CR Stochastic Cooling System 1-2 GHz

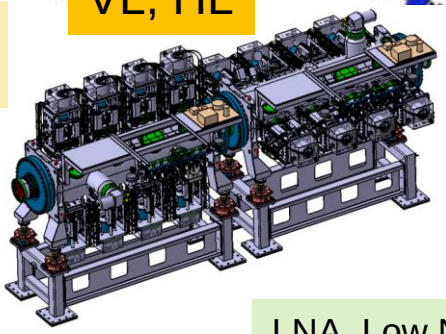
CR UHV aim for requested beam lifetimes of 100 s:
basic static P ≤ 3 ·10^{-9} mbar (N_2 equivalent) at room temperature, **without in situ bakeout**

C=221.45 m
Bρ=13 Tm

Beam

2 cryogenic plunging PUs
(slotline electrodes)

VL, HL



Palmer PU
(Faltin
electrodes)

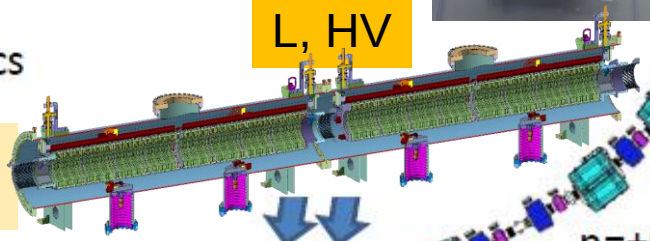
32x 250 W mw
power amps at
kickers
Total=8 kW
to cool in
all planes

Many RF-components
and cables in the building

LNA. Low Noise
preamps at PUs
≤ 43K (≤ 0.6dB)

Microwave damping tubes in all
quad/sextupole chambers in the arcs

L, HV



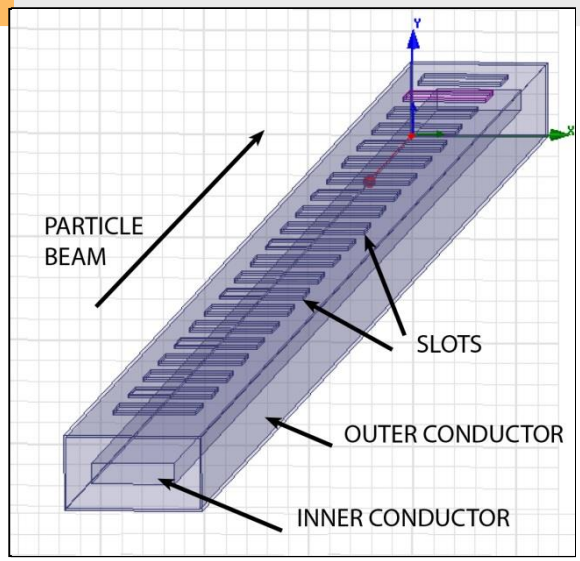
2 kickers
slotring electrodes

$$\eta = \frac{1}{\gamma^2} - \frac{1}{\gamma_{tr}^2}$$

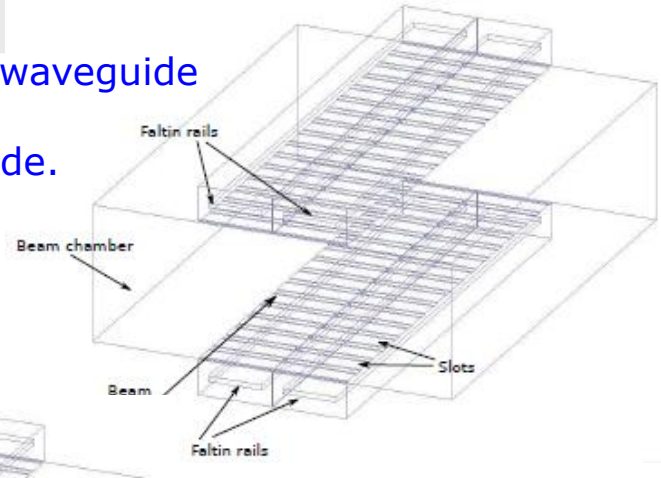
η=+0.014/-0.011 pbars
η=0.18 RIBs
CR optics, lattices, apertures
(frozen since 2016) so as
to serve the stoch. cooling

