FORWARD PHYSICS AT CMS WITH CASTOR

1. Integration in CMS
2. Physics issues
3. Beam test analysis (2003)
4. Tasks in 2004

"QCD at Cosmic Energies" workshop
Erice 29/8-5/09, 2004

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CASTOR - T2 Integration in CMS

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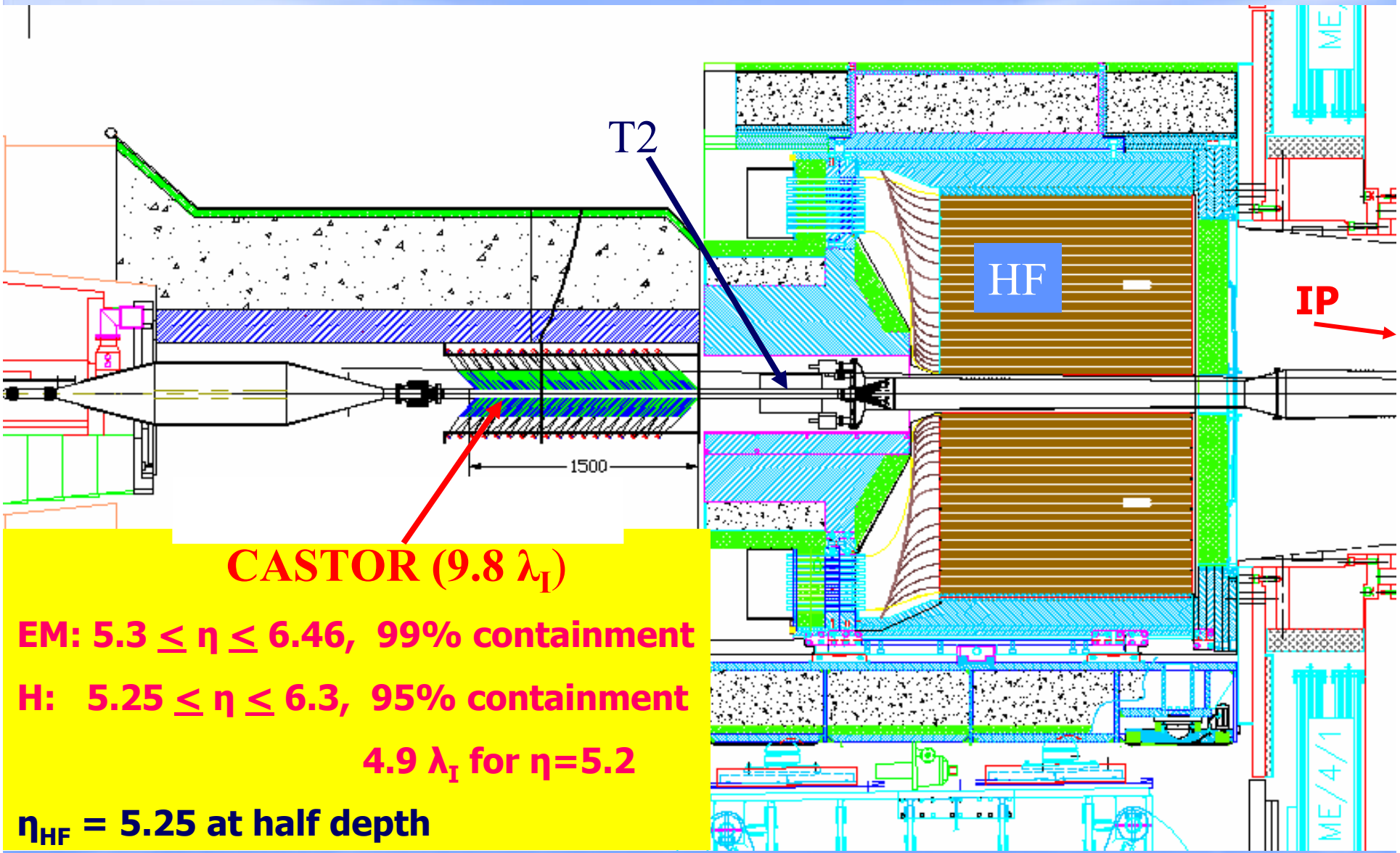

CASTOR (9.8 λ_I)

EM: 5.3 ≤ η ≤ 6.46, 99% containment

H: 5.25 ≤ η ≤ 6.3, 95% containment

4.9 λ_I for η=5.2

η_{HF} = 5.25 at half depth

ACCEPTANCES: Multiplicity - Energy

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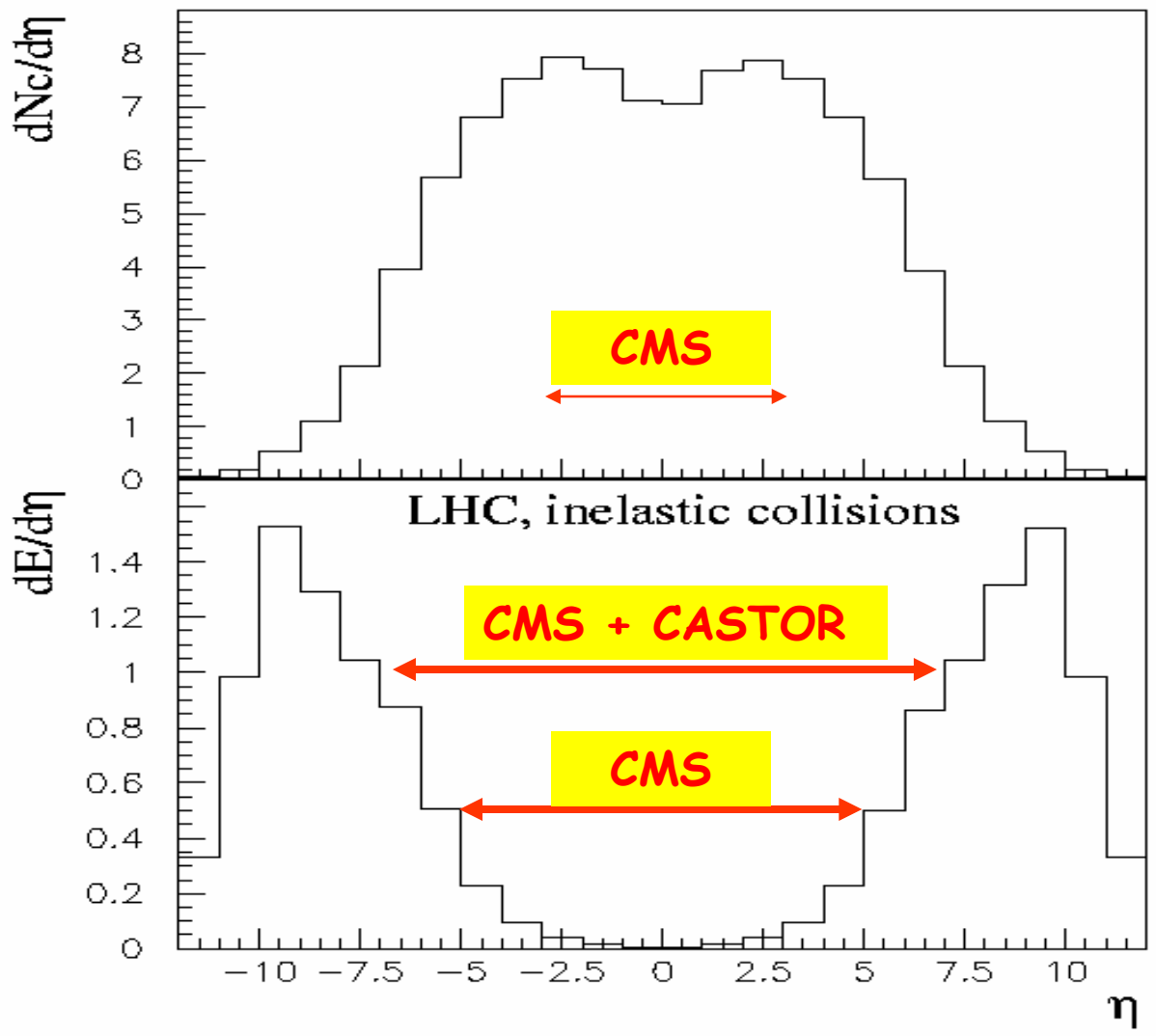

