Ξ^0_c production via semi-leptonic decay in pp collisions at $\sqrt{s}$ =13TeV

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D2H meeting

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- **Last presentation**

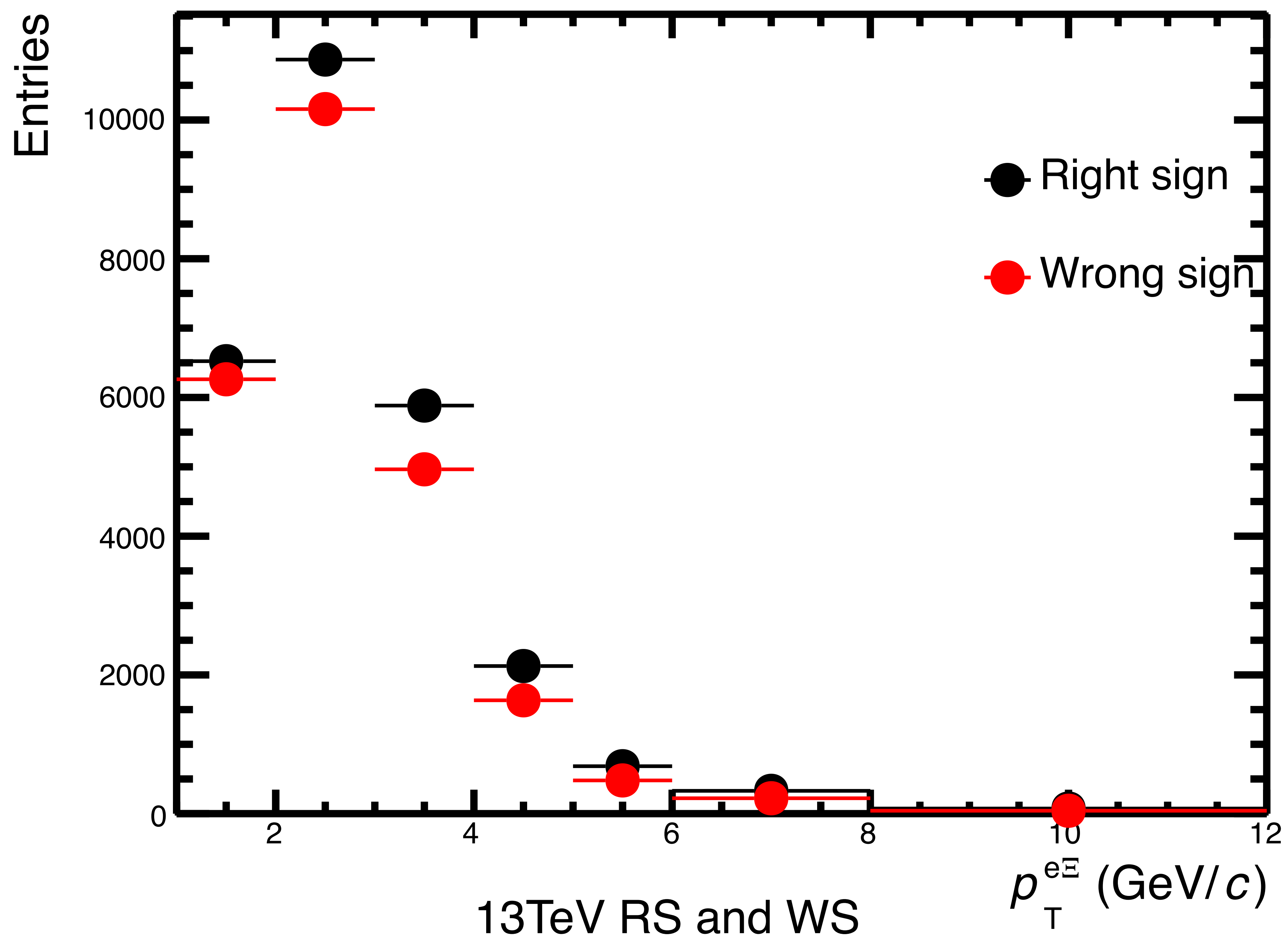
  ➡https://indico.cern.ch/event/913249/contributions/3840564/attachments/2033027/3403278/200506_jj_ForumApproval.pdf

1. **Correction of oversubtraction caused by bottom baryon**
   - Fit Λ_b 7TeV measurement using Tsallis function.
   - Λ_b 7TeV measurement is scaled to 13TeV by FONLL.
   - Multiply branching ratio factor
   - Multiply Ξ_b efficiency
   - Convert Ξ_b pT to eXi pT using response matrix
2. **Systematic uncertainty of oversubtraction**
   - Varying the parameters of the Tsallis function
   - Varying branching ratio fraction
3. **Question mark**
   - Definition of branching ratio fraction

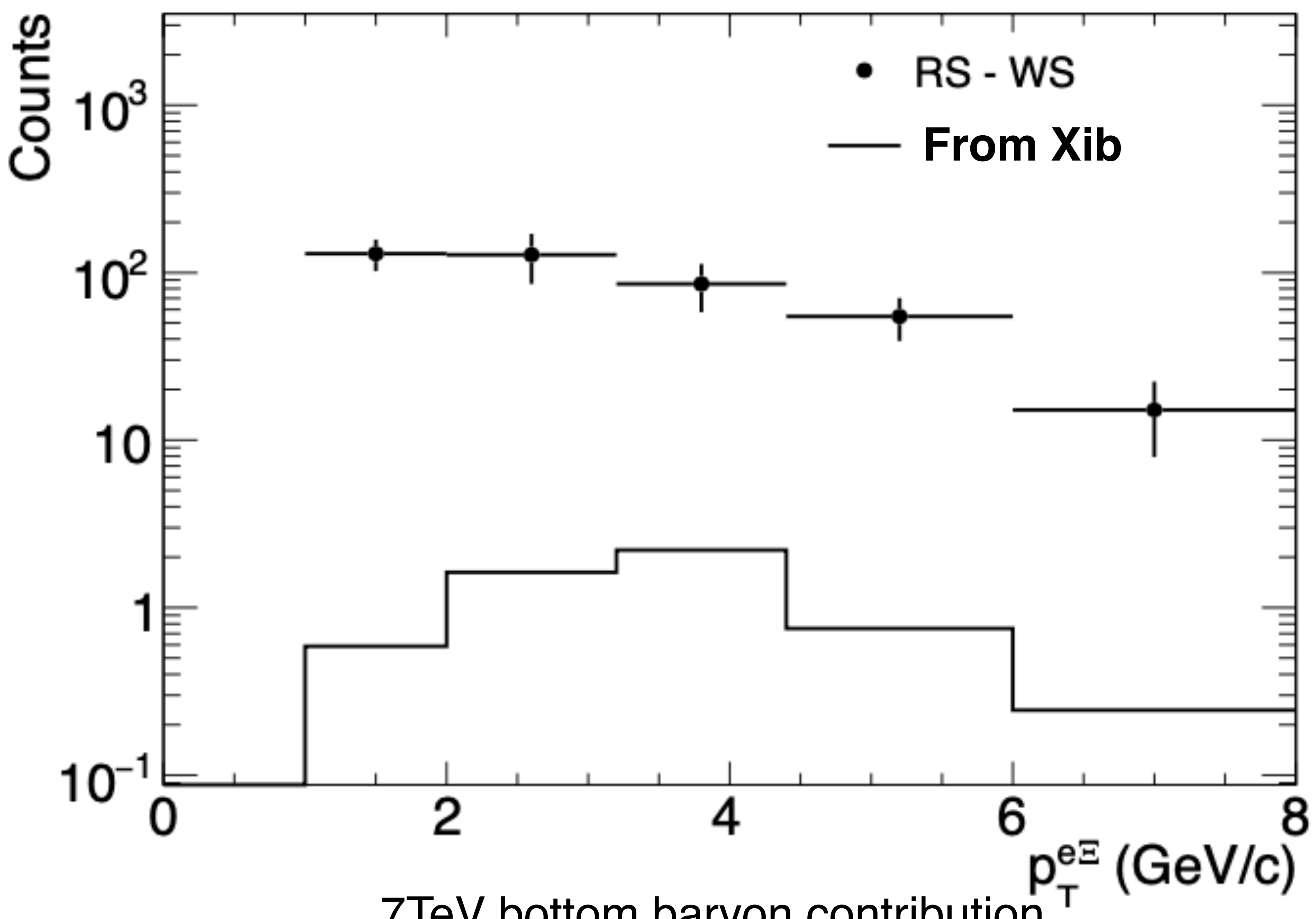
- Correction of oversubtraction caused by bottom baryon

- **Bottom baryon contribution in WS spectra**
  - The raw yield is obtained by subtraction WS spectra from RS spectra.
  - In the WS spectra, there are contributions from bottom baryons, such as $\Xi_b \rightarrow e\Xi\nu$

  ➡The subtracted spectra underestimate the yields of charmed baryons.



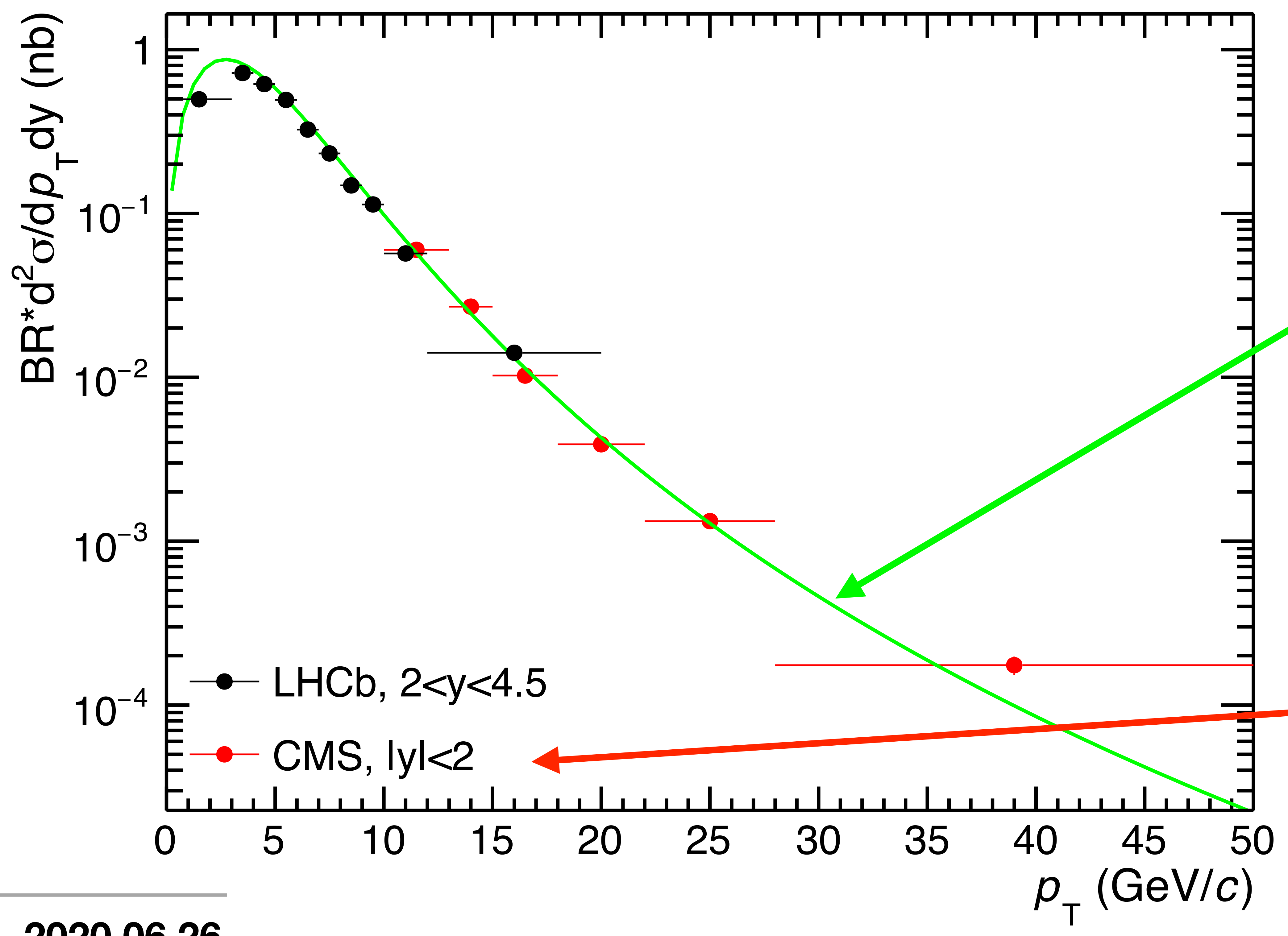
13TeV RS and WS



7TeV bottom baryon contribution

- Correction of oversubtraction caused by bottom baryon

- **Fit Λ_b 7TeV measurement using Tsallis function**
  - The Ξ_b baryons are not measured at LHC energies. → **Assumption : Ξ_b p_T shape is same as Λ_b**
  - Λ_b was measured by CMS and LHCb at 7TeV.
    - CMS measurement is used to fit the spectrum down to 0GeV pT. (*Phys. Lett.*, B714:136–157, 2012)
    - LHCb measurement is not used due to the difference in the rapidity coverage from ALICE.



