News from the ISOLDE group

March 19, 2019

Gerda Neyens

content

- Associates and staff
- Fellows
- Doctoral students
- Visits in 2018
- Outreach activities 2018
- Meetings 2019

Associates & Corresponding Associates & staff

- Associates
  - Deyan Yordanov, February – August 2019
- Staff members:
  - Stephan Malbrunot-Ettenauer (Feb 2017-Jan 2021) **ERC MIRACLS**
  - Karl Johnston, physics coordinator (extended till Sept. 2022)
  - G.N, Isolde group leader, collaboration spokesperson (June 2017 – June 2020)
- ISOLDE User Support:
  - Jennifer Weterings (2002 -) via the ISOLDE Collaboration

CERN Fellows

- Research Fellows:
  - ✓ Hanne Heylen (Oct 2017 – sept 2020 – COFUND) 30% COLLAPS- 70% MIRACLS
  - ✓ Ronald Garcia Ruiz (Jan 2018 – Dec 2019) CRIS
  - ✓ Hopefully good candidates in this round !

- Applied Fellows:
  - ✓ Joonas Konki (March 2018 – Feb 2020, ENSAR2) HIE-ISOLDE experiments
  - ✓ Simon Sels (April 2018 – March 2020, ERC Stephan) MIRACLS
  - ✓ Dinko Atanasov (April 2019 – March 2021, EP-SME) WISARD, low energy exp.
  - ✓ NN (ENSAR2+KT Fund Stephan) 30 keV MR-TOF for ISOLDE and MIRACLS
    - → + second year from ISOLDE Collaboration, if ERINS is not succesfull ?

And many others paid by their home institution.

CERN Doctoral Students

- **Varvara Lagiki** (Sept 2017 – August 2020) MIRACLS
CERN doc. stud. via ERC Miracles

- **Simon Lechner** (Sept 2017 – August 2020) MIRACLS
CERN doc. stud. via the Austrian Doctoral Program

- **Jonas Karthein** (November 2017 – October 2020) ISOLTRAP
CERN doc. stud. via Gentner Doctoral Program (Germany) – MPI-K Heidelberg

- **Jared Croese** (Feb 2018 – Jan 2021) betaDROPNMR
CERN doc. Student, ISOLDE

- **Peter Plattner** (August 2018 – July 2021) MIRACLS
CERN doc. stud. via the Austian Doctoral Program 30m. + 6 m. ERC

