Overview of the MESA

Institut für Kernphysik
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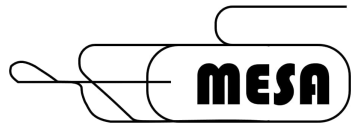
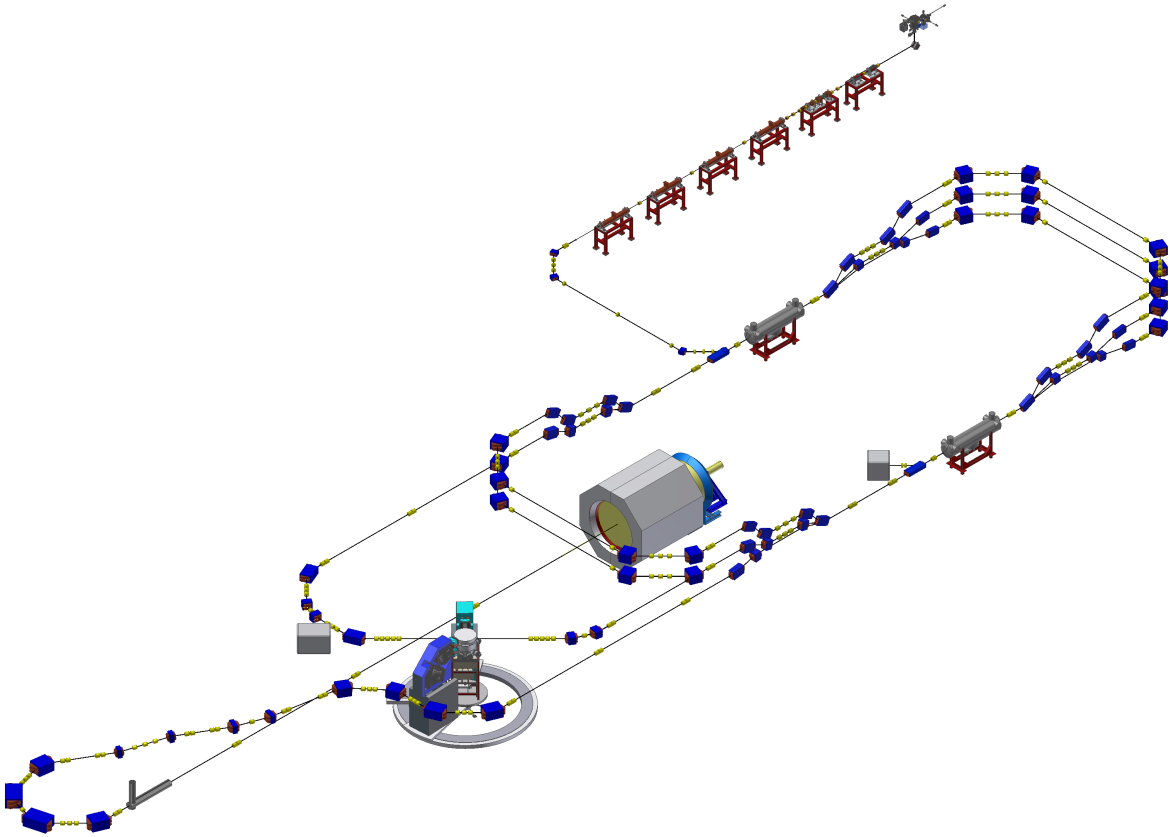
July 10, 2023