CMS - Detector Coverage

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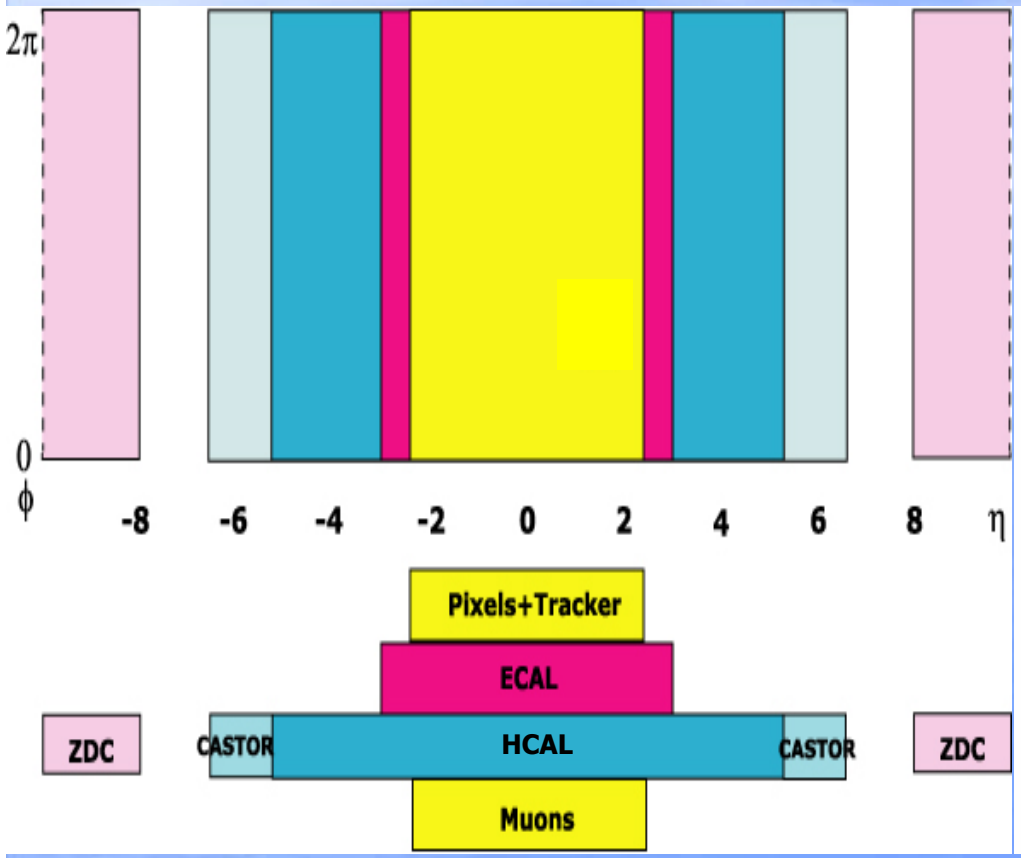

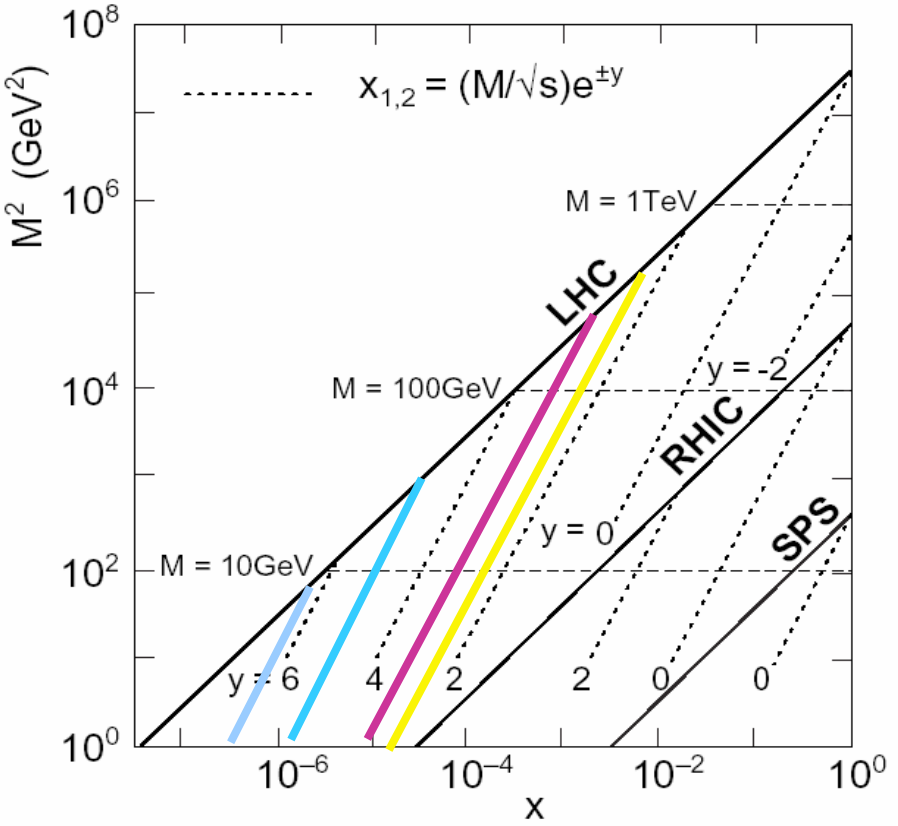

Large Range of Hermetic Coverage

$\eta \sim 12.8$, $x \sim$ up to 10^{-7} and $Q^2 > 1$ GeV^2

Unique Forward Capability

Summary low-lumi Very Forward pp Physics

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- Low x physics: $x = 10^{-5} - 10^{-7}$
  possible in CMS with CASTOR+T2 at $5.2<|\eta|<6.4$
- BFKL searches: Di-jets with large rapidity gaps
  Color singlet exchange events
  Forward J/ψ production
- Diffraction: Extended coverage for vetoing
  Multi-gap detection
- Forward energy flow for cosmic rays
- Exotics in the very forward region: Centauro, DCC, …
- $pp \rightarrow pp + e^+e^-$: Luminosity measurements

