THE PRODUCTION OF ^{22}Na POSITRON SOURCES AT iTHEMBA LABS

C. Naidoo[1], N.P. van der Meulen[1], C Vermeulen[1] and R. Krause-Rehberg[2]

[1]iThemba LABS, National Research Foundation, P.O. Box 722, Somerset West, 7129, South Africa

[2]Martin-Luther-University, Inst. of Physics, 06099 Halle, Germany

Introduction

iThemba LABS (Laboratory for Accelerator Based Sciences) is a multi-disciplinary research centre and one of the National Facilities administered by the National Research Foundation. It provides facilities for:

- basic and applied research, using particle beams
- particle radiotherapy for the treatment of cancer and,
- the production of accelerator–based radionuclides.

iThemba LABS produces ^{22}Na regularly with a high specific activity (> 800 Ci ^{22}Na per gram of sodium). iThemba LABS is presently the sole producer of ^{22}Na positron sources. It can produce positron sources to a maximum activity of 50 mCi (1.85 GBq) and it can be used in ultra high vacuum (UHV) at temperatures between 4…470 K (bakeable).

Production of ^{22}Na

A magnesium target (ca 7 g, 12 mm thick, 20 mm diameter) is bombarded for several weeks with a 66 MeV proton beam at a beam current of 80 µA (in the higher energy window 61.5 → 40.0 MeV). After the bombardment the target is stored for a few days to let the shorter half-life radionuclides decay. The target is dissolved in 3.0 M citric acid and, after dissolution, an ice-cold mixture of triethanolamine (TEA) and methanol is added to obtain a 0.2 M citric acid - 0.6 M TEA - 80% methanol solution. This solution is then pumped through a column containing 10 g of the macroporous cation exchanger AG MP - 50 (in the triethanolammonium form). ^{22}Na is retained by the resin and the magnesium is eluted with 0.2 M citric acid - 0.6 M TEA - 80% methanol, followed by 0.1 M EDTA - 0.6 M TEA. The resin is then converted to the ammonium form with 1.0 M ammonia – 80% methanol and ^{22}Na is eluted with 1.0 M ammonium carbonate. The eluate is pumped through a column containing 10 g of the chelating resin Chelex 100 (in the ammonium form) to remove the last traces of magnesium and other elements. The eluate is heated in a conical titanium vessel to evaporate the ammonia and water. ^{22}Na is obtained as the carbonate salt in a small volume (Figure 1). All reagents are purified to remove sodium prior to the ion exchange separation. Within one production run about 300 mCi ^{22}Na is obtained.

