Optical absorption in commercial single mode optical fibers for the LHC machine

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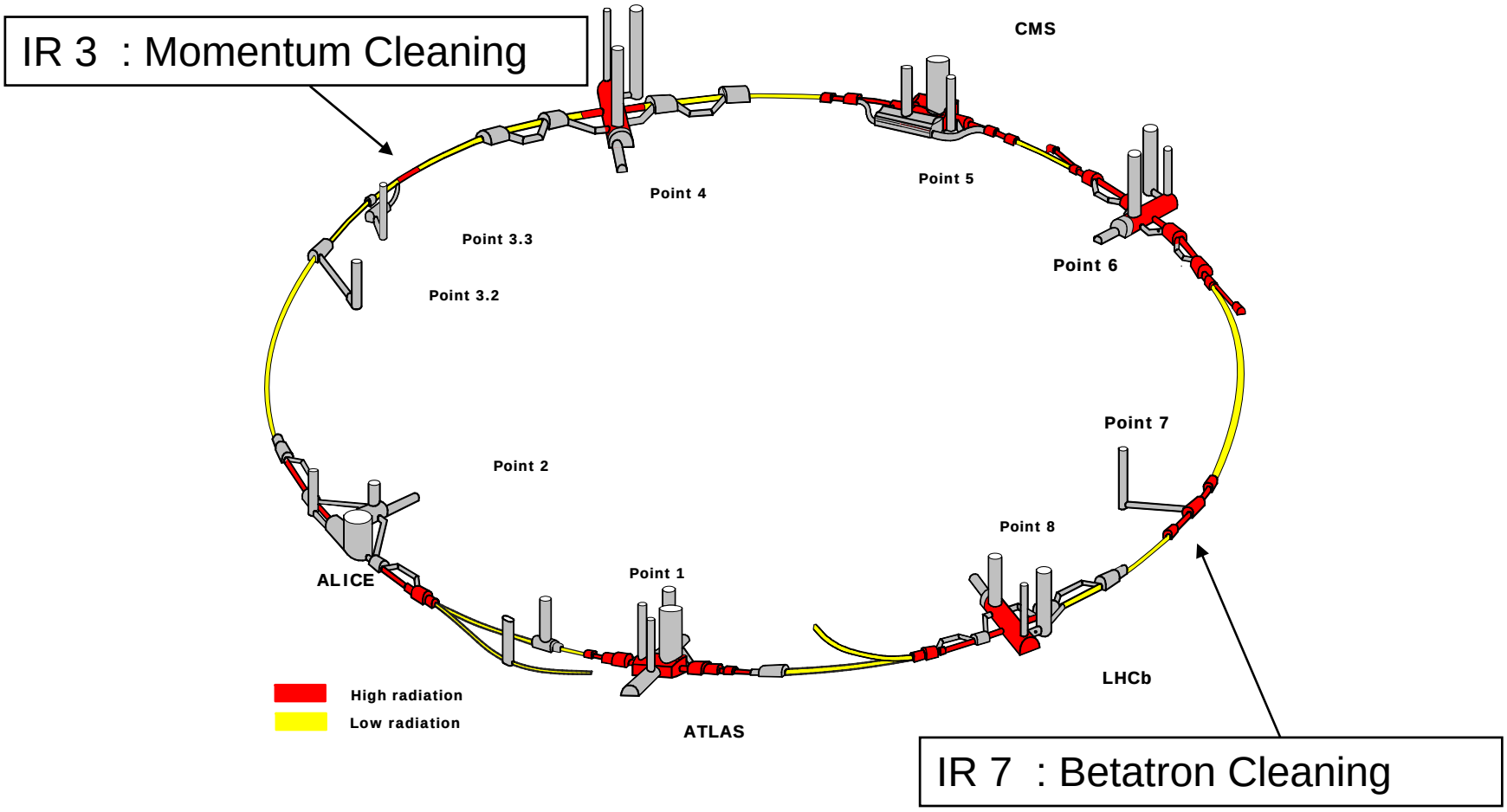
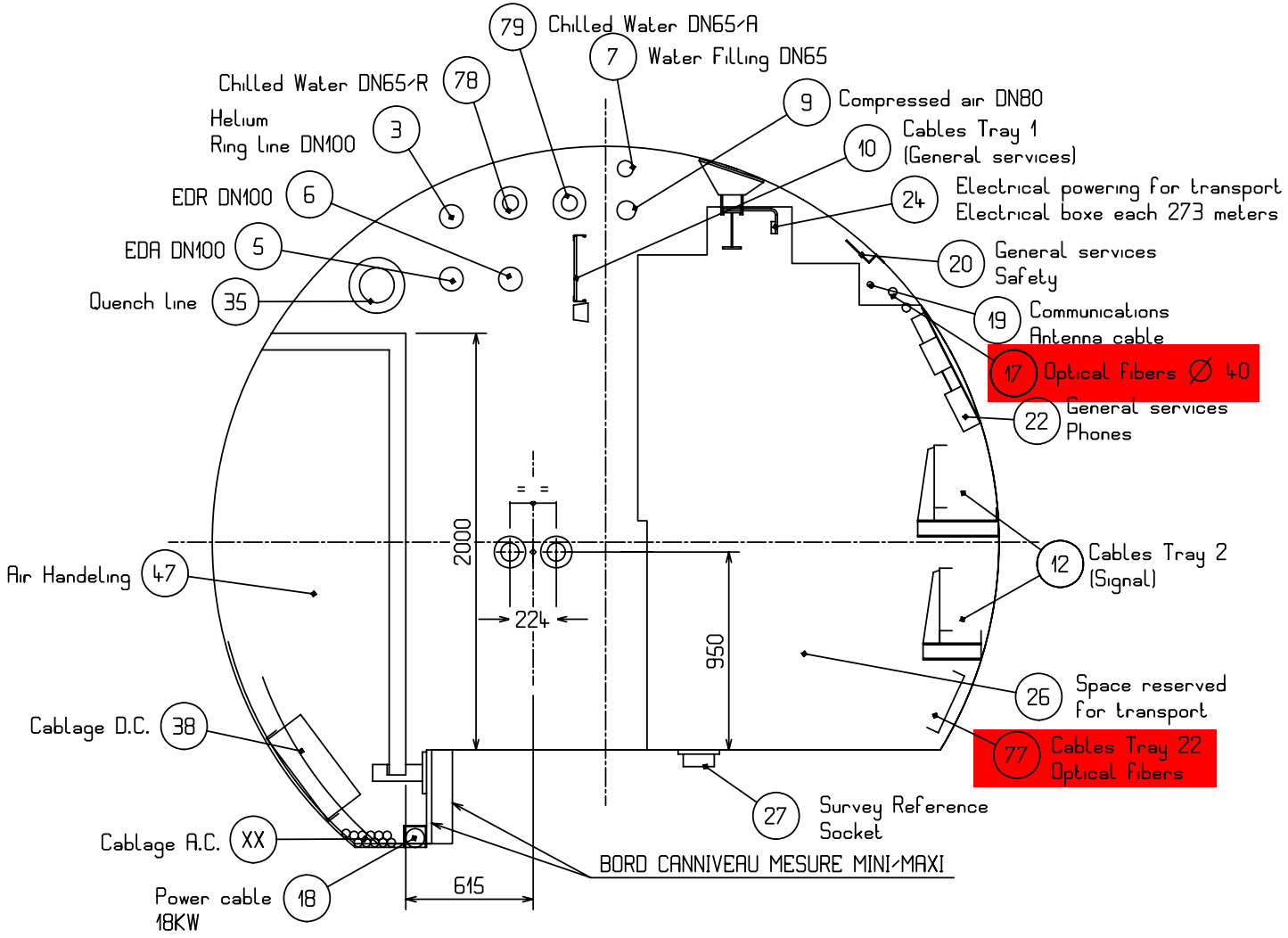
6th LHC Radiation Workshop : 29-30 November 2007 CERN

