ESA-NASA working meeting on Optoelectronics

- Radiation testing of optical fibres and systems at Fraunhofer INT

- Jochen Kuhnhenn,
  Stefan Metzger,
  Henning Henschel

Fraunhofer INT
Institut
Naturwissenschaftlich-
Technische Trendanalysen

Outline

- Radiation effects division of Fraunhofer INT
- Radiation effects in optical fibres
  - *Overview*
  - *Dependencies*
  - *Perspectives*
- Consequences

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Radiation effects division of Fraunhofer INT

- Fraunhofer INT has more than 25 years of experience in the investigation of radiation effects on optical fibres and related systems
- Fraunhofer INT operates several irradiation facilities
  - *Four ^{60}Co-sources for simulations with different dose rates*
  - *Access to 45 MeV protons*
  - *Flash X-ray facility (2.2 MeV electrons or Bremsstrahlung)*
  - *14 MeV Neutron generators*

  and all necessary measuring equipment
- Participation in international standardisation and NATO working groups on radiation effects

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Radiation effects on optical fibres - Overview

- Radiation has many effects on optical fibres

  - *Change of mechanical properties*
    (tensile strength, compaction, degradation of coating material)
  - *Change of refractive index*
    (fibre bragg gratings, interferometers)
  - *Generation of luminescence light (especially Cerenkov effect)*

  - *<u>Radiation induced attenuation</u>*

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Dependencies of radiation-induced attenuation

Manufacturing influences

- *Fibre type (Single mode, graded index, step index)*
- *Dopants of core; dopants of cladding (only for SM fibres)*
- *Preform manufacturer and used processes*
- *Core material manufacturer*
- *OH Content*
- *Cladding core diameter ratio (CCDR) for step-index fibres*
- *Coating material*
- *Drawing conditions*

