Beam Halo Monitor for FLASH

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December 7, 2010

Overview

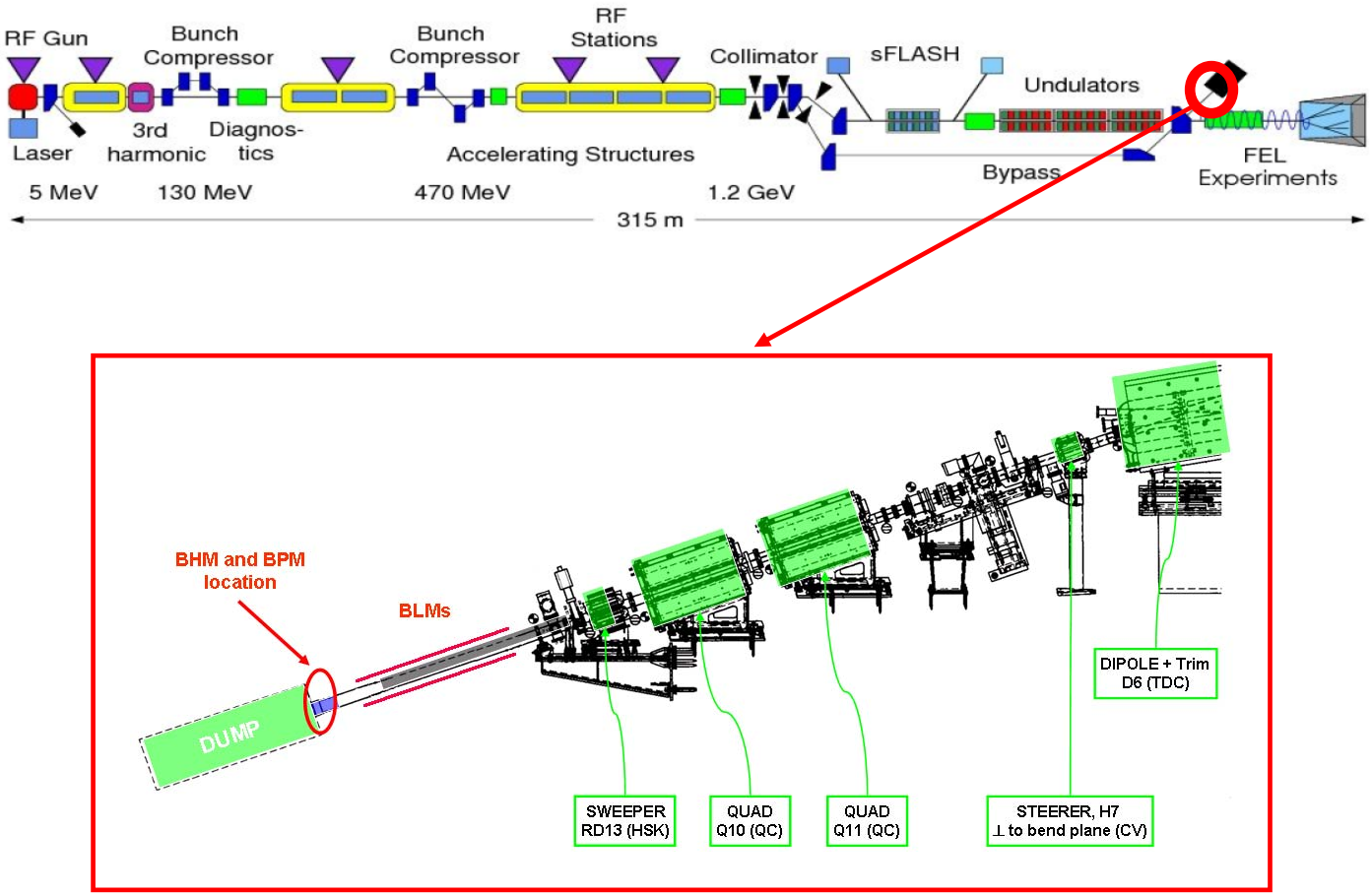
- Purpose
- BHM description
  - Position
  - Sensors
    - Diamonds
    - Sapphires
  - Bias voltage and readout scheme
- Operation experience
- Current status
- Conclusions

Purpose

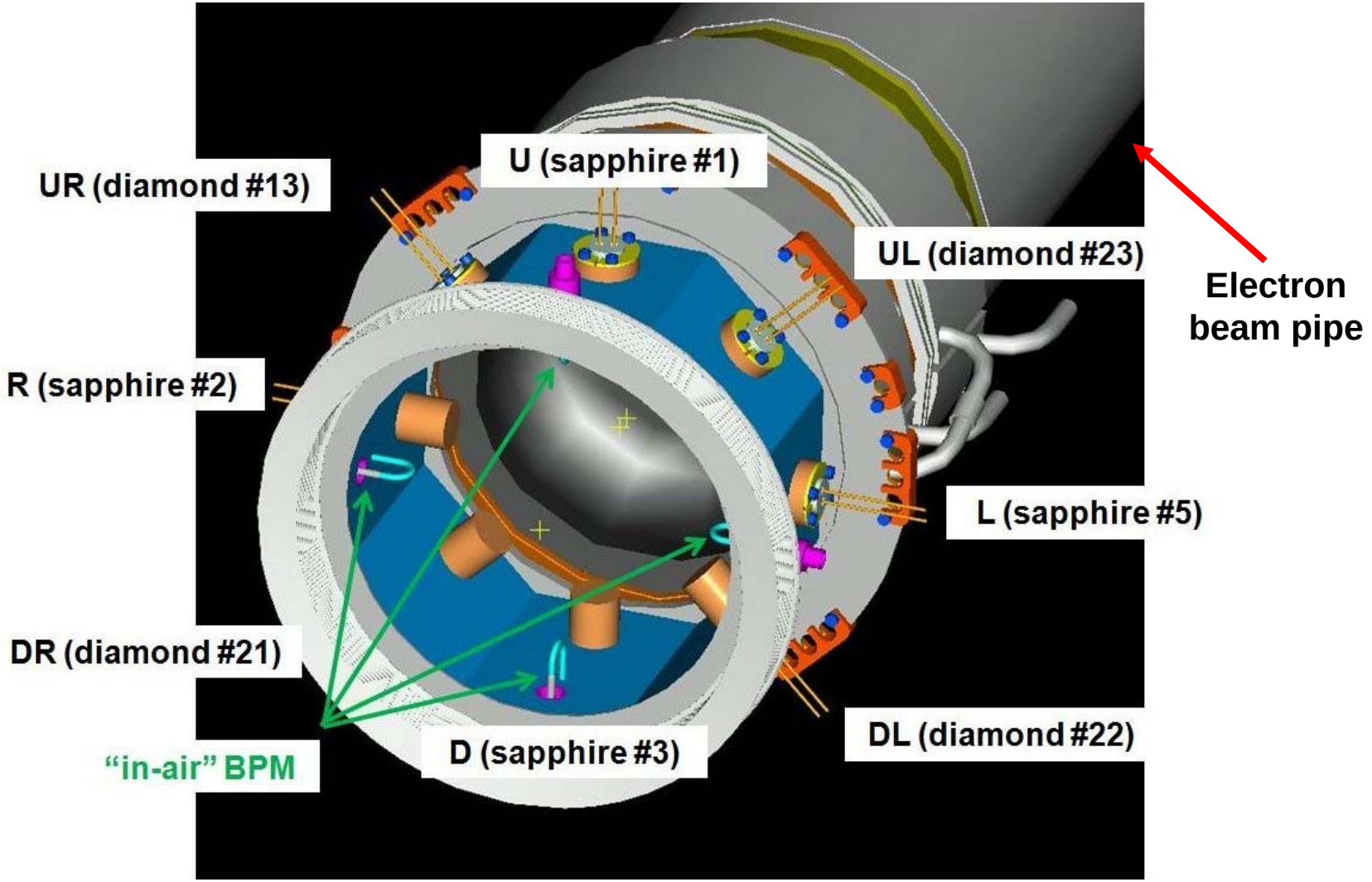
1. Part of the dump diagnostics
2. Supports safe beam dumping
3. Ensures that the beam and also the beam halo stay inside the beam pipe

