

Simulating the Forward Calorimeter for Luminosity Measurements in CMS

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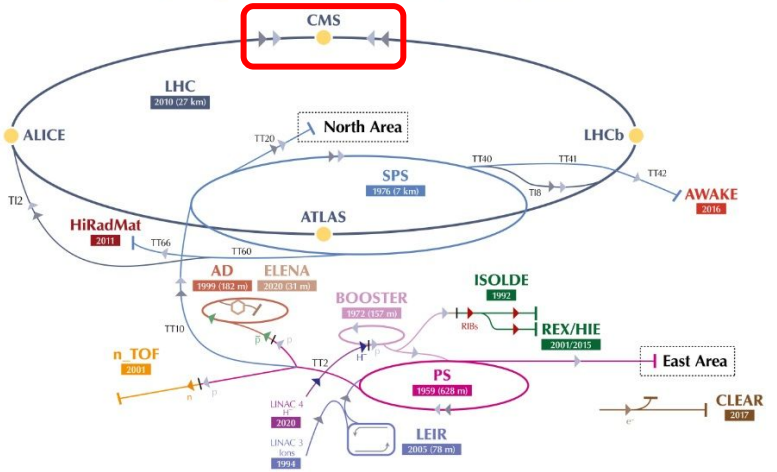


- Context review: the LHC & the CMS experiment
- Particle *collisions* in theory & experiments
- What is luminosity?
- How is luminosity measured?
- Simulating the HF for luminosity measurements in CMS

Context review: the LHC & the CMS experiment

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The CERN accelerator complex
Complexe des accélérateurs du CERN



▶ H^- (hydrogen anions) ▶ p (protons) ▶ ions ▶ RIBs (Radioactive Ion Beams) ▶ n (neutrons) ▶ \bar{p} (antiprotons) ▶ e^- (electrons)

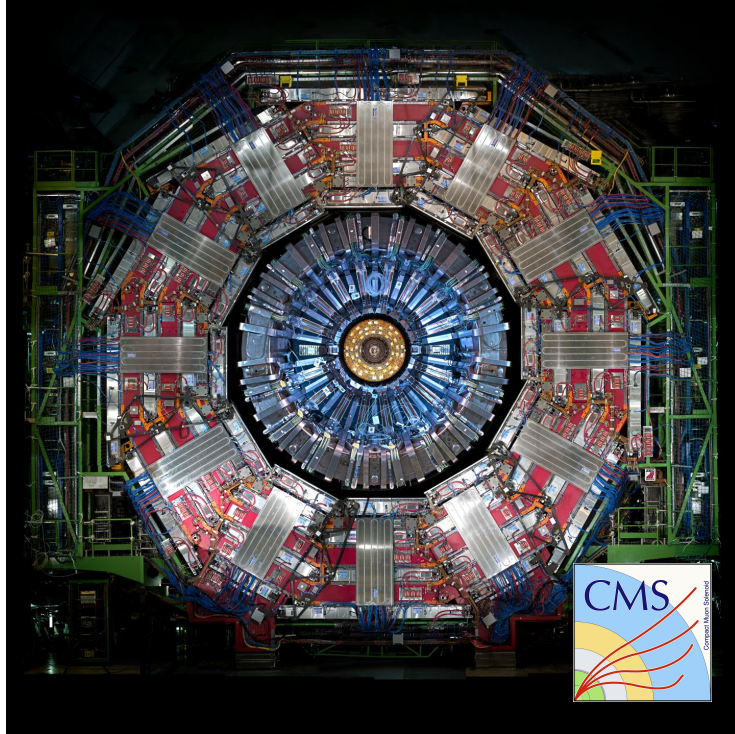
LHC - Large Hadron Collider // SPS - Super Proton Synchrotron // PS - Proton Synchrotron // AD - Antiproton Decelerator // CLEAR - CERN Linear Electron Accelerator for Research // AWAKE - Advanced WAKEfield Experiment // ISOLDE - Isotope Separator OnLine // REX/HIE - Radioactive Experiment/High Intensity and Energy ISOLDE // LEIR - Low Energy Ion Ring // LINAC - LINear ACcelerator // n_TOF - Neutrons Time Of Flight // HiRadMat - High-Radiation to Materials



