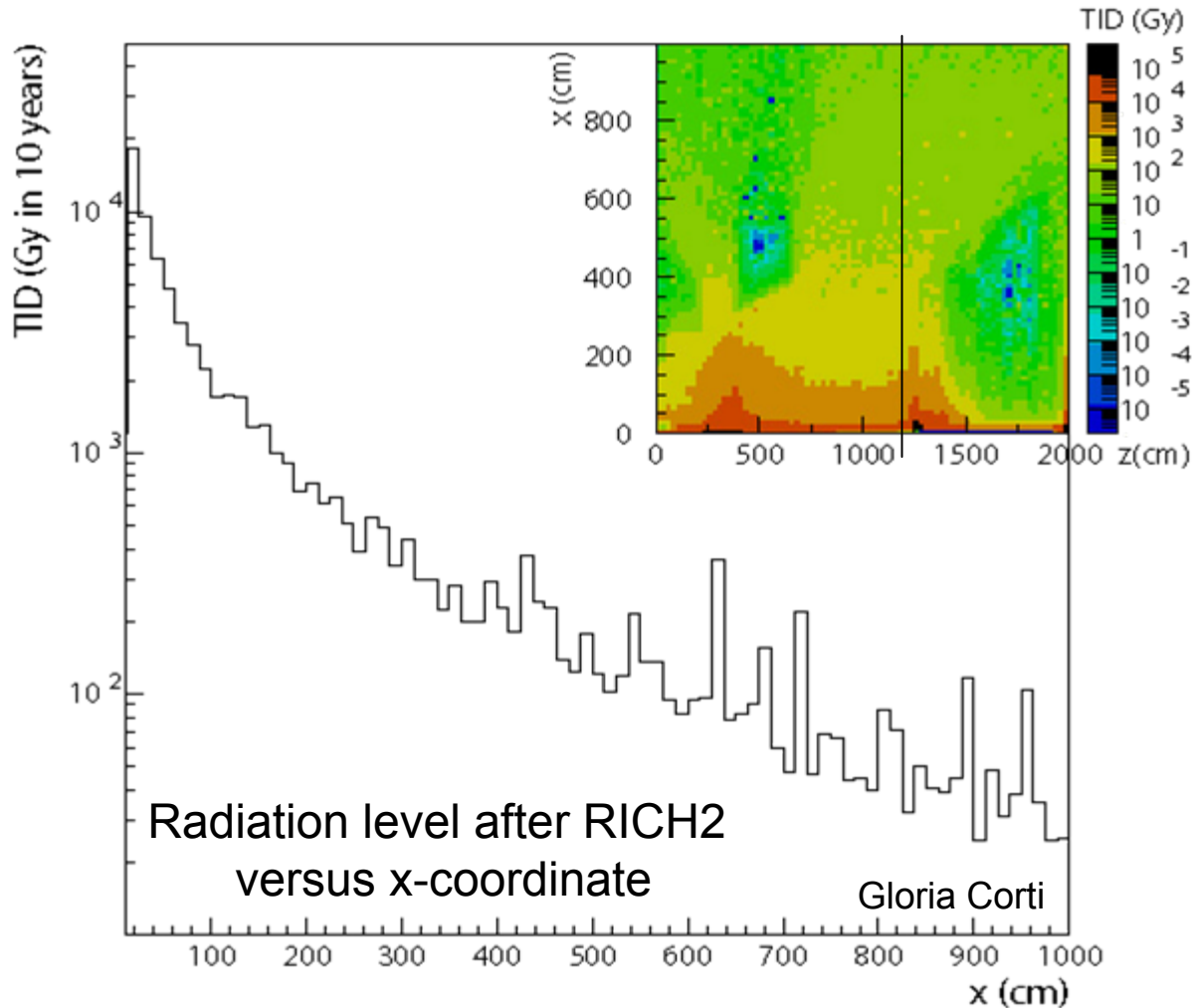


# Radiation Monitors for LHCb

# 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  $\rightarrow$  background
  - Time correlation to electronics or detector performance possible
  - Calibrate simulated radiation levels

# Radiation levels



Radiation level in  
Bending plane over  
5 years  $2 \times 10^{32}$   
+ 5 years  $5 \times 10^{32}$   
[ $1/(\text{cm}^2\text{s})$ ]

