RRTF - HQ
Charm baseline pT distribution in pp, shadowing and fragmentation function

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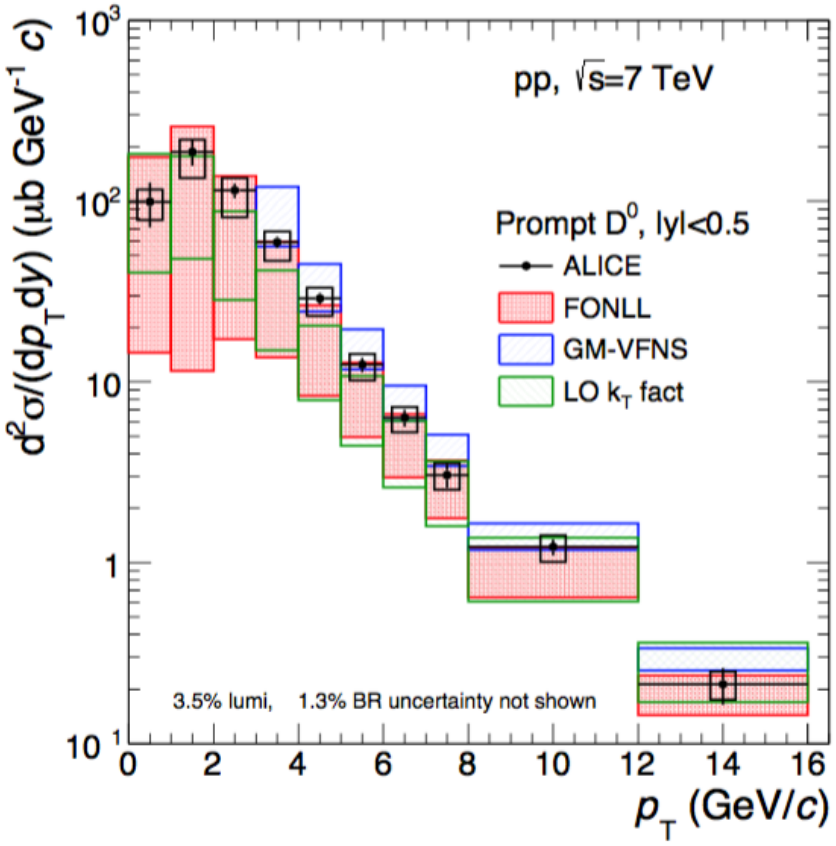
Baseline pT distribution: Procedure

- Data:
  - ALICE D0 meson pp 7 TeV in 0<pT<16 GeV, arXiv:1605.07569 (DONE)
  - CMS D0 meson pp 5 TeV in 2<pT<100 GeV, Prel. (TO BE ADDED SOON)
- Theory: FONLL D0 with 7 scale sets (all with mc=1.5) + central scales with mc=1.3,1.7; energies 5TeV and 7TeV
- Make ratios of Data/FONLL and fit it with a constant
  - Remove global syst. uncertainties from data for this
- Keep the FONLL curves (mass and scale sets) for which fit $\chi^2<2$
- Choose central value (best fit to constant) and 2 extreme cases (extreme slopes, still fitting the data)
- Take the FONLL cross sections for c-quark corresponding to these scale choices at Pb-Pb energies (2.76 and 5 TeV)
  - i.e. we select the FONLL parameters at 5 and 7 TeV and then use the same parameters also for 2.76 TeV

Exercise at 7 TeV

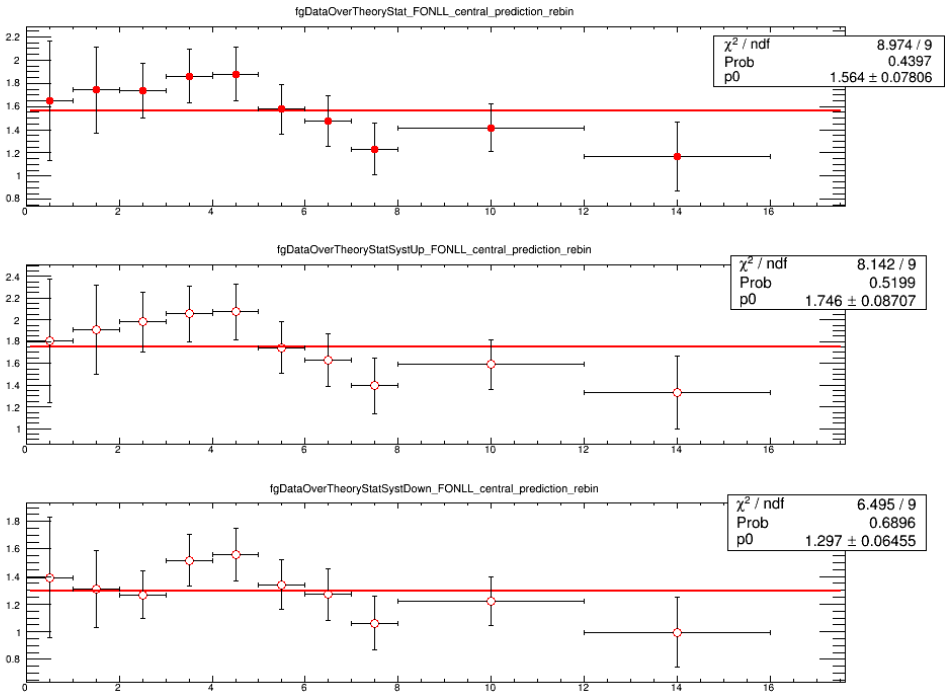
- D0 7 TeV cross section from 1605.07569



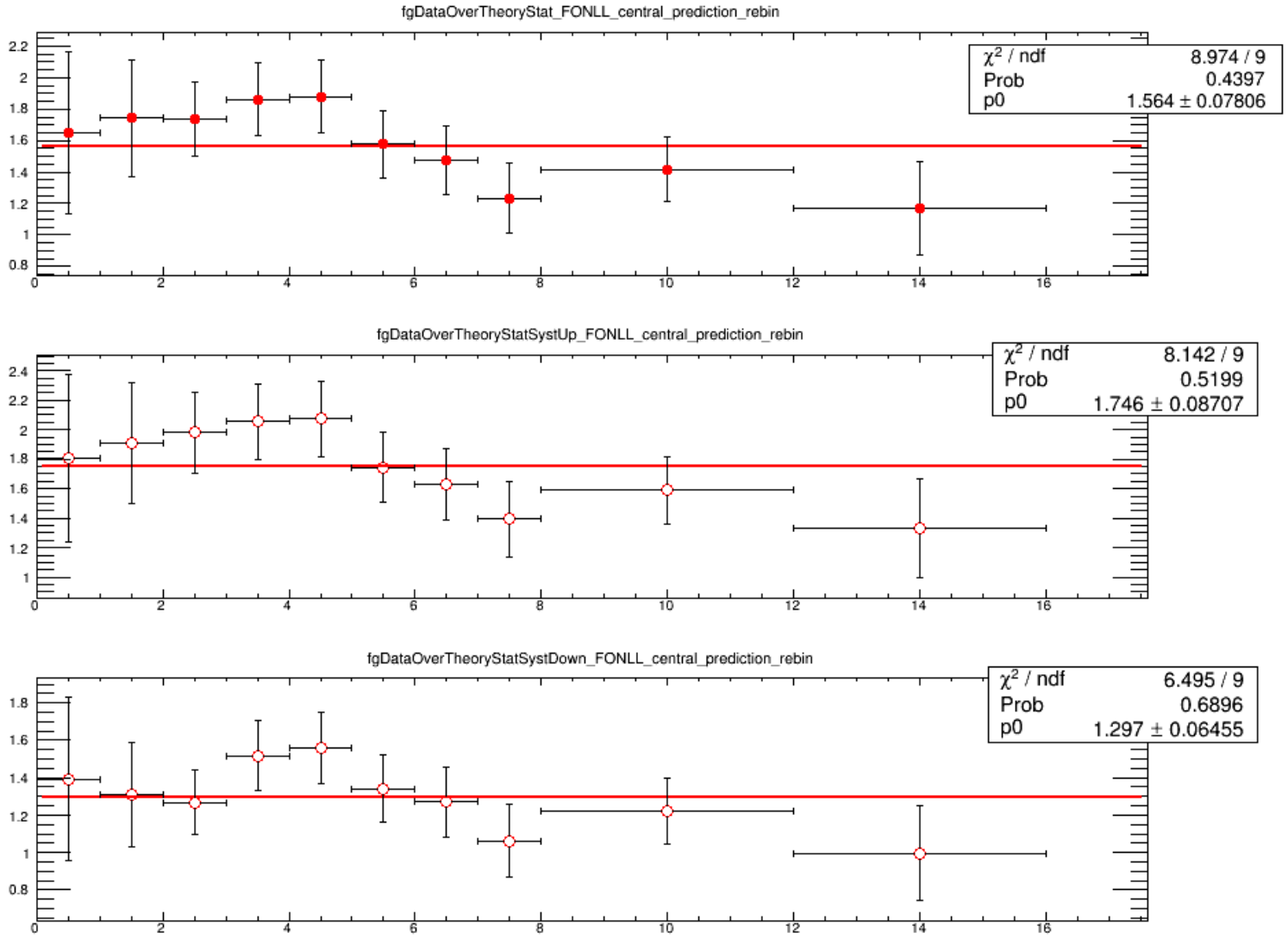
Fit of data/FONLL ratio

- Point-by-point errors are pT-uncorrelated: statistical + yield extraction
- pT-correlated error: tracking+feeddown+PID+Mcshape (i.e. total syst – yield extraction)
- Three fits done for each FONLL curve: a) data, b) data shifted to upper limit of correlated error, c) data shifted to lower limit of correlated error
- FONLL curve is considered to describe the data (i.e. not rejected) if at least one of the three χ^2/ndf is <2

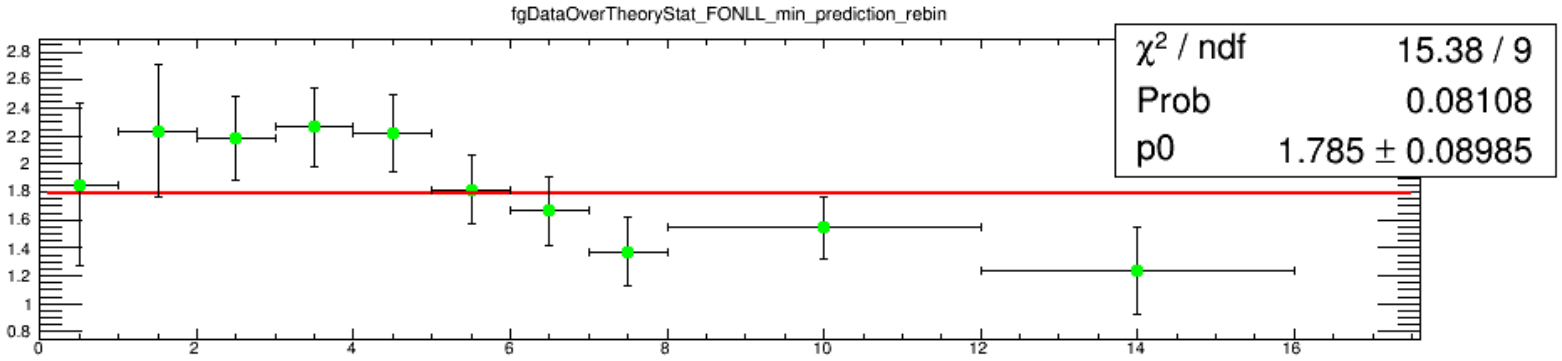
Example: FONLL central curve

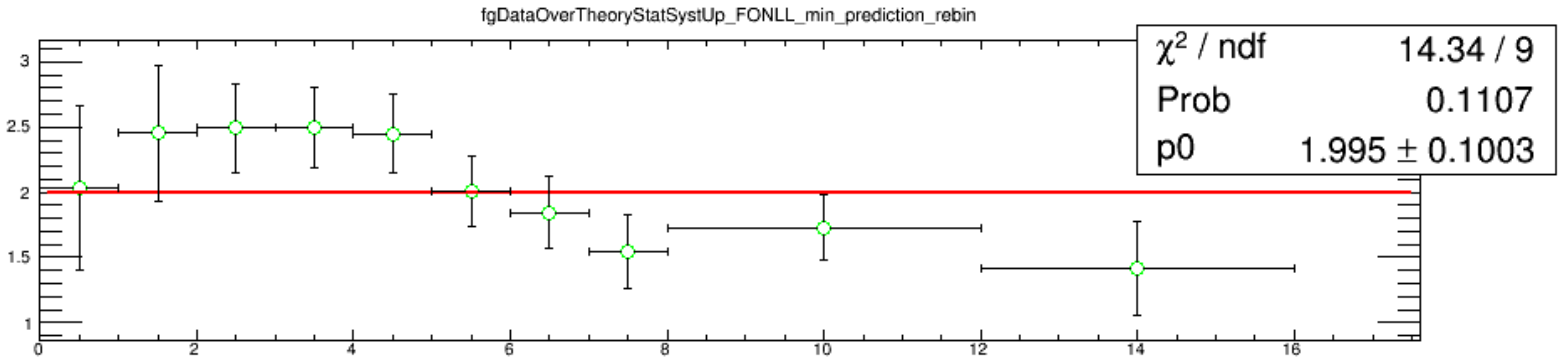


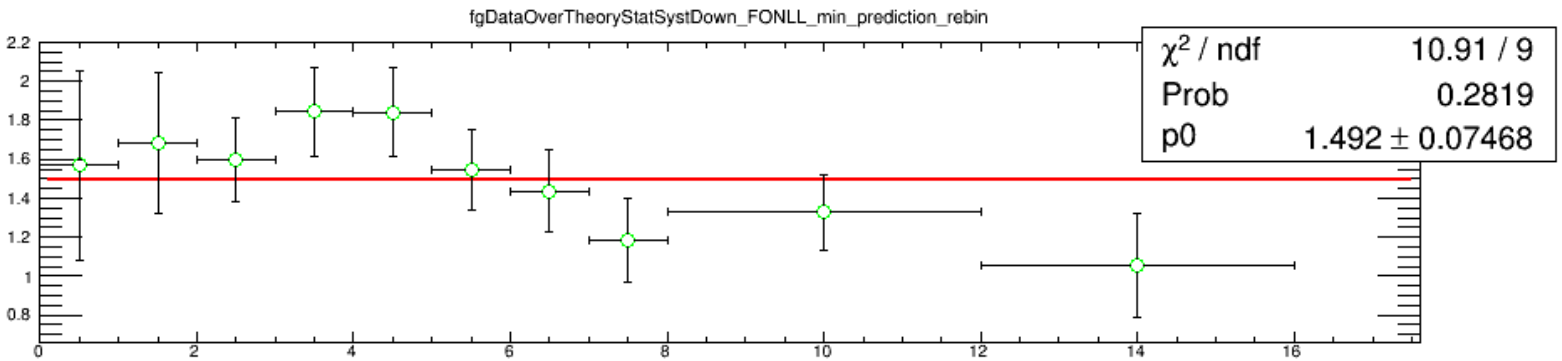
FONLL central, $(\mu_F/\mu_0,\mu_R/\mu_0)=(1,1)$, m=1.5



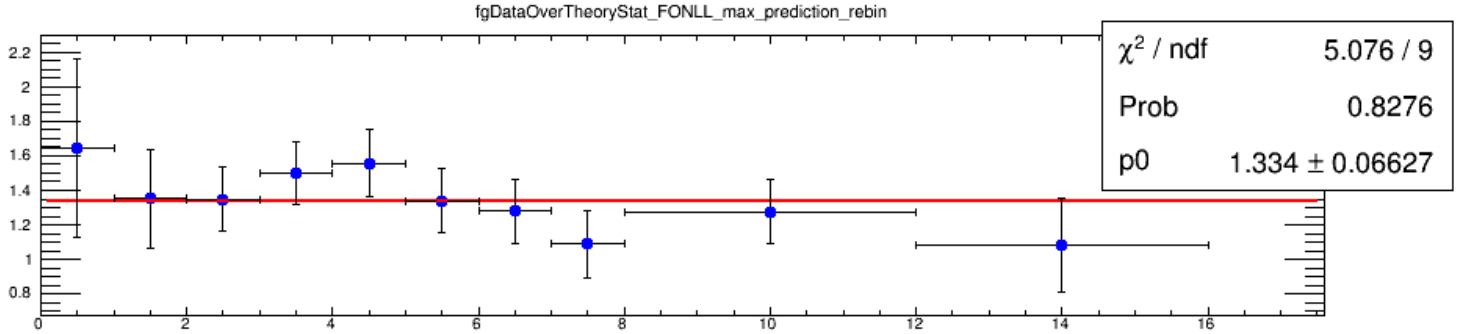
$(\mu_F/\mu_0,\mu_R/\mu_0)=(1,1)$, m=1.7

