



Development of beamlines for CERN's future fixed- target experiments

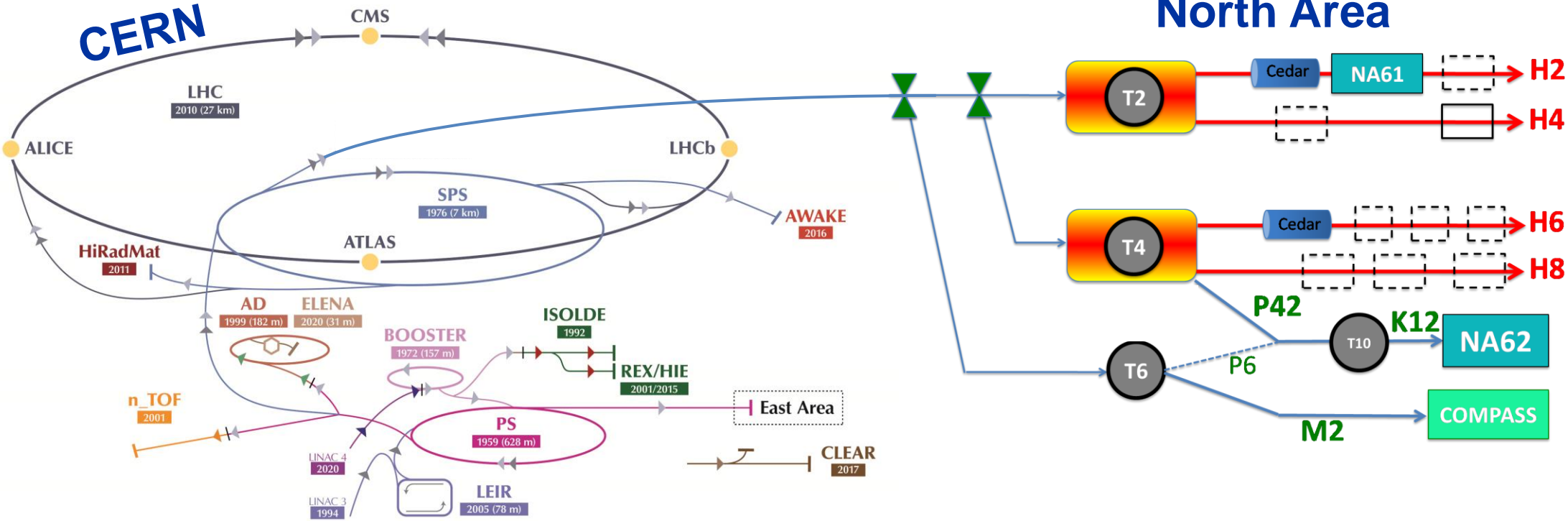
JAI Fest 2023

Florian Stummer

04/12/2023



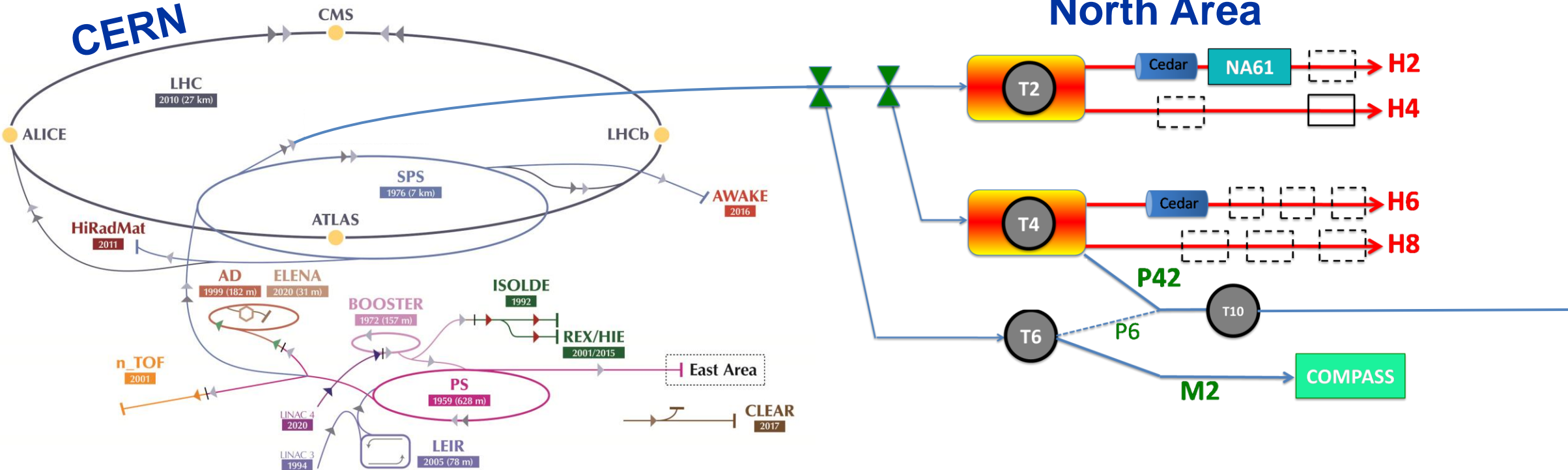
CERN's North Area



K12 beamline



CERN's North Area

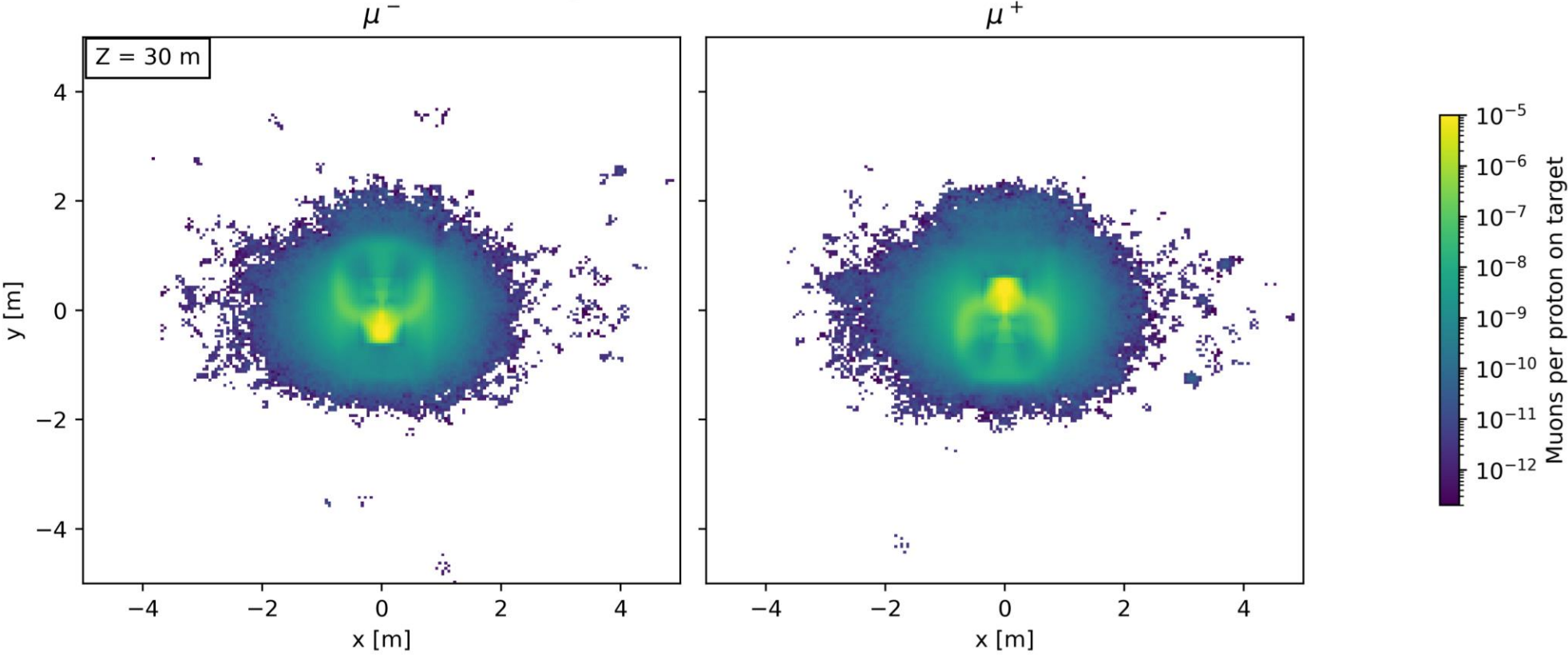


