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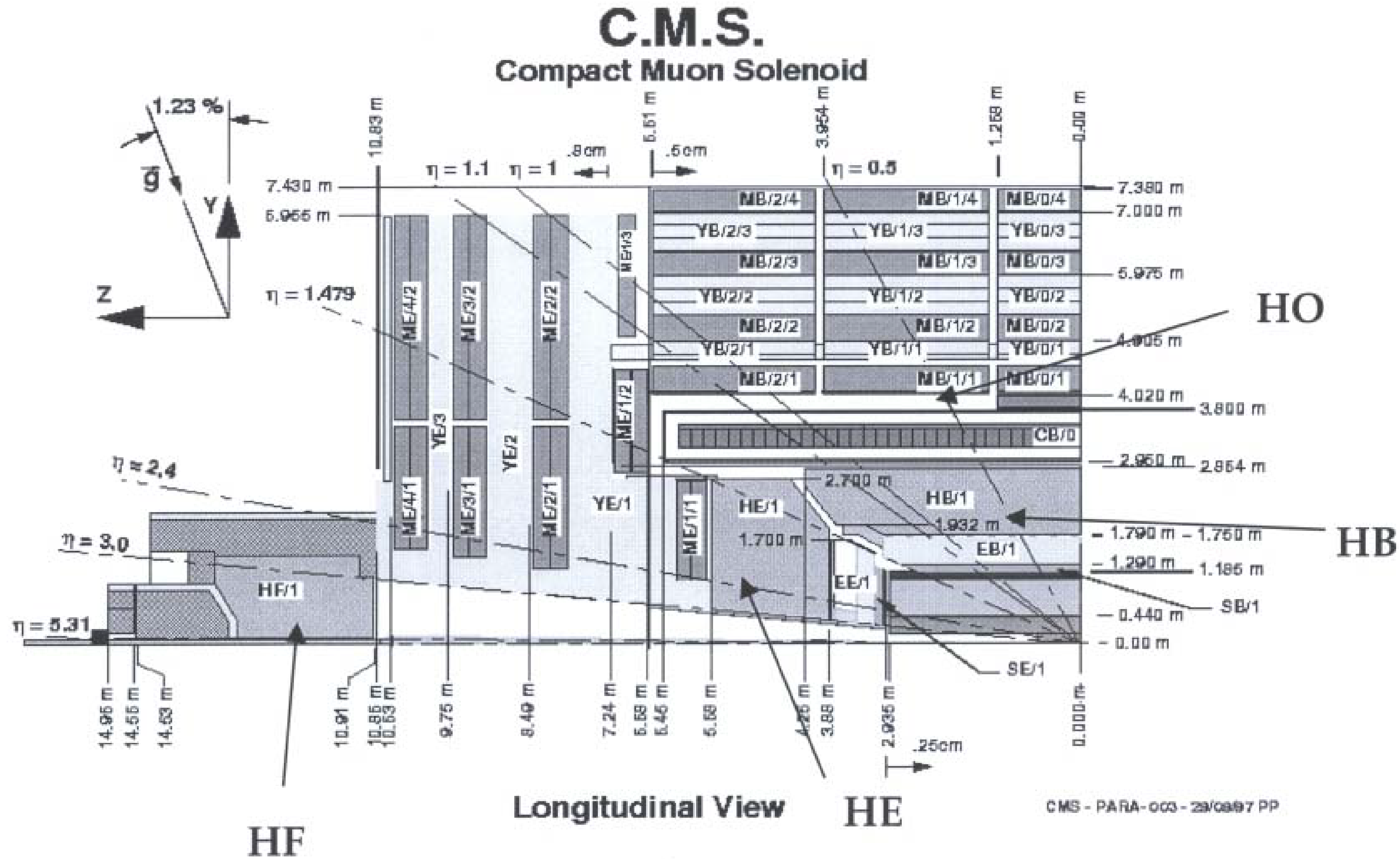
CALOR 2000, ANNECY

CMS HADRON CALORIMETER

- TECHNICAL ISSUES
- DESIGN DETAILS
- CONSTRUCTION : ABSORBER & OPTICS
- CRITICAL ISSUES / SUMMARY

CMS Detector Overview



Requirements

- CMS HCAL in the central region (eta < 3) is a sampling calorimeter : brass plates interspersed with scintillators
- Essential characteristics: good jet energy resolution and missing transverse energy resolution
- This requires:

  => good hermeticity and transverse granularity

  => sufficient depth for hadron shower containment

  => minimal dead zones to measure missing energy

Technical issues specific to CMS

- Calorimeter Performance in 4 Tesla Magnetic field
  magnetic field has two-fold effect on the response of the calorimeter. First it changes light yield of the scintillator and secondly, it affects the particle shower development. The second effect depends on the field orientation.
- HCAL resolution with and w/o crystal ECAL

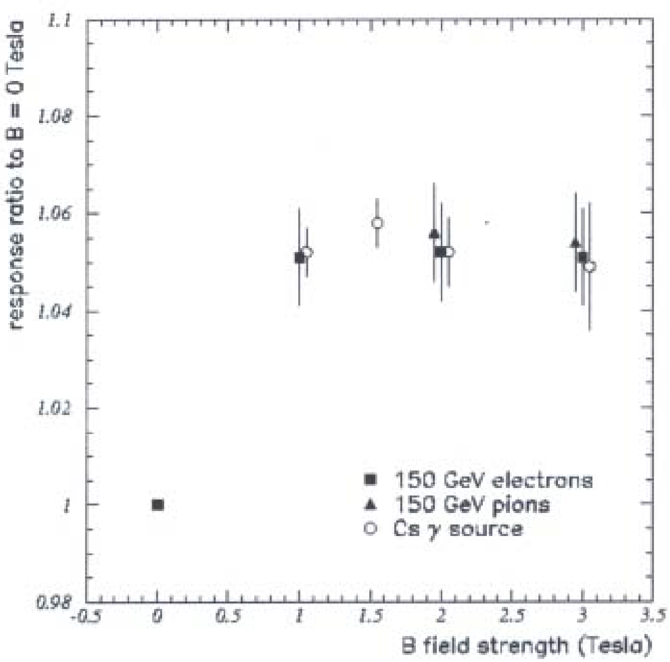
  presence of highly non-compensating lead tungstate crystal electromagnetic calorimeter (ECAL) degrades the overall response of the combined ECAL+HCAL calorimeter to hadrons.
- Radiation damage of clear and WLS fibers

  assuming int. luminosity of 5x10**5 pb-1 for first ten years

  of LHC operations, radiation dose will reach 30 kRads for HB (eta=1.1). Radiation dose scales with 1/theta**3, so that

  high eta region (eta ~3.0, HE) is affected most (6 Mrads).

Magnetic Field effect, Endcap configuration

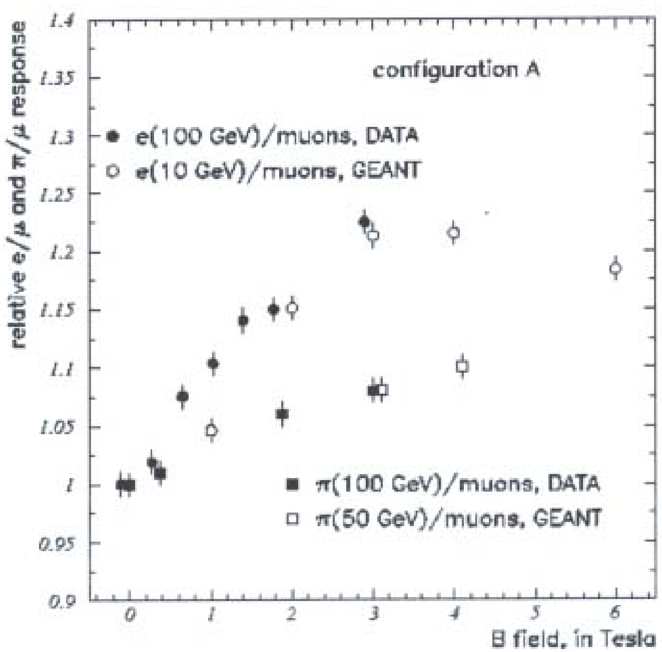


Average response of pions, electrons as a function of B field.

Increased response of pions and electrons is same as response of scintillator to gamma source.

