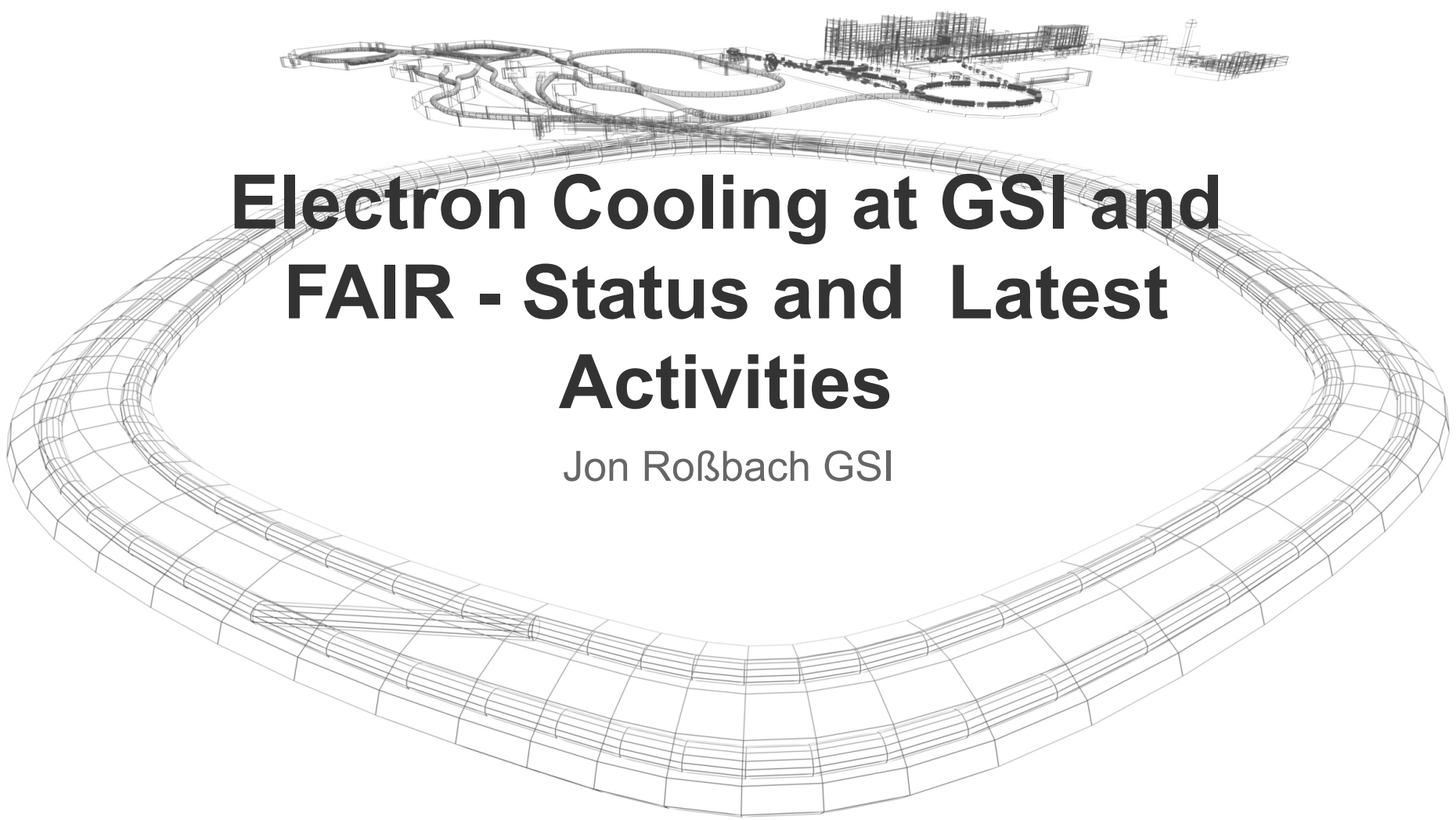
