Asia-Europe Physics Summit 23-28 March 2010

Optics Labs & CERN : Chance Encounter in 1998

A CERN team visiting PINSTECH (Pak. Instt. of Nuclear Science and Technology), Islamabad in October 1998. The Team was looking for partners who could contribute to the design and fabrication of parts and modules for the CMS Detector.

The Team had some spare time. So they were also taken for a visit to Optics Labs next door…..

Collaboration became possible because Optics Labs had some clear expertise

- It is the only dedicated and integrated laser lab of the country, with considerable expertise in lasers, optics, and electronics. It is involved in research, teaching and production for over 35 years.
- It houses excellent infrastructure in designing and fabrication of opto-mechanica,-electronics components and modules

Hence a Natural Partner for CMS

LASER RESEARCH IN PAKISTAN AND CMS / CERN

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Former Chief Scientist / DG Optics Labs, PAEC

FOUR MAJOR CONTRIBUTIONS

- Magnet Feet for CMS (Fabrication only)
- Resistive Plate Chambers (Assembly & Test)
- Assembly and Test of Carbon Frames and RODS for TOBs
- Laser Based Position Monitoring System for Tracker of CMS (design, fabrication, installation)
- Part of Int. Data Processing - GRID

In 2000, CMS COLLABORATION HAD :

36 NATIONS; 160 INSTITUTIONS; 2008 Sc. / Eng.

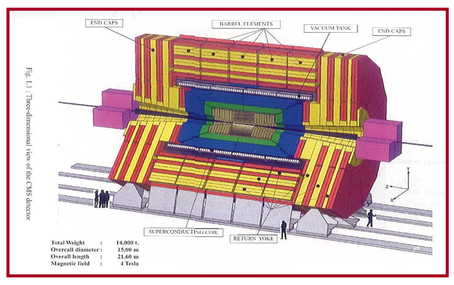
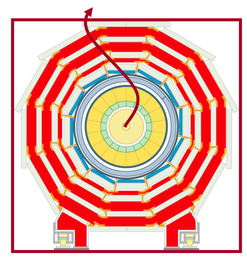
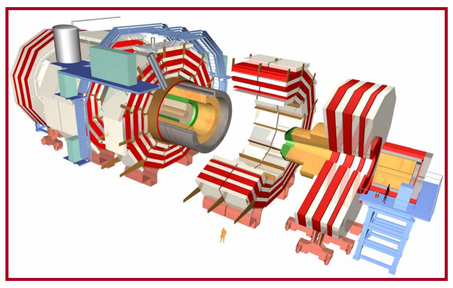


Fig. 1.1 : Three-dimensional view of the CMS detector





Total Weight : 12,500 Tons; Total Length :~22 m
Diameter : ~15 m ; Magnet : 4 Tesla
SC cable: 4.2°K, 20 kilo Amps, 27,000A/mm^2

Profile of the Laser Programme in Pakistan

Pakistan started a modest programme in lasers in June 1969 at the Atomic Energy Centre, Lahore. This has grown over the years to become first…. "Optics Labs, " ...which itself has given birth to (NILOP) National Instt. of Lasers and Optics in Islamabad

>> over 600 professionals <<

- **Build A Wide Array Of Complete Laser Systems**
  - –UV to IR (Solid State, Metal Vapour, Liquid, Gas)
  - –Pulsed (psec - nsec), Moderate Rep rates
  - –Fixed Frequency / tunable
- **Design and Fabricate:**
  - –Optical Components / Modules / Systems
  - –Optical Coatings
  - –Precision Mechanics / Electronics

- Grow Laser Crystals / YAG / Saphire / GaN
- Atomic / Molecular Spectroscopy ; LIS
- Atomic Clocks, BEC
- Laser Land Levelers for Farmers

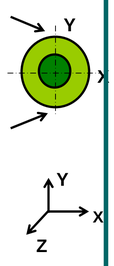
SOME CLIENTS:
Universities and Industry in Pakistan
Europe (IFCA Spain; RWTH, Aachen, Germany)

The Tracker has 40 laser based Position Monitoring Modules from Optics Labs, Pakistan.

2007: Loading The Tracker inside CMS.

