CMS Beam and Radiation Monitoring

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On behalf of the CMS BRM Group

CMS Beam Conditions and Radiation Monitoring

- CMS BRM
  - Composed of 6 systems:
    - BCM1 (Beam Conditions Monitor)
    - BCM2
    - Pixel Luminosity Telescope (PLT)
      - Not yet endorsed; awaiting a TDR
    - RADMON
    - BSC (Beam Scintillator Counters)
    - Passive Monitors

- Idea is to have online monitoring of the beam and radiation conditions over time scales ranging from 25ns to 100s
- This is to be backed up by monitoring based on passive monitors for long term measurements and total dose

BCM requirements

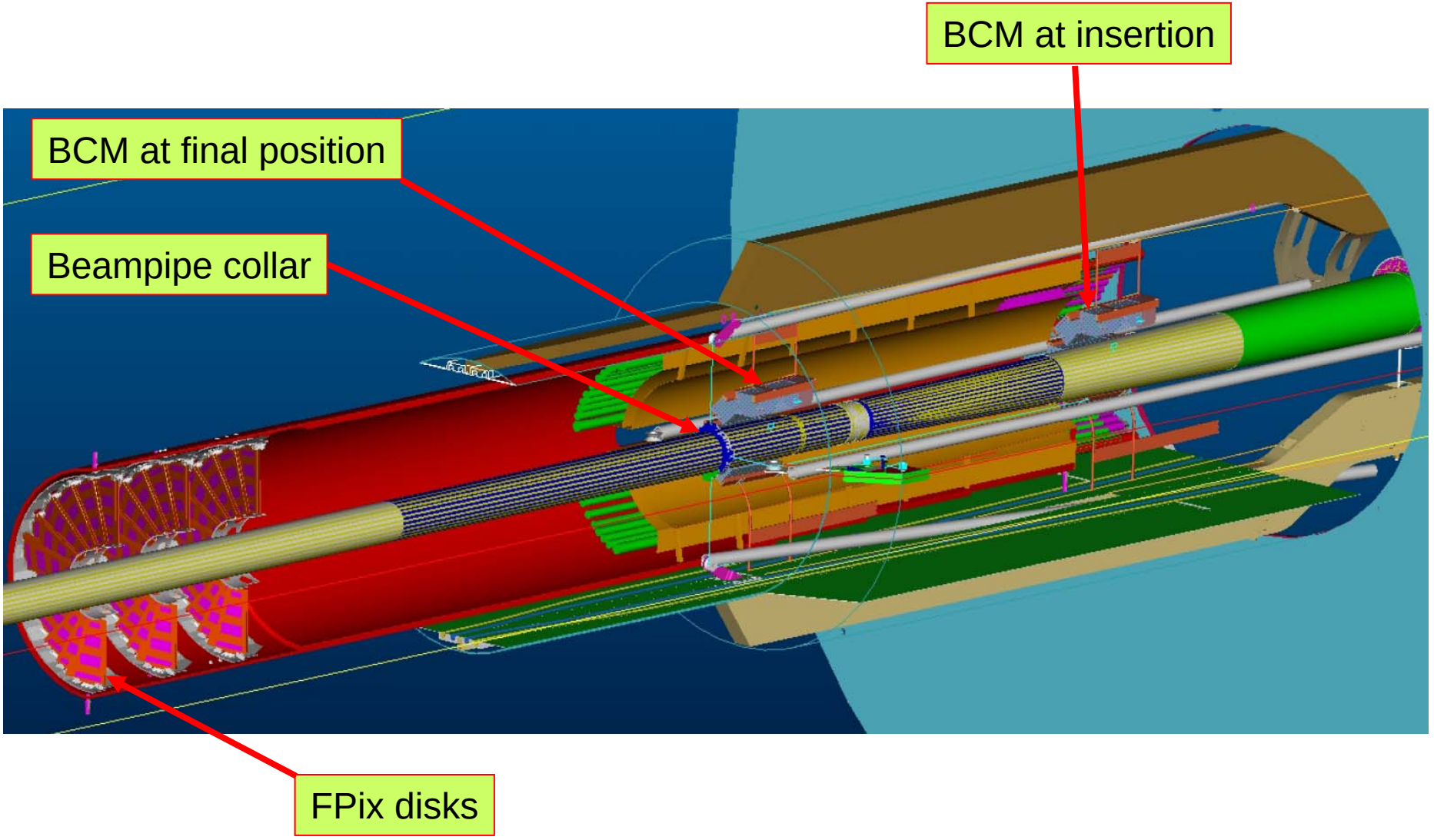
- **Placement of BCM:**
  - Close to beampipe
  - **BCM1: in front of conical beampipe section, at same inner radius as Barrel Pixel Detector**
  - **BCM 2: Outside Forward hadron Calorimeter; shielded from IP, Open to showers coming from the TAS**
- **Function**
  - monitor particle fluxes within CMS; **throw abort when necessary**

- **Mechanical Design**
  - **BCM should be independent of the Beampipe supports**
  - **BCM should be completely independent of the pixel and HF systems**
  - **Must incorporate the possibility of a Pixel Luminosity Telescope (PLT) in the inner tracker volume**

- **Monitoring time scales**
  - **Slow** = 40 μs Integration time matches the BLM monitors of the LHC.
    - This monitoring is done by BCM2
  - **Medium** = 1 μs integration time:
    - This monitoring is done by BCM1
    - Leakage current monitoring inside the Tracker volume. Sensitive to 3us abort gap
  - **Fast** = MIP sensitive front end electronics that provides asynchronous monitoring on the 25ns time scale
    - This monitoring is done by BCM1, in an independent subsystem

- **Interface to the BIC**
  - Initially Slow and Medium timescale monitoring to feed into the BIC
  - Fast Monitoring to be incorporated into BIC input once validated in-situ

BCM1: In-situ overview



BCM1 Design Constraints

The BCM is the last object to be installed in the inner tracker volume

=> BCM should not interfere with anything

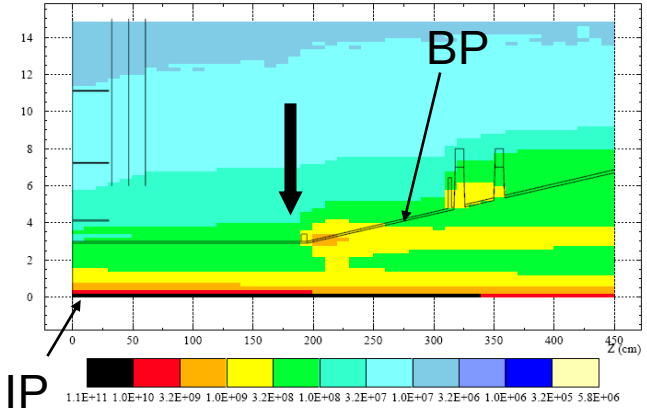
and

should provide best possible monitoring of beam halo/background in vicinity of Pixel detector

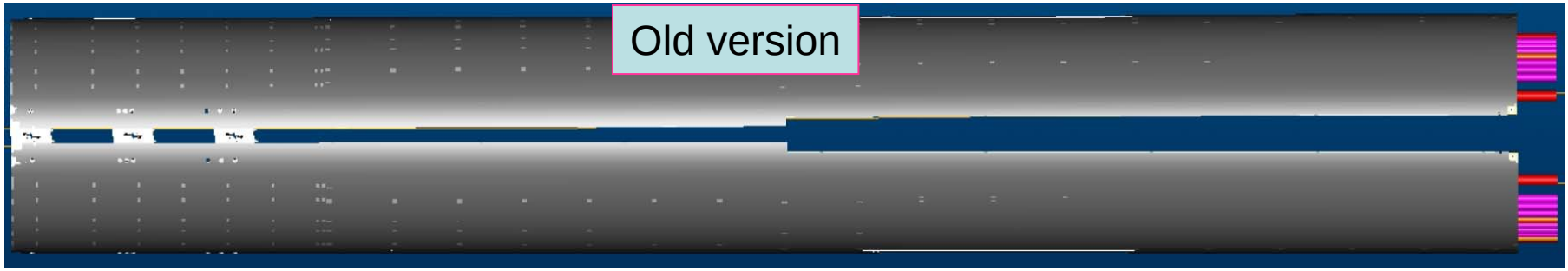
z-position of BCM: z = ±1.710 to ± 1.840 m

- Location implies
  - ~6.25ns from IP
  - Further away in z than the BP support collar (z= ± 1.632m)
  - Away from the low energy electron flux coming from the conical BP section
  - Possible to position BCM sensors at a radial position comparable to inner radius of pixels
  - Must be insertable/removable

