Status and Perspectives of the HELIAC-Project

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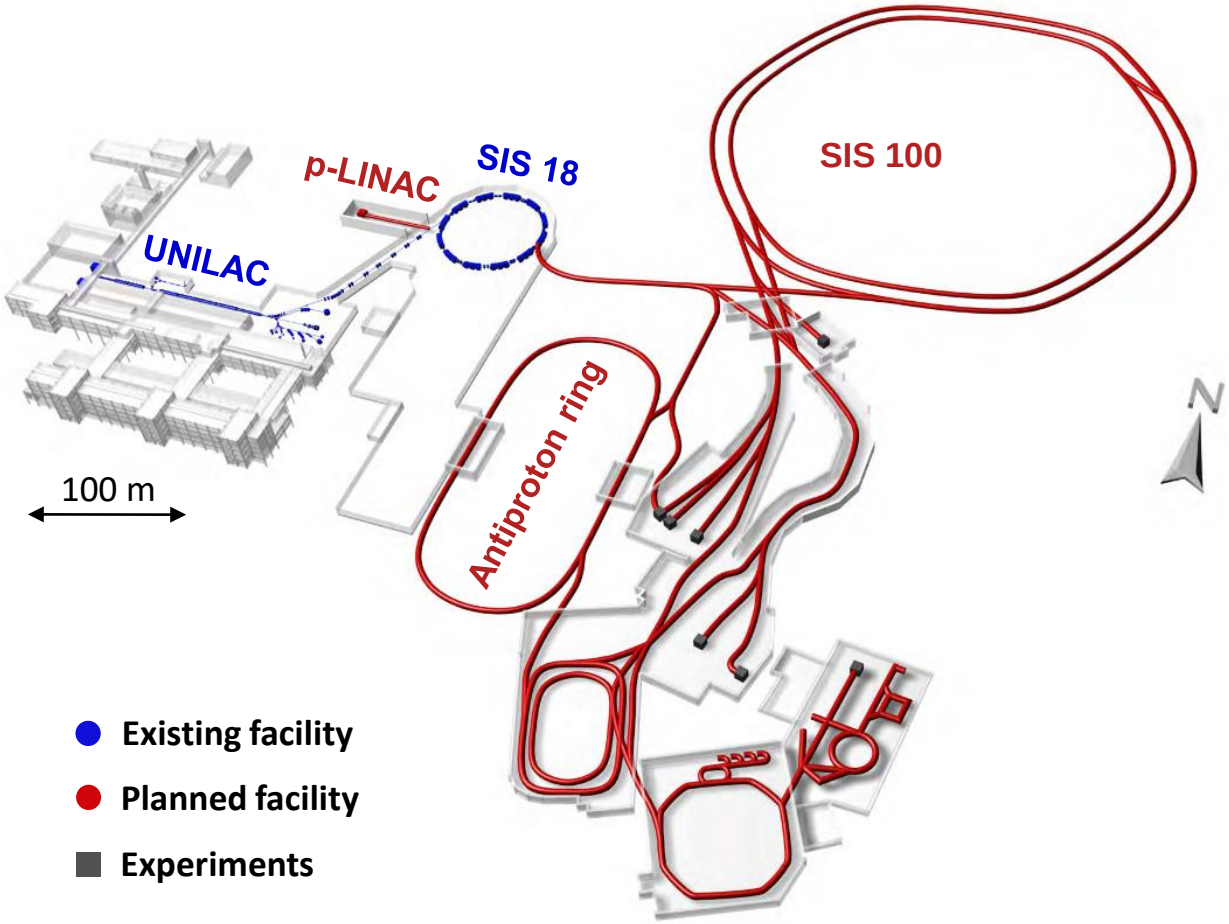
HELIAC
GSI DARMSTADT

Introduction

FAIR Requirements
- high *peak* beam currents
- low duty factor (~0.1 %)
- → low repetition rate (max. 3 Hz)

UNILAC-Poststripper RF Upgrade
- optimised for FAIR requirements
- low duty factor / rep. rate

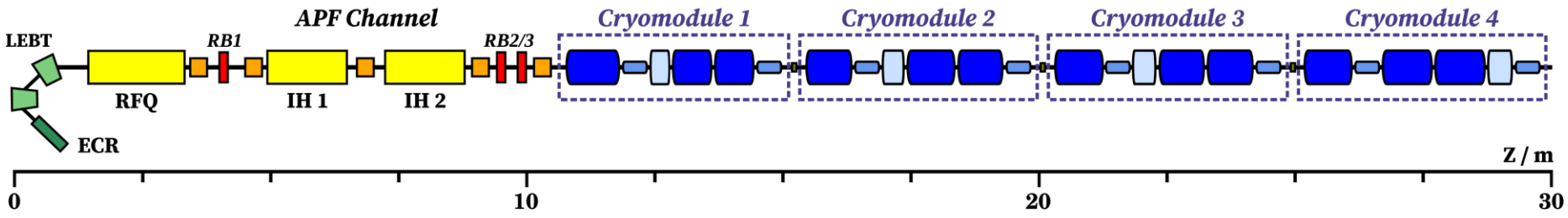
Super Heavy Element Requirements
- high *average* beam currents
- high duty factor (~100 %)
- high repetition rate or just *c.w.*