Forward energy flow for Cosmic Rays

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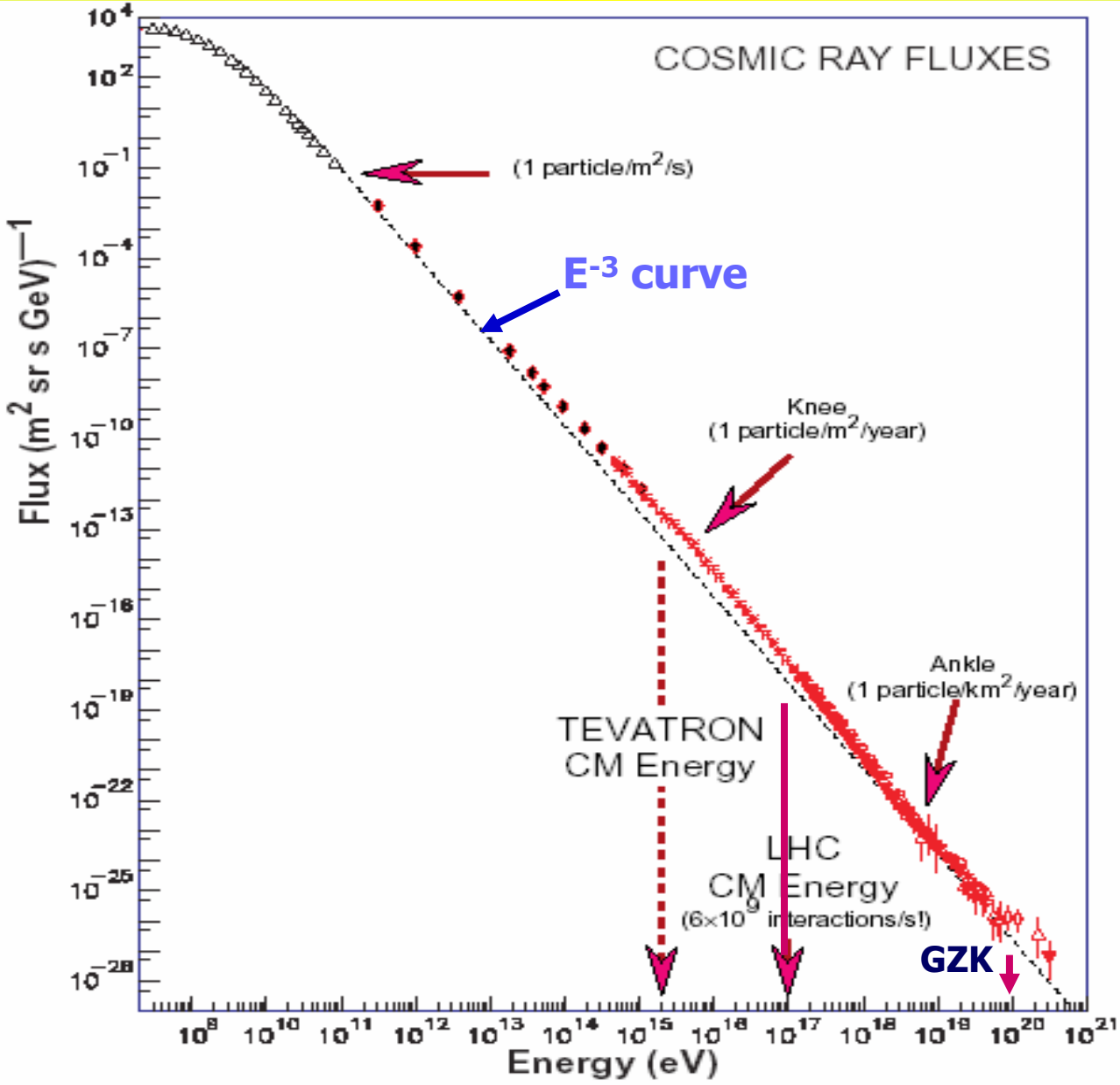
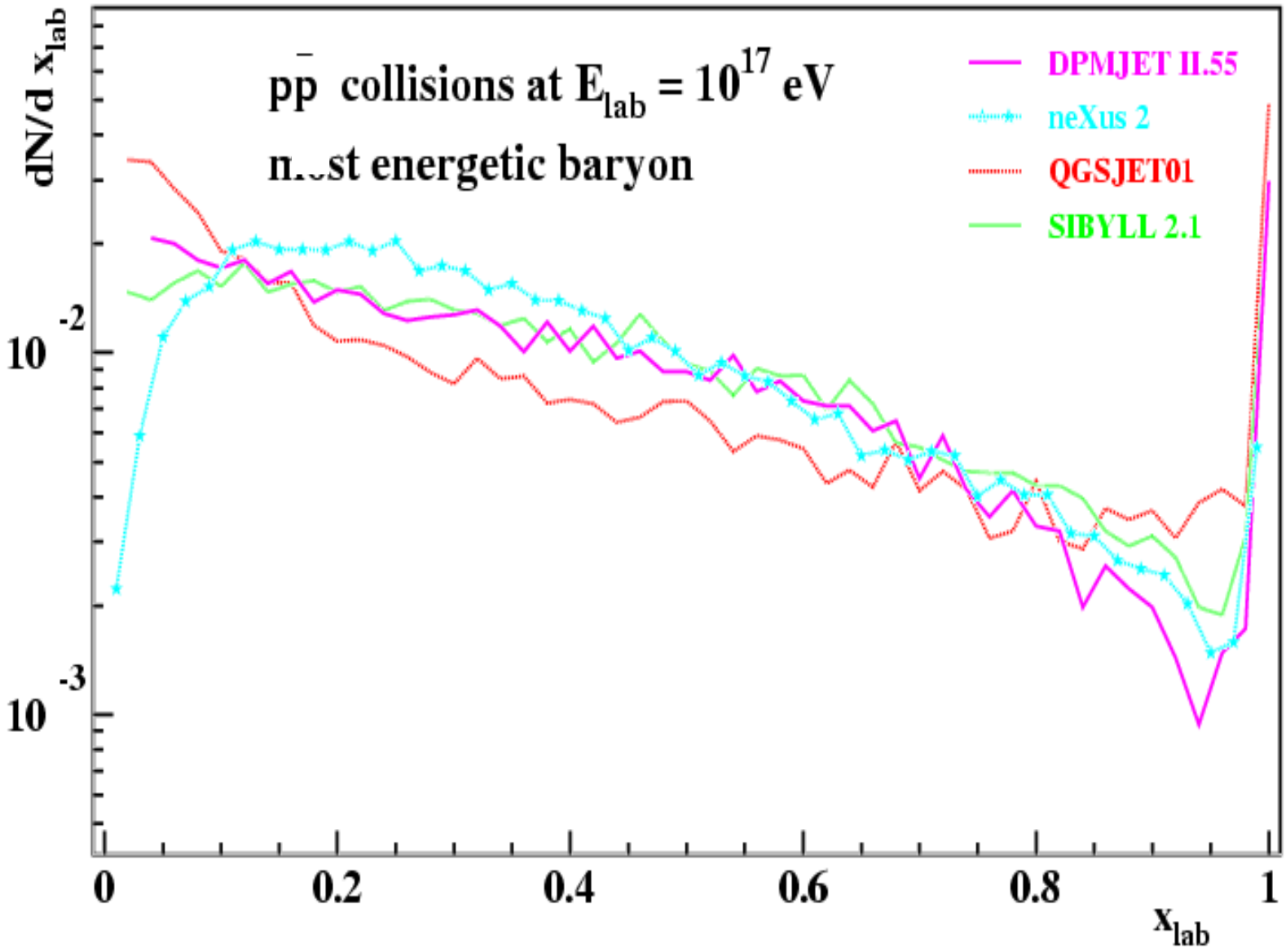
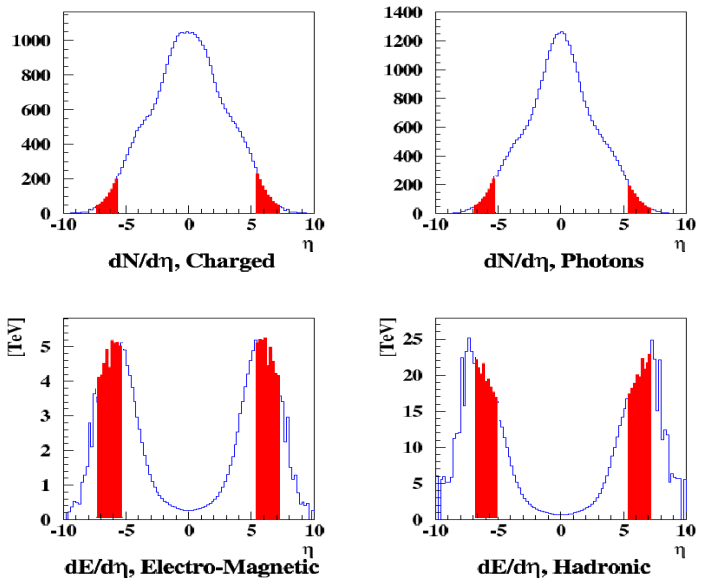



dN/d x_lab
p p̄ collisions at E_lab = 10^17 eV
most energetic baryon
DPMJET II.55
neXus 2
QGSJET01
SIBYLL 2.1
10^-2
10^-3
0
0.2
0.4
0.6
0.8
1
x_lab

