

Production of PET isotope Lanthanum-133 at McMaster University Cyclotron Facility



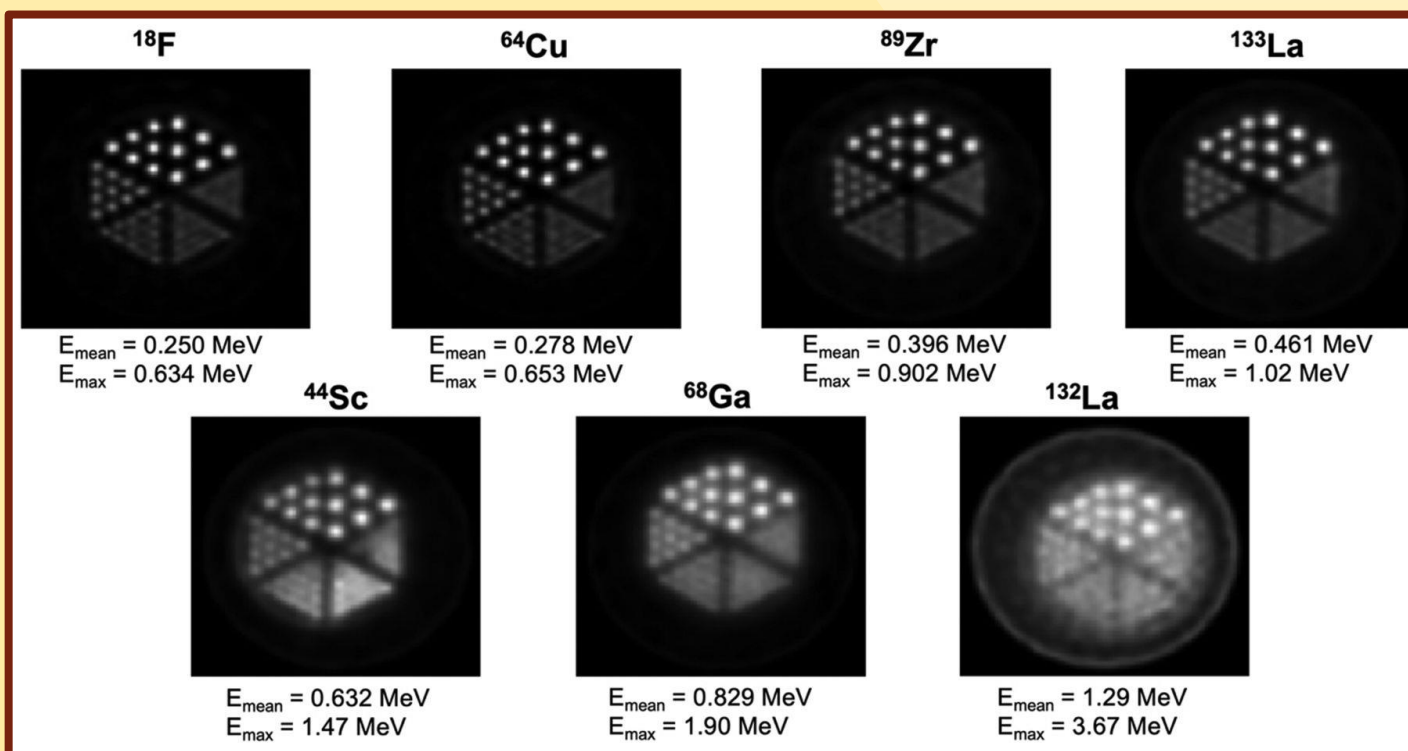
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INTRODUCTION & PURPOSE

- **Targeted isotope:** Lanthanum-133.
- Low-energy positron-emitting isotope with high intensity and low emission of high-energy gamma, making it simpler to handle with reduced patient dose.⁽¹⁾⁽²⁾
- Possesses these required qualities for obtaining high resolution and low noise positron emission tomography (PET) images.⁽²⁾
- Chosen as a potential alternative to ²²⁵Ac, since La chemically mimics Ac in non-radioactive environments, thereby suggesting it as an ideal counterpart for theragnostic purposes.⁽¹⁾⁽²⁾
- Additionally, serves as an alternative to ¹³²La and ⁶⁸Ga, with lower positron energies than both and longer half-life than ⁶⁸Ga.⁽²⁾⁽³⁾



