# Search for intrinsic charm at ATLAS experiment

**Yu. Yu. Stepanenko[1,3]**

in collaboration with

**G. Lykasov[1], V. Bednyakov[1], S. Brodsky[2], A. Lipatov [1,4], A. Prokhorov[1], S. Turchikhin[1], J. Smiesko[5]**

[1]JINR, Dubna,

[2]SLAC, Stanford University,

[3]Gomel State University, Gomel, Belarus

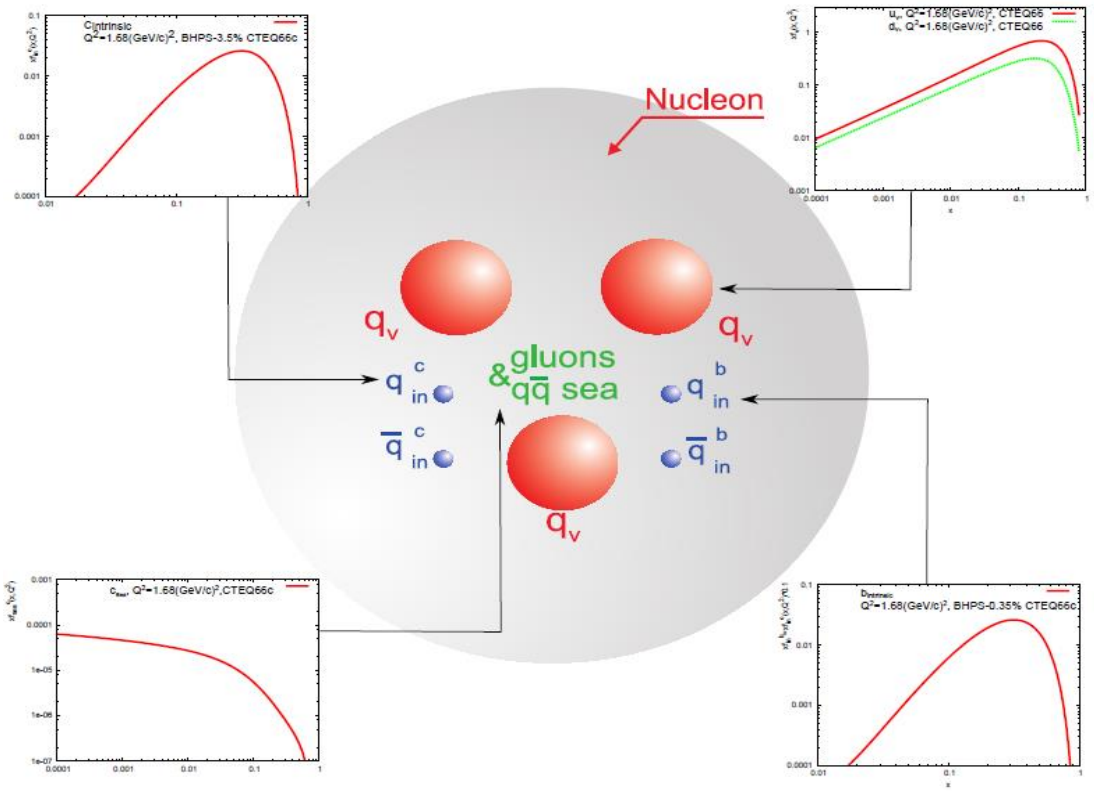
[4]SINP, MSU, Moscow,

[5]Comenius University in Bratislava

Physics of fundamental interactions
dedicated to 50th anniversary
of Baksan Neutrino Observatory
6-8 June 2017, Nalchik

# Intrinsic Charm (IC) in proton

## Intrinsic $Q\bar{Q}$ in proton

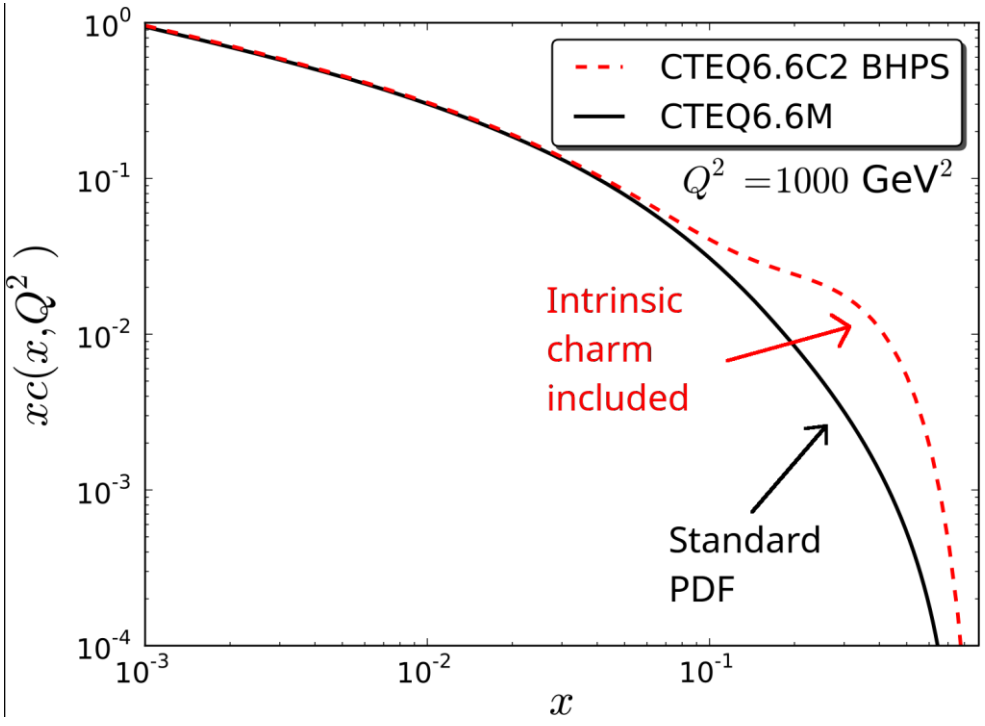



- **BHPS model** (S.J. Brodsky,P. Hoyer, C. Peterson and N.Sakai, Phys.Lett.B9(1980) 451; S.J. Brodsky, S.J. Peterson and N. Sakai, Phys.Rev. D23 (1981) 2745.)
- *extrinsic* and *intrinsic* contributions in proton
- Existence of the 5-quark state in proton: valence $uud$ and heavy intrinsic $c\bar{c}$ $(b\bar{b})$ pair, i.e $|uudc\bar{c}>$

Schematic view of a nucleon consisting of three valence quarks $q_v$, quark-antiquark $q\bar{q}$ and gluon sea, and pairs of the intrinsic charm $(q^c_{in}\bar{q}^c_{in})$ and intrinsic bottom quarks $(q^b_{in}\bar{q}^b_{in})$. Right top corresponds to valence u(x) and d(x) distributions at $Q^2$ =1.68 (GeV/c)$^2$; the left bottom is the sea charm quark distribution; the left top is the intrinsic charm x-distribution and the right bottom is the intrinsic bottom x-distribution at the same $Q^2$ value

