A New Measurement Method For Tritium Rapid Detection by LSC

IM.CAEP
Xu Qinghua
xuqinghuawork@sina.com

Outline

- Background
- Results and discussion
  - Materials and methods
  - Background
  - FOM value for channel
  - Sample spectra
- Sumary

Background

- There are many places related to occupational radiation of tritium.
- The rapid measurement of tritium was needed.
- The sample size is very small.
    - HTO/HT in the air.
    - The tritium in plant and animal sample.
- The activity concentration of natural water samples is so low.
- Liquid scintillation counting (LSC) is the most commonly used technique for measuring tritium.

Quantulus 1220

- ^{3}H configuration:

  SP 11 — random coincidence spectrum

  SP 12 — beta event spectrum (3H) + random coincidence + background

  SP 21 — guard detector spectrum (not in coincidence with the beta events)

  SP 22 — guard coincidence events (effective guard pulses)

Materials and methods

- Ultra Low Level Liquid Scintillation Spectrometer Wallac 1220 Quantulus manufactured by PerkinElmer.
- ULTIMA GOLD LLT cocktail.
- 20 ml glass vials (low potassium borosilicate glass) and 20 ml Teflon-copper vials.
- Distilled raw water (deep well water).
- Tritiated water 600 dpm/ml (reference date September 28, 2002).
- Standards, backgrounds and samples were mixed with a scintillation cocktail. The preparation method of background and standard was the same as the preparation of samples.

Background

Table.1 The composition of background samples

Entry	Vial type	Cocktail	Others
1	-	-	-
2	Glass	-	-
3	Teflon-copper	-	-
4	Glass	-	-
5	Glass	-	Glass
6	Teflon-copper	14	-
7	Glass	5	-
8	Glass	10	-
9	Glass	14	−
10	Glass	20	−
11	Glass	14	Tritium standard

Background

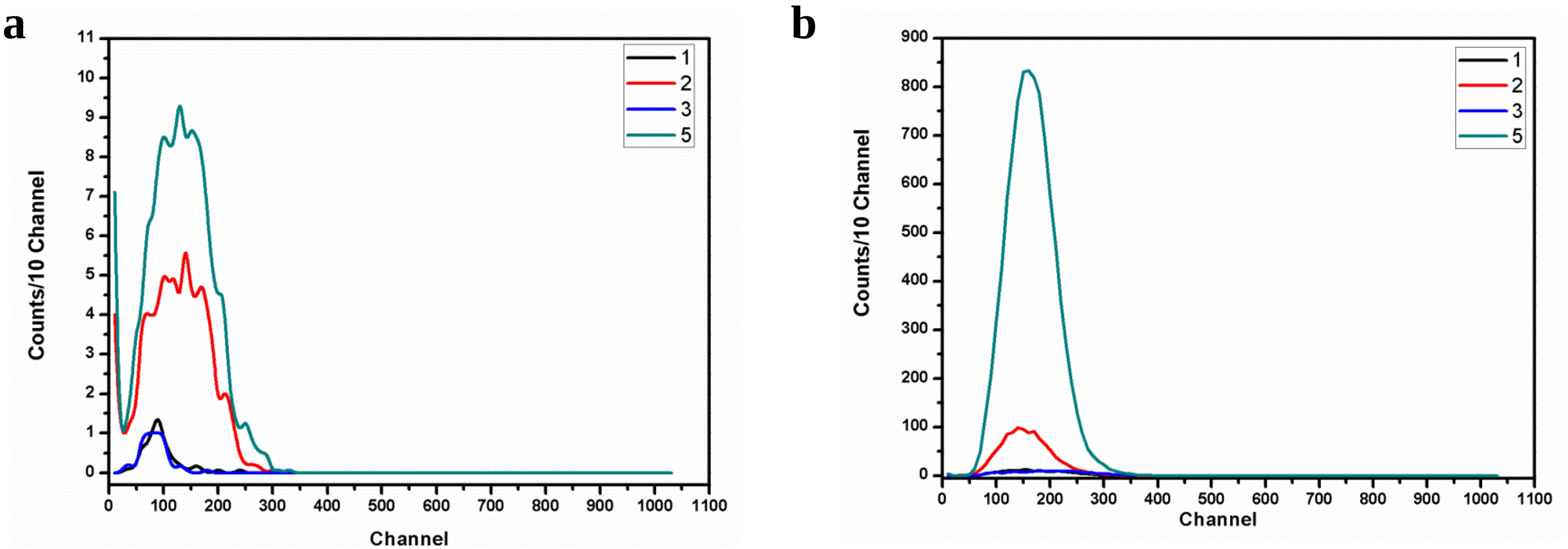
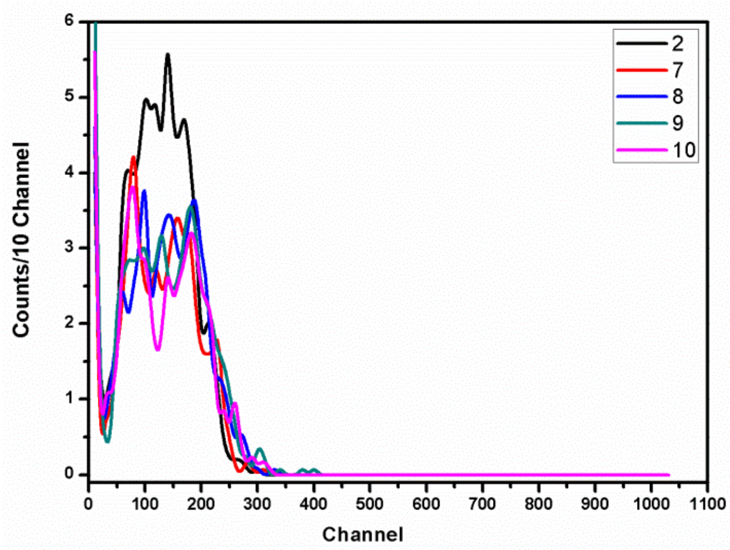


