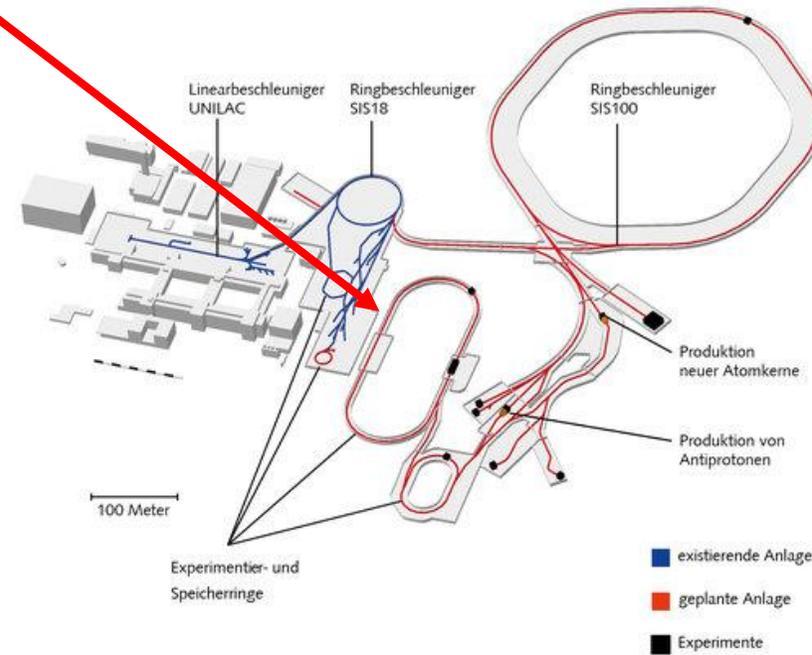
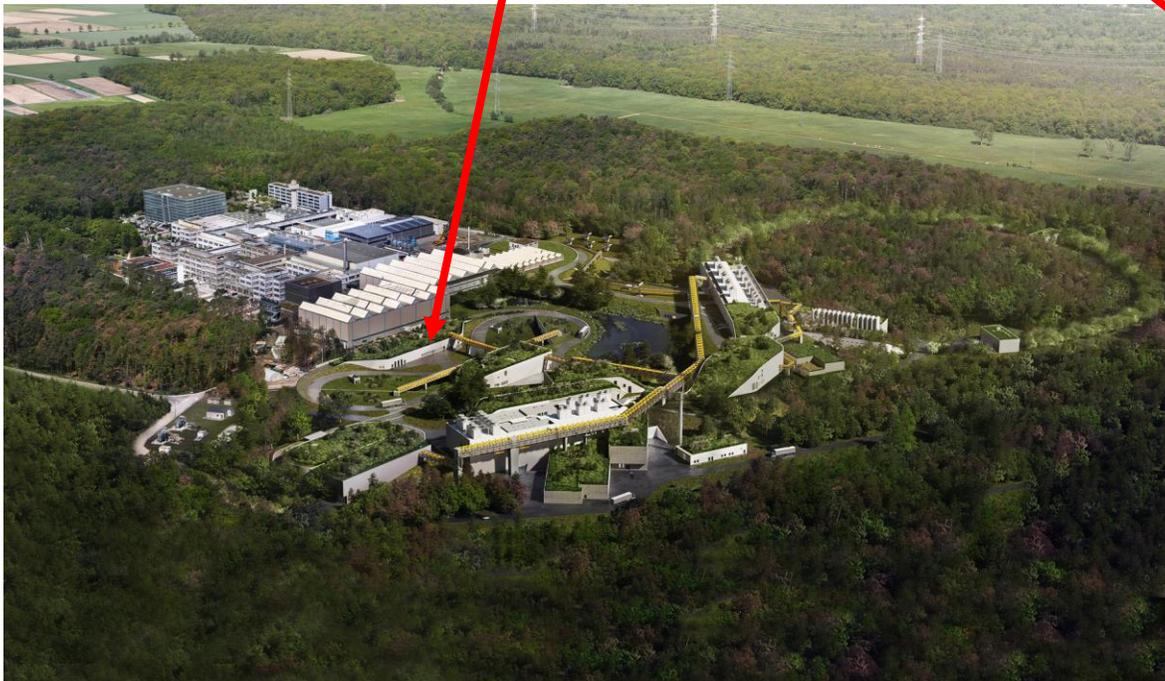


Or: From Electron cooling to medical physics....and Back?

Kurt Aulenbacher, Helmholtz Institut Mainz (HIM)  
Cool-25, Stony Brook  
October, 29, 2025  
Presenting work by HIM Section ACID-II  
(K.A. T. Beiser, J. Dietrich and W. Klag),

## - HESR@FAIR



FAIR FACILITY ion accelerator complex under construction in Darmstadt/Germany (animation: ) <https://fair-center.de/>

