Integration issues in the tunnel and Impact on general LHC systems

- Space requirements
- Radiation levels
- Existing/missing infrastructure and associated equipments
- Interferences with Single Event Errors mitigation works
- Installation planning

  Illustrated by IR phase-1 upgrade case,

  Extension to other LHC upgrades as:
- Modification of the matching sections
- Additional collimators
- Upgrade/consolidation of the RF system

  Summary
- Underground service galleries at Pt1 & Pt5

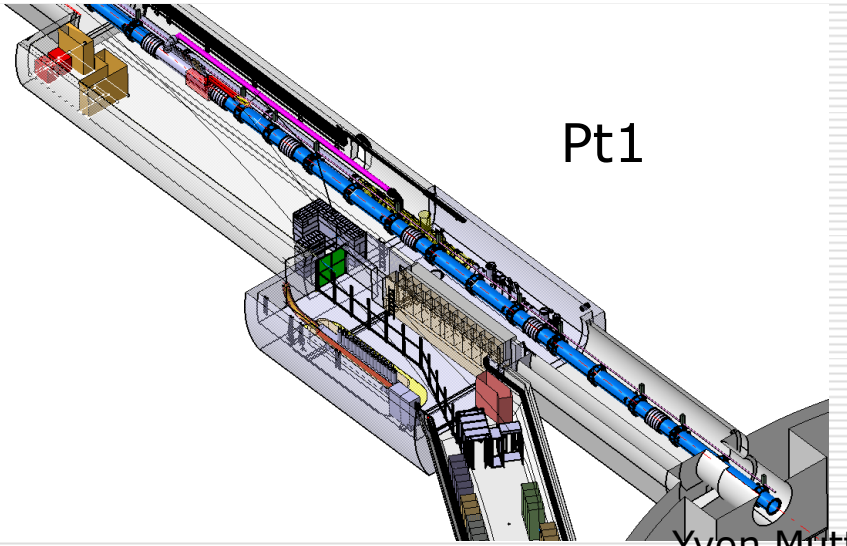
Forewords

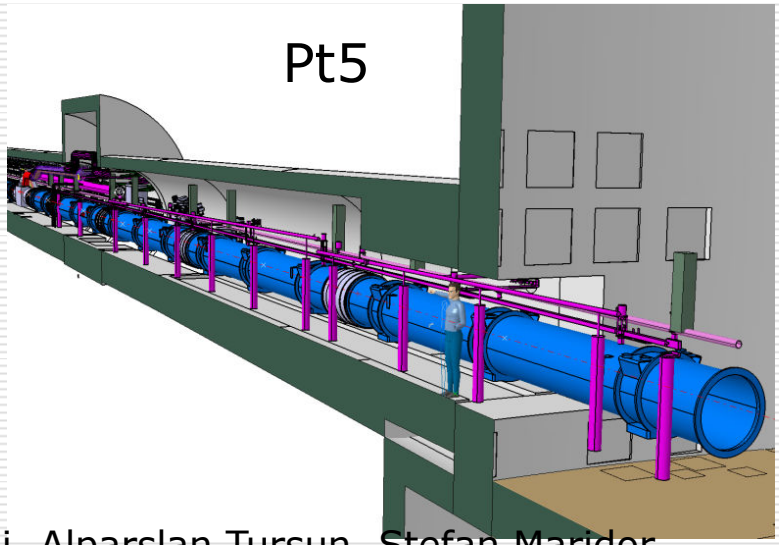
The presentation will not address the integration aspects nor planning impacts of:

- Works related to the consolidation/repair of potentially faulty bus-bar interconnects or to the implementation of the improved machine protection systems;
- Completion of some installations that are part of the LHC baseline and already prepared to occur during the forthcoming shut downs (Ex installation of 2 dilution kickers at Pt6, in addition to the 8 already in place).

Space requirements for the new triplet (1/2)

- Integrations along the beam line are well advanced at Pt 1 & 5:



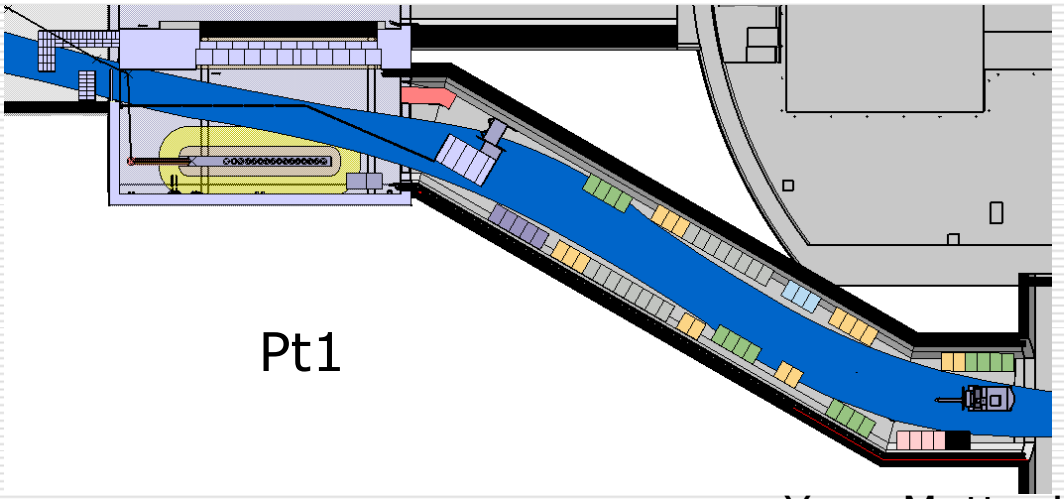


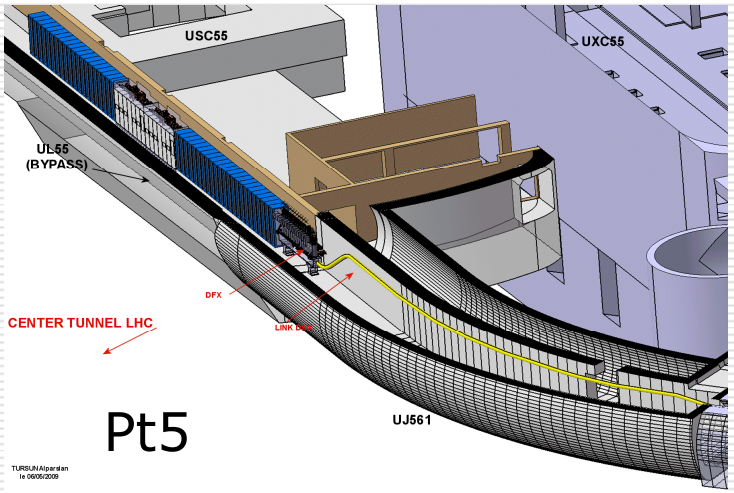
Yvon Muttoni, Alparslan Tursun, Stefan Maridor

Integration work started in 2008: although the project was in a mature state (CDR edited as LHC Project Report 1163 – 12/11/2008), it took ~1year to settle many "details" that are essential for the integration in the LHC tunnel.

Space requirements for the new triplet (2/2)

- Integration of supply, control, quench protection systems still on-going:



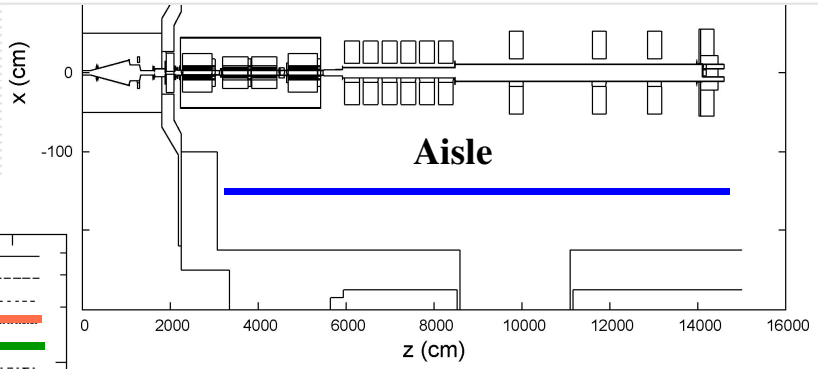


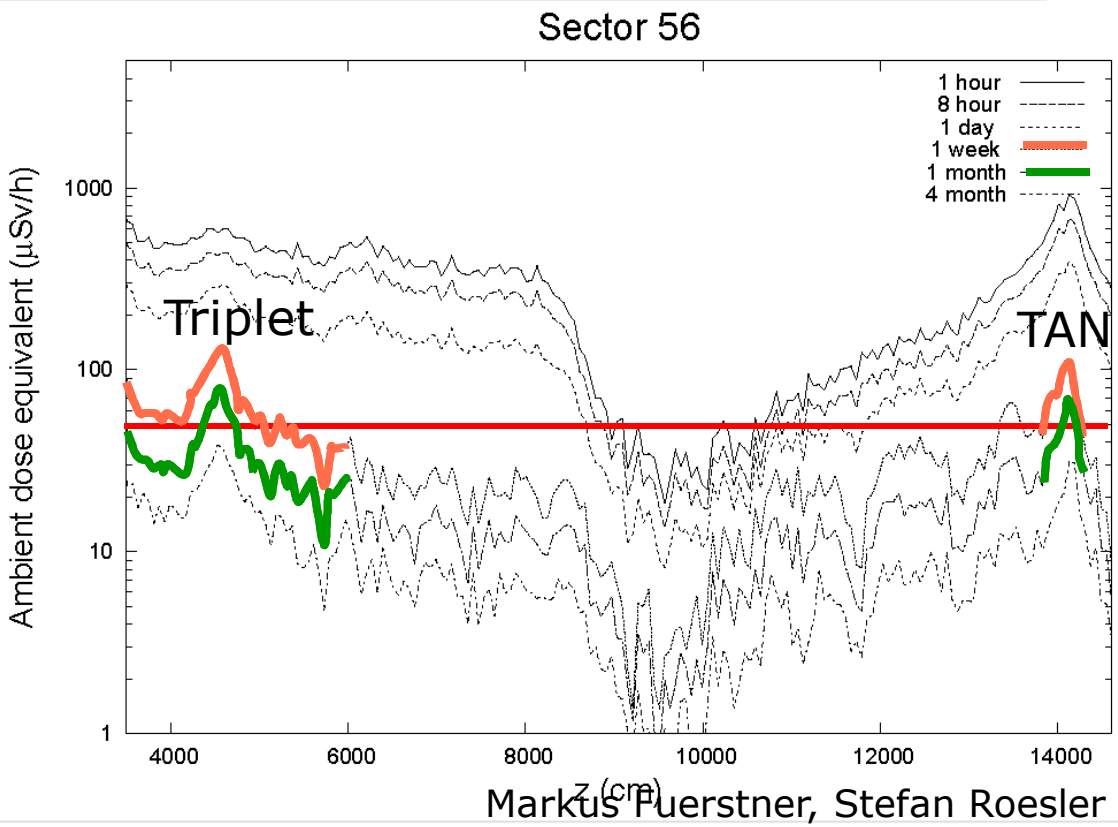
Yvon Muttoni, Alparslan Tursun, Stefan Maridor

