# Long Term Investigation of the Degradation of Coaxial Cables in an Ionizing Radiation Environment

M. Kuntzsch, R. Schurig, HZDR
S. Burger, T. Weber, el-spec GmbH

IBIC 2018
Shanghai China

el spec group GmbH

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ELBE.

## ELBE

- Short introduction

## Motivation

- CW Accelerator environment
- Broadband BAM measurement

## Measurement setup

- Mapping of radiation field
- S-parameter measurement

## Long term measurement and results

- Dose measurement
- Degradation documentation
- Determination of the loss factors

## Summary and outlook

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Michael Kuntzsch | m.kuntzsch@hzdr.de | Institut für Strahlenphysik | www.hzdr.de

# Motivation

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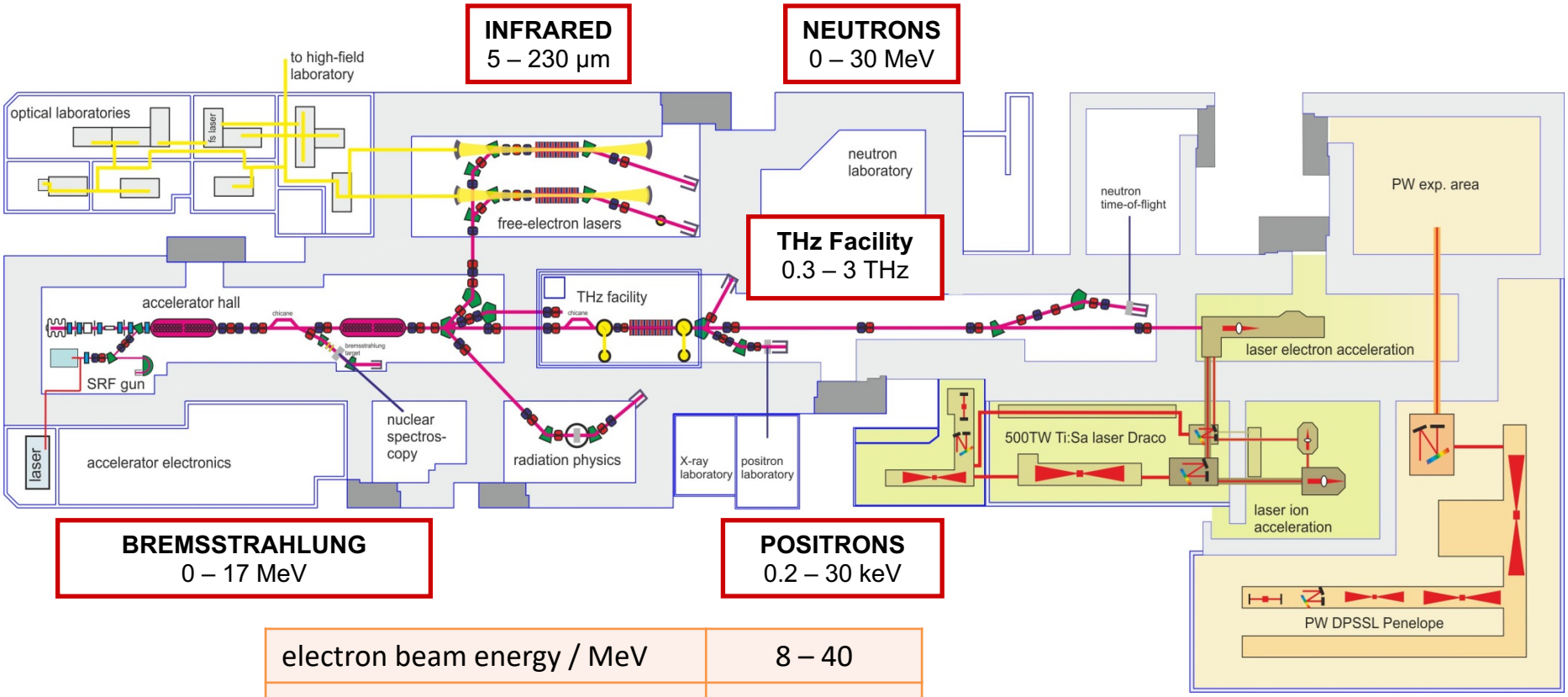


| | |
|---|---|
| electron beam energy / MeV | 8 – 40 |
| average cw beam current / µA | **1600** |
| bunch charge / pC<br>- thermionic injector<br>- SRF photo injector | <br>100<br>300 (1000) |
| minimal Bunch length/ ps | 0.2 |

