CASTOR
a very forward Calorimeter at CMS

HERA – LHC workshop

14-03-2007

Apostolos Panagiotou, Athens

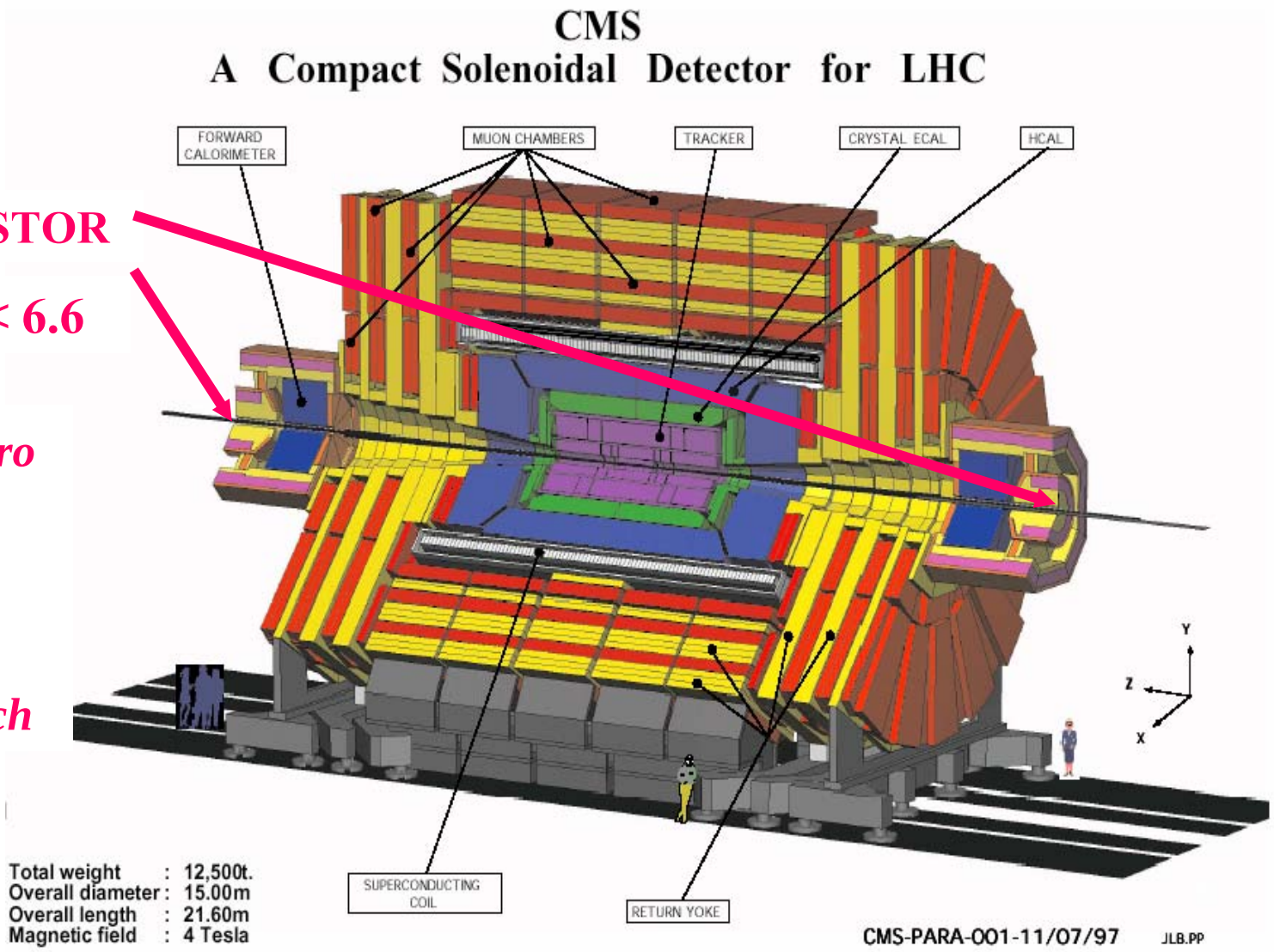
http://cmsdoc.cern.ch/castor/

CASTOR in CMS

CASTOR

$5.3 < \eta < 6.6$

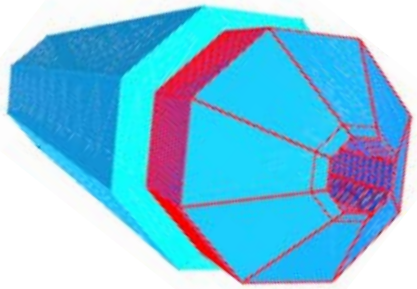
Centauro And Strange Object Research



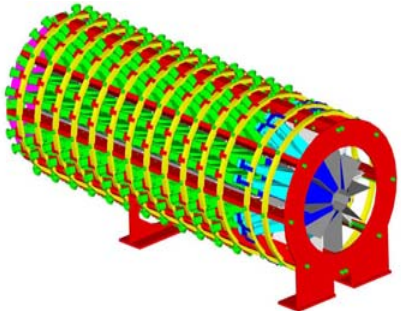
CMS Forward Detectors

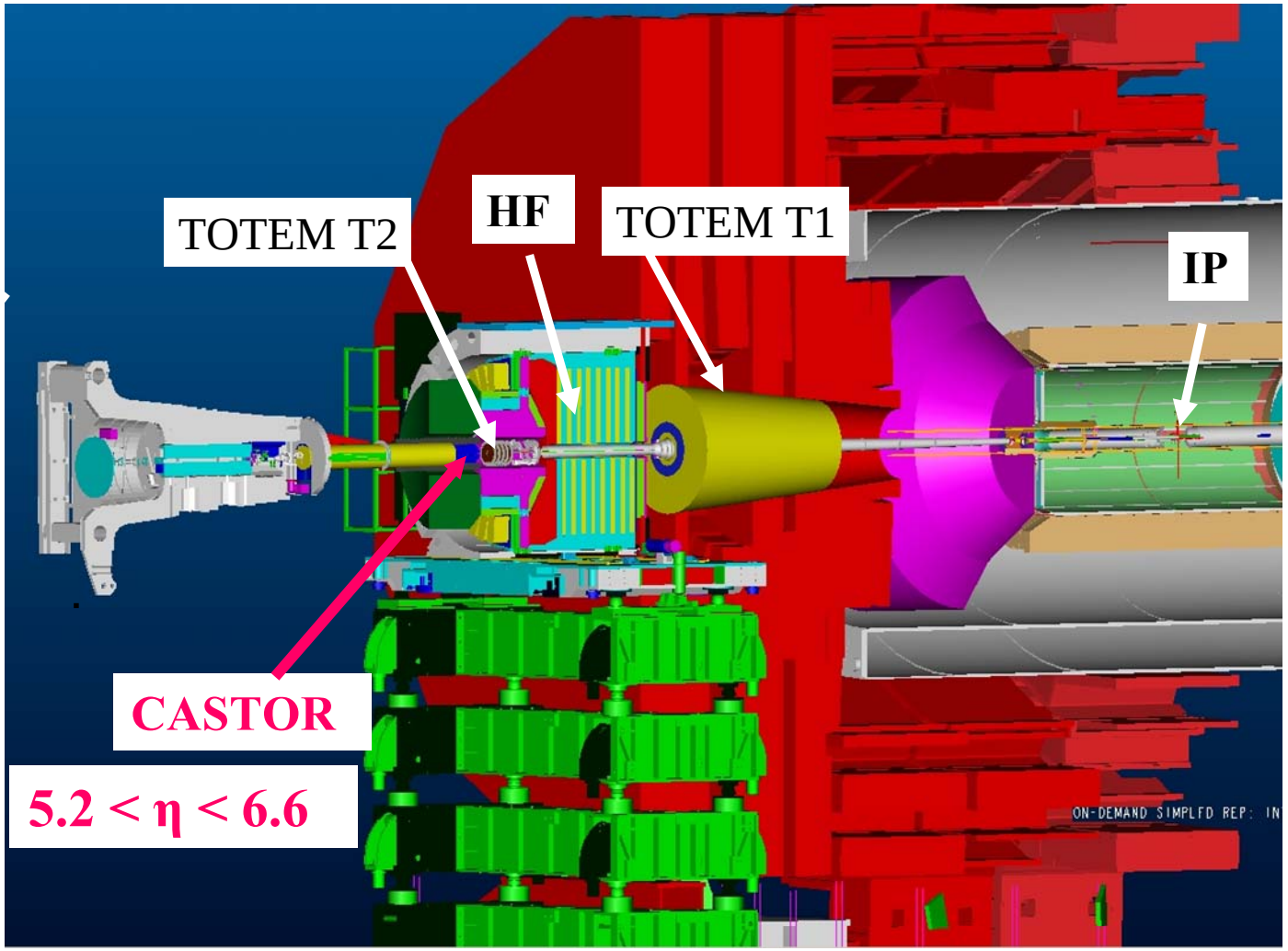
Tungsten-Quarz

Cerenkov Calorimeter

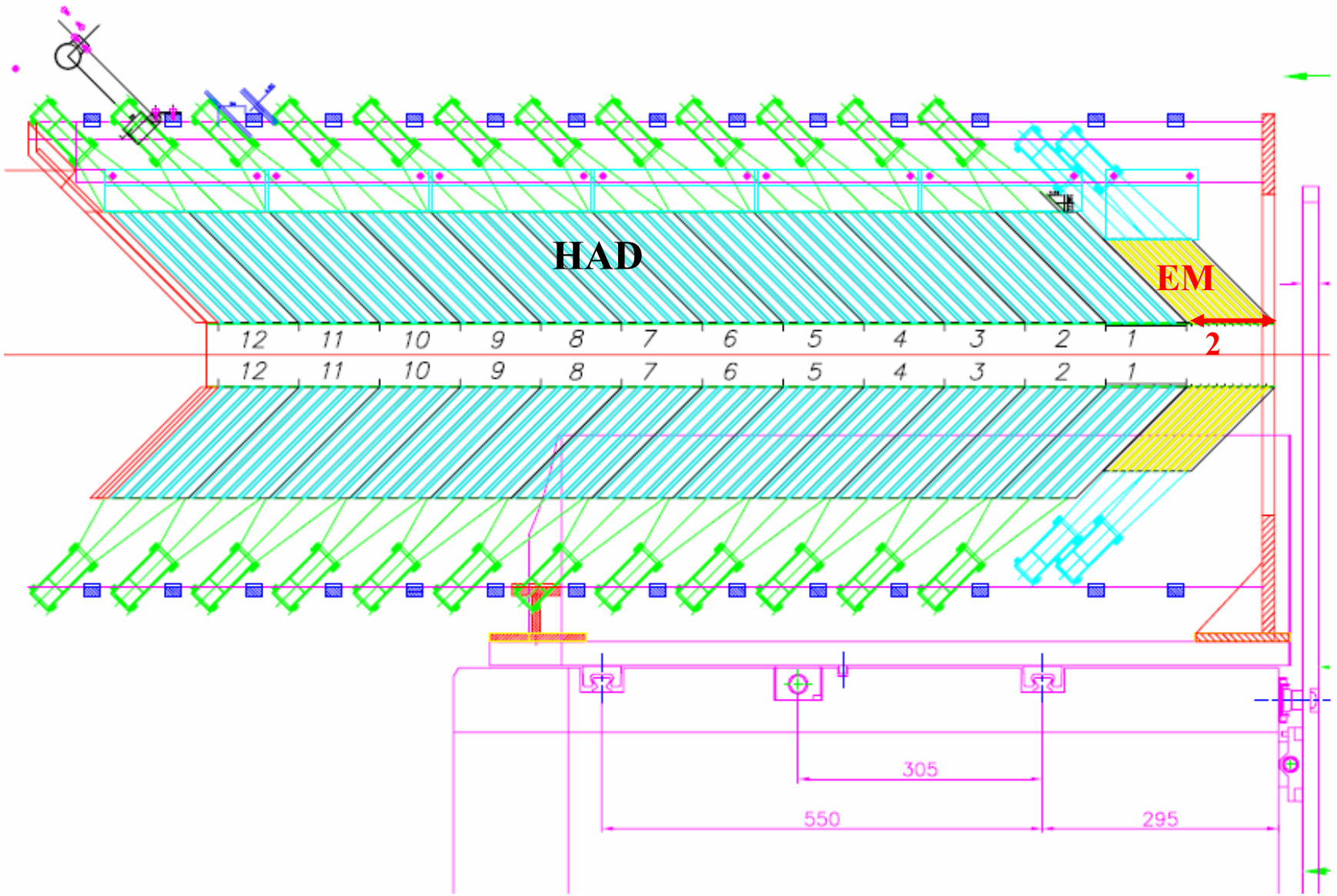


read out by photomultiplier

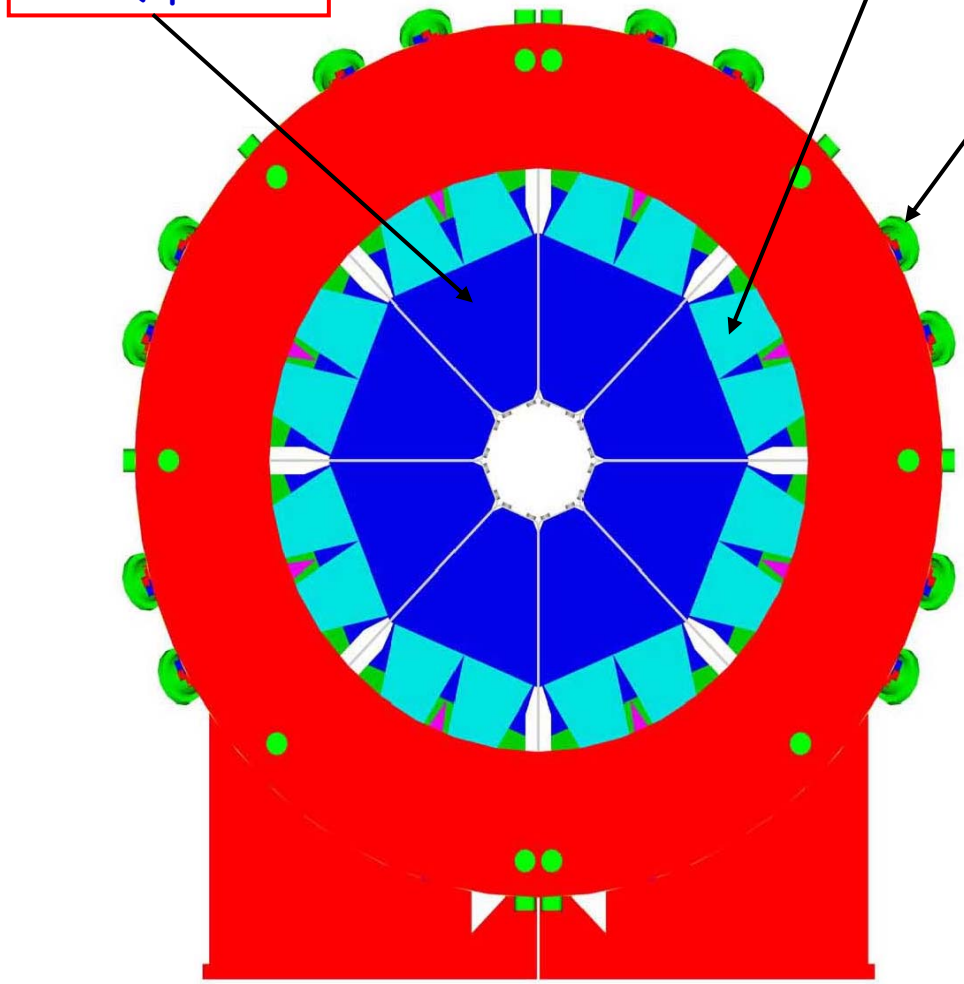


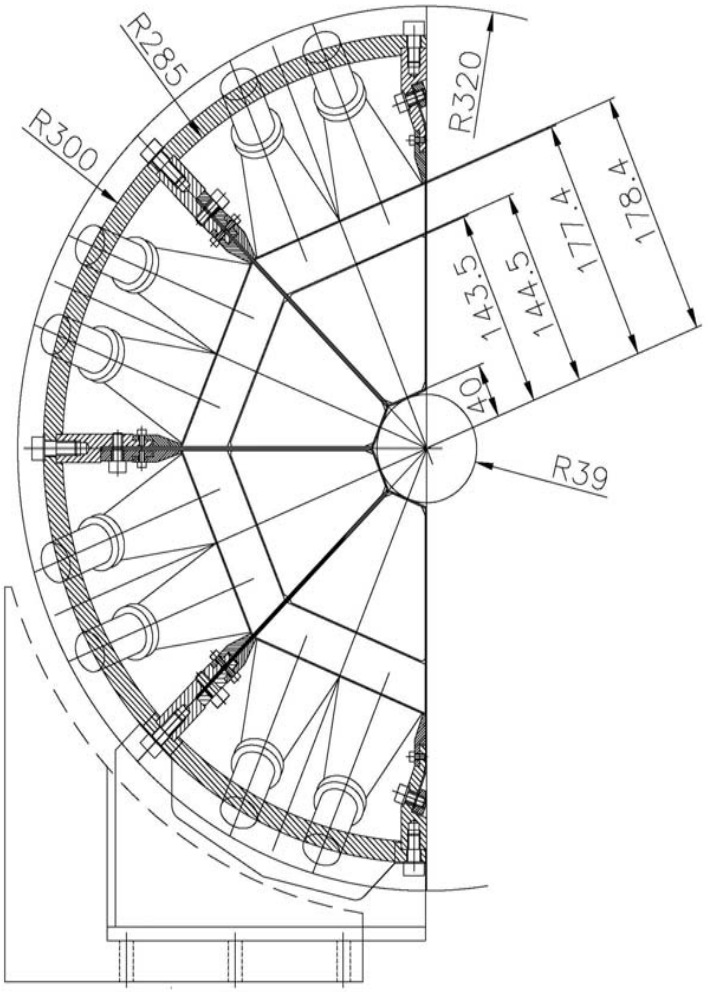


CASTOR Calorimeter Design



CASTOR Calorimeter Design

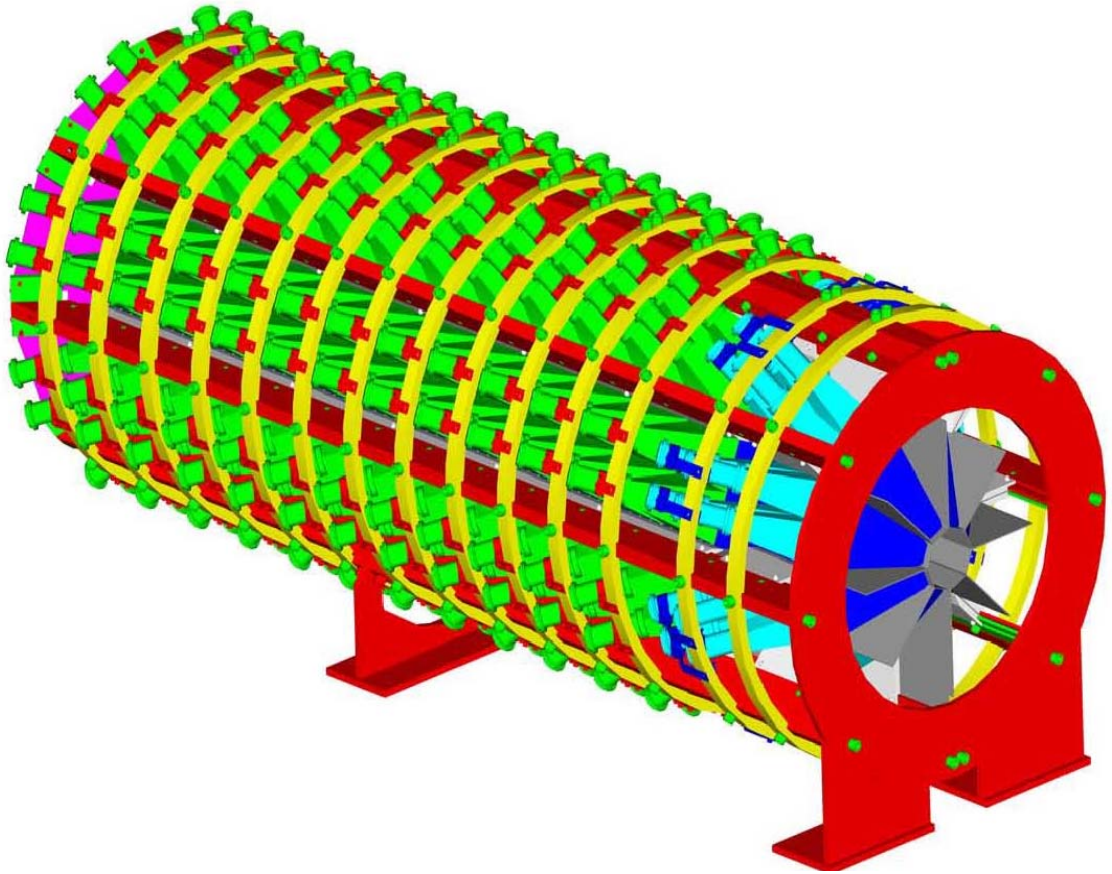




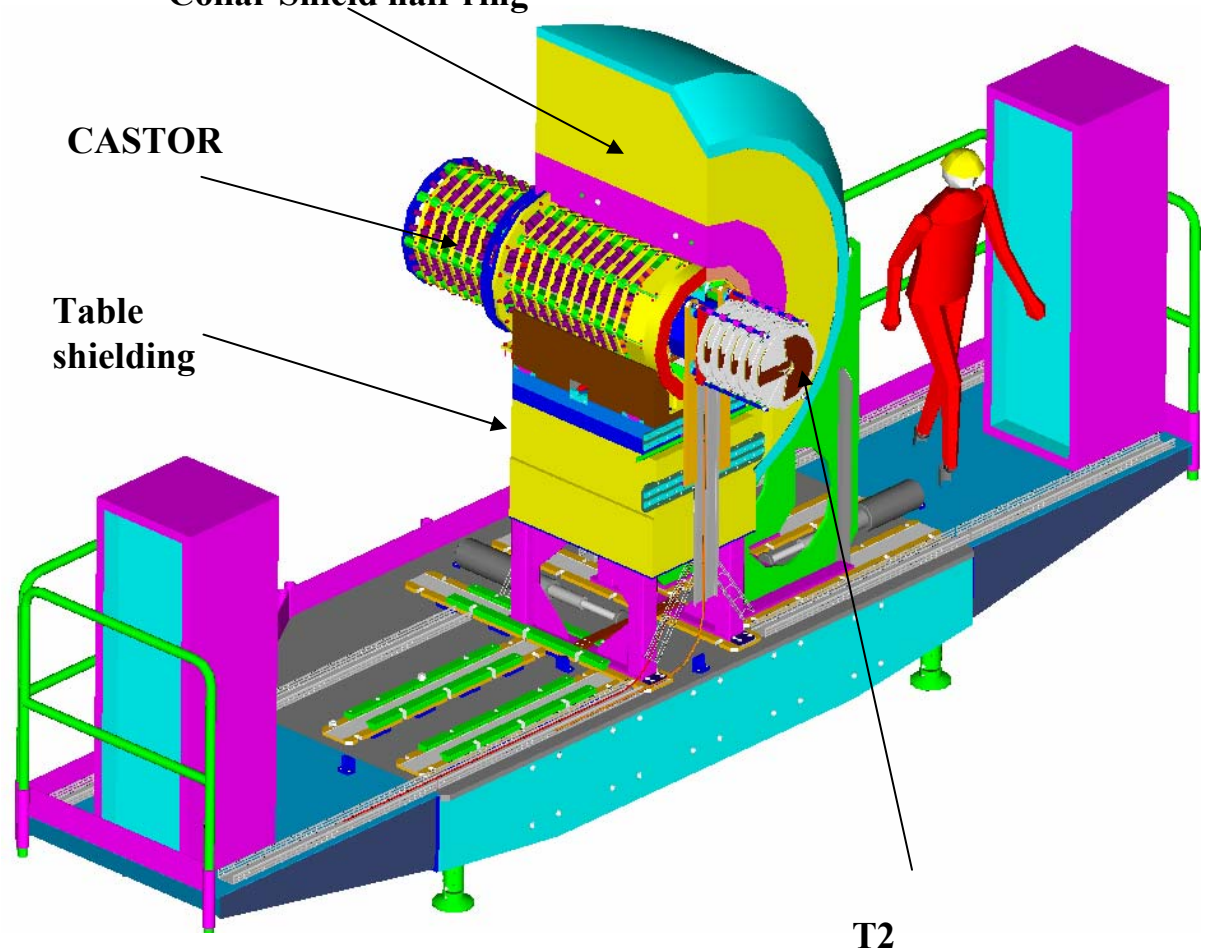
CASTOR Calorimeters Design

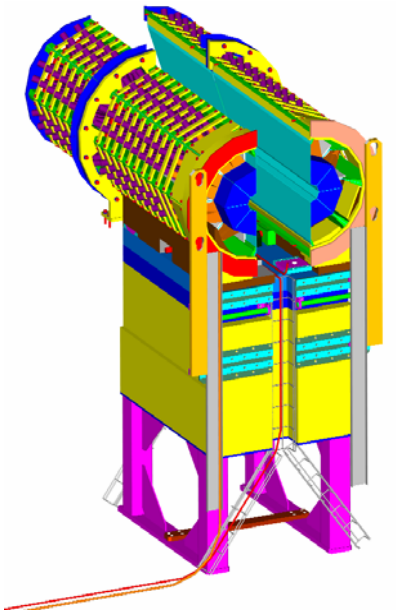
#1: Long calorimeter "LCAL": (2)EM + (12)HAD sections, 224 chan. ($10\lambda_I$)

#2: Short calorimeter "SCAL": (2)EM + (8)HAD sections, 160 chan. ($7\lambda_I$)



