Status of the HIE ISOLDE PROJECT

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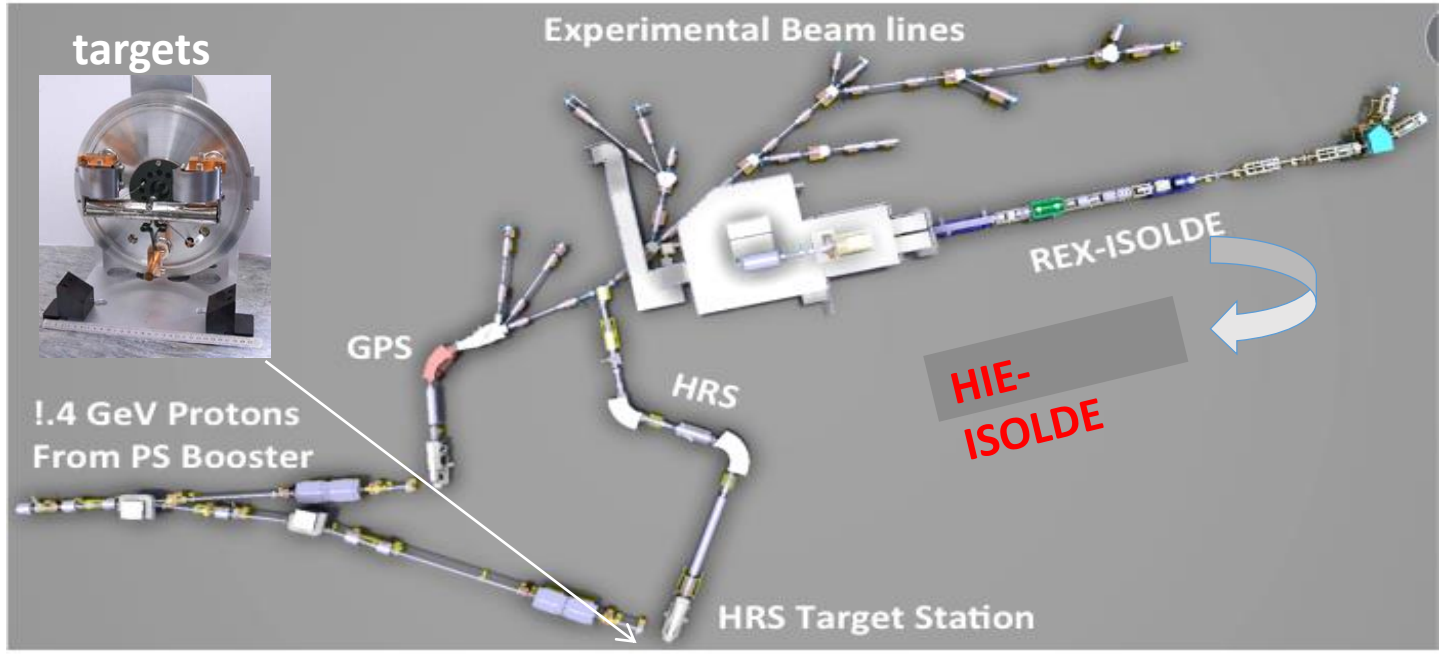
ISOLDE Facility

- ISOLDE is the CERN radioactive beam facility
- Nuclei produced via reactions of high intensity high energy proton beam with thick and heavy targets.
- Provides low energy or post-accelerated exotic beams
- Around 50 experiments per year



