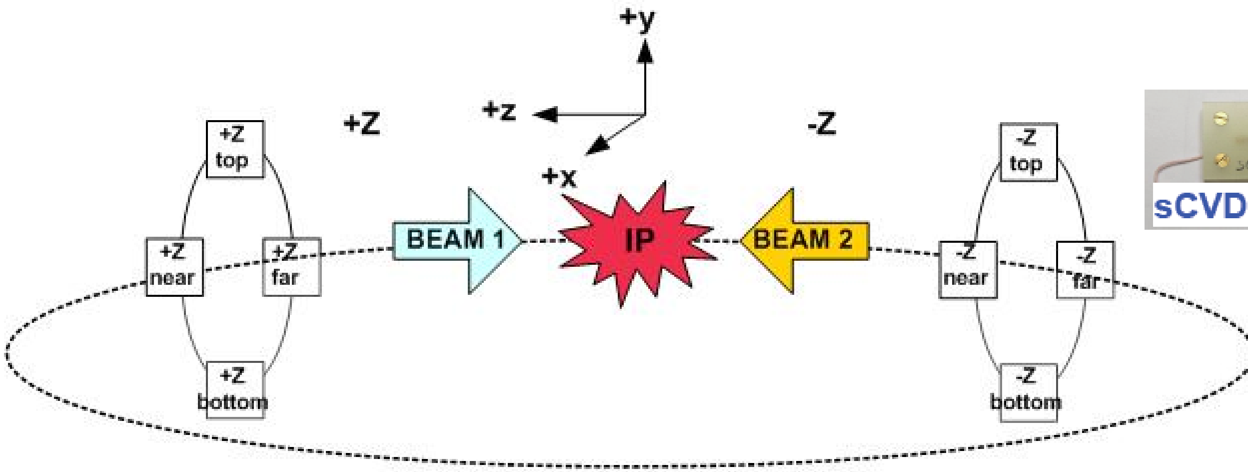
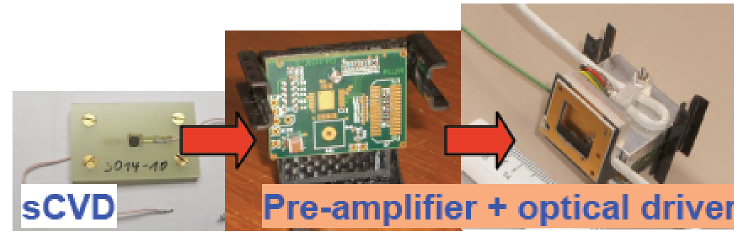
Current status of Fast Beam Condition Monitor BCM1F at CMS

