



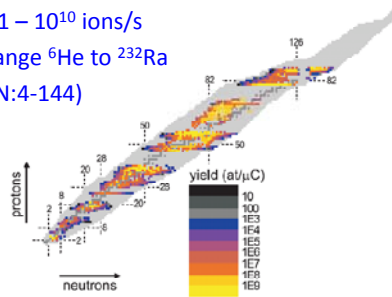
The science programme at ISOLDE



Karsten Riisager
 Dept. of Physics and Astronomy
 University of Aarhus

Facility for isotope production



- Energy range 10^{-6} eV (10 mK) to 3 MeV/u
- Intensity $1 - 10^{10}$ ions/s
- Isotope range ${}^6\text{He}$ to ${}^{232}\text{Ra}$
(Z: 2-88, N:4-144)



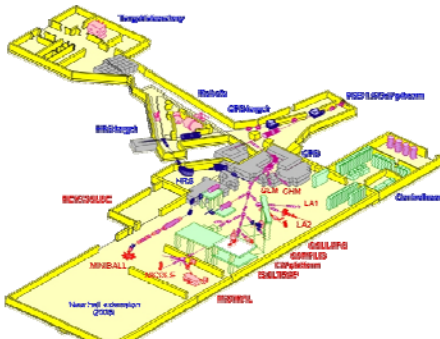





Motivation (a reminder...)

- Nuclear physics (incl. applications) thrives on variety
- Intrinsic many-particle structure (2 fermions !)
 – multitude of quantum states, a rich variety of phenomena
 – finite # particles, structure still varies rapidly
- Progress needed on many fronts
 – need different experimental techniques
 – need many isotopes



ISOLDE (2008)



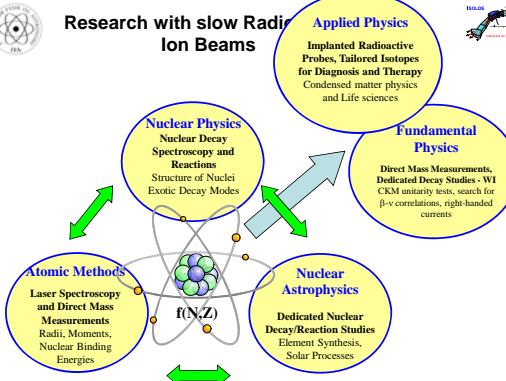



ISOLDE: a unique facility

- Ideal driver beam for ISOL
- Variety of beams: leading laboratory for developments in
 – target/ion-sources
 – ion beam manipulation
 – experimental set-ups
- Strong users community

Research with slow Radioactive Ion Beams



- Atomic Methods**
Laser Spectroscopy and Direct Mass Measurements
Radii, Moments, Nuclear Binding Energies
- Nuclear Physics**
Nuclear Decay Spectroscopy and Reactions
Structure of Nuclei
Exotic Decay Modes
- Nuclear Astrophysics**
Dedicated Nuclear Decay/Reaction Studies
Element Synthesis, Solar Processes
- Applied Physics**
Implanted Radioactive Probes, Tailored Isotopes for Diagnosis and Therapy
Condensed matter physics and Life sciences
- Fundamental Physics**
Direct Mass Measurements, Dedicated Decay Studies - WI
CKM unitarity tests, search for β - ν correlations, right-handed currents

Examples of research themes

- Nuclear Physics** (abstract ID number)
 - shell closures • shape evolution (6,31,74) • shape coexistence (18,33,62) • halo nuclei (96)...
- Fundamental interactions**
 - P, T violation (45) • neutrinos (59,66) • V_{ud} (69)
- Solid state physics**
 - semiconductors • spintronics (64) • nano... (88)
- Biophysics, medical physics**
 - radioisotopes (44) • heavy metal toxicity

De novo designed heavy metal ion binding proteins

Angular frequency (rad/s)

pH = 6.5
pH = 7.9
pH = 8.7

Iranzo et al. Chem. Eur. J., 2007, 13:9178

Determination of lattice positions

experiment simulation $S_{\beta\alpha}$ sites

ECSLI Mn beam time:
 β^- emission channeling patterns from ^{61}Co in GaN

$^{61}\text{Mn} \rightarrow ^{61}\text{Co} + e^- + \bar{\nu}_e$
 $^{61}\text{Co} \rightarrow ^{61}\text{Ni} + e^- + \bar{\nu}_e$

- ^{61}Mn implanted ($\sim 10^{13} \text{ cm}^{-2}$)
- wait 25 min + anneal at 800°C
- emission channeling patterns measured from ^{61}Co β^- particles
- fit results: ^{61}Co on substitutional Ga sites

"Island of inversion"

Normal sd -shell configuration
 $Op0h$, spherical

Island of Inversion
E.K. Warburton, J. A. Becker and B. A. Brown, PRC41(1990)1147.

