MARS: Momentum Achromat Recoil Spectrometer

Part 2

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Cyclotron Institute
Momentum Achromat Recoil Spectrometer
Space, momentum, and energy distributions for the beam after passing through Q1-Q2 and D1.
Slits #2 Coffin-Moment

$^{27}\text{Al} \ (30.0 \text{ MeV/u}) + \text{H}_2 \ (100,000 \mu\text{m})$; Settings on $^{28}\text{Si}$; Config: MMDSDMNCSCMM

dp/p=3.85% ; Brho(Tm): 1.3637, 1.3637

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Space, momentum, and energy distributions for the beam after passing through Q3 and D2.
Momentum Achromat Recoil Spectrometer
Wien Filter-Y space

$^{27}\text{Al}$ (30.0 MeV/nu) + H2 (100000 μm); Settings on $^{28}\text{Si}$; Config: MMDSMDNC-SMM

$dp/d\nu=3.85\%$; Brho(Tm): 1.3637, 1.3637
D3-Yspace

$^{27}$Al (30.0 MeV/u) + H2 (100000 μm), Settings on $^{27}$Si, Config. MMDSMCNCSMM

$dp/\gamma = 3.85\%$, $B_{Ho}(Tm) = 1.3387, 1.3837$
dE-raw

\[ dE-Y\_TargDet \]

\[ dE \] [ch]

-300 -200 -100 0 100 200 300

-300 -200 -100 0 100 200 300

Y position [0.1 mm]

\[ dE \] [ch]

3500 3000 2500 2000 1500 1000 500

3500 3000 2500 2000 1500 1000 500

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Okaaay…so now what?
Example –RUN1107: β-delayed p-decay of $^{31}\text{Cl}$

- Primary beam $^{32}\text{S} @ 40\text{A MeV} - \text{K500 Cyclotron}$
- Primary target LN$_2$ cooled H$_2$ gas $p=2$ atm
- Secondary beam $^{31}\text{Cl} @ 34\text{A MeV}$

- Purity: > 85 % (at target det)
- Intensity: ~ 2-3000 pps
- Difficult - pure & intense 31Cl
MARS Settings – Marsinator II

Primary beam settings

Secondary beam settings
Production and separation of $^{31}$Cl

- Check beam from cyclotron on viewer - centered
- Set MARS for primary beam – used values found with Marsinator
- Close coffin slits and adjust $D_{12}$ to find and center the beam – found at $D_{12}=765.7$A
  ($D_{12\text{-calc}}=785.7$A)
- Set MARS for secondary beam – used values found with Marsinator
- Find FC position in coffin for maximum primary beam intensity – found at 190cm
Position calibration for target detector

Method 1 – use 5-finger mask

Method 2 – close S4 slits to 0.1mm in between at y = 0 and ±6mm

Used Method 2
- D₃ set
- D₃=1
- S4 –

**TargDet_dEvsY**

| TargDet_dEvsY | Entries 58163 | Mean x -52.97 | Mean y 1089 | RMS x 70.38 | RMS y 239.8 |

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- Close S4 as much as possible – T/B=2.5/0.411cm – M/q selection
- D_{12} scan – maximize 31Cl production and try to center – found D_{12}=665.9A
- Q_4-Q_5 scan – improve focusing (x and y) – Q_4=-64A and Q_5=90A
- Another D_3 scan to
- Closed S4 B to 0.2

^{31}Cl production rate
8.3ev/nC ~ 3600 pps
Impurities ~ 20%
Implantation of $^{31}$Cl - steps

- Exact same setup
- Drop target detector
- Start rotating the degrader
- $^{31}$Cl ions should disappear from p-det for $\varphi_{p, \text{calc}} = 39.3^\circ$
- $^{31}$Cl ions should disappear from $\beta$-det for $\varphi_{b, \text{calc}} = 28.3^\circ$
- $\varphi_{\text{middle, calc}} = 35^\circ$
- Rotated degrader from $0^\circ$ to $44^\circ$
- Found $\varphi_b = 34^\circ$, $\varphi_{p, \text{calc}} = 44^\circ$, and $\varphi_{\text{middle}} = 39.6^\circ$
31Cl β-delayed p-decay

- Raw
  - Counts
  - Energy (keV)

- a) SE = Single Escape, DE = Double Escape
Primary beam $^{20}\text{Ne} @ 25\text{A MeV}$ – K500 Cyclotron
Primary target LN$_2$ cooled H$_2$ gas p=2 atm
Secondary beam $^{20}\text{Na} @ 22\text{ A MeV}$

Purity: $>？!\%$ (at target det)
Intensity: $\sim？!\text{ pps}$ difficult - $？!$

$(p,2n)$ reaction
MARS Settings – Marsinator II

Primary beam

Secondary beam
Production and separation of $^{20}$Na - steps

- Check beam from cyclotron on viewer – make sure it’s centered, if not adjust BLD1
- Set MARS for primary beam – use values found with Marsinator
- Close coffin slits and adjust $D_{12}$ to find and center the beam – start at $D_{12-calc} = 586.1A$
- Set MARS for secondary beam – use values found with Marsinator
- Find FC position in coffin for maximum primary beam intensity
- Position calibration for target detector
- D₃ scan – identify ions and set for ²⁰Na – start from D₃ calc = 135.6Å
- S4 – fully open – Particle Identification
- Close S4 as much as possible – M/q selection
- D₁₂ scan – maximize ²⁰Na production and try to center – start from D₁₂ calc = 510.4Å
- Q₄-Q₅ scan – improve focusing (x and y) – Q₄ calc = -50.3Å and Q₅ calc = 73.9Å
- Another D₃ scan to bring ²⁰Na closer to y=0 if needed
- Close slits more if there are impurities that can still be filtered
- Measure production rate and purity of the beam
Implantation of $^{20}$Na - steps

- Drop target detector
- Start rotating the degrader
- Expect something like…

**Graphical Representation**

- Plot showing $\Delta E$ vs. $E(\beta)$
- Energy degrader (rotating, motorized)
- 18” dia chamber
- Strips W1-65 µm at 1 mm
- % effic

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Expected …

- $^{20}$Na ($T_{1/2}=448$ ms) is a known $\beta$-delayed $\alpha$–emitter: 2.148, 3.801 and 4.894 MeV
- Implanted in $\beta$-det would give an instructive $\alpha+\beta$ spectrum (as in top fig, from Run0507)
- Implanted in the thin p-det, would show better resolution for $\alpha$ peaks (less $\beta$ energy loss), like in lower figure
- Is $\beta\gamma$ emitter too: we will have a gamma-ray spectrum measured with Ge detector