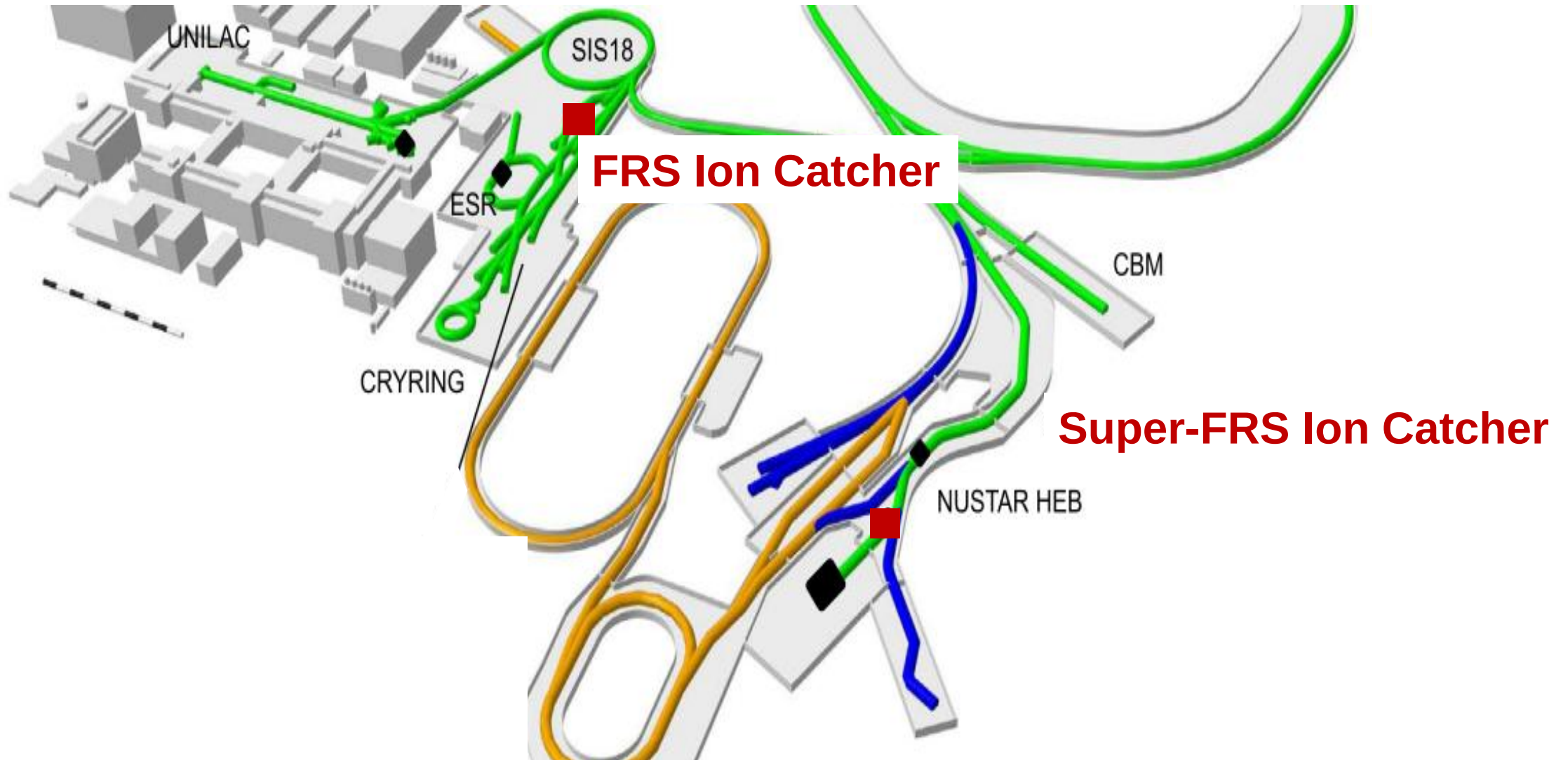


Towards AI-Assisted Low-Energy Beamline Optimisation at the (Super-)FRS Ion Catcher

