

### Documenti (2016, Nov 17):

- Proto-proposal:
- <u>https://twiki.cern.ch/twiki/bin/view/CMS/PrecisionTimingFinalReport#Draft1\_2016\_Nov\_17th</u>
- Talk CMS Week Mumbai:
- <u>https://indico.cern.ch/event/586669/contributions/2363647/attachments/1373358/2084155/Ti</u> mingBombAy.pdf

#### [T. Tabarelli de Fatis]

## Basic motivation: improve pileup suppression at HL-LHC

## An interaction of interest at less than 1% of the collisions simultaneously produced

If beam-spot sliced in successive O(25) ps time exposures, the number of vertices per time exposure drops down to Run 1 LHC pileup levels (beam spot time spread ~180 ps)

## Elements of the timing upgrade

#### **Calorimeter upgrades:**

Provide precision timing (~30 ps) on high energy photons in ECAL, on photons and high energy hadrons in HGCal Precision timing only for showers

 We propose additional (thin) timing layers
 MIP timing with 30 ps precision and 100% efficiency
 Acceptance: Inl<3.0 and p<sub>T</sub>>0.7 GeV in the barrel and outer endcap





### > 200 pileup collisions



HL-LHC baseline (as of ECFA):  $t_{RMS} = 180 \text{ ps}, z_{RMS} = 4.8 \text{ cm}$ 

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## Track-vertex association – with track timing



With timing, 'effective peak density' down to LHC level !

- Consolidate reconstruction at 140 PU (Faint HL-LHC)
- 2. Extend performance at 200 PU (Bright HL-LHC)
- 3. Provide robustness against adjustment of luminosity scenarios

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## Lepton efficiency: impressive gain!



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# Further performance benefits



Other demonstrated ot expected significant impacts:

- Diphoton events with ECAL and track timing (shown in the past)
- Expected gain in b-jet tagging (scaling argument)
- [ and possibly in HLT and computing time performance ]

## 4D reconstruction of tracks + photon time

- At HL-LHC, substantial failure rate of default vertex identification (BDT) for  $H \rightarrow \gamma \gamma$  events
  - ε(Iz<sub>vtx</sub>-z<sub>true</sub>I) < 30% at 200 PU (~ 80% in Phase I)</p>
- Test photons against 4D vertex information from tracks Photon time alone insufficient to locate the vertex (except for  $|\Delta \eta|$  large)



Great impact of global event timing: effective pileup reduced to ~30









# Performance resolution qualified in test beams Radiation hardness good for the barrel

- Must operate SiPMs at ~ -25-30 °C (self-heating and dark rate)
- Several vendors available for crystals and SiPMs (FBK)





# Endcap timing layer



At the end of the HGCal construction (2024)

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#### Endcap timing layer B I C O C C A

#### Silicon sensors with internal gain

- Two sensors under discussion
  - Rad hardness qualification outstanding
  - Finalization od sensors ~ 3y



NFN	Process to reach a decision on	
	a proposal for the timing upgrade of CMS	
DEC	<ol> <li>Start a review process within CMS</li> <li>Reviewer being appointed by Upgrade Coordination</li> <li>Performance, technical feasibility, timeline and cost</li> </ol>	<b>low!</b> า ัร
JAN	2. Present an updated document at the CMS Week J	an 30 <sup>th</sup>
FEB	<ul> <li>→ can report at WGM meetings</li> <li>3. Give an information talk to the LHCC</li> </ul>	eb 21 <sup>st</sup>
MAR	<ul> <li>4. Review report at WGM</li> <li>→ End of the review process</li> </ul>	lar 16 <sup>th</sup>
APR	5. CMS decision at CMS week	<b>pr 3</b> rd
ΜΑΥ	6. Formally present CMS position to LHCC	lay 9 <sup>th</sup>
	In parallel, start to form a proto-collabora	tion and
	13 Involve more groups in the studies and R&D	

## Timing upgrade Italia e altri CMS

- Italia deve consolidare/definire interessi:
  - Eol Barrel :
    - USA: Caltech, Princeton, Notre Dame, Virginia
    - Eu: CERN, Lisbona, ETH Zurich
    - Italia: MiB Rm1 PD
      - RD + SiPM (FBK) + Meccanica + Clock/elettronica (?)
  - Eol Endcap :
    - USA: Brown, Kansas, FNAL, Florida, MIT, Wisconsin – Madison
    - Italia: Torino
      - UFSD + Elettronica + Clock
- Opportunità (molte!) e trappole (una?)
  - Altri gruppi italiani interessati?
- Self-plagiarism: "The timing upgrade will make, again, CMS unique and at the forefront of research"

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