Status of Gflash
Lateral Shower Profile Tuning

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Overview

Situation:

- Gflash hadronic lateral shower profile was tuned in the past for
  p = 0 ... 2.5 GeV/c using minimum bias data.
- For p> 5 GeV/c we still use H1 default
- Good tuning at ~10-20 GeV advantageous for various physics analyses

This talk:

- Study single track response using jet calibration data (>7M events)
- **Structure of hadronic E/p profiles**
- MC performance for particle momenta 3 – 24 GeV (central part only)
- Which data / energy points are useful for tuning?
- Plots shown here reflect quality of parameter tune currently used by CDF

Data Samples

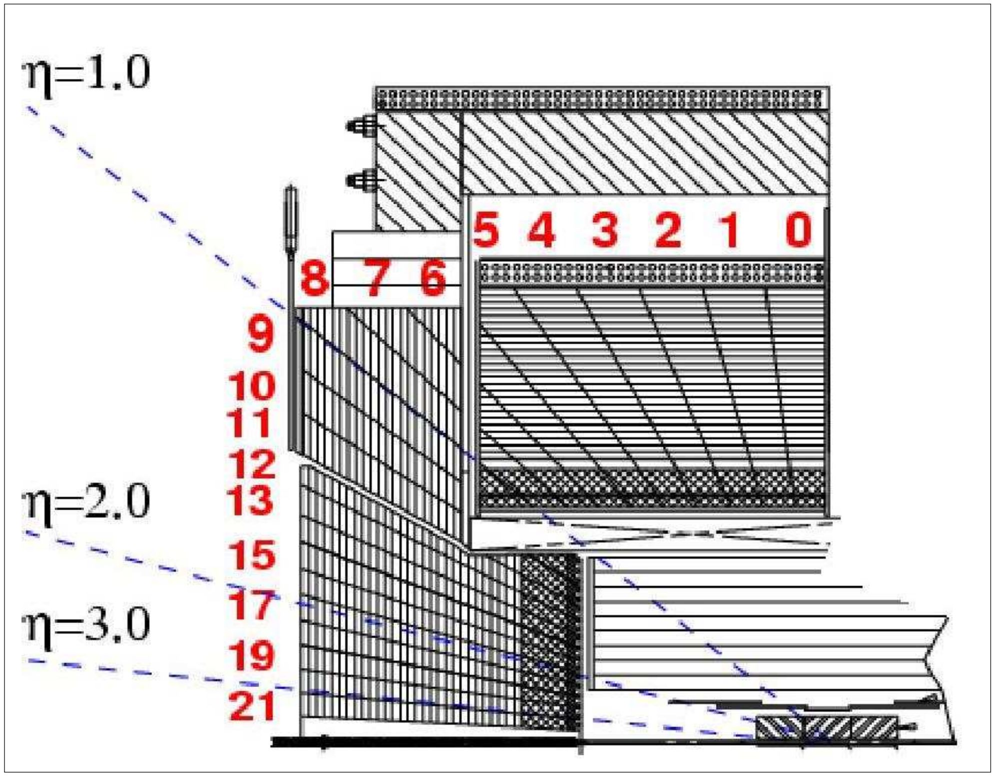
Samples:

- Jet calibration data
  gjtc0d (5.3.3_nt) ~ 6.2 M
  gjtc01 (5.3.3_nt) ~ 1.3 M
- Single track MC
  FAKEEV (5.3.3_nt) ~ 9.6M

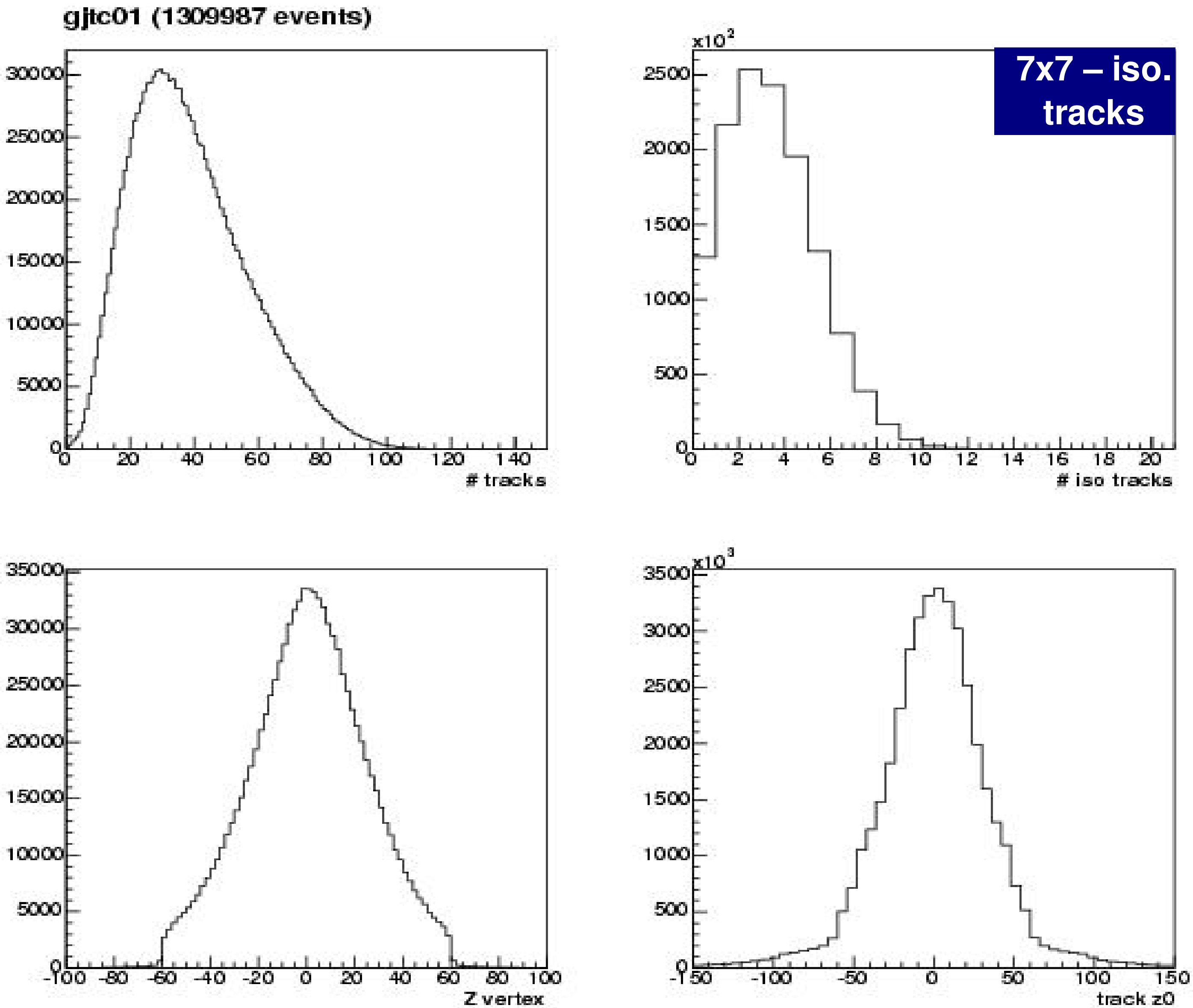
MC plots shown are based on charged pions (for now)

Requirements (central part):

	data	MC
N_{vertex}	= 1	–
$\|z_{vertex}\|$	<60cm	same
$\|z_0\|$	<60cm	same
$\|d_0\|$	<1cm	same
7x7 iso	yes	same
CES iso	yes	same
COT stereo, axial:		
tower 0-5:	≥30	≥30
tower 6-8:	≥30	≥25
SVX axial:		
tower 0-5:	–	–
tower 6-8:	–	4

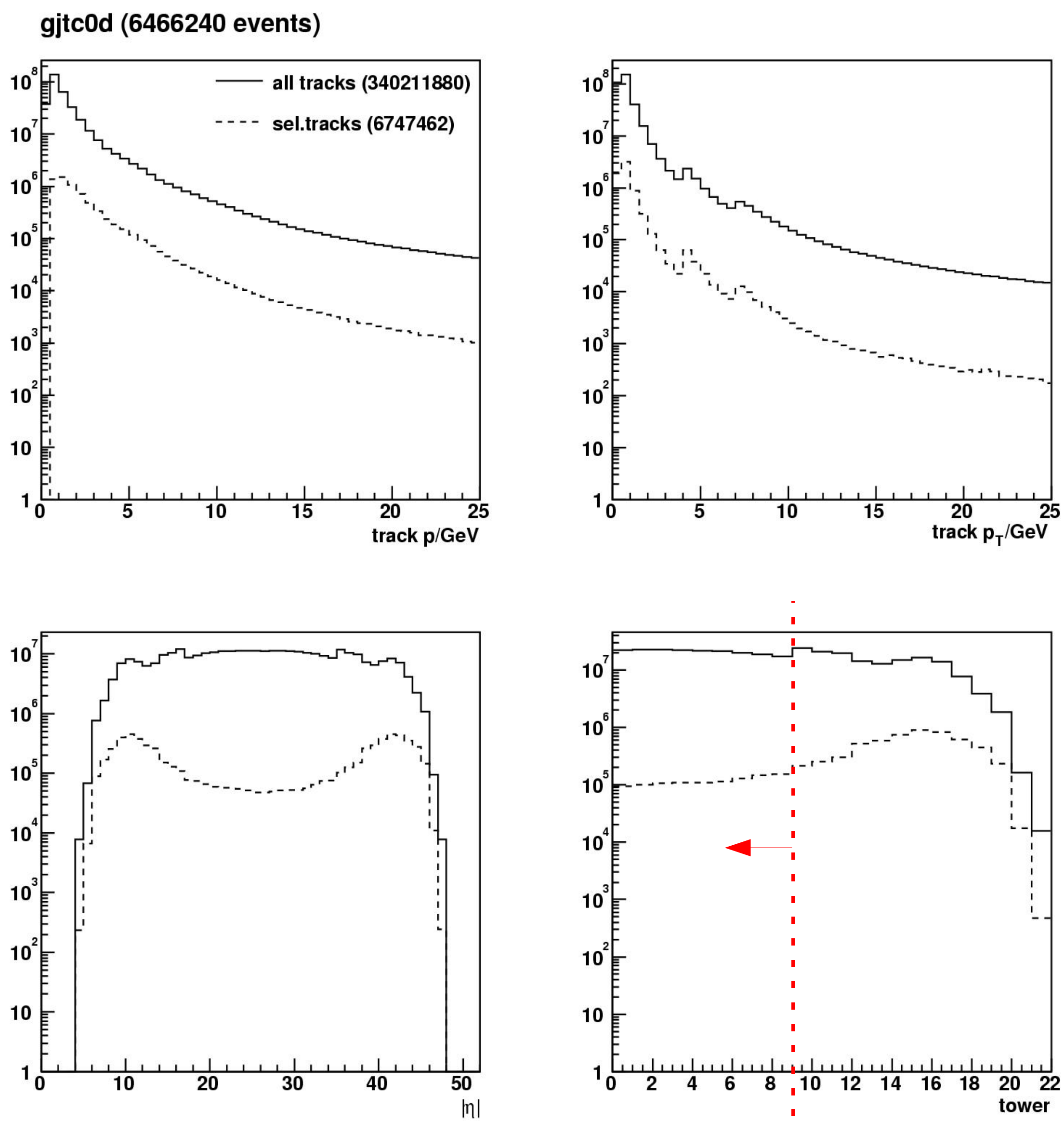


Track Quantities

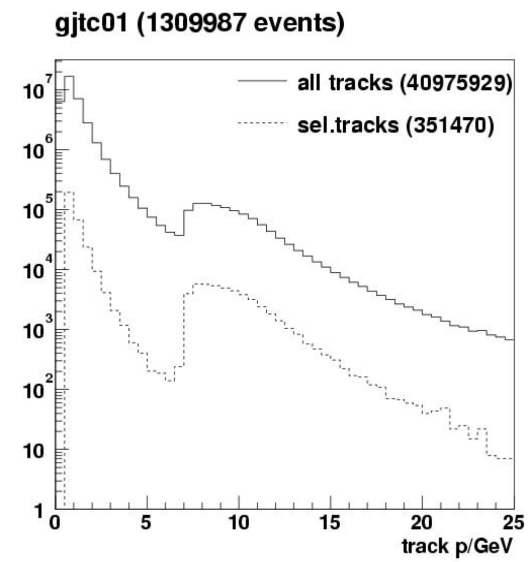


Track Spectra

gjtc0d



gjtc01



Selected isolated tracks (tower 0-8):

p / GeV	gjtc01	gjtc0d	FAKEEV
< 2	285068	780776	—
2 – 3	13497	43122	0.8 M
3 – 5	4264	50178	1.6 M
5 – 8	10534	73816	2.4 M
8 – 12	31674	26018	1.6 M
12 – 16	5255	4151	1.6 M
16 – 24	1038	823	1.6 M
>24	140	124	—