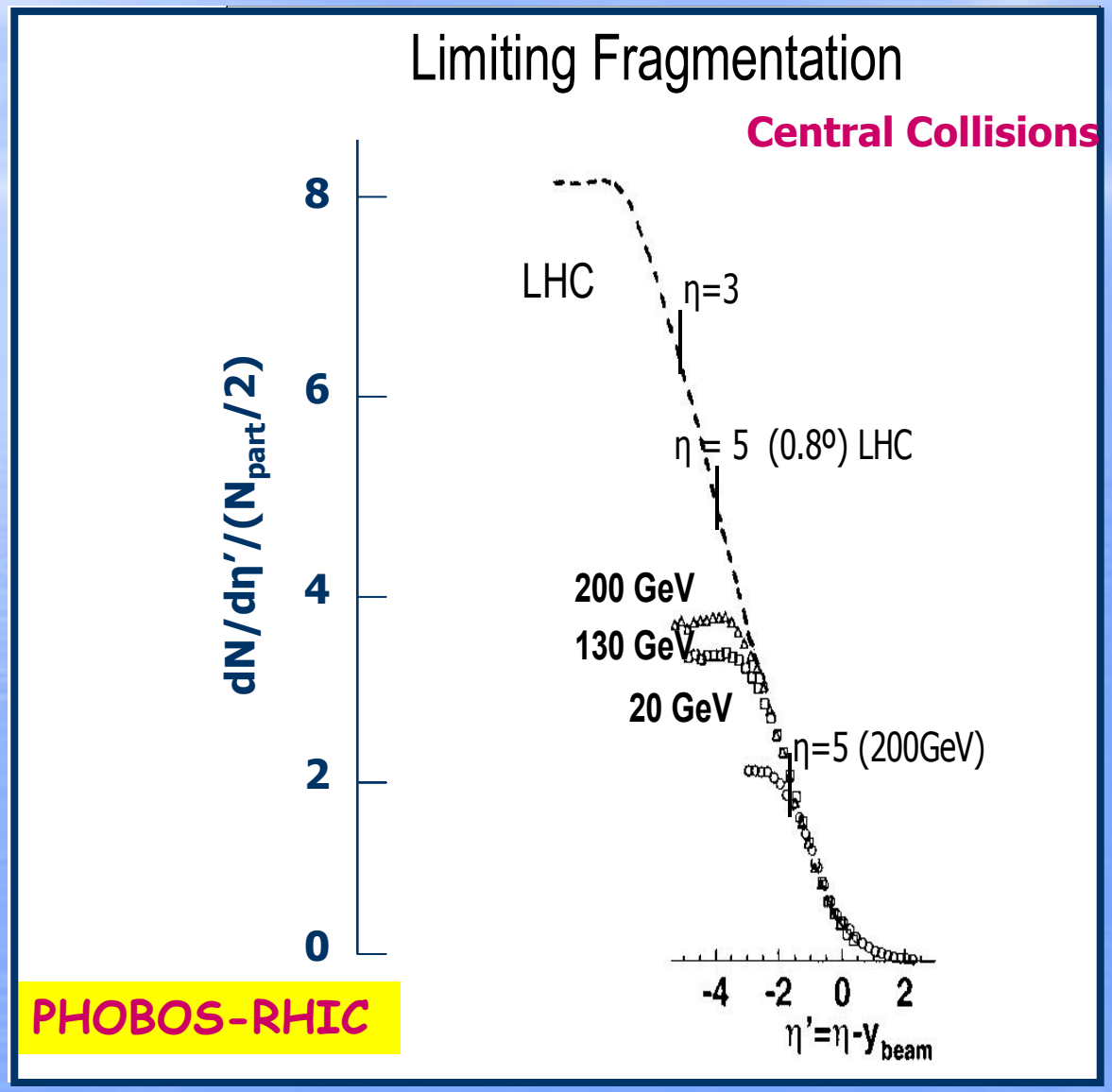
Summary Very Forward A+A Physics



- Limiting Fragmentation
- Peripheral and ultra-peripheral collisions
- Total energy flow, E_T measurement vs impact parameter
- Exotic C-R events: Centauro, Long Penetrating hadrons=Strangelets?
- Other "new" Physics: Disoriented Chiral Condensate

  Colour Glass Condensate

Limiting Fragmentation



Colour - Glass Condensate

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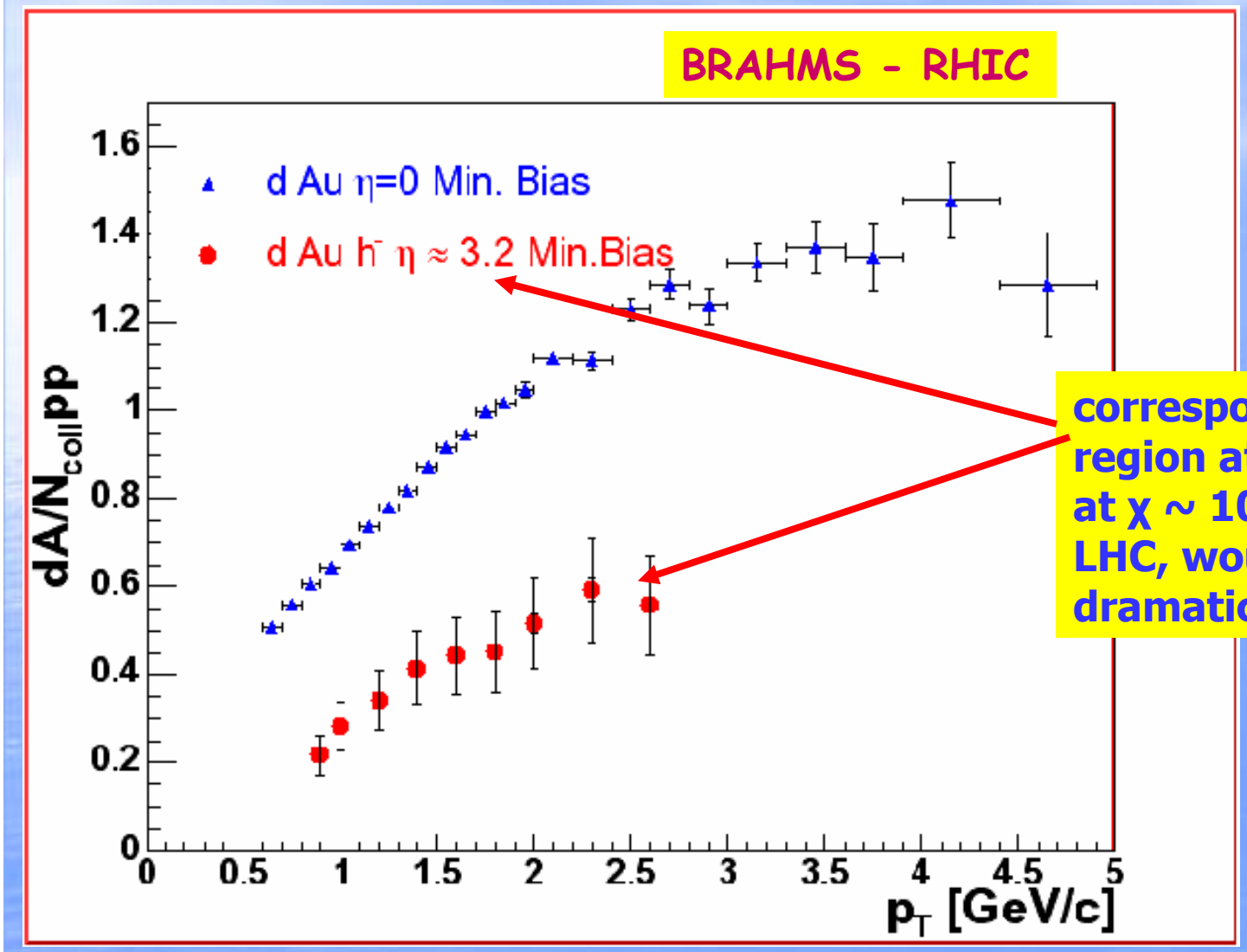
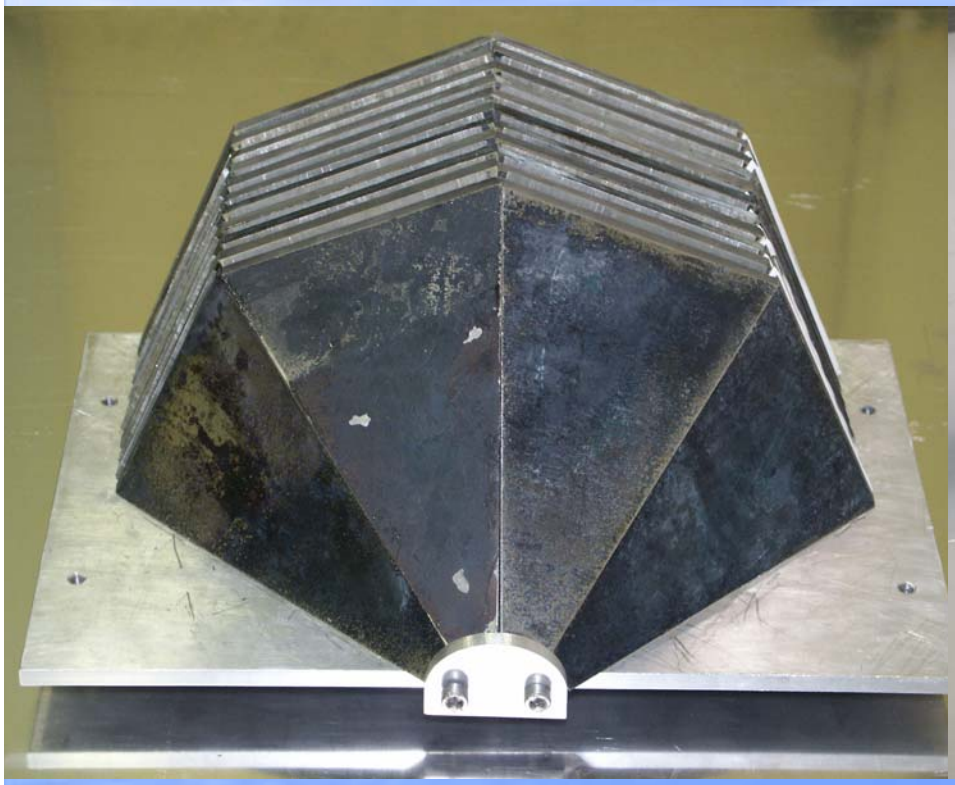
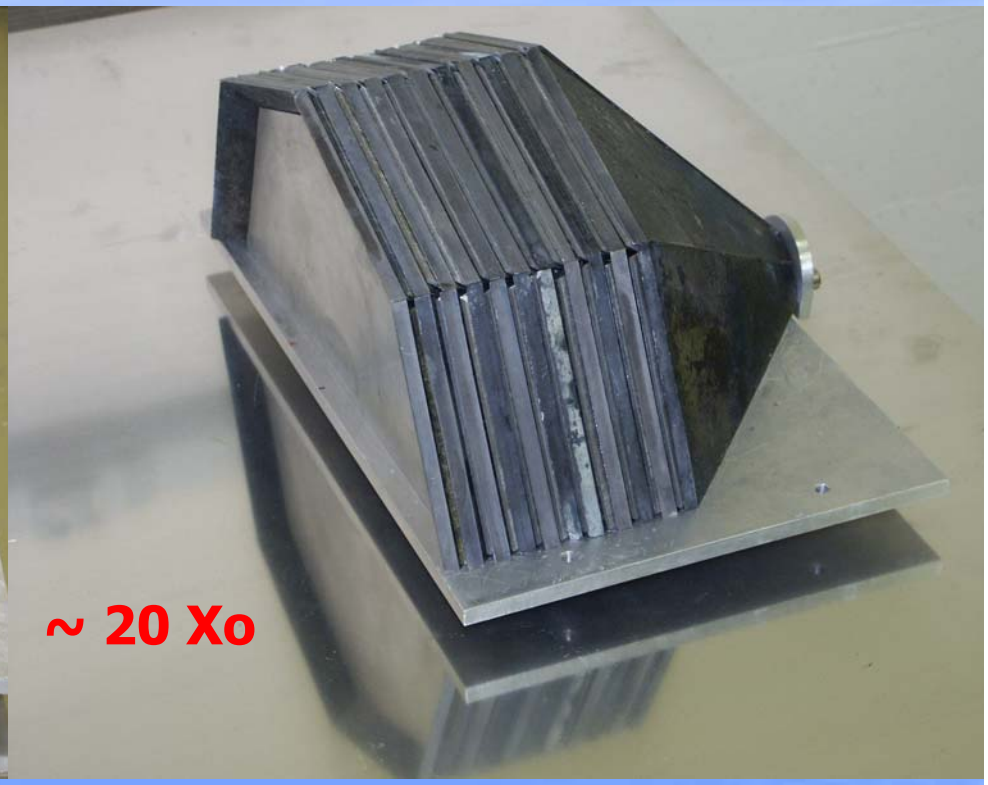
BRAHMS - RHIC