System bandwidth 1-2 GHz

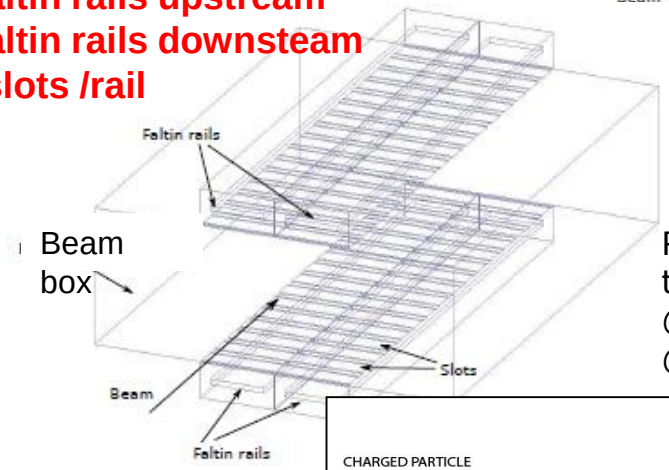
Palmer PU for precooling of RIBs



A Faltin PU=rectangular coaxial waveguide with slots which couple energy from the beam into the waveguide.
Synchronisation by design
$V_{phase} = V_{particle}$ *RIBs 0.83 c*



Palmer PU=
4 Faltin rails upstream
4 Faltin rails downsteam
49 slots /rail



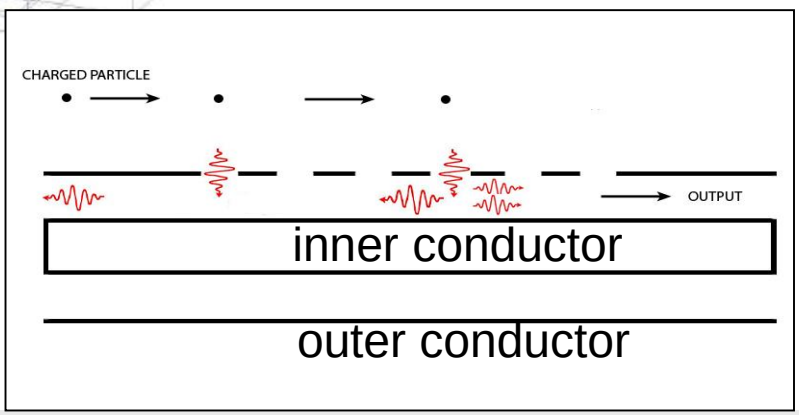
Rare isotopes have high Q→ strong signal.

Faltin electrodes:
flat freq. response but large/ insensitive.
compromise high coupling impedance ←→ high phase nonlinearity

specified fixed electrode apertures :
Horizontal/Vertical = ± 200 mm/ ± 66 mm w.r.t. beam axis

need to fill the beam box with ferrite to damp the unwanted rf modes in 1-2 GHz

Real life: phase slip between travelling wave and particle
@low f : $V_{phase} > V_{particle}$
@high f : $V_{phase} < V_{particle}$



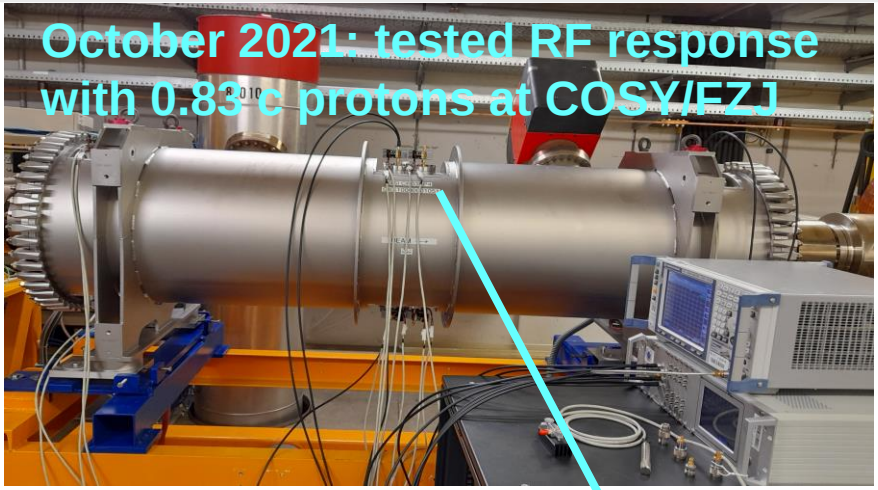
L. Faltin, Nucl. Instr. and Meth. 148, p.449-455, (1977).

