



Luminosity measurement normalization based on Van der Meer scans at CMS

M. Zanetti (MIT) on behalf of the CMS Luminosity group
(Princeton, MIT, Minnesota)



Outline



- ✓ Description of the methods to determine the effective Area
- ✓ The October VdM scan campaign
- ✓ Length scale calibration
- ✓ Standard VdM analysis
- ✓ Beam Imaging techniques
- ✓ Method results and comparisons
- ✓ Ghost charge analysis
- ✓ Discussion about ideal setup for next VdM scan series
- ✓ In the backup additional material not directly related to luminosity measurement: properties of the beam spot and luminous region during the scan

- ✓ Aim at calibrate the instantaneous luminosity measurement by determining at the same time in a dedicated setup both the rate and the luminosity (from beam parameters):

$$\sigma_{vis} = \frac{R_0}{L_0} \quad L(t) = \frac{R(t)}{\sigma_{vis}}$$

- ✓ The measurement of the LO is performed exploiting a beam scan in the transverse plane and relies on the experiment to measure the effective area:

$$R(\Delta) \propto \int \rho_1(x)\rho_2(\Delta - x)dx \propto \exp\left(-\frac{\Delta^2}{A_{eff}}\right)$$

- ✓ The beam intensity is measured by means of accelerator instrumentation (BCT). The component of the beam which does not contribute to the luminosity but is included in the BCT measurement can be determined by the experiments on the basis of timing of the signals or the location of the collision vertices

- ✓ The Standard analysis is based on the rate evolution as a function of the beam separation:

$$L_0(\Delta x, \Delta y) = \frac{R(\Delta x, \Delta y)}{\sigma_{Vis}} = \frac{R(\Delta x)R(\Delta y)}{\sigma_{Vis}} = \nu N_1 N_2 \int \rho_{1x}(x) \rho_{2x}(\Delta x - x) dx \int \rho_{1y}(y) \rho_{2y}(\Delta y - y) dy$$

$$\sigma_{Vis} = \frac{\int R(\Delta x, \Delta y_0) d\Delta x \cdot \int R(\Delta x_0, \Delta y) d\Delta y}{\nu N_1 N_2 R(\Delta x_0, \Delta y_0)}$$

- ✓ The beam separation comes from the knob and relies on the knowledge of the relation between:
 - correctors current → magnetic field → beam trajectory
- ✓ The scale of the effective area needs therefore to be calibrated



Methods: Beam imaging



- ✓ In the standard approach the information about the luminous region is integrated away. Look for a way to use the extremely precise info from the vertex detectors
- ✓ (V. Balagura) If we consider a scan in a given plane ($\xi=x,y$) and we revert the integration by integrating over the beam separation (Δ), what we get is the beam centered in the coordinate system:

$$R(\xi) \propto \int \rho_1(\xi) \rho_2(\Delta - \xi) d\Delta = \rho_1(\xi)$$

- ✓ If one beam is scanned at the time the scale of Δ is completely negligible.
No length scale calibration needed
- ✓ In reality the integral is a sum and the shape obtained is the convolution of the bare beam profile with the vertex resolution:

$$R(\xi) \propto \sum \{ [\rho_1(\xi) \rho_2(\xi_s - \xi)] \otimes V \} \delta\xi = \rho_1(\xi) \otimes V$$

- ✓ Where for the equality to hold it is assumed:
 - Equality of step sizes
 - ρ and V as linear superposition of Gaussians
- ✓ Effective area directly from the density functions integration:

$$\frac{1}{A_{eff}^{\xi}} = \int \rho_1(\xi) \rho_2(\xi) d\xi$$



Length scale calibration



Length scale calibration (fill 1439)

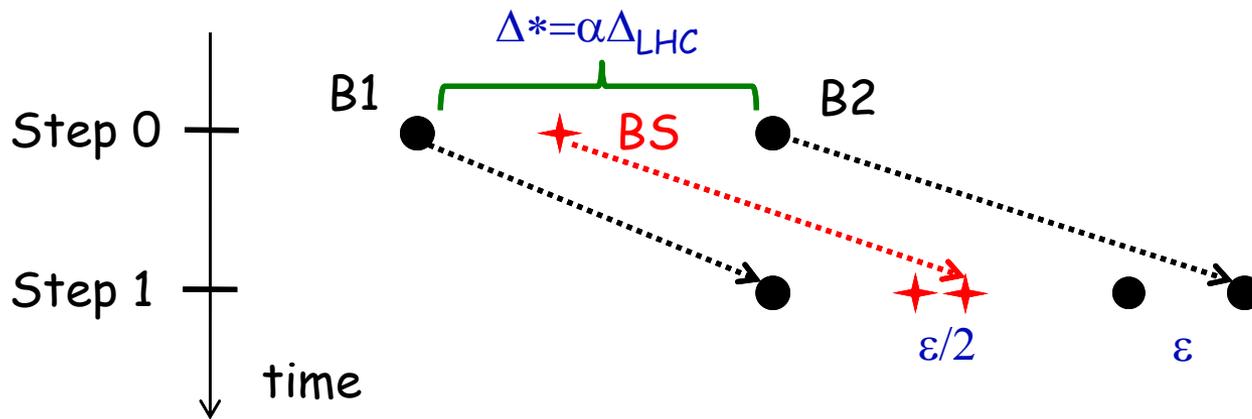


- ✓ Standard physics fill, very short (~15 min) EOF exercise.
- ✓ Compare LHC "length scale" with CMS one (assuming the latter to be more accurate) by comparing the movement of the beam spot w.r.t the assumed movement of the beams
- ✓ Idea is to keep the beams at a distance such to maximize the sensitivity of the lumi on the displacement:

$$\max \frac{\partial L}{\partial \Delta} \rightarrow \Delta = \sqrt{2} \sigma$$

- ✓ In addition to the standard comparison of the beam spot and beam positions, the variation of the luminosity help in distinguishing which beam is moving at "faster" or "slower" pace
- ✓ Calibration done with 5 steps per plane of 30 sec each with beams at nominal 70 μm .
- ✓ CMS used the same trigger configuration as for the VdM scans:
 - Trigger gated on only 3 BXIDs
 - 2 kHz on disk, zero bias and min bias trigger only

Definitions



- ✓ If B1 and B2 are moved by nominal Δ_{LHC} , each is moved by the real quantity:

$$\Delta_{B1}^* = \alpha_1 \Delta_{LHC} \quad \Delta_{B2}^* = \alpha_2 \Delta_{LHC}$$

- ✓ We define: $\frac{\alpha_1 + \alpha_2}{2} \equiv \bar{\alpha}$ $\alpha_2 - \alpha_1 \equiv \varepsilon$ $\alpha \sim 1, \varepsilon \sim 0$

- ✓ The BS then gets moved by:

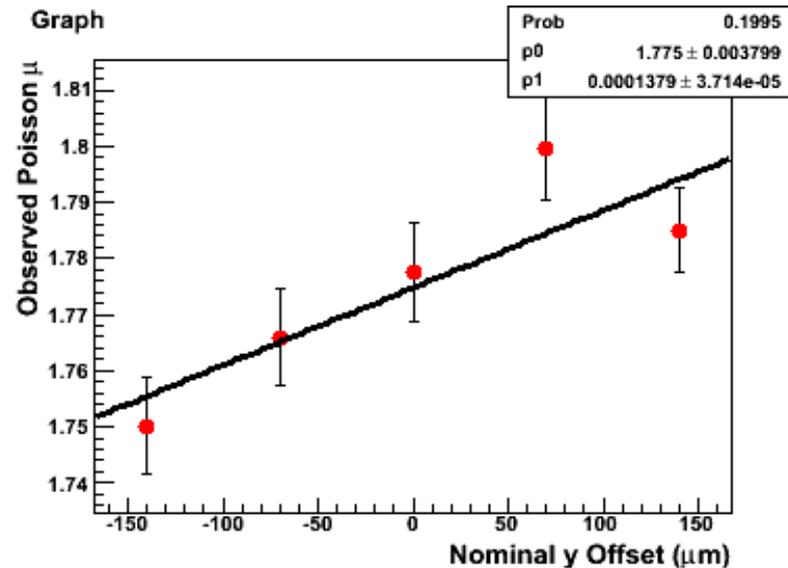
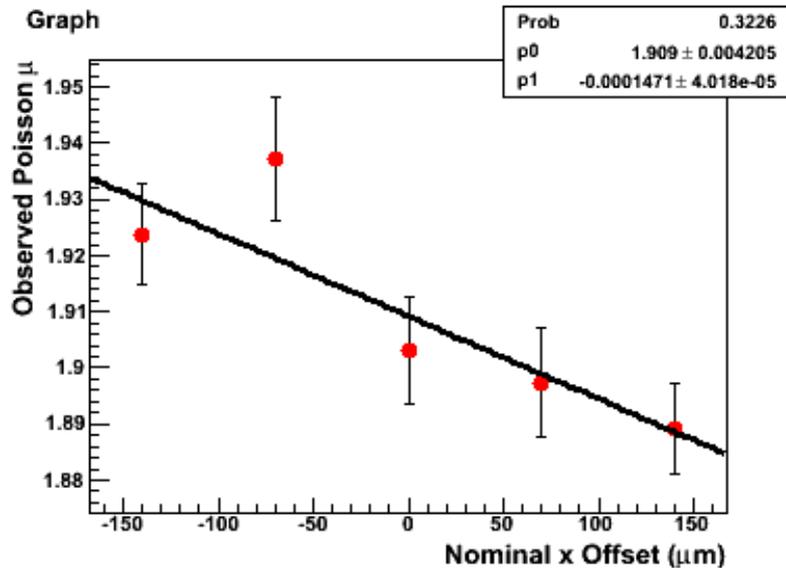
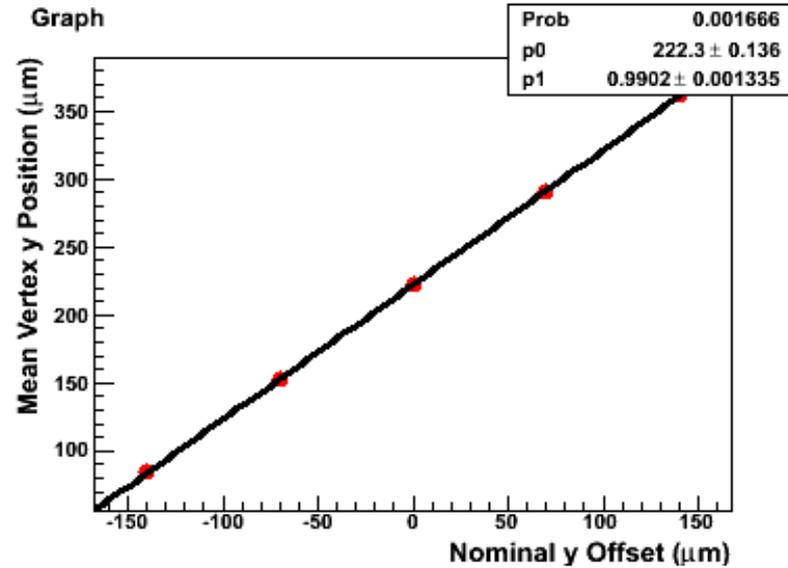
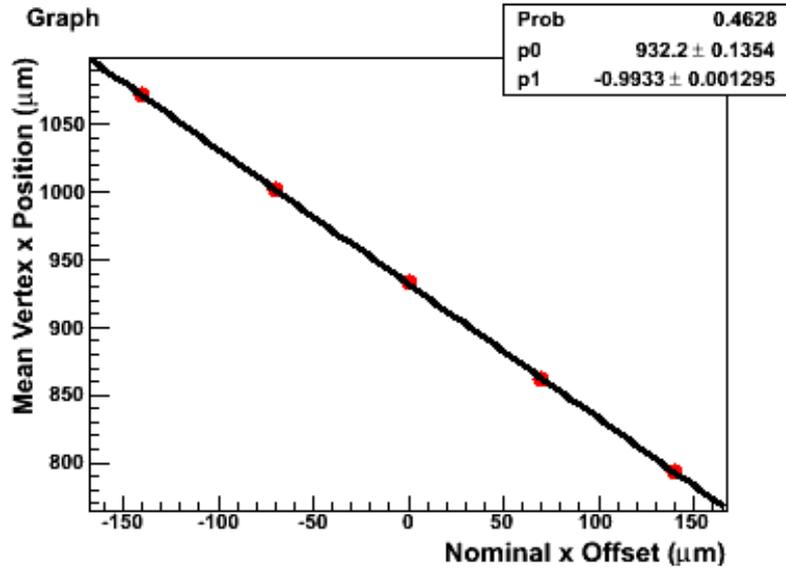
$$\Delta_{BS} = \bar{\alpha} \Delta_{LHC}$$