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GSI Darmstadt, JLU Gießen

“Catch” a relativistic beam and put it in an ion trap to study its ground state properties, with different means of spectroscopy



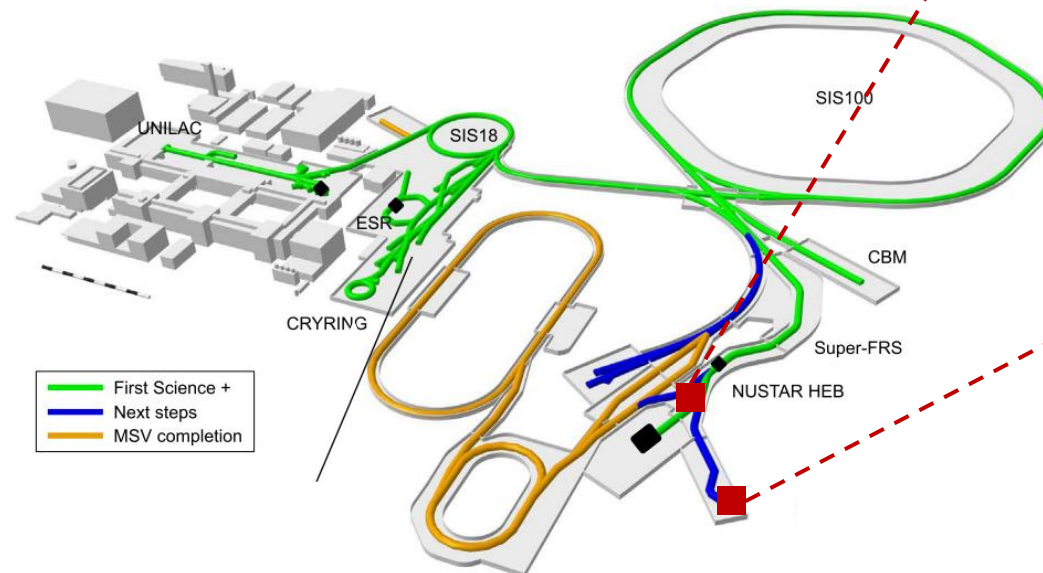
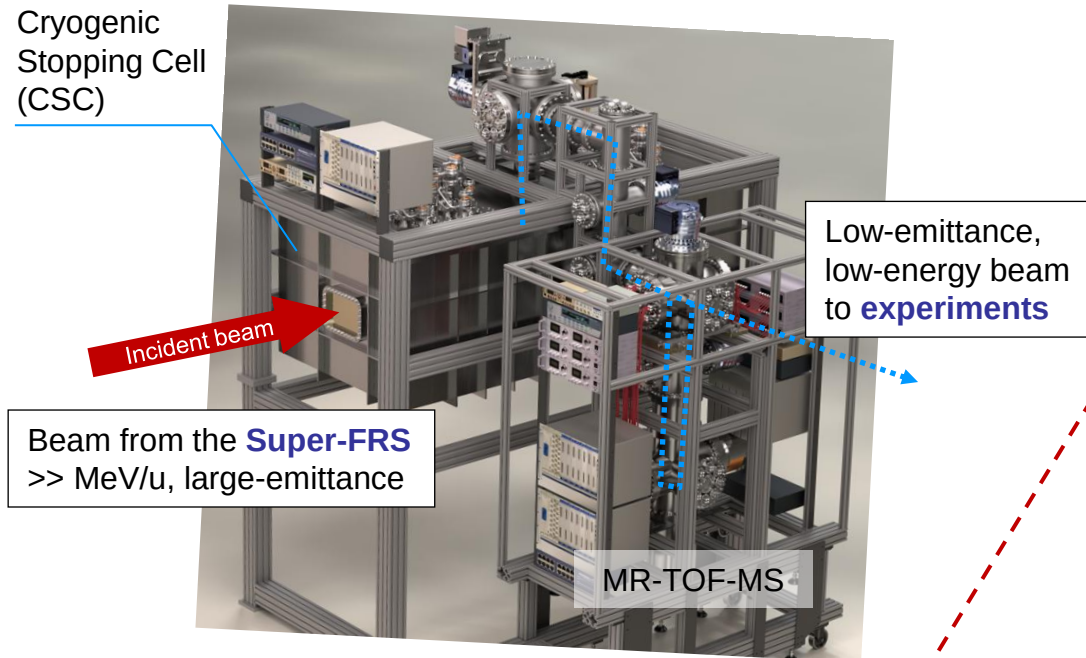
FRS Ion Catcher – Experiments with radioactive beams



