Double D meson analysis with CMS pPb data

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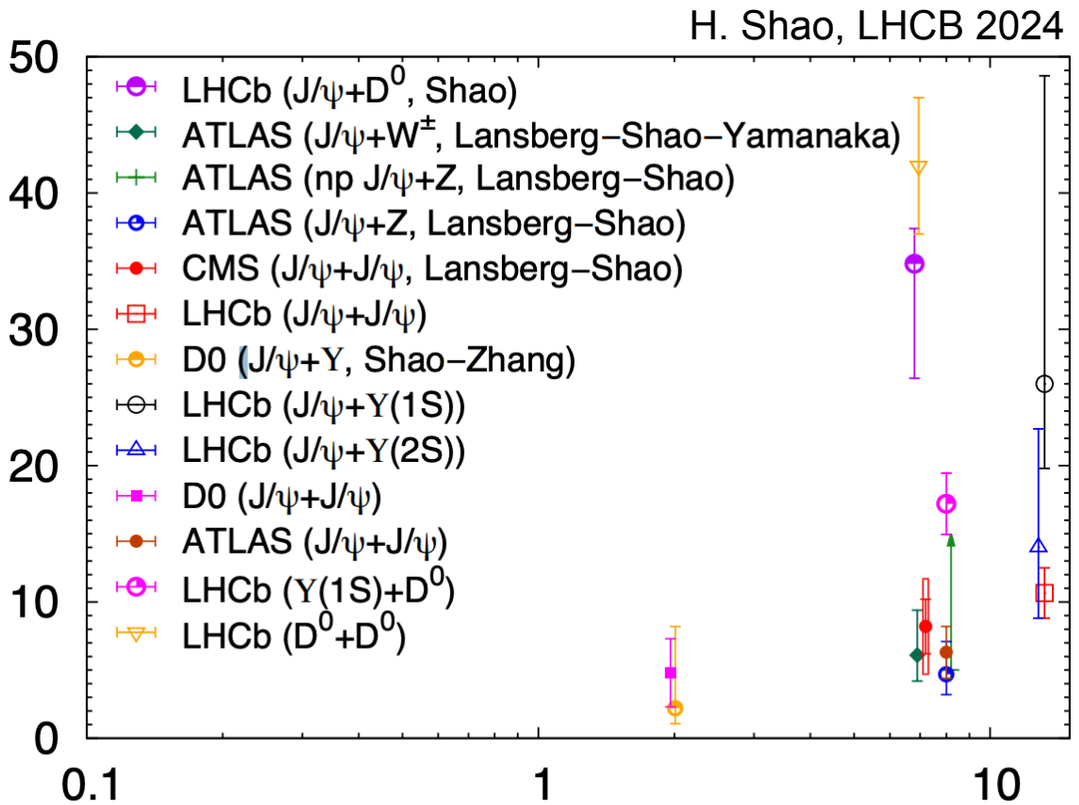
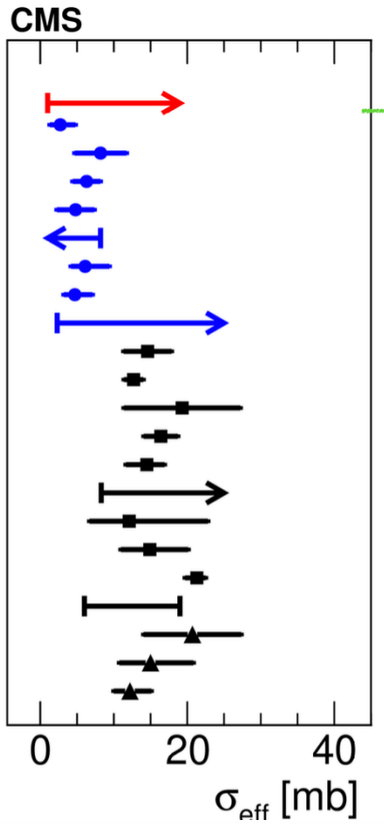
D-D analysis

- Heavy flavor corrleation
- Double D0 ↔ double J/ψ for DPS study in pPb
  - Provide precision measurement of cross correlation in higher pT compared to LHCb result in mid rapidity
    - Model constraint (fwd-**mid**-bkwd)
- CADI created with HIN-24-012