- ✓ The difference of the luminosity from two steps is therefore:

$$\partial L \cong -L \frac{\alpha \Delta_{LHC}^2 \varepsilon}{2 \sigma_{eff}^2} \Rightarrow \varepsilon \cong -\frac{\delta L}{L} \frac{2 \sigma_{eff}^2}{\Delta_{LHC}^2}$$



BS and Lumi vs nominal separation



Length Scale results

Parameter	x		y	
	Value	Error	Value	Error
$\bar{\alpha}$	0.9933	0.0013	0.9902	0.0013
μ_0	1.909	0.004	1.775	0.004
μ slope	-1.47×10^{-4}	0.40×10^{-4}	1.37×10^{-4}	0.37×10^{-4}
ϵ	0.0070	0.0019	-0.0071	0.0019
α_1	0.9898	0.0016	0.9937	0.0016
α_2	0.9968	0.0016	0.9867	0.0016

- ✓ Results not yet corrected for natural luminosity decay (should be small, LS lasted only 4 minutes per plane)
- ✓ For the double beam scan the correction is simply the average of the scale factors
- ✓ For the single beam scan the individual beam scale factors need to be considered



VdM scans, fill 1386 and 1422



Scans description



- ✓ Fill 1386, "Double beam scan":
 - Nominal optics ($\epsilon \sim 3 \mu\text{m}$, $\beta \sim 3.5 \text{m}$, $\alpha \sim 100 \mu\text{rad}$), 8×10^{10} ppb, 6 colliding bunches in IP1/5
 - beams starting respectively from $+3\sigma$ and -3σ (nominal $\sigma \sim 60 \mu\text{m}$)
 - Beams moved at the same time towards the other edge at 0.5σ steps, 25 seconds per step
 - One scan per plane
- ✓ Fill 1422, "Single beam scan":
 - Same conditions as for fill 1386, but for number of bunches (3 only in CMS)
 - One beam moved at the time with the other kept at nominal position
 - Max excursion $\pm 4.5 \sigma$ (MP restrictions). 0.5σ steps, 25 seconds per step
 - 4 scans: 2 beams, 2 planes
- ✓ CMS trigger and DAQ conditions
 - Special trigger/DAQ configuration with only 2 triggers enabled:
 - Zero Bias: BPTX AND, constant prescale, 500 Hz on disk
 - Minimum Bias: (BSC and/or pixel tracks) variable prescale, up to 1.5 kHz on disk
 - Online lumi DAQ recording every crossing
 - Central DAQ recording only 3 BXs



Standard Analysis



Standard Analysis



- ✓ Based on standard luminosity monitors measurements:
 - Online (central DAQ independent), based on the full rate:
 - HF towers occupancy
 - HF Et Sum
 - Offline:
 - HF zero counting (Et>1 GeV, in HF+ and HF-, $|\Delta t| < 8\text{ns}$ between HF+ and HF-)
 - Vertex zero counting (≥ 1 reco'ed vertex within $|z|=15\text{cm}$)
- ✓ Fit the $R(\Delta)$ distribution with a double gaussian and determine the effective area from the σ 's

$$\sigma_{eff}(i) = \frac{\sigma_{1i}\sigma_{2i}}{h_i\sigma_{2i} + (1-h_i)\sigma_{1i}}$$

- ✓ Both scans from fills 1386 and 1422 are considered

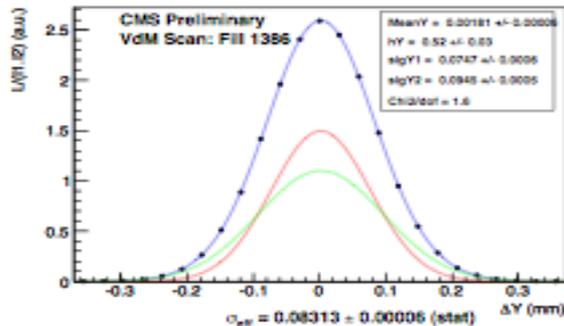


Standard Analysis Systematics

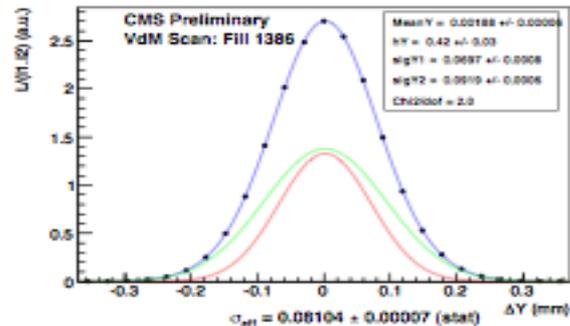


- ✓ Same list as for Spring scan (i.e. already approved..). Values still to be properly computed. Here are reported the ones from previous note (very conservative):
 - Beam background, 0.1%
 - Fit Systematics 1.0%
 - Beam shape 3.0%
 - Zero point 2.0%
 - Length scale calibration 2.0%
- ✓ What is new is the way we apply length scale correction (explained before)

