CMS **B**eam **C**ondition **M**onitoring

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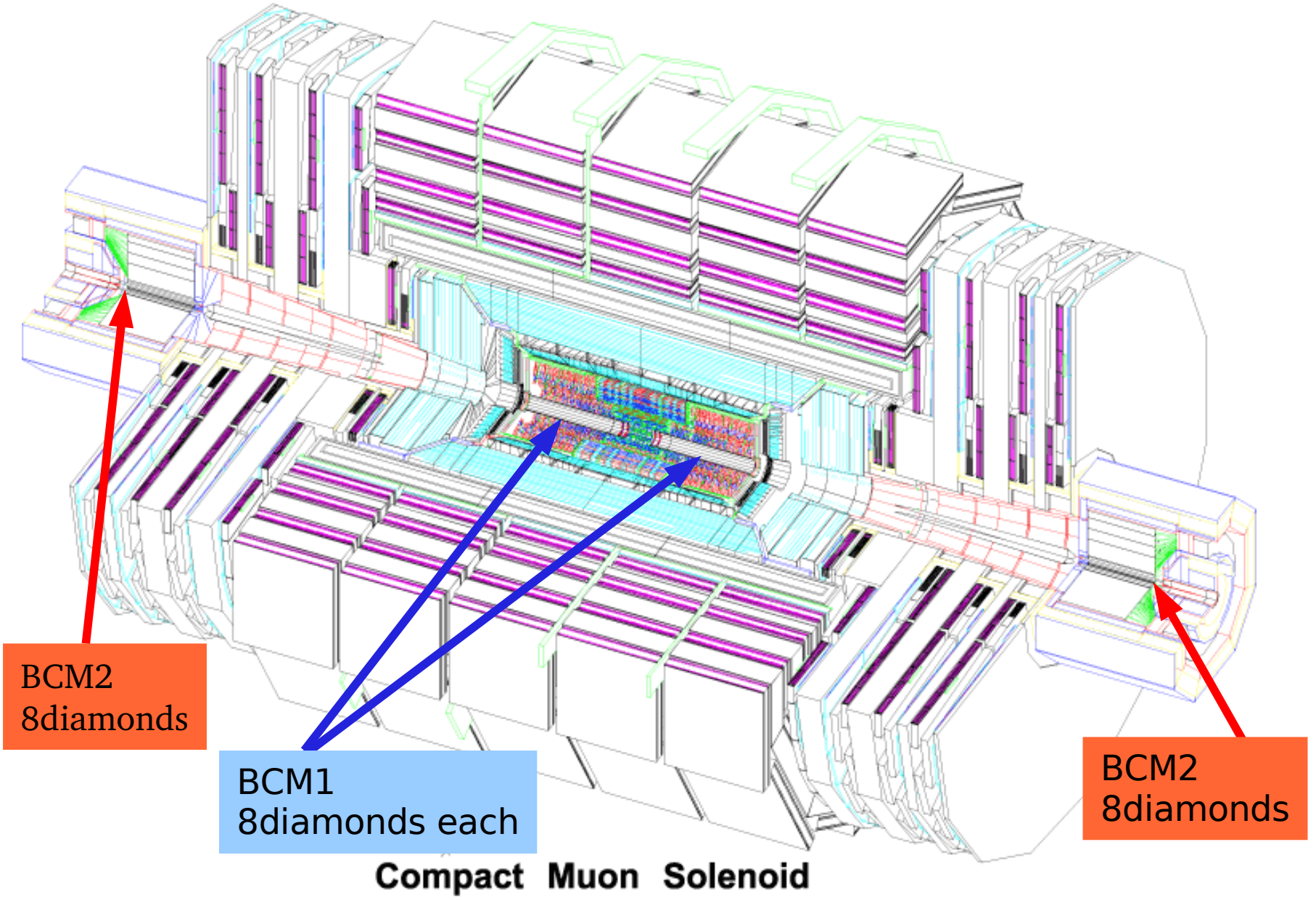
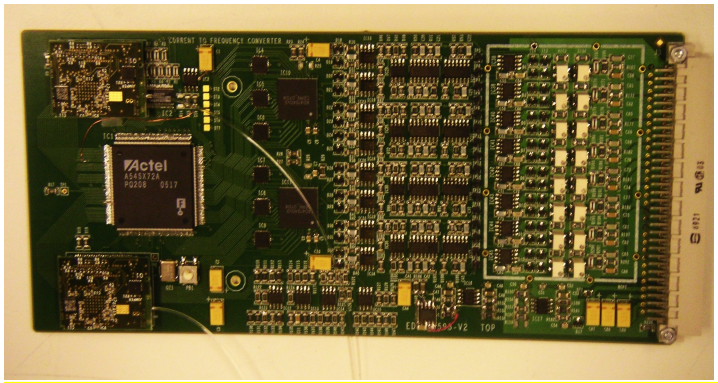


Beam Condition Monitoring at LHC

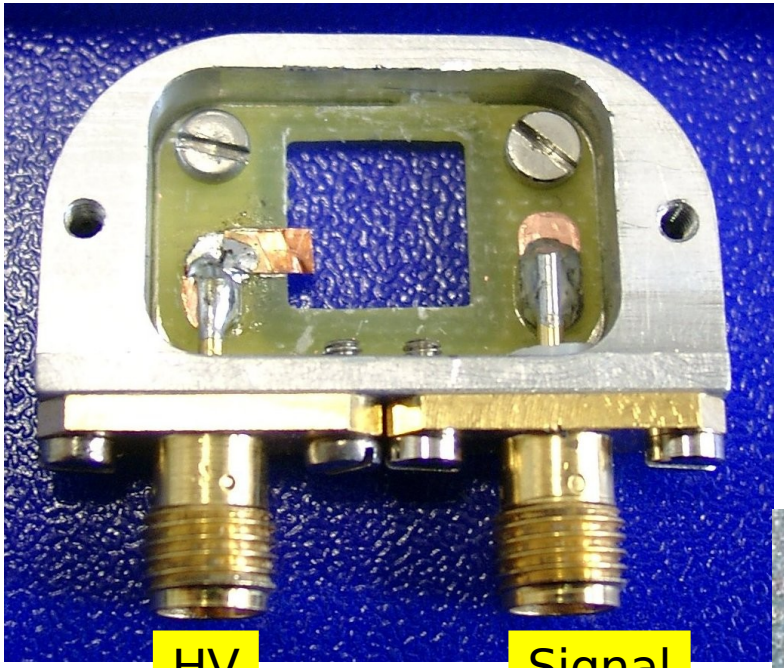
- BCM at LHC is done by about 3700 gas ionization chambers which are placed around the ring
- if their signal gets too large a beam dump is requested to prevent a quenching of the superconducting magnets or damage on the machinery
- there is no space in the experimental areas for these chambers, so another solution was needed to monitor the beam without interruption in these areas
- For CMS this is the Beam Radiation Monitoring System consisting of 6 subsystems of which 3 are diamond based and placed inside the CMS detector
- BCM2 consists of 16 (opt 32) pCVD diamonds, which are placed near the beam pipe
- the readout of BCM2 is based on the same electronics and software as the gas ionization chambers, so the data is immediately available via the LHC beam monitoring system