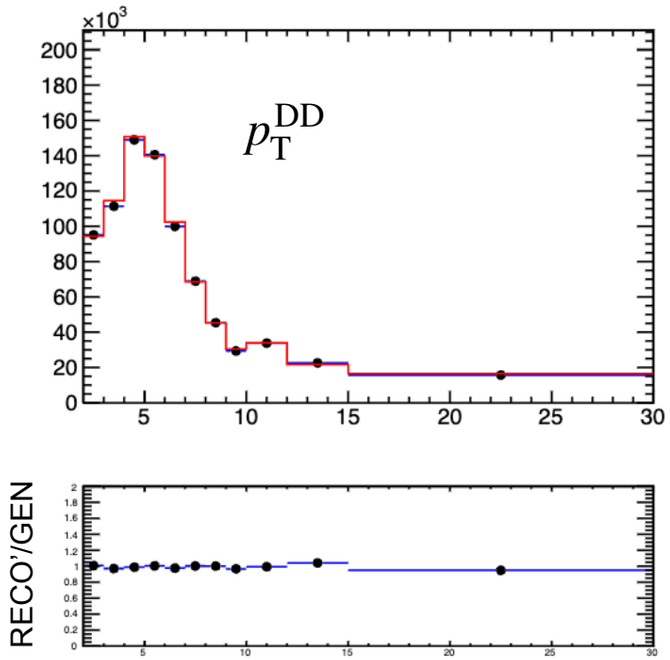
FINAL HP24

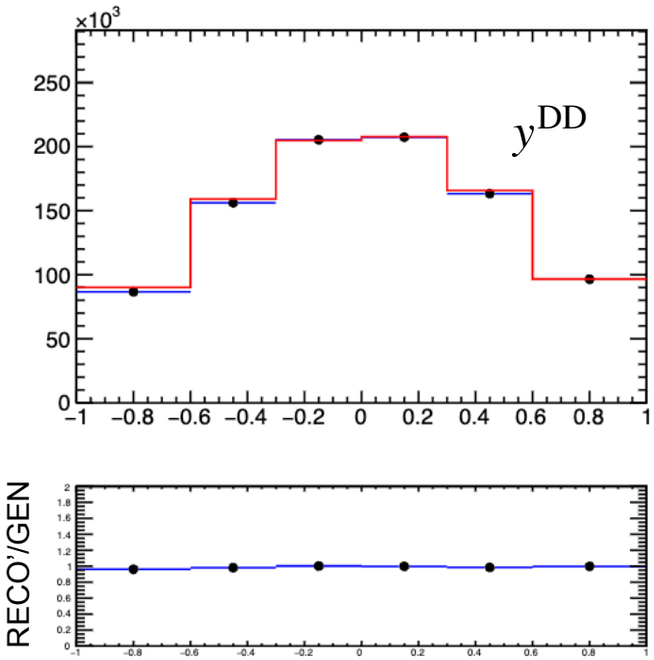
arXiv.2407.03223

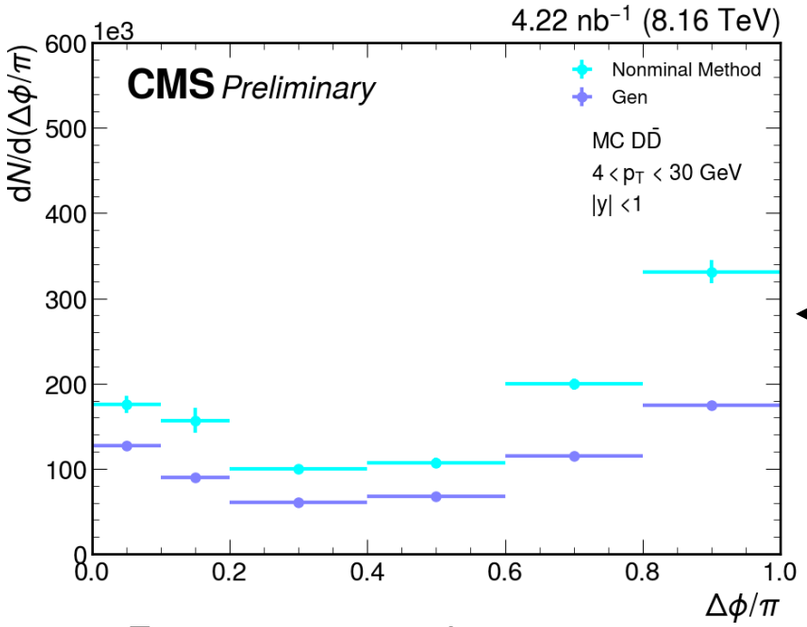
pPb → J/ψ+J/ψ, √sNN=8.16 TeV, **CMS** (this work)	
pp → J/ψ+J/ψ+J/ψ, √s=13 TeV, **CMS**	Nat. Phys. **19** (2023) 338
pp → J/ψ+J/ψ, √s=7 TeV, **CMS***	Phys. Rept. **889** (2020) 1
pp → J/ψ+J/ψ, √s=8 TeV, **ATLAS**	Eur. Phys. J. C **77** (2017) 76
pp → J/ψ+J/ψ, √s=1.96 TeV, **D0**	Phys. Rev. D **90** (2014) 111101
pp → J/ψ+Υ, √s=1.96 TeV, **D0***	Phys. Rev. Lett. **117** (2016) 062001
pp → W+J/ψ, √s=7 TeV, **ATLAS***	Phys. Lett. B **781** (2018) 485
pp → Z+J/ψ, √s=8 TeV, **ATLAS***	Phys. Rept. **889** (2020) 1
pp → Z+b→J/ψ, √s=8 TeV, **ATLAS***	Nucl. Phys. B **916** (2017) 132
pp → γ+b/c+2-jet, √s=1.96 TeV, **D0**	Phys. Rev. D **89** (2014) 072006
pp → γ+3-jet, √s=1.96 TeV, **D0**	Phys. Rev. D **89** (2014) 072006
pp → 2-γ+2-jet, √s=1.96 TeV, **D0**	Phys. Rev. D **93** (2016) 052008
pp → γ+3-jet, √s=1.96 TeV, **D0**	Phys. Rev. D **81** (2010) 052012
pp → γ+3-jet, √s=1.8 TeV, **CDF**	Phys. Rev. D **56** (1997) 3811
pp → 4-jet, √s=640 GeV, **UA2**	Phys. Lett. B **268** (1991) 145
pp → 4-jet, √s=1.8 TeV, **CDF**	Phys. Rev. D **47** (1993) 4857
pp → 4-jet, √s=7 TeV, **ATLAS**	JHEP **11** (2016) 110
pp → 4-jet, √s=7 TeV, **CMS**	Eur. Phys. J. C **76** (2016) 148
pp → 4-jet, √s=13 TeV, **CMS**	JHEP **01** (2022) 177
pp → W+2-jet, √s=7 TeV, **CMS**	JHEP **03** (2014) 032
pp → W+2-jet, √s=7 TeV, **ATLAS**	New J. Phys. **15** (2013) 033038
pp → WW, √s=13 TeV, **CMS**	Phys. Rev. Lett. **131** (2023) 091803

Correction method validation

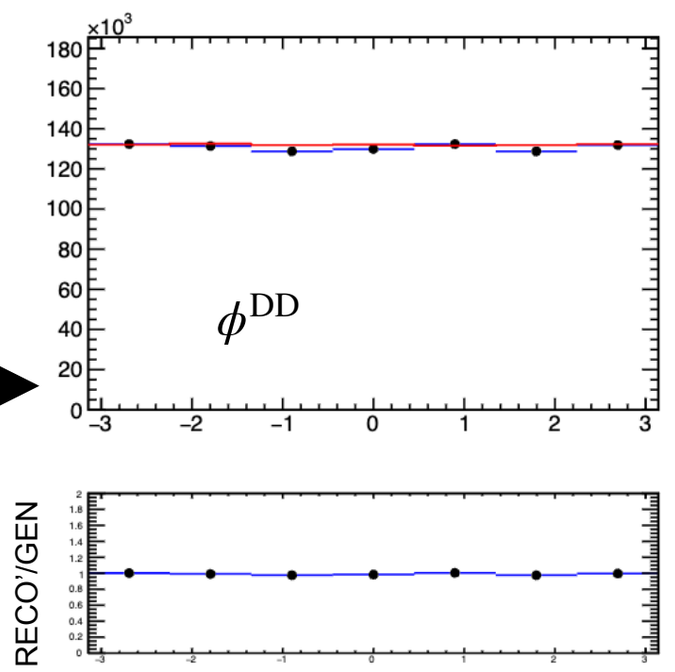
- When applied no BDT, single D0 efficiency correction works
  - pre-approval comment from Zhen hu, no need for dedicated SPS, DPS sample for yield correction
  - Debugging problem..







