New Design Ideas for Cerenkovs

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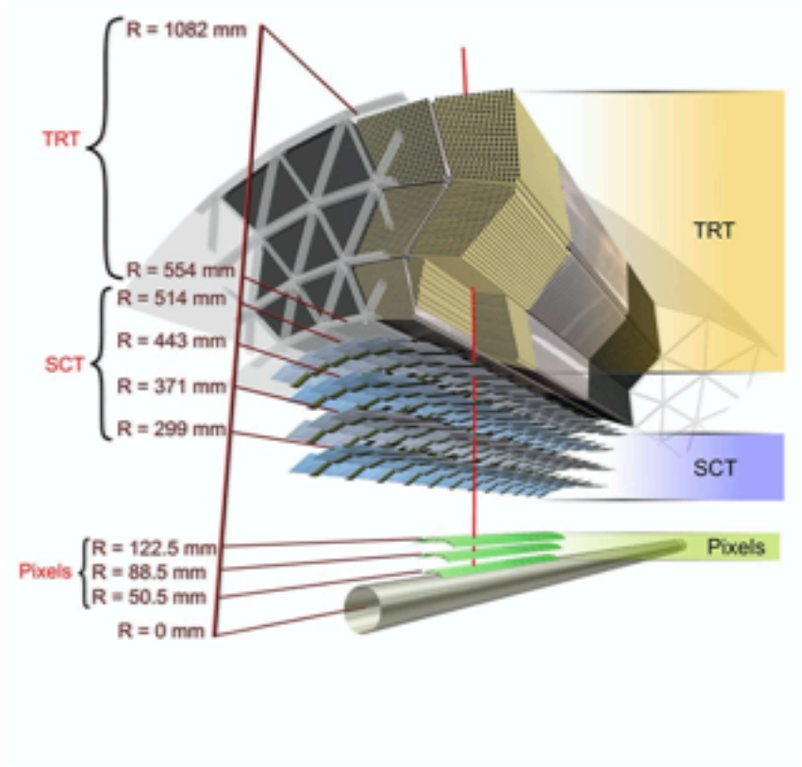
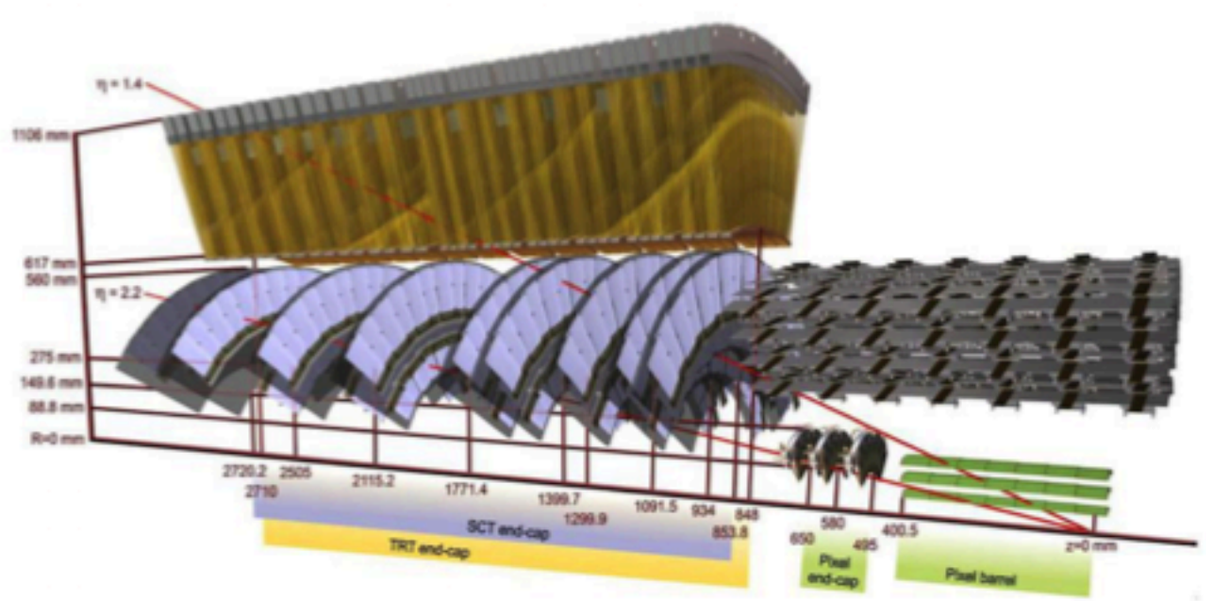
HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

