# The MESA Project

Mainz Energy Recovering Accelerator: A small accelerator and its experiments…

Kurt Aulenbacher

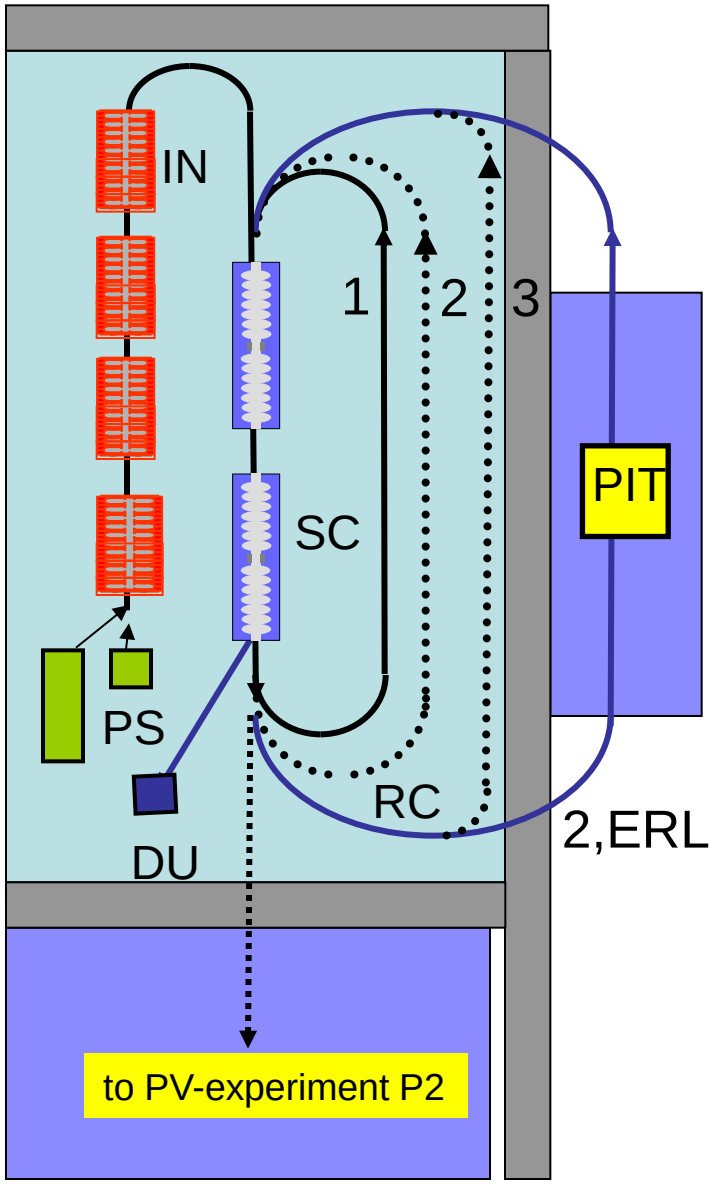
on behalf of MESA Accelerator Working Group

# Outline



- Conceptual  overview
- Main components & functions
- Status of main components

# MESA Concept-from 2009




## MESA main objectives

1. Precision measurement of the weak mixing angle (P2-experiment)
2. Accelerator physics: Multi-turn, superconducting ERL
3. New experimental technique for nuclear and particle physics: The PIT - high luminosity/low background at low energies

**MESA BEAM PARAMETERS (as of today):**

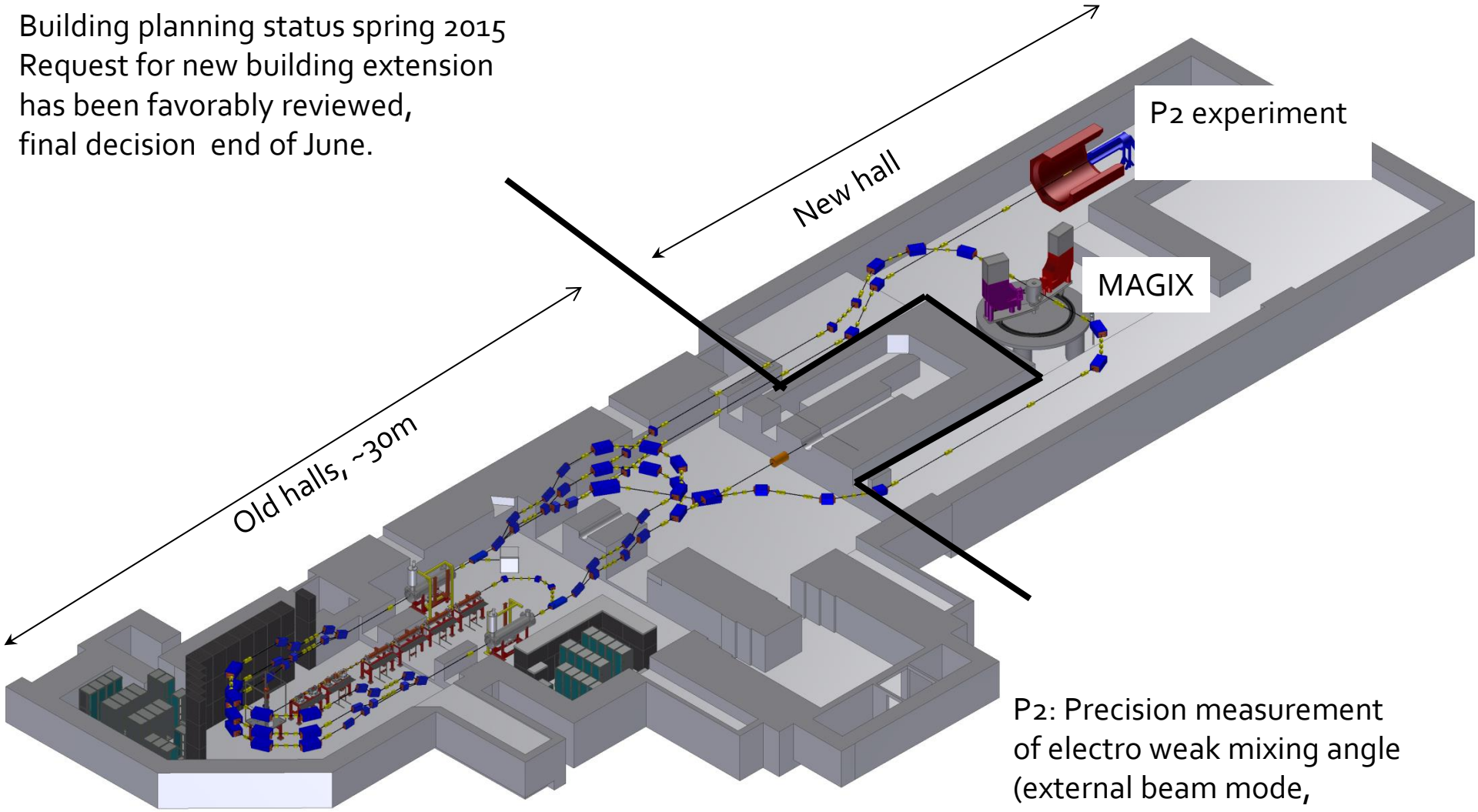
**CW beam**

EB-mode: 150 µA, ~~200~~ 155 MeV spin polarized beam (liquid Hydrogen target L~$10^{39}$)

ER-mode: 1 mA (10 mA), 105 MeV unpolarized beam (Pseudo-Internal Hydrogen Gas target, PIT L~$10^{35}$)

# MESA Concept-now

Building planning status spring 2015
Request for new building extension
has been favorably reviewed,
final decision  end of June.




