HERA-LHC workshop
DESY 12-16.March 2007

Studies for Calorimetric Coverage at Large Rapidities at CMS

on behalf of SMIX (the Small-x and Multiple InteraXions) Initiative
V.Andreev, K.Borras, A.Bunyatyan, A,Campbell, M.Deak, P.Göttlicher, H.Jung, M.Kapichine, I.Katkov, L.Khein, O.Lukina, L.Lytkine, Z.Staykova

- *Introduction*
- *Forward Detectors at CMS*
- *- Present coverage*
- *- Possible extension*
- *Acceptance studies*
- *Summary*

Physics Interest

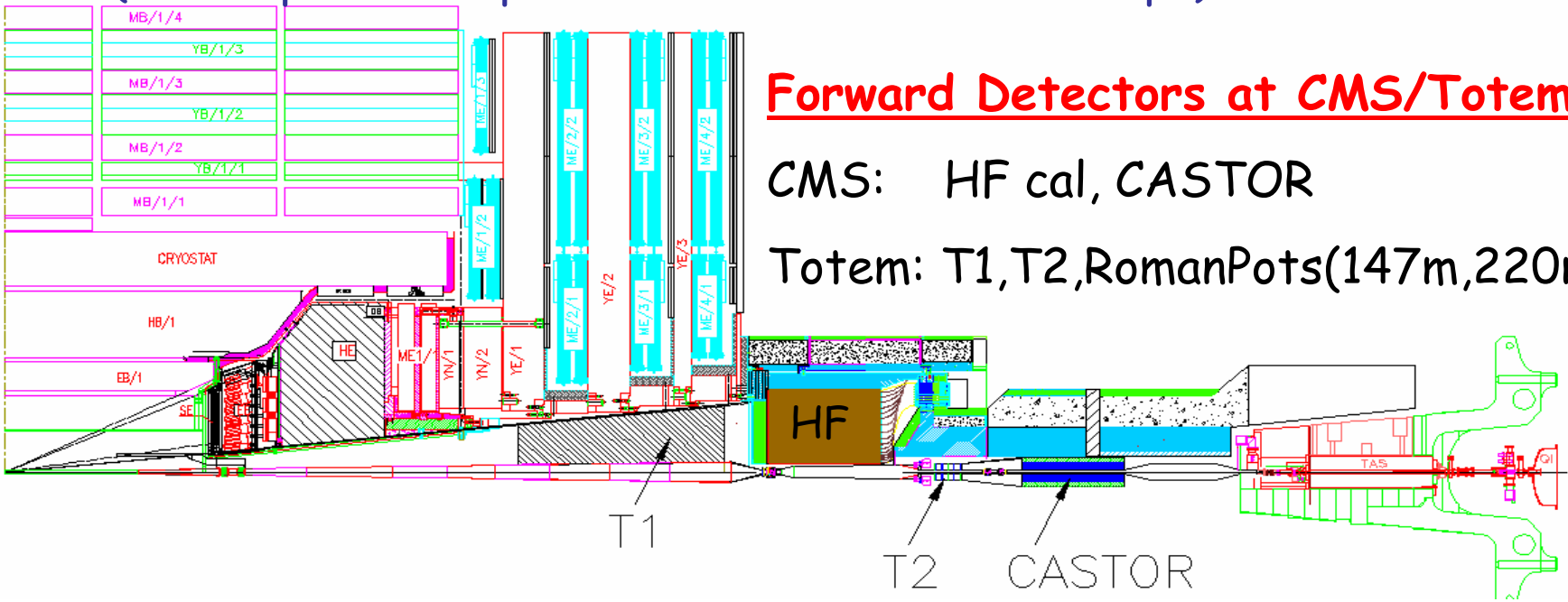
- understand mechanism of **Multiple Interactions** and **Underlying Events**
  connection to diffraction and saturation
- connection to small x physics: BFKL/CCFM dynamics, saturation
  contribution in all physics channels: Higgs, top, etc.

·Crucial for understanding of QCD and background for high-pt processes

- Measurements involve
  - tracks and long range correlations
  - forward jets and correlations with central jets

- Measurements have to be done at LHC low lumi phase
- Best would be both sides equipped and complete angular coverage at large rapidities

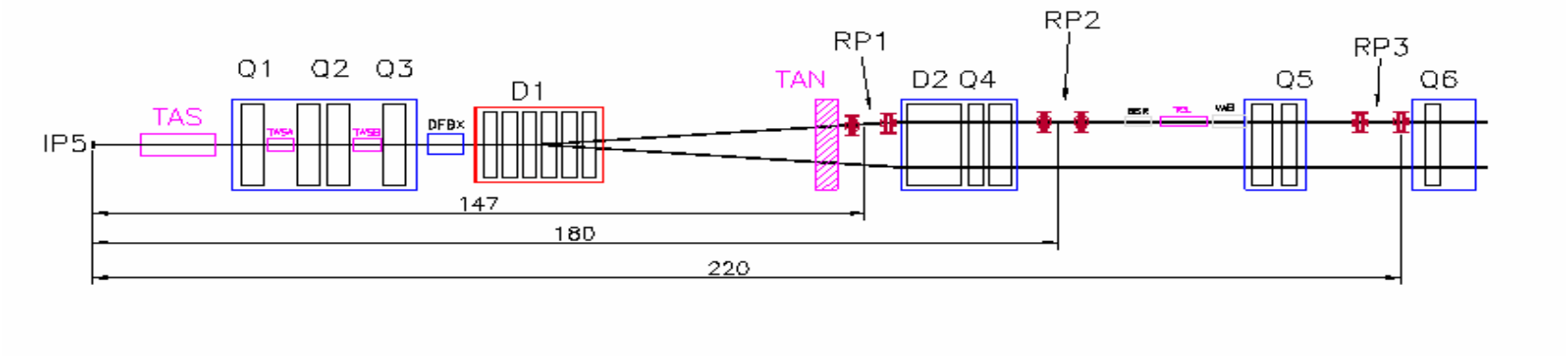
Aim of this study- to investigate technical possibilities of increasing the acceptance of very forward energy measurement (also reported in previous HERA-LHC workshops)



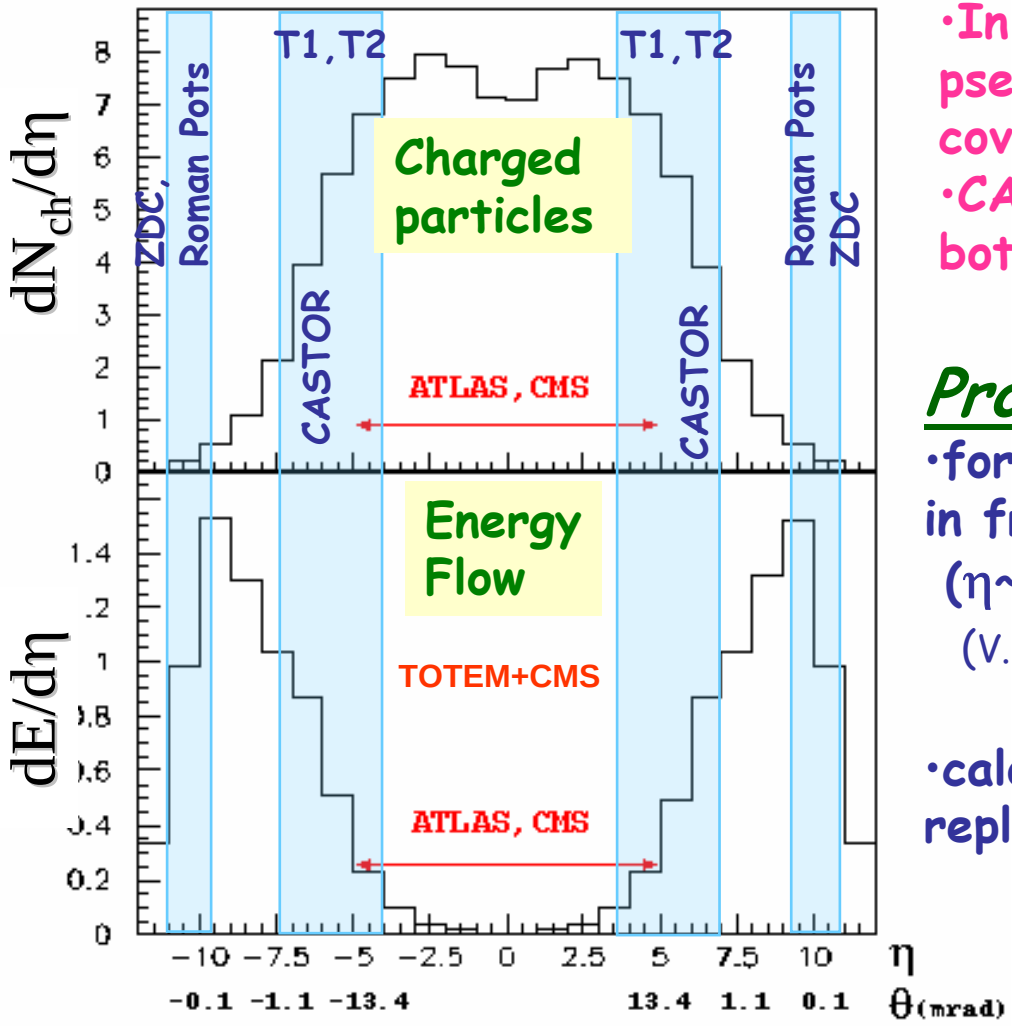
Forward Detectors at CMS/Totem

CMS: HF cal, CASTOR

Totem: T1,T2,RomanPots(147m,220m)



