

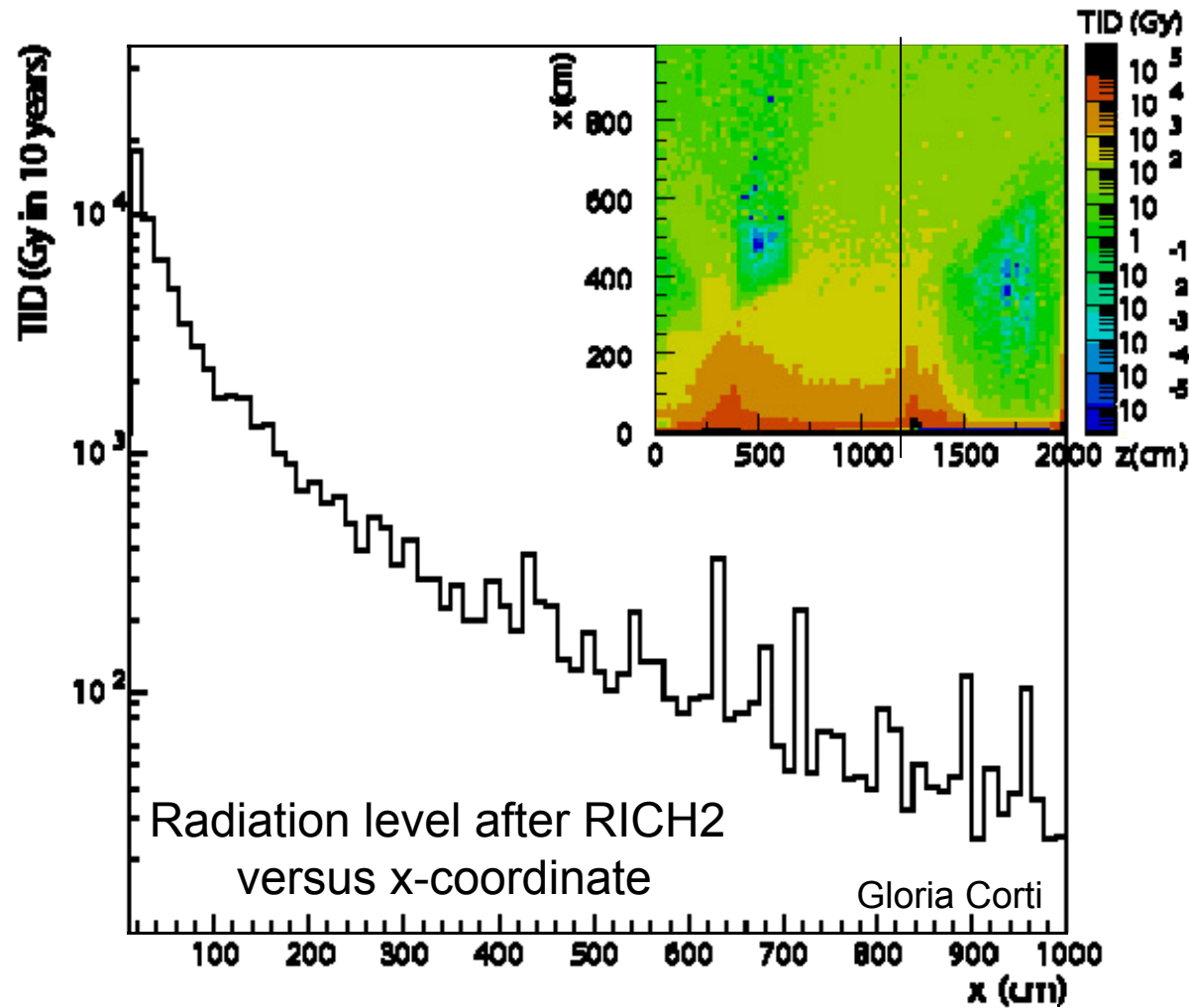


Radiation Monitors for LHCb

Goals

- Radiation levels up to $>10\text{kGy}$ predicted for 10 years of LHCb running
- Level of radiation has influence on detector and electronic performance
- Active radiation monitors give levels every second
 - Feedback during run possible -> background
 - Time correlation to electronics or detector performance possible
 - Calibrate simulated radiation levels

Radiation levels



Radiation level in
Bending plane over
5 years 2×10^{32}
+ 5 years 5×10^{32}
[1/(cm²s)]

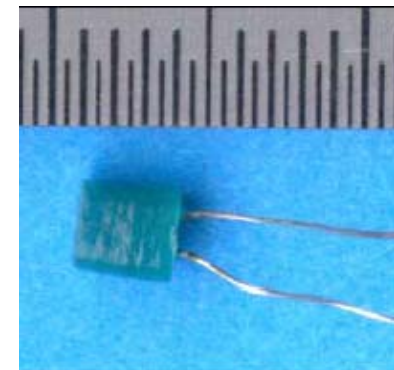
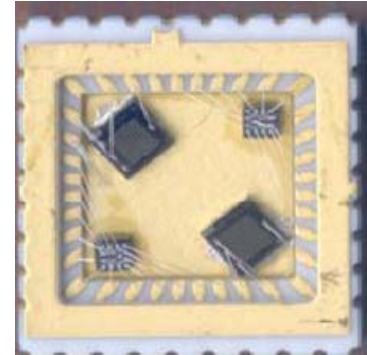
Radiation levels

