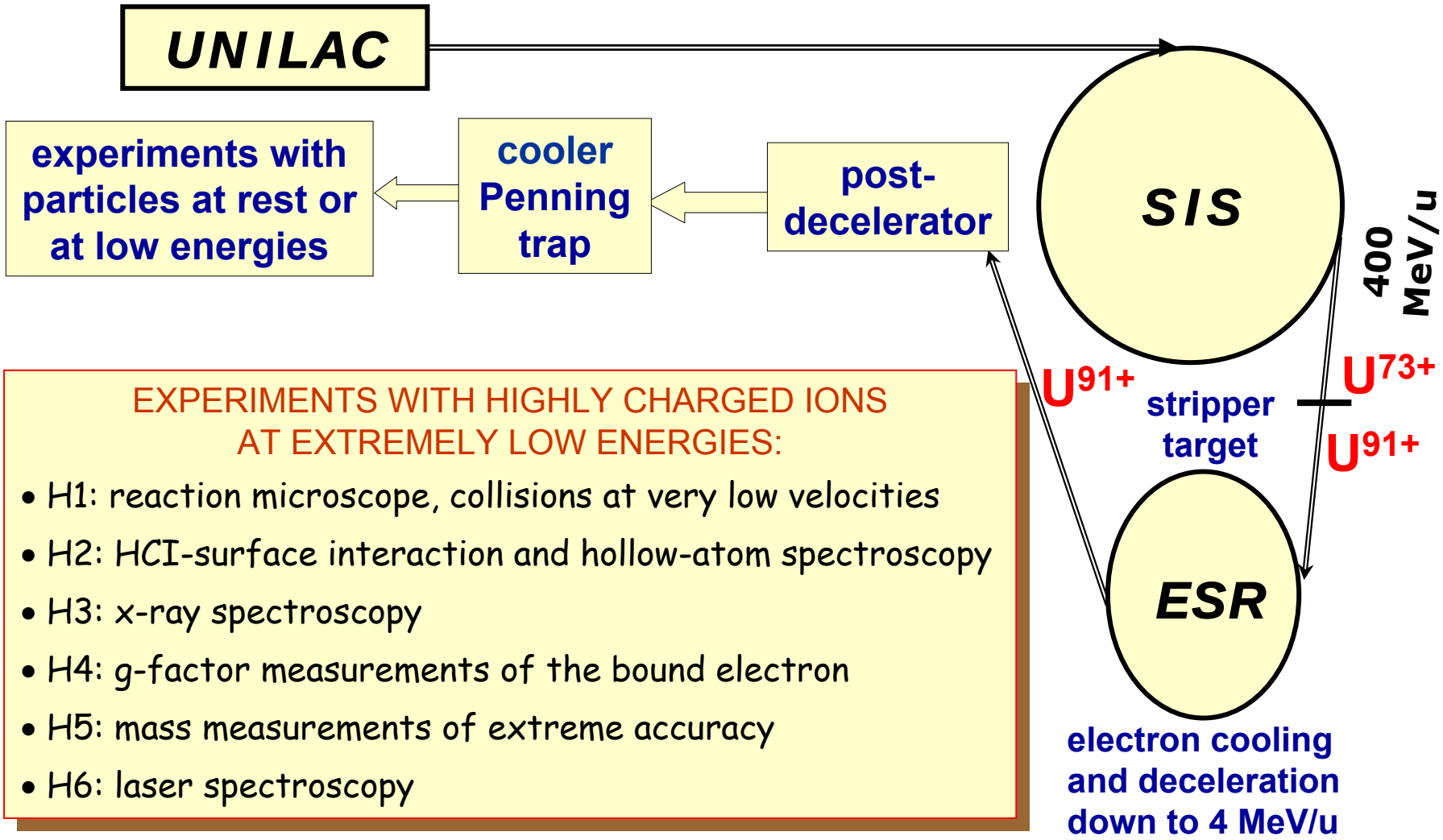
HITRAP Experiments



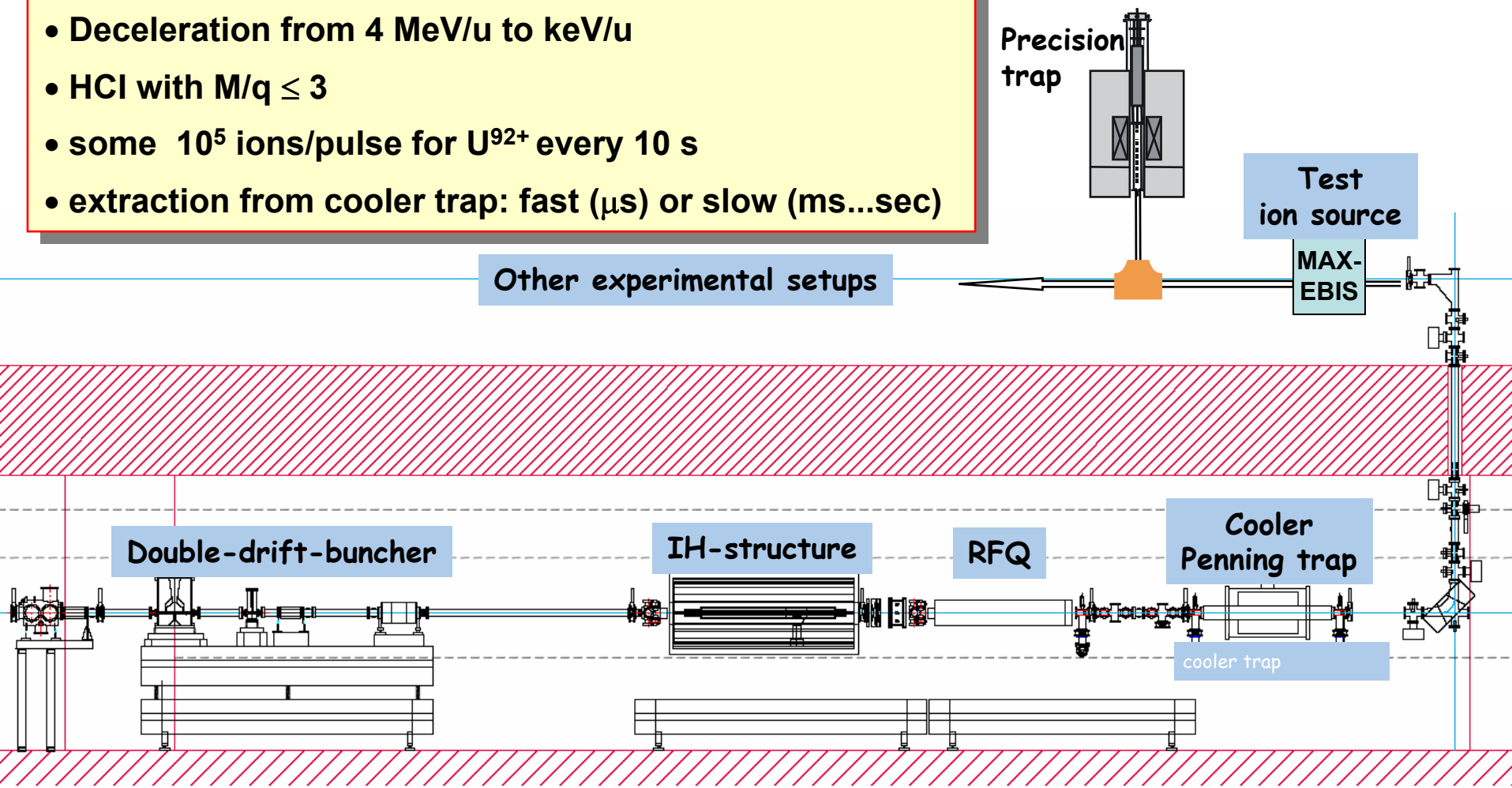
EXPERIMENTS WITH HIGHLY CHARGED IONS AT EXTREMELY LOW ENERGIES:

- H1: reaction microscope, collisions at very low velocities
- H2: HCI-surface interaction and hollow-atom spectroscopy
- H3: x-ray spectroscopy
- H4: g-factor measurements of the bound electron
- H5: mass measurements of extreme accuracy
- H6: laser spectroscopy

HITRAP overview in the re-injection channel at ESR

Operational Parameters:

- Deceleration from 4 MeV/u to keV/u
- HCI with M/q ≤ 3
- some 10^5 ions/pulse for U^{92+} every 10 s
- extraction from cooler trap: fast (μs) or slow (ms...sec)

