Danish research at ISOLDE

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on behalf on Danish ISOLDE users

rECFA meeting, Copenhagen, May 12-13 2022

Overview

- The ISOLDE facility
- Nuclear physics
  - Nuclear astrophysics
  - ^{8}He and ^{9}Li decays
- Chemistry and biophysics
  - Biomolecular structure and function
  - Quadrupole moments from molecular experiments
- Other applications of radionuclides
  - ISOLDE helping ESS
  - Medical radionuclides (MEDICIS/PRISMAP)

Karsten Riisager

AARHUS UNIVERSITY

Hans Fynbo

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Lars Hemmingsen

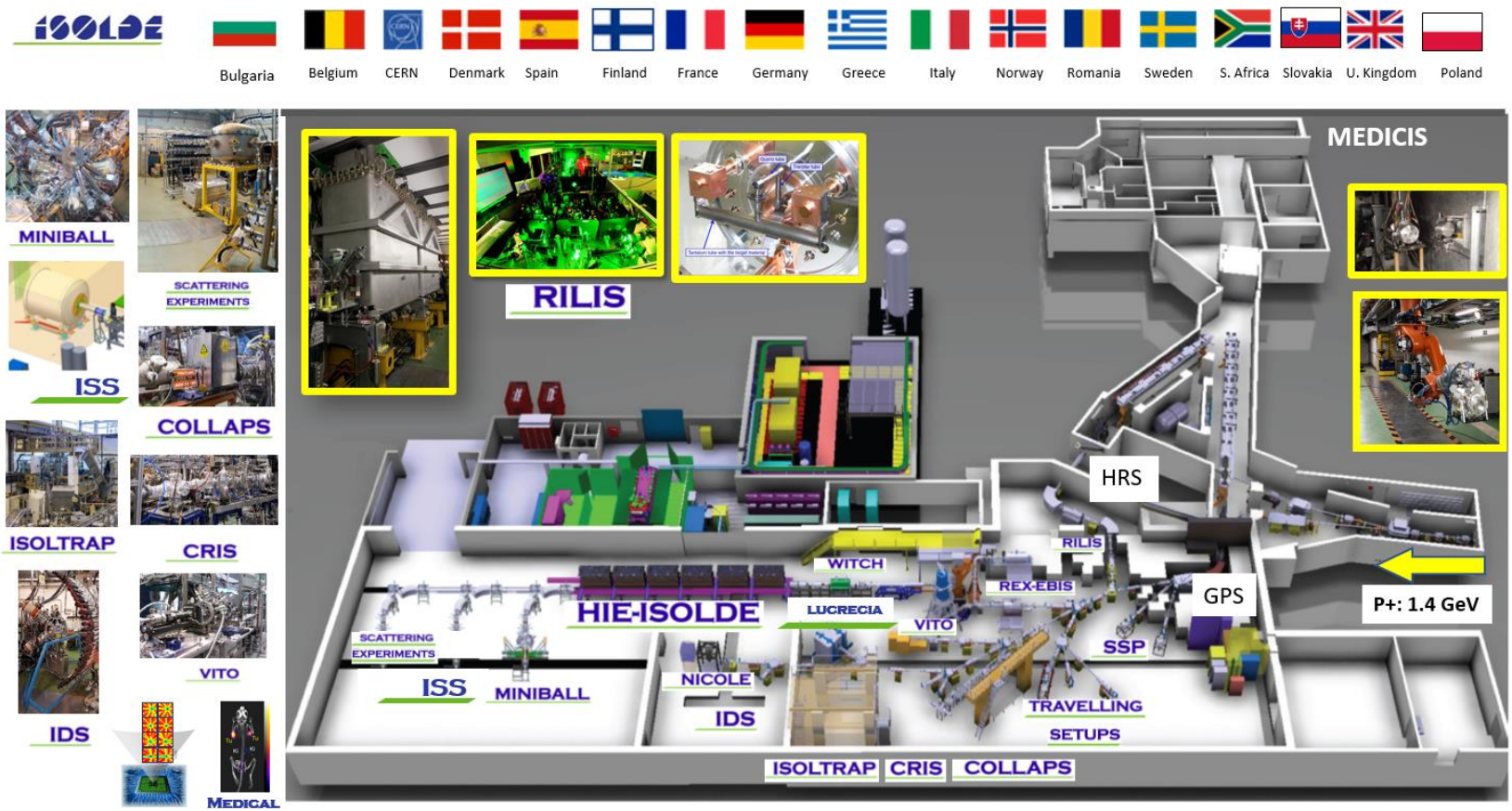
UNIVERSITY OF COPENHAGEN

Mikael Jensen

DTU Technical University of Denmark

ISOLDE

The ISOLDE facility