- Additional cuts are applied depending on signal definition

Lateral Shower Profile in Gflash

Lateral shower profile:

E: energy of incident particle
x: shower depth
r: radial distance from shower center
$R_0(E,x)$: log-normal pdf
n=1(2) for HAD (EM) showers

$$f(r) = \frac{2 r R_0^2}{r^2 + R_0^2}, \qquad \int_0^{\infty} f(r)\, dr = 1$$

$$\langle R_0(E,x)\rangle = \left[R_1 + (R_2 - R_3 \log E)\, x\right]^n$$

$$\sigma_{R_0} = \left[(S_1 - S_2 \log E)(S_3 + S_4 x)\right] \langle R_0(E,x)\rangle$$

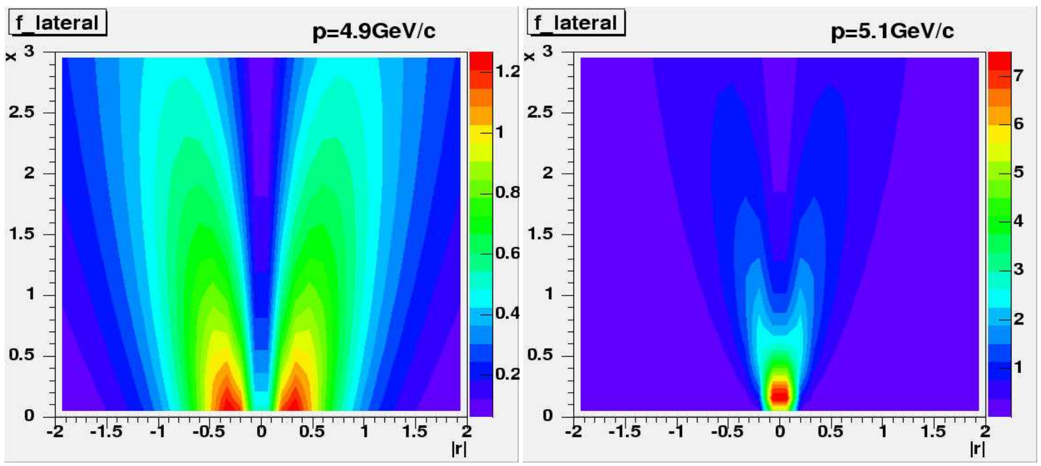
core term | **spread term**

- spread of shower increases with shower depth and decreases with energy of incident particle
- tuning parameters: R_1, R_2, R_3, S_1, S_2, S_3, S_4

Current parametrization

p<5GeV/c: (tuned with MinBias):
R_1=0.49, R_2=0.407, R_3=0.065

p>5GeV/c: (H1 default):
R_1=0.0149, R_2=0.407, R_3=0.061



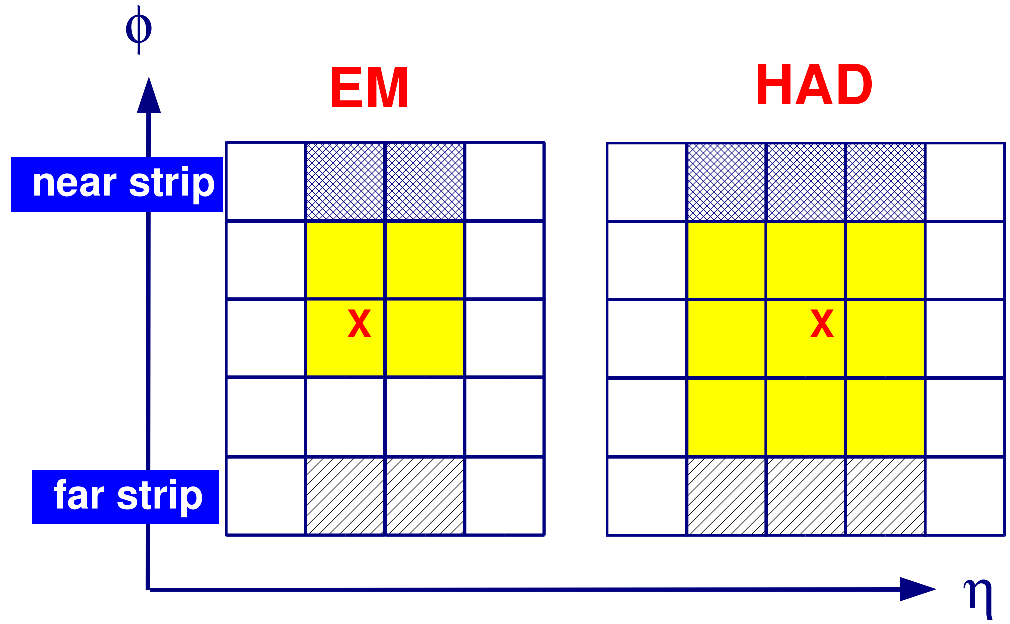
E/p Signal & Background Definition

E/p	EM	HAD
Signal	2x2 blocks	3x3 blocks
Backg	2x far strip	3xfar strip

X extrapolated track impact point

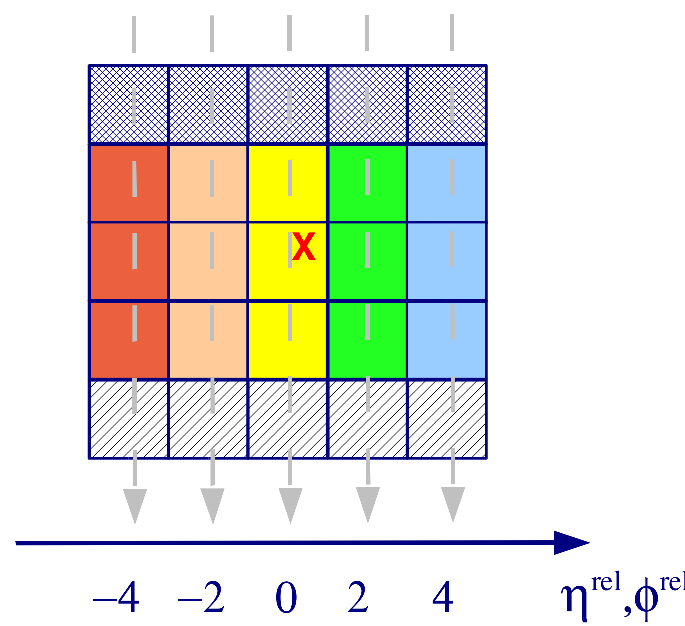
(yellow box) signal contribution

(hatched box) background estimate



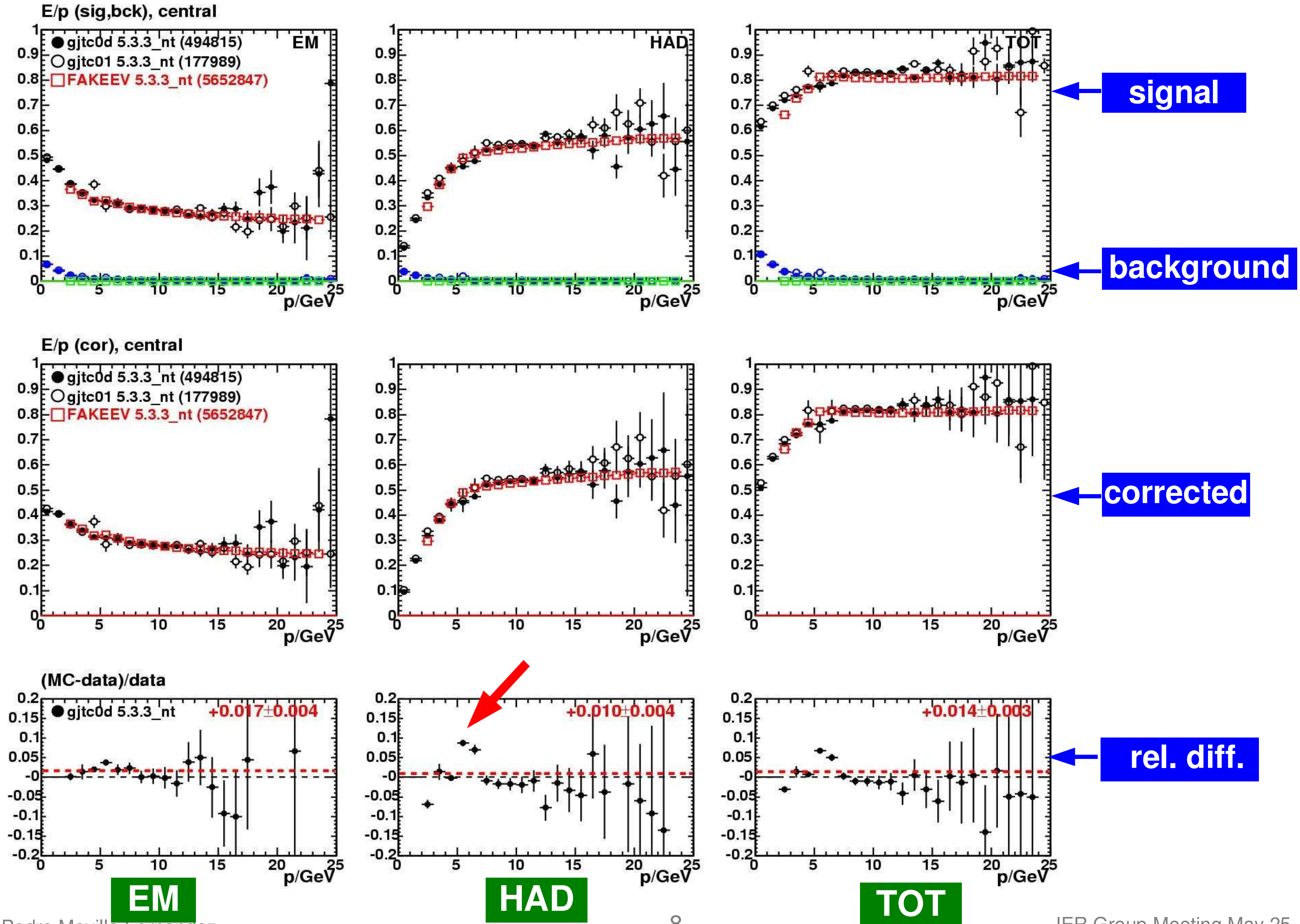
- Tracks are extrapolated to CES/PES for both EM and HAD compartment
- Impact point must be well contained (0.9x0.9 in η^{rel},ϕ^{rel} from target center)

E/p profile	EM and HAD
Signal	transverse 1x3 stripes
Backg	1.5 x (far block + near block)

