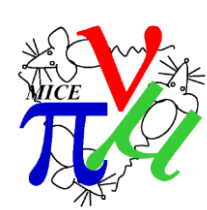


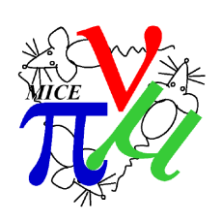
# Beam Commissioning of Step IV and Cooling Demonstration Status

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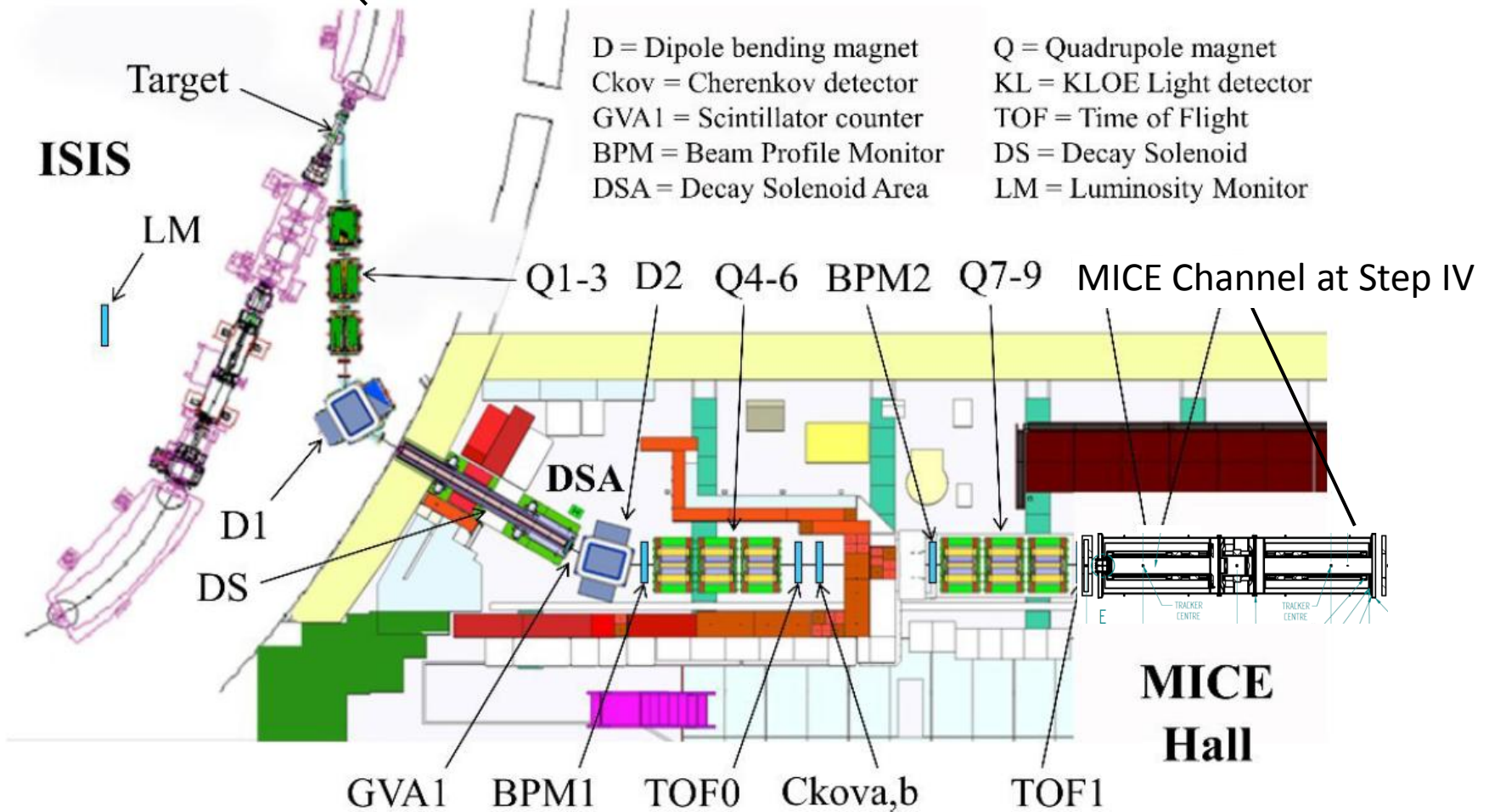
# Outline

- Step IV Beam Commissioning
  - Introduction
  - Beam line Pre-Commissioning
  - Beam line Commissioning
  - Beam Commissioning of MICE Channel
- Cooling Demonstration
  - Introduction
  - Progress since the last MPB
  - Final optimisation

