Metrology measurements of the Dee mechanical structures for the CMS Tracker Endcap Double-Disks (TEDD) at the HL-LHC

C.Greenberg, N.Chanon, M.Marchisone, on behalf of the CMS Tracker group

IP2I Lyon, Université Claude Bernard Lyon 1, CNRS/IN2P3

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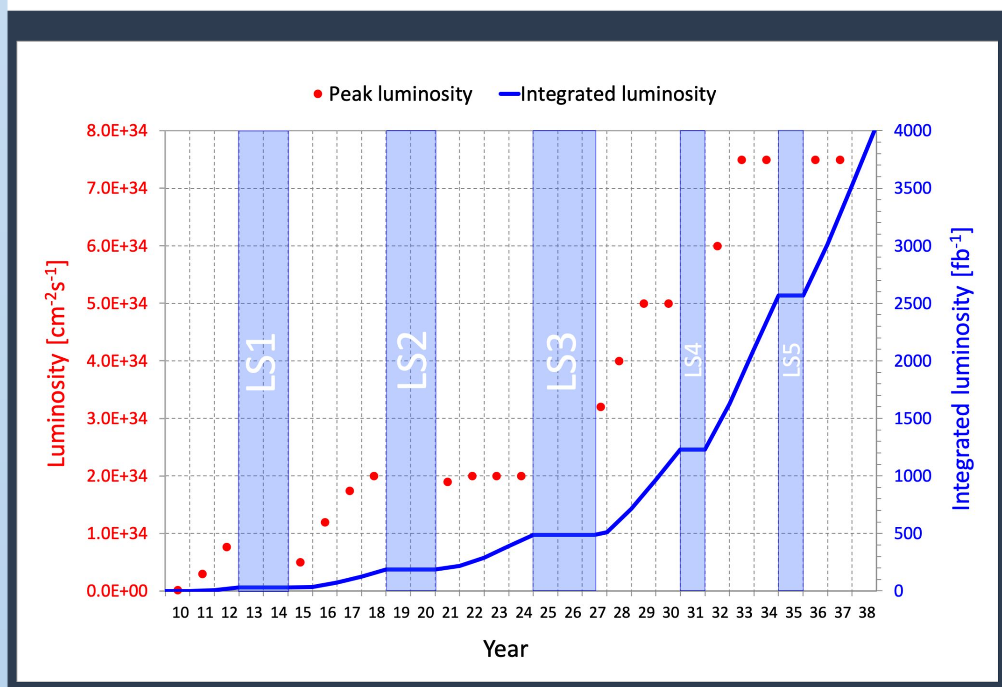
Why the CMS tracker needs an upgrade?

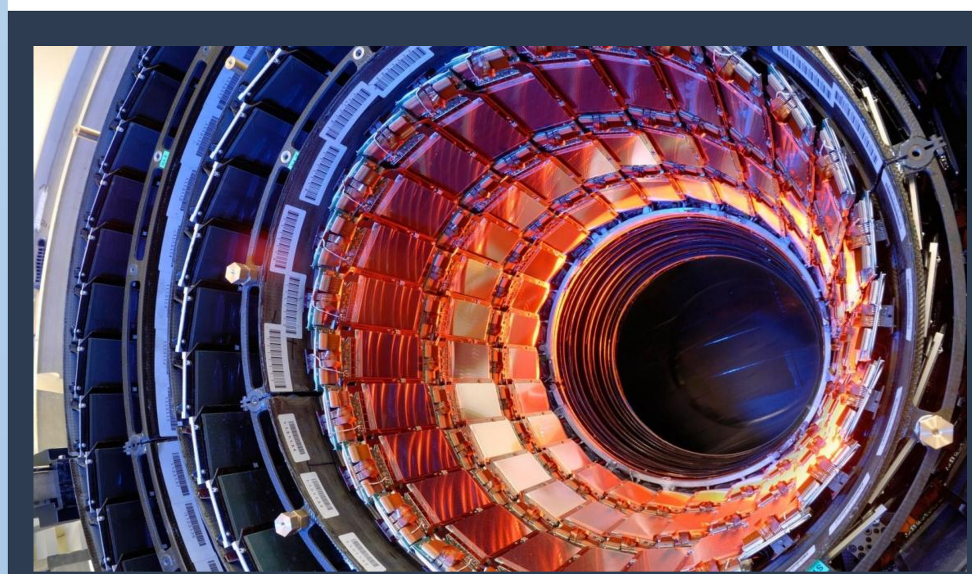


Key performance points of the HL-LHC:

- increase pile-up up to ~200 (~60 in Run3)
- Integrated luminosity of ~4000/fb
- Peak Luminosity ~ 3.6x higher than current LHC

➔ The CMS tracker needs an upgrade to sustain HL-LHC new features

The CMS Tracker upgrade for the HL-LHC



The CMS tracking detector:

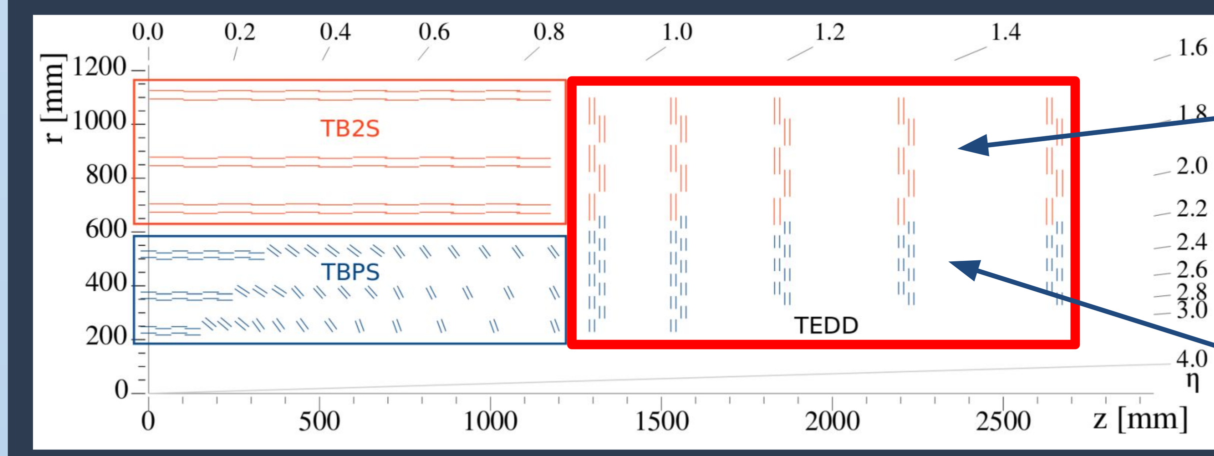
- It reconstructs charged tracks at >99% efficiency and measure their momentum
- Primary and secondary vertex reconstruction

The CMS tracker upgrade **key features**:

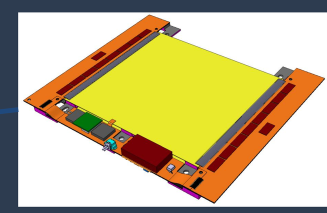
- Increased transparency ➡ Makes the tracker lighter
- Increased detection range ➡ up to |η| < 4 (Run3 detection: |η| < 3)
- Extracts information faster ➡ up to 40MHz at Level 1 trigger

Tracker Endcap Double-Disks (TEDD)

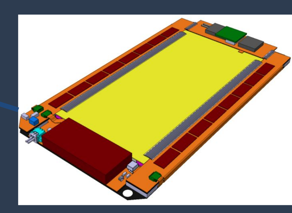
Layout of the future outer tracker of the CMS experiment.