BHM description

Position

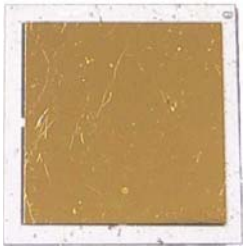


View from the dump



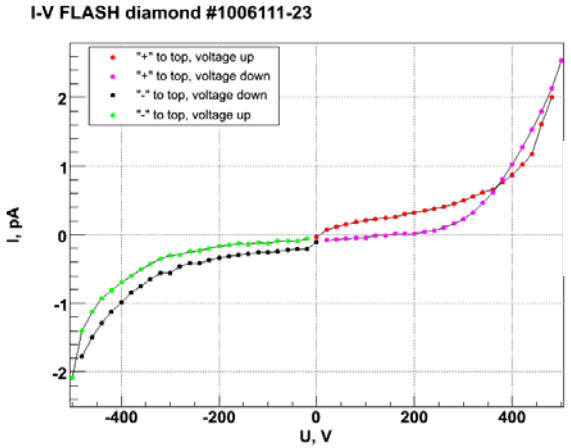
Sensors

1. pCVD diamond produced by Diamond Detectors Ltd.
   Dimensions 12×12×0.3 mm^3
   Metallization: 10×10 mm^2 50/50/200 nm Al/Ti/Au

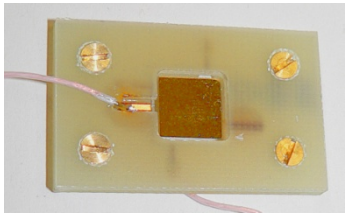


2. Single crystal sapphire (Al_2O_3) produced by CRYSTAL GmbH
   Cut [0001]
   Dimensions 10×10×0.3 mm^3
   Metallization: 8×8 mm^2 50/50/200 nm Al/Ti/Au