Existing GSI facility and future FAIR complex

Introduction

He**lmoltz**Li**near**Ac**celerator – **HELIAC



Source

Parameter	Unit
Type	ECR
Frequency	18 GHz

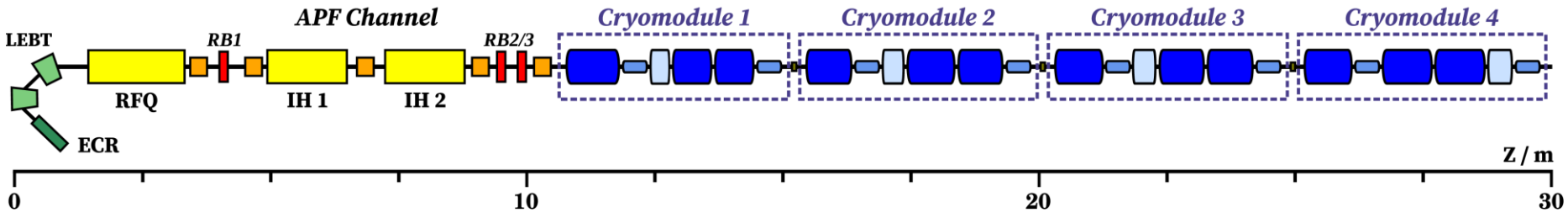
Normal-Conducting Injector

Parameter	Unit	Value
Output energy	MeV/u	1.4
RF Cavities		6
Operation mode		cw
A/Z		≤ 6

Superconducting Accelerator

Parameter	Unit	Value
Output energy	MeV/u	3.5 – 7.3
Beam current	mA	≤ 1
Operation mode		cw
A/Z		≤ 6
RF Cavities	#	12
RF Bunchers	#	4
Transversal Focussing	2 Solenoids per Cryom.	

Status



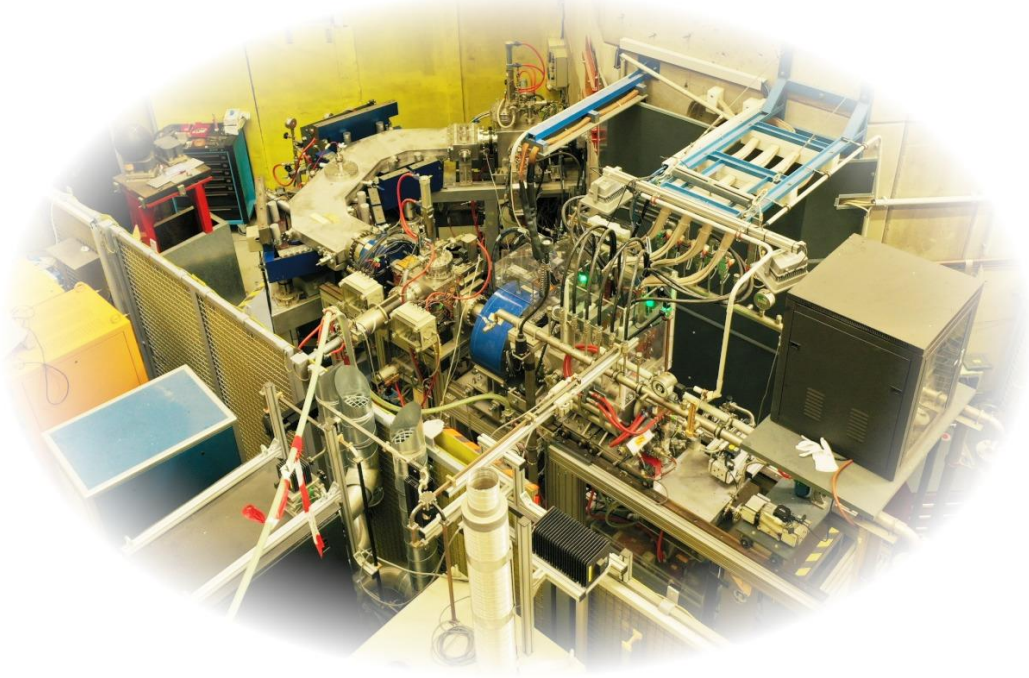
Source

- High charge states are desired:
- → 18-GHz-ECR (Jyväskylä design)
- LEBT
  - Spectrometer
  - Transport to RFQ

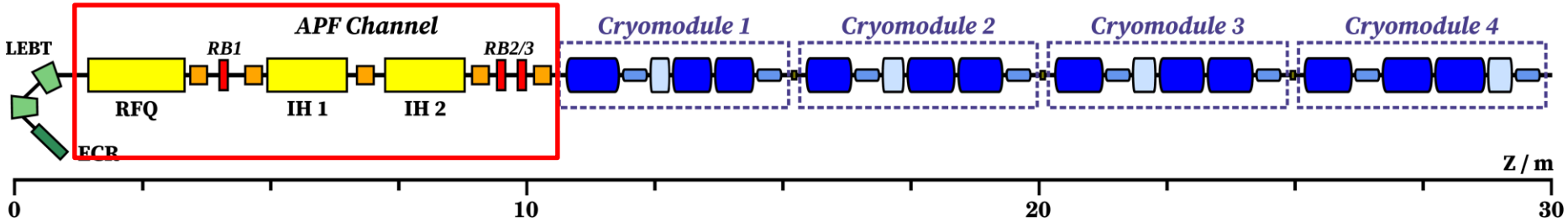
Funding for 18GHz-ECR & LEBT still unclear!

