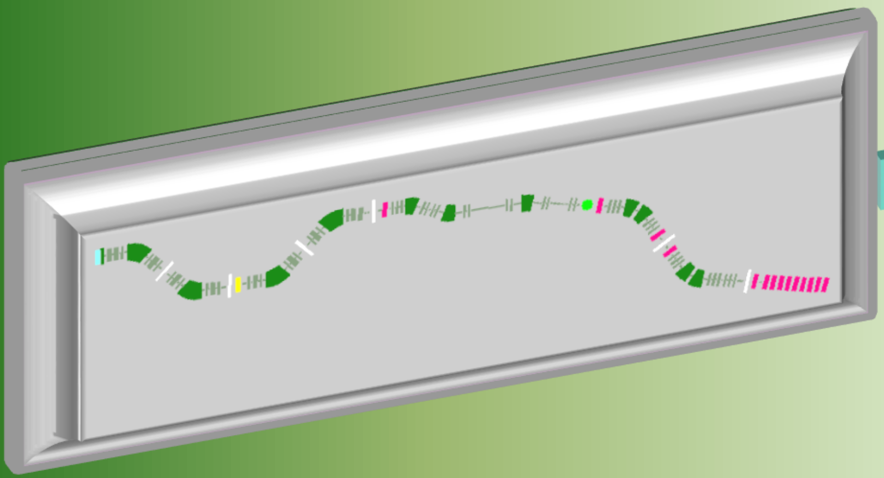
Oleg B. Tarasov
NCSL / MSU, USA

Production of Fast Rare Ion Beams

26-31 / 08 / 2013
Euroschool on Exotic Beams 2013, Dubna
Euroschool on Exotic Beams 2013, Dubna

LISE++



LISE++

1. Introduction to production of Fast Rare Ion Beams
2. Production Area
3. Separation
4. Identification
5. Production of new isotopes
6. LISE++ : Utilities
7. Radioactive beam physicist task

Euroschool on Exotic Beams: 20th anniversary !

EUROSCHOOL ON EXOTIC BEAMS

organized by the "Instituut voor Kern- en Stralingsfysika, K.U.Leuven" in the framework of the Human Capital and Mobility Program of the Commission of the European Communities.

Leuven, Belgium September 6 - 10, 1993

paying back tuition loans after 20 years…

Lecture Notes in Physics
Volume 651 2004

The Euroschool Lectures on Physics with Exotic Beams, Vol. I

Editors: Jim Al-Khalili, Ernst Roeckl

ISBN: 978-3-540-22399-3 (Print) 978-3-540-44490-9 (Online)

"In-Flight Separation of Projectile Fragments" by David J. Morrissey and Brad M. Sherrill

Lect. Notes Phys. 651, 113–135 (2004)

Lecture Notes in Physics
Volume 700 2006

The Euroschool Lectures on Physics with Exotic Beams, Vol. II

Editors: Jim Al-Khalili, Ernst Roeckl

ISBN: 978-3-540-33786-7 (Print) 978-3-540-33787-4 (Online)

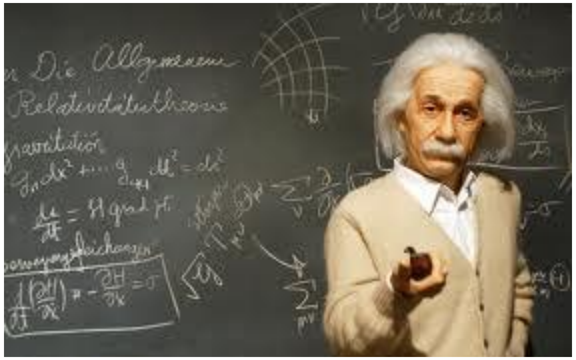
"Isotope Separation On Line and Post Acceleration" by Piet Van Duppen

Lect. Notes Phys. 700, 37–77 (2006)

"Production and acceleration of rare-isotope beams" by Giovanni Bisoffi

Euroschool 2012, Athens, Greece

ISOL & In-flight methods, ion sources, accelerators et al.
http://iks32.fys.kuleuven.be/files/euroschool/2012_Giovanni_Bisoffi.zip



What is approach to the "Production of exotic beams" lectures at 2013 ?

After discussions with some outstanding theorists, professors, who have brilliant ideas for physical motivation of an experiment,

it seems to me, that the good direction of this year lectures is to create a manual how to prepare a technical part of the proposal for the in-flight production and selection experiment.

Step by step from the beginning with the use of examples prepared with the LISE^{++} code.

Production of .... ??