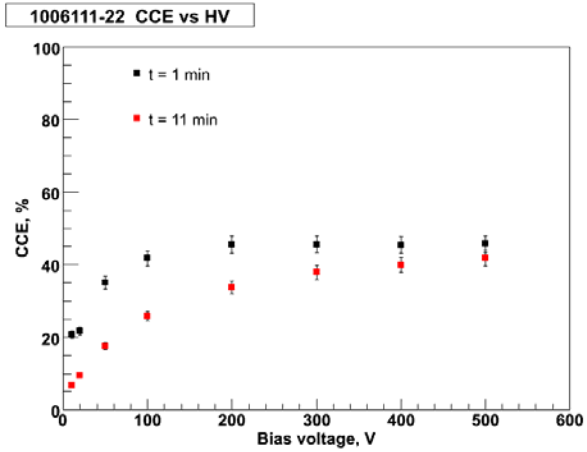
Diamonds



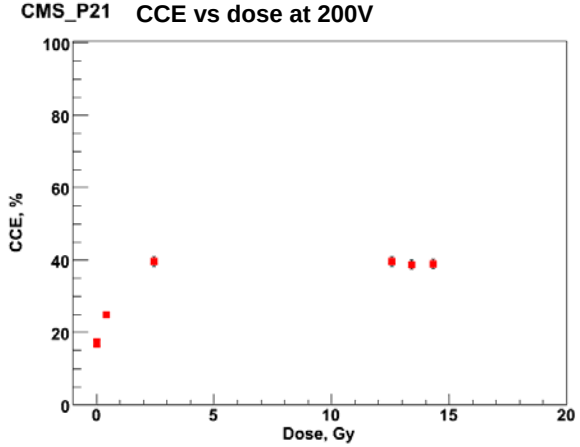
Current-voltage characteristics



A sensor assembled for tests



Polarization



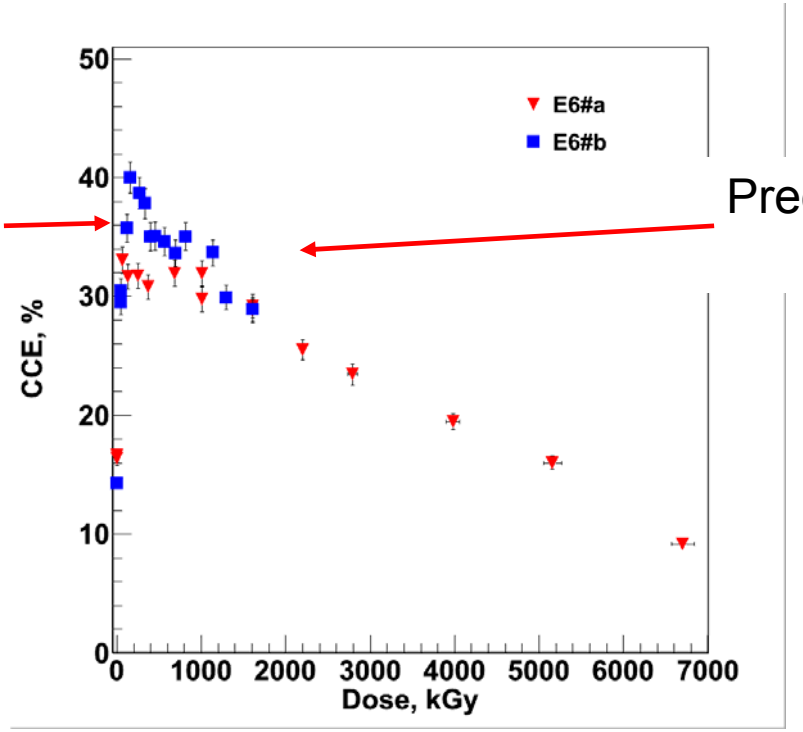
Pumping with a ^{90}Sr
A < 3 MBq

$$CCE = \frac{Q_{inj}}{Q_{coll}}$$

Radiation tolerance

10 MeV electron beam @ S-DALINAC

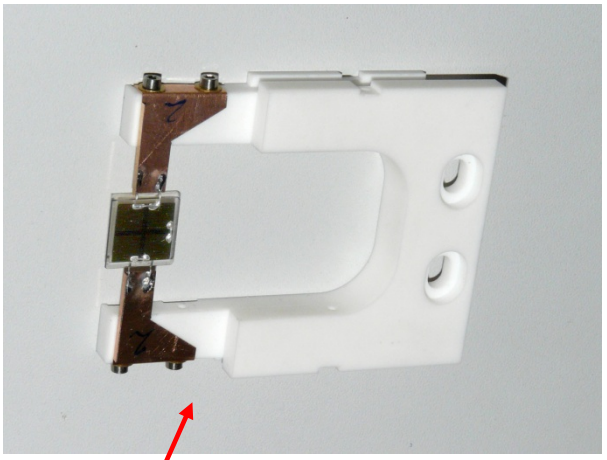
Predominant pumping

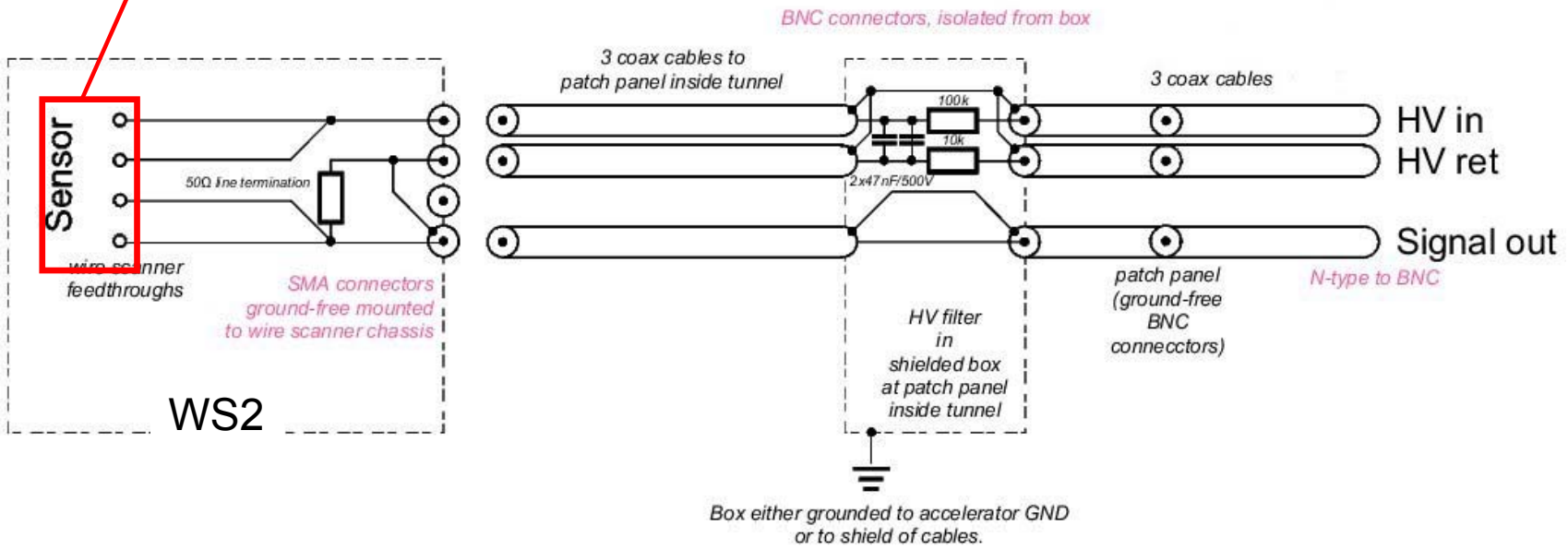


Predominant signal degradation

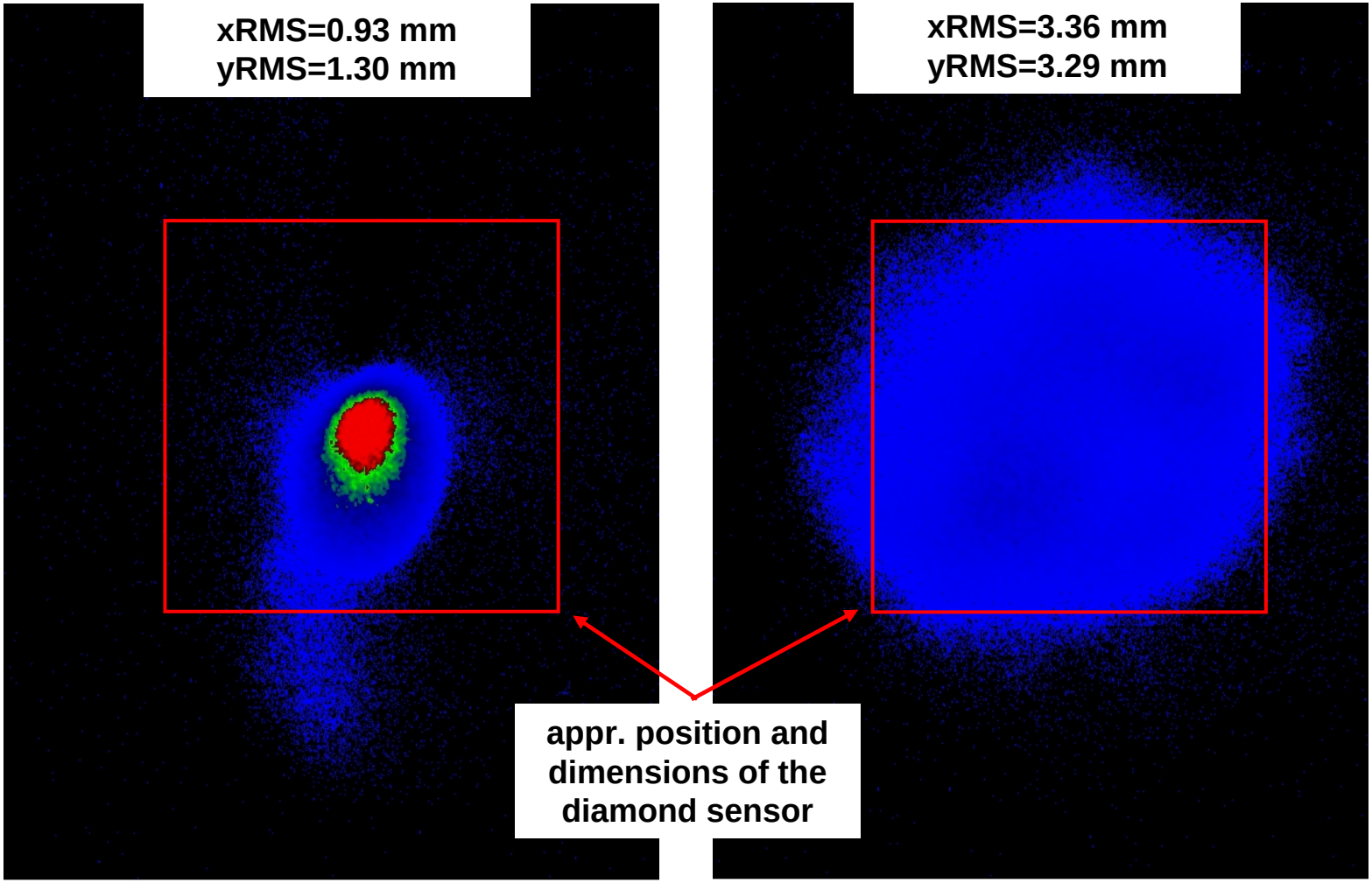
Moderate signal degradation up to 7 MGy

Test at PITZ

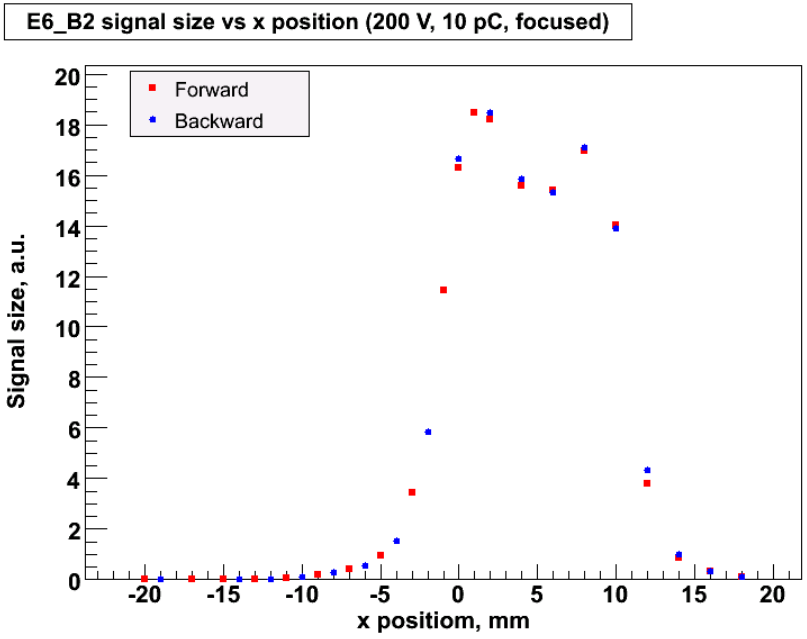



BNC connectors, isolated from box