Fig.1. SP11(left) and SP12(right) spectra of empty load, empty vials and glass vial with glass.

Entry	Vial type	Cocktail	Others
1	-	-	-
2	Glass	-	-
3	Teflon-copper	-	-
5	Glass	-	Glass

Background

c



d

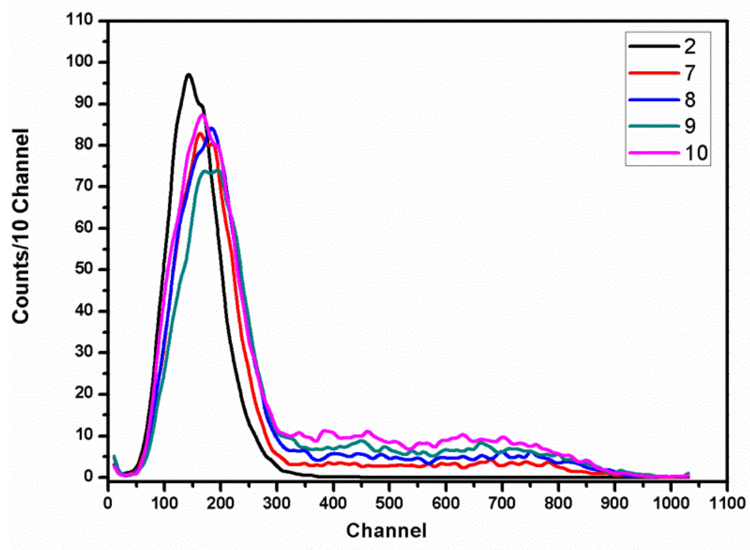
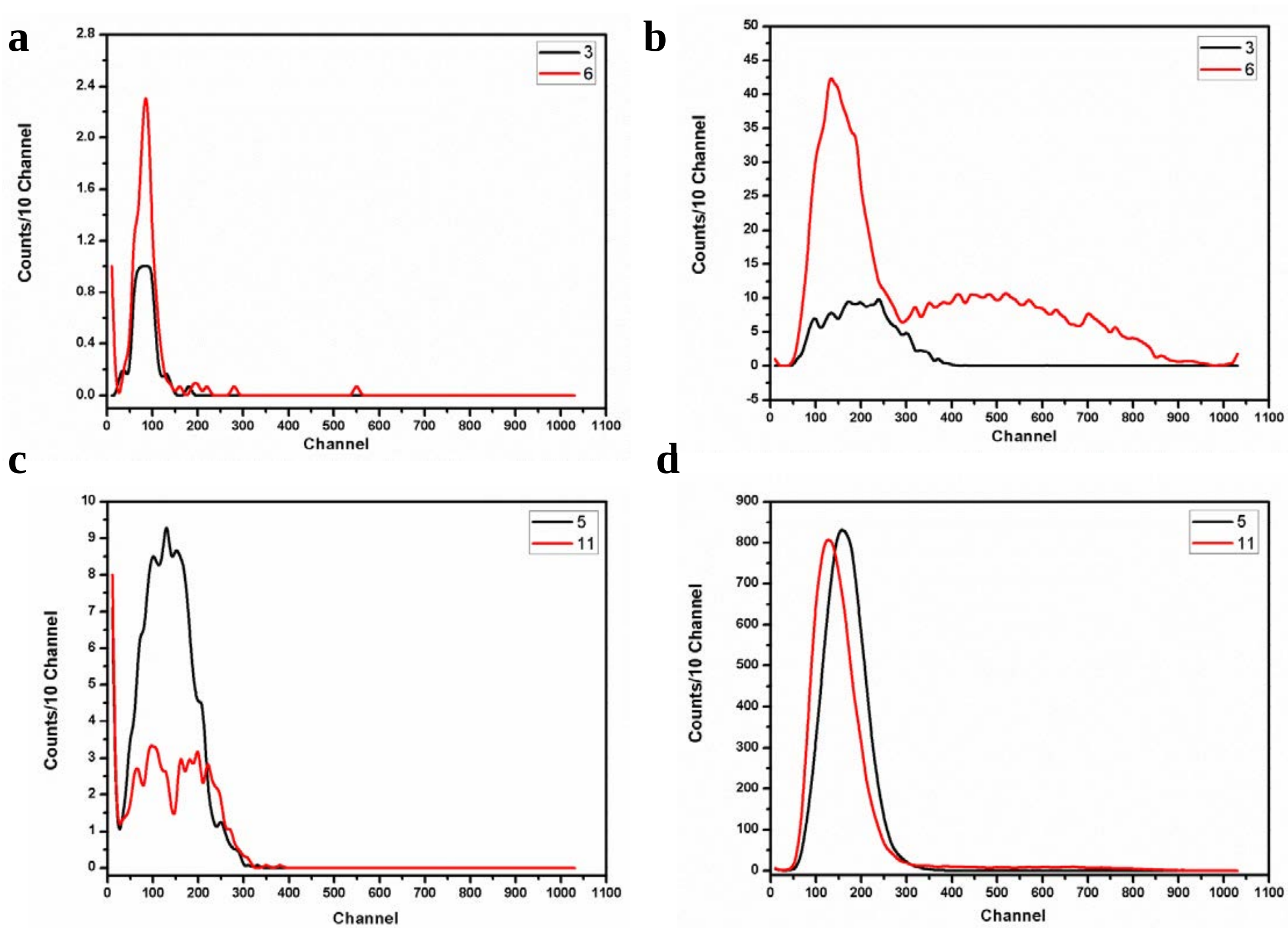


Fig.1. SP11(left) and SP12(right) spectra of empty glass vials and glass vial with cocktail.

Entry	Vial type	Cocktail	Others
2	Glass	-	-
7	Glass	5	-
8	Glass	10	-
9	Glass	14	−
10	Glass	20	−

Background



Entry	Vial type	Cocktail
3	Teflon-copper vials	-
6	Teflon-copper vials	14

Entry	Vial type	Cocktail	Others
5	Glass	-	Glass
11	Glass	14	Tritium standard

Fig.2. SP11(left) and SP12(right) spectra of empty vials, glass vials with glass and vial with tritium standard.

FOM value for channel

Table.2 FOM vs channel.

Entry	Channel	Counts	Efficiency	Background	FOM
1	150-170	1962.5	0.08	22.3	0.00028
2	140-180	3220.1	0.13	35.8	0.00046
3	130-190	4413.6	0.18	49.7	0.00062
4	120-200	5537.3	0.22	62.8	0.00078
5	110-210	6506.9	0.26	79.9	0.00084
6	100-220	7338.6	0.29	93.2	0.00092
7	90-230	7973.5	0.32	106.6	0.00095
8	80-240	8391.8	0.33	116.2	0.00096
9	70-250	8603.4	0.34	123.1	0.00095
10	60-260	8700.9	0.35	128.78	0.00093
11	50-270	8751.6	0.35	133.3	0.00091
12	40-280	8782.6	0.35	138	0.00088
13	30-290	8805.6	0.35	143.5	0.00085
14	20-300	8825.7	0.35	148.3	0.00083
15	10-310	8846.3	0.35	152.3	0.00081
16	0-320	8858.4	0.35	155.4	0.00079

Underground water, 20 metres distance to the surface.

