

Sustaining competences for HESR-Antiproton cooling at HIM

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Presenting work by HIM Section ACID-II
(K.A. T. Beiser, J. Dietrich and W. Klag),

- **Introduction : Accelerator research at HIM**
- **Turbine powered prototype for HESR cooler**
- **Physics programme to sustain competences until HESR comes online**



HIM on the Campus of JGU: HIM is a joint venture of JGU and GSI
-supported by the surrounding institutes of Physics, Nuclear physics (operating the MAMI accelerator) and the department of chemistry.
The scientific focus of HIM is on fundamental physics.

Objectives of HIM-section Accelerators and integrated detectors (ACID)

1. FAIR: HESR-Cooler support: Beyond 2MV:→4-8MV

(ACID-II, head: Kurt Aulenbacher)

2. Provide accelerator solutions for SHE research by GSI and JGU

groups: low beta SRF ion accelerator cavities

(ACID-I, head Winfried Barth)

Mission...under difficult conditions

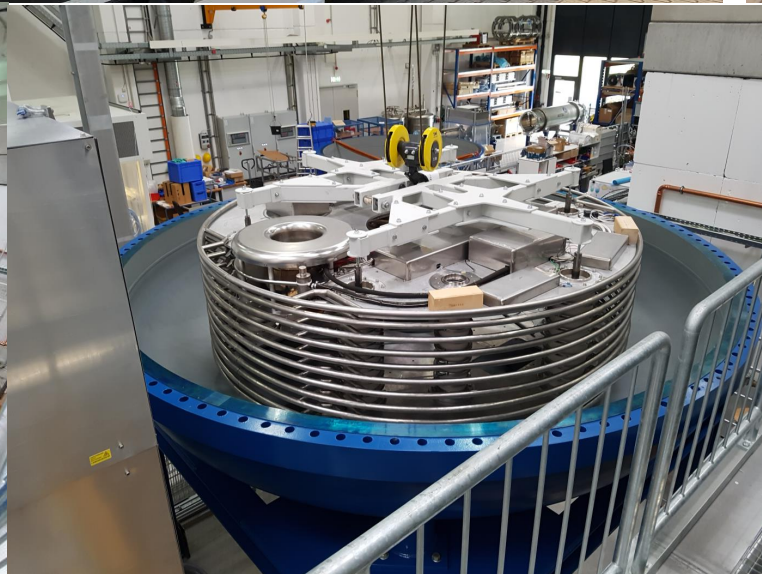
- ACID-II cooler group does R&D on small, well defined aspects aiming at the 8MeV device needed for HESR antiproton cooling
- Such a scale of research is well adapted to the possibilities of HIM (somewhat in between university research and „big science“)
- Since last COOL, progress has been achieved (this report)
- **But:** Construction of HESR has seen further delays of **several years**

→ **What does this mean for HIM/ACID-II?**

- To be continued: Test set-ups for collector optimization & control , non invasive beam diagnostics, ion trapping,.... (Poster this afternoon by Th. Beiser)
- Now-2026: Scalable Multi-plattform design to achieve several MV range for HESR, platforms powered by turbines
- 2028+:?? Joint effort with GSI/FAIR (or others?) to have „full energy“ antiproton cooler at HESR
- Now-2028 Research in applied physics with components so far developed to bridge the period until HESR future timeline becomes clear.

HESR-cooler „prototype“ status

The "BIG Blue Bubble" HV-Tank



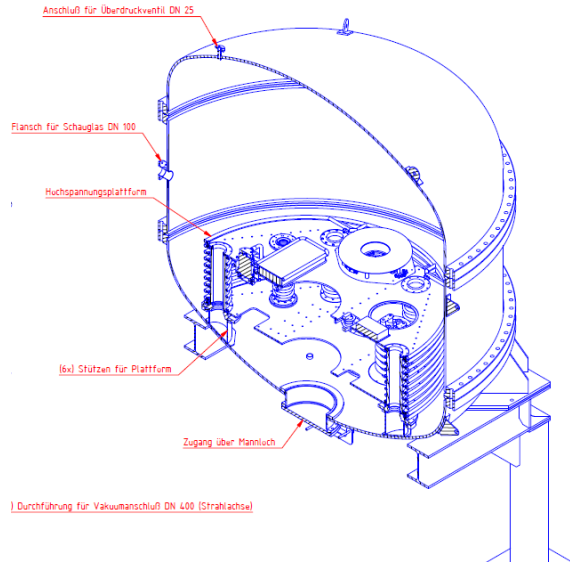
Modular HV-design



- 600 kV Modules (first platform built by BINP/Novosibirsk)
- Electrical loads on each platforms powered by > 3kW-gas turbines
- Second platform due in 2022but will not be delivered
- Operation of turbines with Nitrogen in closed cycle necessary!

