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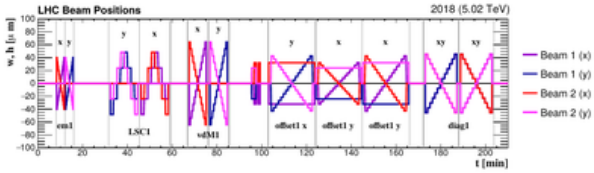
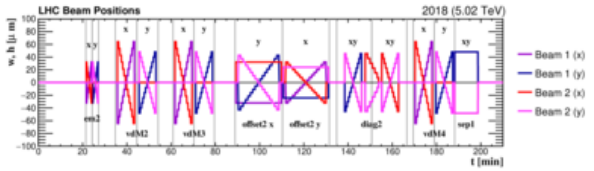
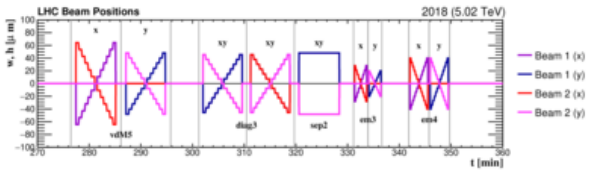
CMS luminosity measurement using nucleus-nucleus collisions in Run 2

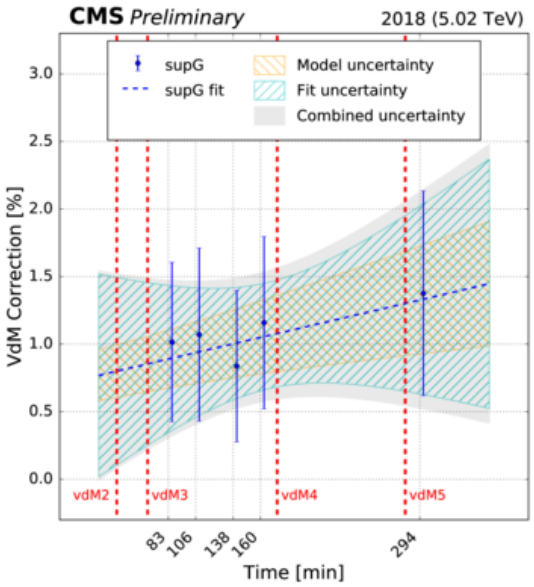
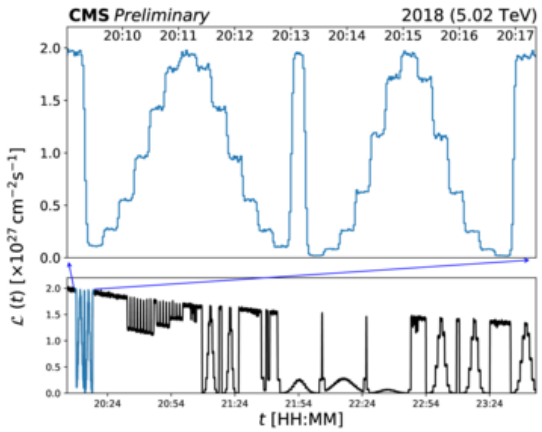
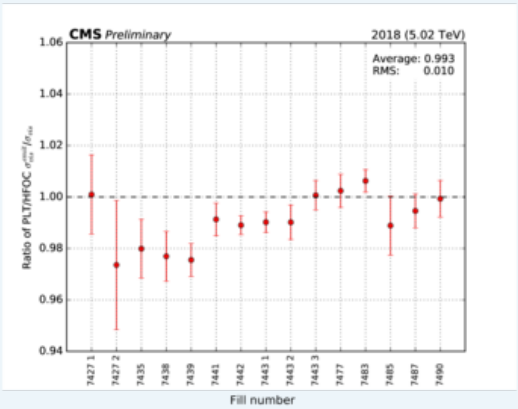
Abstract