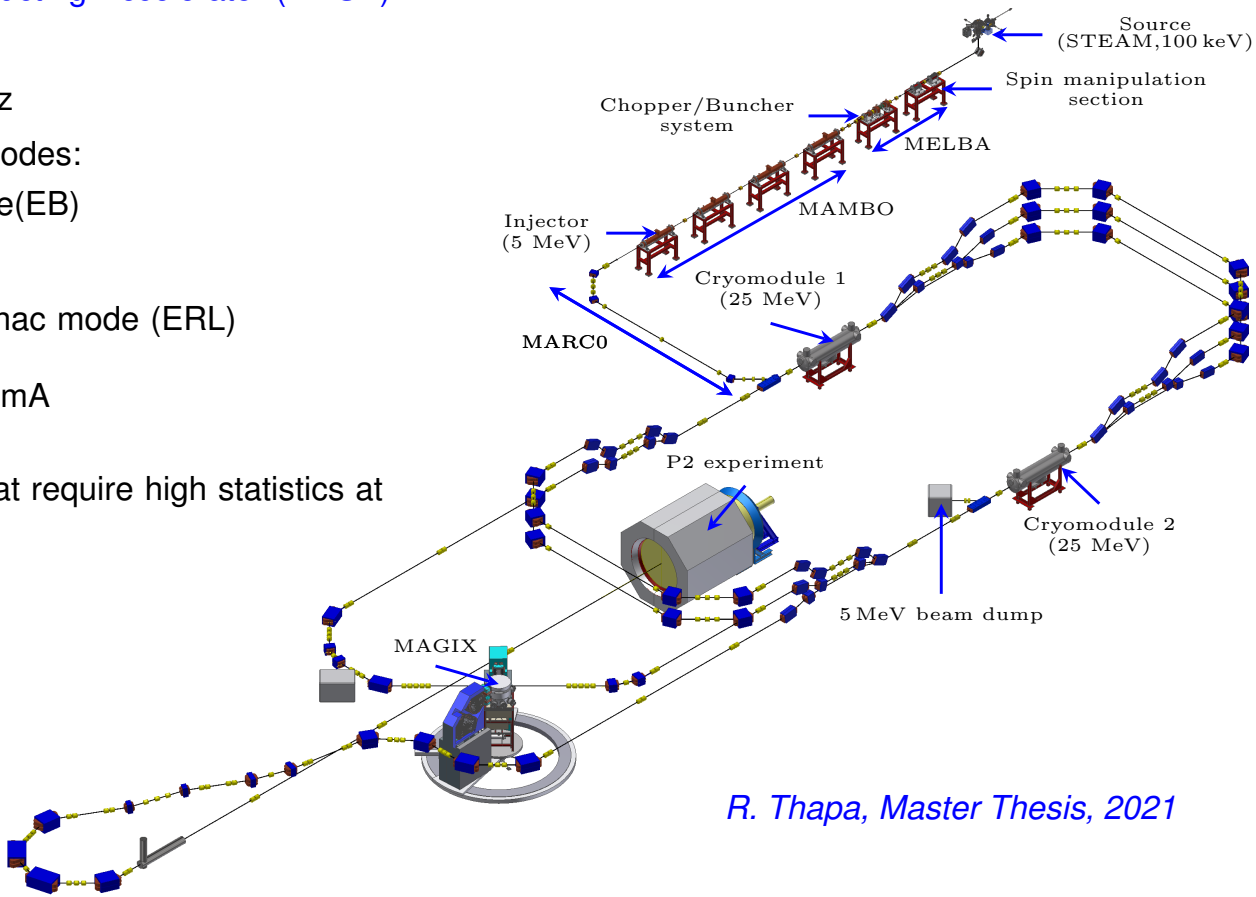
Outline



Introduction and motivation

Mainz Energy-recovering Superconducting Accelerator (MESA)

- CW electron accelerator
- Operation frequency 1.3 GHz
- Planned to operate in two modes:
  - External Beam mode(EB)
    Polarized beam
    155 MeV, 150 µA
  - Energy Recovery Linac mode (ERL)
    Unpolarized beam
    105 MeV, Stage I: 1 mA
    Stage II: 10 mA
- Can support experiments that require high statistics at relatively lower cost.