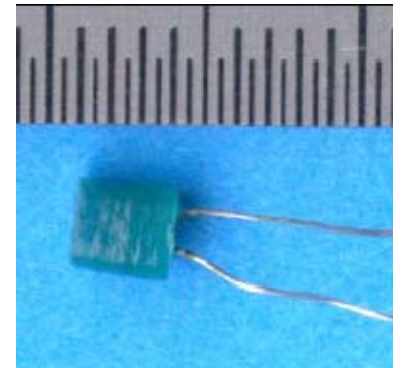
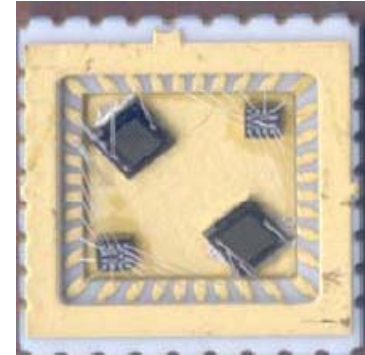
# Radiation levels

- $10^3$  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

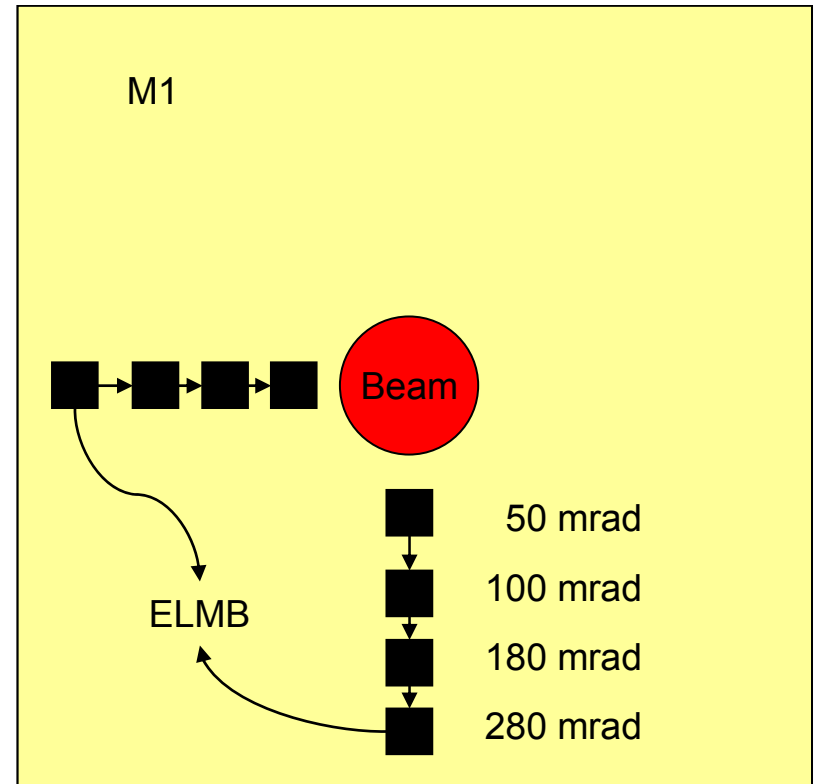
# Active monitors

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



# Position active monitors

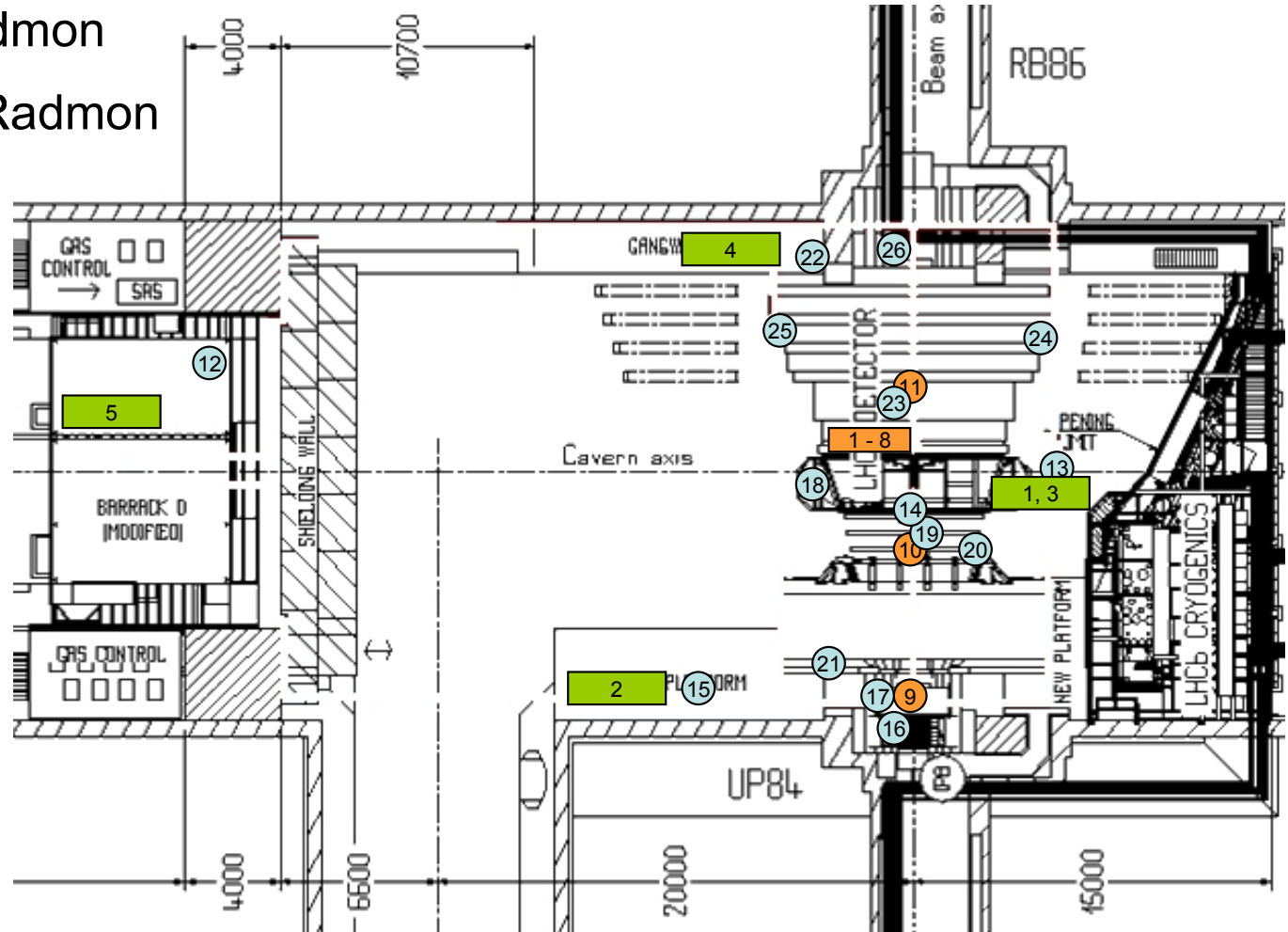
- Detector acceptance
  - x-y cross section after RICH2 at 50/100/180/280 mrad
