Plans for Proton/Ion Radiography at IMP, Lanzhou, China

Presented by
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Outline

- Brief Introduction to IMP, Lanzhou
- Plans for Heavy Ion or Proton Radiograph
- Summary and Acknowledgement
Introduction of IMP, Lanzhou
The Institute of Modern Physics (IMP) was founded in 1957 in Lanzhou.

The National Laboratory of Heavy Ion Research Facility in Lanzhou (HIRFL) - 1991, it focus on:

- basic research in heavy ion physics and its related interdisciplinary science
- the accelerator physics and technology
- the applications of nuclear technology
Introduction of IMP, Lanzhou

~570 staffs, ~150 senior scientists and senior engineers, including two academicians of CAS

~200 students, working at IMP,..

The budget per year is about 200M C¥, among it

- Chinese Academy of Sciences: ~100M C¥
- Ministry of Science and Technology: ~18M C¥
- NDRC and Ministry of Finance: ~60M C¥
- National Natural Science Foundation: ~20M C¥
- Local government: ~2M C¥
Introduction of IMP, Lanzhou

1960s
K=69
C: 10MeV/u

1980s
K=450
C: 100MeV/u

2008-
12.1 Tm
1.1 AGeV\((^{12}\text{C}^{6+})\)
520 AMeV \(U^{72+}\)
2.8 GeV(p)

9.4 Tm
760 AMeV \(^{12}\text{C}^{6+}\)
500 AMeV \(U^{92+}\)
### Superconductor ECR Ion Source at Lanzhou

<table>
<thead>
<tr>
<th>f (GHz)</th>
<th>SECRAL 18</th>
<th>VENUS 28 or 28+18</th>
<th>GTS 18</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{16}\text{O}$</td>
<td>6(^+)</td>
<td>2300</td>
<td><strong>2400</strong></td>
</tr>
<tr>
<td></td>
<td>7(^+)</td>
<td><strong>810</strong></td>
<td>600</td>
</tr>
<tr>
<td>$^{40}\text{Ar}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11(^+)</td>
<td>810</td>
<td></td>
<td>510</td>
</tr>
<tr>
<td>12(^+)</td>
<td>510</td>
<td><strong>860</strong></td>
<td>380</td>
</tr>
<tr>
<td>14(^+)</td>
<td>270</td>
<td><strong>514</strong></td>
<td>174</td>
</tr>
<tr>
<td>16(^+)</td>
<td>73</td>
<td><strong>133</strong></td>
<td>50</td>
</tr>
<tr>
<td>17(^+)</td>
<td>8.5</td>
<td><strong>14</strong></td>
<td>4.2</td>
</tr>
<tr>
<td>$^{129(136)}\text{Xe}$</td>
<td>20(^+)</td>
<td><strong>505</strong></td>
<td>320</td>
</tr>
<tr>
<td>26(^+)</td>
<td>410</td>
<td>290</td>
<td>228</td>
</tr>
<tr>
<td>27(^+)</td>
<td>306</td>
<td>270</td>
<td>168</td>
</tr>
<tr>
<td>28(^+)</td>
<td><strong>260</strong></td>
<td>222</td>
<td>120</td>
</tr>
<tr>
<td>30(^+)</td>
<td>101</td>
<td><strong>116</strong></td>
<td>60</td>
</tr>
<tr>
<td>31(^+)</td>
<td>68</td>
<td>67</td>
<td>40</td>
</tr>
<tr>
<td>33(^+)</td>
<td>31</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>34(^+)</td>
<td>21</td>
<td>15</td>
<td>8</td>
</tr>
<tr>
<td>35(^+)</td>
<td>12</td>
<td></td>
<td>5.4</td>
</tr>
<tr>
<td>36(^+)</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>37(^+)</td>
<td>5</td>
<td></td>
<td>2.3</td>
</tr>
</tbody>
</table>
5 terminals including
• 2×Atomic, Molecular and Cluster
• 1.5×Irradiative material
• 0.5×nuclear astrophysics
• 1×irradiative biology

320KV/Q HV ECRIS Platform in Building 6
HIRFL-SFC (K=69)
HIRFL-SSC (K=450)
HIRFL-RIBLL

RIBLL Main Performances

<table>
<thead>
<tr>
<th></th>
<th>RIBLL</th>
<th>RIPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta \Omega$ (msr)</td>
<td>$&gt;7 \text{msr}$</td>
<td>$\sim 5 \text{msr}$</td>
</tr>
<tr>
<td>$\Delta P$</td>
<td>$10%$</td>
<td>$6%$</td>
</tr>
<tr>
<td>$\Delta B_\rho/B_\rho$</td>
<td>$6 \times 10^{-4}$</td>
<td>$\sim 10^{-3}$</td>
</tr>
<tr>
<td>$A/\Delta A$</td>
<td>$&gt;400$</td>
<td>$&gt;150$</td>
</tr>
</tbody>
</table>