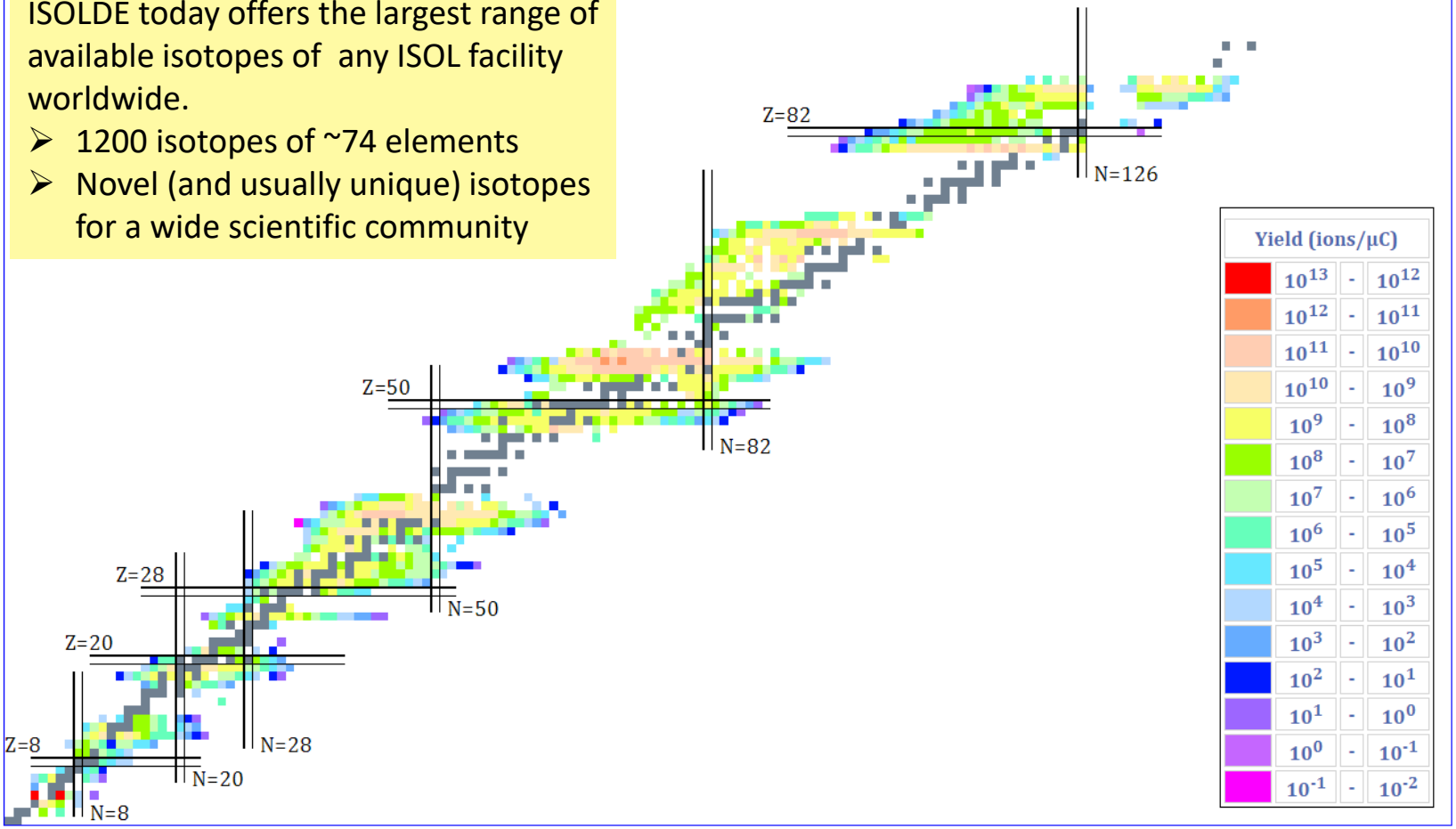


The ISOLDE facility

Nuclear chart for ISOLDE

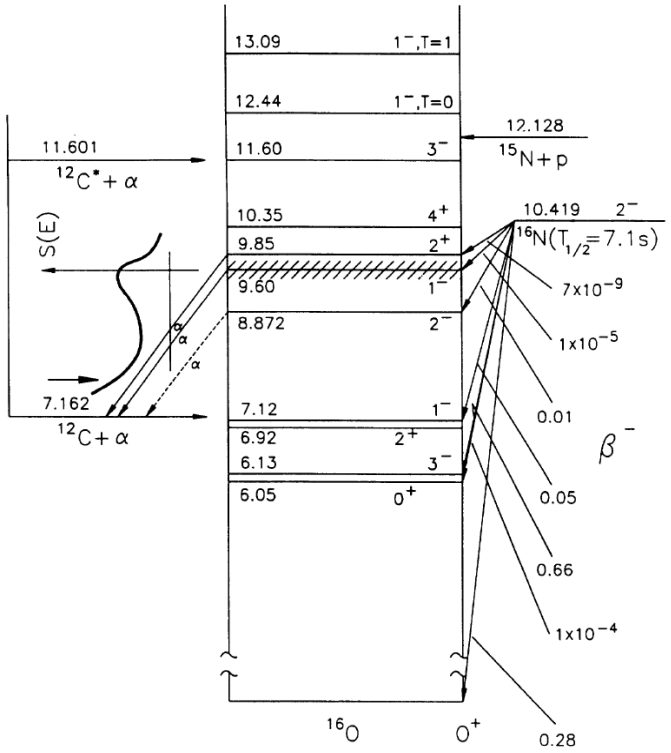
ISOLDE today offers the largest range of available isotopes of any ISOL facility worldwide.

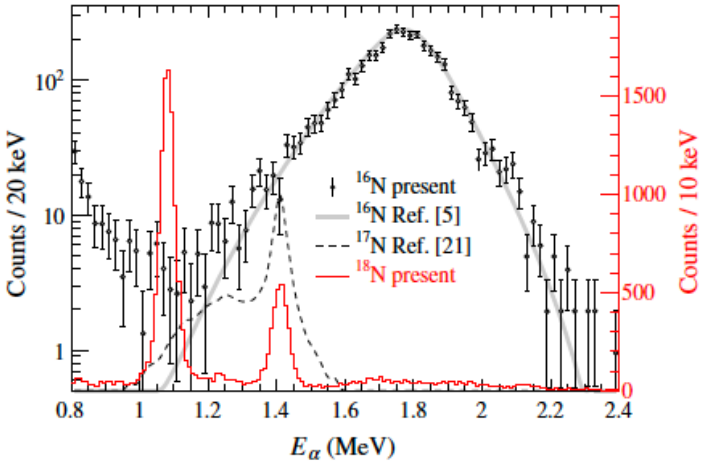
- 1200 isotopes of ~74 elements
- Novel (and usually unique) isotopes for a wide scientific community

