# RIB Overview
# - Super-FRS -

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HIC4FAIR workshop,
Hamburg, 29.07.2015

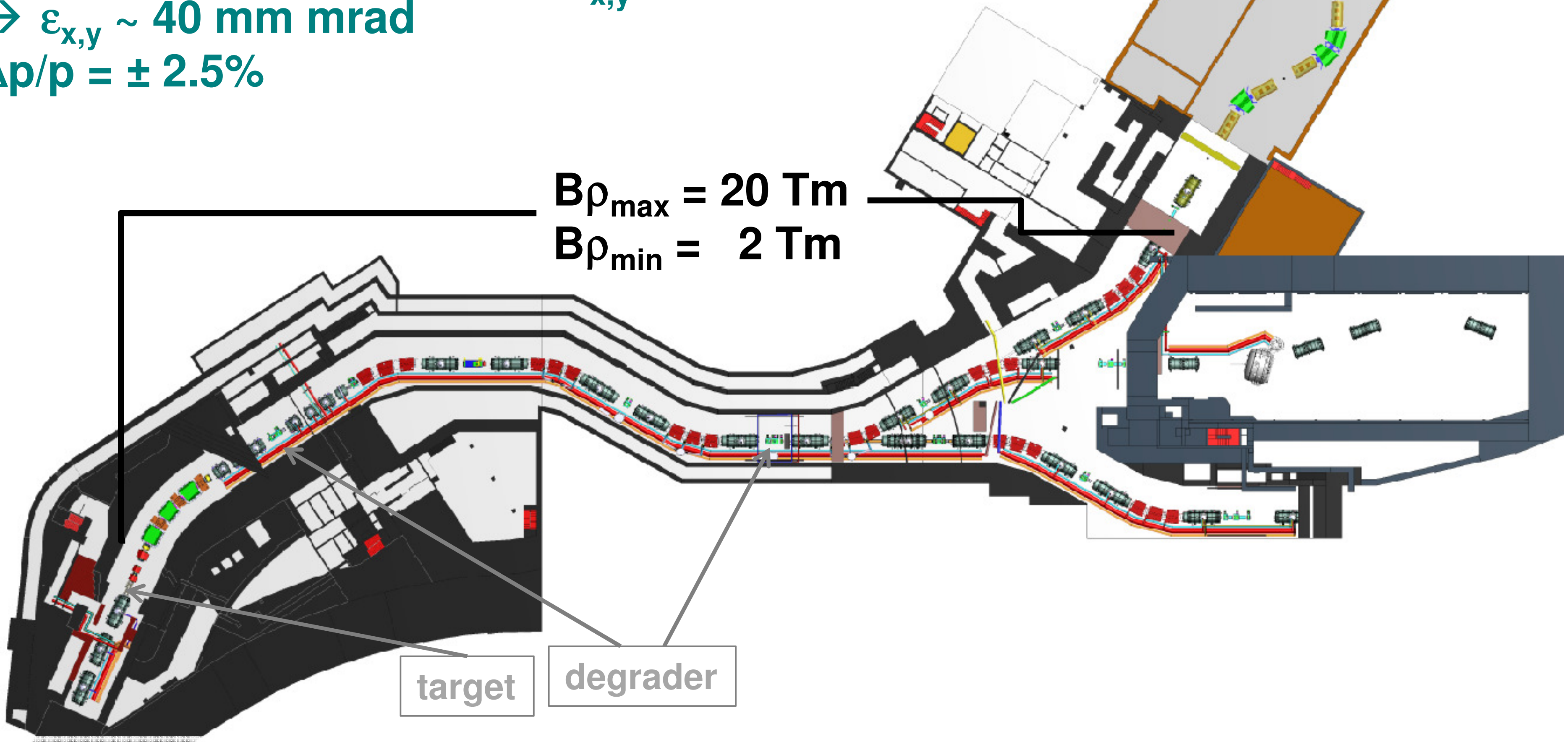
- System Overview
- Parameters and Requirements for Operation
- Experimental Areas

# Super-FRS

**initial acceptance:**
**$\Delta A = \pm 40$ mrad**
**$\Delta B = \pm 20$ mrad**
**→ $\varepsilon_{x,y} \sim 40$ mm mrad**
**$\Delta p/p = \pm 2.5\%$**

**after thick shaped degraders**
**$\Delta A$, $\Delta B \sim 20$ mrad, $\Delta p/p = \pm 2.5\%$,**
**but $\varepsilon_{x,y} \sim 100\text{-}300$ mm mrad**

