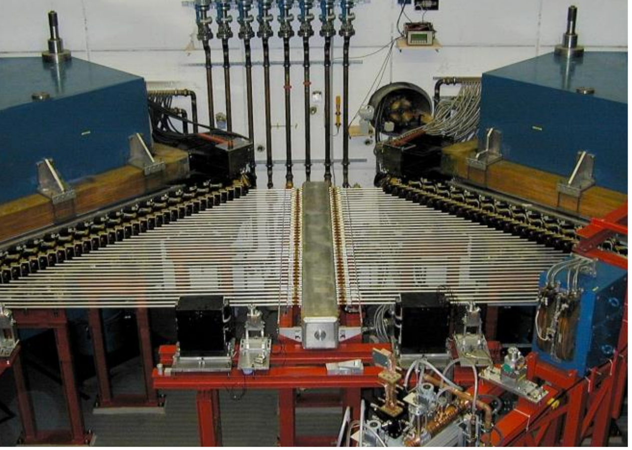
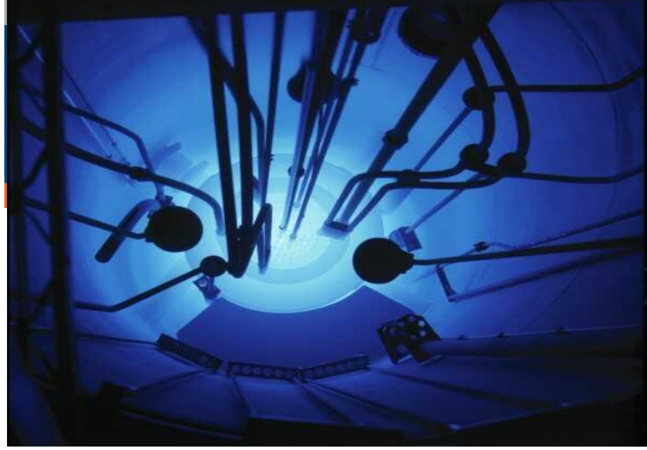


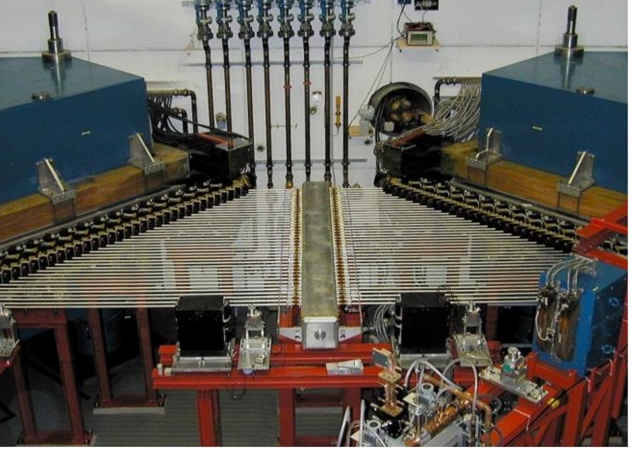


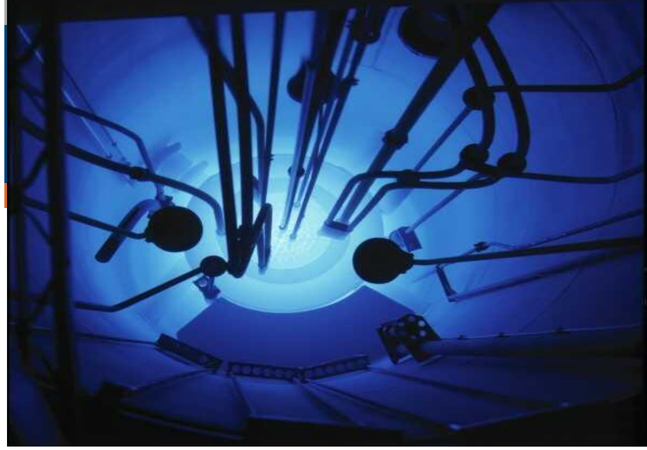
ORC process for reducing power consumption at the energy recovering electron cooler system for FAIR

Kurt Aulenbacher, Helmholtz-Institut Mainz (HIM)

24. October 2013

HELMHOLTZ ASSOCIATION
GSI
JG|U JOHANNES GUTENBERG UNIVERSITÄT MAINZ





- HIM is a joint venture between GSI & University of Mainz
- HIM-section: Accelerators & Integrated Detectors (ACID)
- One project: FAIR/HESR related research (electron cooler) (HESR consortium - leading institute: Forschungszentrum Jülich)

Kurt Aulenbacher, Helmholtz-Institut Mainz (HIM) 24. October 2013

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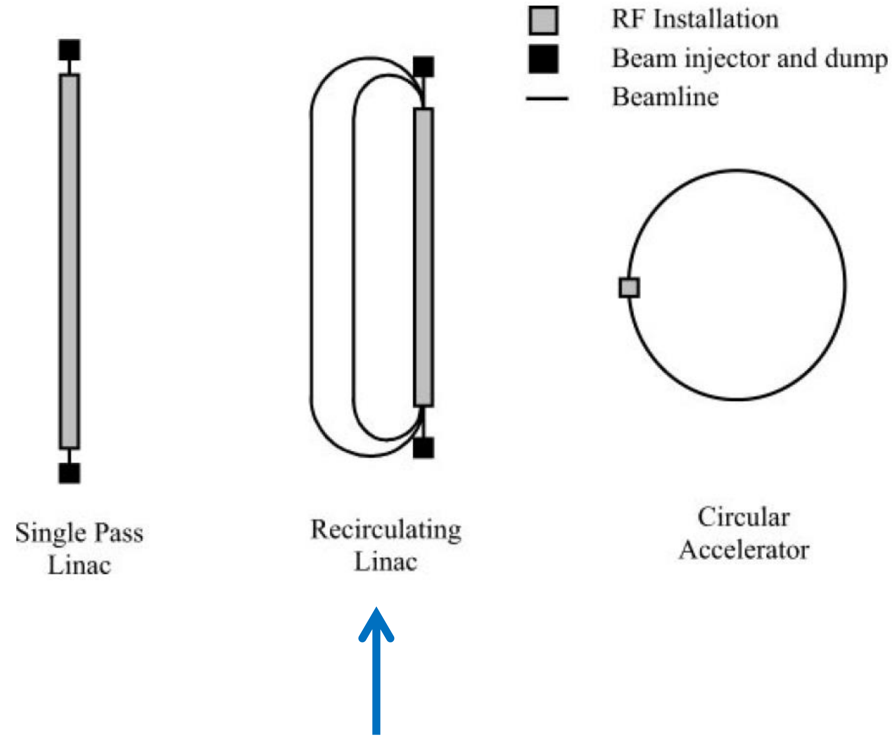
Outline