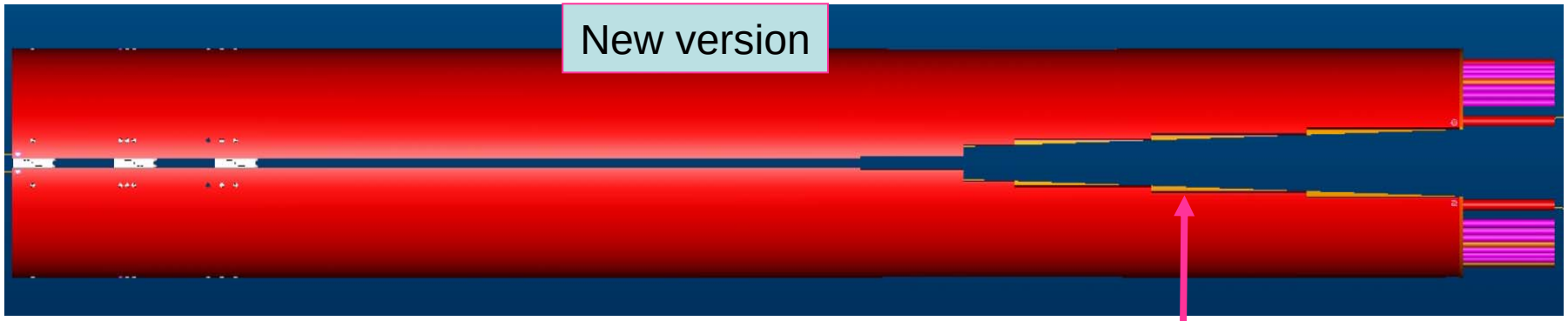
=> Required some modification to Forward Pixel Service Cylinder and Beam Pipe supports



Forward Pixel service cylinder modification



Looking from above

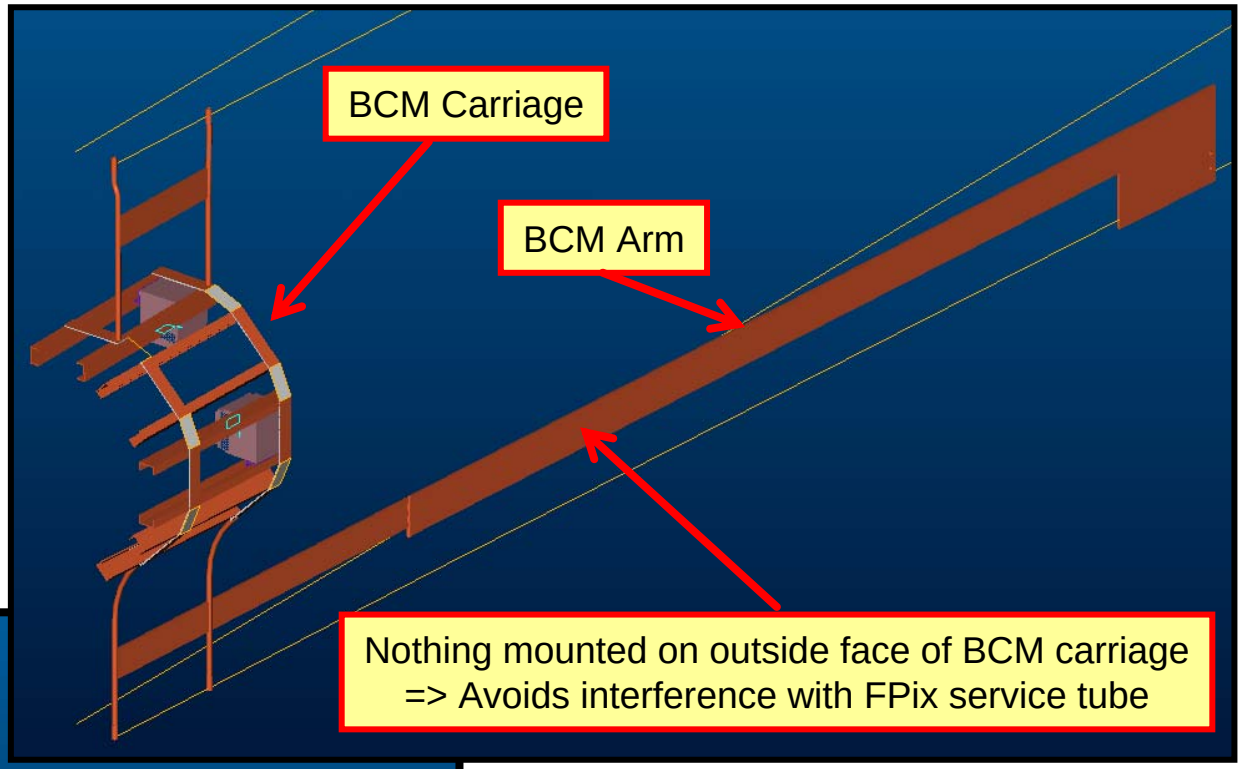


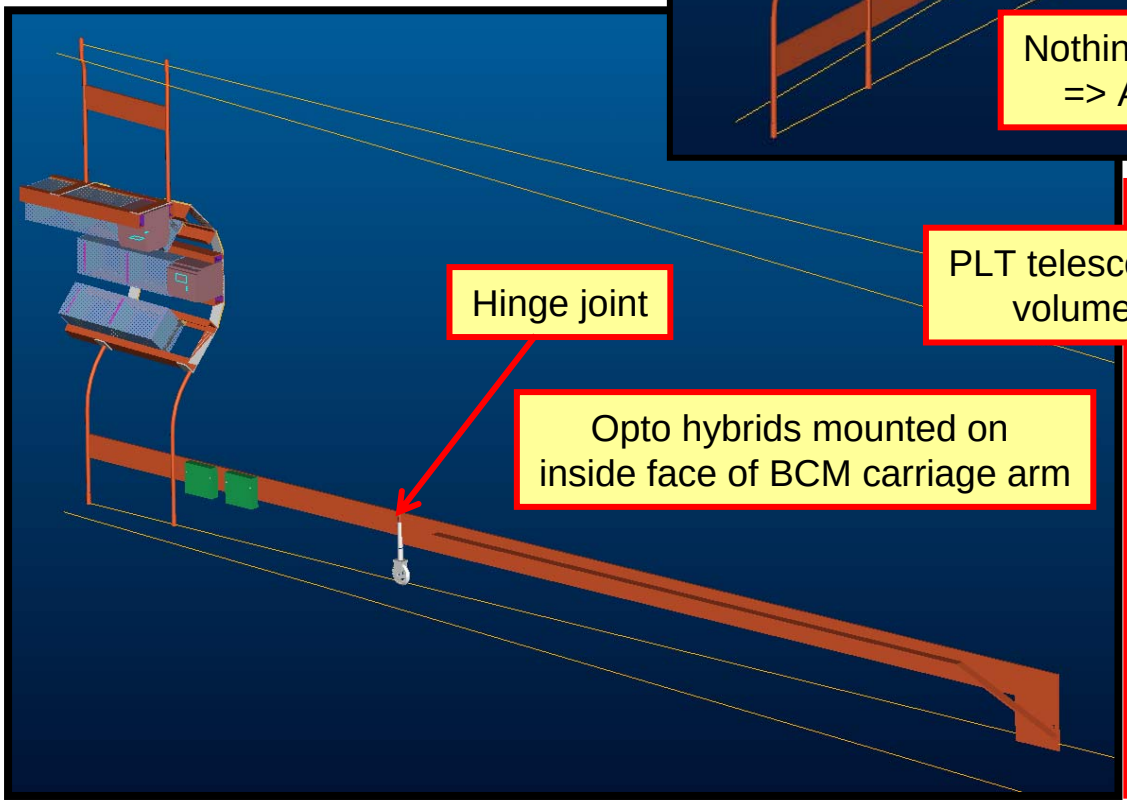
No change in the way the disks are mounted