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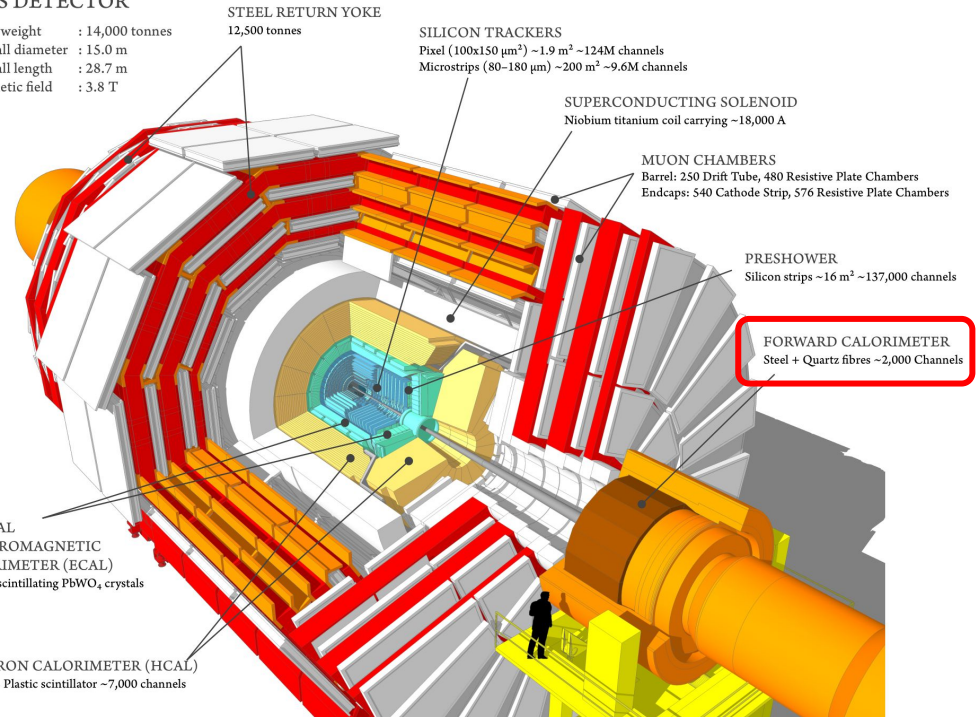


Context review: the LHC & the CMS experiment

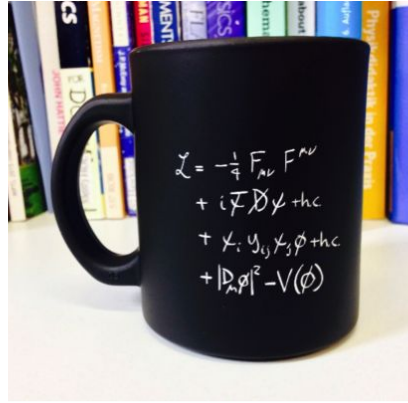


CMS DETECTOR

Total weight : 14,000 tonnes
Overall diameter : 15.0 m
Overall length : 28.7 m
Magnetic field : 3.8 T



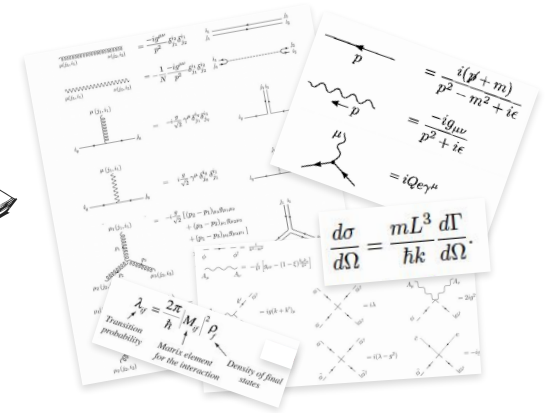
Particle collisions in **theory** & experiments



A lagrangian determined by the principles of the theory of special relativity, quantum field theory and local gauge invariance.