Belgium CERN Denmark

Finland France Germany

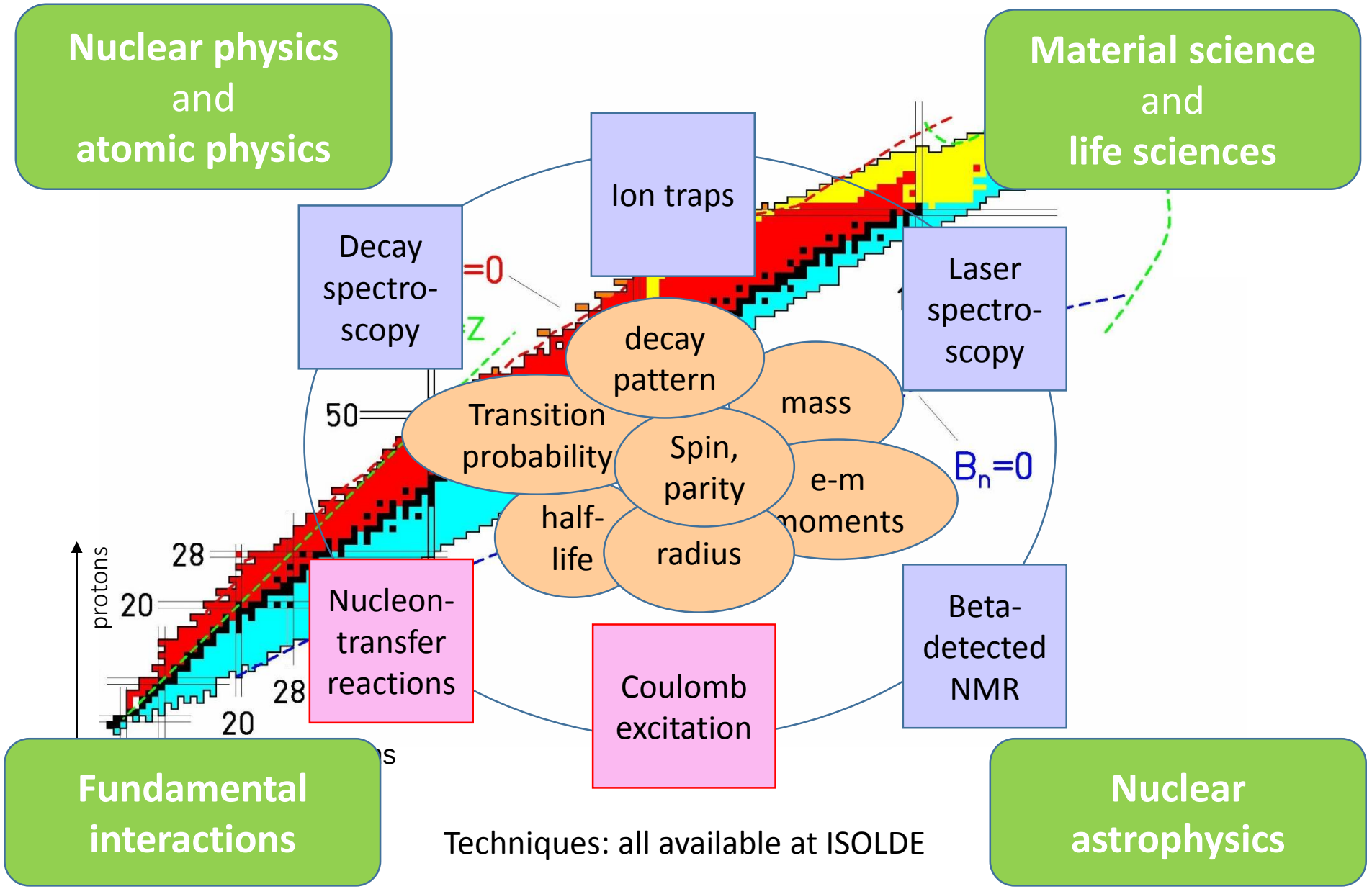
Greece Italy India

Sweden Slovakia United Kingdom

Ireland Norway Poland

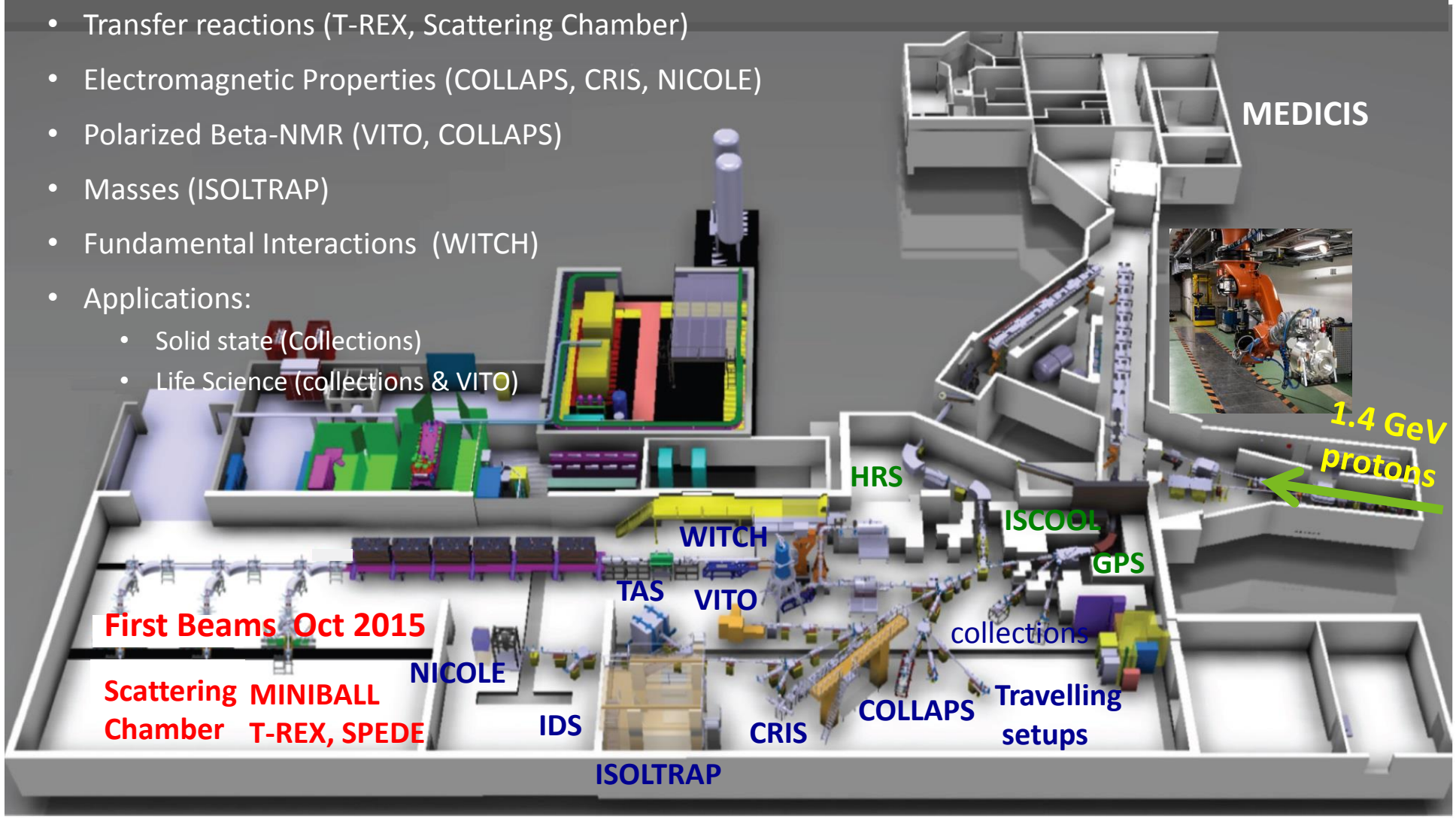
Romania Spain South Africa

ISOLDE: Research with Radioactive Nuclei



Techniques: all available at ISOLDE

- Decay spectroscopy (IDS, TAS,..)
- Coulomb excitation (MINIBALL+ CD + SPEDE)
- Transfer reactions (T-REX, Scattering Chamber)
- Electromagnetic Properties (COLLAPS, CRIS, NICOLE)
- Polarized Beta-NMR (VITO, COLLAPS)
- Masses (ISOLTRAP)
- Fundamental Interactions (WITCH)
- Applications:
  - Solid state (Collections)
  - Life Science (collections & VITO)

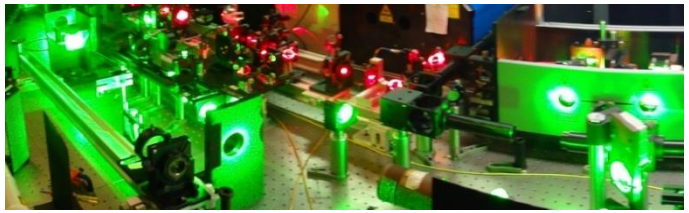


— Post-accelerated Exps (5.5 MeV/u), — Low Energy (30-60kV) Exps, — Machine elements

Highlights from ISOLDE

RILIS: Ionisation potential of Astatine

S. Rothe et al, **Nature Communications** 4 (2013), 1835



Least abundant element on Earth
Series of Rydberg states
Ionisation Potential = 9,31751 (8) eV

REX-ISOLDE + MINIBALL : Octupole deformation in 220Rn and 224Ra

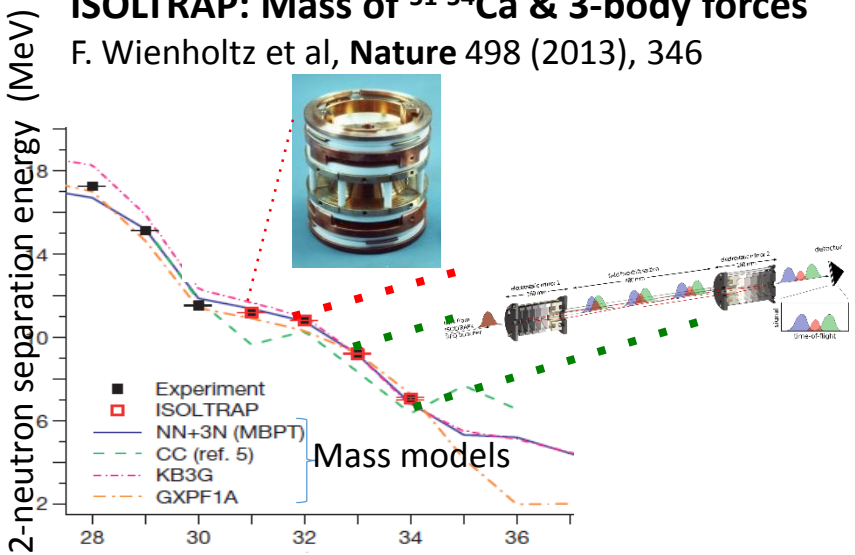
L.P. Gaffney et al, **Nature** 497 (2013) 199

