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Fast Beam Condition Monitor (FBCM) for precision luminosity measurement at HL-LHC @CMS

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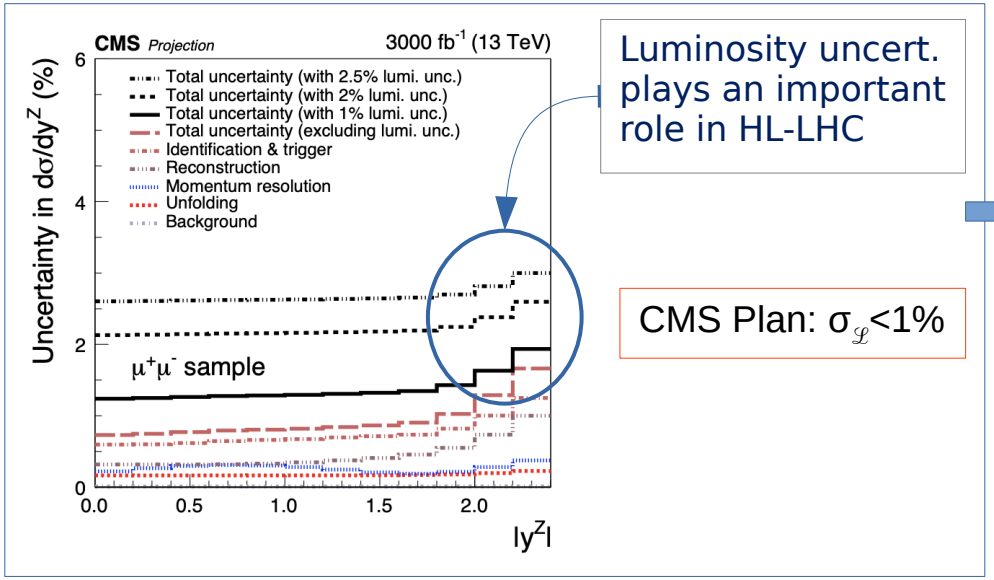
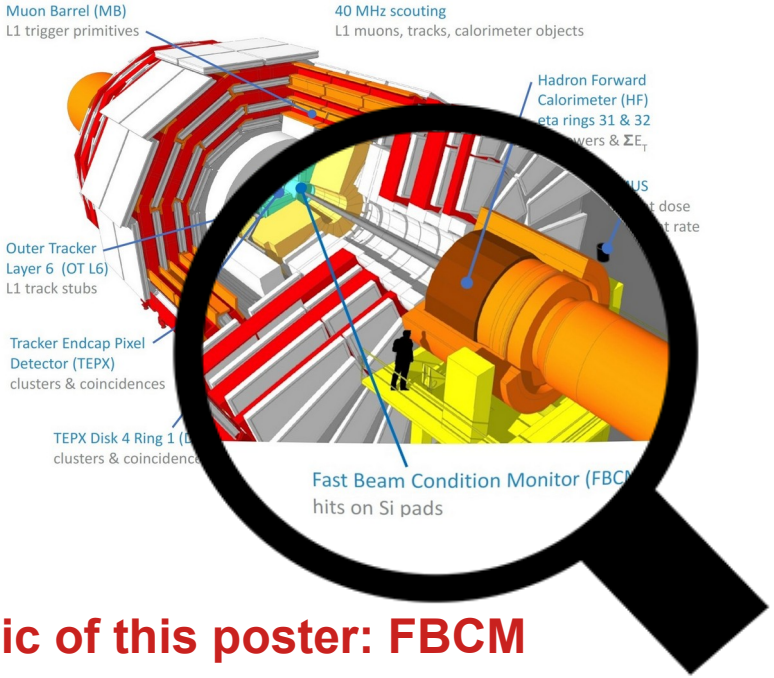
- & Deutsches Elektronen-Synchrotron, DESY



Luminosity uncert. plays an important role in HL-LHC

CMS Plan: $\sigma_{\mathcal{L}}$<1%

CMS full potential will be exploited to measure the luminosity



Topic of this poster: FBCM

A system based on silicon-pad sensors with a fast digital read-out and active cooling in the Tracker volume

FBCM functionality

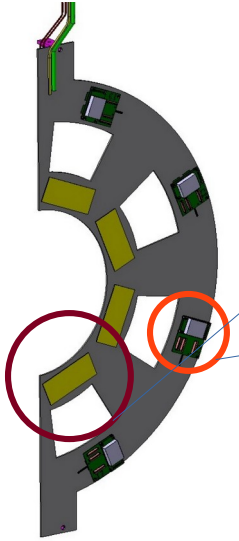
- Luminosity measurement
- Independent operation
- Orthogonal systematics
- Bunch-by-bunch measurement @40 MHz
- Very low online $\sigma^{stat.}$ per second
- Linear operation (up to PU=200)
- Sub-BX timing
  - Beam-induced background (BIB) measurement