P2: Precision measurement
of electro weak mixing angle
(external beam mode,
polarized beam)

# MESA Project Group

**SRF-Systems**
**F. Schlander**
T. Stengler (PhD-st.)

**Sources & LEBT**
**K. Aulenbacher**
S. Friederich,
V. Bechthold (PhD-st.)

**High Power & RT RF**
**R. Heine**
C. Matejcek (PhD-st.)
P. Heil, B. Ledroit (MSc-st.)

**Warm Systems**
**L. Hein**
S. Heidrich , I. Alexander (PhD-st)
C. Stoll (MSc-st)

**Beam Dynamics**
**F. Hug (des.)**
D. Simon (PhD-st.)

**Beam Control & Feedbacks**
**J. Diefenbach**
R. Herbertz (PhD-st)

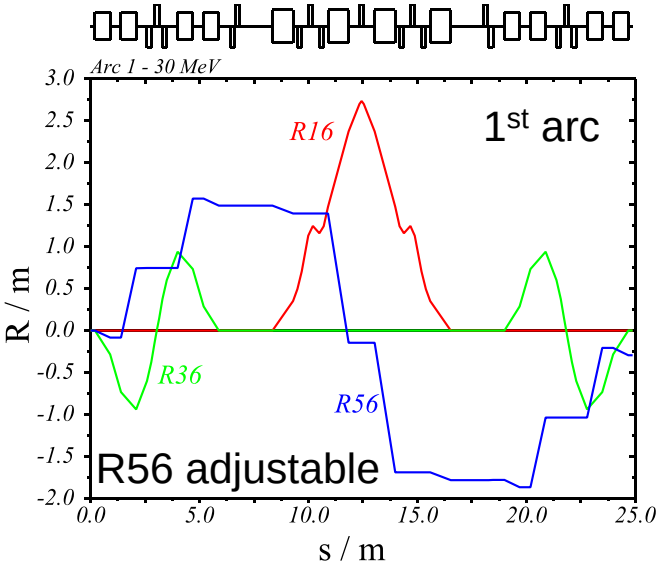
## KPH-Departments

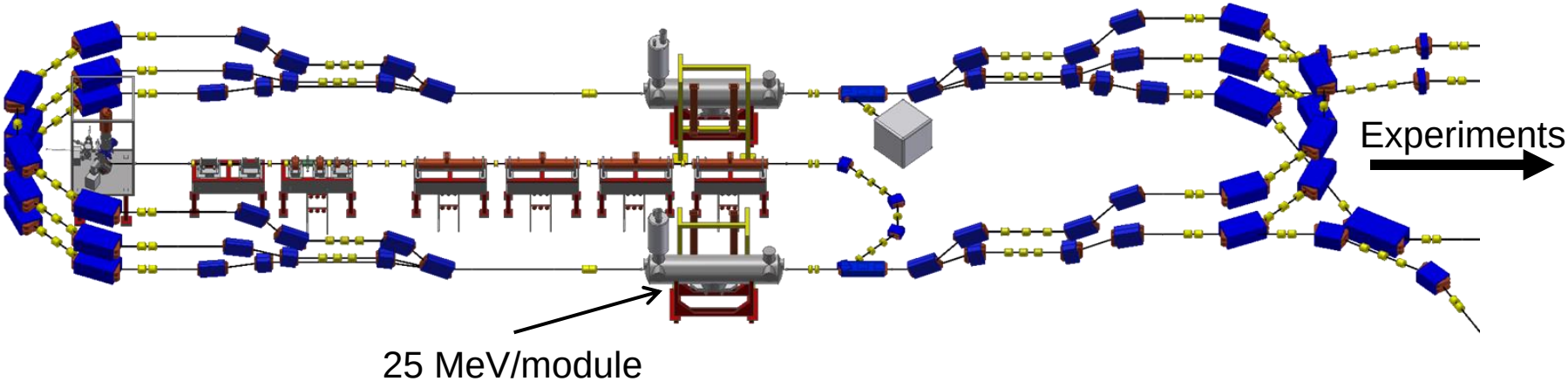
- MAMI (H. J. Kreidel)
- Vacuum and Cryogenics (E. Schilling)
- Electronic workshop (W. Lauth)
- Mechanical workshop (P. Jennewein)
- IT (K.W. Krygier)
- Rad. prot. (J. Diefenbach)
- Installation (A. Thomas)
- Tech-Design (K. Aulenbacher)

# MESA Lattice



- Lattice was modelled with:
  - in house matrix optics program
  - MAD X
  - PARMELA for space charge and pseudo damping due to main linac modules