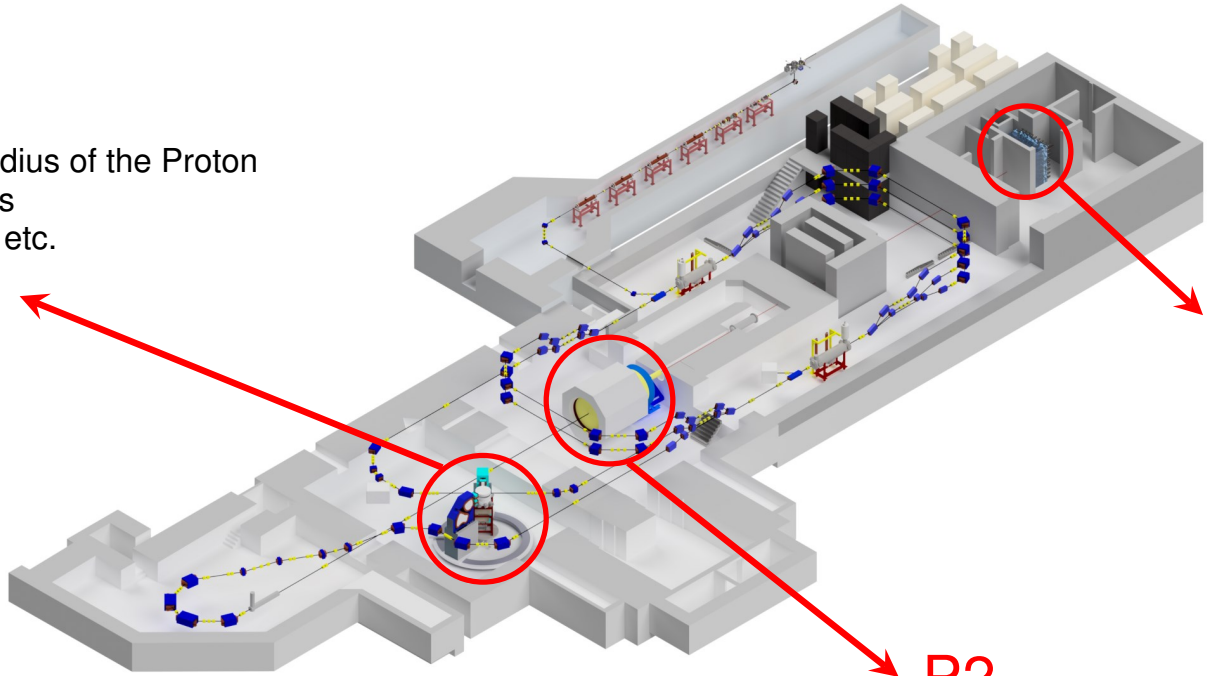


R. Thapa, Master Thesis, 2021

Introduction and motivation

ERL mode
Magnetic Radius of the Proton
Dark Photons
Dark Matter, etc.

