Comparison between DPM and FTF

Anastasia Karavdina [1)] & Donghee Kang [2)]

Institut für Kernphysik
Universität Mainz [1)]

Helmholtz Institute Mainz
Universität Mainz [2)]

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Background MC @ PANDA

DPM

- is a generic annihilation background generator

- based on the Dual Parton Model (DPM), which is a synthesis of the Regge theory, topological expansions of QCD and parton model

FTF

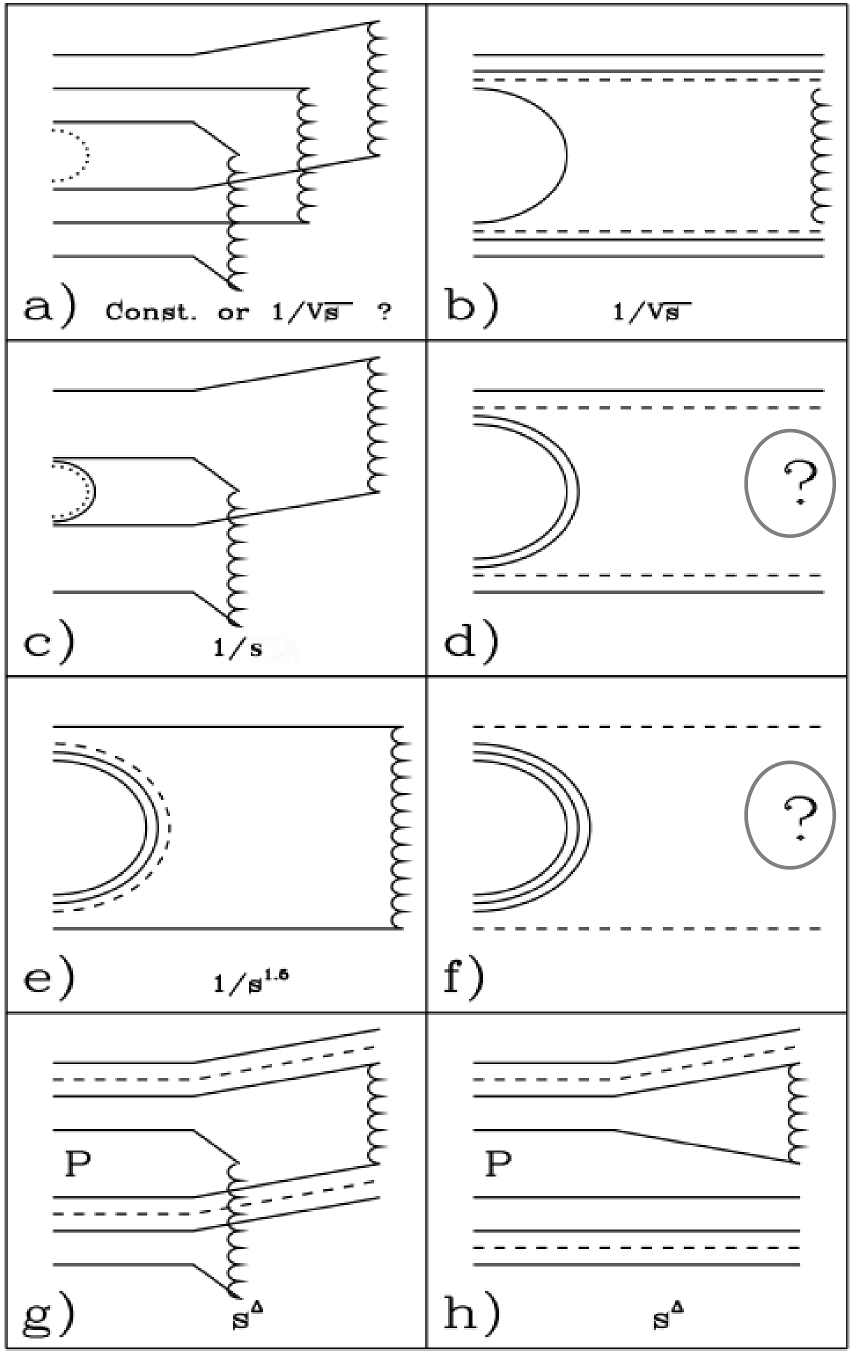
- Extension of DPM approach

- New tuning parameters based on the FRITIOF Model (FTF)

- is used as a hadronic interaction model in GEANT4

- Recently implemented by Aida Galoyan within PANDAroot framework

MC parameterization



DPM

$$\sigma_a = \frac{51.6}{\sqrt{s}} - \frac{58.8}{s} + \frac{16.4}{s^{1.5}}$$

$$\sigma_b = \frac{77.4}{\sqrt{s}} - \frac{88.2}{s} + \frac{24.6}{s^{1.5}}$$

$$\sigma_c = \frac{93}{s} - \frac{106}{s^{1.5}} + \frac{30}{s^2}$$

$$\sigma_g = \frac{18.6}{s^{0.08}} - \frac{33.5}{\sqrt{s}} + \frac{30.8}{s}$$

$$\sigma_d = \sigma_e = \sigma_f = \sigma_h = 0$$

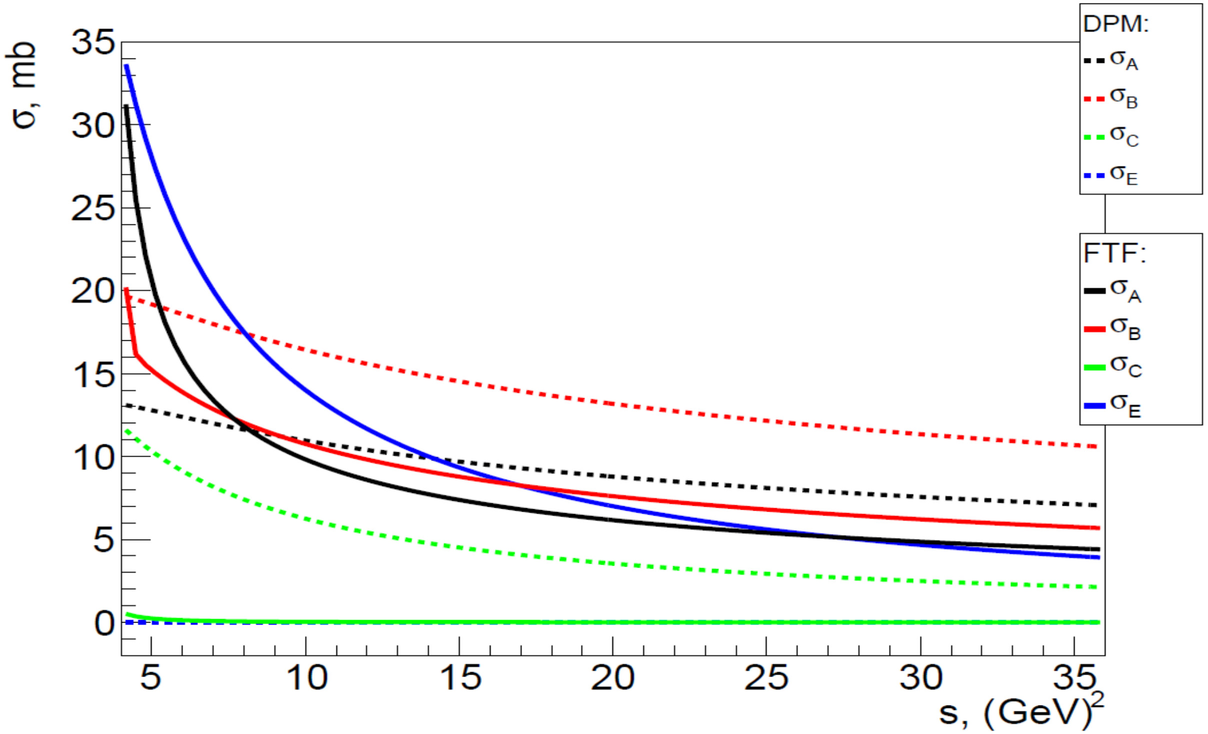
FTF

$$\sigma_a = \frac{25}{\sqrt{s-4m^2}}, \sigma_e = \frac{140}{s}$$

$$\sigma_b = \begin{cases} 15.65 + 700 \cdot (2.173 - \sqrt{s})^2 & \text{if} \sqrt{s} \le 2.172 \\ 34/\sqrt{s} & \text{if} \sqrt{s} \ge 2.172 \end{cases}$$

$$\sigma_c = \frac{2}{\sqrt{s-4m^2}} \cdot \left(\frac{(m_p + m_t)}{s} \right)^2$$

MC parameterization



At high energies

$$\sigma_a^{FTF} < \sigma_a^{DPM}$$
$$\sigma_b^{FTF} < \sigma_b^{DPM}$$
$$\sigma_c^{FTF} < \sigma_c^{DPM}$$
$$\sigma_e^{FTF} > \sigma_e^{DPM}$$

For sub-process, the assumed σ_{sub} that are used to generate events are different

- multi – particle production : σ_a

  $$p\bar{p} \to 2\pi^+2\pi^-\pi^0, 2\pi^+2\pi^-, 3\pi^+3\pi^-, 3\pi^+3\pi^-\pi^0$$

