Carl von Ossietzky Universität Oldenburg

RADNEXT activities in Oldenburg

Vanessa Wyrwoll
PhD student: Andreas Pflaum

RADNEXT WP05/JRA1
08/06/2022

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No **101008126**

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Outline

Introduction, ECSS and medical dosimetry standards

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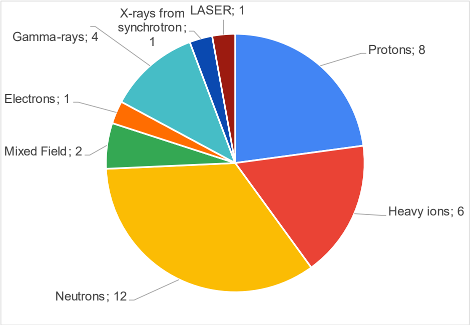
Outline

EUROPEAN COOPERATION FOR SPACE STANDARDIZATION

Introduction, ECSS and medical dosimetry standards



RADNEXT facilities and current results

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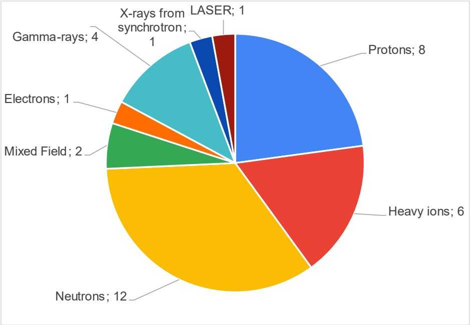

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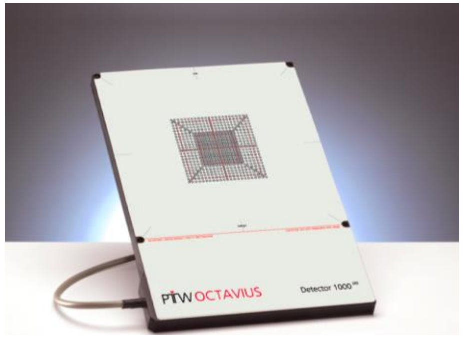
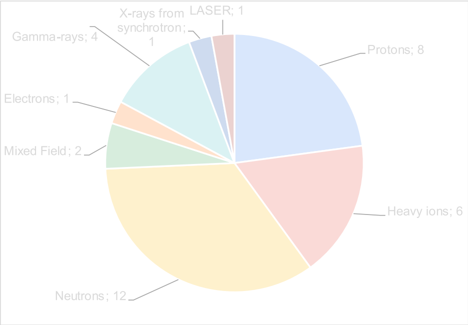


Next steps

Outline

Introduction, ECSS and medical dosimetry standards



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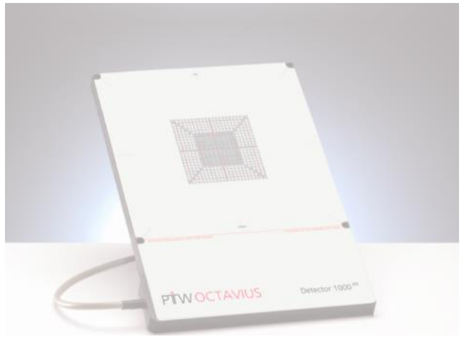

Next steps

Introduction

WP05-JRA1 Main tasks

1. **Definition of the correlation matrix between the facility needs** and the established or innovative monitoring solutions as well as the **definition and standardization of the relevant beam parameters** to be monitored across the facility network
2. **To investigate innovative instrumentation** regarding their potential high impact on facility operation and optimization of radiation to electronics testing
3. **To develop, characterize and qualify low-cost detectors and dosimeters** and have them accessible to RADNEXT users.

Main objective: rendering the facility network more accessible, homogeneous and complementary.

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Introduction

WP05-JRA1 Main tasks – Uni Oldenburg

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Introduction
ECSS standard - Total ionising dose calculation

$$D = \frac{1}{\rho}\int_{E_1}^{E_2} \psi(E)\frac{dE}{dx}(E)dE$$

ρ= mass density of the material
ψ(E)= the differential energy spectrum defined between E1 and E2
dE/dx = stopping power in units of energy loss per unit particle pathlength

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Introduction
Medical physics dosimetry standard

$$D = (M - M_0) \cdot N \prod_{i=1}^{n} k_i$$

M = detector reading

M_0 = detector reading for zero level (no irradiation)

N = multiplying factor under calibration conditions in water

k_i = all correction factors, relevant for the measurement

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Introduction
Beam quality correction $k_{Q,R}$

Ratio between the dose in water and in the SV of used beam

$$k_{Q,R} = \frac{\left(\frac{D_w}{D_{chamber}}\right)_{experimental\ beam}}{\left(\frac{D_{water}}{D_{chamber}}\right)_{calibration}}$$

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Ratio between the dose in water and in the SV of calibration beam (Co-60)

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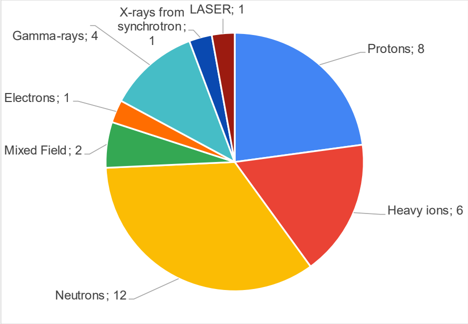
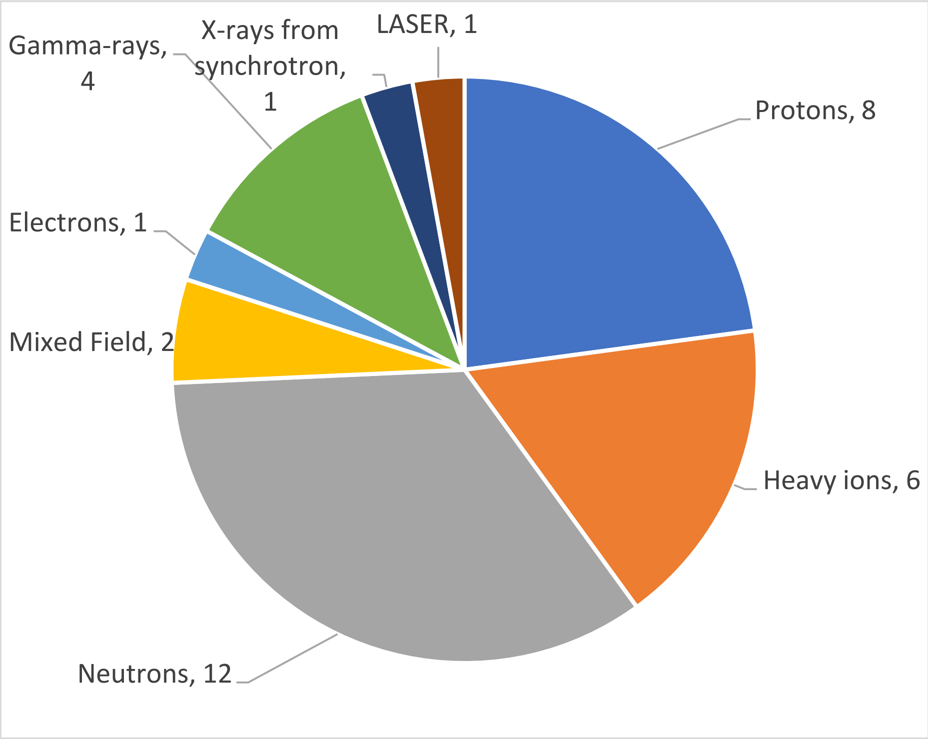


