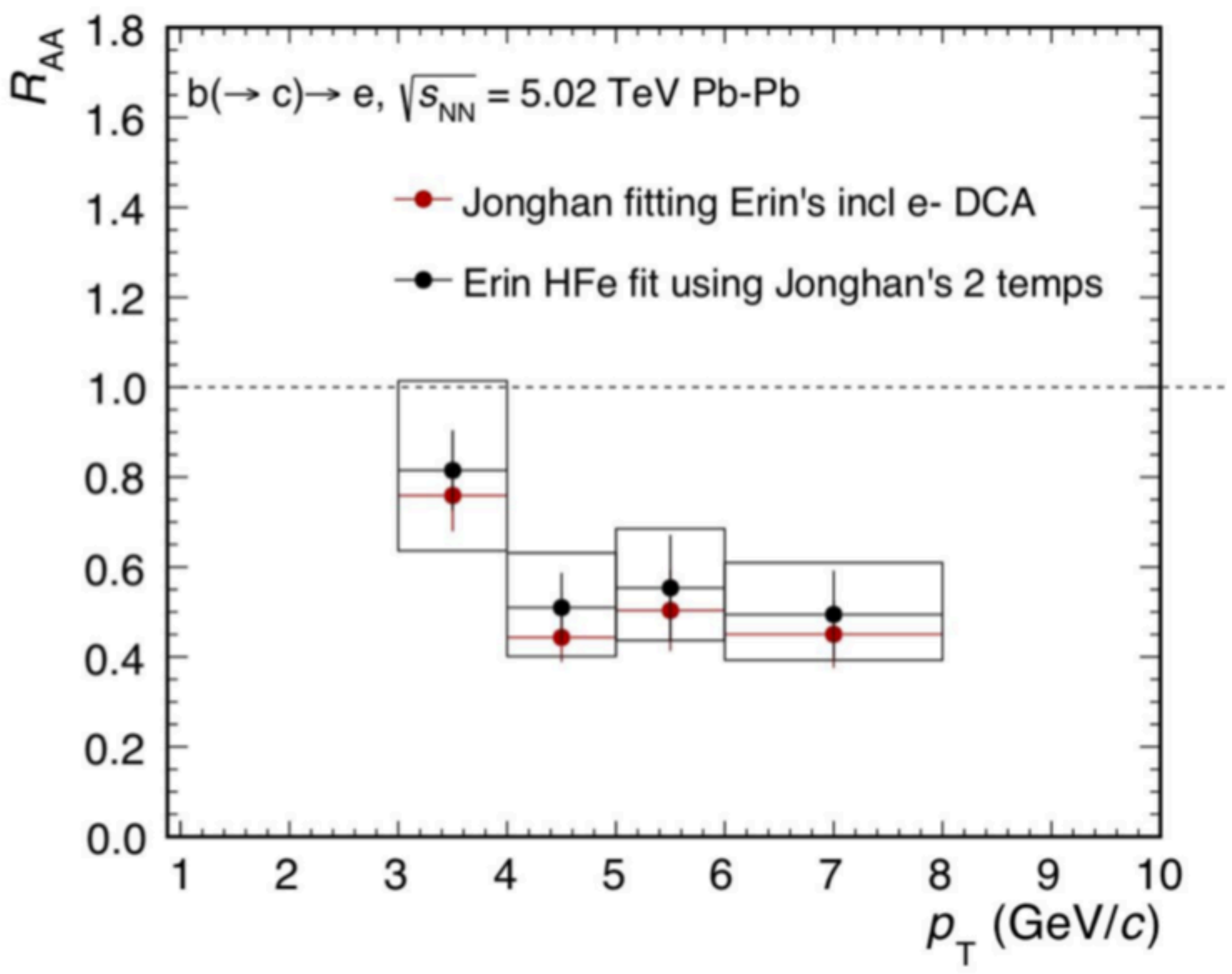
- New Λ_c weight decreases the beauty yield for p_T > 3GeV/c in both analyses
  - Λ_c contribution decreases → wider charm template → beauty yield decreases

