



Run II Performance of Luminosity and Beam Condition Monitors at CMS

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On behalf of

CMS BRIL

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CMS BRIL: Beam Radiation Instrumentation and Luminosity



Università & INFN, Bologna

Conseil Européen pour la Recherche Nucléaire
(CERN)

Deutsches Elektronen-Synchrotron (DESY) 

IHEP Protvino

Karlsruher Institut für Technologie (KIT) 

University of Minnesota

University of Canterbury

University of Kansas

Moscow State University

Northwestern University

Princeton University

Rutgers, State University of New Jersey

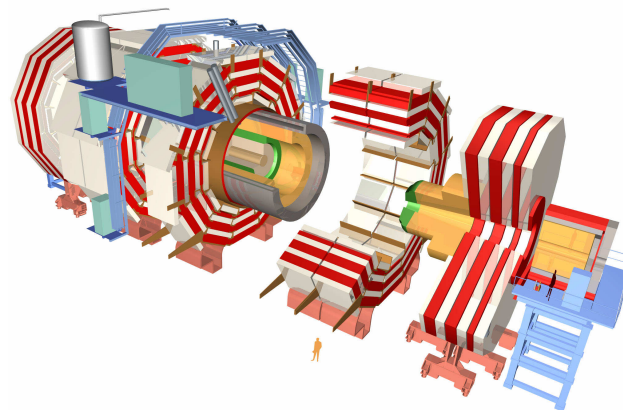
University of Tennessee

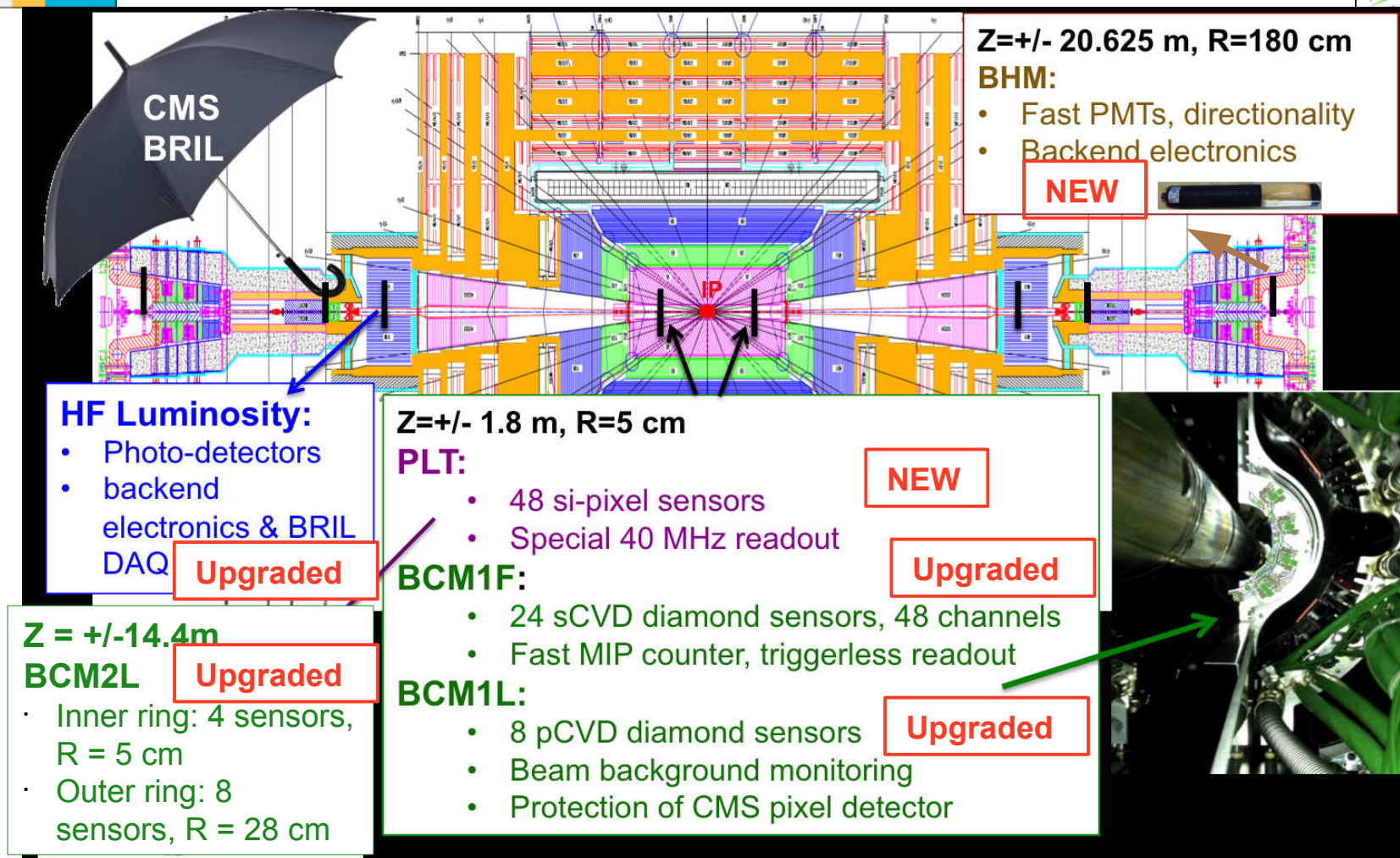
Vanderbilt University

University of Wisconsin

Highlighted BRIL deliverables include

- Real-time integrated and per-bunch luminosity