allowed beam loss: ≤10 µA

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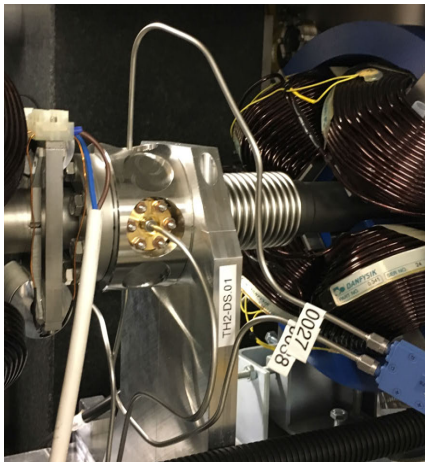
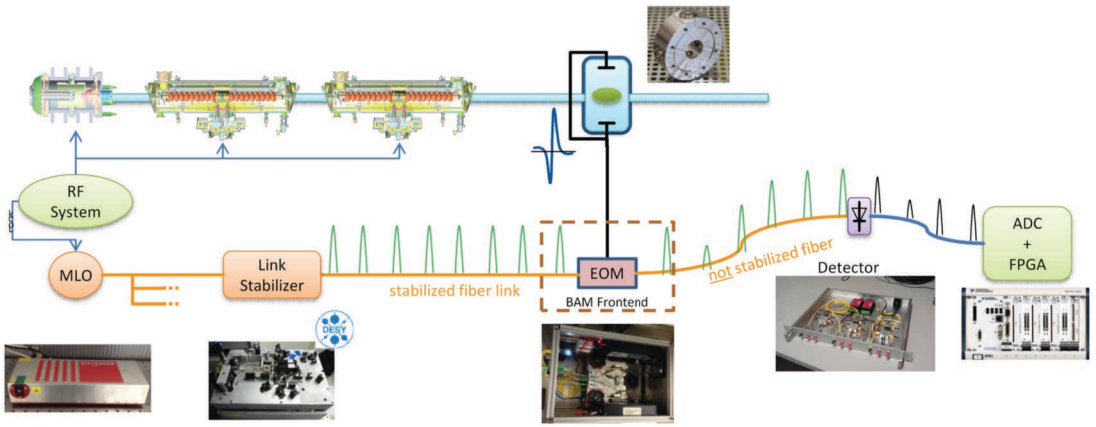
# Motivation

- beam loss up to 10 µA generates Bremsstrahlung on the Gray/minute (Gy/min) level
- for high accuracy arrival time measurements cables with high bandwidth (40 GHz) and low insertion (IL) loss are required
- limited data for high bandwidth applications in ionizing radiation fields available





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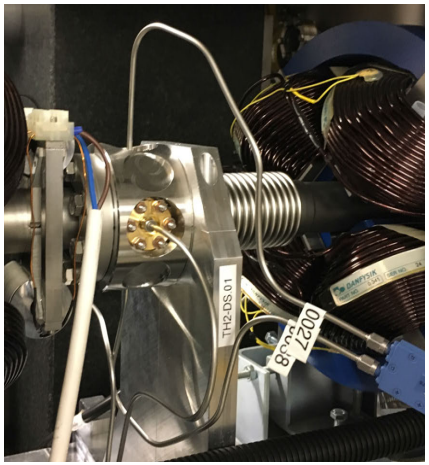