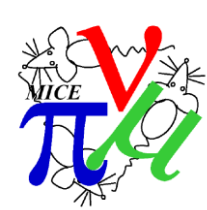


# Step IV Beam Commissioning

# Introduction

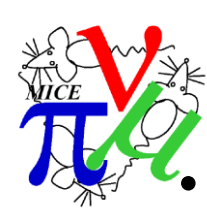


MICE Beam Line  
Conceptual Layout



# Vocabulary

- **Beamline pre-commissioning:** Repeat of Step I phase space reconstruction with new beamline settings (which will take into account Diffuser modifications and special settings)
- **Beamline commissioning:** commissioning of beamline and USS optics matching including the effect of the Diffuser (requires SSU magnetic field and Tracker, both commissioned). **In particular Upstream Tracker reconstruction will be used for the first time!**
- **MICE Cooling Channel commissioning:** assessment of MICE Channel optics, alignment without absorber. **Reconstruction in both Trackers is essential!**



# Beam line Pre-Commissioning

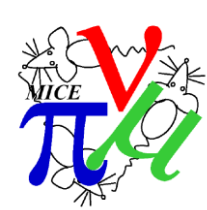
Hardware needs to be re-tested

- Nothing new beyond Step I operations, however we need to re-test the hardware! We plan to re-measure 3 momentum setting **this week-end (18<sup>th</sup>-19<sup>th</sup> April )** with 10k useful triggers at TOF1.
- Optimisation to improve transmission
  - Q123 scan was performed in March operations -> **data analysis in progress**
  - Further studies expected in April, in particular this week-end.
- Updated settings taking into account modifications (updated Diffuser, PRY effect on B field between TOF1 and Tracker, etc.) need to be tested against matching at TOF0 with Step I tomography
  - Requires DS, proton absorber, all beam line magnets, TOF0 and TOF1
  - This activity starts **this week-end!**
- Large beta (beam size) setting for Tracker commissioning without magnetic field needs to be tested -> **this week-end!**



# Beam line Commissioning

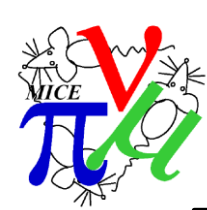
- Necessary to test the muon beam matching to the MICE Channel
  - Requires DS, proton absorber, all beam line magnets, TOF0 and TOF1, the Diffuser, commissioned Upstream Tracker (requires B field in USS) and full Tracker reconstruction.
  - Requires beta, alpha and emittance reconstruction at all 5 Tracker planes to test the behaviour of the beam.
  - 9 settings (beam matrix), each  $\sim 10\text{k}$  triggers,  $\sim 10\text{h}$  of useful beam
  - Most likely will need to be repeated – **15 shifts (including the contingency)**
  - Needs to be done after Magnet Commissioning (at least SSU) – we aim for this July!



# Beam Commissioning of MICE Channel

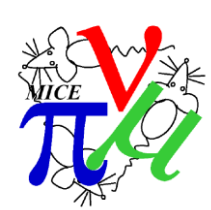
- This is needed to assess the beam optics in Step IV Channel
  - Requires all beam line elements and magnets in the channel, TOF0, TOF1 and both Trackers, **but no absorber**
- This will allow to assess the orbit using beam
  - By checking if mean values of transverse position and divergence are sufficiently close to zero
- Optics can be assessed by 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,  $\sim 1$ h), however we may already take 100k for precision ( $\sim 3$  shifts- including magnet tuning, beam line setting etc.).



