

DOSE DISTRIBUTION IN SPD BOX AND CR-39 PNTD RESULTS: COMPARISON BETWEEN NPI AND NIRS

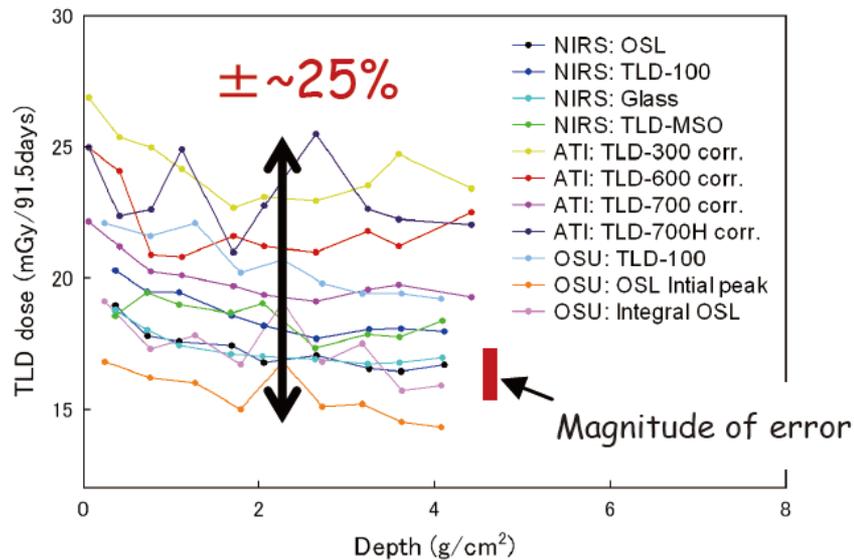
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E. R. Benton, H. Kawashima, M. Kurano, Y. Uchihori, H. Kitamura,
Y. Koguchi, S. Shurshakov and ICCHIBAN WG

NIRS, NPI, IBMP, OSU, Chiyoda technol corporation
and ICCHIBAN WG

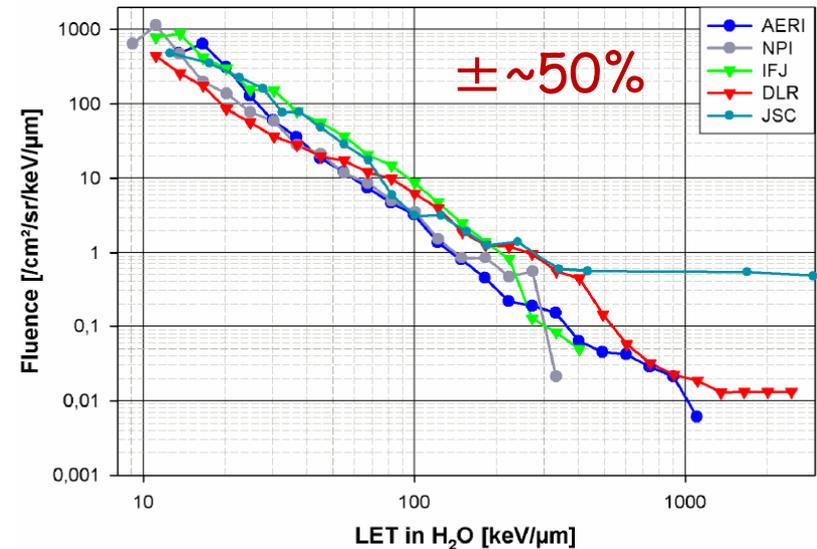
Variations of results for two kinds of detectors on Space Experiments

- from previous experiments -

Luminescence detectors



CR-39 detectors



T. Berger et al., (2010)

- Luminescence detectors

Differences can be explained by the differences on neutron sensitivity and further calibration in lower LET (0.1 – 10 keV/μm)

- CR-39 detectors

Home work for Nakahiro (even though he is in prison)