Closed cycle operation

- Tank can **accommodate two platforms (2 turbines im parallel)**
- Operation turbine circuit designed by Prof. M. Wirsum, Institut für Kraftwerkstechnik, RWTH Aachen



Schaltschema des Turbinenkreislaufs

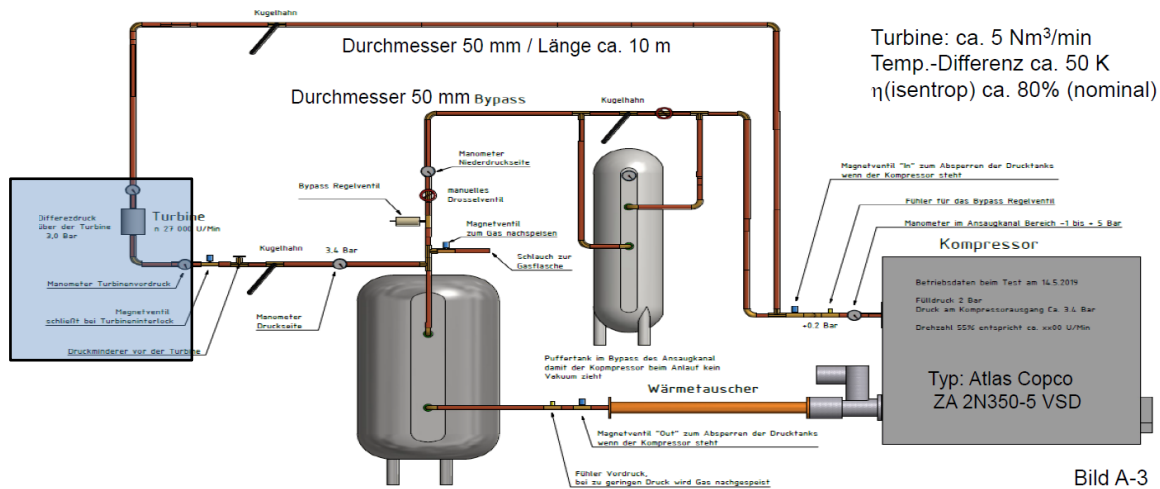
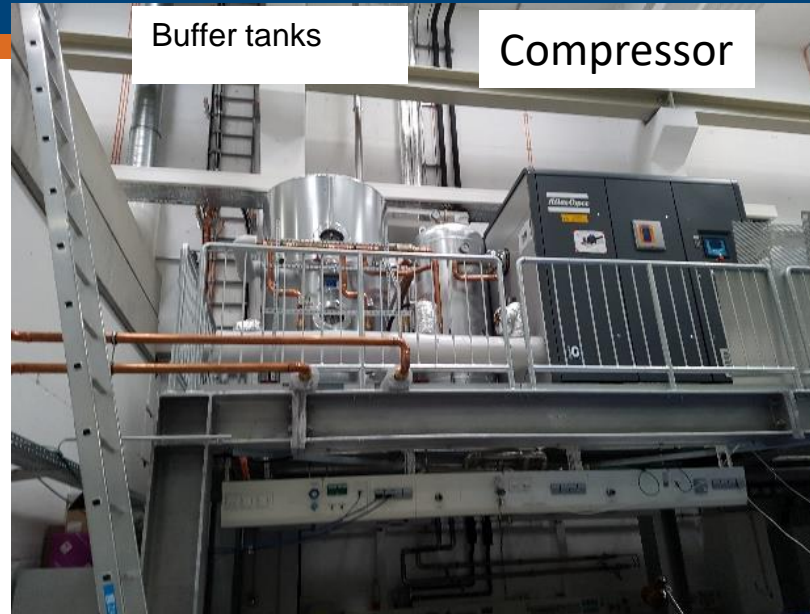


