

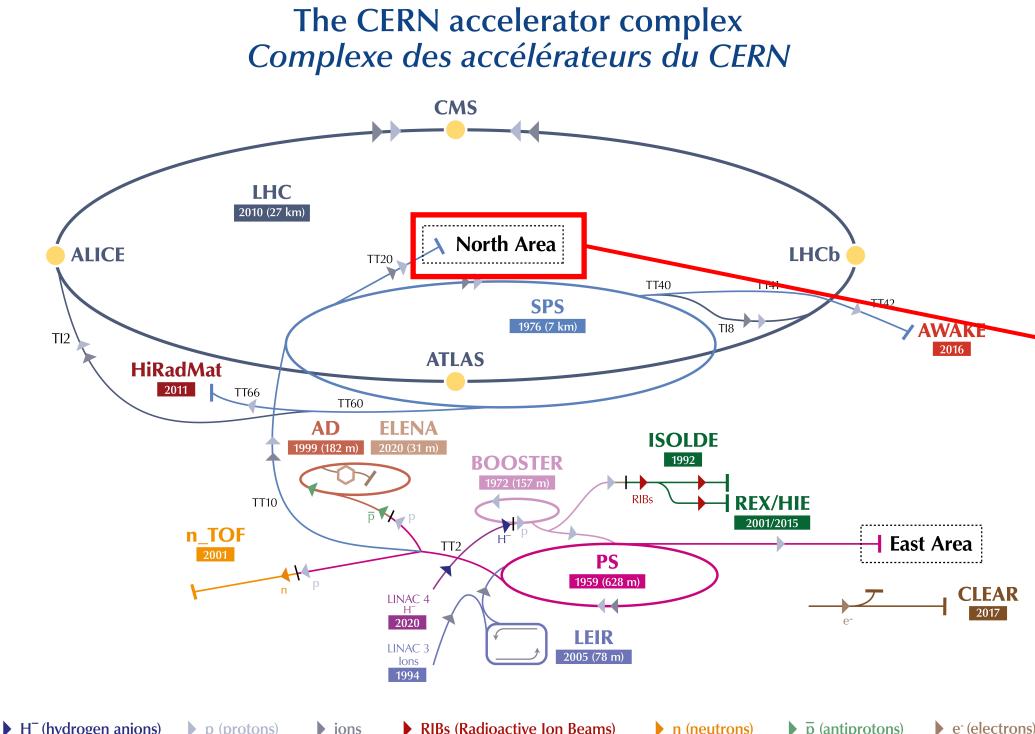
# M2 Experimental Beamline Optics Studies for next generation Muon Beam Experiments at CERN

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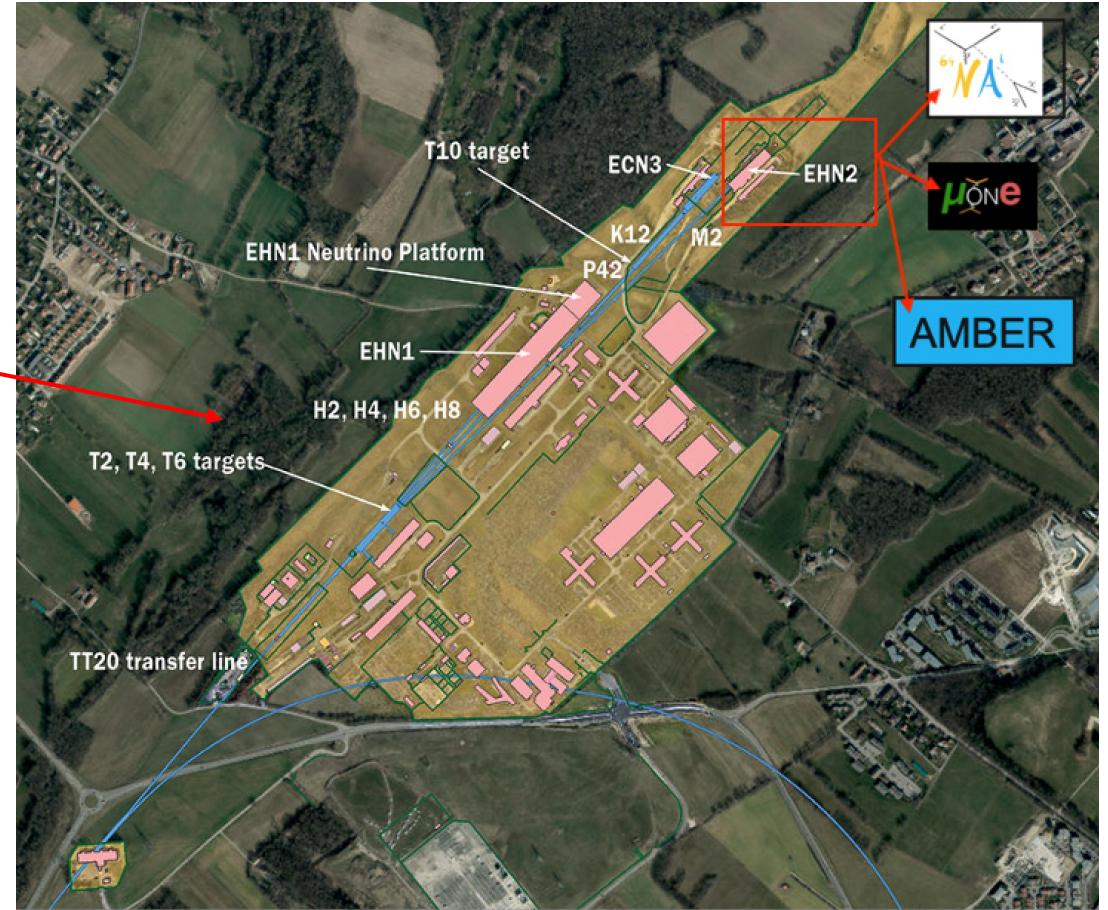