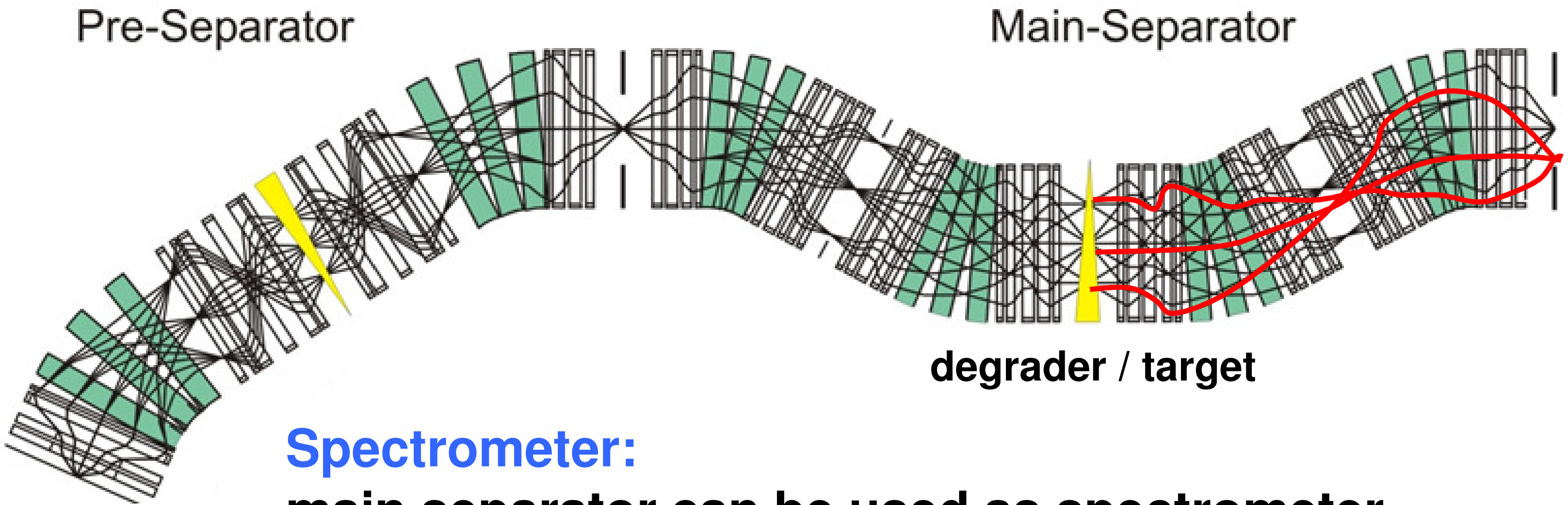
**$B\rho_{max} = 7$ Tm**
**$B\rho_{min} \sim 0.7$ Tm**




**$B\rho_{max} = 100$ Tm ($^{238}U$ 2.7 GeV/u)**

# Separator / Spectrometer

**Principle:** Two achromatic energy-loss spectrometers, but dispersive in mass and charge. Energy loss in degrader depends on Z, is analyzed at end. R=1500 for $\Delta x = \pm 1$ mm on target, similar limit due to energy-loss straggling in degraders.




**Spectrometer:**

main separator can be used as spectrometer.
with tracking detectors $\Delta x < 1$mm.
Also other optics modes with larger dispersion.

Energy Buncher, also as high resolution spectrometer and dispersion matching with main separator.

# Primary Beams

**Types:** 52 elements identified, often as rare isotope:
$^{1}H$, $^{2}H$, $^{7}Li$, ... $^{40}Ar$, $^{48}Ca$, $^{86}Kr$, $^{112}Sn$, $^{124}Xe$, .., $^{208}Pb$, $^{209}Bi$, $^{232}Th$, $^{238}U$

**Intensities:** max. of all types in slow extraction.
protons only up to $10^{11}$ - $10^{12}$/s.
fast extraction, some limitations for $Z > 50$
Uranium $5 \times 10^{11}$ / pulse (with enlarged spot on target)

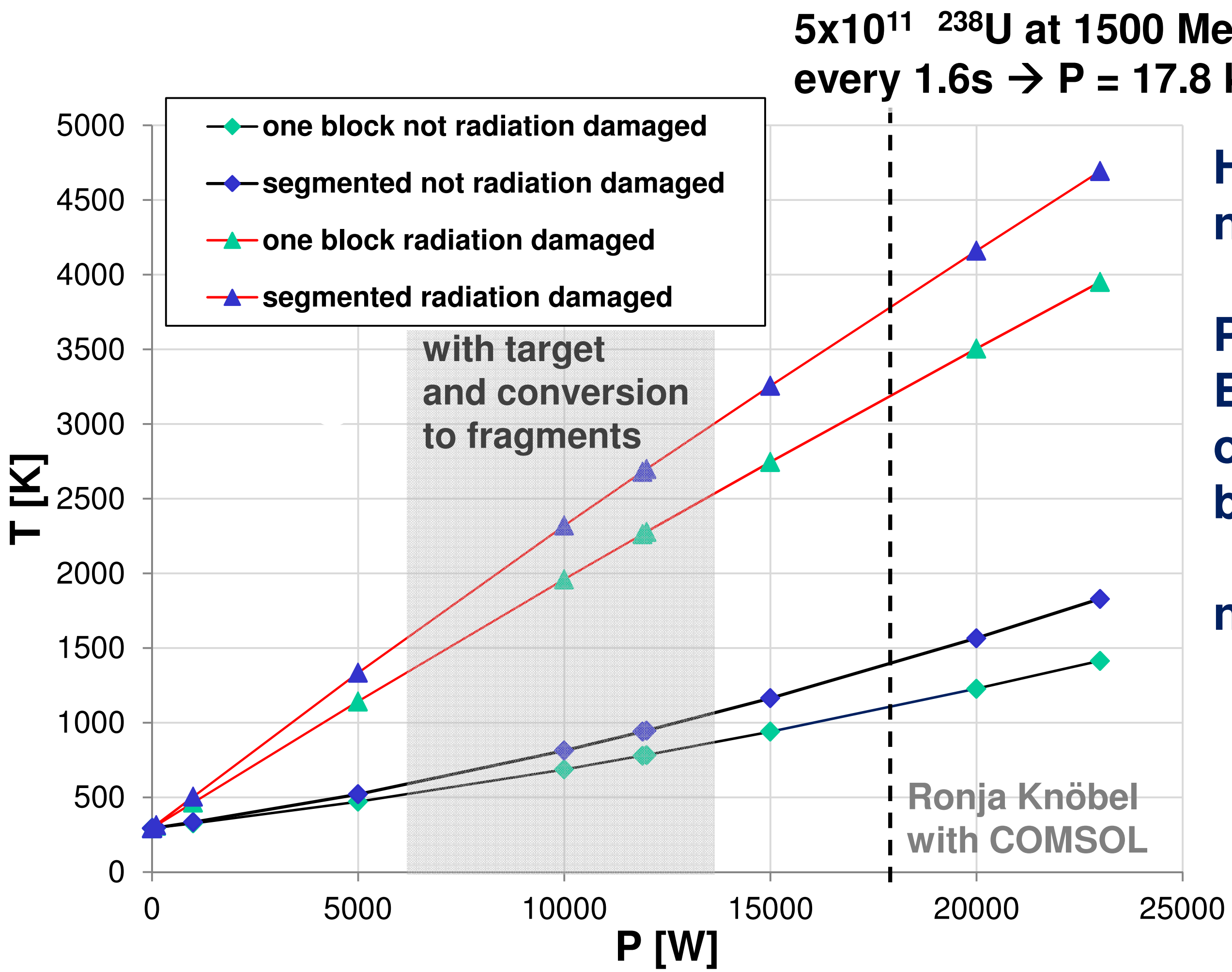
**Slow extraction** for experiments in HEB, LEB, inside Super-FRS
**Fast extraction** for coupling to CR

