Exclusive DPE Higgs generators in fast CMS simulation

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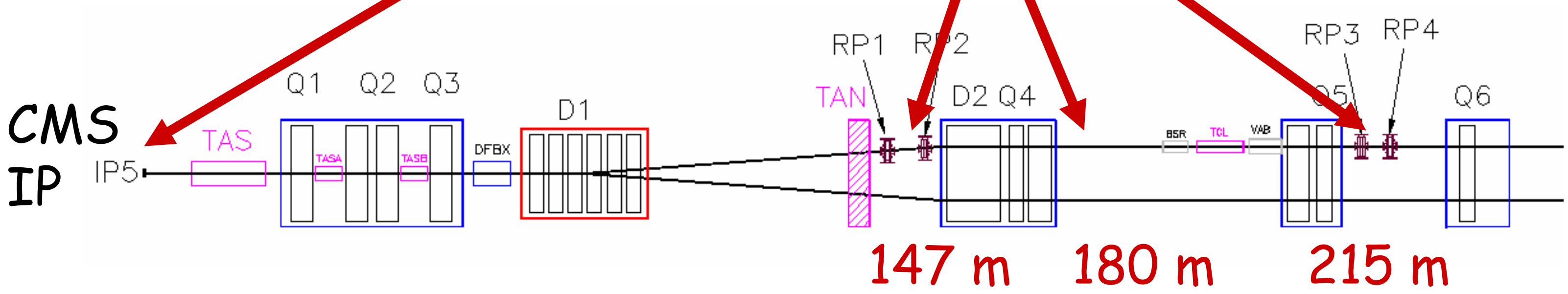
HERA-LHC meeting - CERN 19/01 2005

1. Comparison of DPEMC, ExHuMe and EDDE at parton, hadron and detector levels

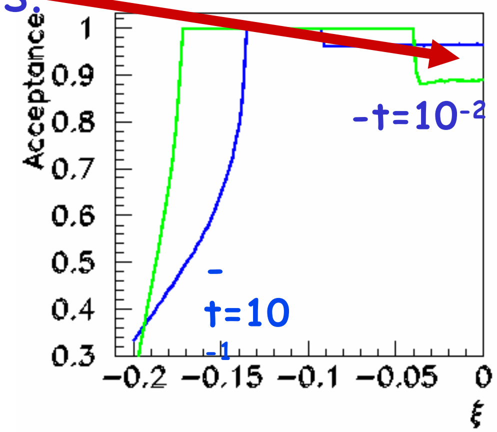
2. Event yields for H->bb and H->WW

The TOTEM Experiment

TOTEM physics program: total pp, elastic & diffractive cross sections
Apparatus: Inelastic Detectors & Roman Pots (3 stations)

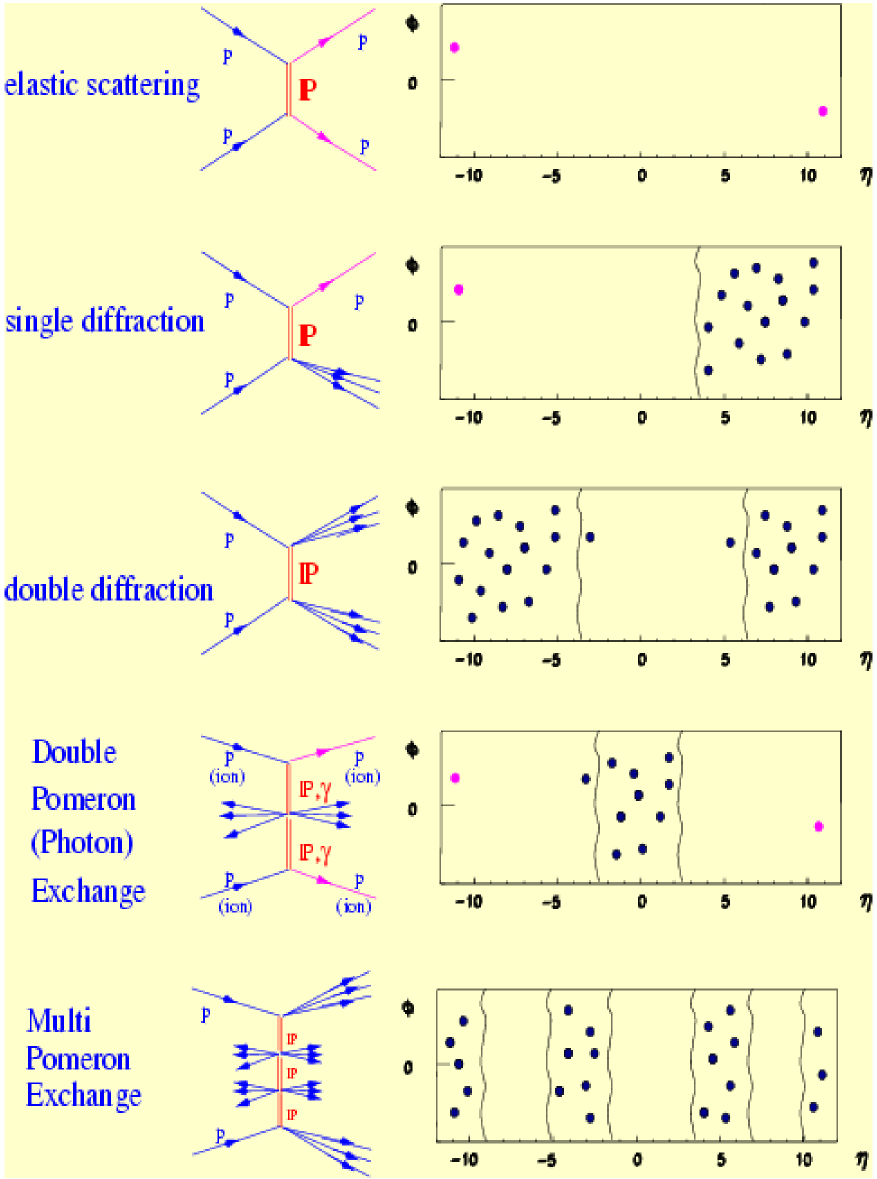


High β* (1540m): Lumi 10^{28}-10^{31} $cm^{-2}s^{-1}$ (few days or weeks)
>90% of all diffractive protons are seen in the Roman Pots
Proton momentum measured with a resolution ~10^{-3}



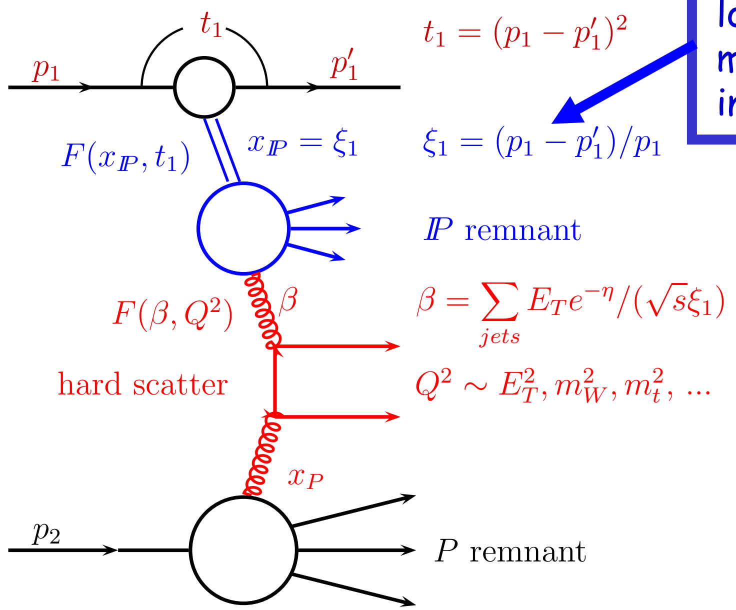
Low β*: (0.5m): Lumi 10^{33}-10^{34} $cm^{-2}s^{-1}$
215m: $0.02 < \xi < 0.2$
300/400m: $0.002 < \xi < 0.2$ (RPs in the cold region)

Diffraction at LHC:



- PP scattering at highest energy
- Soft & Hard Diffraction

proton momentum loss measured in RPs



ξ < 0.1 $\Rightarrow$ O(1) TeV "Pomeron beams"

E.g. Structure of the Pomeron F(β,Q^2)

β down to ~ 10^{-3} & Q^2 ~10^4 GeV^2

Diffraction dynamics?