1. **Energy recovering accelerators**
2. **Example: Electron coolers**
3. **ORC as a (potential) solution for a special problem in electron cooling**

Basic types of particle accelerators



Recirculating Linacs:
~1980‘s: used for **cost/power** reduction
in c.w. –machines (Mainz, JLAB)
>2000: New Principle: **Energy recovery Linac**:

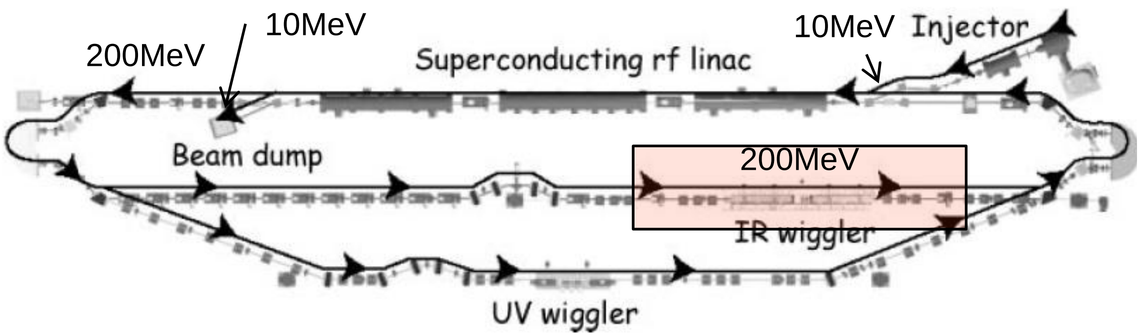


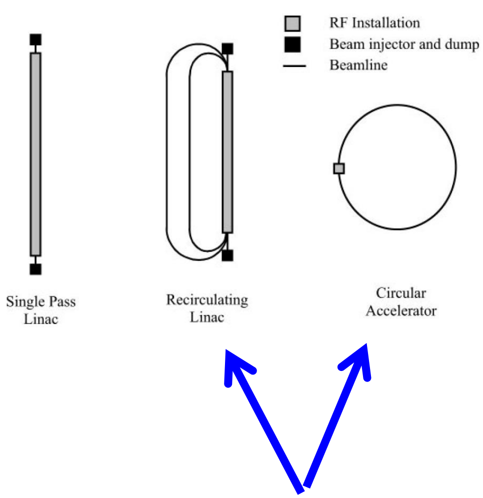
Figure 6 Schematic of JLab 10-kW IR/1-kW UV FEL upgrade configuration

L. Merminga et al.
Annu Rev. Part. Sci. 53:387-429 (2003)

TABLE 3 System parameters of the JLab IR and UV FEL upgrade

Parameter	IR FEL Upgrade	UV FEL
Beam energy at wiggler	80–210 MeV	200 MeV
Average beam current	10 mA	5 mA
Bunch charge	135 pC	135 pC
Bunch repetition rate	74.85 MHz	74.85 MHz
Normalized emittance (rms)	13 mm-mrad	5–10 mm-mrad
Bunch length at wiggler (rms)	200 fs	200 fs
Peak current	270 A	270 A
FEL extraction efficiency	1%	0.25%
$\delta p/p$ before wiggler (rms)	0.5%	0.125%
$\delta p/p$ after wiggler (full)	10%	5%
CW FEL power	>10 kW	>1 kW