$$C \cdot p_T \left[1 + \frac{\sqrt{p_T^2+m^2}-m}{nT}\right]^{-n}$$

CMS: $n = 7.6 \pm 0.4$, $T = 1.10$ GeV (

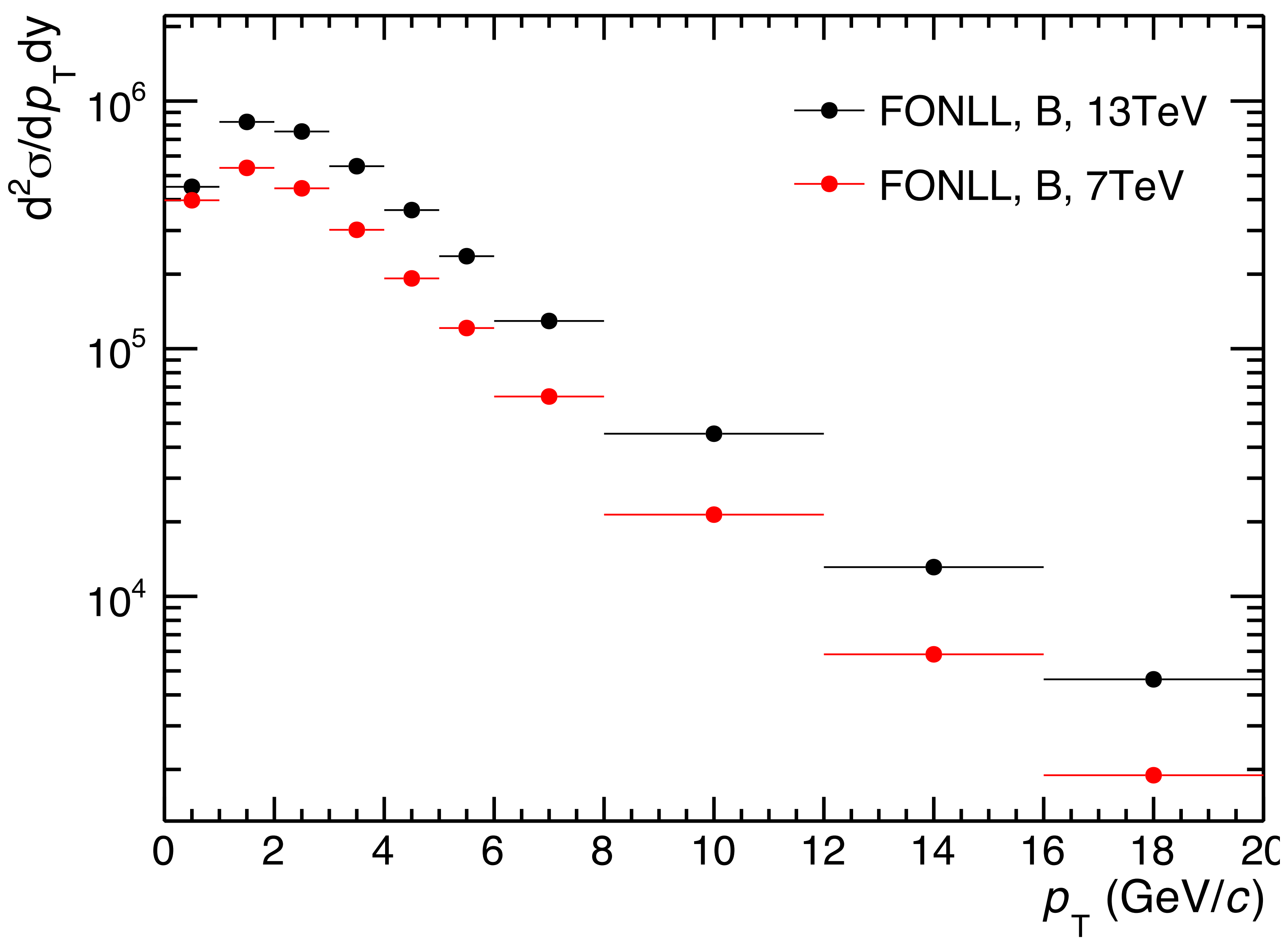
$$\frac{d\sigma(pp \to \Lambda_b X)}{dp_T^{\Lambda_b}} \times \mathcal{B}(\Lambda_b \to J/\psi\, \Lambda) = \frac{n_{sig}}{2 \cdot \epsilon \cdot \mathcal{B} \cdot \mathcal{L} \cdot \Delta p_T^{\Lambda_b}},$$

- Correction of oversubtraction caused by bottom baryon

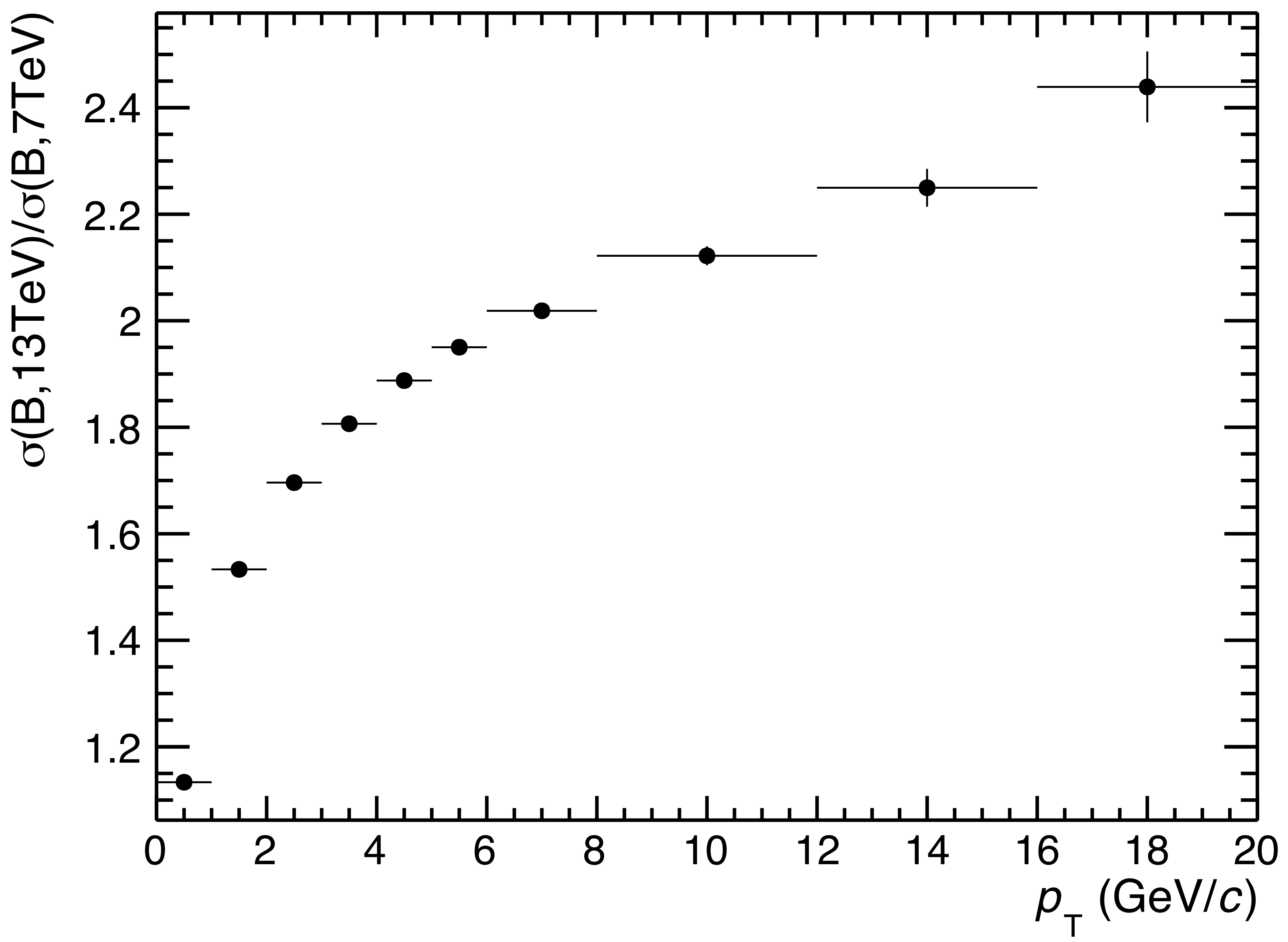
- **Λ_b 7TeV measurement is scaled to 13TeV by FONLL**
  - Since Λ_b was measured at 7TeV, energy scaling is needed using FONLL.
  - There is no Λ_b 13TeV spectrum in FONLL but there is B meson spectrum.

    ➡ **Assumption : B ratio (13TeV/7TeV) is same as Λ_b ratio (13TeV/7TeV)**

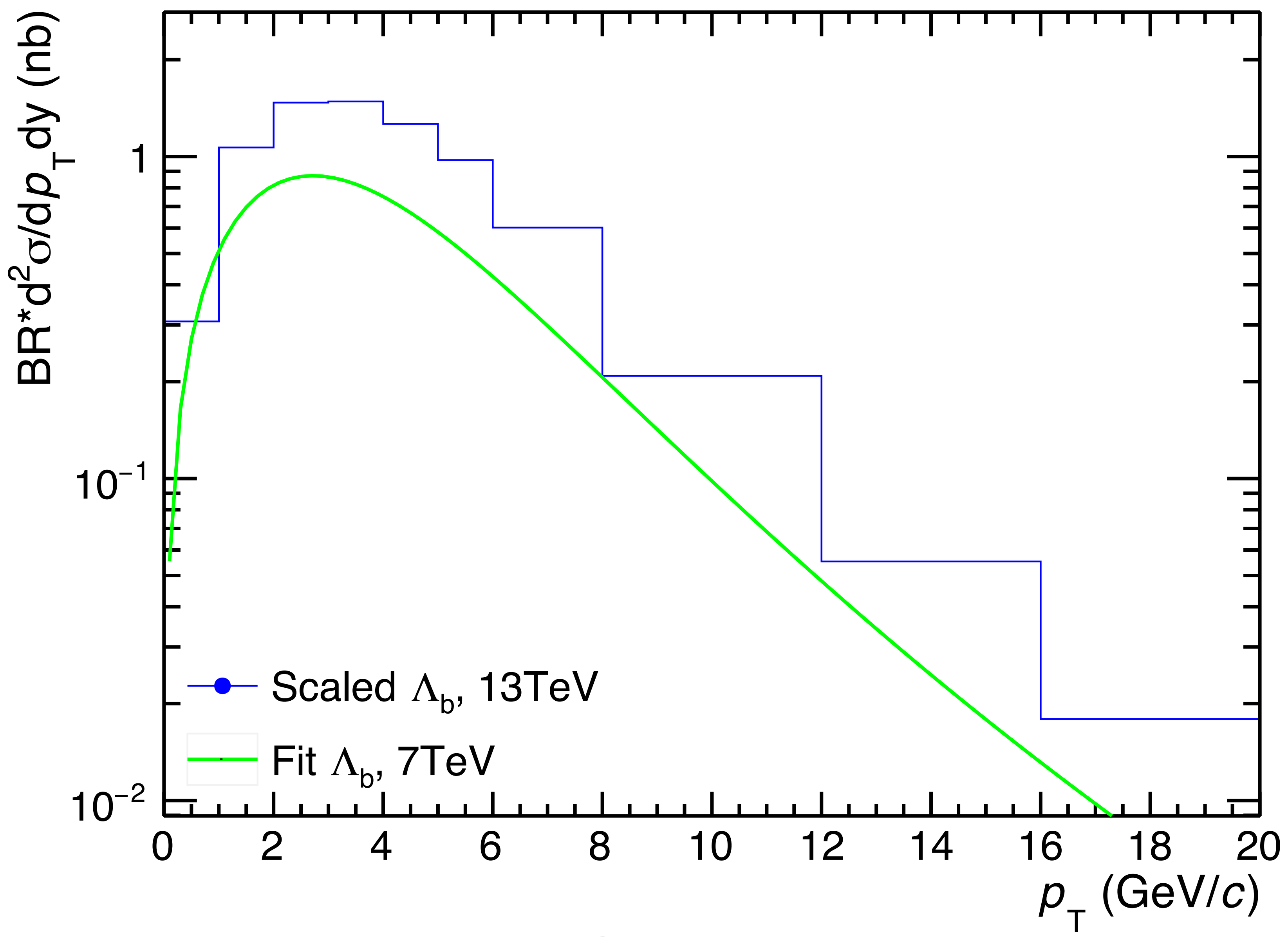
    → **Baryon and meson energy dependence of fragmentation function are same.**
  - 7TeV Λ_b cross section is scaled to 13TeV Λ_b by scale factor obtained B meson ratio.