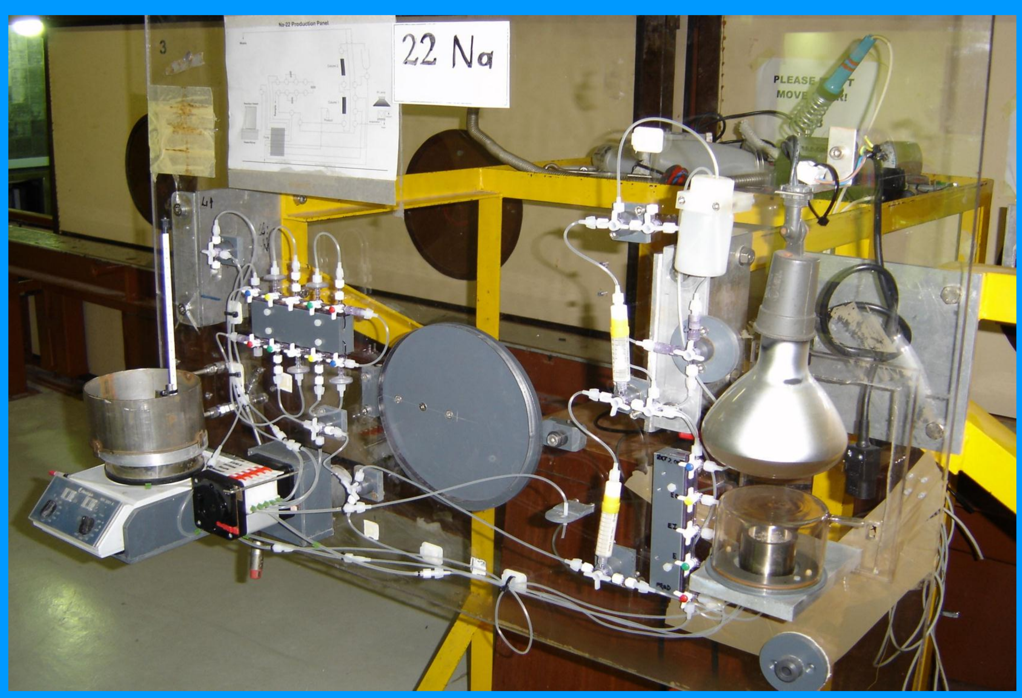
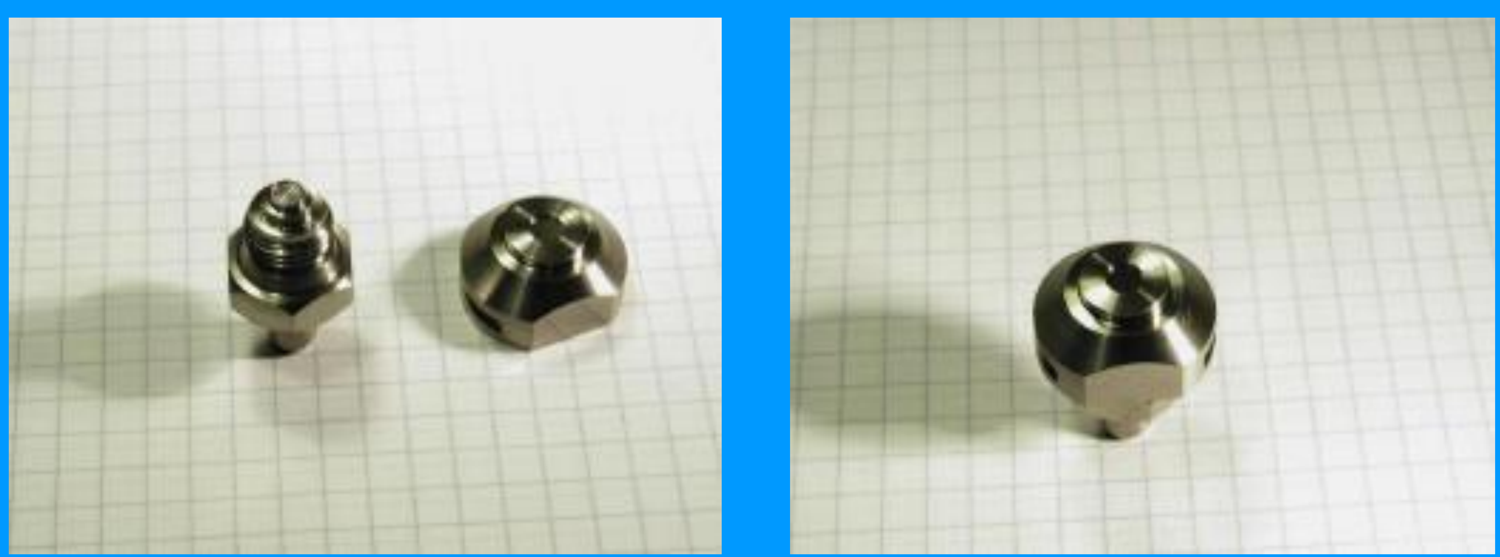


Figure 1. Hot-cell panel for ^{22}Na recovery from target.

Design of the Source Capsule

The source capsule was designed and described by Krause-Rehberg *et al* [1] and is available in two sizes. The capsule consists of a front part and a rear part, both made from titanium metal, both parts having a thread to screw the front part onto the rear part (Figure 2). The front part has a 5 micron thick titanium window with a diameter of 4 mm, covered with a titanium ring which is welded with a laser beam onto the front part. On the post of the rear part is a tantalum cylindrical reflection plate, in the form of a cup, with a depth of 0.2 mm and a diameter of 3.7 mm. Each capsule is individually tested to be ultra high vacuum tight down to 10^{-8} mbar.



Rear part - opened capsule

Front part -sealed capsule

Figure 2. The source capsule .