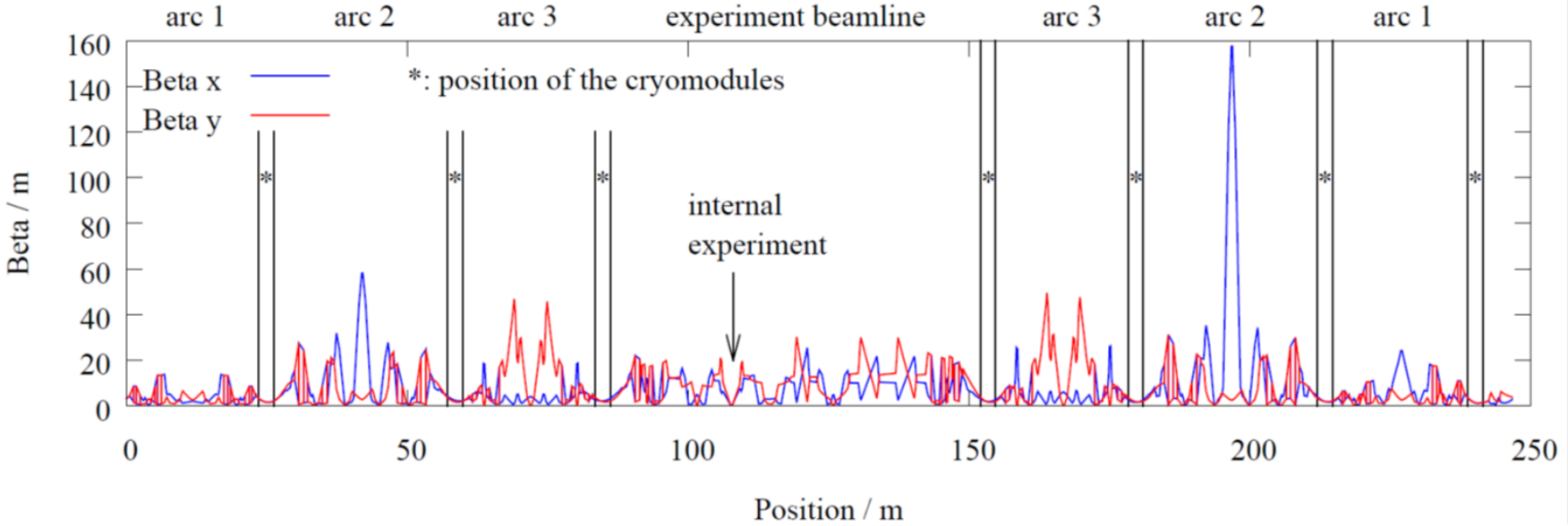


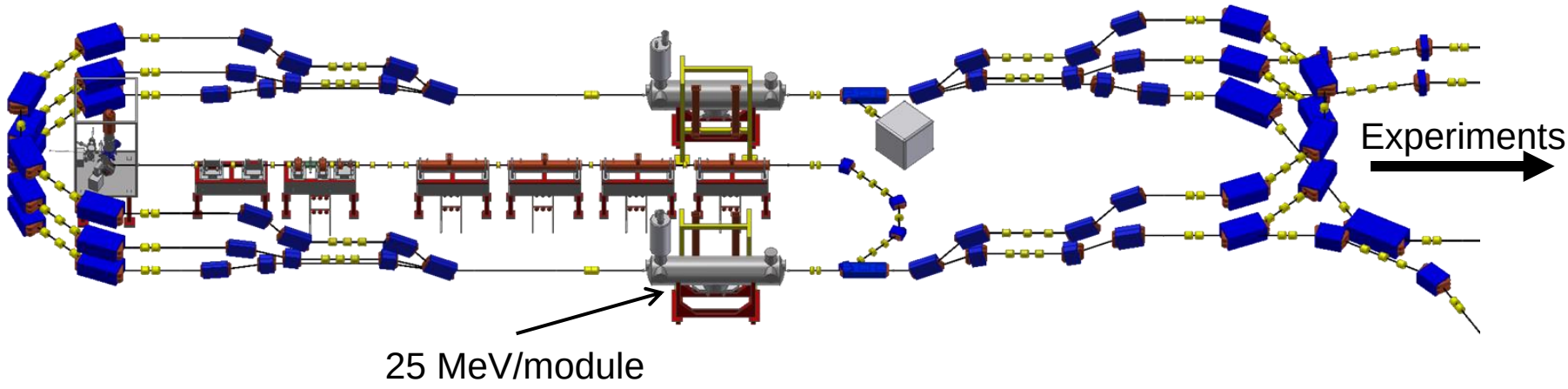




D. Simon presented at IPAC15, MOPWA046

# MESA Lattice

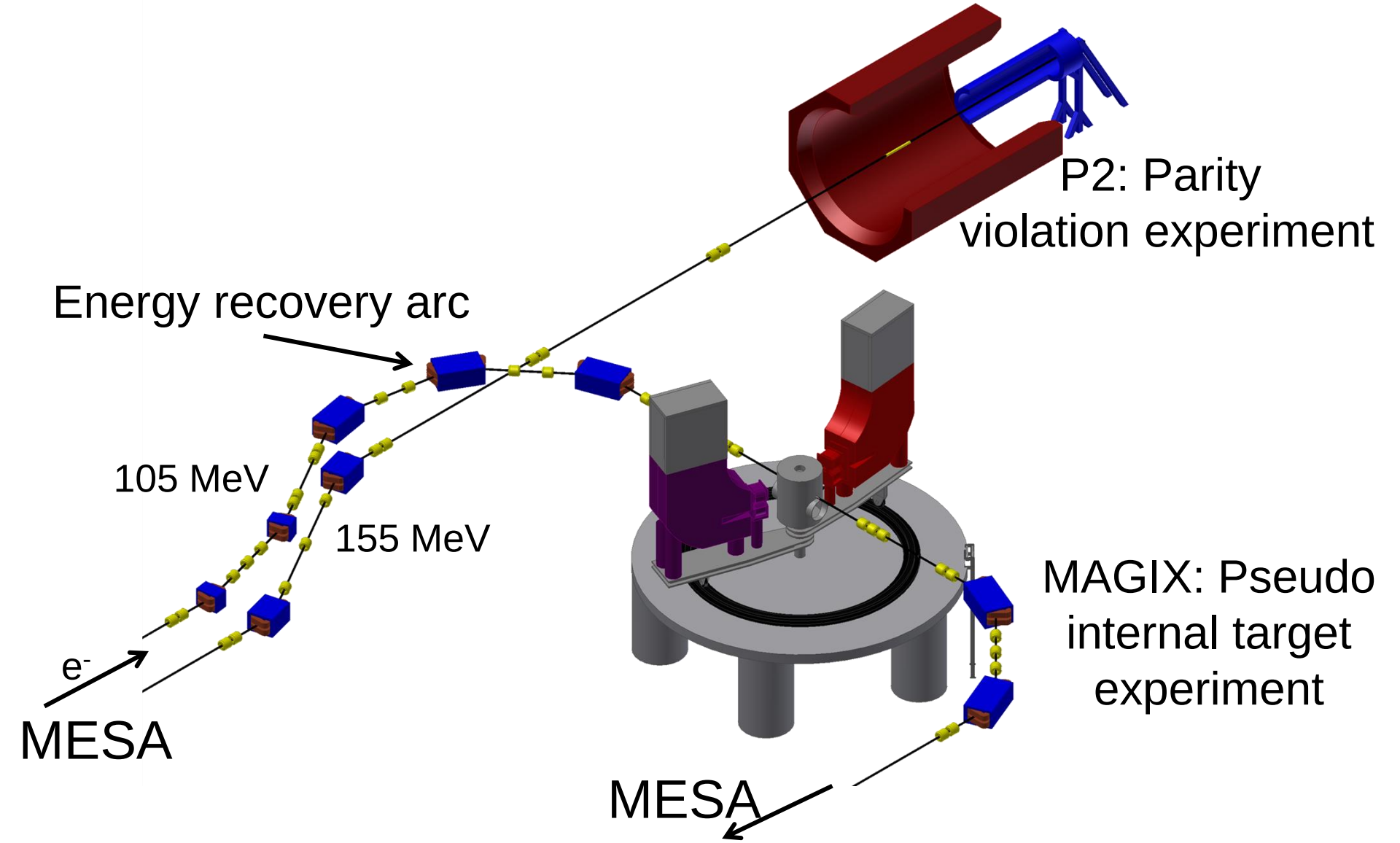
## Beta functions from PARMELA for MESA in ERL mode