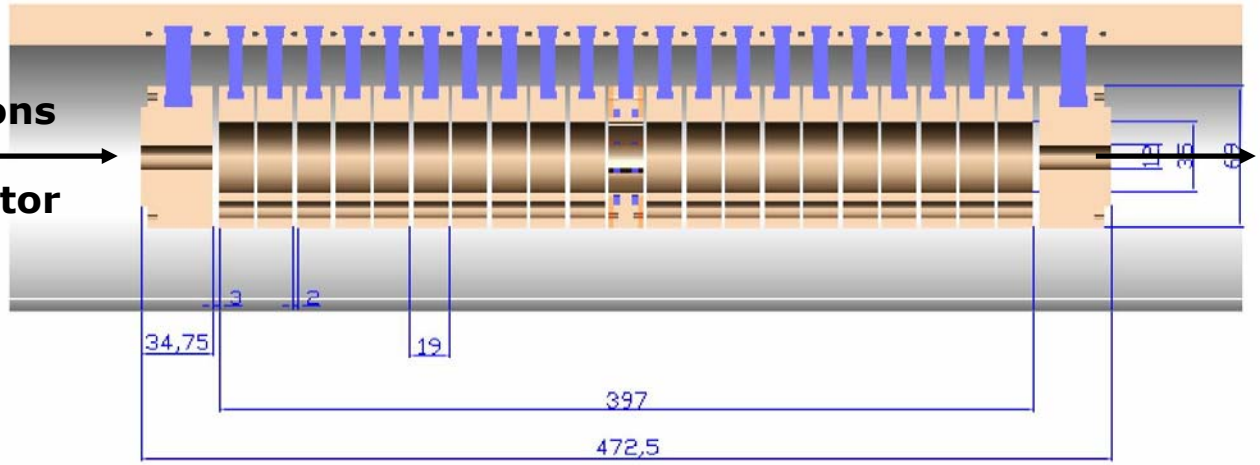


from ESR: 4 MeV/u → 0.5 MeV/u → 6 keV/u

HITRAP Cooler Penning trap

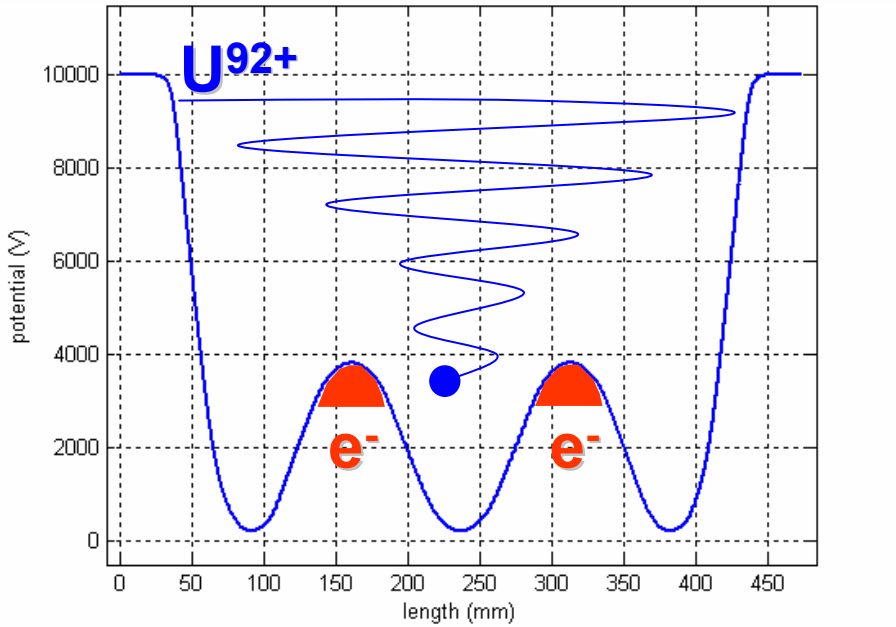
• electron cooling • resistive cooling to T = 4 K

highly charged ions from HITRAP decelerator

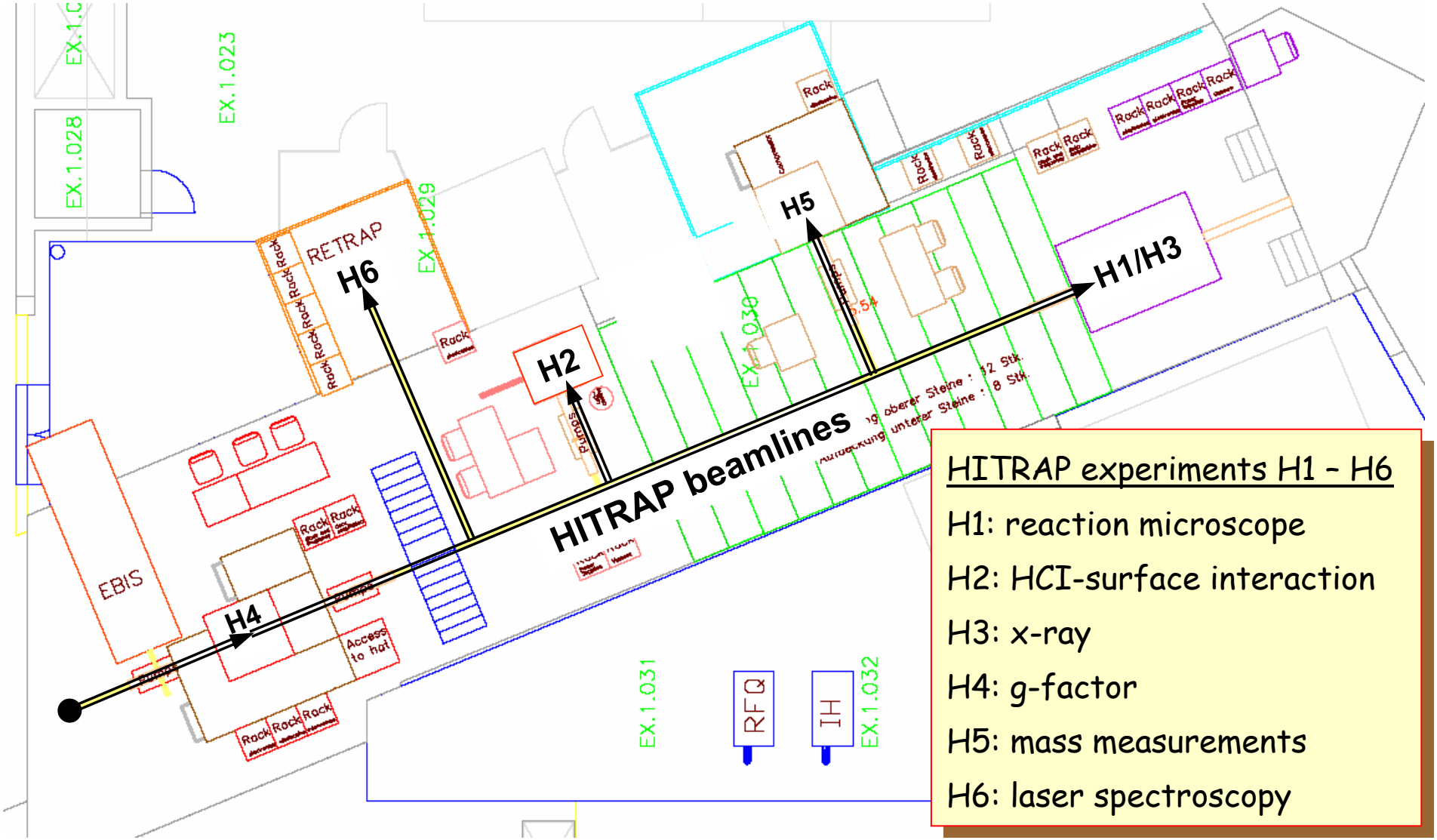


cooled HCI to HITRAP experiments

→ *see talks by*
F. Herfurth
G. Zwicknagel



Area for HITRAP experiments
(in ESR hall, 2nd floor, above HITRAP decelerator)



