CMS HLT for Phase II

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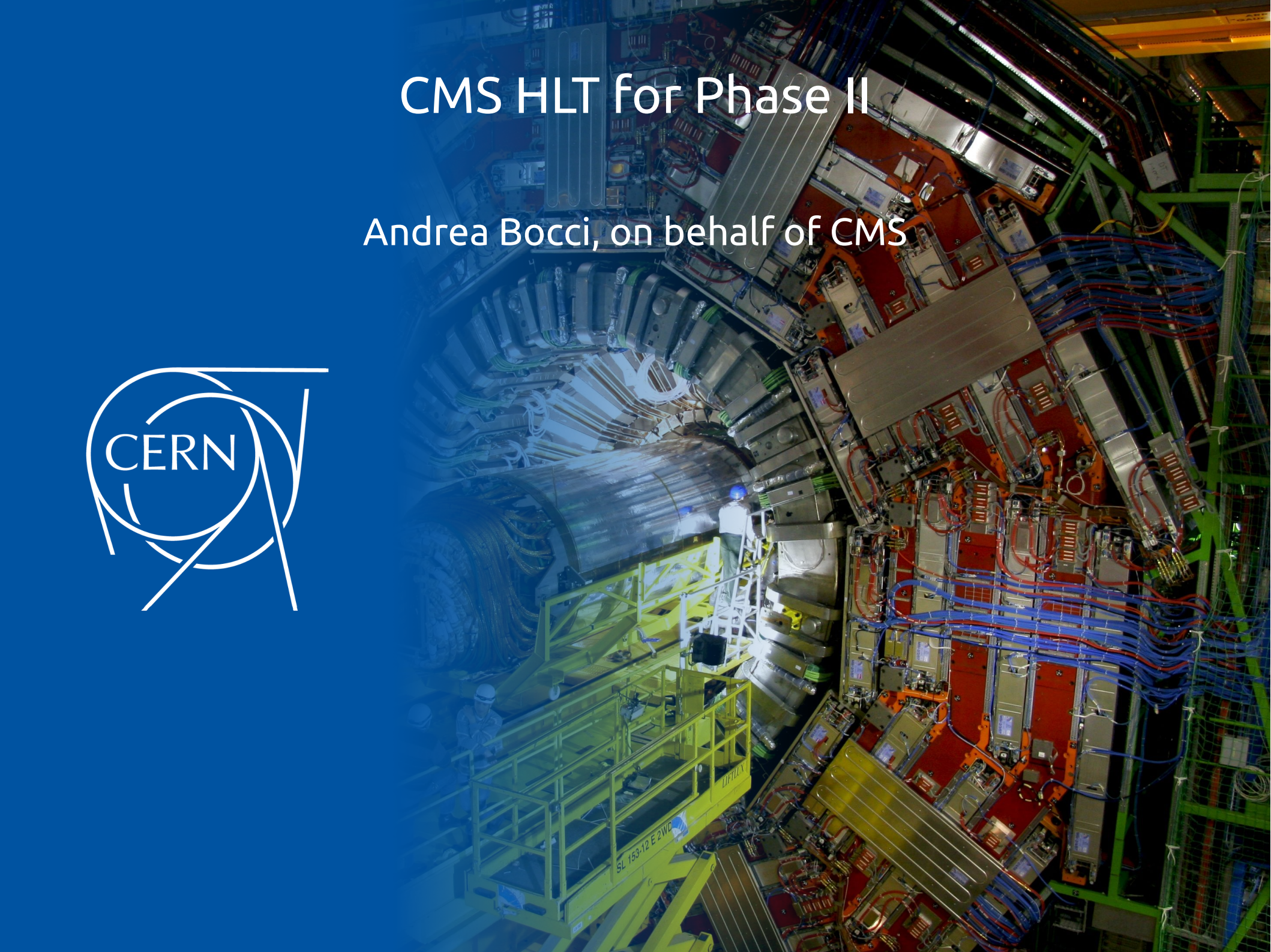