Derenzo phantom images reconstructed with maximum a posteriori estimation for different PET radionuclides, presented in order of increasing positron emission energy.⁽³⁾

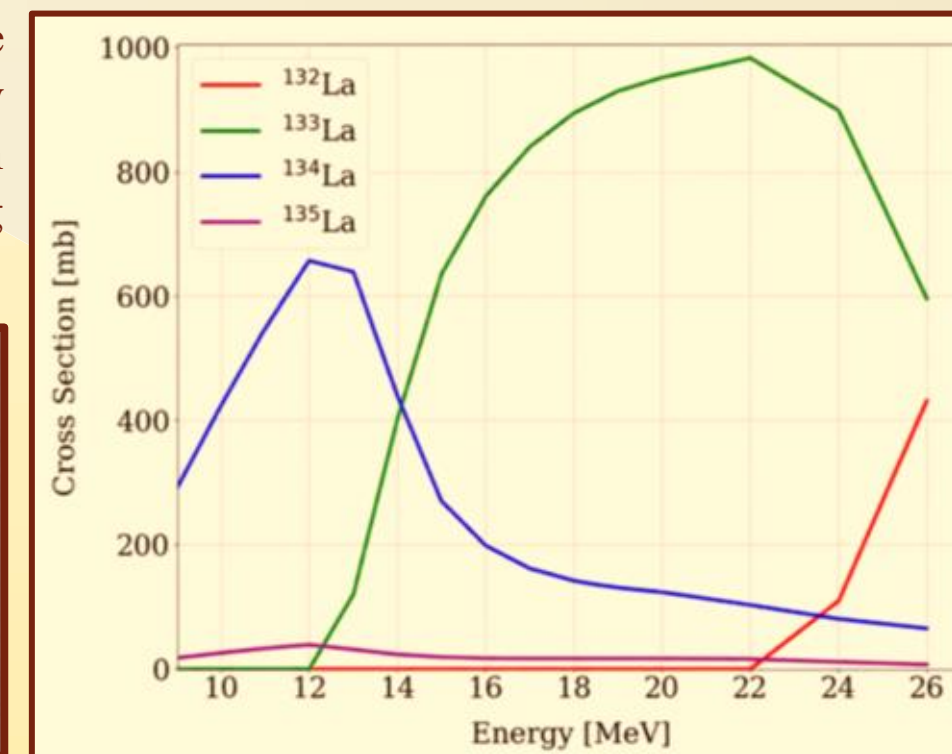
MATERIALS & METHODS

- **Target Material:** BaCO₃ pressed into a silver backing disc and covered with a 100 μm aluminum foil.
- **Target:** Disc and cover foil was assembled into a shuttle and loaded in the solid target station.
- **Irradiation:** By the ¹³⁴Ba(p,2n)¹³³La reaction on 16.5 MeV GE PETtrace cyclotron with the proton energy degraded to 14.2 MeV.