D. Simon presented at IPAC15, MOPWA046

# MESA Experiments



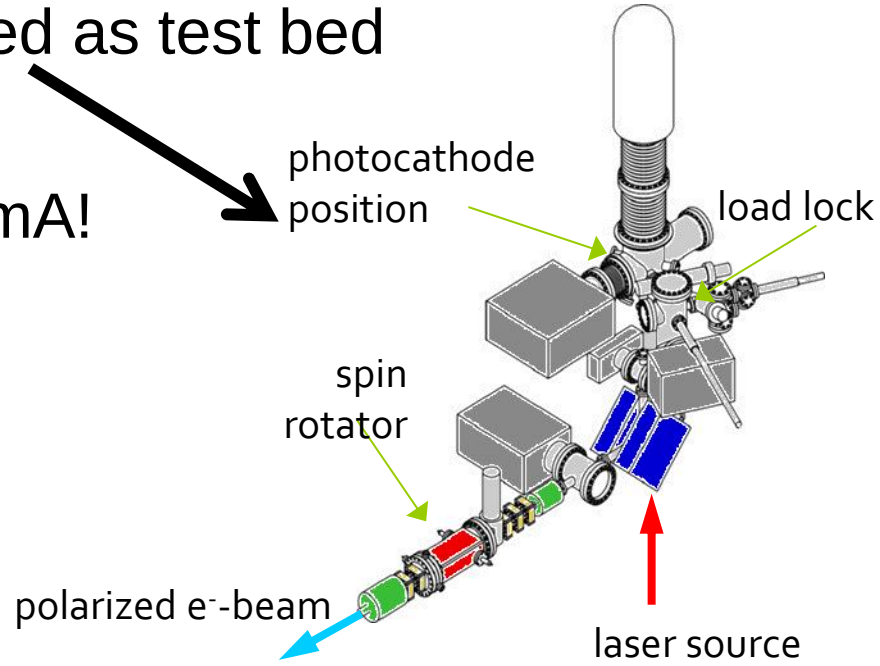
# MESA Main components

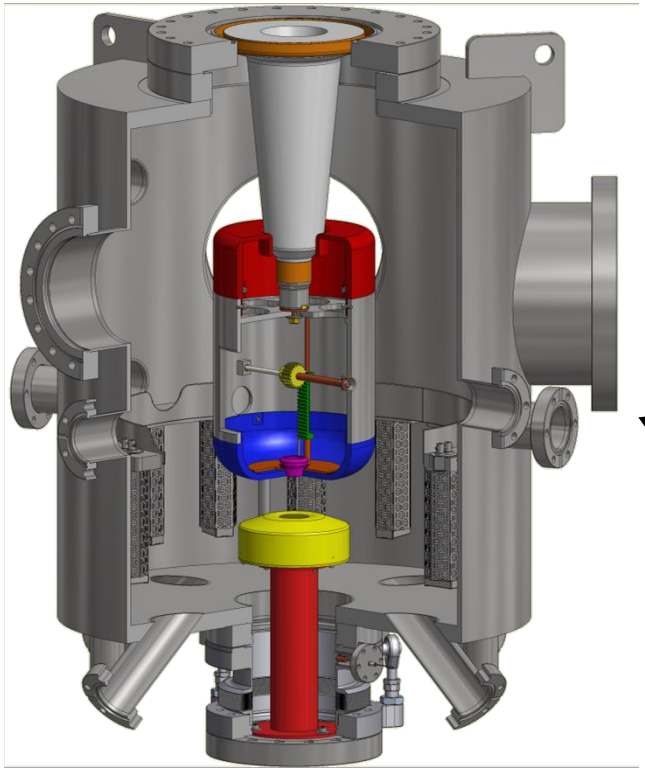


| Component | Function | Status |
|---|---|---|
| MESA Low energy Beam Apparatus, MELBA → | Source, spin rotation, chopper/buncher, a.m.m. | Design nearly finished, Under construction |
| MilliAMpere BOoster injector, MAMBO | 5 MeV, 50kW beam | Design nearly finished, Start tendering |
| Mesa Enhanced ELBE Cryomodule, MEEC | 2*25 MeV Energy gain per pass, 1mA current in ERL on target at 100MeV | Ordered at RI Instruments |
| MESA Arcs MARC-0 to MARC-5 | 6 *180 deg deflections 5,30,55,80,105,130 MeV | Detailed magnet design ongoing. |
| MESA Infrastructure Specific Component, MISC | Beamlines Cryogenic circuit, Vacuum,supports, beam diagnostics | Design started for some issues, but many open Tasks! |

# MELBA:Polarized Photo Source

- Existing photo source PKA2 used as test bed
- Copy of MAMI source
- 100 keV, 1MeV/m→ o.k. for >1mA!



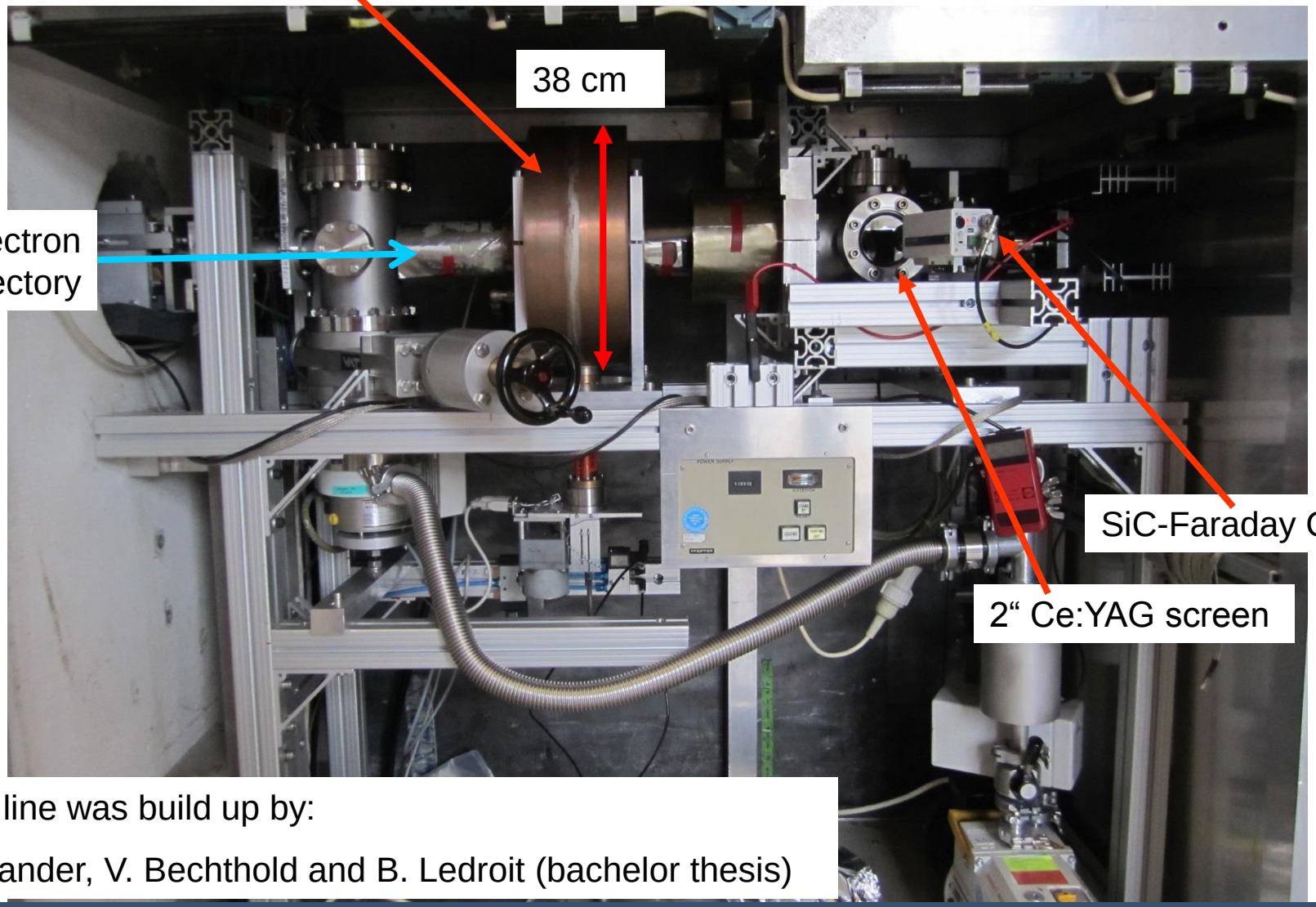
- Upgrade Program STEAM
- New designed inverse cathode (→ JLAB)
- 100-200 keV, 2-5MV/m

→ probably o.k. for >10mA.

