Direct Activation of Argon with a DT generator

R.Svoboda

September 7, 2017

DT generators

- $D + T \rightarrow n + {}^4He \quad E_n = 14.1$ MeV
- Used in Super-Kamiokande directly inside the detector to activate 16-O to 16-N via (n,p)
- Used in SNO and SNO+ outside the detector to activate CO2 gas which is piped into the detector in a sealed system
- Commerical devices used in oil well logging and in research – “easy” to obtain and use

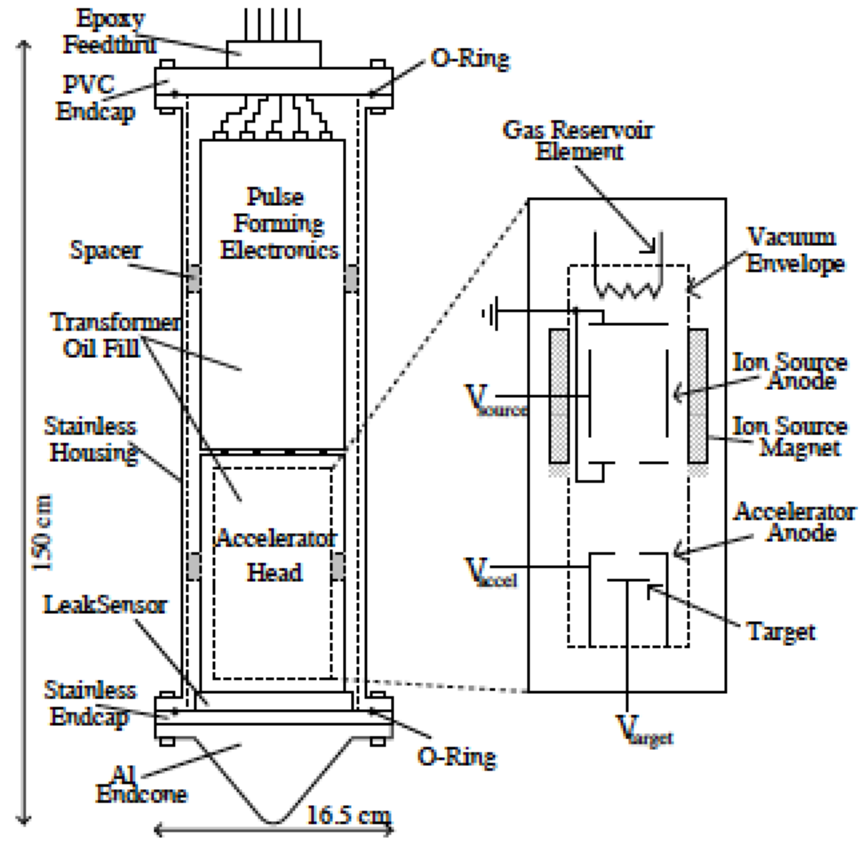

Figure 3.16: Schematic of the DTG accelerator head and pulse-forming electronics unit encased in the stainless steel housing. Additionally, the internal components of the accelerator head are shown.


NewYorkYankees

DUNE concept

- 40Ar(n,p)40Cl (analog of the reaction used in SK and SNO) gives a 1.35m daughter with 7.5 MeV Q-value
- Is this useful as a low energy calibration?
- Would it have unexpected consequences?

Isotope	reaction	daughter	threshold	cross-section	production per 10^10 n/kg	half-life	decay mode	Q-value	summary
40-Ar	(n,g)	41-Ar	6.10	3.50E-04	5.26E+07	109.61m	b-	2.492	short lived
99.6035%	(n,p)	40-Cl	-6.70	0.015	2.26E+09	1.35m	b-	7.482	short lived
-35.03989453	(n,d)	39-Cl	-11.09	0.002	3.01E+08	55.6s	b-	3.442	short lived
	(n,t)	38-Cl	-12.12	8.60E-07	1.29E+05	37.2m	b-	4.917	short lived
	(n,a)	37-S	-2.50	0.011	1.65E+09	5.05m	b-	4.865	short lived
	(n,2n)	39-Ar	-9.87	0.83	1.25E+11	269y	b-	0.565	
	(n,3n)	38-Ar	-16.47			stable			stable, not made by DT
	(n,4n)	37-Ar	-28.31			35.0d	e	0.814	not made by DT, electron capture irrelevant
38-Ar	(n,g)	39-Ar	6.60	1.50E-04	1.42E+04	269y	b-	0.565	
0.0629%	(n,p)	38-Cl	-4.13	8.20E-02	7.79E+06	37.24m	b-	4.917	
-34.71482031	(n,d)	37-Cl	-8.02			stable			stable
	(n,t)	36-Cl	-12.07	1.00E-06	9.50E+01	301000 y	b-	0.71	estimated cross section
	(n,a)	35-S	-0.22	2.40E-02	2.28E+06	87.37d	b-	0.167	very low energy
	(n,2n)	37-Ar	-11.84			35.0d	e	0.814	electron capture irrelevant
	(n,3n)	36-Ar	-20.63			stable			stable, not made by DT
	(n,4n)	35-Ar	-35.88			1.8s	e	5.966	not made by DT, electron capture irrelevant
36-Ar	(n,g)	37-Ar	8.79	4.60E-04	2.32E+05	35.0d	e	0.814	electron capture irrelevant
0.3336%	(n,p)	36-Cl	0.10	0.35	1.76E+08	301000 y	b-	0.71	
-30.23153906	(n,d)	35-Cl	-6.28			stable			stable
	(n,t)	34-Cl	-12.67	1.00E-06	5.04E+02	32m(IT)/1.5s			est cross section
	(n,a)	33-S	2.00			stable			stable
	(n,2n)	35-Ar	-15.26			1.8s	e	5.966	not made by DT, electron capture irrelevant
	(n,3n)	34-Ar	-28.00			0.84s	e	6.062	not made by DT, electron capture irrelevant
	(n,4n)	33-Ar	-45.06			0.17s	e,ep	10.597	not made by DT, electron capture irrelevant

DT generator can produce about 3x10^8 n/s on a good day, so look at 10^10 impinging on 1 kg to be injected into detector

This gives 2.3 billion 40-Cl atoms

Also gives other stuff (to first gen), with 39-Ar being the biggest worry. You get about 1.2×10^{11} of them!

Does that matter?

Natural argon has about 1 Bg/kg of 39-Ar, which corresponds to $1.7x10^{10}$ atoms.

So in 5 kilotons you have $8.4x10^{16}$

Therefore for your 2.3 billions 40-Cl you get an increase of 39-Ar in the detector of $(1.2x10^{11}/8.4x10^{16}) = 0.0000014\%$

So it doesn't matter

Need to follow up by tracking daughters

But is it useful?