HITRAP experiments H1 – H6

H1: reaction microscope

H2: HCI-surface interaction

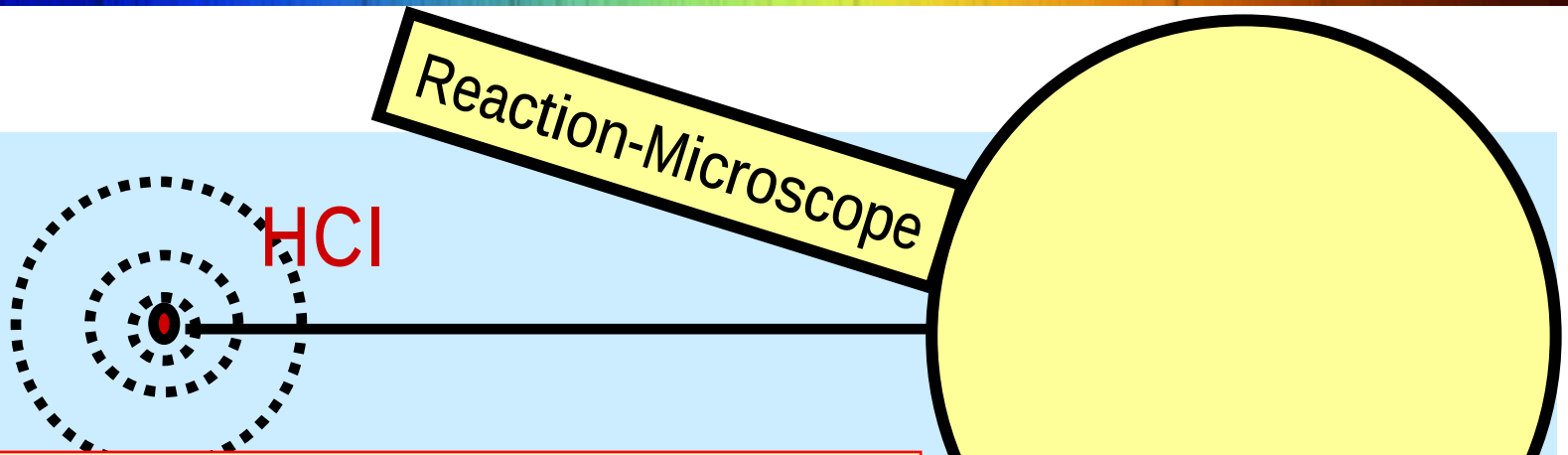
H3: x-ray

H4: g-factor

H5: mass measurements

H6: laser spectroscopy

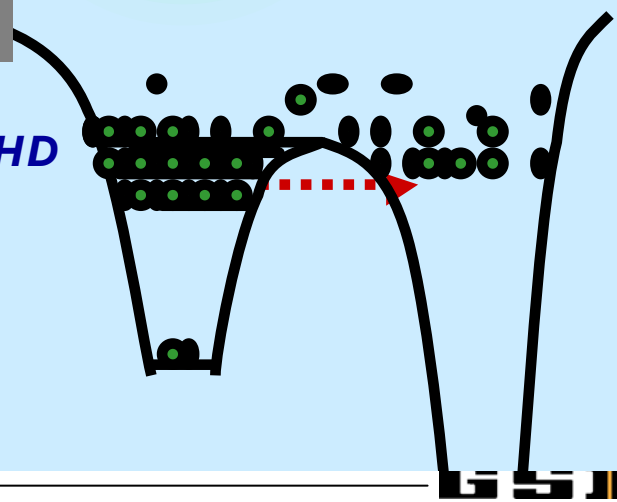
Collision studies and x-ray spectroscopy with slow highly charged ions up to U^{92+}



- **collision dynamics of slow HCI explored with a reaction microscope**
- **x-ray spectroscopy of ground and excited states**

Exp. H1: collision studies
J. Ullrich, R. Moshammer, MPI-K HD
M. Weidemüller, Freiburg