RADNEXT facilities and current results

Next steps

RADNEXT facilities
Beam parameters



Important missing parameters to know for efficient
Experiments:

Proton facilities:

- Temperature stability
- irradiation field size
- beam spot size
- dosimetry accuracy
- pulse width

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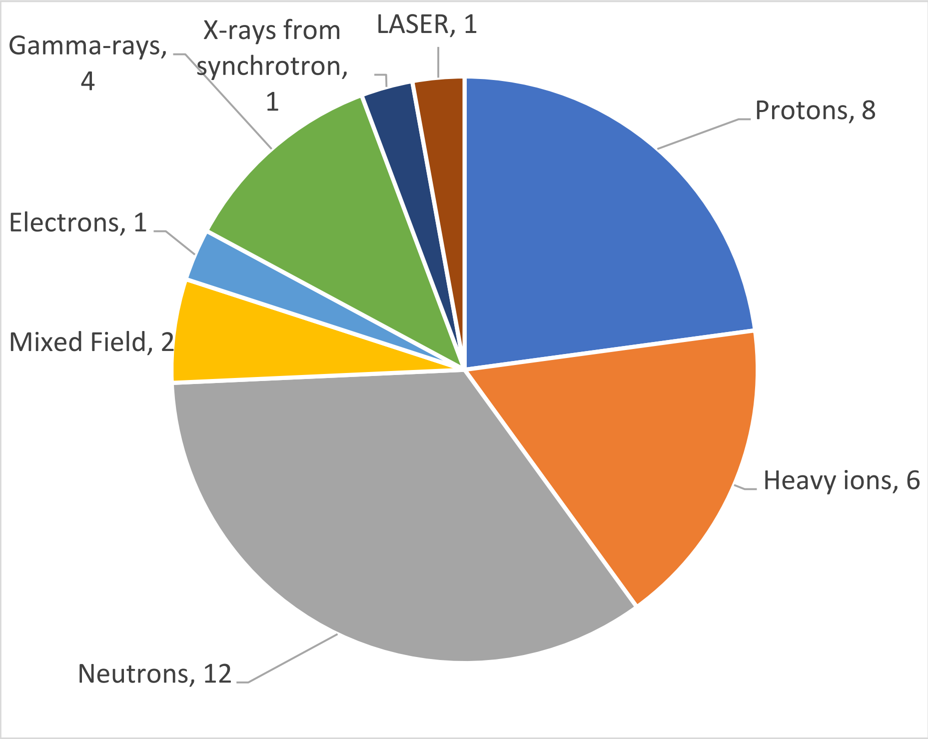
RADNEXT facilities
Beam parameters



Important missing parameters to know for efficient
Experiments:

Heavy ion facilities:

- minimum energy
- uniformity of irradiation field
- qualify the uniformity
- method to change energy
- Temperature stability
- irradiation field size
- beam spot size
- dosimetry accuracy
- pulse width
- pulse repetition
- length of existing cabling

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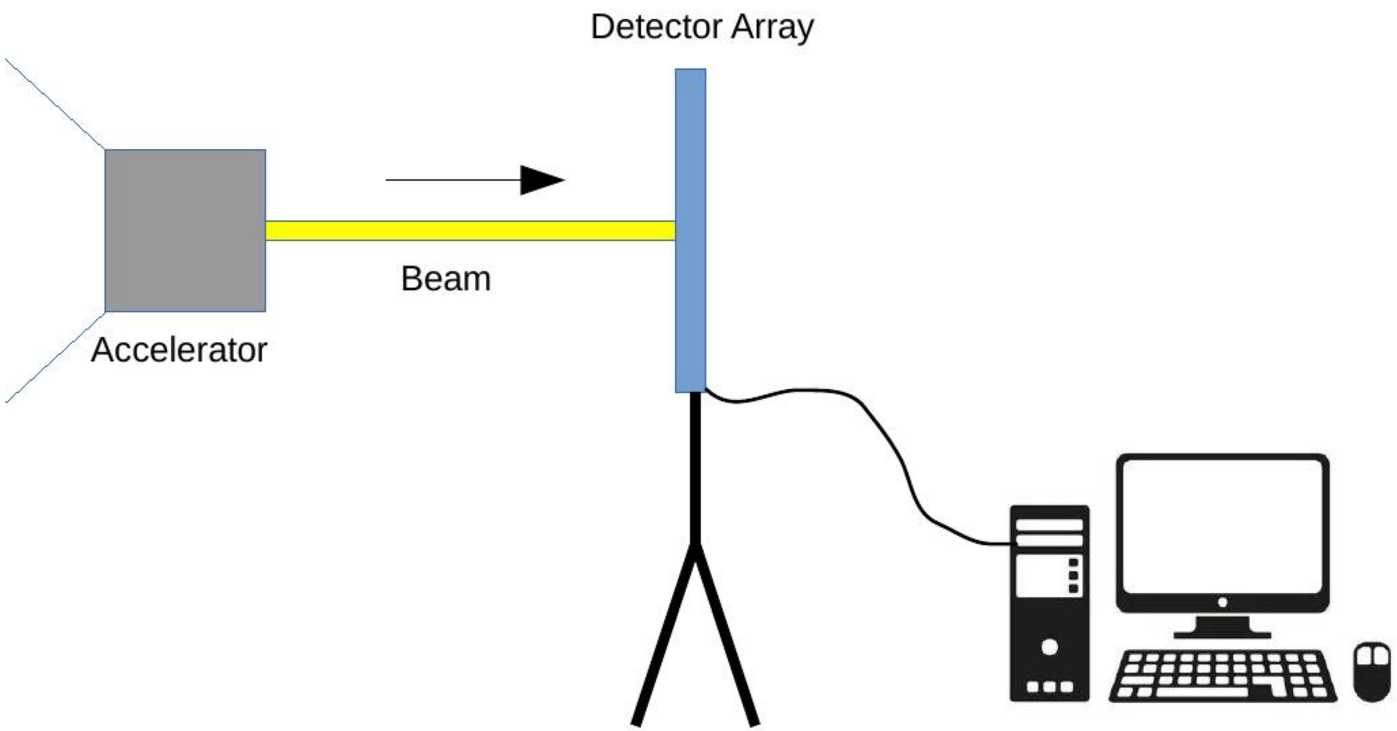
Experimental setup using detector arrays