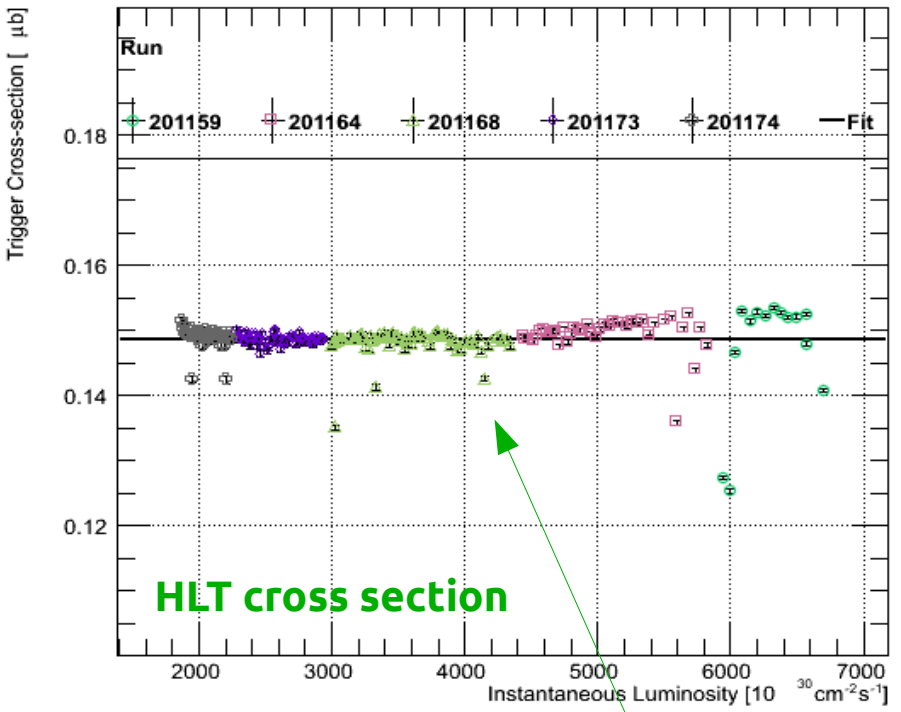
the challenge

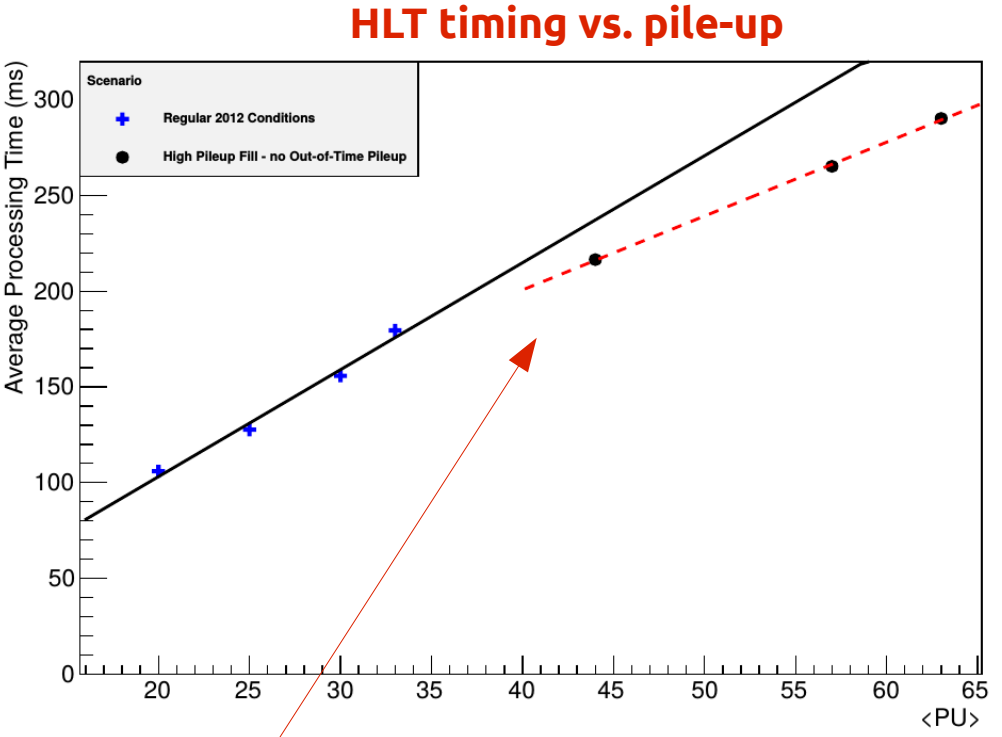
- Phase II scenario
  - 14 TeV collisions
  - 25 ns bunch spacing
  - luminosity up to **~5e34 $cm^{-2}s^{-1}$ (~8e34 $cm^{-2}s^{-1}$)**
  - pileup up to **~140 (~200)** collisions per bunch crossing

- The plan
  - include the **Tracker** information in the **Level 1 Trigger**
  - increase the Level 1 Trigger rate from **100 kHz** to **500 kHz (750 kHz)**
  - increase the High Level Trigger rate from **1 kHz** to **5 kHz (7.5 kHz)**

- The challenge
  - achieve the same rejection factor (**100 : 1**) …
  - … with a reasonable **computing power**

lessons learned





- looking at the HLT behaviour in 2012:
  - the overall HLT rate is **robust against pileup**
    - rate increases linearly with luminosity
  - the HLT cpu usage increases **linearly with pileup**
    - neglecting the impact of a tighter L1 selection

