GSI Helmholtzzentrum für Schwerionenforschung GmbH

# CRYRING@ESR INTRODUCTION AND OVERVIEW.

## Operators training.

Svetlana Fedotova

# Agenda

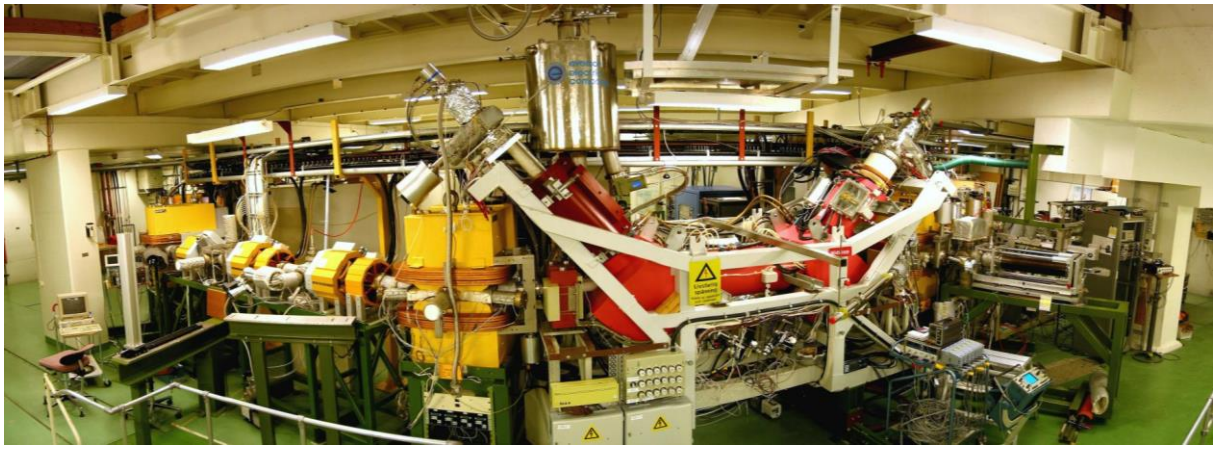
- Origin and location of CRYRING@ESR.
- Purposes of CRYRING@ESR facility
- Injection into CRYRING@ESR
- CRYRING ring assembly
- CRYRING@ESR commissioning status and future plans

# Origin and location of CRYRING@ESR.

**Heavy ion storage ring:**

Stores, cooles, accelerates and decelerates heavy HCI.

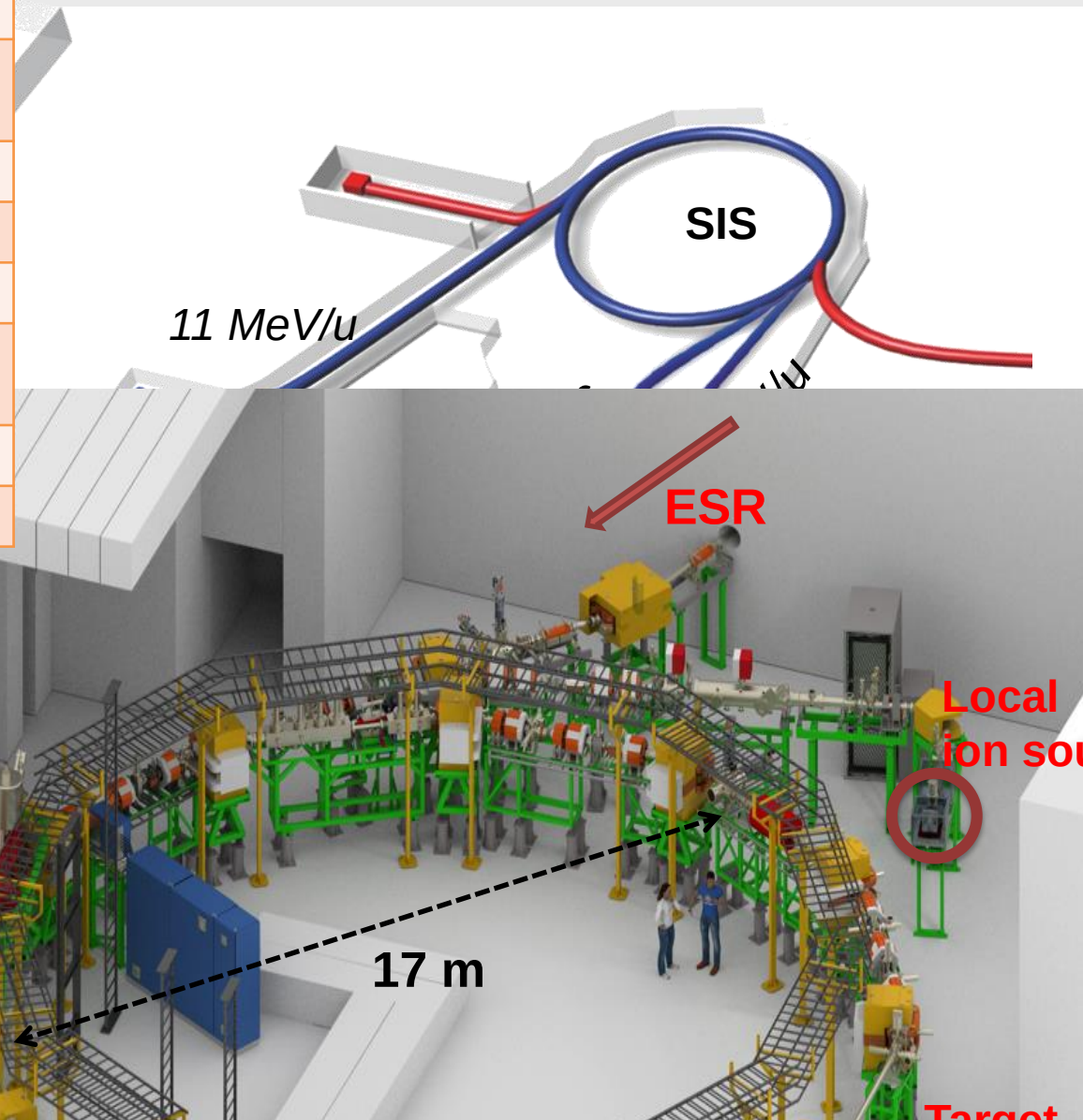
Manne-Siegbahn Laboratory (MSL), Stockholm 1992-2010



GSI, Darmstadt 2013- present

# Main CRYRING@ESR characteristics
# Origin and location of CRYRING@ESR.

| | |
|---|---|
| **Circumference** | 54.17 m (ESR/2) |
| **Vacuum pressure** | $10^{-11}$-$10^{-12}$ mbar |
| **Ion energy** | < 300 keV/u - 14 MeV/u |
| **Rigidity for ions** | 0.054 - 1.44 Tm |
| **Magnet ramping** | 1 T/s (4 T/s, 7 T/s) |
| **Stand-alone operation** | local ion beam (300 keV/u, q/A > 0.25) |
| **Beam injection** | multiturn and fast |
| **Beam extraction** | slow and fast |



