

# A fiber tracker with SiPM readout for nuclear cross section measurements in particle therapy

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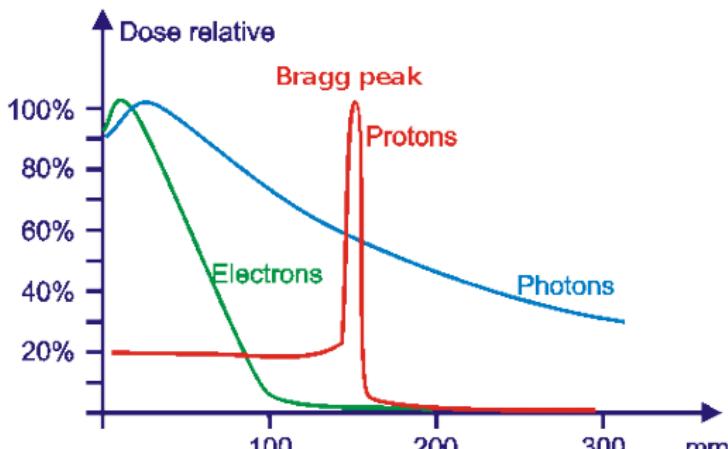
IDPASC, 20th April 2012

# Overview

- ① Particle Therapy
- ② Experimental Setup
- ③ Fiber tracker
- ④ Measurements
- ⑤ Summery & Outlook

# Particle Therapy

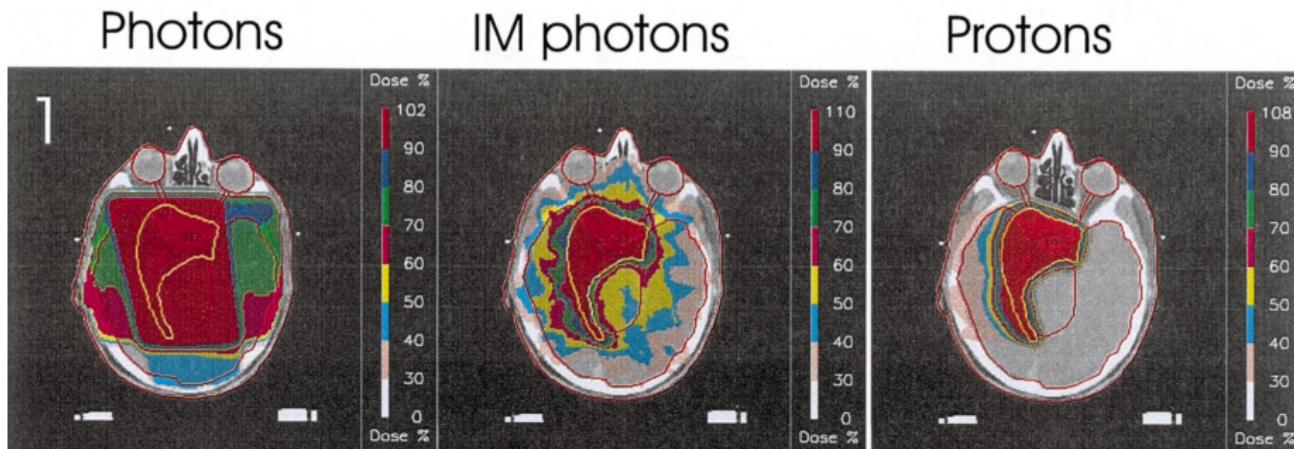
- Radiation therapy: one form of cancer treatment
- Nowadays most often done with photons
- But also possible with protons, electrons or ions
- Different dose delivery in tissue



Source: J.F. Heron, Université de Caen, Oncoprof, [www.oncoprof.net](http://www.oncoprof.net)

# Treatment Planning

- Ion therapy (proton, carbon)
- With this precise energy deposition also high precision in planning needed



Source: Anthony J. Lomax et al, Radiotherapy and Oncology 51 (1999)

III, Physikalisches Institut B

**RWTHAACHEN**

# Geant4

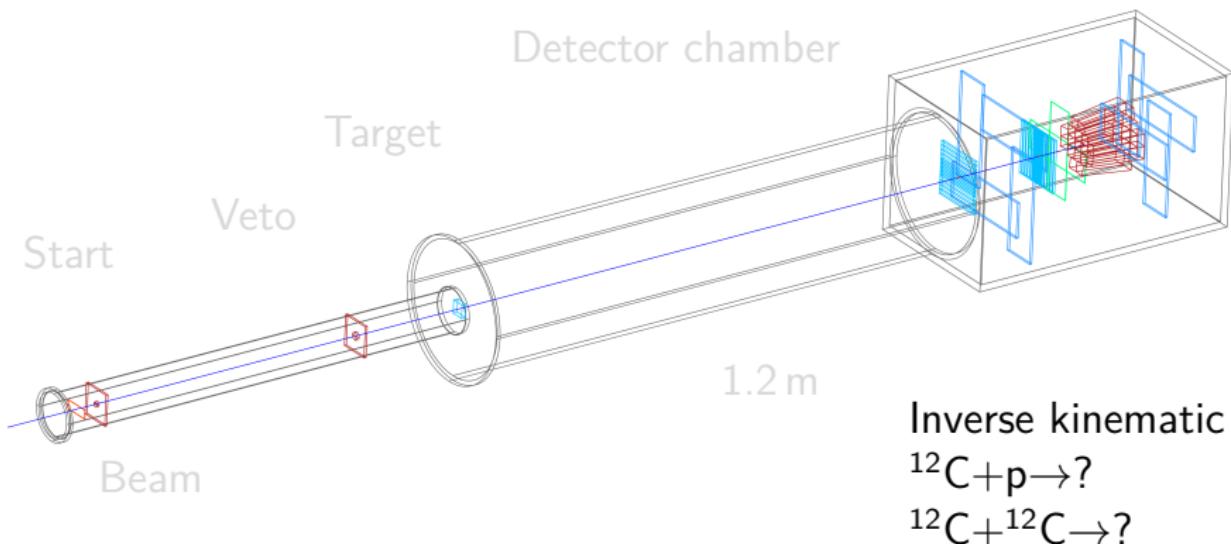
- Our idea: Planning possible with Monte Carlo simulations including nuclear reactions?  
(So far too slow, but hopefully possible in the future.)
- We use MC toolkit Geant4
- Designed for high energy particle physics (GeV-TeV)
- Energies in particle therapy 0-200 MeV
- Nuclear cross sections for inelastic scattering known insufficiently  
(few measurements, large errors)

