Status and perspectives of the

JYFL Accelerator Laboratory

Iain Moore

University of Jyväskylä, Finland

JYFL Acclab: principal infrastructure

JYVÄSKYLÄN YLIOPISTO UNIVERSITY OF JYVÄSKYLÄ

- Part of the Department of Physics
- Centre for Excellence (2012 2017)
- Over 6000 beam time hours a year
- One of the leading stable-ion beam facilities in the world
- EU- Access Laboratory since FP4 ENSAR in FP7
- International infrastructure in Finland
 over 200 users a year, foreign investments of 10 M€
- One of 3 accredited European Space Agency (ESA) test facilities

	.cc Long Kange plan z	010
Accelerator laboratory JYF University of Jyväskylä, Fir	°L. nland	A ANS
Electron accelerator ELSA of Bonn, Germany	, University	JYFL
European Centre for Theor Studies in Nuclear Physics Related Areas, ECT*, Trent	retical s and to, Italy	
Forschungszentrum Jülich (COSY and HPC), Jülich, G	1, FZJ Germany	
Institut de Physique Nucléains, IPNO, Orsay, Fran	nce	
Grand Accélérateur Nation	tal d'Ions	
		. 4. 20
of 10 M£		Laboratori Nazionali
s of 10 M€	Schwerionenforschung GmbH, GSI, Darmstadt,	del Sud of INFN, LNS, Catania, Italy
s of 10 M€ y (ESA)	Schwerionenforschung GmbH, GSL Darmstadt, Germany European Organisation for Nuclear Research, CERN	del Sud of INFN, LNS, Catania, Italy Laboratori Nazionali di Frascati of INFN, LNF, Frascati, Italy
s of 10 M€ ⁄ (ESA)	Schwerionenforschung GrmbH, GSL, Darmstadt, Germany European Organisation for Nuclear Research, CERN (ALICE, AD, COMPASS and ISOLDE), Genève, Switzerland	del Sud of INFN, LNS, Catania, Italy Laboratori Nazionali di Frascati of INFN, LNF, Frascati, Italy Laboratori Nazionali di Legnaro of INFN, LNLLegnaro (Padova), Italy
s of 10 M€ y (ESA)	European Organisation for Schwerionenforschung GmbH, GSL, Darmistadt, Germany European Organisation for Nuclear Research, CERN (ALICE, AD, COMPASS and ISOLDE), Genève, Switzerland Kernfysisch Versneller Instituut, KVI, Groningen, The Netherlands	del Sud of INFN, LNS, Catania, Italy Laboratori Nazionali di Frascati of INFN, LNF, Frascati, Italy Laboratori Nazionali di Legnaro of INFN, LNL_Legnaro of INFN, LNL_Legnaro (Padova), Italy Mainzer Mikrotron, MAMI, University of Mainz, Germany



Current Nuclear Research Facilities in Europe

J JÜLIC

A

JYFL Acclab: prior to upgrade (~2008)

JŸFL





JYFL Acclab: new lab extension + MCC30/15

JYFL

JYVÄSKYLÄN YLIOPISTO UNIVERSITY OF JYVÄSKYLÄ



JYFL Acclab: present status and future

JŸŶFL

JYVÄSKYLÄN YLIOPISTO UNIVERSITY OF JYVÄSKYLÄ



Operation of the JYFL K130 cyclotron





Recent highlights of ion source R&D (2011)

Metal ion beam production – first isotopic MIVOC ⁵⁰Ti beam

19 μ A ⁵⁰Ti¹¹⁺ from 14 GHz ECRIS \rightarrow 45 pnA on target



I.D. Moore, ECOS 2012, June 18-21 2012

JYVÄSKYLÄN YLIOPISTO

UNIVERSITY OF JYVÄSKYLÄ

New extraction for 14 GHz ECRIS in 2012

JYVÄSKYLÄN YLIOPISTO UNIVERSITY OF JYVÄSKYLÄ

Objective of simulations (IBSimu) to design a geometry capable of handling 3× more beam with the same or improved emittance.