Feynman diagrams for scatterings and decays representing the possible interactions and dynamics of matter particles.



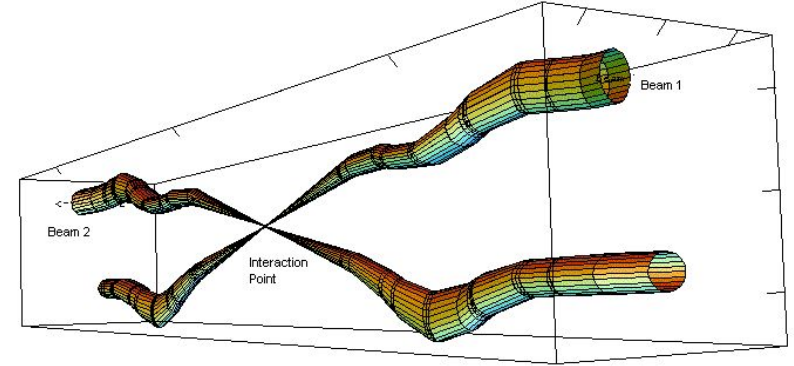
Predictions of cross sections and decay (production) rates are the main **observable quantities in experiments**.

Particle collisions in theory & experiments

pp collision
(qq, gg or qg)



$\sim 10^9$ protons
per bunch



Relative beam sizes around IP1 (Atlas) in collision



$\sim 10^3$ bunches circulating in the LHC


Bunch crossing frequency of 40 MHz

~ 50 pp collisions per bunch crossing

$\sim 10^9$ collisions per second

???

What is luminosity?

 A measure of how tightly packed the particles are in the beams; it is directly related to the number of collisions in each BX.

Instantaneous luminosity

Rate at which particles are brought together to collide.

$$\mathcal{L}(t) = \frac{\gamma n_b N_p^2 f}{4\pi\beta^* \epsilon_n}$$

$$\frac{dN}{dt} = \sigma \mathcal{L}(t)$$





Integrated luminosity

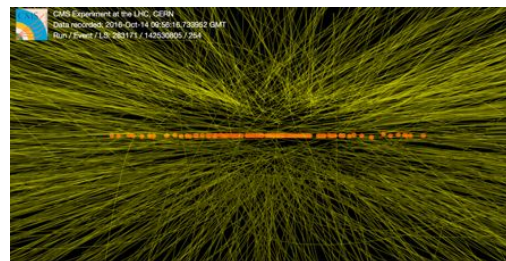
Measure of the accumulated number of collisions over time.

$$L = \int \mathcal{L}(t) dt$$

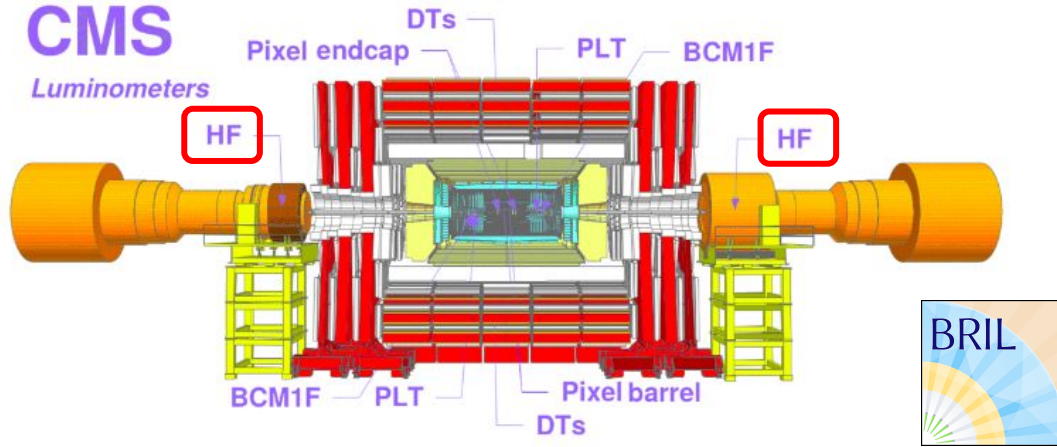
$$\sigma = \frac{N_{sel} - N_{bkg}}{L A \epsilon}$$