 - **Luminosity essential for physics analysis**
- Machine-induced background measurements
 - **Vital monitoring of LHC beams**
- Tracker safe-operation condition
 - **Necessary for CMS data-taking**
- Beam abort functionality
 - **Protects CMS detector**





“Golden” locations for maximum incoming-outgoing separation
 Systems complementary

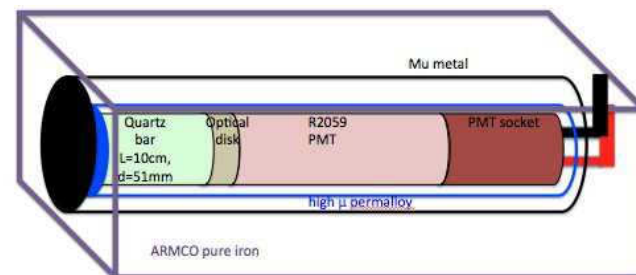


Beam Halo Monitor (I)



Measure machine-induced background (MIB)
at high radius (180 cm)

- Charged MIB particles (muons) from incoming beam
- Directional Cherenkov light produced in quartz bar
- Light detected by photomultiplier



40 modules: 20 modules per incoming beam

Distance from IP: 20.6 m (rotating shielding)

uTCA ADC system produces full-orbit histograms





Beam Halo Monitor (II)

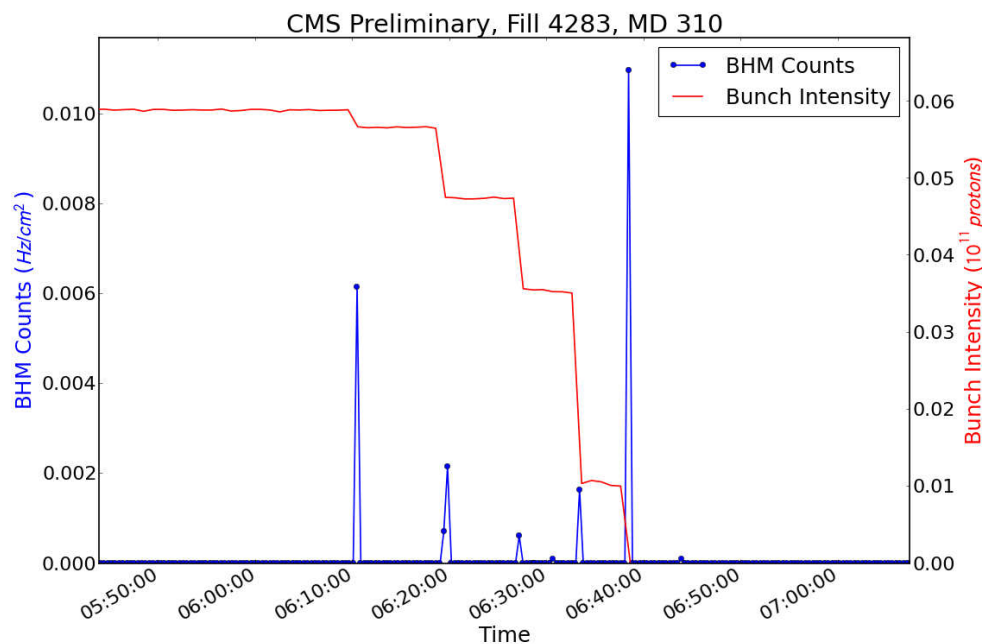
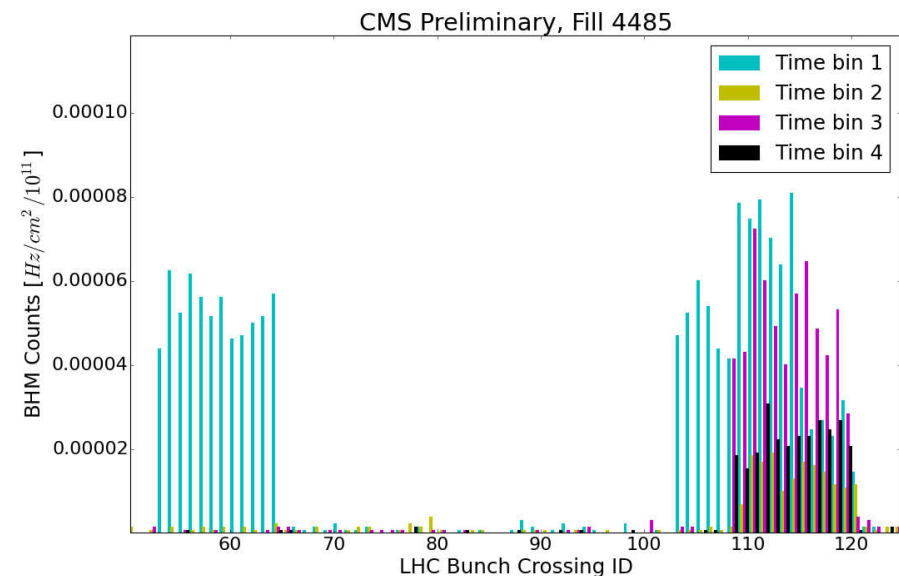