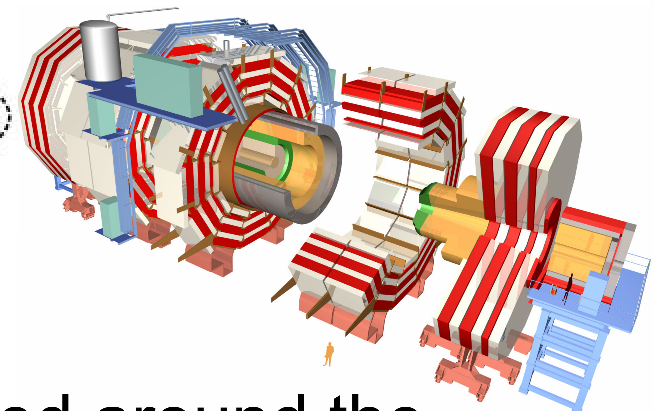
Jessica Leonard

DESY-Zeuthen

BCM1F







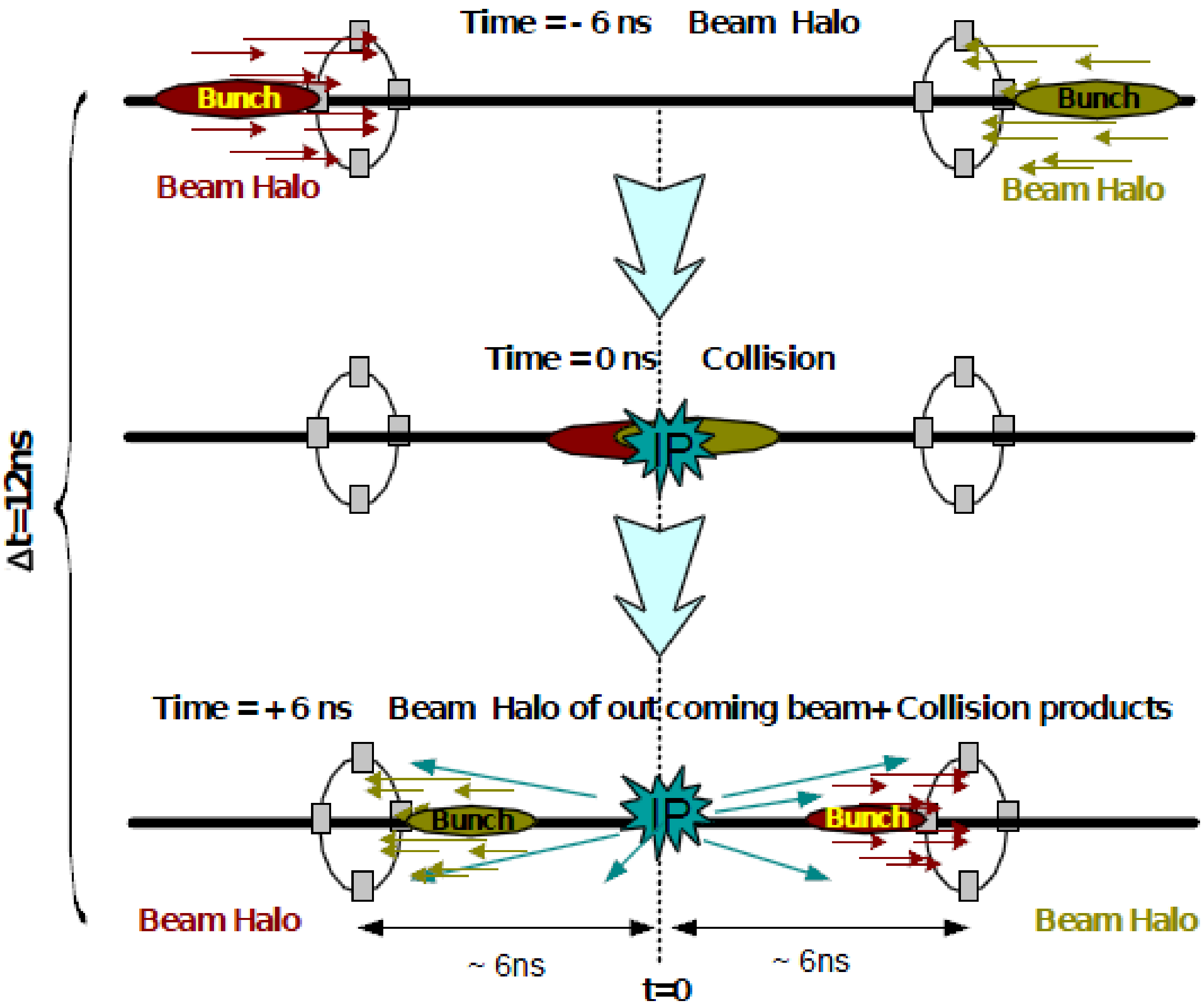
Fast beam condition monitoring

8 single-crystal CVD diamonds positioned around the beam-pipe, 5 mm x 5 mm, radial distance 4.5 cm, 1.8 m from IP