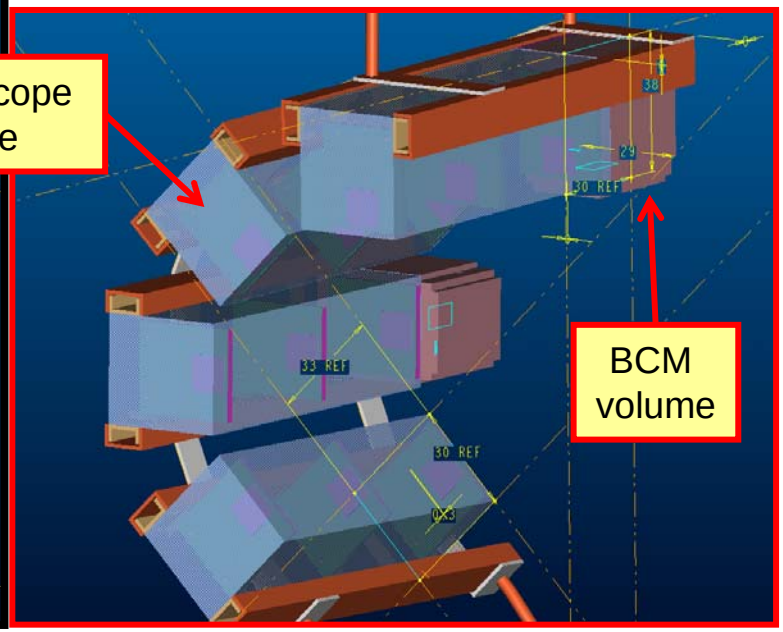
Section of service tube that is cut away
- Staggered step
- Makes opening for BCM to pass

The Endorsed Mechanical structure

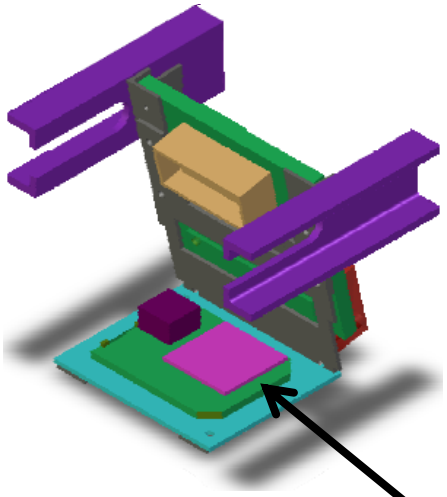
BCM1 Max length= 1076mm



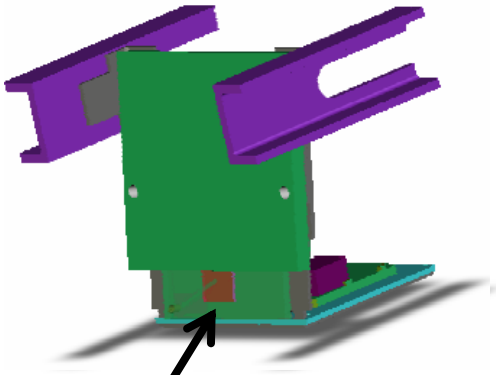




BCM Unit



Carbon fibre frame
Modular design
Compact



BCM1_ L

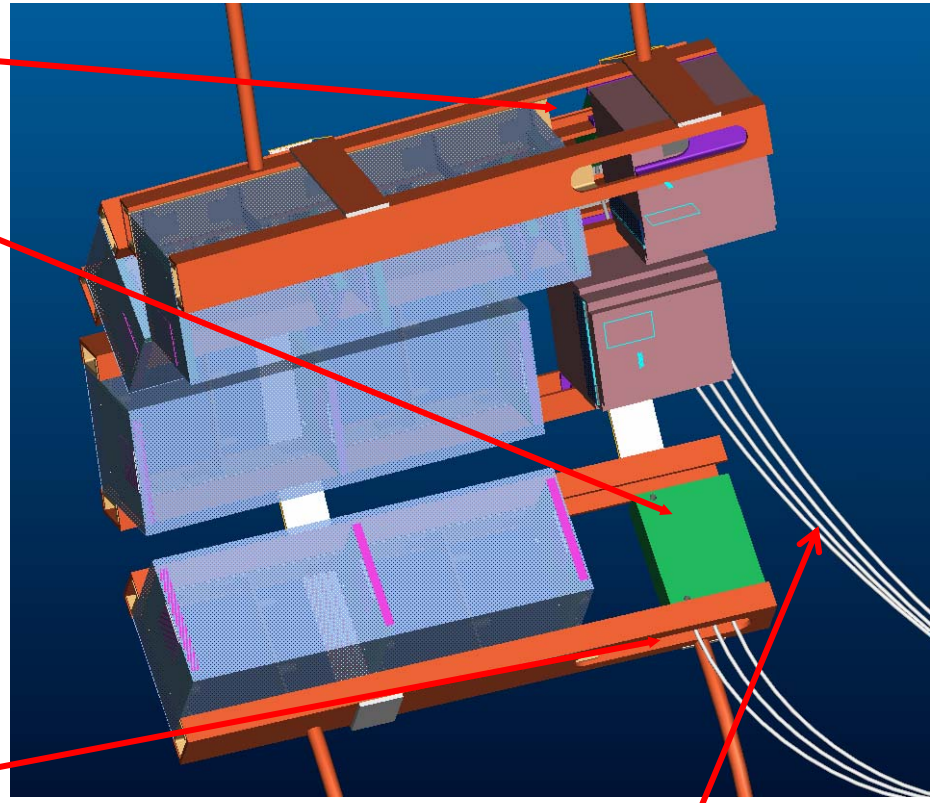
- Leakage current measurement
- Sensor: polycrystalline diamond
  - 10x10x0.4mm
  - 7000e-/MIP
- No front end electronics
- Bias voltage: 400V (nominal)
- Sensor orientation set by need for ExB to avoid anomalous leakage currents
  - Test beam in Week 25 and 26
- No direct cooling

BCM1_ F

- Bunch by bunch measurement
- Sensor: Single crystal diamond
  - 5x5x0.4mm
  - 18000e-/MIP
- Dedicated front end electronics
- AFP amplifier -> optohybrid
- Bias voltage: ~100V (nominal)
- Limited space for front end electronics
- No direct cooling

