

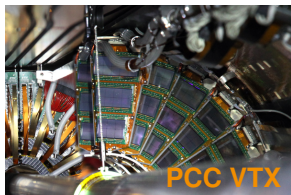
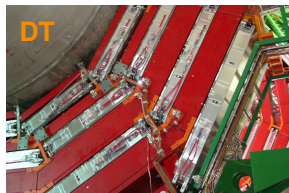
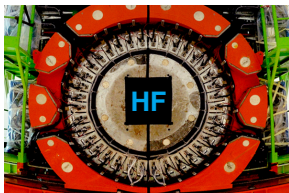
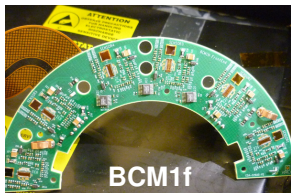
Luminosity Measurements at the CMS Experiment.

Towards reduction of the systematic uncertainty



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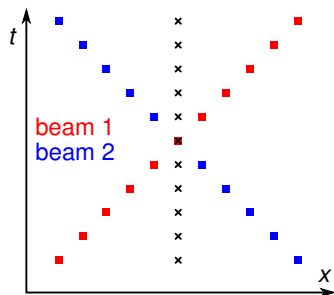
Measuring Luminosity



$$\frac{dN}{dt} = \mathcal{L} \cdot \sigma_{\text{vis}}$$

- > luminosity: measure for number of collisions
- > measurement of luminosity:
 1. calibrate visible cross section σ_{vis}
 2. collect event rate over whole year

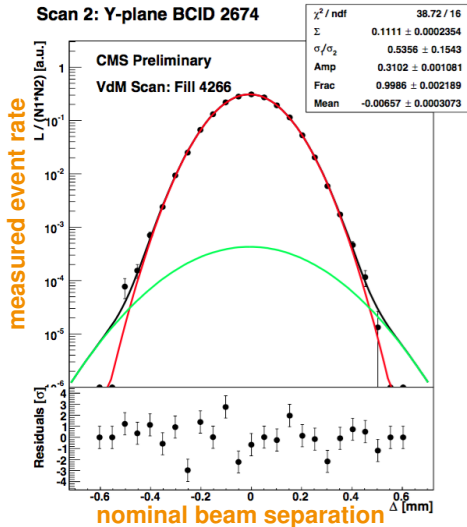
Van der Meer Scan Method



$$\Sigma_x = \frac{1}{\sqrt{2\pi}R_0} \int_{-\infty}^{+\infty} R(\Delta x) d(\Delta x)$$

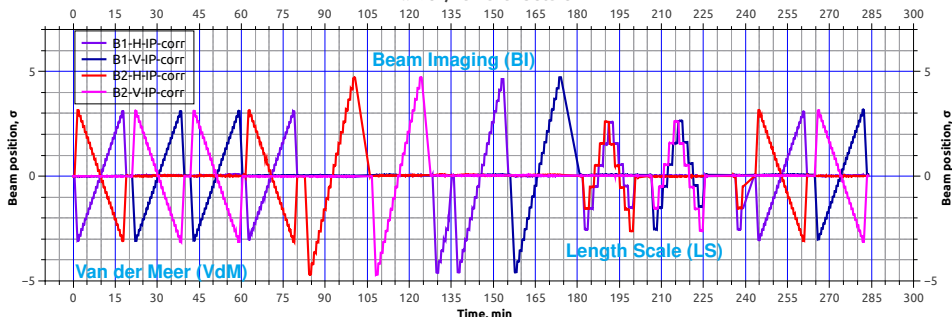
$$\sigma_{\text{vis}} = \frac{2\pi}{N_1 N_2 f} \Sigma_x \Sigma_y R_0$$

- > assume factorizable beam shape
- > take nominal beam positions

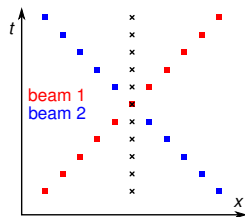


VdM Scan Campaign in 2016

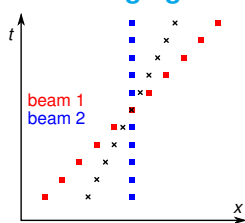
Fill 4954, VdM and LS scans



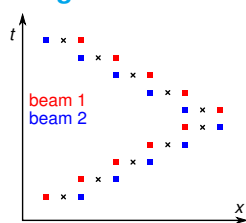
Van der Meer scans



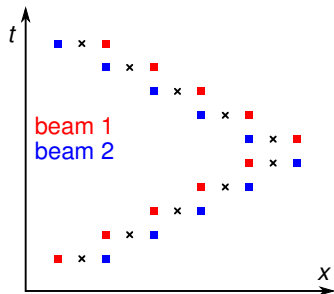
Beam Imaging scans



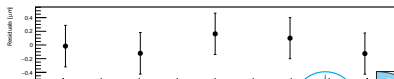
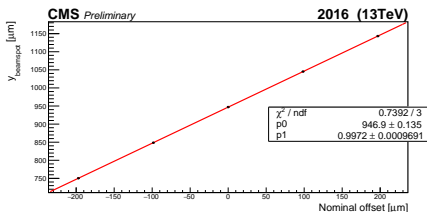
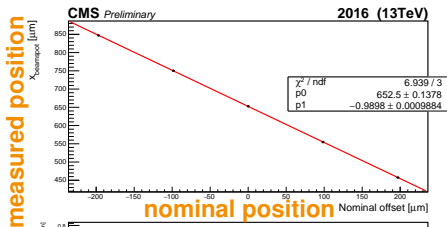
Length Scale scans



