Use of phoswich detector for simultaneous monitoring of high energy photon and its applications in *in vivo* lung counting

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objective

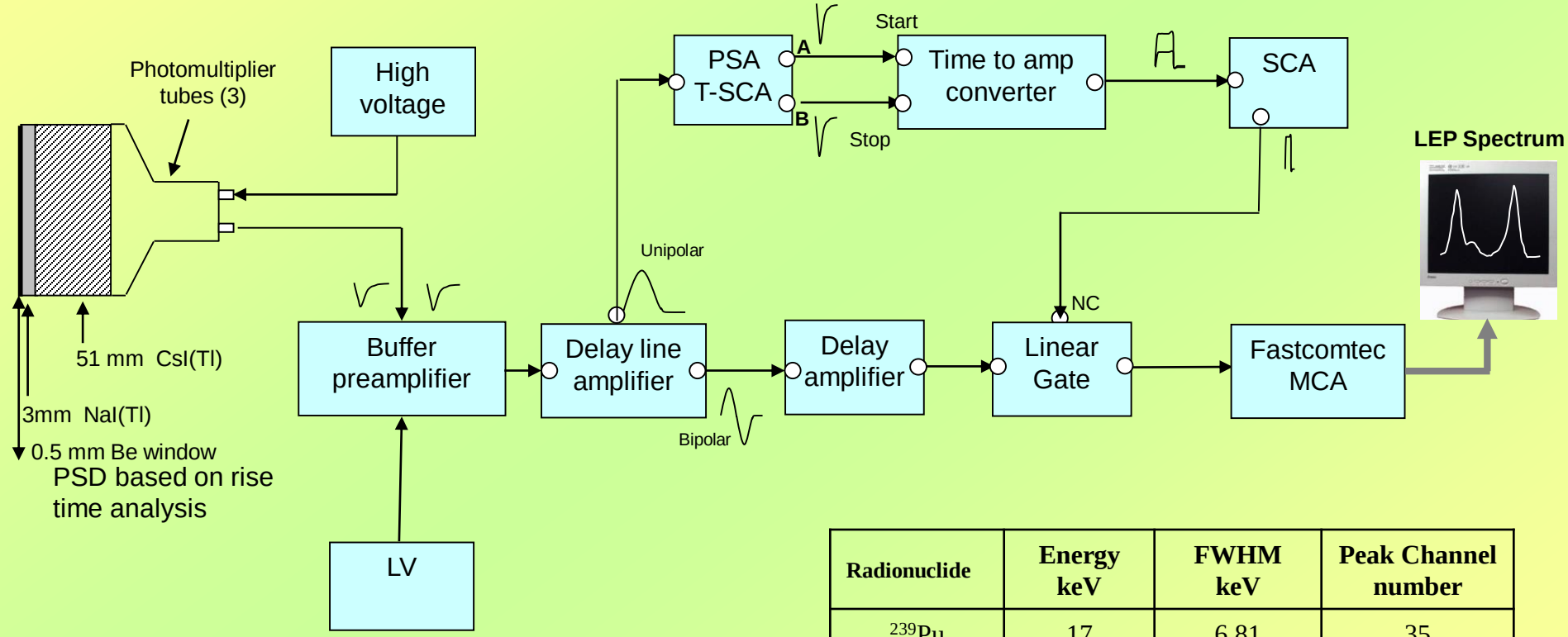
- Simultaneous measurement of both actinides and fission products using phoswich lung monitoring system.
- While meeting the above objective system parameters of low energy photon measurement (actinides) shall not be altered.

To meet the objective

- Usually the pulses from NaI detector, along with PSD electronics is utilised for the in-vivo assessment of actinides, which are low energy photon emitters.
- The pulses from CsI portion of Phoswich are utilised only for the background reduction in the low energy regions (PSD) and not for spectral measurements, though the signals carry pulse height information of the high energy photons.
- Simultaneous recording of pulse height spectrum from CsI detector can provide the information about HEP source present in the subject body (which is most probable in fuel cycle facilities) or environment around the detector, from a single measurement.
- The modification does not call for splitting detector signals or inclusion of any additional electronic module to the PSD electronics.

What was done?