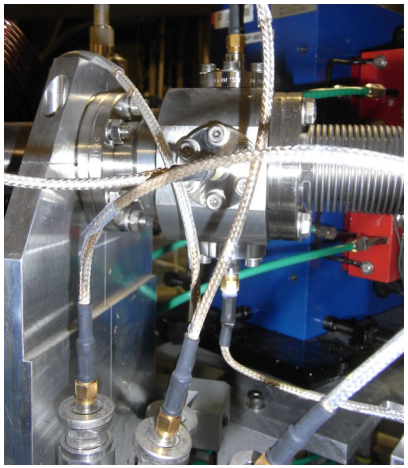

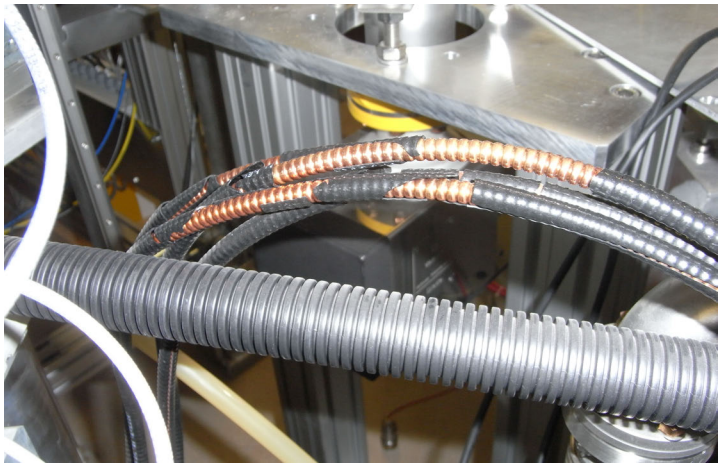


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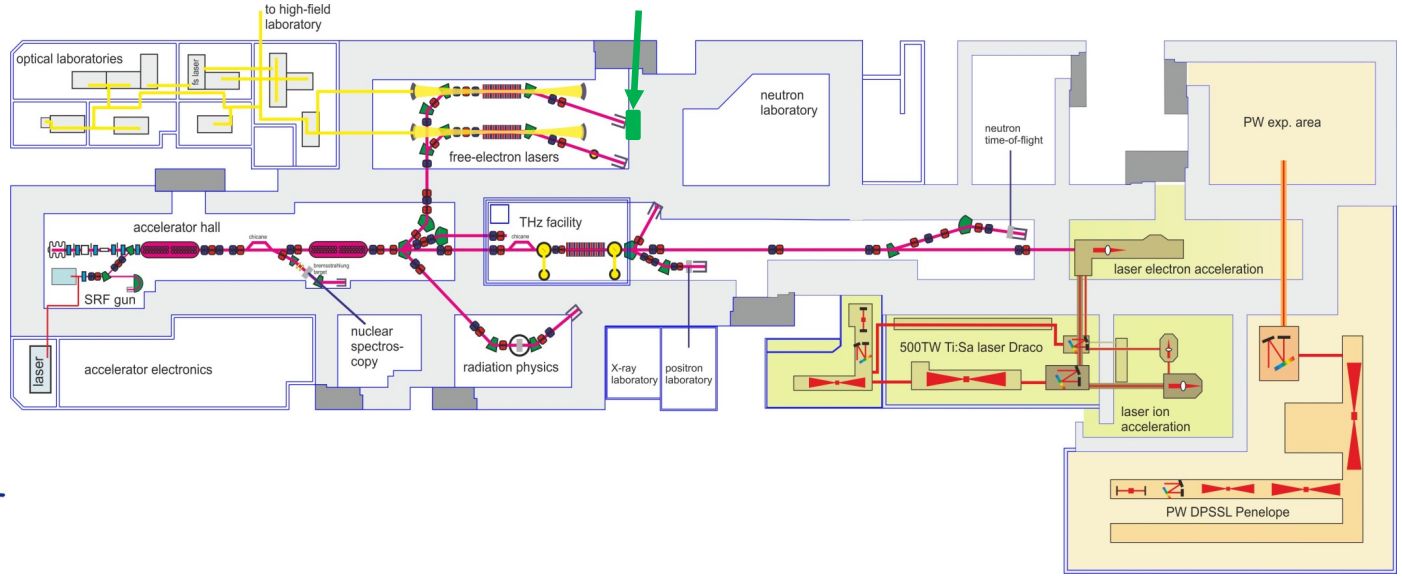
# Motivation

- Setup of a test-stand to acquire the necessary data in a reasonable time frame
- Questions to be answered:
  - Can a PTFE-based cable be used in such an environment for a long time?
  - How does the radiation effects the spectral response of a cable?
  - Are there differences between cable types made of the same/ or similar materials?

Test setup behind beam dump of U100 undulator

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# Setup location and dose mapping

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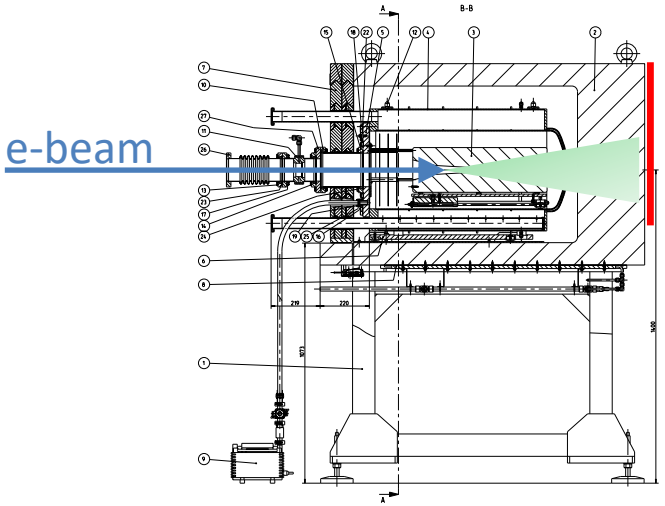
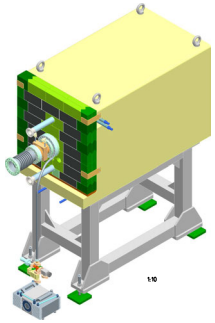
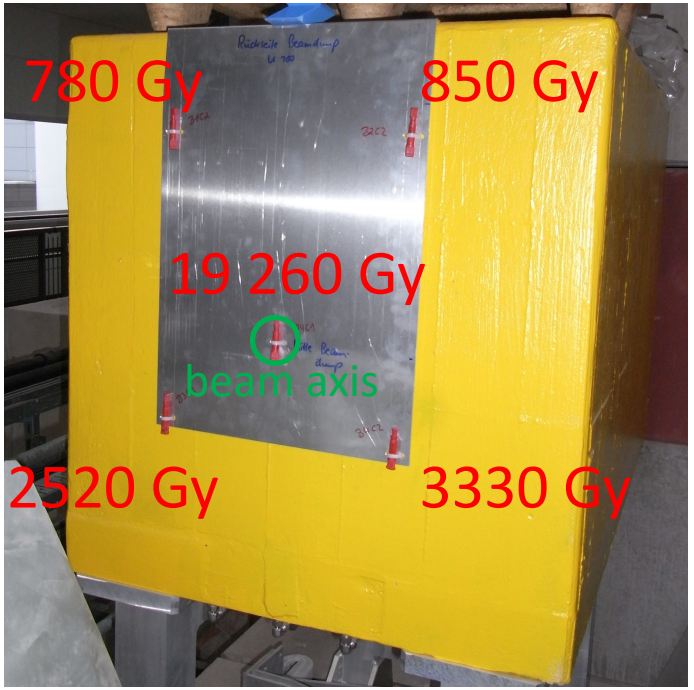
- parasitic setup behind FEL-dump
- devices under test can be mounted on dedicated aluminum plate
- preliminary coarse dose mapping performed for 3 months
- maximum dose of 19.2 kGy on beam axis