https://webh11.cern.ch/radworkshop/Registration.htm

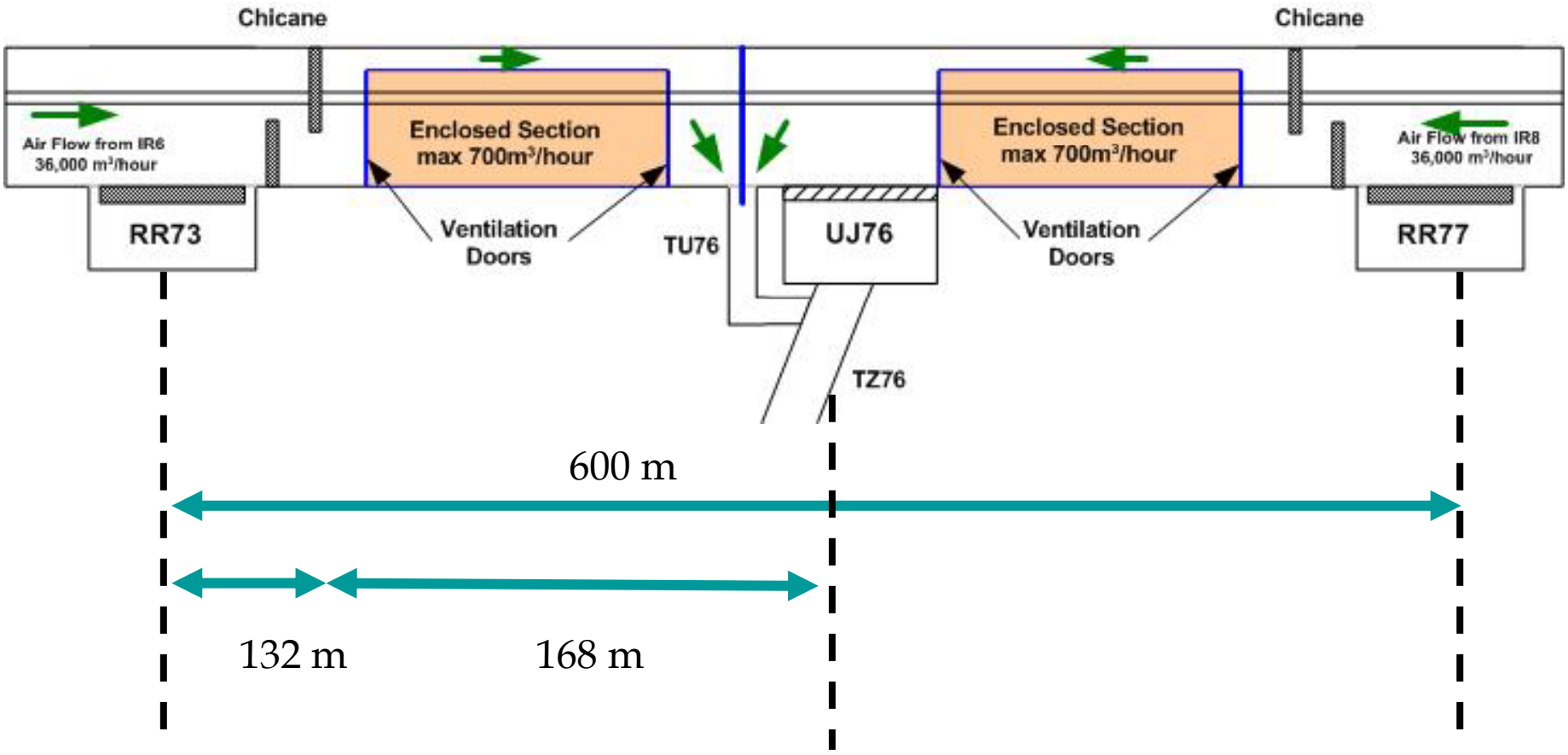
Radiation levels in the LHC



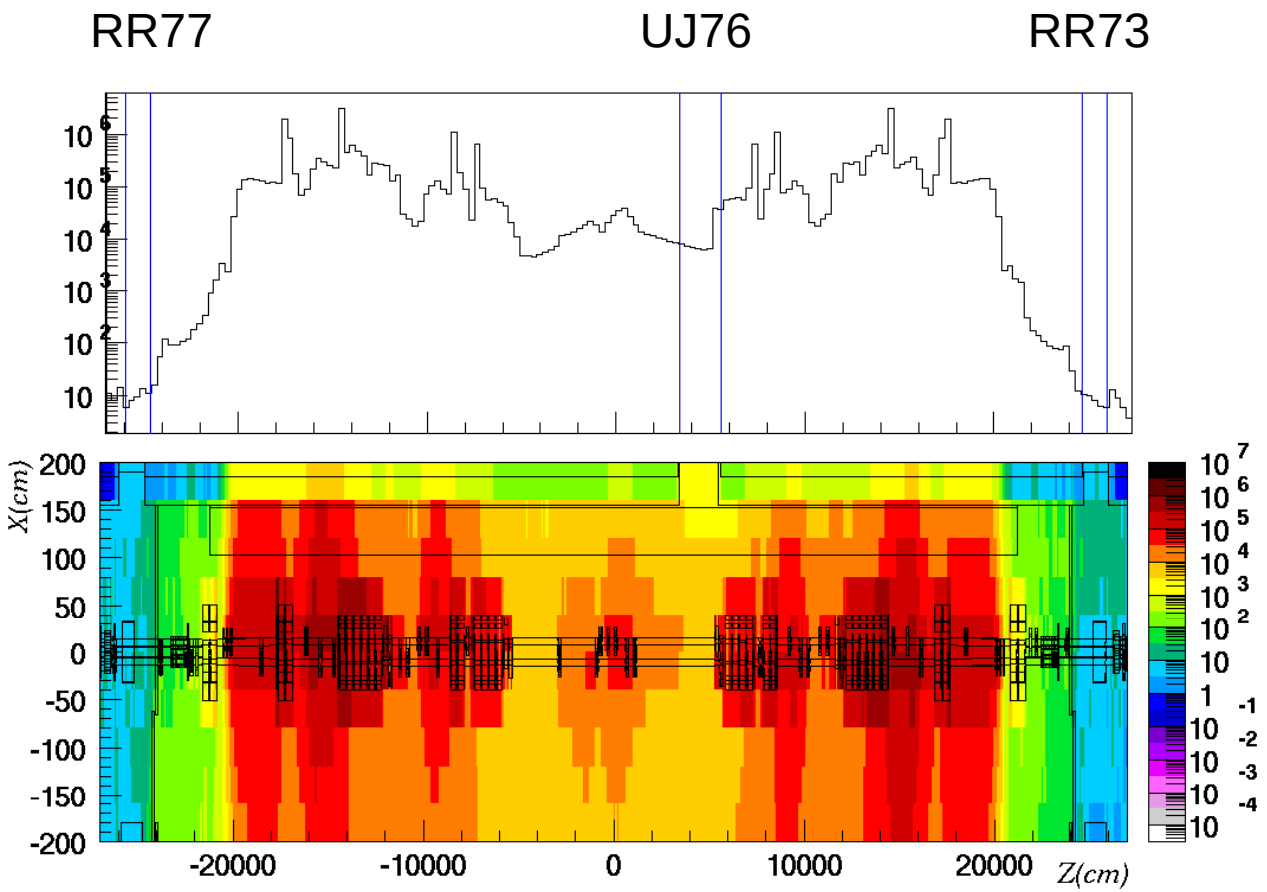
Optical fibers in Collimation areas



Fiber architecture LHC Point 7



MC simulations collimation area IR7



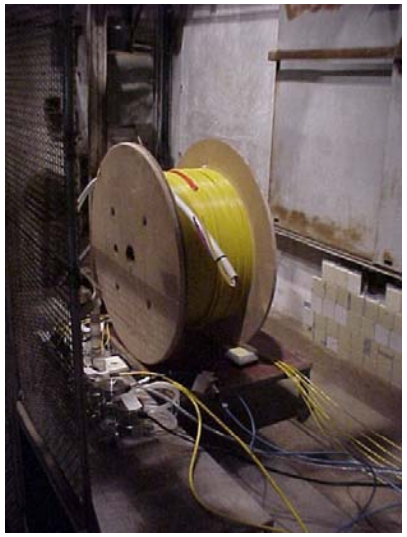
Dose rate distributions along the tunnel in Gy/year

