Hadronic E/p Tuning for Plug/Crack

Pedro A. Movilla Fernández (LBNL)

Simulation Group Meeting

Oct. 19th, 2006

Overview

Gen-7 hadronic calorimeter response tuning status:

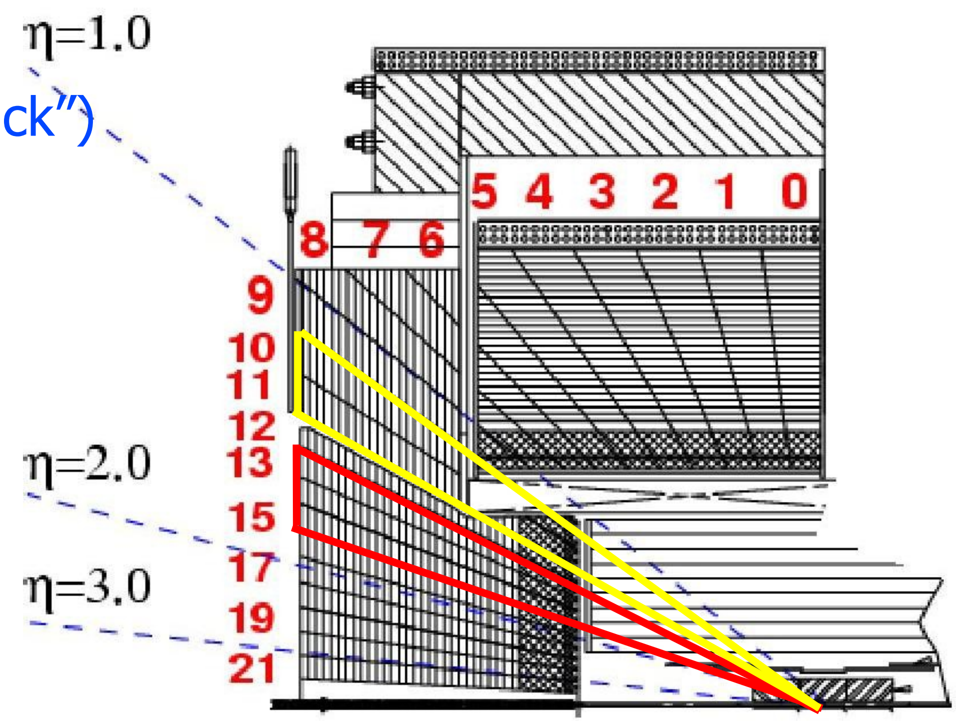
- We have final version for lateral profile in Central and Plug.
- Absolute ⟨E/p⟩ response tuning in Central also finalized .
- Agreement data vs. MC in Central: 1-2%

This talk:

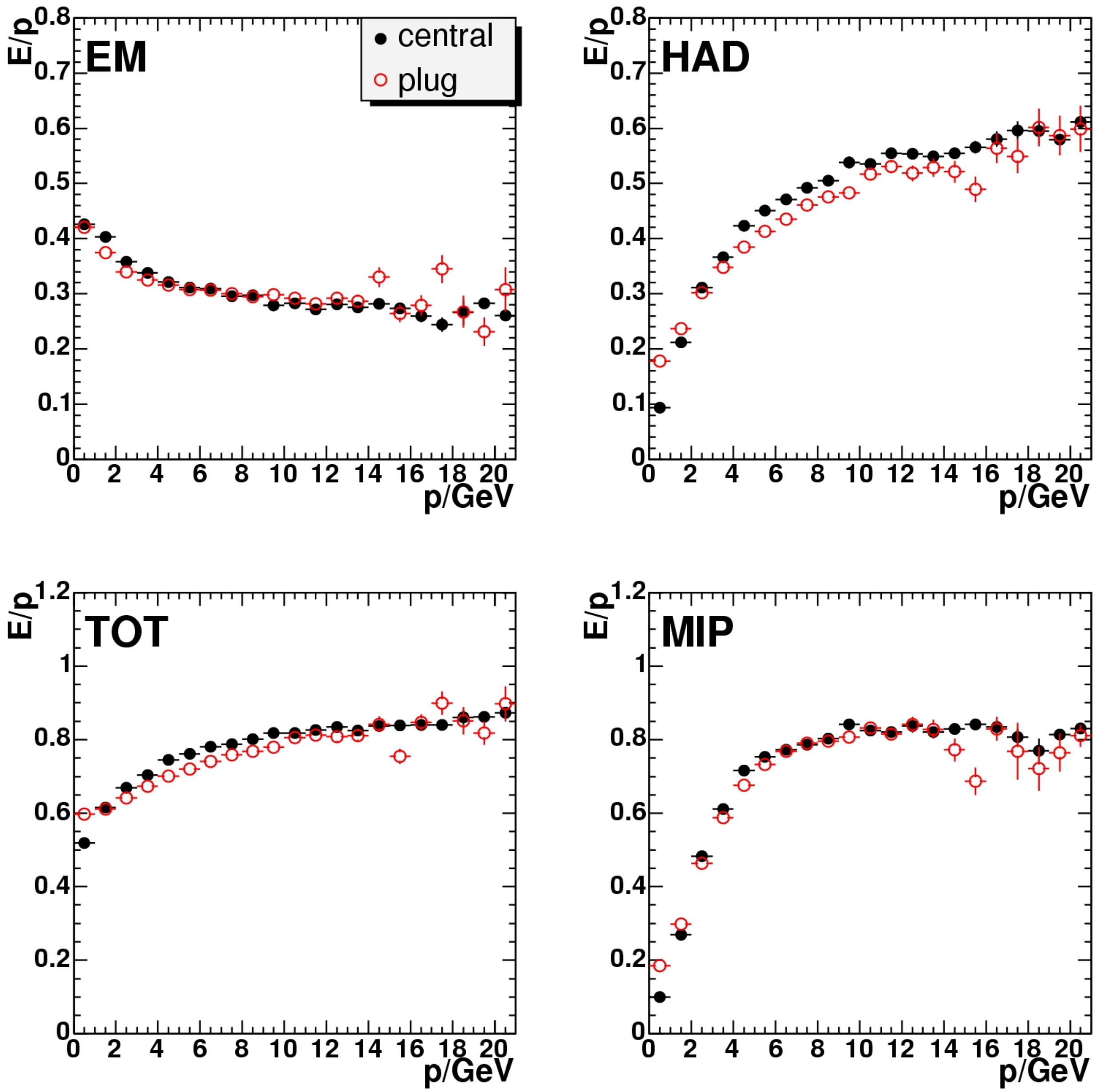
- Update of Plug E/p response tuning.

  - Towers used: 13-15 ("Plug"); 10, 11 ("Crack")
  - Data sets used: gmbs0d & gjtc0d
  - Focus on IO track response
  - Energy range: 0-20 GeV
  - See JER group talk of Aug-23 for more analysis details.

- Dependence on flavor mixture.



Data Plug vs. Central



- Different analyses in Plug and Central give a pretty consistent picture of the measured E/p responses.

Absolute Response Tuning

- Gen-5/6

  GflashSim/gfinha.F:

  ```
  FEDP = 0.7366+0.1699*TANH(0.6569*(XLNE-2.0826))
  ```

  GflashSim/gfshow.F:

  ```
  PBYMIP(1) = 2.30-0.48*TANH(7.45*(XLNP-1.74))
  PBYMIP(2) = 3.01+0.19*TANH(5.04*(XLNP-1.32))
  ```

- Starting point:

  ```
  PBYMIP(1) = 1.82
  PBYMIP(2) = 3.20
  FEDP = 0.7366+0.1699*TANH(0.6569*(XLNE-2.0826))
  ```

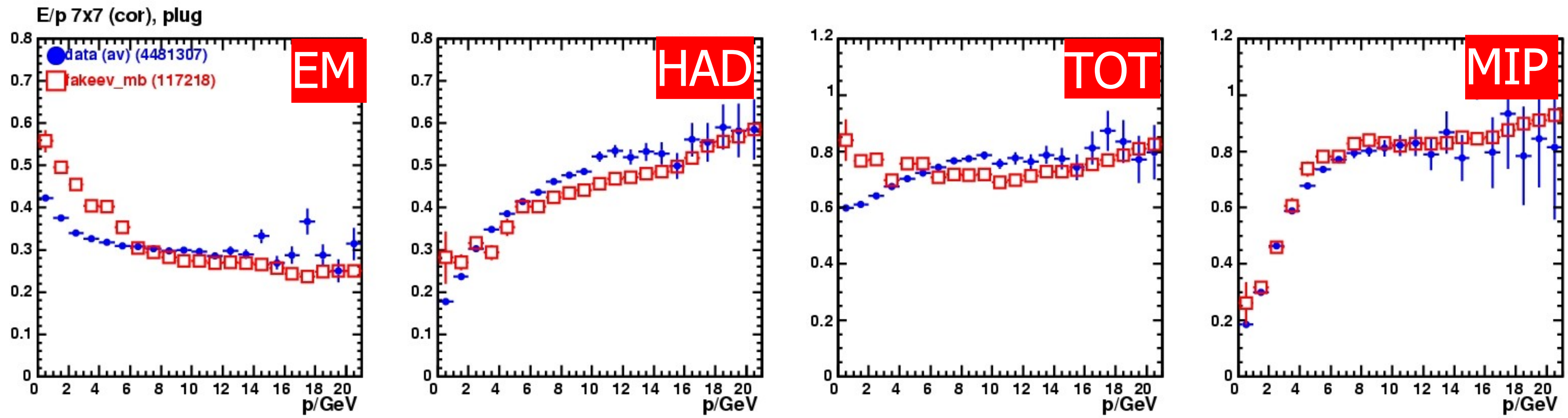
  ← Test beam default

- Crack response: tower-by-tower scaling factors of the relative sampling fractions above.