Exp. H3, x-ray spectroscopy
T. Stöhlker, M. Trassinelli



Collision studies and x-ray spectroscopy with slow highly charged

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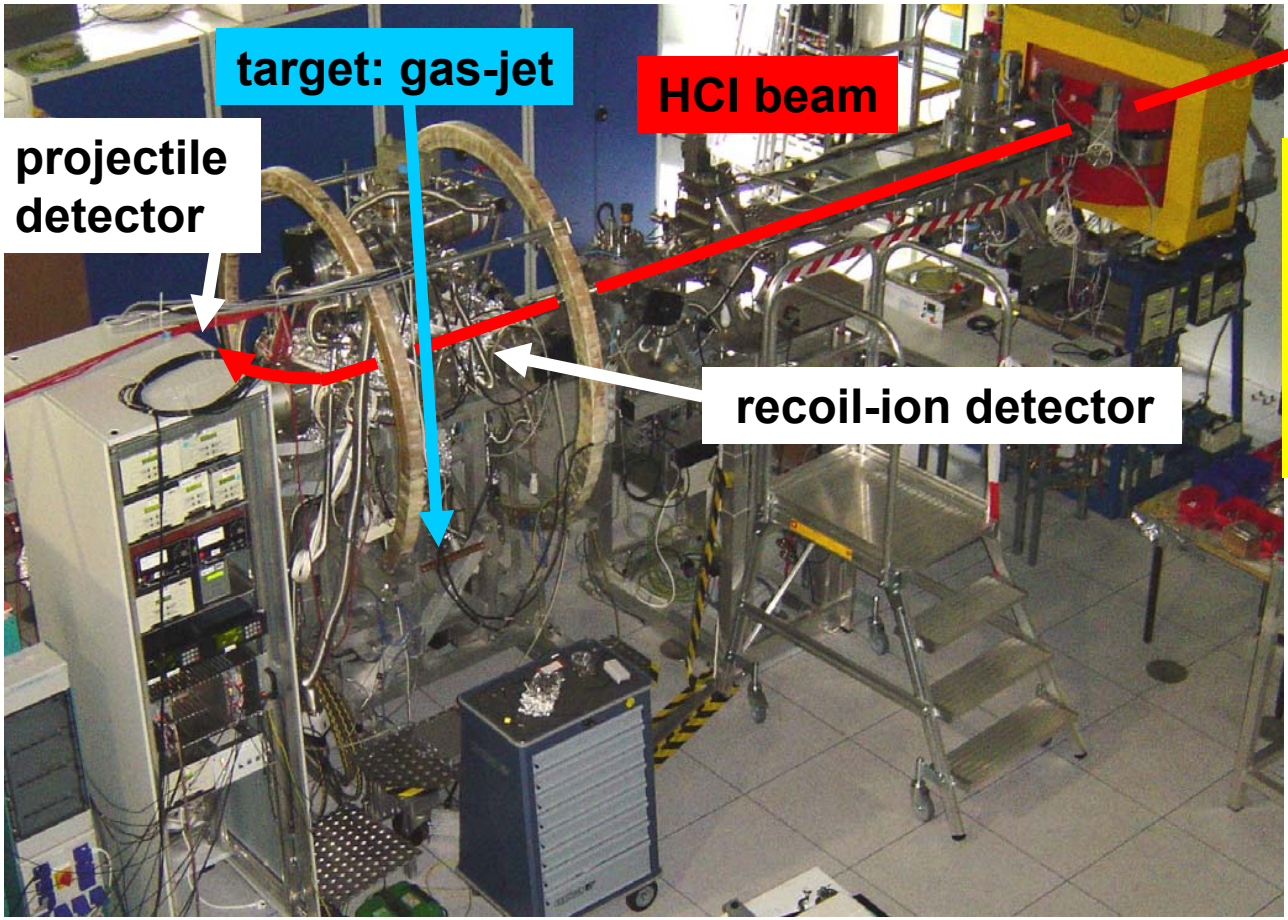


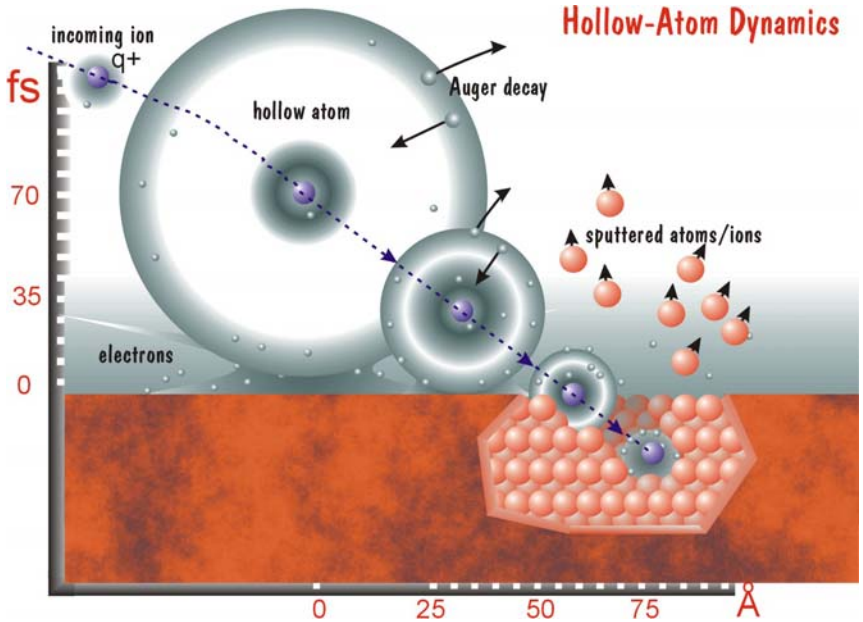
Status:
tested at MPI-K
and ready
for installation
at HITRAP

