Physics opportunities with the new Schottky pickups in the CR

**F. Bosch, C. Brandau, P. Hülsmann, C. Kozhuharov, Yu.A. Litvinov,
F. Nolden, M.S. Sanjari, M. Steck, P.M. Walker, N. Winckler**

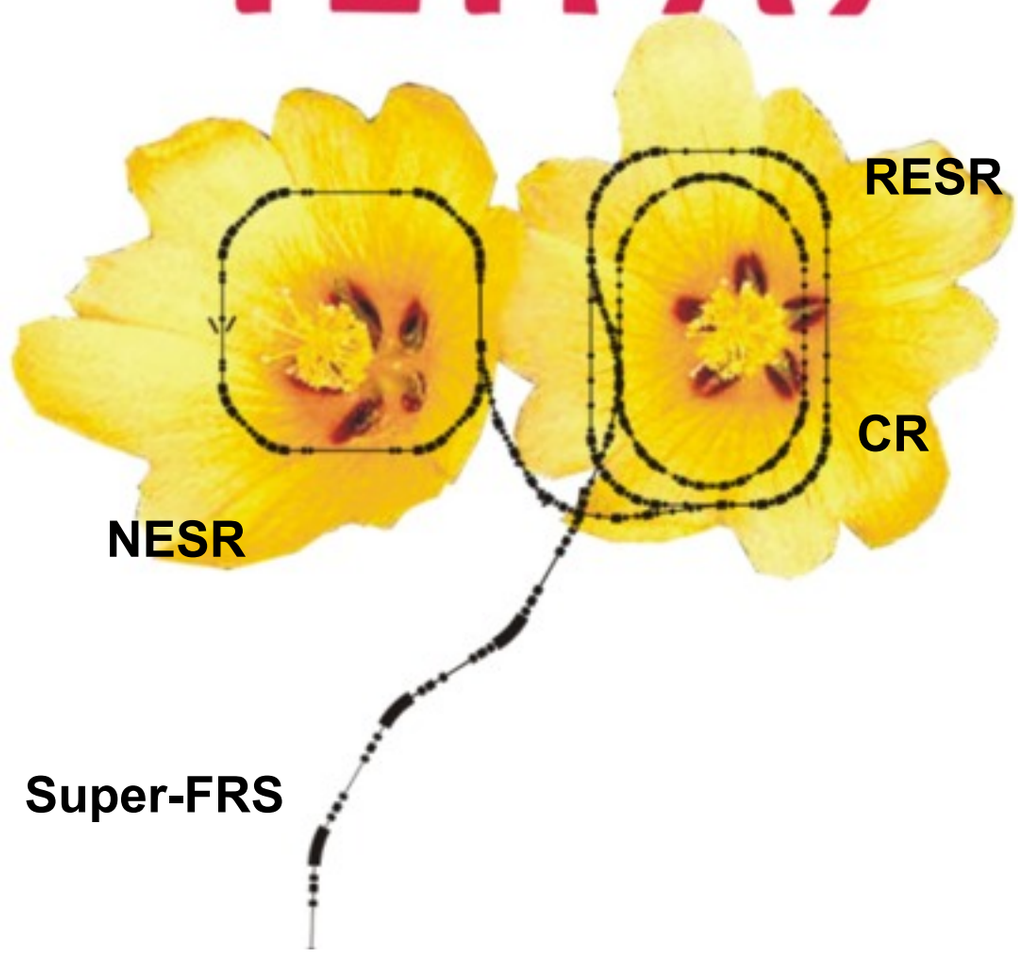
**ILIMA Open Meeting at the NuSTAR Week
28 February 2012
GSI, Darmstadt**

Physics opportunities with the new Schottky pickups in the CR

F. Bosch, C. Brandau, P. Hülsmann, C. Kozhuharov, Yu.A. Litvinov,
F. Nolden, M.S. Sanjari, M. Steck, P.M. Walker, N. Winckler

ILIMA

FAIR - CORE Facility



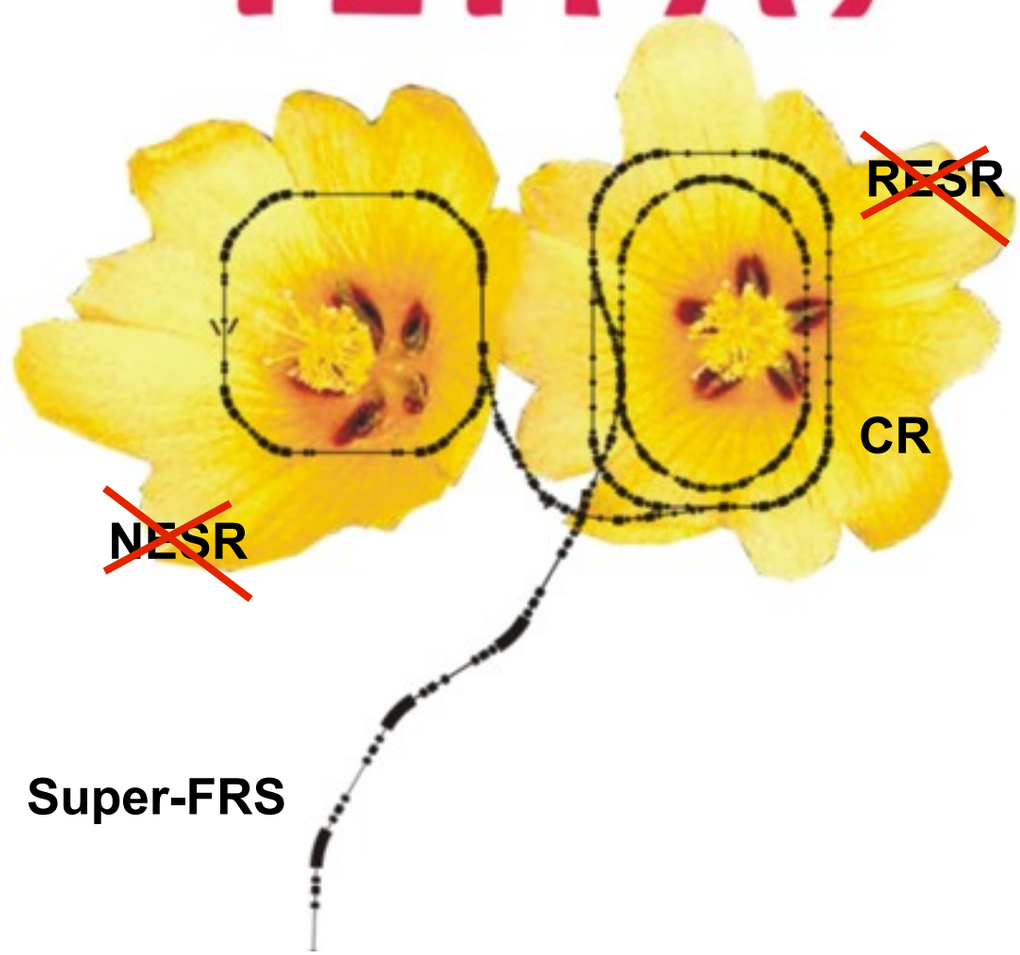
ILIMA Open Meeting at the NuSTAR Week
28 February 2012
GSI, Darmstadt

Physics opportunities with the new Schottky pickups in the CR

F. Bosch, C. Brandau, P. Hülsmann, C. Kozhuharov, Yu.A. Litvinov,
F. Nolden, M.S. Sanjari, M. Steck, P.M. Walker, N. Winckler

ILIMA

FAIR - CORE Facility



FAIR - Modularized Start Version (MSV)

ILIMA Open Meeting at the NuSTAR Week
28 February 2012
GSI, Darmstadt

ILIMA Set-Up at FAIR

ILIMA LoI (2004)
ILIMA TP (2005)
ILIMA TP Update (2006)

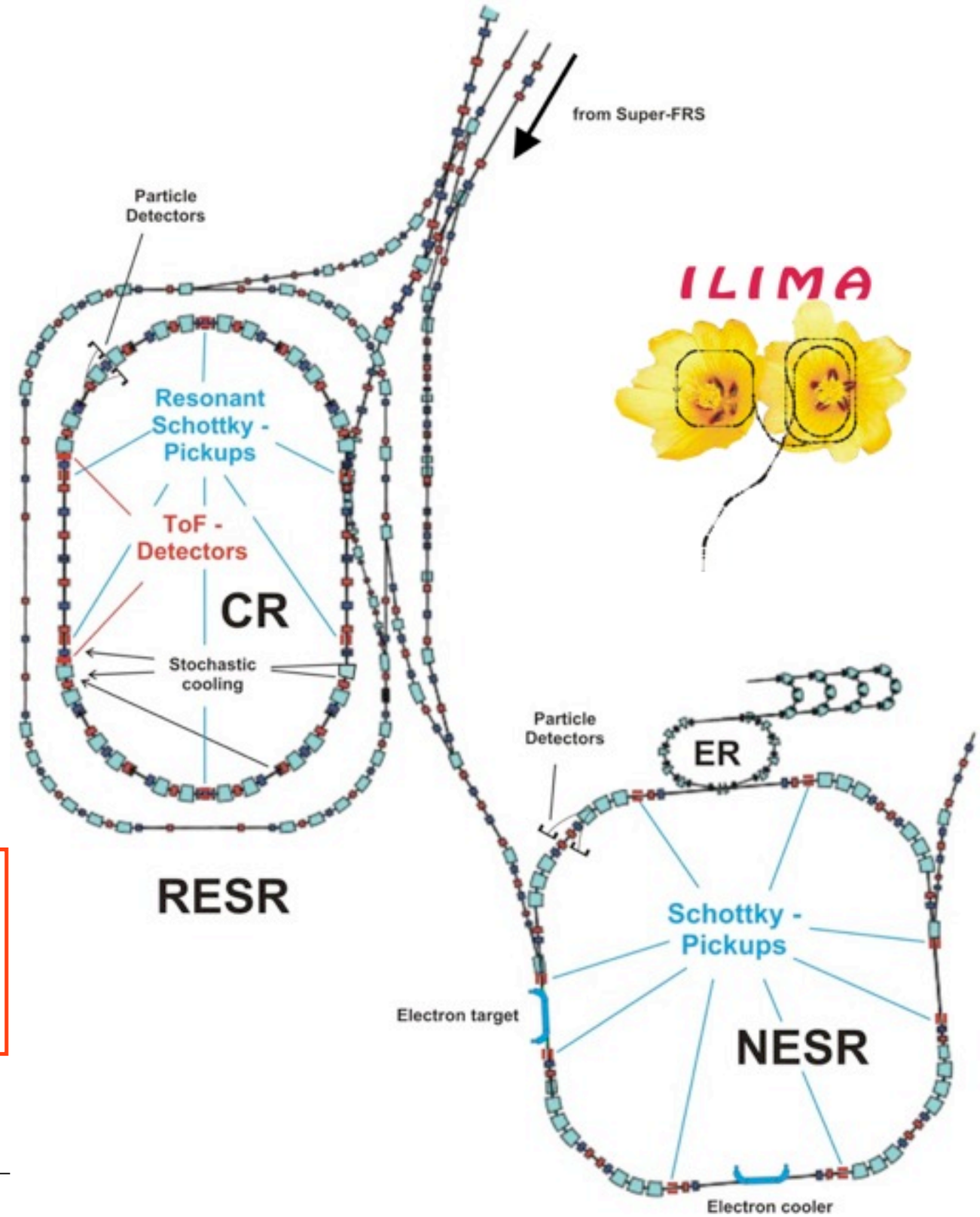
Isochronous Mass Spectrometry in the CR

$$\gamma \rightarrow \gamma_t$$

Schottky Mass Spectrometry in the CR & NESR

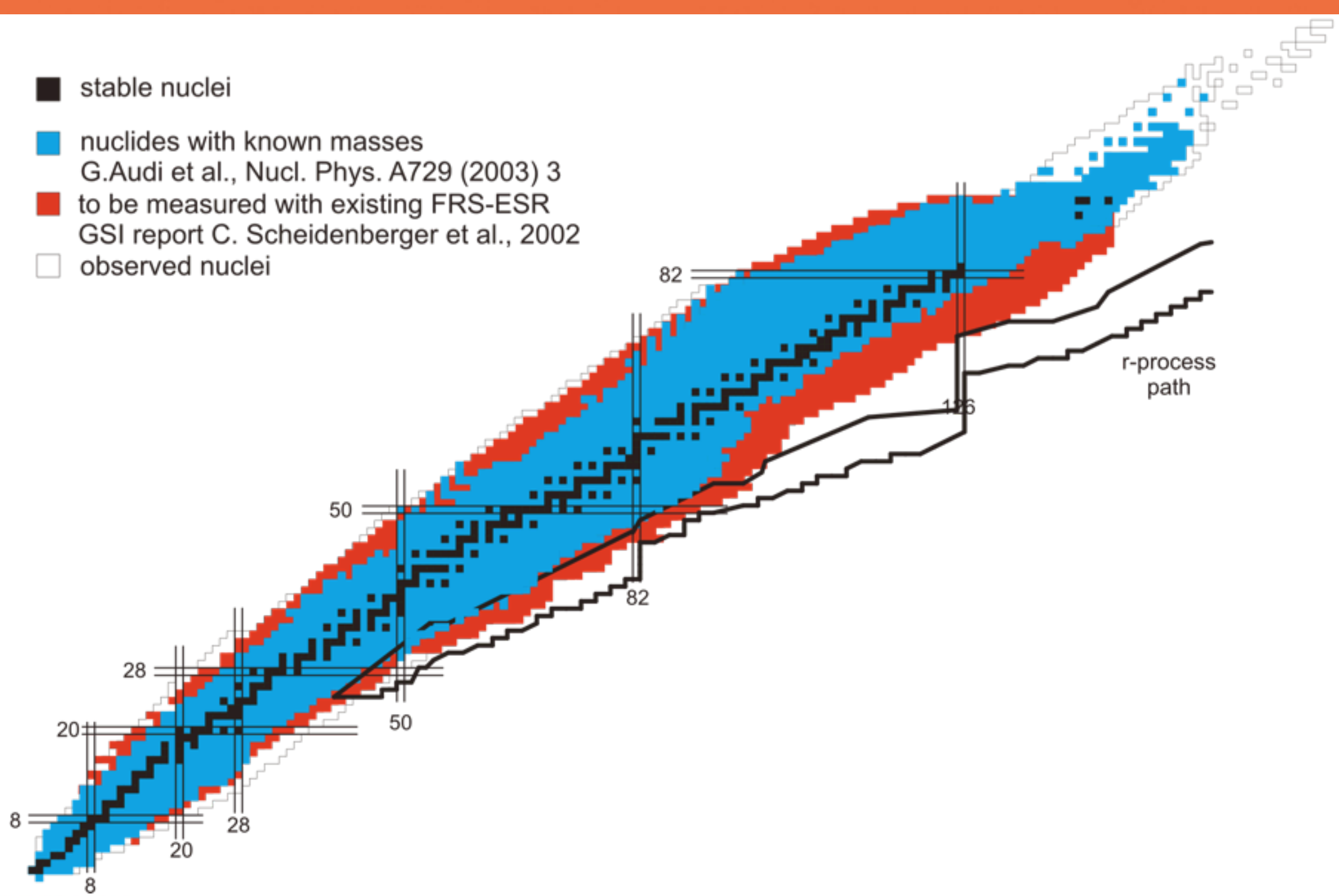
$$\frac{\Delta v}{v} \rightarrow 0$$

$$\frac{\Delta t}{t} = -\frac{\Delta f}{f} = \frac{1}{\gamma_t^2} \cdot \frac{\Delta(m/q)}{m/q} + (\frac{\gamma^2}{\gamma_t^2} - 1) \cdot \frac{\Delta v}{v}$$



