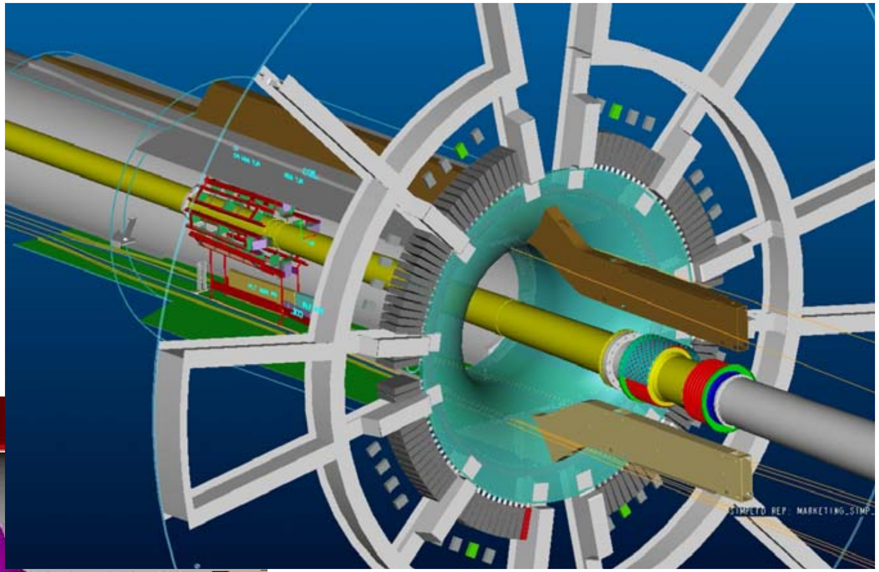
Radiation Monitoring at CMS

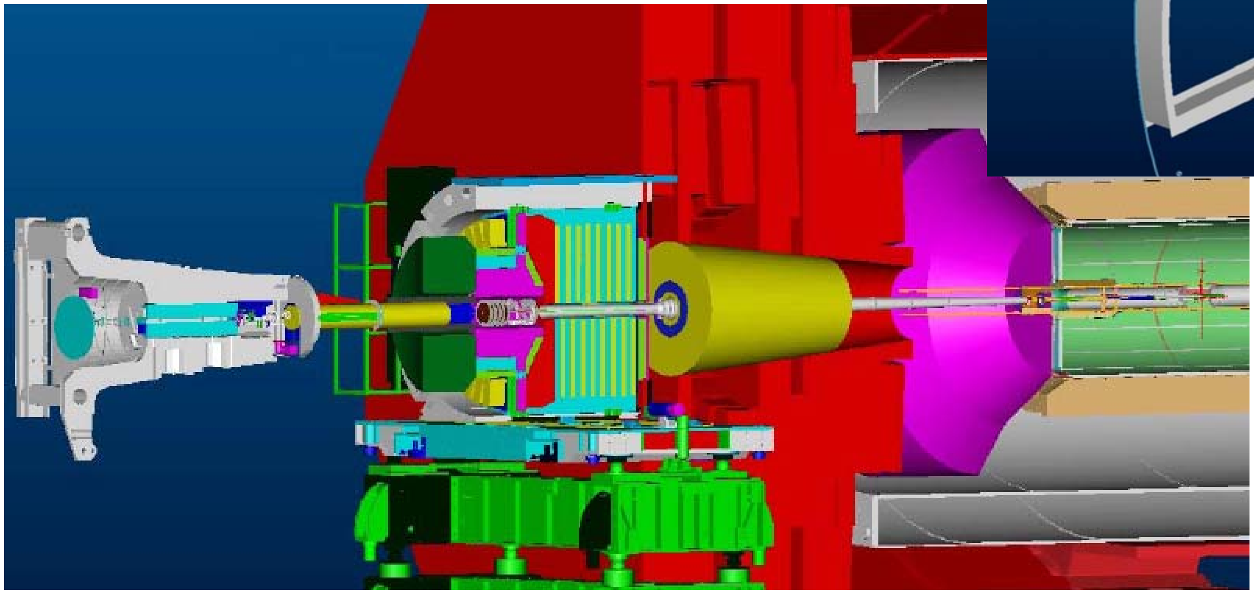
Alick Macpherson

- Fast beam monitoring
  - BCM1
  - BCM 2
- Online Run by Run monitoring in CMS
  - DOH responsivity
  - Radiation damage in fibres
- Online monitoring Around CMS
  - RADMON+RAMSES
- Backup Monitoring
  - Passive dosimeters
- Monitoring specific to Commissioning
  - Beam Scintillator Counters

