Status of Zero Degree Calorimeter for CMS Experiment

O.Grachov, M.Murray

University of Kansas, Lawrence, KS

A.S.Ayan, P.Debbins, E.Norbeck, Y.Onel

University of Iowa, Iowa City, IA

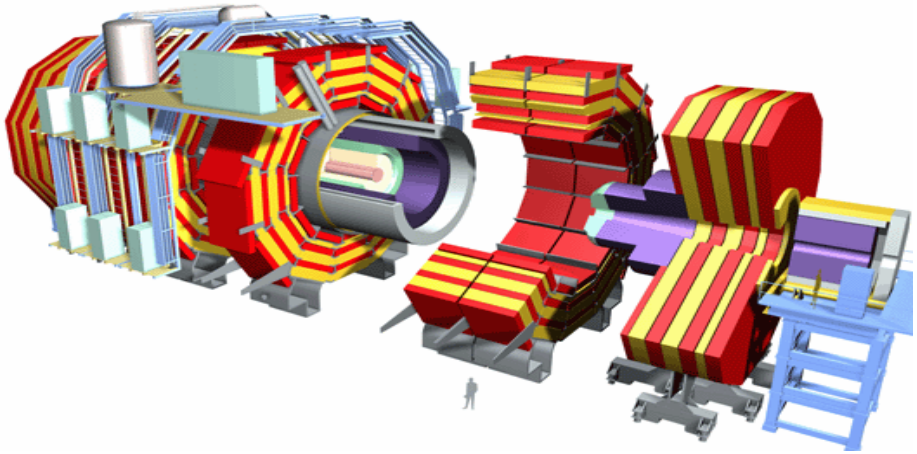
D.d'Enterria

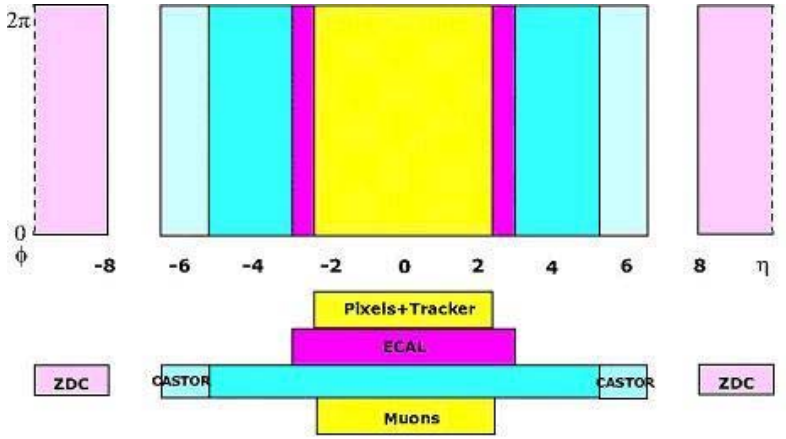
CERN PH/EP, CH-1211 Geneva

Outline

- Introduction
- Scientific Motivation
- Description of ZDC
- Radiation Environment
- HAD Section
- EM Section
- Electronics
- Installation Schedule

Introduction





Acceptance of CMS

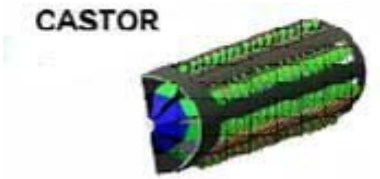
Forward detectors

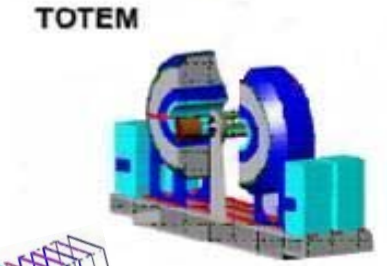
ZDC

Acceptance:

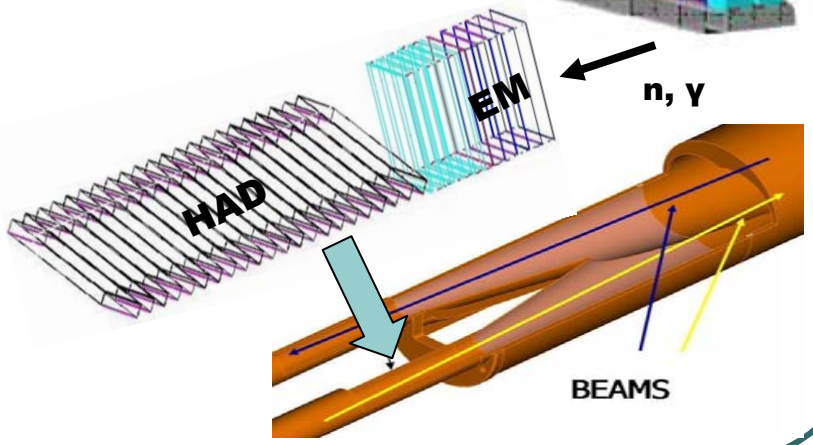
θ ≤ 400μrad

|η| ≥ 8.5



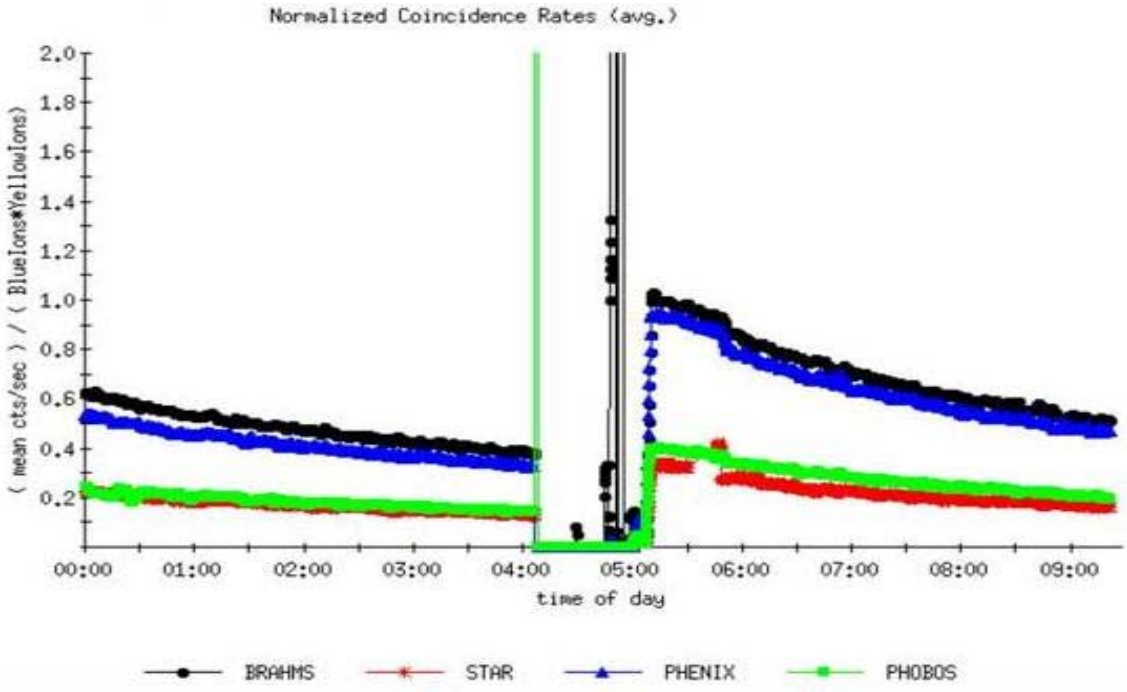


ZDC



Scientific Motivation

Beam tuning and luminosity monitoring tool (pA, AA beam tuning)