Aim of this study- to investigate technical possibilities of increasing the acceptance of very forward energy measurement



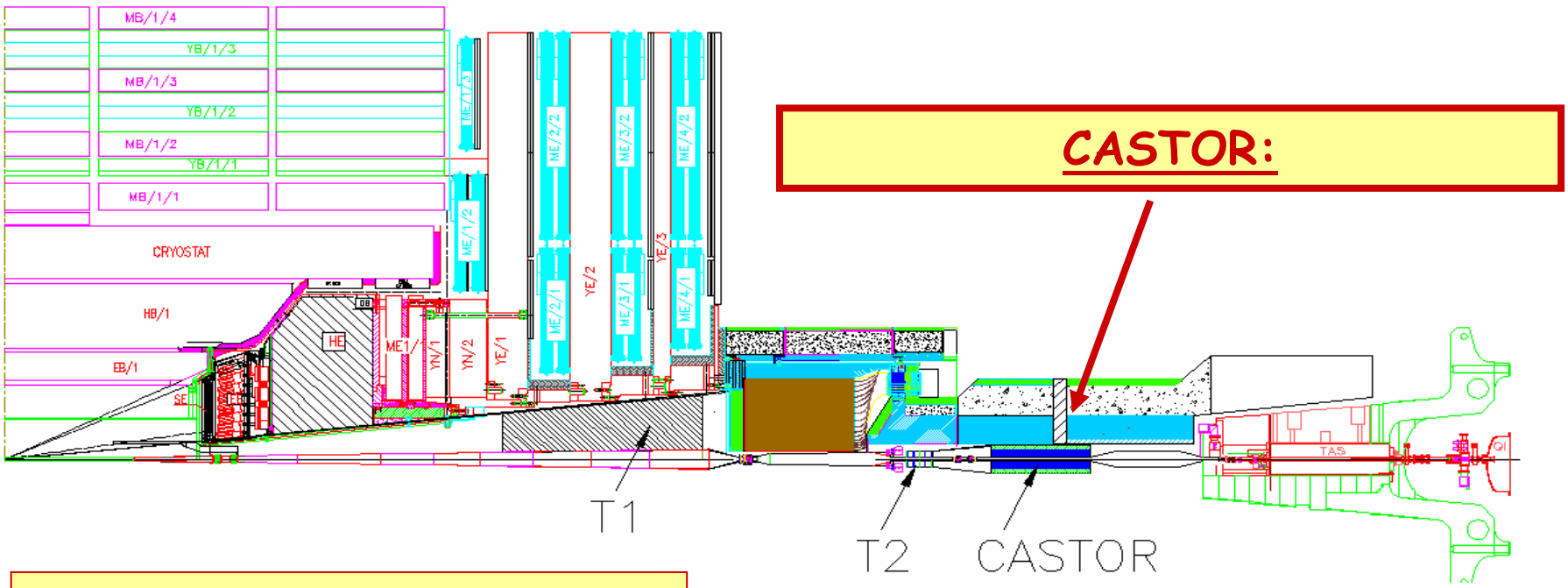
- In present configuration the pseudorapidity region 6.6÷10 not covered
- CASTOR might not be available on both sides at beginning

Proposed upgrades:

- forward hadron calorimeter at 135m in front of TAN
  (η~ 8÷12, E~2÷5.5 TeV)
  (V.Andreev, HERA-LHC workshop 2006)

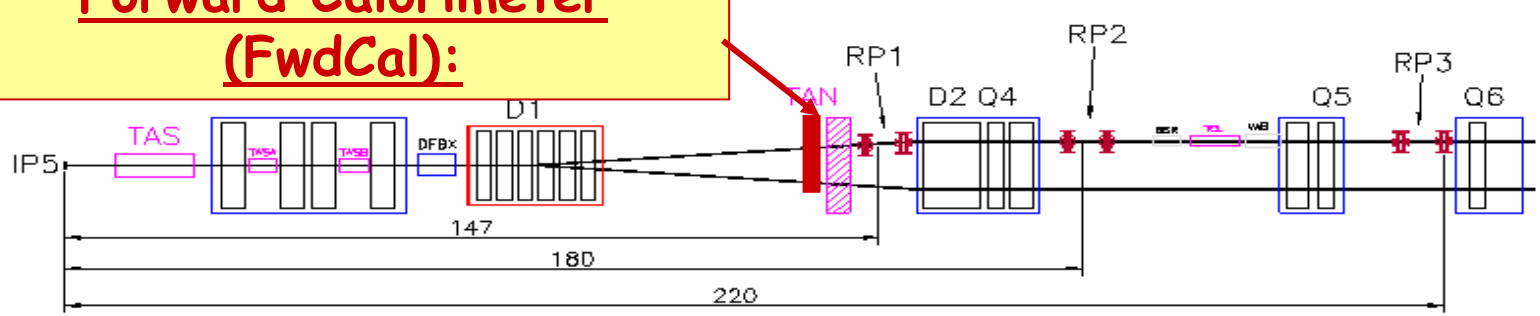
- calorimeter at 15m (later to be replaced by CASTOR)

Detector studies



CASTOR:

Forward Calorimeter (FwdCal):



Forward Calorimeter

Acceptance studies (see talk V.Andreev, HERA-LHC workshop 2006):

- use transformation matrix for each magnet element (dipoles, quadrupoles, drift spaces)
- The particle's trajectory is obtained by multiplying the matrixes of each element
- For each magnet element check acceptance using the real beampipe dimensions