Binning allows for separation between beams

- Collision products can be subtracted out from machine-induced background hits

Beam loss events observed during bunch excitation

- Hit rate correlates with beam losses





Beam Abort System: BCML



Protect silicon tracking detectors from catastrophic beam loss events

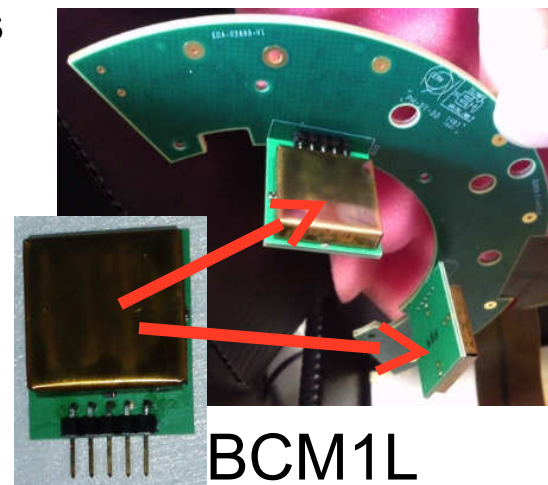
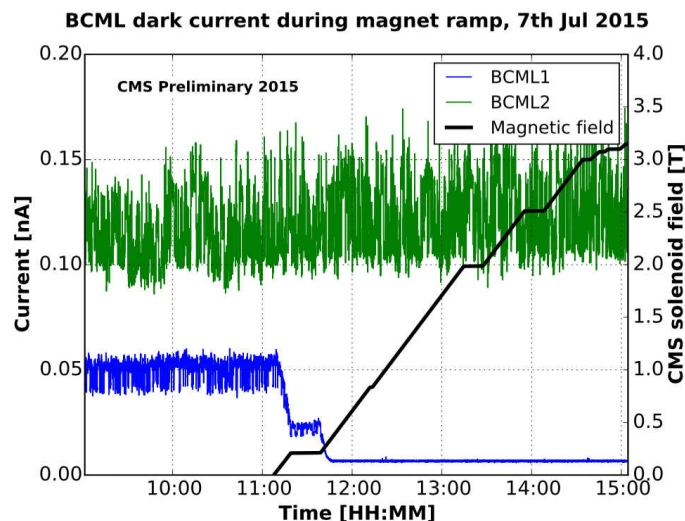
- Polycrystalline CVD diamond sensors
- Initiates beam abort if current in one channel above predefined threshold

Upgrade: sensor replacements

BCML1 location inside tracker volume: magnetic field suppresses erratic currents

- BCML2 outside magnetic field range

BCML talk later in this session:
Radiation damage in BCML diamonds, F. Kassel



BCM1L

BCM2L





Pixel Luminosity Telescope (I)