# Purposes of CRYRING@ESR facility

**CRYRING@ESR is a prototype for FAIR**

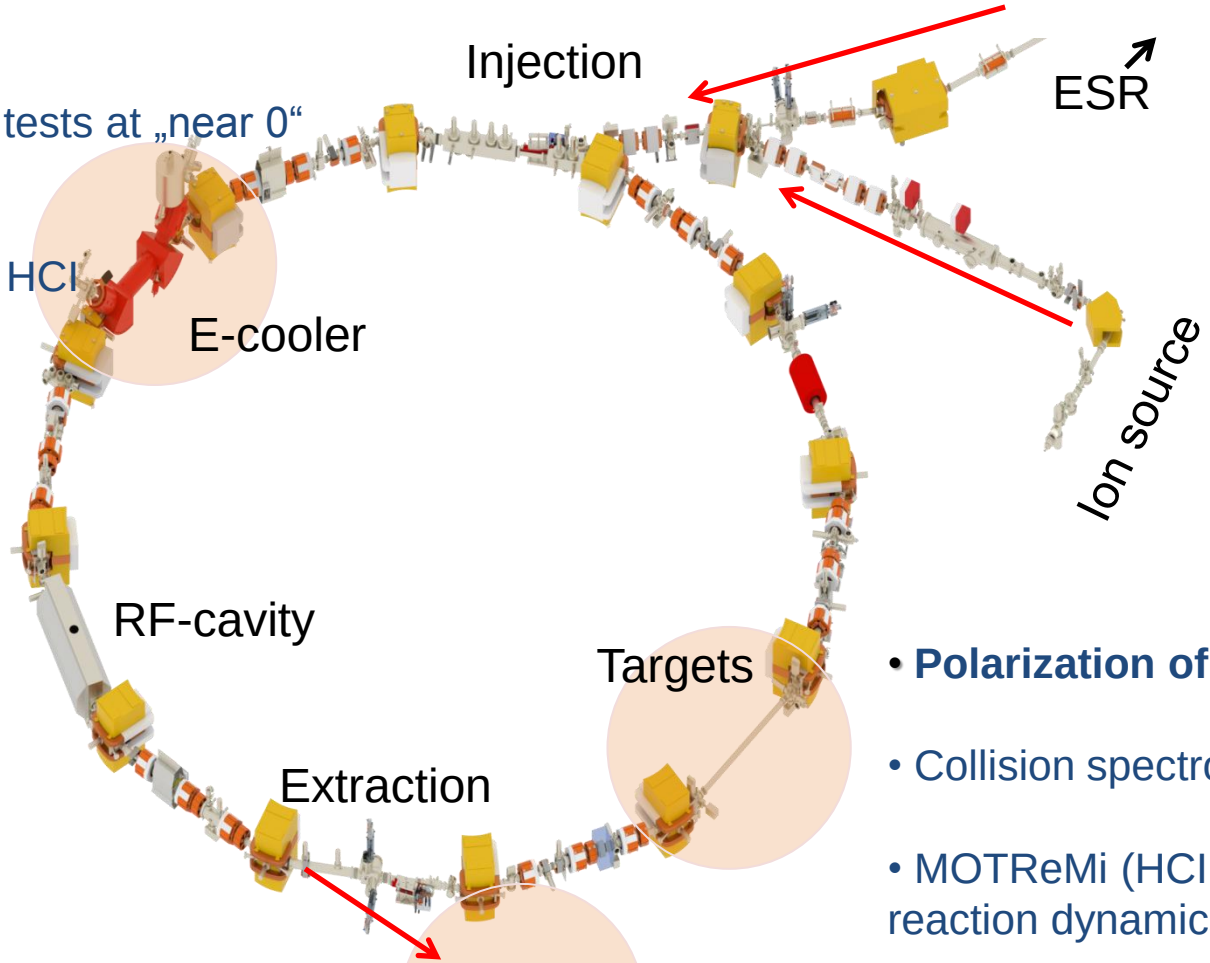
- Tests of novel detectors and beam diagnostics systems
- Tests of FAIR accelerator control system
- Tests of FAIR safety and radiation protection access systems
- Standalone operation during commissioning
- Training of personnel on new control system

**Scientific Opportunities**

- Heavy HCI (up to $U^{92+}$) at low energy 100 keV/u -10 MeV/u: covers the energy gap between the ESR (> 4 MeV/u) and HITRAP (<10 keV/u)
- Exotic short-lived ions: Fast ramping (~1s)
- Atomic, nuclear, biophysics, materials research
- Photonic, electronic and atomic collisions, extraction towards downstream experiments
- Research may continue even during major shutdowns (at limited ion ranges).

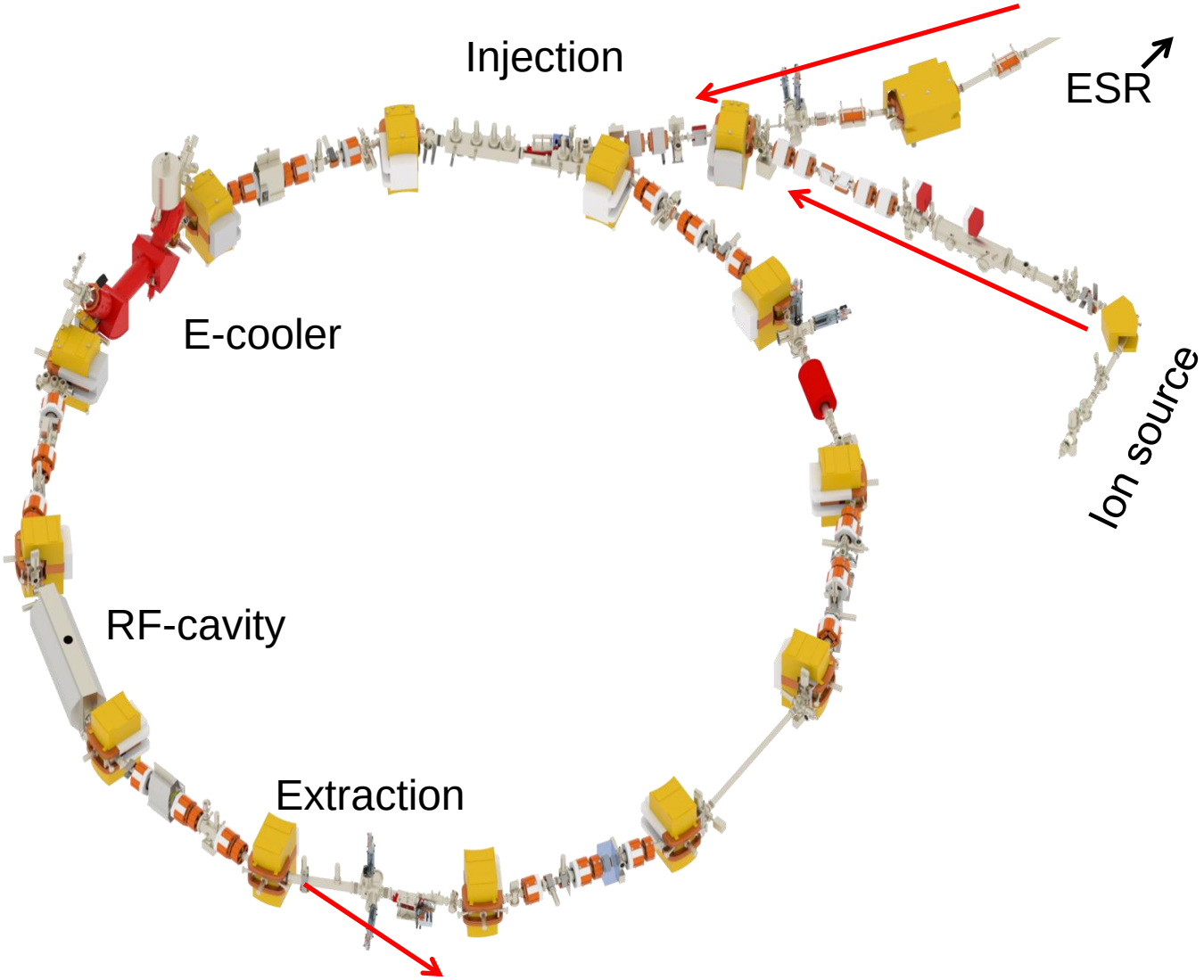
# Experiments with CRYRING

- **Dielectronic recombination- Laser spectroscopy**
- Atomic and nuclear tests at „near 0“ relative energies
- Strong field QED in HCI