From pre approval, nominal BDT selection

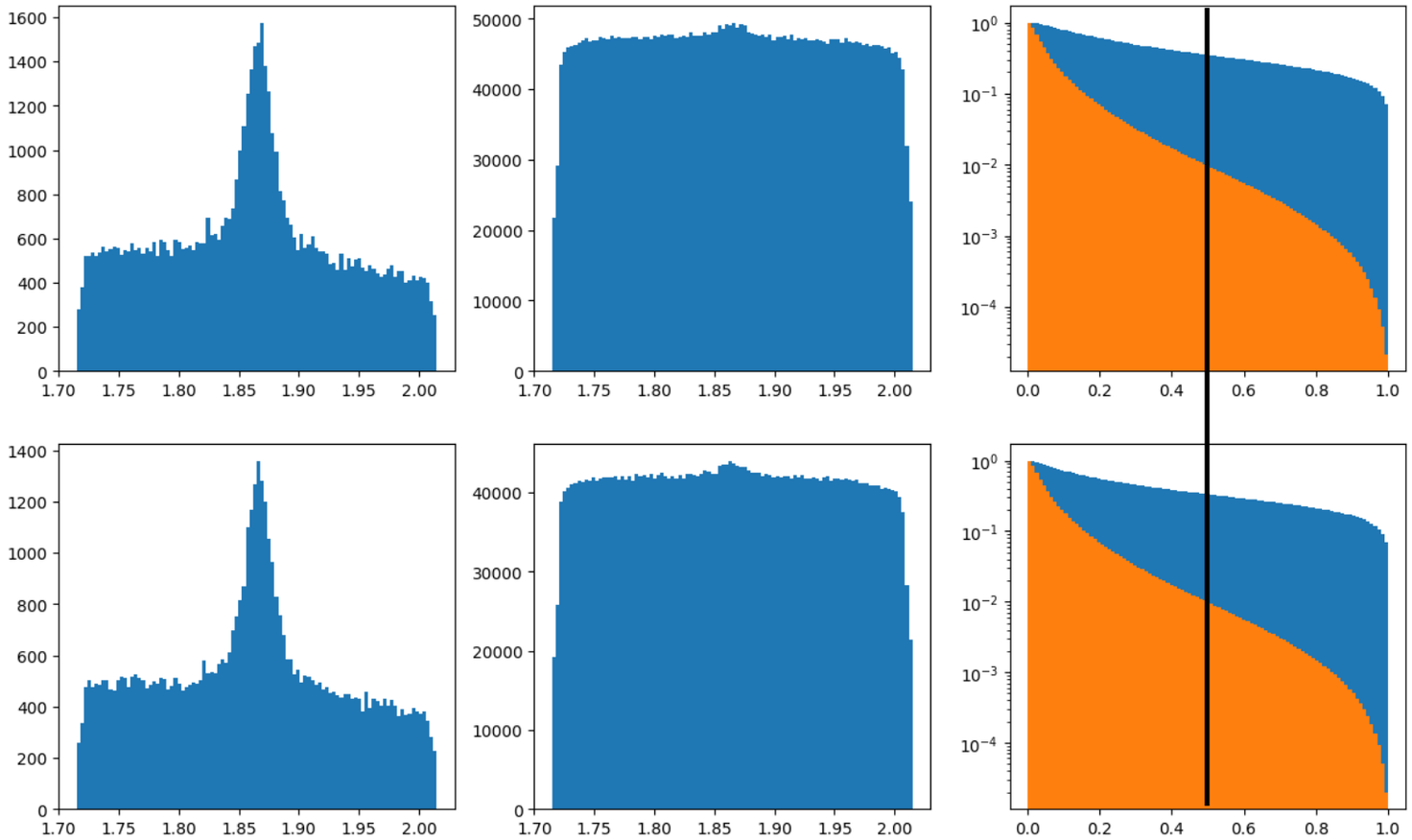


$$\mathrm{RECO}' = \frac{N^{\mathrm{DD}}}{\alpha\varepsilon^{\mathrm{D0}}(p_{\mathrm{T},1}, y_1, \phi_1)\alpha\varepsilon^{\mathrm{D0}}(p_{\mathrm{T},2}, y_2, \phi_2)}$$