K12 beamline

SHADOWS



Muon background mitigation for SHADOWS



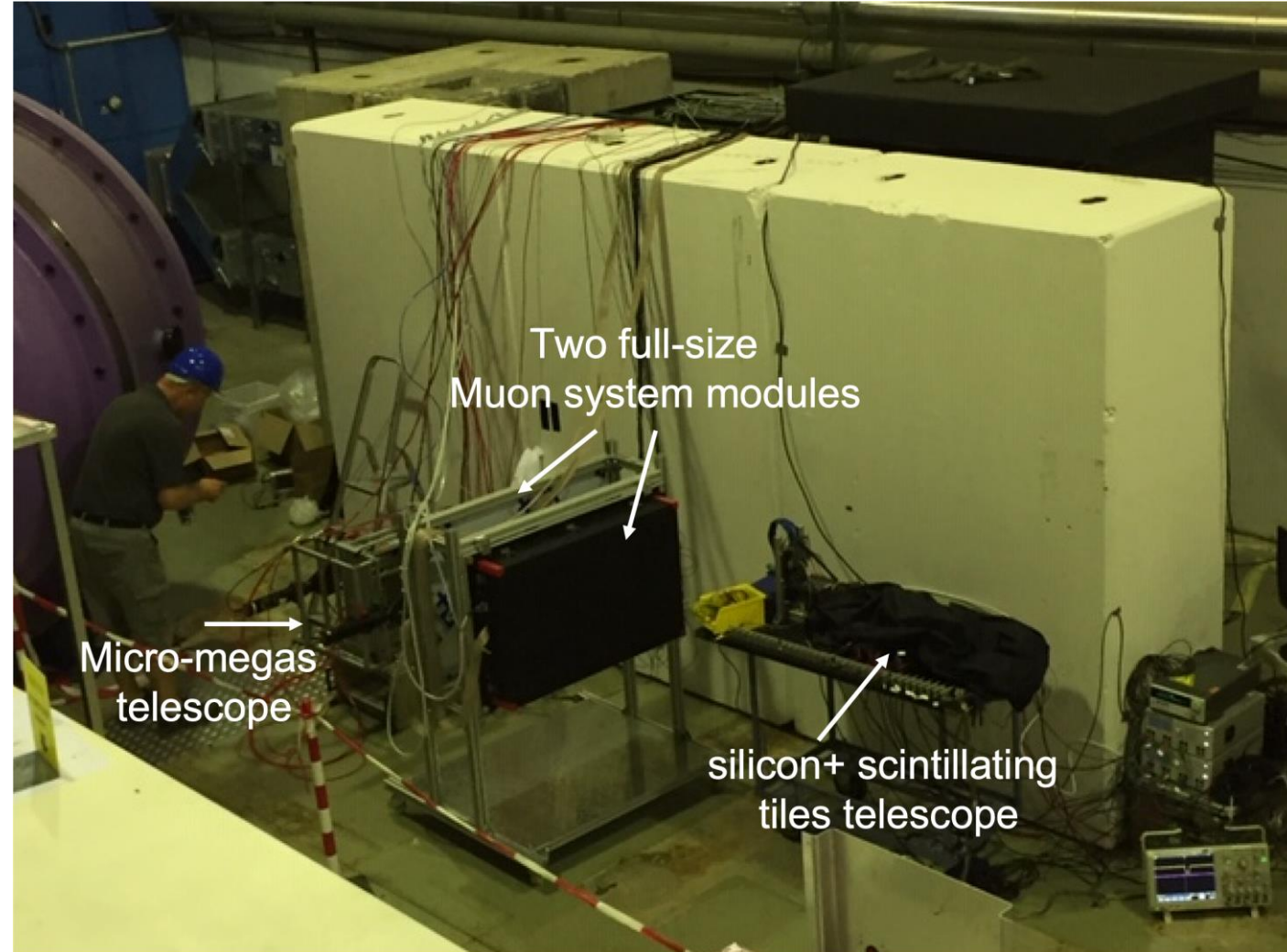
Calibrating the simulation with measurement data

- NA62 already validated the BDSIM model on-axis
- For SHADOWS we had to do the same off-axis
- This led to the Muon Flux Measurement in ECN3 in June 2023

→ Calibration was successful

→ The muon background off-axis behaves the same as on-axis comparing measurement and simulation

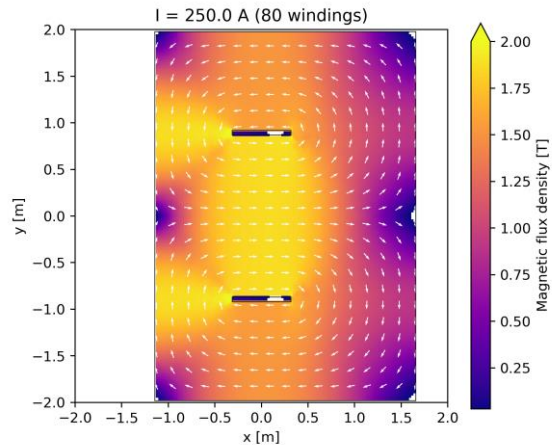
→ The BDSIM simulations can be trusted off-axis as well