- Start version: 14-GHz-ECR @ GSI

HLI 14-GHz-ECR @ GSI



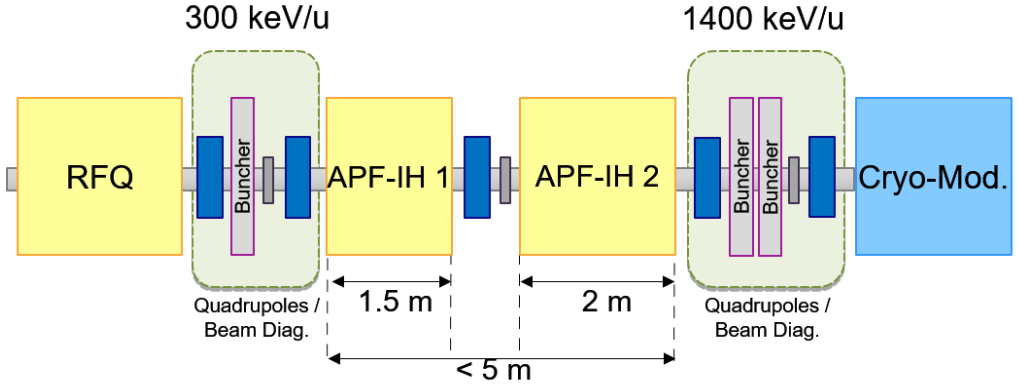
Status



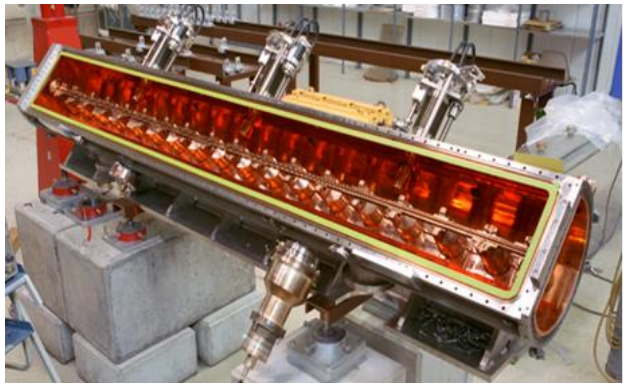
Source: 14GHz ECR

n.c. Injector

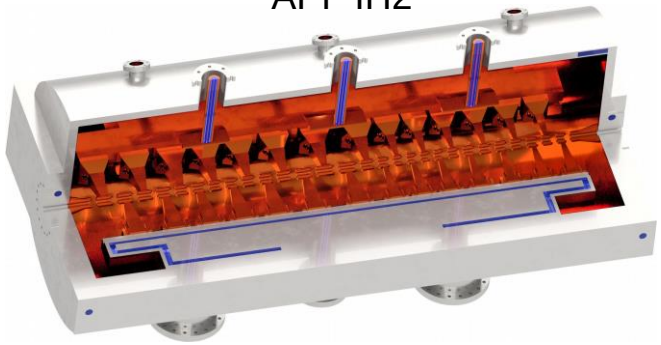
- Start version: old(1991) HLI RFQ
  → 25% duty factor vs. 100 %
- APF IH-DTL with two-cavities (IH1&IH2)
  Alternating **P**hase **F**ocusing
- APF DTL capable 100% duty factor capable
- Manufacturing started
- Start version: existing vacuum tube rf-amplifiers
  → 25% duty factor vs. 100 %



