



# HELIAC Project Status: Moving Towards Realization

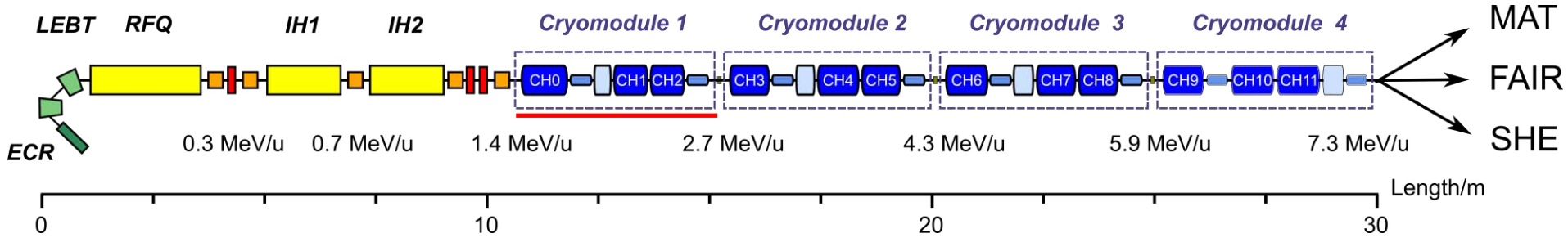
Maksym Miski-Oglu

05.02.2026

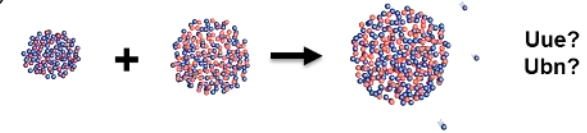


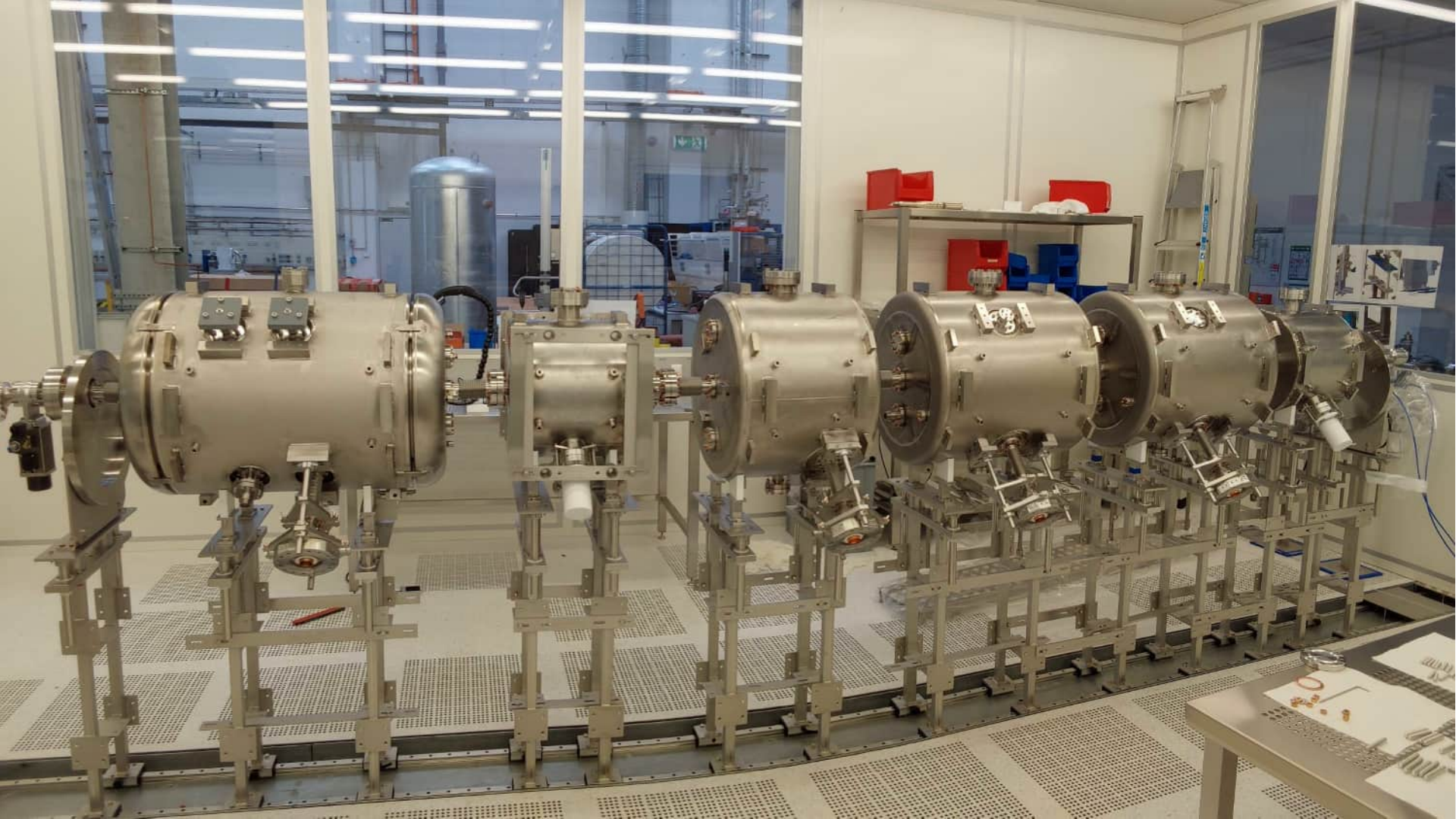
- Prior fire:
  - Variable-energy beams for SHE research: up to 10 MeV/u,  $A/q < 6$
  - Duty cycle: up to 25%
  - Beams: ... Ca, Ti, Cr, Ni, .....
- All rf-supplies are destroyed
- Major readout systems of Beam Diagnostics is destroyed
- HELIAC: restore and further strengthen GSI's SHE research program