- ➔ Racks in the UL14/16 are in the passage area, need to be remove to leave way to magnet convoys – Control racks on 3rd floor of US15
- ➔ No complete solution for Pt5 right, space available does not allow to fit all racks required (Power converter, energy extraction & control)
- ➔ Note that heat load inventories have not been done yet, some air cooling units may be required …

Radiation levels in the triplet region (1/2)

- Fluka simulation of residual dose rate:
  Pt5 with all field maps (CMS, Q1/2/3 & D1)
  and nominal yearly rate (10^7 s, 10^9 int./s)



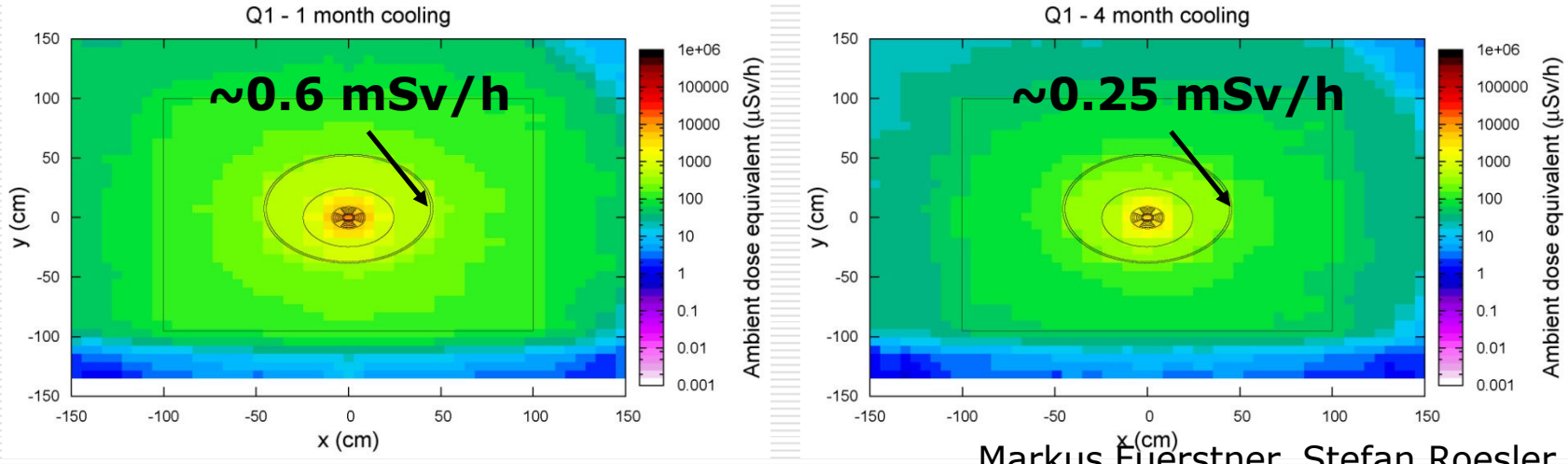


50 μSv/h
(limited stay area threshold)

➔ Need to wait ~2 weeks to start preparation work along the triplet.

Radiation levels in the triplet region (2/2)

- Activation of the Q1 assembly after 1 year at nominal conditions



Markus Fuerstner, Stefan Roesler

- ➔ Disconnection and handling in a high radiation area (> 100 µSv/h)
- ➔ Work to be done by radiation workers, type III DIMR required (maximum)
- ➔ Dedicated tooling and protection must be developed,
  with consequences on ability to carry work in parallel.

Existing/missing infrastructure and associated equipment

- Modification of the cryogenic distribution, addition of extension lines
- Dismantling, modification and re-installation of the survey system
- Replacement of the TAS, TAN, handling of very active components
- Modifications of the beam pipe and vacuum system
- Removal and re-installation of the BLM's
- New beam instrumentation, installation of associated services
- Rerouting of cable trays, pipes, etc…

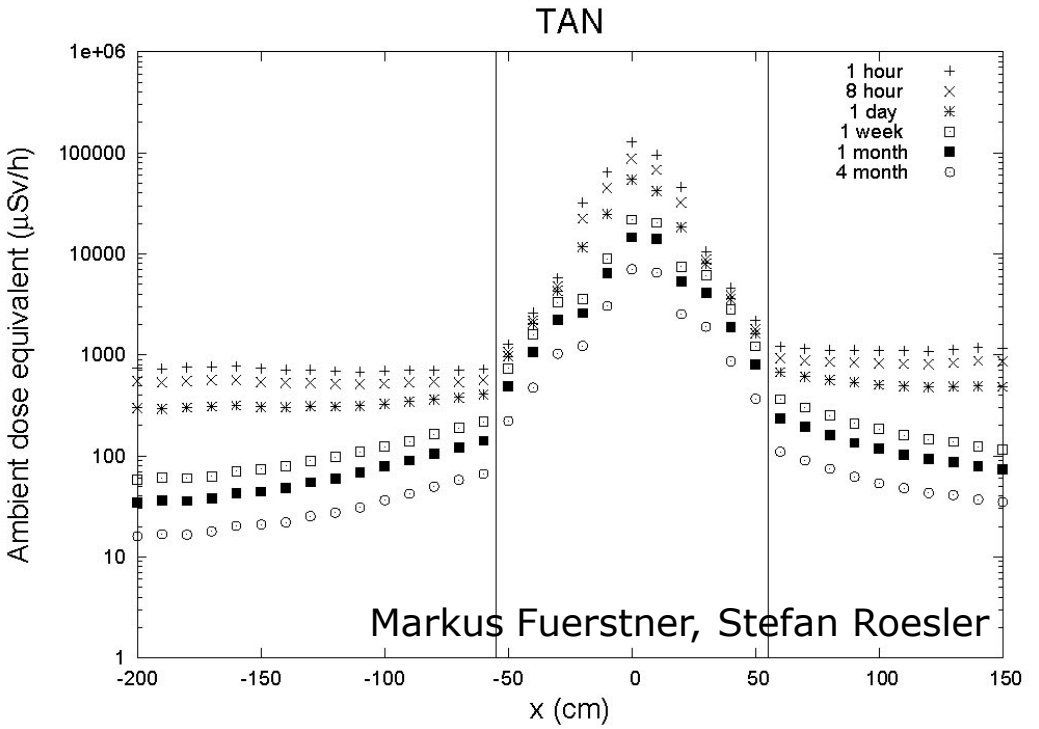
  (Only the routing of the DSX cold link has been studied so far)

