CheapCal (AP 2.4)

Alessia Brignoli
PhD student

Humboldt-Universität zu Berlin

Bundesministerium
für Bildung
und Forschung

High-D Consortium meeting
21st - 22nd February 2022

Overview

- Generic R&D: plastic-scintillator based tracker and/or calorimeter using plastic scintillator plates structured with wavelength shifting fibres

- Close collaboration between:
  - ***Humboldt-Universität zu Berlin***: Darkbox, Prototype testing, photon transport simulations, data analysis
  - ***Justus-Liebig Universität Gießen***: scintillator characterization, SiPM array, SiPM amplifier, general support
  - ***Johannes Gutenberg-Universität Mainz***: Link to SplitCal, general support
  - ***Technische Universität München***: prototype preparation (milling, gluing), teflon block for fiber coupling to SiPM array, general support

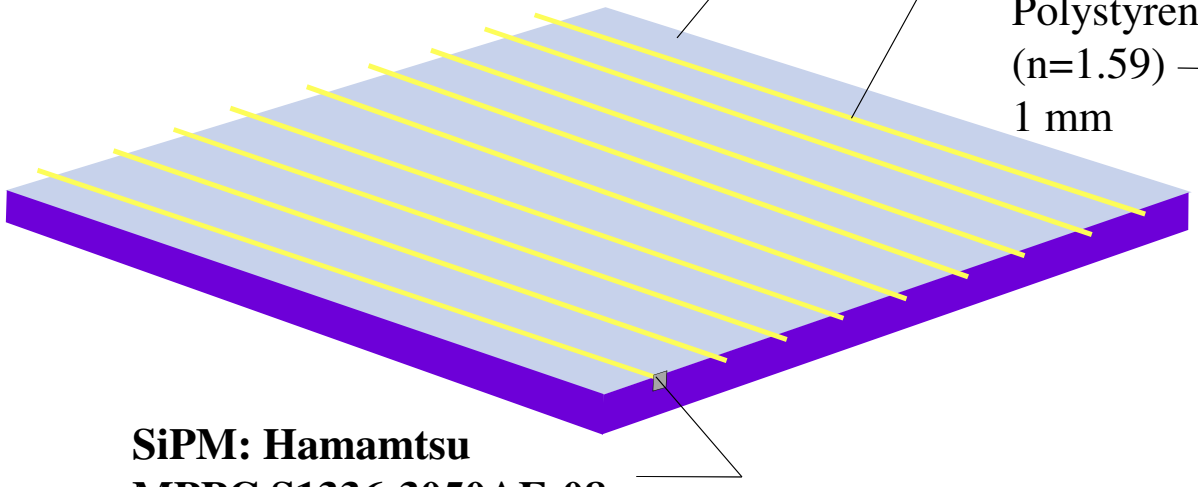
CheapCal R&D idea

The idea is to explore whether a fibre-structured scintillator detector can be built with:

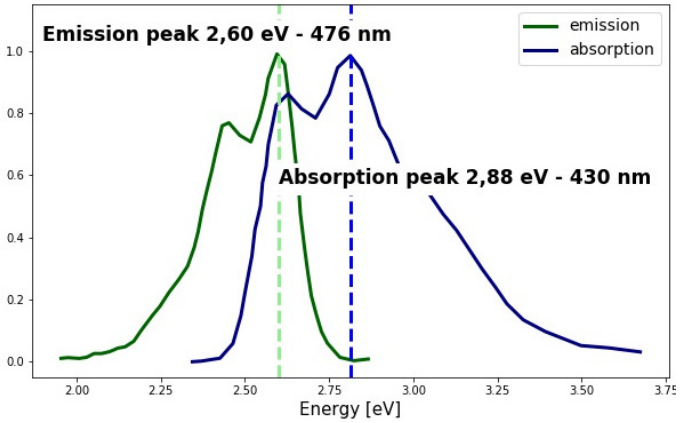
- 3D spatial information
- sufficient light yield in the individual fibres to obtain spatial and/or energy information
- affordable costs
- acceptable construction effort

Extruded plastic scintillator: UNIPLAST
Polystyrene (1.5% PTP, 0.01% POPOP)
7 mm thick
25 cm x 50 cm plates

Wavelength shifting fibres: Kuraray Y-11
Polystyrene core (n=1.59)
1 mm
PMMA cladding (n=1.49)
0.02 mm



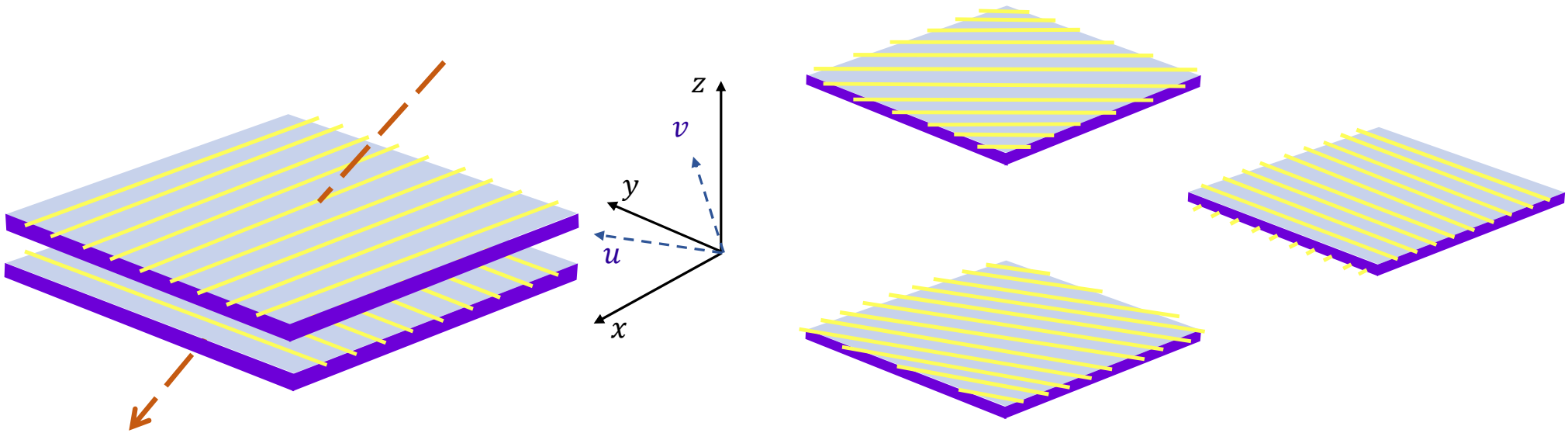
SiPM: Hamamtsu
MPPC S1336-3050AE-08



CheapCal R&D idea

The idea is to explore whether a fibre-structured scintillator detector can be built with:

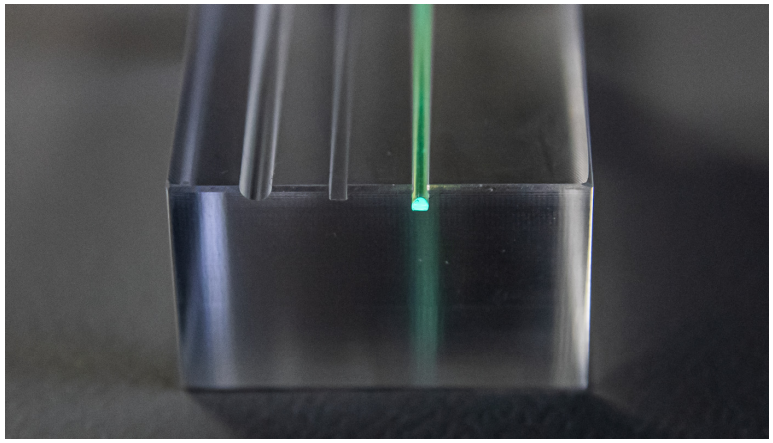
- 3D spatial information
- sufficient light yield in the individual fibres
  to obtain spatial and/or energy information
- affordable costs
- acceptable construction effort



Photon transport simulation

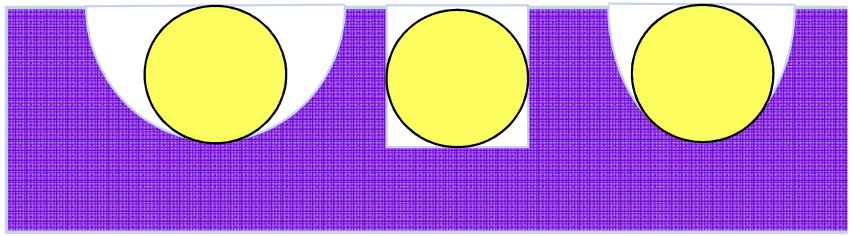
In order to estimate the best configuration possible for the fiber, a simulation for photons transportation in Geant4 is currently been working on. The main question is related to the light collection to the fibers and the photons transportation inside the fiber. Considered parameters:

- Groove shape



A PMMA block for testing the milling of different groove geometries (TU München)

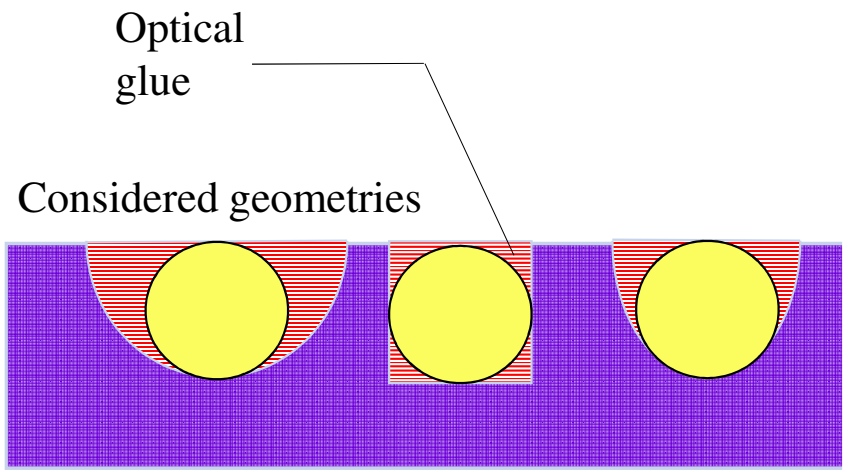
Considered geometries

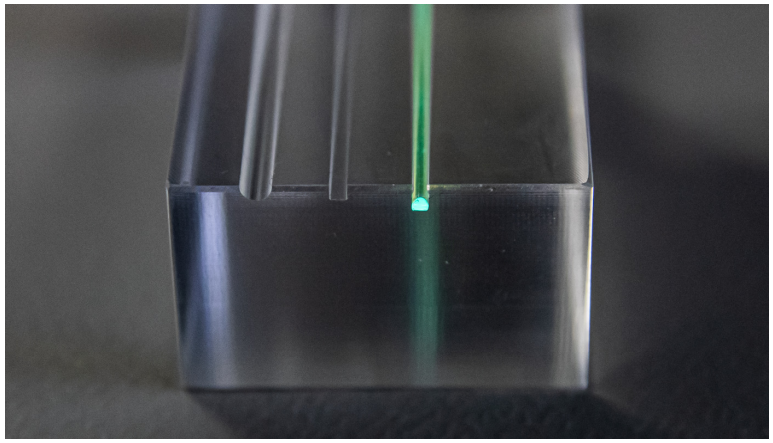


Photon transport simulation

In order to estimate the best configuration possible for the fiber, a simulation for photons transportation in Geant4 is currently been working on. The main question is related to the light collection to the fibers and the photons transportation inside the fiber. Considered parameters:

- Groove shape
- Use of optical glue





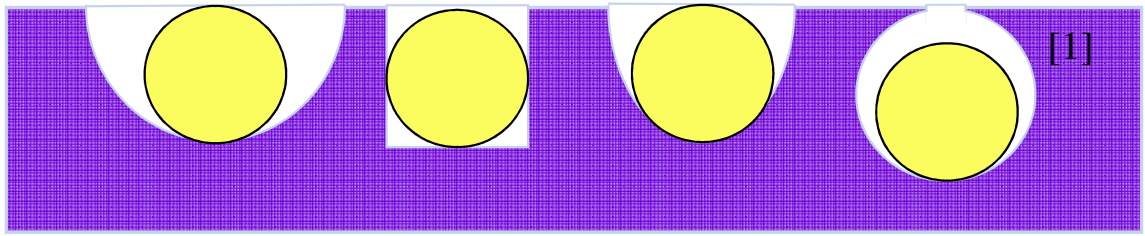
A PMMA block for testing the milling of different groove geometries (TU München)