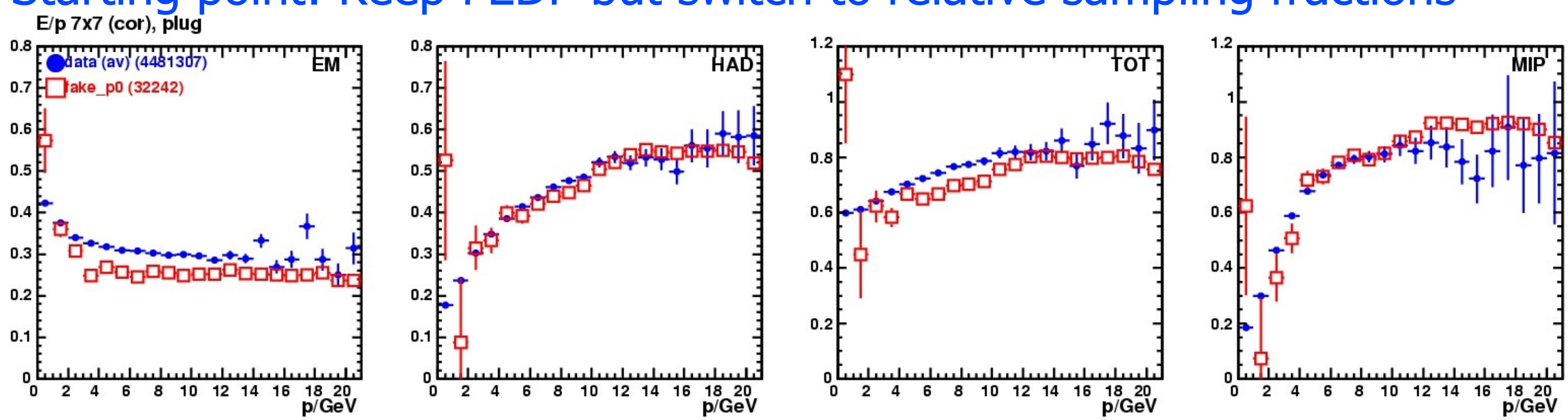
- Simulation: particle gun (FAKEEV) + cdfSim/ProductionExe 6.1.4
  - 8 particles per event within $|\eta|$=0.72-2.1
  - Pion/Kaon/Proton=.6/.3/.1
  - flat spectrum
  - Pythia Minimum Bias events added on top

Initial Picture

Old picture: Gen-5 with new lateral profiles



Starting point: Keep FEDP but switch to relative sampling fractions



Comments on Tuning Procedure

- Initial guideline: fix relative sampling fractions to result from test beam tuning (or keep at least constant within 0-20 GeV), respect constraint from test beam tuning during FEDP fit.

- Tried three different tuning series
  - P series: fix PEM sampling to test beam value
    use 57 GeV test beam constraint for FEDP
  - Q series: allow PEM sampling to float
    use 57 GeV test beam constraint for FEDP
  - R series: give up any constraints

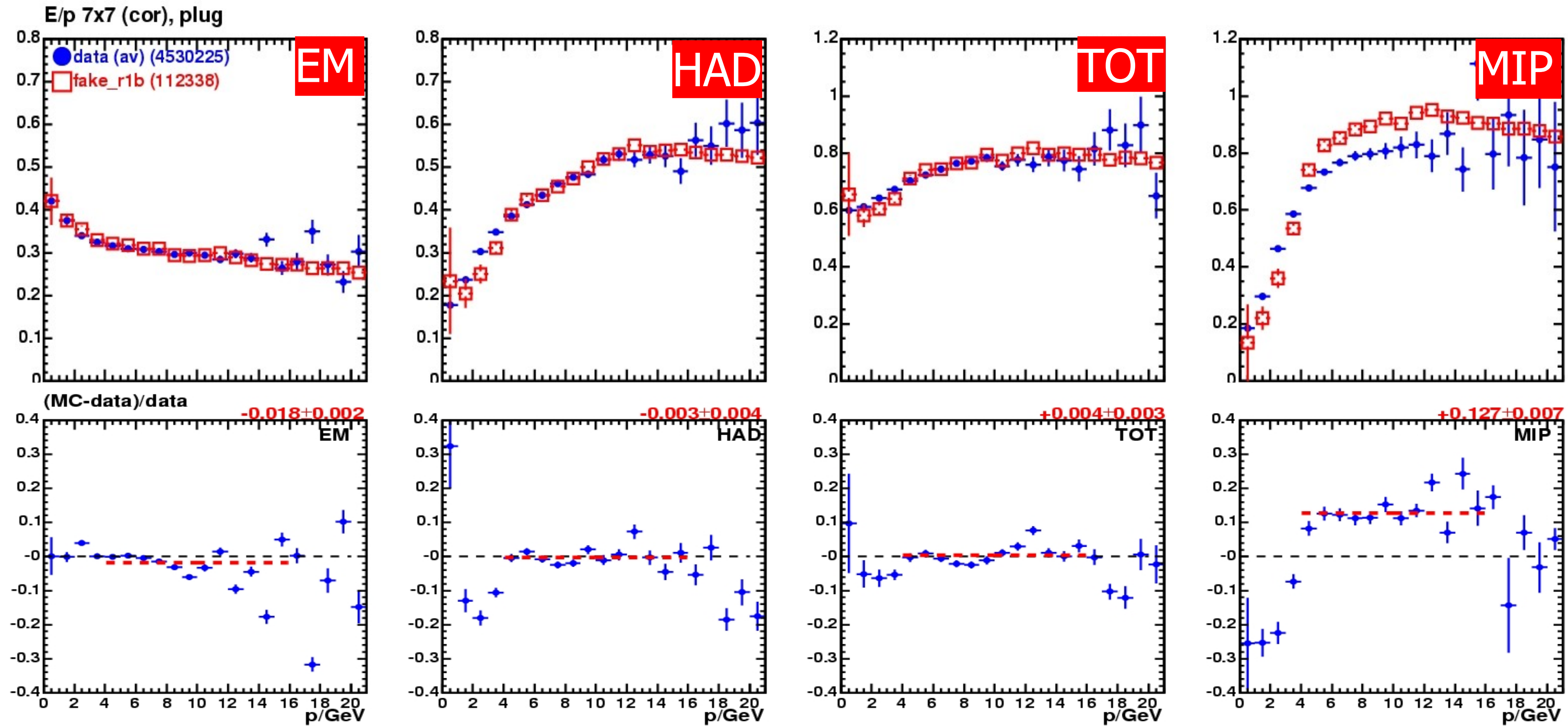
Test beam tuning differs form in-situ tuning...

- w.r.t. the MC lateral shower profile used:
  - bias on FEDP: constant FEDP plateau at high p is higher for narrow profiles

- w.r.t. MC flavor composition used:
  - test beam: pions only, in-situ: mixture of pions, Kaons, protons

...it might be a good idea to treat in-situ and test beam information separately (R series)

... after two iterations (Plug)

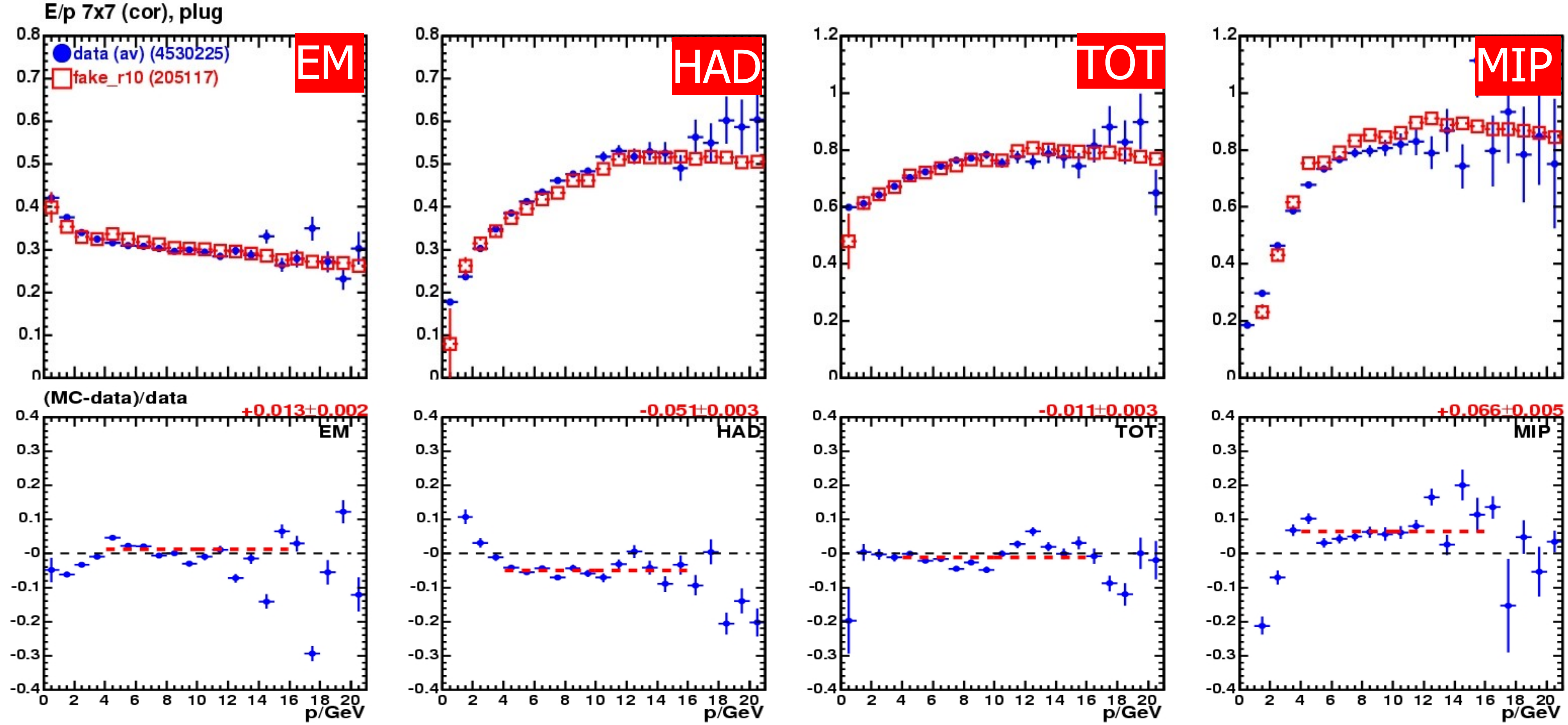



```
PBYMIP(1)= 2.17
PBYMIP(2)= 3.20
FEDP = 0.6707 + 0.1375 * TANH( 1.3161 * ( LOG(P) - 1.3345 ) )
```

R1b

- Typical picture in the beginning:
  - nice agreement in EM, HAD and TOT
  - MIP response: excess of MIP at high p and deficit at low p

R Series Results (Plug)

