Magnet and Beam Commissioning at Step IV

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Outline

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- Magnet Commissioning
- Beam Commissioning of MICE Channel
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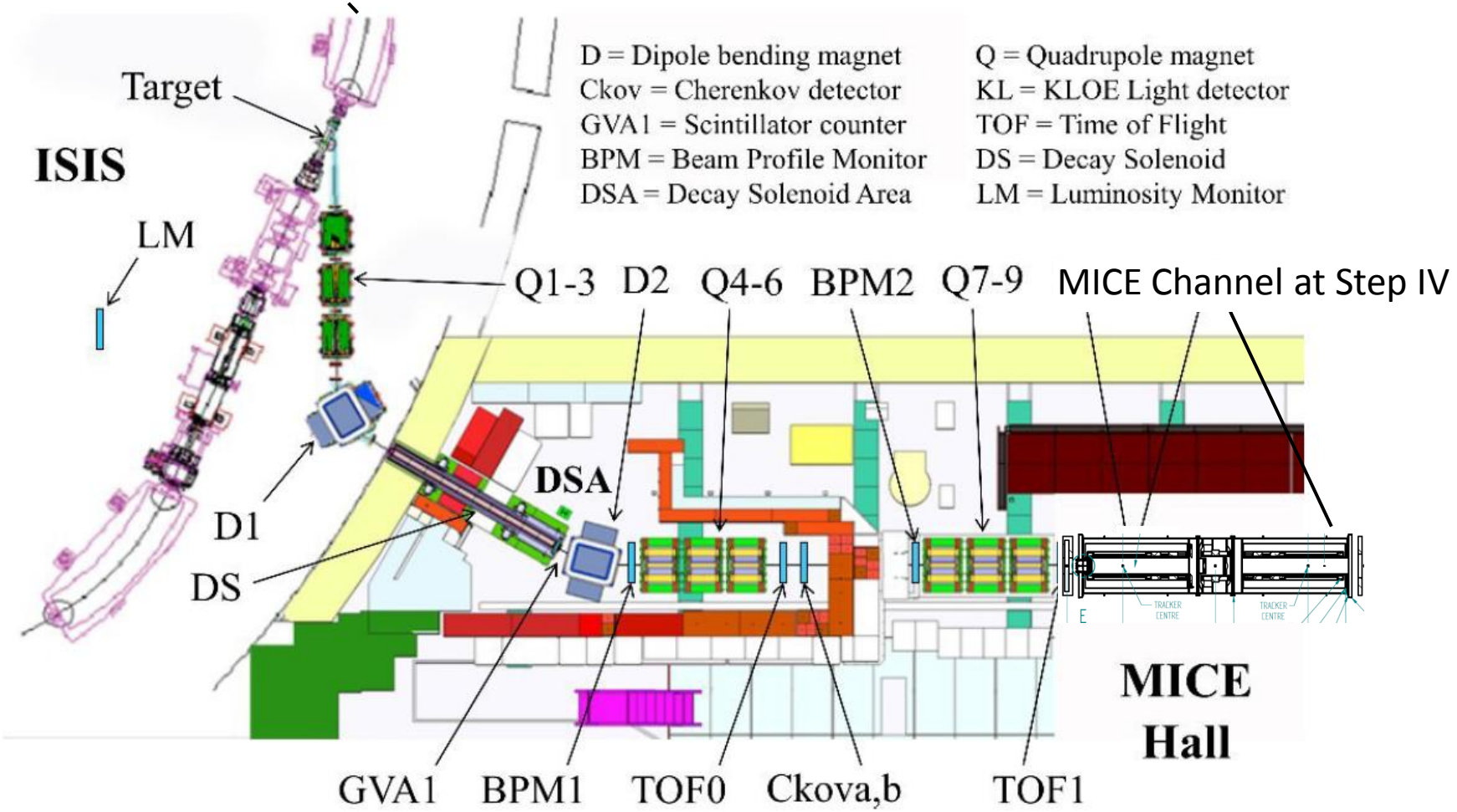
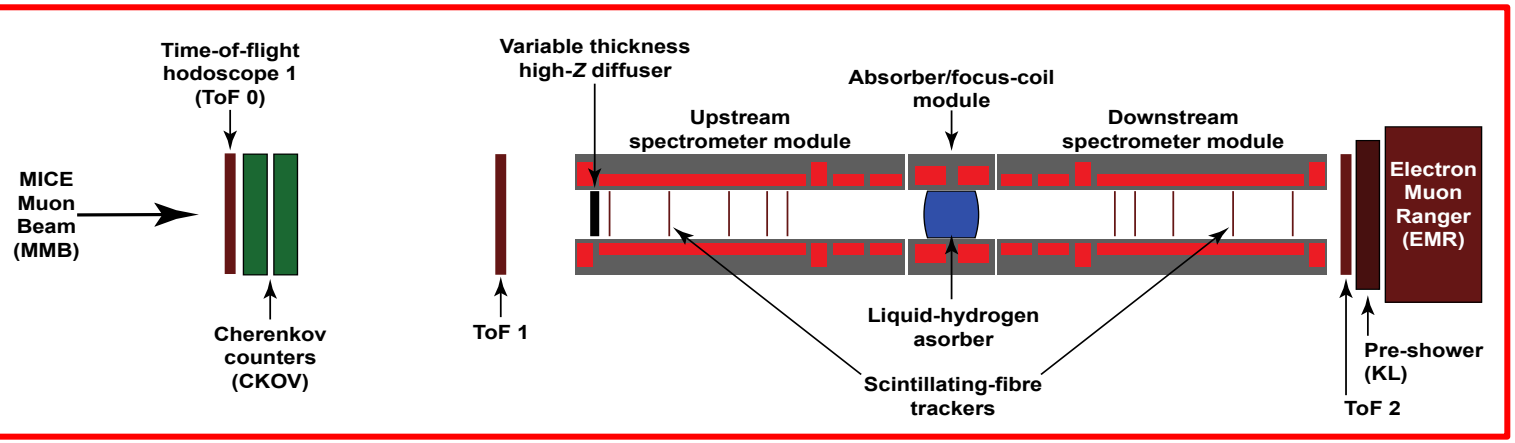
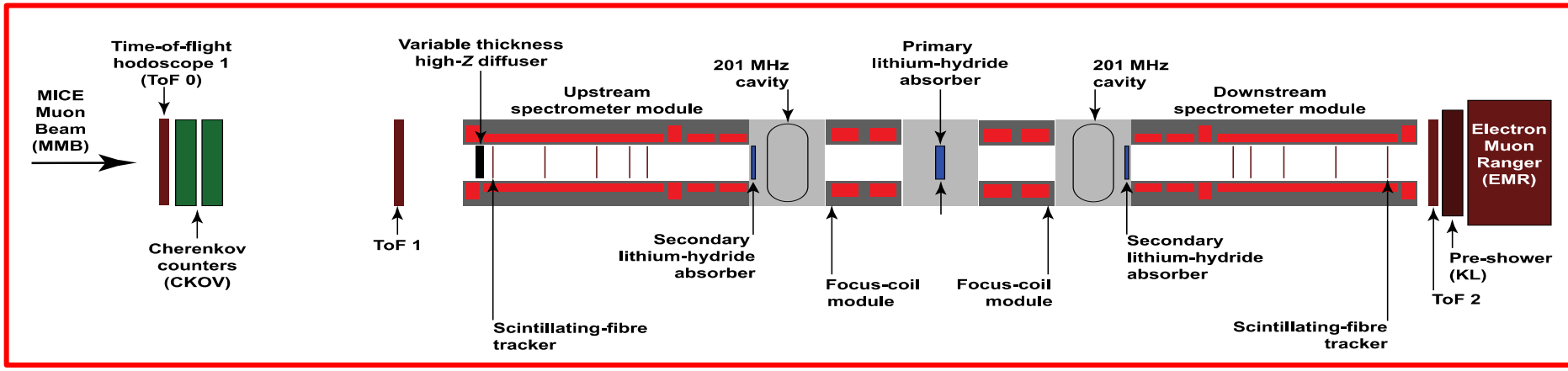
Introduction