- pion radiation with baryon – antibaryon : σ_b

  $$p\bar{p} \to \Lambda\bar{\Lambda}\pi^0, \Lambda\bar{\Lambda}\pi^+\pi^-$$

- binary reactions : σ_b, σ_e

  $$p\bar{p} \to \pi^+\pi^-, K^+K^-, n\bar{n}, \Lambda\bar{\Lambda}$$

- 3 meson final state : σ_e

  $$p\bar{p} \to \pi^+\pi^-\pi^0$$

- 2 particle production at low energy : σ_c

  $$p\bar{p} \to \pi^+\pi^-, \pi^0\pi^0, K^+K^-$$

- diffraction dissociation : σ_g, σ_h

  $$p\bar{p} \to p\pi^0\bar{p}, p\pi^+\pi^-\bar{p}, p\pi^-\bar{n}$$

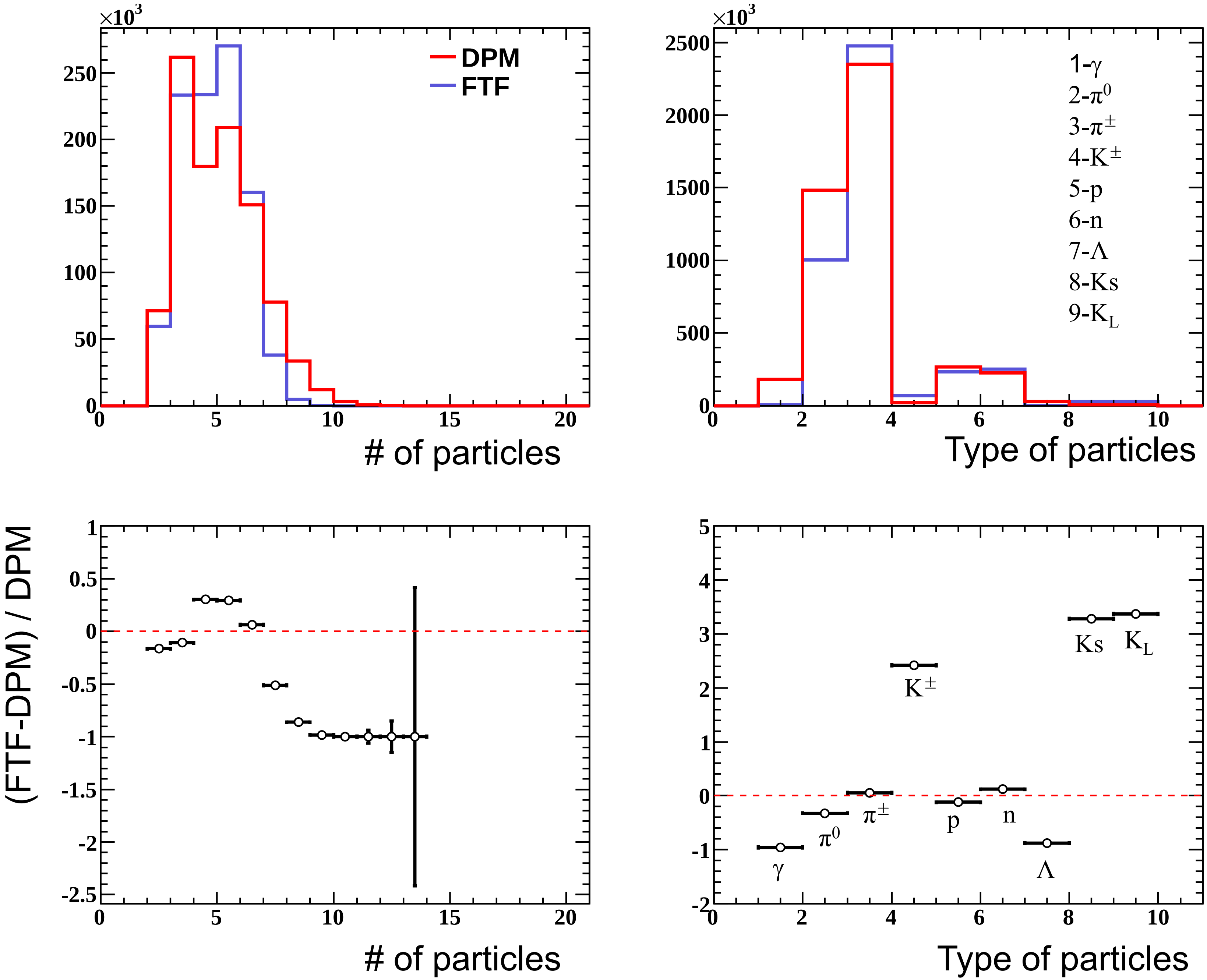
How much does MC true level differ from FTF to DPM?

- Inelastic events only for both DPM and FTF (each 1M events)
- 2 different $\sqrt{s}$ = 2.4 & 5.5 GeV/c^2 (p_{beam} =1.9 GeV/c & 15.1GeV/c)
- Resonances have zero width in FTF and "realistic" width in DPM
- Options of FTF depending on inelastic hadronic interaction, cascade, fission, and nuclear de-excitation models in valid energy range [1),2)]
  - Ftfb : FTF + binary (all cascade processes for low energy interaction)
  - Ftfp : FTF + precompound (simplified by absorption process only)

1) E. Atomssa, GEANT3-GEANT4 hadronic response comparisons, *PANDA Collaboration Meeting*, Dec.2013
2) A. Galoyan. Physics of antiproton-proton and antiproton-nucleus annihilation processes implemented in Geant4, *PANDA Collaboration Meeting*, Sep.2013