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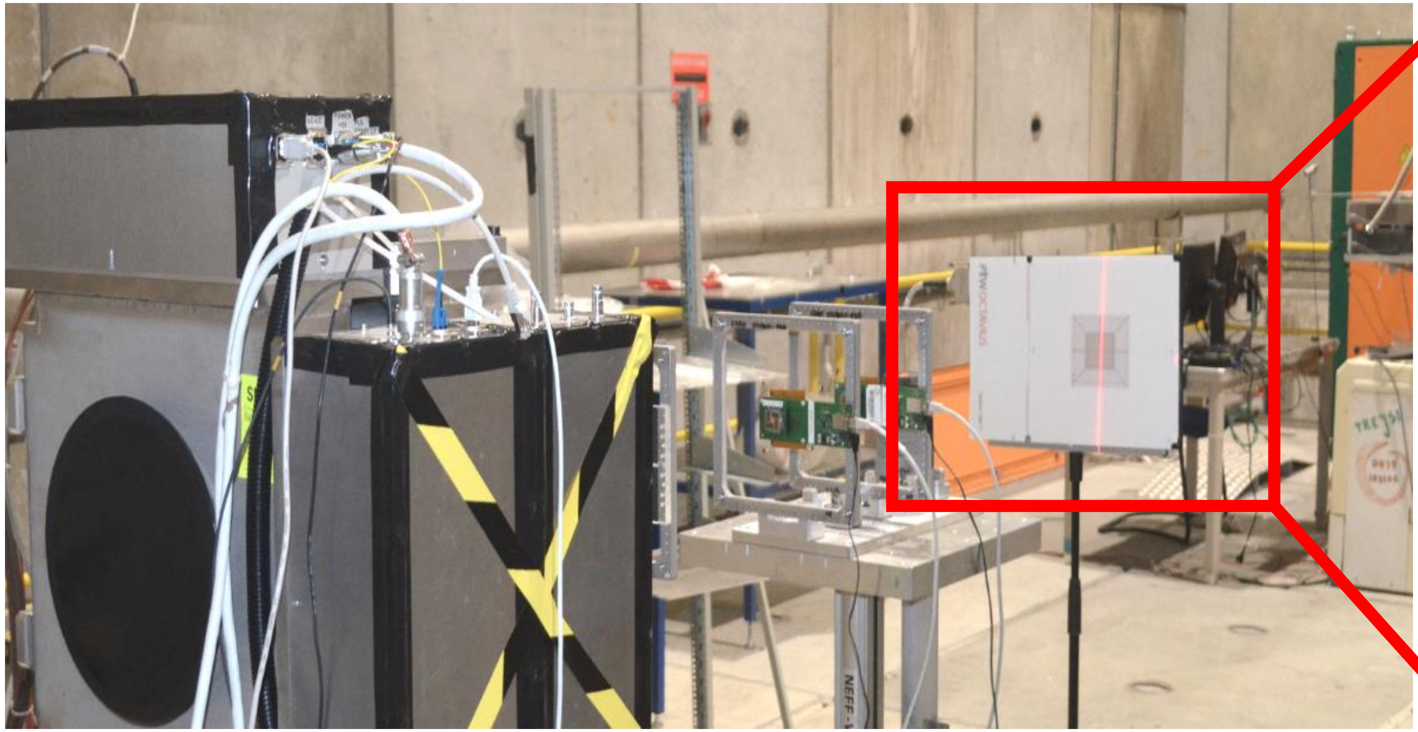
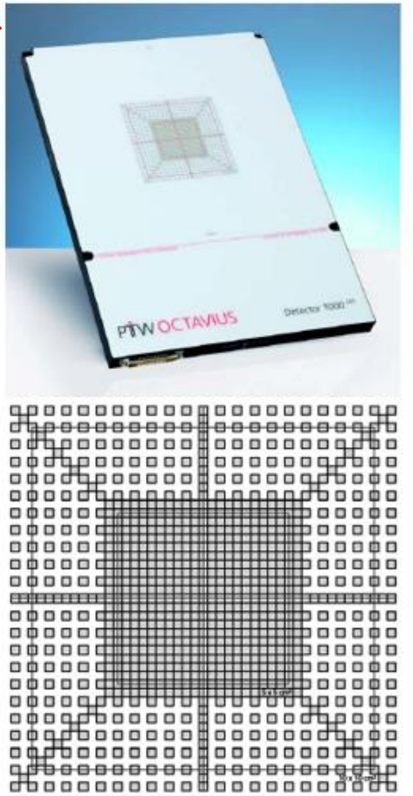
Detector array 1000SRS