- 10^3 to 10^4 Gy at silicon detectors
- 10^2 to 10^3 Gy at outer tracker and calorimeters
- 10 - >100 Gy at on detector electronics
- <10 Gy in bunker and balcony racks

Estimates for 10 years of running

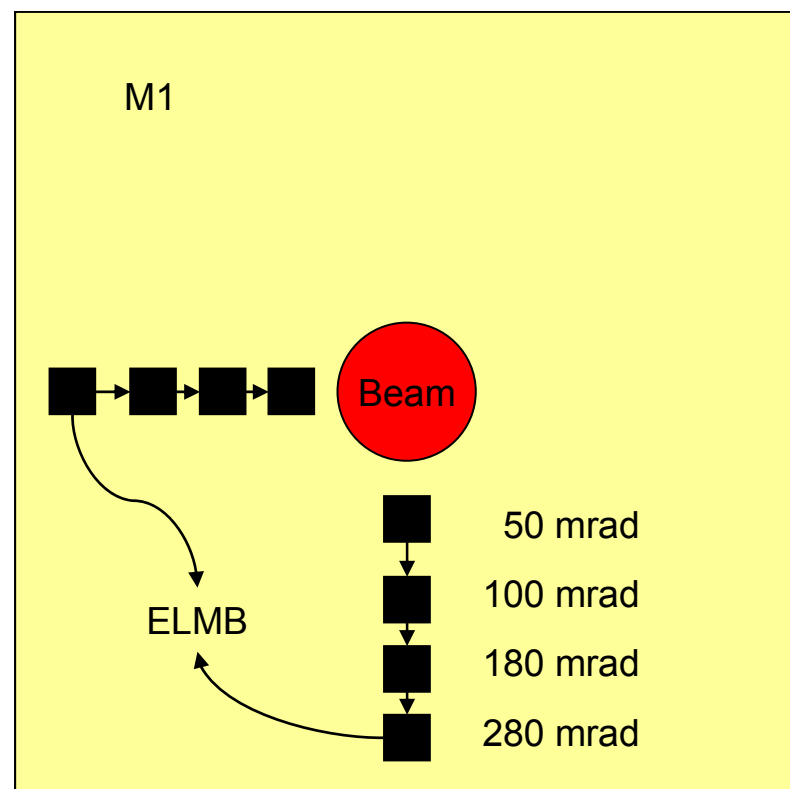
Active monitors

- Thin Oxide RadFET: 0.1 to 10 kGy
- Thick Oxide RadFET: 10^{-3} to 10 Gy
- High sensitive silicon diode 10^8 to 2×10^{12}
1MeV equ. Neutrons/cm²
- Particle detector diode 10^{11} to 5×10^{14}
1MeV equ. Neutrons/cm²
- Temperature sensor
- Chosen by RADMON group