B meson cross section



B meson cross section ratio (13TeV/7TeV)
Scale factor



Scaled Λ_b cross section

- Correction of oversubtraction caused by bottom baryon

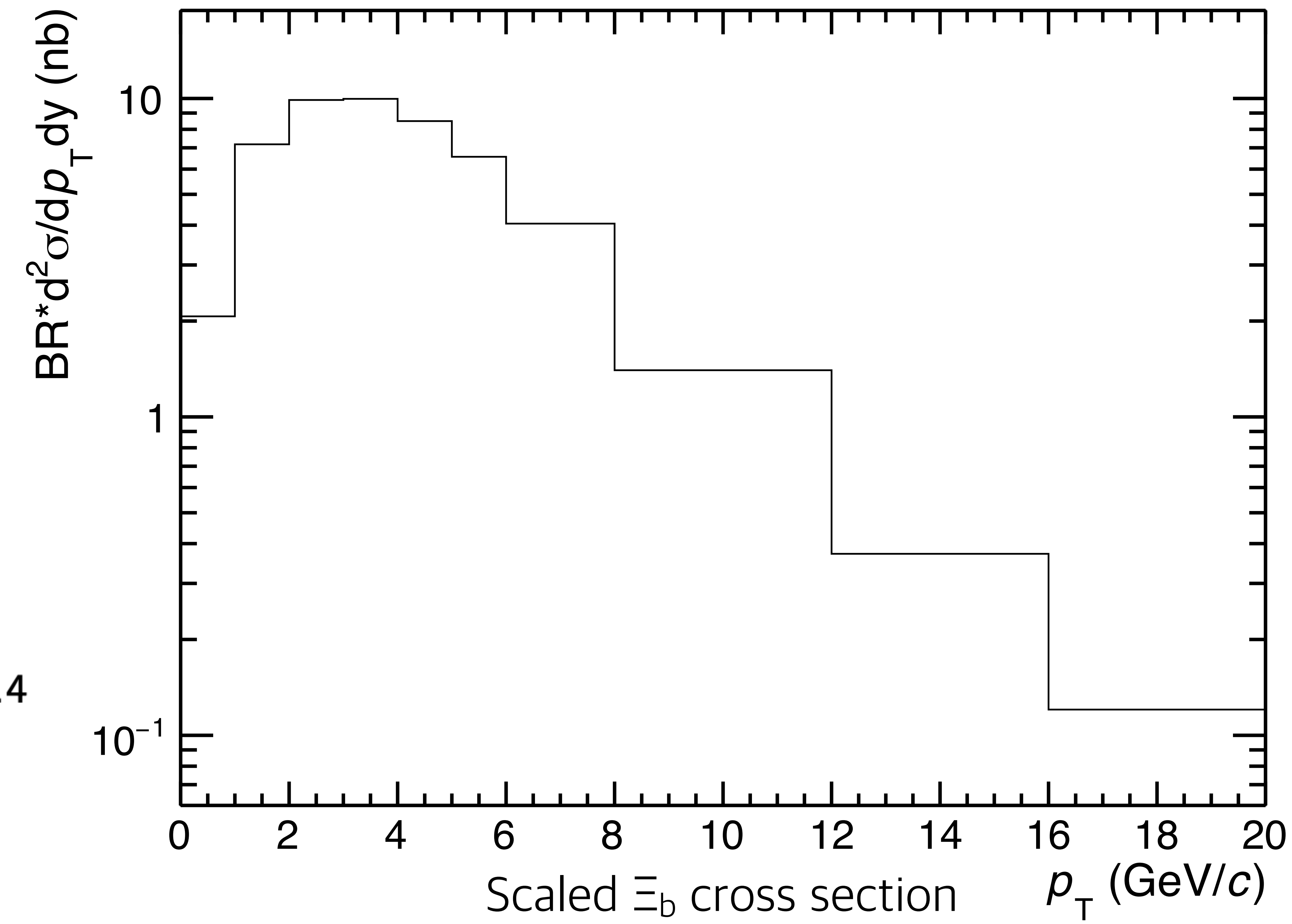
- **Multiply branching ratio fraction**
  - CMS measurement contains branching ratio Λ_b to $J/\psi\Lambda$.

$$\frac{d\sigma(pp \to \Lambda_b X)}{dp_T^{\Lambda_b}} \times \mathcal{B}(\Lambda_b \to J/\psi\,\Lambda) = \frac{n_{sig}}{2 \cdot \epsilon \cdot \mathcal{B} \cdot \mathcal{L} \cdot \Delta p_T^{\Lambda_b}},$$

  - Branching ratio fraction is multiplied to 13TeV Λ_b cross section to get a Ξ_b cross section.
    - Branching ratio is obtained at PDG

$$\frac{BR(b \to \Xi_b)BR(\Xi_b \to e\Xi\nu)}{BR(b \to \Lambda_b)BR(\Lambda_b \to J/\Psi\Lambda)} = \frac{3.9 \times 10^{-4}}{5.8 \times 10^{-5}}$$

Γ_1	$\Xi^- \ell^- \overline{\nu}_\ell X \times$ B($\overline{b} \to \Xi_b$)	$(3.9 \pm 1.2) \times 10^{-4}$	S=1.4
Γ_1	$J/\psi(1S)\Lambda \times$ B($b \to \Lambda_b^0$)	$(5.8 \pm 0.8) \times 10^{-5}$	