CERN H8 beam line SPS-NA 150 GeV/n ^{208}Pb





OCTAVIUS 1000SRS
liquid filled

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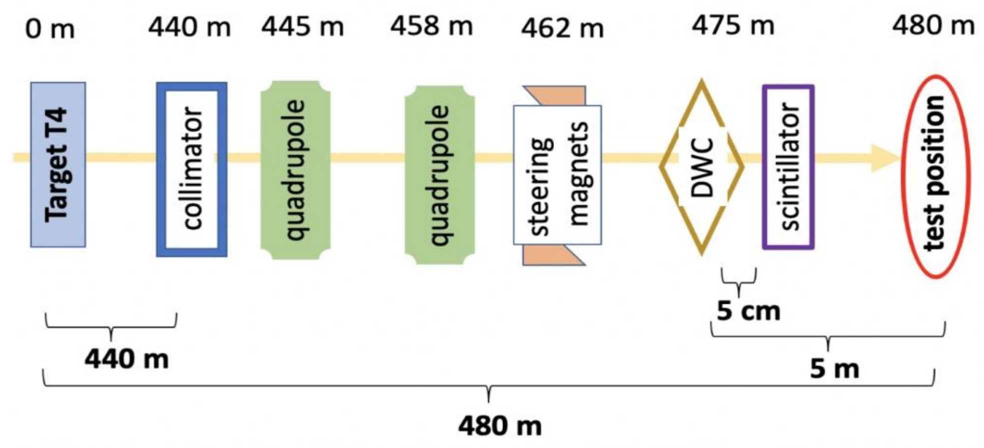
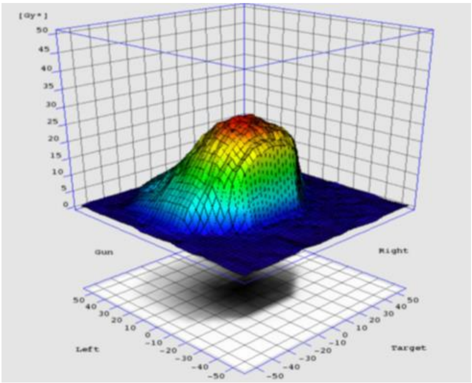
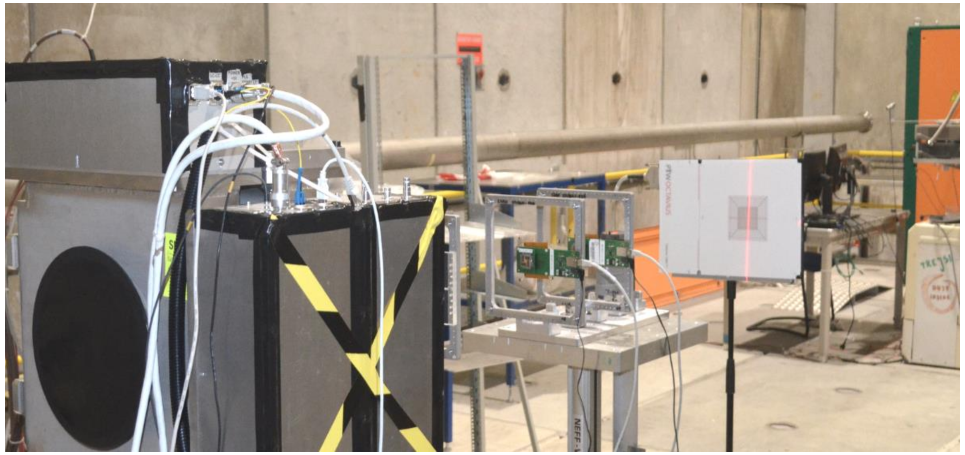
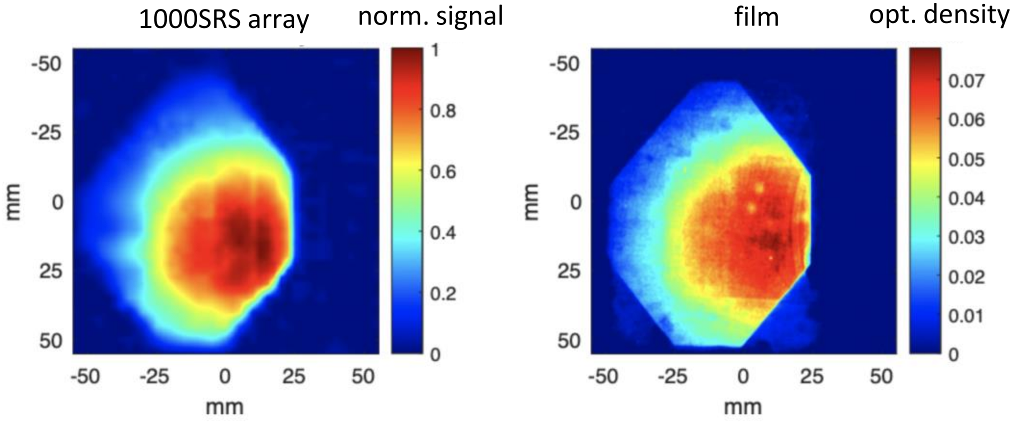
Previous results

CERN H8 beam line SPS-NA 150 GeV/n ^{208}Pb









Wyrwoll V et al Nuclear Inst. and Methods in Physics Research, A 987 2021 164831

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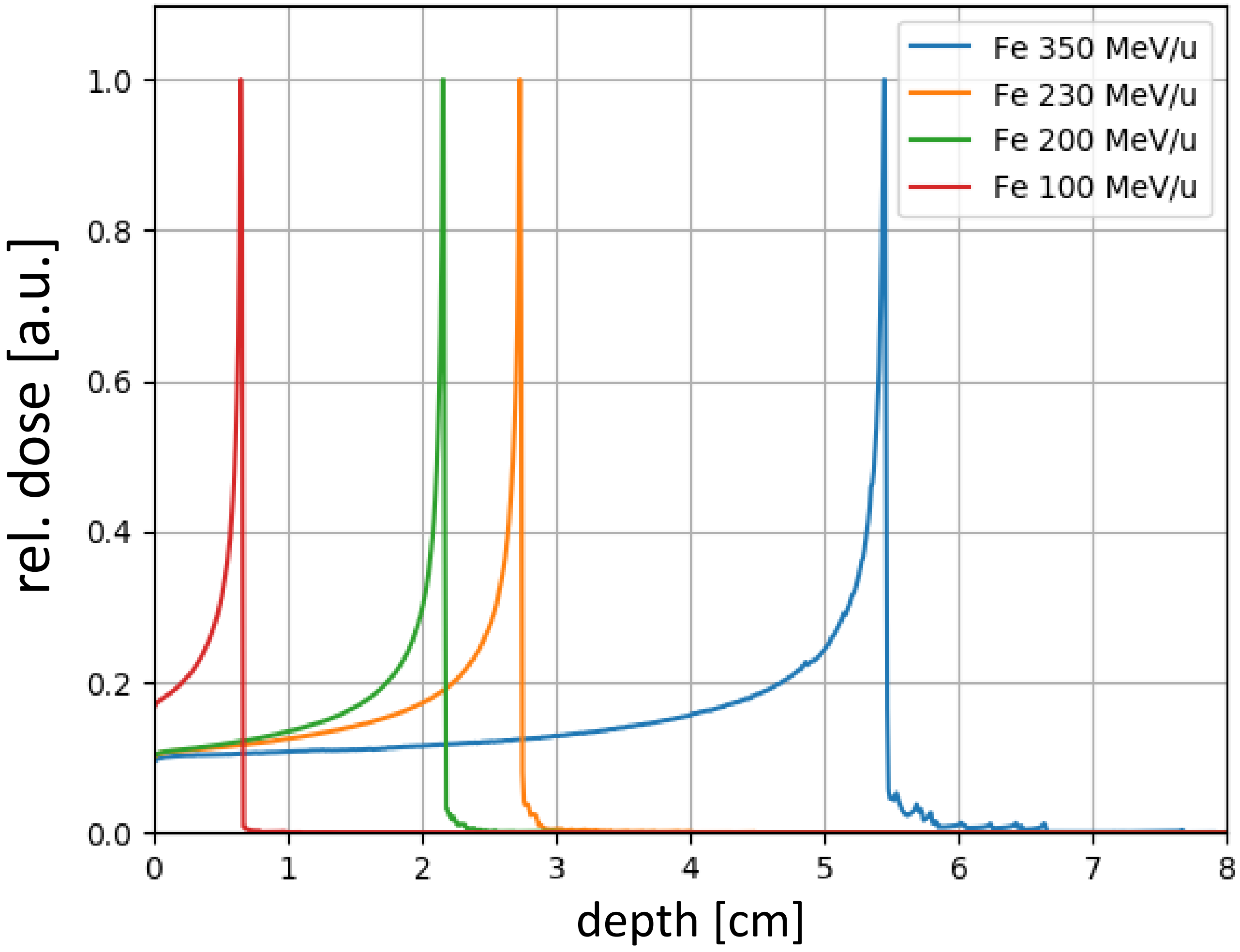
Current results – $k_{Q,R}$ calculations in water

