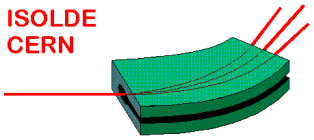
ISOLDE
CERN



Team **REX**

Latest news from REX

Didier Voulot for the
REX-team

- The 2009 campaign
- New beams
- Beam spot
- Charge exchange
- Consolidation
- Mass resolution tests
- Beta NMR set-up
- Diamond detectors

REX campaign 2009

(1) 72Kr
MINIBALL Coulex/shape measu. 2.85 MeV/u
☹ 9-gap vacuum failure: run cancelled

(2) 94,96Kr
MINIBALL Coulex 2.85 MeV/u
☹ Isolde vacuum failure half way through the run

(3) 62Mn/Fe, 63Mn
MINIBALL Coulex 2.86 MeV/u
-> Fe isotopes produced by in-trap decay of Mn
☹ PSB problems + linac RF (24h stop)

(4) 138Xe
MINIBALL Coulex/g-factor meas. 2.87 MeV/u

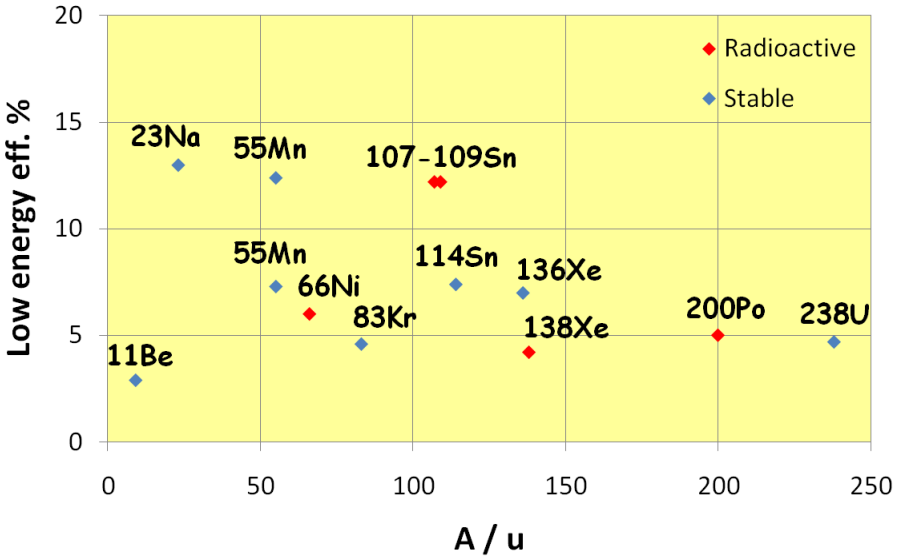
(5) 29,30Na
MINIBALL Coulex 2.85 MeV/u

(6) 200Po
MINIBALL Coulex/shape measu. 2.85 MeV/u
-> Heavy beam 5% low energy eff.

(7) 107,109Sn
MINIBALL Coulex energy 2.85 MeV/u
-> long run: 10 days

(8) 11Be
Transfer reactions at MINIBALL 2.86 MeV/u
-> stripping foils + isotopically pure buffer gas
☹ Cathode failure

(9) 66Ni
Transfer reactions at MINIBALL 2.9 MeV/u
-> long run: 10 days



* A number of failures:
  one run cancelled
  several runs hampered by problems

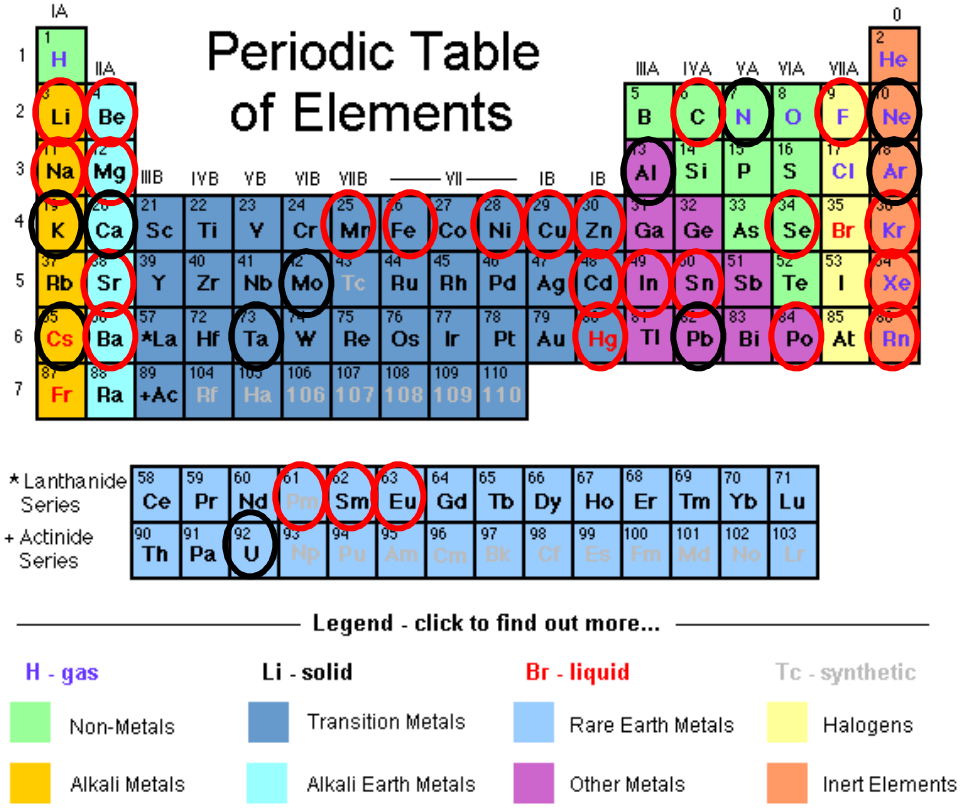
* Despite all problems we managed to deliver beams to (almost) all users