Candidates for searches for permanent EDMs:

- Radiums-223 and 225 promising

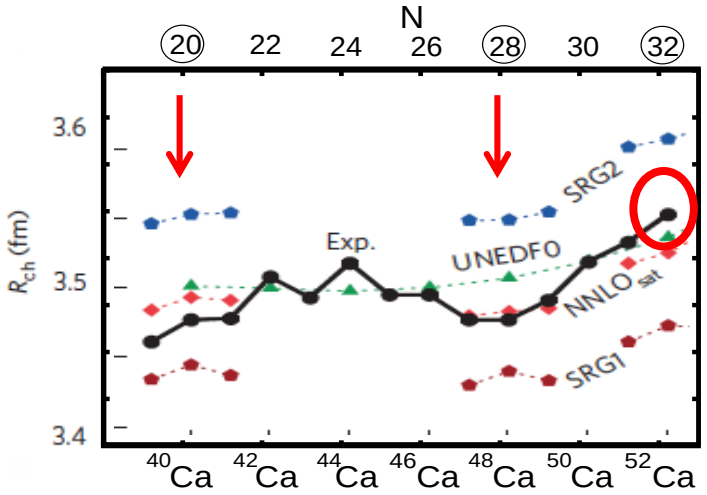
ISOLTRAP: Mass of $^{51-54}$Ca & 3-body forces

F. Wienholtz et al, **Nature** 498 (2013), 346



COLLAPS: Radii of $^{40-52}$Ca

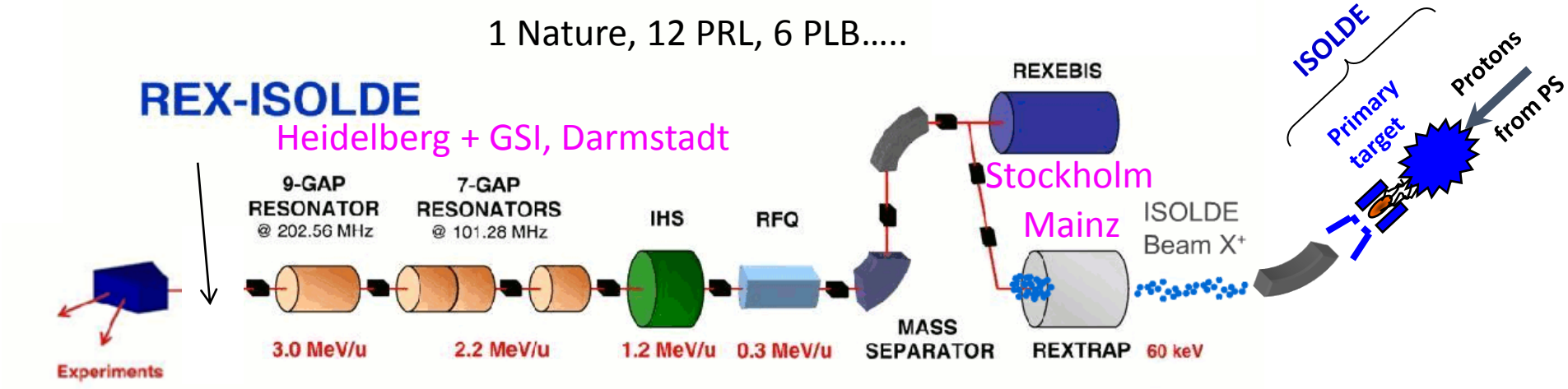
R. Garcia-Fdez et al, **Nature Phys** Feb 2016, 594



Post-accelerator: REX-ISOLDE

- **Built @ different Universities**
- Approved in 1994 as an experiment: “Radioactive EXperiment..”
- First beams @ 2.2 MeV/u in Oct 2001
- Upgrade to 3.1 MeV/u completed in 2004
- REX Universal post-accelerator from He to Ra (A=224) >
  100 different beams
- In 2006 a new hall extension in preparation for HIE-ISOLDE

1 Nature, 12 PRL, 6 PLB…..



Physics program @ REX

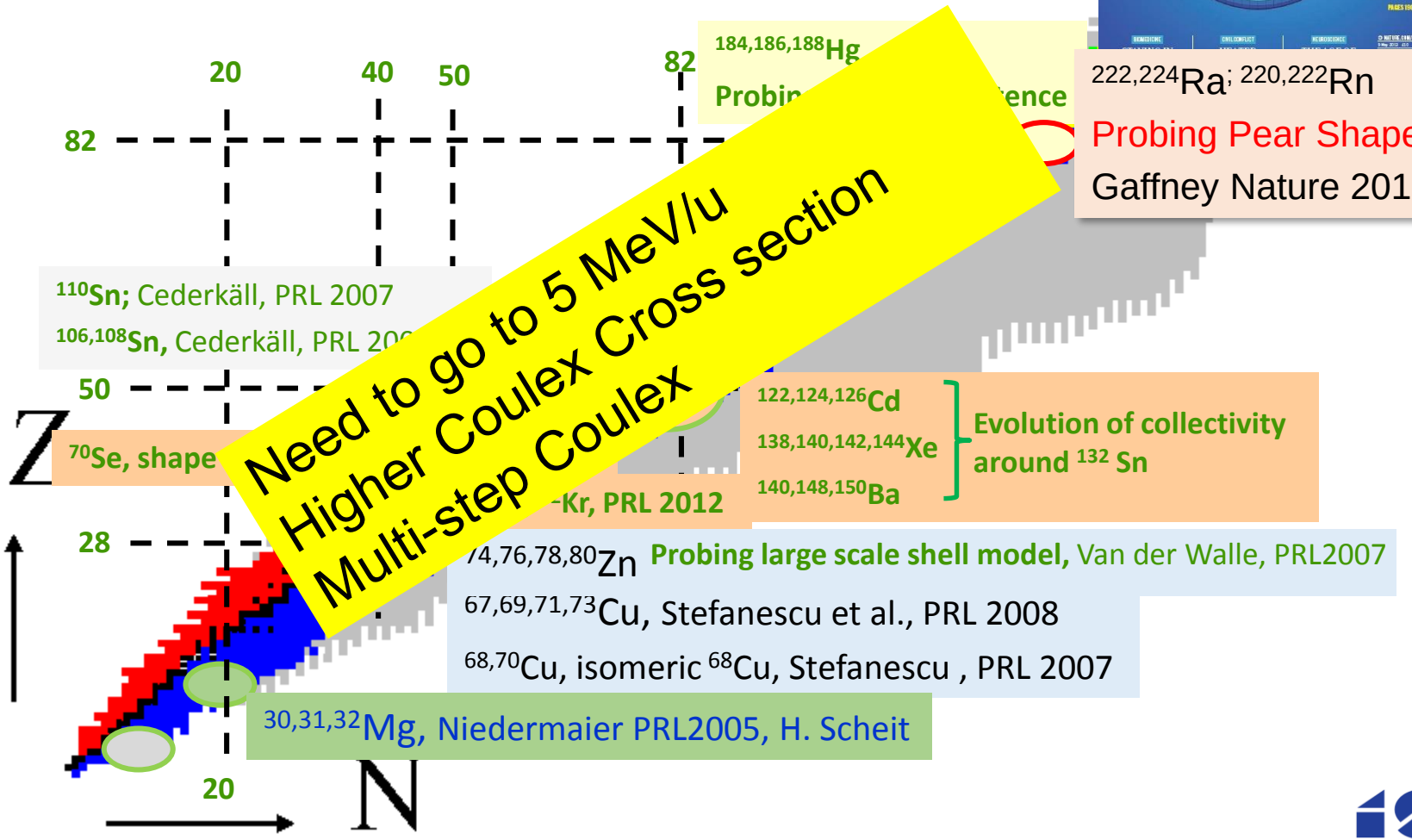
Coulomb excitation with Miniball:

- collectivity versus individual nucleon behaviour

^{222,224}Ra; ^{220,222}Rn

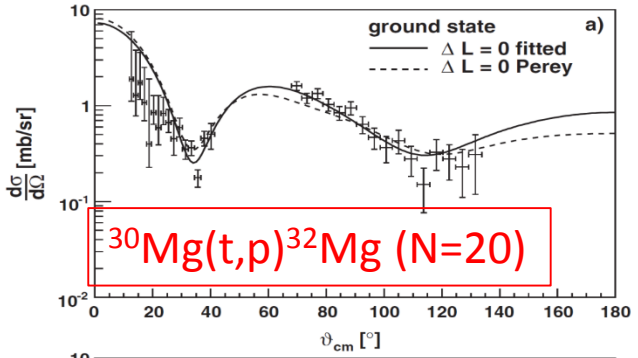
Probing Pear Shape

Gaffney Nature 2013

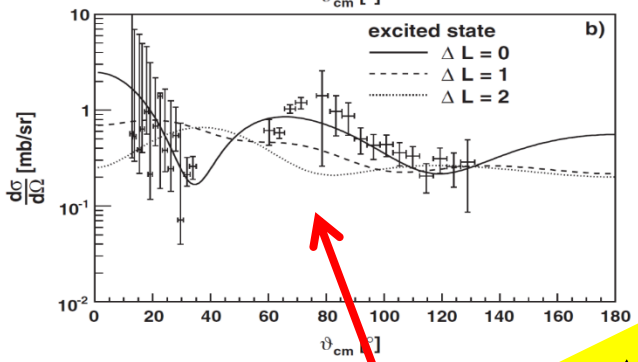


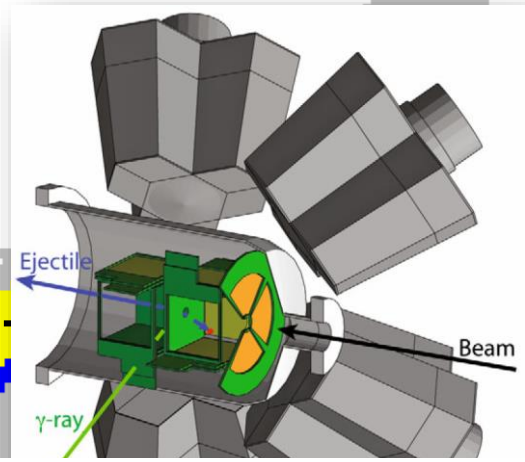
Transfer Reactions @ REX

- reaction studies:
  operties
  structures



^{30}Mg(t,p)^{32}Mg (N=20)





82

28

t(^{72}Zn,p)^{73}Zn Heilgartner

t(^{44}Ar,p)^{46}Ar Now

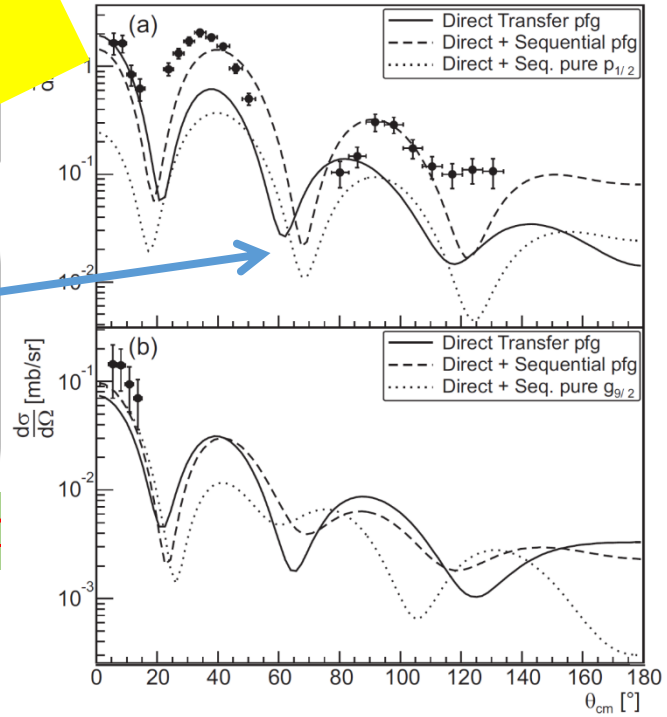
Need to go to 10 MeV/u
Transfer reaction studies