B field lines are perpendicular to the scintillator plates

Magnetic Field Effect, Barrel configuration

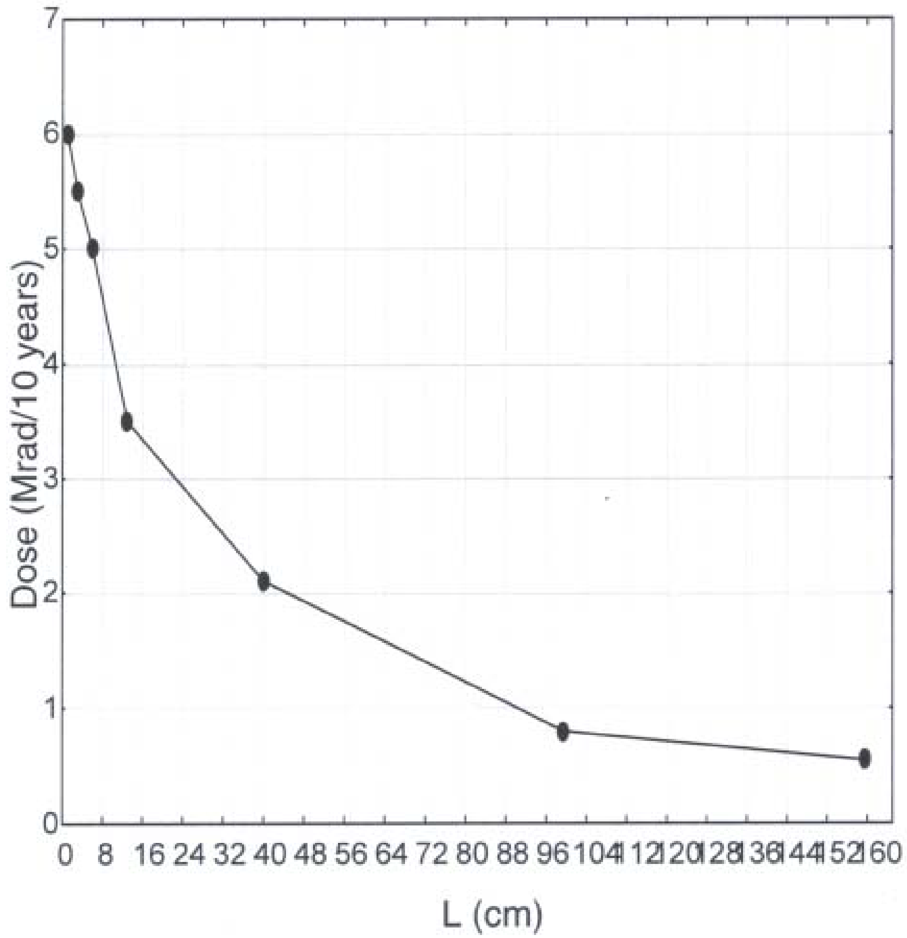


Effect of B field on response of pions and electrons

B field parallel to scintillator planes

Overall scintillator brightening effect is removed, since response of pions and electrons is divided by response to muons

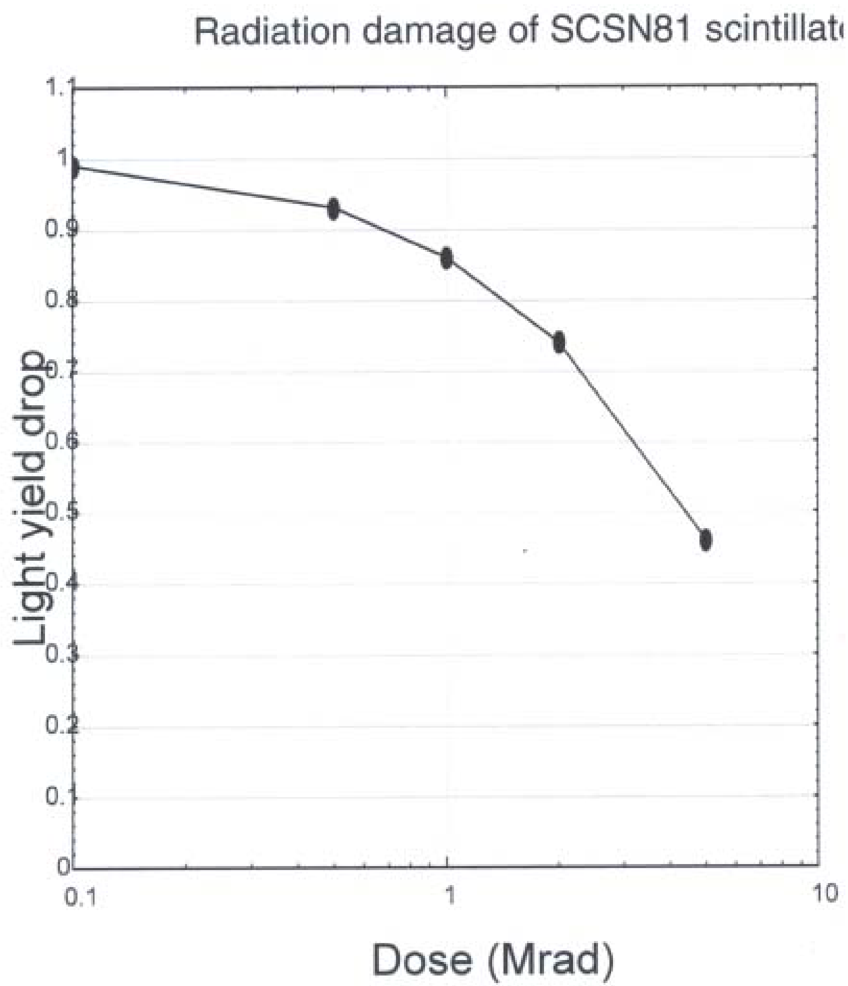
Radiation Dose at eta =3



Longitudinal distribution of dose vs calorimeter depth at eta=3 for 10 years of LHC operation:

=> Maximum dose of up to 6 Mrads at the front face of Endcap calorimeter

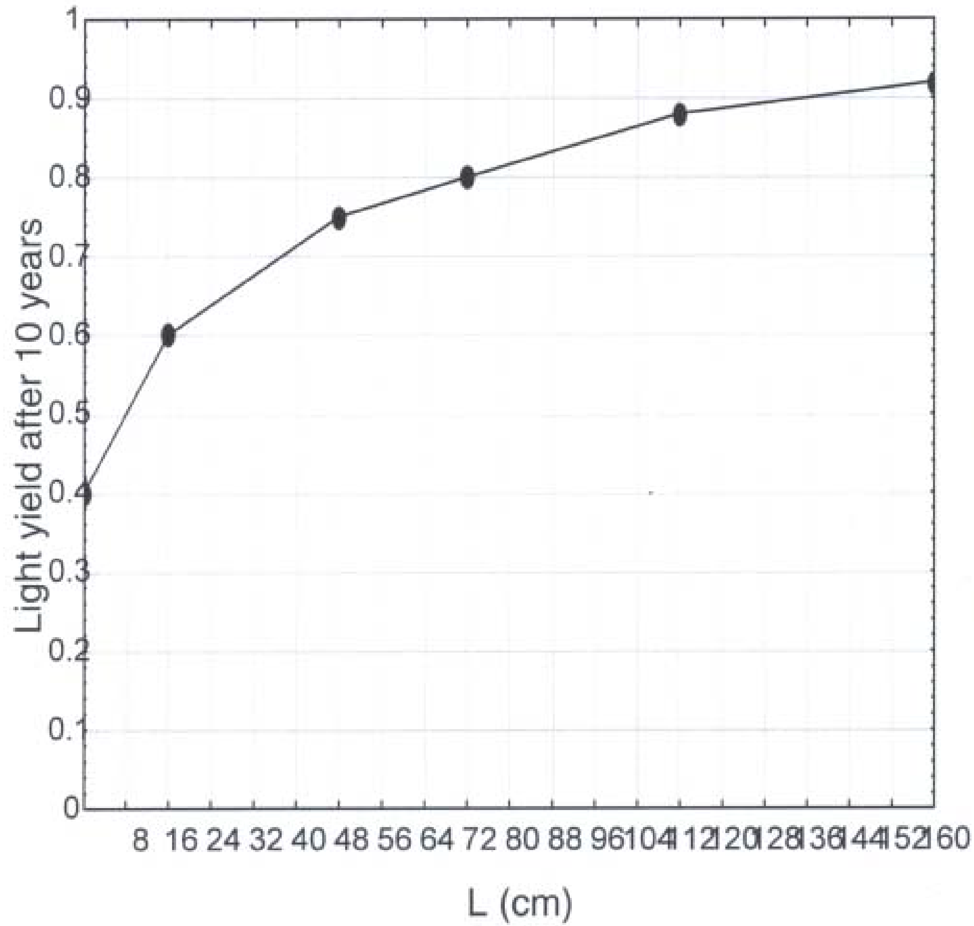
Radiation damage of scintillator



Radiation damage of scintillator (SCSN-81) vs Dose, after 3 weeks of annealing

=> Factor of 2 light reduction at 6 Mrads

Light Yield Degradation at eta=3

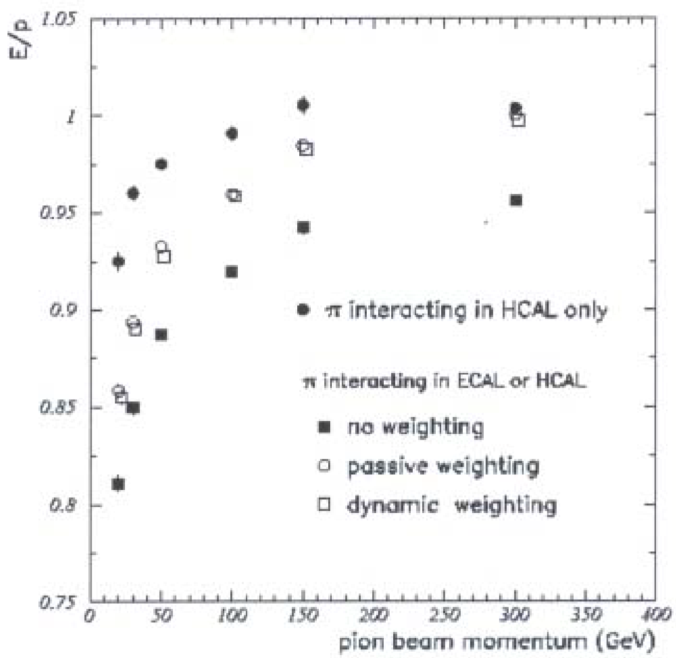


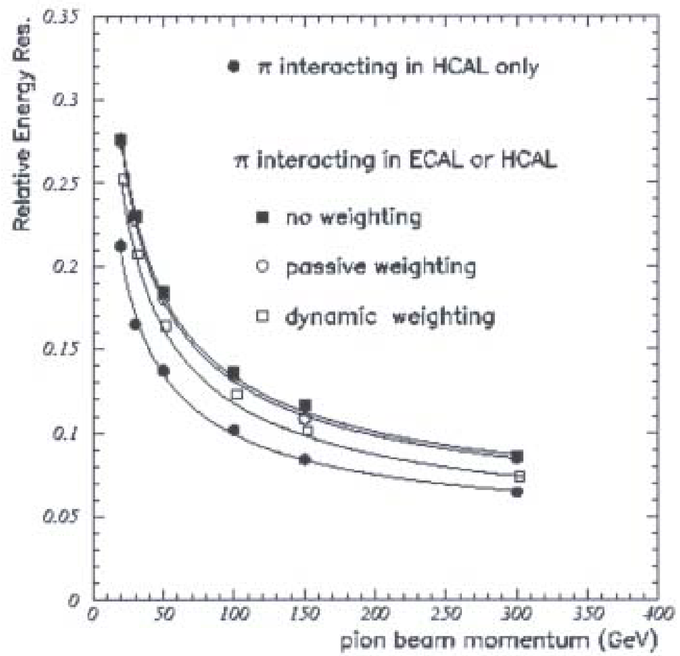
Dependence of light yield degradation after 10 years of LHC vs HE depth at eta =3:

=> Longitudinal segmentation

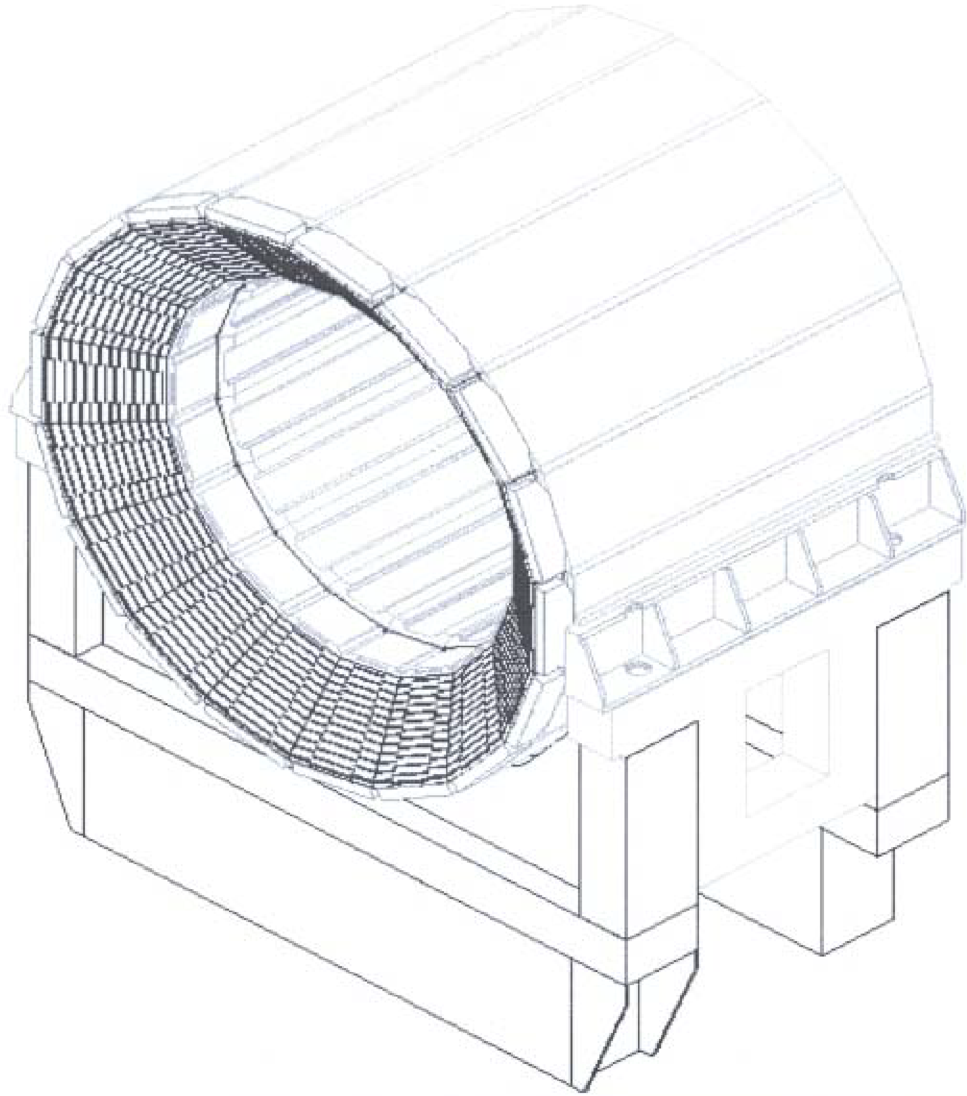
=> Compensate using source calibration

Combined ECAL+HCAL response:

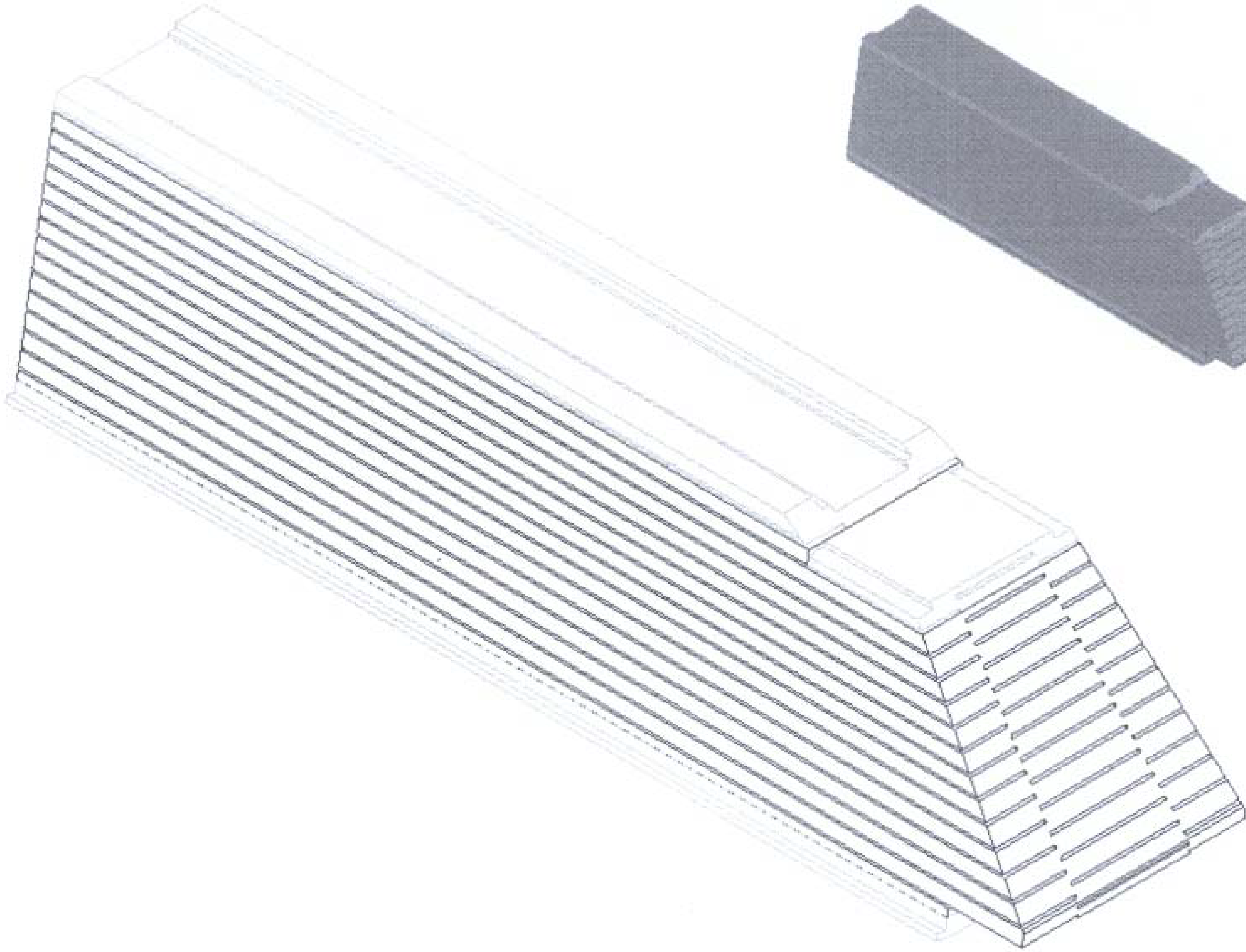




HCAL Half-Barrel



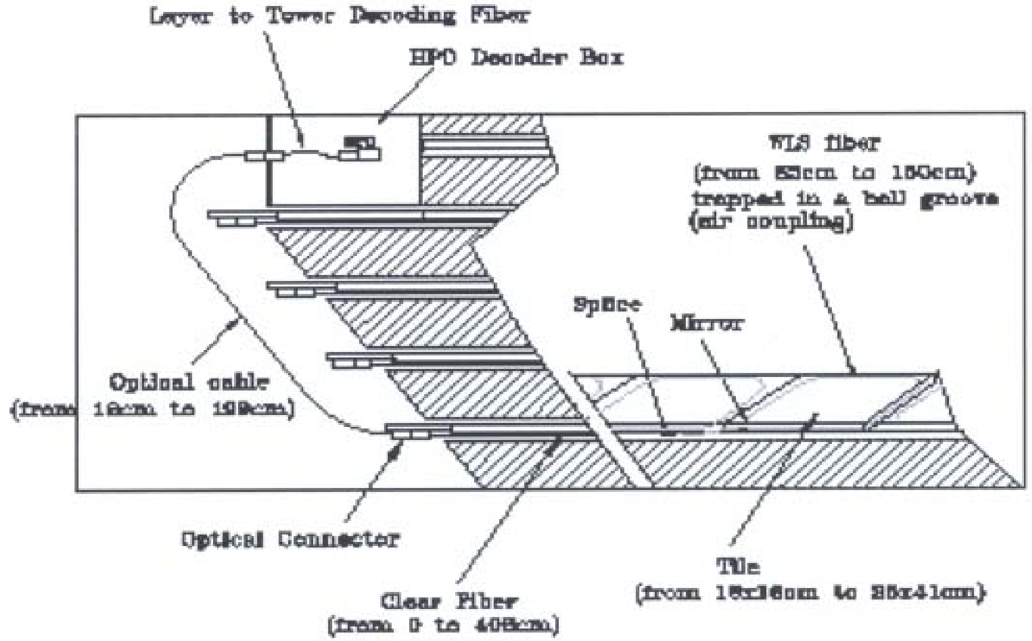
HB Wedge



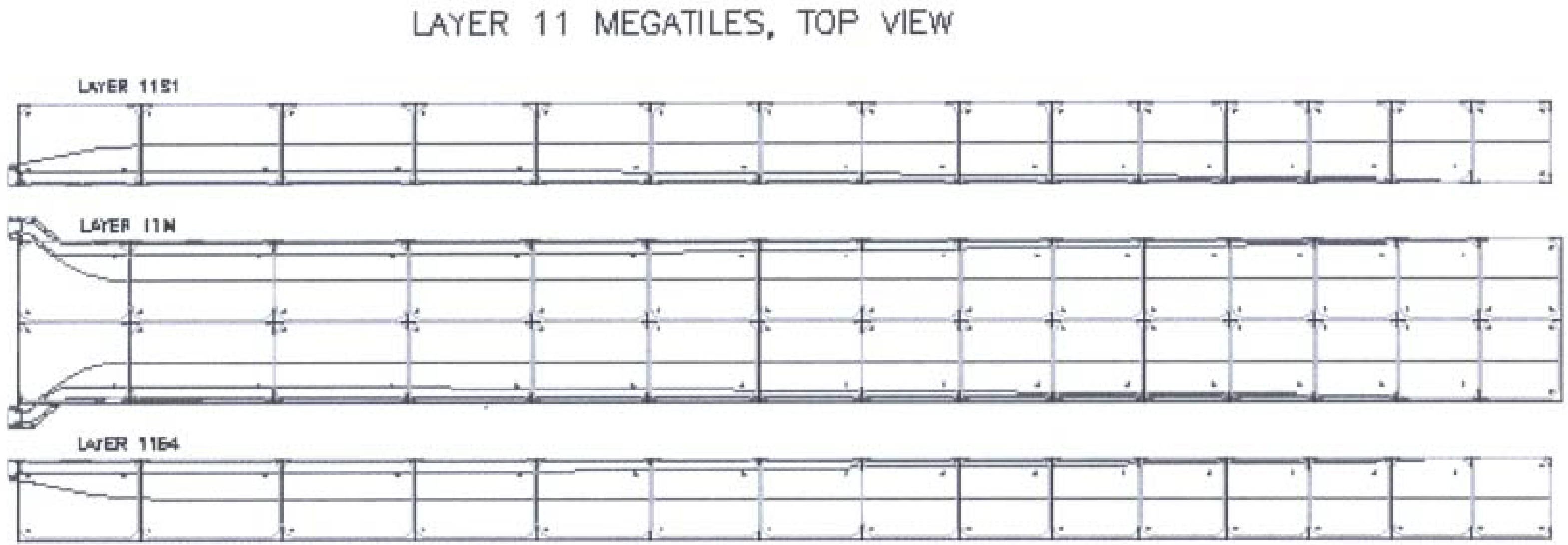
Design of Optical System

- Scintillation light is collected by wavelength shifting (WLS) fibers embedded in the tiles
- outside the tile, WLS fibers are spliced to clear fibers
- clear optical fiber cables with mass terminated connectors carry light to the outside of the detector
- decoder boxes re-group fibers from layer-wise to tower-wise scheme and house photodetectors
- CMS HCAL HB, HE and HO have adopted most of design features of the CDF End Plug Upgrade