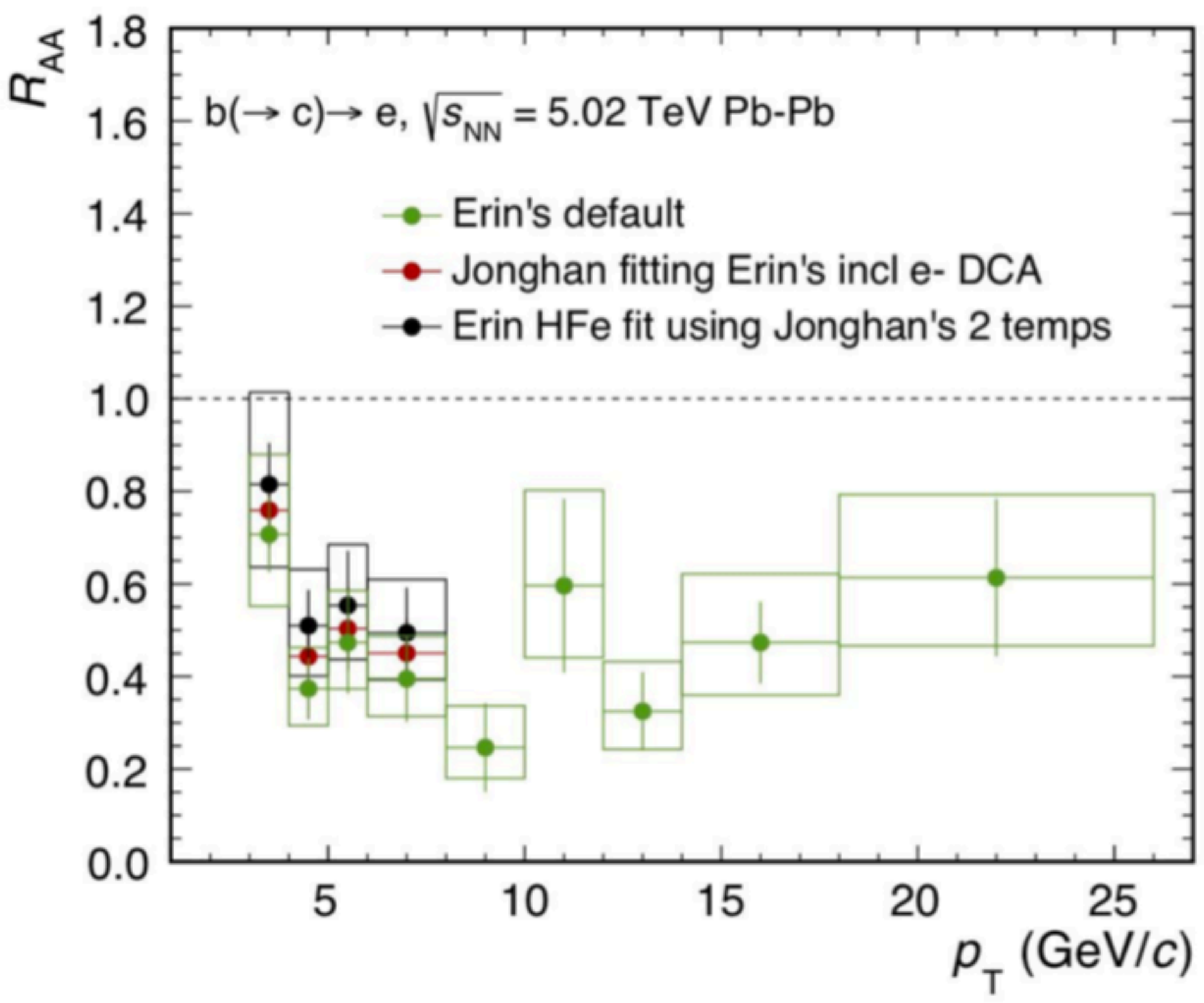




Cross-check with TPC+TOF

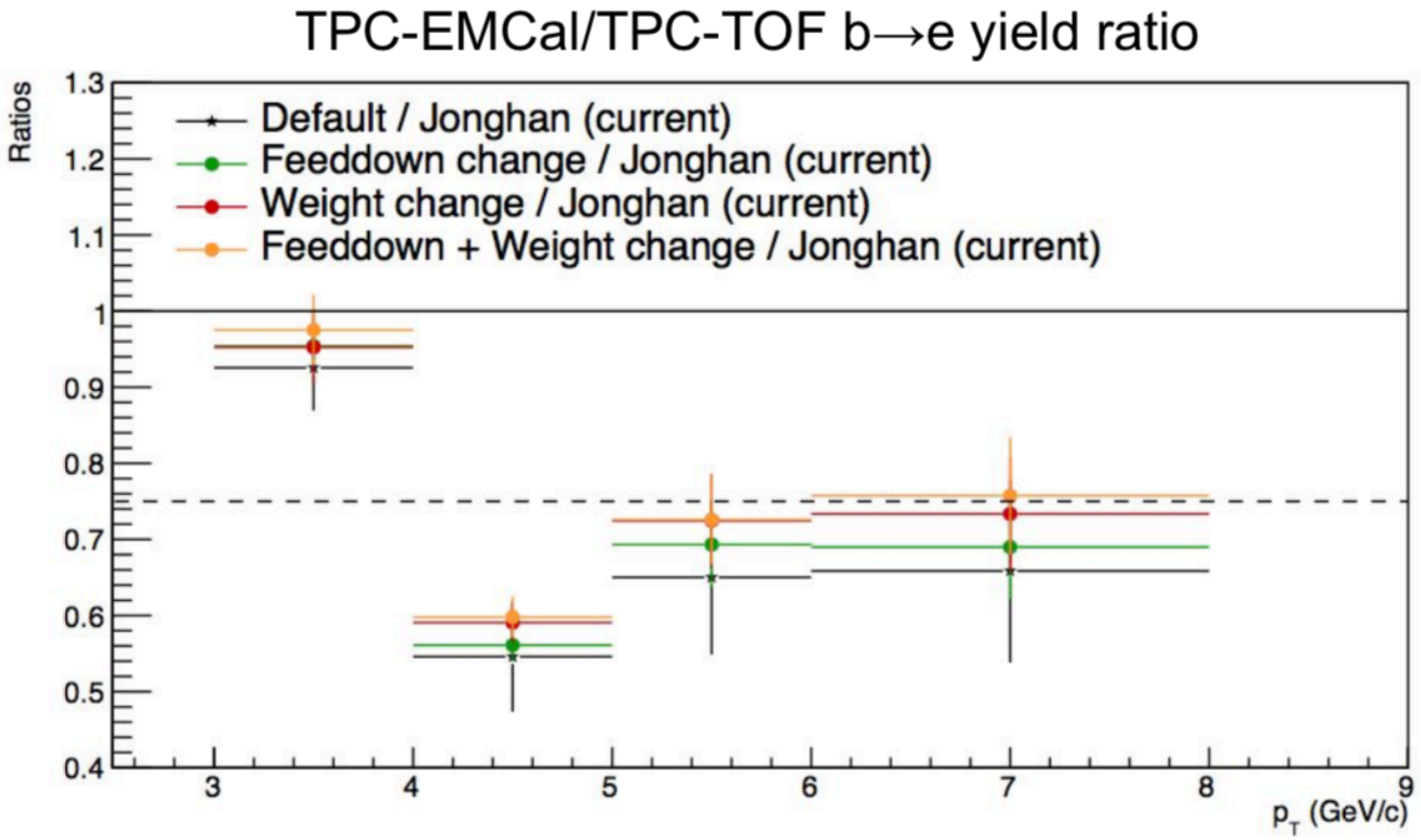
- Fit TPC+EMCal data with TPC+TOF templates
  - Fit inclusive electron DCA with 4 templates (charm, beauty, Dalitz and conversion)
  - Fit HFe DCA with 2 templates (charm and beauty)
- Both template fits are in agreement
- Higher than default TPC+EMCal points

