Beam Halo Monitor for FLASH

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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

Electron beam pipe

UR (diamond #13)
R (sapphire #2)
DR (diamond #21)
“in-air” BPM
D (sapphire #3)
UL (diamond #23)
L (sapphire #5)
DL (diamond #22)
1. pCVD diamond produced by Diamond Detectors Ltd.
   Dimensions $12\times12\times0.3$ mm$^3$
   Metallization: $10\times10$ mm$^2$ 50/50/200 nm Al/Ti/Au

2. Single crystal sapphire ($\text{Al}_2\text{O}_3$) produced by CRYSTAL GmbH
   Cut [0001]
   Dimensions $10\times10\times0.3$ mm$^3$
   Metallization: $8\times8$ 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

$CCE = \frac{Q_{\text{inj}}}{Q_{\text{coll}}}$
Radiation tolerance

10 MeV electron beam @ S-DALINAC

Predominant pumping

Predominant signal degradation

Moderate signal degradation up to 7 MGy
Test at PITZ

WS2

Sensor

Wire scanner

Through SMA connectors

Ground-free mounted to wire scanner chassis

50Ω line termination

3 coax cables to patch panel inside tunnel

HV in

HV ret

Signal out

BNC connectors, isolated from box

3 coax cables

HV filter

In

Shielded box at patch panel inside tunnel

Patch panel (ground-free BNC connectors)

N-type to BNC

Box either grounded to accelerator GND or to shield of cables.
Beam profile on High2scr1

Focused

xRMS=0.93 mm
yRMS=1.30 mm

Unfocused

xRMS=3.36 mm
yRMS=3.29 mm

appr. position and dimensions of the diamond sensor
Expected charge produced in diamond by 10 pC beam
~ 230 nC

1 a.u. ~ 1 nC
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 after 10 MGy
Bias voltage and readout scheme

Tunnel 4 m 55-60 m

Building 49
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

Diamond

Sapphire

Single bunch

Multi bunch
Signal from a sapphire sensor in time and frequency domain

Sweeping frequency 1.1 Hz

Harmonics
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
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
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.