## - HESR@FAIR Status and Future



Photo: October 2025 - <https://fair-center.de/>

## - HESR@FAIR COOLER Prototype Status and Future

HESR  
Operation 2035+



SIS-100  
Operation begins  
2028/2029

Antiproton target  
and collector rings

FAIR FACILITY ion accelerator complex under construction in Darmstadt/Germany

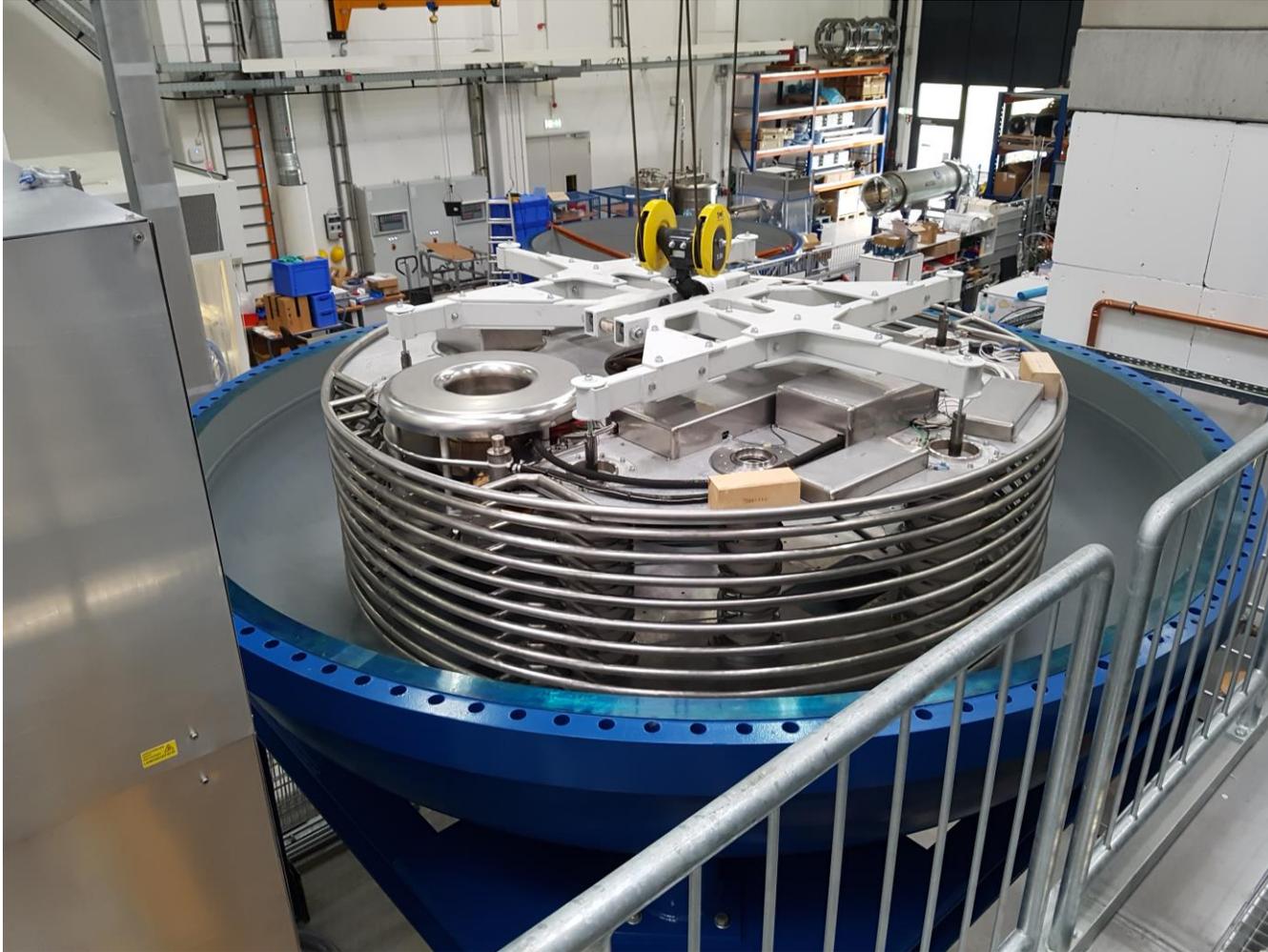
# Status Cooler at HIM

# The “BIG Blue Bubble” HV-Tank



# Modular HV-installation

- 600 kV Modules (first platform build by BINP/Novosibirsk)



Tank during installation of first platform

Pressure tank in operation  
(Oct. 2025)

# Mission...with obstacles...

- The focus was on scalable high voltage platforms (N\*600kV) with turbogenerators to power the solenoid channel.

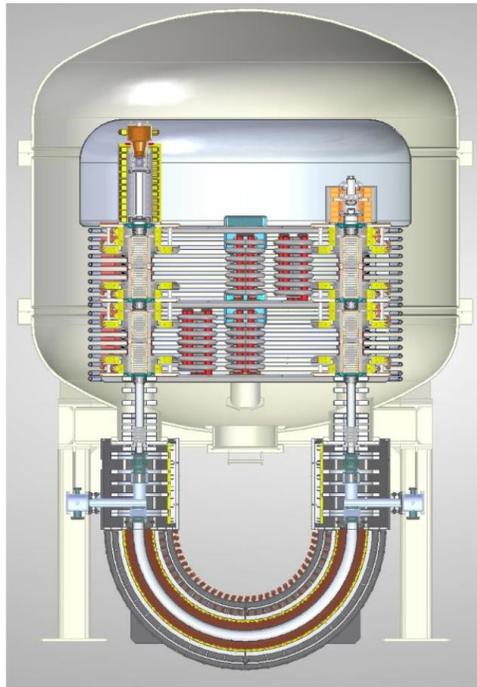
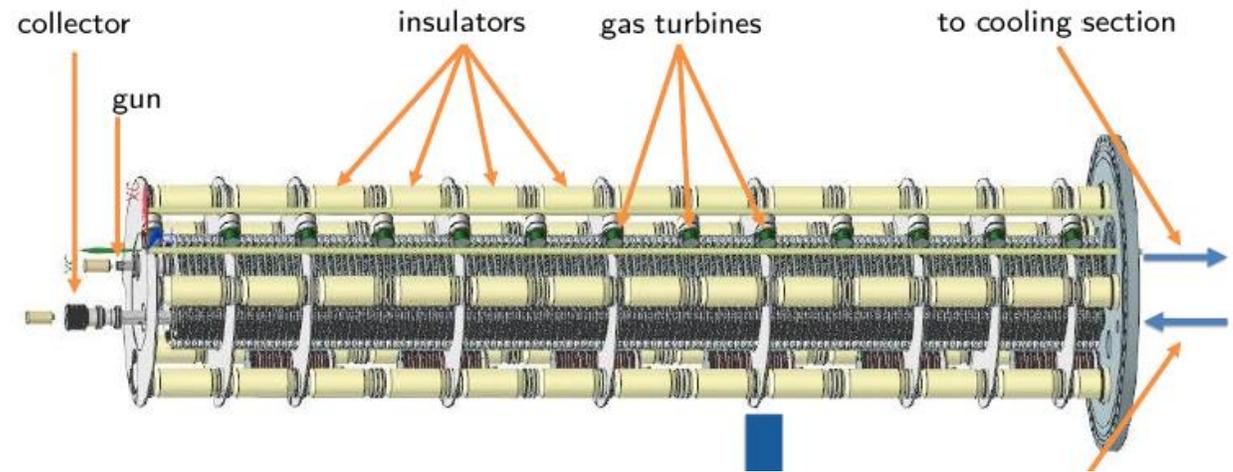


Figure 1.2: General picture of test-bench 1.2 MeV

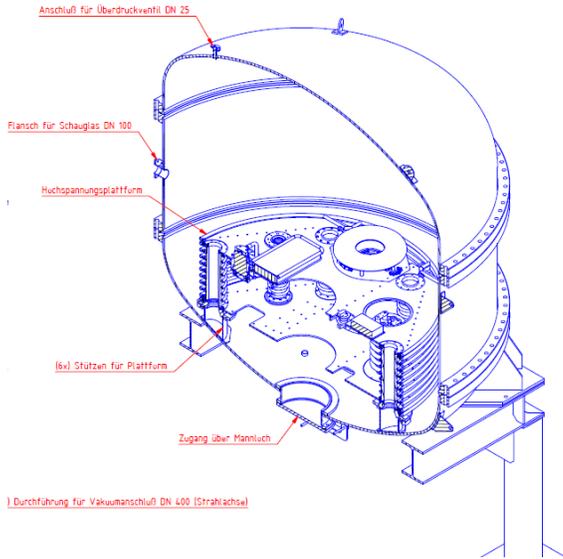
## VISION OF COMPLETELY MAGNETIZED 8 MeV COOLER



- Two obstacles: Cooperation with BINP-Novosibirsk **stopped February 2022**  
moreover: HESR **many years in the future!**

- **HESR@FAIR COOLER Prototype Status and Future**
- **“Hibernating” the know how - example: medical spin-off**
- **Hibernating the prototype as versatile platform ? example: EDM-ring**