Exclusive final states ?

- Gap dynamics in pp presently not fully understood! 1

Procedure

1. INPUT

Results of Helsinki group studies:

- Acceptance (ξ_{gen})
- Offset (ξ_{gen})
- Resolution (ξ_{gen})

for 3 Roman Pot locations: 420m, 308m and 215m and for clockwise and anti-clockwise moving protons.

2. FAMOS

Put the above information into FAMOS (Fast Monte Carlo Simulation for CMS) and smear $\xi_{gen} \rightarrow \xi_{sim}$ using a MC event generator.

All configurations foreseen:

(420m); (308m); (215m); (420m+308m); (420m+215m); (308m+215m); (420m+308m+215m).

3. CHECK

Check if the implementation of the above info is correct by comparing

- Acceptance (M_{gen})
- Resolution (M_{gen}) = $(M_{gen} - M_{sim})/M_{gen}$

obtained by Helsinki with that obtained by FAMOS.

DPE Higgs event generators

1. **DPEMC 2.4** (M.Boonekamp, T.Kucs)
   - Bialas-Landshof model + rap.gap survival probability
   - Herwig for hadronization

2. **EDDE 1.1** (V.Petrov, R.Ryutin)
   - Regge-eikonal approach
   - Pythia for hadronization

3. **ExHuMe β version** (J.Monk, A.Pilkington)
   - KMR model for exclusive diffraction
   - Pythia for hadronization

All three models available now in the fast CMS simulation!

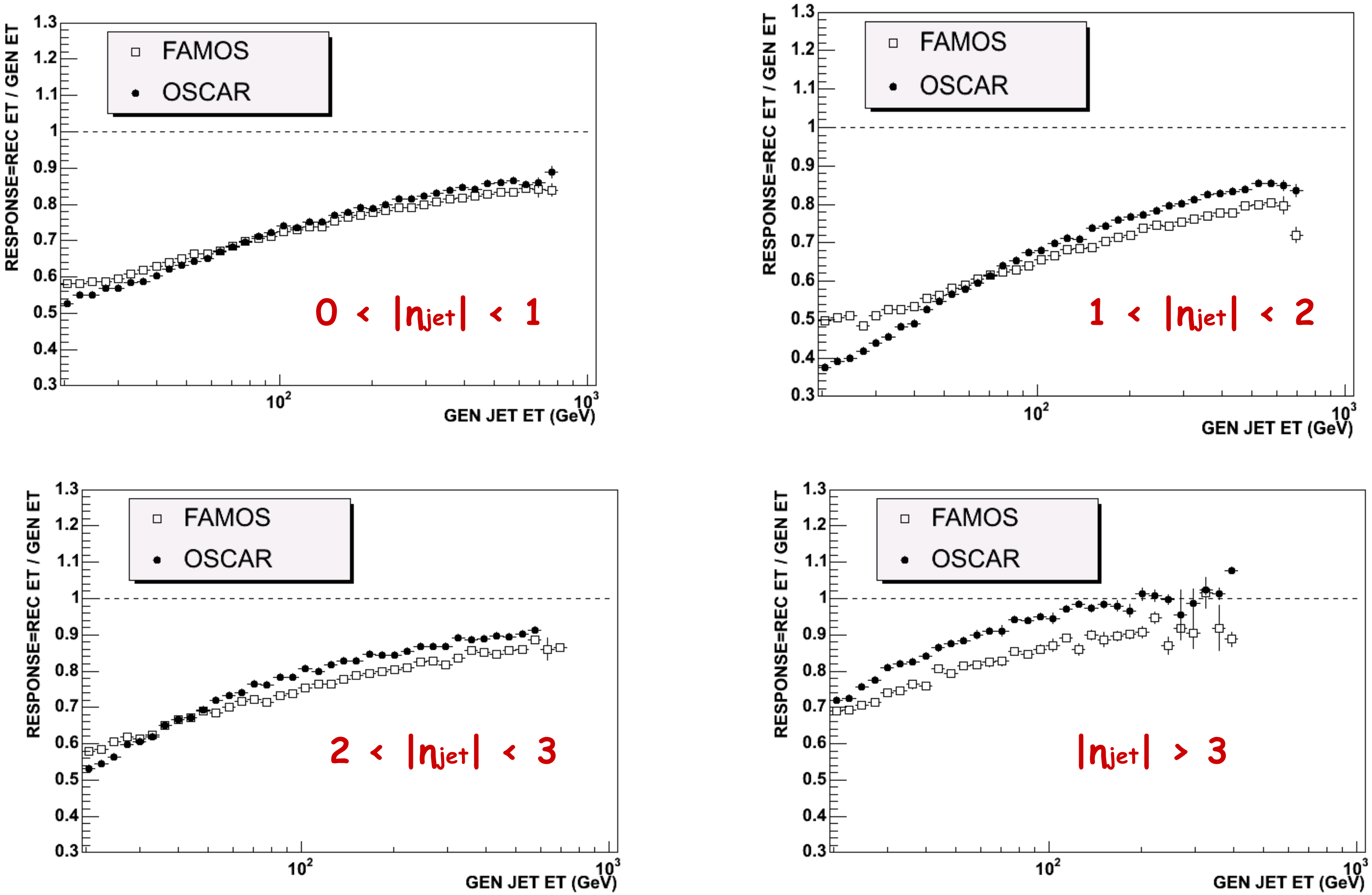
FAMOS_1_0_0

Fast CMS simulation program has seen a lot of effort and improvement last year. While still being improved and debugged, it can (and it is) already used for physics analyses.