3 coax cables to patch panel inside tunnel
3 coax cables
100k
10k
2x47nF/500V
HV in
HV ret
Signal out
Sensor
50Ω line termination
wire scanner feedthroughs
SMA connectors ground-free mounted to wire scanner chassis
WS2
HV filter in shielded box at patch panel inside tunnel
patch panel (ground-free BNC connecctors)
N-type to BNC
Box either grounded to accelerator GND or to shield of cables.

Beam profile on High2scr1

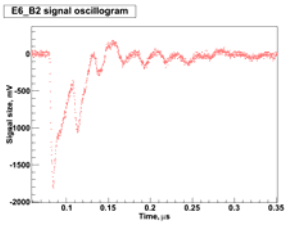


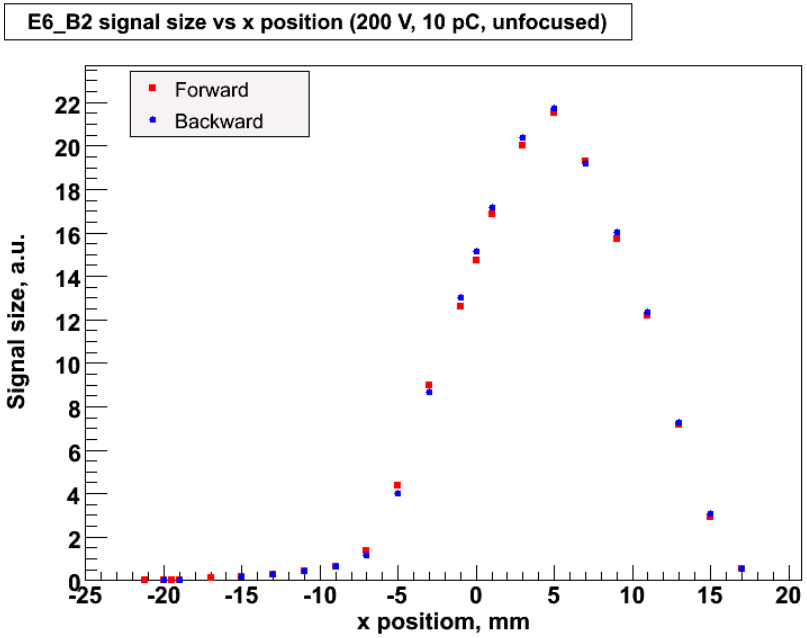
Horizontal scan of the beam



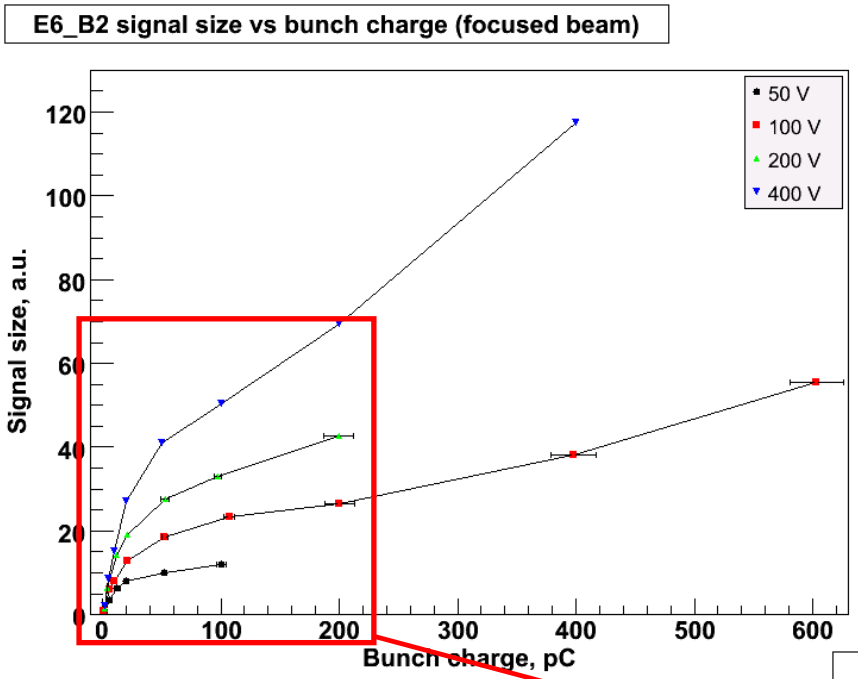
Expected charge produced in diamond by 10 pC beam ~ 230 nC