➔ Most of these works accompany the upgrade of the triplets and must be done during the same extended shut down;

➔ Handling of activated material will again require extensive preparation, contracts with external firms could need some revision

Some comments about the TAN

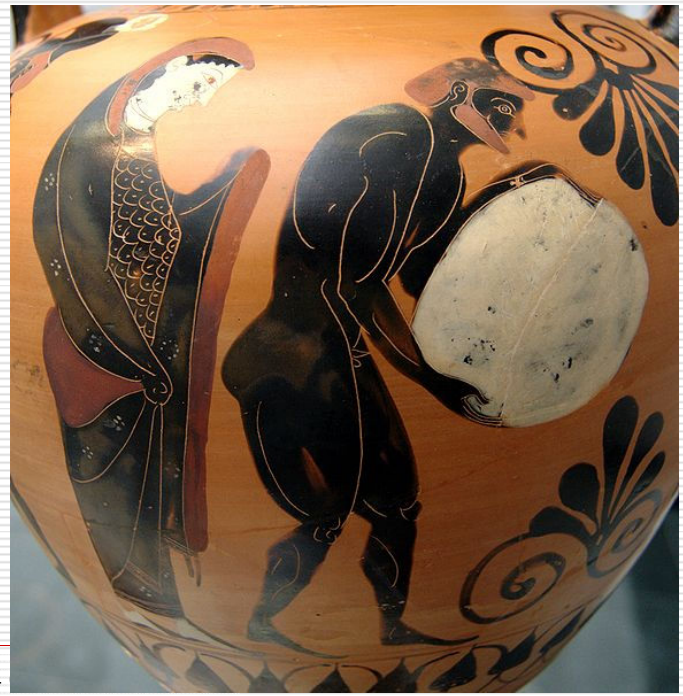
- The TAN's need to be replaced to account for a different beam separation with the new triplet.
- Inner cores of the TAN's are among the most activated material in the LHC:
  10-100 mSv range remains after nominal beams for several months.
- Additional handling at Pt5:
  TAN's must be lifted at Pt4/6



- ➔ Case for a study of an adjustable TAN, to be installed as soon as possible
- ➔ It is a warm element, that could be replaced during any shut down