Produce bunch-by-bunch information on flux of beam halo and collision products

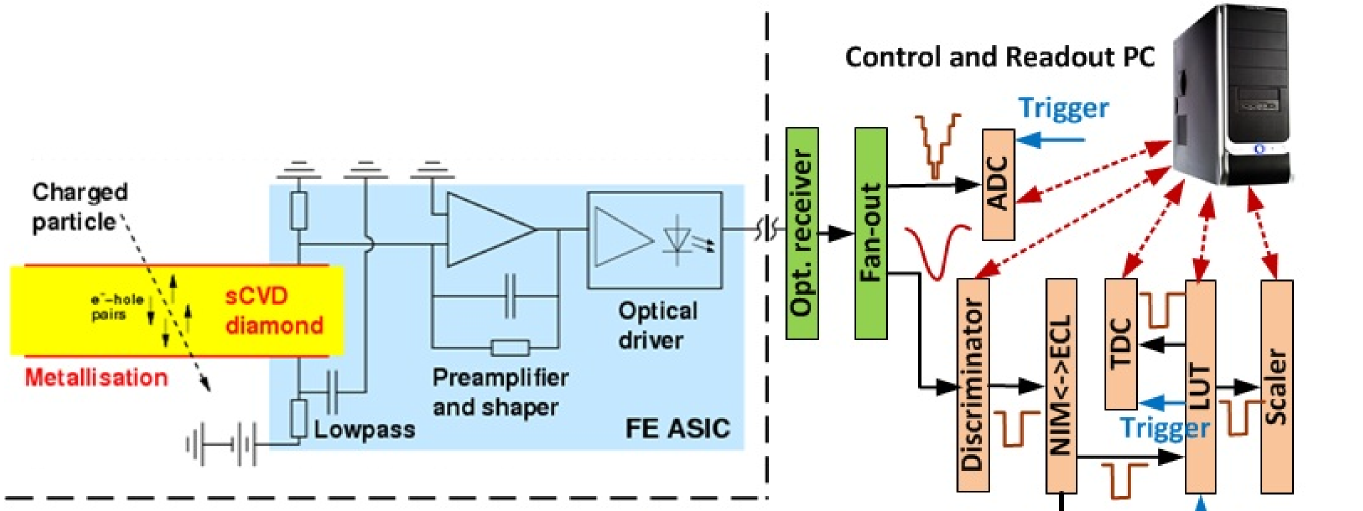
– Combinations of hits

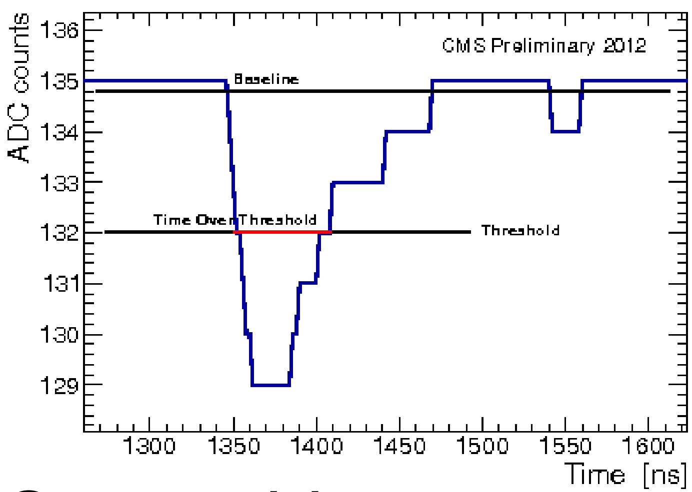
Beam Arrival Times

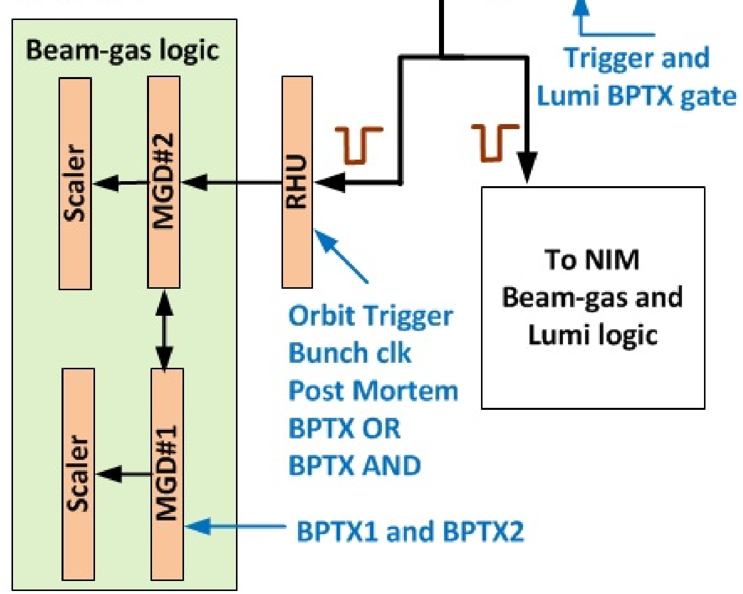


Small geometric acceptance: only "see" small fraction of bunches

BCM1F Electronics





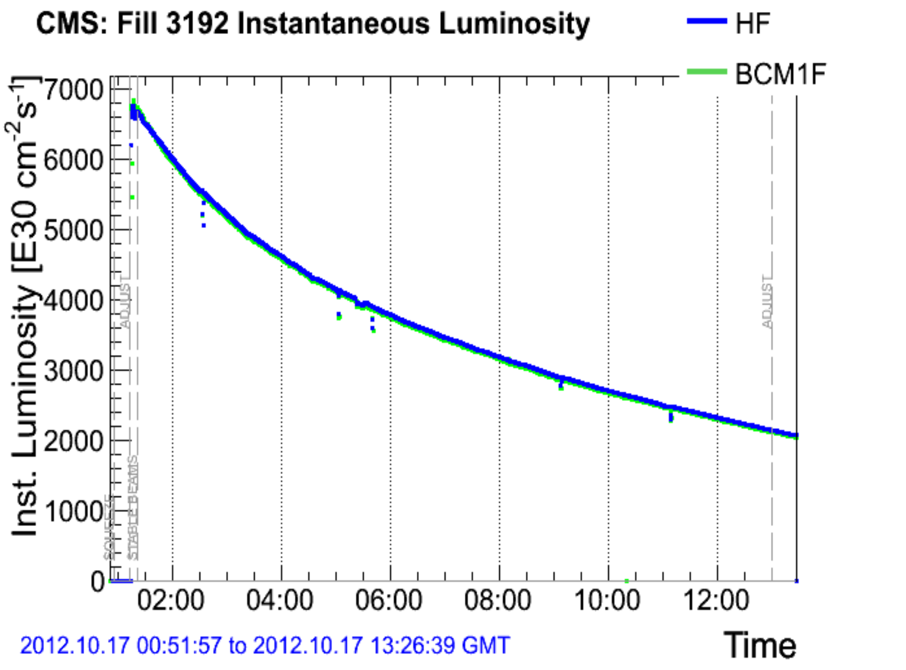


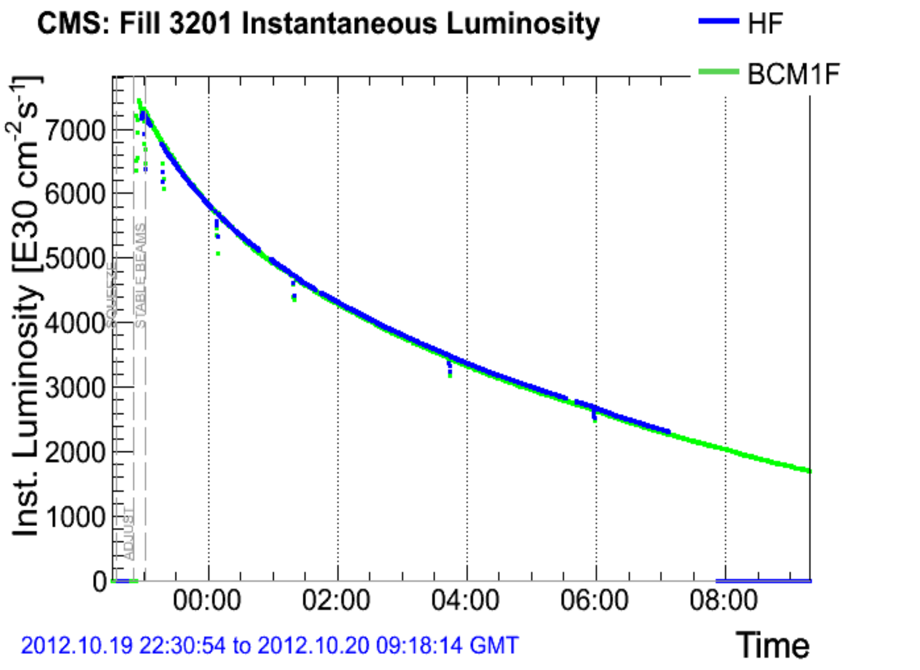
Output: hit rates

BCM1F as Online Luminometer

Demonstrated potential as online luminometer in 2012

- Validation of primary luminosity calculations (HF, pixel)
- Recover missing luminosity for glitch in primary calculation