Measurements of:

- Masses $\rightarrow$ binding energies
- Lifetimes
- Discovery of new long-lived excited states
- Determination of decay branching ratios
- Search for new radioactive decay modes
- Production and characterization of radioactive molecules
- Spontaneous fission
- ...

Super-FRS Ion Catcher



In front of High-Energy Branch (FHF1, possibly FLF2, FLF3):

Early Science / First Science

- Mass, P_{xn} measurements, isomers, fission studies ...
- High-rate experiments (e.g. MNT reaction studies)
- Laser spectroscopy
- Commissioning and PID



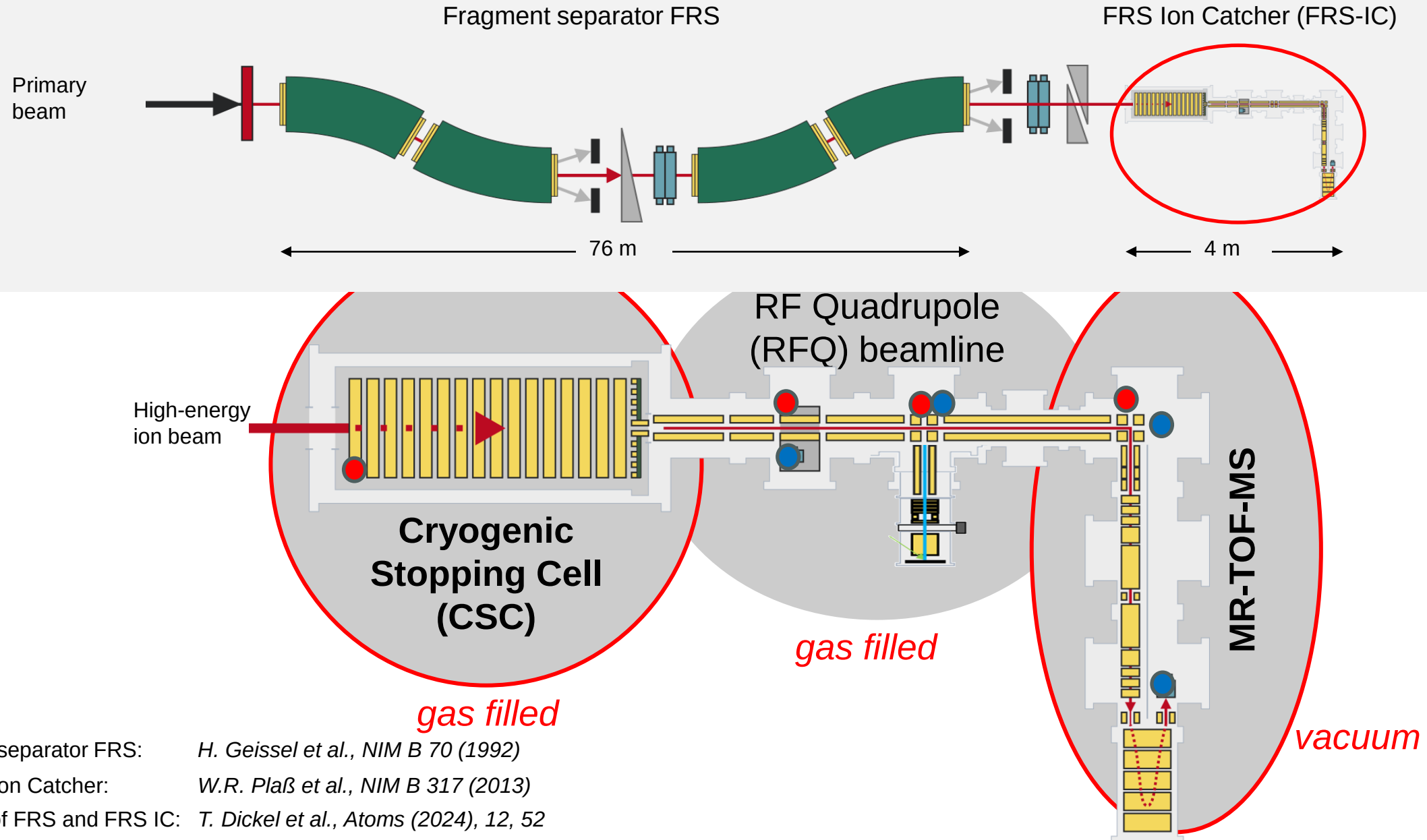
Low-Energy Branch (FLF6):

