Characterisation of CR-39 Detectors at the CERF Reference Facility at CERN

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1) Introduction

The CERN-EU high-energy Reference Field (CERF) is a calibration facility dedicated to detector testing, where above its concrete roof, a neutron field similar to the one encountered at commercial flight altitudes of 10 to 20 km can be found. The CR-39 detectors were irradiated at 2 different positions (CT5 and CT12).

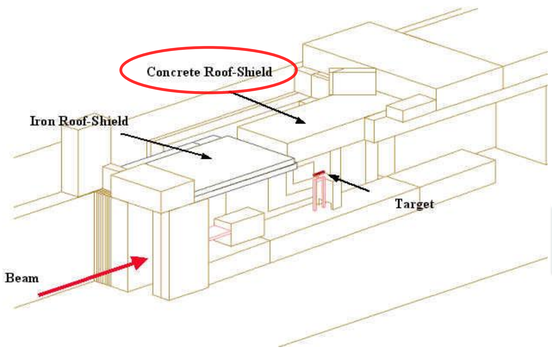


Fig 1. Complex neutron field on the concrete Roof-Shield situated right above the irradiated target

2) Materials

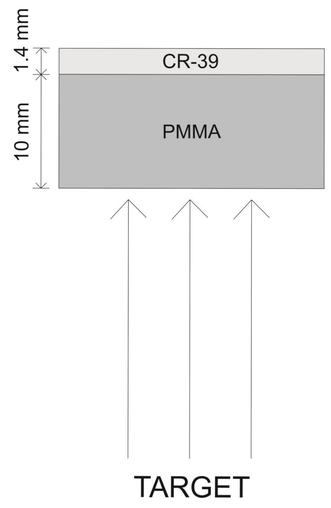


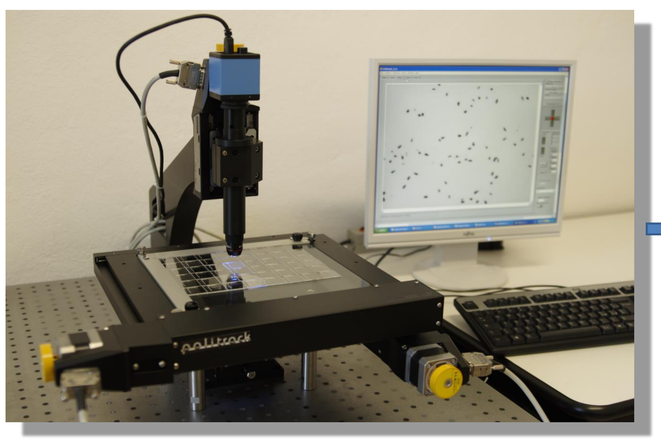
Fig 2. Layout of the passive detection system at the position CT 12 which is right on top of the irradiated target (neutron source).

CT 1	CT 5	CT 9	CT 13
CT 2	CT 6	CT 10	CT 14
CT 3	CT 7	CT 11	CT 15
CT 4	CT 8	CT 12	CT 16

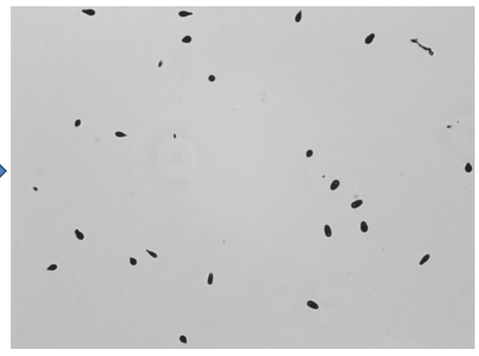
TARGET

Fig 3. Top view of the concrete roof of the CERF facility showing the positions CT 5 and CT 12 of the neutron detectors.

3) Track Analysis and LET determination

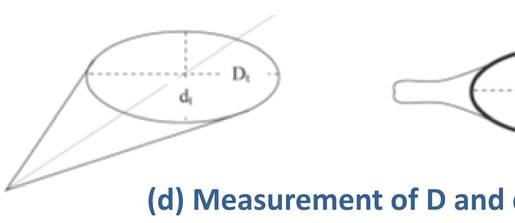


(a) Politrack™ SSNTD automatic reader

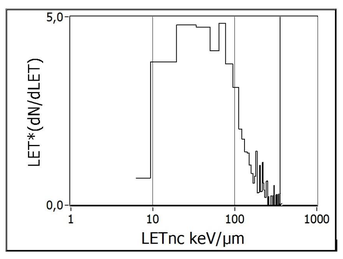


(b) Raw image captured with Politrack

(c) On line image analysis



(d) Measurement of D and d



(e) *LET* distribution (the suffix nc indicates that it is a quantity measured with Nuclear track detector CR39)

4) Repeatability of measurements

The CHI² is the statistical check to control that the tracks are Poisson distributed on the detector surface. The measurements follow closely the expected CHI² value of 1.

