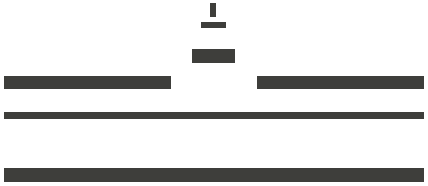


Westfälische
Wilhelms-Universität
Münster

Small Animal PET with MWPC

small animal **p**ositron **e**mission **t**omography

with **m**ulti-**w**ire **p**roportional **c**hambers

wissen.leben
WWUMünster

Jennifer Bersch

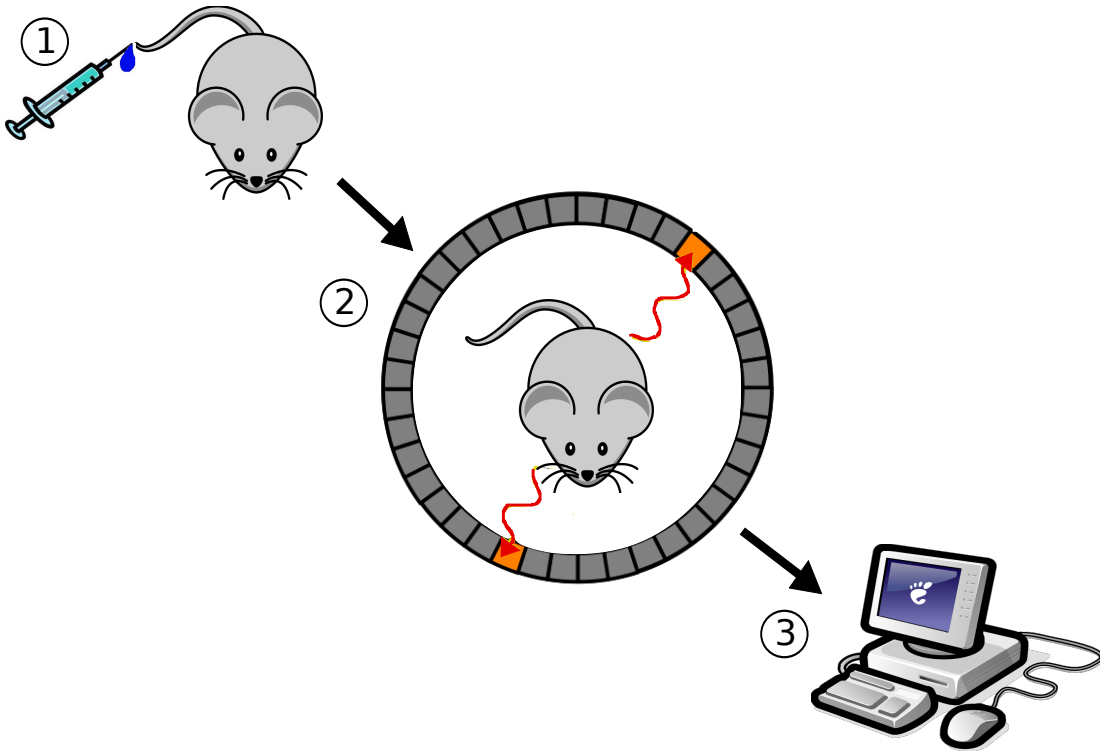
12. Oktober 2011

outline

1. the principle of PET
2. simulations regarding sensitivities
3. γ-to-e^- converter manufacture and test device

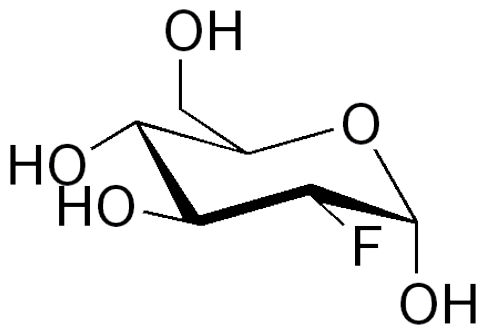
principle of PET

1. injection of radio-pharmaceutical
2. detection of decays
3. reconstruction with algorithms



