Radiation Test Results

Preliminary measurements from exposure to gamma rays at SCK-CEN

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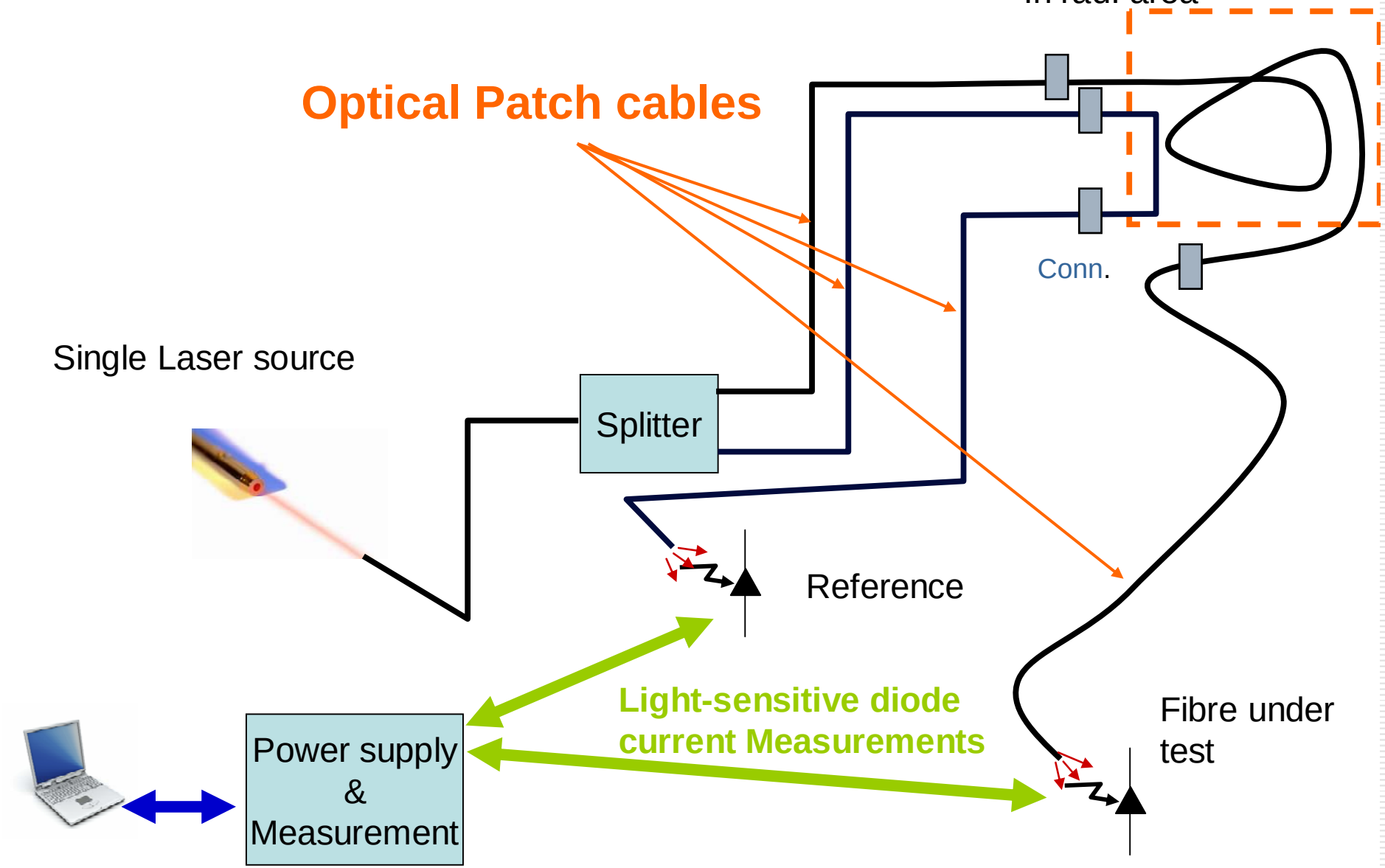
Also Presented: Some SMU group tests.

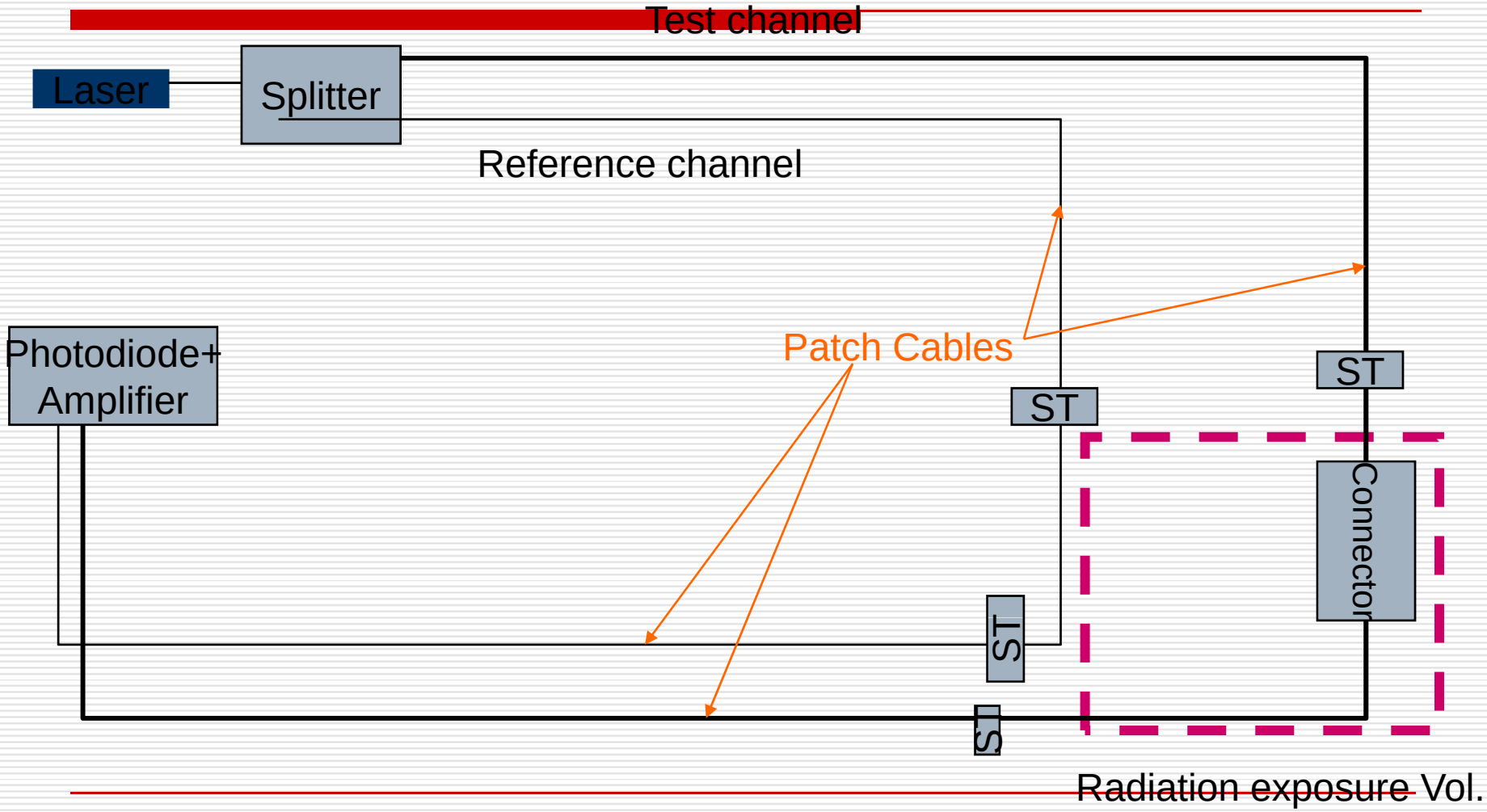
The active tests

- 50m lengths of three different Ericsson fibres
  - High dose only @ 850nm
- 50m lengths of Infinicor (Corning?) fibre
  - High and low dose tests @ 850nm
    - Including results from SMU (Andy Liu)
  - High and low light level tests (VCSEL vs. LED)
- 50m length of SMF28 Single Mode fibre
  - @ 1310nm → True for all SM tests.
- MM Fused Taper Splitter (1x4)
- SM PLCC splitter (1x4)
- MM and SM LC-LC connectors