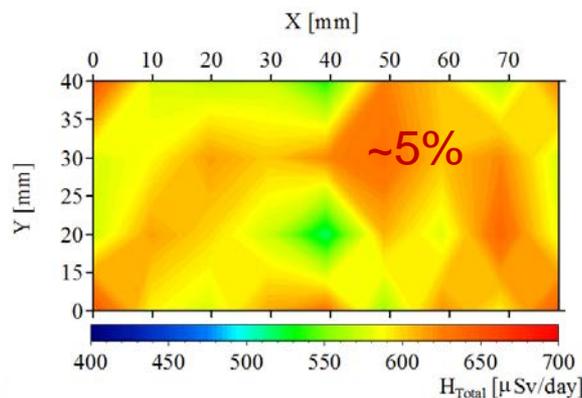
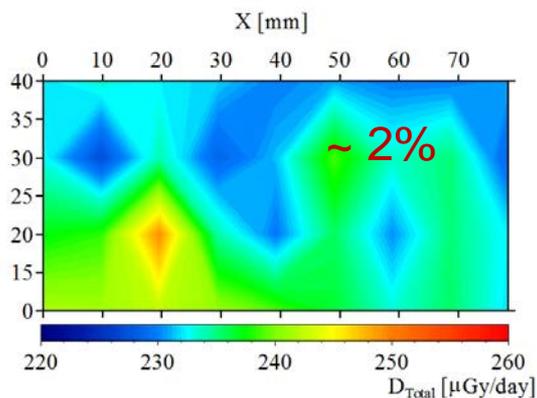
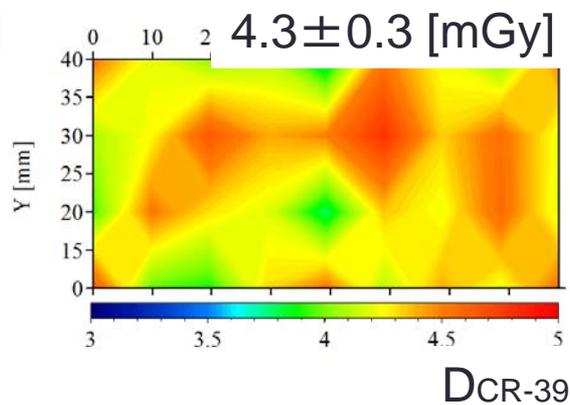
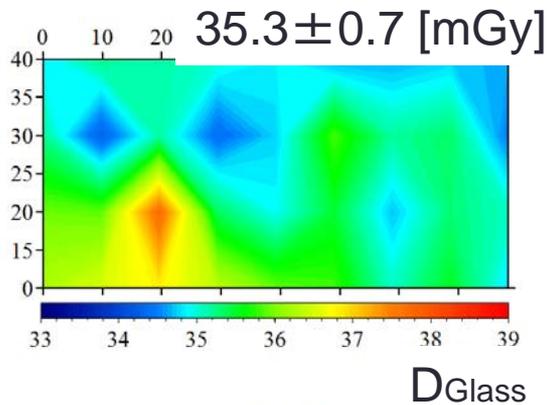
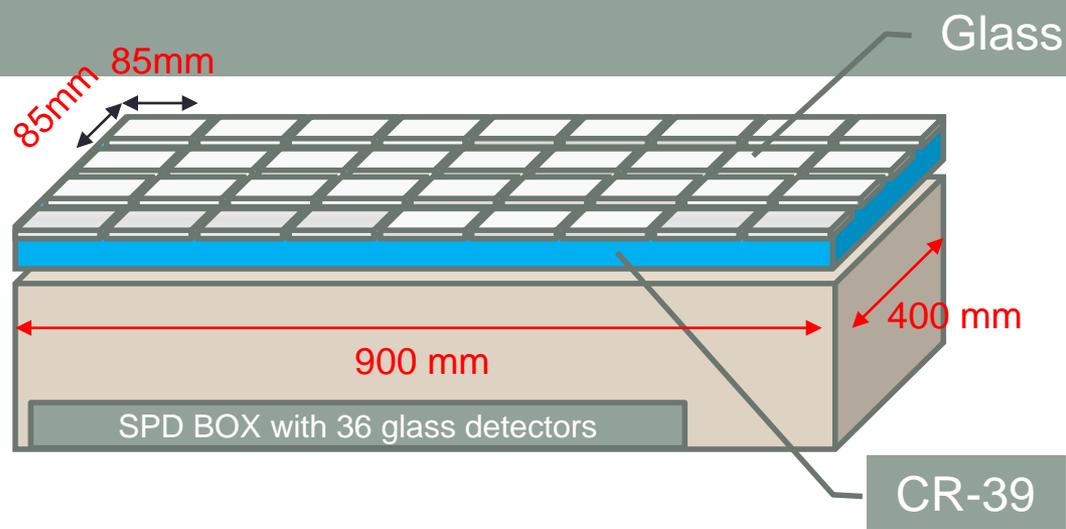
Where do the variations come from?

- Variation of radiation field (throughout the SPD box being measured (compared))

For CR-39 analysis

- Variations of results from statistics (measured area)
- Angular correction of response
- Bulk etch (Missing contribution from short range particles)
- Human dependence (Selection of tracks to be measured)

Variations of radiation field - SPD BOX -



- We verified variations on dose in SPD box (DOSEMAP-SPD).
- This is an indicator to verify detectors stacking in the SPD box.
- Luminescence detectors were measured by Chiyoda Technol.
- CR-39 detectors were measured by NIRS.