S. Friederich presented at IPAC15, TUPWA044

# LEBT: Deflecting Cavity Tests

## 1.3 GHz deflecting cavity - first working RF component for MESA

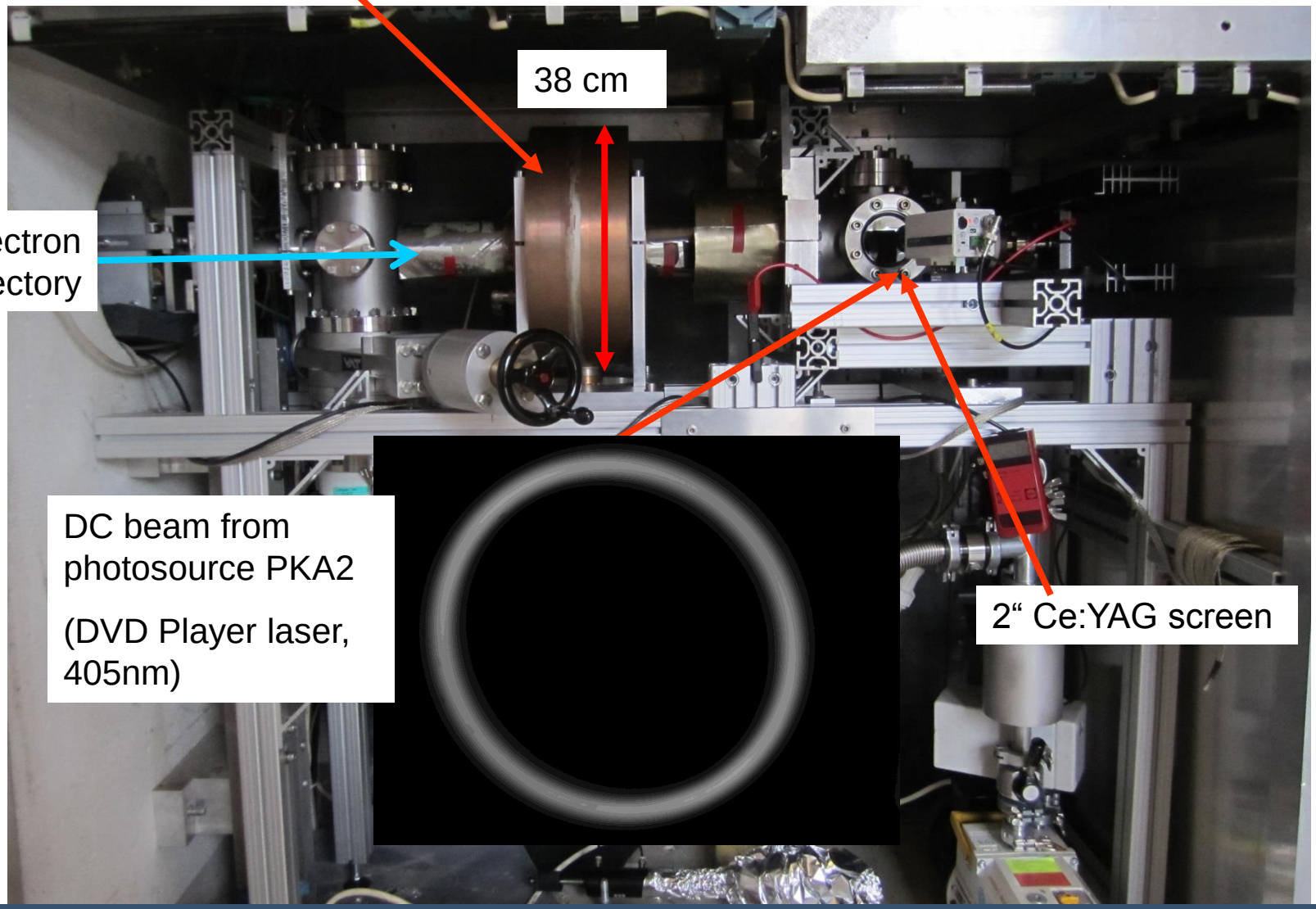



Beam line was build up by:

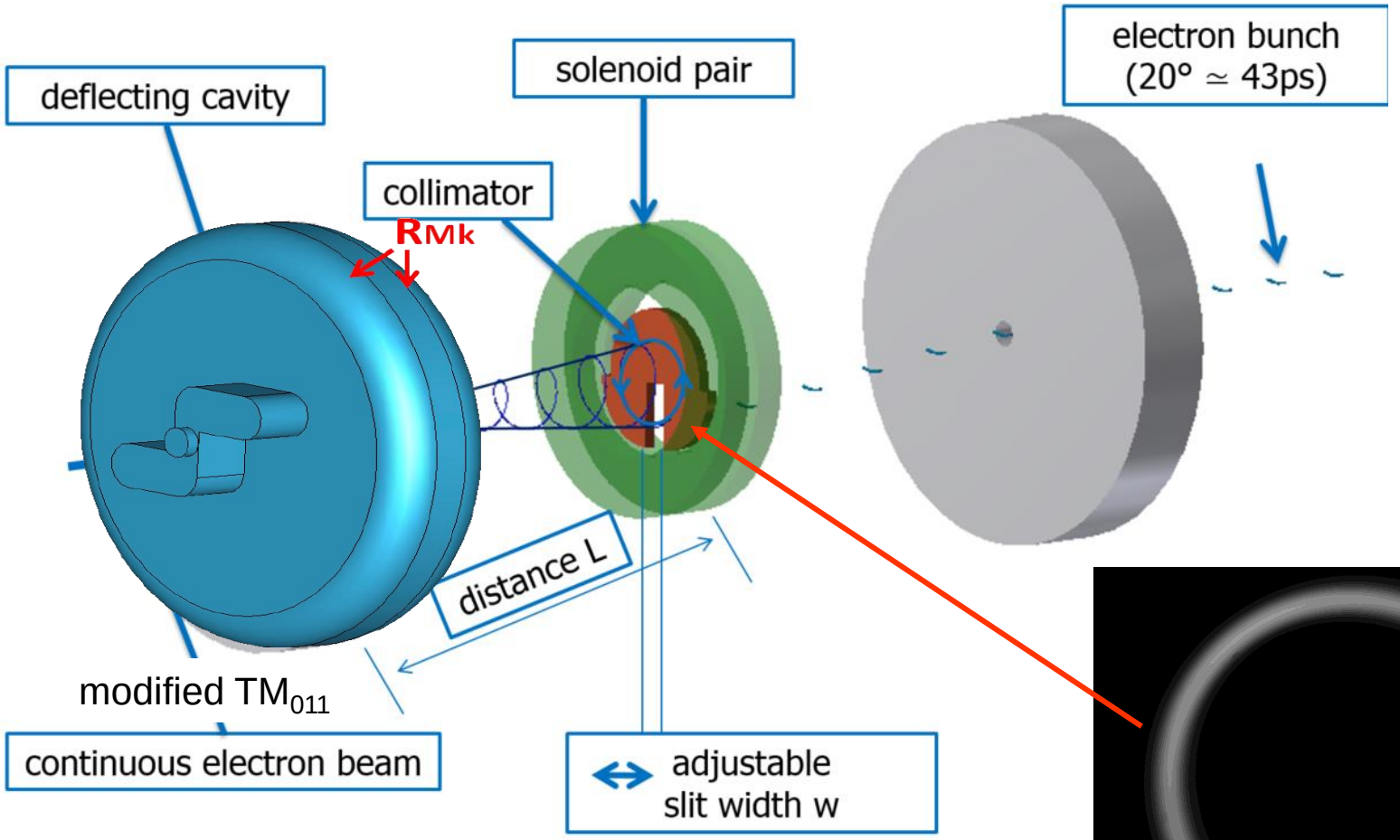
I. Alexander, V. Bechthold and B. Ledroit (bachelor thesis)