$2p2h$ (intruder), deformed

Monte Carlo shell model sd/pf model space: Na isotopes

Y. Utsuno, et al. Phys. Rev. C70(2004) 044307.

An example: $^{30-33}\text{Mg}$

- Magnetic moments $^{31,33}\text{Mg}$, COLLAPS

Yordanov et al. PRL 99 (2007) 212501
Kowalska et al PRC77 (2008) 034307

$\mu = -0.7456 (5)\mu_N$

Spin 3/2
 $2p2h$ g.s. (intruder)

IS427

An example: $^{30-33}\text{Mg}$

- Coulex of $^{30,32}\text{Mg}$ and ^{31}Mg – Reiter et al
Niedermaier et al, PRL 94 (2005) 172501

Mg isotopes

REX-ISOLDE MINIBALL (PRELIMINARY)

IS410

An example: $^{30-33}\text{Mg}$

- 2nd 0⁺ in ^{30}Mg at 1788 keV, weak mixing – Schwerdtfeger, Thirof et al, arXiv:0808.0264

More results: H. Mach et al.

IS414

An example: $^{30-33}\text{Mg}$

- 2nd 0⁺ in ^{30}Mg at 1788 keV, weak mixing – Schwerdtfeger, Thirof et al, arXiv:0808.0264
- Coulex of ($^{30,32}\text{Mg}$ and) ^{31}Mg – Reiter et al (Niedermaier et al, PRL 94 (2005) 172501)
- Transfer d($^{30}\text{Mg}, ^{31}\text{Mg}$)p, (t,p)... – Bildstein et al
- Magnetic moments $^{31,33}\text{Mg}$, COLLAPS – Yordanov et al, PRL 99 (2007) 212501; Kowalska et al PRC77 (2008) 034307
- Masses, MISTRAL – Lunney et al, Eur. Phys. J. A28 (2006) 129
- Level lifetimes – Mach et al, Eur. Phys. J. A25 (2005) 105
- Radii, beta-decay studies,...