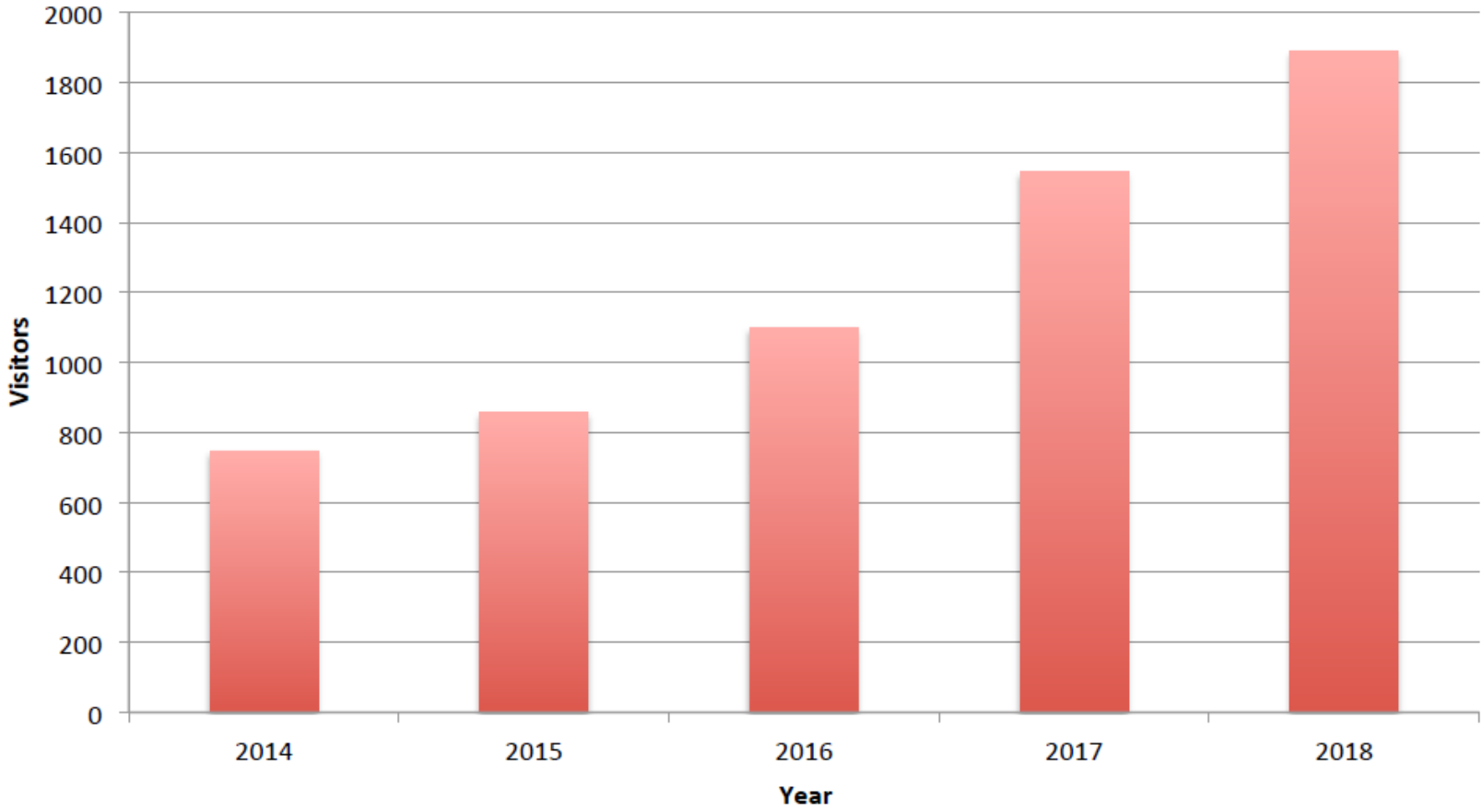
- **Katarzyna Maria Dziubinska-Kuhn** (Sept 2018 – August 2021) betaDROPNMR
CERN doc. stud. Via SWISS Fund and KT-Med

- **Karolina Kulesz** (Oct 2018 – Sept 2021) betaDROPNMR/ Univ. Geneva
CERN doc. stud. Via the ERC beta-drop NMR

And many others paid by their home institution
(+ eventual subsistance from the collaboration).