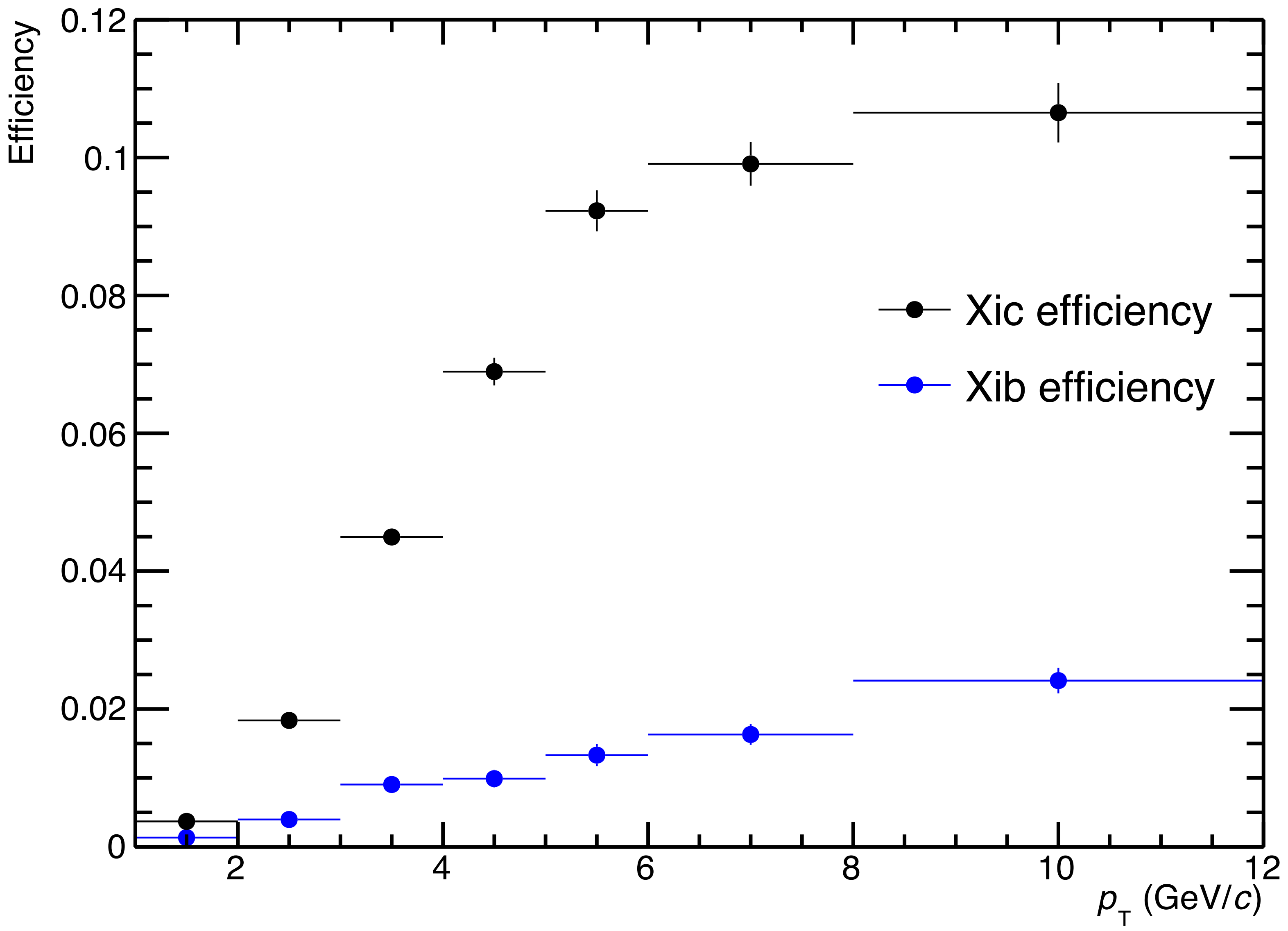
Scaled Ξ_b cross section

- Correction of oversubtraction caused by bottom baryon

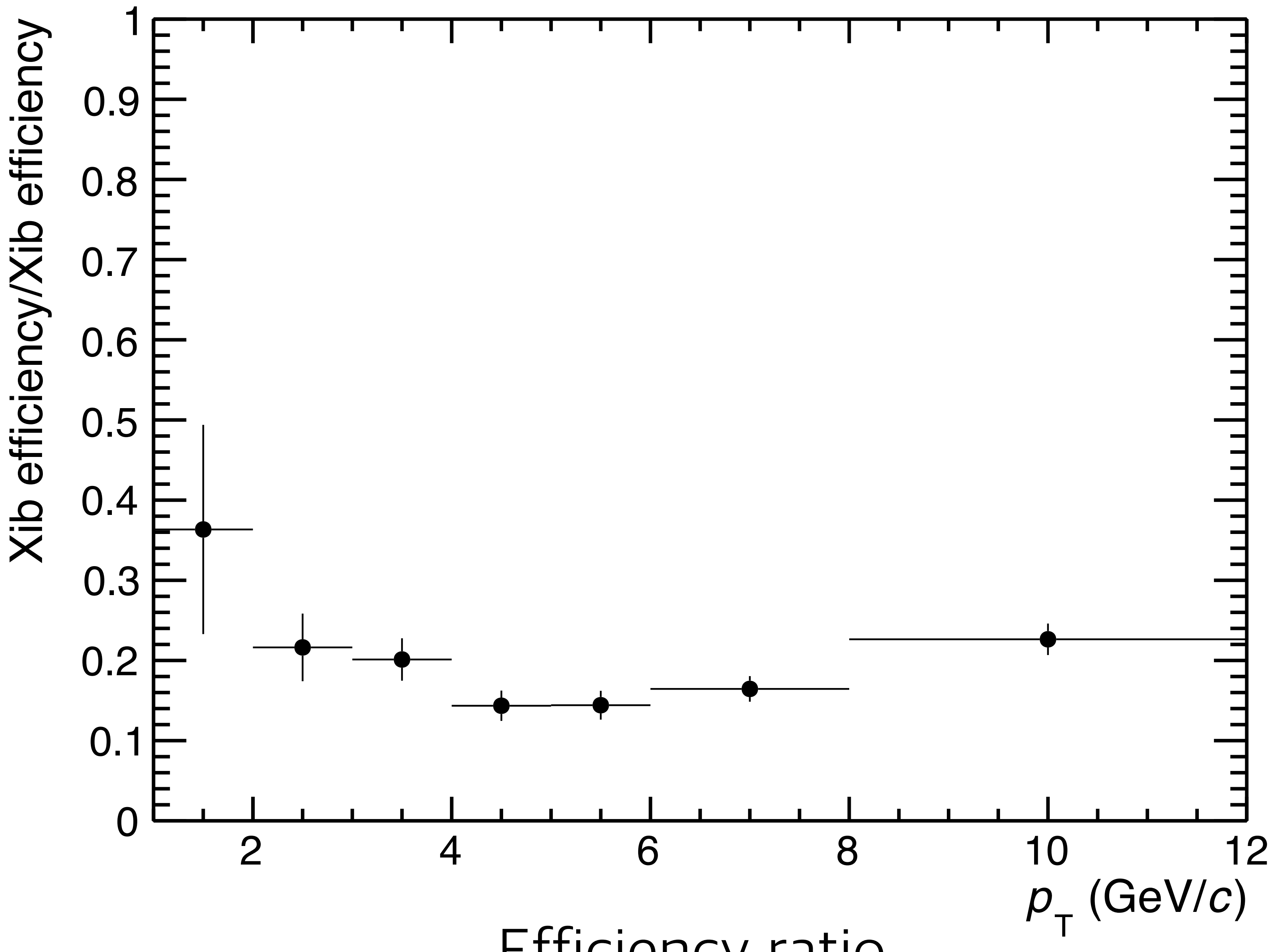
- **Multiply Ξ_b efficiency**
  - To get a Ξ_b yield in pp collisions at 13TeV, efficiency and some factors are multiplied.

$$N^{raw}_{\Xi_b} = Br\frac{d\sigma^{\Xi_b}}{dp_{\mathrm{T}}dy}2\Delta p_{\mathrm{T}}\Delta y \cdot \epsilon \cdot L_{int} \qquad \epsilon = \frac{\Xi_b(Reco, WS)}{\Xi_b(Gen)_{|y|<0.5}}$$

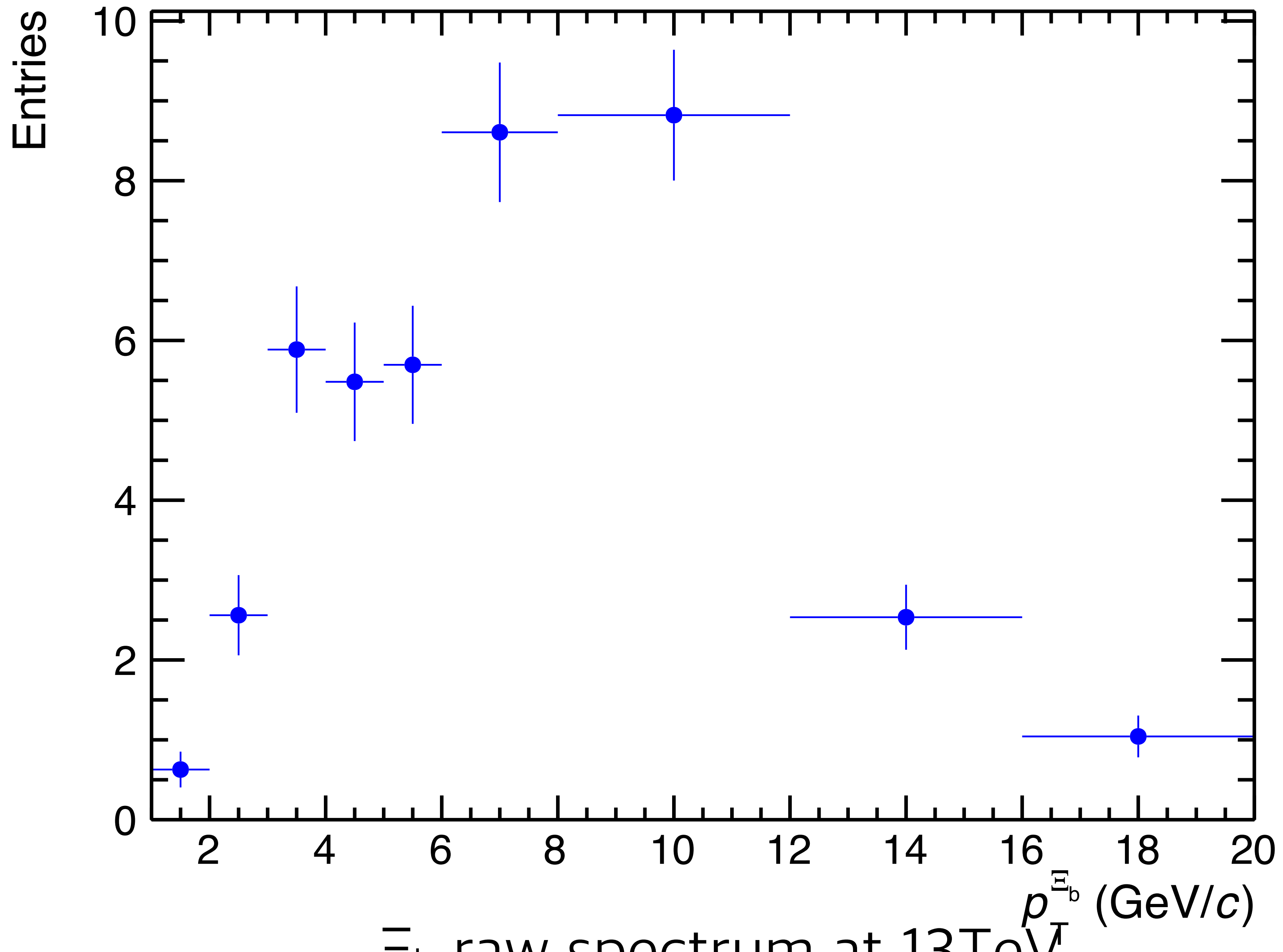
  - L_{int} is calculated same as 13TeV Ξ_c analysis.
  - Cuts are applied which same as Ξ_c analysis (track cut, Xi topology cut, pair cut …)