→ Validation of Geant4 needed

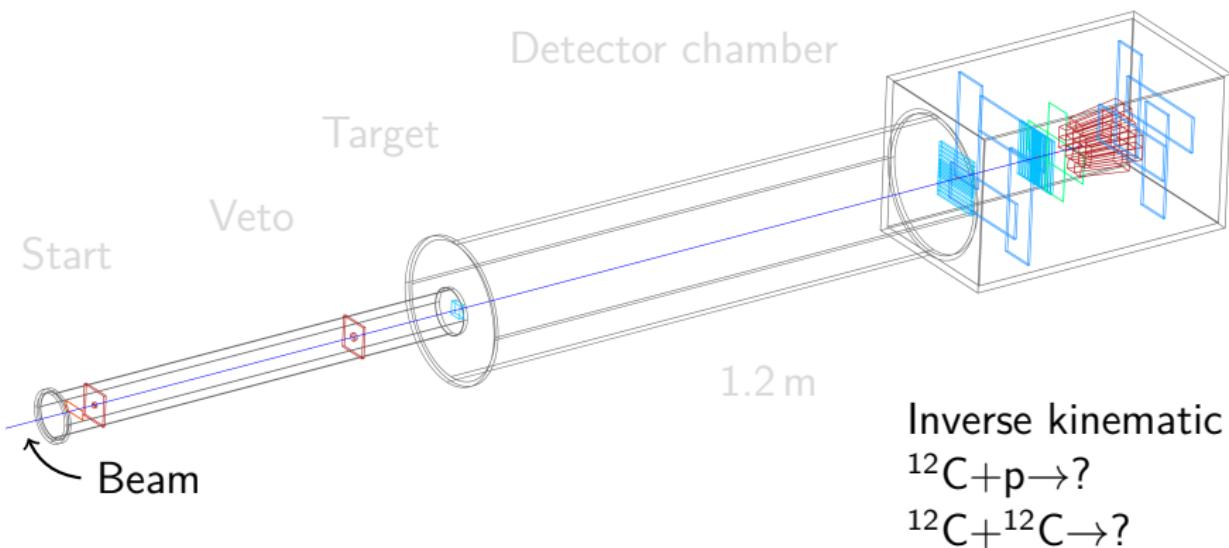
# Experimental Setup

- Time-of-flight spectrometer
- Determine A, Z of fragments of nuclear interactions
- → Identify the reaction
- Measure TOF,  $dE/dx$ , E
- Scintillation detectors
- Most detectors with SiPM readout