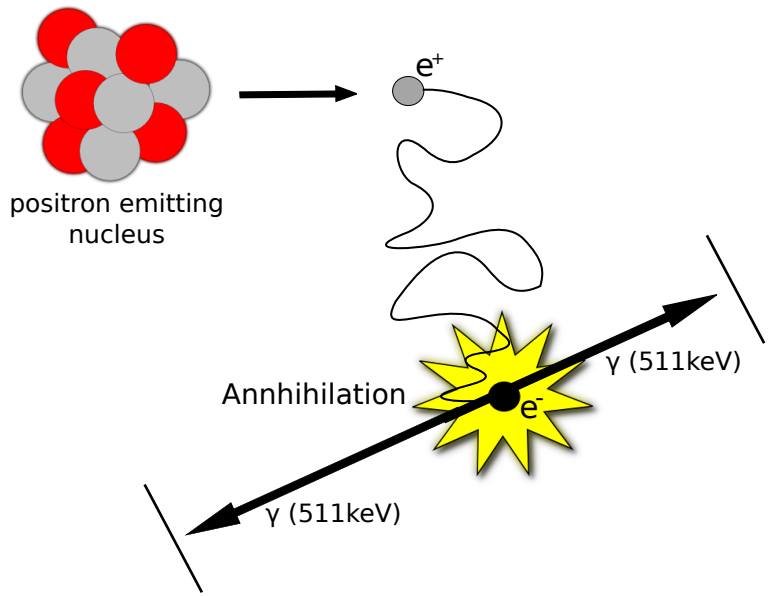
annihilation

radio-pharmaceutical:
e.g. glucose marked with F-18



$\Longrightarrow$ F-18 undergoes β^+-decay:

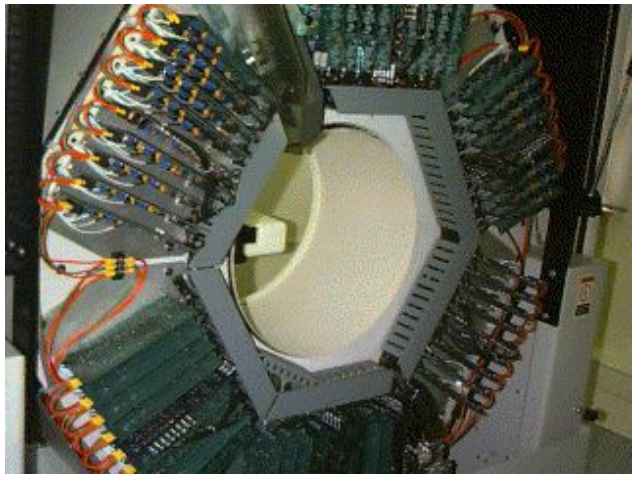
$$p \rightarrow n + e^+ + \nu_e$$



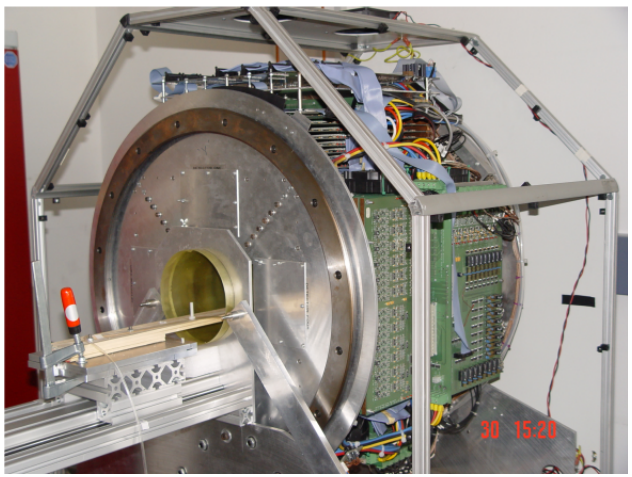
annihilation process of two 511 keV photons