Efficiency of Xic and Xib



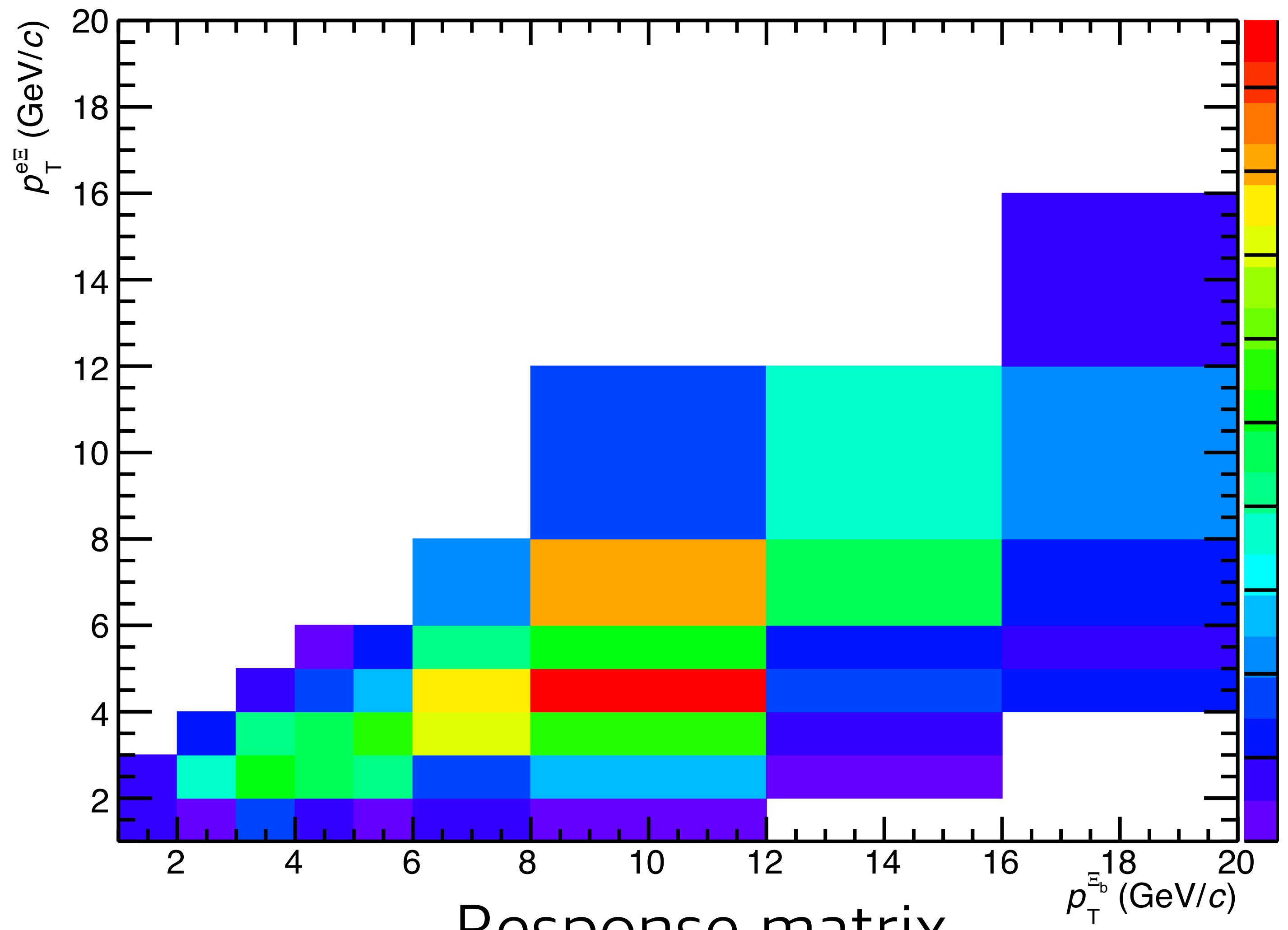
Efficiency ratio



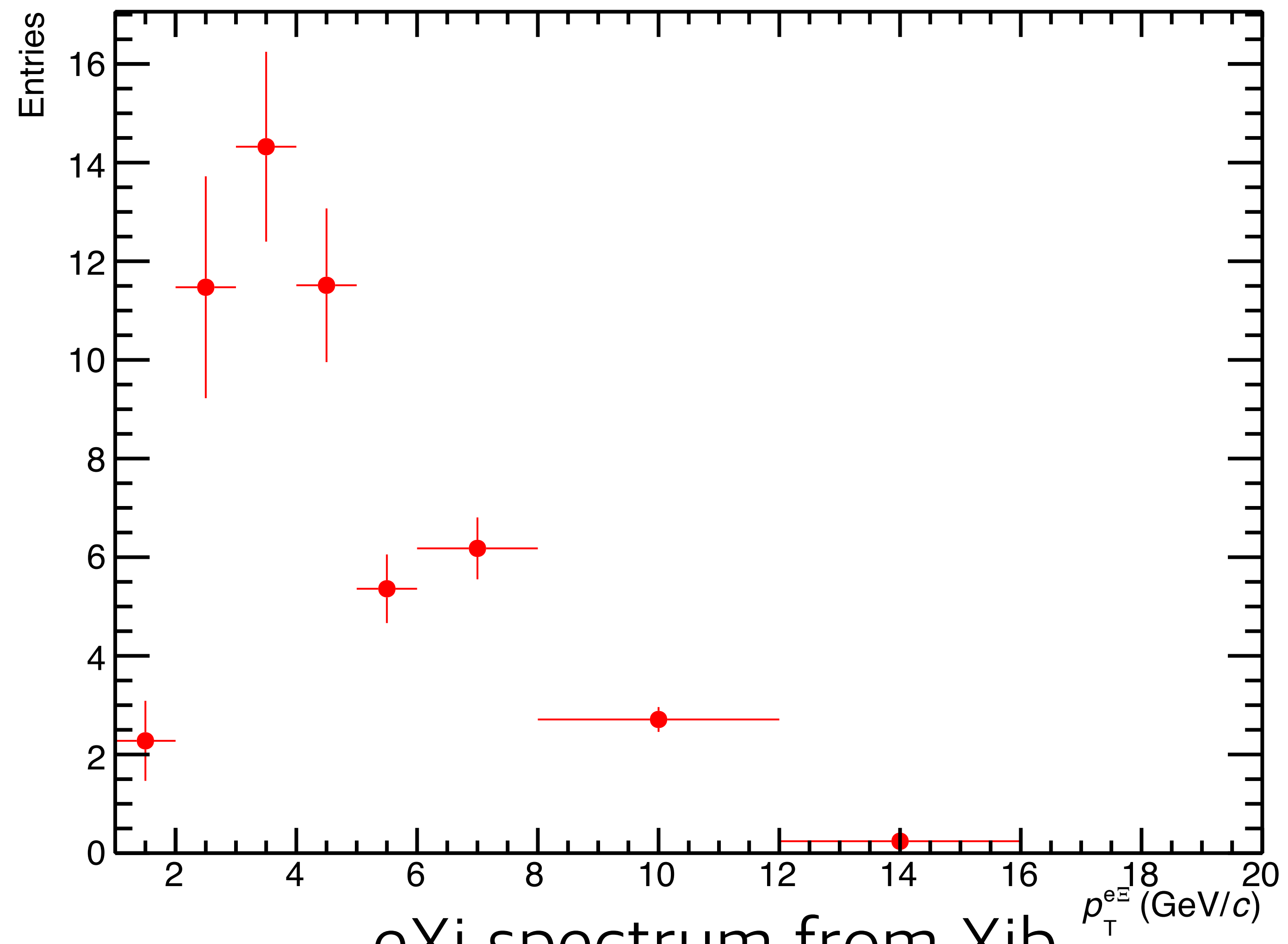
Ξ_b raw spectrum at 13TeV

- Correction of oversubtraction caused by bottom baryon

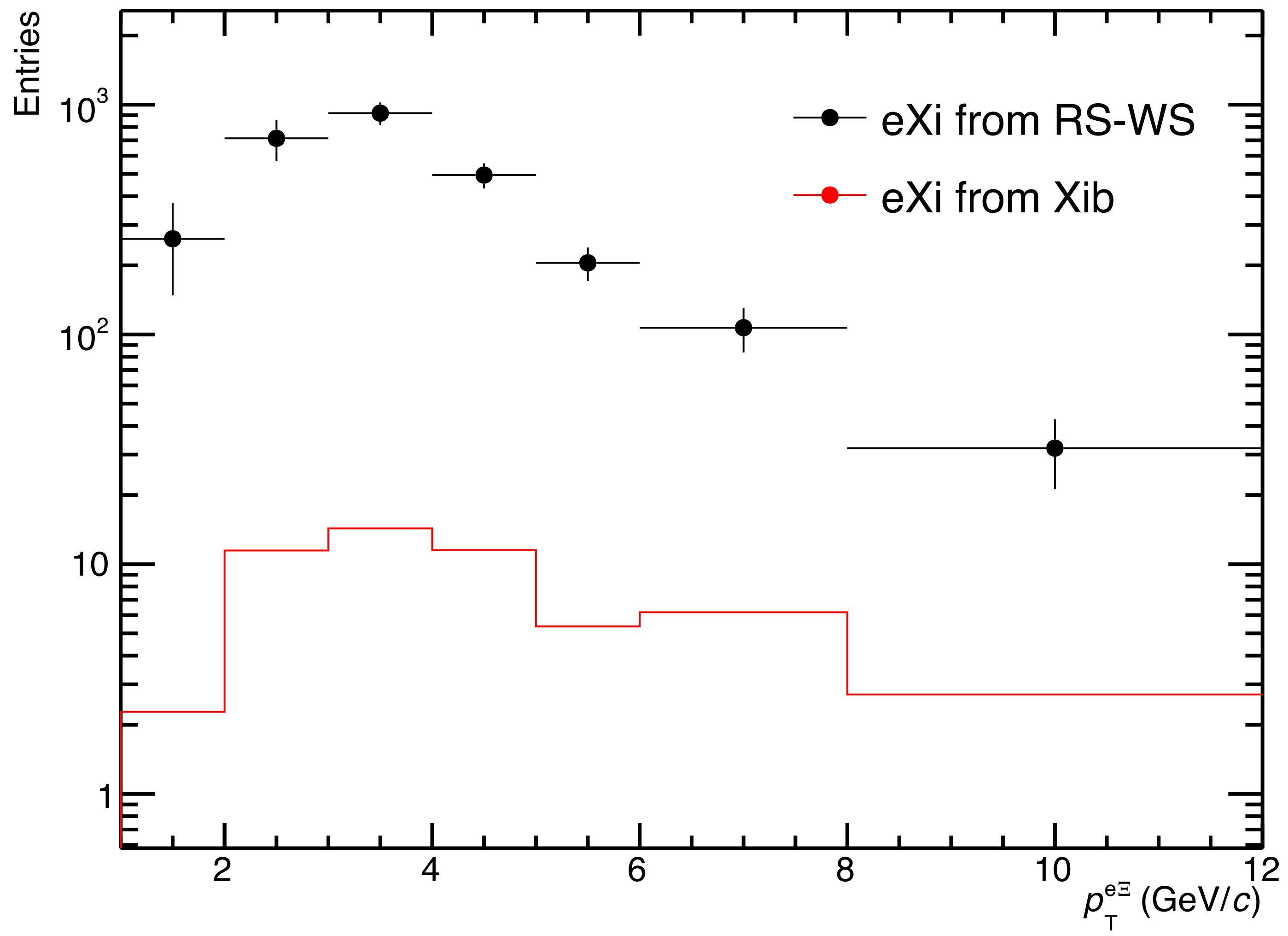
- **Convert Ξ_b p_T to eΞ p_T using response matrix**
  - Ξ_b spectrum is folded to eΞ spectrum using response matrix
    - Bin by Bin folding is done.
  - Ξ_b contribution in WS is 2% at low p_T region, and 10% at high p_T region.
    - At high p_T, b production increases.