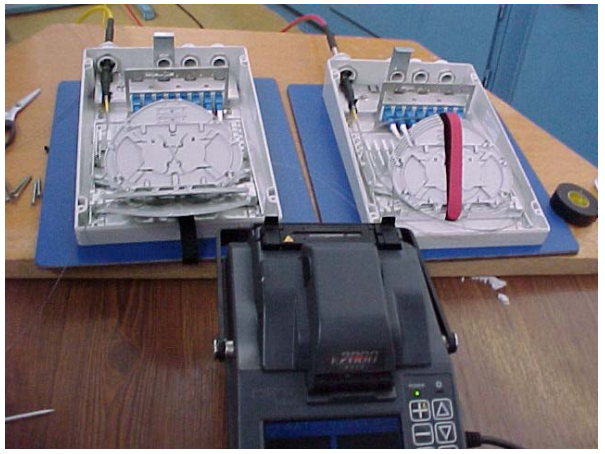
Engineering Constraints for fibers

- SM radiation hard optical fibers
  - RIA < 10 dB/km after 100 kGy
  - 1310 nm
  - High Energy Physics radiation field
- Fibers in cables – cables to be blown
- Commercial manufacturer
- Series production ~3000 km
- Lead time ~1.5 years

Standard LHC optical fibers

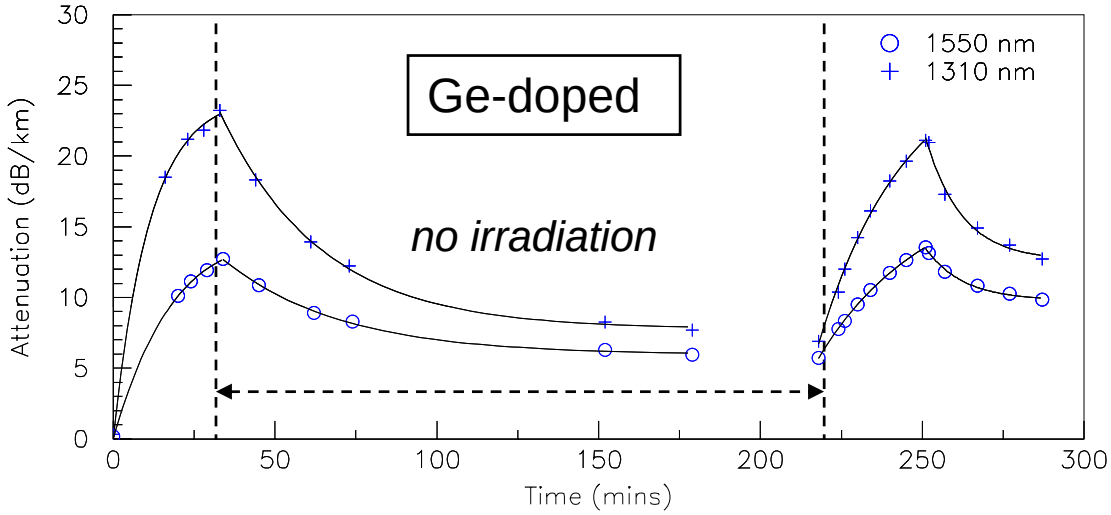
- Ge-P doped SM fiber
  - MCVD produced
  - Draka NK Cables Ltd.
  - 85/125 μm
- Ge-doped SM fiber
  - PCVD produced
  - Draka Fiber Tech. BV
  - 85/125 μm





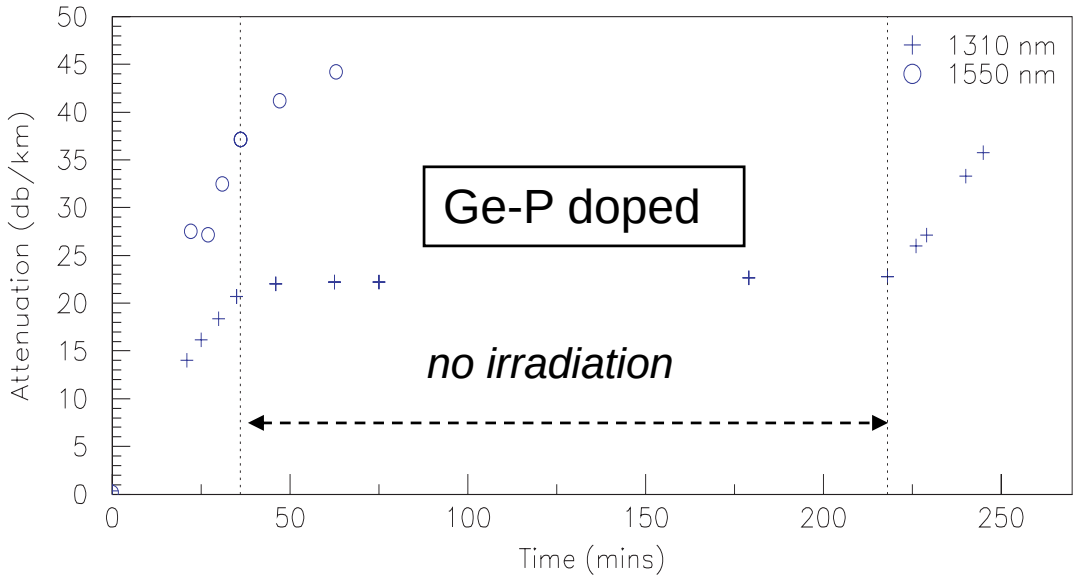
Co-60 Irradiation (CEA-Saclay)