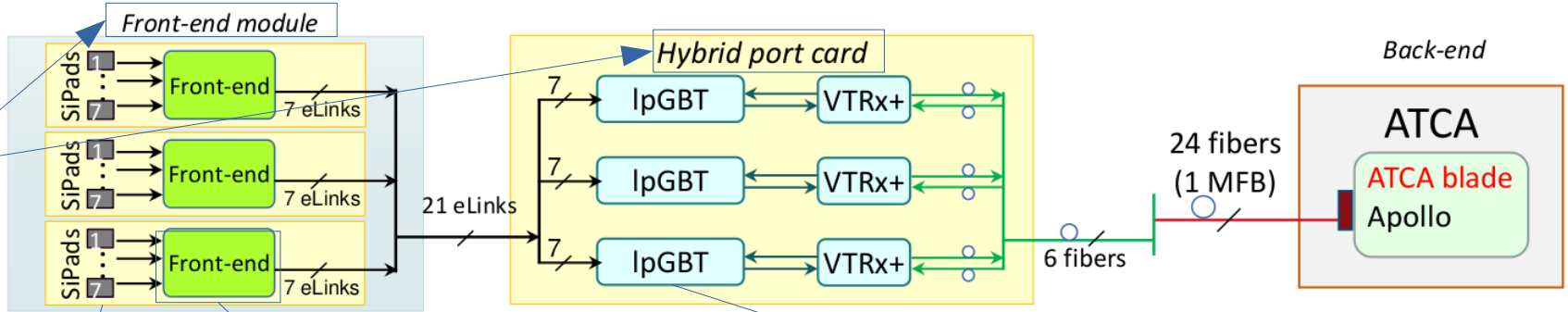
z=±283.5 cm
8.5 cm < R < 21 cm, $|\eta|$~ 3.5
2(±Z)X2 FBCM quarter

Radiation environment:

For R > 12 cm
~3.5 hits/cm^2 per bunch-crossing
@ 3000 fb^{-1}

- TID < 200 Mrad
- 1MeV neq fluence < 3.4x10^{15}



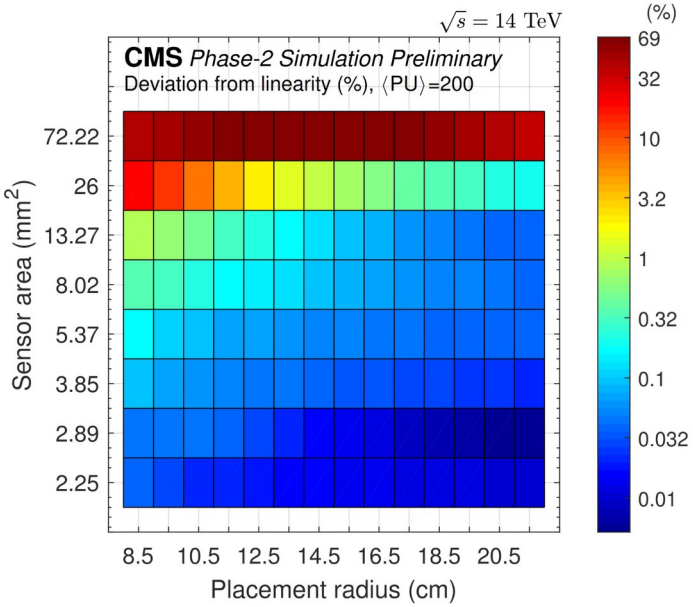


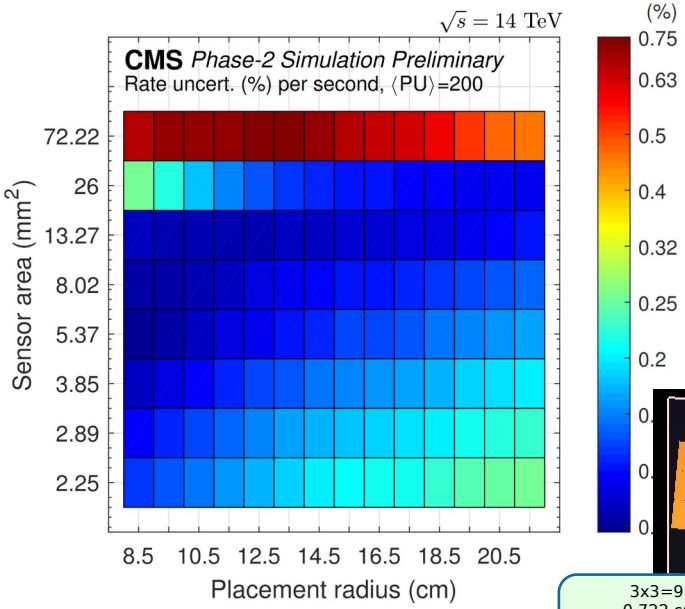
lpGBT continuously samples the semi-digital output @ 1.28 Gb/s

AC-coupled sensors
Using the available technologies developed for Phase-II CMS upgrade