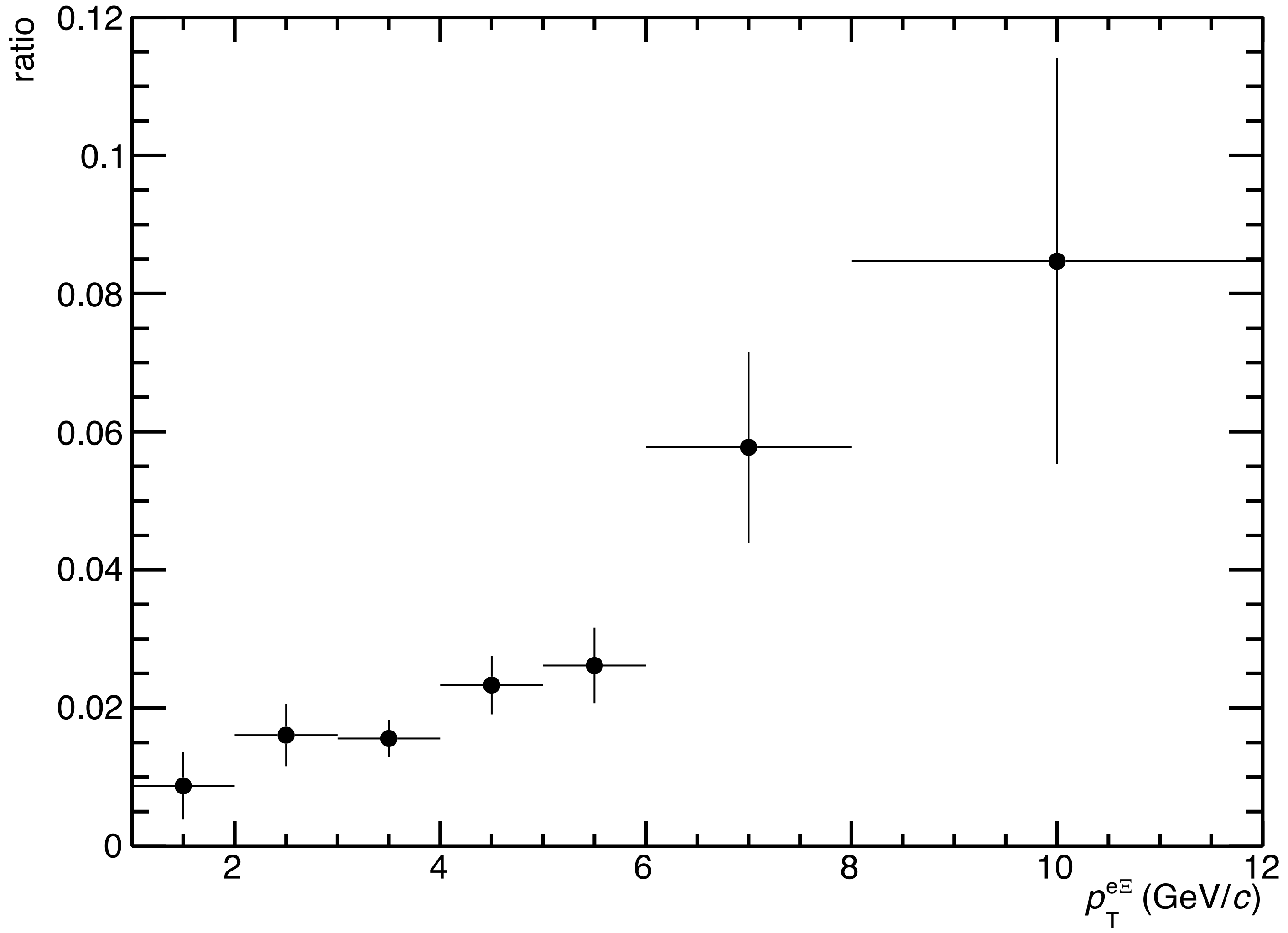
Response matrix



eXi spectrum from Xib



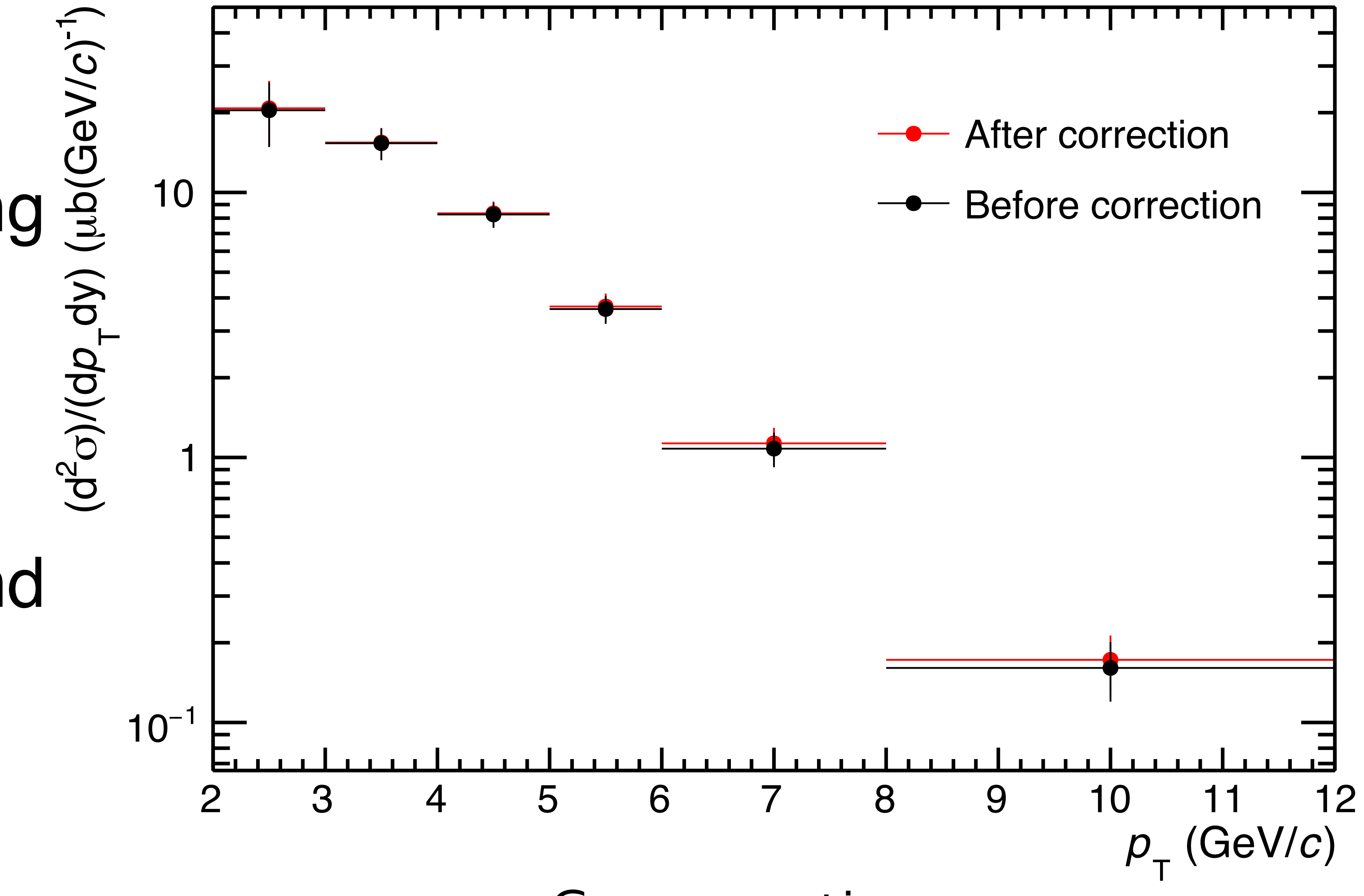
eXi pair spectrum



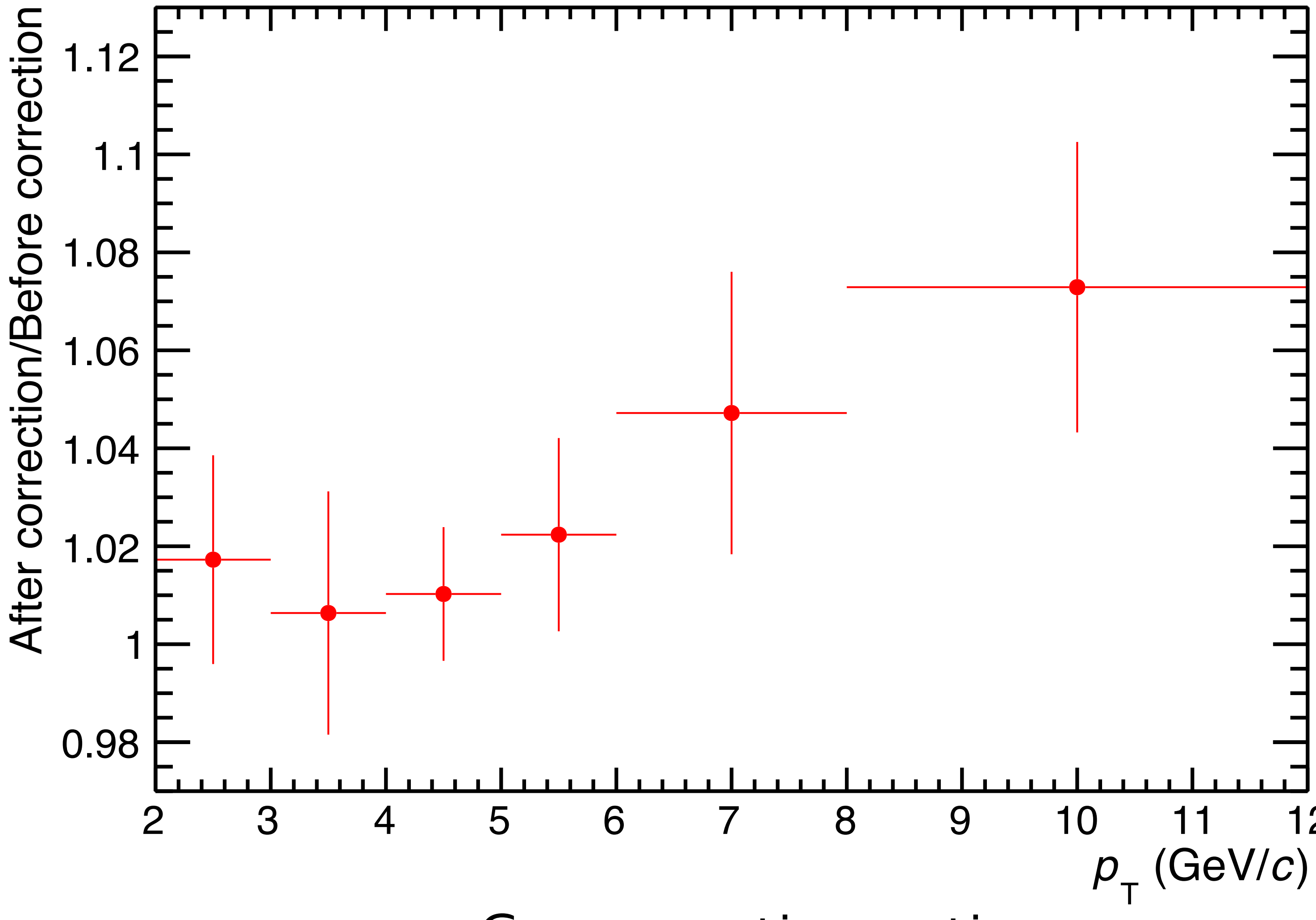
eXi pair ratio

- Correction of oversubtraction caused by bottom baryon

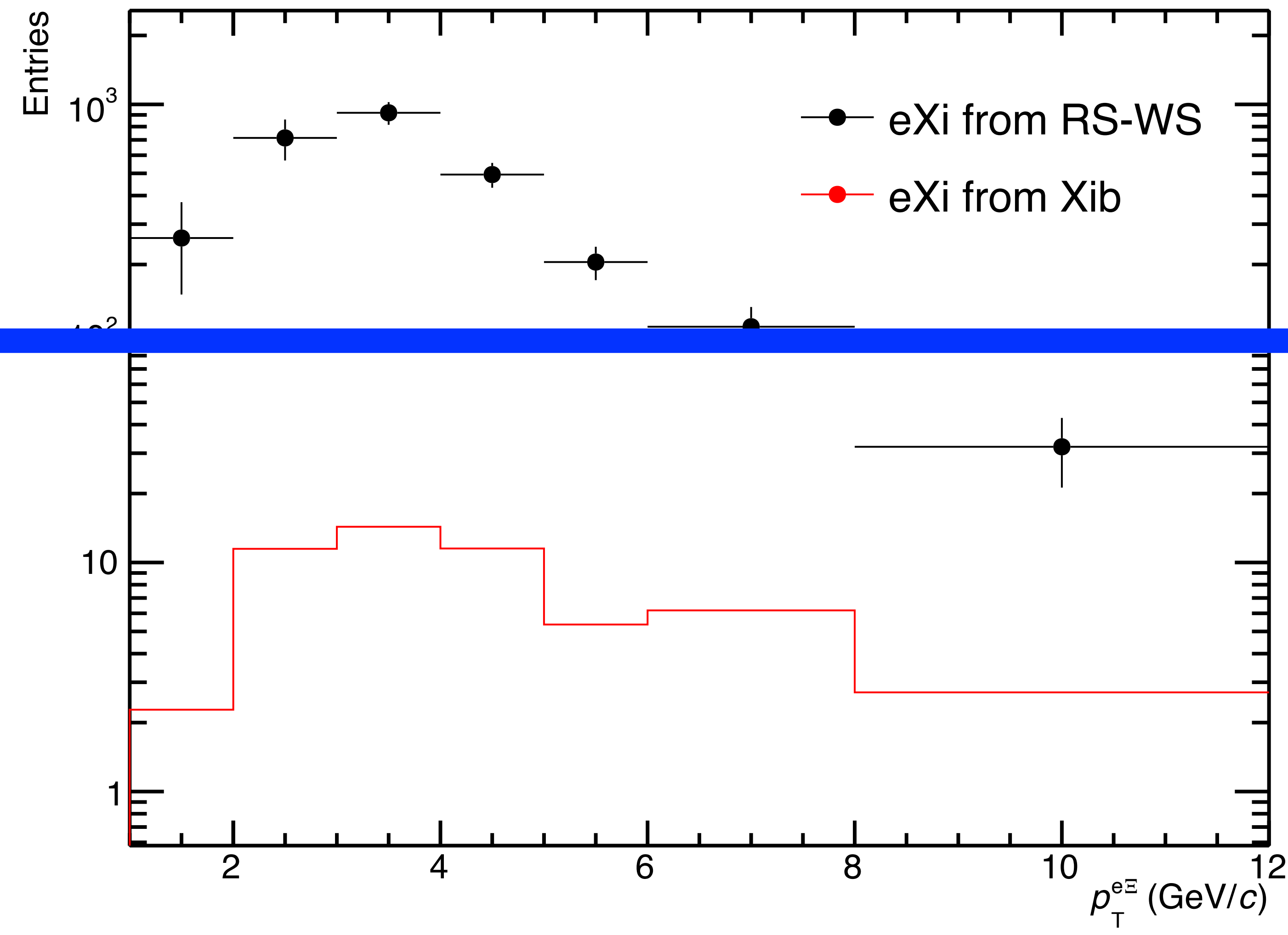
- **Convert Ξ_b p_T to eΞ p_T using response matrix**
  - Ξ_b spectrum is folded to eΞ spectrum using response matrix
    - Bin by Bin folding is done.
  - Ξ_b contribution in WS is 2% at low p_T region, and 10% at high p_T region.
    - At high p_T, b production increases.
  - eΞ pair from bottom baryon is added to eΞ pair from RS-WS.
  - Bottom baryon contribution increases the cross section 1~7%.