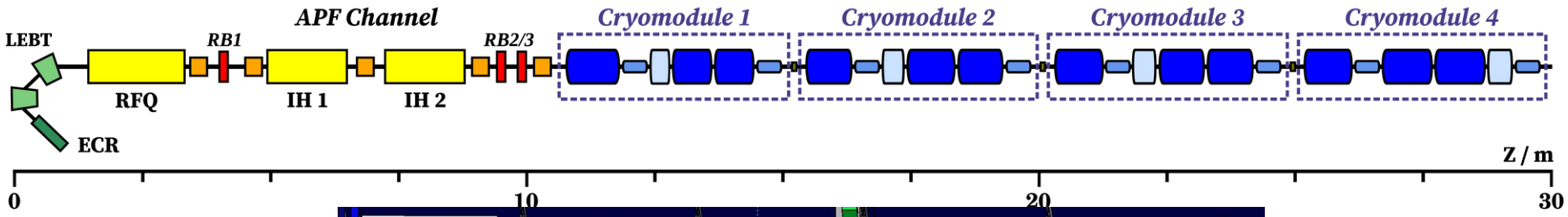
old HLI RFQ



APF IH2



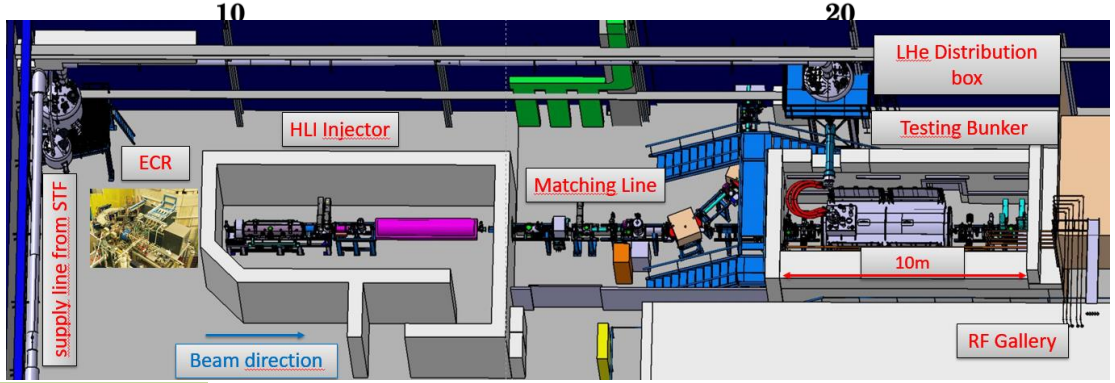
Status



Source: 14GHz ECR

n.c. Injector: RFQ +APF

s.c. Accelerator



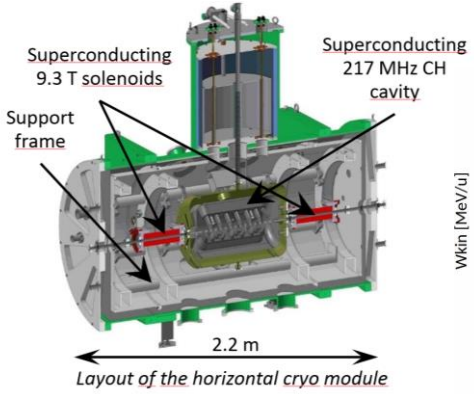
Test of Cryostat & Solenoids

CH Cavity Qualification (2017)

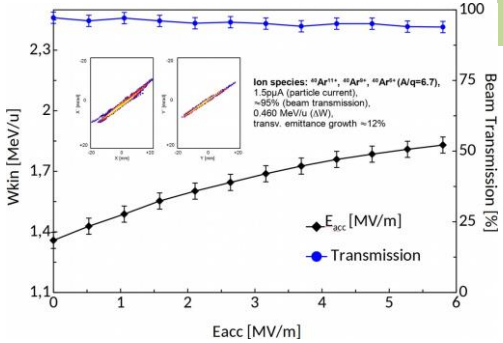
Helium & Test Infrastructure (2021)

Cryomodule Qualification (2023)

Entire HELIAC Setup



Layout of the horizontal cryo module



HIM HELMHOLTZ Helmholtz-Institut Mainz

Test Site @ GSI

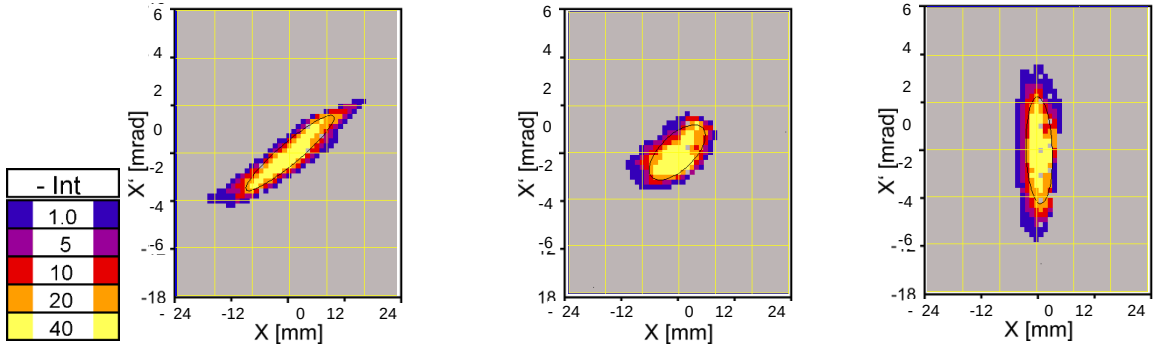
sc Solenoid Commissioning

CM1 with dummy cavities

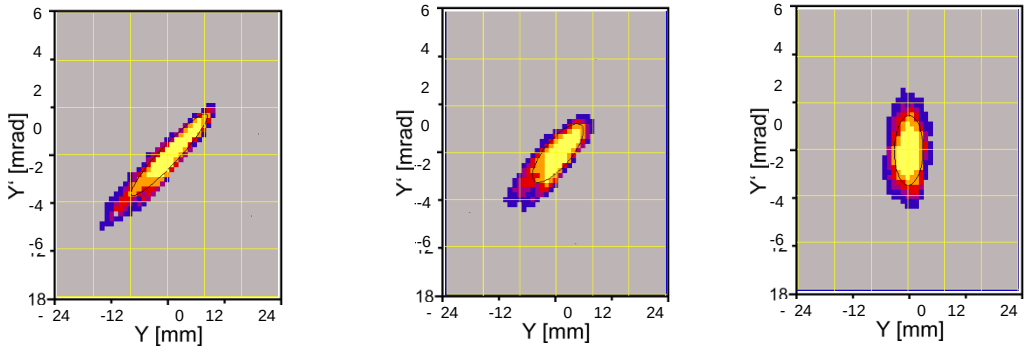
2021

(Ar^{8+} beam)

w/o solenoid	**>Focus** I_{Sol1} **= 15A**	**Focus** I_{Sol2} **= 25A**
emittance:5.4 mm mrad	*5.73 mm mrad*	*6.44 mm mrad*