1 a.u. ~ 1 nC

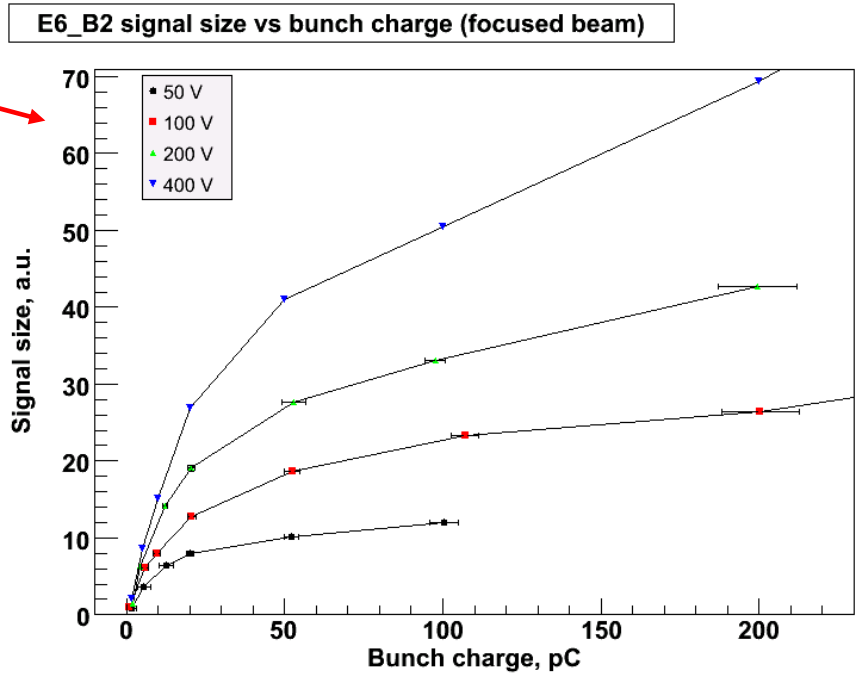




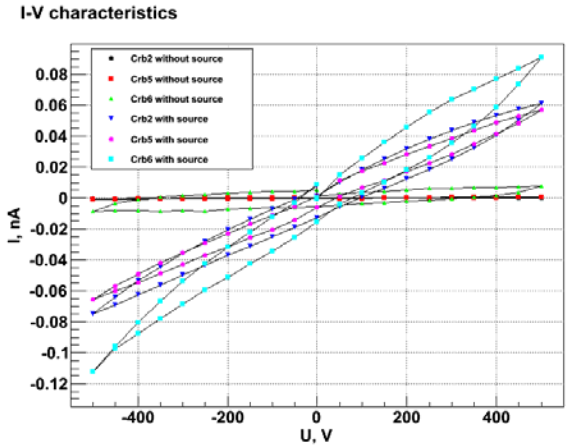
Signal as a function of the bunch charge



The sensor is in the center of the beam



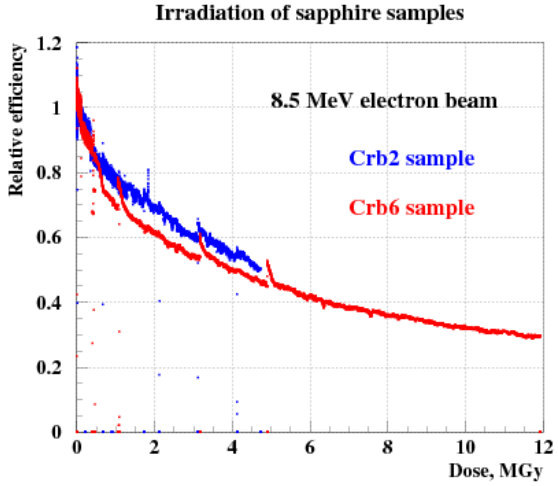
Sapphires



Signal as a response to a single MIP is too low to for detection

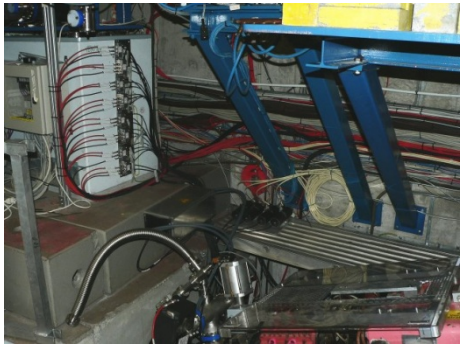
Signal as a response to particle flux from ^{90}Sr: estimated CCE 2-3 %

