WG3 (Cryomodule) summary & plan with recommendation to the CB

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Objectives

- Warm or cold magnets?
- Technical spec. and interfaces for cavity helium vessel and tuner
- Coupler requirements and assembly constraints
- Alignment requirements for cavities and quads
- Dimensions , T and P for cryomodule cryogenic lines (depending on cryogenic scheme adopted)

- ***Prepare ingredients for:***
  - ***The preparation of the technical specification for the prototype cryomodule***
  - ***And refining the objectives for the prototype cryomodule program***

Machine layout issues & recommandation 1/2

- Key feature (outcome sectorisation workshop): availability of the machine
  - High reliability/maintainability
  - Possibility of changing a cryomodule with “short” intervention
    - Full segmentation seems an interesting option
    - But needs to be deepely analysed (technical/cost)
  - Segmentation has important impact on cryomodule design:
    - Cryogenics lines sizes and layout
    - Technical service module
    - Connection to CDL
    - C/W transitions

Machine layout issues & recommandation 2/2

- Nominal temperature:
  - For the time being: Tmax = 2K (31mbar) on each He bath (outside cavity surface)
  - T optimisation seems necessary: decreasing the temperature: Q versus cryogenics cost

Magnets issues

- FD and FODO schemes seems equivalent;
- FD seems to be preferable for reduced layout length. For low β: possibility of changing the scheme (FD+3+FD+3) may result in more compact layout. To be further investigated. No impact for β=1 prototype cryomodule
- New Quad alignment spec.: ±0.2mm (1σ)
  - Not impossible but tight (XFEL has ± 0.3mm)
  - Major advantage for having warm magnets
- Correction (to be included in the general mech. layout):
  - 1 steerer for each quad;
- Diagnostic :
  - Today 1 BPM per quadrupole doublet (mid length)
  - Possibility of using BPM as diagnostics for matching (QPU), but position between doublet to be reviewed
  - Need of additional diagnostic to be included ?

Magnets issues

- SPL quadripole, in general easy design (both warm and cold versions)
- Possibility of warm magnets would result in full segmentation with distribution line
- Present layout:
  - 10 Tesla/m ; L ≤ 400mm ; Ø~400mm ; m~300kg;
  - consistant with the present layout for segmented version;
  - but:
    - 1 steerer to be included in the design,
    - the H- stripping has to be further inverstigated, could require reduced gradient i.e. longer magnets (=longer machine)
    - BPM could be placed within the warm quad (outer diam. then slightly larger)
- Estimated total power consumption : 400kW
- Heat loads: ~10^{-2}, 10^{-1} W @2K
- Pulsed working conditions (several Hz, could be up to 50 Hz):
  → no pb (but care concerning the coupling with the power supply);
- Permanent magnet version still would require trimming;
- Power converter architecture (individual or series) to be compared;
- Further comparison between power converters for cold or warm magnets

Coupler integration needs

- Outer conductor of coaxial power coupler in contact with LHe bath at the coupler/cavity interface;
- Heat intercept:
  - 5-8K not optimal;
  - other temperature range can be investigated:
    - eg. 2K spilling, warm-up from ~5K up to 300K
- Position : vertical upward is the prefered option for wave guide connection in the tunnel & transportation
  - Consequence for cryomodule design: bi-phase pipe needs to be sideways (has to be above cavity)

Cavity He vessel and tunner assembly

- LHe tank: Ti for the prototype
- Coupler port directly in the 2K LHe bath
- Heat loads: what are the static and dynamic loads?
- Presently adopted inter-cavity bellow zone is questioned in terms of leaking field and associated heat loads. It could be subjected to change
- Present cavity alignment spec. (not addressed in this workshop): ±0.5mm (1σ)
- Microphonics : tuner may handle it

(Dynamic & static) Heat loads

- Present budgets are based on bibliography.
- More specific values for SPL should be elaborated:
  - dynamic losses should evaluated on (SPL type) representative set of cavities only
  - Static losses: also depending on segmentation choice
- HP SPL: 10% cryogenic duty cycle doubles heat laods compared with formal version

  → double the installed cooling capacity needs

  → increases the cryogenic line diameter: x1,4

  → requires investigation on the cavity surface heat exchange

Cryogenics issues

- Pressures specifications are proposed:
  - Design pressure for cavity and low pressure circuit have to be defined (6 bar seem too high for cavities):
    - Maximum allowable pressure (at RT and at cold) will be checked by CEA
- A cryogenic scheme has to be chosen and further investigated
  - Number of pipes (inside the cryostat)
  - Pipes diameters (at present only sizes for distribution lines presented)
- HP new version heat loads have a fundamental impact on pipes sizes (cryomodule design) and cryoplant
- Avoid flanges for interfaces into the cryogenic piping

Survey issues

- The alignment of the SPL is not really challenging (if SPL - SPS connection available)
  - Cryostat must be equipped with survey reference targets and a tilt reference (standard LHC equipment)
  - Cryostat must be supported with a precise realignment system (e.g. LHC jacks system)
- Internal metrology will be more challenging
  - Alignment method should be decided (e.g. laser tracker):

    → position of the alignment fiducials w.r.t a reference axis (by measurement or adjustment of fiducials)
  - For the cryostat prototype: need to verify the internal position of the components
    - monitoring of the cavities and quads with respect to external fiducials on the cryostat (sensor type and protocol should be chosen)
    - Integrate alignement metrology in the design
    - Use of WPM (Tesla system) shall be investigated

Further work

- Cryomodule prototype requires urgent (end of the year) decisions to be in timr for 2012:
  - Refining objectives of the prototype
  - Choice of layout segmentation
  - Choice of cryogenic “baseline” scheme
    - HL to be coped with (HP new version!)
    - Cooling scheme (also choice for coupler)
    - Final sizes, pressures, temperature

→ Support from the Collaboration Board is needed to freeze the objective of the prototype

THANK YOU FOR YOUR ATTENTION!

SPECIAL THANKS TO ALL SPEAKERS FOR THEIR EXCELLENT WORK!