Palmer Pick-Up: Successful test with beam at COSY

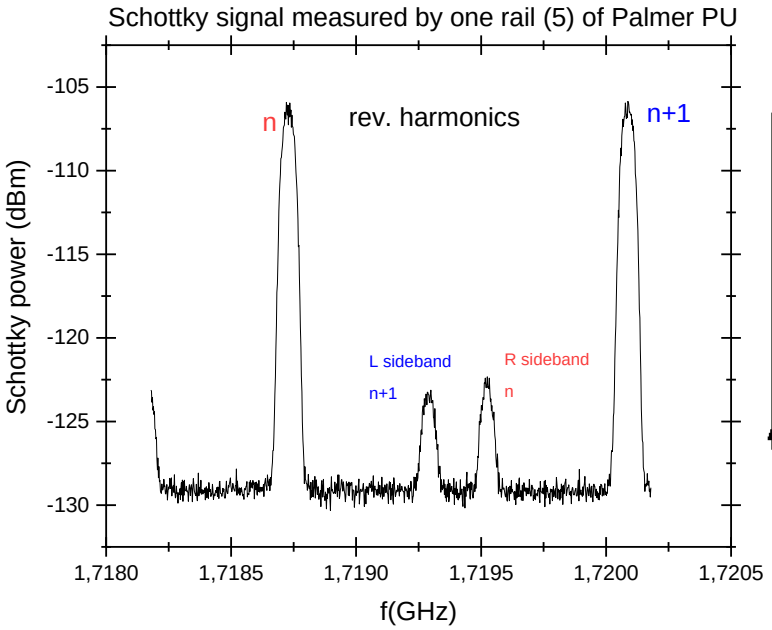
Palmer PU designed for optimum response within 1-2 GHz band, at RIB velocity v=0.83 c

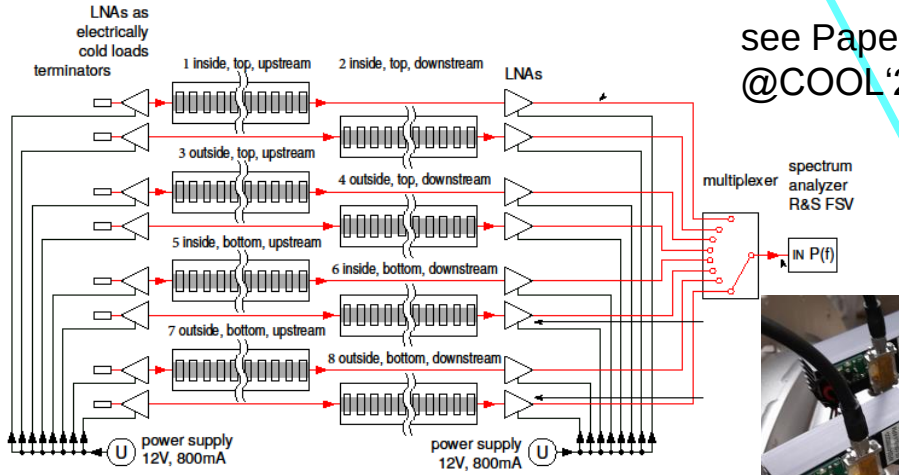
all 8 rails work!!
deliver good signals
at characteristic beam frequencies
(rev. harmonics + vertical betatron)