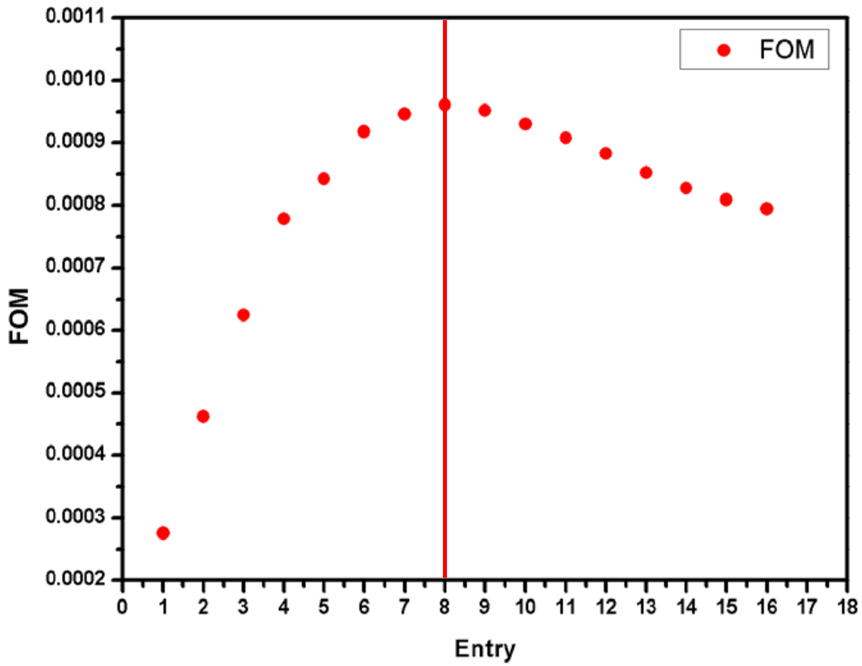


Fig.5a. FOM vs channel.

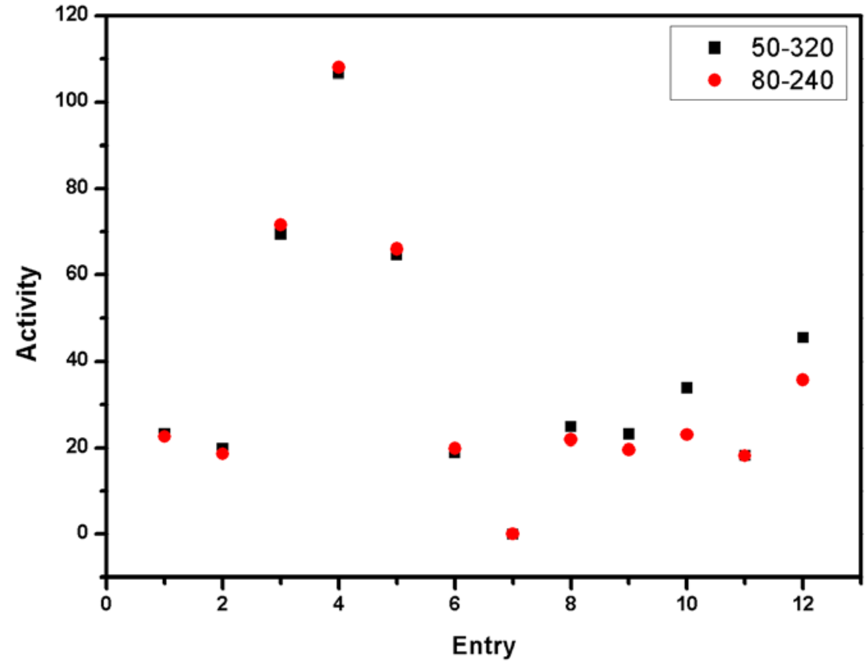
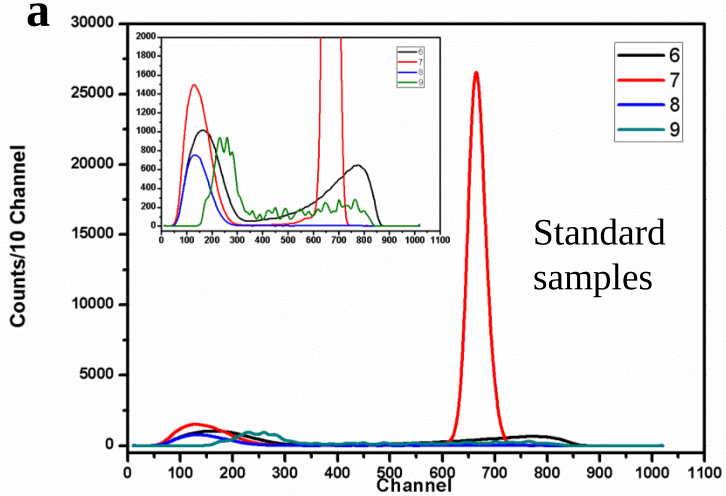


