

# Light guide dosimeters and loss monitors

The logo for TESLA, featuring the word "TESLA" in a bold, black, sans-serif font. The letters are set against a background of a light gray, stylized, repeating pattern that resembles a light guide or a series of connected nodes.

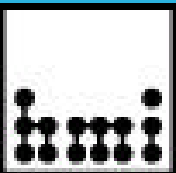
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# Motivation

- Sensor for continuous online-monitoring of
  - radiation sensitive components (Undulator, Electronics)
  - accelerator sections with spatial resolution
  - fast beam losses

Dosimetry in small and tiny spaces

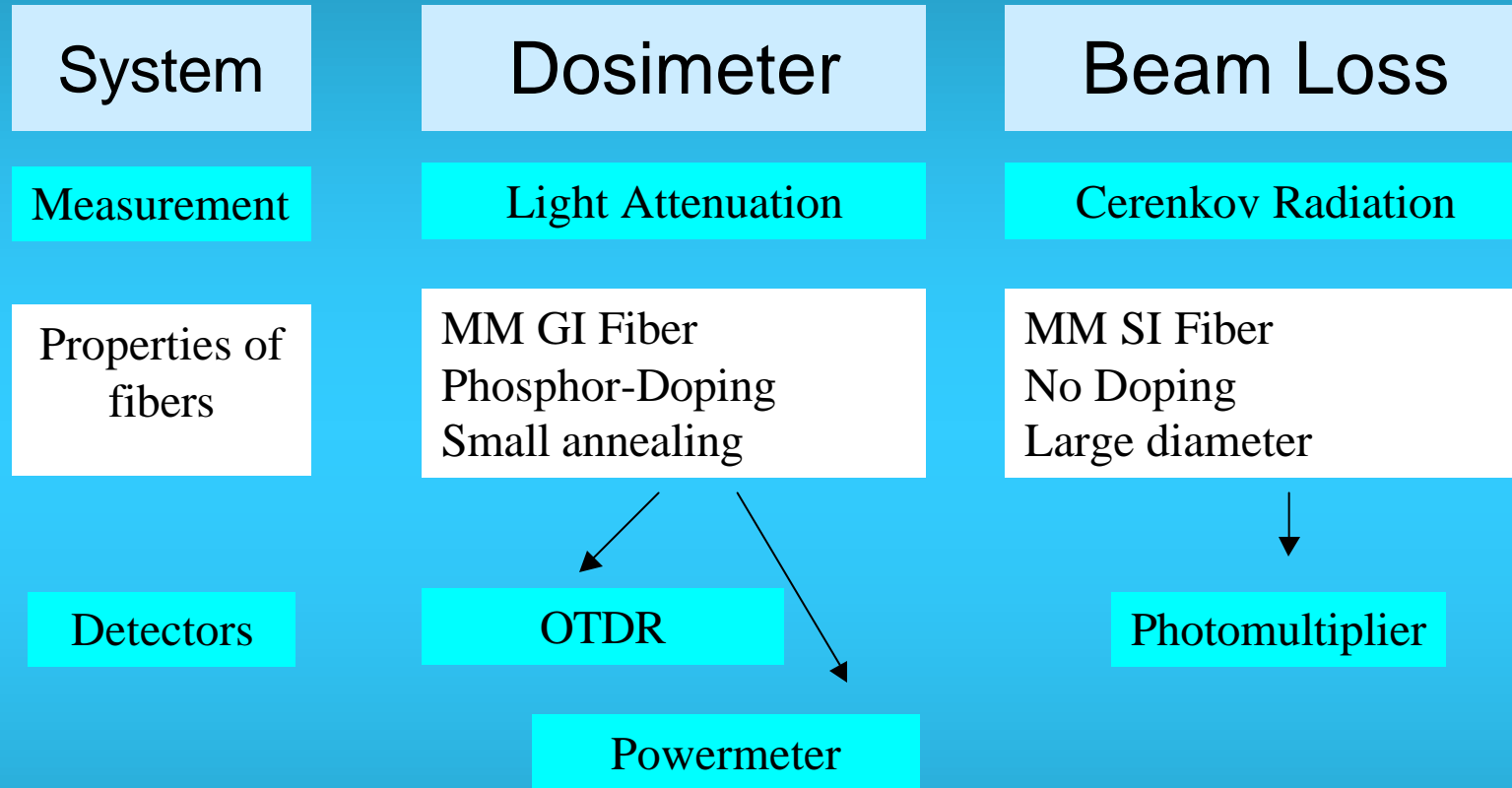
Insensitive to electromagnetic fields

Maintenance free operation

Three different systems have been studied:

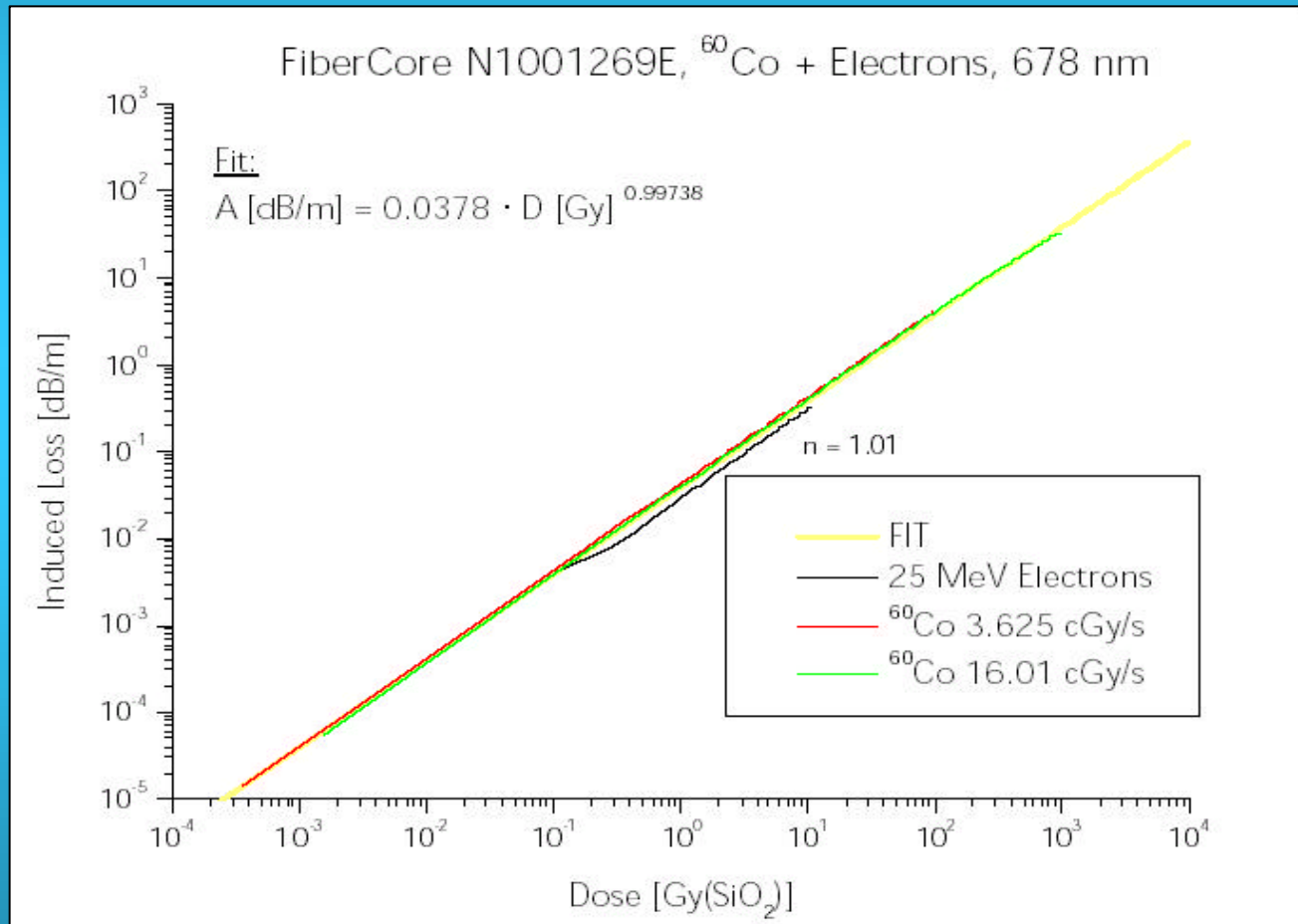


# Light Guide Systems



## Dosimeter Fiber:

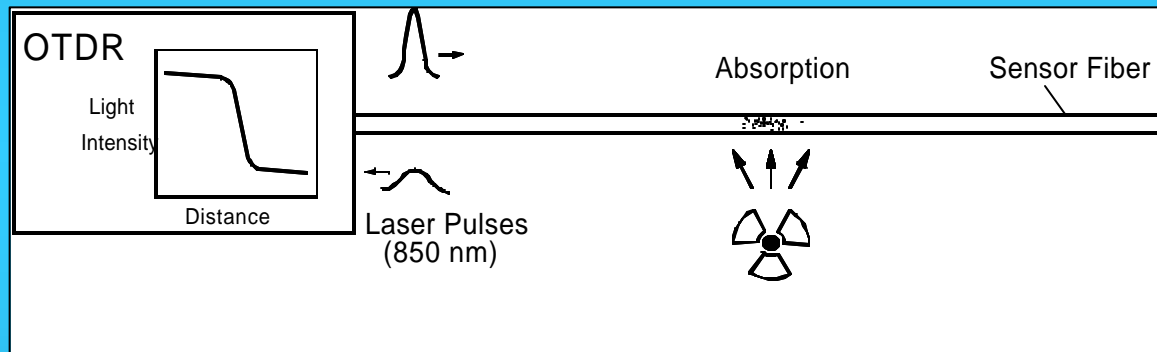
Optical fibers show (wavelength-dependent) a nearly linear increase of attenuation after irradiation with ionizing radiation independent from dose-rate and -source



# OTDR

Goal: Continuous Online-Measurement of the local dose (e.g. along the LINAC)

Radiation creates color-centers in fiber  
⇒ Measurement of the attenuation with OTDR



- short Laser pulse enters the light guide
- Rayleigh Scattering reflects light back to detector
- Color centers absorb backscattered light
- Absorption is proportional to the dose

# OTDR Measurement

**OTDR: Tektronix TFP2A**

**Laser pulse duration: 3 ns (FWHM) at 850 nm**

↳ **local resolution 0.6 m**

**Optical Fiber : FiberCore N2900107GA**

**Linear attenuation up to 2000 Gy**

**TTF-fiber length < 300 m**

↳ **no laser pulse widening**

⇒ **due to the fiber bandwidth the local resolution along the accelerator is constant**