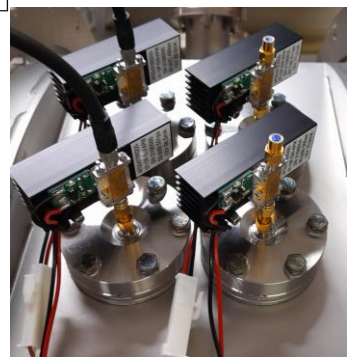
coasting beam, v=0.83 c
$N=1.8 \cdot 10^{10}$ protons



see Paper S301
@COOL'21 Workshop



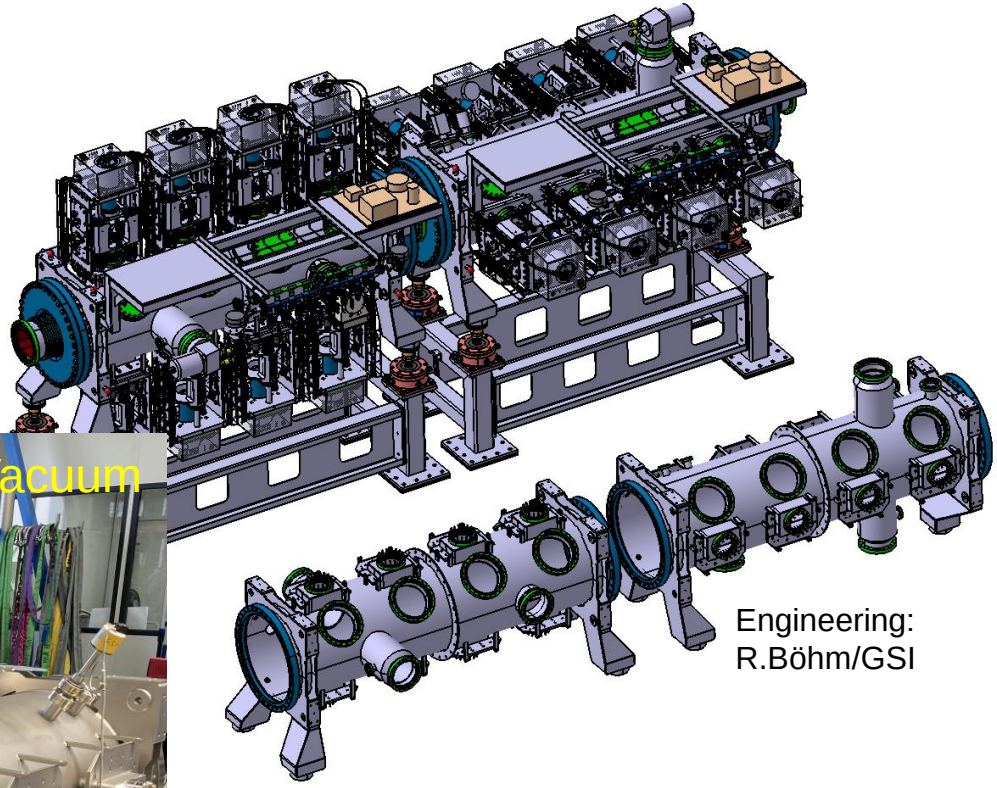




C. Dimopoulou, C. Peschke, S. Wunderlich/GSI
R. Stassen, N. Surkhno, D. Prasuhn/FZJ

Challenging Cryogenic Plunging Pick-Ups

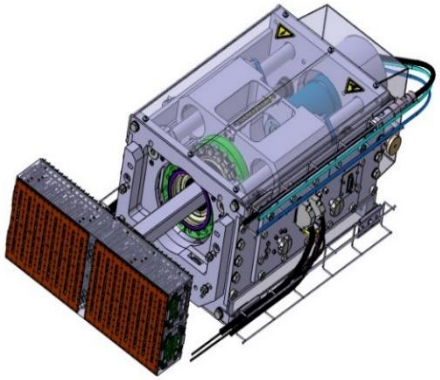
2 vacuum tanks being manufactured according to GSI drawings.
Expect FAT & delivery Q4/2021