Results dose mapping

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# Long term measurement setup

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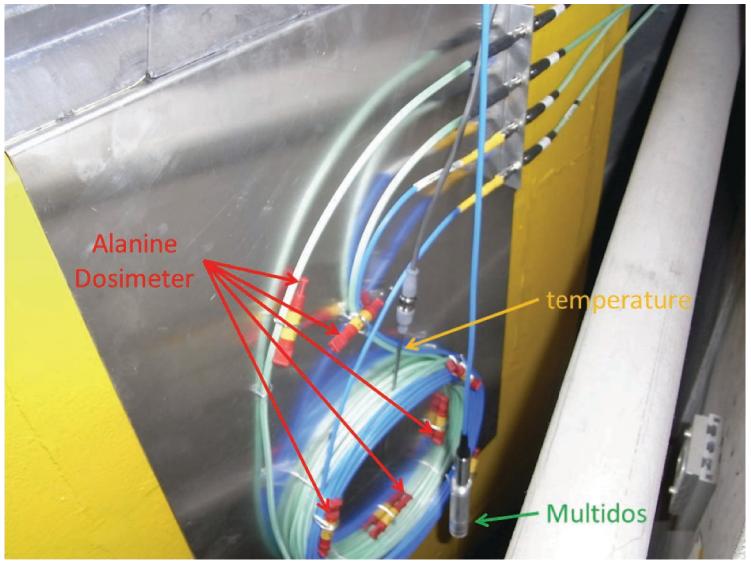
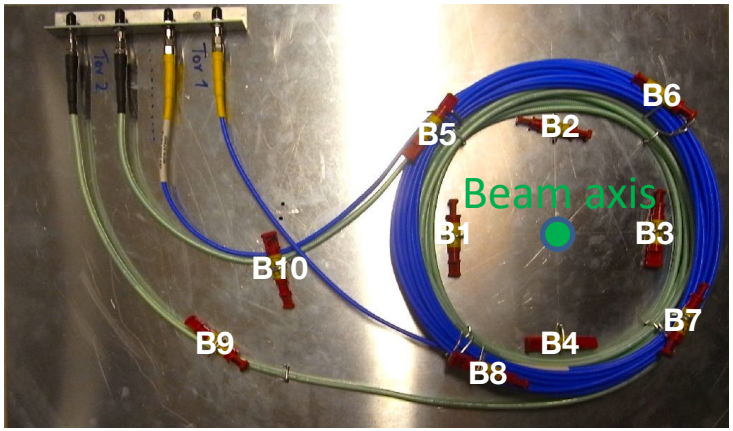
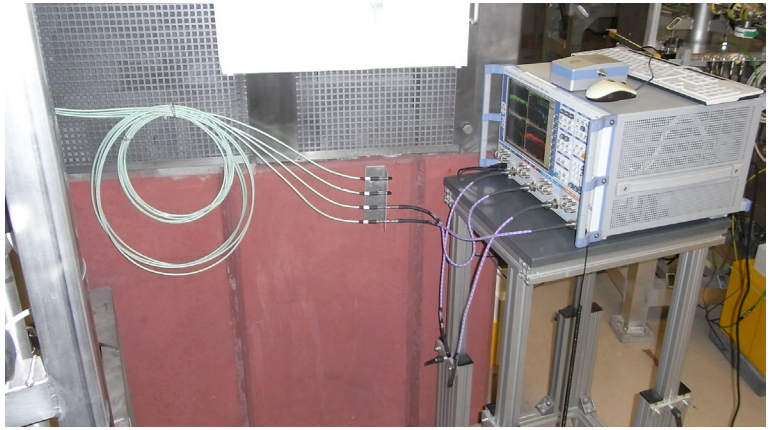
- 10 alanine dosimeters for post mortem analysis of total dose
- 1 Multidos probe for online dose measurement
- temperature probe
- two types of cable
  - Cable under test 1 (CUT1, 8 m, blue)
  - Cable under test 2 (CUT2, 10 m, green)
- connection to patch panel
- S-parameter measurements