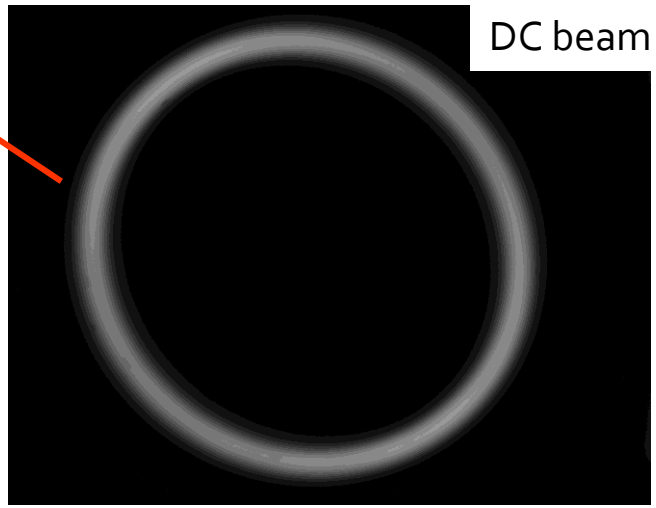
# LEBT: Deflecting Cavity Tests

## 1.3 GHz deflecting cavity: first RF component for MESA!



# LEBT: Circular Chopper (d.c.-operated)

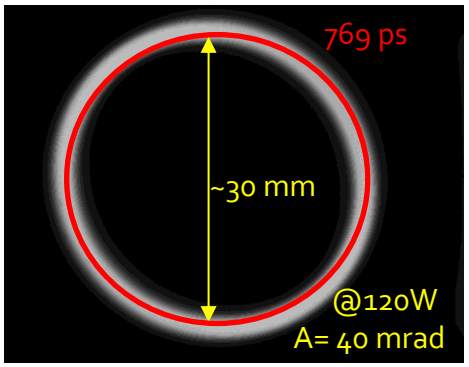


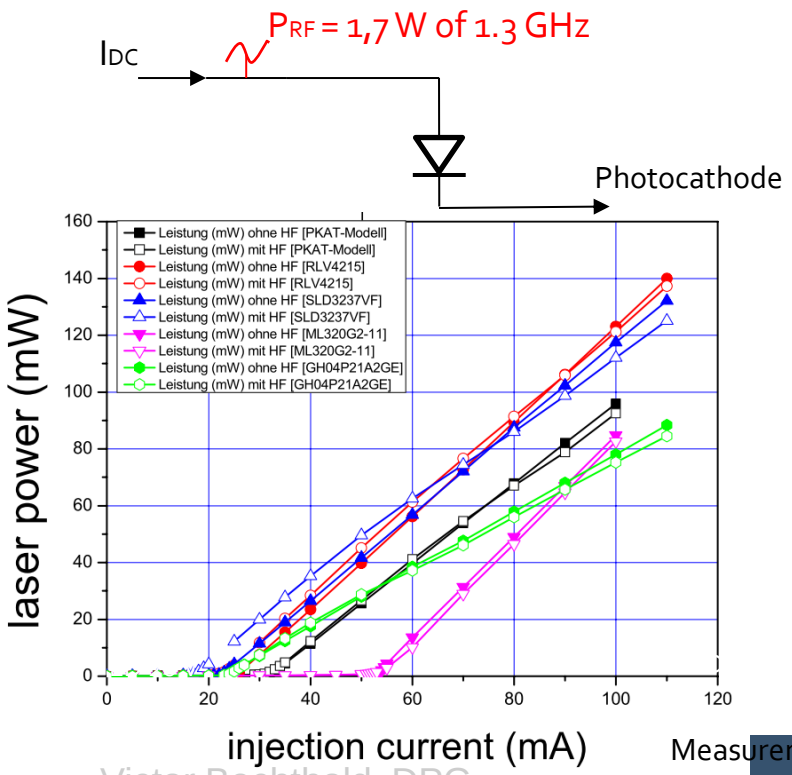




In principle, the chopper can be avoided, if a r.f. synchro-photosource is used, **but there are caveats**!
f/2f buncher system can accept ≤ 180 degree:
Laser pulse convolutet with response must be shorter

