Common Systems, Infrastructure and Facilities

This part of the proposal for 2010-16 is about:

-Modifying the Common Systems & Infrastructure of the CMS apparatus to maintain or improve safety & reliability, or to accommodate detector consolidation/upgrade.
-Re-configuring & equipping facilities for upgrade assembly & integration

Divided into 10 projects/tasks:

(1) Safety systems for the protection of personnel and equipment
(2) Magnet and magnetic field measurement/simulation
(3) Yoke, Shielding and Moving Systems
(4) Experiment Beampipe
(5) Beam Radiation Monitoring System
(6) Experiment Service Infrastructure
(7) Beam, radiation, cosmic ray or environmental Test Facilities
(8) Surface assembly buildings, workshops, laboratories, and storage space
(9) Logistics and Integration
(10) Planning and Coordination

….the following summarises the main activities in each:

Safety Systems

General Safety

safe areas and evacuation route
magnetic-field tolerant public address system

Detector Safety system (DSS)

shifter friendly user-interface
maintainability of racks

Sensor systems

rad. tolerant opening/closing sensors
environment monitoring (fibre-optic sensors)

Nitrogen, dry air and compressed air

factorise functions
introduce redundancy
capacity to run Tracker cold.

Safety systems

Fire prevention, detection and extinguishing

extend filter farm system

Radioprotection precautions, measuring & traceability equipment

equipping buffer zones & workshops (esp SX5 building)
screening instruments for faster RP turnaround

Access control

speed up access procedures and issue of sensitive keys

Safety Training

pt 5 specific training

Magnet

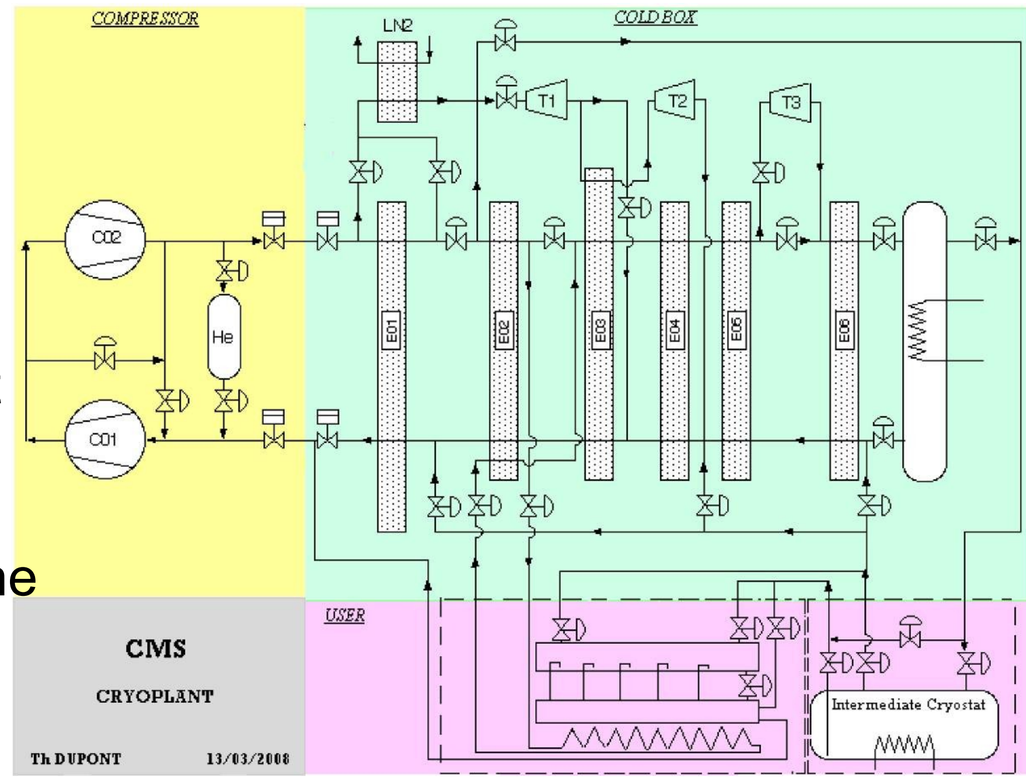
Magnetic field off: ~ no useful physics
Magnet on-off-on: limited number of such cycles in lifetime

Helium compressor pair
- critical single point failure
- replacements now only built to order
- provision for redundant pair foreseen

Compressor lubricant separator
- prevent pollution of high-pressure unit

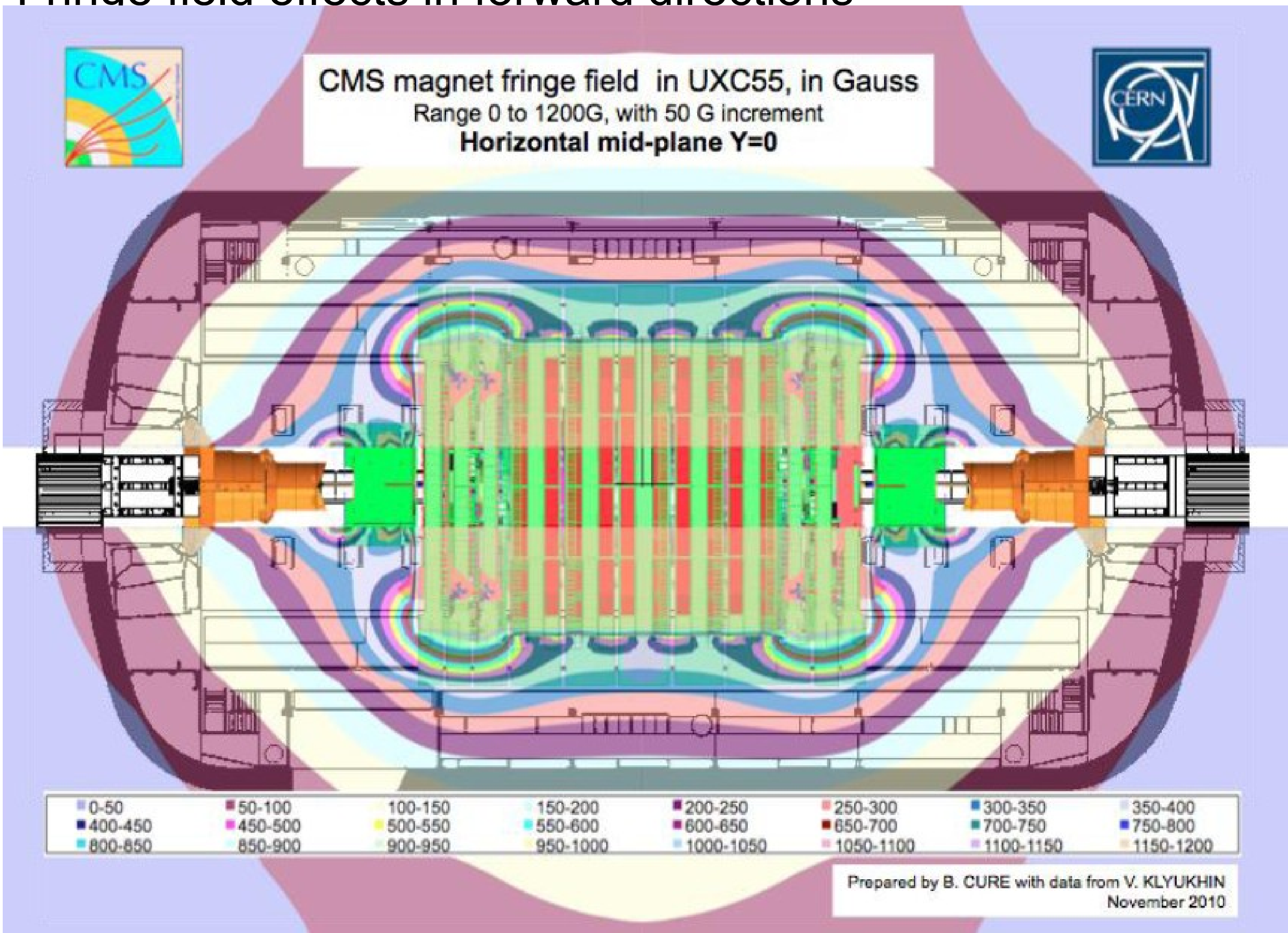
Cold box
- redundancy or cold-swap of pre-turbine filters to avoid ramp-down for regen.