* Some promising results: 200Po, in-trap decay, transfer reaction of 66Ni

REX beam collection

New beams 2009

^{8,9,11}Li
^{10,11,12}Be
^{10}C
^{17}F
^{24,25,26,27,28,29,30}Na
^{28,29,30,31,32}Mg
^{61,62,63}Mn
^{61,62}Fe
^{66,68}Ni
^{67,68,69,70,71,73}Cu
^{74,76,78,80}Zn
^{70}Se
^{88,92,94,96}Kr
^{96}Sr
^{100,102,104,122,124,126}Cd
^{108}In
^{106,107,108,109,110}Sn
^{138,140,142,144}Xe
^{140,142,148}Ba
^{148}Pm
^{153}Sm
^{156}Eu
^{182,184,186,188}Hg
^{200}Po
^{202,204}Rn

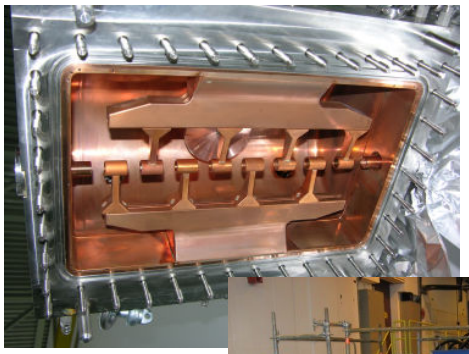


72 radioactive isotopes of 25 elements

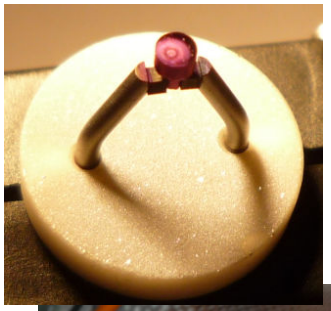
A selection of stable elements charge bred

Why so many failures?/ What can we improve?

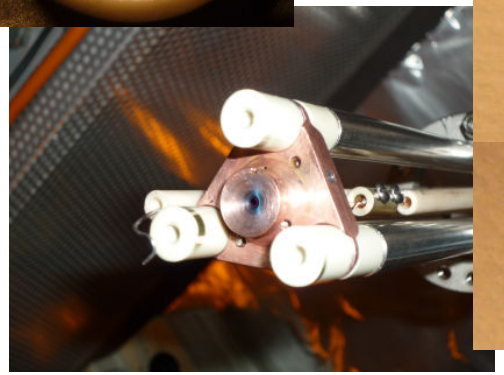
* 9-gap vacuum seal
  - -> REX tunnel => easier access to equipment = faster intervention
  - -> Experience gained with silver seals (know-how + spare parts + documentation)



* ISOLDE vacuum blackout
  - -> new vacuum control system (this shutdown for ISOLDE, next year for REX?)



* EBIS cathode
  - -> try new cathode material (not many options)
  - -> investigate the cause of the problem: analyze defunct cathodes, try different mode of operation/cleaning procedure … (would need EBIS test bench)



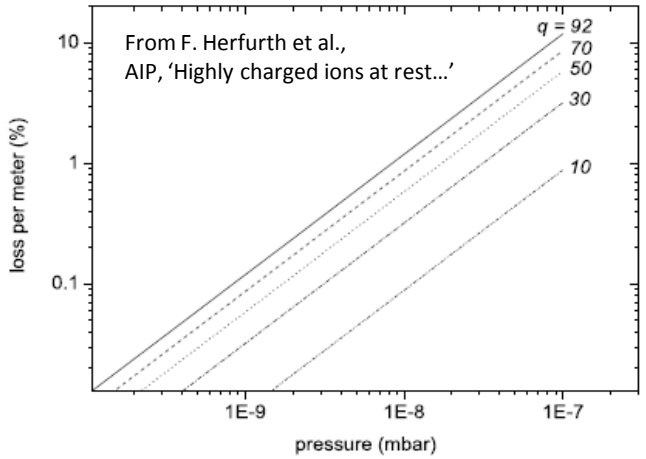
Charge exchange/heavy ions

Limited efficiency for heavy ion beams
Used to blame the EBIS:
-> moderate electron beam
-> heating losses / radiative recombination

True but could also be due to charge exchange in the separator and linac

Theory
Salzborn approximation for <25 keV/u

$$\sigma_{q,q-1} = 1.43 \cdot 10^{-12} \cdot q^{1.17} \cdot I^{-2.76} cm^2$$



Investigation

Deteriorated pressure in part of REX mass separator from 2E-7 to 1.3E-6 mbar
=> separator transmission reduced with 40% for 238U48+

Compared transmission for light (A/q=4) and heavy beam (238U57+, A/q=4.17)
A/q similar but transmission ~20% lower for the heavy beam

Losses must occur in the linac (most likely before the IHS?)

The transmission is not affected by a vacuum deterioration from ~1E-6 mbar to a few E-6 mbar after the linac at 3 MeV/u beam energy

NB. TRIAC/TOKAI has also seen charge exchange after the RFQ

Goal:

- reduce separator pressure from 2E-7 mb to < 1E-8 mb

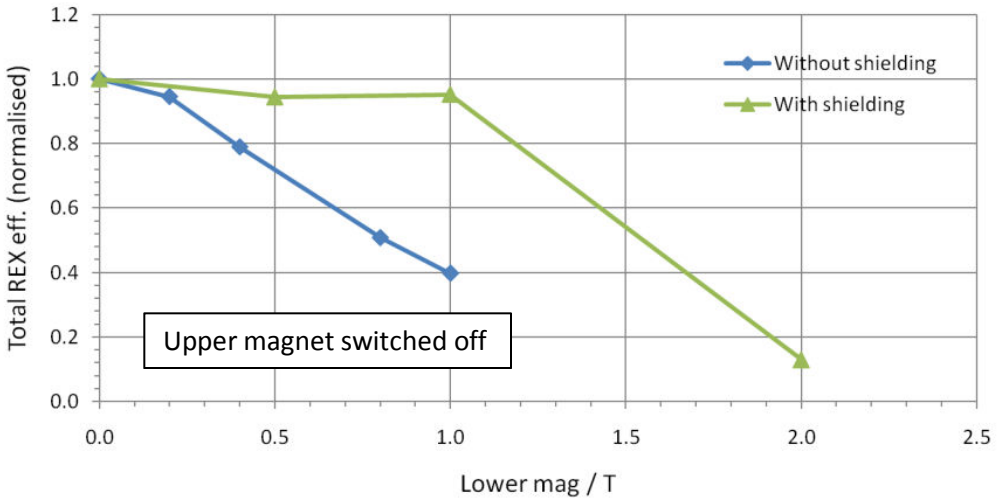
- all linac sectors below 5E-7 mb

- small modifications in mass separator this shut-down
- modification of linac's diagnostics boxes
- optionally more ambitious modifications of separator vacuum 2010-2011

REX separator shielding to WITCH magnetic field

Tested beam transport and A/q-scaling with B-field on
-> transport can work for limited B-field (3T lower magnet) with large steering
-> A/q-scaling does not work

=> WITCH magnet should not be energized while REX is setting up or delivering radioactive beam



Shielding provided by WITCH

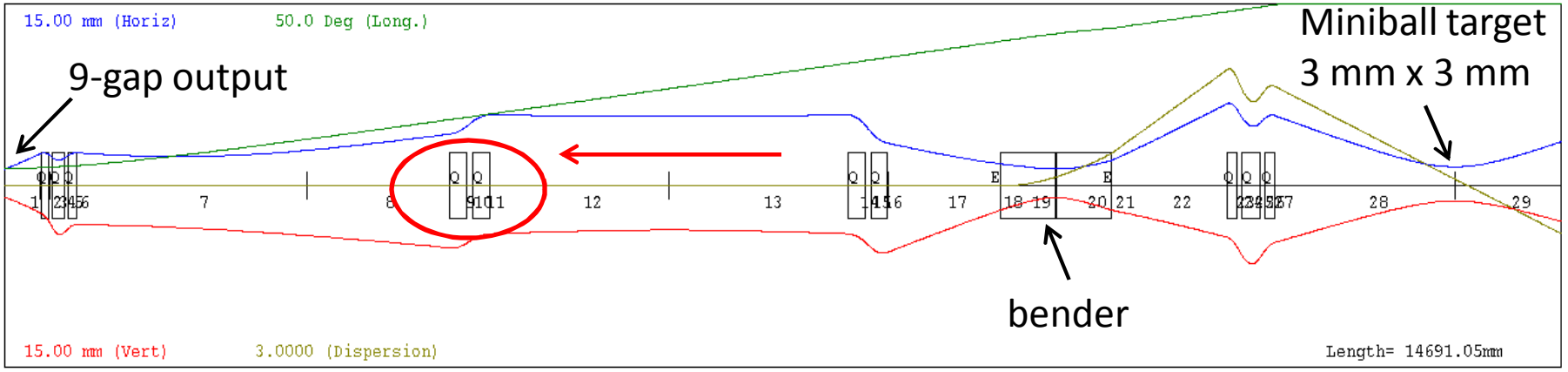
Short news…

• PAM - new picoampere meter for REXTRAP tested
In-house production by BE-BI, to replace obsolete Keithley 485
Variable integration time, noise level few 100 fA, very promising
->To be used after the general upgrade of the REXTRAP control system
-> Could be used elsewhere on REX and ISOLDE

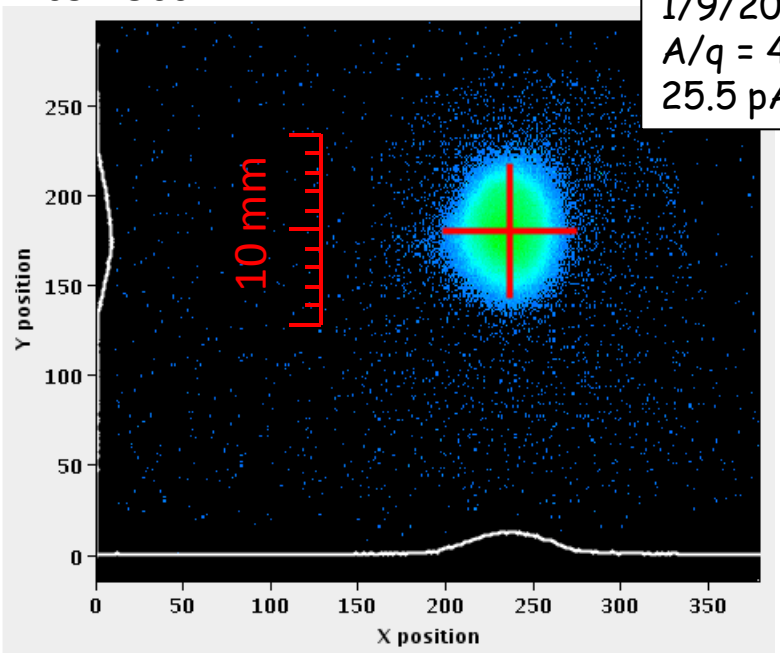
•The upgrade of the REXTRAP control system has now been fixed to shutdown 2010-2011. All groups agree. Detailed solutions under discussion with the involved groups.