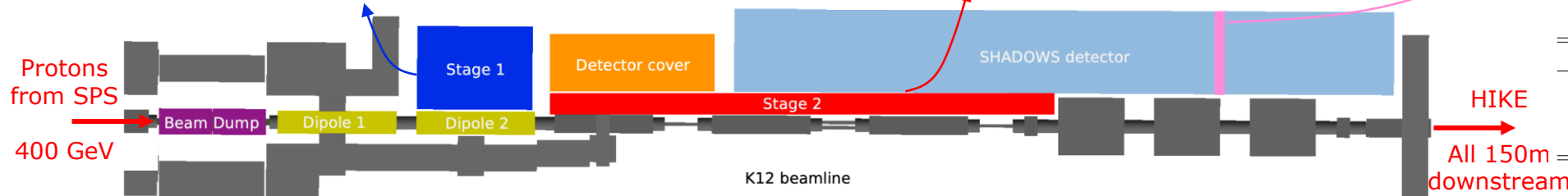
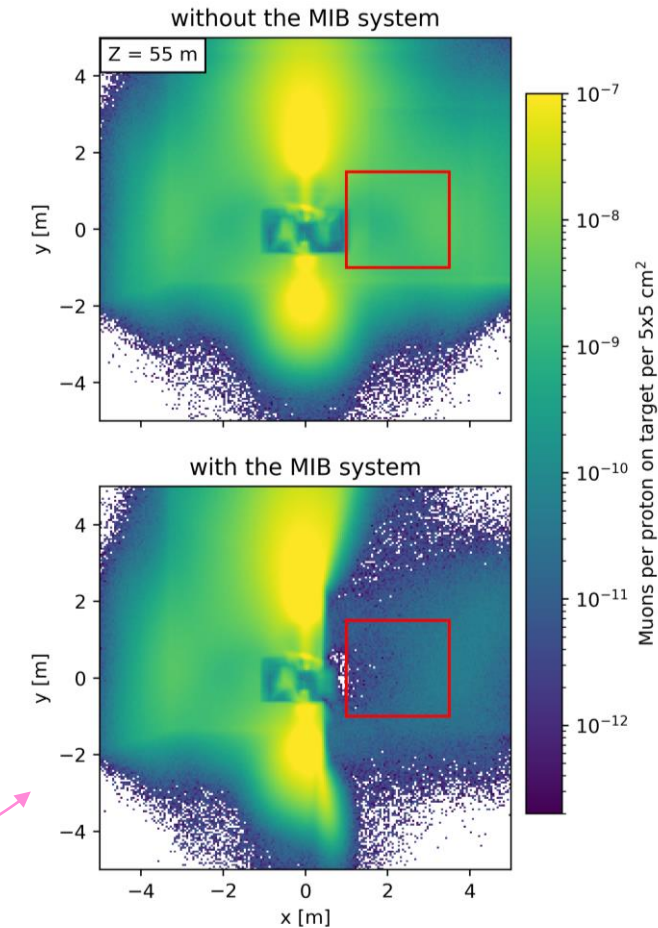
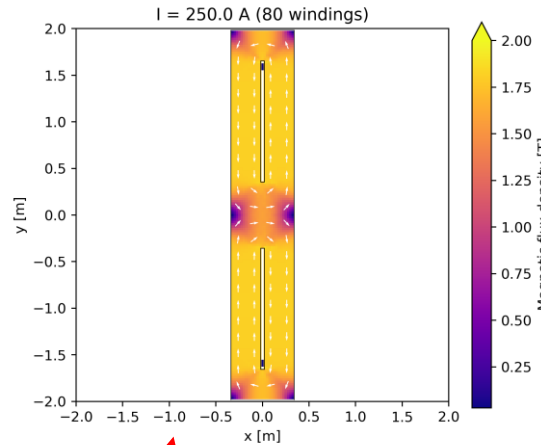
Conceptual Design of the Muon Sweeping System for SHADOWS

- Main background at SHADOWS detector location consists of muons
- Dedicated muon sweeping system consisting of magnetized iron blocks (MIBs) is designed to reduce the background