# Physics Beyond Colliders Proposals for the M2 Beamline

- Several projects for the ENH2 beamline in the CERN North Area have been proposed in context of PBC:

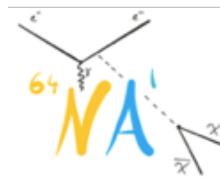


LHC - Large Hadron Collider // SPS - Super Proton Synchrotron // PS - Proton Synchrotron // AD - Antiproton Decelerator // CLEAR - CERN Linear Electron Accelerator for Research // AWAKE - Advanced WAKEfield Experiment // ISOLDE - Isotope Separator OnLine // REX/HIE - Radioactive Experiment/High Intensity and Energy ISOLDE // LEIR - Low Energy Ion Ring // LINAC - LiNear ACcelerator // n\_TOF - Neutrons Time Of Flight // HiRadMat - High-Radiation to Materials



# Physics Beyond Colliders Proposals for the M2 Beamline

- Several projects for the ENH2 beamline in the CERN North Area have been proposed in context of PBC:
  - **NA64 $\mu$**  is the muon program of NA64e looking for a dark photon and a new massive gauge boson,  $Z_\mu$ , that couples predominantly to the 2<sup>nd</sup> and 3<sup>rd</sup> lepton generations.
    - Requires medium to high intensity focussed 160 GeV/c muon beam with divergence < 1.5 mrad.
    - Setup around 15 - 25 m long and about 120 cm x 60 cm transversely.
    - In 2021 they aim to do a test run with a minimal setup of 13 m.
  - **MUonE** - aims to investigate the hadronic contribution to the vacuum polarisation in context of  $(g-2)_\mu$ 
    - Requires high intensity 160 GeV/c, low divergence muon beam.
    - Full setup around 40 m long.
    - In 2021 they aim to do a pilot run with up to three stations and the ECAL requiring a space of 7 m.
  - Successor to the COMPASS experiment - **A QCD Facility (AMBER)**
    - The EHN2 hall currently hosts COMPASS with a 55 m long setup.
    - In 2021 they aim to do a test run for their proton radius measurement with the TPC and 160 GeV/c  $\mu$  beam requiring a space of about 9 m.