corresponds to ~ central region at LHC. The effects at $\chi \sim 10^{-6}$, attainable at LHC, would be much more dramatic.

EM - PROTOTYPE
W-PLATES + Q-FIBRE / PLATES





CASTOR PROTO BEAM TEST 2003

Energy Linearity of Q-Plate & APD

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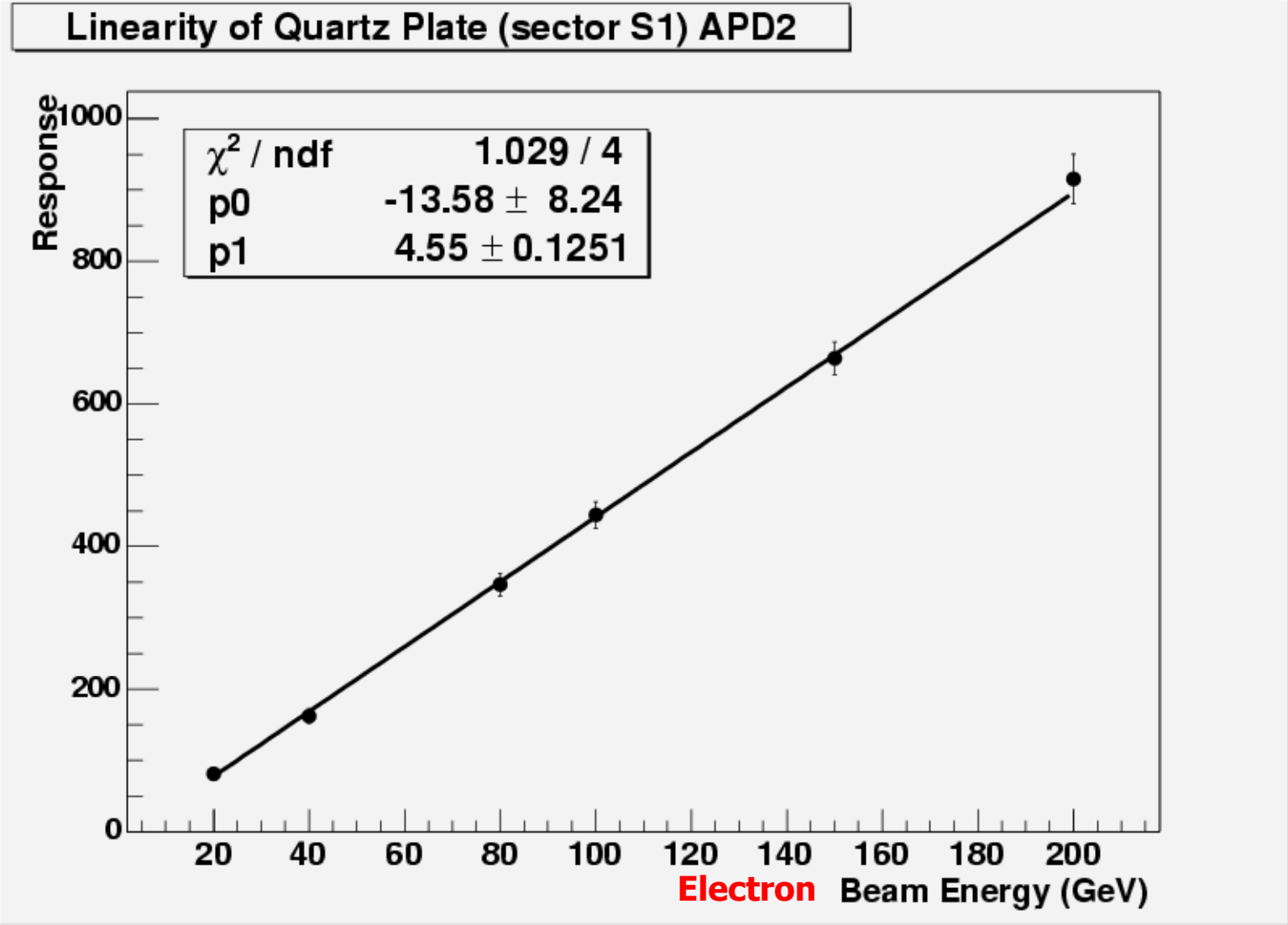