0.2

0.3

3. (122)



0.1

0.05 0.05 0.04 0.03 0.02



Preliminary test last week indicates a factor of two improvement in beam transmission through the beamline and K130 cyclotron.



0.5

0.4

Future plans: beam transport

- Beam transport improvement:
 - Reduce ECRIS to dipole magnet distance
 - Beam line on HV to decrease space charge



RF-driven H⁻ source for MCC30/15 cyclotron

Advanced sputtering device under development: Ti, Mo, Zr beams etc.

JYVÄSKYLÄN YLIOPISTO UNIVERSITY OF JYVÄSKYLÄ

 $\phi \propto \frac{I_{beam}}{---}$

to K130

20103

Industrial applications at JYFL





- ESA accredited test site
- Radiation tests of space electronics
- Cocktail beams (ECR development)
- 35 space users since 2005





Irradiation of thin polmer films for health and car industries.







Production of radiopharmaceuticals



The K130 cyclotron

- Weekly production of ¹²³I ($T_{\frac{1}{2}}$ = 13 h)
- Local company (MAP) fabricates a compound and "flys" it to hospitals



Plans for the MCC30/15 cyclotron

- Restart iodine production
- Establish a laboratory for synthesising FDG from ${}^{18}F(T_{\frac{1}{2}} = 110 \text{ min})$ for PET application.

Diagnosis of brain-based diseases in 30 largest hospitals in Finland and in Karolinska Institutet in Stockholm



A. Virtanen



Accelerator-based materials physics





• Active detector development, digitization techniques, new analysis tools: aim to be a world leading lab for ion-beam analysis of materials.



https://www.jyu.fi/fysiikka/en/research/accelerator/abasedmat

Rare isotope beam science at IGISOL

JYFL



IGISOL-4: a new facility 2011-2012

JYVÄSKYLÄN YLIOPISTO UNIVERSITY OF JYVÄSKYLÄ

Optical access for K=130 MeV manipulation/ **Off-line sources:** K=30 MeV polarization (discharge, carbon cluster...) Laser ionization/spectroscopy: **Yield station** in-source and in-jet Deca spectrosco More beam time available for longer, complex experiments. **Collinear laser** Space for post-trap decay spectroscopy **MR-TOF-MS** spectroscopy Ultra-pure Xe samples for CTBTO Mass spectrometry RF hot cavity • & post-trap spectroscopy 172 days of proposals to go!

https://www.jyu.fi/fysiikka/en/research/accelerator/igisol

JYFL

Current status (June 2012)

JŸFL





Goal: towards more exotic n-rich nuclei

JYVÄSKYLÄN YLIOPISTO UNIVERSITY OF JYVÄSKYLÄ

Independent isotope production cross sections for fission of ²³⁸U





Neutron converter & fission target (& moderator)



Courtesy of D. Gorelov



Beam time at TSL, Uppsala, 18-21 June. Energy and angular spread of neutrons.



Nuclear structure at the limits with RITU

JYVÄSKYLÄN YLIOPISTO UNIVERSITY OF JYVÄSKYLÄ



SAGE spectrometer: $e^- - \gamma$ coincidence



A unique device offering the possibility of extracting information from highly converted transitions.



M. Scheck et al., PRC 83 (2012) 037303

JYFL



P. Papadakis et al., AIP Conf. Proc. 1090 (2009) 14

2011-2012 campaign:

- ²⁵³No
- ²⁵⁵Lr
- ^{249,251}Md
- ¹⁷⁷Hg
- ¹⁵²⁻¹⁵⁴Sm
 - ¹⁸⁸Pb





New spectrometers





A plunger for lifetime measurements at JYFL.

- First campaign to start 2012.
- Complementary with Coulomb excitation measurements on post-accelerated ISOL beams at ISOLDE.