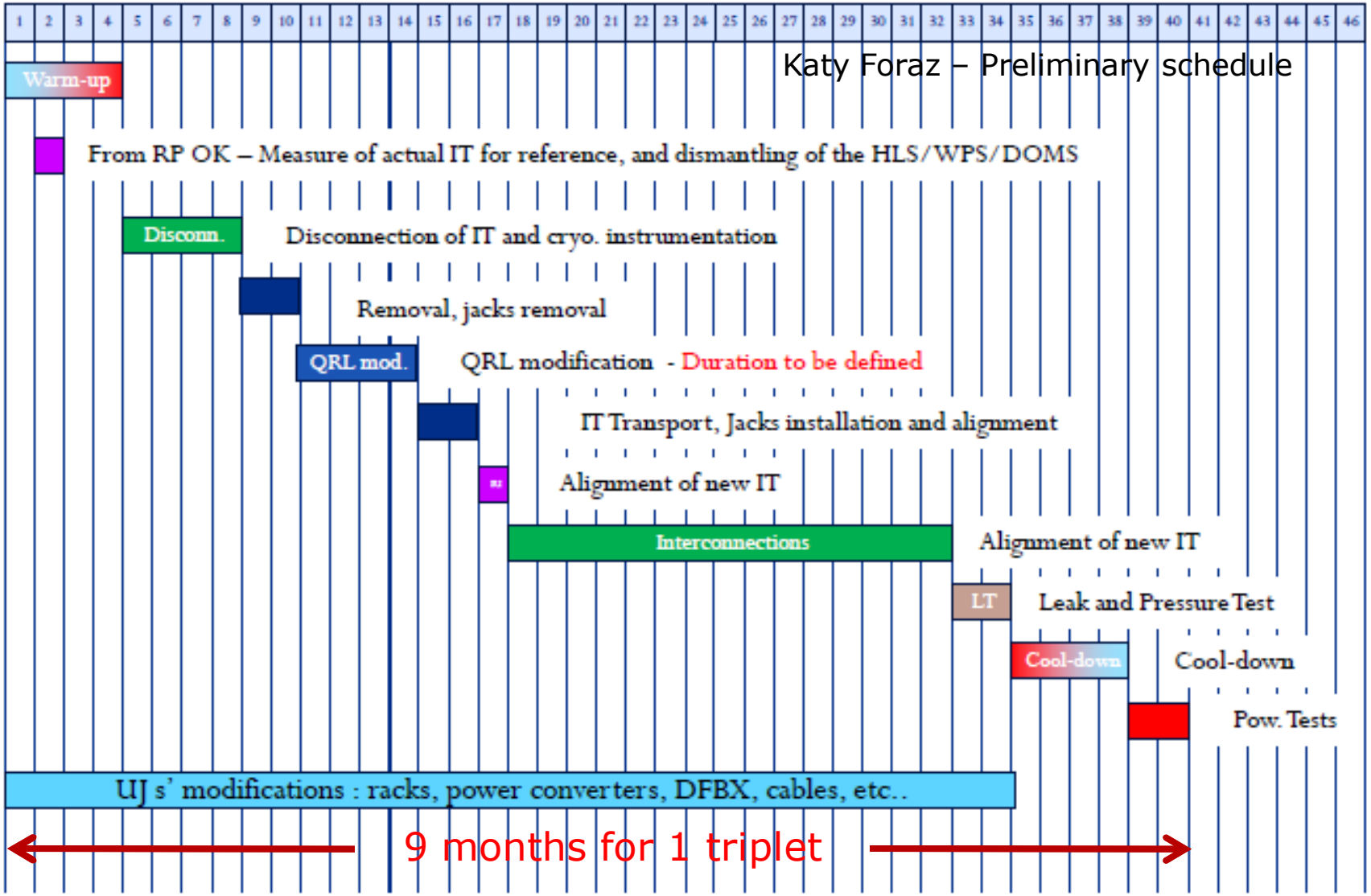
Interferences with SEE mitigation work

- SEE mitigation works around Pt1 and Pt5 will occur to cope with the increase of luminosity toward nominal conditions.
  (see presentations from Markus Brugger and Roberto Losito)
- Such works clearly get some priority since they directly impact on the overall efficiency of the LHC.
- Additional shielding and equipment relocation will modify the local environment and the underground integration needs to be revised accordingly.
- It is then quite adventurous to advance important installation/modification of services associated to the IR phase-1 upgrade.



Persephone supervising Sisyphus pushing his rock in the Underworld

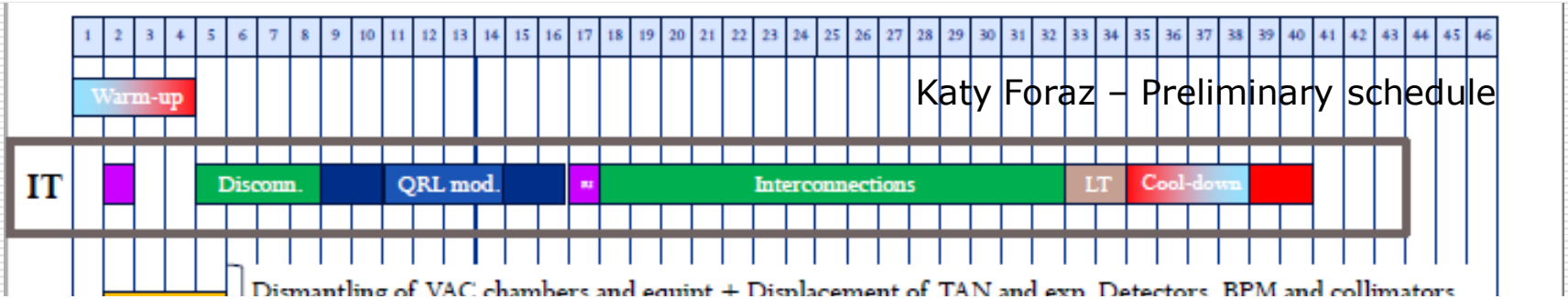
Installation planning



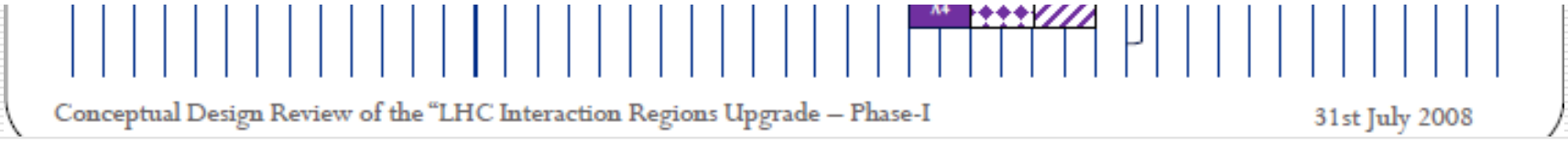
Modification of the matching sections Pt1 & Pt5 (1/2)

- All specifications should be fixed as soon as possible to start the integration work
- Will involve work in high radiation area and handling of activated elements
- Infrastructure will require modifications: cryogenic distribution and DSL powering links
- Installation/modification of the control and powering equipment in the RR's will need to cope with SEE mitigation developments
  - ➔ Activities are very similar to the installation of the new triplets;
  - ➔ Should minimize successive modifications of the MS, search a solution also valid for the phase-2 upgrade of the triplet

Modification of the matching sections Pt1 & Pt5 (2/2)



- Only a draft version, many task duration need to be consolidated
- Lots of activities involve the same expertise's as those required for the installation of the new triplets
- Global duration for the 4 matching sections, together with the installation of the new triplets, will obviously depend on the resources (teams and tooling) we can requisite to work in parallel
- Intense and tightly dependant co-activities always carry some risk of slippage: planning contingency must be envisaged
- Access points are limited (PM15, PM56), basically no material access at Pt5, need to transport from Pt4 or Pt6



Additional collimators (1/2)