**B$\rho$ range** needed for NUSTAR experiments 3.2 – 70 Tm.
SIS-100 lower B$\rho$ limited, but often needed -> use SIS-18

**Energy spread:** for some spectrometer experiments $\Delta p/p$ close to $10^{-4}$.
for fragment production slow extraction $\Delta p/p < 10^{-3}$
fast extraction with bunch compression $\Delta p/p < 0.5\%$

# Power Limit on Beam Catcher

## with design of static graphite catcher for fast extraction




**Here most critical case n-deficient from U beam.**

**Picture varies with Bρ setting and spot size on corresponding beam catcher BC1 to BC3.**

**n-rich settings less critical.**

**no problem for slow extraction**

# Bρ range of primary beams

## Requirements by different experiments

| case | Z | A | q SIS | E [MeV/u] | Bρ [Tm] |
|---|---|---|---|---|---|
| R3B | 92 | 238 | 28 | 1700 | 69.79 |
| R3B, EXL | 92 | 238 | 28 | 1500 | 63.67 |
| MATS | 92 | 238 | 28 | 400 | 26.98 |
| 100Sn (high) | 54 | 124 | 20 | 1000 | 34.96 |
| MATS | 79 | 197 | 25 | 400 | 25.00 |
| Hyper nuclei 9C | 6 | 12 | 6 | 3200 | 26.85 |
| Hyper nuclei 6Li | 3 | 6 | 3 | 2273 | 20.50 |
| MATS 100Sn | 54 | 124 | 20 | 400 | 19.66 |
| delta.res. (high) | 54 | 124 | 20 | 1200 | 39.62 |
| delta.res. (low) | 54 | 124 | 20 | 400 | 19.66 |
| MATS 19C | 18 | 40 | 10 | 400 | 12.68 |
| tensor 6Li | 3 | 7 | 3 | 1000 | 13.20 |
| tensor 6Li | 3 | 7 | 3 | 600 | 9.48 |
| eta-prime p | 1 | 1 | 1 | 2500 | 11.10 |
| tensor p | 1 | 1 | 1 | 1200 | 6.44 |
| tensor p | 1 | 1 | 1 | 900 | 5.30 |
| tensor p | 1 | 1 | 1 | 600 | 4.08 |
| tensor p | 1 | 1 | 1 | 400 | 3.20 |

# Beam and Beamline Requirements

**Bρ change in Super-FRS: needs to be done very often (2-20 Tm) with ramping to saturation ~ 15 min, FRS today 2 min, only going up is faster, also faster for small changes < 0.1%**