Bild A-3

Ongoing work-closed cycle operation



Turbine outside tank



Buffer tanks

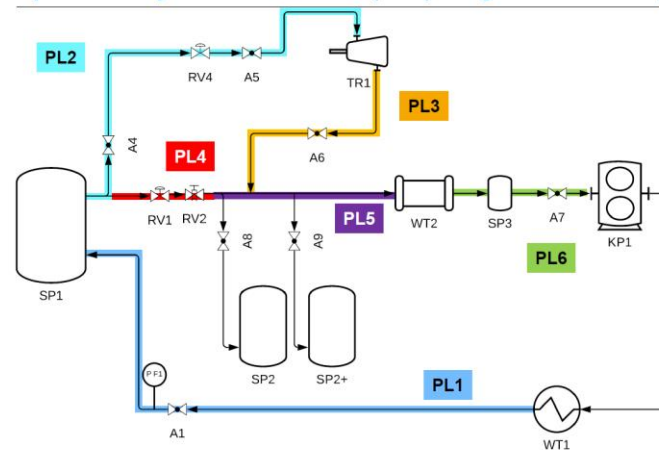
Compressor



Heat exchanger

- Closed gas circuit designed in cooperation with RWTH Aachen
- Extreme delays for delivery of heat exchanger and regulation valves
- **Turbine tests within closed gas cycle in Q2/23 successful!**
- Installation of turbine and operation in Tank in Q4/23
- Operation of 600keV module seems possible (but lot of work) even without external support

Optimiertes hydraulisches Modell (HM2): Vergrößerter Pufferspeicher SP2 / SP2+



Merkmale:

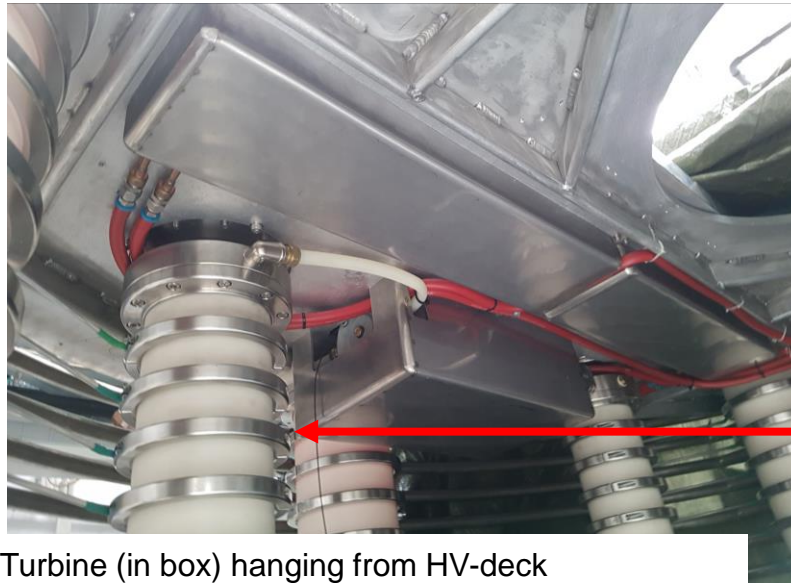
- Niederdruckspeicher mit verdoppeltem Volumen
- Niederdruckspeicher nicht durchströmt (nur Puffer)
- Niederdruckleitungen mit 100 mm Innendurchmesser
- Kühler WT2 vor Verdichtereintritt zur Stabilisierung des Betriebs

Bild O-1

Some impressions

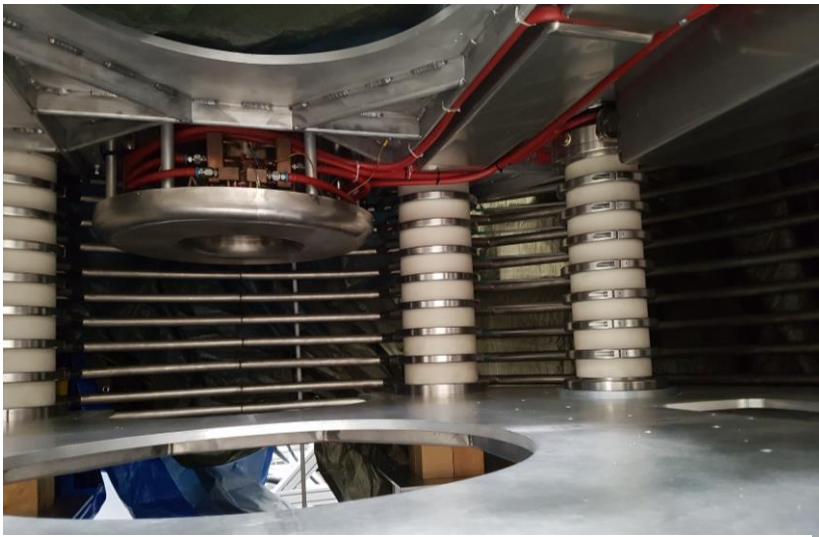


Compressor station for up to three turbines



Turbine (in box) hanging from HV-deck

Insulators with gas tube inside



Solenoid hanging from HV-deck



HV-generator

Next step: Operation with
Turbine in tank on 600kV
Platform (but without HV!)

- Test Operation of the turbine, electronics and solenoid (no or reduced HV)
- Filling the tank - 600kV operation
- Multi-turbine operation

After these steps are done (~ 2025), the status of HESR may have become clearer....