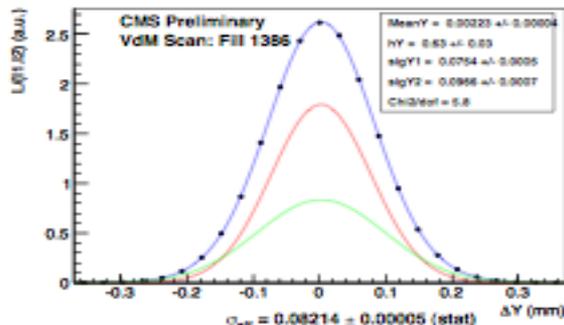
Online Results fill 1386 Y plane



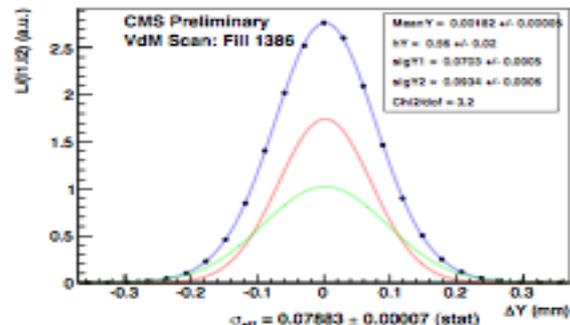
(a) BX = 1



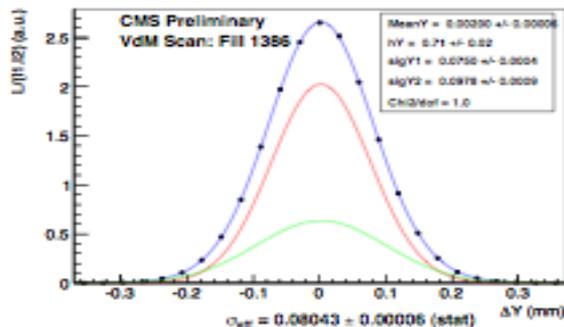
(b) BX = 501



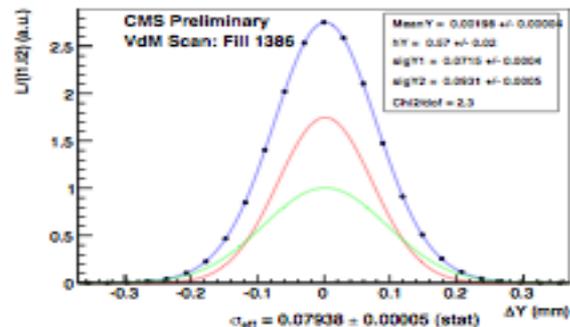
(c) BX = 862



(d) BX = 1451

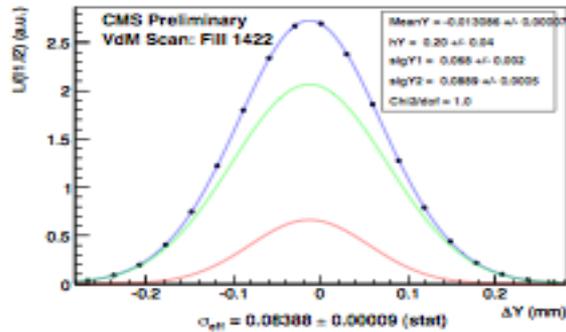


(e) BX = 1651

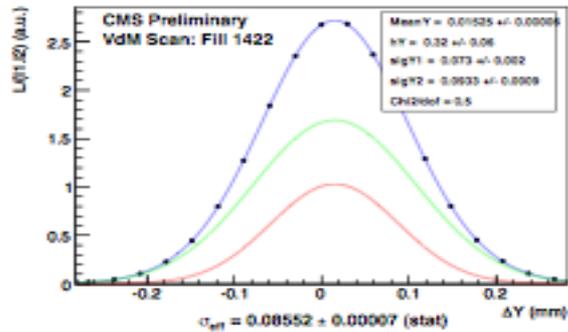


(f) BX = 2301

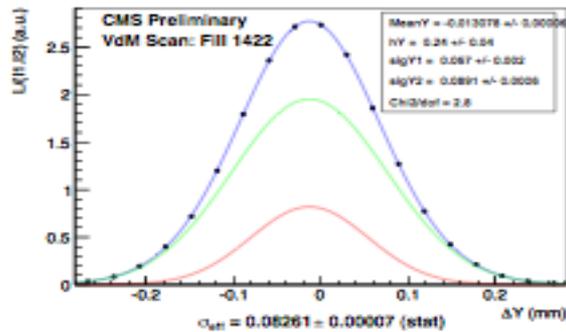
Online Results fill 1422 Y plane



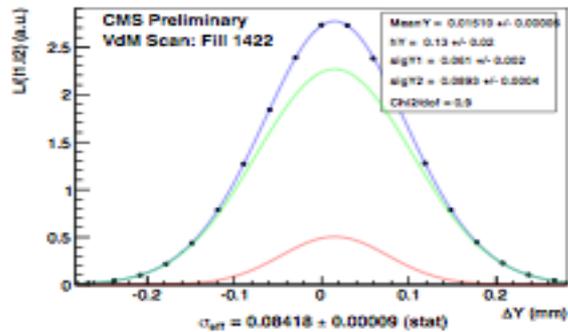
(a) Y Scan 1, BX = 1



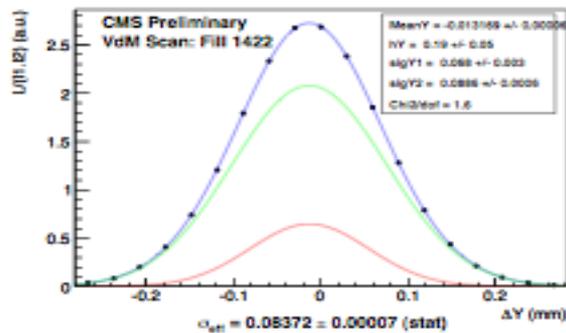
(b) Y Scan 2, BX = 1



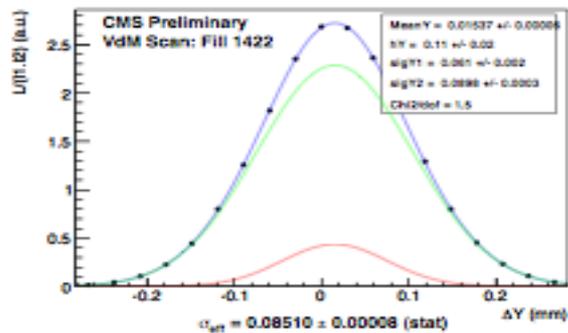
(c) Y Scan 1, BX = 51



(d) Y Scan 2, BX = 51



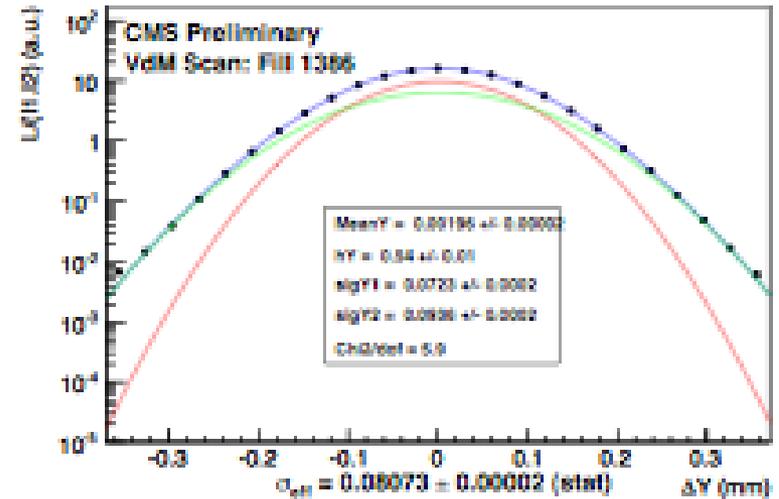
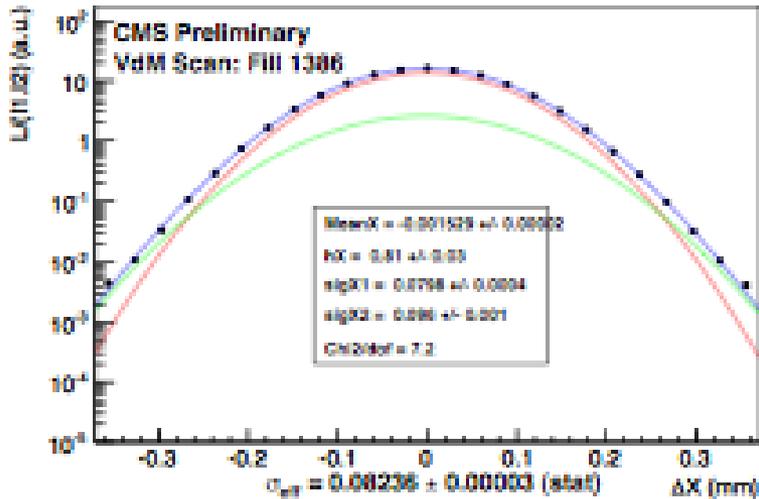
(e) Y Scan 1, BX = 101



(f) Y Scan 2, BX = 101

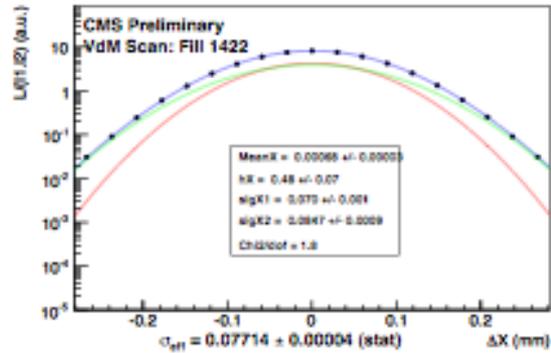
Online Results, tail zoom

All BXs fill 1386 (6σ wide scan)

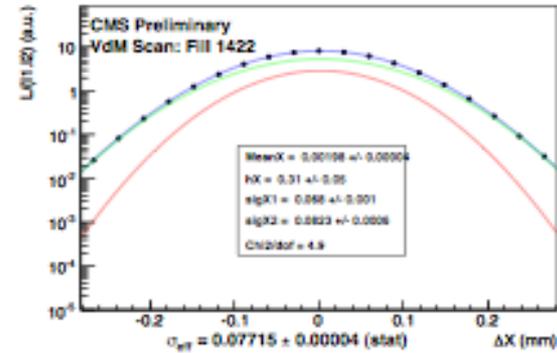


Online Results, tail zoom

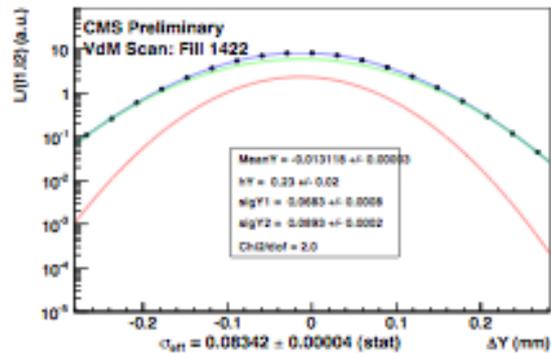
All BXs fill 1422 (4.5σ wide scan)



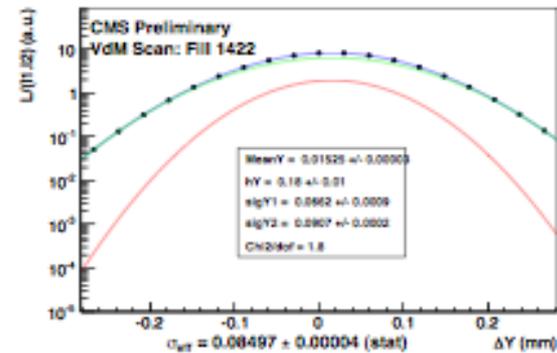
(a) X Scan 1



(b) X Scan 2



(c) Y Scan 1



(d) Y Scan 2

- ✓ There might be an effect of the limited scan range in the vertical plane
- ✓ To have a feeling about the how import this can be, look at scan 1386 and artificially restrict the fit range. There the effect is of the order of few per mille



Single Beam Imaging



Beam imaging technique

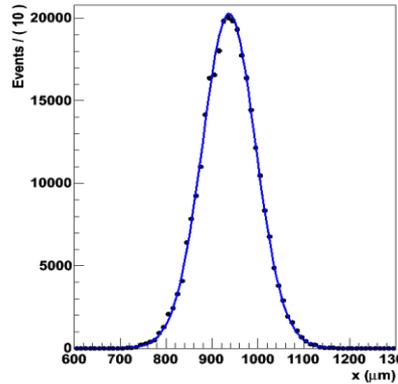


- ✓ The observable is build up from the Primary Vertices reconstructed in the event
 - With quality cuts applied, average vertex resolution $\sim 25 \mu\text{m}$
- ✓ The method is applied only to fill 1422. Integrate luminous region in Δ separately for X and Y, b1 and b2, BX 1, 51, 101 (12 distribution to be unfolded)
- ✓ Several possibilities (including unfolding w/o assuming the beam PDF). Currently exploiting an unbinned max likelihood fit
- ✓ Assume double gaussian shape for the beam and gaussian for the vertex resolution. PDF is conditioned with vertex uncertainty per event
 - Vertex resolution scale corrected by means of the width obtained from the pulls (from data themselves)

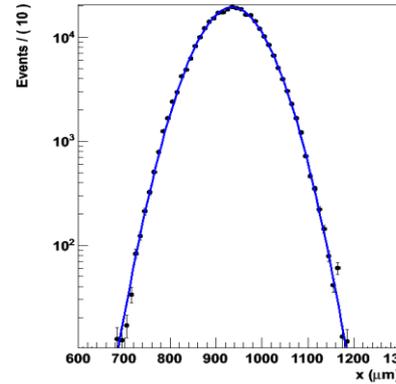
$$f(\xi) = \left[\frac{h_\xi}{\sqrt{2\pi}\sigma_{1\xi}} e^{-\frac{(\xi - \mu_\xi)^2}{2\sigma_{1\xi}^2}} + \frac{(1 - h_\xi)}{\sqrt{2\pi}\sigma_{2\xi}} e^{-\frac{(\xi - \mu_\xi)^2}{2\sigma_{2\xi}^2}} \right] \otimes V(\xi; \mu = 0, \sigma_r | d(\sigma_r))$$

Fit examples

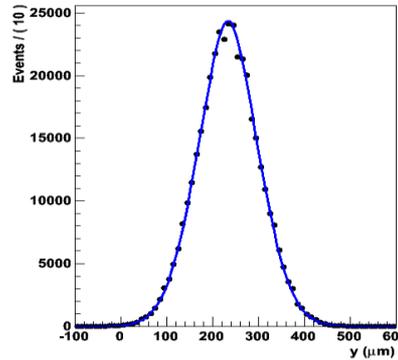
B1H Bx=101



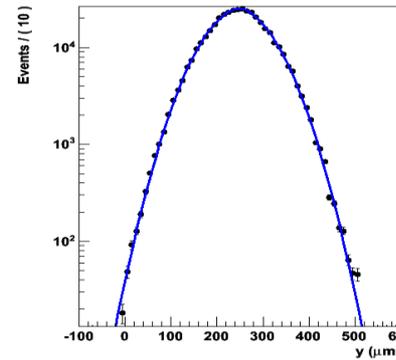
B2H Bx=101



B1V Bx=1



B2V Bx=1



- ✓ Error is estimated from the distribution of the A_{eff} obtained by varying the fit parameters ($\pm 1 \sigma$) around the minimum accordingly to the covariance matrix
- ✓ In all cases, statistical uncertainty of the order of few per mille

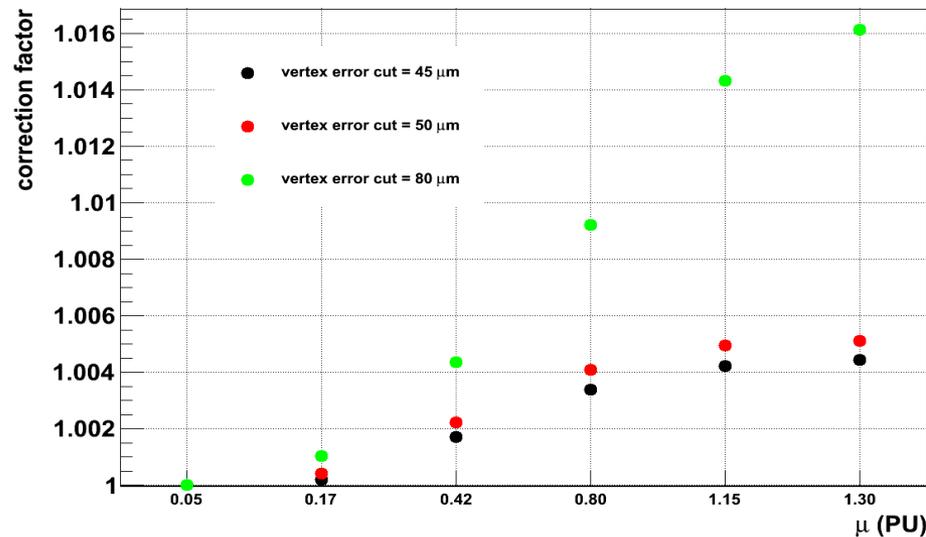


Biases and Systematics



- ✓ Vertex reconstruction efficiency
 - Pileup (varying with beam separation)
- ✓ Vertex resolution scale
 - A possible scale error in the quantity we need to unfold from the observable has a direct impact on A_{eff} □
- ✓ Limited scan range
 - Scan up to 270 μm with a sigma of max 60 μm
- ✓ Tilt of CMS axes w.r.t scan axes
 - Correction enters with the cosine of the angle, second order effect, negligible

- ✓ Run a MC full detector simulation with the various pileup scenarios we had during the scan ($\mu=1.3, 1.15, 0.8, ..$)
- ✓ For different vertex quality cuts, measure the efficiency.
- ✓ Efficiency defined as:
 - Denominator: total number of collisions vertices (from MC)
 - Numerator: total number of reconstructed vertices
- ✓ Correction factor computed as variation in efficiency w.r.t to the lowest pileup scenario
- ✓ Overall negligible correction with unperceivable impact on A_{eff}