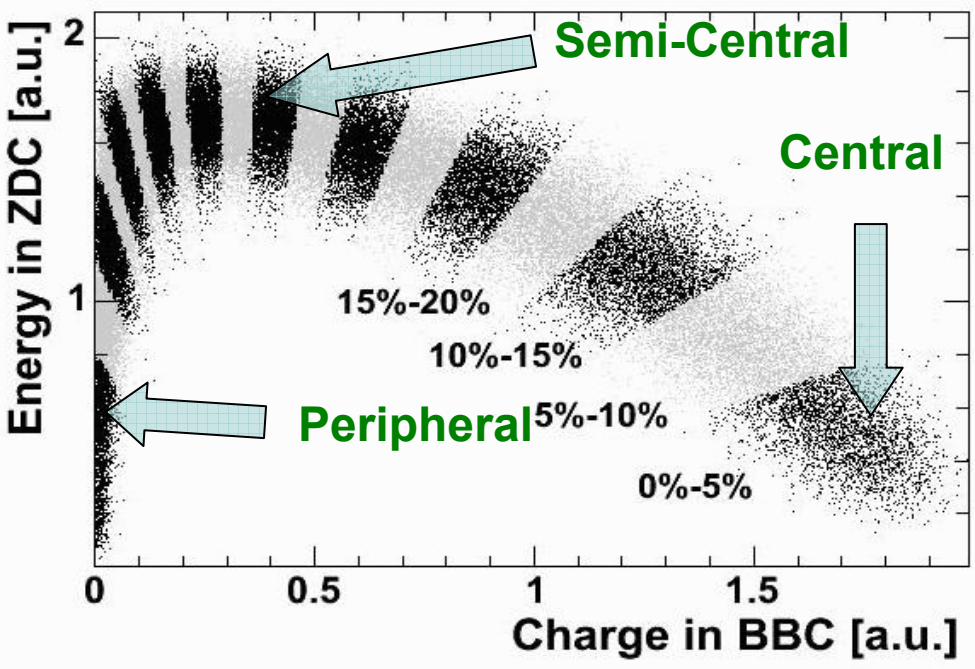


Real-time luminosity at the four RHIC experiments (BRAHMS, STAR, PHENIX, PHOTOBOS) given by the ZDC coincidence rates versus time.

Scientific Motivation

Centrality determination, reaction-plane and global event characterization of AA and pA collisions

Basic minimum bias trigger and centrality



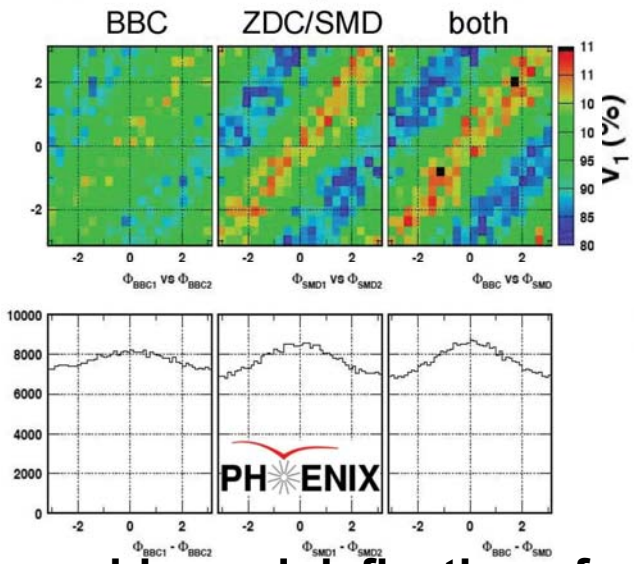
Scatter plot of total neutron multiplicity measured by ZDC (sum of two arms) versus the charged particle multiplicity measured by BBC (beam – beam counters).

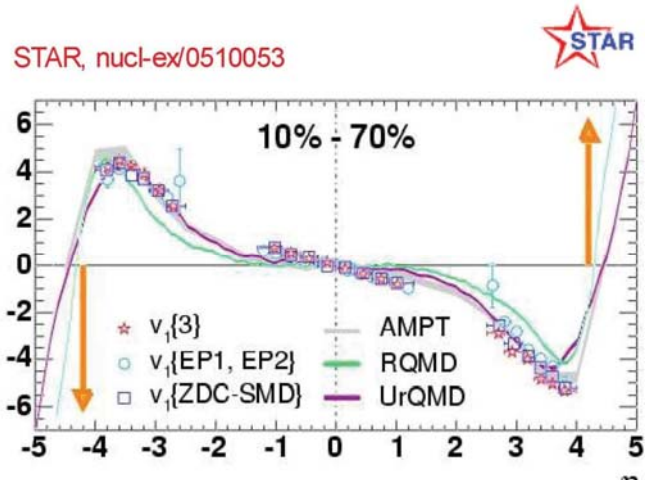
Scientific Motivation

Centrality determination, reaction-plane and global event characterization of AA and pA collisions

AA reaction-plane determination

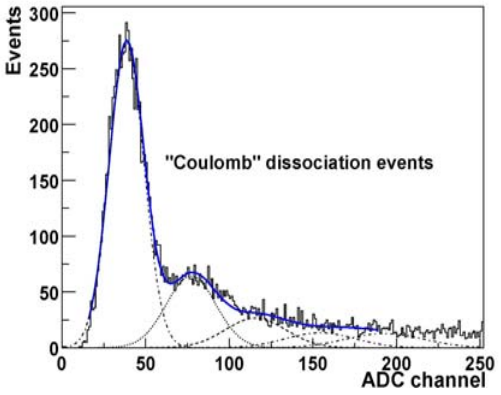
Directed flow v1 is largest at ZDC location:





- sideward deflection of spectators neutrons
– initial parton pressure

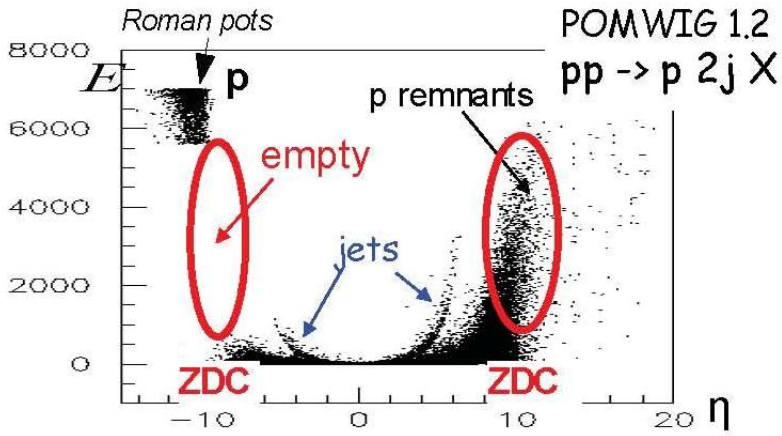
pA, AA absolute luminosity



Reference process: electromagnetic dissociation

Scientific Motivation

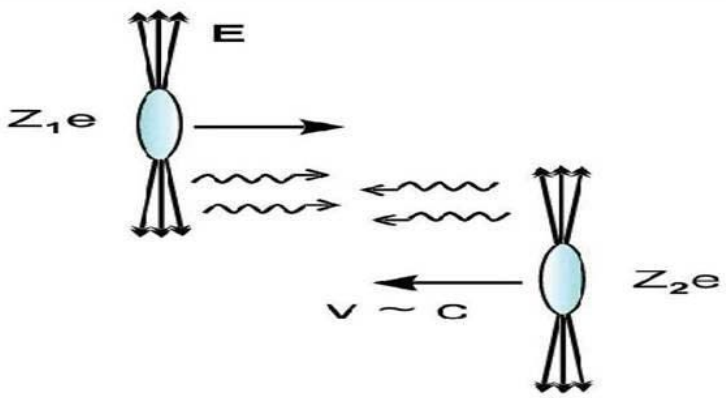
Diffractive pp collisions



ZDC reduces to "zero" holes and cracks in CMS (full 4π coverage).

