Calibration with Radioactive Sources

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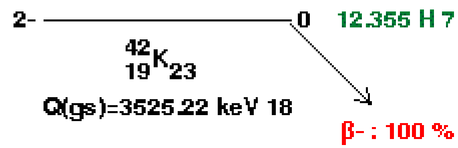
DUNE Calibration Task Force

Phone Meeting, 7-Sep-2017

NEW: Ar-42



Author: Jun Chen and Balraj Singh Citation:Nuclear Data Sheets 135, 1 (2016)

Parent Nucleus	Parent E(level)	Parent Jπ	Parent $T_{1/2}$	Decay Mode	GS-GS Q-value (keV)	Daughter Nucleus	Decay Scheme	ENSDF file
$^{42}_{19}K$	0	2−	12.355 h 7	β^-: 100 %	3525.22 *18*	$^{42}_{20}Ca$		

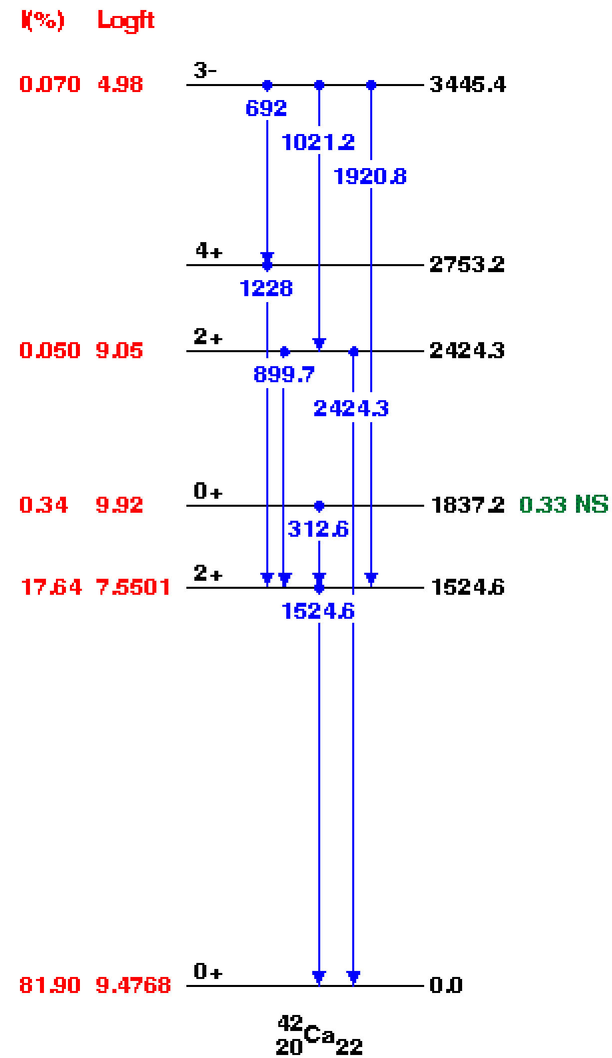
Beta-:

Energy (keV)	End-point energy (keV)	Intensity (%)	Dose (MeV/Bq-s)
21.41 *21*	79.8 *7*	0.070 % *10*	1.50E-5 *21*
415.41 *20*	1100.9 *4*	0.050 % *10*	2.1E-4 *4*
702.95 *20*	1688.0 *4*	0.34 % *3*	0.00239 *21*
824.32 *17*	2000.6 *3*	17.64 % *9*	0.1454 *7*
1565.86	3525.22 *18*	81.90 % *9*	1.2824 *14*