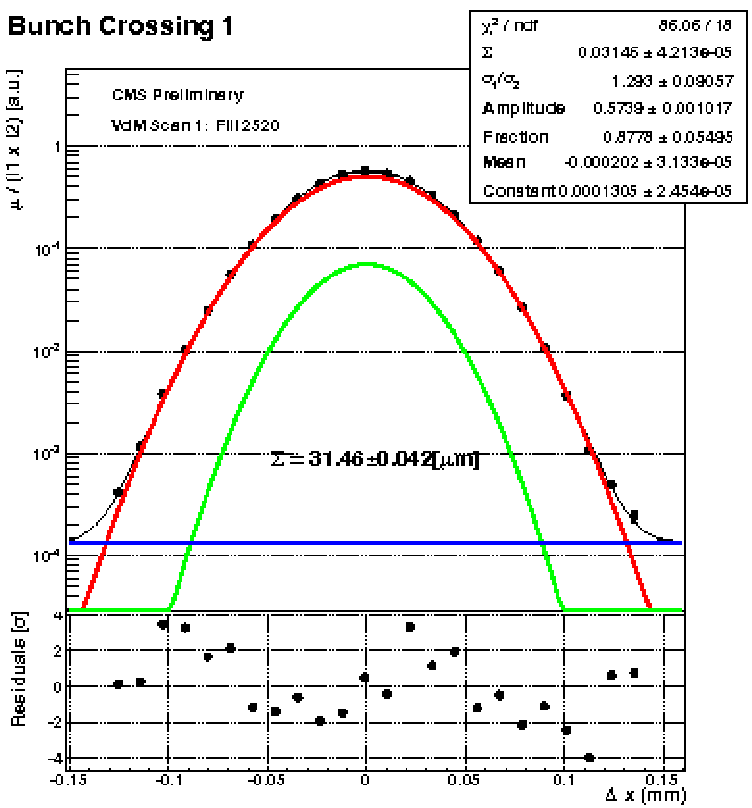


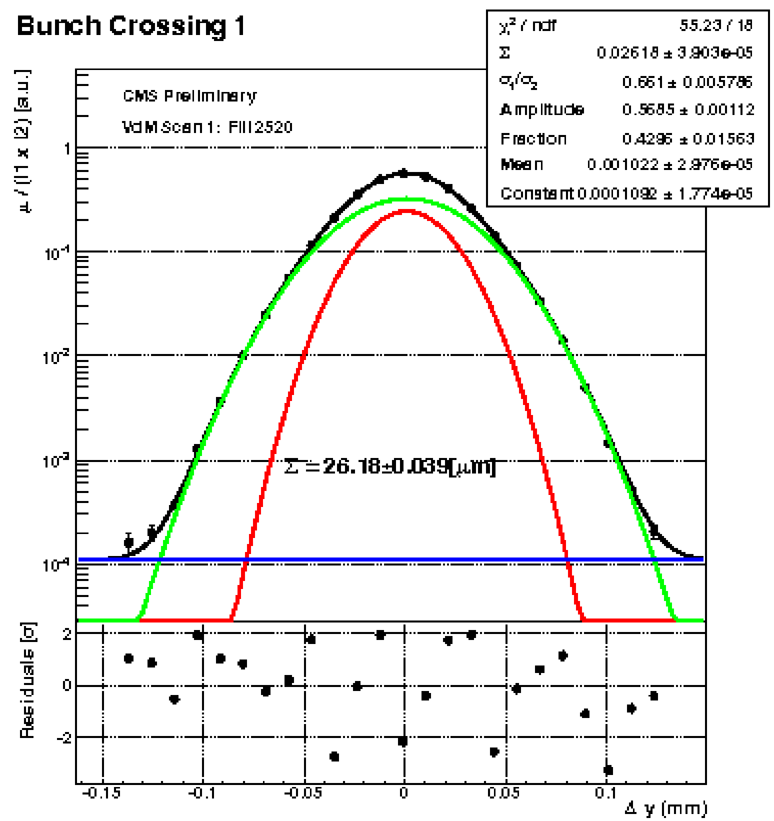


Luminosity Calibration Results

Rate as function of beam separation

Measured width gives calibration constant

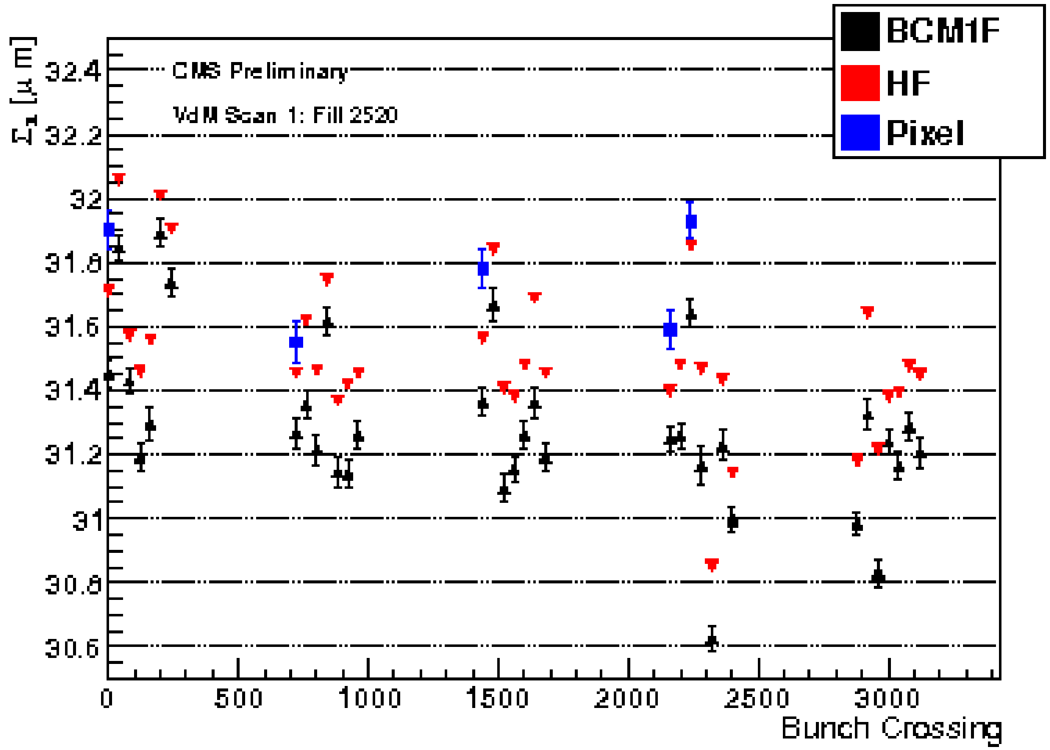




Comparison to Other Subdetectors

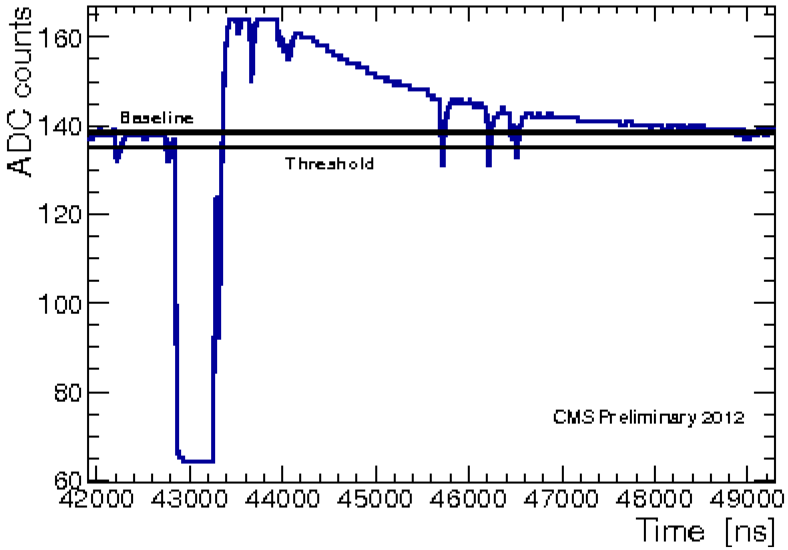
Compare bunch-by-bunch measured beam width to that measured by other luminosity subdetectors