By PhD student Andreas Pflaum



- Measurements of $k_{Q,R}$ have to be made in a sufficiently flat area of the beam
- Deeper Bragg Peak leads to smaller gradient in measurement area
- Reference point: 9 mm for 1000SRS, 6.9 mm for 1600XDR

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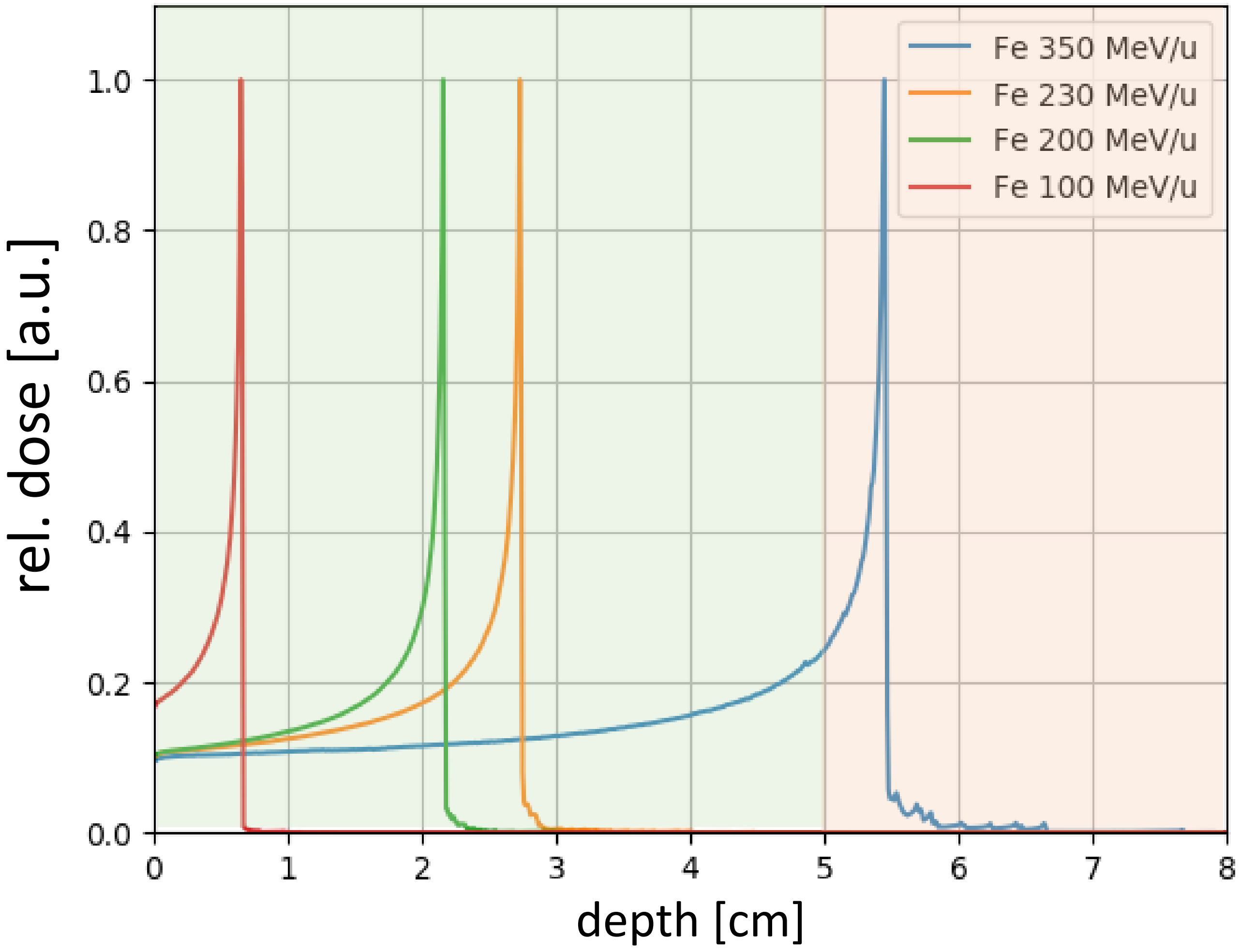

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→ Bragg Peak at 5 cm in water below surface is desirable