Co-60 irradiation of standard LHC optical fibers



Co-60

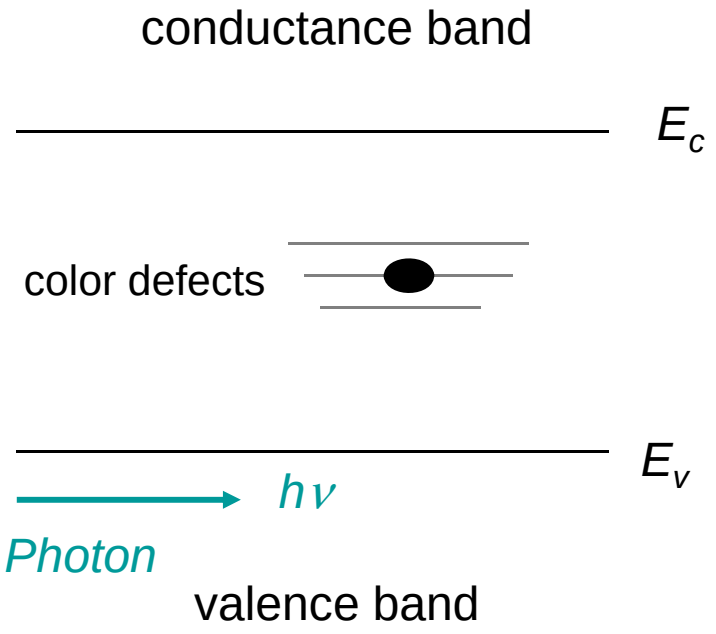
1 kGy/hr

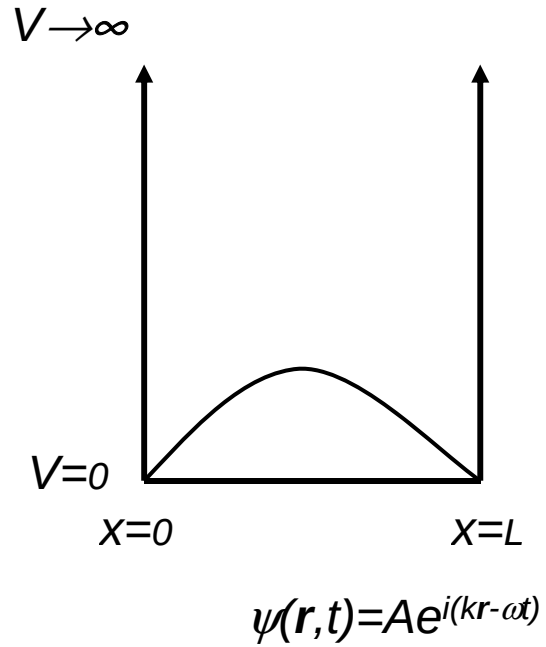


Co-60

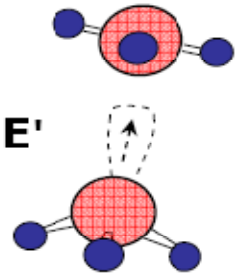
500 Gy/hr

Radiation Induced Absorption

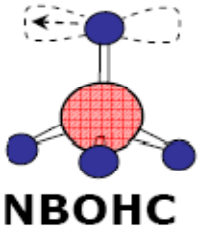




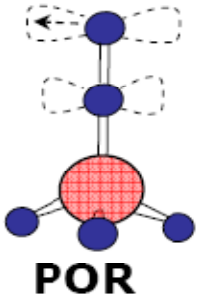
Paramagnetic color defects



218 nm

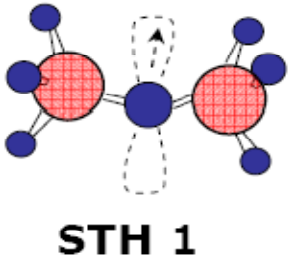


630 nm

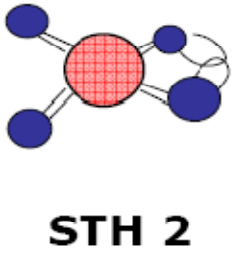


163 nm

630 nm

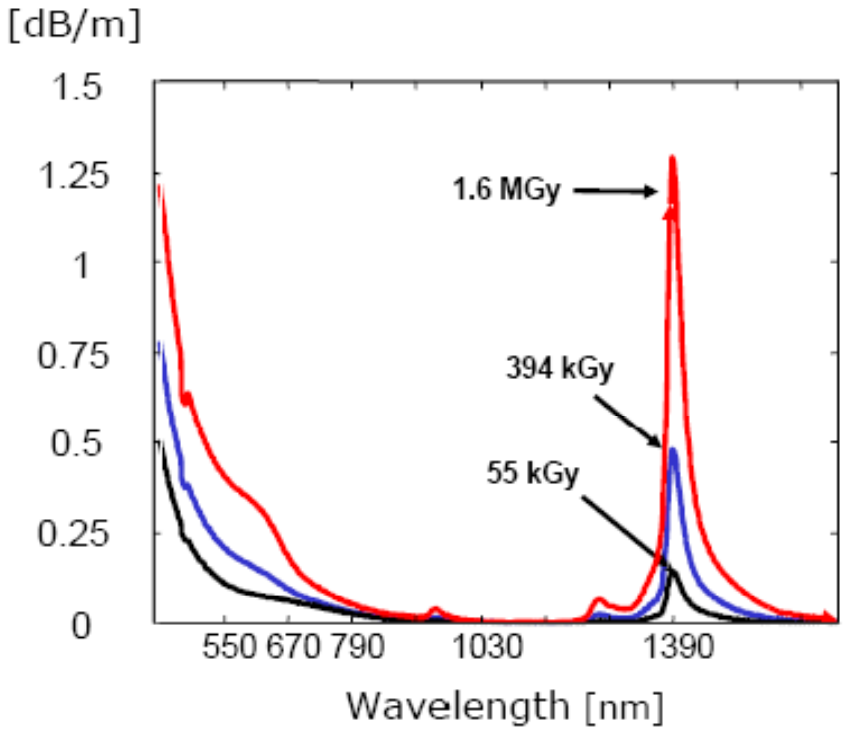


660 nm



760 nm

Attenuation spectrum irradiated SM fibers



From literature studies & experience

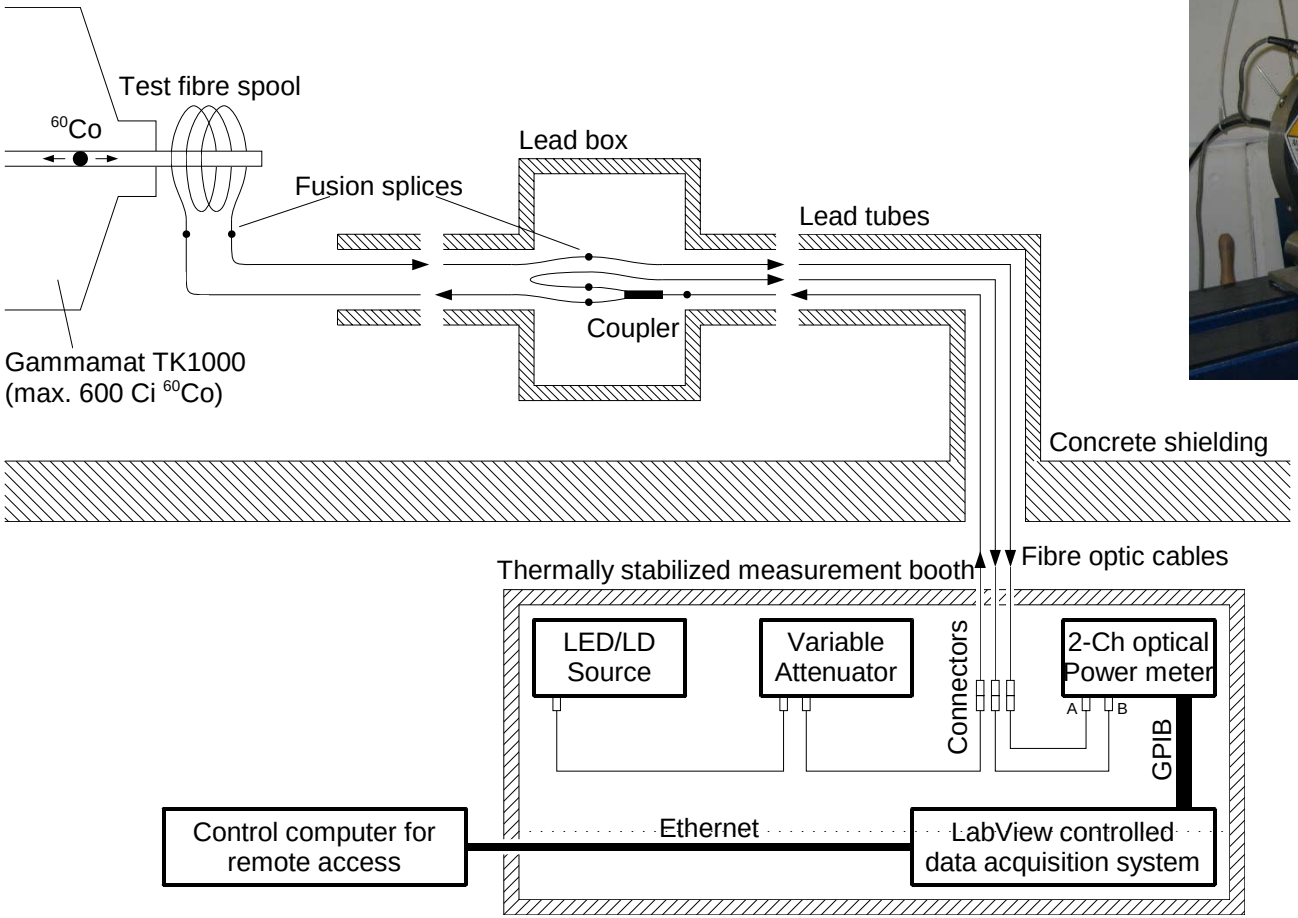
- Radhard SM fibers (?) for long wavelengths
  - Pure Silica Core (PSC)
  - Fluorine doped
  - Low OH content

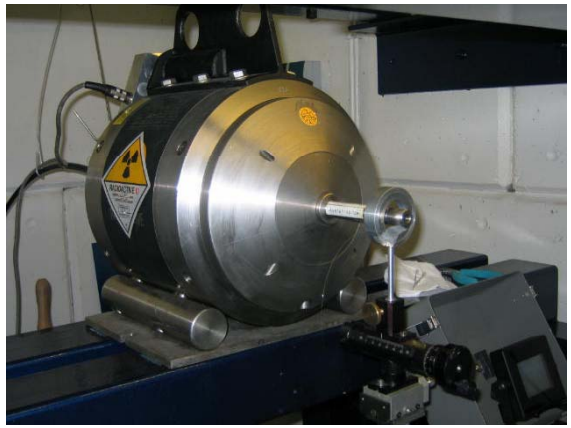
  Neutron irradiation ?