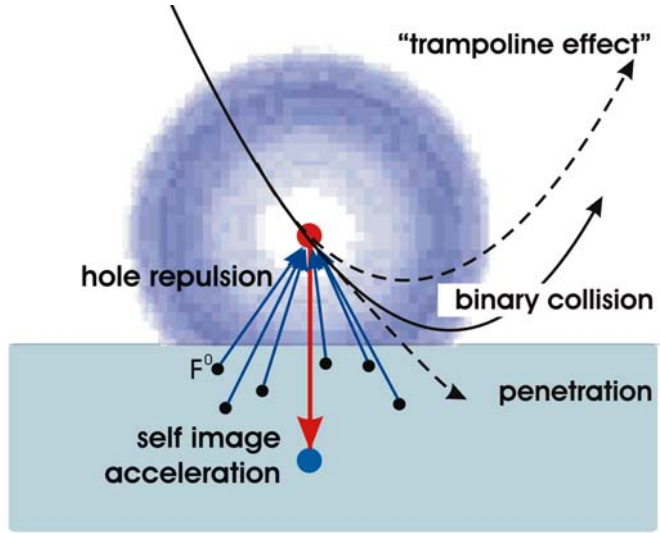
HCI-surface interaction with slow highly charged ions up to U^{92+}

Questions to be addressed:

- **hollow-atom** spectroscopy
- **high-spin states** via electron capture from magnetized surfaces
- **electron dynamics** at surfaces and thin films
- interaction of HCI with **microcapillaries**
- **trampoline effect** existent above a critical charge state?
- **surface lithography** by means of HCI impact?

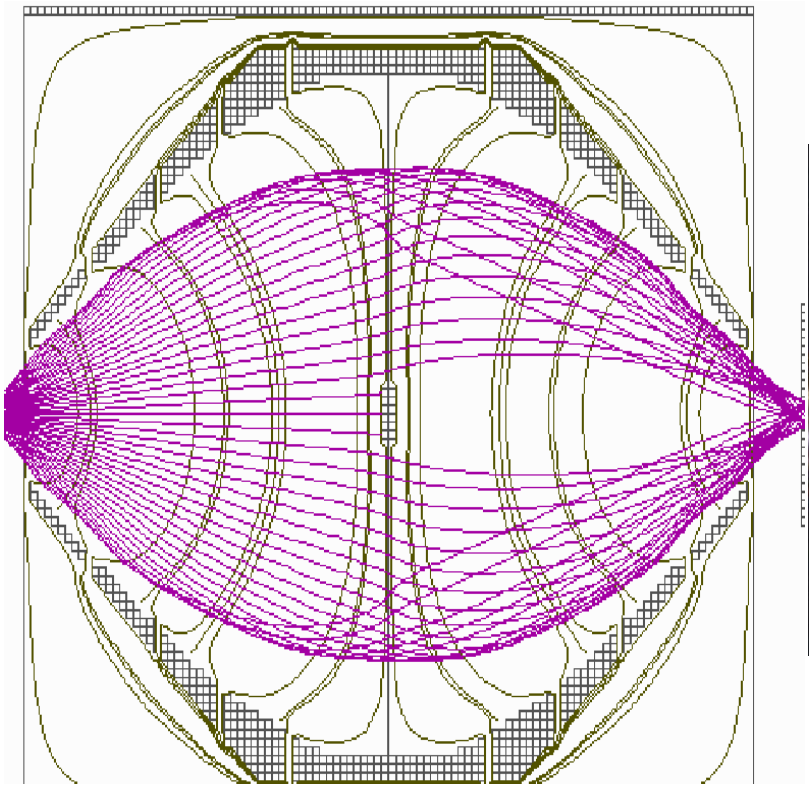
Exp. H2, groups:
R. Hoekstra/R. Morgenstern, KVI Groningen
R. Schuch, Stockholm
A. Warczak, Krakow
J. Burgdörfer, Vienna

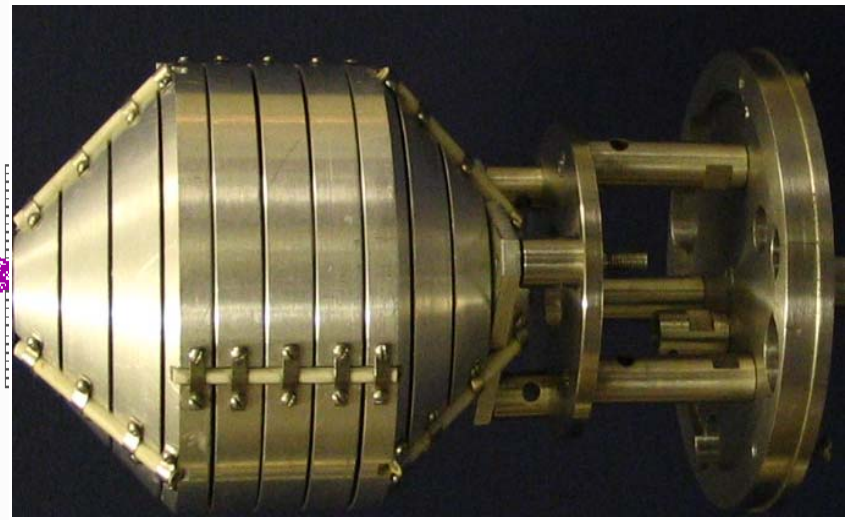




HCI-surface interaction with slow highly charged ions up to U92+

New electrostatic spectrometer designed for energy-resolved large-angle electron detection





g-Factor measurements on highly charged ions

Test of quantum electrodynamics in extreme fields

- g-factor of the bound electron
- electron correlations and relativistic effects