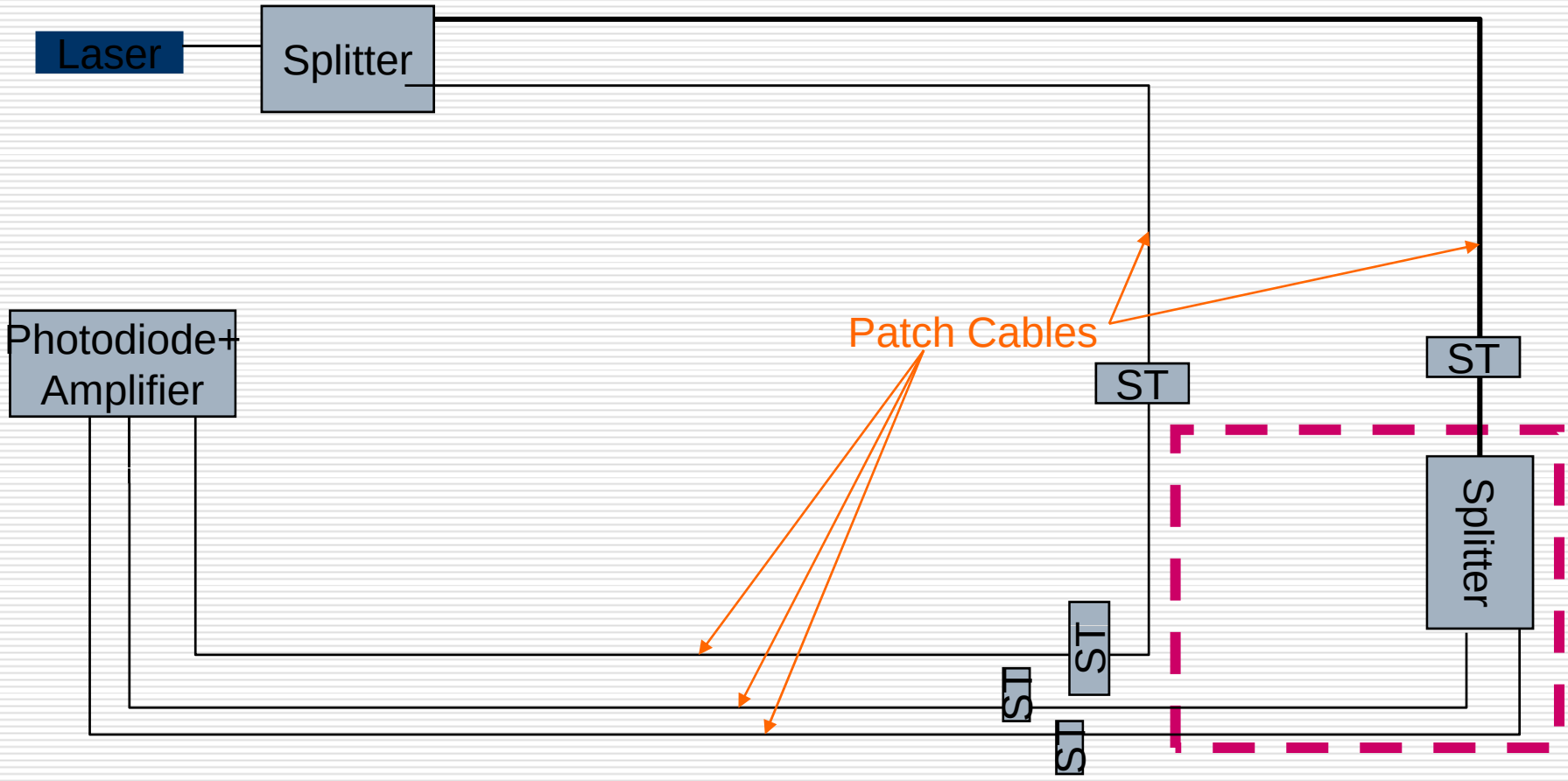
Test set-up: Fibre exposure



Test Setup → Connector-loss Test

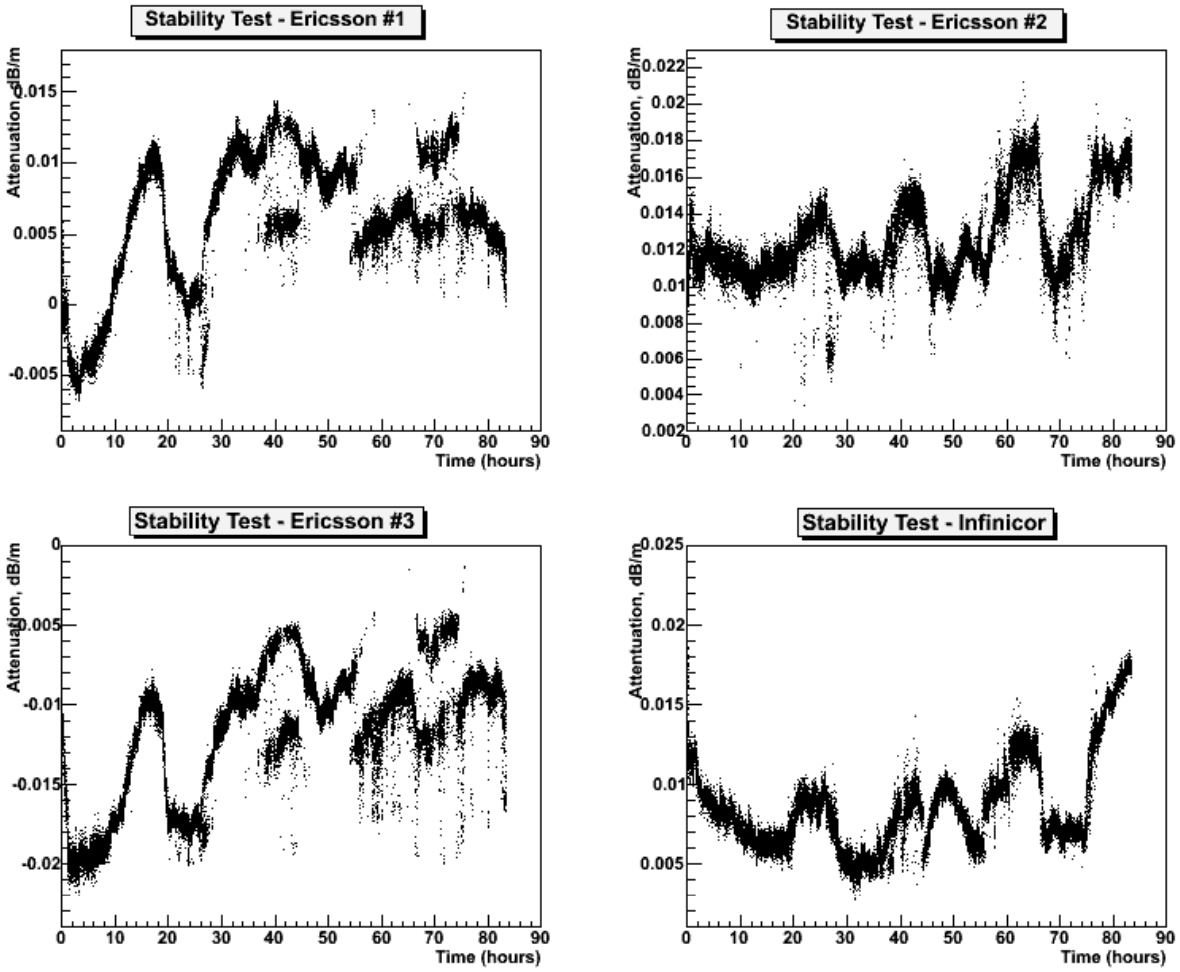


Test Setup → Splitter test



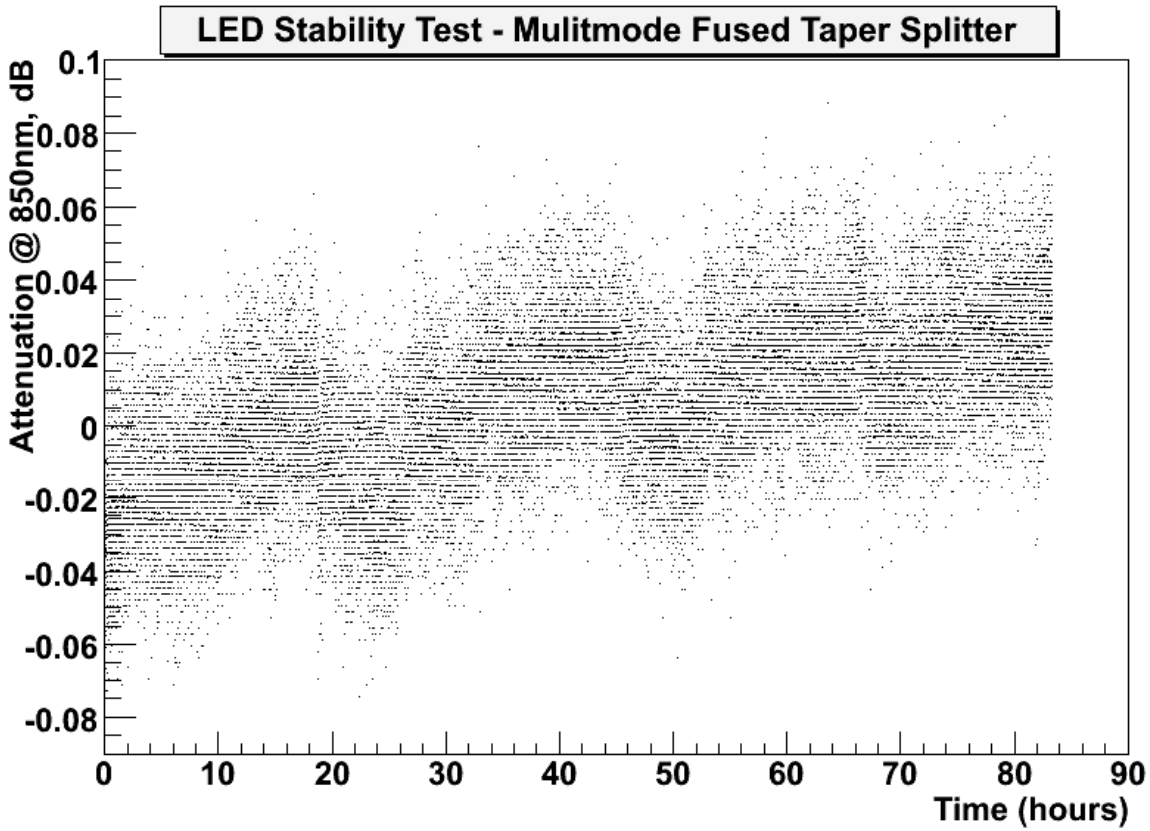
System Stability tests

- Ran system for extended time periods.
  - Find stability limitations
  - Example shown at right for Laser sources
  - LED sources; next slide.



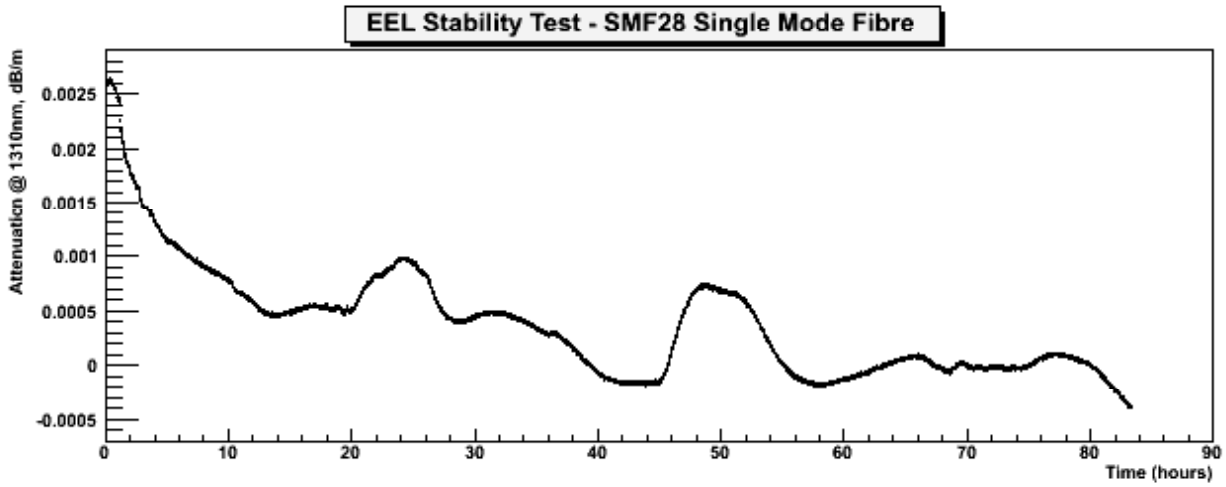
System Stability tests

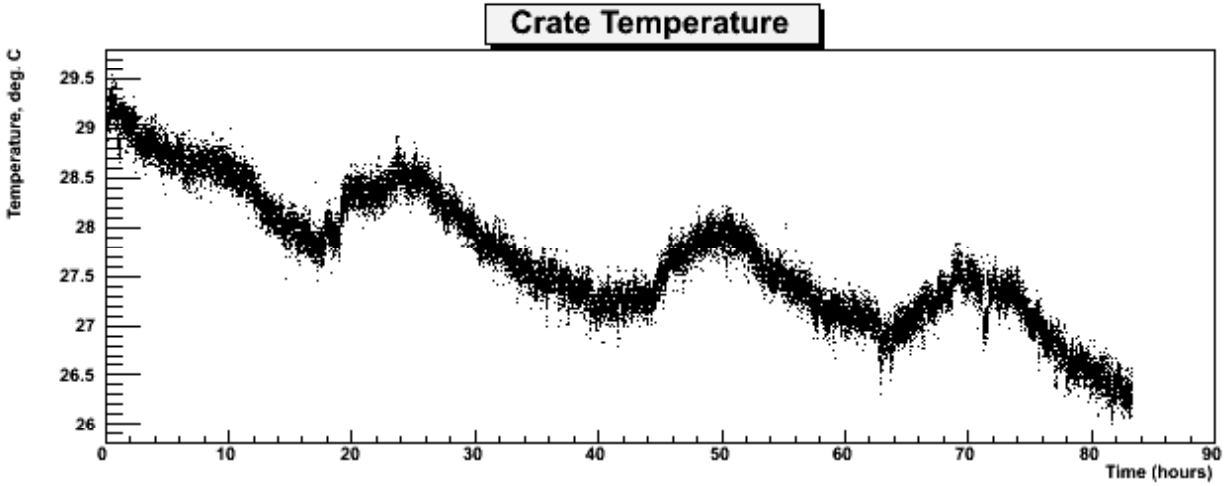
- LED light source
  - Low light levels
  - Highly Stable