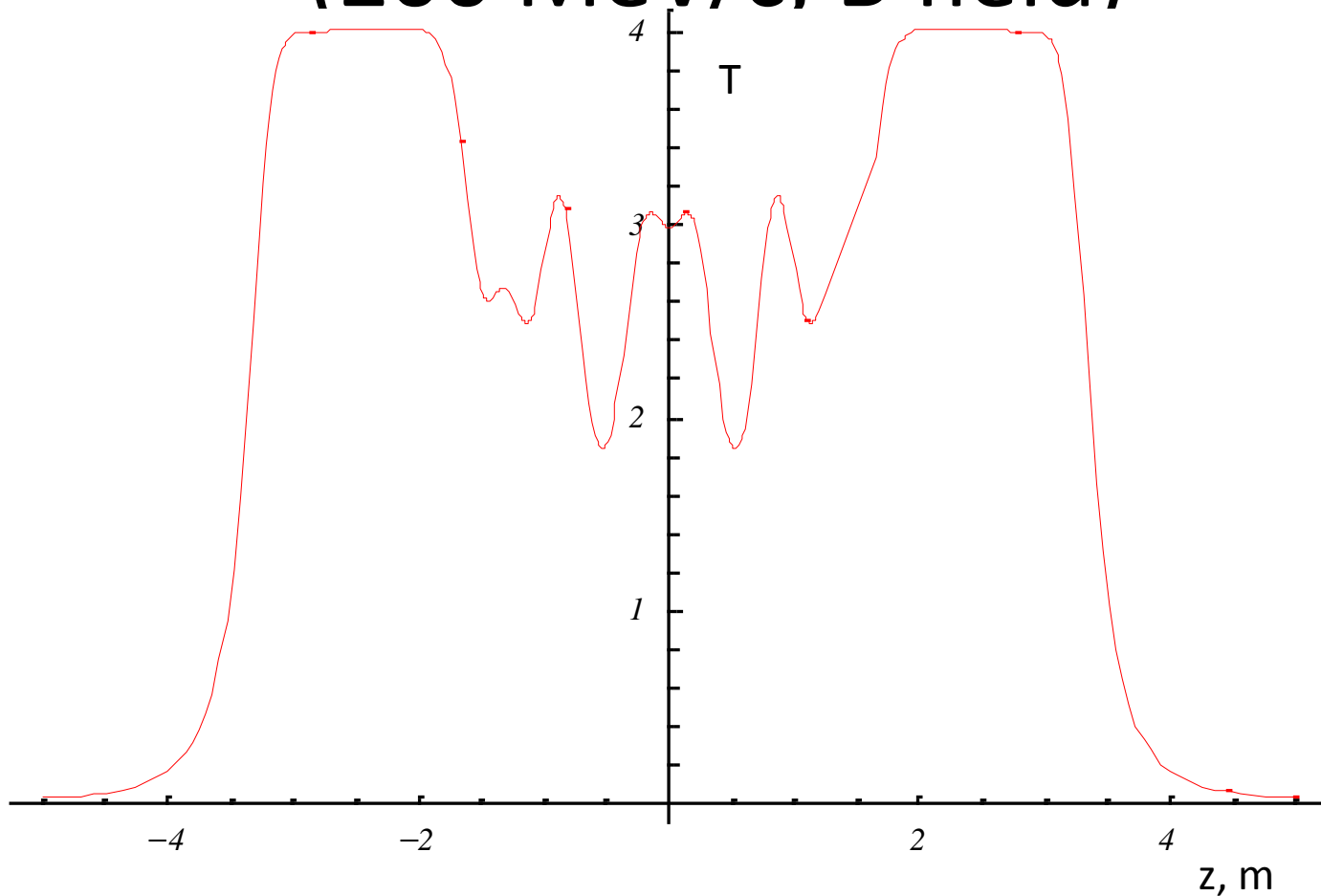


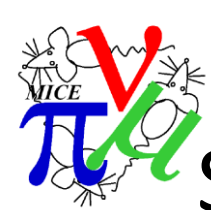
## Beam Commissioning of MICE Channel (2)

- 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.