- **Production of Exotic Beams**

- **Stable ^{12}C is one of most exotic nuclei ?!**

Selected for a Viewpoint in Physics
PRL 106, 192501 (2011) PHYSICAL REVIEW LETTERS week ending 13 MAY 2011

Ab Initio Calculation of the Hoyle State

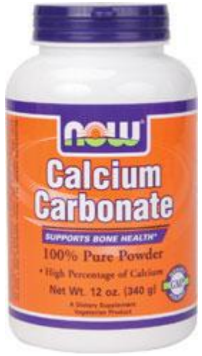
Evgeny Epelbaum,[1] Hermann Krebs,[1] Dean Lee,[2] and Ulf-G. Meißner[3,4]

The Hoyle state plays a crucial role in the helium burning of stars heavier than our Sun and in the production of carbon and other elements necessary for life. This excited state of the carbon-12 nucleus was postulated by Hoyle as a necessary ingredient for the fusion of three alpha particles to produce carbon at stellar temperatures. Although the Hoyle state was seen experimentally more than a half century ago nuclear theorists have not yet uncovered the nature of this state from first principles. In this Letter we report the first *ab initio* calculation of the low-lying states of carbon-12 using supercomputer lattice simulations and a theoretical framework known as effective field theory. In addition to the ground state and excited spin-2 state, we find a resonance at −85(3) MeV with all of the properties of the Hoyle state and in agreement with the experimentally observed energy.

triple α process

- **Stable ^{40}Ca : $.32/oz, whereas stable ^{48}Ca : $7M/oz**

^{48}Ca is exotic or rare?



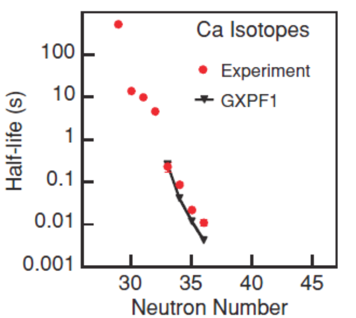
- **Production of Radioactive Ion Beams**

- **Do not speak in public a word "radioactivity" that scares our neighbors. They already have problems with the radon in their basements according to EPA (Environmental Protection Agency). We are not guilty for that!**

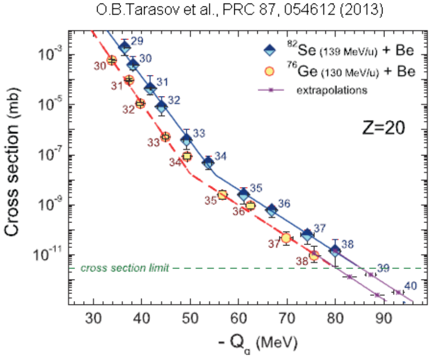
- **Production and acceleration of rare-isotope beams**
  (Euroschool 2012)

- **That is really rare for the In-flight method, mostly is unachievable for the ISOL method**

P.Mantica et al., PRC 77, 014313 (2008)



O.B.Tarasov et al., PRC 87, 054612 (2013)



So…

Fast Rare Ion Beams

Please, do not mix with the Facility for Rare Isotope Beams!

Important step forward for FRIB

A note from Thomas Glasmacher

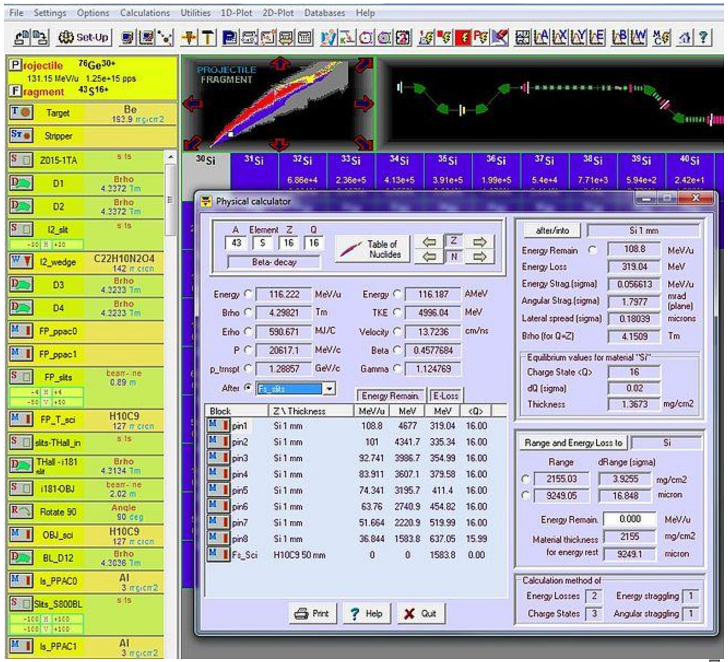
On August 1, 2013, the Department of Energy's Office of Science (DOE-SC) approved Critical Decision-2 (CD-2), Approve Performance Baseline, and Critical Decision-3a (CD-3a), Approve Start of Civil Construction and Long Lead Procurements, for the Facility for Rare Isotope Beams (FRIB) project. CD-2 formally establishes the cost and schedule for the FRIB project. The Total Project Cost for FRIB is $730M, of which $635.5M will be provided by DOE and $94.5M will be shared by the community. FRIB will be completed by June 2022 and the project is managing to an early completion in December 2020.