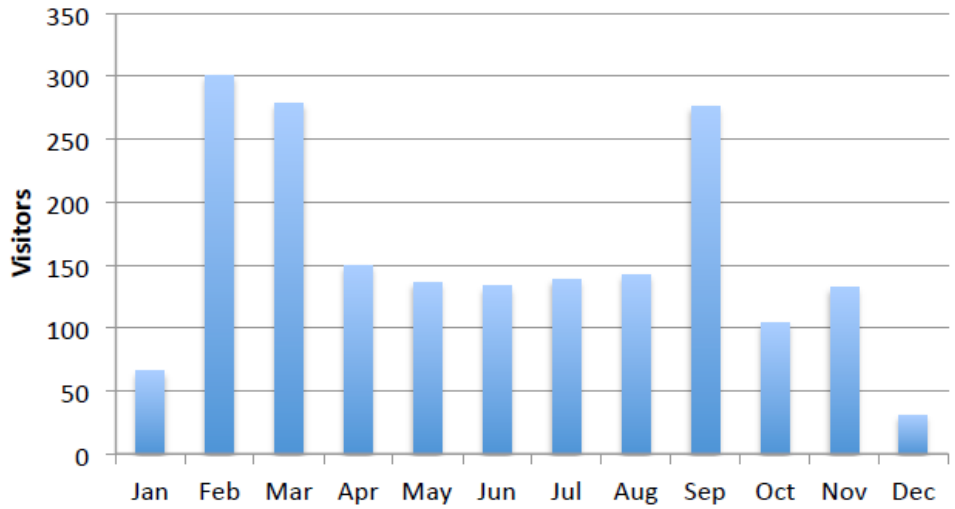
ISOLDE Visits 2018

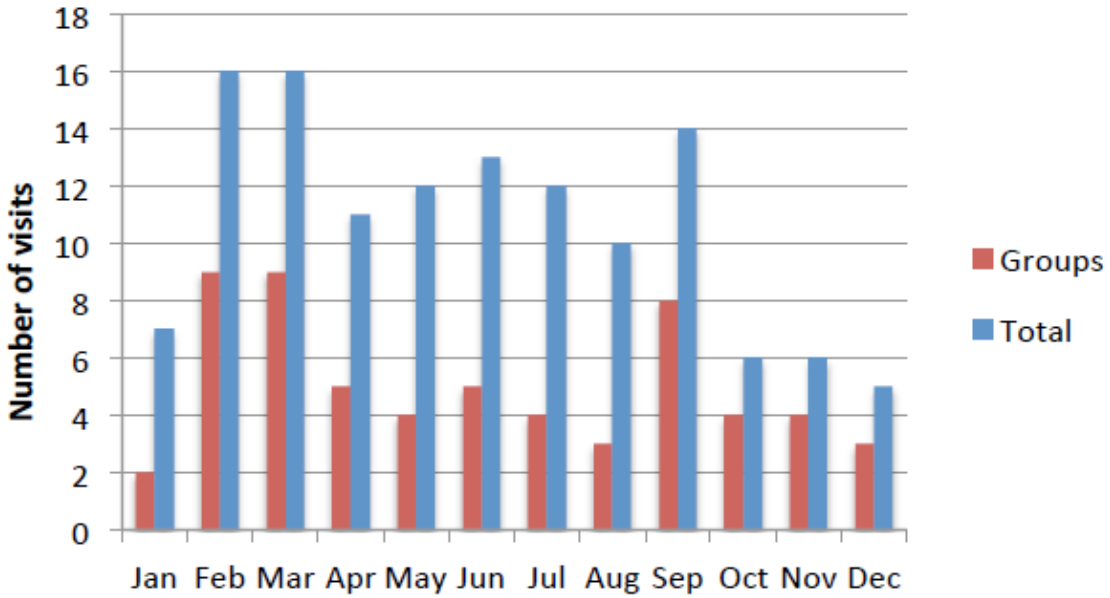
- ISOLDE Visits: increase by almost factor 3 in 5 years !
- Thanks to enthusiastic help of many local PhD, Post-docs, Fellows, …
- Thanks to coordination by Hanne Heylen (Fellow since 2017)



ISOLDE Visits 2018

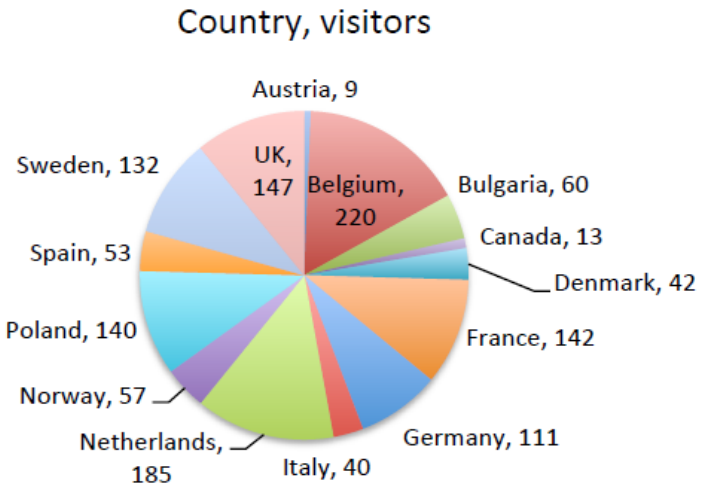
Number of visitors and visits/month





Total 2018: 1889 visitors, 156 visits

- Personal: 55 visitors
- Professional: 52 visitors
- VIP: 138 visitors
- Groups: 1644 visitors



Outreach 2018 - 1

NUCLEAR PHYSICS

Copper reveals nickel's doubly magic nature

Teams at CERN's ISOLDE facility and at RIKEN in Japan have found evidence that an exotic isotope of the metallic element nickel (^{78}Ni) is doubly magic, opening a new vista on an important region of the nuclear-stability chart.

Like electrons in an atom, protons and neutrons in a nucleus have a penchant for configurations that offer extra stability, called magic numbers. Nuclei that have magic numbers of both protons and neutrons are of particular interest for understanding how nucleons bind together. Examples are ^{16}O, containing eight protons and eight neutrons, and ^{40}Ca (20 protons and 20 neutrons), both of which are stable nuclides.