• Beam challenge of the year – breeding test of neutron rich Ra (224Ra)
Few percent efficiency for 300 ms breeding time -> heavy Rn and Ra beam available for experiment, radiation limits permitting

Beam spot and linac scalability



XL65.BO60



1/9/2009
A/q = 4 beam
25.5 pA (3E7pps)

- new optics
- use standard settings
- FC after Miniball
- also coming new steering magnets

-> Improved beam-spot and focusing at Miniball

-> Faster set-up and beam steering

-> Reliable scaling

Still not perfect: need steering, stray beam on detectors, losses on collimators…
-> check alignment
-> check beamspot at Miniball (Colutron MCP)

Linac consolidation I

- Linac RF cooling and ventilation

  New ventilation for the RF room + Modification of RF amplifier (water cooling with heat exchangers)

  -> improve temperature stability + cleanliness

  -> longer RF tube lifetime (25kCHF/piece)

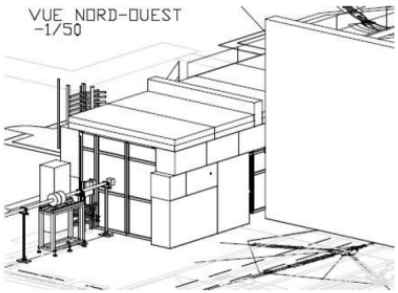
- Linac shielding

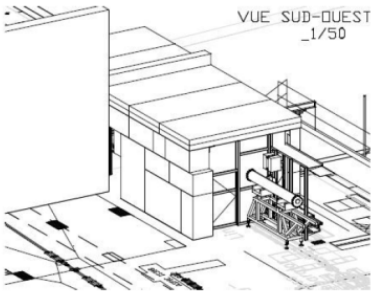
  Construction of shielding tunnel around the linac

  -> remove lead boxes on cavities

  -> faster and easier access to equipment

  -> less X-ray background at Miniball?





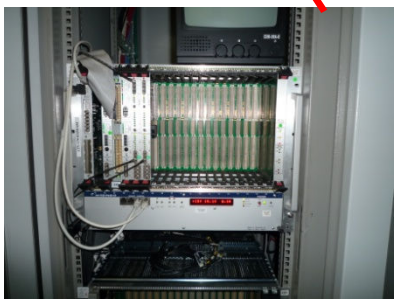
Linac consolidation II

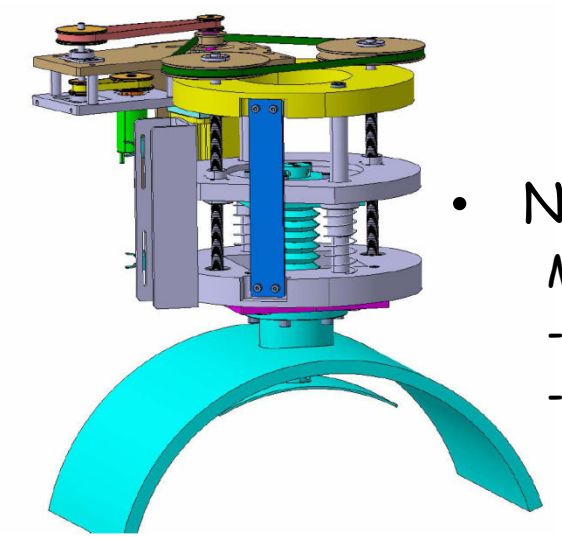
- Beam instrumentation controls

  Replace old control system (RS485, MS Visual Basic Windows based system) with control server based on a VME crate + dedicated VME cards

  -> CERN standard easier to maintain

  -> modular system (possibility of extension and modification)





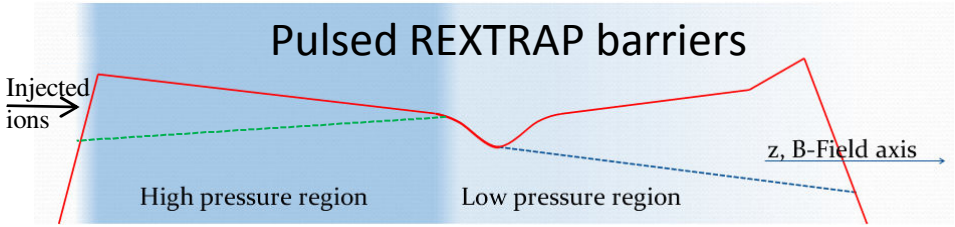
- New tuner mechanics for the 7-gaps

  More reliable, easier to maintain

  -> less RF interruptions

  -> under construction (maybe installed next year)

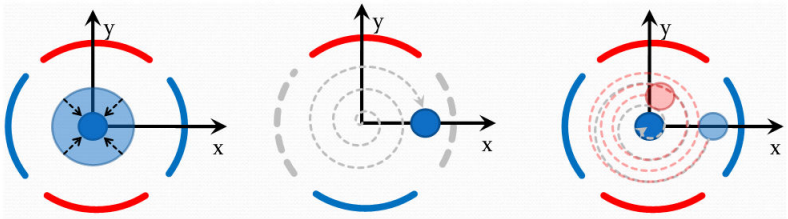
mass resolution tests – final results



ISCOOL used as cooler and buncher
rep. rate 200 ms

Mass separation operation cycle

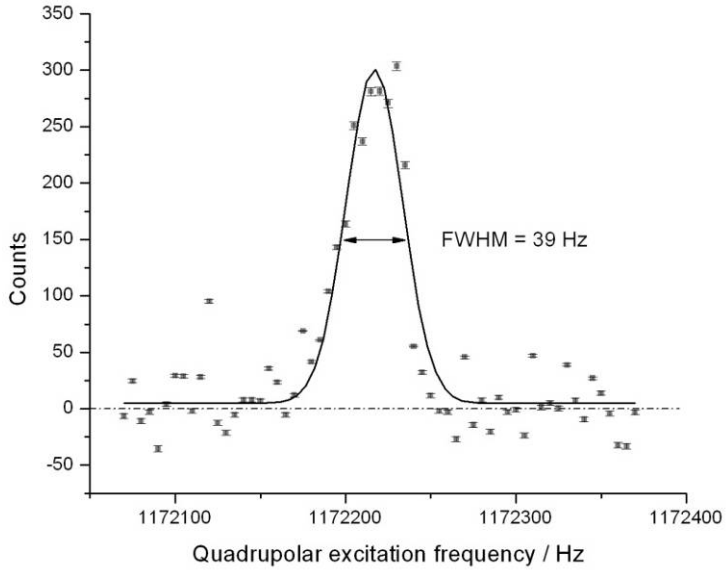
- cool down the ion cloud
- shift out the ion cloud with a dipolar excitation
- selectively re-centre the desired species