Miscellaneous
- spares for power & control systems



Magnetic field measurement & mapping

Hardware:Flux loop system for measurements in yoke + more Hall probes in fwd.
Software: Effect of shielding disks YE4
Fringe field effects in forward directions



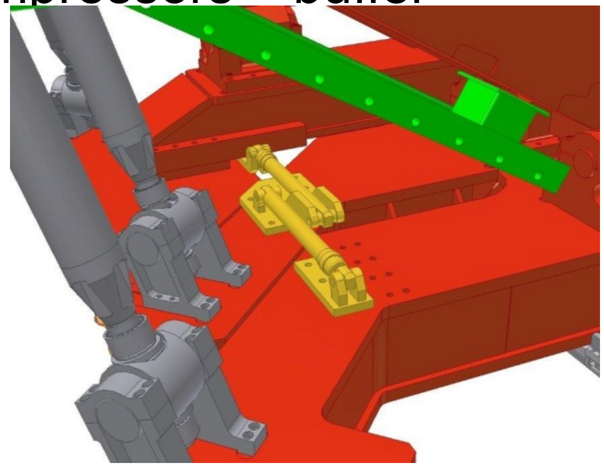
Yoke, Shielding, Moving

Safer, more flexible movement, with lowered risk to beampipe

-air pad compressed air source: bottles → compressors + buffer

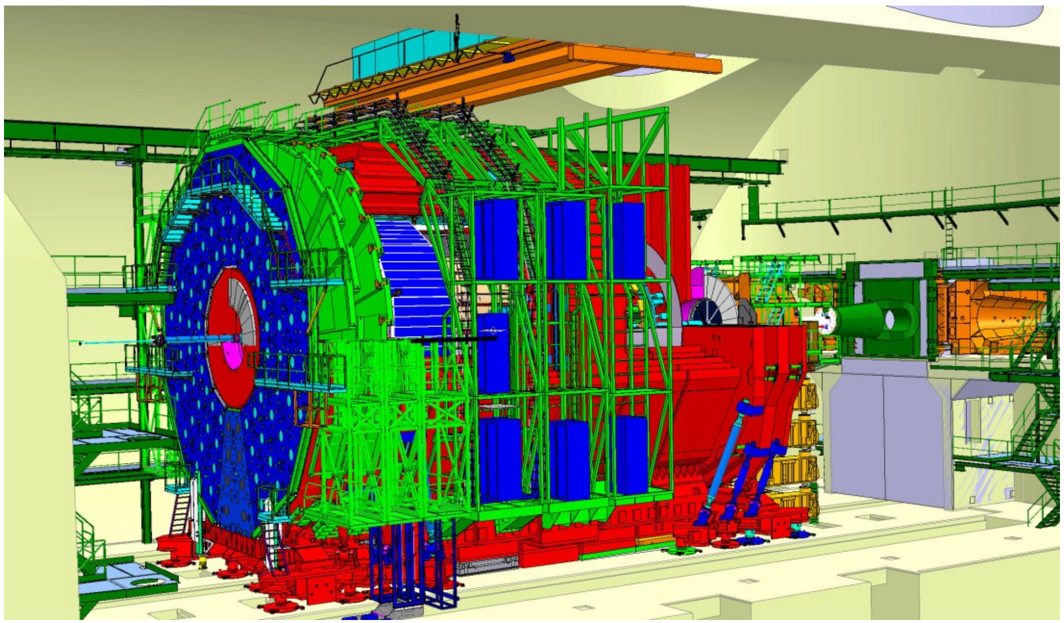
-forward opening with bp at vacuum

-hydraulics for inter-disk movement



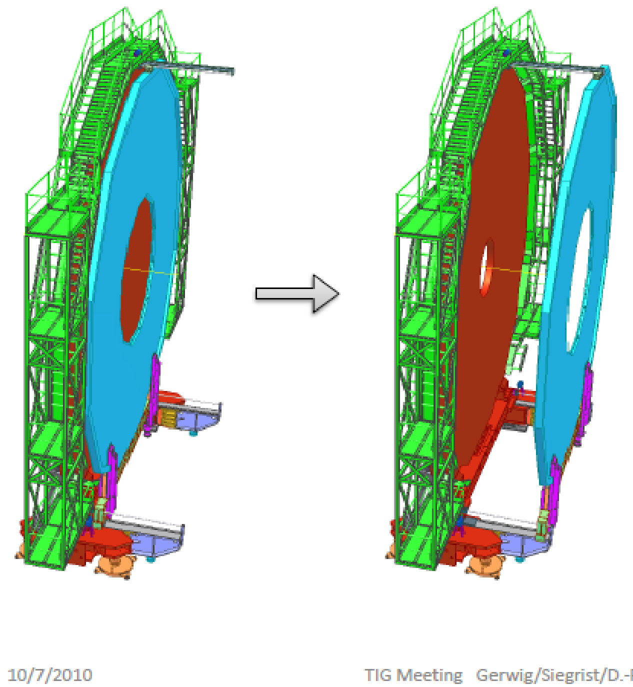
YE4 Disks

-completion of the high lumi shielding system



Key part of the forward muon upgrade

Yoke, Shielding, Moving

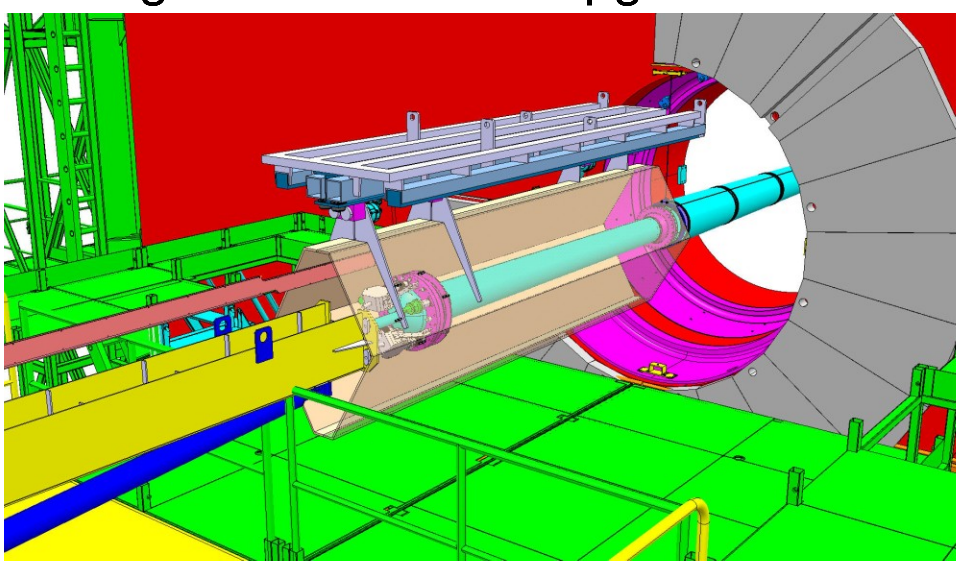


YE4 pushback system

- mitigate effect of scrambled sequence in forward muon upgrade
- YE4(+z) an YE4(z) construction 2012-13
- endcap muon layer(-z) 2013-14?

Radiation shielding

-protect personnel from activated elements during maintenance & upgrade activities