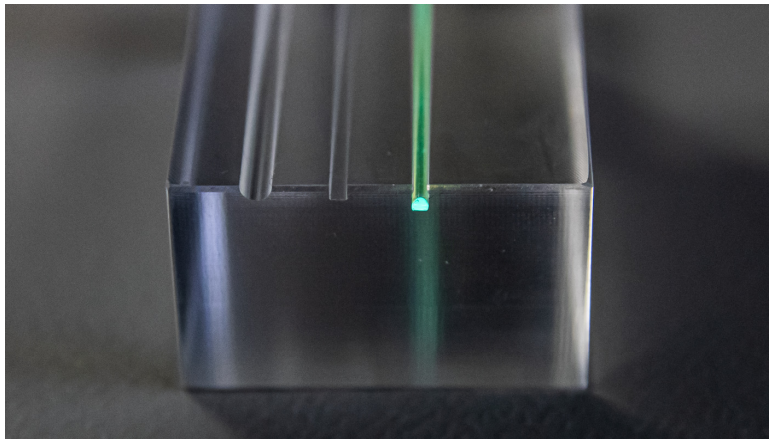
Photon transport simulation

In order to estimate the best configuration possible for the fiber, a simulation for photons transportation in Geant4 is currently been working on. The main question is related to the light collection to the fibers and the photons transportation inside the fiber. Considered parameters:

- Groove shape
- Use of optical glue

Considered geometries





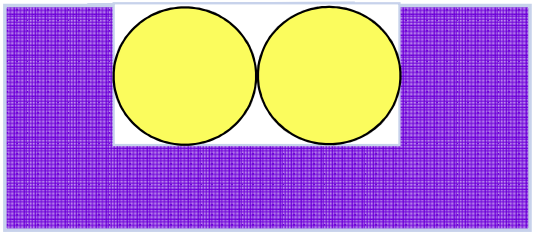
A PMMA block for testing the milling of different groove geometries (TU München)

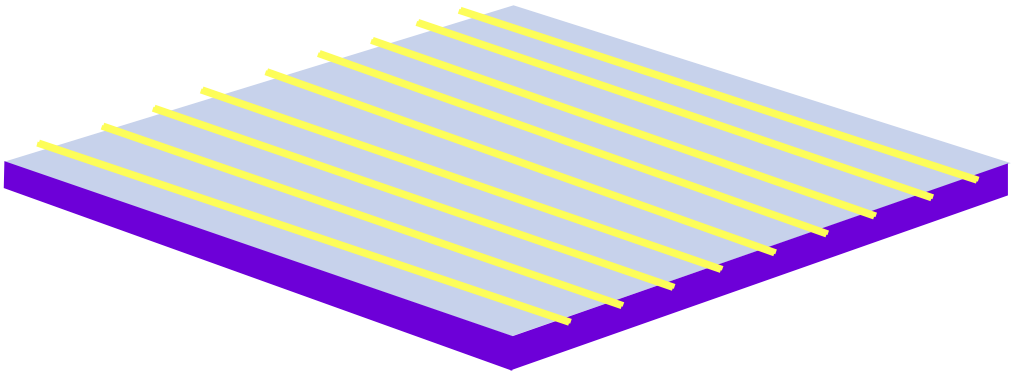
[1] The CMS Outer Hadron Calorimeter- Acharva, Bannaje Sripathi *et al* - CMS-NOTE-2006-127

Photon transport simulation

In order to estimate the best configuration possible for the fiber, a simulation for photons transportation in Geant4 is currently been working on. The main question is related to the light collection to the fibers and the photons transportation inside the fiber. Considered parameters:

- Groove shape
- Use of optical glue
- One or two fibers in the same groove

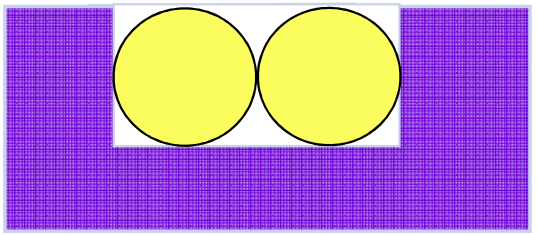


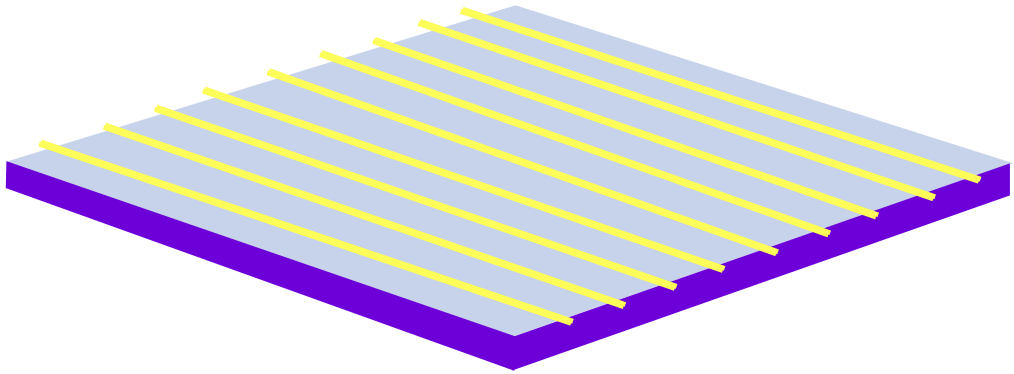


Photon transport simulation

In order to estimate the best configuration possible for the fiber, a simulation for photons transportation in Geant4 is currently been working on. The main question is related to the light collection to the fibers and the photons transportation inside the fiber. Considered parameters:

- Groove shape
- Use of optical glue
- One or two fibers in the same groove
- Thickness of the plastic scintillator

