A Beijing Radio-activity ion-beam facility (BRIF) &

Compact pulsed hadron source

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content

- A Beijing Radio-activity ion-beam facility (BRIF) at China Institute Atomic Energy
- A Compact Pulsed Hadron Source (CPHS) at Tsinghua university
Beijing Radio-activity ion-beam facility
BRIF Status

— A project of Beijing Radioactive Ion-beam Facility is under constructed in China Institute of Atomic Energy (CIAE), which is composed of a compact proton cyclotron, a on-line isotopic separator and a superconducting linac booster.
— The first beam will be get in the end of 2013.
— The total budget of this project is about 400million yuan (60M$)
A Beijing Radio-activity ion-beam facility (BRIF)
At China Institute Atomic Energy

1. A 100 MeV/200uA proton cyclotron
2. An isotope separator on line system
3. A superconducting Linac booster model
Driving cyclotron accelerator

Proton
Energy: 100 MeV
Intensity 200 μA
CYC main magnet under construction
100MeV cyclotron is under construction
ion source

At the ISOL system, RNB are produced in a thick high temperature target via spallation, fission or fragmentation reaction. The reaction products are released from the target via diffusion and effusion and bass through a tube to ion source.

The ion source of our ISOL are electron beam plasma ion source. A prototype radioactive target/ion source has been developed at CIAE.
Isotopic separator
two isotopic magnetic analyzers

90°
ρ = 0.6 m
mass resolution: 1000;

Isobar separator.
high-voltage platform with potential up to 300 kv
two isobar magnetic separation:

100°
ρ = 2.5 m
mass resolution: 20000
ISOL magnets

The target process chamber 2012.6.

ISOL magnet 100 Deg.

Target test table: 2010 12
High intensity neutron beam line

Single energy neutron line

Irradiation physics beam line

Biomedical beam line

Radiation isotopic beam line

ADS test beam line
QWR sputtering
A Beijing Radio-activity ion-beam facility (BRIF) At China Institute Atomic Energy
Compact Pulsed Hadron Source (CPHS) status
A Compact Pulsed Hadron Source (CPHS) has been developed in Tsinghua University Beijing. The Accelerator parts consists of

- A high-intensity ECR ion source and lebt
- A 3 MeV radiofrequency quadrupole linac (RFQ),
- A 13 MeV drift-tube linac (DTL),
- HEBT and neutron target.
CPHS project

- 13MeV/50mA, 0.5ms/50Hz
- Neutron target
- Neutron instrument
## Main parameters of CPHS

<table>
<thead>
<tr>
<th>Species</th>
<th>proton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam power</td>
<td>16 kW</td>
</tr>
<tr>
<td>Output energy</td>
<td>13 MeV</td>
</tr>
<tr>
<td>Average Current</td>
<td>1.25 mA</td>
</tr>
<tr>
<td>Repeat. frequency</td>
<td>50 Hz</td>
</tr>
<tr>
<td>Particle per pulse</td>
<td>$1.56 \times 10^{14}$ Protons</td>
</tr>
<tr>
<td>Duration of pulse</td>
<td>500 μs</td>
</tr>
<tr>
<td>Peak current</td>
<td>50 mA</td>
</tr>
<tr>
<td>Beam duty factor</td>
<td>2.5%</td>
</tr>
<tr>
<td>RF frequency</td>
<td>325 MHz</td>
</tr>
<tr>
<td>Ion source extraction energy</td>
<td>50 keV</td>
</tr>
<tr>
<td>RFQ output energy</td>
<td>3 MeV</td>
</tr>
<tr>
<td>DTL output energy</td>
<td>13 MeV</td>
</tr>
</tbody>
</table>
### ECR Ion source

1. **Species**: p
2. **Energy**: 50 keV
3. **Current**: 60 mA
4. **Emittance**: <0.20 πμ, norm, rms
5. **Lifetime**: >120 hours
6. **Frequency**: 2.45GHz
7. **Power**: 1.5~2.0kW
8. **Proton ratio**: >90%
LEBT solenoids with H+V steerers inside:
### Main parameters for CPHS RFQ