# Closed cycle operation



## Schaltschema des Turbinenkreislaufs

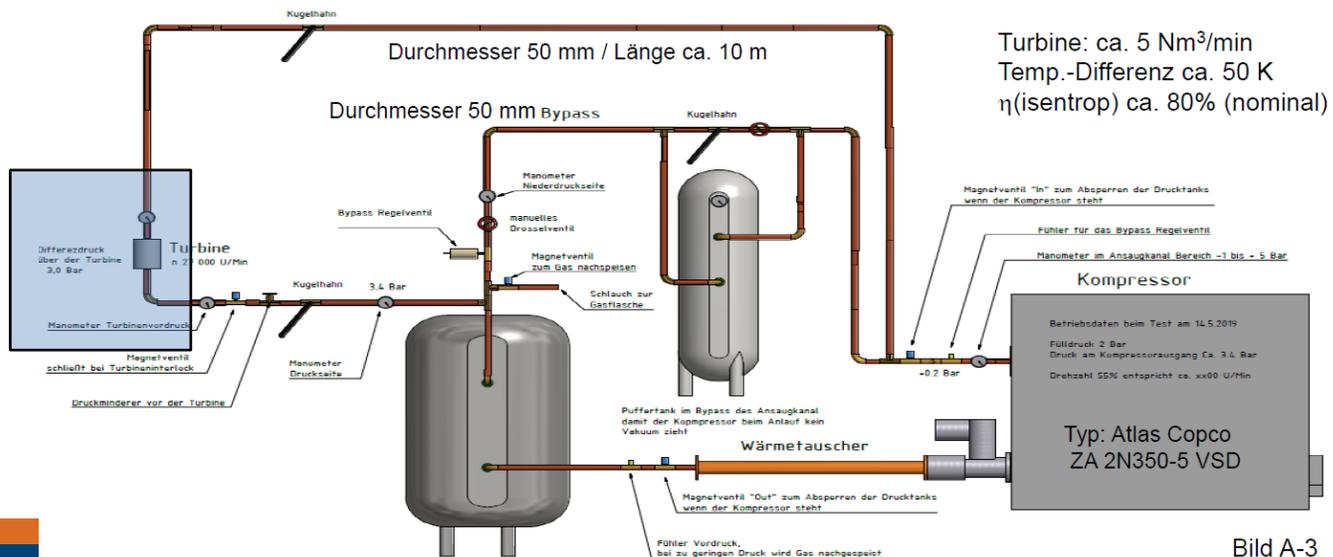


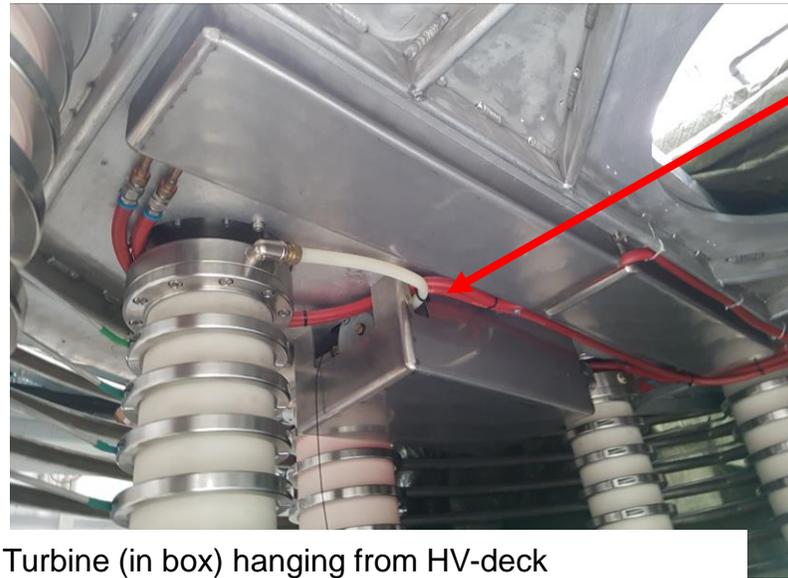
Bild A-3

- Tank can **accommodate two platforms + gun and collector**
- operation with Nitrogen in closed cycle,
- Operation turbine circuit designed by M. Wirsum, Institute for Power plant technology RWTH Aachen

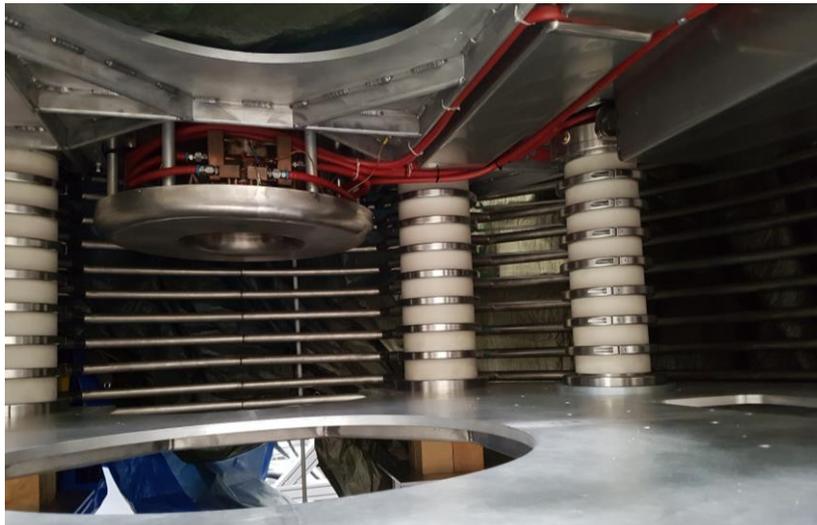
# Hardware status



Compressor station for up to three turbines



Turbine (in box) hanging from HV-deck



Solenoid hanging from HV-deck



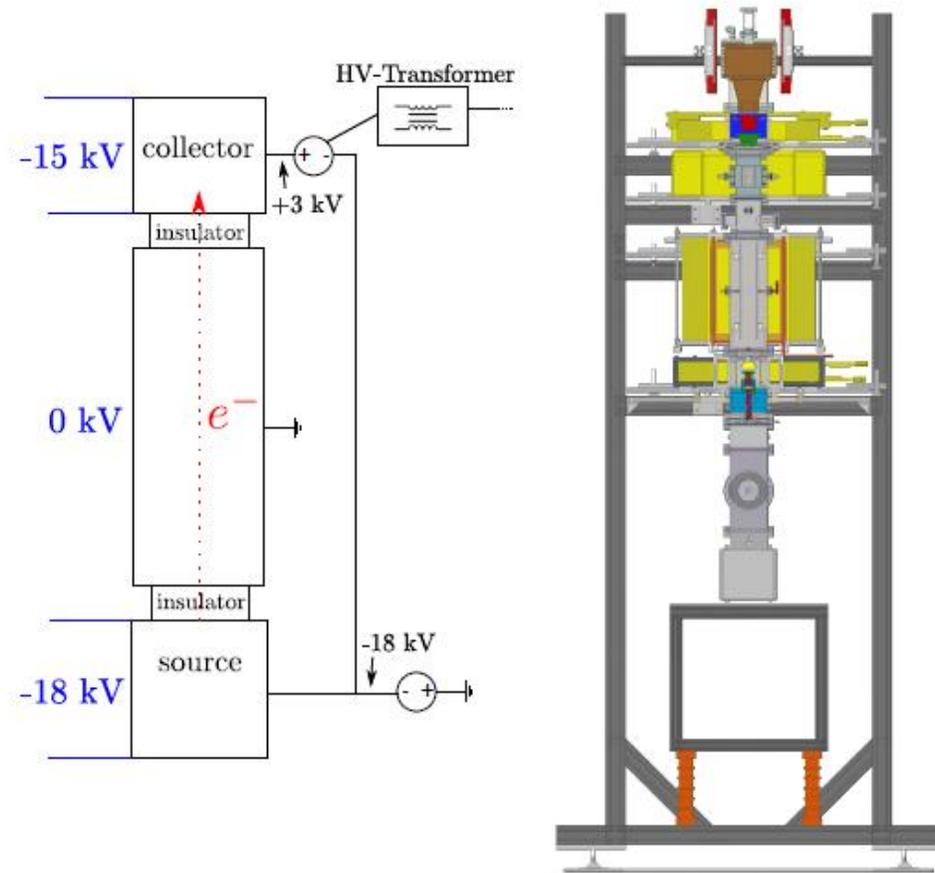
HV-generator

- Reverse engineering: communication with BINP hardware OK.
- Gas tank filled with 3bar Nitrogen, no leaks.
- Turbine supplies Cockcroft Walton and solenoid under HV.
- HV limited by to 80kV (internal safety ?  
→ reverse engineering)

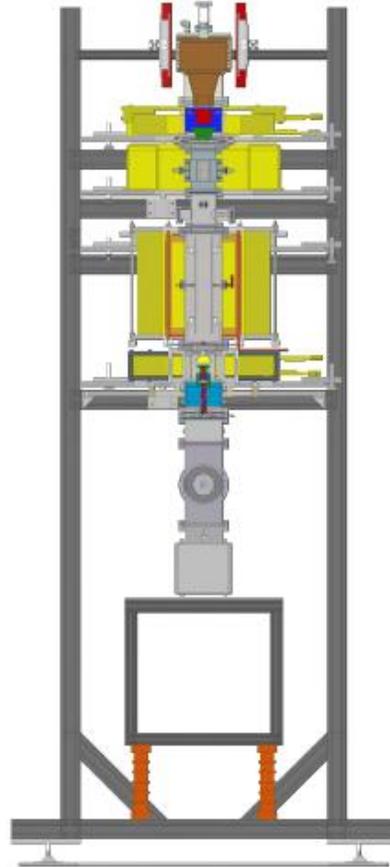
# Whats next?