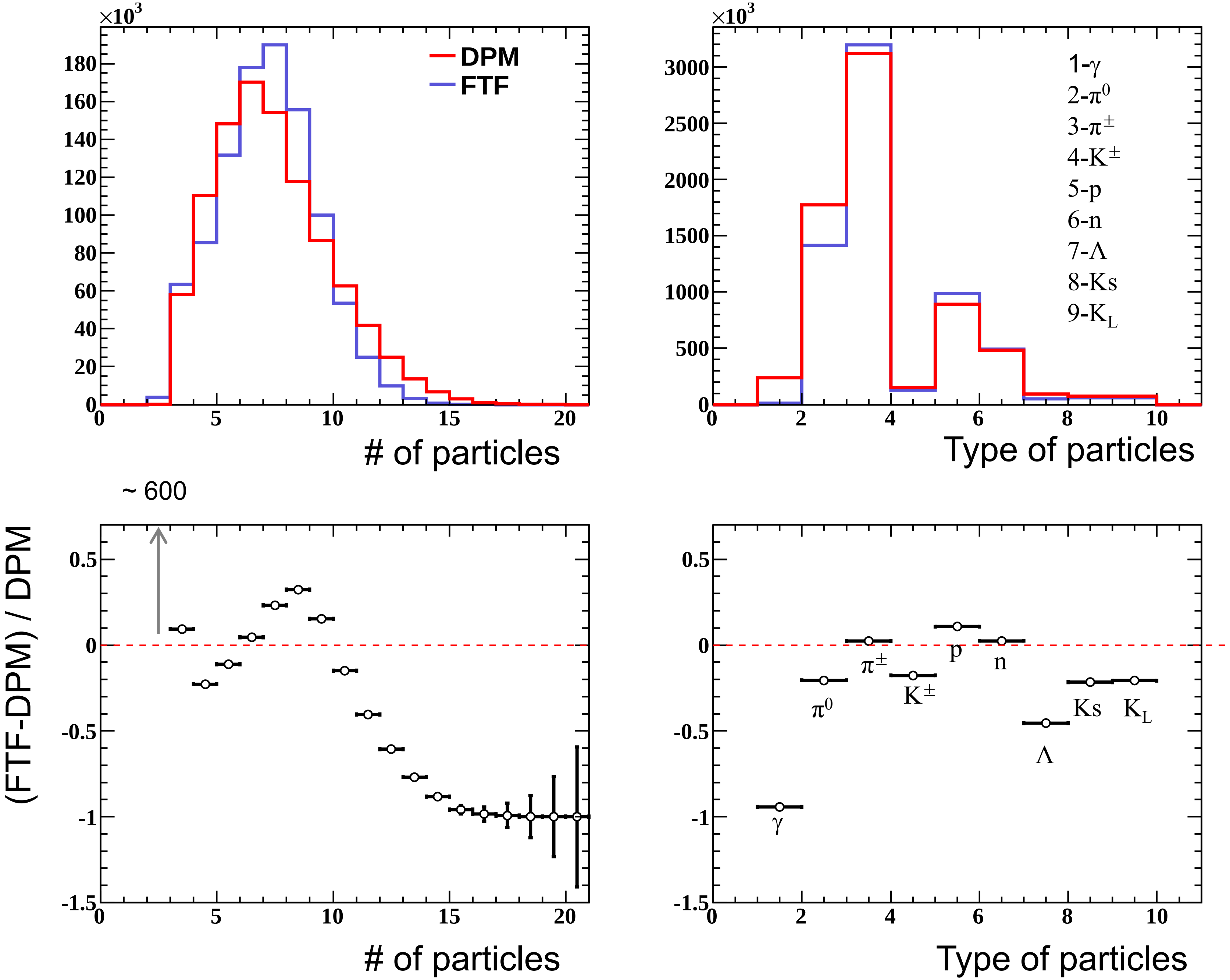
Comparison $p_{beam} = 1.9$ GeV

$$\sqrt{s} = 2.4\ (\mathrm{GeV/c})^2$$



Comparison $p_{beam} = 15.1$ GeV

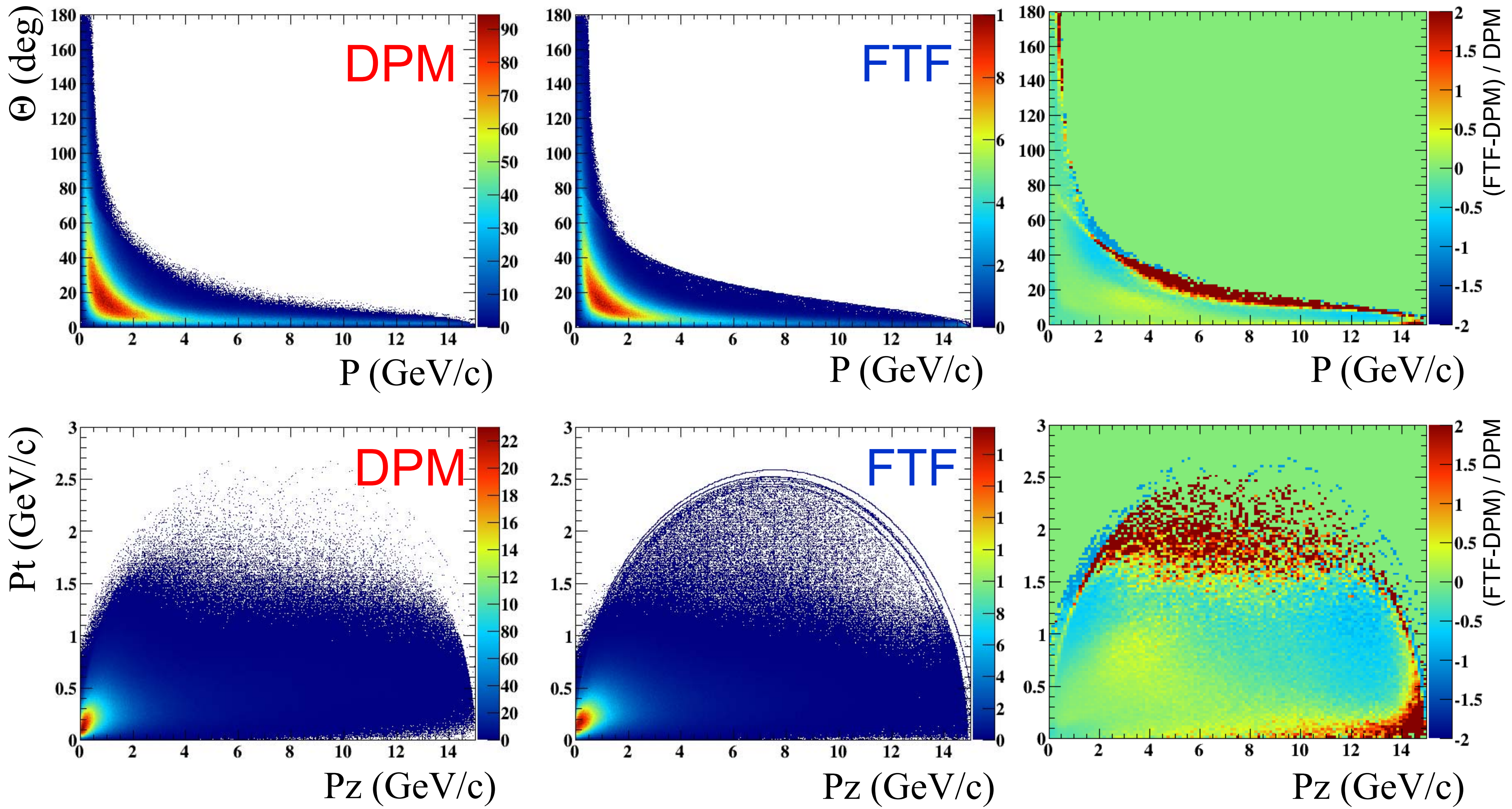
$\sqrt{s} = 5.5\ (\mathrm{GeV/c})^2$



Comparison p_{beam} = 15.1 GeV

All primary particles

$\sqrt{s} = 5.5\,(\mathrm{GeV/c})^2$



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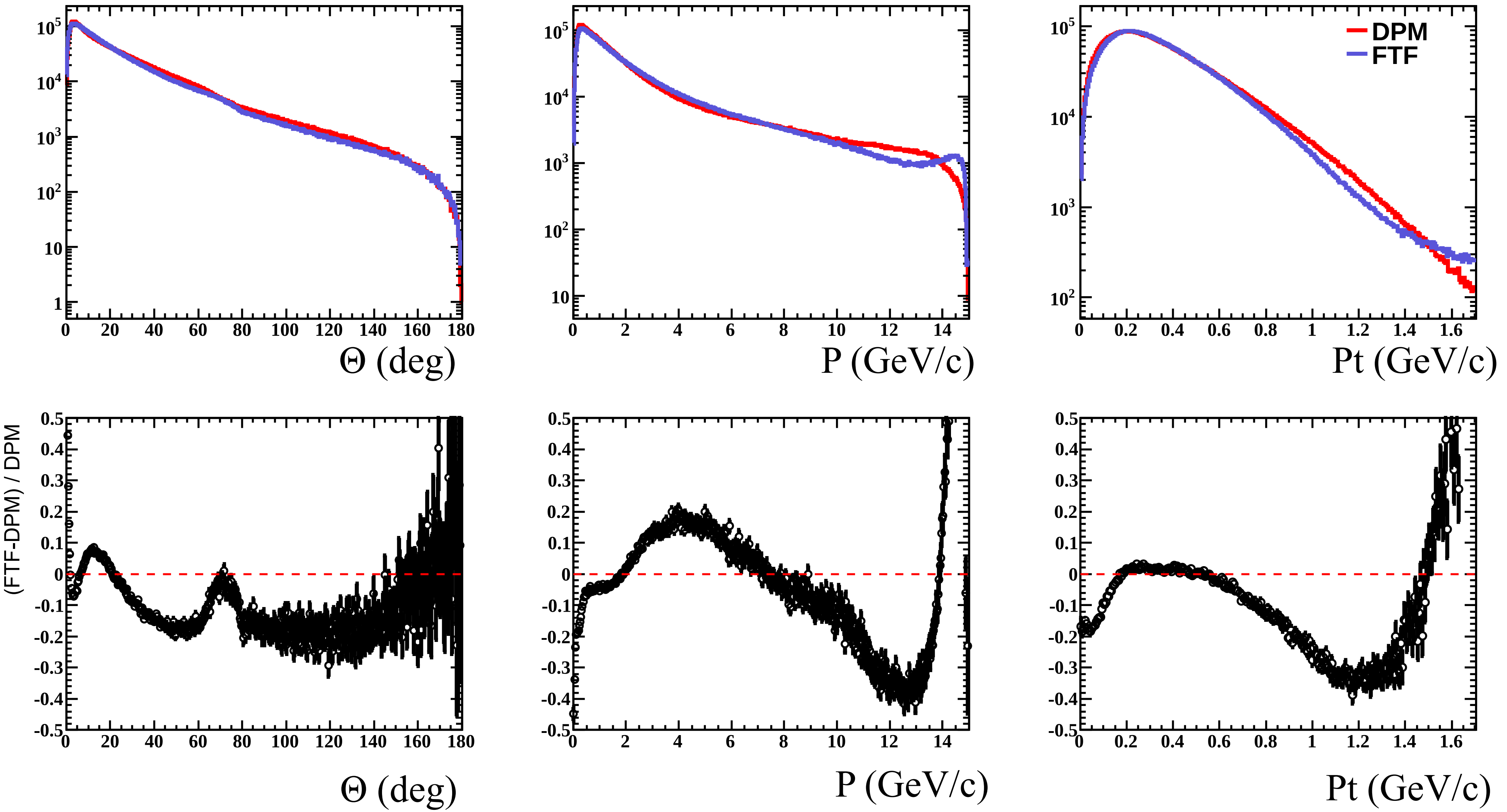
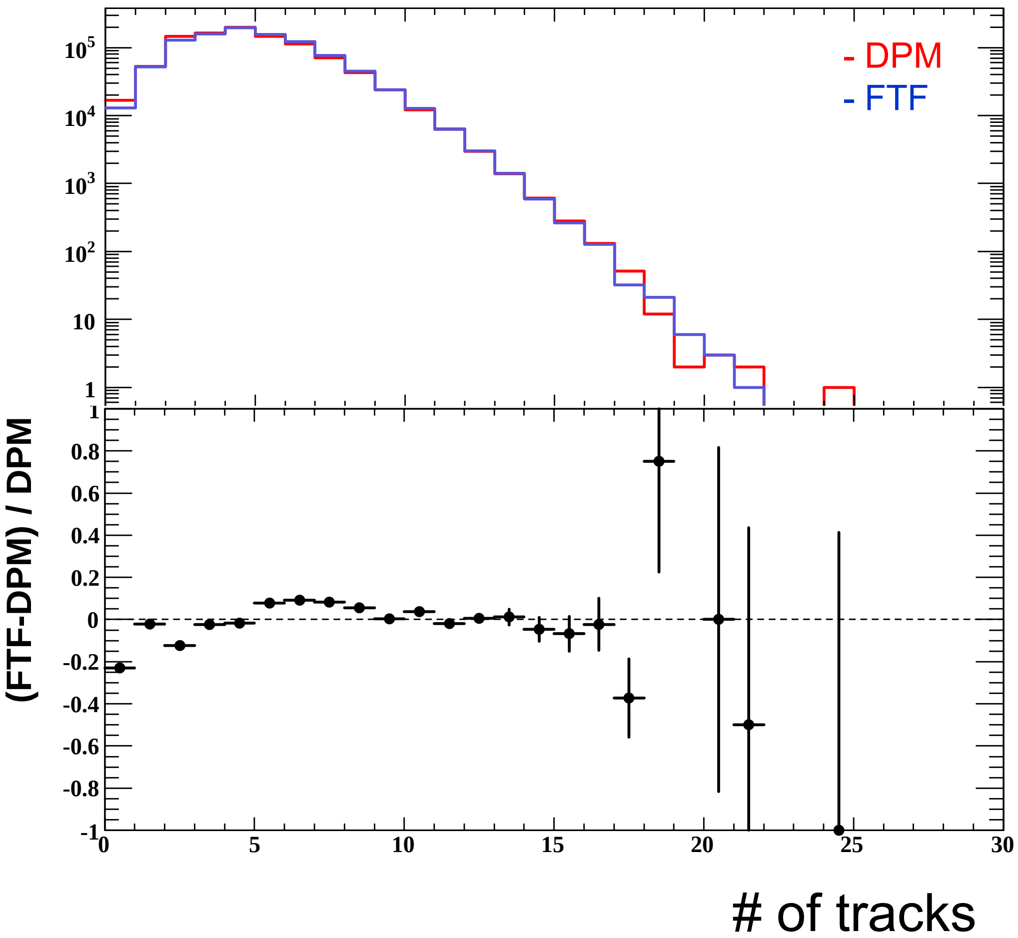


Track multiplicity

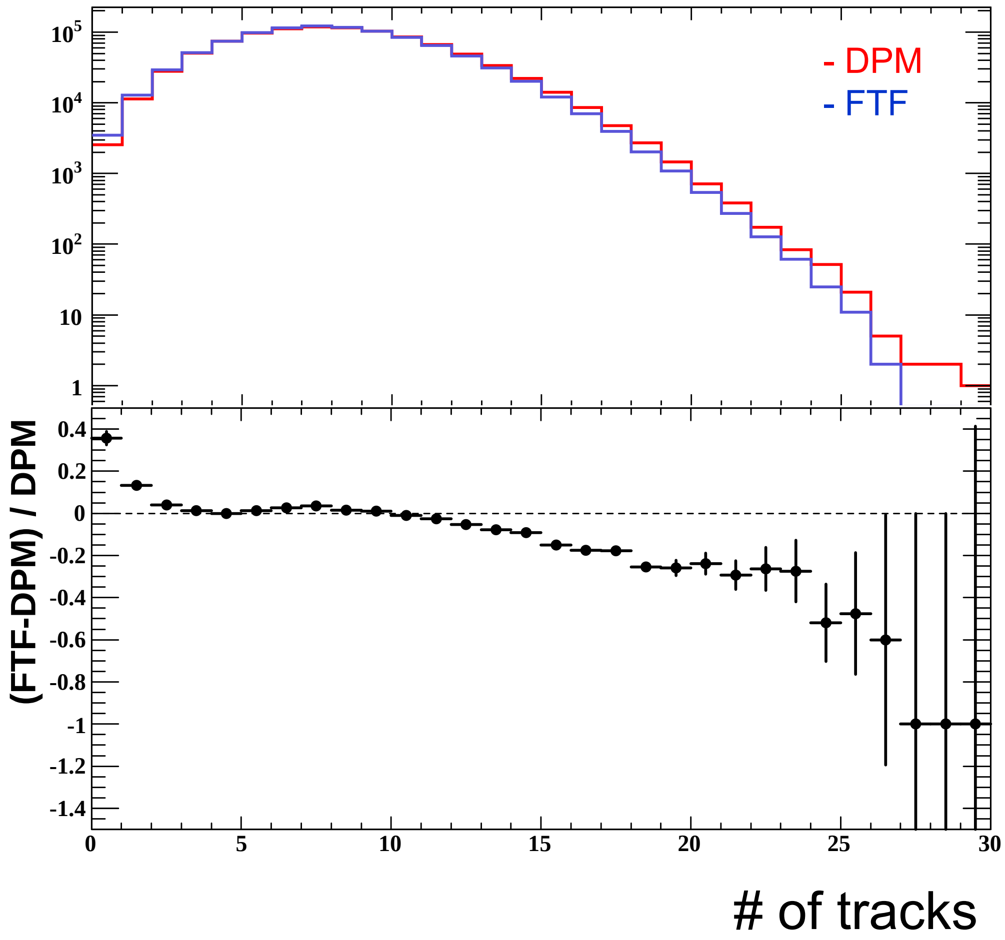
How much does reconstruction differ from FTF to DPM?

- Simulation : PANDAroot release rev.26329 (2014.10.29) Oct14
- Inelastic events only (each 1M events) @ $\sqrt{s} = 5.5\,(\mathrm{GeV/c})^2$

Charged tracks $p > 100\,(\mathrm{MeV/c})^2$



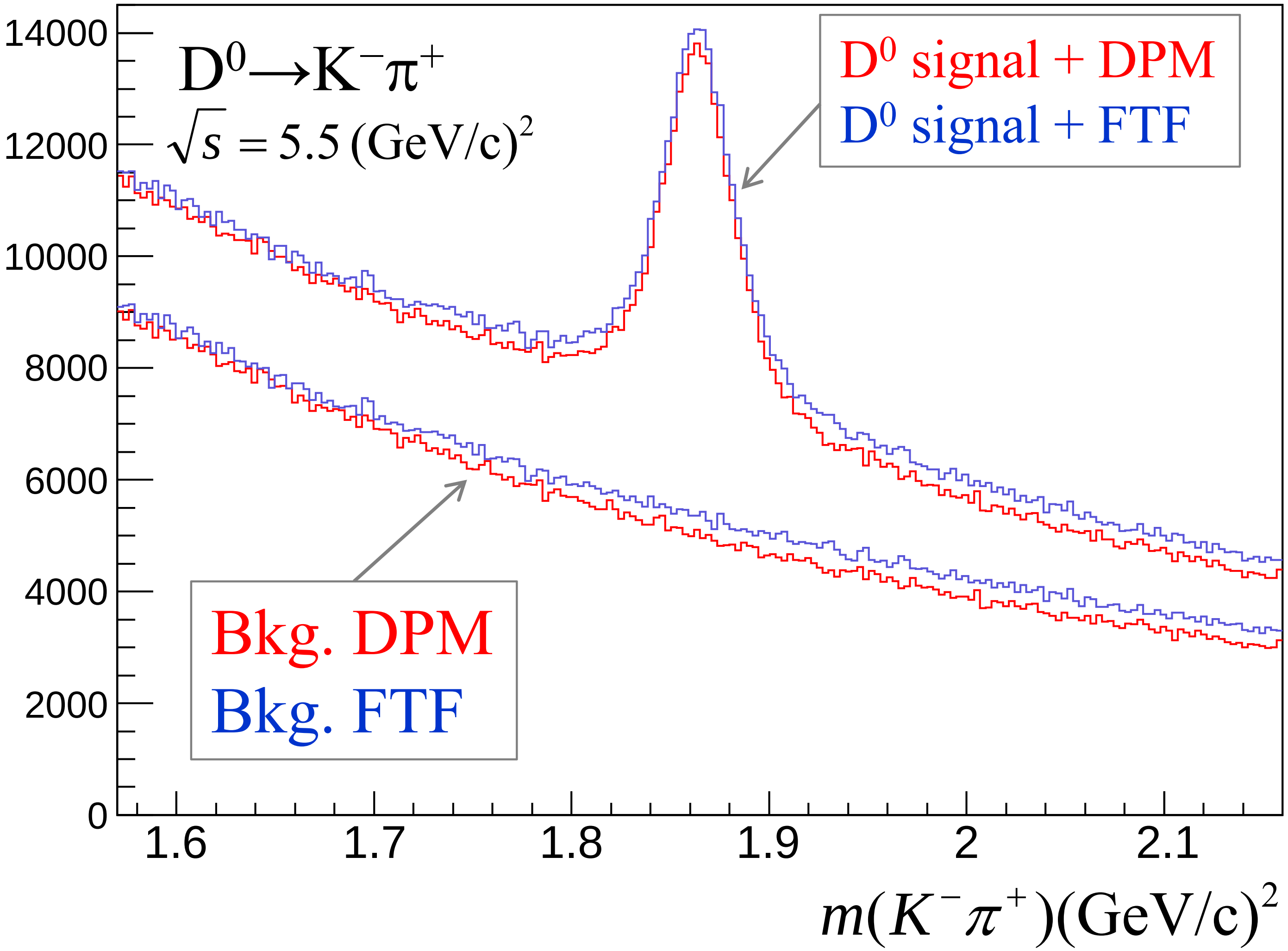
Neutral tracks $E > 100\,(\mathrm{MeV})$