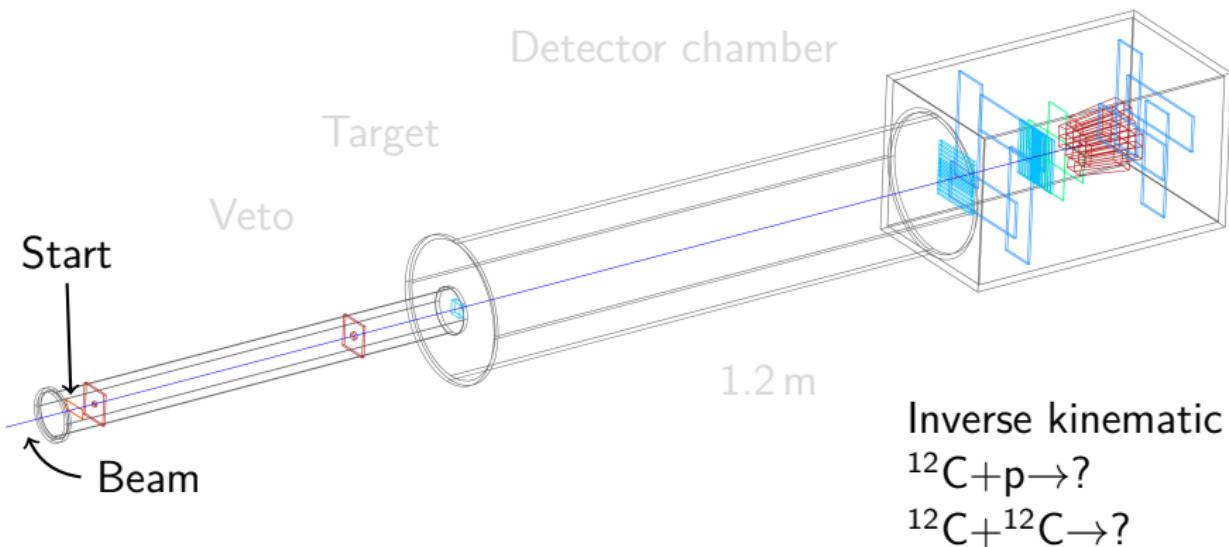
# Experimental Setup



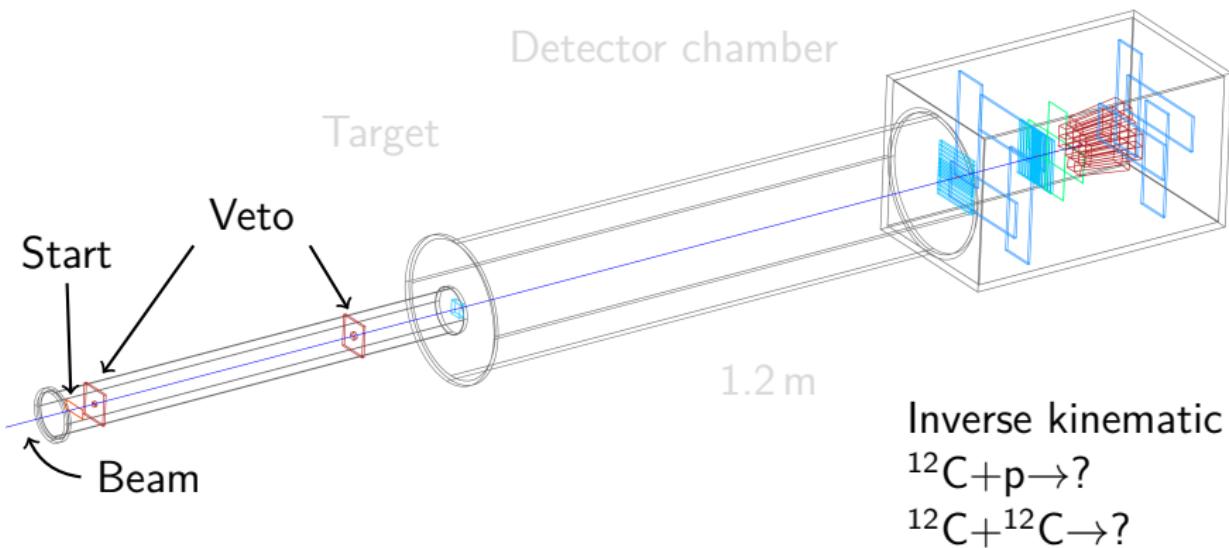
# Experimental Setup



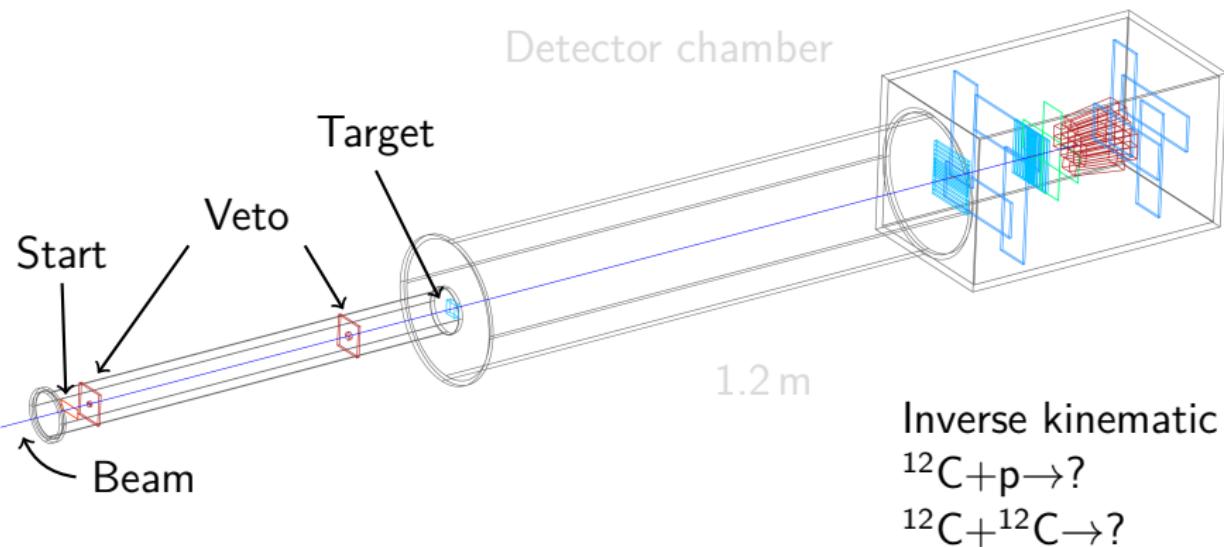
