Nuclear Excitation Functions for Isotope Production: Targeted Radionuclide Therapy via $^{nat}Ir(d,2n)^{193m}Pt$

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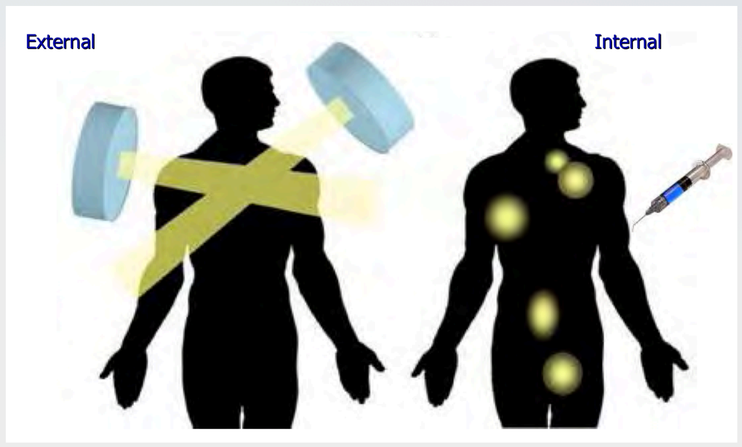
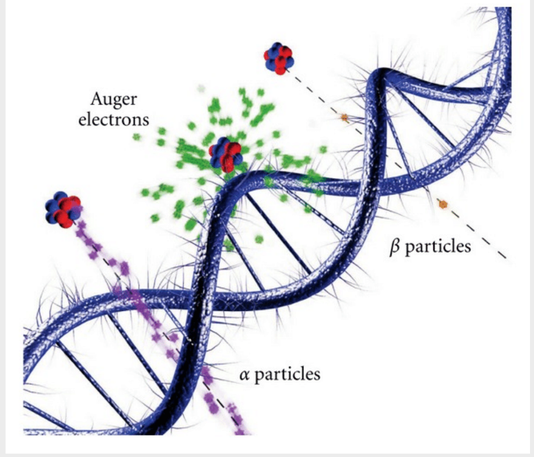
Motivation



[1]

- Targeted radionuclide therapy is an emerging alternative to external beam radiotherapy, sparing healthy tissue from exposure to radiation through the delivery of short-range dose.
- Platinum radionuclides have potential in therapeutic radiopharmaceutical applications.
- The auger electron emitter ^{193m}Pt ($t_{1/2}$ = 4.33 days [2]) is well-suited for treating small metastases & tumors due to high local energy deposition.
- ^{193m}Pt emits approximately 25 high-LET Auger, conversion and Coster-Kronig electrons per decay [3], with energies in the range 0.9-7 keV, with range smaller than the cellular nucleus itself [4].
- When incorporated into DNA, these will induce multiple double-strand breaks and lead to cell death.



[5]

- This experiment is part of a larger campaign to expand cross section libraries with the U.S. Nuclear Data Program.
- Along with production of medically valuable radionuclides, it also prodvides unique opportunities to gain information about level density in highly-excited nuclear states, through independent measurements of isomer to-groundstate branching ratios, such as ^{193m}Pt ($J^{\pi}=13/2^{+}$) to ^{193}Pt ($J^{\pi}=1/2^{-}$)[2].

Method

- A stack of ten iridium target foils, and ten nickel, ten cupper and three iron monitor foils (all 25μm thickness) were irradiated with a 33 MeV deuteron beam at 128 nA for 60 minutes.
- This is a method to measure production cross sections at multiple energies using one single incident beam [6].
- The activities in the different foils were counted using a pre-calibrated Ortec GMX HPGe detector for 4 weeks.
- Through an exponential decay curve fit, end of beam activities A_0 were estimated for every product produced.