**Dynamic range about >12 dB @ 850 nm**

↳ **limitation of the max. dose and length**

Installation of fibers along the vacuum chamber to get fast results



## Results - OTDR

Time period 17 Day's in 11/2000

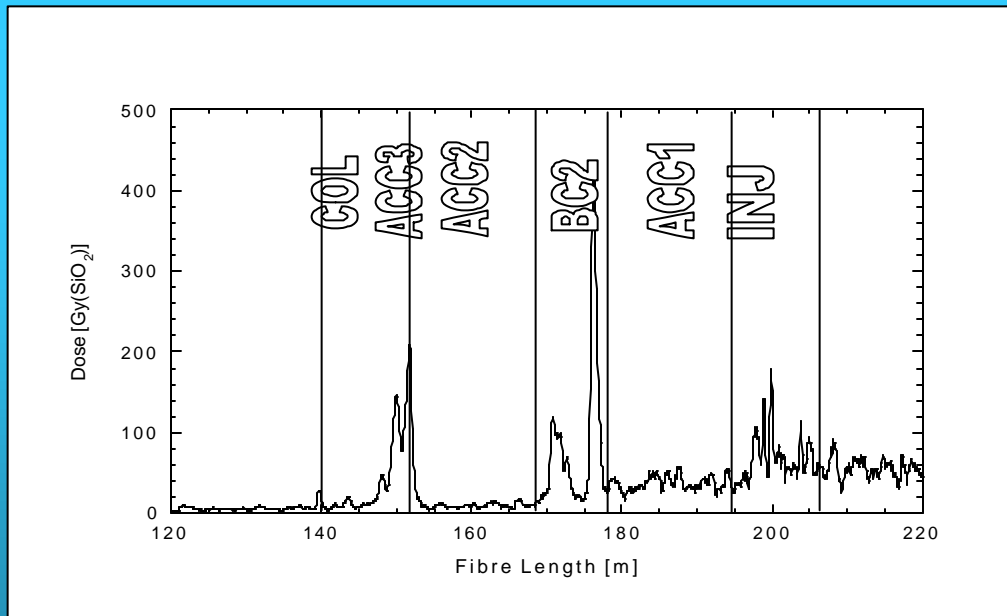
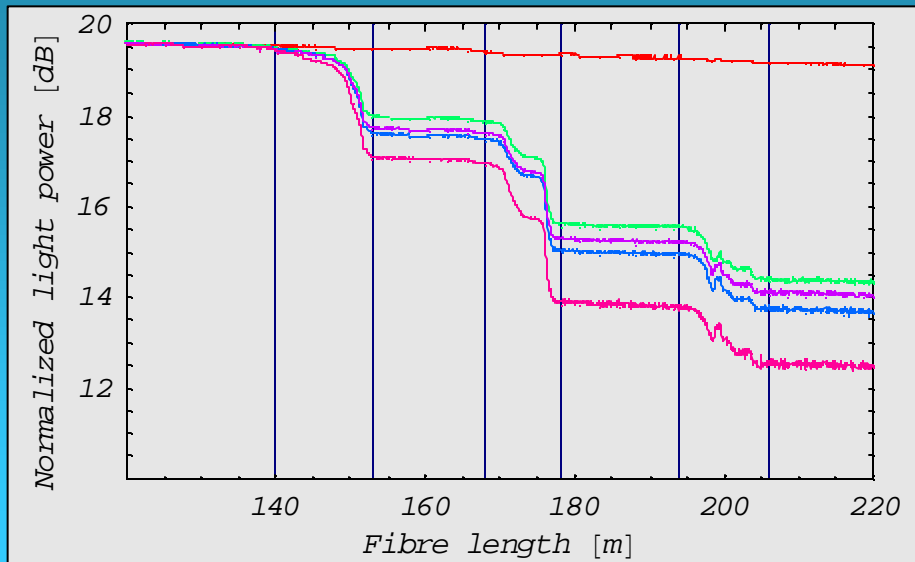
Beam direction from the right

dynamic range limits observation of  
max. dose and max. length

noisy signal in the injector region  
(INJ)

Dose budget:

- Bunch compressor BC2 up to 450 Gy
- temp. Beam-line ACC3 up to 200 Gy
- above 180 m the noise starts
- resolution < 3 Gy (noise limit)

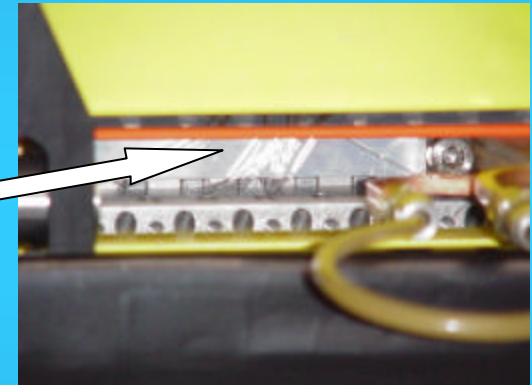
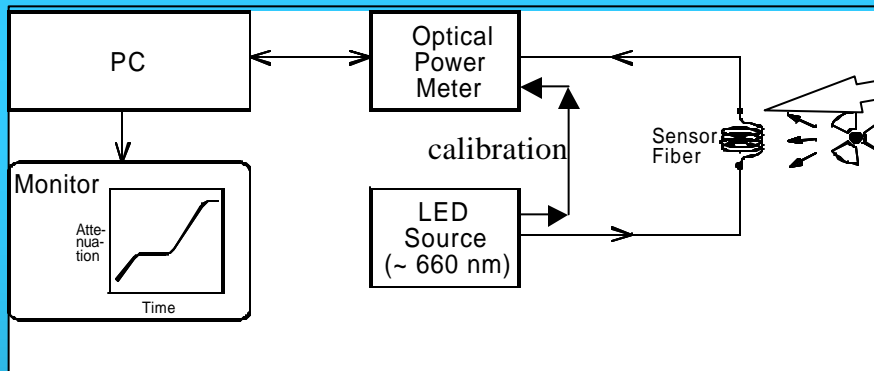