Detection modules:

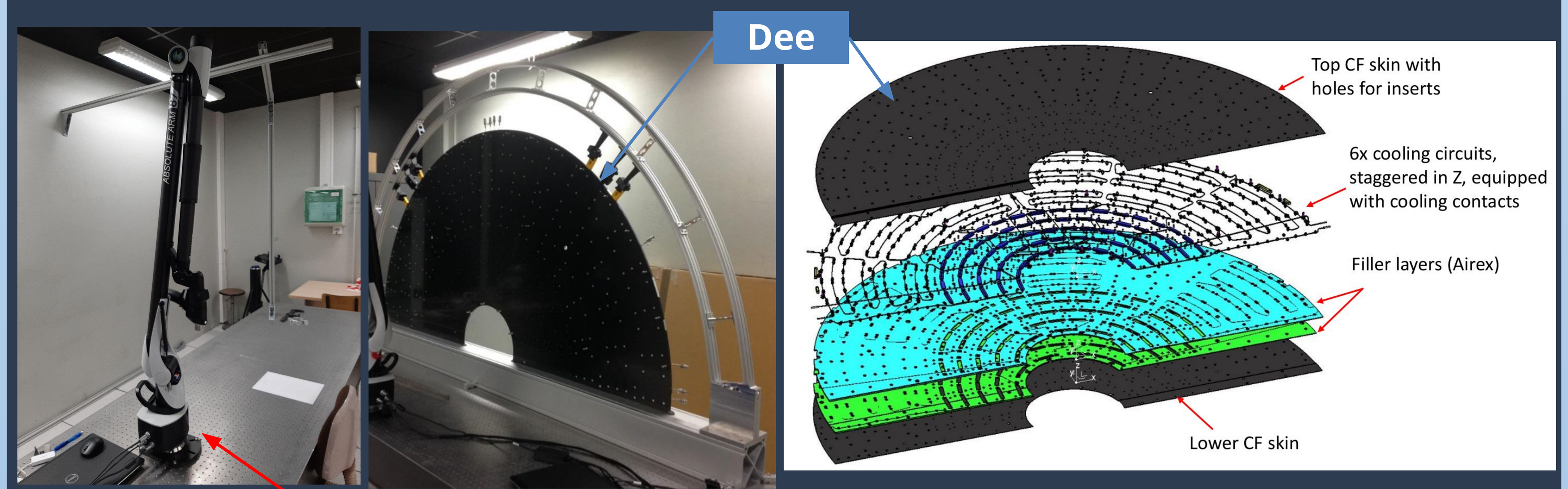


2S - strip-strip



PS - pixel-strip

Each TEDD is composed of 5 double-disks. Each disk is made of 2 Dees.
The Dee is the elementary mechanical structure of the project. It will hold the silicon detection modules and embeds the cooling circuits [2].



Mechanical arm for metrology measurements.

The TEDD concept [1]:

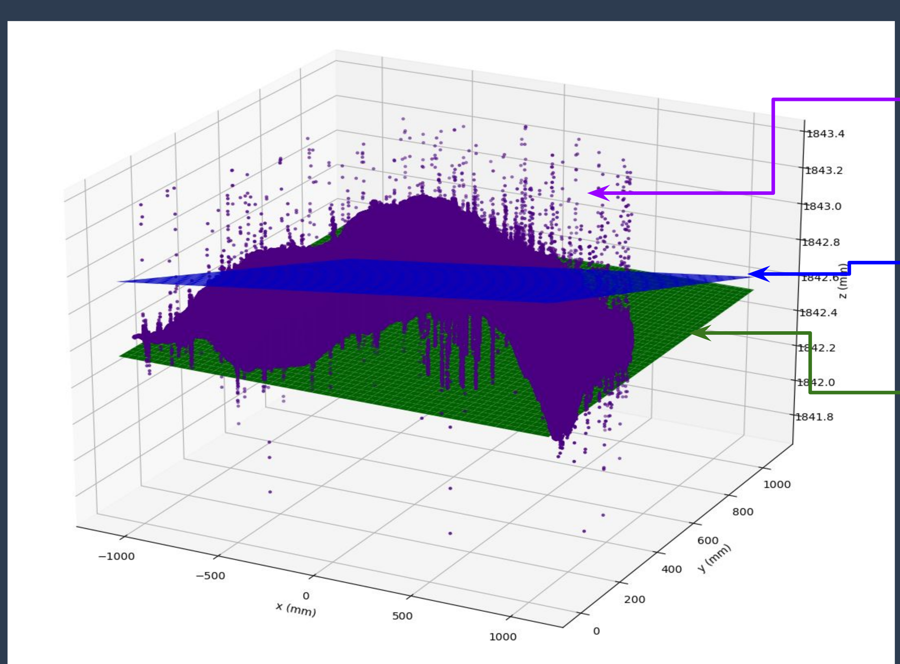
- Cooling at -35°C using CO2 at phase transition.
- Cooling pipes integrated as part of the Dee structure to maximize the weight.