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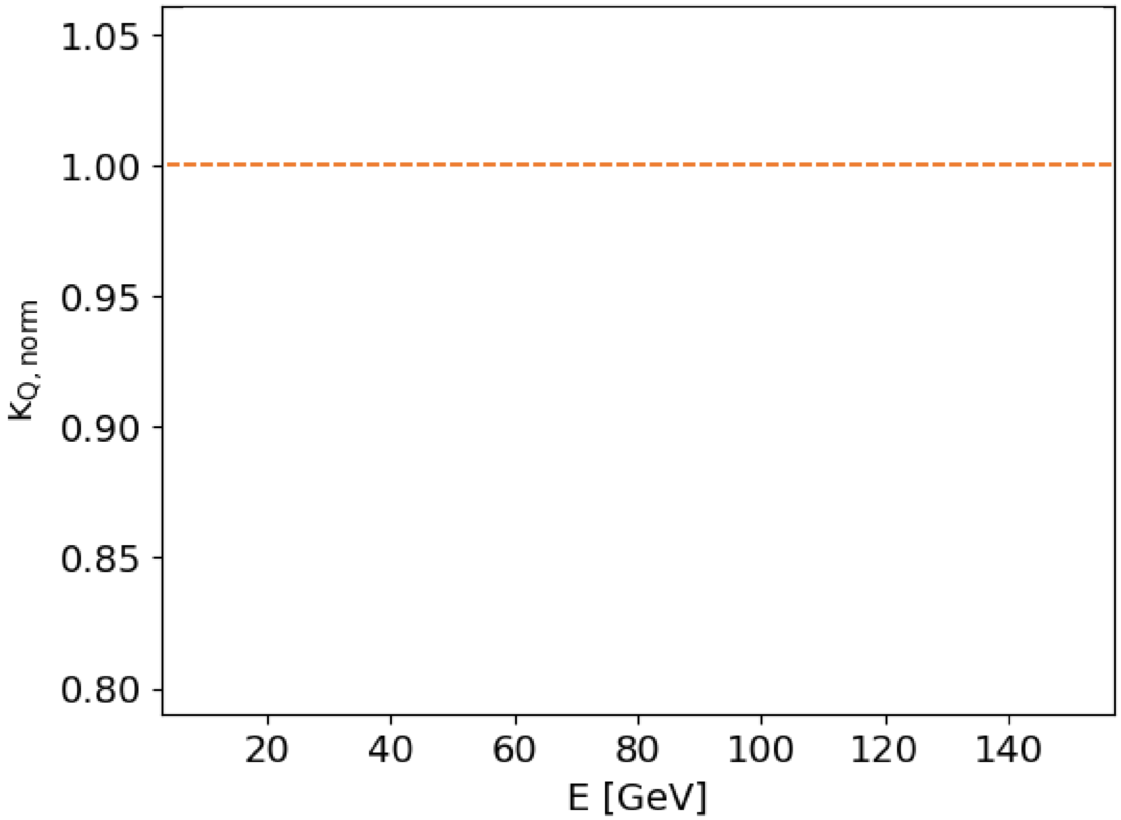
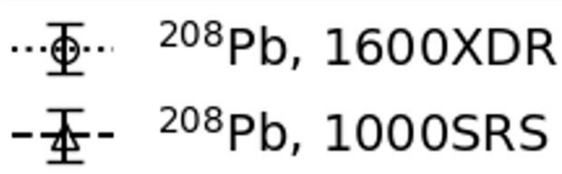
Current results – correction factor $k_{Q,R}$

By PhD student Andreas Pflaum





For ultra high energy 208Pb beam (10 GeV - 150 GeV):

- Nearly constant value of kQ for liquid filled OD 1000SRS
- Lower values of kQ with higher energies in case of vented OD 1600XDR

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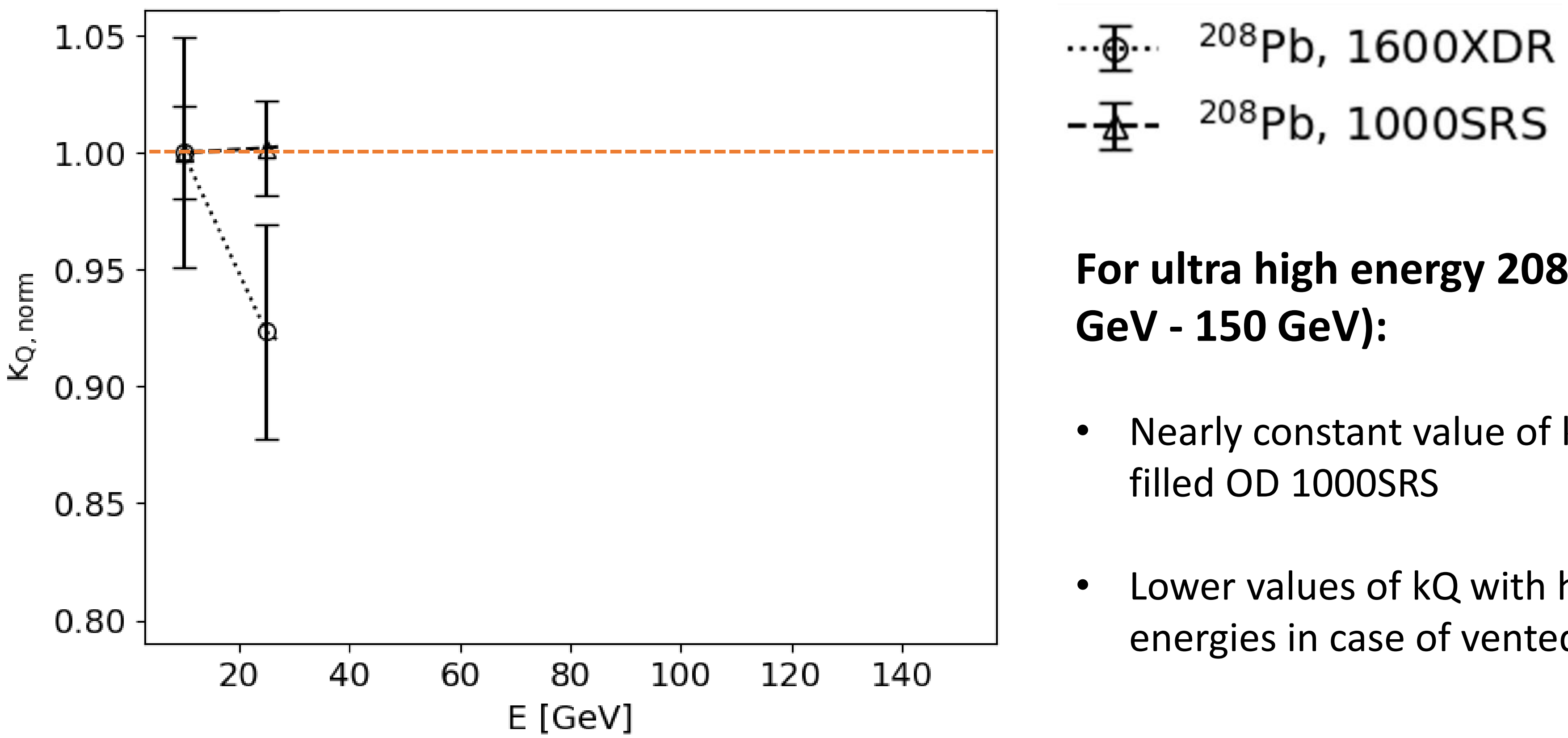