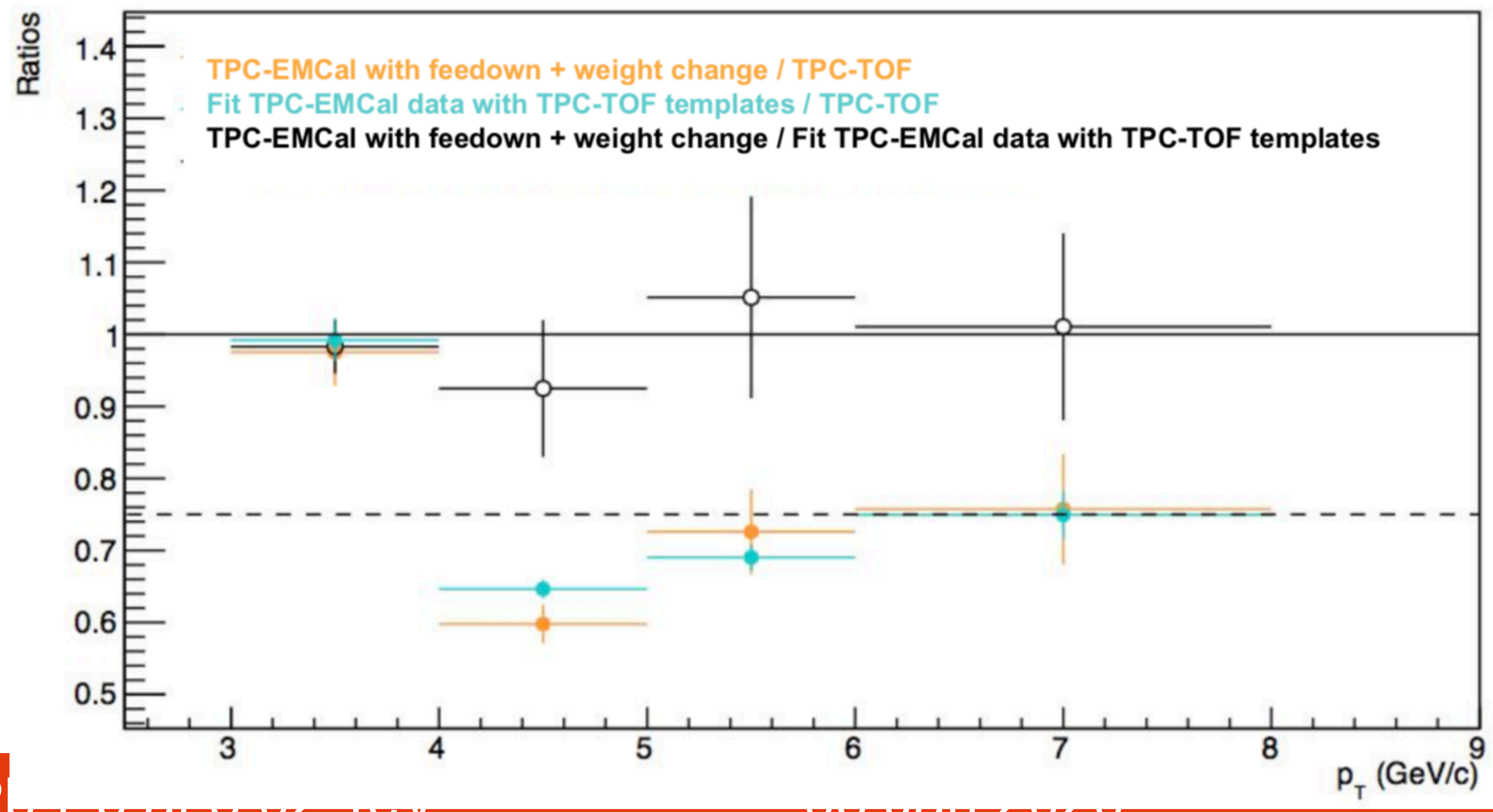




Cross-check with TPC+TOF

- Use same beauty feed down procedure as TPC+TOF
  - Previous method checked up to electron's great-grandmother, but TPC+TOF method checks 100x back in the decay chain for a beauty mother
- Use exact same weight as TPC+TOF
  - Adopted all correction functions used in TPC+TOF
- Use both TPC+TOF feed down method + weight
  - Increases beauty yield slightly
- Fit TPC+EMCal inclusive electrons with 4 templates
  - Agrees with TPC+EMCal results when the TPC+TOF feed down and weights are used
- Conclusion : difference in results is not from the MC, but an intrinsic difference in the data





Reception Test