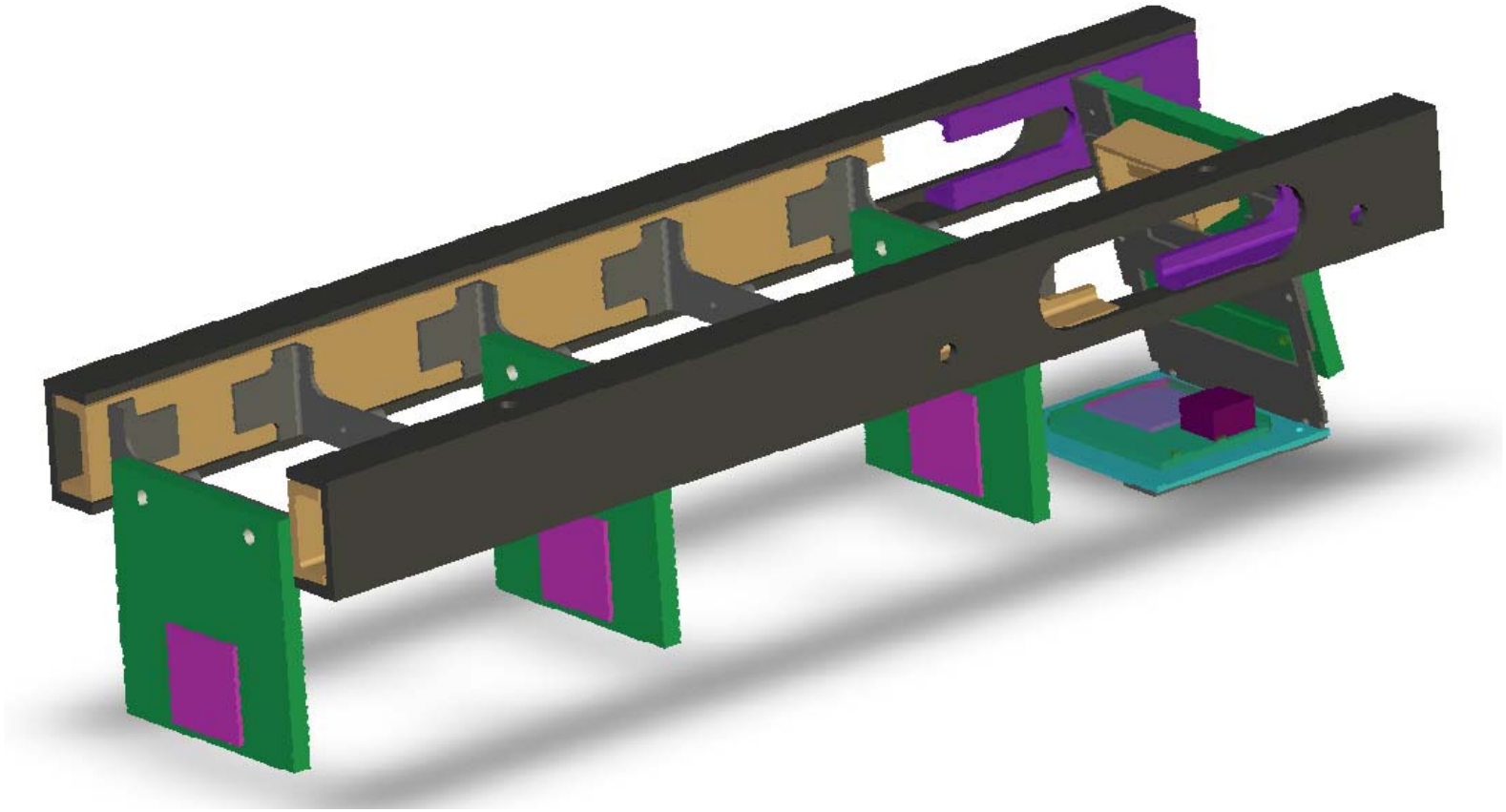
Inside the BCM carriage

- **Total length of carriage is 136.5 mm**
- Gap between PLT and BCM=13.5 mm
  - Reason: Add end flange in between PLT and BCM for PLT cabling
- Optohybrids for BCM (1 per BCM unit)
  - Installed in the diagonal positions of the carriage
  - Needed for the BCM_F (bunch by bunch) readout
  - Location
    - Minimised distance from Amp to OH
    - Not at larger radius as need to avoid vertical BP support wire
  - Standard DOH
    - TK tested to 10 MRad
- Optimized slots for cable routing
  - Cables routed out bottom of carriage
  - Ensures cables do not exceed outer radius of Carriage ie no snaggs