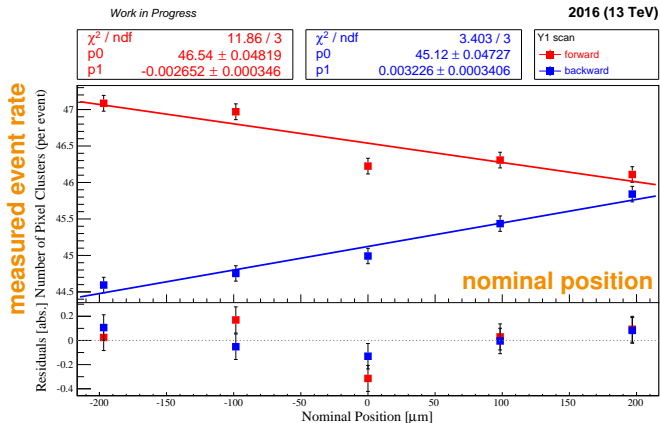
Average Length Scale Corrections



- > measure vertex position as function of nominal position
- > obtain correction:
 - 1.1% horizontally
 - 0.5% vertically
 - $\pm 0.8\%$ uncertainty



Per-Beam Length Scale Corrections



> beam 1:

-0.8% horizontally

-1.0% vertically

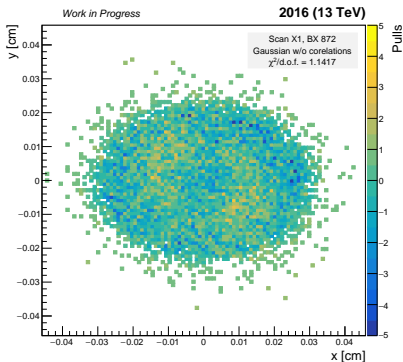
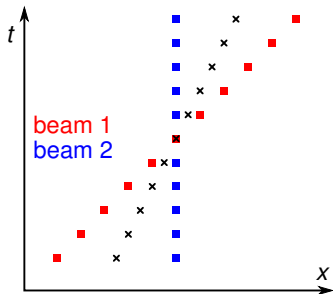
> beam 2:

-1.3% horizontally

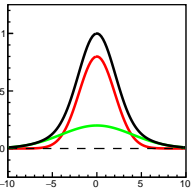
-0.1% vertically



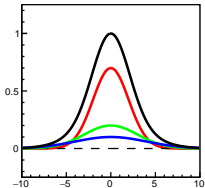
Beam Shape Modelling



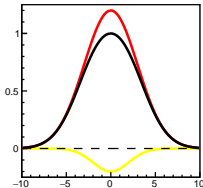
Double Gaussian



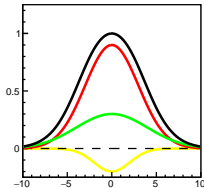
Triple Gaussian



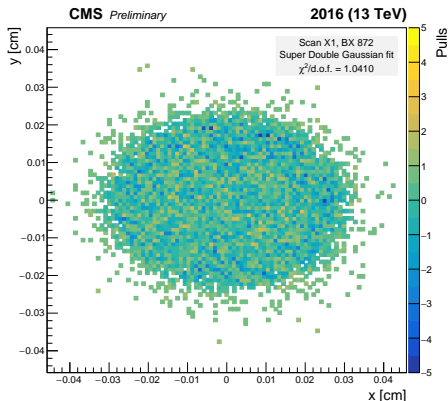
Super Gaussian



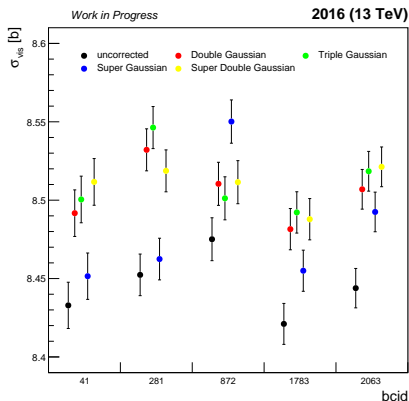
Super Double Gaussian



XY Correlation Corrections



- > best fit: Super Double Gaussian model



- > correction: +0.8 %
- > uncertainty: ± 0.9 %

Conclusions: Uncertainty of Measured Luminosity

Systematic	2015 (CMS-PAS-LUM-15-001)		2016 (CMS-PAS-LUM-17-001)	
	Correction [%]	Uncertainty [%]	Correction [%]	Uncertainty [%]
INTEGRATION				
Internal stability			–	0.5
Cross detector stability	–	1.0	–	1.5
Linearity			–	0.6
Dynamic inefficiency	–	0.4	0 – 1	0.3
Type 1 corrections	7 – 9	0.6	7 – 12	0.7
Type 2 corrections	0 – 4	0.7	0 – 4	0.5
CMS deadtime	–	0.5	–	0.5
NORMALIZATION				
XY correlations	1.1	1.5	0.8	0.9
Beam current calibration	–	0.3	–	0.3
Ghosts and satellites	–	0.2	–	0.4
Length scale	-0.5	0.5	-1.6	0.8
Orbit drift	–	0.4	–	0.4
Beam-beam deflection	1.8	0.4	1.5	0.4
Dynamic- β	–	0.5	–	0.5
TOTAL		2.3		2.5



Thank you for your attention.