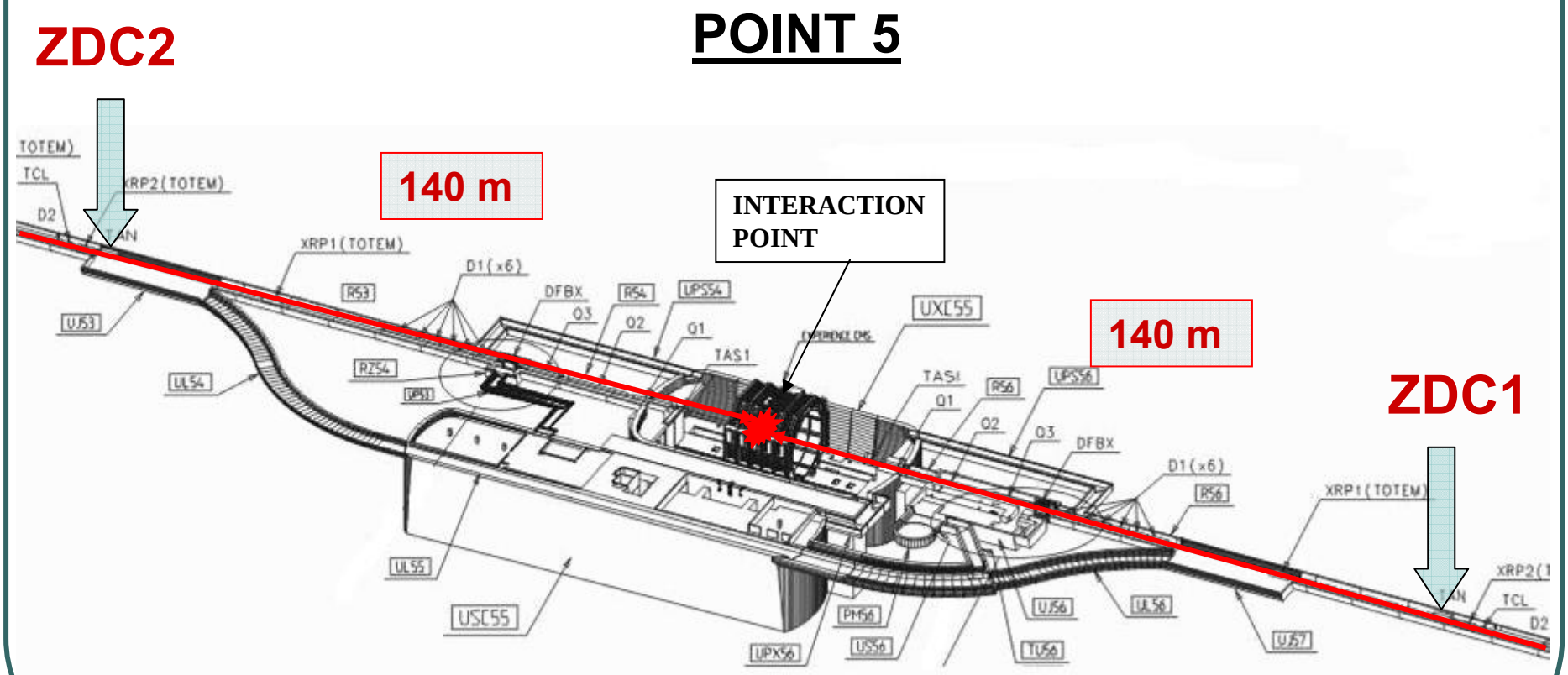
It will help in all diffractive (Pomeron, γ-mediated) analysis.

γγ, γA: LHC as a photon Collider



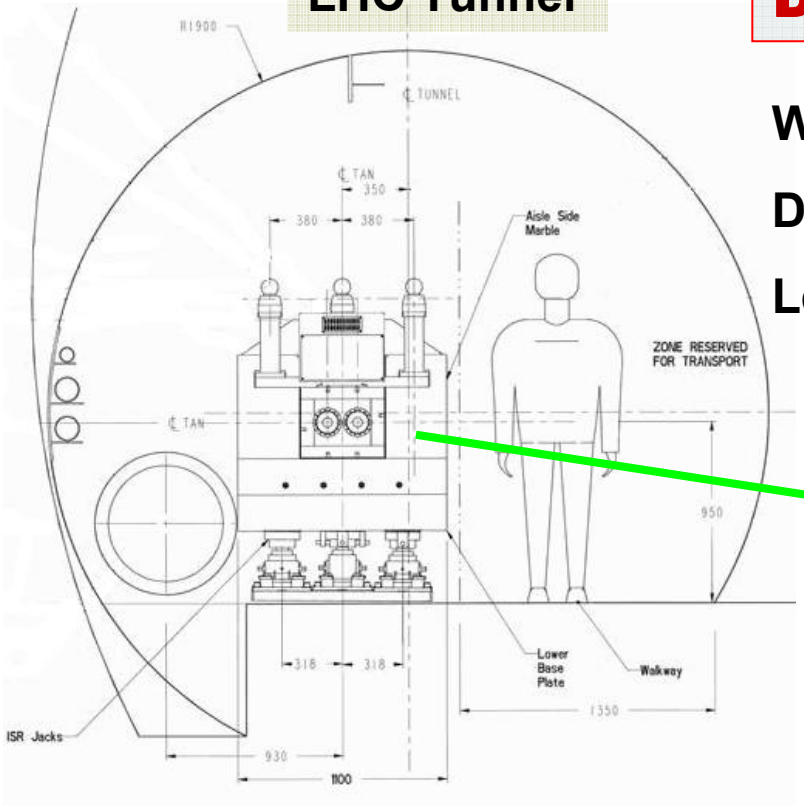
ZDC for neutron tagging

Description of ZDC

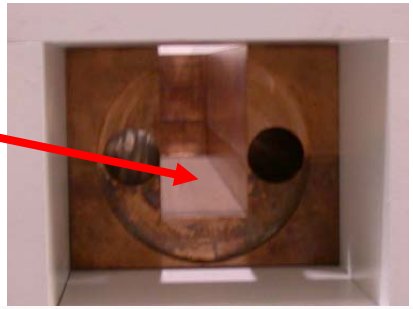


Description of ZDC

LHC Tunnel



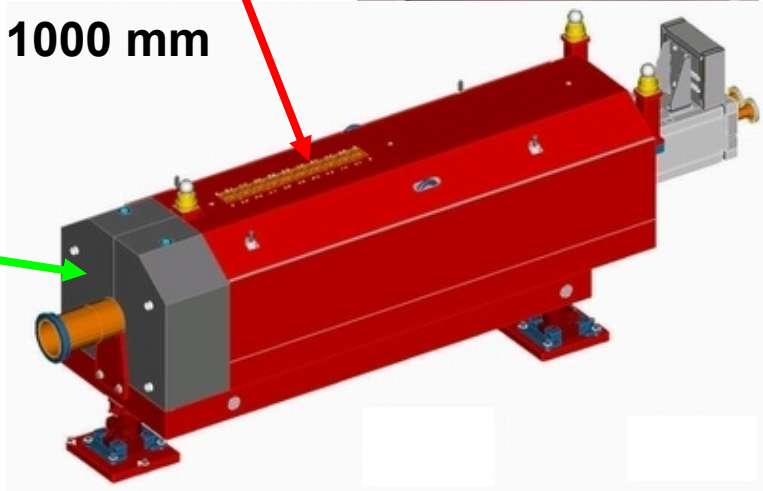
Detector slot



Width 96 mm

Depth 607 mm

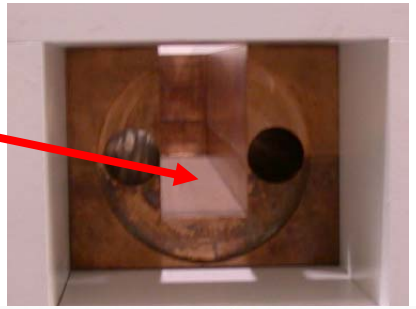
Length 1000 mm



Neutral particle absorber (TAN)