FACILITY FOR RARE ISOTOPE BEAMS

Why LISE^{++} ? What is it ?

"Step by step from the beginning with the use of examples prepared with the LISE^{++} code"

- The code operates under MS Windows environment and provides a highly user-friendly interface.
- It can be freely downloaded from the following internet addresses: http://lise.nscl.msu.edu
- The program LISE^{++} is designed to predict the intensity and purity of radioactive ion beams (RIB) produced by In-flight separators.
- The LISE^{++} name (2002) is borrowed from the well known evolution of the C programming language, and is meant to indicate that the program is no longer limited to a fixed configuration like it was in the original "LISE" program, but can be configured to match any type of device or add to an existing device using the concept of modular blocks.
- The LISE code (1985) was named after the fragment separator LISE.
- The main functions of the program:
  - ❑ predict the fragment separator settings necessary to obtain a specific RIB;
  - ❑ predict the intensity and purity of the chosen RIB;
  - ❑ simulate identification plots for on-line comparison;
  - ❑ provide a highly user-friendly graphical environment;
  - ❑ allow configuration for different fragment separators.
- The program is constantly expanding and evolving from the feedback of its users around the world.
- The LISE^{++} package includes configuration files for most of the existing fragment and recoil separators found in the world.
- Many "satellite" tools have been incorporated into the LISE^{++} framework (will be discussed in Friday)



Reference:
"Radioactive beam production with in-flight separators", O.T. and D.Bazin, NIM B (2008) 4657-4664.

Why LISE^{++} ? Where is it used? (1)

"how to prepare a technical part of the proposal ?"

So, for the in-flight RIB facilities with the PAC system for proposals LISE^{++} configurations files have been developed by local fragment separator groups.

BigRIPS @ RIBF

http://www.nishina.riken.jp/RIBF/BigRIPS/intensity.html

RIBF RIKEN NiSHiNA CENTER

RIKEN Nishina Center for Accelerator-Based Science

Introduction to RI Beam Factory and Users' Information

Nishina Center Top RIBF Top

Facility Information
- Accelerator
  - Intensity
- BigRIPS
  - Intensity
- RIPS
- GARIS
- SAMURAI
- SHARAQ(CNS)
- SR2
- Biology Beamline
- Material Beamline
- CRIB(CNS)
- KISS(KEK)
- DAQ

User Guide
- Access to RIBF
- User Procedures
  - FAQ
- For new visitors

HOME > BigRIPS > Technical Information > Secondary beam intensity expected

BigRIPS

Overview | Concept | Configuration | Technical Information | Publication list /Link

Device Information (password protected) | Secondary beam intensity expected | BigRIPS optics | ZeroDegree optics

Technical Information - Secondary beam intensity expected

- The LISE++ input file for BigRIPS is ready for use
- Production cross section for the ^{48}Ca+Be reaction at 345A MeV.
- Production cross section for the in-flight-fission ^{238}U (345 A MeV)+Be
- Production cross section for the in-flight-fission ^{238}U (345 A MeV)+Pb
- Estimated RI beam intensities (for the first two years)
- Estimated RI beam intensities (nominal operating value)

The LISE++ input file for BigRIPS is ready for use

You can make detailed calculation using the LISE++ code [1] based on the standard configuration and ion ZeroDegree and the experimental cross sections that we measured for in-flight fission of ^{238}U (345 A MeV) +

A1900 @ NSCL

http://www.nscl.msu.edu/exp/propexp/procedure

NSCL

National Superconducting Cyclotron Laboratory
Call for Proposals—PAC 37

February 2, 2012

Dear NSCL User:

We invite proposals for beam time to be considered at the next meeting of the NSCL Program

