Radiological study of the nuclear facility S3 of SPIRAL2

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Plan

• GANIL and SPIRAL2 facility: the future of GANIL
• S3 facility
• Neutron production and modelling
• Radiological study results
• Conclusion
GANIL : common laboratory CEA/DRF & CNRS/IN2P3

Nuclear physics on exotic heavy ions

Nuclear reaction mechanisms

Nuclear structure

High knowledge and technical/scientific expertise about accelerators physics and engineering (cryogenics, high vacuum, ion sources, beam diagnostics...)

Interdisciplinary research (materials irradiation...)

5 Cyclotrons

5 > 95 MeV/n

6 < Z < 92

SPIRAL2

Spiral2 Linear accelerator (p,d,α,Hi)

Spectrometer S3, Neutron source, Low energy ions
GANIL/SPIRAL2 facility

LINAC:
- 33 MeV p
- 40 MeV d
- 14.5 AMeV HI

A/q=3 HI source up to 1 mA

A/q=6 Injection

CIME cyclotron RIB at 1-20 AMeV (up to 10 AMeV for fiss. fragments)
GANIL/SPIRAL2 facility

http://u.ganil-spiral2.eu/chartbeams/
The quest for new nuclides

Nuclear masses measurement

Radioactivity of neutron/proton-rich nuclides

Shell structure far from stability
Single –particle levels far from stability

The synthesis of super-heavy elements

The elements and their origin

Fundamental interactions : searching for physics beyond the standard model

Neutron for Sciences ; Medical applications

Interdisciplinary research
S3: The Super Separator Spectrometer for LINAC Beams

Diagram showing components such as Target, Open Multipoles, Beam dump, Closed SC Multipoles, Beam, FISIC collision point, Electric dipole, Detection chamber, Mass spectrometer, Low energy branch, Multi-purpose Experimental Room, and a path to DESIR.
S3 : Objectives of the radiological study

1. Neutron energy deposit on electronic components

2. Neutron energy deposit on superconductor elements

3. Neutron dose equivalent : neutron map on S3

Method : Monte Carlo simulations (PHITS, MCPN, …)
**S3 : Nominal operation conditions**

**Reference beams of physics : 5 kW**

<table>
<thead>
<tr>
<th>Ion beam</th>
<th>Energy (MeV/n)</th>
<th>Intensity (10^{14} pps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12C</td>
<td>7</td>
<td>3.7</td>
</tr>
<tr>
<td>22Ne</td>
<td>5</td>
<td>2.8</td>
</tr>
<tr>
<td>48Ca</td>
<td>5</td>
<td>1.3</td>
</tr>
<tr>
<td>58Ni</td>
<td>5</td>
<td>1.1</td>
</tr>
<tr>
<td>58Ni</td>
<td>10</td>
<td>0.54</td>
</tr>
<tr>
<td>48Ca</td>
<td>10</td>
<td>0.65</td>
</tr>
<tr>
<td>20Ne</td>
<td>14</td>
<td>1.1</td>
</tr>
<tr>
<td>40Ar</td>
<td>14</td>
<td>0.56</td>
</tr>
</tbody>
</table>

**Dimensioning beam: 12C (15 MeV/n) at 45 kW**

**3. Neutron dose equivalent**

**1 & 2. Neutron energy deposit**
S3 : Choice of the transport code

$n^{38}S(12\text{ MeV/u}) + ^{\text{natCu}}$

- PHITS
- EXP-TTNY (M. FADIL et al. 2015)
- MCNPX
S3: building and equipements

Modelling code: PHITS2.88
S3: building and equipments

- Laser area
- Beam dumps area
- Spectrometer area

Laser area -1
Laser area -2
Neutron production: enveloppe beam
Neutron energy deposit for electronic components (20Ne (14 MeV/n) 5 kW)

- T2L1C1: 765 Gy
- T3L1C1: 1270 Gy
- T4L1C1: 4.85 Gy
Neutron energy deposit: Heat on superconductor elements (20Ne (14 MeV/n) 5 kW)
Neutron energy deposit: Heat on superconductor elements (20Ne (14 MeV/n) 5 kW)
Neutron dose equivalent: 45 kW of 12C (15 MeV/n)
Neutron dose equivalent: 45 kW of 12C (15 MeV/n)

1st beam-dump: 45 kW

2nd beam-dump: 45 kW

VC: 100 W

$10^2 \mu\text{Sv/h}$

$10^3 \mu\text{Sv/h}$
Neutron dose equivalent: 45 kW of 12C (15 MeV/n)

Present configuration

1st configuration

2nd configuration
Neutron dose equivalent: 45 kW of 12C (15 MeV/n)
Neutron dose equivalent: 45 kW of 12C (15 MeV/n)
Conclusion

- $^{20}\text{Ne}$ (14 MeV/n): enveloppe beam for secondary particles, especially neutrons
- PHITS: more adapted to S3 nuclear reactions simulations
- Few arrangements still needed in S3 building (Laser aeras)
- Environment very hostile for electronic components