A 0.5 to 3.0 MeV MONOENERGETIC POSITRON BEAM

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Abstract

An adjustable, 0.5 to 3 MeV monoenergetic positron beam has been constructed at Brookhaven. Currently a ^{22}Na source with a W(100) foil transmission moderator produces a 1.1 mm FWHM beam with an intensity of 3×10^5 e^+/sec at a target located downstream from the accelerator. The divergence of the beam is less than 0.1° at 2.2 MeV energy. A SOA gun with 2 lens transport system brings the beam to a focus at the entrance of an electrostatic 3 MeV Dynamitron accelerator. The post acceleration beam transport system comprises 3 focusing solenoids, 4 sets of steering magnets and a 90° double focusing bending magnet. The beam energy spread at the target is <1 keV FWHM deduced from the beam size. Below we describe the positron extraction optics and acceleration, the construction of the beamline and the beam diagnostic devices. The salient beam parameters are listed at the end of this paper.

POSITRON EXTRACTION OPTICS

The positron beam is generated using a 70 mCi ^{22}Na source capsule (fabricated by NEN) in a transmission geometry with a 6000 Å thick W(100) single crystal moderator foil[1] as shown in figure 1. The positrons are extracted with a modified SOA gun followed by a 65 cm long two lens element transport system, which injects a 400 eV beam through the 4 mm entrance aperture of the main accelerator. We have also installed a set of steering plates into the transport system to guide the beam. The aperture and the transport lens system also serve as a passive filter reducing the contribution of the unmoderated positron by a factor of 10^5. This is the essential step to obtain a highly monoenergetic beam.

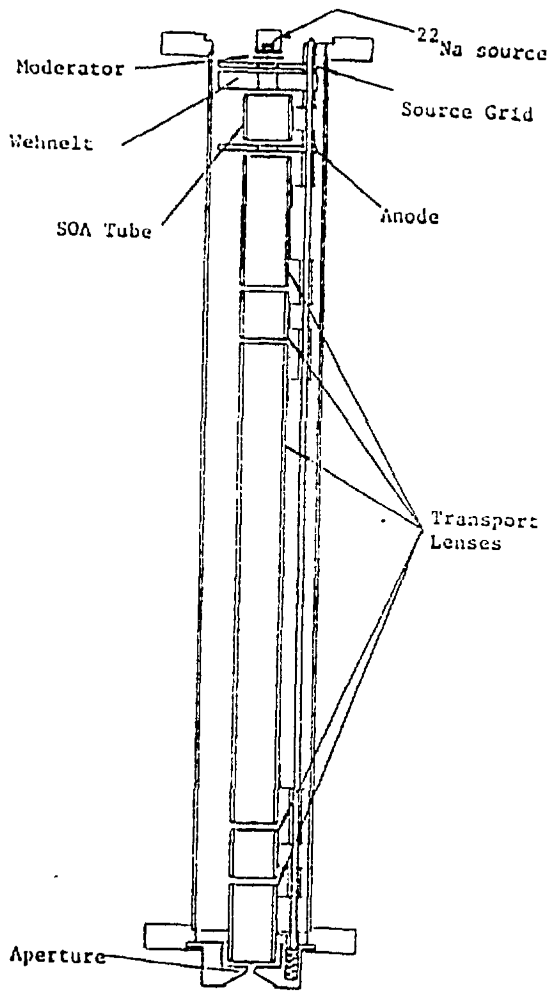

Figure 1. The positron extraction optics, which consists of a modified SOA gun followed by a 65 cm long two lens transport system.

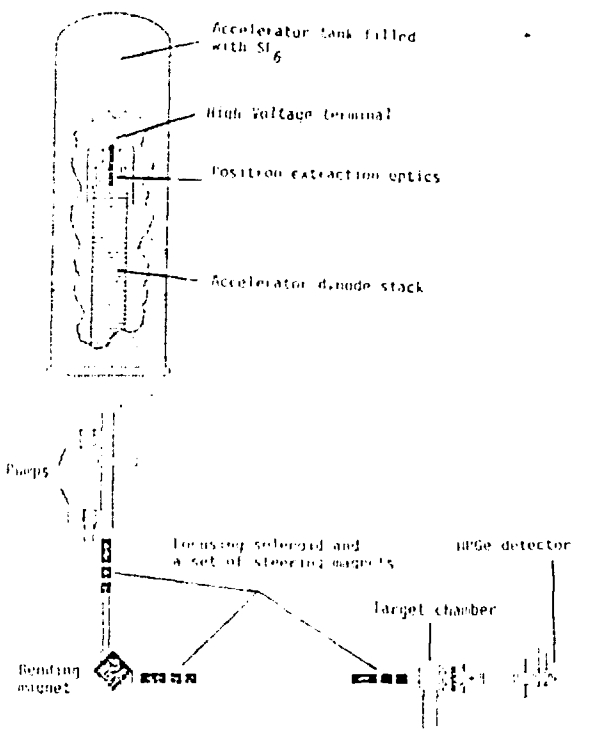

Figure 2. The 3 MeV positron accelerator and the beam line, pumped by cryopumps to a base pressure of $5x10^{-7}$ torr. Positrons are focused by 3 solenoids and 4 sets of steerers (1st set inside the accelerator tank is not shown for clarity).