Invariant mass distribution

Test of invariant mass distribution with DPM and FTF background

- Fixed event ratio with signal σ = 10 mb and background σ = 50 mb
- Data set with no PID and using track combination



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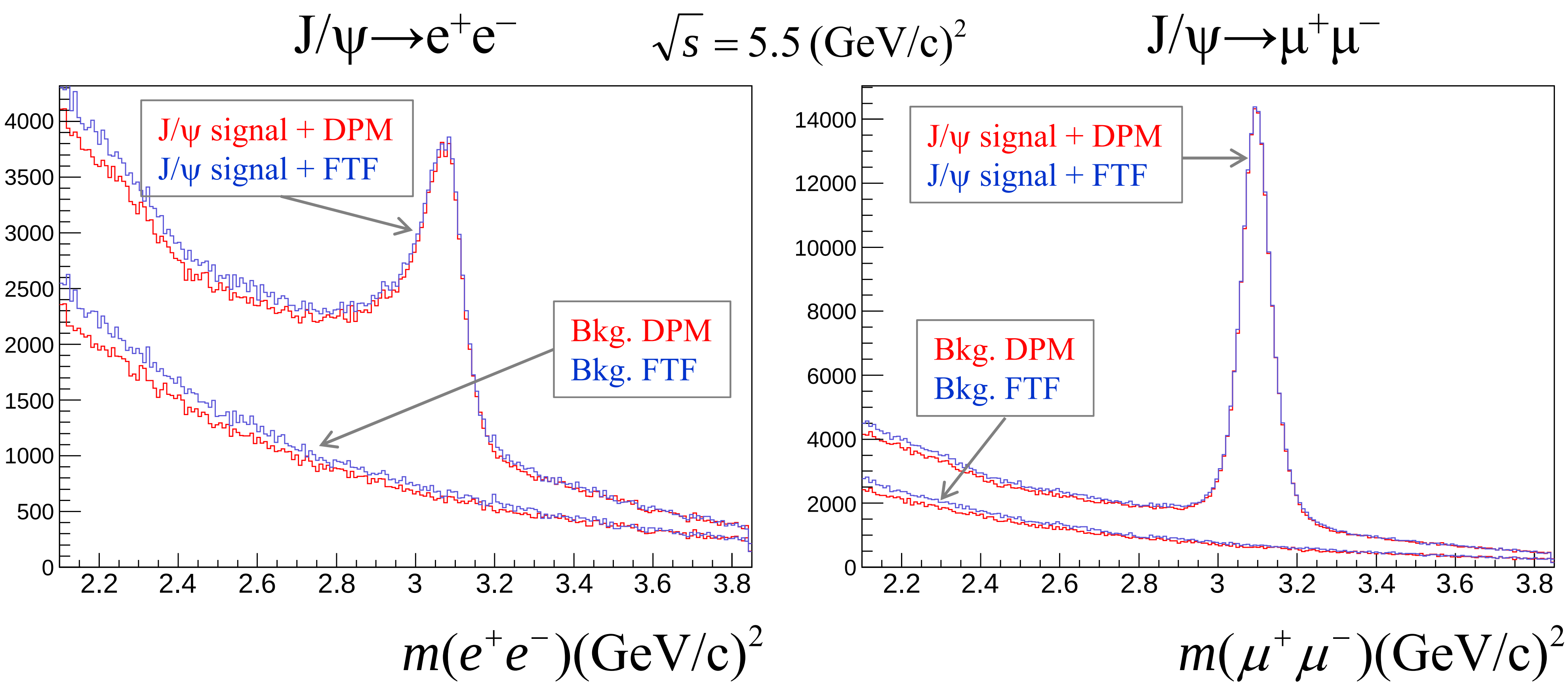
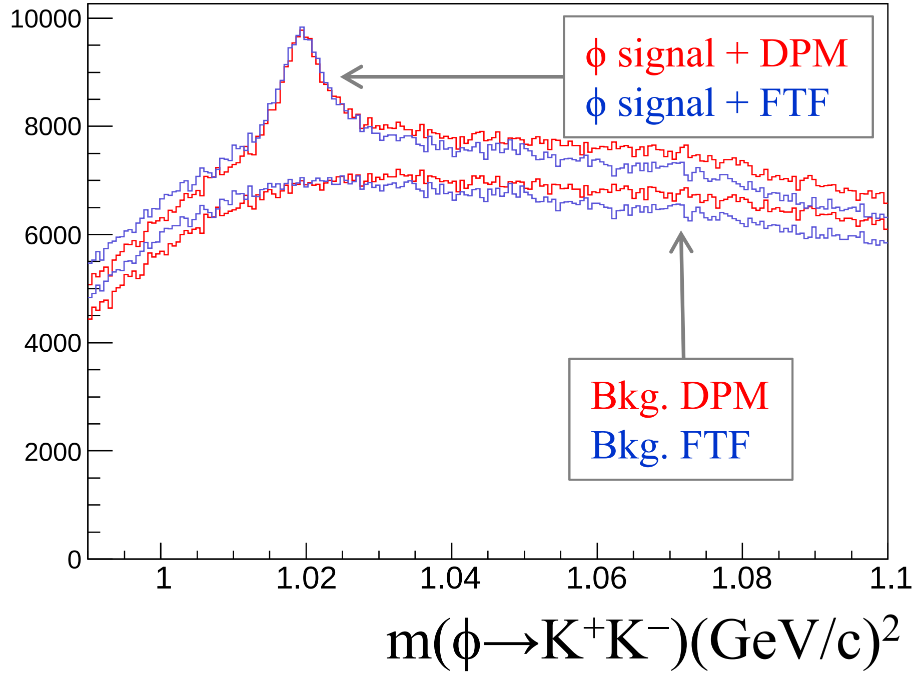


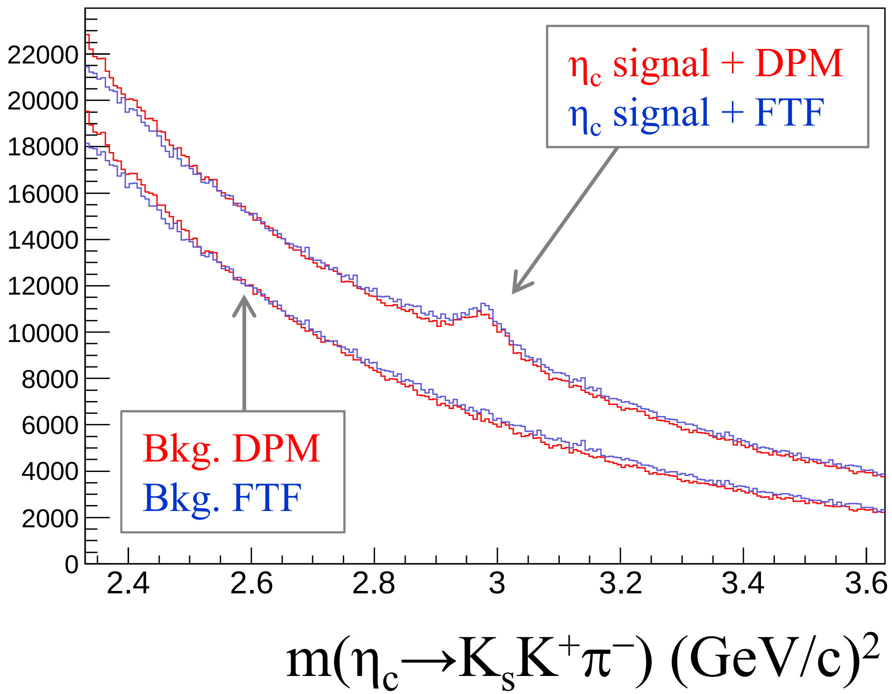
Invariant mass distribution

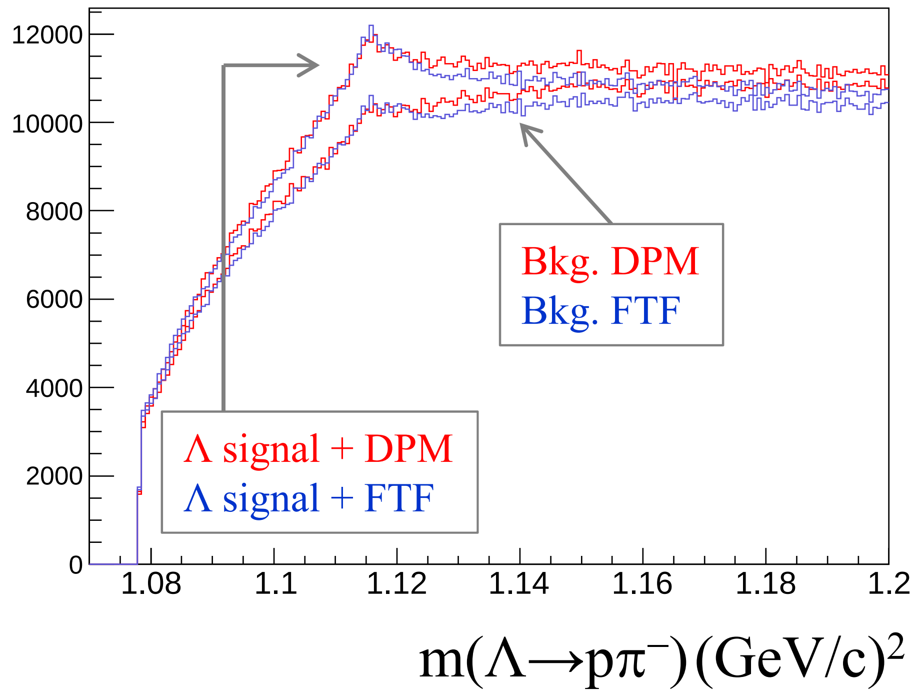
Other physics channel @ $\sqrt{s} = 5.5\,(\mathrm{GeV/c})^2$