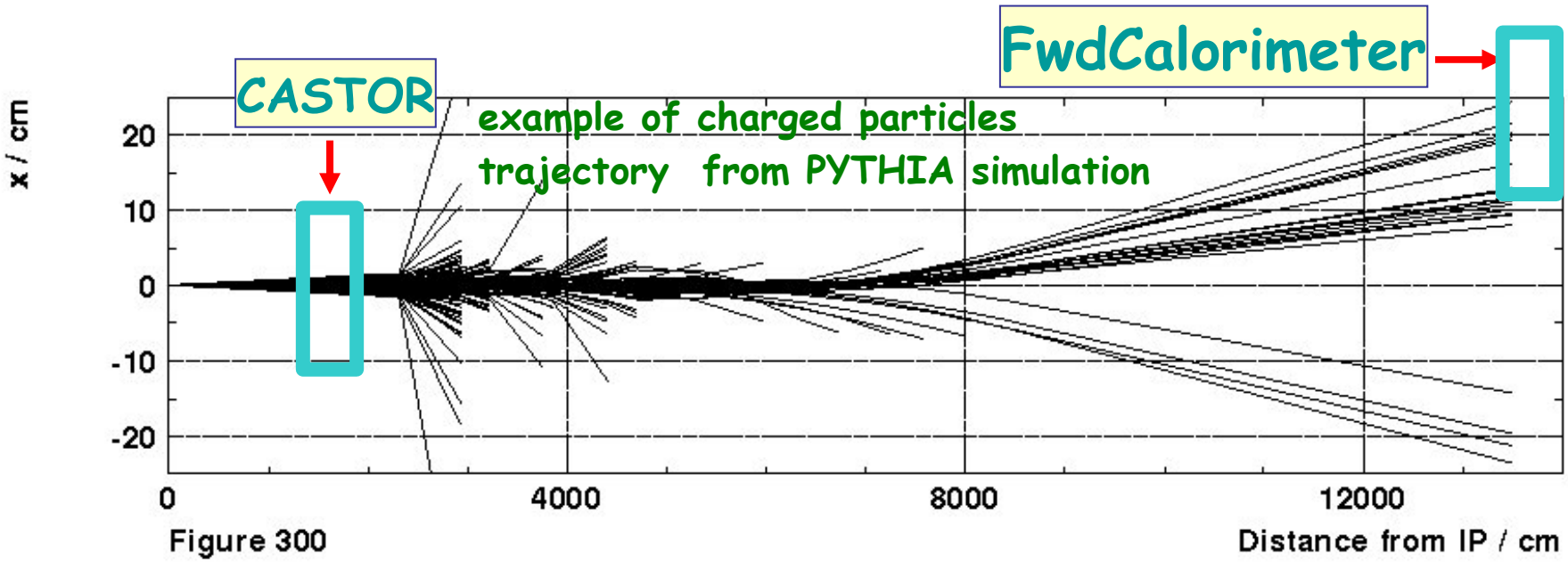
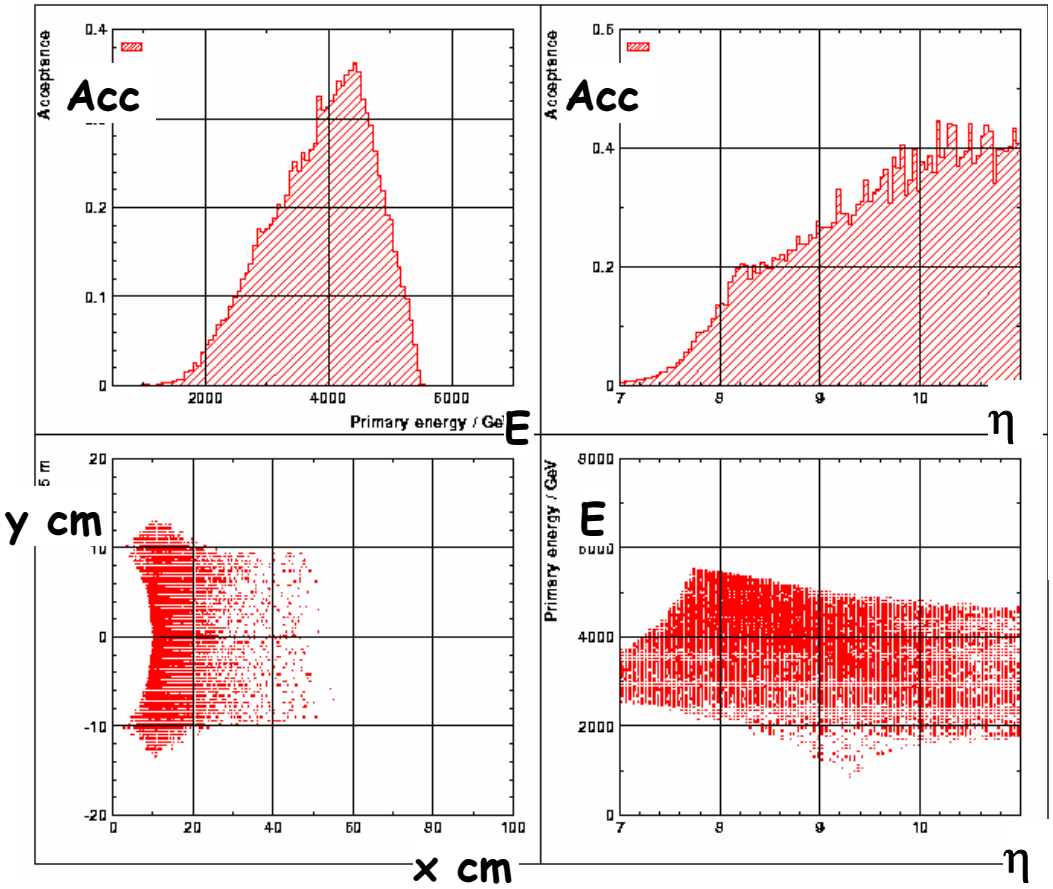


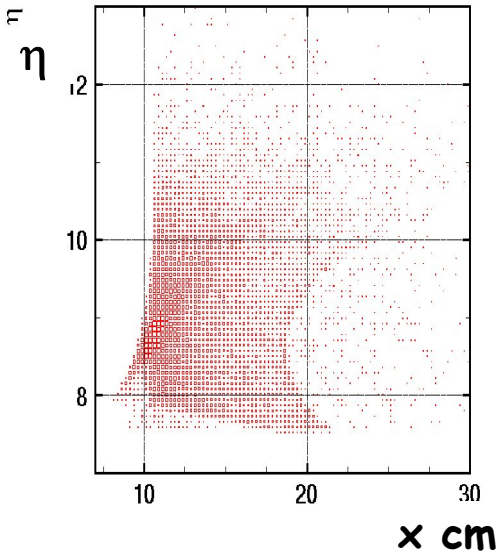
Figure 300

Need a hadronic calorimeter for charged particles at 135m in front of TAN, ~10cm from the beam

(Zero Degree Calorimeter at 135m detects only neutral particles)

acceptance defined by the aperture of beampipe and magnet elements, determined from the space distribution of scattered particles (V.Andreev, HERA-LHC workshop 2006)