System Stability tests

- EEL Light source Single mode





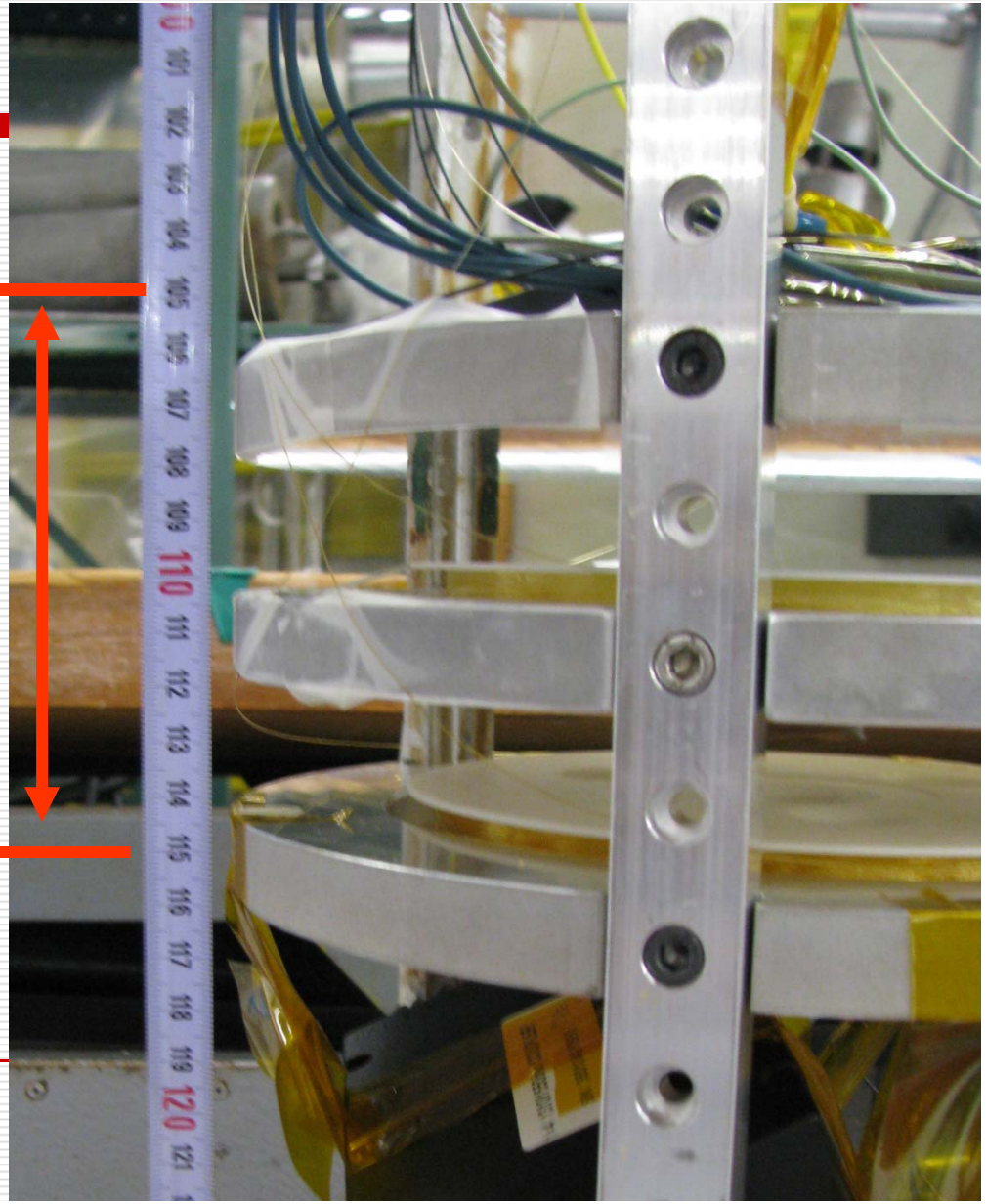
The two locations

- RITA

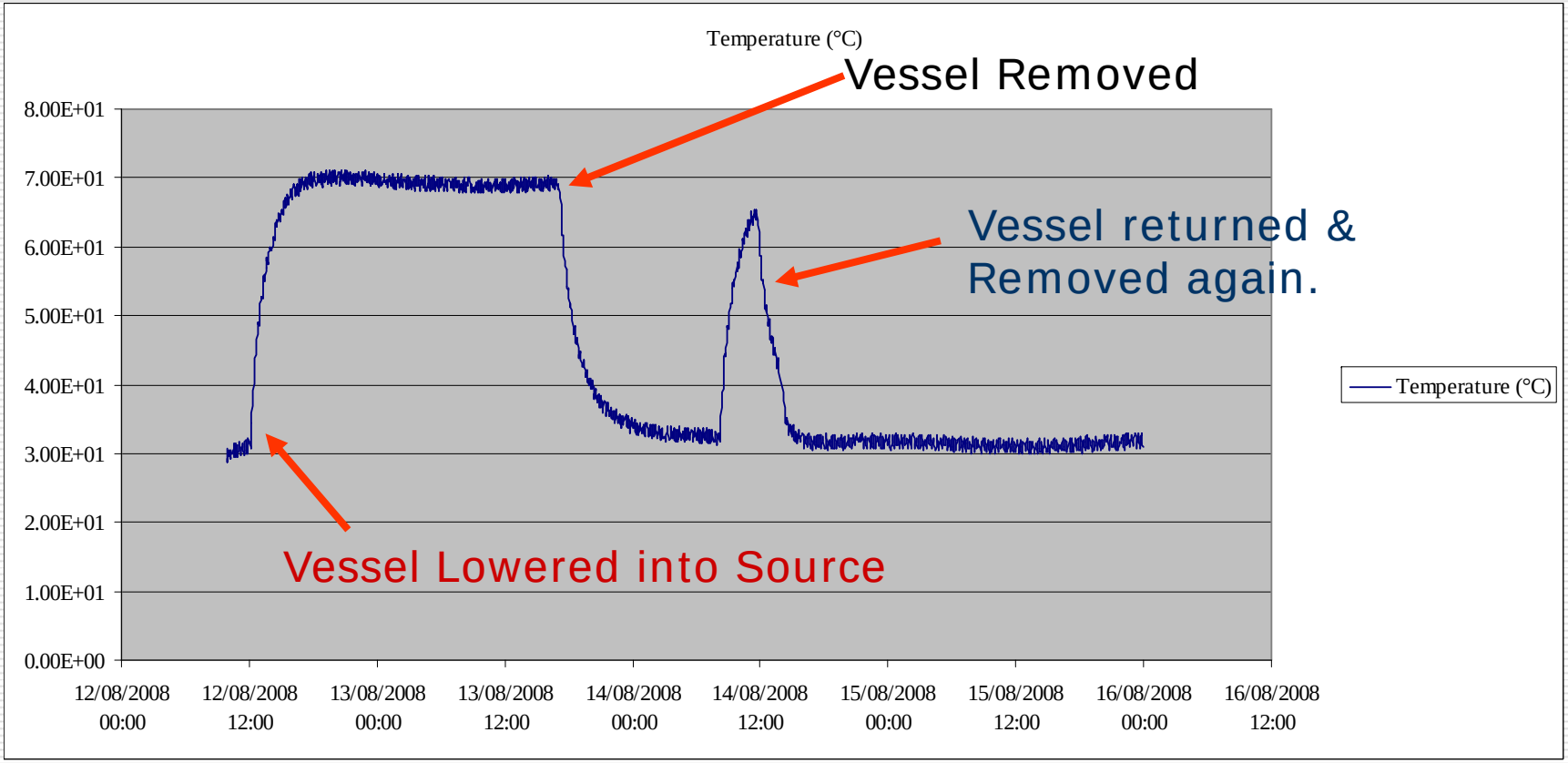
- BRIGITTE

The γ sources

- BRIGITTE
  - 10cm region of highest dose
    - Managed to fit all active tests into this volume
  - 25.1kGy/hr
- RITA
  - 1.12kGy/hr
- SMU
  - 0.42kGy/hr
  - 0.38kGy/hr
  - 0.026kGy/hr