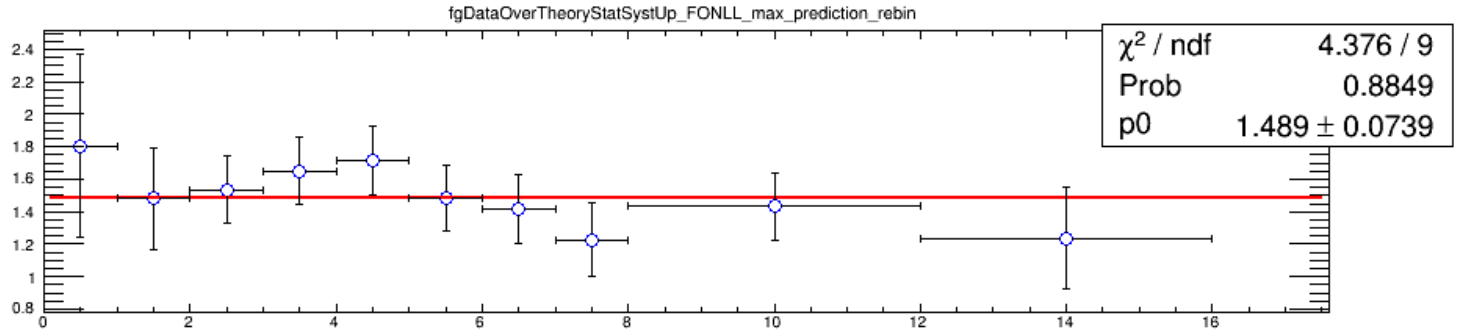


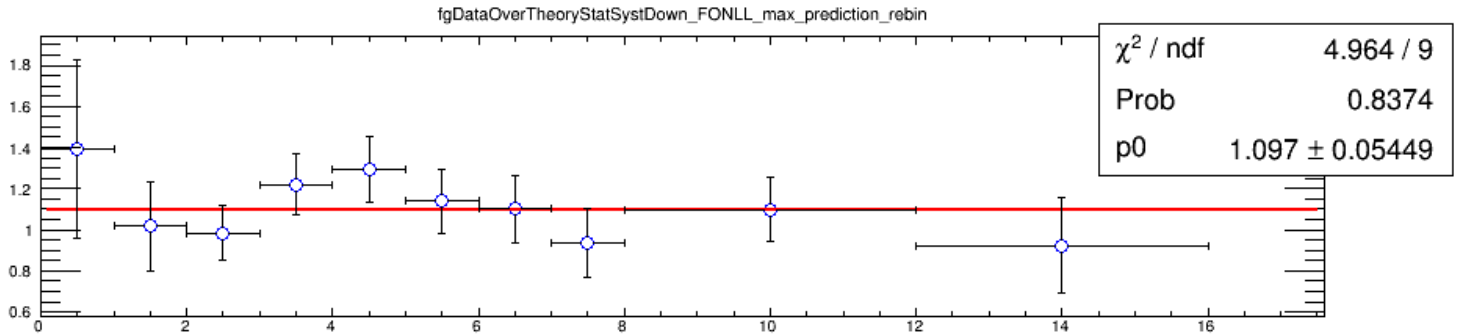




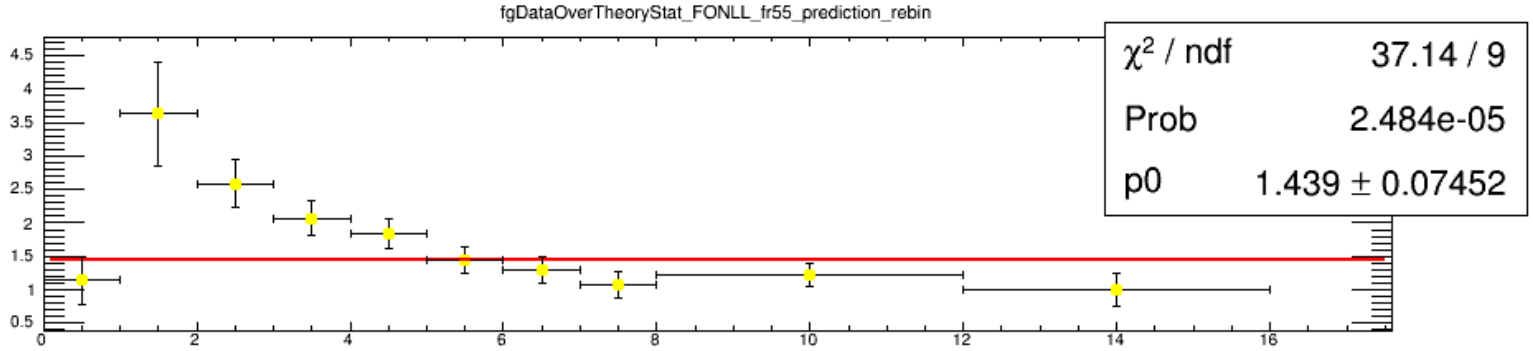
$(\mu_F/\mu_0,\mu_R/\mu_0)=(1,1)$, m=1.3

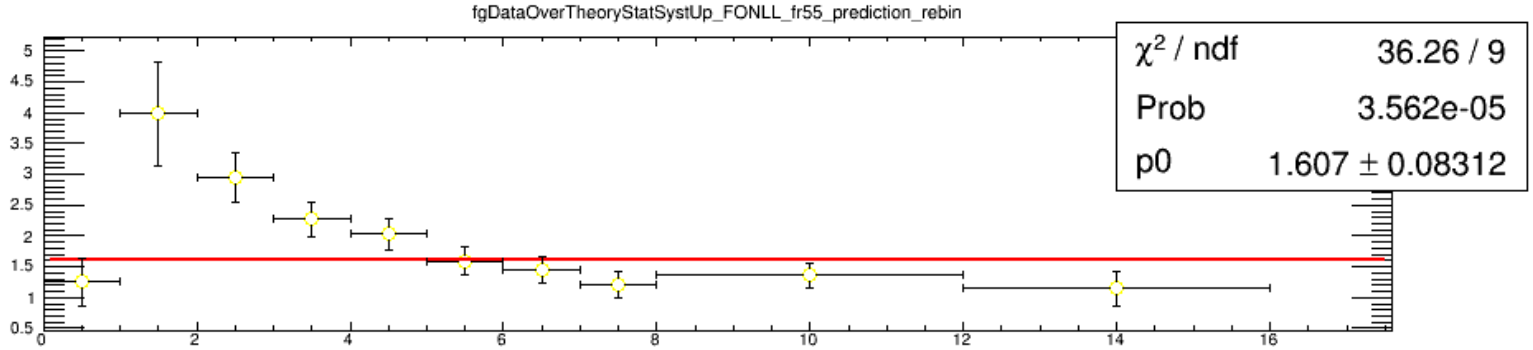


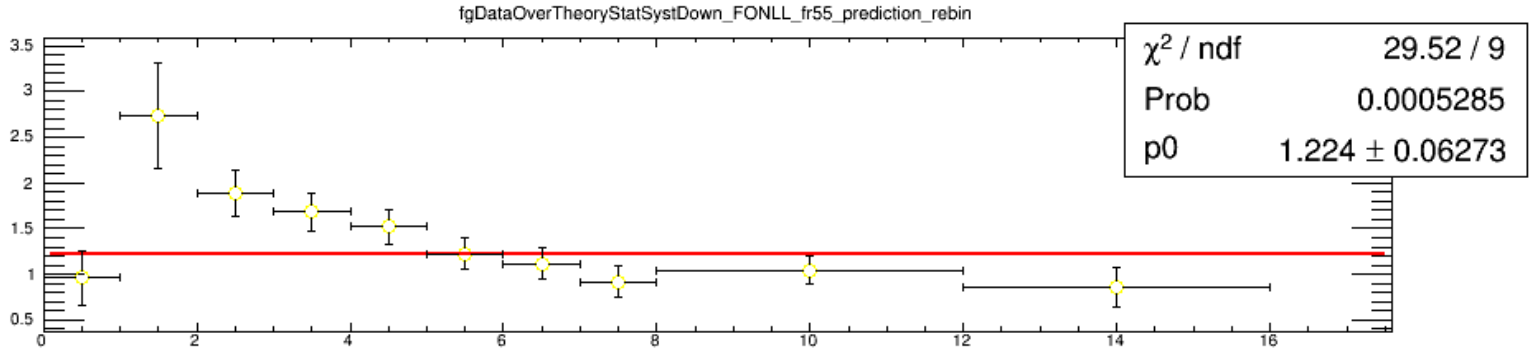




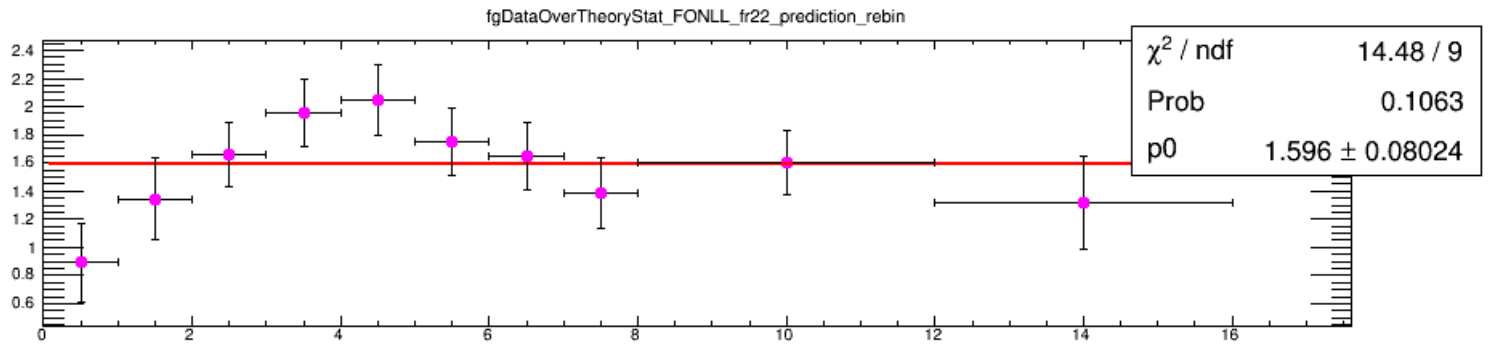
$(\mu_F/\mu_0,\mu_R/\mu_0)=(0.5,0.5)$, m=1.5

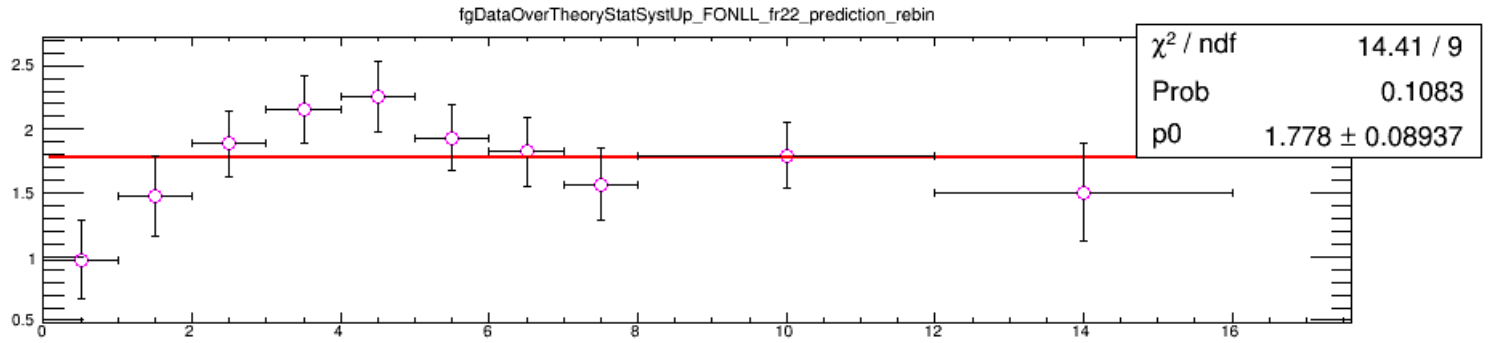


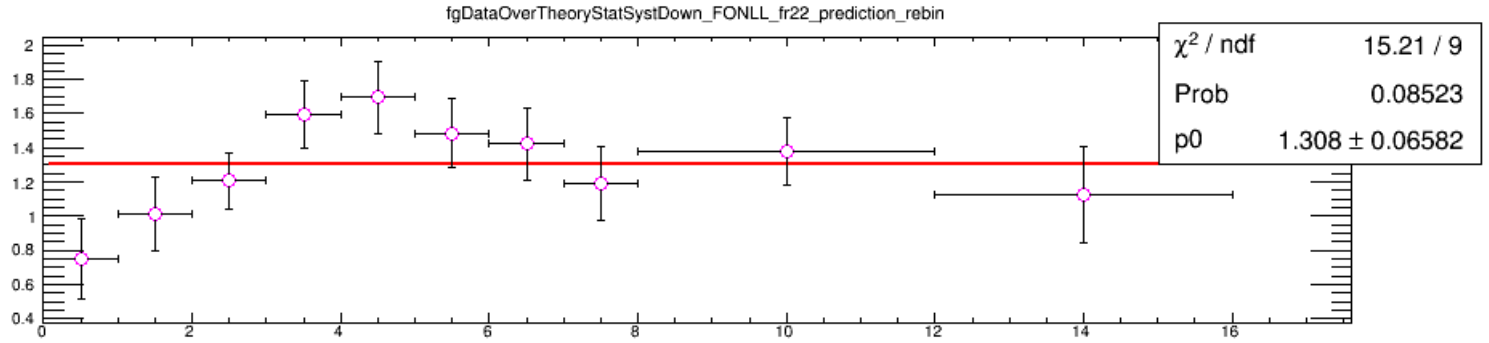




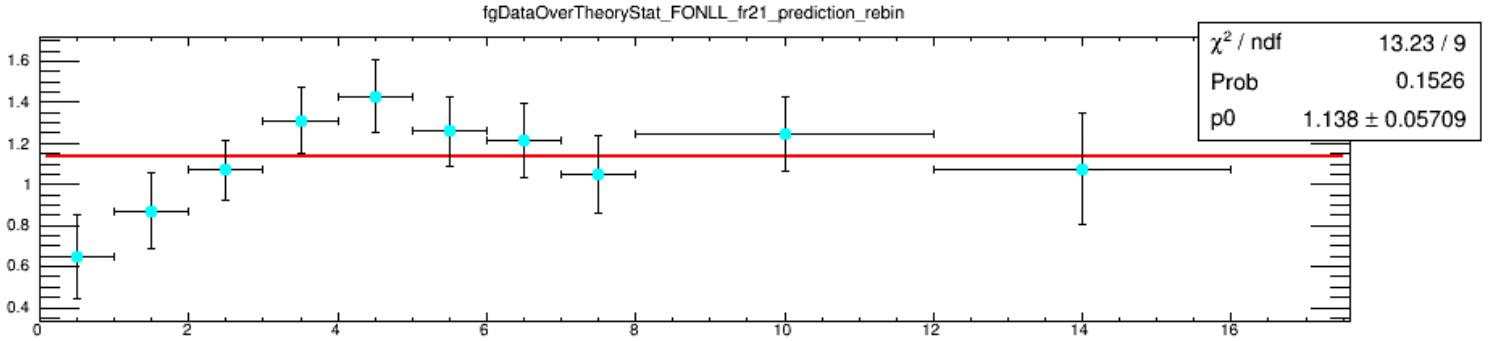
$(\mu_F/\mu_0,\mu_R/\mu_0)=(2,2)$, m=1.5

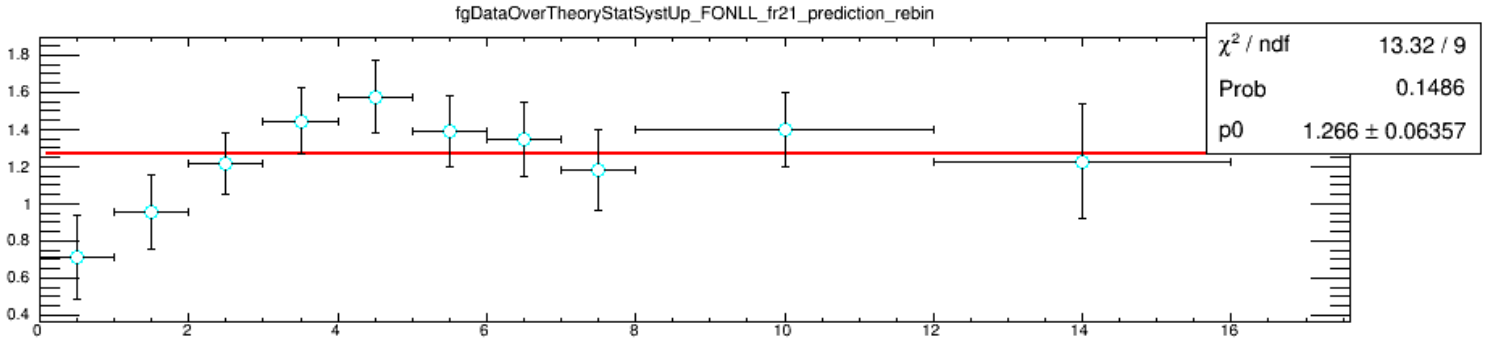


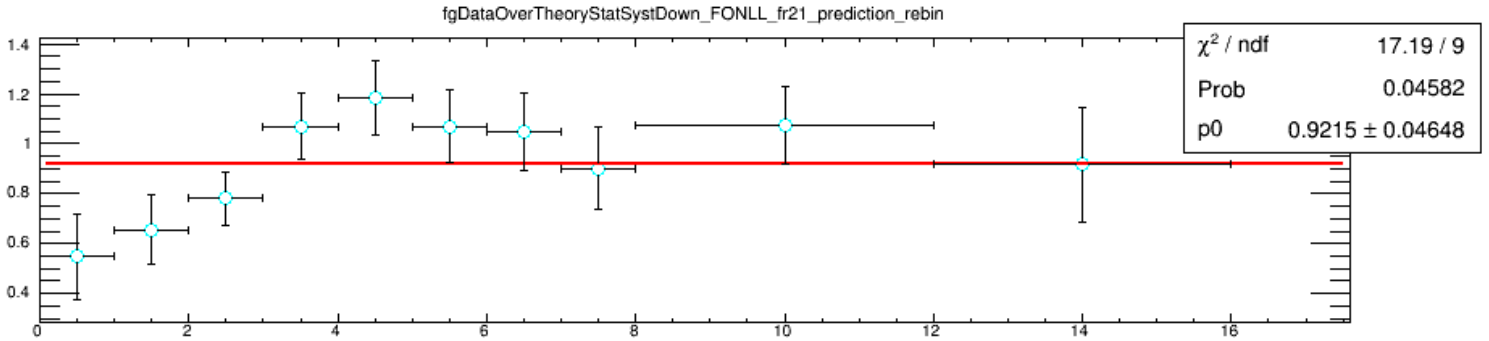




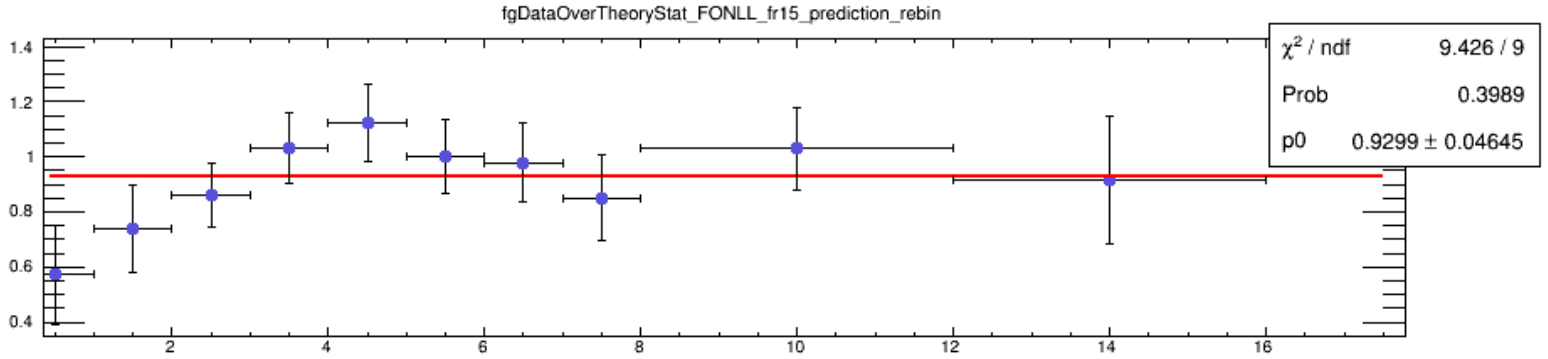
$(\mu_F/\mu_0,\mu_R/\mu_0)=(2,1)$, m=1.5