Engineering:
R.Böhm/GSI

Finalizing 3D engineering & procurement of inner subsystems

Challenging Cryogenic Plunging Pick-Ups

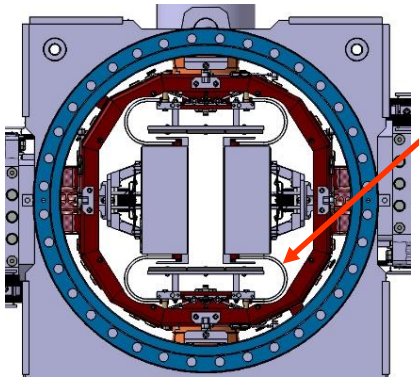


16 Motor Drive Units: ready,pre-assembled in house; stored

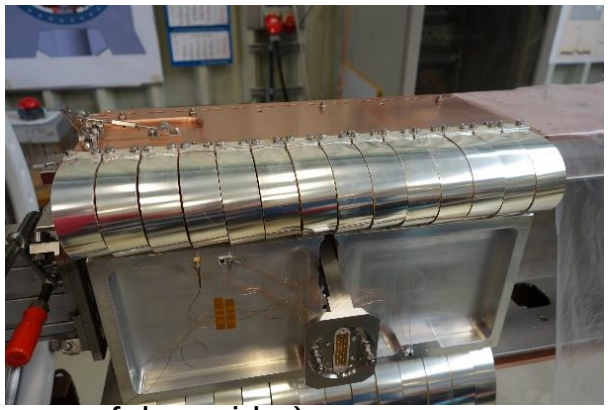
~3500 Ag/CuBe plunging foils and their Ag/Cu holders (incl. spares)

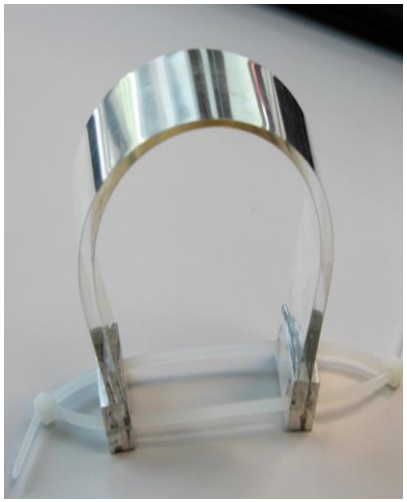
CuBe foils thermally treated in vacuum oven GSI TechLAB

2021-2022: galvanic Ag-plating (1 provider, manually)



Flexible Ag/CuBe foils at 30 K



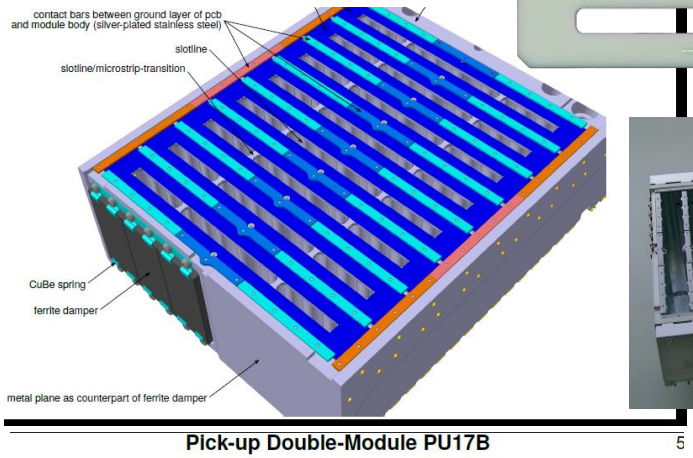


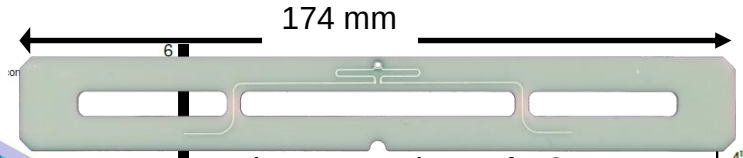
>2022: UHV soldering of foils on holders (1 succesful provider)