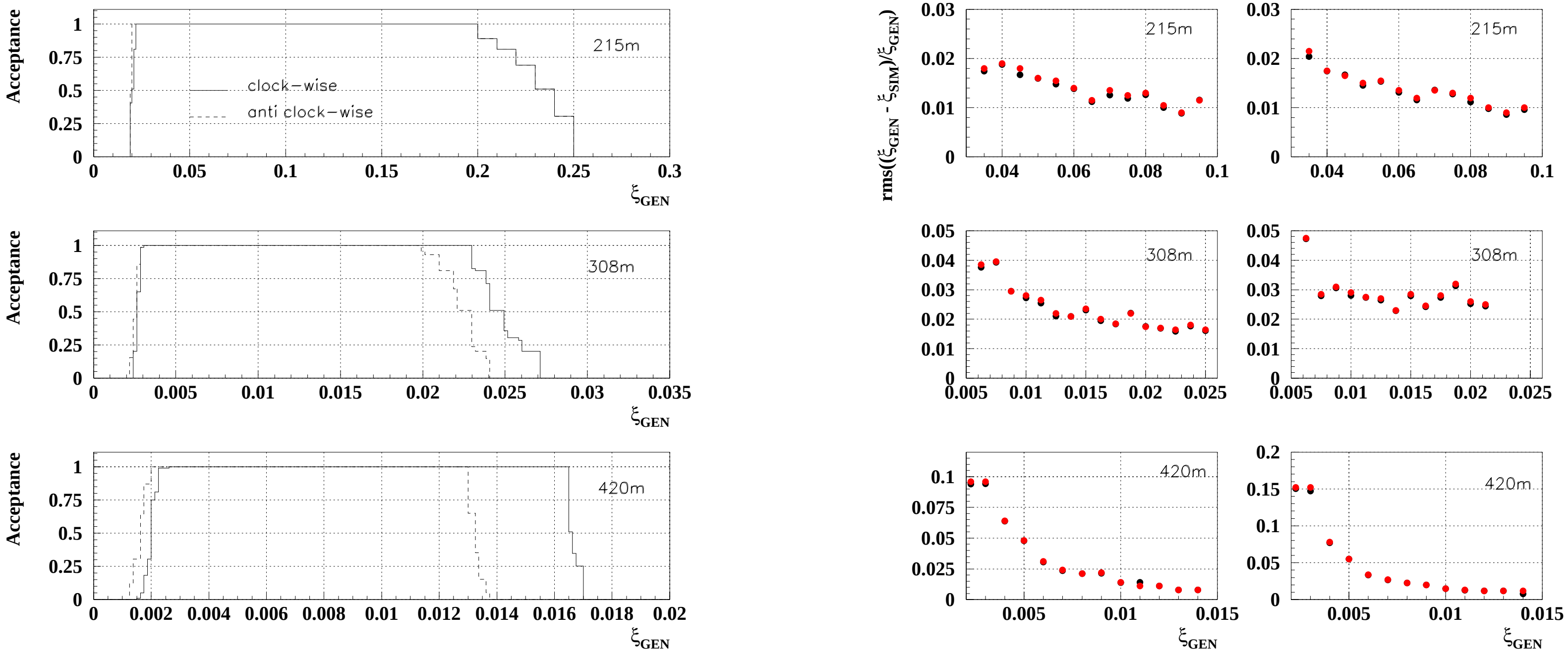
Main chapters:

- Fastcalorimetry, FastElgamma, FastElMatching
- FastTsim, FastBtag
- FastJets, FastMET, FastHLTMET
- FastMuon, FastMuonTrigger
- FastTotem (just Roman Pots)

FAMOS_1_0_0: Jet energy scale



1. INPUT + 2. SMEARING



- **Simulation parameters:**
- Initial conditions

Transverse vertex position	σ_{xy} = 16 μm
Beam energy spread	σ_E = 1E-4
Beam divergence	σ_θ = 30 μrad

Detector simulation

Position resolution	σ_{xy} = 10 μm
Beam position resolution	σ_{xy} = 5 μm
Detector misalignment	Δ_{xy} = 10 μm
Absolute beam position	Δ_{xy} = 10 μm

Smearing:

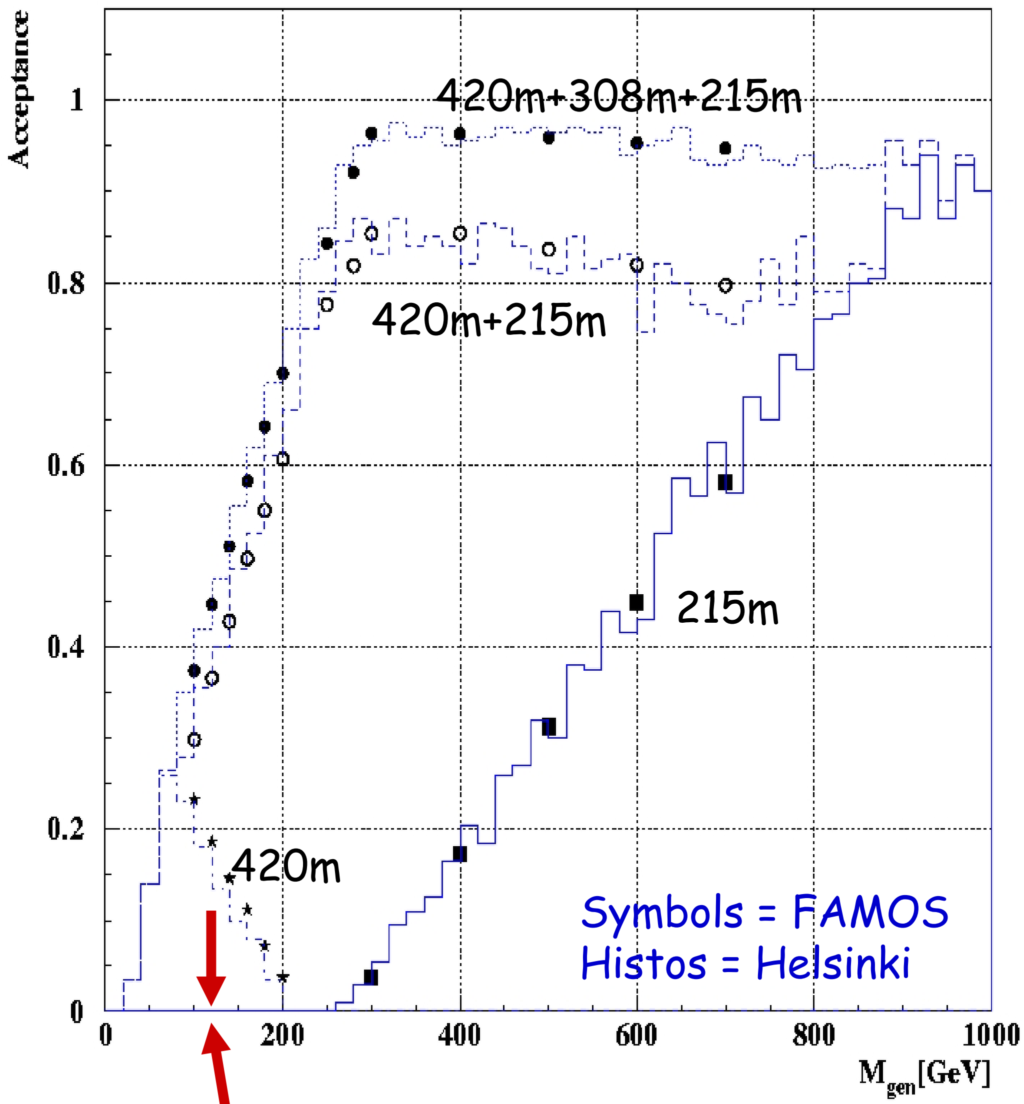
clockwise moving protons:

$$\xi_{sim1} = \xi_{gen1} * (1 - offset(\xi_{gen1}) + \sigma_{IP1}(\xi_{gen1}) * r_{IP,Gauss} + \sigma_{other1}(\xi_{gen1}) * r_{other1,Gauss})$$

anti-clockwise moving protons:

$$\xi_{sim2} = \xi_{gen2} * (1 - offset(\xi_{gen2}) - \sigma_{IP2}(\xi_{gen2}) * r_{IP,Gauss} + \sigma_{other2}(\xi_{gen2}) * r_{other2,Gauss})$$

3.CHECK: M_H Acceptance



SM Higgs! Needs new RPs at 300/400m ?
= technical challenge: cold region, trigger