Description of ZDC

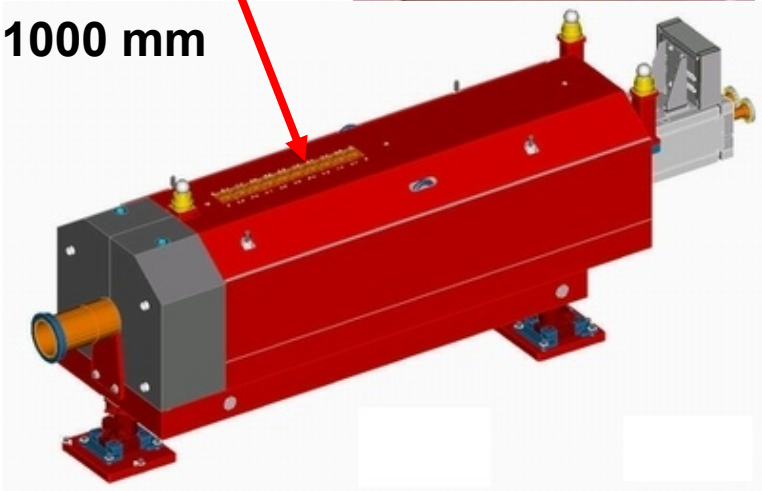
Detector slot



Width 96 mm

Depth 607 mm

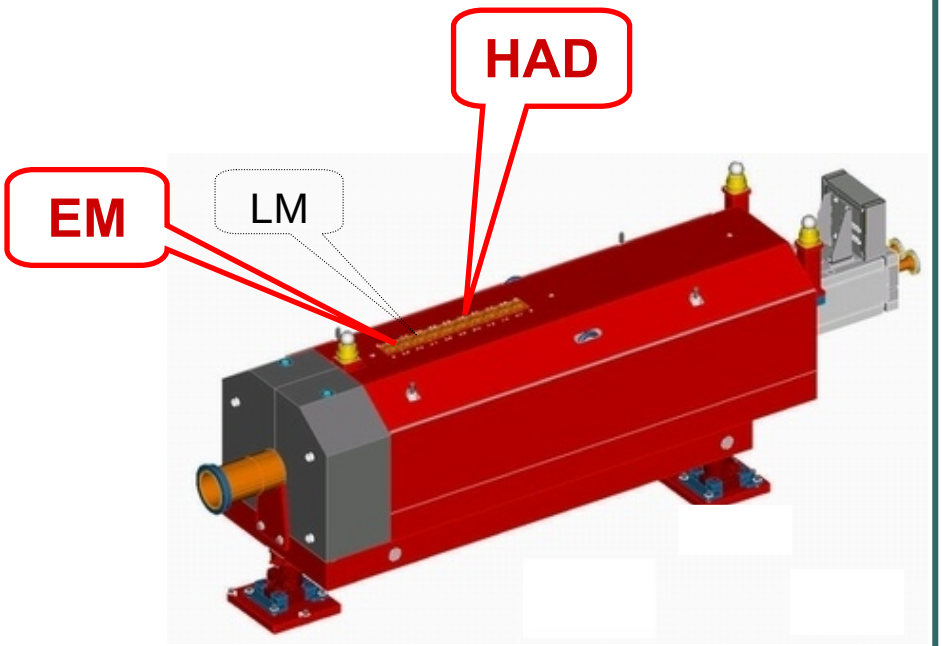
Length 1000 mm



Neutral particle absorber (TAN)

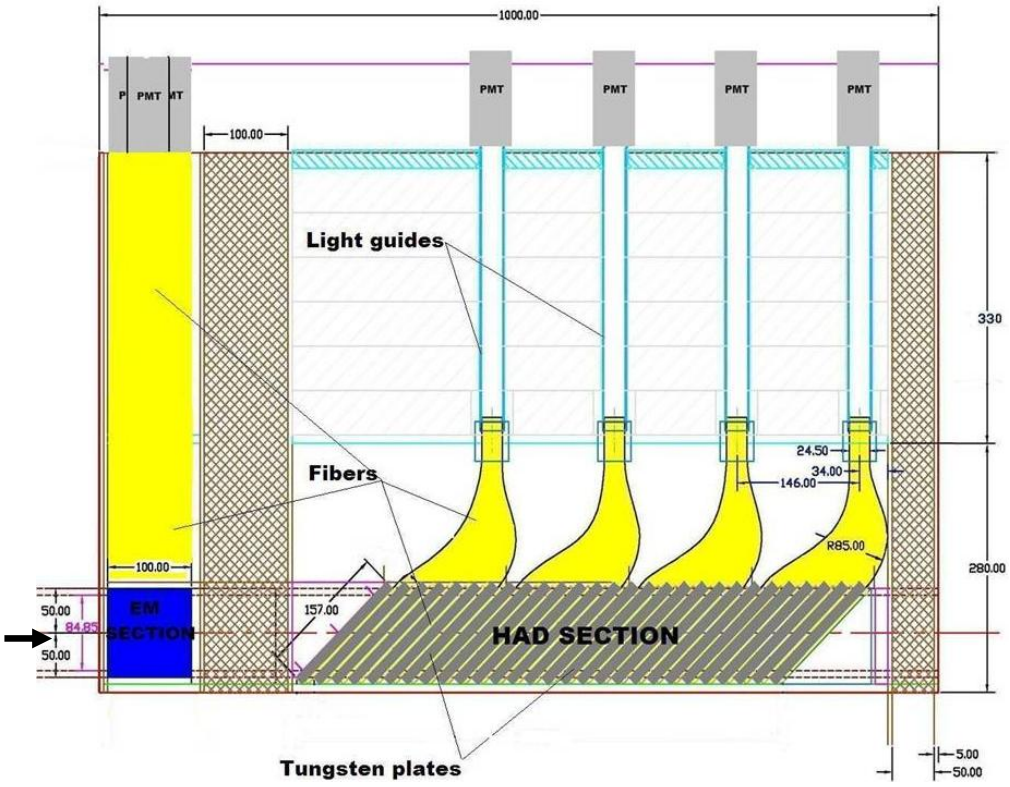
Description of ZDC

The detector slot will house the pp machine Luminosity Monitor (LM). It will have a length of 10cm and will need to have an absorber in front of it. This absorber will be the Electromagnetic Section (**EM**) of the ZDC with length of 10cm. The ~75cm behind the luminosity monitor will be used for the Hadron Section of ZDC (**HAD**)



Neutral particle absorber (TAN)

Description of ZDC



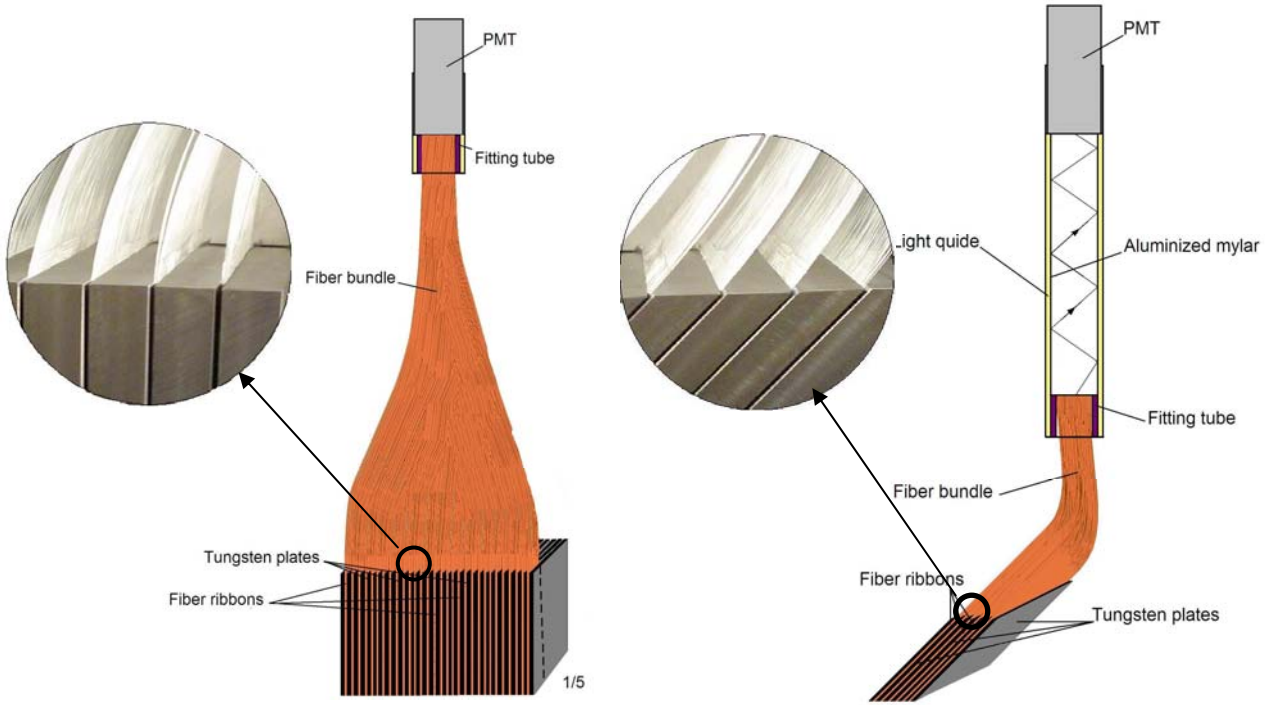
The physical characteristics of the ZDC

	HAD Section	EM Section
Sampling ratio	15.5mm W /0.7mm Q	2mm W /0.7 mm Q
Number of cells	24	33
Number of Nuclear Interaction (Radiation) Length	~5.6 λI	(~19Xo)

Schematic illustration of the detector's design.