One of the main efforts in modern nuclear physics is to create systems at the extremes of nuclear stability to test whether these magic numbers, and the nuclear shell model from which they derive, are still valid. Two usual suspects are ^{132}Sn (with a half-life of 40 s) and ^{78}Ni (0.12 s). Sn (tin) is the element with the highest number of

A Welker

The mass spectrometer setup ISOLTRAP at CERN's ISOLDE radioactive-beam facility.

stable isotopes (10), attesting to the magic nature of its 50 protons.

The next magic number is 82, corresponding to the number of neutrons in ^{132}Sn. Nickel has a magic number of 28 protons but the recipe for adding the magic 50 neutrons to make ^{78}Ni has proven challenging for today's radioactive beam factories. CERN's ISOLDE facility has now got very close, taking researchers to the precipice via nickel's nuclear neighbour ^{79}Cu containing 50 neutrons and 29 protons.

Andree Welker of TU Dresden and collaborators used ISOLDE's precision mass spectrometer ISOLTRAP to determine the masses and thus binding energies of the neutron-rich copper isotope ^{79}Cu, revealing that this next-door neighbour of ^{78}Ni also exhibits a binding-energy enhancement. To probe the enhancement, Ruben de Groote of KU Leuven and collaborators used another setup at ISOLDE called CRIS to measure the electromagnetic moments of the odd-*N* neighbour ^{79}Cu, providing detailed information about the underlying wave functions. Both the ISOLTRAP masses and the CRIS moments were compared with large-scale shell-model calculations involving the many relevant orbitals. Both are in excellent agreement with the ISOLDE results, suggesting that the predictions for the neighbouring ^{78}Ni can be taken with great confidence.

An independent study of ^{79}Cu carried out by Louis Olivier at the IN2P3–CNRS in France and colleagues based on a totally different technique has reached the same conclusion. Using in-beam gamma-ray spectroscopy of ^{79}Cu at the Radioactive Isotope Beam Factory at RIKEN in Japan, the team produced ^{79}Cu via proton "knockout" reactions in a 270 MeV beam of ^{80}Zn. No significant knockout was observed in the relevant energy region, showing that the ^{79}Cu nucleus can be described in terms of a valence proton outside a ^{78}Ni core and affirming nickel's doubly magic character.

Further reading

R de Groote *et al.* 2017 *Phys. Rev. C* **96** 041302.
L Olivier *et al.* 2017 *Phys. Rev. Lett.* **119** 192501.
A Welker *et al.* 2017 *Phys. Rev. Lett.* **119** 192502.

- CERN Courier

January 2018: by V. Manea and D. Lunney

ISOLDE

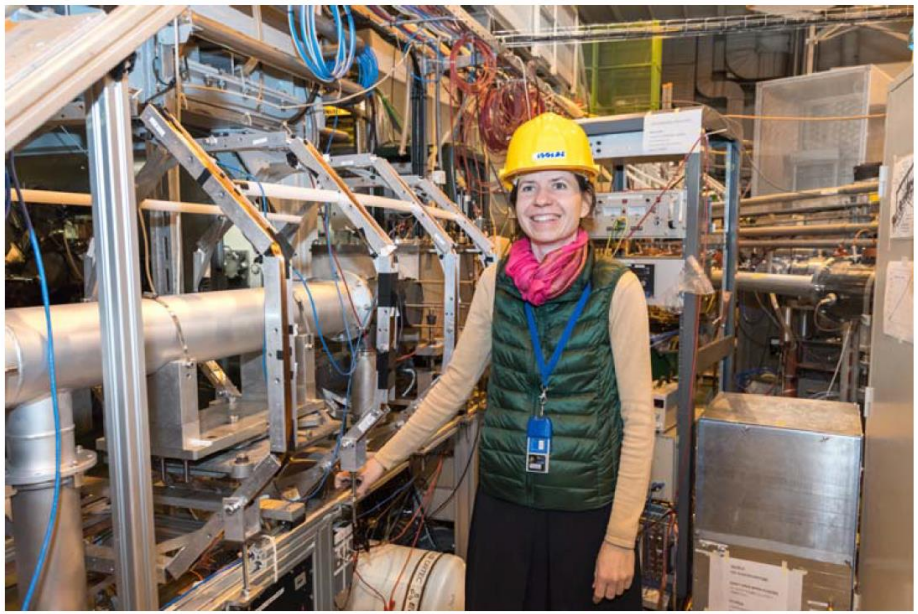
Outreach 2018 - 2

Voir en français (/fr/news/news/isolde-peers-world-dna)