**Spot Size on Target:**

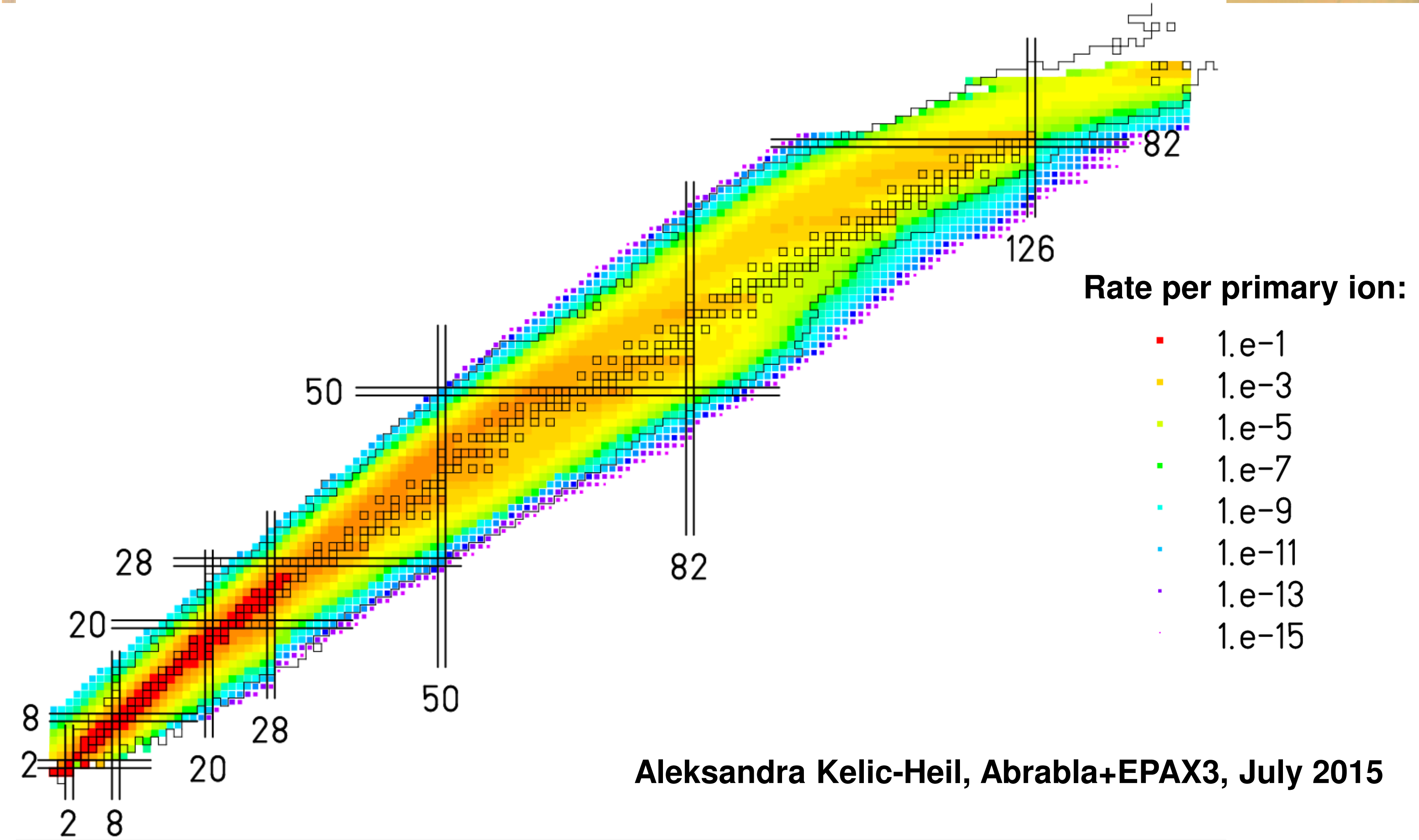
**Target focusing system works with ε = 25 mm mrad focused to $\sigma_x$= 1 mm at Bρ = 89 Tm, in slow extraction mode $\sigma_x$ = 0.4mm. Even smaller is possible at lower Bρ.**

**Fast interlock system and beam interruption**

- **stop slow extraction, beam dump**
- **fast extraction, prevent SIS kicker**

**Fast detection of power supply failures in HEBT + Super-FRS (dipoles Δt < 20ms), otherwise beam shift at Super/FRS too large.**