# Powermeter

Goal: Precise, sensitive and fast online-dosimetry

Radiation creates color-centers in fiber

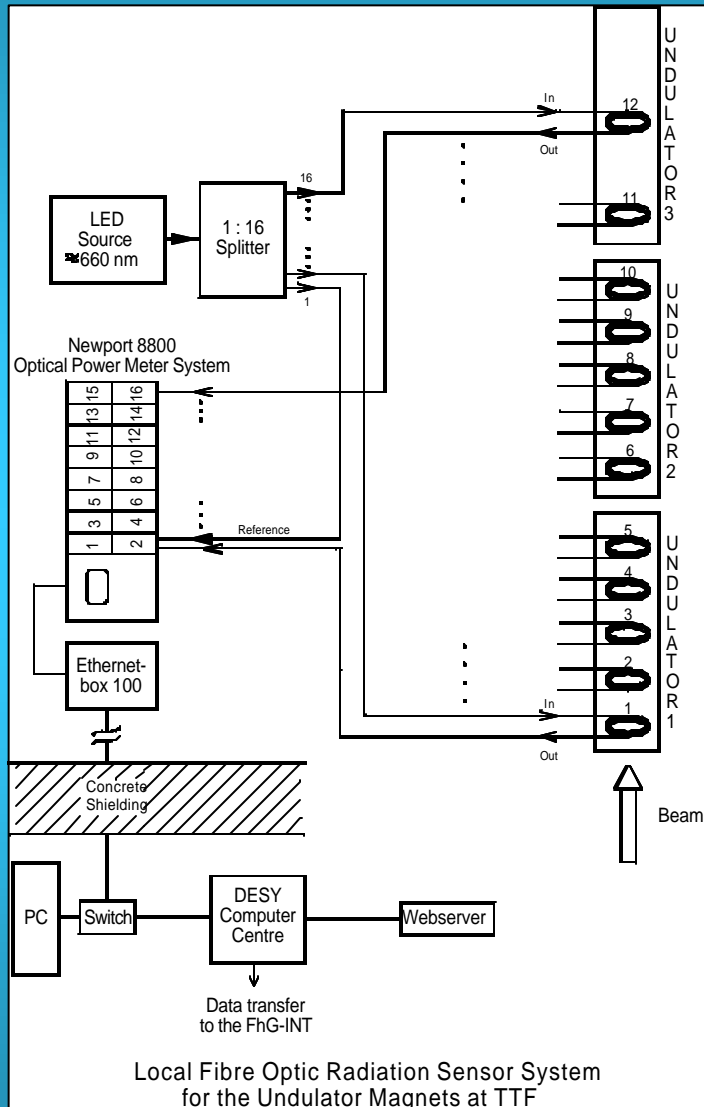
⇒ Measurement of the attenuation with Powermeter



- light from Laser LED enters the light guide
- continuous measurement of the light power (attenuation)
- position of sensor defines spatial resolution