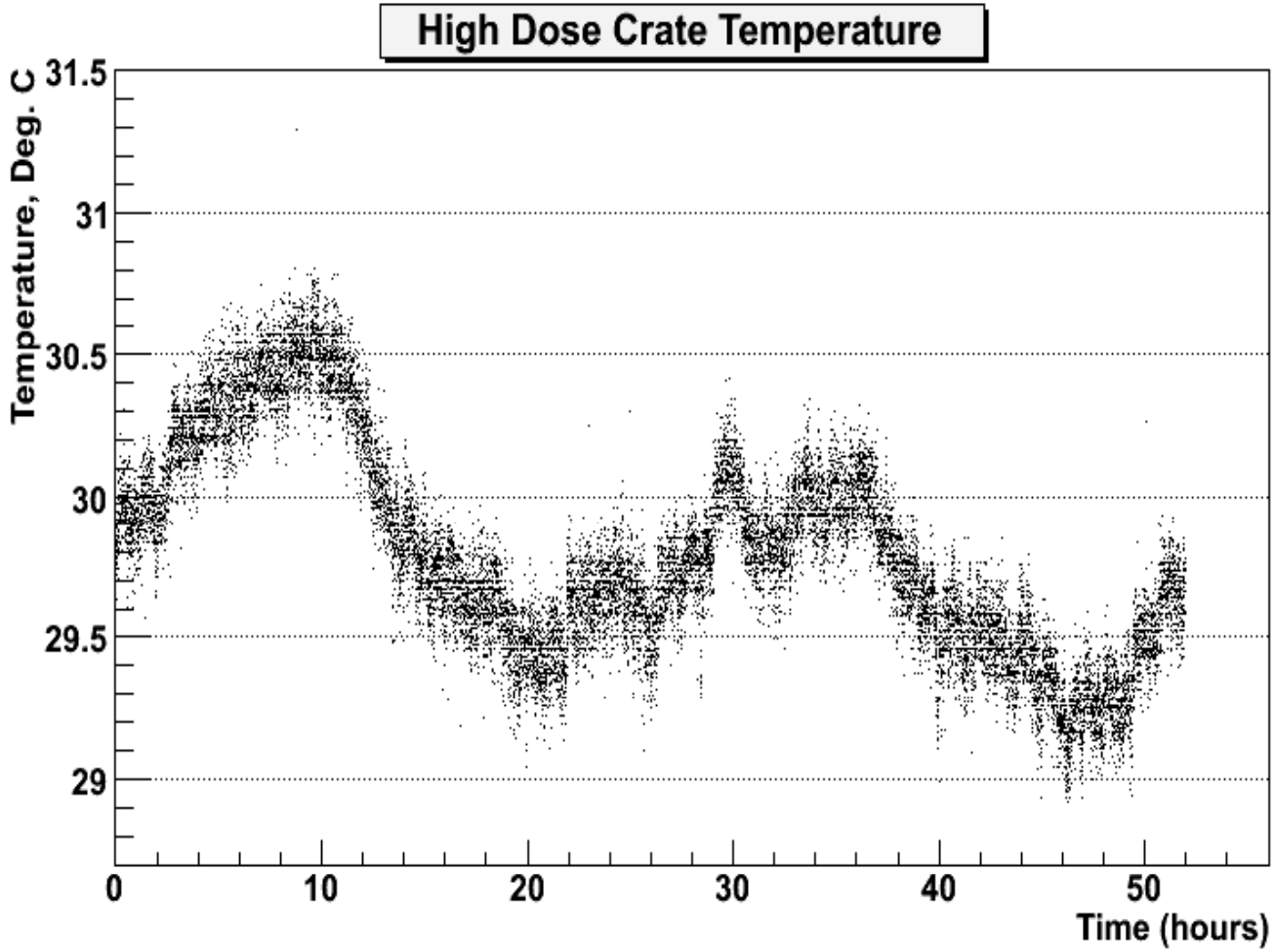
Temperature in the vessel



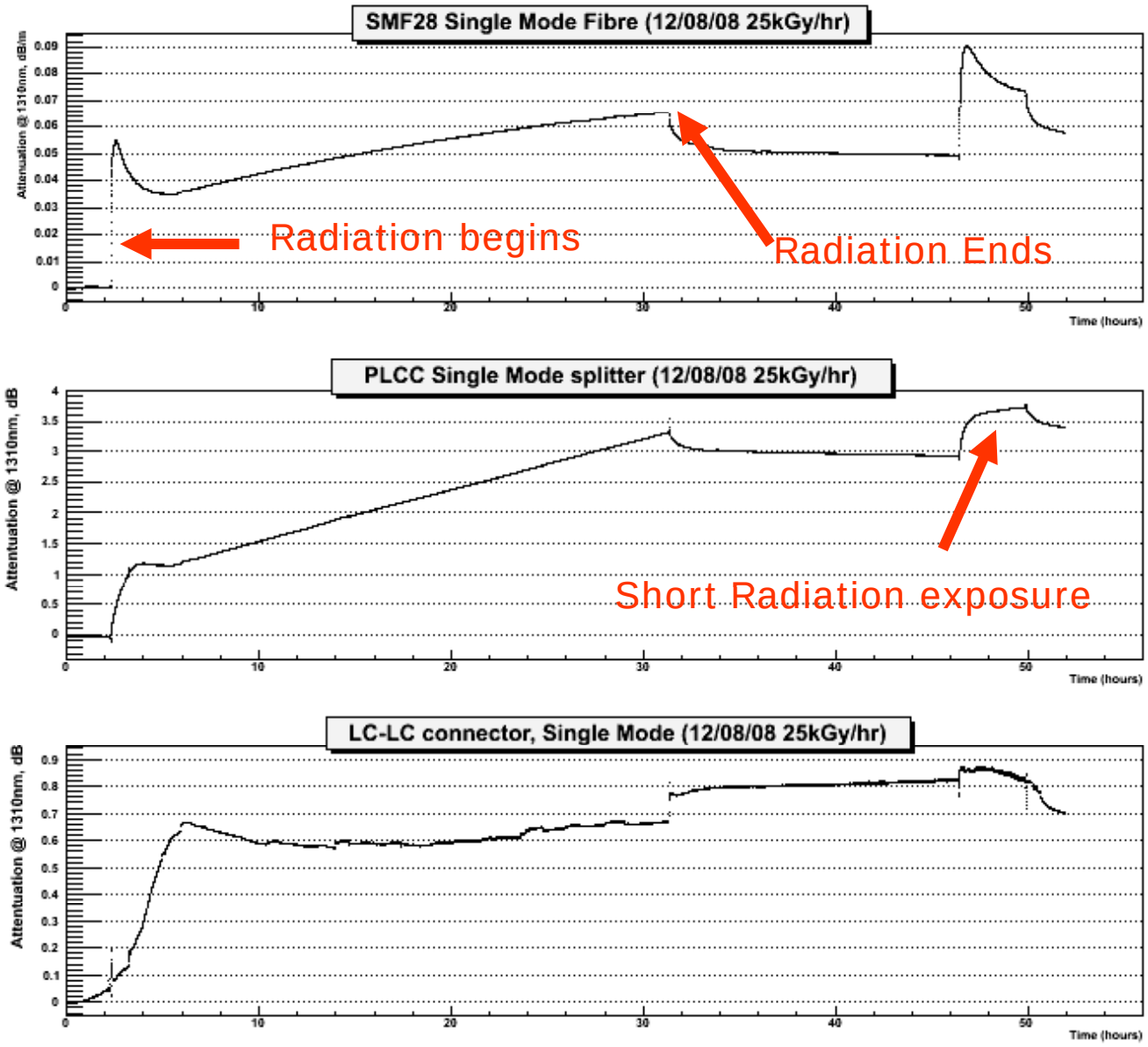
The Temperature in RITA was the same as average room temperature.

Crate Temperature

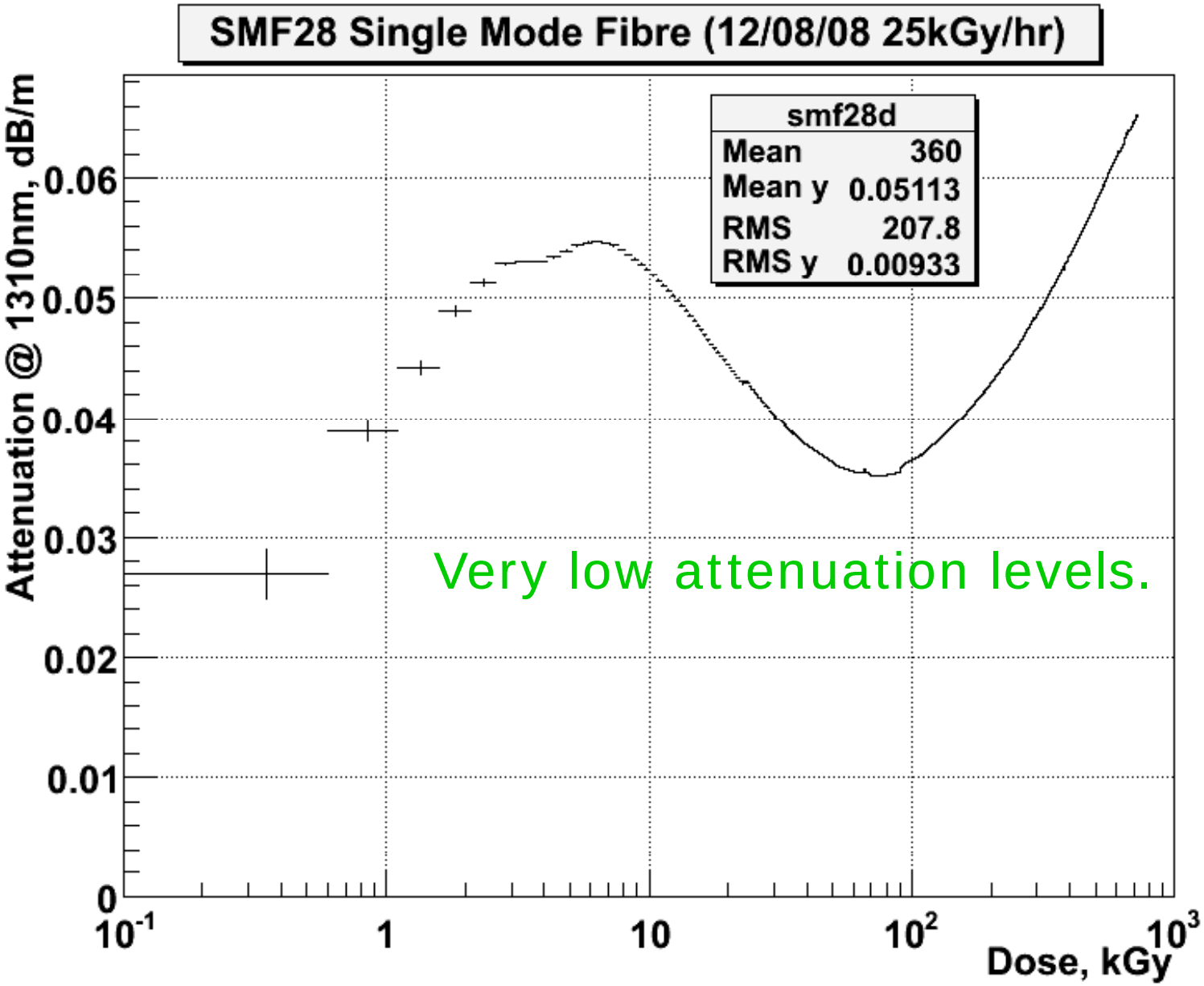
Temp. in the crate containing light sources.