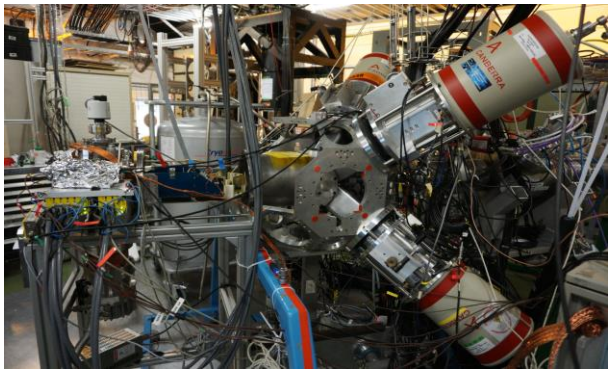


Nuclear astrophysics

^{16}N decay and ^{12}C(α,γ)^{16}O







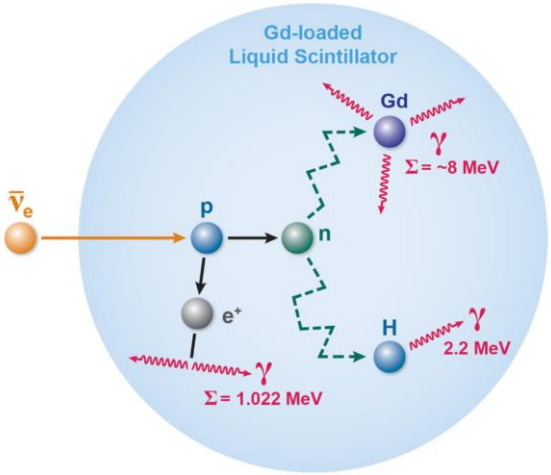
KVI : Refsgaard et al. PLB 752, 296

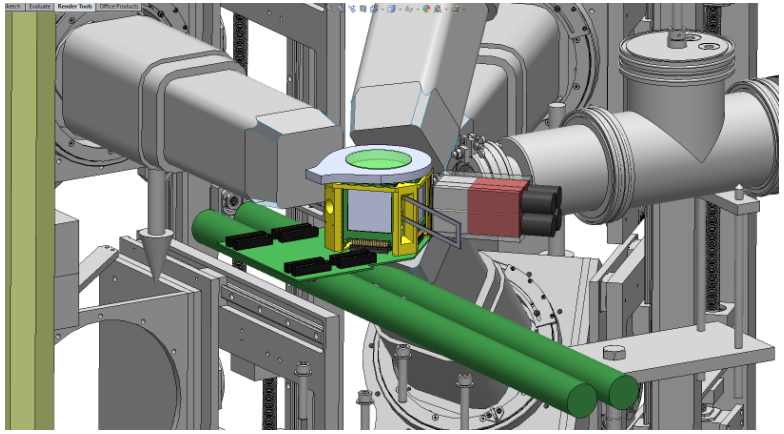
CERN: Kirsebom et al., PRL 121, 142701

Nuclear physics

Low-energy neutrinos: ^{8}He, ^{9}Li background

- Beta-delayed n emission mimics neutrino-signal
- Need complete experimental characterization (for GEANT4)