# Rates of nuclides produced from 52 considered primary beams



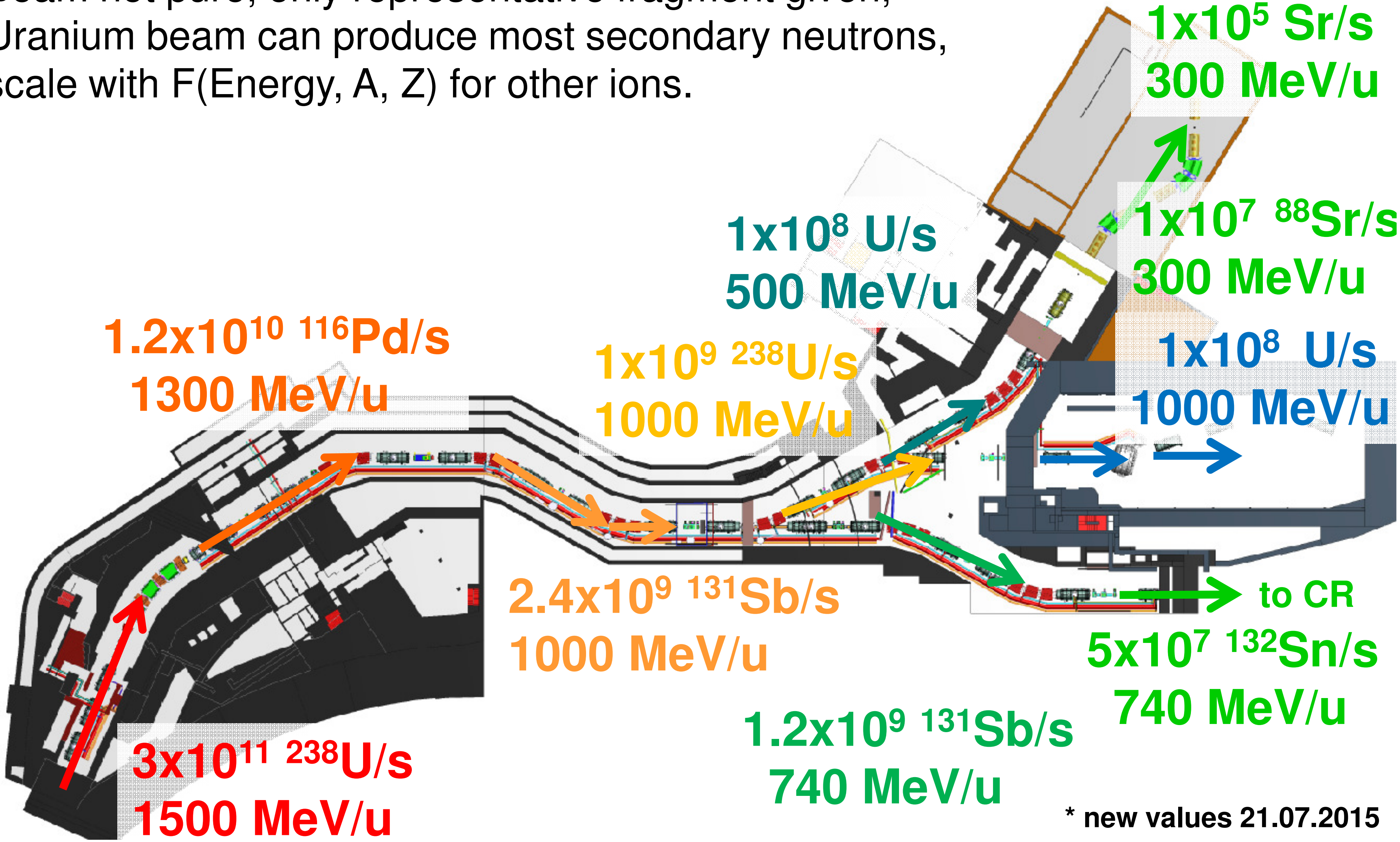

**Aleksandra Kelic-Heil, Abrabla+EPAX3, July 2015**

**more details in talk tomorrow ...**

# Maximal Intensities

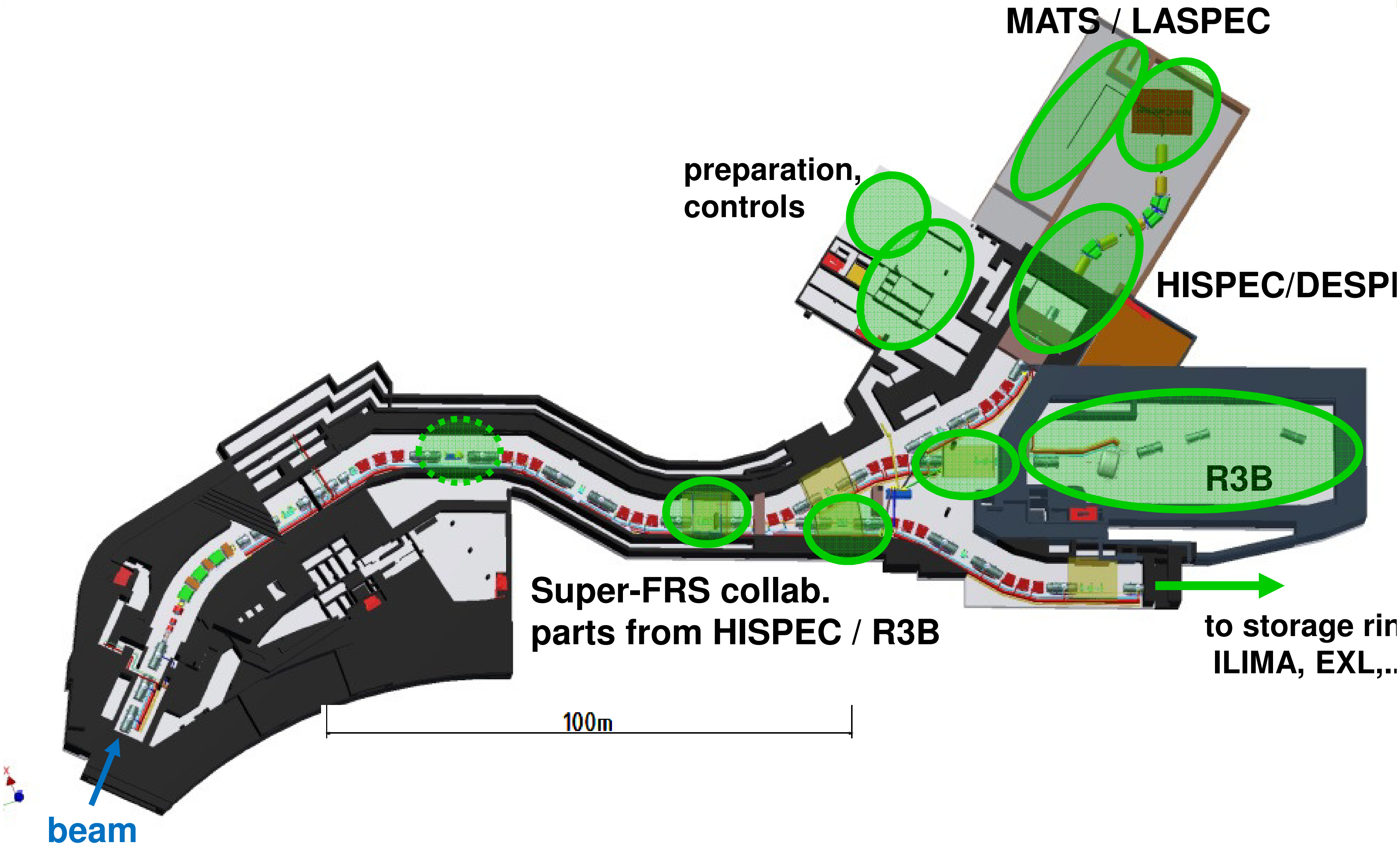
**in reasonable settings, input for radiation protection**

Beam not pure, only representative fragment given,
Uranium beam can produce most secondary neutrons,
scale with F(Energy, A, Z) for other ions.