It is essential for:

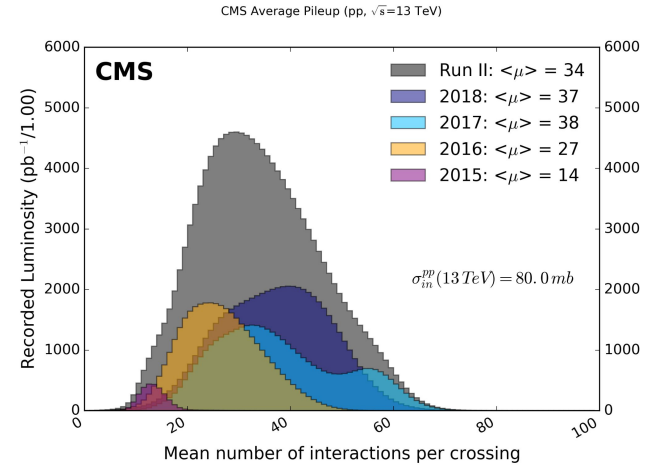
-  **Monitoring** beam conditions for optimization of LHC operations to produce the most collisions possible.
-  **Optimization** of trigger rates and quality of the beams.
-  **Protection** of the LHC machine and sensitive parts or sub-detectors of the experiments.
-  Nearly any **physics** analysis that will be performed on the resulting data.
...but very tricky to determine experimentally.



How is luminosity measured?