M_H acceptance and resolution depend on ξ_1 and ξ_2 acceptances and resolutions through

$$M_H^2 = \xi_1 * \xi_2 * s$$

Hence

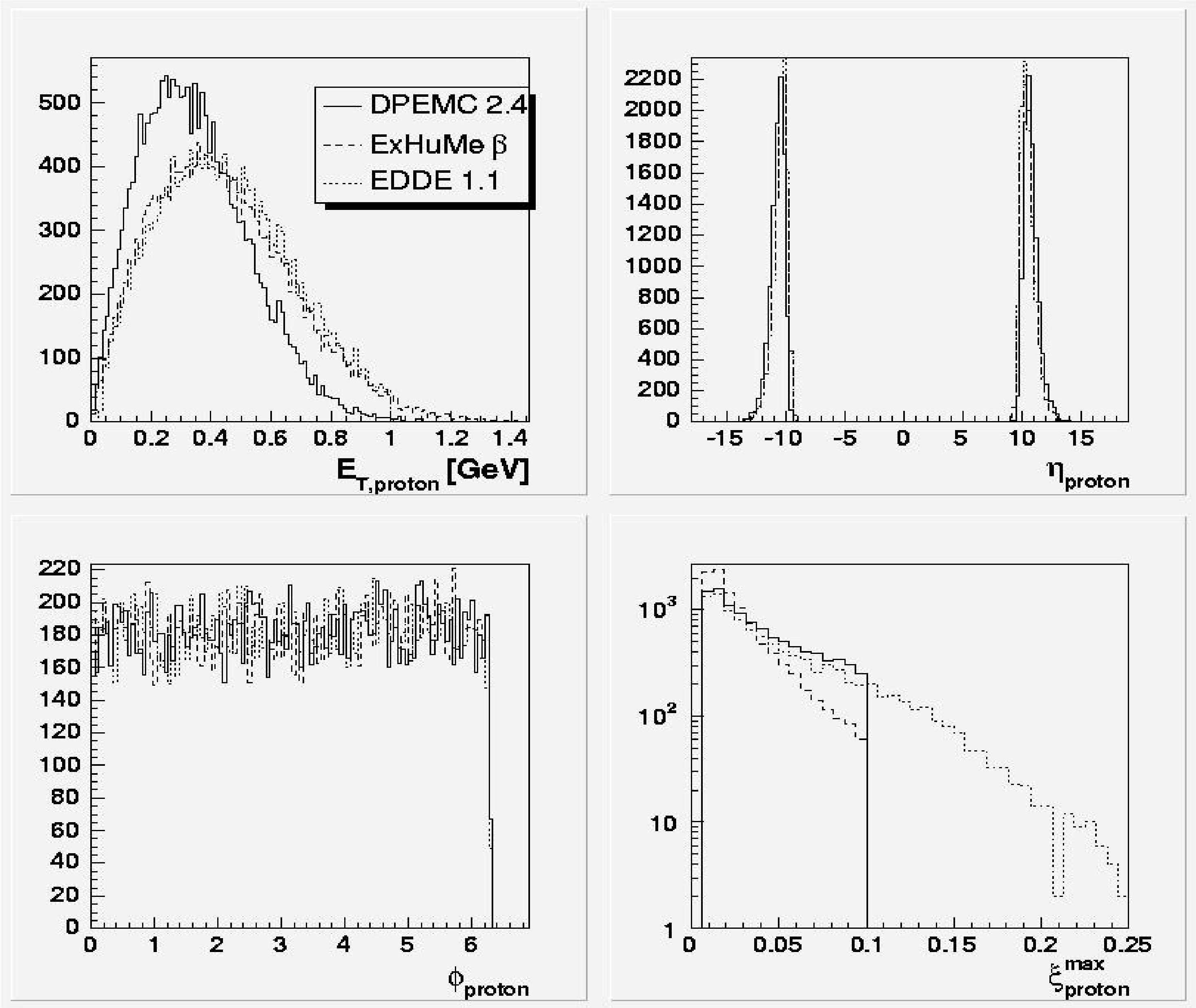
$$M^2_{gen} = \xi_{gen1} * \xi_{gen2} * s$$

$$M^2_{sim} = \xi_{sim1} * \xi_{sim2} * s$$

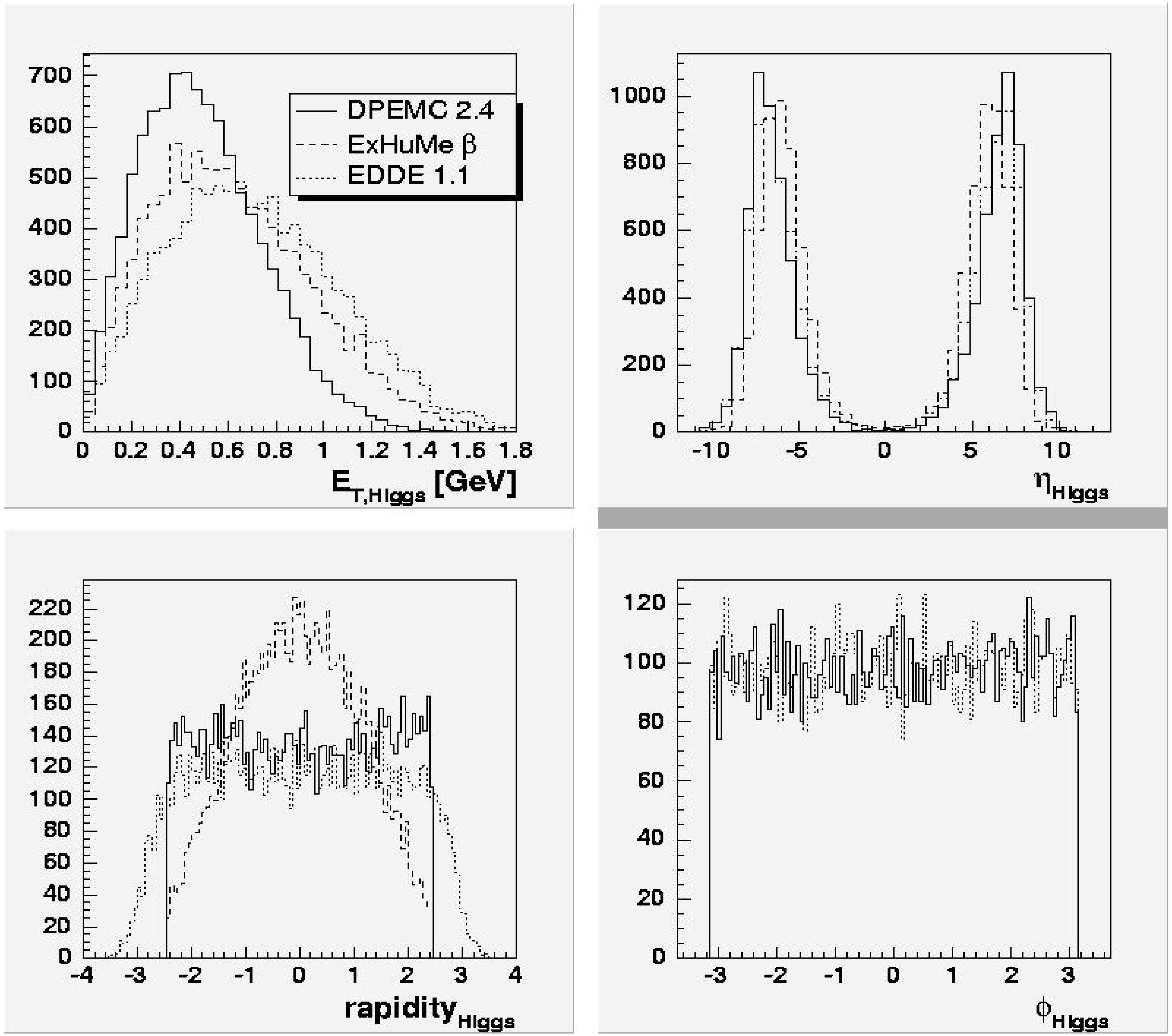
RP selection sequence:

If ξ_{gen} falls into acceptance regions of more RPs, the most distant RP is taken (because of better resolut.).