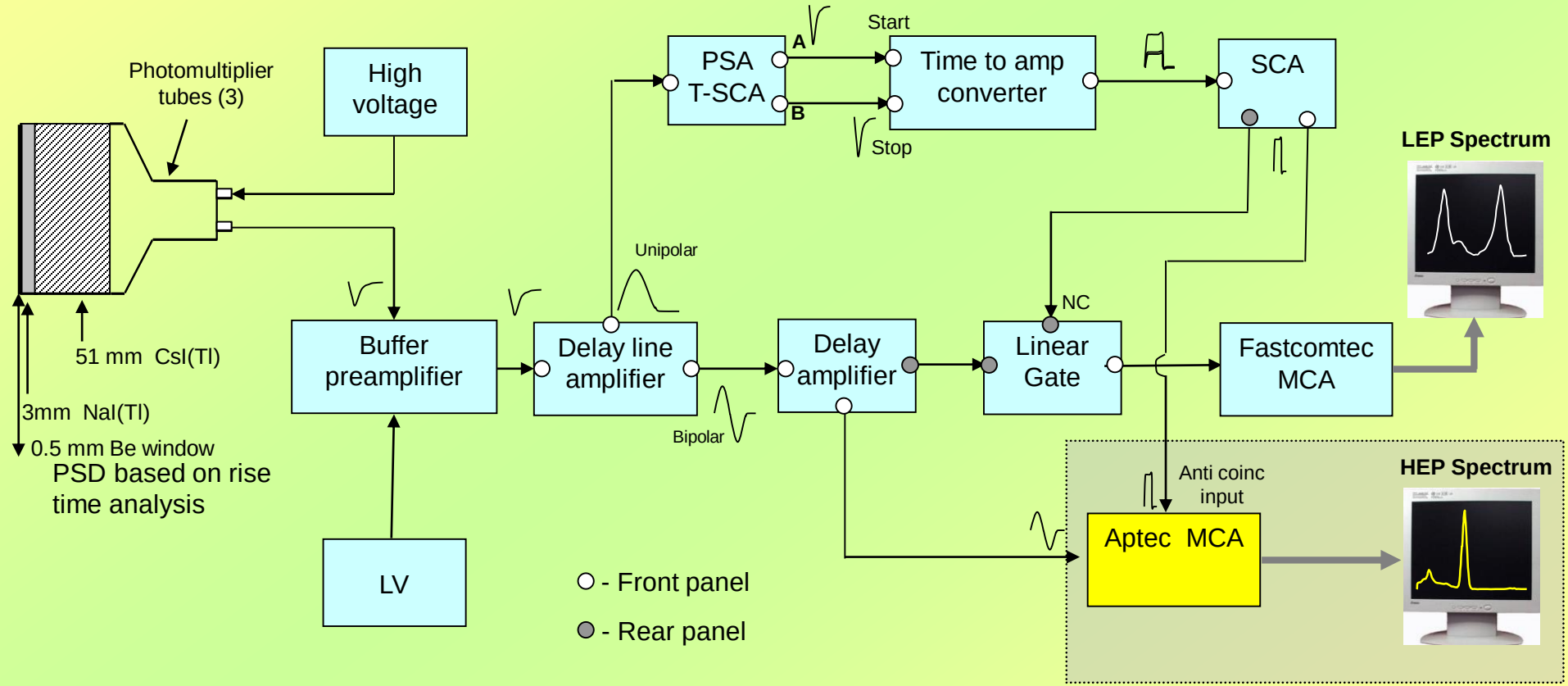
PSD electronics for recording only the low energy photon spectrum