computing power

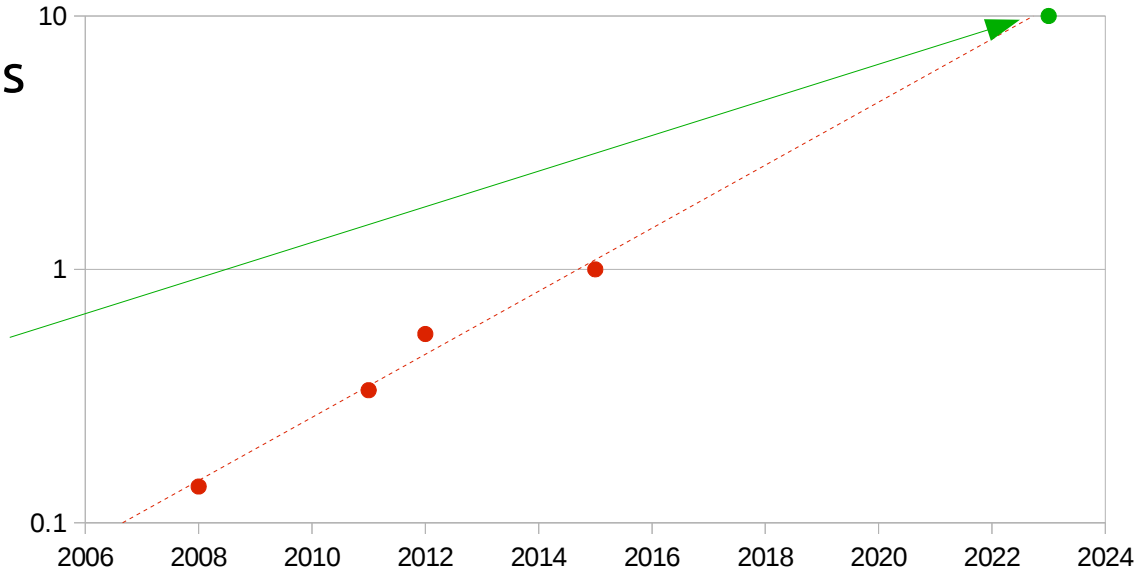
- in 2015, we estimate the HLT cpu budget around **~300 ms/ev.**
  - with a Level 1 Trigger rate of **100 kHz**
  - at a peak luminosity of **~1.4e34 $cm^{-2}s^{-1}$**
  - at a peak pileup of **~40** collisions per bunch crossing

- extrapolating to Phase II (2023), at ~5e34 $cm^{-2}s^{-1}$ (~8e34 $cm^{-2}s^{-1}$)
  - a factor **×5 (x7.5)** in input rate
  - a factor **×3.5 (x5)** in pileup

- leading to **×17.5 (x37.5)** required increase in computing power
  - over the next 8 years

computing power

- extrapolating to Phase II (2023), at ~5e34 $cm^{-2}s^{-1}$ (~8e34 $cm^{-2}s^{-1}$)
  - a factor ×**5** **(x7.5)** in input rate
  - a factor ×**3.5** **(x5)** in pileup
- leading to ×**17.5** **(x37.5)** required increase in computing power
  - over the next 8 years
- look at the power of the HLT nodes
  - bought in 2008, 2011, 2012
  - and foreseen for 2015
- extrapolating to 2023 we could estimate increase by a factor ×**10**
- this still leaves a factor ×**2** **(x4)**



computing power

- even an optimistic extrapolation leaves a factor ×2 or x4 uncovered
- take advantage of the L1 Track Trigger information
  - to **speed up the track reconstruction at HLT**
  - to be investigated, and evaluated
- software improvements
  - the efficiency of the (online and offline) reconstruction is continuously improving
  - **can we gain another factor ×2 or x4 ?**
- hardware improvements
  - take advantage of *accelerators* (**GPUs**, **many-core CPUs**, hybrid approaches)
  - need a **significant effort** in software development
  - the effort in CMS is starting ~ now

rejection power

- can we achieve the same rejection power (**100 : 1**) ?
  - in the harsh Phase II conditions (pileup up to ~200)
  - on top of the L1 Track Trigger

- overall, the L1 should have similar purity to the present system
- the L1 Trigger will have different purity or different objects
  - HLT can have different rejection for different objects, as long the overall rate fits the budget
  - higher rejection power at HLT where the L1 is less selective, and vice versa

"*Provided that the upgraded detectors will have the expected performance this reduction is certainly achievable by HLT algorithms similar to those being used now.*"

rejection power

Category	L1 Triggers	L1 rate (w/ overlaps)	Required reduction	HLT rate
Muons	μ, μμ	21 kHz	~ 21	1 kHz
E/Gamma	e, ee, iso-e, γ, γγ	102 kHz	~ 102	1 kHz
Taus	τ, ττ, e+τ, μ+τ	75 kHz	~ 75	1 kHz
Hadronic	jets, e+MHT, μ+MHT, HTT	138 kHz	~ 138	1 kHz
Others	MET, others	160 kHz	~ 160	1 kHz
Total rate (w/o overlaps)		500 kHz	100	5 kHz

VERY PRELIMINARY!

- L1 rates at **~5e34 $cm^{-2}s^{-1}$**, including a safety factor **×1.5**
- HLT rates assume an equal share among the physics objects
  - not necessarily the case !
  - highest rejection required for hadronic triggers

rejection power

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- **to be studied !**
  - check the actual HLT b/w sharing in 2015
  - adapt the 2015 HLT menu (more or less) to run in Phase II conditions
  - integrate the L1 track Trigger objects in the HLT