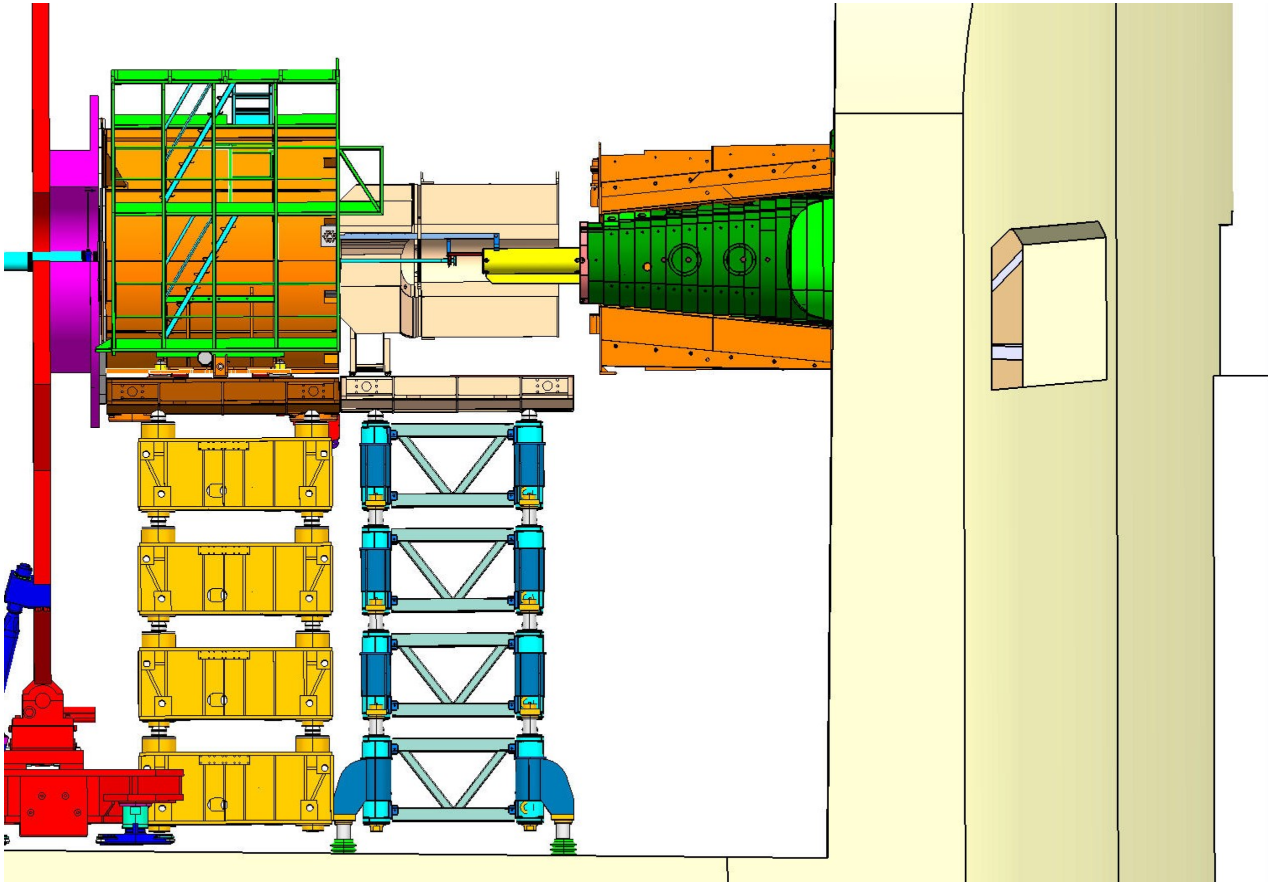


Urgent to test in 2012-2
before activation significant

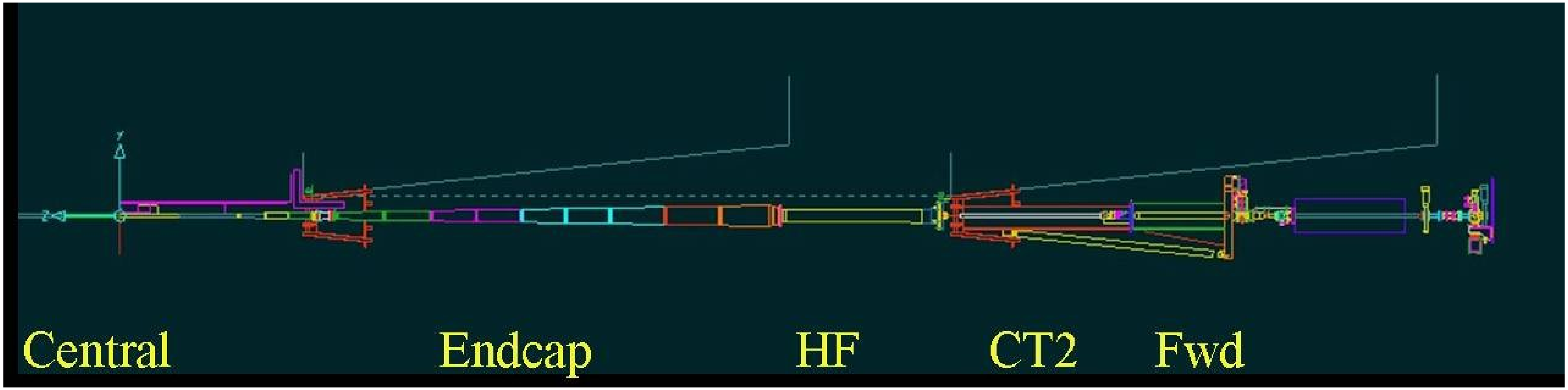
Yoke, Shielding, Moving

Forward Region

correct for underestimated magnetic fields and forces
apply ALARA to dose received in forward closing sequence
allow forward detectors to be swapped in with bp at vacuum (if needed)



Beampipe



Reduce central Be pipe diameter

- aim for ~23mm
- 12 facet pixel layer1
- maintain η = 4.9 ec cones

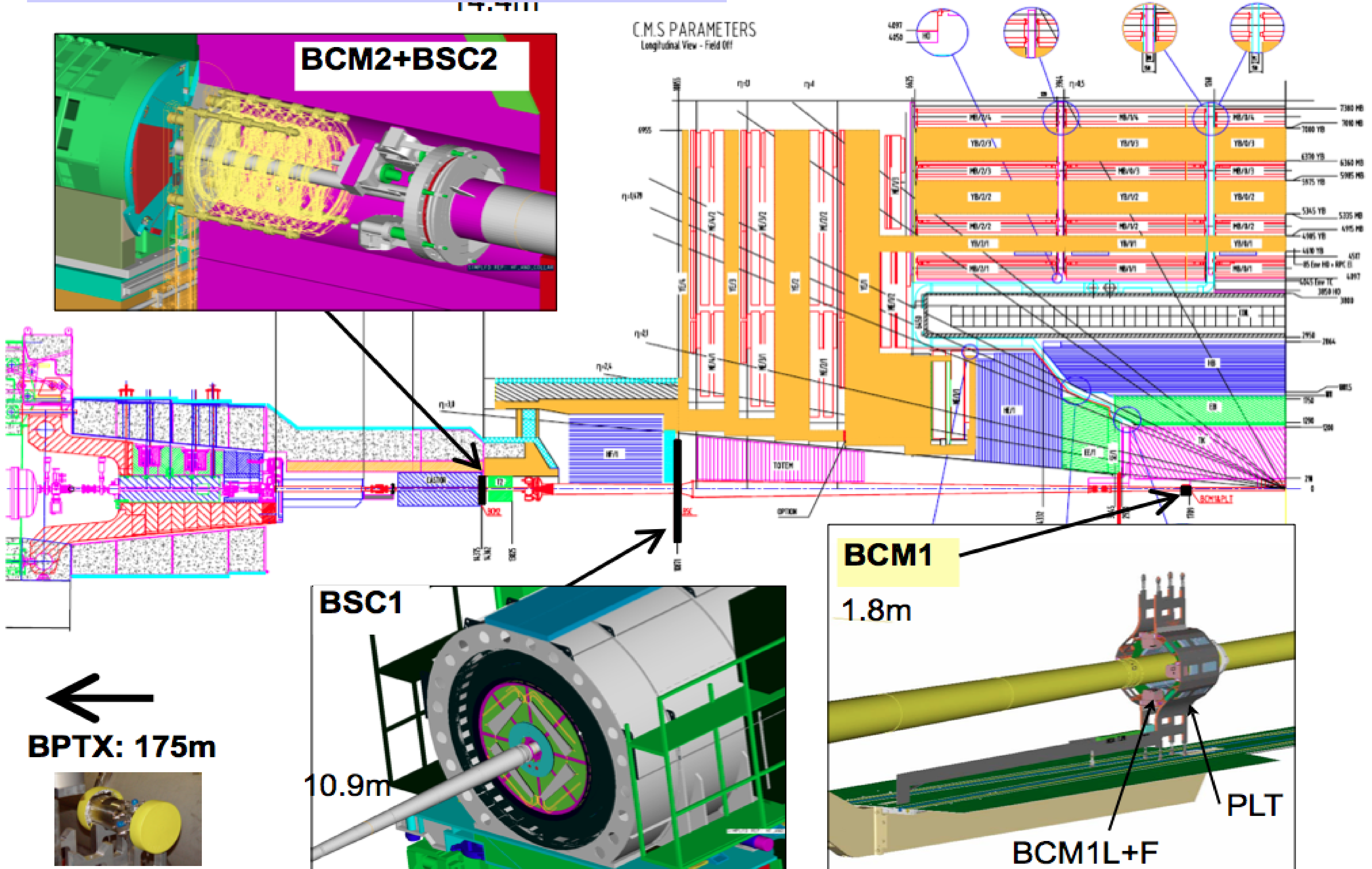
To check:

beam stay-clear vs z
sagging
vacuum stability
supports

Quantity	Original estimate	Measurement
Construction tolerance	2.6mm	<0.6mm
Installation tolerance	2.6mm	2.7mm
Sagging between supports	2.2mm	<3.0mm (for r=25mm pipe)
YB0 yoke distortion	1.4mm	<0.5mm
Field induced yoke movement	1.2mm	<1.0mm
Cavern movements	5mm	<1.0mm
Linear sum	15mm	<8.8mm
Assumed "stay-clear" radius	14mm	14mm
Min beam pipe radius	**29mm**	**~23 mm**