New BDT training

Sample:
Non diffractive Soft QCD
MC $\mathrm{D}^0 \to \mathrm{K}^- + \pi^+$

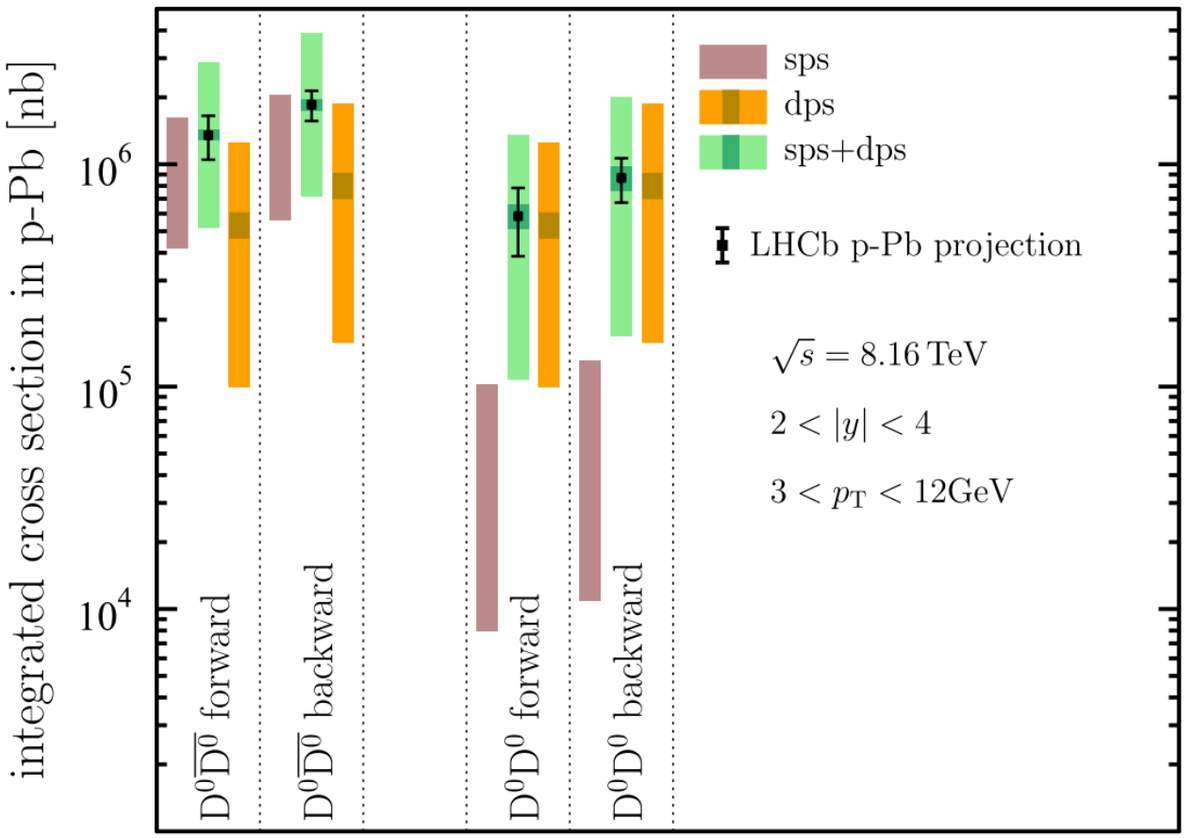
Train

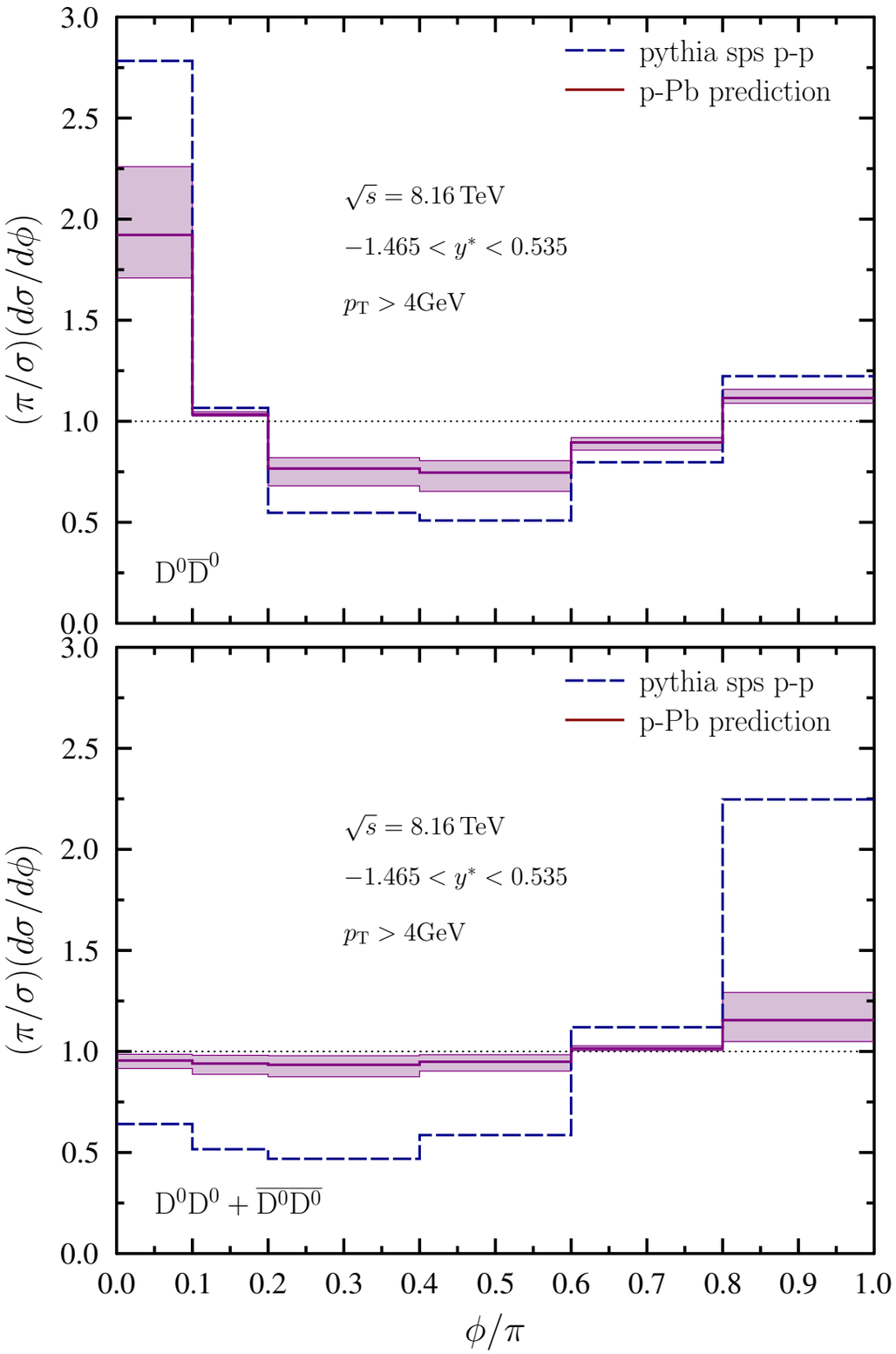


- Aiming for better bias control
  - Training using decay geometry variable as well as D^0 kinematics

Theory prediction and data

- Correlation smearing from DPS contribution
  - Extreme for same-signed D_0





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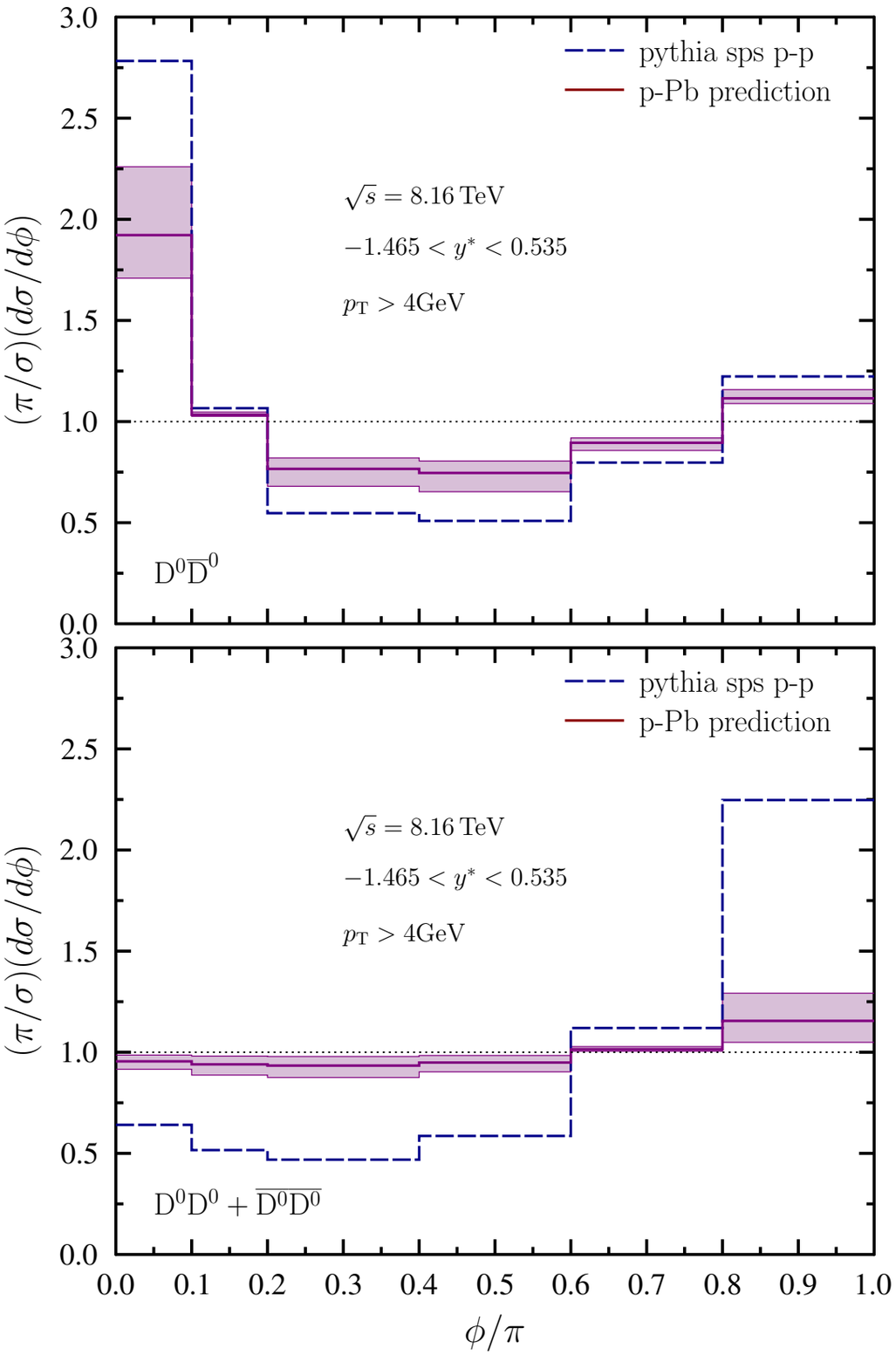