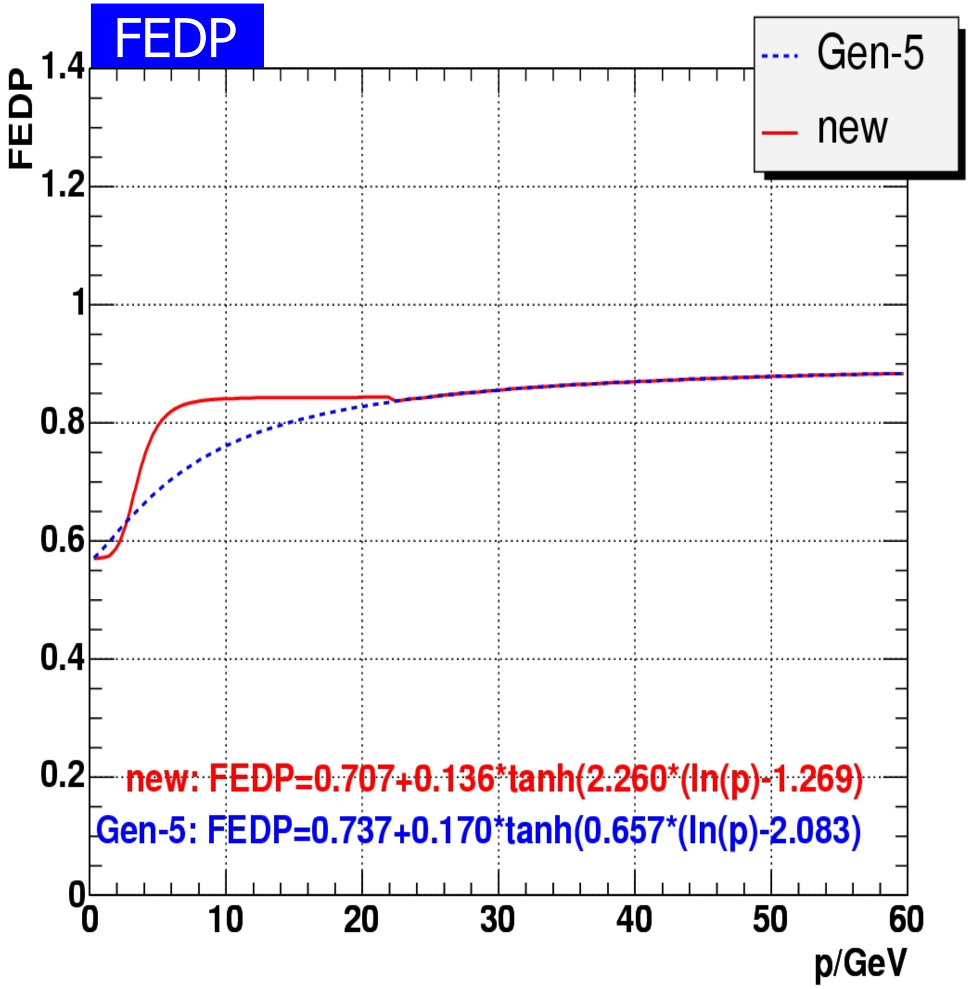


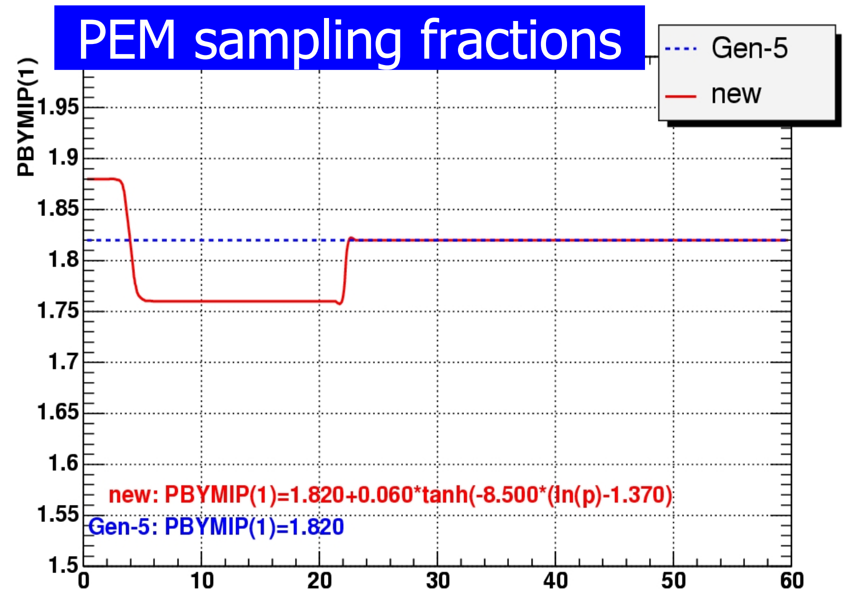

```
PBYMIP(1)= 1.82 - 0.060 * TANH( 8.50 * ( LOG(P) -1.37 ) )
PBYMIP(2)= 2.70 - 0.625 * TANH( 8.50 * ( LOG(P) - 1.37 ) )
FEDP = 0.7071 + 0.1362 * TANH( 2.2600 * ( LOG(P) - 1.2692 ) )
```

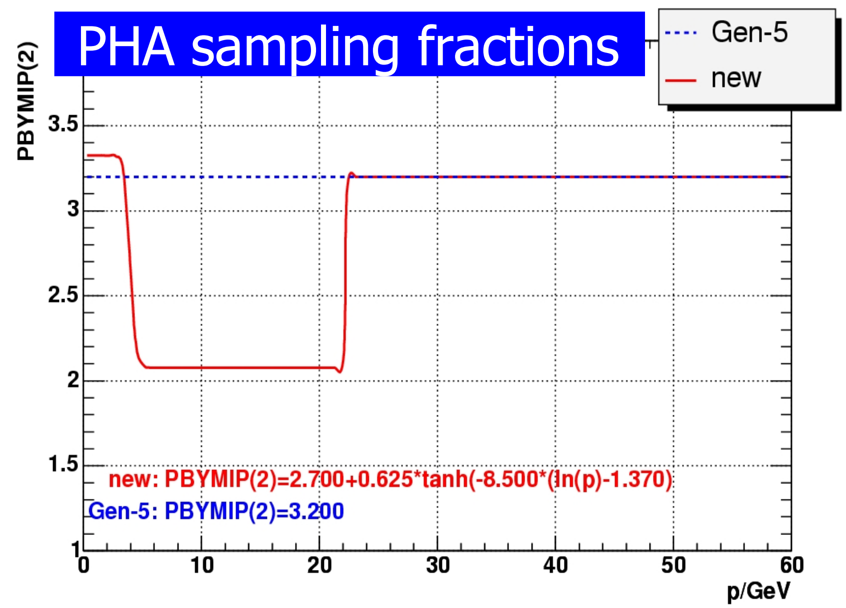
R10

- Control of MIP response difficult, requires variation of PBYMIP(2) between ~3.2 (low p) and ~2.1 (high p); test beam value (57GeV) is 3.20
- I am still running a job to improve PEM response at <4GeV.

Parameters

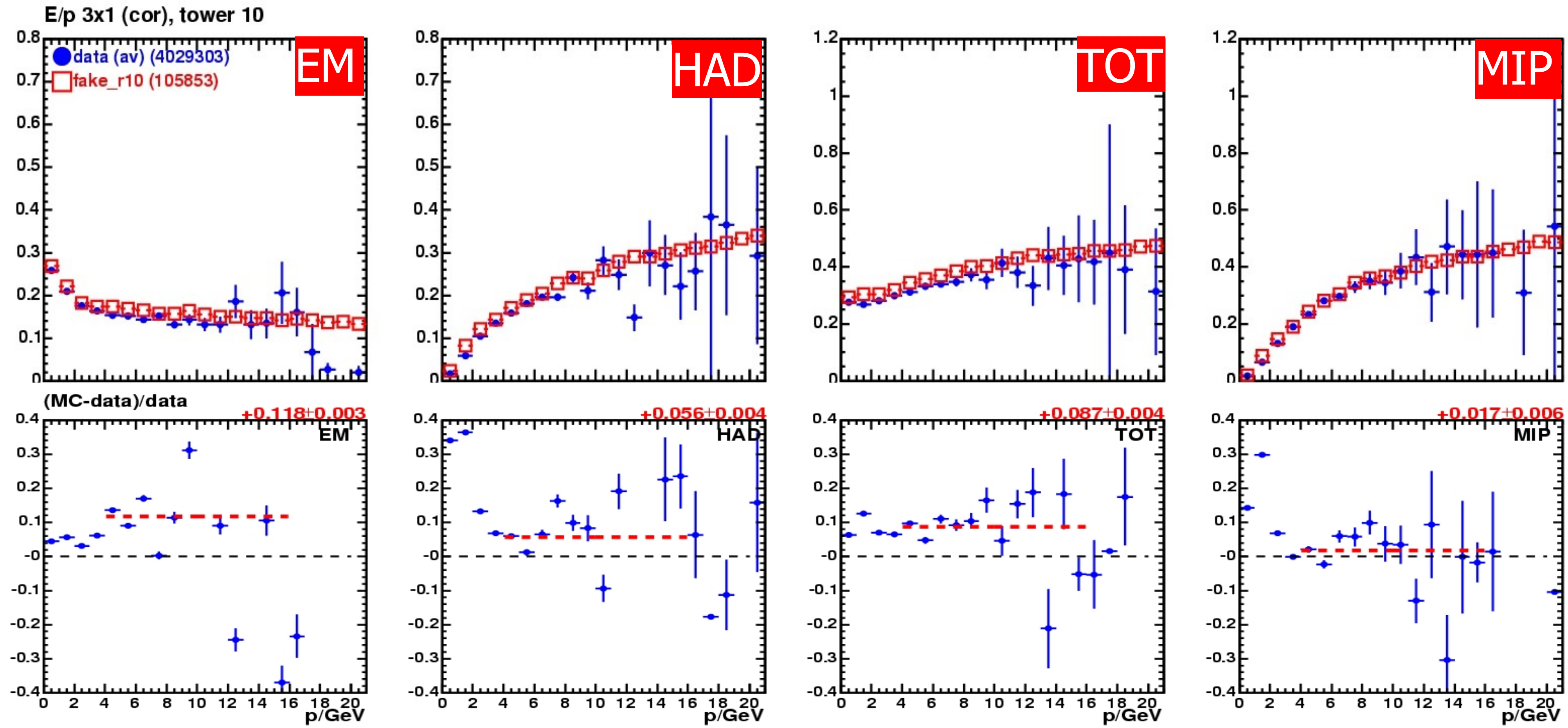






- Getting the MIP response right requires stretching FEDP plateau into low energies.
- Smooth transition of FEDP at ~24 GeV.