Stage 1
optimized for muon charge separation

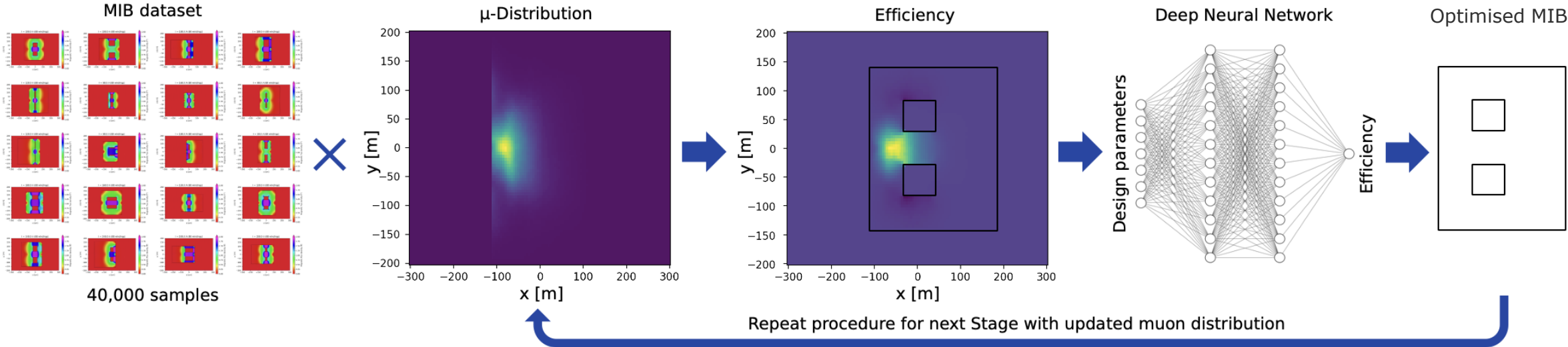


Stage 2
optimized for muon sweeping



	$\mu^+ + \mu^-$	μ^+	μ^-
rate without MIB	100 MHz	50 MHz	50 MHz
MIB reduction factor	~ 120	~ 110	~ 150
rate with MIB	0.8 MHz	0.5 MHz	0.3 MHz