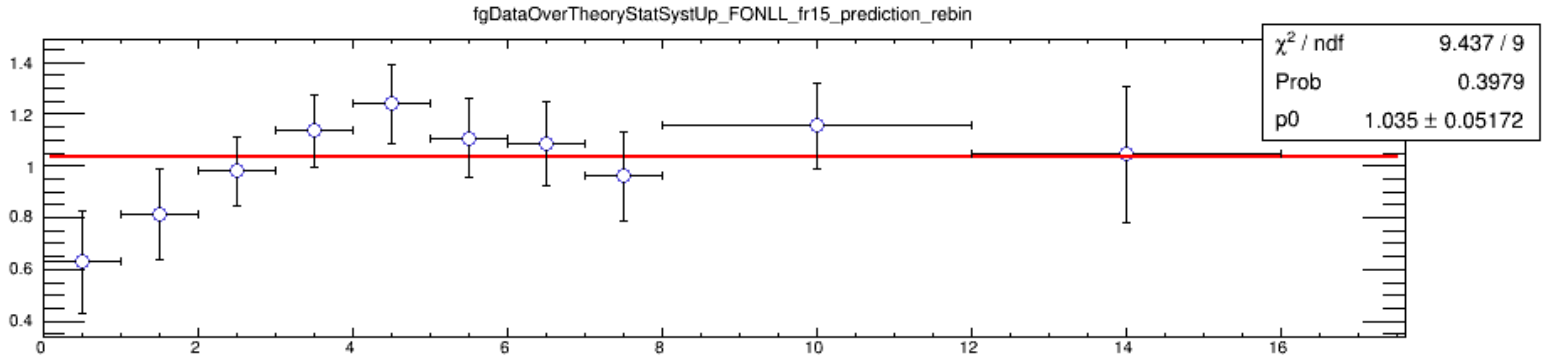


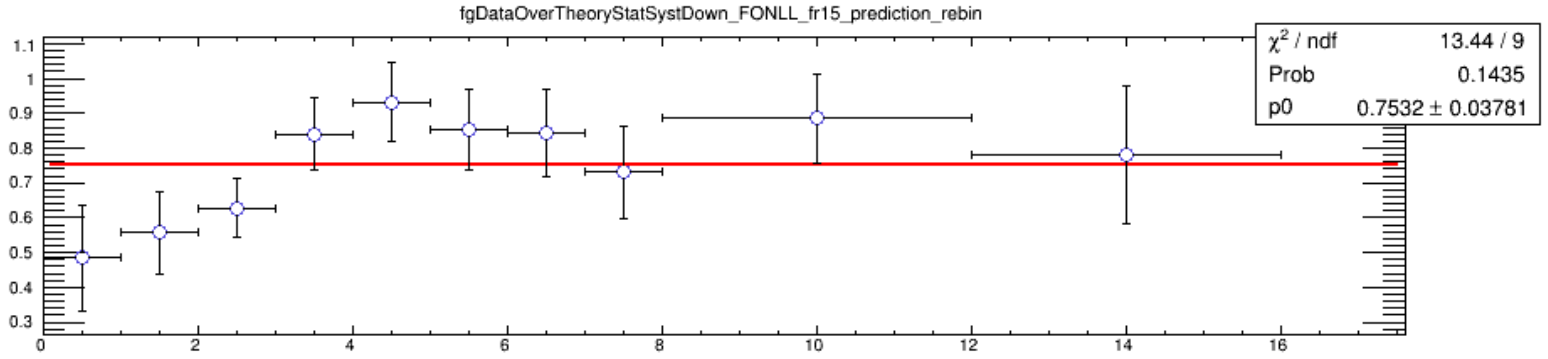




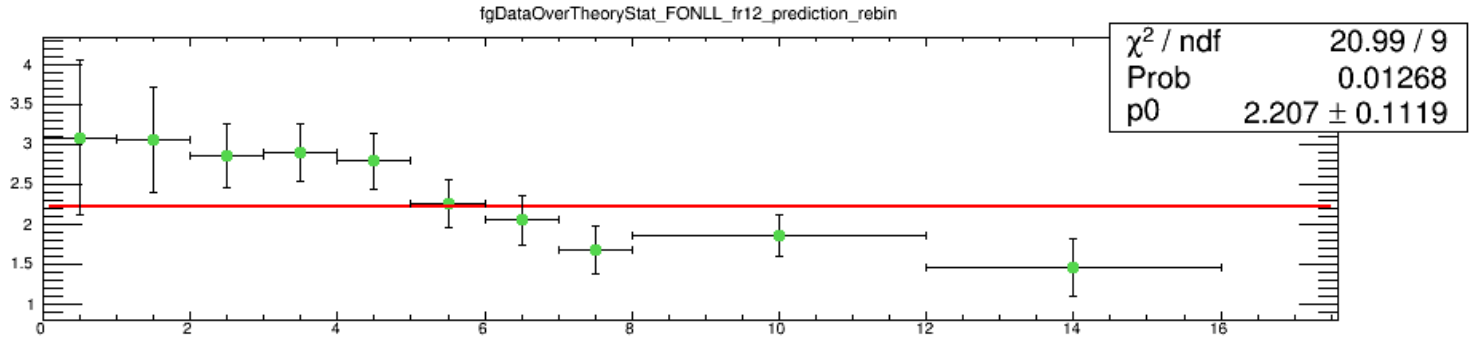
$(\mu_F/\mu_0,\mu_R/\mu_0)=(1,0.5)$, m=1.5

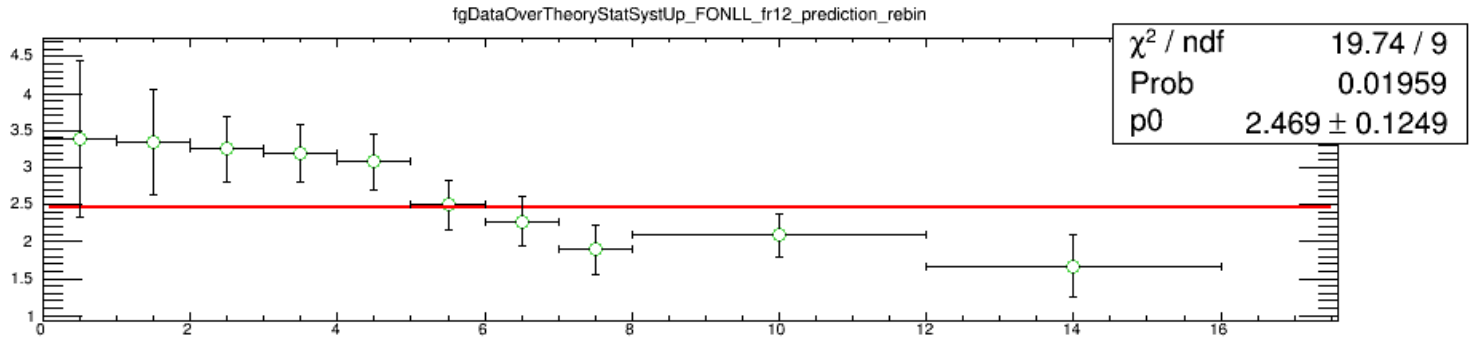


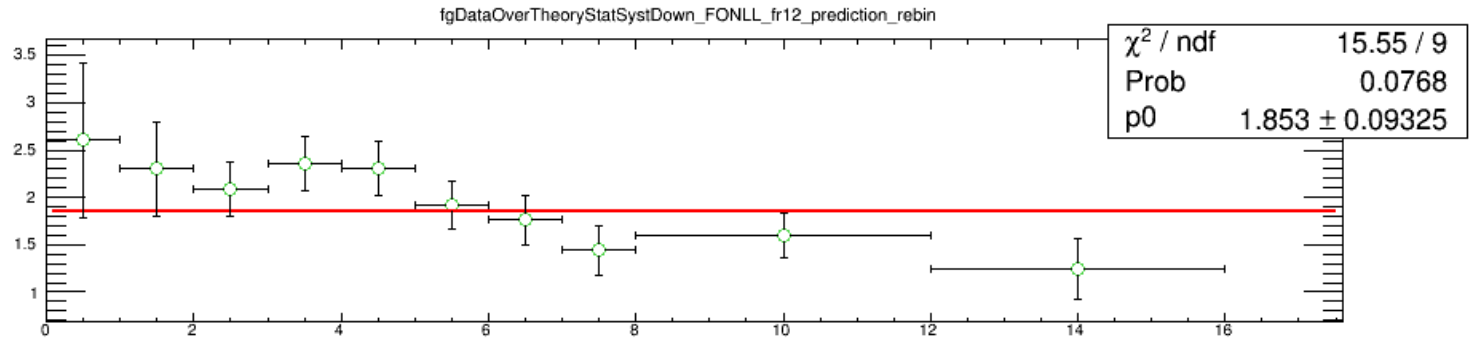




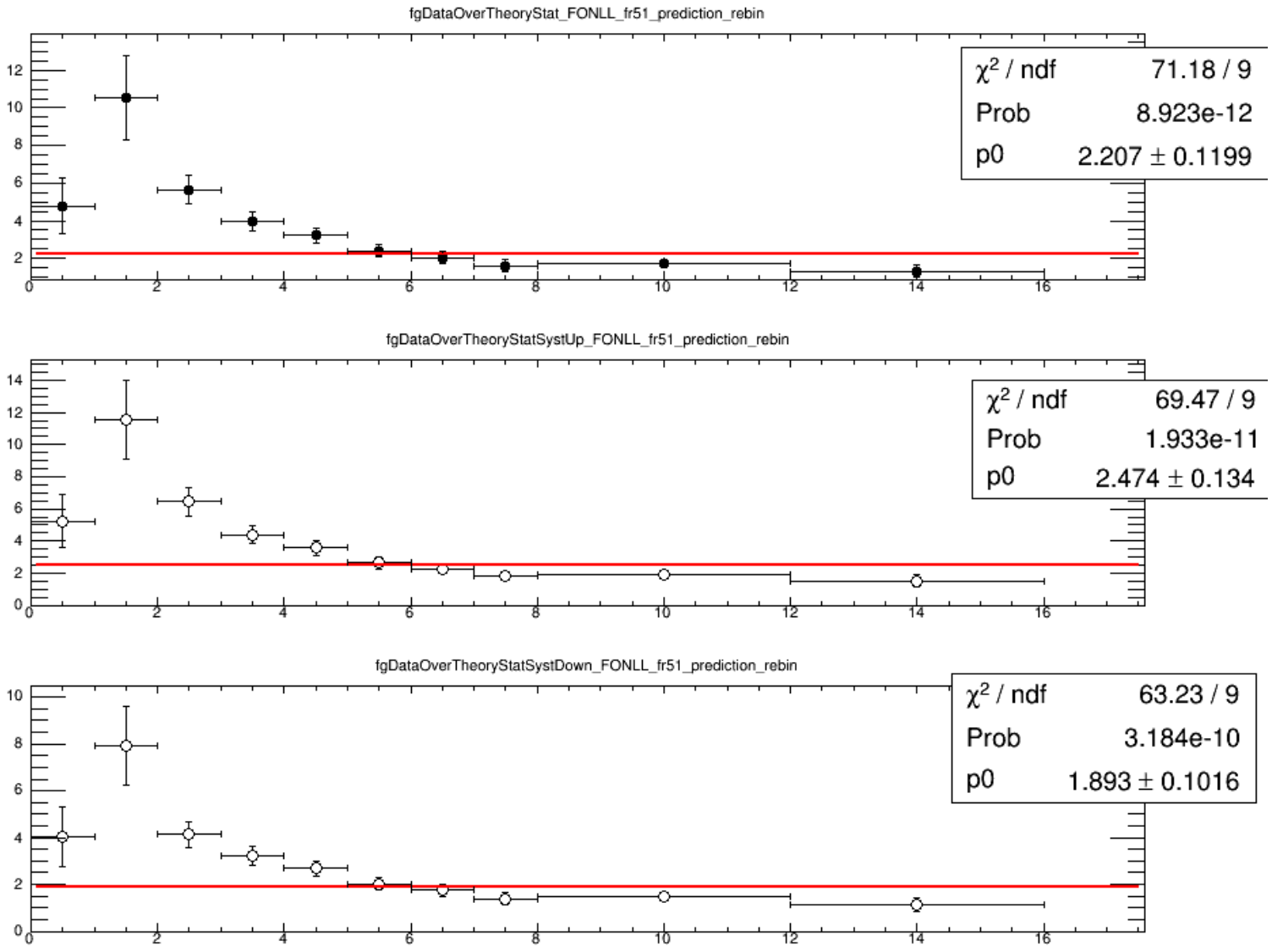
$(\mu_F/\mu_0,\mu_R/\mu_0)=(1,2)$, m=1.5







$(\mu_F/\mu_0,\mu_R/\mu_0)=(0.5,1)$, m=1.5



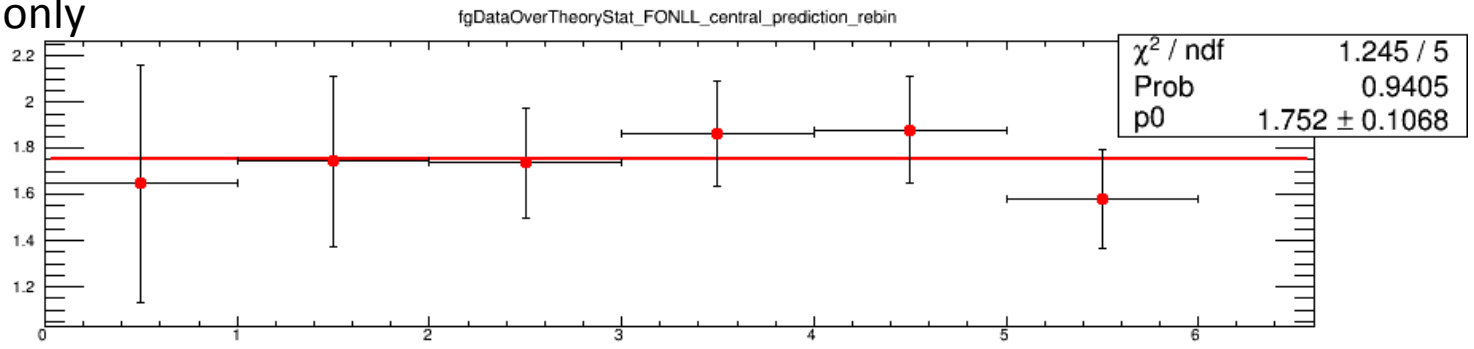
Summary

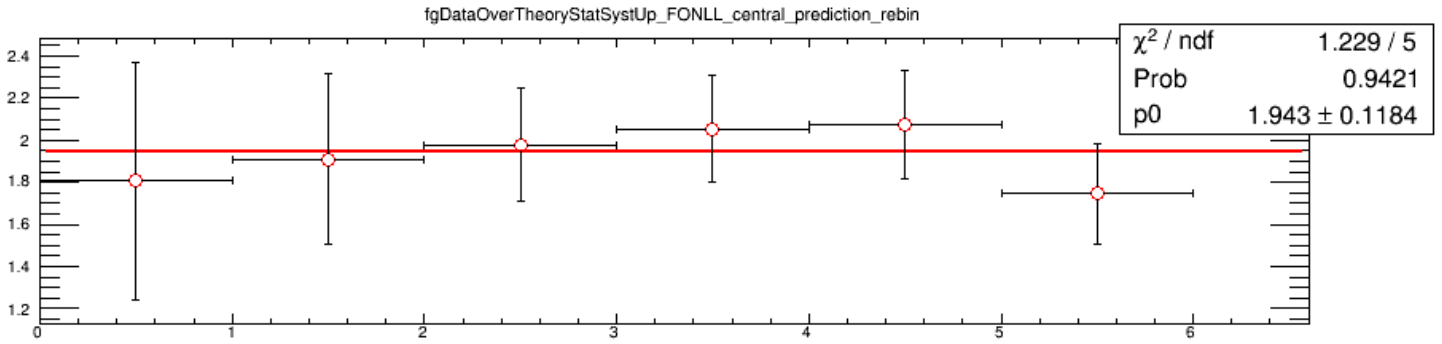
FONLL curve	Smallest χ^2	χ^2 for Data(centr)	Fit Data(centr)/ FONLL
fr 1 1, m=1.5	0.72	1.00	1.56+-0.08
fr 1 1, m=1.7	1.21	1.71	1.79+-0.09
fr 1 1, m=1.3	0.49	0.56	1.33+-0.07
fr 0.5 0.5	3.28	4.13	1.44+-0.07
fr 2 2	1.60	1.61	1.60+-0.08
fr 2 1	1.47	1.47	1.14+-0.06
fr 1 2	1.73	2.33	2.21+-0.11
fr 1 0.5	1.05	1.05	0.93+-0.05
fr 0.5 1	7.02	7.91	2.21+-0.12

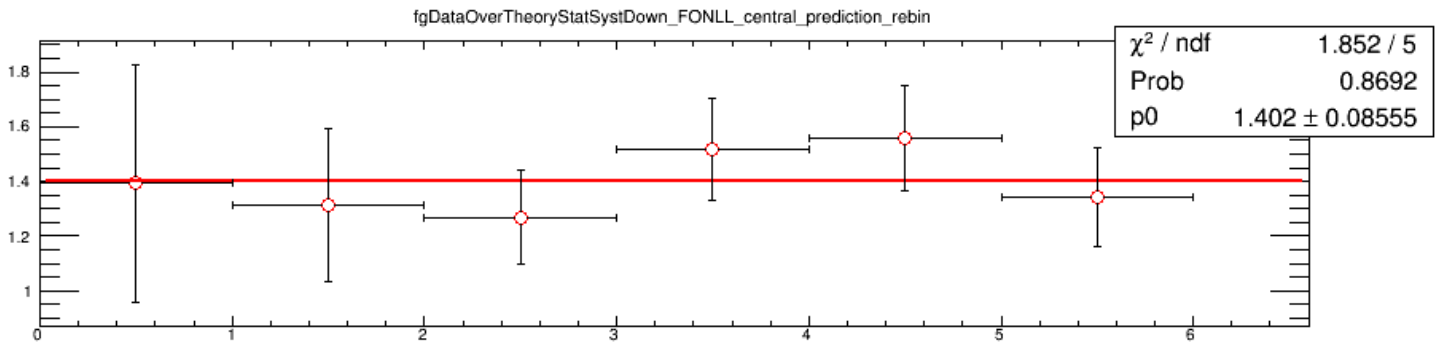
- Best fit of the shape is FONLL set with (1,1) and mc=1.3
- The two sets (0.5,0.5) and (0.5,1) have the smallest chi2 > 2
- However, some of the other sets have a clearly different slope than data for pT<6 GeV, see slides 9-11 → decided to repeat exercise also with fit in 0-6 GeV only