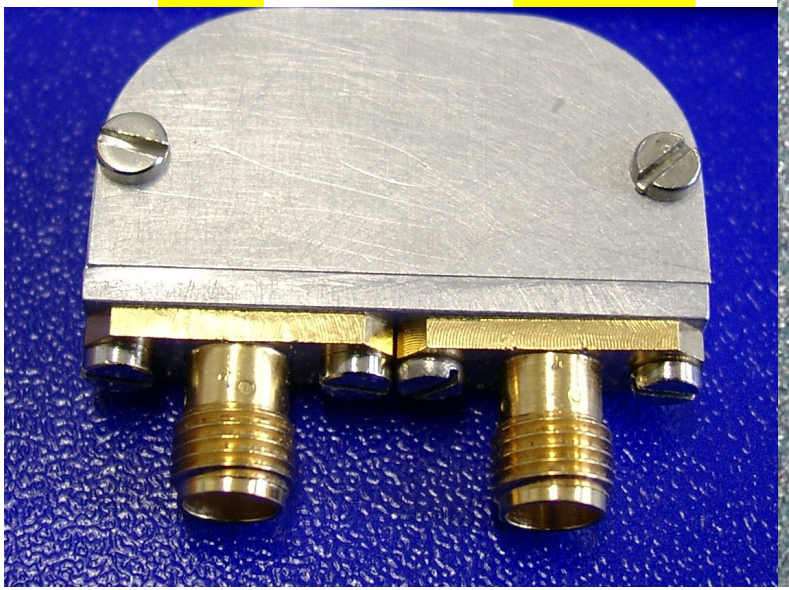
Layout of BCM2



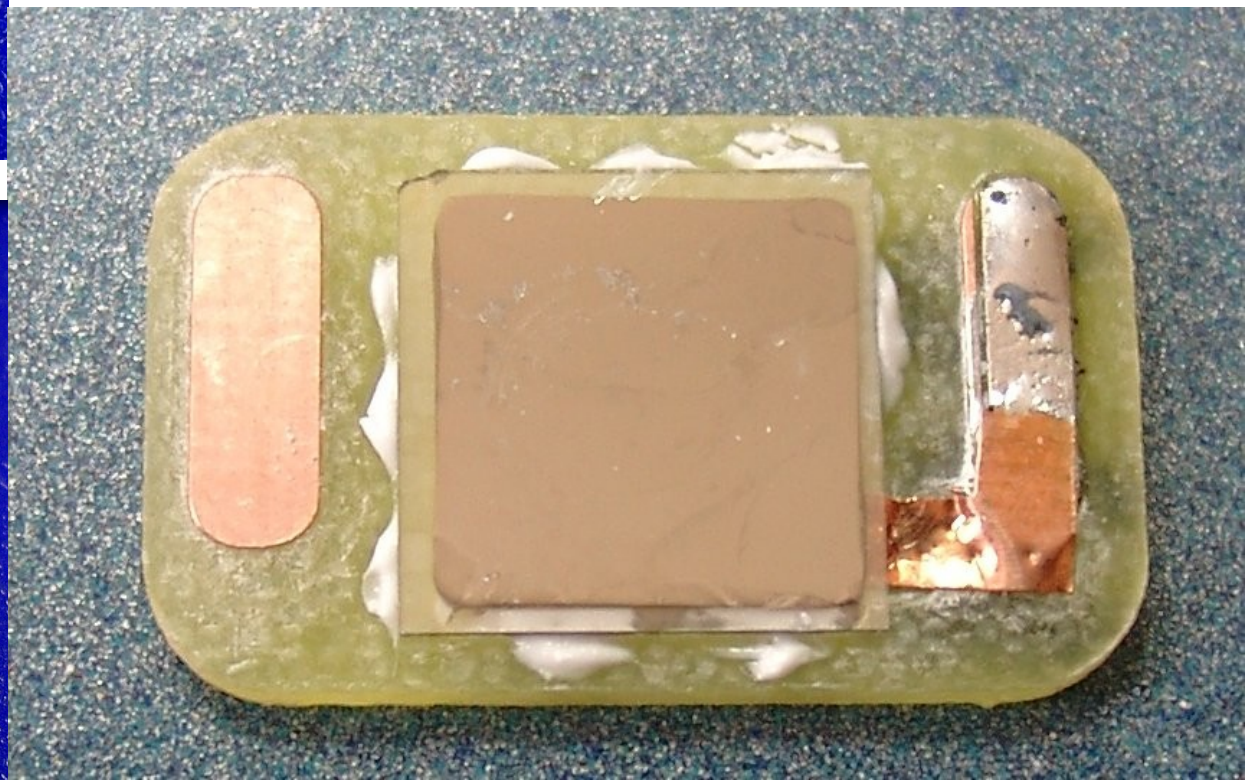
Tunnelcard with current to frequency converter from LHC Beam Monitoring Group (Dehning, Effinger)