- **Polarization of ion beams**
- Collision spectroscopy
- MOTReMi (HCI structure, reaction dynamics)
- Experiments with an extracted beam

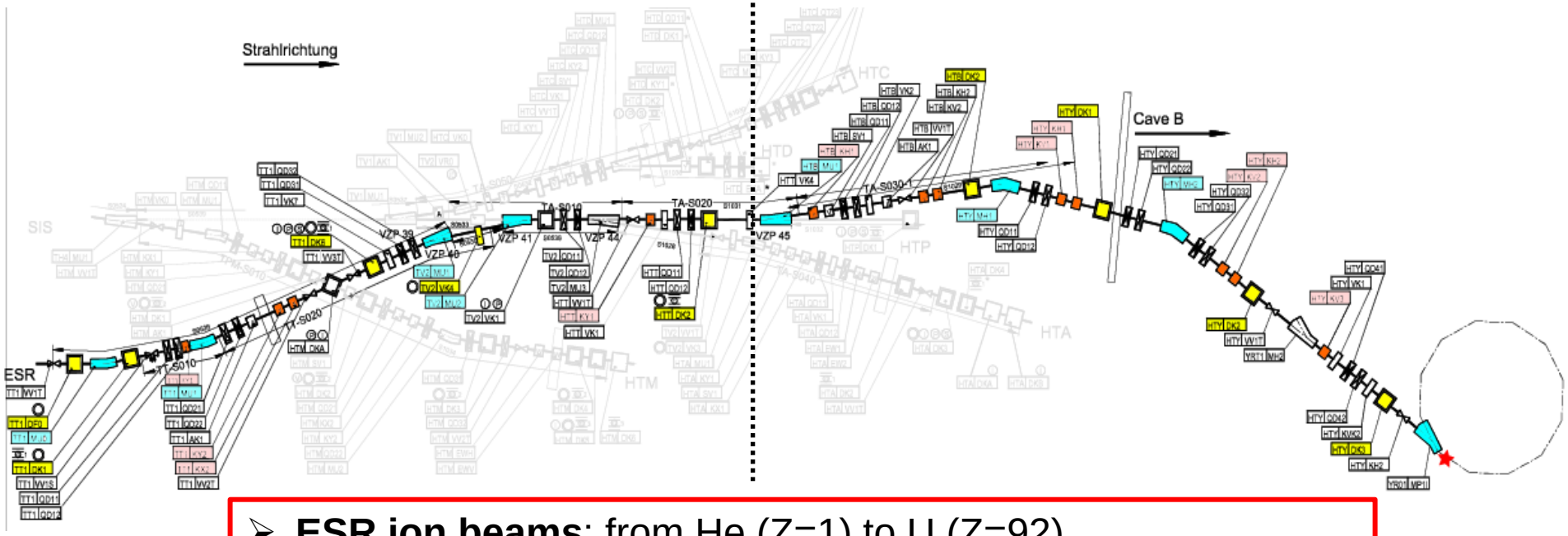
# Injection into CRYRING@ESR



# Injection into CRYRING@ESR

**Transfer line from ESR towards CRYRING: GTT1VV1T – GHTBMU1**

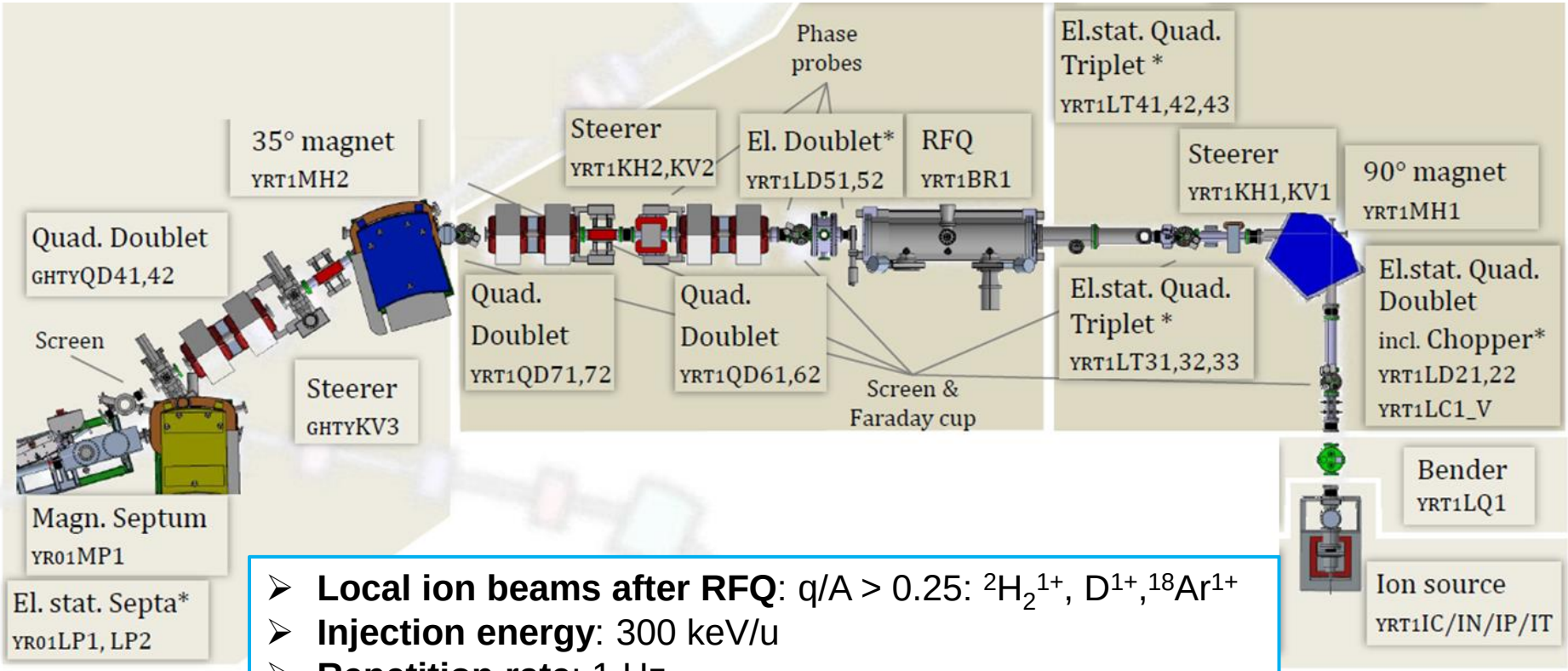
**Injection line up to CRYRING ring: GHTBMU1 – YR01MP1I**




- **ESR ion beams**: from He (Z=1) to U (Z=92)
- **Injection energy at CRYRING**: from 4 MeV/u to 14 MeV/u
- **Repetition rate**: 1 per 60 s
- **Pulse length**: 4 µs
- **Beam intensity**: $10^7$ -$10^8$ particle per pulse

