CMS luminosity measurement for nucleus-nucleus collisions at 5.02 TeV

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Luminosity introduction

- Determines the rate of particle collisions
- Relates the cross section of process to the observed rate

$$R(t) = \frac{dN}{dt} = L(t) \cdot \sigma_{process}$$

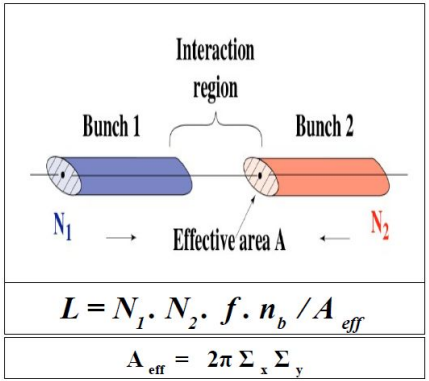
$$\sigma_{vis} = \frac{2\pi \cdot \Sigma_x \cdot \Sigma_y}{N_1 \cdot N_2 \cdot f \cdot n_b} \cdot R_{peak}$$

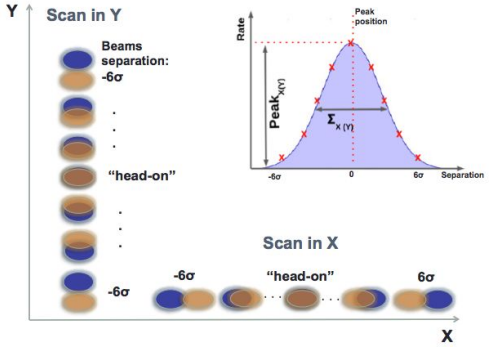
Why precise luminosity measurement is important?

➜ Real-time feedback on accelerator performance

Luminosity measurement

- Using well-known physics process
- Using machine parameters ➜ Beam overlap widths are obtained from vdM scan



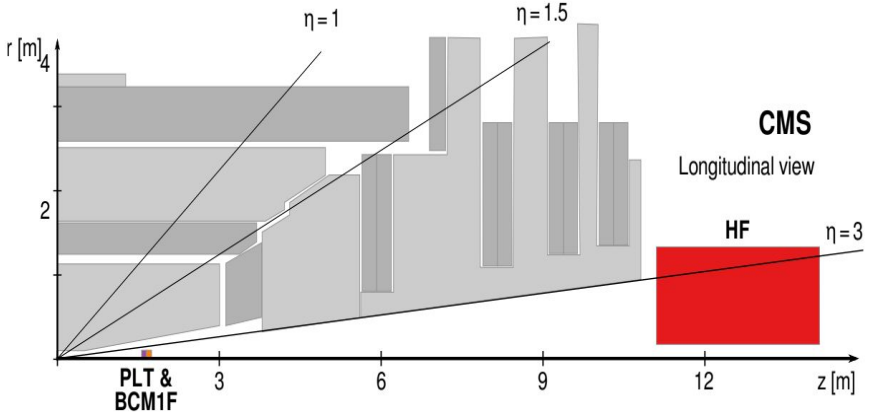


- Beams are separated in X, Y in discrete steps and measure the rate
- Various corrections applied
- Detector dependent calibration constant σ_{vis} measured then used during physics fills

CMS luminometers

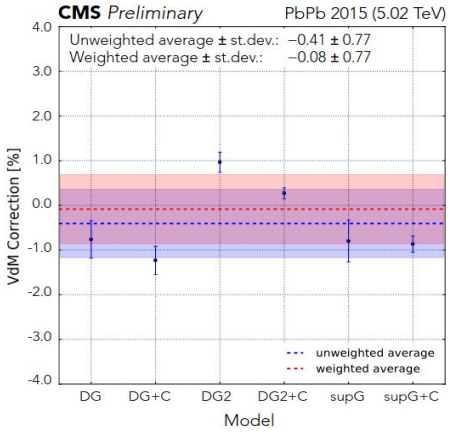
Requirement: linear measured rate-luminosity response or at least correctability

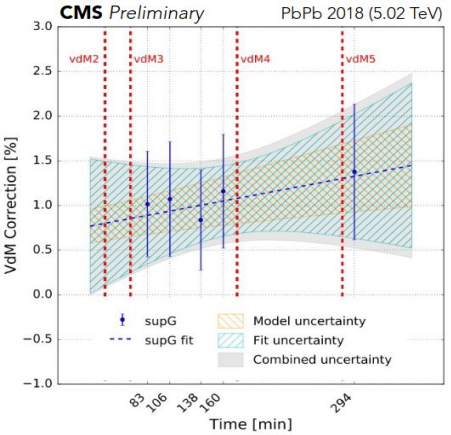
- Pixel Luminosity Telescope
- Hadron Forward calorimeters
- Fast Beam Condition Monitor
- Beam Position Monitors



Corrections to absolute luminosity

- Bunch current normalization
- Non-collision rate
- Orbit drift
- Length scale calibration
- Beam-beam effects
- Transverse factorizability





Source	2015 [%]	2018 [%]	Corr
Normalization uncertainty			
Bunch population			
Ghost and satellite charge	0.3	0.5	Yes
Beam current calibration	0.2	0.2	Yes
Noncolliding bunches			
Noncollision rate	0.5	0.2	No
Beam position monitoring			
Random orbit drift	0.5	0.1	No
Systematic orbit drift	0.2	0.2	Yes
Beam overlap description			
Length scale calibration	0.5	0.5	Yes
Beam-beam effects	0.2	0.3	Yes
Transverse factorizability	1.1	1.1	No
Result consistency			
Cross-detector consistency	2.5	0.4	No
Scan-to-scan variation	—	0.5	No
Statistical uncertainty	0.2	0.1	No
Integration uncertainty			
Detector performance			
Cross-detector stability	0.7	0.8	No
Noncolliding bunches			
Noncollision rate	0.1	0.1	Yes
Total normalization uncertainty	2.9	1.5	—
Total integration uncertainty	0.7	0.8	—
Total uncertainty	3.0	1.7	—

Combined 2015+2018: 1.6% precision

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