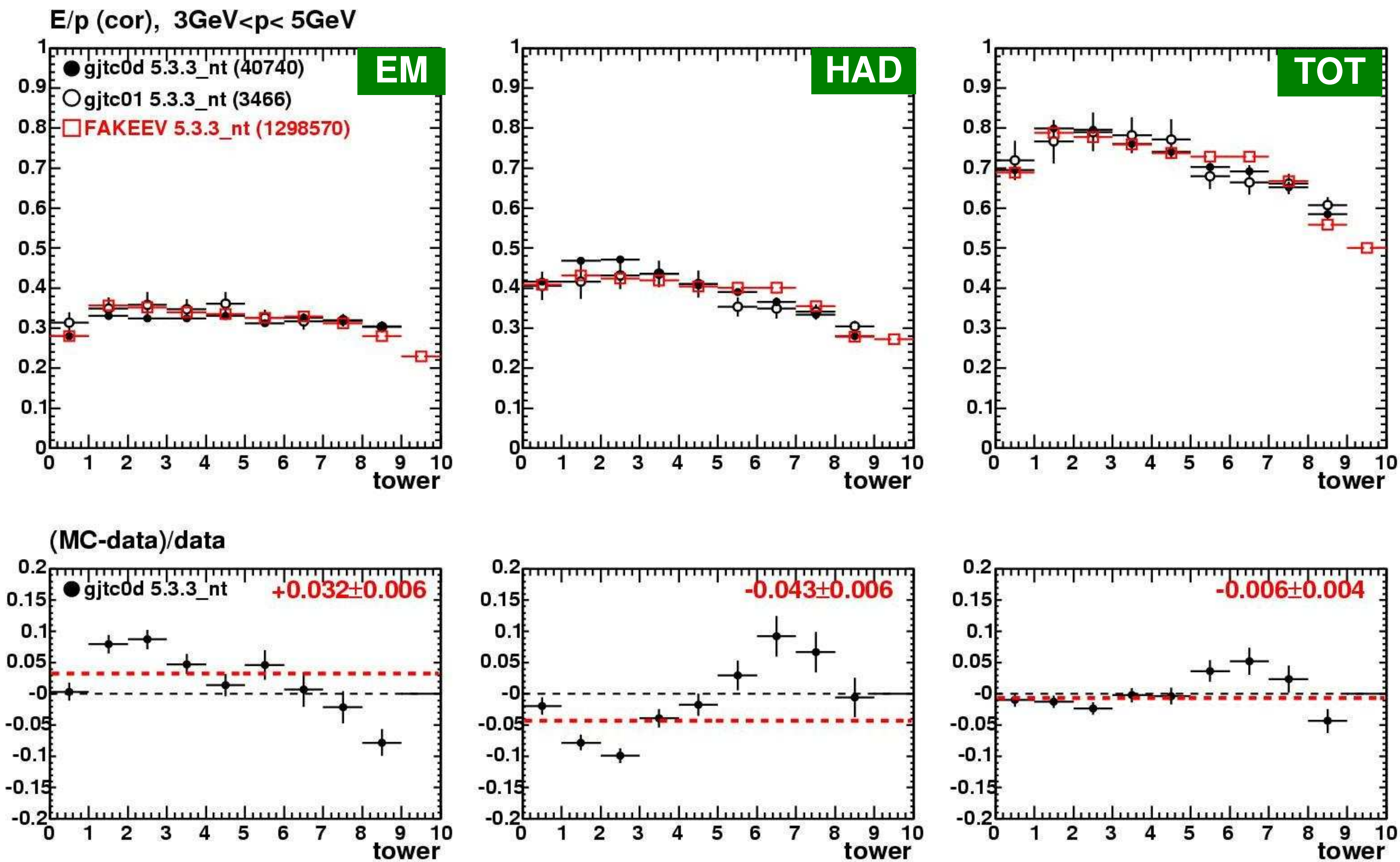


- Each block has its individual background contribution
- For η (φ) profiles we demand track impact point to be within 60% ϕ^{rel} (η^{rel}) strip w.r.t. block center

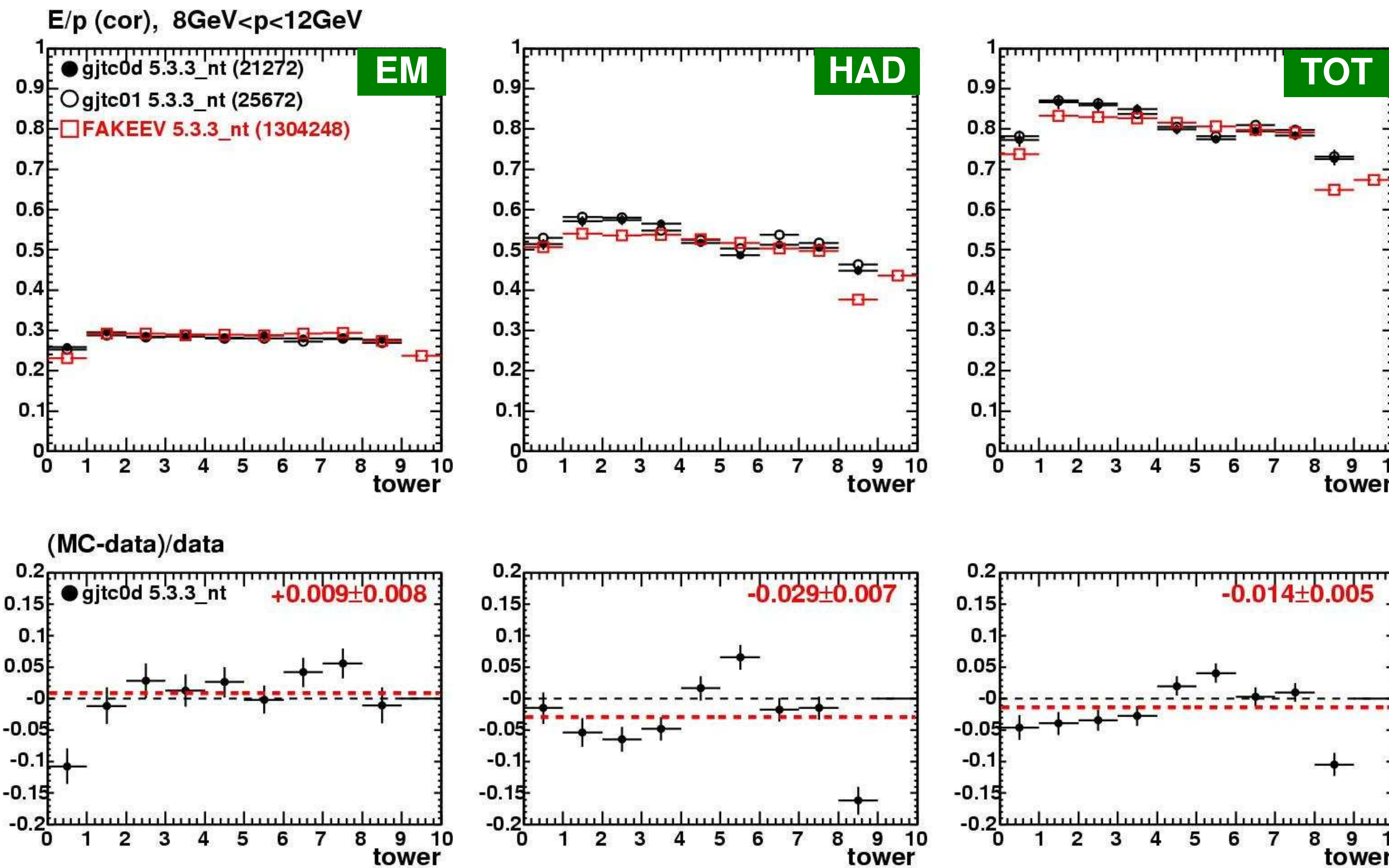
⟨E/p⟩ vs. p


E/p (sig,bck), central
gjtc0d 5.3.3_nt (494815)
gjtc01 5.3.3_nt (177989)
FAKEEV 5.3.3_nt (5652847)
EM
HAD
TOT
p/GeV
signal
background
E/p (cor), central
corrected
(MC-data)/data
gjtc0d 5.3.3_nt
+0.017±0.004
+0.010±0.004
+0.014±0.003
rel. diff.
EM
HAD
TOT

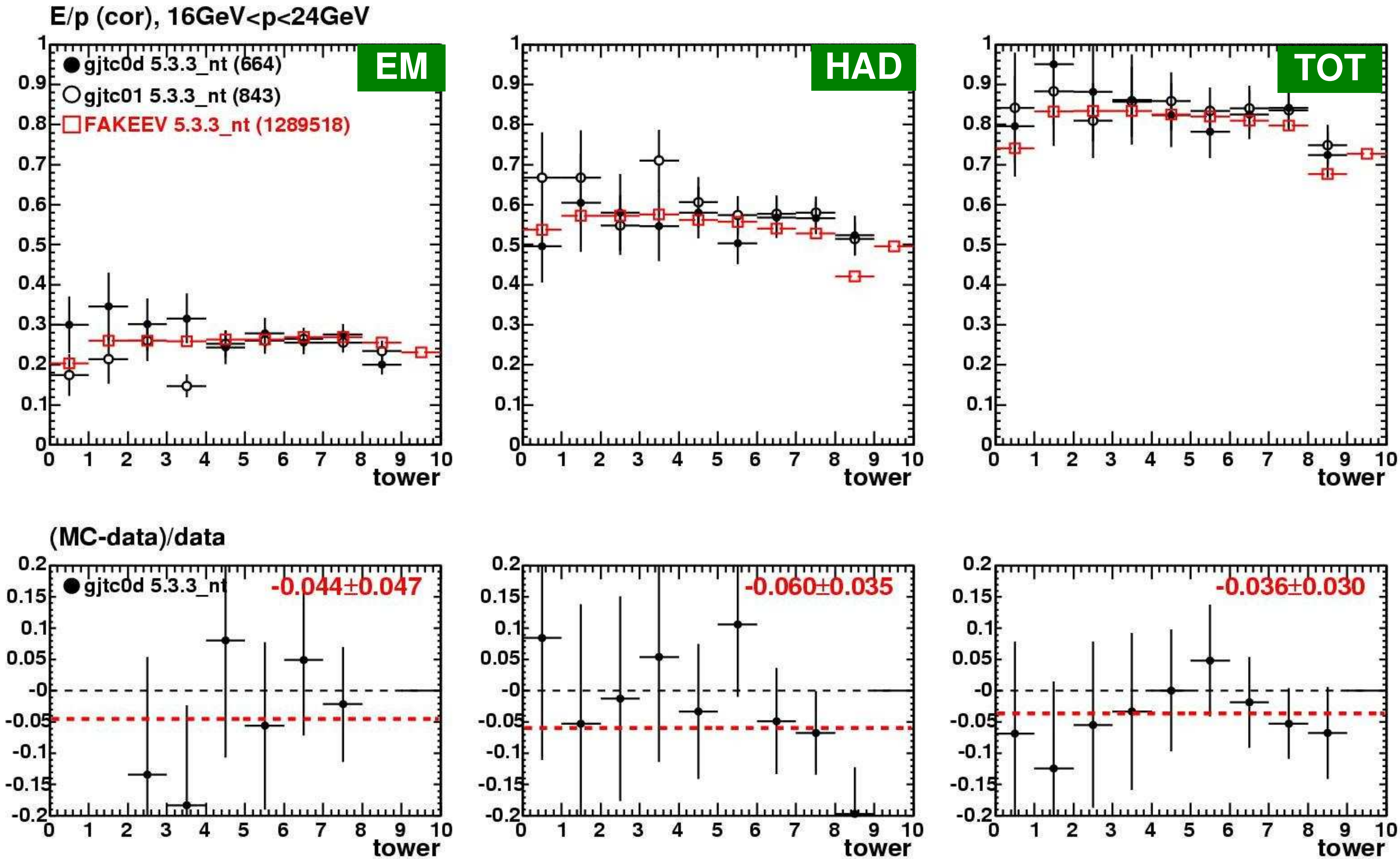
⟨E/p⟩ vs. tower (3-5 GeV)



⟨E/p⟩ vs. tower (8-12 GeV)



⟨E/p⟩ vs. tower (16-24 GeV)

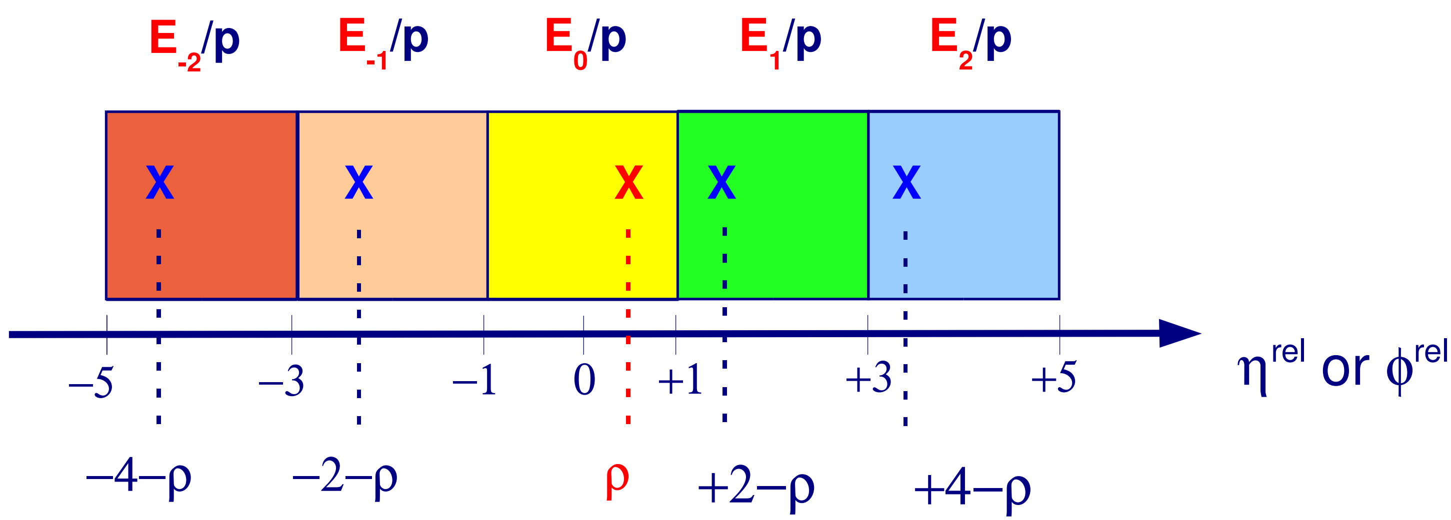


Lateral Profile Coordinates

- What we measure is **E/p vs. track impact point** using local tower coordinates