# Experimental Setup



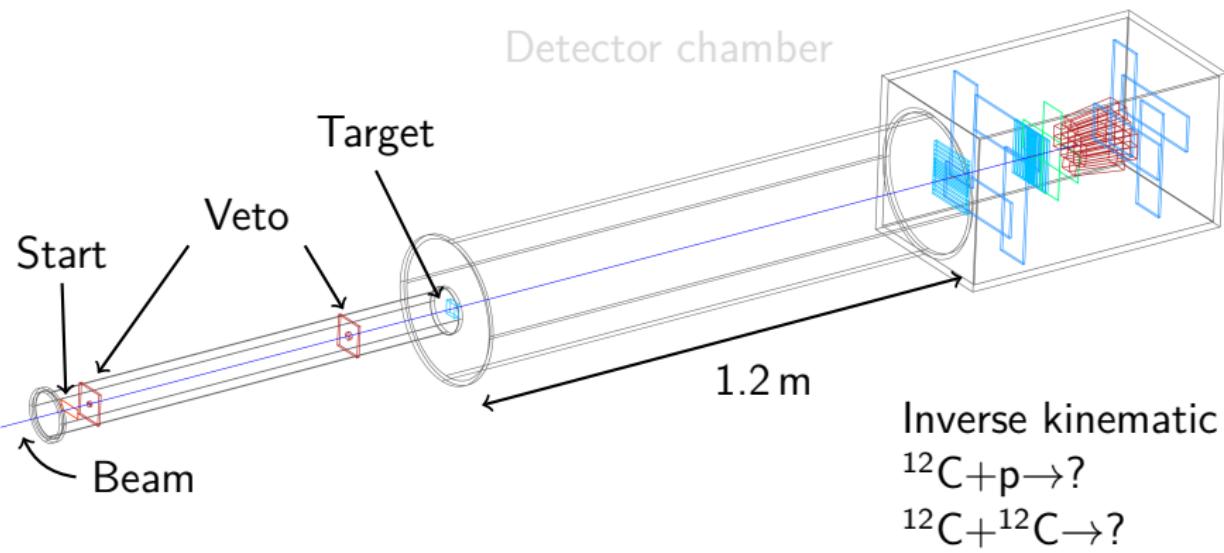
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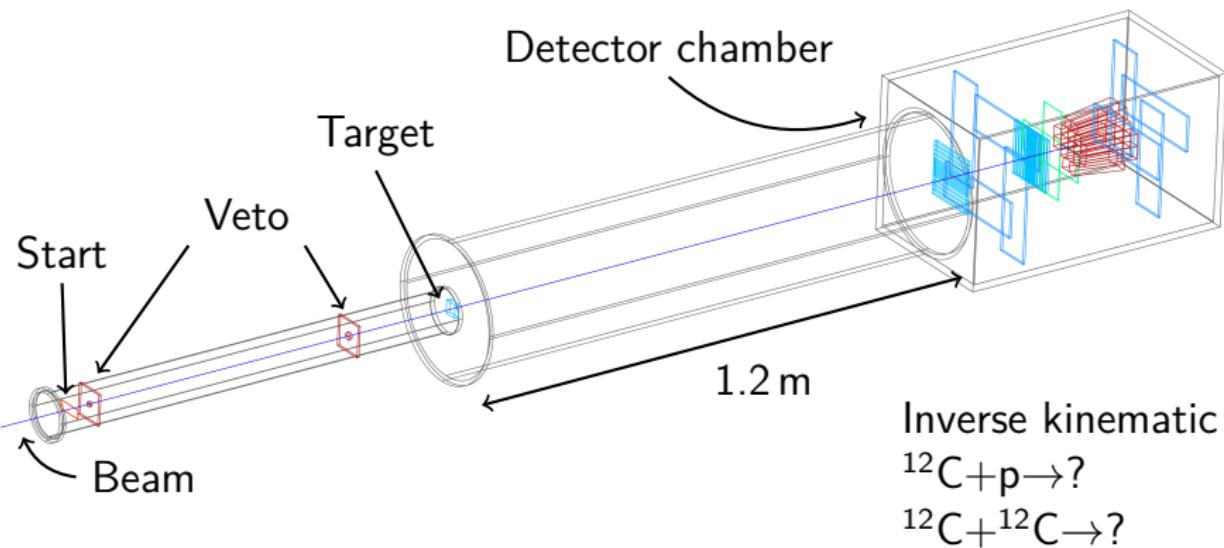
# Experimental Setup