Fig.5b. Activity measurement for different channel range.

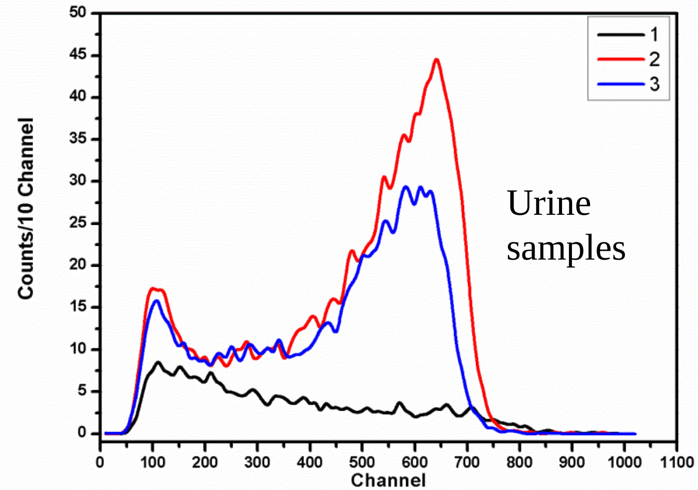
8	80-240	8391.8	0.33	116.2	0.00096

Samples spectra

a



b



c

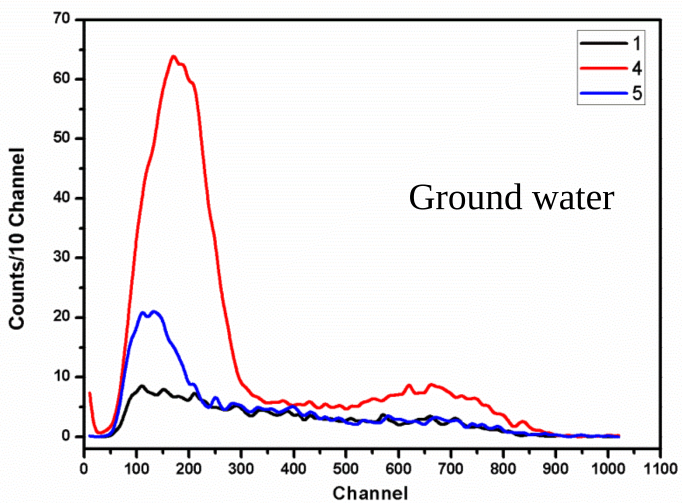


Table.3 The composition of samples

Entry	vial	Cocktail/mL	Sample
1	Glass	14	Tritium free water 6mL
2	Glass	14	Urine 6mL
3	Glass	14	Urine 6mL
4	Glass	14	Ground water 6mL
5	Teflon-copper vials	14	Ground water 6mL
6	Glass	14	K standard 6mL
7	Glass	14	Plutonium standard 6mL
8	Glass	14	Tritium water standard 6mL
9	Glass	14	Uranium standard

Fig.6. Samples spectra for the tritium detection model.