R Series Results (T10)

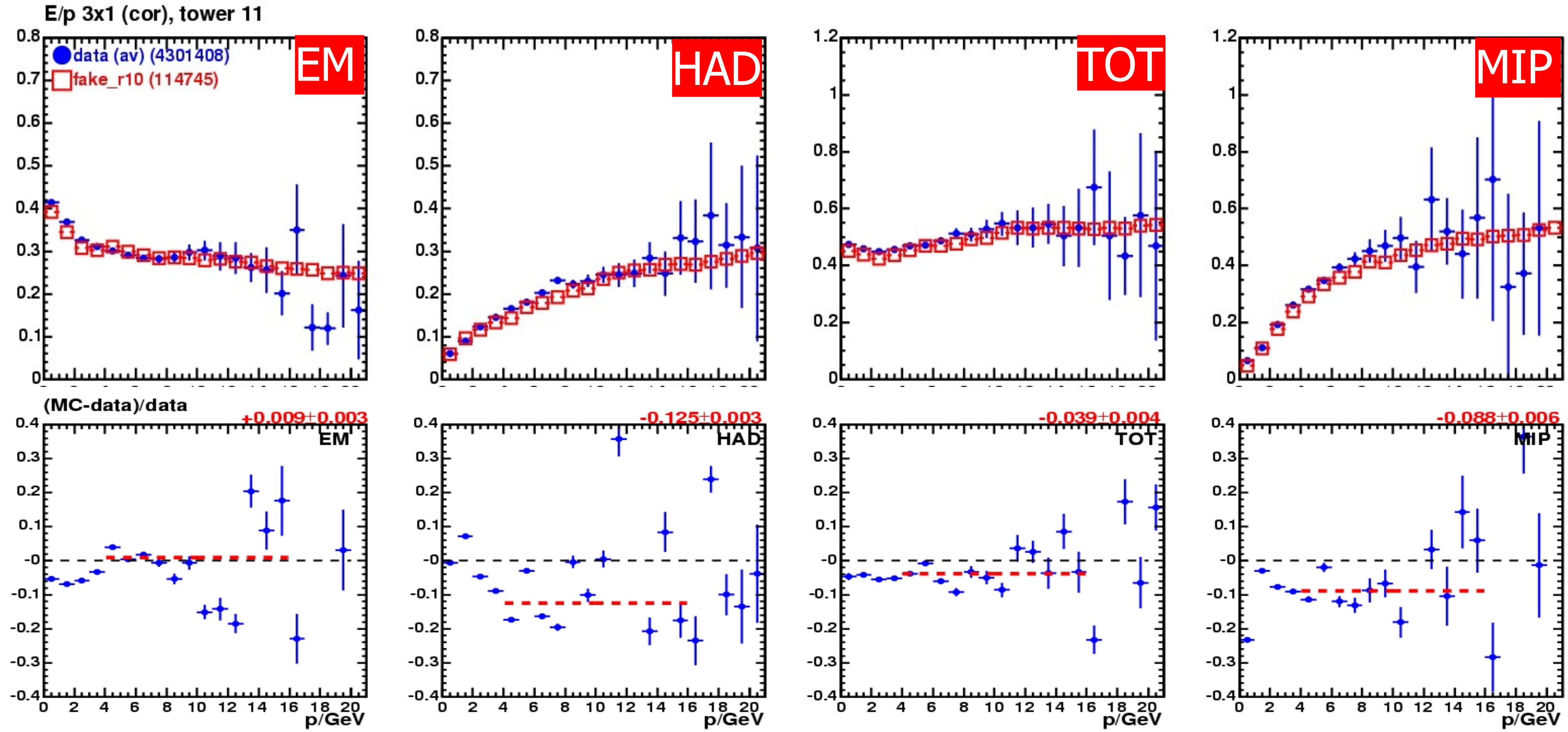



```
PBYMIP(1)= 1.82 - 0.060 * TANH( 8.50 * ( LOG(P) -1.37 ) )
PBYMIP(2)= 2.70 - 0.625 * TANH( 8.50 * ( LOG(P) - 1.37 ) )
FEDP = 0.7071 + 0.1362 * TANH( 2.2600 * ( LOG(P) - 1.2692 ) )
PBYMIP_PEM_TOWER10=PBYMIP(1)*0.64
PBYMIP_PHA_TOWER10=PBYMIP(2)*0.78
PBYMIP_WHA_TOWER10=PBYMIP(5)*0.59
```

R10

- Response (1x3 tower strips) after adjusting the T10 scaling factors.
- Picture improved much but still suboptimal.

R Series Results (T11)

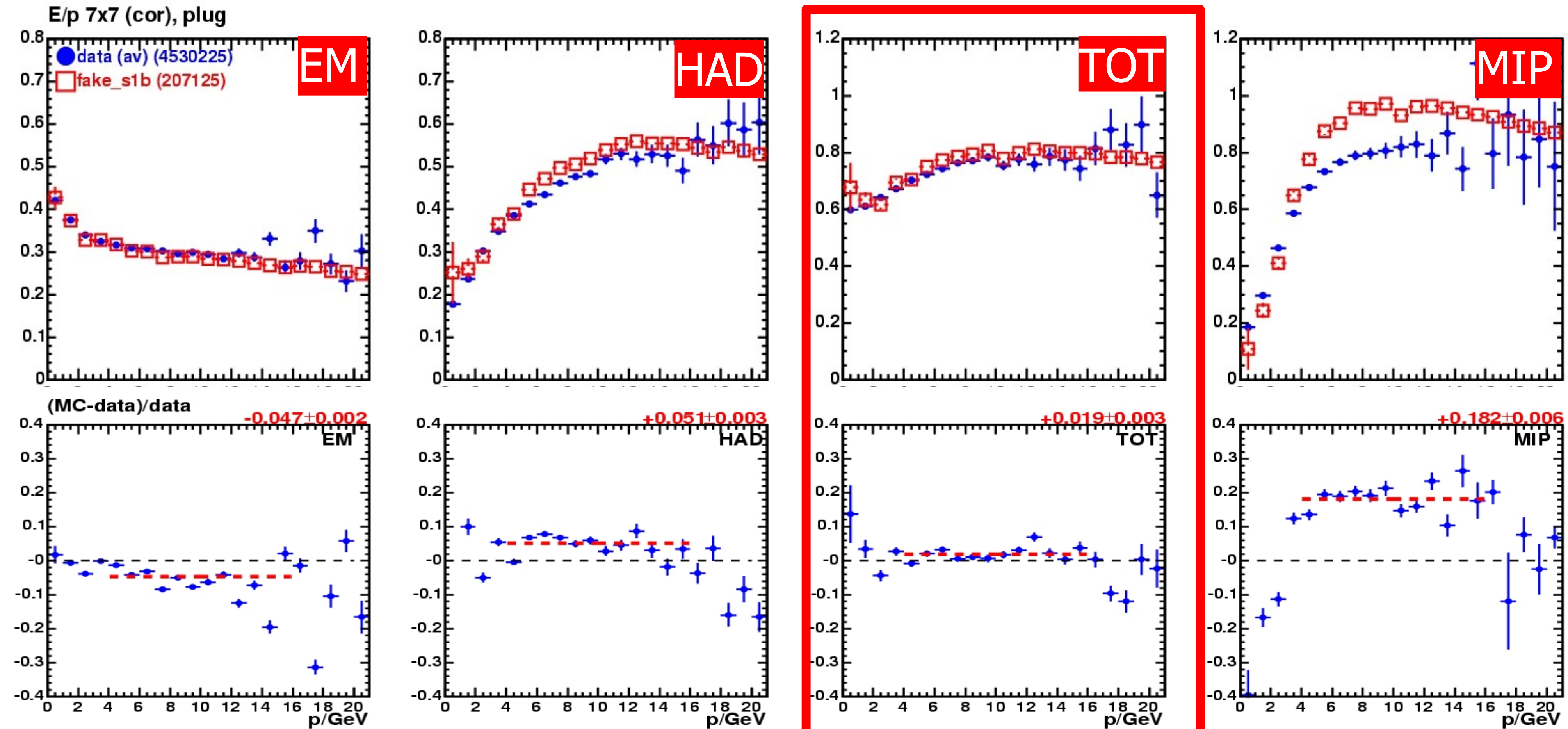



```
PBYMIP(1)= 1.82 - 0.060 * TANH( 8.50 * ( LOG(P) -1.37 ) )
PBYMIP(2)= 2.70 - 0.625 * TANH( 8.50 * ( LOG(P) - 1.37 ) )
FEDP = 0.7071 + 0.1362 * TANH( 2.2600 * ( LOG(P) - 1.2692 ) )
```

R10

- Scaling factor for tower 11 unchanged (Gen-5).
- I am still running a job to get a better agreement of the crack response.

Alternate Approach with Fixed Sampling Fractions

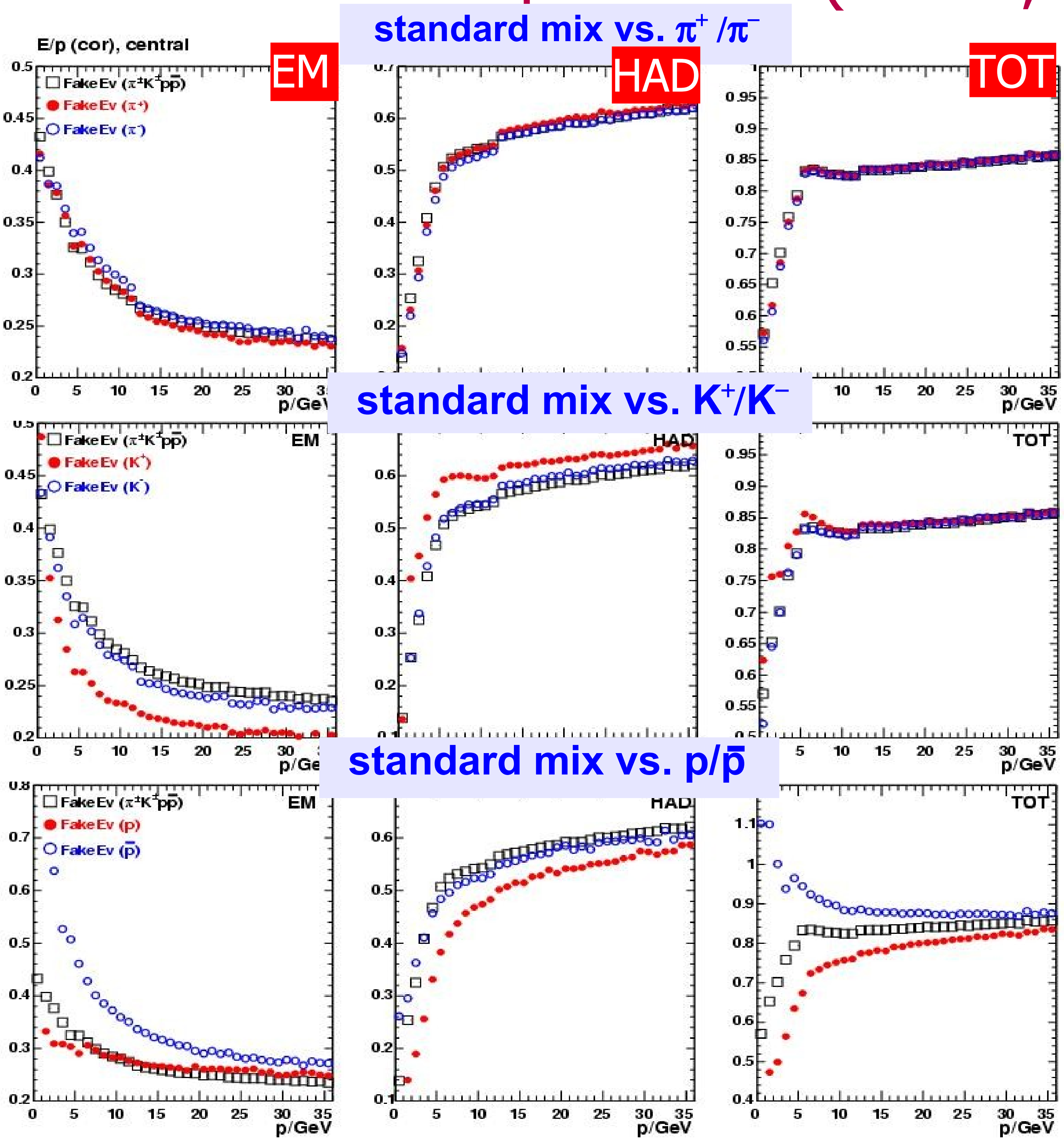



```
PBYMIP(1)= 1.82
PBYMIP(2)= 3.20
FEDP = 0.6927 + 0.1211 * TANH( 1.5397* ( LOG(P) - 1.2759 ) )
```