# Experimental Setup



# Experimental Setup

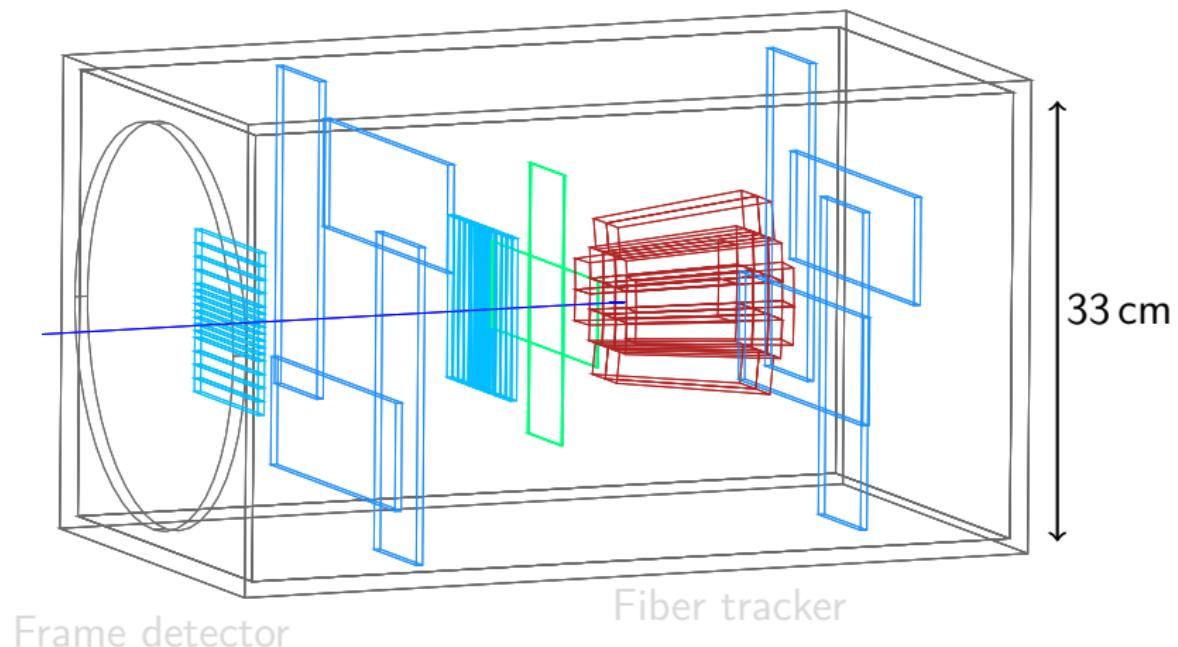


# Experimental Setup

Bar tracker

Calorimeter

Tail catcher

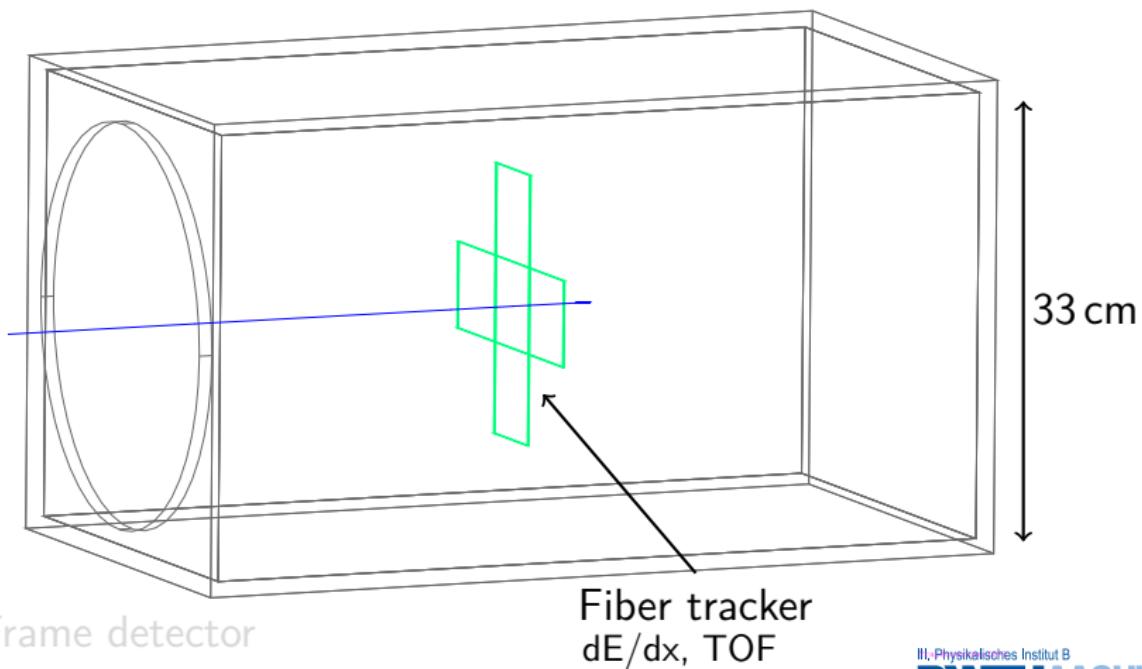


# Experimental Setup

Bar tracker

Calorimeter

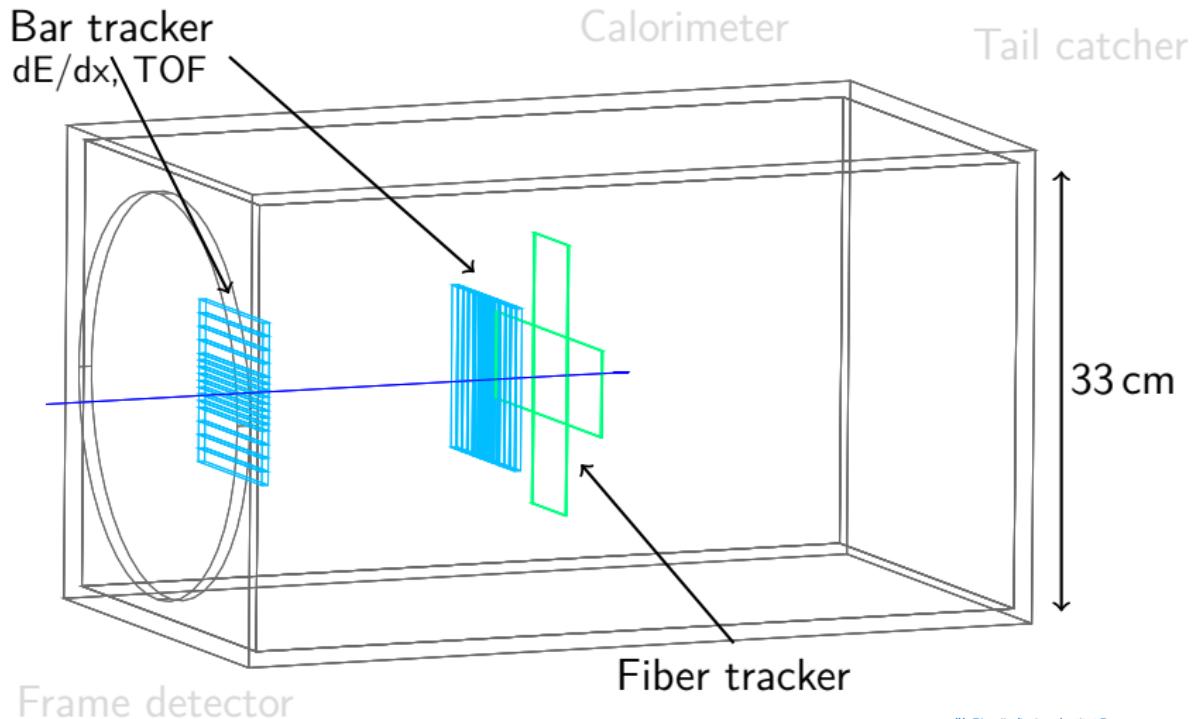
Tail catcher



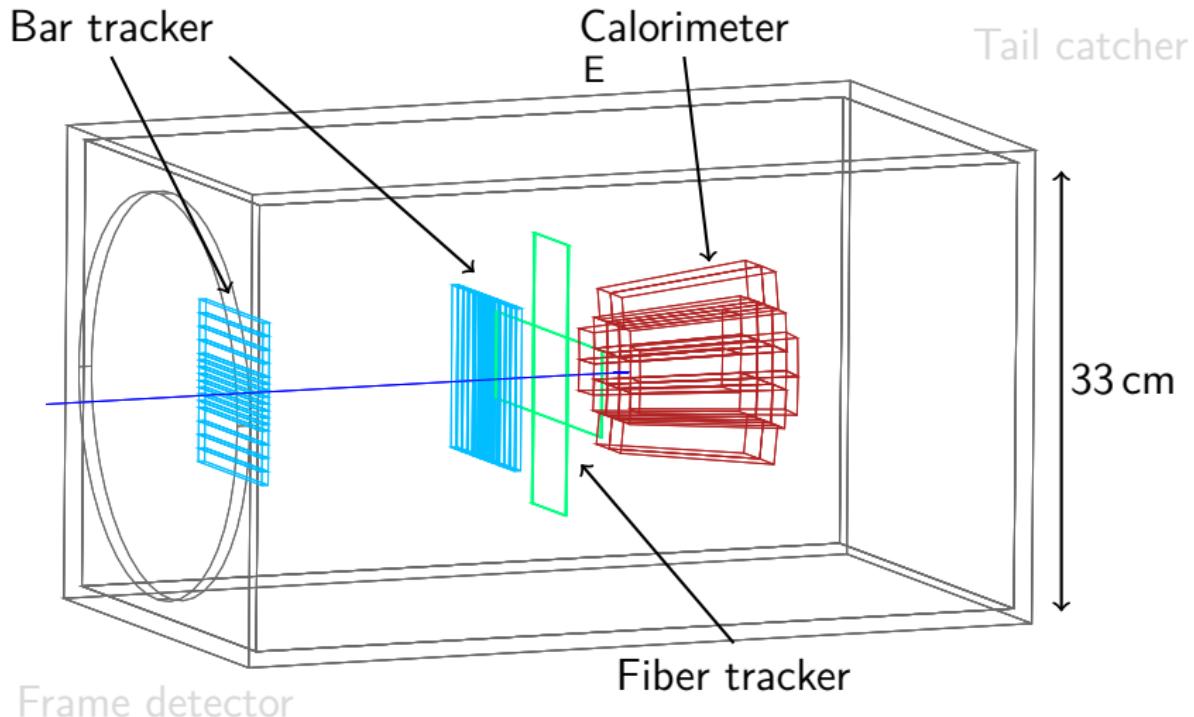
Frame detector

Fiber tracker  
 $dE/dx$ , TOF

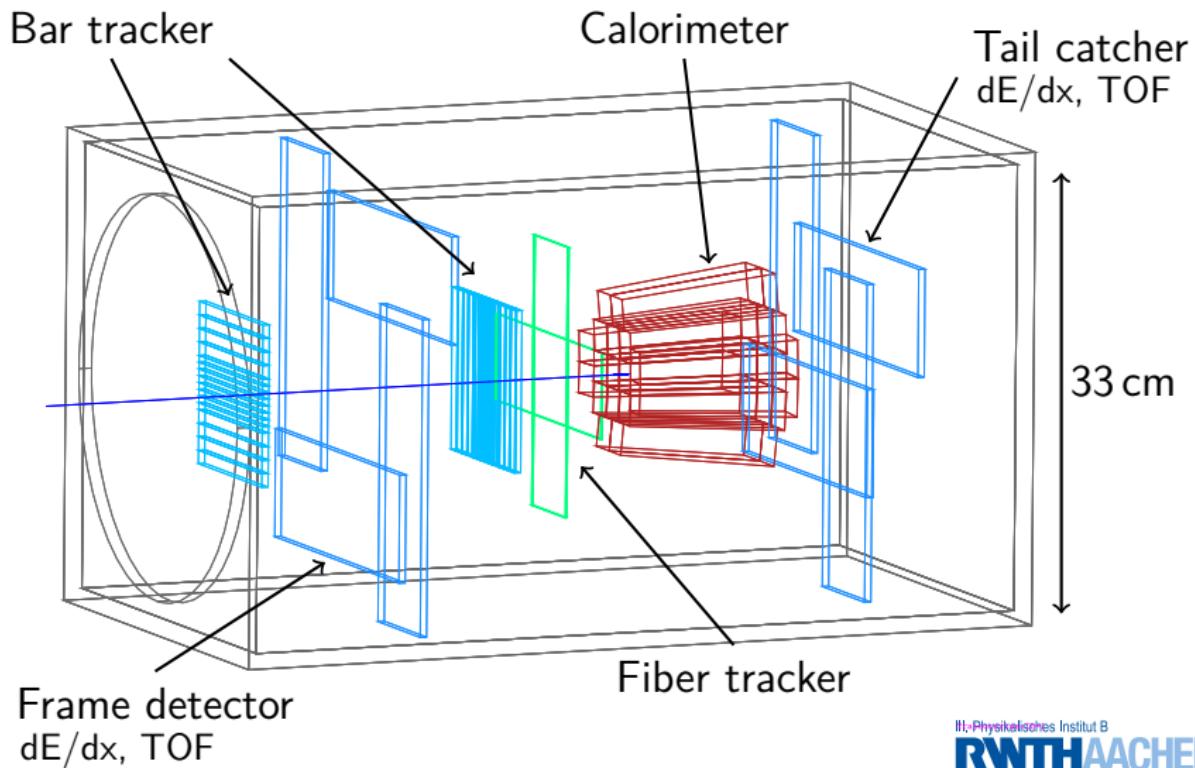