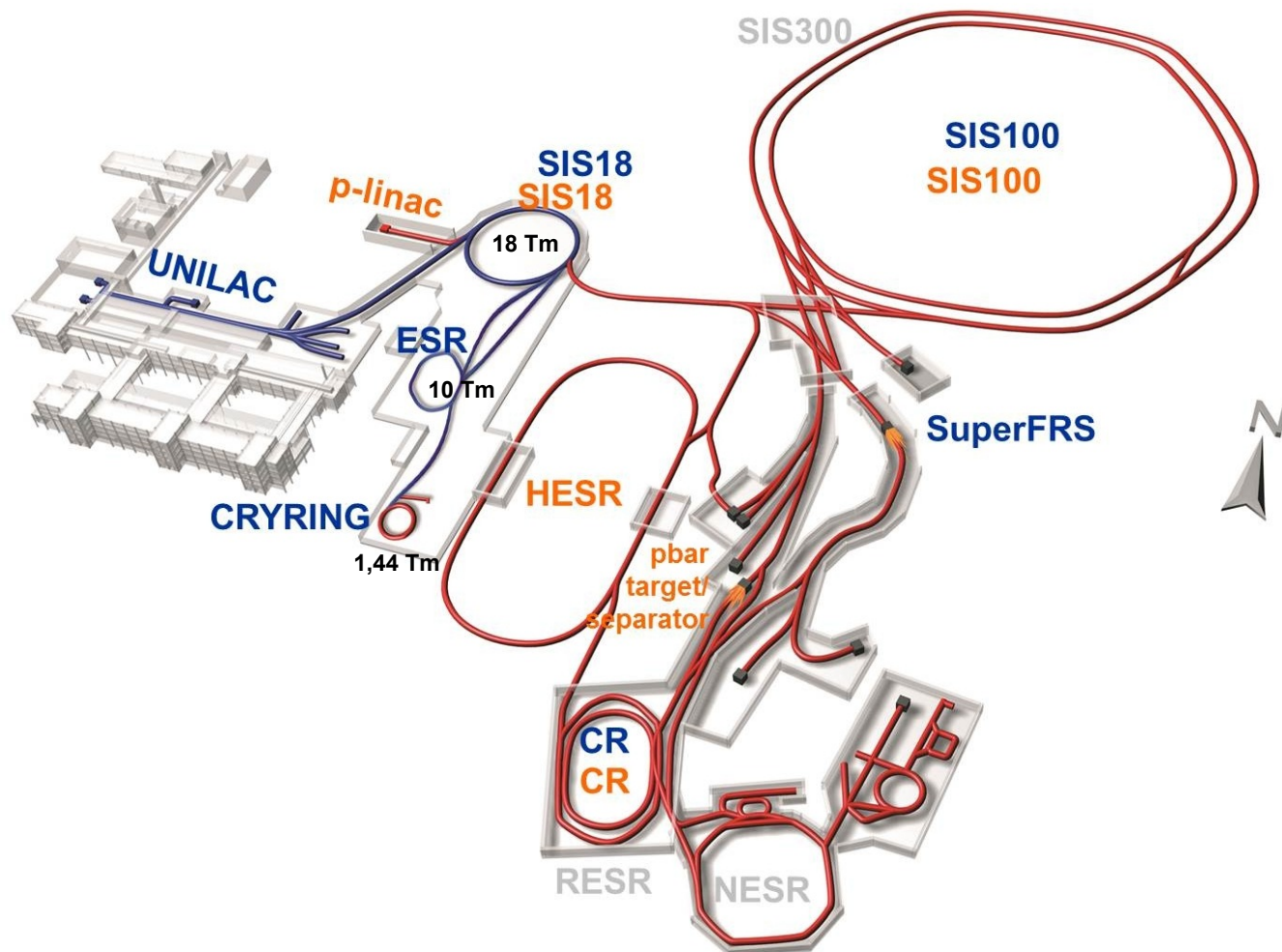