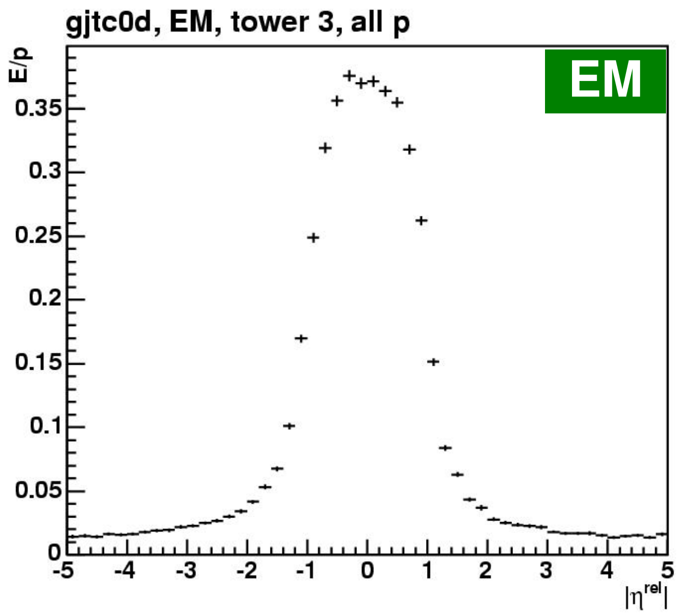
$$\phi^{rel} = \frac{\phi - (\phi^{max} + \phi^{min})/2}{(\phi^{max} - \phi^{min})/2} \qquad \eta^{rel} = \frac{\eta - (\eta^{max} + \eta^{min})/2}{(\eta^{max} - \eta^{min})/2}$$

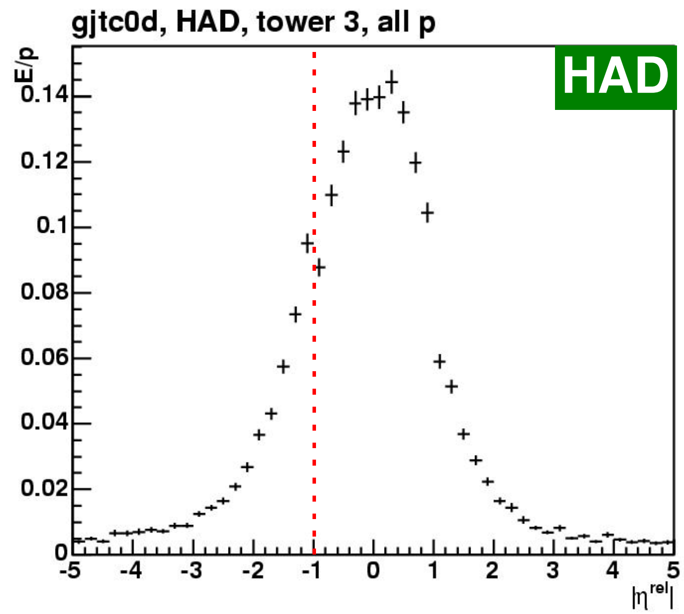
η^{min}, η^{max}, ϕ^{min}, ϕ^{max}: boundaries of the target tower



- Convention: negative values face towards center, positive values towards plug
- One track gives 5 entries in profile histograms shown
- η^{rel}, ϕ^{rel} is NOT the quantity r of the shower profile formula $f(r)$!

Structure of Lateral Profiles

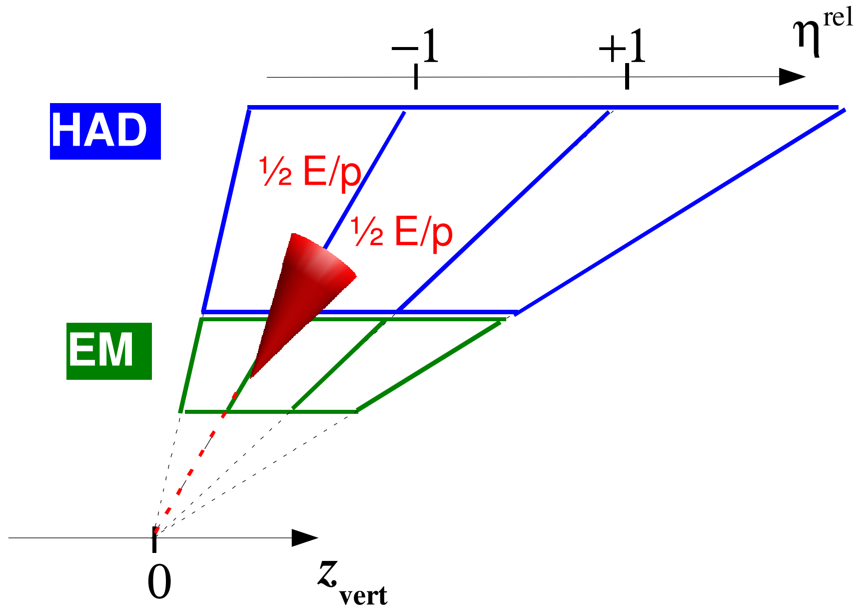




- Profiles are not symmetric in η
  - sign convention – we do not average forward/backward contribution
  - misalignment of shower cone axes w.r.t. tower boundaries caused by tracks from displaced z vertices
- HAD profiles are more asymmetric than EM profiles
  - cone extrapolation from CES /PES to inner HAD surface enhances misalignment effect
- Extreme asymmetries can produce kinks at η^{rel}=-1
- Profiles are symmetric in ϕ^{rel}

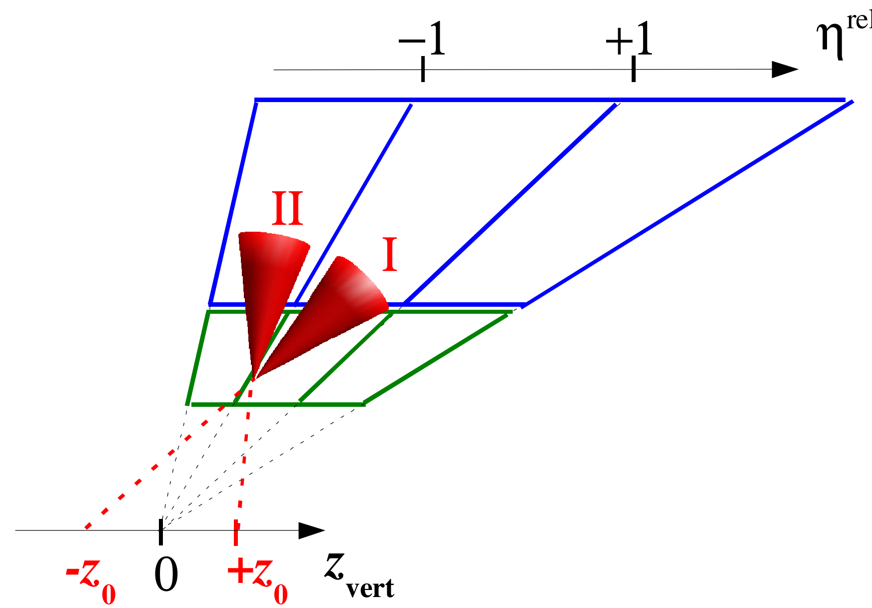
Structure of Lateral Profiles (2)

Ideal vertices:



- Symmetric scenario
  $\Rightarrow$ E/p smooth at η^{rel}=-1
- E/p(-1)=E/p(+1)= ½ E/p(0)
  (if shower at η^{rel}=0 is fully contained in target tower)

Shifted vertices:

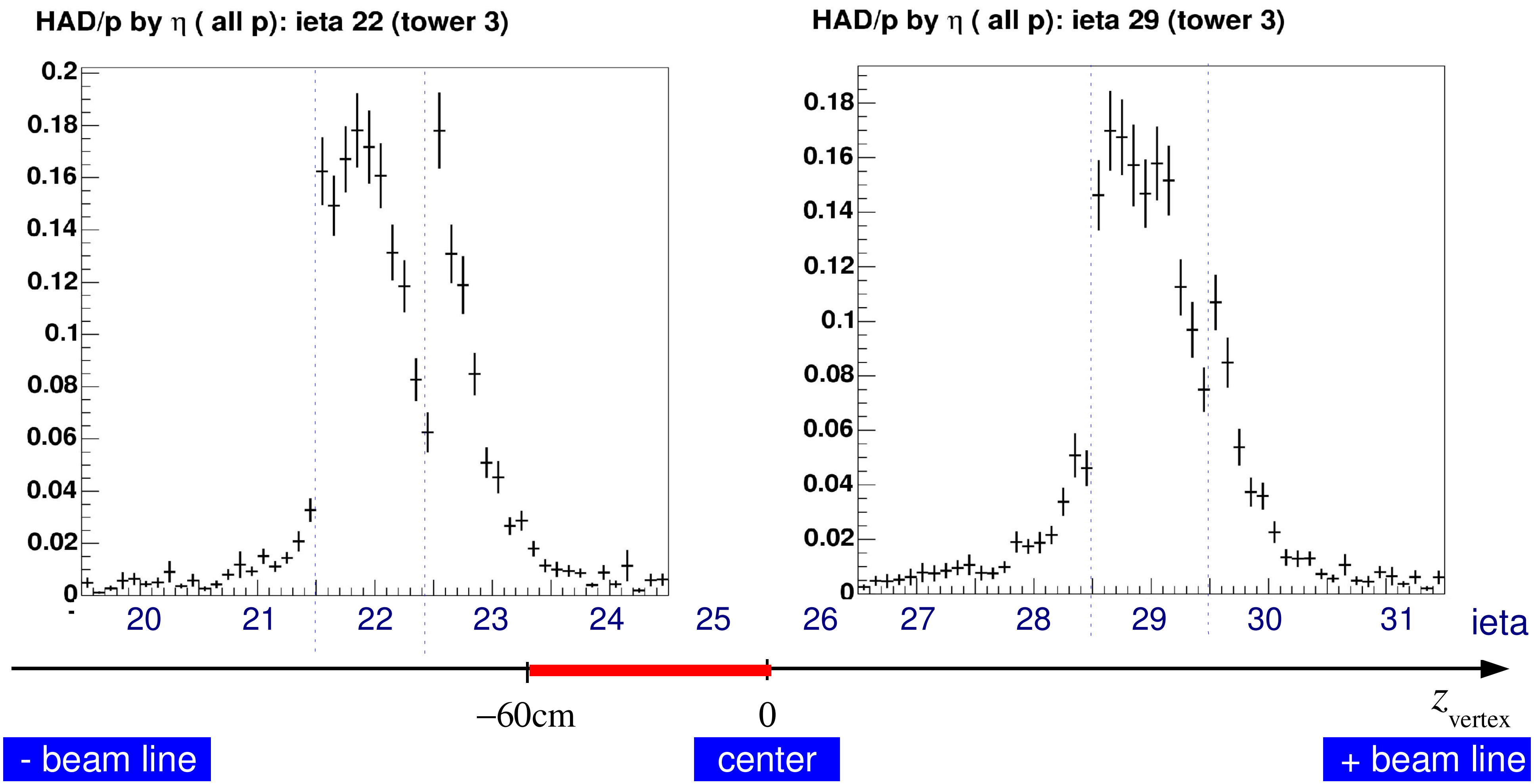


- Asymmetric contributions from tracks with z_{vert}<0, z_{vert}>0:
- Shower I has larger path length trough EM than shower II
  $\Rightarrow E_{II}^{(HAD)} > E_{I}^{(HAD)}$
- Explains both kink at η^{rel}=-1 and gap at η^{rel}=+1

Structure of Lateral Profiles (3)