FONLL central, $(\mu_F/\mu_0,\mu_R/\mu_0)=(1,1)$, m=1.5

0-6 GeV only

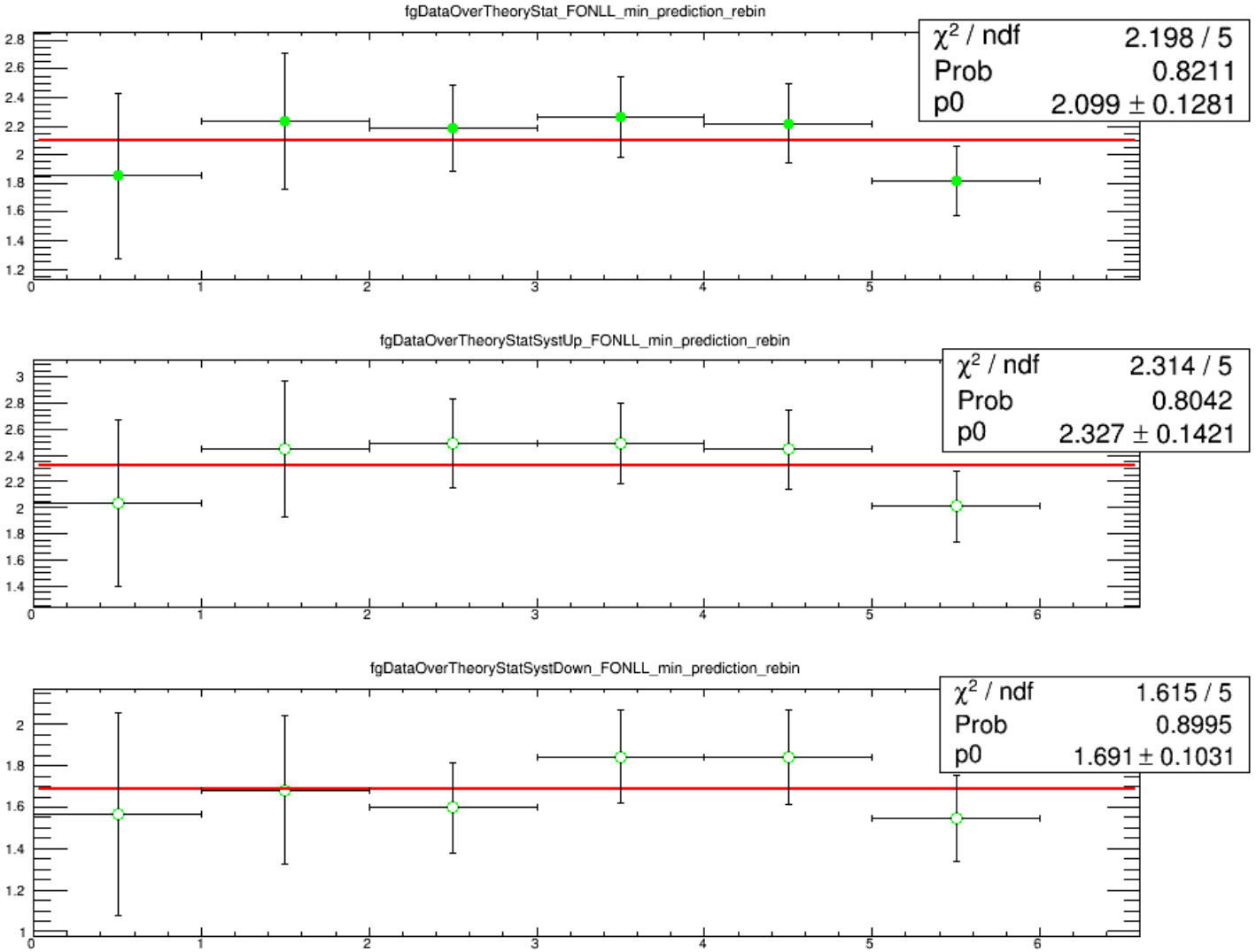






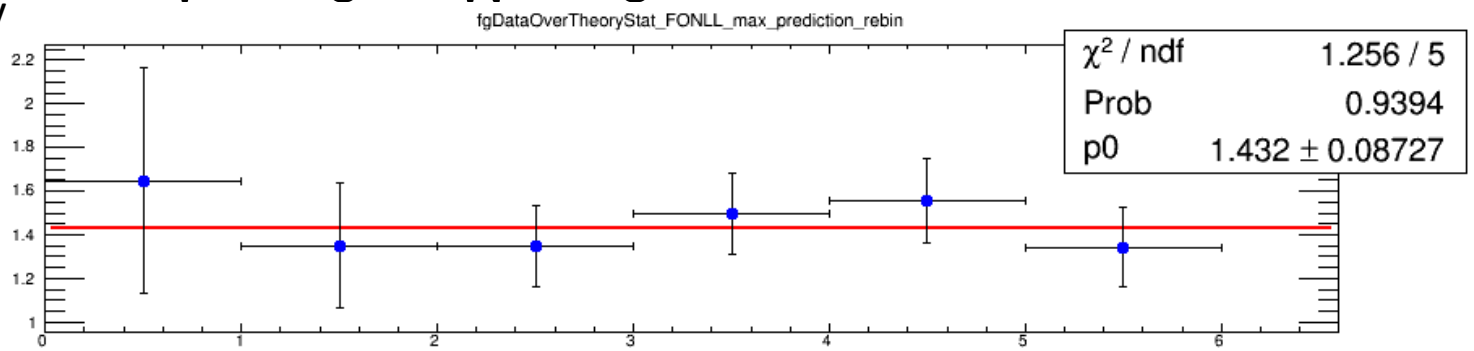
$(\mu_F/\mu_0,\mu_R/\mu_0)=(1,1)$, m=1.7

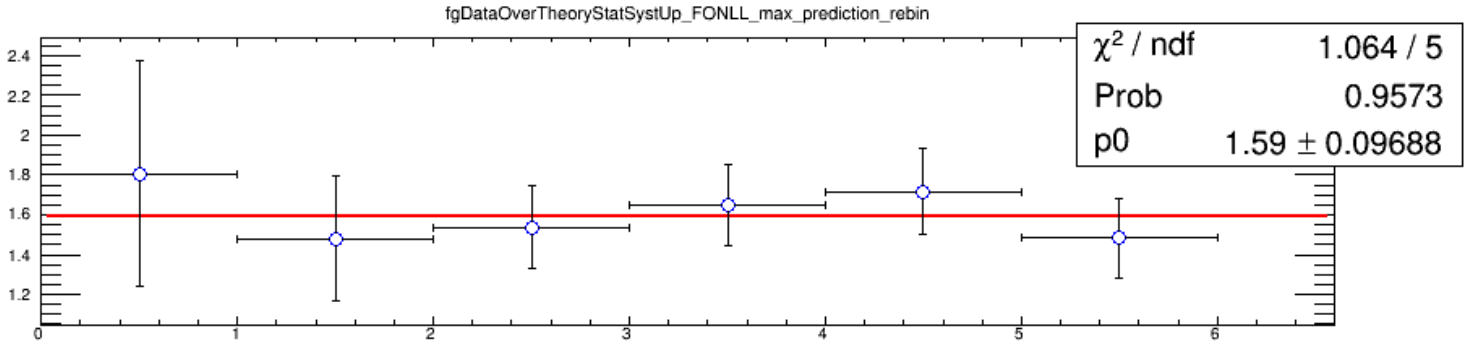
0-6 GeV only

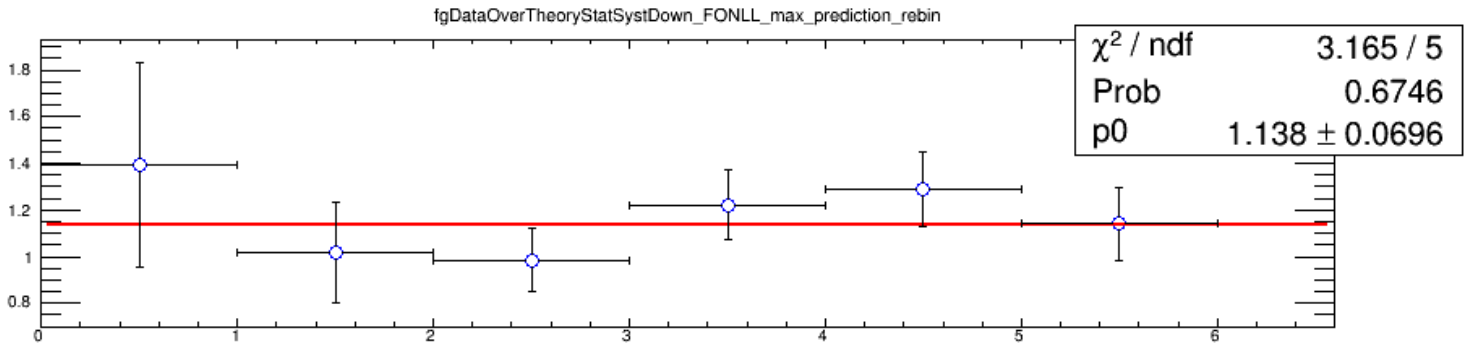


$(\mu_F/\mu_0,\mu_R/\mu_0)=(1,1)$, m=1.3

0-6 GeV only

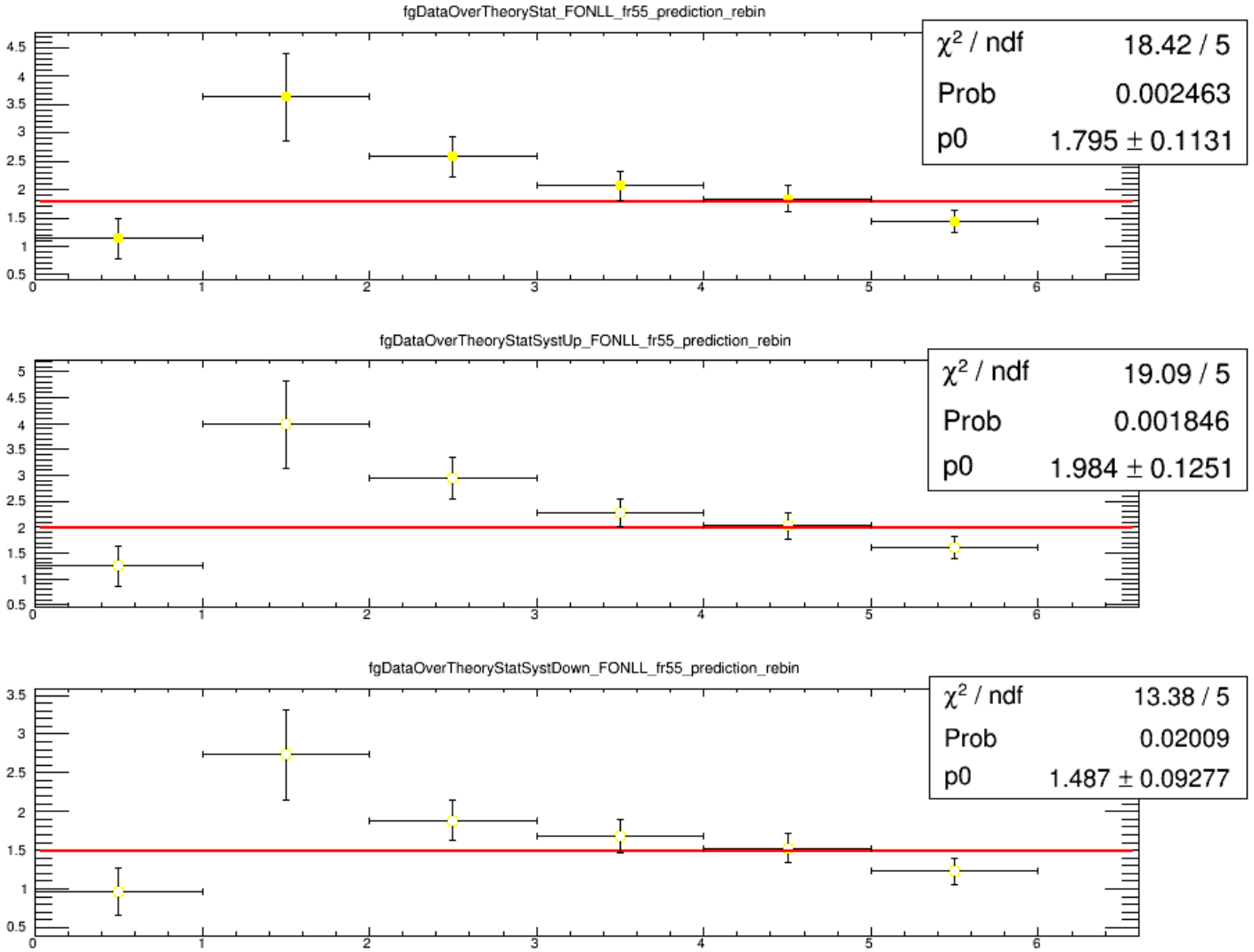






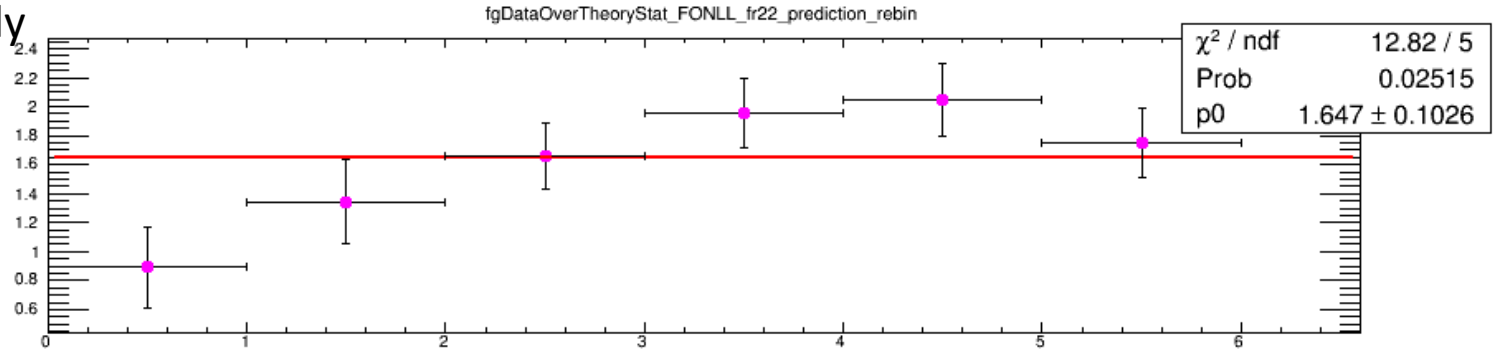
$(\mu_F/\mu_0,\mu_R/\mu_0)=(0.5,0.5)$, m=1.5