Slotline electrode module

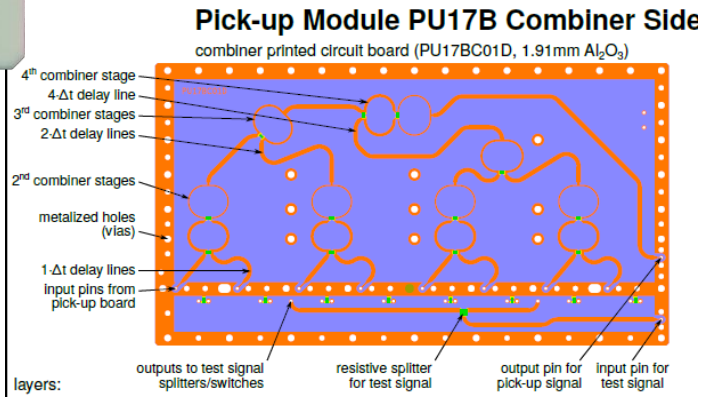
-re-designed for feasibility
-contracted full scope (pre-series, series, spares) metallised ceramic RF boards
-Prototype module: received all pieces & ceramics; full assembly & RF tests Q1/2022

8 single slot PCB
with 1 hole & 3 slots

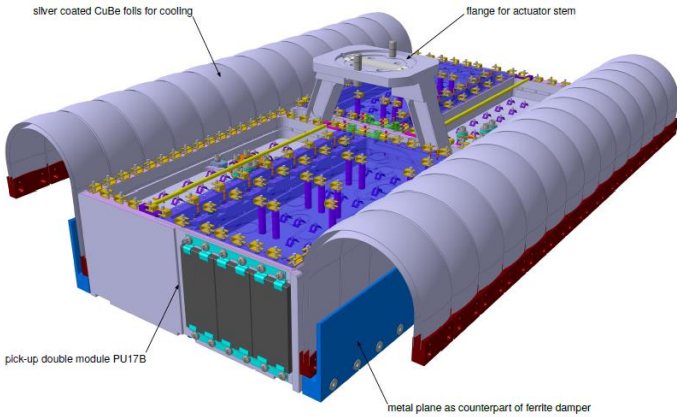




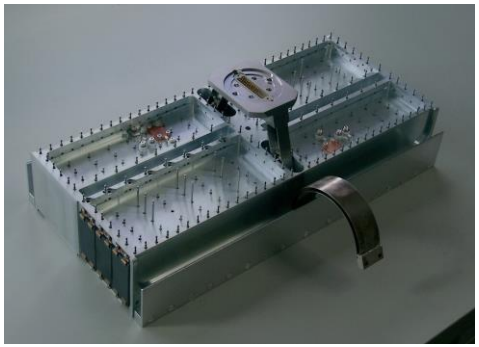
microscope photo of PCB

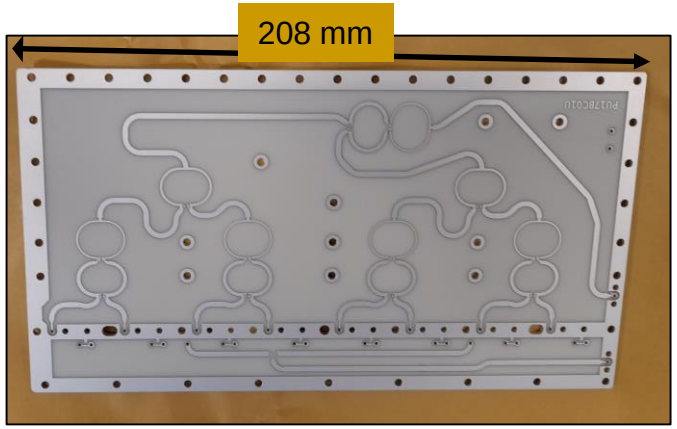


Pick-up Double-Module PU17B



2019 C. Peschke
Engineering: M.Meister/GSI



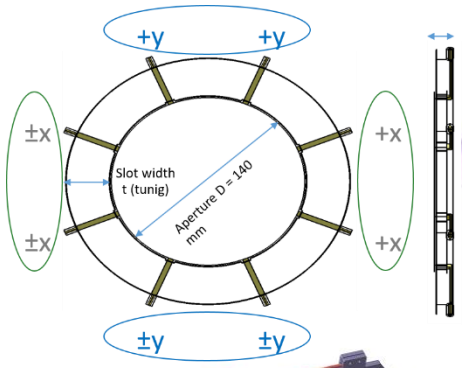


Kickers

Decision to adapt the well-proven FZJ HESR slot-ring concept to CR case.

