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Low Energy FFAGs for Isotope Production

David Bruton, Roger Barlow, Rob Edgecock, Carol Johnstone, Adina Toader, Basil Gonsalves
- Radioisotopes
- The Design
- Simulations using in house code
- Simulations in OPAL
- Target Studies
Medical Isotope Production Options

- Reactors
  Stop
  - NRU, Canada (40% of Tc)  2016
  - HFR, Netherlands (30% of Tc)  2022

- Accelerators
  - Current production small scale
  - 10-100MeV
  - High Beam Currents
The machine

- 4 Separate Sector Magnets
- Radially varying field
- Edge Fields provide Focusing
Radial Field variation
Edge Profile

- Field drop off at edge varies with radius
- Provides focusing/defocusing effects
**PIP (Proton Isotope Producer)**

4 Possible versions:

- **4 MeV** - Neutron production for security applications
- **10 MeV** - For production of \(^{18}\text{F}, ^{11}\text{C}, ^{113}\text{mIn}, ^{87}\text{mSr and } ^{121}\text{I}}\)
- **14 MeV** - For production of \(^{99}\text{mTc}}\)
- **28 MeV** - For production of \(^{211}\text{At}}\)
**Tune and Time of Flight**

- Vertical Tune passes though an integer resonance
- Machine is Isochronous to within 1%
PIP(14 and 4) using internal code
Beta Function

Twiss Parameters

Vertical

Horizontal
Acceptance

- Acceptance Very large
- Important for recirculation
Studies with OPAL
Accelerating Alphas

Requires a frequency of 3.765 - 3.795 MHz
1.35 - 2.15 % higher than half the proton RF

RF Frequency of 3.715 (Half the proton RF)
Requires scaling the fields to 98.25%
Emittance
Target: Internal or External

- External

- Internal

Can interact

Can't interact – energy too low

Can interact
Molybdenum Target

Energy Dependence of $^{100}\text{Mo}(p,2n)^{99}\text{Tc}$ Cross Section

- Cross section (mb) vs. Proton Energy (MeV)
- Data from Tackacs et al. 2002 and Talys

Graph showing the energy dependence of the cross section for the $^{100}\text{Mo}(p,2n)^{99}\text{Tc}$ reaction.
Target Thickness

Attenuation of 19MeV Proton Beam through a Mo$^{100}$ Target

Yields for 2mA beams for 1hr
Further work

- Tracking Studies: Investigate integer tune crossing, Include real field map, continue studies with new iterations of field map.

- Magnet studies: Design feasibility, Central region and injection

- Target Studies and Extraction: Internal/External, Charge Exchange/electrostatic deflector