Note: beam power in Interaction region is 2MW
But RF-power needed is only 100kW

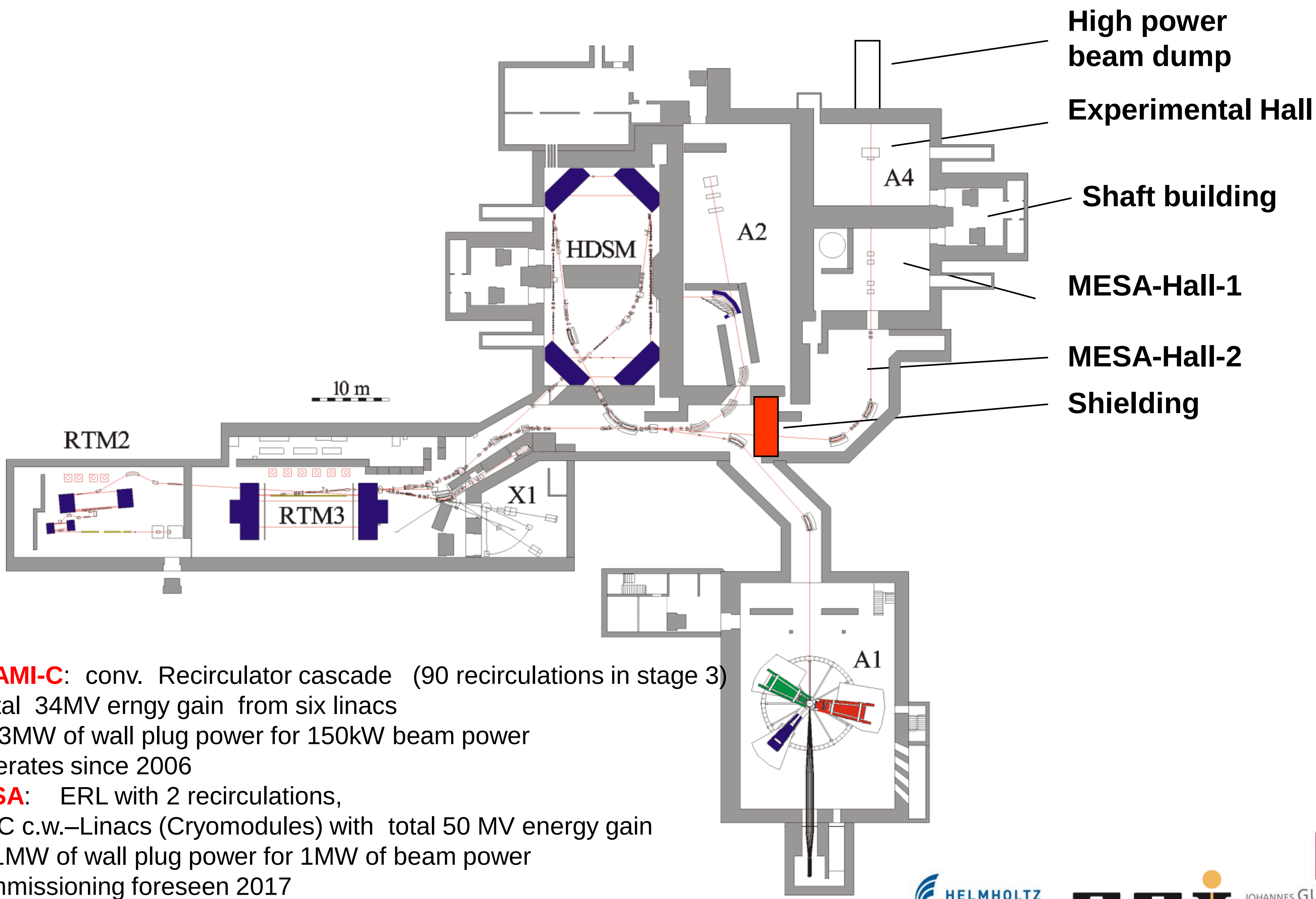


Comparing Ring and ERL:

→ The ring recirculates particles, the ERL recirculates also the energy
→ In ERL, each particle passes the interaction region **only once**
→ Much stronger interaction possible in ERL-mode!
→ ERL emittance in stationary equilibrium much better

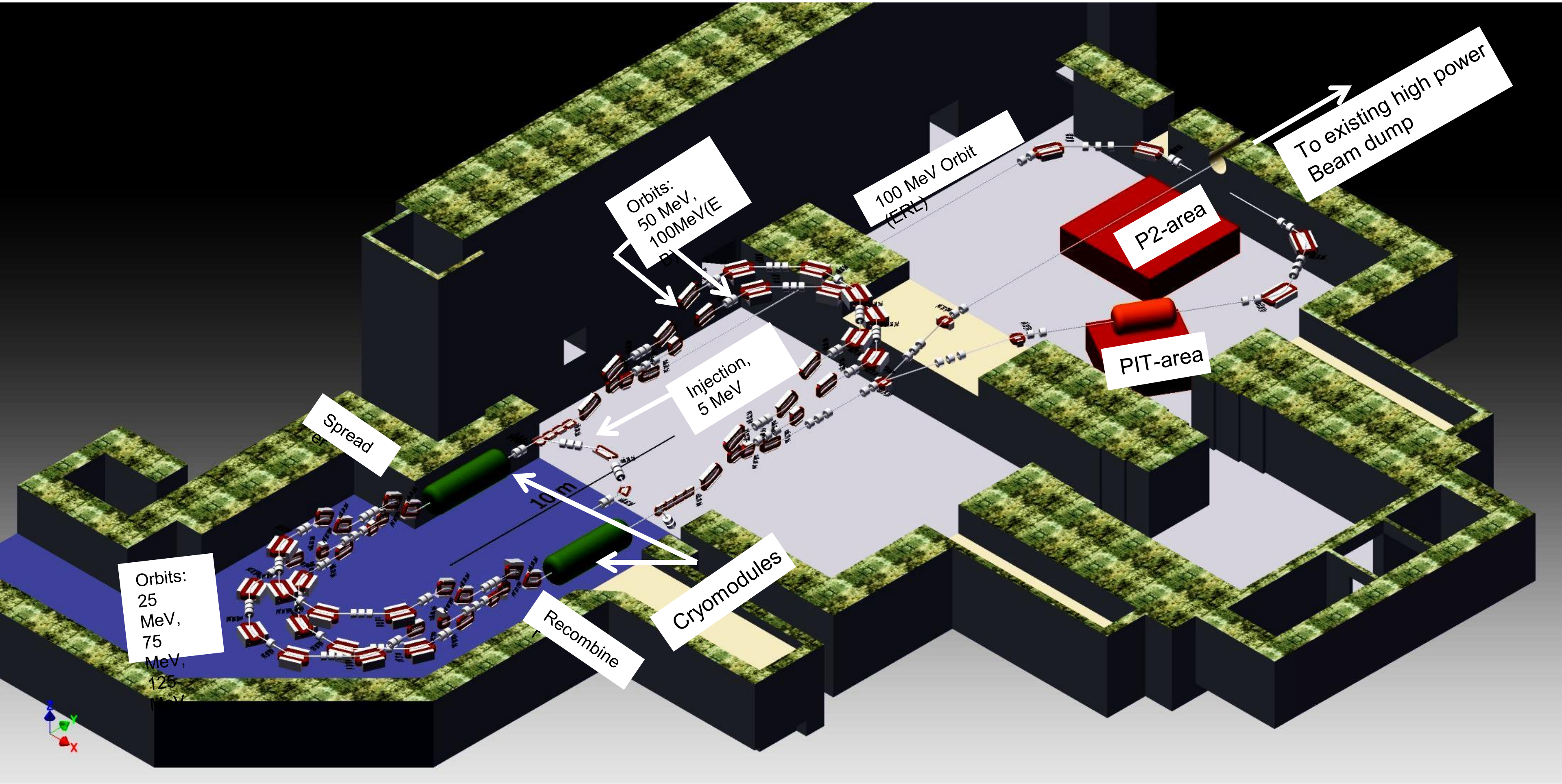
Potentail large scale Application:
eN-Colliders or advanced light sources with GW-beam powers