Generic View of Optics Readout System



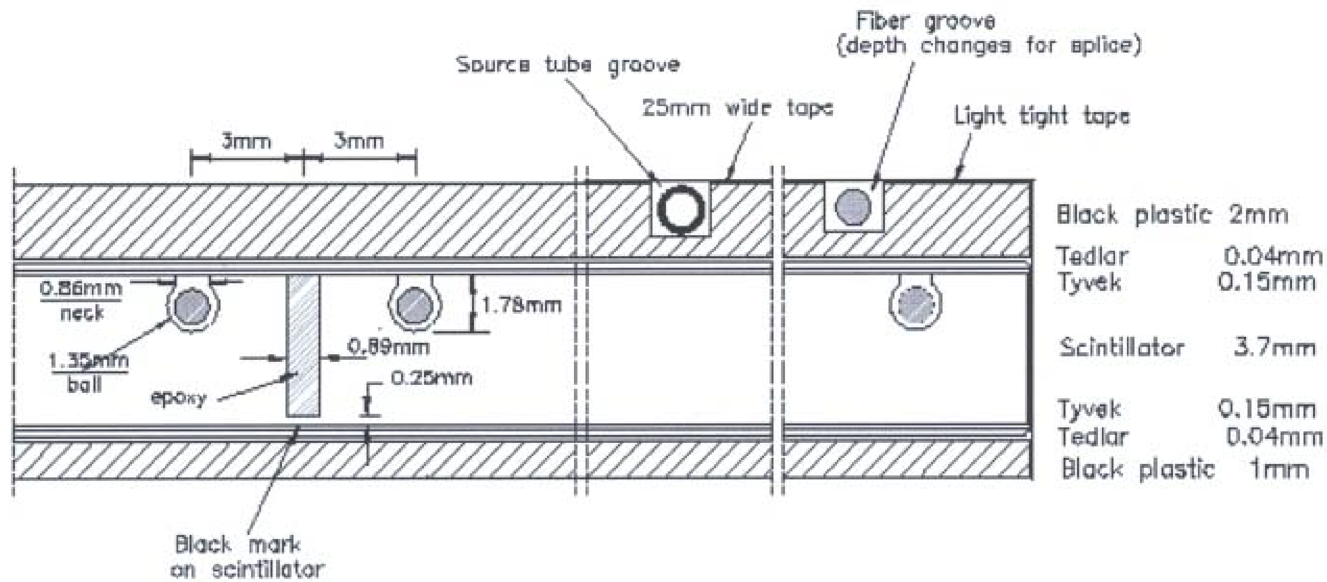
Optics-Megatiles



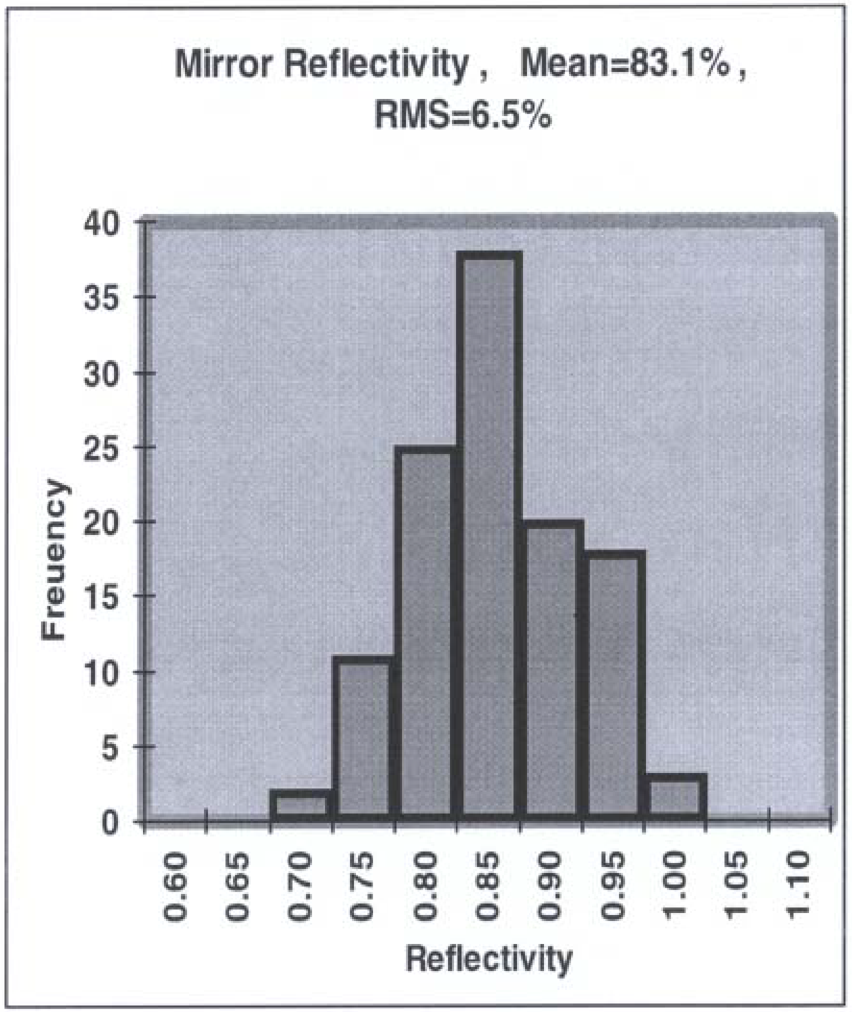
Components are the machined scintillator plates, cover plates, fiber assembly (WLS spliced to clear fiber, optical connector) pigtails