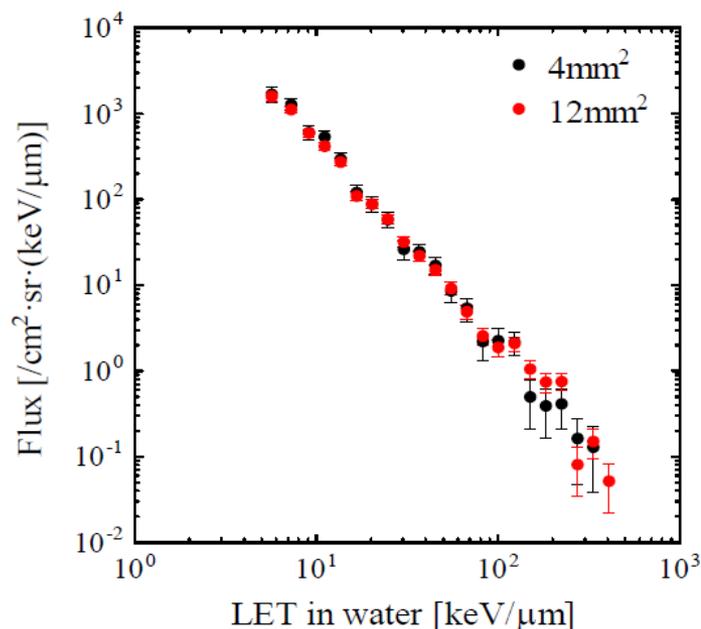
Variations in dose were verified

- Glass $\sim 2\%$
- CR-39 $\sim 6\%$

in dose.

- These will be a kind of variations (errors) that can be targeted.

Variations of results from statistics (measured area)



Three trials for 4mm² measurement on a CR-39

What was changed?

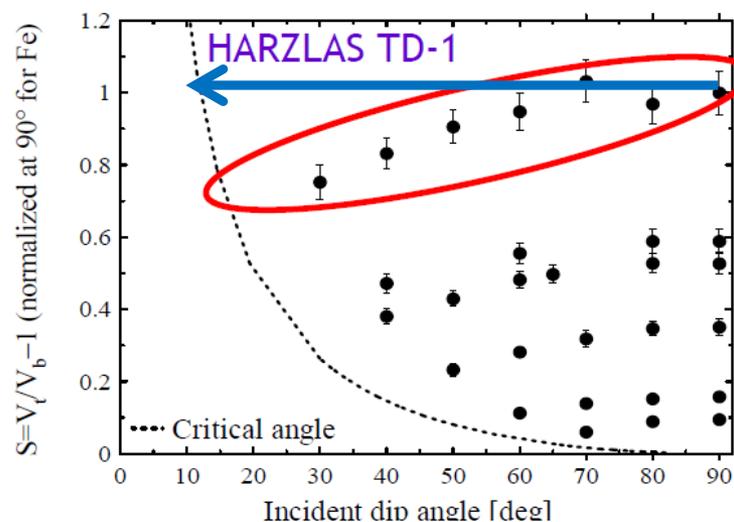
- Number of Measured Tracks
1,030 (4mm²) to 3,027(12mm²)
- Maximum LET track
366 (4mm²) to 477 KeV/μm (12mm²)

Remarkable difference was not found!!

Dose results for 4mm² and 12mm² area sizes. LET threshold: 10 keV/μm.

	D [mGy]	H [mSv]	D rate [uGy/d]	H rate [uSv/d]	Q	Track density [cm ⁻²]
4mm ²	2.1 ± 0.1	24.1 ± 2.6	15.1 ± 1.0	177.8 ± 19.4	11.8 ± 1.5	6432
12mm ²	2.1 ± 0.1	27.3 ± 1.7	15.7 ± 0.6	201.2 ± 12.2	12.8 ± 0.9	6308

Angular correction on response



	Absorbed dose [$\mu\text{Gy}/\text{day}$]	Dose equivalent [$\mu\text{Sv}/\text{day}$]	Mean QF
Non-corrected	27.5 ± 1.1	430.6 ± 18.7	15.7
Corrected($\alpha=3.47$)	28.8 ± 1.1	442.0 ± 18.9	15.4
Corrected($\alpha=15.76$)	33.3 ± 1.2	482.5 ± 20.0	14.5