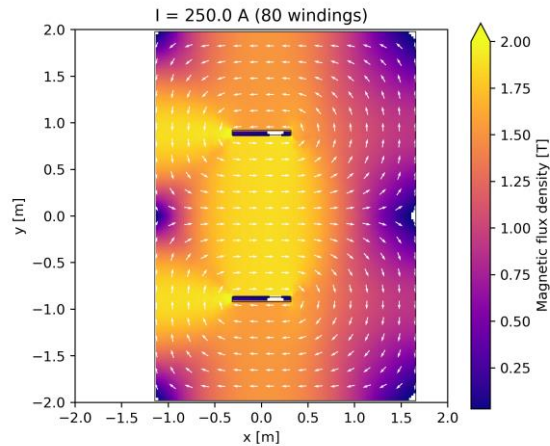
MIB Optimisation Process - Workflow



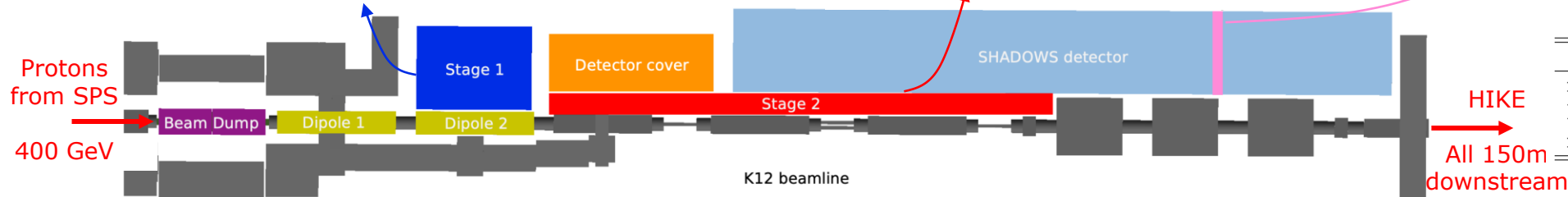
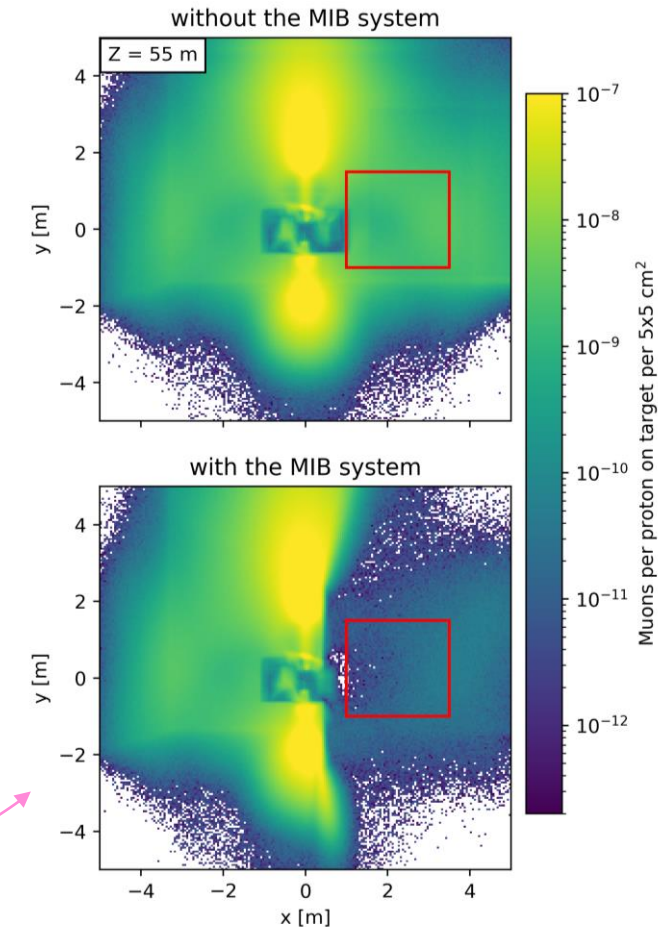
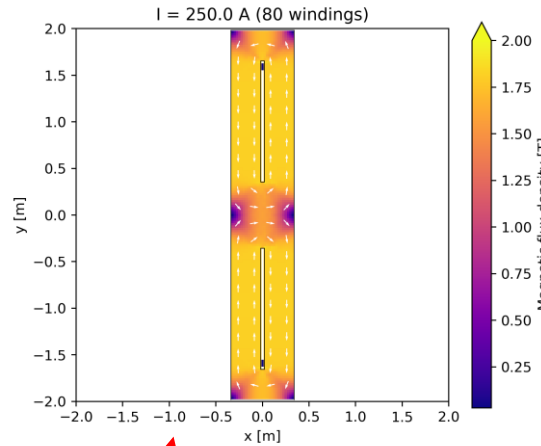
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rate without MIB	100 MHz	50 MHz	50 MHz
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Finding the main handles for the muon background

- **Magnetize the detector cover as well**
 - Detector cover → Stage 3
 - Allows us to shrink it in size and pull SHADOWS closer to the Beam Dump
- **The width of Stage 2 is key**
 - Altering the width of stage two allows us to choose the Muon Reduction Rate between 0 and ~150
 - Moving SHADOWS closer to the beamline improves its signal
 - Now the experiment can choose its signal vs background ratio → 40 cm Stage 2 width was chosen



SHADOWS Integration Study: Impact on the MIB Design

- **Limits to be considered in MIB design:**

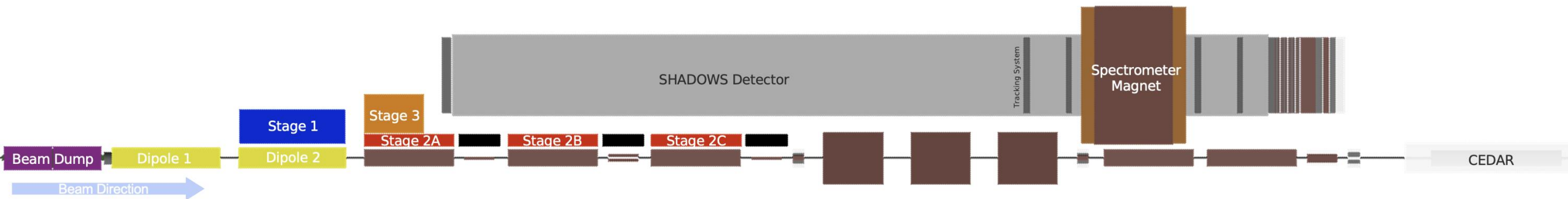
- Height limit from the experimental hall (floor → max height ~2.4m)
- Current density in the coils (no water-cooling)
- Max. current from the power supplies (250A)
- Envelopes of the beam line elements
- Accessibility of the beamline elements
- Weight limits from the crane