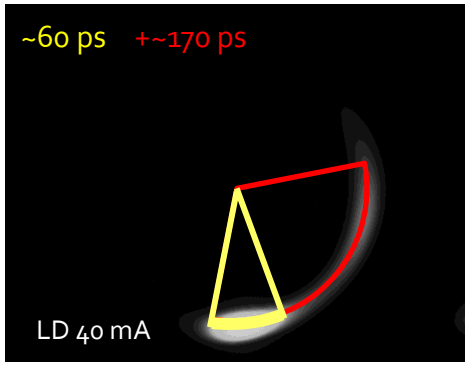
# 1.3 GHz pulsed beam, Ce: YAG screen

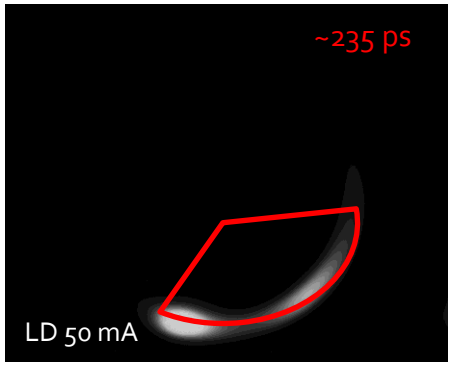
DC laser beam, without RF

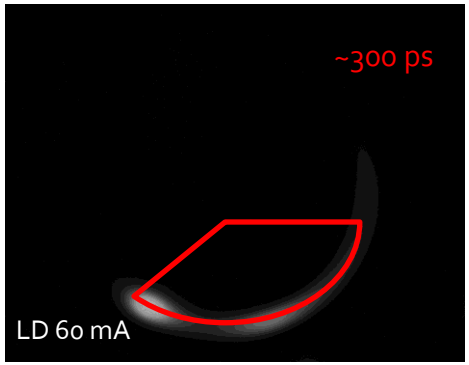


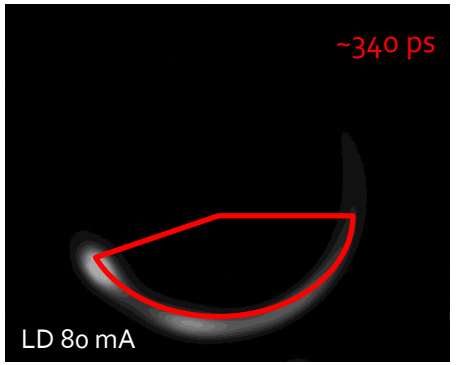



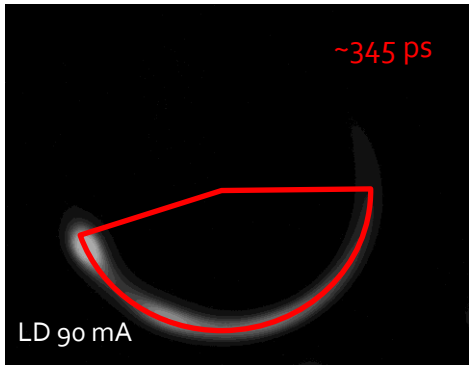

pulsed laser diode $f_{RF}$ = 1.3 GHz:

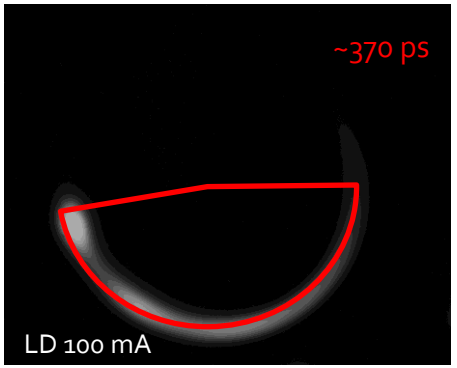


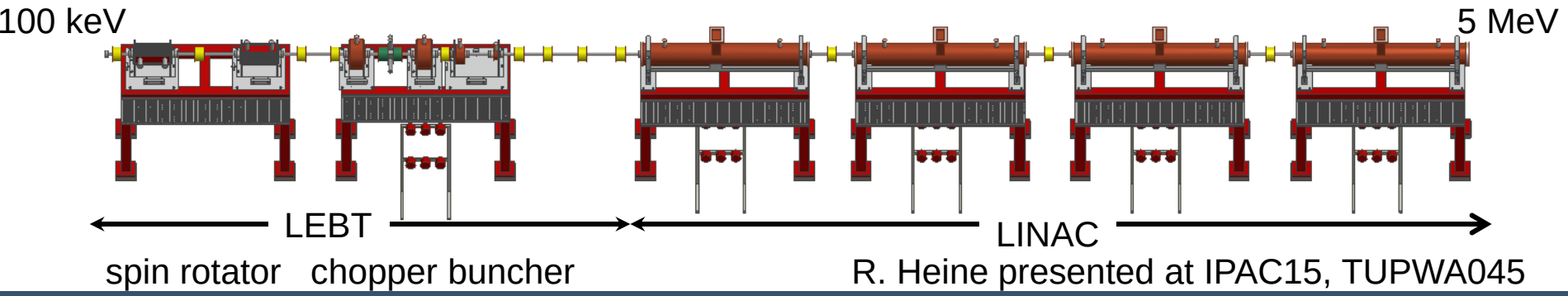




Measurements (February 2015) by: I. Alexander, ongoing PhD thesis, University Mainz

# Injector: Milliampere Booster – MAMBO



- Inspired by the MAMI injector LINAC
- 4 room temperature RF bi-periodic pi/2 standing wave structures @ 1.3 GHz
- 1 graded-β, 3 const. β sections
- Energy gain ΔE=1.25 MeV/section
- Beam dynamics with PARMELA 3D
- RF and thermal design with CST Studio Suite