Energy Resolution of Q-Plate & APD

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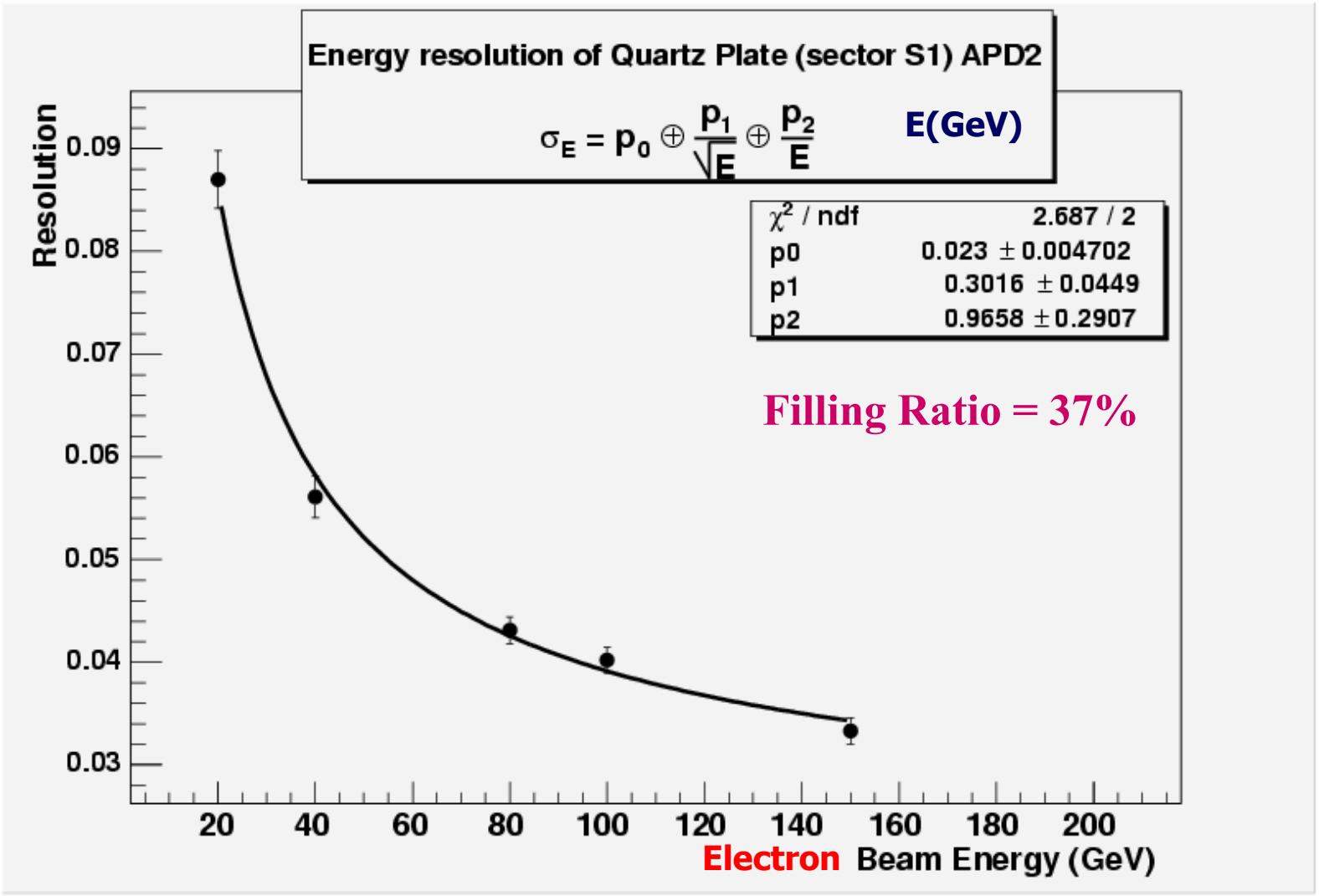
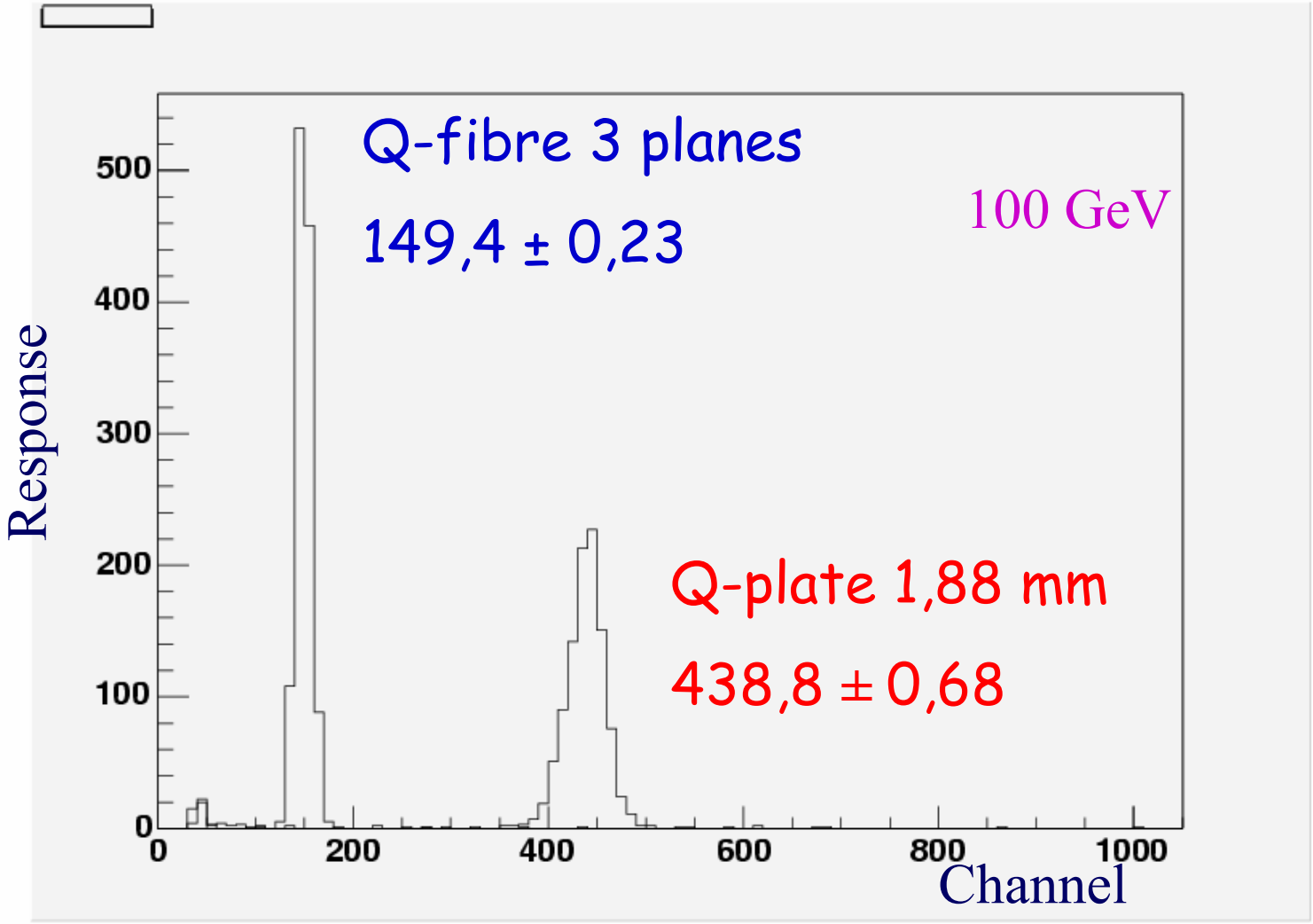


Light Production: Q-Fibre & Q-Plate (APD)