The “obvious” next step -???

V. Parkhomchuk et al. Design study for the high voltage test bench of 1.2 MeV , BINP 2019

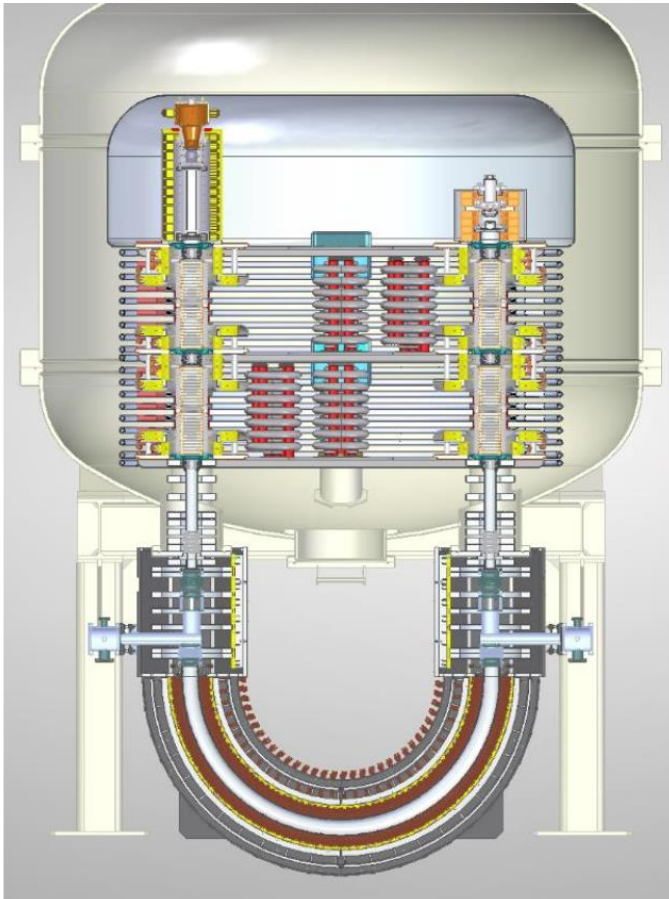


Figure 1.2: General picture of test-bench 1.2 MeV

- 2018-2019: Design study by BINP for usage of Prototype stage at HIM
- fabrication of second platform to test:
 - scalability (2*600kV)
 - heat management
 - machine protection
 - voltage stability
 - acceleration tubes & vacuum

Device presently is a „technology platform“
→ Can it be used for something else ?

Using the device for applied/fundamental research ??