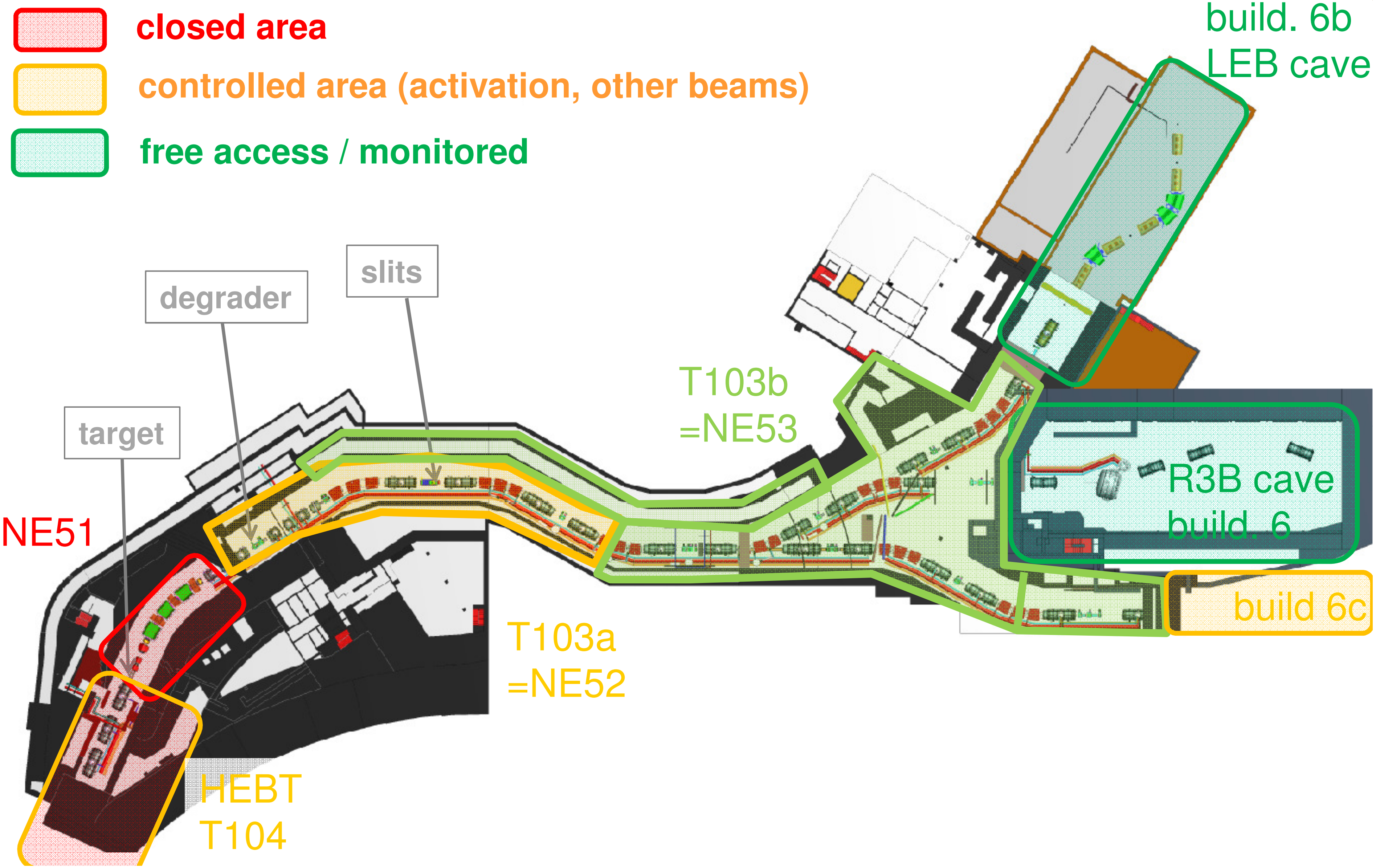

* new values 21.07.2015

# Experiment Places



# Radiation Protection Areas

## status after beam time

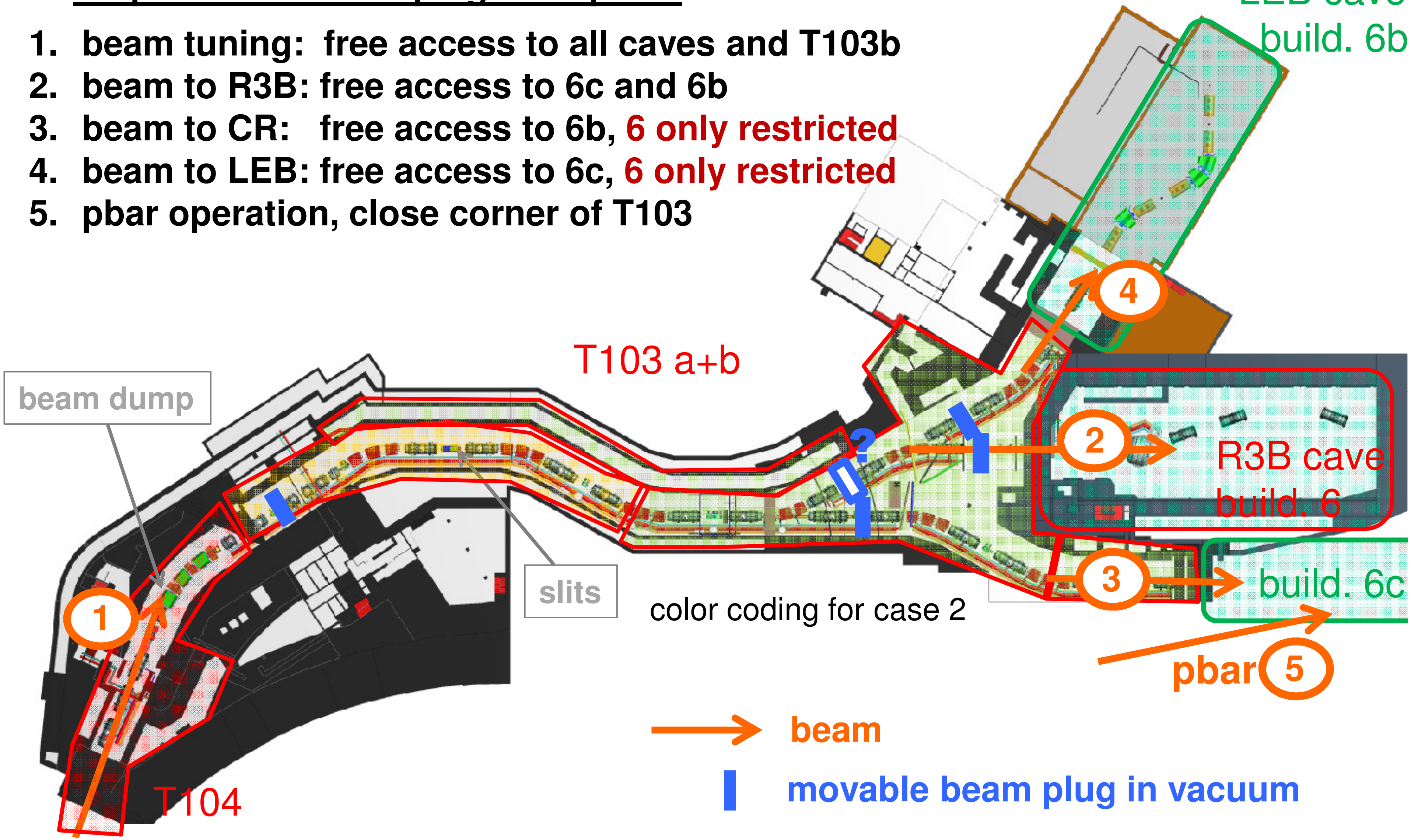


# Access to Areas

## during beam times

<u>**Requirement: beam plug + 2 dipoles**</u>

1. **beam tuning: free access to all caves and T103b**
2. **beam to R3B: free access to 6c and 6b**