BCM2 sensor

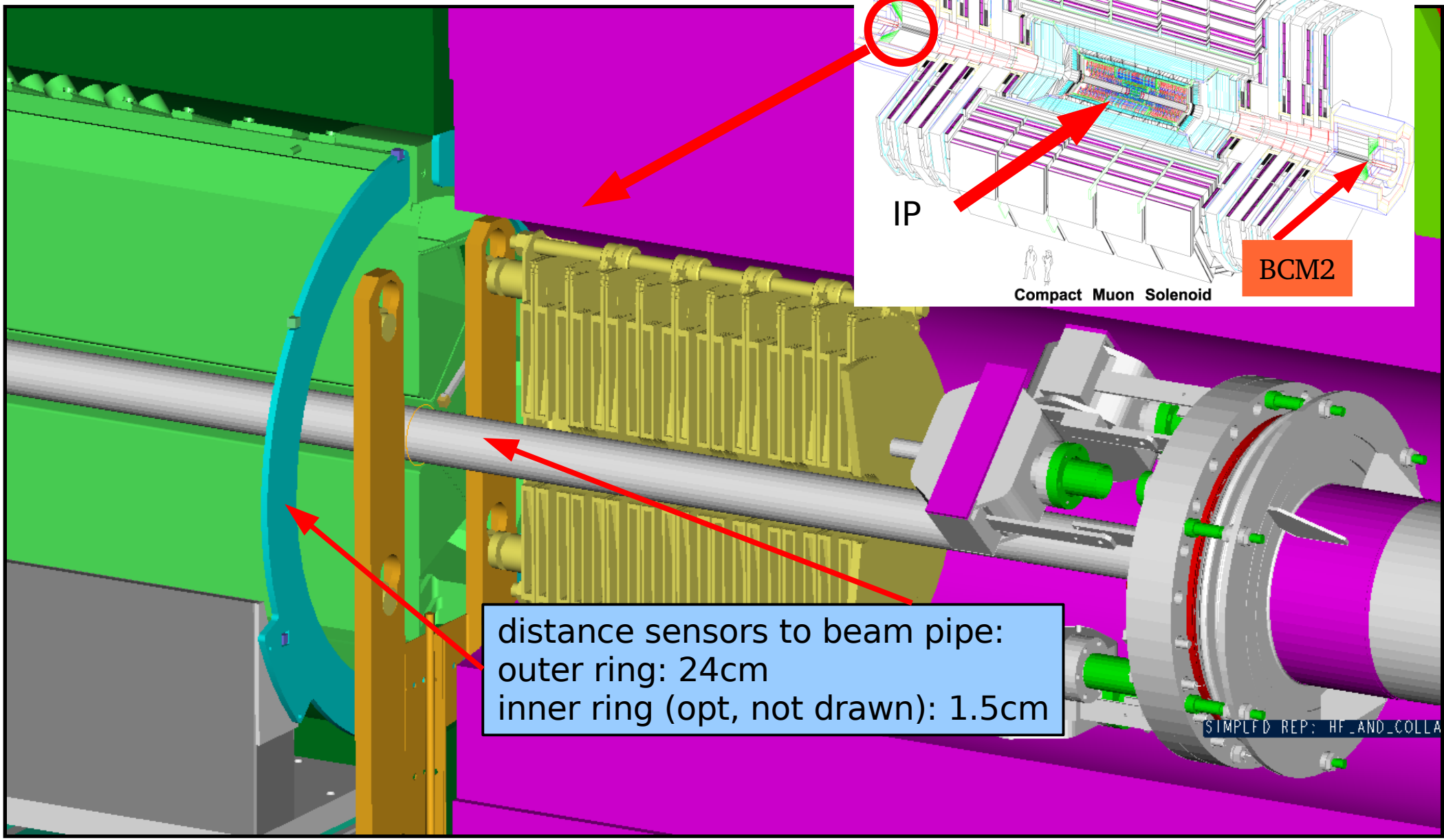




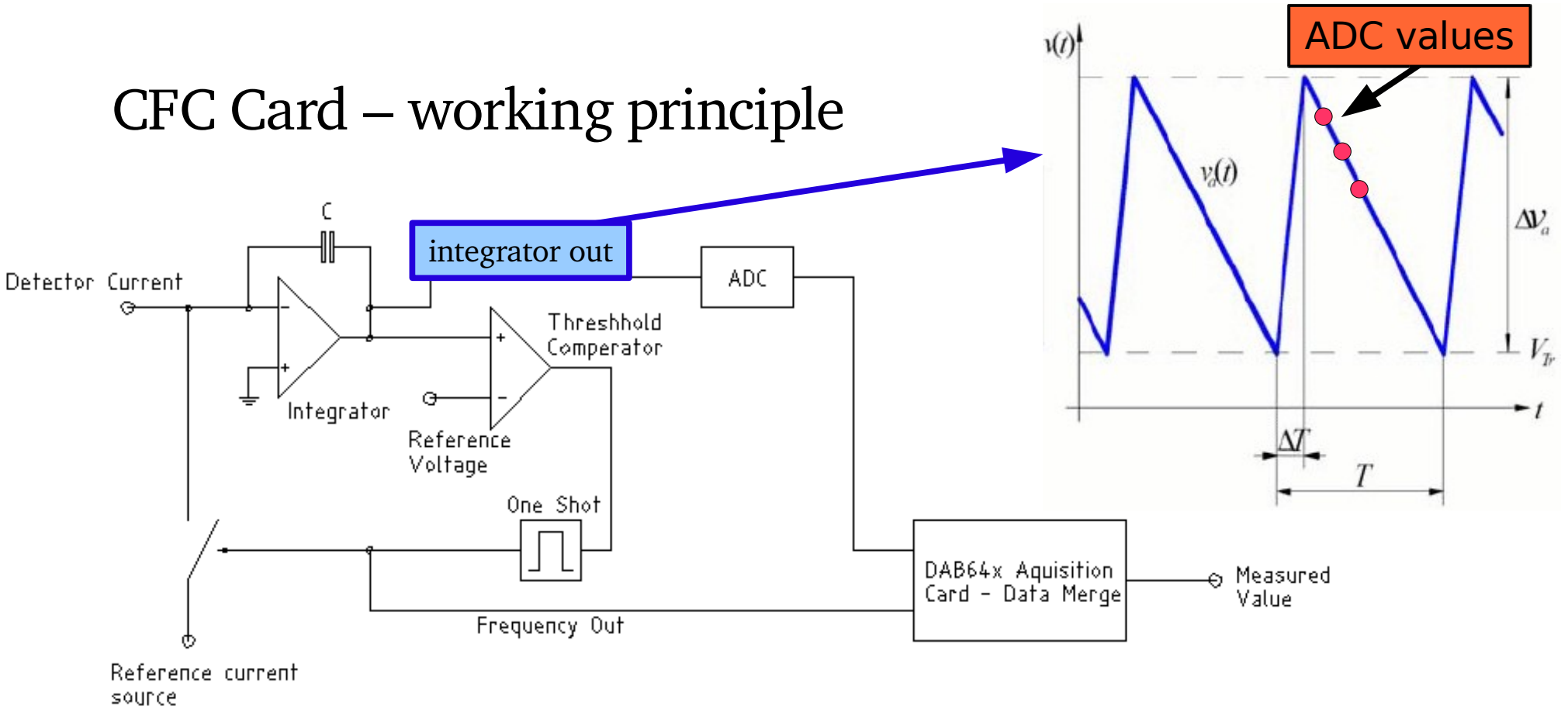
- pCVD 350μm 10x10mm
- mounted in a box of aluminum for shielding
- metalization visible from both sides
- contact with bond wires and silver epoxy glue
- CMS sensor metalized by Bob Stone, Rutgers University
- metalization: Tungsten-Titanium
- measured CCD: 250μm