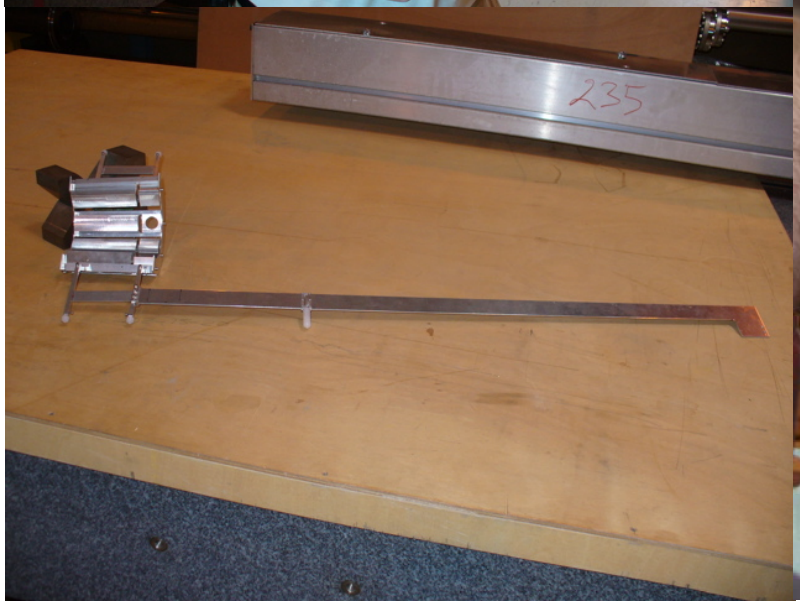


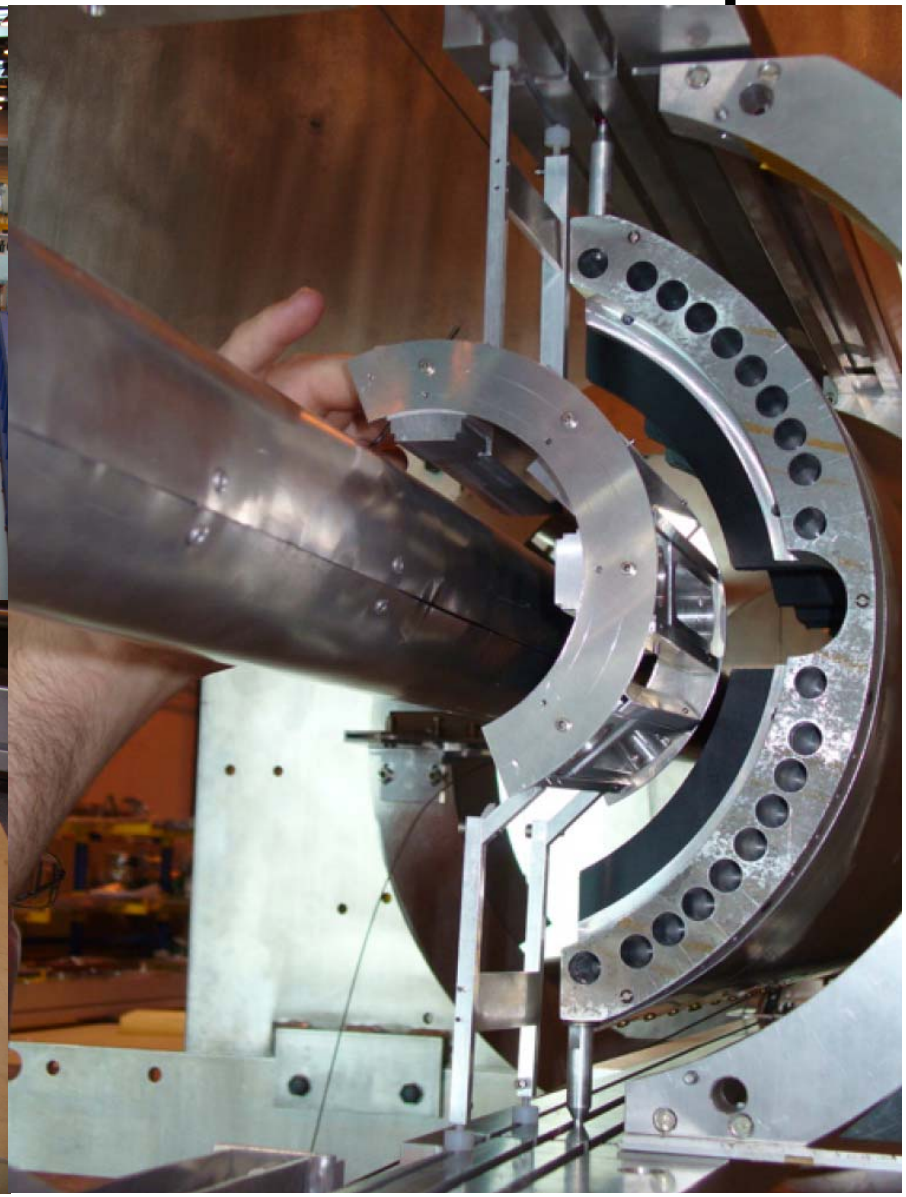
Cables not routed as shown here

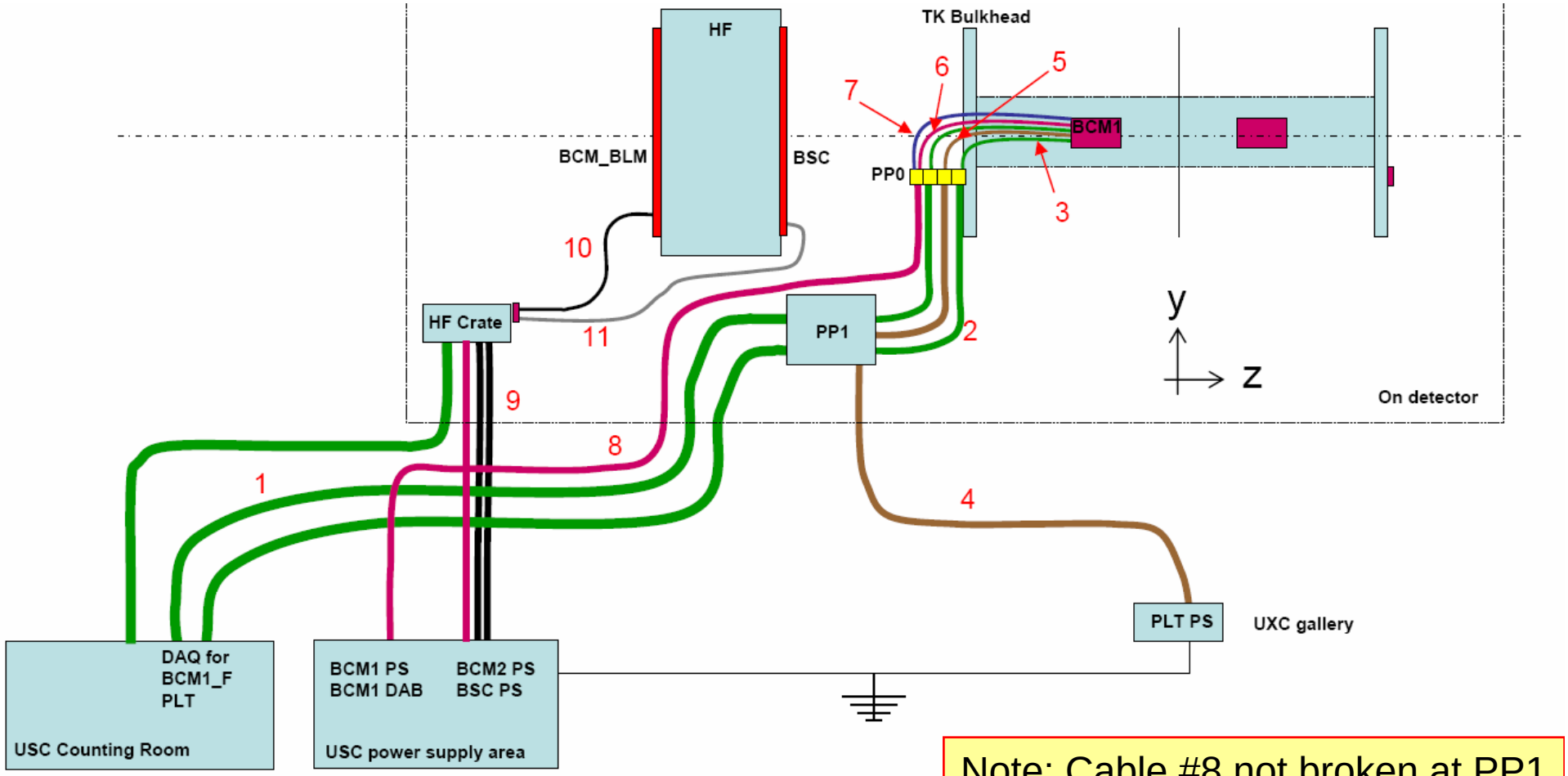
BCM Telescope Unit



BCM1 Mechanical Mock-up







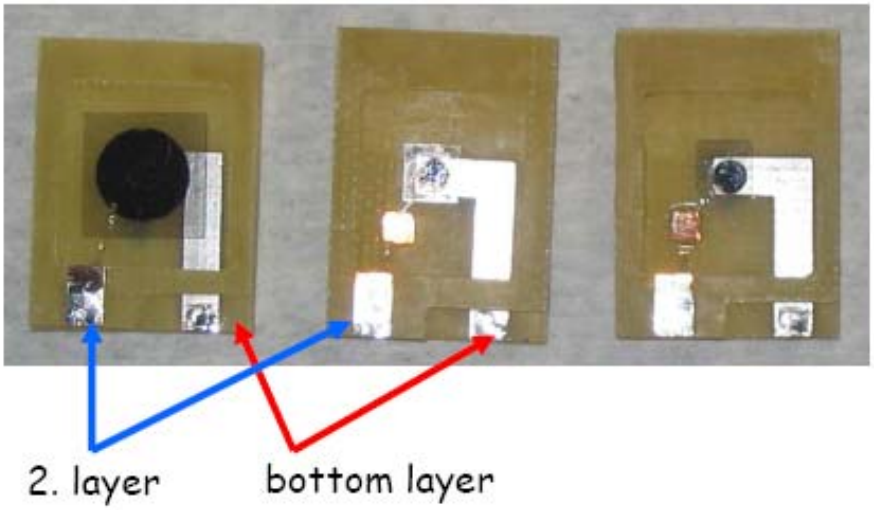
Note: Cable #8 not broken at PP1

1. Multi-ribbon optical fibre
2. 12-way optical fibre ribbon
3. Single fibre fannout
4. Pixel MSC cable
5. Front end cabling
6. Signal lines
7. LV power line for BCM1
8. 16 x shielded twisted pair
9. Shielded HV cable: 37 x conductor. 2 cables (1 BSC HV, 1 BCM2 HV)
10. Lemo lines; 2 per sensor
11. BSC HV lines

Cabling sketch

Packaging of sensors

We were very careful with contamination on the boards, clean with Acetone, then UV cleaning,

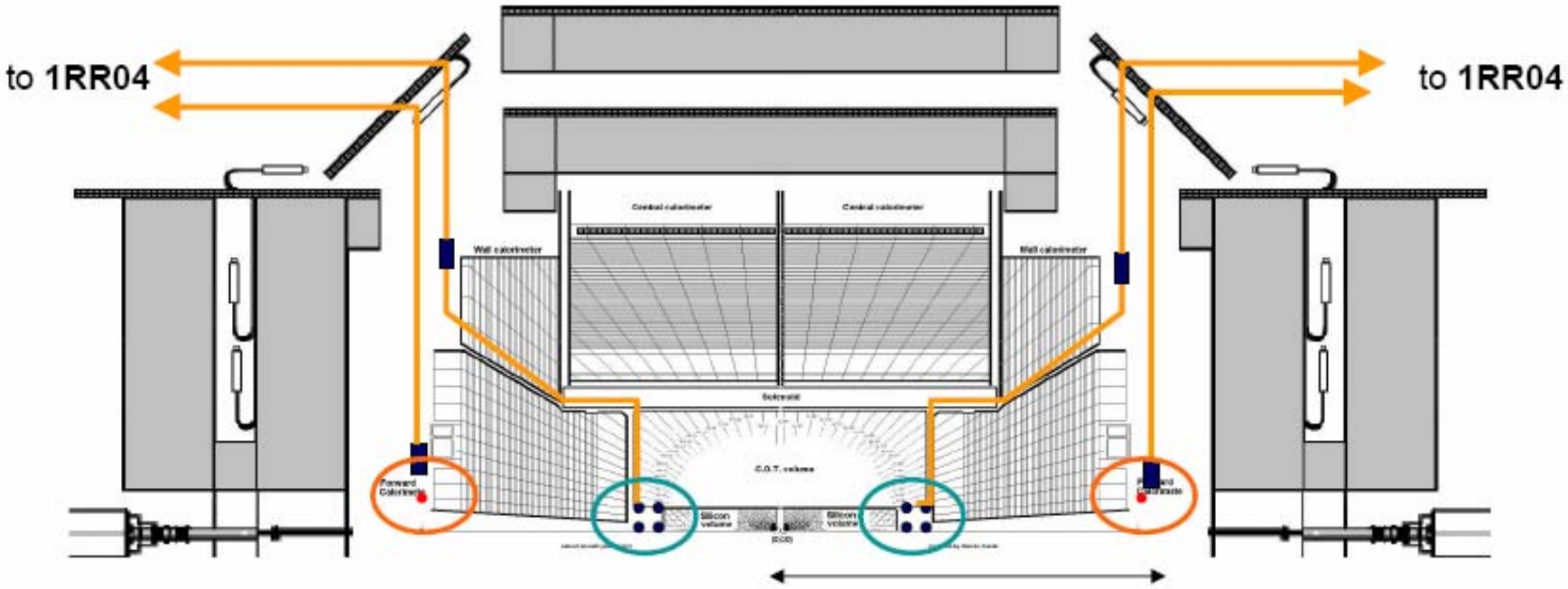


Less than 1pA leakage current due to G10 packaging!

Diamond leakage current < 10pA

secure' bonds with silver epoxy:

Position in CDF



Z=4.3 m, r=10.7cm

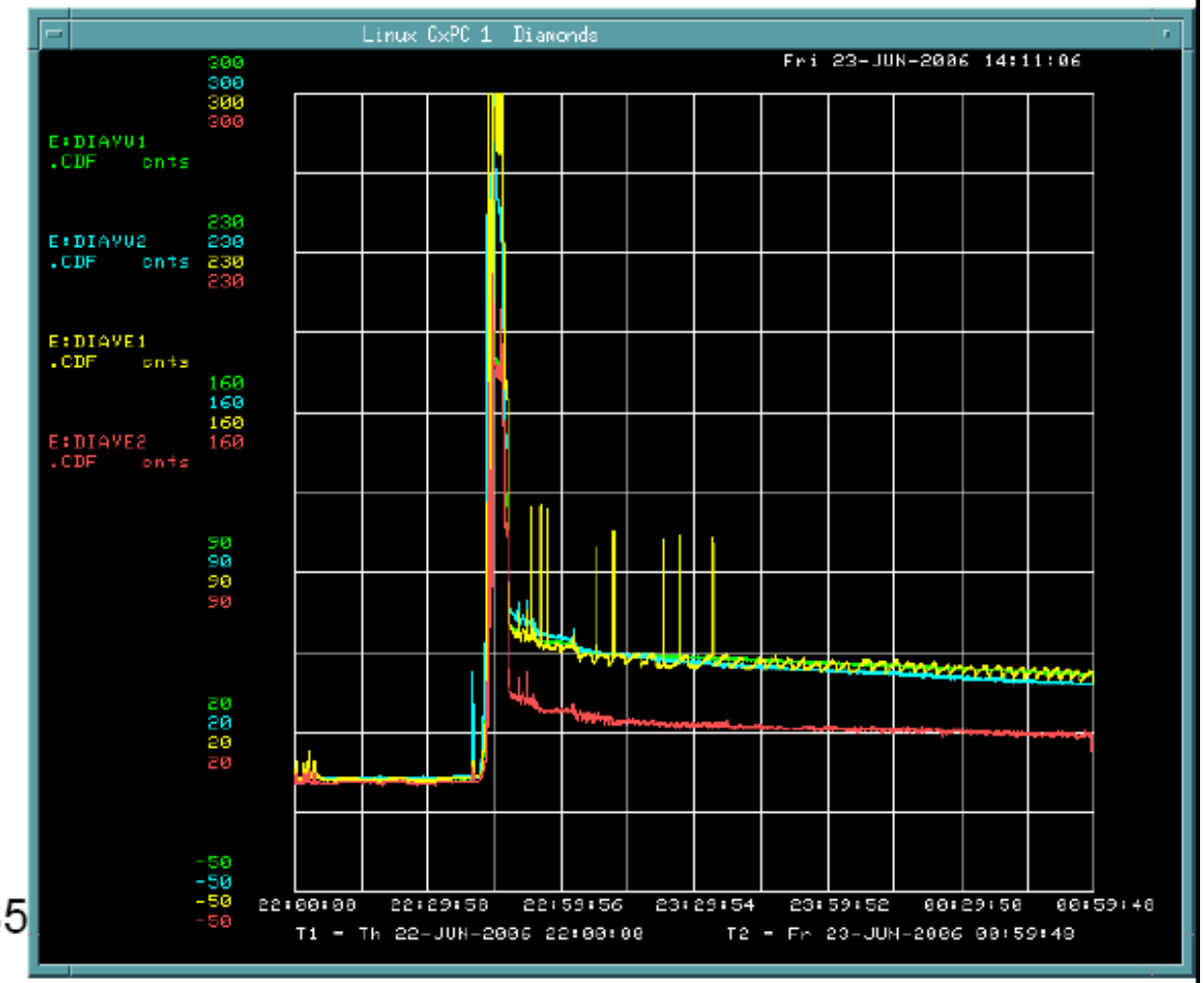
Signs of Life

CDF_W_BLM

CMS_W_S4

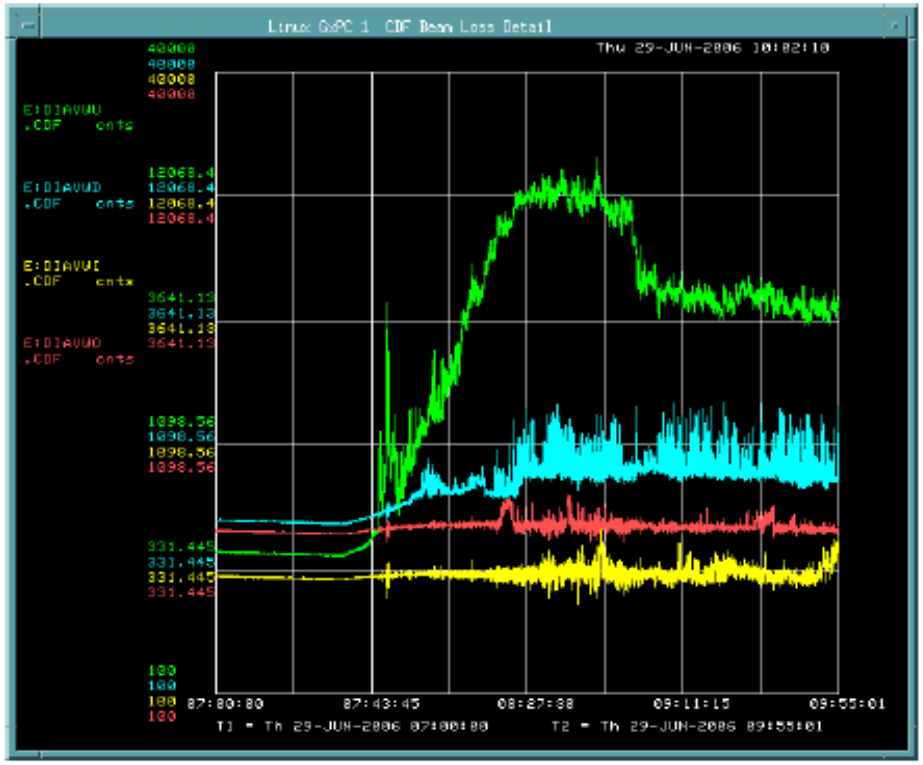
CMS_E_BLM

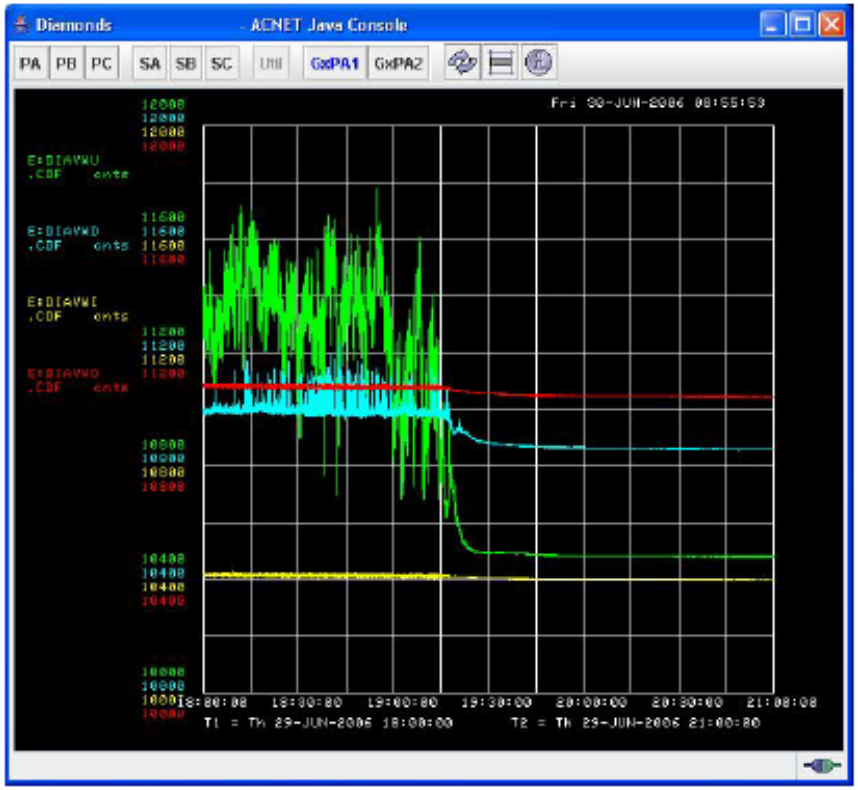
CMS_E_S5



- noise on CDF diamond => cable ? Will check next during upcoming access
- poly crystal vs. single signal ~ 2.5-3 (thy 64 mm^2/9mm^2* 220 um/500 um =3.1)
- we observe difference in S4/S5 although characterization results were the same ?