Recent highlights

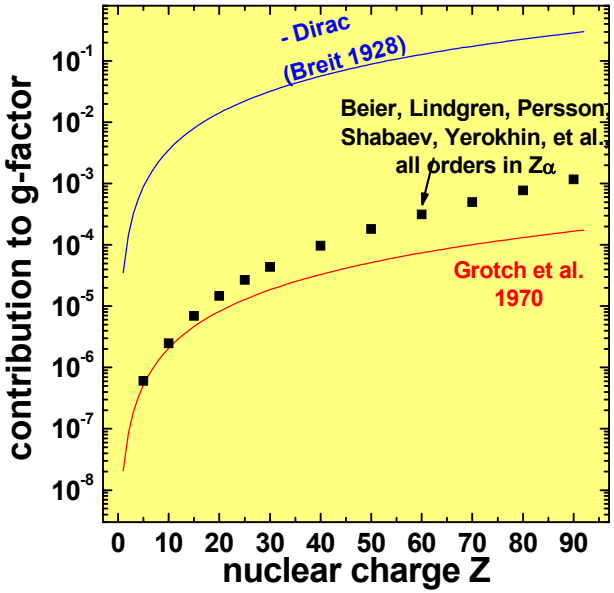
- g-factor measurements on H-like carbon $^{12}C^{5+}$ and oxygen $^{16}O^{7+}$ with accuracy better than 10^{-9}
- determination of electron mass