- “Hibernating” the know how - example: medical spin-off
- “Hibernating” the prototype as versatile platform **?** example: EDM-ring

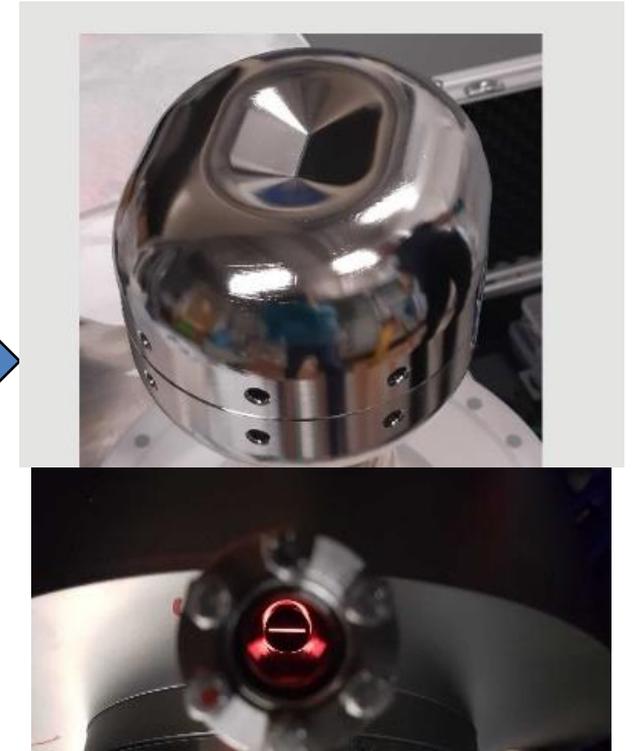
Experience with high quality beam from „test cooler“ (1A, 30kV) → 300mA 300kV „line focus tube“



Test set-up: 1A electron beam for HESR



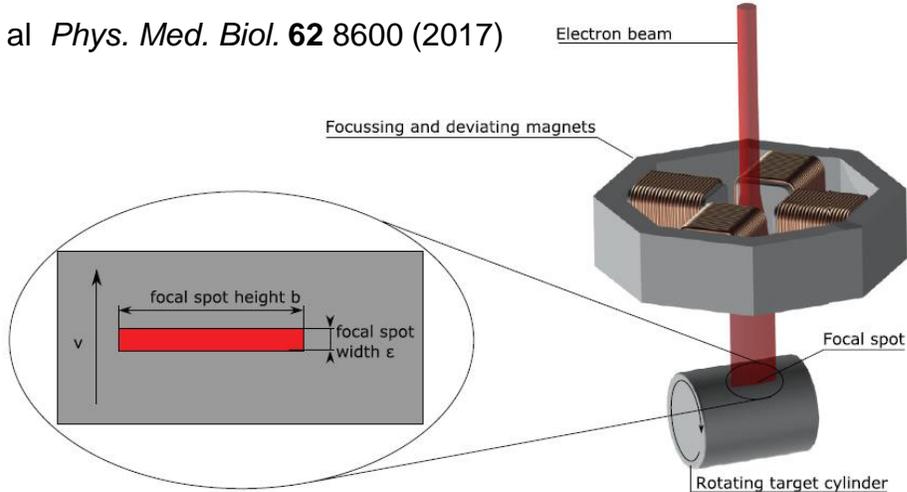
Test cooler Egun with BaO-cathode



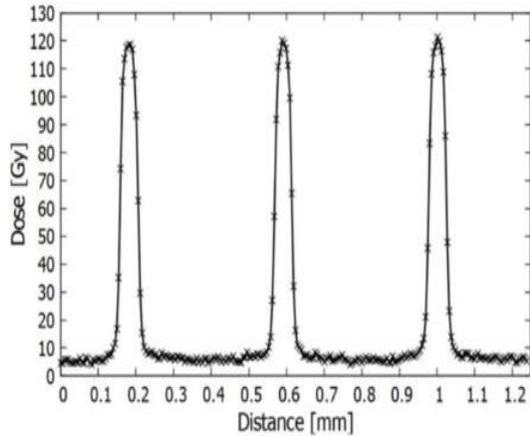
Line focus Egun with BaO-cathode

# Why X-ray microbeams ?

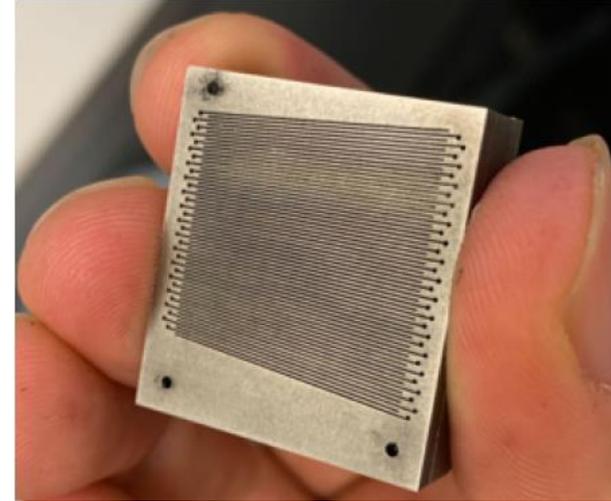
Bartzsch et al *Phys. Med. Biol.* **62** 8600 (2017)



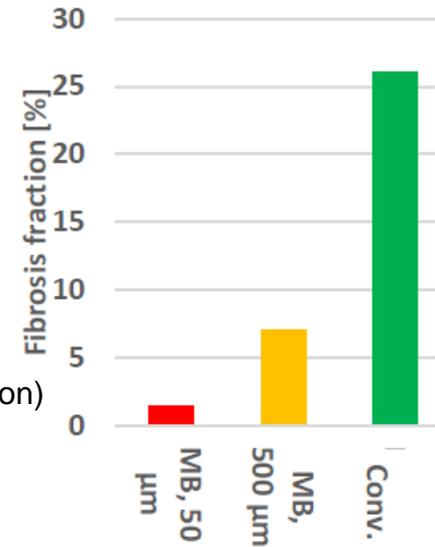
A



Results from ESRF  
(1km circumference synchrotron)