Beam Radiation Monitoring

RADMON: 18 monitors around UXC
PASSIVES: Everywhere



Beam Radiation Monitoring

Pixel Luminosity Telescope
- under construction: install 2012-1

Fast Beam Condition Monitors
- collaborate with LHC BI

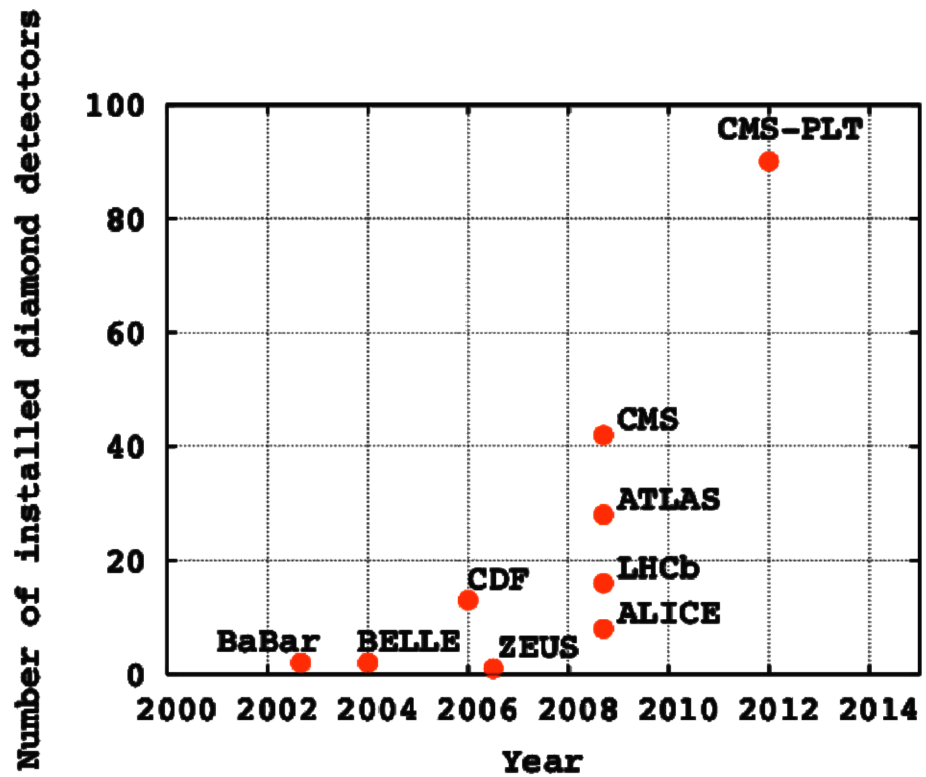
Beam Condition Monitors & abort func
- readout based upon LHC BLM
  - keep systems contemporary
  - keep collaborative effort with

Beam Scintillator Counters
- rad tolerant upgrade in 2012-13

Beam Pickup Timing for the eXperime
- zero-bias trigger remains invalua
  - needs electronics consolidati

Detectors for benchmarking radiation

CMS-BRM at the forefront of practical applications of diamond detectors



Simulation invaluable for numerous aspects of background and access planning
- additional monitoring, especially neutron monitoring and passive
-“HF RADMON” (prop chamber) & Medipix neutron Camera measured n flux
- foresee additional units

Experiment Service Infrastructure

Upgrade to:

maintain reliability at higher luminosity, radiation load & activation
eliminate perceived weaknesses threatening data-taking efficiency
replace obsolescent parts
accommodate upgraded detector

Cooling system

- establish cold operation of Si Tracker (isolate/backup from HVAC)
- filter farm cooling 600kW → 1MW (attempting in 2010-11!)
- RPC cooling : reduce operating temperature to nominal UXC temp.
- equip YE3 manifold to accommodate RE4
- improve leak tolerance/ detection/ suppression (YE1 manifold re-build)
- USC rack system extension for trigger/DAQ upgrades
- separate SCX control room cooling from filter farm

Experiment Service Infrastructure

Electrical distribution:

further improve CMS “ride-through” of electrical transients

- extend UPS & diesel coverage of SCX control room & service cavern
- install harmonic filters

Heating, Ventilation & Air Conditioning

- improve ventilation seals for shafts, safe areas and USC-UXC-LHC (as needed to maintain safe access to/work in underground zones)
- maintain minimum cavern humidity (~30% RH – workers, electronics)

Test facilities

Beam, radiation, cosmic ray or environmental test facilities

Needed for: -controlled investigation of anomalous detector behaviour
-upgrade R & D and beam validation

SPS North area: H2 beamline

-permanent combined calorimetry test apparatus
-large beam energy range due to special low energy tertiary beamline

SPS North area: H4 beamline

$-\eta-\phi$ moving platform in environmentally controlled zone, calibration laser

Large area cosmic ray tracking telescope

- replace ISR system when moving muon assembly/test to 904

Irradiation facilities

-γ, π, n, mixed field: new GIF and mixed field facilities to be supported

High Magnetic Field Facilities:

- refurbish vac & controls of M1 3T large aperture (1.4m) magnet, SPS North Area beamline H2 (should be joint project with PH, EN?)
- purchase small bore (20cm) 4T magnet for short tests of small objects.

CMS assembly & lab areas: future

External constraints : entire 3000m^2 CMS area in ISR destined for rad material treatment
entire 1500m^2 CMS area in 867 destined for machine ra material handling.

Agreed Solution (endorsed by HSE and later by Site Committee on 24/9/2009):

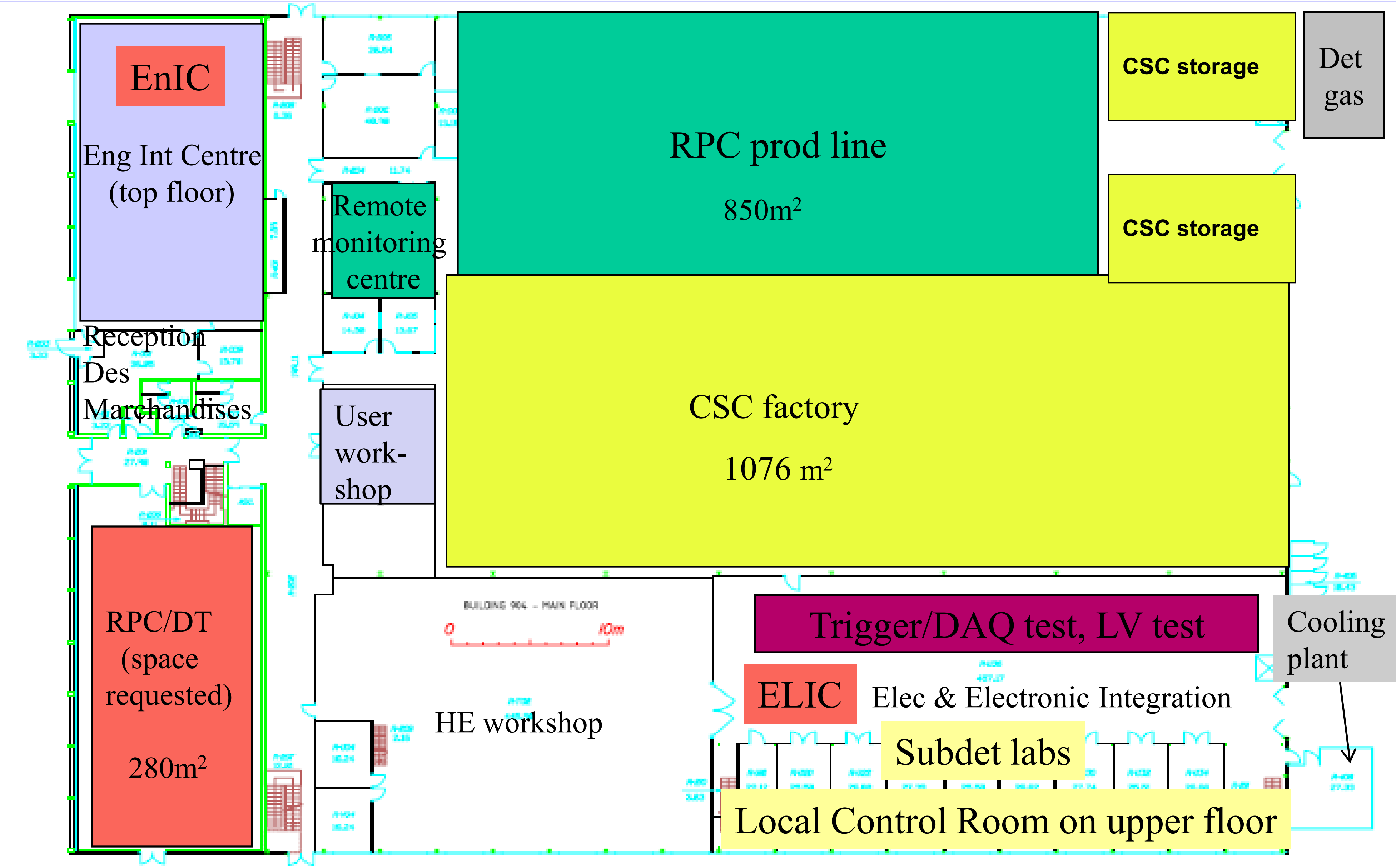
For maintenance of equipment exposed to beam in UXC (including activated material)[1]
—-> Concentrate activity in existing SX5 building, LHC Point 5, Cessy.

For maintenance of non-activated equipment NOT exposed to beam in UXC or elsewhere, And for upgrade.
—-> Concentrate activity in 186 (Meyrin) & 904 (Prevessin) + some additional smaller zones (eg 892)

Concentration ensures that CERN staff TSO and support technicians can be assigned to each of these sites. Key infrastructure will be included in TI desk monitoring.

Key building for upgrade: 904

nerve-centre for all future CMS calorimetry & muon upgrade projects



Logistics and Integration

Cranes and rigging equipment & personnel

- resources to match the intense efforts expected in 2012-3,2016

Tooling and Working platforms

- CSC/RPC tooling adapted to accommodate YE4
- shielding installation tooling
- climate controlled enclosure for working on cold Si detectors in UXC
- simplified beampipe support for some configurations to reduce risk

Engineering Integration:

- additional effort on top of M & O & host lab provision
- averages to 2 FTE engineers plus tech/draughting

Electronic & Electrical Integration

- additional effort on top of M & O provision
- averages to 1 FTE engineer plus some tech assistance.