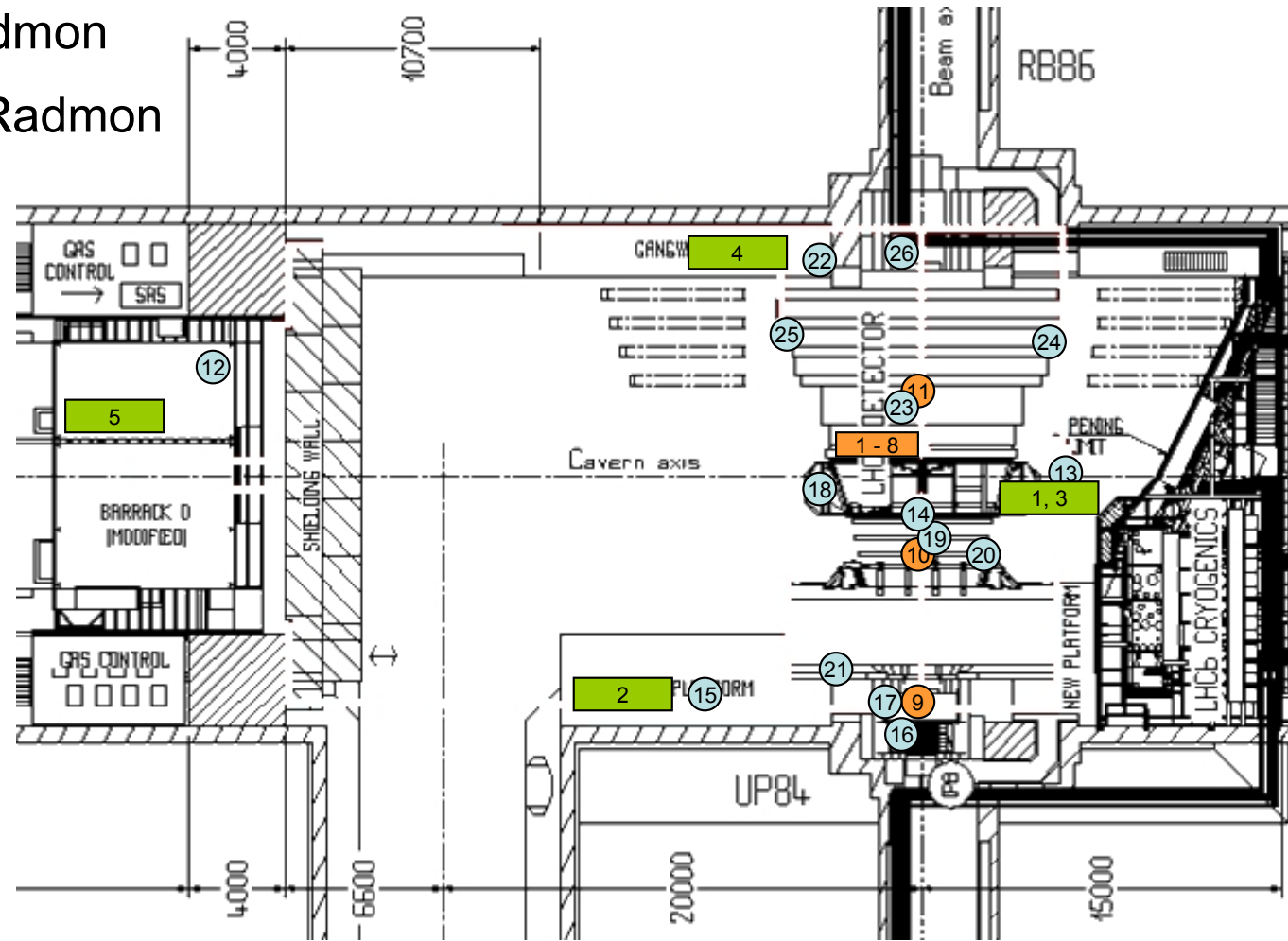
Position active monitors

- Detector acceptance
 - x-y cross section after RICH2 at 50/100/180/280 mrad
 - 3 additional sensors along z at 320 mrad
- Electronics
 - 12 sensors at major FE-electronic areas (boxes and racks)
- Reference in D3



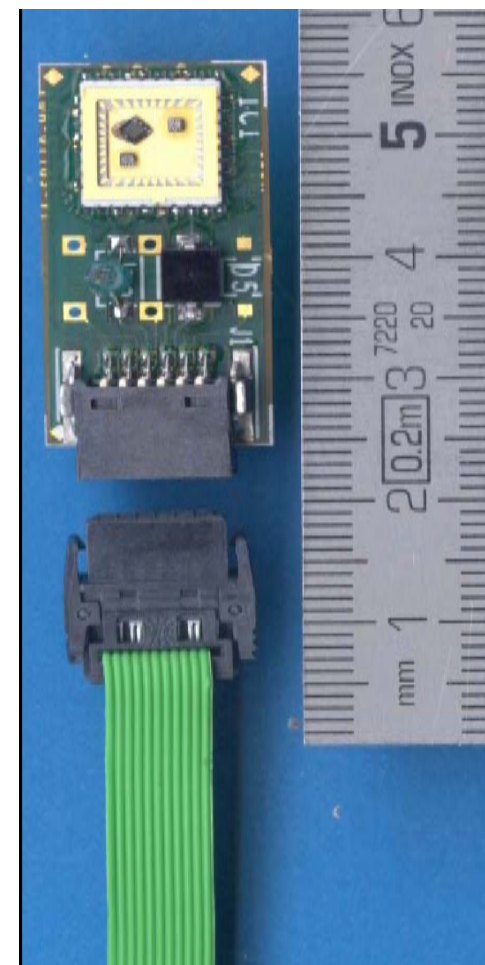
Position top view

- Detector Radmon
- Electronics Radmon
- ELMB



Package

- Small (few cm) package
- Low material budget
 - 250 μm PCB
- 4 sensors + PT100 + reference resistor
- Developed by RADMON group



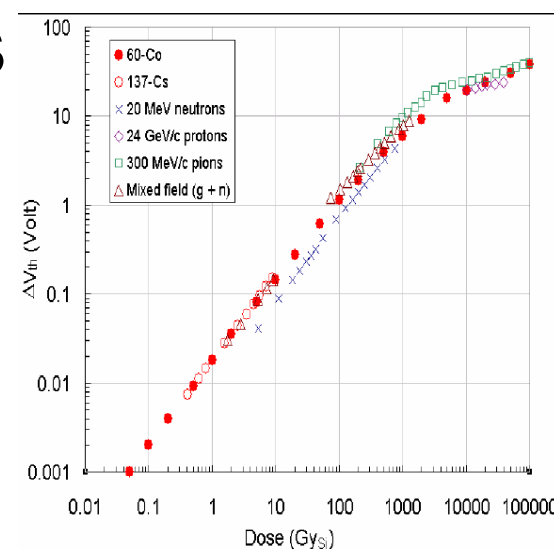
Measurement

- Threshold voltage for RadFETs
- Forward Voltage PIN-diode
- Leakage current detector diode
- Readout system developed by Ljubljana ATLAS group
 - ELMB has 64 ADC channels
 - ELMB DAC for I_{BIAS}