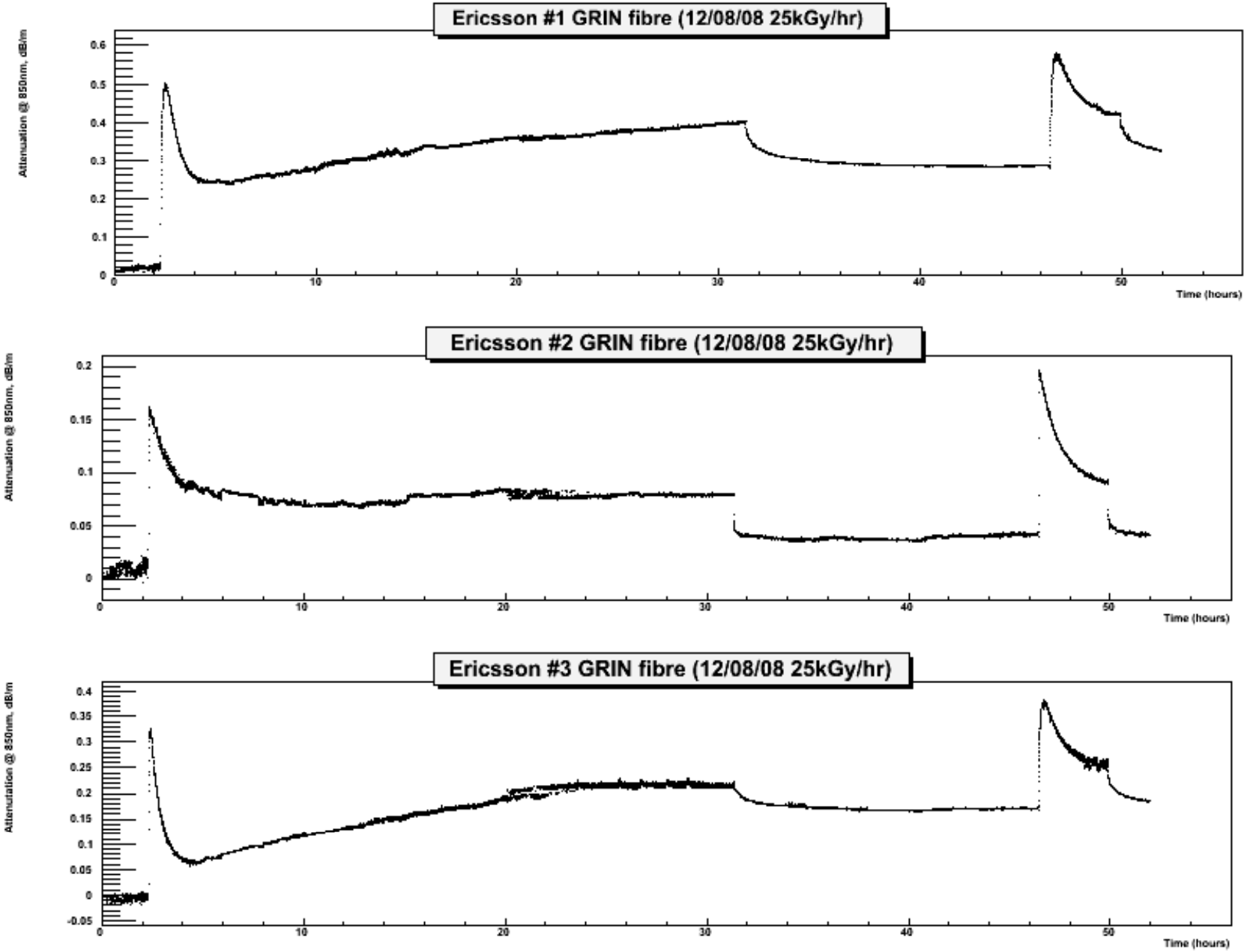
Single Mode Data @ 1310nm



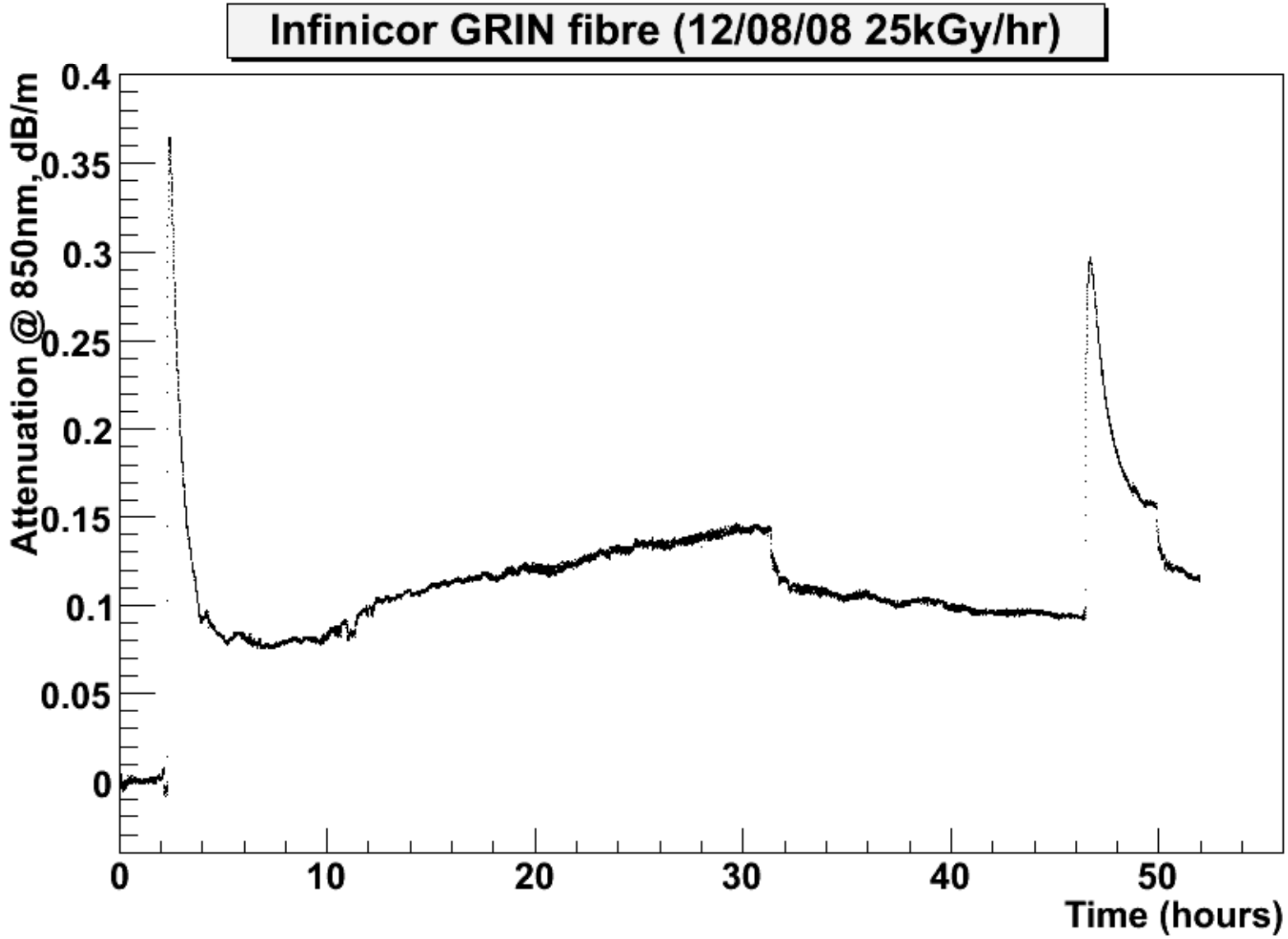
Single Mode Data

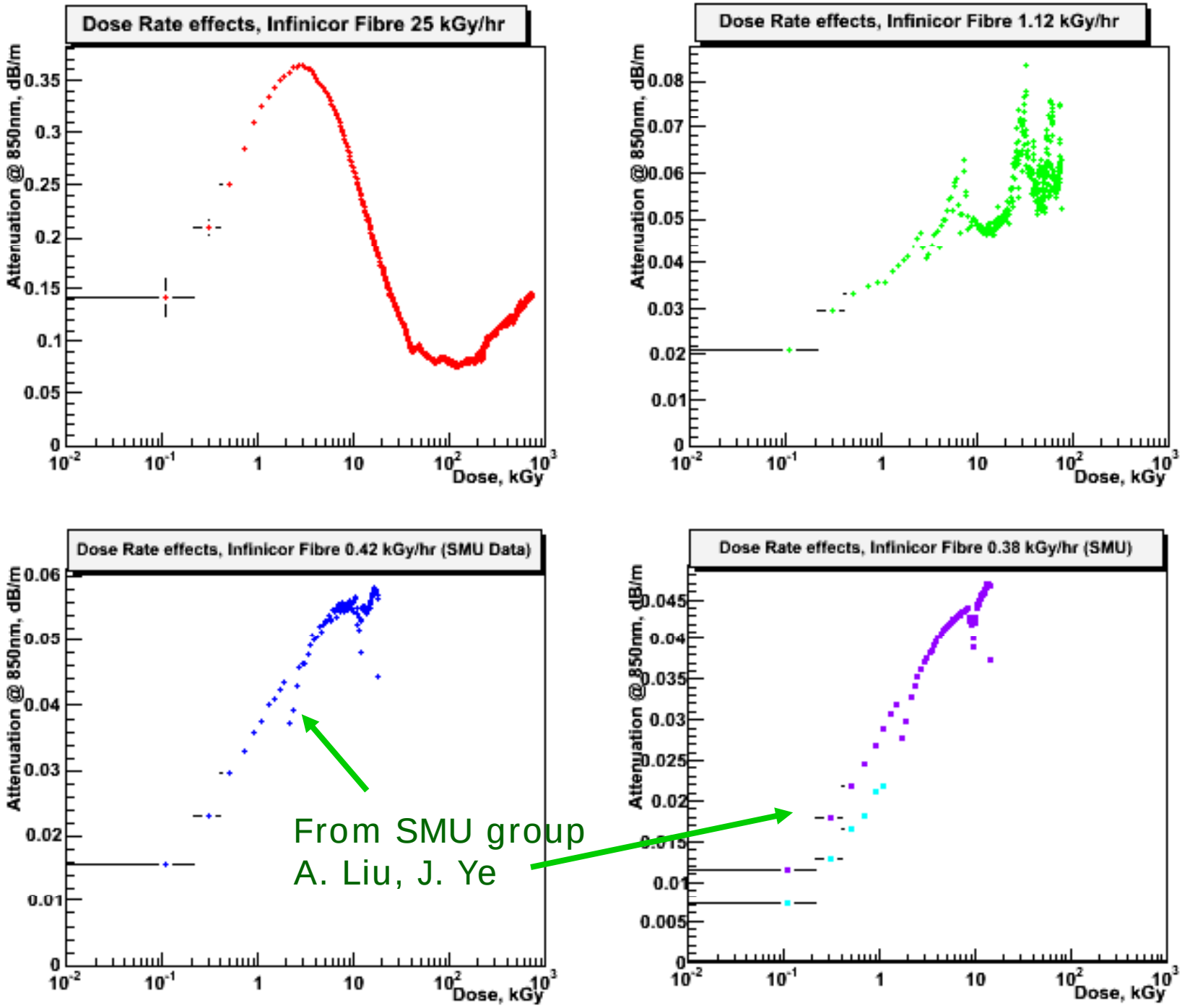


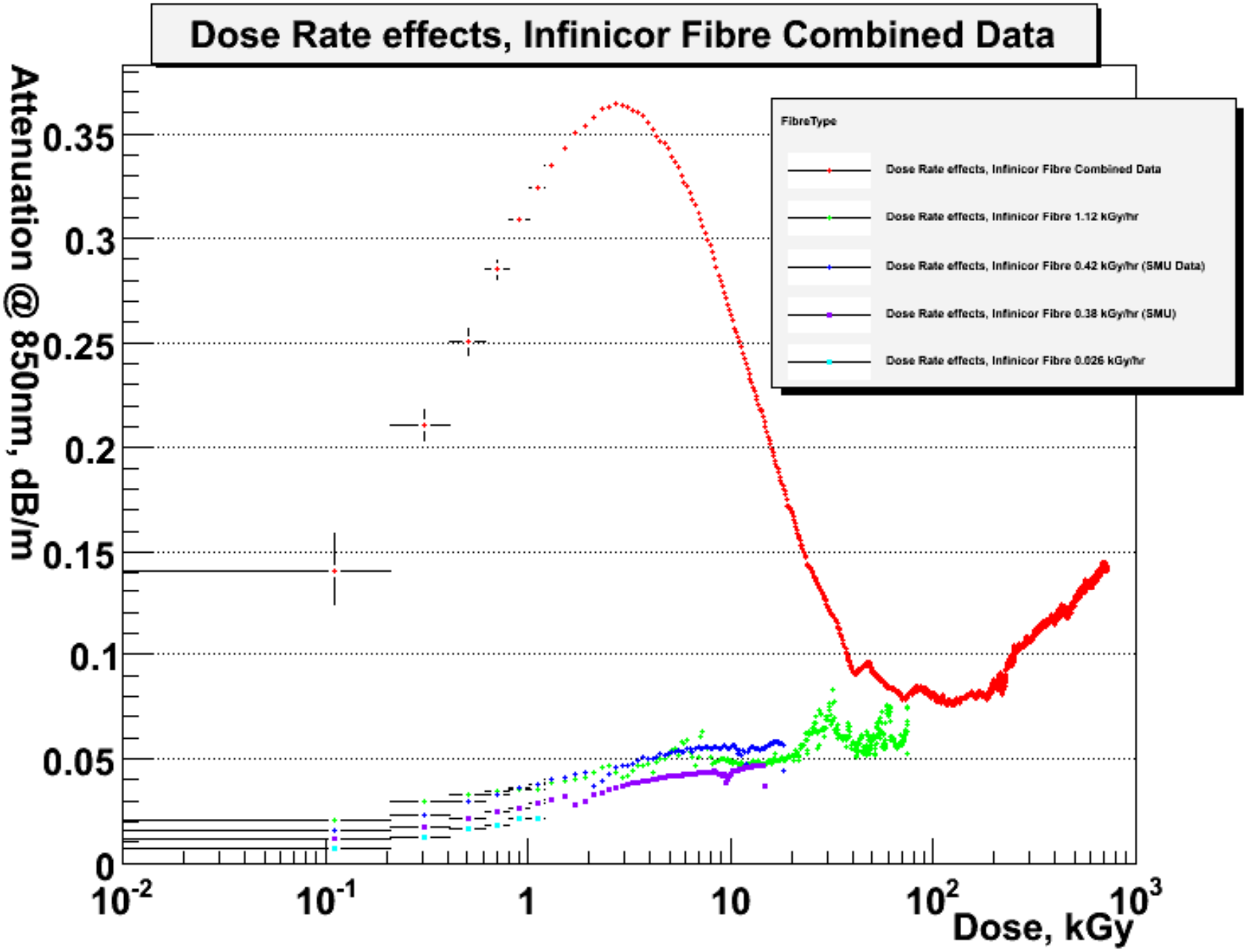
Graded Index Ericsson Fibres

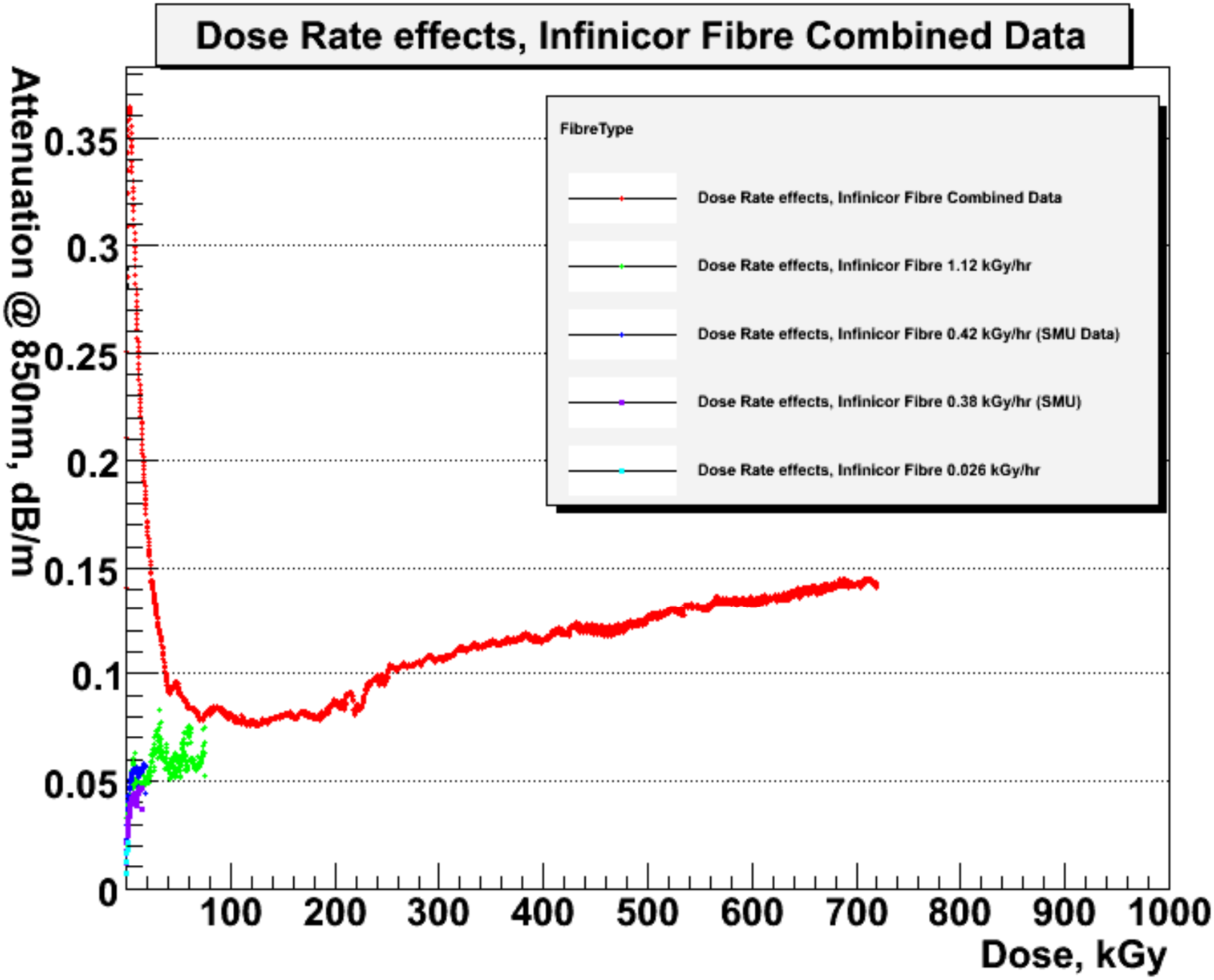


Graded Index Infinicor




Dose Rate effects, Infinicor Fibre 25 kGy/hr
Dose Rate effects, Infinicor Fibre 1.12 kGy/hr
Dose Rate effects, Infinicor Fibre 0.42 kGy/hr (SMU Data)
Dose Rate effects, Infinicor Fibre 0.38 kGy/hr (SMU)
Attenuation @ 850nm, dB/m
Dose, kGy
From SMU group
A. Liu, J. Ye