Description of ZDC

Diagram of optical read-out schemes



Horizontal tower of EM section

Longitudinal tower of HAD section

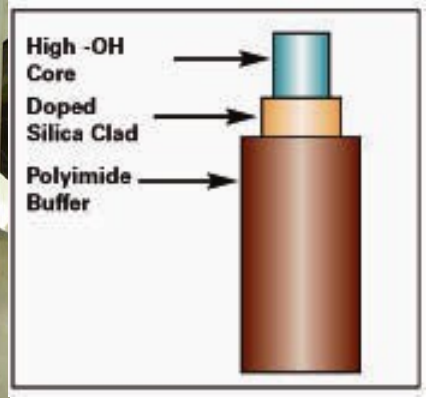
Construction material

Absorber:
tungsten alloy, THA18

Radiator:
quartz/quartz fibers

Photodetector:
PMT R7525

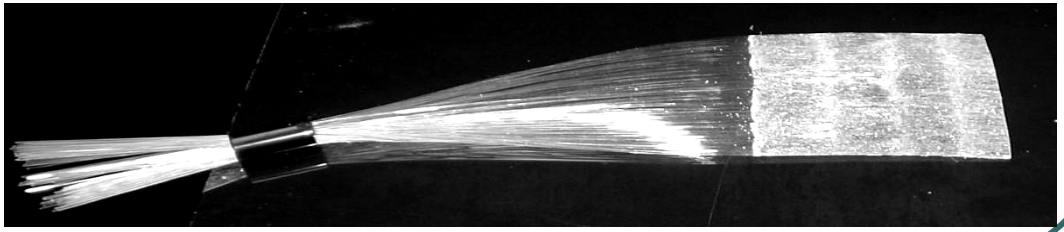
Description of ZDC



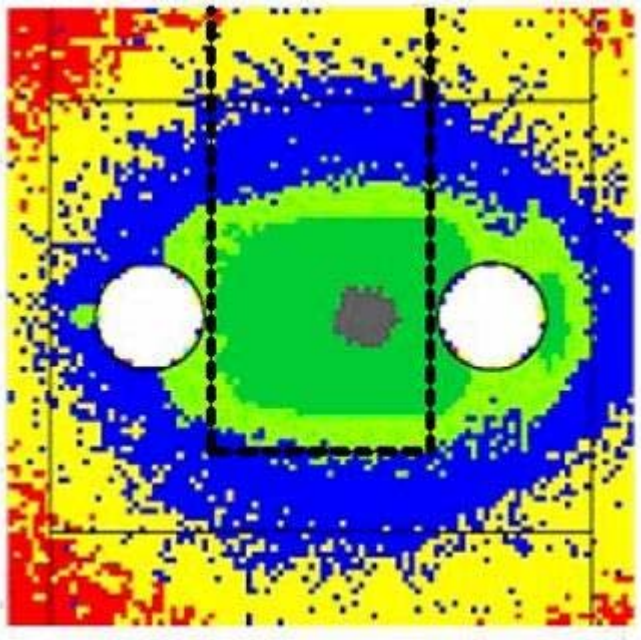
Structure of Quartz/Quartz fiber:

0.6 mm – diameter of core;
0.63 mm – diameter of doped silica clad;
0.05 mm - thickness of polyamide buffer

Fiber bundle



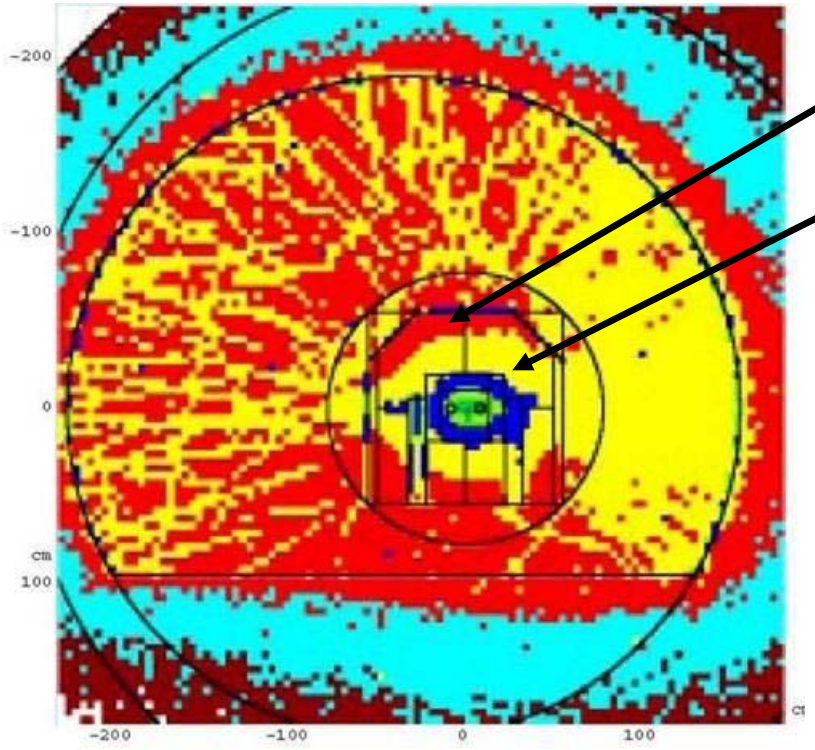
Radiation Environment



Isocontours of yearly accumulated dose (dashed line is a contour of the ZDC).

For one month of Pb + Pb run: 30 MRad
For p + p : 18 GRad/year
(N.V.Mokhov et al., FERMILAB – FN – 732, April 2003)
It was shown [P.Gorodetzky, Rad. Phys. and Chem. 41 (1993) 253.; http://uscms.fnal.gov/pub/hcal_tdr/] that the quartz/quartz fibers can withstand up to 30 GRad with only a few percent loss in transparency in the wavelength range of 300-425 nm. This should be sufficient for early p-p (first years of LHC operation) and for heavy-ion runs .