MAMI & MESA at IKP-Mainz



- **MAMI-C**: conv. Recirculator cascade (90 recirculations in stage 3)
  total 34MV erngy gain from six linacs
  → 3MW of wall plug power for 150kW beam power
  operates since 2006
- **MESA**: ERL with 2 recirculations,
  2 SC c.w.–Linacs (Cryomodules) with total 50 MV energy gain
  → 1MW of wall plug power for 1MW of beam power
  commissioning foreseen 2017

MESA-Layout

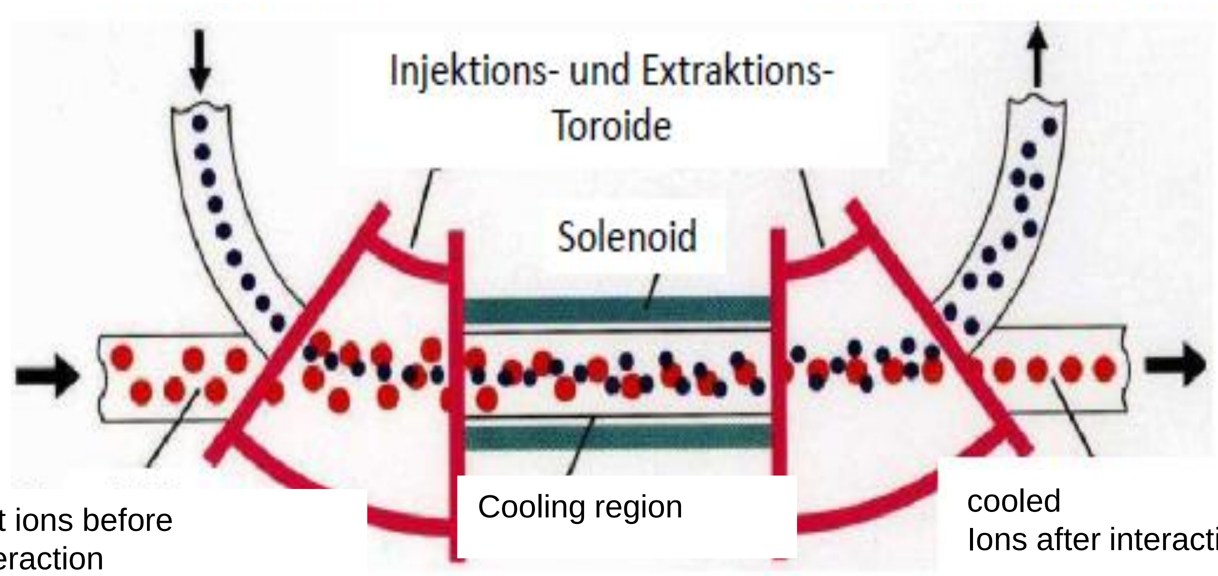


Lattice inspired by CERN-LHeC test facility appraoch

Similar - but also different: Electron coolers

Electron-source

To electron collector



Hot ions before interaction