BRIL: Beam Radiation, Instrumentation, and Luminosity



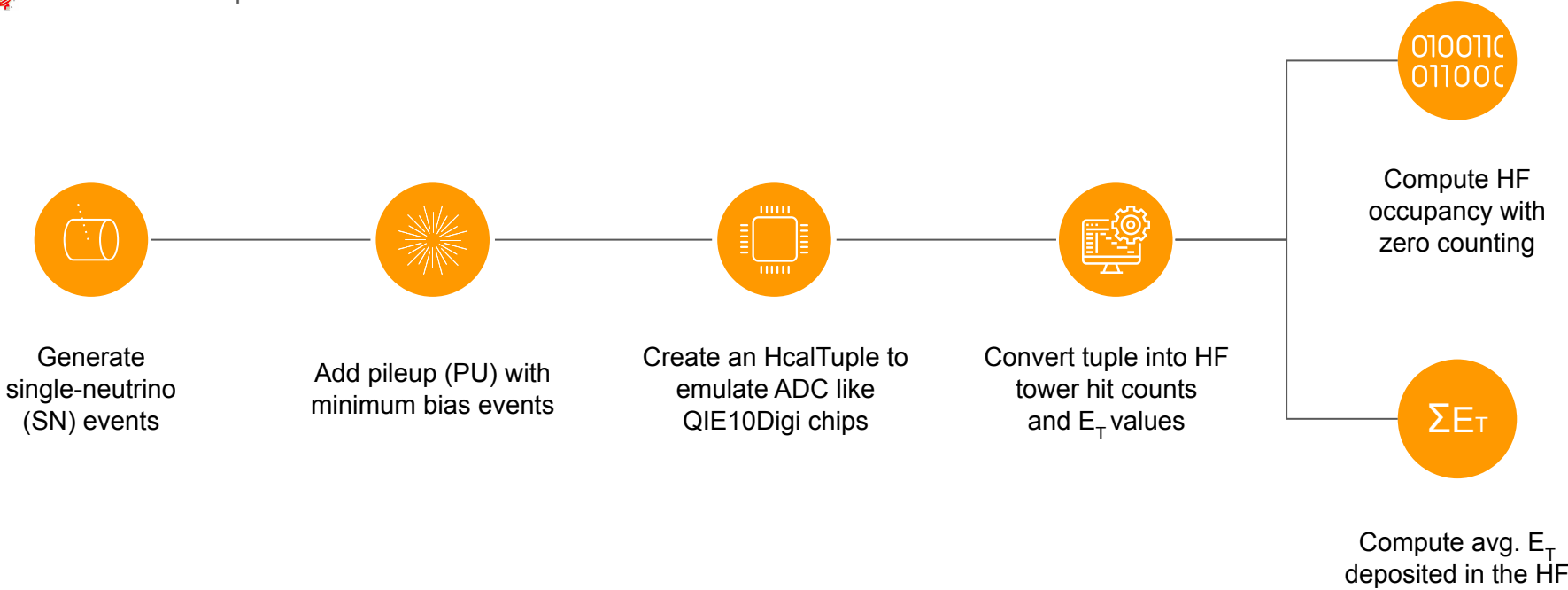
Pileup

The HF can be used for luminosity measurements with two different methods: zero counting (HFOC) and measuring the total E_T deposited in the detector (HFET)

Simulating the HF for luminosity measurements in CMS ⁸



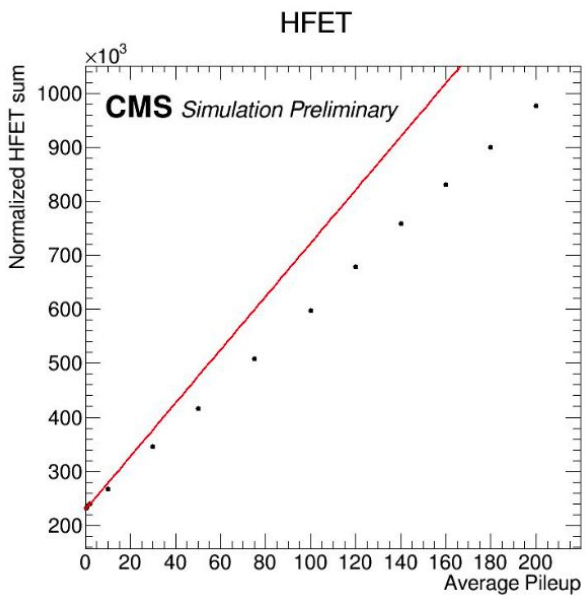
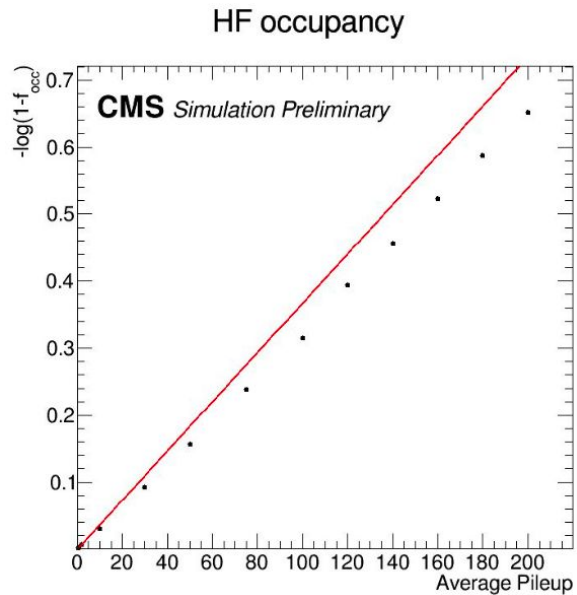
Overview of the process:



Simulating the HF for luminosity measurements in CMS ⁹



Preliminary tryouts with low statistics.





Simulating the Forward Calorimeter for Luminosity Measurements in CMS








THANK YOU!! :P



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