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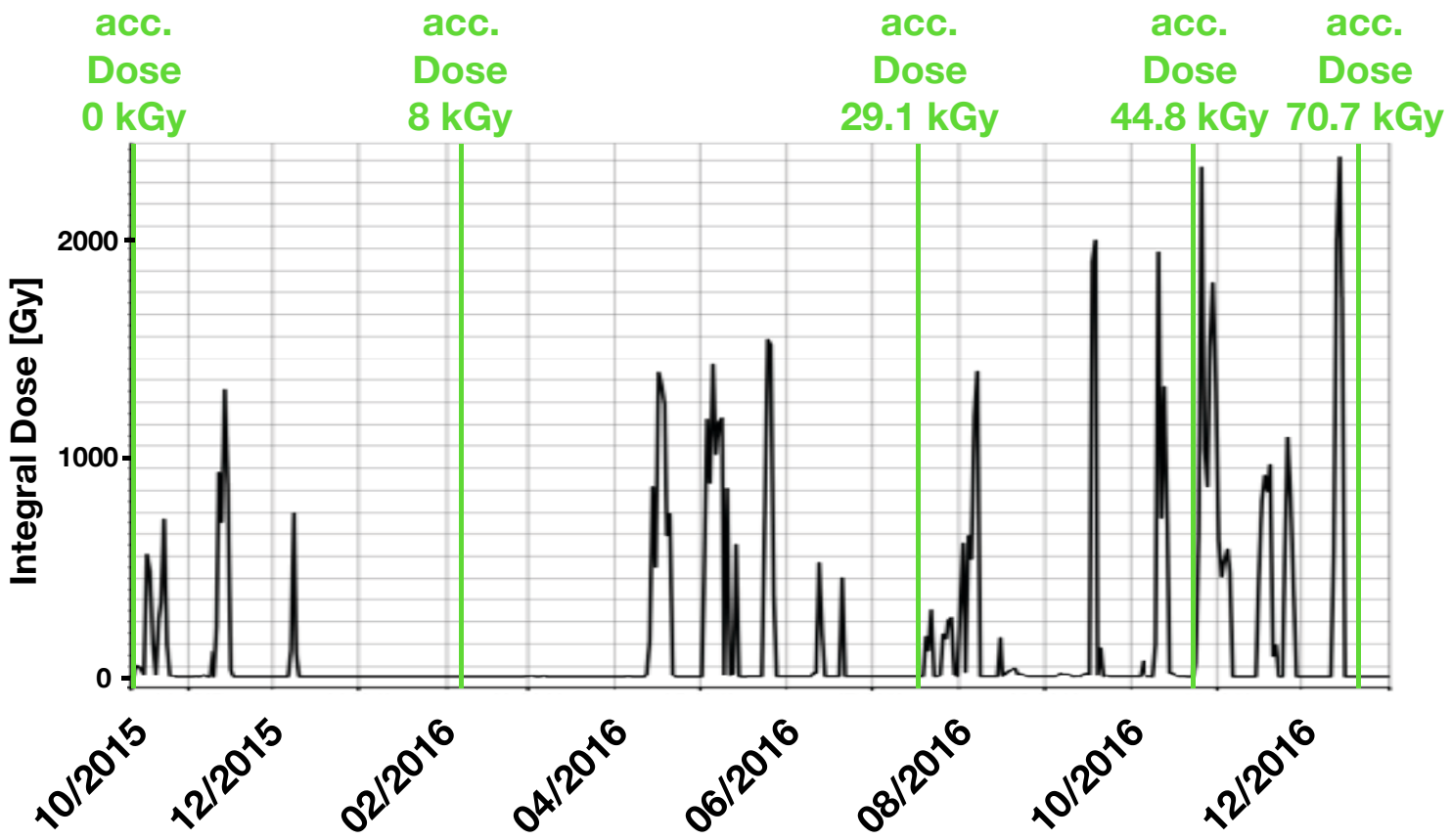
# Long term measurement

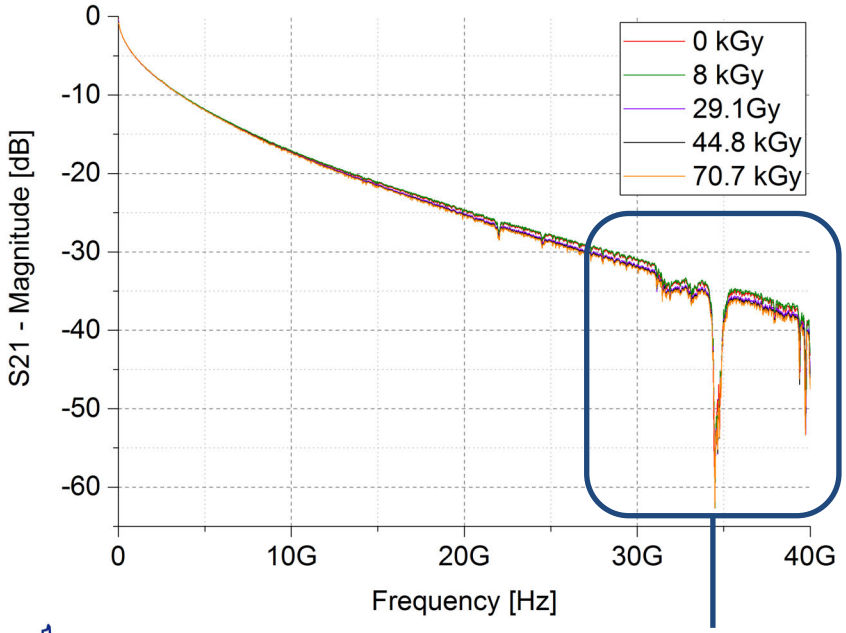
- single radiation probe (Multidos)
- after significant dose accumulation, S-parameters measurement



