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PROPOSAL TO THE ISOLDE COMMITTEE

REQUEST FOR BEAM DEVELOPMENT

CERN[1]-DARESBURY[2]-LOUVAIN LA NEUVE[3]-ORSAY[4]-OSLO[5]-Collaboration

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SUMMARY

The first experience in operation of the ISOLDE targets and ion sources in the PS Booster beam is reported. For solid targets the expected delay time reduction was observed. This makes the ISOLDE beams bunched with the Booster repetition rate and a pulse shape which is strongly element dependent. In case of production of Ar from the CaO target the beam intensities of the SC ISOLDE could be reproduced. For molten metal targets a shock wave effect caused by the proton beam pulse makes the present La target essentially useless and sets a stringent beam intensity limit of 5E12 protons per pulse for the Pb target. Targets and proton beam time is requested for the study of yields and pulse shape of the radioactive beams and for the investigation of technical solutions to the shock wave phenomena of the molten metal targets.

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1. Introduction.

Already before the move to the PS-Booster (PSB) the proton-beam time-structure of 7 pulses of 2.4 μs duration every 1.2 s was identified as the major challenge to the target and ion-source technique. It was also recognized that an intensive target development programme should be undertaken in order to exploit efficiently the properties of the Booster beam. This beam structure can have both beneficial effects and deleterious effects on the performance of the targets. On the one side the power deposition, the shock wave and the cascade of nuclear reactions may enhance the release and make the targets faster as indicated by the delays measured by the Orsay group in their PS experiment[1]. They observe delay half times down to 50 ms compared to the SC ISOLDE ones of typically 1 s. If such targets could be developed the ISOLDE beam would become bunched and a number of experiments could improve their signal to noise ratio by only activating the datataking during the pulse. On the other side it was feared that the cascade of lower energy particles could lead to local overheating and a strongly pulsed outgassing of the targets which would lower the efficiency of the ion sources. The acoustic shockwave also known from the AA targets, where it caused a break down of the mechanical properties of the solid target due to a metal fatigue like phenomenon, was not expected to do any damage to a molten metal. Calculation of the power depositions by means of the FLUKA 86 code, also used by the AA antiproton target group, indicate that only the Pb target is at risk for overheating when the beam exceeds 0.5 μA average current.

2. First experience with the ISOLDE targets in the PSB beam.

In the first half year of ISOLDE operation at the 1GeV proton beam of the PS-BOOSTER a number of interesting phenomena were observed which could be linked to the strongly bunched character of the beam. The physics programme has now been started and enough experience with the new beam is available so that the direction of the beam development programme can be clearly defined and the target and beamtime needs may be requested.

Two different types of targets have now been used. The high temperature targets which consist of solids like powders of MgO, CaO and foils of Ta and the molten metal targets of La and Pb. The solid targets supported without problems the full booster beam of average 2 μA and possibly more as indicated by the Ta-foil target which was tested for extended periods with 3.7 μA average proton beam. The expected effect of reduced delay can be seen in fig.1 which shows the delaytime distribution p(t)[2] (or pulseshape) at the SC and Booster for Ne released from a MgO target. It is found that for these targets the delay half-time[2] $t_{1/2}$ is 3 times shorter at the PSB than at the SC. Similar observations were observed for a number of products from the CaO target which in addition allowed to reproduce the SC ISOLDE yields at the PSB ISOLDE as shown in fig. 2.

A consequence of the fast release is that most of the ISOLDE beams will be pulsed at the PSB repetition rate and with a element dependent pulse shape like the one shown in fig. 1.

The first operation of a molten La target of which the current layout is seen in fig. 2 gave a unpleasant surprise. Within minutes after turning the proton beam on the Cs beams were seen to fluctuate strongly which usually is a sign of La metal in the line or in the ionizer rather than a delaytime effect since the delays of molten metal are expected to be unaffected by the beam properties. Shortly after the ionizer and the line was filled with La and the excessive La vapor in the extraction gap caused persisting HT breakdowns. Since it could have been an accidental overheating a second target was tested with lower electrical target heating, but it gave the same result. A disassembly of the two targets, in the new target laboratory, showed the line and ionizer to be partly filled with La and large amounts (grams) of La had flown and evaporated out of the ionizer.