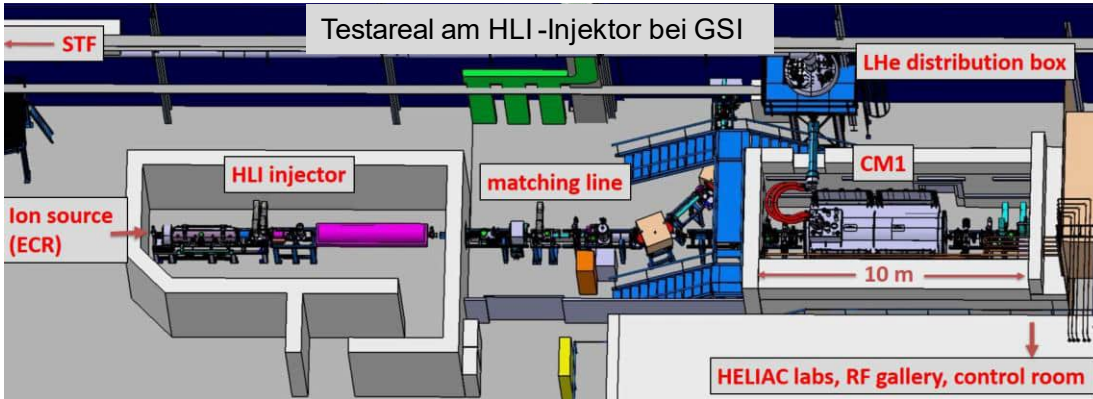
# HElmholtz LInear ACcelerator – HELIAC



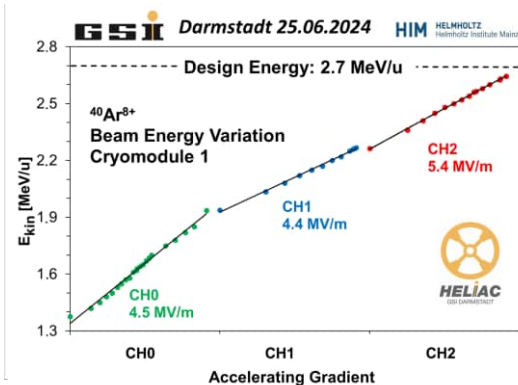
- Variable output energy: **3.5 – 7.3 MeV/u**
- Beam current:  $\leq 1$  mA in **cw-mode** (1mA for  $\text{Ar}^{+10}$  and 0.1mA for  $^{48}\text{Ca}^{+11}$ )
- Ion species with  $A/q \leq 6$
- Up to 8x more beam on target due to cw mode and 18GHz ECR
- Electric power consumption is 1 MW (1/5 of UNILAC)
- HELIAC has been optimized for the needs of SHE & MAT programs and could be used as SIS18-injector for medium intensities
- CM1 currently under Test operation
- Starting version: 18GHz ECR + Injector + CM1 + CM2 + CM3








- In operation since December 2023
- 8 Cold campaigns; 2 with beam
- Stable operation of cryogenic infrastructure
- Remaining challenges:
  - rf-control loops are unstable
  - rf-buncher does not meet the frequency
  - HLI beam is not perfect
- Root causes are understood
- Solution within SIBAF-Project



## Superconducting Ion accelerator as Basis technologie for Fusion research

**SIBAF: Supraleitender Ionenbeschleuniger als Basistechnologie für die Fusionsforschung**



CM1 @ Testbunker  
Einbauort für die Bestrahlungskammer

AP 1. Entwicklung der MAT-Fusionsplattform	AP 2. Erhöhung der Schädigungsraten	AP 3. Erhöhung der Eindringtiefe
<b>HELIAC-Prototyp (4 MeV/u)</b> Der bestehende HELIAC-Prototyp (CM1) wird aufgerüstet, um die dedizierte Bestrahlungskammer für Fusionsmaterialien zu betreiben	<b>Erweiterung des HELIACS durch</b> <ul style="list-style-type: none"><li>Elektron-Zyklotron-Resonanz-Quelle und Strahltransportsystem</li><li>Hochleistungs-Radiofrequenz-Quadrupol-Kavität</li><li>Hochleistung HF-Versorgung für Dauerstrichbetrieb</li></ul>	<ul style="list-style-type: none"><li>Konzeptionelles Design des supraleitenden CM4 Energy-Booster-Kryomoduls</li><li>Zusammen mit CM1 und CM2 - CM3 (Im Bau) werden Ionenstrahlen mit 10 MeV/u (d.h. ~100 µm Eindringtiefe) geliefert.</li></ul>
<b>Inbetriebnahme der Fusionsbestrahlungskammer</b> <ul style="list-style-type: none"><li>Bestrahlung und Analyse</li><li>Kühlung und Heizen der Proben</li><li>Probenwechselsystem</li><li>Spezielle Halter für Materialanalyse</li><li>Ankopplung In-Situ Methoden</li></ul>	<b>Fusionsmaterialien Bestrahlung und -Analyse</b> <ul style="list-style-type: none"><li>Probenbestrahlung mit max. Schädigungsraten: ~0,5-2 dpa/Stunde</li><li>Programm für sequenzielle Bestrahlungen (zuerst He-Implantation und dann Bestrahlung mit Schwerionen (z.B. C, Ar, Xe, Fe, W))</li><li>Entwicklung eines Energiemodulators zur homogenen Tiefendosisverteilung</li><li>Bestrahlung von Materialien unter kontrollierten Atmosphären</li></ul>	

**HELIAC**

- Nutzung der neuen Fusionsplattform durch Forscher (in Deutschland und darüber hinaus) und Unternehmen, die Materialien und Technologien für Fusionsreaktoren entwickeln.
- Integration der Plattform in vorhandene Konsortien.