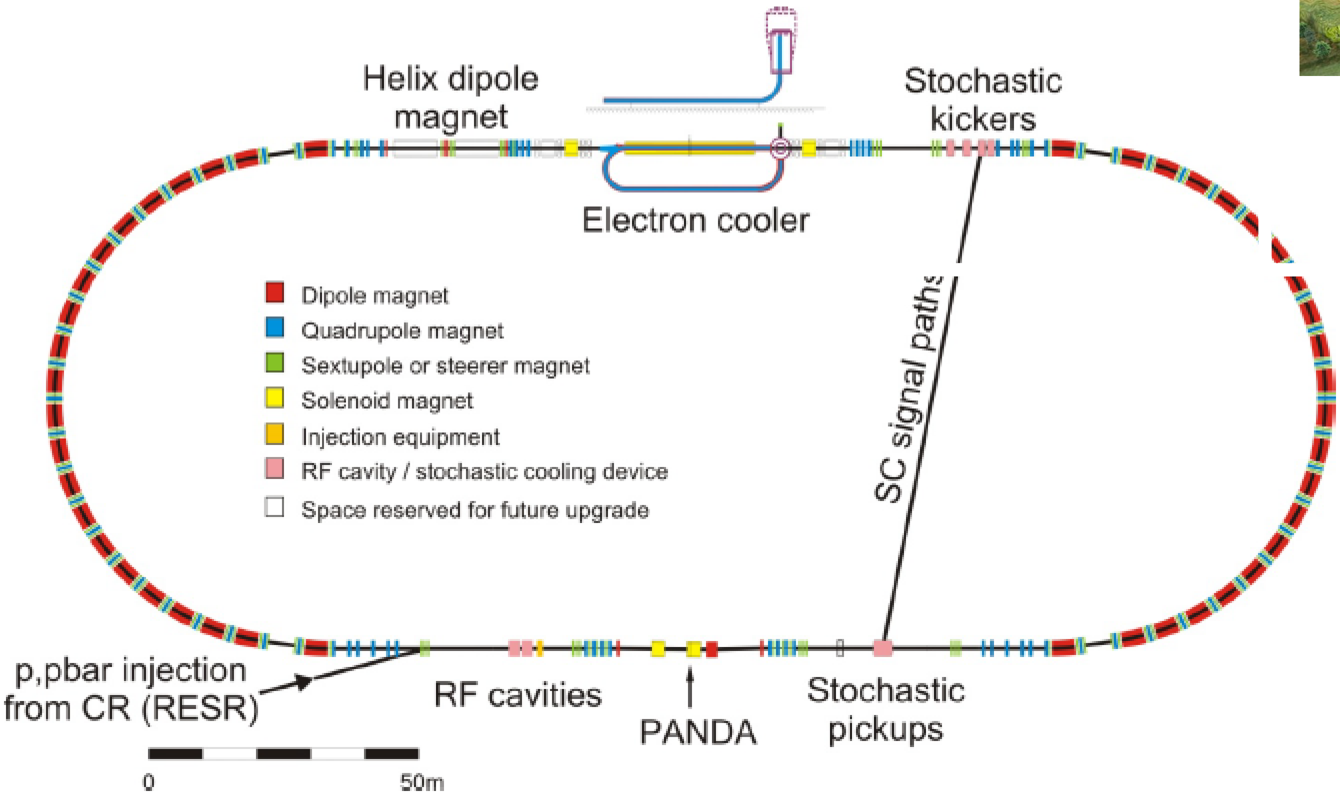
Cooling region

cooled
Ions after interaction

Condition: $v_{ion}=v_{elec} \rightarrow$ relativistic-limit:: $E_{ion}=(m_{ion}/m_{el})*E_{el}$

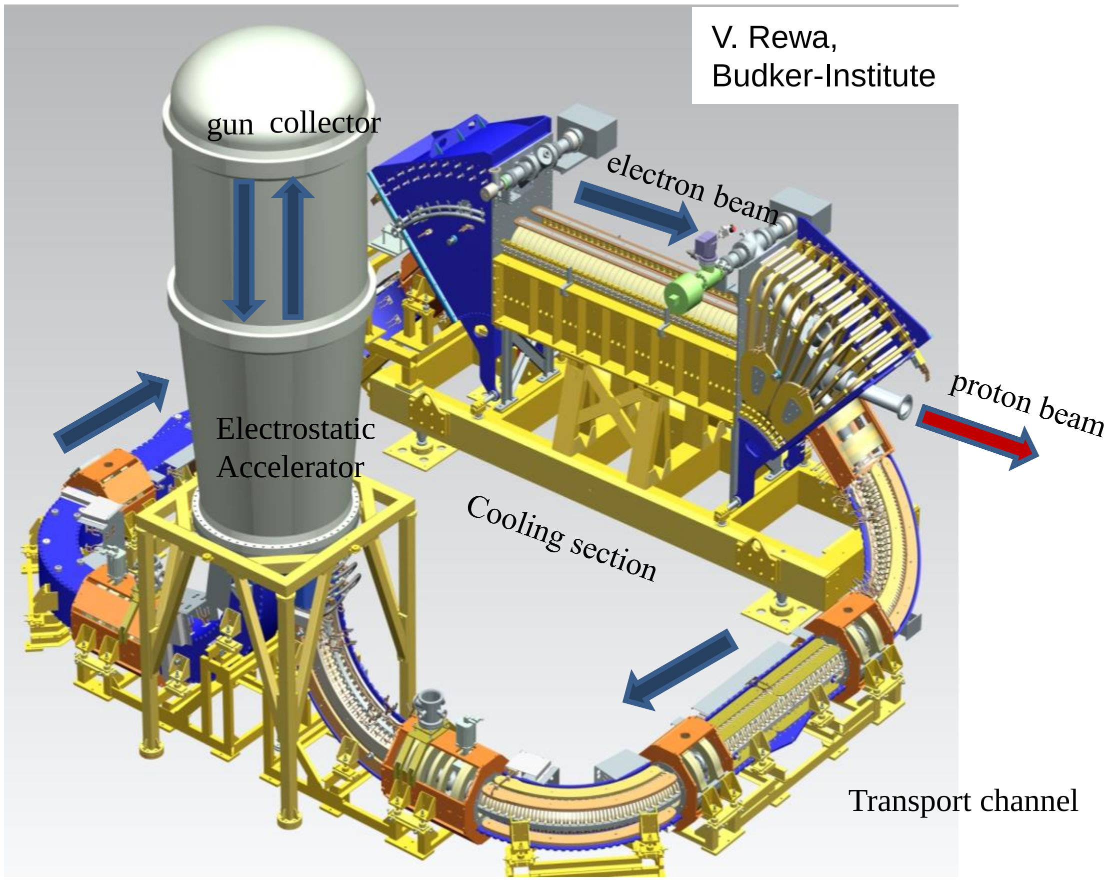
50Tm HESR-ring at FAIR

Full antiproton energy of HESR ~14GeV
→Electron beam energy max. 8MeV
Beam power for efficient cooling 4-24 MW



igure 1: Schematic view of the HESR. Positions for injection, cooling devices and experimental installations are ıdicated. The upper straight is housing electron cooler, stochastic kickers, and space for a future upgrade. The lower