MAGIX



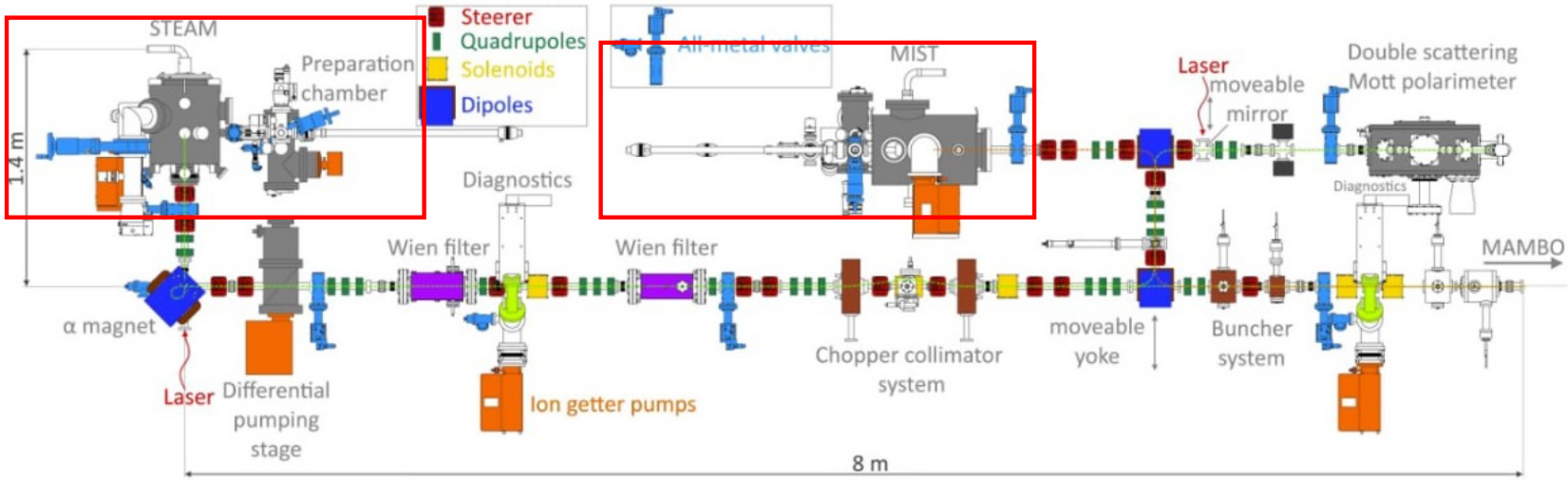
DarkMESA

Parasitic experiment
Light Dark Matter (LDM) search

P2

EB mode
Weak mixing angle $\sin^2 \theta_W$

MELBA – Source and laser



S. Friederich et al., IPAC2021

- MELBA stands for ”MESA Low energy Beam Apparatus”
- Two rf synchronized laser driven DC photoguns are planned, i.e., STEAM and MIST.

Small Thermalised Electron Source (STEAM)	MESA Inverted Source Two (MIST)
Polarised source (P>85 %)	Unpolarised source
GaAs based superlattice	Multi alkali K_2CsSb
150 µA to 1 mA	10 mA
Alpha magnet	Dogleg