emittance:4.72 mm mrad	*4.52 mm mrad*	*4.69mm mrad*

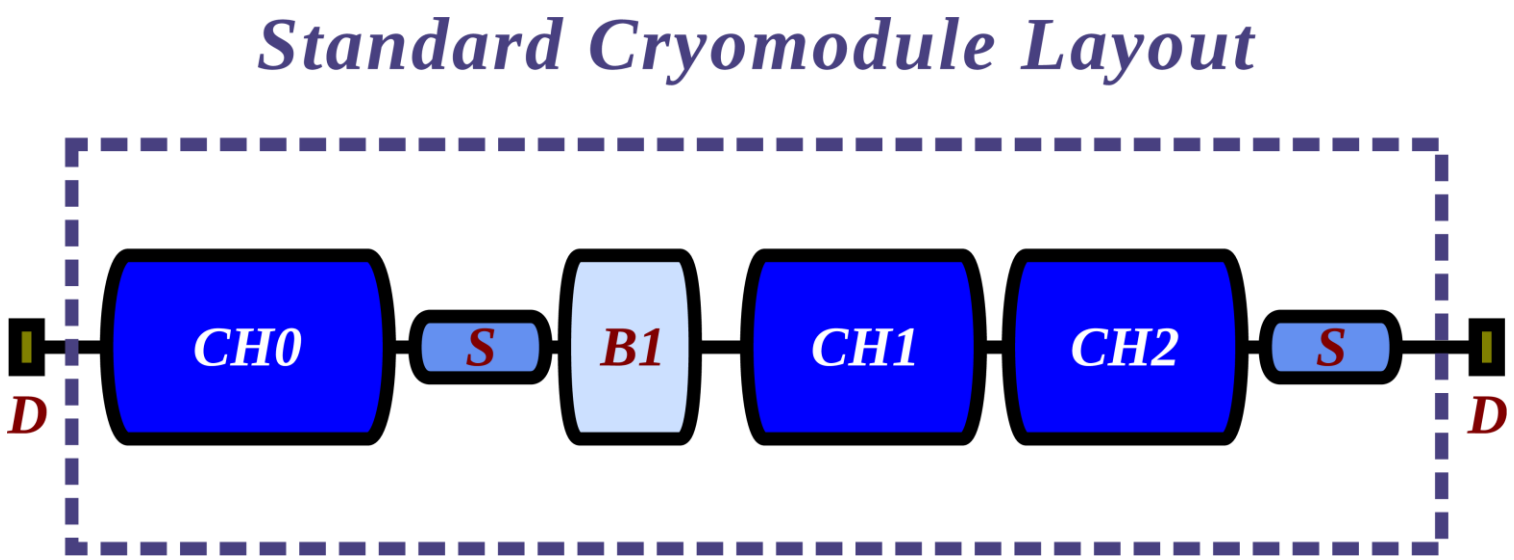


62 eμA	**61 eμA**	**60 eμA**

Cryomodule Qualification

Advanced CW Linac Demonstrator

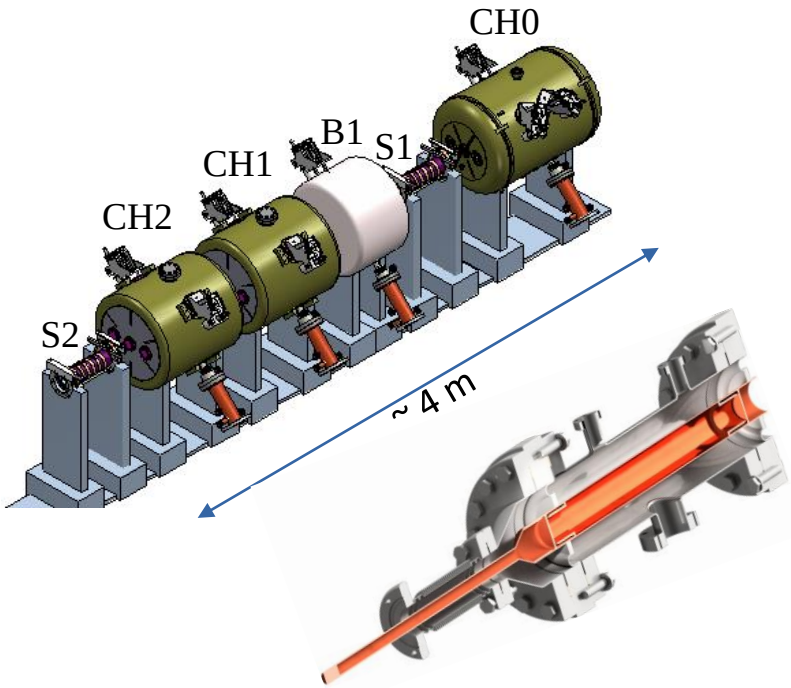
- 3 CH cavities
- 1 Rebuncher
- 2 Solenoids