HELMHOLTZ GEMEINSCHAFT

Nuclides in reach with ILIMA

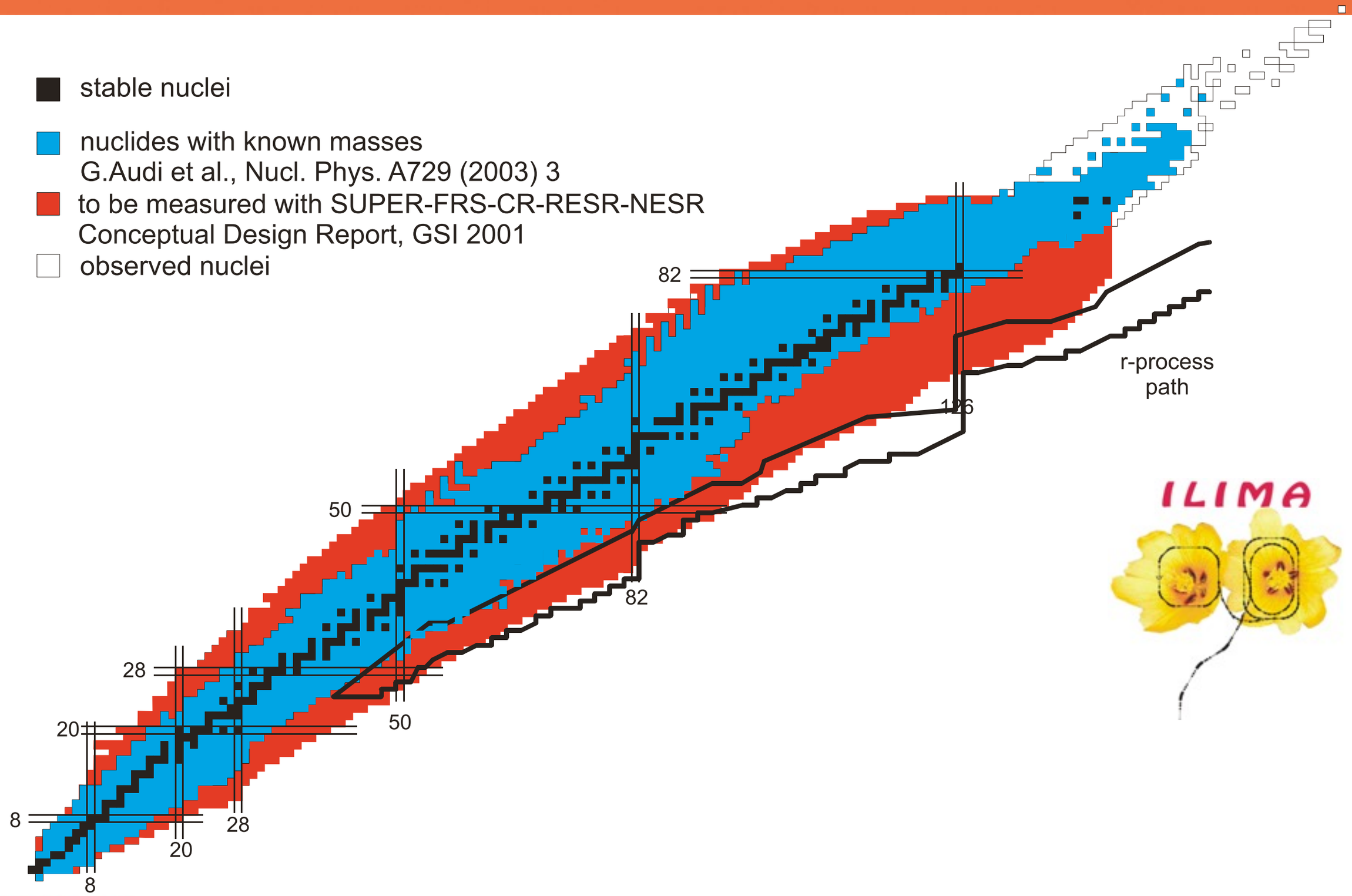


HELMHOLTZ
GEMEINSCHAFT

GSI

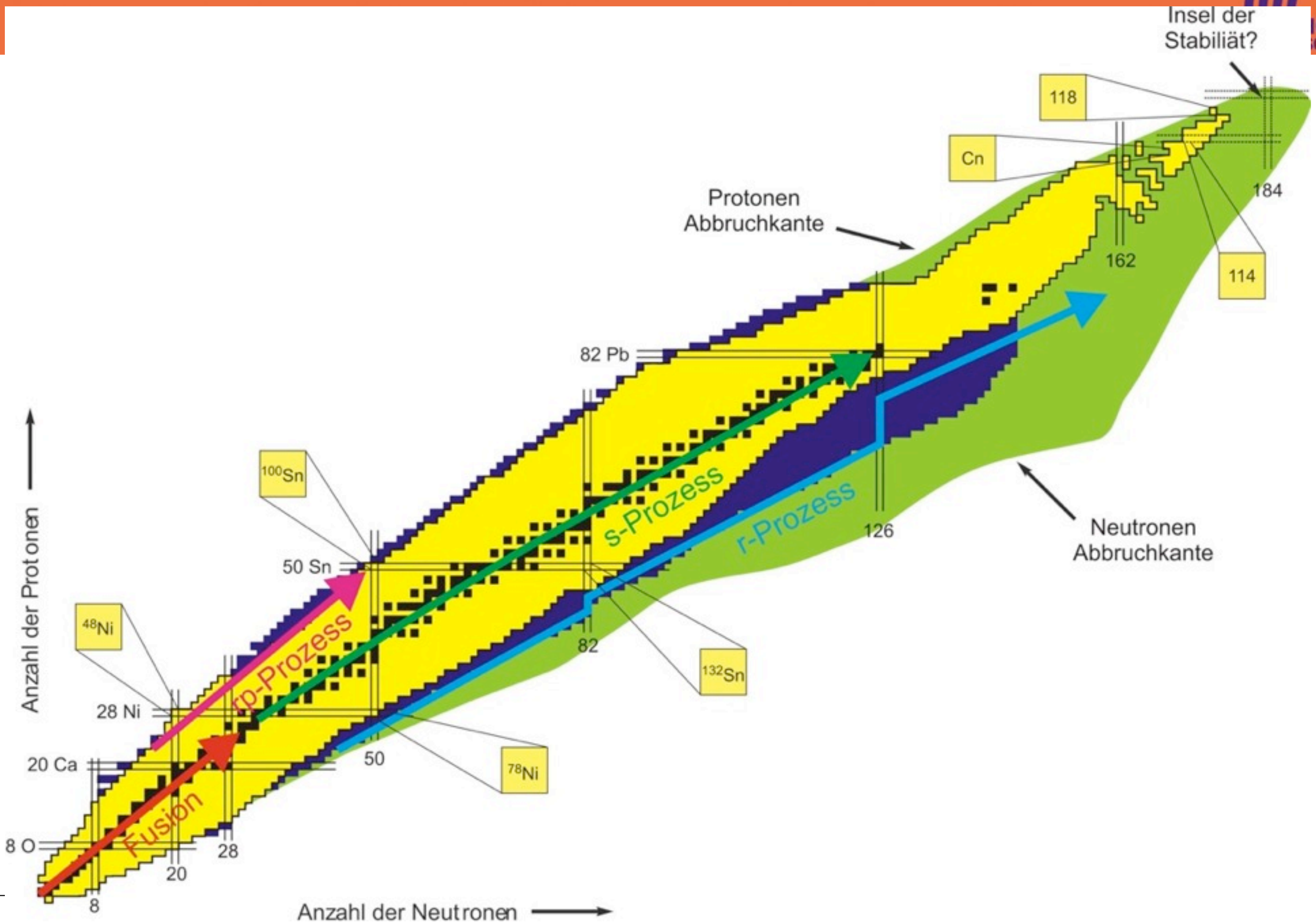
Nuclides in reach with ILIMA

- stable nuclei
- nuclides with known masses
  G.Audi et al., Nucl. Phys. A729 (2003) 3
- to be measured with SUPER-FRS-CR-RESR-NESR
  Conceptual Design Report, GSI 2001
- observed nuclei