Position of BCM2



CFC Card – working principle

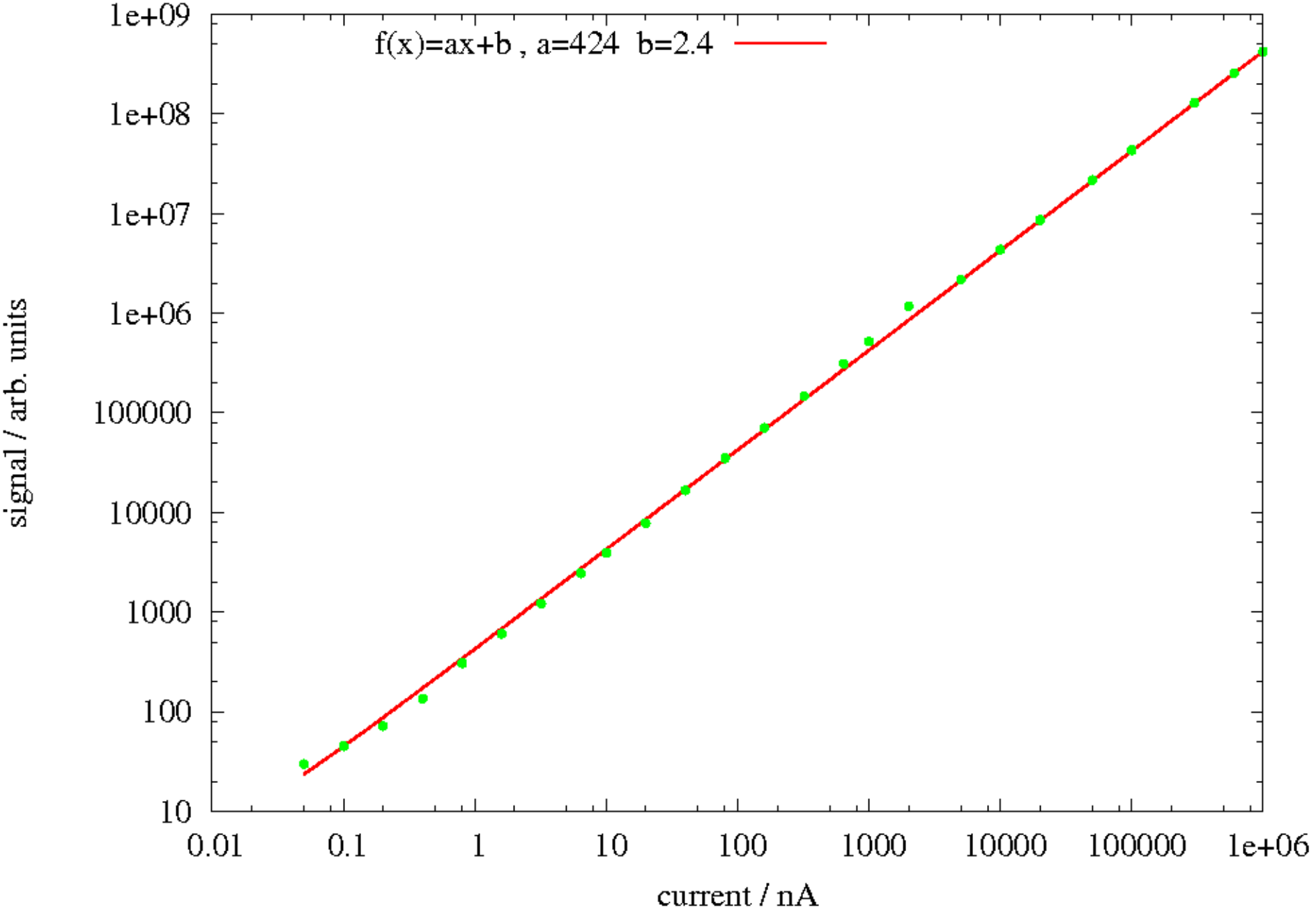


Principle: after reset: C is discharged with detector current.
To continuously check the card an additional current source of 10 pA discharges as well, so at least every 20s a trigger will be given to a counter indicating that C was discharged below the threshold.

Every 40 us the counter on the board is readout telling how many times the capacitor was discharged, which is a measure of the sensor current. Additionally an ADC converts the integrator voltages into digital values which can be used to calculate the slope of the discharge, which is important for low detector currents.

Properties:
- 8 channel design
- high dynamic range 10pA – 1mA
- low noise readout
- radiation hard design
- opt. readout with USB