- no significant difference between DPM and FTF

- small variation (~1-2%) in mass range and each physics channel







Influence on the optimization

- Test of ranking procedure and optimization to find the best kinematic variable, which is an important process used in online software trigger

- If FTF and DPM background data based approach

  - show similar kinematic distribution, best variable should be same (small systematic uncertainty)

  - has some difference, best ranked variable should be different (large systematic uncertainty)

Influence on the optimization

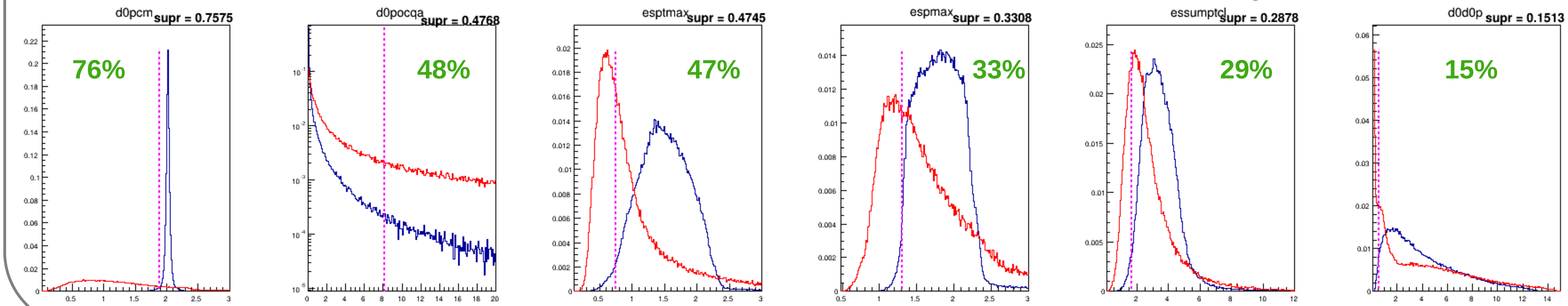
- Ranking procedure of $\bar{p}p \rightarrow D^0\overline{D}^0 \rightarrow K^-\pi^+ + \mathrm{Any}$ @ online software trigger

$\sqrt{s} = 5.5\,(\mathrm{GeV/c})^2$

DPM based

Bkg. DPM ; Signal $D^0 \rightarrow K^-\pi^+$

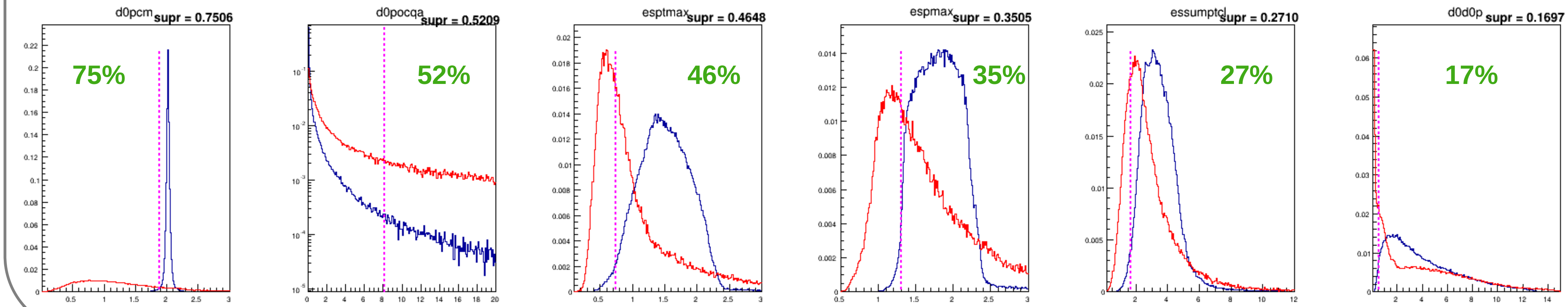
$P_{D0,CM}$ | $POCA_{dist.}$ | p_{Tmax} | p_{max} | $\Sigma\, p_{T,charged}$ | $p_{D0,lab}$



FTF based

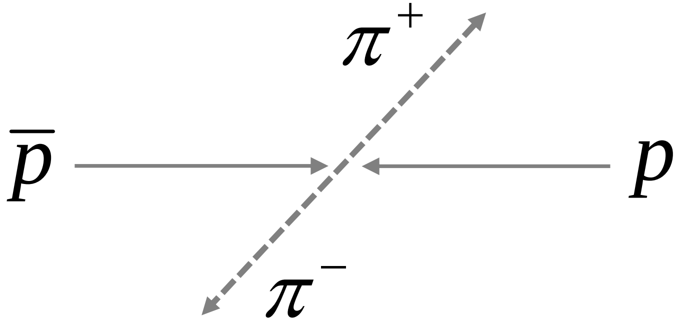
Bkg. FTF ; Signal $D^0 \rightarrow K^-\pi^+$

$P_{D0,CM}$ | $POCA_{dist.}$ | p_{Tmax} | p_{max} | $\Sigma\, p_{T,charged}$ | $p_{D0,lab}$



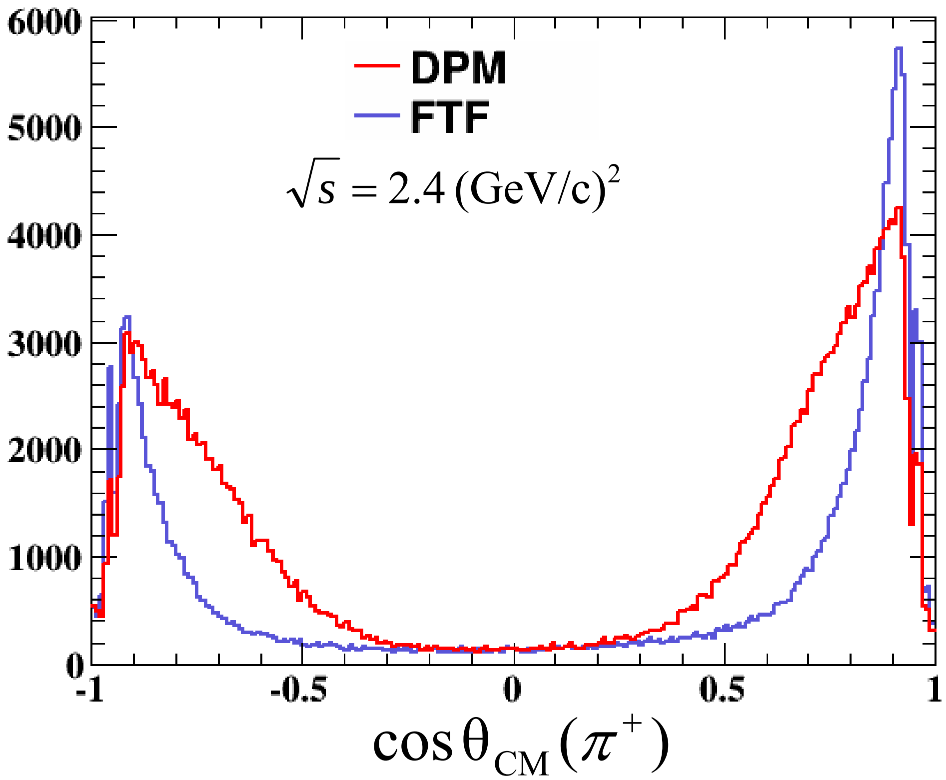
Compare of sub-process

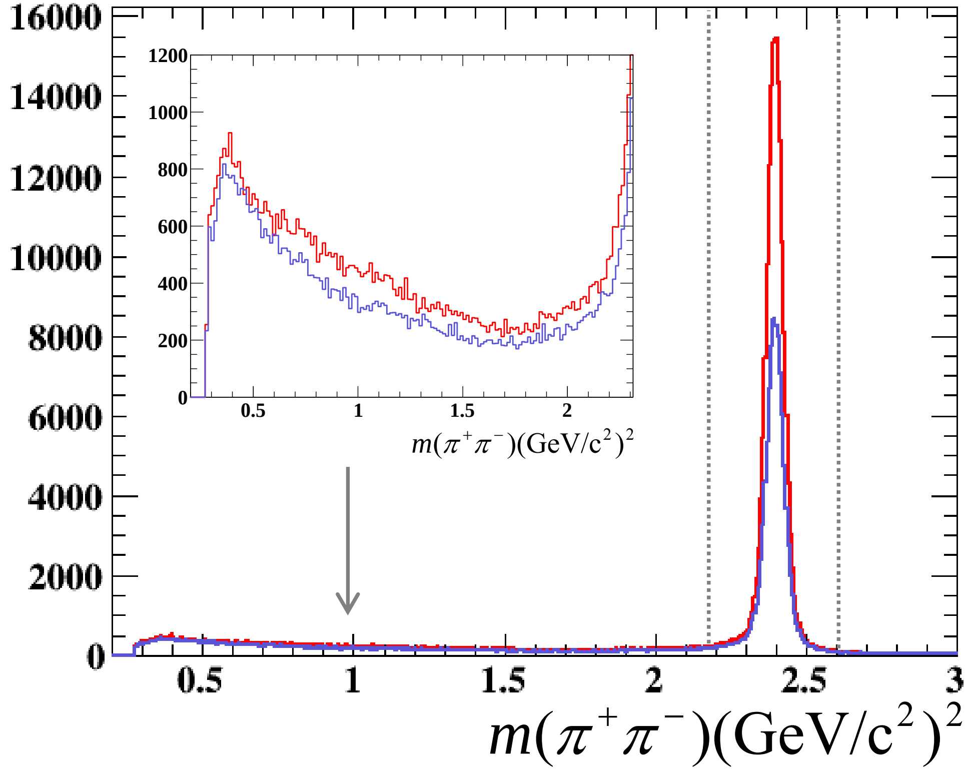
- DPM and FTF event filtered $\bar{p}p \to \pi^+\pi^-$



- 0.1M events for each generator
- Data set with no PID

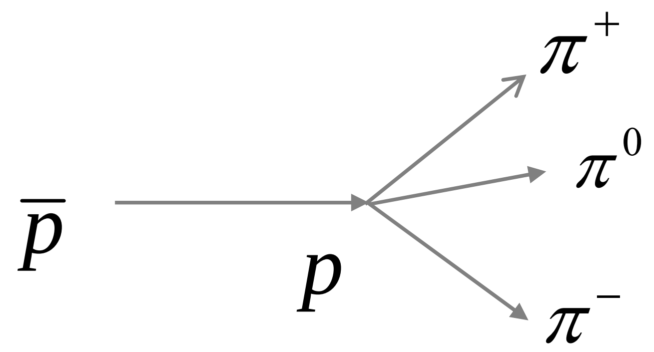
$\mathbf{eff_{DPM}} > \mathbf{eff_{FTF}}$