Agreement within 1% on average



Improving Timing Performance: Front-End

- High-amplitude signal saturates front-end electronics (preamplifier) → "overshoot," inefficiency



- Long rising time (25 ns) and signal time (100 ns) → inefficiency
- New front-end ASIC designed to improve this behavior (see talk from Dominik Przyborowski)

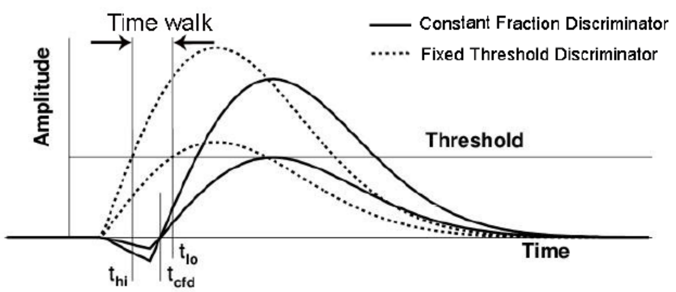
Improving Timing Performance: Discrimination

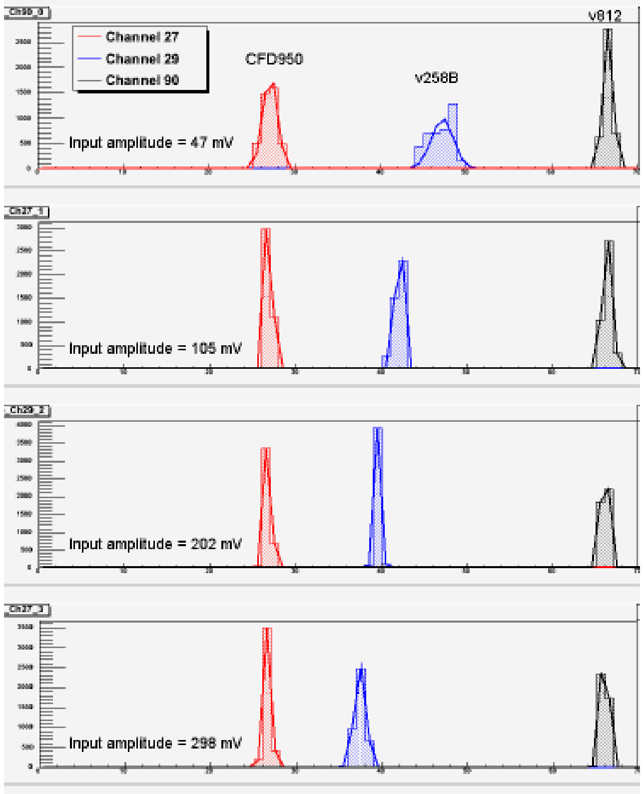
Current discriminator: CAEN v258B fixed-threshold discriminator

- Does not discriminate pulses closer than ~12 ns: deadtime causes loss of consecutive signals
- Triggers pulses of different amplitudes at different times: “time walk” ΔT ~12 ns

CFDs significantly improve on FTD time walk

- v812: better time resolution for trigger of single pulse
- CFD950: better resolution between consecutive pulses

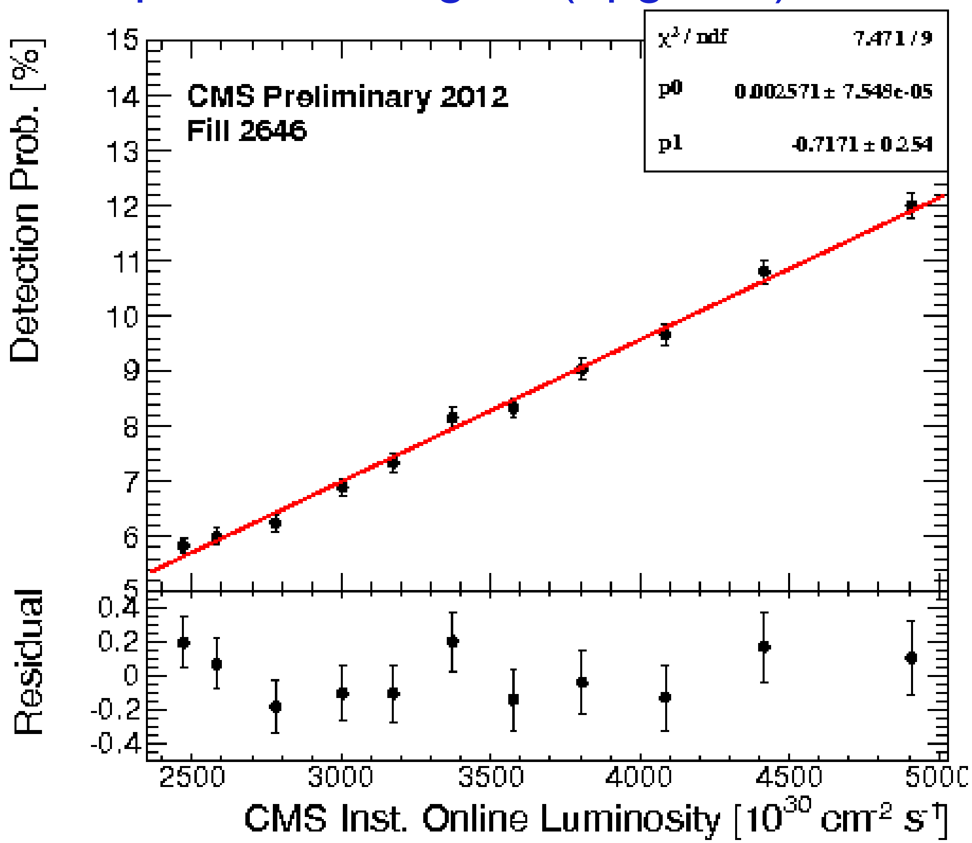




Hit Probability

Single hit probability per bunch (only 1st bunch used: avoid inefficiencies)