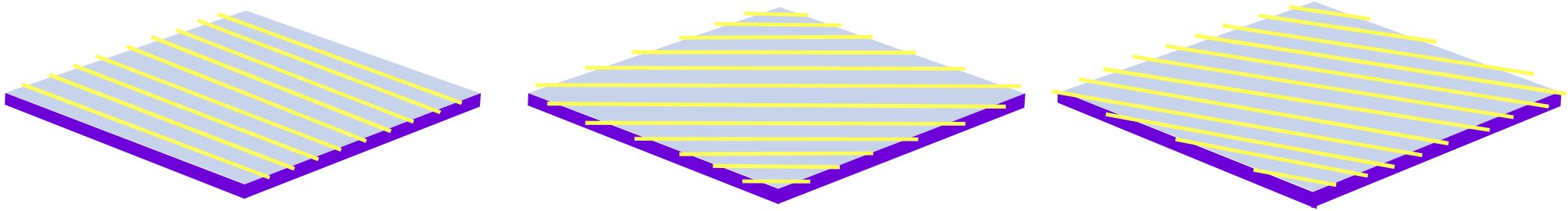




Photon transport simulation

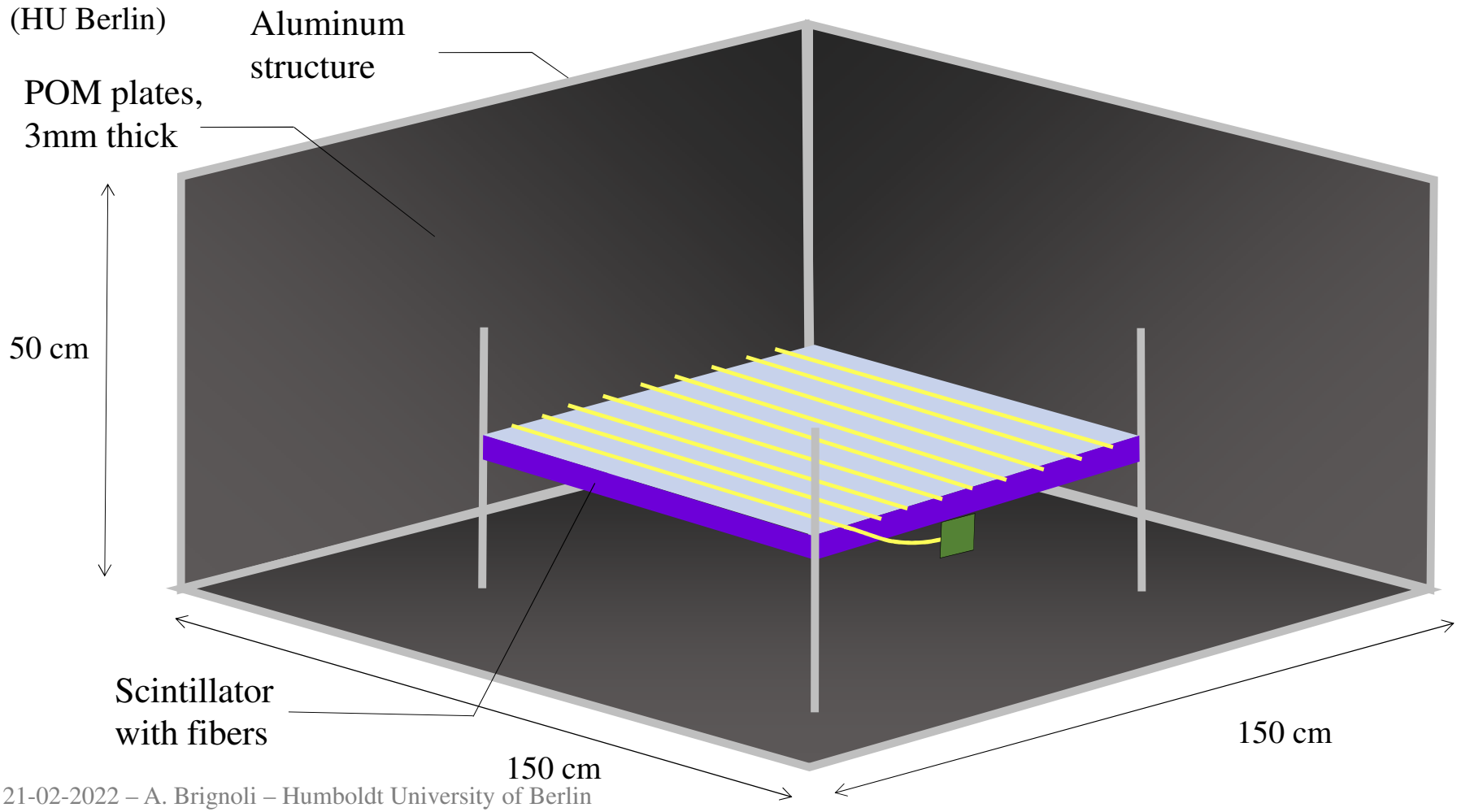
In order to estimate the best configuration possible for the fiber, a simulation for photons transportation in Geant4 is currently been working on. The main question is related to the light collection to the fibers and the photons transportation inside the fiber. Considered parameters:

- Groove shape
- Use of optical glue
- One or two fibers in the same groove
- Thickness of the plastic scintillator
- Orientation of the fibers and distance between adjacent fibres