Vertex Resolution scale

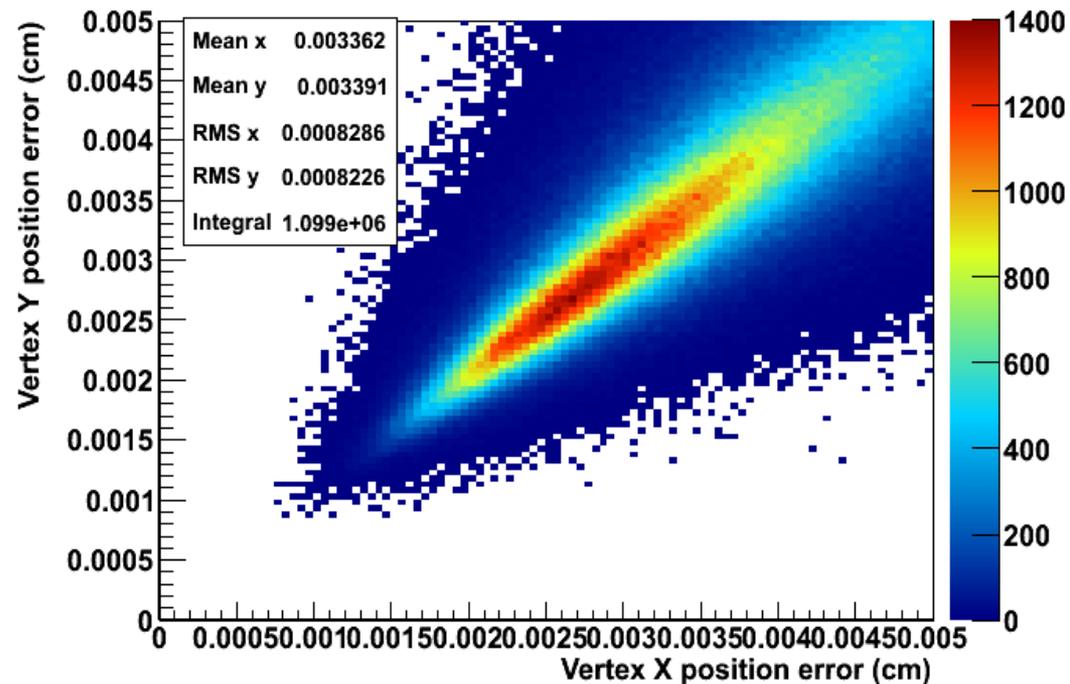
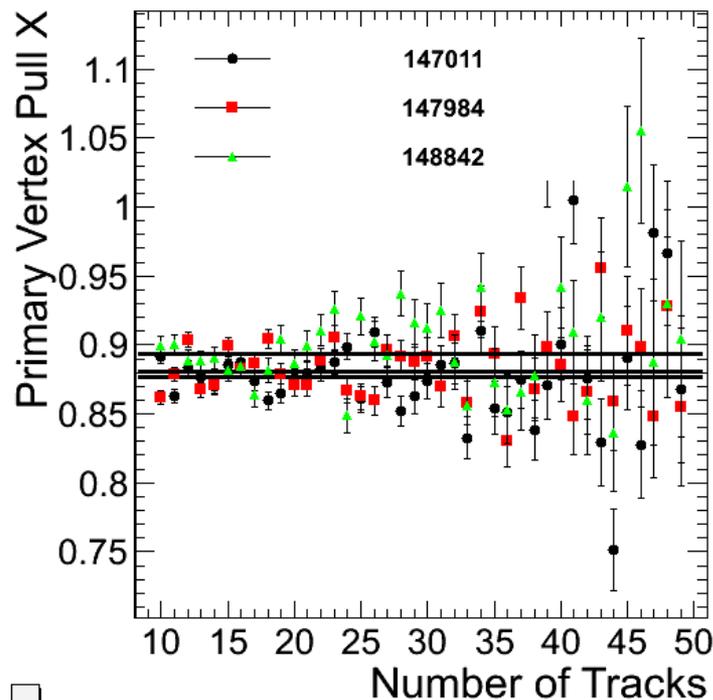


- ✓ Vertex resolution scale obtained from the pulls
- ✓ Pulls have been computed directly from the data (split tracks into 2 sets and compute the distance of the 2 new vertices)
- ✓ Correction factor=0.88+/-0.01

	run 147011	run 147984	run 148842
rescale factors	0.881 ± 0.003	0.879 ± 0.003	0.891 ± 0.004

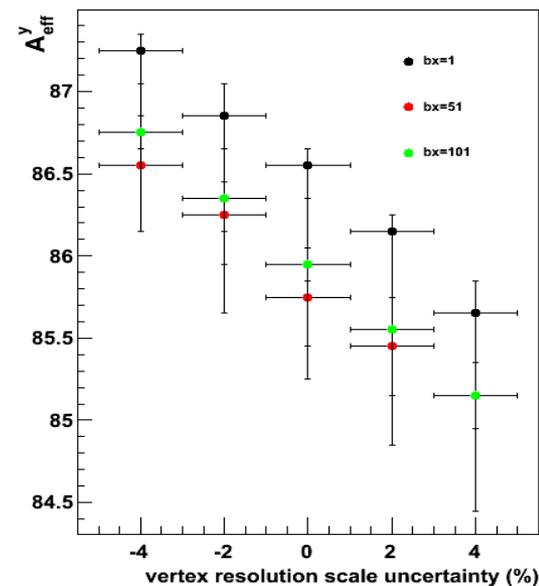
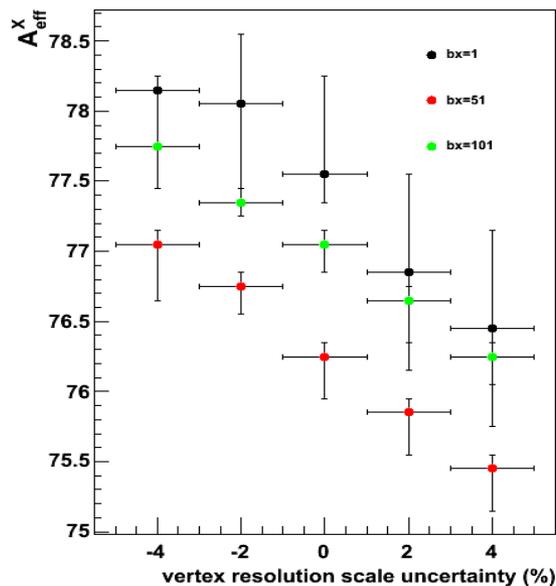
CMS preliminary 2010

$\sqrt{s} = 7 \text{ TeV}$



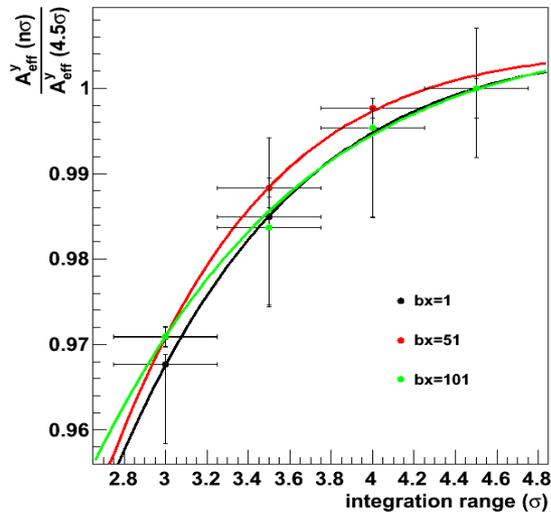
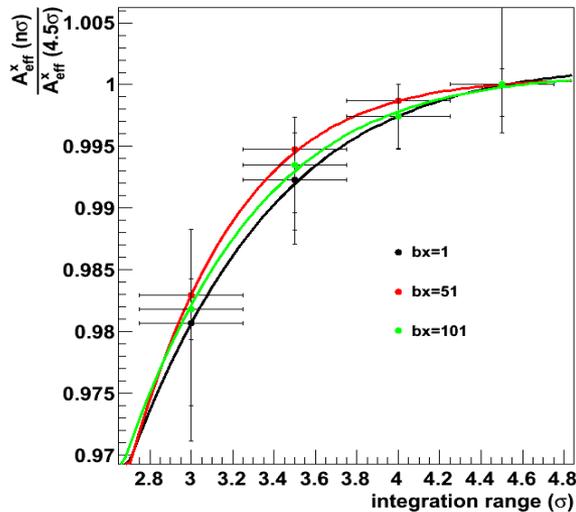
Vertex Resolution scale

- ✓ Assume vertex position uncertainty scale off w.r.t nominal by +/- 4% unfolding
- ✓ Compare results for the A_{eff} , resulting variation $\sim 0.5\%$ for 2% scale error



Integration range

- ✓ Restrict integration over Δ to smaller ranges (4, 3.5, 3 nominal σ) and check the effect on A_{eff}
- ✓ Plateau is reached for horizontal plane, still not right there for the vertical one.
- ✓ Bias/error can be estimated by:
 - Fitting with the error function the evolution of the observable and predict its value at plateau
 - Assign as (one direction) uncertainty the difference $A_{eff}(4.5\sigma) - A_{eff}(4\sigma)$



	BX 1	BX 51	BX 101
X	0.1%	<0.1%	<0.1%
Y	0.4%	0.5%	0.6%



Results and Comparison



Comparison Fill 1422



Scan	Method	BX=1		BX=51		BX=101	
		Aeff	Error	Aeff	Error	Aeff	Error
xb1	HF Online	76.35	0.04	76.00	0.06	76.56	0.07
	HF Offline	77.56	0.43	77.76	0.47	77.44	0.46
	Vertex Offline	77.36	0.40	77.40	0.43	77.64	0.42
xb2	HF Online	76.95	0.09	76.51	0.07	77.01	0.07
	HF Offline	78.74	0.47	76.71	0.53	78.42	0.53
	Vertex Offline	78.42	0.44	76.84	0.48	78.27	0.49

	BX1	BX51	BX101
Std Online	76.65	76.26	76.79
Std Offline	78.02	77.18	77.94
BeamImage	77.35	76.10	77.05
RMS %	0.88%	0.76%	0.80%

Scan	Method	BX=1		BX=51		BX=101	
		Aeff	Error	Aeff	Error	Aeff	Error
yb1	HF Online	83.35	0.09	82.09	0.07	83.19	0.07
	HF Offline	84.89	0.53	83.61	0.56	84.54	0.56
	Vertex Offline	85.00	0.49	83.93	0.52	84.85	0.52
yb2	HF Online	84.38	0.07	83.06	0.08	83.97	0.08
	HF Offline	85.08	0.52	84.66	0.57	85.22	0.57
	Vertex Offline	85.40	0.48	84.97	0.52	85.32	0.53

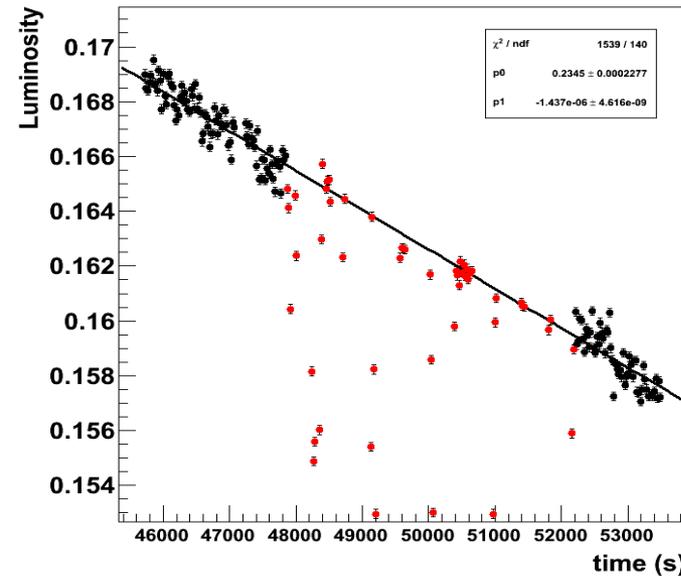
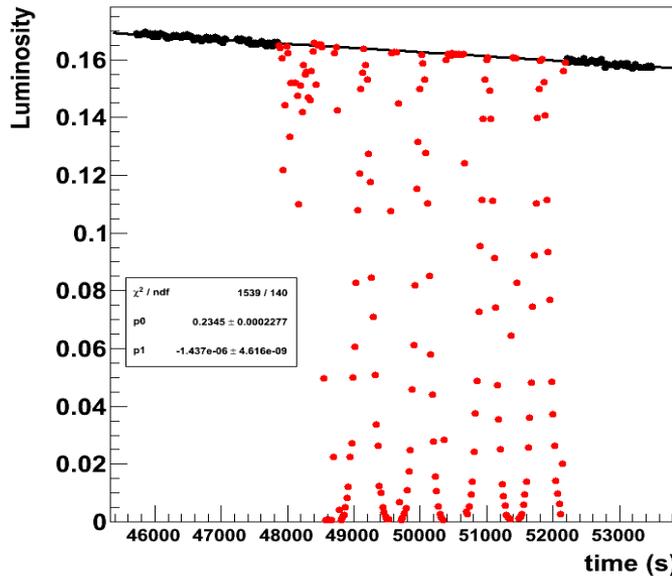
	BX1	BX51	BX101
VdM Online	83.87	82.57	83.58
VdM Offline	85.09	84.29	84.98
BeamImage	86.55	85.75	85.95
RMS %	1.58%	1.89%	1.40%