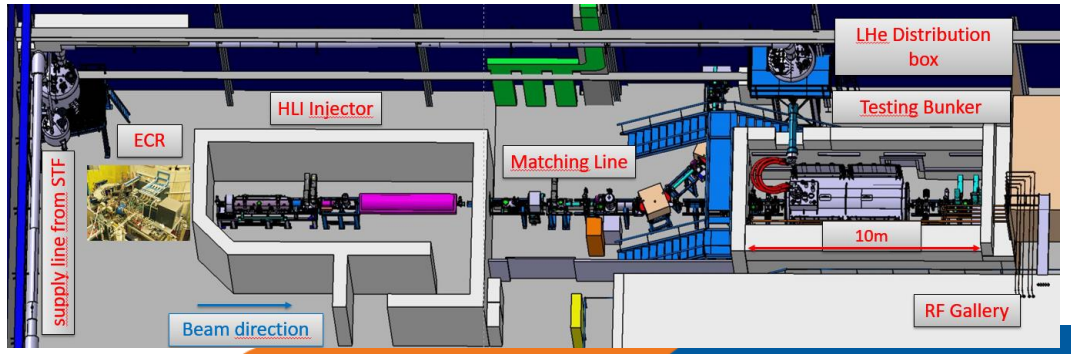


Cryomodule Qualification

Test of fully equipped standard cryomodule:

- Components delivered:
  - Cavities & Solenoids
  - Power couplers
  - RF amplifiers+LLRF
  - Cryostat
- Clean and precise assembly required
- Many „firsts“:
  - Assembly procedures
  - Auxiliary constructions
  - Transport HIM ↔ GSI
- Test site + infrastructure





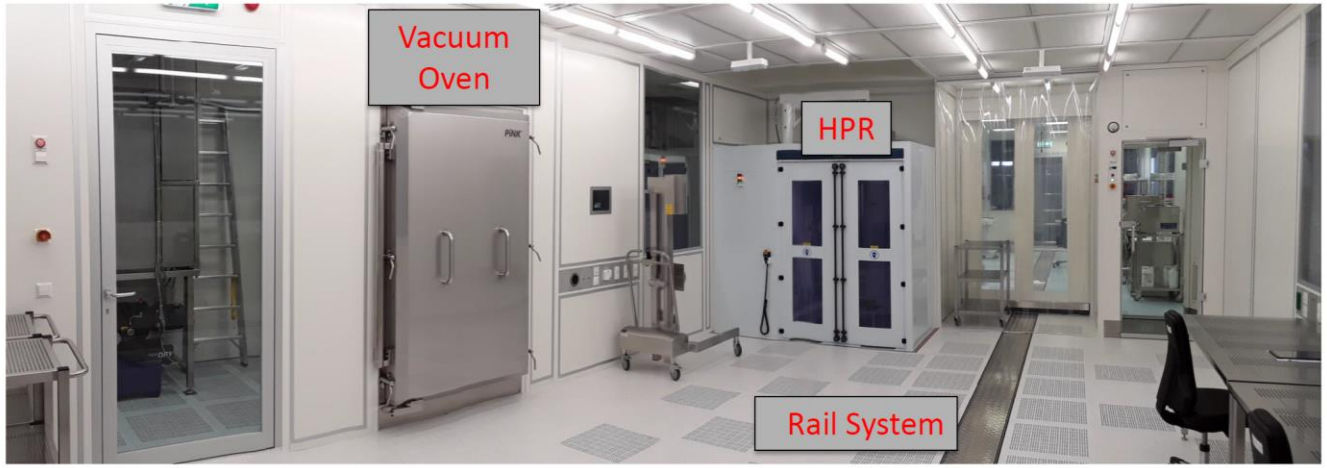
Clean Room Infrastructure @ HIM

Unique infrastructure for SRF R&D

- Two interconnected clean rooms
  $42m^2$ (ISO6)+$42m^2$ (ISO4)
- Ultra high purity water supply (18MΩ/cm)
- Ultrasonic bath and conductance rinse
  outer surfaces of everything must be grease free..
- High Pressure Rinse (HPR) with 100Bar
  removal of particulates & contamination from inner surfaces of vacuum bellows, cavities, solenoids …..
- Weekly cleaning by external company on Friday
- We are ready for Assembly!

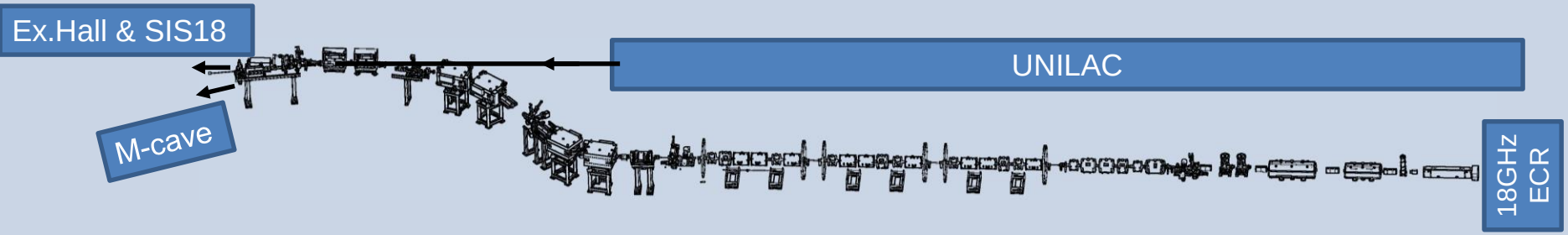
ISO 6 Clean Room

ISO 4 Clean Room



Integration with Cryostat

Summary & Time Schedule



- HELIAC is designed to fit into existing SH2/SH3
- Feasability study for civil construction/tunnel
- STF cryogenic plant for supply of HELIAC
- ECR 18GHz+LEBT -> purchasing on hold
- RFQ-> old HLI RFQ (25% duty)
- IH1/IH2 in manufacturing
- CM1 is in assembly/testing
- CM2 is in manufacturing (fully financed)
- CH-Cavities for CM3 are in manufacturing

- Bending magnets from GSI-Stock, power supplies to be ordered
- Most of beam line magnets on GSI-Stock, most of power supplies to be ordered
- For „basic approach“ (25% duty) reuse of existing high power rf-amplifiers
- Requires the planing i.e. manpower now!