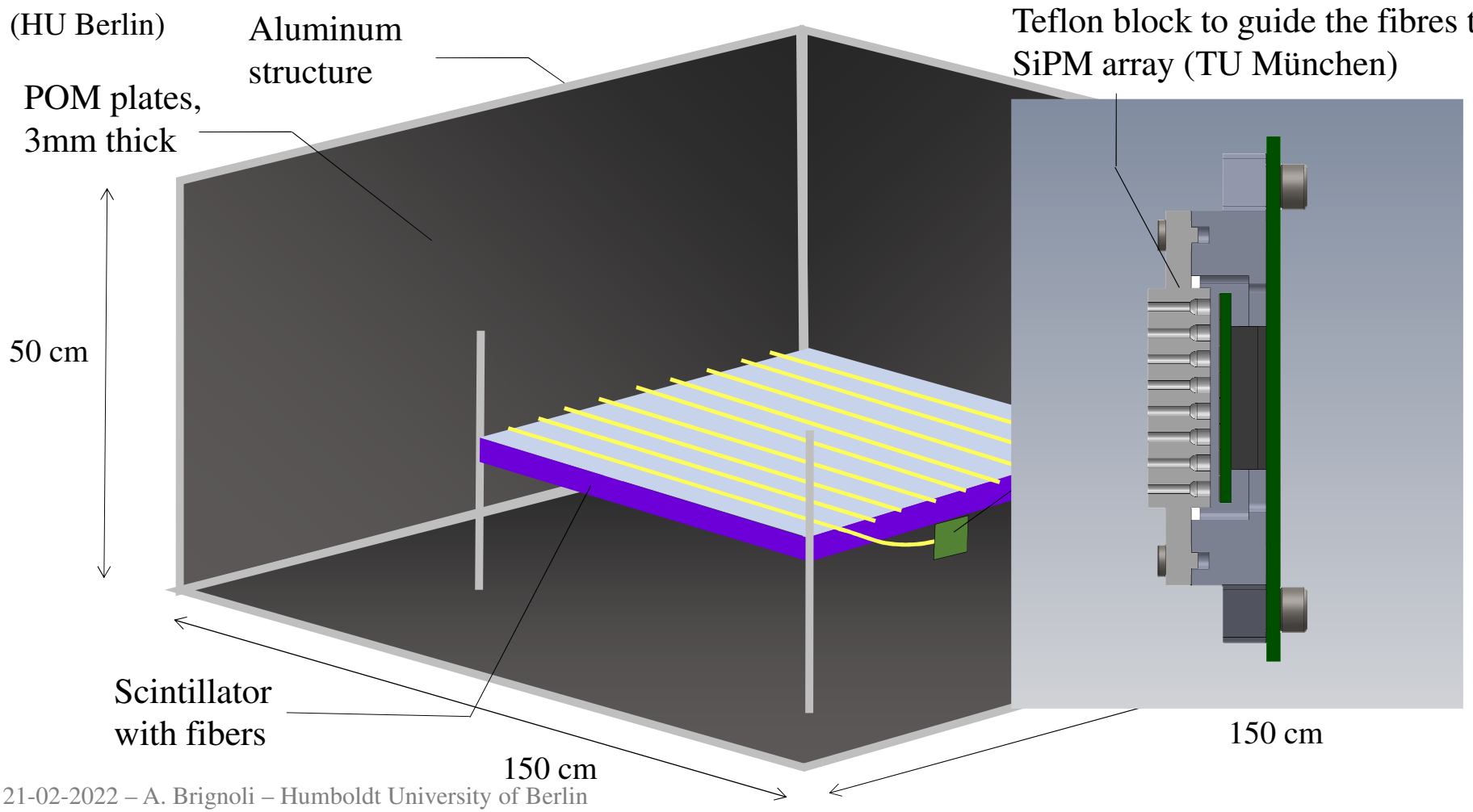


Possible orientations

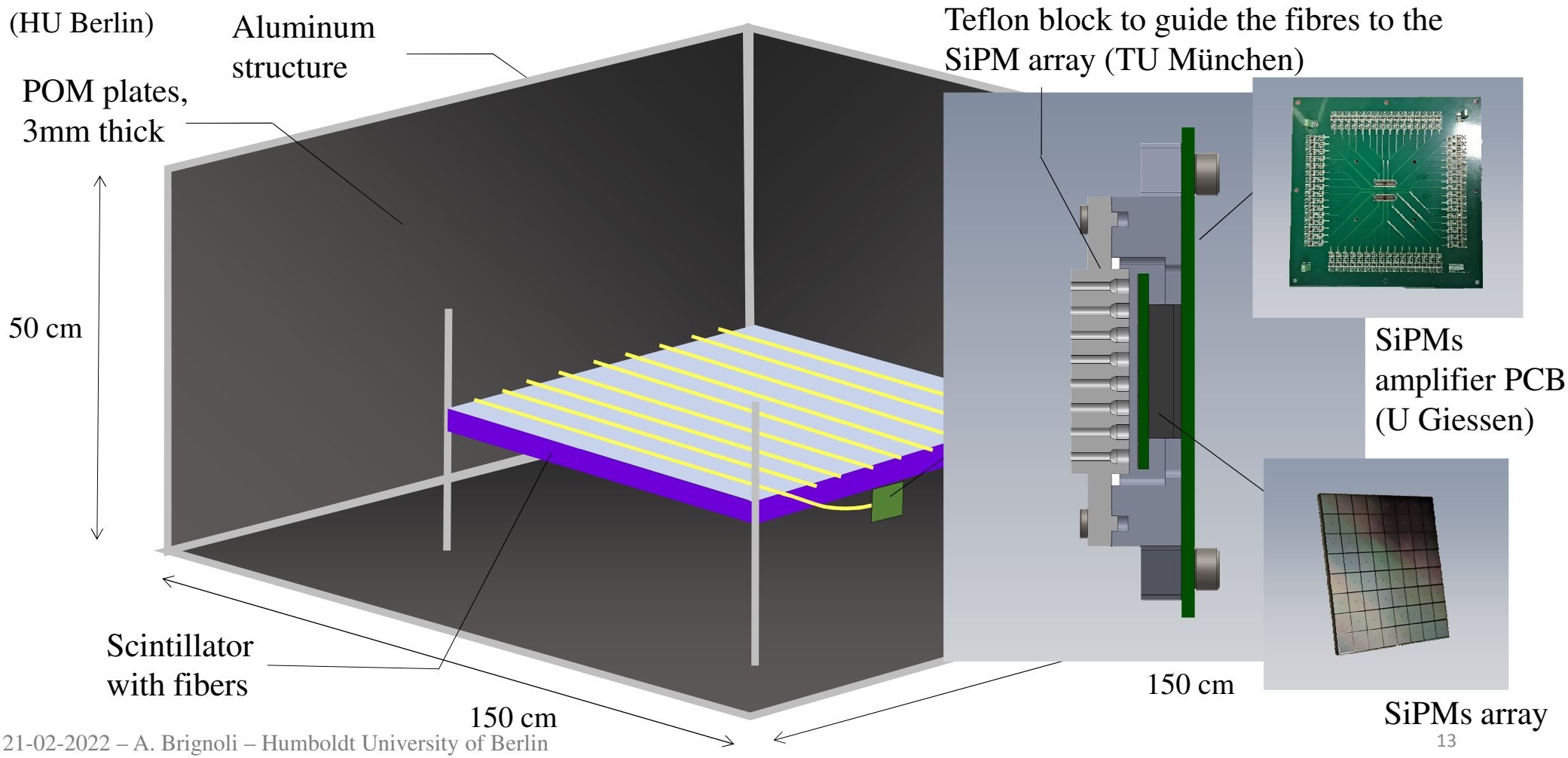
Test set up


(HU Berlin)
Aluminum structure
POM plates, 3mm thick
50 cm
Scintillator with fibers
150 cm
150 cm