First Science++

- Mass measurements
- Laser spectroscopy experiments
- In-cell decays, ...

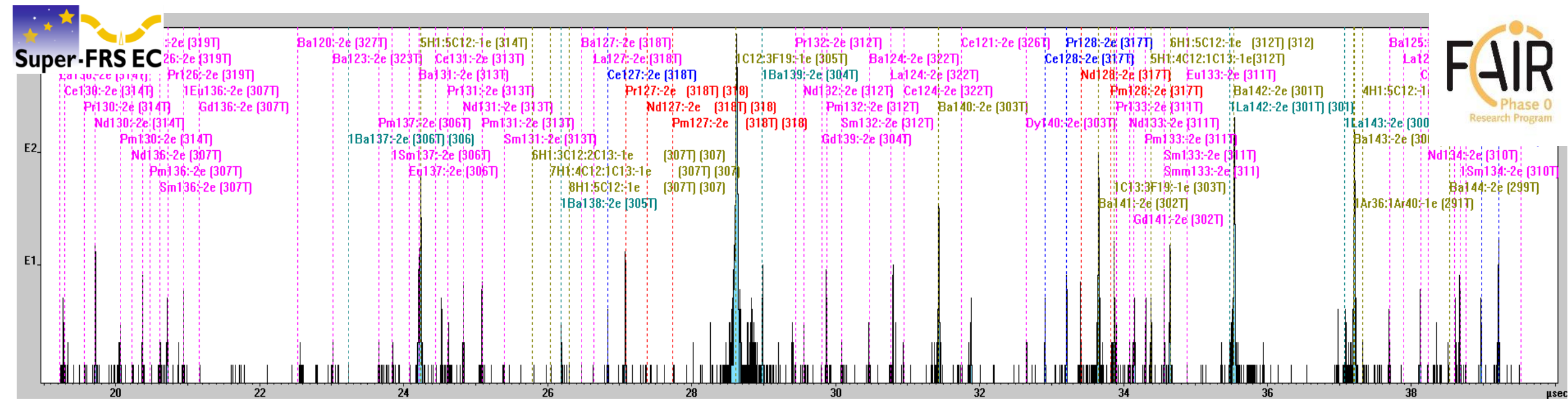


The FRS Ion Catcher at GSI



Fragment separator FRS: *H. Geissel et al., NIM B 70 (1992)*
The FRS Ion Catcher: *W.R. Plaß et al., NIM B 317 (2013)*
Coupling of FRS and FRS IC: *T. Dickel et al., Atoms (2024), 12, 52*

Boundary conditions and goals



- Atomic and molecular ion species in different charge states
 - Transport in gas with RF structures
 - Depends on m/q and “size” (ion mobility)
 - Transport in vacuum with RF structures
 - Depends on m/q
 - Transport in vacuum with electrostatic field
 - Indirectly depends on m/q and “size” (ion mobility)