Fast Monitoring: BCM

- Synthetic diamond sensors place close to the beam pipe
- System to be installed ~ April 2007
- BCM 1: z= ±1.9m r = 4.3cm
  - As close as possible to the IP
- BCM 2: z= ±14.35m r= 30cm
  - Shielded from the IP by the HF
  - Provides direction of beam halo

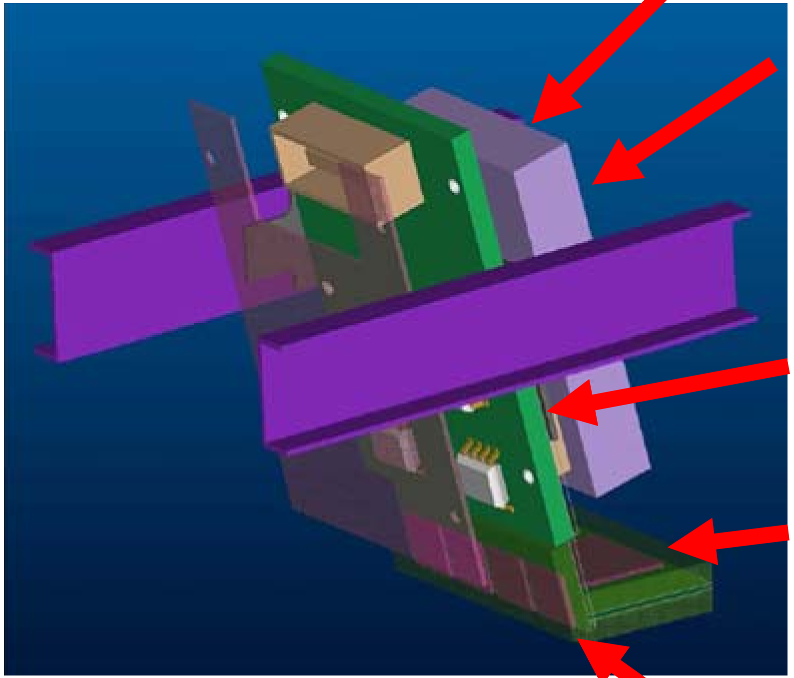




Diamond signals on
bunch by bunch basis

Generates alarm/abort based
On summed average over
up to 108 bunch crossings

The BCM1



CMS Opto hybrid converts single crystal signal to optical signal, passes it to USC

Photo diode of OH: On run by run basis monitor responsivity of photo diode. Will Decrease with irradiation. Minimal annealing

Silicon pin diode: mounted on board for cross check of run by run radiation damage
Not readout during data taking

Poly crystalline diamond sensor: Simple monitoring of leakage current. No front end electronics

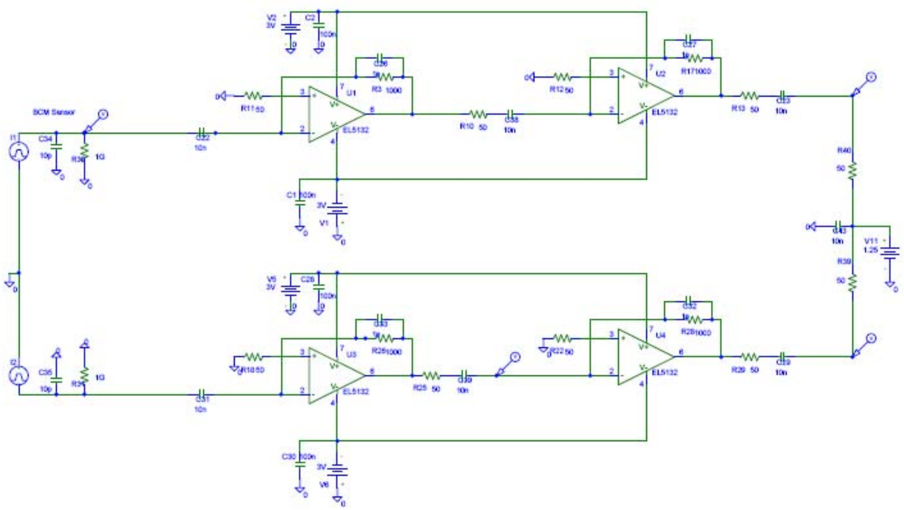
Single crystal sensors: fast readout into frontend amplifier chain