Duration: 3 years

Invest: 5764Mio. €

Personel: 2195 Mio.€:

2x PostDoc GSI/LIN

1x PostDoc GSI/LRF

1x PostDoc +2x PhD HIM/ACID1

1x PostDoc GSI/MAT

**Significant Improvement of staffing situation!**

### AP1.1 Enhancement of HLI-Injector

- Reduction of transverse beam emittance → collimator slits
- Integration of test area into the GSI control system

### AP1.2 Enhancement of CM1

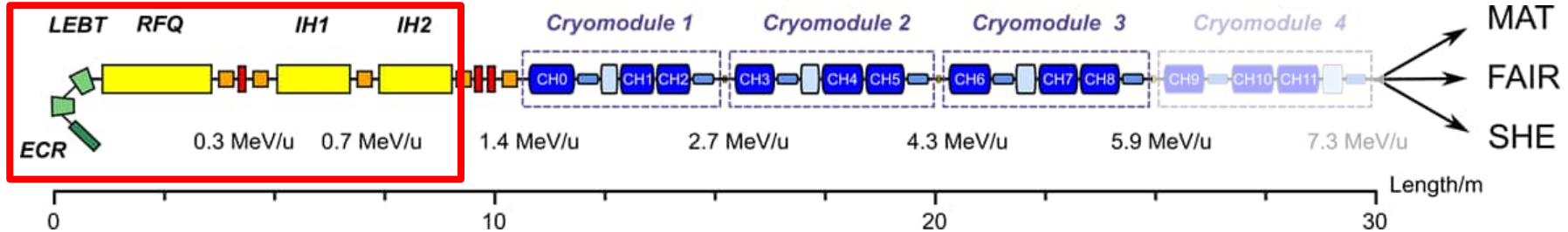
- Frequency correction of superconducting buncher B1
- Development of digital LLRF system

### AP1.3 Material research

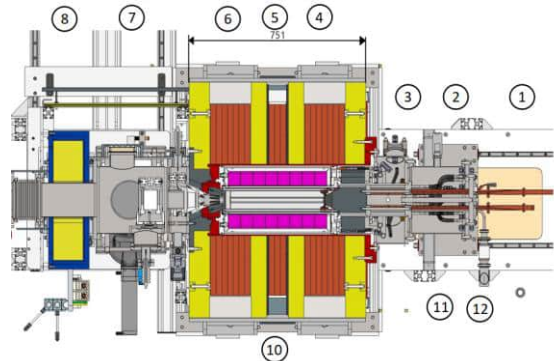
- Pulsed He-Ion beam (5ms@50Hz) up to 4MeV/u, Ar-Ion up to 3MeV/u
- Irradiation chamber for fusion material tests behind CM1
- “Bragg Peak Stacking” – emulate radiation damage in first wall of Fusion Reactor

# SIBAF-Project AP2: nc Injector Development

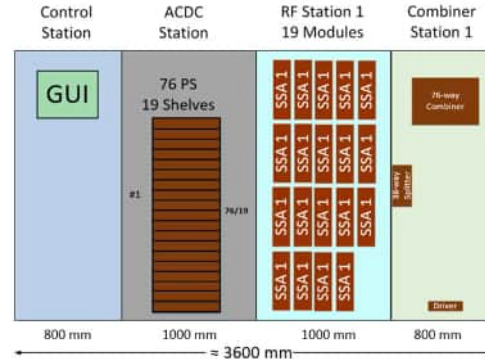
Superconducting Ion accelerator as Basis technologie for Fusion research



18 GHz ECR-Source (1.1 Mio€)  
HIISI-Design University of Jyväskylä



cw RF-Amplifiers (1,8Mio€)  
1x 150kW , 2x 60kW  
(108MHz mod. of MYRRA design)