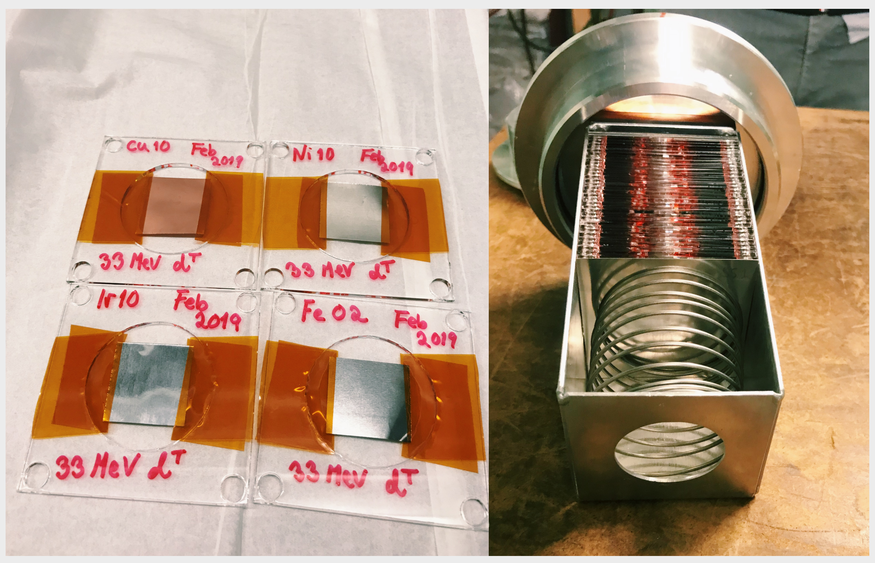


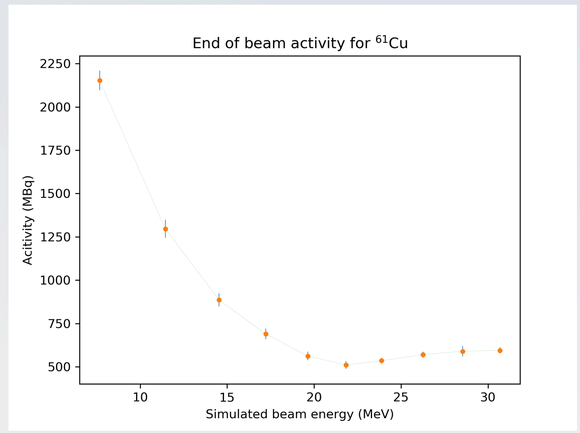
Figure 3
Left: Characterized foils were mounted on a plastic frame with Kapton tape on edges to prevent beam degradation in tape.
Right: Targets were stacked in target holder.

- Activation analysis involves quantifying beam current φ through well-known cross sections [8] of the monitor foils, to measure the cross sections for the produced products through the following equation

$$\sigma = A_0 / N_T \varphi (1-e^{-\lambda \Delta t(irr)})$$

where N_T is number of nuclei/cm^2 in the target, λ is the decay constant for a particular nucleus and Δt_{irr} is irradiation time.

Preliminary results



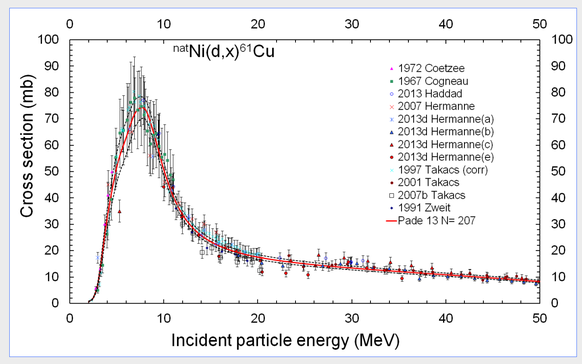
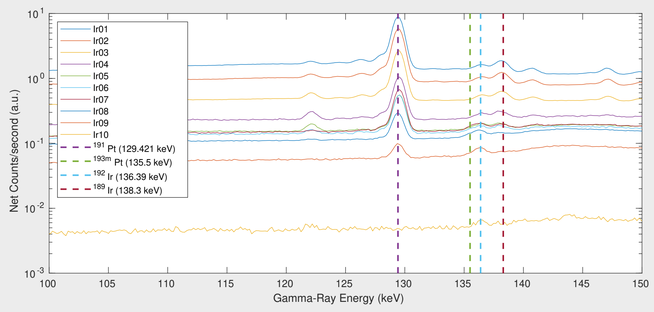


Figure 6
Top: End of beam activity plotted against beam energy for ^{61}Cu (nickel-monitor reaction), $t_{1/2}$=3.33 hours [7].
Bottom: Excitation function for ^{61}Cu [8].



- Based on X-rays and decay gamma (I_{γ}=0.11%), preliminary analysis suggest that the cross section is highest for deuterons at approximately 13-18 MeV.

Future work

- Perform a thick target irradiation with optimum energy window using cross section data provided by this experiment.
- This will provide mCi-scale activity to facilitate a measurement of ^{193m}Pt auger spectrum, and to develop labeling chemistry in collaboration with Rutgers University.

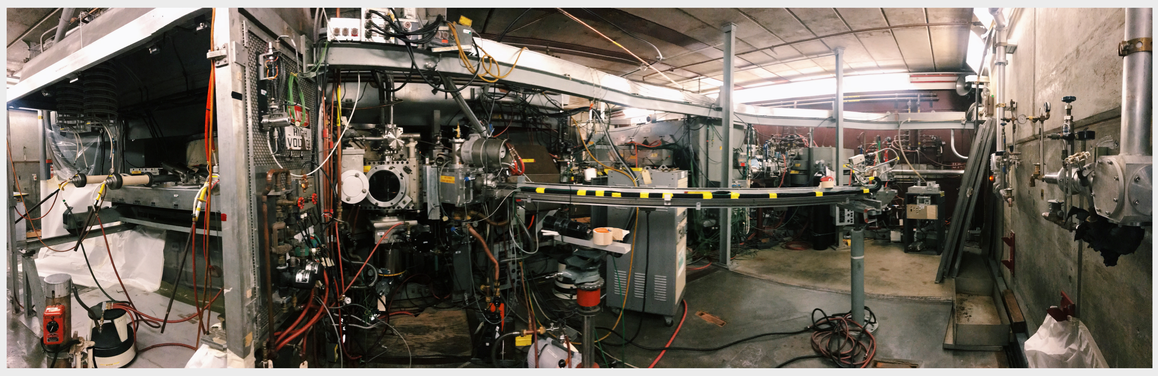


Figure 4
Lawrence Berkeley's 88-Inch Cyclotron

References

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