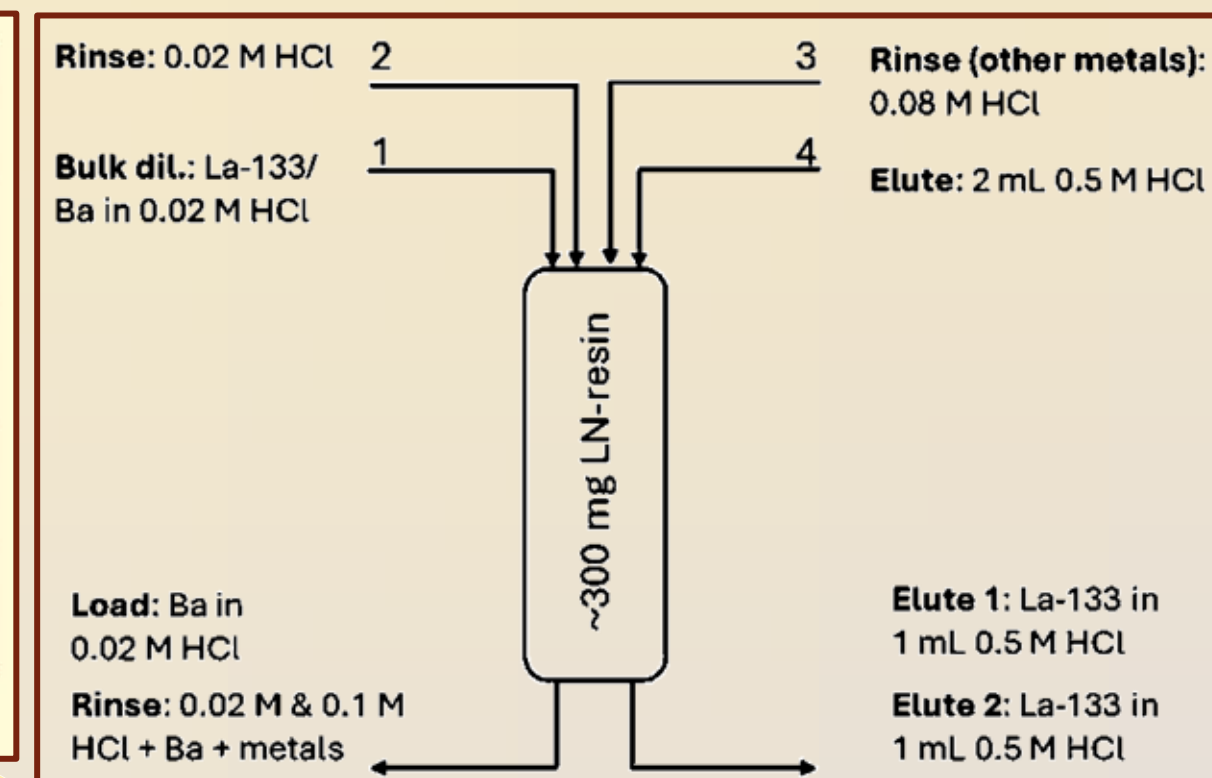


MATERIALS & METHODS

- **Post-irradiation:** Target material dissolved in 3 mL 0.5 M HCl, diluted to a final HCl concentration of 0.02-0.04 M, and trapped on an LN resin.
- **Separation & Elution:** Trapped La is rinsed with 10 mL 0.02 M HCl then with 3 mL 0.1-0.08 M HCl and eluted with two 1 mL 0.5 M HCl.
- **Counting:** Radioisotope identification and quantification were performed by gamma spectroscopy using an HPGe detector.
- **Radiolabeling:** DOTA labelling was performed by adding 0.025 nmol/μL DOTA chelator to sodium acetate buffer (pH 6) and mixed with ¹³³La, corresponding to a molar activity of 0.4–11.0 MBq/nmol, and analyzed by instant thin-layer chromatography (iTLC).
- **ICP:** Trace metal analysis were performed by using inductively coupled plasma optical emission spectroscopy (ICP-OES), testing for Ba, La, Zn, Ag Fe, and Ni.