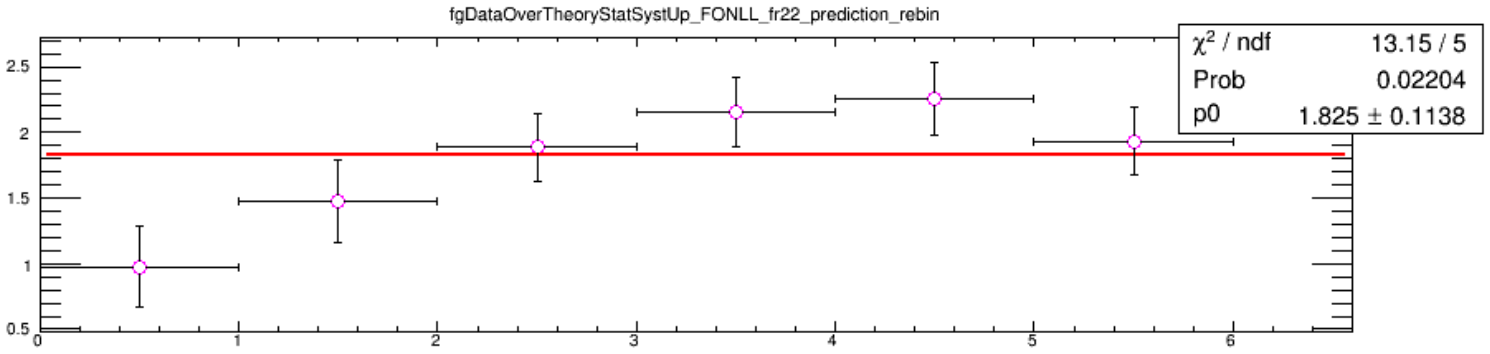
0-6 GeV only

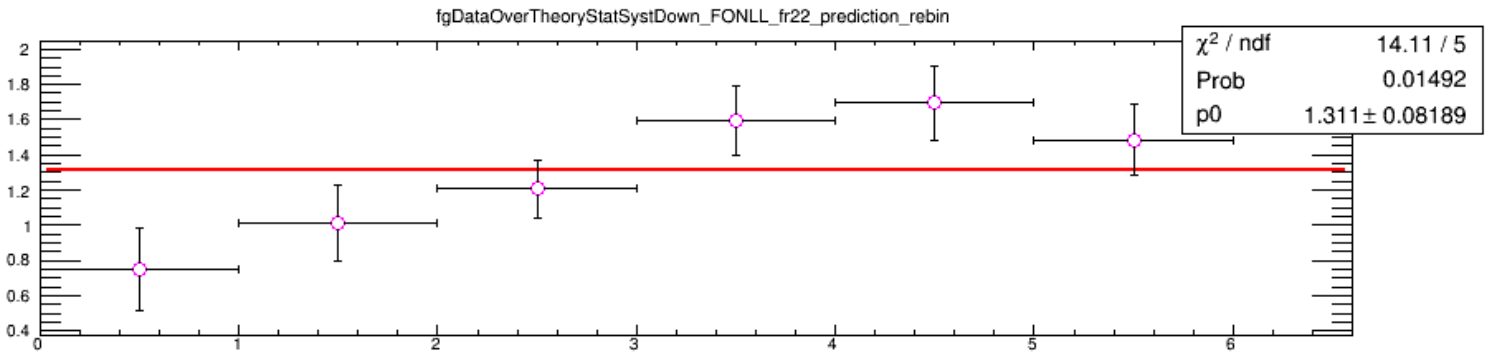


$(\mu_F/\mu_0,\mu_R/\mu_0)=(2,2)$, m=1.5

0-6 GeV only

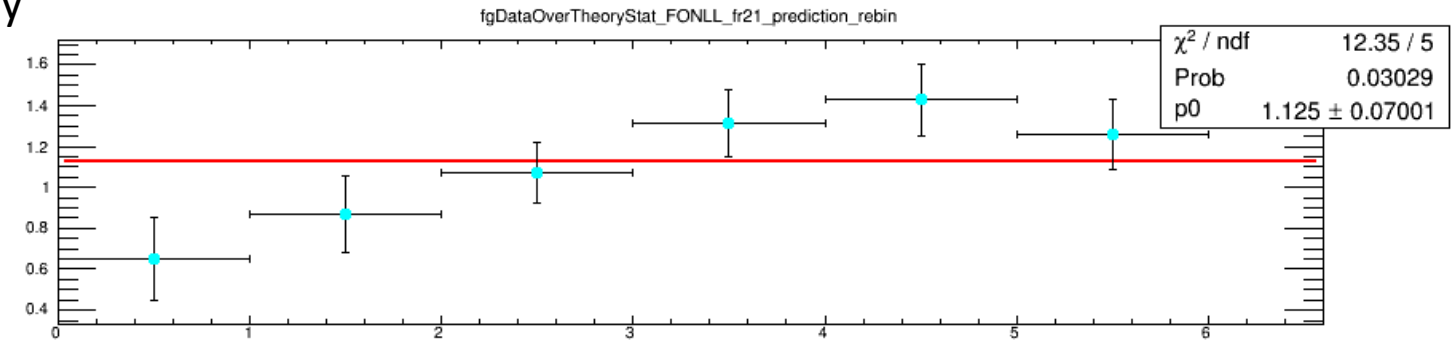


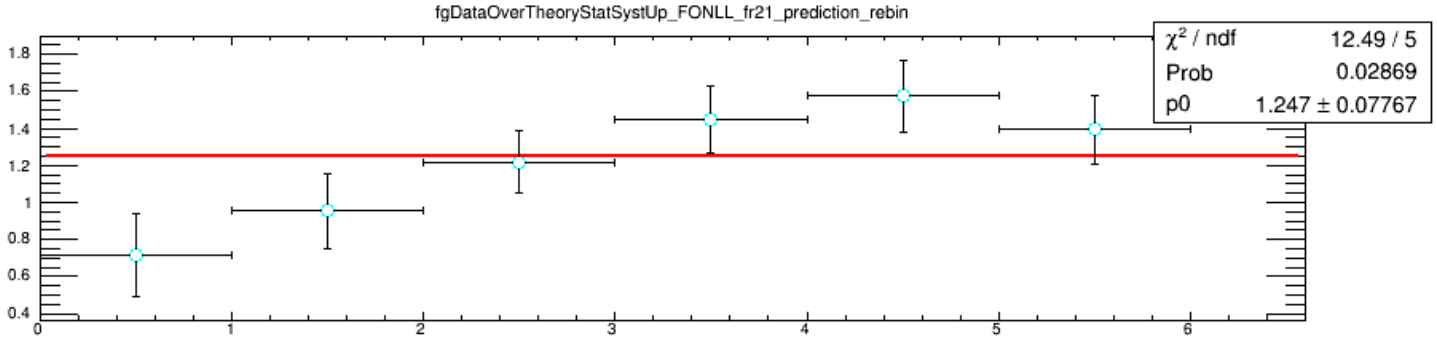


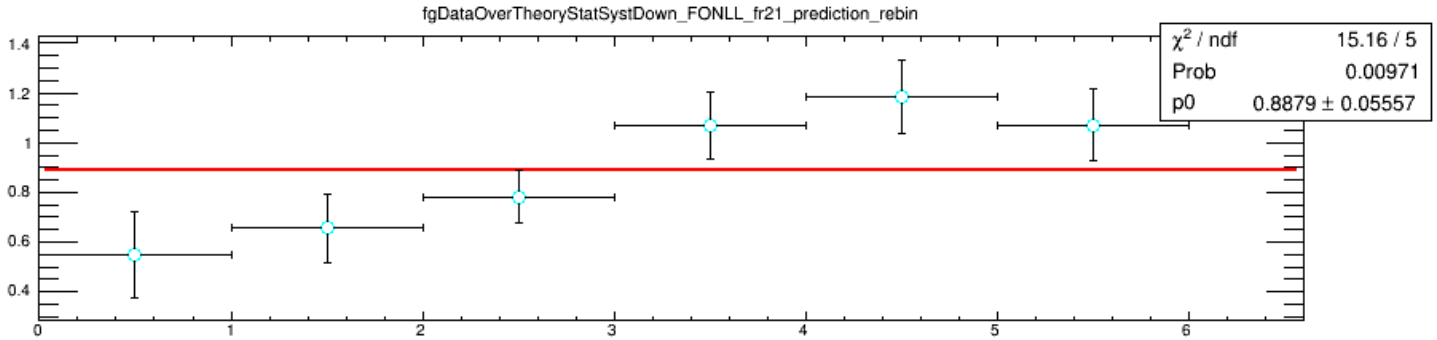


$(\mu_F/\mu_0,\mu_R/\mu_0)=(2,1)$, m=1.5

0-6 GeV only

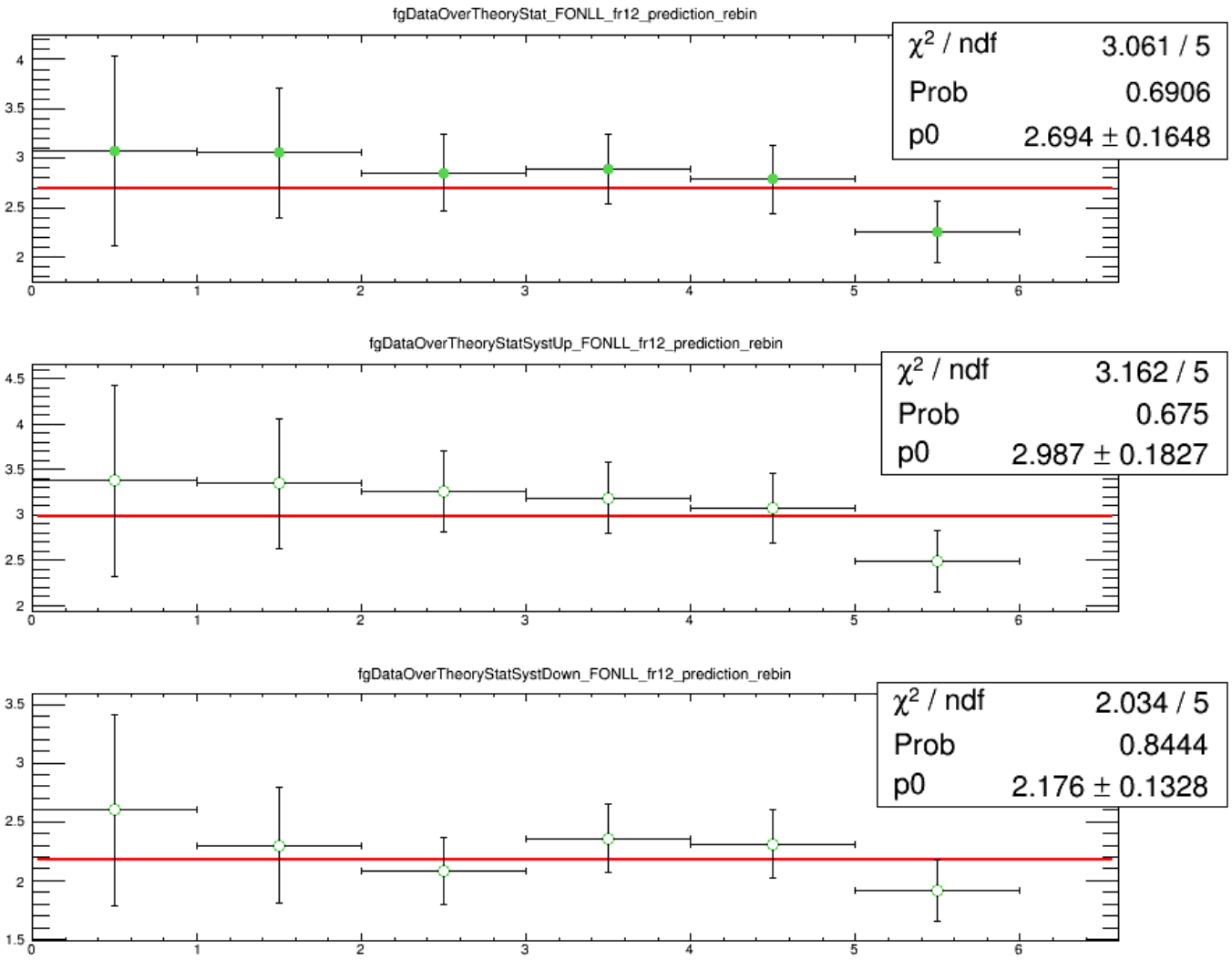






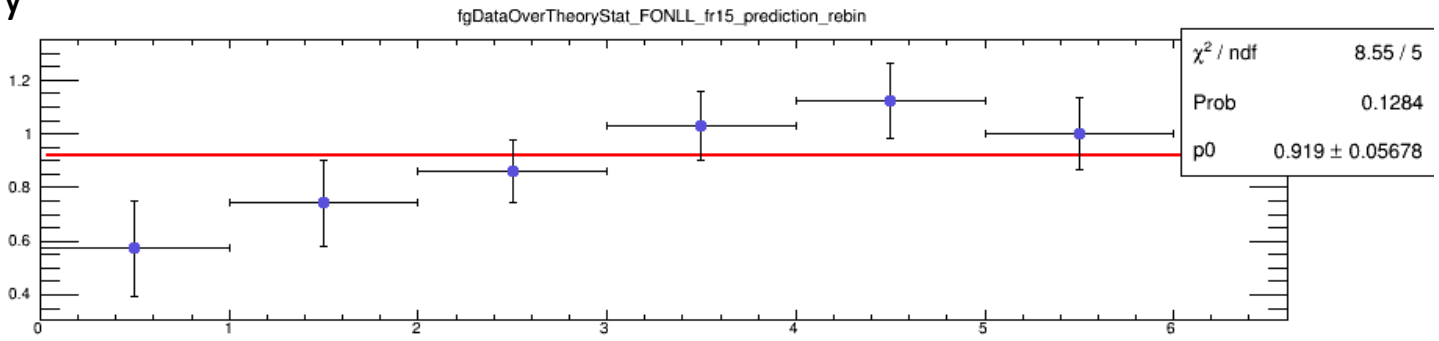
$(\mu_F/\mu_0,\mu_R/\mu_0)=(1,2)$, m=1.5

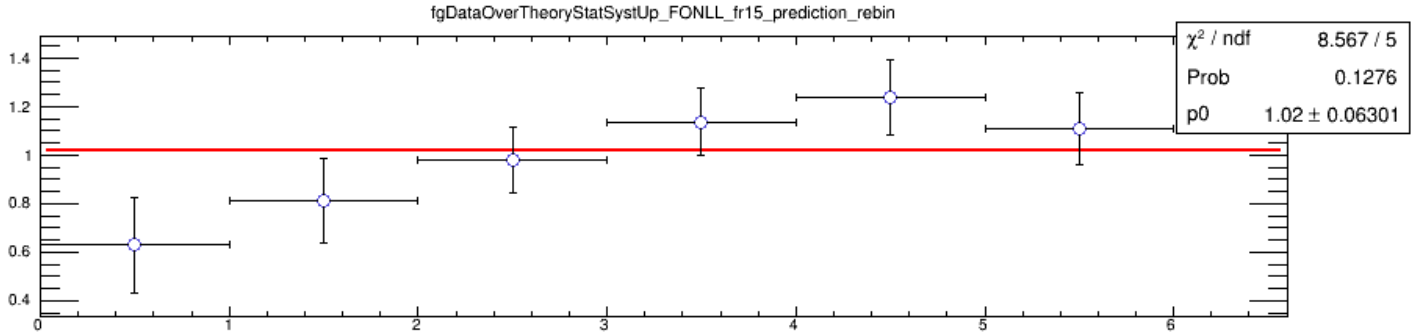
0-6 GeV only

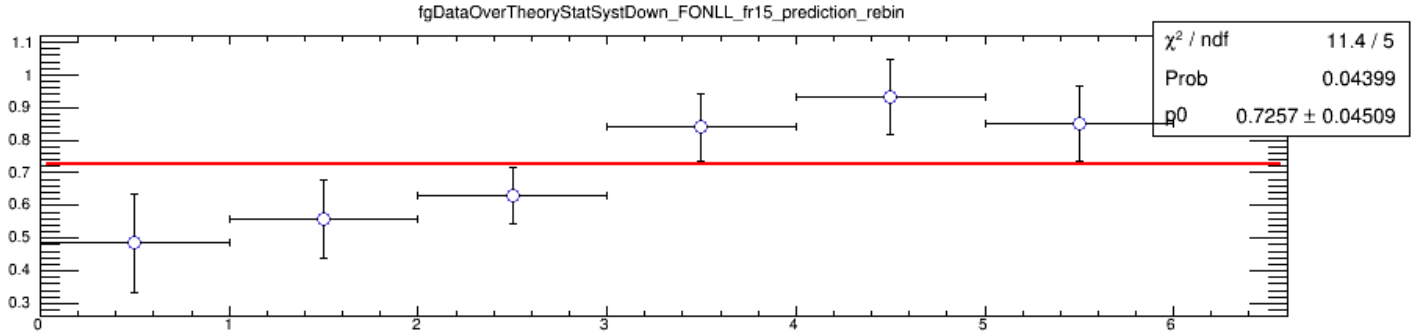


$(\mu_F/\mu_0,\mu_R/\mu_0)=(1,0.5)$, m=1.5

0-6 GeV only

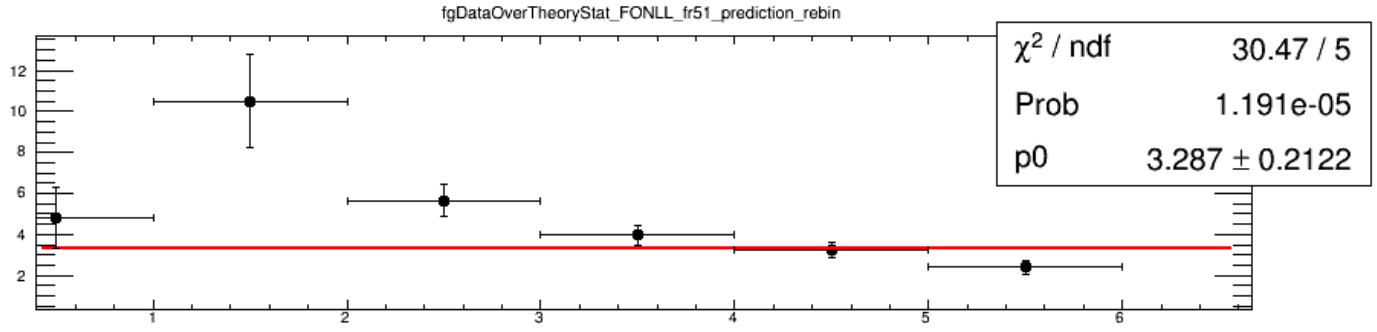


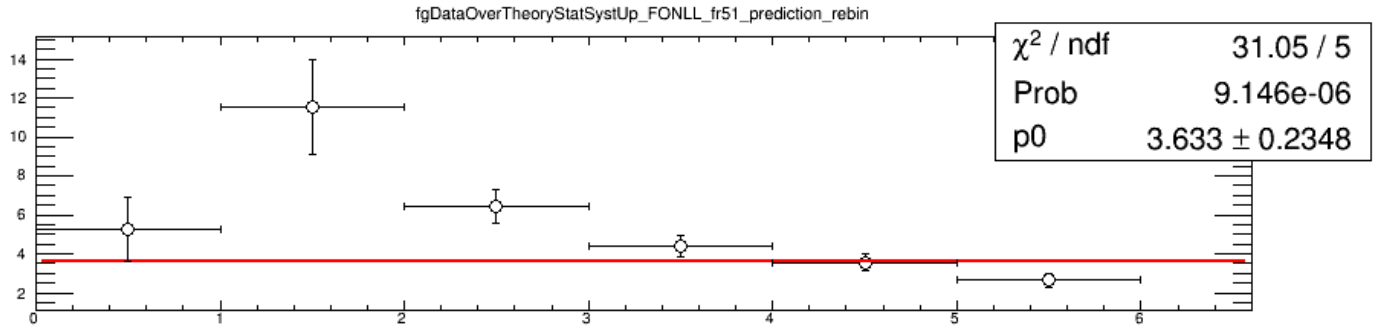


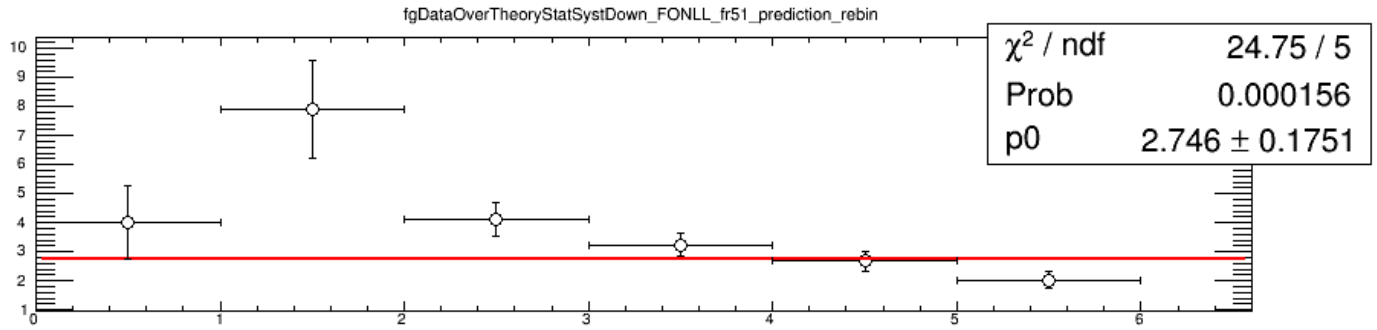


$(\mu_F/\mu_0, \mu_R/\mu_0)=(0.5,1)$, m=1.5

0-6 GeV only







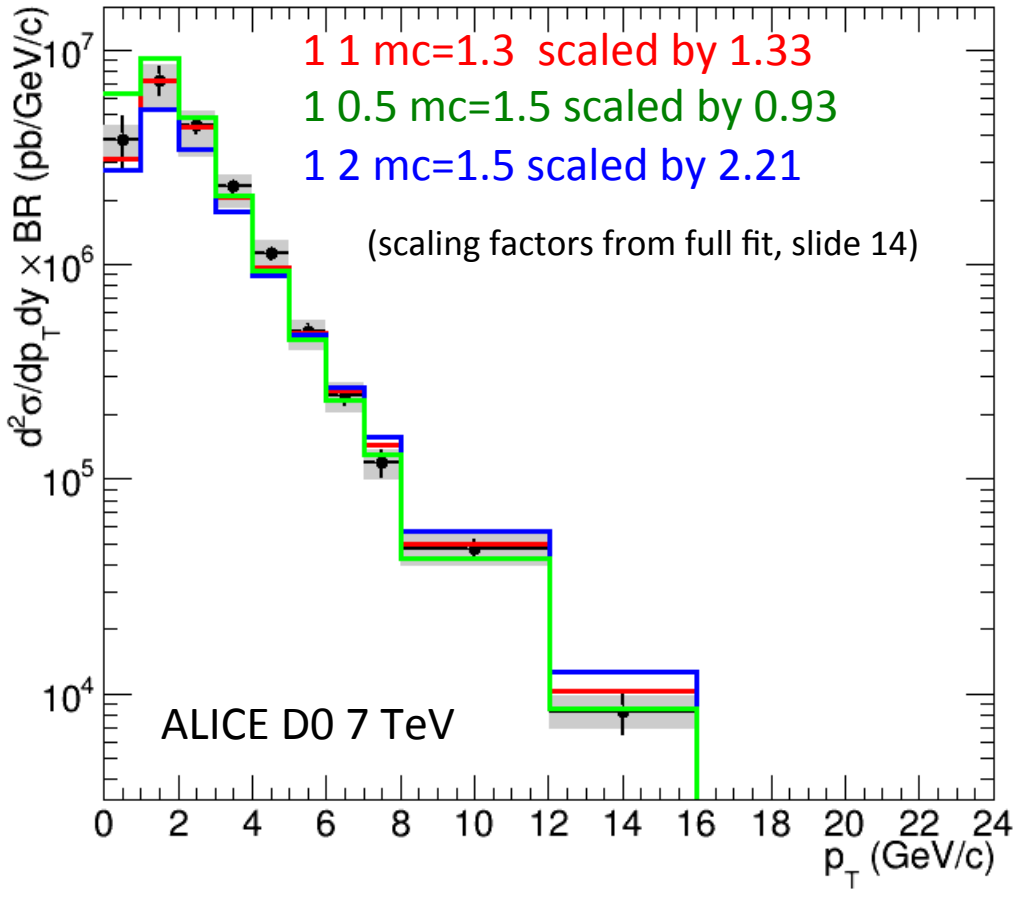
Summary

0-6 GeV only

FONLL curve	Smallest χ^2	χ^2 for Data(centr)	Fit Data(centr)/ FONLL
fr 1 1, m=1.5	0.25	0.25	1.75+-0.11
fr 1 1, m=1.7	0.32	0.44	2.10+-0.13
fr 1 1, m=1.3	0.21	0.25	1.43+-0.09
fr 0.5 0.5	2.68	3.68	1.80+-0.11
fr 2 2	2.56	2.56	1.65+-0.10
fr 2 1	2.47	2.47	1.13+-0.07
fr 1 2	0.41	0.61	2.69+-0.16
fr 1 0.5	1.71	1.71	0.92+-0.06
fr 0.5 1	4.95	6.09	3.29+-0.21