# Experimental Setup



# Experimental Setup



# Experimental Setup



# Fiber tracker

- 5 layers of scintillating fibers, each with a diameter of 250 µm
- 256 fibers → 64 mm wide
- 17 cm long

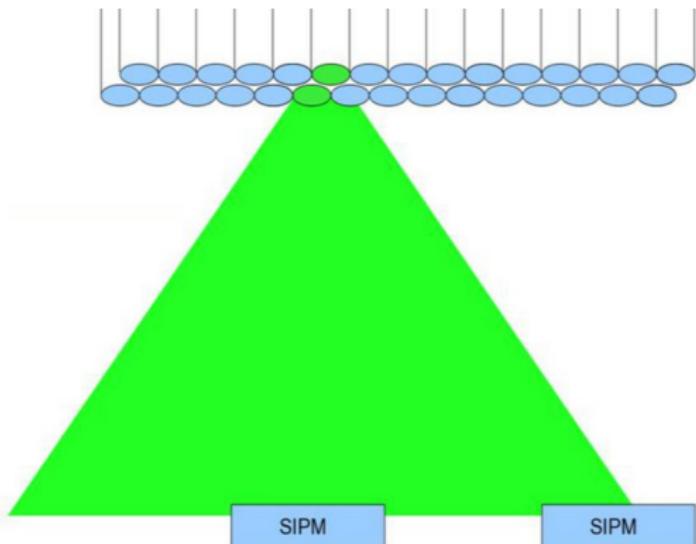


Source: [www.perdaix.de](http://www.perdaix.de)

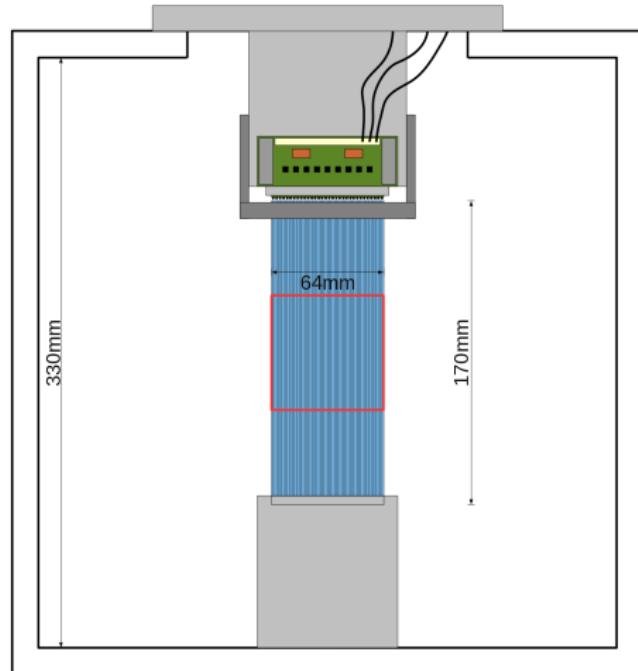


# Fiber tracker

- Read out with 32  
1 mm × 1 mm SiPMs  
(SMD, Hamamatsu)
- Pitch of 2 mm
- Gap between end of fibers  
and SiPMs 1.5 mm filled  
with optical gel
- → less SiPMs needed