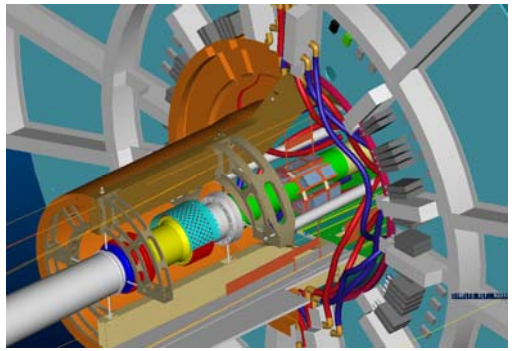
Solenoid Trip and Ramp-Up





See increase in dark current during recent solenoid trip

Installation and Insertion

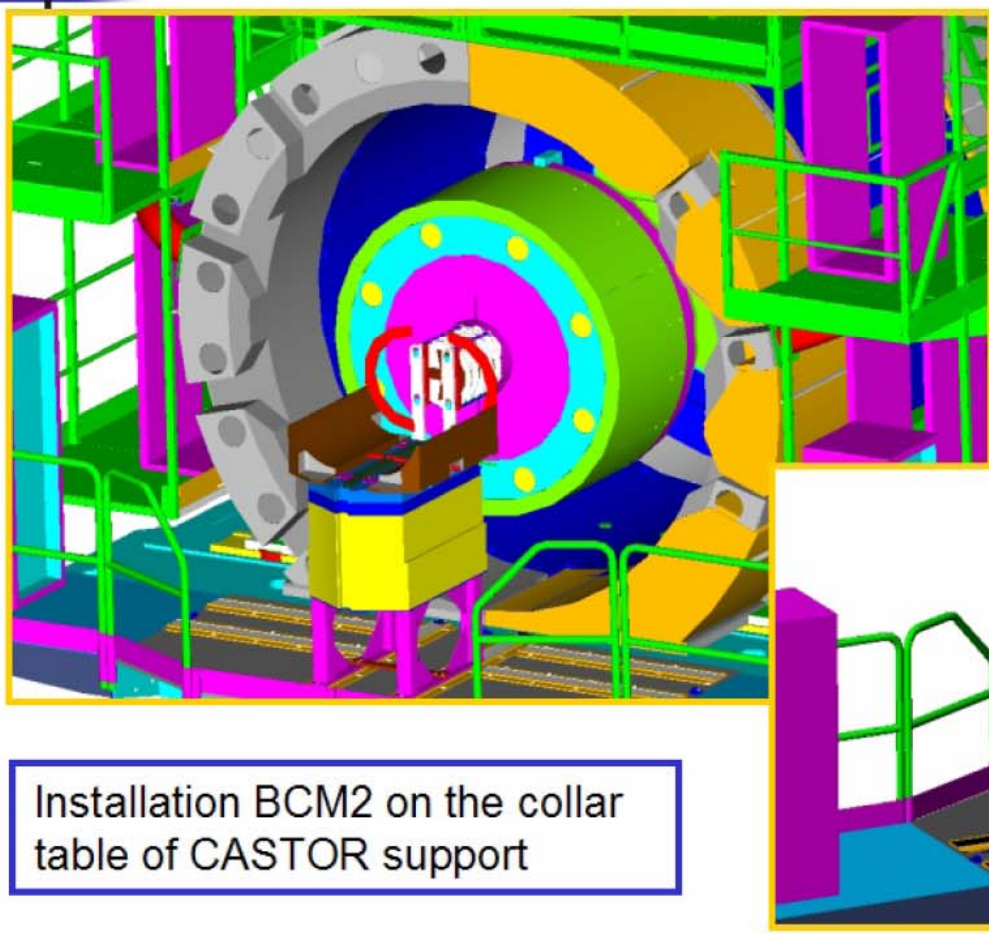


- **BCM1 Installation:**
  - **Starts after survey and alignment completed**
  - **Starts after BPix and FPix installed and cabled up**
  - **Starts after Beam pipe supports have been cabled up**

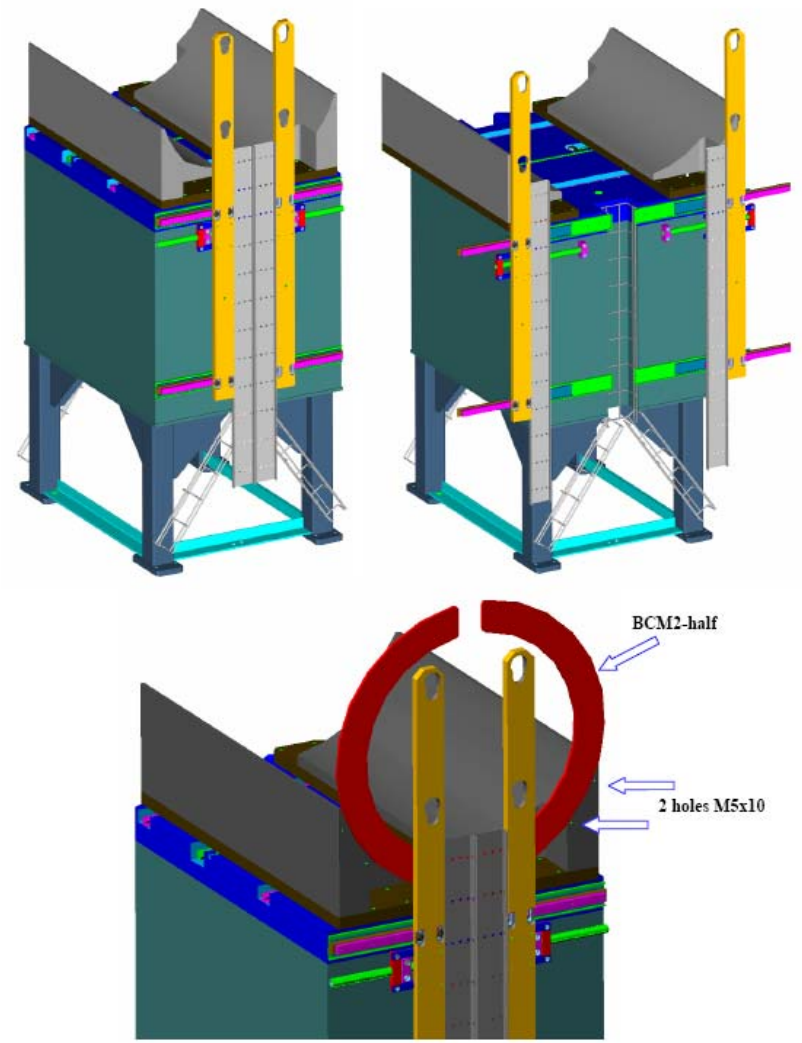
Installation and Insertion sequence

1. Remove lower ¼ carbon fibre wheels on one side
2. Position BCM carriage (in its transport/installation structure) below and to one side of the beam pipe
3. Dismount the to part of the BCM carriage transport structure to allow the BCM to be raised
4. Combined x and y direction raise BCM installation platform to bring the BCM to the correct y position, such that it is in line with the BCM rails
5. Move platform in z so to dock with the pixel rail plate
6. Partially insert the BCM carriage so that both front and back foot engage in the BCM rail of the pixel rail plate (back foot at to z=2775mm) ie top feet now engaged in rail plate
7. Disengage Carriage support frame that associated with the travel/installation structure
8. Insert BCM carriage structure using the BCM arm. Stop at final position
9. Remove BCM installation platform
10. Lock arm at z=2775mm
11. Cable to PP0
12. Re attach lower ¼ carbon fibre wheels
13. Repeat steps 1 trough 12 for the other side
14. Test cabling
15. Repeat steps 1 though 14 for the other end
16. Hand over to Tracker integration for close up of bulkheads and go to USC area

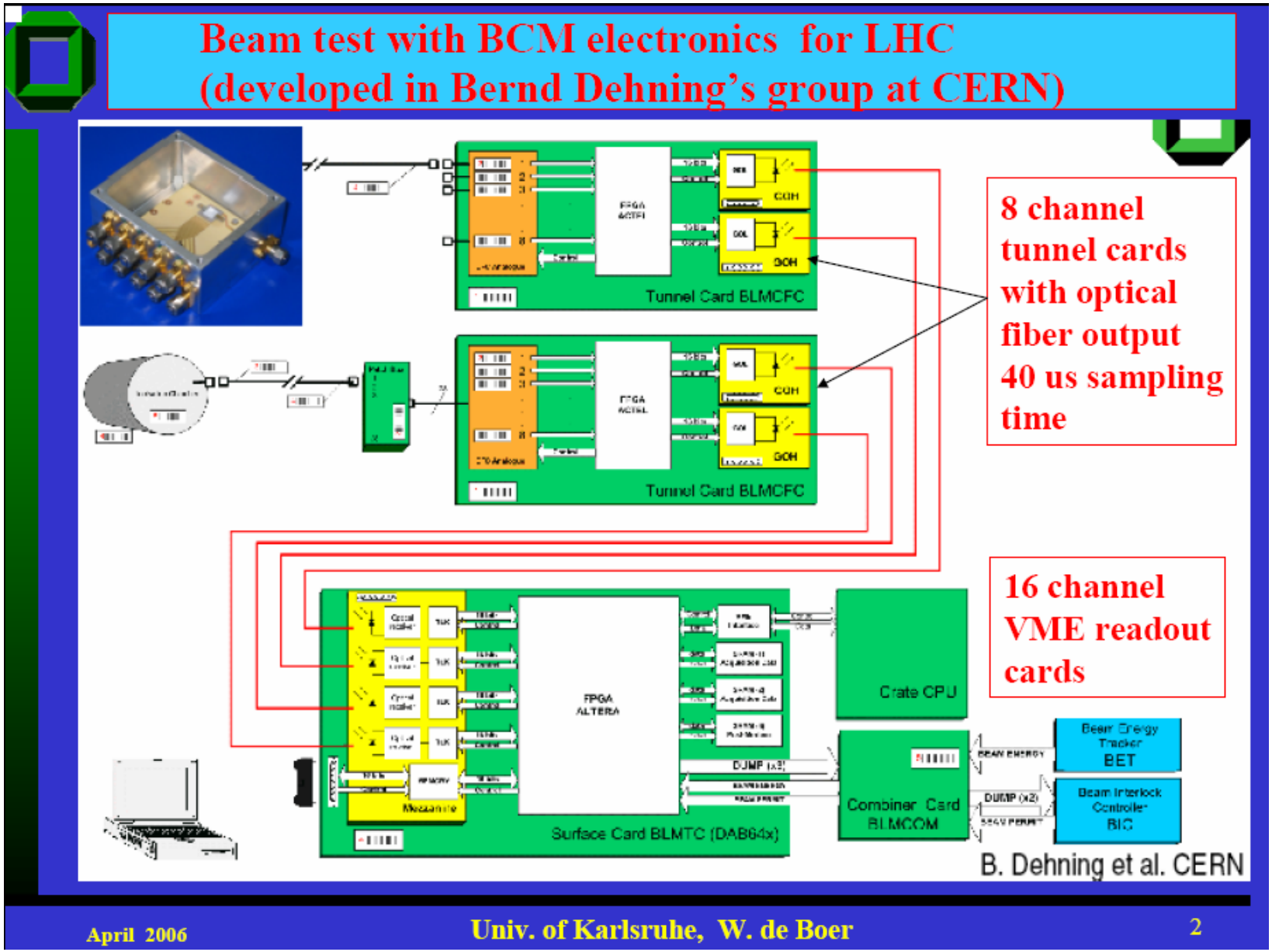
BCM2 Installation/integration (courtesy of Dmitry Druzhkin)