HNO_3 and DMSO

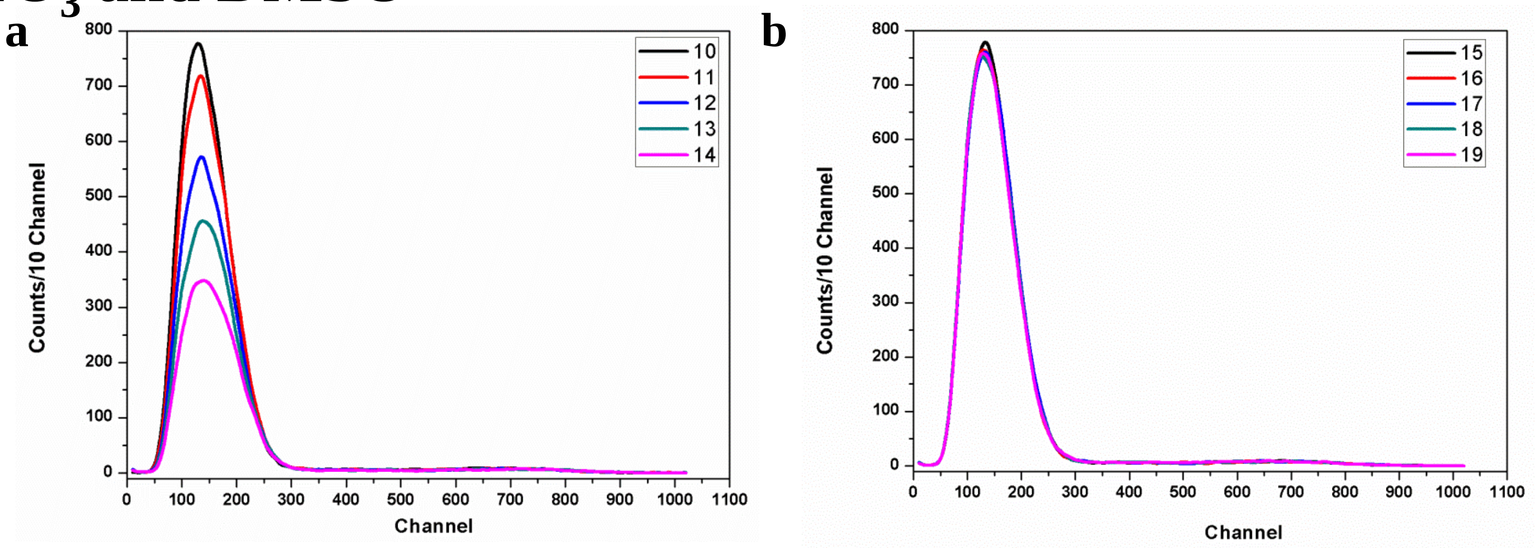


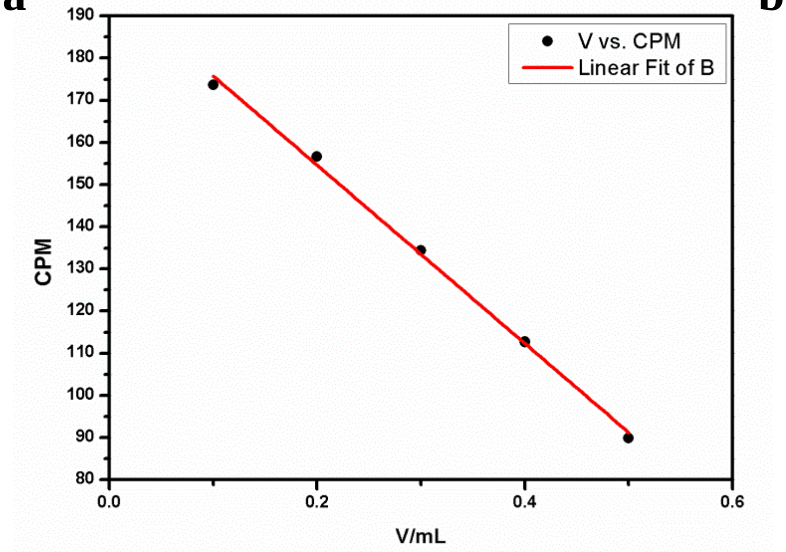
Fig.7a. Effect of HNO_3 and DMSO on the tritium detection.

Table.4 The composition of quenching samples

Entry	vial	Cocktail/mL	Addition
10	Glass	16	0.1 mL, 34% HNO_3
11	Glass	16	0.2 mL, 34% HNO_3
12	Glass	16	0.3 mL, 34% HNO_3
13	Glass	16	0.4 mL, 34% HNO_3
14	Glass	16	0.5 mL, 34% HNO_3
15	Glass	16	0.1 mL, DMSO
16	Glass	16	0.2 mL, DMSO
17	Glass	16	0.3 mL, DMSO
18	Glass	16	0.4 mL, DMSO
19	Glass	17	0.5 mL, DMSO