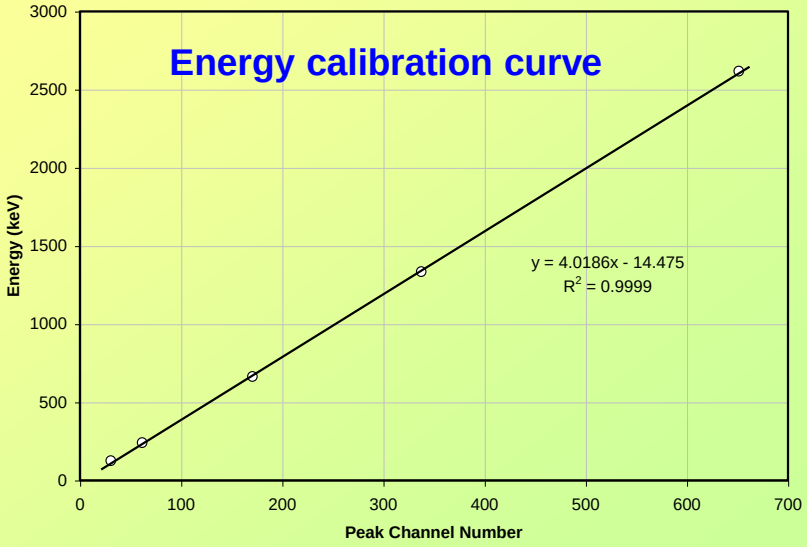
Radionuclide	Energy keV	FWHM keV	Peak Channel number
^{239}Pu	17	6.81	35
^{241}Am	60	7.73	135
^{57}Co	122	12.06	263
Figure Of Merit 3.0 (timing spectrum)			

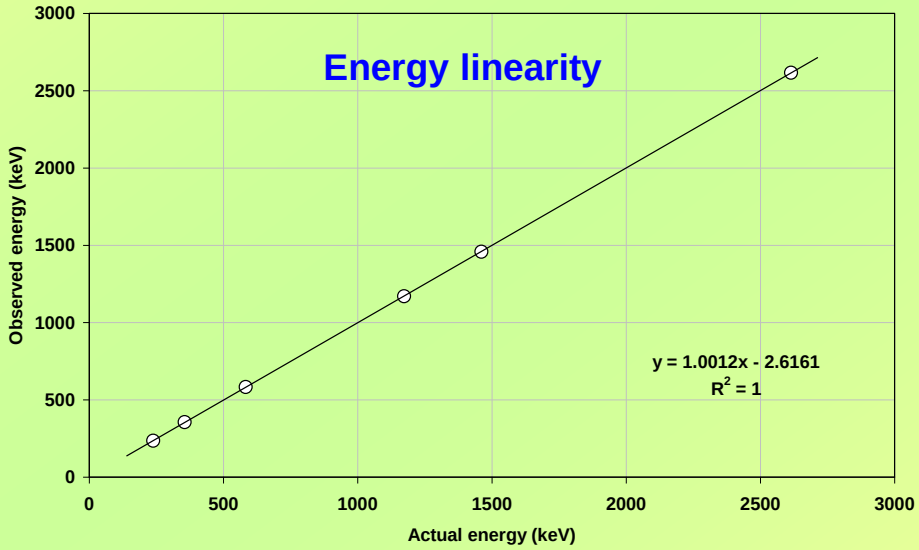
What was done?

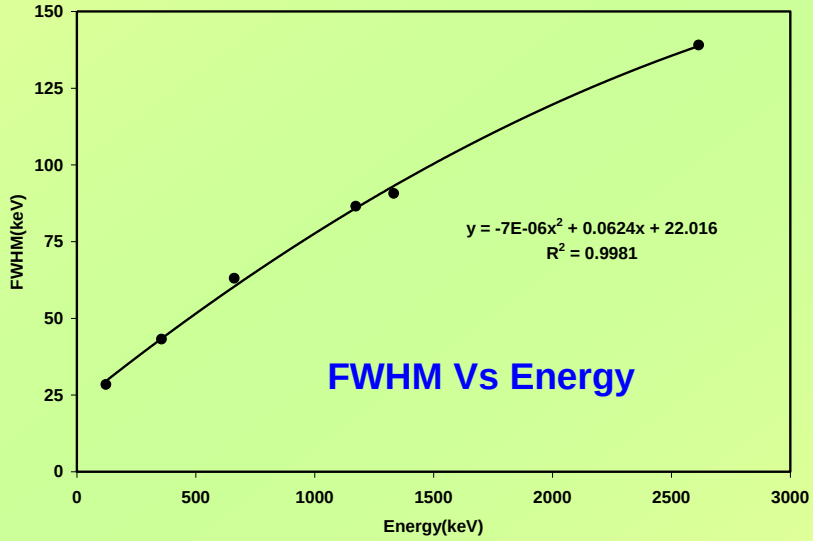
PSD electronics for simultaneous recording of both low energy photon & high energy photon spectrum