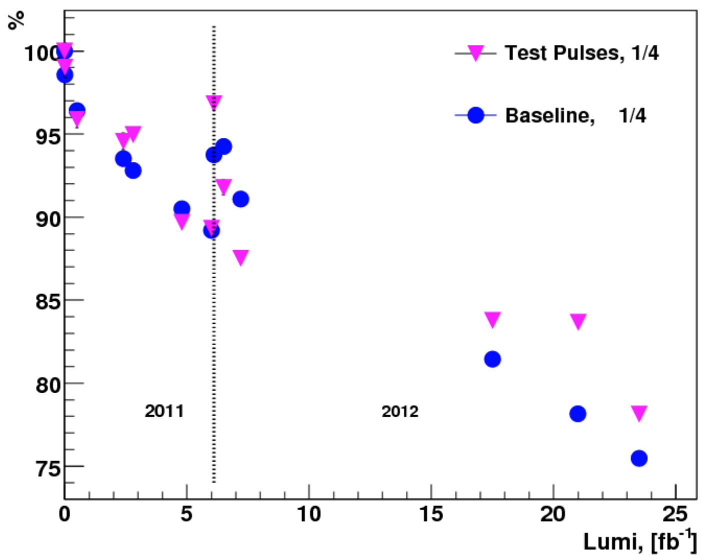
- Insensitive to pileup
- Linear extrapolation to higher (upgrade) luminosities reasonable

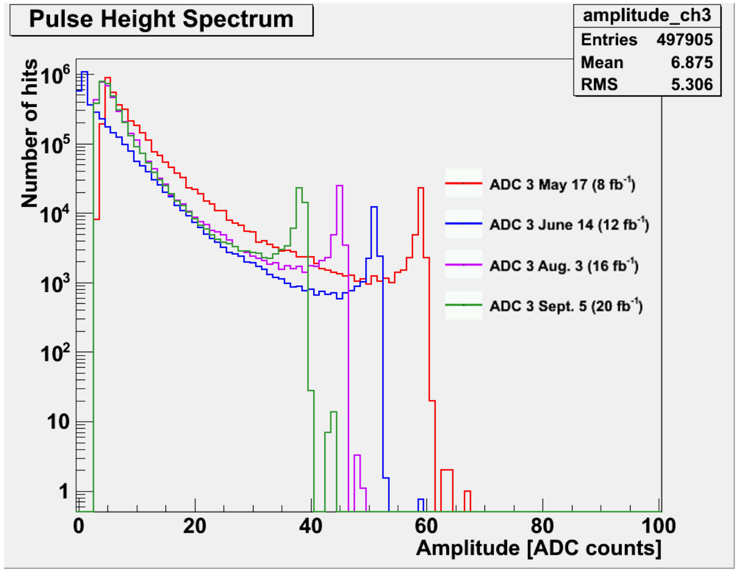


Effects of Radiation: Front-end Electronics

Radiation damage of laser driver visible in decreasing signal amplitude

- 25% gain lost in BCM1F optical transmission after 23 fb^{-1}, fluence 6.73 e13 cm^{-2}