↳ **Our goal is to assess the ability to mount the detection modules on the Dee by analyzing metrology measurements.**

Measuring Dee planarity

In this poster we present selected results of the metrology study, focusing on Dee planarity and precision on insert position.
The metrology measurements presented in this poster were taken from a Dee prototype produced in 2021. Analysis and measurements were performed at IP2I (Lyon).

We scan the Dee surface with the laser of the mechanical arm and obtain measurement points:



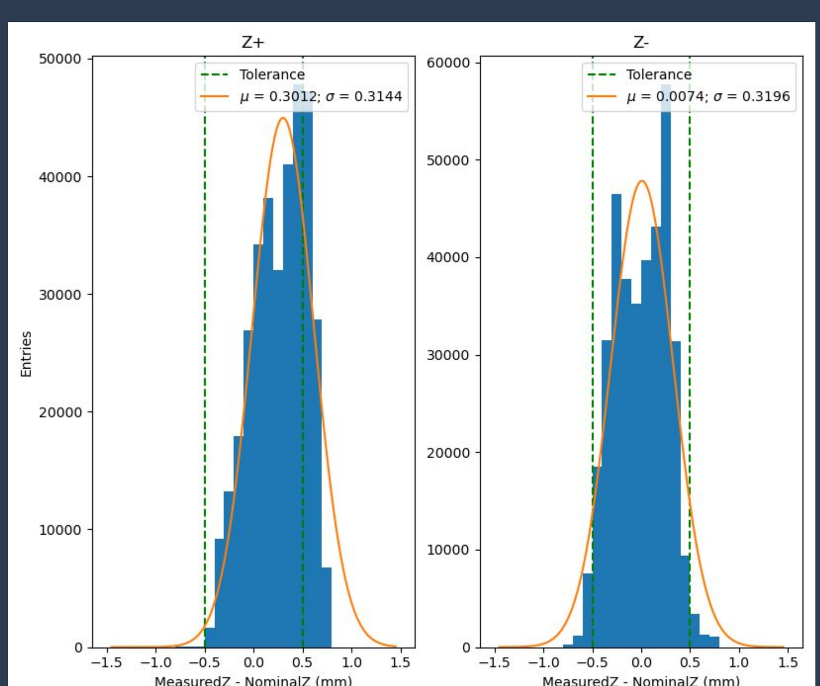
Measurement points: Taken with the laser scan of the mechanical arm (~500k points taken for this analysis)

Fitted plane: Points are fitted to a plane using a minimized chi-squared method.