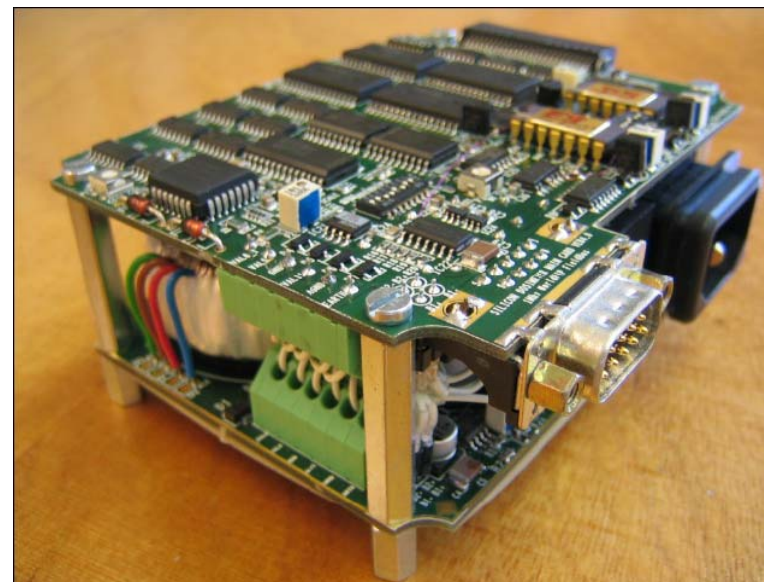
Data logging

- ELMB has CANbus interface
- CAN to USB
- PVSS control
- 1Hz rate for radiation values
- Data archive: Condition DB



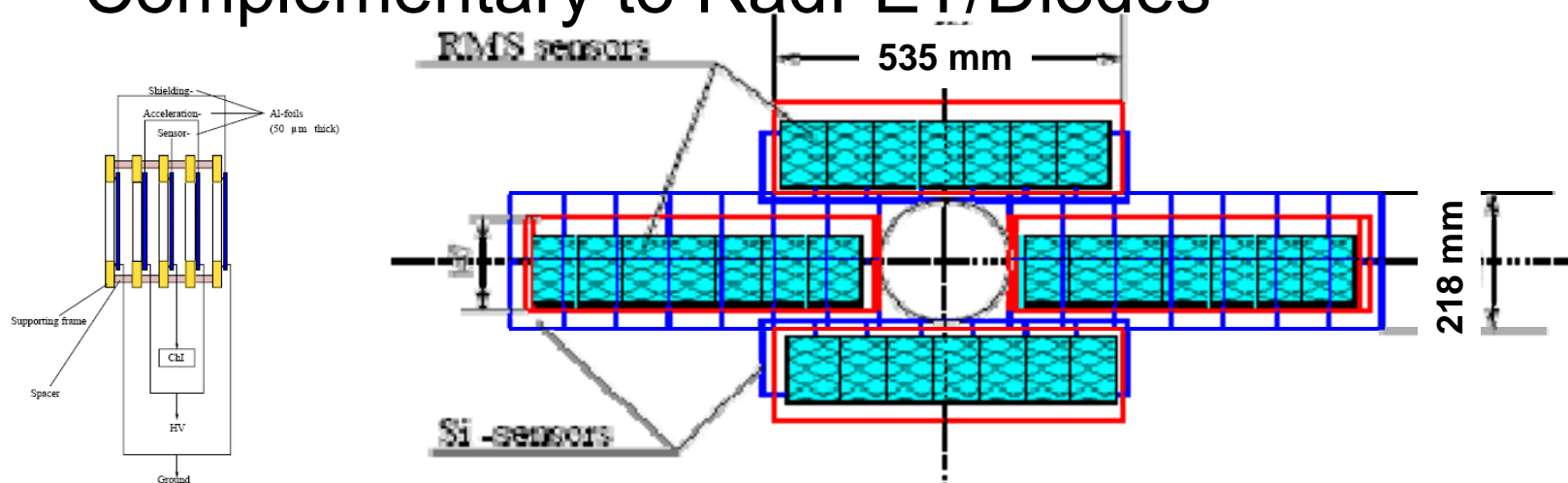
Radmon box TS/LEA

- LHC machine radiation monitor
- 10 installed at point 8 (Cryogenics)
- Allows x-check with RadFETs and diodes