# Powermeter Installation at TTF

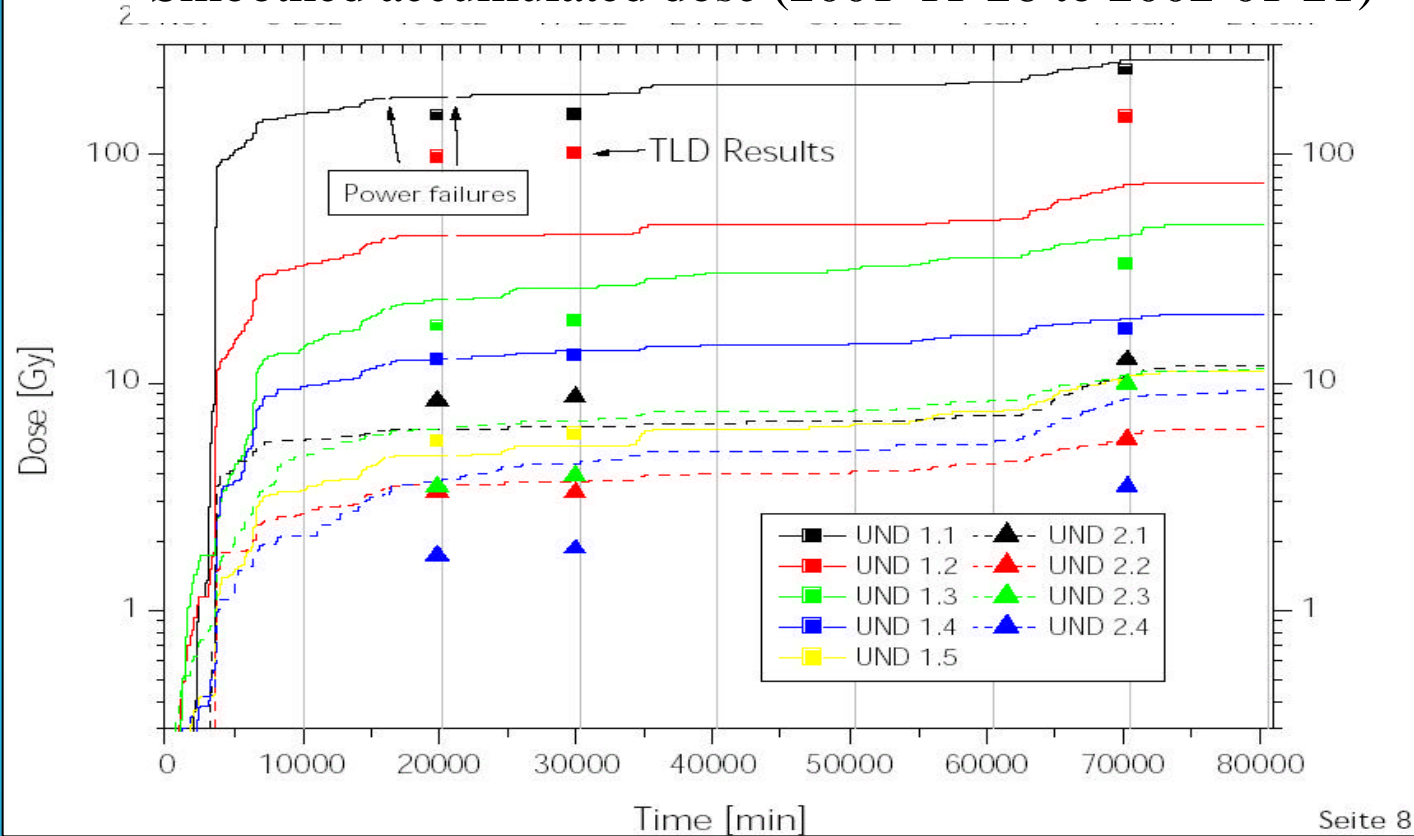


- 5 - 20 Fiber windings around beam pipe
- Dynamic range > 50 dB
- Resolution: 140 mGy