HELIAC/Timeline

2017	Demonstrator Beam Test
2019	Cryo-Infrastr.&Test Area
2021	Adv. Dem. Cryostat Test
2022	CM1@HIM-Clean Room
2023	Beam Test@GSI
2024	CM1-Test Operation
2025	Setup of HELIAC-Bunker
2026	HELIAC-Commissioning/ Ion source&Injektor
2027	CM1&Link2UNILAC
2028	Basic Approach (CM1&2&3)
>2028	Full scale expansion/ cw-capability&CM4-install.

Thank you for Attention!

EQUUS

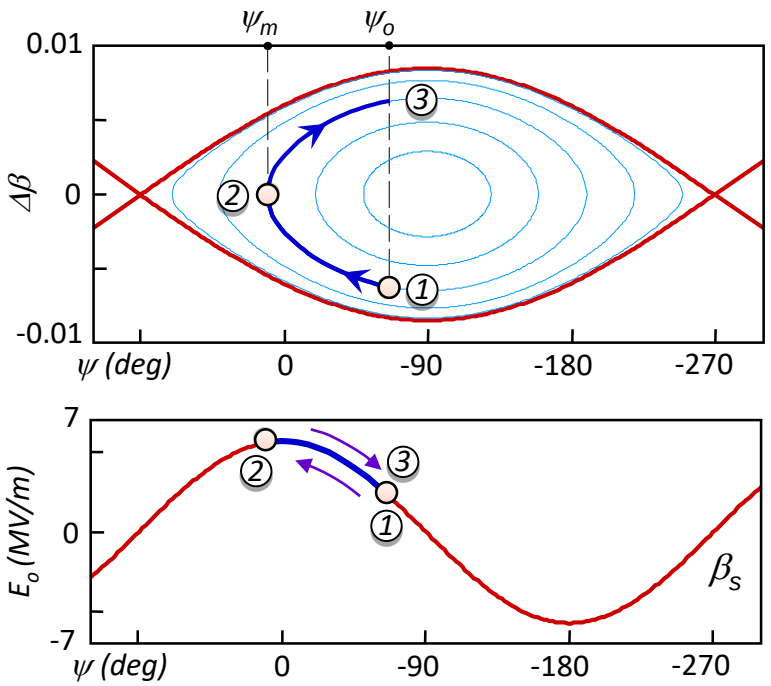
EQUUS - EQUidistant mUltigap Structure

① Particles too early less acceleration → obtain longitudinal focussing

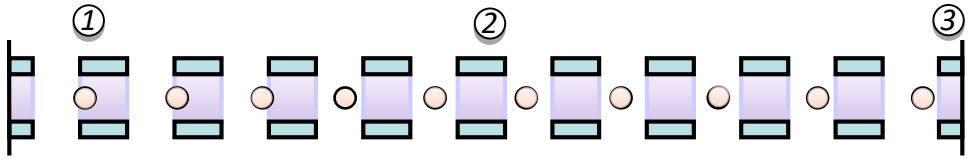
② Particles synchr. acceleration → reach max. longitudinal defocussing

③ Particles too early less acceleration → obtain longitudinal focussing

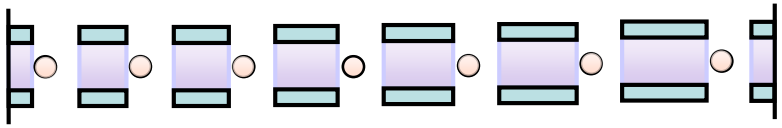
Longitudinal motion of an accelerated bunch in the constant-β-section