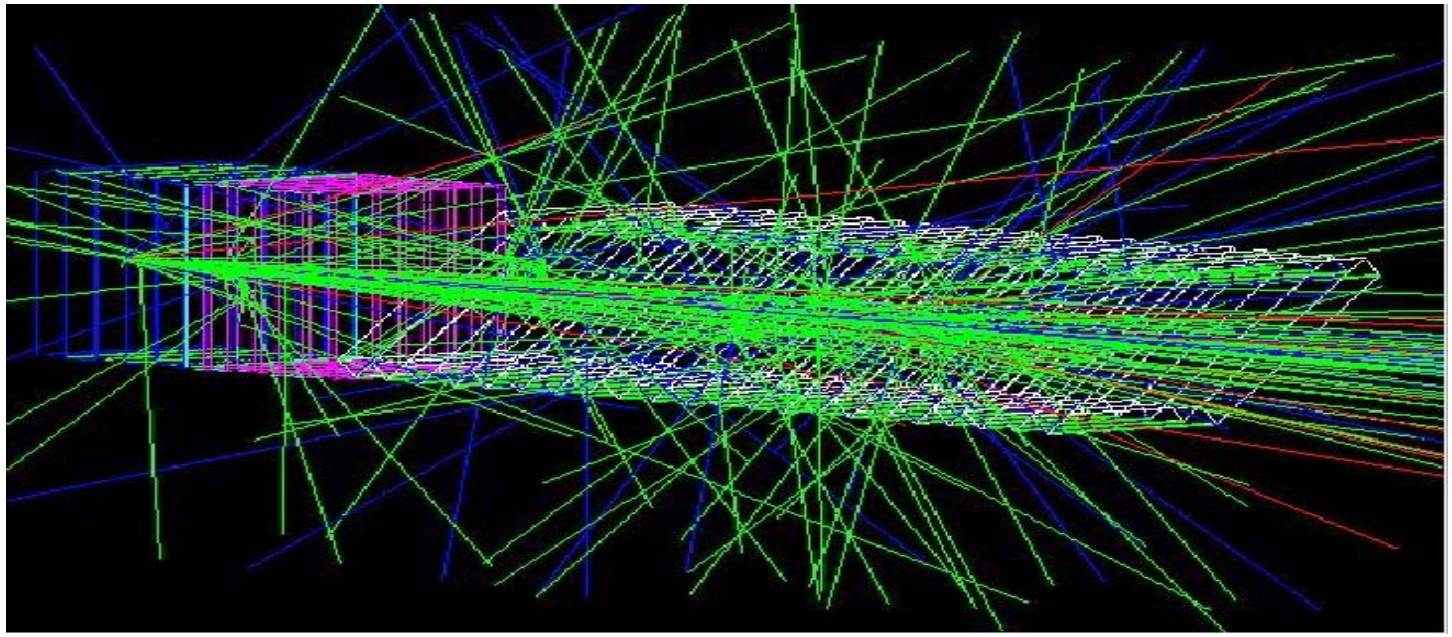
Radiation Environment



Yearly absorbed dose isocontours in the TAN and around at 55 cm from the entrance to the TAN core.

ZDC PMT area should see 10kRad/year during normal pp operation. This is comparable to the HF PMT R7525 environment and we can use this PMT with the same radiation shielding as HF.

HAD Section



GEANT 4 Neutrons with energy:

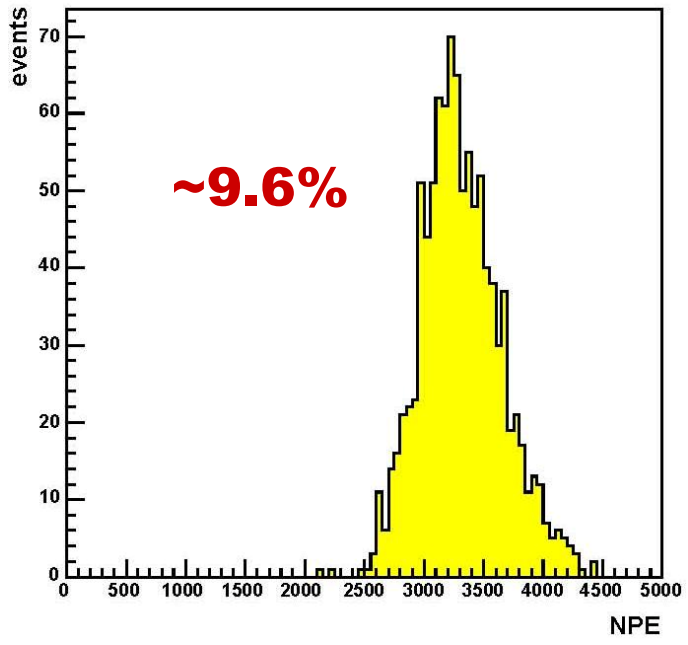
0.5 TeV
1.0 TeV
2.0 GeV

Geometry:

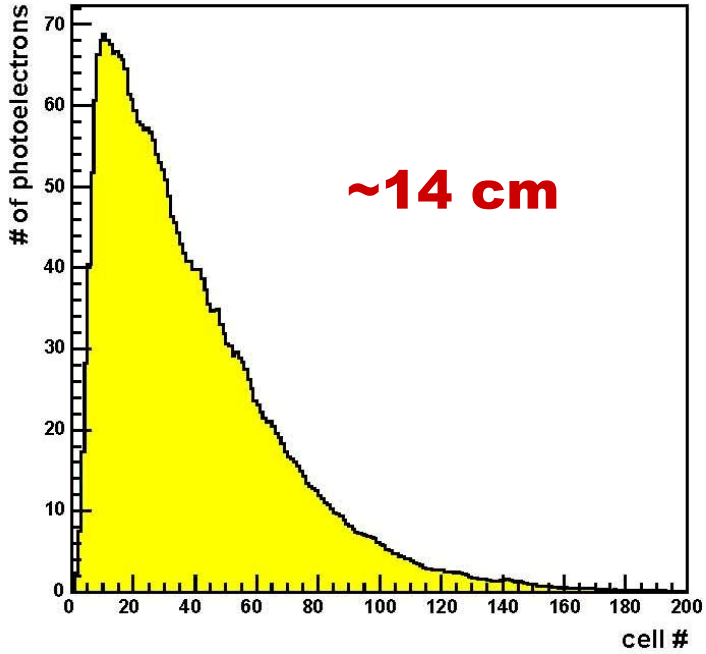
5mm, 10 mm W plate: 200, 100 cells
400, 600 and 800 microns core Quartz Fiber

HAD Section

1 TeV neutron photoelectron profile for 10 mm tungsten plate, 600 μm core quartz fiber cells (1000 neutrons)



Photoelectron distribution



Longitudinal photoelectron profile

HAD Section

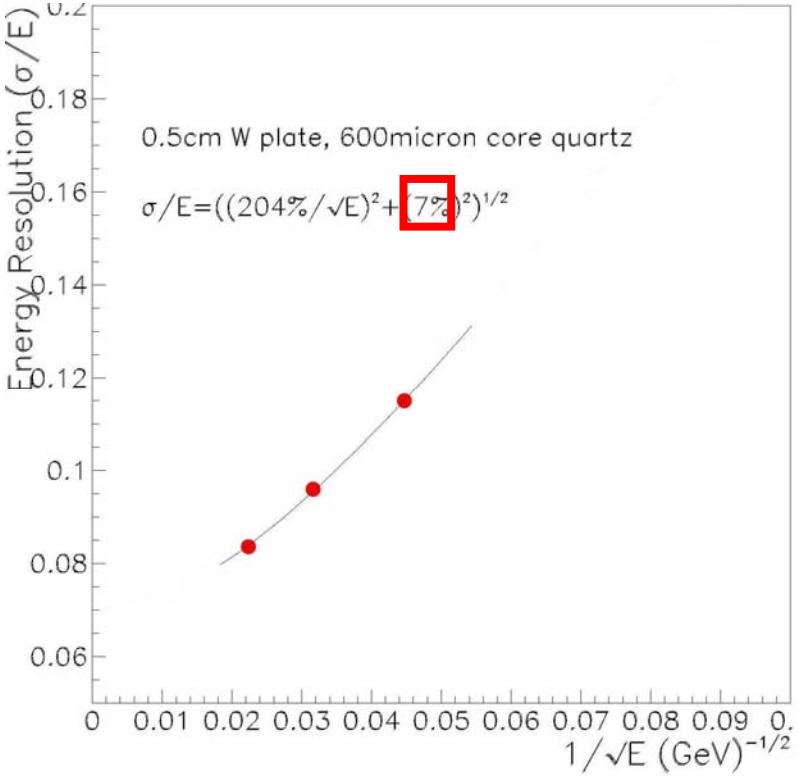
Resolution (and mean number of photoelectrons) vs. plate thickness & fiber diameter