# Intrinsic charm density in a proton as a function of IC probability w

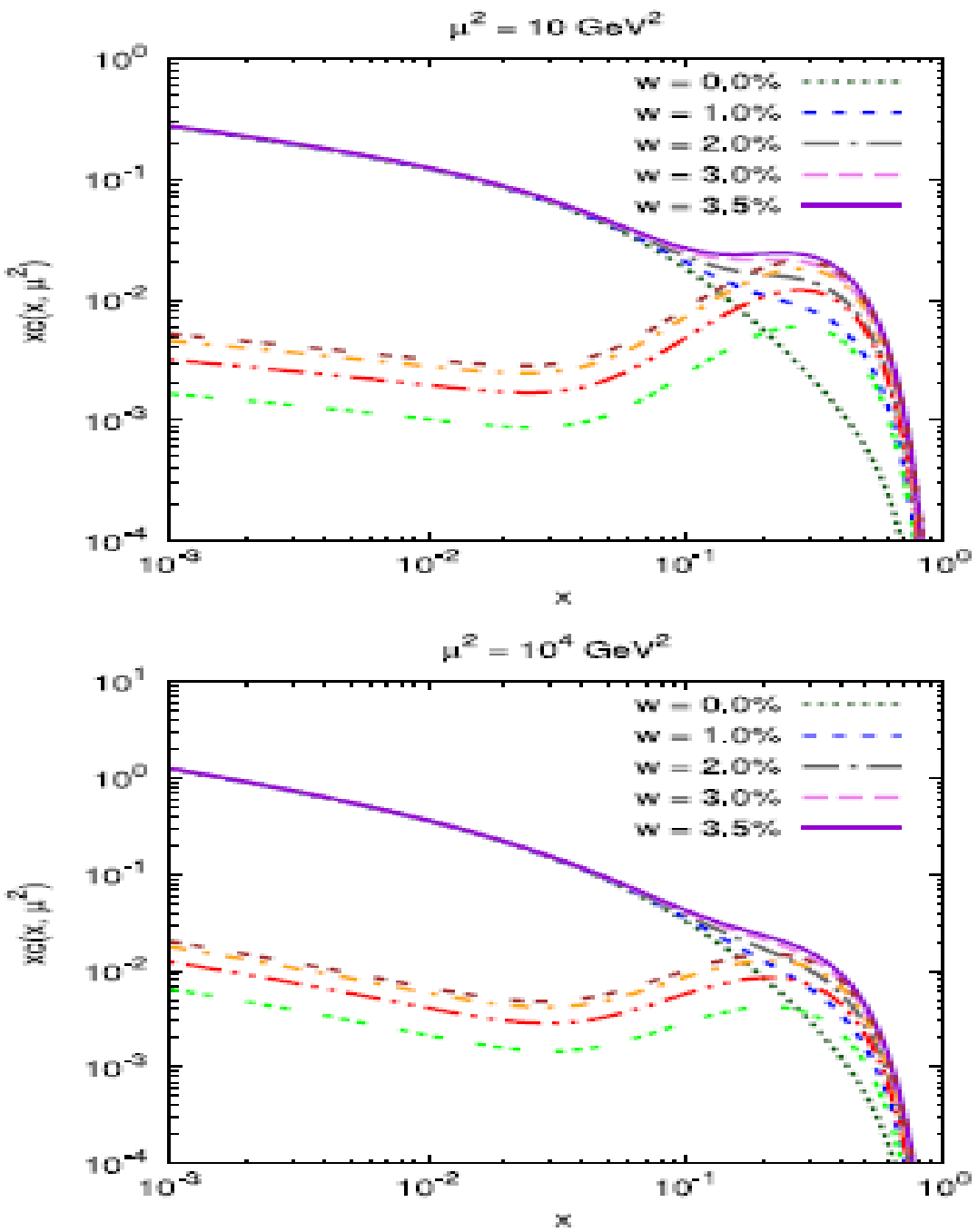
- PDF has shape similar to that of valence quarks
- The largest intrinsic charm contribution possible 3.5 % (constraints from the HERA data)
- The intrinsic charm contribution dominates compared to the extrinsic one at x>0.1
- IC effect expected at hight pT (pT>100 GeV) and forward η region (1.5<eta<2.4)

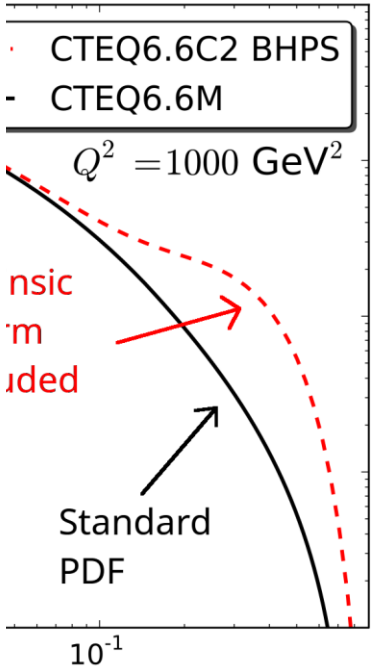



$$x = \frac{2p_T}{\sqrt{S}} \sinh(\eta)$$

# Intri ton as w

- PDF h that c
- The la charr possi (cons HERA
- The i contr comp extri
- IC eff hight and f (1.5<




$h(\eta)$

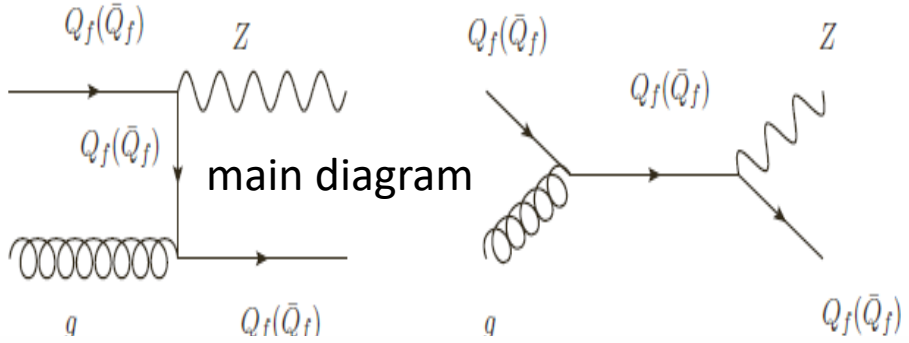
# Main goal

***searching for the signal of the intrinsic charm (IC) contribution in proton from the analysis of the prompt photon or Z/W boson production in p-p collision accompanied by heavy c(b)-jet.***

## We have predictions on *IC*

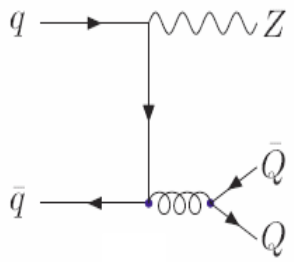
- ***PP->γ + c +X :*** *V.A.Bednyakov, M.A.Demichev,G.Lykasov, T.Stavreva, M.Stockton, Phys.Lett. B728, 602 (2014)*
- ***PP->Z/W+ c(b)+X :*** *H.Beauchemin, V.A.Bednyakov, G.Lykasov, Yu. Yu. Stepanenko, Phys.Rev.D92, 034014 (2015)*
- ***PP->γ/Z+ c(b)+X :*** *A. Lipatov, G.Lykasov, Yu. Stepanenko V.A.Bednyakov, Phys.Rev.D94, 05301 (2016)*
- ***Collider tests of heavy PDF:*** *S.J.Brodsky, V.A.Bednyakov, G.Lykasov, S.Tokar, J.Smiesko, Prog. In Part. Nucl.Phys., 93, 108,(2017).*