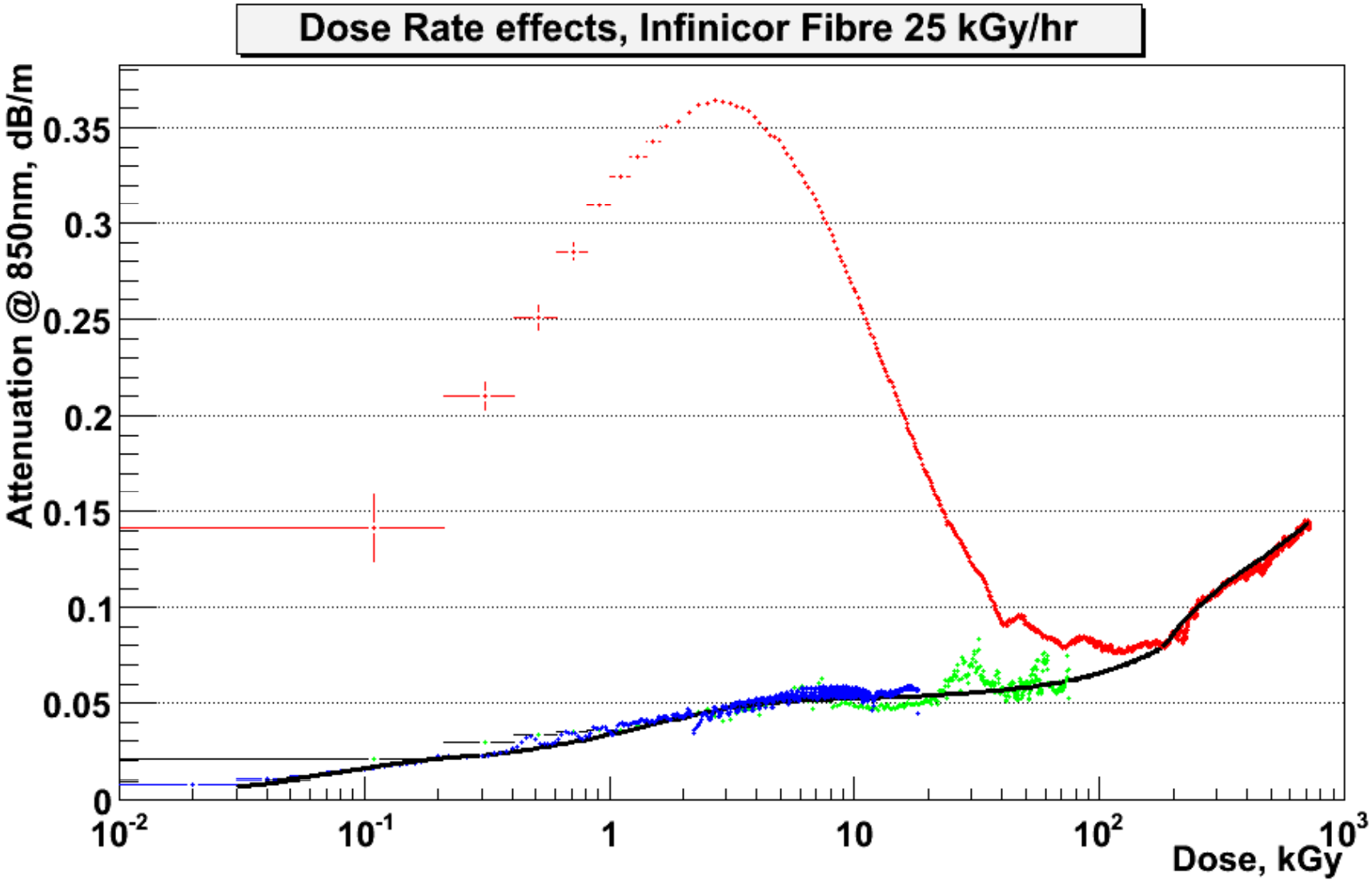

Dose Rate effects, Infinicor Fibre Combined Data
Attenuation @ 850nm, dB/m
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
10^{-2}
10^{-1}
1
10
10^{2}
10^{3}
Dose, kGy
FibreType
Dose Rate effects, Infinicor Fibre Combined Data
Dose Rate effects, Infinicor Fibre 1.12 kGy/hr
Dose Rate effects, Infinicor Fibre 0.42 kGy/hr (SMU Data)
Dose Rate effects, Infinicor Fibre 0.38 kGy/hr (SMU)
Dose Rate effects, Infinicor Fibre 0.026 kGy/hr


Dose Rate effects, Infinicor Fibre Combined Data
Attenuation @ 850nm, dB/m
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
100
200
300
400
500
600
700
800
900
1000
Dose, kGy
FibreType
Dose Rate effects, Infinicor Fibre Combined Data
Dose Rate effects, Infinicor Fibre 1.12 kGy/hr
Dose Rate effects, Infinicor Fibre 0.42 kGy/hr (SMU Data)
Dose Rate effects, Infinicor Fibre 0.38 kGy/hr (SMU)
Dose Rate effects, Infinicor Fibre 0.026 kGy/hr

Parameterising Infinicor Data

- Function pass through zero at zero dose.
- 0.03 to 0.3 kGy total dose
  - SMU tests @ 0.42kGy/hr
- 0.3 kGy to 75kGy total dose
  - Oxford tests @ 1.12kGy/hr
- 180.0kGy to 720kGy
  - Oxford tests @ 25kGy/hr
- In the gap between 75kGy and 180kGy
  - Just interpolated linearly.

Parameterisation Results



Parameterisation results

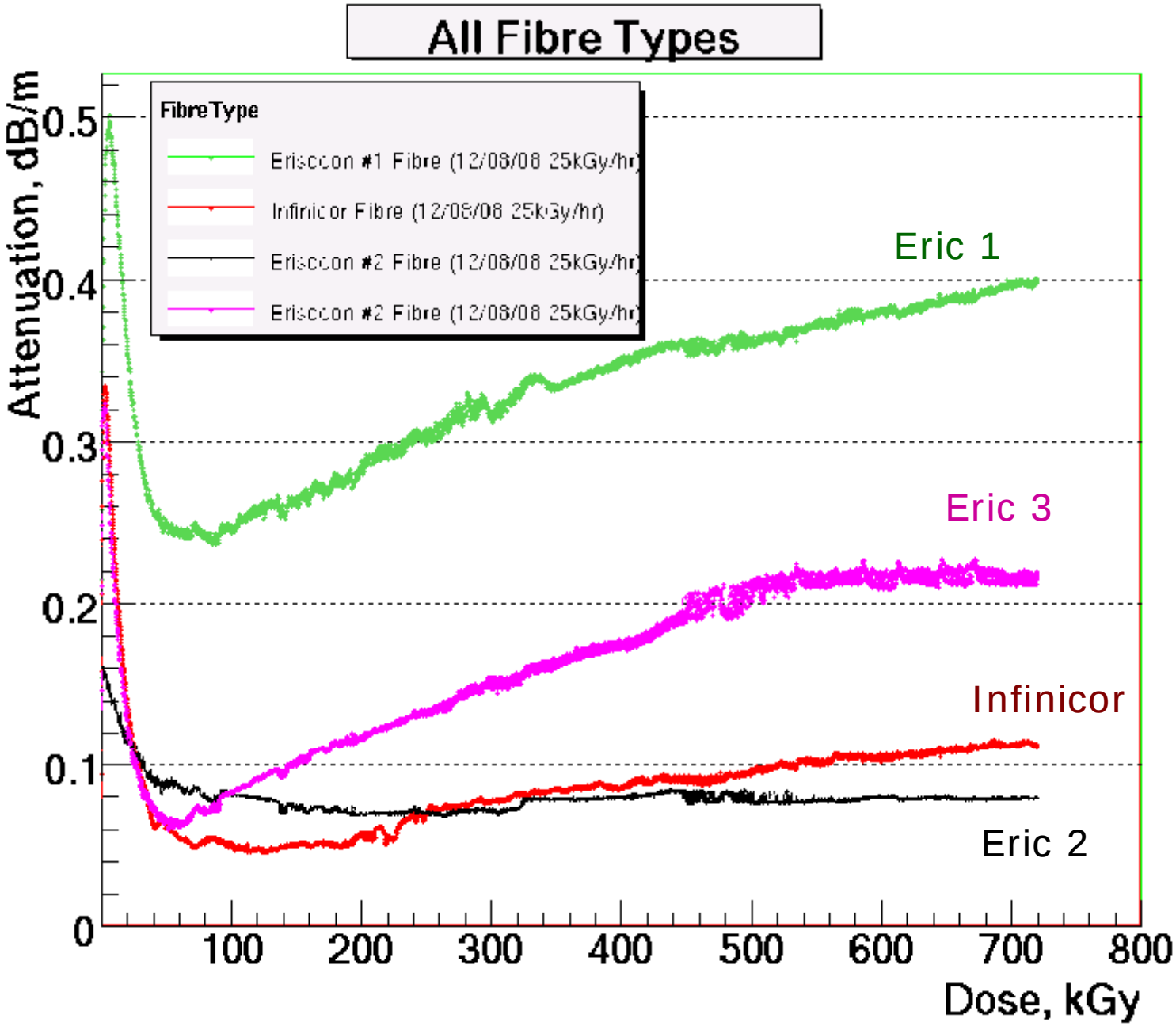
- Infinicor fibre total loss
  - Assume typical ATLAS fibre run.
  - Use parameterization previously found
- Total loss is 0.36 dB
  - Conservatively