Logistics & Integration

Logistic support teams: NB careful not to underestimate upgrade costs in this area:

Projected CMS M & O A budget lines based on an outdated LHC operating pattern:

-annual (~4 useable month) shutdown mid-Nov to mid-March.

-one end of CMS opened each shutdown (on average)

-single (mostly re-certification driven) annual maintenance cycle performed on items such as moving equipment and access devices.

-extra logistic teams required 4 months/year from the Collaboration, Field Support Units (FSU), survey & beampipe teams and contractors.

-integration, planning, field coordination efforts cover only shutdown maintenance (ie what would have to happen even if no upgrade)

Simple count of useable shutdown months 2010-16, gives:

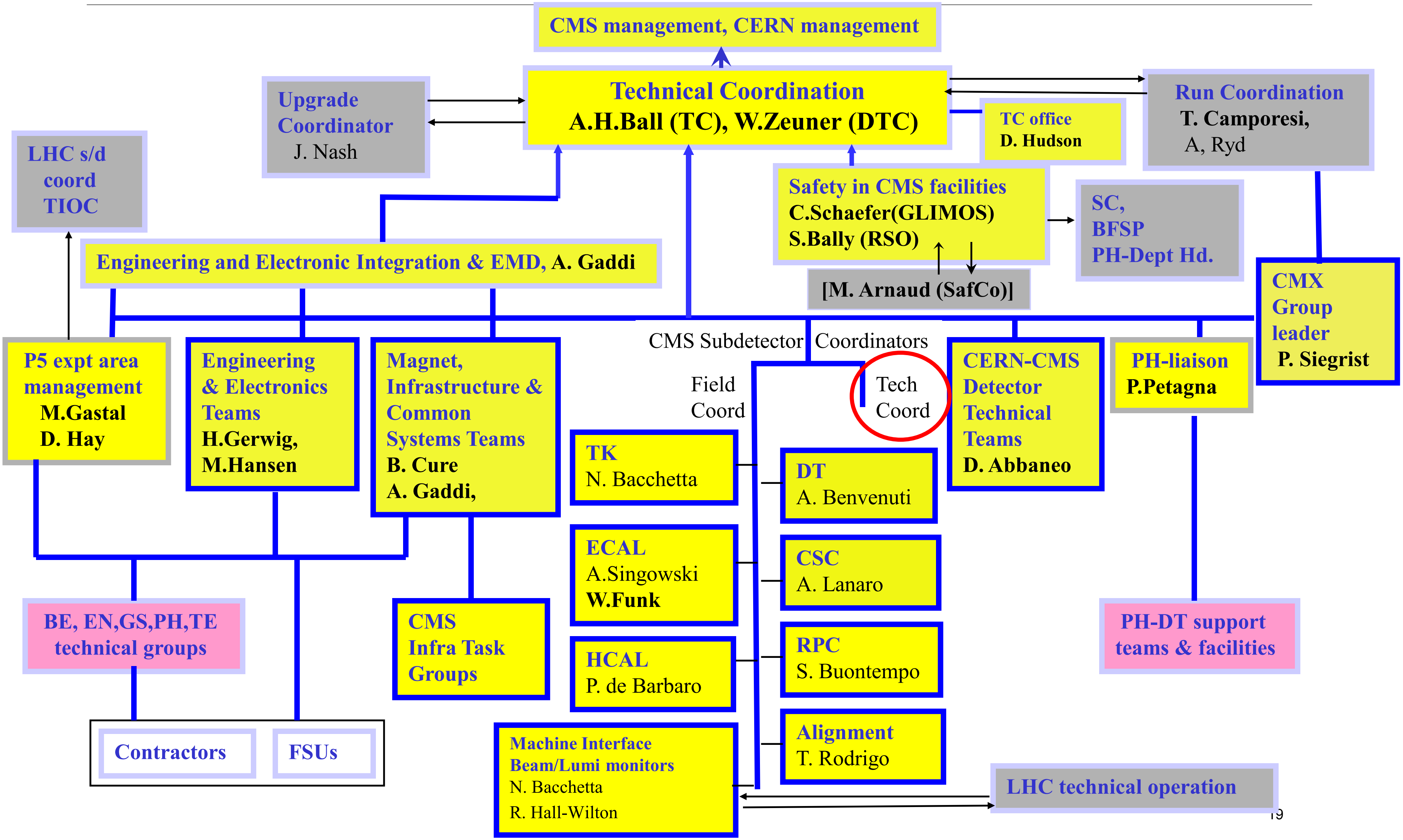
baseline model: 23 months

actual planning: 39 months

Simplistically, scale M & O provisions by at least 39/23

Reality is worse, since 2012-13 will be as intense as 2008 or 2009.

CMS Technical Organisation: Overview
for Operation, Maintenance & Upgrade Projects



Planning & Coordination

Constraints: timescale for installation of consolidation & upgrade items mostly set by readiness wrt the 2012-3 and 2016 shutdowns

technical stops (2013) 2014 can also be useful for completing 2012-3 work without full opening (maintenance permitting)

configurations of CMS limited by
- -beampipe support
- -size of UXC wrt CMS
- -procedures for bp bakeout

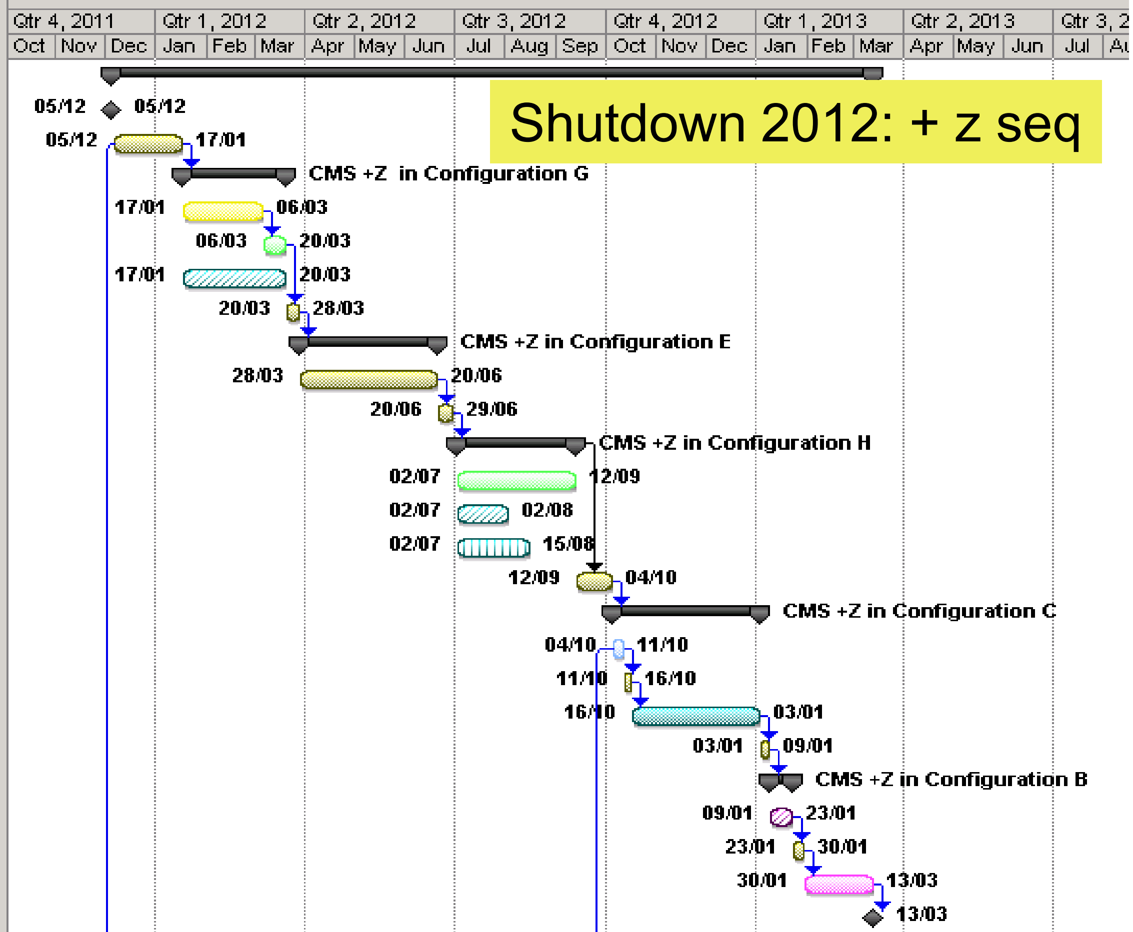
Planning : pixel & beampipe forced to be 2016
need detector fully open *(both ends)* or in bakeout most of time
compatible with HCAL barrel & endcap HPD→SiPM refurb