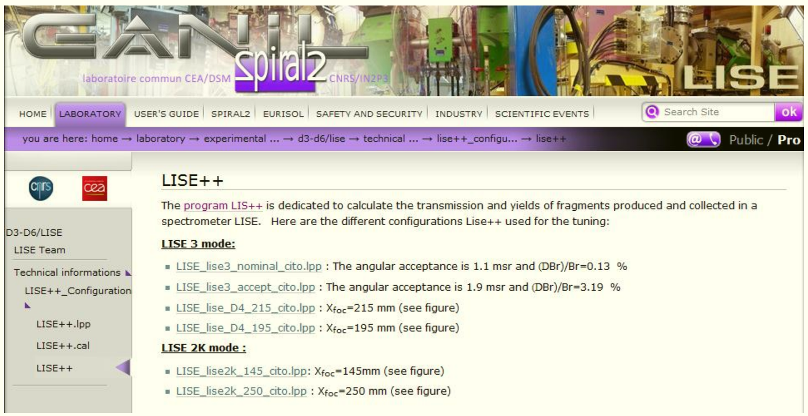
(C) An electronic copy of the LISE++ files used to obtain rare isotope intensity estimates with the official version of LISE++ (referenced in item 3 of the "Notes for PAC37" below). The LISE files can be e-mailed to the A1900 Device Contact at the time of submission of the proposal.

Why LISE++ ? Where is it used? (2)

So, for the in-flight RIB facilities with the PAC system for proposals
LISE++ configurations files have been developed by local fragment separator groups

LISE @ GANIL

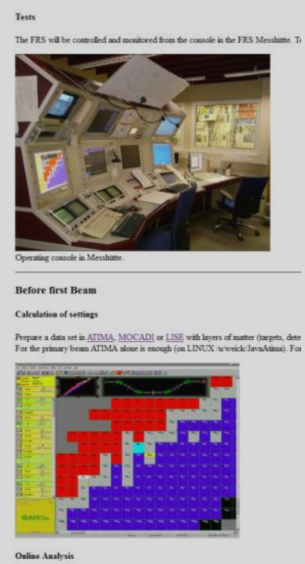
http://pro.ganil-spiral2.eu/laboratory/experimental-areas/lise/technical-informations/lise-_configuration/lise/

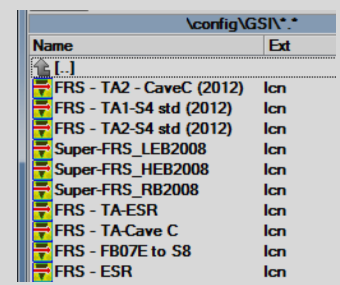


FRS @ GSI

http://web-docs.gsi.de/~weick/frs/frs-steps.html

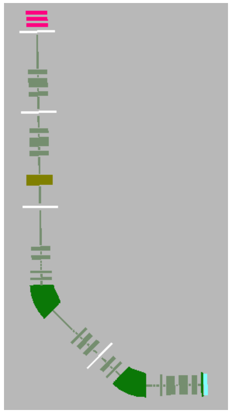
How to set up the FRS –
From SIS extraction of primary beam to isotope identification

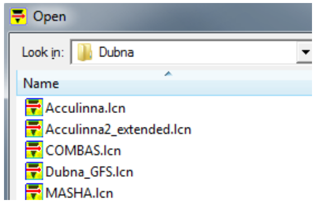




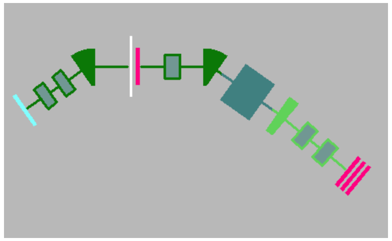
in-flight RIB facilities without the PAC system for proposals

ACCULINNA & COMBAS @ FLNR

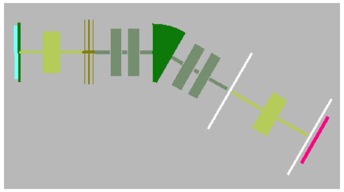




MARS @ TAMU



RESOLUT @ FSU



The Content of the Lectures

Production of radioactive ion beams, I
(27 August 14:30-16:00)

1. **Introduction to RIB production**
2. **Production Area**

Production of radioactive ion beams, II
(28 August 09:30-11:00)

3. **Separation**
4. **Identification**
5. **Production of new isotopes**

Recap-session LISE++
(30 August 11:30-13:00)

6. **LISE^{++} : Utilities**
7. **Radioactive beam physicist task**

Acknowledgements (as Copyright issue)

Would like to thank MSU colleagues

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Discussions

with B.M.Sherrill (MSU), D.J. Morrissey (MSU) and A.Gade (MSU)

are very appreciated