3D design of COSY Cooler



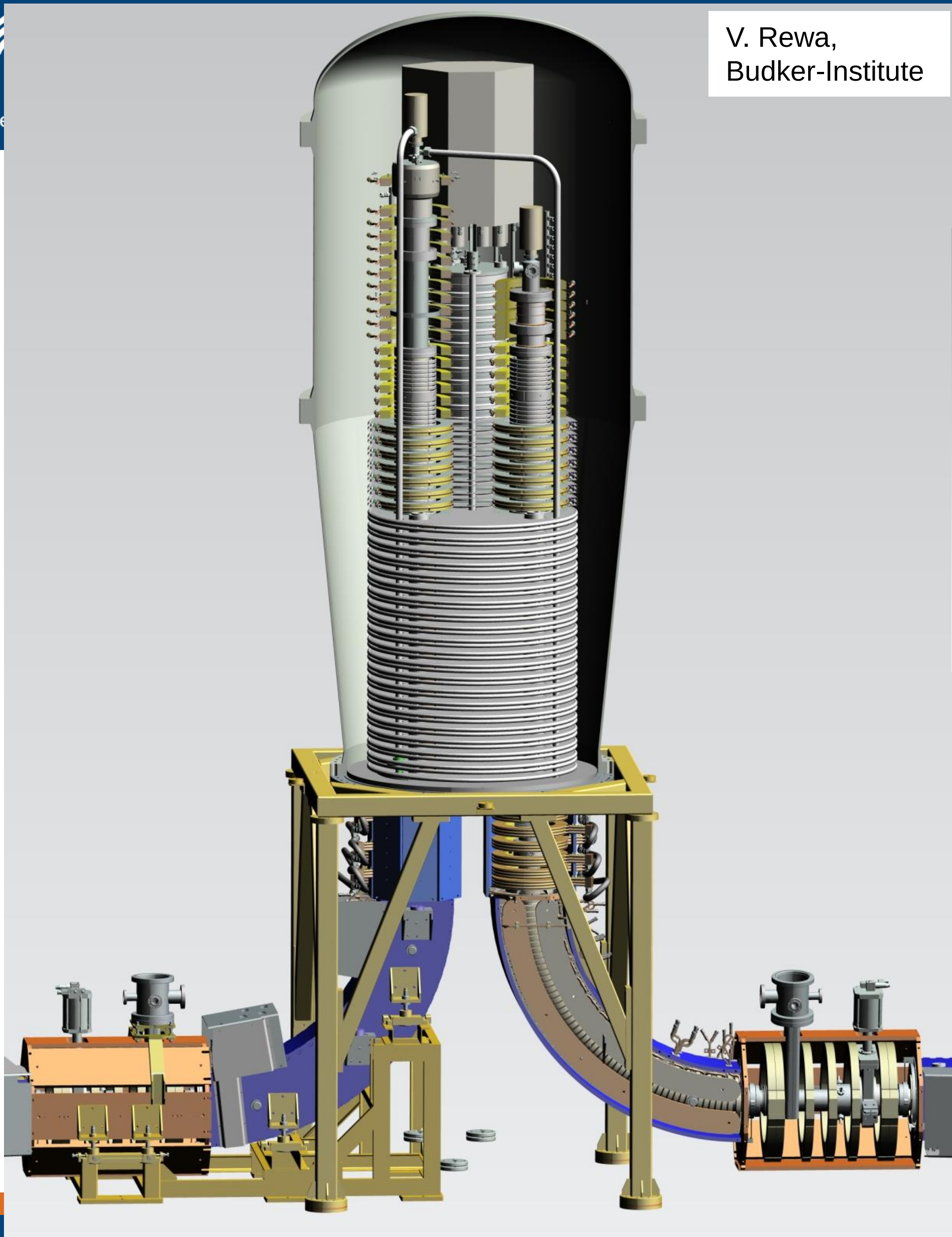
New cooler at COSY/Jülich

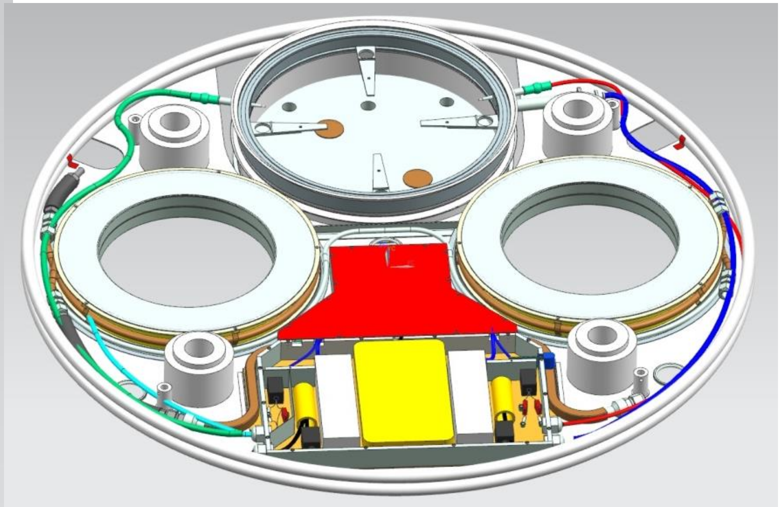
Designed by Budker Institut Novosibrisk for FZ Jülich.
(in commisioning, first Cooling of 200MeV protons Sunday, 20.10. 2013

-“magnetized beam“

-2MW of beam power

2MV cascade transformer





Each section contains;

- high-voltage power supply +/- 30 kV;

- power supply of the coils of the magnetic field (2.5 A, 500 G);

- section of the cascade transformer for powering of all electronic components;

33 high-voltage section

8MV HESR cooler

HESR cooler: solenoid channel problem & turbine concept

- Solenoids must be powered by floating power supply.
- Turbines for U>2MV → Suggestion of BINP-Novosibirsk: 60kV/Turbogen (400Watt)
- **Not realized** for Jülich 2MV-cooler due to **unreliability** of Turbogen (status 2009)
- 2012: ACID contacts German company DEPRAG: Offer for 5kW Turbogens, high reliability
  (V. Parkomchuk: Each 5kW Turbogen may excite 500kV Cascade transformer)

~40cm

Two 5kW Turbogenerators have been ordered, delivery 11/2013
(Design differs from catalogue illustration , 8000 hour operation specified)