Cooling
60 ms

Dipolar excitation
20 ms

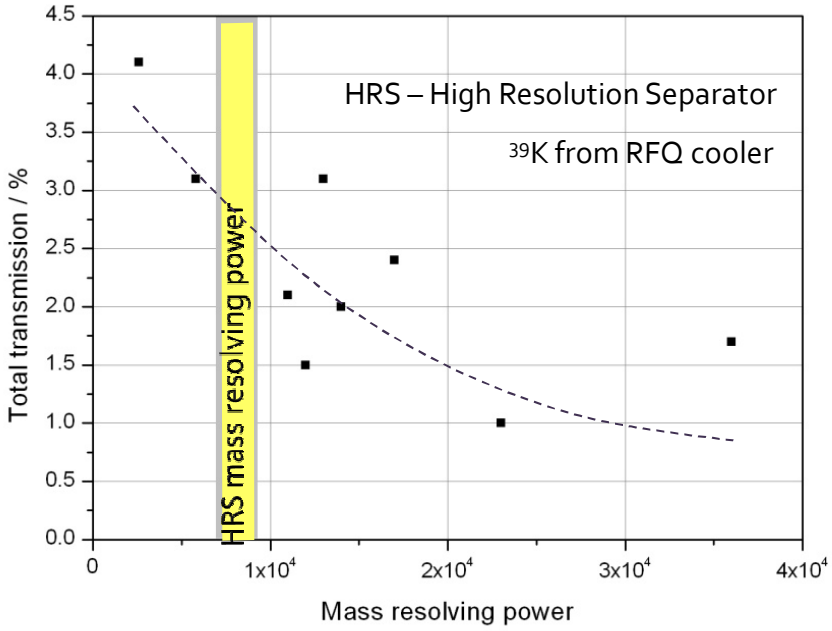
Selective cooling
120 ms



Resonance curve for ^{39}K
Mass resolution = **3.0E4**
REXTRAP + REXEBIS transmission **2.5 %**
98% suppression

mass resolution tests – final results

Measured after the REXEBIS -> trap cooling sufficient contamination suppression 20-50 (lower limit)



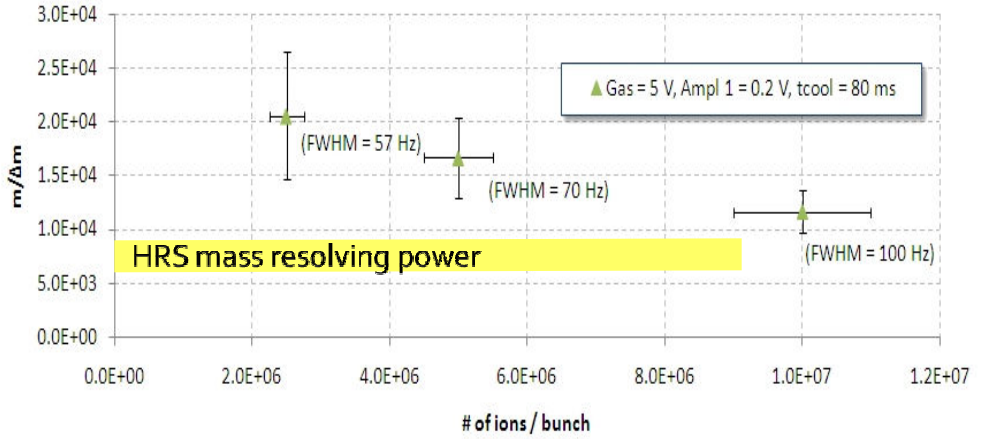
Compare with 17% without mass resolution

Space charge effects > 1E6 ions/pulse

Frequency shifts -> can be compensated for

Peak broadening -> reduced mass resolution

Current limit includes stable contaminants



Apart from efficiency and space charge…

1. Total cycle time 100 to 200 ms
   Limits the use of nuclides with halflives < 100ms
2. Setup not evident – at least 8 h; slowly gaining experience
3. Processes in the trap not fully understood
   (Multiple peaks appearing for single element !?!)

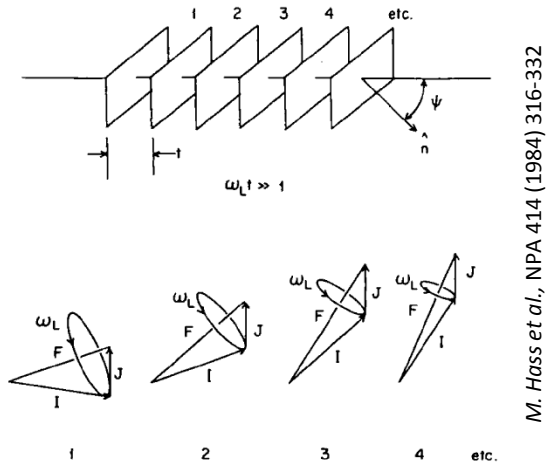
Work by A. Gustafsson

Real test to come: isobarically contaminated radioactive beam

β-NMR setup

Goal to obtain nuclear
spin-polarized radioactive beams

• nuclear structure (moments, reactions …),
nuclear methods in the solid-state physics,
biophysics etc. …