linearity of the CFC card



Test Setup

diamond

10m cables

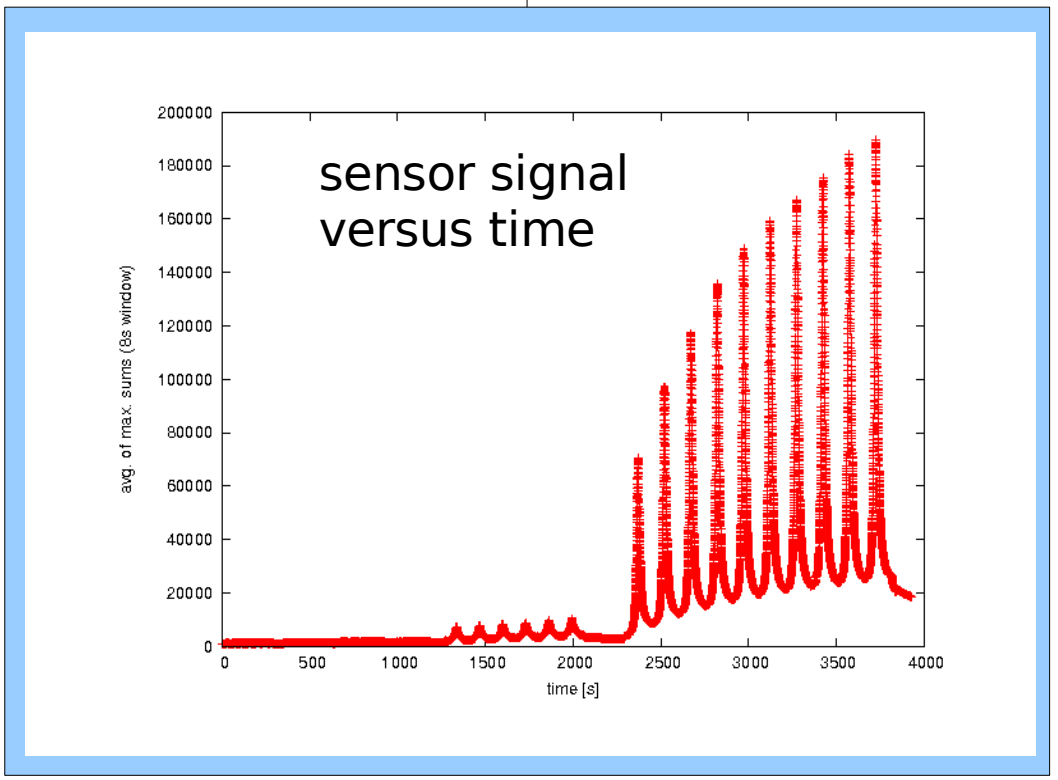
CFC-Card

optical fibers

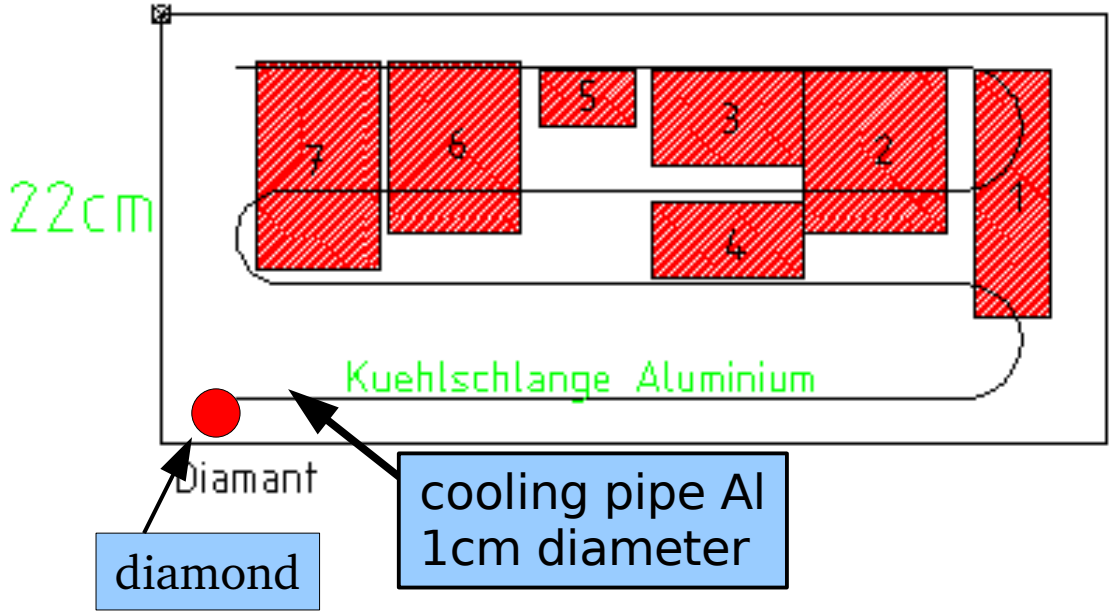
USB readout electronics

proton beam

KAZ
Karlsruher cyclotron
26MeV protons



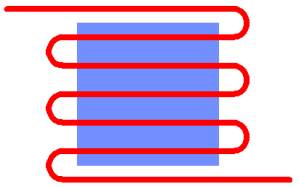
first measurements of scattered radiation