Scale of the Problem

Tracker Max. distortion @ R=1.2m : - 0.314 mm (top & bottom			
Required Precision			
Vert. Position mm	R (μm)	R ϕ (μm)	Z (μm)
200	100	15	500
700	300	15	500
1200	600	50	2000



The Laser Position Monitoring System was tested at CERN;
Can give precision of ~2 micron

- CMS is designed for high momentum resolution of muons.
- Places a very stringent demand upon the spatial resolution and therefore the detector alignments.
- Need to know where the detectors are w.r.t each other

12 Years of Collaboration with CERN

Some Contribution of Optics Labs :

- **Position Monitoring System of Detectors** in the **Tracker**, + work on **Link** with **End Caps / Muon Chambers**:
  - **Process** Feasibility
  - **Testing** of Components for Radiation Damage
  - **Fabricated / Tested** Prototypes for **Performance**
  - **Convergence** between the various proposals from Germany, Hungary, Spain, Portugal and Pakistan
  - **Have Supplied and Integrated 40 Modules**
- **Assembly of the Tracker Outer Barrel RODs** (TOB RODs) which are a self-contained assembly
  - **Design of Test Jigs /Processes** for Individual Modules and RODs
- **Installation**, Validation, and Testing at CERN

Tracker Performance: Heart Of The CMS

TRACKER PERFORMANCE depends as much on

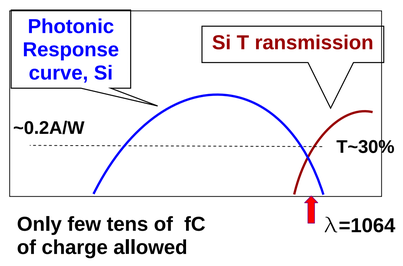
- Intrinsic Detector Capability
- Stability of the Structure (Design… Materials … Stiffness / Stability)

Very Very Heavy /LargeStructure. It moves / distorts due to: Gravity, Magnetic field, Temperature Gradients, Differential Expansions (e.g, Si, Steel, Al, CF, quartz) ,

Features of the Position Monitoring System

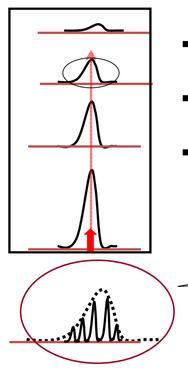
The laser pulse produces photo-electrons in the Si .

Laser also transmitted to other detectors if correct λ. Electronic read-out system same for high energy particles as well as the laser



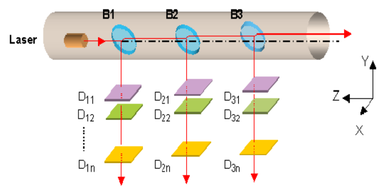
Only few tens of fC of charge allowed

Fire the laser: **Read the Laser's Centre of Gravity (COG)**

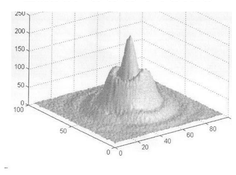


- Read the signal / laser position (c.o.g.) from each detector in turn
- One shot gives relative positions of many detectors at the same instant
- Repeat the sequence

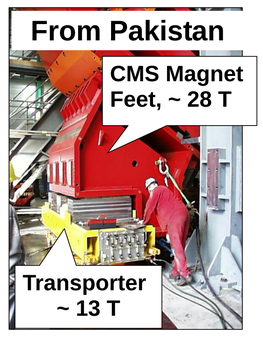
Thus Relative Positions can be continuously Monitored



Laser COG Profile



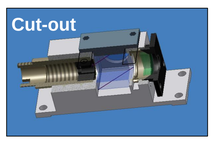
From Pakistan

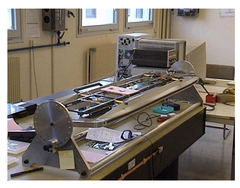


Optical Compnents.

- Only Rad-Hard materials usable.
- n fluence: $4x10^{14}$; γ rays : 10 MegaRad ;Used the 10 MW Pinstech Reactor
- Studied 13 Diff. Glasses; 3 Diff. Opt.Cements; HR / AR / Metallic Coating [Some glasses / coatings /cements had not been studied previously]
- Tests of adhesion / abrasion of coatings.
- Stability of a large distribution

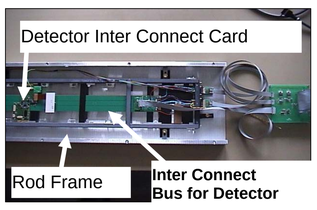
- Specs. of Optical Components
- Fabricated & Tested Prototypes
- Produced the Final Modules





Assembly and Test Setup For Integrated Rods

Production, Assembly and Testing of RODs at CERN



Electrical Test Setup for Assembled Rods of CMS Tracker

Completely assembled Rod: 6 Det. Modules Under Test.