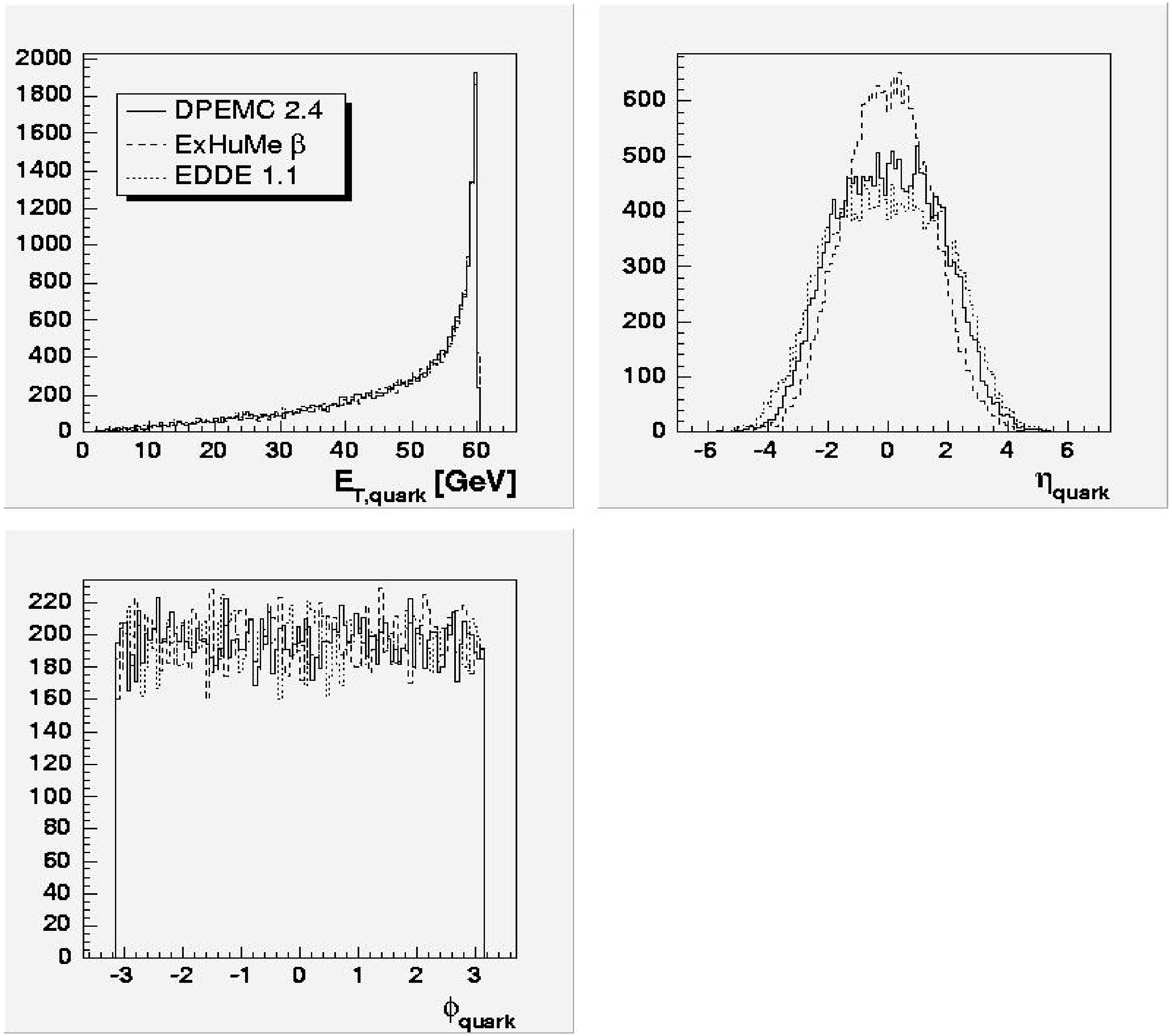
Parton level: Protons



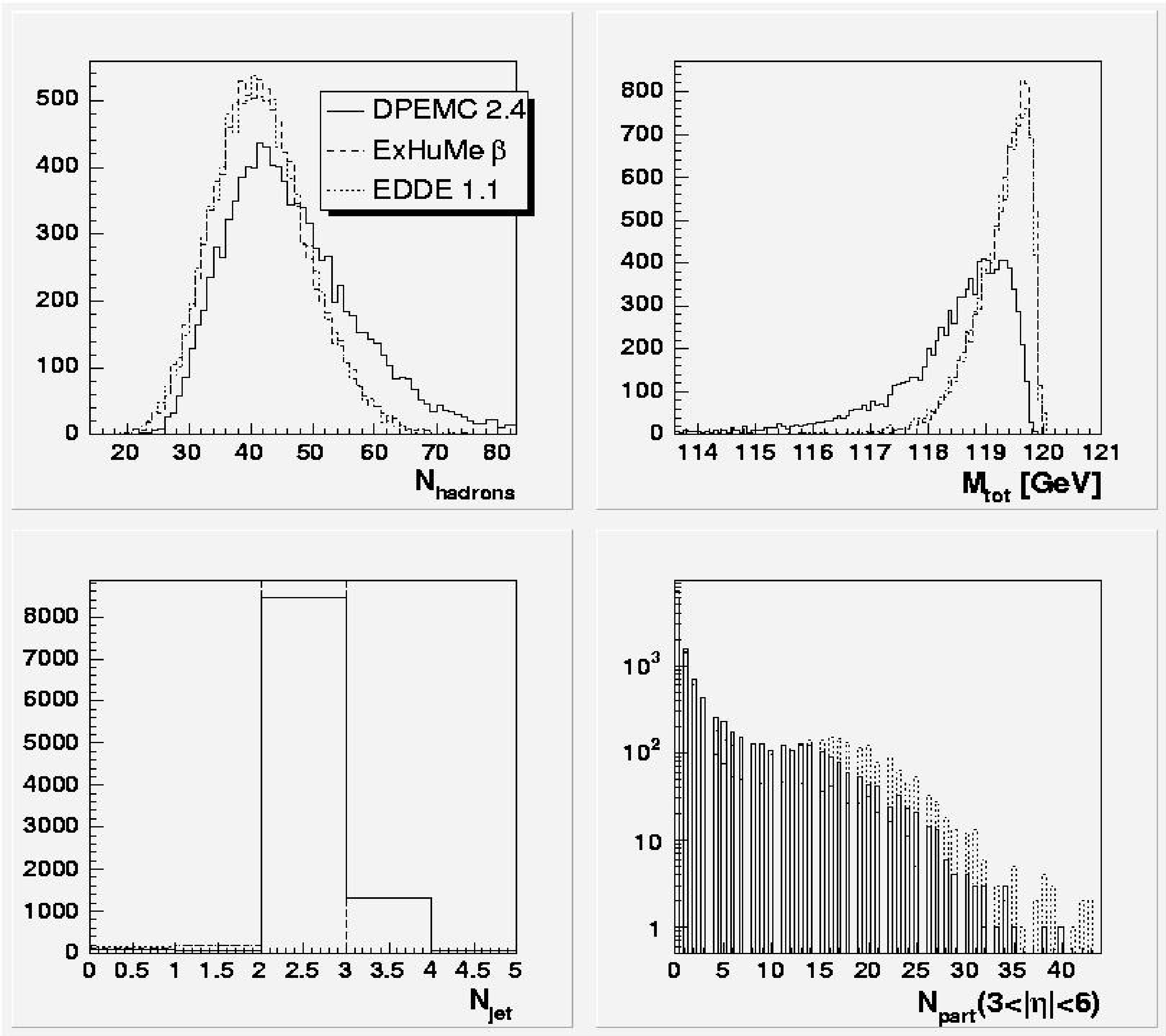
Parton level: Higgs



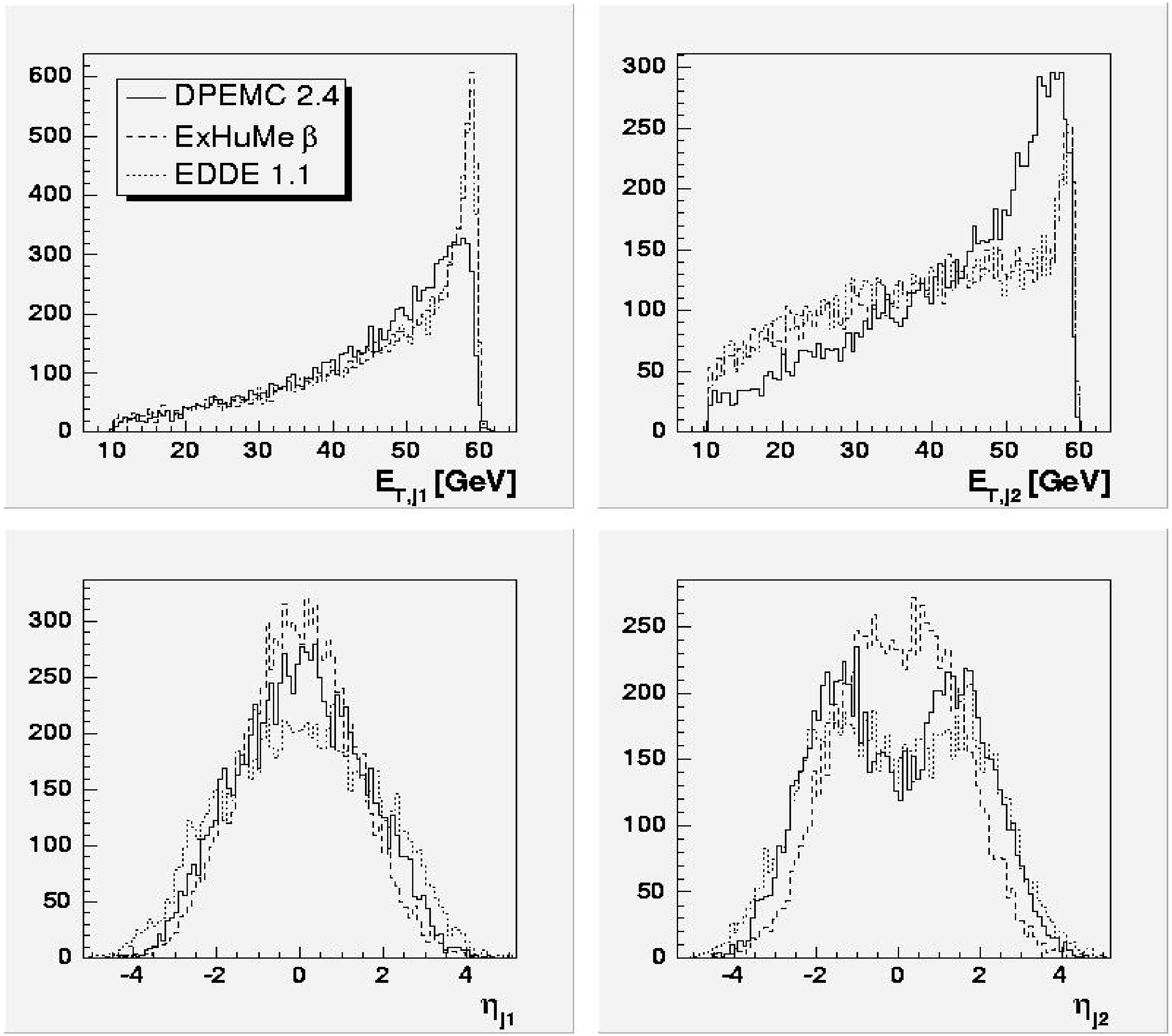
Parton level: b-quarks



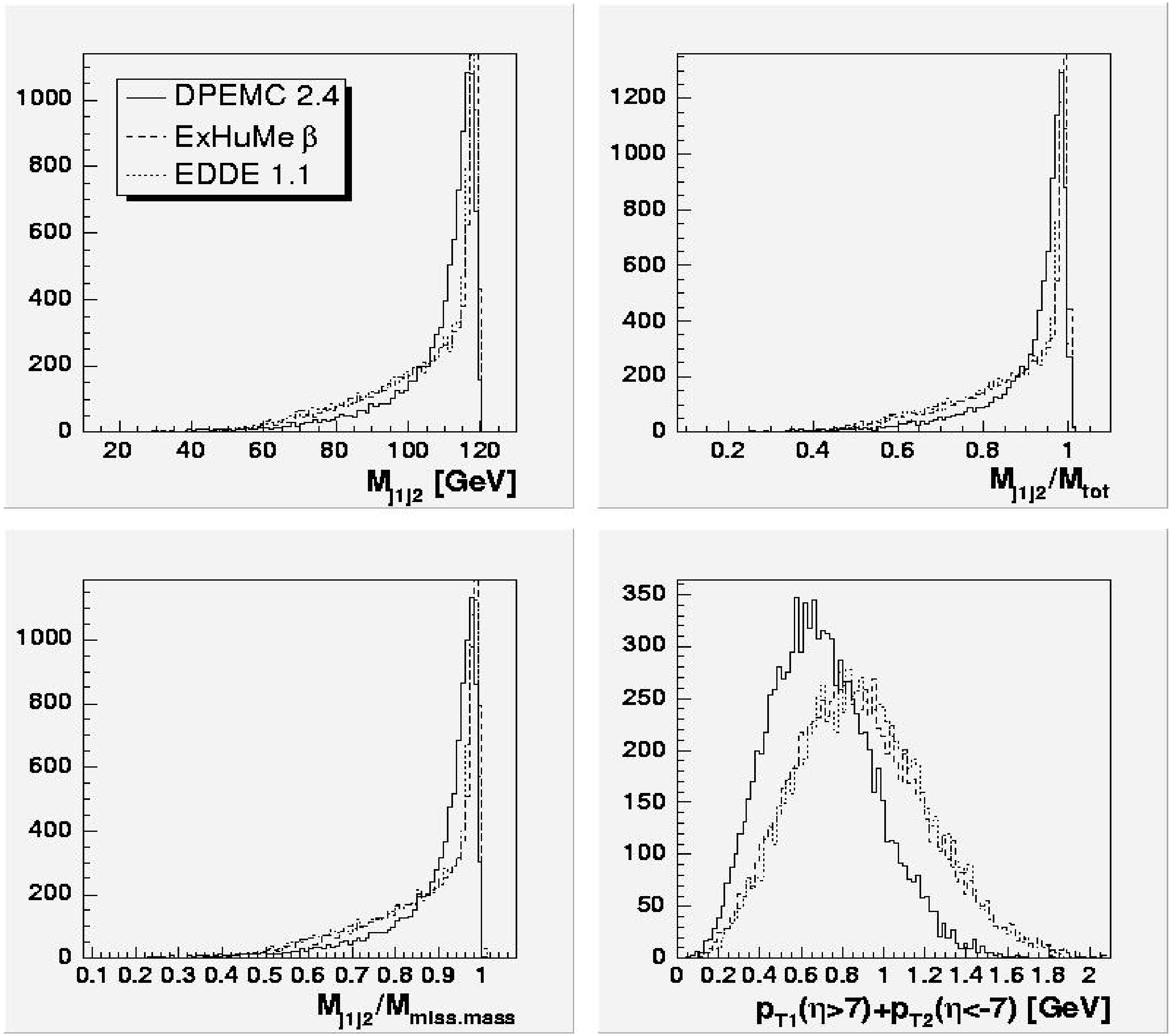
Hadron level: all particles



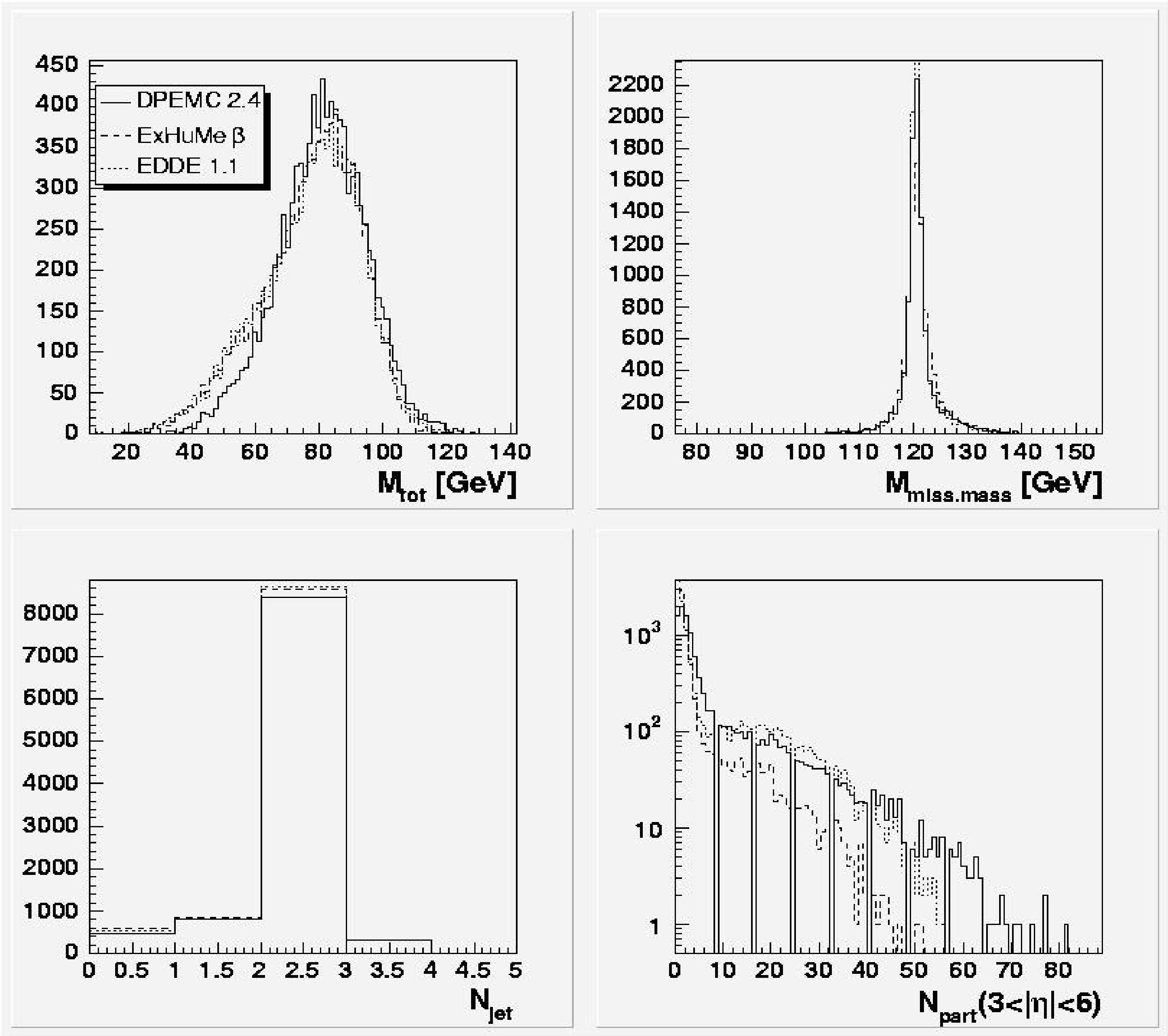
Hadron level: b-jets



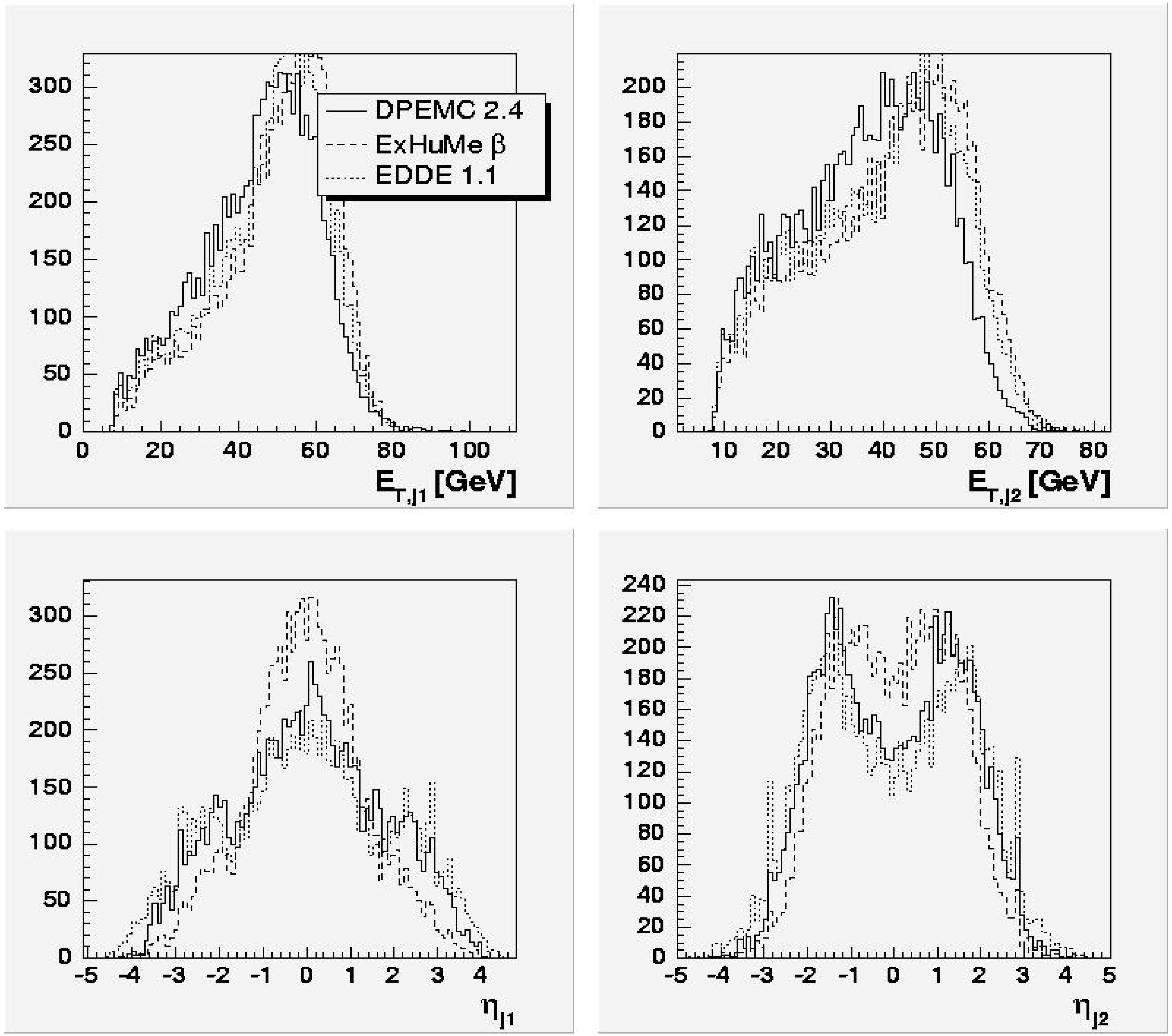
Hadron level: b-jets and particles



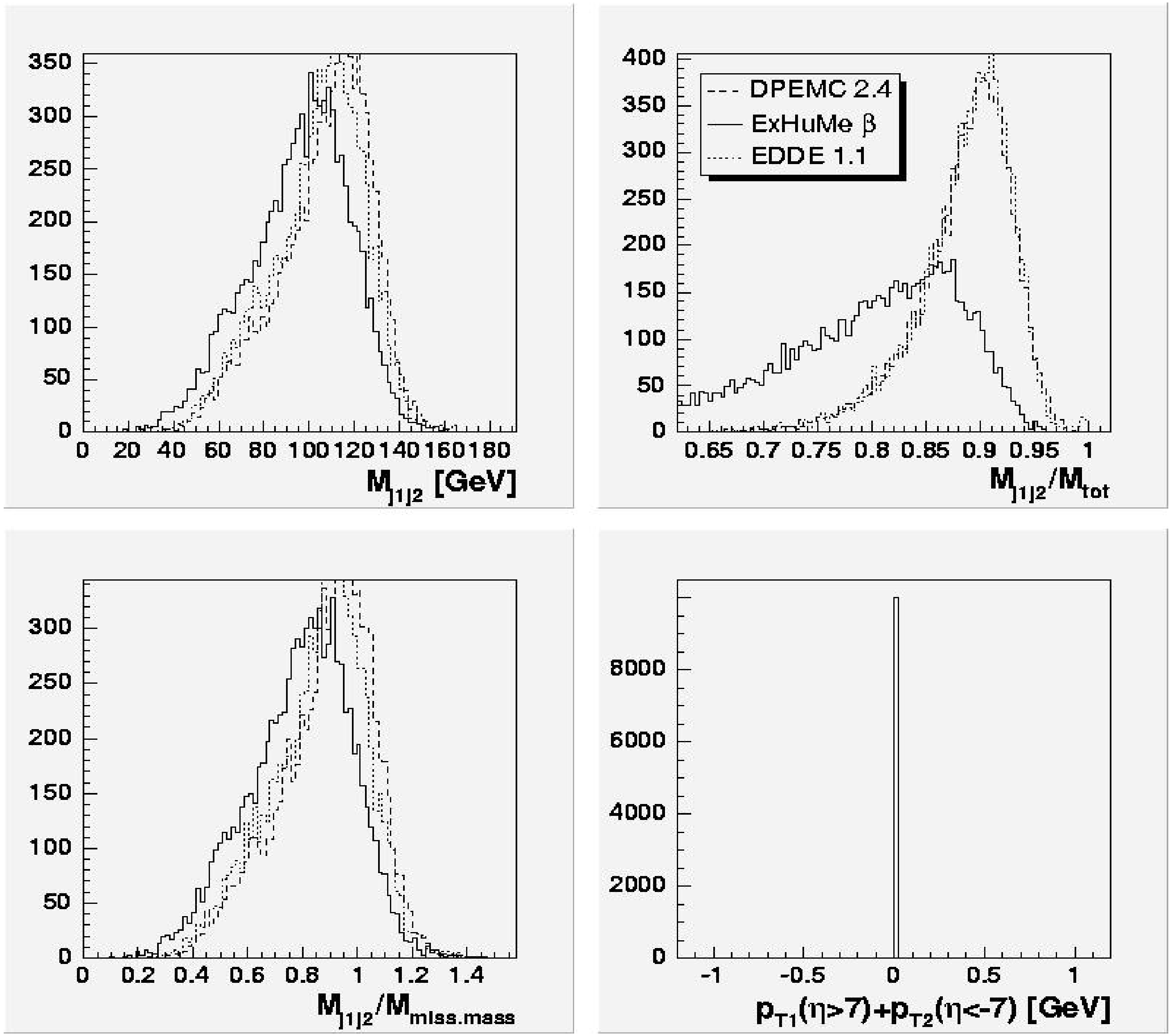
Detector level: all particles



Detector level: b-jets



Detector level: jets and particles



Excl.DPE H->WW:Event yields per L=10 fb-1

Both protons accepted in one of three RP stations (220,308,420):