CASTOR Integration





Institutions in CASTOR

Groups contributing to the project:

- Athens — Design, MC sim's, funding; Project coordination
- Antwerp — PMTs, trigger, DAQ, funding; Electronics coordination
- CERN — Beam test reports; SW-Physics coordination
- CuKurova — PMT testing
- DESY — Structure calculations, construction, electronics
- JINR Dubna — Design, manpower; Technical coordination
- INR, Moscow — Light guides & 2mm Q-plates
- ITEP, Moscow — Laser/LED calibration system, funding
- INP, Krakow — Calorimeter/tooling design, MC sim's - Physics
- Northeastern — Readout devices, MC, construction, funding
- UIC, UI, UK, MIT: Applied for NSF-MRI grant, construction

Recent Developments

☆1st CASTOR workshop @ CERN (19-20/01):

- Thorough presentation of pp and HI Physics with CASTOR
- Thorough discussion of "electronics" issues
- DESY group in CASTOR (electronics, construction)
- Coordination of some tasks by Institutes/persons

☆CMS-Forward/TOTEM mini-workshop @ CERN (15/02):

- CASTOR is now an "approved" project in CMS
- Aim for two calorimeters for day 1 (04/08). Different construction scenaria: LCAL + SCAL / LCAL (partially equipped) / 2 channels combined
- Parallel construction at different Labs (US and Europe)
- Electronics concerns: Help from HCAL (borrow components, know-how)
- Funding, with present resources LCAL with 160 channels possible

☆New Institute in CASTOR: Northeastern University

- (2) Postdocs (MC/SW); (1) technician; construction; funding (2008 +)

Construction-Implementation Schedule for two Calorimeters-v1.0

Construction & Implementation Schedule for two Calorimeters v1.0

		TIME													
	TASKS	3/07	4/07	5/07	6/07	7/07	8/07	9/07	10/07	11/07	12/07	1/08	2/08	3/08	4/08
1	Construction 2nd (½) LCAL skeleton														
2	Fabrication 1120 Q-plates														
3	Fabrication 560 W-plates														