ISOLDE peers into the world of DNA

Researchers at CERN's ISOLDE facility have used an ultrasensitive variant of NMR spectroscopy to study DNA interactions

22 JUNE, 2018 | By Ana Lopes (/authors/ana-lopes)



ISOLDE researcher Magdalena Kowalska is leading the study into DNA molecules using isotopes. (Image: Sophia Bennett/CERN)

Though known for particle physics, CERN's facilities also dip their toes into other fields. For example, researchers at CERN's nuclear physics facility, ISOLDE (https://home.cern/about/experiments/isolde), have been investigating DNA molecules. The researchers have applied an ultrasensitive variant of nuclear magnetic resonance (NMR) spectroscopy, called beta-NMR, to these molecules in both solid and cell-like liquid environments. Beta-NMR has been used widely to study exotic nuclei and solid materials, but this is the first time the technique has been applied

- CERN News: Experiments – June 2018

https://home.cern/news/news/experiments/isolde-peers-world-dna

Outreach 2018 - 3

CERN Courier July/August 2018

News

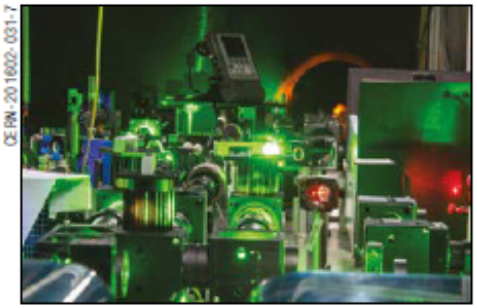
NUCLEAR PHYSICS

ISOLDE mints chromium for structure studies

CERN's radioactive ion-beam facility ISOLDE has stamped a new coin in its impressive collection. Long considered the domain of high-energy, in-flight rare-isotope facilities, chromium has now been produced at ISOLDE in prodigious quantities, thanks to a new resonant ionisation laser-ion source (RILIS) scheme. Together with the latest calculations based on chiral effective field theory, the result provides important guidance for improving theoretical approaches that bridge the gap between nuclear matter and the low-energy extension of quantum chromodynamics (QCD).

Certain configurations of protons and neutrons are more bound than others, revealing so-called magic numbers. Chromium has 24 protons, situating it squarely between magic calcium (with 20 protons) and nickel (with 28). Of particular interest to nuclear physics are isotopes with a large excess of neutrons.

The RILIS is a chemically selective ion source which relies on resonant excitation of atomic transitions using a tunable laser. In the new ISOLDE experiment, Maxime Mougeot of CSNSM/Université Paris-Saclay and collaborators used RILIS to venture 10 neutrons further on the nuclear chart to ^{63}Cr. With a total of



CERN-2018-002-031-7

ISOLDE's resonant ionisation laser-ion source (RILIS), which provided the first beams of neutron-rich chromium isotopes.

39 neutrons, ^{63}Cr lies exactly between the magic neutron numbers 28 and 50 and has a half-life of just 130 ms.

The masses of the newly forged chromium isotopes, as measured by ISOLDE's precision Penning-trap mass spectrometer ISOLTRAP, offer insights into its shape and structure. Magic-number nuclides have filled orbitals that favour spherical shapes, but not so the chromium nuclides weighed by ISOLTRAP, which are deformed. Whereas in some areas of the nuclear chart deformation sets in very suddenly with the addition of a further neutron, the remarkably smooth neutron binding energies of chromium show that deformation sets in very gradually – contrary to previous conclusions.

The ISOLDE measurements were compared with different theoretical results, including a very first attempt by a new *ab-initio* approach called valence-space in-medium similarity renormalization group (VS-IMSRG). While several *ab-initio* approaches exist, until now they have been restricted to the near-spherical cases that have very few valence protons and neutrons. The latest VS-IMSRG results are the first for such open-shell nuclides.

"It turns out that the *ab-initio* VS-IMSRG, an interaction derived from chiral effective field theory which reduces QCD to its relevant degrees of freedom at the nuclear scale, failed to predict these results," explains Mougeot. "So the recent chromium measurements are constructive and important for advancing this promising technique, which bridges the gap between first-principle calculations and the structure of nuclei at the extremes of the nuclear landscape."

Further reading

M Mougeot *et al.* 2018 *Phys. Rev. Lett.* **120** 232501.
T Day Goodacre *et al.* 2017 *Spectroc. Acta B* **129** 58.