ISOLTRAP: $^{80-81}\text{Zn}$

S. Baruah et al, PRL 101 (2008) 262501

$v_c = \frac{1}{2\pi} \frac{q}{m} B$ N=50 still robust shell at Z=30

IS413

REX – Coulex: agree J. Van De Walle et al, PRL 99 (2007) 142501

IS412

Halo nuclei

Open delayed-particle channels in the ^{11}Li beta decay

IS417

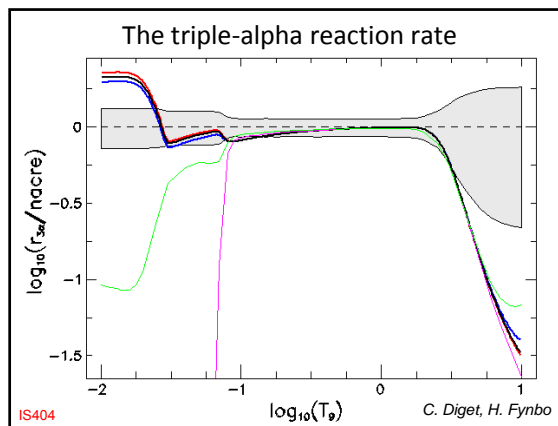
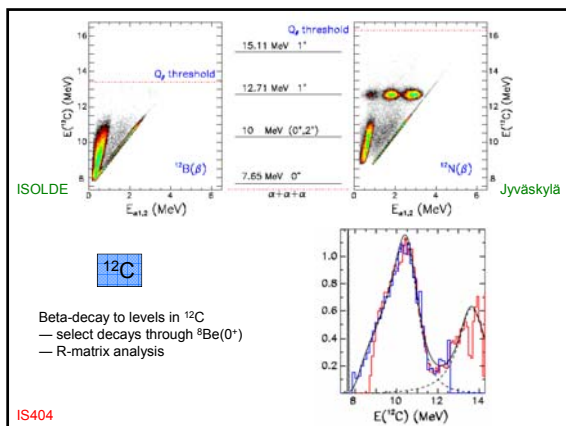
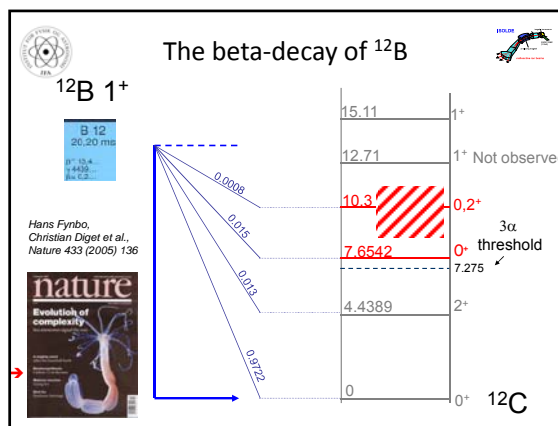
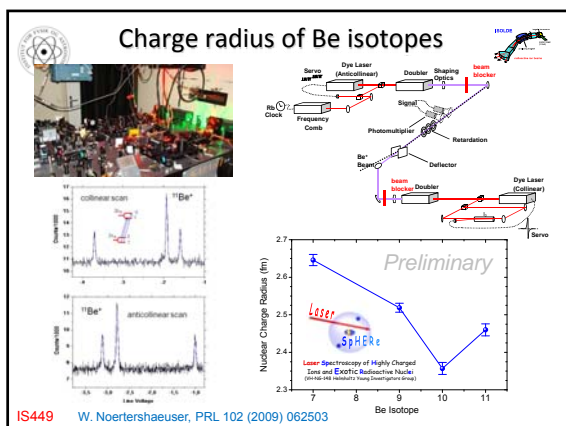
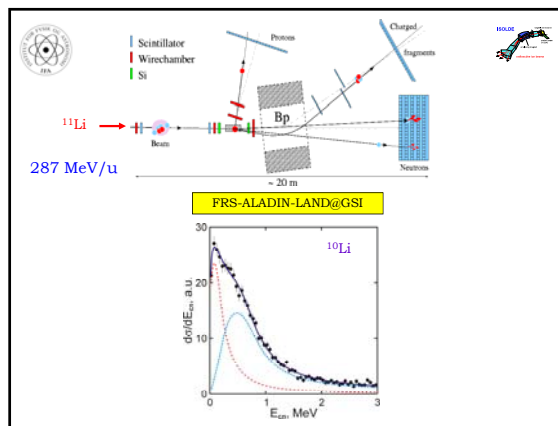
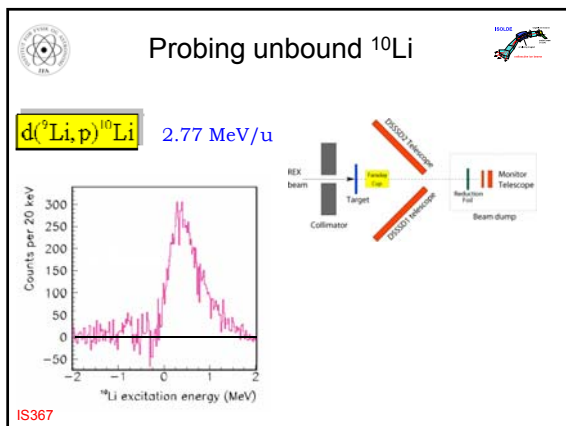
Multi charged-particle branch




M. Madurga et al, submitted to PLB

Kinematic identification of (beta-delayed) decay branches: $^4\text{He} + ^7\text{He}$, $^3\text{H} + ^8\text{Li}$ etc


Selecting one channel reveals new level at 16.3 MeV

IS417





Existing program needs upgrades of:
Beam "quality"
Intensity
Energy



Thanks to:

- The ISOLDE Physics Group
- The ISOLDE Technical Group
- The ISOLDE Collaboration

- Hans Fynbo
- Lars Hemmingsen
- Alexander Herlert
- Mark Huyse
- Björn Jonson
- Magdalena Kowalska
- Miguel Madurga
- Peter Reiter
- Piet Van Duppen