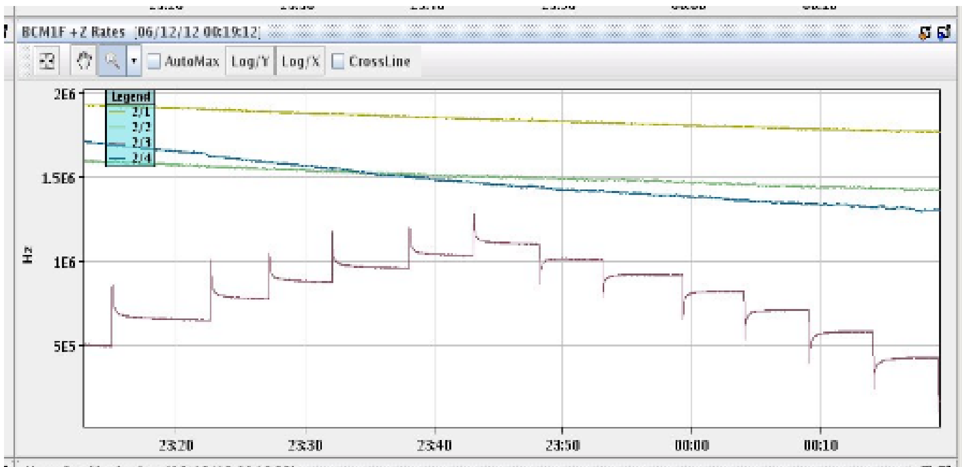


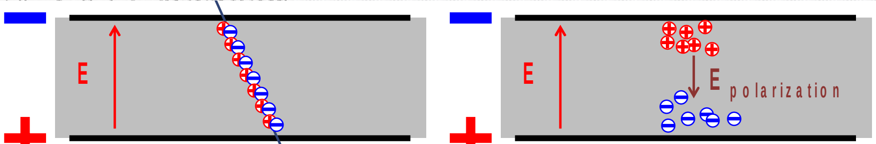


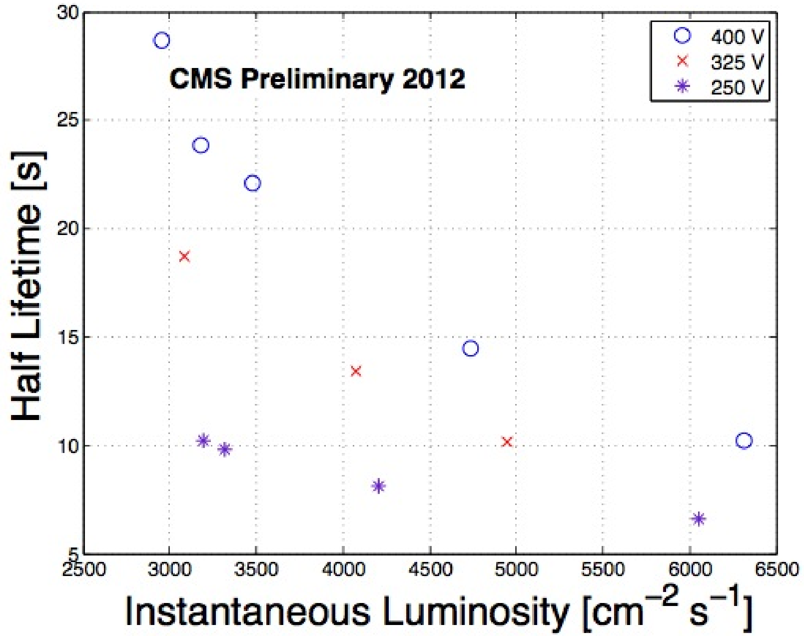
Improvements for upgrade

- Test pulse of two amplitudes: check for linearity
- Move laser driver to lower-radiation field

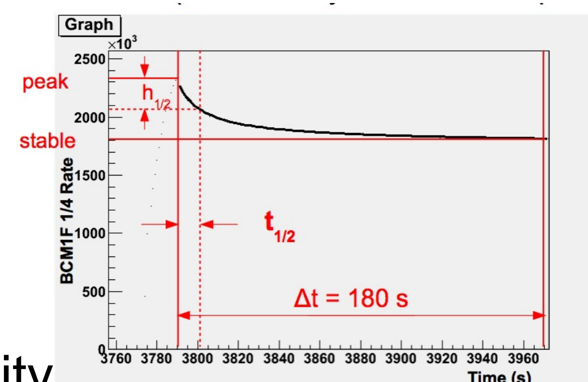
Effects of Radiation: Diamond Sensors







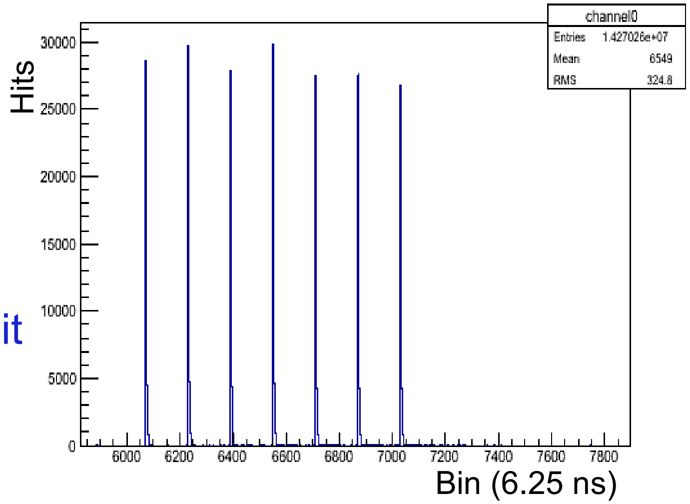
- Polarization → Inefficiency, changes with time
- Change in response depends on HV, luminosity
- Ongoing investigation
  - Recent study: thinning diamond appeared to improve polarization, more study needed
- Important to characterize systematic error on luminosity calibration



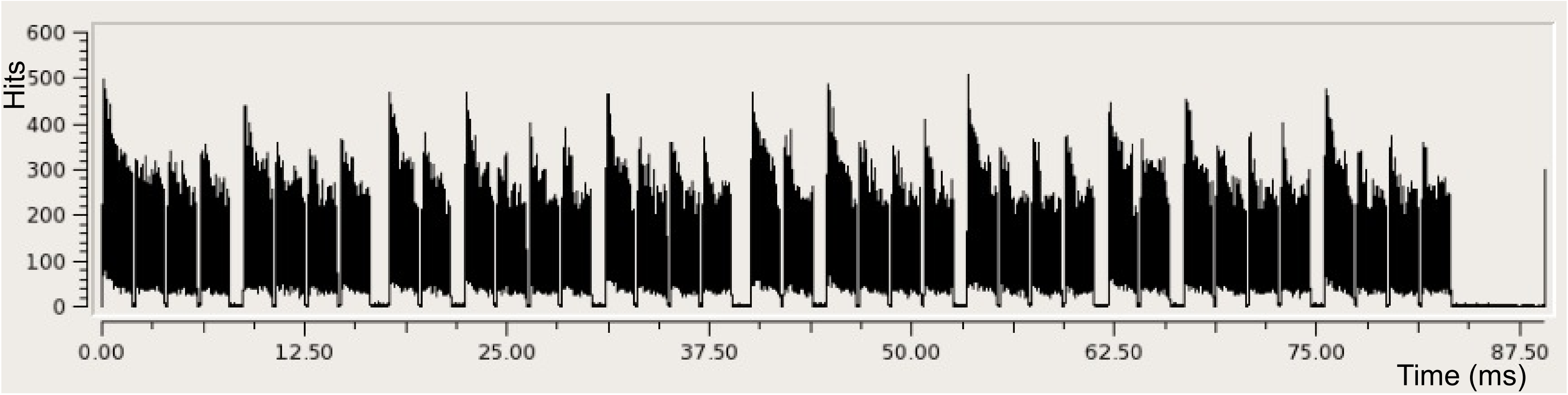
Recording Histogramming Unit (RHU)

Readout of full-orbit histograms, collection of post-mortem information

- No deadtime
- 8 input channels
- Additional input signals: orbit clock, bunch clock, beam abort
- Bins of 6.25 ns (4/bunch bucket), 14256 bins/orbit
- Configurable sampling period