Running **now** at

ISOLDE Decay Station

NIM A949, 162904
arXiv:2204.09215

ISOLDE

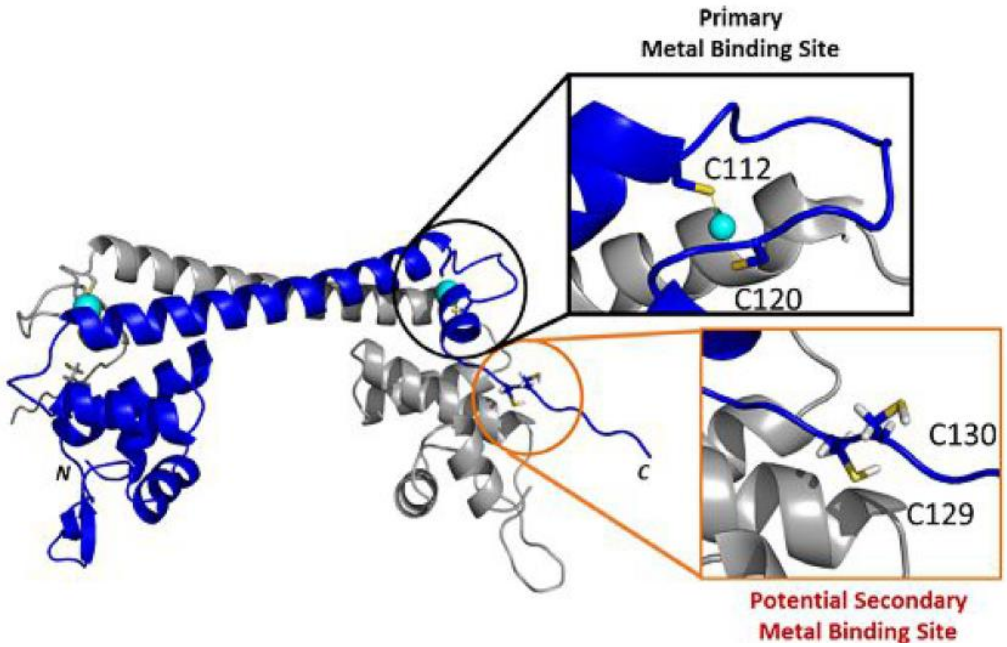
Post accelerated beams

REX (2001) – gradual upgrade to 3 MeV/u
HIE (2010-18) – reaching 10 MeV/u
Borge, Riisager, EPJ A 52:334
Di Pietro, Riisager, Van Duppen, JPG 44, 044013

- Coulomb excitation, lifetimes (Miniball, plunger)
- Transfer reactions (Miniball+Trex, ISS, ..)
- Multipurpose scattering chamber

From nuclear physics to molecular properties

Intracellular control of metal ion concentration by metallosensor proteins – CueR senses Cu(I):



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Uni of Szeged
Biological Research Centre of the Hungarian Academy of Sciences

SBIC
Bringing Inorganic Chemistry to Life

But does not respond to divalent metal ions, potentially because a secondary metal site provides auxiliary ligands – a ^{199m}Hg Perturbed angular correlation of γ-rays (PAC) study.

Balogh *et al.* Chem. Eur. J. 2019, 25, 15030 – 15035

Fromsejer *et al*. Phys.Chem.Chem.Phys 2021, 23, 25689-25698

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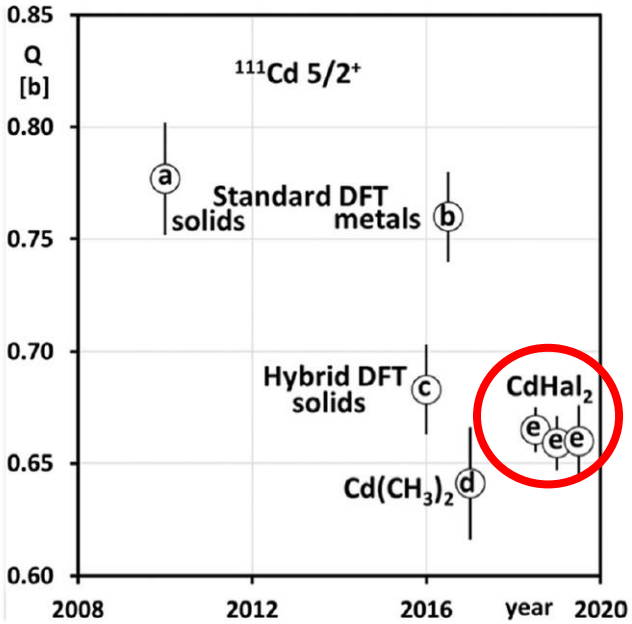
From molecular properties to nuclear physics

The *first gas phase PAC* experiments combined with state of the art (CCSD(T)) electronic structure calculations (project lead by H. Haas, CERN)



CdHal$_2$ is:
- $CdCl_2$
- $CdBr_2$
- CdI_2

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Uni of Duisburg-Essen
Uni of Aveiro
Uni of Lisbon

provided most accurate determination of excited state nuclear quadrupole moments of ^{199}Hg and ^{111}Cd:

Q(^{199}Hg, 5/2$^-$) = +0.674(17) b and Q(^{111}Cd, 5/2$^+$) = +0.664(7) b.