Data

Requirement: $z_{vert}<0$, $z_0<0$

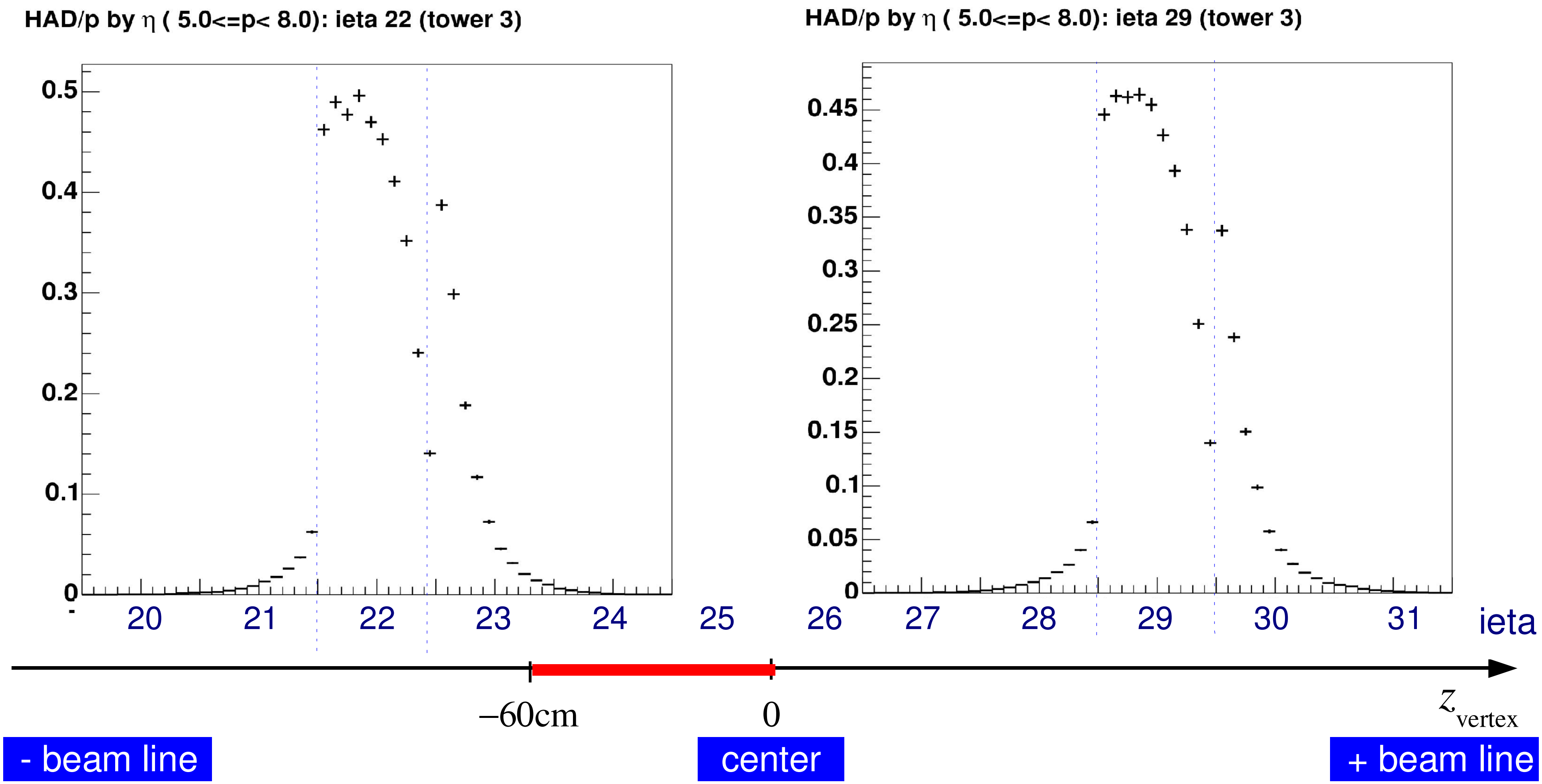


Clearly enhanced kink structure, according to expectation.

Structure of Lateral Profiles (4)

MC

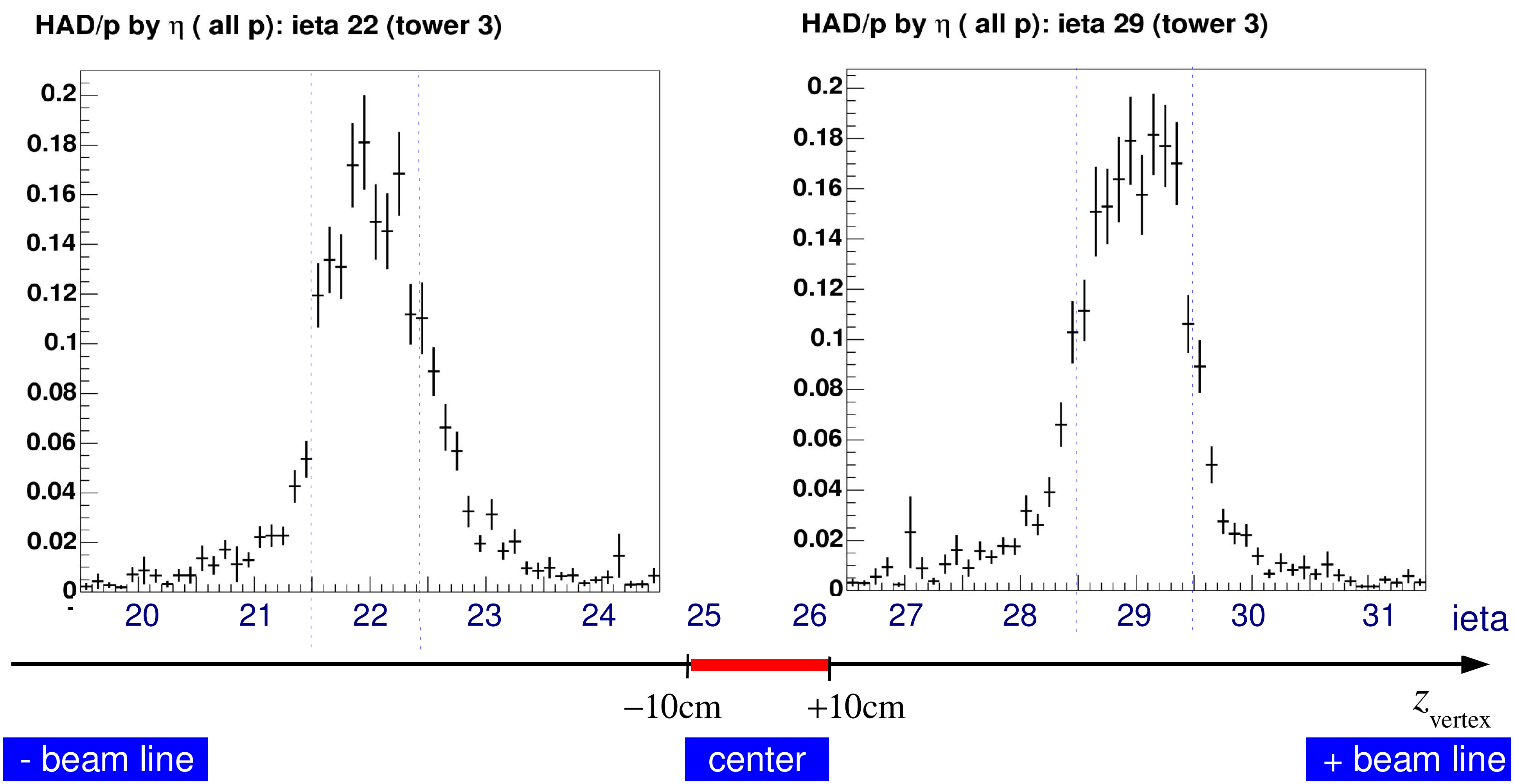
Requirement: $z_{vert}<0, \ z_0<0$



Extrapolation effect also present in details of simulation.

Structure of Lateral Profiles (4)

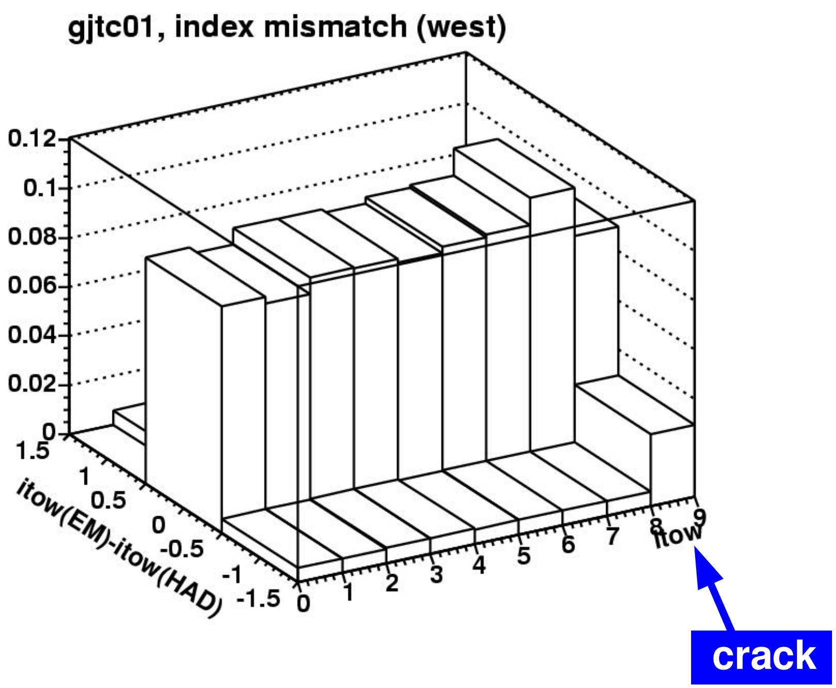
Requirement: $|z_{vert}|<10\text{cm}$

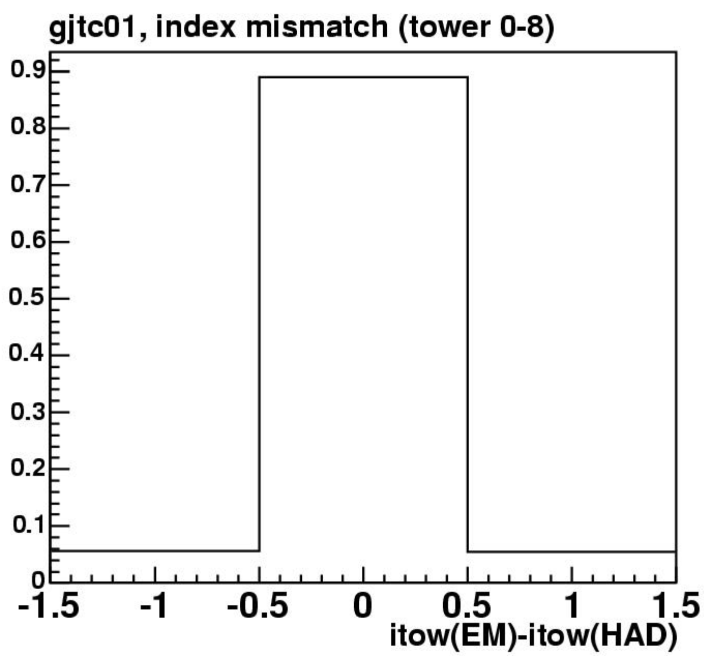


Less overlap to adjacent towers,
much smoother transitions, more symmetric profiles...