4	Fabrication 224 light guides														
5	Delivery/testing PMT. Production bases														
6	FE/Trigger/DAQ electronics														
7	Assembly LCAL														
8	Surface testing LCAL														
9	Installation LCAL in beam line														
10	Construction SCAL skeletons														
11	Fabrication 800 Q-plates														
12	Fabrication 400 W-plates														
13	Fabrication 160 light Guides														
14	Assembly SCAL														
15	Surface testing SCAL														
16	Installation SCAL														
17	Installation cables & services														

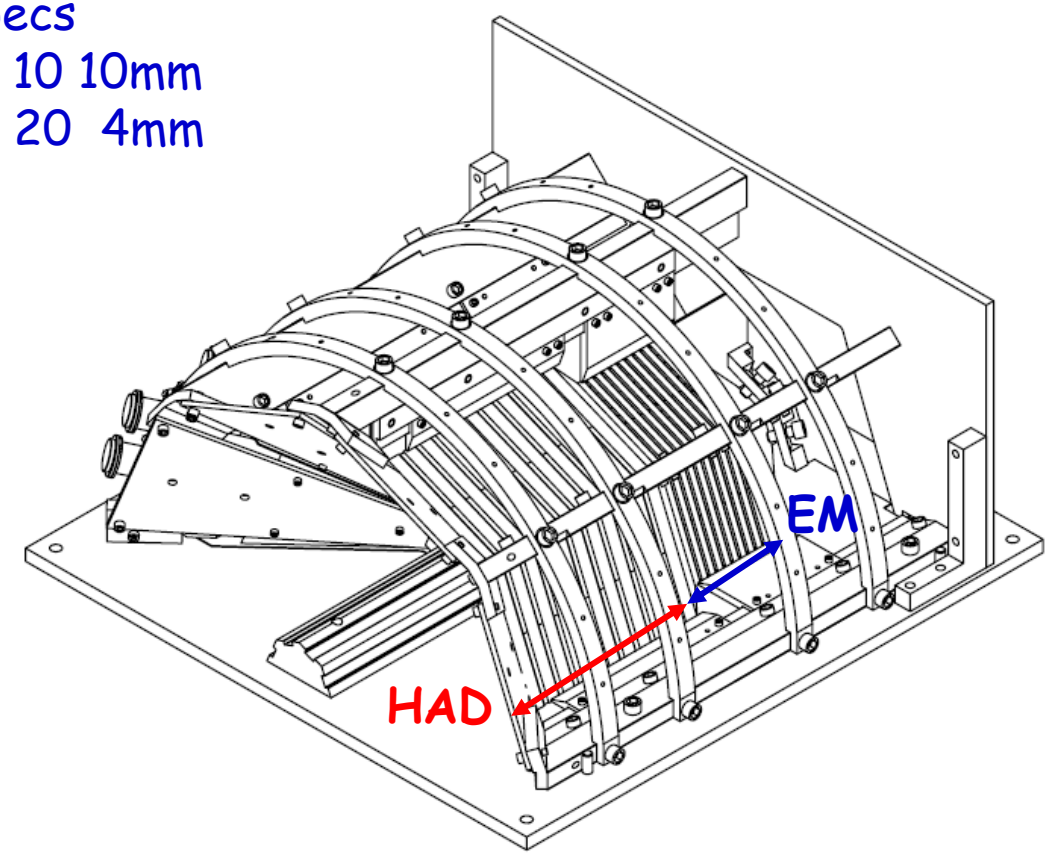
- A very tight & ambitious schedule. To succeed, we need to have "construction", "assembly" and "installation" teams working in parallel.
- Construction of calorimeter skeletons in the US Labs, assembly at CERN.
- It also assumes that FE/DAQ electronics (at least for partial instrumentation) will be available and a strong team will implement them.