3. **beam to CR: free access to 6b, 6 only restricted**
4. **beam to LEB: free access to 6c, 6 only restricted**
5. **pbar operation, close corner of T103**

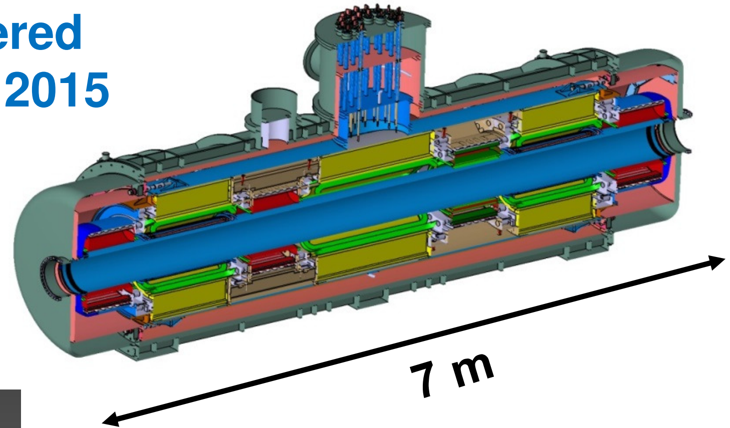


# Magnets

After target: normal conducting, radiation hard (3Q, 1H, 3D)

SC multiplets including some sextupoles
23 long (triplet) + 8 short (doublet)