HNO_3 and DMSO

a



b

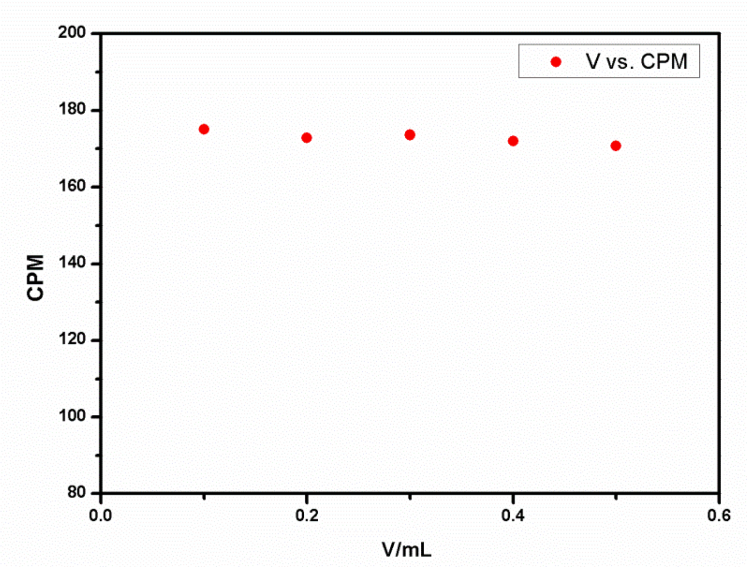


Fig.7b. Line of V vs. CPM on the tritium determination effected by HNO_3 and DMSO .

Results and discussion

Lines fitted to the efficiency vs. SQP(E)

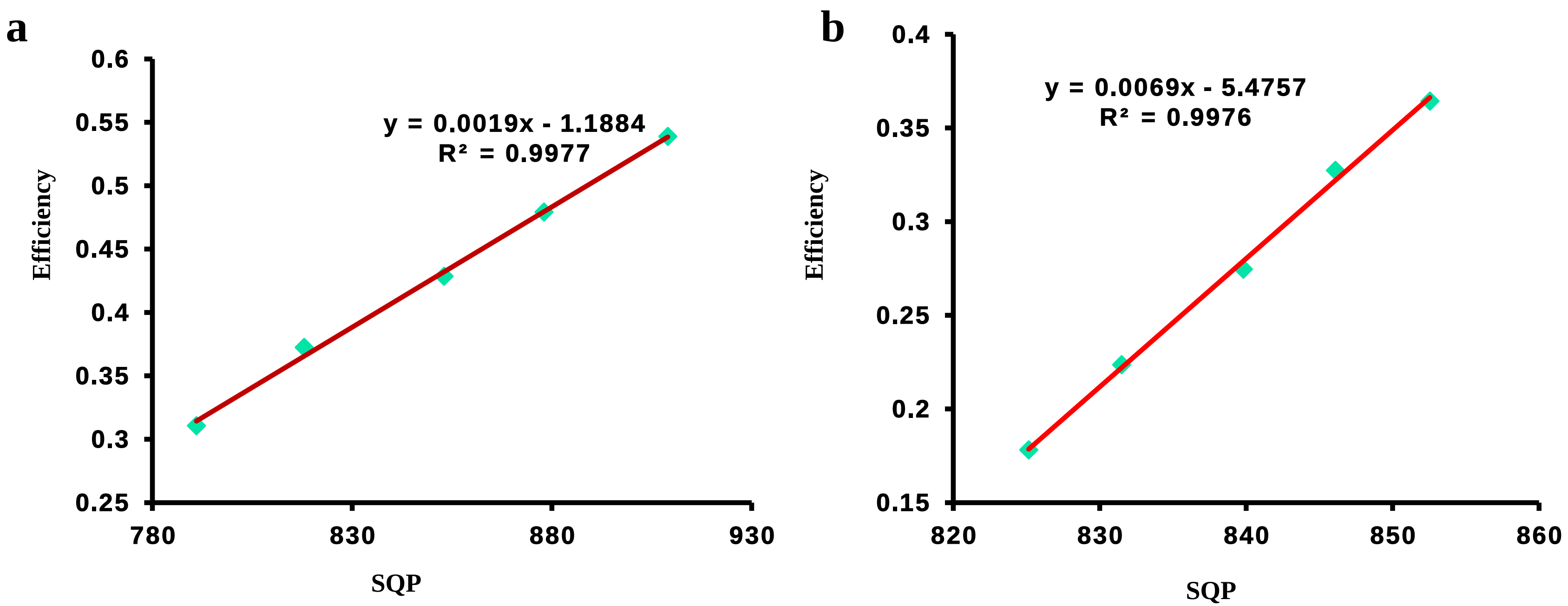


Fig.8. The lines fitted to the efficiency vs. SQP(E): the standard quench parameter take with the tritium activity was 160 Bq, and quench reagent was H_2O (left); the tritium activity was 160 Bq, and quench reagent was HNO_3 (right).