CASTOR Pre-Prototype Construction/Assembly Study

Construction of 32cm long, ($\frac{1}{2}$) calorimeter: (2) EM + (2) HAD sections
Instrumenting one octant: (4) EM-RUs + (4) HAD-RUs

- Skeleton: design specs
- Steel-plates: 10 5mm + 10 10mm
- Plexiglass plates: 20 2mm + 20 4mm

✓ Design DUBNA (Y.E.+E.Z.)
✓ Construction DESY

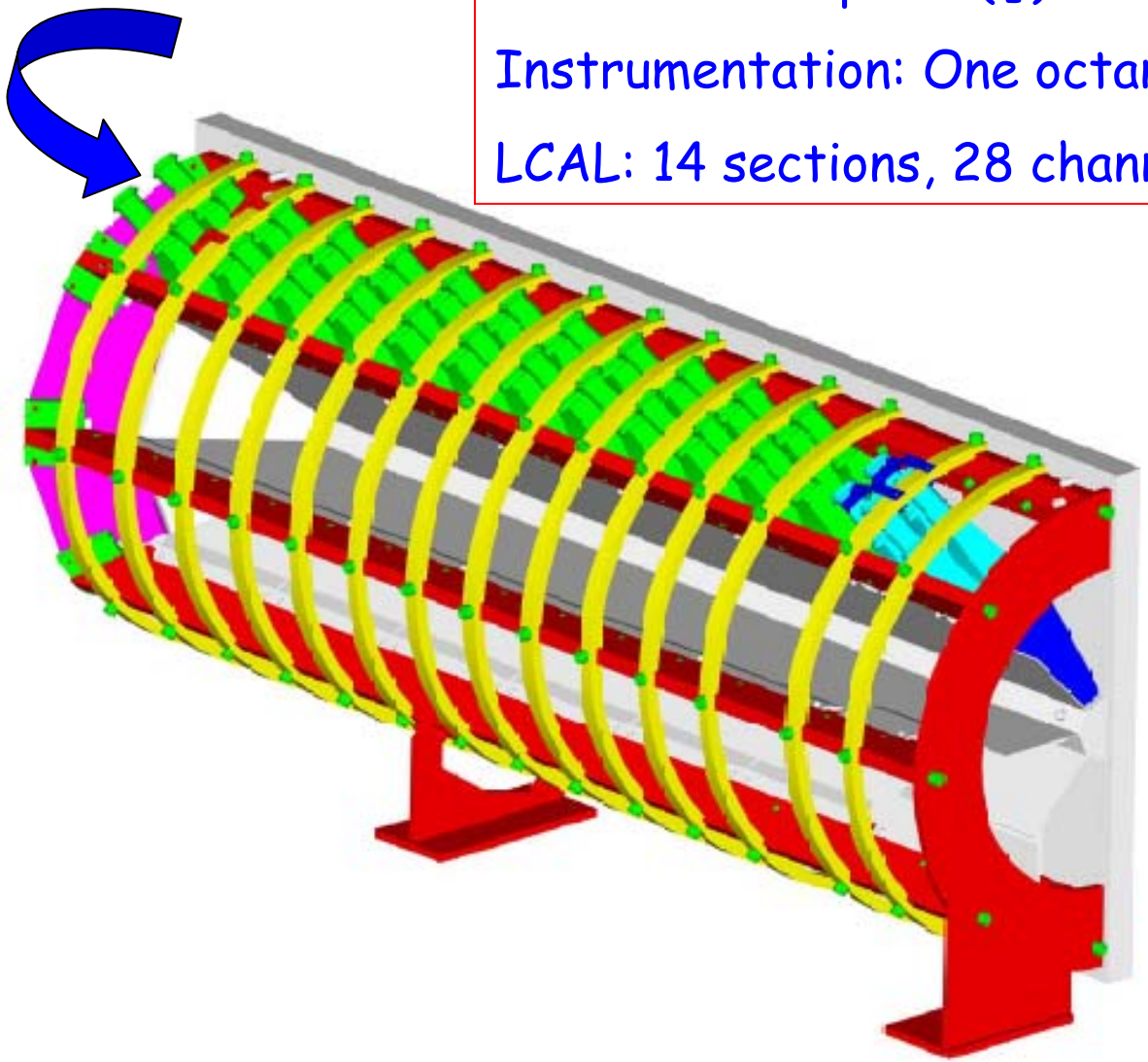


CASTOR Prototype: Beam Test 2007

Skeleton: Complete ($\frac{1}{2}$) calorimeter

Instrumentation: One octant

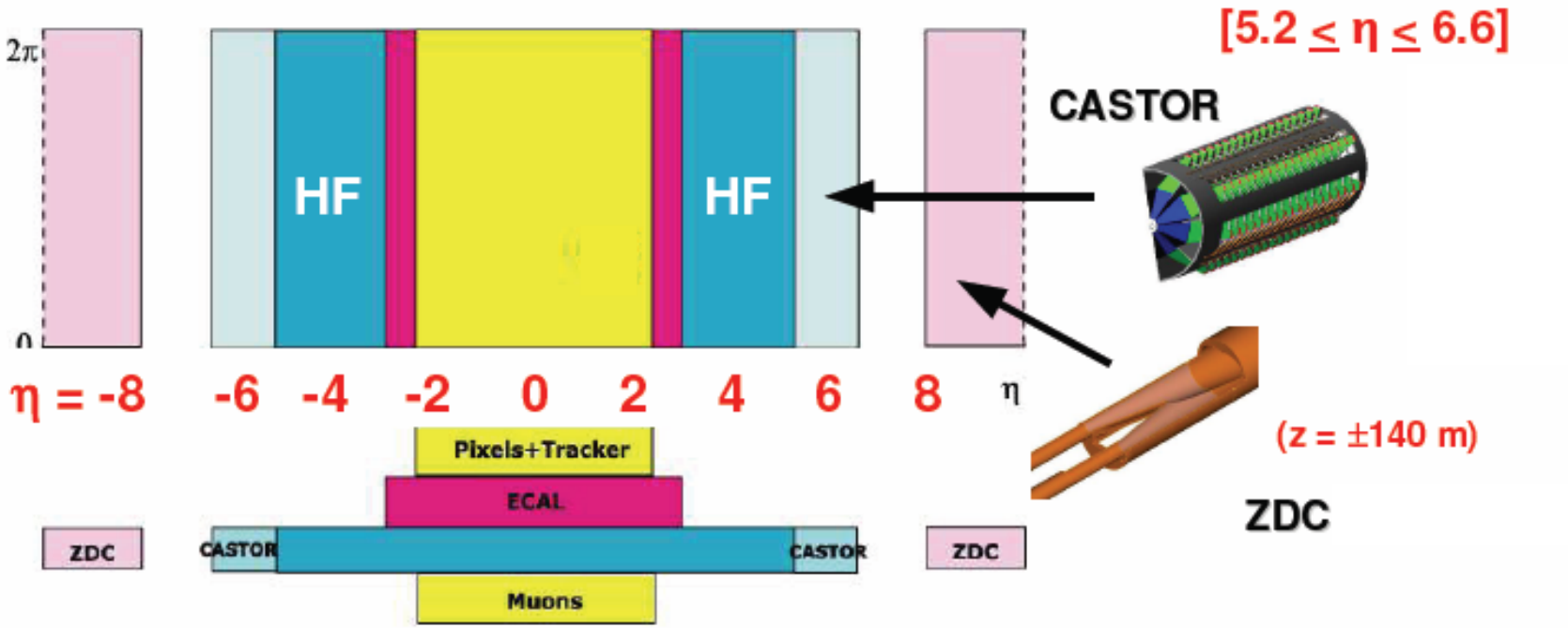
LCAL: 14 sections, 28 channels



Heavy Ion Physics with CASTOR

CMS Acceptance

- HF,CASTOR,ZDC + TOTEM: Quasi-full acceptance at LHC



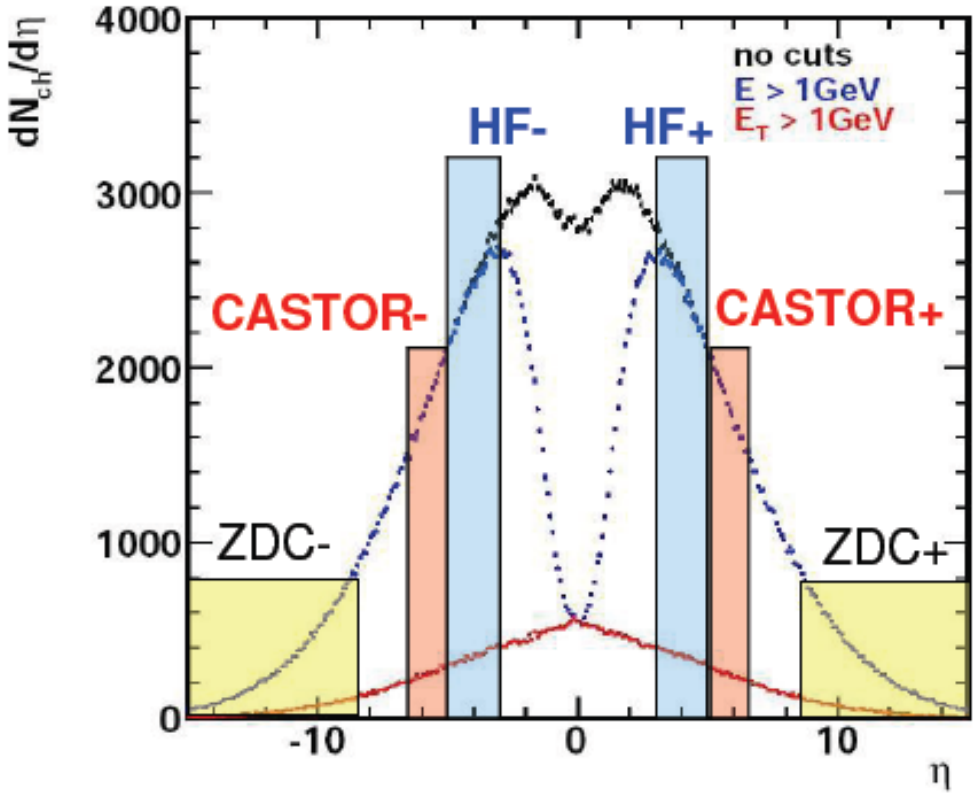
- Detection capabilities within $\eta \leq 6.7$ (and $\eta \geq 8.1$, neutral).
- Strong diffractive physics (rap-gaps, ultraperipheral AA) possible
- Hard scatt. measurements (jets, DY) possible at $x \sim 10^{-4}$-10^{-6}

HI Forward Physics with CASTOR

- Global event characterization:
  - (1) Level-1 minimum bias trigger