Compare of sub-process

- DPM and FTF event filtered $\bar{p}p \rightarrow \pi^+\pi^-\pi^0$



- 0.1M events for each generator
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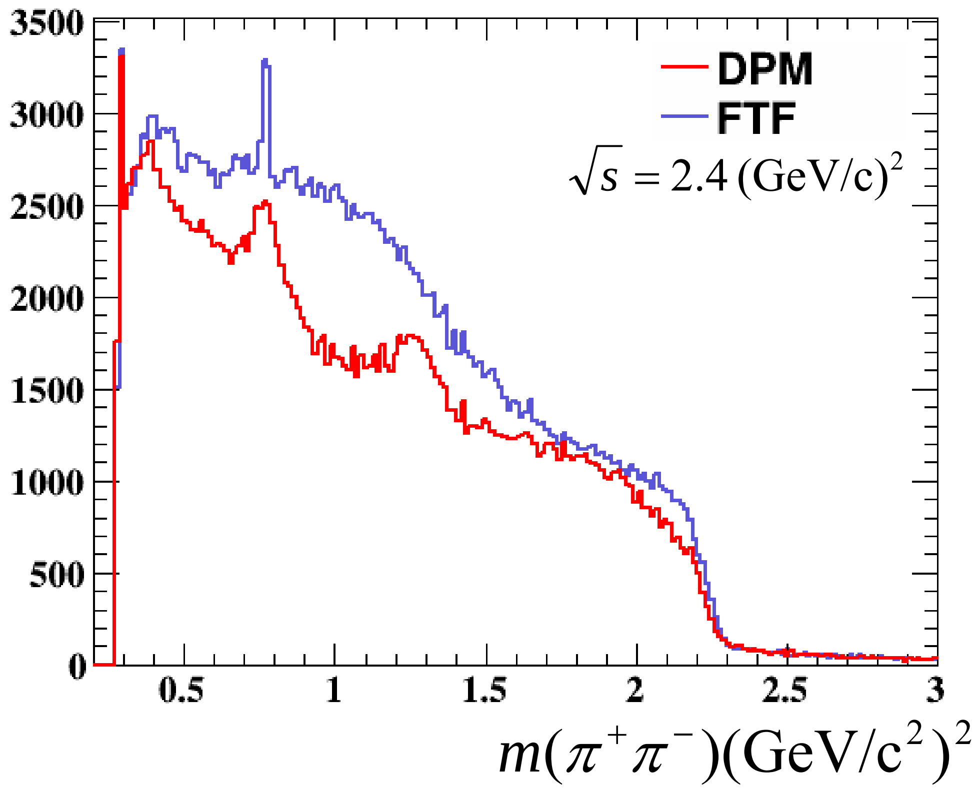
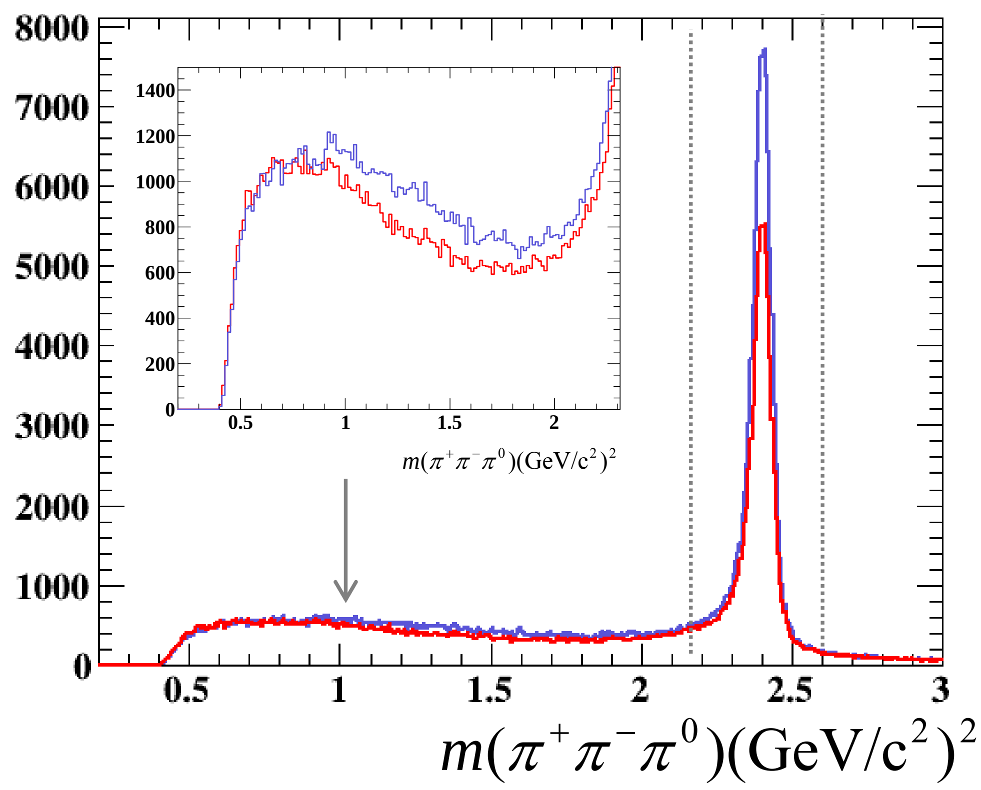
$\mathbf{eff_{DPM}} < \mathbf{eff_{FTF}}$



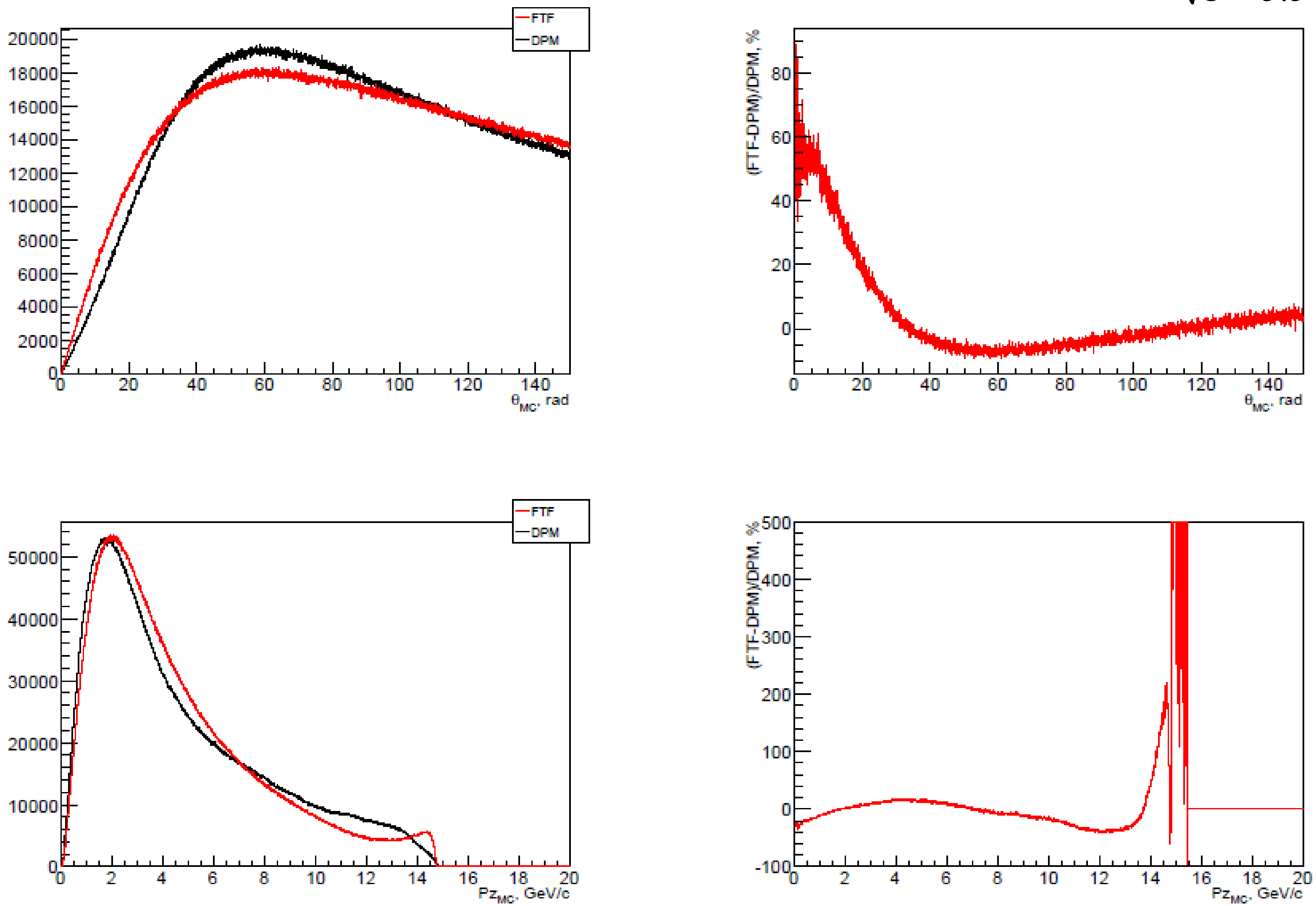


Application to LMD analysis

θ and P_z in region θ<150 mrad

Our background studies show that LMD background particles have $P_z \sim P_{beam}$ and θ<150 mrad

$\sqrt{s} = 5.5\ (\text{GeV/c})^2$



Application to LMD analysis

0.1 M inelastic events

$\sqrt{s} = 5.5\,(\mathrm{GeV/c})^2$

After ...	DPM	FTF	(FTF-DPM)/DPM, %
Hit rec	10335	12276	18.8
Trk search	1017	1651	62.3
X&Y cut	39	228	485
M cut	37	224	505

– cellular automate has been used for track search
– M cut is a momentum cut @ high energy mode

- For LMD study FTF predicts 5 times more background
- $(B/S)_{DPM}$ ~ 0.2% → $(B/S)_{FTF}$ increase to ~ 1 %

Outlook

- Compared FTF with DPM in the MC truth and reconstruction level

- Need to consider two different size of systematic uncertainty for MC background description
  - no significant difference at global analysis (e.g. online software trigger)
  - show some difference in the analysis of sub-processes

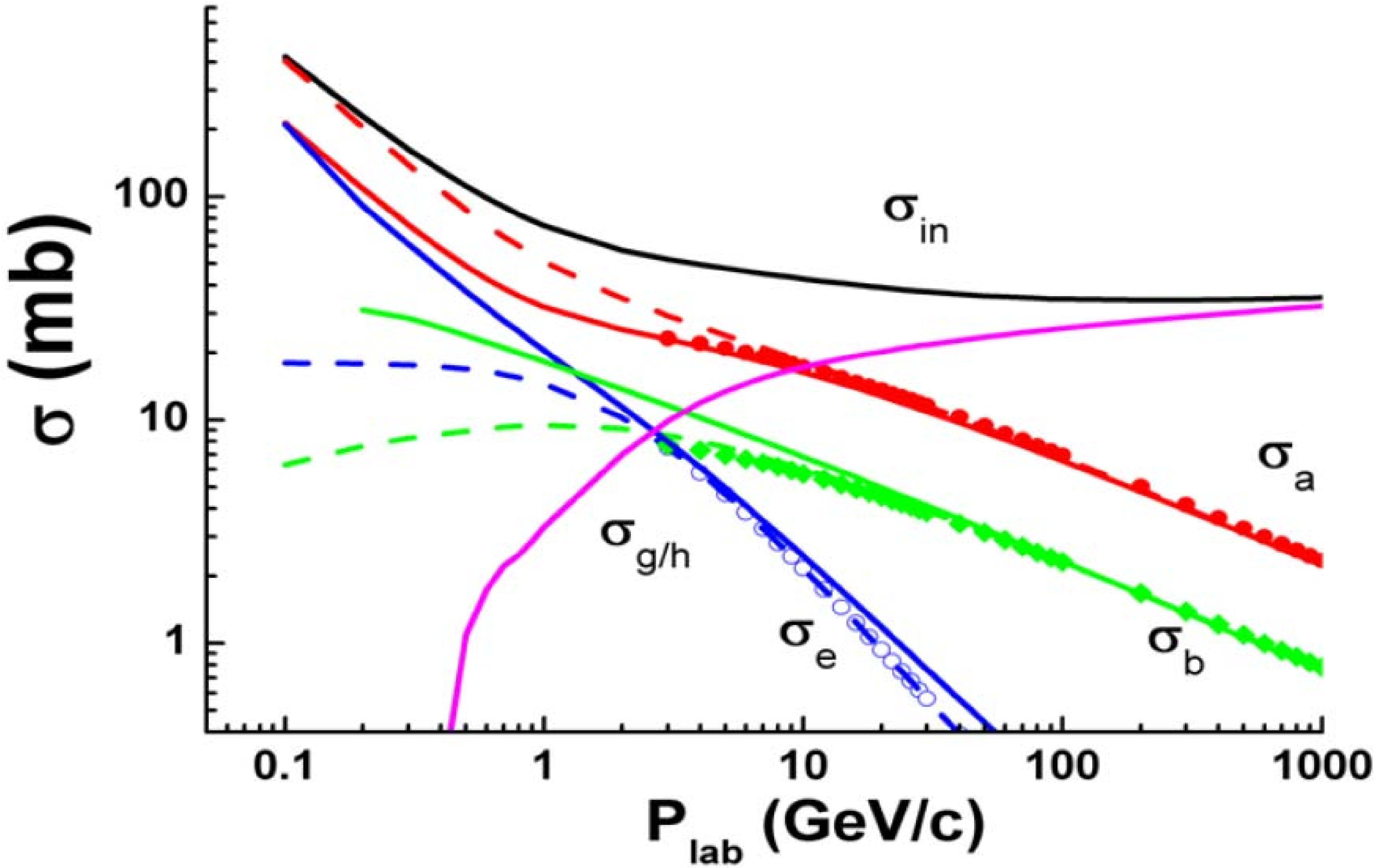
- Development of user Interface for FTF as like PndDpmDirect