Results and discussion

Comparation of the efficiencies

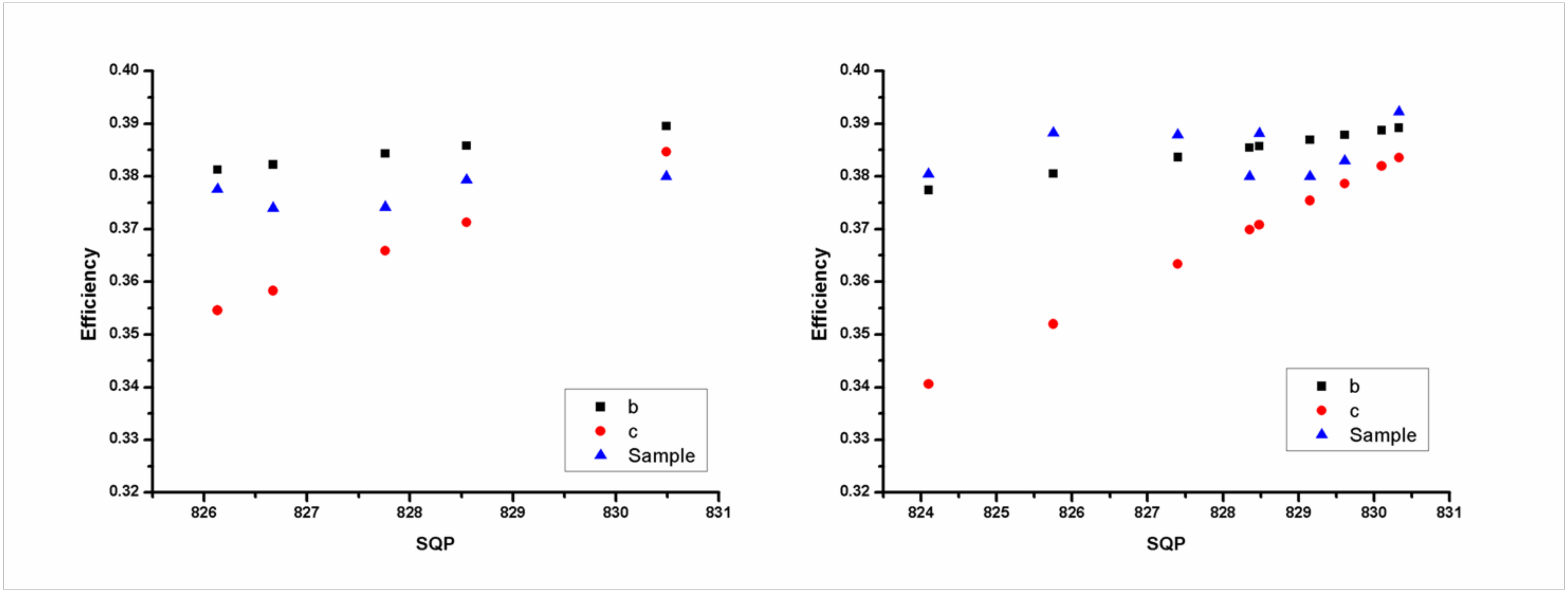


Fig.9. Efficiency received from different standard quenching parameter using tritium water standard. The left was distilled samples and the right was undistilled. a: Efficiency achieved from the equation vision on Fig.8b; b: Efficiency achieved from the equation vision on Fig.8c; Sample: Efficiency received from added standard.

Summary

- The presence of potassium 40 in the glass bottle causes background elevation in the sample measurement process.
- In the process of rapid measurement, the beta radioactive ions in solution will cause high measurement results, the position of the peak shift to the right.
- The influence of other β dacay cna be reduce by the shift of the peak.
- In the process of rapid measurement, efficiency of liquid scintillation counting methods can be constructed from standard quenching parameter using tritium water standard.

Thank you for your attention !