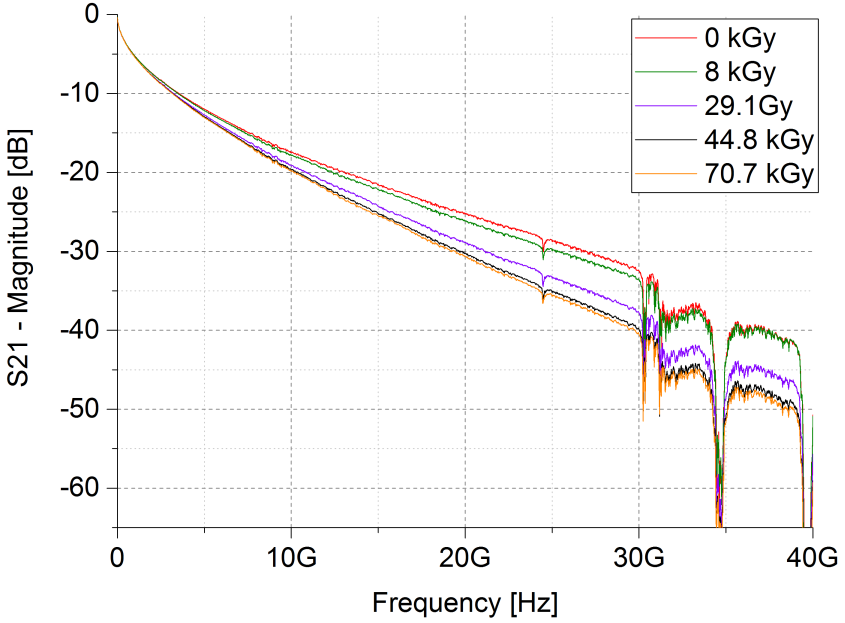
# S-parameter measurement results

- dose dependent degradation could be. measured
- cable under test showed higher level degradation

cable under test 1




cable under test 2




Notches introduced by patch cables
(cable under test 2 – type)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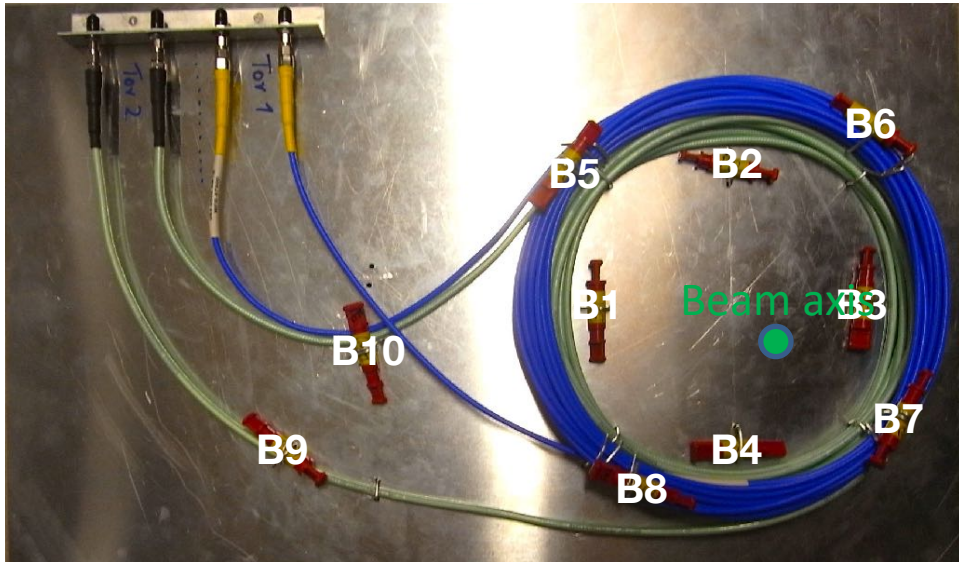
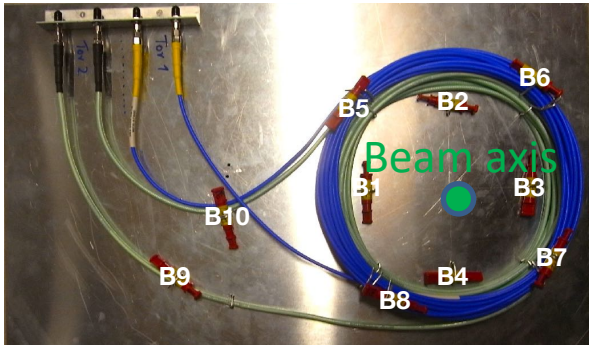
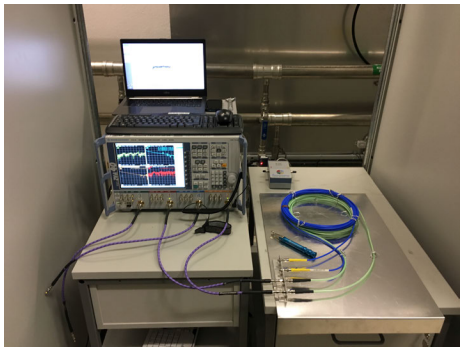
# Final dose analysis




| Name | Accumulated Dose |
|---|---|
| B1 | 64.28 kGy |
| B2 | 51.36 kGy |
| B3 | 93.85 kGy |
| B4 | 83.66 kGy |
| B5 | 30.38 kGy |
| B6 | 29.52 kGy |
| B7 | 57.85 kGy |
| B8 | 43.81 kGy |
| B9 | 9.40 kGy |
| B10 | 13.80 kGy |