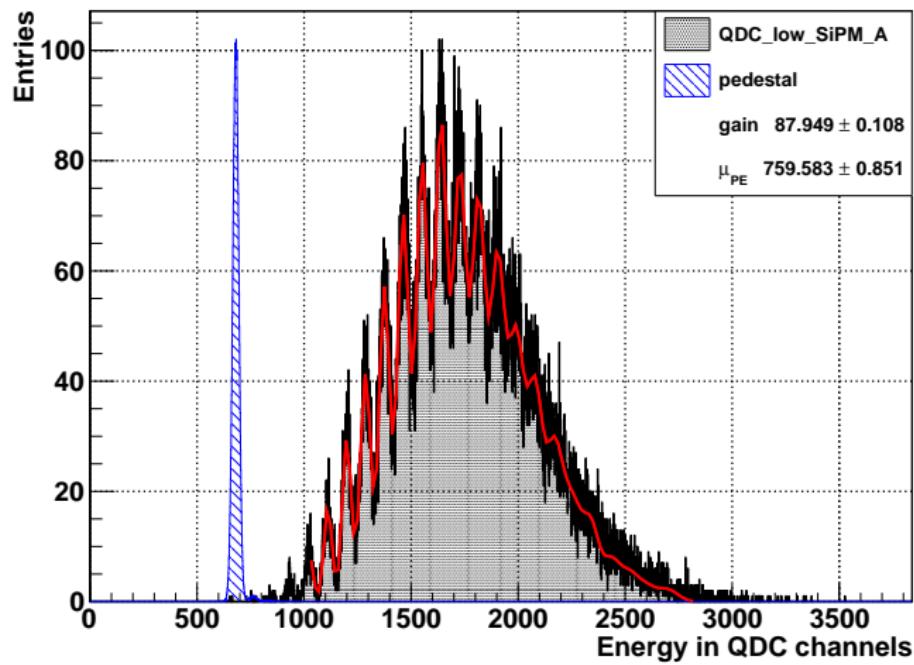
# Electronic Setup



- Tracker hanging in the chamber
- Preamplifier designed by electronic workshop

# Measurements

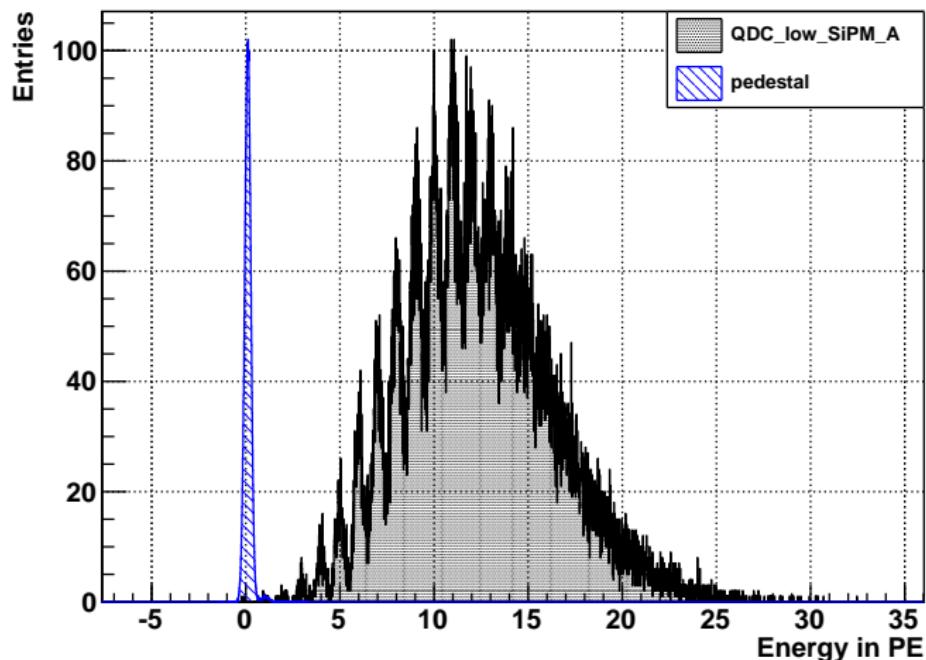
- Energy spectra with QDC (charge to digital converter)
- Fit of added Gaussians to convert QDC channels to photon equivalents (PE) which is proportional to the energy



Laser with  $\lambda = 266 \text{ nm}$  (UV)