S1b

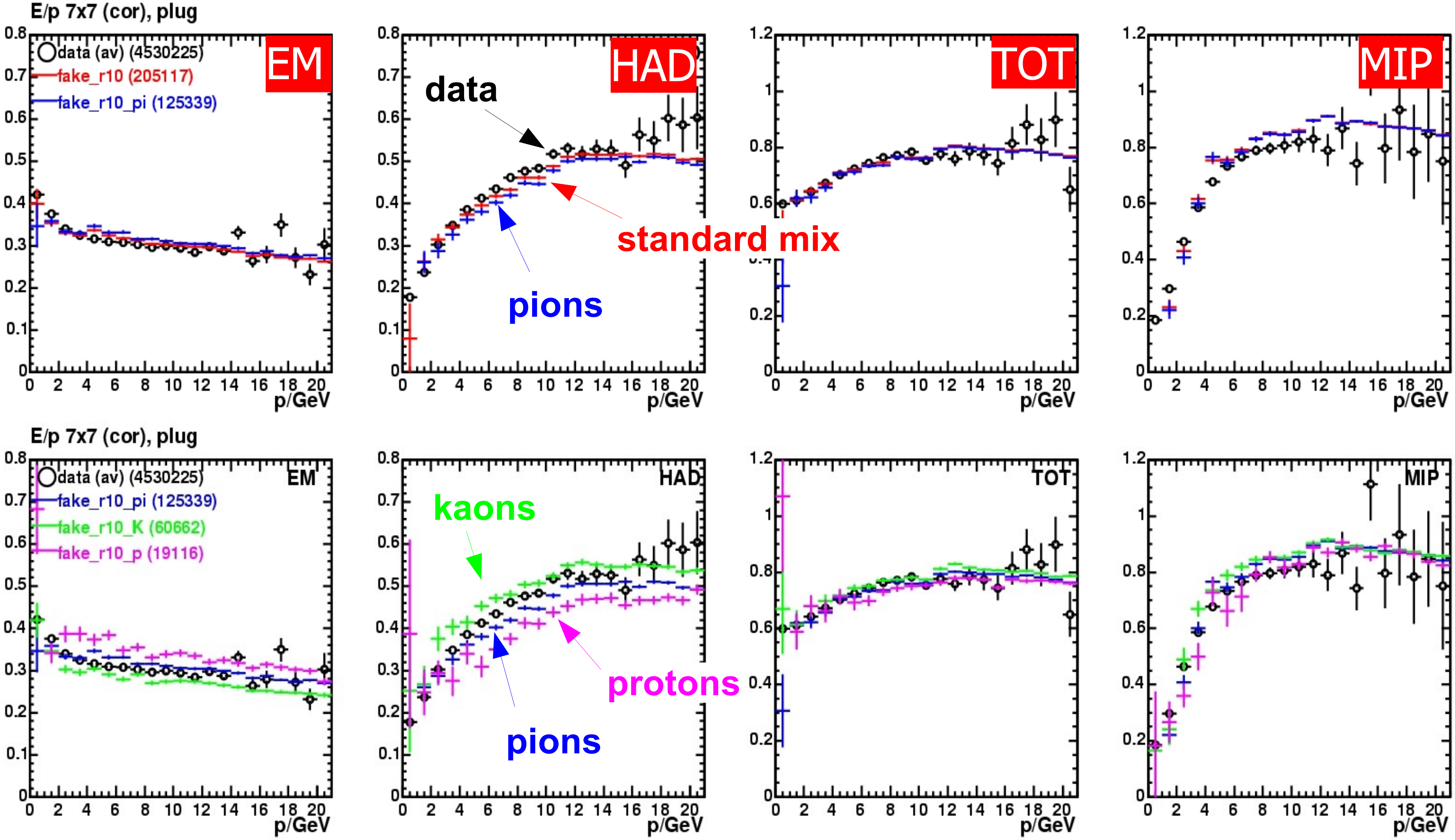
- Relative sampling fractions fixed to test beam tuning. Just focus in TOT response (above picture not perfect, need one more iteration.)
- It would be useful to have also an alternate parametrization with “natural” parameter values validated by JER people.

Flavor Dependence (Gen-5, Central)



- See my talk SGM given Dec-01-2005.
- Start location of hadronic shower strongly depends on the flavor content. -> large impact to individual responses EM, HAD.
- NB: GFLASH treats pion/kaon/proton showers equally. Flavor dependence shown here is pure effect of Geant cross sections!

Flavor Dependence (Plug, R10)



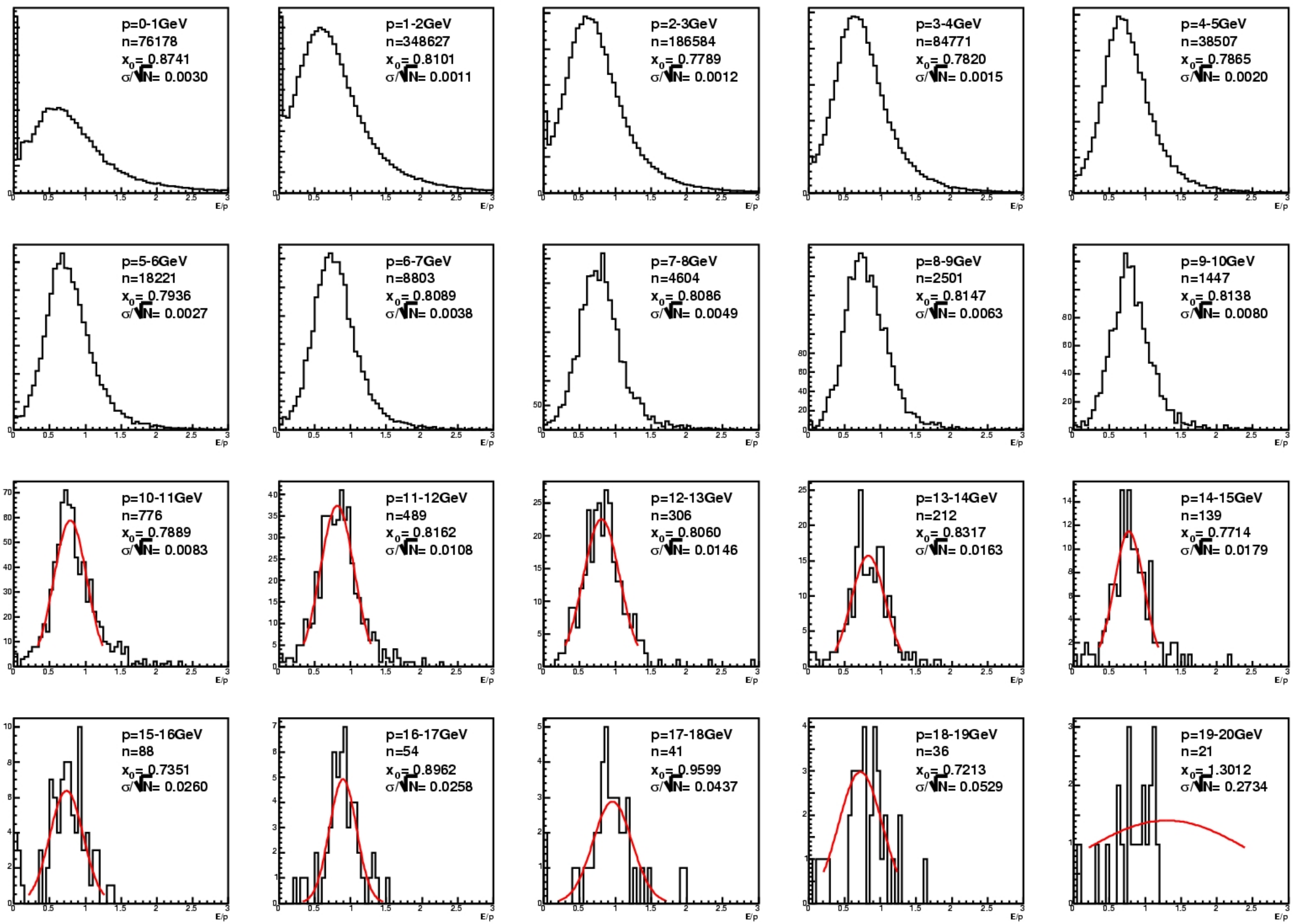
- Above plots: FAKEEV flavor/anti-flavor = 50%/50%. (NB: Minbias spectrum dominates low p).
- Large flavor dependence in EM and HAD due to dependence on shower start.
- Only very little effect to TOT and moderate effect to MIP since complete shower shapes are well contained in both cases.

Conclusions

- Have tried various tuning series: constant sampling fractions are disfavored in each case when trying to get all distributions right.
- However, TOT response is tunable within 2-5% of data response.
- Smooth transition at p~20-25GeV to simulated response based on test beam tuning possible.
- Flavor composition might introduce an uncertainty of the tuned sampling fractions. TOT and MIP less affected.
- E/p distributions (see appendix): problem with the simulated shower shapes at very low energies but ok at high energies.
- I suggest to validate two alternate tuning versions:
  version 1: energy dependent sampling fractions which try to get PEM, HAD, TOT and MIP right (R10)
  version 2: relative sampling fractions fixed to test beam tuning (S1b) or slightly modified constant (R1b) with focus mainly on TOT
- We need an additional validation based on individual PEM/PHA responses to check the relative sampling fractions!