EQUUS



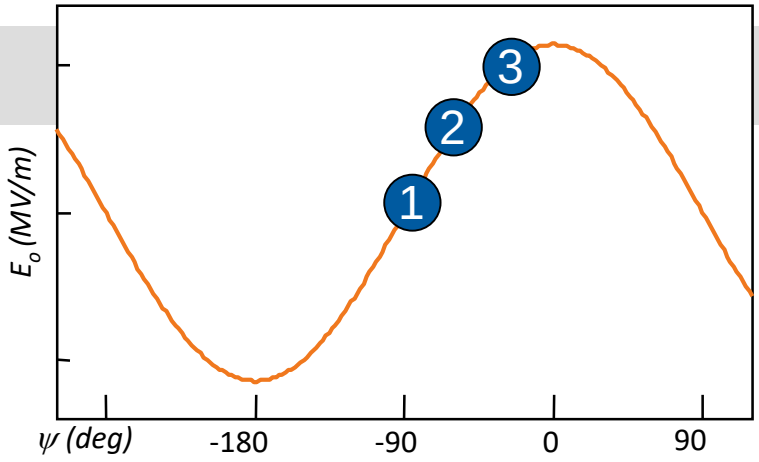
Resonant Acceleration at φ=-30



APF

APF: **A**lternating **P**hase **F**ocusing

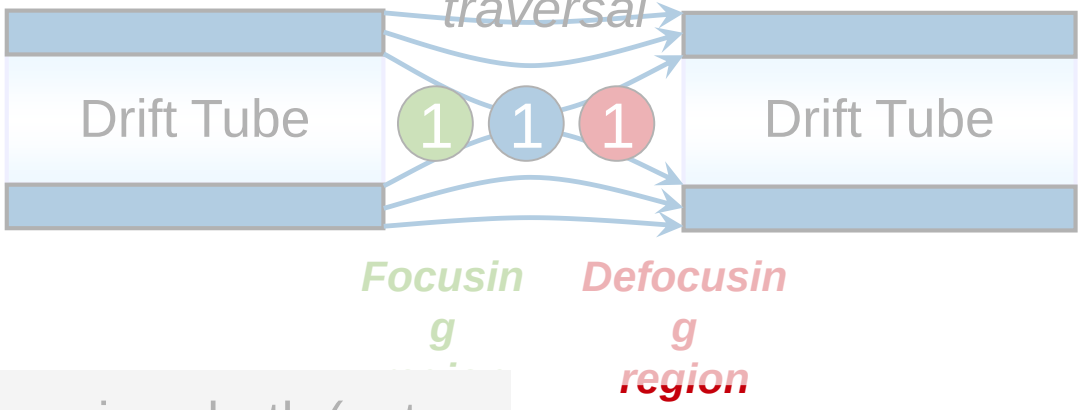
Longitudinal:



→ focusing

Transversal: *Field increases during particle traversal*

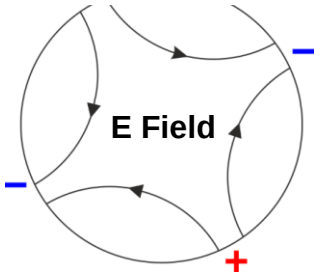
→ net **de**focusing



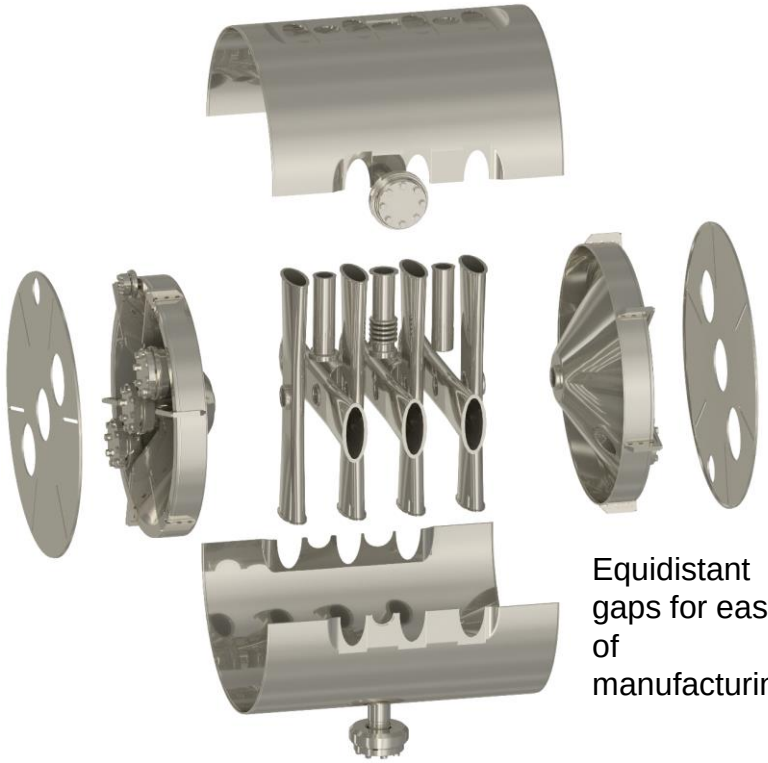
→ F0D0-Lattice gives both (net effect)

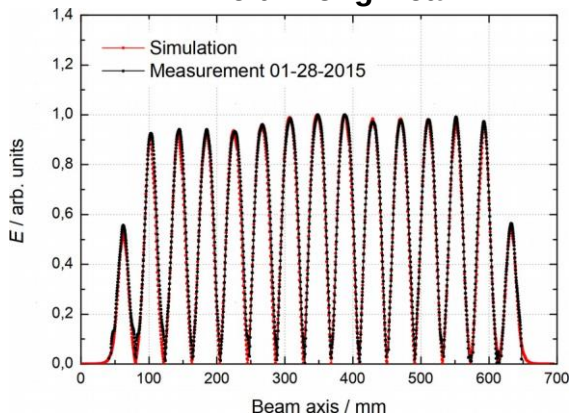
Cross-Bar-H-Mode Cavities

H_{211} mode of pillbox cavity



Parameter	Unit	Value
β		0.059 – 0.12
Gradient	MV / m	5.5 – 7.1
Q_0		~ 10^9
Operation mode		cw
Gaps	#	5 – 15
Diameter	m	0.4
Effective Length	m	< 1
Material		Niobium



Equidistant gaps for ease of manufacturing

E Field Along Beam