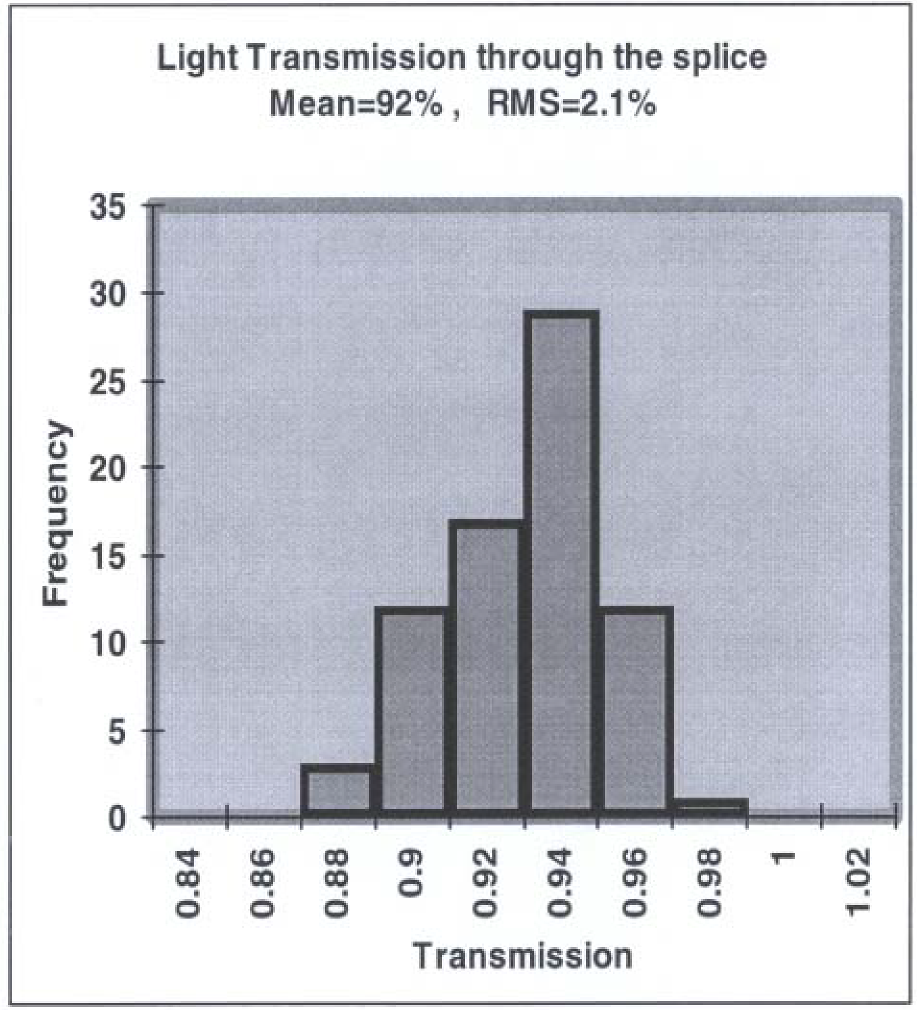
Optics-Megatiles

Cross section view of a megatile

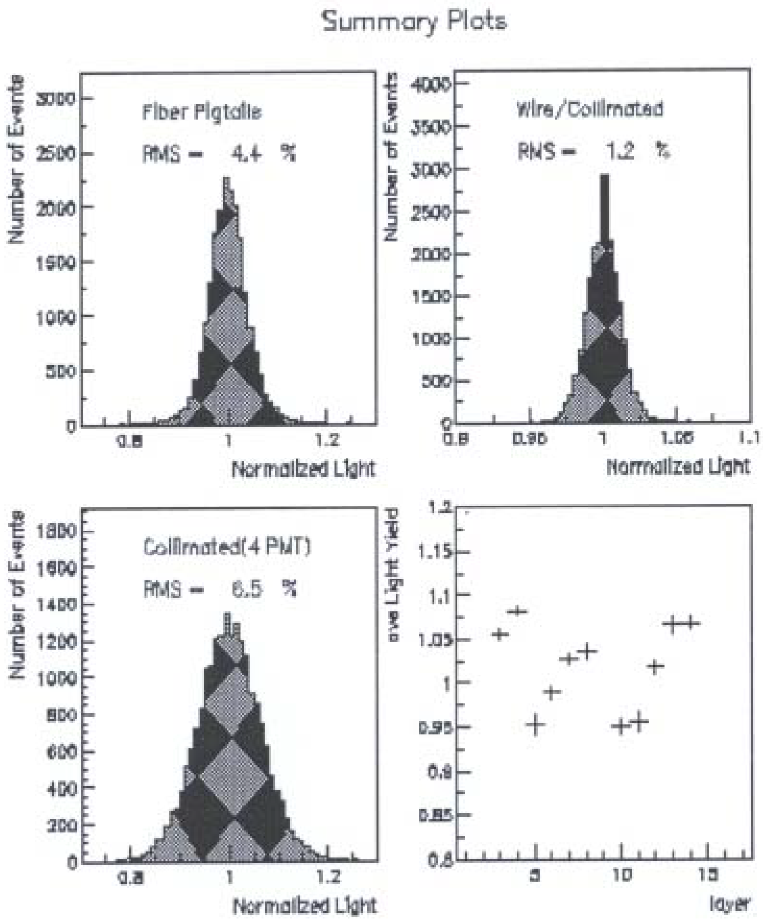


Mirror reflectivity and Splice transmission tests





Optics Quality Control



Over 20,000 scintillator tiles built and measured

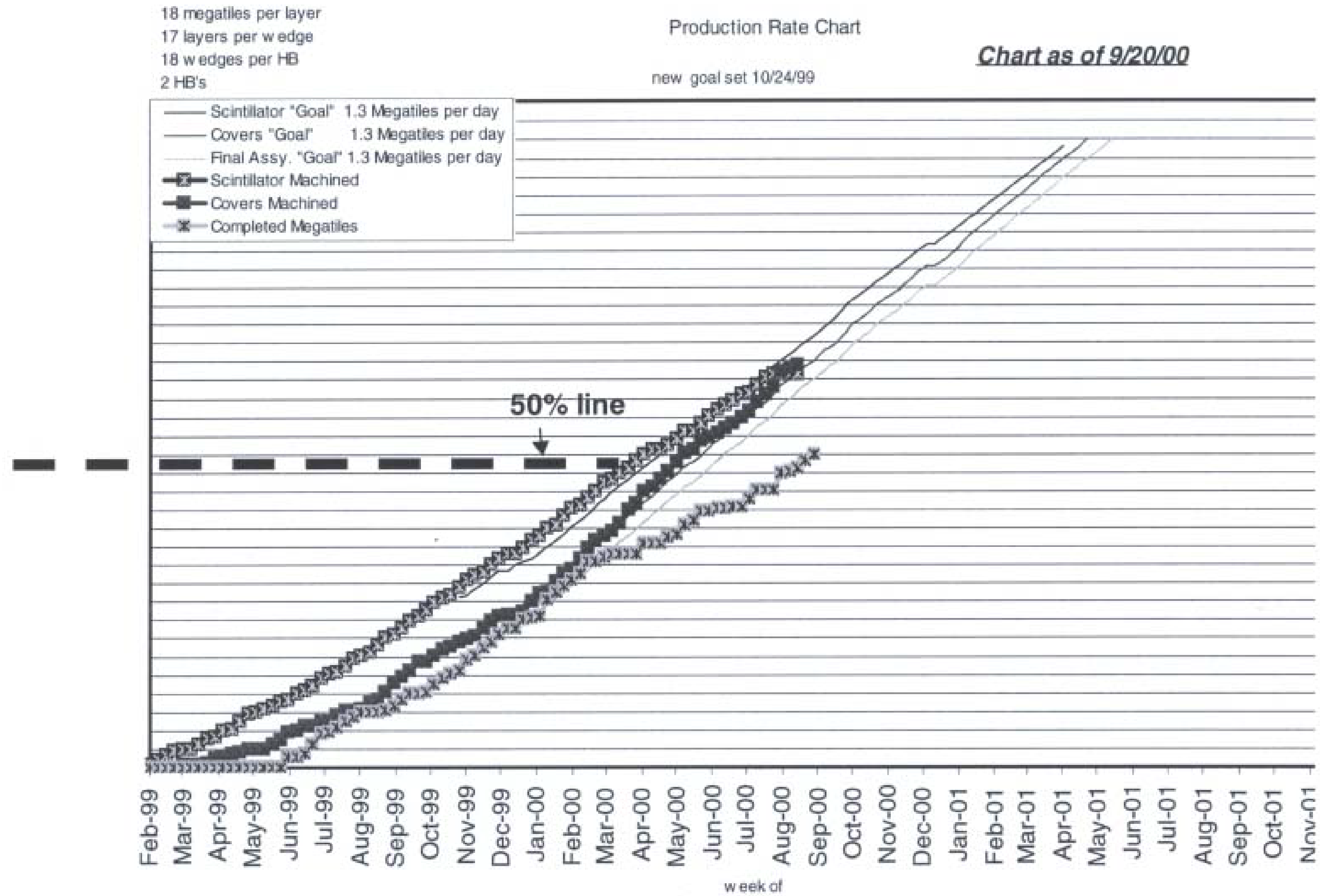
RMS of fibers = 4.4%

RMS of tiles = 6.5%

RMS of wire/coll = 1.2%

RMS of average layer light yield = 4.6%

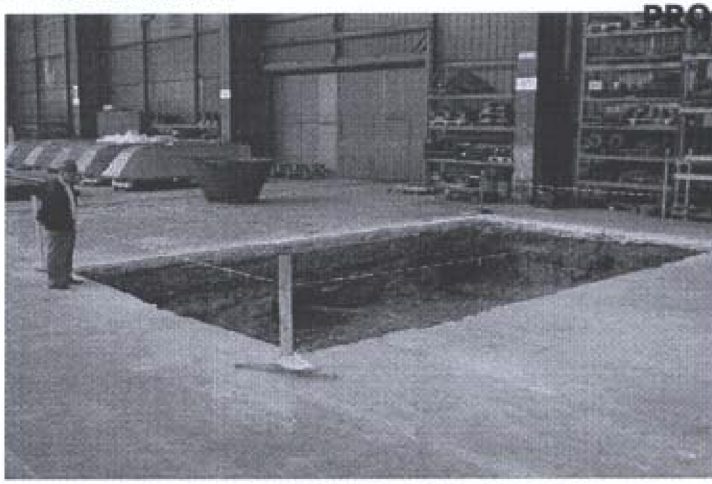
Assembly of Optics for HB



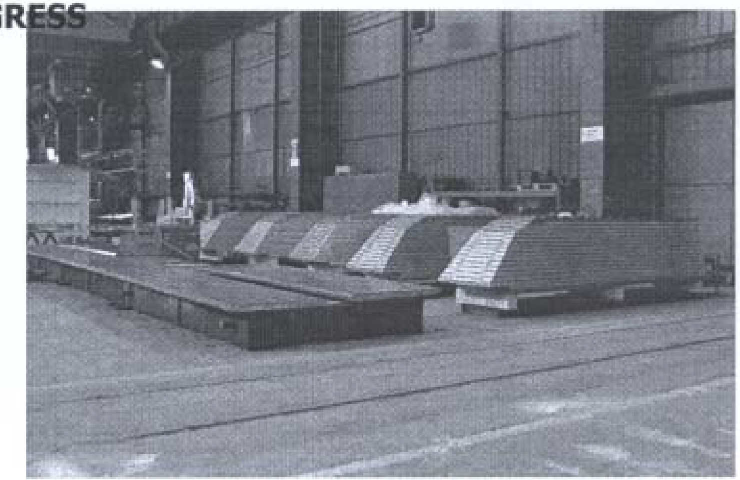
felguera construcciones mecánicas, s.a.