Ralf's shopping list (see precedent presentation):

1) Installation of 2 TCLP collimators at Pt1/5: collimators available, infrastructure prepared
   ➔ could be installed during normal shut down, to be coordinated with TOTEM for Pt5
2) Installation of 30 "advanced phase II" collimators at Pt3/7: infrastructure prepared, R&D prototyping ongoing
   ➔ could be installed during normal shut downs as they become available
3) Installation of cold collimators in DS at Pt3/7 ➔ see next
4) Installation of cold collimators in DS at Pt2 ➔ see next
5) Installation of 2 additional warm collimators at Pt1/5: associated to lower β* optics, new infrastructure required
   ➔ could be integrated and installed together with the modification of the matching sections
6) Installation of cold collimators in DS at Pt1/5 ➔ see next

Additional (cold) collimators (2/2)

- All specifications should be fixed as soon as possible to start the integration work (Ex impact on injection at Pt2, DFBA's displacement)
- Will involve work in high radiation area and handling of activated elements (Ex at Pt3/7)
- Infrastructure will require modifications: cryogenic distribution and powering lines for quadrupoles and DFBA's displacements
- Installation/modification of the control and powering equipment in the RR's will need to cope with SEE mitigation developments
  - ➔ Problematic very similar to the installation of the new triplets or modification of the matching sections
  - ➔ Rearrangement of the magnets in dispersion suppressors requires the same expertise's as in these two cases: cutting lines, handling/transport, survey, interconnects, tests
  - ➔ Such activities would hardly fit inside a normal 4-5 months shut down (under investigation – J.P. Tock)
  - ➔ Global duration for the 2/4/6/10 DS's, will obviously depend on what we also want to implement during the extended shut down and on the resources we can requisite…

Upgrade/consolidation of the RF system

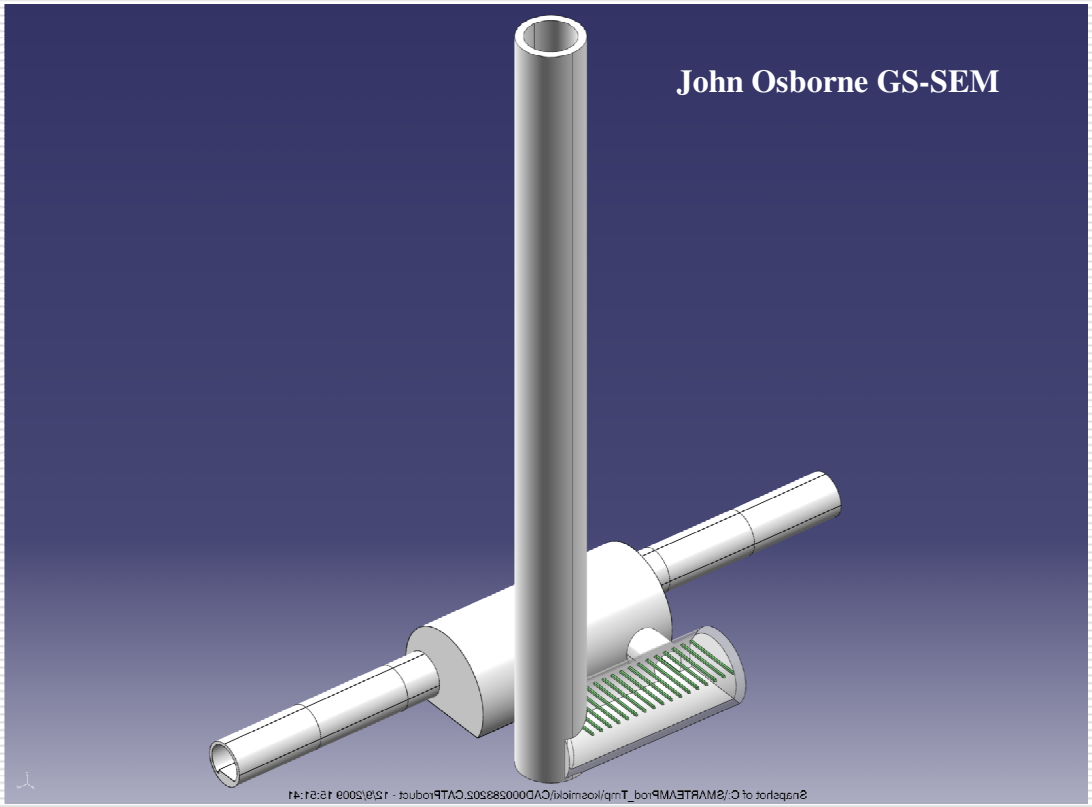
- Installation of 200 MHz capture cavities: space has been reserved for 4 cavities on each beam
  - ➔ the ACN's could be installed during a normal shut down
- Installation of additional transverse damping and feedback: space has been reserved for one additional module per ring
  - ➔ the ADT's could be installed during a normal shut down
- Installation of RF dedicated 4.5K cooling capacity: requires a new underground refrigerator cold box and cryogenic distribution
  - ➔ no integration yet, corresponding space probably available in UX45
  - ➔ installation during a single normal shut down quite challenging, but it could span over consecutive shut downs
- Crab Cavity at Pt4: no space available if 200 MHz capture cavities + additional dampers are installed; cavity temperature (2K or 4.5K) has a strong impact on the modification of the cryogenic distribution
  - ➔ need a more mature proposal to evaluate integration issues

Summary

- Space available underground just fits the needs of the LHC baseline: any modification/upgrade encounters strict limitations at Pt1 and Pt5 where there are no service galleries (UA's).
- The installation of the triplet upgrade phase-1 at Pt1 and Pt5 will probably require a ~1year extended shut down.
- Foreseen SEE mitigation works interfere with the present layout of services associated to the new triplet: it actually precludes early preparation that could reduce substantially the down time period.
- There are still many unknowns concerning the modifications of the matching section and the installation of cold collimators: precise specifications are required to start the integration process and propose a sound planning for underground interventions.