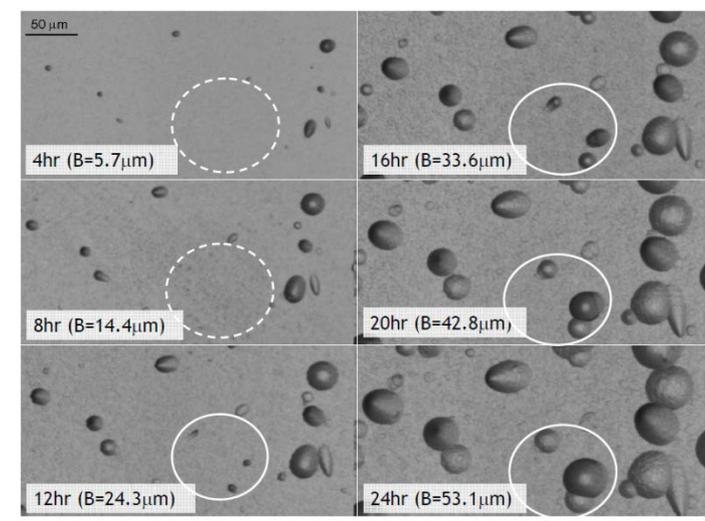
Doke et al., RM, 28 (1997) 445
Yasuda et al., RM, 43 (2008) 5269

- Difference of absorbed dose of $\alpha=15.76$ correction for Non-corrected case: **+21.1%**
- Difference of dose equivalent of $\alpha=15.76$ correction for Non-corrected case: **+12.1%**

Significant difference cause by angular dependence
- Need (check) angular correction on each material

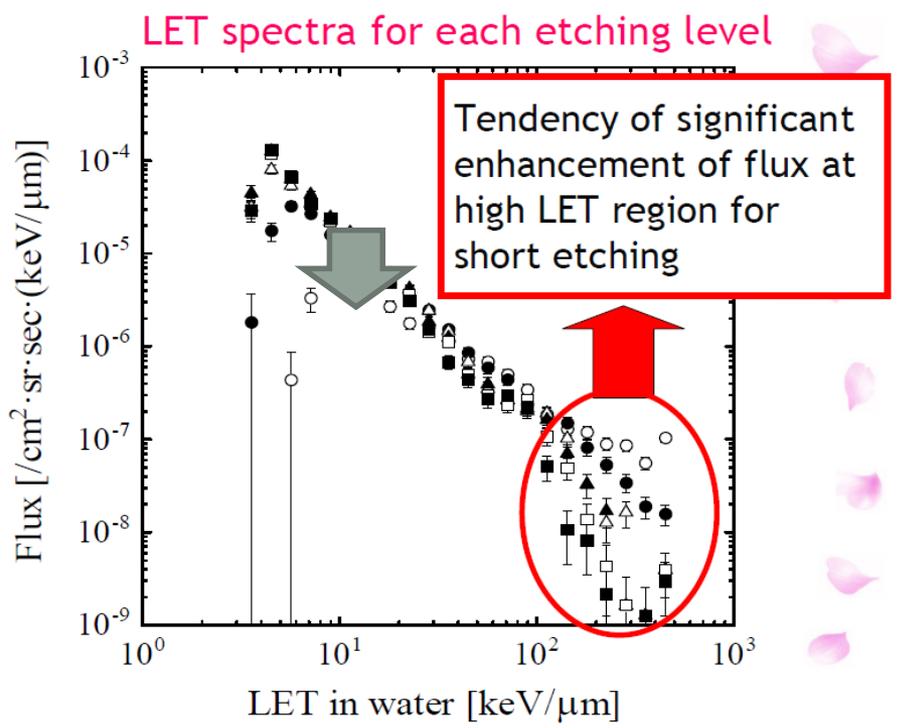
Bulk etch (Missing of contribution for short range particles)

We have applied continuous etching from 6 μm to 53 μm



Absorbed & dose equivalent rates (LET ≥ 10 keV/ μm) for each etching level

T [hr]	B [μm]	Absorbed dose [$\mu\text{Gy/day}$]	Dose equivalent [$\mu\text{Sv/day}$]	Mean QF
4	5.7	25.4 \pm 1.1	421.5 \pm 18.6	16.6
8	14.4	14.8 \pm 0.7	233.7 \pm 12.3	15.8
12	24.3	10.2 \pm 0.5	142.7 \pm 8.8	14.0
16	33.6	9.0 \pm 0.4	120.8 \pm 7.9	13.4
20	42.8	7.6 \pm 0.4	97.3 \pm 6.8	12.7
24	53.1	6.4 \pm 0.3	73.0 \pm 5.5	11.5



Significant difference cause by Bulk Etch
 - Need (check) bulk on each material for single etching