In the following ISOLDE experimental period a Pb target for production of Hg was planned. A similar effect but less pronounced due to the vertical line seen in fig. 2 was expected to occur for this target. An old Pb target # 308 from ISOLDE-3 was used for a destructive test of the maximum beam the target would stand. The proton beam was raised very slowly from 1 pulse of 1E12 protons per supercycle to 7 pulse of 1E12 protons per supercycle without rise in the Pb beam. From then on the intensity per pulse was raised above 1E12 protons per pulse and a gradual rise in Pb beam intensity was observed. At 5.7 E12 protons per pulse (i.e. 0.05 μA) the acceleration HT and front end vacuum broke down due to a Pb burst in the ion source. From then on the separator could no more be started with this target due to Pb overload. A new Pb target # 005 was mounted and was successfully operated for 12 days to the end of the scheduled time with a proton beam of only 0.025 μA. After a disassembly of target # 308 drops of Pb were found in the transfer line .

3. Discussion of the molten metal targets.

The displacement of the target material into the line may be explained by either an overheating so that it distills out into the line or by a mechanical shock wave that ejects the material.

Repeated calculations of the energy deposition in the target, with newer versions of the Fluka programme that follows the hadronic cascade down to lower energy, confirm that a thermal overheating is unlikely to be responsible for the observed phenomena.

It is quite clear that the momentum imparted to the target material by the proton burst is sufficient to displace all of the liquid material. The problem is to determine in which way and how much the approximately half cylindrical liquid target volume is disturbed. The liquid may be moved in a wave-like pattern characterized by an amplitude or may be disrupted into drops ejected from the surface and characterized by size and ejected hights. Only when this is known can a target container with appropriate baffles and volume be constructed.

There seems in fact to exist programs which may calculate the disruption of liquids by proton beams but it will take quite some time before we have obtained them and learned to use them. We suggest therefore first to investigate the phenomena experimentally.

4. Proposed experimental programme.

Since a visual inspection of the target metal surface, even with TV cameras, will be quite difficult we suggest to measure the possible wave amplitude and appearance of a gas cloud by means of a special La target equipped with a number of electrodes and a flow constriction of the line as shown in fig. 4

. Based on this experience we will construct and test further prototype versions of the La target. Only when the problems are solved prototypes of Sn and Pb targets which also needs additional cooling will be constructed and tested.

In order to exploit the expected proton beam enhanced release and increased production cross sections, time should be reserved for the investigation of the yield and delay time distributions of the present target and ion source configurations in connection with the pulsed PSB beam. For this purpose it is suggested to continue to use about one shift beamtime on each of the about 16 production targets planned to be used in 1993.

5. Target and beam time requests.

Out of the 20 target units planned to be build in 1993 we request to use a total of 4 units only for testing molten metal targets.

Number of requested shifts.

For the 4 molten metal targets 4X6	24
For the remaining 16 targets	16
Total	40 shifts.

Figure captions

Figure 1. Delay time distribution (pulse shape) of the Ne released from the MgO targets

Figure 2. Ar beam intensities obtained at the SC ISOLDE and The PSB ISOLDE.

Figure 3. Layout of the presently used La and Pb targets.

Figure 4. Layout of the proposed La target for testing of gas and liquid schock wave amplitudes.

References

[1]F. Touchard et. al. Nucl. Instr. and methods 186(1981)329.
[2]H. L. Ravn, Phys. Rept. 54(1979)201