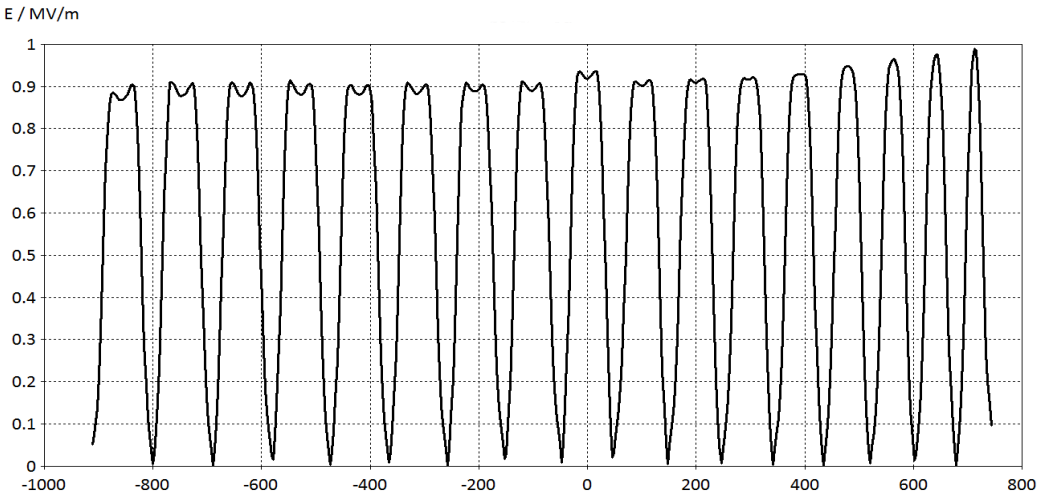
# Injector: Milliampere Booster – MAMBO

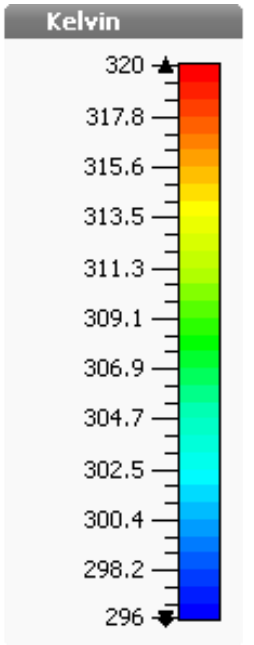


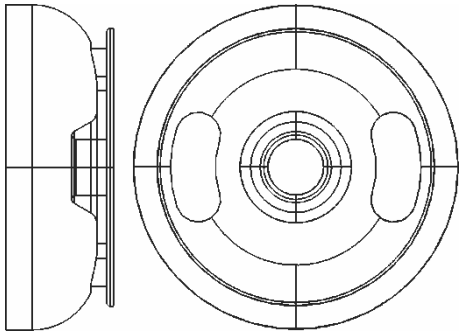
## e.g. Section 1

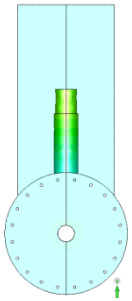
graded-β,
β = 0.548 … 0.957

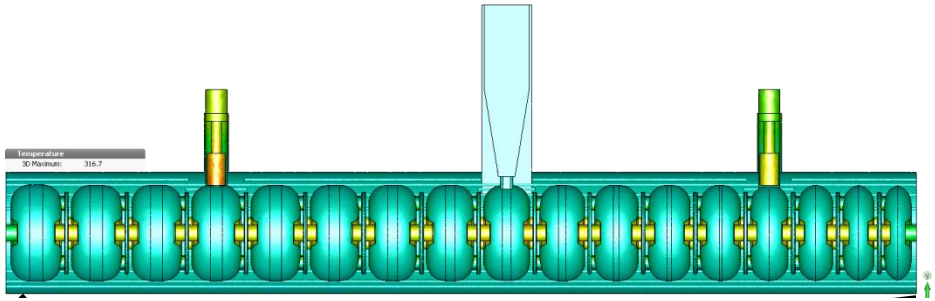
$R_s$= 49.7 MOhm
$Q_0$=21500
L=1658 mm

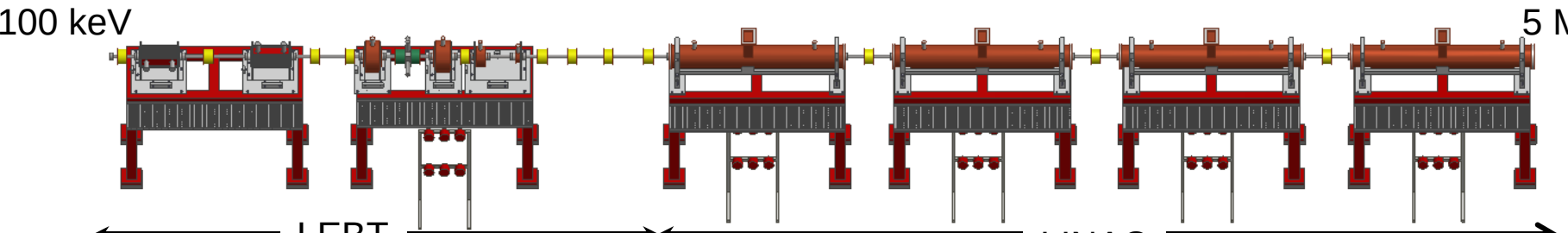




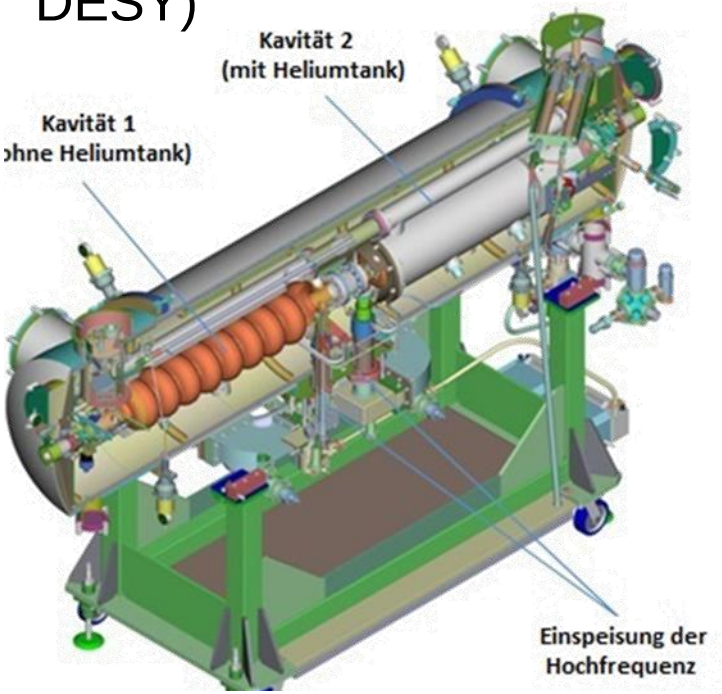


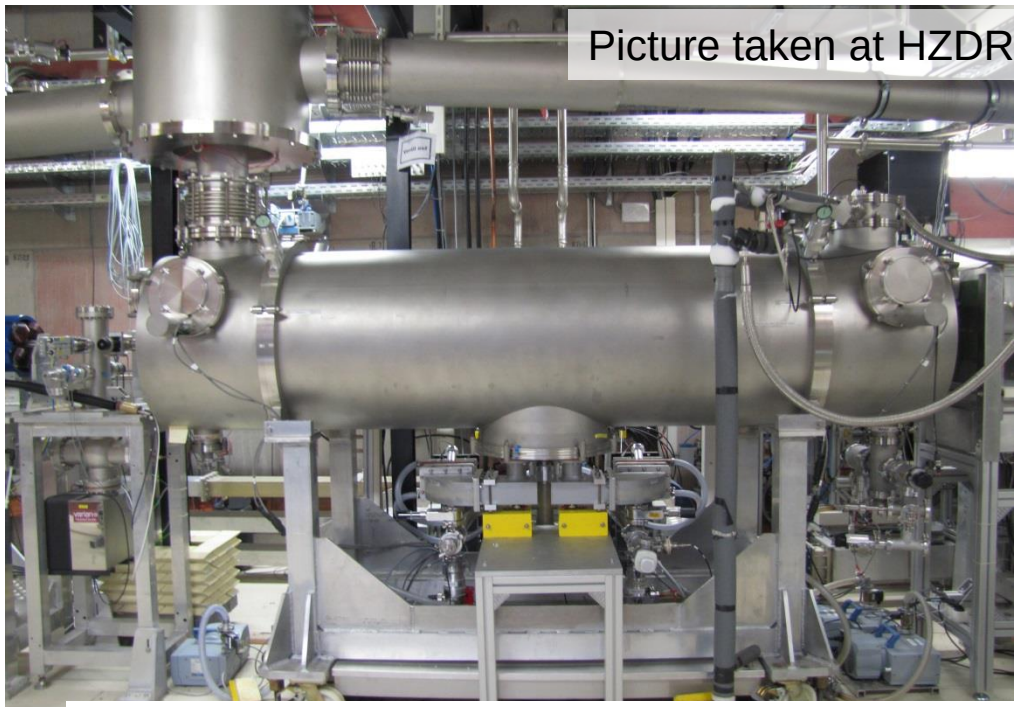

R. Heine presented at IPAC15, TUPWA045

# The MEEC solution: SRF modules

- Order has been placed in March 2015 at Research Instruments
- Two ELBE Rossendorf Modules with modifications (turn key):
  - XFEL Tuner (Piezo) → reconstruction of He-tank
  - XFEL HOM Damper with sapphire feed through (CW!)
- Additional 4K/2K cold box and controls developed by RI (consulted by DESY)




J. Teichert et al. NIMA 557 (2006) 239




F. Schlander presented at IPAC15, WEPMA041

# Summary & Outlook

- The MESA Project is well on the way
- Particle source and LEBT will be available in 2016
- MAMBO RF & thermal design is finished
- SRF modules shall be delivered in Apr./Jun 2017

- But still a lot to be done:
  - MAMBO prototyping and tendering
  - Tendering of SSA RF amplifiers
  - Design of 5 MeV beam line
  - Design of main accelerator magnets (starting in Aug.)
  - Reconstruction of our caves (planning started in 2014)