EM/HAD Track Extrapolation

CES/PES extrapolation vs. HAD inner surface extrapolation

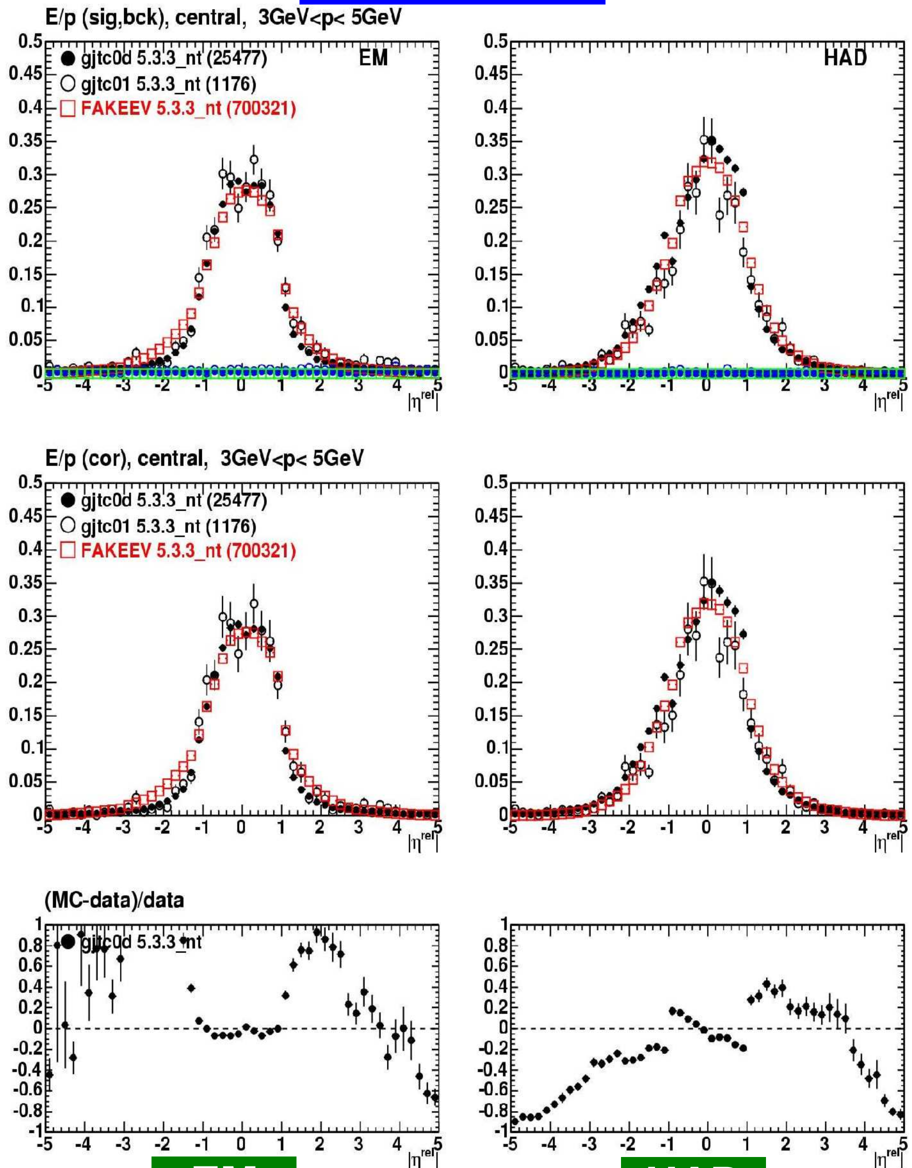




- Tower 0-8: ~ 10% mismatch (mainly due to z vertex displacement)
- Big effect in crack region
- How to handle starting point of hadronic shower in EM?
  EM has ~1 absorption length
  By requiring minimum EM deposition we consider hadronic showers starting near EM surface
  → Good for unambigous impact point definition but we loose ~1/3 statistics

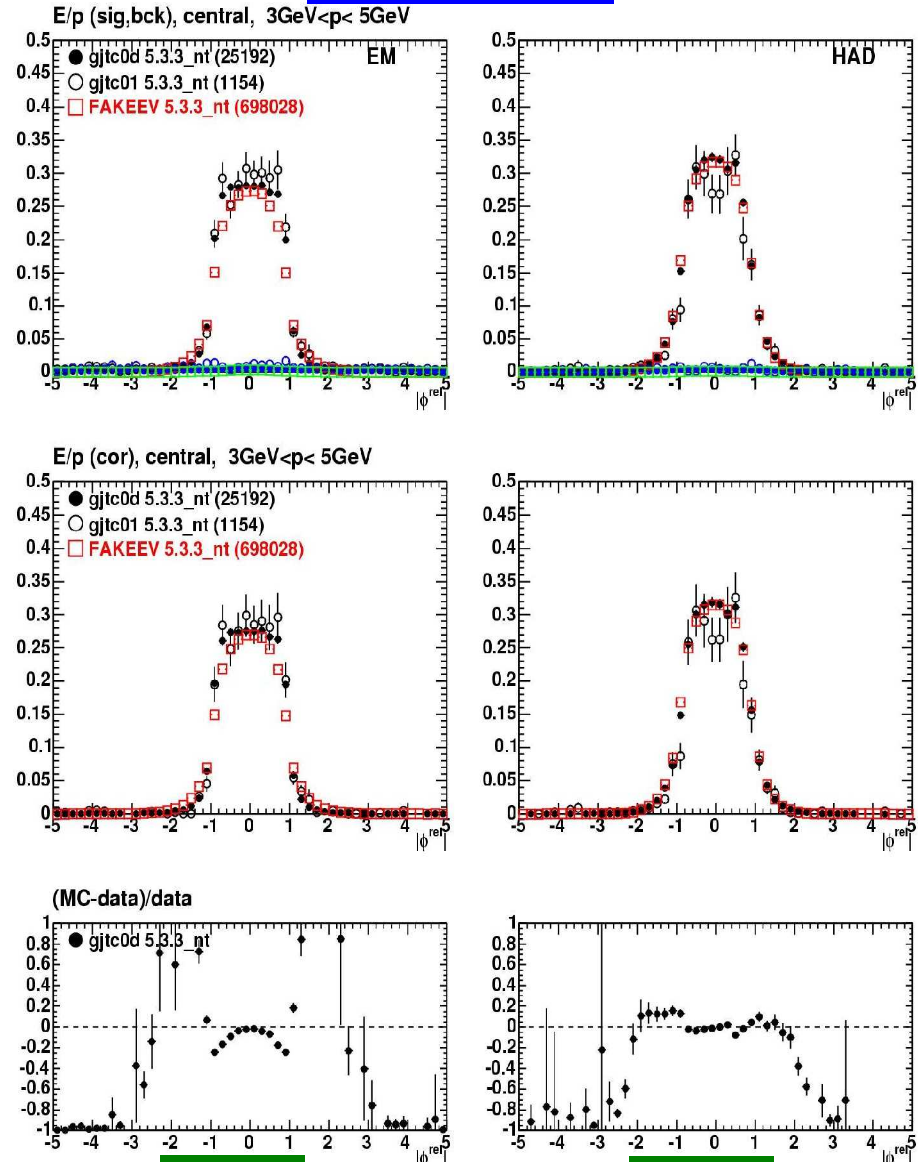
E/p lateral (central, 3-5 GeV)

relative η



EM **HAD**

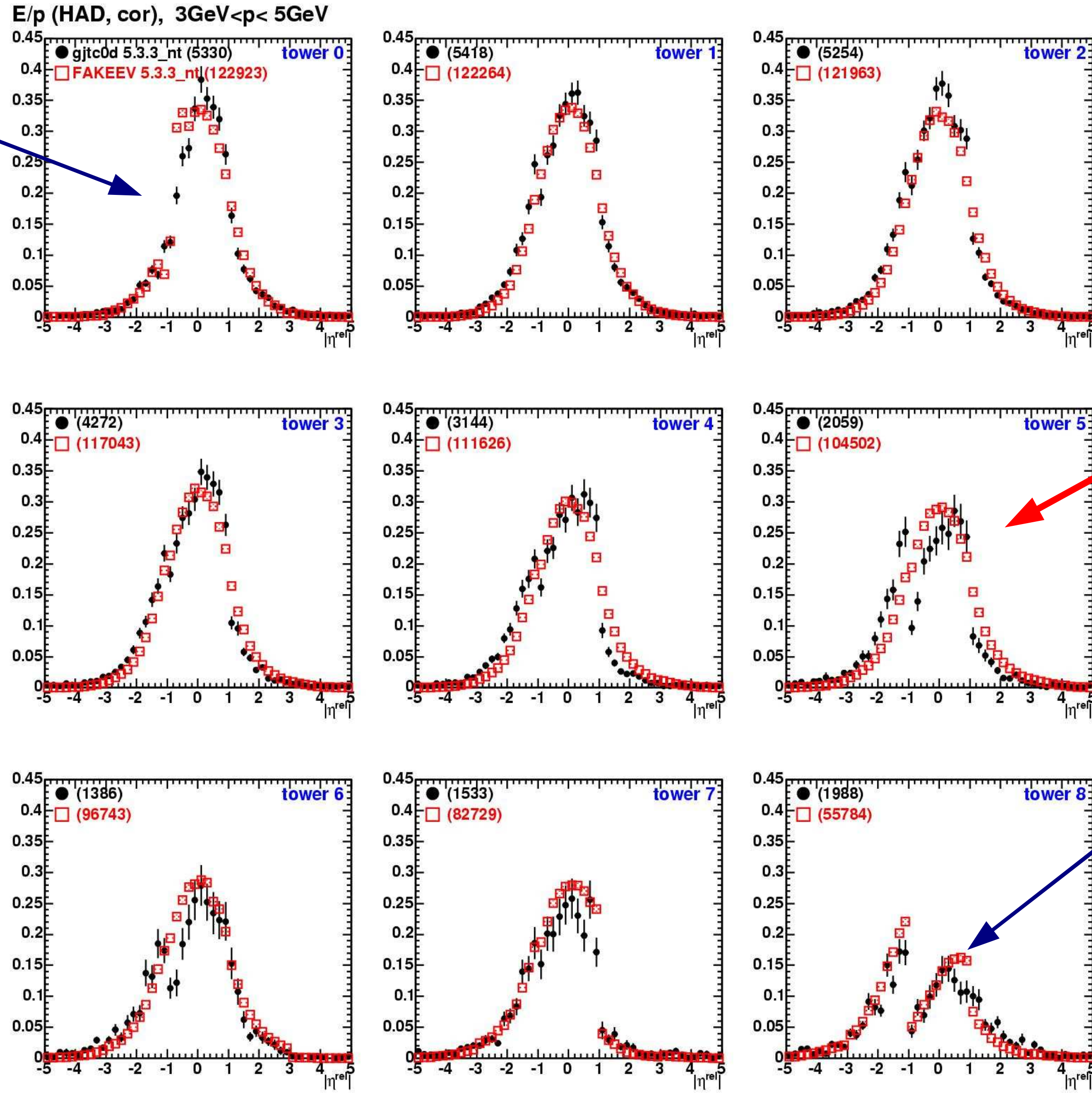
relative φ



EM **HAD**

E/p vs. η^{rel} (HAD, 3-5 GeV)

90° crack

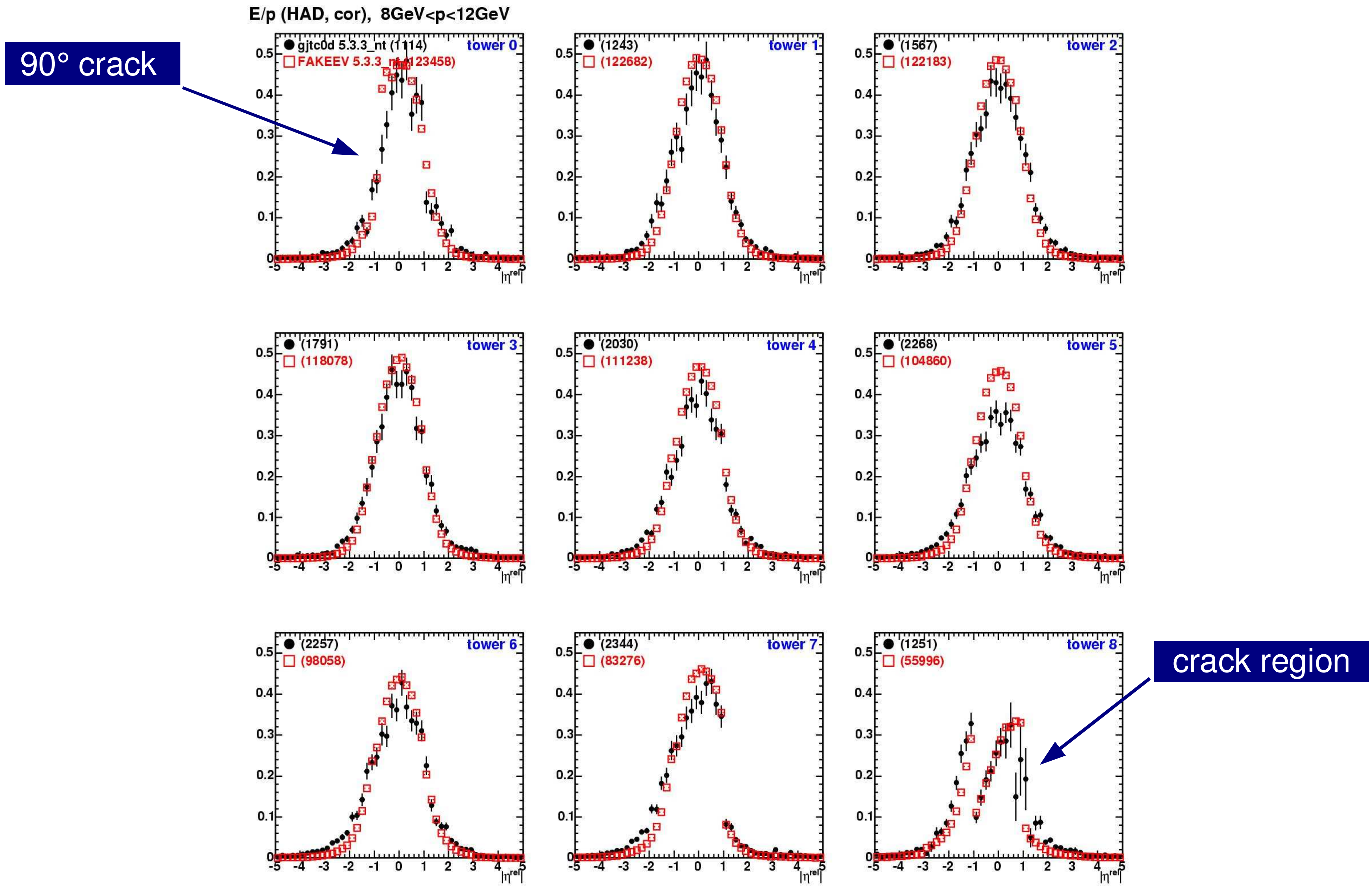


???