# Measurements

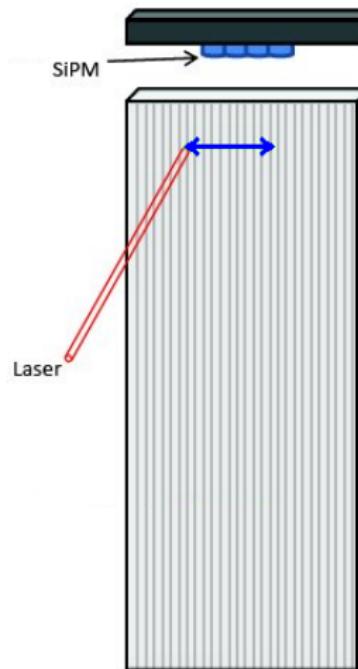
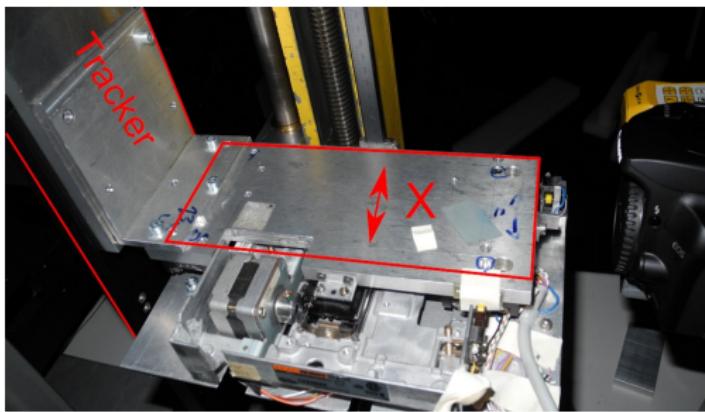
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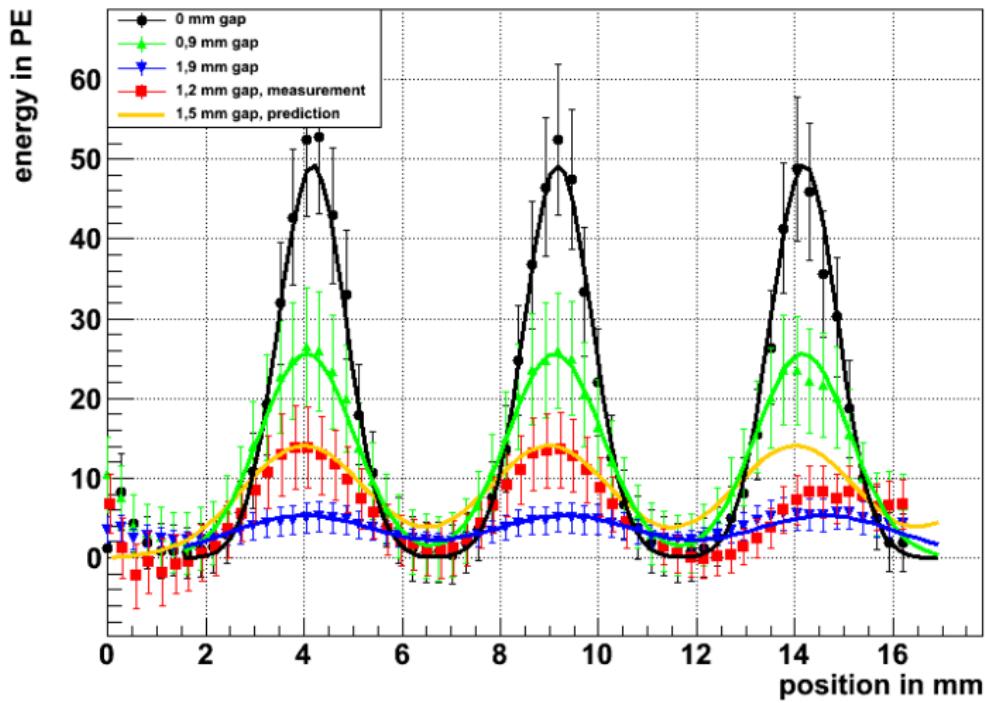
# Measurements with laser

- Tests with laser
- Stepping motor to scan the detector in  $240 \mu\text{m}$  steps
- Built from three floppy disk drives



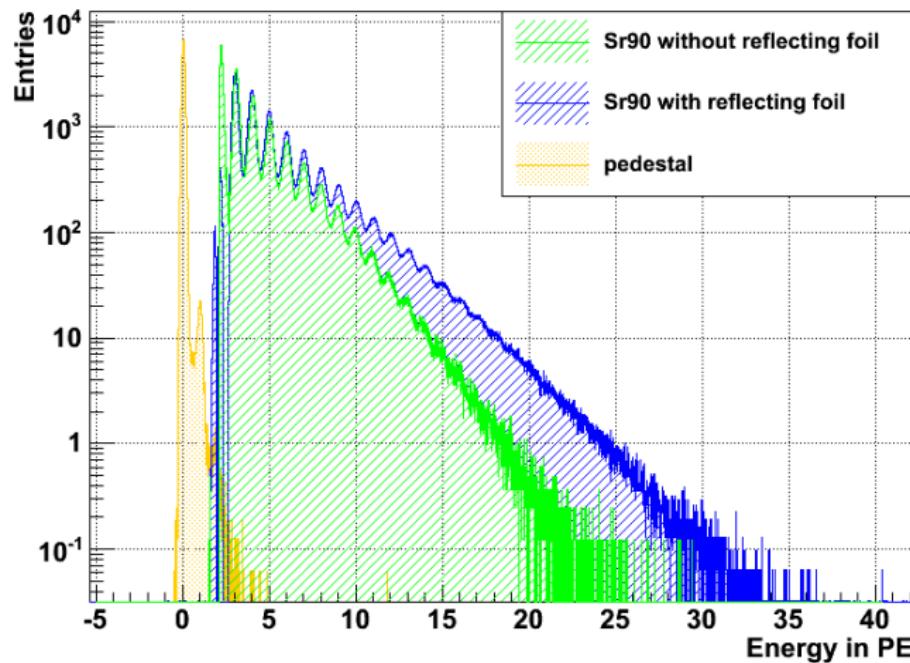
# Measurements with laser

- Measuring profile of fiber tracker
- Test with 4 SiPMs with a pitch of 5 mm



# Measurements with radioactive source

- Measurements with radioactive source  ${}^{90}\text{Sr}$
- Comparison: with and without reflecting foil
- Number of photons per MeV increased by 60%



## Summary

- ① Prototype with 4 SiPMs
- ② Measurements with laser and radioactive source  $^{90}\text{Sr}$
- ③ Electronics designed and manufactured

## Outlook

- ① Full assembly within the next few weeks
- ② Hodoscope measurements with cosmic muons
- ③ Measurements in clinical accelerator
- ④ Test beam at Forschungszentrum Jülich this year

Thank you for your attention!

Questions?