Nuclear Reaction investigation and RIB Physics was done here. synthesis about 25 new isotopes till now; Nuclear structure, SHE investigation…
Clinic Treatments (103+6 trials)

- Before treatment
- 20 days after
- 5 months after
Cooling Storage Ring with 300kV Cooler

CSRm & CSRe

300kV E-Cooler
Slow extraction for $^{12}$C$^{4+} - 300$MeV/u in CSRm

From Scintillation Crystal

2008.05.21 03:31
Mass Measurement of RIBs in Isochronous Mode: $\gamma = \gamma_{tr} = 1.395$

$$\frac{df_{rev}}{f_{rev}} = \left( \frac{1}{\gamma^2} - \frac{1}{\gamma_{t}^2} \right) \frac{dP}{P} - \frac{1}{\gamma_{t}^2} \frac{d(m/q)}{m/q}$$

$\Delta M/M \approx 10^{-5}$
Cancer Therapy at CSR (>10 trails)
CSR Experimental platform

- SSC
- SFC
- CSRe
- CSRm

External Target

Internal Target

Mass Measurement

Hadron Physics

C. Therapy

HED Physics

P/I Radiography
Main Physics Goals at CSR

- Nuclear Structure (RIB)
- Phase of Nuclear Matter
- Hadrons-Nucleon Physics in $E < 1.1 \text{AGeV} \text{ HI}$ & $< 2.88 \text{GeV} (3.65 \text{GeV/c})$ Proton
- High Charge State of Atomic Physics
- High Energy Density Physics
- Astrophysics (Key Point)
- Applications: Irradiative Material, Biology
Upgrading of the injection of CSR by building a LINAC and a P. line

LINAC: A Linear Accelerator is under constructing in order to get more intense heavy ion beams.

For 2.8GeV proton beam (Hadron Phys.) & For Intense Heavy Ion Beams (HED)
Other projects

GSI-FAIR @ Darmstadt

Proved proj. 2010-14 (840MRMB)

p~Xe ions, C(430MeV/u)
Focused on:
- Cancer therapy
- Space industries
- Material sciences
- Mutation breeding
- Proton/Ion radiography

Prof. Dr. Rudolf Bock @Lanzhou
International Collaboration

➤ Germany: GSI-FAIR, HEDgeHOB, SPARC…
     Julich-COSY ...

➤ Russian: ITEP…

➤ US: RHIC-STAR, RIA, HIFVNL…

➤ Japan: RIKEN-RIBF…

➤ France: GANIL, SPIRAL-II…

➤ ……
Outline

- Brief Introduction to IMP, Lanzhou
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Plans for Proton or Ion Radiograph @IMP

- 2008- started designing and two series quadrupoles were constructed;
- The goal is to Investigate HEDM
- Dr. LIU, Yong is responsible

Dr. LIU, Yong
y.liu@impcas.ac.cn
Proton or Ion Radiography (PIRG) at Lanzhou

Totally 25m in length; first try putting Image Plane just behind the Object.
Ion-beam optics

Main parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>particle/energy (GeV/u)</td>
<td>p(0.8<del>2.2), C(0.4</del>0.83)</td>
</tr>
<tr>
<td>Max. irrad. diameter (mm)</td>
<td>100</td>
</tr>
<tr>
<td>Intensity (proton)</td>
<td>$1 \times 10^{10}$~$1 \times 10^{11}$</td>
</tr>
<tr>
<td>Particle/pixel</td>
<td>$10^4$</td>
</tr>
<tr>
<td>pixel/frame</td>
<td>$10^6$~$7$</td>
</tr>
<tr>
<td>Q surface field (T)</td>
<td>1.2</td>
</tr>
<tr>
<td>Q bore radius (mm)</td>
<td>60</td>
</tr>
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</table>

Budget

<table>
<thead>
<tr>
<th>Project</th>
<th>Budget (M¥)</th>
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<tr>
<td>Beam line upgrade</td>
<td>3</td>
</tr>
<tr>
<td>Plasma target and diag.</td>
<td>3</td>
</tr>
<tr>
<td>Ion-beam optics</td>
<td>12</td>
</tr>
<tr>
<td>Optics and detector</td>
<td>4</td>
</tr>
<tr>
<td>Graphic procession</td>
<td>1</td>
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<tr>
<td>summation</td>
<td>23</td>
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</table>
Summary and Acknowledgement

- Heavy Ion Research Facility at Lanzhou (HIRFL) has accelerators, which is suitable for PRIOR.
- We are just starting this field, guidance and cooperation are warmly welcomed!
Welcome you to Lanzhou!
Thanks to the organizers!
Thanks for your attention!