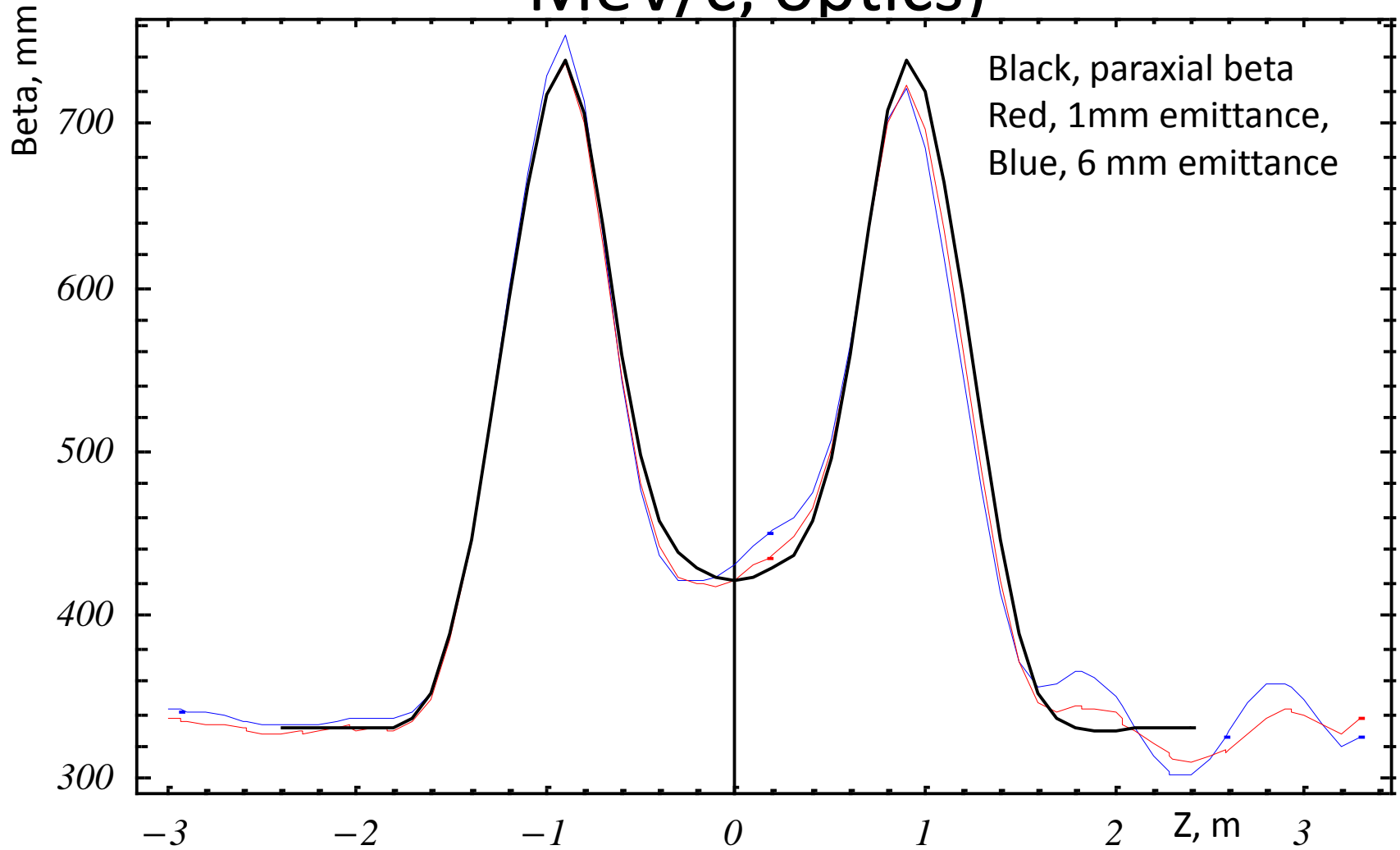


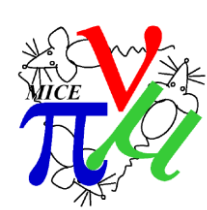
# Symmetric lattice for commissioning (200 MeV/c, B field)