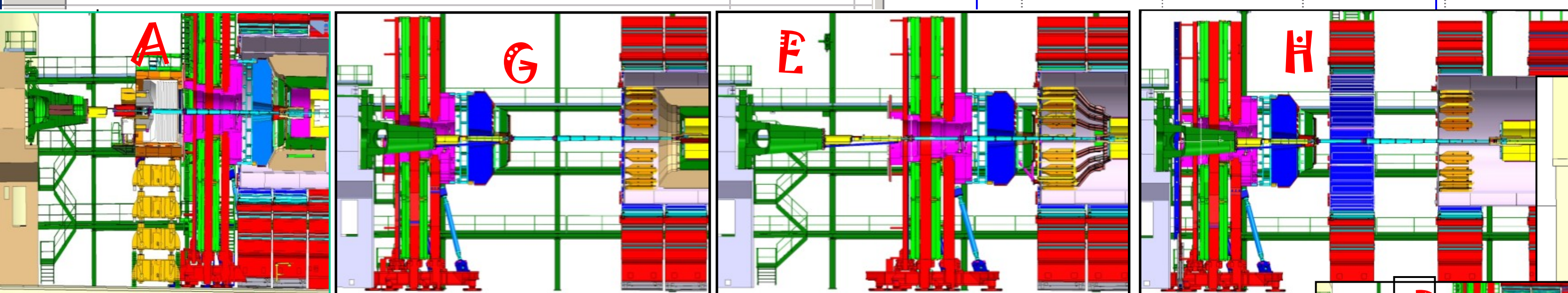
YE4 construction forced to be 2012-3
need detector closed or near closed at one end most of the time
compatible with HO HPD→SiPM refurb
YE4 pushback in case one end RPC/CSC arrives after YE4. (eg 2014)

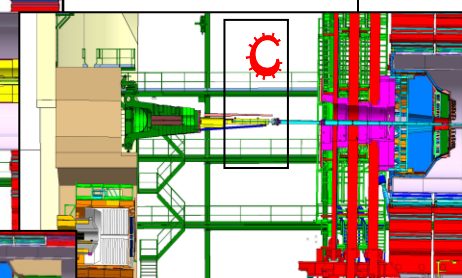
TC and EAM teams need equivalent strength to 2008-9 for this intensity of activity

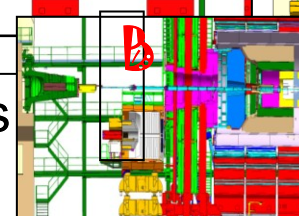
Shutdown 2012: + z seq

	Task Name	Duration
1	**+Z end sequence**	**258 days**
2	CMS in Configuration A	0 days
3	Go to configuration G	17 days
4	**CMS +Z in Configuration G**	**36 days**
5	Install PLT, Service PIX & TK	28 days
6	Replace faulty HB Readout modules on YB+2	1 wk
7	Service RPC & CSC chambers on YE+1	36 days
8	Go to configuration E	5 days
9	**CMS +Z in Configuration E**	**48 days**
10	Assemble YE+4 + new jacking system	6 wks
11	Go to configuration H	6 days
12	**CMS +Z in Configuration H**	**42 days**
13	Change HO Phototransducers on YB+2IP, YB+1AIP, YB0+Z	42 days
14	Service RPC on YB+2/+1/0+Z	18.5 days
15	Service DT on YB+1 & YB0 + upgrade infrastructure	26 days
16	Go to configuration C	13 days
17	**CMS +Z in Configuration C**	**52 days**
18	Perform Magnet Test	4 days
19	Pull out YE+4 using new jacking system	2 days
20	Install CSC station 4	46 days
21	Go to configuration B	3 days
22	**CMS +Z in Configuration B**	**8 days**
23	Install T1	8 days
24	Go to configuration A	4 days
25	Pump Down CMS Beam pipe	3 wks
26	CMS Ready for beam	0 days







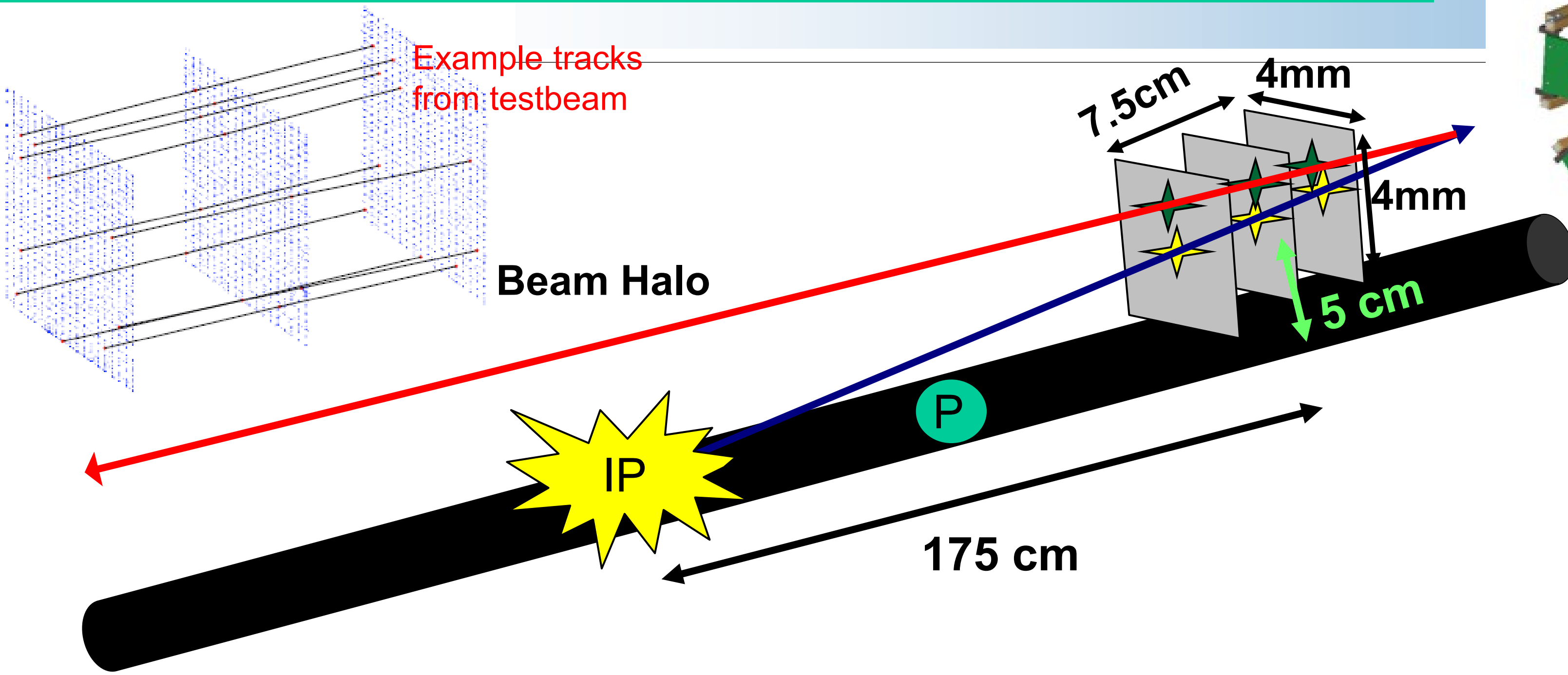


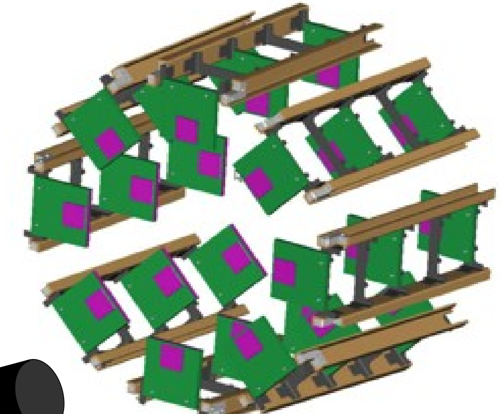
The working planning already reached 230 discrete tasks

Extras

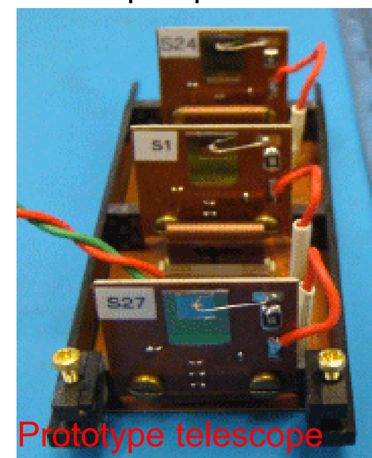
More about: assembly building 904
PLT
BSC upgrade

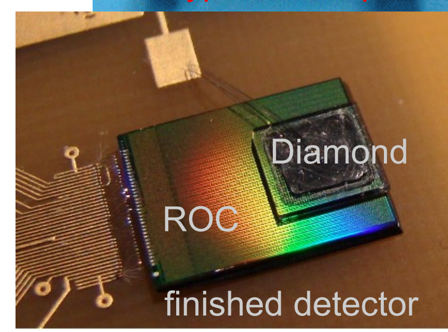
Pixel Luminosity Telescope





8 telescopes per "end"