A detailed wireframe model of a particle accelerator, likely the FAIR (Facility for Antiprotons and Ion Research) project. The model shows a large, circular ring structure with multiple layers of pipes and support structures. In the background, there are smaller, more complex structures representing the main building and other facilities.

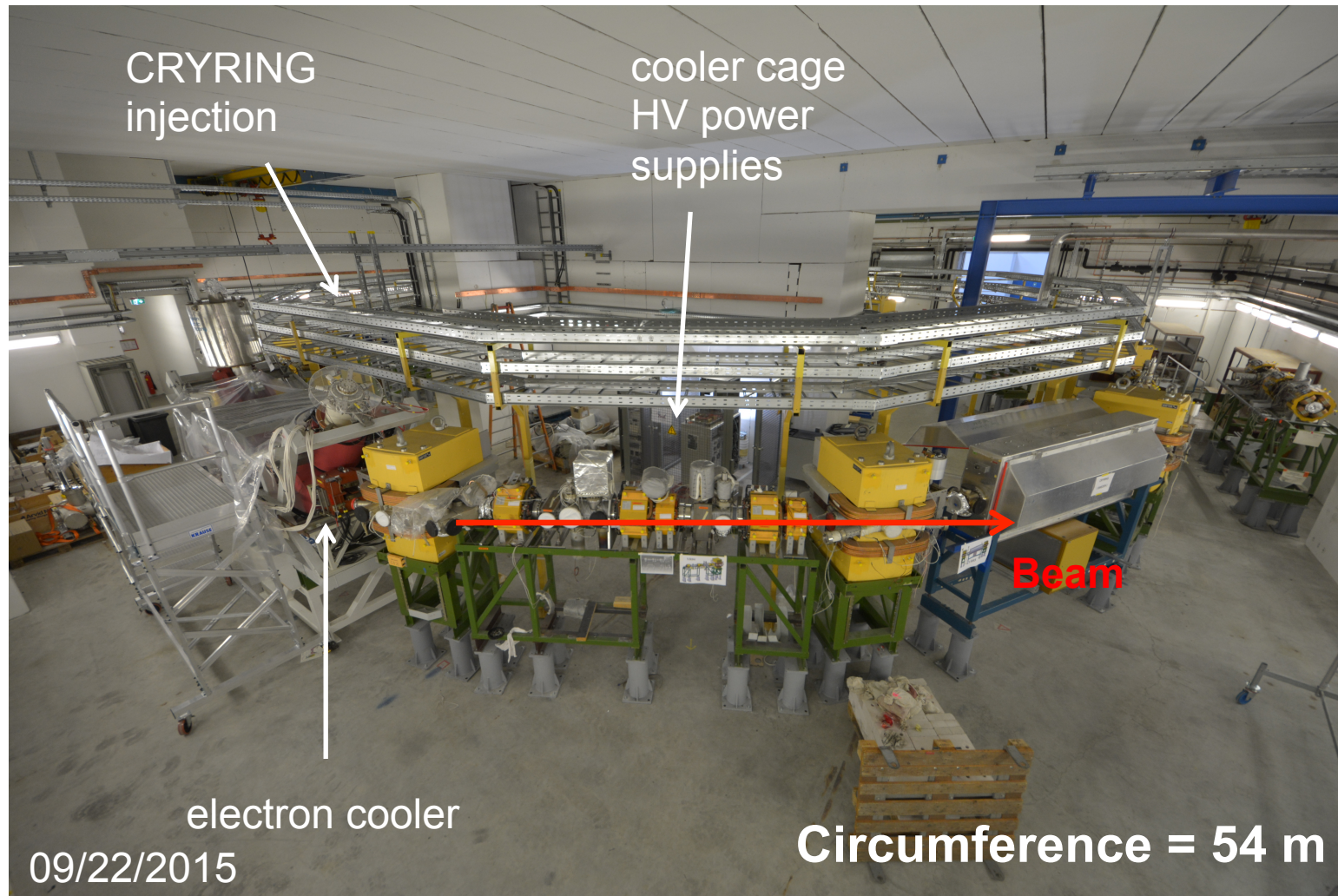
Electron Cooling at GSI and FAIR - Status and Latest Activities

Jon Roßbach GSI

- Overview GSI/FAIR
- CRYRING : Latest Activities
- Recent ESR operation
- HVDC measurements at the ESR electron cooler
- Outlook



CRYRING@ESR



Typical operation parameters ESR/CRYRING electron coolers



ESR

e- energy (HV)	2-220 keV (± 1 eV)
e- current	0-1 A
cathode diameter	2 inch
guiding magnetic field (no expansion option)	0.02-0.1 T
cool. section length/circumference	2%
vacuum	10^{-12} - 10^{-11} mbar

CRYRING

e- energy	up to 6 keV
e- current	up to 0.15 A
cathode diameter	0.16 inch
guiding magnetic field (adiab. expansion)	
gun (sc solenoid)	up to 4 T
cool. sect.	up to 0.3 T
cool. section length/circumference	2%
vacuum	10^{-12} - 10^{-11} mbar

Very cold e- beam

for recombination studies!