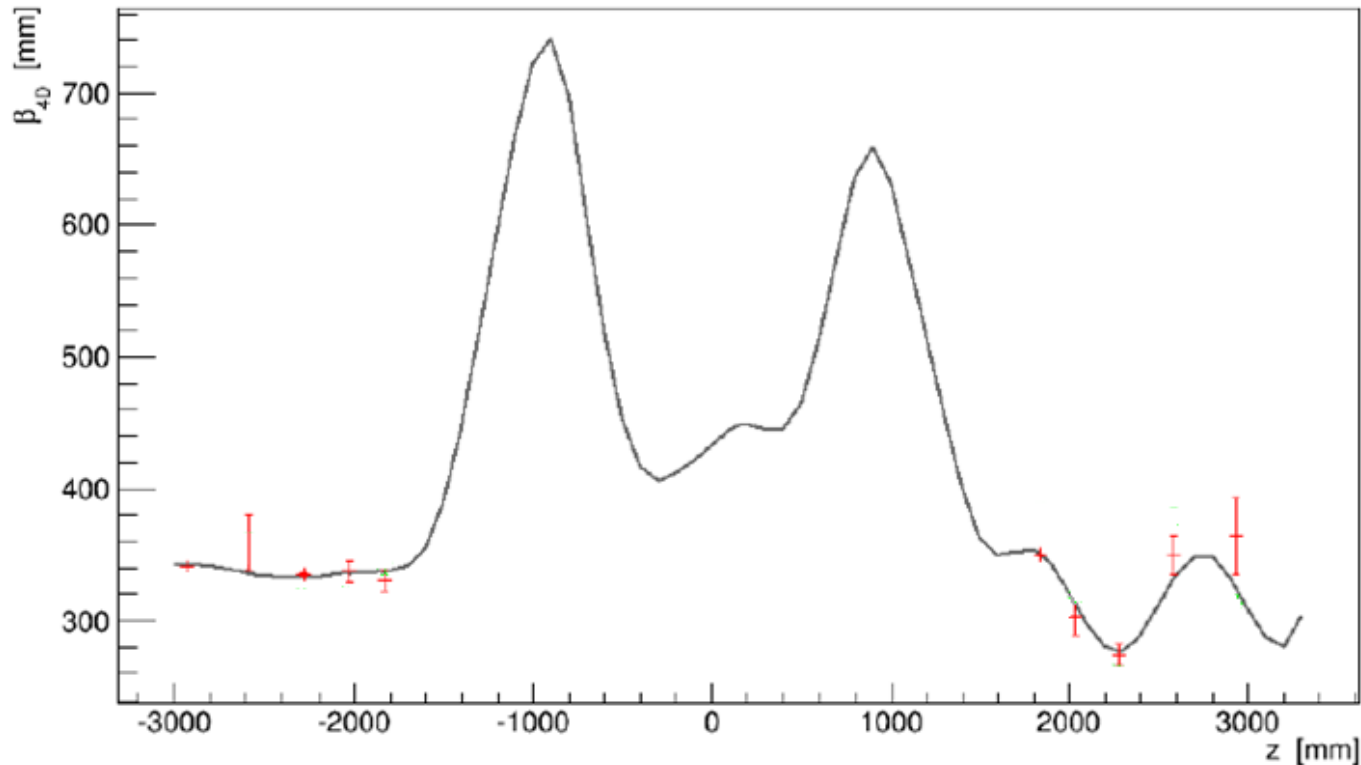


# Symmetric lattice for commissioning (200 MeV/c, optics)

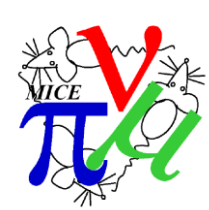




# Betatron function reconstruction in the Mice Step IV Channel

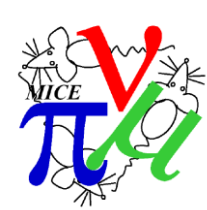


*Preliminary*



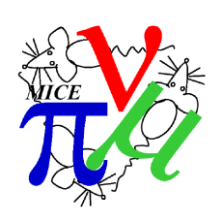
# Summary for shift request for Step IV beam commissioning

- Beam line pre-commissioning with beam (does not require Tracker) – **8 shifts**
- Beam line commissioning (requires Tracker - essential) – **15 shifts**
- Beam Commissioning of MICE Channel - **21 shifts**

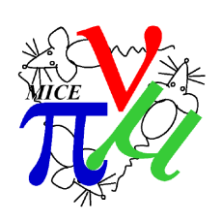


# Summary - Beam Commissioning of STEP IV

- Beam line pre-commissioning will allow to prepare the main commissioning. **We are working on it right now (March- April operations)**
- Beam line commissioning will follow as soon as SSU is commissioned and its Tracker is commissioned with the magnetic 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!

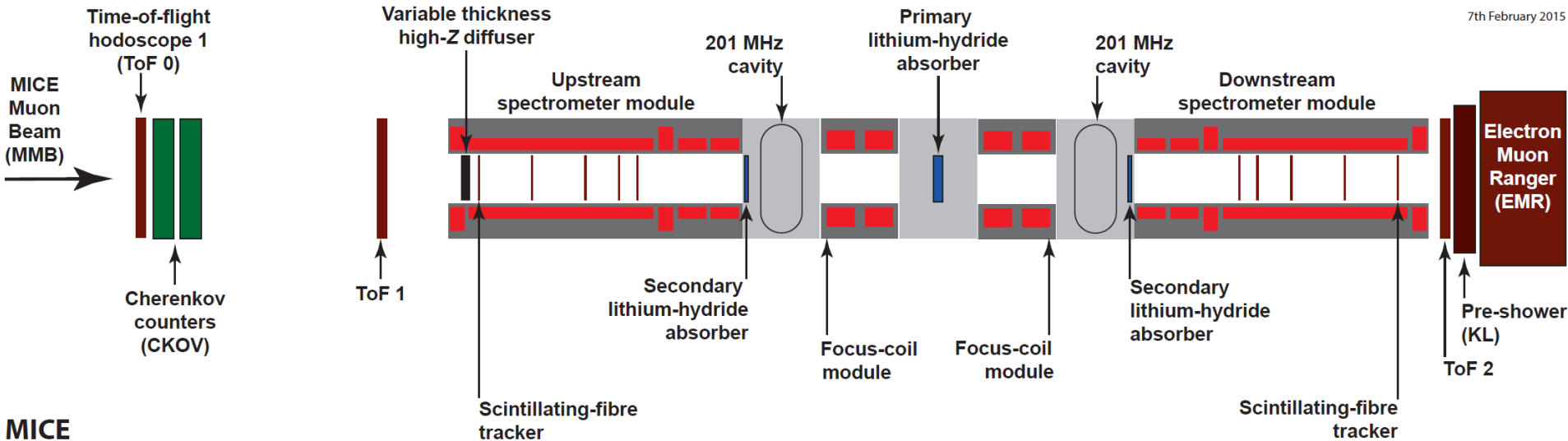


# Cooling Demonstration



# Introduction

7th February 2015



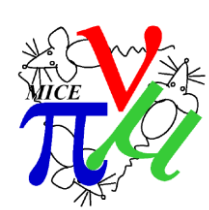
MICE

- The consistent solution to demonstrate ionization cooling with partial RF re-acceleration was established using existing MICE magnet systems (SSs and FCs) and already tested 200 MHz RF setting (SCTS at MTA/FNAL)