Preparation of a ^{22}Na source

The rear part of the capsule is clamped in a holder with the post facing upwards and level. 10 µl of the concentrated ^{22}Na carbonate solution is dispensed in a vial and the activity measured by γ ray-spectroscopy, using a Ge-detector. ^{22}Na is then transferred, in 10 µl volumes, into the tantalum cup with a semi-automated dispensing apparatus. (Figure 3). The water is evaporated, to incipient dryness, before the next volume is dispensed into the cup to prevent the build-up of salts forming a ring around the edge of the cup. When the required activity of ^{22}Na has been transferred into the cup, the front part of the capsule is loosely screwed onto the rear part and the ^{22}Na activity accurately measured with a Ge-detector. More activity can be added if required. The capsule is finally sealed to a defined torque value (20 Nm) using a special holder to clamp the capsule tightly (Figure 4).

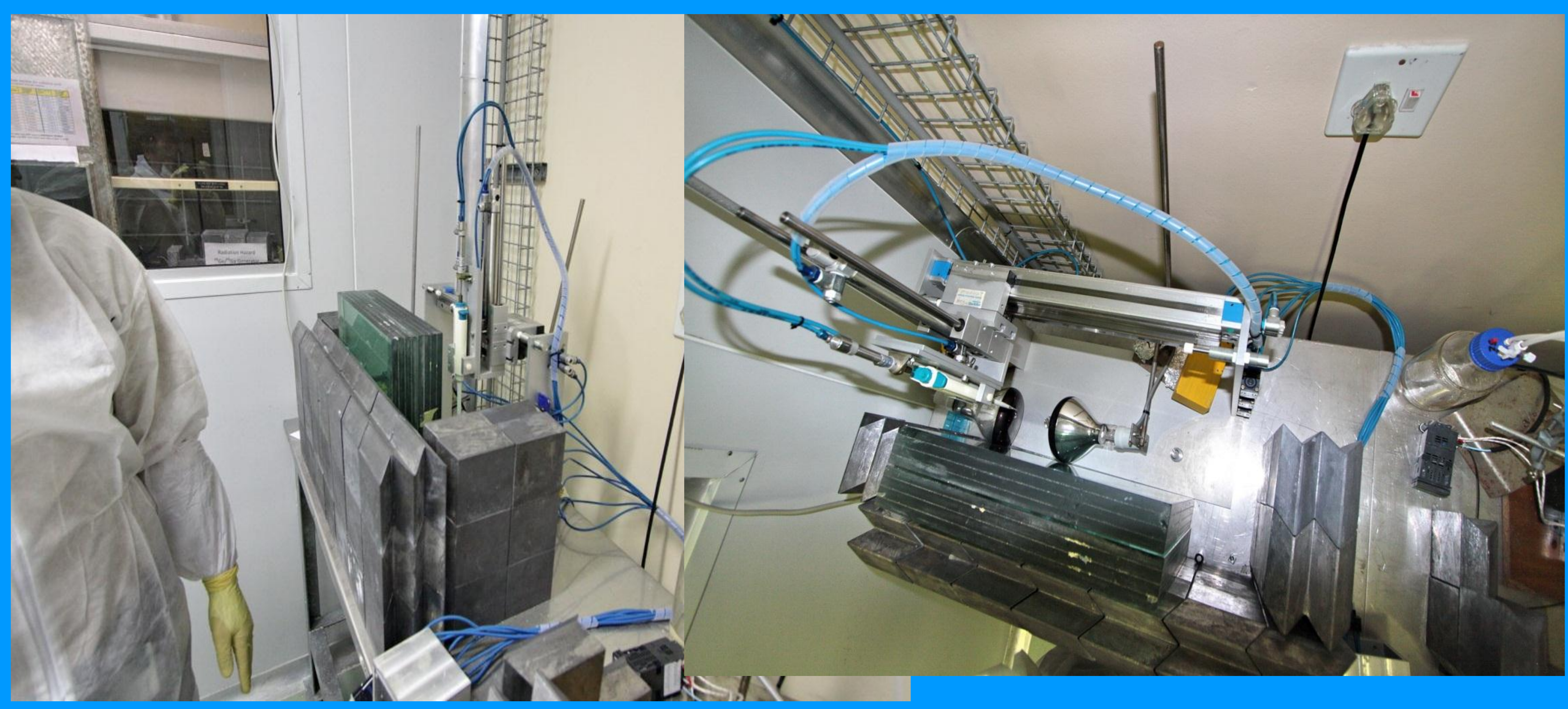


Figure 3. Dispensing apparatus.