- Not only $\bar{p}p$ reaction, but also $\bar{p}A$ reaction is available with FTF

Backup

Contributions of FTF model processes to $\bar{p}p$ inelastic cross sections

A. Galoyan. Physics of antiproton-proton and antiproton-nucleus annihilation processes implemented in Geant4, *PANDA Collaboration Meeting*, Sep.2013



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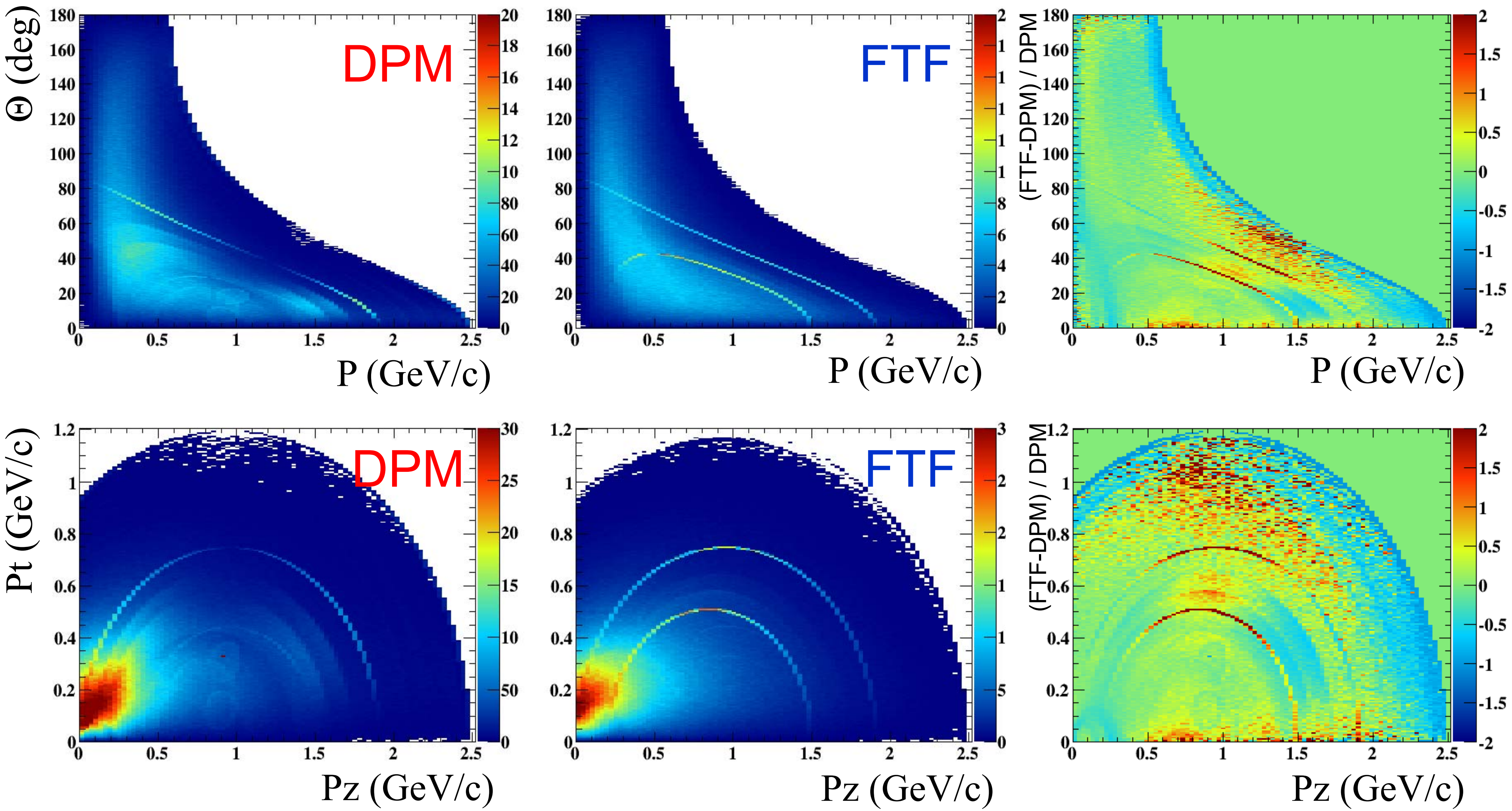

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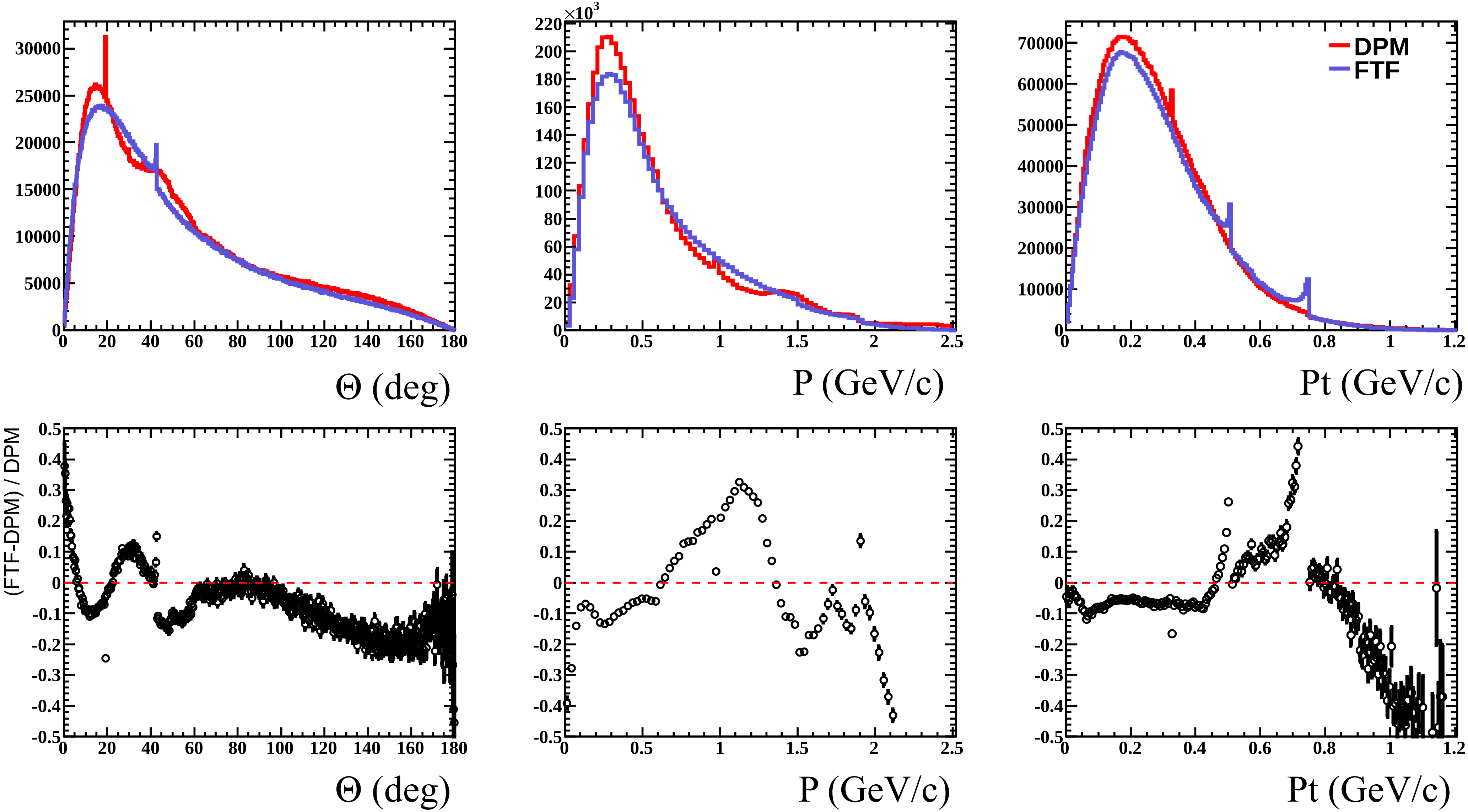
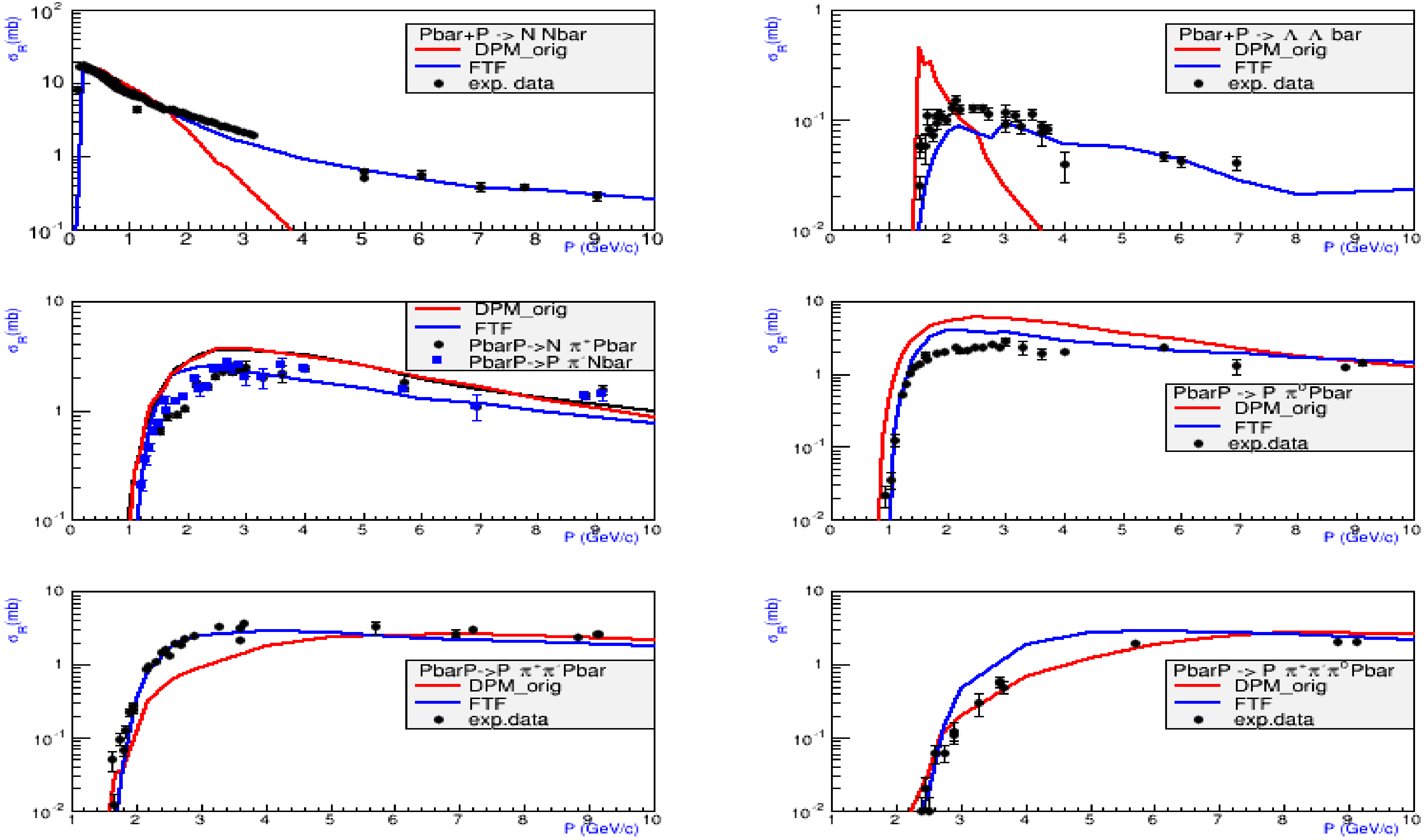