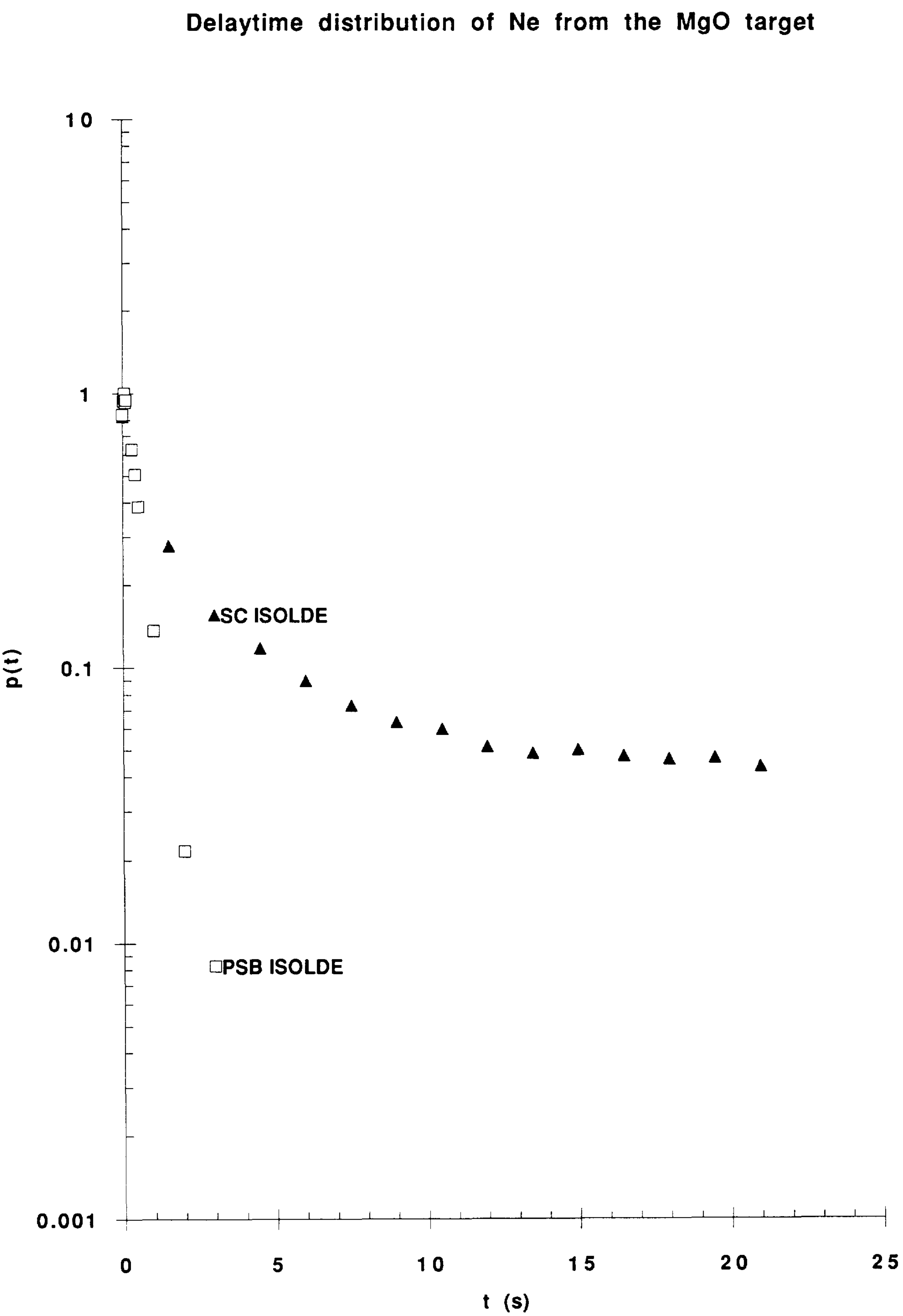

Delaytime distribution of Ne from the MgO target
10
1
0.1
0.01
0.001
p(t)
▲SC ISOLDE
□PSB ISOLDE
0
5
10
15
20
25
t (s)

Figure 1.