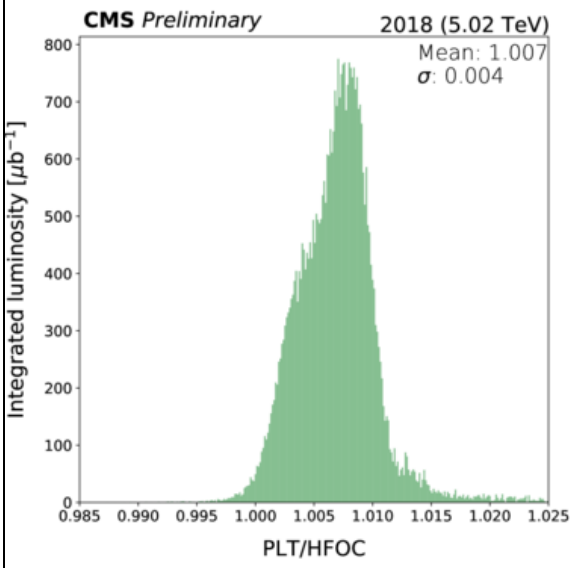
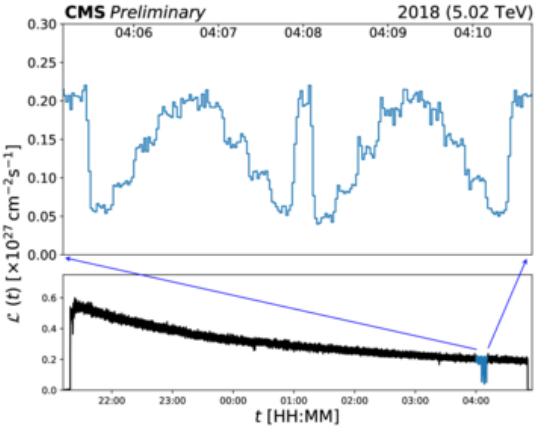
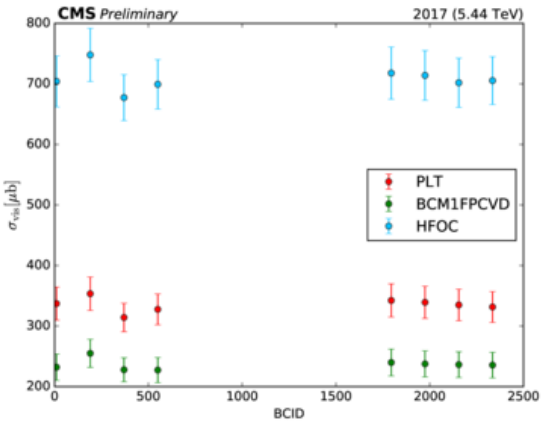
Material about the calibration of the luminosity delivered to the CMS experiment during the lead-lead (PbPb) and xenon-xenon (XeXe) data-taking periods in 2018 and 2017 at nucleon-nucleon center-of-mass energies of 5.02 and 5.44 TeV, respectively, is presented. Three subdetectors are highlighted: the Fast Beam Conditions Monitor (BCM1F), the forward hadron calorimeter (HF), and the Pixel Luminosity Telescope (PLT).

For the PbPb data set, the absolute luminosity is determined by integrating the subdetector rate as a function of beam separation, using the the so-called van der Meer (vdM) scan technique. Corrections and their uncertainty are derived based on a series of additional types of scans. One of the so-far dominant source of systematic uncertainty is related to the horizontal-vertical factorization of the bunch density profiles. The total uncertainty is includes time stability of the vdM-calibrated subdetector response.

Short vdM-like (emittance) scans, performed in CMS during both the PbPb and XeXe data-taking periods, are studied and considered as promising alternative technique also for planned data-taking periods with lighter nuclei.