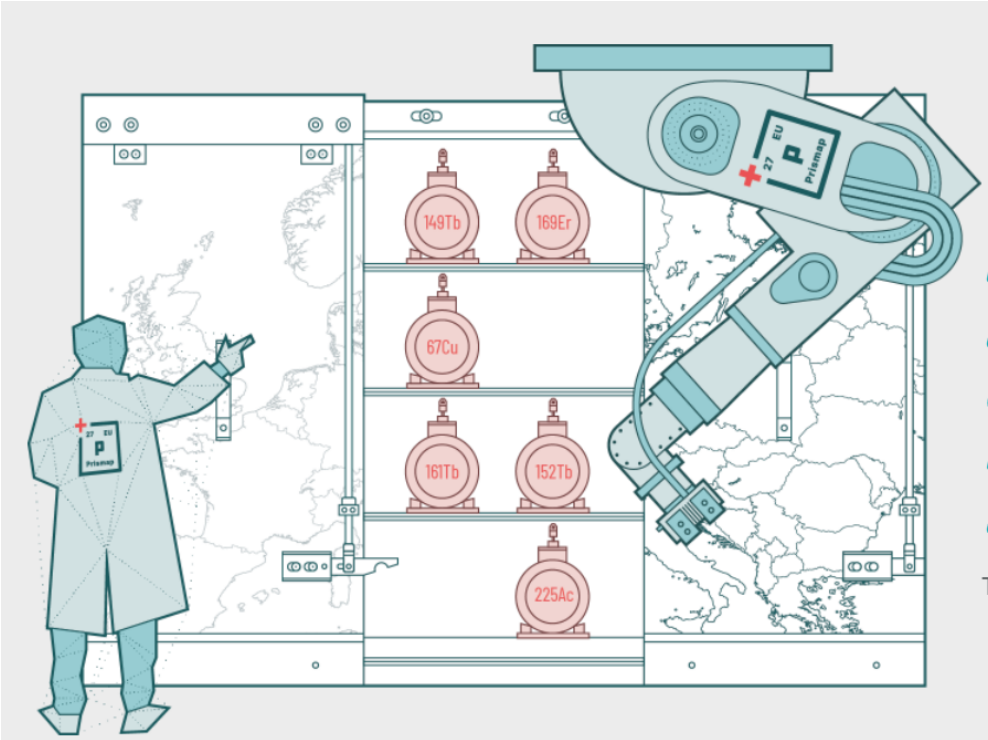
Haas *et al.*, Phys. Rev. Lett. 126, 103001 (2021)
Fromsejer *et al.*, 2022, Chem. Phys. Lett., Accepted

ISOLDE helping ESS

Irradiation of W blocks at ISOLDE – ESS safety check of their target: measure amount of emission of ^{125}I, noble gases and ^{3}H (prof. Mikael Jensen, Hevesy Lab, DTU)

Medical radionuclides

ISOLDE/MEDICIS is an important part of the new European isotope production program: Prismap (www.prismap.eu)



We're about to build the most extensive infrastructure for non-conventional medical radionuclides ever available in Europe

Thierry Stora, CERN — PRISMAP Coordinator

Which also includes the Hevesy Lab, DTU, Denmark (prof. Mikael Jensen)