M. Hass et al., NPA 414 (1984) 316-332

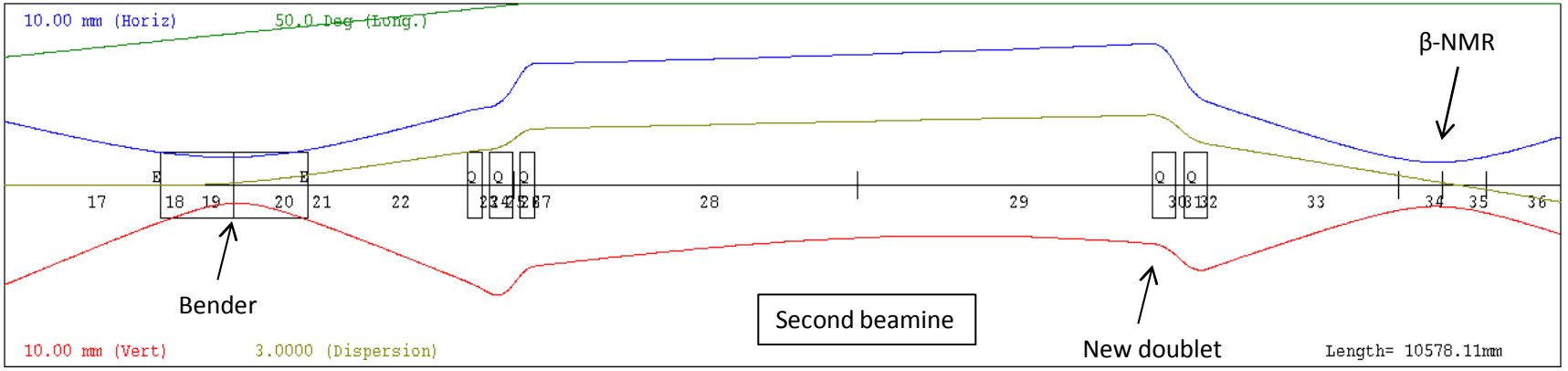
• Tilted foil for polarization
• β-NMR setup as diagnostics tool

Beta-NMR setup from HMI Berlin
Now under installation after REX

Preliminary installed
- magnet
- sample chamber
- scintillators, light guides and PM tubes
- vacuum system
- electronics
- beam-line quadrupole magnet

Special thanks to Dr. W-D Zeitz
for his assistance

β -NMR setup



Next steps

* Install beam line system

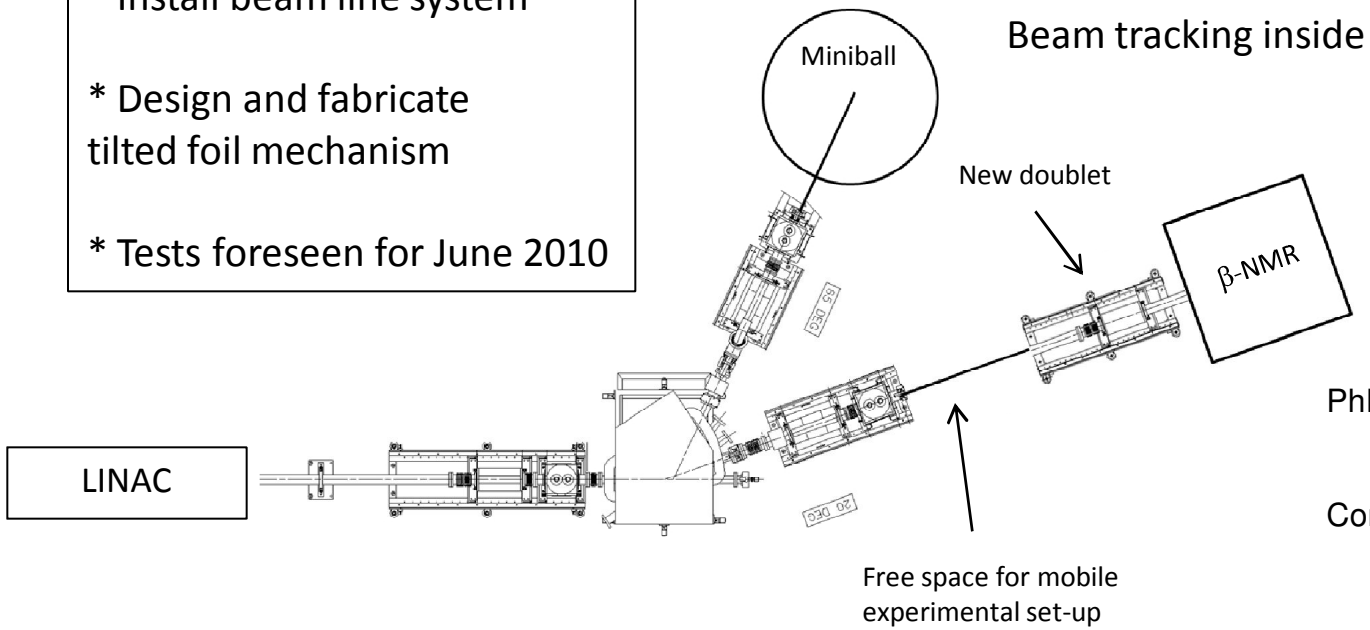
* Design and fabricate tilted foil mechanism