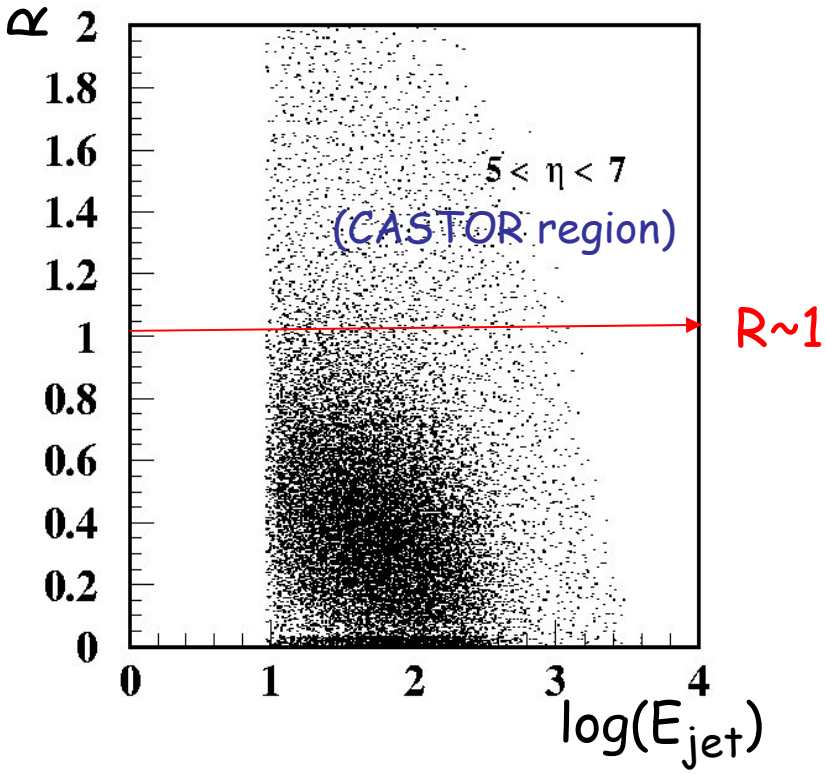


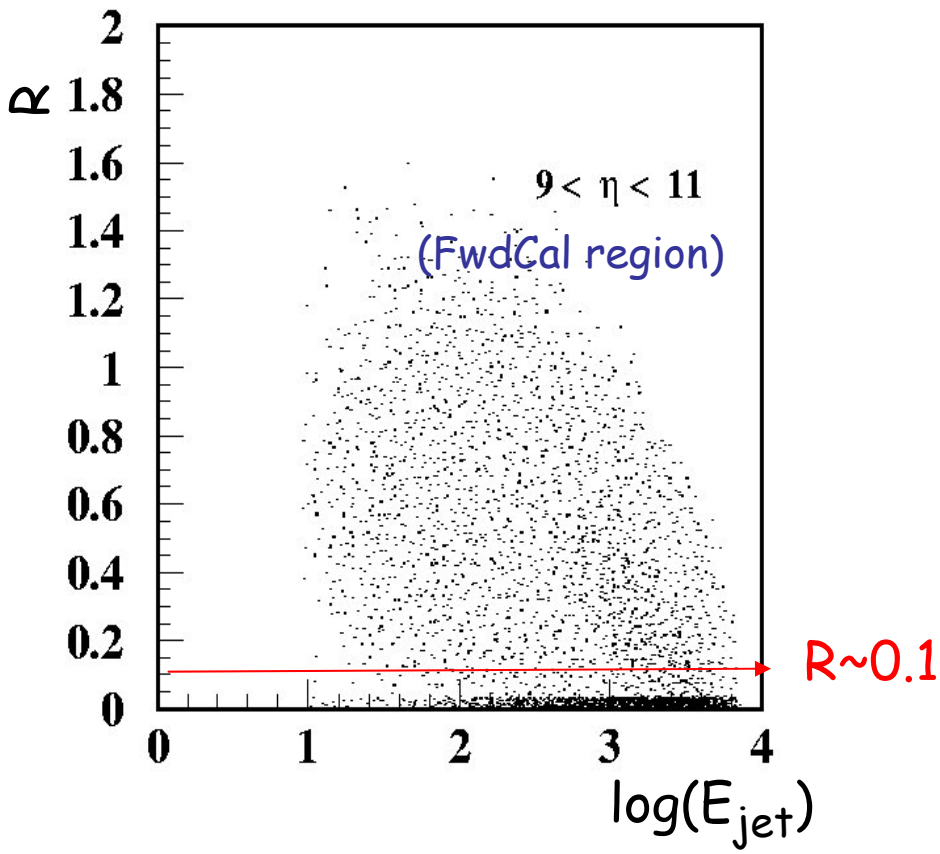
For η reconstruction one needs both x and E measurement

acceptance 5-30% for E=2÷5.5TeV, 7<η<11

Jet measurement

Jet radius vs jet energy

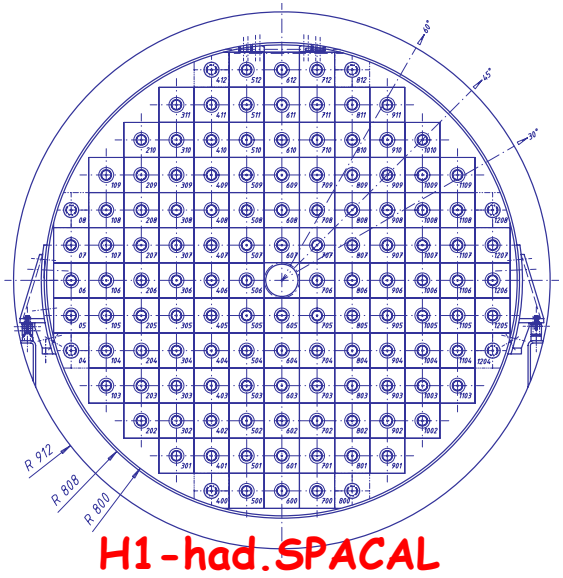




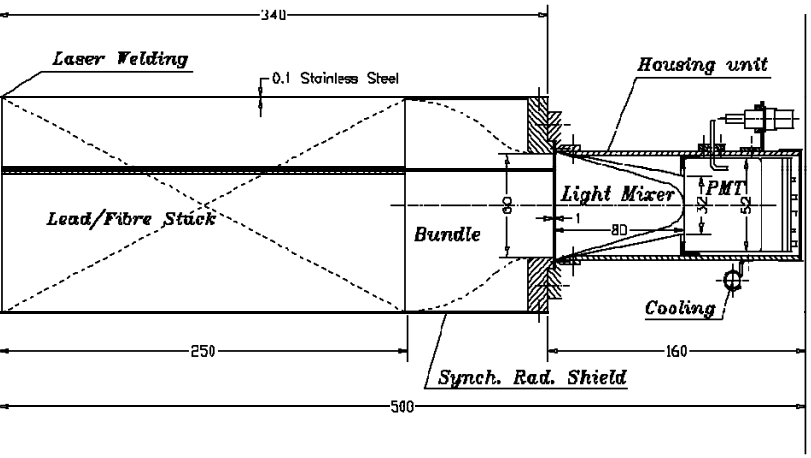
Narrowing of forward jet: R ~0.7 ($5 < \eta < 7$) ➔ R ~ 0.1 ($9 < \eta < 11$)

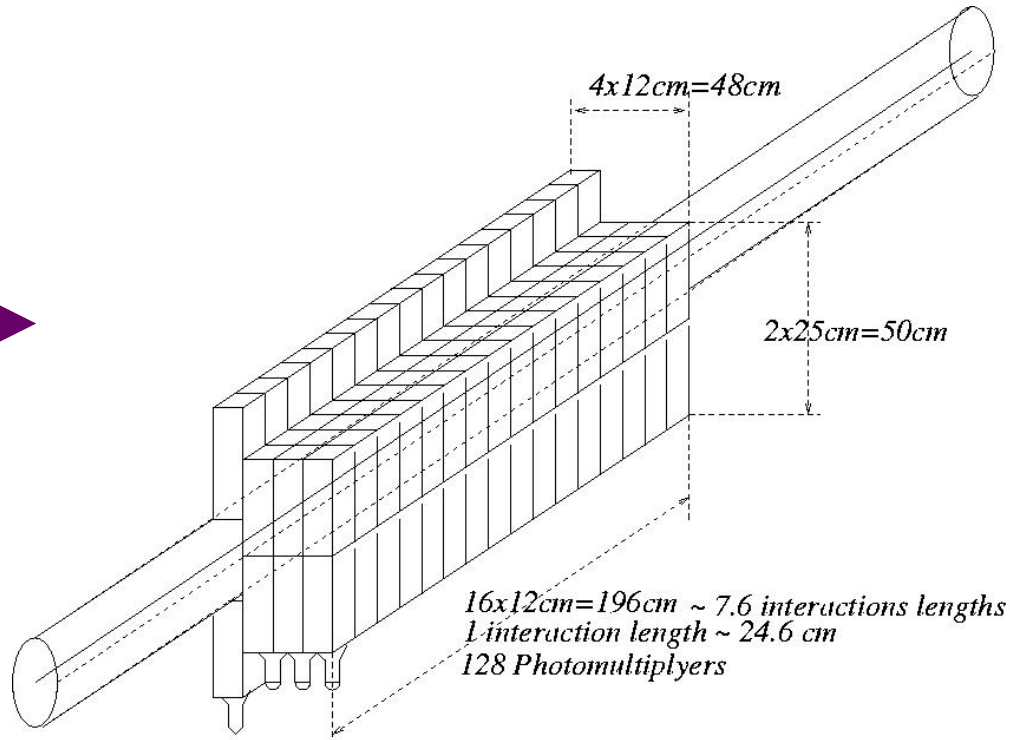
➔ at $9 < \eta < 11$ Forward Jet equivalent to one leading particle

FwdCal-Possible implementation- Re-arrange H1- hadronic SPACAL



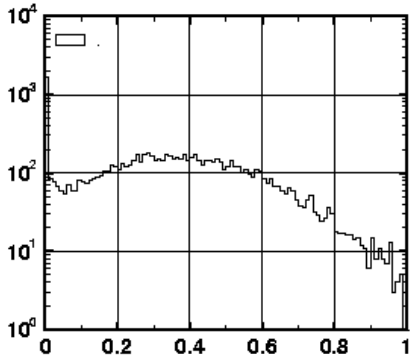
H1-had.SPACAL

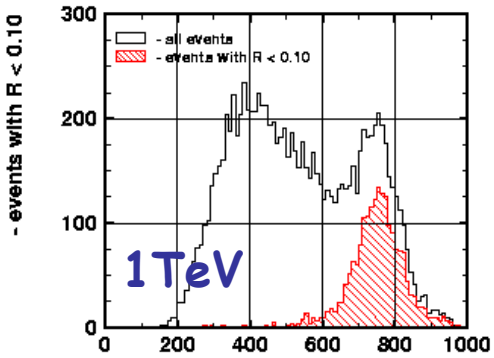




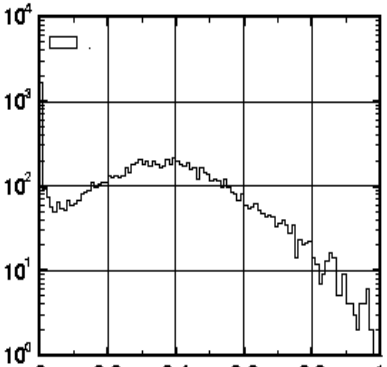
each module- sensitive volume $12x12x25cm^3$ (~0.5λ x 0.5λ x 1λ),
Hamamatsu R2490-06 PMs