Screening test- sample collection

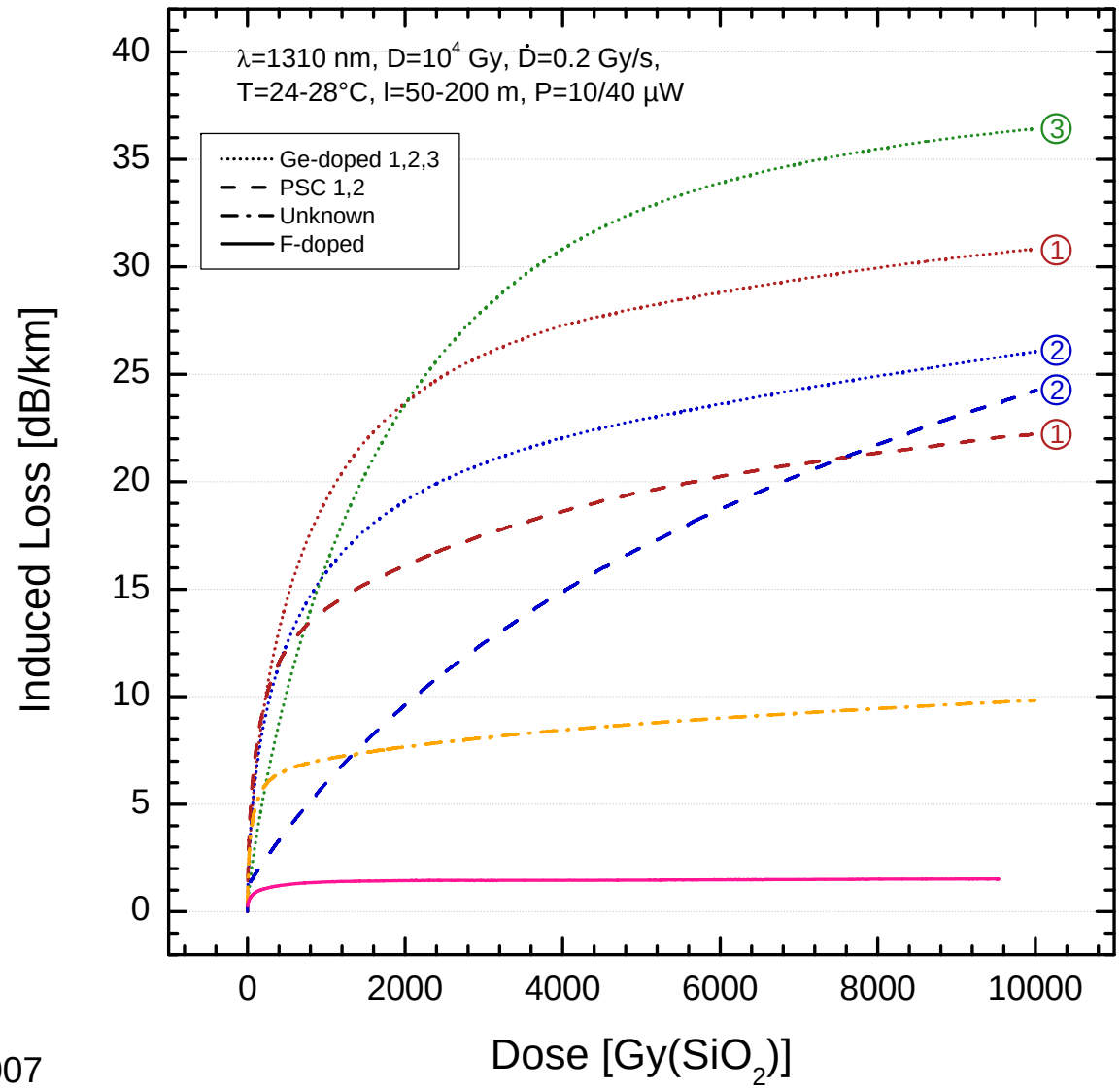
- Fiberware
- Fujikura Ltd Japan
- Heraeus
- J-plasma
- Nufern
- Oxford Electronics
- Sumitomo
- Verillon
- Corning
- J-fiber
- Draka