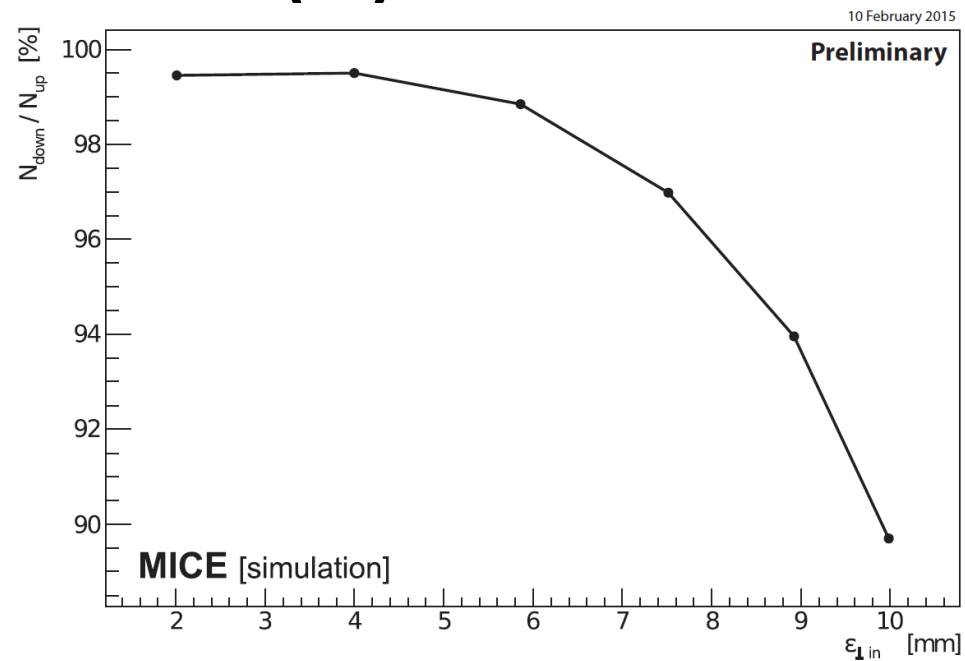
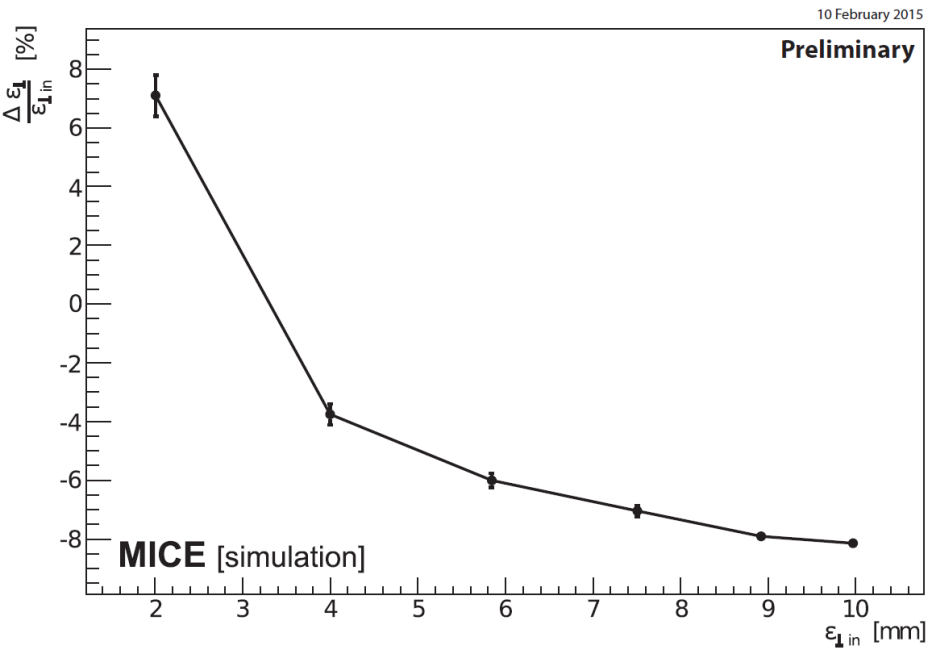
-> we know, what we are doing!

- This allows to meet the deadlines requested by funding agencies simultaneously providing necessary input for physics community to prepare for a future (the Neutrino Factory, a Muon Collider and future muon projects).

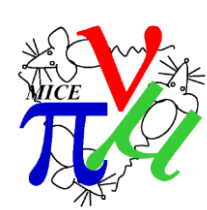




# Introduction (2)

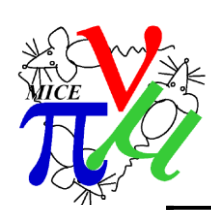


- The established solution allows for a broad range of beams to be measured with observable 4D normalized emittance reduction/increase with decent transmission.
- We are confident, we can do the necessary experimental job to **demonstrate muon ionization cooling**.