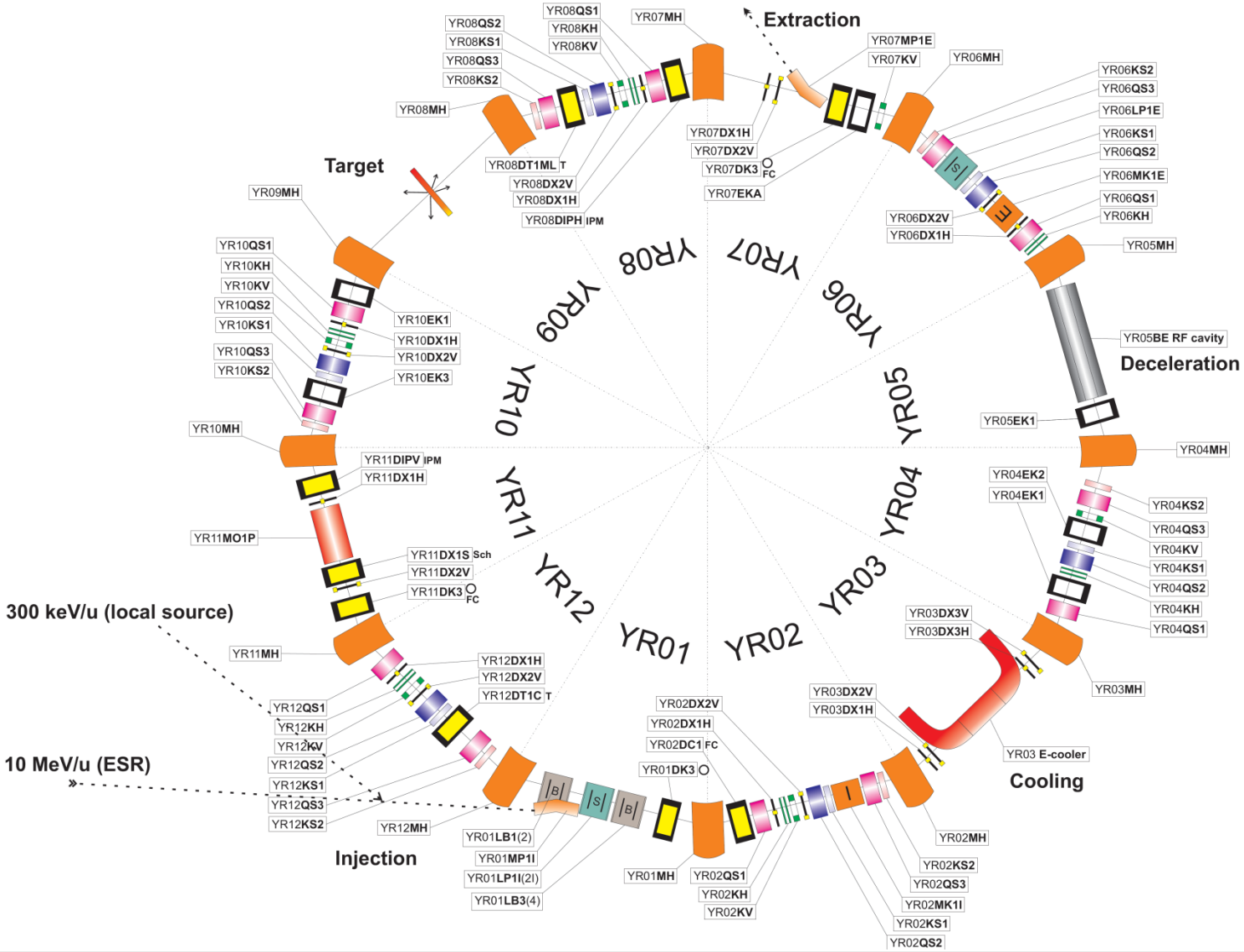
# Injection into CRYRING@ESR

**Local injection line from the ion source up to the ring:**
**YRT1IN – YR01MP1**




- **Local ion beams after RFQ**: q/A > 0.25: $^{2}H_2^{1+}$, $D^{1+}$, $^{18}Ar^{1+}$
- **Injection energy**: 300 keV/u
- **Repetition rate**: 1 Hz
- **Pulse length**: 1 µs – 1 ms
- **Beam intensity**: max 10 µA ($6*10^7$ part per 1µs pulse)

# CRYRING ring assembly



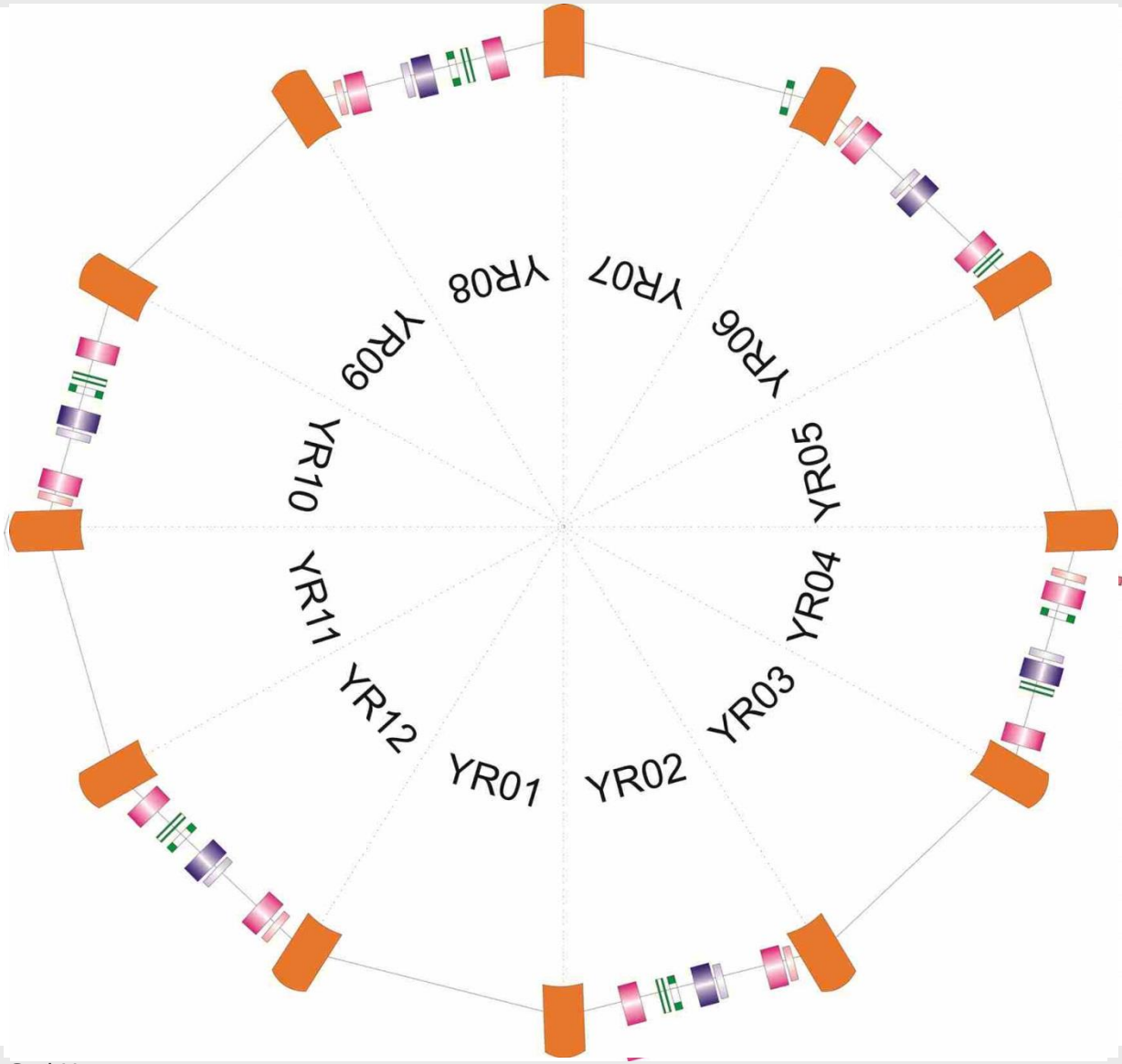
# CRYRING ring assembly: magnet straight sections

- **12 Dipoles**: ramped
  Bending angle 30°
  Max field 1.2T
  Nom current 1097A

- **18 Quadrupoles**: ramped
  12 Focusing
  6 Defocusing
  Max field 5 T/m
  Nom current 336 A

- **12 Sextupoles**:
  6 Focusing
  6 Defocusing
  Max field 27 T/m$^2$
  Nom current 10 A

- **12 Correction dipoles**:
  6 Vertical
  6 Horizontal
  Max field 0.03 T
  Nom current 10 A



