S364 Experiment:
$\Delta - \text{Resonance in Isobaric Charge-Exchange reactions}$

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May 19, 2011
The Analysis that the isobar charge-exchange reactions provide a useful tool to study the matter distribution at the periphery of the nucleus. This kind of reactions are sensitive to the neutron and proton distributions in a nucleus.
The Isobaric Charge-exchange reactions are possible in a very peripheral collisions where only one interaction nucleon-nucleon are possible. In this case for the $^{124}\text{Sn}$ projectile with $^{124}\text{Sb}$ and $^{124}\text{In}$ yields

1. $\text{n} \longrightarrow \text{p}$
2. $\text{p} \longrightarrow \text{n}$
Charge-exchange reactions

In this nuclear reaction the projectile changes its charge in one unit.

Charge exchange reactions are possible in two channels:
Charge-exchange reactions

In this nuclear reaction the projectile change its charge in one unit.

Charge exchange reaction are posible in two channels:

1. Quasilastic Channel
In this nuclear reaction the projectile change its charge in one unit.

Charge exchange reaction are posible in two channels:

1. **Quasilastic Channel**
2. **Inelastic Channel:** $\Delta$ resonace formation.
Motivation

1. Nuclear medium properties of $\Delta^-$ resonance

Figure: Gardee C, Annu. Rev. Nucl. Part. Sci. 1991.41:187-218
Motivation

Using relativistic exotic projectiles

1. Nuclear medium properties of $\Delta -$ resonance
Motivation

Using relativistic exotic projectiles

1. Nuclear medium properties of $\Delta -$ resonance
2. Energy dependence.
Using relativistic exotic projectiles

1. Nuclear medium properties of $\Delta$ resonance
2. Energy dependence.
3. Density dependence, skin nuclei
Motivation

Using relativistic exotic projectiles

1. Nuclear medium properties of Δ resonance
2. Energy dependence.
3. Density dependence, skin nuclei
4. Sensitivity to neutron and proton distributions with peripheral collisions.
The FRS (FRagment Separator) is a high-resolution magnetic spectrometer, identifies all projectile residues that come of the reaction with the target. The identification is based in the behavior of charged particles moving in the presence of a magnetic field.
Figure: s364 Experimental Setup

\[
\frac{\Delta B_\rho}{B_\rho} \approx 2 \times 10^{-4}; \quad \frac{\Delta Z}{Z} \approx 7 \times 10^{-3}; \quad \frac{\Delta A}{A} \approx 2.4 \times 10^{-3}
\]
Direct Beams: $^{124}Sn$, $^{112}Sn$

1. Reaction $S0$
2. Stable Beams
Direct Beams: $^{124}\text{Sn}$, $^{112}\text{Sn}$

1. Reaction $S0$
2. Stable Beams

Secondary Targets: $^{118}\text{Sn}$, $^{109}\text{Sn}$

1. Reaction $S2$
2. Unstable Beams
3. $^{124}\text{Sn} \rightarrow ^{118}\text{Sn}$
4. $^{112}\text{Sn} \rightarrow ^{109}\text{Sn}$
Beam request: $S0$ reaction

**Target Dependence:**
1. Direct Beam: $^{124}Sn$
2. Energy $1000\, MeV/u$
3. Targets: $C, CH_2, Cu, Sn, Ta, Pb$
4. Rate Limit: 100KHz at MUSIC1
5. Secondary target: OUT

**Energy Dependence:**
1. Direct Beams: $^{124}Sn$
2. Energy ($MeV/u$): 400, 600, 800, 1000
3. Target $C$

**Figure:** Red line: Total Cross Section for N-N, Blue: Elastic, Green: Inelastic
Secondary Beams: $^{118}\text{Sn}$, $^{109}\text{Sn}$

Production Target S2 reaction

* Secondary Targets: $\text{CH}_2$, C, $2\text{g/cm}^2$

Rate Limit: $3.7 \times 10^5 \text{proj/s}$ at SCI1

Removing the C contribution of $\text{CH}_2$, we can obtain proton ($H$) information

<table>
<thead>
<tr>
<th>Beam</th>
<th>$\sigma (mb)$</th>
<th>$\text{proj/s}$</th>
<th>$\text{prod/s}$</th>
<th>$S_4$</th>
<th>$\sigma (mb)$</th>
<th>$\text{prod/h}$</th>
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</thead>
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<tr>
<td>$^{124}\text{Sn}$</td>
<td>19</td>
<td>$2.3 \times 10^8$</td>
<td>$2.96 \times 10^5$</td>
<td>$^{118}\text{Sb}$</td>
<td>0.5</td>
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<td>$^{118}\text{Sn}$</td>
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<td></td>
<td>$^{118}\text{I}$</td>
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<tr>
<td>$^{112}\text{Sn}$</td>
<td>5.6</td>
<td>$8 \times 10^8$</td>
<td>$2.98 \times 10^5$</td>
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<tr>
<td></td>
<td>$^{109}\text{Sn}$</td>
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<td>$^{109}\text{I}$</td>
<td>0.01</td>
<td>1107</td>
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</table>

http://www.usc.es/genp/s364.html
**Beam time request:** Date: 20-25 June, 2011

<table>
<thead>
<tr>
<th>Beam</th>
<th>Measure</th>
<th>Beam time</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{124}$Sn</td>
<td>FRS Calibrations</td>
<td>1 day</td>
</tr>
<tr>
<td>$^{124}$Sn → empty</td>
<td></td>
<td>2h</td>
</tr>
<tr>
<td>$^{124}$Sn → $C \rightarrow ^{124}Sb$ → $^{124}I$</td>
<td></td>
<td>2h</td>
</tr>
<tr>
<td>$^{124}$Sn → $C, CH_2, Cu, Sn, Ta, Pb$</td>
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<td>8h</td>
</tr>
<tr>
<td>$^{124}$Sn → 400, 600, 800 MeV</td>
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<td>6h</td>
</tr>
<tr>
<td>$^{118}$Sn → empty</td>
<td></td>
<td>2h</td>
</tr>
<tr>
<td>$^{118}$Sn → $C \rightarrow ^{118}Sb$ → $^{118}I$</td>
<td></td>
<td>6h</td>
</tr>
<tr>
<td>$^{118}$Sn → $CH_2 \rightarrow ^{118}Sb$ → $^{118}I$</td>
<td></td>
<td>6h</td>
</tr>
<tr>
<td>$^{112}$Sn</td>
<td>FRS Calibrations</td>
<td>1 day</td>
</tr>
<tr>
<td>$^{112}$Sn → empty</td>
<td></td>
<td>2h</td>
</tr>
<tr>
<td>$^{112}$Sn → $C \rightarrow ^{112}Sb$ → $^{112}I$</td>
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<td>2h</td>
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<tr>
<td>$^{109}$Sn → empty</td>
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<td>2h</td>
</tr>
<tr>
<td>$^{109}$Sn → $C \rightarrow ^{109}Sb$ → $^{109}I$</td>
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<td>6h</td>
</tr>
<tr>
<td>$^{109}$Sn → $CH_2 \rightarrow ^{109}Sb$ → $^{109}I$</td>
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B. Ramstein European Physical Journal A 16 (2003) 583-597, see pg 1