- Best fit of the shape is (1,1) with mc=1.3
- Reject (0.5,0.5), (0.5,1), (2,1) and (2,2)
- (1,0.5) and (1,2) could be taken as “extremes” still fitting, see next slide

Summary and proposal

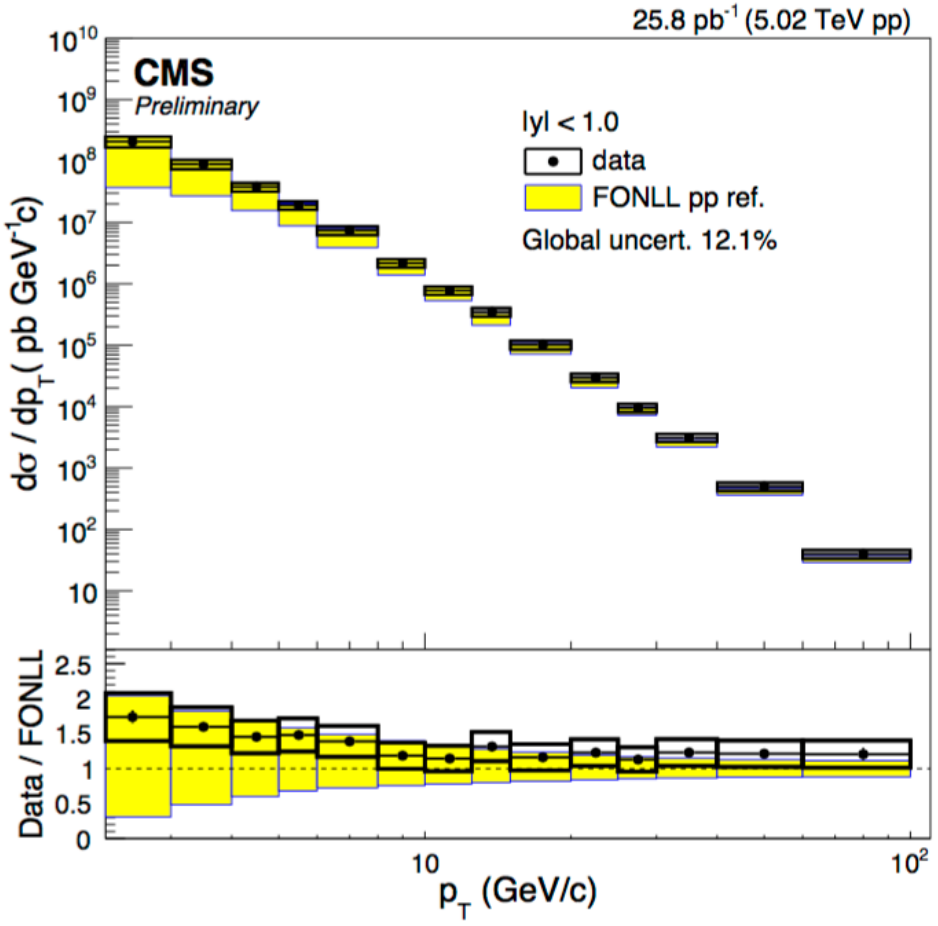


→ Propose to use these three with the same parameters and scaling factors at 2.76 and 5 TeV

→ Scaling factors do not matter for RAA and v2, only for absolute dN/dpT

Exercise at 5 TeV

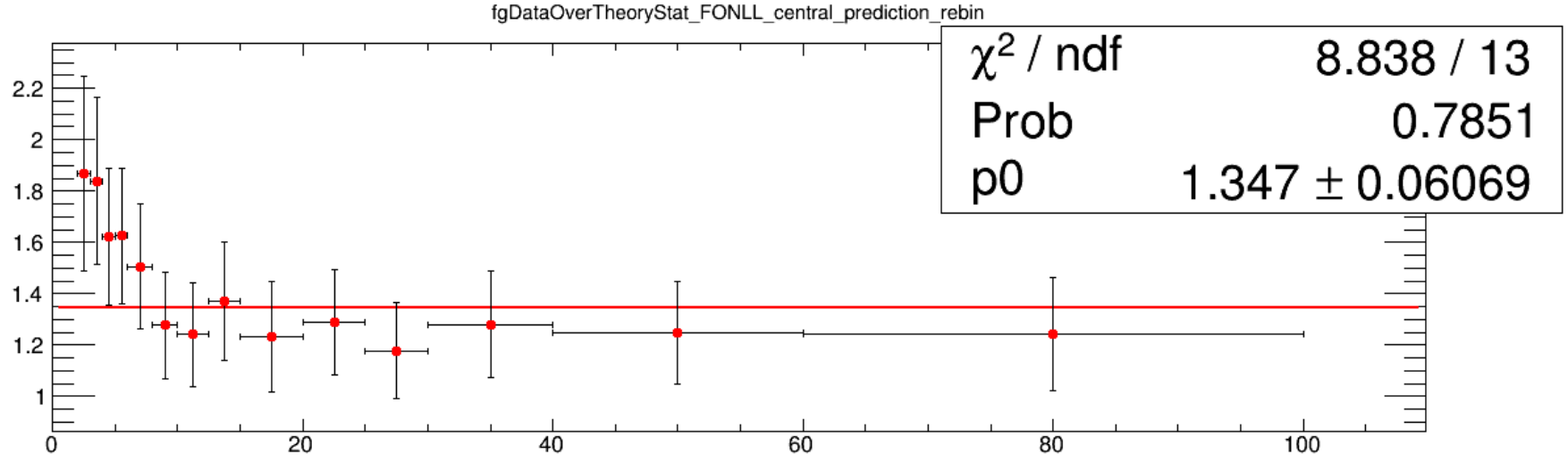
- D0 7 TeV cross section from PAS-HIN-2016-001

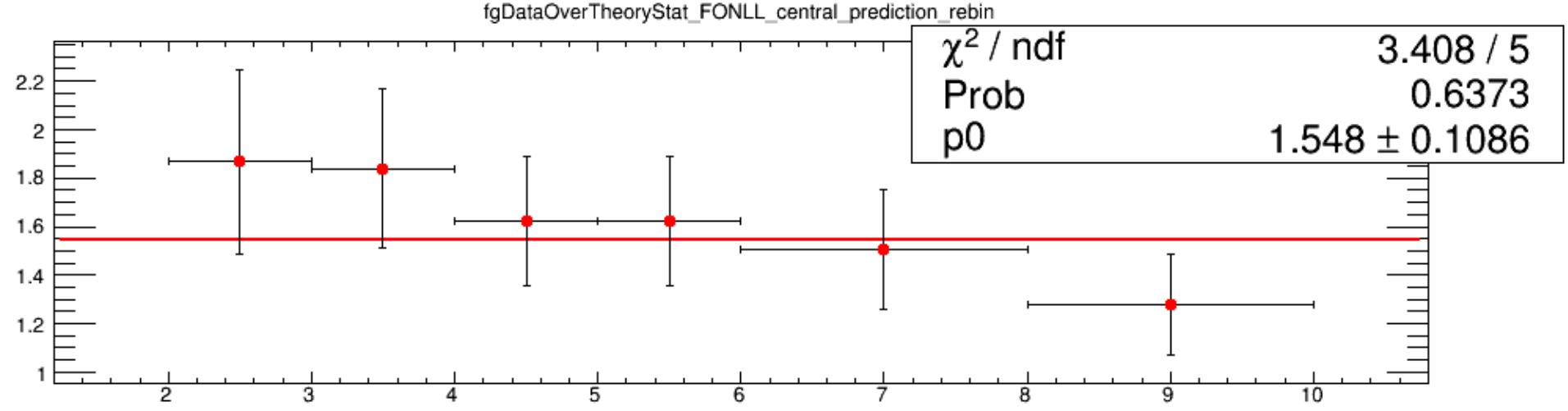


Fit of data/FONLL ratio

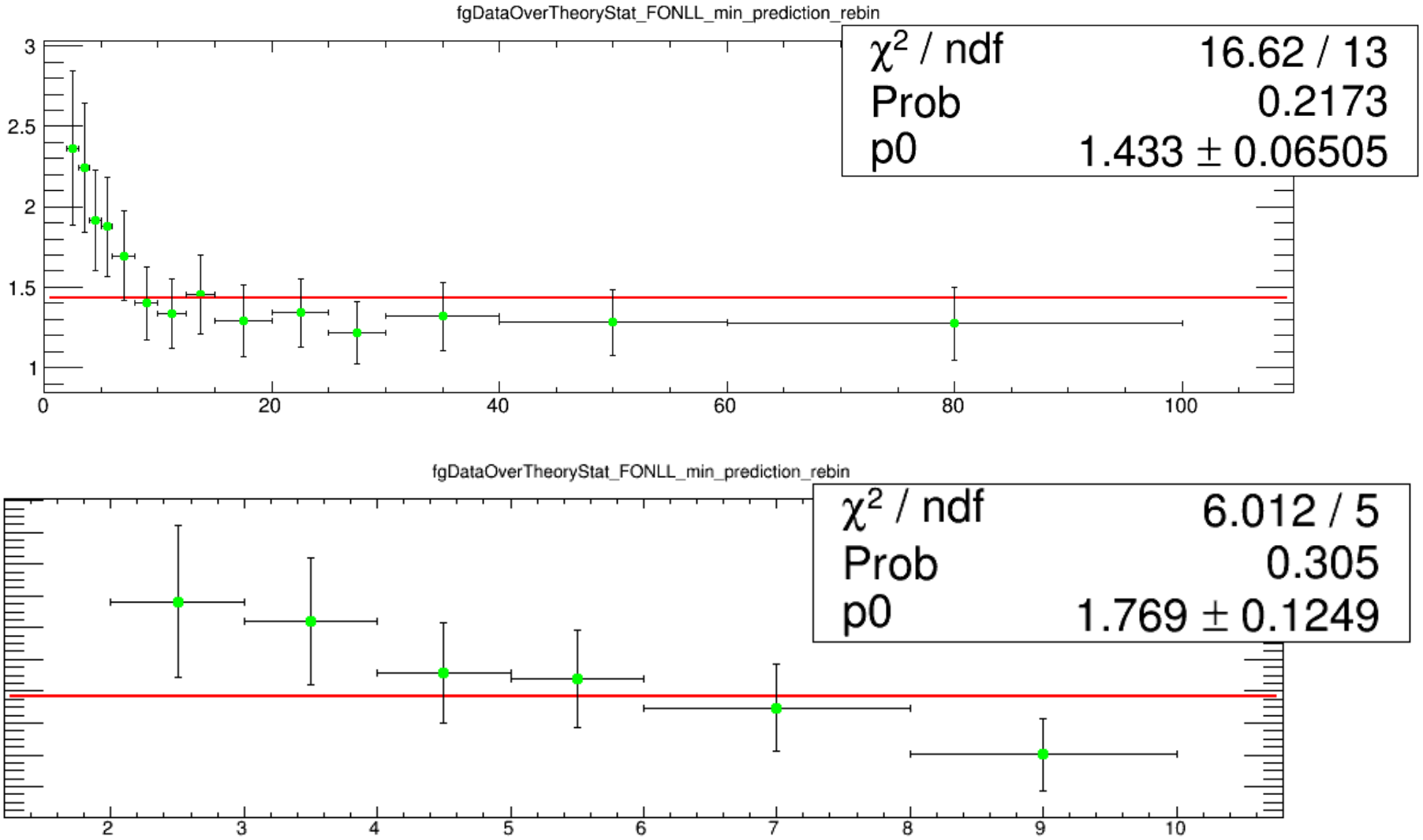
- Point-by-point errors are pT-uncorrelated: statistical + point-by-point syst
- pT-correlated error: global norm 12.1%, but doesn't affect the shape
- One single fit done for each FONLL curve
- FONLL curve is considered to describe the data (i.e. not rejected) if at least one of the three χ^2/ndf is <2

