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The CMS tracker—Construction issues for large detector systems with industry involvement

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For the CMS collaboration

Abstract

445 m^2 of wafer material will be used to cover the active tracking volume with 24,328 silicon sensors with a surface of 206 m^2. 75,376 APV front-end chips with 9,648,128 electronic channels will be available on 11,920 modules (partially double sided). This unprecedented detector requires attention to logistics, industry involvement, quality assurance issues and design validations. These will be discussed in this document.

Keywords: Silicon sensors; Silicon detector; CMS; Construction issues; Beam loss; Quality assurance; Integration

1. Layout and design

The cylindrical tracking volume (see Fig. 1) is defined by a ten layer barrel detector and two end-caps of nine disks each consisting of seven rings of detectors. Barrel layers 1, 2, 5, 6 and endcap rings 1, 2, 5 consist of two modules mounted back to back with a 100 mrad tilt. Modules in barrel layers 5–10 and endcap rings 5–7 are composed of two daisy-chained sensors, with an increased thickness from 320 to 500 μm to compensate larger capacitive noise by higher signal. The detector will be operated at −10 °C. More detailed descriptions are found in Refs. [1,2]. The read out is analogue, interconnected by an optical fiber system.

2. Tracker logistics

The large number and diversity of all components forces the CMS tracker collaboration to establish a particular logistic and industrial like assembly and quality assurance programme close to ISO 9000. The detector commissioning is subdivided into Inner Barrel (TIB), Outer Barrel (TOB) and Endcaps (TEC) for the three Consortia INFN, US, and Central Europe respectively. Seven institutes monitor the quality of the 24,328 sensors consisting of 15 geometry types, two

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institutes check and assemble all 15,232 front-end hybrids (3 types) with pitch adapters (24 types), seven institutes are responsible for high precision robotic assembly of the modules (26 different types) and 13 institutes bond and test the assembled modules. Ten centers integrate modules into the basic elements, like rods, shells, and petals for TOB, TIB, TEC, respectively. The full logistics scenario is displayed in Fig. 2. All needed data of all the various elements and production steps are stored in a central database in Lyon, which also serves as an inventory, keeping shipping and assembly information. The database is accessible via a Java tool or many webpages dedicated to e.g. sensor data or module assembly. The different components and total quantities are summarized in Table 1. CMS calculates 10% real spares plus 10% spares for handling issues during production.

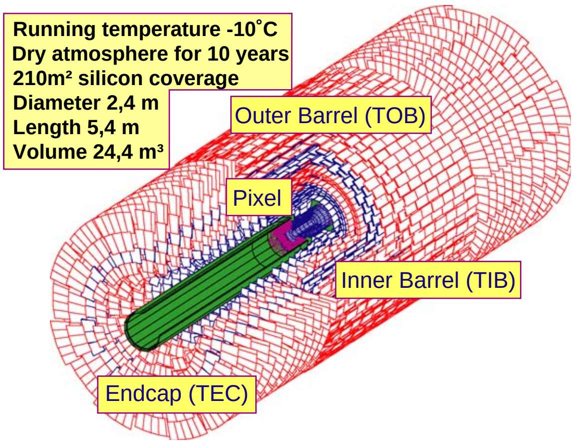

Fig. 1. The CMS All-Silicon Tracker Layout.

Table 1
Number of individual components and production capacity to finalize CMS

Thick sensors	18,192
Thick sensors	6,136
Front-end hybrids/full modules	15,232
FE ASCIS	75,376
Electronic channels	9,648,128
Analog optical links for 65 m transm	>40,000
Front end drivers (ADC boards)	440
Peak module assembly per day	52

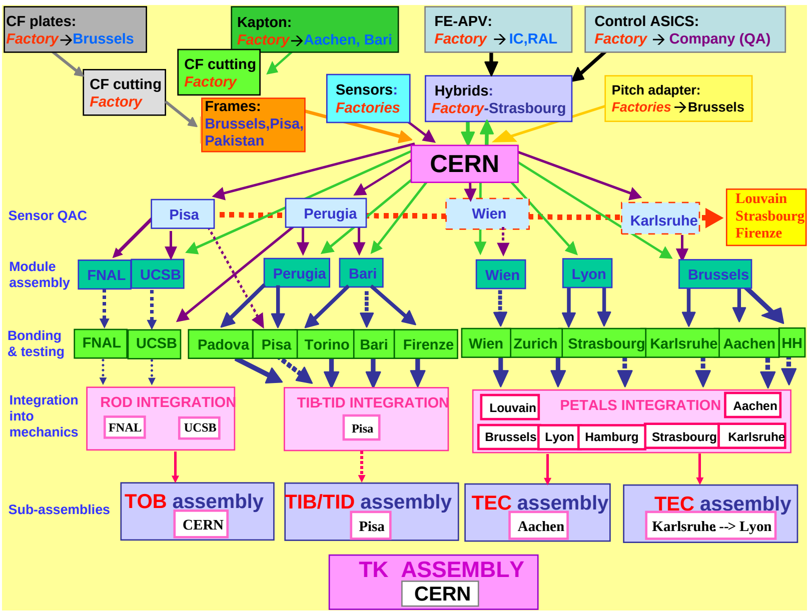

Fig. 2. Tracker logistics—the manifold of institutes gives an impression about the complexity to design and build a large device by the means of universities and research institutes. The three consortia are visible in the vertical orientation, the sequence of horizontal branches indicates the evolution from simple parts to complex structures culminating in the final tracker.