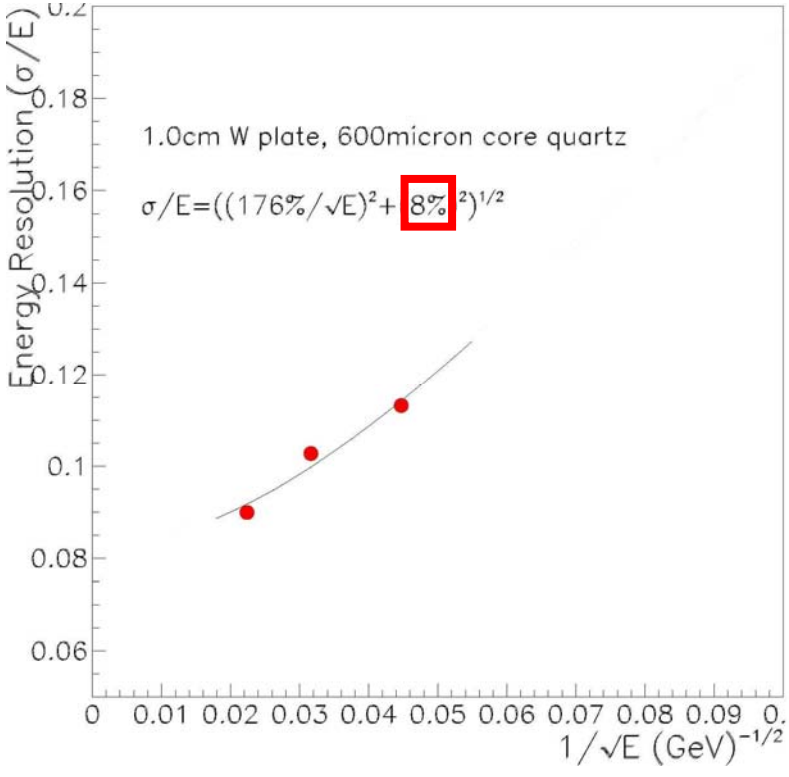
Plate		10 mm			5 mm	
Fiber	0.4 mm	0.6 mm	0.8 mm	0.4 mm	0.6 mm	0.8 mm
0.5 TeV	11.3(0497)	11.3(0760)	12.5(1039)	10.8(1033)	11.5(1583)	11.3(2212)
1.0 TeV	9.8(1026)	10.1(1586)	9.6(2143)	9.6(2125)	9.6(3309)	10.6(4558)
2.0 TeV	9.1(2127)	8.9(3281)	9.1(4454)	8.8(4314)	8.3(6820)	8.6(9774)

At the TeV scale, we have not observed a significant difference in the resolution between 5 mm and 10 mm tungsten plates and different quartz fiber core diameter.

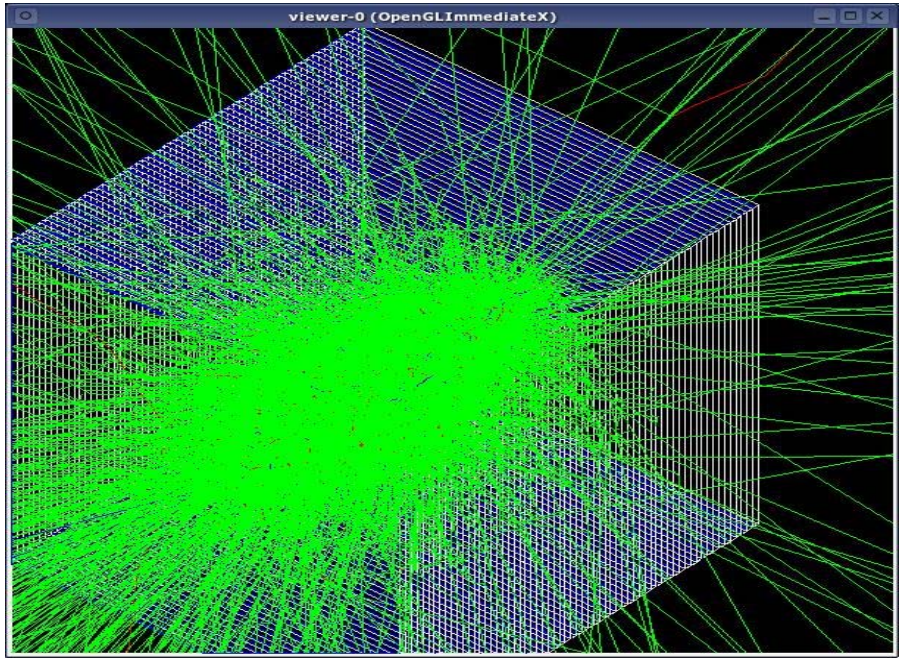
HAD Section

Energy resolution





EM Section



GEANT 4
Photons with energy:

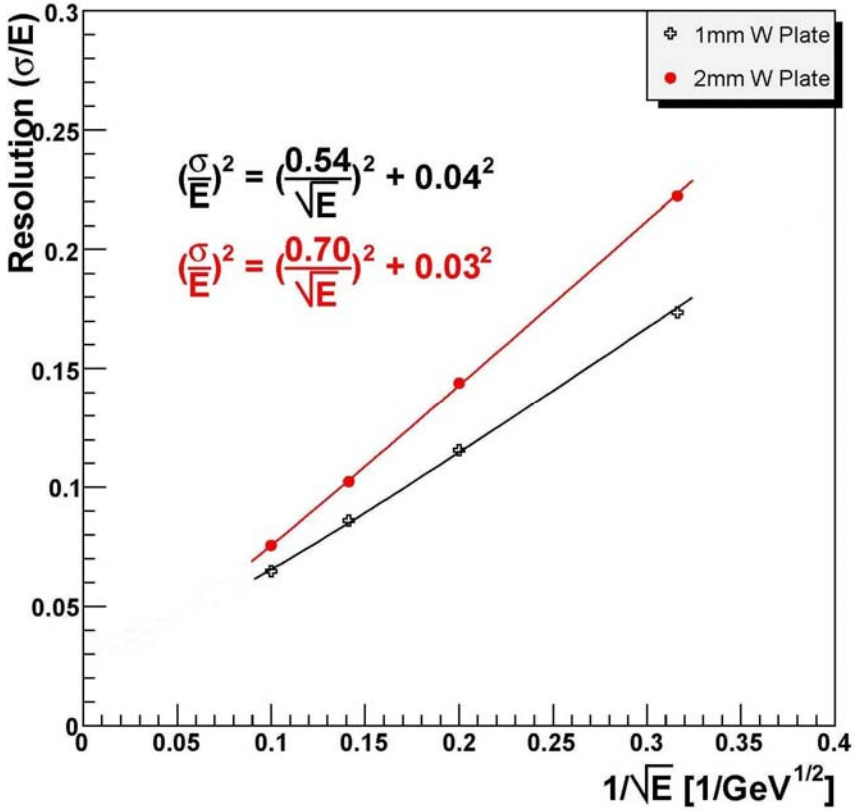
10 GeV
25 GeV
50 GeV
100 GeV

Geometry:

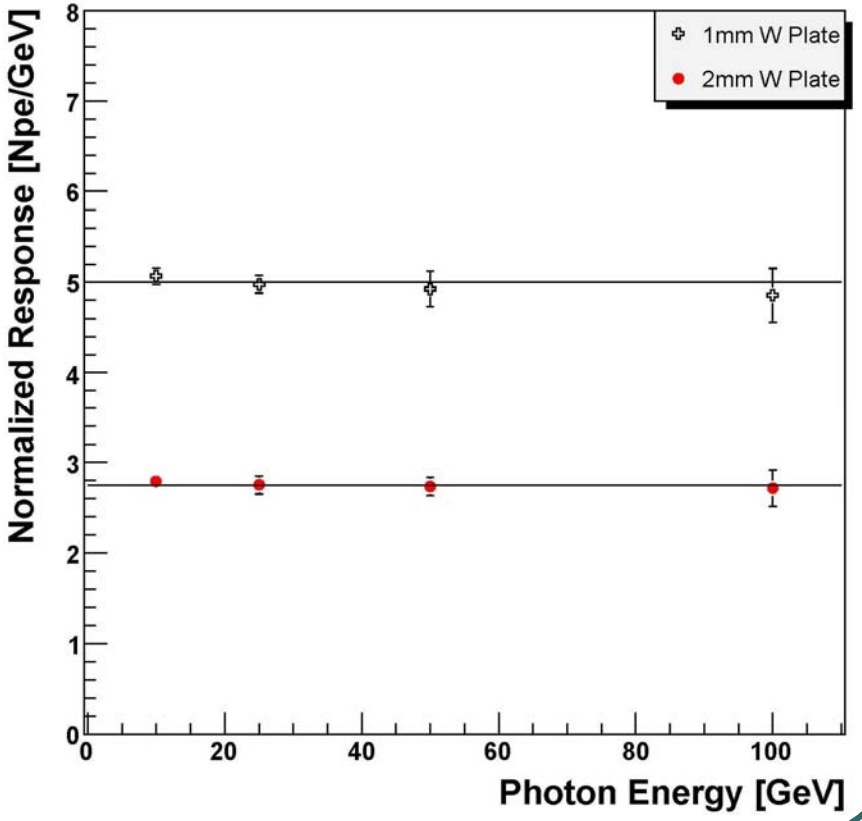
2mm W plate, 600 microns core Quartz Fiber: 33 cells x 3 mm = 9.9 cm
1mm W plate, 600 microns core Quartz Fiber: 50 cells x 2 mm = 10 cm

