Phased Approach to the LHC Insertion Upgrade and Magnet Challenges

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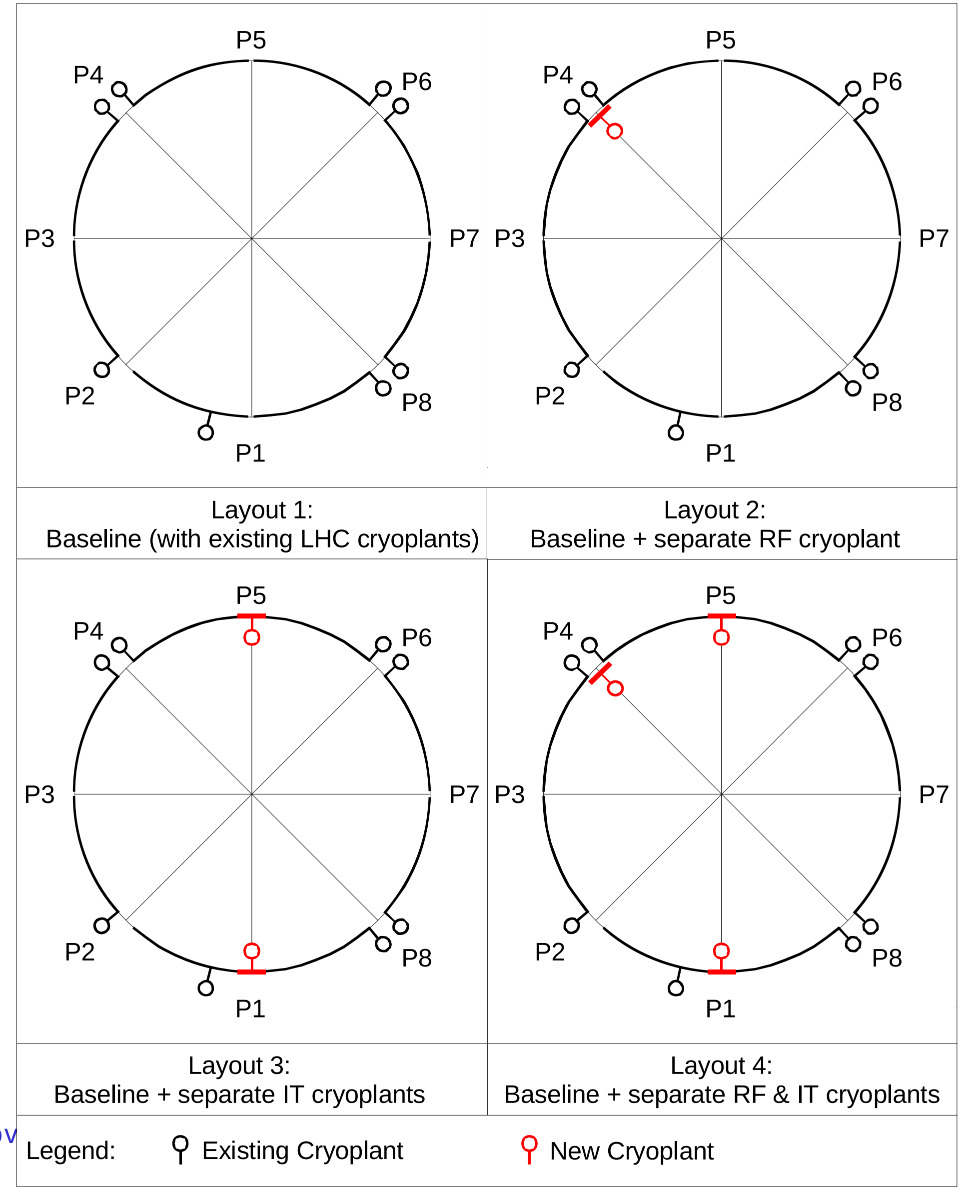
Some boundary conditions for LHC upgrade

- LHC is (almost) complete and the sectors are being progressively cooled down and commissioned.
- There is a wealth of ideas how to upgrade the LHC systems, mostly in the insertions.
- LHC relies on the injector chain and its reliability, which has priority in maintenance and upgrade.
- Any upgrade of the LHC insertions in the first period of running has to comply with the operations schedule and existing infrastructure.
  - Some examples follow …