PET-detectors

scintillator based

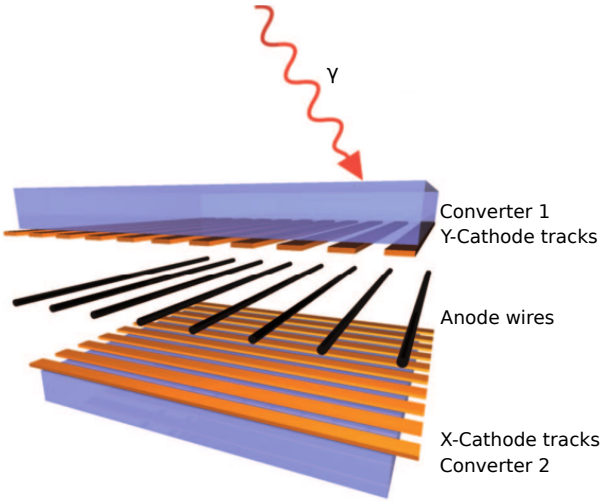


MWPC based

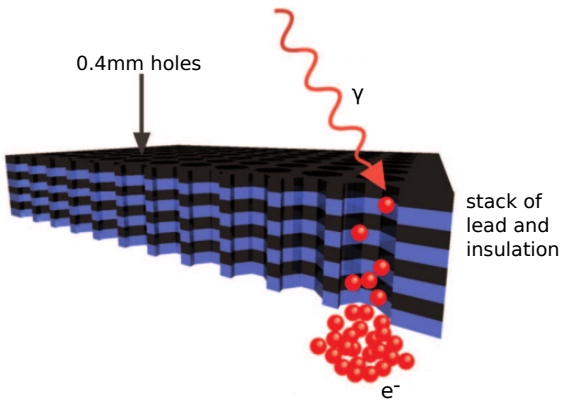


MWPC based

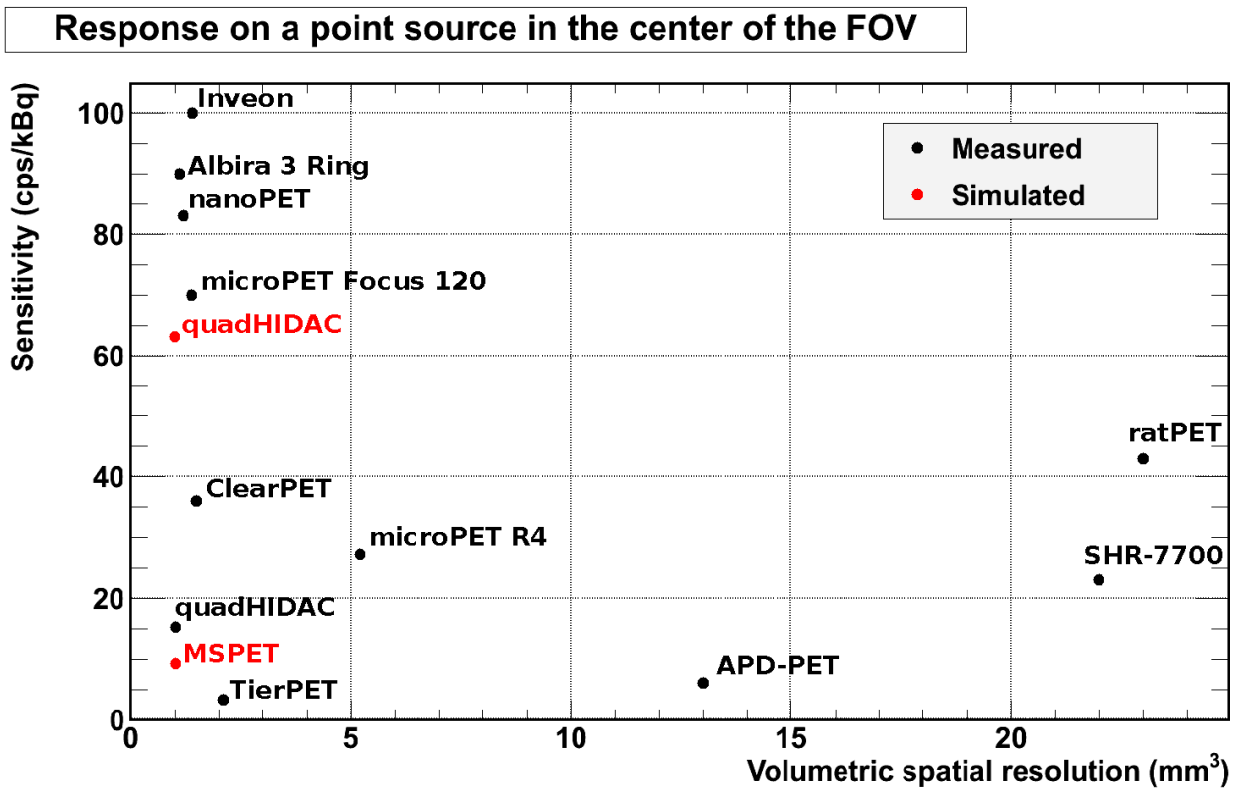
top: MWPC between two converters



bottom: close-up of converter: conversion of photons leads to avalanche due to electric field