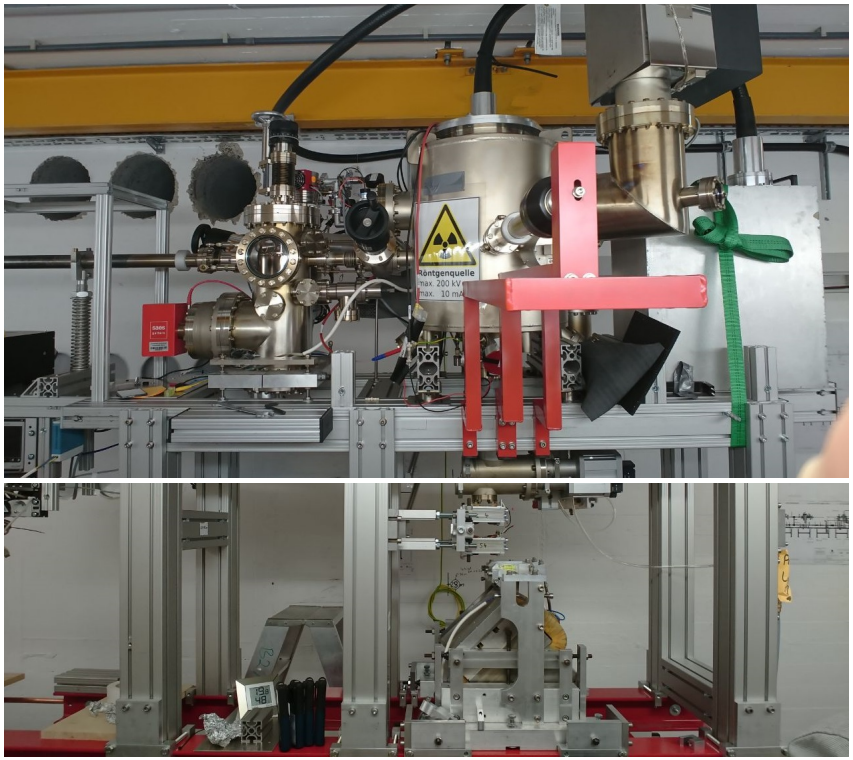
MELBA – Source and laser status

Source and beam injection system

- Installation of the STEAM and alpha magnet done.
- Second injection beamline dynamics with dogleg has been investigated by PhD student A. Kalamaiko. The vacuum chamber is ready for fabrication.
- Study of the helicity correlated electron beam asymmetries in collaboration with Indiana University starting this year.
- Heat dissipation method of photocathode in MIST under investigation by postdoc. M. Dehn.

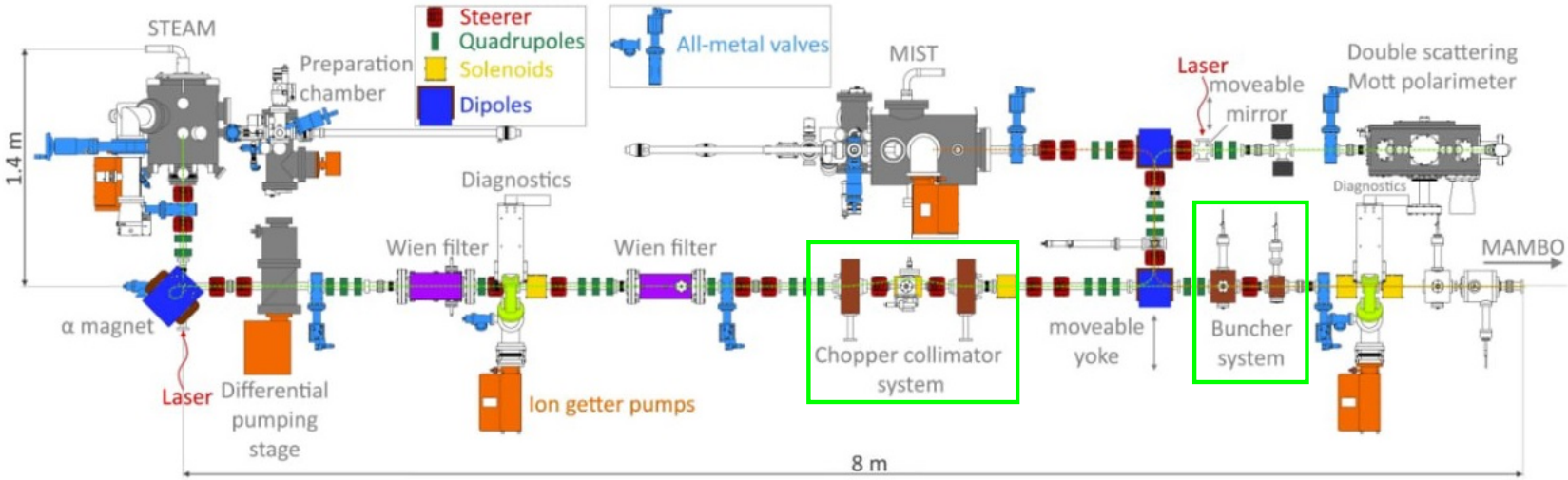
Laser

- Taiko laser with wavelength ≈400 nm already purchased and tested at MAMI for beam diagnostics.
- MANNY laser with wavelength 775 nm will be bought next year. Its prototype was tested at MAMI. It will be used for a polarised beam production.