Cryogenic layout configurations



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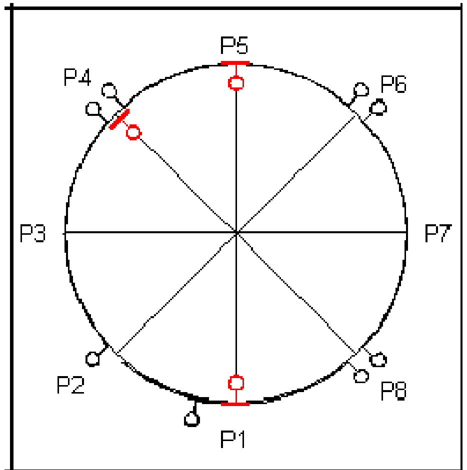
Equivalent installed capacity of additional cryoplants

Cryoplant		Inner Triplet cryoplant			RF cavities cryoplant
Operating temperature	[K]	1.8	2.0	4.5	4.5
Power to be extracted	**[kW]**		**3.4**		**4.5**
Contingency coefficient	**[-]**			**1.5**	
Installed capacity	**[kW]**		**5.1**		**6.7**
Equivalent capacity @ 4.5 K	[kW]	18.3	16	5.1	6.7



Layout 4:
Baseline + separate RF & IT cryoplants

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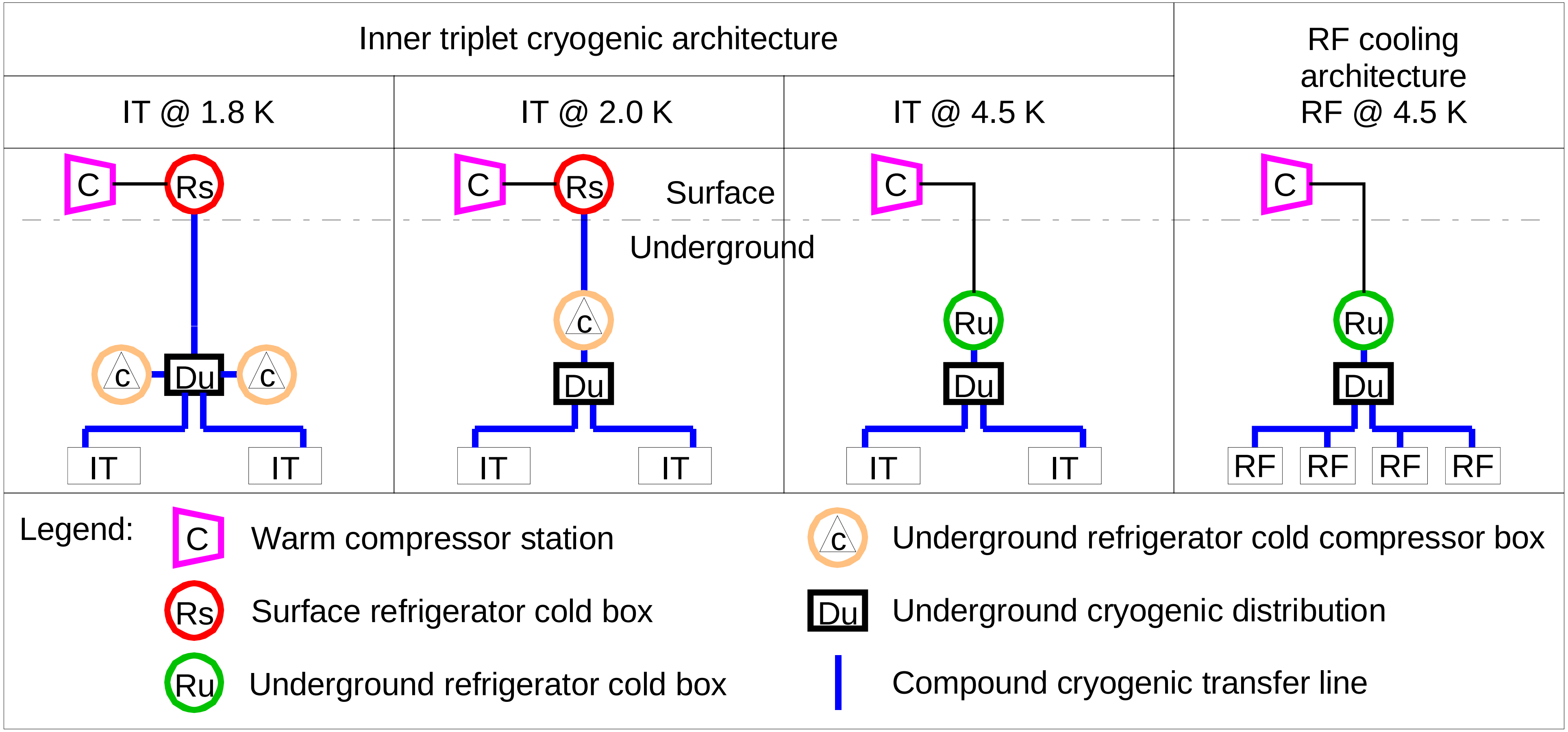
Cryogenic architecture