# Final RF analysis



- S-parameter measurements performed using vector network analyzer
  - before installation and irradiation, mounted on sample plate
  - after installation and irradiation, mounted on sample plate
  - after (carefully) unwinding the cables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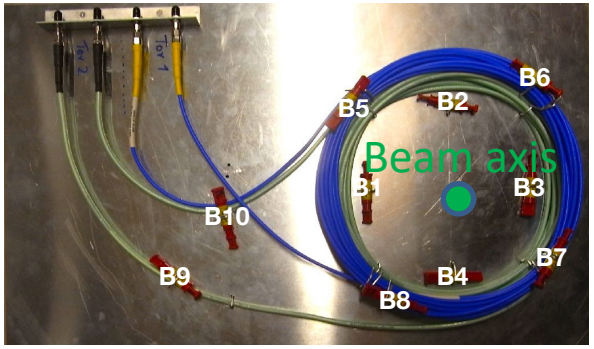


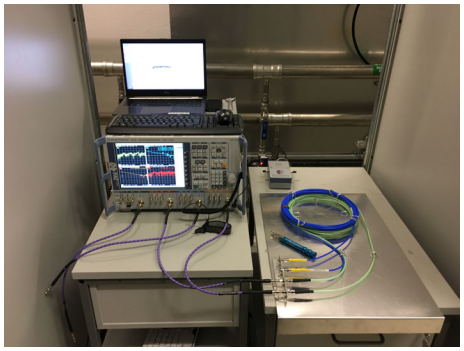

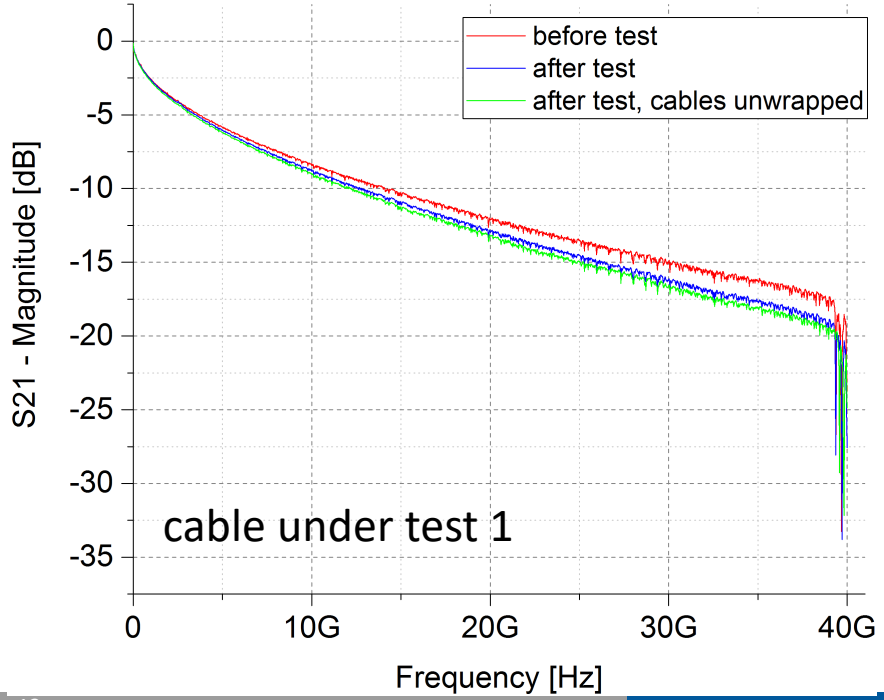


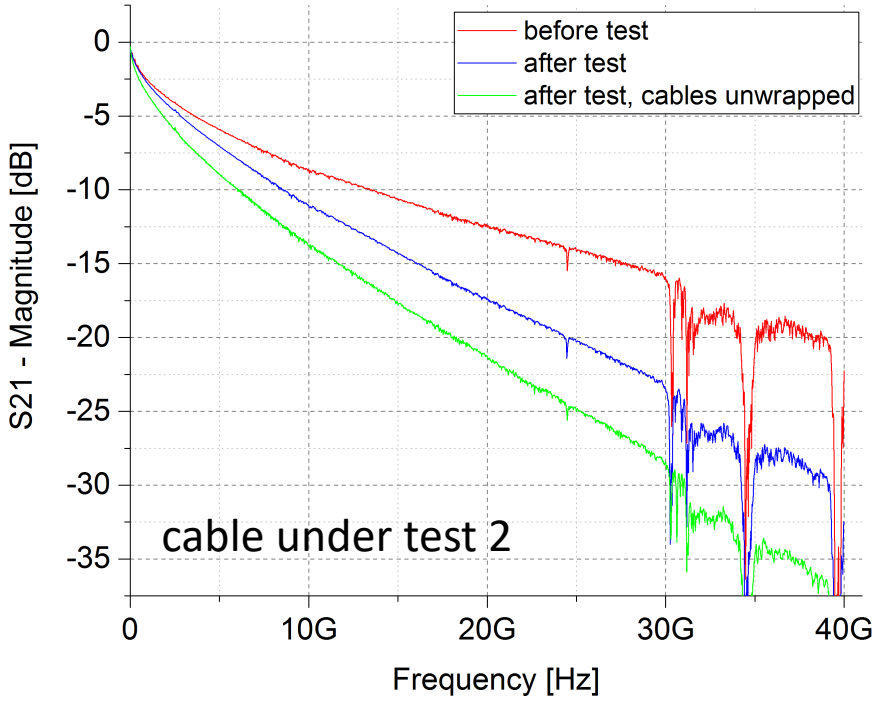

# Cable equation fit

- Insertion loss is defined by resistive (K1) and dielectric (K2) losses

$$IL(f) = K1 \cdot \sqrt{f} + K2 \cdot f$$

| | K1 | K2 |
|---|---|---|
| CUT1 before test | 0.313 | 0.0053 |
| CUT1 after test | 0.319 | 0.0099 |
| CUT1 unwound | 0.319 | 0.0099 |
| CUT2 before test | 0.249 | 0.0066 |
| CUT2 after test | 0.250 | 0.0308 |
| CUT2 unwound | 0.250 | 0.0340 |