Pbar-P channel cross sections with baryons in final states

http://g4validation.fnal.gov:8080/G4ValidationWebApp/G4ValHAD.jsp



Exp. Data: E.Bracci et al.,CERN/HERA 73-1(1973)

Pbar-P annihilation channel cross sections

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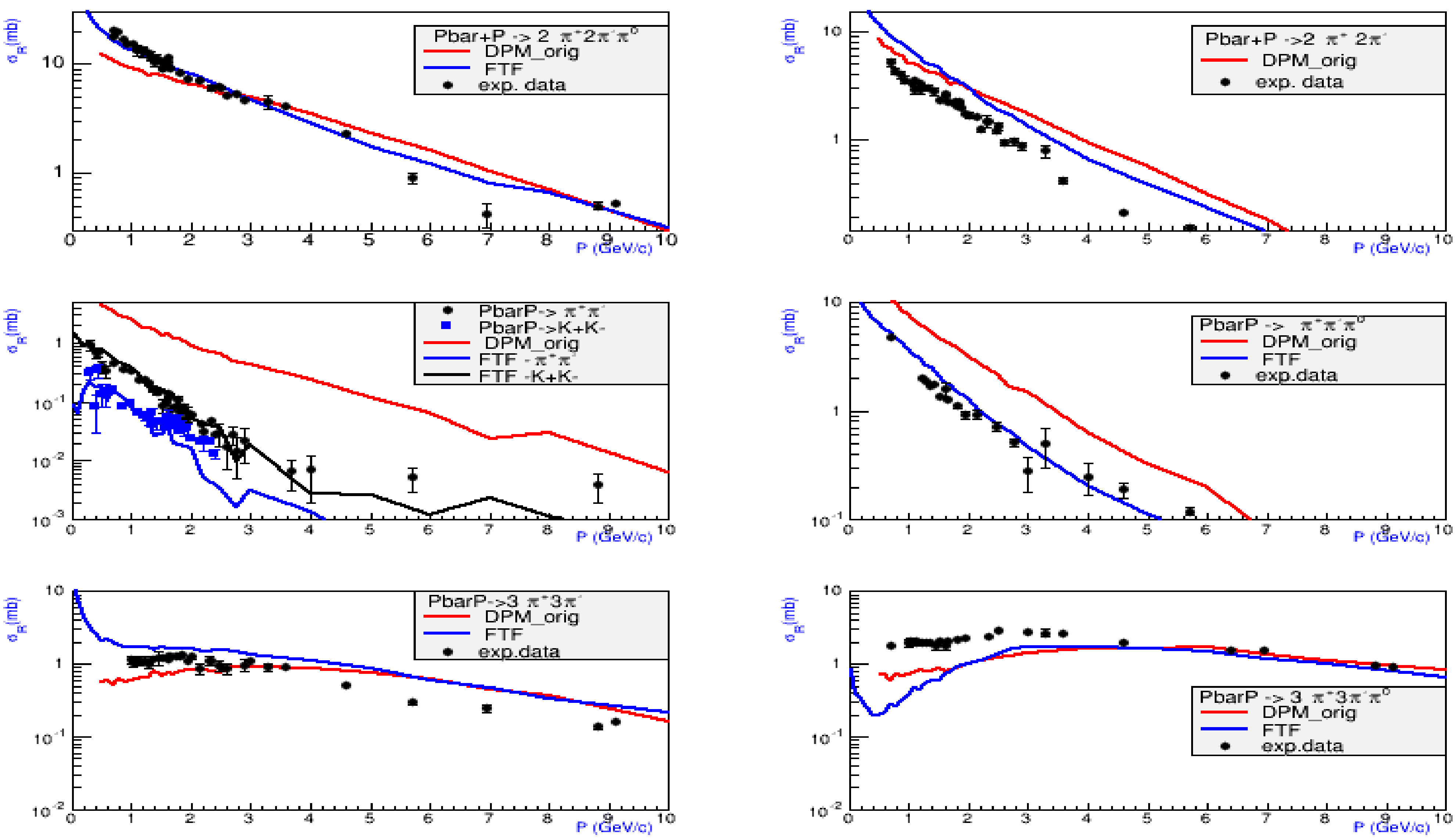

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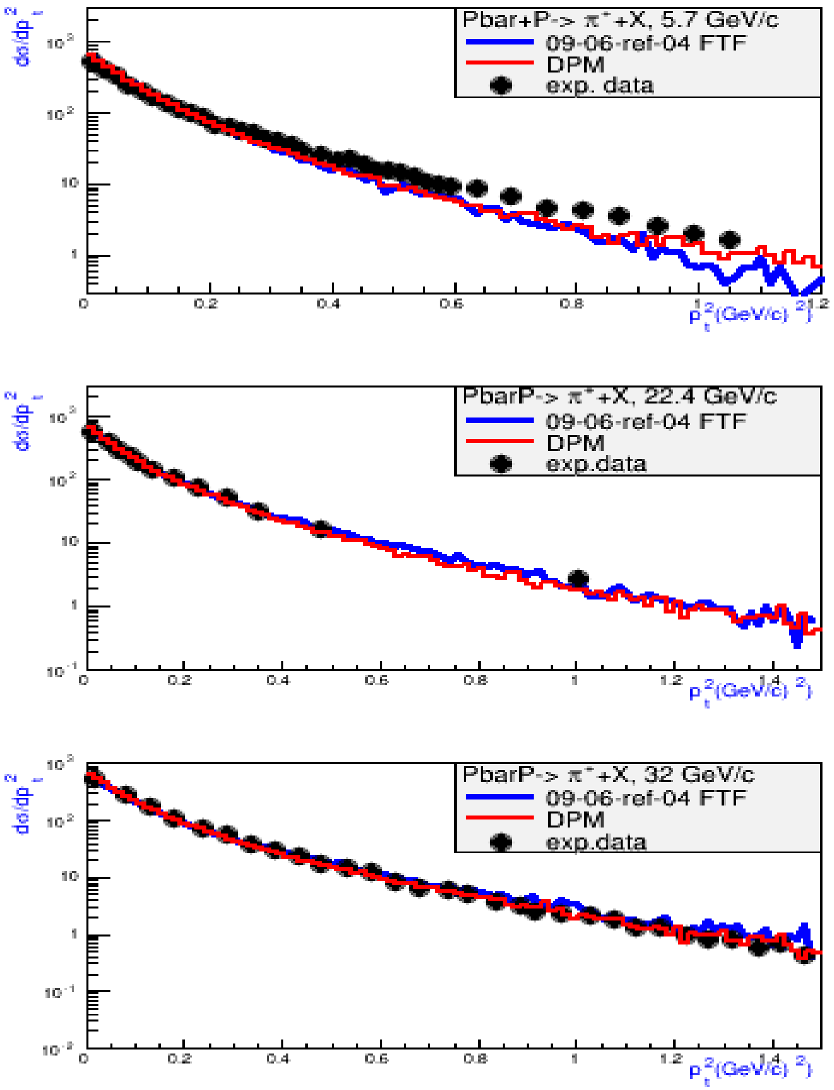
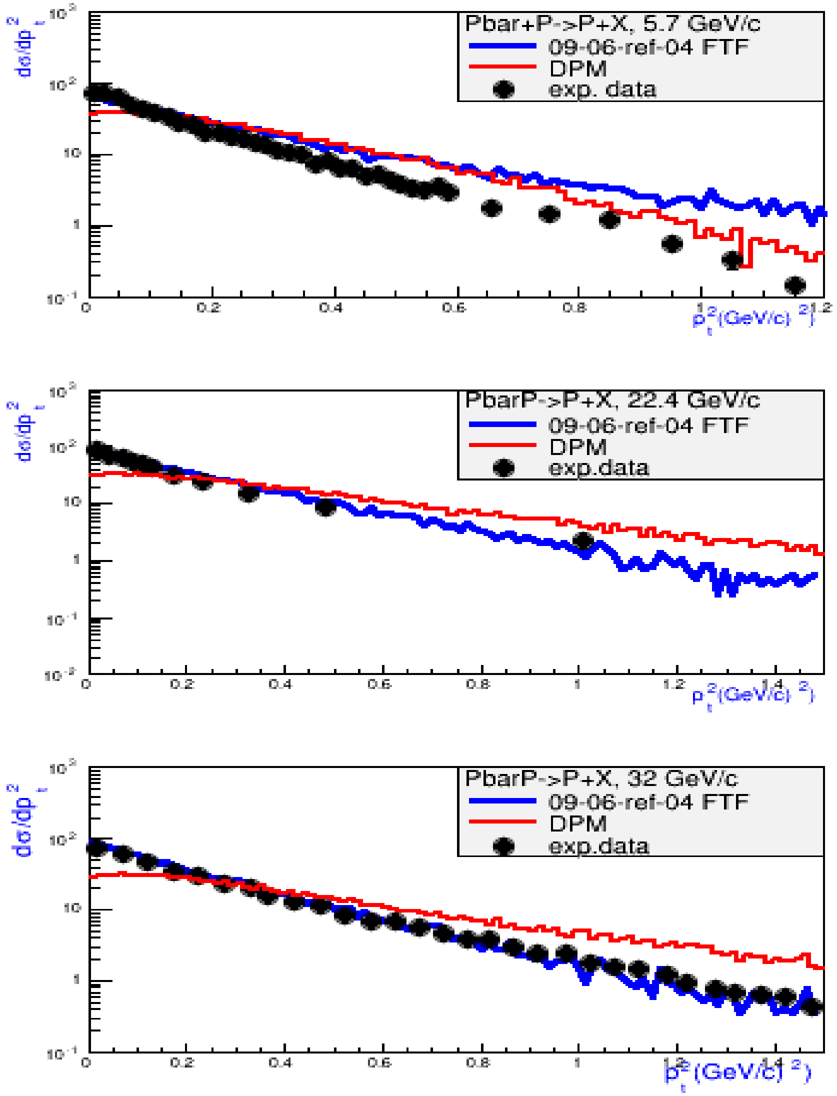
Results for inclusive cross sections of Antiproton–Proton reactions

P_T^2 of $\pi+$ mesons



P_T^2 of Protons



Exp. Data: J. Chyla, Czech. J. Phys. B 30 1980
E .G. Boos et al., Nucl. Phys. B174 45, 1980
E.V. Vlasov, Z. Phys. C - Particles and Fields 13, 95, 1982