Theoretical cross sections of relevant nuclear reactions using TENDL-2019.⁽²⁾



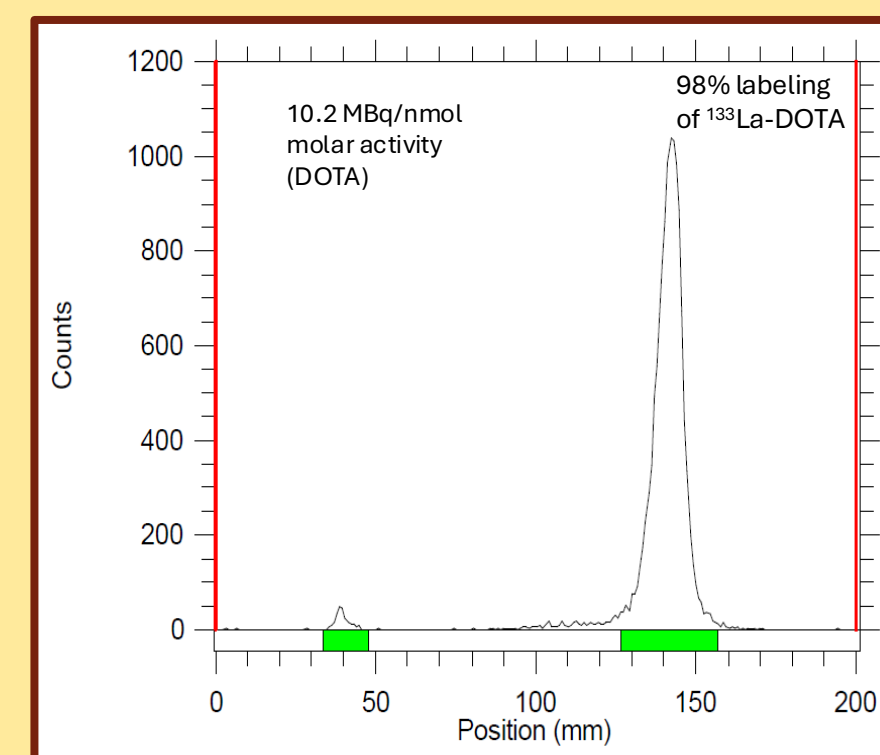
RESULTS

- September 2025 onwards, the ¹³³La production was evaluated using 85% ¹³⁴Ba-enriched BaCO₃.
- Radiolabeling and trace metal analysis were only performed on enriched target material irradiation.

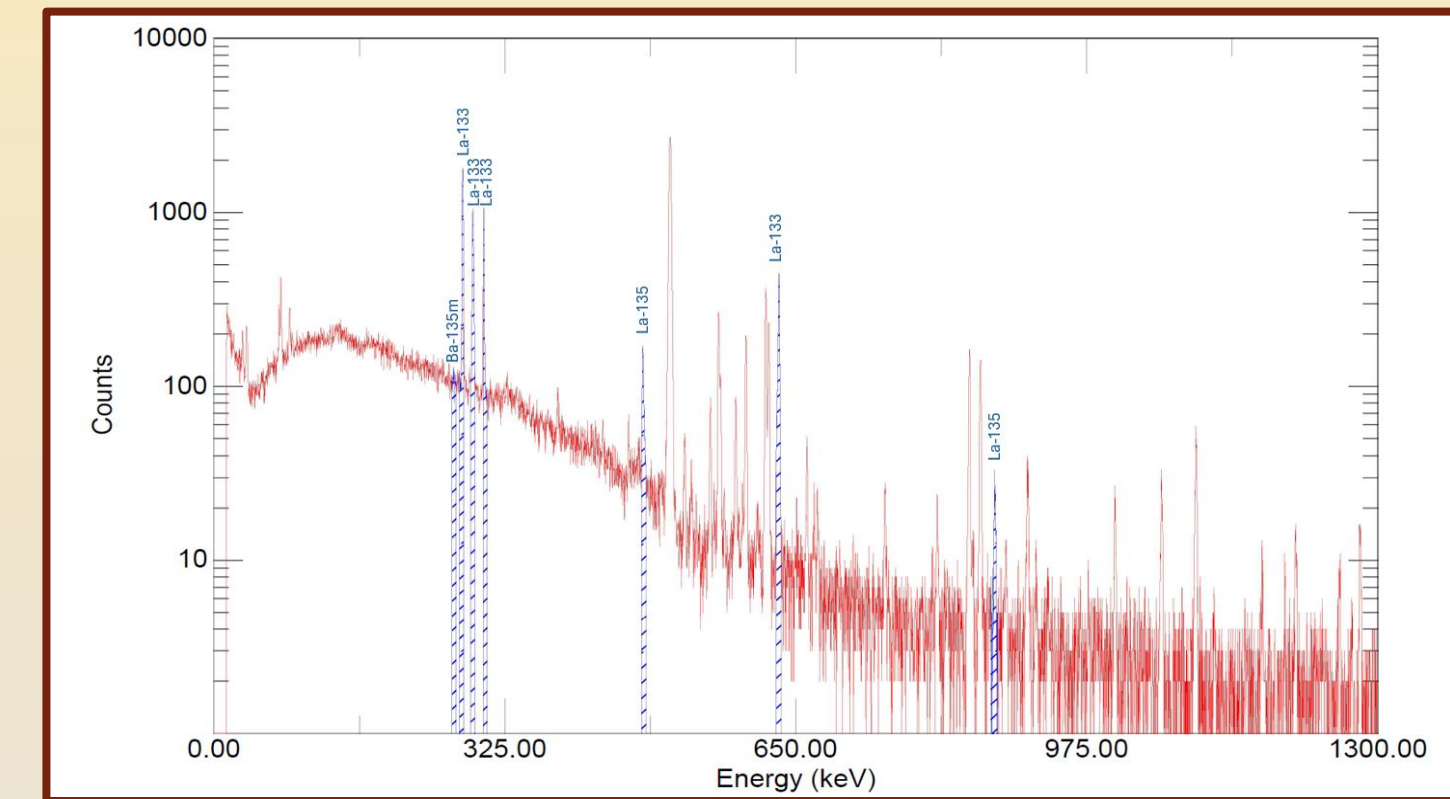
Production ID	Irradiation Current (μA)	Irradiation Time (mins)	BaCO ₃ (mg)	¹³³ La EOB (MBq)	Other ¹³³ La* EOB (MBq)	%-recovery of ¹³³ La in Elute 1 & Elute 2	¹³³ La EOP (MBq/mL)	¹³³ La conc. at QC (MBq/mL)	Molar activity ICP metals** (MBq/nmol)	Apparent Molar activity DOTA*** (MBq/nmol)
20250602	10	60	73 (^{nat} Ba)	1.9	17					
20250722	15	60	78 (^{nat} Ba)	7.4	42					
20250903	10	90	85 (^{nat} Ba)	5.4	38					
20250919	10	60	77 (¹³⁴ Ba)	130	19	74.7% & 13.7%	52.0	54.2	4.6 (Ag <0.6 ppm)	1.1 (78%) 0.4 (100%)
20251017	10	60	45 (¹³⁴ Ba)	109	14	71.8% & 24.6%	59.1	57.6	9.3 (Ag <0.2 ppm)	4.6 (100%)
20251128	10	90	45 (¹³⁴ Ba)	191	22	85.5% & 11.9%	68.9	66.0	6.8 (Ba <0.3 ppm)	10.6 (82%) 5.3 (100%)
20251203	10	90	46 (¹³⁴ Ba)	173	23	75.2% & 22.4%	89.0	68.5	14.6 (Ba <0.3 ppm)	11.0 (98%) 5.5 (100%)