sensitivity vs spatial resolution



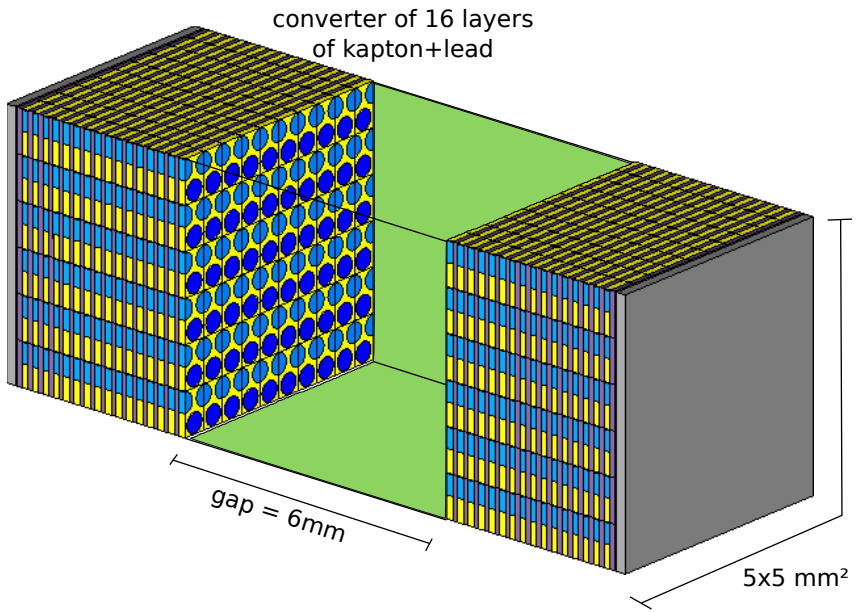
- popular field of research
- quadHIDAC in the range of minimal resolutions
- quadHIDAC's perspective is promising due to high potential regarding sensitivity

Geant4

Geant4: *"toolkit for the simulation of the passage of particles through matter"*

simulation:
quadHIDAC geometry
had been implemented

- 2 detector blocks
- 8 modules per block
- 2 converters à 16 layers per module
- centered point source