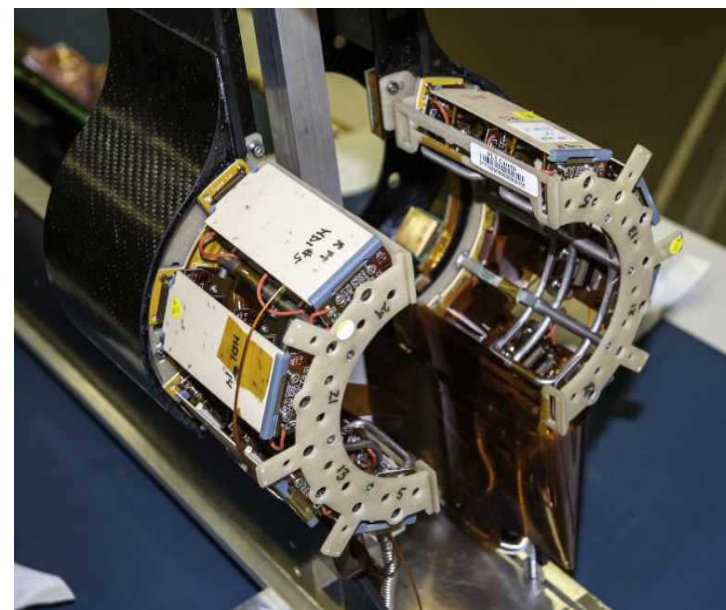
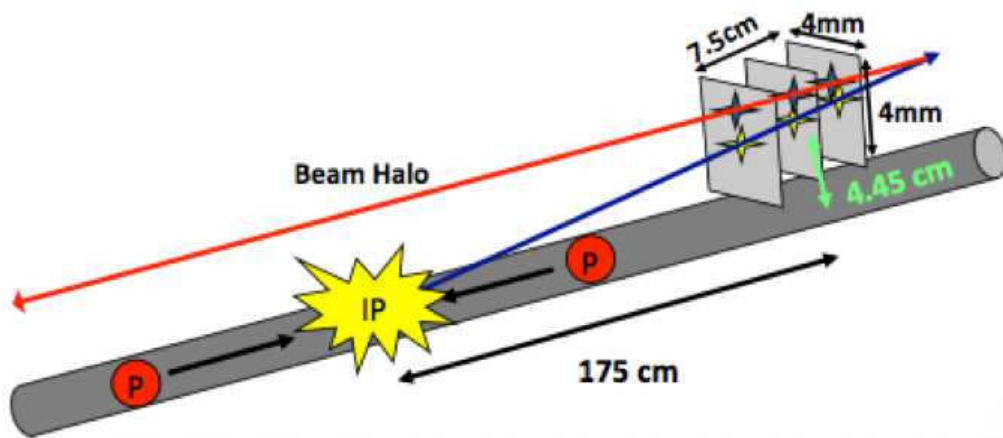
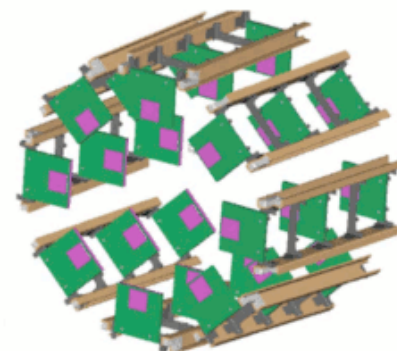
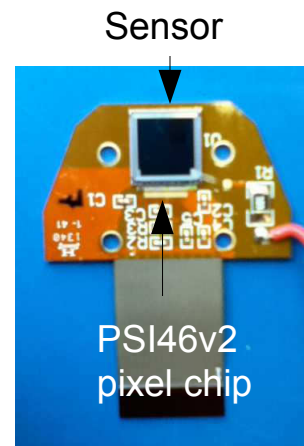


Dedicated standalone luminosity monitor

- 8 3-plane silicon-pixel telescopes per end

Bunch-by-bunch luminosity: 1% statistical precision at 1 Hz

- Deadtime-free 3-fold coincidences using standard CMS pixel chip
- Full pixel readout: systematics, alignment, background studies, etc.