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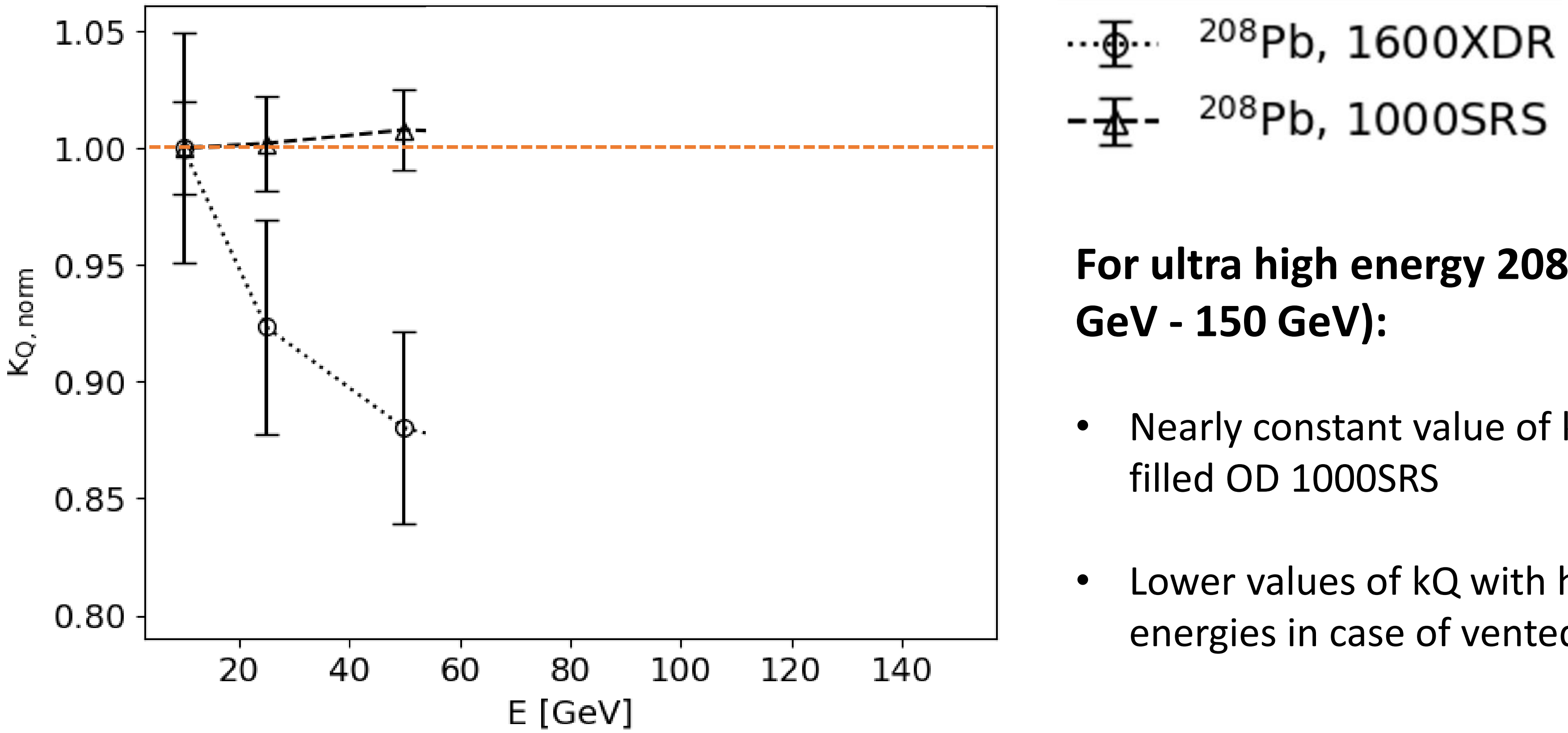

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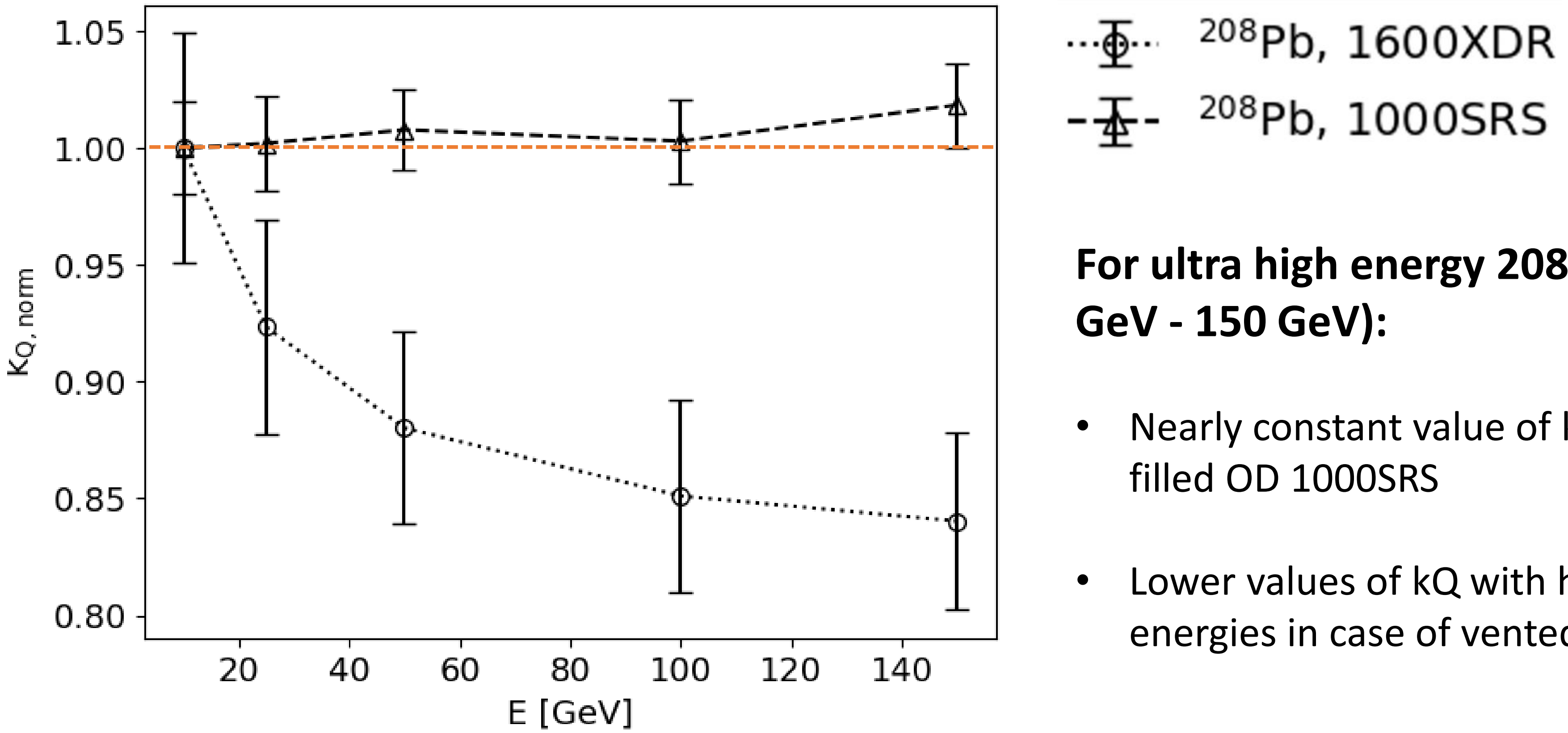

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Current results – simulations of modified arrays