Screening test at Fraunhofer INT

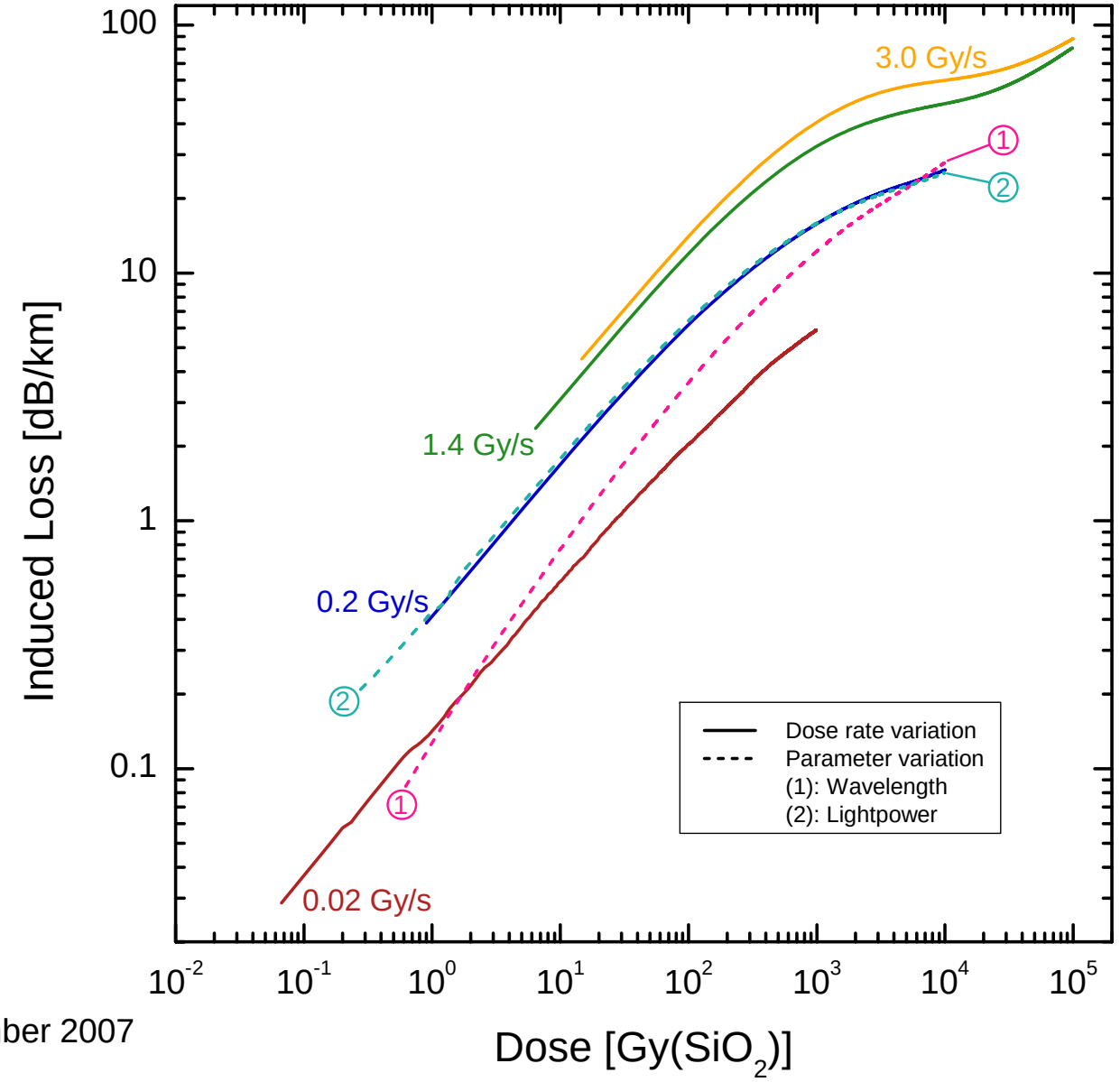




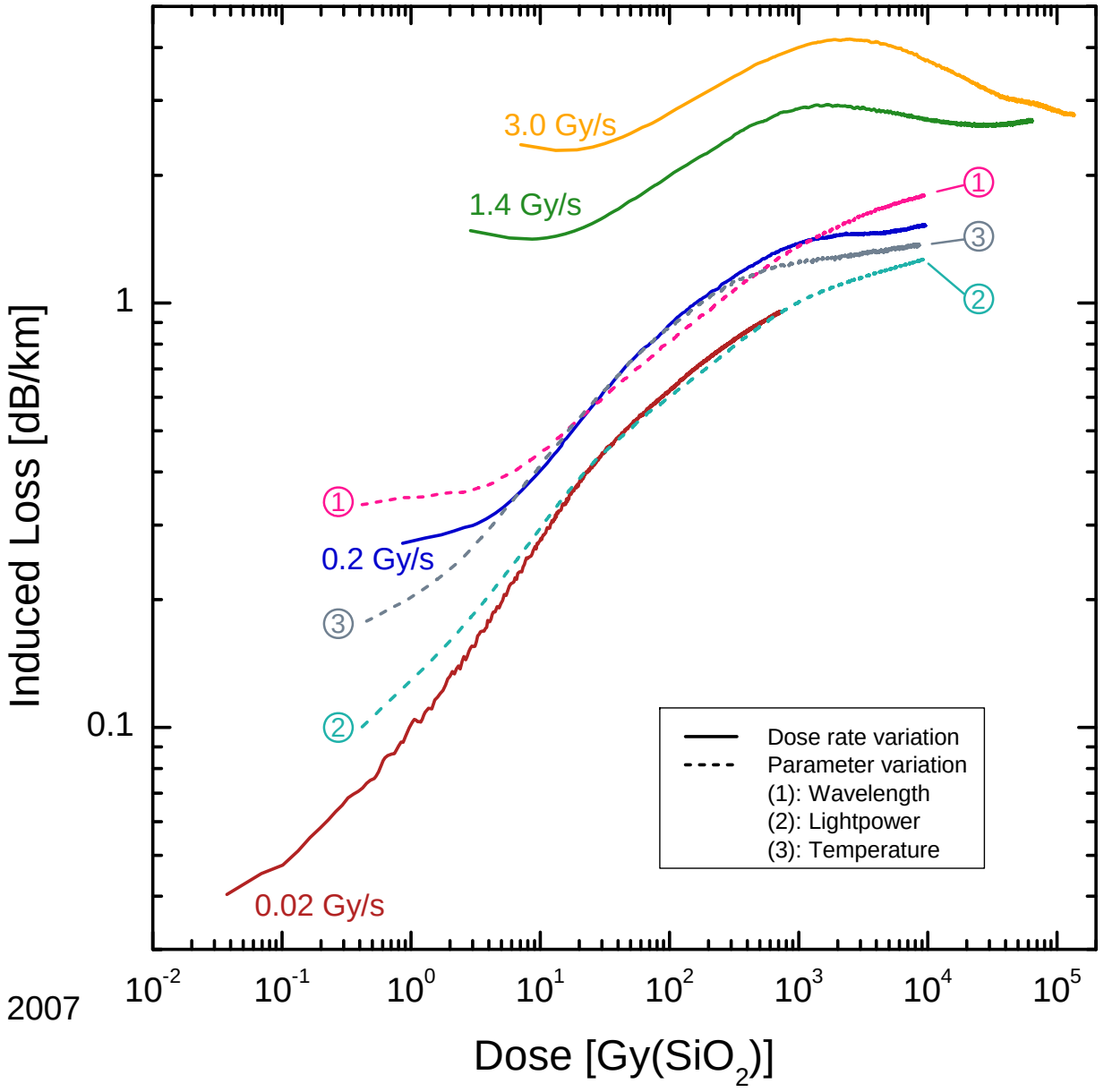
Radiation Induced attenuation



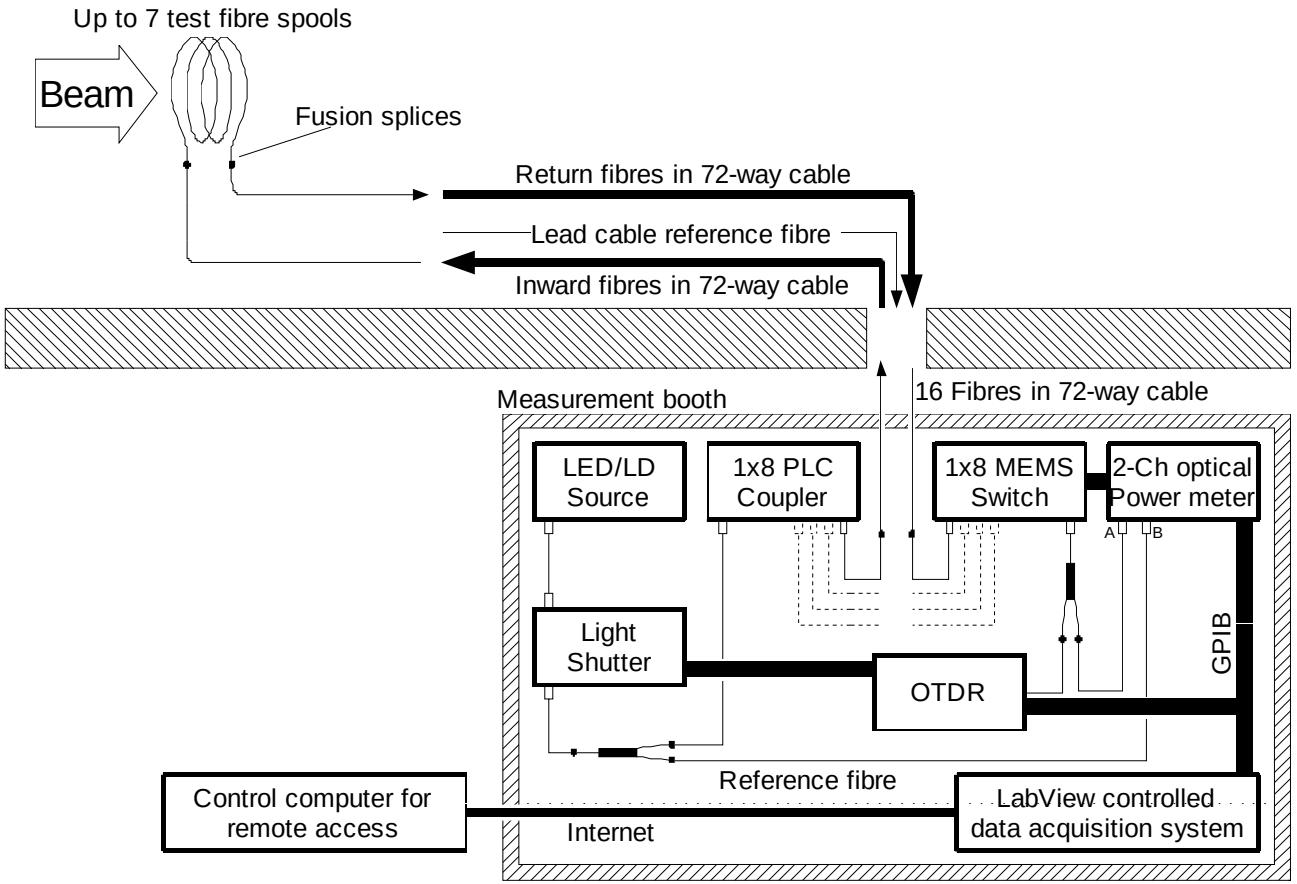
Standard Ge-doped SM fiber