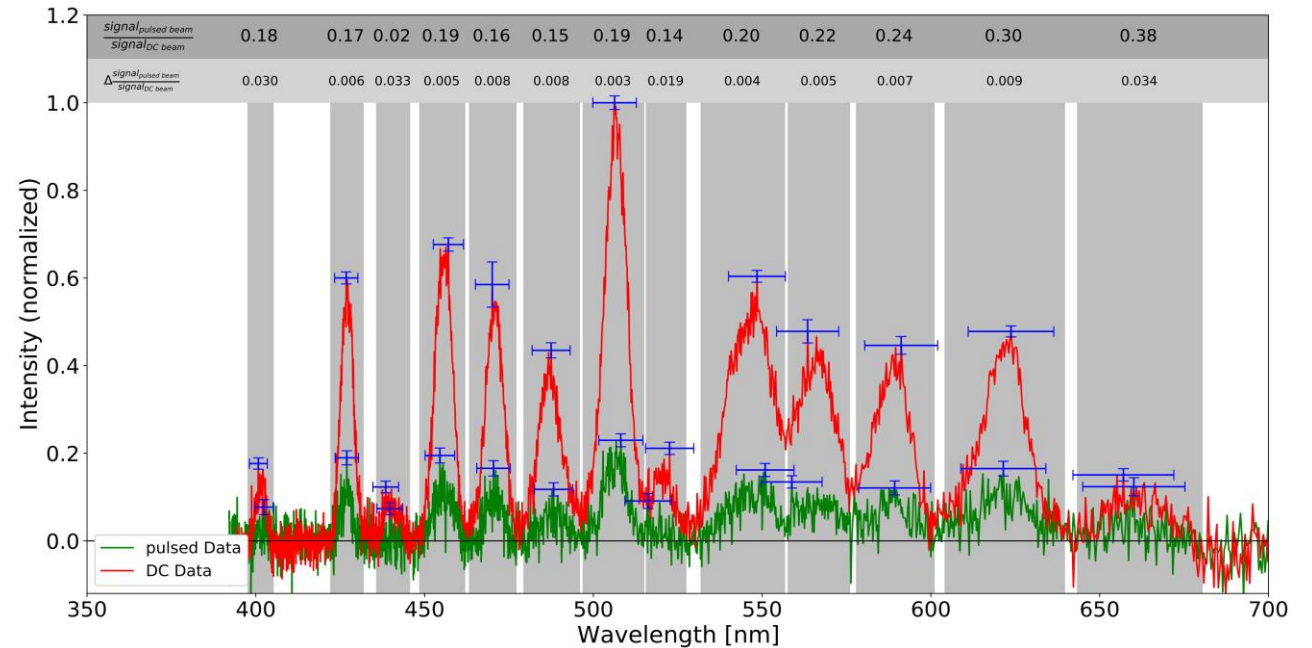
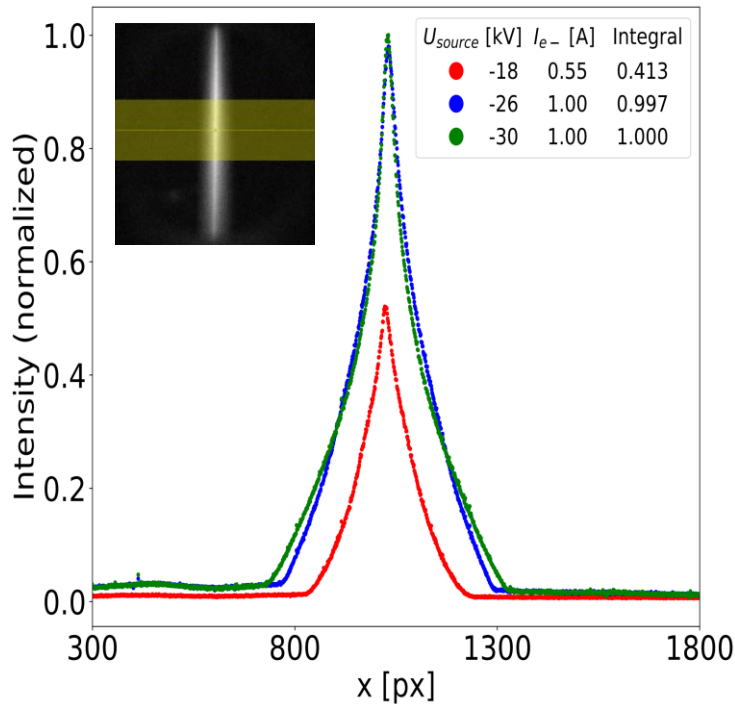
There are many 600kV DC- accelerators in the world, but...
“Big Blue Bubble” has special features.

- Large power/good cooling available on terminal
- Lot of space at the terminal
- No SF6 needed.
- Accessibility relatively good

What could we do with it? → several ones
already discussed at COOL21

„Bridging“ project: Use experience with high current devices for
applied (medical research) with or without the prototype!

Non-invasive optical observation of ion-trapping in UHV
-See poster by Thomas Beiser this afternoon!



Left: Profiles of ion distributions at different beam intensities

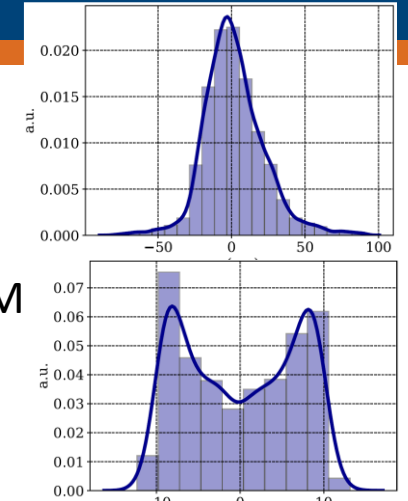
Right: effect of slight reduction of duty cycle – strong suppression of ions