Wedges at FMC

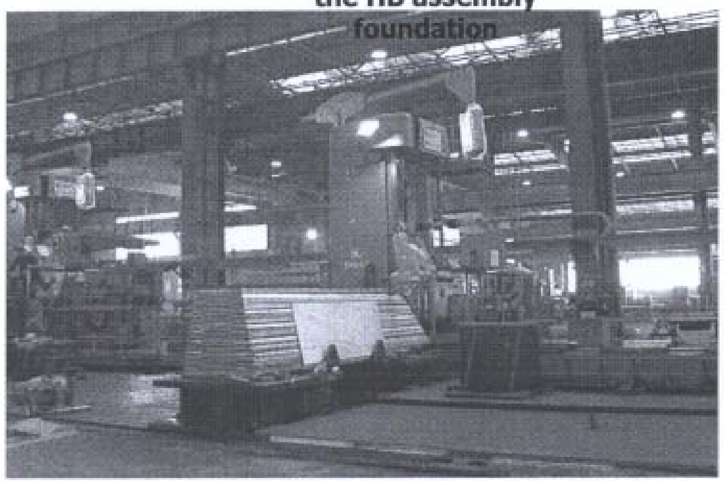
±HB MANUFACTURING PROGRESS



Preliminary works for the HB assembly foundation



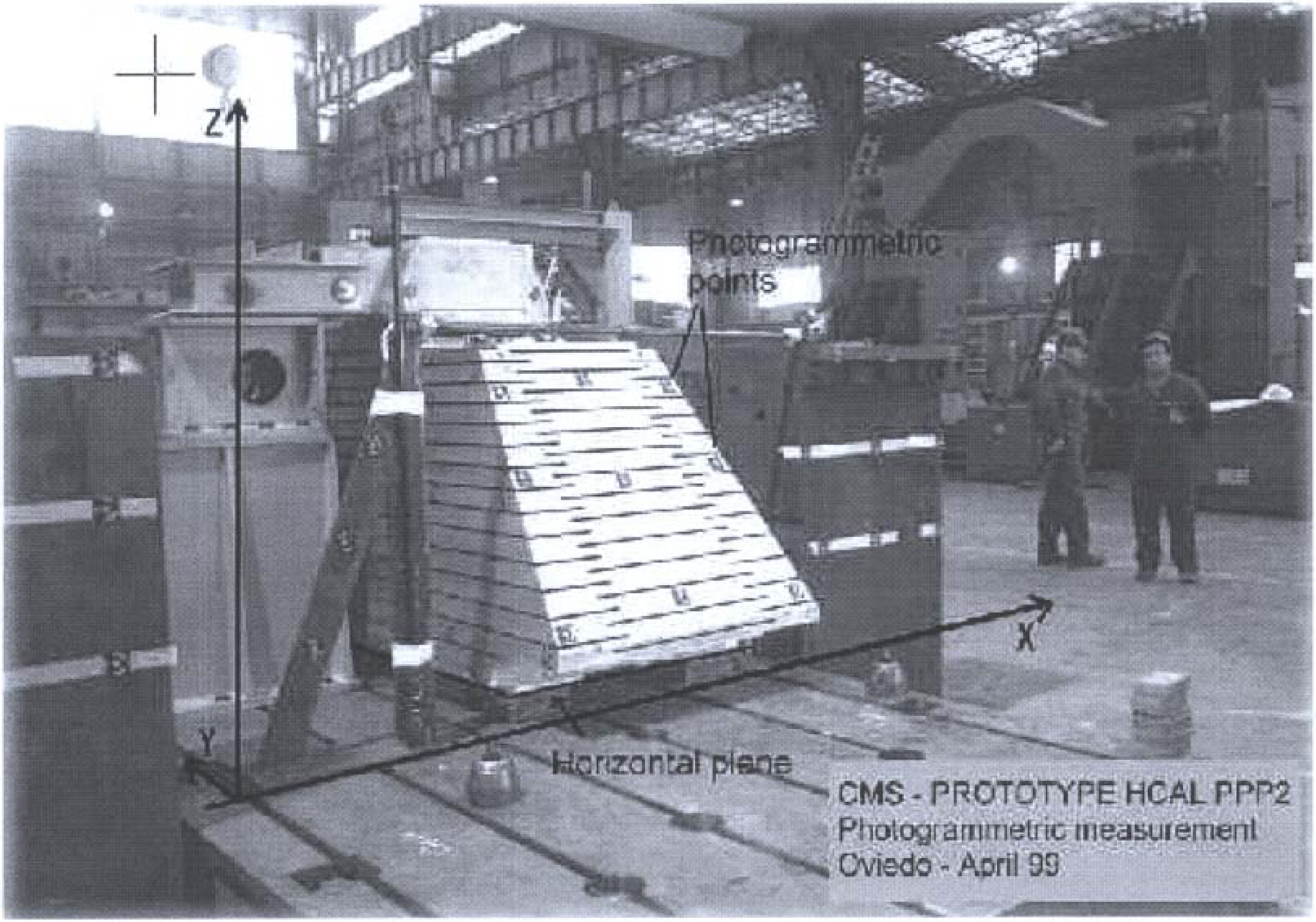
5 wedges of the 2nd set Finished



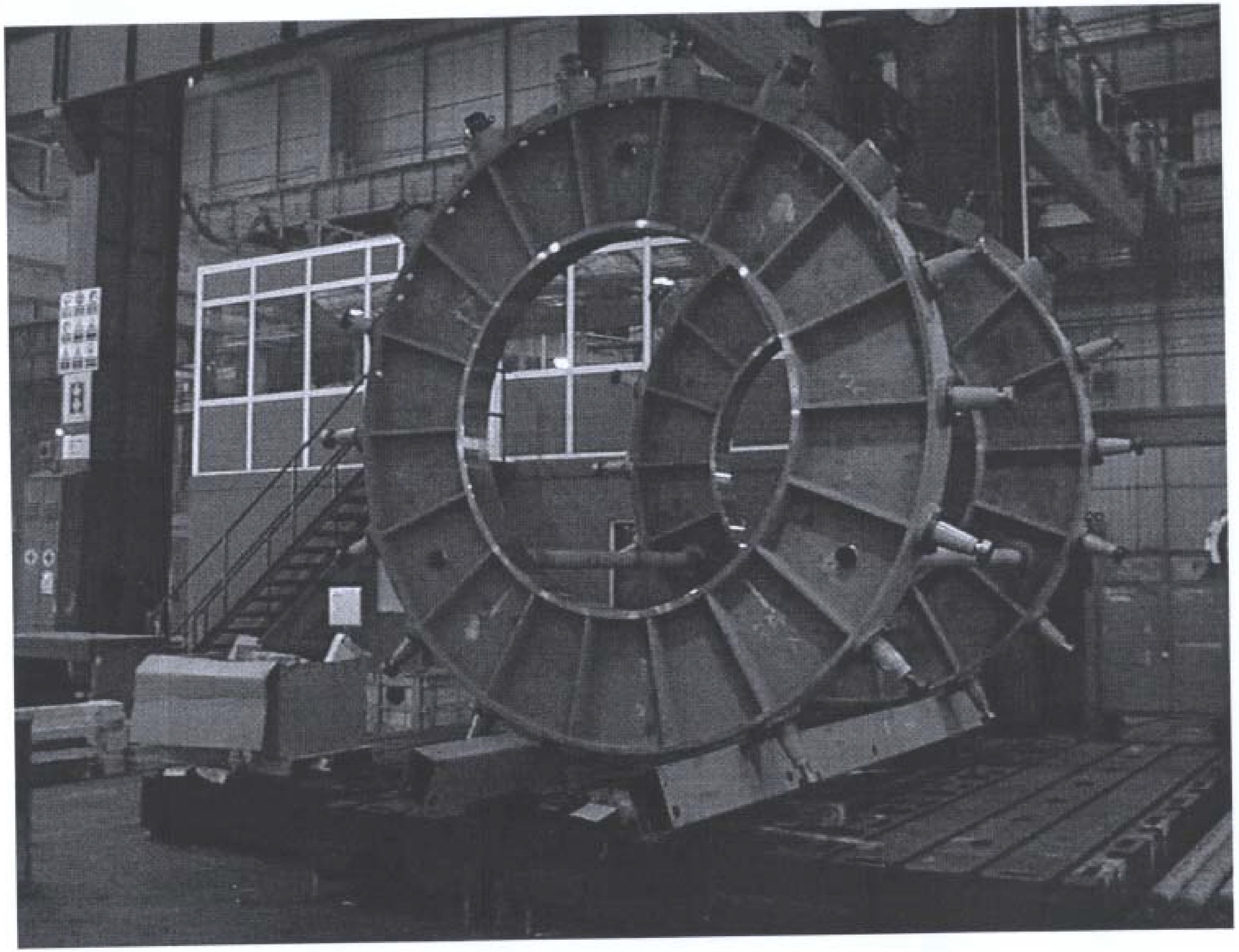
Last wedge of the 2nd set Final machining