Optimization for:

- rate
- alignment in specific parts
- time profile
- transport time
- rate capability

Additional challenge:

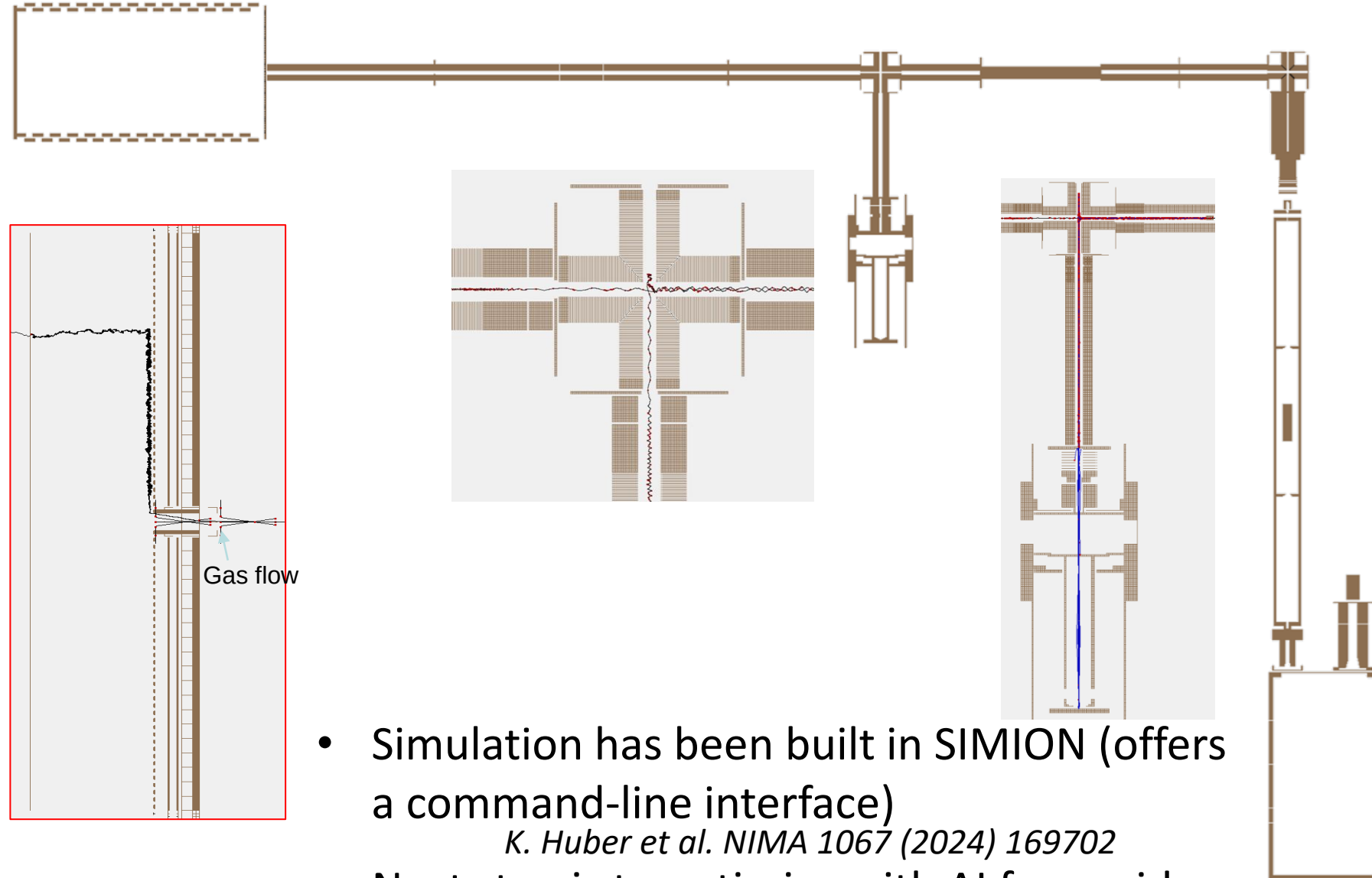
Used ion source only delivers specific species, and the detectors only give limited/specific information