Figure 4. Special holder for sealing of the source.

Quality Control

The capsule is thoroughly washed with deionized water and methanol (x3), followed by subsequent drying. The washing solution from each step (x3) is collected in folded towels and tested for ^{22}Na contamination (< 15 Bq). This is followed by the 24 hour vacuum test on the capsule (Figure 5) and the washing process of the capsule with deionized water and methanol (x3) is repeated once again. Finally, the source is wipe tested by iThemba LABS Radiation Safety Division before it is released for packing. An aluminium cap is placed over the window to protect it against damage during shipment. The source is then packed in a lead pot, the lead pot is sealed and finally packed in a container for shipment to the end-user.

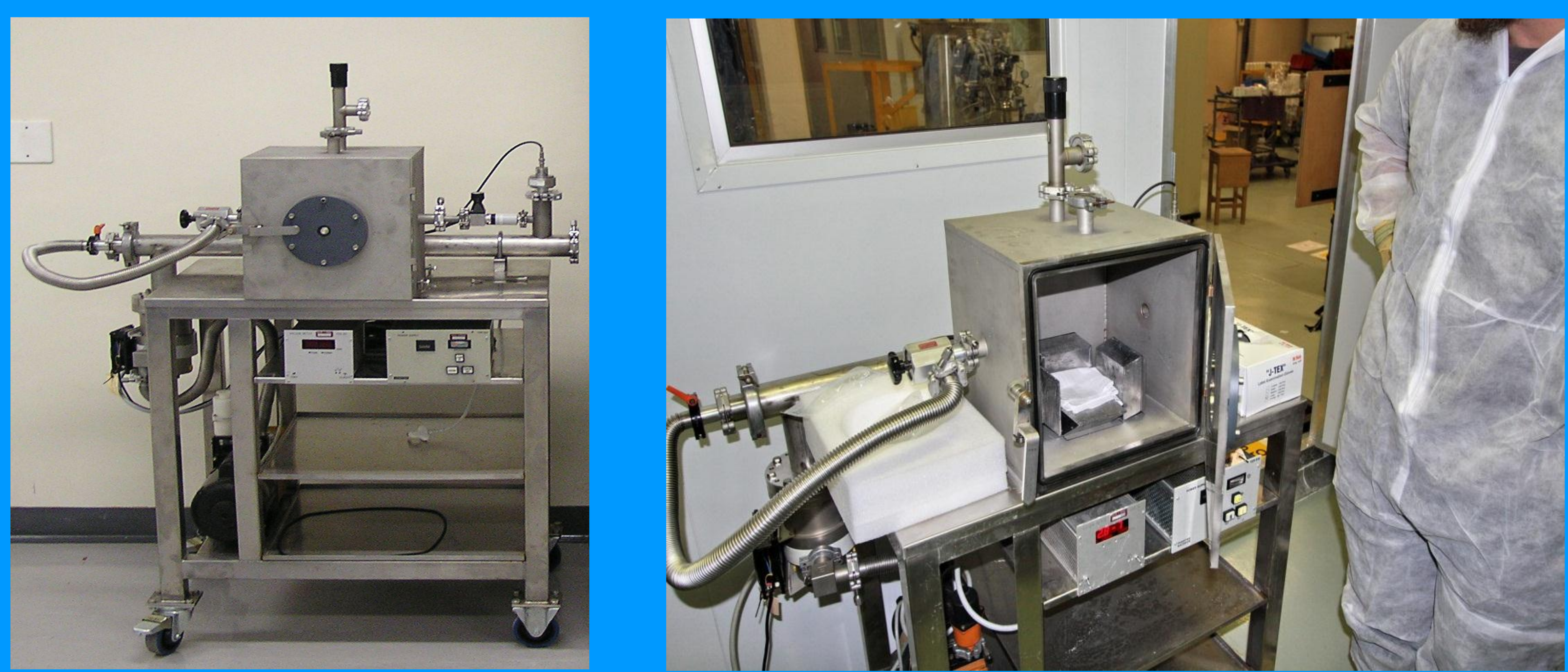


Figure 5. Vacuum Testing of sealed capsules

References:

1. http://positron.physik.uni-halle.de/poster/Poster_SLOPOS9.pdf