# Comparison with TLD Measurements

## Smoothed accumulated dose (2001-11-26 to 2002-01-21)



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Deviation:  
mostly < 25 %

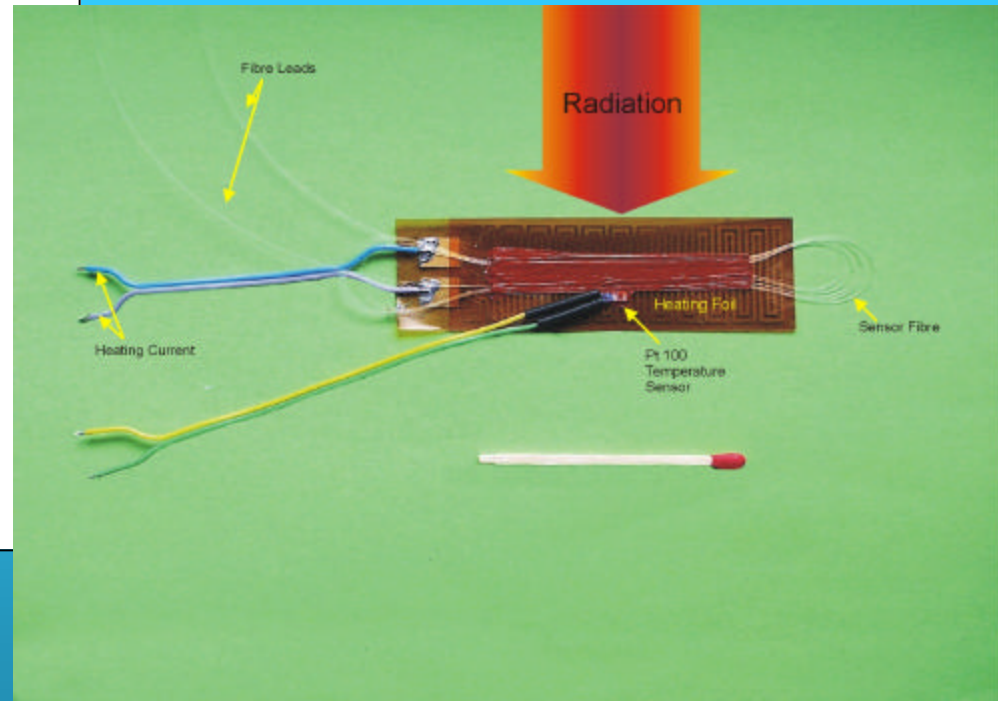
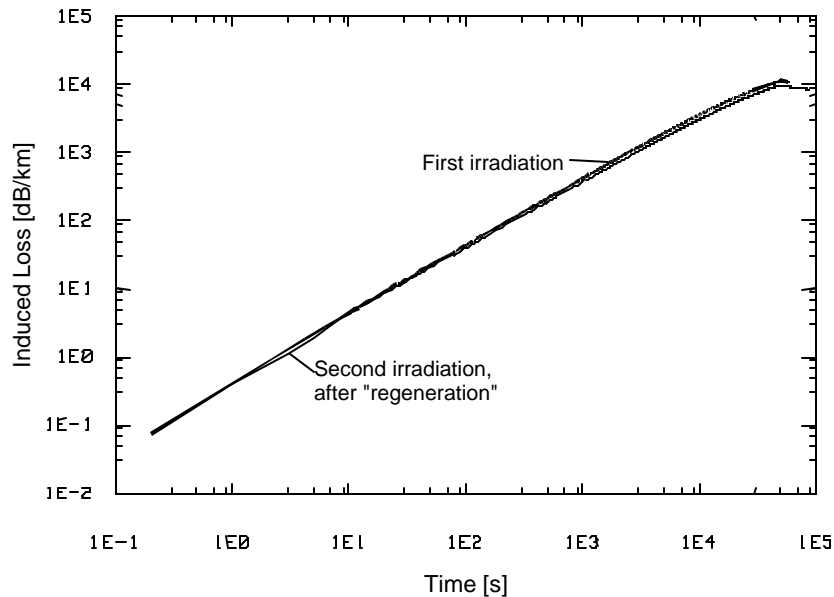
Reasons:  
• not same position  
• TLD Error 10-20 %

# Regeneration for fibers with temperature

Goal: Maintenance-free long-term use

Temperature **250 °C**

**90 %** regeneration within < 5 min



# Summary

<b>Measurement-System:</b>	<b>OTDR</b>	<b>Powermeter</b>	<b>Cerenkov</b>
<b>Application</b>	Online local dose detection by averaging	Online local dose detection in real time	Online local dose detection in real time
<b>Comment</b>	No single bunch resolution	No single bunch resolution	Single bunch resolution in a train
<b>Detector response</b>	A few minutes	A few ms	A few ns
<b>Range of dose [Gy]</b>	3 – 450 limited by OTDR	0.14- 2000 limited by fiber	Not calculated yet
<b>Range of wavelength [nm]</b>	850 - 1330	860	200 – 850
<b>Resolution length</b>	$\leq 1\text{m}$	$\leq 0.01\text{ m}$	$\leq 0.2\text{ m}$
<b>reasonable Fibre length*</b>	$\leq 5\text{km}$	$\leq 1\text{ km}$	$\leq 1\text{km}$

\* depending on max. dose and position resolution