CMS Barrel Timing Layer: final design validation through latest test beam results

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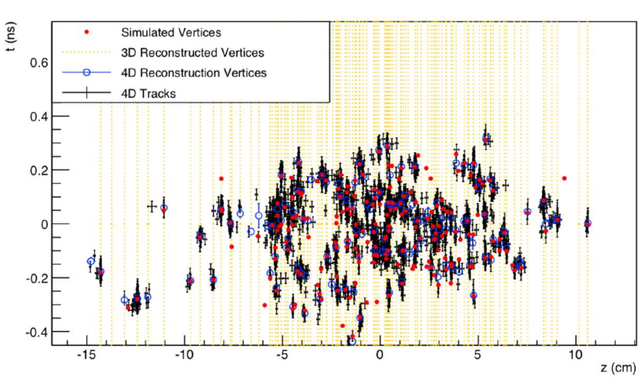
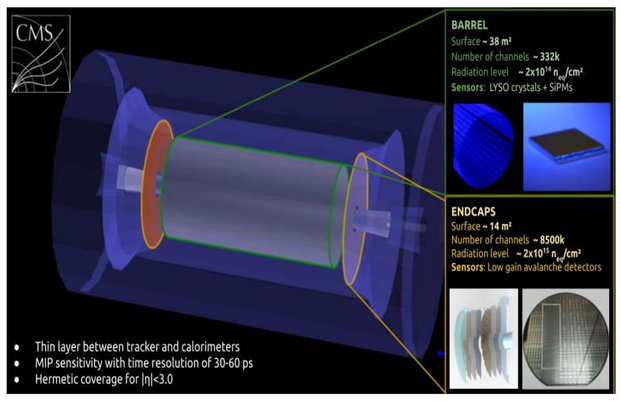
The MIP Timing Detector

High-Luminosity LHC:

- Increased radiation damage induced to detectors
- High pileup (PU) levels

→ Upgrades needed: a new timing layer will be installed into CMS to mitigate PU. The MIP Timing Detector (MTD) will provide time resolution of 30-60 ps

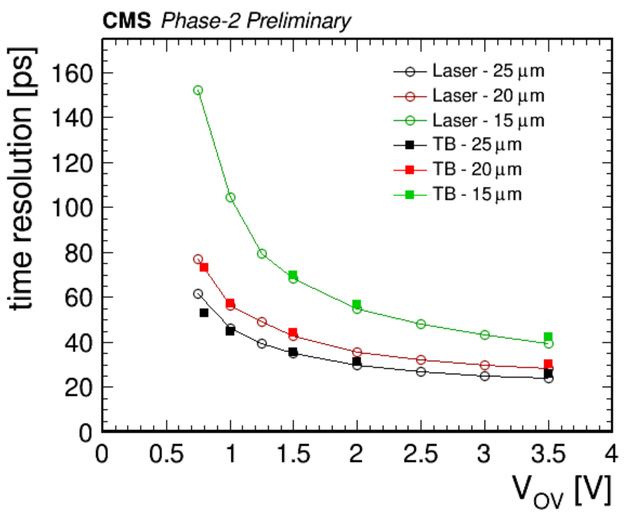


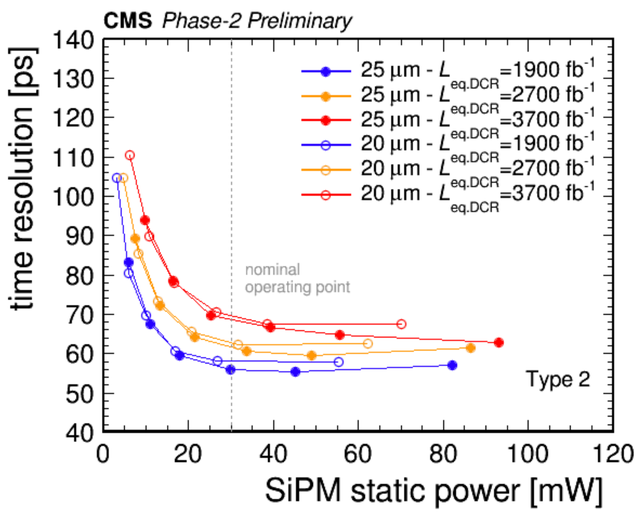


Test beam campaigns

Several module optimization studies were explored:

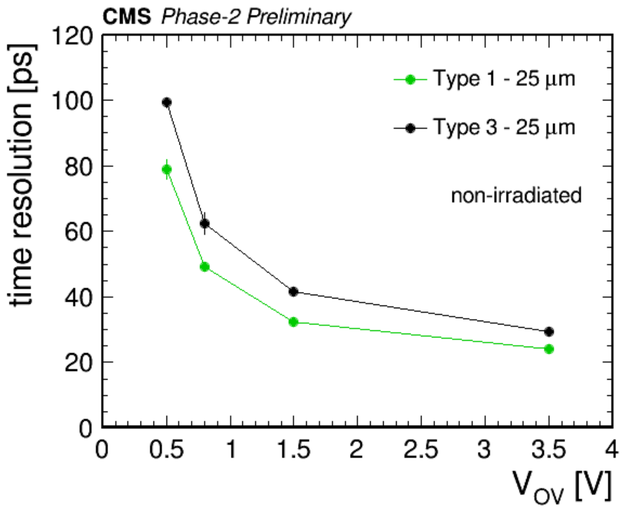
- SiPM cell size

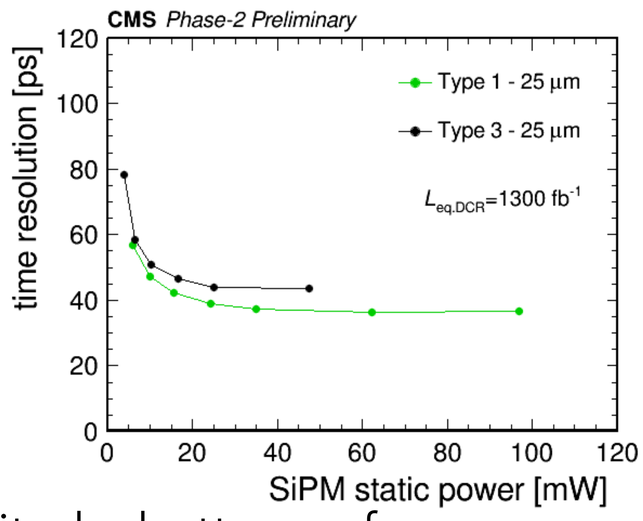




25 µm SiPMs demonstrated superior performance

- Module thickness



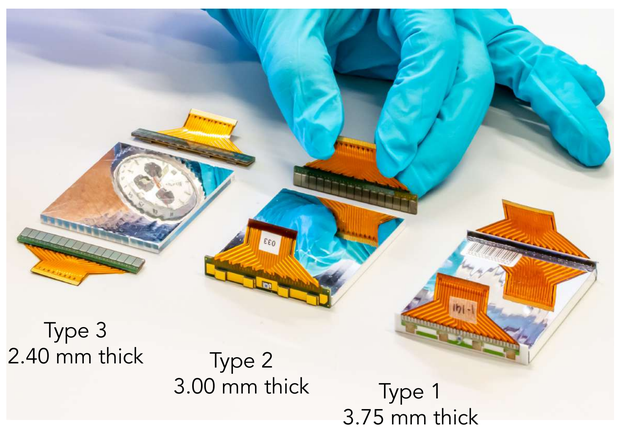


thicker modules exhibited a better performance

References: scan me

The Barrel Timing Layer

Elementary unit: sensor module comprising an array of 16 LYSO crystal bars coupled to SiPM arrays

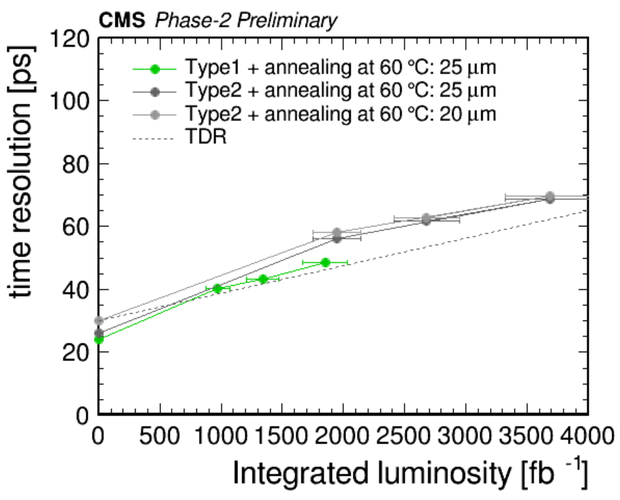


$$\sigma_t^{BTL} \sim \sigma_t^{ele} \oplus \sigma_t^{phot} \oplus \sigma_t^{DCR}$$

BTL's main challenge will be dealing with the radiation-induced damage of SiPMs (Dark Count Rate, DCR). To mitigate this effect:

- Smart thermal management: involving cold operation at -45°C and annealing at 60°C
- Module optimization aimed at increasing the signal yield and reducing the electronics noise

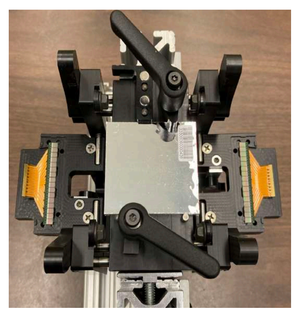
From validation to production



- Goal design achieved with final prototypes
- Definition of final design with 25 µm SiPM and the thickest modules

Prototyping effort complete & target performance demonstrated → moving to production

- 4 BTL Assembly Centres (BAC)
- Common tools for module assembly finalized
- Plan of producing 2 trays/ month/BAC
- Final installation expected by summer 2025



Commissioning in CMS starting in 2027