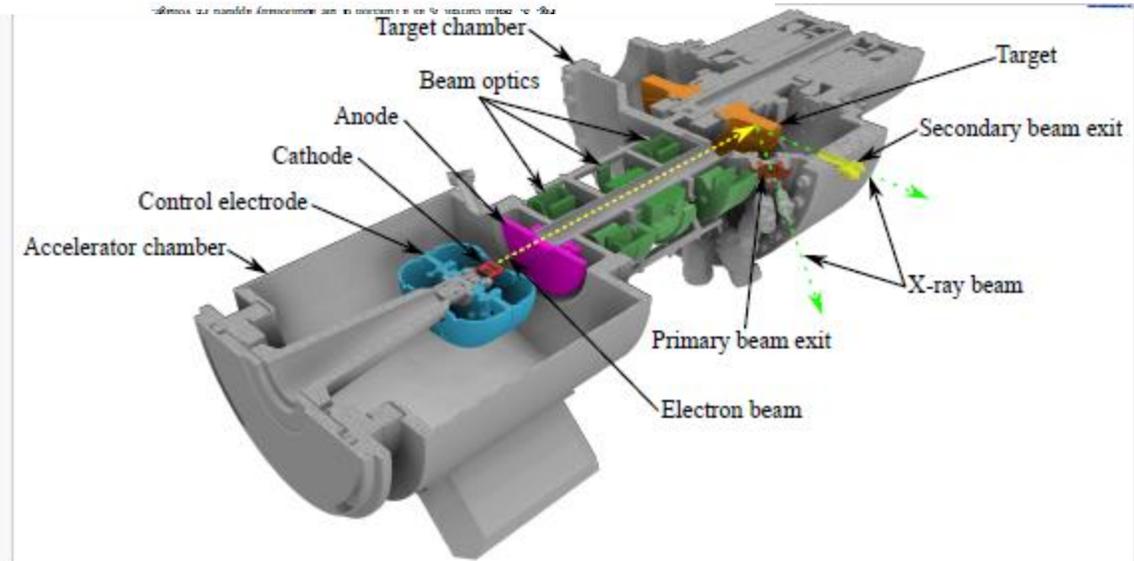
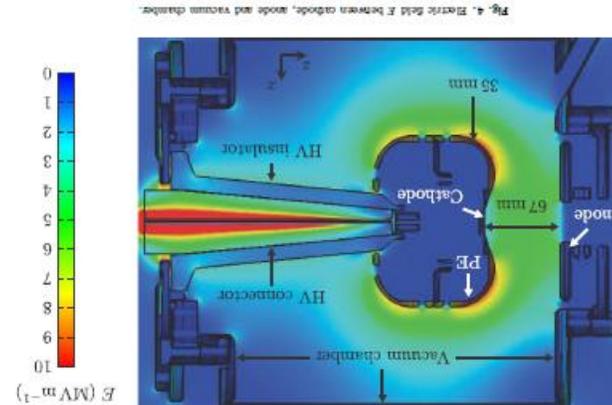
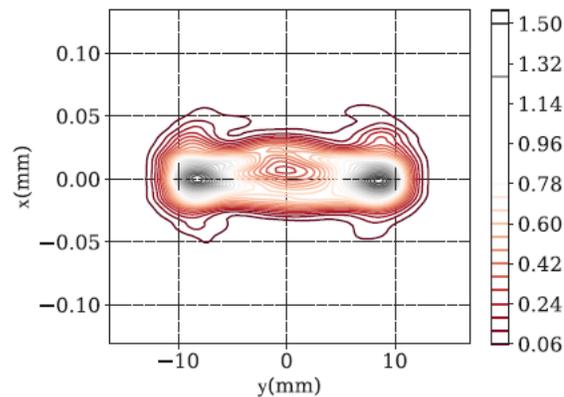
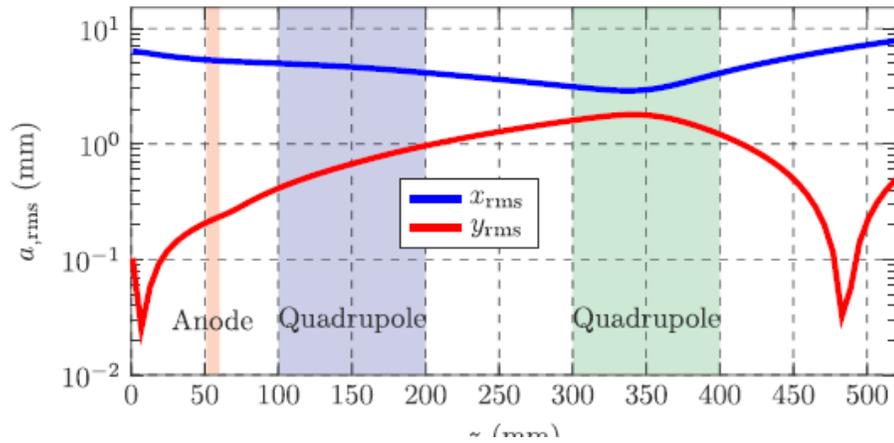


C. Petrich TUM

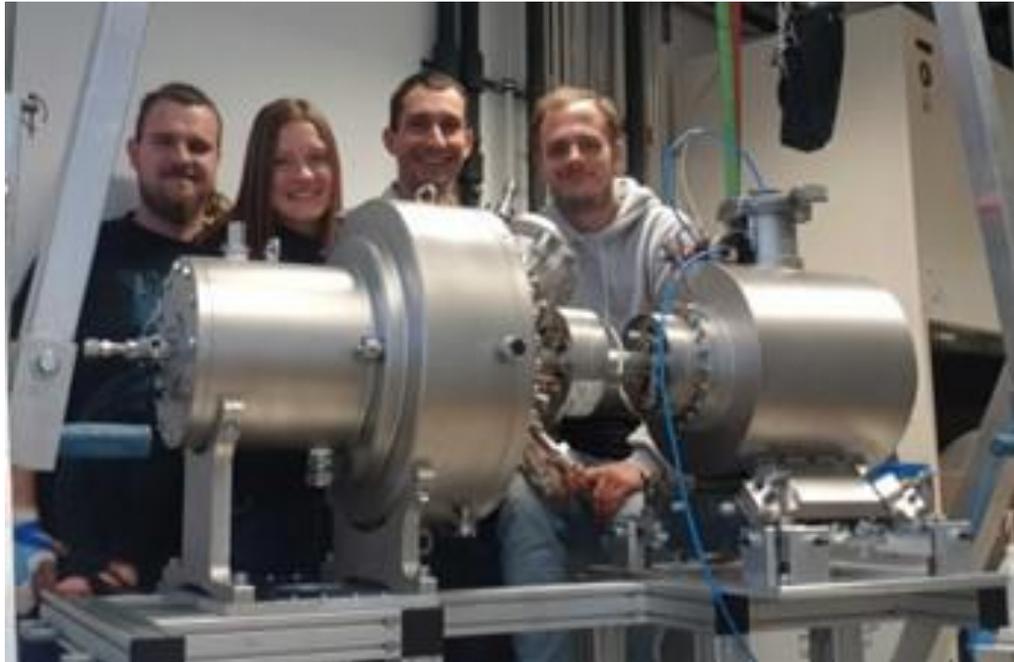


Side effects incidence  
for same total dose

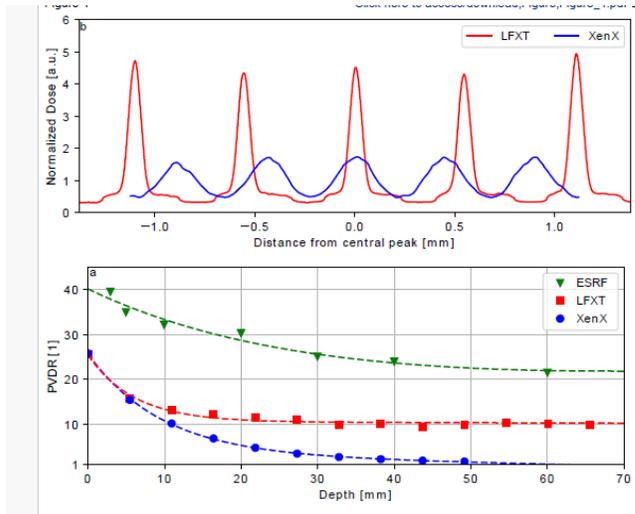
Experience with high quality beam from „test cooler“ (1A, 30kV) towards 300mA 300kV „line focus tube“