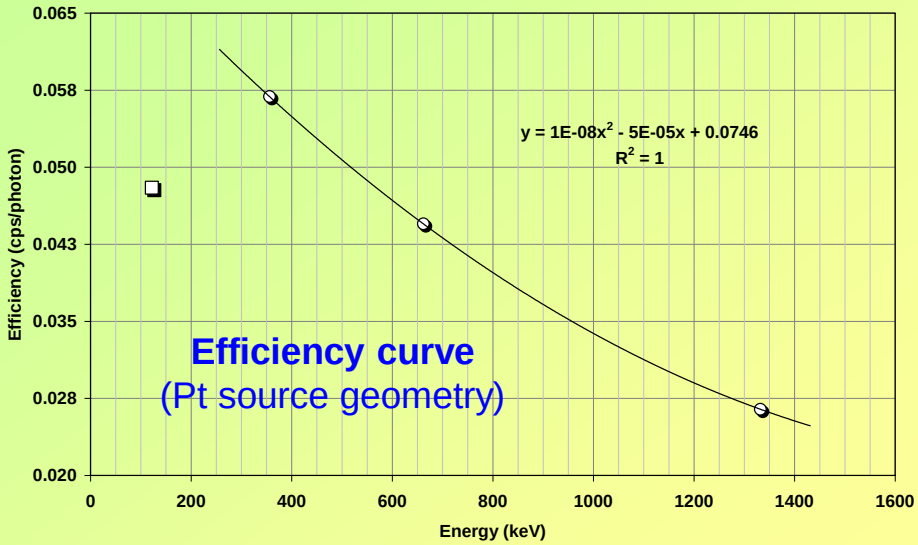


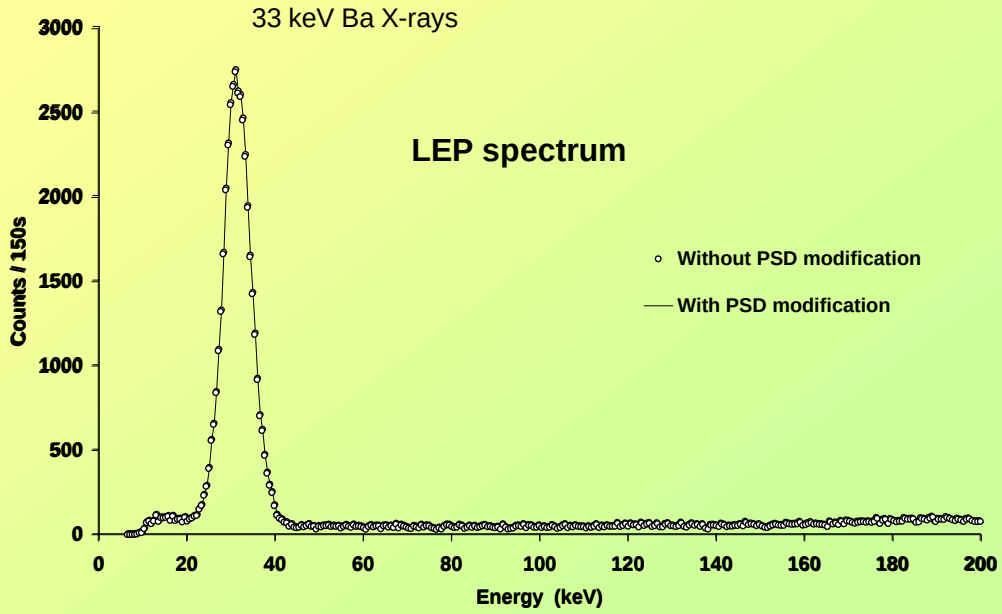
Performance evaluation as Gamma Ray Spectrometer with modified PSD