CASTOR GEOMETRY

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- W-plate (5 mm) at 45°: $7.105 \times 10^{-2}\ \lambda_I = 1.94675\ X_o$
- Fused silica plate (2 mm) at 45°: $6.615 \times 10^{-3}\ \lambda_I = 2.4175 \times 10^{-2}\ X_o$
- Sampling Unit (SU) = W + Q $= 7.7665 \times 10^{-2}\ \lambda_I = 1.971\ X_o$
- Reading Unit (RU) = 7 SUs = $0.5437\ \lambda_I = 13.8\ X_o = 73.5$ mm

- **EM-section**: 2 RU = $27.6\ X_o = 1.09\ \lambda_I$
- **H-section**: (2+16) RU = $9.79\ \lambda_I$

- Number of Electronic channels (RUs) = 16 x 18 = 288

- Number of APDs = 288 x 4 = 1152

- $\Delta\eta \sim 1.2$
- Reading Unit = $0.544\ \lambda_I = 13.8\ X_o$
- (16) Sectors in φ (22.5°)
- Depth: EM = 2 RU
  H = 18 RU

CASTOR ACTIVE VOLUME

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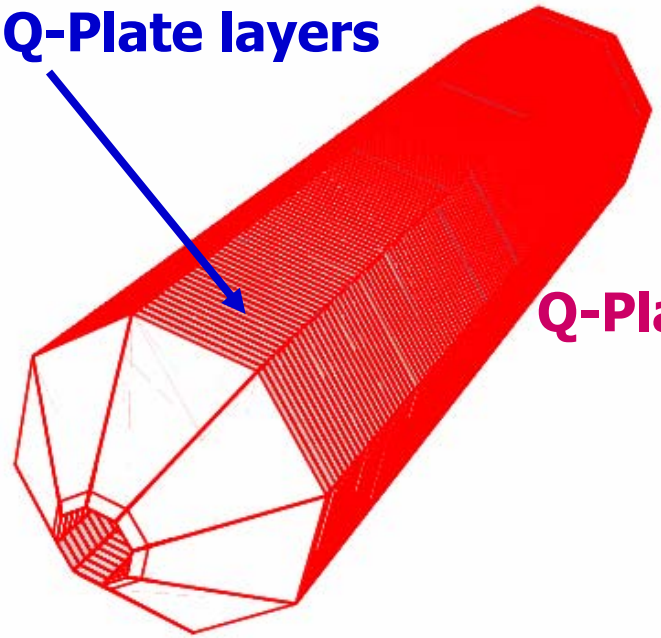
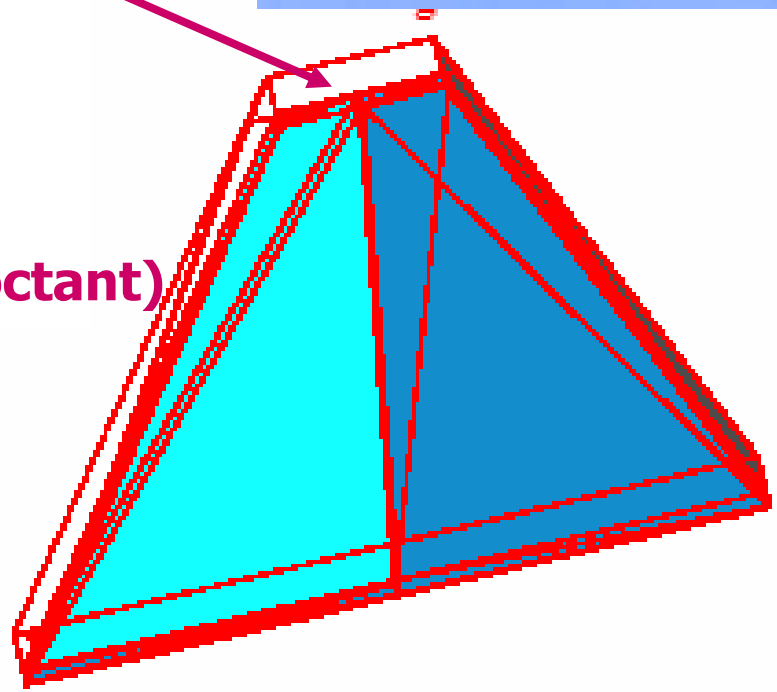
W/Q-Plate layers



W-Plate (octant)

Q-Plate (semi-octant)



CASTOR in GEANT4-OSCAR

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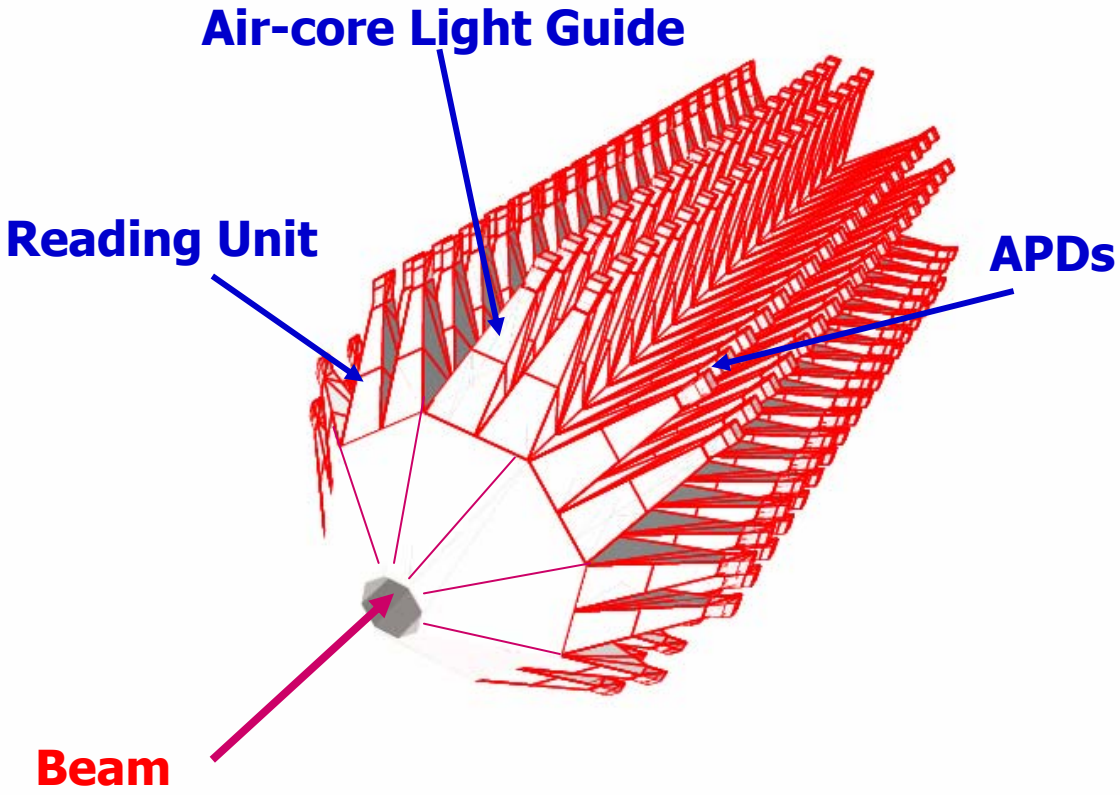
Simulation of the CASTOR calorimeter in CMS environment: GEANT4-OSCAR.