- ✓ Out of the box comparison. VERY PRELIMINARY
- ✓ All standard analysis results has got length scale calibration applied
- ✓ Overall O(1%) agreement between independent methods



Examples of Zero Point calculation (std HF online method, fill 1422)

Luminosity Evolution



- ✓ Decrease of luminosity due to emittance growth and intensity decrease. During each individual scan (fill 1422) $\sim 0.6\%$
- ✓ L_0 can be estimated at the "Zero Points" i.e. when the beams are perfectly overlapped
- ✓ The value of the A_{eff} is extrapolated from when it is measured to a given Zero Point. This is done on the basis of the emittance measurement performed by the Wire Scanners and BSRT (at IP4)
 - Uncertainty $\sim 8\%$



σ_{vis} from Std Online HF



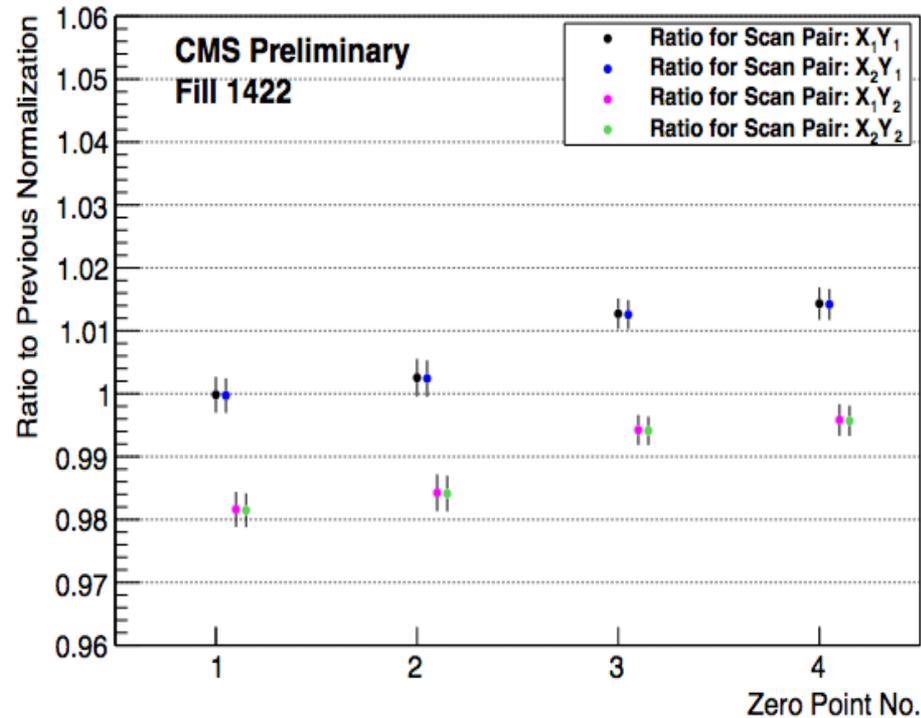
- ✓ In the following results for the luminosity normalization are shown. This uses the effective area as computed from the HF online standard method and the currents as stored in the LHC DB
- ✓ In fill 1422 (single beam scan) A_{eff} can be estimated twice for each plane (b1 against b2, b2 against b1). Therefore 4 combination of $A_{eff}^x A_{eff}^y$ can be considered
- ✓ Here we only want to show:
 - Effect of the corrections
 - Consistency between scans/fills
- ✓ Central values NOT final!



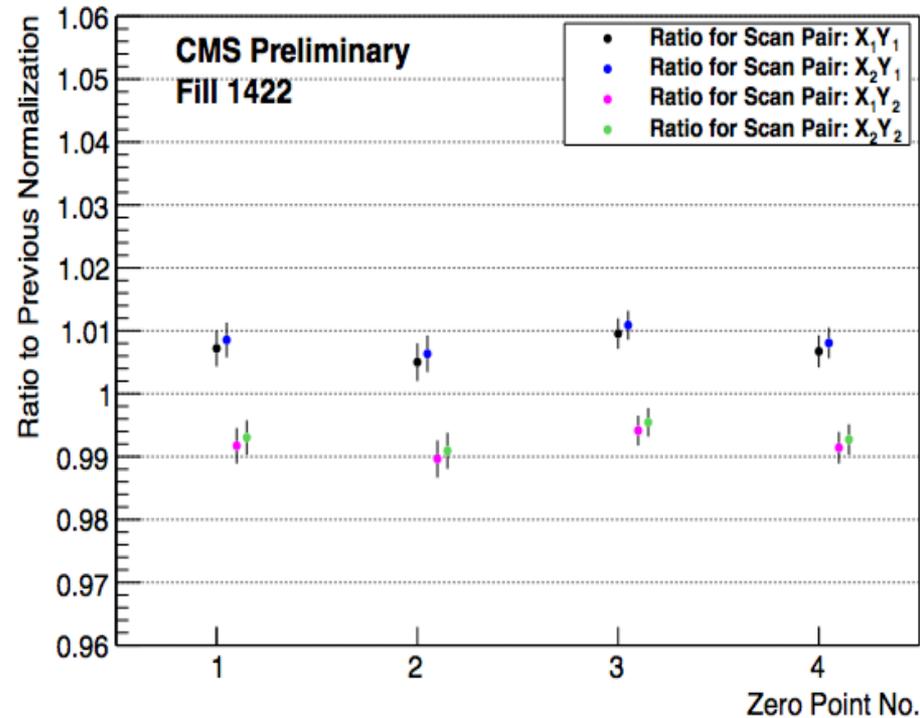
Effect of emittance correction



raw



emittance corrected



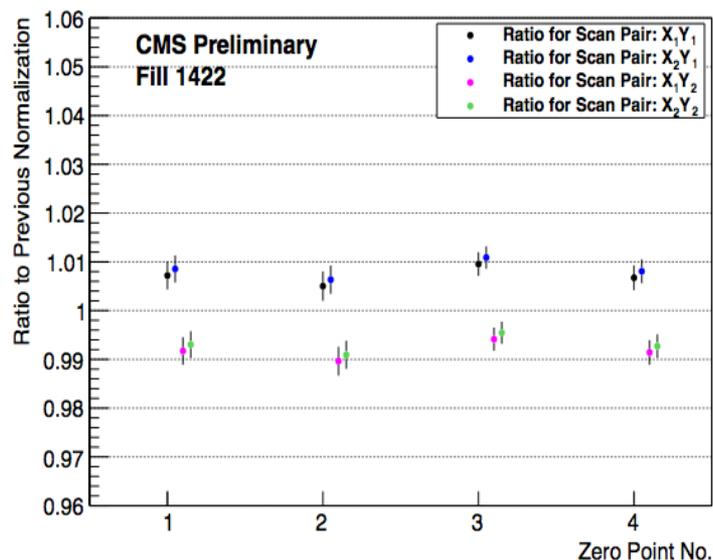
Emittance correction flattens out all the Zero Point estimations



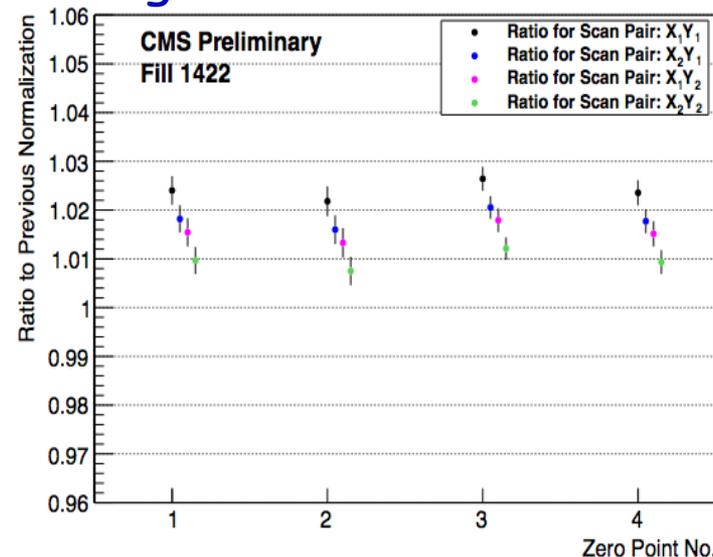
σ_{vis} from Std Online HF, fill 1422



emittance corrected



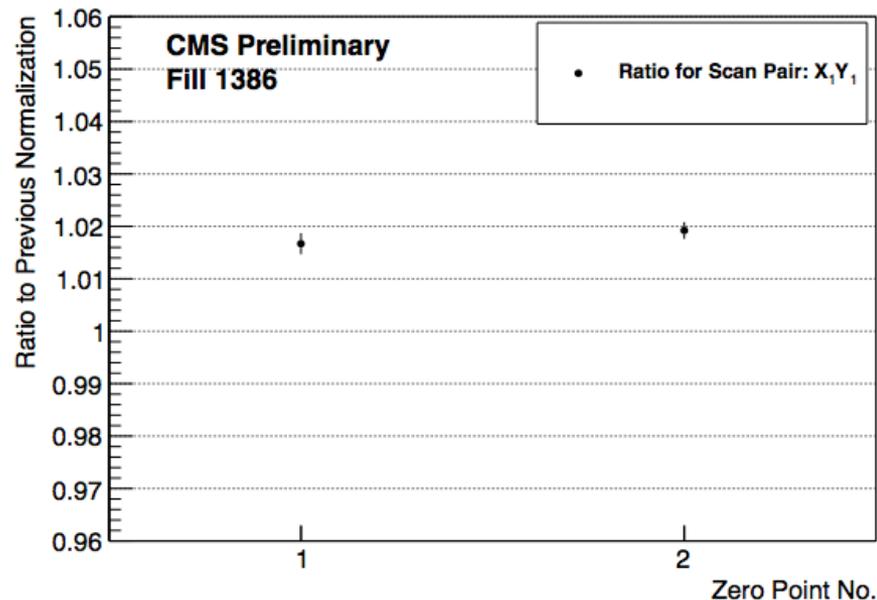
length scanle calibrated



- ✓ Two distinct sets of value disappear but a clear pattern is still there (1.5% spread)
- ✓ A possible explanation is a incorrect estimation of the difference of individual beam scales (ϵ parameter).
- ✓ This might be due to the missing correction of natural luminosity decrease.
- ✓ From a preliminary analysis it seems that the additional correction goes in the right direction but with an insufficient magnitude
- ✓ Otherwise, could it be an hysteresis effect between LS and VdM scan?