- Results from ISOLTRAP in PRL – by Dave Lunney and Maxime Mougeot

ISOLDE

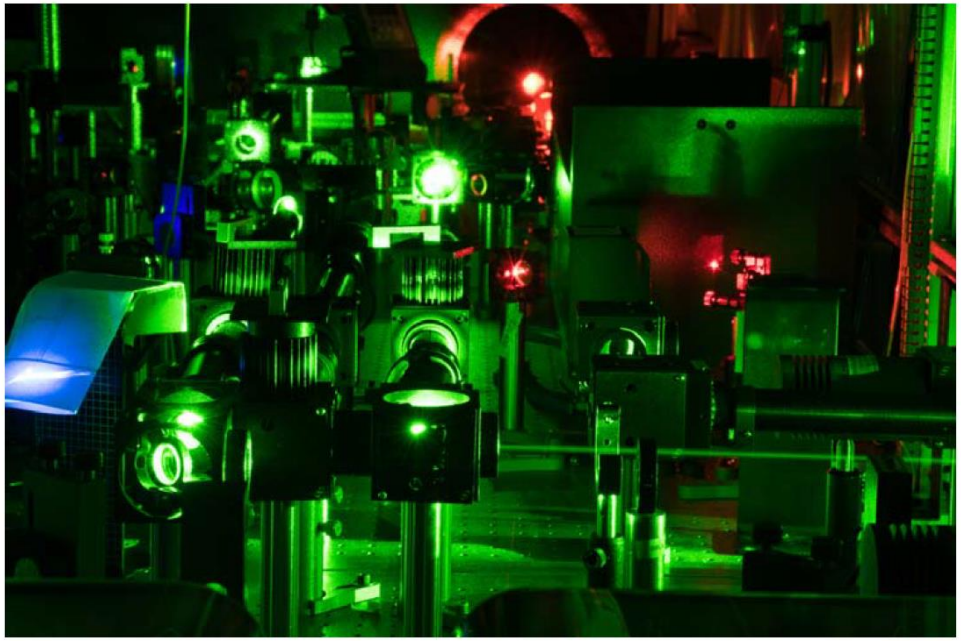
Outreach 2018 - 4

Voir en français (/fr/news/news/physics/isolde-mints-isotopes-chromium)

ISOLDE mints isotopes of chromium

CERN's ISOLDE facility has produced neutron-rich chromium isotopes, which have been weighed by the ISOLTRAP precision balance

6 JULY, 2018



ISOLDE's resonant ionization laser ion source (RILIS) provided the first beams of neutron-rich chromium isotopes to the ISOLTRAP precision balance. (Image: Noemí Carabán González/CERN)

CERN's nuclear physics facility, ISOLDE (https://home.cern/about/experiments/isolde), has minted a new coin in its impressive collection of isotopes. The facility has forged neutron-rich isotopes of the element chromium for the first time, and in prodigious quantities. These isotopes

- CERN Accelerating News – July 2018

  https://home.cern/news/news/physics/isolde-mints-isotopes-chromium

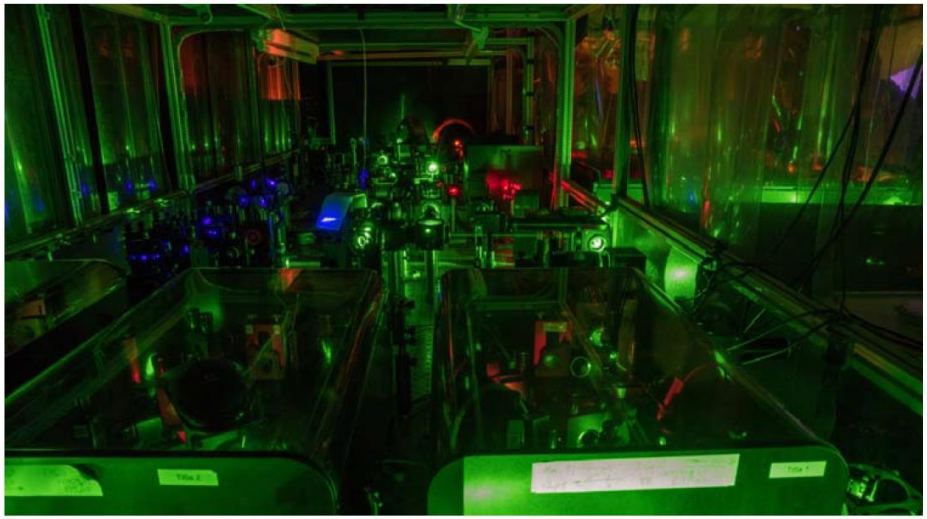
Outreach 2018 - 5

Voir en français (/fr/news/press-release/physics/rugby-or-football-isolde-reveals-shape-shifting-character-mercury)