Collaborations

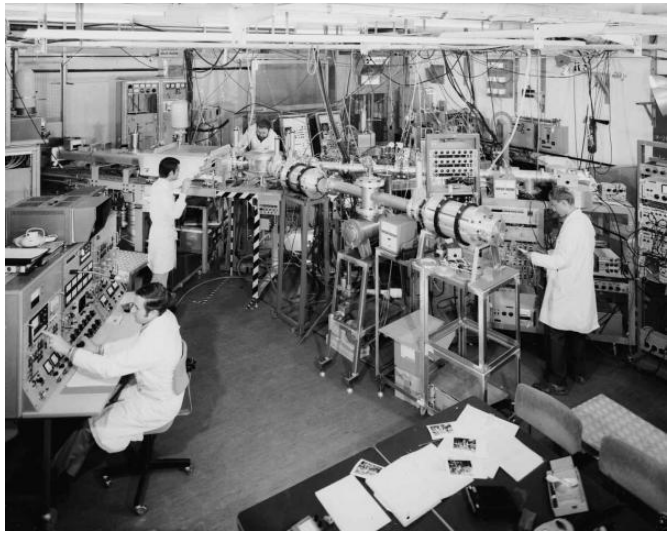
- Spain, CSIC, Madrid – Maria Jose G. Borge, Olof Tengblad, …
- Sweden, Chalmers, Göteborg – Björn Jonson, Thomas Nilsson, …
- Spain, Universidad Complutense, Madrid – Luis M. Fraile
- Sweden, Lund Universitet, Lund – Joakim Cederkäll
- USA, University of Tennessee, Knoxville – Miguel Madurga
- Romania, IFIN-HH, Bucharest – Razvan Lica, Christof Sotty
- Poland, University of Warsaw – Marek Pfützner,…
- USA, University of Michigan – Vincent L. Pecoraro
- Hungary, University of Szeged – Attila Jancso, Bela Gyurcsik
- Switzerland, University of Zurich, Roland K. Sigel, Eva Freisinger, Silke Johannsen
- Canada, TRIUMF / UBC - Andrew McFarlane, Iain McKenzie, Monika Stachura
- USA, University of Northern Kentucky - Matthew Zacate
- France, ILL – Ulli Köster
- …

Science – summary and future

- "Small science" addressing fundamental questions from nuclear physics to biochemistry => extensive international collaboration
- Run more / longer experiments per year
  → Fulfil high demand for beam time
- Better quality beams (intensity/purity)
  → e.g. around ^{132}Sn : region of interest for astrophysics r-process path (link to origin of elements, neutron-star mergers, gravitational waves)
- Faster release
  → Shorter lived (thus more exotic) isotopes
  → Those are typically of highest interest (astrophysics, nuclear modelling, …)
- Expand the user group, and re-initiate eMS collaboration including Danish Research

Thank you for your attention !

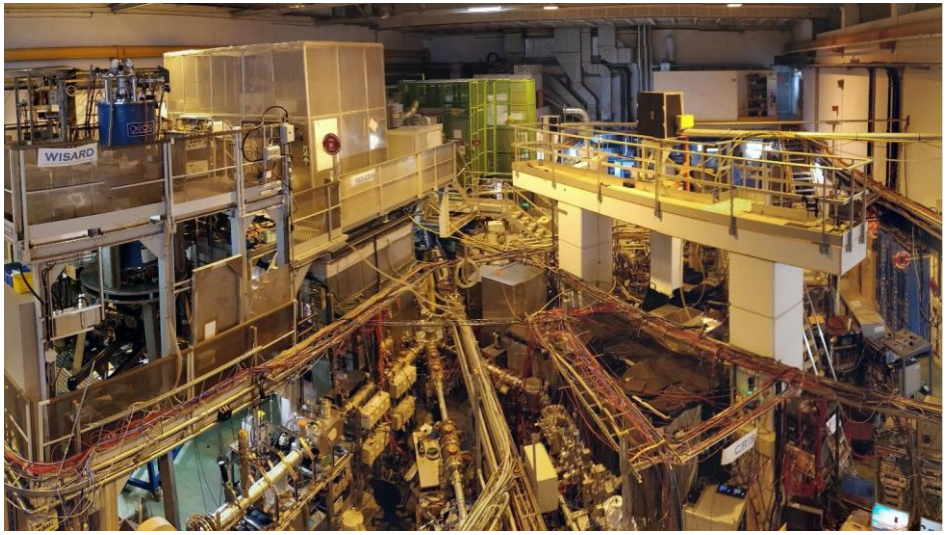
ISOLDE 1967
First proton beam



Karl Johnston

Joao G.M. Correia

Juliana Schell



ISOLDE now