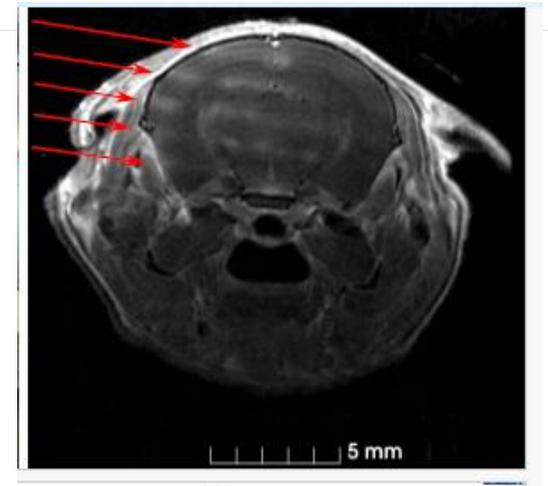
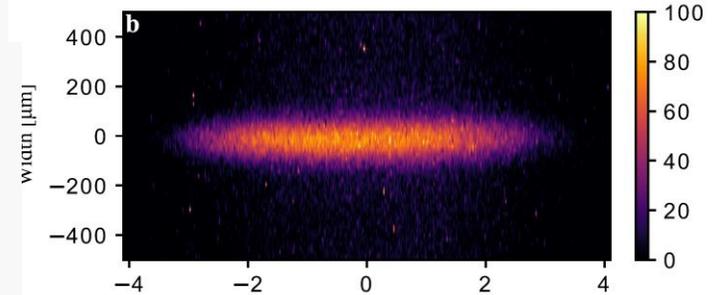
Electron source design and assembly at HIM/MAINZ  
 Operating at TU-Munich/Garching  
 Microbeams with relevant dose rate are now  
 available on the laboratory/clinical scale



Ch. Matejcek et al. *Physica Medica* 106 (2023) 102532



Peak to valley dose distribution (PVDR)



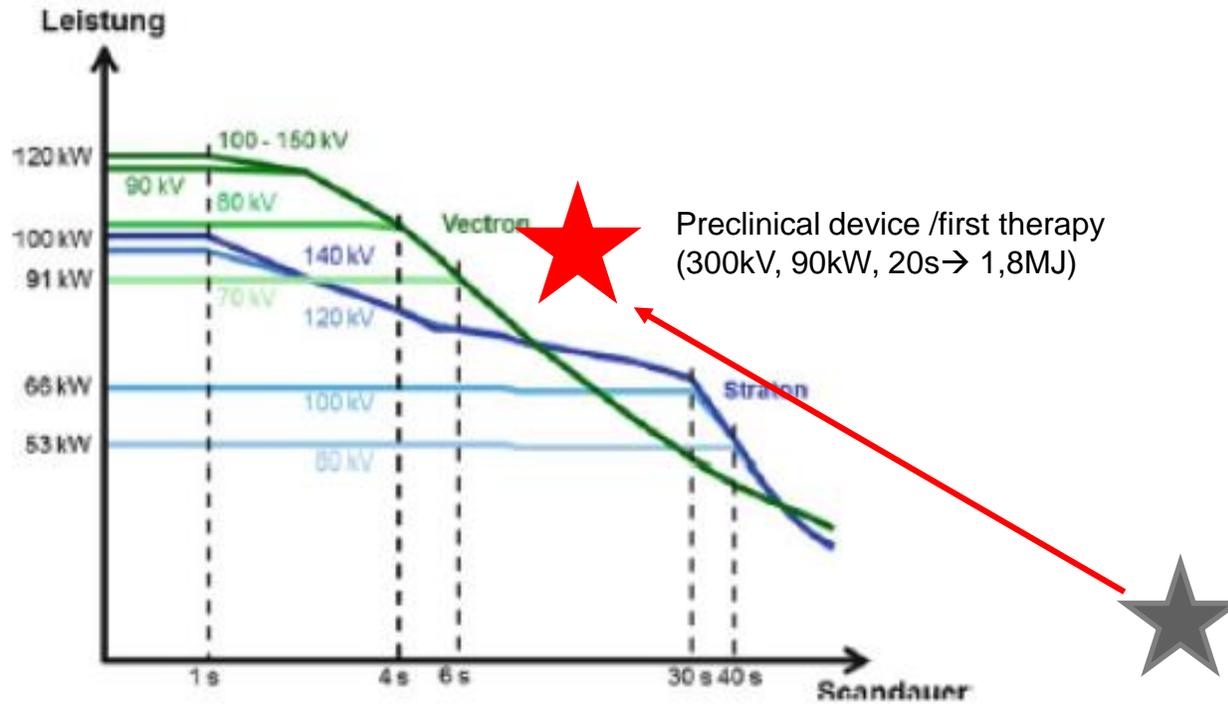
Upper: Xray source distribution  
 Lower: Mouse brain after irradiation

C. Petrich et al. Accepted for publication  
 International Journal of Radiation Oncology

# Development path until ~ 2030



Ideal Therapy device („Microflash“)  
(600kV, 1MW, 2 s → 2MJ heat load)



A lot of engineering work, but first therapy device seems possible

W. Schlegel et al. (ed's) Medizinphysik, Springer

- “Hibernating” the prototype as versatile platform  example: EDM-ring

# Combine MESA and HESR components ?

1. Continue cooler developments - Goal: demonstrate „turbine driven“ 600kV beam until 2026
2. Accelerator developments for FAIR-Phase 0 at MAMI-C and Helmholtz Excellence network activities at MESA
3. High power beam competence enables **new approach** for radiation therapy „Line focus X-ray tube“

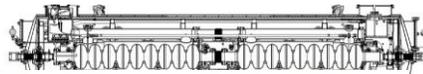
ACID-2's 2022 crisis-reaction:  
→ „diversify“



Project 1. - Further activities depend on future expansion of FAIR



Project 2. Accelerator research for Helmholtz Excellence network experiments **at MESA** (and FAIR-0 at MAMI-C)



Project 3 – Line focus X-ray tube- Increase of activities & resources because initial successes have already attracted third party funding.