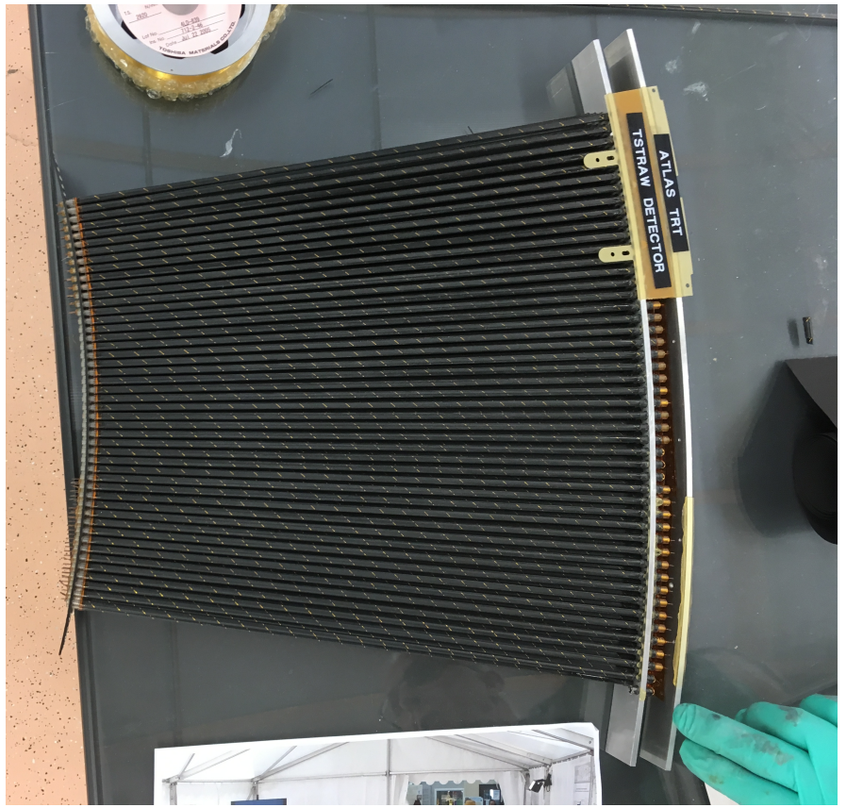
DESY.

ATLAS TRT Straw Tubes for LUXE Cerenkovs?



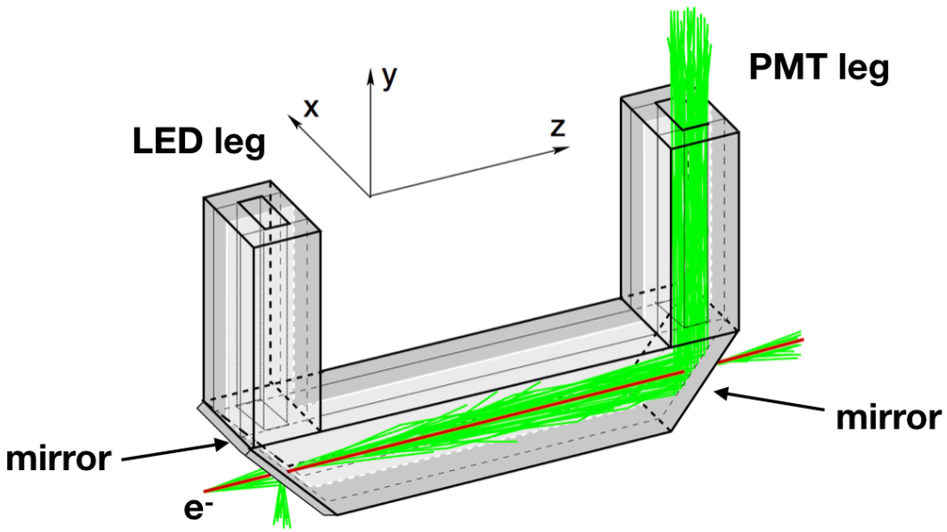


- small Cerenkov channel segmentation gave us headache (inter-channel wall, manufacturing, stability etc.)
- ATLAS transition radiation tracker (TRT) consists of thousands of straw (drift-) tubes
- straw tube: gas-filled aluminium-coated kapton foil tube (~3-4mm dia.) with anode wire inside
- our idea: use straw tubes instead of metal channels for Cerenkovs!