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species</td>
<td>Proton</td>
</tr>
<tr>
<td>Type</td>
<td>Four-vane</td>
</tr>
<tr>
<td>Frequency</td>
<td>325 MHz</td>
</tr>
<tr>
<td>Input beam energy</td>
<td>50 keV</td>
</tr>
<tr>
<td>Output beam energy</td>
<td>3.0 MeV</td>
</tr>
<tr>
<td>Peak current</td>
<td>50 mA</td>
</tr>
<tr>
<td>Emittance (norm. rms)</td>
<td>$0.2\pi$ mm·mrad</td>
</tr>
<tr>
<td>Maximum surface field</td>
<td>32 MV/m (1.8Ek)</td>
</tr>
<tr>
<td>Pulse length</td>
<td>0.5 ms</td>
</tr>
<tr>
<td>Pulse repetition rate</td>
<td>50 Hz</td>
</tr>
<tr>
<td>RF peak power</td>
<td>538 kW</td>
</tr>
<tr>
<td>Beam duty factor</td>
<td>2.5%</td>
</tr>
<tr>
<td>Section number</td>
<td>3</td>
</tr>
<tr>
<td>Total length</td>
<td>296.87 cm</td>
</tr>
</tbody>
</table>
Distribution of main parameters for tow design version
(left: constant V; right: vary V)
The length contrast for tow design version
IFMIF RFQ vary V design

RFQ的纵向长度 (cm)
The Twiss parameters for CPHS

<table>
<thead>
<tr>
<th></th>
<th>Const B</th>
<th>Low B</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>3.03</td>
<td>1.30</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.135</td>
<td>0.109</td>
</tr>
</tbody>
</table>

The Twiss parameters for IFMIF

<table>
<thead>
<tr>
<th></th>
<th>Const B</th>
<th>Low B</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>2.10</td>
<td>1.35</td>
</tr>
<tr>
<td>$\beta$</td>
<td>5.90 c</td>
<td>7.74</td>
</tr>
</tbody>
</table>
4. Field tuning

Quadrupole, Dipoles 1 and 2, Sequence number 46 (1)

Fields normalized to design average.

Quadrupole and dipole components after tuning
4. Field tuning

Frequency spectrum after tuning

Operating mode
## Design parameter DTL

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value 1</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF peak power</td>
<td>1.2</td>
<td>MW</td>
</tr>
<tr>
<td>RF duty factor</td>
<td>3</td>
<td>%</td>
</tr>
<tr>
<td>Synchronous phase</td>
<td>-30 to -24</td>
<td>degree</td>
</tr>
<tr>
<td>Accelerating field</td>
<td>2.2 to 3.8</td>
<td>MV/m</td>
</tr>
<tr>
<td>Focusing magnet type</td>
<td>PMQ</td>
<td></td>
</tr>
<tr>
<td>Lattice type</td>
<td>FD</td>
<td></td>
</tr>
<tr>
<td>Quad focusing gradient</td>
<td>8.34</td>
<td>kG/cm</td>
</tr>
<tr>
<td>Cell number</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Length</td>
<td>4.4</td>
<td>m</td>
</tr>
</tbody>
</table>
DT picture
Basic parameters

- Frequency: 325 MHz
- Klystron output power: 2.5 MW
- Repetition rate: 50 Hz
- RF pulse width: 0.7ms.
- RF amplitude error: ±1%
- RF phase error: ±1 deg.
RF power system

- RF power system consists of signal generator (325MHz), amplifier, klystron, pulsed high voltage power supply, modulator, crowbar, RF transportation subsystem, control and interlock subsystem.

Block diagram of RF power system
Design of RF transmission

Block diagram of RF power transmission subsystem
Target: beryllium
13MeV Be(p,n) reaction, 6.2e-3 n/p, ~3.3MeV
16kW heat deposition, water cooling
Moderator: solid methane
PT410 refrigerator +pure Al rod for cooling
Reflector: light water
Shielding: borated poly. + lead
TMR Assembly

Proton beam: 13MeV, 16KW, average I=1.25 mA, 50Hz, 500μs
Target: Be, D=63.5mm, t=1.2mm
Moderator: solid methane, 20K, 110*110*18 mm
Reflector: light water, 300K

SLAB geometry of the TMR assembly

Thank Mr. B.Zhong and Mr. Q.X. Feng for providing the design documents of TMR and the following MCNP simulations
CPHS project

- 13MeV/50mA, 0.5ms/50Hz
- Neutron target
- Neutron instrument
CPHS project
13MeV/50mA, 0.5ms/50Hz
Neutron target
Neutron instrument
Thank You