Turbine powered floating power generator prototype

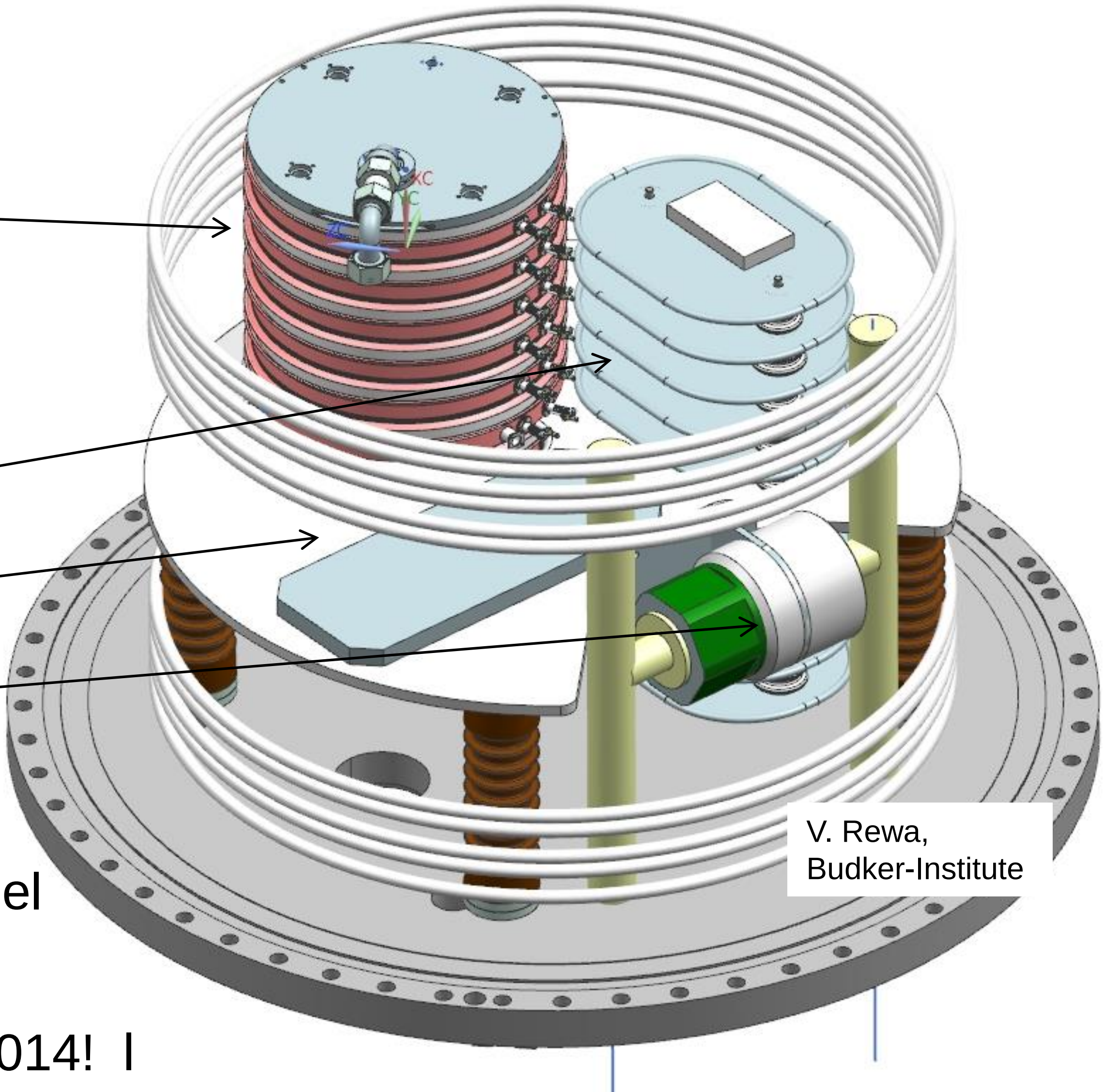
500kV cascade transformer

10*50kV d.c-supplies

Converter

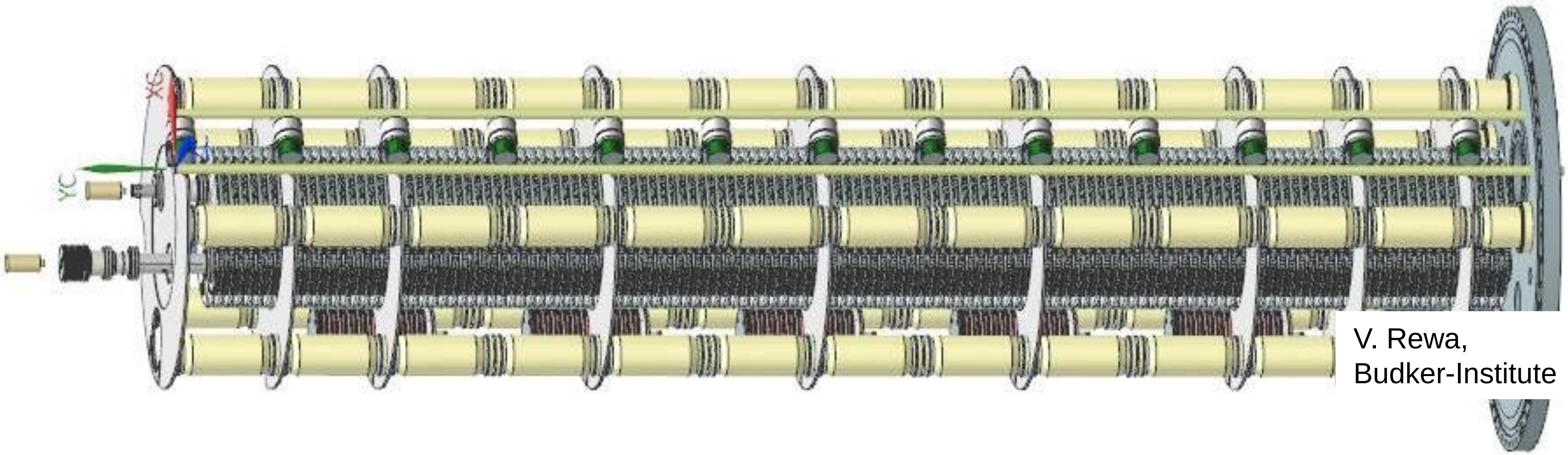
Turbine

SF6-pressurized vessel



Prototype testing at BINP in 2014!