MICE Beam Line
Conceptual Layout

Introduction (2)





MICE Step IV and Cooling Demonstration

Vocabulary

- Beamline pre-commissioning: Repeat of Step I phase space reconstruction with new beamline settings (taking into account Diffuser modifications and special settings)
- Magnet Commissioning: commissioning of all the systems required to have the MICE Cooling Channel ready for beam (includes, QD/QP system, electrical tests, magnet training etc.)
- Beamline commissioning: commissioning of beamline and USS optics matching including the effect of the Diffuser (requires SSU magnetic field and Tracker, both commissioned)
- MICE Cooling Channel commissioning: assessment of MICE Channel optics, alignment with empty absorber.

Beam line Pre-Commissioning

- Required to test new beam settings for the operations and Tracker commissioning without B field -> started!
- Hardware needs to be re-tested -> done!
  - Nothing new beyond Step I operations, however hardware not used for many months
- Step I setting needs to be repeated (~10k useful triggers) -> done (analysis ongoing)! Good outcome expected!
  - Again to test if nothing changed! It will also allow to cross-check with improved MC modelling
- Updated momentum settings need to be tested against matching at TOF0 with Step I tomography ->started, however no break through can be claimed yet!
  - Requires new settings to be developed and their MC performed (ASAP)
  - Requires DS, proton absorber, all beam line magnets, TOF0 and TOF1
- Large beta (beam size) setting for Tracker commissioning without magnetic field needs to be tested -> two initial setting were tested, but unsuccessful (this allowed to create the 3rd setting, which awaits experimental testing when DS is back.
- In summary: 10h of useful beam including tuning time and contingency -> 4 shifts (data taking is only a small fraction of the estimated time)
  - May need to be repeated ->8 shifts, the time may be shared with Trackers (3 useful shifts taken up to date)
  - Should be done before the Magnet Commissioning (we still have a chance)

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, the 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 (the first analysis of this procedure was presented at this meeting)
  - 9 settings (beam matrix), each ~10k triggers, ~10h of useful beam
  - Most likely will need to be repeated – 15 shifts (including the contingency) -will we have these time ?
  - Needs to be done after Magnet Commissioning (at least SSU)
  - ...however we will start testing with B field to understand the Diffuser effect ASAP.

Magnet Commissioning

Results of study performed by

MICE Magnet Integration Task Force (MMITF)

Requirements for the Magnet Commissioning

- The realistic goal is to achieve stable operation in solenoid mode first and in flip mode afterwards.
  In both modes with sufficient margins in M1 and M2 currents for tuning (below the quench limit)
  - ❑ 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 (please see additional slides)
- 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 and QDS/QPS tests completed in advance.
- Sufficient supply of LHe needs to be secured
  - Discussions with BOC indicate Liquid Helium availability will not be an issue!
  - Each magnet will be equipped with its own dewar and the transmission line.
- It will be followed by individual magnet training
  - SS will be trained in parallel (training of E2 coils alone will be performed first (for both magnets?), which will allow for several quenches in short period of time). This will be followed by training of all SS's coils together, but 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 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 observations

- We will start in solenoid mode
  - MC studies show comparable cooling performance and the forces are relaxed in the solenoid mode (easier magnet commissioning)
- If magnets are commissioned quickly at the solenoid mode the commissioning of the flip mode will follow.
  - If not, the commissioning of the solenoid mode will be followed by physics run in this mode and the flip commissioning will be made afterwards.

Combined training solenoidal (flip) mode

- Setting magnets to the max allowed currents [A]:
  - E2: 253 (249)
  - C: 274 (278)
  - E1: 234 (234)
  - M1: 265 (281) ?
  - M2: 280 (256) ?
  - FC: 120 (180)

•The settings does not corresponds to realistic optics settings (all optics settings are being designed with currents below those given).
•After achieving the training settings we will tune down to several operating settings (standard matrix + a few special settings).

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 (empty LH2 absorber)
- This will allow to asses the orbit
  - By checking if means of transverse position and divergence are sufficiently close to zero
- 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 (will we have time??) already take 100k for precision (~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 , solenoid mode.
- Before filling 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.
- This will allow us to build knowledge and confidence before the start of the real physics with the absorber filled!

Summary for shift request for beam commissioning

- Beam line pre-commissioning with beam (does not require Tracker)– 8 shifts -> 3 usefull shift taken up to date.
- Beam line commissioning (requires Tracker - essential) – 15 shifts
- Beam Commissioning of MICE Channel - 21 shifts (will we have time??)
  - At this stage we do not know, how much time is required for magnet tuning, so this is only a guess.
  - We will use the available time!

Summary

- Beam line pre-commissioning has been started (3 useful shifts taken, data at Step I settings taken and in analysis)
- We have the plan for magnet commissioning (thanks to the hard work done by MMITF). Although the combined operation of the MICE channel will be challenging, we are convinced it will be successful.
- Beam line commissioning will follow as soon as SSU is commissioned and its Tracker is commissioned with the magnetic field. However we will start testing the effect of Diffuser even without B field.
- The beam commissioning of the Channel will allow to build knowledge and confidence before the start of the real physics with the absorber filled. We have the consistent plan of actions, however there will be limited time left in July so we will likely need to continue in September.