Installation BCM2 on the collar table of CASTOR support



BCM2 Readout: Using the BLM



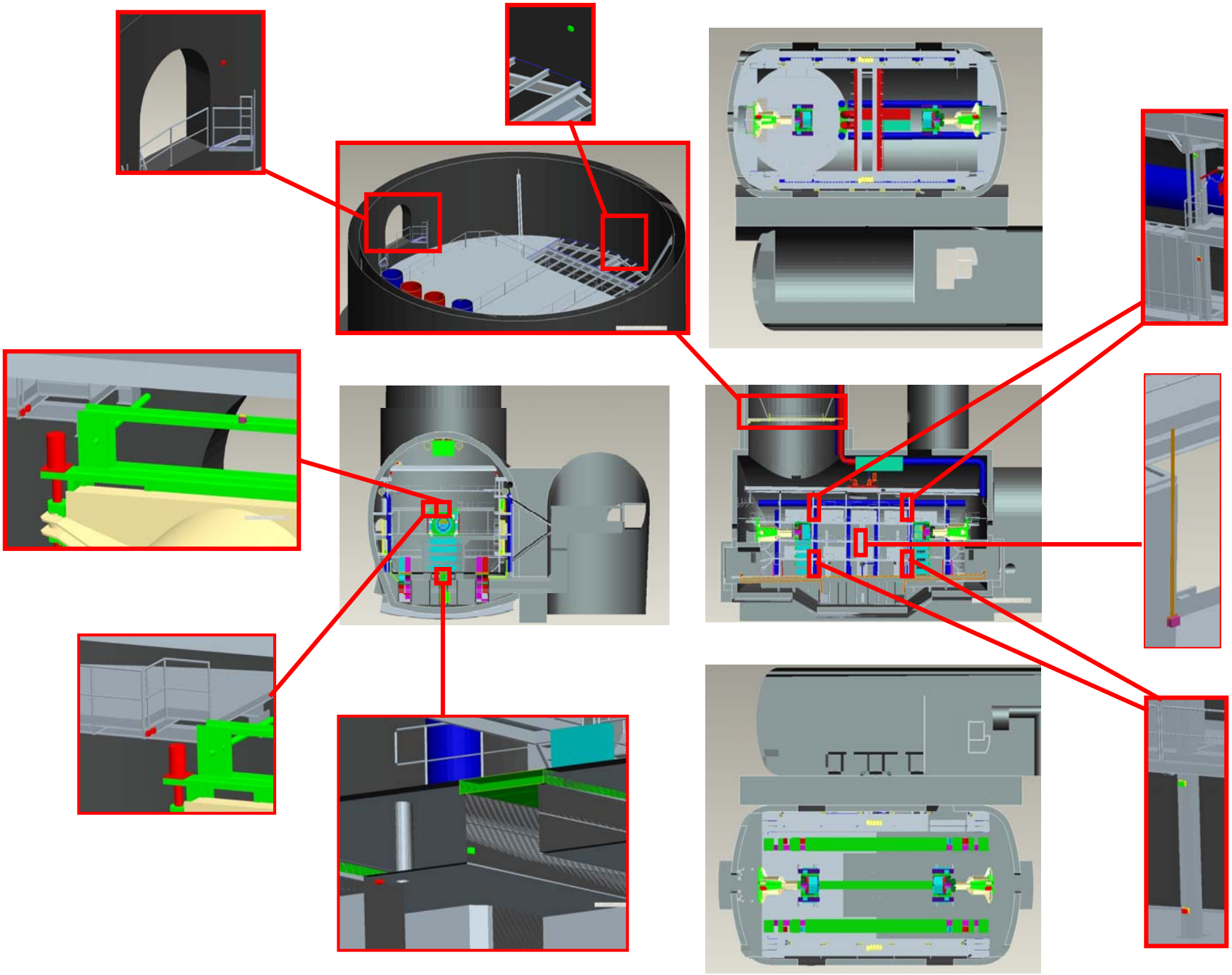
RADMON locations in CMS

- Chain A

1.	Start point at US56	X= ? Y= ?Z= ? We need to get this in the model		
2.	USC Trigger tunnel exit	X=20.525	Y=1.800	Z=-0.200m
3.	Z=0 UXC wall. Near side	X= 10.607	Y= 0.266	Z= -3.322m
4.	–Z UXC wall. Near side top	X= 13.125	Y= 4.029	Z= -10.497m
5.	UXC Access Shaft	X= -10.216	Y= 23.645	Z= -13.975 m
6.	-Z UXC wall Near Side bottom	X= 13/125	Y= -8.298	Z= -10.649m
7.	-Z UXC wall Far Side bottom	X= -11.125	Y= -8.318	Z= -10.557m
8.	–Z UXC wall Far Side top	X= -13.125	Y= 4.039	Z= -10.405m
9.	In front of TAS	X= 1.091	Y= 5.908	Z= -25.576m
10.	HF (On the HF via cable chain)	X= -2.125	Y= -1.295	Z= -14.778m
11.	Termination	On the HF		

- Chain B

1.	Start point at US56	X= ? Y= ?Z= ? We need to get this in the model		
2.	TX54	X= -30.758	Y=7.000	Z=-17.868m
3.	+Z UXC wall Near Side bottom	X= 13.125	Y= -8.146	Z=9.804m
4.	+Z UXC wall. Near side top	X= 13.125	Y= 3.777	Z=9.951m
5.	In front of TAS	X= -1.086	Y= 5.825	Z= 25.723m
6.	Cave (UXP)	X= 2.443	Y= -10.014	Z= 0.336m
7.	Z=0 UXC wall. Far side	X= -10.607	Y= -0.266	Z= 3.322m
8.	+Z UXC wall Far Side top	X= -13.134	Y= 3.769	Z= 10.593m
9.	+Z UXC wall Far Side bottom	X= -11.125	Y= -8.384	Z= 10.443m
10.	HF (On the HF via cable chain)	X= -2.115	Y= -1.295	Z= 14.778m
11.	Termination	On the HF		



Summary Comments

- RADMON
  - Awaiting final agreement on locations
  - Concern over powering/grounding scheme
    - Must separate RADMON from detector
- Passives
  - Will work with TS-LEA and will adopt passive monitors as used by Totem. ie consistency throughout CMS
- BSC
  - Mechanical location on front of HF
  - Readout chain hardware fully integrated with HF
  - Awaiting test beam with HF in August 06
- BCM
  - BCM1
    - Prototype readout based on Tevatron BLM cards is now ready for testing with diamonds installed in CDF
    - All CMS polycrystalline diamonds now delivered. Now being metalised and tested
    - Poly and single crystal diamonds undergoing leakage current QA in Magnetic field (CERN East Hall)
    - Mechanical structure endorsed at EDR; proceeding to optimise with manufacturer
    - Front end electronics for fast readout based on CERNs AFP chip (rad hard 0.25um)
    - Full mechanical insertion test with BCM, Beam pipe and Pixels is ongoing, with no major problems
  - BCM2
    - Full readout based on LHC_BLM system
    - Mechanical infrastructure based on independent mounting on CASTOR support table
    - Frontend electronics validated in Magnetic field equiv to CMS fringe field
    - Starting the LHC and CMS interface designs