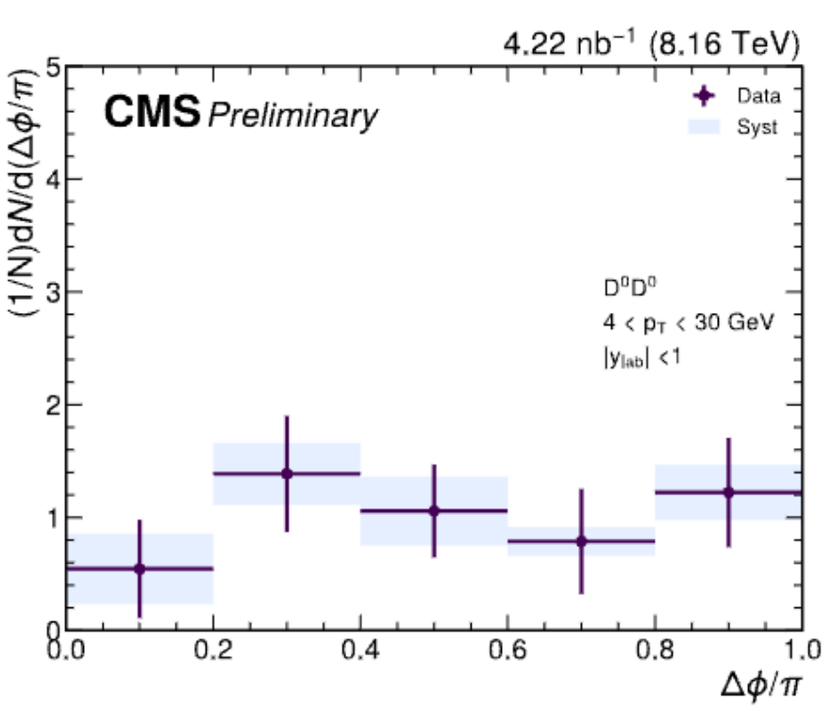

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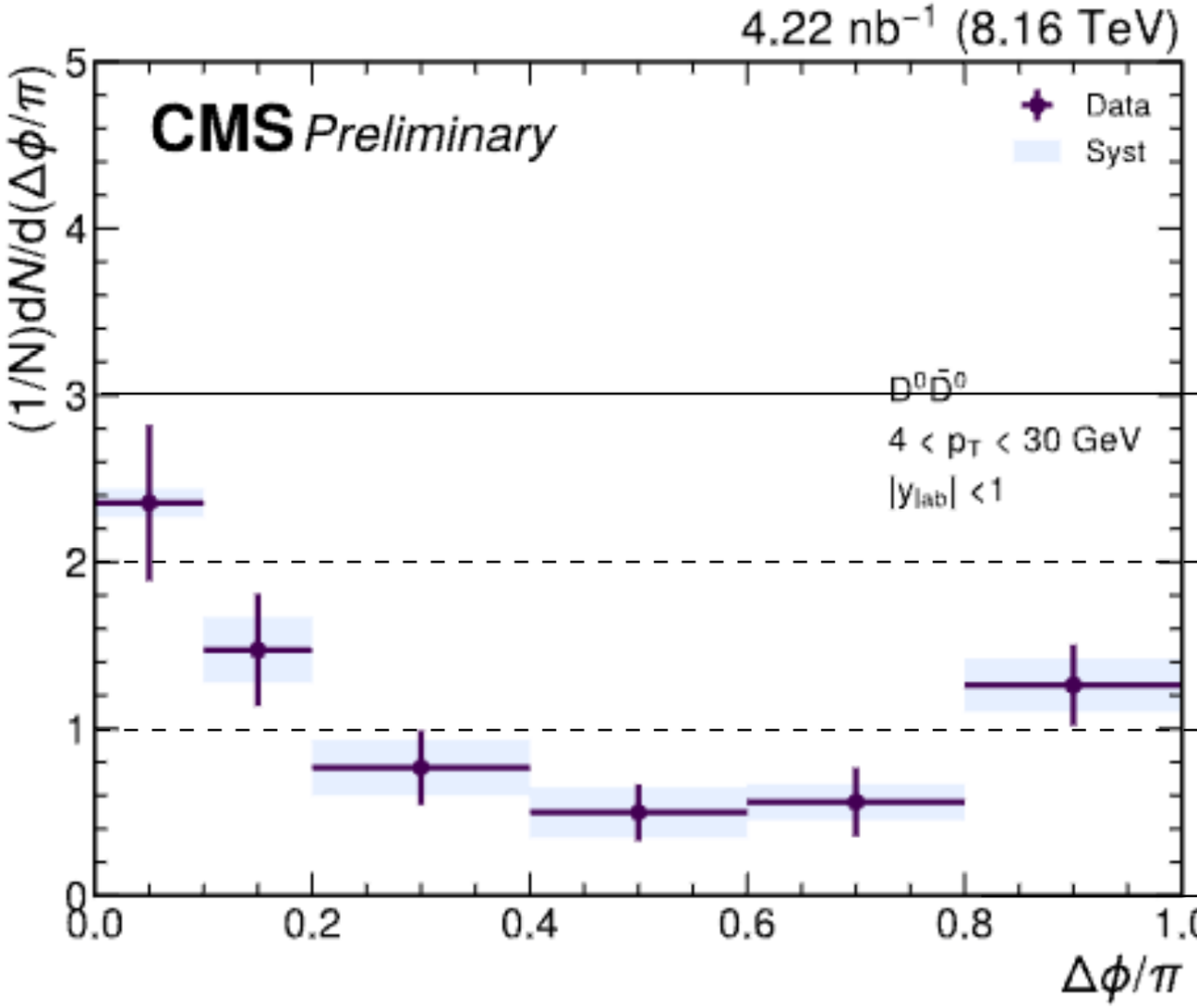
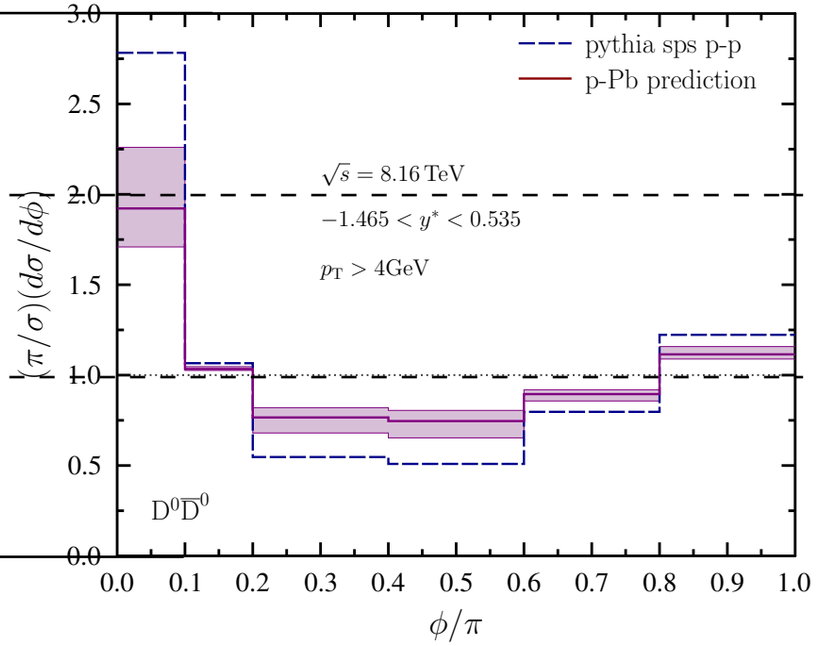