  - 3 additional sensors along z at 320 mrad
- Electronics
  - 12 sensors at major FE-electronic areas (boxes and racks)
- Reference in D3



# Position top view

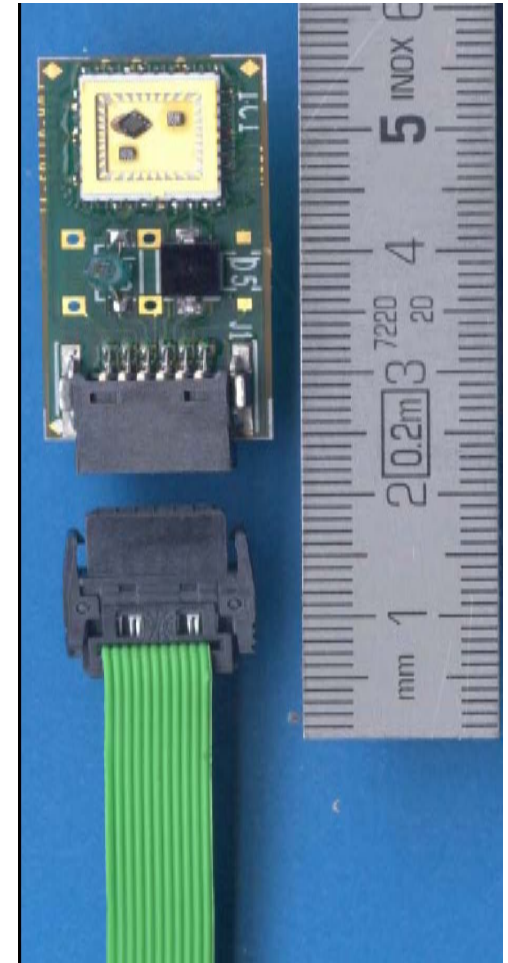
- Detector Radmon
- Electronics Radmon

■ ELMB



# Package

- Small (few cm) package
- Low material budget
  - 250  $\mu\text{m}$  PCB
- 4 sensors + PT100 + reference resistor
- Developed by RADMON group