FONLL central, $(\mu_F/\mu_0,\mu_R/\mu_0)=(1,1)$, m=1.5

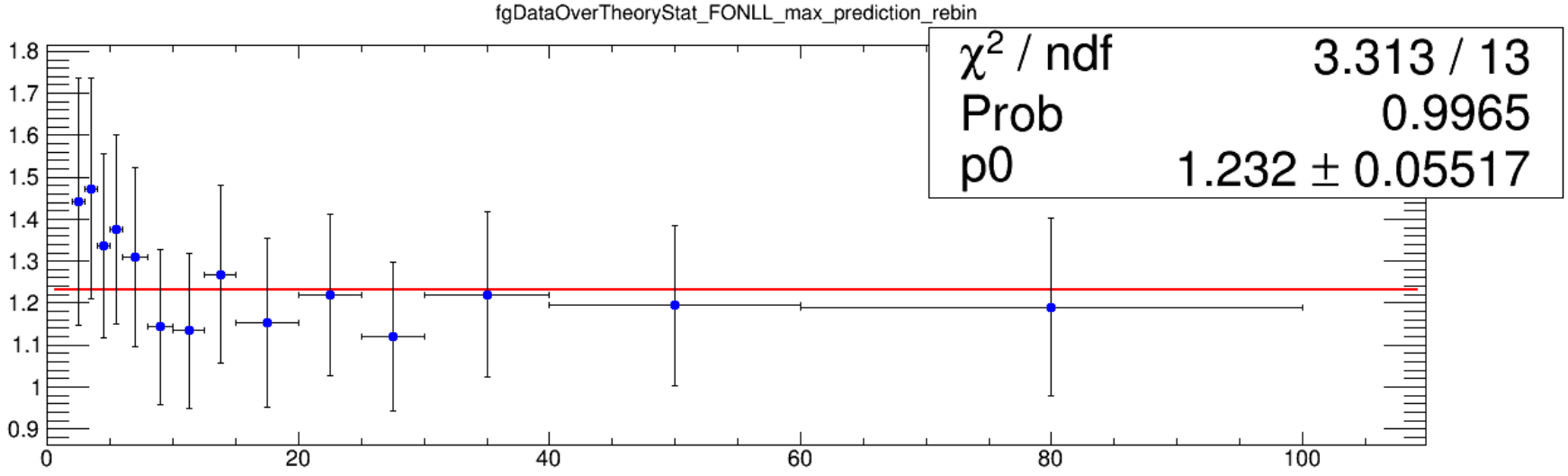


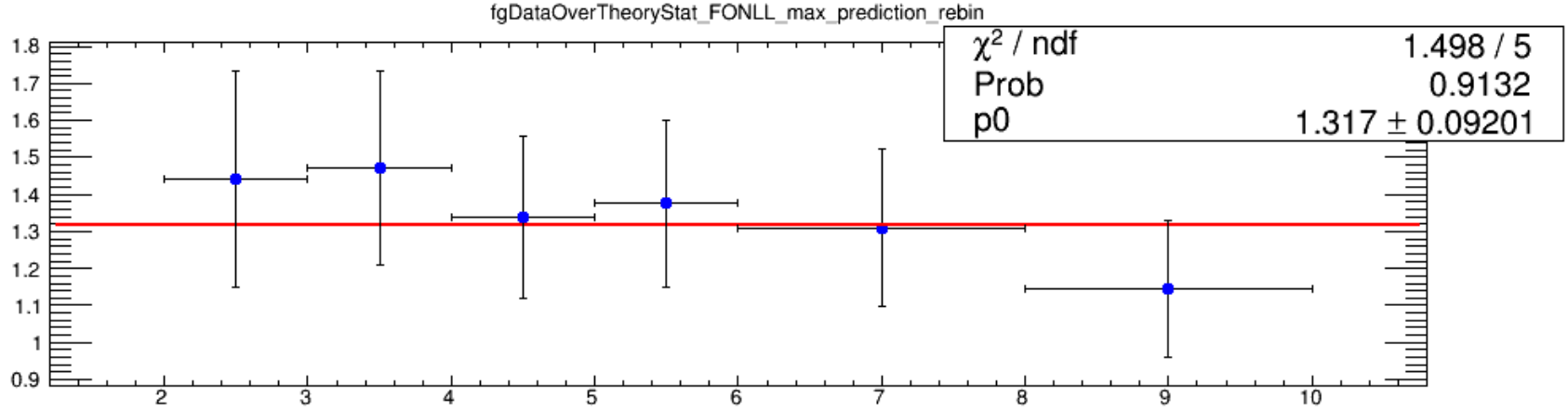


$(\mu_F/\mu_0,\mu_R/\mu_0)=(1,1)$, m=1.7

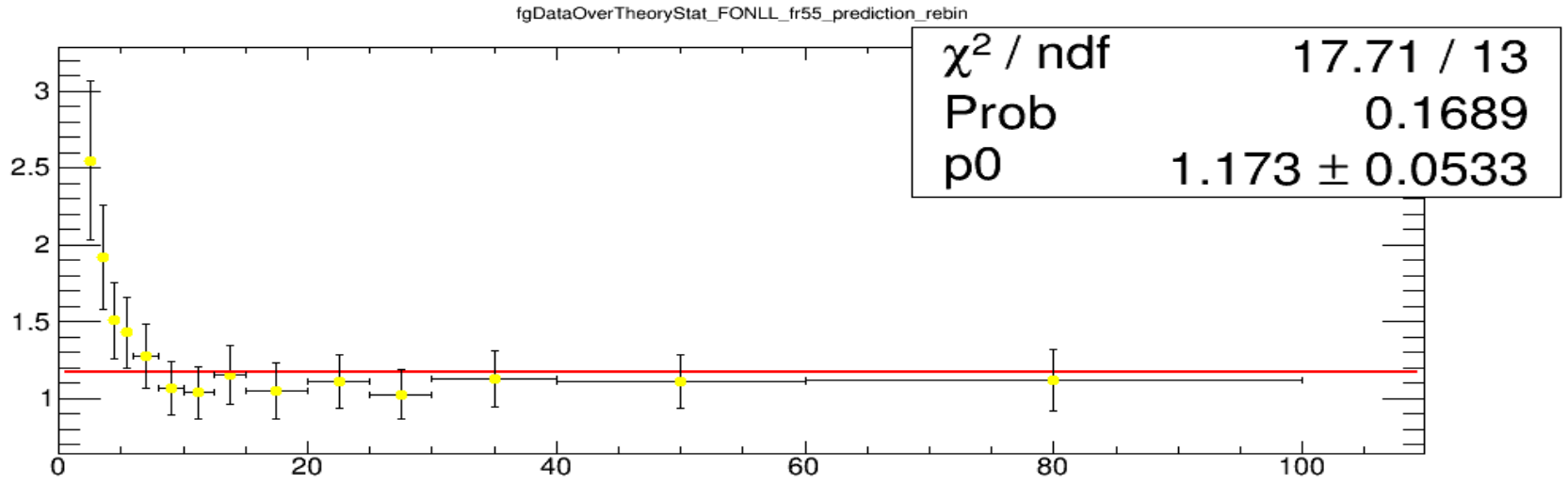


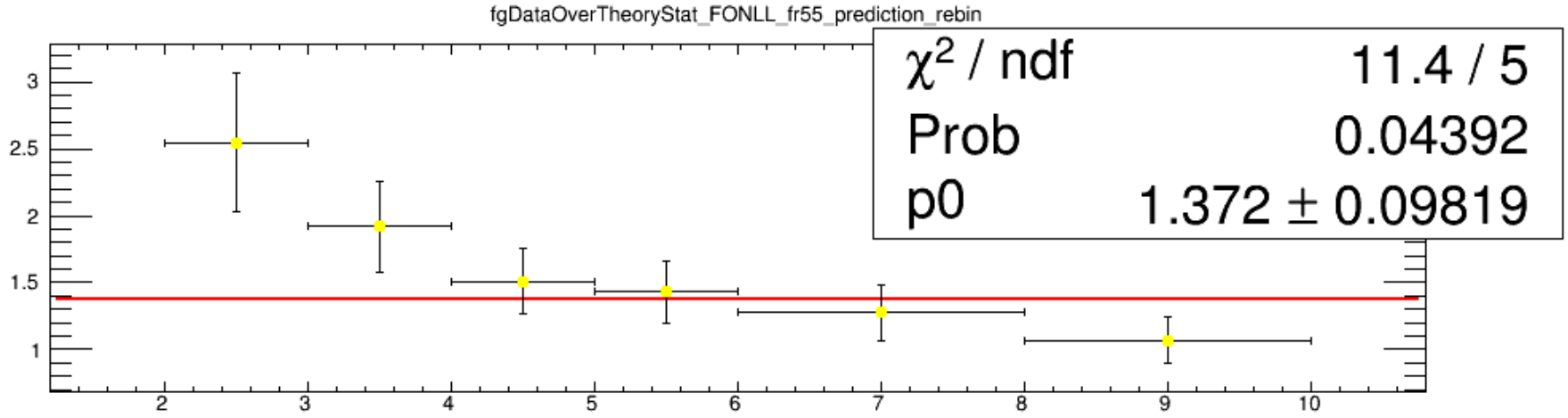
$(\mu_F/\mu_0,\mu_R/\mu_0)=(1,1)$, m=1.3



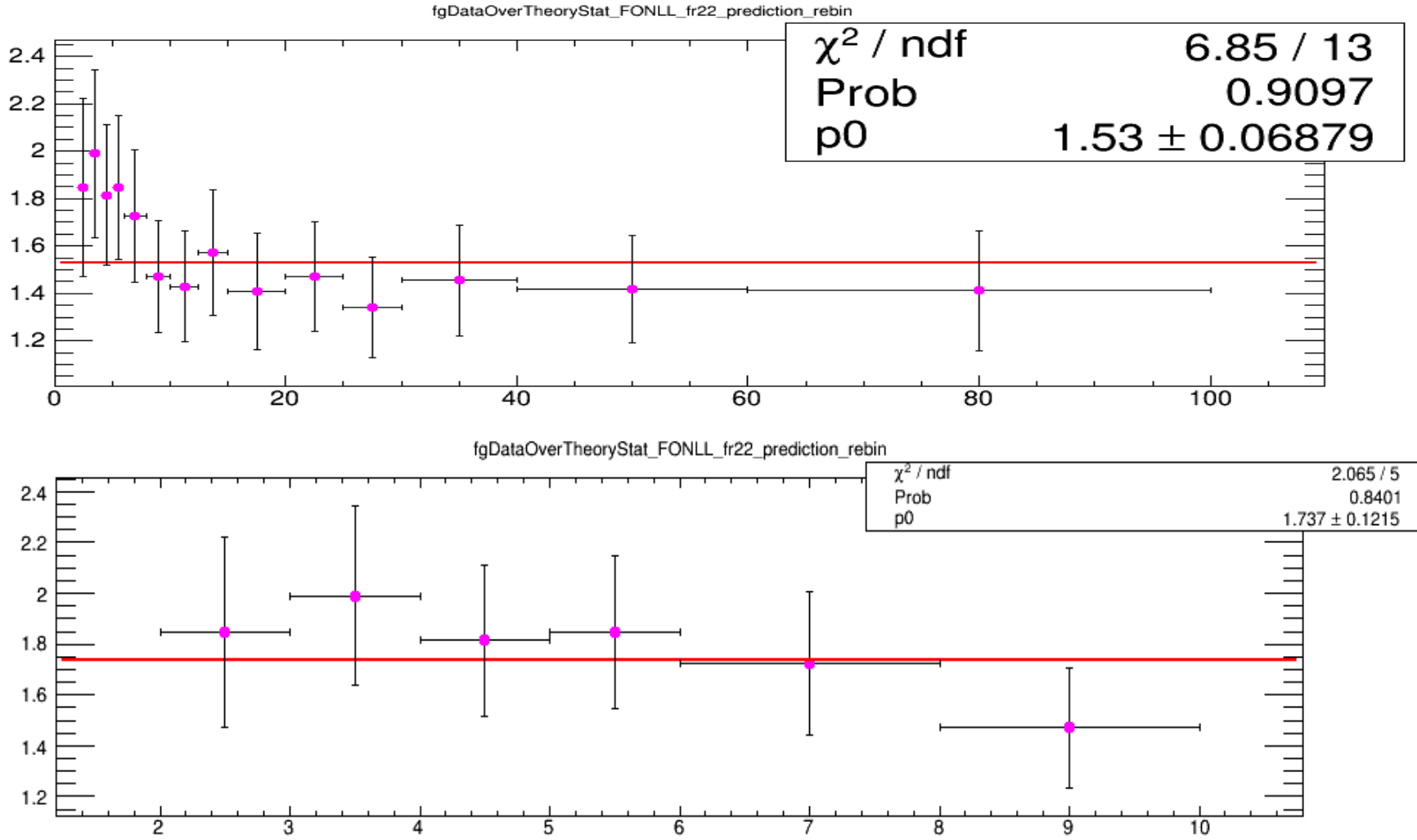


$(\mu_F/\mu_0,\mu_R/\mu_0)=(0.5,0.5)$, m=1.5

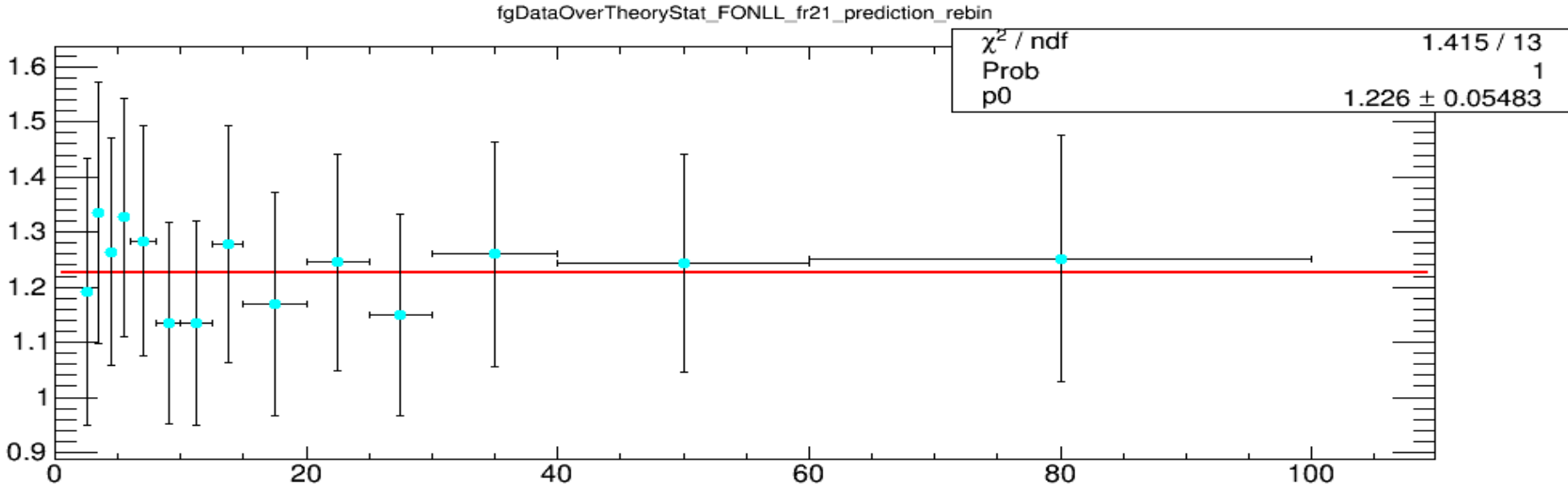


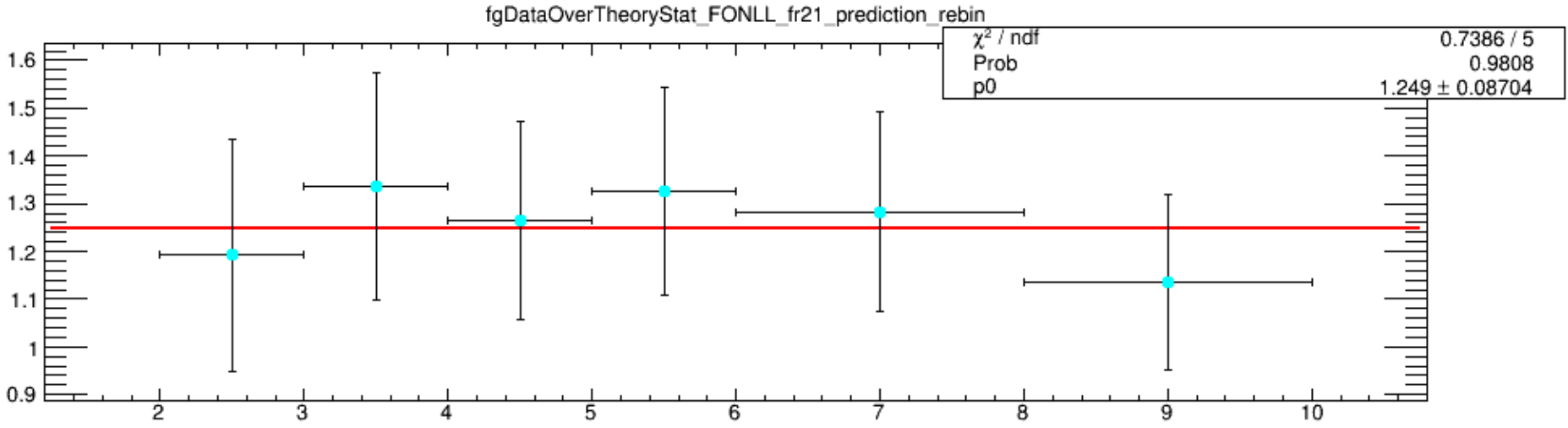


$(\mu_F/\mu_0,\mu_R/\mu_0)=(2,2)$, m=1.5

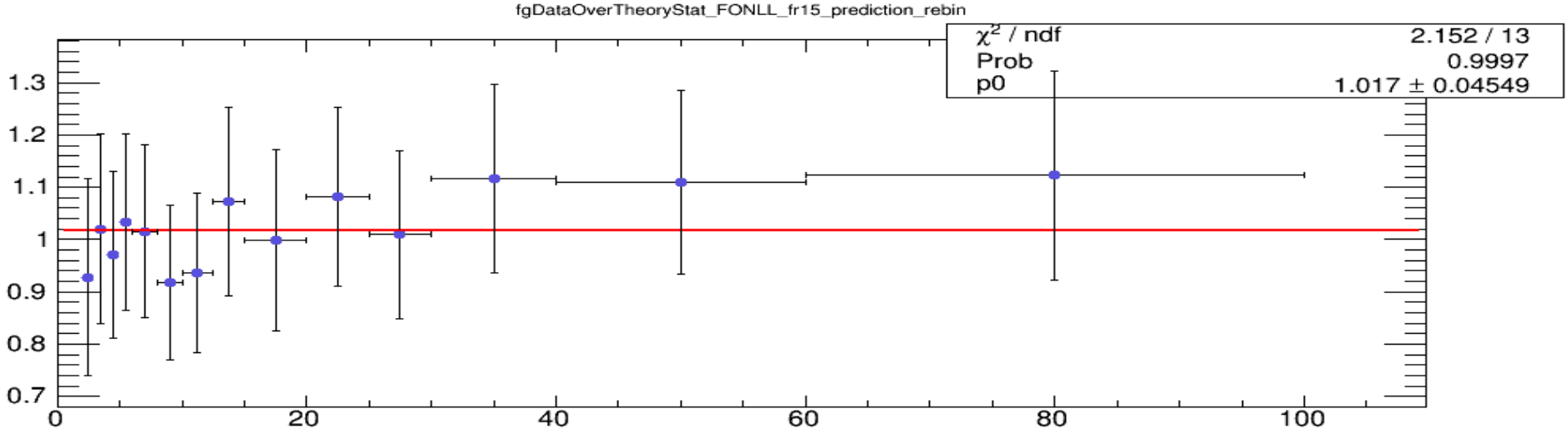


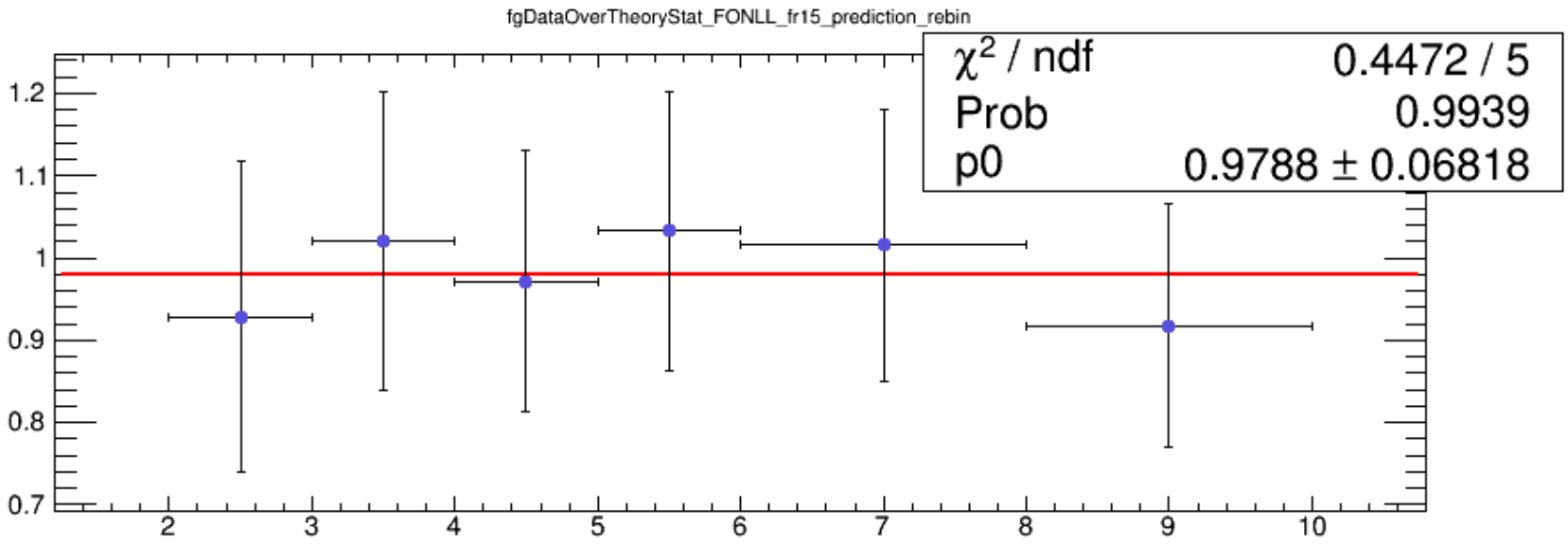
$(\mu_F/\mu_0,\mu_R/\mu_0)=(2,1)$, m=1.5