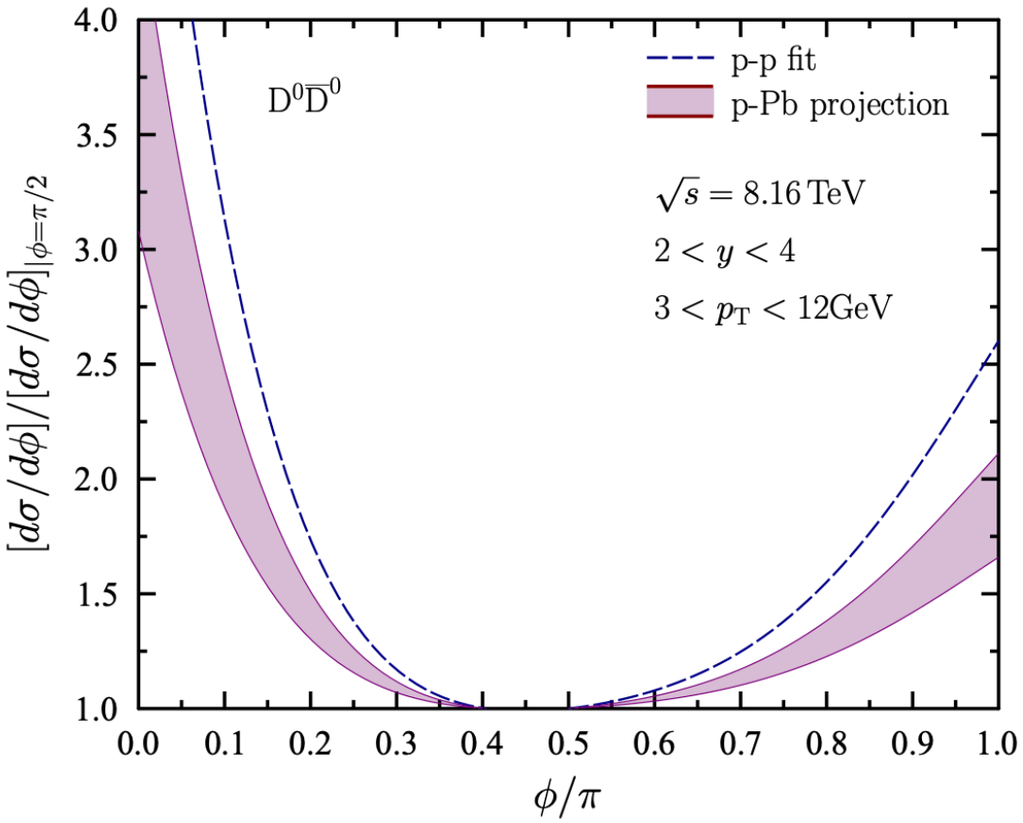
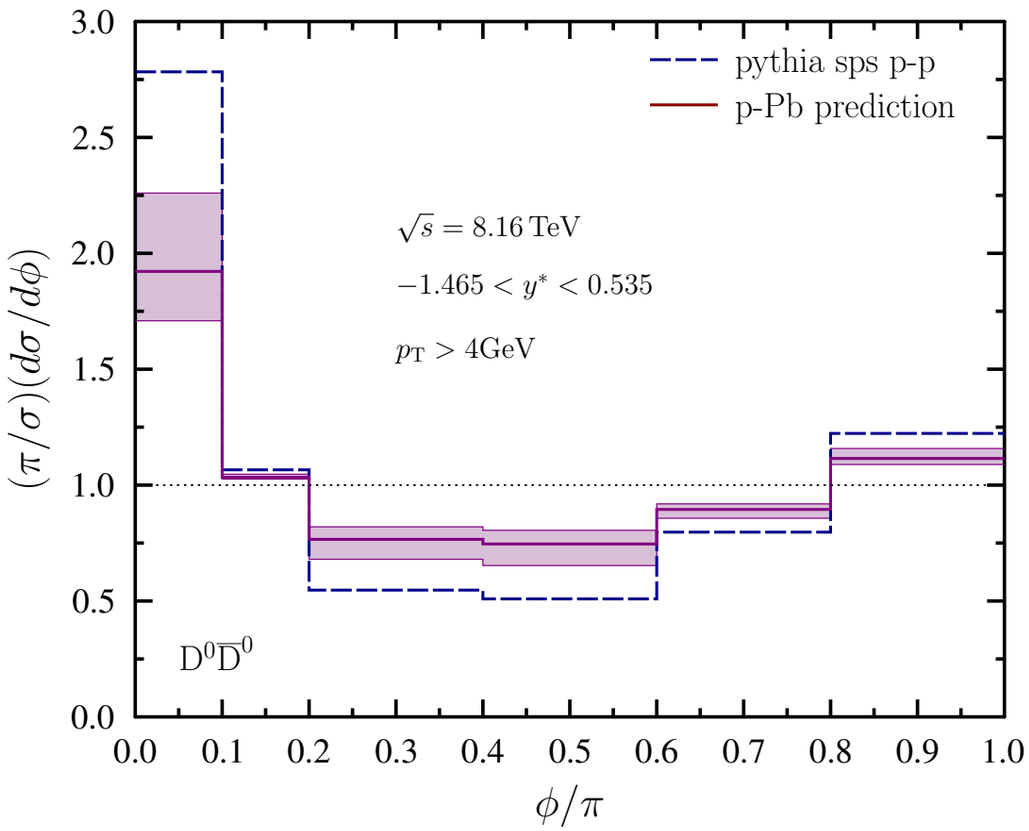




- Qualitatively well matching with data/pred
  - Under construction!