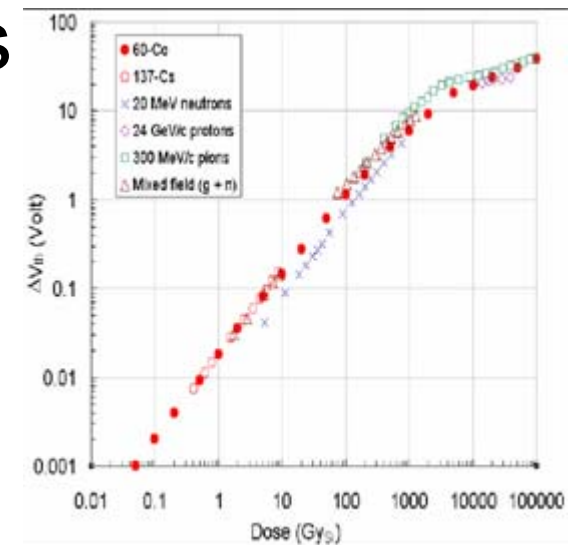
# Measurement

- 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  $I_{BIAS}$



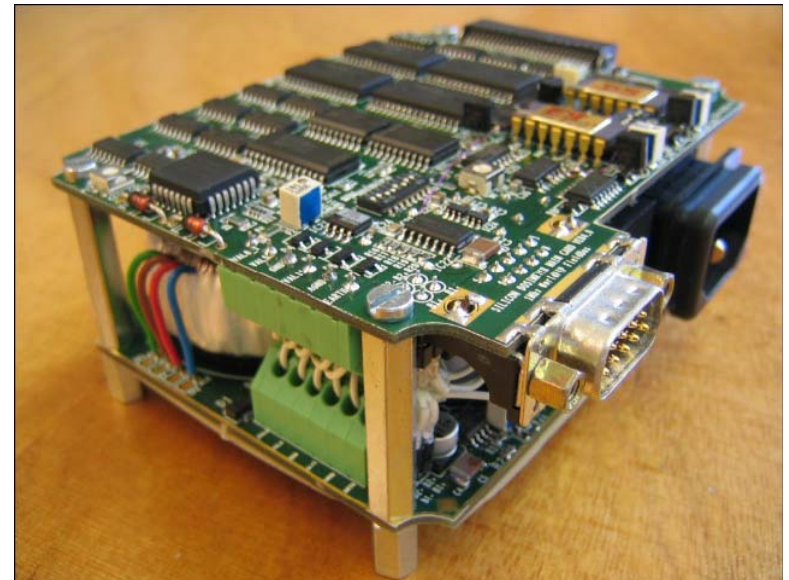
# Data logging

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



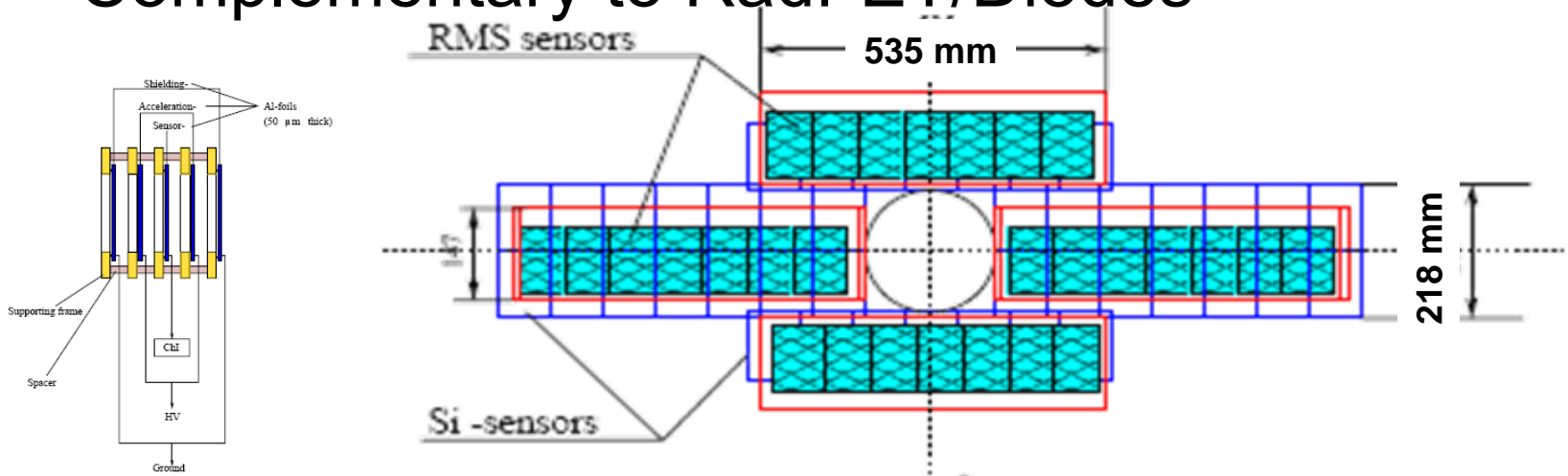
# Radmon box TS/LEA

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