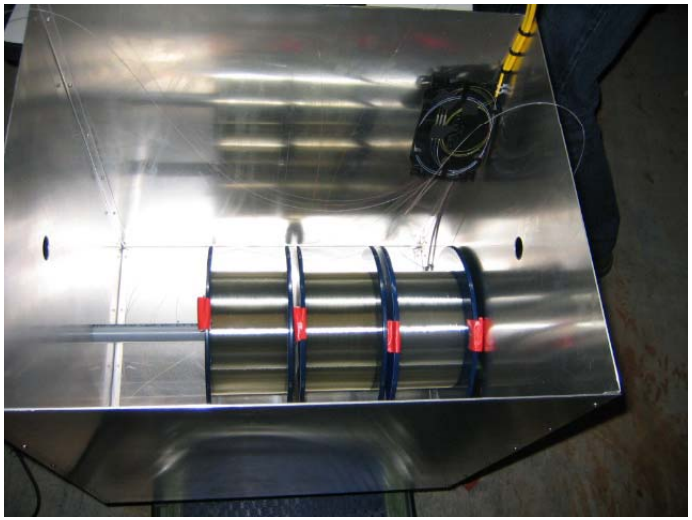
Radiation hard F-doped fiber

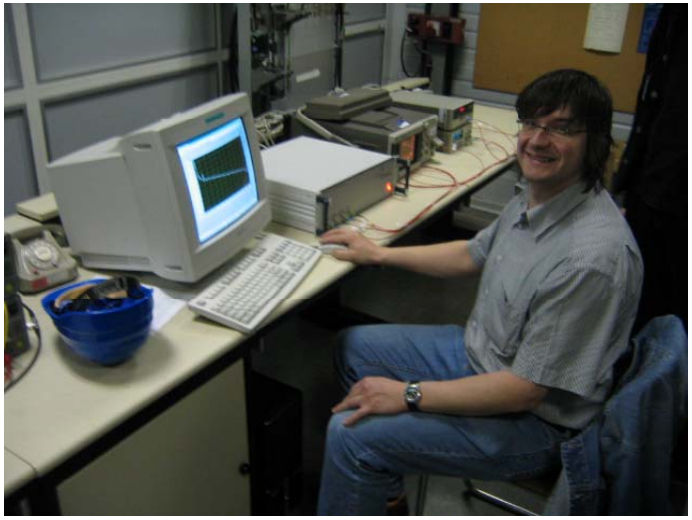


High Energy Physics irradiation test at CERN

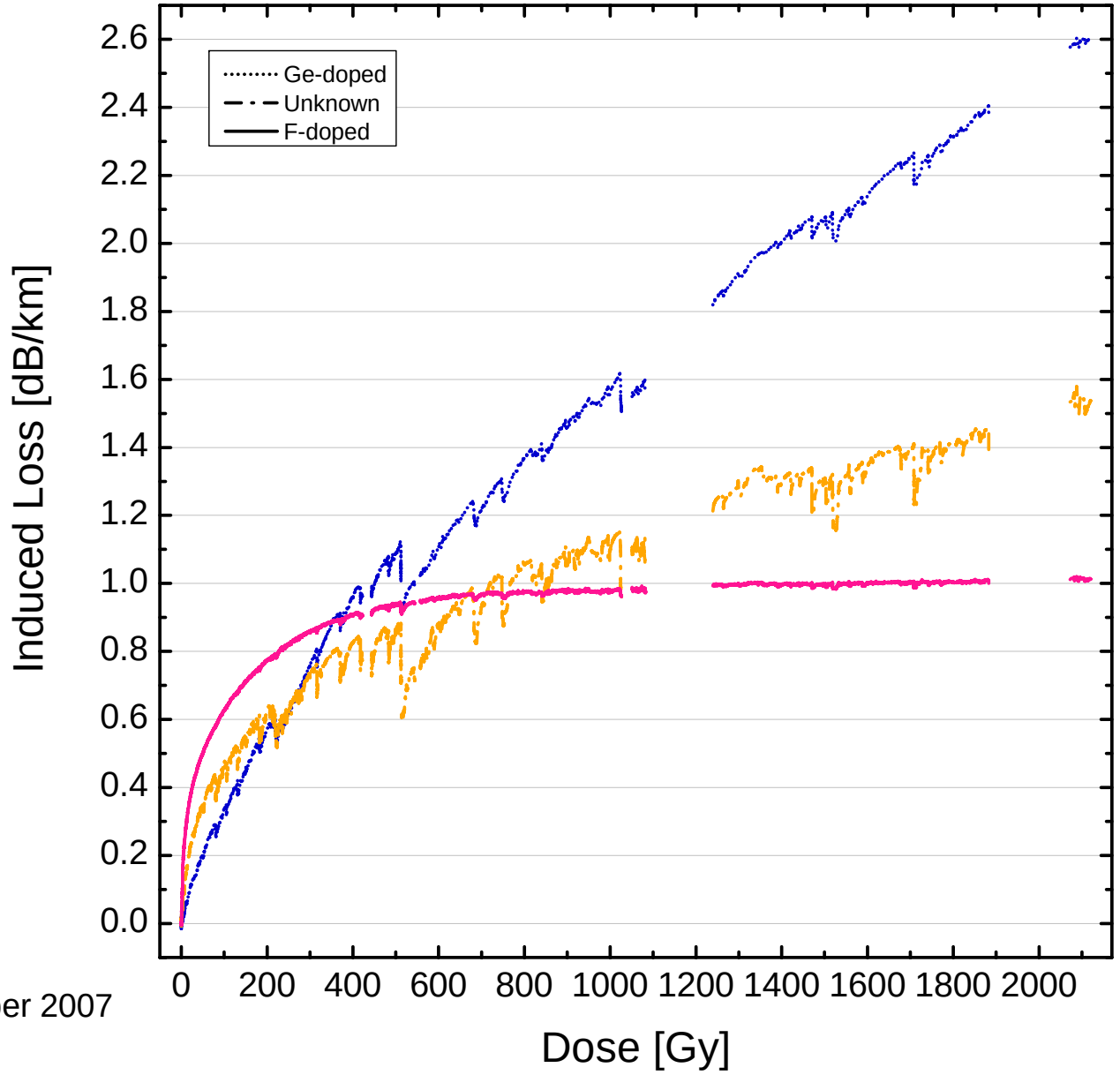


LHC Radiation Test Facility (TCC2)