ordered
June 2015



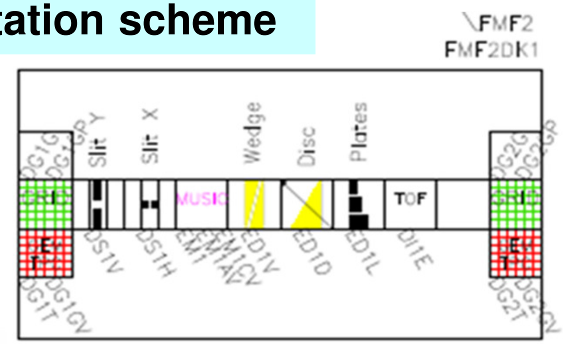


24 SC dipoles
time critical path,
specs being refined,
SC cable ordered

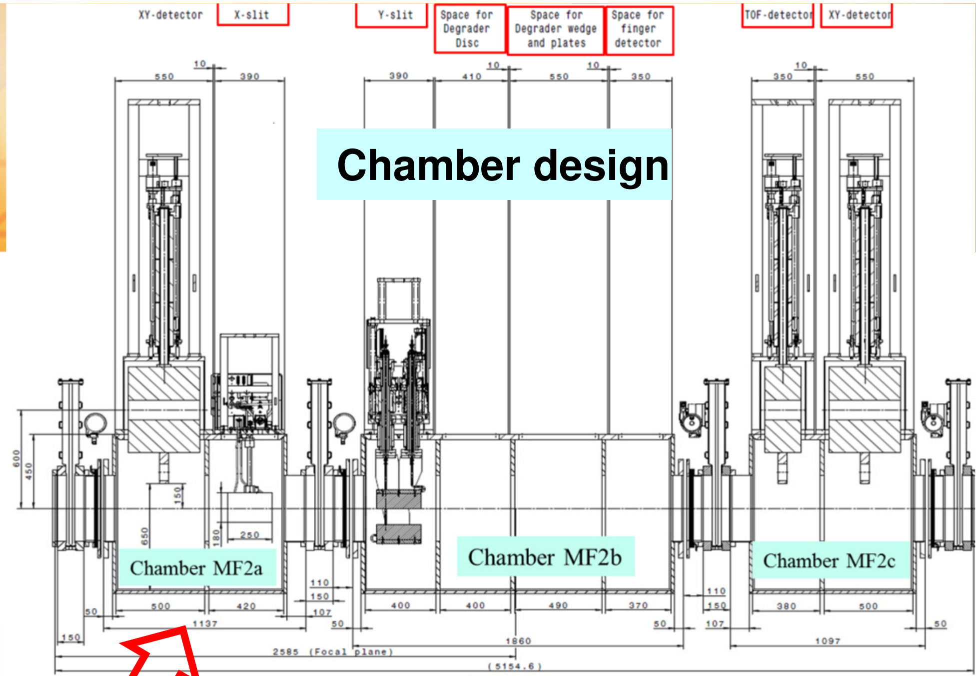
EB buncher SC magnets
Indian in-kind (similar type)

# Focal Plane Installation
# - example FMF2 -

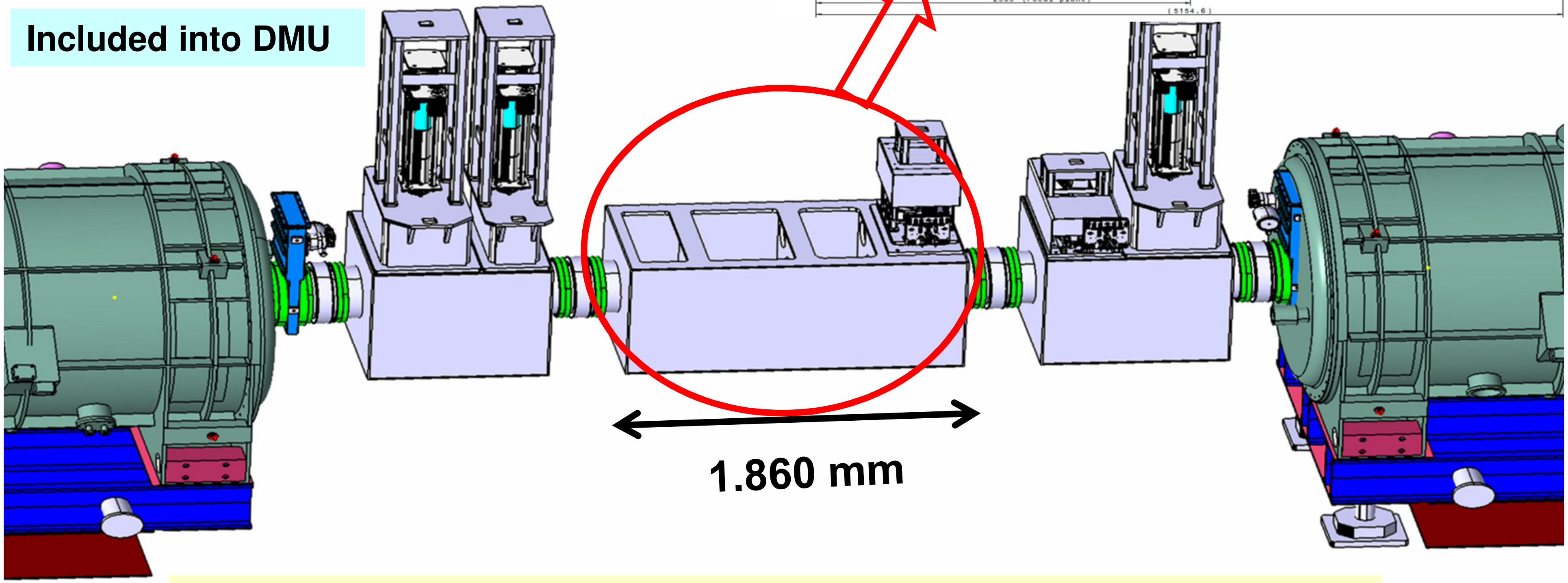
**Instrumentation scheme**




**Chamber design**




**Included into DMU**




- experiments require more flexible focal-plane arrangement

# Summary

**Super-FRS is Bρ–ΔE–Bρ separator like FRS, but twice to cope with higher rates. Use 2nd part as spectrometer, also the extra energy buncher.**

- **Beams of different Bρ needed, fast +slow extraction.**
- **Usually max. intensity wanted of many ion types, only for fast extraction limit of $5 \times 10^{11}$ U/pulse.**
- **Machine protection needed.**
- **Super-conducting magnets largest share ordered.**

- **Different experimental areas also in Super-FRS tunnel.**
- **Defined max. intensities, areas of activation.**
- **Possibilities of parallel access still have one open question.**