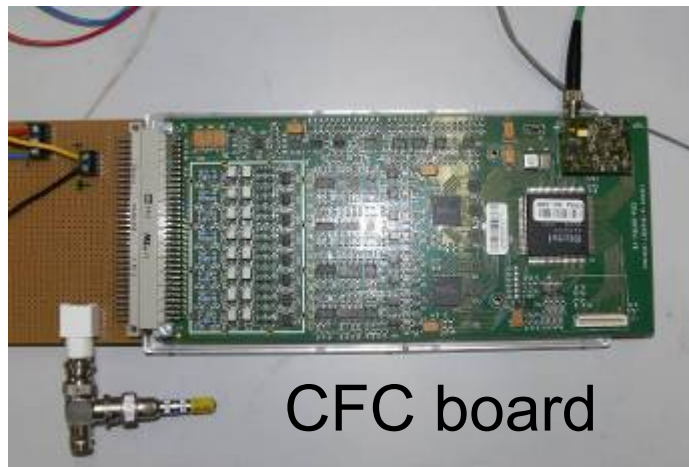
Metal foil detector

- Aluminum foil sensor for inner Tracker
 - Developed by the Kiew group
 - 28 cells covering 75 mm x 110 mm each
 - Complementary to RadFET/Diodes



Beam condition monitor

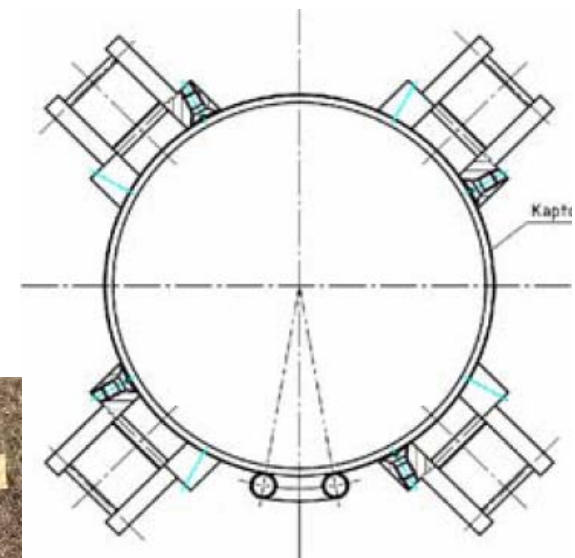
- Diamond sensors very close to the beam
- 3 stations with 8 sensors each
- Optical data transmission
- TELL1 DAQ board used