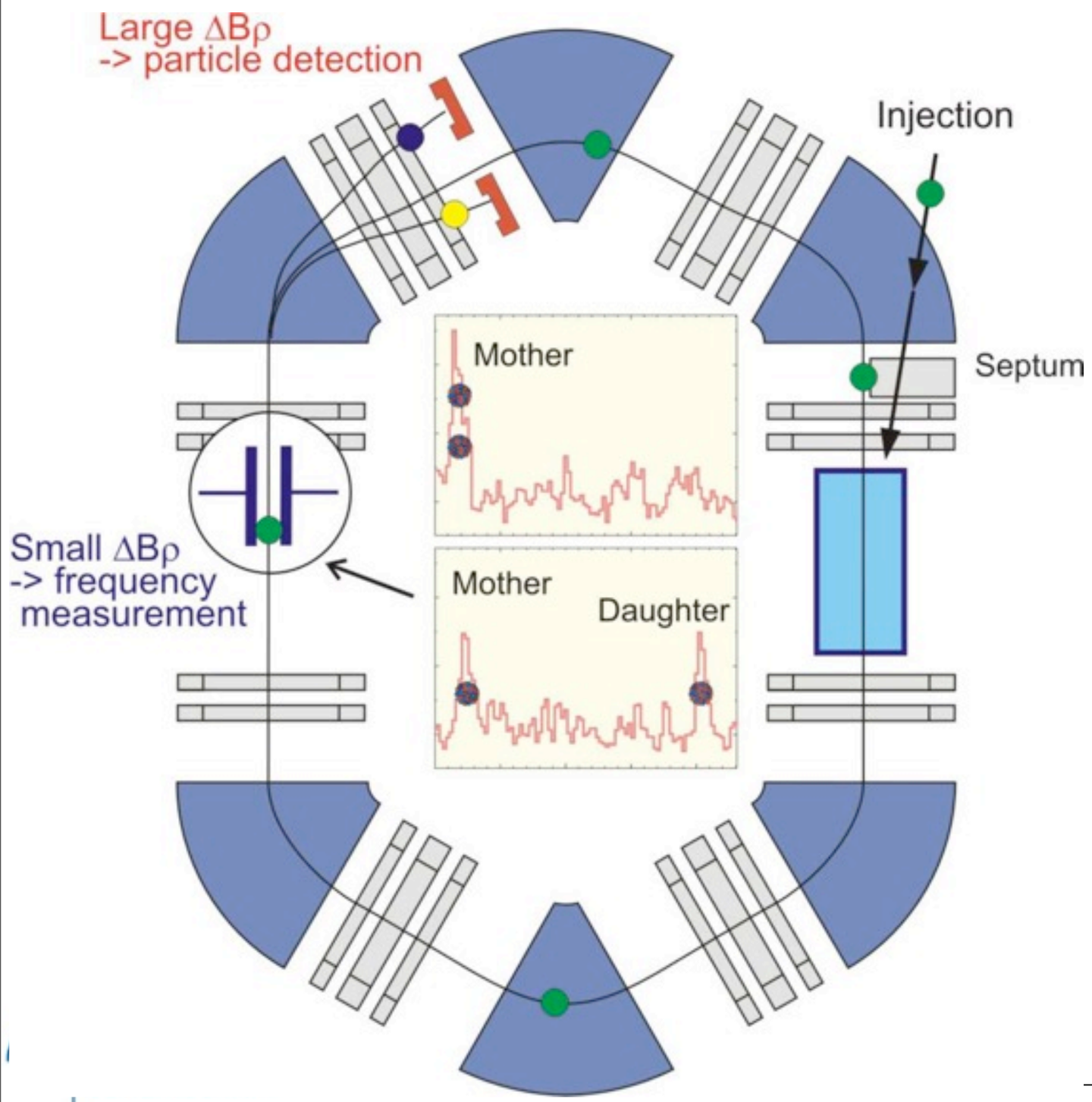


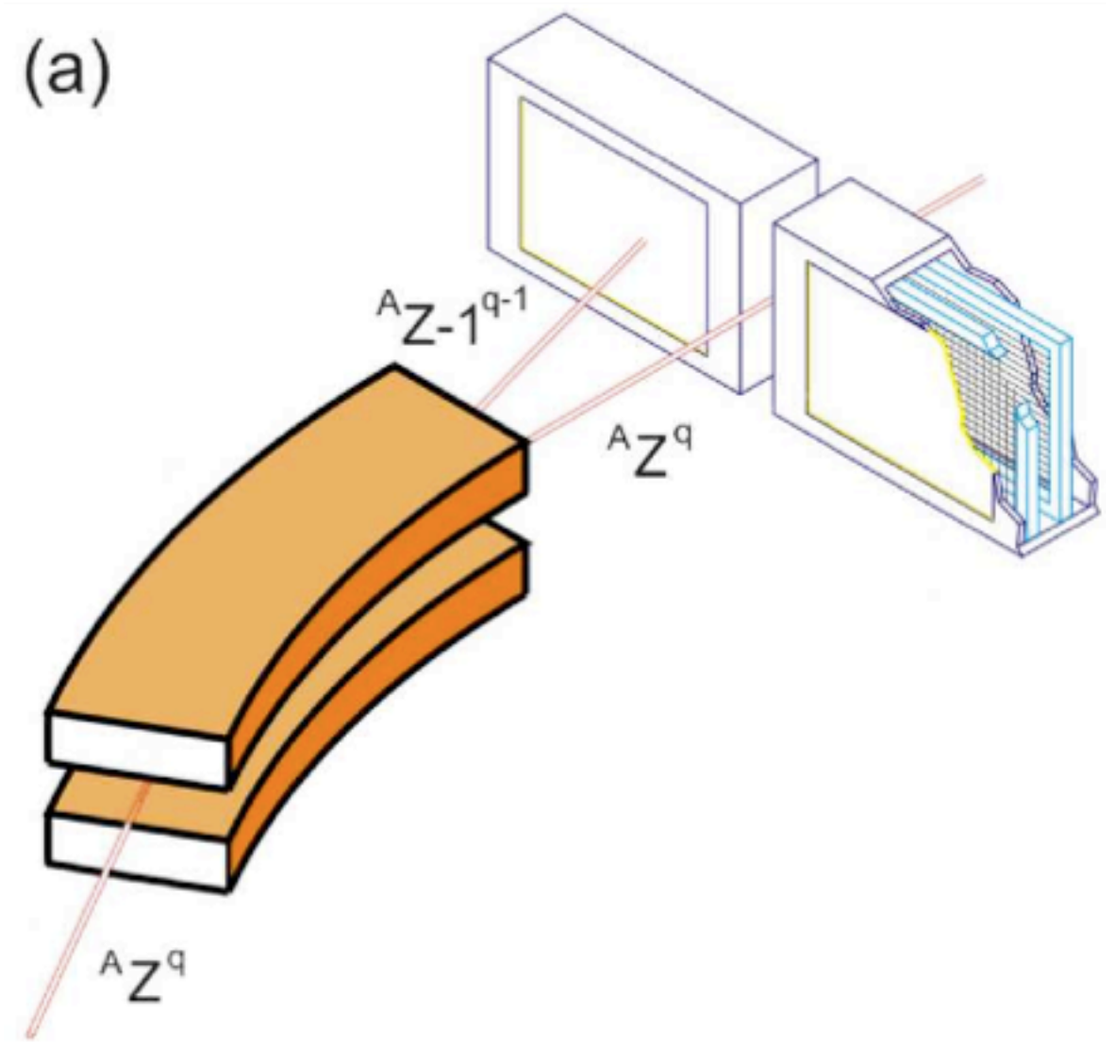
ILIMA

The Chart of Nuclides



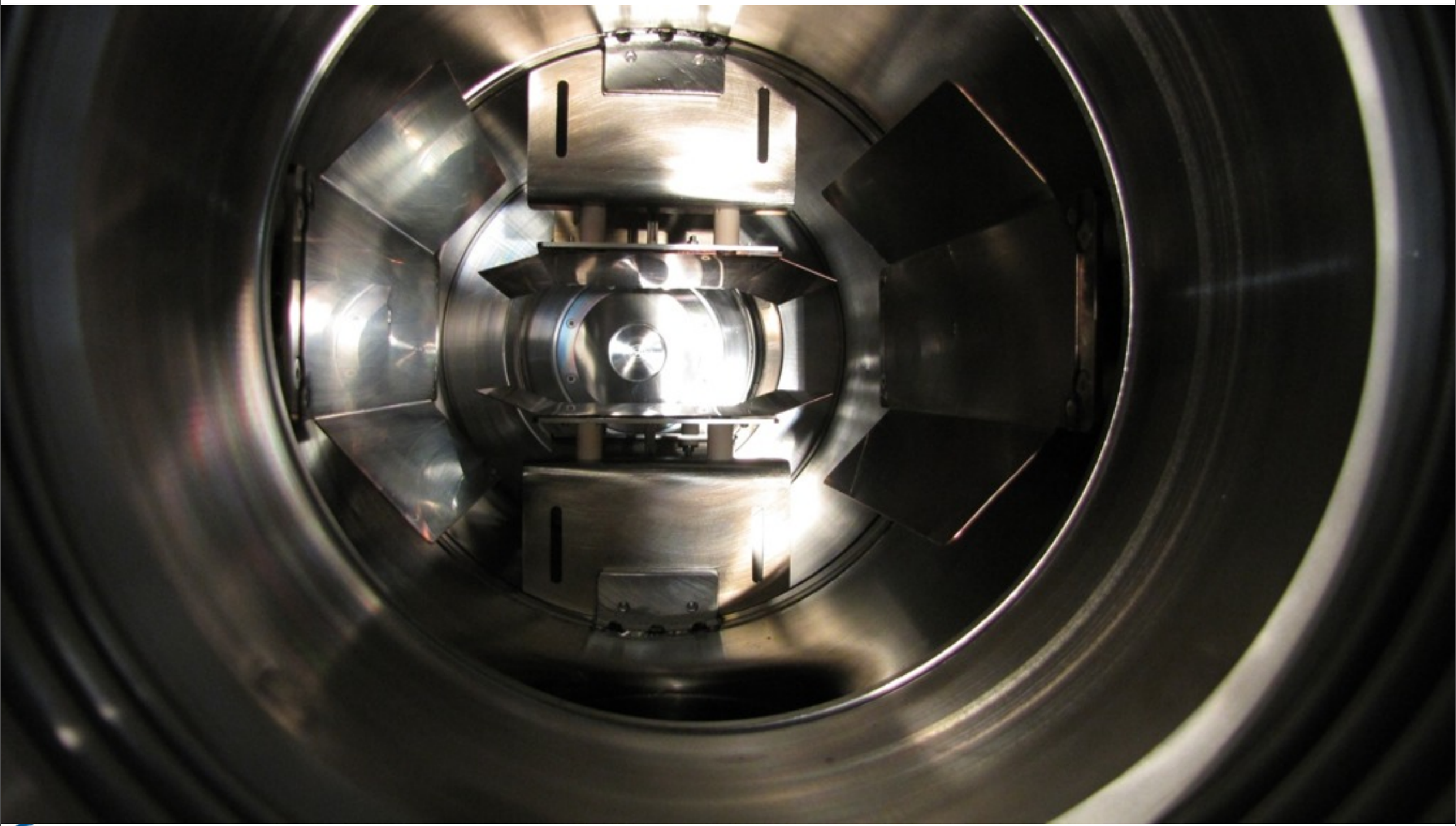
In-Ring Half-life Measurements



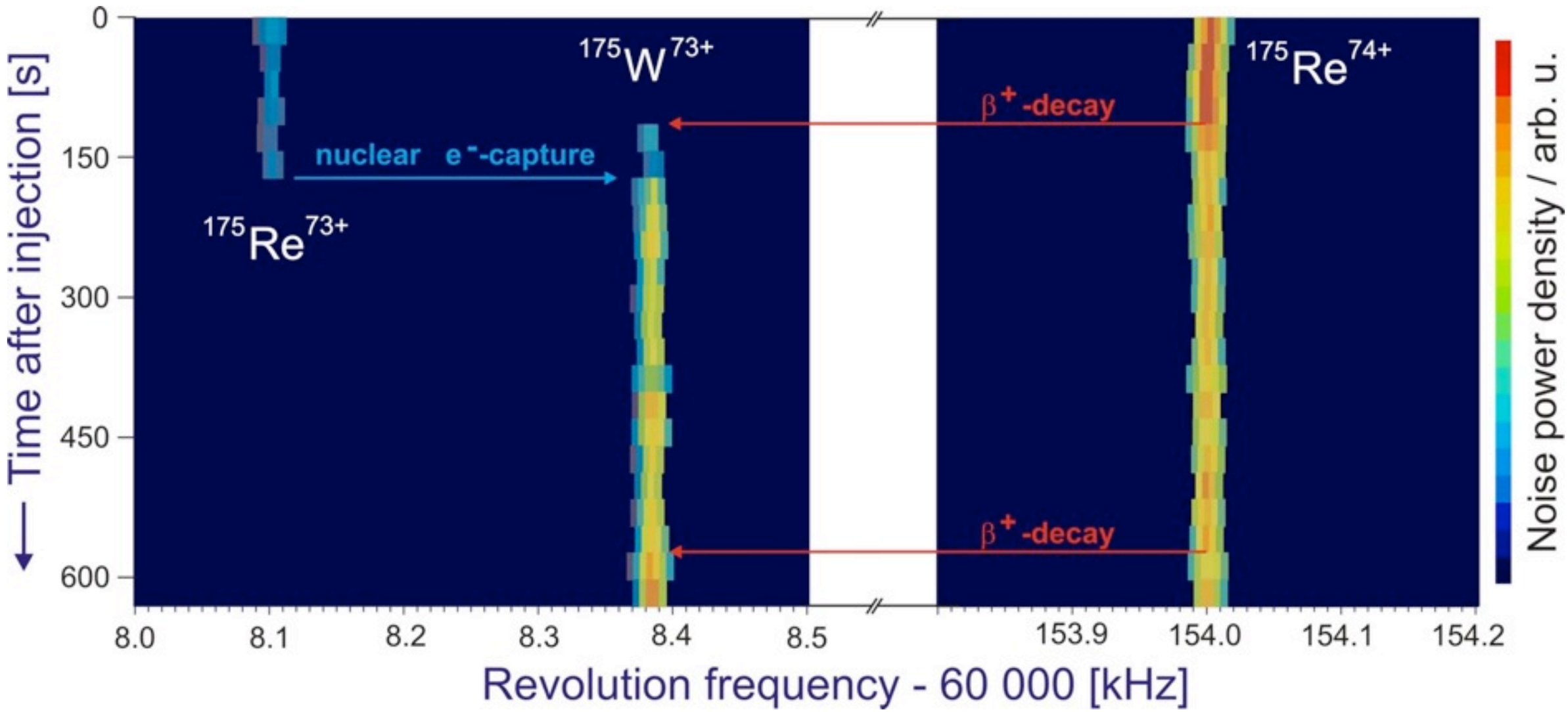


See the talk of Iris Dillmann

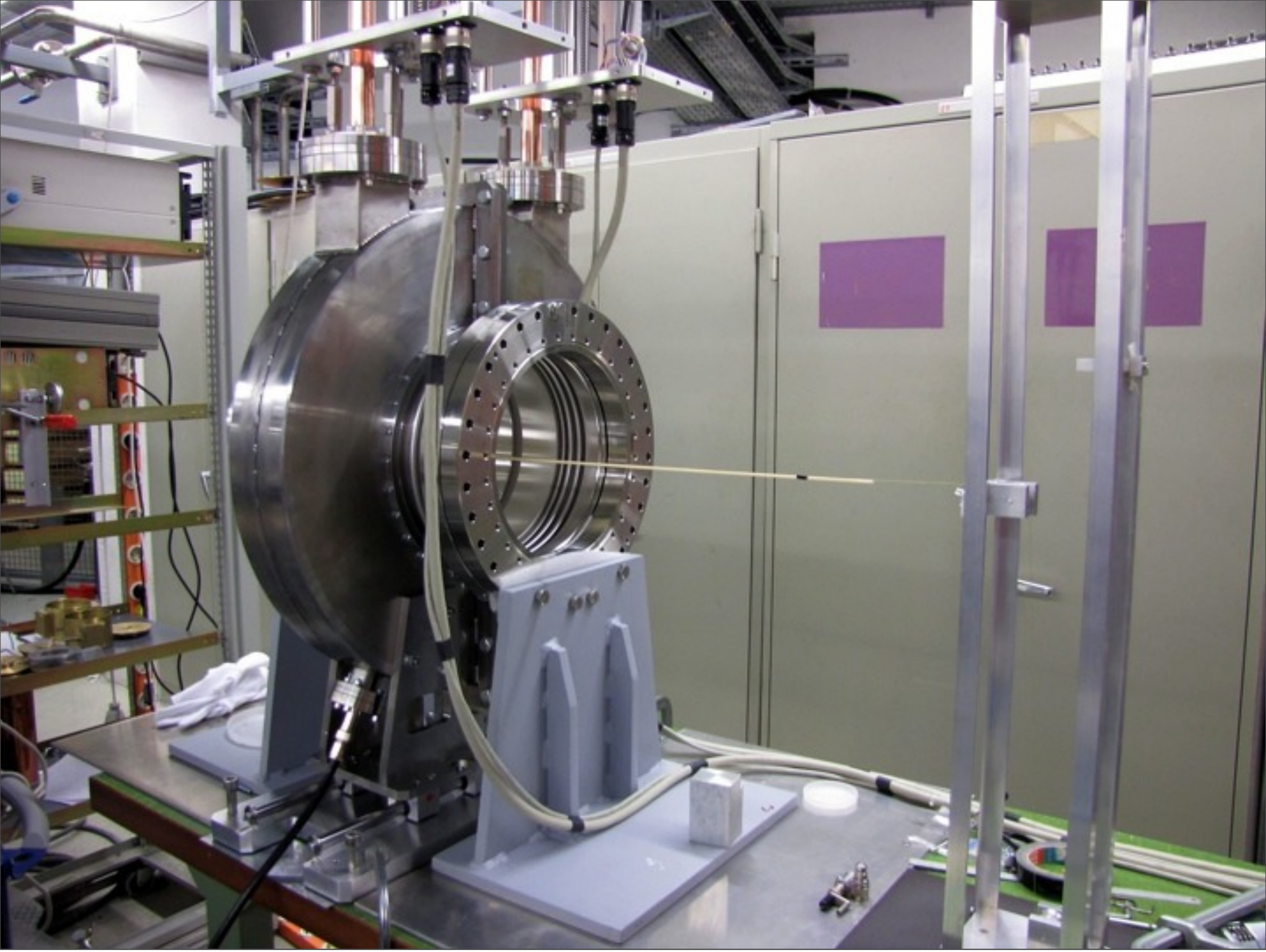
Capacitive Schottky Pick-up in the ESR



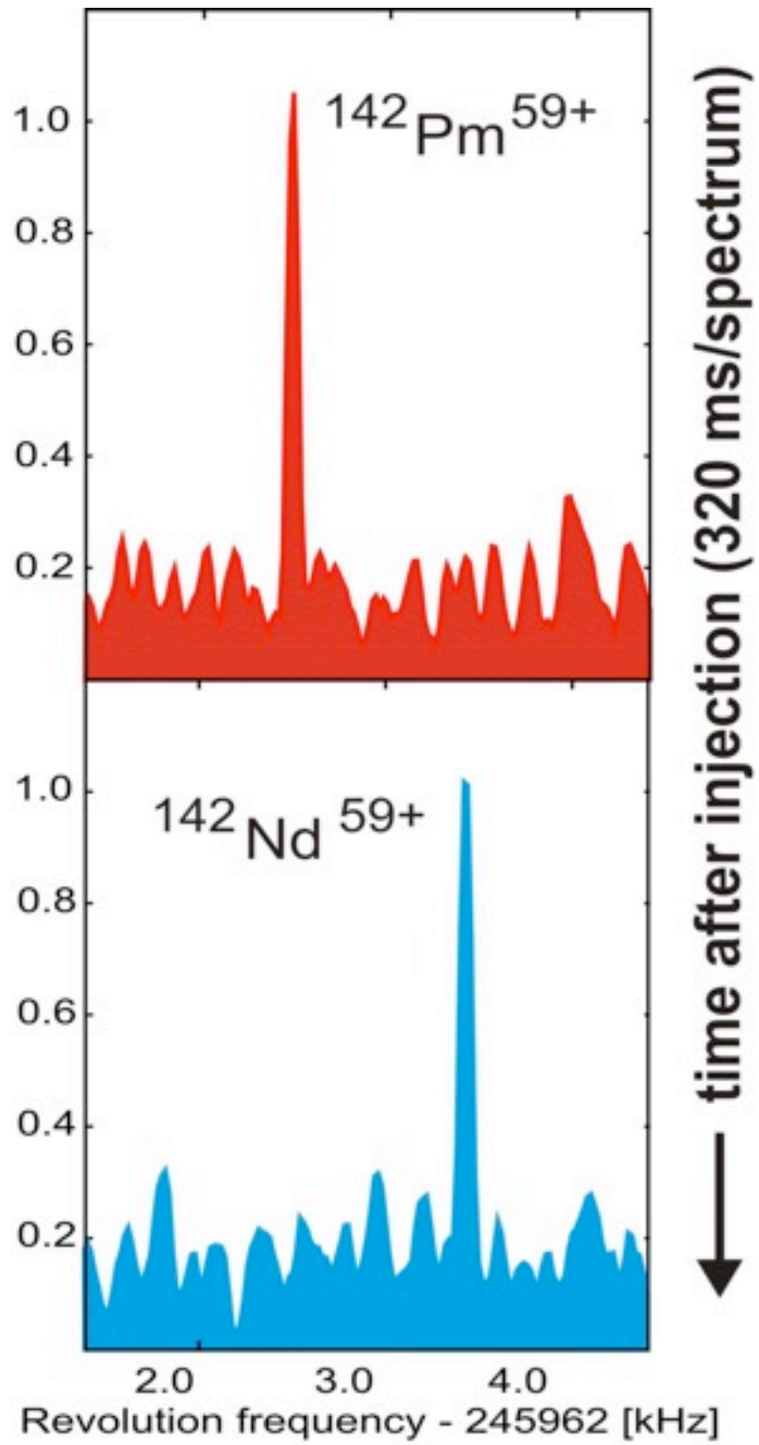
In-Ring Decays of Single Ions

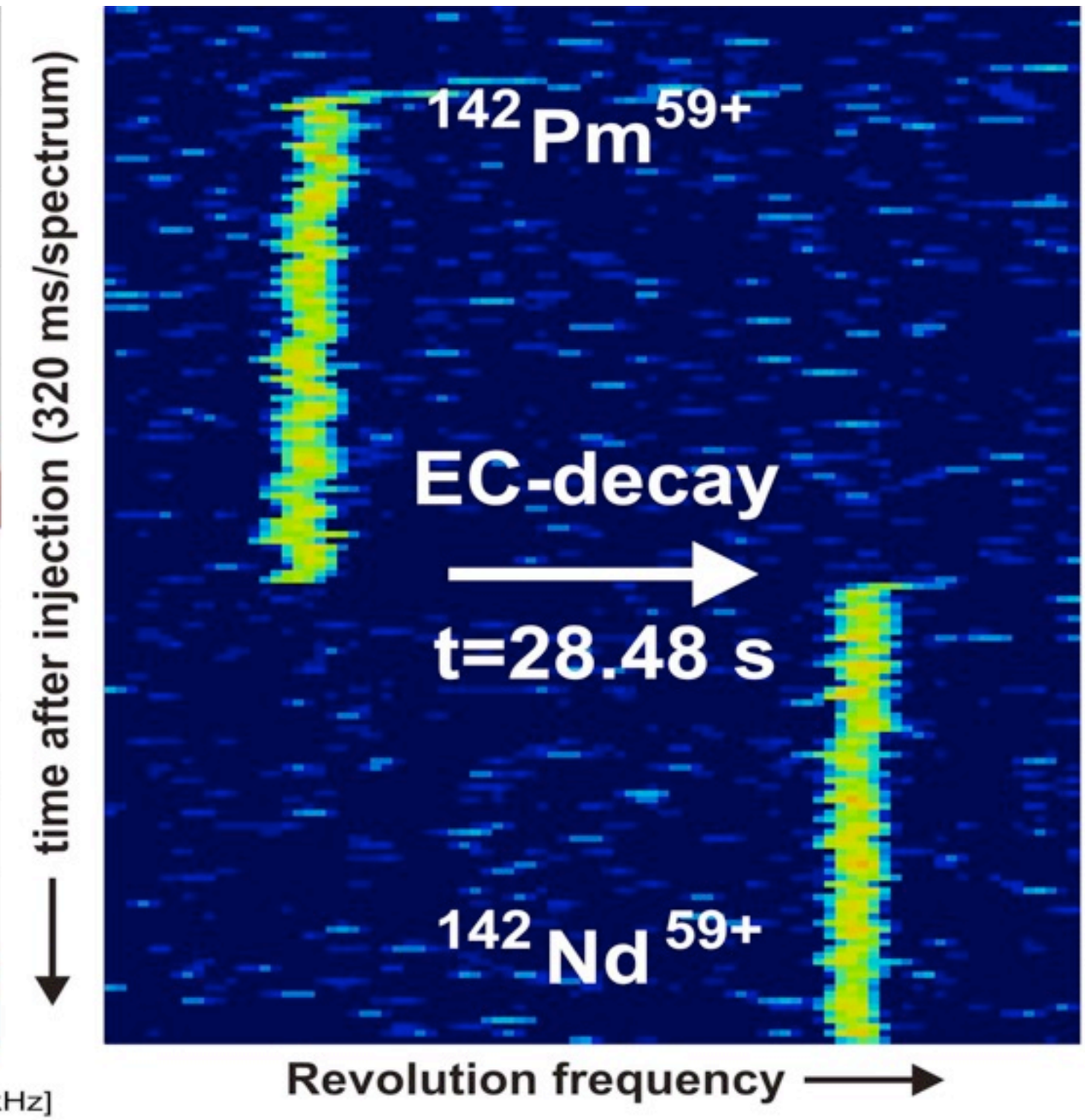


Problem: Pure time resolution !!!