By PhD student Andreas Pflaum

Ion	Energy [MeV/u]	1000SRS mod. [Gy/min.]	1000SRS [Gy/min.]	1600XDR mod. [Gy/min.]	1600XDR [Gy/min.]
Au	100	63,34	8,01	$1,3 \cdot 10^6$	19,39
U	100	159,13	7,00	$22,2 \cdot 10^3$	94,76
Fe	100	2607,26	183,86	$55,1 \cdot 10^3$	1331,67

- Modifications of the arrays with reduced cover material have been simulated

- Simulations show significantly higher dose signal for modified arrays at low energies

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- Particle flux has to be adjusted to not exceed measurement range
- Modifications are useful in a region of 100 MeV/u for heavy ion beams

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Current results - open questions for database

By PhD student Andreas Pflaum

- Uniformity (same as beam flatness?)
  - Information according to which definition?
  - D_{max} and D_{min} within central 80% of beam width:

$$F = 100 * \frac{D_{max} - D_{min}}{D_{max} + D_{min}}$$

- Field Size
  - Information according to which definition?
  - width of 50% isodose relative to the dose on the central axis

- Heavy Ions: Energy for each type of ions? Is a list as an attachment for each facility possible?

- Definition of Dosimetry Accuracy? In which way is the dosimetry performed?

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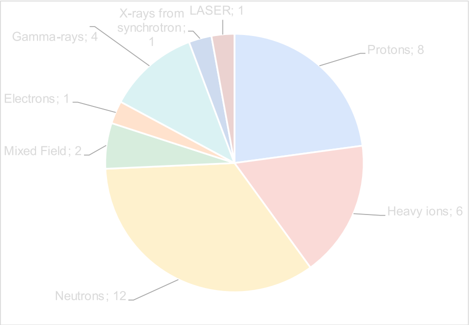

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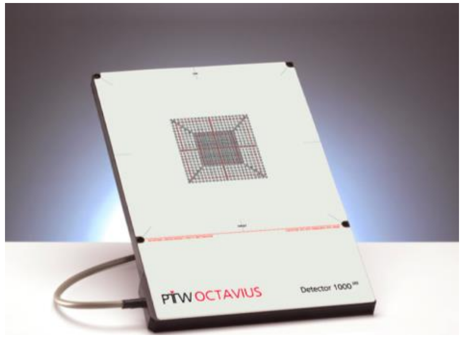

Next steps

Next steps

- Modification of 1000SRS and 1600XDR to measure with lower beam energy and flux
- Experiments at GSI or GANIL
- Experiments in other RADNEXT test facilities
  - Progressing in collecting beam parameters of RADNEXT facilites
- Close collaboration with St Etienne, exchange of PhD students to enable the best possible knowledge transfer within the WP

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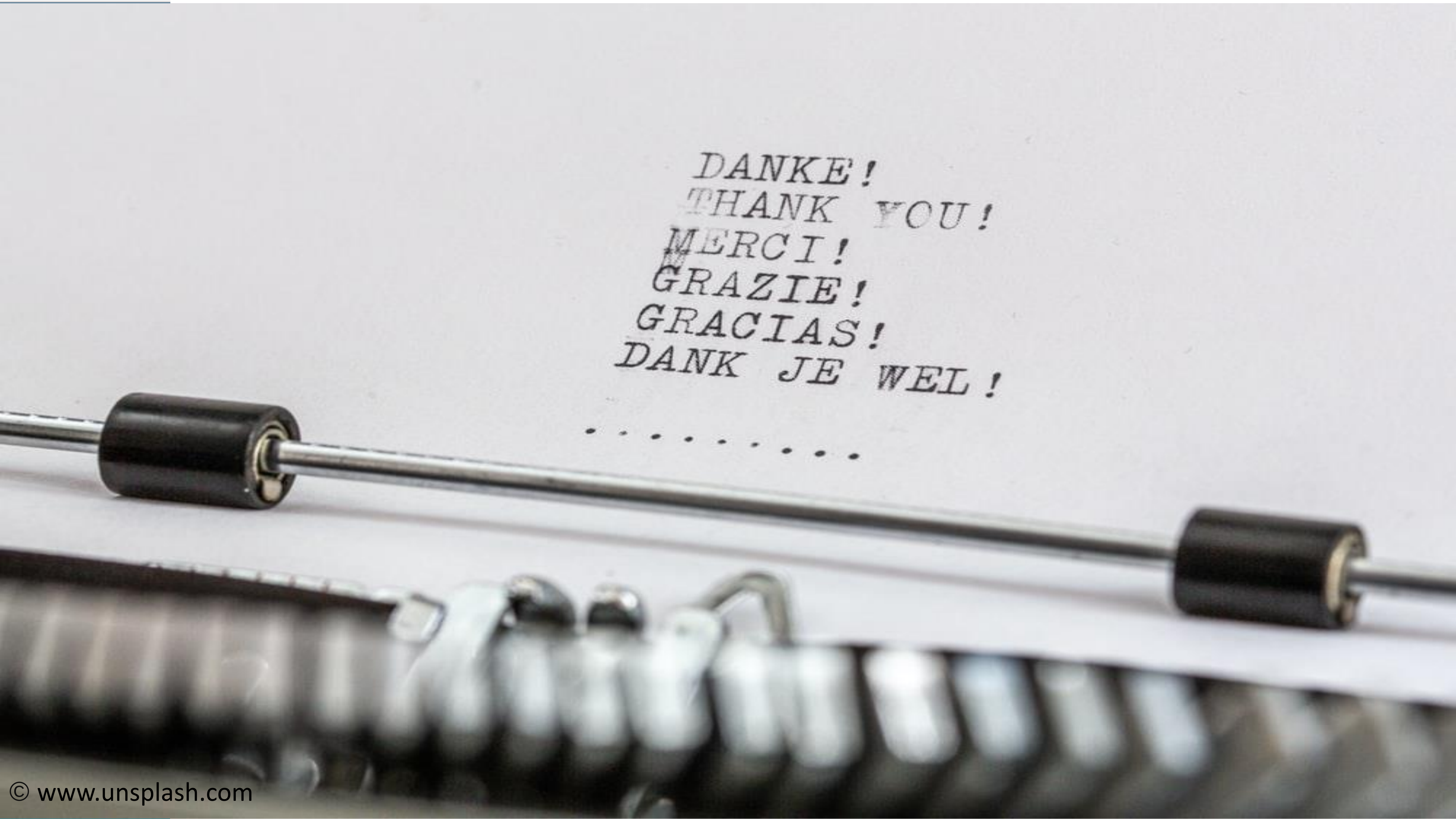
DANKE!
THANK YOU!
MERCI!
GRAZIE!
GRACIAS!
DANK JE WEL!