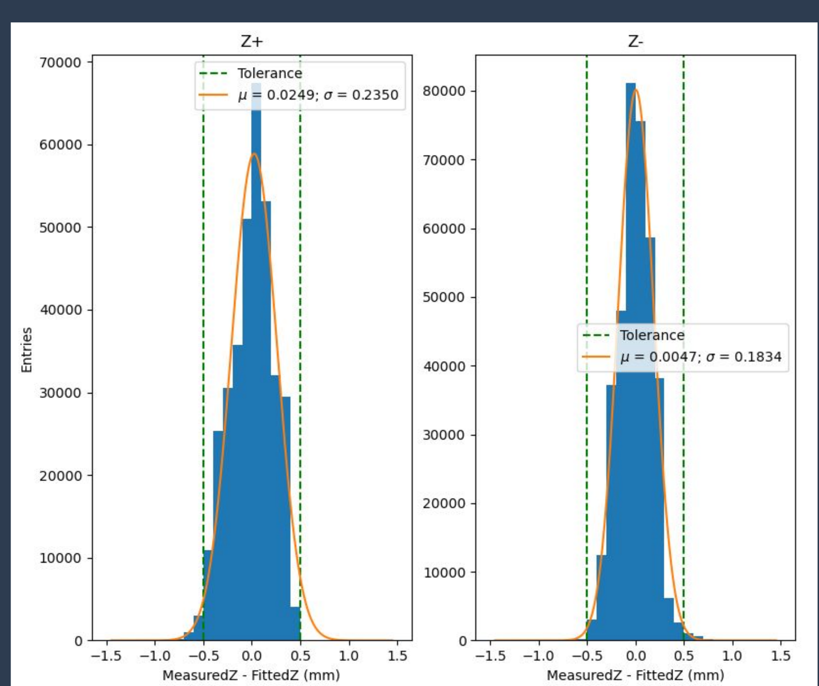
Nominal plane: Previous analysis used this reference plane to assess the Dee's planarity.

In this study we want to compare the use of a fitted plane as reference instead of the nominal plane.

Distribution of the distance between measured points and nominal plane for both sides of the Dee (old technique)



Distribution of the distance between measured points and fitted plane for both sides of the Dee

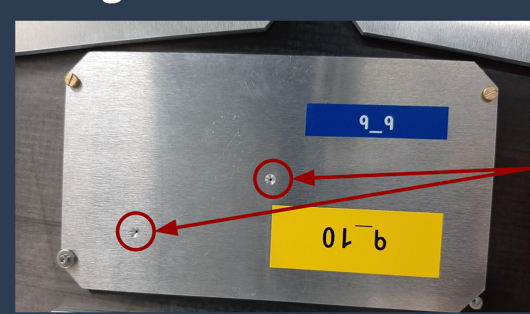


- We can see an improvement on the width of the distributions using a fitted plane rather than the nominal plane.

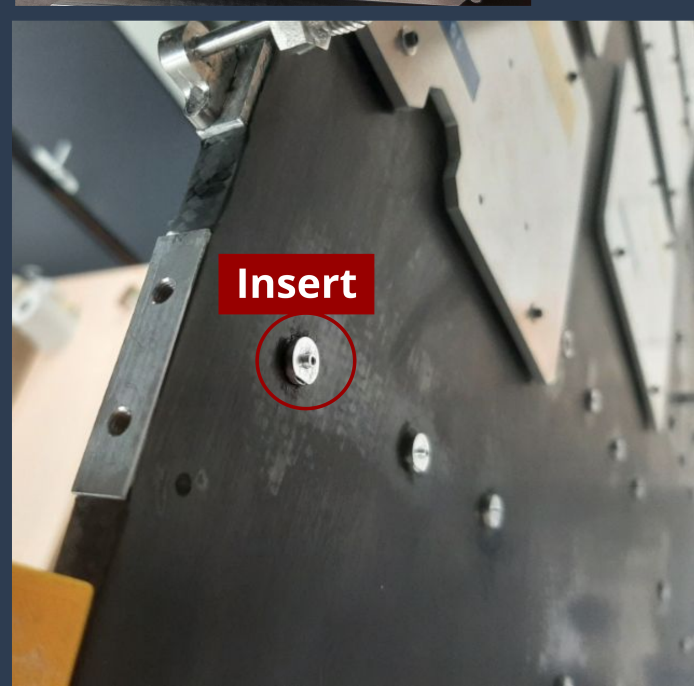
➔ **In this study, we remove the bias on the planarity of the Dee by using a fitted plane as reference plane. The measurements respect the tolerance, which is indicated by a red dashed line. The planarity of the Dee prototype satisfies the specifications.**