Medical application is an ideal bridging project

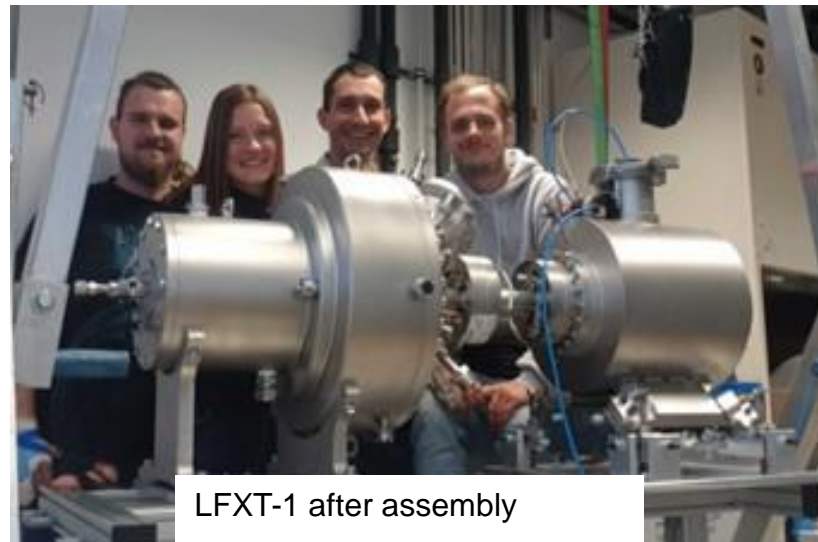
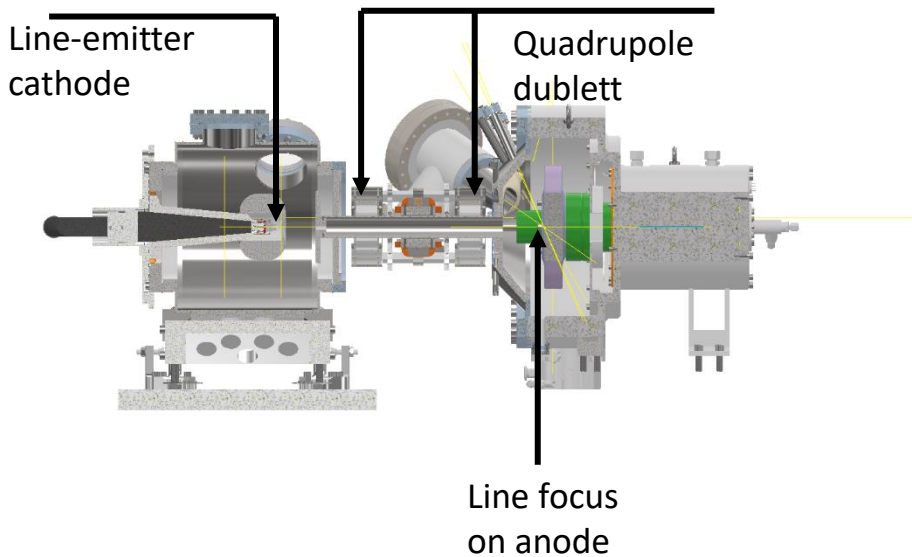
- **Existing competences will be sustained**
- **Easy to motivate**
- **Additional funding possible → no budget impact on cooler research**

New project – 300 and 600 kV LFXT

- High aspect ratio „line“ focus increases cooling capacity by orders of magnitude.(*,**)
 → extremely high power/X-ray brilliance possible(*)
- Multi-disciplinary cooperation (TUM, HZM, HZJ, HIM) for „preclinical prototype“
- ACID2 has designed electron gun + focusing optics (300kV, 300mA, conditioning has started at TUM
- ACID2 will design 600kV, 2A source for future clinical devices
- 600kV tests (low duty cycle) at HIM using **big blue bubbletank** envisaged