  - (2) Event-by-event determination of AA centrality (impact parameter)
- Low-x QCD:
  - (3) Forward particle multiplicity
  - (4) Limited fragmentation (extended longitudinal scaling)
  - (5) Perturbative probes of gluon saturation ("CGC")
- High (net) proton density:
  - (6) Baryon stopping, baryochemical potential
- Ultra-high energy cosmic ray models
  - (7) Forward Energy / Particle flow
- Unconventional states in cosmic rays [P. Katsas]:
  - (8) "Centauros" events: "Strangelets" (?), "DCCs" (?)

L1 minimum bias Trigger

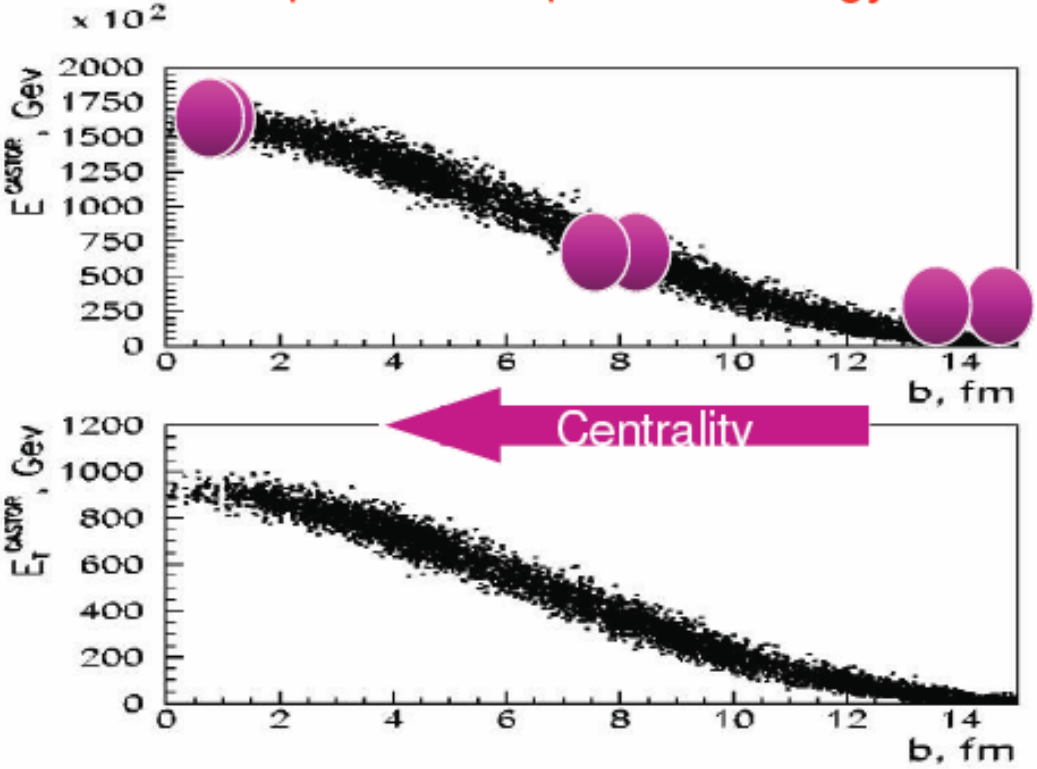
- HF^{+}.AND.HF^{-} (+ZDC) is default L1 PbPb trigger under consideration
- $CASTOR^{+}$.AND.$CASTOR^{-}$ (+ZDC as done at RHIC) could provide more "genuine" minimun bias events (with reduced hard QCD activity)



HYDJET PbPb-5.5 TeV hadron distribution (for dN/dη=3000)

Nucleus – nucleus Reaction Centrality

- Centrality = crucial parameter to determine the amount of nuclear collision overlap: volume, particle/energy density of system.