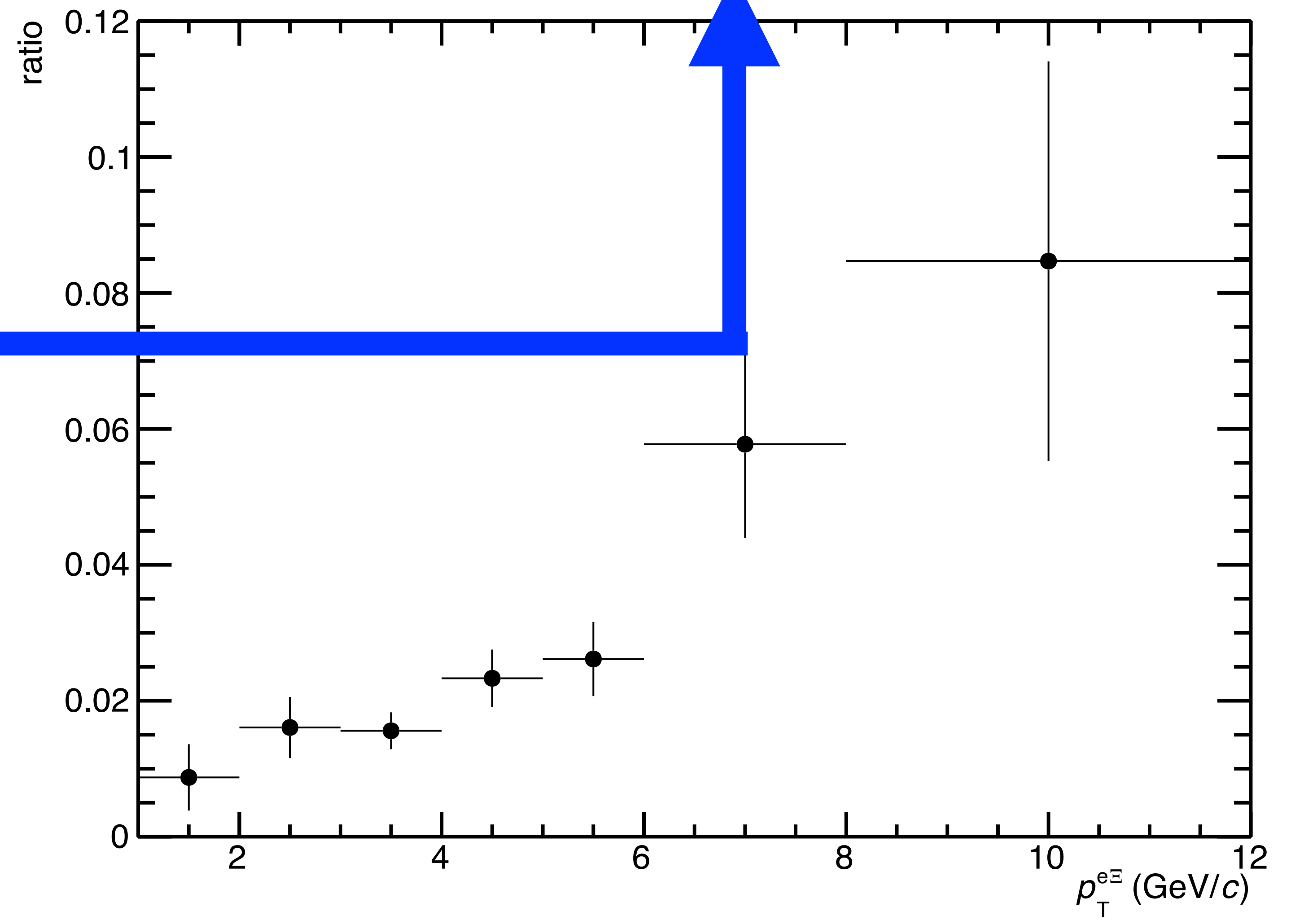
Cross sections



Cross section ratio



eXi pair spectrum



eXi pair ratio

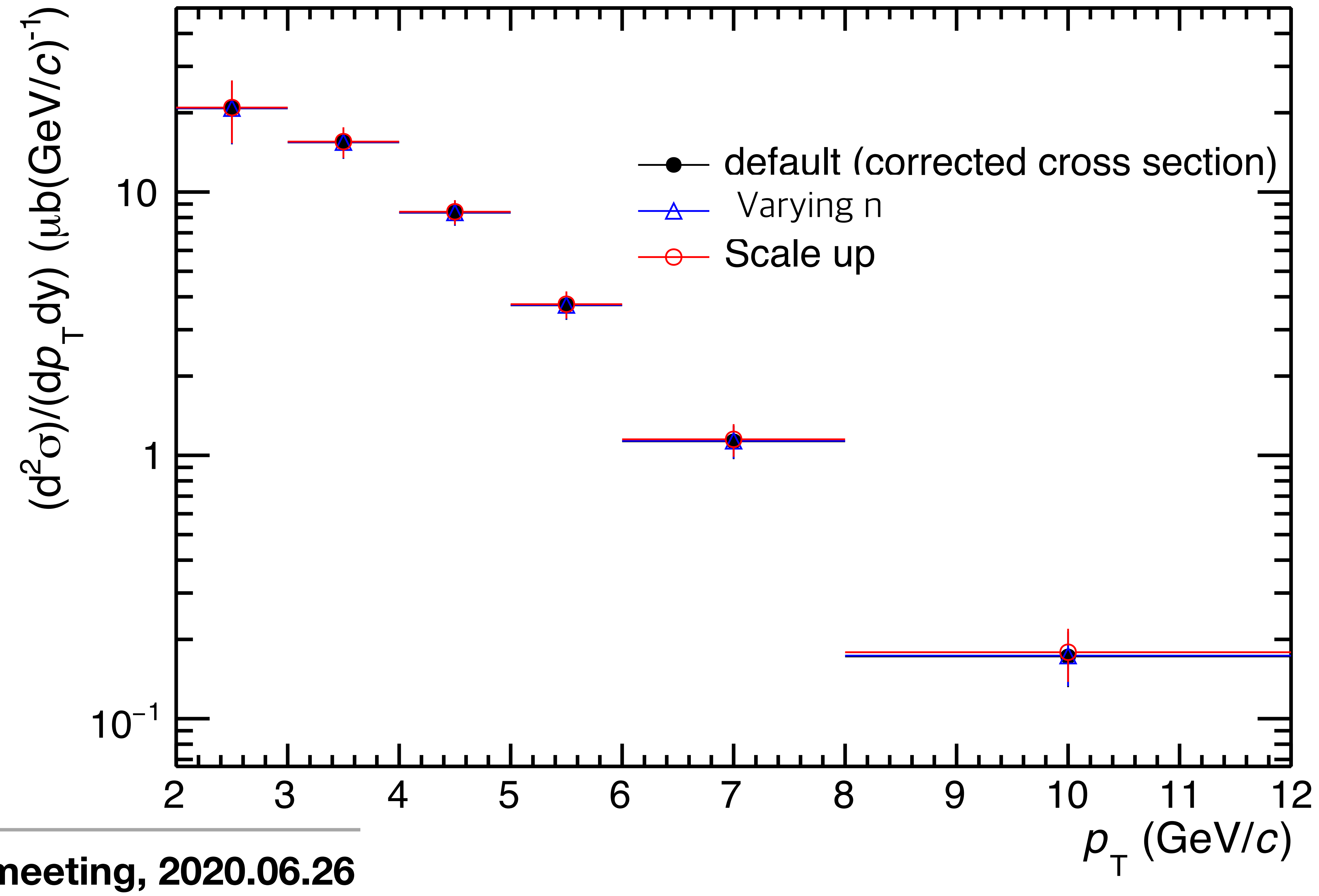
- Systematic uncertainty of oversubtraction

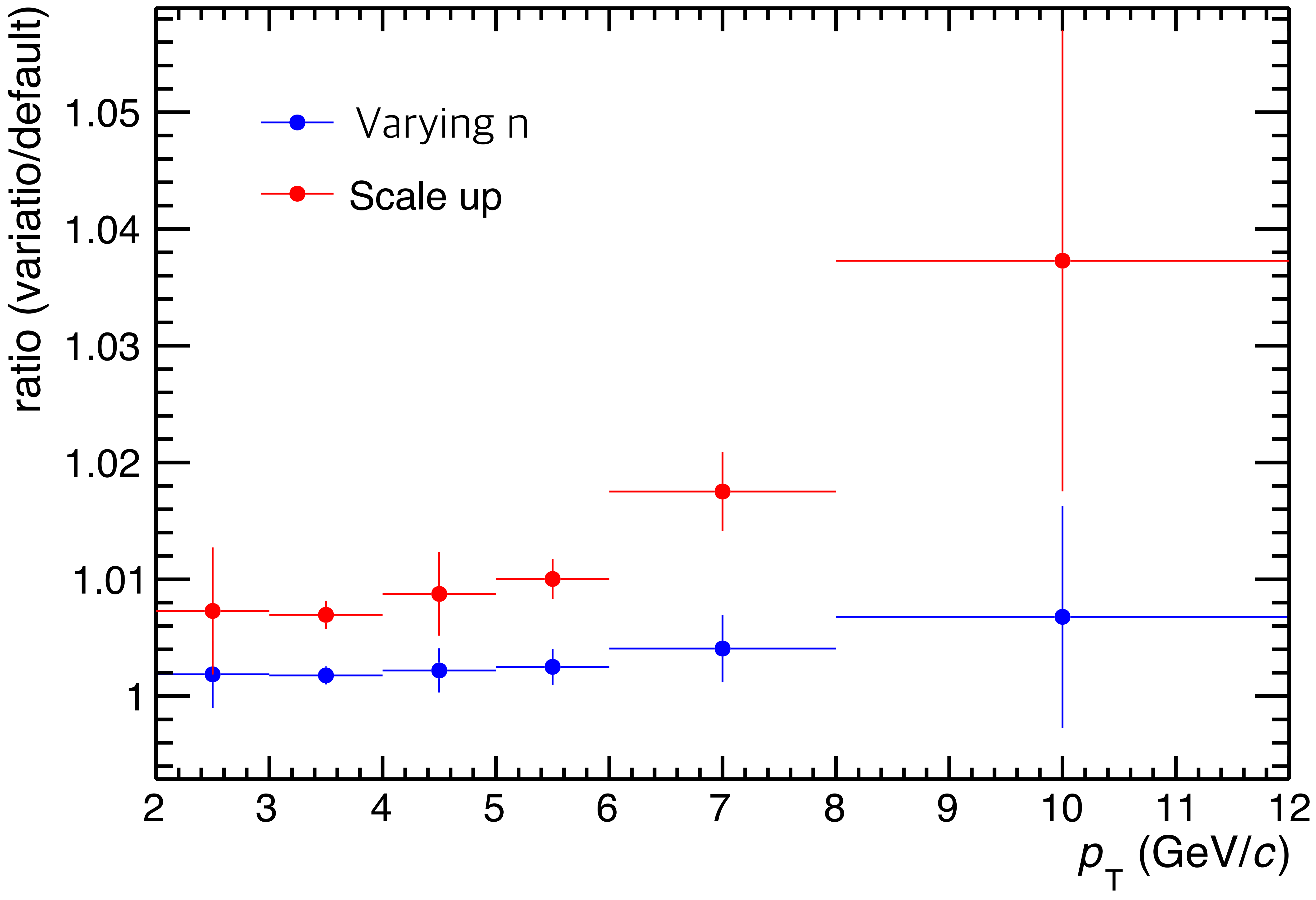
$$C \cdot p_T \left[1 + \frac{\sqrt{p_T^2+m^2}-m}{nT}\right]^{-n}$$

CMS: $n = 7.6 \pm 0.4$, $T = 1.10$ GeV (

- **Varying the parameters of the Tsallis function**
  - The uncertainties on the bottom baryon correction are estimated by varying the parameters of the Tsallis function.
    1. Varying n : varied by 1σ (7.6→8.0)
    2. Scale up: CMS estimated the uncertainties on the cross section in the p_T range above 10 GeV/c to be ~50%

       ➡The normalization of the Λ_b spectrum is scaled up by the uncertainty.
  - **Systematic uncertainty is assigned by scale up as 1% at 2 to 6 p_T and 2% 6 to 12 p_T.**