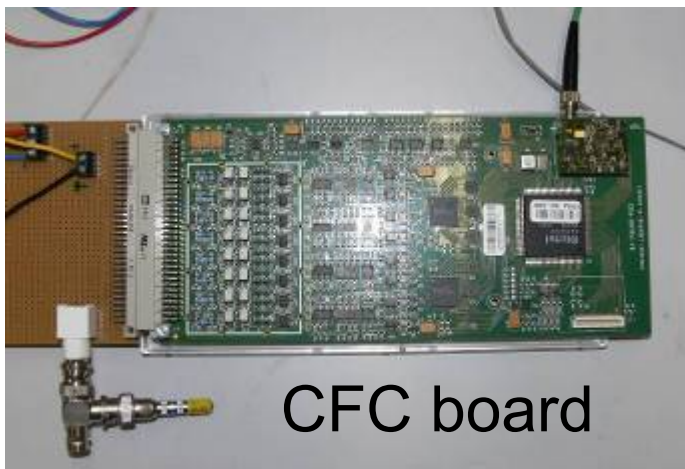
# Metal foil detector

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

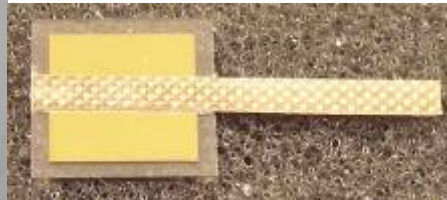


# Beam condition monitor

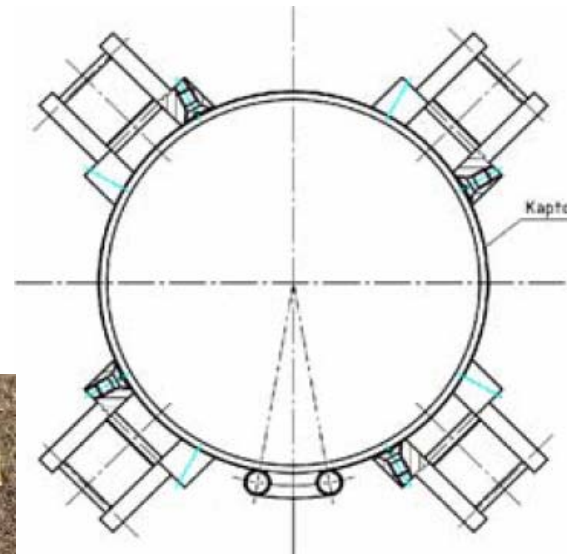
- Diamond sensors very close to the beam
- 3 stations with 8 sensors each
- Optical data transmission
- TELL1 DAQ board used