- Difference for mean absorbed dose: 12.2^{+51.8%}_{-47.7%} [$\mu\text{Gy/day}$]
- Difference for mean dose equivalent: 181.5^{+56.9%}_{-59.8%} [$\mu\text{Sv/day}$]

Bulk etch (Missing of contribution for short range particles)

BUT for combine method (short and long etch)

Absorbed & dose equivalent rates (LET ≥ 10 keV/ μm)
by etching level combination

[Case] short etching: 4h (B=5.7) + long etching: Any

T [hr]	B [μm]	Absorbed dose [$\mu\text{Gy}/\text{day}$]	Dose equivalent [$\mu\text{Sv}/\text{day}$]	Mean QF
4+12	5.7+24.3	27.5 ± 1.1	430.6 ± 18.7	15.7
4+16	5.7+33.6	27.3 ± 1.1	427.9 ± 18.6	15.7
4+20	5.7+42.8	26.9 ± 1.1	426.1 ± 18.6	15.8
4+24	5.7+53.1	26.7 ± 1.1	425.3 ± 18.6	15.9

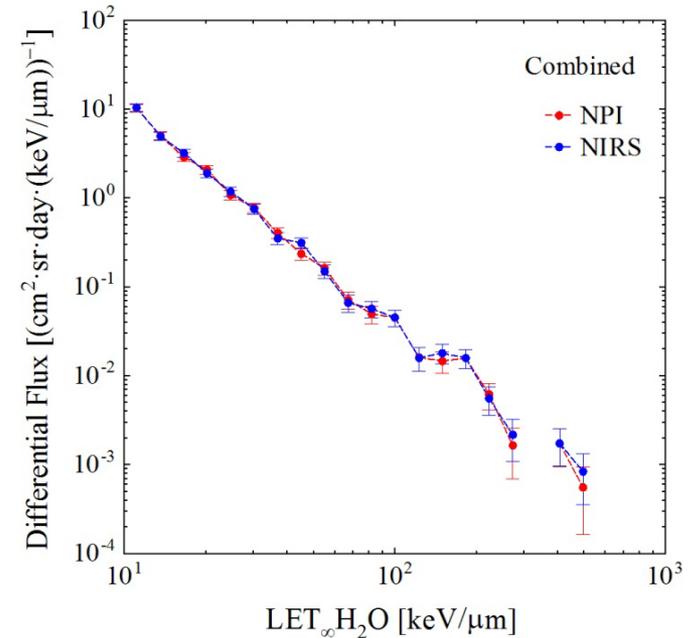
- Difference for mean absorbed dose: $27.1^{+1.5\%}_{-1.5\%}$ [$\mu\text{Gy}/\text{day}$]
- Difference for mean dose equivalent: $427.5^{+0.7\%}_{-0.5\%}$ [$\mu\text{Sv}/\text{day}$]

The difference in dose amount among each etching level combination is very small !

Human dependence

Measured conditions

- Captured whole images to be measured (The same material and bulk etch)
- Shared the images to NPI and NIRS
- **Selected “non over etched” track**
- Used the same software (PitFit) to measure track size
- Used the same calculation code (SpaceBeam3) to derive dose results by taking some correction factors into account



Combined data	Number of tracks	D [mGy]	H [mSv]	Q
NPI	730	5.9 ± 0.2	63.4 ± 4.2	10.8 ± 0.8
NIRS	762	5.8 ± 0.3	61.6 ± 4.0	10.7 ± 0.9

Short etching data	Number of tracks	D [mGy]	H [mSv]	Q
NPI	638	5.2 ± 0.2	60.6 ± 4.1	11.7 ± 1.0
NIRS	658	5.1 ± 0.3	57.3 ± 3.9	11.3 ± 1.0

Long etching data	Number of tracks	D [mGy]	H [mSv]	Q
NPI	672	5.0 ± 0.2	43.1 ± 3.1	8.7 ± 0.7
NIRS	687	4.8 ± 0.3	40.0 ± 3.2	8.3 ± 0.9

Results

- Variations of radiation field where to be measured (compared) SPD BOX
TLD ~ 2% and CR-39 ~5% variations

For CR-39 analysis

- Variations of results from statistics (measured area)
No significant different in between measured 4mm² to 12mm² area.
- Angular correction on response
Significant difference caused by angular dependence on the response (material and etching combination).
- Bulk etch (Missing of contribution for short range particles)
Significant difference caused by single etching.
We recommend to use “short and long combination”.
- Human dependence (Selection of tracks to be measured)
No significant difference was found when we are controlling the several conditions on “track selection criteria” and “calculation”, etc.