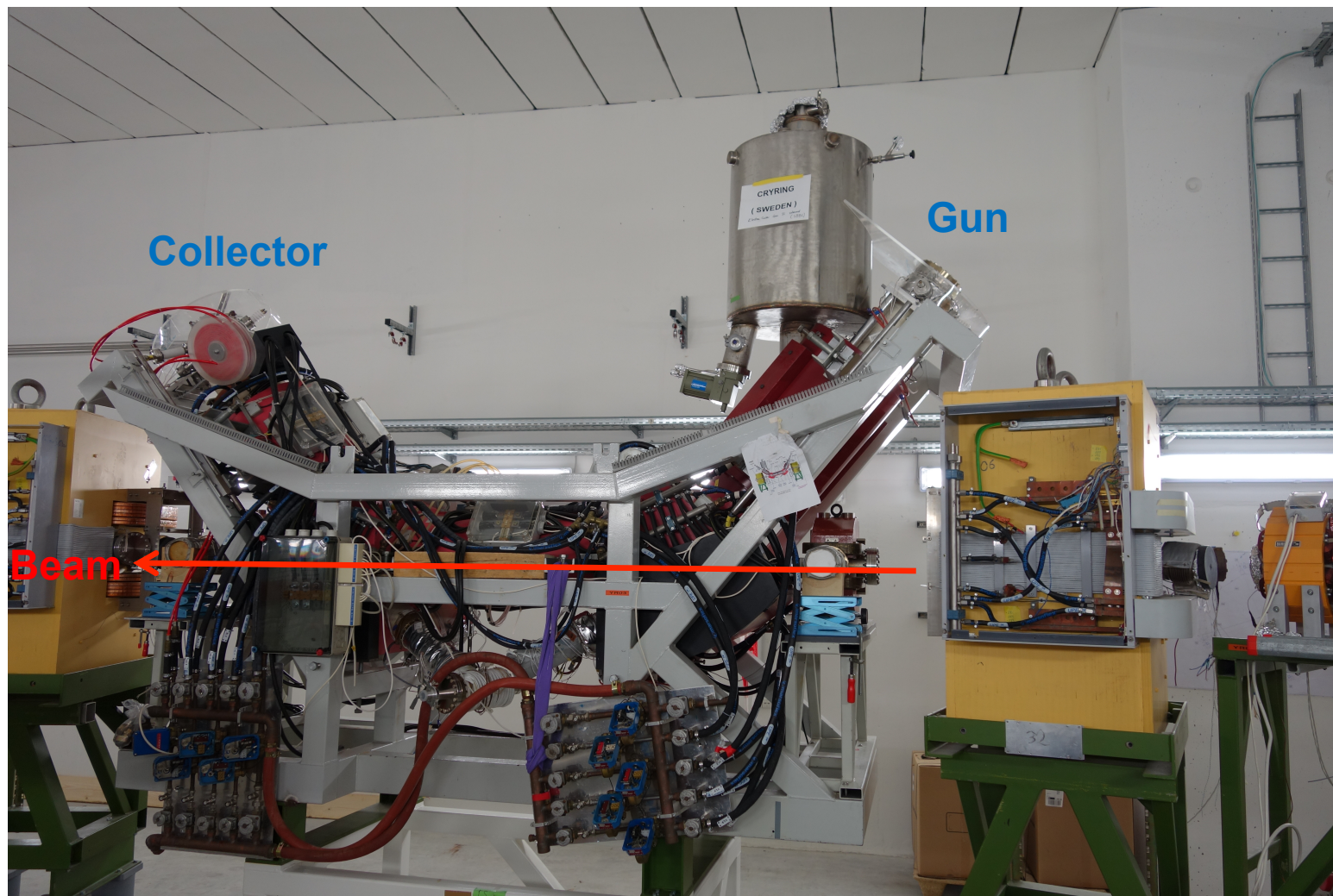
adiabatic expansion factor: 10-100
typically: gun to cool. section
magnetic field 3 T to 0.03 T
(e- beam diameter 4 mm to 40 mm)

Sweden experience:

$kT_{\text{transv}} = 1.5\text{-}3.5$ meV

$kT_{\text{lon}} = 0.05\text{-}0.20$ meV (//→// relaxation)

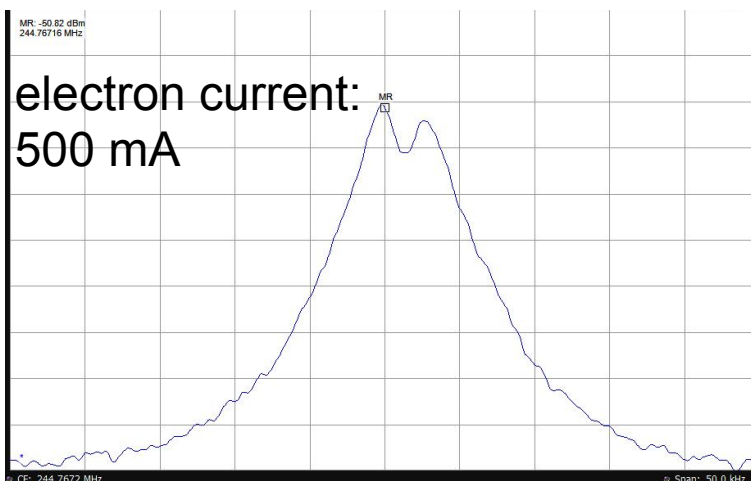
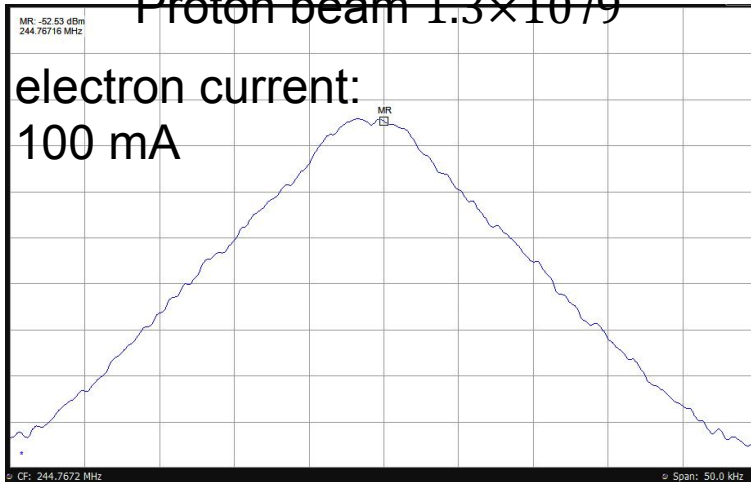
CRYRING Electron cooler