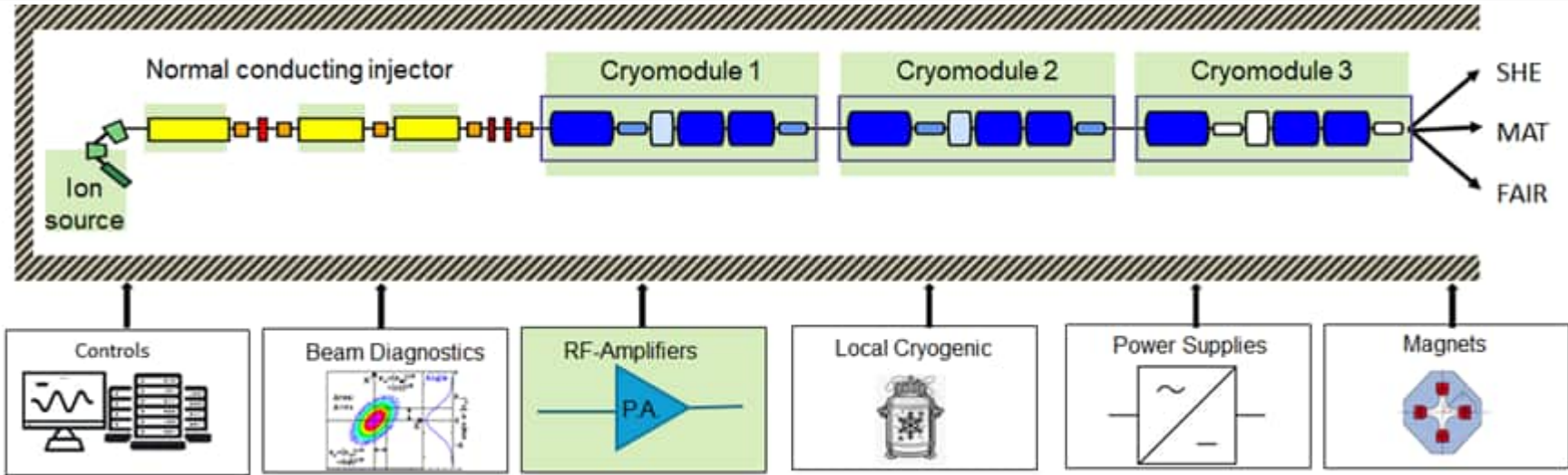


cw RFQ (1,1 Mio€)  
4-rod RFQ IAP Frankfurt



**SIBAF provides the “missing link” by delivering