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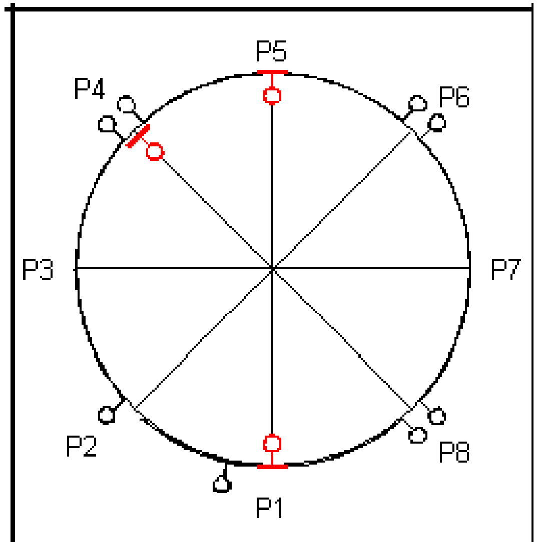
Estimated cost of cryogenic upgrade

IT operating temperature	IT upgrade	RF upgrade	Total
[K]	[MCHF]	[MCHF]	[MCHF]
1.8	**69**	**14**	83
2	**56**	**14**	70
4.5	**28**	**14**	42



Layout 4:
Baseline + separate RF & IT cryoplants

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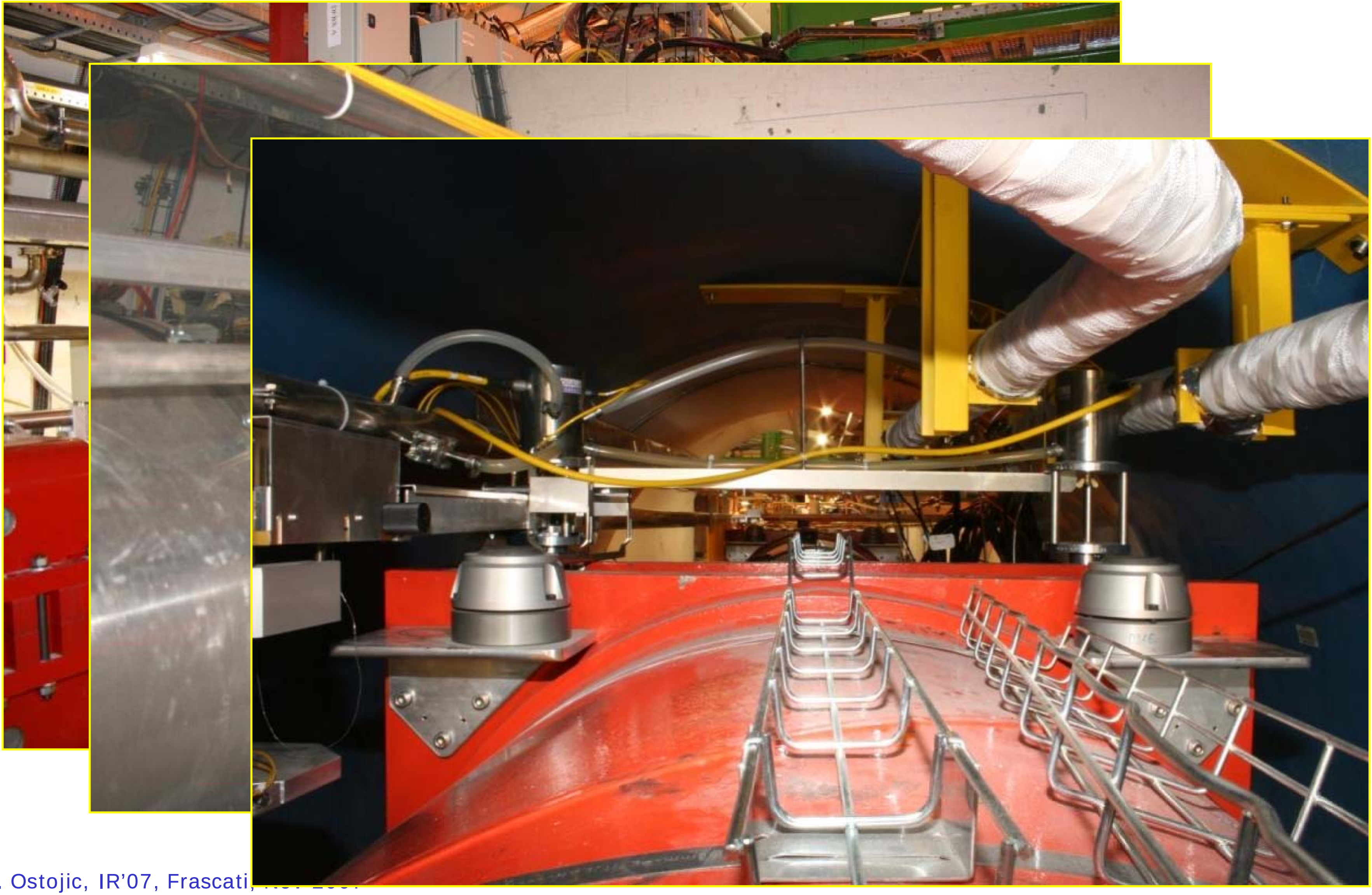
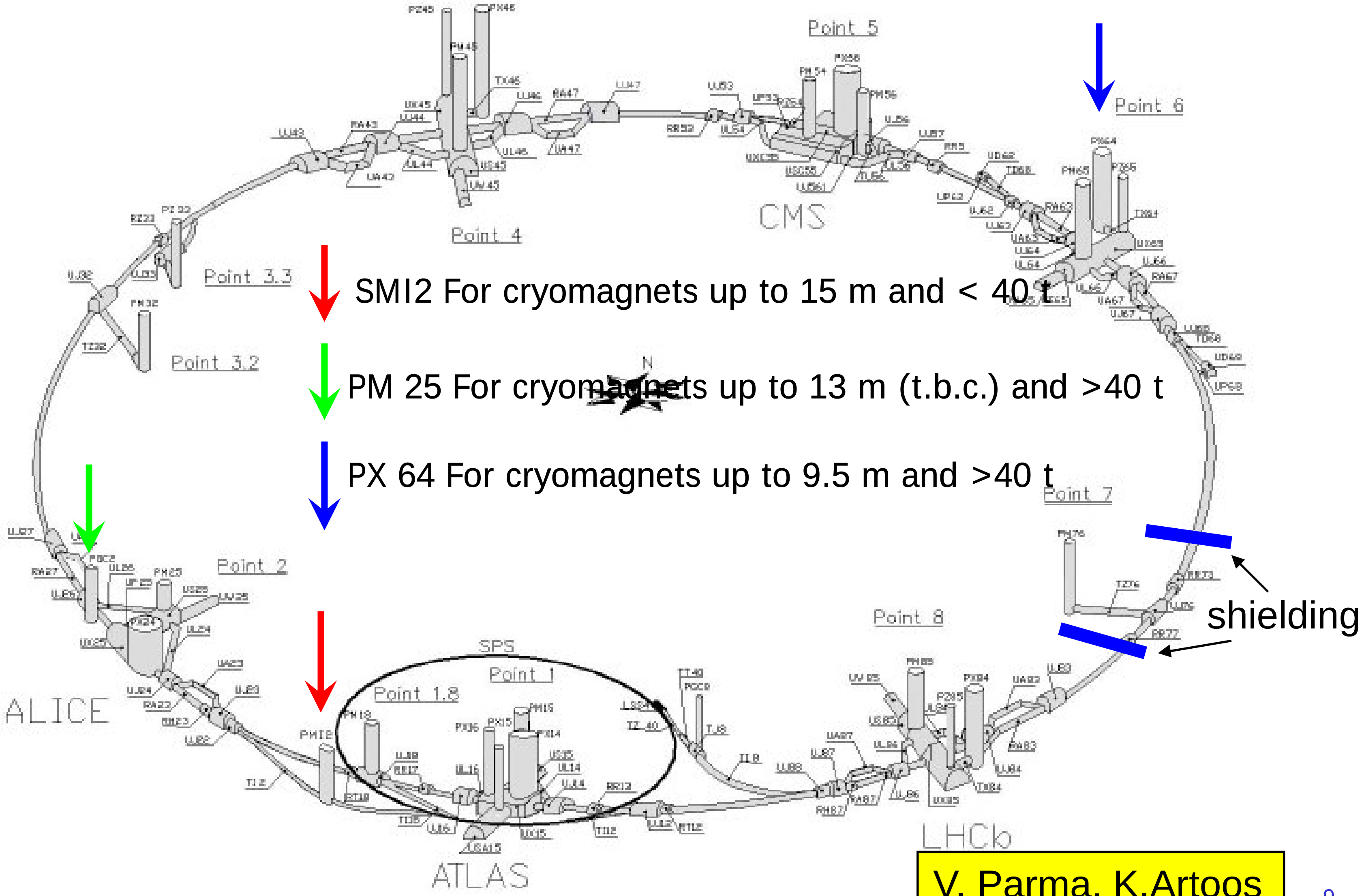
Tunnel configuration in IP1