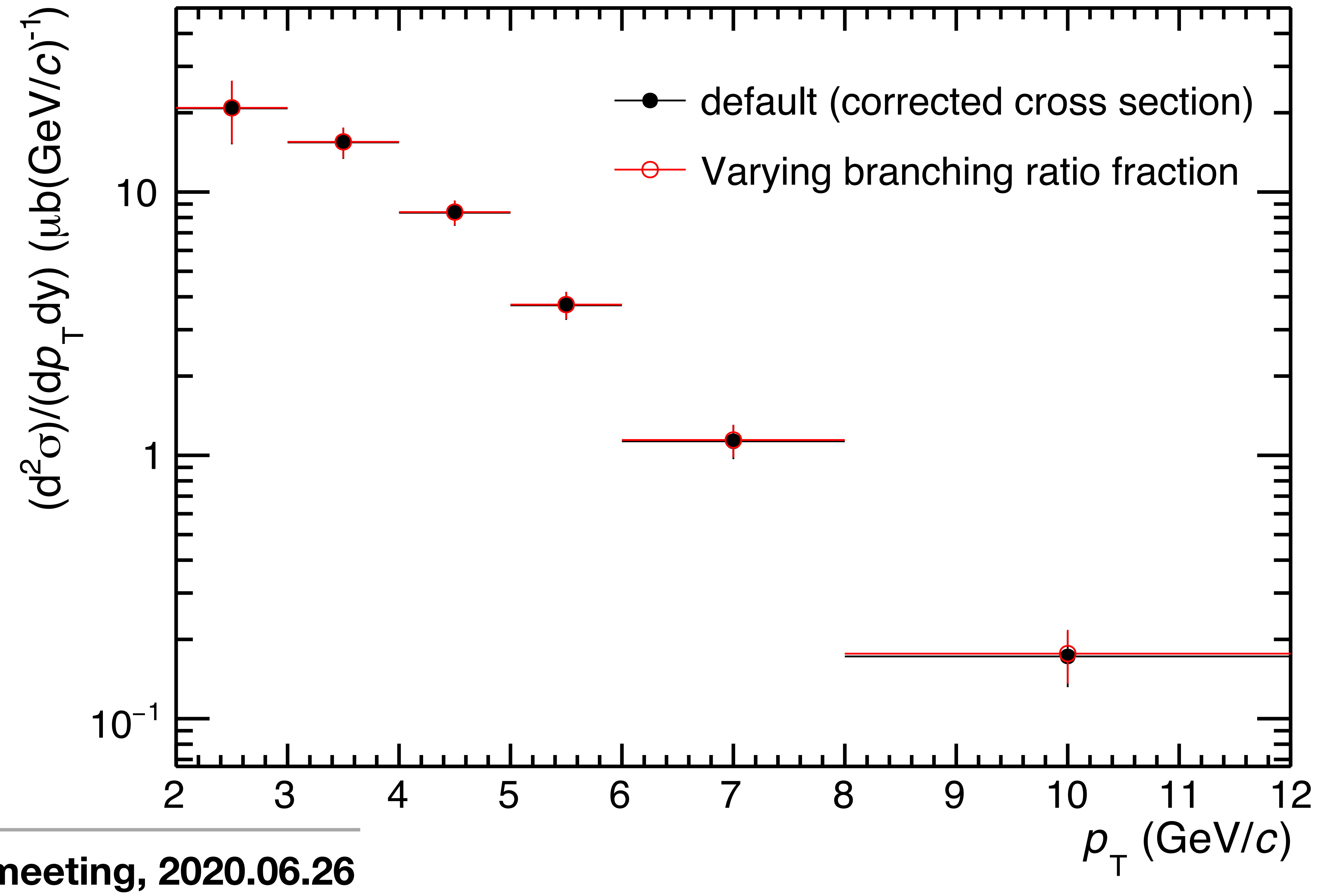


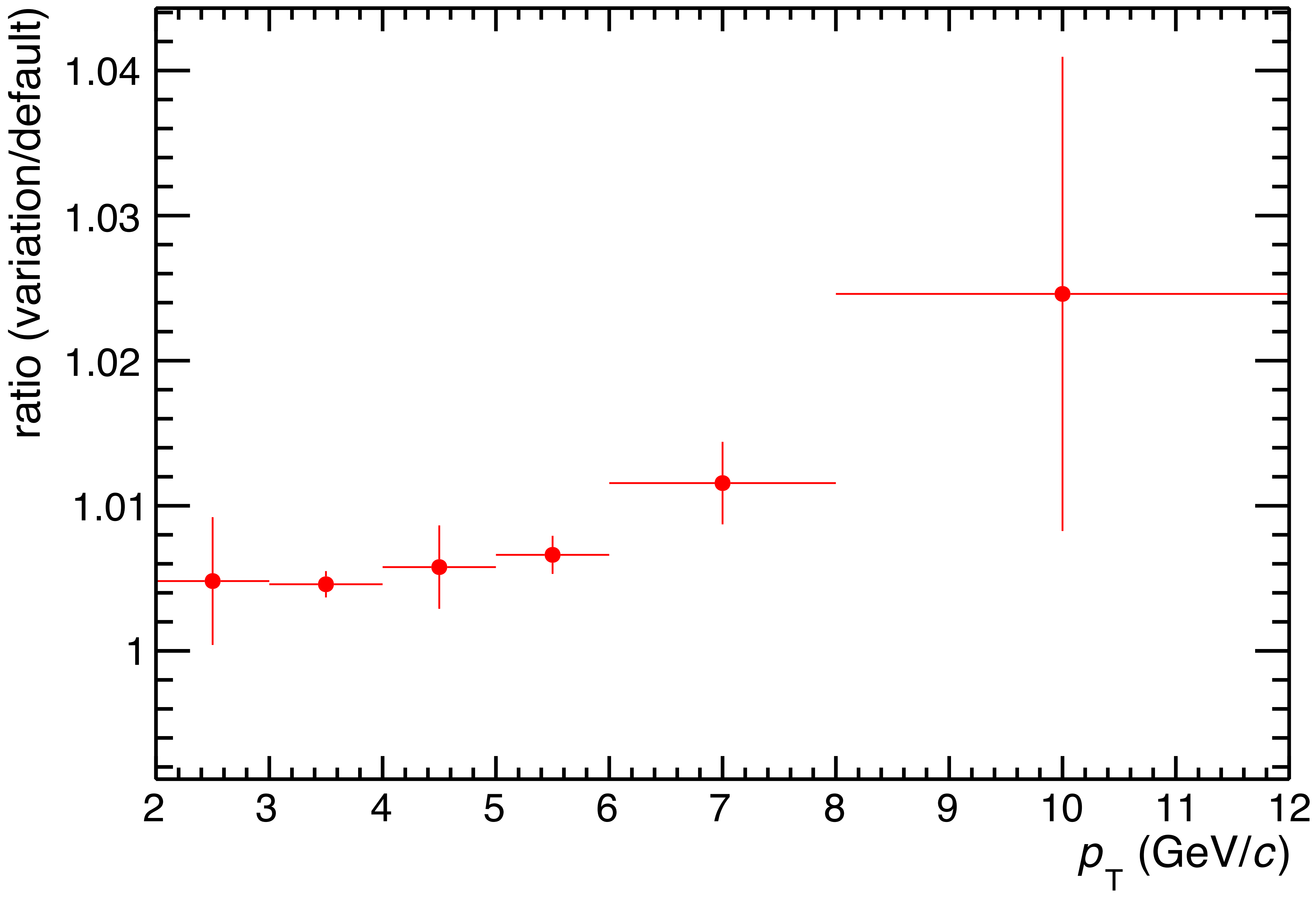
- Systematic uncertainty of oversubtraction

$$\frac{BR(b \to \Xi_b)BR(\Xi_b \to e\Xi\nu)}{BR(b \to \Lambda_b)BR(\Lambda_b \to J/\Psi\Lambda)}$$

- **Varying branching ratio fraction**
  - The $\Xi_b \to e\Xi X$ spectrum is generated based on $\Lambda_b \to J/\psi\Lambda$ spectrum.
  - The uncertainties on the $B(b\to\Xi_b)B(\Xi_b\to e\Xi X)$ (30%) and $B(b\to\Lambda_b)B(\Lambda_b\to J/\psi\Lambda)$ (14%) are added in quadrature

    ➡Total uncertainties of branching ratio fraction is 33%.
  - **Systematic uncertainty is assigned as 1% at 6 to 12 p_T.**
    - **cf) Uncertainty of scale factor obtained by B meson (FONLL) will not affect to cross section.**





- Question mark

- **Definition of branching ratio fraction**
  - In 7TeV analysis, CMS Λ_b cross section is used to correct the bottom baryon contribution.
    - Same Λ_b spectrum which used in 13TeV analysis.
  - In 7TeV analysis, branching ratio fraction is defined as

$$\frac{BR(b \to \Xi_b)BR(\Xi_b \to e\Xi\nu)}{BR(b \to \Lambda_b)BR(\Lambda_b \to e\Lambda\nu)}$$

  - In 13TeV analysis, branching ratio fraction is defined as

$$\frac{BR(b \to \Xi_b)BR(\Xi_b \to e\Xi\nu)}{BR(b \to \Lambda_b)BR(\Lambda_b \to J/\Psi\Lambda)}$$

Since CMS Λ_b cross section is defined as

$$\frac{\mathrm{d}\sigma(\mathrm{pp} \to \Lambda_\mathrm{b} X)}{\mathrm{d}p_\mathrm{T}^{\Lambda_\mathrm{b}}} \times \mathcal{B}(\Lambda_\mathrm{b} \to \mathrm{J}/\psi\,\Lambda) = \frac{n_\mathrm{sig}}{2 \cdot \epsilon \cdot \mathcal{B} \cdot \mathcal{L} \cdot \Delta p_\mathrm{T}^{\Lambda_\mathrm{b}}},$$

- Summary and Plan

- **Correction of oversubtraction caused by bottom baryon**
  - CMS Λ_b measurement is used to fit the spectrum down to 0GeV pT at 7TeV.
  - B meson ratio(scale factor) generated by FONLL is used to scale the Λ_b cross section.
  - Branching ratio fraction is multiplied to 13TeV Λ_b cross section to get a Ξ_b cross section.
  - Ξ_b contribution in WS is 2% at low p_T region, and 10% at high p_T region.
  - Bottom baryon contribution increases the cross section about 1~7%
- **Systematic uncertainty of oversubtraction**
  - Systematic uncertainty is assigned by scale up as 1% at 2 to 6 p_T and 2% 6 to 12 p_T.
  - Systematic uncertainty is assigned by branching ratio fraction as 1% at 6 to 12 p_T.
  - Systematic uncertainty generated n(fitting parameter) and scale factor is not assigned.

- **Plan**
  - All systematic uncertainty are recalculated with bottom baryon correction.
  - Check the charge asymmetric background??
  - Any suggestions??

Back up

- Cut list

Event cut variables	Cuts
Physics selection	AliVEvent::kINT7
Primary vertex	Within 10cm
Pile up	Rejection

Track cut variables	Cuts
Track Filter bit	kTrkGlobalNoDCA
Number of CrossedRows	>70
CrossedRows over findable clusters	>0.8
Number of TPC PID clusters	>50
Ratio to findable cluster	>0.6
ITS/TPC refit	TRUE
Number of ITS cluster	>=3
pt	>0.5
|η|	<0.8
SPD hit	Both
|TOF nσ|	<3
TPC nσ	$f(P_T) \sim 3$

$f(P_T) = -3.9+1.17P_T-0.094P_T^2$

Xi cut variables	Cuts
Number of CrossedRows	>70
CrossedRows over findable clusters	>0.77
Λ Mass tolerance (MeV/c2)	7.5
Ξ Mass tolerance (MeV/c2)	8
DCAof V0 to PV(cm)	>0.03
DCA f V0 daughters PV (cm)	>0.073
V0 cosine pointing angle to Ξ vertex	>0.983
DCA of bachelor track to PV (cm)	>0.0204
V0 decay length (cm)	>2.67
Ξ decay length (cm)	>0.38
TPC nσ (proton)	<4
TPC nσ (pion)	<4

- eXi pair distribution from Xib

- **Track cut and Xi topology cut are applied.**
- **Invariant mass distribution does not have a peak due to missing neutrino.**
  - Opening angle cut is applied.
  - Above 2.5GeV is rejected since 2.5GeV is pair mass cut for Xic analysis.
- **Opening angle distribution is obtained after invariant mass cut**
  - Below 0 is rejected since 0 is pair opening angle cut for Xic analysis.