key components for the NC injector.**

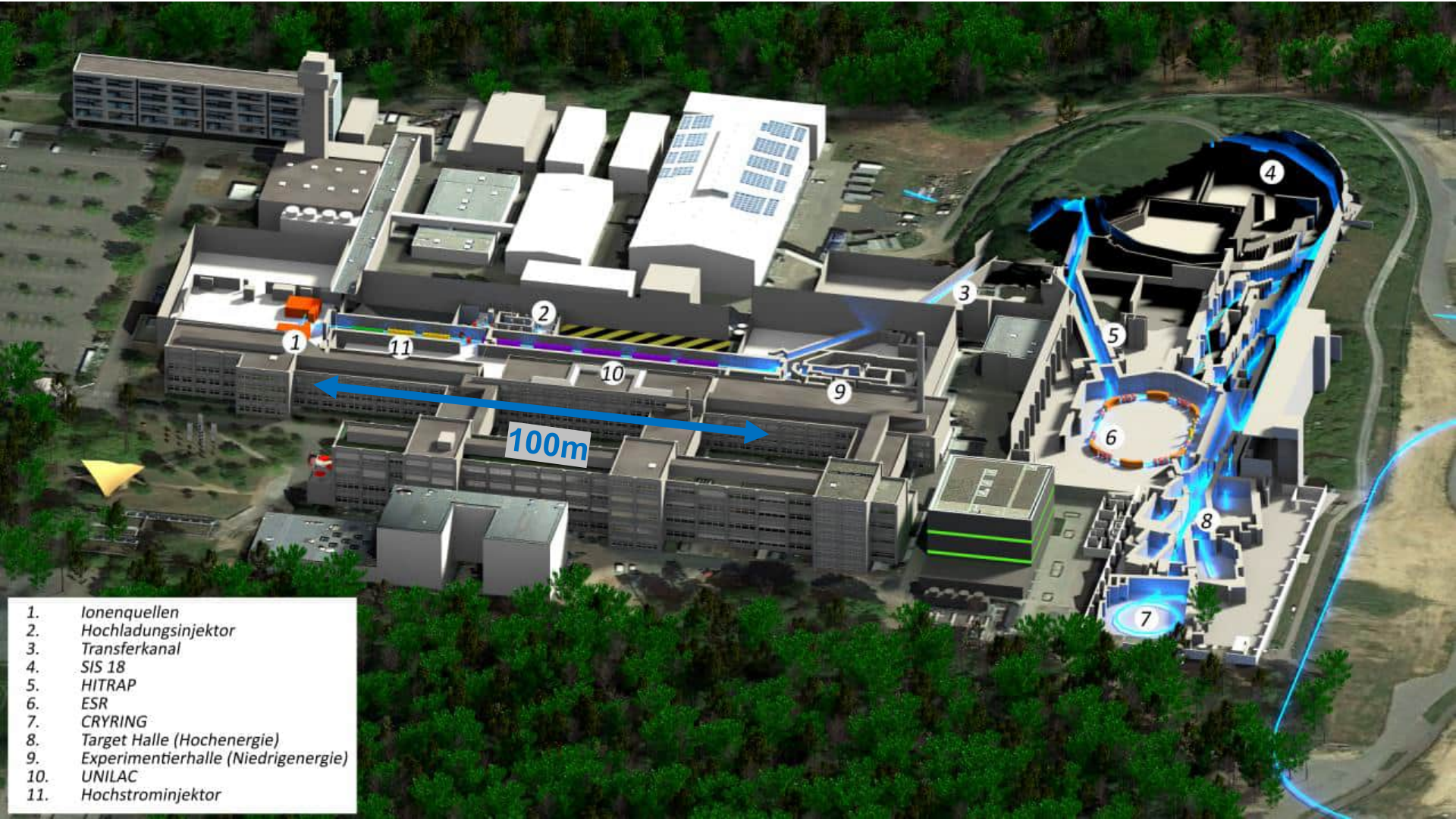
# Components for starting version of HELIAC (CM1-CM3)