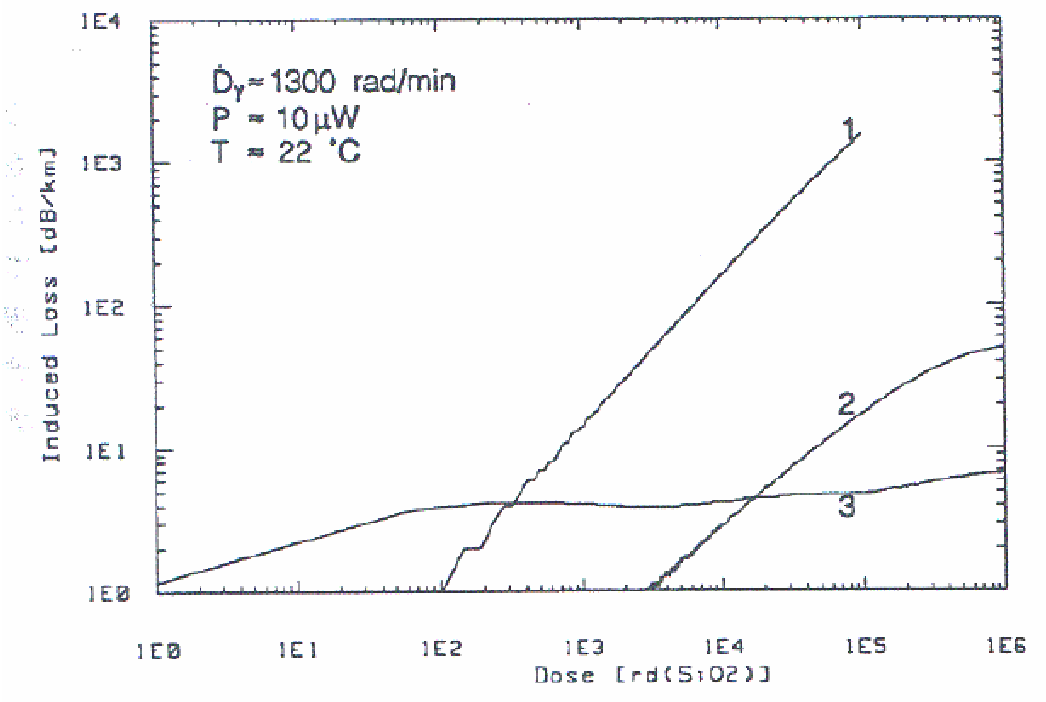
Operation conditions

- *Wavelength*
- *Light power*
- *Launch conditions*
- *Temperature*

Radiation Environment

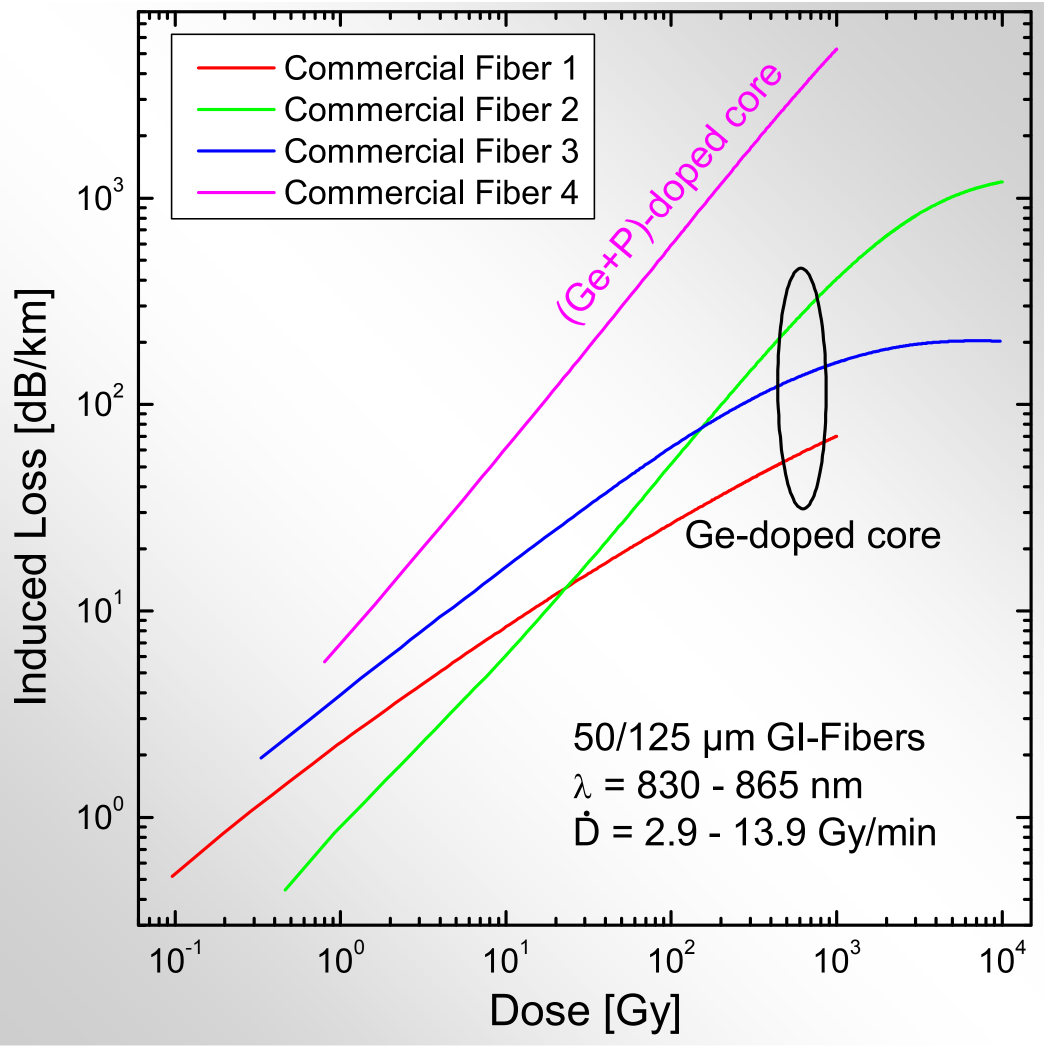
- *Total dose*
- *Dose rate*
- *Irradiation history*

Fibre type dependency



1: (Ge+P)-doped GI fibre, λ=1310 nm
2: Ge-doped SM fibre, λ=1310 nm
3: Pure silica core SI fibre (high OH), λ=830 nm