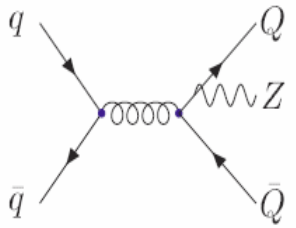
# pp->Z\γ+Q+X (Q-heavy flavor c\b)



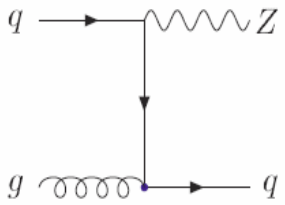

main diagram

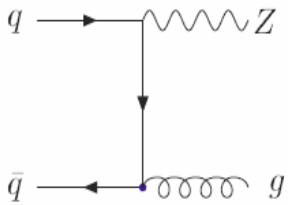


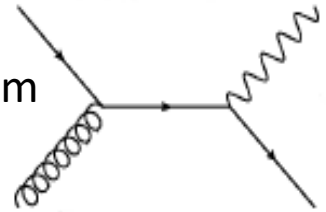



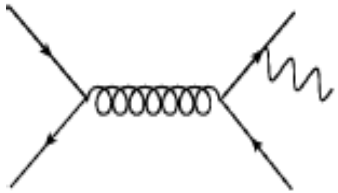

ISR and FSR

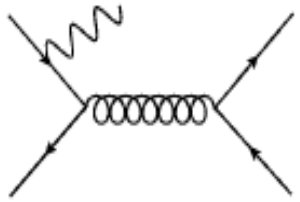


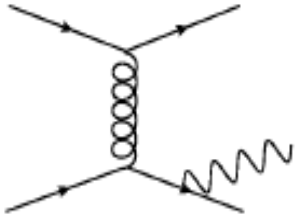

main diagram

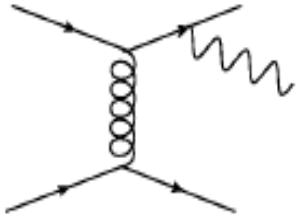






ISR and FSR contribution, fragmentation