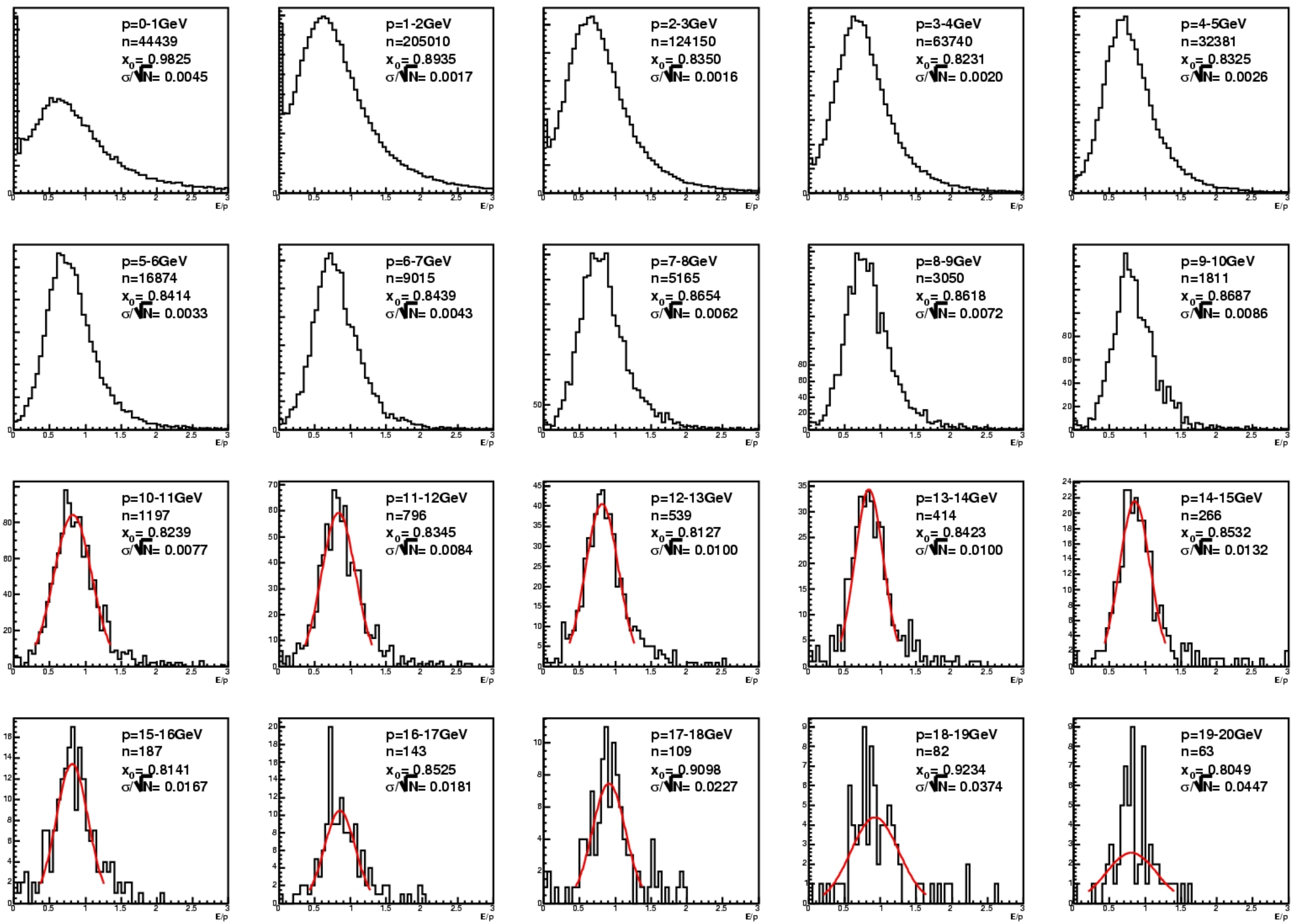
Appendix: E/p distributions

TOT, gmbs0d

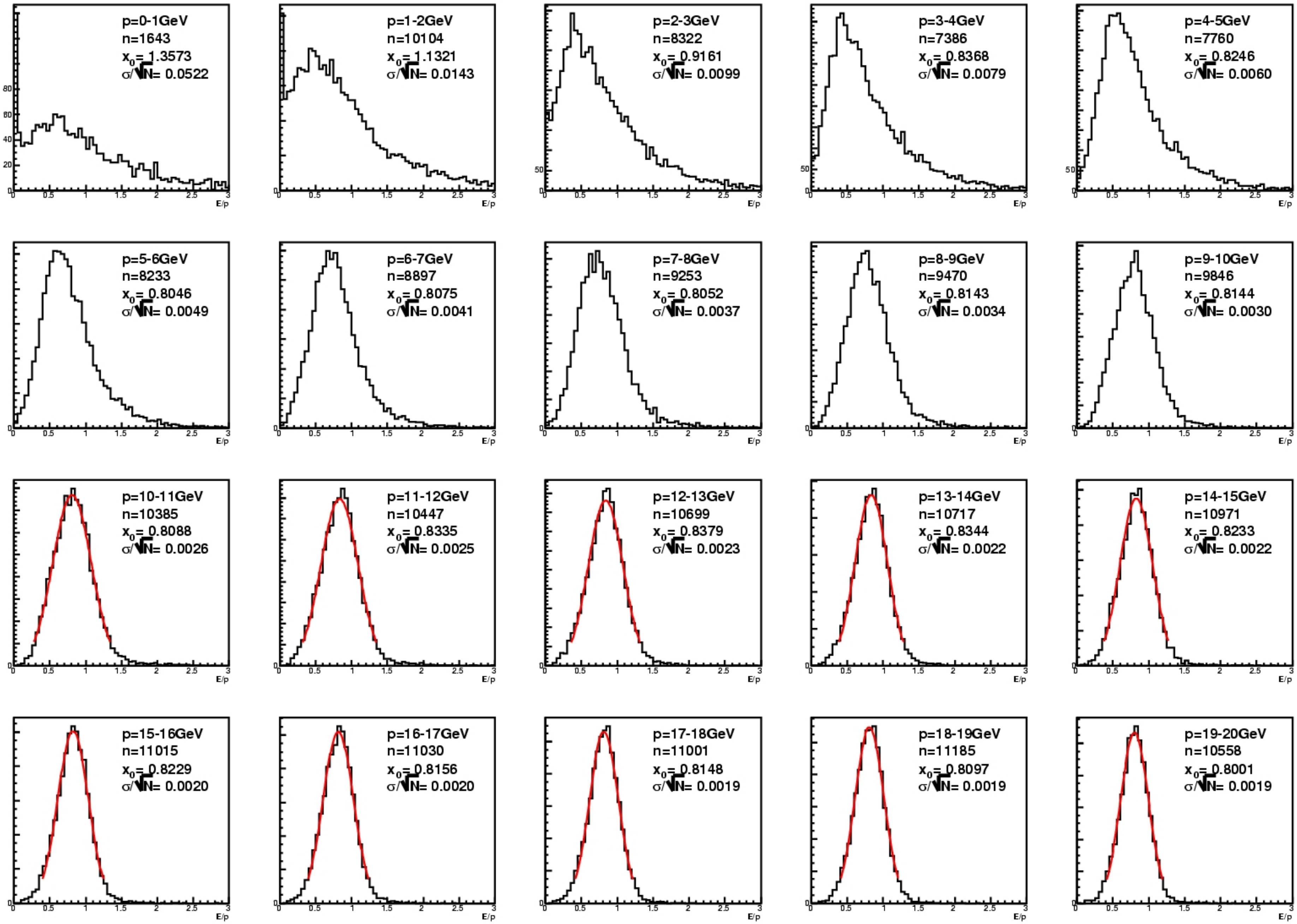


p=0-1GeV
n=76178
x_0= 0.8741
$\sigma/\sqrt{N}$= 0.0030
p=1-2GeV
n=348627
x_0= 0.8101
$\sigma/\sqrt{N}$= 0.0011
p=2-3GeV
n=186584
x_0= 0.7789
$\sigma/\sqrt{N}$= 0.0012
p=3-4GeV
n=84771
x_0= 0.7820
$\sigma/\sqrt{N}$= 0.0015
p=4-5GeV
n=38507
x_0= 0.7865
$\sigma/\sqrt{N}$= 0.0020
p=5-6GeV
n=18221
x_0= 0.7936
$\sigma/\sqrt{N}$= 0.0027
p=6-7GeV
n=8803
x_0= 0.8089
$\sigma/\sqrt{N}$= 0.0038
p=7-8GeV
n=4604
x_0= 0.8086
$\sigma/\sqrt{N}$= 0.0049
p=8-9GeV
n=2501
x_0= 0.8147
$\sigma/\sqrt{N}$= 0.0063
p=9-10GeV
n=1447
x_0= 0.8138
$\sigma/\sqrt{N}$= 0.0080
p=10-11GeV
n=776
x_0= 0.7889
$\sigma/\sqrt{N}$= 0.0083
p=11-12GeV
n=489
x_0= 0.8162
$\sigma/\sqrt{N}$= 0.0108
p=12-13GeV
n=306
x_0= 0.8060
$\sigma/\sqrt{N}$= 0.0146
p=13-14GeV
n=212
x_0= 0.8317
$\sigma/\sqrt{N}$= 0.0163
p=14-15GeV
n=139
x_0= 0.7714
$\sigma/\sqrt{N}$= 0.0179
p=15-16GeV
n=88
x_0= 0.7351
$\sigma/\sqrt{N}$= 0.0260
p=16-17GeV
n=54
x_0= 0.8962
$\sigma/\sqrt{N}$= 0.0258
p=17-18GeV
n=41
x_0= 0.9599
$\sigma/\sqrt{N}$= 0.0437
p=18-19GeV
n=36
x_0= 0.7213
$\sigma/\sqrt{N}$= 0.0529
p=19-20GeV
n=21
x_0= 1.3012
$\sigma/\sqrt{N}$= 0.2734
E/p