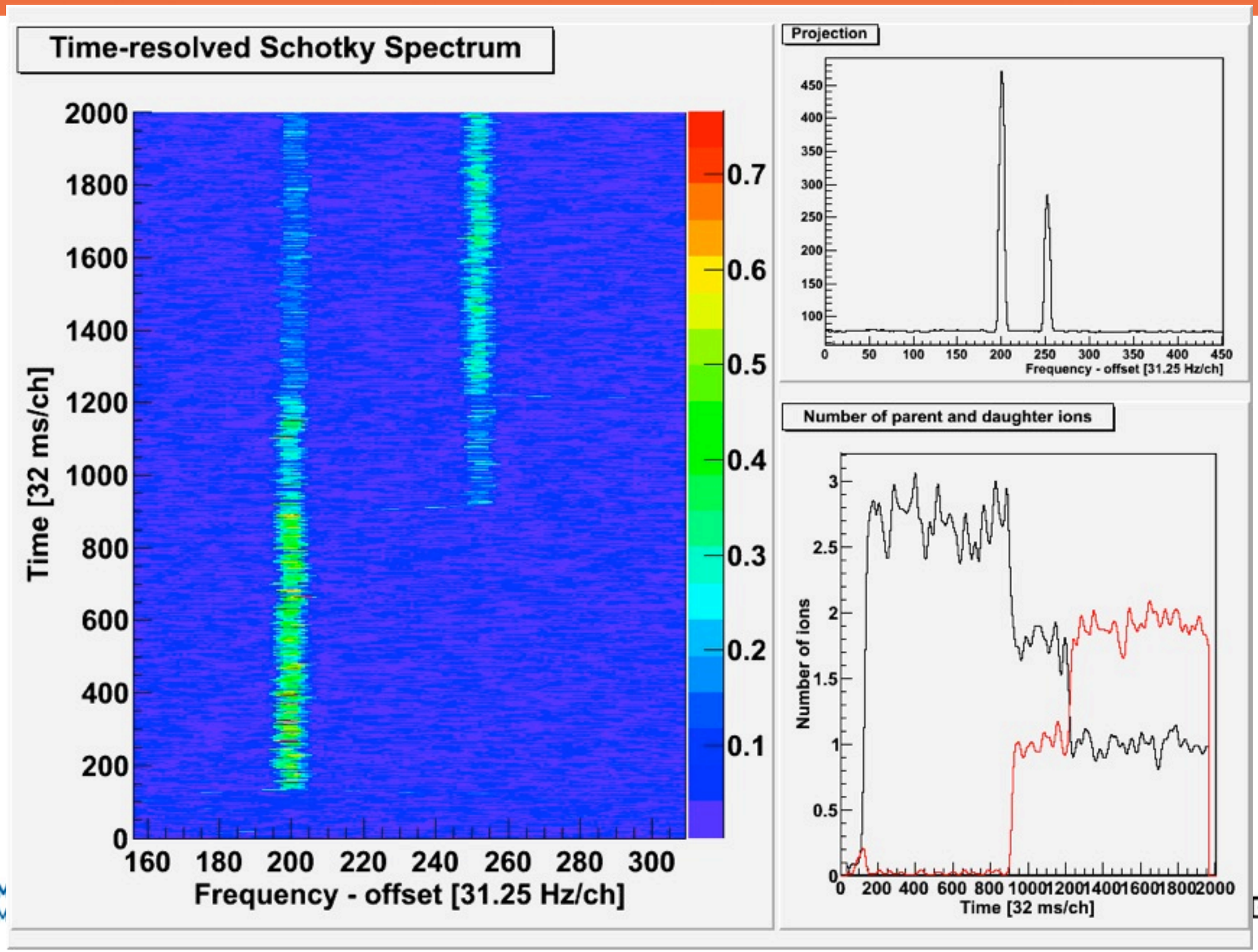
Single ion sensitivity



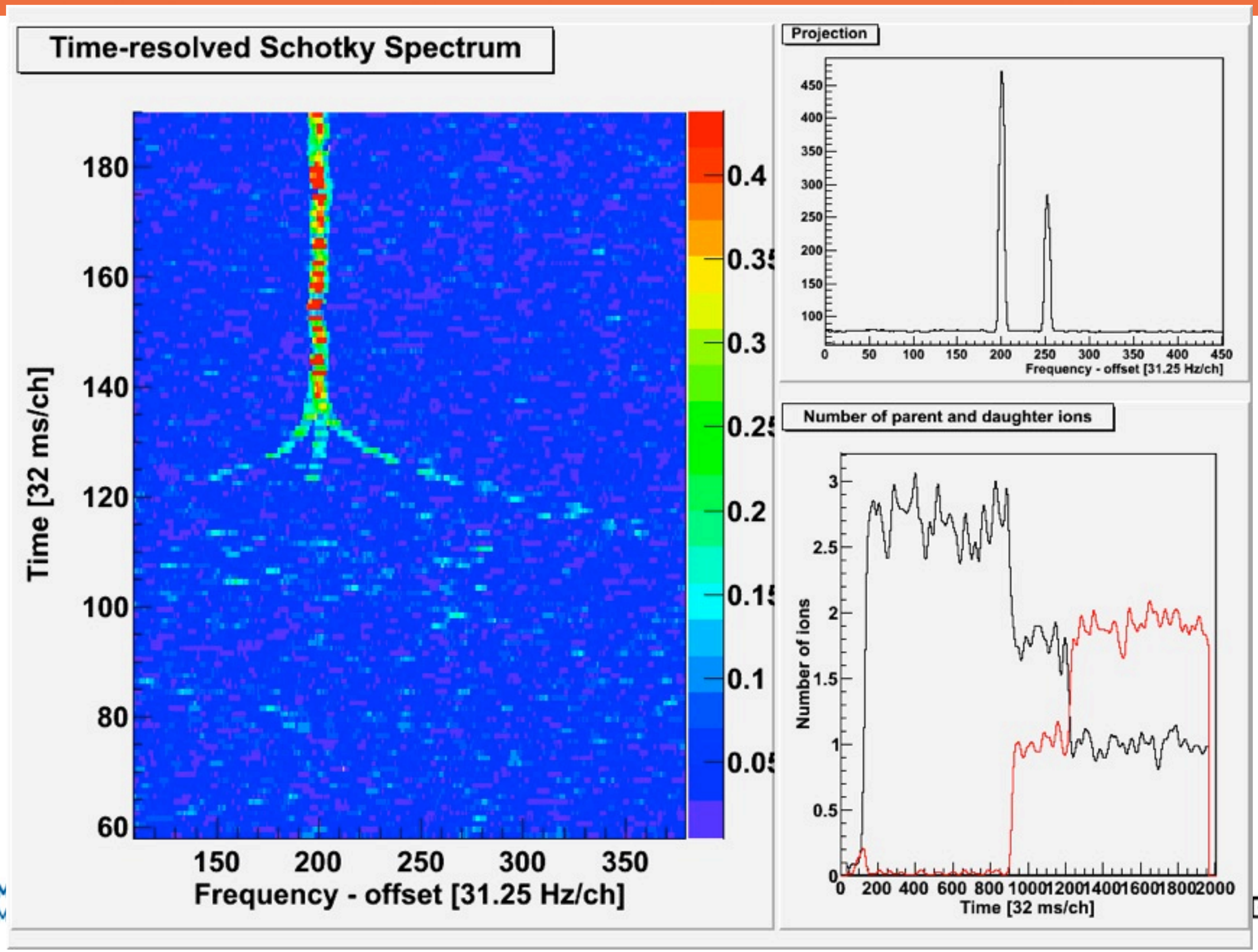


ESR (GSI)