diamond

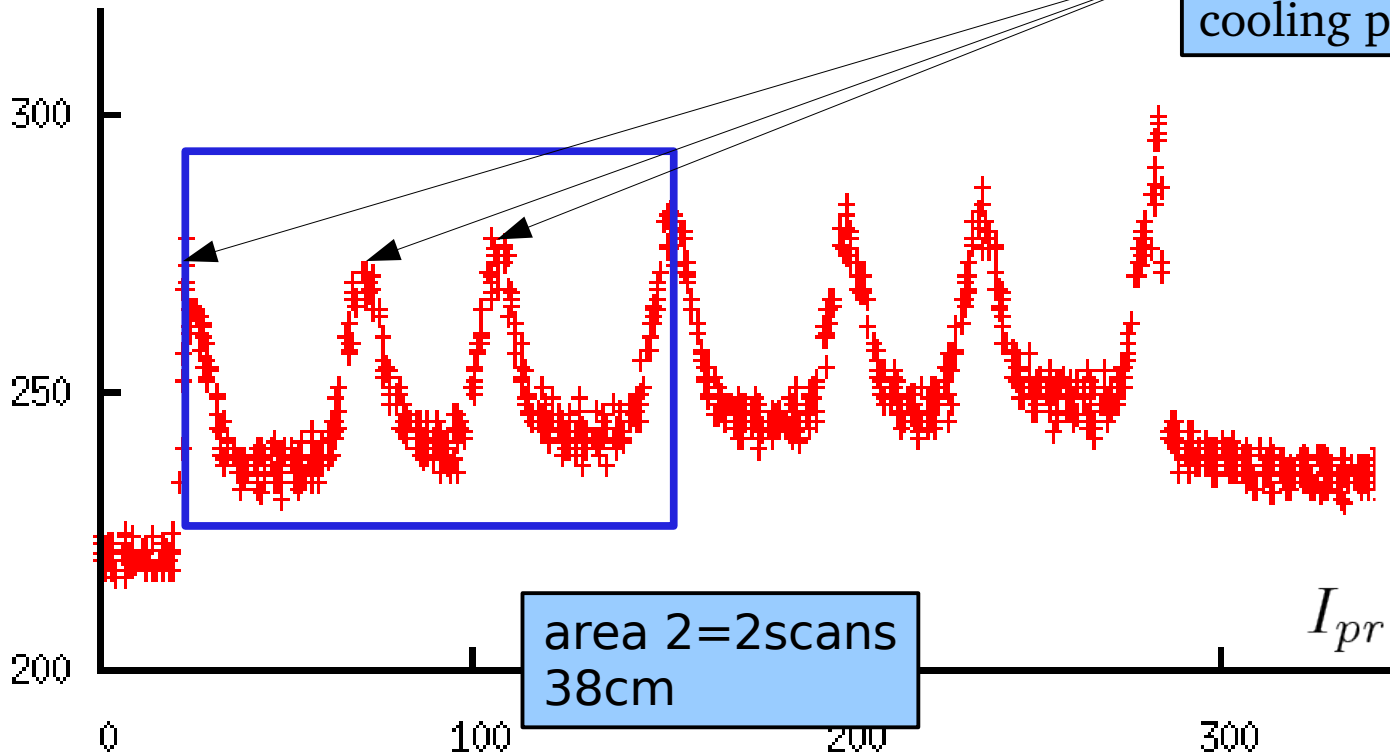
cooling pipe Al
1cm diameter

scan mode:



and back

More signal if beam is over cooling pipe.