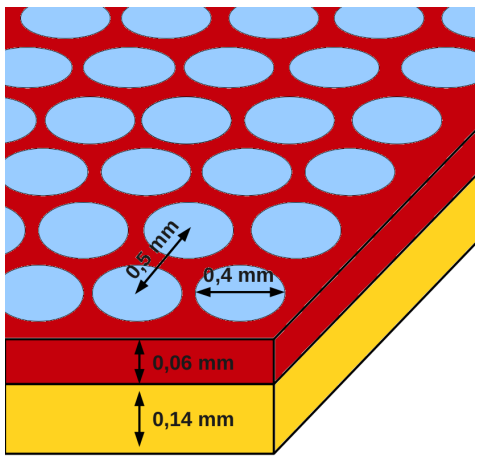


5x5 mm^2 cut of the converter as implemented in Geant4

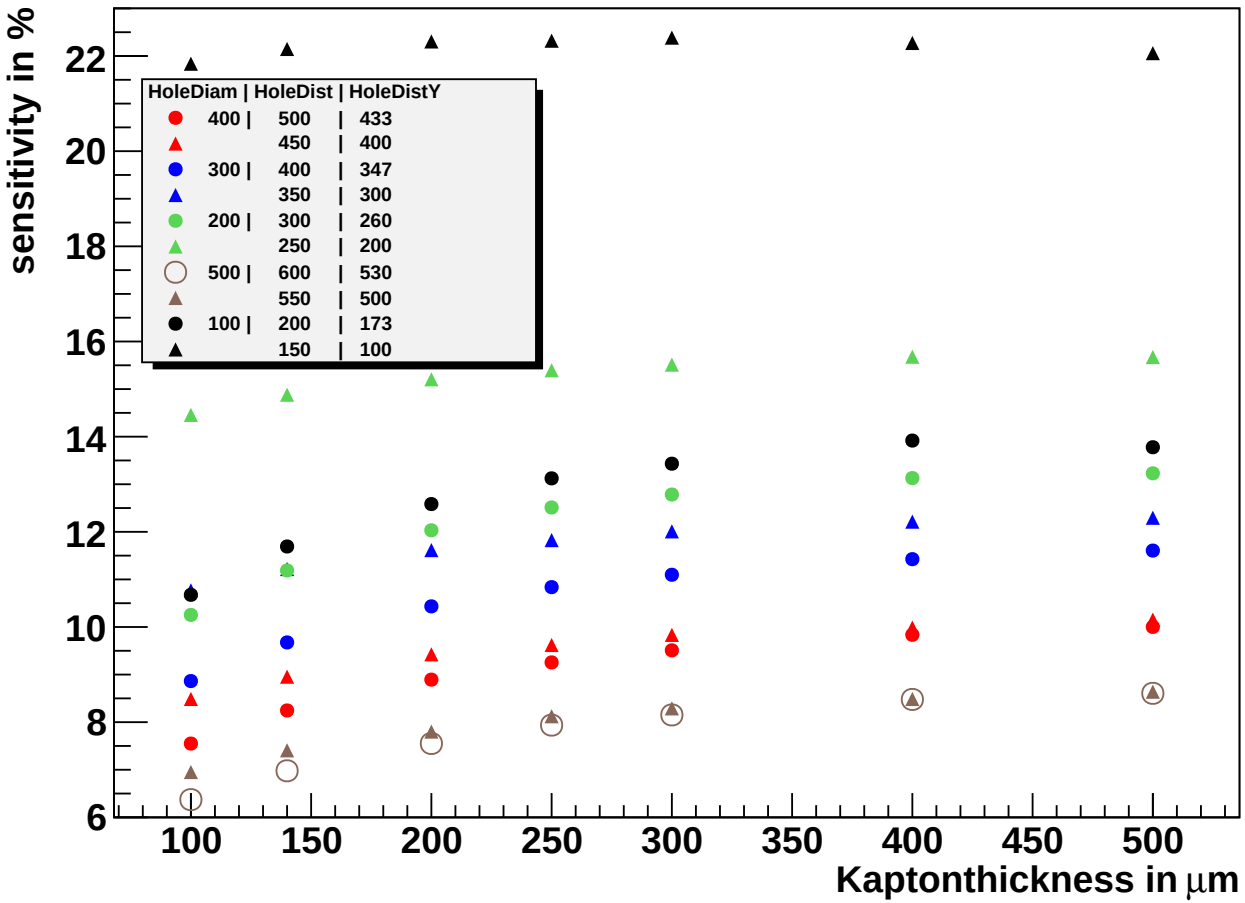
variable parameters

To find a promising converter setup, the following parameters can be taken into account:

- diameter of holes
- horizontal/diagonal distance of holes
- layer thickness of lead
- layer thickness of kapton
- number of layer



results of Geant4 simulations

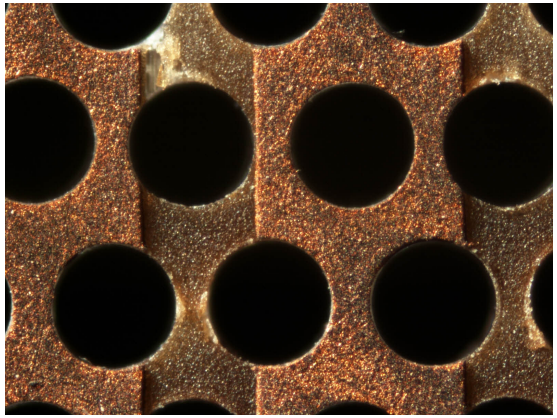


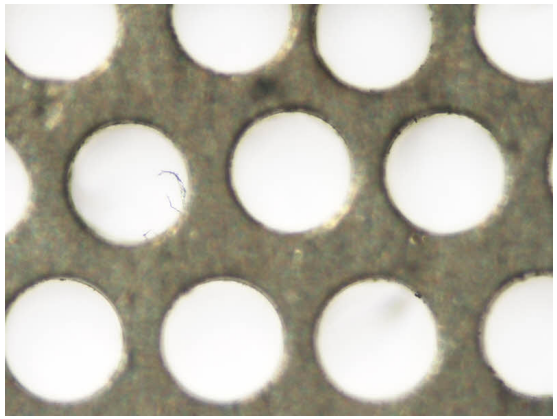
- plateau for $> 300\ \mu$m
- smaller pitches are superior at equal diameters
- small diameters promise high sensitivity

building a converter

To be considered...