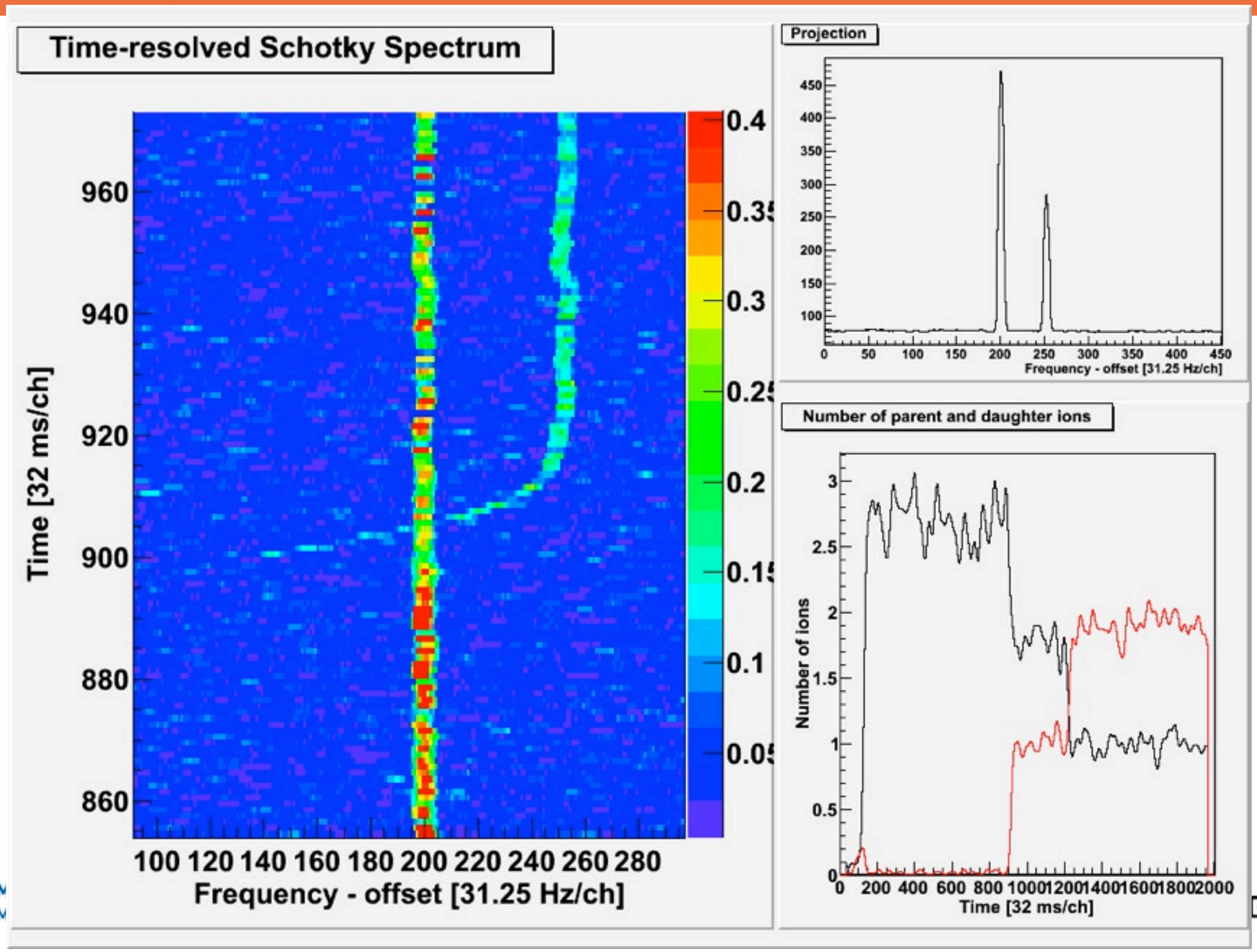
Three Parent He-Like ^{142}Pm Ions



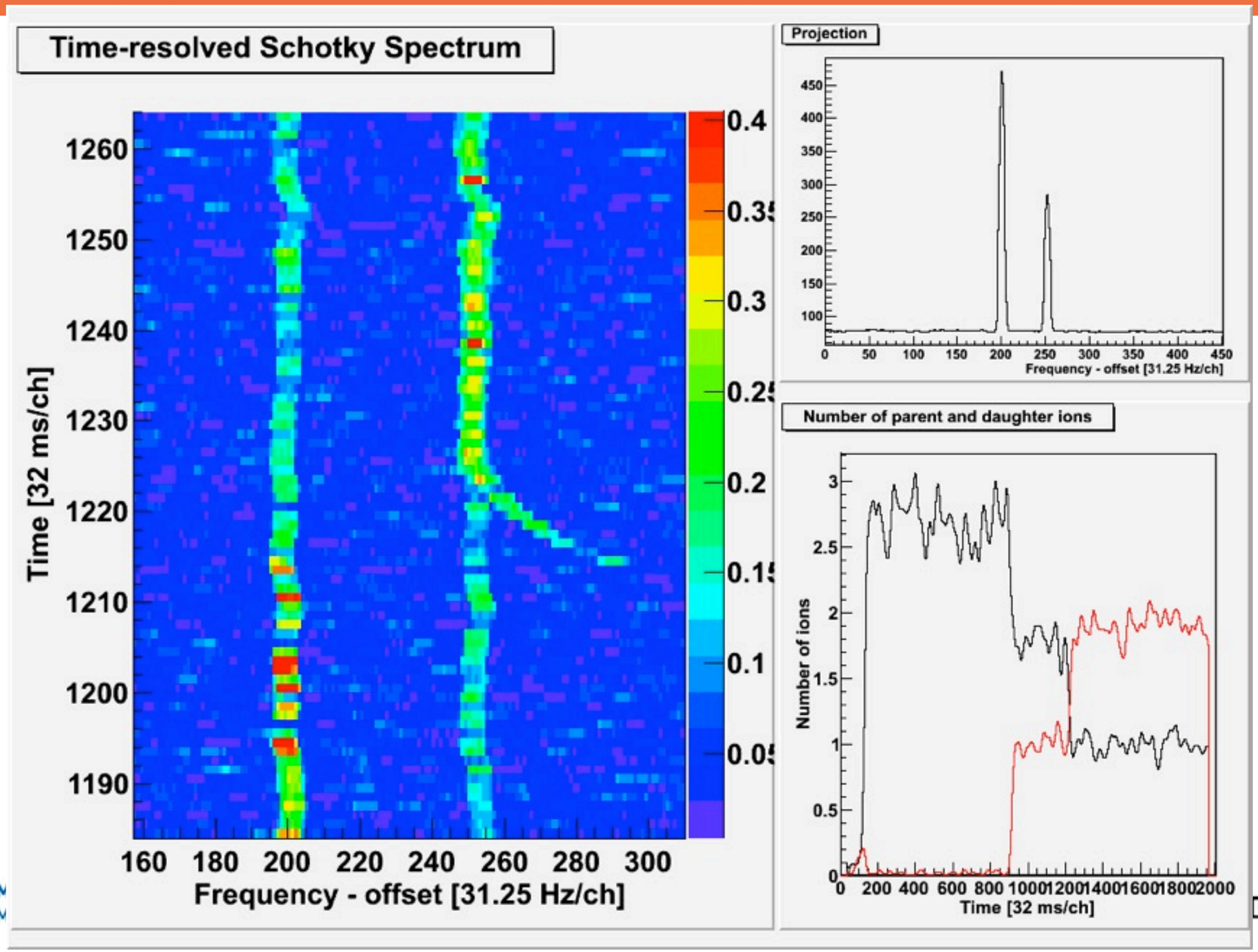
Three Parent He-Like ^{142}Pm Ions



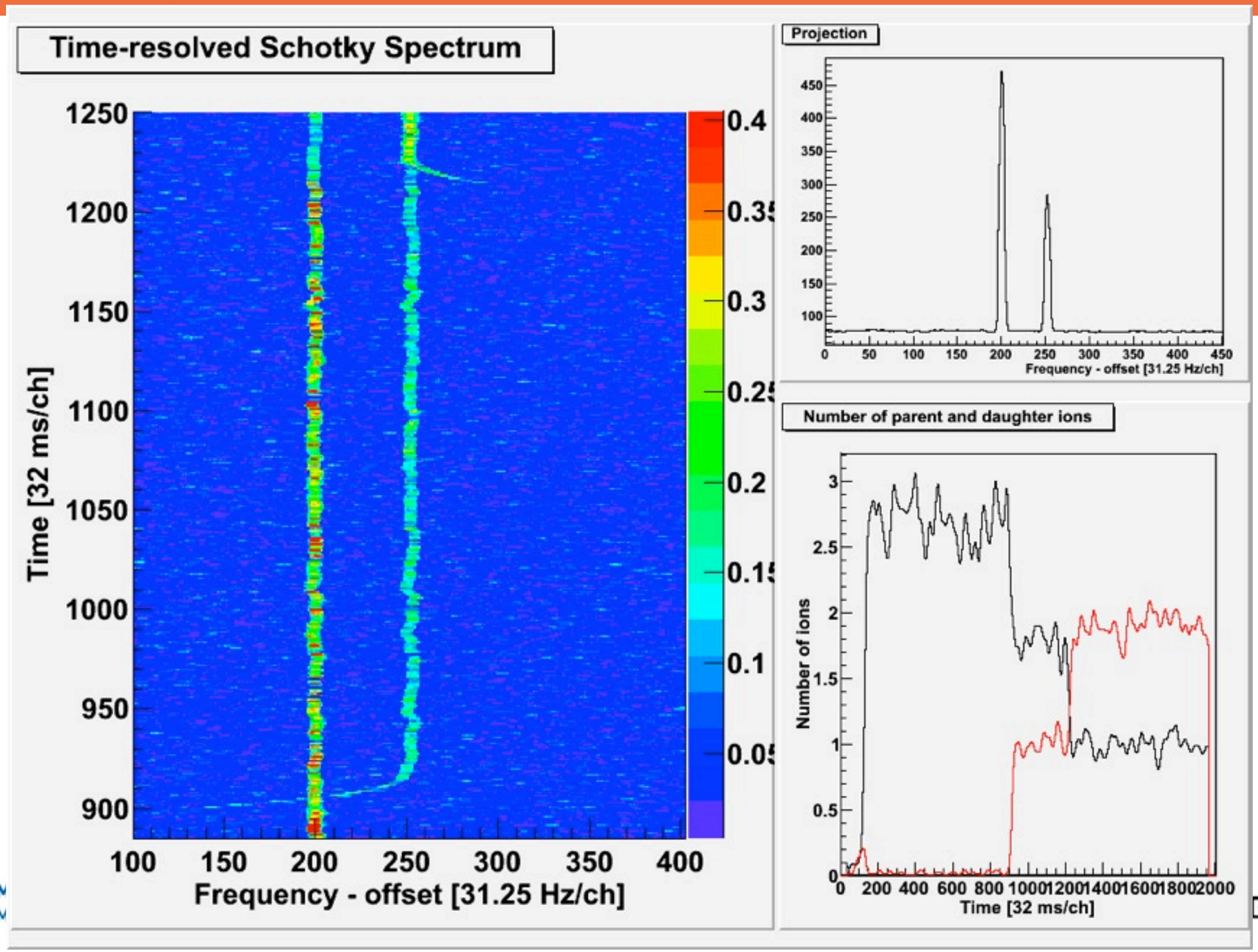
Three Parent He-Like ^{142}Pm Ions



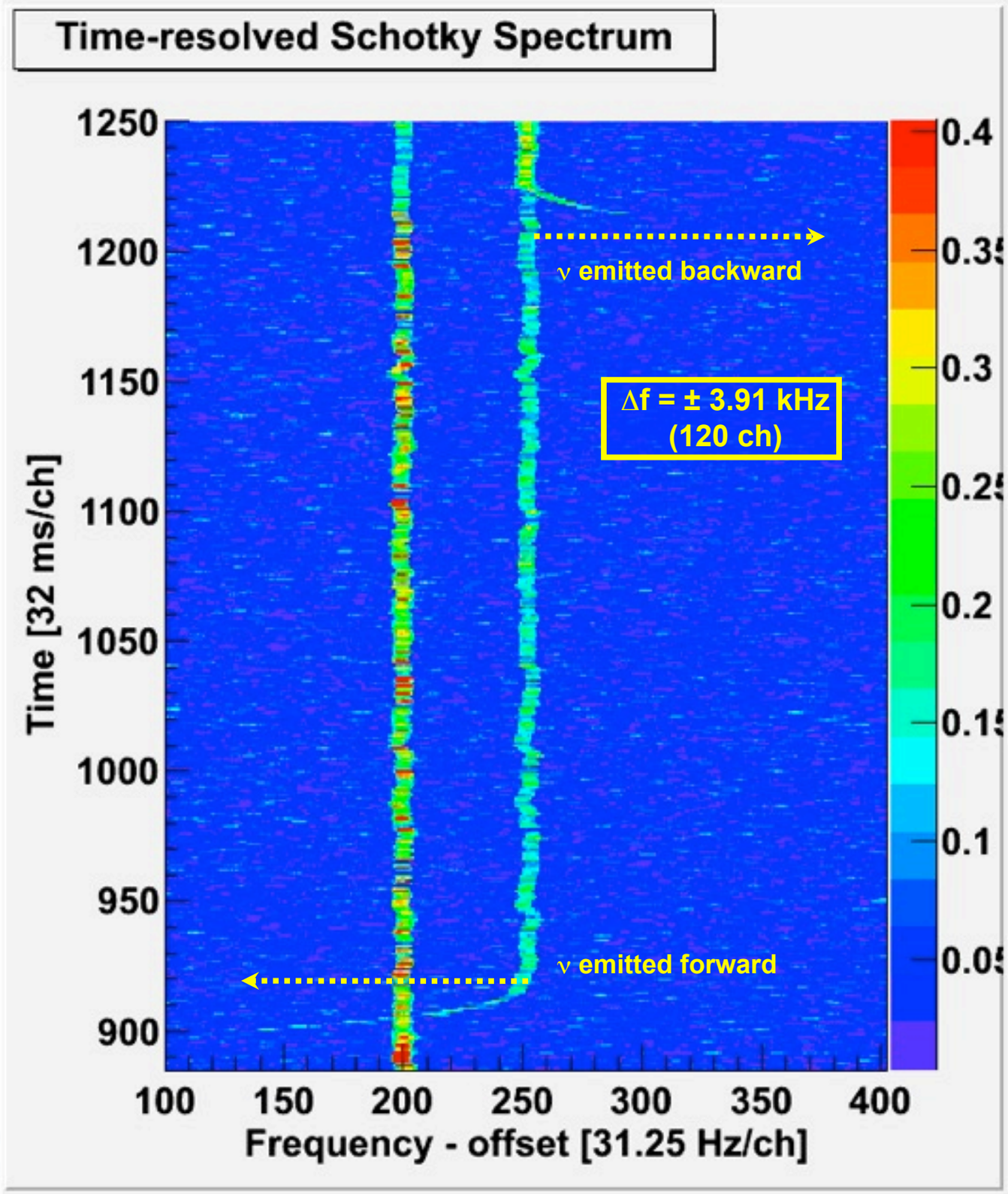
Three Parent He-Like ^{142}Pm Ions

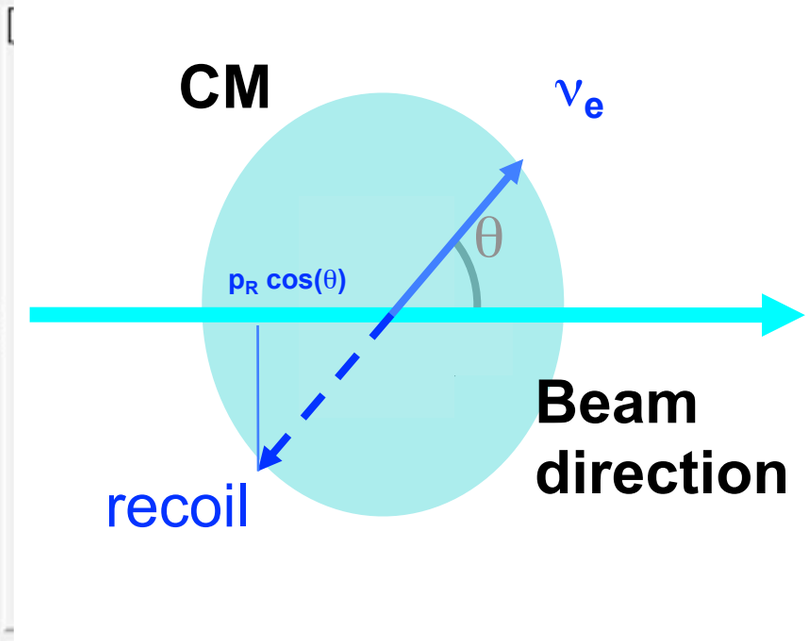


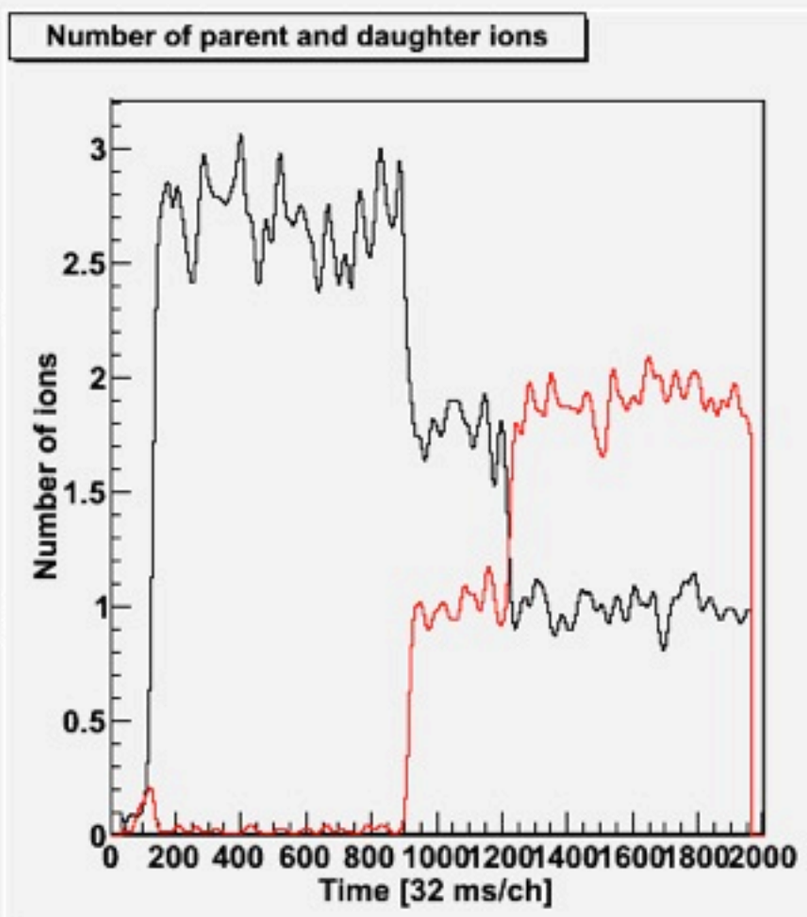
Three Parent He-Like ^{142}Pm Ions

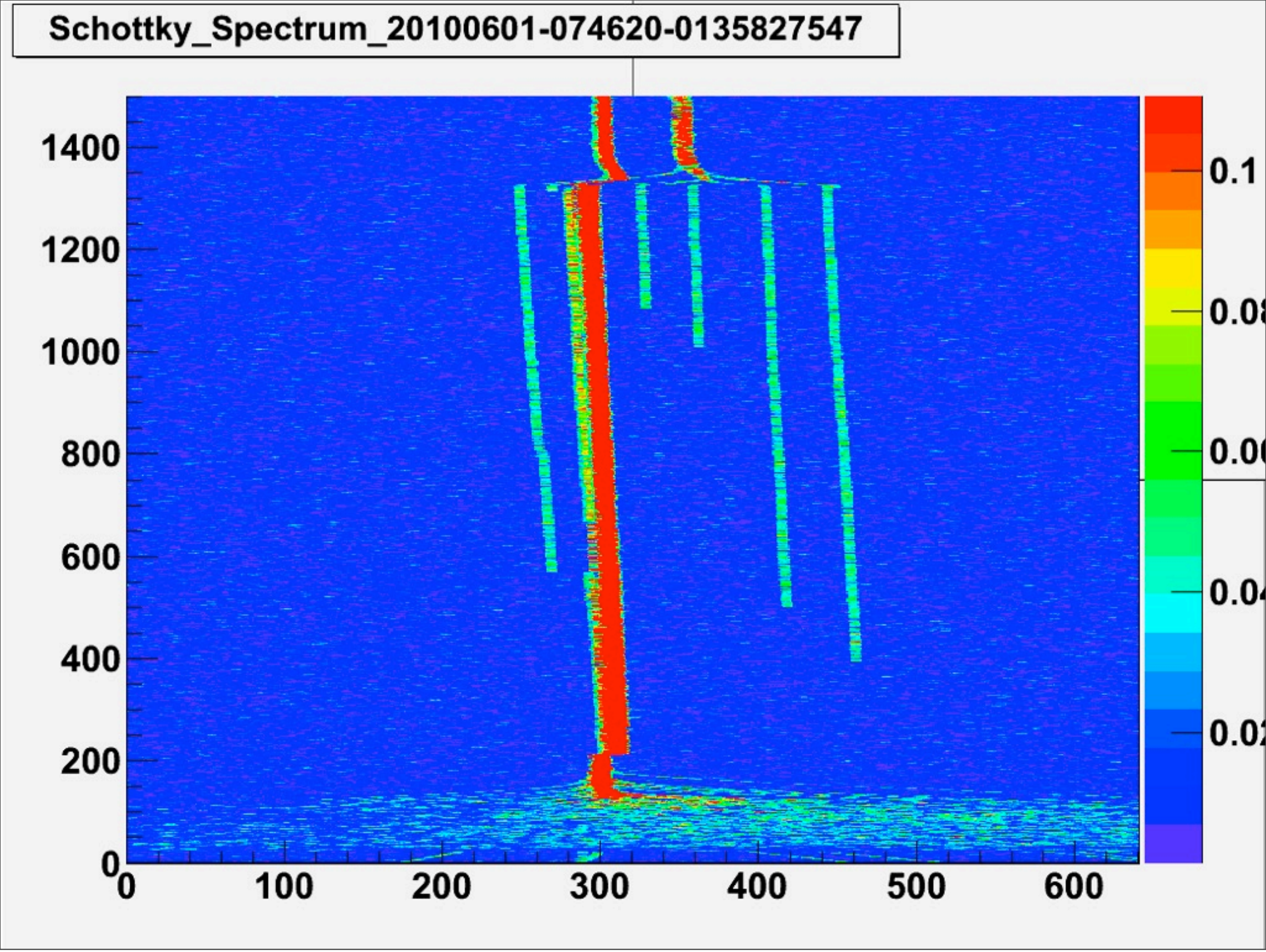


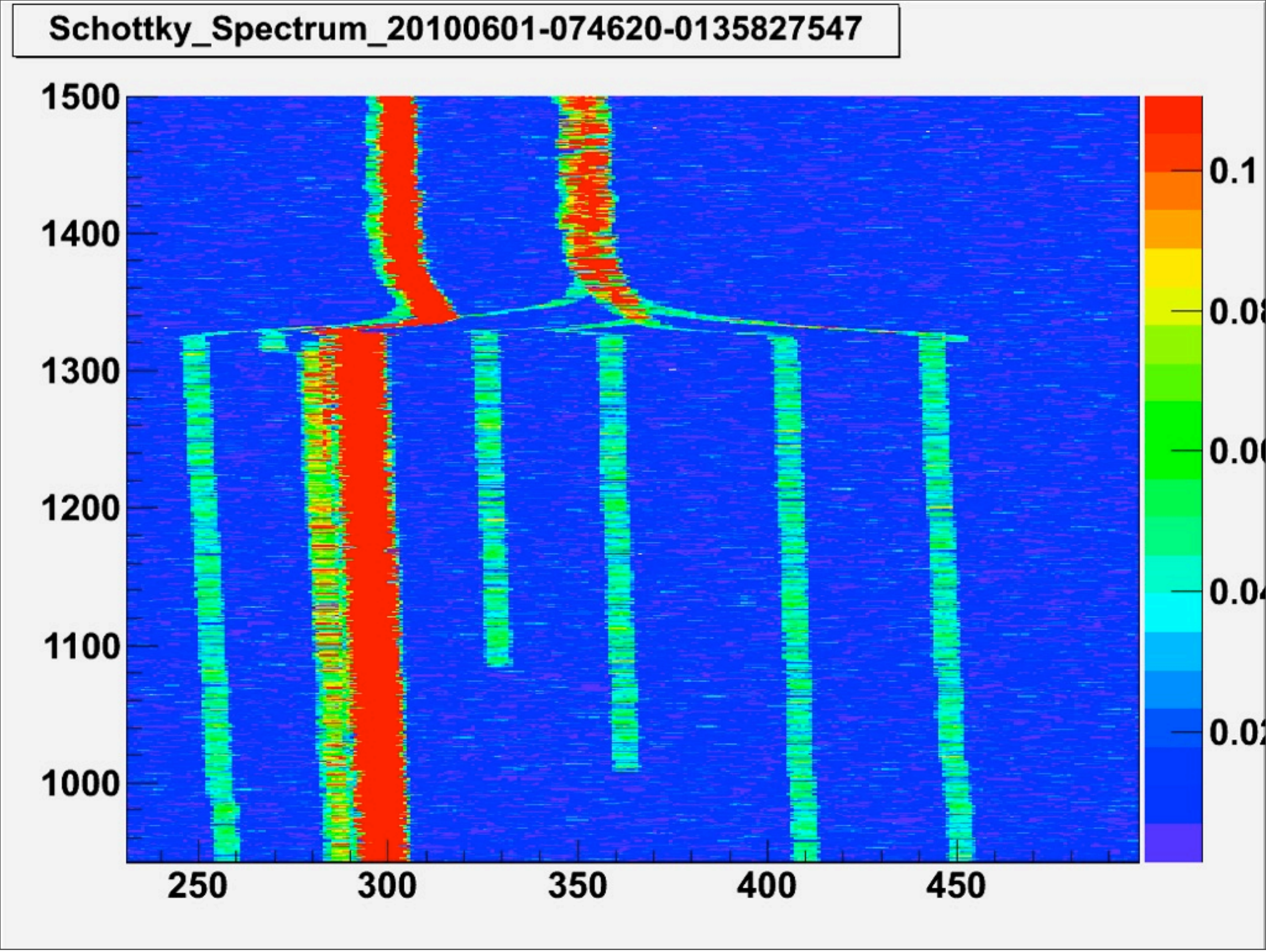
Three Parent He-Like ^{142}Pm Ions





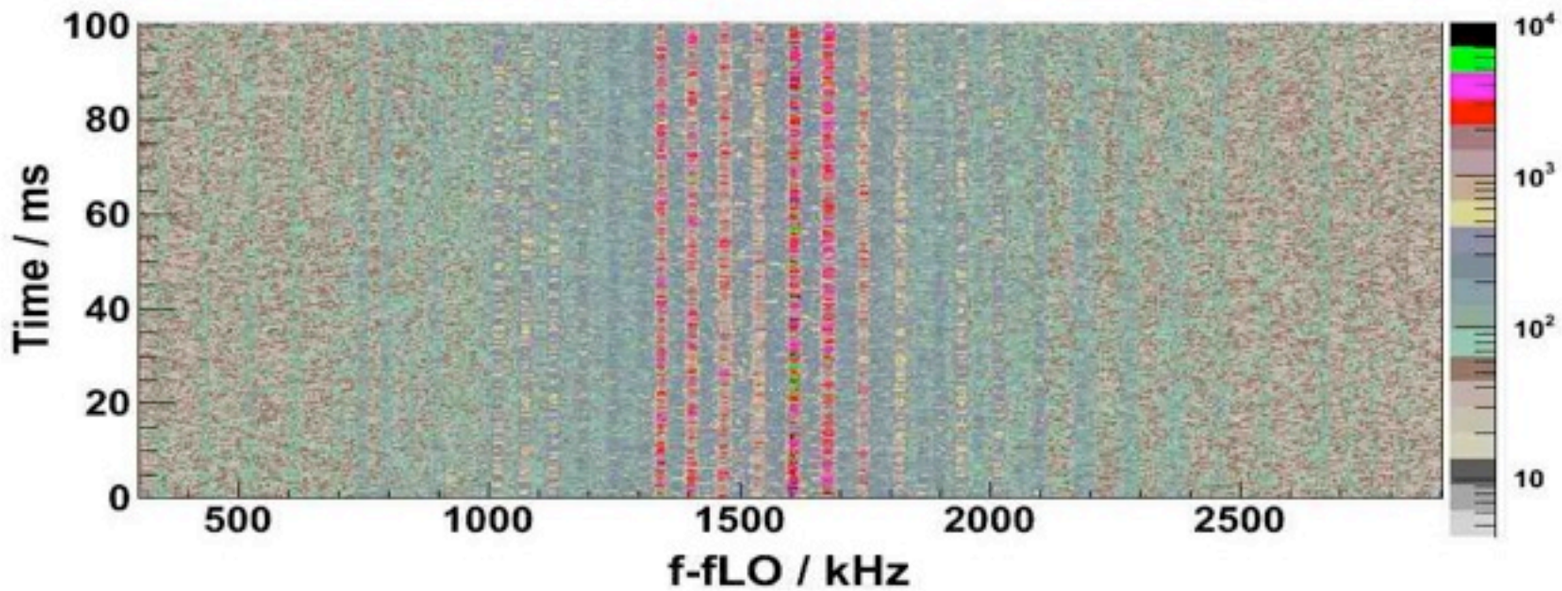



Schottky_Spectrum_20100601-074620-0135827547
1400
1200
1000
800
600
400
200
0
0
100
200
300
400
500
600
0.1
0.08
0.06
0.04
0.02


Schottky_Spectrum_20100601-074620-0135827547
1500
1400
1300
1200
1100
1000
250
300
350
400
450
0.1
0.08
0.06
0.04
0.02

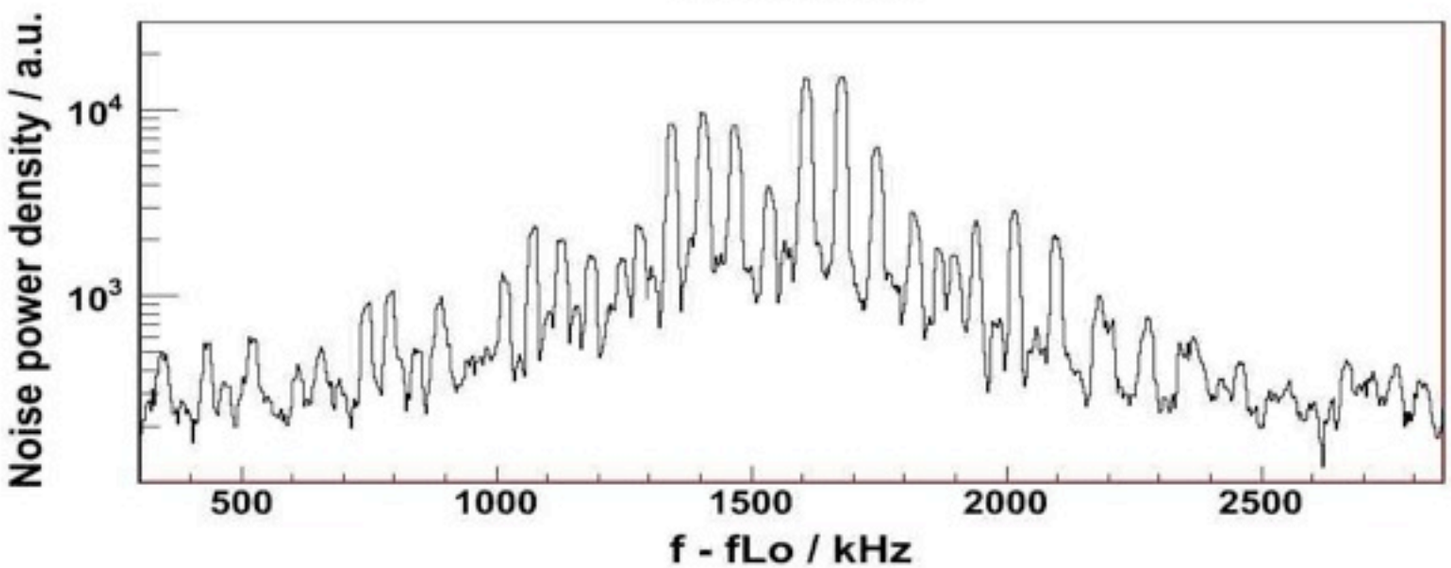
New resonant Schottky pick-up

Hot Fragments (Iso. Mode)—Broad band



Each frame:

320 ms



Spectrum of 16 ms

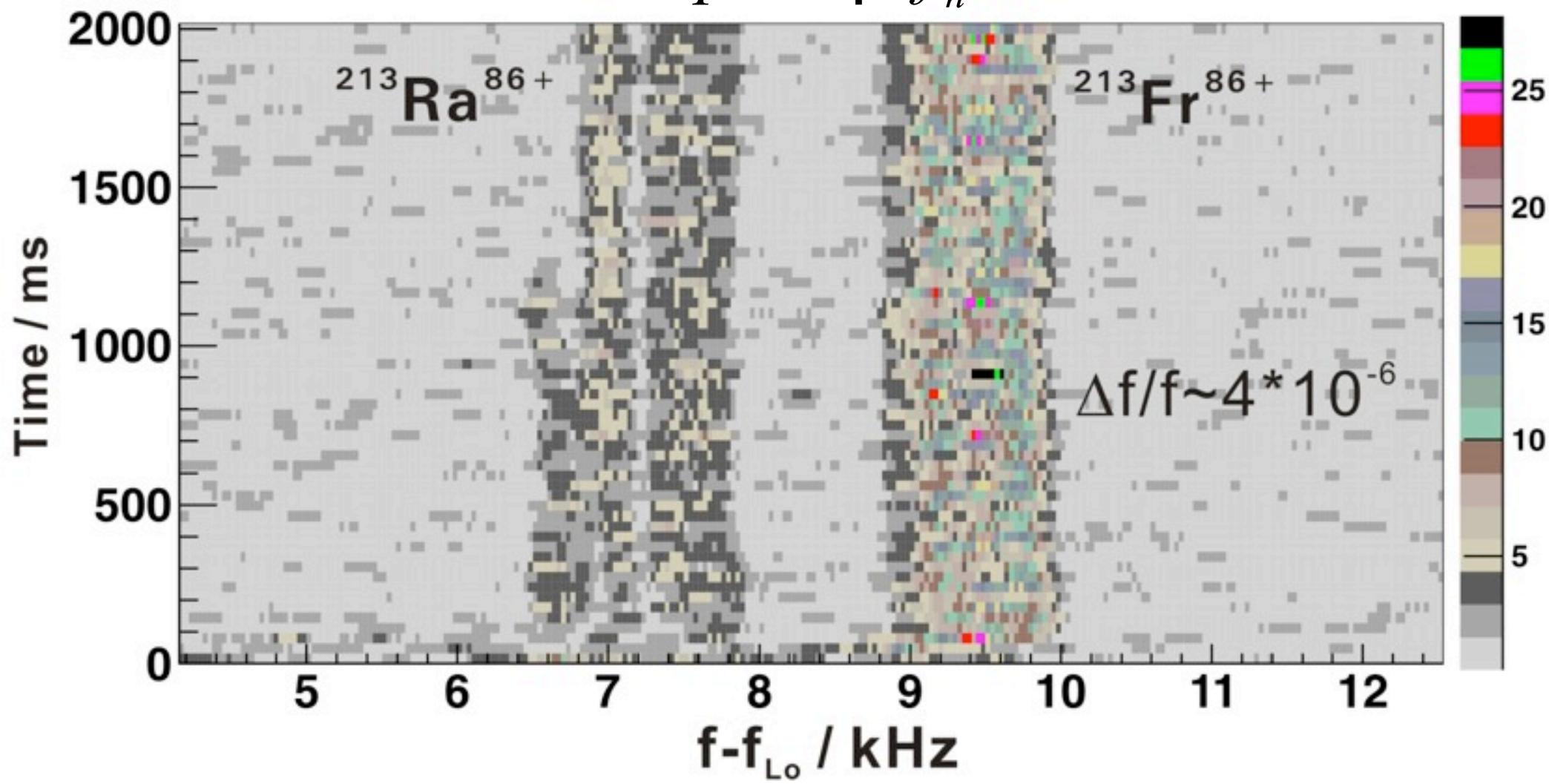
Resolving power

$f/\Delta f \sim 17000$

C. Brandau & M.S. Sanjari, New Generation DAQ

Hot Fragments (Iso. Mode) – Narrow band

$$\frac{\Delta p}{p} = \frac{1}{\eta}\frac{\Delta f_h}{f_h}$$

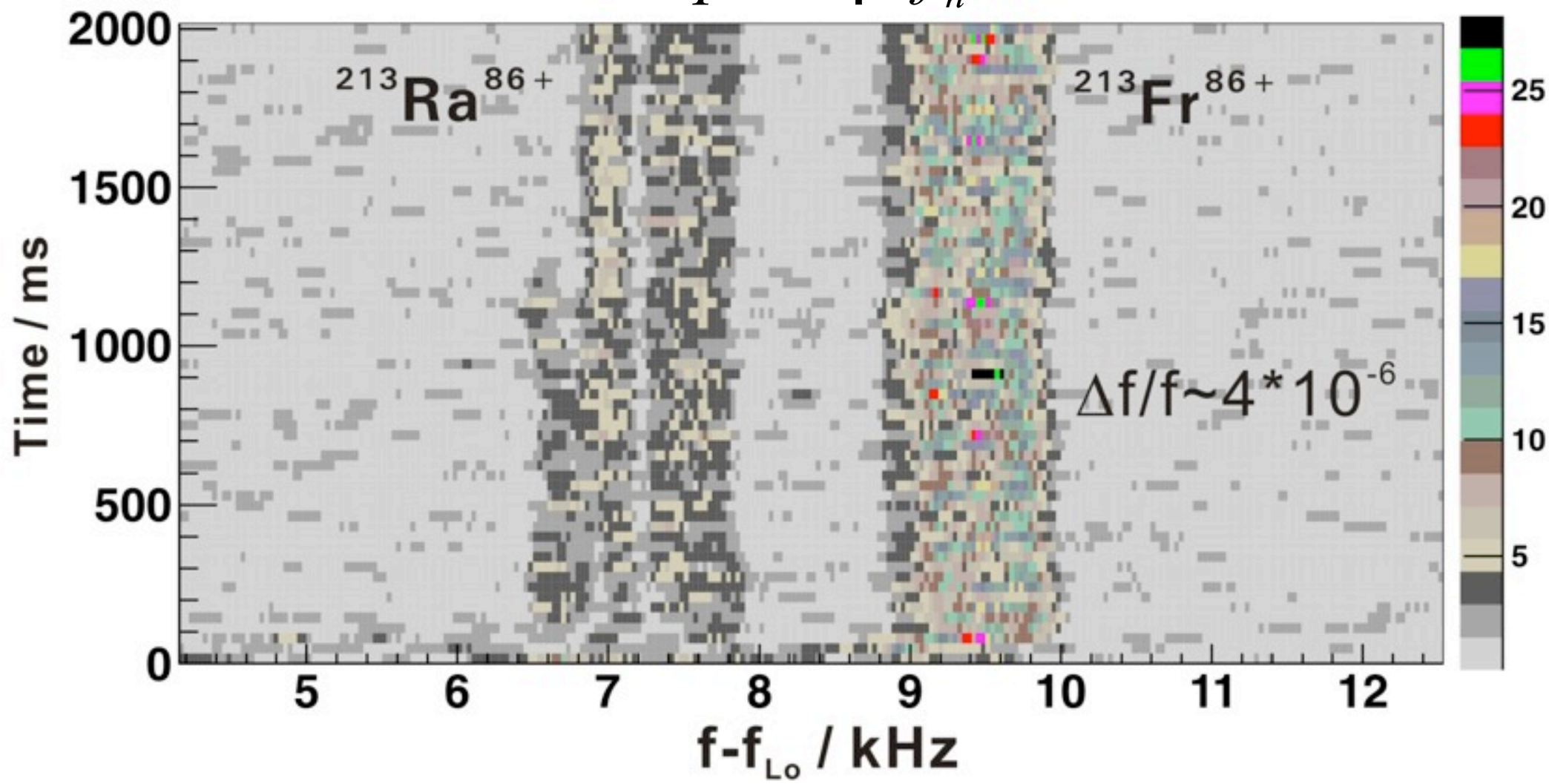


With this new resonant Schottky pick-up, one could see the momentum dispersion for each particle ..

Hot Fragments (Iso. Mode) – Narrow band

dm/m ~ 2 df/f ~ 125000

$$\frac{\Delta p}{p} = \frac{1}{\eta}\frac{\Delta f_h}{f_h}$$



With this new resonant Schottky pick-up, one could see the momentum dispersion for each particle ..

FAIR - CORE Facility → ILIMA (Isomeric Beams, Lifetimes, Masses)

FAIR - CORE Facility → ILIMA (Isomeric Beams, Lifetimes, Masses)

FAIR - MSV → MA (Masses)

FAIR - CORE Facility → ILIMA (Isomeric Beams, Lifetimes, Masses)

FAIR - MSV → MA (Masses)

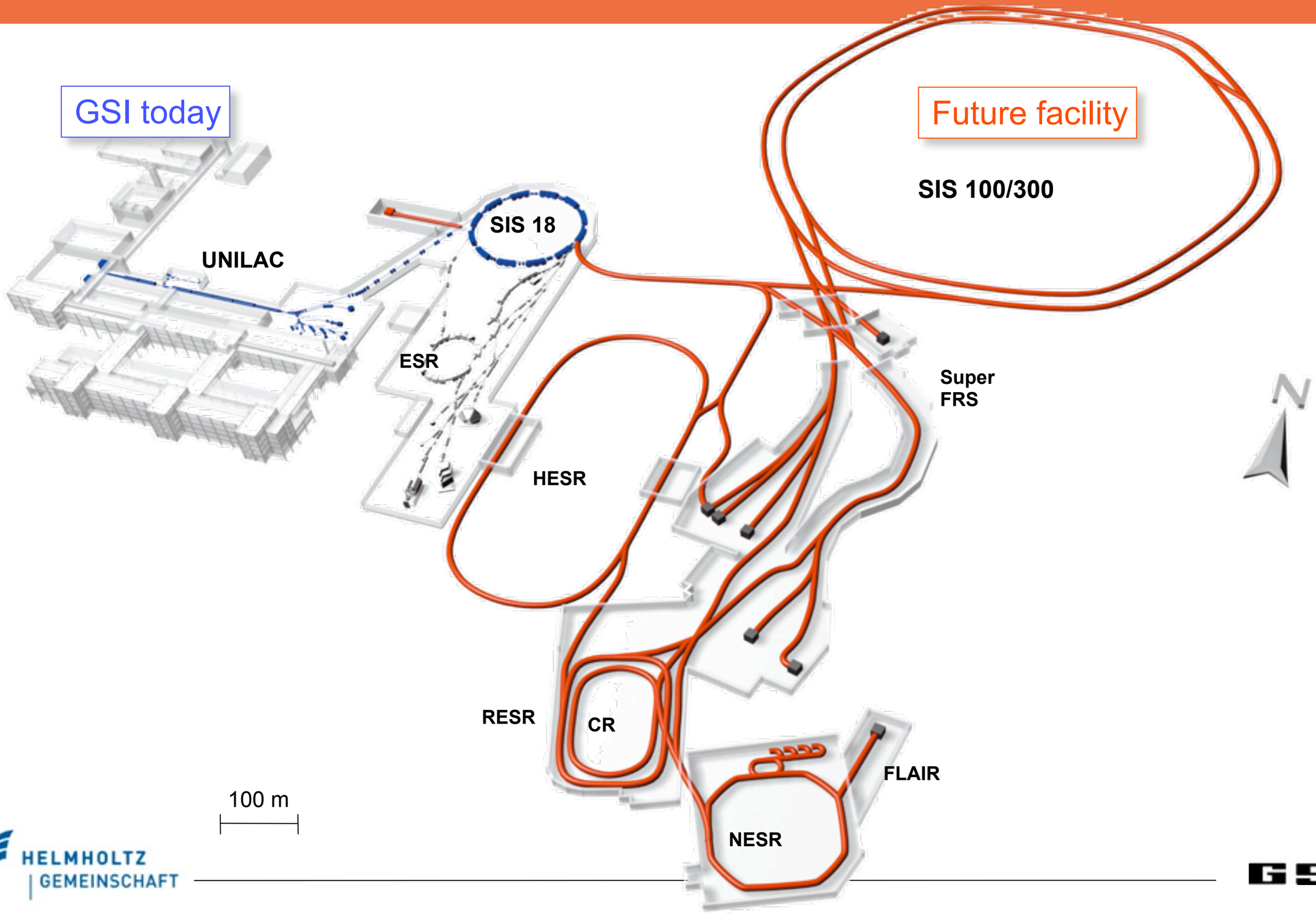
Multiple Resonant Schottkies → LIMA (Lifetimes, Masses)

Physics opportunities with the new Schottky pickups in the HESR

**F. Bosch, C. Brandau, P. Hülsmann, C. Kozhuharov, Yu.A. Litvinov,
F. Nolden, M.S. Sanjari, M. Steck, P.M. Walker, N. Winckler**

**ILIMA Open Meeting at the NuSTAR Week
28 February 2012
GSI, Darmstadt**

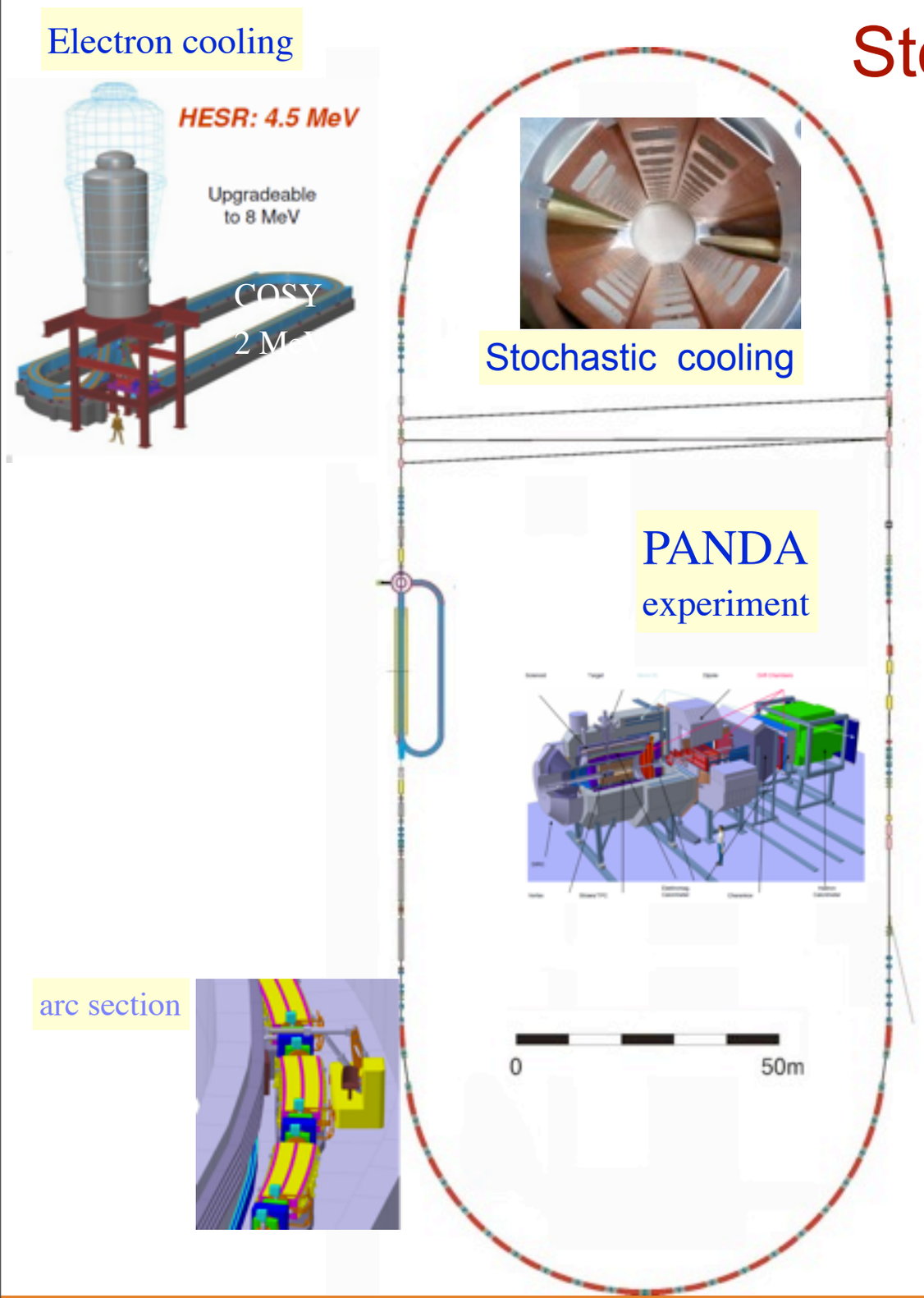
FAIR - Facility for Antiproton and Ion Research



HELMHOLTZ
GEMEINSCHAFT

GSI

The High Energy Storage Ring HESR



Storage of heavy ions

HESR Parameters

- circumference 574 m
- Injection energy 740 MeV/u
- $B\rho$ = 50 Tm
- for U^{92+}: 4.937 GeV/u
- γ_{MAX}=6.30; β_{MAX}=0.987
- momentum (energy) range 1.5 to 15 GeV/c (0.8-14.1 GeV)
- injection of antiprotons from CR accumulation with barrier bucket and stochastic cooling (later accumulation in RESR)
- internal cluster and jet target