8.5 MeV electron beam @ S-DALINAC



30 % of the initial value of the signal after10 MGy

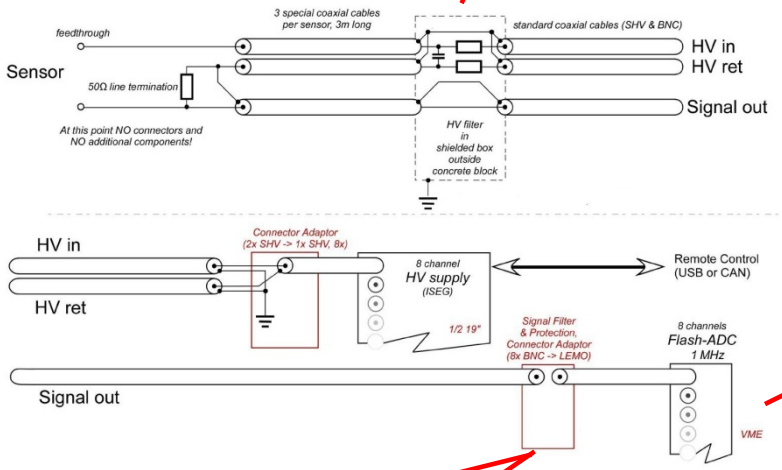
Bias voltage and readout scheme

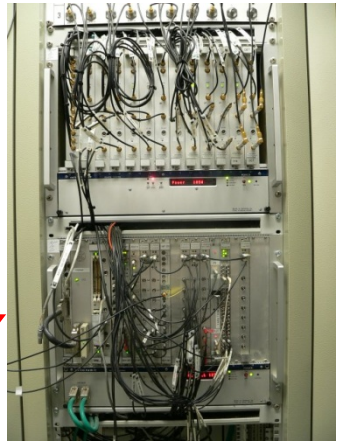


Tunnel

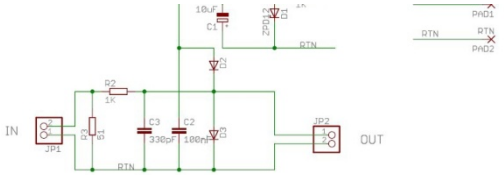
4 m

55-60 m



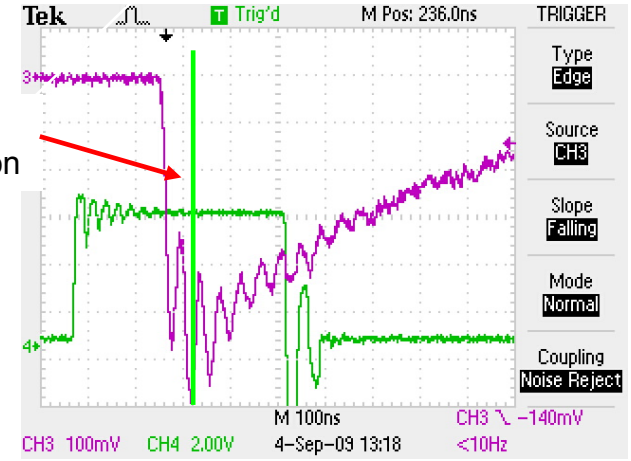


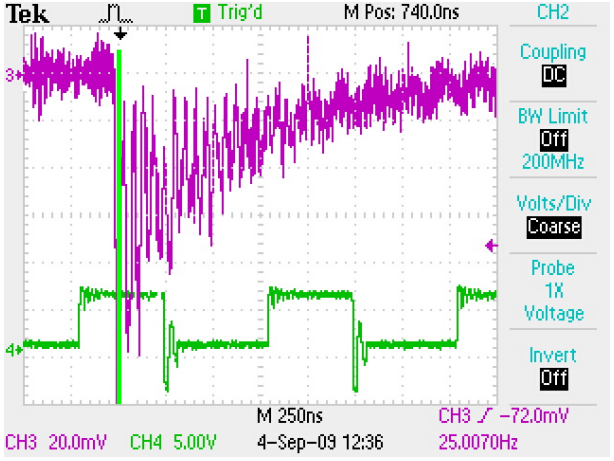
Building 49



Operation experience @ FLASH

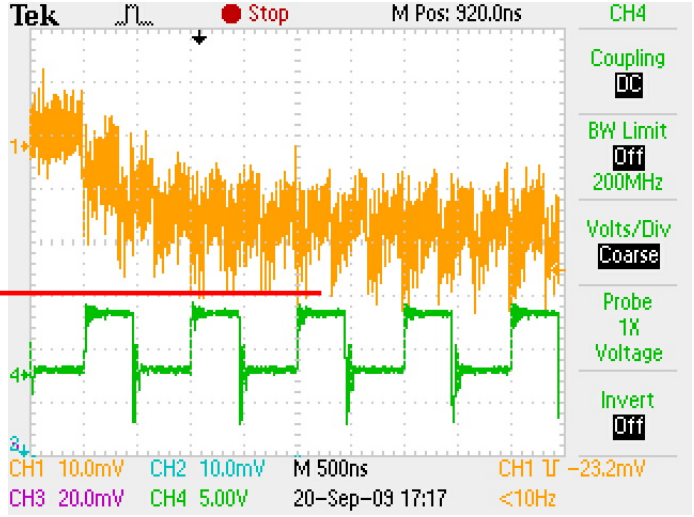
Actual clock/
sampling position





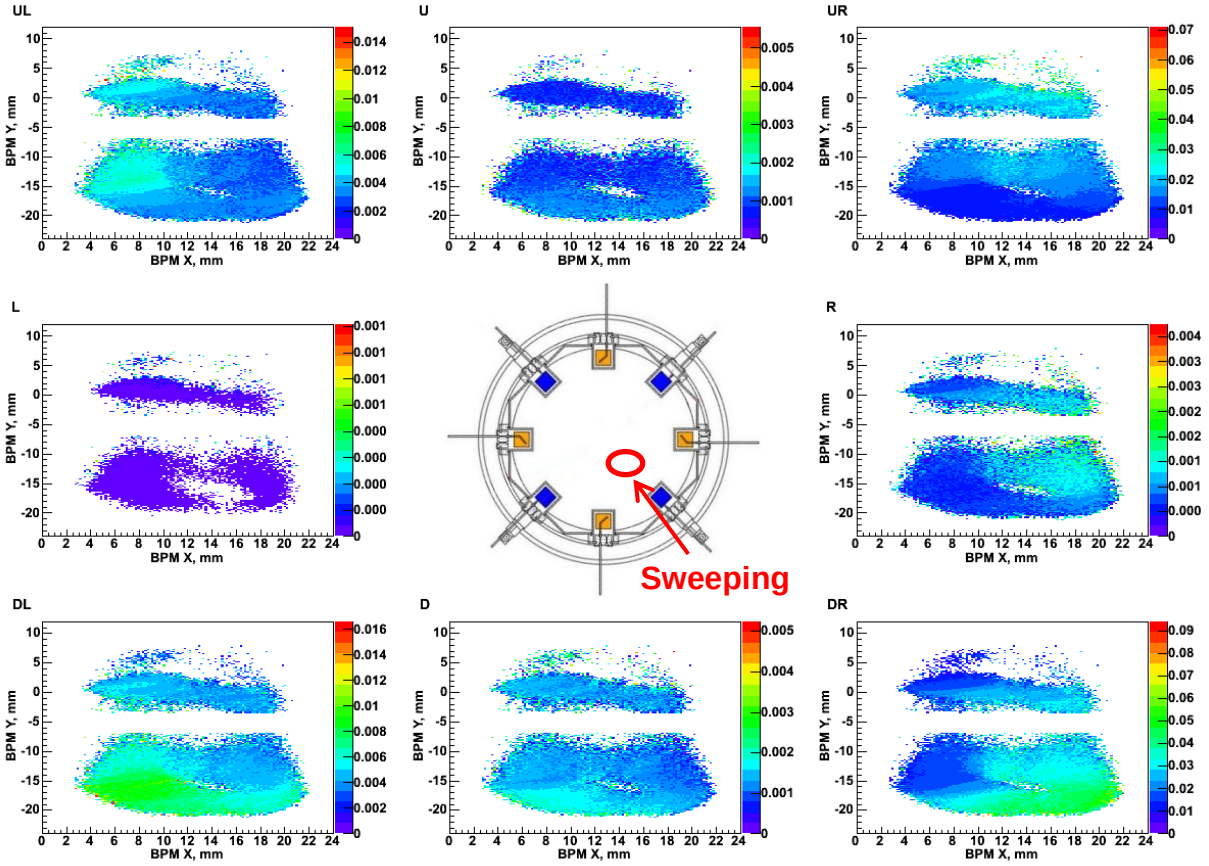
Analog signals from a diamond (left) and a sapphire (right) as a response to 1 bunch

Amplitude reaches plateau after the 6th bunch (if the conditions from bunch to bunch remain the same)