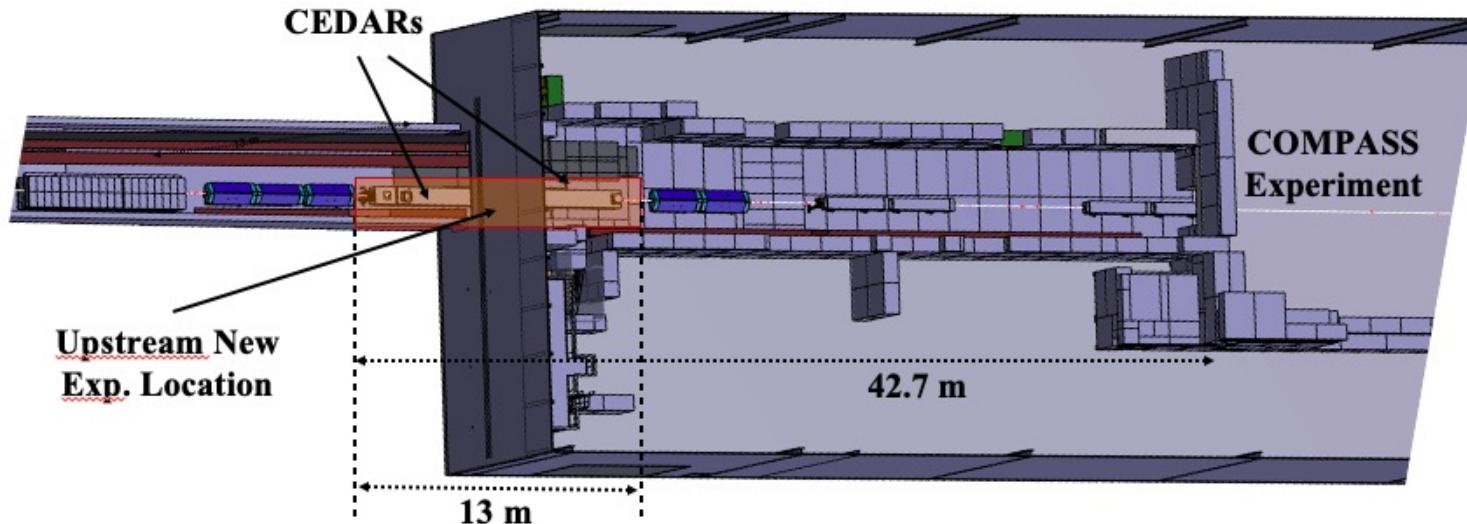


AMBER

**All 2021 test runs have been approved.**

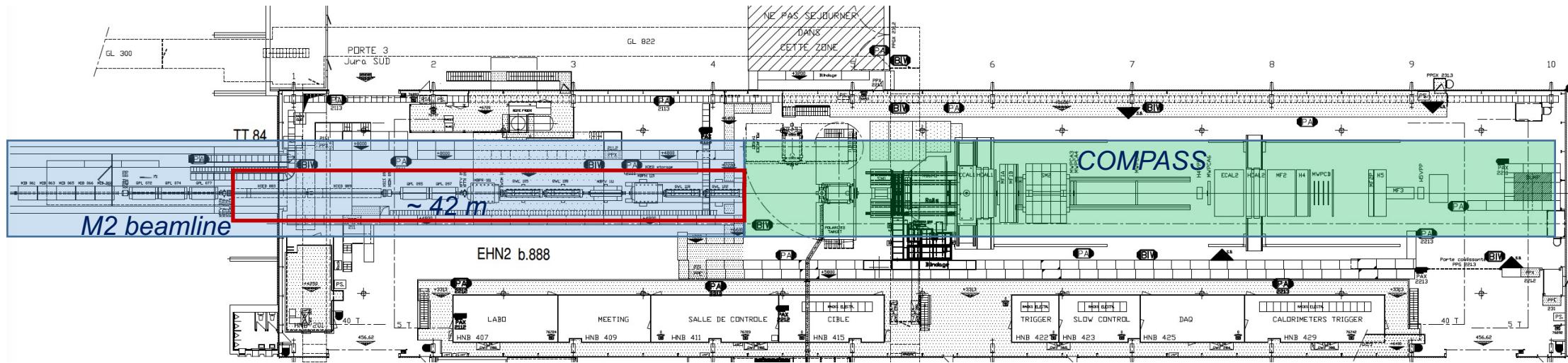
# Space required for the installation

- Currently the EHN2 hall houses the 55 m long COMPASS spectrometer to be used for the approved AMBER Drell Yan runs in 2022 and beyond.
- Upstream of the COMPASS setup 2 CEDAR detectors are located which will not be used during the 2021 COMPASS transversity run.
- This 13 m available space was deemed feasible for all three 2021 test runs without any major modifications to the beamline.