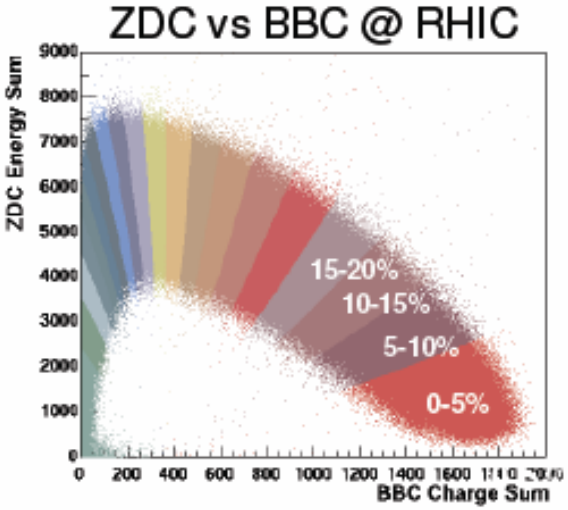
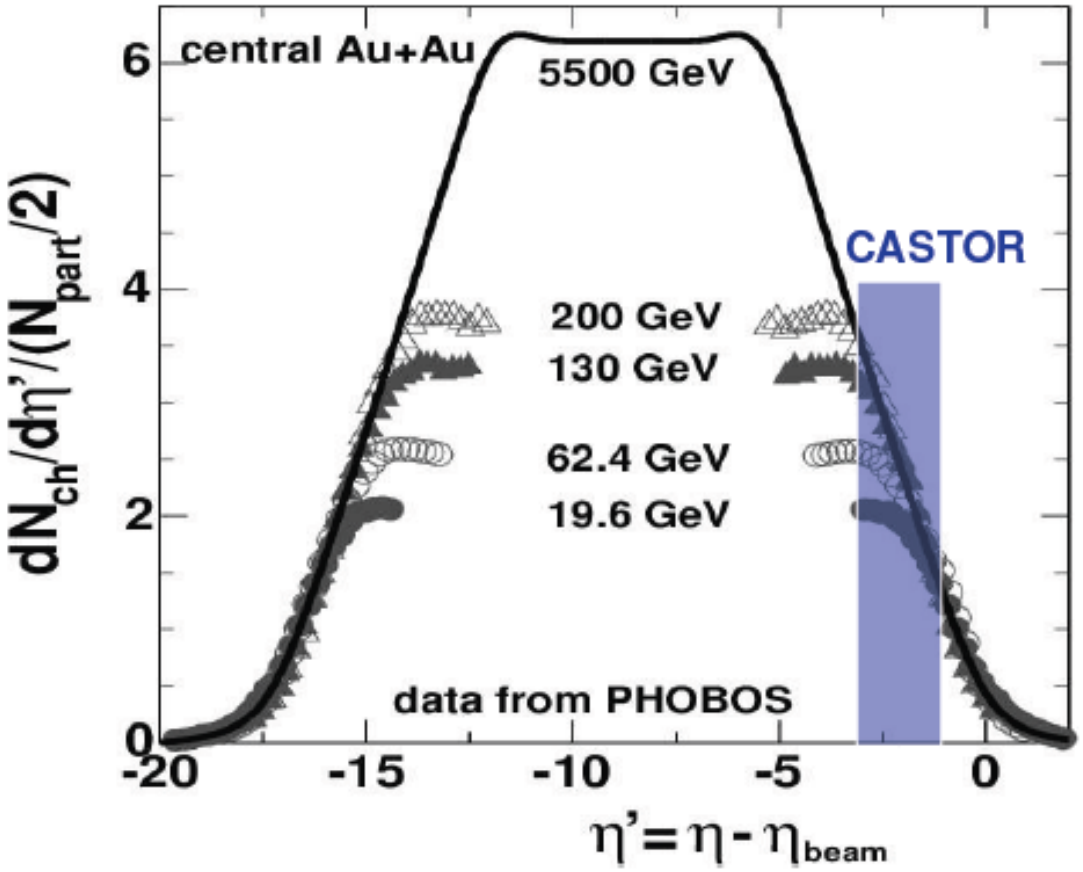


Figure 3: The distributions of energy and transverse energy deposited in CASTOR as a function of the impact parameter, *b*, for the highest energy Pb-Pb collisions at the LHC.

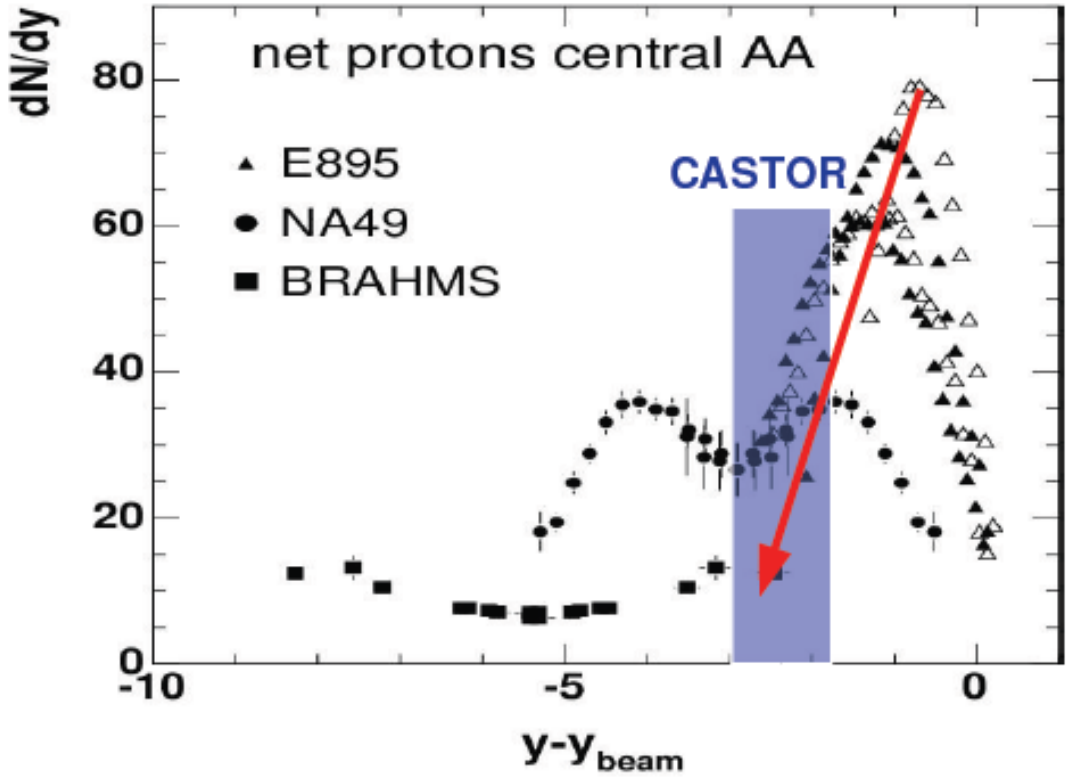
- E_{tot},E_T in CASTOR = monotonic functions of b. Correlation of CASTOR E_T with ZDC E_T will provide yet more accurate determination of centrality.

Longitudinal Scaling

- Pseudo-rapidity hadron distributions, dNch/dη', show universal "limiting fragmentation" property, described by gluon saturation models (again T2 likely needed for track counting):