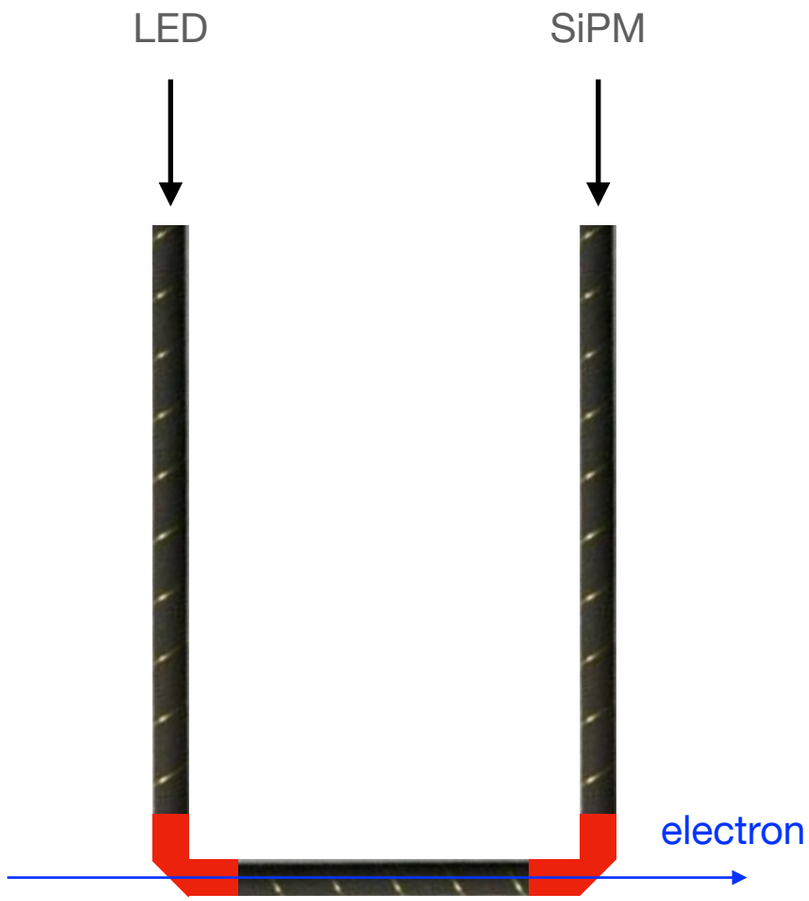
Cerenkov “Straw Tube” design

“old” design



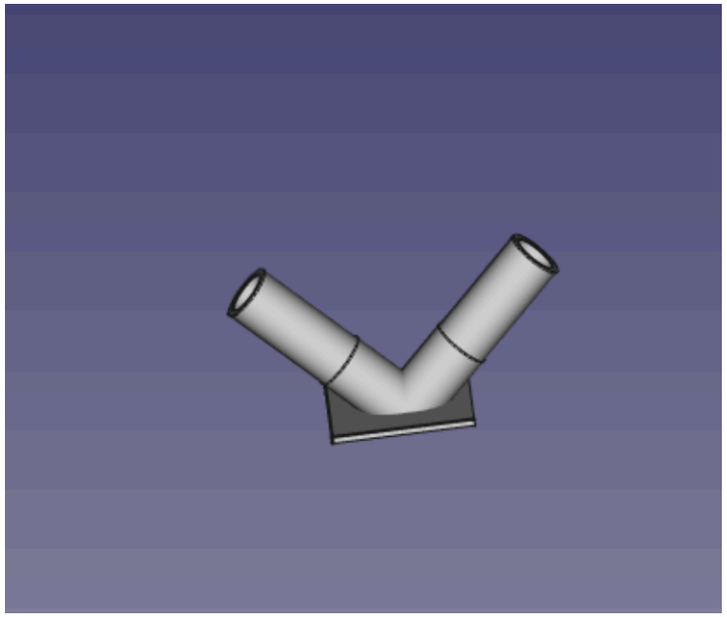
- aluminium “layers”
- achieving 1.5mmm channel size is difficult
- inter channel metal “wall” 0.3mm