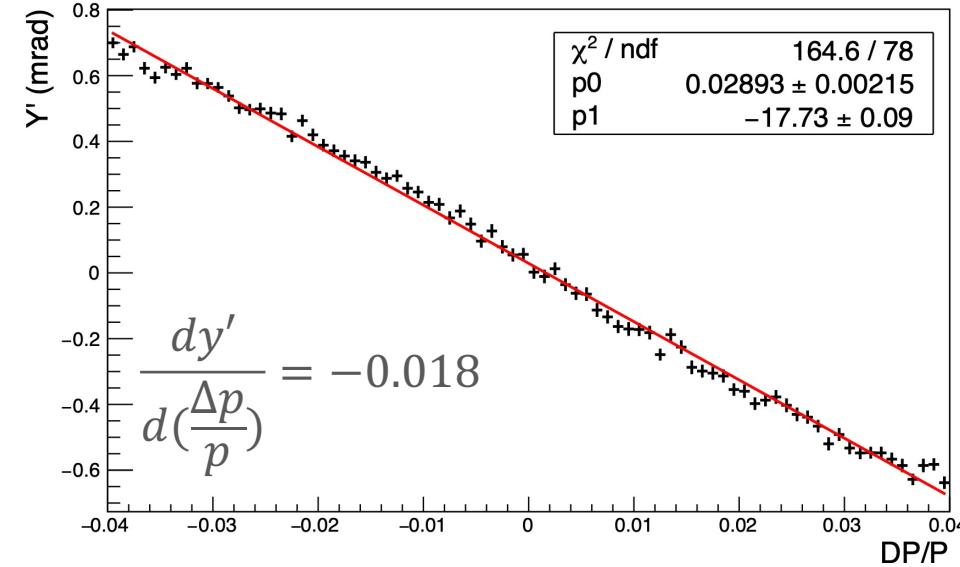
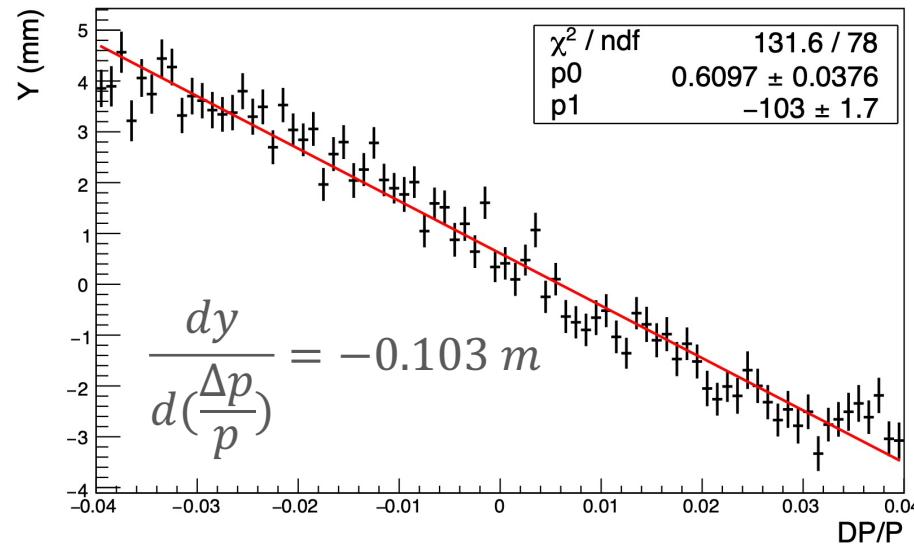
# Space required for the installation

- After the 2021 runs NA64 $\mu$  would require a space of 25 m, MUonE would require a space of 40 m for their full setup and AMBER will require their 55 m long COMPASS spectrometer.
- In order to accommodate NA64 $\mu$  and MUonE the beamline elements downstream of the current CEDARs will be removed.
- A rail system will be installed and the magnets and detector components will be installed on it to reduce the change-over time.
- All integration studies for the 2021 runs as well as the rail design have been completed.