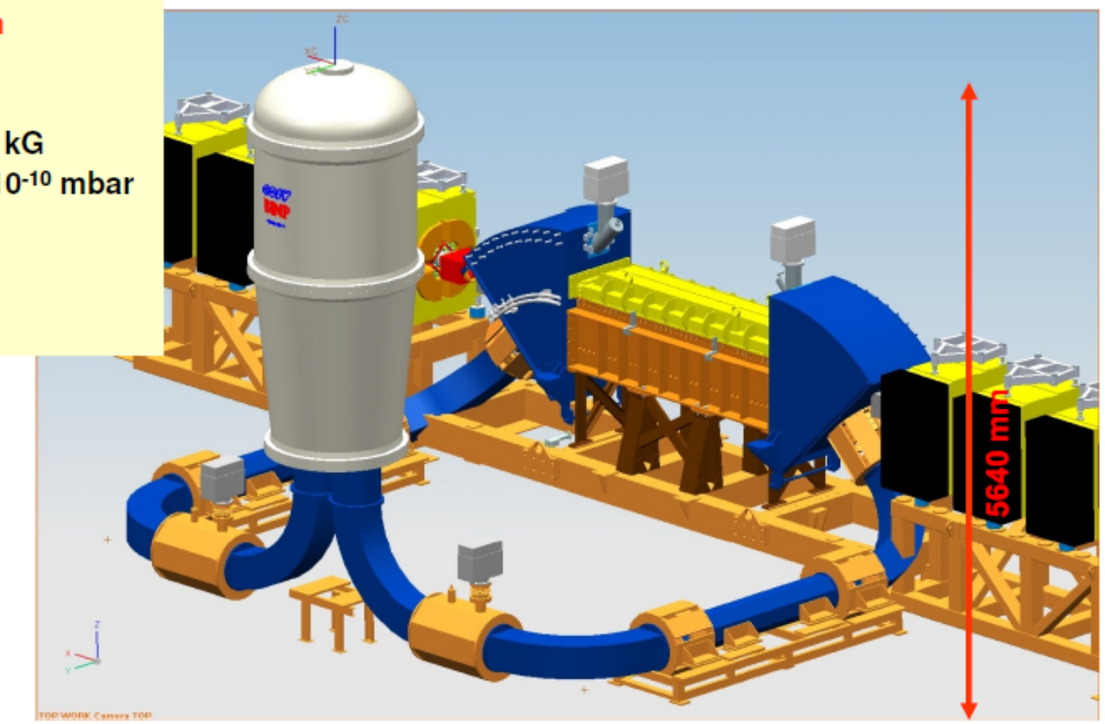
Most of the equipment foreseen for the NESR can be transferred to the HESR

Electron cooling: 2 MeV COSY Cooler in HESR

Technical Design – Layout BINP

Basic Parameters and Requirements

Energy Range:	0.025 ... 2 MeV
High Voltage Stability	$< 10^{-4}$
Electron Current	0.1 ... 3 A
Electron Beam Diameter	10 ... 30 mm
Cooling section length	2.694 m
Toroid Radius	1.00 m
Variable magnetic field (cooling section solenoid)	0.5 ... 2 kG
Vacuum at Cooler	10^{-9} ... 10^{-10} mbar
Available Overall Length	6.390 m
Maximum Height	5.7 m
COSY beam Axis above Ground	1.8 m

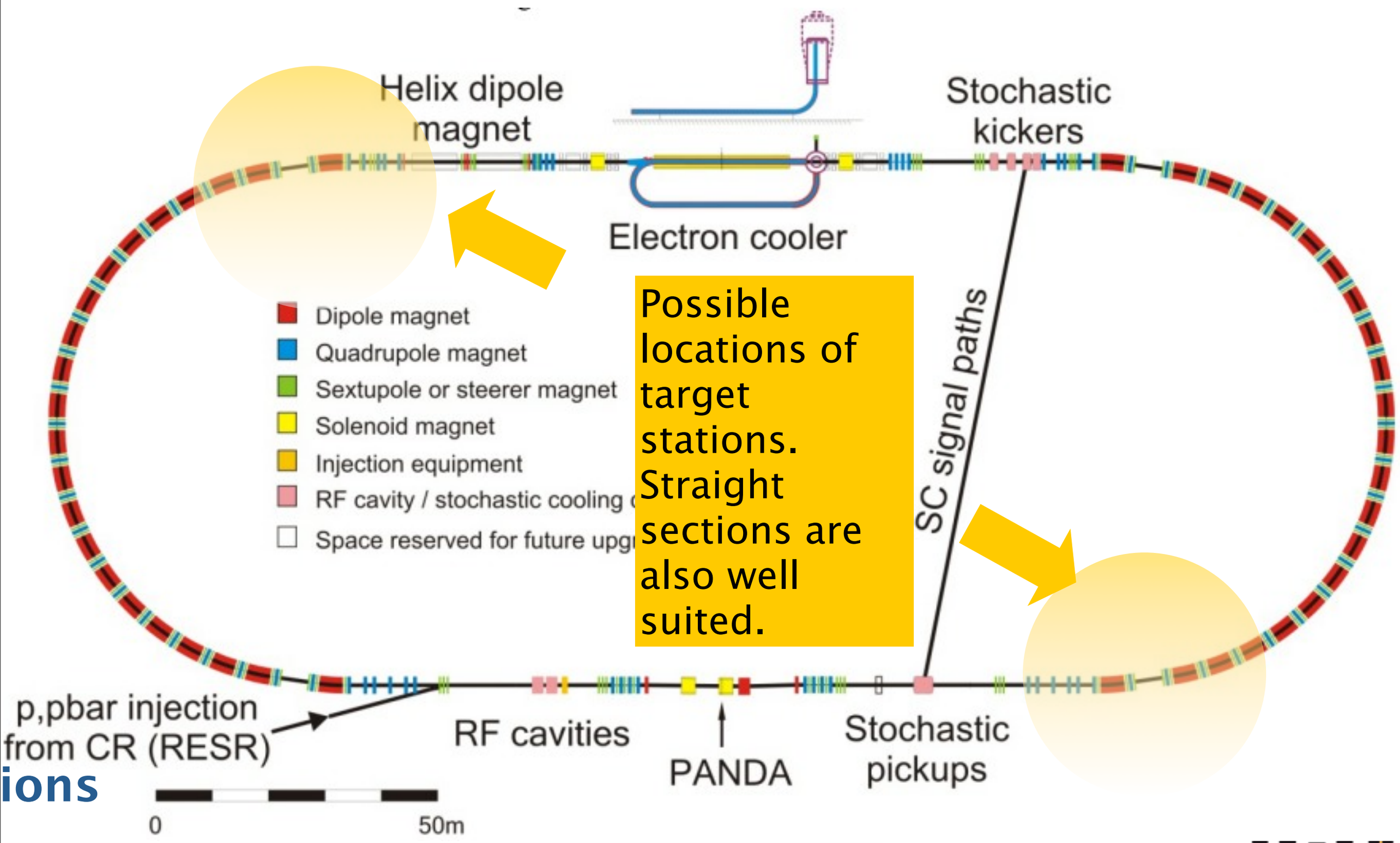


Final Version from January 2010

12th of April 2011 Jürgen Dietrich Institut für Kernphysik (IKP-4) Folie 4

Courtesy of J. Dietrich

Experimental Conditions at the HESR



Possible locations of target stations. Straight sections are also well suited.

ions

SPARC Experiments at the HESR:

A Feasibility Study

Thomas Stöhlker[1,2,3], Reinhold Schuch[4], Siegbert Hagmann[1,5], Yuri A. Litvinov[1,2]
for the SPARC Collaboration*
Christina Dimopoulou[1], Alexei Dolinskii[1], & Markus Steck[1]

FAIR - CORE Facility → ILIMA (Isomeric Beams, Lifetimes, Masses)

FAIR - MSV → MA (Masses)

Multiple Resonant Schottkies → LIMA (Lifetimes, Masses)

FAIR - CORE Facility → ILIMA (Isomeric Beams, Lifetimes, Masses)

FAIR - MSV → MA (Masses)

Multiple Resonant Schottkies → LIMA (Lifetimes, Masses)

ILIMA @ HESR → ILIMA (Isomeric Beams, Lifetimes, Masses)

ILIMA Set-Up at FAIR

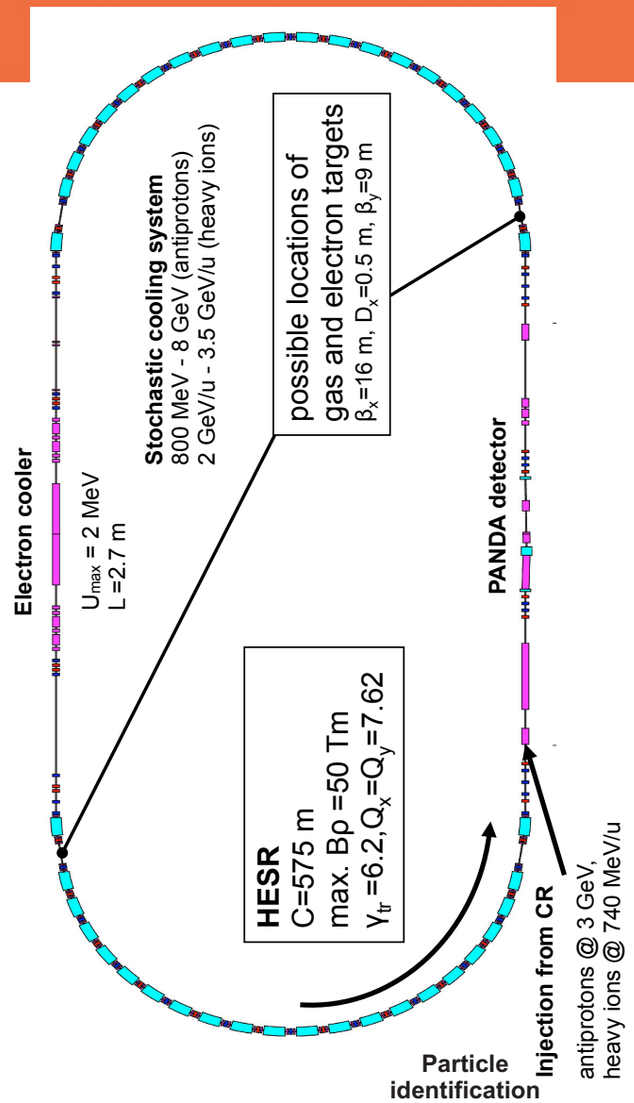
Isochronous Mass Spectrometry in the CR

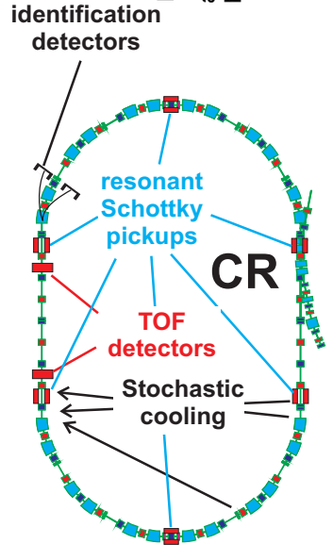
$$\gamma \rightarrow \gamma_t$$

Schottky Mass Spectrometry in the CR & HESR

$$\frac{\Delta v}{v} \rightarrow 0$$

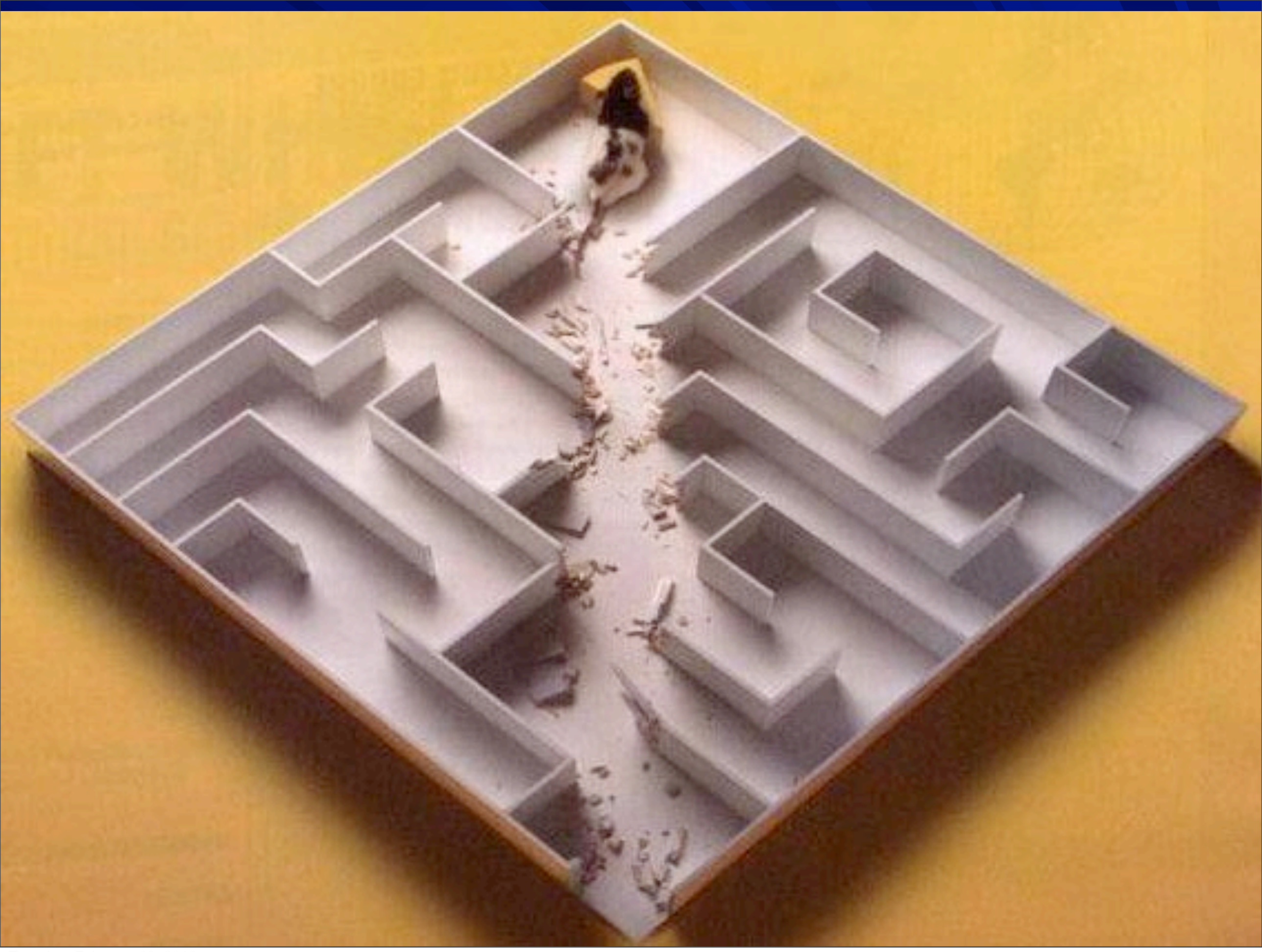
$$\frac{\Delta t}{t} = -\frac{\Delta f}{f} = \frac{1}{\gamma_t^2} \cdot \frac{\Delta(m/q)}{m/q} + (\frac{\gamma^2}{\gamma_t^2} - 1) \cdot \frac{\Delta v}{v}$$





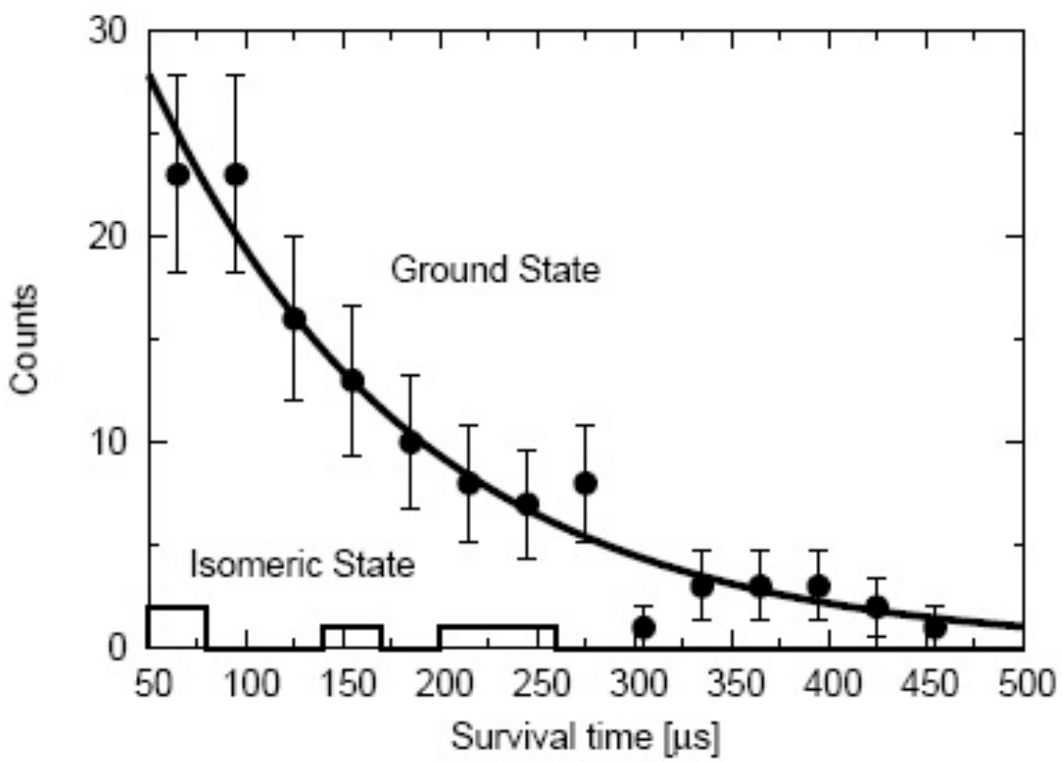
HELMHOLTZ GEMEINSCHAFT

GSI

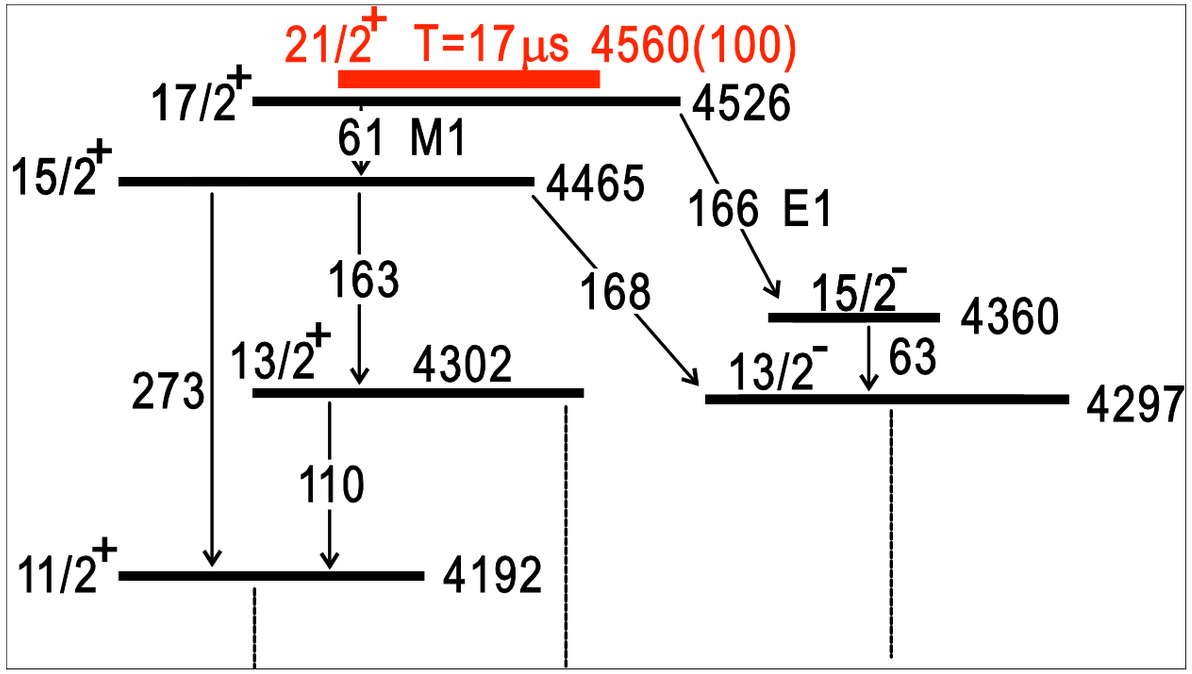


Extension of IMS for short-lived isomer investigation

"lifetime" in the ring



Level scheme



→ In support of the shell-model calculation and also complement to the "missing" information in g-ray spectroscopy