EM Section

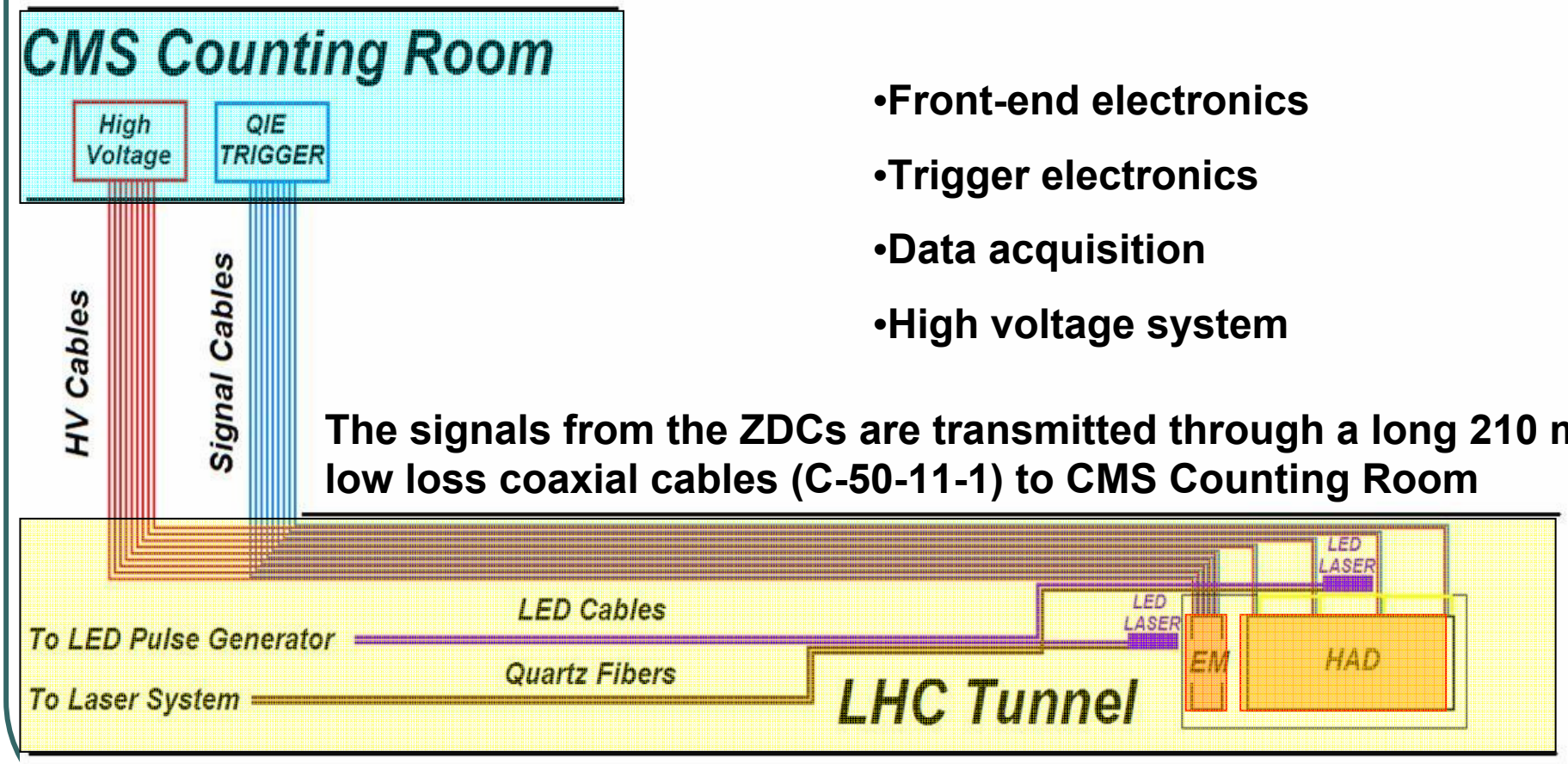
Energy Resolution



Response Linearity to Photons



Electronics

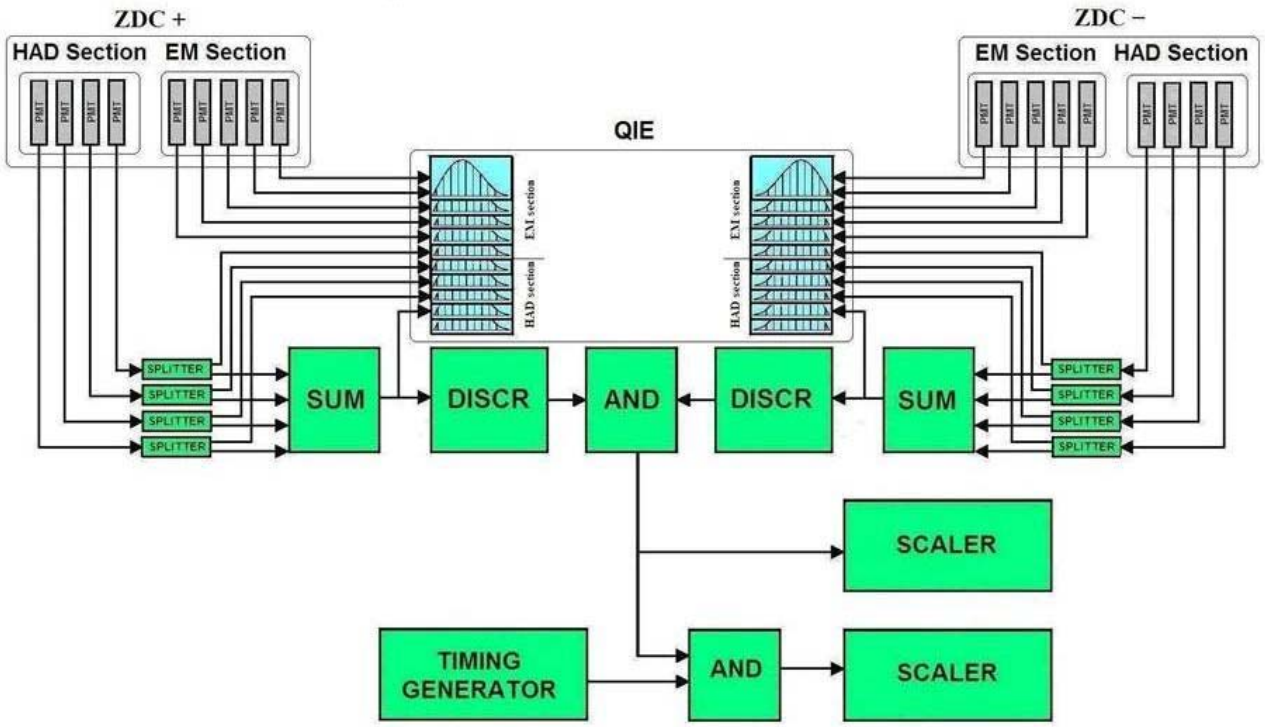


- Front-end electronics
- Trigger electronics
- Data acquisition
- High voltage system

The signals from the ZDCs are transmitted through a long 210 m low loss coaxial cables (C-50-11-1) to CMS Counting Room

Electronics

ZDC electronic circuit



- **MB-trigger**
- **UPC-trigger**
- **Tuning beams**
- **Real-time luminosity**

Installation Schedule

Start 06/04/2007 for 2 weeks

- No major problems in the detector installation schedule vs machine installation schedule

Start 9/18/2006 for 2 weeks