Loss Estimates

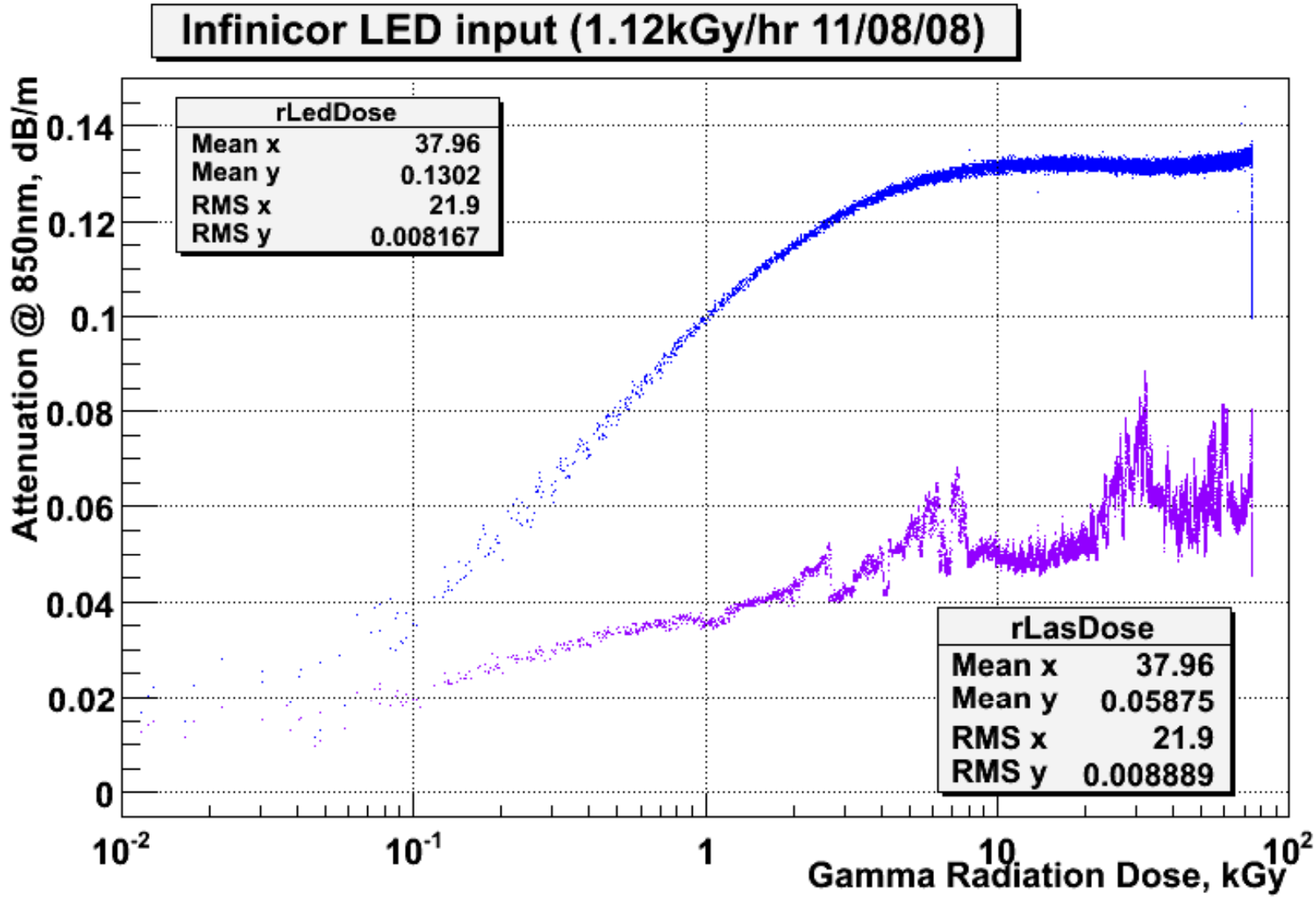
- Assume L(SLHC)= 3000 fb^{-1}
- Safety factor = 1.5 (r<110) or 5(r>110).

	Fibre routing (cm)					loss (dB)	
step	rstart	rend	zstart	zend	length (cm)	POF	Infinicor
1	30	110	100	100	80	**0.166**	**0.065**
2	110	110	100	340	240	**0.428**	**0.134**
3	110	420	340	340	310	**0.316**	**0.131**
4	420	420	340	0	340	**0.003**	**0.012**
5	420	572	0	0	152	**0.001**	**0.002**
6	circumferential step		delta phi =pi, r = 572		1797	**0.118**	**0.005**
7	572	1200	0	0	628	**0.002**	**0.008**
	Total				**35.5**	**1.03**	**0.36**

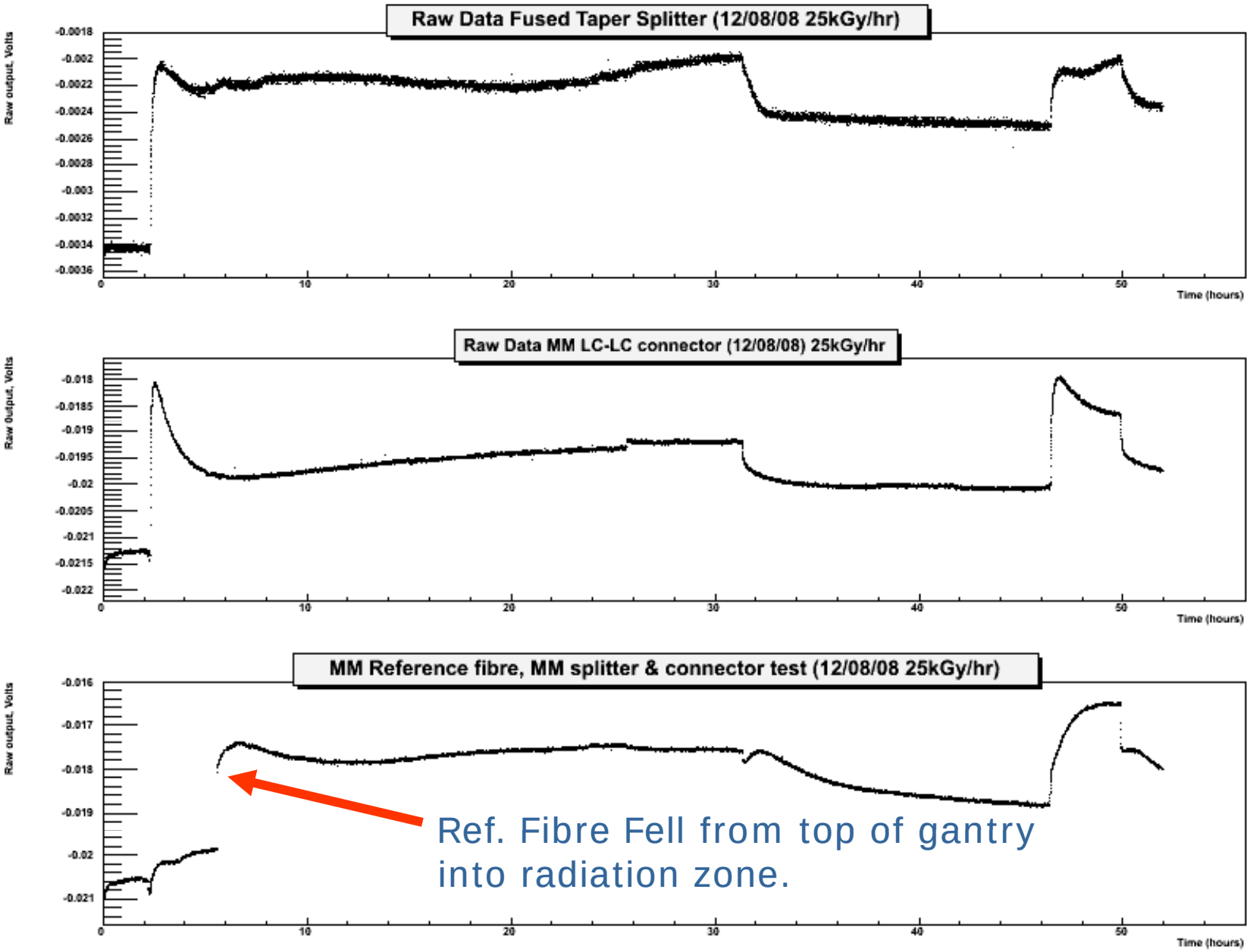
Which fibre is best?