- **Conclusions:**

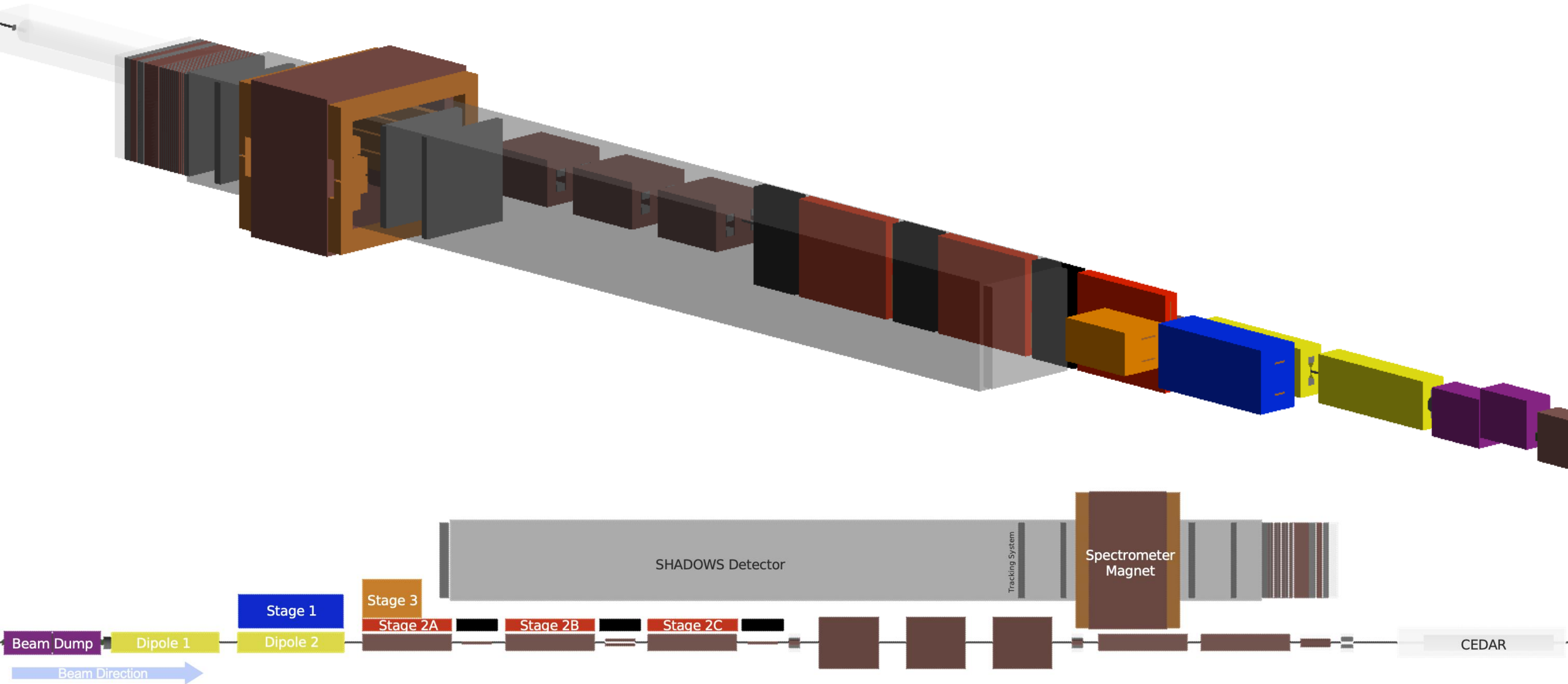
- Split up Stage 2 in three parts
- Fill the gaps with crane-liftable iron/concrete blocks as passive shielding