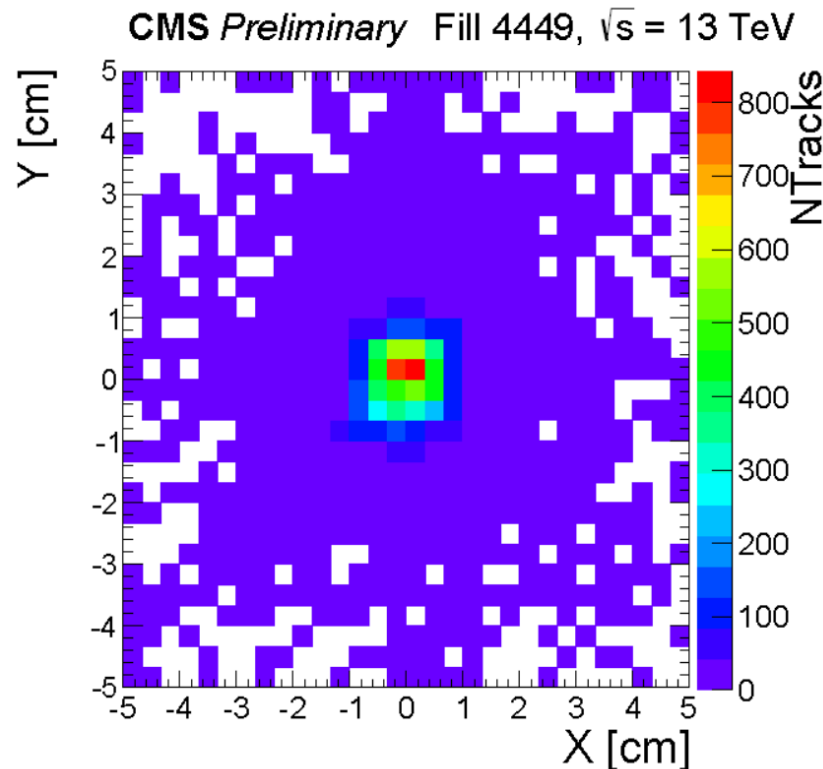
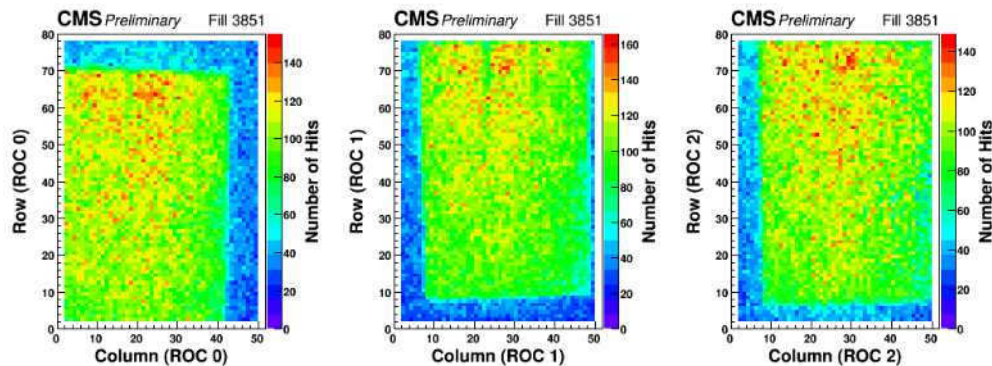
Pixel Luminosity Telescope (II)



Pixel information verifies performance of triple coincidences

- Triple-coincidence tracks seen during collisions
- No tracks seen without collisions – zero noise
- Uniform track occupancies across active area of pixel sensors

Tracking information also allows reconstruction of beam spot





Fast Beam Condition Monitor BCM1F (I)



Bunch-by-bunch measurement of beam background flux and collision products

- 24 5mm x 5mm single-crystal CVD diamond sensors (Run I: 8 sensors)

New fast frontend ASIC

- 130 nm technology, fast rise time and recovery

Realtime Histogramming Unit (RHU)

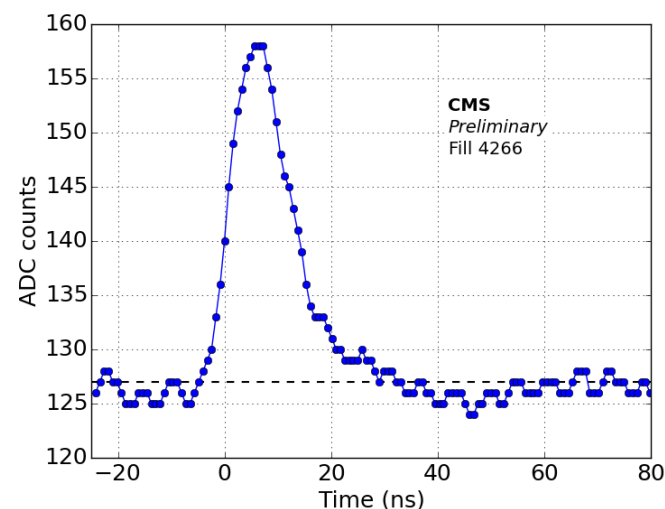
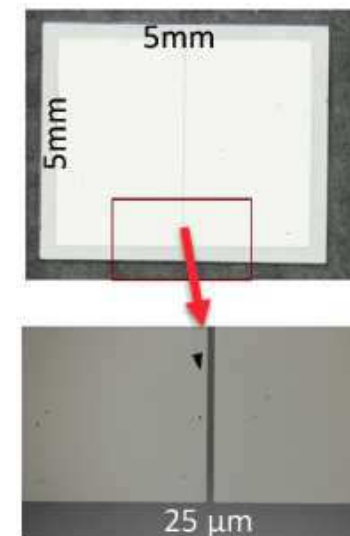
- Deadtimeless full-orbit histograms
- 6.25-ns binning = 4 bins per bunch crossing