- Comparison in fwd LHCb kinematics and CMS mid rapidity
  - Higher pT threshold for CMS advantage for clearer signal and smaller FF scale uncertainty

DPS with nPDF modification

H. Shao, LHCB 2024

DPS in Heavy-Ion Collisions

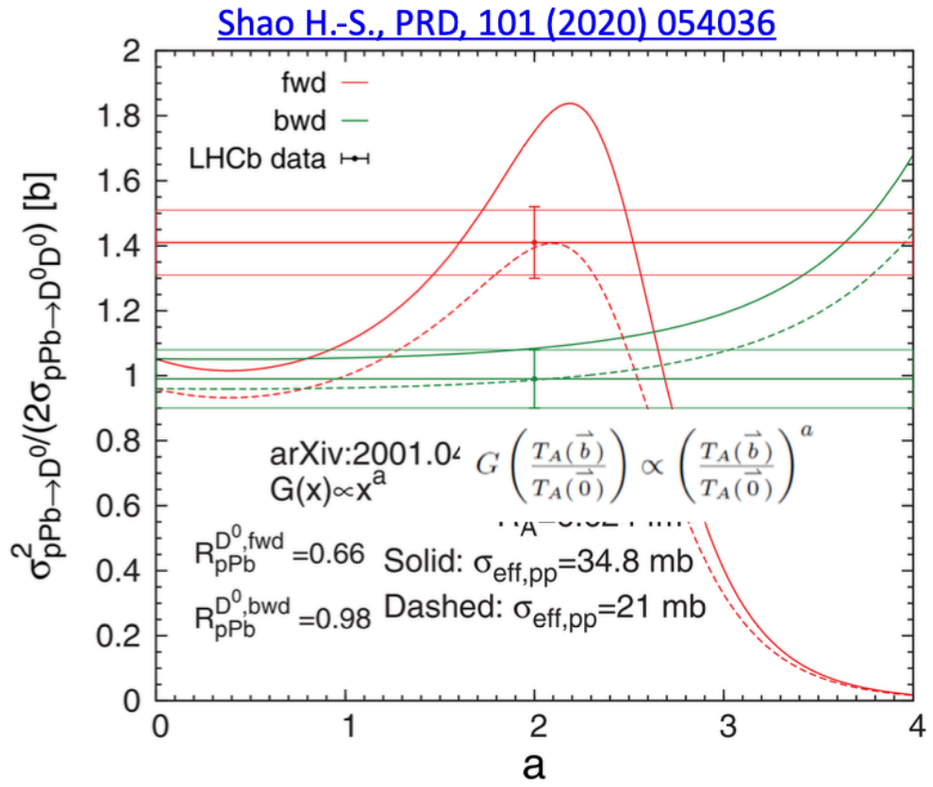
LPTHE LABORATOIRE DE PHYSIQUE THEORIQUE ET HAUTES ENERGIES

- **For example, considering** $pPb \to D^0 D^0 X$ [HSS (PRD'20)]

$$R^{\rm DPS}_{p{\rm Pb}\to D^0+D^0} = R^{D^0}_{p{\rm Pb}} R^{D^0}_{p{\rm Pb}} \left[\frac{3^{1-2a}(a+3)^{2a}}{2a+3} + \frac{\sigma_{{\rm eff},pp}}{\pi R_A^2}(A-1)\frac{9^{1-a}(a+3)^{2a}}{4(a+2)}\right]$$
$$+ \left(R^{D^0}_{p{\rm Pb}} + R^{D^0}_{p{\rm Pb}}\right)\left[1 - \frac{3^{1-2a}(a+3)^{2a}}{2a+3} + \frac{\sigma_{{\rm eff},pp}}{\pi R_A^2}(A-1)\left(\frac{3^{2-a}(a+3)^{a}}{2(a+4)} - \frac{9^{1-a}(a+3)^{2a}}{4(a+2)}\right)\right.$$
$$\left. + \left[-1 + \frac{3^{1-2a}(a+3)^{2a}}{2a+3} + \frac{\sigma_{{\rm eff},pp}}{\pi R_A^2}(A-1)\left(\frac{9}{8} + \frac{9^{1-a}(a+3)^{2a}}{4(a+2)} - \frac{3^{2-a}(a+3)^{a}}{(a+4)}\right)\right]\right.$$
$$G\left(\frac{T_A(\vec{b})}{T_A(\vec{0})}\right) \propto \left(\frac{T_A(\vec{b})}{T_A(\vec{0})}\right)^a$$

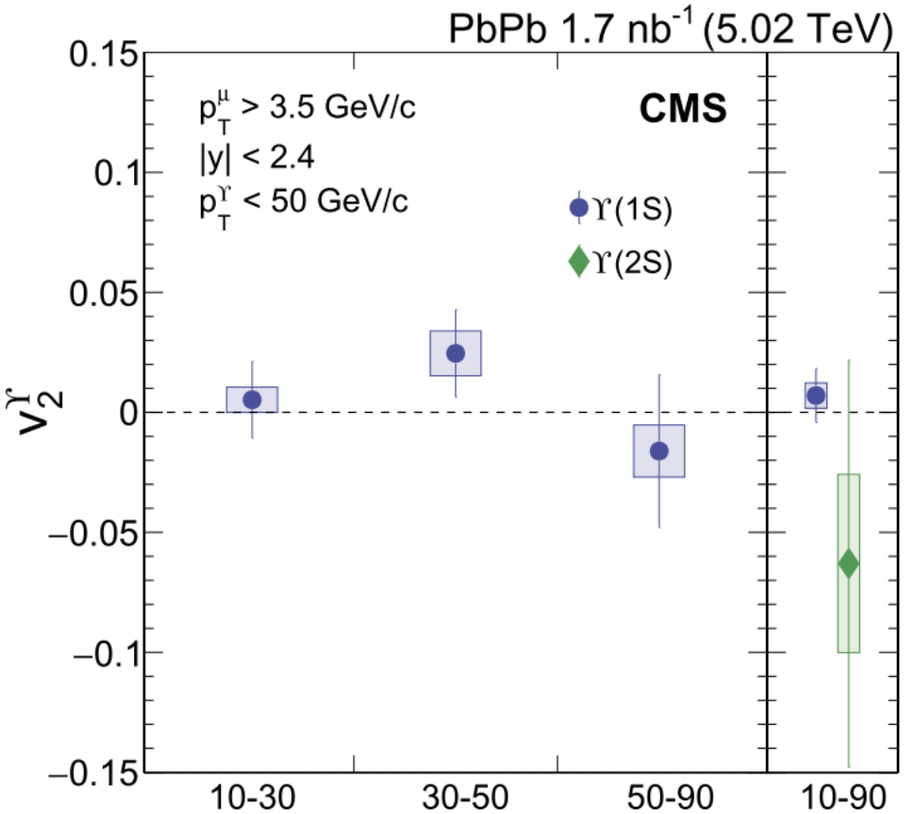
$$R^f_{pA} \equiv \frac{\sigma_{pA\to f}}{A\sigma_{pp\to f}}$$