ESR operation with protons at 400 MeV

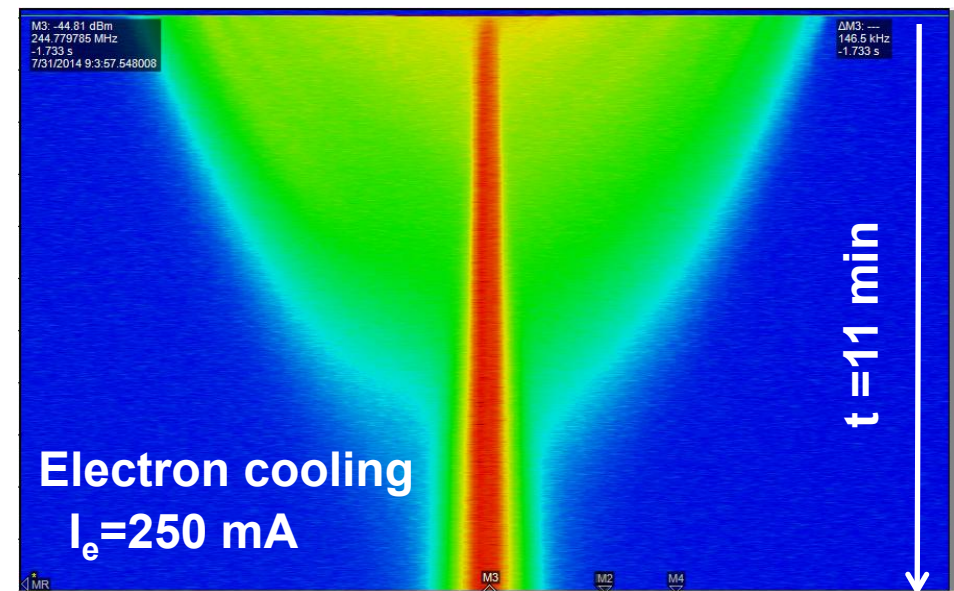
Shottky signal suppression

Proton beam 1.3×10^{19}



resonant shottky pickup at 245 MHz (span=50kHz)

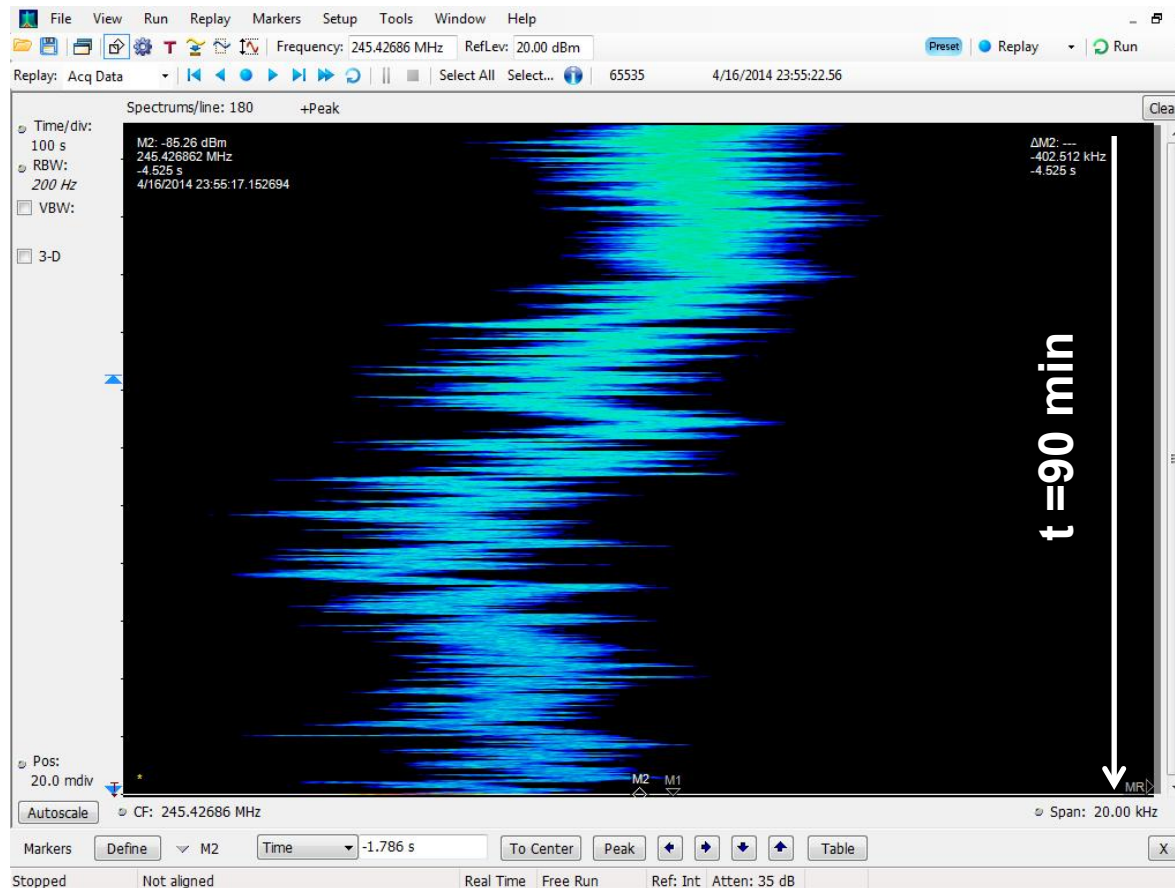
Motivation= feasibility tests for antiprotons
(possible future option at FAIR)



