

### AGATA @ HIE-ISOLDE

- ISOLDE overview
- spectroscopy at REX-ISOLDE
- HIE-ISOLDE
- perspectives with AGATA





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### **ISOLDE at CERN**



# **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. Largest selection worldwide
- Provides low energy or post-accelerated exotic beams
- > 500 Users from 100 Institutions, 50 experiments / year



PSB upgrade (2018) PSB upgrade (2018) energy (1.4 -> 2GeV)



## **Present ISOLDE beams**



Nearly 1000 isotopes of over 70 chemical elements – largest choice for any ISOL facility 4



## Recent ISOLDE high lights



18

**REX-ISOLDE + MINIBALL : Octupole deformation in 220Rn and 224Ra** L.P. Gaffney et al, **Nature** 497 (2013) 199

Candidates for searches for permanent EDMs:

- Radon-221 not suitable
- Radiums-223 and 225 promising



#### ISOLTRAP: Mass of 54Ca and 3-body forces

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

- Confirmation of N=32 as magic number far from stability
- Validation of three-body forces using chiral perturbation theory



#### **RILIS: Ionisation potential of Astatine**

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



Least abundant element on Earth High-precision study via Rydberg states



# Physics program @ REX

REX-ISOLDE was running from 2001-2012 108 different beams already used at REX- ISOLDE of 700 available! Coulomb excitation with Miniball:

collectivity versus individual nucleon behaviour



## **Transfer Reactions @ REX**



# **Near Future: HIE-ISOLDE project**

#### **Energy Upgrade:**

HIE-ISOLDE project includes construction of a SC LINAC to upgrade the energy of the postaccelerated radioactive ion beams to 4.3 MeV/u in 2015 and up to 10 MeV/u by 2017

- Approved Dec 2009
- Officially started Jan 2010
- Yacine Kadi project Leader
- Budget 43 M\$

#### **Intensity Upgrade:**

A design study for the intensity upgrade addresses the technical feasibility and cost estimate for operating the facility at **10 kW** once LINAC4 and PS Booster are online (2019).

# **SC-LINAC Installed in 3-phases**



## **Three beam lines**

Layout accommodates for 3<sup>rd</sup> experimental station
Fully modular (3x repeat of same solution)



## schedule

- 2016-2017: HIE-ISOLDE phase II: 10 MeV/u
- mid-2018-2019: Shut down to implement LINAC 4 that
- increase in power of a factor of 6
- mid-2018-2019: Shut down
- increase in energy of the PS-Booster from 1.4 GeV to 2 GeV
- Increase in Intensity a factor of 1,4 to 6 depending on the reaction



## **Advantages of HIE-ISOLDE**

Intensity & beam quality & efficiency Energy upgrade to 5.5 MeV /A  $\longrightarrow$  10 MeV /A

<sup>32</sup>Mg(d,p)<sup>33</sup>Mg



 $<sup>\</sup>Rightarrow$ access to the sign of deformation



Single particle information through the spectroscopic factors

High energy needed to learn about the "l" transfer

# Physics @ HIE-ISOLDE (2014)

- May 2010: 34 Lol submitted
- I Nov 2012: INTC endorsed the increase of 2 GeV-proton energy for ISOLDE
- 27 experiments approved
- 600 shifts already allocated for day 1 physics 50



Isospin symmetry

50

Collectivity versus Single Particle

126

82

- Magic numbers far from stability
- Shape Coexistence
- Quadropole and octupole degrees of freedom



## Instrumentation

- MINIBALL + T-ReX (upgrade planned) : **COULEX + Transfer** Multipurpose reaction chamber **CORSET** chamber for Fusion-fission reactions SPEDE: added to Miniball+T-REX Helios type device MAYA/ACTAR: resonant scattering + transfer.
- TSR storage ring,



22

2

1

1

1





field

#### **Detector Configuration MB alone**



 $\Delta x = 8.5 \text{ mm} (\text{w/ PSA}) \implies \Delta \theta_{\gamma} = 4^{\circ}$ 

#### AGATA a $\gamma$ -ray tracking spectrometer

Reconstructed initial gamma rays with: - gamma ray energy

- 1st interaction position  $\rightarrow$  Doppler correction
- 2nd interaction position  $\rightarrow$  Polarization

B. Alikhani, NIM A, 675(0):144 - 154, 2012.

• < 4 mm FWHM resolution obtained



1st interaction positions after PSA and Tracking

### **Detector Configuration MB + AGATA**



#### **Detection Efficiency**



### **Position resolution & Doppler effects**



### **Doppler broadening**



#### **Detection sensitivity MB + AGATA**



 $E_{beam}$  = 5.5 MeV/u (IS551) and 4.0 MeV/u (IS552, IS553) I<sub>beam</sub> @ MINIBALL (I<sub>ISOLDE</sub> typically factor 10-50 higher)

#### **Detection sensitivity MB + AGATA**



<sup>67</sup>Ni:  $\gamma$ -ray cascade 2697 keV + 694 keV

Increase in detection efficiency for  $\gamma\gamma$ -coincidence:

AGATA + MINIBALL 5.0 times more statistics than MB

#### **Detection sensitivity MB + AGATA**



<sup>67</sup>Ni: γ-ray cascade 1667 keV + 1030 keV + 694 keV

Increase in detection efficiency for  $3\gamma$ -coincidences: AGATA + MINIBALL 7.3 times more statistics than MB

## Summary

#### HIE-ISOLDE

- 2015 start with 4.3 MeV/u at A/q = 4.5
- 2016 increase of energy to 5.5 MeV/u
- 2017 final energy 10 MeV/u
- 2018 -2019 CERN shutdown installation of LINAC4
- 2020 increase of intensity by a factor of 2-3; increase in energy of PS-Booster to 2 GeV

#### AGATA @ HIE-ISOLDE LOI

- The ISOLDE community is interested to host the AGATA detector.
- Considering the time scale of the HIE-ISOLDE project and the expected increase in intensity due to the advent of LINAC4 and the increase of energy of the PS-Booster we would like that the AGATA collaboration considers the option of moving the AGATA detector to couple to MINIBALL for 2020-2022.
- The period from 2017-2018 is not very efficient as the second long-shutdown at CERN is foreseen now for mid-2018.
- This move will require a certain effort for the AGATA collaboration, as ISOLDE as such has no strong technical in-house support.
- At the same time we think we can guarantee ample beam time and the largest variety of tailored made radioactive beams in the world.