# TRIUMF: FROM MESONS TO RARE RADIOISOTOPES

BY JOHN D'AURIA AND GEOFF D'AURIA

John M. D'Auria, professor emeritus, Simon Fraser University, Fellow of the American Physical Society. John D'Auria completed this interview three months before his death.

## AN INTERVIEW WITH JOHN M. D'AURIA BY HIS SON GEOFF

*Tell me about the transition TRIUMF made from its early scientific program to what it has become today.*

Usually a facility has a lifespan of about 20 years and is dedicated to one main type of science or physics. The TRIUMF facility, built in the early '70s, was constructed to study and use mesons in different types of physics and non-physics experiments. After 20 years, and a good program of scientific results, it was considered time to close.

An attempt was made to upgrade the facility, to improve its production capabilities at higher energy, and it was called KAON. But the price tag proved too high for Canada.

However, scientists at the lab pulled a switcheroo, a major change in focus.

*What happened?*

Using the high proton production capabilities of the intense proton beam, the facility decided to make rare (radioactive) isotopes.

But it wanted to do something unique.

It was known from locations in Europe — CERN — that one could produce rare isotopes on an ISOL (isotope separator online) device.

**SUMMARY**

**Three months before his death, Simon Fraser University Professor (Emeritus) John D'Auria dictated the following recollection on the history of rare isotope science at TRIUMF to his son Geoff. John is considered one of the "founding fathers" of the rare isotope program at TRIUMF, which is now the primary research focus of the laboratory.**

Luckily, a small group at TRIUMF studied and learned how to use the 500 MeV intense proton beam to make rare isotopes. This resulted in a new prototype facility called TISOL.

At the TISOL facility, some key experiments were performed.

[This was the Red Giant experiment]

The experiment was important. There was a reaction: alphas plus carbon to make O16. They needed to know where this reaction took place, what was the resonance energy. Since we couldn't use alphas because of the Coulomb barrier, we did the reaction in reverse. Alphas plus carbon-12 make nitrogen-16; nitrogen-16, when it decays, gives you carbon-12 and alphas. So we studied the reaction in reverse. That was unique.

*What effect did TISOL have on the future direction of TRIUMF?*

TISOL showed there were good experiments you could do [with this approach].

You have to remember, TRIUMF was a meson facility. Now they were showing we can also do rare isotope experiments.

With the anticipated demise of TRIUMF on the horizon, the director of TRIUMF switched the focus of the science at TRIUMF to the science of rare isotopes.

But the unique feature added was to then accelerate these rare isotopes to energies of importance to studying reactions occurring in exploding stars.

It turns out there were four major components of this: spectroscopy, fundamental physics testing the Standard Model, condensed-matter physics, and the most important — the initial driving force — the use of an accelerator with the rare isotopes to study key reactions occurring in exploding stars.

In order to achieve this important goal, which drove the facility, one needed an ISOL device, one needed an appropriate low-velocity accelerator, and one needed a facility in which to measure the reaction of interest.

[No one knew how to build the low-velocity accelerator of the variety required to reach this goal. So, the TRIUMF team built it.]

And so ISAC was born. The name "ISAC" refers to the combination of an ISOL device with an accelerator.

And the many scientists at TRIUMF had to start learning a new language.

The first reaction we studied was sodium-21 plus a proton to make magnesium-22.

*How is that experiment performed?*

The half-life of sodium-21 is, I don't know, minutes. So you can't study that reaction with a proton beam, right? So, you study it with a sodium-21 beam on a hydrogen target.

*Now, how do you get sodium-21?*

You take 500 MeV protons hitting a silicon target. One of the products is sodium-21. You diffuse it out, you ionize it. Once you've ionized it, you can control it. You [then] take it through your low-velocity RFQ accelerator to give it the right velocity to match the velocity of the stellar reaction.

So, you've got this sodium-21 hitting hydrogen, picking up the proton, and becoming magnesium-22.

*How do you separate the magnesium-22 produced from the sodium-21 in the beam?*

We built the so-called very elaborate mass separator device called DRAGON.

It separates mass. You're separating mass 21 from 22, [which is] very hard. You have a beam of about, let's say, 15,000 beams/second. How do you pull out one reaction from that? You have to take advantage of the mass difference between 21 and 22. That's all DRAGON is.

With the success of the first Dragon experiment on sodium-21, other experiments followed. With the successful production of rare isotopes at ISOL, the other major areas of research profited with major results.

A fifth group that joined was the TITAN mass measurement group, measuring all sorts of exciting masses of very short[-lived] isotopes [very exotic isotopes].

The bottom line was this 20-year old accelerator lab, TRIUMF, was given a new life and can now live another 30 years.

*What resulted from the success at ISAC1?*

Ultimately, with the success of ISAC1, ISAC2 was built.

The accelerator for ISAC1 accelerated particles below the Coulomb barrier to match stellar reactions. ISAC2 was built to accelerate these rare isotopes to above the Coulomb barrier.

[Nuclear reactions that happen above the Coulomb Barrier are those that happen in super nova and create the very heavy elements in the universe.]

Finally, given the large number of facilities built to receive beams of rare isotopes at TRIUMF, but with the availability of only one beam, they decided to make another facility to make more beams. This was called ARIEL. And they also developed new ways of making these beams.

*Are ISAC1, ISAC2, and ARIEL limited to physics research?*

[No.] In addition, methods were found to allow large production of medical isotopes for commercial purposes in the new facility.

Think of a pencil. That's what the target for an ISOL looks like, a pencil. A beam goes through it. It gets heated. Stuff comes out. But you're only using about 30 per cent of the beam. You put another pencil behind it and use that for medical isotope production, independently.

[So, for every experiment, you're also creating medical isotopes as a byproduct.]

*So, what is TRIUMF today?*

[In short,] TRIUMF was built to do meson and proton physics studies, nuclear physics. What we did was converted it into a device to make rare isotopes, which are studied.

In this transition from mesons to rare isotopes, a facility has been created that is essentially unique in the world using old technology to do new science.

John D'Auria passed away on October 22, 2017 at the age of 78. At the time of his passing he was still active in developing a program to produce at TRIUMF the therapeutic medical isotope 225Ac, the "Rarest Drug on Earth". The project recently achieved a major success with the first joint production run of the isotope.

-John D'Auria and Geoff D'Auria, October 2019