# CRYRING ring assembly

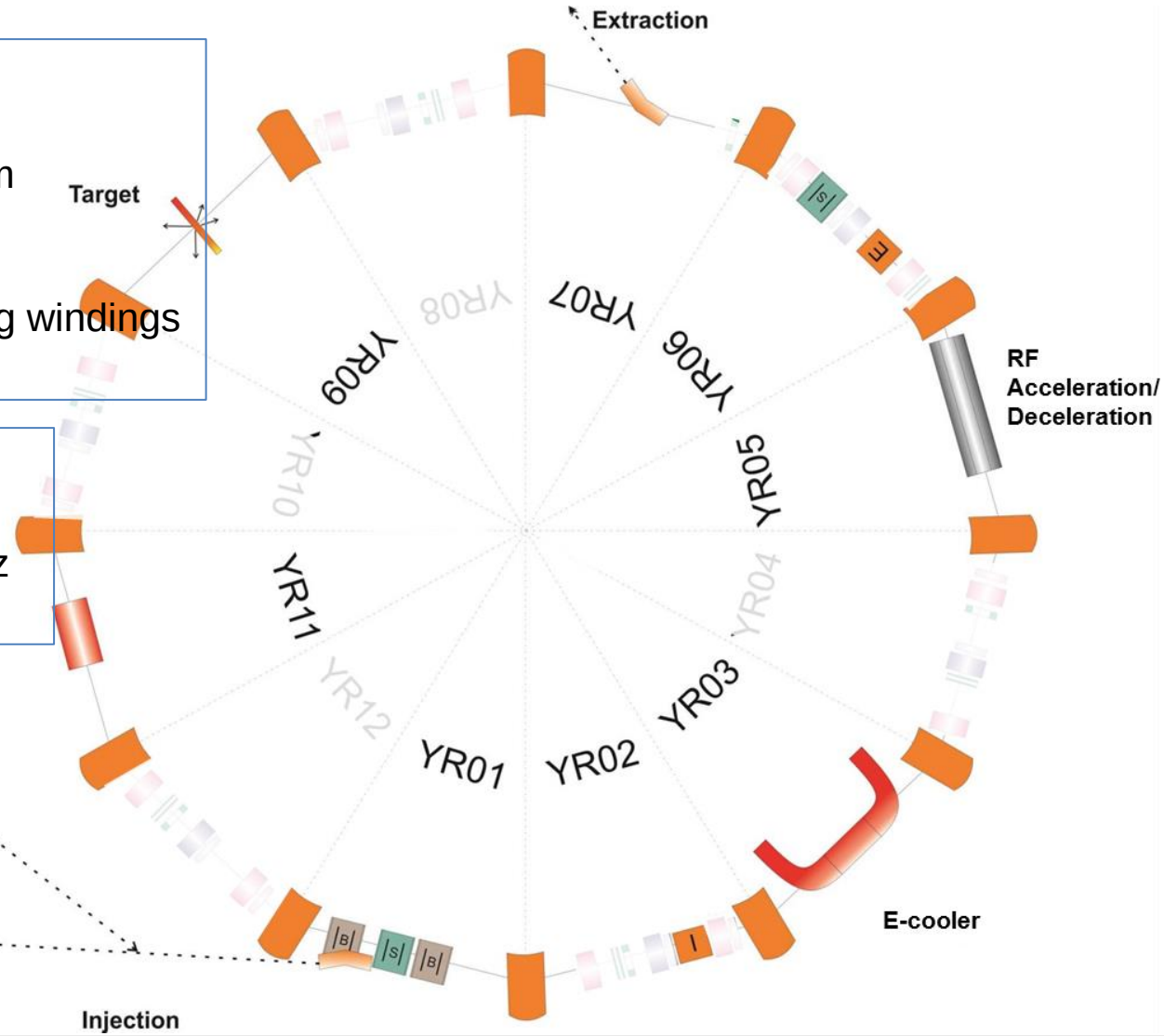
- **E-cooler:**

~20 voltage and current supplies:

- 7 Guiding magnets for e- beam
- Superconducting gun solenoid
- Compensation solenoid
- 2 Correctors + 2 dipols backleg windings
- 10 Steering coils

- **RF driven drift tube:**

- Slow ramping mode (1 T/s)
- RF frequency 40 kHz- 2.4 MHz
- RF voltage 0-1000$V_{p\text{-}p}$

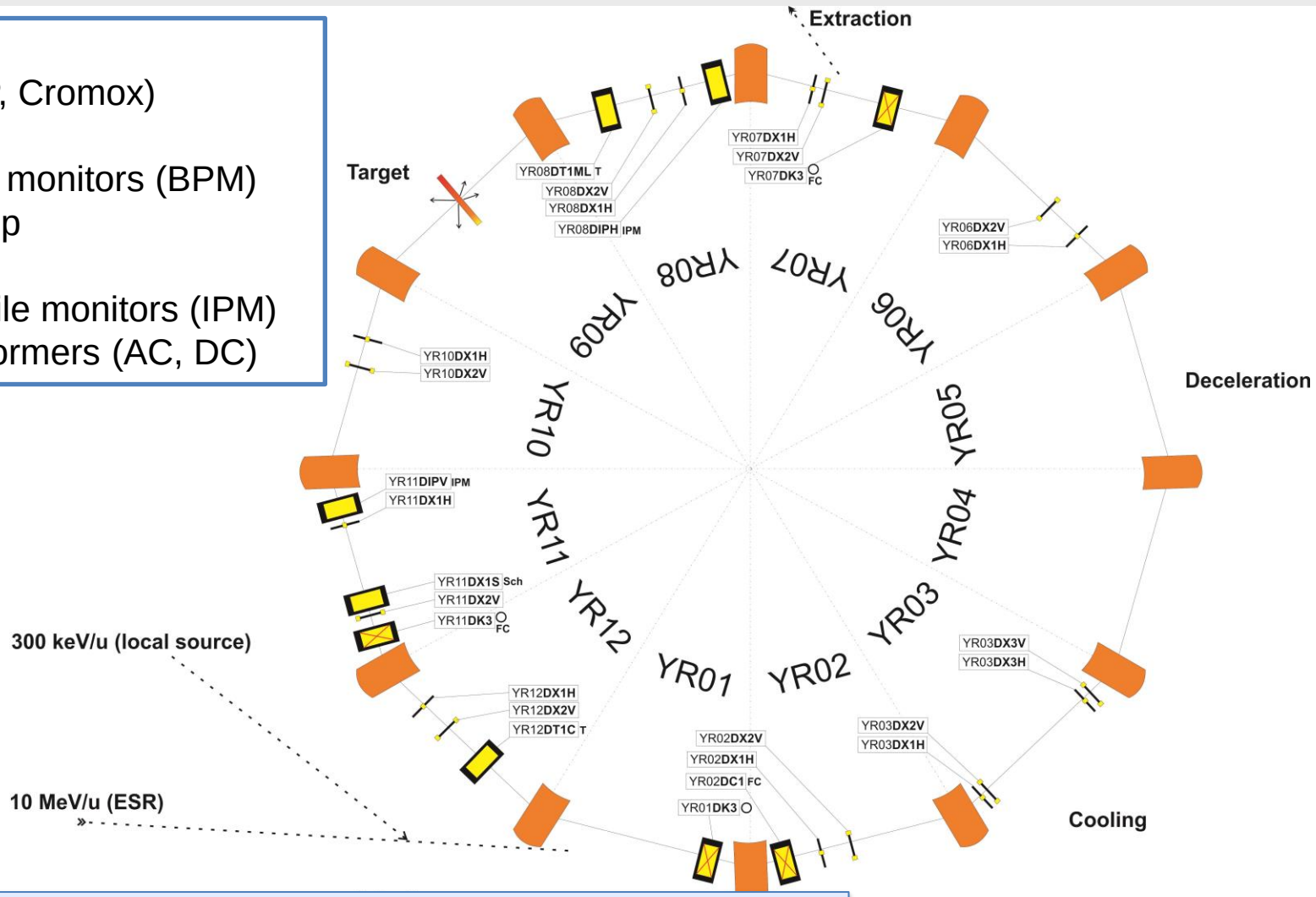


# CRYRING ring assembly: Diagnostics

- Faraday cups
- Screens (MCP, Cromox)