Core dopant dependency in GI fibres



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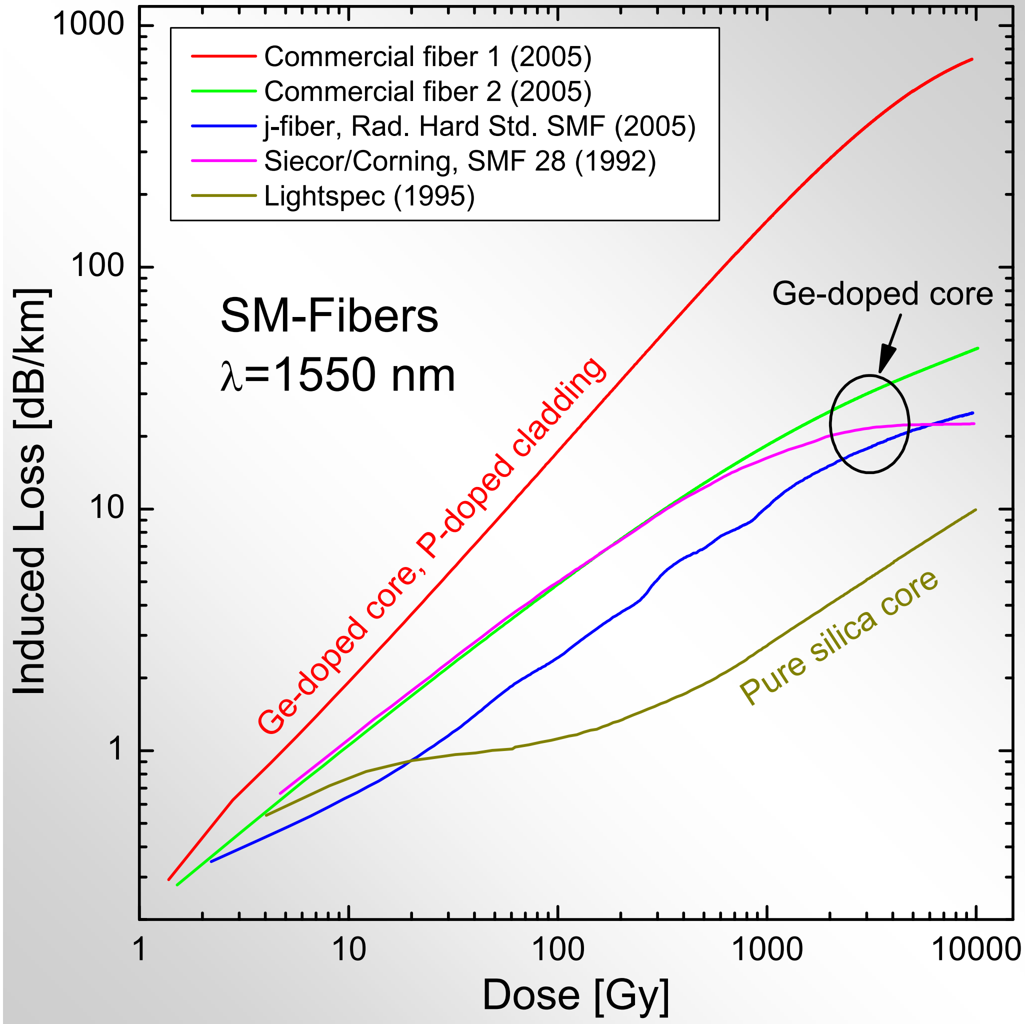
Core and cladding dopant dependency in SM fibres