* Tests foreseen for June 2010

TRACE3D beam calculations into β-NMR setup

5 mm beam diameter over 60 cm distance

Beam tracking inside magnetic field to follow

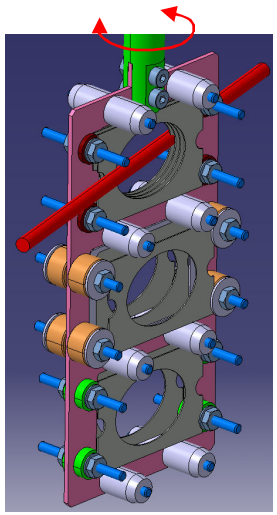


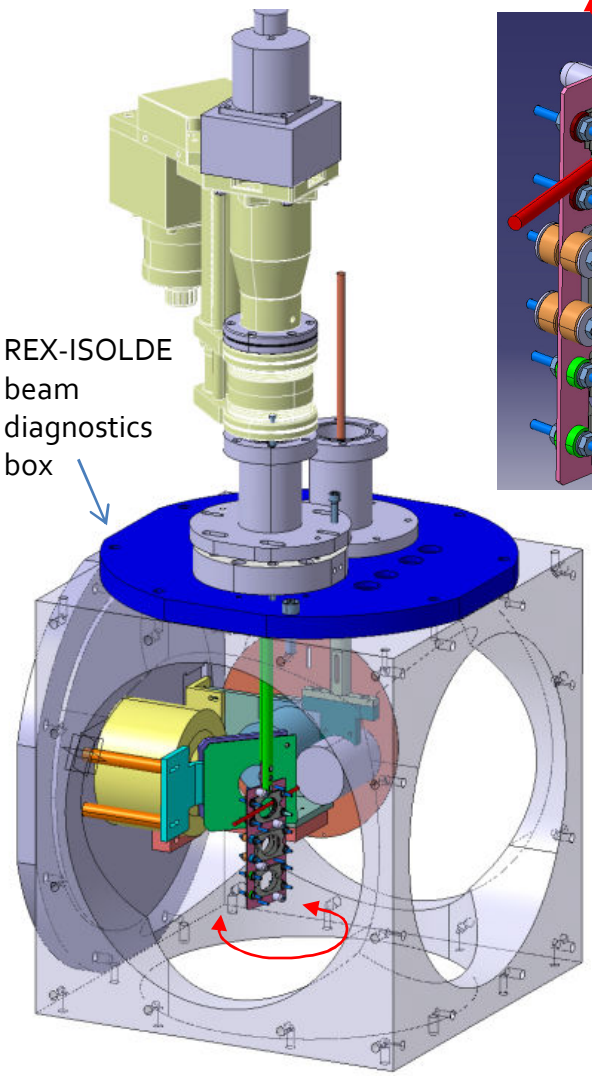
β-NMR collaboration invites interested parties

PhD students:
C. Sotty and H. Tornqvist

Contact persons:
G. Georgiev CNRS
K. Jonston CERN
F. Wenander CERN

Mobile tilted foil setup





Mobile setup with several degrees of freedom

Latest news

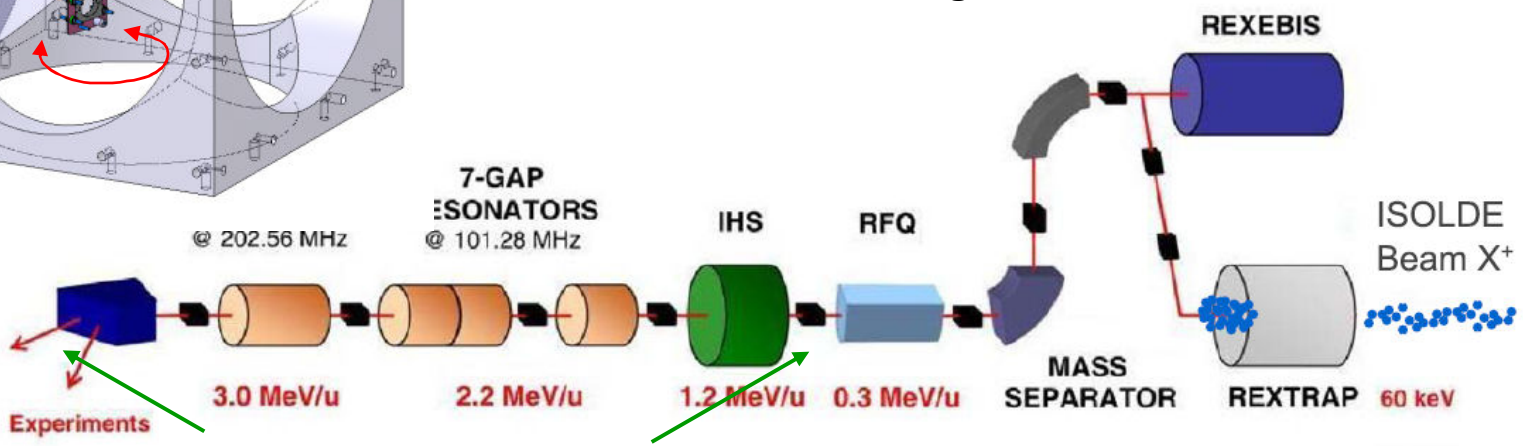
1. Stepper motor for foil inclination/rotation is operational

2. New larger foils arrived (40x12 mm2)

Initial test scheduled for week 48

- Coulex at 3 and 2.2 MeV/u
- Stable polarized 21Ne (3/2+ g.s.)
- Use Miniball particle and gamma detectors

At a later stage installation at 300 keV/u

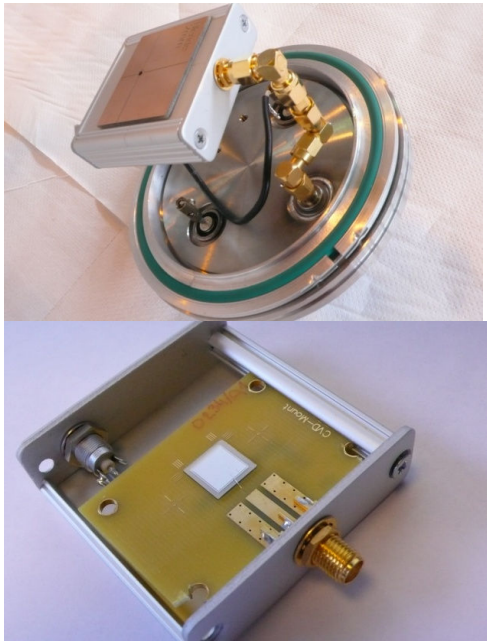


possible positions

Diamond detectors for REX beam diagnostics (HiE-REX)