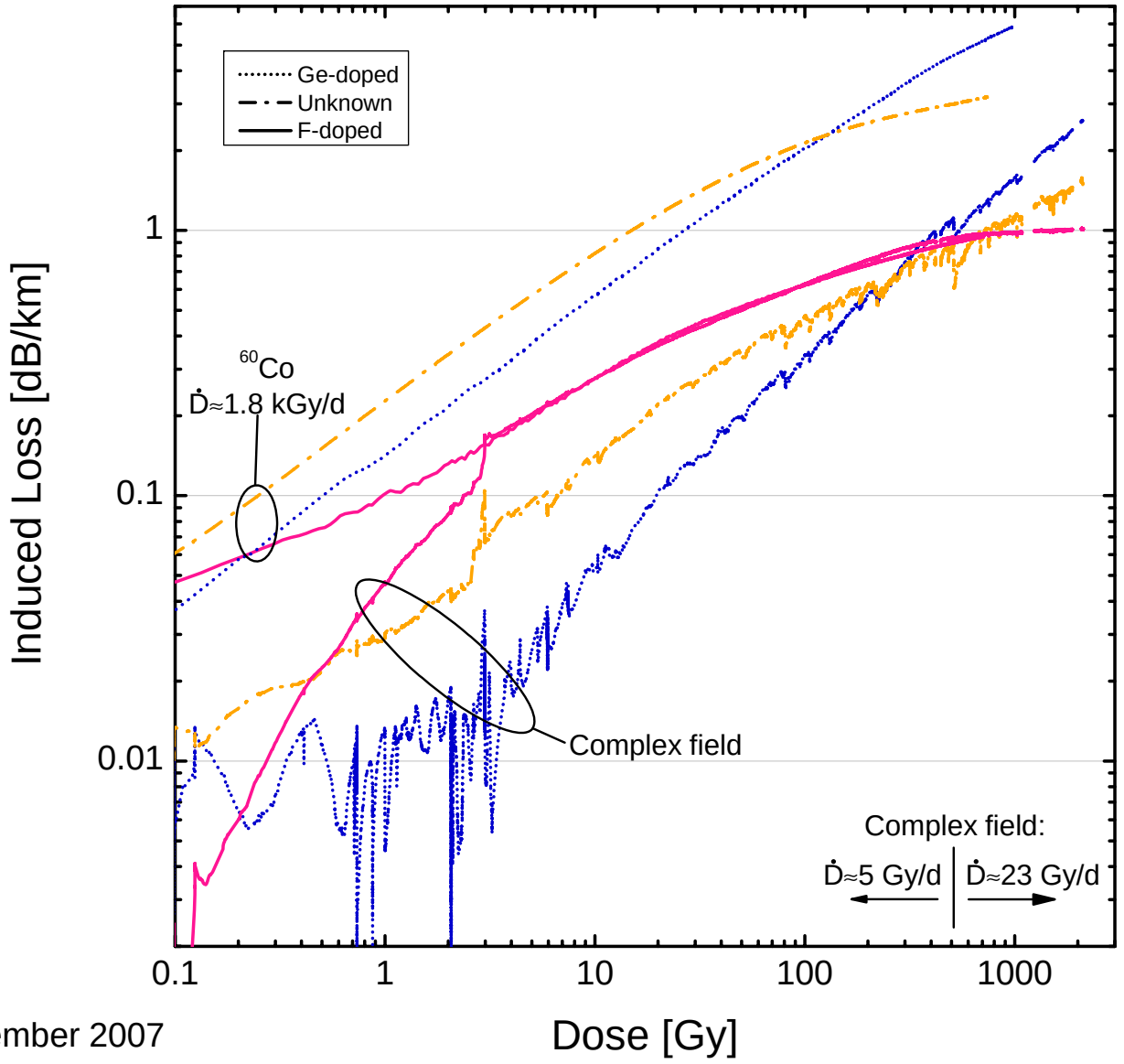




High Energy Physics Radiation field



High Energy Physics vs Co-60



Related press releases

London, 17th April 2007CERN Selects Fujikura's Radiation Resistant FibreFibre to provide communications links within world's largest particle accelerator
Fujikura today announced that its radiation resistant single mode optical fibre has been selected by CERN, the European Laboratory for Particle Physics, to provide communication links within the world's largest particle accelerator – the Large Hadron Collider (LHC) – near Geneva, Switzerland.
Fujikura will supply 2,500km of fibre to collect beam instrumentation data from the LHC. To provide reliable communications, the fibre must be able to withstand localised radiation levels of up to 20 kGy/year – enough to cause radiation-induced attenuation in normal optical fibre.

Fujikura FutureGuide® - RR, Radiation Resistant optical fibre

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Fiber resists CERN's radiation to carry data
2 May 2007
A radiation-resistant fiber is soon to be used in the world's largest particle accelerator for essential communication links.
A radiation-resistant, single-mode optical fiber developed by Fujikura has been selected by CERN for essential communication links within the world's largest particle accelerator - the Large Hadron Collider (LHC).

Fujikura receives order for radiation resistant optical fiber from CERN, the world's largest particle physics research center

Optical Fibers

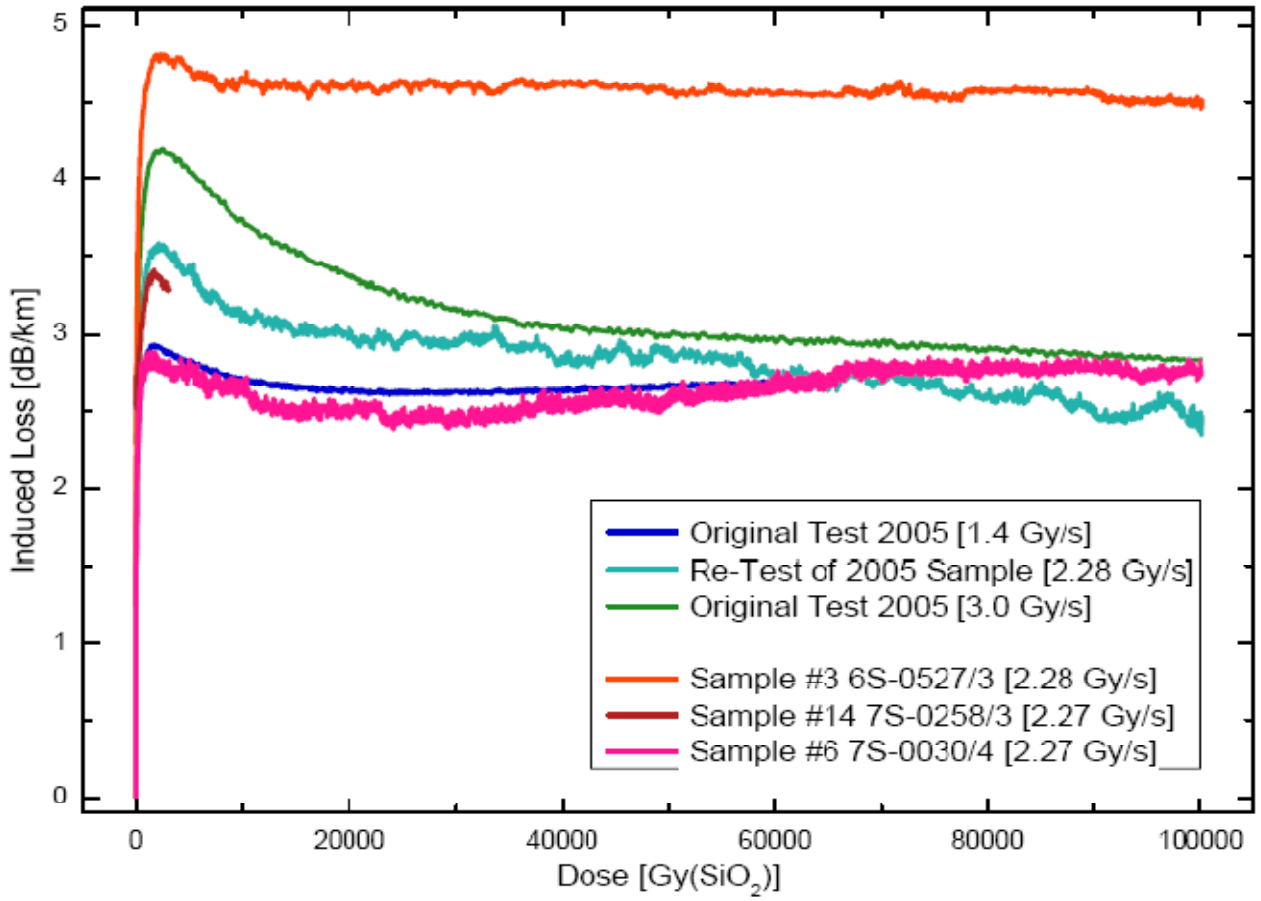
フジクラニュース
Fujikura News
July.2007 No.312

CERN Selects Fujikura`s Radiation Resistant Fibre
04/19/2007
Fujikura Ltd. announced that its radiation resistant single mode optical fibre has been selected by CERN to provide communication links within the world's largest particle accelerator - the Large Hadron Collider (LHC) - near Geneva, Switzerland. Fujikura will supply 2,500km of fibre to collect beam instrumentation data from the LHC. To provide reliable communications, the fibre must be able to withstand localised radiation levels of up to 20 kGy/year enough to cause radiation-induced attenuation in normal optical fibre.

The McGraw-Hill Companies
BusinessWeek

Conclusions

- F-doped SM fibers from Fujikura Ltd show superior performance and have been selected for the LHC :
  - Production of 3000 km from Nov 06 – Aug 07 completed
  - Sample tests of series production ongoing
- RIA in Co-60 and HEP radiation fields comparable
  - radiolysis
  - knock on process
  - particle type
  - particle energy
- RIA < 5 dB/km at 1310 nm and 1550 nm (< 1 MGy)

  unprecedented result – meets LHC specifications

Series sample testing (60Co)