The science programme at ISOLDE

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Facility for isotope production

- Energy range $10^{-6}$ eV (10 mK) to 3 MeV/u
- Intensity $1 \times 10^{12}$ ions/s
- Isotope range $^{6}$He to $^{232}$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: 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 Radiactive Ion Beams

Applied Physics
- Implantation of radionuclides
  - Diagnostics for Medicine and Therapy
  - Combined matter physics
  - Life sciences

Nuclear Physics
- Nuclear Decay Spectroscopy
  - Structure of Nuclei
  - exotic Decay Modes

Atomic Methods
- Laser Spectroscopy
  - Direct Mass Measurements
  - Rad. Measures, Nuclear Binding Energies

Nuclear Astrophysics
- Dedicated Nuclear Decay Reaction Studies
  - Element Synthesis, Star Processes
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

Determinaton of lattice positions

ECLi Mn beam time:
- $\beta^-$ emission channeling patterns from $^{61}$Co in GaN

- $^{65}$Mn implanted ($10^{14}$ cm$^{-2}$)
- wait 25 min + anneal at 800°C
- $\beta^-$ emission channeling patterns measured from $^{61}$Co $\beta^-$ particles
- fit results
- $^{61}$Co on substitutional Ga sites

"Island of inversion"

An example: 30-33Mg

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

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

$\mu = 0.7466$ (5)$\mu_B$

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

An example: 30-33Mg

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

Mg isotopes
An example: $^{30-33}$Mg

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

More results: H. Mach et al.

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

- 2nd $0^+$ in $^{30}$Mg at 1788 keV, weak mixing – Schwerdtfeger, Thirolf et al, arXiv:0808.0264
- Coulex of ($^{30,32}$Mg and $^{31}$Mg) – Reiter et al (Niedermaier et al, PRL 94 (2005) 172501)
- Transfer $d(^{30}$Mg,$^{31}$Mg)p, (t,p)... – Bildstein et al
- Radii, beta-decay studies,...

ISOLTRAP: 80-81Zn

Neutron separation energy (MeV) versus N


Halo nuclei

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

Multi charged-particle branch

Kinematic identification of (beta-delayed) decay branches: $^7$He $\rightarrow ^7$He $\rightarrow ^7$Li $\rightarrow ^7$He $+ ^1$He $\rightarrow ^7$Li + $^1$He etc

Selecting one channel reveals new level at 16.3 MeV

M. Madurga et al, submitted to PLB
Probing unbound $^{10}$Li

$d(^{3}$Li,$p$)$^{7}$Li  2.77 MeV/u

Charge radius of Be isotopes

The beta-decay of $^{12}$B

The triple-alpha reaction rate

Beta-decay to levels in $^{12}$C
  — select decays through $^{8}$Be(0$^+$)
  — R-matrix analysis
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Existing program needs upgrades of:
Beam “quality”
Intensity
Energy