- **Simulations with Stage 2 of 40cm width:**

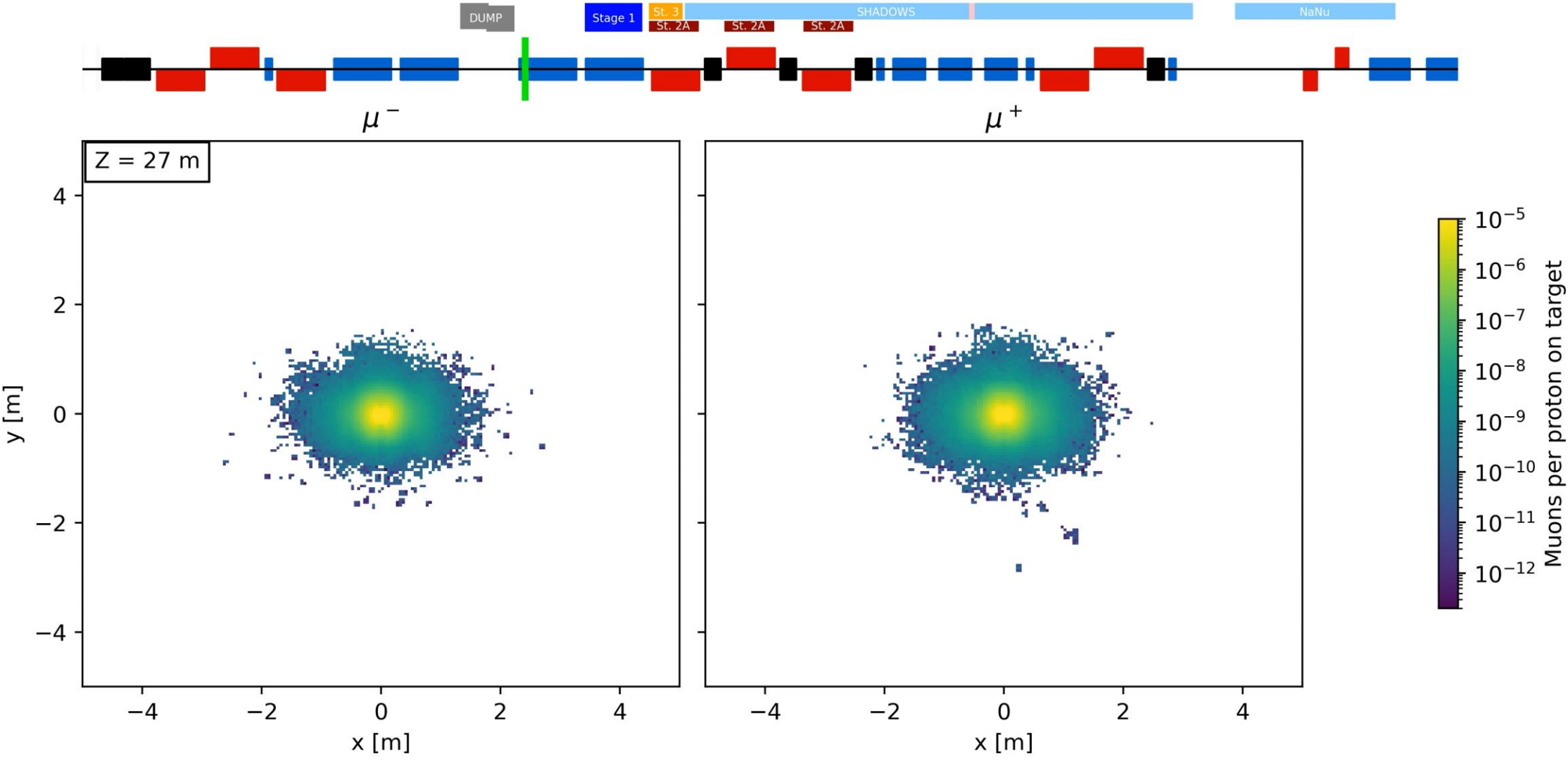
	$\mu^+ + \mu^-$	μ^+	μ^-
rate without MIB	147 MHz	81 MHz	66 MHz
MIB reduction factor	~ 70	~ 58	~ 94
rate with MIB	2.1 MHz	1.4 MHz	0.7 MHz



The optimised SHADOWS setup

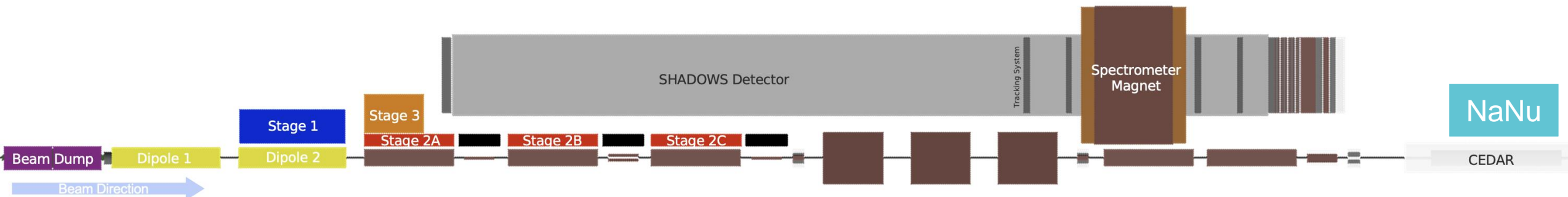


Muon evolution (BDSIM/Geant4)



Outlook

- **Will we see this experiment being installed?**
 - There are two proposals for ECN3 after Run 3
 - HIKE + SHADOWS
 - SHiP
 - Decision is due end of this year
- **Next steps in this study**
 - Investigate background mitigation concepts for the neutrino detector NaNu
 - Continue the studies heading towards the final system for the TDR if the proposal is accepted





Questions