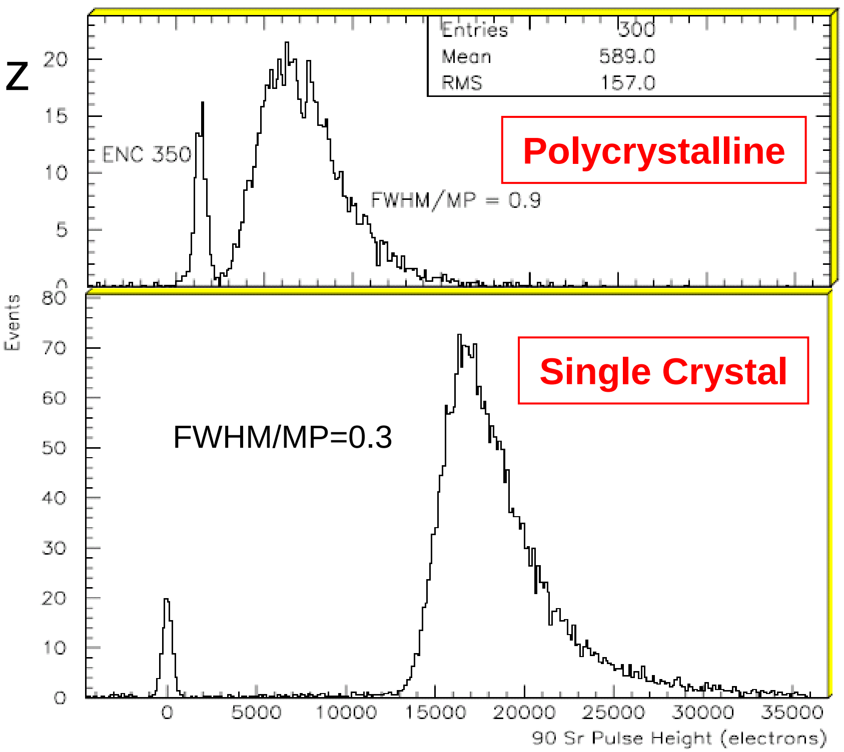
Size of unit: 28 x45x20 mm

BCM1 Front end

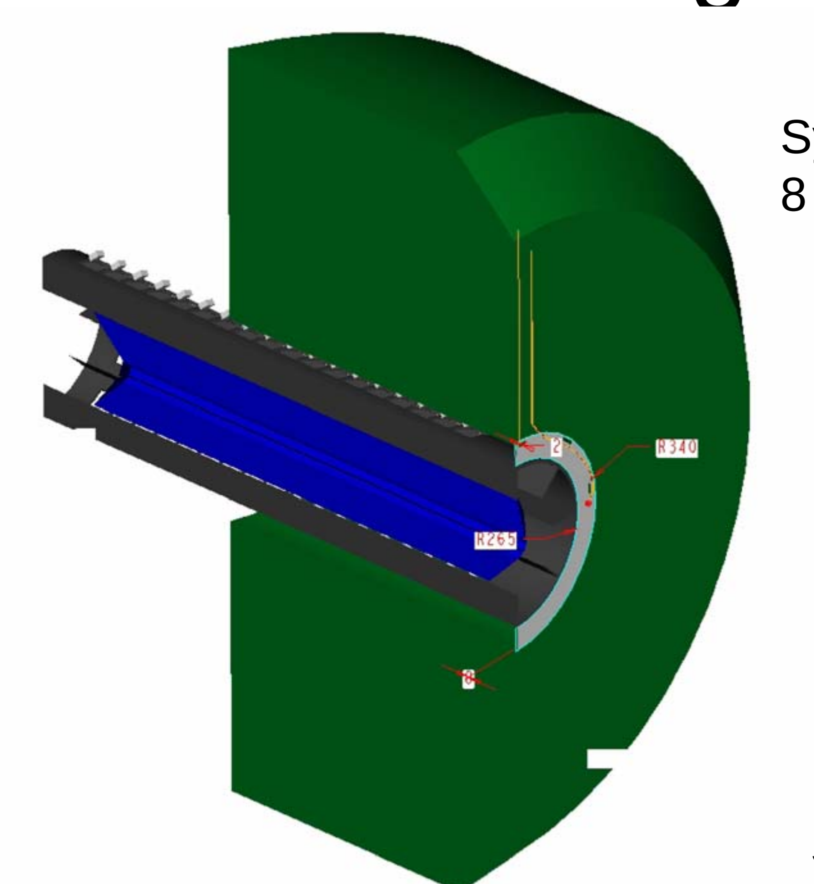
- Move sensor baseline to single crystal=> factor 3 in signal