Ni,p)^{67}Ni Diriken

t(^{66}Ni,p) ^{68}Ni Elseviers

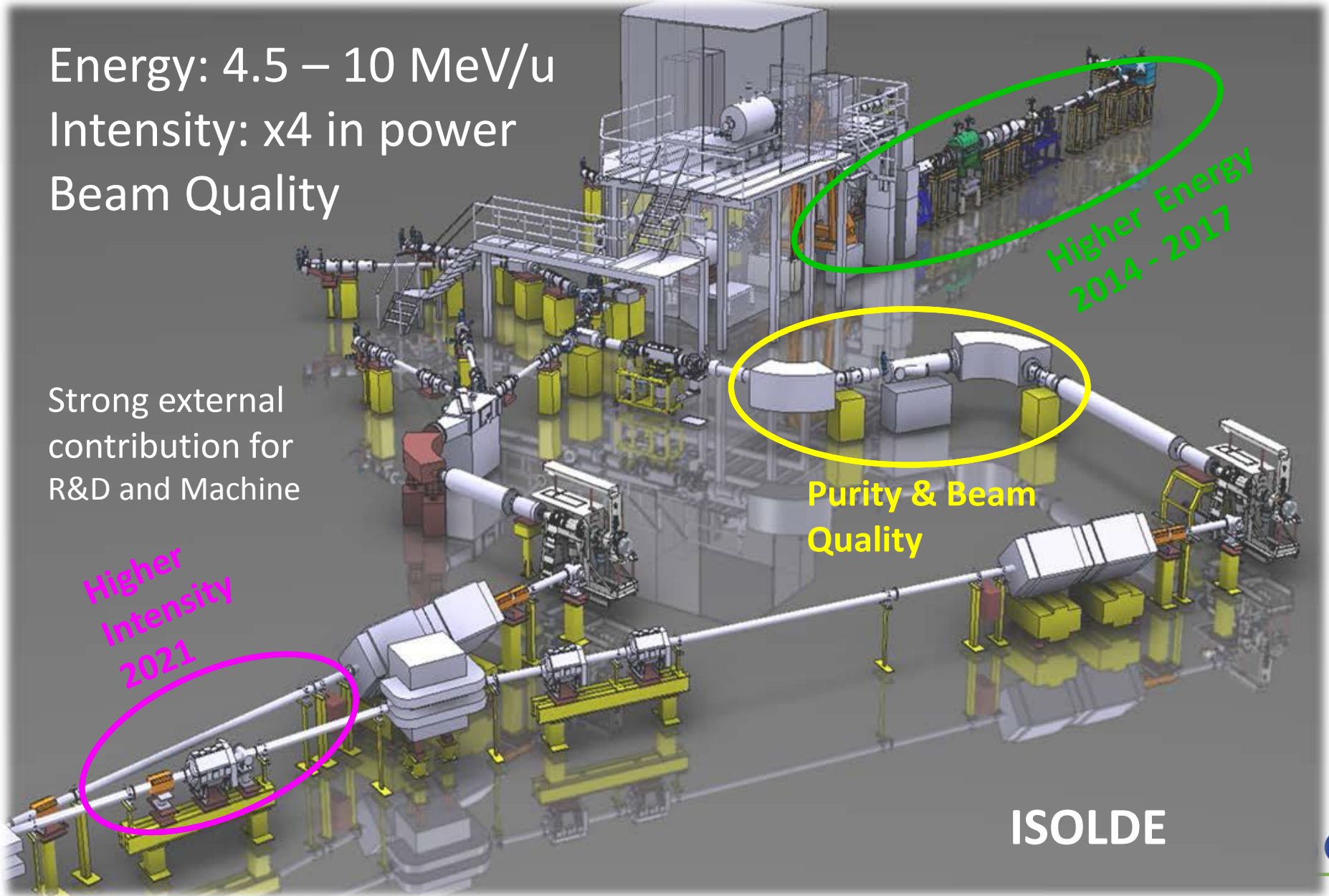
d(^{78}Zn,p)^{79}Zn Orlandi

d(^{30}Mg,p)^{31}Mg, K. Wimmer, PRL 201



Light nuclei, halos & clusters
d(^{8}Li,p)^{9}Li*; Tengborn PRC (2011) d(^{9}Li,p)^{10}Li
d(^{11}Be,p)^{12}Be Johansen PRC (2013)

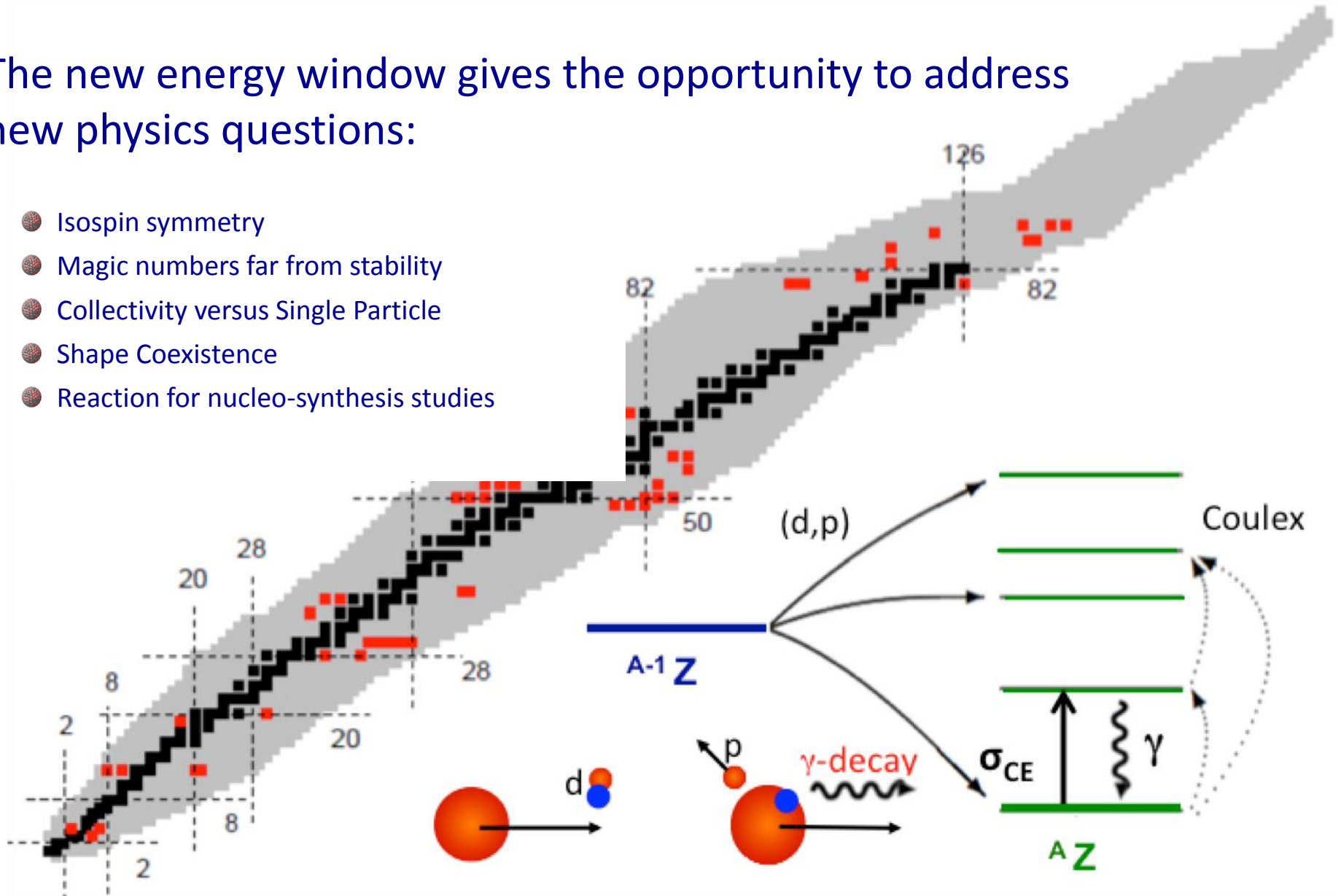
The HIE-ISOLDE project (2010 -)



Physics at HIE-ISOLDE

The new energy window gives the opportunity to address new physics questions:

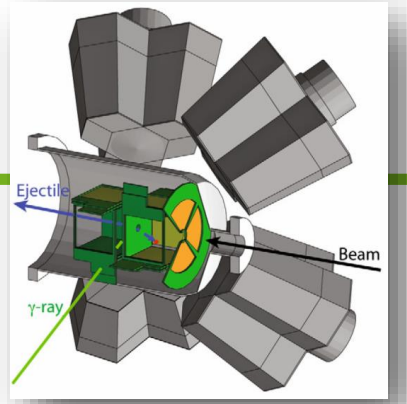
- Isospin symmetry
- Magic numbers far from stability
- Collectivity versus Single Particle
- Shape Coexistence
- Reaction for nucleo-synthesis studies



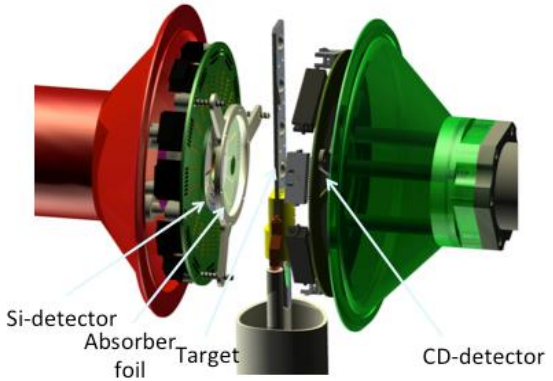
HIE-ISOLDE Opportunities:

Reaction	Physics	Optimum energy
(d,p), (^{3}He,α), (^{3}He,d), (d,n),… transfer	Single-particle configurations, r- and rp-process for nucleosynthesis	10 MeV/u
(^{3}He,p), (d,α), (p,t), (t,p)	pairing	5-10 MeV/u
Few-nucleon transfer	Structure of neutron-rich and proton-rich nuclei	8 MeV/u
Unsafe Coulomb excitation	High-lying collective states	6-8 MeV/u
Compound nucleus reactions	Exotic structure at drip line	5 MeV/u
Coulomb excitation, g-factor measurements	Nuclear collectivity and single-particle aspects	3-5 MeV/u
(p,p'γ), (p,α), …	nucleosynthesis	2-5 MeV/u

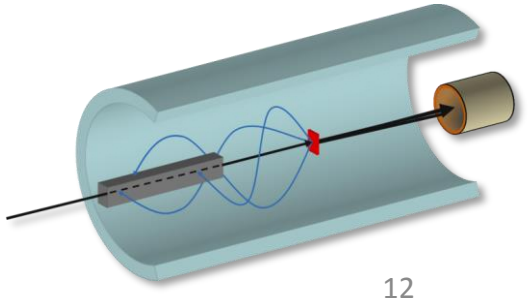
Instrumentation

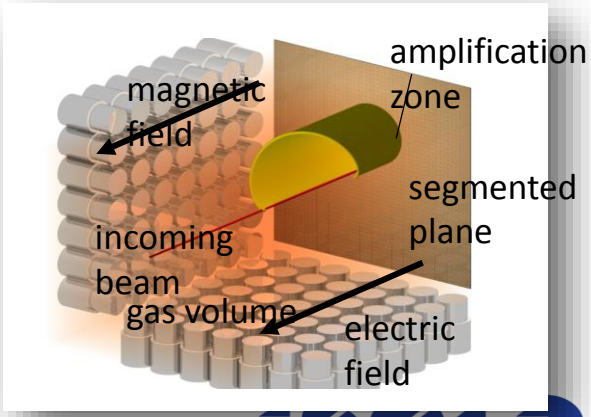


- Miniball + T-REX (upgrade planned) :
  COULEX + Transfer. (2016) C-REX
- Multipurpose reaction chamber
- CORSET chamber for fusion-fission reactions



- SPEDE: added to Miniball+T-REX
- ISOL Solenoidal Spectrometer: ISS (Hall →@ TSR)
- MAYA/ACTAR: resonant scattering + transfer
- Zero type spectrometer
- TSR storage ring

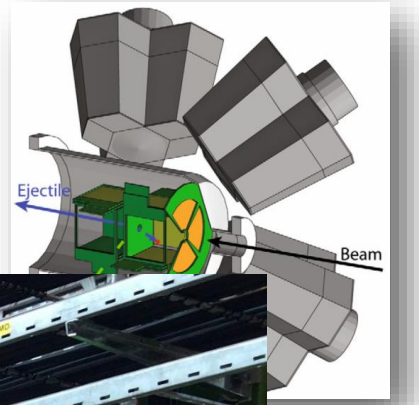




Installation of first Cryomodule in place for 4.3 MeV/u

HEBT installation

(re-) Installation of experiments



8th of May 2015

Scattering chamber on XT02

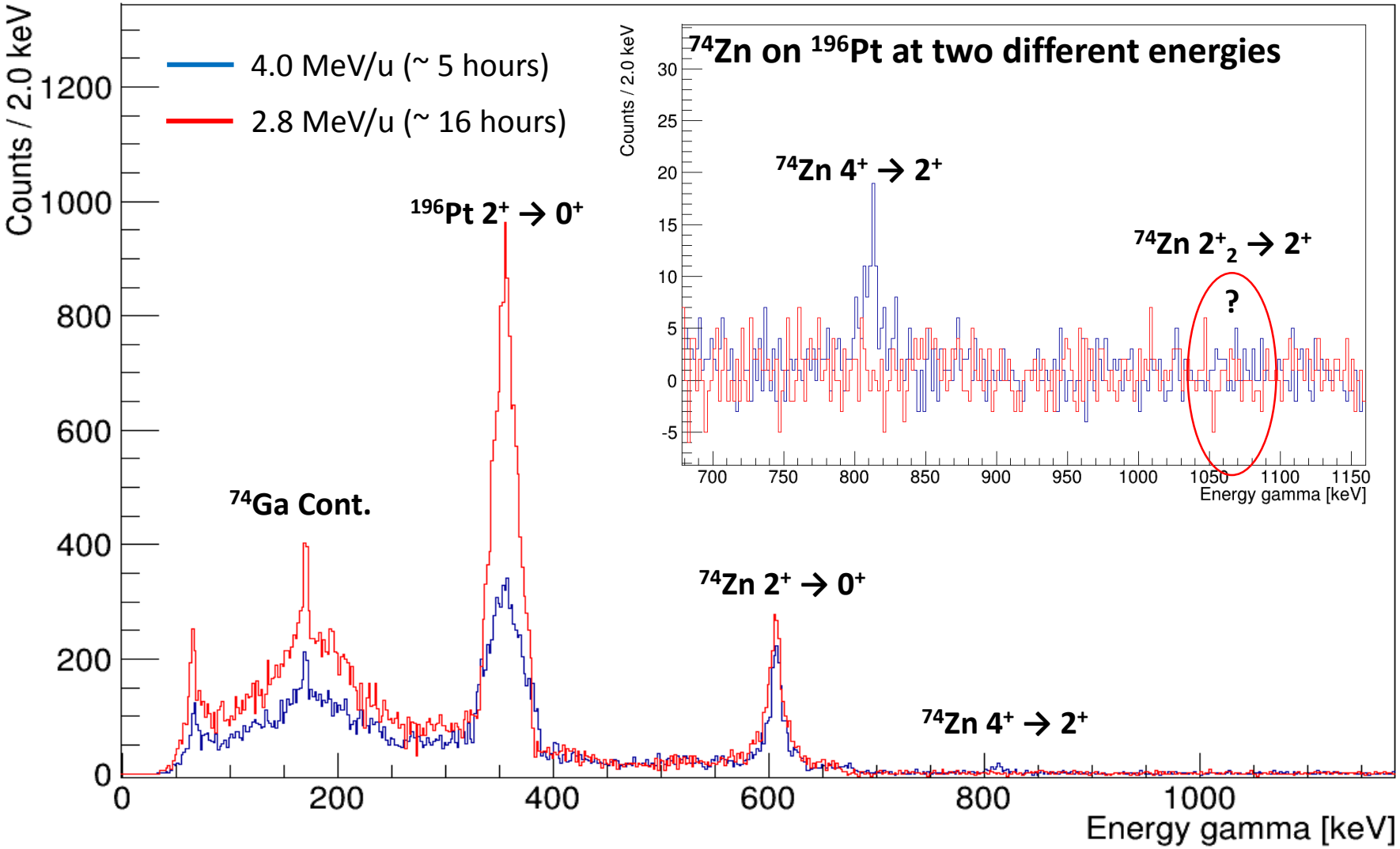
1st beam delivered: 22nd October 2015

1st beam of $^{74}Zn^{25+}$ to HIE-ISOLDE
Afterwards on ^{76}Zn

- HOWEVER: Special beam permit: operation of cryomodules only during working hours, and not during weekend, power coupler unstable and was heating after extended operation. Also 9-gap amplifier non-optimal.
- Stability of the lasers allowed for night-time operation of Zn → opportunistic REX (2.85MeV/u) run during off-hours.
- Heavy load on the operators but greatly appreciated by the users.
- Demonstration of machine, but impractical for normal useage.