uTCA fast ADC system

- In development: Peak-finding/deconvolution algorithms

BCM1F talks later in this session:

- Test beam results, M. Hempel
- Luminosity measurement, O. Karacheban





Fast Beam Condition Monitor BCM1F (II)

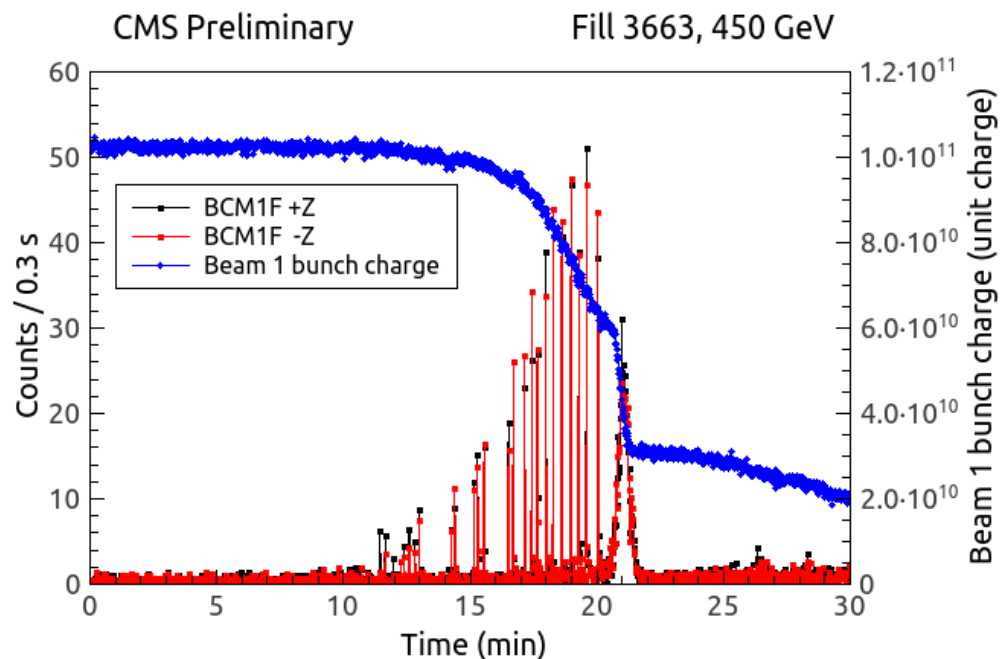
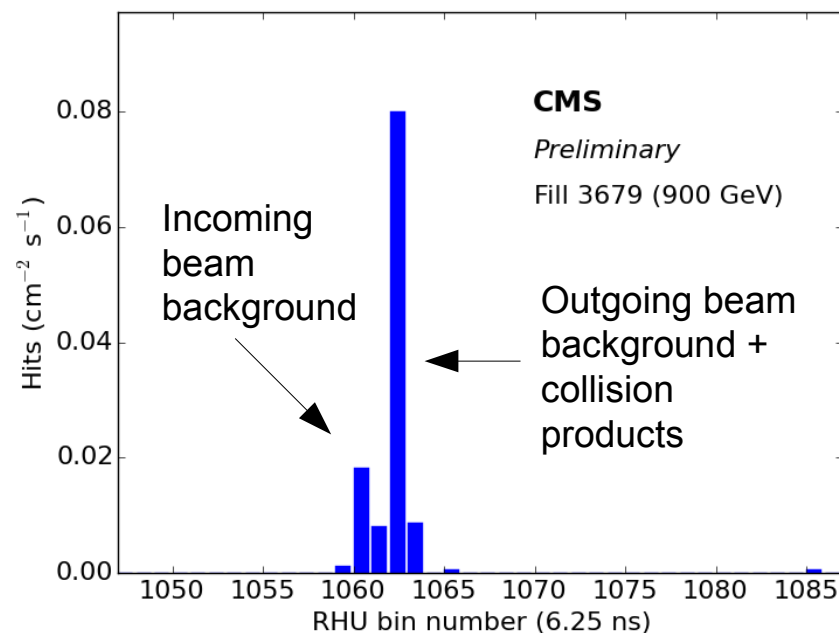