- Beam position monitors (BPM)
- Schottky pickup

- Ionization profile monitors (IPM)
- Current transformers (AC, DC)



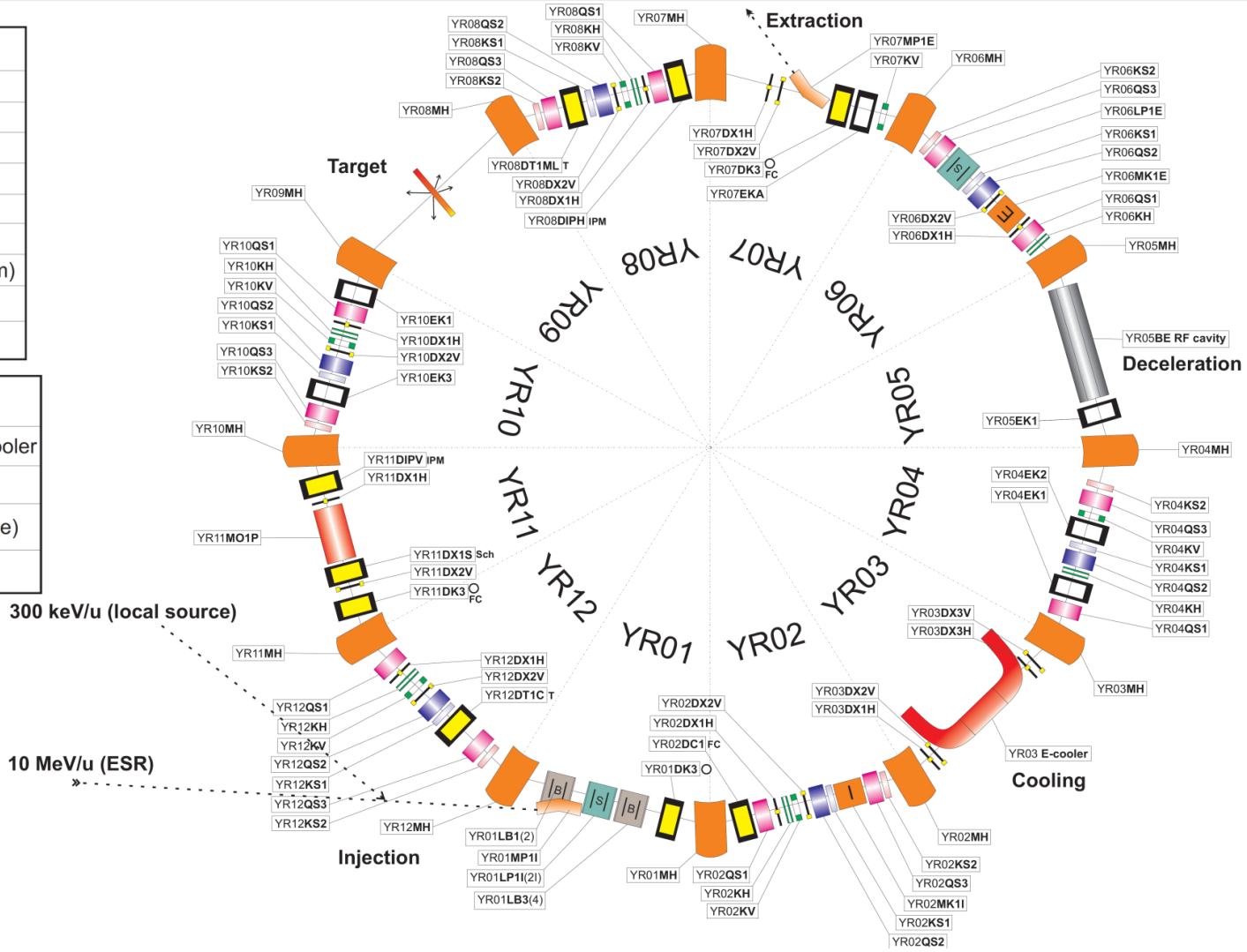

➢➢ For details about the diagnostics see presentation of H. Bräuning

# CRYRING ring assembly

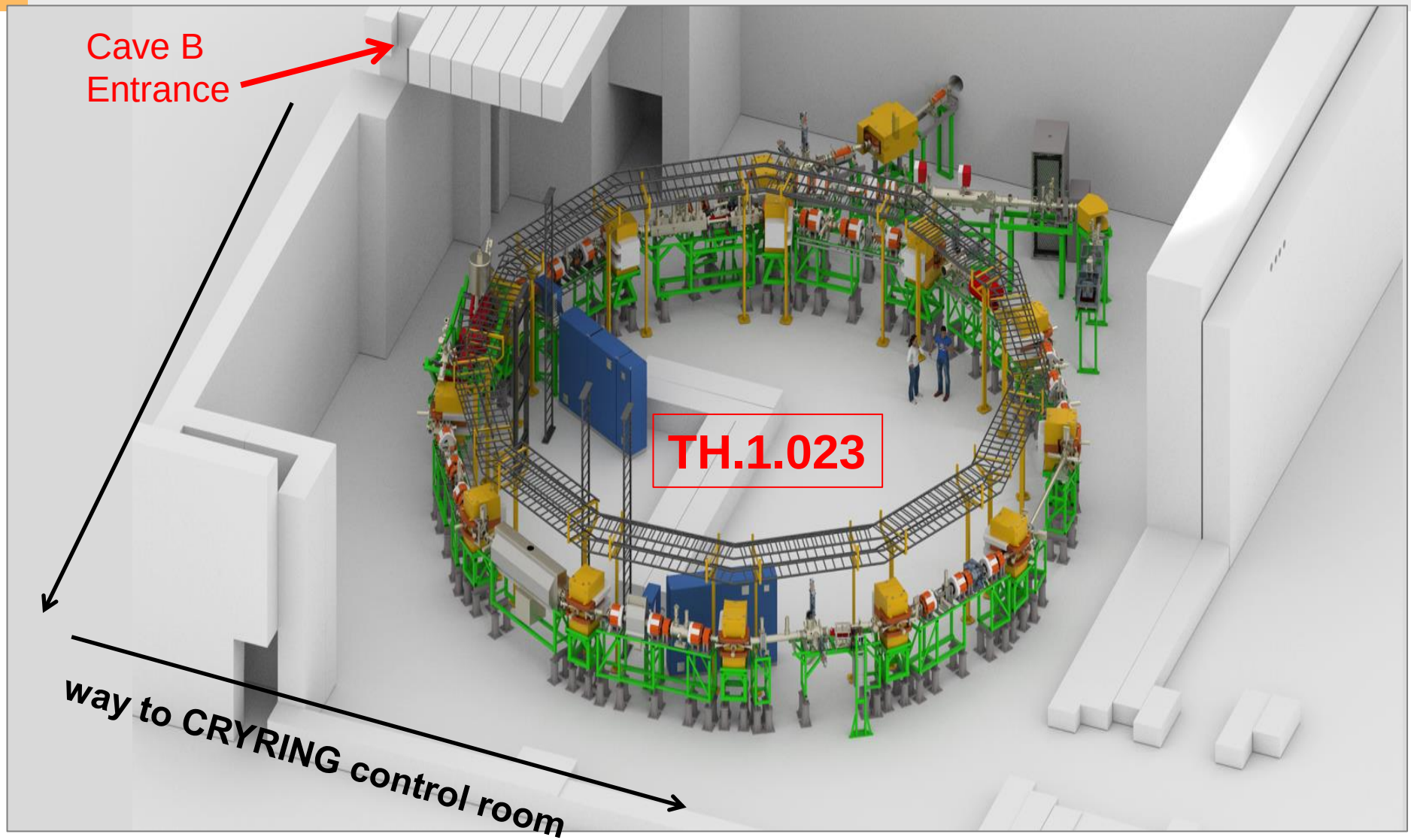
| | |
|---|---|
| | Dipole magnet (m) |
| | Focusing quadrupole (m) |
| | Defocusing quadrupole (m) |
| | Focusing sextupole (m) |
| | Defocusing sextupole (m) |
| | Horizontal correction (m) |
| | Vertical correction (m) |
| | Septum for injection/extraction (m) |
| I | Injection kicker (m) |
| E | Extraction kicker (m) |