Goal: Multi-MV stack



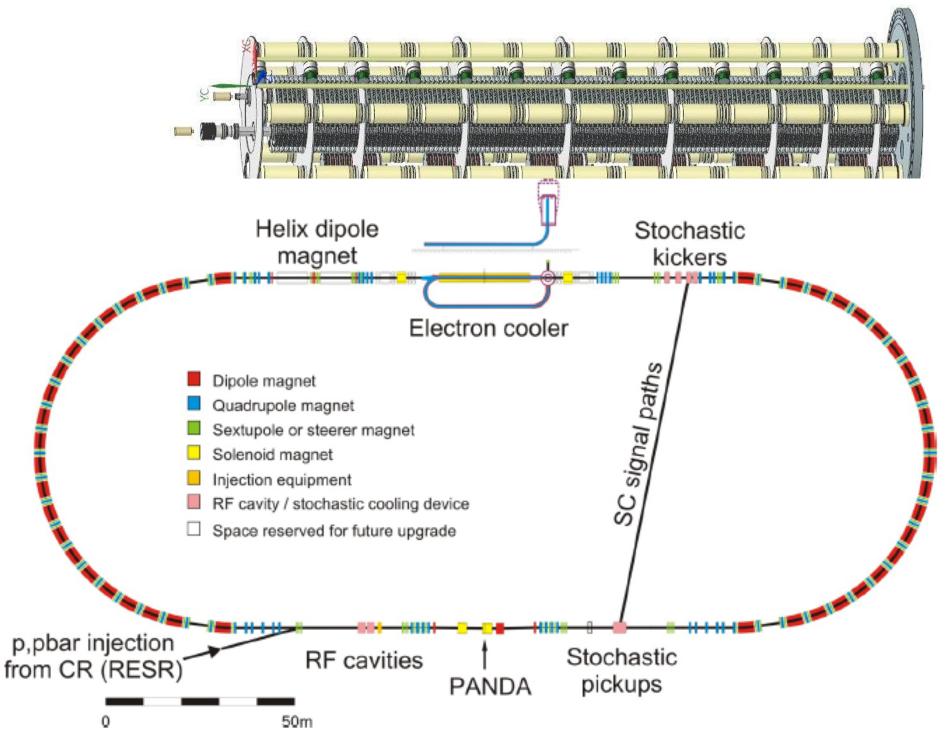
V. Rewa, Budker-Institute

Technical challenges:

- **Using SF6 as fluid is desirable (Turbines not optimized)**
- **Kompressor for expansion turbines is not energy efficient**

New idea: SF6 is gas with capabilities as ORC medium

Goal: Multi-MV stack



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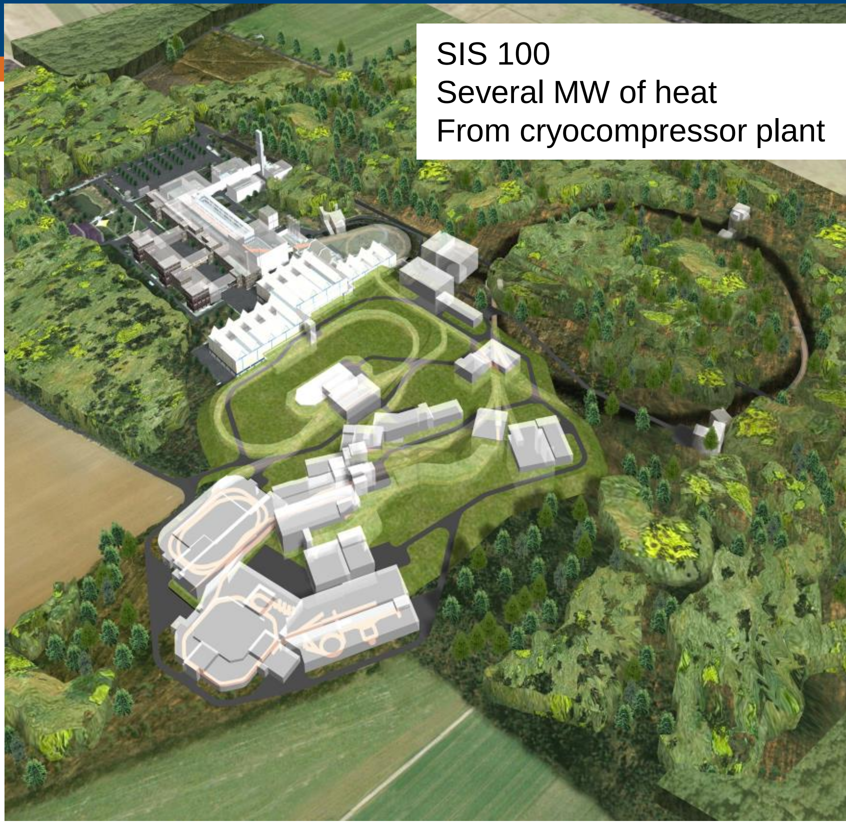

New idea: SF6 is gas with capabilities as ORC medium:
Research study for layout of plant in the near future!

HESR cooler: timeline 2013-18

- *2 Turbogenerators ordered, delivery to BINP end of 2013*
- *Challenge: Convert Turbogen to SF6 medium/energy efficiency: full scale device requires ~1.5MW of electrical power for compressor.*
- *Negociations with Universities on facing these challenges*

Main Projects/Milestones for the mid term future together with partners/collaborators:

2014- Operation/Optimization of Turbogenerators using SF6 (TU-collab)
2016 explore using Organic Rankine Cycle (ORC) instead compressor
→ reduce el. energy consumption by order of magnitude (TU-collab)
2014: Demonstration of Turbo powered HV generator (BINP, FZJ)
2016: Study/design of full scale SF6 gas handling system (Industry)
2016: Decision on feasibility of concept (BINP,FZJ)
2017: Technical design report for full scale cooler (BINP, FZJ)

Alternatives are being studied in parallel!

Thank you for your attention