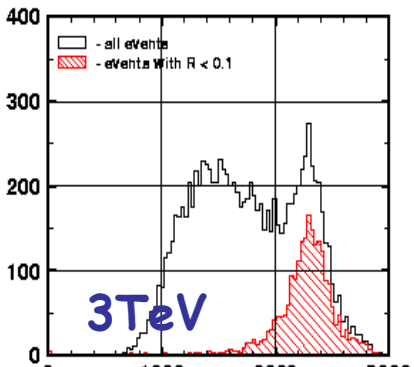
Energy reconstruction:
large dead material in front (effective beampipe thickness ~40cm),
➔ showers which start in beampipe can not be measured accurately.
Fraction of energy in first layer helps to distinguish events with showering before calorimeter (E_{1layer}/E <0.1 (→20-25% events), similar for energies 1÷5TeV)



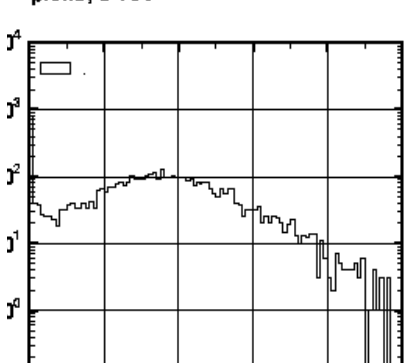


Look - pions, 3 TeV

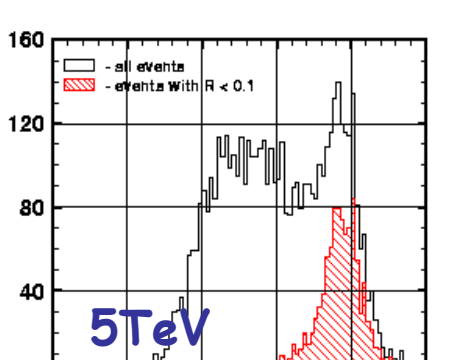




pions, 5 TeV



Date 7/03/2007



sufficient resolution with shower shape cuts achievable

Summary on Forward Calorimeter

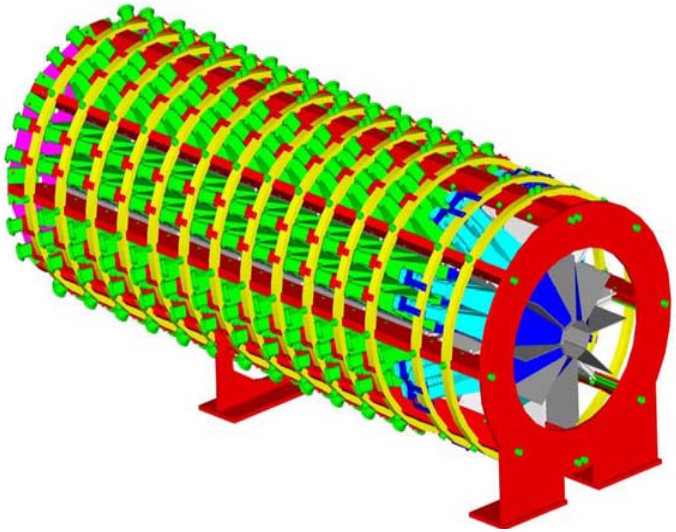
Acceptance studies:

- The calorimeter at 135 m will accept the positive charged particles with E ~ 2.0 ÷5.5 TeV at η ~ 8 ÷12
- Assume precision of hit point reconstruction in calorimeter ~5mm and energy resolution ~6÷7%
- η resolution 0.25-0.5 (depending on E and η range)

Detector studies:

- Sandwich calorimeter: lead + sensitive layers: re-arrange H1-SPACAL modules
- Radiation level near FwdCal at 135m is reasonable (numbers from ZDC TDR)
- Optionally, tracker (or Si diodes from ZEUS-HES) in front of calorimeter to improve coordinate resolution

studies for CASTOR calorimeter



CASTOR was initiated in the framework of Heavy Ion physics at LHC (224 channels, $10\lambda_I$)

Attracts new collaborators interested in low-x physics

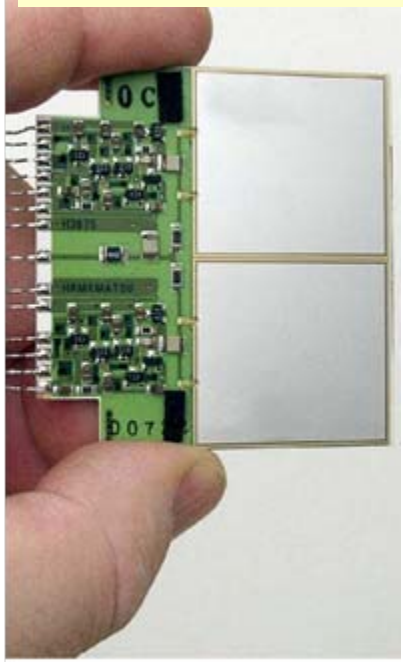
➔

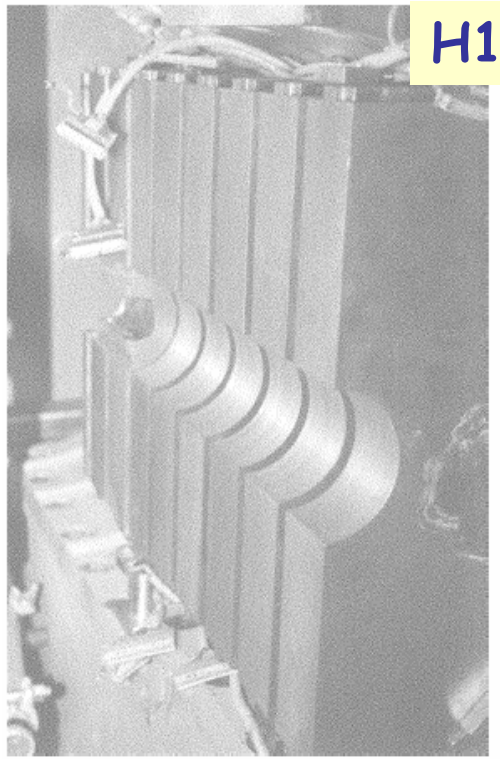
- Need coverage for both sides.
- Need to measure at low luminosity in the early LHC phase.

In case CASTOR installation delays, we propose a temporary backup solution- calorimeter on one side, using re-cycled components from H1 and ZEUS

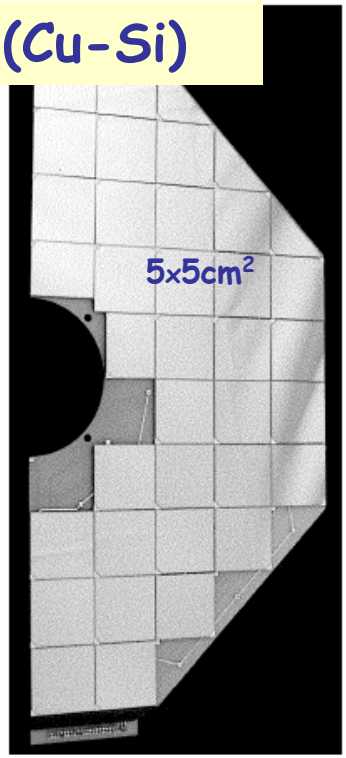
a possible CASTOR alternative

ZEUS-HES Si diode





H1 Plug (Cu-Si)



Re-use diodes of ZEUS Hadron-Electron-Separator (HES)

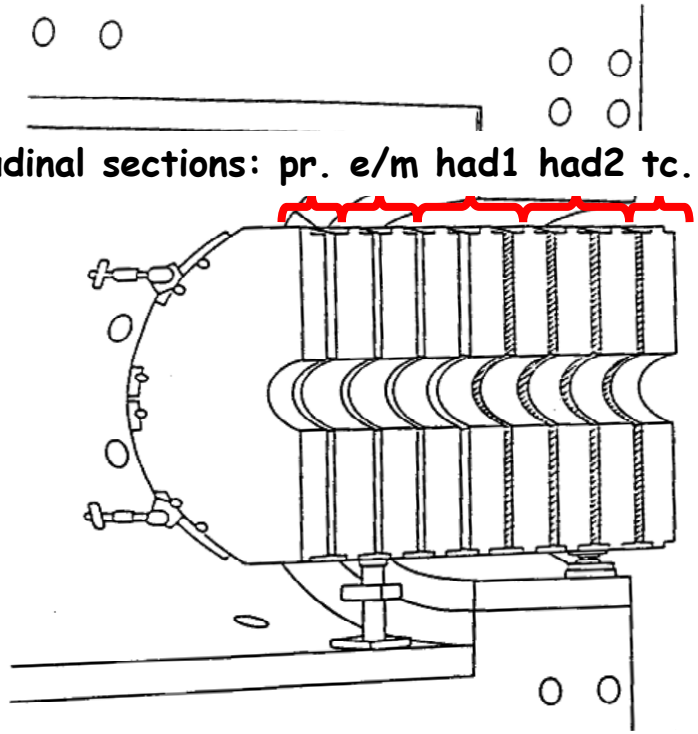
20,000 Si pad detectors; Active area : 3.32×2.96 cm^2