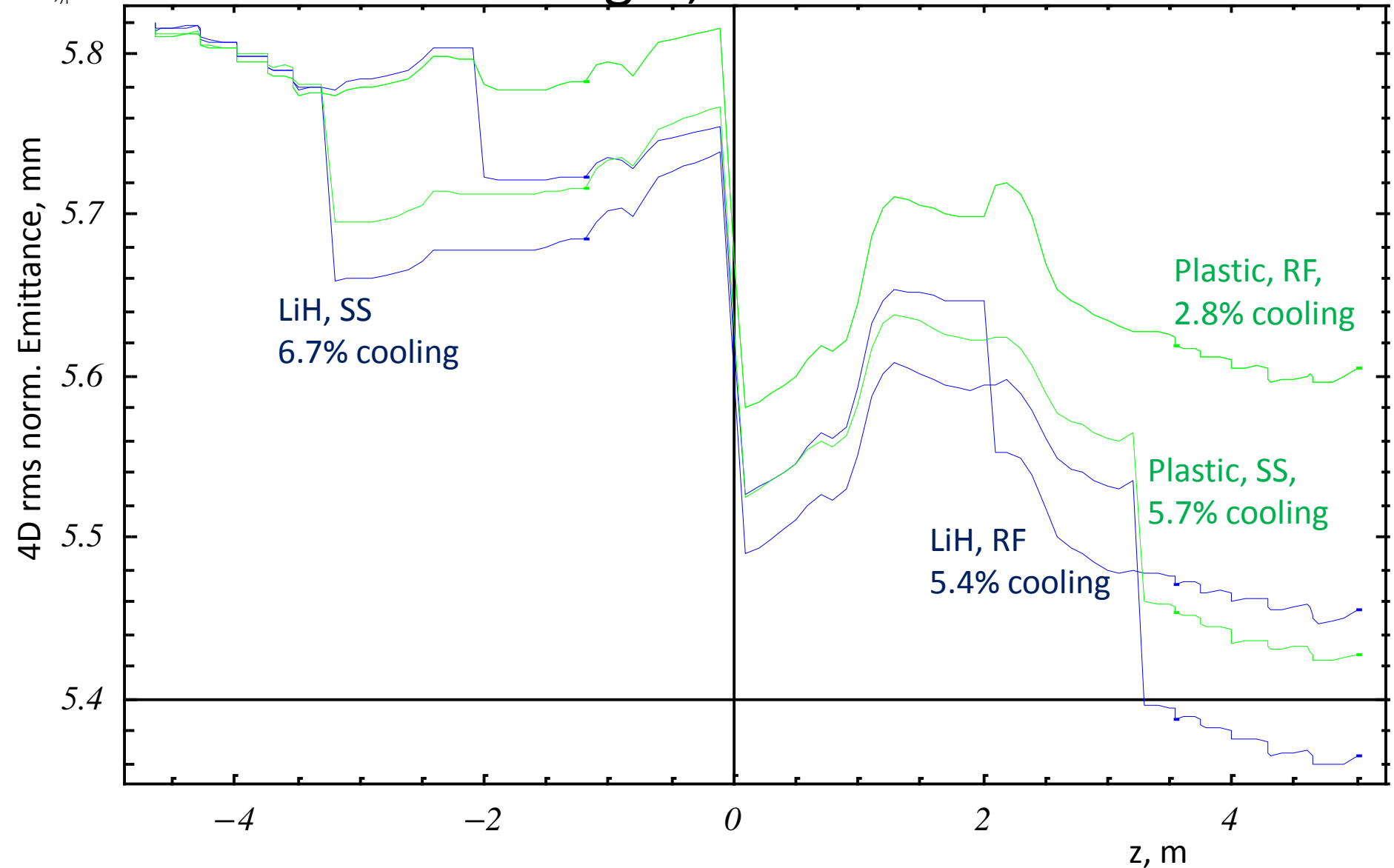


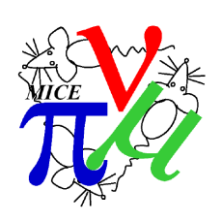
# Progress since the last review

- Additional bellows were added to allow for a flexible RF cavity module inspection (potentially very useful in operation)
  - additional length increase has no significant effect on performance -> **checked in MC simulations**
- Backup solution using plastic for Secondary Absorbers was simulated and conclusions have been drawn.
  - Movable LiH SAs are preferred (between SS and RF module)
  - However backup solution with fixed plastic SAs inside SS is a possibility
- Engineering for the solution using both Radiation Shutters and the movable LiH absorbers located between the SS and the RF cavity module was performed and is now our baseline
  - Radiation Shutters provides confident safety protecting Trackers from radiation induced by dark current originating from RF cavities under any circumstances
  - Movable Secondary Absorbers allow for removal of correlated background induced by dark current originating from RF cavities (stopping electrons), contribute significantly to the cooling and allow for easy testing of bare lattice (in contrary to fixed option).
- Optimisation of the final length between the FCs is in progress showing that we are already close to the optimum value.