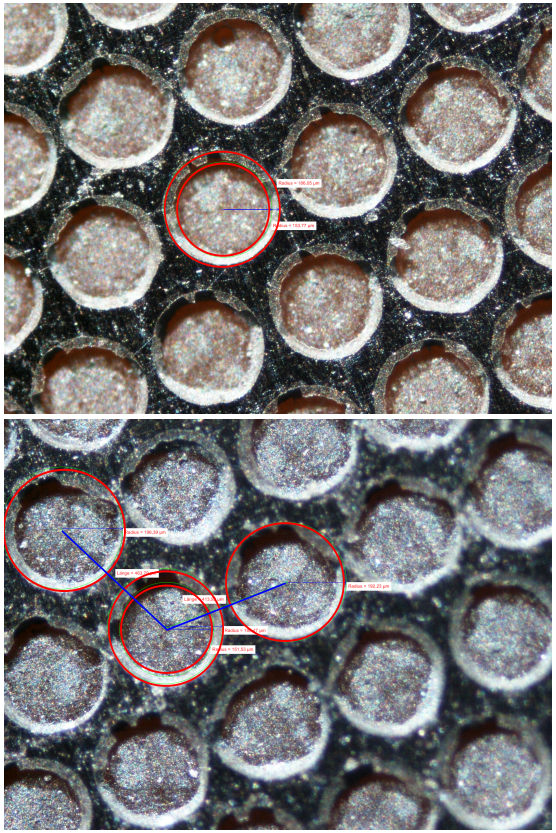
- ...material
- ...geometry
- ...fabrication
- ...alignment
- ...voltage supply





right: *converter of present quadHIDAC module*

status quo I: etching



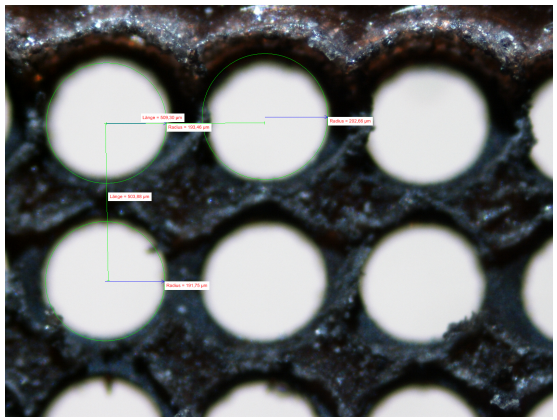
top: *center of probe*
bottom: *edge of probe*

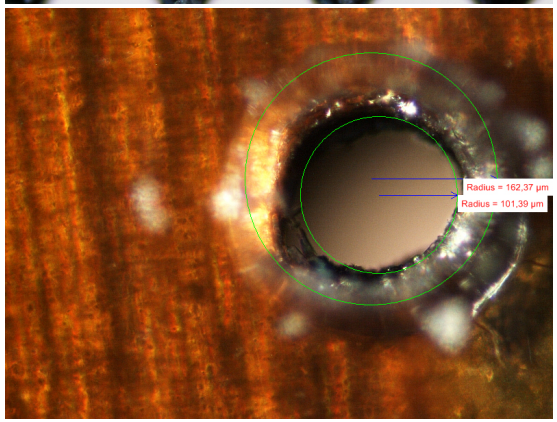
lead etching at Fraunhofer IPM Freiburg

- inner radius: $\sim 150\,\mu$m
- outer radius: $\sim$ 185-195 μm
- horizontal pitch: $\sim 410\,\mu$m
- diagonal pitch: $\sim 460\,\mu$m

$\Longrightarrow$ future probe parameters:
radius $= 150\,\mu$m
pitch $= 500\,\mu$m