Installation of STEAM and alpha magnet. *Courtesy of S. Friederich.*

MELBA – Chopper and Buncher

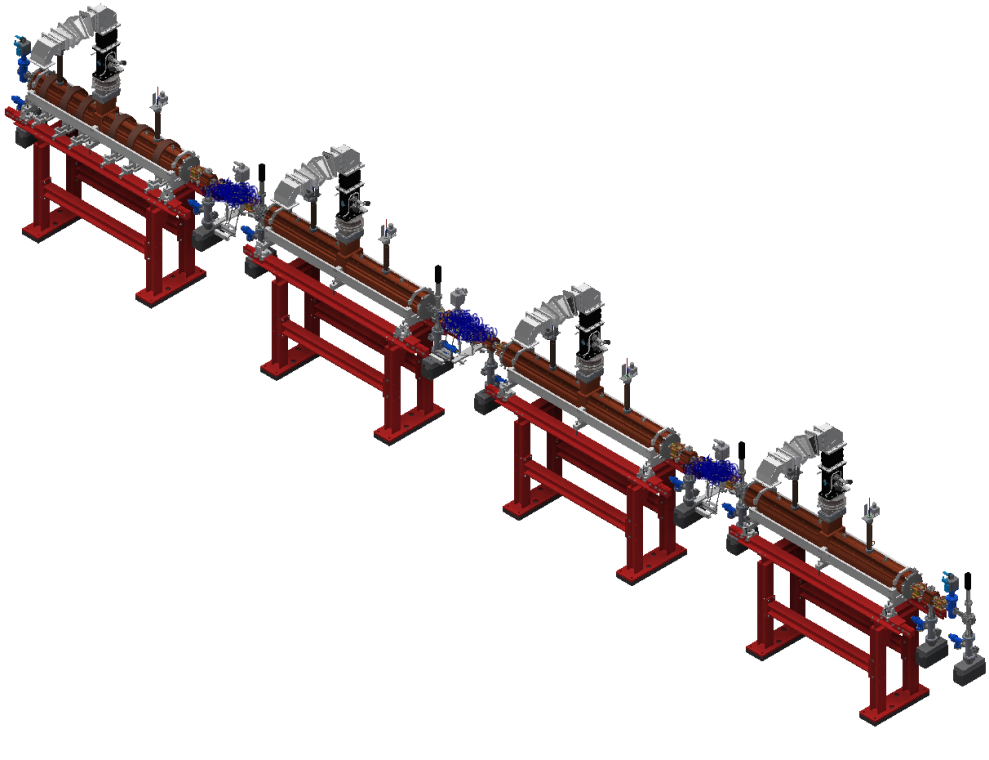


S. Friederich et al., IPAC2021

- Chopper consists of two deflecting cavities, a pair of solenoids and a collimator.
- With the chopper system, bunch length can be pre-shaped to match the acceptance of the buncher system.
- Buncher consists of two cavities and a solenoid.
- To match the acceptance of MAMBO, buncher system longitudinally compresses the charge bunches to ultra-short bunches .

MilliAMpere BOoster (MAMBO)

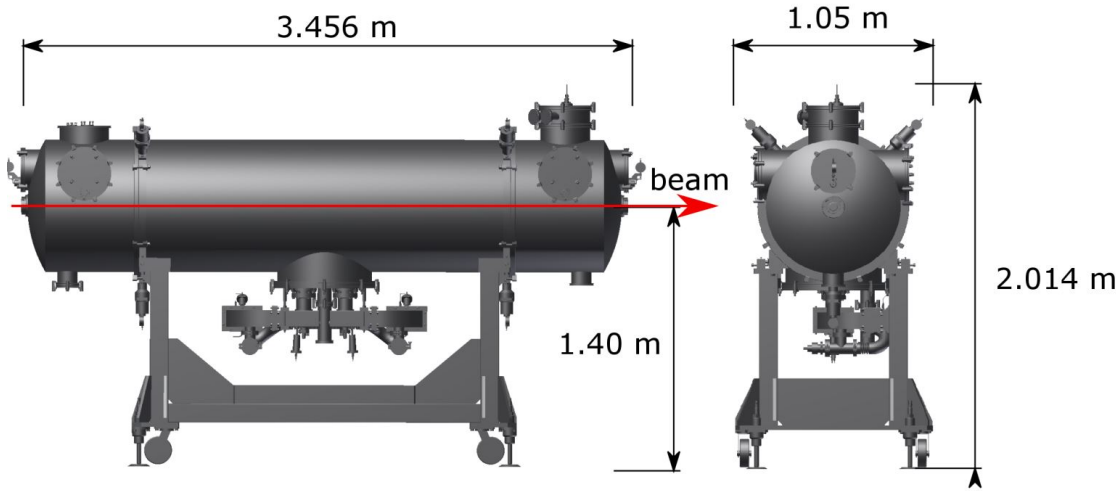
- MAMBO consists of four accelerating sections.
- First one is β graded and others are constant β.
- Consists normal conducting bi-periodic $\pi/2$ RF cavities.
- Preaccelerates the beam to 5 MeV.
- Each section offers 1.25 MeV energy gain.
- All three constant β sections are available.
- β graded section is expected to be delivered soon.