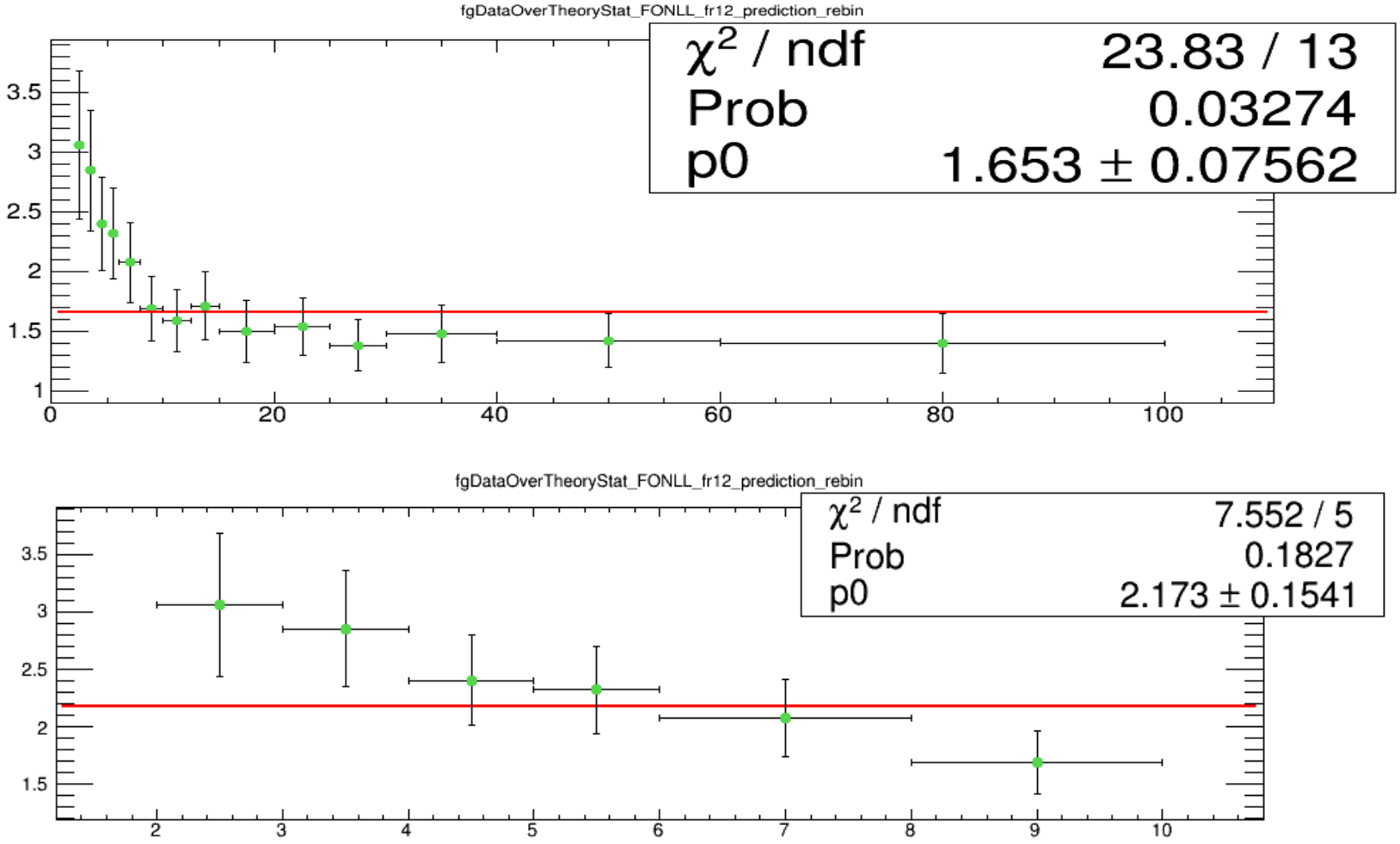


$(\mu_F/\mu_0,\mu_R/\mu_0)=(1,2)$, m=1.5

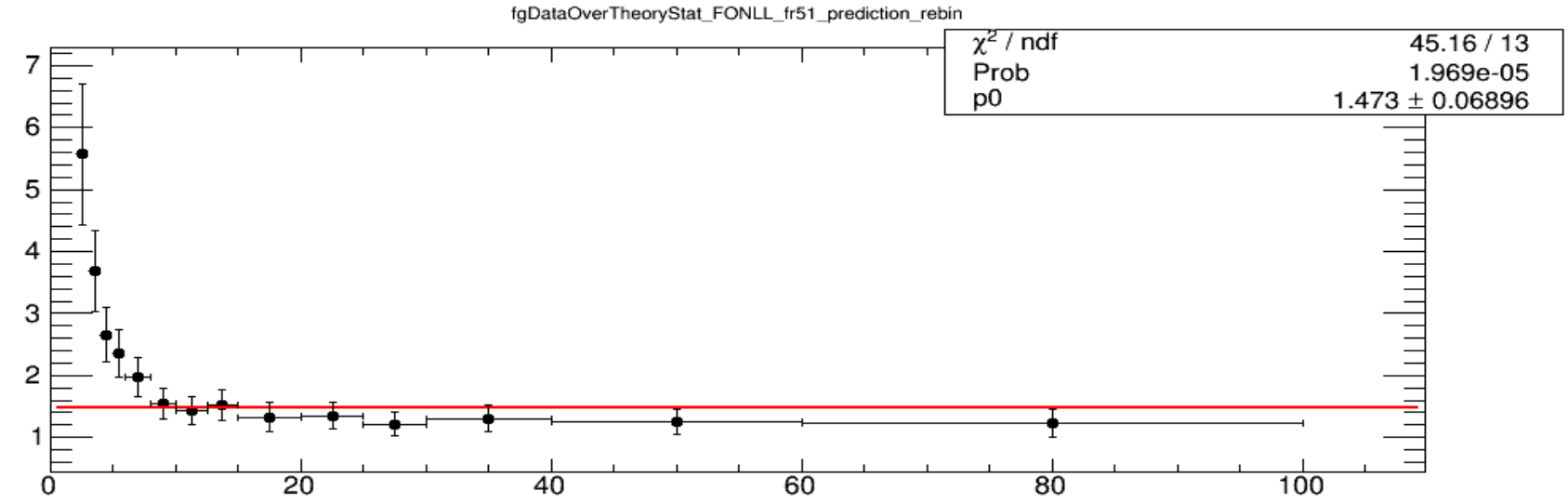


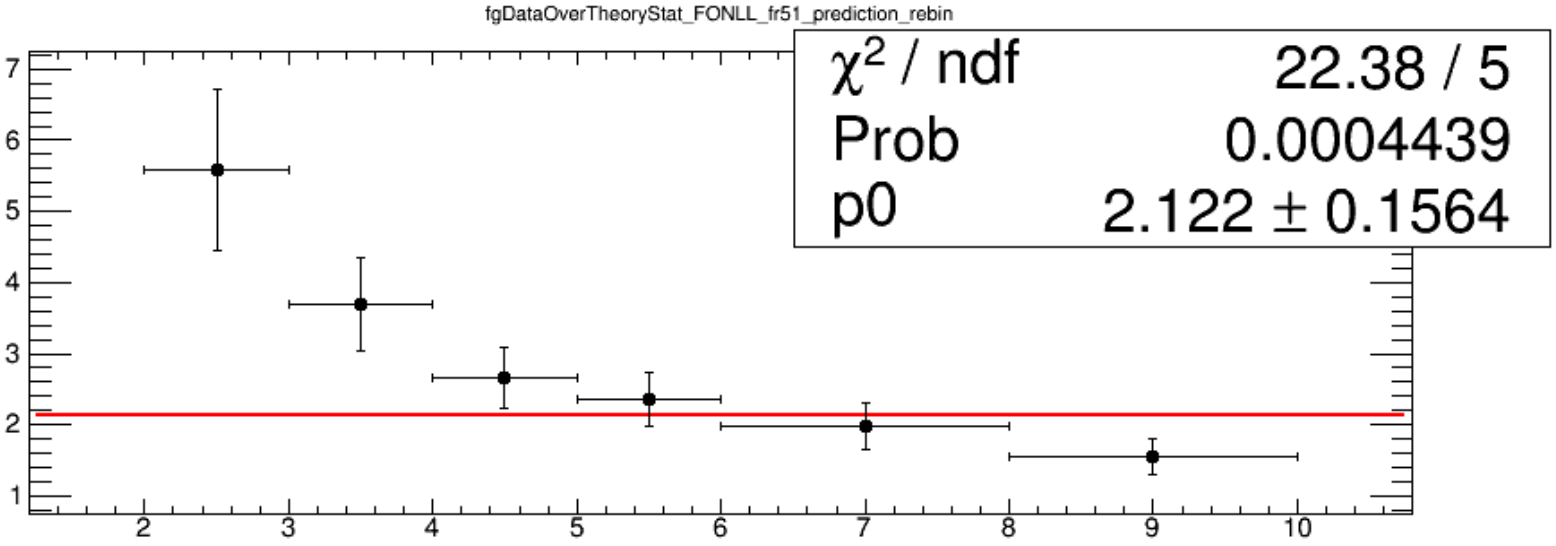


$(\mu_F/\mu_0,\mu_R/\mu_0)=(1,0.5)$, m=1.5



$(\mu_F/\mu_0,\mu_R/\mu_0)=(0.5,1)$, m=1.5





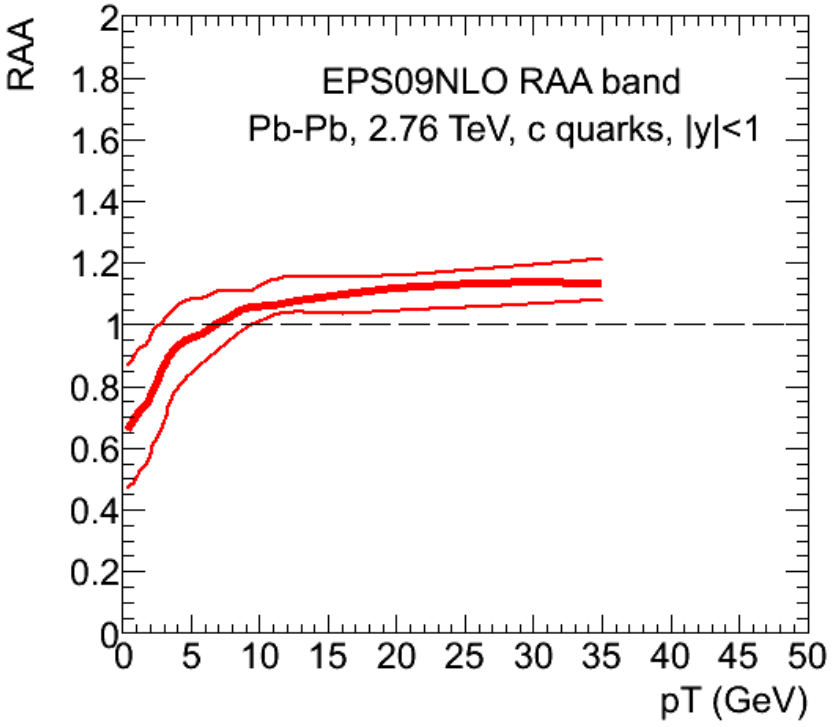
Summary CMS 5 TeV

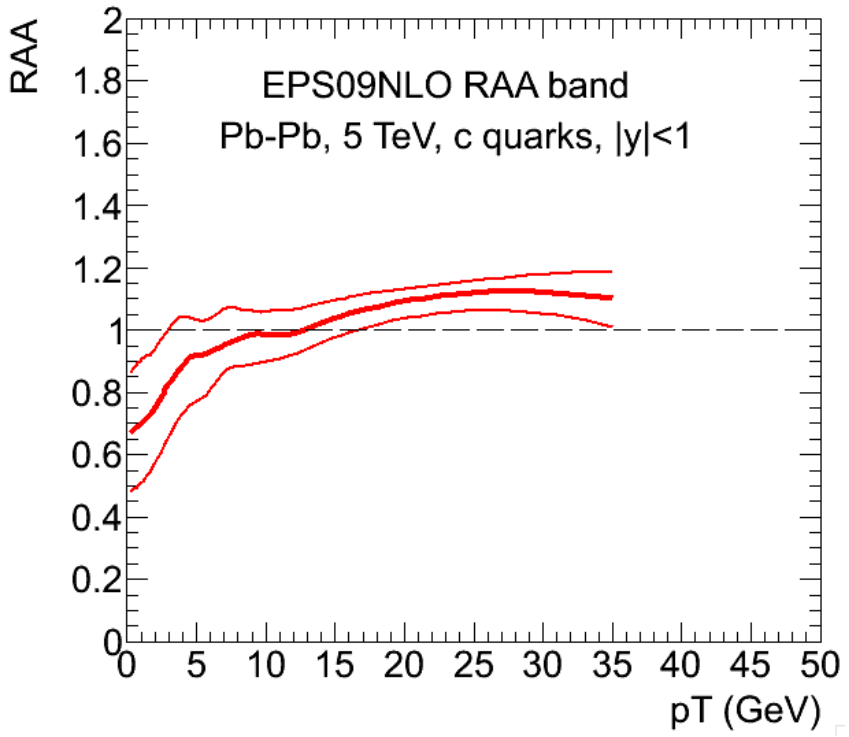
FONLL curve	χ^2 2-100 GeV	χ^2 2-10 GeV	Fit Data/FONLL 2-100 GeV
fr 1 1, m=1.5	0.68	0.68	1.35+-0.06
fr 1 1, m=1.7	1.28	1.20	1.43+-0.07
fr 1 1, m=1.3	0.25	0.30	1.23+-0.06
fr 0.5 0.5	1.36	2.28	1.17+-0.05
fr 2 2	0.52	0.41	1.53+-0.07
fr 2 1	0.18	0.15	1.23+-0.05
fr 1 2	0.17	0.09	1.02+-0.05
fr 1 0.5	1.83	1.51	1.65+-0.08
fr 0.5 1	3.47	4.48	1.47+-0.07

- The shape that best fits at 7 TeV is among the best: (1,1) and mc=1.3
  - The ratio data/theory is compatible at the two energies: 1.33+-0.7 vs 1.23+-0.6
- The two sets (0.5,0.5) and (0.5,1) have chi2 > 2 also at 5 TeV, as at 7 TeV
- The two "extreme" sets at 7 TeV can be taken as extremes also at 5 TeV

Shadowing

- RAA for c quarks with MNR+EPS09NLO
- Proposal: multiply the input c-quark pT spectrum from FONLL by this RAA and use the band to define a band on final RAA and v2
- Result very similar for 2.76 and 5 TeV (EPS09 flat at low x)





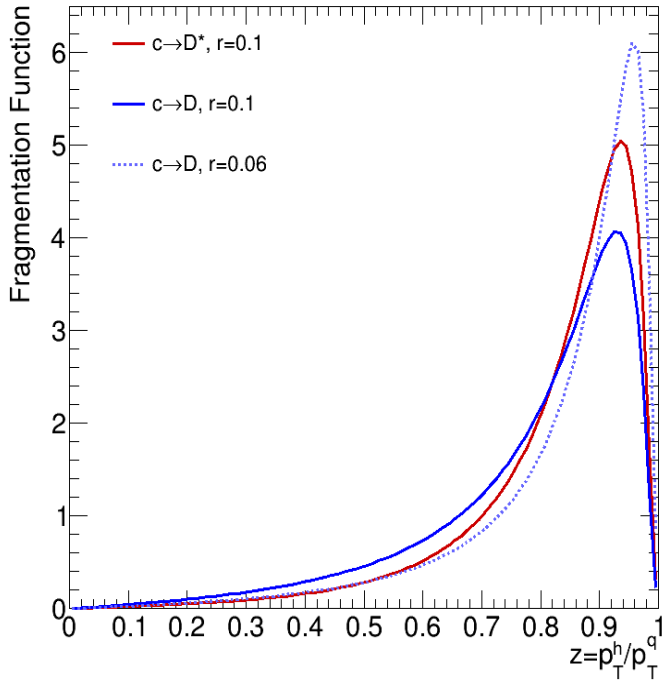
Fragmentation function

- BCFY functional forms used in FONLL
  - From Braaten et al., PRD51 (1995) 4819
  - Different for vector and pseudoscalar states
  - One parameter (r)

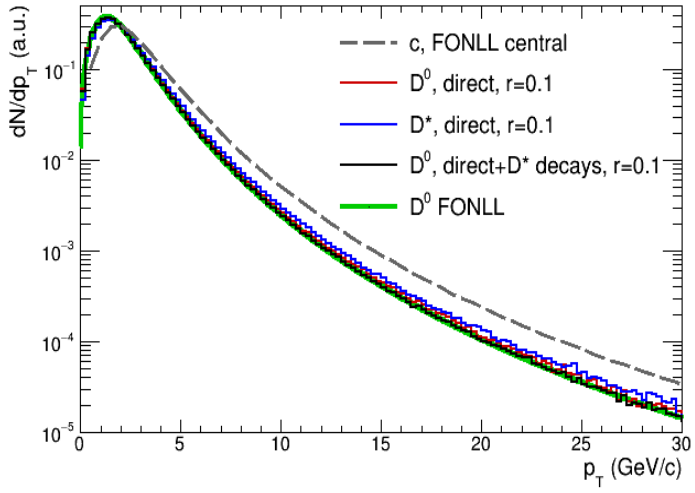
$$D_{Q\to P}(z) = N\frac{rz(1-z)^2}{(1-(1-r)z)^6}\left[6-18(1-2r)z+(21-74r+68r^2)z^2 -2(1-r)(6-19r+18r^2)z^3+3(1-r)^2(1-2r+2r^2)z^4\right], \quad (31)$$

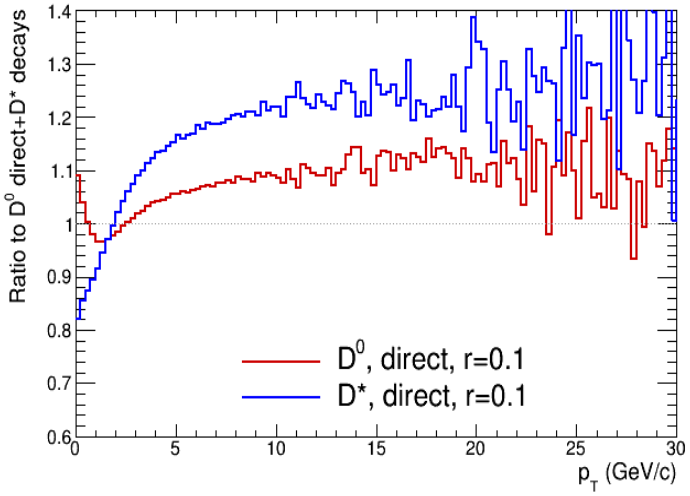
$$D_{Q\to V}(z) = 3N\frac{rz(1-z)^2}{(1-(1-r)z)^6}\left[2-2(3-2r)z+3(3-2r+4r^2)z^2 -2(1-r)(4-r+2r^2)z^3+(1-r)^2(3-2r+2r^2)z^4\right]. \quad (32)$$

- In FONLL, r tuned on D* fragmentation function measured in e+e- by ALEPH
  - → r=0.1 for mc =1.5 GeV
  - → r=0.06 for mc = 1.3 GeV



Fragmentation function





- Simple test:
  - generate c quarks with the pT distribution given by FONLL (gray dashed line)
  - Make them fragment into D0 (red histo) , D* (blue histo) with BCFY, r=0.1
  - Make the D* decay into D0 (PYTHIA)
  - Sum the direct D0 to those from D* decays
  - Compare to FONLL (green histo)

  → Small difference between spectra of directly produced D0 (c->D0 with the pseudoscalar frag. func) and the full calculation with D* decays

- Proposal:
  - Use **Eq. 31 from BCFY** paper
  - Use same for RAA numerator (in case of vacuum fragm) and denominator (pp)
  - Parameter r set according to c quark mass, as in FONLL:

    r=0.1 for mc =1.5 GeV

    r=0.06 for mc =1.3 GeV