status quo II: laser technique



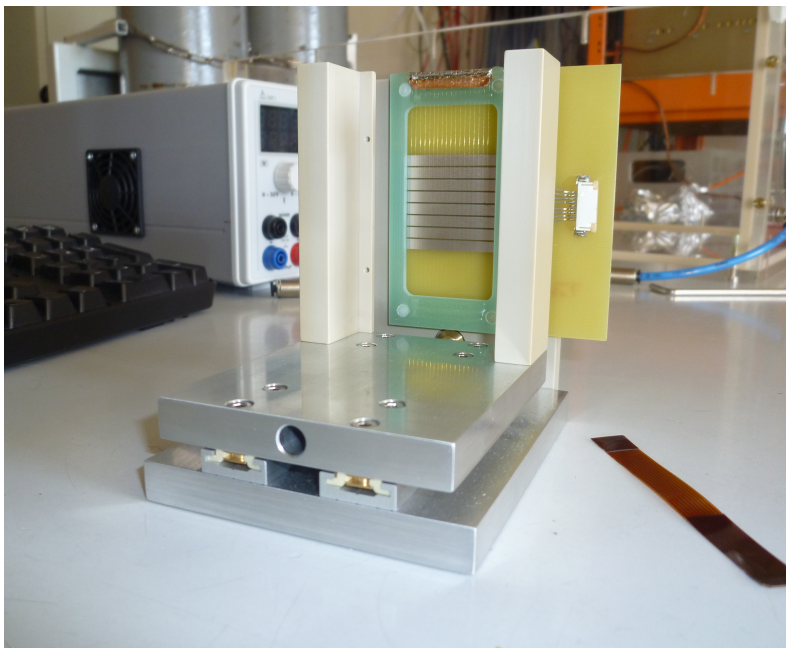


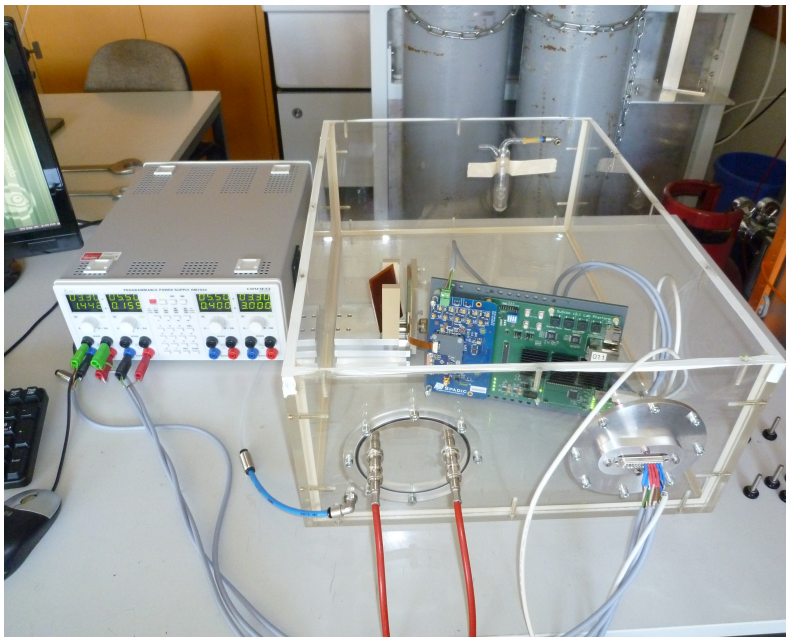
laser probes from rofin laser techniques

- **top:** double layer probe
  - UV-laser
  - radius $\sim$ 190-200 μm
  - pitch $\sim$ 500-510 μm
  - kapton has melted
- **bottom:** multi layer probe
  - inner radius $\sim$ 100 μm
  - outer radius $\sim$ 160 μm
  - sparks very likely

converter testing

In order to evaluate the prototype converters, a test device has been constructed.





summary and outlook

- Geant4 simulations give promising results regarding sensitivities
- Garfield simulations will be run to complete understanding of sensitivity behavior
- prototype converters can soon be produced
- to adjust the test device a test converter has been drilled
- the test device will be launched within the upcoming weeks