CFC board

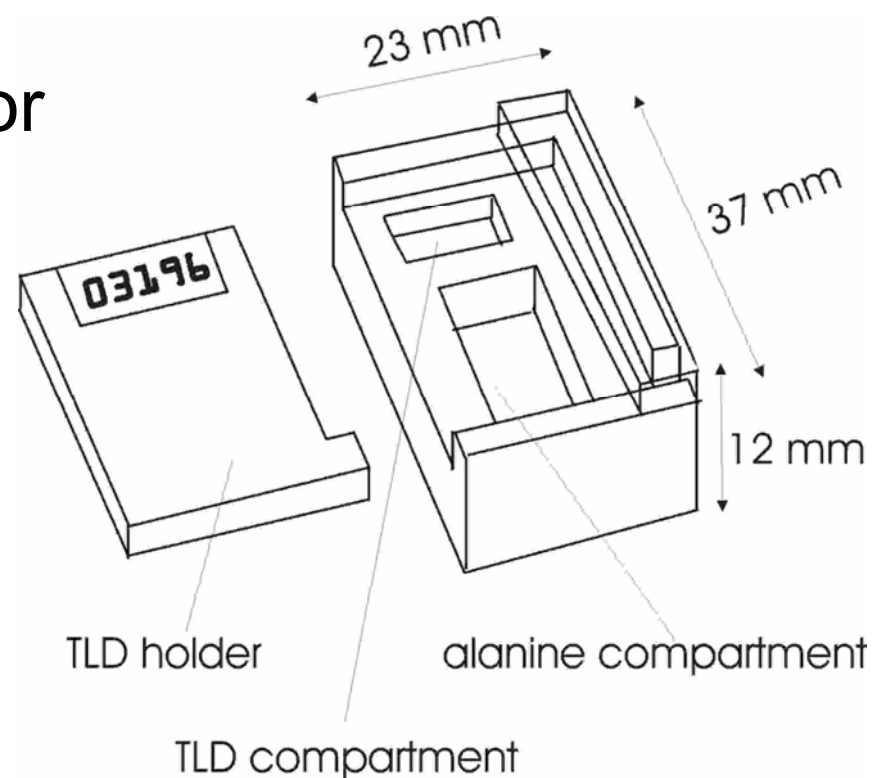


CVD diamond







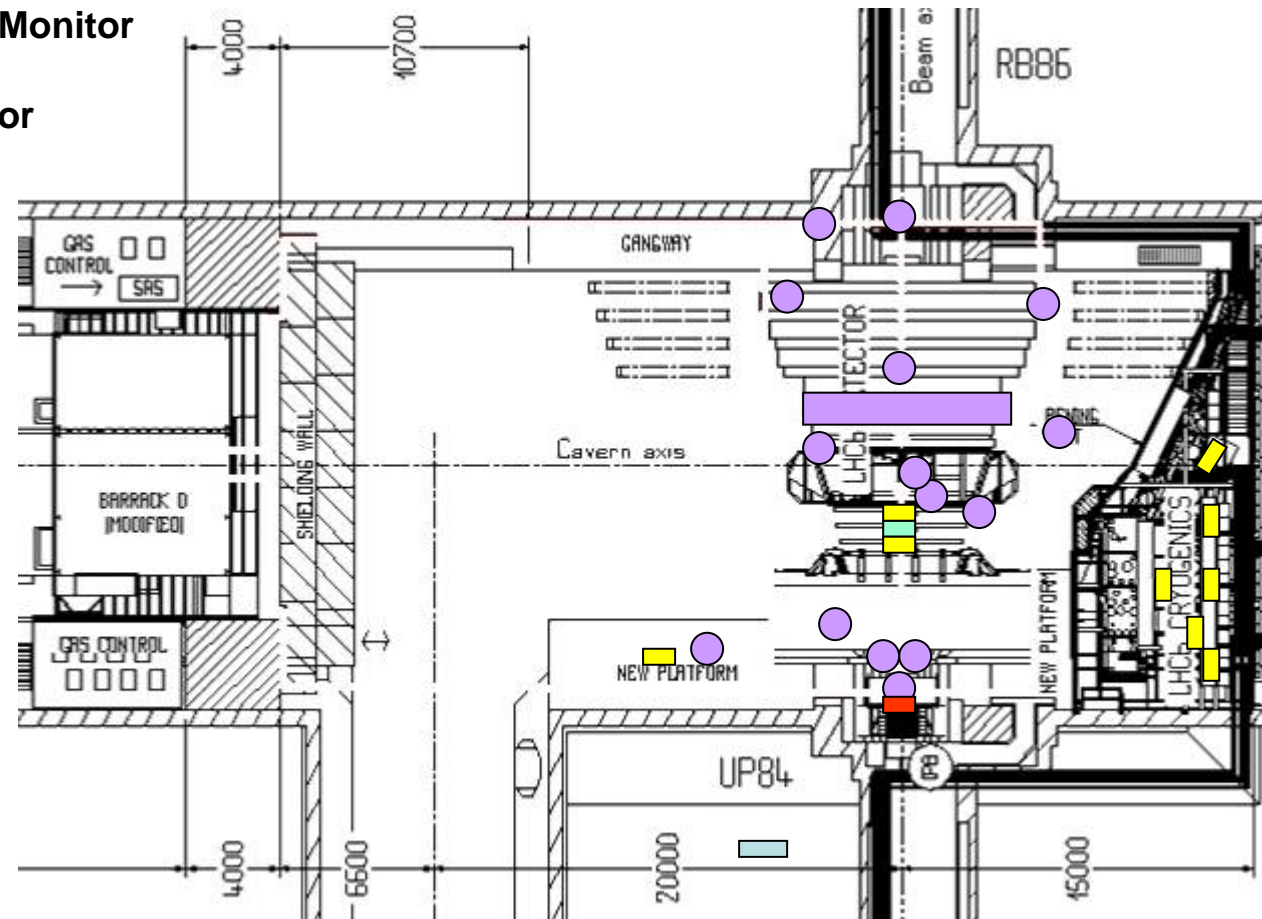
Passive sensors

- Installation at active monitor positions for x-check
- Additional 20 sensors per calorimeter:
SPD/PS, ECAL, HCAL
- See talk of Ch. Ilgner



Positions

-  Beam Condition Monitor
-  Metal Foil Detector
-  TS/LEA boxes
-  Passive Radmon

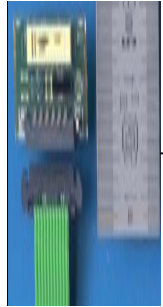


Radiation background signal

- Radiation background at detector for LHC
- Combination of BCM, TS/LEA RADMON, Al-foil and active monitors
- Technical implementation to be seen

Next steps

- Lab setup with sensors, ELMB (DAC)
- Produce electronics for all 26 sensors
- Order 32 sets of sensors from RADMON group / M. Glaser



Summary



- Radiation map with RadFETs and diodes at 26 positions, ATLAS readout
- Passive monitor radiation map
- Dedicated radiation monitoring for
 - Inner tracker – metal foil detector
 - Beam condition – diamond sensors
 - Cryogenics at point 8 – TS/LEA box





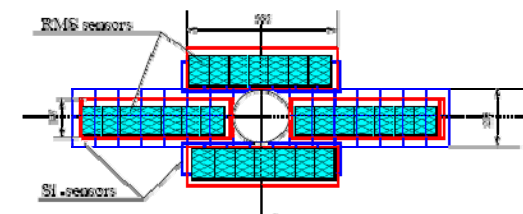
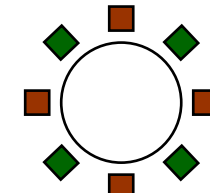
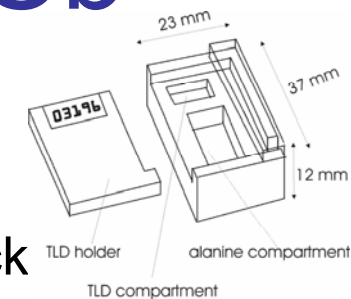
Backup