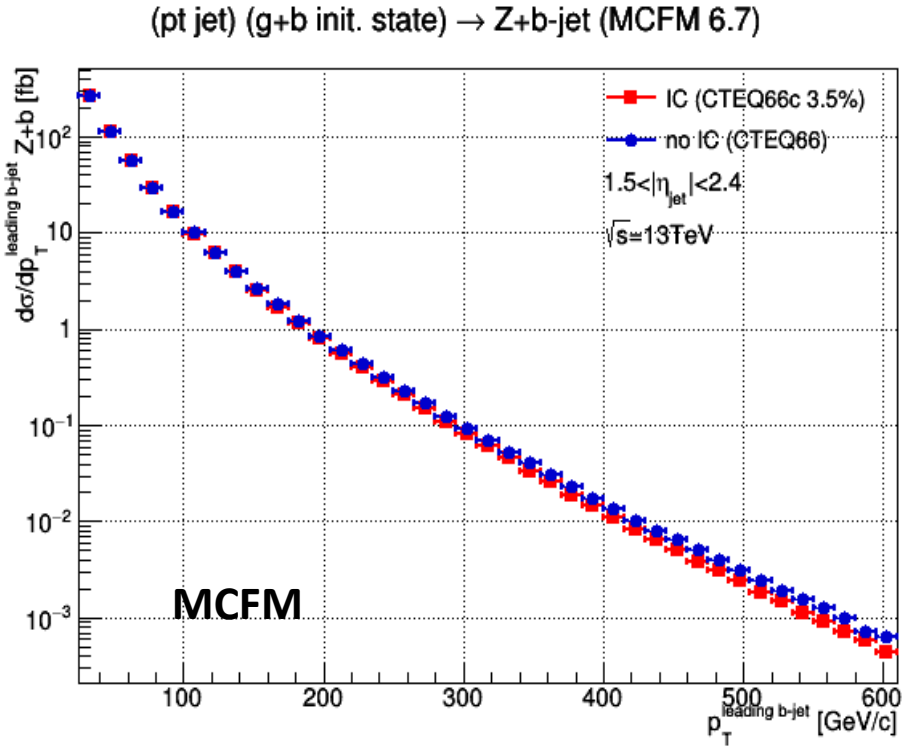


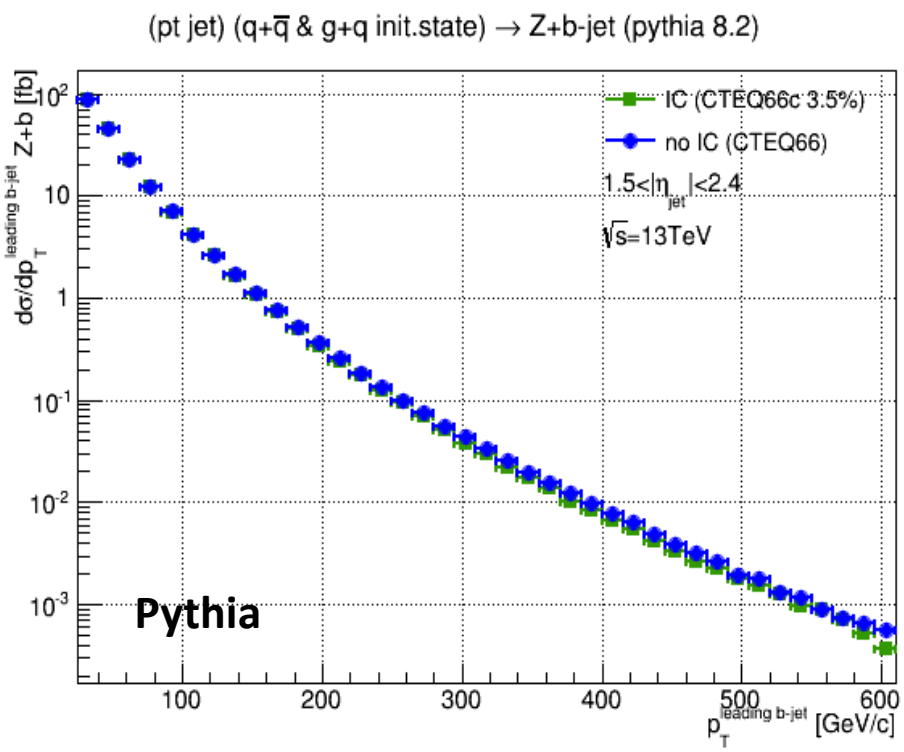


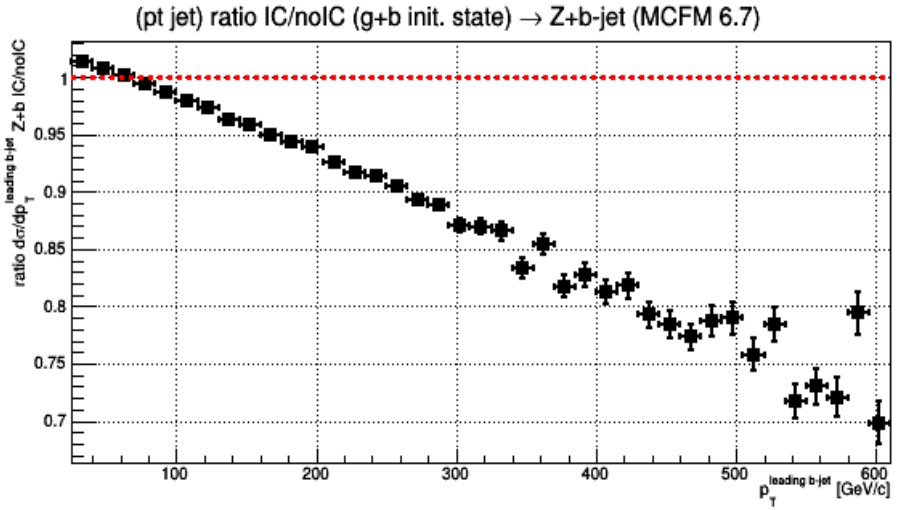
**pp-> Z+Q+X**

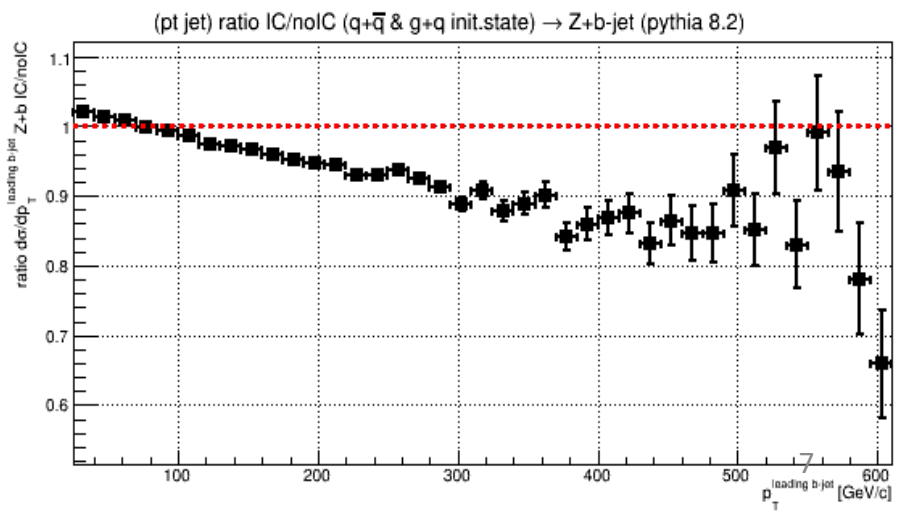
**pp-> γ+Q+X**

# pT leading jet distribution Z+b-jet

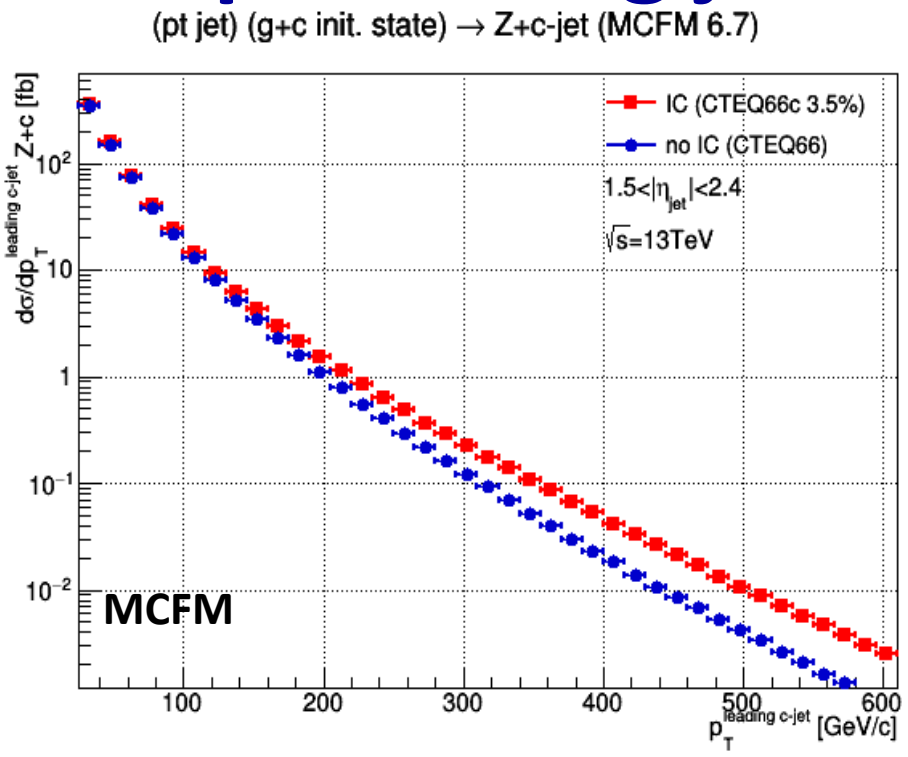


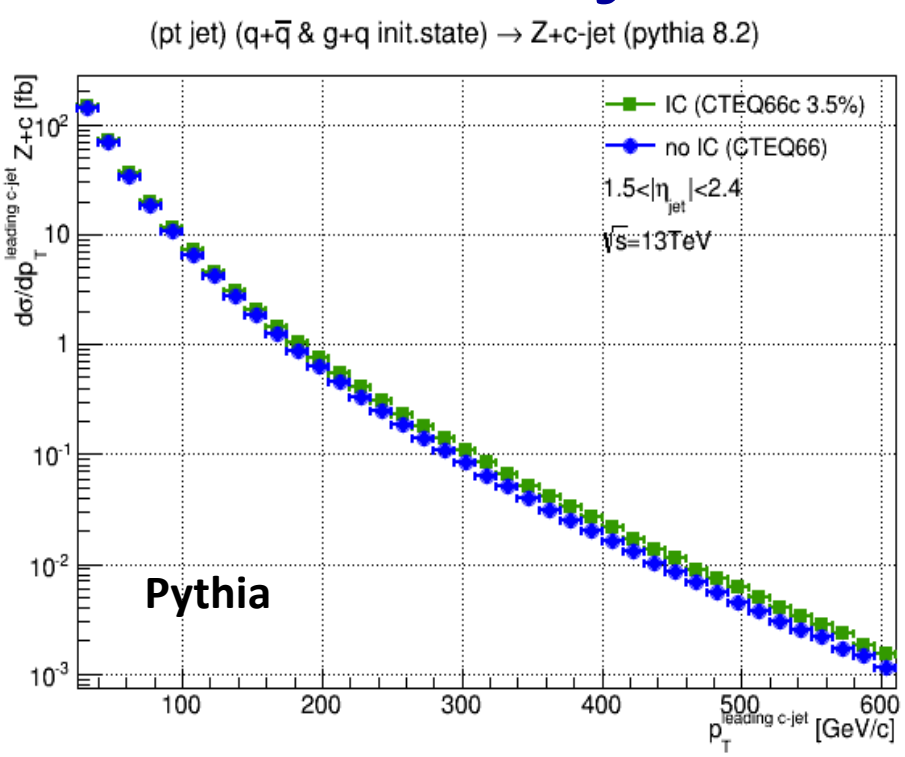



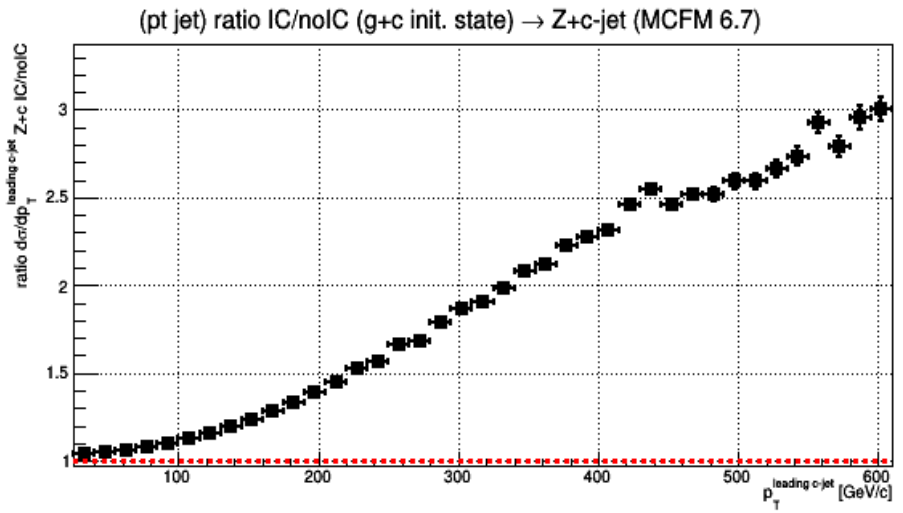



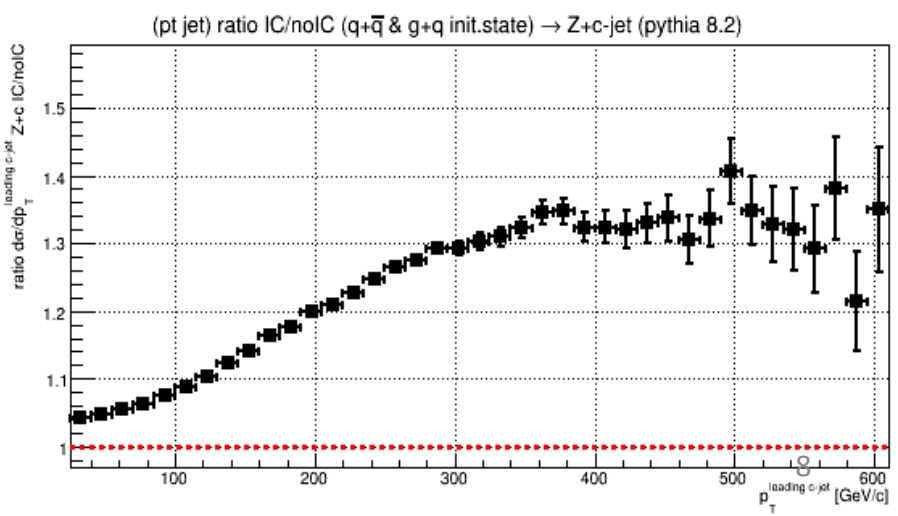



# pT leading jet distribution Z+c-jet

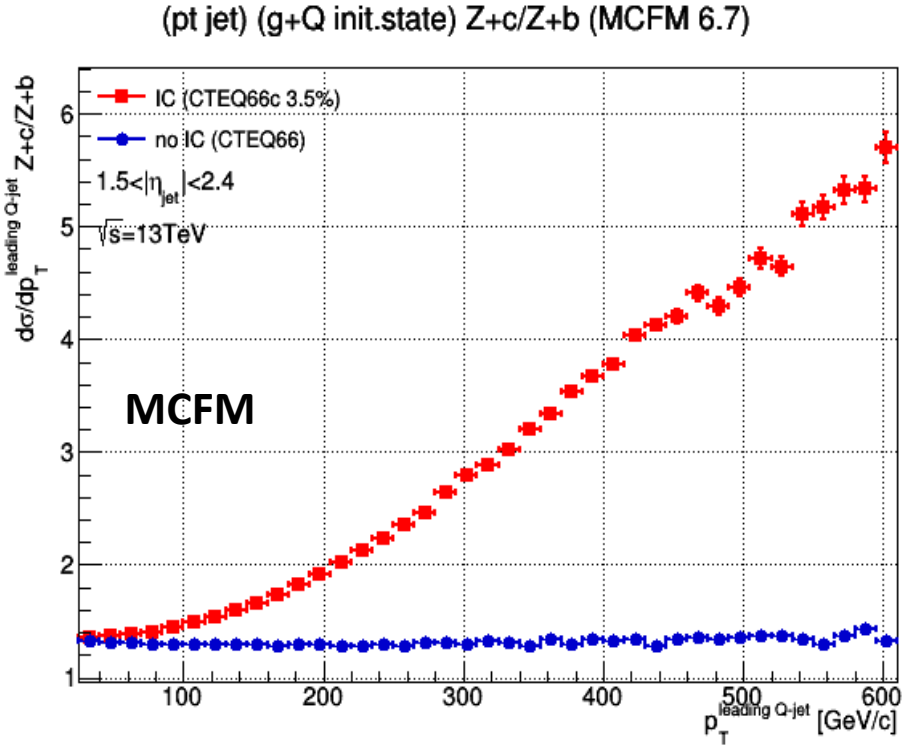