Possible applications:

- intensity measurements: large dynamic range (from particle counting mode to pA) + radiation hardness
- energy measurements/beam composition
- time/phase measurements (fast response)

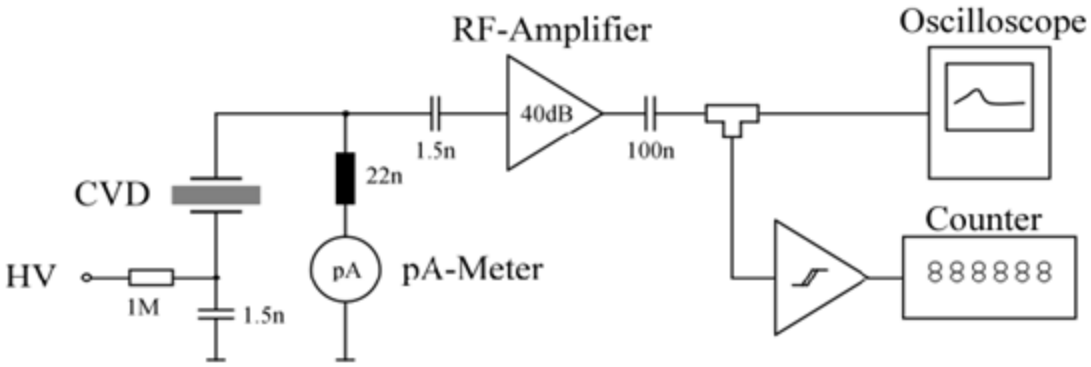


Test with poly-crystalline and single crystal CVD diamond detectors with C4+ and A/q 4 beam at 1.9 and 2.8 MeV/u

pCVD, 10x10 mm², 500 um thick
plated with square 8x8 mm² Al electrodes
thickness of 25 nm

sCVD, 5x5 mm², 500 um thick
plated with 3 mm diameter Au electrodes
thickness of 500 nm

Manufacturer: Diamond Detectors Ltd
own contact layers



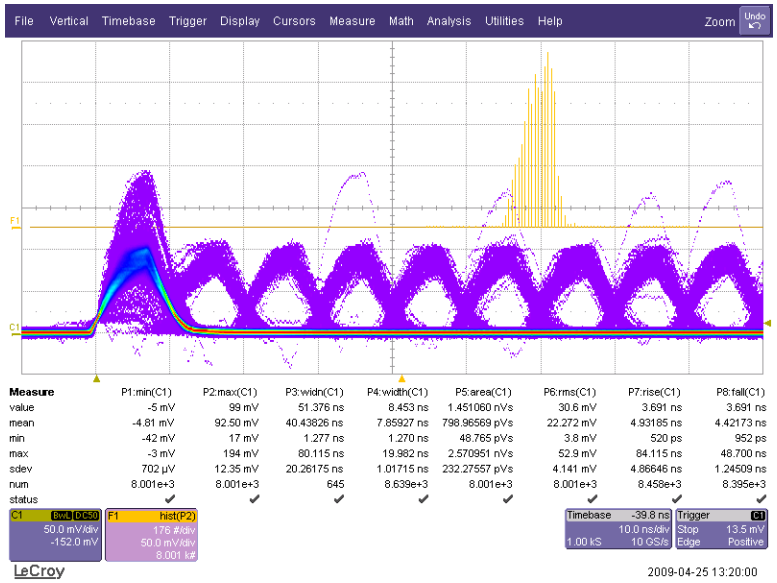
Diamond detectors for REX beam diagnostics (HiE-REX)

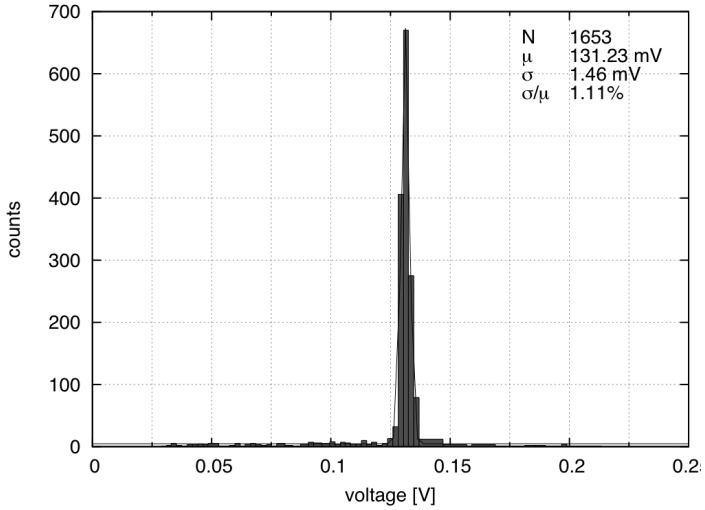
For sCVD

+ Very low noise level (< 1mV)
  -> Noise discrimination easy

+ Particle counting up to 1E4 part/s

+ ~1% energy resolution 12C4+ 1.9 MeV/u
  with 1000 V bias





Some problems with pCVD :

1. fluctuating leakage current (tens pA to nA)
2. signal height polarity and time dependent
3. signal size decreases with beam loading / time

… more work needed but great potential

Test 'outsourced' to:
E. Griesmayer, ATLAS/CERN and
Bergoz Instrumentation, St Genis, France

Big THANKS from the REX-team to

Jarno VAN de WALLE

for his outstanding contribution to the success of

REX/Miniball in the last four years

… and welcome to Janne PAKARINEN