Challenges and Status

Challenge

The system has:

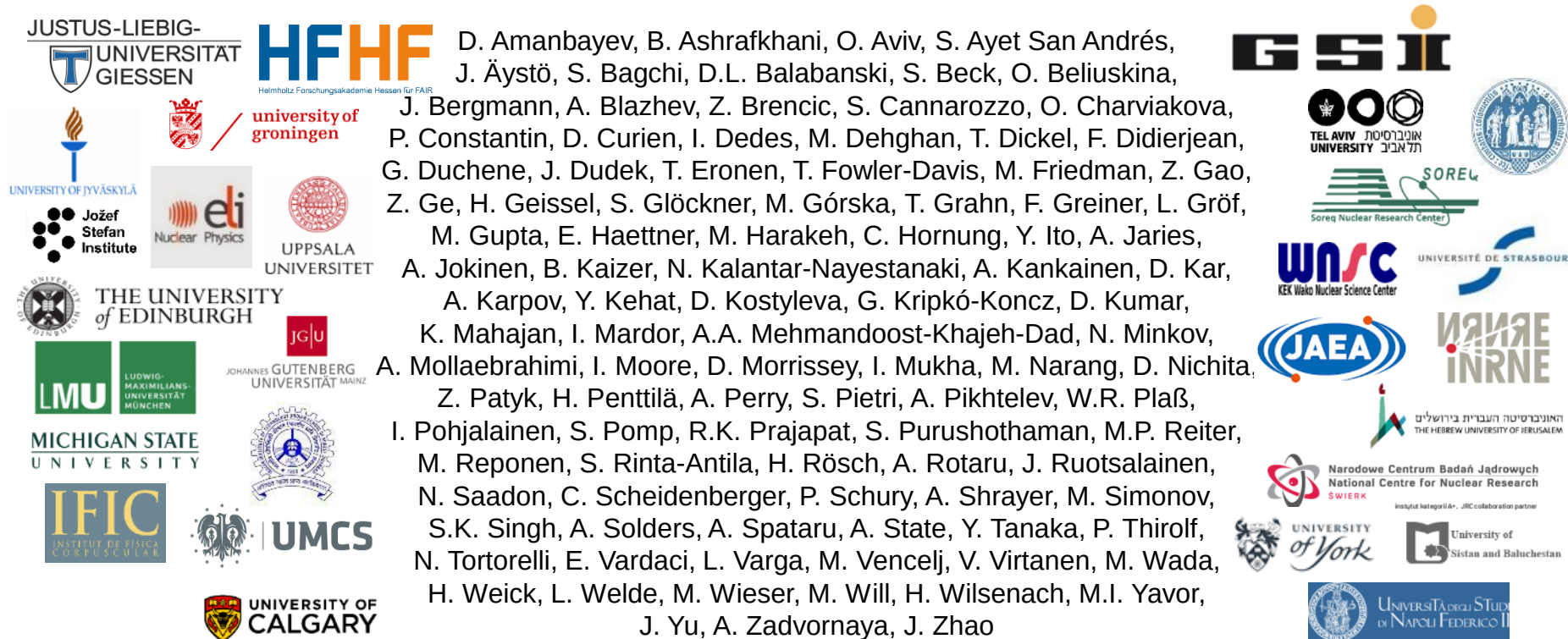
- 8 different pressure regions
- 12 RFs
- More than 100 DC voltages
- More than 20 timing signals
- 8 ion sources
- 9 detectors
(only one measuring position)



- Simulation has been built in SIMION (offers a command-line interface)
K. Huber et al. NIMA 1067 (2024) 169702
- Next step is to optimize with AI for a wide set of ion species and conditions

Acknowledgements

Super-FRS Experiment Collaboration



Zixuan Yue

New PostDoc from JLU Gießen starting at GSI in September