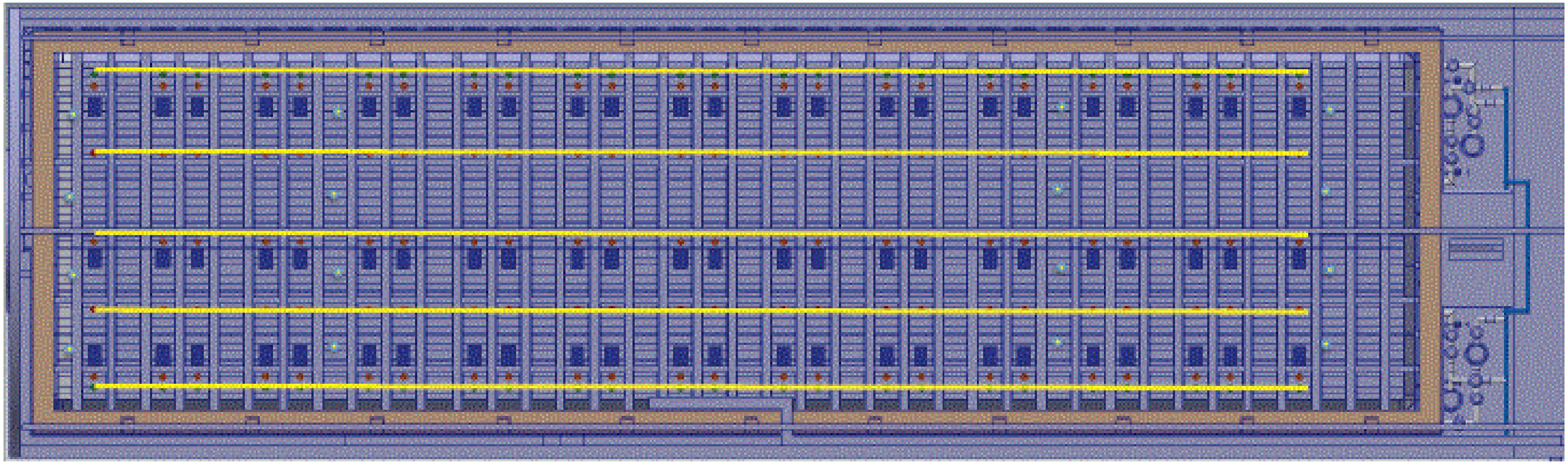
Mean beta- energy: 1430.5 keV *25*, total beta- intensity: 100.00 % *13*, mean beta- dose: 1.430 MeV/Bq-s *3*

Gamma and X-ray radiation:

Energy (keV)	Intensity (%)	Dose (MeV/Bq-s)
312.60 *25*	0.336 % *20*	0.00105 *6*
692.0 *8*	0.0033 % *7*	2.3E-5 *5*
899.7 *4*	0.052 % *3*	4.64E-4 *23*
1021.2 *9*	0.0201 % *14*	2.05E-4 *15*
1228.0 *15*	0.0024 % *11*	2.9E-5 *13*
1524.6 *3*	18.08 %	0.2756
1920.8 *10*	0.041 % *4*	7.9E-4 *8*
2424.3 *7*	0.020 % *3*	4.8E-4 *7*



Radioactive sources/movable TGradiant



- A 58Ni-252Cf source will emit 8-9 MeV gammas which are in the right range for calibration the energy response in the SN region. As absolute energy calibrations would otherwise be difficult this capacity should be foreseen.
  - A Ni source will probably need ~100mm space including N moderator.
- Dynamic T-gradient monitors should also be foreseen at the detector ends and it is reasonable to combine these functions in single larger penetrations. Assume a 250 mm crossing tube.
- 16 penetrations total. 8 roughly centered in each TPC drift and 8 at the ends of the detector. The penetrations at the ends should not be more than 0.5m from the field cage but sufficiently far away not to risk the field.
  - Need to check rate when a natural position is determined.

External radioactive source deployments

$^{58}Ni(n,\gamma)^{59}Ni$

TRI-PP-96-7
Apr 1996

A 7–9 MeV isotopic gamma ray source for detector testing

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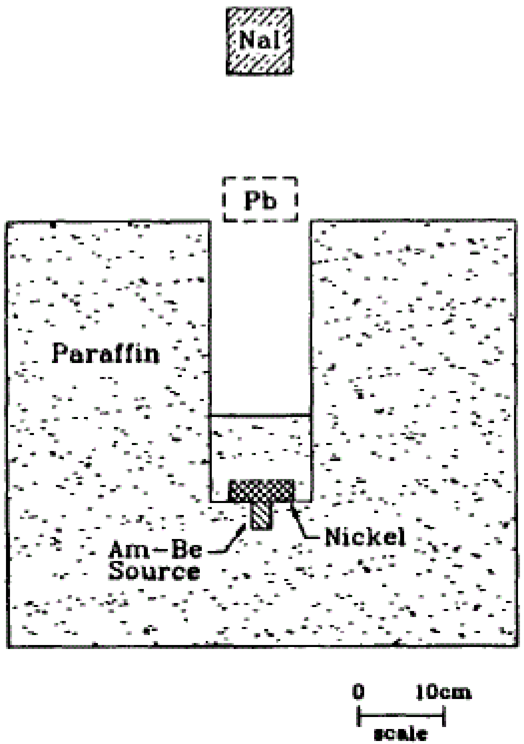


Table 1 - Thermal (n,γ) Rates from natural Ni taken from ref. [3]

Gamma Energy (MeV)	Rate (photons/100 captures)
8.997	26
8.532	11
8.119	2.5
7.817	6
7.528	4
7.22	0.4
7.05	0.6
6.839	9
6.58	2
6.34	1
6.10	1.3
5.99	0.4
5.82	3
5.70	0.6
5.31	1.3

[3] E. Troubetzkoy and H. Goldstein, "A compilation of information on gamma ray spectra resulting from thermal neutron capture", USAEC Report, ORNL-2904 Oak Ridge National Laboratory, 1960.

