Comments on a choice of the target material
L.Afanasyev

Since the proposal have been written two points important for the choice of the target material occurred.

1. The values of the pion scattering lengths predicted by CHPT was changed [1]. Consequently the predicted value of the $A_{2\pi}$ lifetime also changed from $3.7 \cdot 10^{-15}$ s to $3.0 \cdot 10^{-15}$ s.

2. The angle between the proton beam and the setup axis was changed from 3.5° in the proposal to 5.7°. It was decided to increase the target thickness in order to increase the target efficiency and compensate a reduction of the $A_{2\pi}$ yield for the new geometry. Now the target thickness should be equivalent, in sense of the multiple scattering, to 30 μm of Ta instead of 20 μm in the proposal.

In the proposal all main data concerning the choice of the target material are presented in Figure 5.5 and Table 5.2. In the following figure and table the same information is presented for the new value of the lifetime and the new target thickness.

In Figure 1 the number of $A_{2\pi}$, to be produced in the target to obtain the $A_{2\pi}$ lifetime within 10%, is shown as a function of the atom lifetime for targets equivalent to 30 μm of tantalum and the ratio of accidental to real coincidences equal to 2.0.

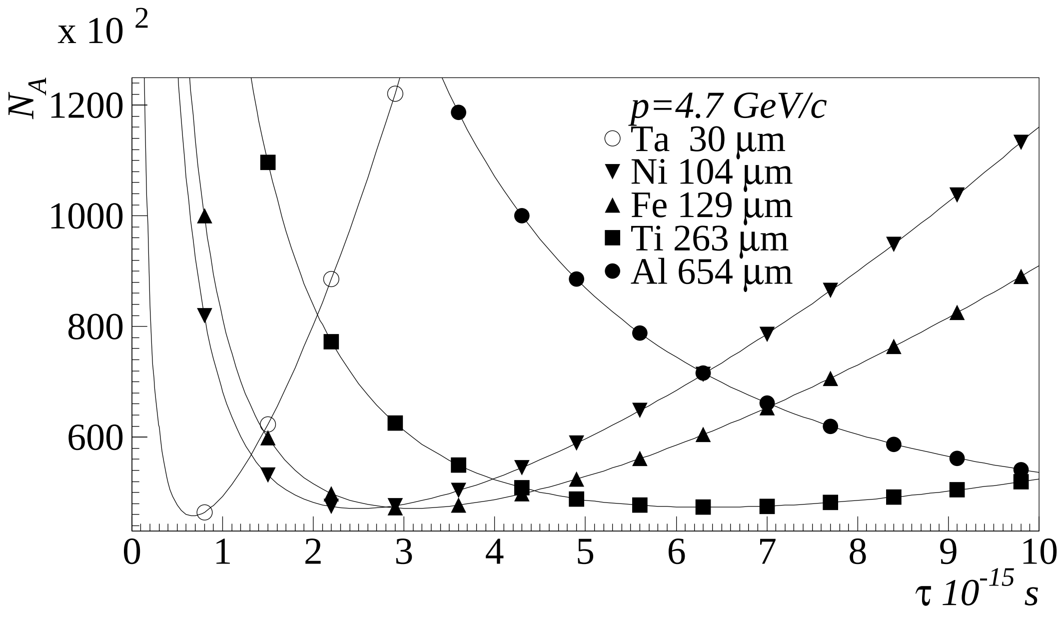

Figure 1: The number of $A_{2\pi}$ to be produced in the target to obtain the $A_{2\pi}$ lifetime within 10% as a function of atom lifetime for different targets equivalent to 30 μm of tantalum.

Some illustrative and final numbers are given in Table 1. For different materials with nucleus charge Z and for the ground state of $A_{2\pi}$ the total cross sections σ_{1S}^{tot} and corresponding interaction lengths $\lambda_{\text{int}} = A/\sigma_{1S}^{tot}\rho N_0$ are given. Calculations were performed for the $A_{2\pi}$ lifetime $3.0 \cdot 10^{-15}$ s and momentum 4.7 GeV$/c$, leading to an annihilation length $\lambda_{\text{anh}} = 15.1\,\mu$m. For targets with thicknesses S, which are equivalent in radiation lengths to 30 μm of tantalum, the following numbers are found: the probabilities of $A_{2\pi}$ breakup P_{br}, the relative accuracy in P_{br} measurement δP_{br} and the number of produced atoms N_A, required to obtain the lifetime within 10%.

Table 1:

	Z	σ_{1S}^{tot} cm^2	λ_{int} μm	S μm	P_{br}	δP_{br}	N_A
Be	04	$1.35\cdot10^{-22}$	600.	2585.	0.133	$3.2\cdot10^{-2}$	$4.6\cdot10^{5}$
Al	13	$1.29\cdot10^{-21}$	128.	654.2	0.222	$3.7\cdot10^{-2}$	$1.4\cdot10^{5}$
Ti	22	$3.53\cdot10^{-21}$	49.7	263.1	0.325	$4.1\cdot10^{-2}$	$6.1\cdot10^{4}$
Fe	26	$4.86\cdot10^{-21}$	24.1	129.9	0.435	$3.8\cdot10^{-2}$	$4.7\cdot10^{4}$
Ni	28	$5.60\cdot10^{-21}$	19.4	104.3	0.471	$3.5\cdot10^{-2}$	$4.8\cdot10^{4}$
Cu	29	$5.97\cdot10^{-21}$	19.6	105.2	0.470	$3.5\cdot10^{-2}$	$4.8\cdot10^{4}$
Mo	42	$1.21\cdot10^{-20}$	12.8	70.2	0.541	$3.0\cdot10^{-2}$	$5.6\cdot10^{4}$
Ta	73	$3.47\cdot10^{-20}$	5.18	30.0	0.672	$1.7\cdot10^{-2}$	$1.2\cdot10^{5}$
Re	75	$3.65\cdot10^{-20}$	4.01	23.3	0.699	$1.4\cdot10^{-2}$	$1.8\cdot10^{5}$
Pt	78	$3.93\cdot10^{-20}$	3.84	22.3	0.704	$1.3\cdot10^{-2}$	$1.9\cdot10^{5}$

From Figure 1 one can conclude that the Fe target is the most suitable for the $A_{2\pi}$ lifetime measurement for the range of the lifetime from 2.9 to $4.5 \cdot 10^{-15}$ s. The Ni and Cu target can be used also.

At choice of foils available on a market it is reasonable to take ones which are thinner or do not strongly exceed in thickness the values given in the table. Foils from different materials should have the value of the multiple scattering as close as possible.

References

[1] Bijnens J. et al., Phys.Lett. **B374** (1996) 210.