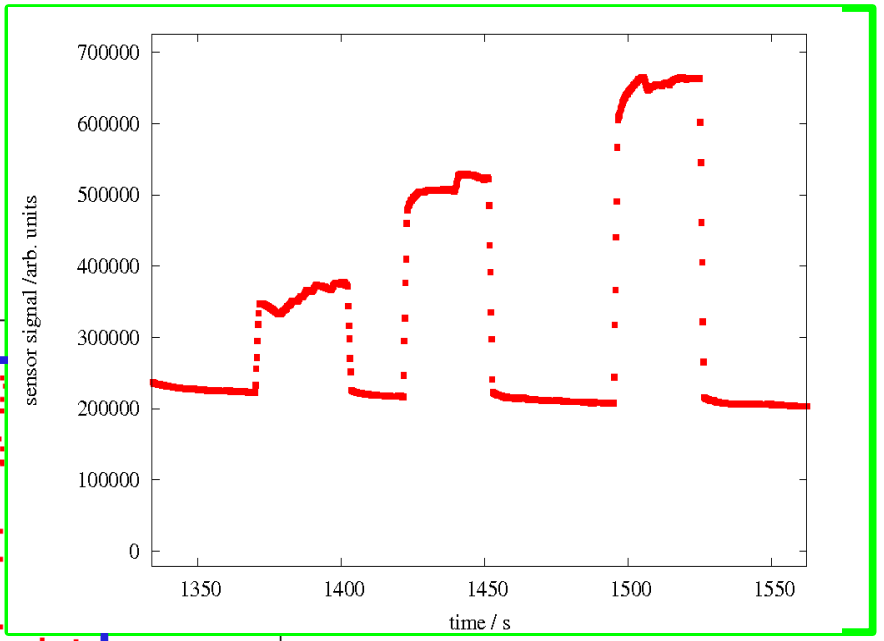


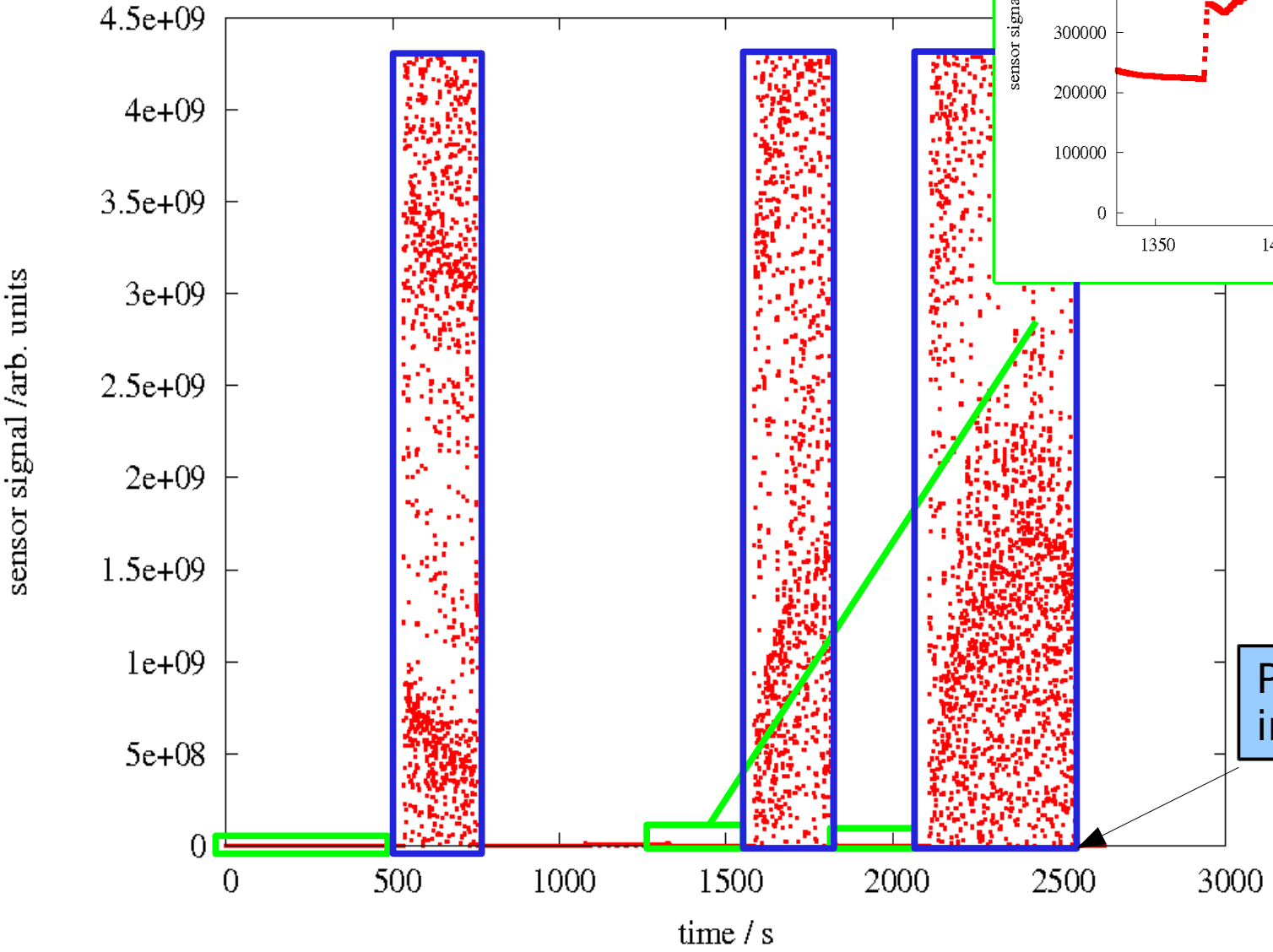
area 2=2scans
38cm

$I_{proton} = 4\mu A$

relative CCD measurements

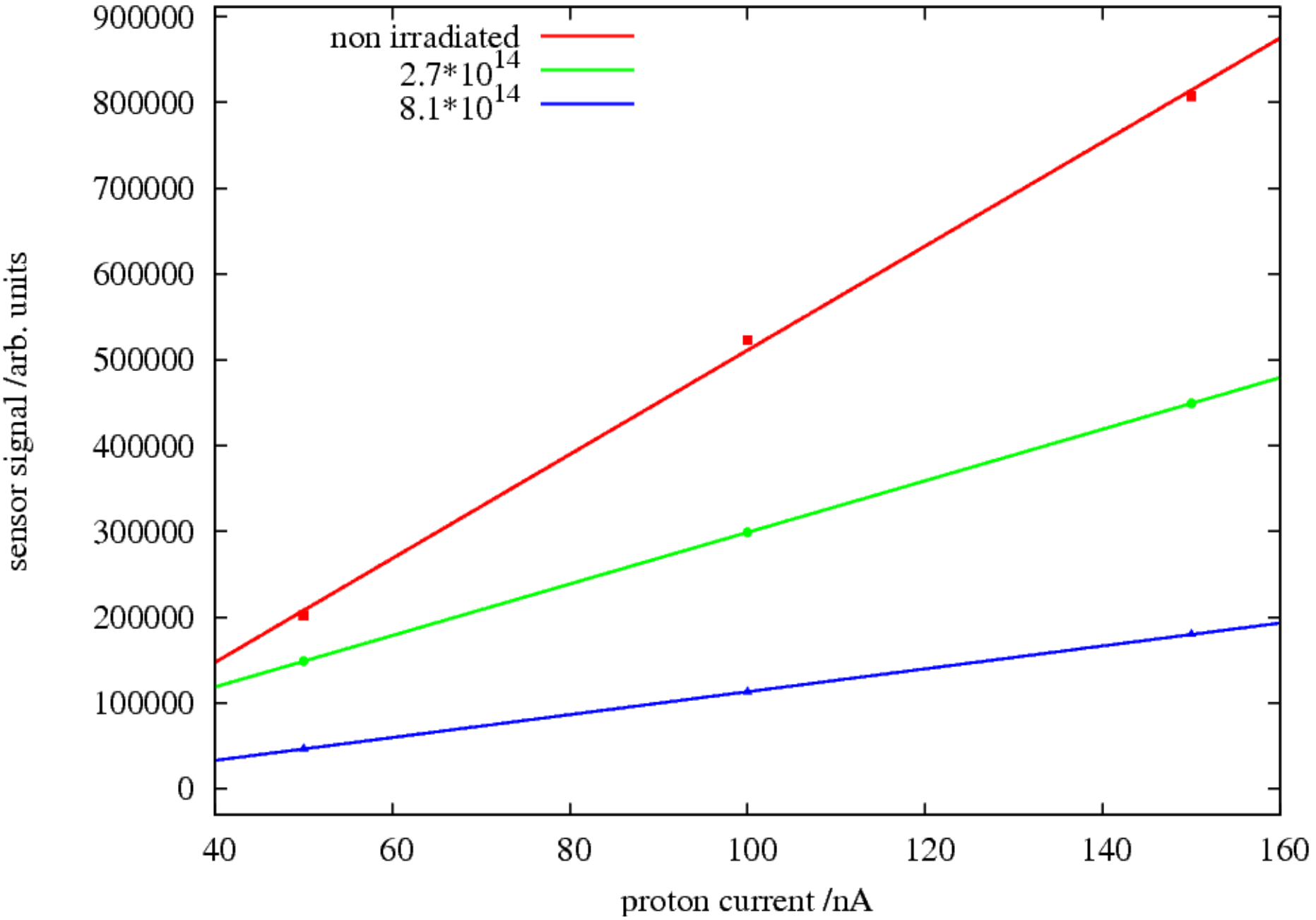
principle: measure sensor current as function of beam current after different fluences. Decrease in signal is decrease of CCD.