Reproducibility

- ✓ In order to check the reproducibility, one can compare σ_{Vis} from the two fills (single vs double beam scan)
- ✓ Standard HF online method is considered
- ✓ Averaged results from fill 1422 matches very well what obtained from fill 1386:
 - $\sigma_{Vis}^{new} / \sigma_{Vis}^{old} = 1.018$ vs 1.017





Ghost charge analysis



Ecal based ghost charge analysis



- ✓ Crossing angle in October scan prevents head on collisions between satellite and main bunches with beams perfectly overlapping
- ✓ Two options are possible:
 - Collisions from ghost-ghost before the scan
 - Collisions from main-ghost during the VDM scan at specific beam displacements
- ✓ Time dependent analysis in place, but no results available yet (statistics might be a limiting factor)



Thoughts about setup for ideal scan



- ✓ Number of bunches
 - Only a few, to allow per-bunch analysis
 - NO Trains!
- ✓ Crossing angle (negligible for A_{eff})
 - If ~ 0 , we can measure with CMS the satellite population
 - If ~ 100 mrad we can hardly measure satellite collision (probably new beam instrumentation can), but they do not contribute to lumi.
- ✓ Beta*
 - The larger the better beam imaging works. 3.5 m is anyway already ok.
 - The larger the smaller the pileup (zero counting methods do no care much)
 - The smaller the higher the rate
- ✓ Beam intensity
 - $\sim 8e10$ seems to be fine for both DCT and beam-beam effect. How high can we go?



Thoughts about setup for ideal scan



- ✓ Scan range
 - 6 sigma seems ok, but check wider ranges could be a useful exercise
- ✓ Scan dynamics
 - Single beam scan is very instructive
 - Double beam scan is simpler to correct for in terms of length scale
 - Opposite sense of scan might help spotting out hysteresis effects
- ✓ Length scale calibration
 - To be done with (also) the beams at $\sqrt{2} \cdot \sigma$. Very short and effective
 - The combination with local scan (3 steps) at each beam point can help
 - More points needed
- ✓ (frequent) Scans performed in standard physics conditions are extremely useful



Conclusions



- ✓ The October 2010 VdM scan campaign was an extremely instructive exercise.
- ✓ Analysis is ongoing but preliminary results are very encouraging and consistent with those from the spring scan campaign
- ✓ Different methods for estimate the effective are give comparable results.
- ✓ Aim at an effective area error of few percent.



BACKUP

Supporting Material

Beamspot movements during VdM scans



Beamspot during VdM scans



- ✓ Look at the beam spot (center of luminous region) movements during the scan to cross check predictions and possibly spot out unexpected features
 - *x-angle, non gaussianities, tilts between CMS and LHC axes, etc.*
- ✓ The different ways the scans have been performed help in comparing and noticing different effects
- ✓ In general none of these effect should influence sizably the overall luminosity normalization

NB: in the following "X,Y" indicate CMS (horizontal and vertical)coordinates, "H,V" the LHC ones



Fill 1422 (single beam scan)



- ✓ BS X follows the beam that is moved during scan in H
 - $\delta X_{BS}/\Delta_{beams} = \sigma^2_1/(\sigma^2_2+\sigma^2_1)$ when b2 at rest (perfect gaussians)
 - $\delta X_{BS}/\Delta_{beams} = \sigma^2_2/(\sigma^2_2+\sigma^2_1)$ when b1 at rest
 - Average = 0.5
- ✓ If X_{CMS} not parallel to H_{LHC} , BS X moves during V scan (analogous for Y and V)
 - Compare slopes should for the two beams (B1 scanned against B2, B2 scanned against B1). They should be ~the same
- ✓ BS Z moves during scan in H (x-angle)
- ✓ No x-angle in vertical, BS Z shouldn't move during V scan

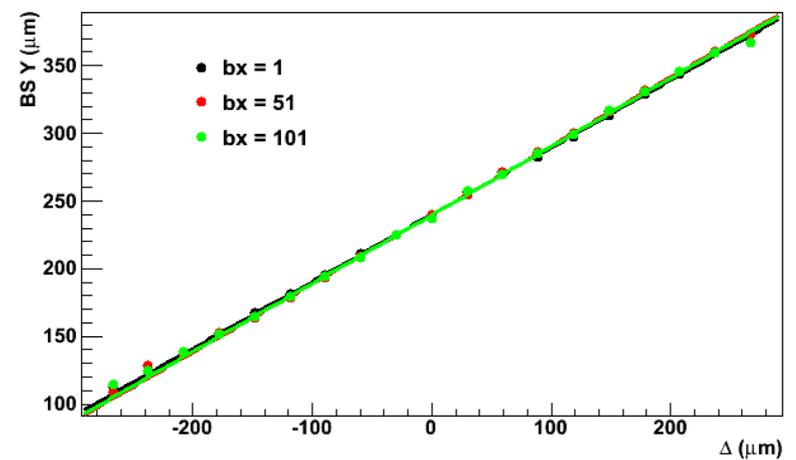
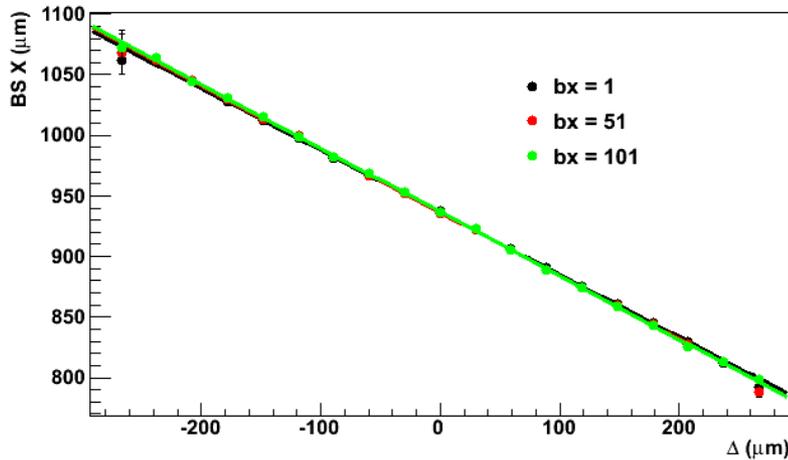
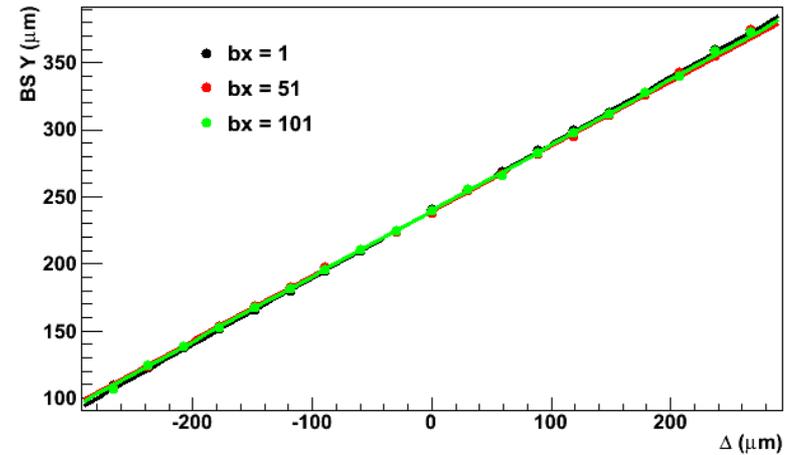
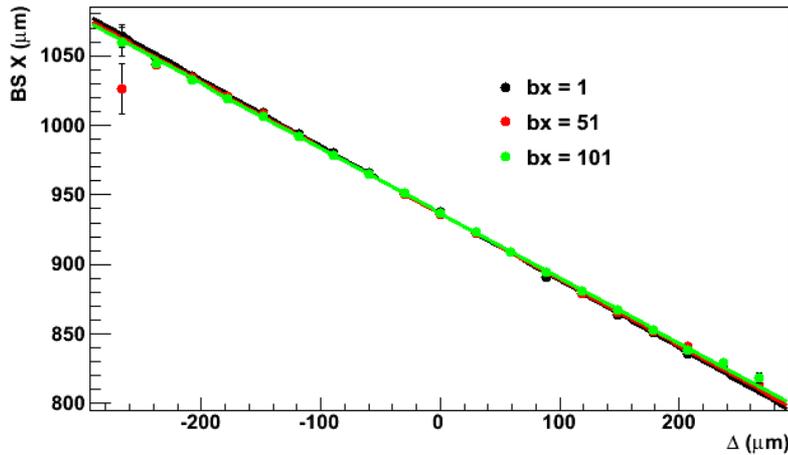


1422, X-H and Y-V correlations



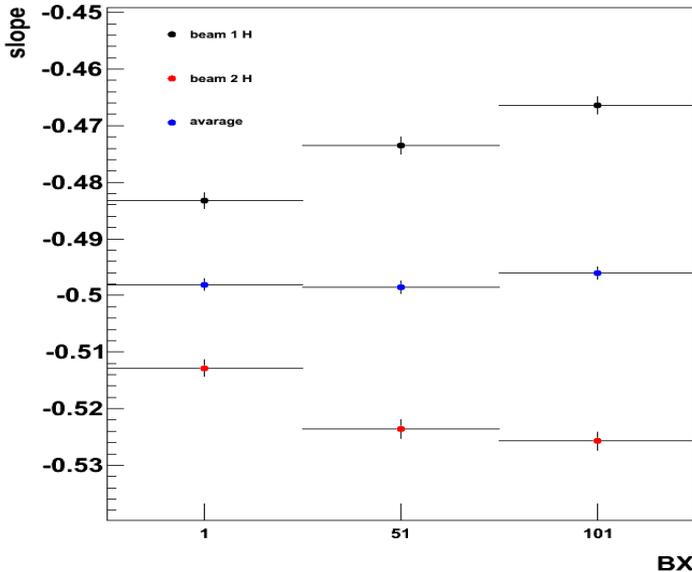
H

V

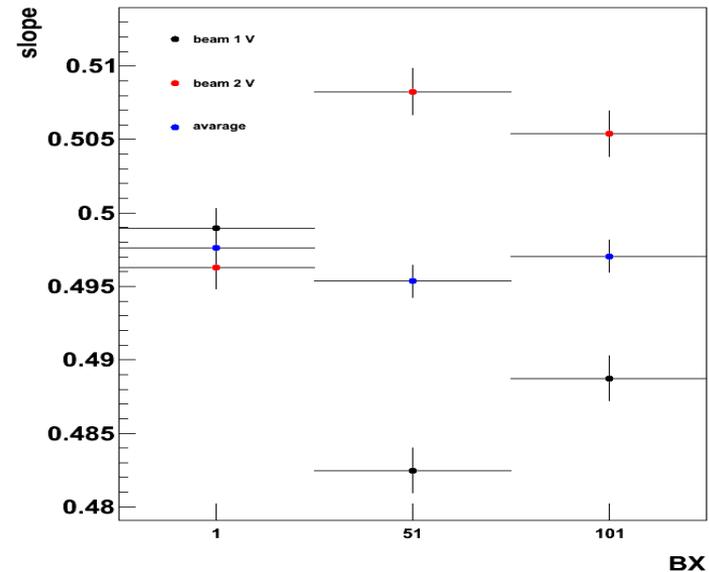


1422, X-H and Y-V fit results

H



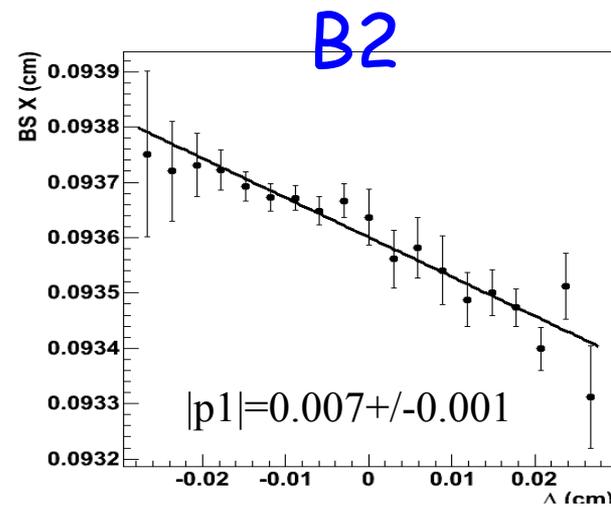
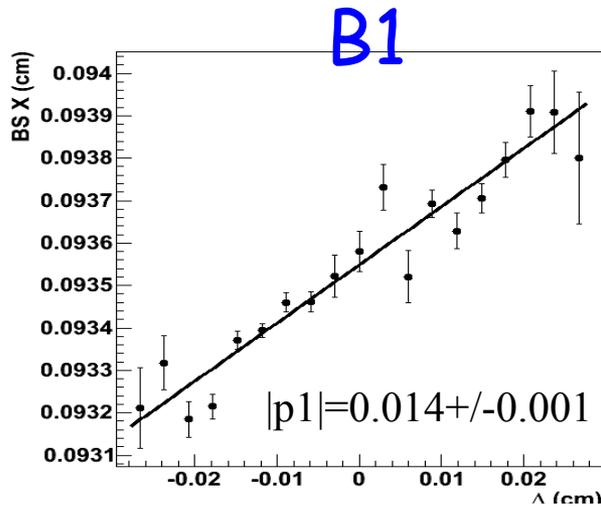
V