Rugby or football? ISOLDE reveals shape-shifting character of Mercury isotopes

An unprecedented combination of experimental nuclear physics and theoretical and computational modelling techniques has been brought together to reveal the full extent of the odd-even shape staggering of exotic mercury isotopes, and explain how it happens

1 OCTOBER, 2018



(//cds.cern.ch/images/CERN-PHOTO-201602-031-9)

Lasers at ISOLDE. RILIS experiment (Image: CERN)

Geneva 1st October 2018. An unprecedented combination of experimental nuclear physics and theoretical and computational modelling techniques has been brought together to reveal the full

- CERN Press Release – October 2018

https://home.cern/news/press-release/physics/rugby-or-football-isolde-reveals-shape-shifting-character-mercury

Outreach 2018 - 6

CERN Accelerating Science – August 2018

HIE-ISOLDE's Phase 2 reaches completion

The HIE-ISOLDE project is on its way to providing radioactive nuclei at higher energies than before

21 AUGUST, 2018

CERN's ISOLDE (/about/experiments/isolde) facility has been in operation for more than 50 years (/about/updates/2017/10/meet-isolde-where-did-it-all-begin). It produces radioactive isotopes for studies of the structure of atomic nuclei and a variety of other purposes including medical applications. Now, Phase 2 of its HIE-ISOLDE upgrade (/about/updates/2017/10/meet-isolde-future-physics-hie-isolde) has reached completion.

This will allow ISOLDE to accelerate radioactive beams to energies up to 10 MeV per nucleon ("nucleon" is the collective term for protons and neutrons in the nucleus); the pre-upgrade maximum energy was 2.8 MeV per nucleon. The increase in energy will help study a variety of nuclear reactions with radioactive isotopes, opening up new possibilities for nuclear-structure research.

The HIE prefix stands for "High Intensity and Energy". With the end of Phase 2, the facility has completed an important part of its "Energy" upgrade. The "Intensity" upgrade is foreseen for Phase 3, and will allow ISOLDE to remain at the forefront of nuclear and astrophysics research for another ten to fifteen years.

Find out more about the final stages of Phase 2 of the upgrade and what it means for ISOLDE in the video below.

https://home.cern/news/news/accelerators/hie-isoldes-phase-2-reaches-completion

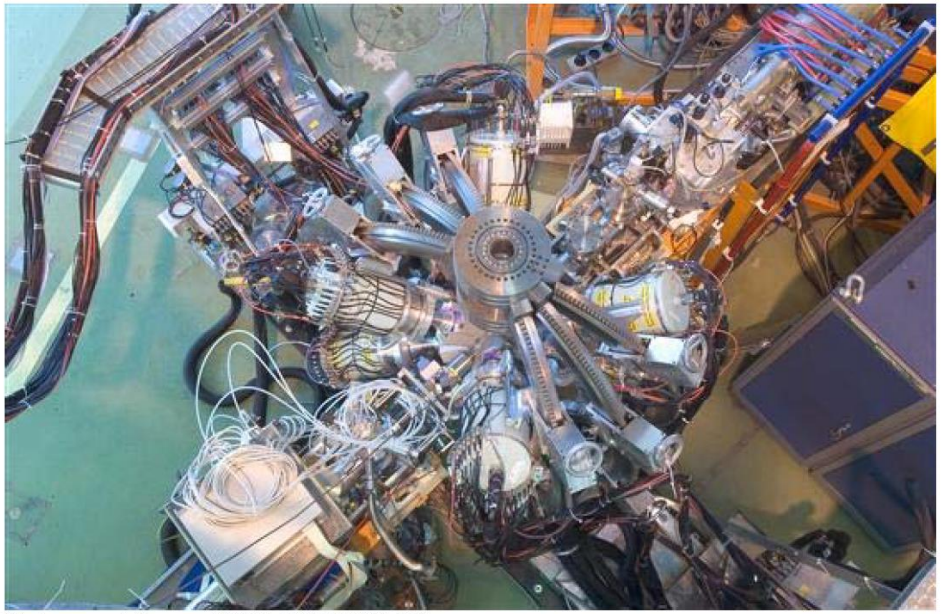
https://youtube/uL8IH3xaY7Q

Outreach 2018 - 7

First result from HIE-ISOLDE is doubly magic

The first result to emerge from the HIE-ISOLDE accelerator is the confirmation that the tin-132 nucleus belongs to the doubly magic group of nuclei