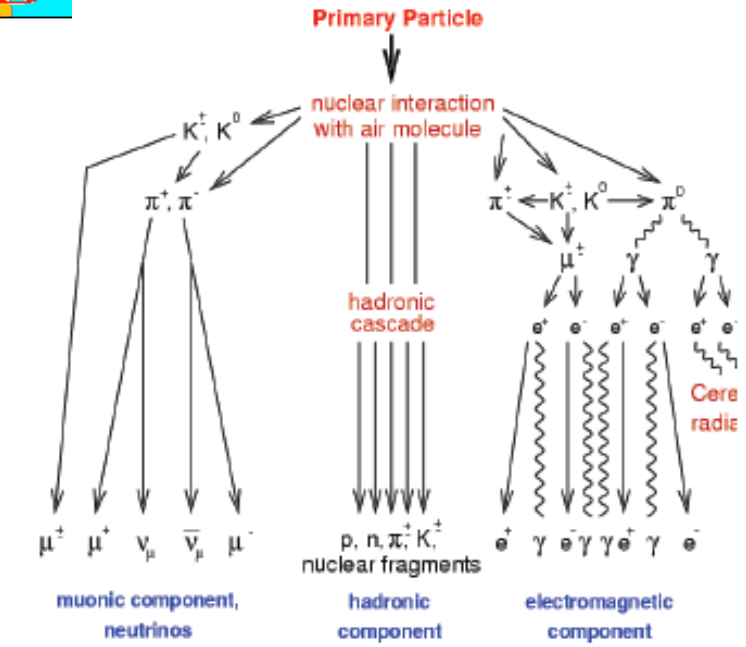


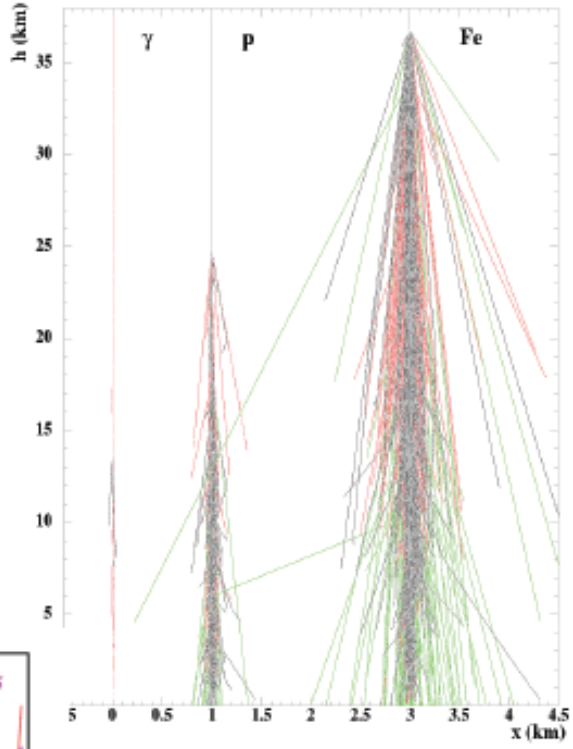
Baryon Transport & Stopping



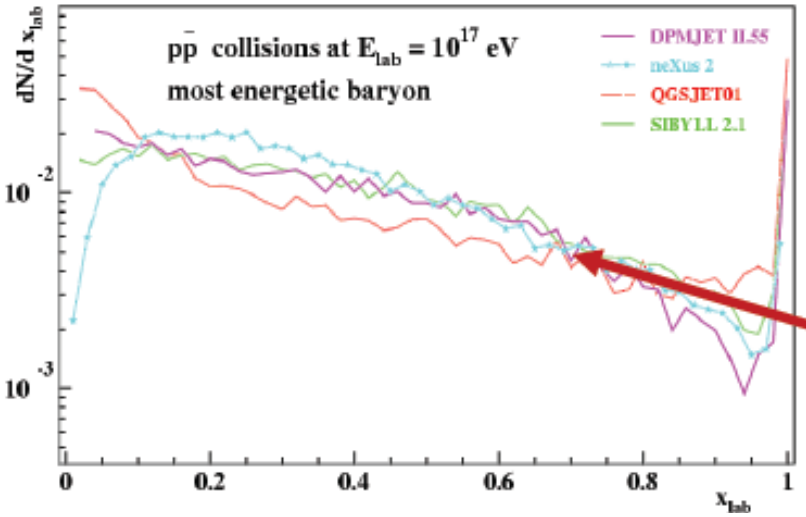
- Peak of net proton (Np – $\bar{N}$p) rapidity density moves away from beam rapidity ($y_{beam} = \ln(\sqrt{s})/m_N$) for increasing energies: Maximum net baryon density at LHC expected around $\eta \sim 5 - 7$ (CASTOR).
- Study of the mechanism of baryon stopping and transport, as well as properties of system over wide range of baryo-chemical potential.

UHE Cosmic Rays via extended Air-showers





Knowledge of the energy and particle flow in high-energy p+N,O, Fe+N,O collisions is crucial for cosmic ray showers >100 PeV:

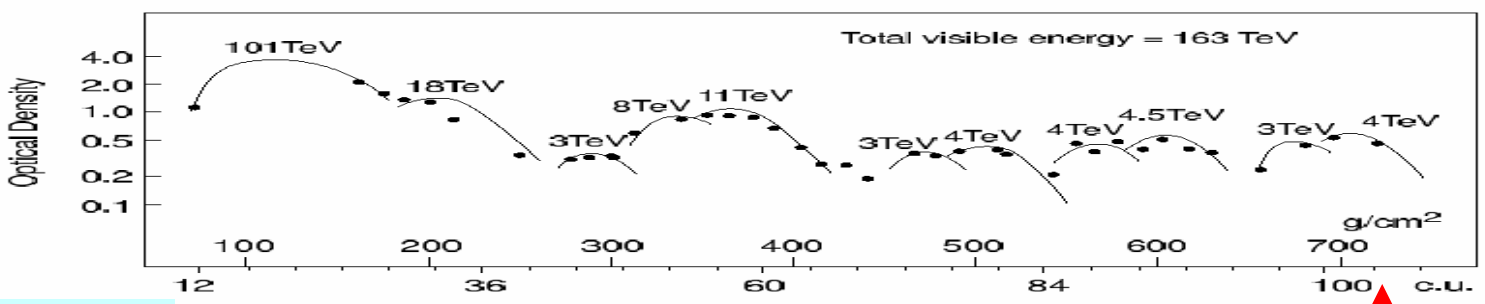


Determination of E,mass of cosmic rays depends on hadronic MC. Forward region poorly known. Models differ by factor 2 or more. Need forward particle/energy measurements e.g. dE/dη…

Cosmic Rays "Exotica"

E ~ 10^{15} - 10^{17} eV cosmic rays ("Centauro") observed with anomalous (~ 0) number electromagnetic component and forward "long-flying" (i.e. non-interacting) component

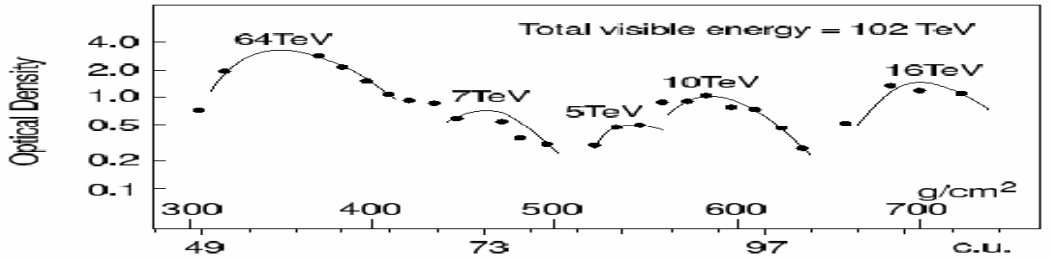
"Strangelet" ? "DCC" ?

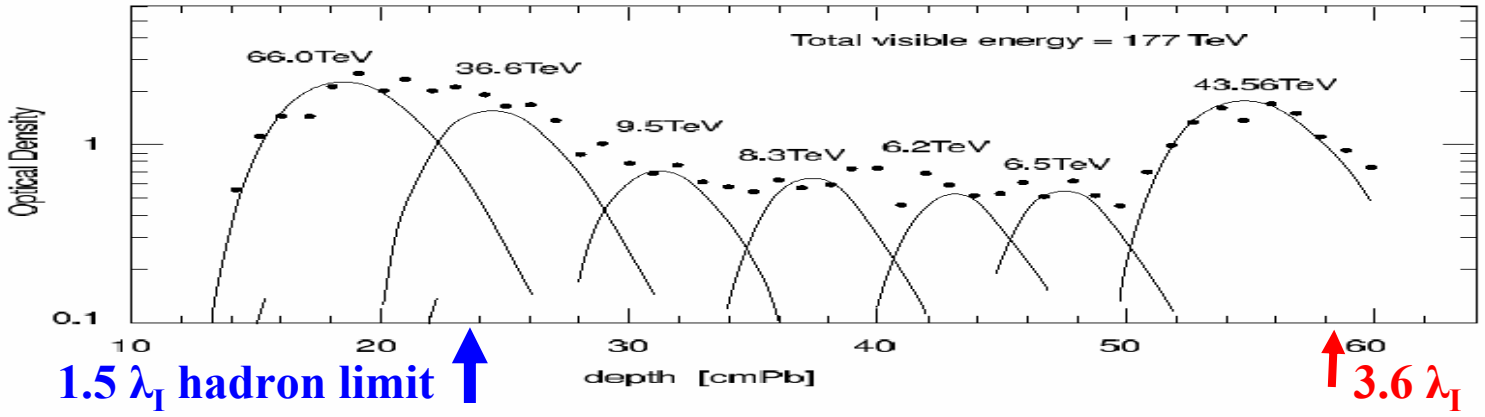


3.6 λ_I

Measurement settings:

100 µm shower core diameter → threshold ~ 3 TeV





1.5 λ_I hadron limit

3.6 λ_I

Summary of Physics Topics

- CMS is the largest-acceptance colider experiment ever: None of the other LHC experiments (ALICE, ATLAS) can compete in forward Physics studies.
- CASTOR p-p: excellent possibilities for rapidity-gaps physics & low-x QCD measurements
- CASTOR PbPb,pPb: Interesting possibilities (most not explored yet!):
  - Global event characterization: L1 min.bias, event centrality
  - Gluon saturation physics (would require T2 for track counting and polar angle): dN/dη, pQCD probes
  - "Large" baryon density physics: dNp-pbar/dη,
  - Cosmic-rays connection: calibration of forward hadronic models, study of "exotica" events