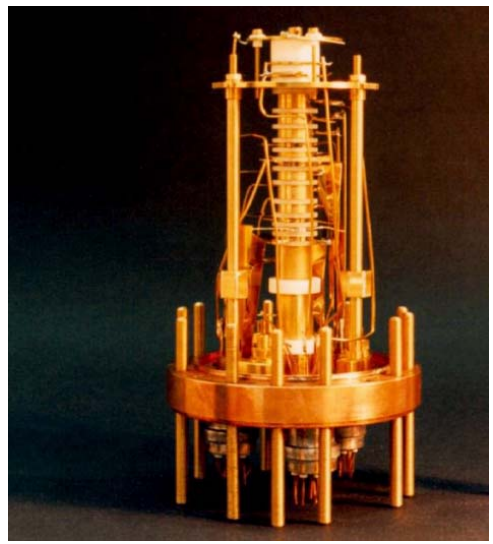
Status of uranium trap

- preparation of injection from HITRAP ongoing

SMILETRAP/Stockholm

- measured masses of HCI = critical input parameters for g-factor determination

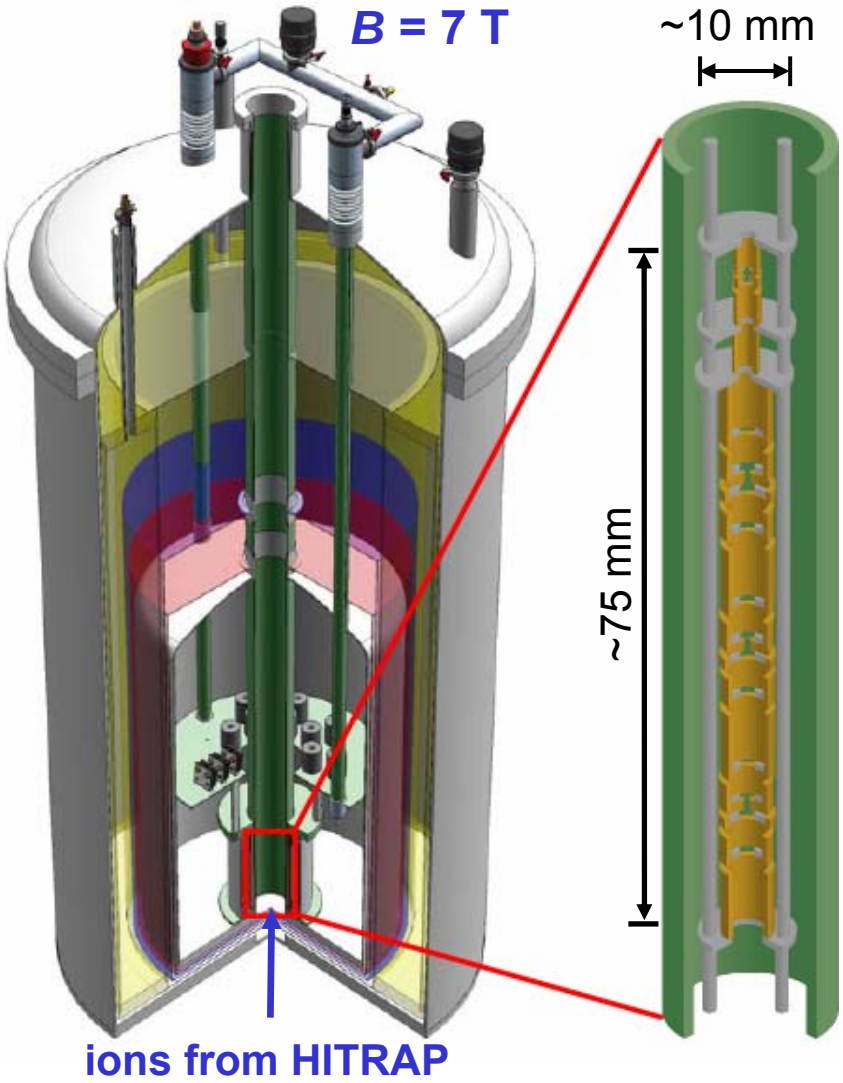




Exp. H4, groups:
K. Blaum, Mainz/GSI
R. Schuch, Stockholm

High-accuracy mass measurements with heavy HCI

novel four-fold Penning trap mass spectrometer

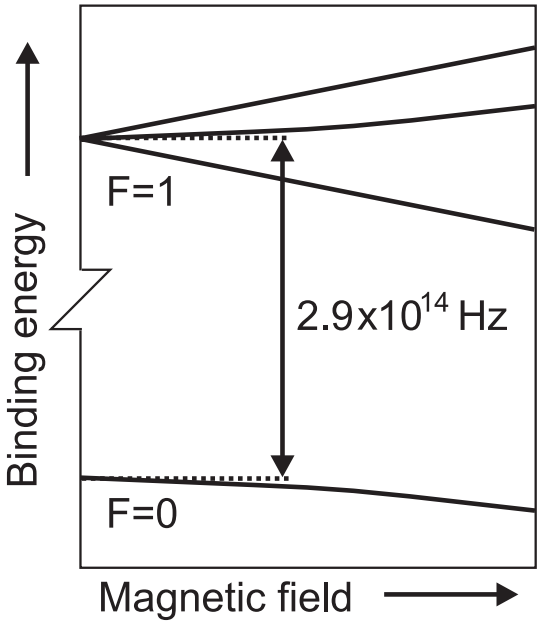


- measurement of cyclotron frequency in different charge states
- determination of atomic and nuclear binding energies

$\delta m/m < 1 \cdot 10^{-11} \rightarrow$
$\delta mc^2 \approx 2$ eV $\rightarrow$
'weighing' of Lamb shift

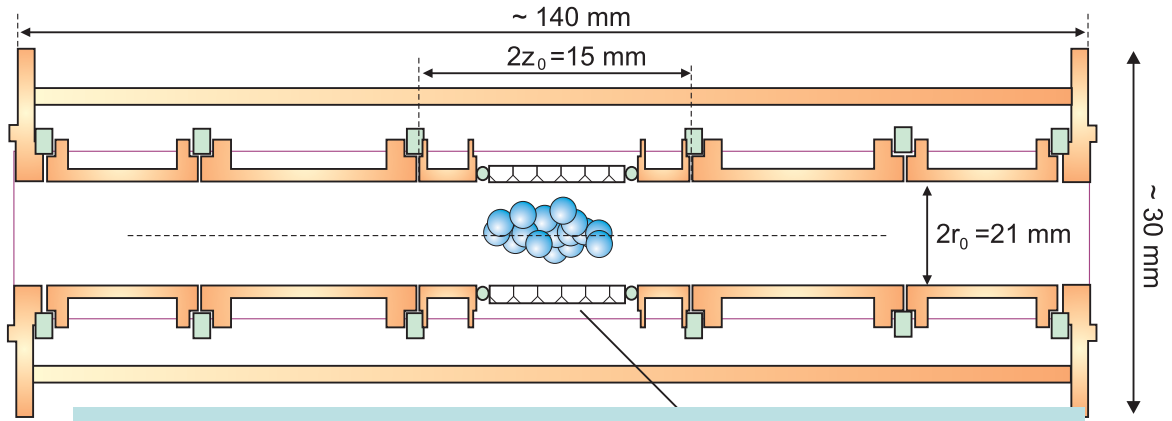
Exp. H5
