Radiation Effects Facility (RADEF) at Jyväskylä

Outline

• General aspects
• Equipment description
• Accelerator capabilities and operation
• Future developments
Location...

...and how to get to JYFL
Accelerator Laboratory of the University of Jyväskylä

- Part of the Department of Physics (JYFL)
- Basic research in nuclear-, accelerator- and materials physics
- Applications in space- and medical physics & paper industry
- Center of Excellence status of the Academy of Finland
- EU’s Major Research Facility i.e. “Large Scale Facility”
**Machine description**

**K-130 cyclotron:**
- Heavy-ions up to Xe ≤ 1.3 GeV, protons ≤ 60 MeV
- All gaseous and 19 metallic elements
- Dedicated beam cocktails for the irradiation tests

- Two ECR (6.4 and 14.5 GHz) ion sources for heavy-ions
- TWTA transmitter for double/triple frequency mode
- Multicusp ion-source for protons
Usage and management

- Beam times for basic research
  - Two annual calls of proposals to PAC
- Dedicated beam times for
  - MAP MedTech Ltd. - radioisotope production (~ 10%) - weekly
  - ESA and European space industry (~ 10%) – upon request
Radiation Safety Procedures

VISITORS

Visitors coming for short term work at The Accelerator Laboratory are kindly asked to follow these safety practices.

RADIATION SAFETY

All visitors working inside the controlled area must have personnel dose control. Dosimeters can be provided also by the home institute. Recognition as Category A radiation worker requires a document from the home institute stating this status. This document is valid for one year unless otherwise specified in the document. A document of personnel radiation exposure history is required at the latest if the recording threshold is exceeded in the dose control provided by JYFL (unless “no earlier radiation work” is signed on RS-1).

The data for radiation work and dose control is entered in the computer database with the aid of Form RS-1. At the proper occasion check the validity of your data.

Do this:

- Fill the form RS-1 (first visit or changes) and visit the safety officer. We need the dates of your visit and to assure your dose control and to check your working conditions for every visit.
- Fill the form Visitors and leave it to the safety officer, department office or your host.

GENERAL SAFETY

The laboratory keys are provided by the safety officer. The following practice must be applied in order to maintain the desired safety level:

- Keys must always be given back before you leave. The validity of the entrance key will be canceled if this rule is violated. Never leave your keys reachable for outsiders.
- Lost keys must be notified immediately. The fee of 50 FIM per each lost key will be charged before new keys are delivered.
- Do not deliver the lock codes (controlled area) to unauthorized persons.

Radiation Safety Officer: Teuvo Polkola, room: FL103, phone: 2404.
I’ll try to be in my office 10-11 and 13-14; normally reachable by dialing 2404.

FORMS AND INFO

- Forms and info on radiation safety available in the room S127 (below).
- The safeguards for the radiation practice are included in the Radiation Protection Manual.
The New ESA Sponsored Test Site

ESTEC/Contract No. 18197/04/NL/CP

"Utilisation of the High Energy Heavy Ion Test Facility for Component Radiation Studies"

- The development phase started in summer 2004
- Acceptance test took place in April, 2005
- Inauguration was May 27, 2005
RADEF beam lines

Proton line

Heavy ion line

Beam modification

Beam tuning

Dosimetry and DUT chamber

6th RD50 Workshop – Ari Virtanen
Proton dosimetry

- Flux up to $10^{10}$ cm$^{-2}$s$^{-1}$ $\sim$ 10 nA
- Energy up to 60 MeV
- Current/count measurement with a graphite Faraday cup/PMT-scintillation detector
- PC-controlled xyz-DUT plate
- Al- or polyethylene collimators
- Fast energy change with Al-degraders
- Current monitoring with an ionization chamber
Heavy-ion dosimetry
Beam monitoring

![Graph and Table]

**40Ar^{12+}, 372 MeV, LET=10, R=117**

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<th>DUT</th>
<th>Time (deg)</th>
<th>Fluence</th>
<th>Total Time (sec)</th>
<th>Comment</th>
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6th RD50 Workshop – Ari Virtanen
DUT plate installation

Standard connectors:
- chamber (female) → panel (male) → shack (male)
  - 3 x 40 PIN
  - 2 x D25 PIN
  - 2 x D9 PIN
  - 3 x BNC
  + Ethernet + others upon request
### Standard High Penetration Cocktail (9.3 MeV/A)