Test set up

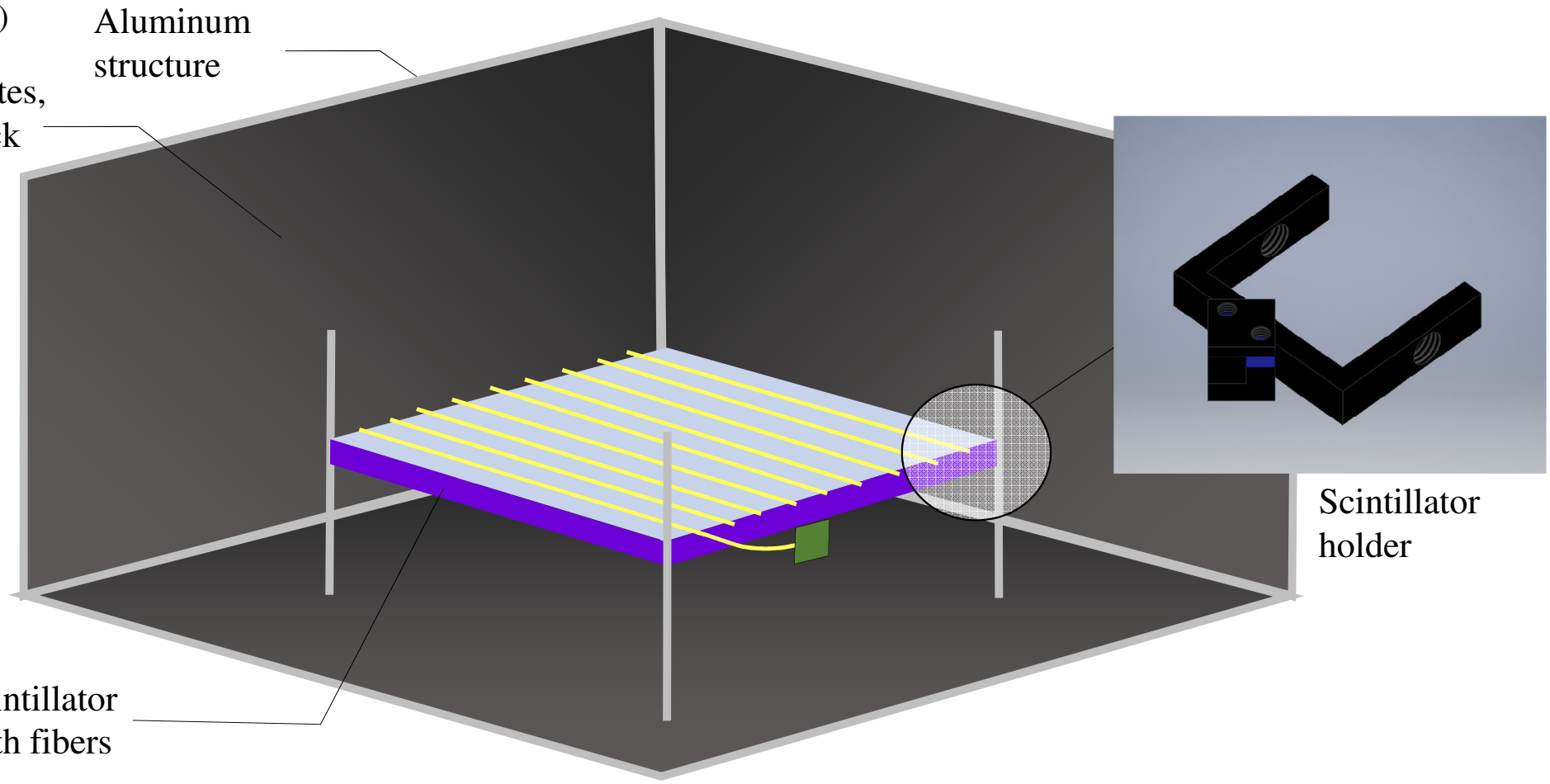

(HU Berlin)
Aluminum structure
POM plates, 3mm thick
Teflon block to guide the fibres to the SiPM array (TU München)
50 cm
Scintillator with fibers
150 cm
150 cm

Test set up


(HU Berlin)
Aluminum structure
POM plates, 3mm thick
Teflon block to guide the fibres to the SiPM array (TU München)
50 cm
SiPMs amplifier PCB (U Giessen)
Scintillator with fibers
150 cm
150 cm
SiPMs array