Incharge R. Heine

MESA Enhanced ELBE-Type Cryomodules (MEECs)

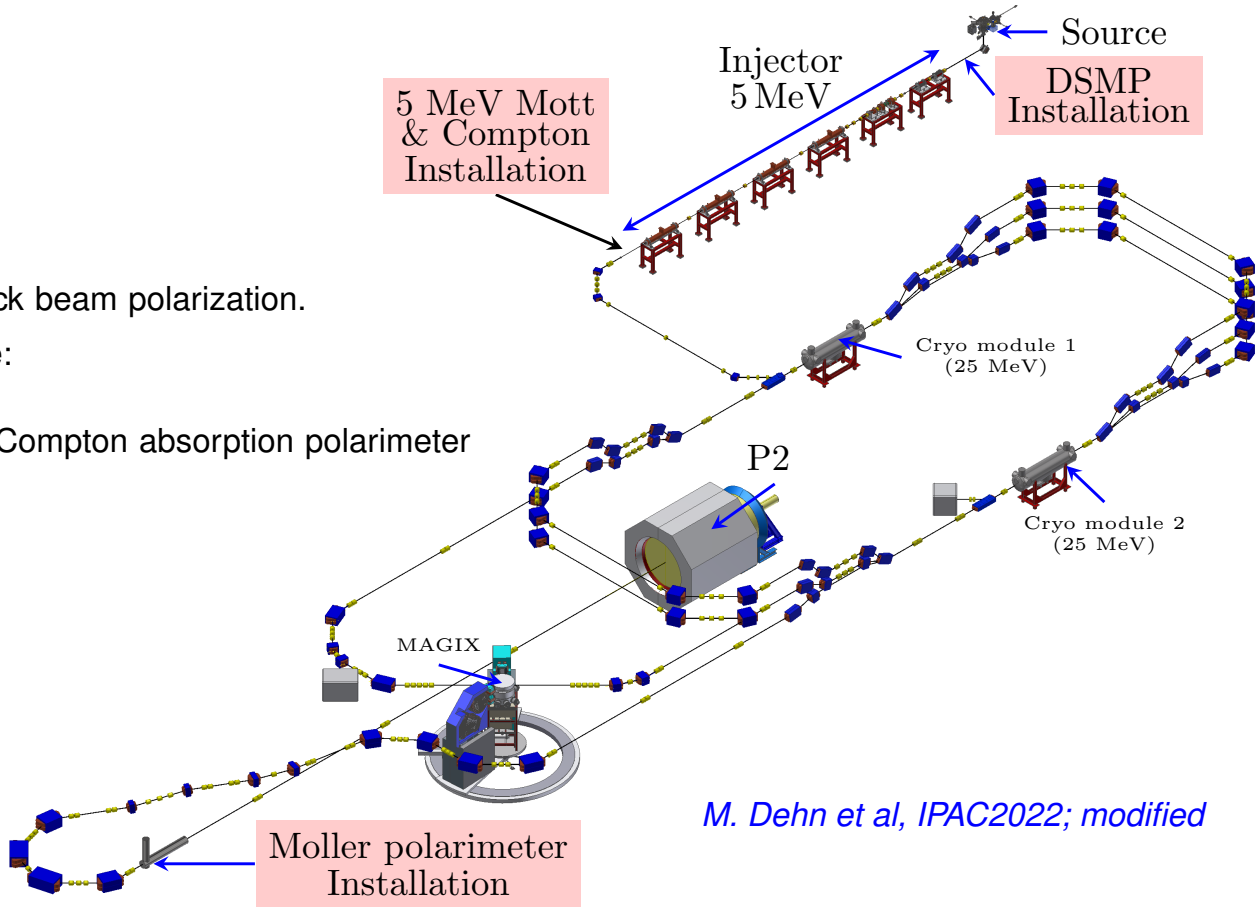
- Four TESLA/XFEL 9-cell SRF cavities are assembled in two modified ELBE cryomodules.
- Operation temperature 1.8 K
- Each cryomodule can provide an energy gain of 25 MeV.
- MEECs fulfilled the site acceptance tests (SAT) and wait to be installed in the main accelerator.
- A spare cryomodule is in the process of refurbishment at the institute.
- PhD student Paul Plattner is investigating superconducting thin films coat on HOM antennas to improve their power limit.