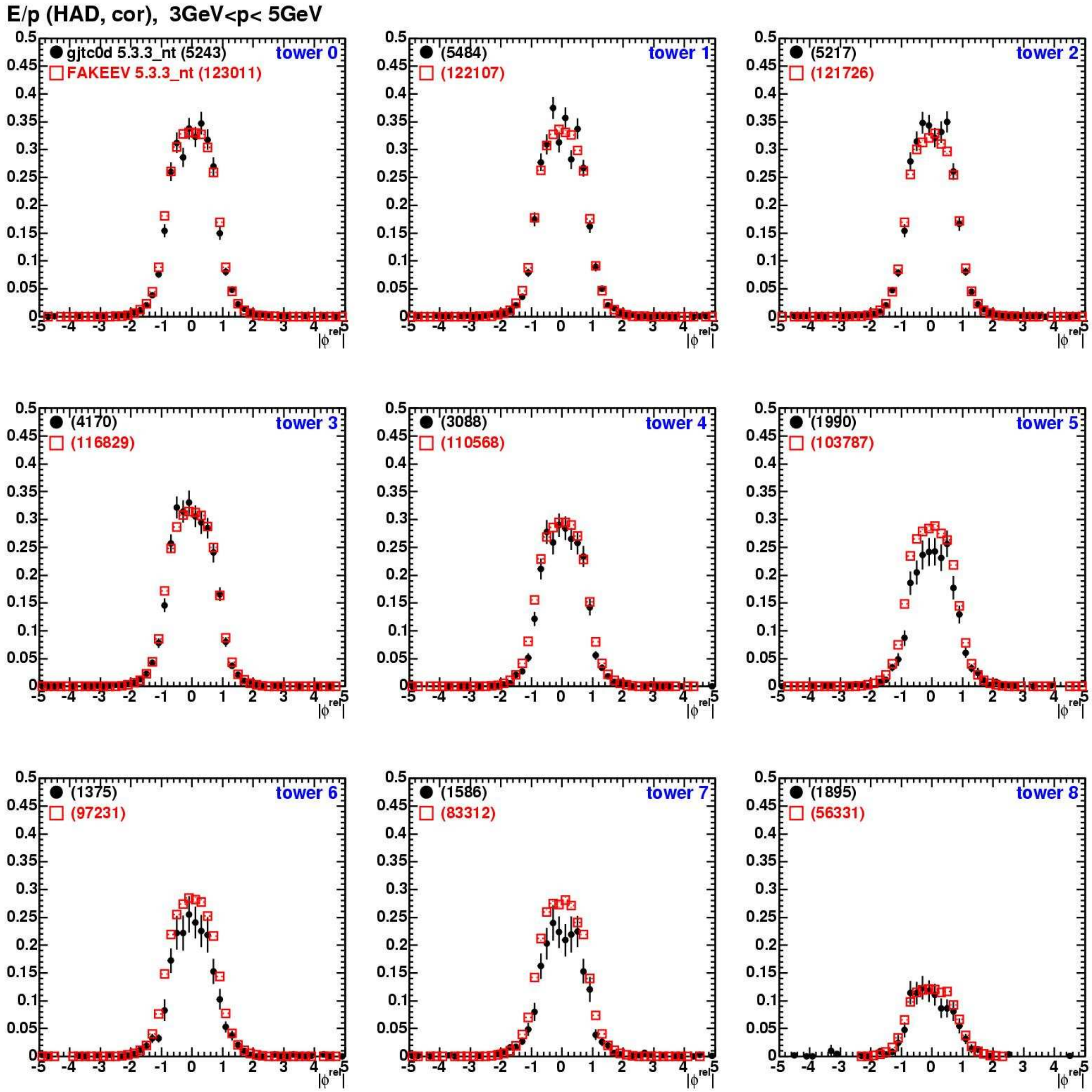
crack region

Kink at η^{rel}=-1 is much more pronounced in data than in MC!

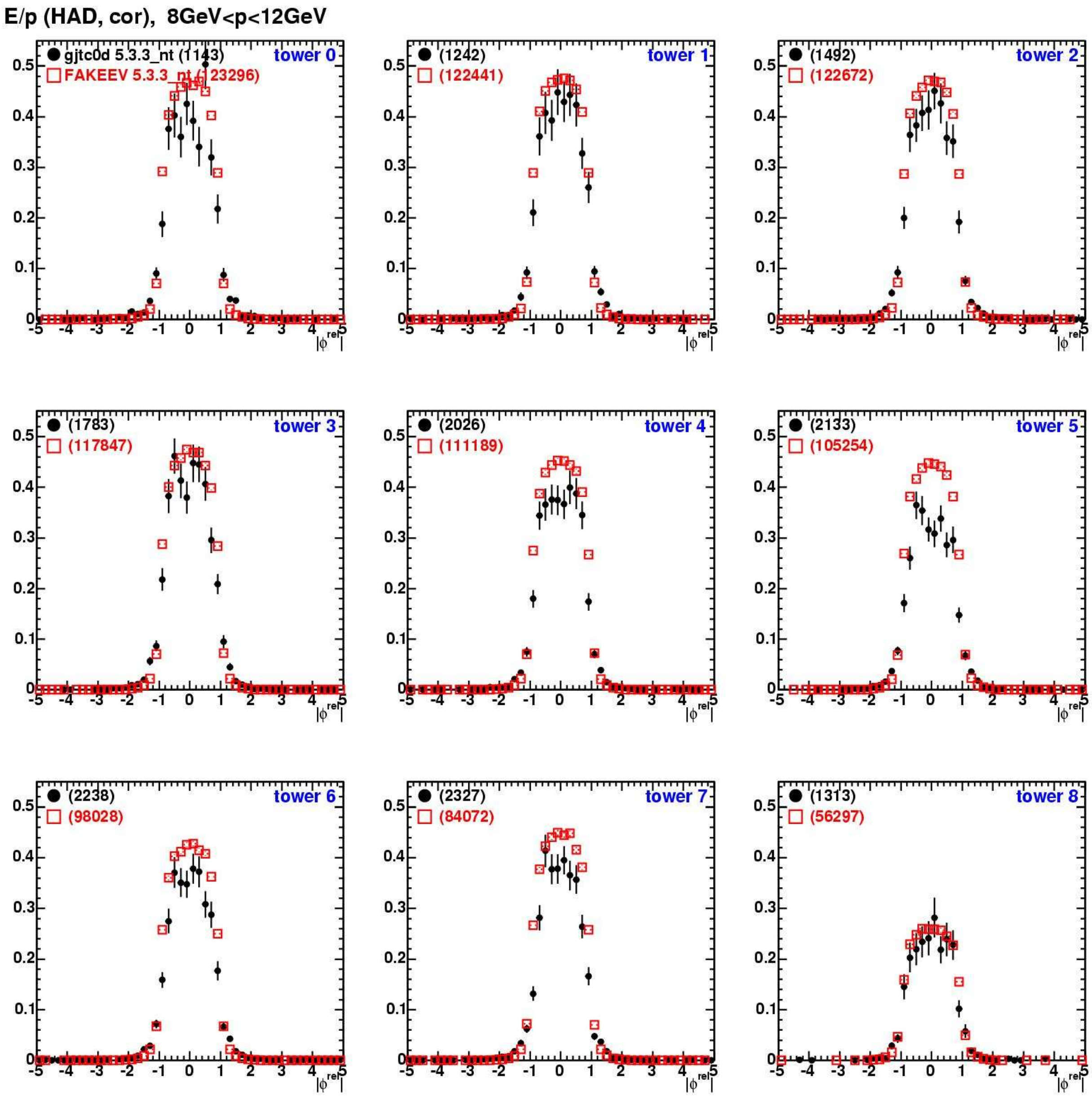
E/p vs. η^{rel} (HAD, 8-12 GeV)



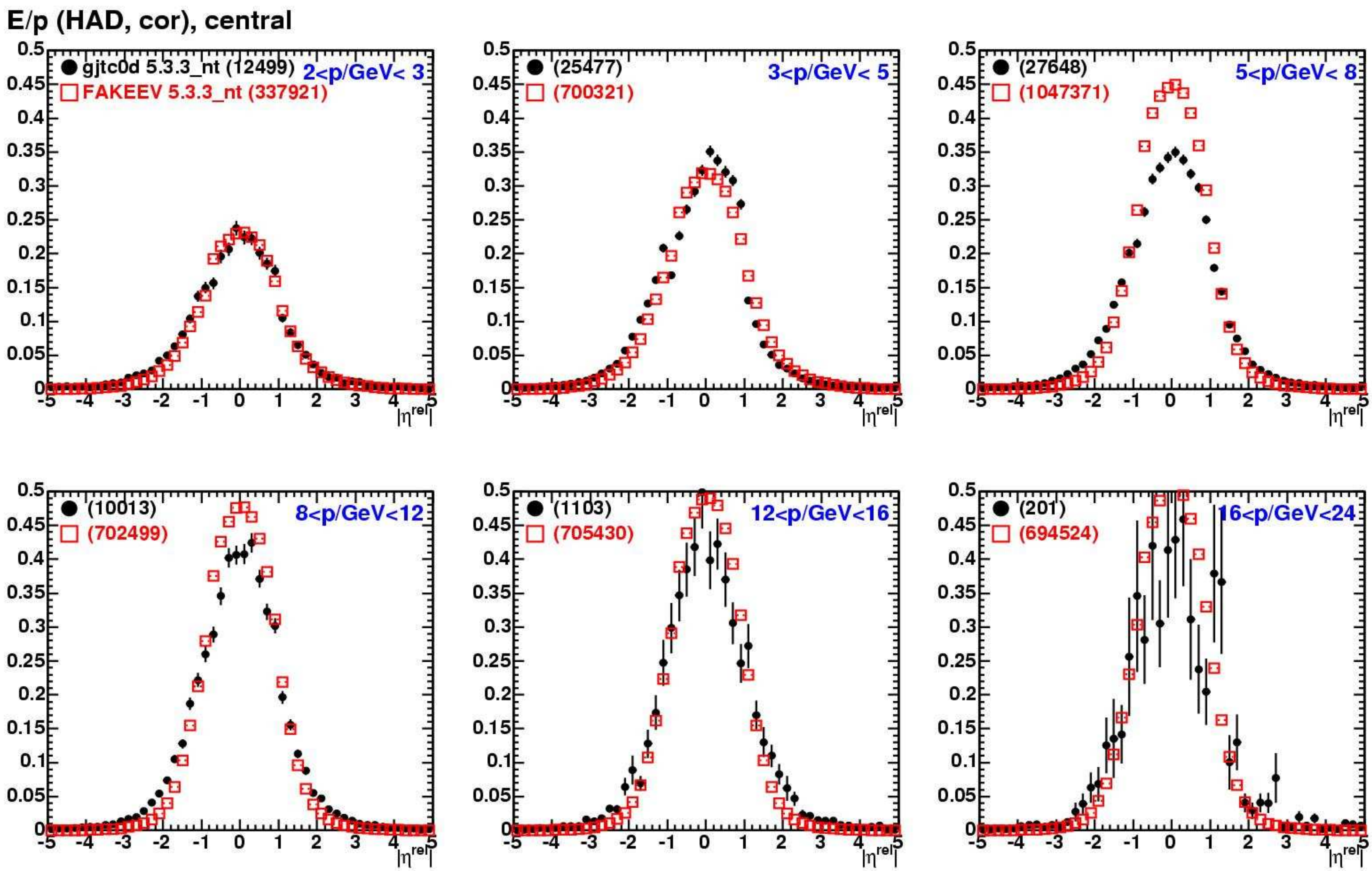
E/p vs. ϕ^{rel} (HAD, 3-5 GeV)