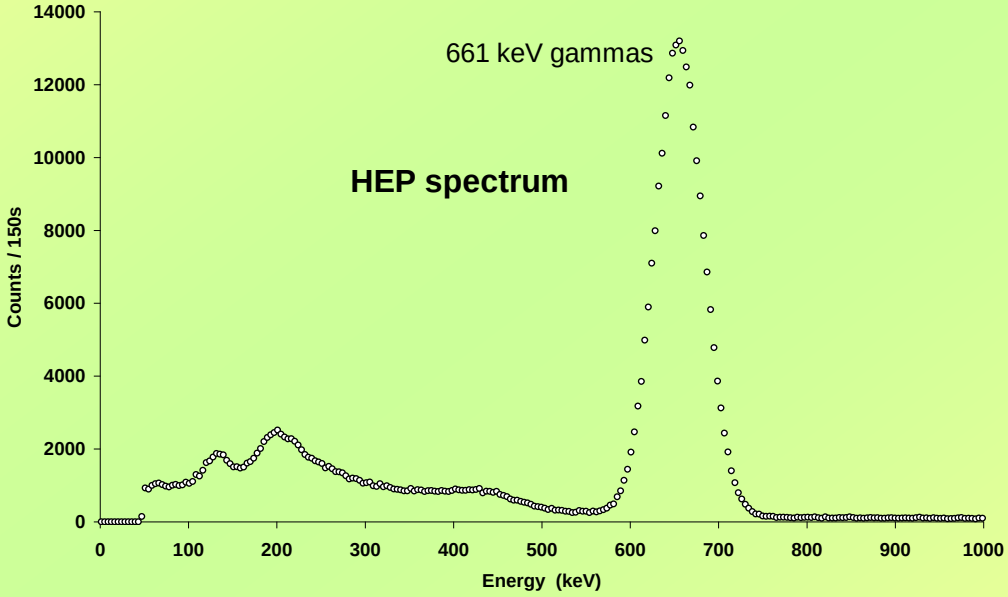








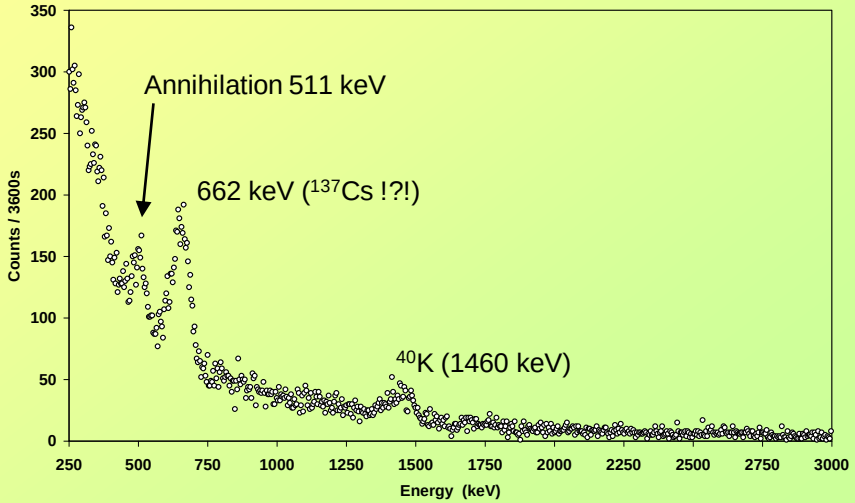




Simultaneous recording of low energy & high energy photon spectrum with ^{137}Cs source

Nuclide	System	Efficiency (cps/Bq)	MDA (Bq)
^{137}Cs	Phoswich	0.0061	16
	SC	0.0025	260
^{60}Co	Phoswich	0.0110	10
	SC	0.0047	140
^{208}Tl	Phoswich	0.0126	3
	SC	0.0014	250