Golden location, histogram binning: separation between beams

- Incoming beam background
- Outgoing beam background + collision products

Machine-induced background measurement

- Detector hit rate corresponds to beam loss





Luminometer Performance



All online luminometers (HF, PLT, BCM1F) have provided luminosity for full 2015 running period

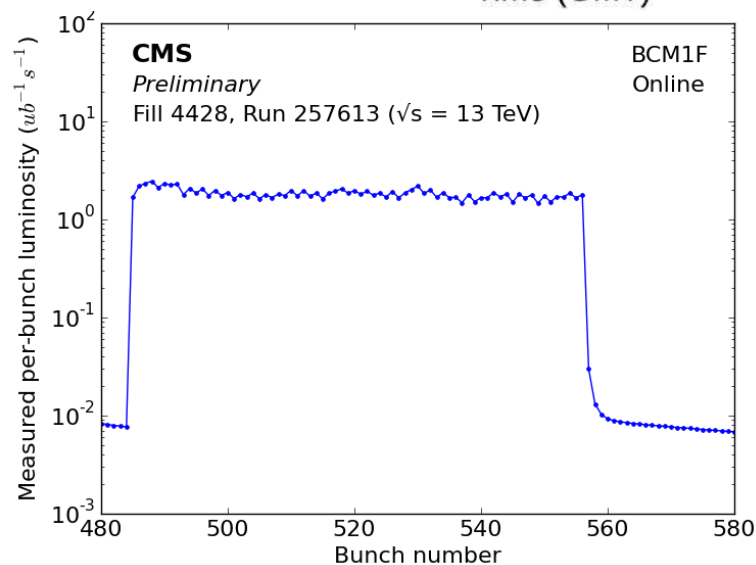
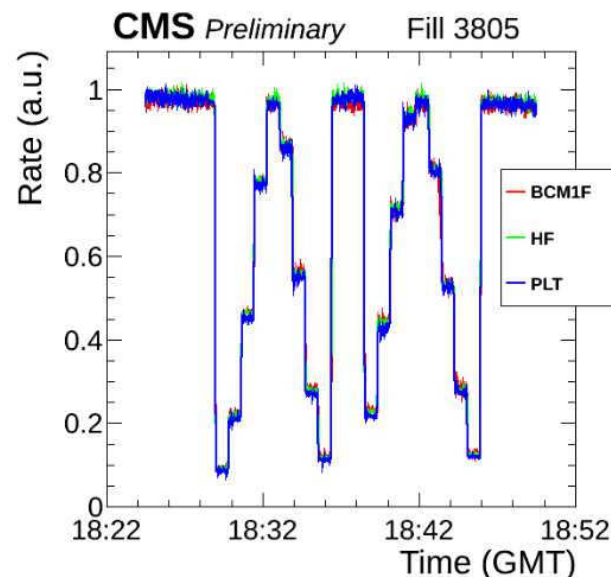
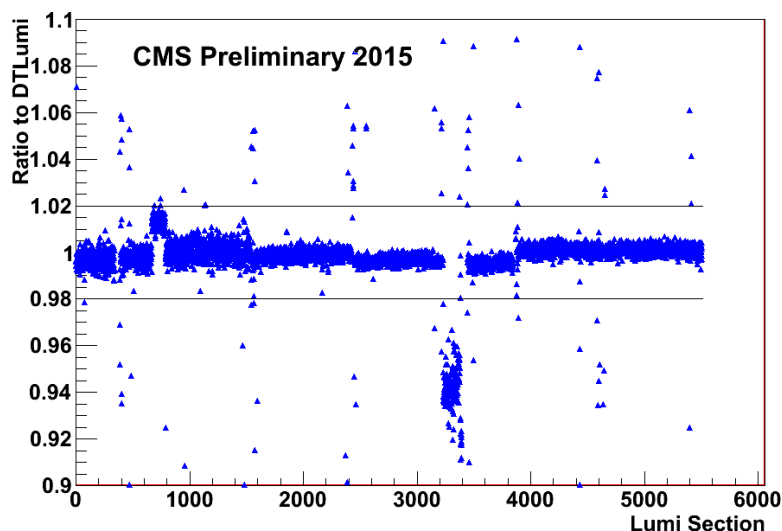
- All track each other well
- Per-bunch measurement