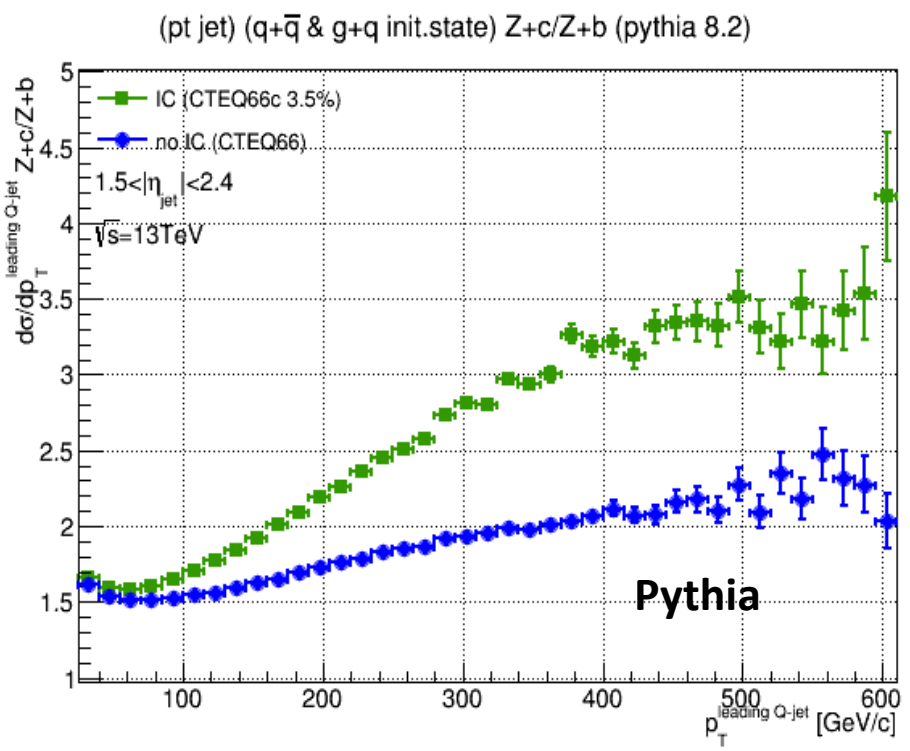



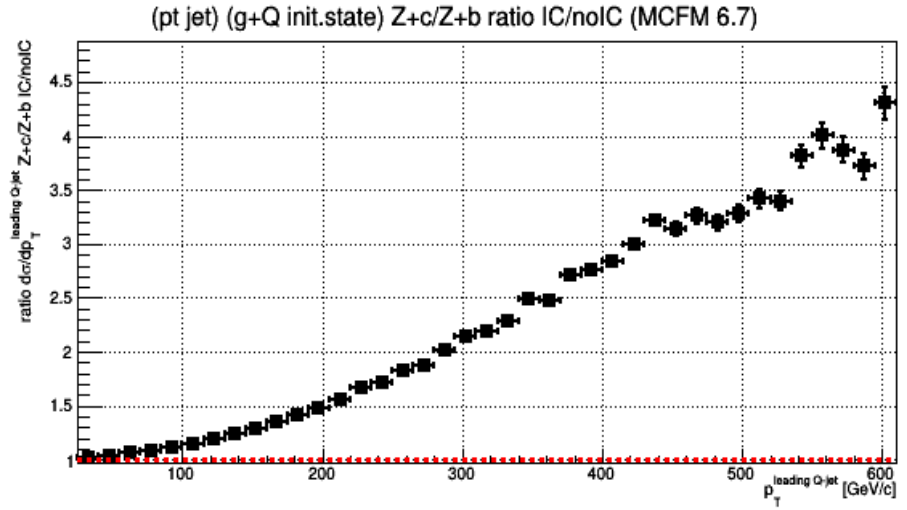



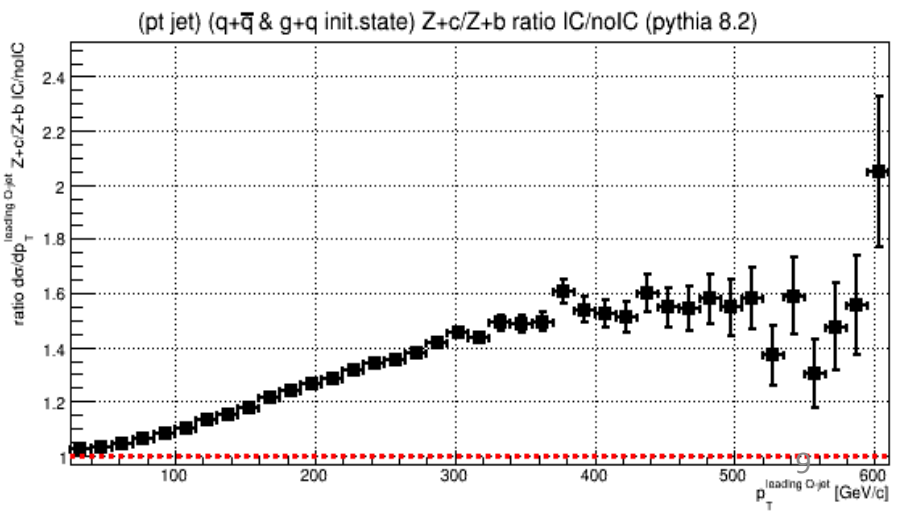



# pT leading jet distribution Z+c/Z+b



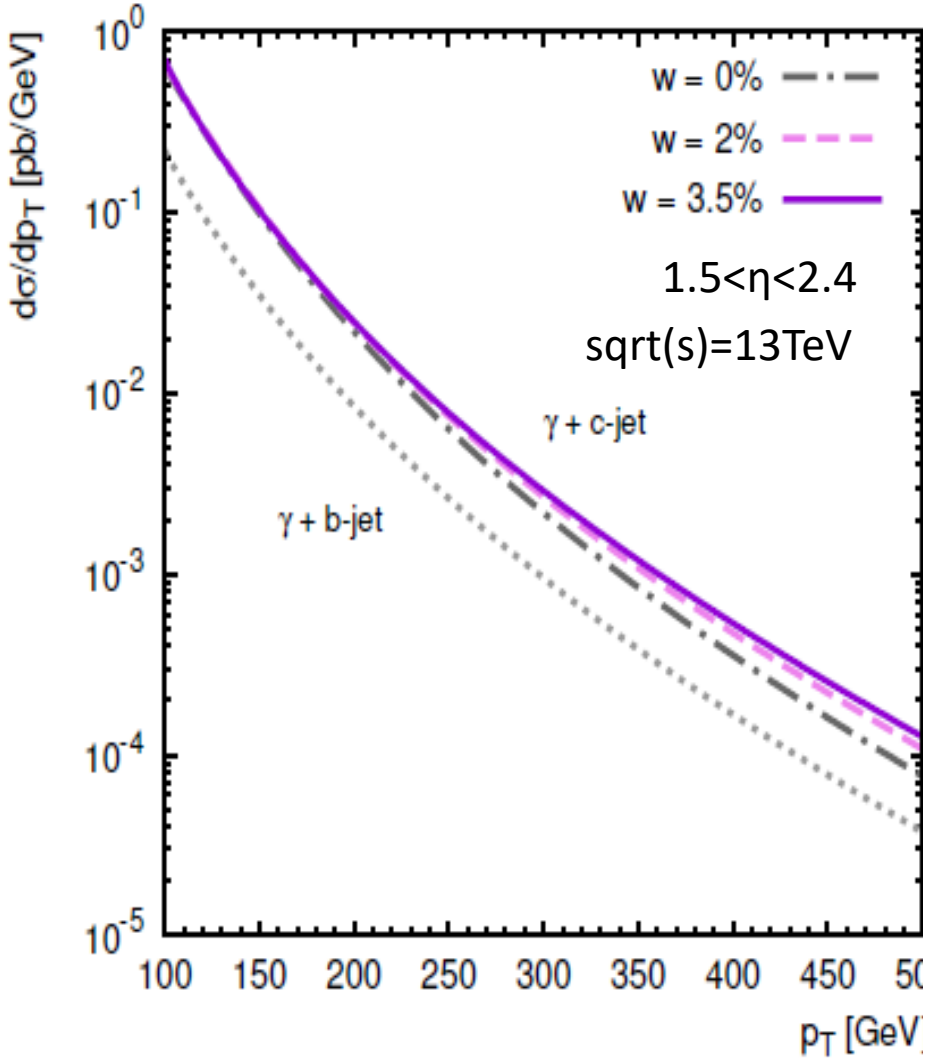



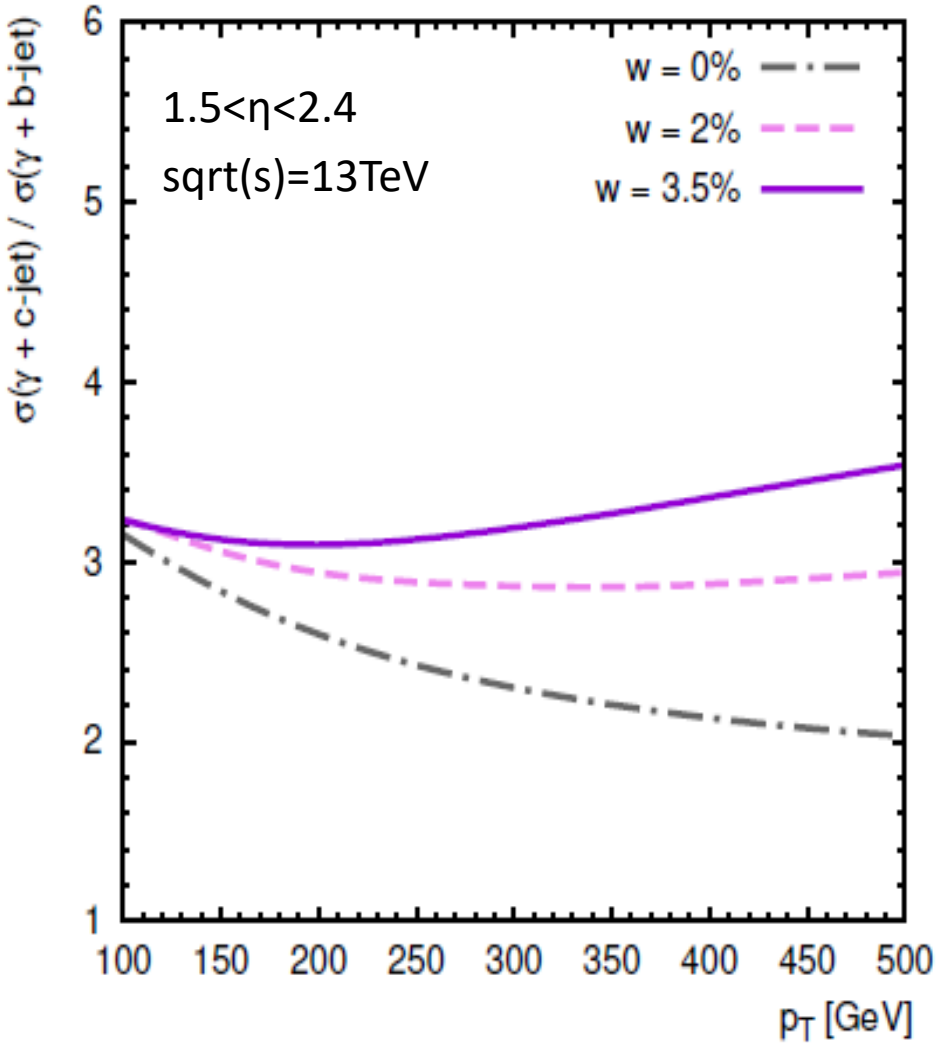



# pT leading jet distribution γ+c-jet/γ+b-jet

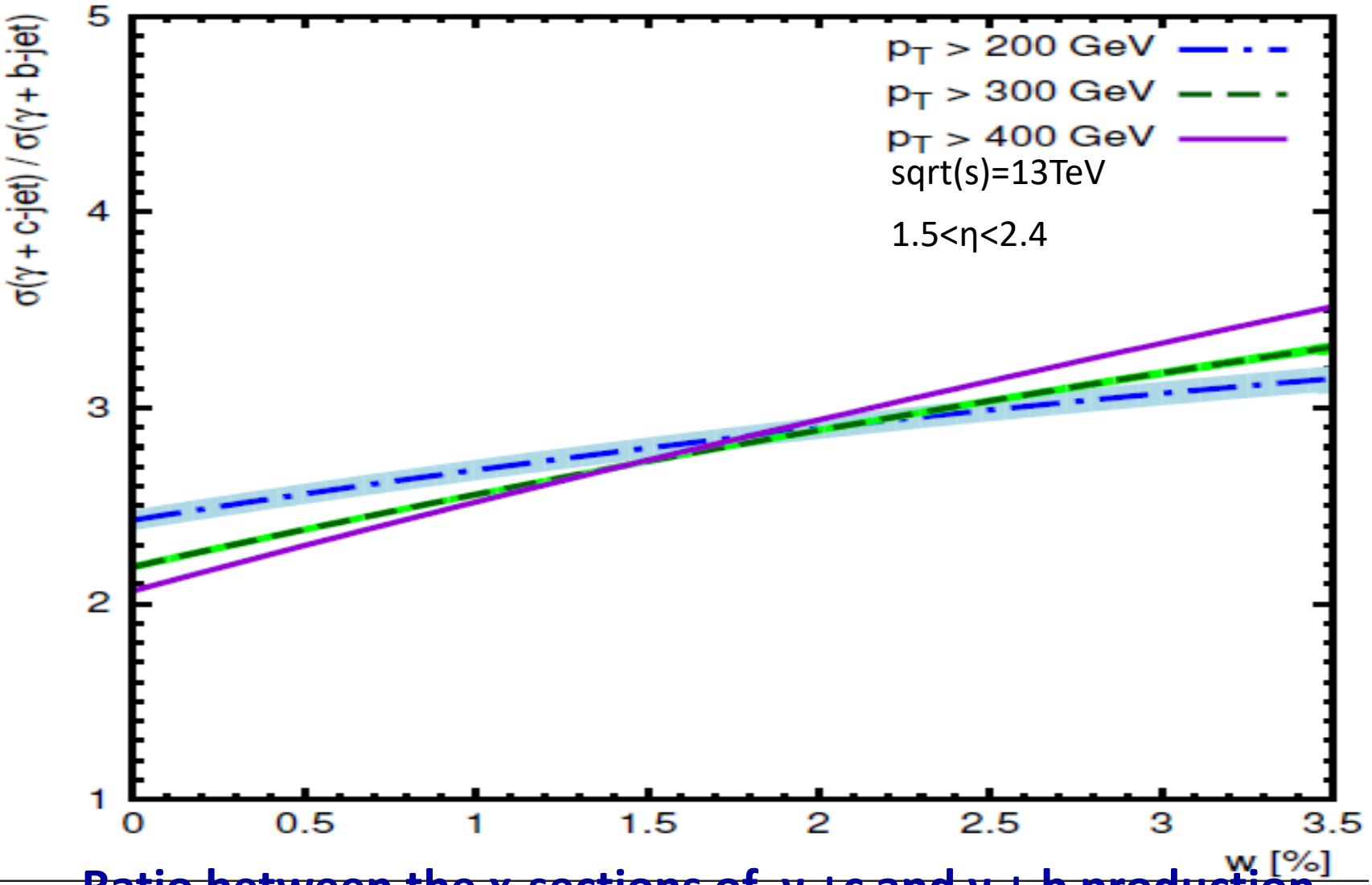
pT leading jet distribution




Ratio γ+c/γ+b

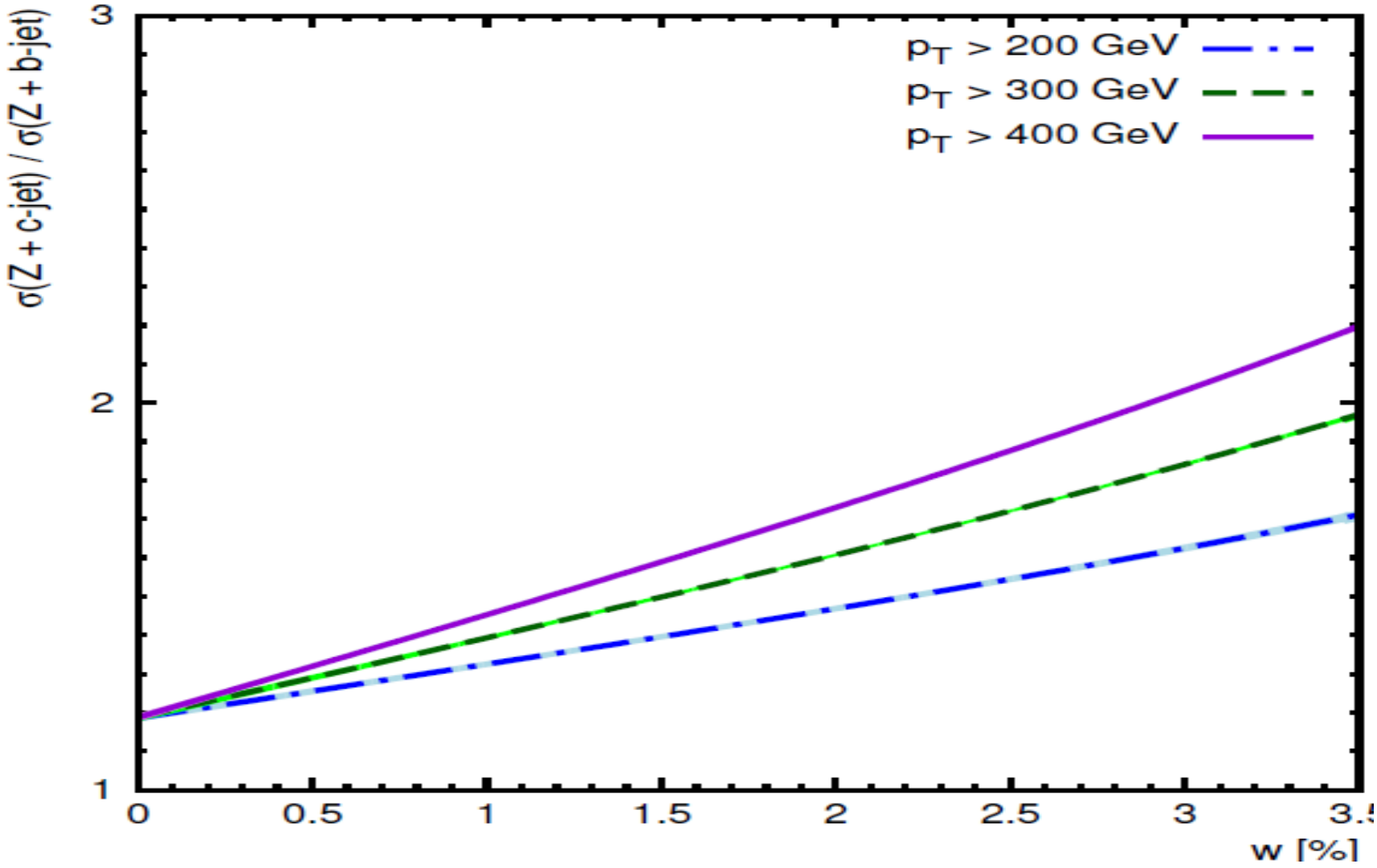