Analog signal, bunch repetition rate 3 MHz

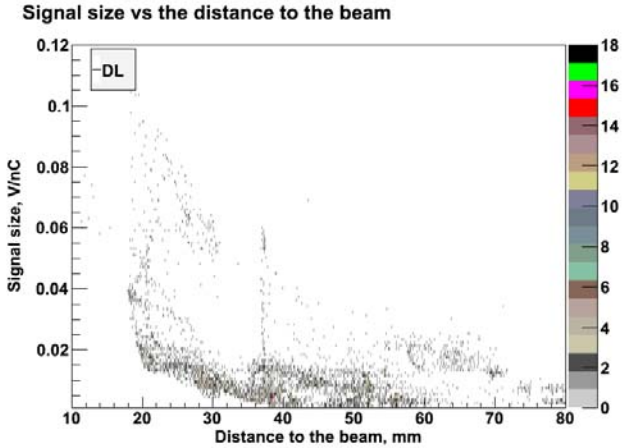
Average signal as a function of the beam position detected by the BPM

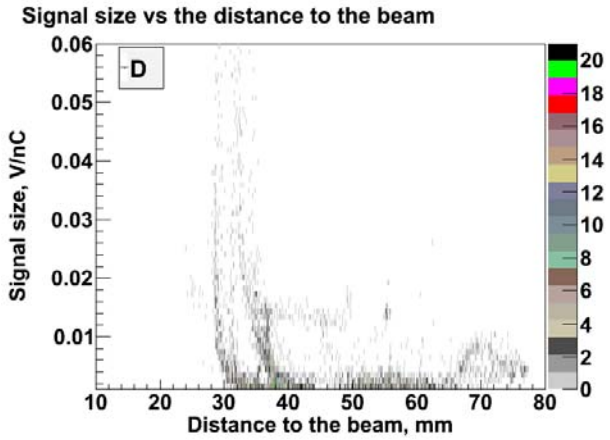


Color-coded, in V/nC

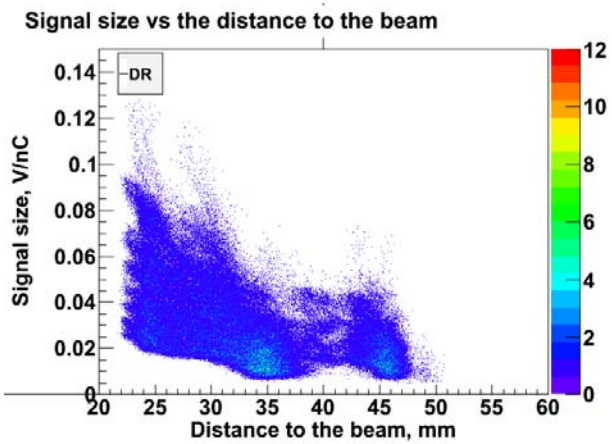
3 MHz bunch rep, multi-bunch operation
First bunches of each train are not taken into account