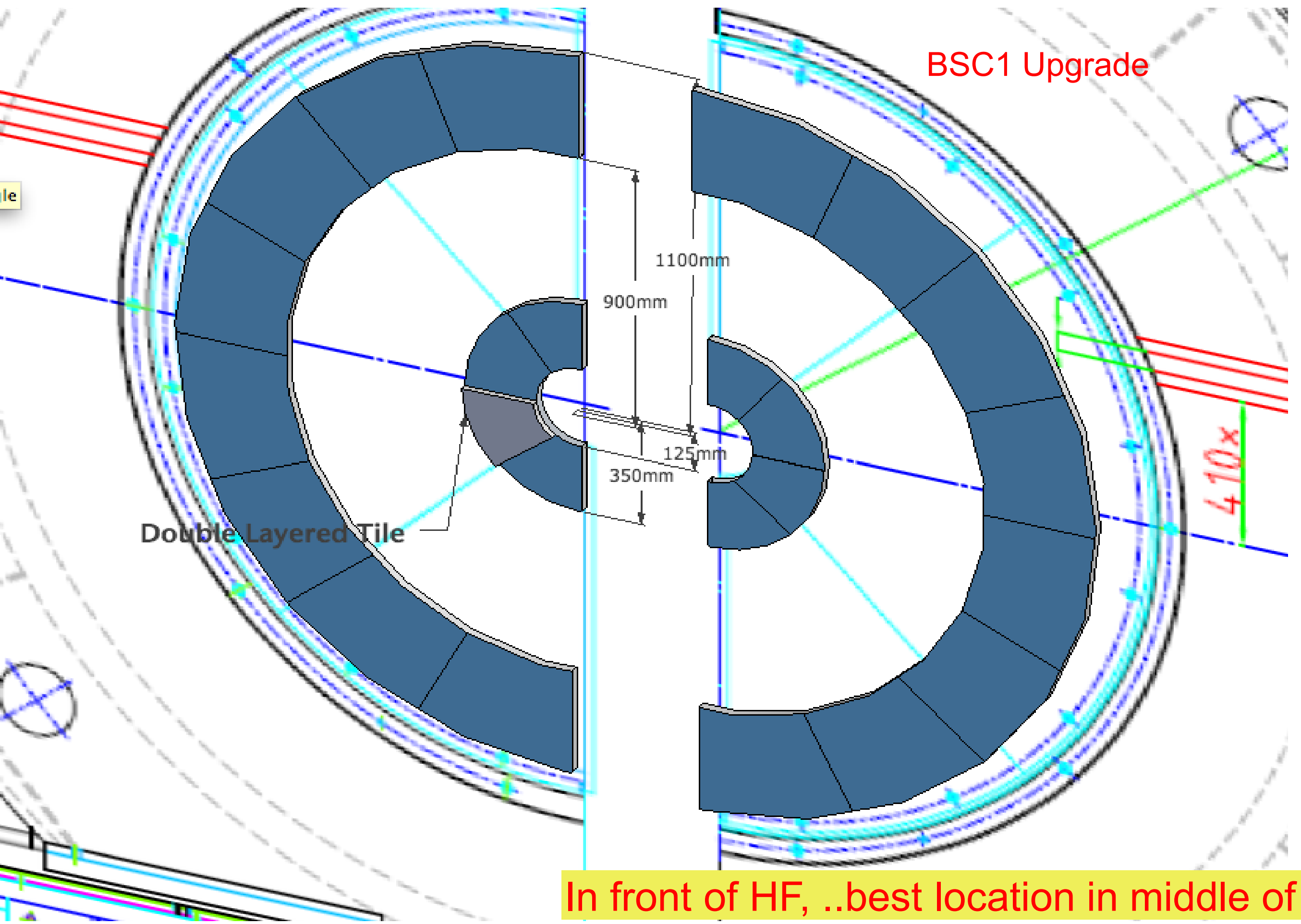




- Measure luminosity by counting tracks pointing at the IP every 25ns *"FAST-OR"*
- Online relative luminosity to a precision of 1%
- Use single crystal cvd diamond, bump bonded to pixel chip PSI46
- Tested in 3 testbeams so far - pixel yield and fast-OR >98%
- 33/60 Detectors are bump bonded at PRISM/Princeton US
- Assembly about to start at CERN
- First diamond pixel tracker to be installed in HEP
- *Testbeam results published: NIM A (2010) in press*

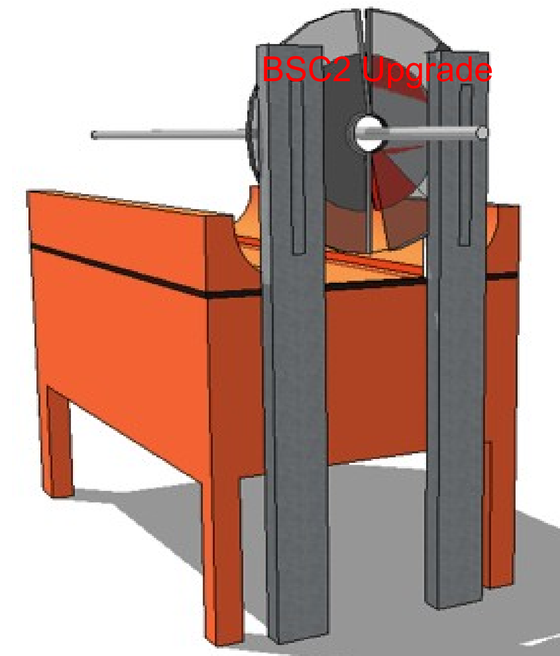
Beam Scintillator Counters Upgrade

- Beam Scintillator Counters designed for startup phase
  - Essential: Min-bias trigger for 2009-10 running
  - Design luminosity for these devices reached
  - Simple, rad-hard replacement required
- 2010 run shows that a beamgas background device for vetoing/triggering essential
- This should have high acceptance for beamgas originating in Long Straight Section

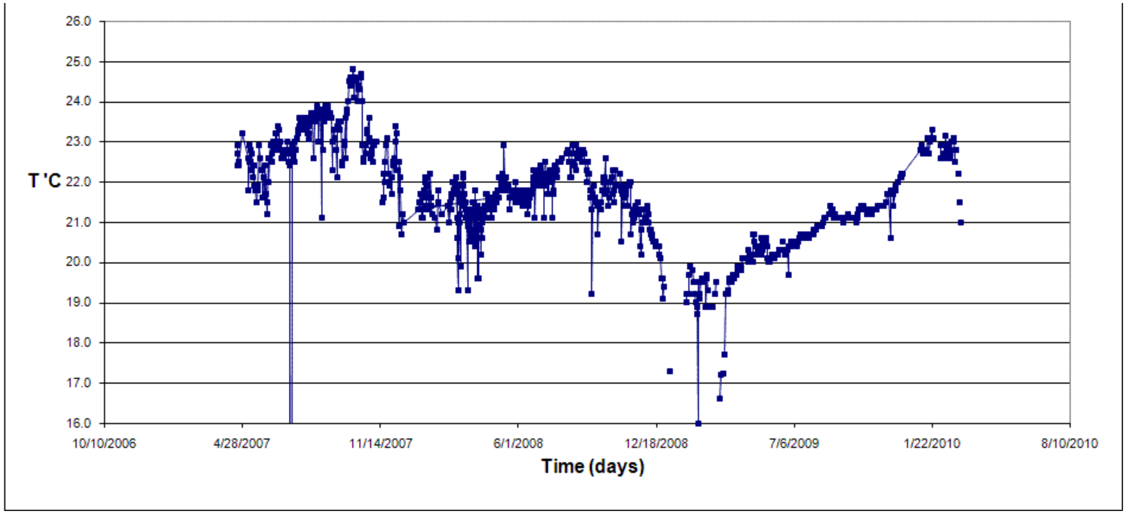


In front of HF, ..best location in middle of T1

- At least 4 planes:
- ±10m,±14.4m
- Present BSC2 alone 30% acceptance, 30% ø coverage