| | |
|---|---|
| | Electron cooler |
| | Compensation magnet for e-cooler |
| | RF cavity |
| \|B\| | Injection bumper electrostatic (e) |
| \|S\| | Injection septum (e) |

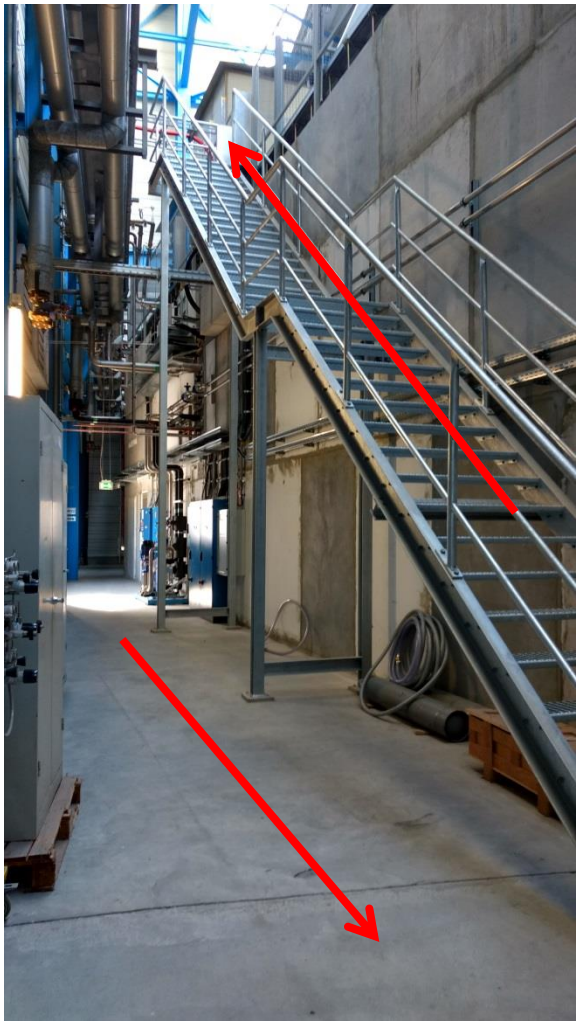
| | |
|---|---|
| | Diagnostics chamber |
| | Experiment chamber |
| | Beam position monitor, horizontal |
| | Beam position monitor, vertical |
| FC | DC Faraday cup |
| | DF Multi-channel plate Fluorescent screen |
| Sch | Schottky detector |
| IPM | IPH / IPV Ionization profile monitor |
| T | Measurements transformer |