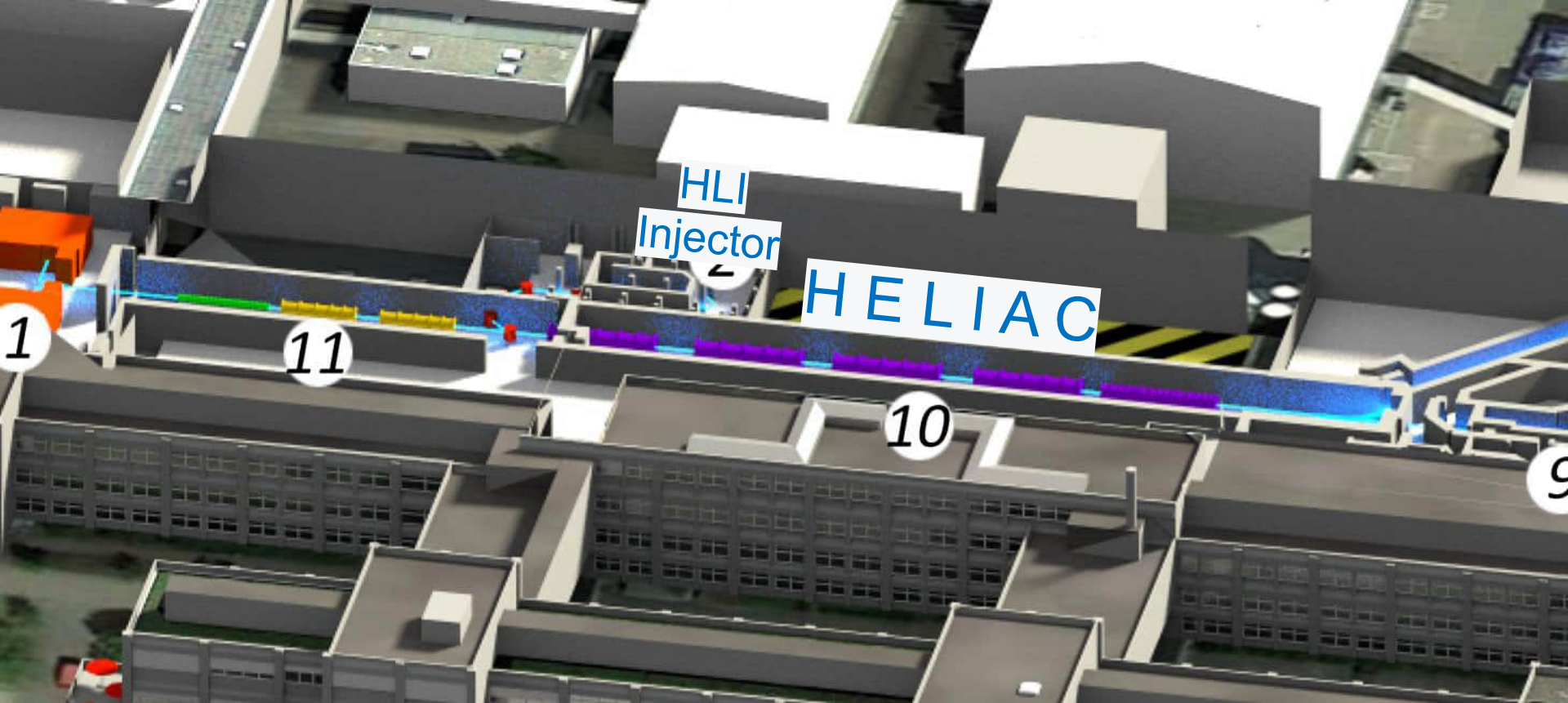
R&D successful, components available by <2030

components not yet secured

- Major components for the start version of HELIAC are either in manufacturing or under development
- Controls, beam diagnostics, local cryogenic, power supplies and magnets are not yet funded



1. Ionenquellen
2. Hochladungsinjektor
3. Transferkanal
4. SIS 18
5. HITRAP
6. ESR
7. CRYRING
8. Target Halle (Hochenergie)
9. Experimentierhalle (Niedrigenergie)
10. UNILAC
11. Hochstrominjektor



- Keep HLI Injector alive as long as possible for SHE program
- Commissioning of HELIAC parallel to operation of HLI+UNILAC

# Start Version: 2031< cw Operation for SHE and MAT <2032

EH  
TK  
M



## VTIS ion source

- Fixed ion species i.e.  $\text{He}^+$  or  $\text{H}$
- Pulsed- and cw-mode
- pinhole for low emittance
- pinhole array for higher emittance



## Sequential Installation & commissioning

- Mobile beam diagnostic bench
- During commissioning phase HLI remain in operation
- 18 GHz ECR development & commissioning on ded. test stand



## Operation of HELIAC

- User operation for SHE with  $^{48}\text{Ca}$  with 5.9 MeV/u

- Prove of Principle is done
  - He-System is working
  - Concept of cryostat with **4x site doors** is a complete success
  - Design energy is achieved
  
- Outlook
  - Construction site is available on 01.07.2029
  - Approval of HELIAC as official GSI-Project expected on upcoming Supervisory Board on 11.06.2026
  - **Work can begin!**

Save Energy, Build HELIAC!