2018

2022

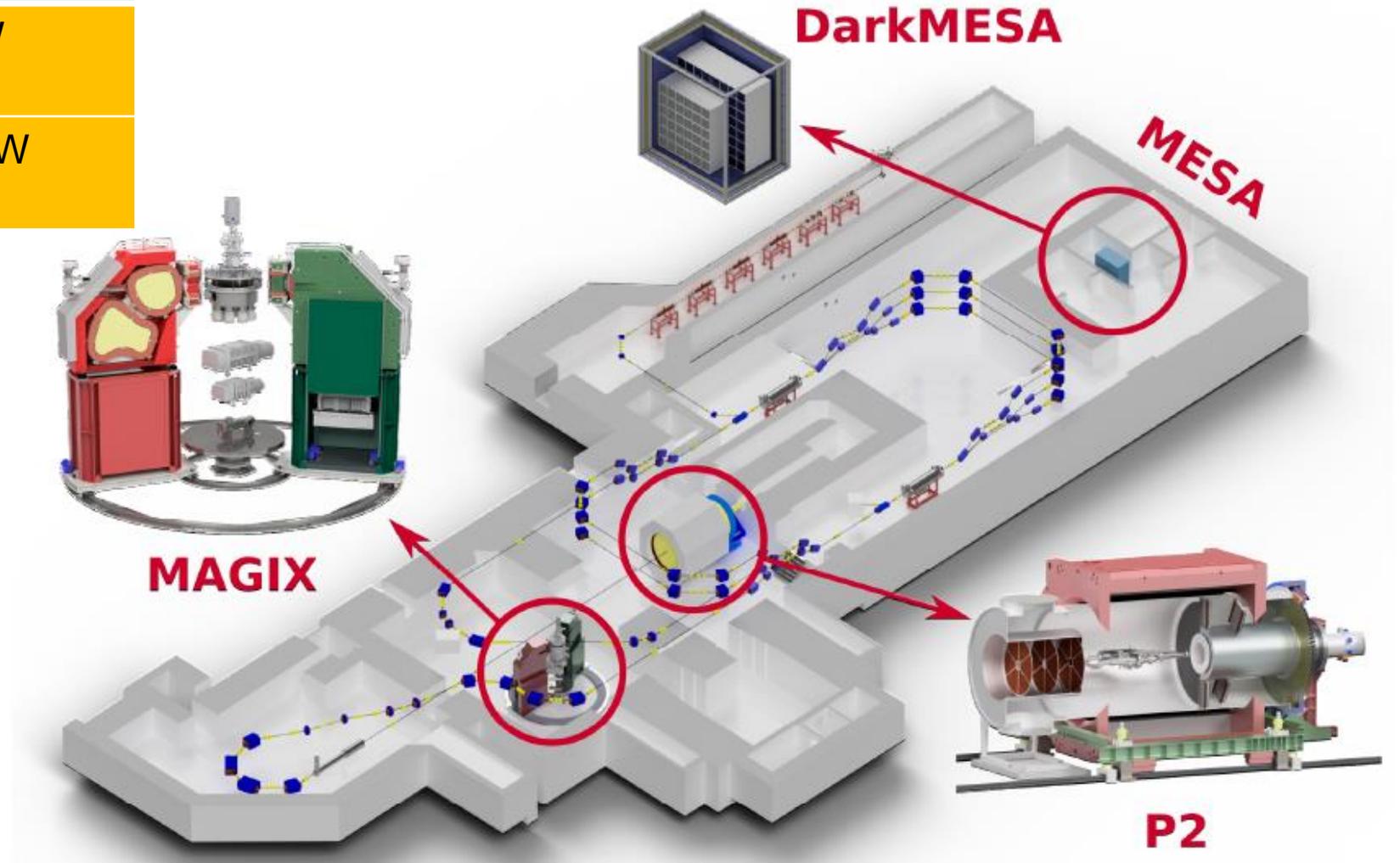
2024

2028

2035

# MESA Operational modes & Experiments

Op-mode	Target	Beam power @target
Ext. Beam (polarized)	Solid/ Liquid	0-25kW
Energy recovery(ERL)	Gas-jet	0.1-1MW

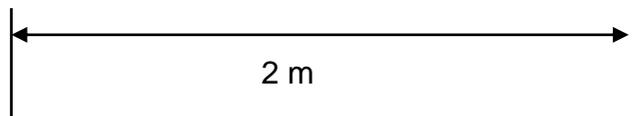
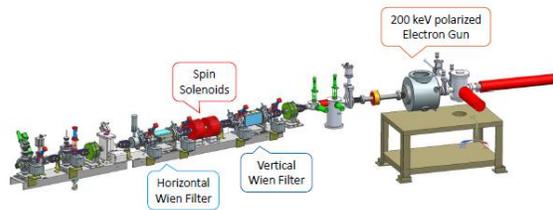


# Using the tank...?

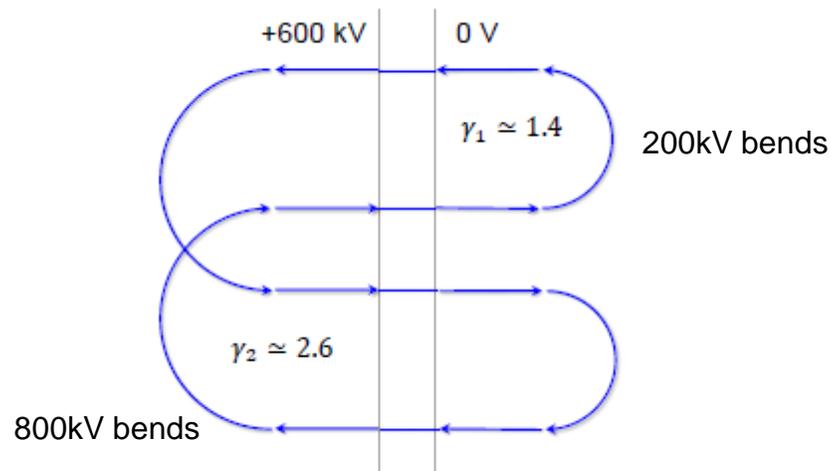
- Hibernating the prototype as versatile platform **?** example: All electric EDM-ring

Based on publications by Jefferson LAB (Derbenev et al. arXiv:2105.11575v1 [physics.acc-ph], 24 May 2021):

Combine the components available at MESA and HIM...



3d-spin rotator at MESA  
(200kV source not shown)



Operating mode of electrostatic  
Figure of 8 EDM Ring proposed  
by Derbenev et al.



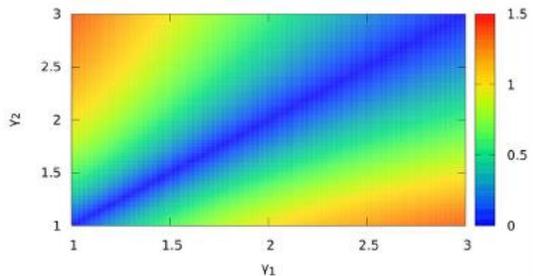
Unique feature: ample power available  
on large HV-platform

- The Figure of 8 periodic system cancels the magnetic g-2 precession.
- The electric fields bending at different energies would cause an EDM-dependent spin precession.
- Electric ring allows clockwise/counterclockwise beams → cancellation of many systematic effects

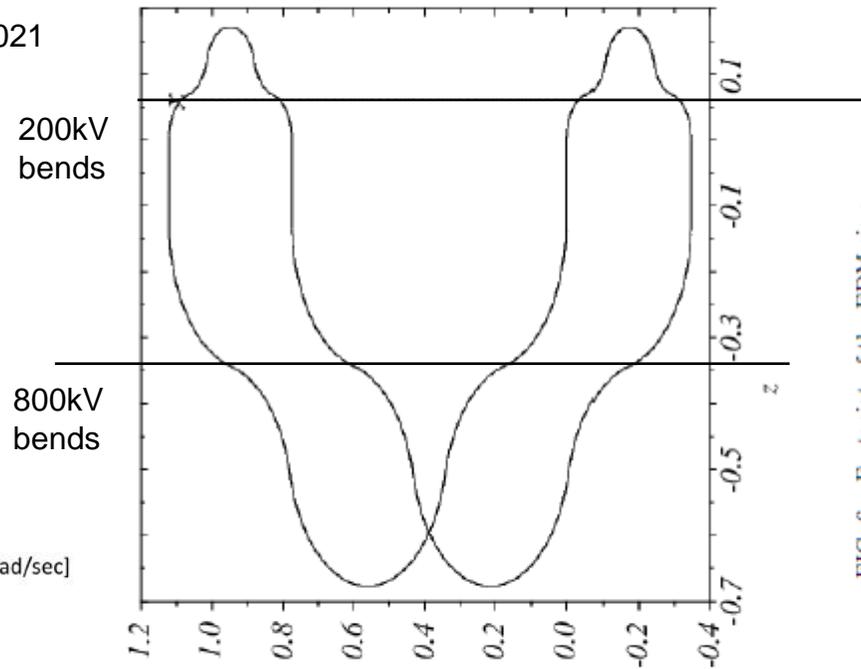
R. Suleiman, V. Morozov, Y. Derbenev

arXiv:2105.11575v1 [physics.acc-ph] 24 May 2021

- Simpler than EDM-ring at „MAGIC“ energy (14.6 MeV)



$$\frac{\partial^2 |\psi_{EDM}^{ST}|}{\partial \eta \partial t} [\times 10^9 \text{ rad/sec}]$$