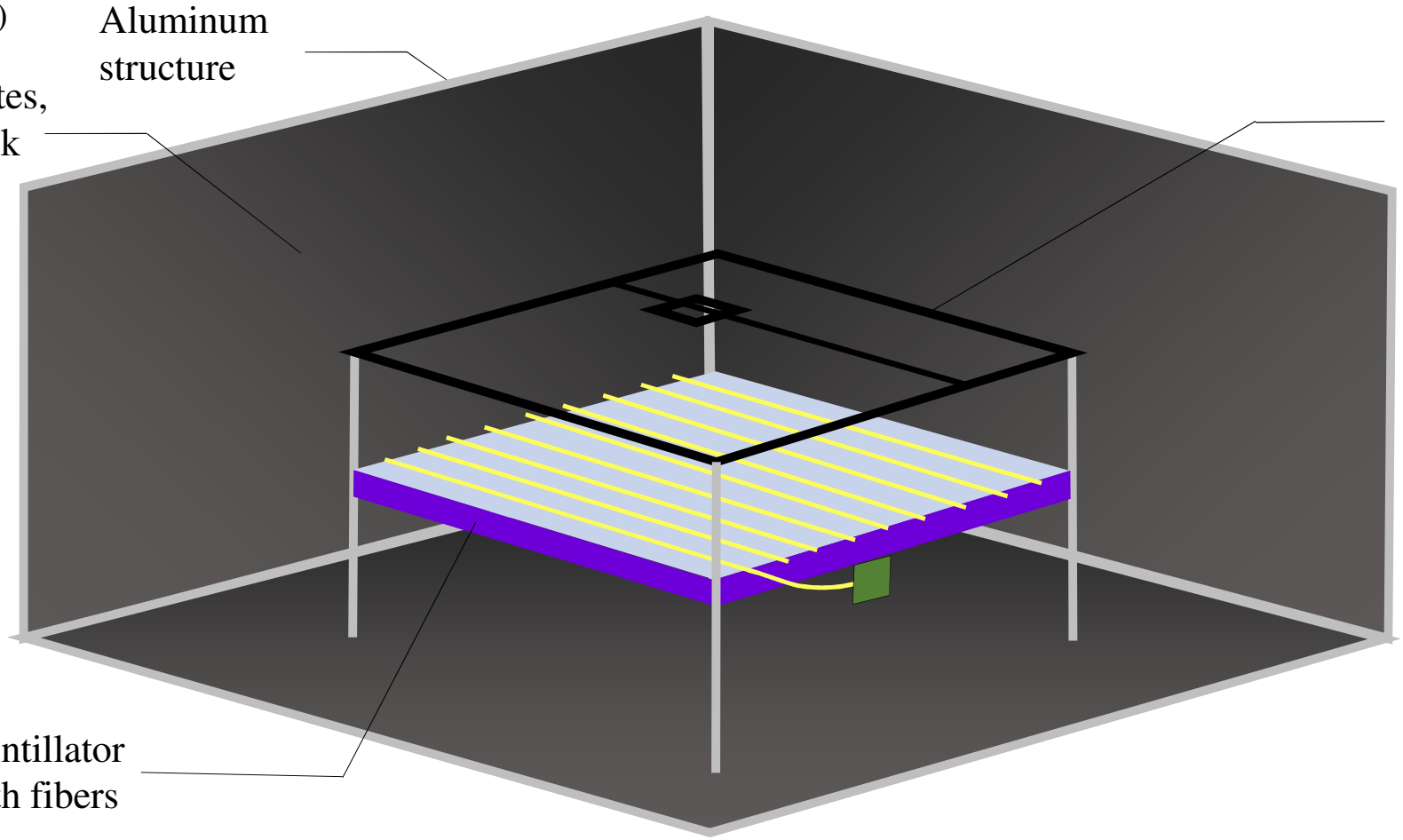
Test set up

(HU Berlin)



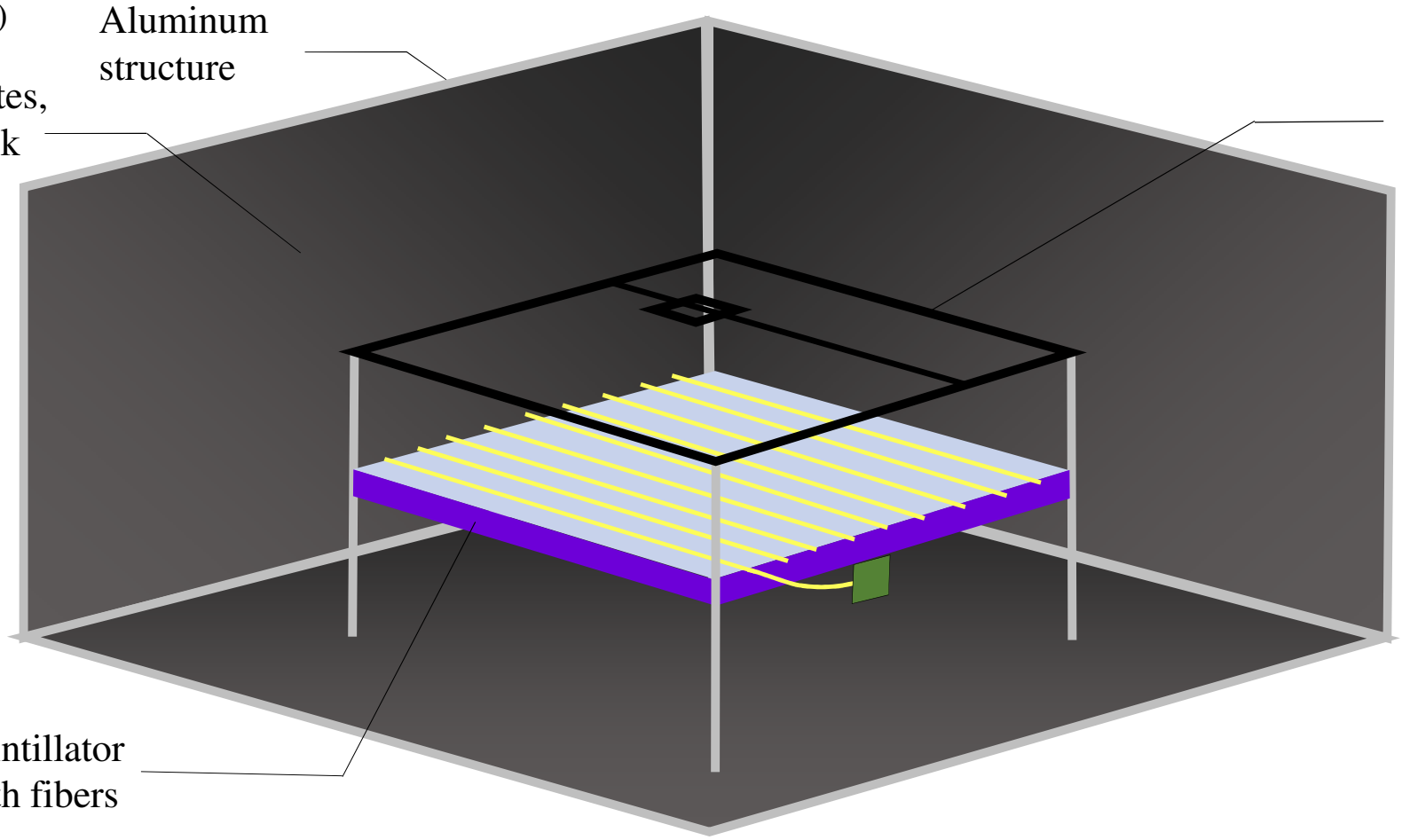
Test set up

(HU Berlin)