  ~1800 electrons/MIP => MIP signal ~1uA into transimpedance amp.
- 2 stage amplification => MIP signal ~10mV.
- OH has 0 to 50 MIP sensitivity.
- Band width of frontend chain 250 MHz
- Need to ensure that it is rad hard.





Radiation Monitoring in the HF Collar Region (BCM2 + fibres)

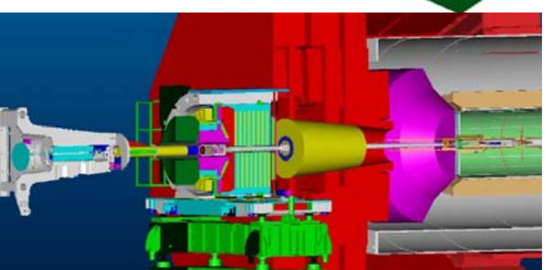


Synthetic Diamond sensors placed behind the HF
8 locations in phi. No front end electronics

2 Rad hard optical fibres layed in "C"s at inner edge of HF (but mounted on the HF collar)

- Measure attenuation of known light signal. Measurement between fills
- Measure of Cherenkov light produced a half ring of fibre. Taken during running. Time resolution <100ns => ideal for abort gap monitoring.

Standard package of passive sensors also placed at this location: Alanine, RPL, TLD.



Online Radiation Monitoring

Photo diode on OH: Track responsivity as a function of fluence

- Responsivity detemined by level of attenuation needed to cause non-reception of signal. Alernatively, measure DOH leakage current
- Measurement taken outside data taking
- Limited annealing in photo diode
- Use OH reset detection mechanism for "binary" responsivity measurement
- Once calibrated, dose measurement can be applied to any DOH in CMS system
- Key issue: calibration of photo diode in mixed field environment
  - Use silicon pin diode in same location: cross check calibration

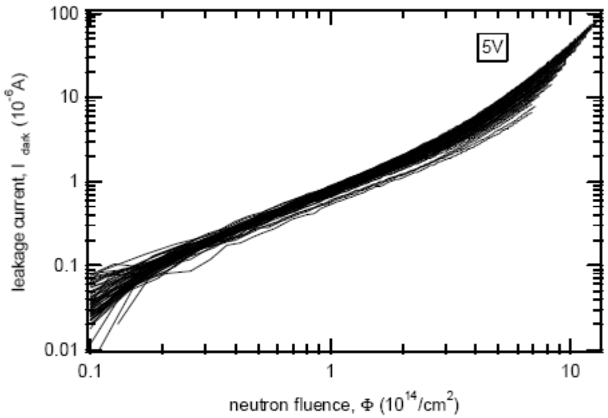


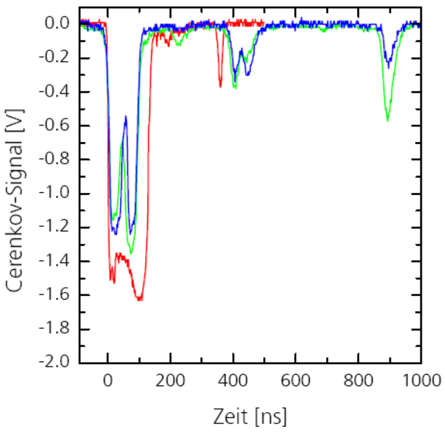
Fig. 9. Leakage current damage at 5V reverse bias in all 60 irradiated photodiodes.