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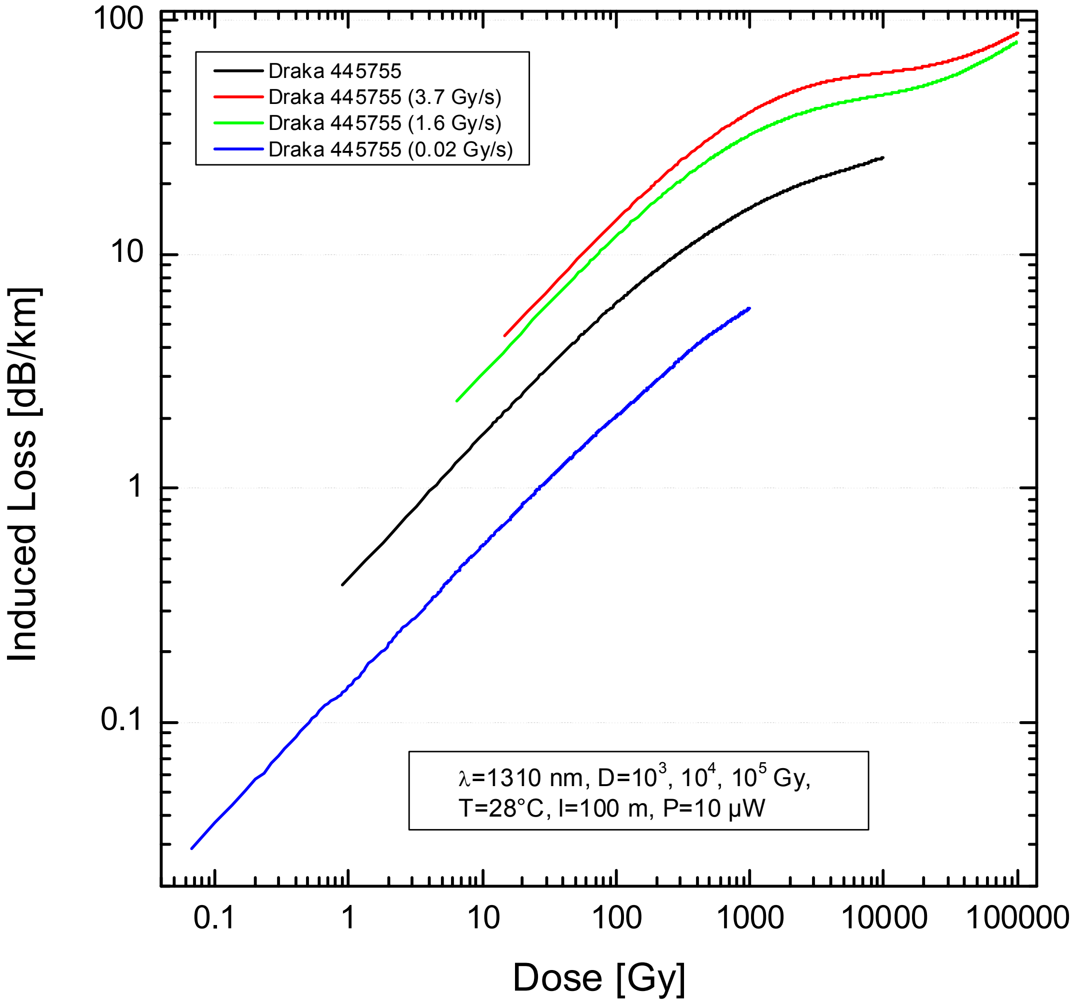
Dose rate dependency



- Measurements with same fibre under identical conditions, but dose rates of:
  - *0.02, 0.22, 1.7, and 3.6 Gy/s*
- Strong dependence on dose rate

Perspectives

- Strong reduction of radiation induced attenuation by special techniques
  - *Hydrogen loading or treatment of pure silica core fibres*
  - *Hollow core photonic bandgap fibres*
- Both techniques were investigated by Fraunhofer INT