Sensor details

- Sensitive P-I-N CMRP 10^8 – 2×10^{12} cm⁻²
- High rate P-I-N BPW 34 $2 \cdot 10^{12}$ – $4 \cdot 10^{14}$ cm⁻²
- RadFET thick Oxide CNRS 10^{-3} –10 Gy
- RadFET thin Oxide REM Oxford 0.1–10kGy
- PT100
- 10KOhm reference resistor

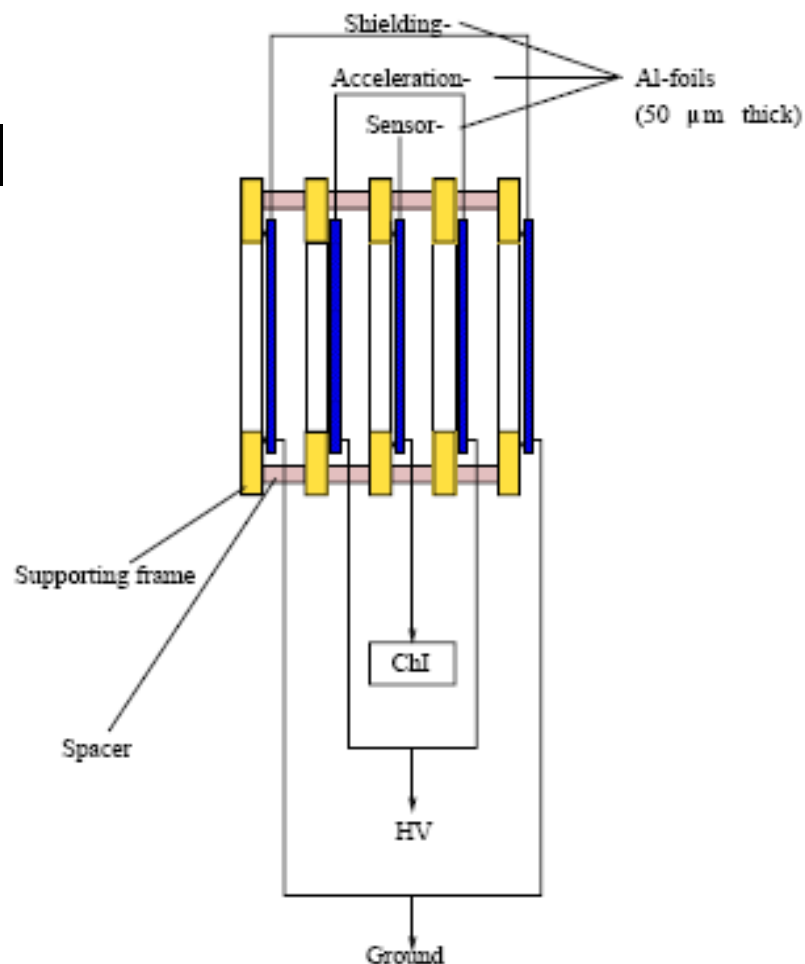
Further sensors at LHCb

- Passive Dosimeters
 - Installation at same +additional positions for x-check
 - See talk of Ch. Ilgner
- Beam Condition Monitor
 - Diamond sensors very close to the beam
- RADMON box (TS/LEA)
 - LHC machine radiation monitor
 - 10 installed at point 8 (Cryogenics)
- Aluminum foil sensor for inner Tracker,
 - Developed by the Kiew group
 - Complementary, covers IT detector