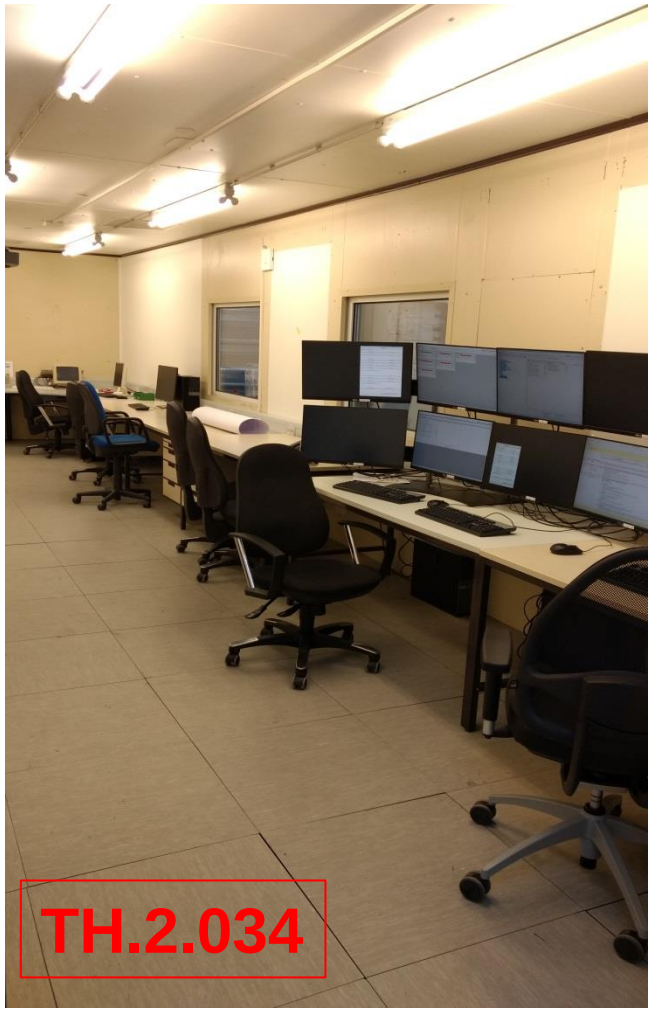


# CRYRING@ESR Control room

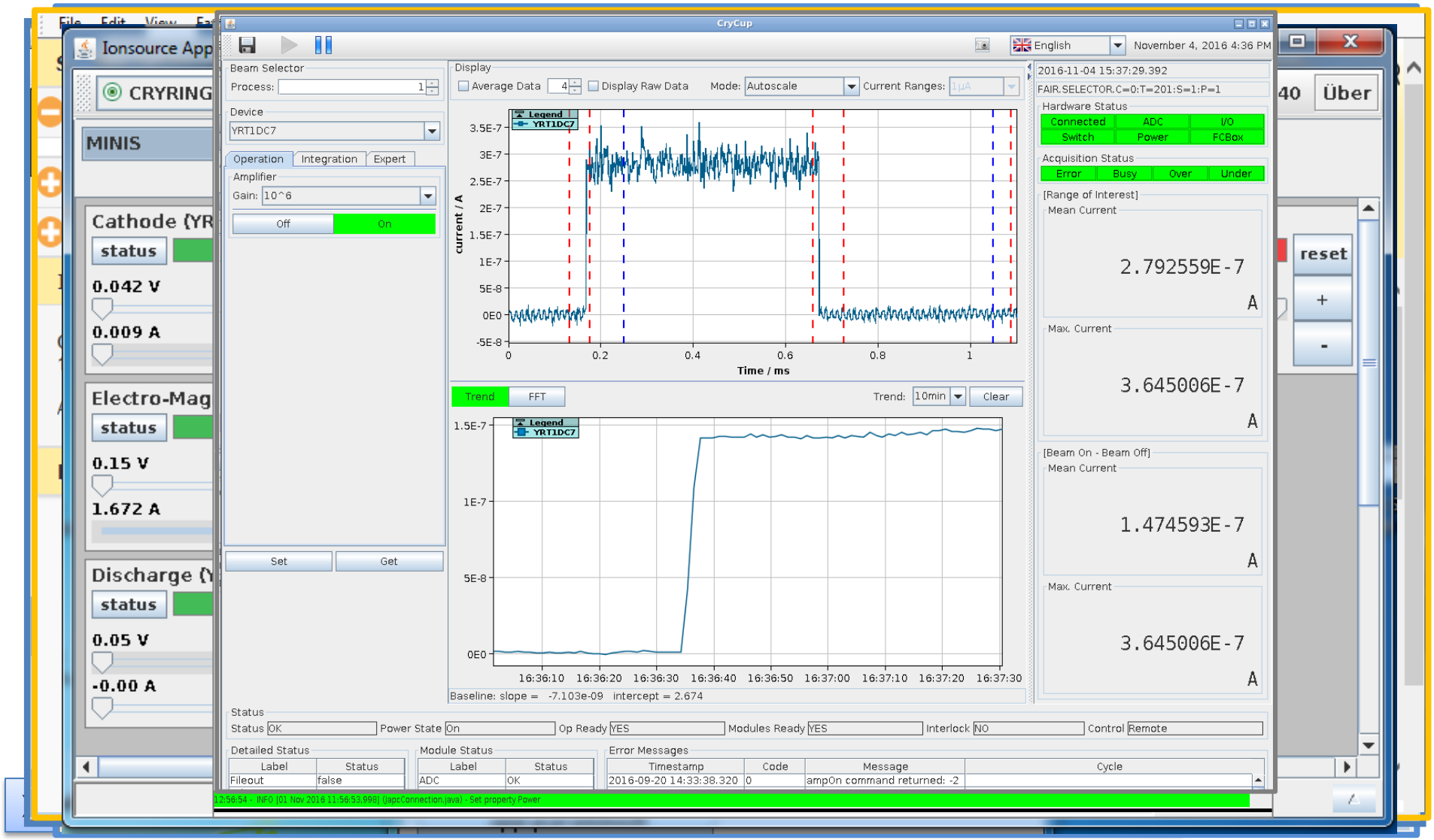


# CRYRING@ESR Control room





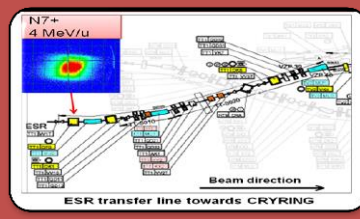
# CRYRING control system



# CRYRING@ESR commissioning: current status

Summer 2014

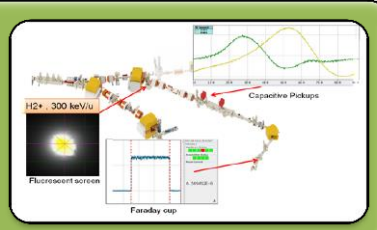
**Extraction from ESR towards CRYRING**




Spring, 2016

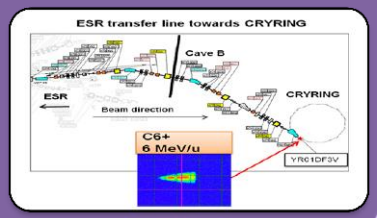
**Commissioning of the CRYRING local injector:**

**Ions transport up to the ring**




July, 2016

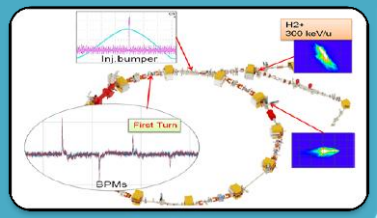
**ESR ions transport up to the ring**



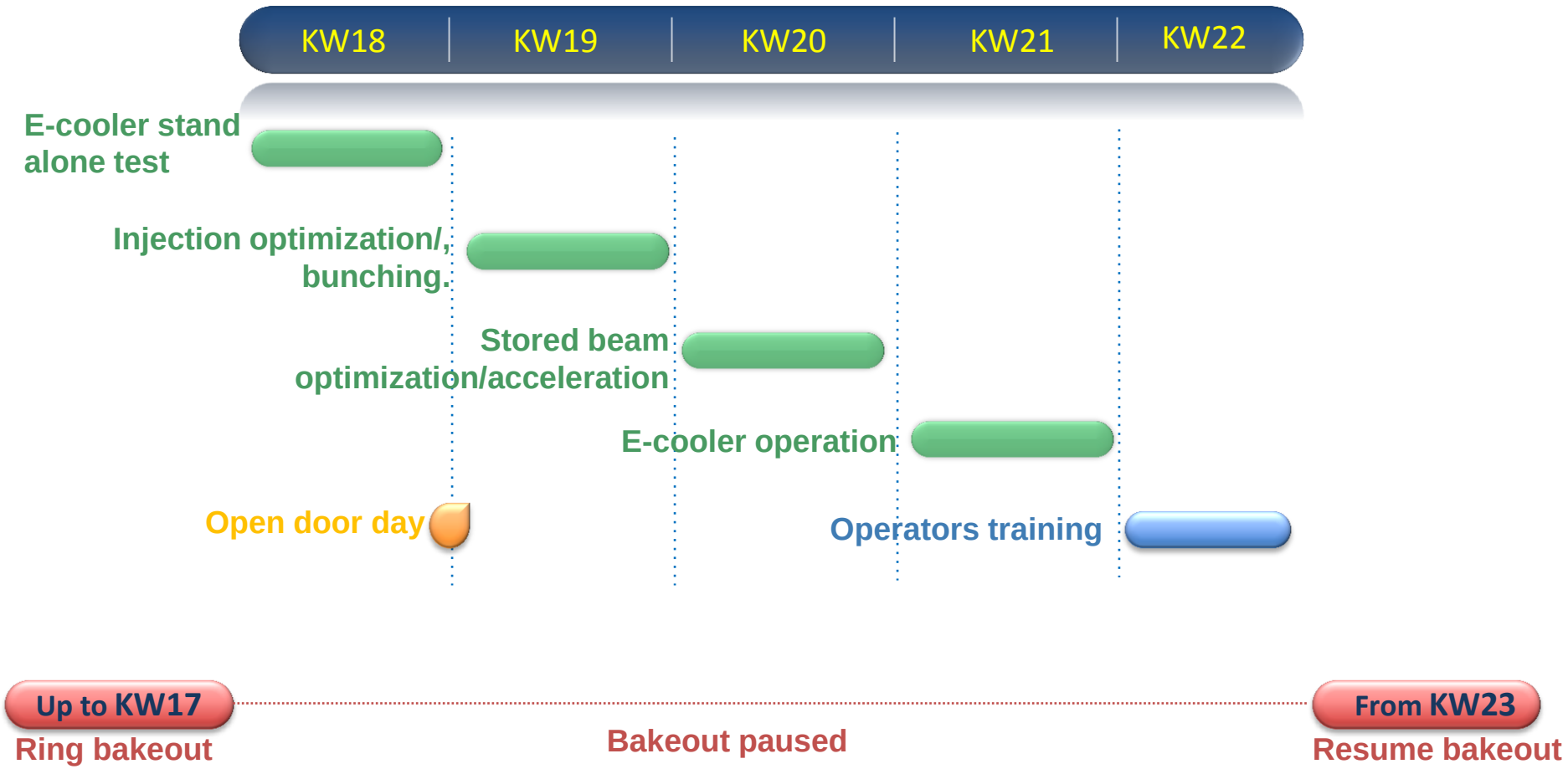

October, 2016

**Commissioning of the ring with local ion source:**

**Injection in the ring and a first turn.**



# Commissioning in Mai-June, 2017



# CRYRING operations in 2017-2019

| AUGUST-SEPTEMBER, 2017 | |
|---|---|
| Commissioning with UHV | Operators training |

| NOVEMBER-DECEMBER, 2017 | |
|---|---|
| Commissioning with UHV<br>First experiment | Operators training |

| 2018-2019 | |
|---|---|
| Ready to accept ESR beam | Scheduled dry runs and beam time |

For dates, look into plan of accelerator operations and a beam time schedule by S. Reimann