6 wedges of the 3rd set Assembled

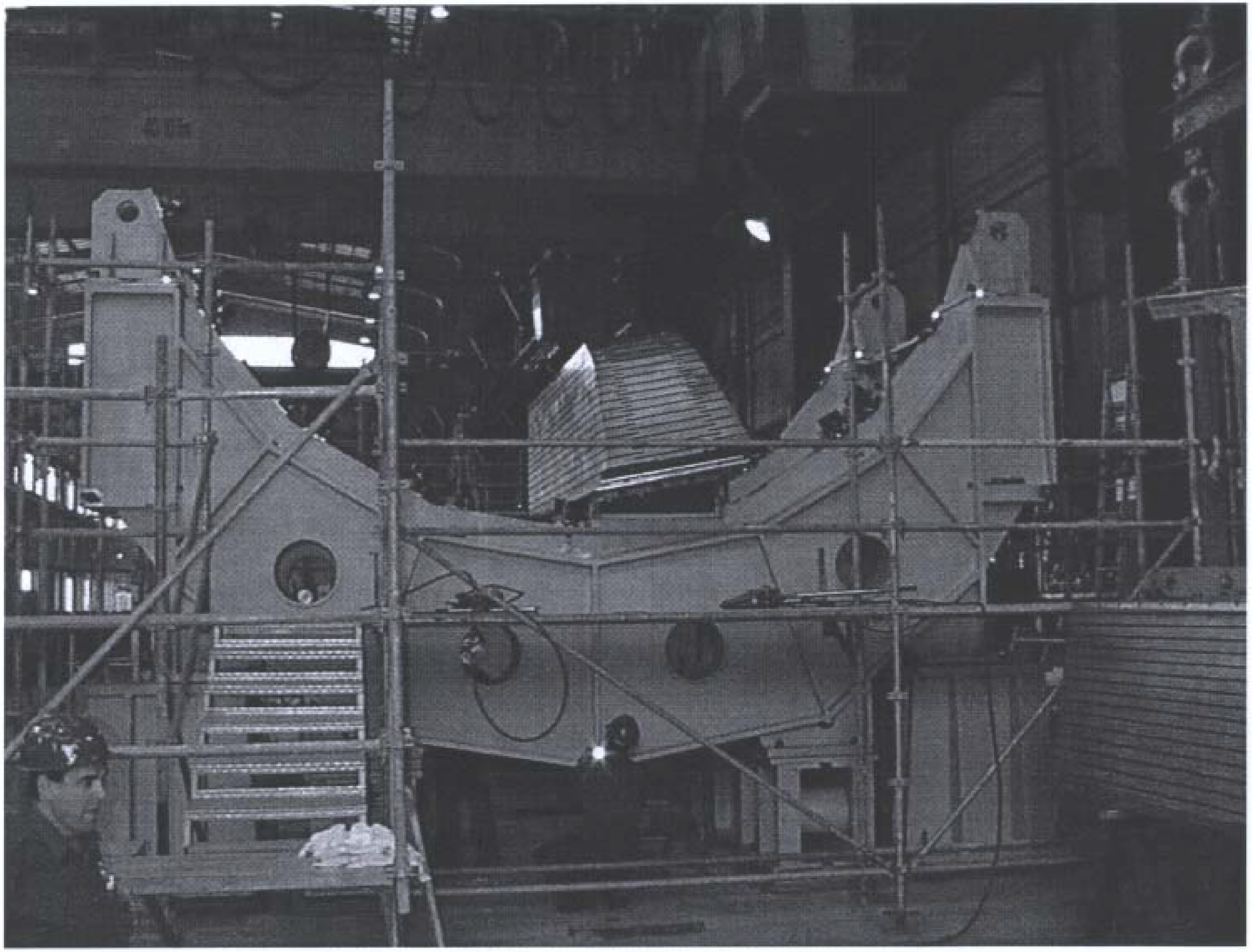
PPP2 Photogrammetry



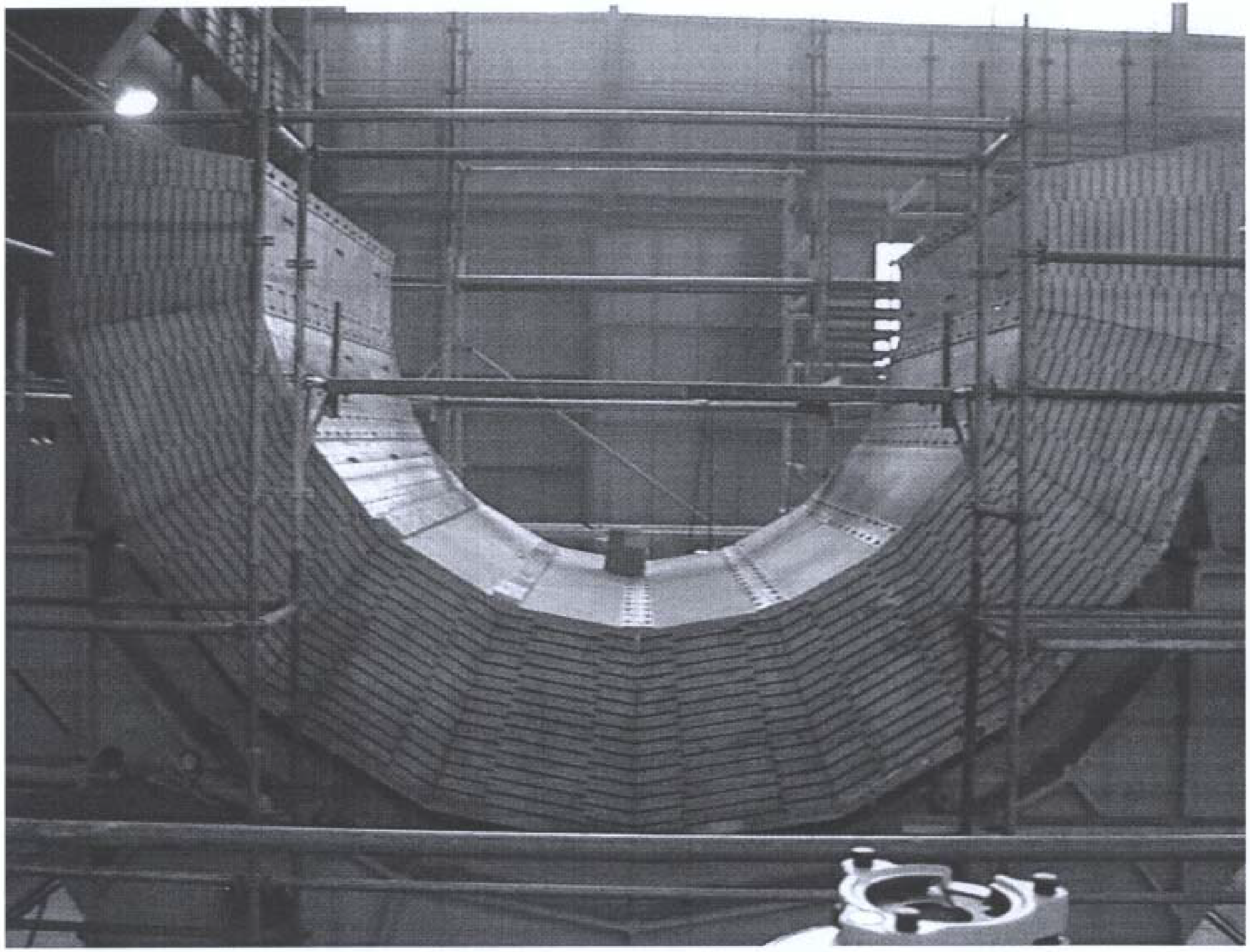
Spiders



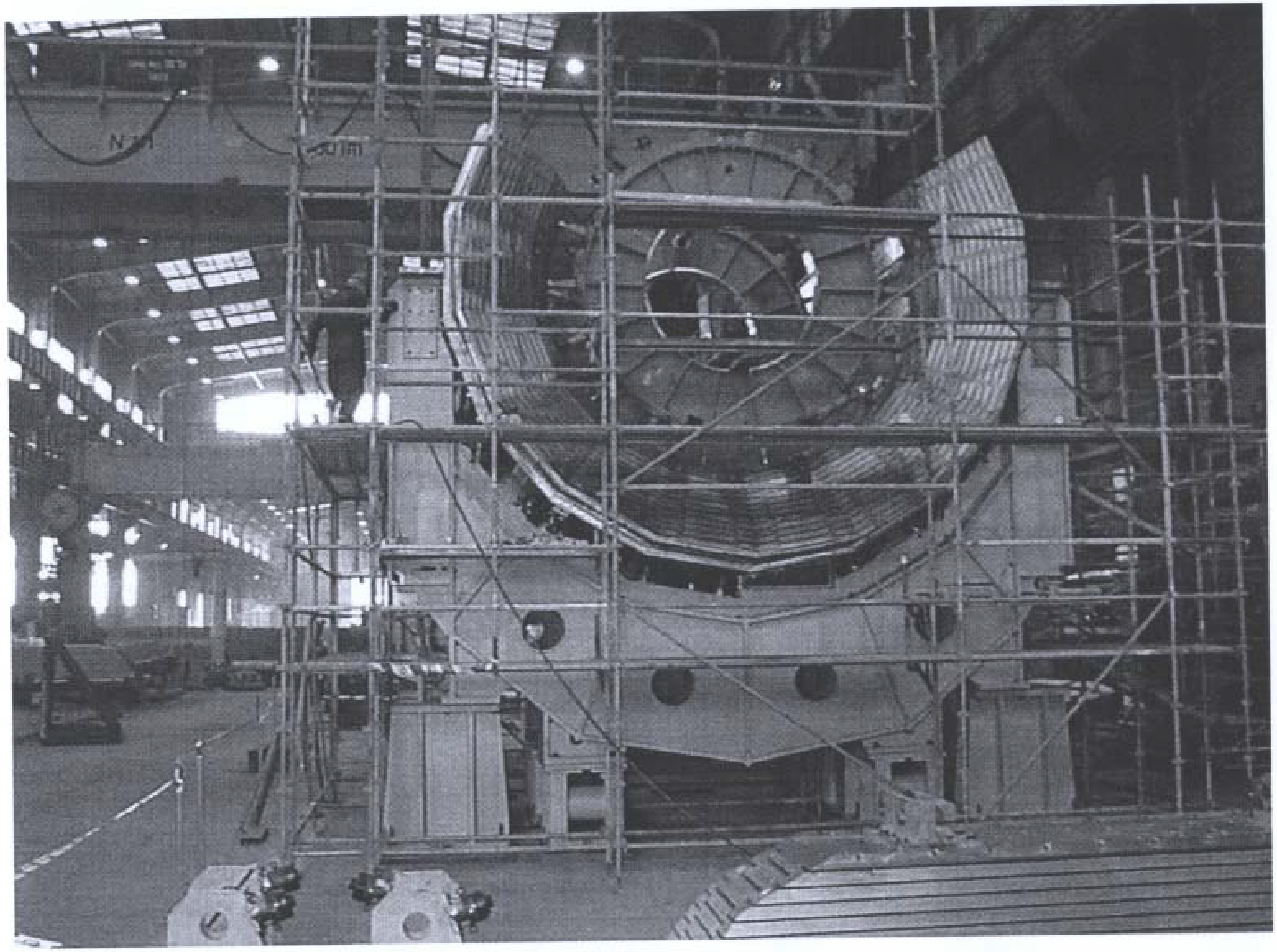
1st wedge on the cradle



10 wedges installed



Barrel assembly at FMC



Status/Conclusions

- Production of absorber wedges and scintillator megatiles reached 50% milestone (HB)
- First 18 absorber wedges (half-barrel) will be delivered to CERN by Dec-2000
- Installation and testing of optics will start in Feb-2000
- Critical items: readout boxes and electronics

Interface between Barrel and Endcap calorimeters