Underground service galleries at Pt1 & Pt5

- New shafts on both sides of Pt1 and Pt5 already mentioned on Tuesday to provide alternate paths for He release
- Shafts and caverns close to the RR's at Pt1/5 where also mentioned yesterday to relocate SEE sensitive equipment



Underground service galleries at Pt1 & Pt5

New Shafts / Base Caverns for RR13, RR17, RR53 and RR57

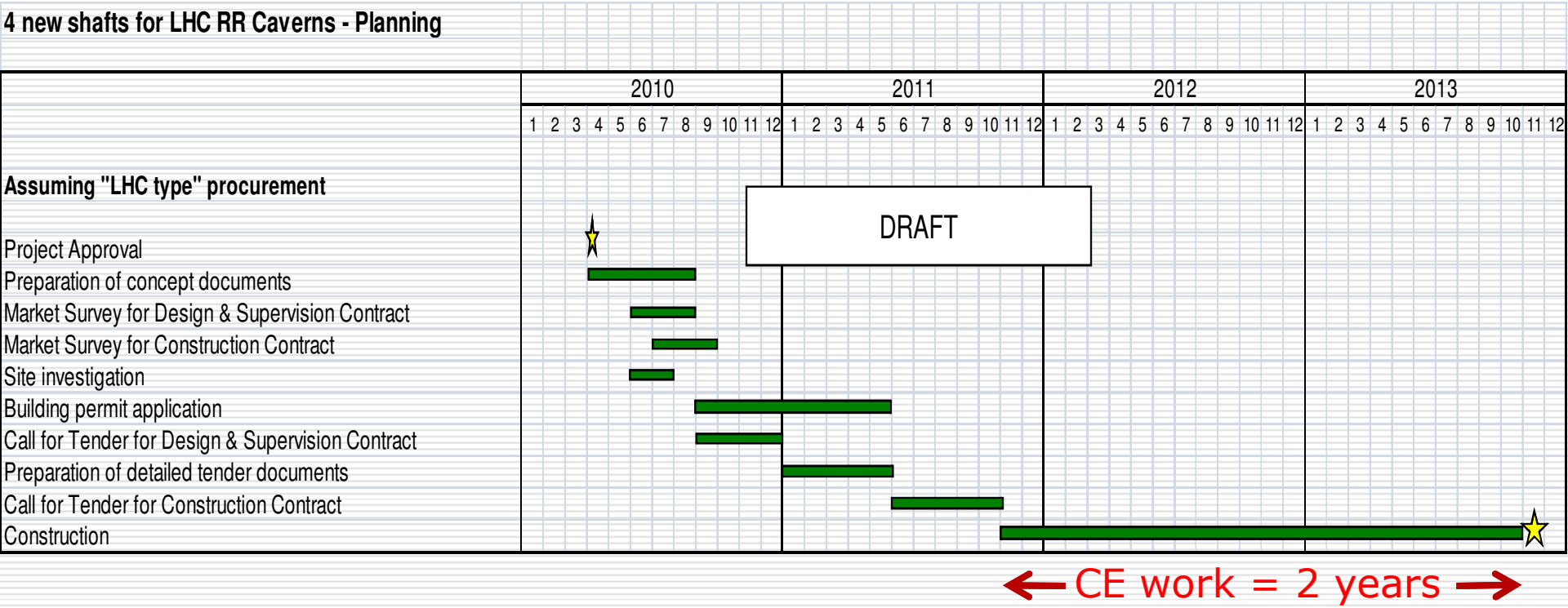
Cost estimate for CE

	RR13	RR17	RR53	RR57		
Site Investigation (boreholes)	50'000		50'000	50'000		150'000
Site Installation	1'000'000		1'500'000			2'500'000
5m diameter shaft	3'500'000	3'500'000	6'000'000	4'000'000		17'000'000
Base Cavern	2'000'000	2'000'000	2'000'000	2'000'000	26%	8'000'000
Access gallery	750'000	750'000	750'000	750'000		3'000'000
10% Contingency for unknown/missing items						3'065'000
12% Consultancy fees						4'045'800
				Total		CHF 37'760'800

	POINT 1	POINT 5
Hauteur	80m	90m
Diametre	5m	5m
Volume	4000m3	4500m3
Morraines	0 à -20m	0 à -50
Molasse	-20m à -	-50m à -90m