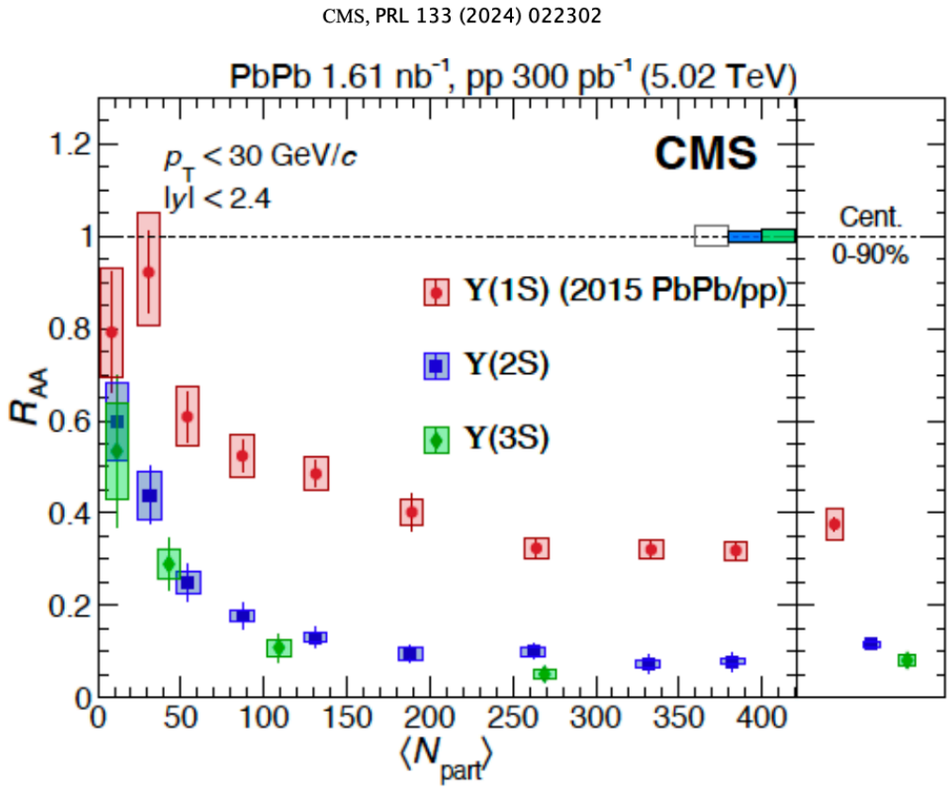
- DPS cross section to use transverse nPDF modification
- LHCb's forward and backward data favors non linear $T_{\rm AA}$ dependence ($a \neq 1$) for the transverse profile

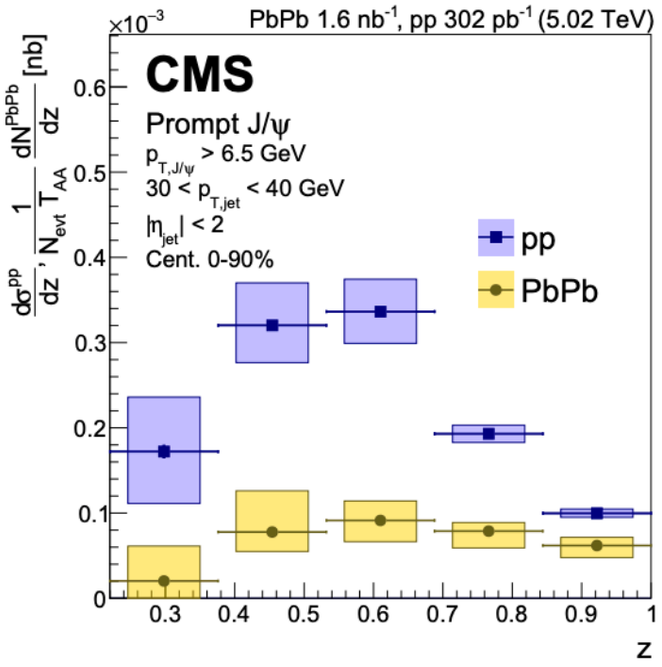


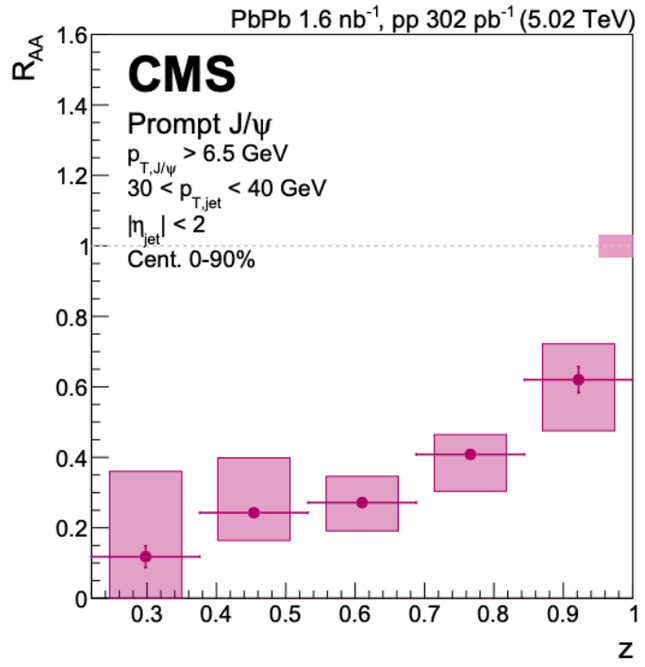
Outlook

- Many moving parameters for HF/quarkonia modification in medium
- HI research in Korea CMS focused on quarkonia
  - We had measured many R_{AA}, v_2 in pp, pPb, and PbPb









Outlook

- Many moving parameters for HF modification in medium
- HI research in Korea CMS focused on quarkonia
  - We had measured many R_{AA}, v_2 in pp, pPb, and PbPb
  - Other useful measurements with dileptons, HF correlation to help reconstruct full picture from the projected measurements