CFC board

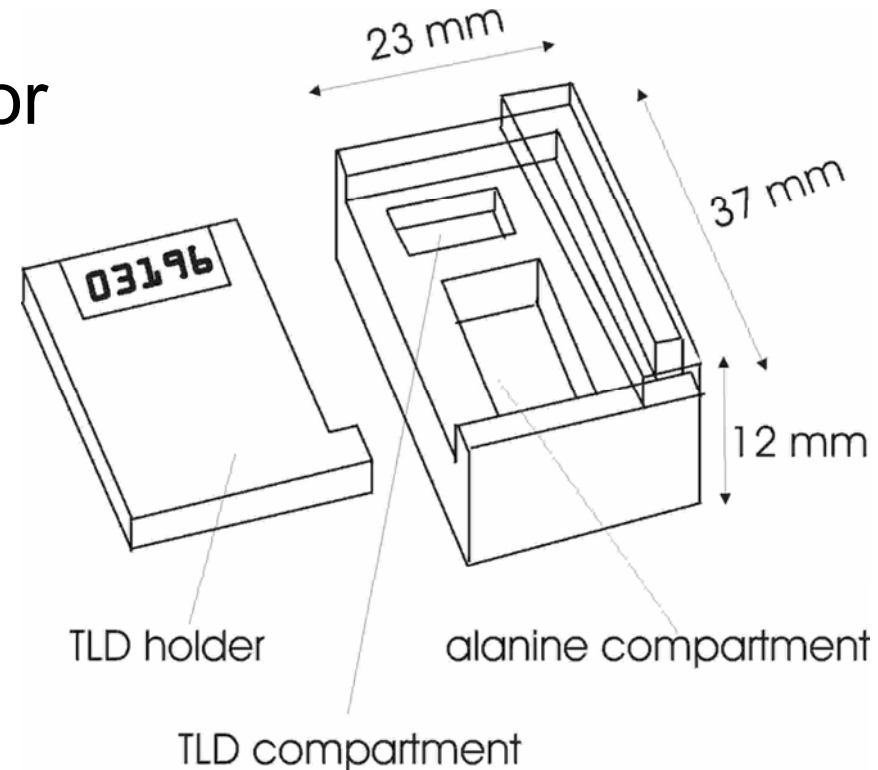


CVD diamond

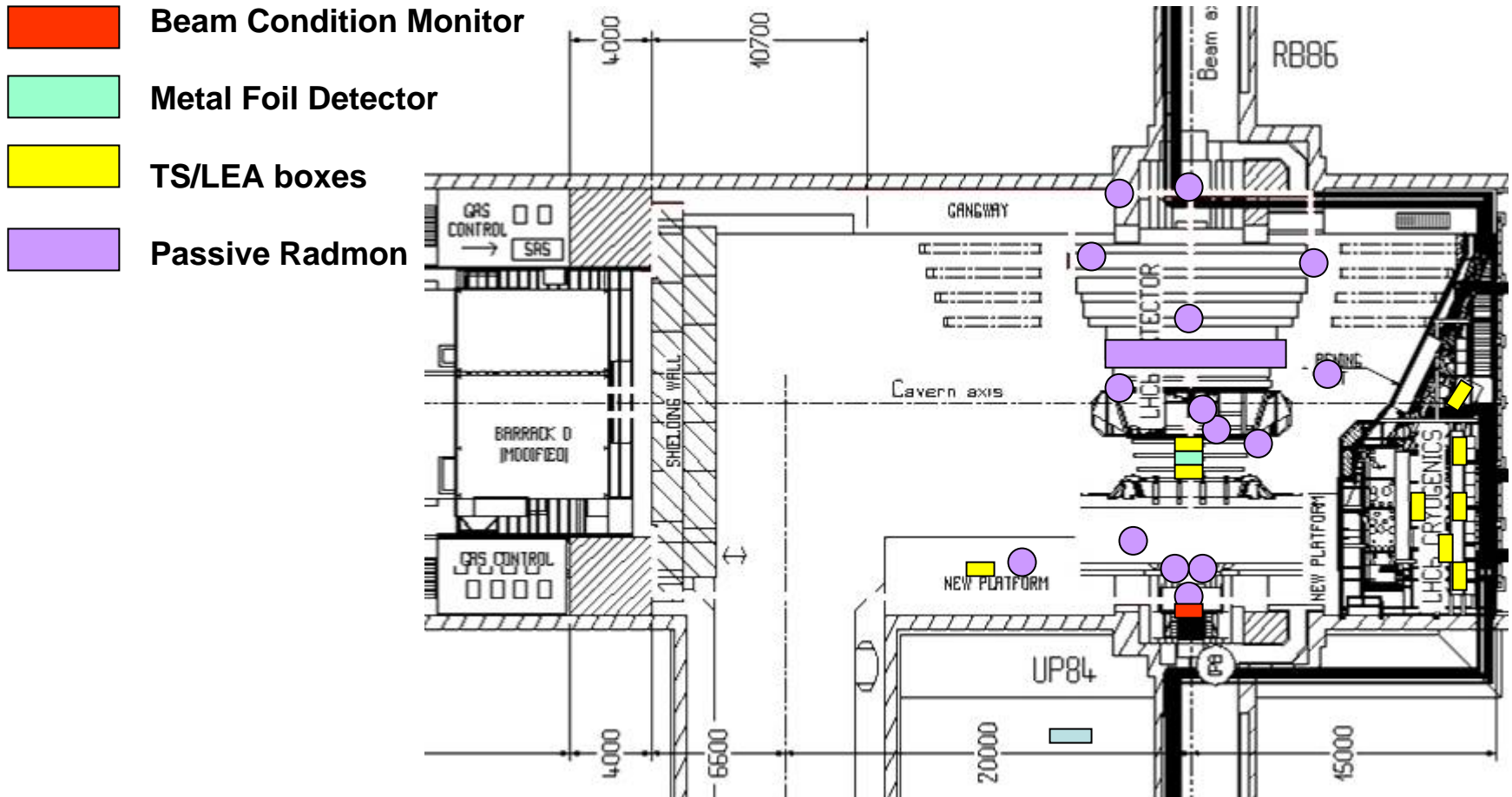


# Passive sensors

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



# Positions



# Radiation background signal

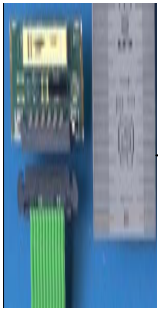
- Radiation background at detector for LHC
- Combination of BCM, TS/LEA RADMON, Al-foil and active monitors
- Technical implementation to be seen