group of K. Blaum
Mainz/GSI

Laser spectroscopy of hyperfine splitting in highly charged ions



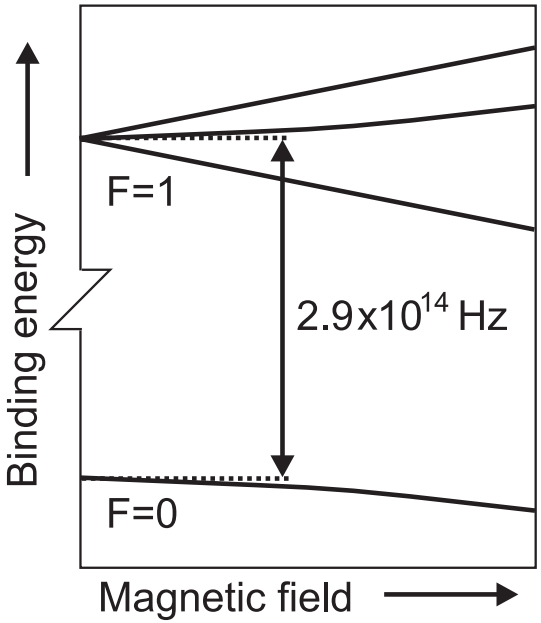
- **HFS wavelengths move into visible for Z>70**
- **very small Doppler width at T = 4 K**
- **relative wavelength accuracy ≤ 10^{-7}**
- **optical pumping for weak interaction studies**

- **QED investigations**
- **nuclear magnetization distribution: test of nuclear models**



Exp. H6, groups:
G. Birkl/Darmstadt
W. Nörtershäuser, M. Vogel, D. Winters
R. Thompson/London

Laser spectroscopy of hyperfine splitting in highly charged ions



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W. Nörtershäuser, M. Vogel, D. Winters
R. Thompson/London

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