Tunnel configuration in IP5

Access points to the LHC tunnel



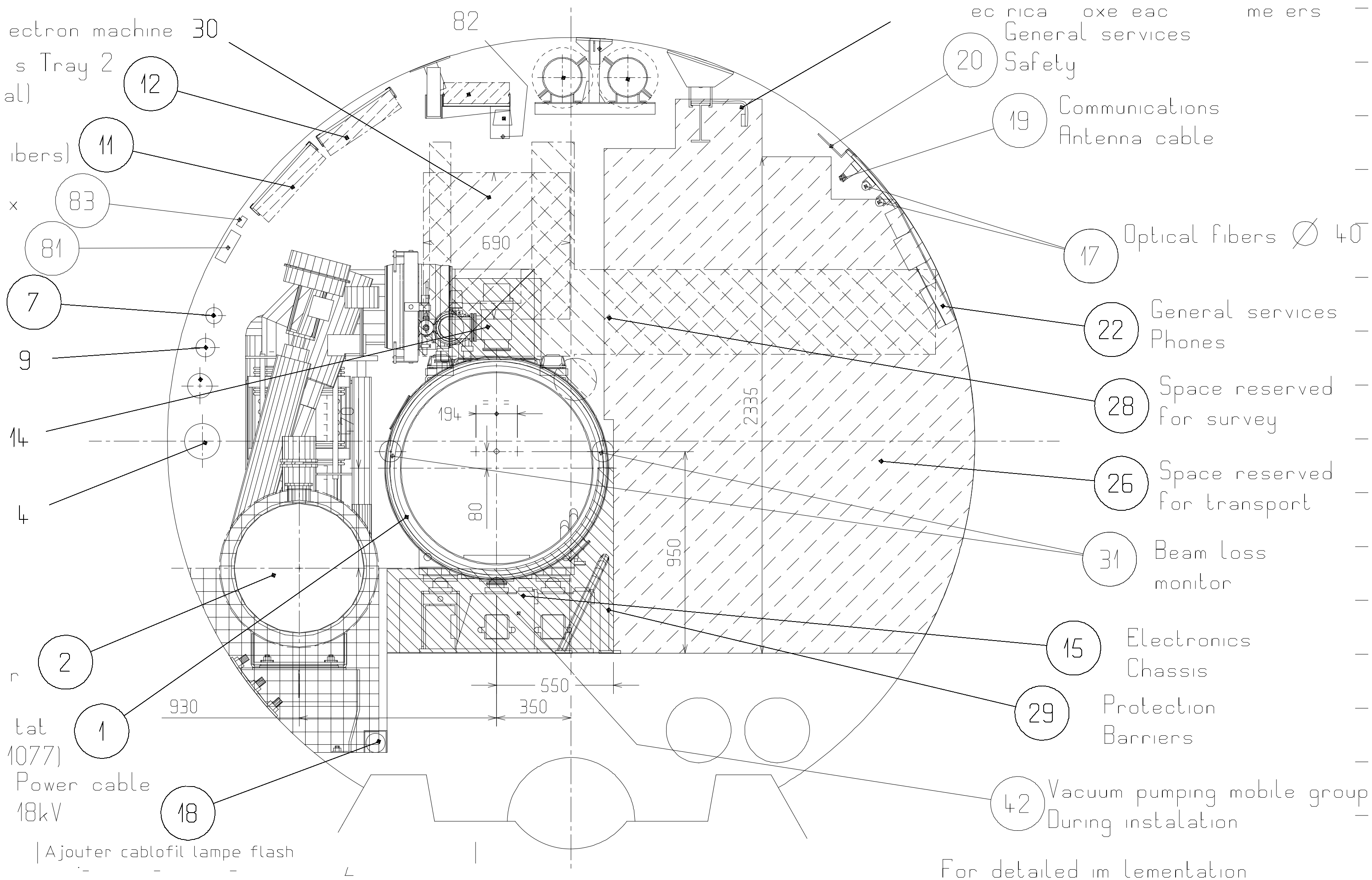
SMI2 For cryomagnets up to 15 m and < 40 t