<table>
<thead>
<tr>
<th>#</th>
<th>$^A_{\text{Ion}}q^+$</th>
<th>E [MeV]</th>
<th>$R_{\text{SRIM}}$ [μm]</th>
<th>$R_{\text{BNL}}$ [μm]</th>
<th>St.power [SRIM]</th>
<th>LET [BNL]</th>
<th>$\Delta m/q$ [%]</th>
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<td>$^{15}\text{N}^{4+}$</td>
<td>139</td>
<td>202.1</td>
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<td>1.7</td>
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<td>2</td>
<td>$^{20}\text{Ne}^{6+}$</td>
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<td>3.5</td>
<td>0.0</td>
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<tr>
<td>3</td>
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<td>- 0.9</td>
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<tr>
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<td>372</td>
<td>117.9</td>
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<td>10.2</td>
<td>10.0</td>
<td>- 0.6</td>
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<tr>
<td>5</td>
<td>$^{56}\text{Fe}^{15+}$</td>
<td>523</td>
<td>97.4</td>
<td>99.0</td>
<td>18.5</td>
<td>18.0</td>
<td>- 5.6</td>
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<tr>
<td>6</td>
<td>$^{82}\text{Kr}^{22+}$</td>
<td>768</td>
<td>94.0</td>
<td>96.0</td>
<td>32.1</td>
<td>30.0</td>
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<tr>
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<td>$^{131}\text{Xe}^{35+}$</td>
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<td>89.1</td>
<td>97.0</td>
<td>60.0</td>
<td>53.0</td>
<td>- 2.6</td>
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</table>

+ Other cocktails with E/A ~ 3.6 MeV/A or 6.1 MeV/A
+ Protons up to 60 MeV
Heavy Ion Test Results – Atmel AT60142E

Atmel AT60142E 3.3 V 512K8 SRAM - Heavy Ion SEE Results (UCL0211), (UCL0404) & (JYFL0504).

![Graph showing cross section vs. ion LET]

- ▲ - Dynamic #01 - Hirex - UCL
- ○ - Dynamic 02 & #03 - Hirex - UCL
- ▣ - Dynamic IDA s/n 02 - UCL
- ○ - Dynamic IDA s/n 03 - UCL

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Heavy Ion Test Results – Atmel AT60142E

Atmel AT60142E 3.3 V 512K8 SRAM - Heavy Ion SEE Results (UCL0211), (UCL0404) & (JYFL0504).

Ion LET - MeV/(mg/cm²)

Cross Section - (cm²/bit)

- Dynamic D2/1 - Hirex - JYFL
- Dynamic #01 - Hirex - UCL
- Dynamic 02 & #03 - Hirex - UCL
- Dynamic IDA s/n 02 - UCL
- Dynamic IDA s/n 03 - UCL

RADECS Thematic Workshop @ JYFL – F1 – Ari Virtanen
Heavy Ion Test Results – Atmel AT60142E

Atmel AT60142E 3.3 V 512K8 SRAM - Heavy Ion SEE Results (UCL0211), (UCL0404) & (JYFL0504).

Ion LET - MeV/(mg/cm²)

Cross Section - (cm²/bit)

- ■ - Dynamic D2/1 - Hirex - JYFL
- ▲ - Dynamic D2/2 - Hirex - JYFL
- ▲ - Dynamic #01 - Hirex - UCL
- ○ - Dynamic 02 & #03 - Hirex - UCL
- ■ - Dynamic IDA s/n 02 - UCL
- ○ - Dynamic IDA s/n 03 - UCL

6th RD50 Workshop – Ari Virtanen
Beam Characteristics and Operation

- Spot size ~ 4 x 4 cm² with a homogeneity of ± 10 %
- Flux adjustable up to ~ 10⁶
- 4 hours reserved for tuning
- Ion change + calibration:
  - inside the same cocktail ~ 1 hour
  - between cocktails ~ 2 hours
  - from heavy ions to protons ~ 4 hours
Future developments

A more penetrating cocktail (10.9 MeV/A) will be developed:

<table>
<thead>
<tr>
<th>#</th>
<th>A Ion^{q+}</th>
<th>E [MeV]</th>
<th>R_{SRIM} [µm]</th>
<th>R_{BNL} [µm]</th>
<th>St.power [SRIM]</th>
<th>LET [BNL]</th>
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<td>1</td>
<td>^{14}N^{4+}</td>
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<td>241.8</td>
<td>247.8</td>
<td>1.6</td>
<td>1.6</td>
<td>0.0</td>
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<tr>
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<td>-1.4</td>
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<td>50.5</td>
<td>-4.8</td>
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</table>

- Third frequency to the ECR will be installed
- Design/construction of a new chamber will be started
- Position sensitive detector for protons will be constructed
Support and contacts

Before the test:
- beam time reservations, planning...
- technical information, help – e.g. mounting fixture...
- hotel reservations, travelling information

During the test:
- Operation of the ion sources, accelerator and RADEF
  – calibrations, flux-, fluence-, homogeneity monitoring...
- Electronic and mechanical workshops
  – cabling, connectors, feed throughs...
- Radiation safety
  – dosimeters, keys...
- Internet, e-mail connections...

All inquiries to ari.virtanen@phys.jyu.fi and more info from www.phys.jyu.fi/research/applications/index.html