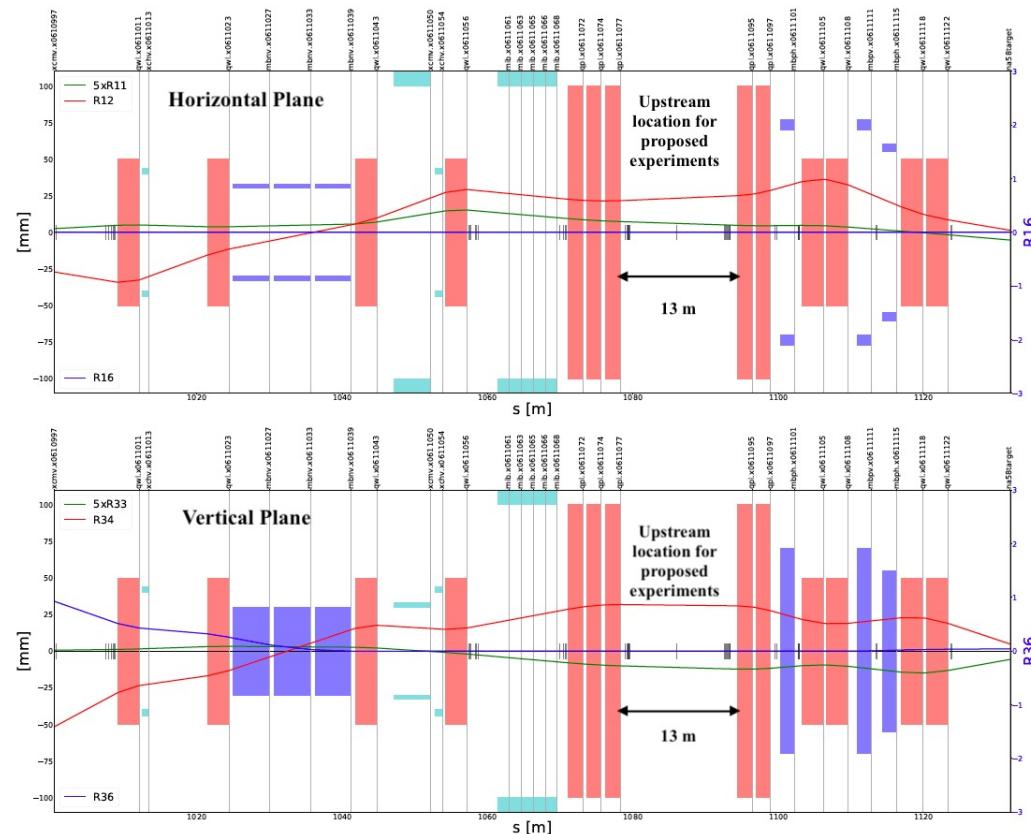


# Optics Studies

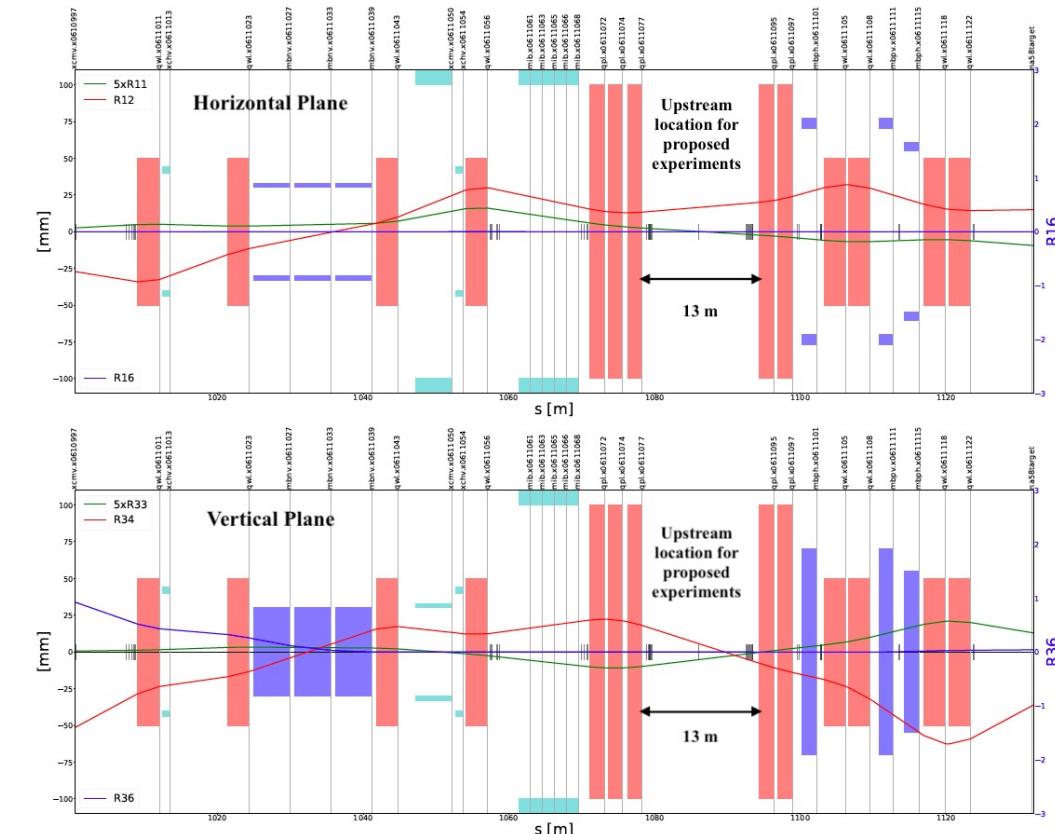
- The M2 beamline is  $\sim 1.1$  km long transporting secondary particles from the target to the EHN2 hall.
- It has a 700 m long hadron section to allow hadron decays to muons followed by 9.9 m Be in a bend to absorb the hadrons with the muons passing through. A 400 m long muon section selects the final muon momentum and cleans the muon beam halo.
- The scattering in the absorbers located inside the vertical bends results in a correlation between  $y$ ,  $y'$  and  $\frac{\Delta p}{p}$ .
- These correlations were added as transport matrix elements, R36 and R46, by means of an arbitrary matrix in MADX to study the optics options at the upstream location.