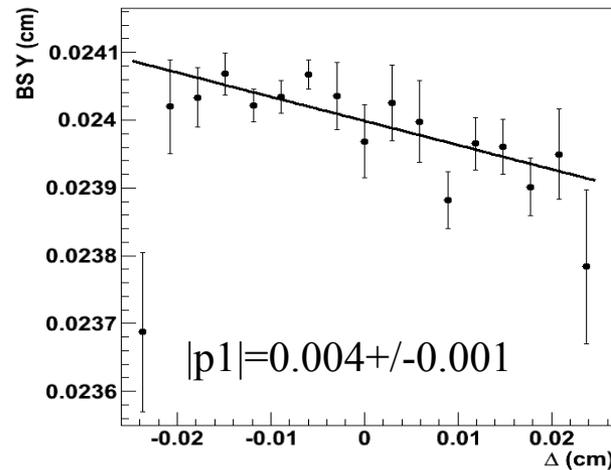
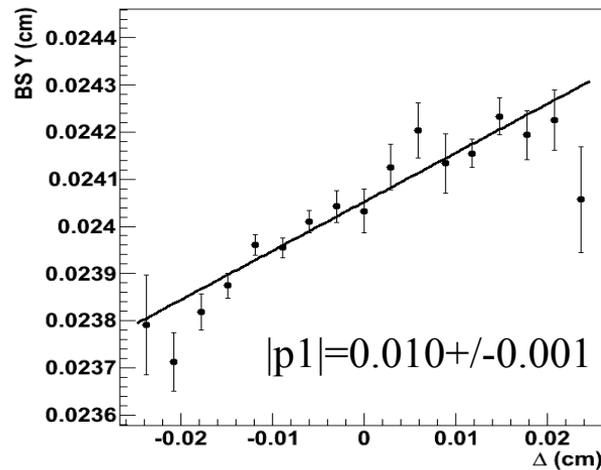
- ✓ For all BXs and both the H and V scan, the average of the slopes are close to 0.5:
 - Average H = -0.4978 ± 0.0006
 - Average V = 0.4967 ± 0.0006
- ✓ Is the difference from 0.5 significant?
- ✓ To be compared with results from beam image analysis

1422, X-V and Y-H correlations

X-V



Y-H



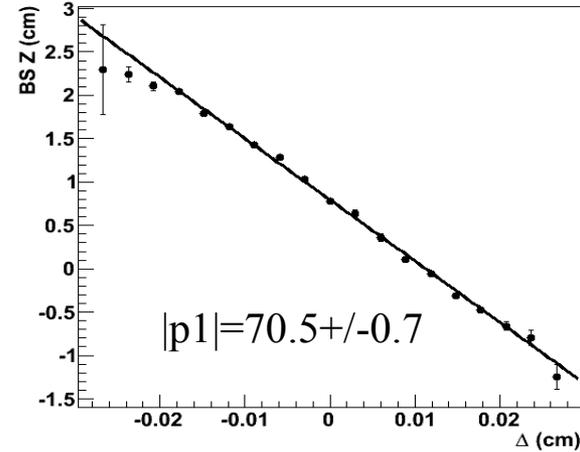
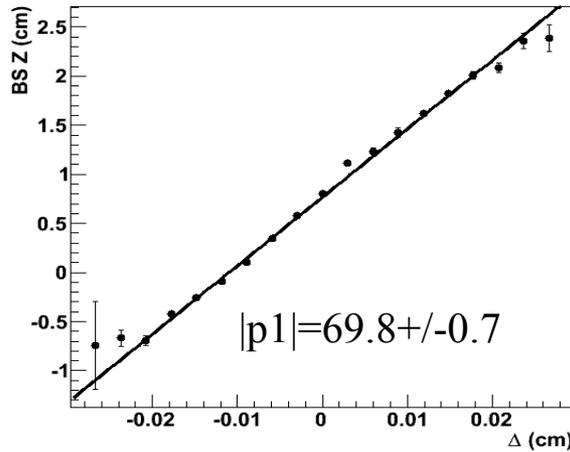
- ✓ Rather sizable slopes, not compatible with CMS to LHC reference system rotation (\sim mrad)
- ✓ Slopes for the two beams significantly different

1422, Z-H and Z-V correlations

B1

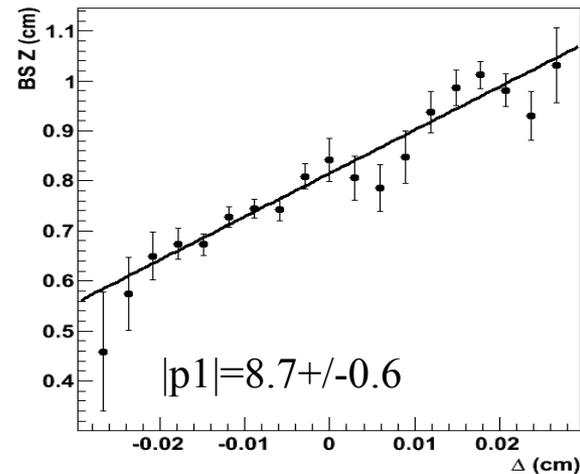
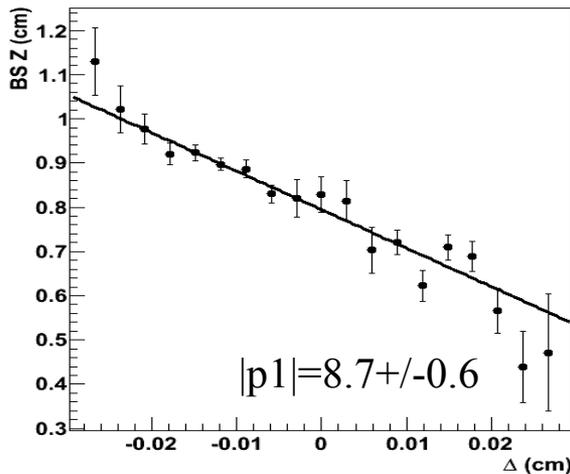
B2

Z-H



Crossing angle

Z-V



What is that?



Note on crossing angle



- ✓ The dependency of the value of $\delta Z/\delta\Delta$ is predictable by (from Massi, perfect gaussians, beams of same width):

$$\frac{\delta z}{\delta\Delta_x} = - \frac{\sin(2\alpha)}{4} \frac{\sigma_z^2 - \sigma_x^2}{\sigma_x^2 \cos^2(\alpha) + \sigma_z^2 \sin^2(\alpha)}$$

- ✓ 70 correspond well to $\sigma_z \sim 6$ cm, $\sigma_x \sim 55$ μm , $\alpha \sim 100$ μrad
- ✓ A non-zero slope during the V scan imply a non zero crossing also in the vertical plane
 - Size of the effect (1/10 w.r.t to H) consistent with the size of related orbit correction
 - CMS solenoid is the possible explanation. Do the other exp observe the same?



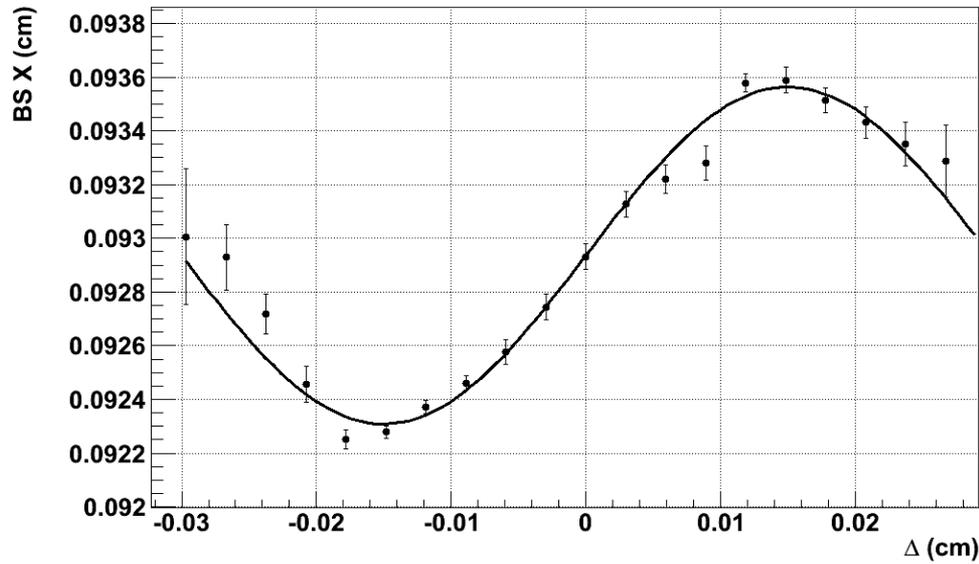
fill 1386 (double beam scan)



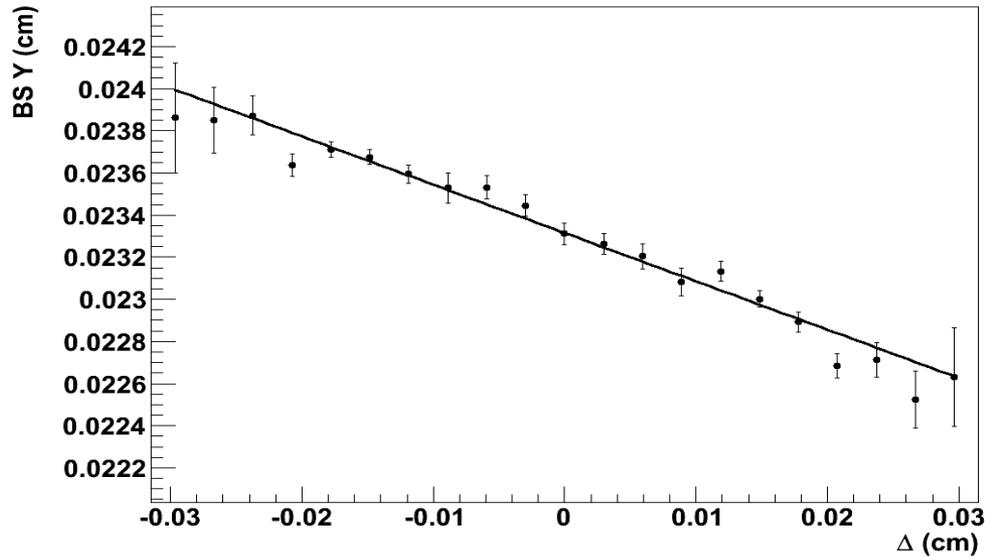
- ✓ BS X should NOT move when scan in H (idem for Y during V scan)
- ✓ Expect similar cross correlations (BS X when scan in V, BS Y when scan in X) as for fill 1422
 - Not possible to distinguish single beam slope
- ✓ Similar BS Z trend during scan in H and V
 - Not necessary the same value for the slopes (possible different beam sizes between the scans)

