EDIT School - Calorimetry Lab1.B

"Detection of cosmic muons using CMS Lead Tungstate crystals"

Experimental protocol

1. Cable the PMT (both HV and signal cable)
2. HV = - 2450 V (Warning : Max HV = - 2500 V !!!)

3. **Compute the gain of the PMT**
   - Look at the single photoelectron (pe) signal with the scope.
   - Proper adjusting of the scope.
   - With the scope, measure the collected charge corresponding to 1 single pe :
     - estimate the area of the signal from the shape of the signal
     - measurement of the signal area (from Measure menu, including the statistics)
     - acquisition of the histogram of the area of the signal

   A(1pe) = ...

   Q(1pe) =................................

   - Compute the PMT gain.

   G = ...

   - Cross-check the obtained value with PMT specs.
   - In the histogram of the single pe signal charge there is an asymmetry towards lower values: What is this?

4. **Measure energy deposited by cosmic muons**
   - Adjust the scope settings to observe cosmic muons and get rid off the noise. To do this, select an appropriate attenuation factor [dB = -20 Log(A1/A2)] using the external attenuators. The muon signal must be fully contained inside the scope window. [Note: max possible voltage scale on the scope: 1V/div]
   - Start the acquisition, including the filling of the histogram of the integrated charge.
   - Record the start time for the acquisition

   start time of the acquisition = ...

   - Compute the expected rate of muons on the crystal and compare it with the measured one.

   muon rate (expected) = ...

   muon rate (measured) = ...

- Using all the elements discussed before **give an estimate of the expected result about the collected charge in the PMT due to the interaction of cosmic muons with the $PbWO_4$ crystal.** Cross-check results and expectations.

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from PDG 'The Review of Particle Physics'
K. Nakamura *et al.* (Particle Data Group), J. Phys. G **37**, 075021 (2010) http://pdg.lbl.gov/

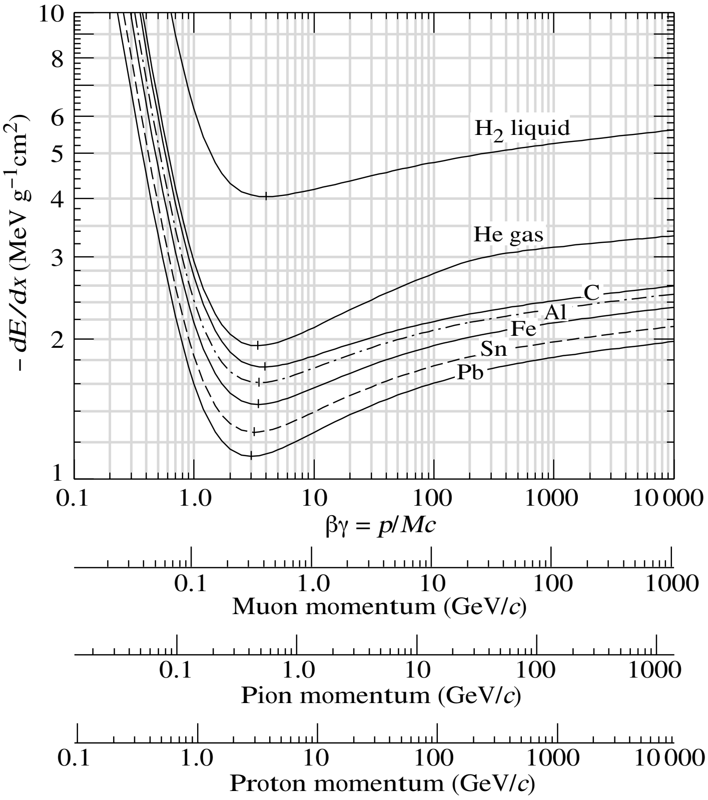

Table 28.4: Properties of several inorganic crystal scintillators. Most of the notation is defined in Sec. 6 of this *Review.*

Parameter: Units:	ρ g/cm^3	MP °C	X_0^* cm	R_M^* cm	dE^*/dx MeV/cm	λ_I^* cm	τ_{decay} ns	λ_{max} nm	$n^\natural$	Relative output†	Hygro-scopic?	$d(LY)/dT$ %/°C‡
NaI(Tl)	3.67	651	2.59	4.13	4.8	42.9	230	410	1.85	100	yes	−0.2
BGO	7.13	1050	1.12	2.23	9.0	22.8	300	480	2.15	21	no	−0.9
BaF_2	4.89	1280	2.03	3.10	6.5	30.7	630^s	300^s	1.50	36^s	no	-1.3^s
							0.9^f	220^f		3.4^f		$\sim 0^f$
CsI(Tl)	4.51	621	1.86	3.57	5.6	39.3	1300	560	1.79	165	slight	0.3
CsI(pure)	4.51	621	1.86	3.57	5.6	39.3	35^s	420^s	1.95	3.6^s	slight	−1.3
							6^f	310^f		1.1^f		
$PbWO_4$	8.3	1123	0.89	2.00	10.1	20.7	30^s	425^s	2.20	0.083^s	no	−2.7
							10^f	420^f		0.29^f		
LSO(Ce)	7.40	2050	1.14	2.07	9.6	20.9	40	402	1.82	83	no	−0.2
$LaBr_3$(Ce)	5.29	788	1.88	2.85	6.9	30.4	20	356	1.9	130	yes	0.2

* Numerical values calculated using formulae in this review.

♮ Refractive index at the wavelength of the emission maximum.

† Relative light output measured for samples of 1.5 X_0 cube with a Tyvek paper wrapping and a full end face coupled to a photodetector. The quantum efficiencies of the photodetector is taken out.

‡ Variation of light yield with temperature evaluated at the room temperature.
f = fast component, s = slow component