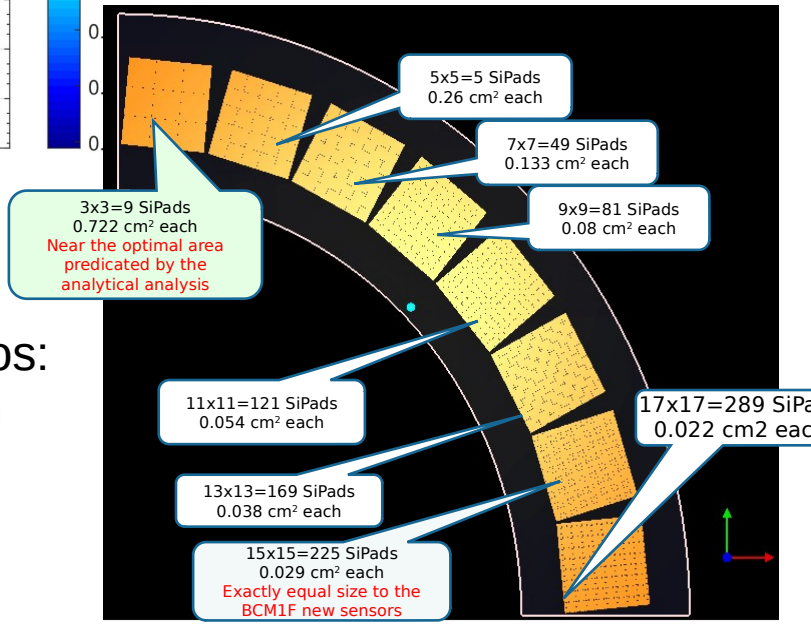
- Front-end ASIC:
  - Plan A: A customized ASIC design,
  - Plan B: Calypso ASIC from the ATLAS BCM' project

FBCM expected performance





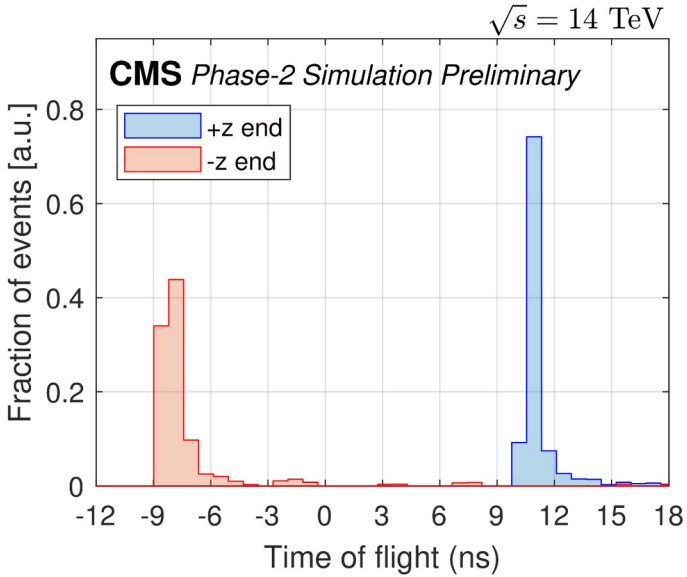
- Larger area sensors:
  - Worse linearity behavior, degraded statistical precision
- Small area sensors:
  - Good linearity behavior, increased statistical precision
- A trade-off between the linearity and stat. uncert.

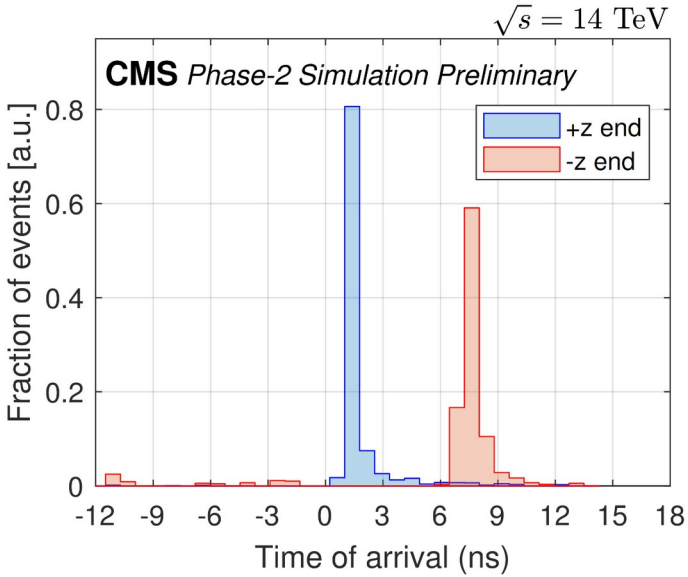


Results are obtained from the full simulation of all possible scenarios:

- GEANT4 – CMSSW simulation
- 8 different size of sensors
- Placement radius spanning
  - from 8 cm to 21 cm
- z=283.5 cm

Beam-induced background (BIB)





The BIB simulations using CMSSW with input from FLUKA:

- Beam-halo, i.e. interactions with LHC collimators
- Interactions with residual gases (carbon, oxygen and hydrogen)
- Assuming only one beam passing from -z to +z.

Using a time binning of 0.78 ns it is possible to:

- Recognize the incoming BIB received @ ToA=6 ns
- in the beginning of a train
- or with a non-colliding bunch after ≈30 empty bunches