Detectors at CT 5	CHI²	Dose (H*10) in mSv	Detectors at CT 12	CHI²	Dose (H*10) in mSv
1810	1.03	1.93	1818	0.98	2.26
1811	1.00	1.98	1829	0.91	2.22
1839	1.07	2.34	1840	0.97	2.33
1846	1.05	2.11	1856	1.03	2.18
1850	0.96	2.28	1868	1.08	2.19
1855	0.95	1.82	1877	0.97	2.18
1871	0.92	2.05	1895	0.95	1.98
1893	0.97	1.86	1906	1.06	2.40
Mean Dose	2.07		Mean Dose	2.22	
St. Dev. %	8.90		St. Dev. %	5.60	
Ref. Dose	5.17		Ref. Dose	4.85	

Table 1. Dose measurement for each detector exposed at CERF at CT 5 and CT12

5) Results

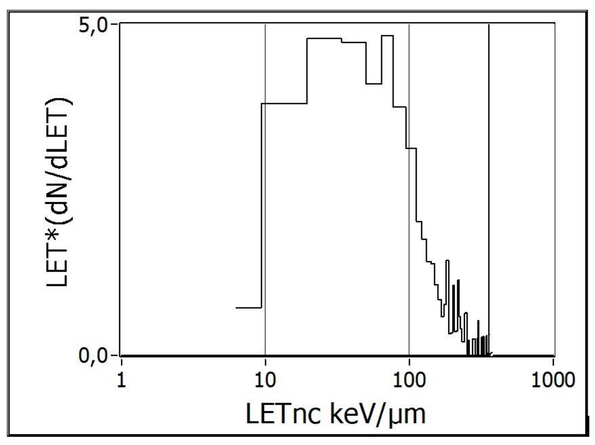


Fig 4. *LET* distribution measured for the position CT 5

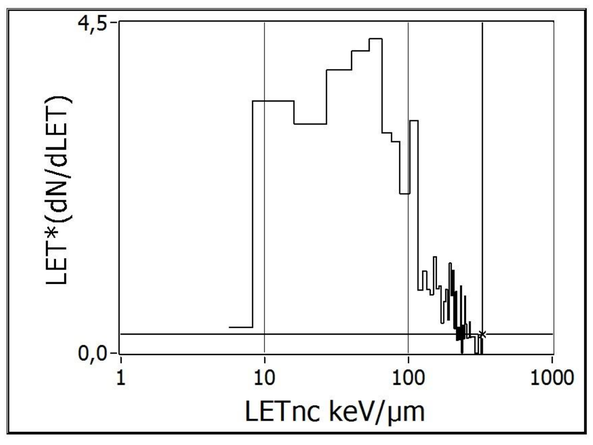


Fig 5. *LET* distribution measured for the position CT12

Position	CT 5	CT 12	Uncertainty (2σ)
Dose in CR-39 (mSv)	3.8	4.1	± 1.4
Reference Dose (mSv)	5.17	4.85	± 0.5
Dose < 100 keV/µm (mSv)	2.0	2.2	
Dose > 100 keV/µm (mSv)	1.7	2.1	

Table 2. Dose calculation from measured LET spectra taking into account the mean sensitivity measured from calibration campaigns illustrated in Table 3.

The results obtained for the dose measured at position CT5 and CT12, in Table 2, are based on the average sensitivity measured in calibration campaigns using monoenergetic neutron beams (Table 3, to be published in NEUDOS 12 proceedings) and confirms the suitability of this detection system for dosimetry in workplace fields.

Beam	Measured Dose (mSv)	Reference Dose(mSv)	Sensitivity
PTB 565 KeV	1.79	3.67	0.49
PTB 8 MeV	1.75	4.90	0.36
PTB 14 MeV	3.49	6.90	0.51
PTB 19 MeV	1.84	2.90	0.64
iThemba 66 MeV 0°	2.38	4.44	0.54
iThemba 66 MeV 16°	1.72	3.20	0.54
iThemba 100 MeV 0°	1.52	2.36	0.64
iThemba 100 MeV 16°	1.75	2.83	0.62
Average Sensitivity			0.54 ± 0.09

Table 3. Average sensitivity calculated from calibration experiments done in monoenergetic neutron beam ranging from 0.5 MeV to 100 MeV.

6) Conclusion

- The dosimeter, that was calibrated in monoenergetic fields of various energies, at the PTB and Ithemba labs, proved effective in measuring the dose in a workplace field having a significant high-energy component.