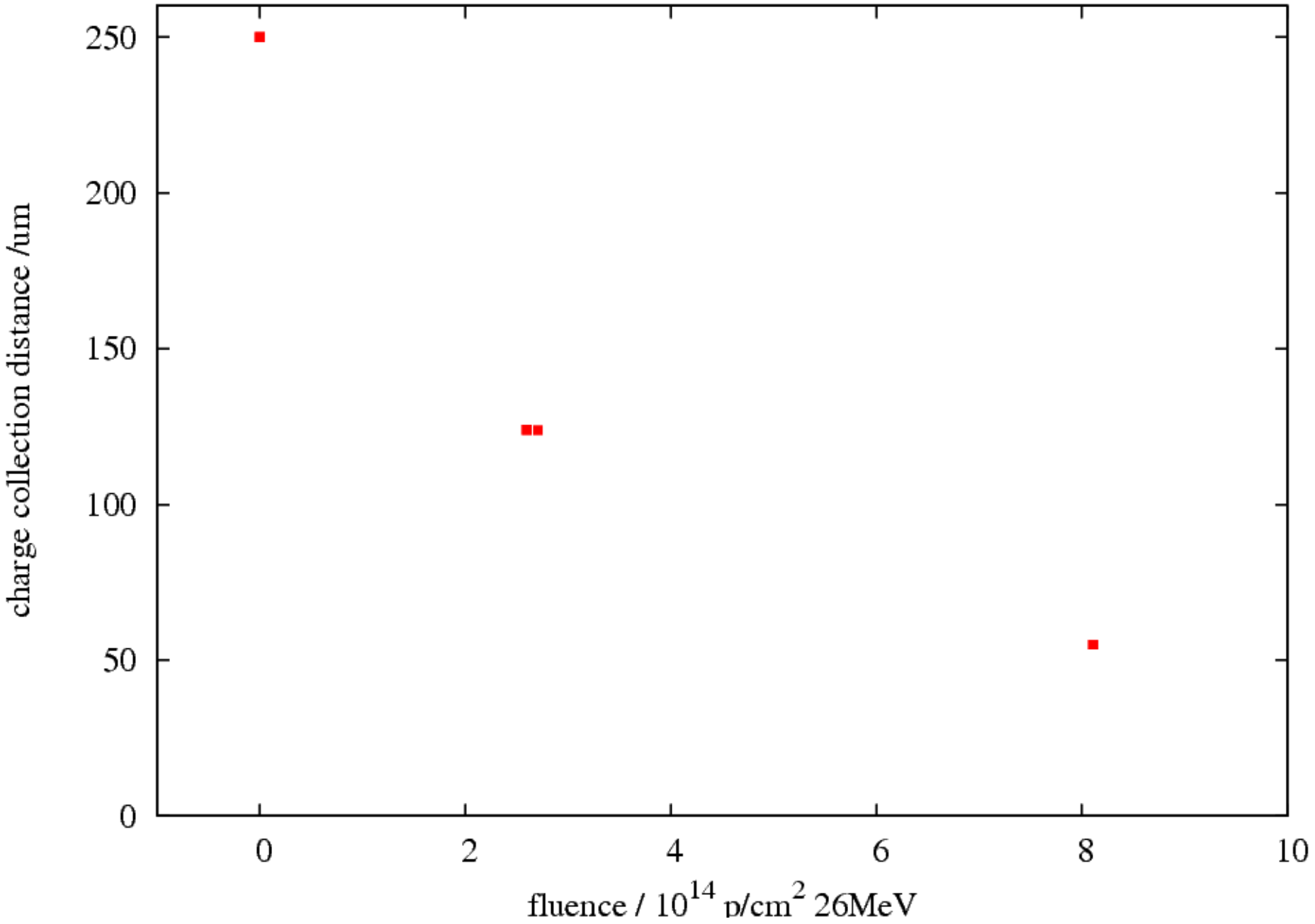


PCB died after this irradiation

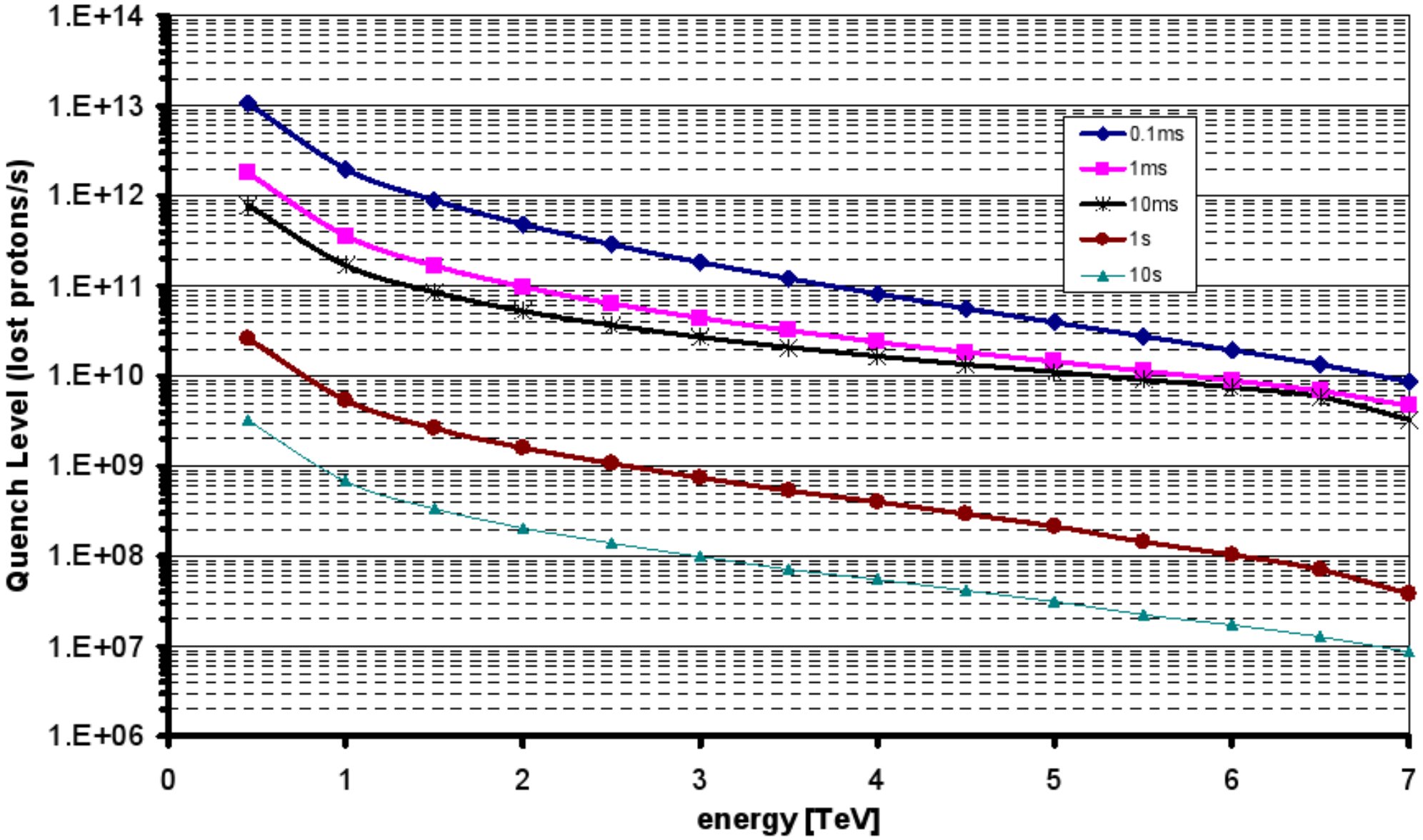
results of CCD measurements



CCD versus fluence



needed sensitivity – quench levels of superconducting magnets



summary

- LHC beam monitoring at CMS done with several systems, 3 of them are diamond based
- same radiation hard readout electronics with high dynamic range used as for the ionization chambers
- first tests with CMS BCM2 diamonds at Karlsruhe
- new, simple approach to measure relative decrease of CCD under irradiation
- degradation of CCD by factor of 4 after irradiation with $8*10^{14}$ 26MeVprotons /cm^2, which is sufficient for 10years LHC (expected fluence at BCM2 ca. 10^{15} Neq/cm^2 approx. $5*10^{14}$ 26MeV p/cm^2)
- to be compared with $2*10^{16}$ 24GeV protons (RD42 measurements)