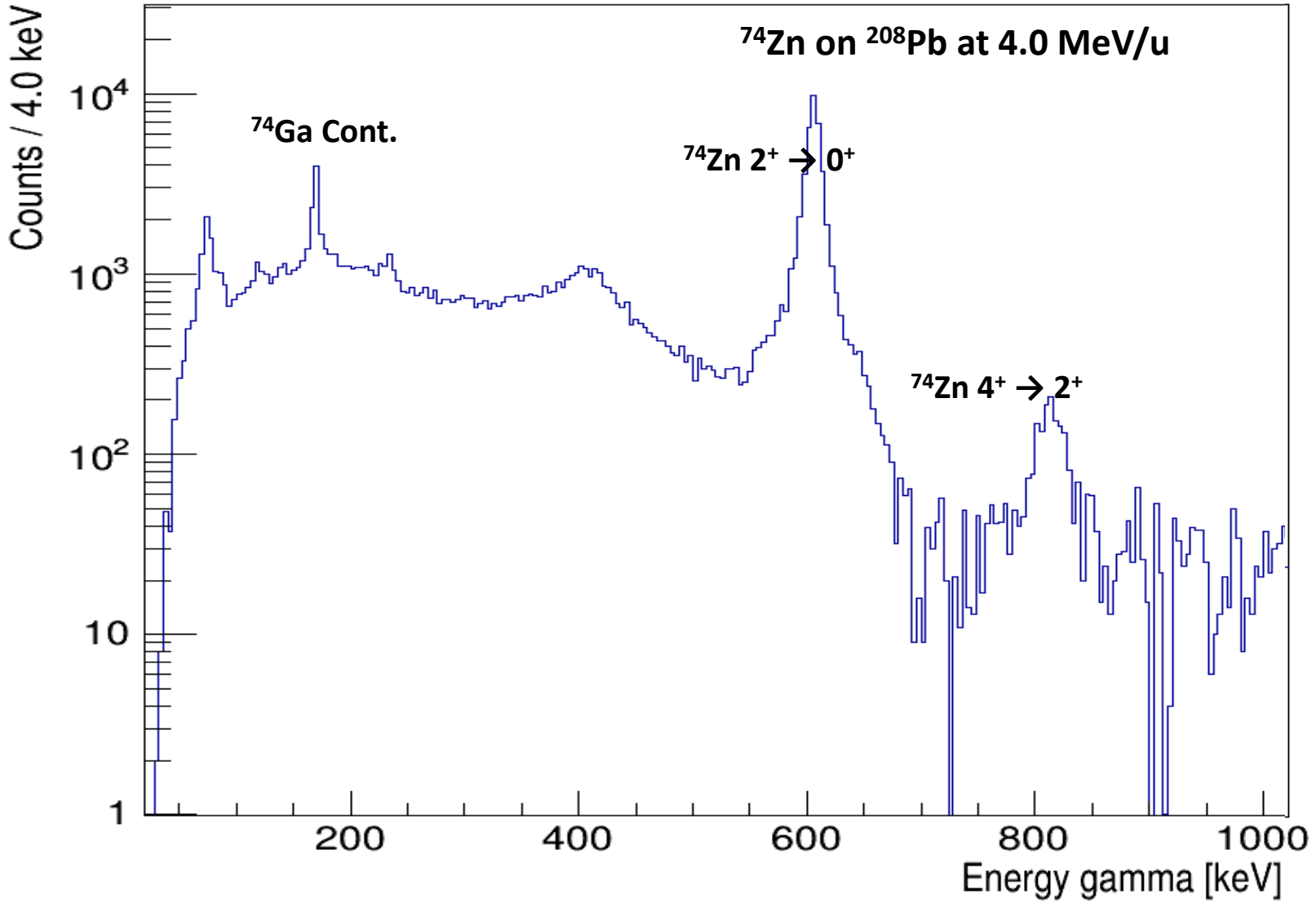
First Coulex experiment at HIE ISOLDE 10/2015

^{74}Zn(10^6 pps) + ^{196}Pt



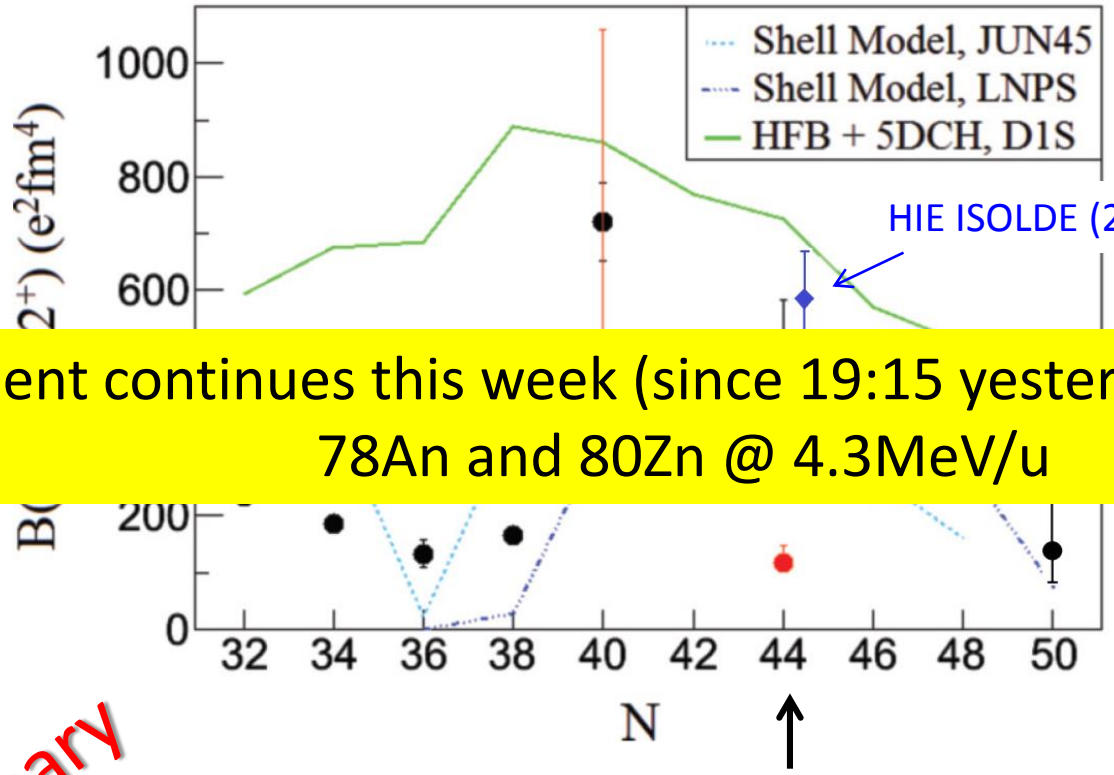
(courtesy of Piet van Duppen)

First Coulex experiment at HIE ISOLDE 10/2015



(courtesy of Piet van Duppen)

An unexpectedly long lifetime of $20^{+1.8}_{-5.2}$ ps was measured for the 4^+ state in ^{74}Zn.