→ sufficient diodes to cover the required space

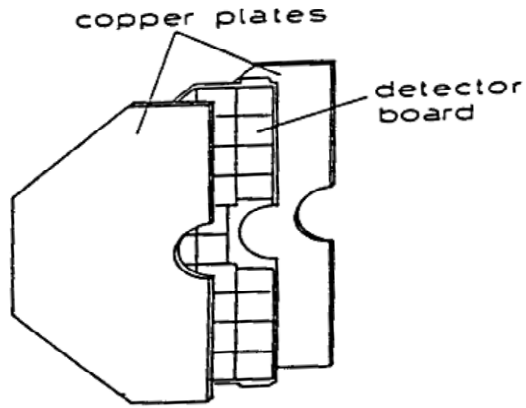
and **Cu absorber from H1-Plug**

l=69cm (≈4.3λ), inner radius=6cm, outer radius=32cm, 8 sensitive layers

a possible CASTOR alternative – H1 Plug + ZEUS HES



5 longitudinal sections: pr. e/m had1 had2 tc.



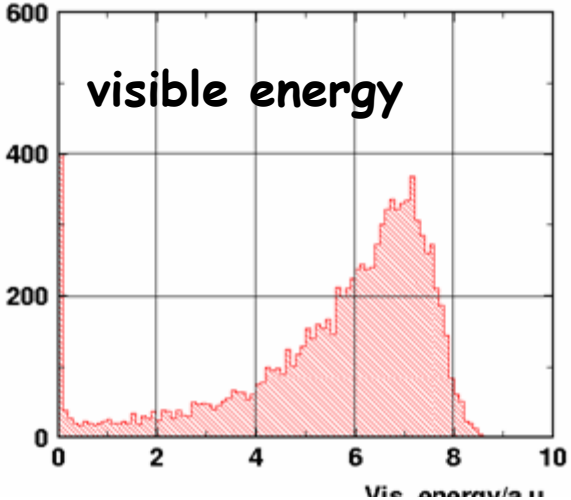
Exploded view of a sealed detector module

- use ZEUS-HES Si diodes with H1-Plug absorber,
- combine layers into 5 longitudinal sections: preshower,e/m,had1,had2,tail catcher; each section 48 readout channels
- (total number of channels= 240 similar to CASTOR)

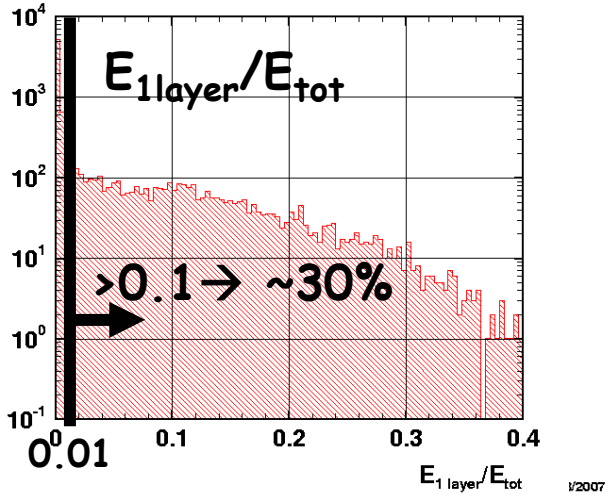
➔use CASTOR infrastructure (cables, readout electronics)

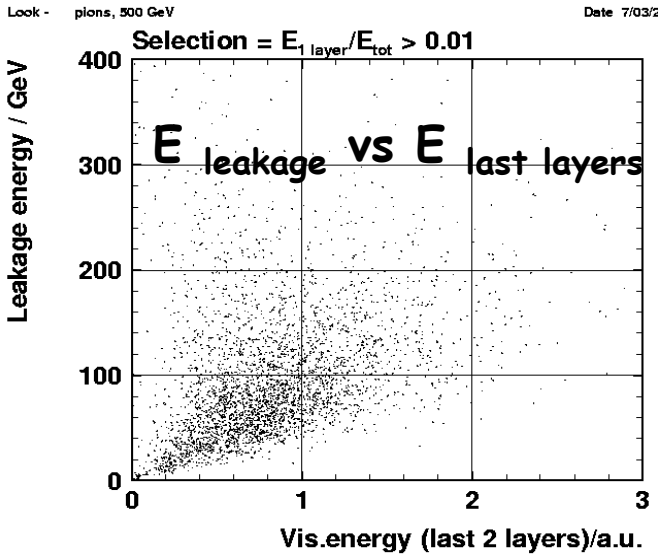
length only 4.3λ→large longitudinal leakage

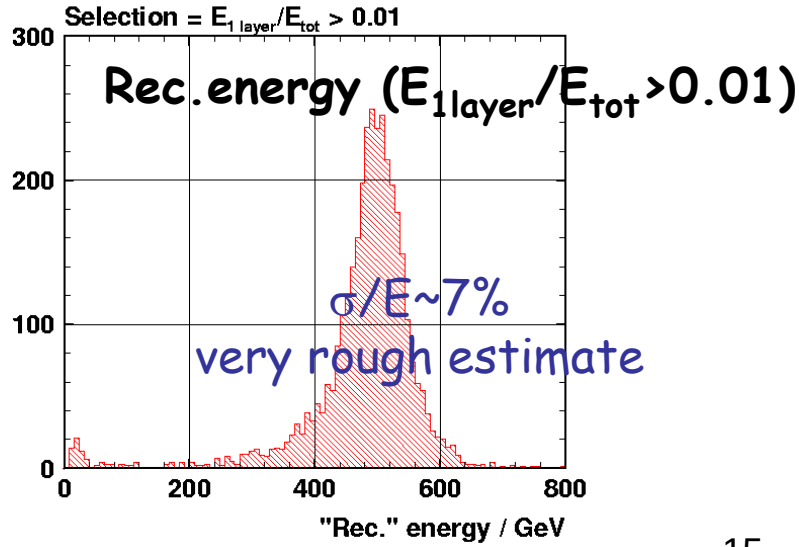
Reasonable resolution for early showers, e.g. for E_{1layer}/E >0.01, and using correlation of leakage with energy. (Similar for energies 100÷1000 GeV)