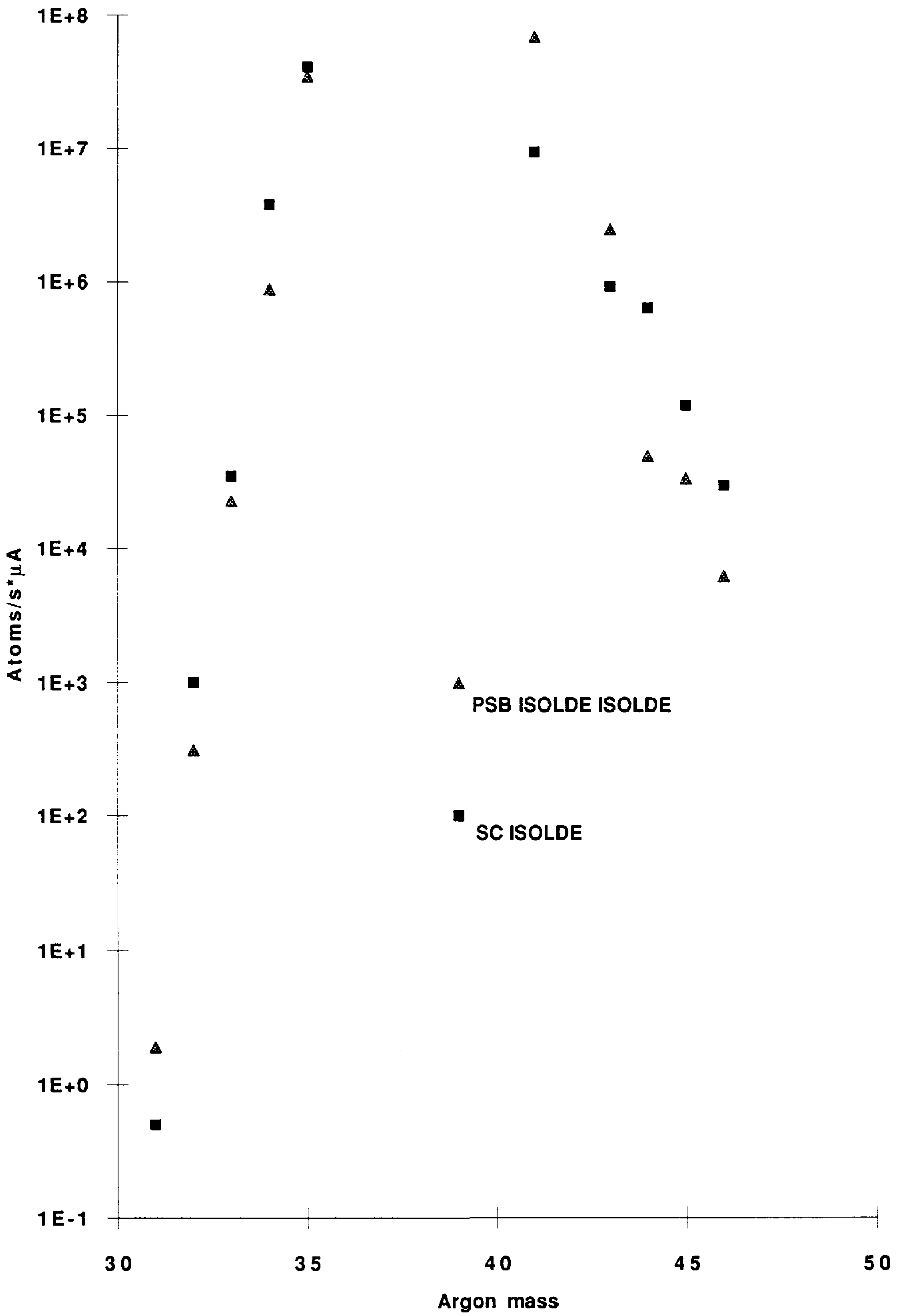
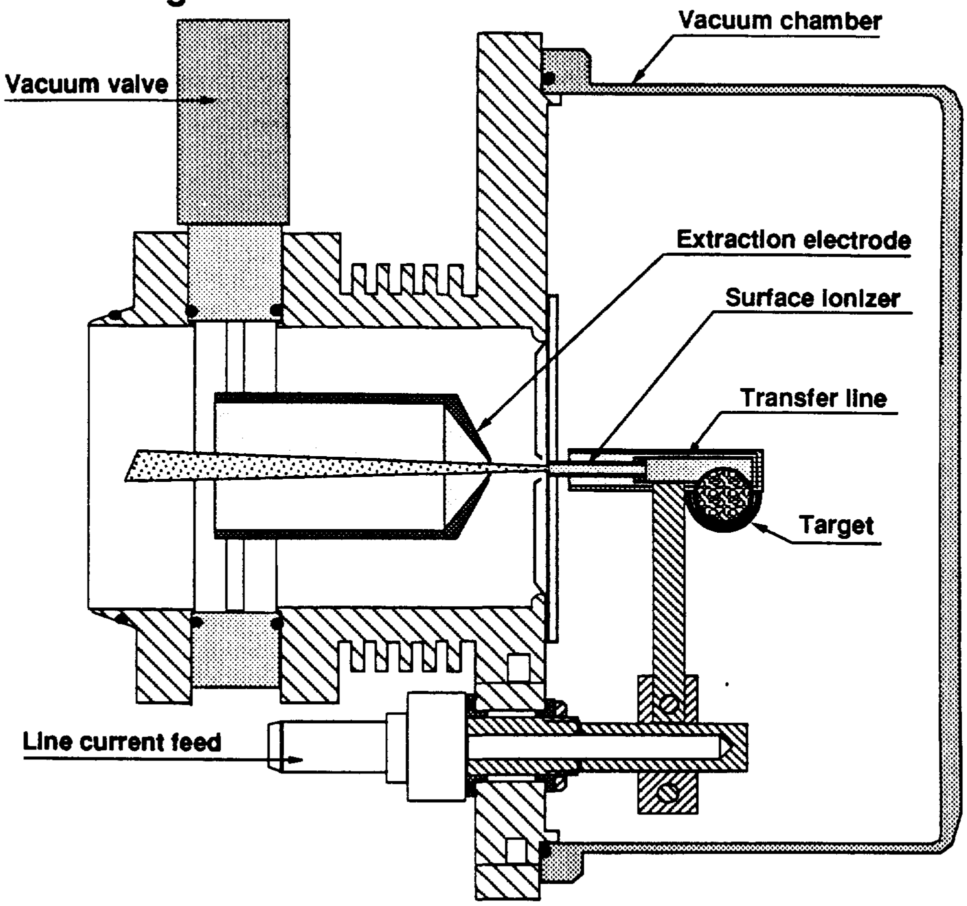