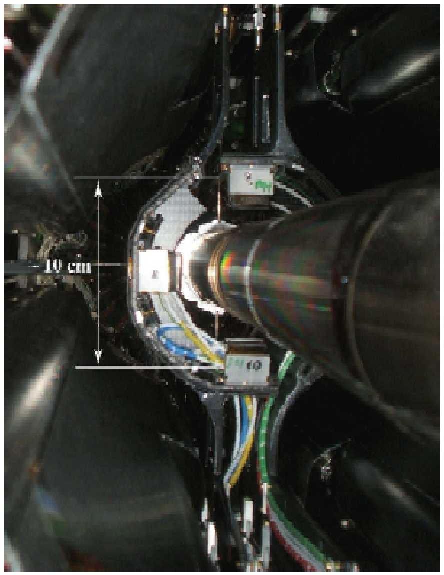


To be added: input for sampling period boundary signal

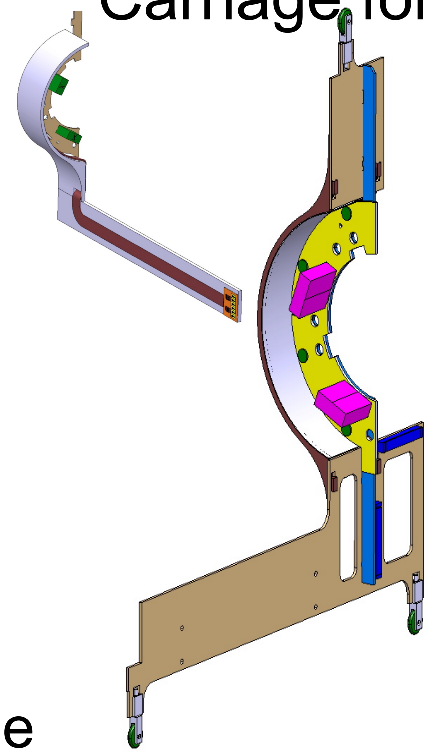


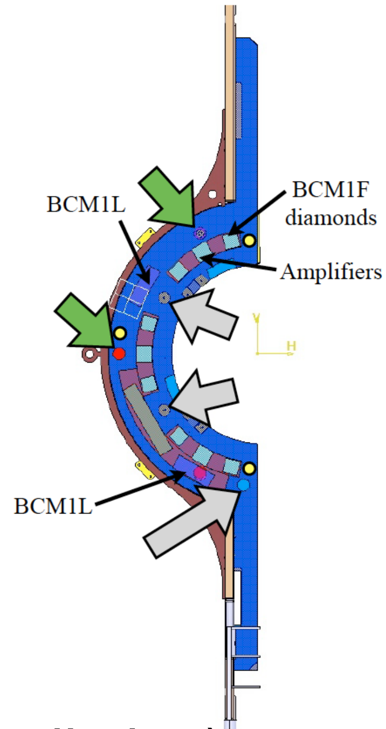
BCM1F Upgrade Concept

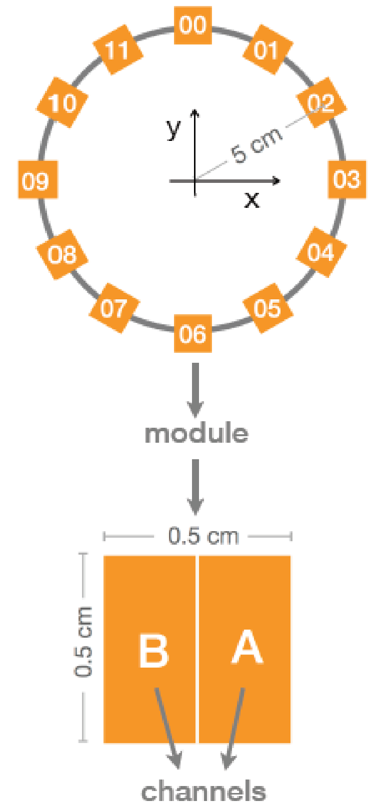
Current carriage



Carriage for upgrade







Carbon fiber carriage

Laser diodes on carriage arm (lower radiation)

Temperature sensor to account for optical response to temperature

24 diamonds, 48 channels

Luminosity 10^{34} cm^{-2}s^{-1} → BCM1F charged particle flux ~3e7 cm^{-2}s^{-1}

Conclusions

BCM1F showed potential as online luminometer in 2012

- Beam overlap agreed to others within 1%
- Hit rate linear over range of luminosities, extrapolation to post-upgrade period reasonable

Future improvements in the works to increase effectiveness

- Timing: new front-end ASIC to reduce “overshoot” inefficiency, constant fraction discriminators tested with good results
- Radiation damage: lower radiation for laser driver, multi-amplitude test pulses
- Polarization observed, investigation still in progress
- RHU, new carriage design

BCM1F Diamonds

Sccvd from element six

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Current discriminator: CAEN v258B fixed-threshold discriminator

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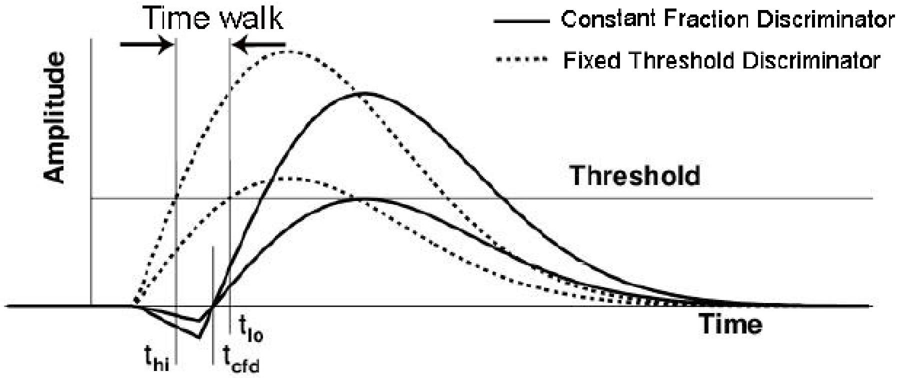
Tested two constant-fraction discriminators: CAEN v812, PSI CFD950

Both CFDs significantly improve on FTD time walk

- v812: better time resolution for trigger of single pulse
- CFD950: better resolution between consecutive pulses



Effects of Radiation: Front-end Electronics

Radiation damage of laser driver visible in decreasing signal amplitude

- Test pulses: amplitude steadily decreasing with exposure to radiation
- Data signal height amplitude spectra: saturation at lower amplitude over time

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