Experimental Conditions at the HESR

- Stochastic cooling & electron cooling **OK**
- Target stations
  - electron-, gasjet-, fiber-targets **OK**
- Particle detectors **OK**
- Ion Stacking **OK**
- Luminosity (number of stored ions) **OK**
- Beam diameter/charge separation **OK**
- Acceleration and Deceleration **OK**
- Coupling of laser to the ion beam line **OK**
- Building / Space for setups **to be investigated**

HESR Electron Cooling (Single Particle Simulation)

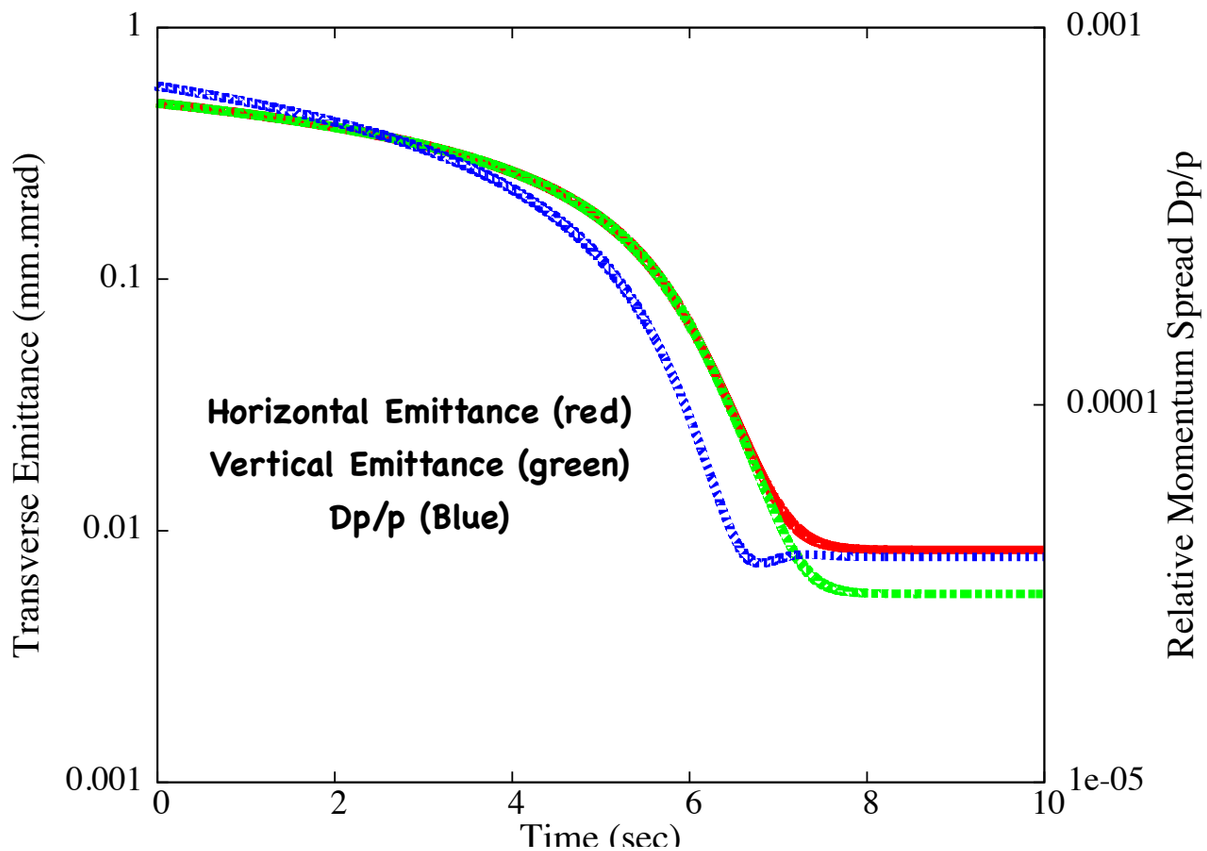
132Sn50+, 740MeV/u, Initial Emittance=0.5 Pi mm.mrad, Dp/p=7e-4

Nparticle=6e8

Cooler Length=2.7 m, I=0.5A, Electron Diameter= 2cm,

Effective electron temperature=1e-2 eV, Transverse electron temperature=0.2 eV

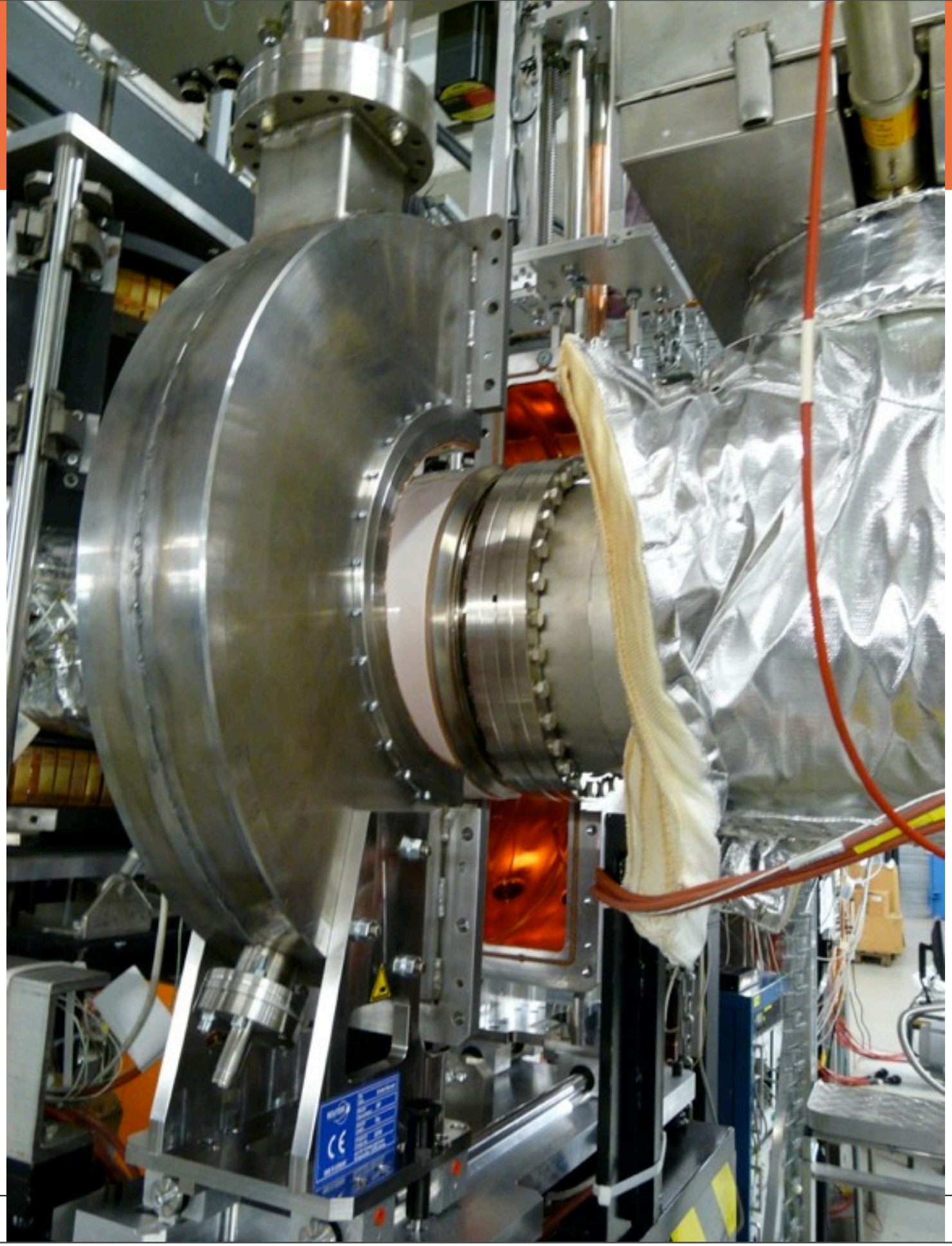
BetaH=10m, BetaV=120m



Electron Cooling of Ions in the HESR

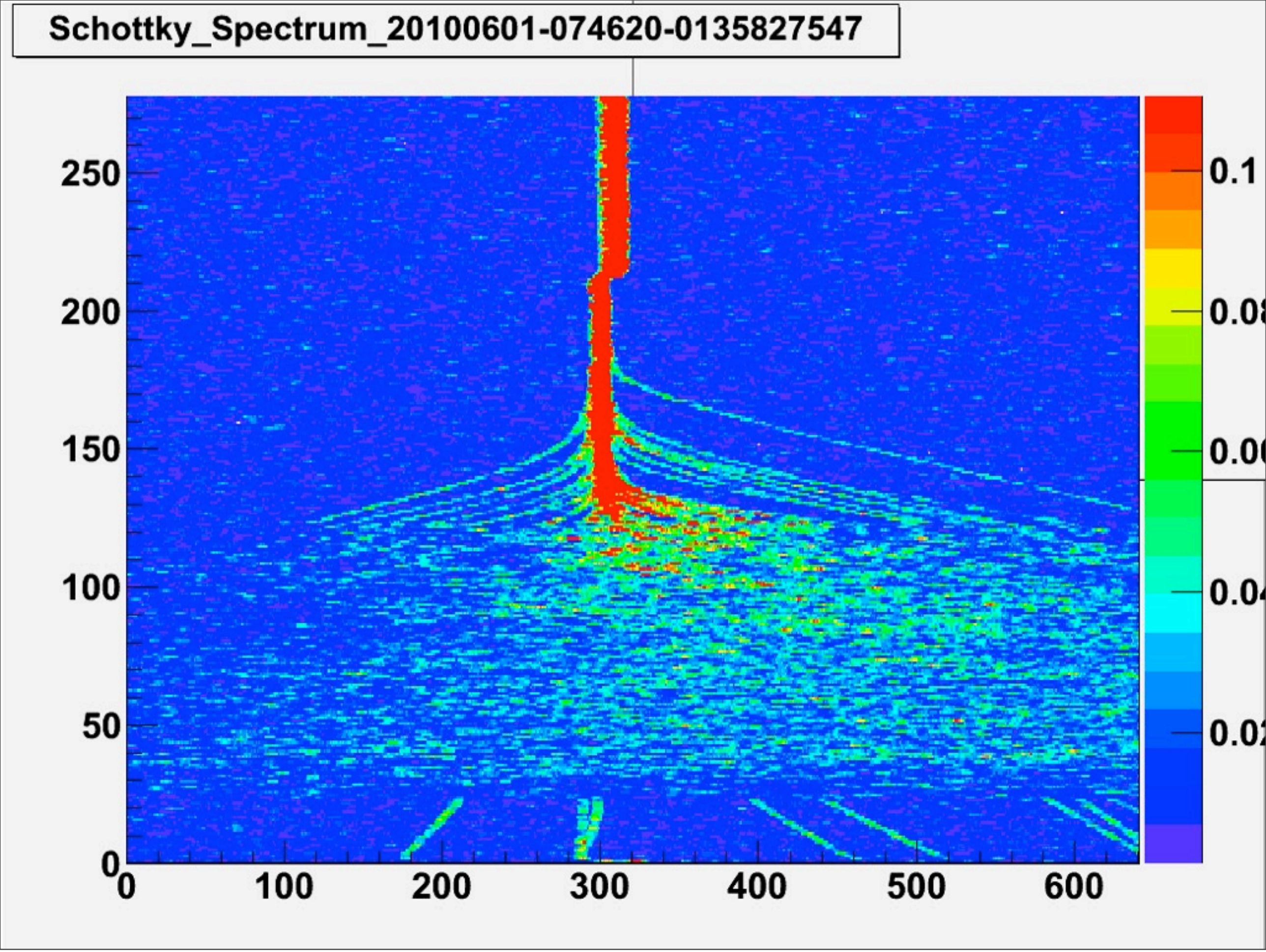
January 2012

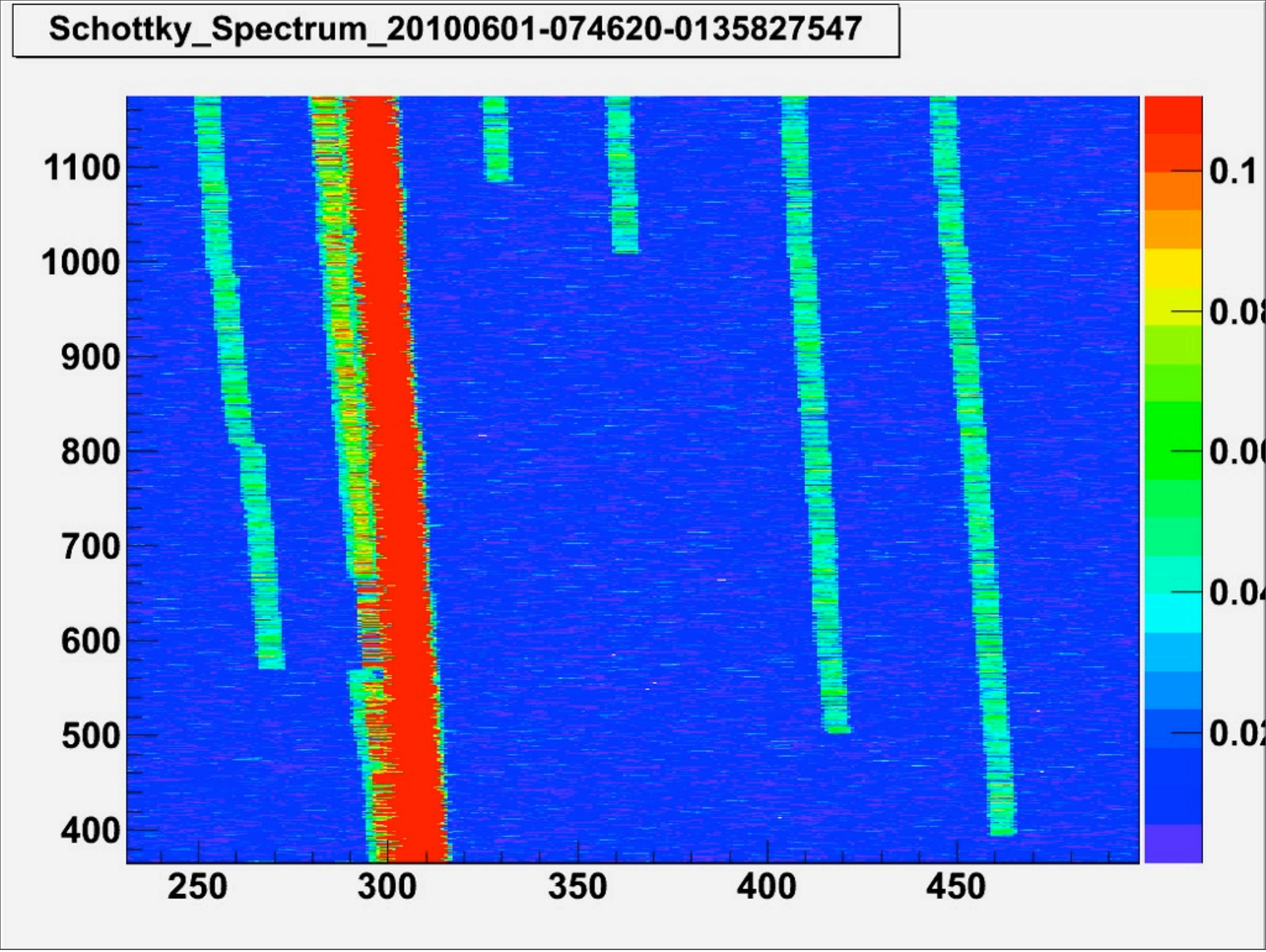
T. Katayama



HELMHOLTZ
GEMEINSCHAFT

GSI


Schottky_Spectrum_20100601-074620-0135827547
250
200
150
100
50
0
0
100
200
300
400
500
600
0.1
0.08
0.06
0.04
0.02


Schottky_Spectrum_20100601-074620-0135827547
1100
1000
900
800
700
600
500
400
250
300
350
400
450
0.1
0.08
0.06
0.04
0.02