Beam Profile (PIC-Simulation)
 ~30*20000 μm at 300mA

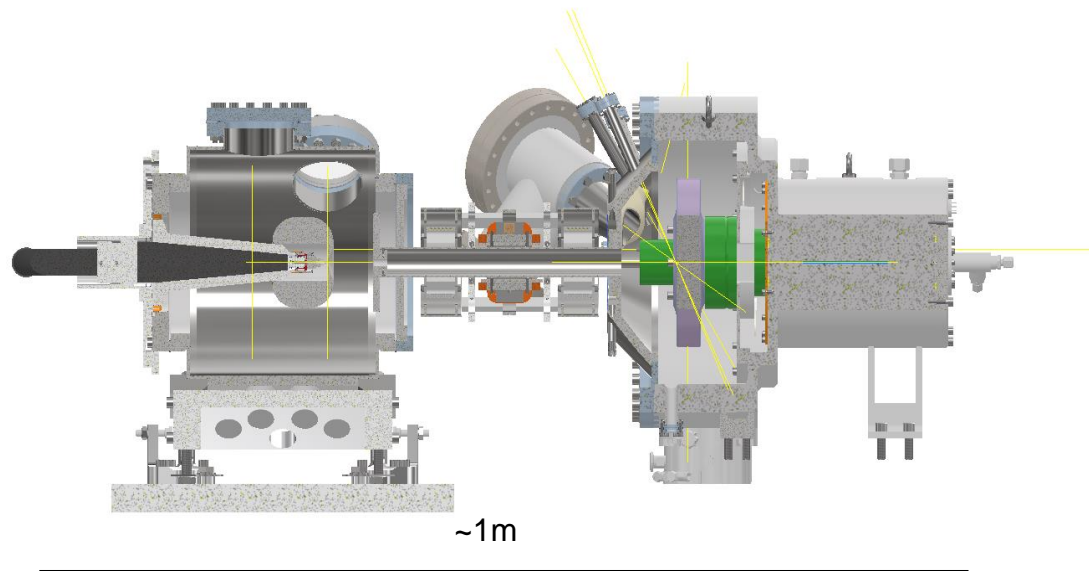


Line emitter

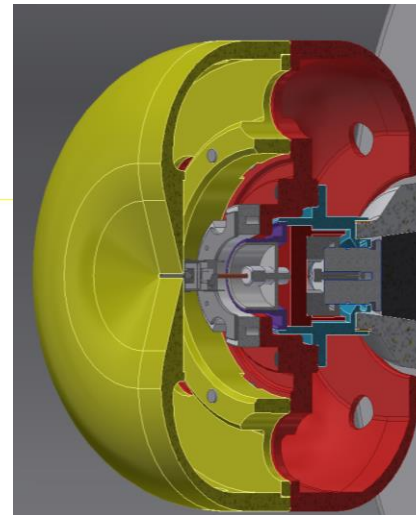


Principle of “Microflash” radiation therapy

J. Winter et al. Physics and Imaging in Radiation Oncology 14 (2020) 74–81



300keV, 300mA
Preclinical prototype (TU Munich)

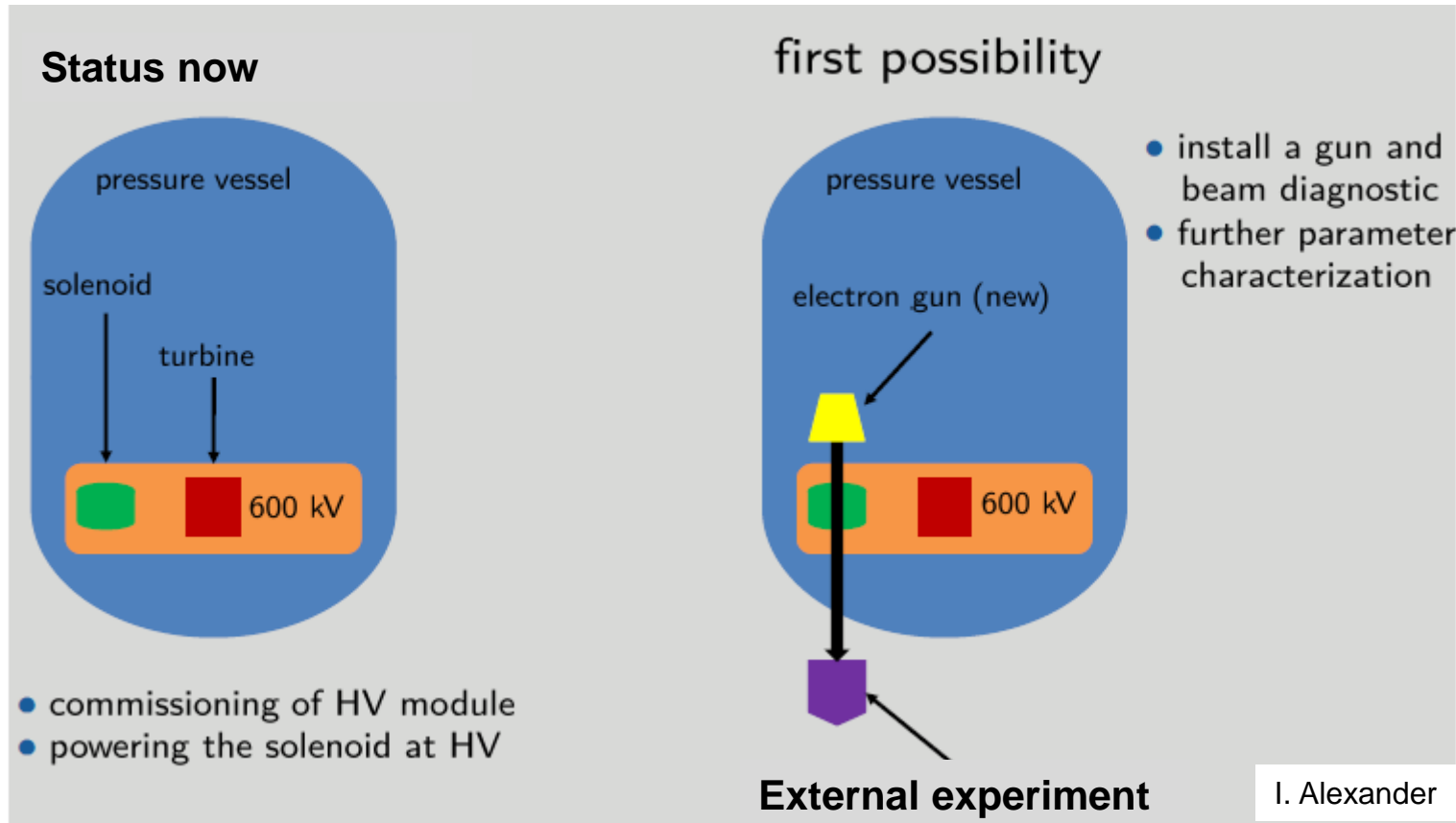


Cathode assembly

Imminent
problem of
such devices:

Dosimetry &
targeting

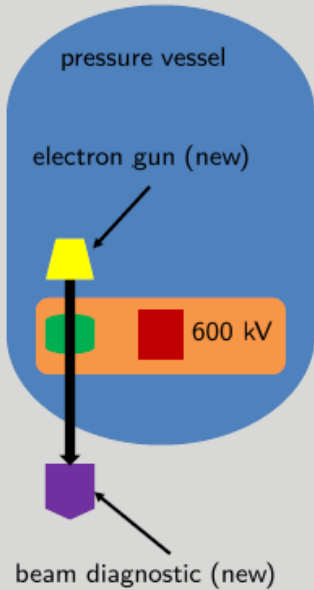
Future extension plans: Medical research



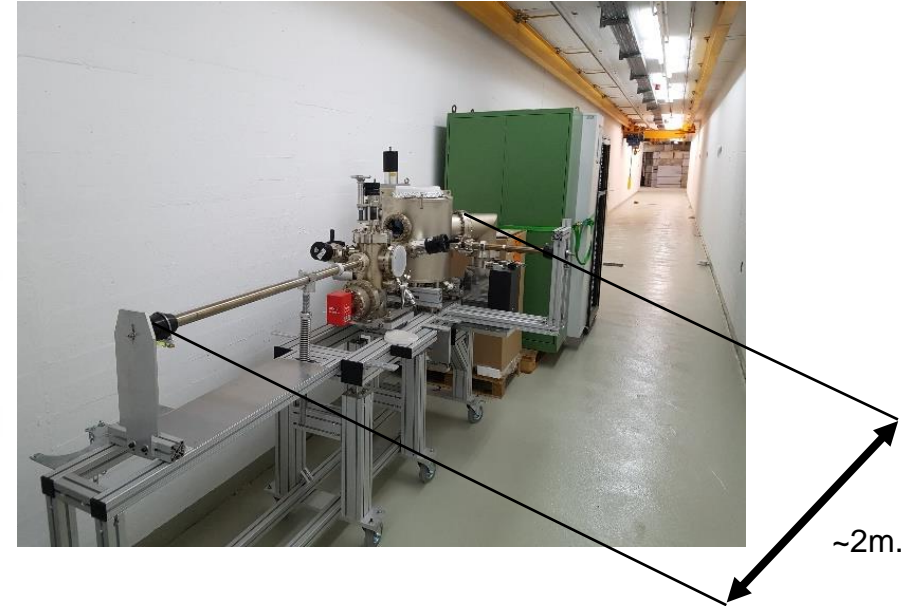
New Funding proposal 2024: Xray “flash guidance dosimetry”

Applied research at Big Blue Bubble?

first possibility



- install a gun and beam diagnostic
- further parameter characterization



Photosource "STEAM"

External experiment:
Dosimetry of X-ray
flashes (ns, >100
Gray/s peak dose
rate)

- will be used with very low duty cycle
- 5ns pulses, 2.5 A, 1-10Hz
- Home build K2CsSb cathode
- "Cheap" 2nd harmonic Nd:Yag Laser needed
- Flash dosimetry

Conclusion

- We continue to develop the HESR-cooler prototype
- Medium range goal (~2025): turbine powered 600kV operation
- Long range strategy depends on decisions on the HESR which may come in a few years from now
- Using existing competences for bridging this period doing applied physics research

Thank you!

Spares

Particle Physics at Big Blue Bubble?



A photosource can also produce **spin-polarized** beams.

Interesting projects, **discussed at SPIN 2021**

- (both profit from Mott polarimetry with good in the $\sim 1\text{MeV}$ energy range)
- Spin correlations in Moller scattering of relativistic particles (already performed at MAMI, 3.5MeV):
Michał Dragowski et al.: Measurement of Polarization Transfer in Møller Scattering
- Electron EDM in all electrostatic ring with two energies (300keV, 600keV), suggestion from JLAB:
R.Suleiman, V.S. Morozov and Ya. S. Derbenev: EDM in small rings