references

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- A. Jeavons. Imaging system using a high-density avalanche chamber converter, 2002. US Patent 6,404,114.
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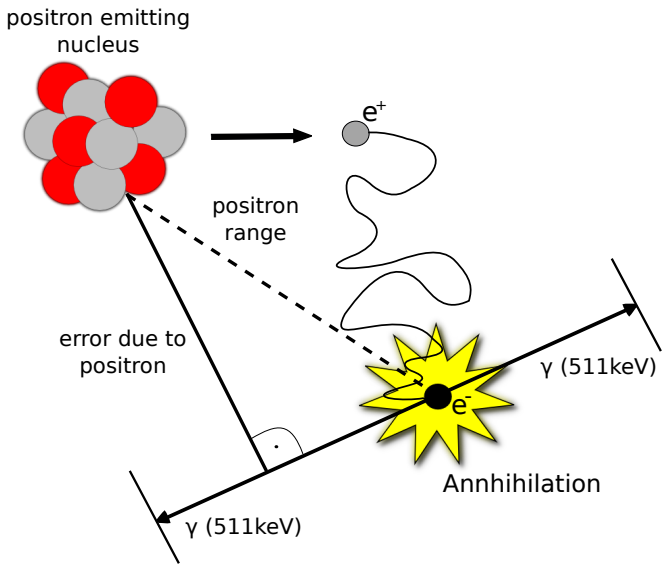
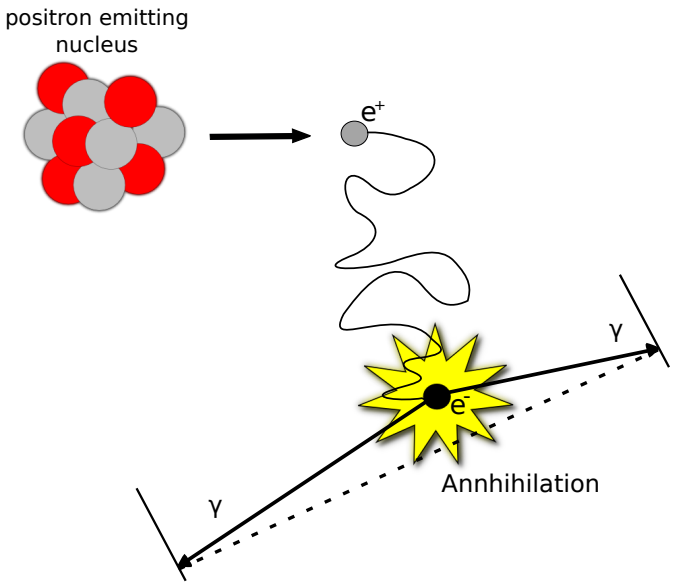
- K.P. Schaefers et al. Performance Evaluation of the 32-module quadHIDAC Small-Animal PET Scanner. J. Nucl. Med. 46 6 (2005) 996.
- D. Vernekohl. Measurements with a Multi-Wire Proportional Chamber for Small Animal Positron Emission Tomography. Diplomarbeit, Institut fuer Kernphysik, Uni Muenster, 2010.

appendix I: positron range and noncolinearity



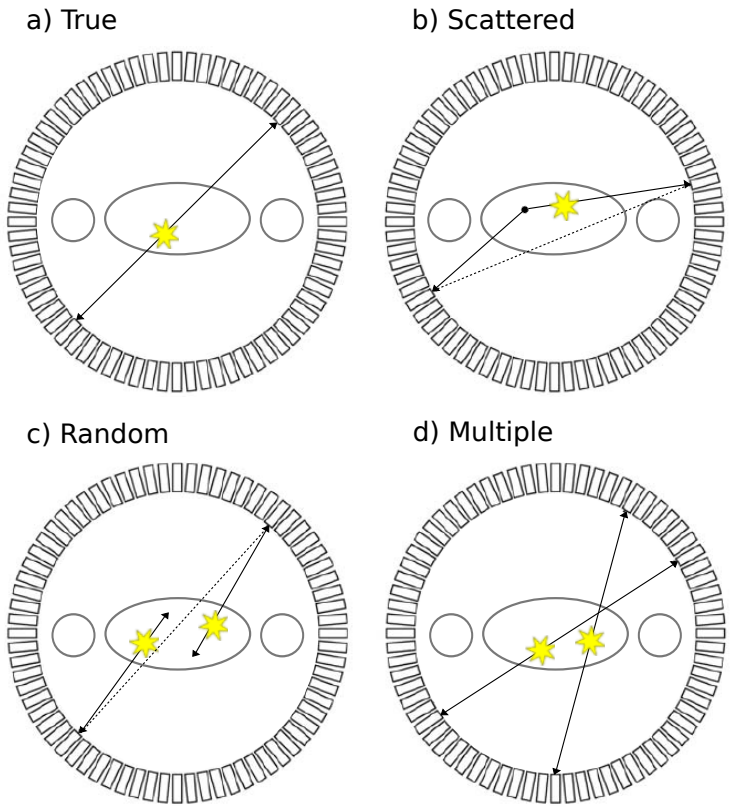
positron range



noncolinearity

errors when determining the position of the β-decay
$\Longrightarrow$ limit for spatial resolution ($\sim 1\,\mathrm{mm}$)

appendix II: types of events



there are four types of events in a PET-detector:
a) true, b) scattered, c) random, d) multiple