Expect responsivity sensitivity at O(10^{14}/cm^2 neutron fluence)

=> Place DOH close to beam pipe, under the ECAL => BCM1 location

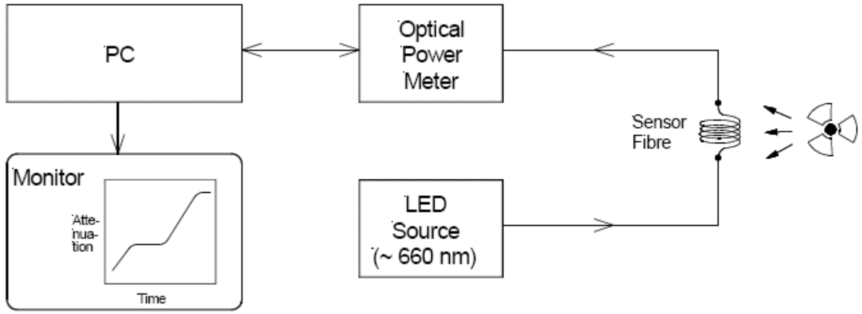
Radiation Monitoring: optical fibres

- Based on existing systems at DESY etc
  - Radiation induced attenuation
  - OTDR
  - Cherenkov light detection
    - Ideal for abort gap (3us) monitoring

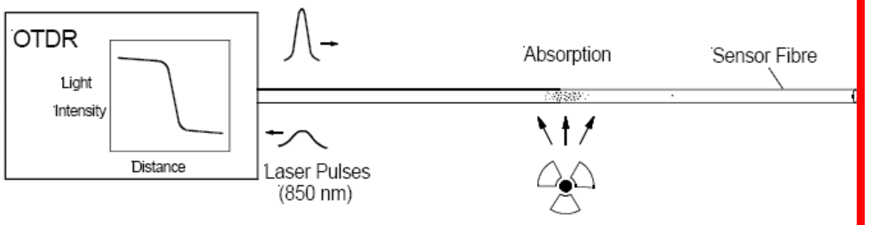


All 3 can use single mode fibres (1310nm)

High precision optical power meters



Optical Time Domain Reflectometry

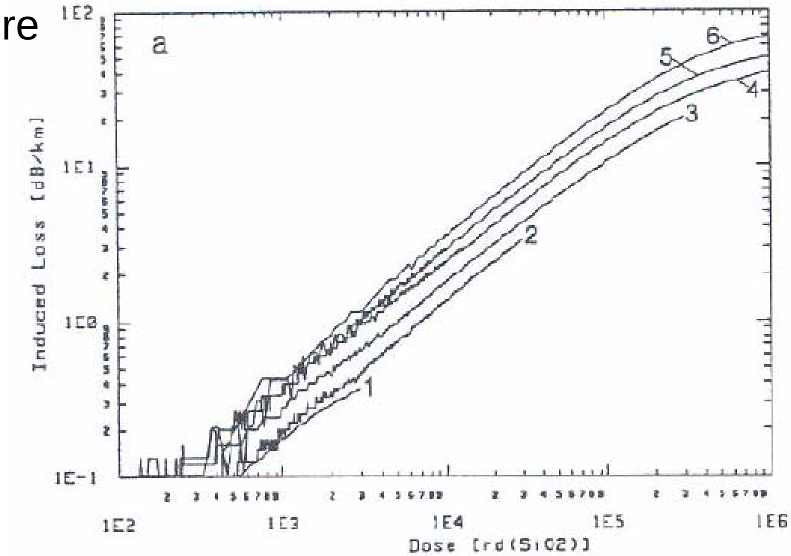


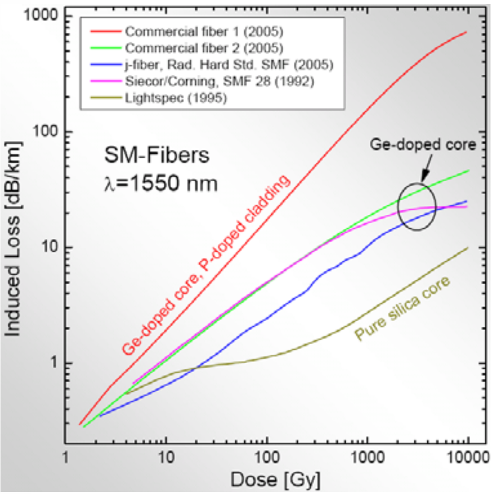
Total dose measurements

Dose rate dependence of the radiation induced loss

Ge doped single mode fibre

1. 0.05 rads/sec
2. 0.25 rads/sec
3. 1rad/sec
4. 4.5 rads/sec
5. 20 rads/sec
6. 160 rads/sec