*Other lanthanum isotopes include: ¹³⁵La (majority), ^{132m}La and ¹³²La. EOB: End of bombardment. **Metal present in highest concentration shown in parentheses. *** Shows molar activity range corresponding to 100-75% DOTA labelling.

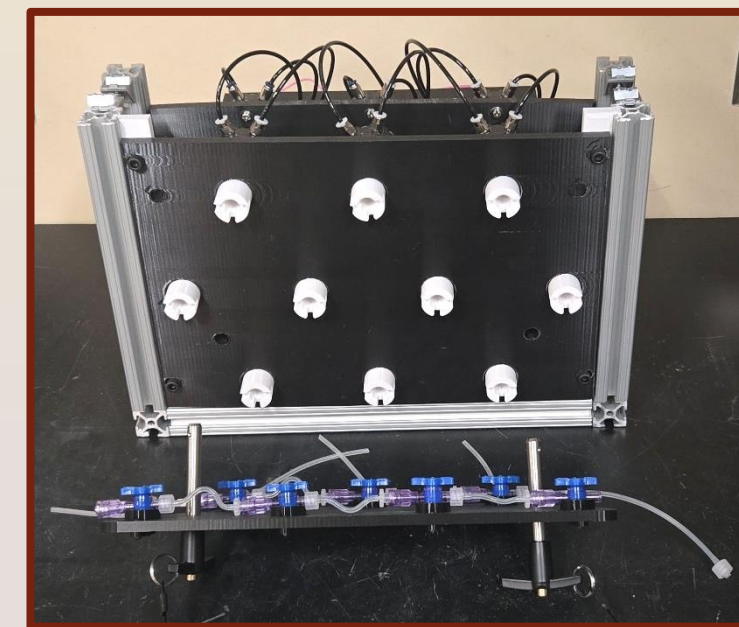
- For the enriched target material, the decrease to 45-50 mg BaCO₃ resulted in better cooling of material during irradiation, due to the thinner layer.
- In the final three productions there were >96% ¹³³La recovery in the 2 mL eluate with most of the activity (>70%) collected in the first 1 mL elute sample.



RESULTS & NEXT STEPS



- Utilize the full 16.5 MeV of the cyclotron proton beam to increase cross-section range and produce more ¹³³La.
- Develop and implement an automated system for post-irradiation separation, which will allow for higher activity to be processed.
- Recycling of ¹³⁴Ba washed out during the separation process.



ACKNOWLEDGMENT

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