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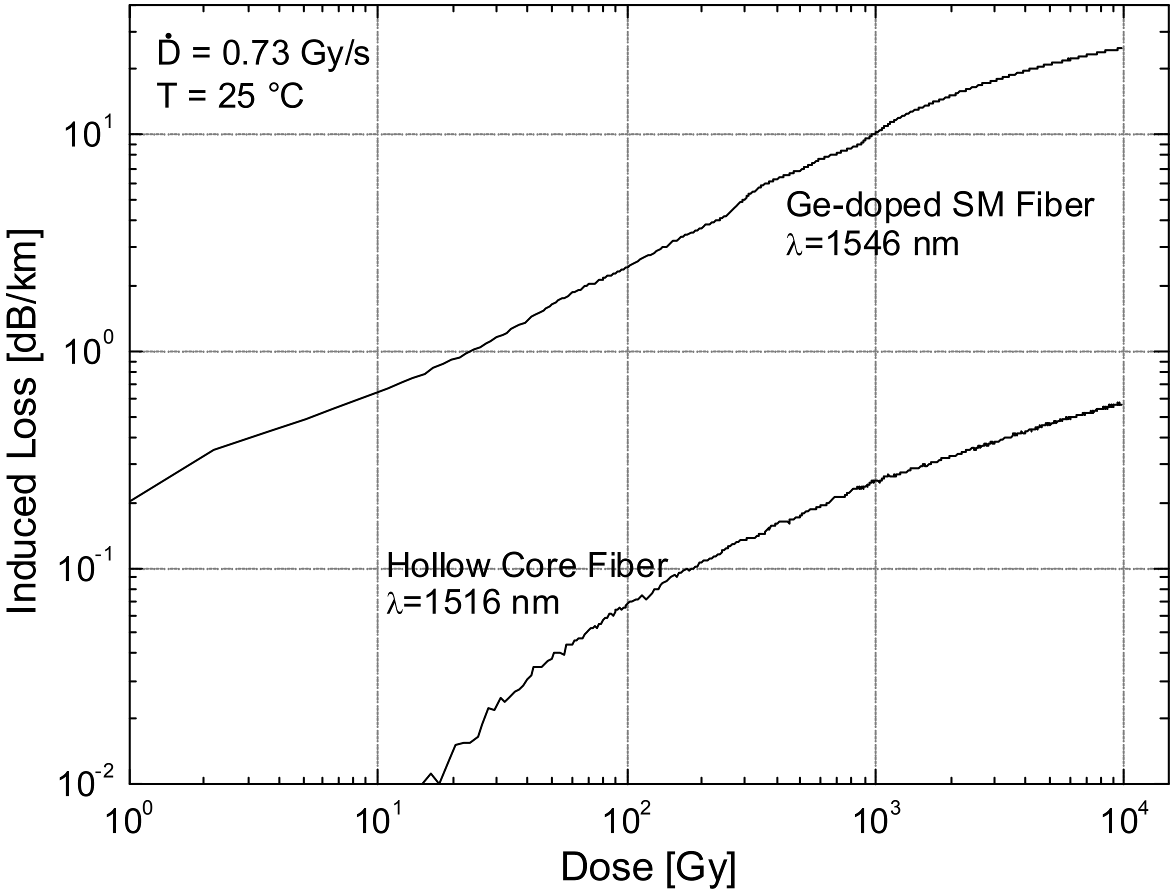
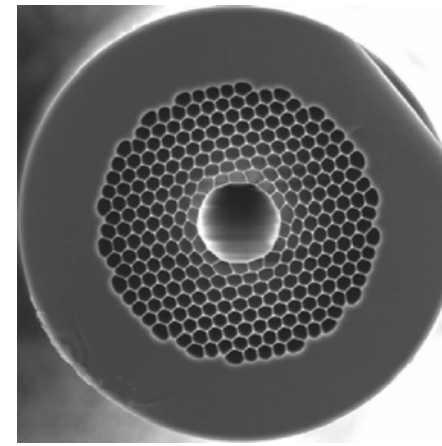
Radiation hardness of Hollow Core Fibres





- Additional advantage: No disturbance by luminescence light

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Consequences

- Complex dependencies of radiation effects lead to the following recommendations:

  - *Existing test standards have to be followed to obtain comparable results at different laboratories*

  - *Separate tests under realistic conditions are necessary to get more reliable and precise data*
    (e.g., actual temperature, wavelength, light power, dose rate)

  - *Quality variations of same products are possible and have to be considered for final realisation*

Thank you very much for your attention

- I'm looking forward to your questions …

Contact:
Dr. Jochen Kuhnhenn
Fraunhofer INT
Appelgarten 2
D-53879 Eurkichen
Germany

Tel.: +49(2251)18200
Fax: +49(2251)18378
Email: kuhnhenn@int.fhg.de