A. Zhokin, P. Katsas (Athens)

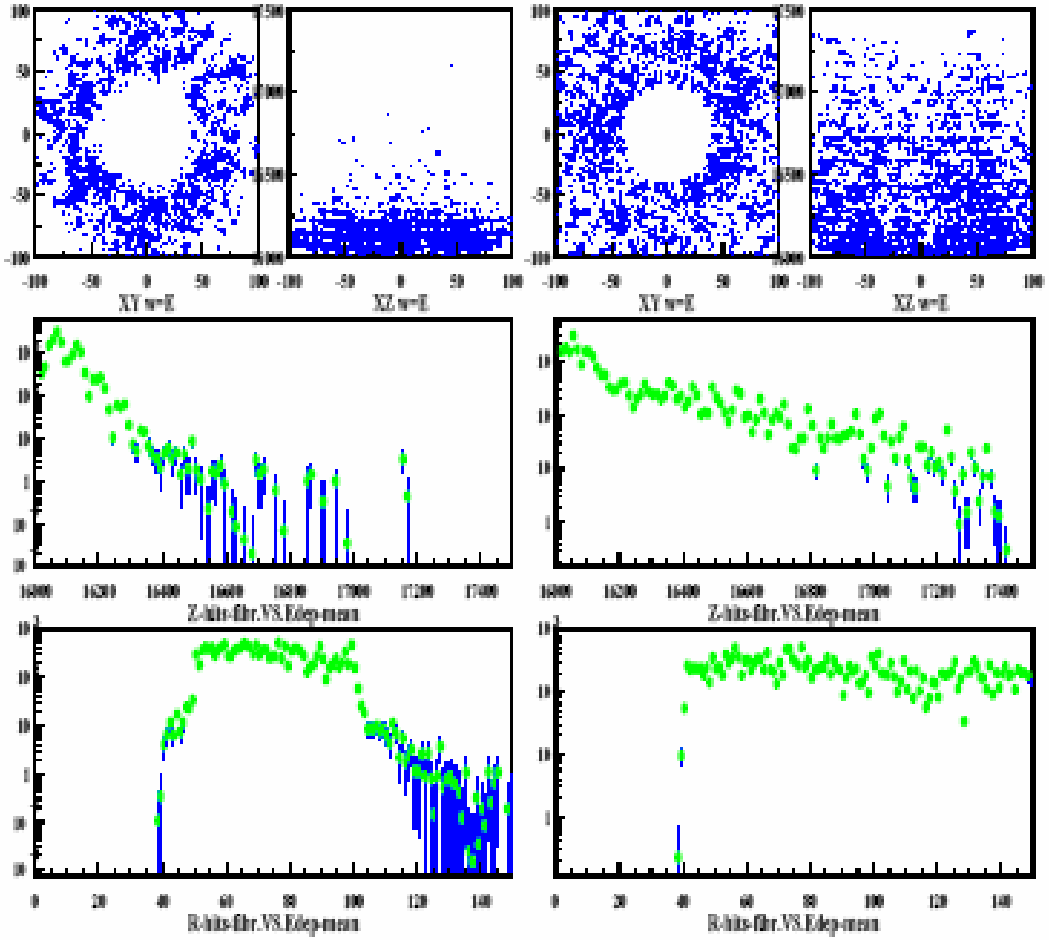


MC SIMULATIONS

HCASTOR

- 2D plots, longitudinal and transversal profiles of $\check{C}$ yield collected by Quartz plates

$\gamma's/10GeV$ $\pi^+/10GeV$



ParticleGun: shooting in some θ-range, $\phi = 0{:}2\pi$

Tasks in 2004

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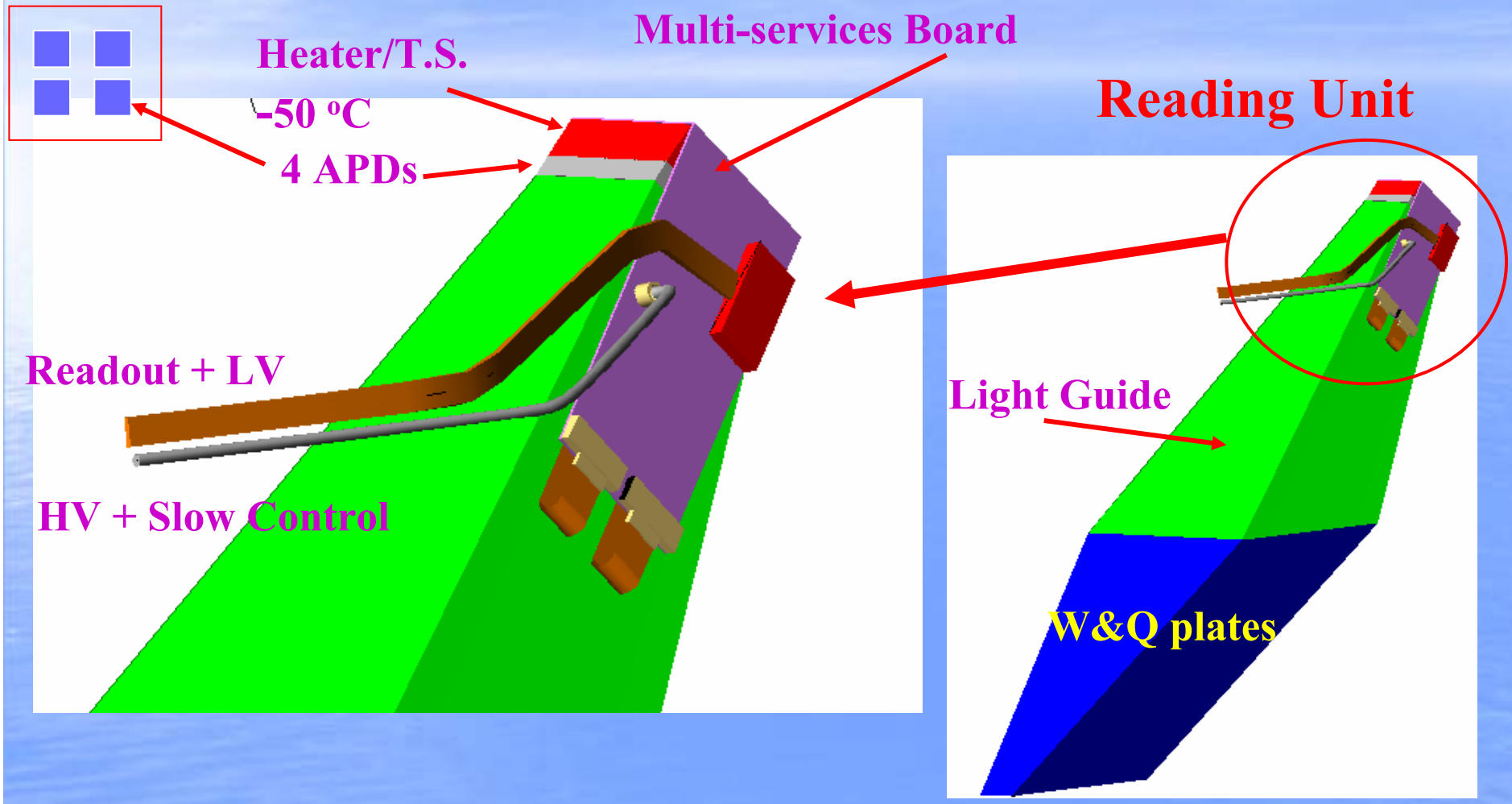
1. Construct 2nd calorimeter prototype (EM / H)
   Beam-test — October
2. Run simulations and PRS with all forward detectors — end 2004
3. Submit the TP to LHCC — end 2004

- The CASTOR Technical Proposal can be found at:
  http://cms.phys.uoa.gr/CASTOR/CASTOR_TDR1.pdf

CASTOR Readout Conceptual Scheme



Radiation Level @ CASTOR

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Location of APD's : R = 30 – 32 cm from beam

Neutron flux (> 100 KeV) = 2×10^{13} fb/cm^2

Integrated Luminosity = 10 fb^{-1} for pp Physics

Total neutron fluence = 2×10^{14} n/cm^2

No permanent effects have been seen for neutron fluence of 2×10^{14}/cm^2 in the APD's for CMS Barrel

New irradiation tests up to 1×10^{15} n/cm^2

Northeastern-RD39

APD Impact on Resolution

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- **Resolution:** $\frac{\sigma_E}{E} = p_0 \oplus \frac{p_1}{\sqrt{E}} \oplus \frac{p_2}{E}$ (E in GeV)

  p_0 : related to stability and reproducibility

  gain variation with bias voltage and temperature

  p_1 : due to intrinsic shower fluctuations

  Photo statistics (area, QE) & excess noise factor

  p_2 : noise contributions

  capacitance as series noise and dark current as parallel noise

- Optimise these parameters to reach **CASTOR** design goal for the EM sector:

p_0 ~ 1%, p_1 ~ 10%, p_2 < 1 GeV ⟶ ~ 1.3% @ 200 GeV

~ 1% @ > 2 TeV