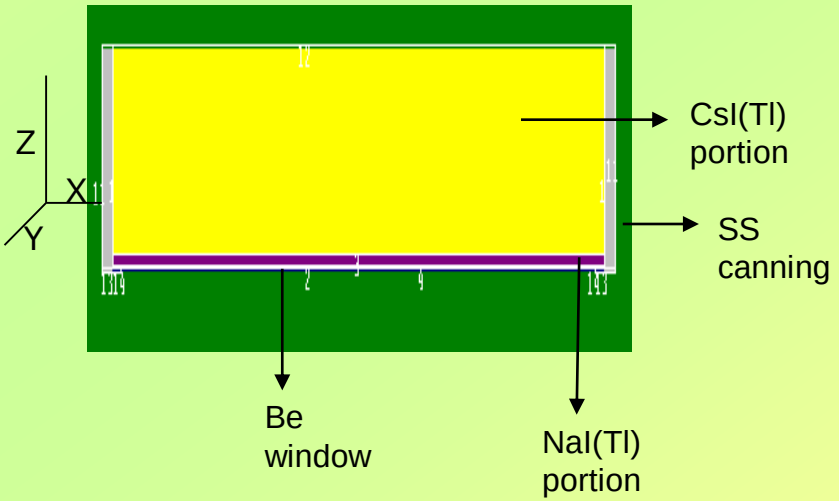
Steel room background spectrum – Detection of ^{137}Cs contamination in CsI portion



- Presence of all possible external sources in the steel room were excluded
- Detector contamination suspected
- Literature survey confirmed
- Personal communication with detector manufacturer