resonant shottky pickup at 245 MHz (span=200kHz)

For same initial beam quality, 10^{18} protons
→ Notch filter stochastic cooling in 8 s !
final rms $\delta p/p$ x10 higher than e- cooling

ESR operation: instability of cooler voltage



longitudinal frequency
spectrum of the beam in ESR
 ± 5 kHz at 245MHz

$$\Delta f/f = \eta \Delta p/p = \eta \gamma/\gamma + 1 \Delta V/V$$

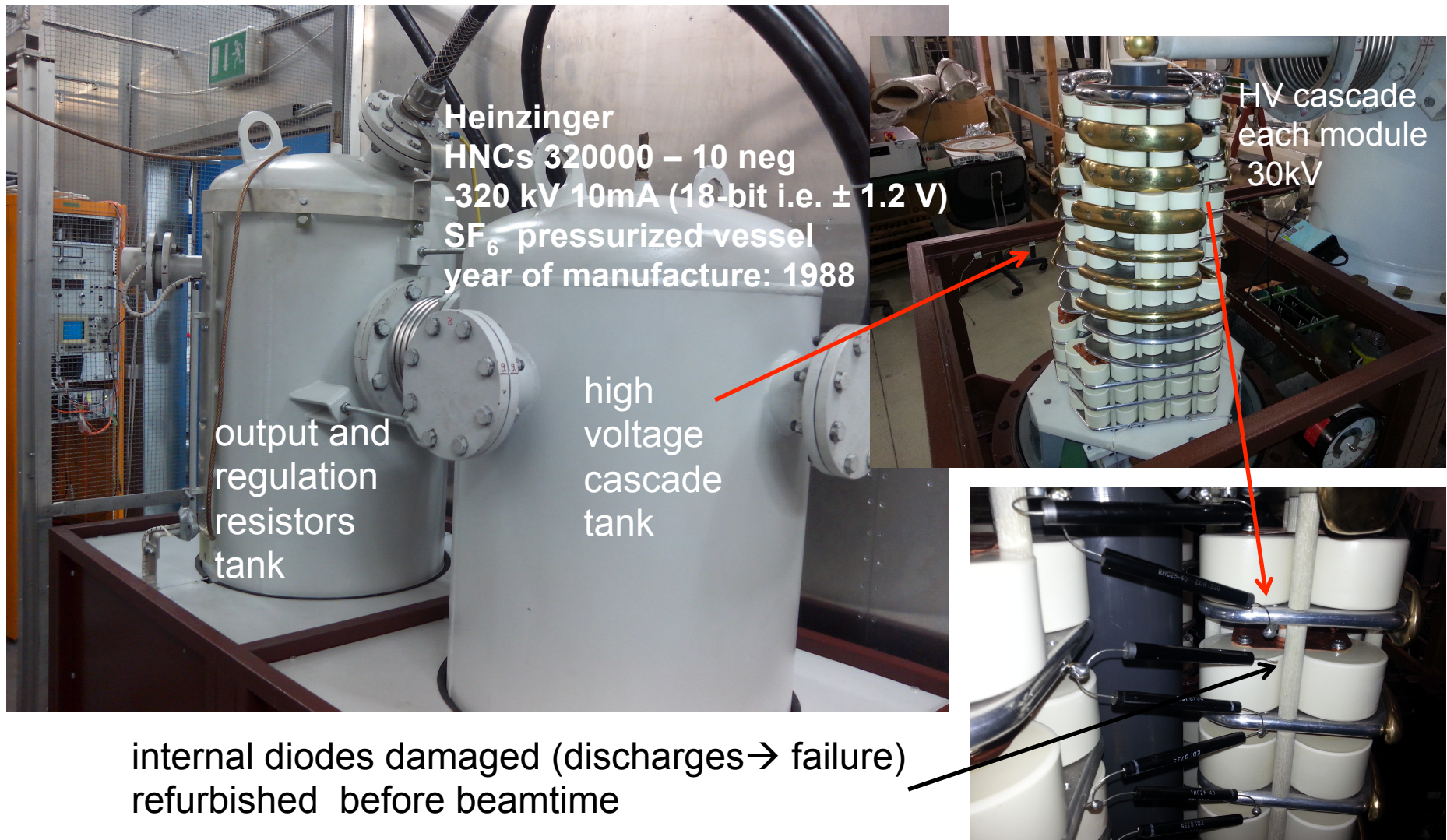
$$\Delta V/V = \pm 10^{-4}$$



$$\pm 20 \text{ V at } 200 \text{ kV!}$$

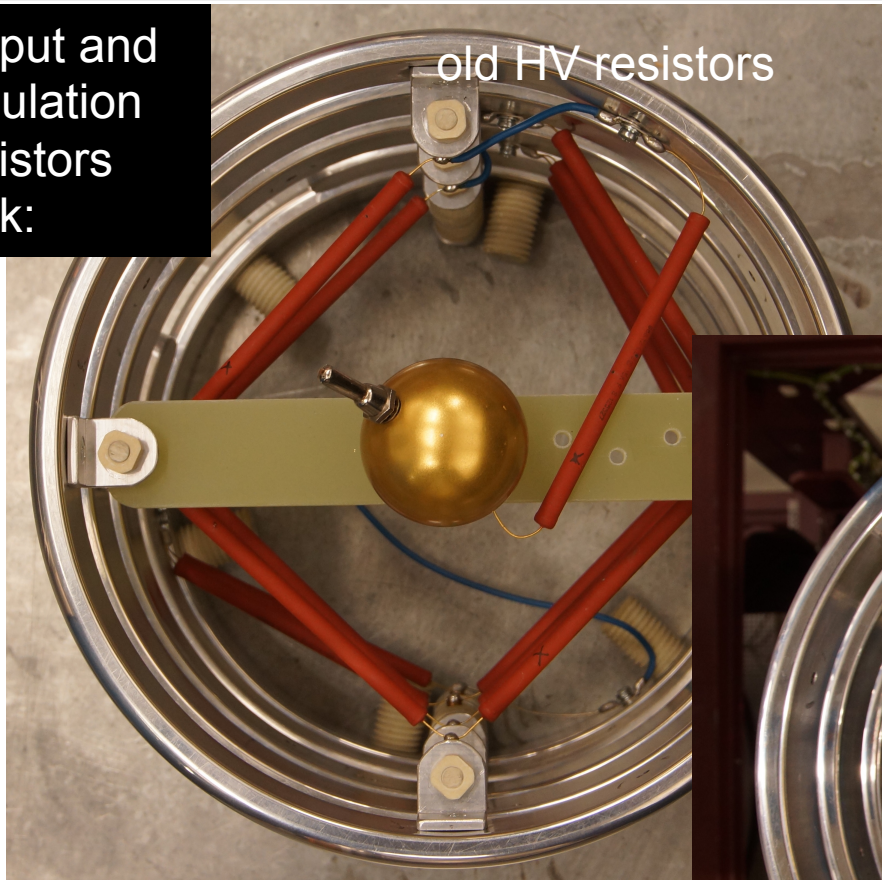
→ Variations independently confirmed
with precise HV divider measuring
the HV output of cooler power supply

