Magnet and Beam Commissioning at Step IV

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Beam line Pre-Commissioning

- Required to test new beam settings for the operations and Tracker commissioning without B field
- Hardware needs to be re-tested
  - Nothing new beyond Step I operations, however hardware not used for many months
- Step I setting needs to be repeated (~10k useful triggers, ~1h)
  - Again to test if nothing changed!
- 3 Updated momentum settings need to be tested against matching at TOF0 with Step I tomography
  - Requires new settings to be developed and their MC performed (ASAP, latest CM40)
  - Requires DS, proton absorber, all beam line magnets, TOF0 and TOF1
  - ~30k triggers, ~3h
- Large beta (beam size) setting for Tracker commissioning without magnetic field needs to be tested
  - ~10k triggers, ~1h
- In summary: 5h of useful beam -> 2 shifts
  - May need to be repeated ->4 shifts, the time may be charged with Trackers
  - Should be done before Magnet Commissioning
  - First Spring ISIS Run (17.03-24.04) or the beginning of the Summer Run (2.06-24.07).

Beam line Commissioning

- Necessary to test the muon beam matching to the MICE Channel
  - Requires DS, proton absorber, all beam line magnets, TOF0 and TOF1, New Diffuser and commissioned Upstream Tracker (requires B field in USS)
  - Requires beta, alpha and emittance reconstruction at all 5 Tracker planes to test the behaviour of the beam
  - 9 settings (beam matrix), each ~10k triggers, ~10h (4 shifts)
  - Most likely will need to be repeated – 8 shifts
  - Needs to be done after Magnet Commissioning (at least USS)

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Magnet Commissioning

Results of study performed by

MICE Magnet Integration Task Force (MMITF)

Requirements for the Magnet Commissioning

- Important decision to be made: do we start with solenoid or flip mode?
  - Needs more MC studies
- The ambitious goal is to achieve stable operation at 180 A in FC (flip mode) with nominal SS settings and nominal solenoid mode.
  - ❑ Testing maximal currents in M1 and M2 coils.
- The realistic goal may be to achieve stable operation at derated FC current of 165 A (flip mode)with sufficient margins in currents for M1 and M2 for tuning freedom or even just the solenoid mode at first.
  - ❑ This will provide us with sufficient flexibility for beam operation (data taking).
- Commissioning will also establish the necessary standards and knowledge required for operations
  - ❑ How to tune the channel
  - ❑ How to switch on/off
  - ❑ How to go from one setting to the other

Assumptions for the magnet commissioning

- A quench in any of the magnets will result in the full MICE channel quench event.
- Quench may propagate between SSs even if FC is off.
- The 48h minimal time between quenches for the FC sets the recovery time for the MICE channel (SSs can quench 1,2 times per day).
  - May be we can take the beam in this period for beam line commissioning, if needed?
- This allows to estimate the time duration and LHe requirements for various scenarios.

Recommended Scenario for MICE magnets commissioning at STEP IV (1)

- Magnets will be installed, connected and a ramping test completed in advance.
- Sufficient supply of LHe needs to be secured
  - ❑ Discussions with BOC indicate Liquid Helium availability will not be an issue!
  - ❑ It is recommended that each magnet will be equipped with its own dewar
- It will be followed by individual magnet training
  - ❑ SS will be trained in parallel, but, only 1 magnet will be ramped at a time (1 quench per magnet per day and 2 quenches per day in 24/7 training operations).
  - ❑ We will start most likely in solenoid mode.
- Once all magnets reached their independent nominal settings, set nominal current in both SSs and start raising current in the FC.
  - ❑ Detecting which coil quenches first knowing the FC current will allow to assess how far we are from the nominal setting:
  - ❑ Depending on experimental findings the procedure may be followed by:
    - ❑ Training the FC with SS currents fixed at nominal (repeating the procedure).
    - ❑ Training the FC with SS currents fixed at derated value (to be defined).
    - ❑ Switching to combined training (Scenario 1 with ramping all magnets simultaneously at approximately 2.5 quench per week incl. 40% contingency)

Additional Recommendations for MICE magnets commissioning at STEP IV

- Test of power supplies and QD/QP systems needs to be performed in advance.
- All magnets needs to be individually quench protected at all times.
- Forces induced on PRY needs to be monitored by observing the displacement
  - ❑ Studies indicate that for nominal settings and magnets powered individually forces are acceptable.
  - ❑ Scheme to monitor displacement is being considered.

Some questions

- Do we start with the solenoid mode?
  - Needs more MC studies to compare physics reach between the modes
- If the solenoid mode is achieved quickly, do we follow with physics or continue with magnet commissioning in the flip mode (FC remembers the training)?
  - Management decisions to be made, may depend on availability of beam and man power.

Beam Commissioning of MICE Channel

- This is needed to assess the beam optics in Step IV Channel
  - Requires all beam line elements and magnets in the channel, TOF0, TOF1 and both Trackers, but no absorber.
- This will allow to asses the orbit
  - By checking if means of transverse position and divergence are sufficiently close to zero
  - May result in requesting realignement
- Optics can be assessed be checking the beta function at all 10 Tracker planes (in both Trackers).
- Transfer matrix through the channel can be measured and compared with simulations.
- The baseline setting with an intermediate emittance can be assessed (10k triggers, 1h), however we may already take 100k for precision (10h, 3 shifts- including magnet tuning, beam line setting etc.).

Beam Commissioning of MICE Channel (2)

- We can choose one setting to make detailed study
  - Symmetric with an intermediate emittance, 200 MeV/c (baseline?)
  - If problems with orbit is discovered
    - We want to know its origin
    - We may perform a perturbation study by running with reduced currents (by 10%?) element by element
    - We need to study this in MC
    - There are 9 settings (as DSS needs to be varied together with its End Coils) -> 9k triggers, 9h of useful beam
    - How much time is required between magnet tunings?
    - We will only learn at Magnet Commissioning (1-3 settings per shift?)

Beam Commissioning of MICE Channel (3)

- Before inserting the absorber we may still want to assess off momentum behaviour of optics by performing measurements for two other momenta.
  - In principle 10k triggers would be sufficient, but again we may want to go for the precision (100k) for each -> 6 shifts in total (again this is a guess).
- This will allow us to build knowledge and confidence before the start of the real physics with the absorber inserted!

Summary for shift request (preliminary)

- Beam line pre-commissioning with beam (does not require Tracker)– 4 shifts
- Beam line commissioning (required Tracker, essential) – 8 shifts
- Beam Commissioning of MICE Channel - 12 shifts
  - At this stage we do not know, how much time is required for magnet tuning, so this is only a guess.

Summary

- We have the plan for magnet commissioning (thanks to the hard work done by MMITF)
- I presented ideas about beam line and MICE Channel beam commissioning
- They need to be re-discussed
- We aim to converge before the August review, so you input is essential...

Acknowledgements

- I would like to thank members of the MICE Magnets Integration Task Force: V Bayliss, S Boyd , T Bradshaw, A D Bross, J Cobb, M Courthold, S Feher , S Griffiths , P Hanlet, T Harnett, K Long, D Orris, R Preece, S Prestemon, M Tucker, S Virostek , S Watson and H Witte for their essential input.
- Special thanks to V Blackmore, M Palmer and C Rogers for their input.