Stable and radioactive beam studies @ ALTO

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The ALTO facility

<table>
<thead>
<tr>
<th>Year</th>
<th>Users</th>
<th>Beam-time</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>200</td>
<td>2983 h 373 UT</td>
</tr>
<tr>
<td>2014</td>
<td>135</td>
<td>2297 h 287 UT</td>
</tr>
<tr>
<td>2015</td>
<td>143</td>
<td>2736 h 342 UT</td>
</tr>
</tbody>
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Experimental areas

- Bacchus
- Split-Pole spectrometer
- ISOL production cave
- ISOL mass separator experimental lines
- Licorne
- e LINAC
- Stable beam with spectrometer
- Stable beam w/o spectrometer
- Radioactive beam lines
- 

\gamma\text{-spectrometers }\text{ORGAM MINORCA PARIS}

cluster, molecular & droplets beams
Astrophysical motivation:

- Gamma-ray emission associated with $^{26}$Al observed in our galaxy.
- $^{26}$Mg coming from $^{26}$Al decay observed in presolar grains
- $^{26}$Al yields depend strongly on reactions $^{26}$Al(n,p)$^{26}$Mg and $^{26}$Al(n,$\alpha$)$^{23}$Na
- Need for better $^{27}$Al spectroscopy ($E_R$, $J\pi$, $\Gamma_p$, $\Gamma_\alpha$) above neutron threshold ($S_n = 13$ MeV)

$^{26}$Al(n,p)$^{26}$Mg and $^{26}$Al(n,$\alpha$)$^{23}$Na in massive star

→ Populating resonances with the $^{27}$Al(p,p')$^{27}$Al* reaction

Split-Pole spectrometer (ALTO) + DSSSDs in reaction chamber

30 new states above neutron threshold in $^{27}$Al
S. Benamara, N. de Séréville et al, PRC 89, 065805 (2014)
Hydrogen gas cells

Development of a kinematically focused neutron source with the p(\(^7\)Li,n)\(^7\)Be inverse reaction


**LICORNE II** – fast-neutron source

H\(_2\) pressure and flow control system

18 Sept. 2015, Kraków, Poland
Previous measurement:
\[ |g(2^+)| = 0.51 (2) \]
R.F. Horstman et al., NPA 248, 291 (1975)

Our result:
\[ |g(2^+)|= 0.538 (13) \]
A. Kusoglu et al. PRL 114, 062501 (2015)

High-accuracy g-factor measurements are essential for constraining the theories!
MINORCA in Orsay (June 2014 – March 2015)

12 ORGAM CS HPGe x 0.1%
8 Miniball TC at ~14 cm from target
7.3% efficiency @ 1.33 MeV

ancillary detectors:
- Orsay plunger (OUPS)
- particle detector
- DSSD
MINORCA – experiments performed

1. **Time dependent recoil in vacuum** for Na-like $^{56}$Fe ions
   - spokespersons: A. Stuchbery, D. Balabanski

2. **Shape coexistence in $^{74}$Se** studied through complete low-spin spectroscopy after Coulomb excitation
   - spokespersons: M. Zielinska, K. Wrzosek-Lipska

3. **Measurement of octupole collectivity in Nd, Sm and Gd nuclei** using Coulomb excitation
   - spokespersons: P.A. Butler, M. Zielinska

4. **Spectroscopy of the neutron-rich fission fragments** produced in the $^{238}$U(n,f) reaction
   - spokespersons: J. Wilson, M. Lebois

5. **Evaluation of the Angular Momentum Dependence of the $^{96}$Mo $\gamma$ Strength Function**
   - spokesperson: B. Goldblum

6. **Lifetime Measurement of $^{100}$Ru**: A possible candidate for the E(5) critical point symmetry
   - spokesperson: Th. Konstantinopoulos

7. **Lifetime measurements in $^{113}$Te**: Determining Optimal effective charges approaching the N=Z=50 doubly-magic shell closure.
   - spokesperson: D.M. Cullen
Most-recent results

- First in-beam experiments of Demonstrator
  - 2,048 Micromegas pads
  - 4 DSSDs + 12 Pad Si integrated
  - Newly-made GET electronics to take data
- 2 successful runs (June to July ’15)
  - $^{12}$C @80 MeV + He gas
  - $^6$Li @11 to 23 MeV + He gas
- 35 visitors (16 domestic, 19 international)
ACTAR TPC: Demonstrator

- Two experiments performed at ALTO:
  - $\alpha$-clustering in light nuclei
First operational RIB facility based on photo-fission → populating the GDR of $^{238}$U

standard ISOLDE target

$\phi = 14 \text{ mm; } L = 140 \text{ mm}$

$\rho = 3.2 \text{ g/cm}^3; \ T \leq 2100^\circ \text{C}$

$\Rightarrow$ Estimated yields for 10 $\mu$A, 50 MeV e$^-$ beam
Rialto: Resonant laser ionisation at Alto

S. Franchoo et al.

Nd:Yag pump laser (532 nm, 90 W)

2 dye lasers (540-850 nm, 8W @ 30W pump, 10 ns pulse width, 3 GHz line width)

BBO doubling units (270-425 nm, >100 mW)
Nuclear structure in $\beta$-decay

- **BEDO setup**
- **neutron detection**
  - TETRA
- **fast timing**
  - LaBr$_3$

- up to 5 Ge detectors ($\varepsilon = 5\text{-}6\%$
- $4\pi$ $\beta$ trigger

- 80 $^3$He tubes $\varepsilon(^{252}\text{Cf}) = 53\%$
- borated polyethylene shielding

- Fast-timing studies using LaBr$_3$ detectors
18 Sept. 2015, Kraków, Poland

Results from BEDO in $\beta$-delayed $\gamma$-spectroscopy mode

$^{82}\text{Ge} \rightarrow ^{82}_{33}\text{As}_{49}$

(1) problem of the spectral distribution of $1^+$ states in the $N=50$ region
(→ responsible for the half-life of the mother nucleus, possible consequences on the r-process)
interpreted by the theoretical work of Severyukhin... Giai et al. (influence of couplings to 2$p$-2$h$ and tensor interaction)

(2) ubiquitous presence of intruder states of the type $1p$-2$h$
→ signature of shape coexistence

shape coexistences: a general phenomenon?

$^{82}\text{Ge} \rightarrow ^{82}_{33}\text{As}_{49}$

Though this phenomenon seems to concern all shell-closure regions: not a single study at $N=50$ for more than 3 decades!
(Z=50 a textbook case)

conclusion: an «island of inversion» is «missed» at $N=50$ by 0.5 MeV only!

Present setups and near-future projects

Laser-Induced nuclear orientation (μ,Q, J^π)

- LTNO (³He/⁴He)
- POLAREX (project)
- MLL Trap (project)
- Mass measurements
- LINO (project)
- Identification station
- TETRA (existing)
- TAS (project)
- BEDO/TETRA (existing)
- Stable and Radioactive beam facility
- R&D on ISOL & RIB
- low-energy physics program based on photo-fission
- R&D and physics at ALTO a step towards a next-generation ISOL RIB facility:
  
  initiate physics program, train ISOL physicists, develop instruments and methodologies