Quantification of ^{137}Cs contamination by MCNP simulation

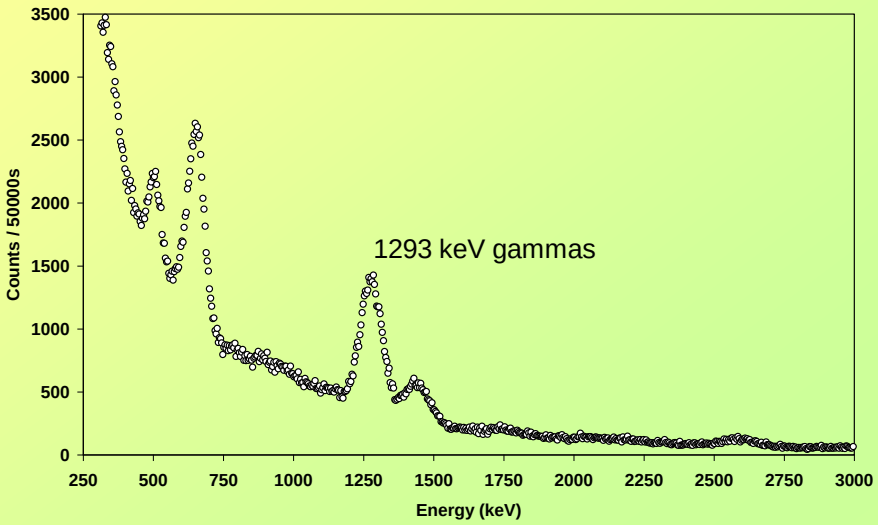
Phoswich detector modeling

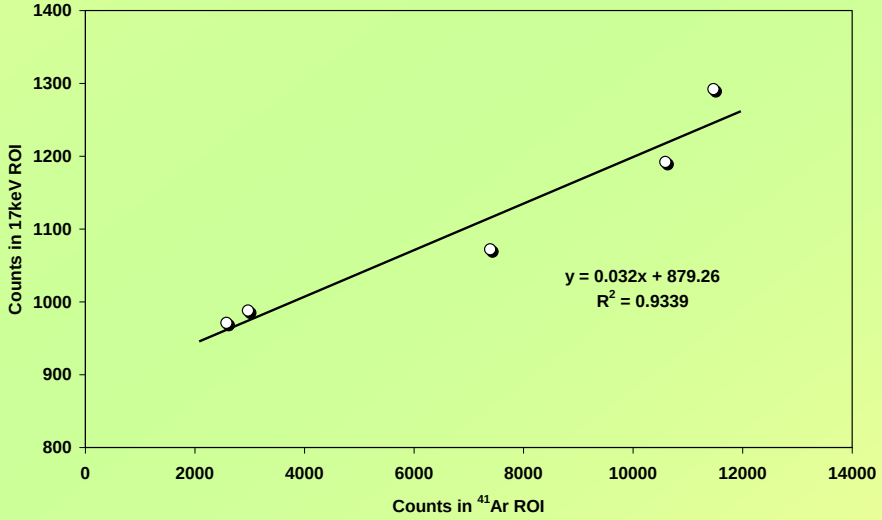


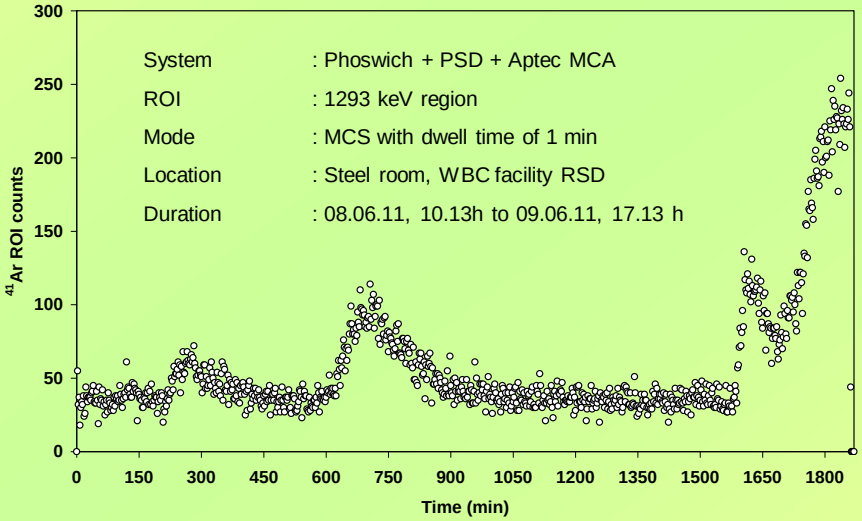
- Efficiency –source inside the detector- using MCNP simulation
- Contribution from 1173 kev beta also
- From the experimental cps-activity estimation
- Closely matching - manufacturer quoted value

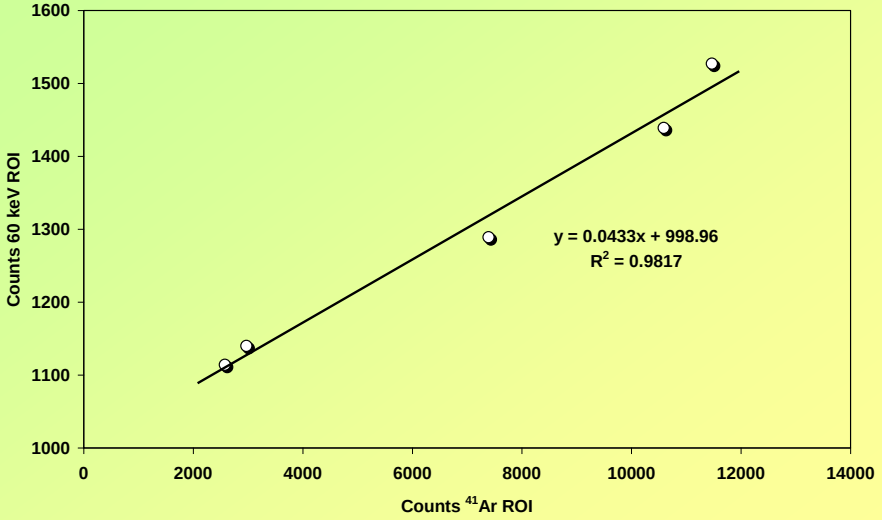
What was learned?