Signal as a function of the distance to the beam

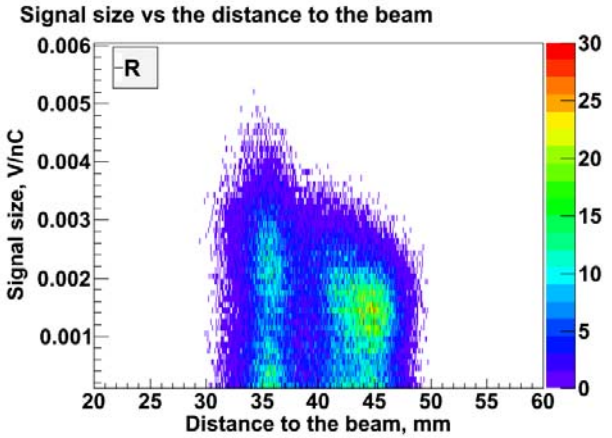




Single bunch

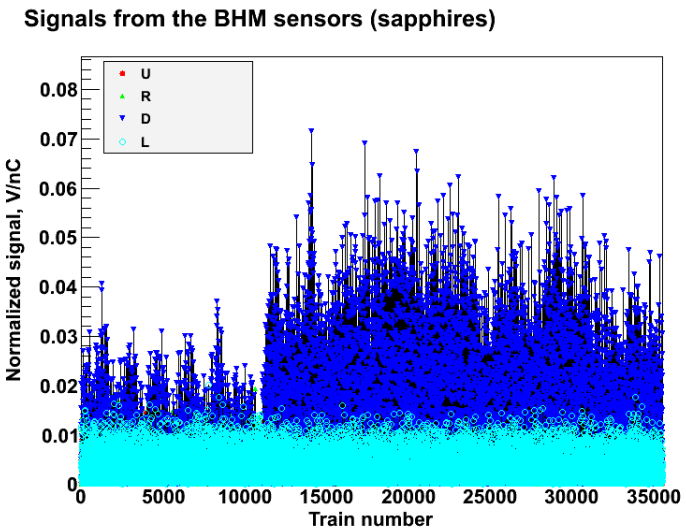


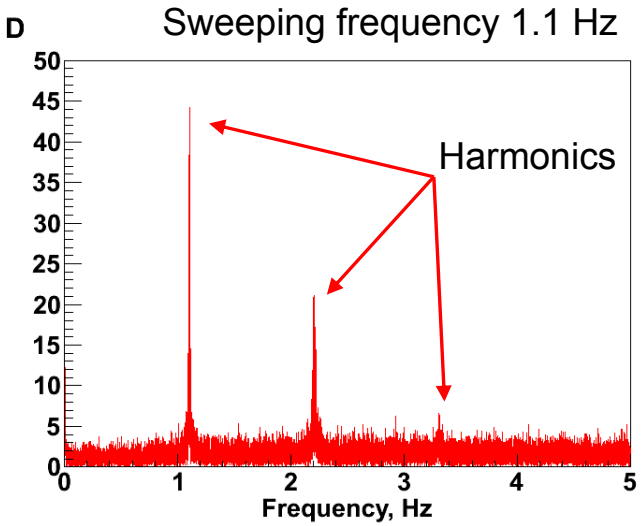
Diamond



Sapphire

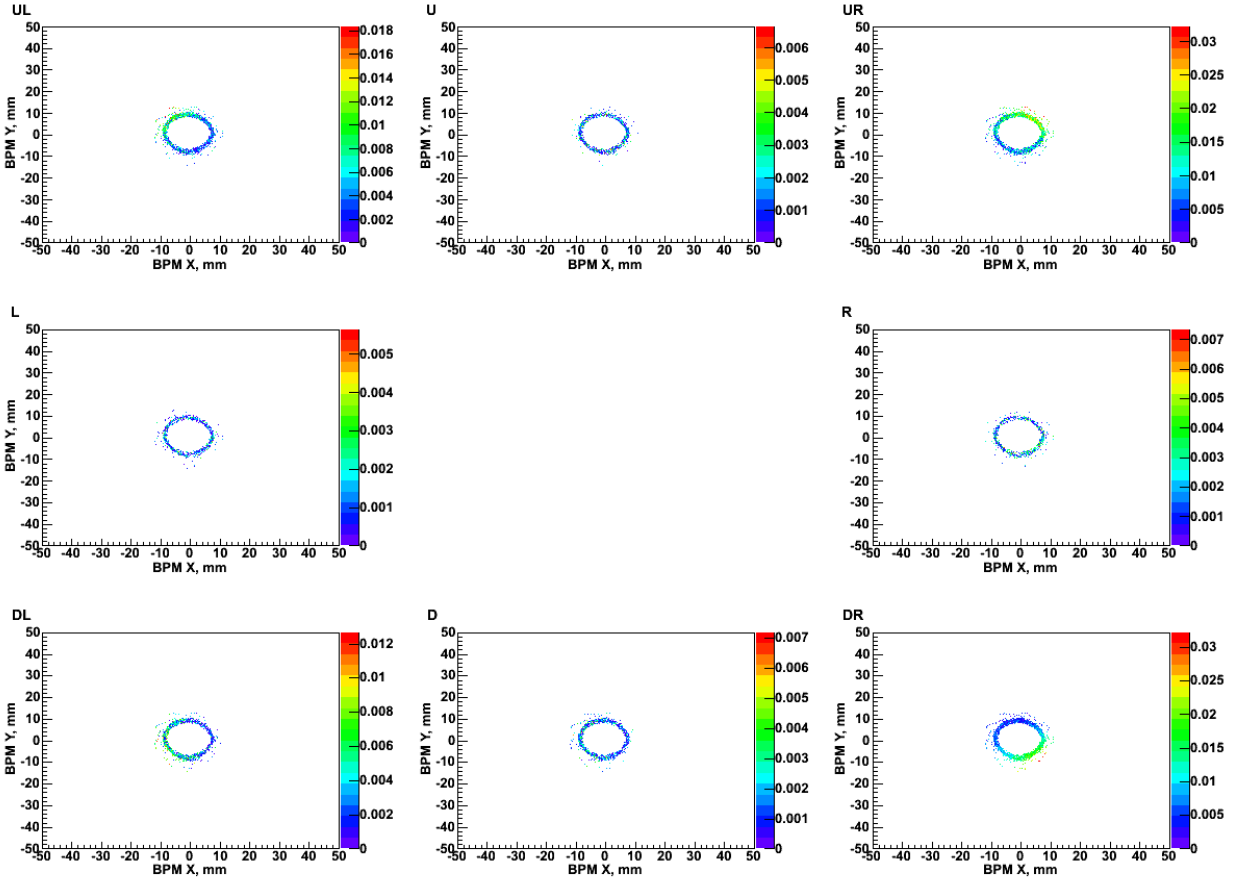
Multi bunch





Signal from a sapphire sensor in time and frequency domain

Possible definition of individual thresholds for the BHM sensors

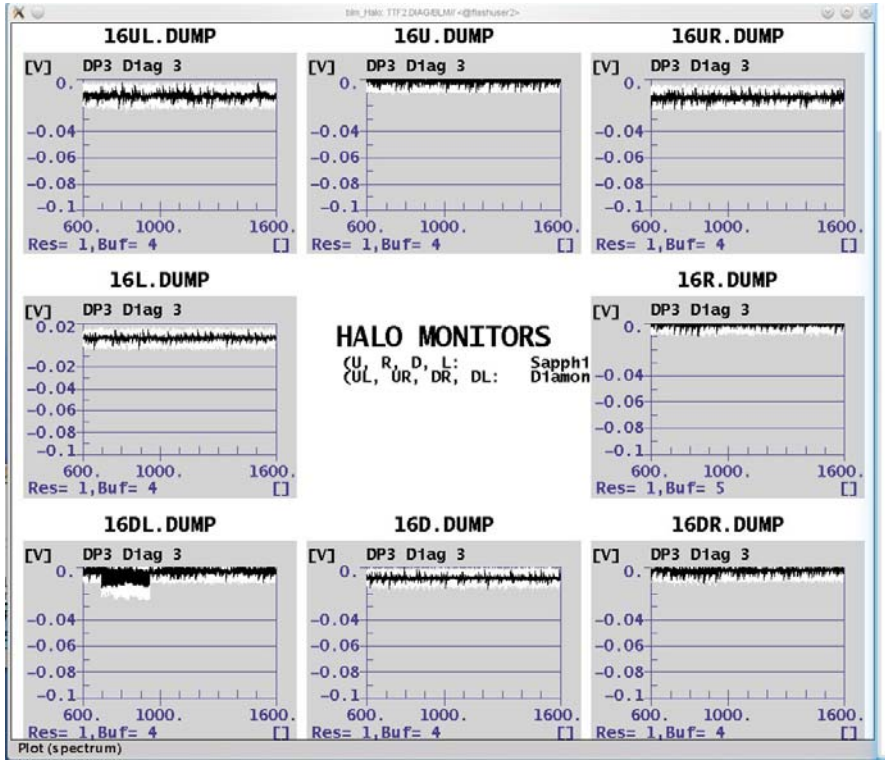


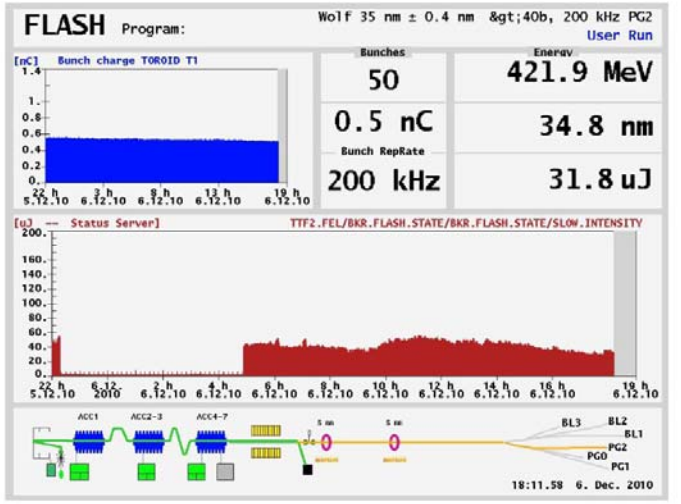
Color-coded, in V/nC

Average signal as a function of the beam position detected by the BPM at different sweeping radii

Current status

The signals from the BHM sensors (digitized and analog after the signal filter) are very small, although the signals before the filter are normal
→ Check what is wrong





06.12.2010 18:15

Summary

1. The BHM system consisting of 4 diamond sensors and 4 sapphire sensors has been commissioned in Sept. 2009 and is in operation at FLASH

2. The sensors applied are capable to withstand doses up to several MGy

3. The BHM system monitors the beam halo with different sensitivities. It signals when the beam approaches the sensors

4. The BHM system can be integrated in the protection system