Can use existing single mode optical fibre installed for CMS tracker

⇒ fibre is routed in from the USC to the tracker bulkhead (~ 120m)

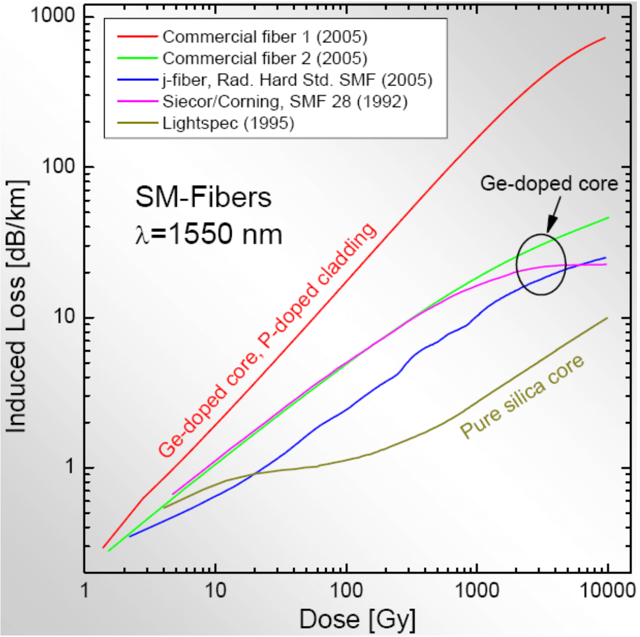
⇒ From bulkhead, attach fibre coils that are positioned within CMS

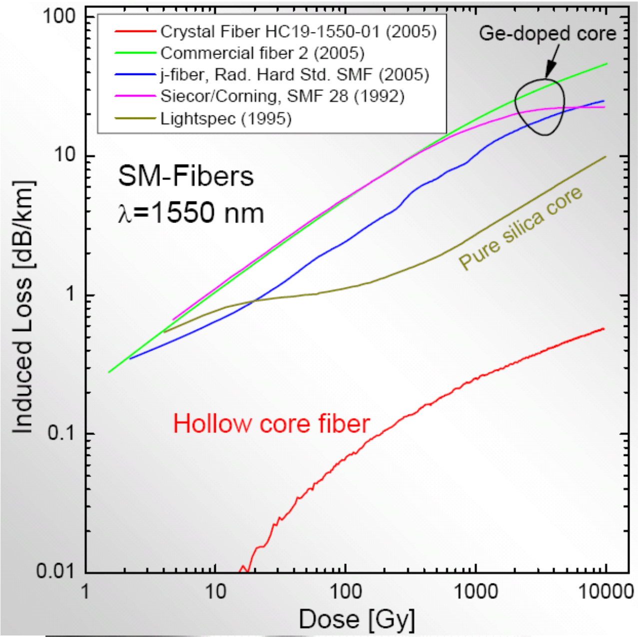
⇒ BCM1, Tracker bulkhead, outer radius of the ECAL, at patch panel 1 on the HCAL

⇒Radiation environment determines choice of fibre/manufacturer

⇒Coil dimension 30x30x5mm

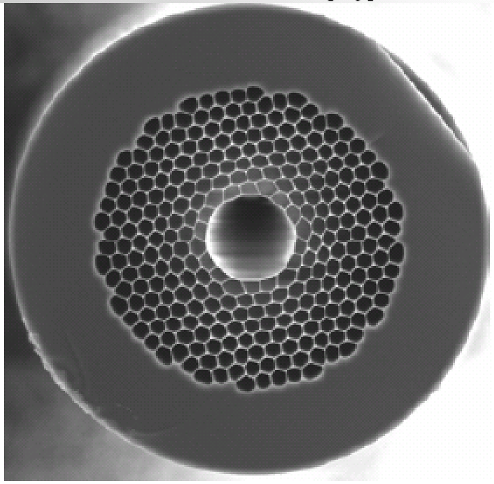
Total dose: high dose regions





<u>Rad hard hollow core fibre</u>

Use for the regions close to the beam
Deploy around the inner radius of the HF collar
Use both for run by run dosimetry and for Cherenkov light measurements



Requires connection splicing to std SM fibres
Calibration tests to be done.