Figure	Caption
pdf version 	Horizontal (x) and vertical (y) beam displacement measurements provided by LHC magnet currents during the first vdM PbPb scan program in 2018 at CMS. Fill 7442 consisted of horizontal-vertical (x-y) emittance scans (em1), at the beginning, and, subsequently, scans with x-y or vertical-horizontal (y-x) configuration: y-x length scale calibration (LSC) scans (LSC1), x-y vdM scans (vdM1), and additional y-x scans with either constant (offset1 x and offset1 y) or variable (diag1) beam separation in the nonscanning or orthogonal directions, respectively. The short unlabeled scan corresponds to large separation scan dedicated to the estimate of the noncollision rate.
pdf version 	Horizontal and vertical beam displacement measurements provided by LHC magnet currents during the second vdM PbPb scan program in 2018 at CMS. The first part of Fill 7443 consisted of x-y emittance scans (em2), at the beginning, and, subsequently, scans with x-y or y-x configuration: x-y vdM scans (vdM2 and vdM3), y-x scans with either constant (offset2 x and offset2 y) or variable (diag2) beam separation in the nonscanning or orthogonal directions, respectively, and additional x-y vdM scans (vdM4). The short scan corresponds to large separation scan (sep1) dedicated to the estimate of the noncollision rate.
pdf version 	Horizontal and vertical beam displacement measurements provided by LHC magnet currents during the second vdM PbPb scan program in 2018 at CMS. The second part of Fill 7443 consisted of x-y vdM scans (vdM5), x-y scans with variable (diag3) beam separation in the nonscanning or orthogonal directions, respectively, and additional x-y emittance scans (em3 and em4). The short scan corresponds to large separation scan (sep2) dedicated to the estimate of the noncollision rate.
pdf version	Calculated x-y factorization correction for the best-fit model (supG) and all studied vdM+offset and vdM+diagonal scan combinations in fill 7443. The error bars correspond to sources of systematic uncertainty added in quadrature for the supG model. The dashed lines show the first-order polynomial fit to all scan combinations, with the solid area denoting the total uncertainty, correlated among the scan combinations. The hatched areas denote subcomponents of the total uncertainty: the fit (right incline) and model (left incline) sources of uncertainty, respectively. The vertical lines

	mark the time of vdM2 5 relative to the second partner in the scan combinations.
pdf version 	Online instantaneous luminosity at CMS during fill 7442. The top panel is restricted to the period where the em1 scan took place, while the bottom panel displays the entire fill once stable beams are declared with blue (black) denoting the em1 (other) scans. The time format corresponds to UTC+1 timezone.
pdf version 	Cross-detector cross section (vis) ratios corrected for noncollision rate in PLT and HFOC, respectively, from emittance scans recorded during fills 7442 7443 and routine data-taking conditions (7435). Fill 7427 corresponds to beam intensity ramp-up. Multiple emittance scans in the same fill are numbered. The mean and the root-mean-square (RMS) variation of the ratios are shown. The uncertainty is of statistical nature only.

pdf version 	The PLT over HFOC luminosity ratio during the entire PbPb data-taking period in 2018: the mean and standard deviation ( ) are found to be 0.7 and 0.4%, respectively. The cross-detector stability uncertainty corresponds to a range that encloses most of the various short- and long-term differences between PLT and HFOC. The cross-detector consistency, i.e., the difference in luminosity measurements during the vdM fill, is 0.4%.
pdf version 	Online instantaneous luminosity at CMS during fill 6295. The top panel is restricted to the period where the emittance scan took place, while the bottom panel displays the entire fill once stable beams are declared with blue denoting the emittance scan. The time format corresponds to UTC+1 timezone.
pdf version 	Uncorrected cross section (vis) as a function of the bunch crossing ID number (BCID) for BCM1F polycrystalline diamond (pCVD), HFOC, and PLT from the emittance scan recorded during fill 6295. The mean and one standard deviation are plotted per BCID, while the root-mean-square is 2 3%.

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