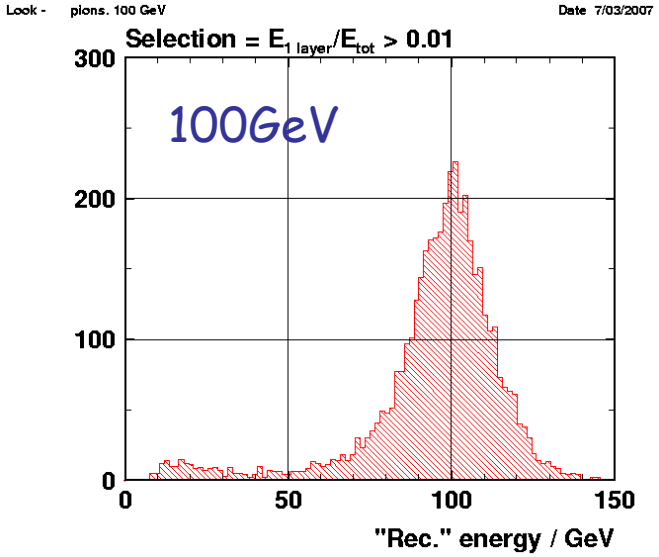
500GeV pions

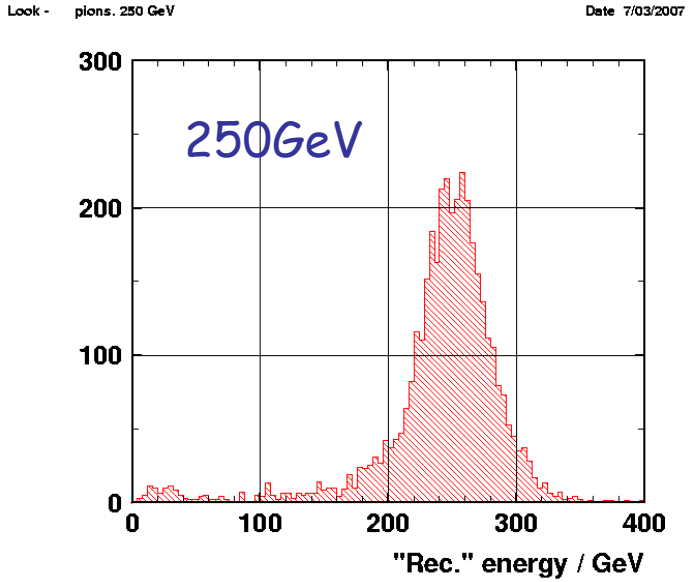


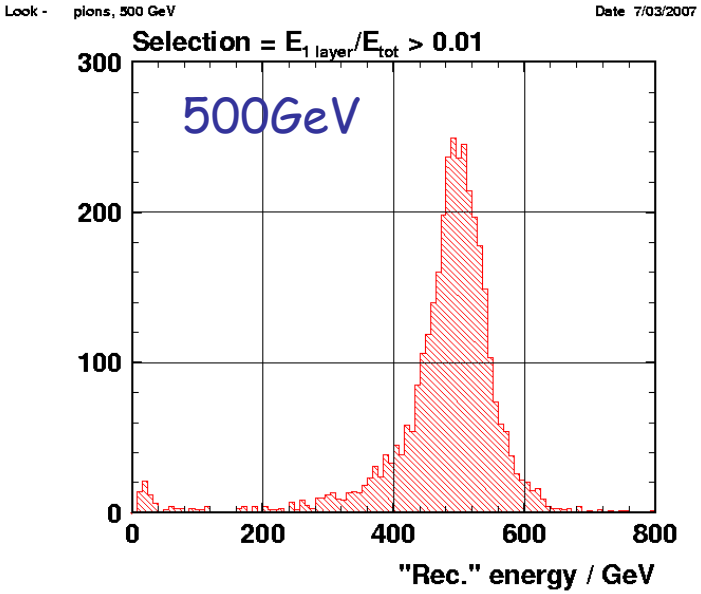


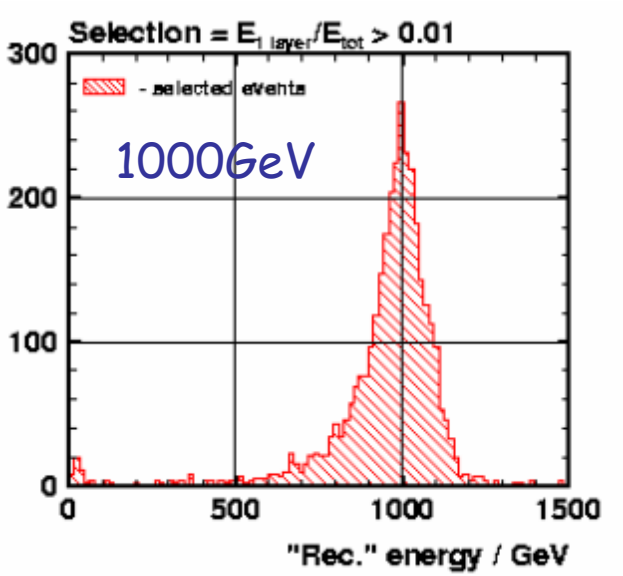


Rec.energy for different input energies (E_{1layer}/E_{tot}>0.01)



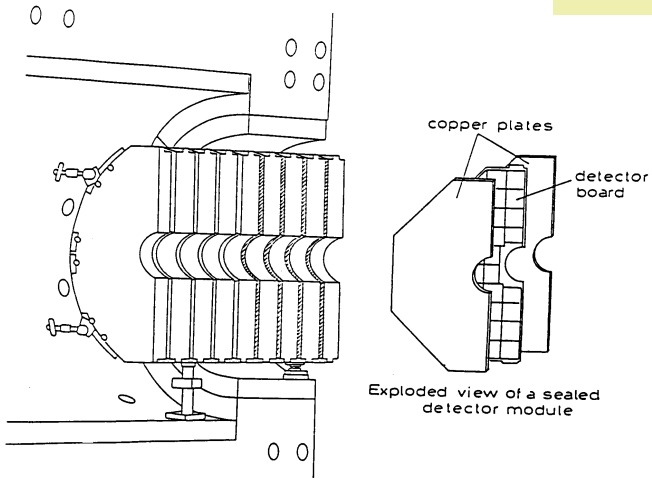






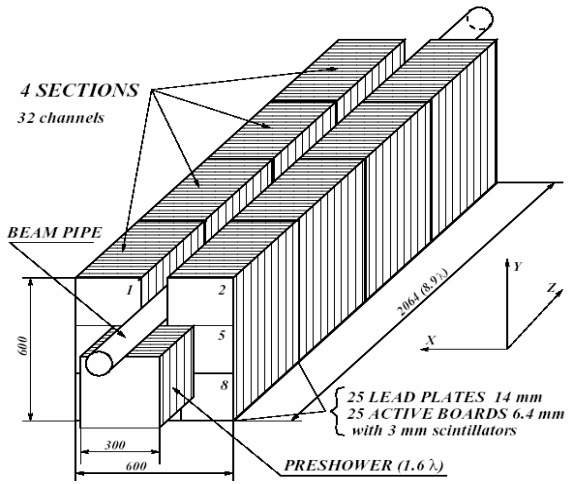
Other options are studied, e.g.

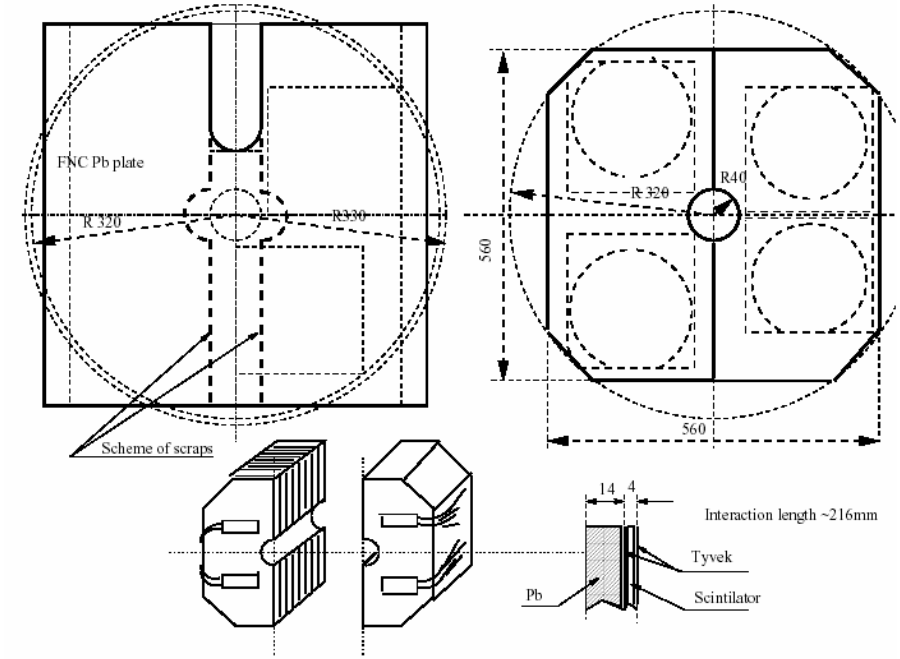
- cover only 180° in φ, but double length (8.6λ)



- modify H1-FNC (Pb-Sc 6.7λ)