# Optics Studies



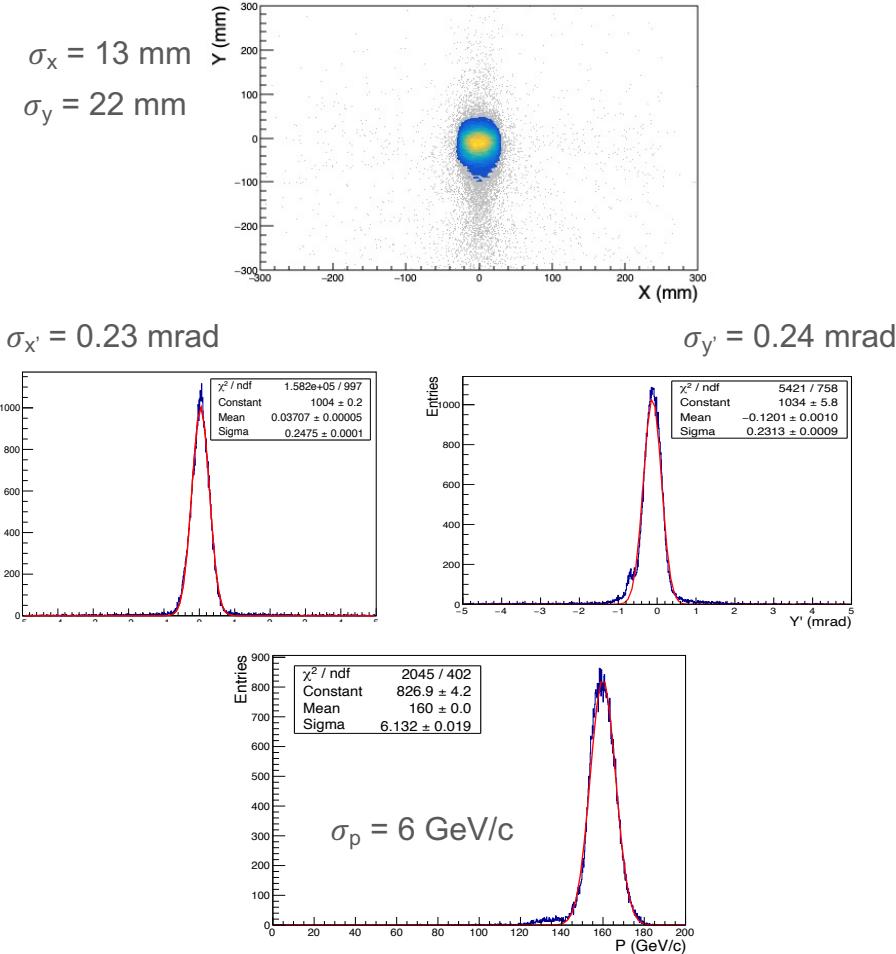
Parallel beam optics for MUonE



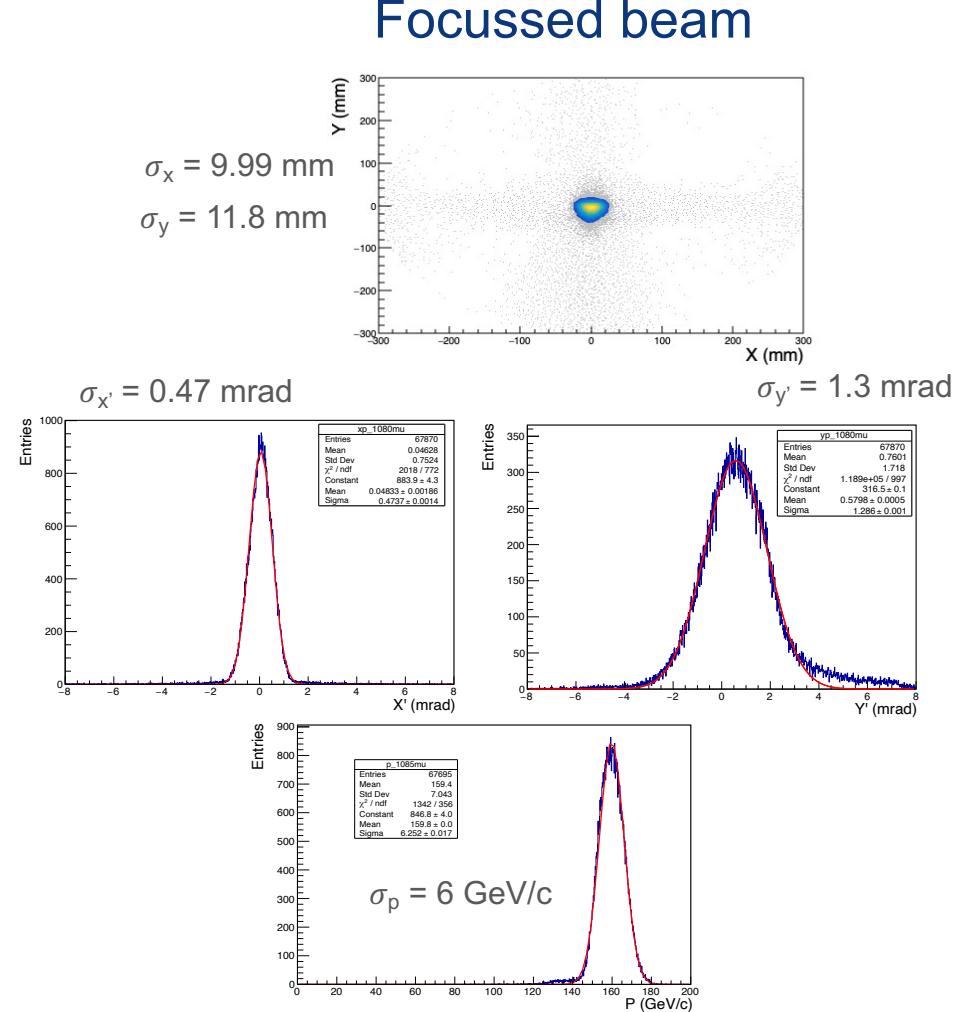
Small beam size optics for NA64 $\mu$  / AMBER

# Upstream Location- Two Optics options

Parallel beam



Focussed beam



# Conclusion

- Three new projects have been proposed for the EHN2 beamline in context of the PBC studies – AMBER, MUonE and NA64 $\mu$ .
- Test runs for all three experiments have been approved.
- Feasibility studies in terms of space, beam parameters and parallel running performed by the Conventional Beams Working Group.
- Space for all three test runs as well as optics options have been finalised.
- Preparation for the 2021 test runs are ongoing – no showstoppers.
- Future studies include higher intensities for Drell Yan, an RF separated option for AMBER, integration of the final MUonE and NA64 $\mu$  setup.

**THANK YOU FOR YOUR ATTENTION !!**