The main acceleration is provided by the accelerator dynode stack powered by a resonating RF-field in the accelerator tank, which is filled with insulating SF_6 gas. The vertical accelerator vessel as well as the beam line are shown in fig. 2.

BEAMLINE AND BEAM DIAGNOSTICS

The 10 m long beamline comprises 3 focusing solenoids 4 sets of steering magnets and a double focusing 90° bending magnet as shown in figure 2. We have installed active collimators at the focal points of the bending magnet restricting the pass energy of the bending magnet to ±5 keV of the nominal beam energy. The active collimators can also be used for beam counting by steering the beam off the centerline.

The beam is diagnosed at the target position by visual inspection of a phosporescent screen coupled to channel electron multiplier array (CEMA). We also counted the positron beam with the CEMA and observed a high detection efficiency of about 60% for 2.2 MeV positrons.

The beam size of 1.1 mm FWHM is measured by moving a target across the beam. The beam energy distribution of <1 keV FWHM can be

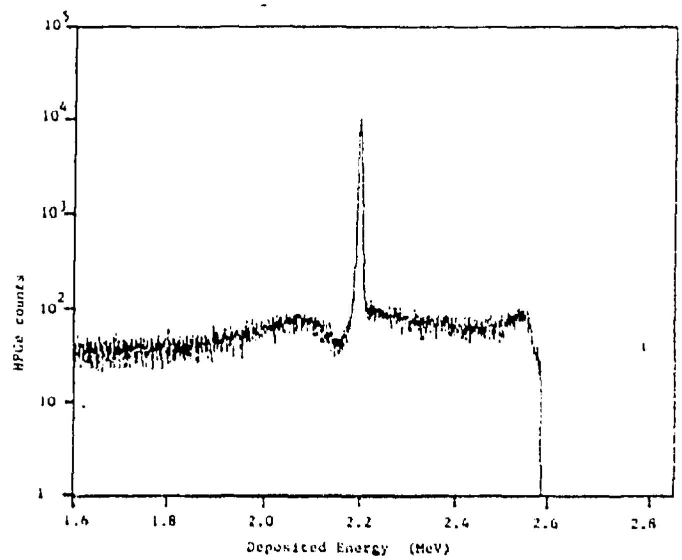

Figure 3. The measured HPGe spectrum of a 2.2 MeV positron beam striking the detector. Resolution of the detector is 3.5 keV FWHM and the width of the spectrum measured by the HPGe detector is 4 keV FWHM. ADC discriminator cutoff is at 2.6 MeV.

estimated from the beam size and from the information that the beam spot moves by ±3 mm if the beam energy is changed by ±1 keV.

The positron beam energy is measured by a 7 mm thick high purity germanium (HPGe) detector, which has a FWHM of about 3.5 keV for 2.2 MeV positrons. The energy calibration of the HPGe detector is obtained by observing both the gamma and conversion electron lines, produced by ^{207}Bi, ^{56}Co and ^{228}Th sources. The measured beam energy width is 4 keV FWHM, consistent with the intrinsic width of <1 keV of the positron beam. The distribution is shown in figure 3. The background on the high energy side is produced by addition of 511 keV annihilation quanta to the beam energy. The low energy background is mainly due to incomplete energy deposition in the 7 mm thick detector and positrons scattering off active slits, which are designed to limit the count rate. We also found that the measured positron beam energy has to be corrected by about 0.5 keV/day corresponding to residual gas (mainly water) condensates on the cooled HPGe detector front from our vacuum system, which has a base pressure of $1x10^{-6}$ torr.

The salient beam characteristics of the present beam are listed in table 1 on the next page.

Work aimed to increasing the count rate is currently in progress.

REFERENCES

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Table 1. Beam characteristics of the 3 MeV positron beam at BNL

Source total activity encapsulated	≈70 mCi
Moderator efficiency (fast positron in, moderated positron out)	5×10^{-4}
Total transport efficiency	≈90%
Positron flux at target	$3\times10^{5} e^{+}/s$
High energy contamination	$<10\ e^{+}/s$
Beam size (diameter)	≈1.1 mm FWHM @2.2 MeV
Beam divergence	<0.1°
Beam energy	<1 keV FWHM @2.2 MeV
Accuracy of beam energy measurement	±100 eV
Usable energy range from	0.5 MeV to 3.0 MeV

The constructed positron beam will be initially used for a Brookhaven--CCNY--Yale collaboration for a search of resonant Bhabha scattering. experiment.

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