Using Cf-252 (or even better AmLi) would significantly reduce size of source, such that it would fit a 20 cm diameter feedthru

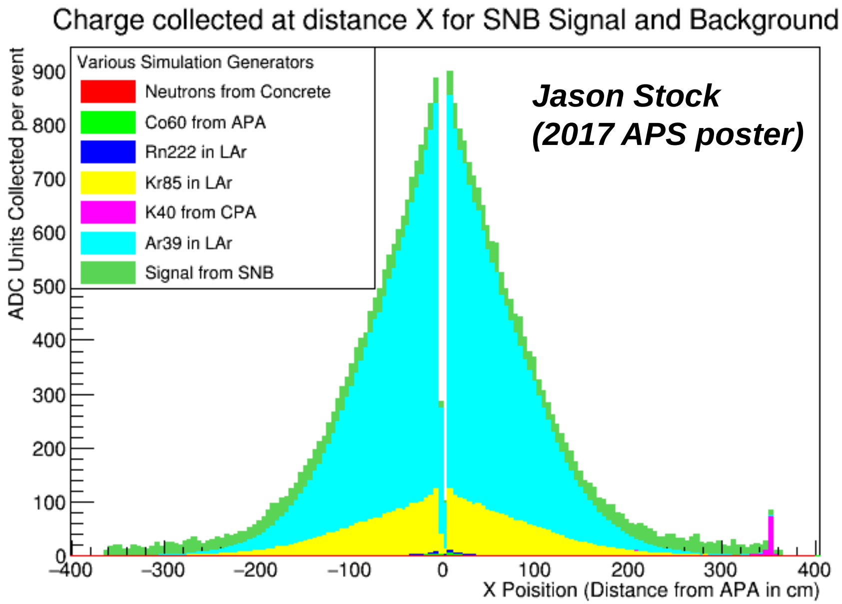
Double Chooz Calibration Deployment System inside Glove Box:

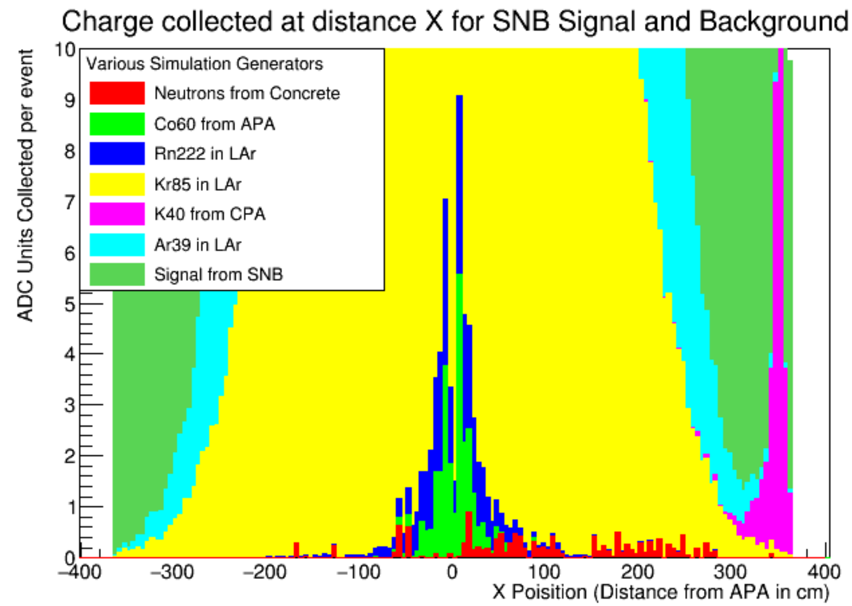
Automated fishline system for target deployments:

+/-2 mm precision over 7 m

-> 2 systems available in Jan 2018

Internal fixed radioactive sources



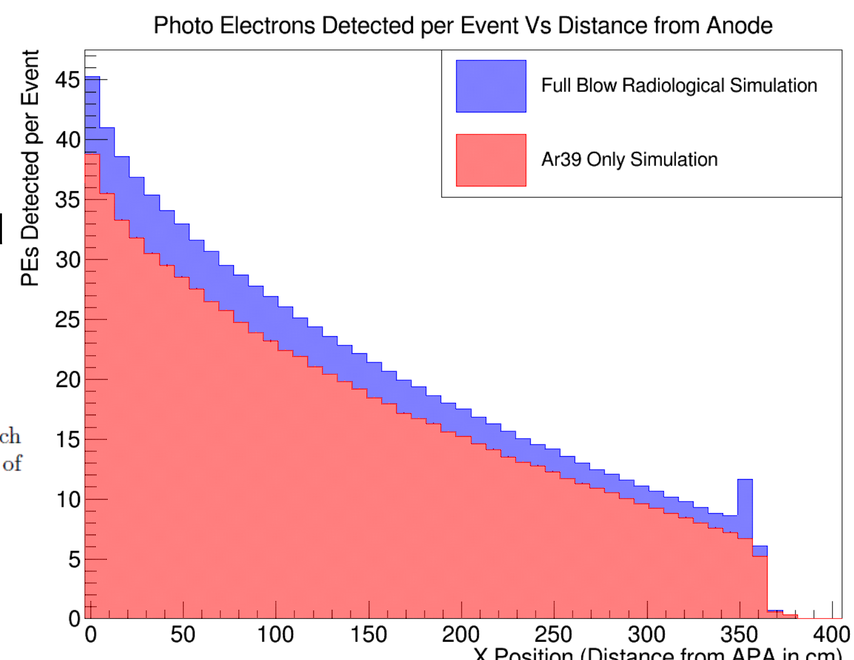


-> SNB events require at least some track-reco to stick out of background! (no simple trigger)

-> But we can spike local points on cathode & FC (electroplating isotopes dissolved in nitric acid and final seal with thin Teflon layer)

Use Thoron (-> Tl-208) or beta sources

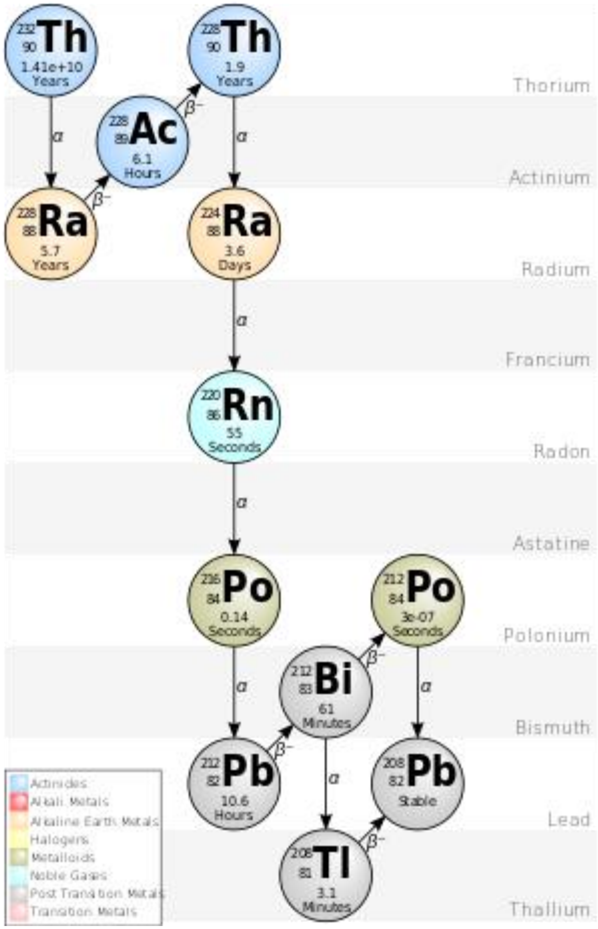
' β-sources with relatively high end point energies, such as for example ^{144}Ce (halflife of 284 d, daughter ^{144}Pr with $\beta- < 2.99$ MeV) or ^{106}Ru (halflife of 368 d, daughter ^{106}Rh with $\beta- < 3.54$ MeV). '



Injected short-lived radioactive sources: Detector Uniformity

⇒ **ensure uniform detector response:**
purity and electron lifetime
(employ purity monitors)

⇒ **impact of complicated flow pattern**
checked with fluid dynamic simulation
(employ RTDs)



Tl-208 gamma of 2.615 MeV
and beta with endpoint energy of up to 1.8 MeV