# 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



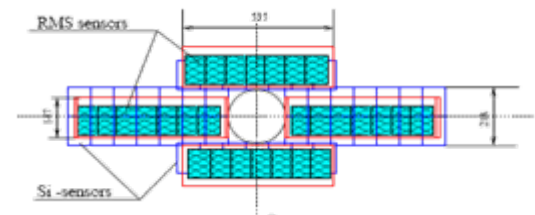
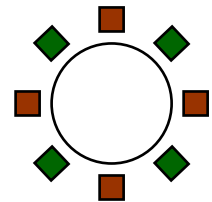
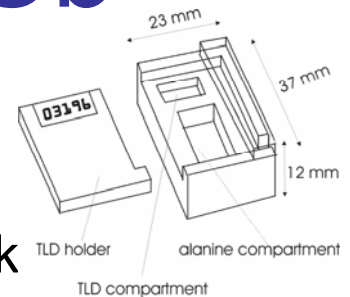
# Backup

# Sensor details

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

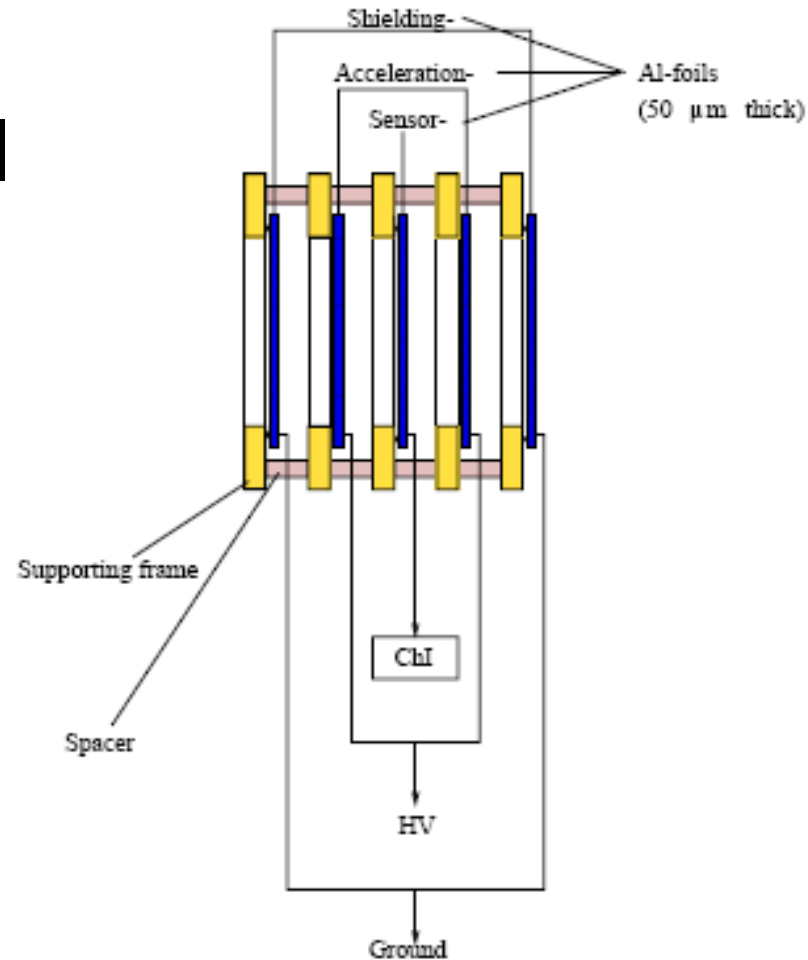