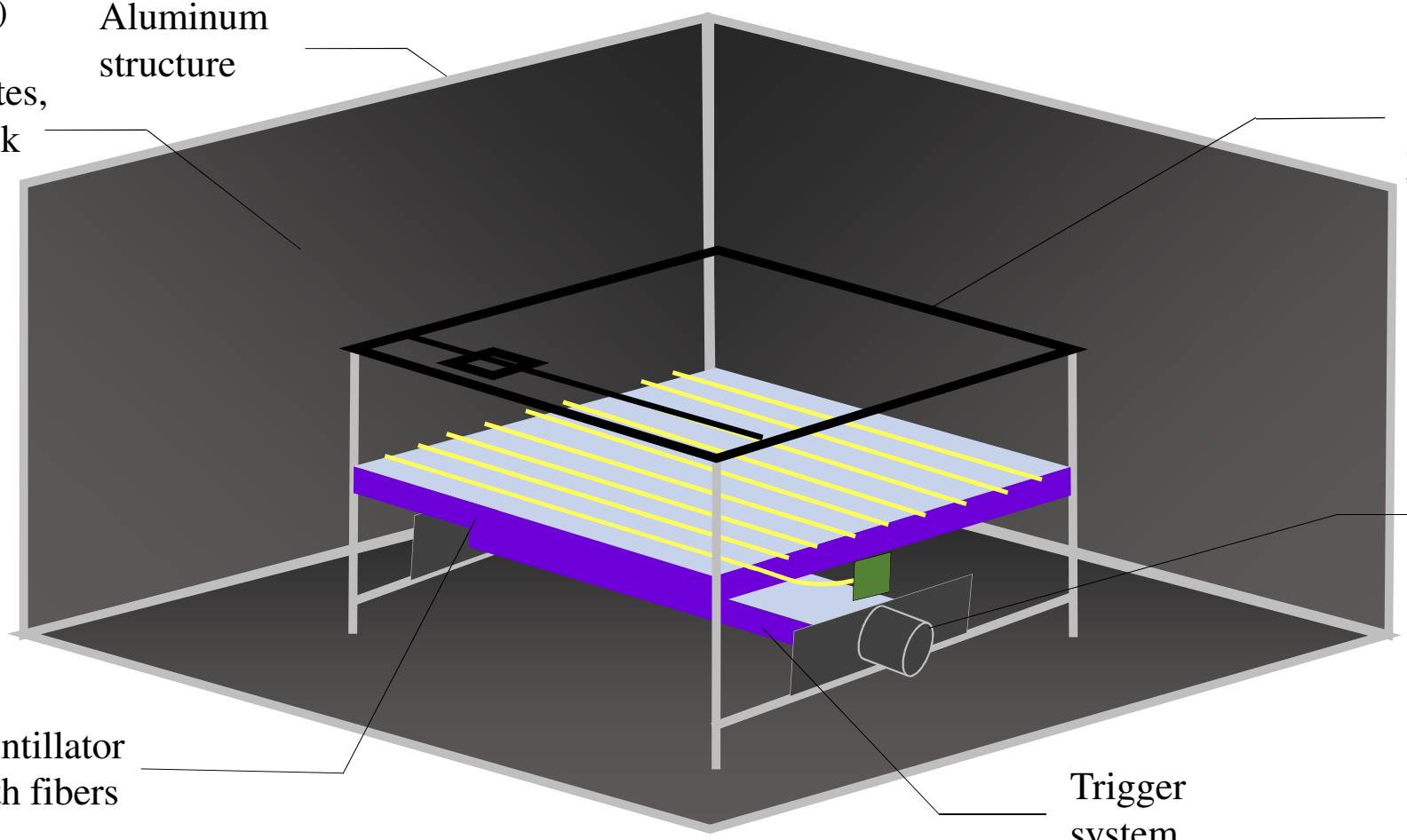
Test set up

(HU Berlin)

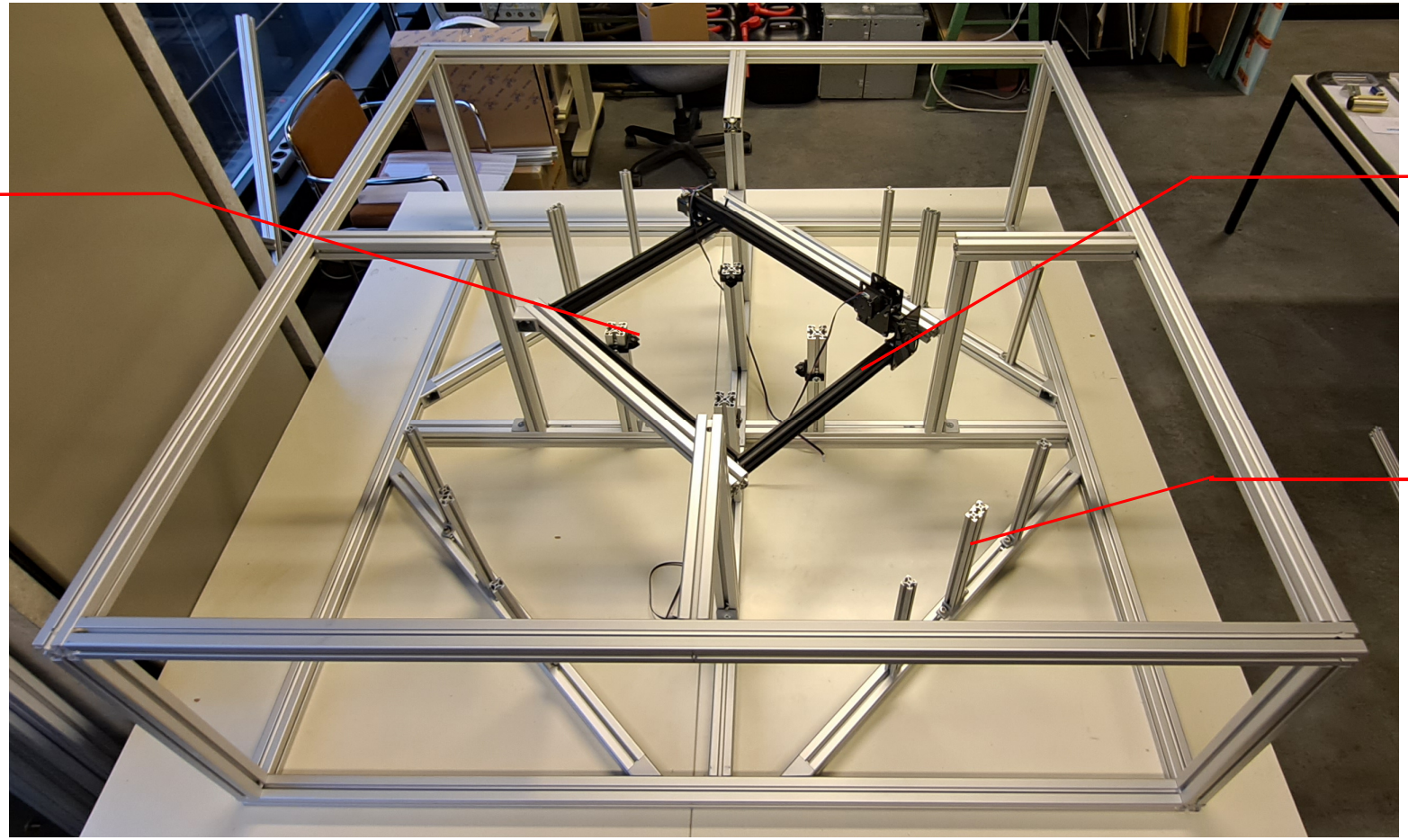


Test set up

(HU Berlin)



Status of the test set up



Next steps

• Decide with the photon simulation on the optimal configuration in terms of light yield collection in the individual fibres as a function of distance between particle entry point and fibre position

• Once decision on groove shape and the configuration for the fibers, the plastic scintillator plates are going to be prepared.

• In the meantime, finalization of the dark box test setup

• Detector tests and comparison with simulation

• Based on test results: further optimization steps

Thank you