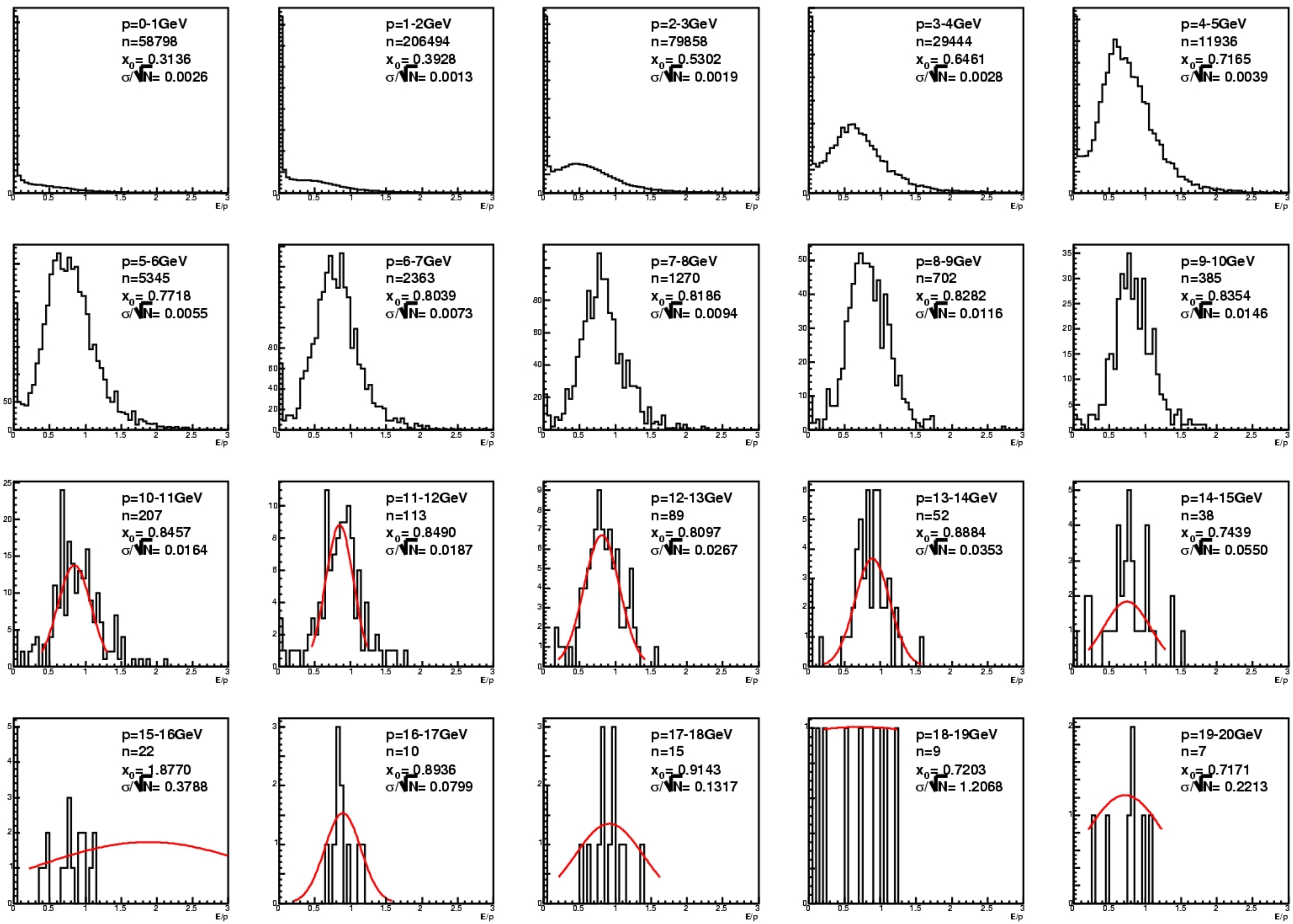
TOT, gjtc0d


p=0-1GeV
n=44439
x0= 0.9825
σ/√N= 0.0045
p=1-2GeV
n=205010
x0= 0.8935
σ/√N= 0.0017
p=2-3GeV
n=124150
x0= 0.8350
σ/√N= 0.0016
p=3-4GeV
n=63740
x0= 0.8231
σ/√N= 0.0020
p=4-5GeV
n=32381
x0= 0.8325
σ/√N= 0.0026
p=5-6GeV
n=16874
x0= 0.8414
σ/√N= 0.0033
p=6-7GeV
n=9015
x0= 0.8439
σ/√N= 0.0043
p=7-8GeV
n=5165
x0= 0.8654
σ/√N= 0.0062
p=8-9GeV
n=3050
x0= 0.8618
σ/√N= 0.0072
p=9-10GeV
n=1811
x0= 0.8687
σ/√N= 0.0086
p=10-11GeV
n=1197
x0= 0.8239
σ/√N= 0.0077
p=11-12GeV
n=796
x0= 0.8345
σ/√N= 0.0084
p=12-13GeV
n=539
x0= 0.8127
σ/√N= 0.0100
p=13-14GeV
n=414
x0= 0.8423
σ/√N= 0.0100
p=14-15GeV
n=266
x0= 0.8532
σ/√N= 0.0132
p=15-16GeV
n=187
x0= 0.8141
σ/√N= 0.0167
p=16-17GeV
n=143
x0= 0.8525
σ/√N= 0.0181
p=17-18GeV
n=109
x0= 0.9098
σ/√N= 0.0227
p=18-19GeV
n=82
x0= 0.9234
σ/√N= 0.0374
p=19-20GeV
n=63
x0= 0.8049
σ/√N= 0.0447
E/p

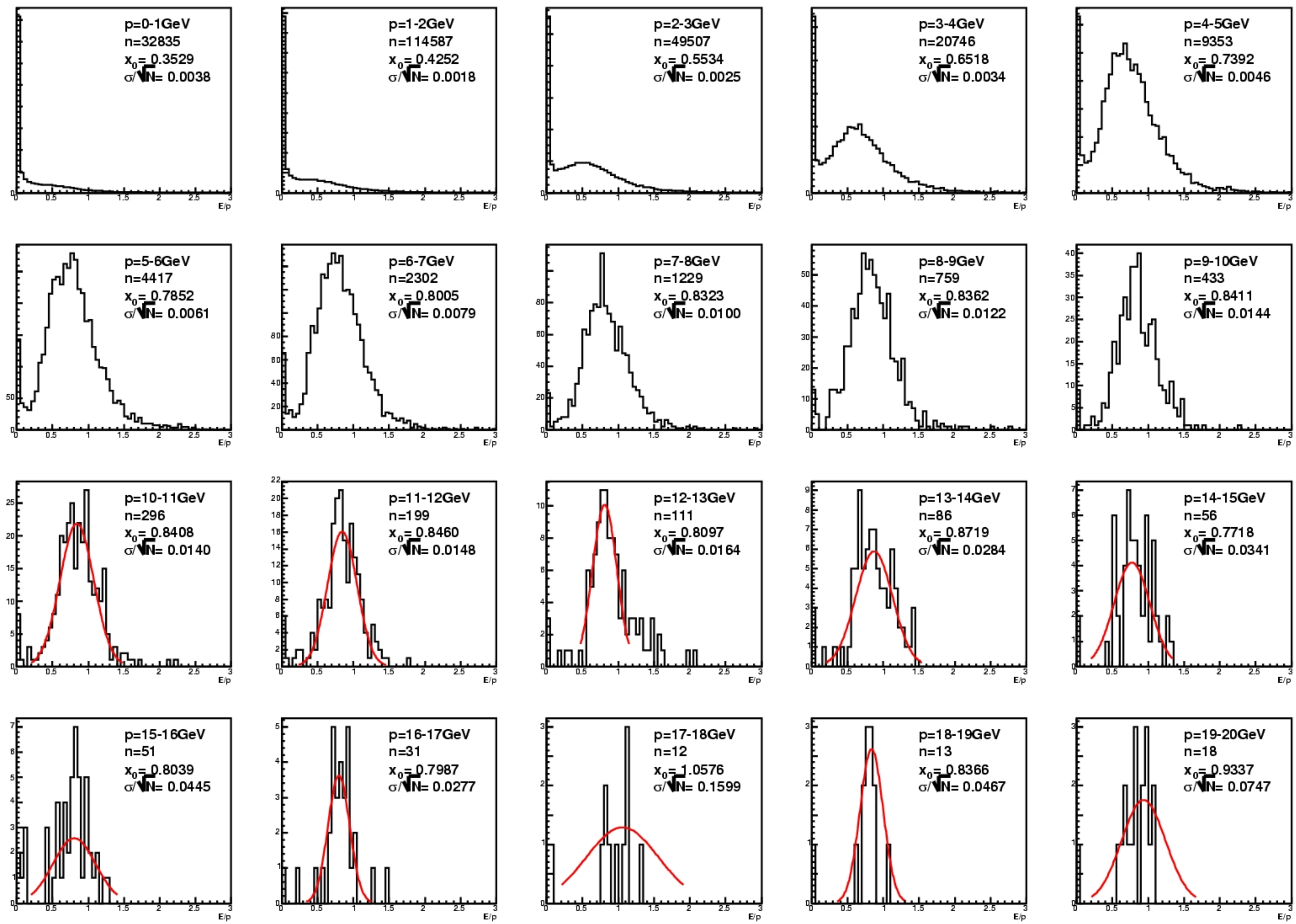
TOT, FAKEEV(R10)