ESR electron cooler: High Voltage power supply



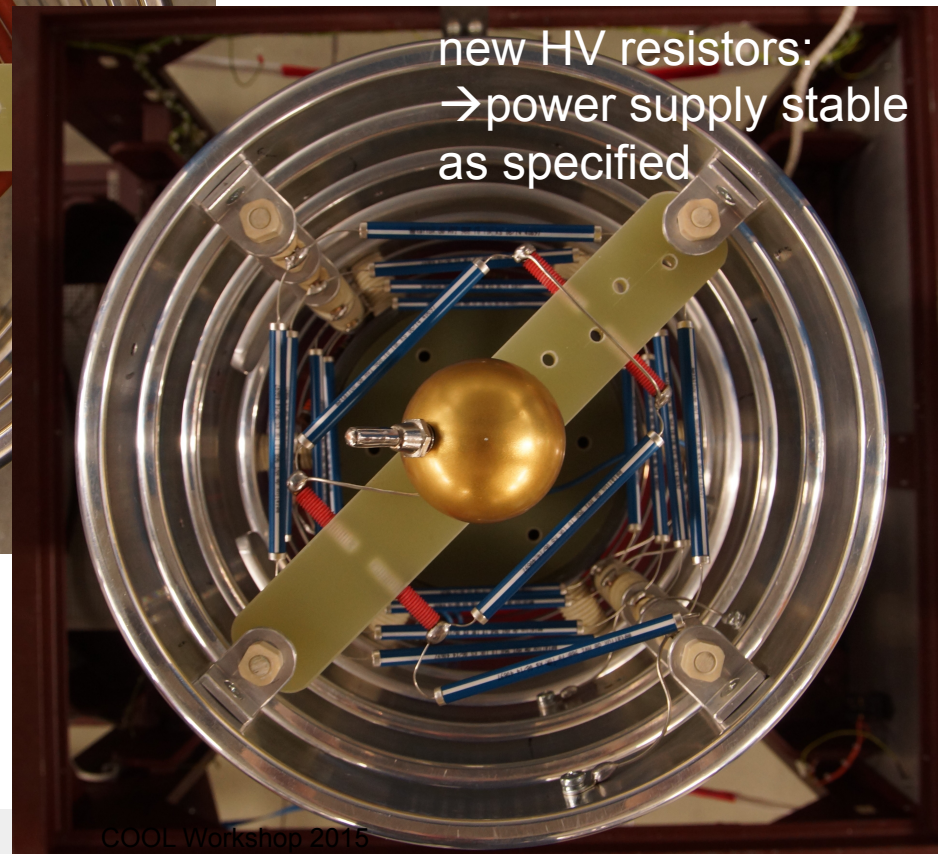
ESR electron cooler: High Voltage power supply

output and
regulation
resistors
tank:



damaged by:

- aging
- mechanical stress

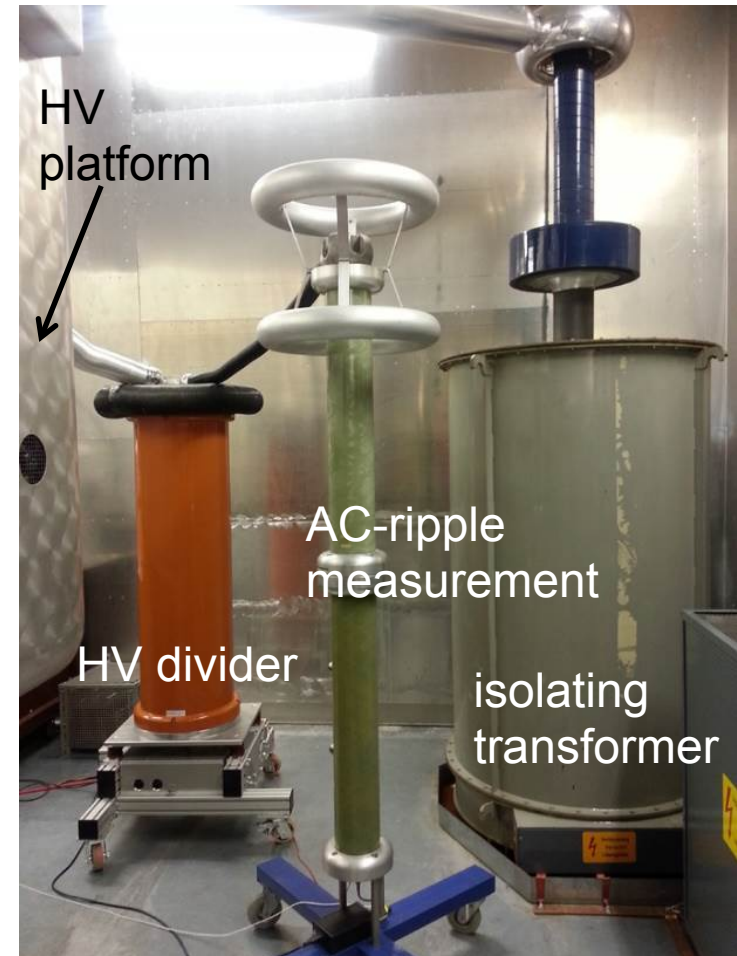


ESR electron cooler: Precise High Voltage DC dividers



←
Ohmlabs
HV divider
HVS
250kV 250M Ω
accuracy:
 10^{-4}
PTB calibrated

→
PTB
HV divider
HVDC2.1
200kV 2000M Ω
accuracy:
 $1.3 \cdot 10^{-5}$!



Outlook

- Integration of improved HV measurement equipment (HVDC dividers) to the ESR electron cooler for next beamtimes
- Also planned for low-energy range < 20 kV at ESR & CRYRING
- Final work on CRYRING electron cooler installation
- CRYRING electron cooler commissioning in early 2016