Metal foil detector

- 5 layers of Al foil
 - 2 shield
 - 2 acceleration
 - 1 sensor



Metal foil principle

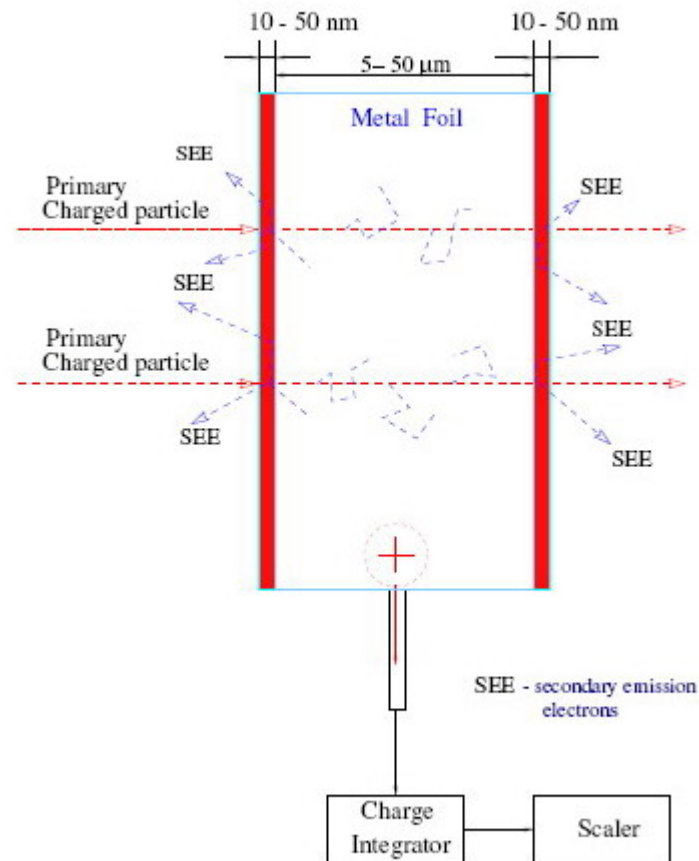


Figure 1: *Metal Foil Detector operation principle.*

Metal foil signal flow

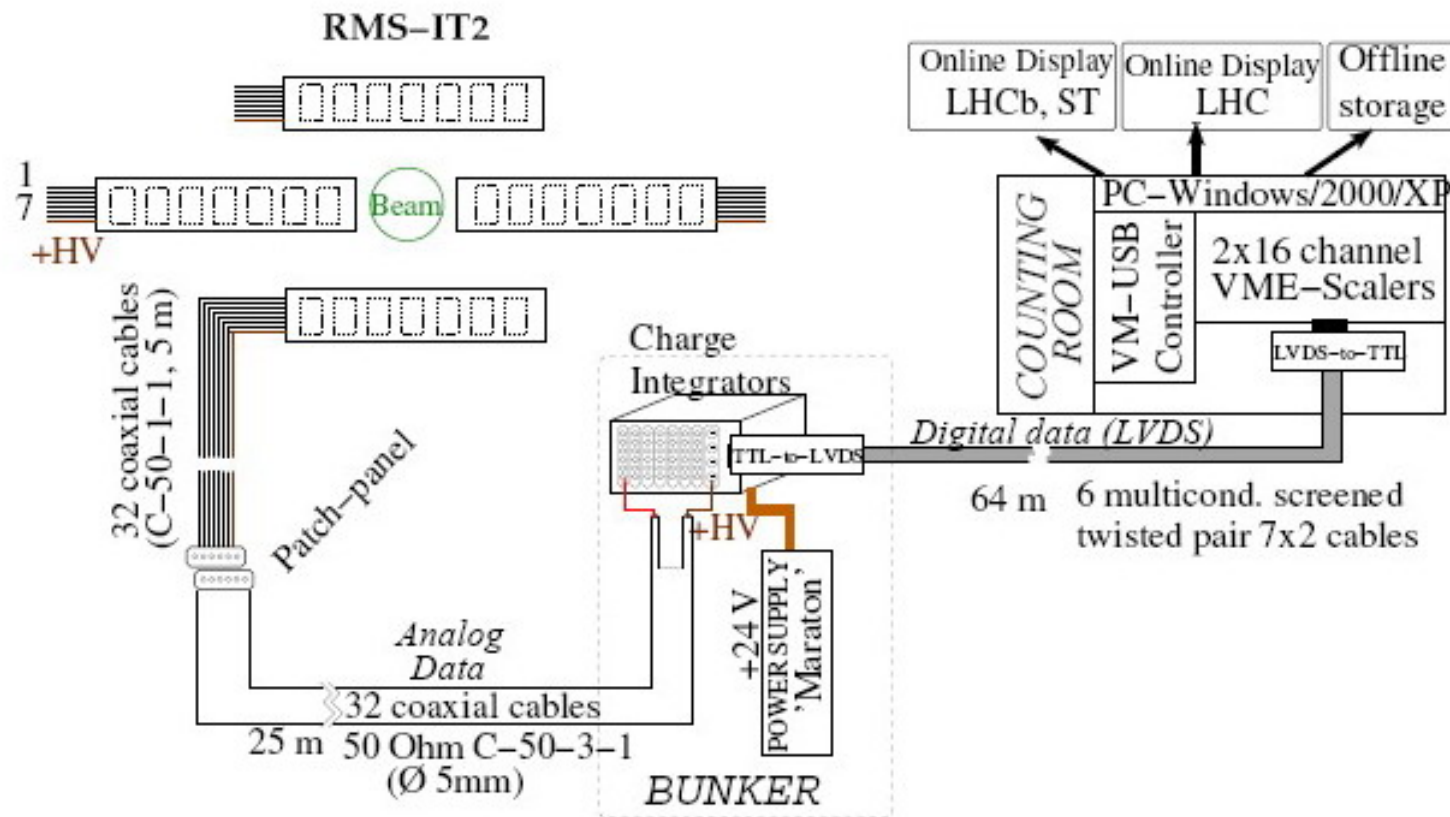


Figure 7: Schematic view of the RMS readout.

Metal foil sensor

