A ^{22}Na source capsule for use in UHV

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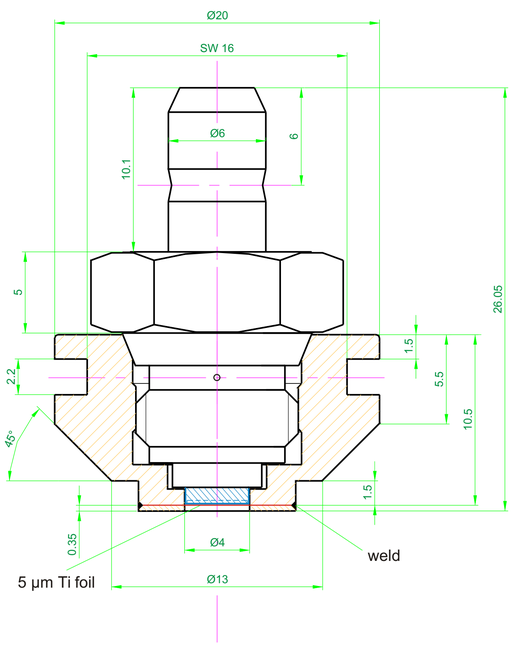
Introduction

- a positron source capsule for use in UHV was developed
- it is designed to be filled with ^{22}Na ($NaCl$ or Na_2CO_3) with an activity up to 100 mCi (3.7 GBq)
- the capsule can be baked up to 180°C
- it was also tested at 77K

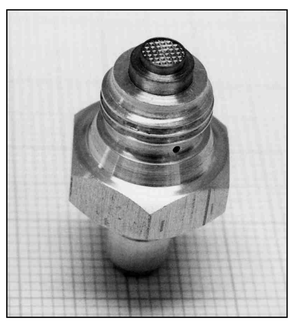
Design of Source Capsule

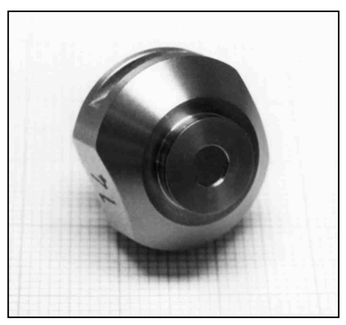
The source capsule is made from 5 parts: the Al rear part ending in a post for fixing the source in the system, a small Ta cylinder on which the 22-Na will be deposited, the Ti front part which has side slits for easy handling by a manipulator (see below), the Ti foil, and a Ti ring which is welded to the Ti front part to fix the foil. The foil is 5 microns thick. The front window has a diameter of 4 mm. The source is closed by a torque spanner with a defined torque. This ensures that the Ta reflection plate (which is on top of the rear part) is located very close to the Ti front window. The Ta plate has a cup-like indentation of depth 0.2mm and diameter 3.7mm.The volume is sufficient to take in a drop of 22-Na solution during the filling procedure. The surface of the bottom of this Ta cup is prepared as a waffle pattern. This ensures that the 22-Na salt drys rather homogeneously.



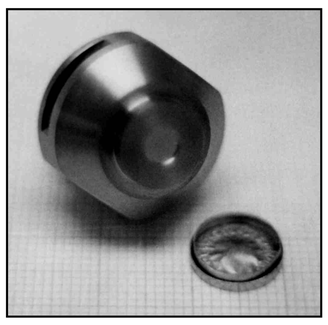
Each source capsule has been tested up to 5 bar overpressure. Moreover, the front part of each capsule was tested to be UHV tight down to 1E-8 Torr. The rear Al part contains a cavity for the neon gas which is created during the decay of 22-Na. A small hole at the side connects this cavity with the front part (see third photo).

Technical Realization





The rear part of the source capsule (left) is made from Al. The ^{22}Na isotope is evaporated on top of the Ta insert which acts as reflection plate. A small hole below the thread opens the volume behind the Ta piece for the created Ne gas. The right photo shows the front part which is completely made from Ti. A special design of the front ring ensures that the foil of the Ti window is drum-like spanned during welding.