# pp → γ + Q +X , Q = c,b



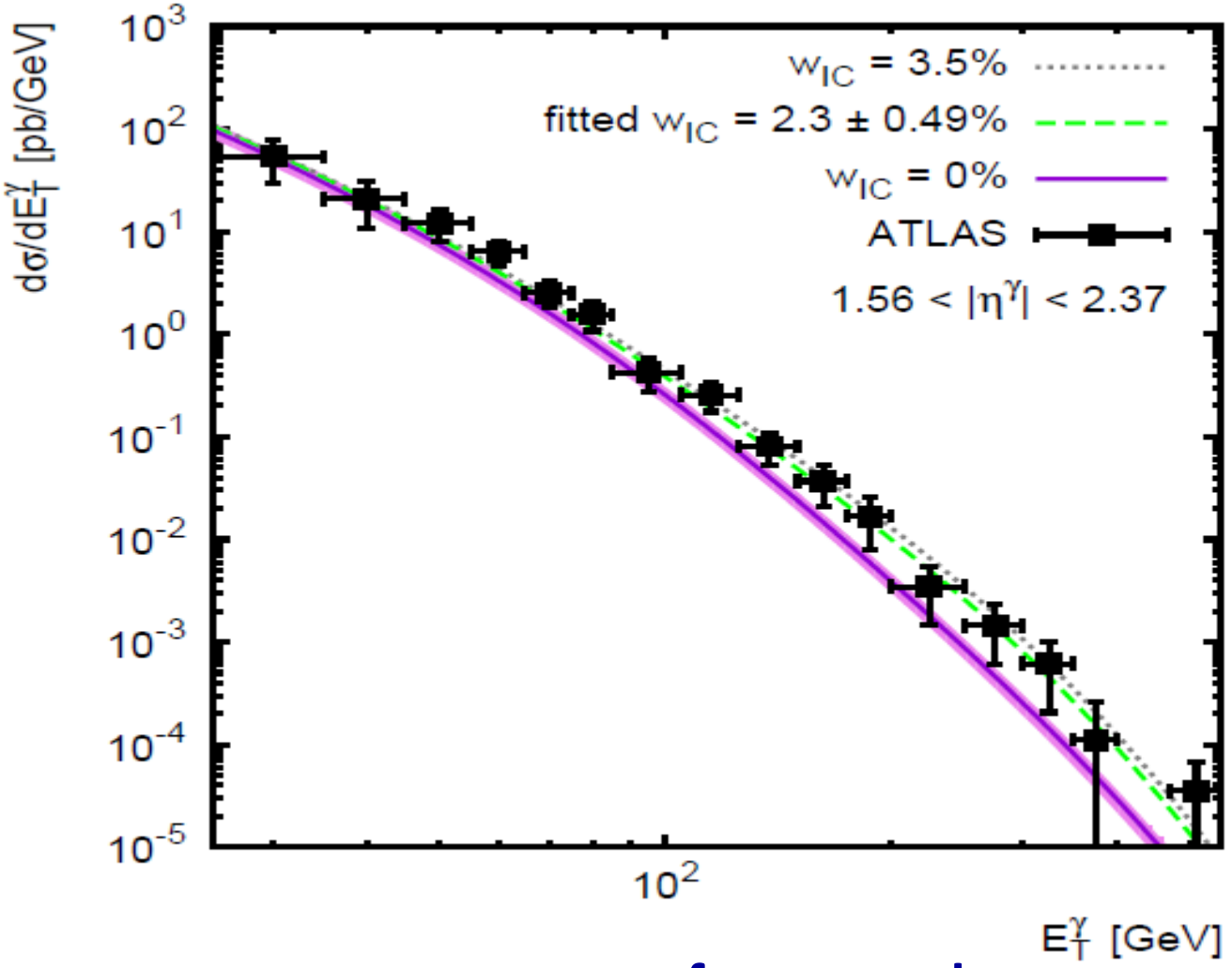

**Ratio between the x-sections of γ +c and γ + b production integrated over $p_T$. Bands mean the QCD scale uncertainty**

# pp→ Z + Q +X , Q = c,b




**Ratio between the x-sections of Z +c and Z + b production integrated over $p_T$. Bands mean the QCD scale uncertainty**

# Finding of the *IC* probability w_{*IC*} from the fit of preliminary ATLAS data




**Transverse energy spectrum of prompt photons γ accompanied by c-jet at different values of $w_{IC}$**

# SUMMARY

1. The hypothesis of *intrinsic* quark components at large x was motivated by possible explanation of the large cross section for the forward open charm production in p-p at ISR.
2. However, the accuracy of such experimental data at large x does not provide precise constraints on the *IC* probability.
3. The production of prompt photons or gauge bosons accompanied by heavy jets (c,b) can provide an ideal method to verify the *IC* probability in proton.
4. The increase of $p_T$ – spectrum of *γ/Z/W* or *c/b*-jets produced at large $p_T$ and the forward rapidity region of ATLAS or CMS due the the *IC* enhancement in the PDF is predicted.
5. We have a preliminary code allowed us to extract the *IC* probability in proton from the ATLAS data.
6. Another NLO generators under under investigation now (SHERPA, MadGraph)

# Thank You for attention!!