PM 25 For cryomagnets up to 13 m (t.b.c.) and >40 t

PX 64 For cryomagnets up to 9.5 m and >40 t

V. Parma, K.Artoos

LHC tunnel cross-section



Transporting magnets in LHC tunnel

Phasing of LHC upgrade(s)

- Due to several reasons (technical and budgetary), the upgrade of equipment in the LHC will be naturally phased and will contain several “targets”.
- New equipment must be installed in such a way as to minimize the disruption to the running the LHC.
- Several bottlenecks are known to limit the luminosity reach of the LHC (e.g. collimation system, triplet aperture). They should be removed as soon as practically possible.

Scope of “Phase I” upgrade of the LHC insertions

- Upgrade of ATLAS and CMS experimental insertions.
- Quadrupole-first option.
- Interfaces with the experiments remain unchanged ($\pm$19 m).
- Wide aperture inner triplet quadrupoles based on available, well characterized LHC dipole cables (Nb-Ti) cooled at 1.9K.
- D1 separation dipole, TAS and beam-line absorbers adapted to the triplet aperture.
- Present cooling capacity of the cryogenic system and other infrastructure elements remain unchanged.
- Modification of other magnets (D2-Q4), and introduction of other equipment in the insertions if resources available.

Goal: enable focusing of the beams to a $\beta^*=0.25$ m in IP1 and IP5, and reliable operation of the LHC at 2 10^{34} $cm^{-2}s^{-1}$ on the horizon of the physics run in 2013.

LIUWG Mandate

As part of the LHC upgrade activities, the LHC Insertions Upgrade Working Group is mandated to develop conceptual and technical designs of the new layout of the inner triplets and other directly associated equipment in the ATLAS and CMS high-luminosity insertions. The goal of this stage of the upgrade is to be able to focus the beams at the two IPs to a spot size corresponding to β^* of 0.25 m, and to reliably operate the LHC with a luminosity of about 2 10^{34} $cm^{-2}s^{-1}$.

The new insertions will be based on the available magnet technology, in particular on the use of Nb-Ti superconducting cables produced for the LHC, and will respect the present interfaces with the two experiments, the available cryogenic cooling capacity and other infrastructure in IR1 and IR5.

The Working Group will report to the overall Project Leader for the LHC Upgrade Activities and will inform regularly the management of the AB and AT Departments. The final results of the studies will be summarized in the Conceptual and Technical Design Reports, to be issued in 2008 and 2009. The reports will contain the final proposal with the planning and costs.

Magnet challenges

- Produce the magnets and perform a string test of the full inner triplet by 2012!
- Finalize the choice of the main quadrupole parameters specific to the layout and optics, and compatible with LHC constraints.
- Focus limited R&D on magnet “transparency”:
  - Thermal optimization of the cable and coil insulation, and of the collaring and yoking structures
  - Thermal coupling to the heat exchanger
- Reduce the specific heat load to 1.9K and 4.5K temperature levels.
- Find cost-effective solutions for “lower” priority equipment (or involve external collaborations).

Summary

- The “phase I” upgrade of the LHC is focused on removing known bottlenecks and enabling reliable operation of the machine at its “ultimate” parameters. This intermediate upgrade must be compatible with the operations schedule and the existing major infrastructure.
  - The shortest route for providing new magnets in a time frame compatible with this goal is to use existing Nb-Ti technology, where improvements for a small series are still possible.
- Achieving optimal operation of the LHC in medium-term requires extensive modifications in the injector chain. The “phase II” (final) upgrade needs to be synchronised with the completion of new injectors, and with substantial improvements in the cryogenic infrastructure in the ATLAS and CMS insertions.