1E+8
1E+7
1E+6
1E+5
1E+4
1E+3
1E+2
1E+1
1E+0
1E-1
Atoms/s*µA
PSB ISOLDE ISOLDE
SC ISOLDE
30
35
40
45
50
Argon mass

Figure 2.

Molten Lantanum target



Molten lead target

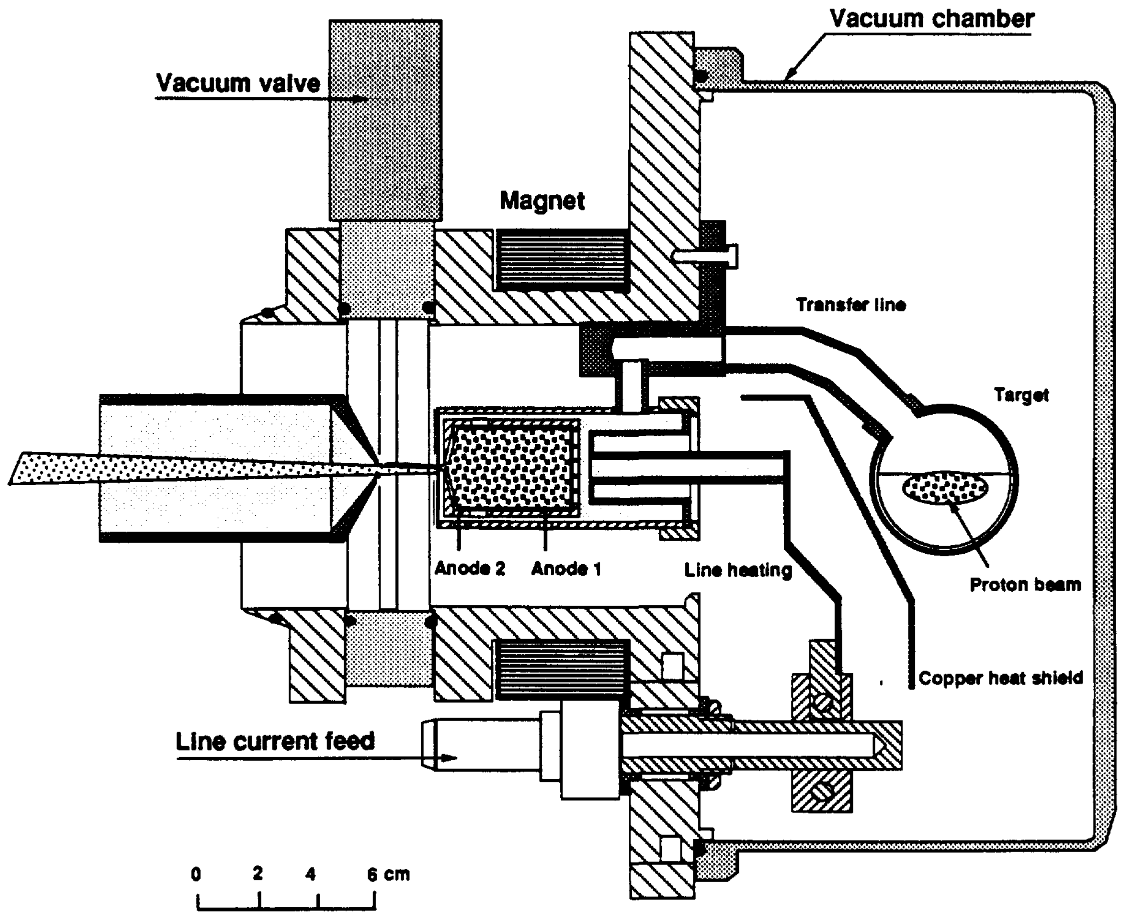


Figure 3

Wave test layout

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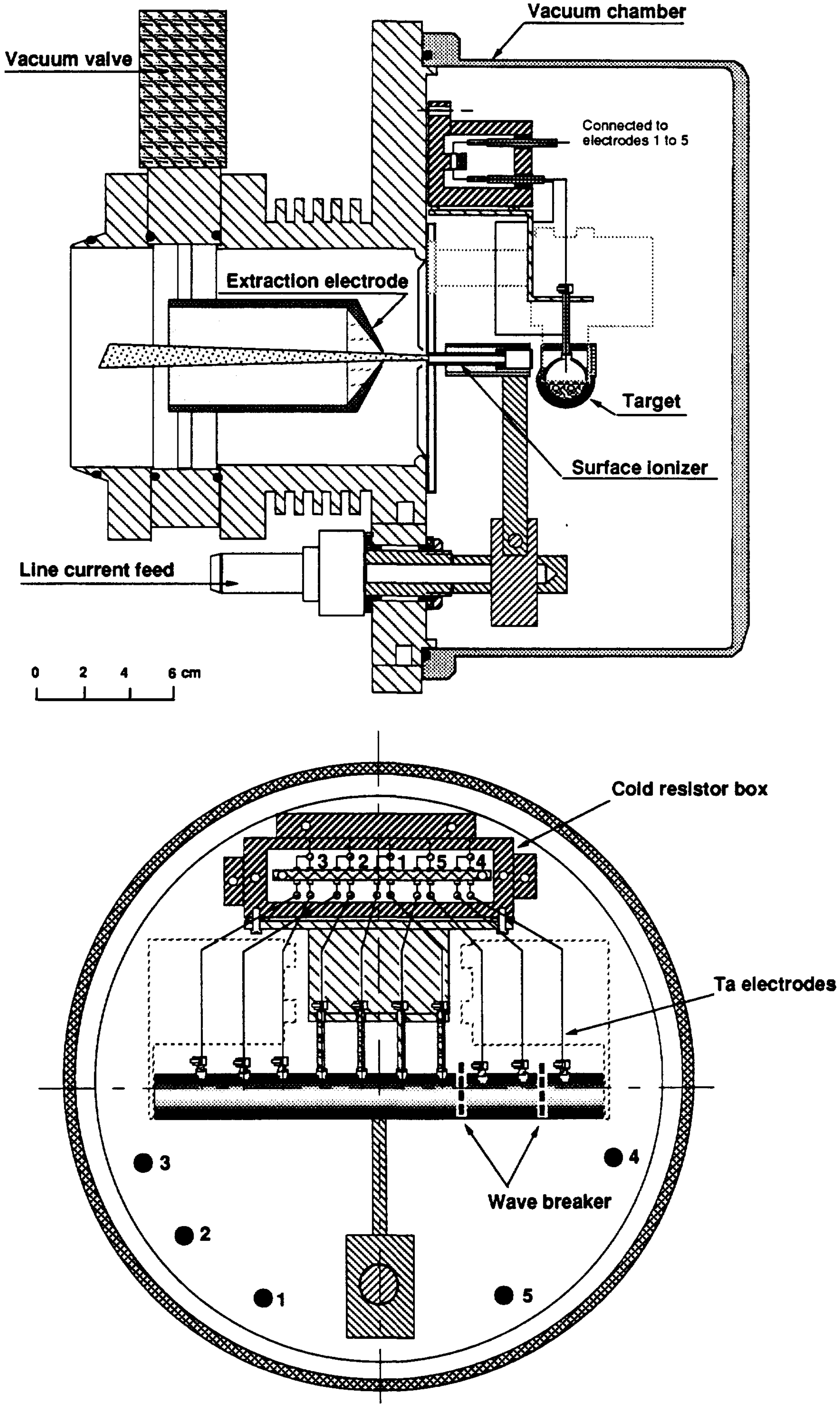

Figure 4