One luminometer “official” lumi provider at a time

- Others used as cross-check/backup

Other detectors provide additional offline luminosity numbers

- Pixel cluster counting, drift tubes





Luminosity Calibration and Uncertainties



Van der Meer scan provides absolute calibration factor: visible cross section

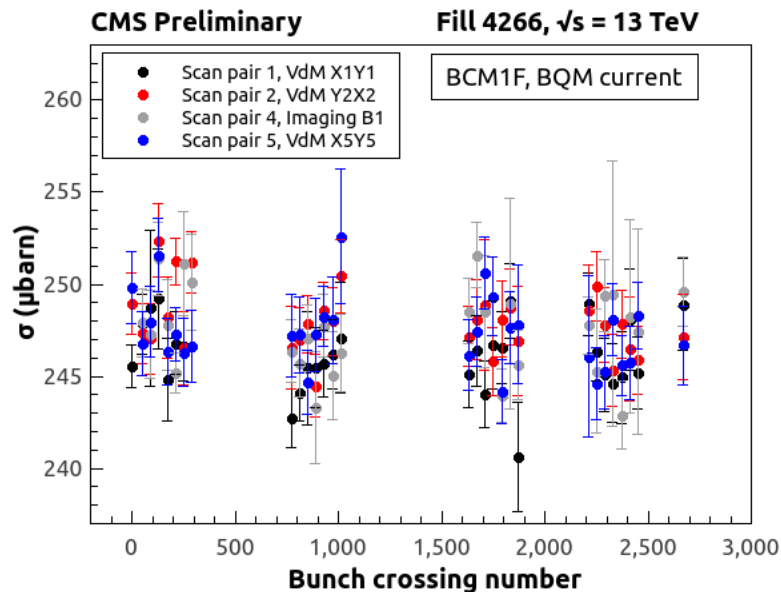
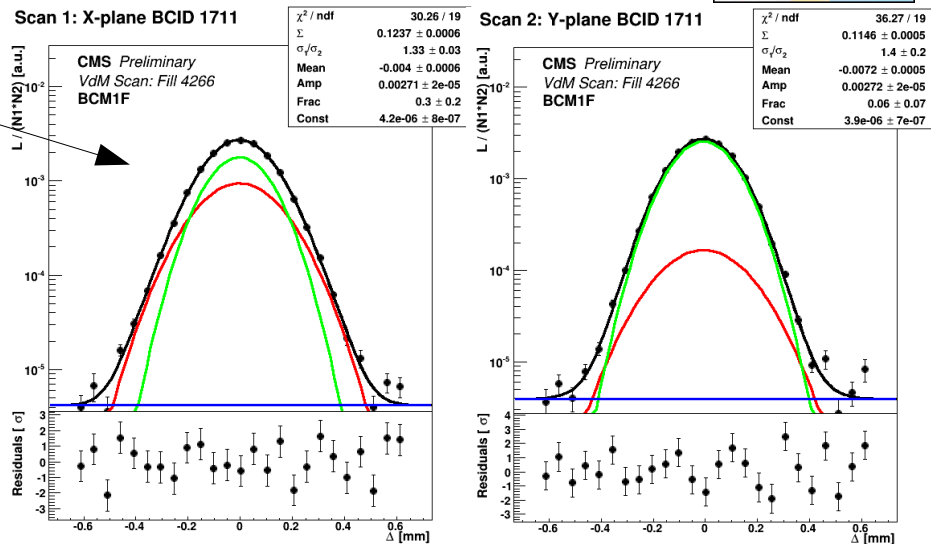
- Beams scanned across each other in x,y; hit rate measured

BCM1F chosen as “official” primary luminometer for 50-ns data-taking

Source	Value
50-ns running	
Calibration uncertainty	2.6%
Stability	4%
Total	4.8%
25-ns running	
Total	4.6%

Uncertainties for 50- and 25-ns running will be updated for Moriond, stay tuned...

Public analysis summary will follow





Conclusion



New BRIL subsystems performed well during 2015:

- Background monitors: machine-induced background, protection of CMS
- Luminometers: consistent, well-calibrated luminosity measurement

Luminosity analysis for 2015 ongoing, refined version to be presented soon

BRIL is looking forward to more successful luminosity and background monitoring in 2016