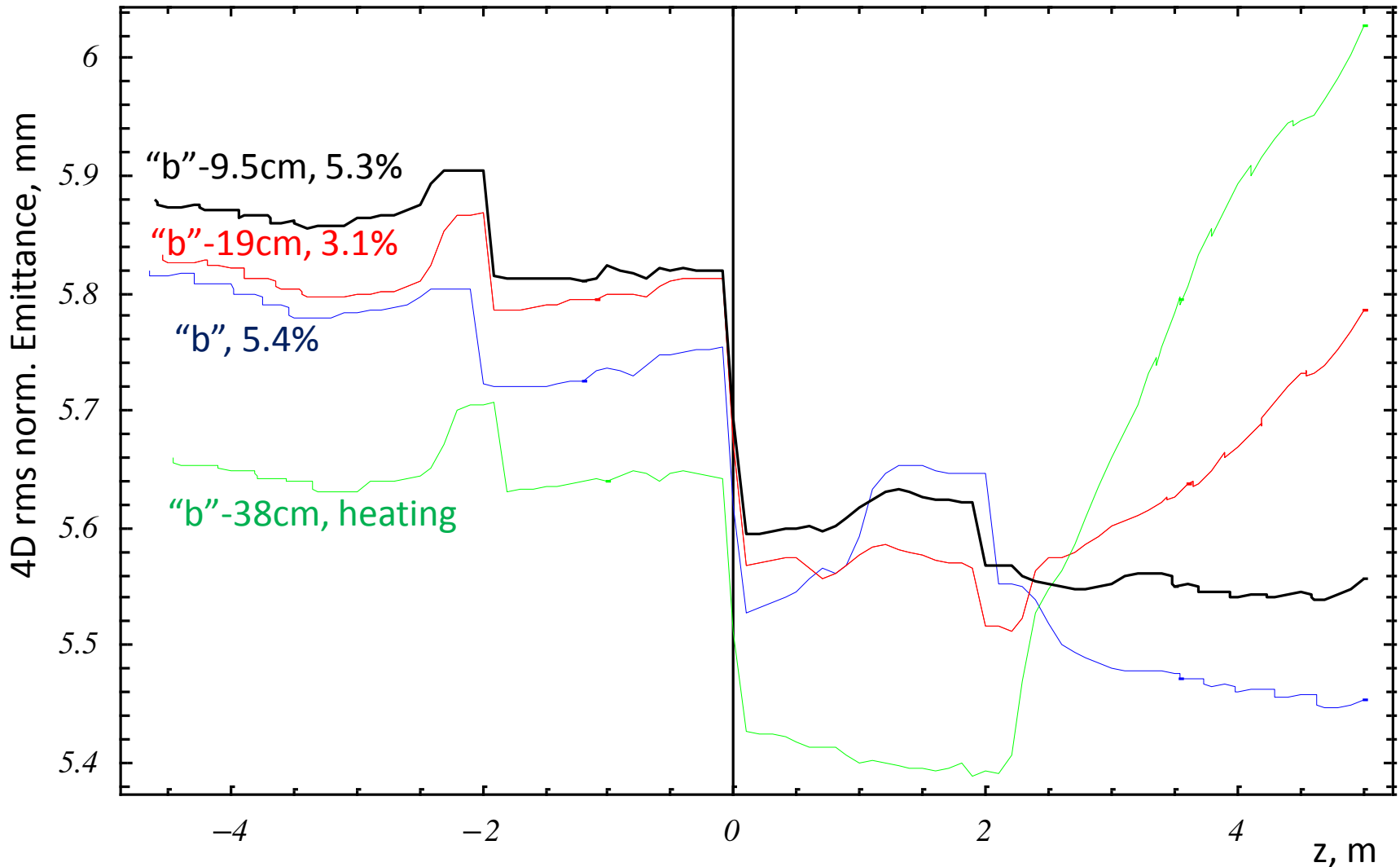


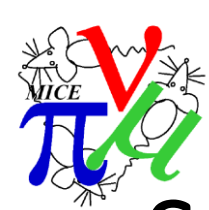
# Baseline cell length, Plastic versus LiH SAs





# Optimisation of Cooling Demonstration, different cell lengths





# Summary – Cooling Demonstration

- We are very confident the established solution will be fit to do the job.
- The changes introduced (the new bellow, Radiation Shutters and movable Secondary Absorbers) will re-ensure safe and flexible operation of the Cooling Demonstration step!
- Optimisation of the final dimensions are in progress, however we are confident we are close to the optimum already!