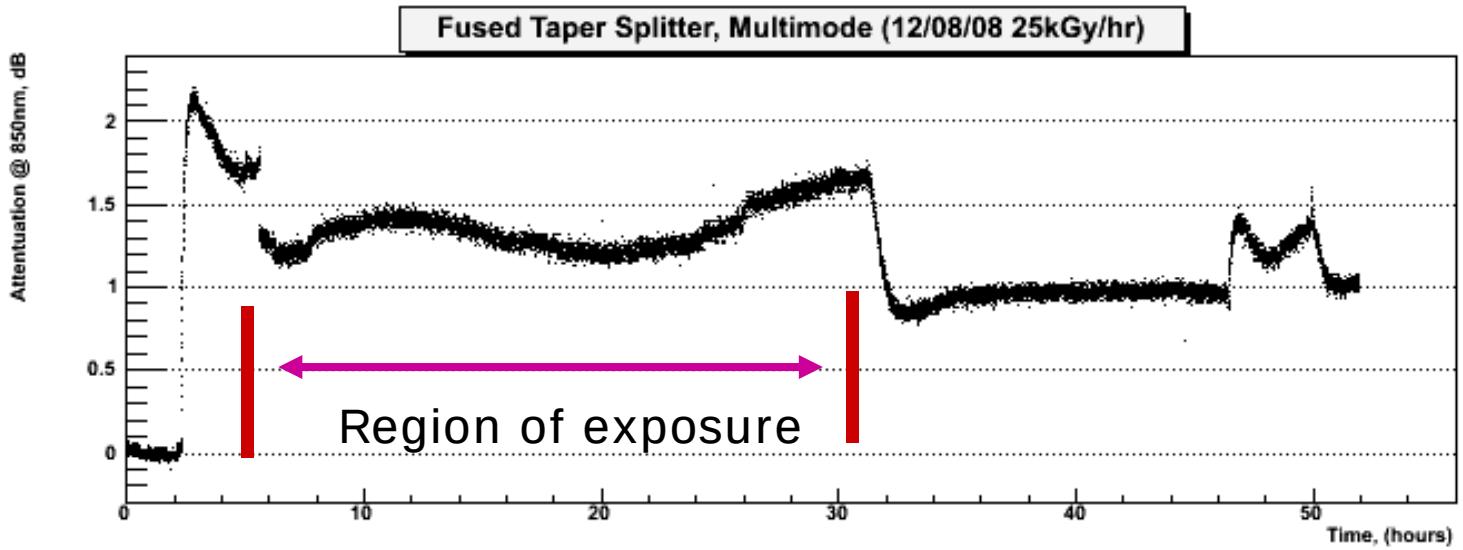
Infinicor Light Intensity effects

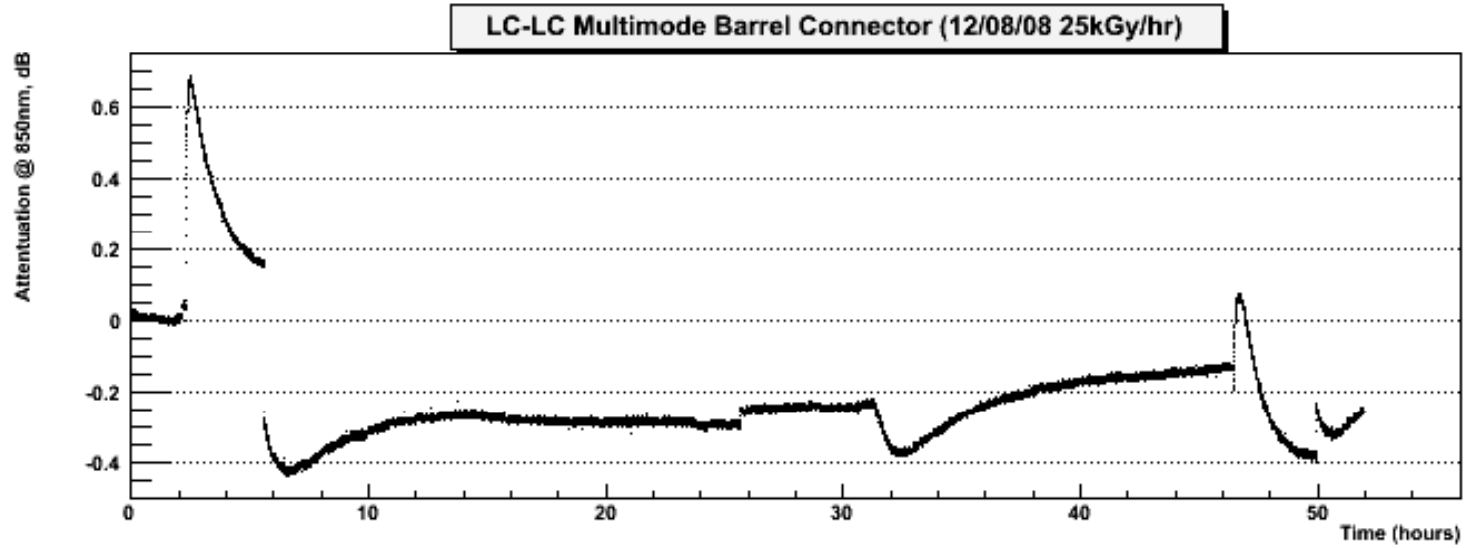


Active MM Component Raw Data

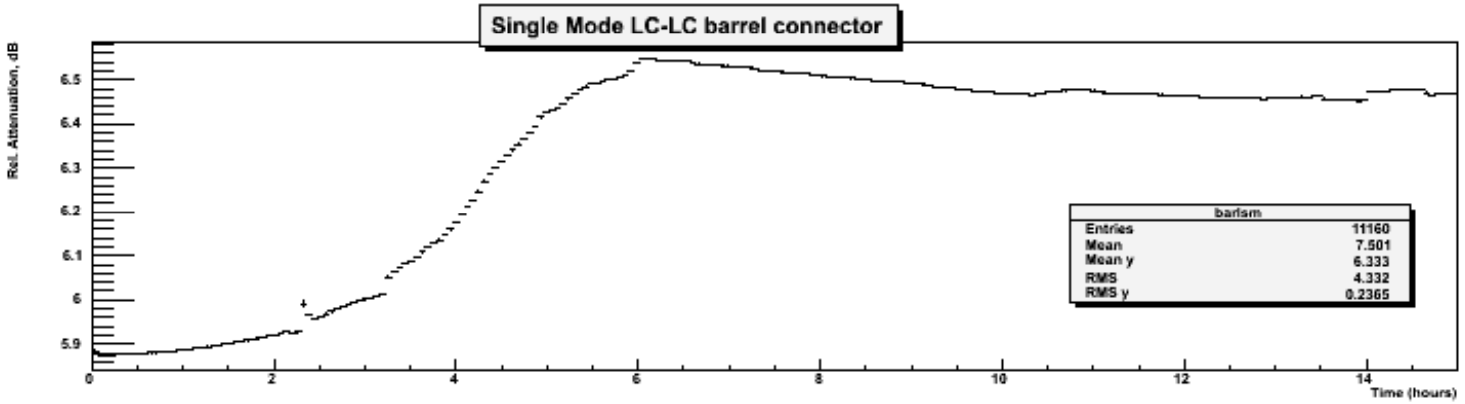


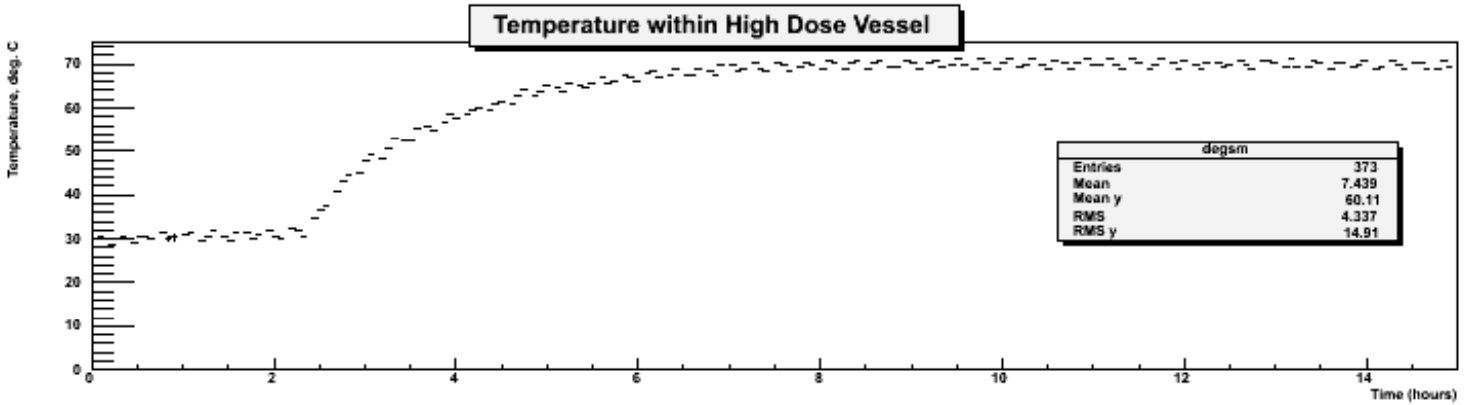
Active MM Component tests

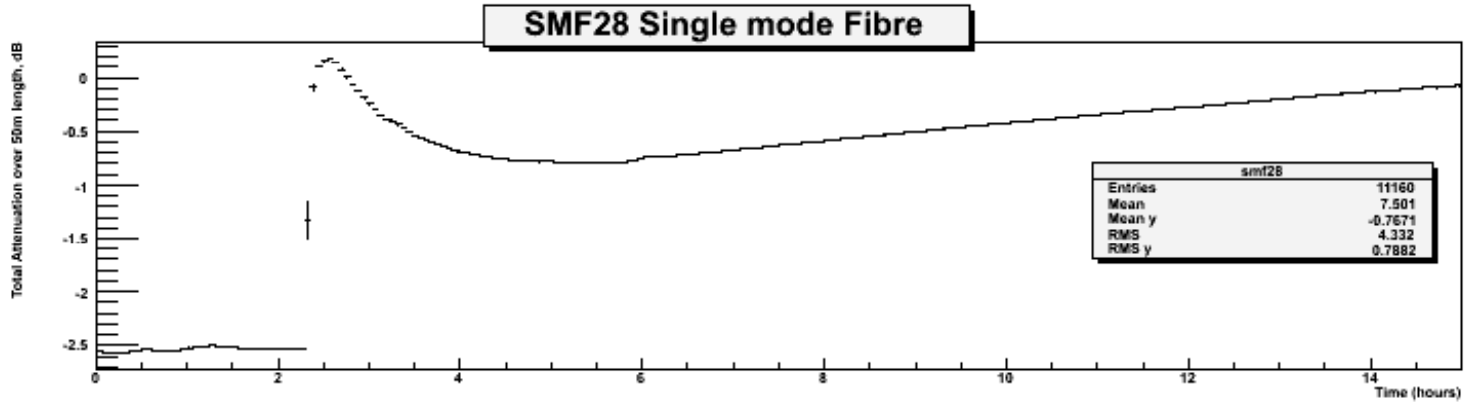




Single Mode LC-LC connector







The Passive tests

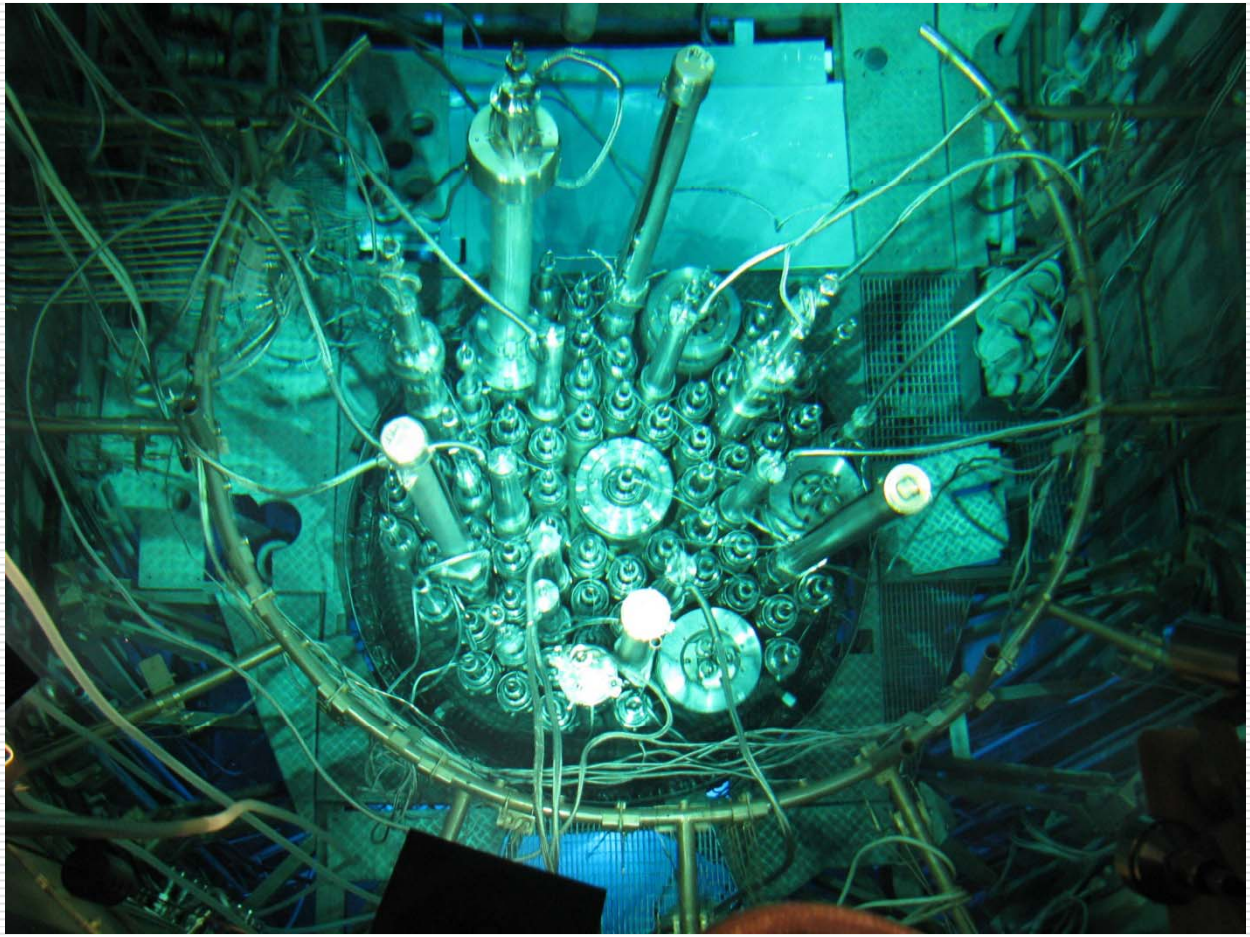
- Components tested before and after irradiation up to 720kGy.
  - 7 fused taper splitters (1 850nm multimode, the remainder 1310nm single-mode) with SC connectors on all in and outputs;
  - 2 single-mode PLCC splitters with SC connectors on all in and outputs;
  - 6 LC-LC Multimode barrels
    - Result→ No damage at 0.02dB level

Passive test results

Device	*Attenuation, dB*	*Standard Dev., dB*
7E (FT splitter SM)	0.20	0.055044
8E (FT splitter SM)	0.40	0.260118
9E (FT splitter SM)	0.41	0.065326
10E (FT splitter SM)	0.55	0.072245
11E (FT splitter SM)	0.21	0.07612
12E (FT splitter SM)	0.33	0.09783
5M (PLCC splitter SM)	4.10	0.030325
6M (PLCC splitter SM)	3.60	0.036641
6E (FT splitter MM)	1.34	0.019436

A working nuclear reactor

(Looking down from above)



The reactor core

(Side View)

Clearly, there have been no discernable side effects.

Conclusions

- SMF-28 Single mode fibre is very rad-hard and likely sufficient for the upgrade.
- Infinicor (Corning) GRIN fibre exhibits and estimated 0.36dB loss in ATLAS.
  - **This includes safety factors!**
- **2** of the three Ericsson fibres tested well and comparable to the Infinicor fibre.
  - **Second source**
    - Manufacturing details for all MM fibres are difficult to obtain.
- Passive Connector tests were highly successful; active tests less so. Radiation damage consistent with zero (MM) or with temperature effects (SM).
- Fused Taper splitter damage is all consistent with radiation damage to the optical fibre that make them up.
  - More tests in this area may be useful.
- PLCC splitters seem inordinately suseptable to ionizing radiaion.
  - An area very much worth further exploration.
- Some temperature effects will be further explored in our environmental chamber at Oxford.

End Of Talk

Next Slides are backup slides

Single Mode Raw Data