- Highly efficient Si detector array
- Fast proton emitters ($t_{\frac{1}{2}}$ <10 ns)
- Veto detector for charged particles

The new vacuum mode separator - MARA: "Mass Analysing Recoil Apparatus"





- Solid angle acceptance (central m/q and energy) 10 msr
- Typical transmission ~12% per charge state



JYVÄSKYLÄN YLIOPISTO Complementarity with RITU UNIVERSITY OF JYVÄSKYLÄ MARA will: Expected completion 2013. Fully digitized, combine with ancillary detectors. Probe N≈Z line up to ¹¹²Ba decay spectroscopy ¹⁰⁰Sn region proton dripline spectroscopy rp process pn pairing interaction mirror nuclei Alpha decays near double magic 100Sn Tagging at the focal plane with recoil, 100SF beta, proton, etc. Ionisation chamber

JYF

Possible future: team MARA & team IGISOL T



• $I_b = 100 \text{ pnA}$, target 0.5 mg/cm²

- Yield at the target ~ 80 ions/s (⁸⁰Zr)
- Yield at focal plane ~ 10 ions/s/charge state
- Isobar yield 10⁴ ions/s/charge state

Isobaric contaminants: ⁸⁰Y, ⁸⁰Sr ~ 5 mb (p2n, 2pn, 3p, A = 79, total $\sigma \approx 400$ mb)

JYVÄSKYLÄN YLIOPISTO

UNIVERSITY OF JYVÄSKYLÄ



- Without mass slits > 10⁶ ions/s
- ✓ Primary beam suppression 10¹⁰-10¹¹

Strong support at Leuven gas cell workshop last month.



Summary and outlook



- Very successful operation of K-130 cyclotron (past 15 years operating at over 6000 hours per year).
- Excellent ECR team. Close collaboration with experimental research groups and active research with worldwide teams. Strong focus on beam development and improvement of beam transmission.
- New laboratory constructed. IGISOL-4 commissioned. Laser and trap facilities to commence 2012. Promises more beam time for longer experiments. Many new developments planned – manpower always needed!
- Applications an important source of income. Aim to expand medical isotope production with light-ion cyclotron. Closer collaboration between RADEF and Pelletron groups.
- RITU/JUROGAM and MARA (with all ancillary devices) to be fully digitized in the future. Expected completion of MARA ~2013.

Close synergy with theory



IN FINLAND DISTINGUISHED PROFESSOR PROGRAMME



In close collaboration with the Centre of Excellence period 2012 – 2017, the FIDIPRO grant has recently been extended for 5 years.

Advanced studies in theoretical nuclear structure to boost our global understanding of nuclear properties. Strong synergy with experimental teams.

Accepted PRL June 2012 with IGISOL team:

Precision Mass Measurements beyond ¹³²Sn: Anomalous behaviour of odd-even staggering of binding energies

J. Hakala,* J. Dobaczewski, D. Gorelov, T. Eronen,[†] A. Jokinen, A. Kankainen, V.S. Kolhinen, M. Kortelainen, I. D. Moore, H. Penttilä, S. Rinta-Antila, J. Rissanen, A. Saastamoinen, V. Sonnenschein, and J. Äystö[‡] Department of Physics, P.O. Box 35 (YFL), FI-40014 University of Jyväskylä, Finland

Points for discussion

- 1. Can stable ion beams compete with fragment separators for the production of N=Z nuclei?
- 2. Channel selection: beta tagging vs. particle evaporation channels
- 3. Can the smaller facilities cope with the demand of beam time once the large scale facilities shut down for upgrades?
- 4. Gas cells and recoil separators can we combine and exploit the physics opportunities offered?
- 5. As primary beam intensities increase, can we tolerate the background, can we improve the selectivity of production?

Thank you for your attention !!





JYVÄSKYLÄN YLIOPISTO UNIVERSITY OF JYVÄSKYLÄ



JYFL



C. Geppert, EMIS conference, 2007.

JYFL

I.D. Moore, Seminar at KVI, May 18th 2012

Ultra-pure ^{131m, 133m, 133, 135}Xe samples



The JYFLTRAP Penning trap facility



MCP or implantation station

7T superconducting magnet + Penning traps

RF cooler-buncher



I.D. Moore, Seminar at KVI, May 18th 2012

Pure isomeric beams available at JYFLTRAP



JYVÄSKYLÄN YLIOPISTO

UNIVERSITY OF JYVÄSKYLÄ