Detection and quantification of ^{41}Ar interference

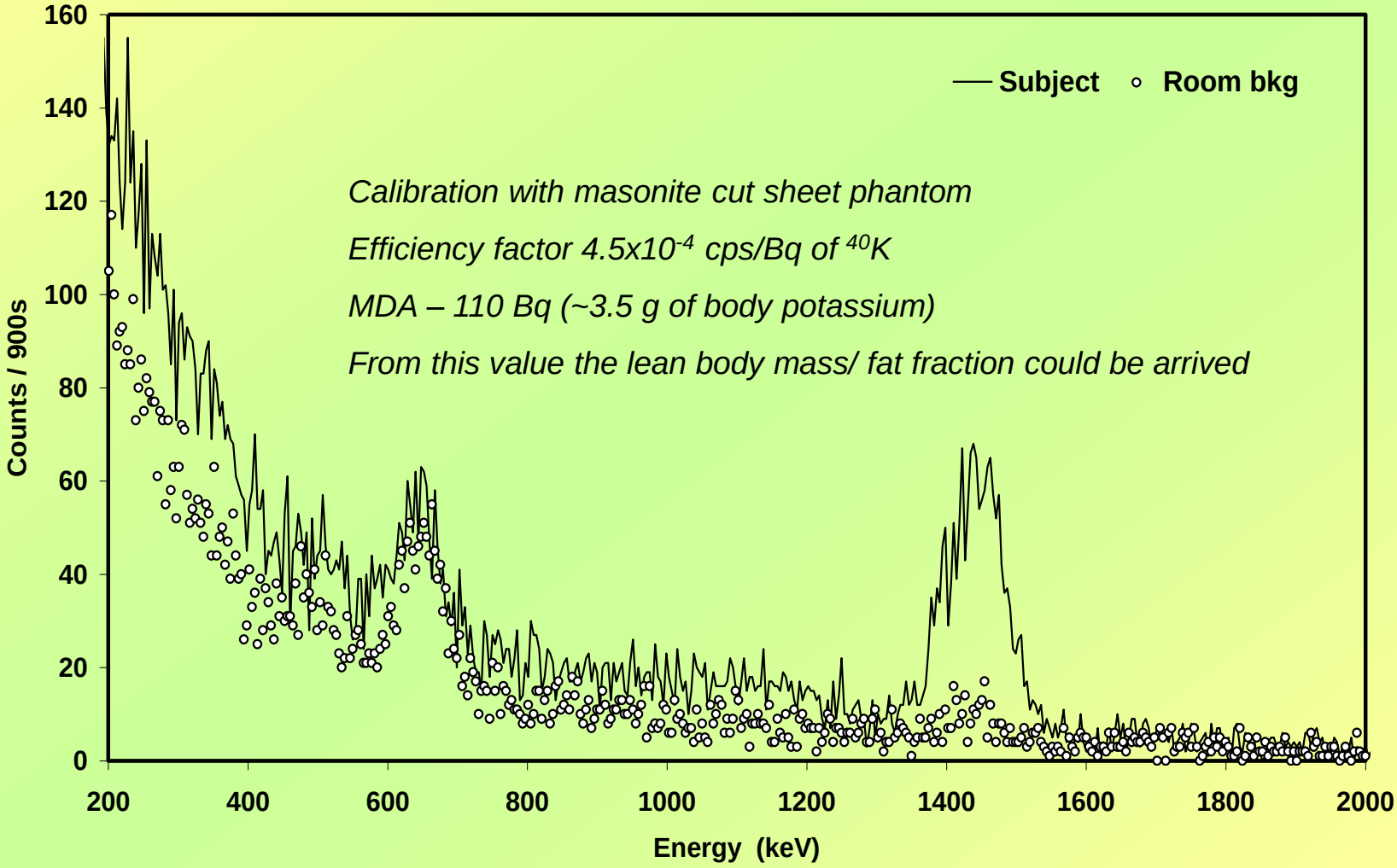








Feasibility study of ^{40}K measurements in subjects



Conclusion

- The PSD electronics is suitably reconfigured without adding any additional electronic modules for simultaneous recording of HE photon spectrum from a single phoswich detector.

- Modification done has not altered the figures of merit of the system established for in-vivo lung monitoring, for which the system has been optimized.

- The phoswich system with reconfigured PSD has good energy linearity with in ±4 keV and a satisfactory FWHM performance in the energy range of 122 keV to 3 MeV. The efficiency calibration exercise with point source geometry demonstrated that HEP spectrum of phoswich could be used for activity estimation.

- Evaluation also revealed that the CsI detector portion of phoswich detector was found to have presence of 1.4 Bq of ^{137}Cs as contamination.

- The interference of ^{41}Ar (a site specific problem) in LEP measurements could be easily detected and quantified.

- Phoswich detector has high sensitivity to ^{40}K variation in the subjects with MDA value of 110 Bq which equivalent to body potassium variation of 3.5 g. This sensitivity can be exploited for estimating Lean Body Mass (LBM) and total body fat fraction which are required as part of lung activity estimation of LEP emitters.

- A single phoswich detector works as lung counter with additional capability to simultaneously detect and quantify any other interfering HE gamma emitters present in the subjects.