After closing the capsule (left photo), it is UHV tight ($<10^{-8}$ Torr). It can be reopened. The slits are made for the manipulator (see right column). In the positron beam system in Halle, the moderator sits directly on top of the source (right photo shows removed moderator). It is a W single crystal foil which is supported by a W ring.

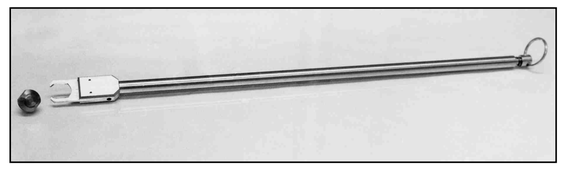
Production of Isotope

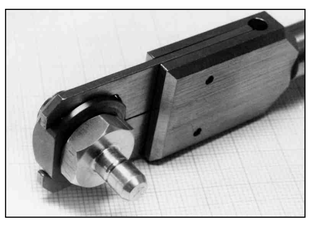
To produce ^{22}Na, a magnesium target is bombarded with a 66 MeV proton beam (120 A)for several weeks. At the end of the bombardment the target is dissolved in 3.0 M citric acid. A mixture of triethanolamine (TEA) and methanol is added to obtain a solution containing 0.2 M citric acid - 0.6 M TEA - 80 % methanol. The ^{22}Na is then separated from the bulk of the magnesium by column cation exchange chromatography on the macroporous resin AG MP-50 (in the triethanolammonium form). The ^{22}Na is retained on the resin and the magnesium eluted with 0.2 M citric acid - 0.6 M TEA 80 % - methanol (150 mL), followed by 0.1 M EDTA - 0.6 M TEA (150 mL). The resin is then converted to the ammonium form by passing 1.0 M NH_4OH 80 % - methanol (100 mL) through the column. The ^{22}Na is eluted with 1.0 M $(NH_4)_2CO_3$ and the eluate passed through a column containing the chelating resin Chelex 100 (in the ammonium form) to remove the last traces of magnesium (and other elements) which may still be present in the eluate. The ^{22}Na passes through the column and the eluate collected in a tapered Ti vessel. The $(NH_4)_2CO_3$ and water are evaporated. Finally, the ^{22}Na is dissolved in a very small volume of water and the solution having typically a specific activity 800 Ci of ^{22}Na per gram of sodium and the chemical purity > 99.9 % Na_2CO_3 is used to prepare the positron sources.

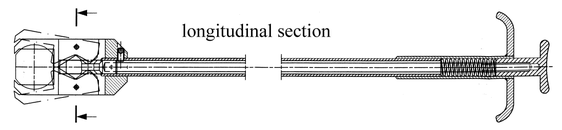
Filling of Source

The post of the bottom (aluminium) section of the capsule is placed in a special holder to keep it upright and level during the filling and evaporation steps. A volume of 10 L of solution A is delivered onto the tantalum reflection plate and the solution evaporated to dryness under an infrared lamp. This step is repeated until the desired activity has been accumulated on the reflection plate. The top (titanium) section is then placed onto the bottom section, slightly tightened and the activity measured. Once it has been determined that the desired amount of activity was deposited, the capsule is finally sealed to the defined torque value. The capsule is then washed with a diluted NaCl solution to ensure that no contamination of the outside surface is present. It is then rinsed with deionised water and, finally, with methanol. A wipe test is performed and if any contamination is found to be present the wash steps are repeated until no contamination is found. Finally, the activity is measured with the titanium window facing the detector. A poly ethelene cap is placed over the top section to protect the titanium window during the packing and shipping process.

The Source Manipulator







For easy manipulation, we constructed a pair of pliers. This allows a save handling without the necessity of touching the source (radiation protection). The source can easily be taken out of the transport container and can be mounted to the system. The complete set of drawings of the manipulator have been made at TU Munich and can be downloaded from our homepage as PDF version or as AutoCad files (www.ep3.uni-halle.de/positrons).

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