57,66,68,75,80,85,90,100% for mh=120,135,140,150,160,170,180,200 GeV resp.

C1) single e: pt1 > 29 GeV, $|\eta 1| < 2.5$
C2) two e: pt1,2 > 17 GeV, $|\eta 1,2| < 2.5$
C3) single μ: pt1 > 14 GeV, $|\eta 1| < 2.1$
C4) two μ: pt1,2 > 3 GeV, $|\eta 1,2| < 2.1$
C5) single e: pt1 > 20 GeV, $|\eta 1| < 2.5$ + 2 quarks: pt1,2>25 GeV, $|\eta 1,2|<5$
C6) single μ: pt1>10 GeV, $|\eta 1| < 2.1$ + 2 quarks: pt1,2>25 GeV, $|\eta 1,2| < 5$

Numbers come from DPEMC generator level.
Only total numbers are scaled by KMR σxBR

mh[GeV]	σxBR[fb	C1	C2	C3	C4	C5	C6	Total
120	**0.34/0.40**	0.14	0.01	0.27	0.02	0.02	0.07	**0.5/0.6**
135	**0.98/0.81**	0.51	0.04	1.04	0.06	0.15	0.28	**2.1/1.7**
140	**1.23/0.92**	0.71	0.07	1.38	0.07	0.24	0.37	**2.8/2.1**
150	**1.72/1.05**	1.32	0.10	2.19	0.12	0.58	0.71	**5.0/3.1**
160	**2.26/1.10**	2.22	0.17	3.08	0.17	1.37	1.34	**8.4/4.1**
170	**2.36/1.01**	2.50	0.20	3.62	0.16	1.54	1.59	**9.6/4.1**
180	**2.22/0.80**	2.46	0.18	3.60	0.16	1.45	1.45	**9.3/3.3**
200	**1.69/0.48**	2.20	0.15	3.00	0.14	1.16	1.18	**7.8/2.2**

Excl.DPE H->bb: Event yields per L=10 fb-1

- **Selection cuts at detector level:**

0) Both protons accepted in one of three (220,308,420) RP stations
1) $N_{jet} > 1$
2) 45 < Etj1*JesCor < 85 GeV, Etj2*JesCor > 30 GeV
3) $|\eta_{j1,2}| < 2.5$
4) $|\eta_{j1} - \eta_{j2}| < 0.8$
5) $2.8 < |\varphi_{j1} - \varphi_{j2}| < 3.48$
6) $M_{j1j2}/M_{tot} > 0.75$
7) $M_{j1j2}/M_{miss.mass} > 0.8$
8) $N_{part}(3<|\eta|<6) = 0$
9) $118 < M_{miss.mass} < 122$ GeV

*KMR calculation

Generator	σxBR[fb]	Acc1*Acc2>0	Nev
DPEMC	2.27	57%	0.4
EDDE	1.94	51%	0.7
ExHuMe	1.3/2.03*	78%	0.8/1.2

Summary

- DPEMC, EDDE and ExHuMe generators made available in the fast CMS simulation

- RP acceptances and resolutions also there

- The generators' codes fast developing, nevertheless large differences between the models observed. Mainly in two basic quantities: $\xi_{\mathbf{proton}}$ and $y_{\mathbf{Higgs}}$

Predictions of basic characteristics are model dependent. To obtain solid S/B ratios, we need to understand the differences.