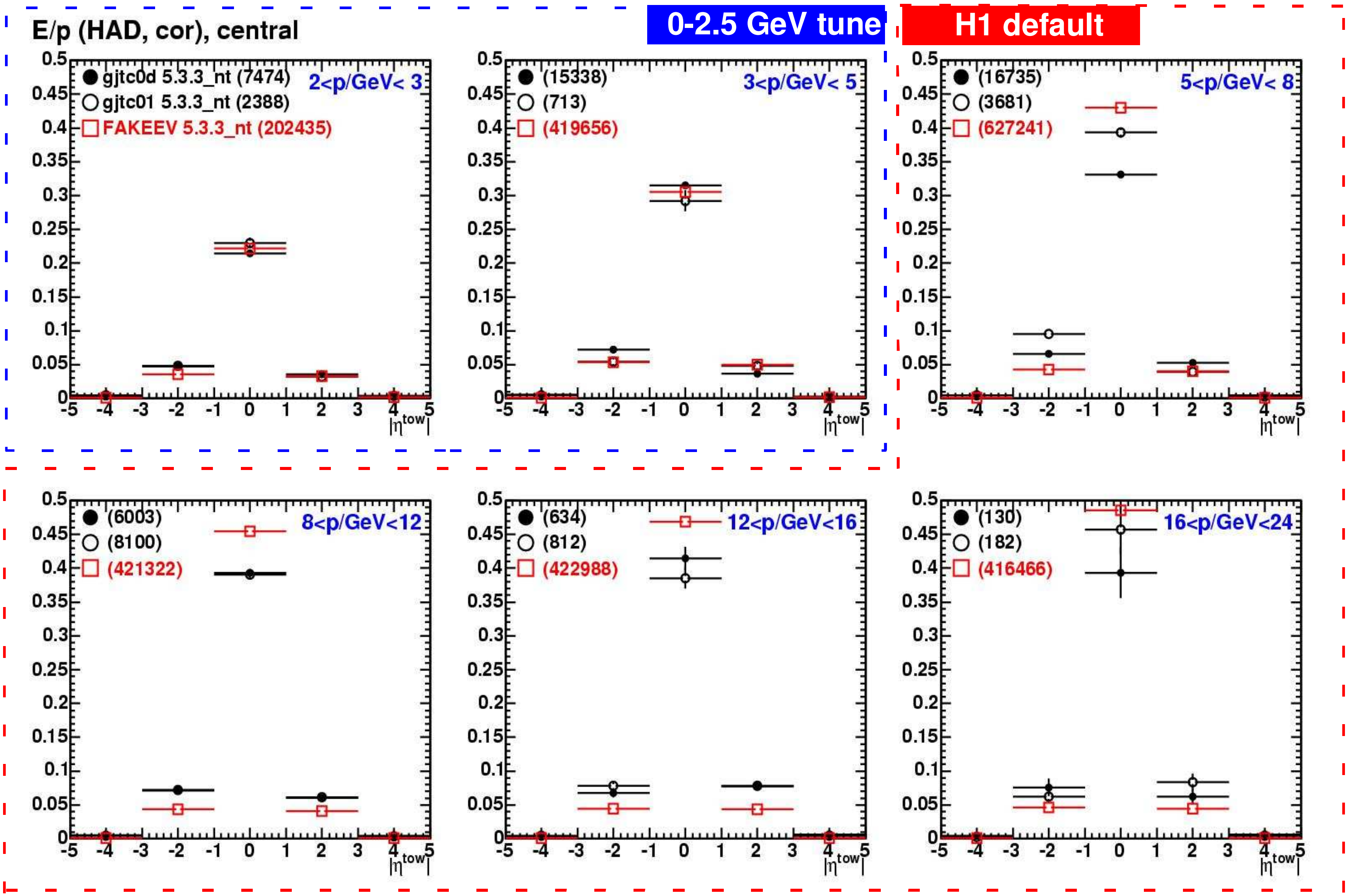
E/p vs. ϕ^{rel} (HAD, 8-12 GeV)



E/p (η^{rel}) vs. p (HAD)

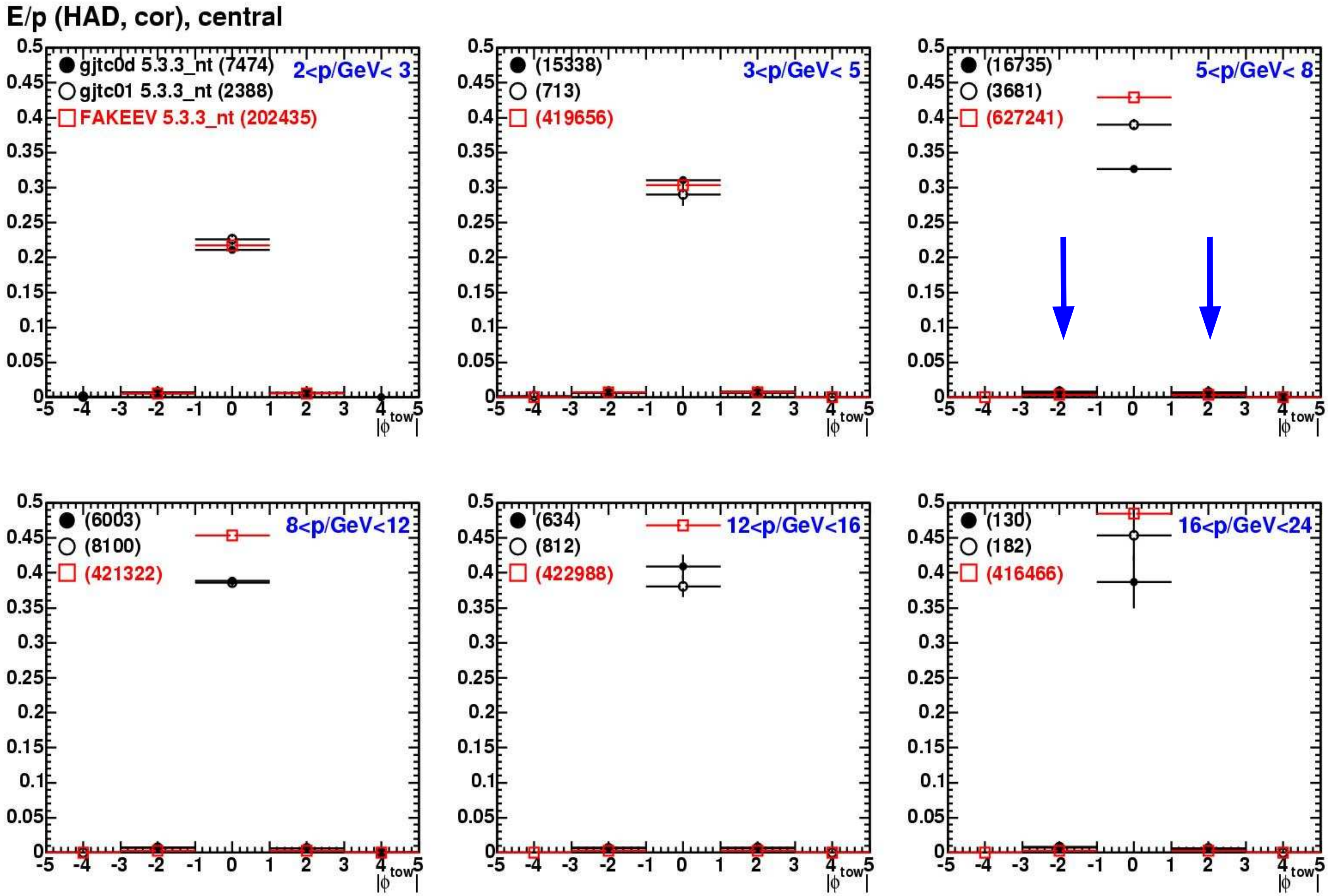


E/p (η^{tow}) vs. p (HAD)



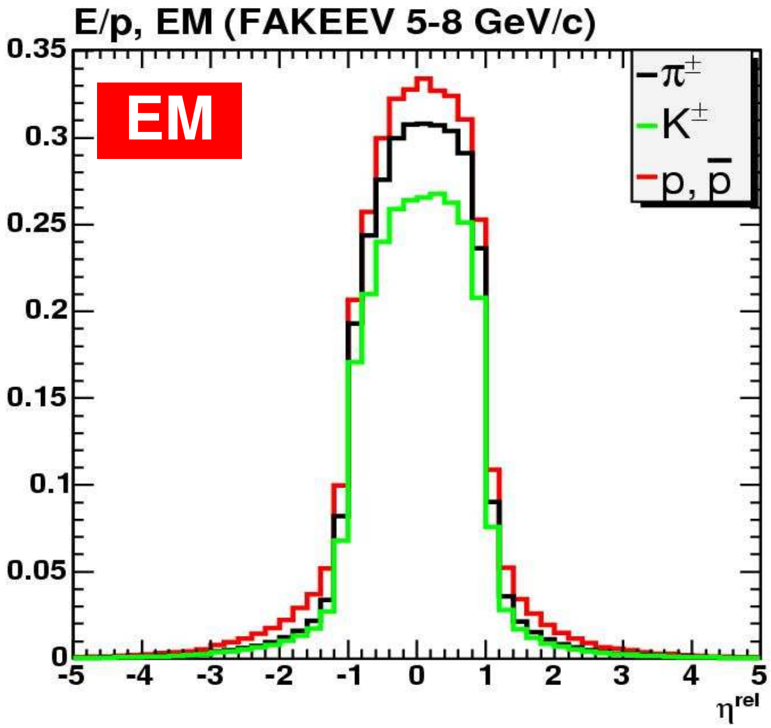
η^{tow} good suitable for initial tuning

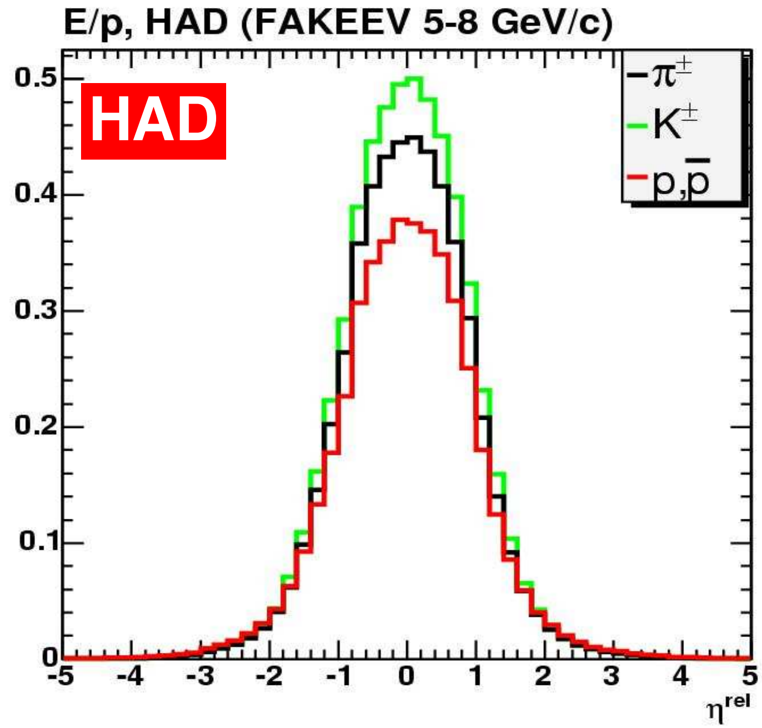
E/p (ϕ^{tow}) vs. p (HAD)



ϕ^{tow} less sensitive to lateral hadronic profile (coarser granularity, presence of cracks)

Dependence on Particle Type





- E/p (HAD): Kaons > Pions > Protons; E/p (EM): reverse
- Have to consider the right mixture for tuning.
- In the past: 60% $\pi^\pm$, 30% $K^\pm$, 10% p/$\bar{p}$

Conclusions

- Kink in HAD profile plots due to extrapolation effects in events with tracks stemming from displaced z vertices
- Kink structure is different for data and MC
  - More stringent z vertex cut can reduce cone “misalignment”
  - EM/p cut can enrich sample with hadronic showers starting at EM surface
  - Thus also cleaner definition of HAD tower coordinates
- Momentum weighting of MC tracks within p bins necessary in order to account for power law in data spectra

<u>For tuning of lateral profile in central part:</u>

- Consider tower 1,2,3,4 (stay away from cracks)
- Tune distributon: $E/p(\eta^{tow})$, $\eta^{tow} = 0, \pm 1$
- Momentum bins and number of usable isolated tracks (gjtc0d/gjtc01)

3-5 GeV	(15k/ 0.7k)	5-8 GeV	(17k/ 4k)
8-12 GeV	(6k/ 8k)	12-16 GeV	(0.6k/ 0.8k)
16-24 GeV	(0.1k/ 0.2k)		

- First tuning iteration is on the way ...