Orbit layout of „Figure of 8“  
Electrostatic storage ring  
(units are meters)

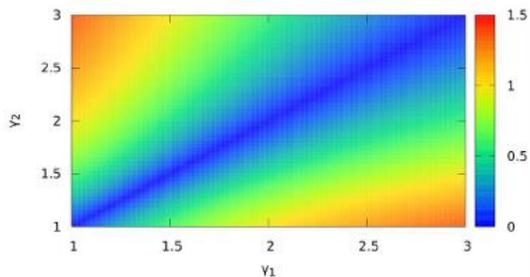
FIG. 6. Footprint of the EDM ring.

EDM Sensitivity of the order  $< 10^{-28} \text{ e} \cdot \text{cm}$  anticipated!

The Figure of 8 periodic system cancels the magnetic g-2 precession.  
The electric fields bending at different energies would cause an EDM-dependent spin precession, to be measured with Mott polarimeter

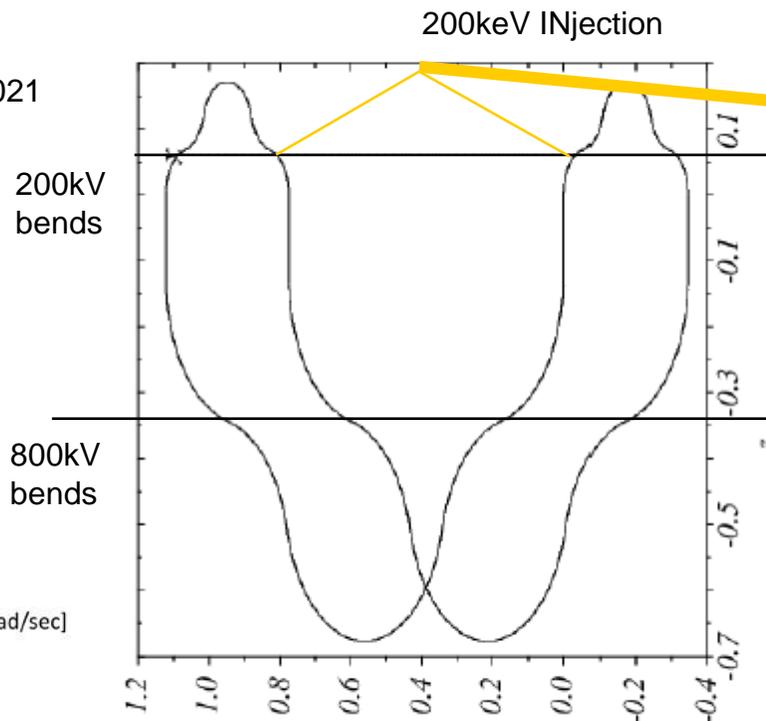
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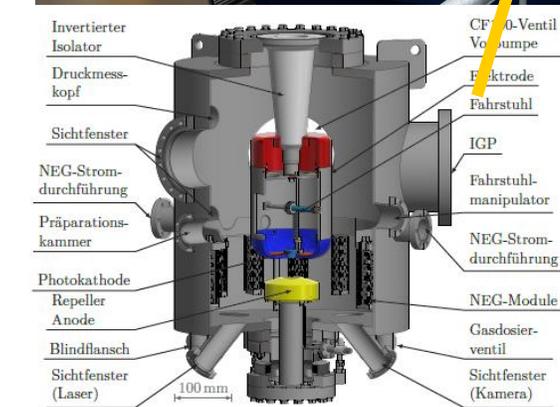
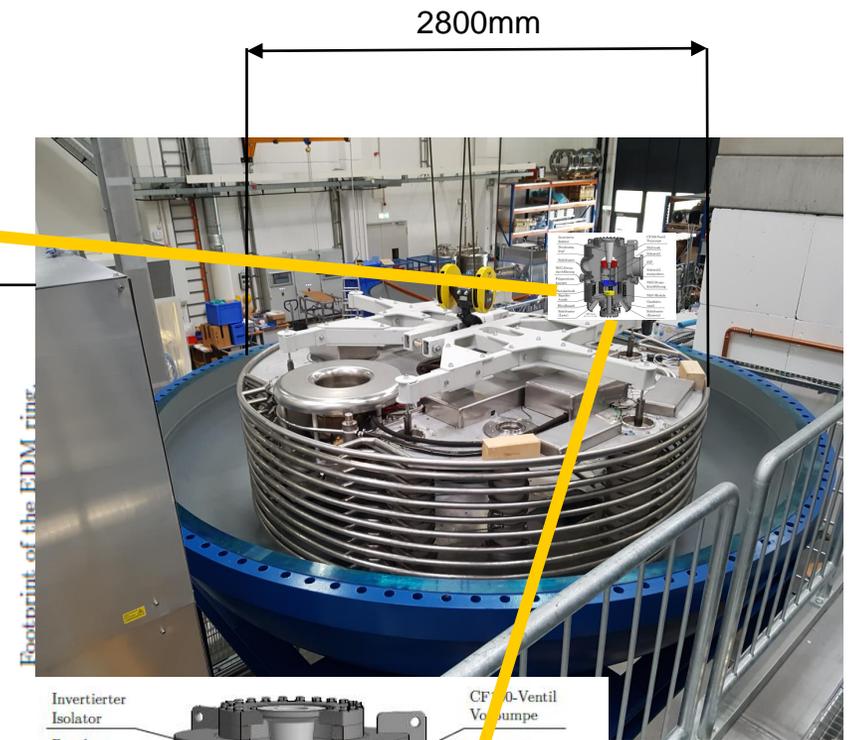


EDM Sensitivity of the order  $<10^{-28}$  e\*cm anticipated!

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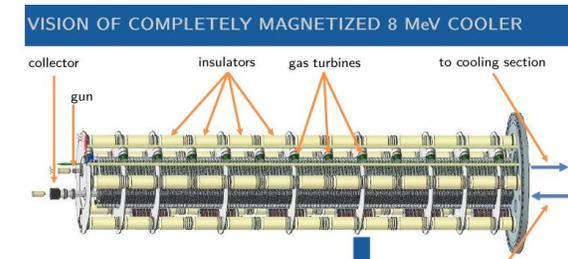


MESA  
electron source



# Conclusion

- BINP and HIM have produced turbine driven HV-Generator for 600 kV with several kW of floating power on terminal
- Ready for installation of electron source, but no immediate project for electron cooling in foreseeable future!
- Intermediate project at HIM: Medical Physics, with high power electron beam
- Perhaps other applications for existing installation?



Thank you!