T. Stengler, SRF2015

Polarimetry at MESA

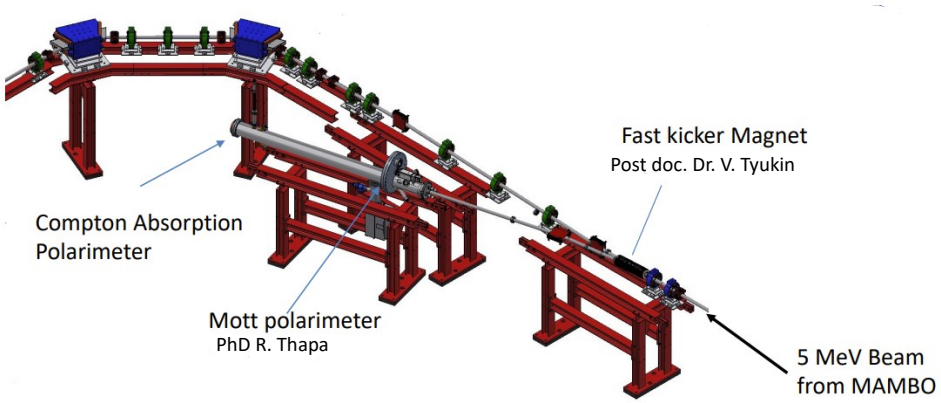
- Polarimeters chain to track beam polarization.
- Planned polarimeters are:
  - 100 keV DSMP
  - 5 MeV Mott and Compton absorption polarimeter
  - 155 MeV Moller



M. Dehn et al, IPAC2022; modified

Polarimetry at MESA – Status

- DSMP is already available. However, for full operation, its existing problems must be solved.
- 5 MeV Mott has been designed and ready for fabrication.
- Fast kicker for the 5 MeV Mott is under fabrication.
- Compton absorption polarimeter already available.
- Moeller polarimeter is under investigation via Geant4 simulation by PhD student Michail Kravchenko and his team.



K. Aulenbacher, MESA-Polarimeter Workshop, 2023

Outlook and summary

Outlook

- Installation of injector beam optics is expected to complete soon.
- 5 MeV Mott is expected to be installed next year spring.
- First test beam is expected to be delivered by the end of this year.

Summary

- MESA will serve as a probe for the frontiers of Nuclear Physics.
- It is a CW electron accelerator with 1.3 GHz operation frequency.
- It will operate in two modes, i.e., EB and ERL mode with polarised and unpolarised electron beams.

Thank you!

For more info, please check the website.`https://www.kernphysik.uni-mainz.de/aulenbacher/#name_oben`