Ability to mount detection modules

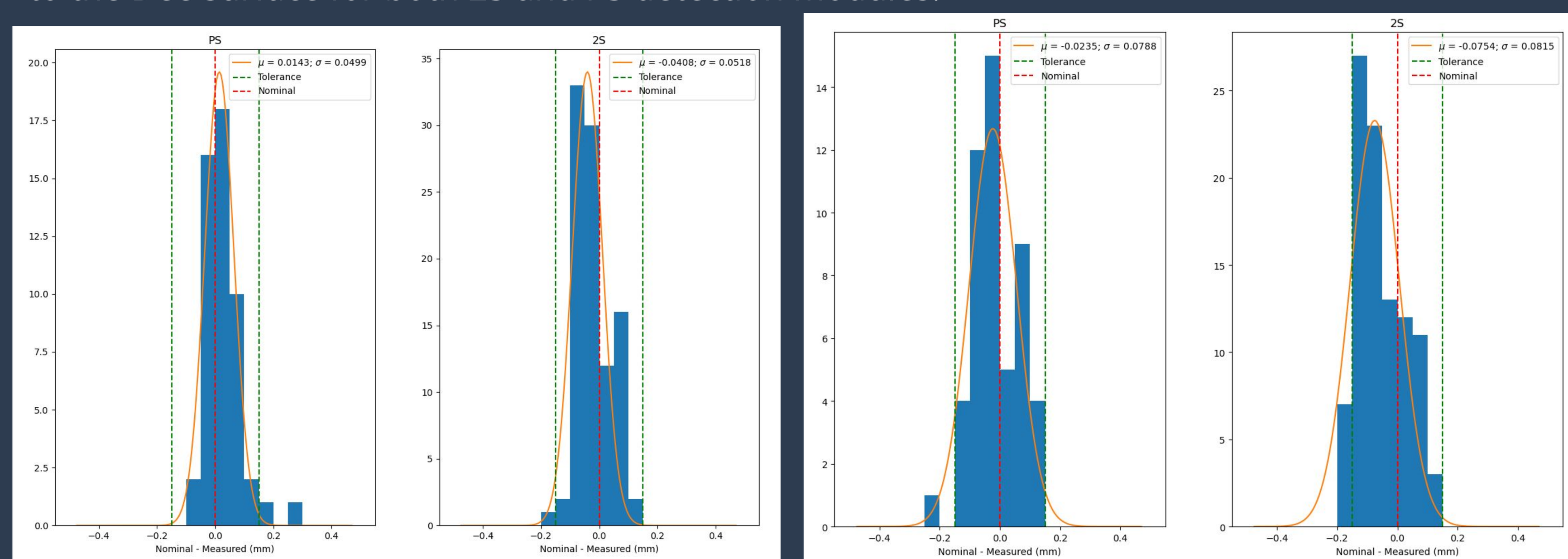
We want to study the precision on the insert position used to mount detection modules along the Dee's surface.



To validate the machining precision of then Dee inserts, dummy modules with high precision mounting holes have been fabricated. Metrology arm probes the two cones of each dummy module to infer their displacement and rotation with respect to the nominal position



The distributions show the modules displacement along the two directions (X and Y) parallel to the Dee surface for both 2S and PS detection modules.



➔ Almost all measurements respect the tolerance (indicated in green dashed lines) and detection modules can be mounted onto a Dee respecting the specifications required

➔ **This analysis framework will be used to analyze future Dees during the construction of pre-production phase (which will start end 2023) and production phase (expected to start in 2024).**

Christopher Greenberg
Université Claude Bernard Lyon 1
IP2I, IN2P3, CNRS
c.greenberg@ip2i.in2p3.fr

[1] The Tracker End-Cap Double Disks (TEDD) of the CMS Phase 2 Outer Tracker - EDMS document ID: 2638103 (v.1) - 2021-10-12

[2] The Phase-2 Upgrade of the CMS Tracker - Technical Design Report - CMS Collaboration CERN-LHCC-2017-009 - CMS-TDR-014, 01-07-2017