ISR: conditions naturally stable enough

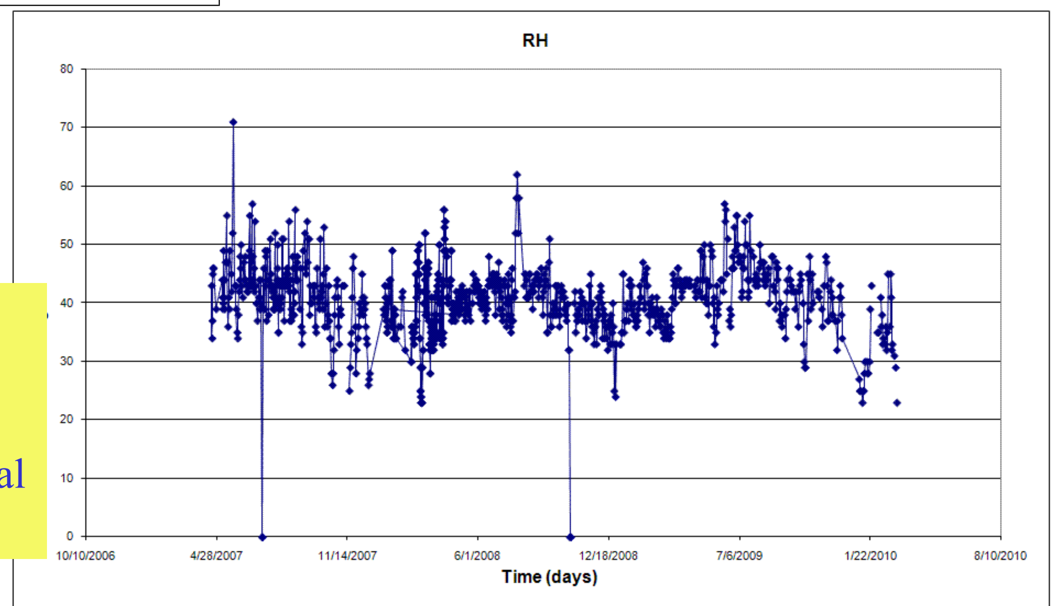


Temperature 21 ± 3 degrees C

(for RPC 20 ± 2 is ideal)

Relative humidity: 45 ± 10 %

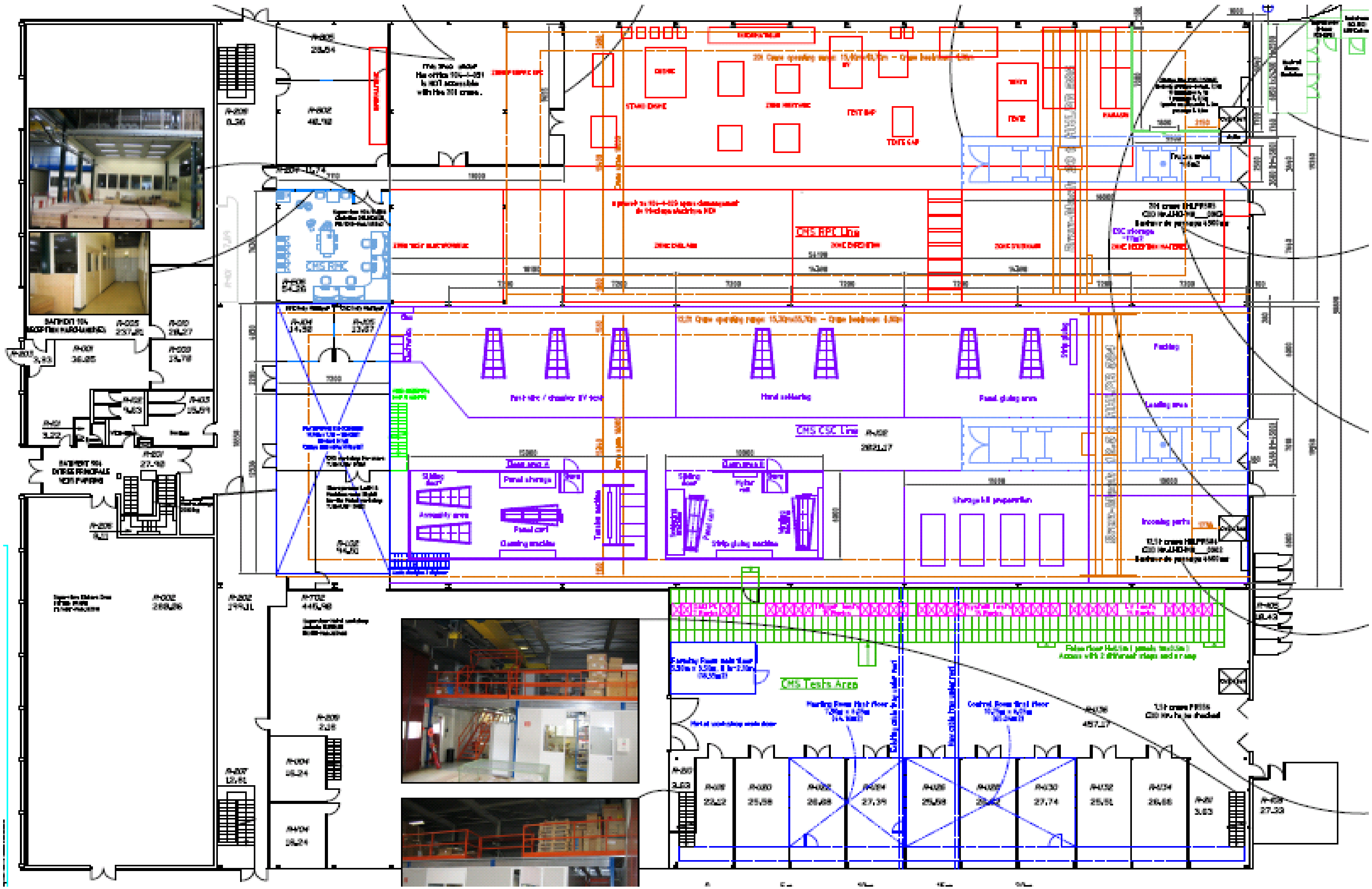
(For RPC 40 ± 5 % is ideal)



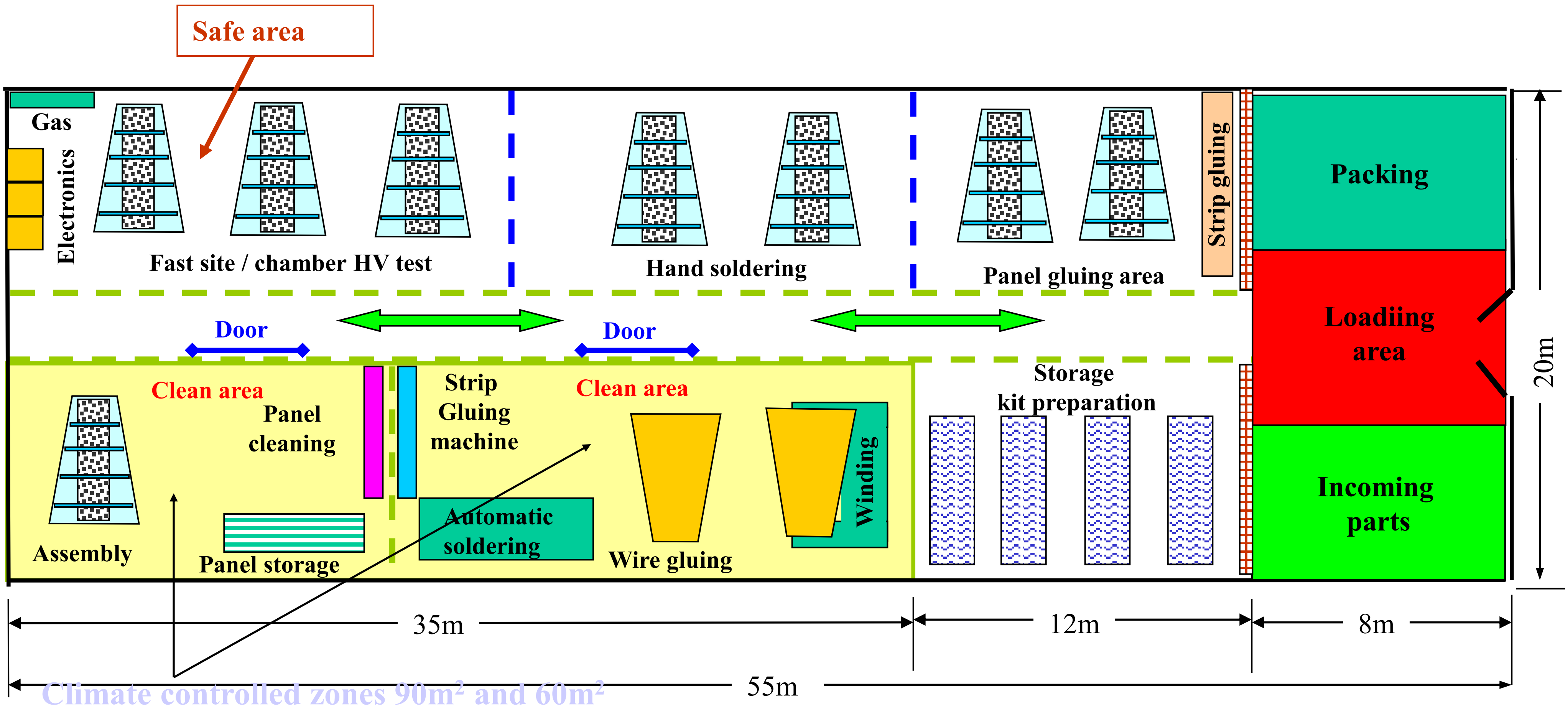
Building mods & HVAC to achieve these conditions in all of 904 VERY expensive:

CMS suggestion to use temperature-controlled internal lab enclosures with central HVAC

904 CSC/RPC production & Test facility



CSC Chamber Factory Production at CERN
Floor Layout at Bldg 904



Production line disassembled at FNAL and is at sea at this moment

O.Prokofiev
Feb 16, 2009

RPC production line