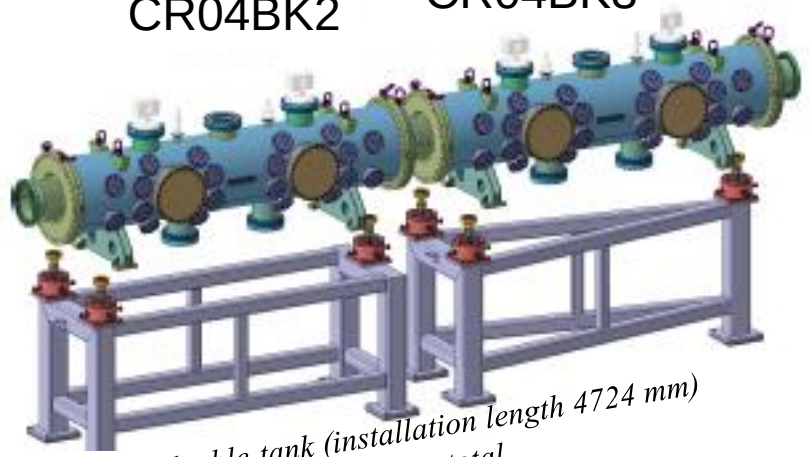
electrodes= slot-rings 1-2 GHz; 140 mm aperture

one tank transverse (HV); one tank longitudinal cooling

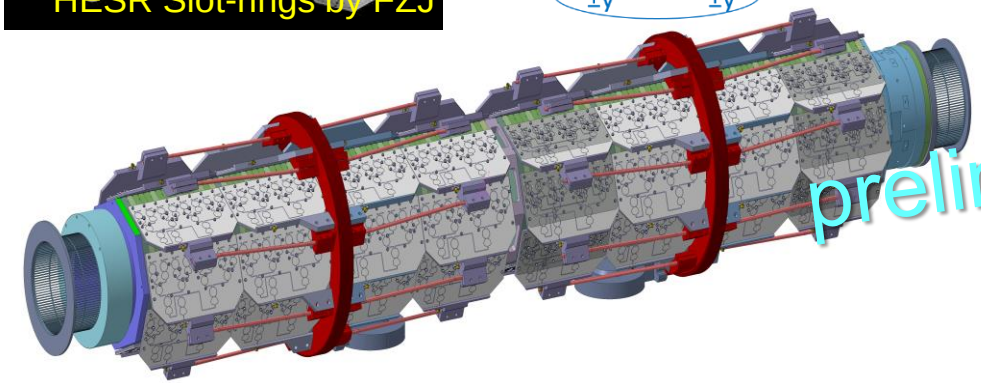


KHV
CR04BK2

KL
CR04BK3



double-tank (installation length 4724 mm) with 256 slot rings in total.



preliminary

2x64 slot-rings (incl. splitter boards) in each tank

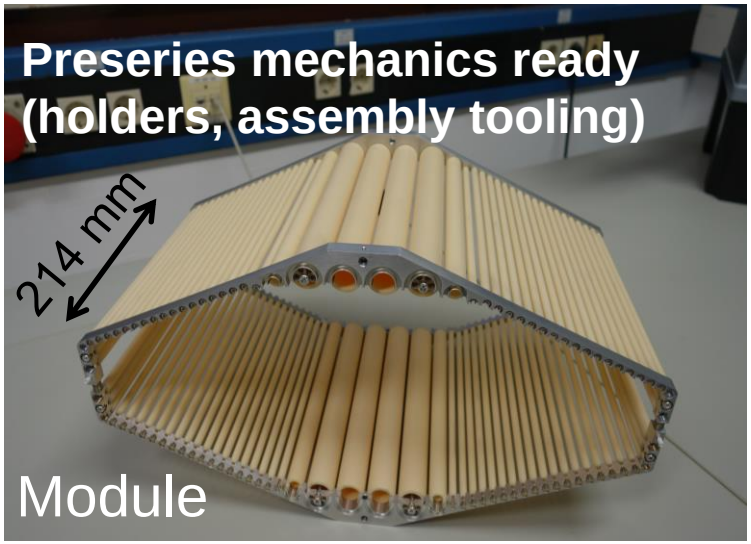
Challenges:

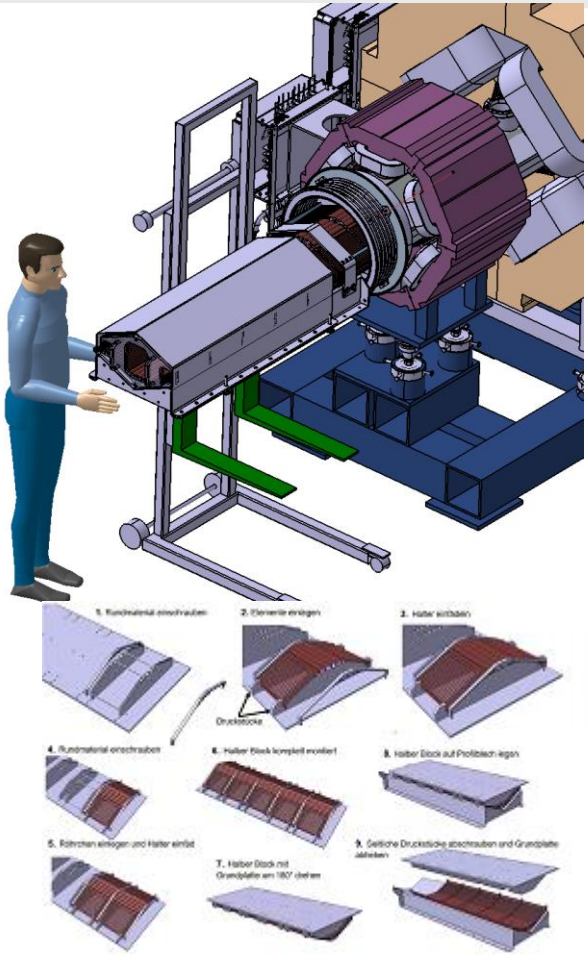
- Space limitations → constrained splitter board size
- Minimization of signal run-time from power amps to kickers
- Heat transfer from splitter boards

Contract for complete CR SC kicker tanks by FZJ team (R.Stassen, B.Breitkreutz, R.Greven): concepts (RF, mechanics, vacuum, cooling water), engineering, production & testing

Microwave damping tubes inside quad/sext chambers

Q1-Q2/2022: testing assembly mechanics + UHV benchmarking with modules inside BINP chamber.





Engineering:
R.Böhm/GSI

2021: mechanically ready after reworking bellow fixings

Status November 2021 at a glance

2.5.10	**CR Stochastic Cooling System**
2.5.10.1.1	Cryogenic Plunging Pick-ups *>>in production (see slides)*
2.5.10.1.1	Palmer Pick-up *>> works! tested with COSY β=0,83 beam*
2.5.10.1.2	Kickers *>>contracted to FZJ, design feasible!*
2.5.10.2.1	Low Noise Preamplifiers (for all pick-ups): *>>ready*
2.5.10.2.2.1	Power Amplifiers 1-2 GHz >> fulfill spec, highly linear *>>20/34 passed SAT, 14/34 repaired-new SAT in 2022*
2.5.10.2.3	RF Signal Processing *>> ongoing*
2.5.10.3	Instrumentation
2.5.10.5	Microwave Damping CR Chambers *>>series tubes: ~15000 coated ceramics tubes delivered* *>> prototype mechanics done (holders, assembly tooling)* *>> Q1/2022: assembly+UHV testing of tubes inside BINP quad chamber*