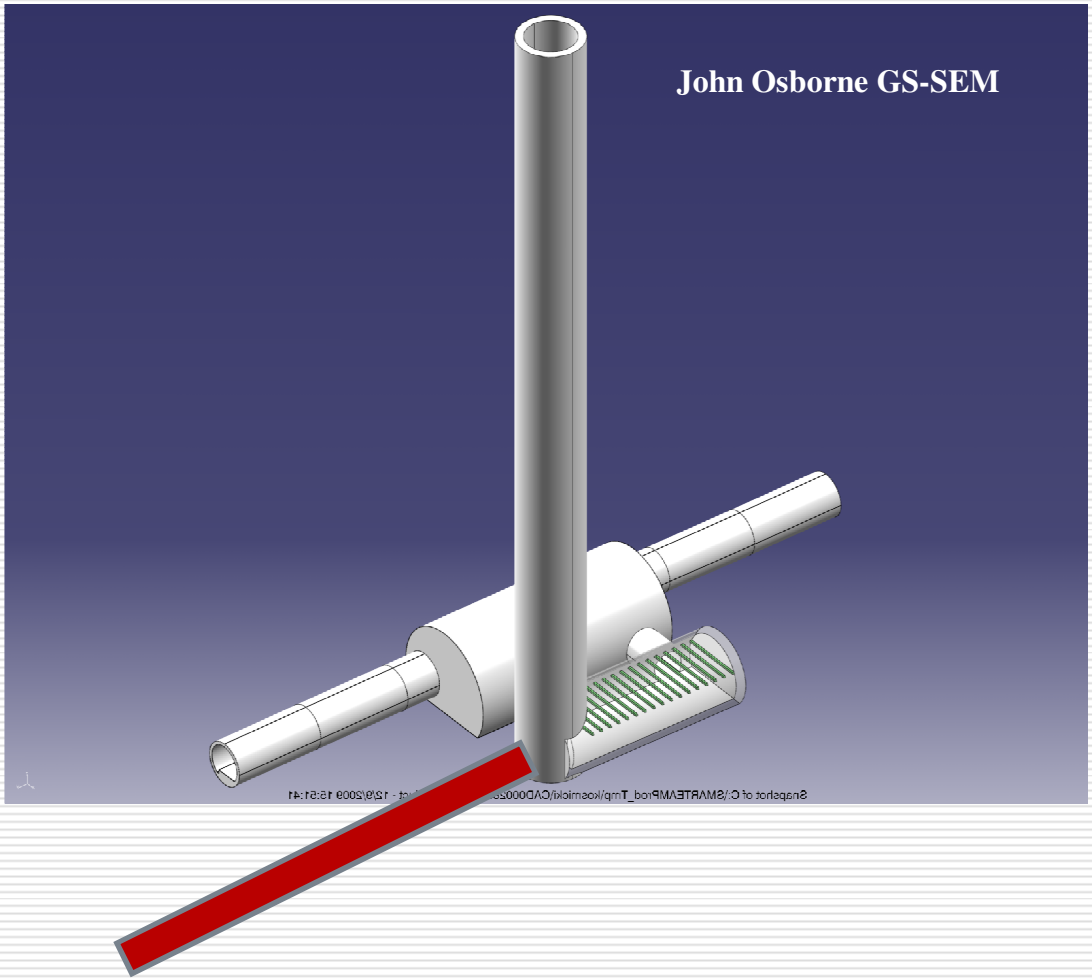
Estimate accuracy +/-20%

Underground service galleries at Pt1 & Pt5

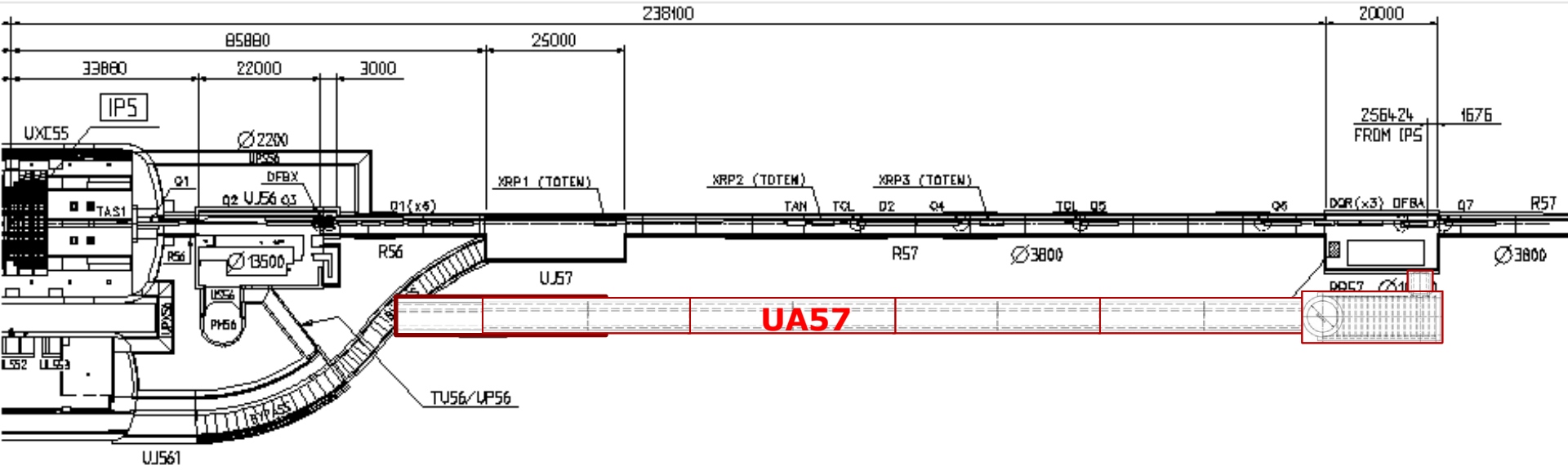


Space for the evolution of the high luminosity insertions

- New shafts on both sides of Pt1 and Pt5 already mentioned on Tuesday to provide alternate paths for He release
- Shafts and caverns close to the RR's at Pt1/5 where also mentioned yesterday to relocate SEE sensitive equipment
- It could be the "seed" for service galleries at Pt1/5



Space for the evolution of the high luminosity insertions



- It is clearly a very important investment
- But can we do without it?
  Long term SEE mitigation, IR upgrade phase-1 & phase-2, local Crab Cavity with dogleg, additional cryogenics, etc…
- Should be discussed at the mid-April workshop that Roberto announced yesterday?