1386, X-H and Y-V correlations

X-H

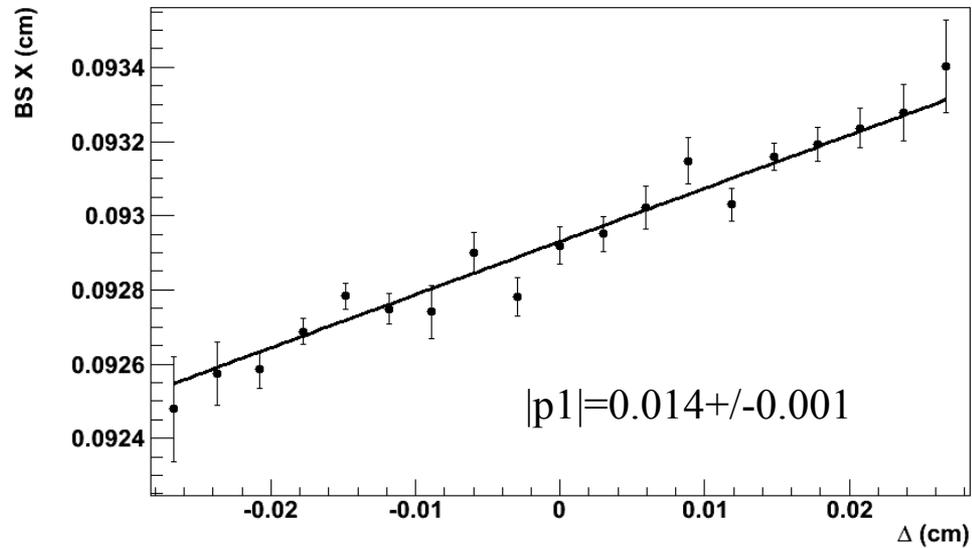


Y-V

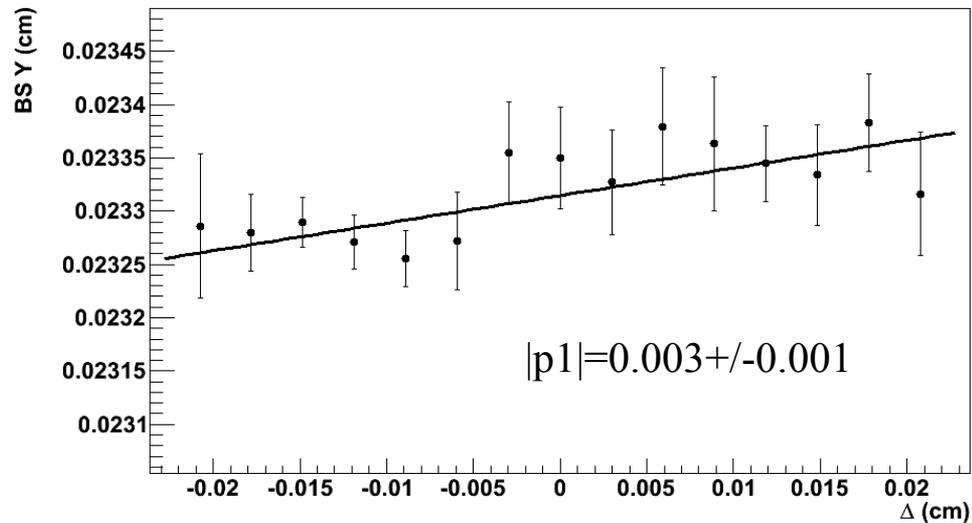


1386, X-V and Y-H correlations

X-V

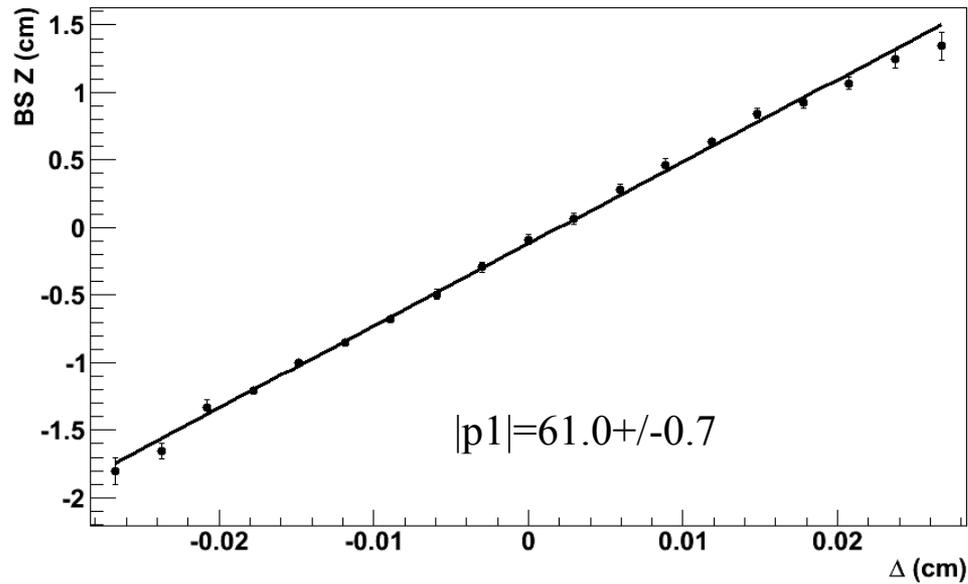


Y-H

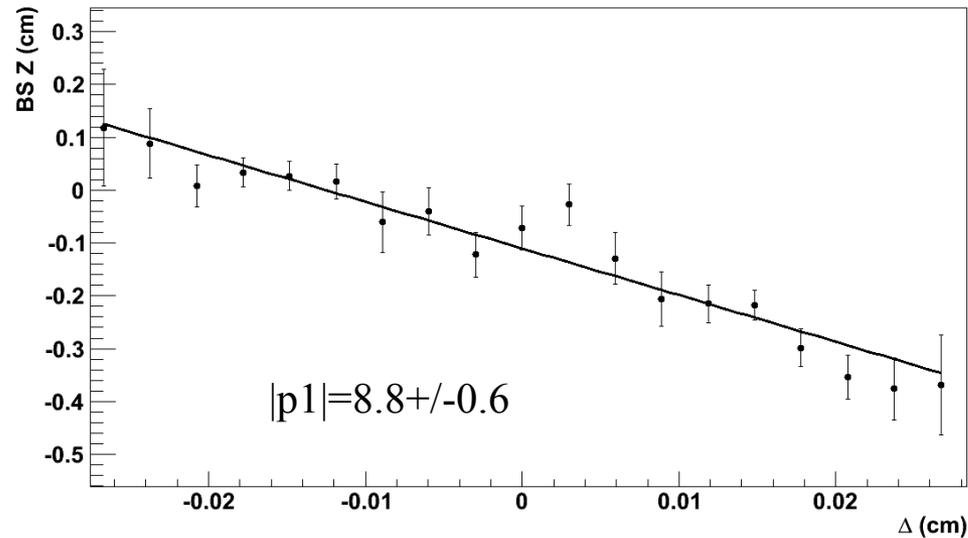


1386, Z-H and Z-V correlations

Z-H



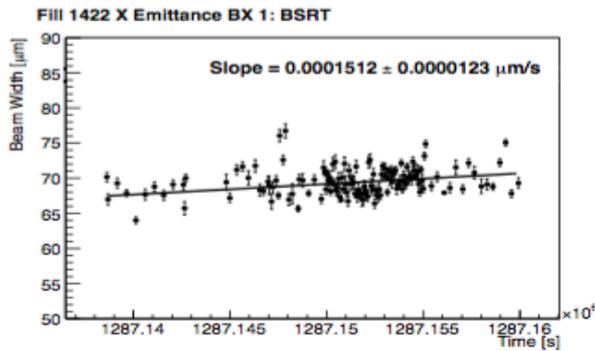
Y-
H



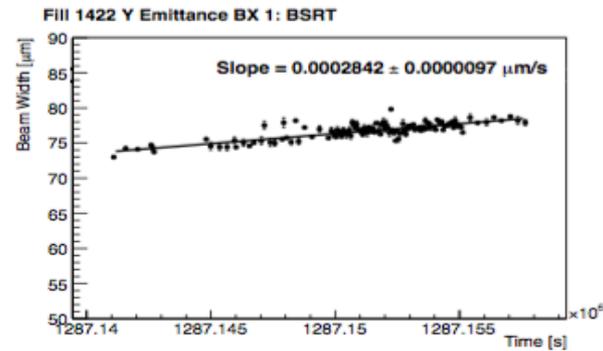


Updated results from spring scans

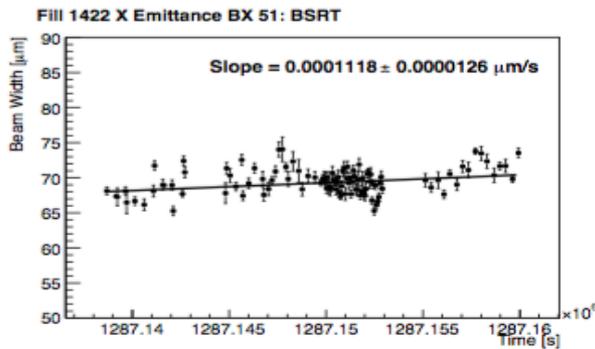
BRST Emittance measurement



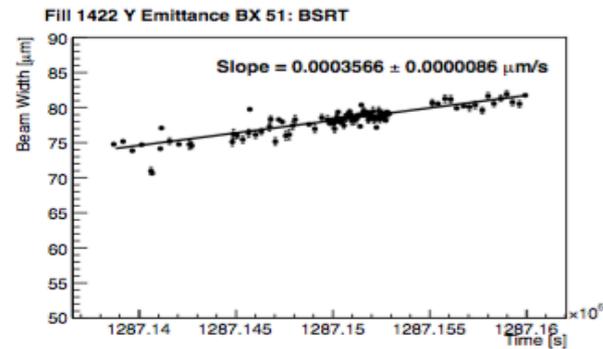
(a) X, BX = 1



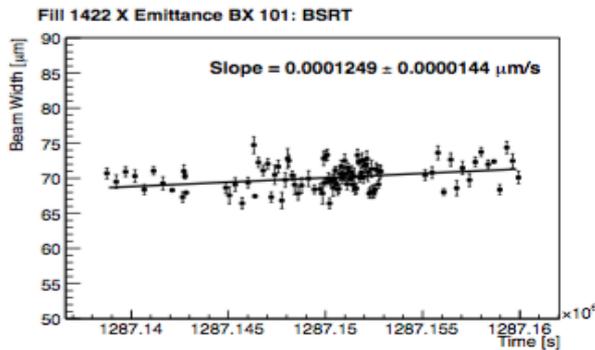
(b) Y, BX = 1



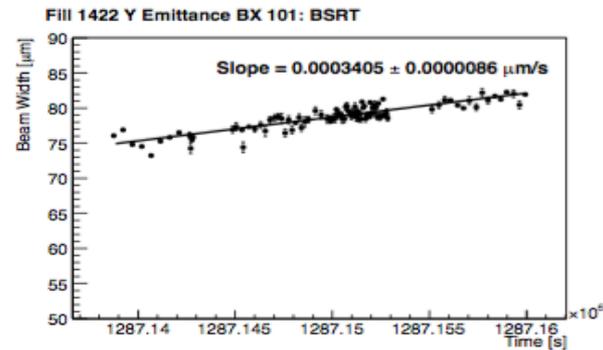
(c) X, BX = 51



(d) Y, BX = 51



(e) X, BX = 101



(f) Y, BX = 101



Spring scans updates



- ✓ The analysis of the currents during fills 1058 and 1089 updated both the error and the central values of the **intensity products** (Table 11 of the BCNWG note):

Fill	Old	New	Ratio
1058	186.2 +/- 18.6	199.6 +/- 7.8	1.072
1089	425.4 +/- 34.0	422.9 +/- 15.4	0.994

- ✓ Normalization from fill 1058 carried twice as big uncertainty as fill 1089. Weighted average mainly driven by 1089
- ✓ New results from the two scans (expressed as **ratio of MC and VdM scan of visible sigmas**) are still in agreement
- ✓ Overall change of luminosity normalization ~0.9%

Fill	Old	New
1058	0.969 (0.6%)	1.039 (0.6%)
1089	1.017 (0.3%)	1.011 (0.3%)
Weighted Average	1.007 (0.27%)	1.016 (0.27%)