- while the resistive losses stay nearly the same, the dielectric losses are increasing
- cable under test 2 was much more sensitive to mechanical stress than before

# Summary and Outlook

- parasitic cable characterization in radiation environment successful done
- measurements showed significant differences between two PTFE-dielectric cables
- cable under test 1 showed very good RF properties and radiation hardness and will be used for bunch arrival time setup in future
- investigations ongoing on the sources of this differences

- Setup can be used to characterize further pieces of equipment that is going to be installed close to the beam line

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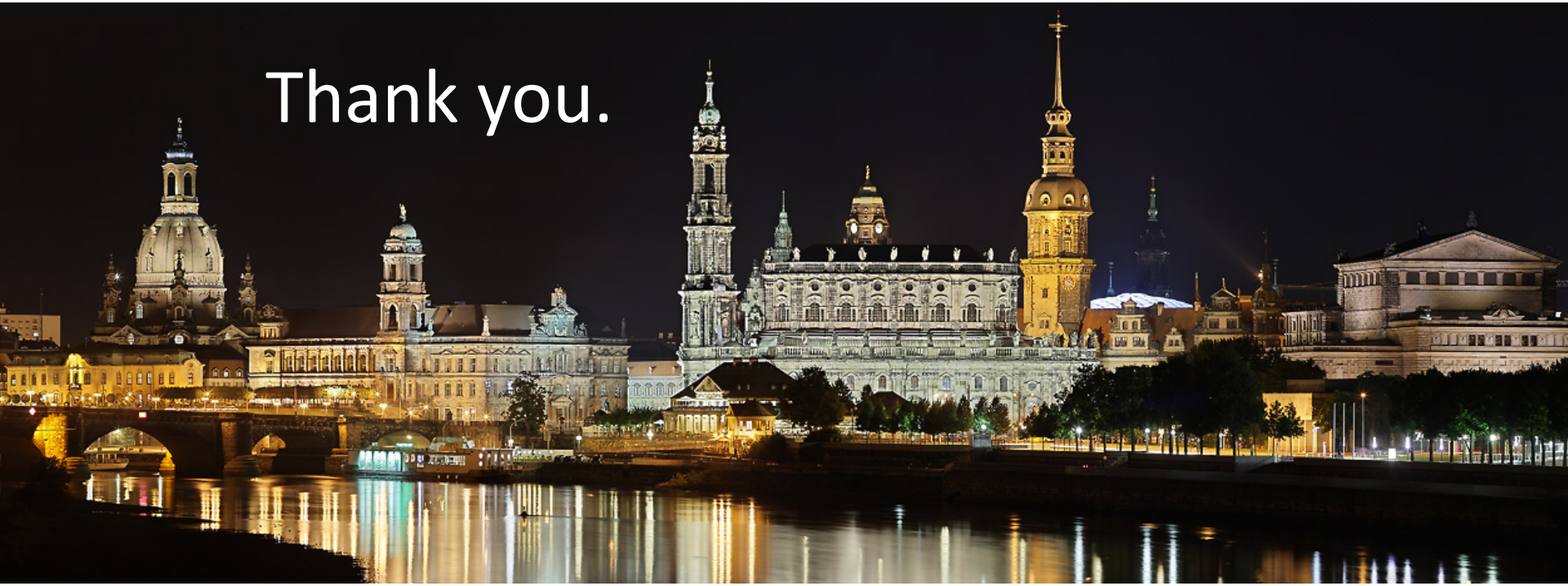


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Whitepaper:
http://www.testkabel.webseiten.cc/index.php?id=10

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