HIE ISOLDE (2015)

Experiment continues this week (since 19:15 yesterday evening) with 78An and 80Zn @ 4.3MeV/u

Preliminary

Louchart PRC 2013
Van De Walle PRL 2007
Shiga PRC2016

Illana Sison, Zielinska to be published

(courtesy of Piet van Duppen)

Installation work: 2016

- Removal of original CM for repair.
- Installation of 2nd CM
- RE-installation of original CM
- Difficult cooling down period, many issues with cryoplant, H20 pollution/Air leaks/Compressor (4 week delay)
- Problem with two cavities.
- Short circuit on solenoid in CM1, but had been dealt with.
- **HOWEVER: no heating of RF coupler… → 24/7 operation**

2016 REX Start-up

- ✓ Consolidation of the vacuum cryo compressor pumps
- ✓ REX machine now under vacuum (RFQ, IH, 7- and 9-Gap structures)

- ✓ **New 9-Gap Amplifier has been installed**

Physics campaign for 2016

Coordinator's burden:

- 42 experiments on the books
- 855 shifts outstanding
- Popularity growing: new proposals coming in all the time!
- LS2 (2018-2020) staring us in the face…..

Assuming a stable machine (i.e. 24/7 operation). Define priorities for 2016

Conclusions from HIE-ISOLDE users workshop 1st February 2016

- 24 approved proposals ask for beam time in 2016 → won't be able to serve more than 7
- Full energy range of accelerator up to 6.0 MeV/u → 5.5MeV/u
- Mass range from ^{18}N up to ^{228}Ra → intermediate masses
- MINIBALL configuration for Coulomb excitation and transfer reactions will be installed for 2016 campaign → going to go with C-REX
- Combination with SPEDE is available after successful stable beam commissioning in summer 2016 → tests continuing
- High number of experiments should be provided to user community → 6 possible (4 week cooling delay)

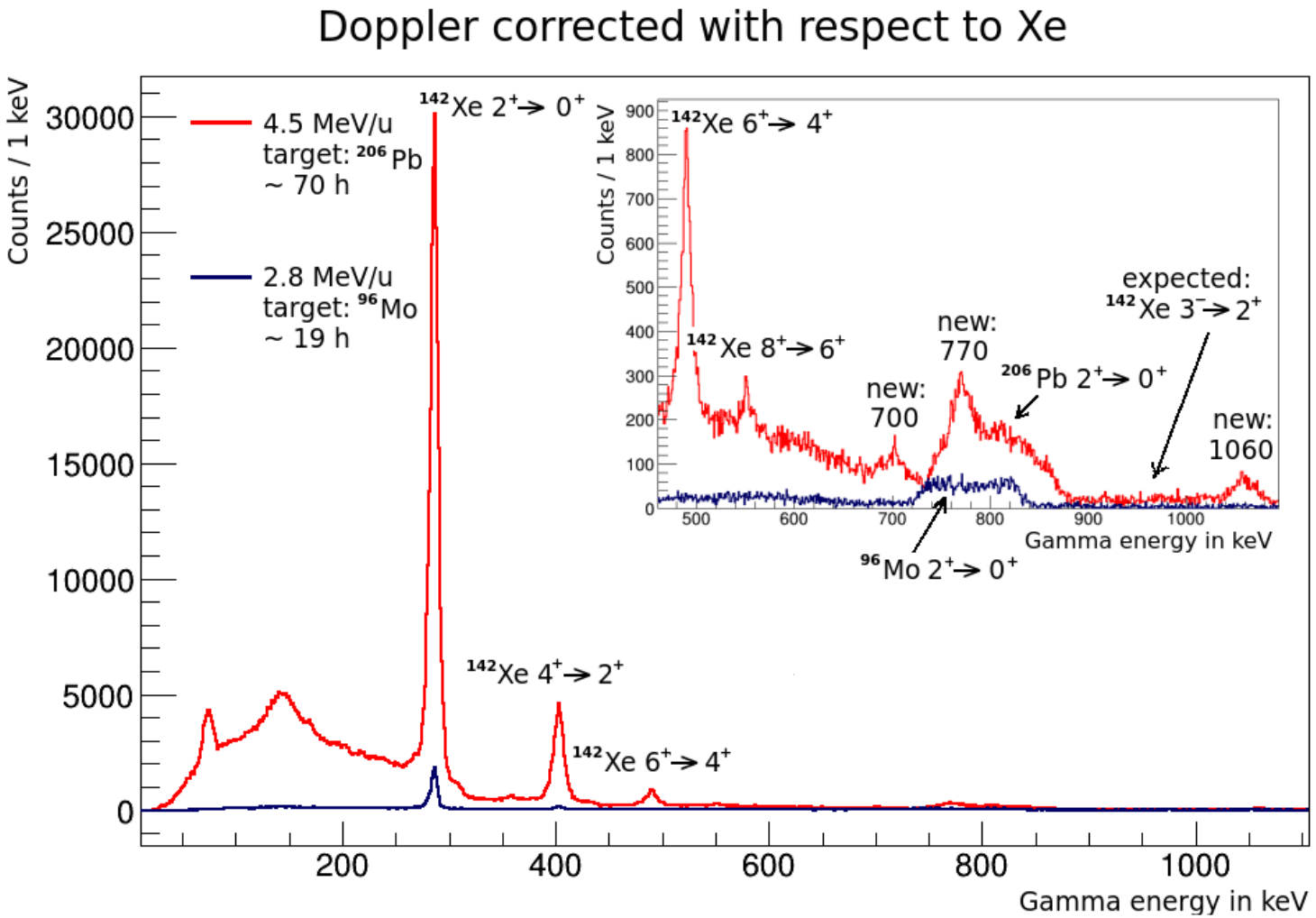
Beams 2016: chosen for intensity, and ramping up of A/q etc

110Sn, 80Zn, 142Xe, 132Sn, 9Li, 66Ni

^{110}Sn beams @ 4.5MeV/u: Sept 9th 2016

1 week of operation exceeded 2015 running hours (~ 3 weeks)

Preliminary data from 142Xe for IS548



Courtesy of corinna Henrich

Celebration of end of Phase I: 28th September 2016

Phase 2: Assembly of CM3, to be installed in 2017

Phase 2: Assembly of CM3, to be installed in 2017

Summary and plans for 2017

- Ongoing commissioning of ISOLDE solenoid spectrometer.
- 1st experiment accepted.
- Installation on 2nd beamline in winter 2017 along with completion of 3rd beamline

- HIE – ISOLDE phase one complete.
- First programme of experiments for 2016 now underway.
- In spite of some downtimes, producing interesting new data.
- 3rd Cryomodule to be installed in Spring 2017
- Aim to maximise the physics campaign in 2017.