# Further sensors at LHCb

- 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

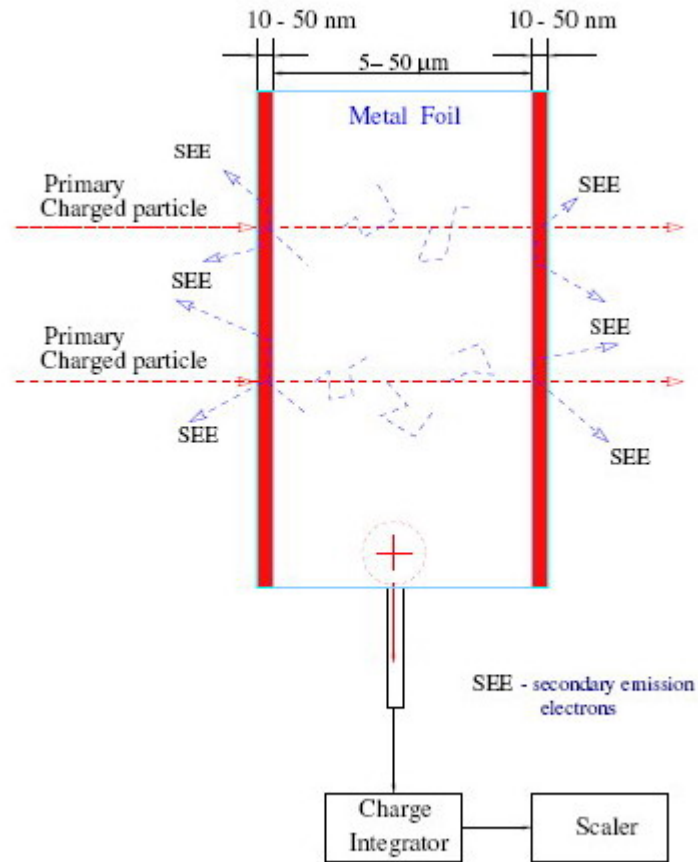


Figure 1: *Metal Foil Detector operation principle.*

# Metal foil signal flow

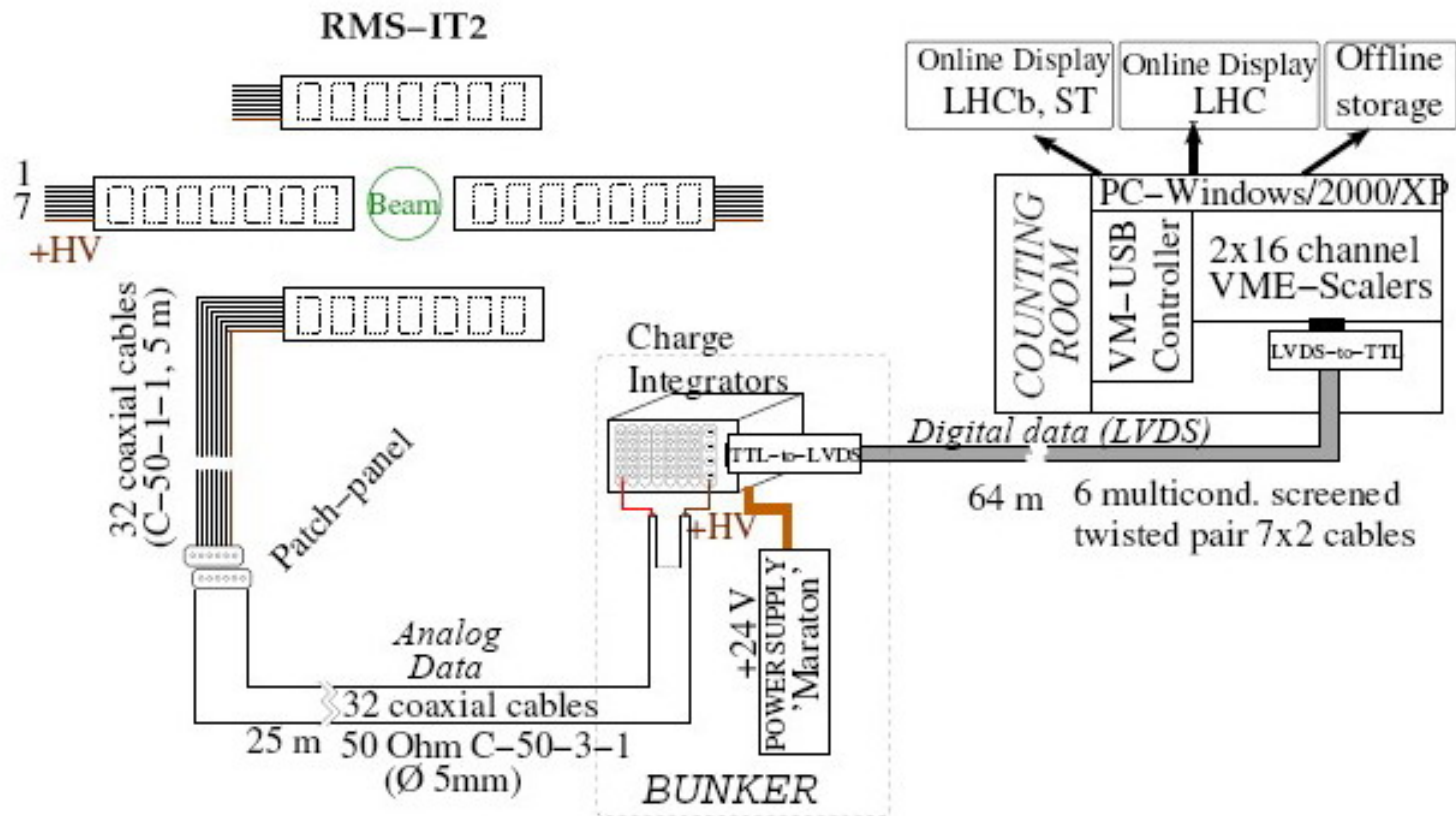


Figure 7: Schematic view of the RMS readout.



# Metal foil sensor