19 DECEMBER, 2018 | By Ana Lopes (/authors/ana-lopes)



(//cds.cern.ch/images/CERN-EX-0506009-07)

The MINIBALL gamma-ray detector array at the HIE-ISOLDE accelerator (Image: Maximilien Brice/CERN)

Physicists are no magicians, but ask them about how protons and neutrons are arranged in atomic nuclei and you'll be sure to hear the term magic. Just like electrons fill up a series of onion-like shells of different energy around an atomic nucleus, protons and neutrons are each

- CERN Accelerating News – December 2018

  https://home.cern/news/news/physics/first-result-hie-isolde-doubly-magic

Outreach 2018 - 8

ISOLDE Workshop 2018 in CERN Courier, Jan 2019

153 participants, 40 talks, 29 posters

4 prizes (sponsored by CAEN)

CERNCOURIER.COM

FIELD NOTES

ISOLDE WORKSHOP

Users highlight successful campaigns

On 5–7 December 2018, the annual ISOLDE Workshop and Users meeting took place at CERN, attracting 153 participants. The programme consisted of 41 presentations, of which 22 were invited talks and 19 were oral contributions selected from 74 submitted abstracts.

ISOLDE, CERN's long-running nuclear research facility, directs a high-intensity proton beam from the Proton Synchrotron Booster (PSB) at a target station to produce a range of isotopes. Different devices are used to extract, ionise and separate the isotopes according to their mass, forming low-energy beams that are delivered to various experiments. These radioactive ion beams (RIBs) can also be re-accelerated using the REX/HIE-ISOLDE linear accelerators (linacs). An energy upgrade of the HIE-ISOLDE superconducting linac was completed this year, enabling RIBs with an energy up to about 10 MeV per nucleon.

A focus of the 2018 ISOLDE workshop

beam lines. A total of 17 different RIBs were accelerated during July–November 2018. Beams of isotopes with an atomic mass from 7 to 228, with the radium-228 beam being the heaviest ever accelerated beam at ISOLDE, were delivered. The HIE-ISOLDE campaign began with seven experiments at the first beam line, with the MINIBALL detector array and its ancillary detectors. In October two experiments used the new ISOLDE solenoid spectrometer at the second beam line

Prize winners *The workshop organiser Gerda Neyens (second from right) with Victoria Araujo-Escalona and Natalia Sokolowska (two most left), who won for the best poster, and Tiago De Lemos*

had been irradiated earlier. The first HIE-ISOLDE physics paper, accepted for publication in *Physical Review Letters*, was also highlighted. It provides the first direct proof that the very neutron-rich tin-132 nucleus, considered to be doubly magic, does indeed merit this special status.

Other sessions were dedicated to the rich low-energy experimental physics programme at ISOLDE. Overview talks were presented on recent achievements in high-precision mass studies, with indium-100 as a highlight; on collinear laser spectroscopy studies, with a long series of antimony isotopes and isomers; on decay-spectroscopy experiments; and on the solid-state physics programmes. Participants also heard about recent studies with antiprotons at the Antiproton Decelerator at CERN and about the extremely exotic isotopes produced at the Radioactive Isotope Beam Factory (RIBF) facility at RIKEN in Japan. The study of exotic isotopes using the VAMOS spec-

Outreach 2019

- In Preparation
  - First successful experiments with ISS at Miniball (Accelerating News)
  - Hg shape staggering for EP Newsletter

- CERN Open Days – September 14-25, 2019
  - More than 80.000 visitors expected
  - ISOLDE participates

- Do you want to contribute to ISOLDE outreach ?
  - Contact me or Karl
  - CERN Courrier: Matthew Chalmers
  - Accelerating News: Ana Lopez, Panos Charitos

Meetings 2019

- ISCC meetings
  - March 19, Mon(!) July 1, Nov. 5
- INTC meetings
  - July 2-3, Nov. 6-7
- ISOLDE Workshop 2019
  - 4-6 December 2018 (Wed.-Fri.)
-