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Nuclear Data for MYRRHA

Workshop for Applied Nuclear Data Activities (WANDA 2021)
With its NURA project, SCK CEN significantly increases its contribution to the fight against cancer. By pooling its knowledge and expertise in terms of radiopharmaceuticals, NURA contributes to the development of the next-generation radiopharmaceuticals. More specifically, NURA performs game-changing research into radiopharmaceuticals for treating different types of cancer in cooperation with clinical and industrial partners.

SCK CEN works actively on the design and construction of a new multi-purpose research plant: MYRRHA, which stands for Multi-purpose Hybrid Research Reactor for High-tech Applications. MYRRHA is a versatile research infrastructure but above all unique. It is the world’s first research reactor driven by a particle accelerator.

With the public-public partnership RECUMO, SCK CEN and the National Institute for Radio Elements (IRE) reach out to one another. SCK CEN will decontaminate the current and future highly radioactive residues and thus reduce the stock. In this way, RECUMO contributes to the security of supply of medical radio-isotopes, which are indispensable in the fight against cancer.
MYRRHA

• MYRRHA – An Accelerator Driven System
  • Demonstrate the ADS concept at pre-industrial scale
    • Can operate in critical and sub-critical modes
  • Demonstrate transmutation
  • Fast neutron source

<table>
<thead>
<tr>
<th>Accelerator</th>
<th>Reactor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particles</td>
<td>Power</td>
</tr>
<tr>
<td>protons</td>
<td>65 to 100 MW$_{th}$</td>
</tr>
<tr>
<td>Beam energy</td>
<td>$k_{\text{eff}}$</td>
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<tr>
<td>600 MeV</td>
<td>0.95</td>
</tr>
<tr>
<td>Beam current</td>
<td>Spectrum</td>
</tr>
<tr>
<td>2.4 to 4 mA</td>
<td>fast</td>
</tr>
<tr>
<td></td>
<td>Coolant</td>
</tr>
<tr>
<td></td>
<td>LBE</td>
</tr>
</tbody>
</table>

Target
- Main reaction: spallation
- Output: $2 \cdot 10^{17}$ n/s
- Material: LBE (coolant)
MYRRHA design

- **Codes**
  - **Core**
    - MCNP6.2
    - ALEPH2
  - **Accelerator**
    - MCNP6.2
    - ALEPH2
    - PHITS

- **Nuclear data**
  - JEFF-3.1.2, JEFF-3.2, JEFF-3.3 & JEFF-4T0
  - ENDF/B-VII.0, ENDF/B-VII.1 & ENDF/B-VIII.0
  - JENDL-4.0 & JENDL-5beta
Nuclear Data Validation: VENUS-F

Besides criticality, we have:
- Kinetic parameters
- CR curve
- Spectral indices
- Axial and radial traverses
- Pb-Bi void
- Fuel Doppler

Extensive database for ND validation!

<table>
<thead>
<tr>
<th>Core</th>
<th>#FAs</th>
<th>FA composition</th>
<th>Reflector</th>
<th>In-Pile Section</th>
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<tbody>
<tr>
<td>CR0</td>
<td>97</td>
<td>9 U+16 Pb</td>
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<tr>
<td>CC5</td>
<td>41</td>
<td>13 U+8 Pb+4 Al₂O₃</td>
<td>Pb</td>
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<tr>
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<td>41</td>
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<tr>
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<td>Pb+C</td>
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<td>CC8</td>
<td>47</td>
<td>13 U+8 Pb+4 Al₂O₃</td>
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<td>Pb+C</td>
<td>thermal and fast spectrum</td>
</tr>
</tbody>
</table>

Source: A. Kochetkov and P. Baeten
Nuclear Data Needs

Nuclear data needs in JEFF-3.3 for MYRRHA:

- Adoption of JENDL-4.0 evaluation for $^{204}$Pb or re-evaluation in the RRR and URR
- New evaluation $^{57}$Fe(n,inel.) including missing resonances
- Re-evaluation $^{18}$B(n,inel.) uncertainty
- Covariance evaluation for $^{209}$Bi(n,n) and $^{209}$Bi(n,$\gamma$)
- Covariance evaluation for $\nu_{n}$, $\nu_{\nu}$, $\nu_{d}$ $^{240}$Pu and $^{235,238}$U and $^{239,242}$Pu
- Reduction of uncertainty $^{240}$Pu(n,$f$)
- Reduction of uncertainty $^{54,57}$Fe(n,n)
- Reduction of uncertainty $^{238}$Pu(n,n)
- Reduction of uncertainty $^{232}$U(n,inel.)

Criticality

Shielding

Radioactive source term and waste management

Benchmarks

• Criticality
  • VENUS-F - MYRRHA mockup
  • Different configurations for nuclear data validation

• Shielding
  • Double-differential neutron yields experiments
  • Neutron transmission experiments

• Nuclear data adjustment
  • Simple configuration
  • Highly sensitive to a single nuclide and reaction channel