MIP, gmbs0d

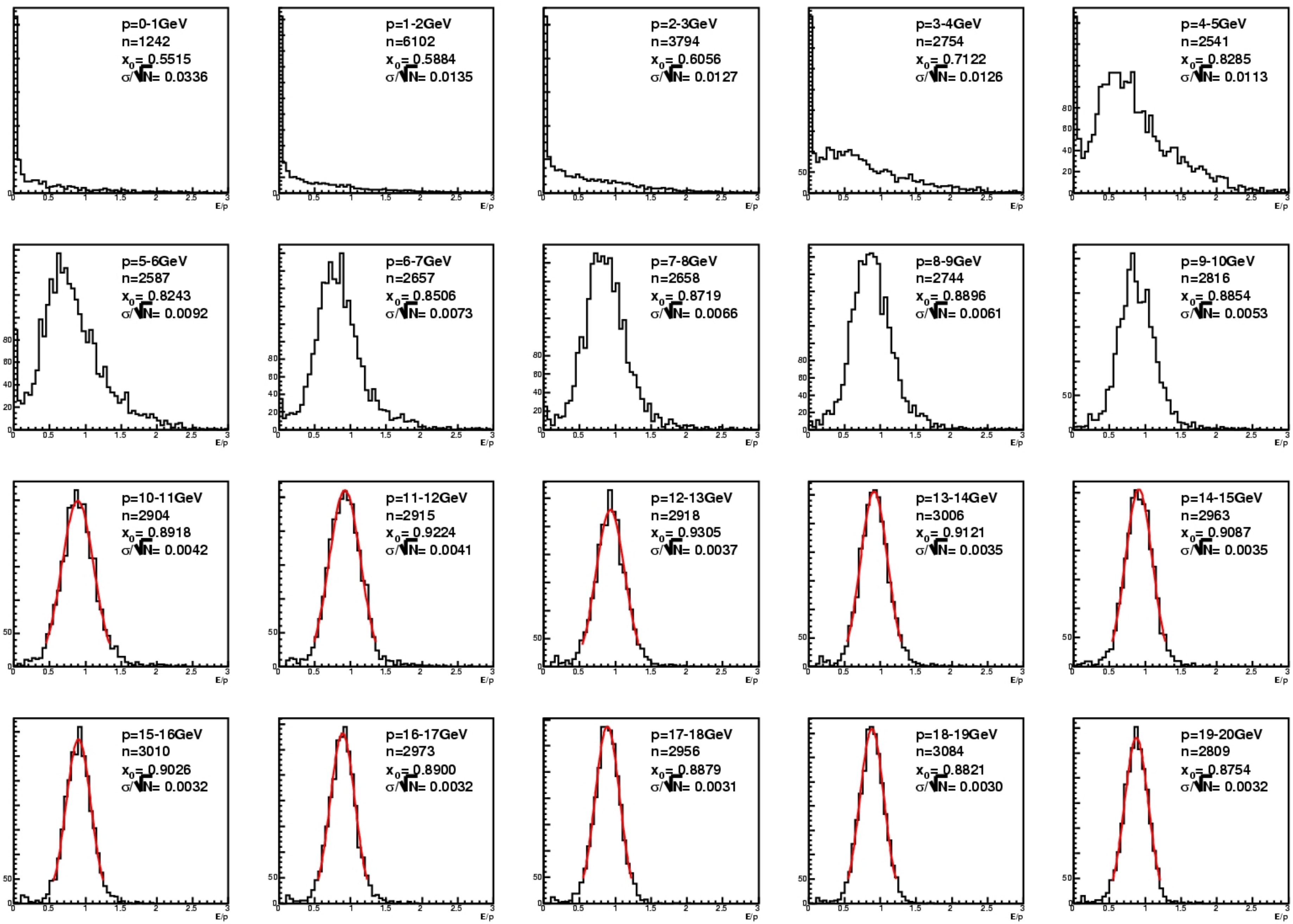

p=0-1GeV
n=58798
x0= 0.3136
σ/√N= 0.0026
p=1-2GeV
n=206494
x0= 0.3928
σ/√N= 0.0013
p=2-3GeV
n=79858
x0= 0.5302
σ/√N= 0.0019
p=3-4GeV
n=29444
x0= 0.6461
σ/√N= 0.0028
p=4-5GeV
n=11936
x0= 0.7165
σ/√N= 0.0039
p=5-6GeV
n=5345
x0= 0.7718
σ/√N= 0.0055
p=6-7GeV
n=2363
x0= 0.8039
σ/√N= 0.0073
p=7-8GeV
n=1270
x0= 0.8186
σ/√N= 0.0094
p=8-9GeV
n=702
x0= 0.8282
σ/√N= 0.0116
p=9-10GeV
n=385
x0= 0.8354
σ/√N= 0.0146
p=10-11GeV
n=207
x0= 0.8457
σ/√N= 0.0164
p=11-12GeV
n=113
x0= 0.8490
σ/√N= 0.0187
p=12-13GeV
n=89
x0= 0.8097
σ/√N= 0.0267
p=13-14GeV
n=52
x0= 0.8884
σ/√N= 0.0353
p=14-15GeV
n=38
x0= 0.7439
σ/√N= 0.0550
p=15-16GeV
n=22
x0= 1.8770
σ/√N= 0.3788
p=16-17GeV
n=10
x0= 0.8936
σ/√N= 0.0799
p=17-18GeV
n=15
x0= 0.9143
σ/√N= 0.1317
p=18-19GeV
n=9
x0= 0.7203
σ/√N= 1.2068
p=19-20GeV
n=7
x0= 0.7171
σ/√N= 0.2213
E/p

MIP, gjtc0d



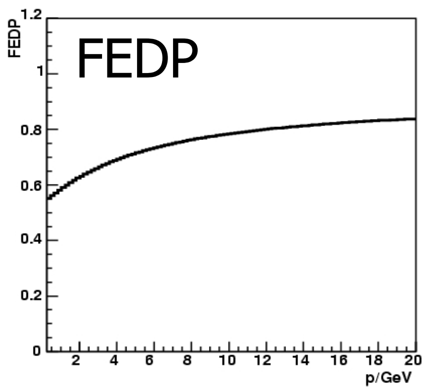
p=0-1GeV
n=32835
x0= 0.3529
σ/√N= 0.0038
p=1-2GeV
n=114587
x0= 0.4252
σ/√N= 0.0018
p=2-3GeV
n=49507
x0= 0.5534
σ/√N= 0.0025
p=3-4GeV
n=20746
x0= 0.6518
σ/√N= 0.0034
p=4-5GeV
n=9353
x0= 0.7392
σ/√N= 0.0046
p=5-6GeV
n=4417
x0= 0.7852
σ/√N= 0.0061
p=6-7GeV
n=2302
x0= 0.8005
σ/√N= 0.0079
p=7-8GeV
n=1229
x0= 0.8323
σ/√N= 0.0100
p=8-9GeV
n=759
x0= 0.8362
σ/√N= 0.0122
p=9-10GeV
n=433
x0= 0.8411
σ/√N= 0.0144
p=10-11GeV
n=296
x0= 0.8408
σ/√N= 0.0140
p=11-12GeV
n=199
x0= 0.8460
σ/√N= 0.0148
p=12-13GeV
n=111
x0= 0.8097
σ/√N= 0.0164
p=13-14GeV
n=86
x0= 0.8719
σ/√N= 0.0284
p=14-15GeV
n=56
x0= 0.7718
σ/√N= 0.0341
p=15-16GeV
n=51
x0= 0.8039
σ/√N= 0.0445
p=16-17GeV
n=31
x0= 0.7987
σ/√N= 0.0277
p=17-18GeV
n=12
x0= 1.0576
σ/√N= 0.1599
p=18-19GeV
n=13
x0= 0.8366
σ/√N= 0.0467
p=19-20GeV
n=18
x0= 0.9337
σ/√N= 0.0747
E/p

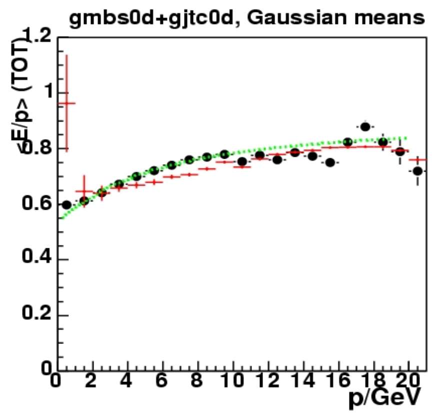
MIP, FAKEEV(R10)



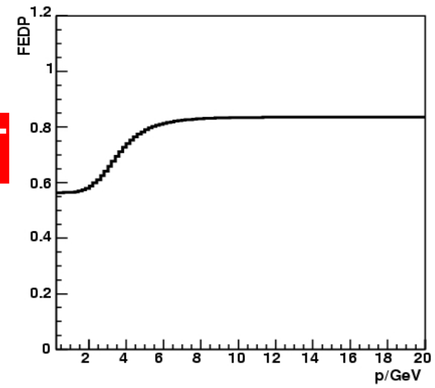
Direct Comparison with Data

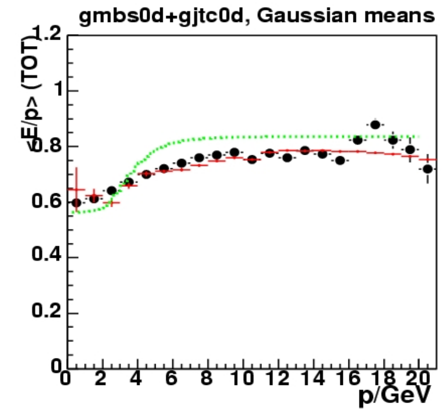
P1 FEDP R10b



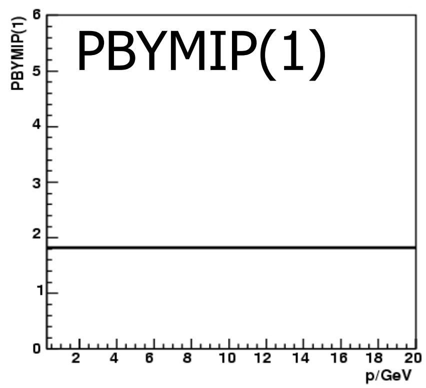


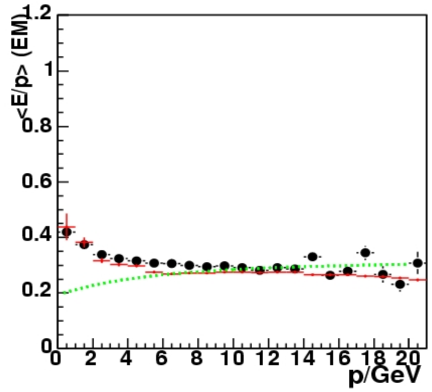
TOT



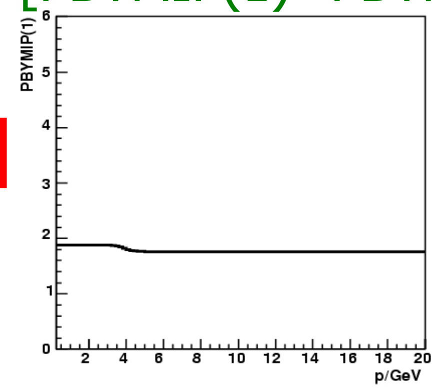


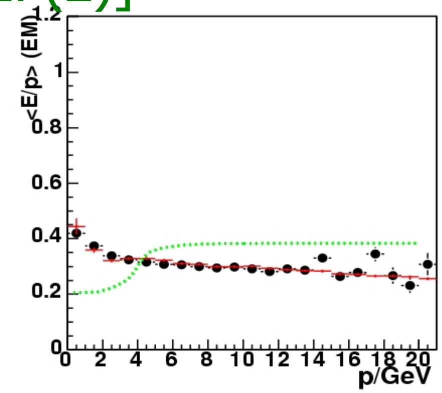
FEDP * PBYMIP(1) / [PBYMIP(1)+PBYMIP(2)]



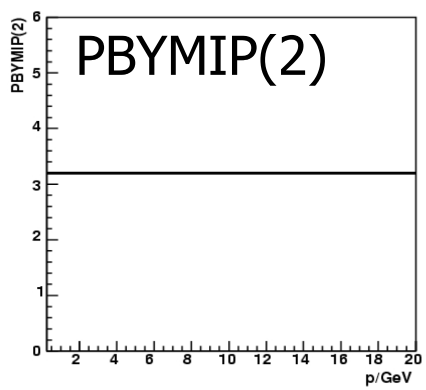


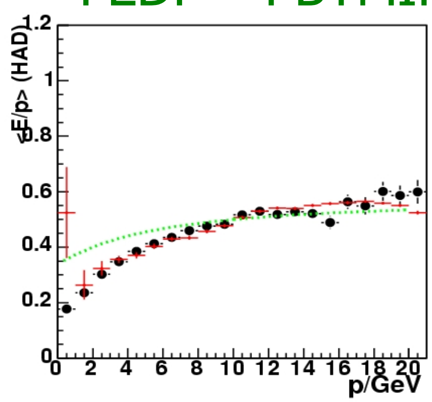
EM





FEDP * PBYMIP(2) / [PBYMIP(1)+PBYMIP(2)]





HAD