→cut Pb plates and re-assemble





Summary

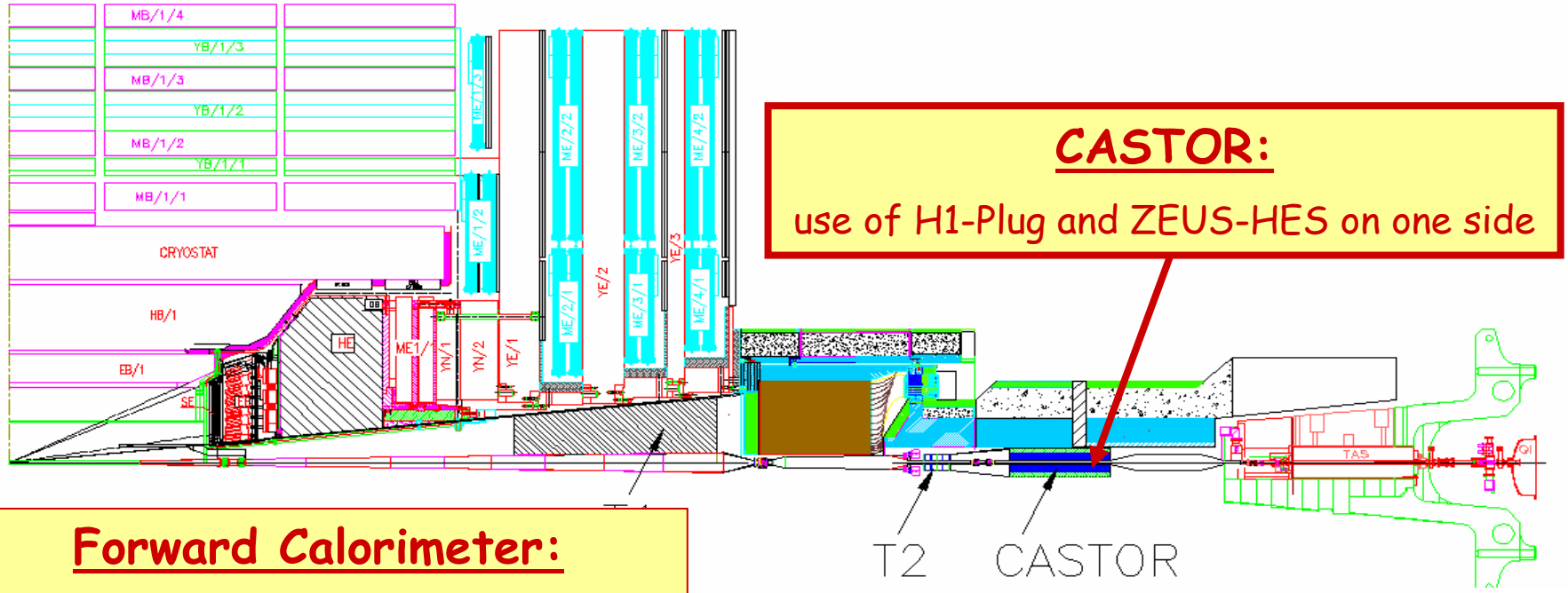
- Proposed detectors complement the existing forward detectors in CMS (Castor, Totem, ZDC)

- Forward Calorimeter at 135m covering rapidity range $8<\eta<12$ and energy range E~2.0÷5.5 TeV will measure the forward energy flow complementary to measurements in other calorimeters at CMS, allowing to tag a forward jet with high-x and study the full evolved parton shower in different schemes

- In case CASTOR is not in time at beginning of LHC, the possibilities for temporary replacement on one side using re-cycled HERA detectors are investigated

Summary

o Proposed detectors complement the existing forward detectors in CMS (CASTOR, Totem, ZDC)

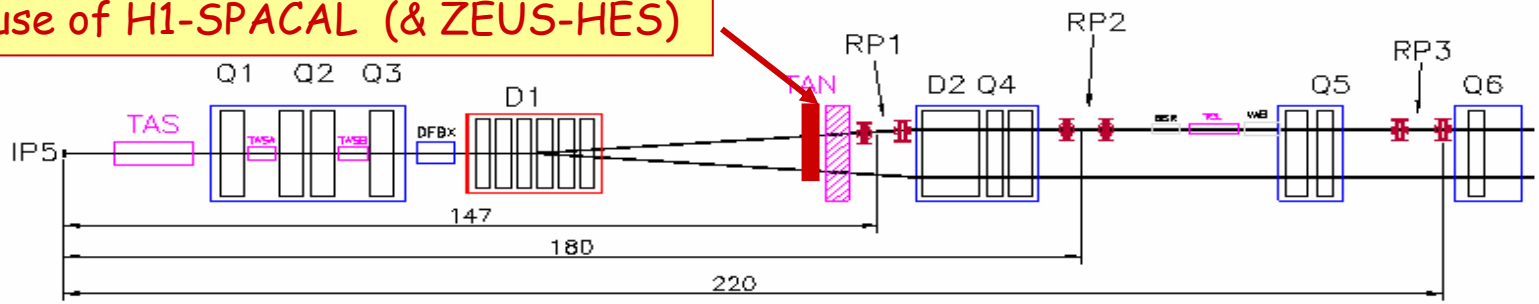


CASTOR:

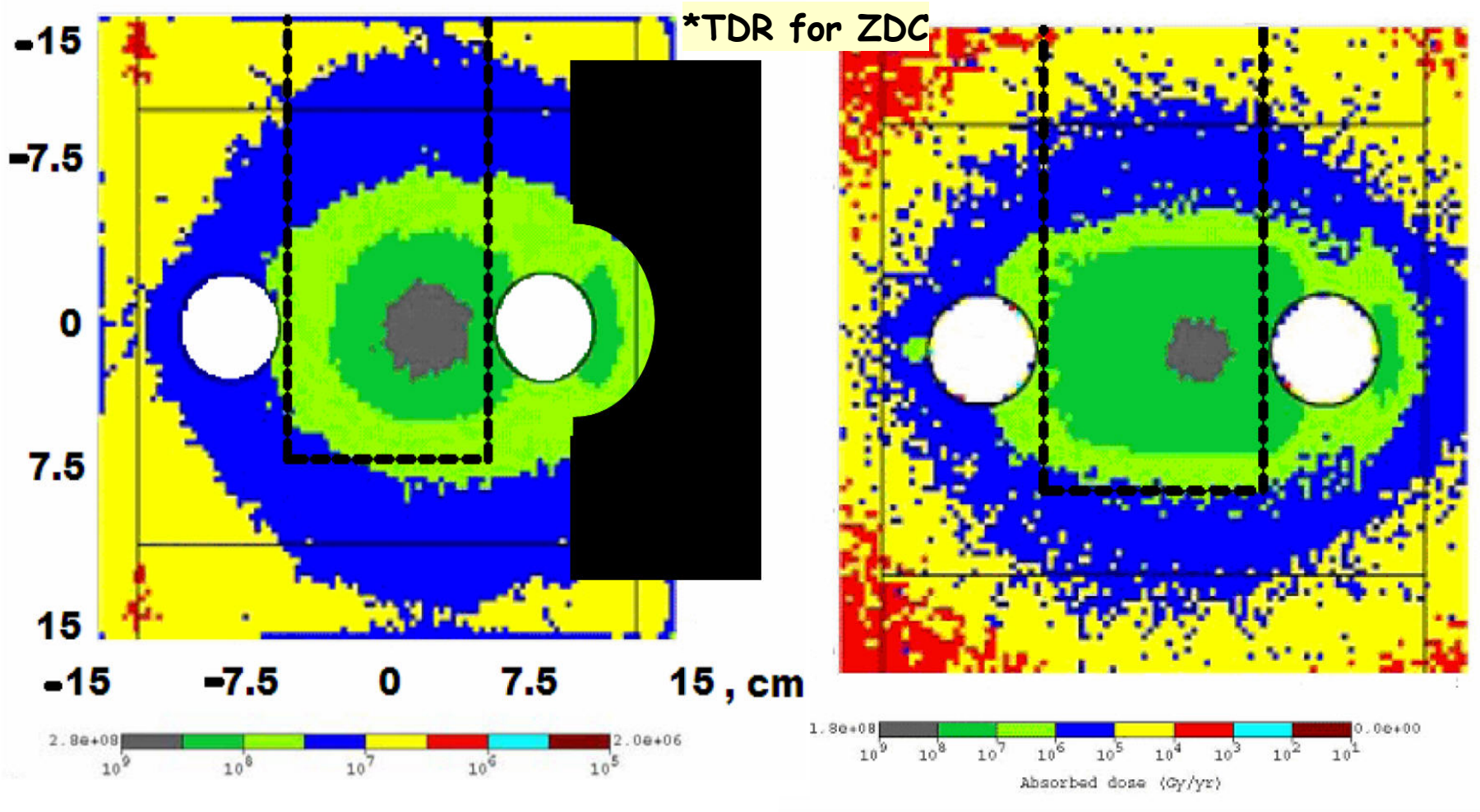
use of H1-Plug and ZEUS-HES on one side

Forward Calorimeter:

re-use of H1-SPACAL (& ZEUS-HES)



Backup



Radiation conditions are reasonable (blue range) ~0.5 MGy/y

and hadron flux ~$0.5*10^8$ (E > 20 MeV) $cm^{-2}s^{-1}$