RADMON

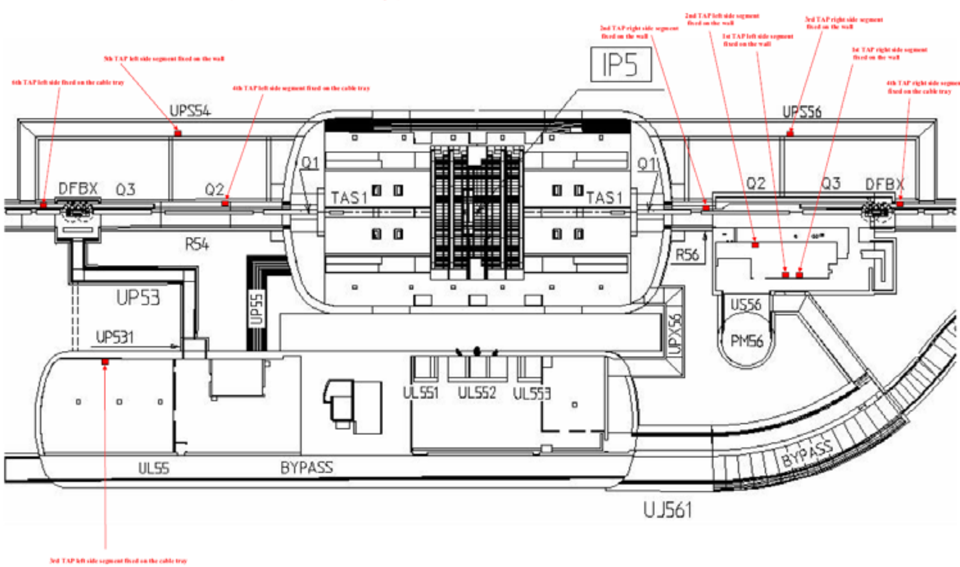
- Use RADMON boxes outside CMS (RADMON: see talk from Thijs)
- Deploy 18 boxes on CMS and around the cavern
- Place RADMON monitors in mutually agreeable locations (TS, CMS)
- Cross calibration: Several locations with RADMON+ RAMSES monitors
- All RADMON and RAMSES locations cross checked with passive monitors

18 Monitors distributed over the cavern in an interlaced symmetric pattern

2 gateways planed, with data locally available in the CMS control room

Work closely with RADMON to build up interface and provide view of LSS around Pt 5 (including CMS)

LHC RadMon (Online dosimetry) WorldFIP TAPbox location.



Passive Monitors

- Will uses a standard passive dosimeter package throughout CMS
  - Package to contain 2 Alannine, 4 RPLs, and 2 x 3 TLDs
    - Expect size to be 15x10x10 mm
  - Details of package composition: Awaiting report from TS
    - TLD-600, TLD-700, TLD-LiF:Mg etc for low/high dose senitivity and sensitivity to hadrons, neutrons and thermal neutrons
    - Dynamic range of different dosimeters (including RPLs)
  - Passive dosimeters to be used as a cross check over the commissioning/Pilot Run stage
  - Estimated that ~ 75 measurement points
    - 150 Alannine, 300 RPL and 375 TLD measurements per CMS.
    - Approach: Use standard package through out CMS as not obvious as to conditions during commissioning/early running. Std package covers full range.
  - Need to understand what is foreseen at CERN in regard to passive dosimeter services

BSC: Our Sacrificial scintillators

- Scintillators to be placed on front of HF for commissioning
- Purpose: Simple raw timing signals
    - Provides halo muon trigger for alignment studies
    - Gives clean comparison of hits from collision vs halo muons.
    - Scintillators recovered from LEP; not radiation hard