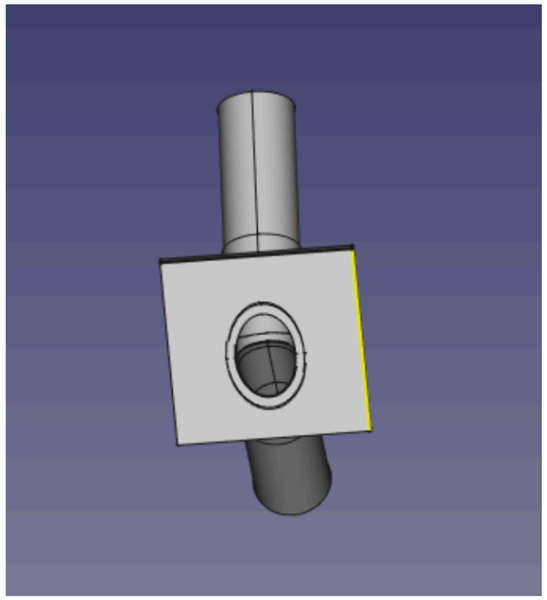
new design

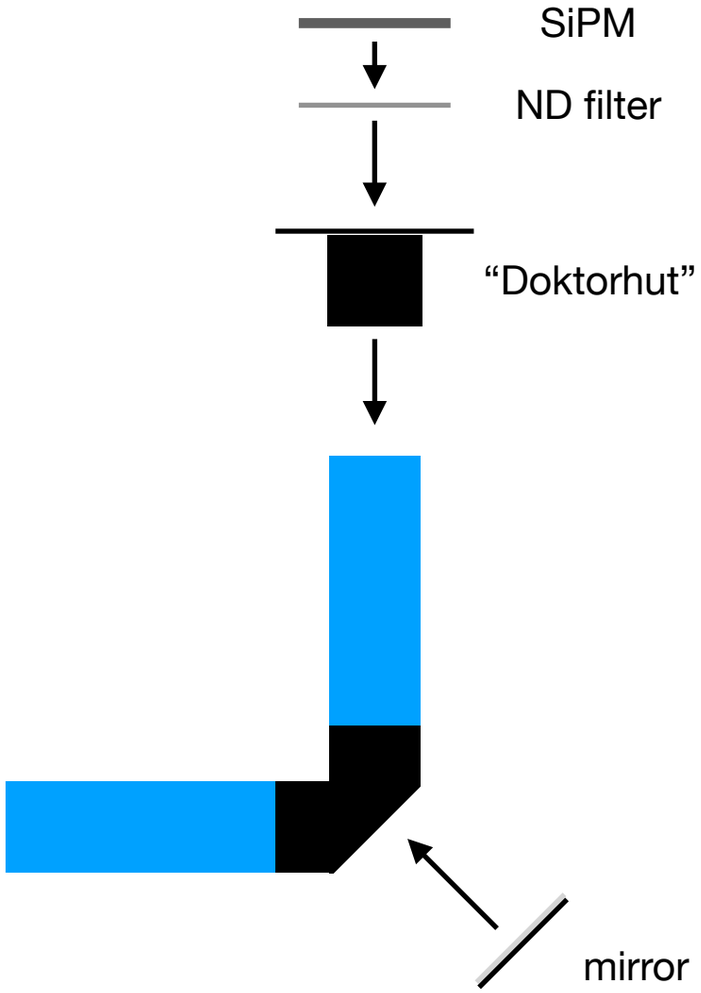


- Carbon/Kapton (Polyimide) composite, aluminium coated
- much less material inside the Cerenkov Box
- much thinner walls (6.1 micron)
- kapton is aluminium coated → reflects (enough) light

Corner & End Connectors

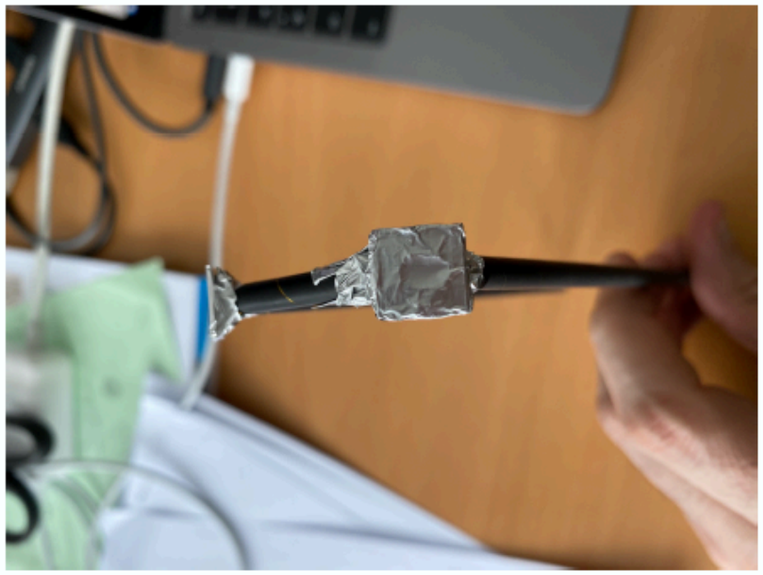






- we need a corner connector to make U-channel shape
- guide the light → mirror at 45°
- leave an oval opening and glue to polished metal plate
- assembly of Cerenkov detector channels becomes much simpler (“click & go”)

First prototype by Louis

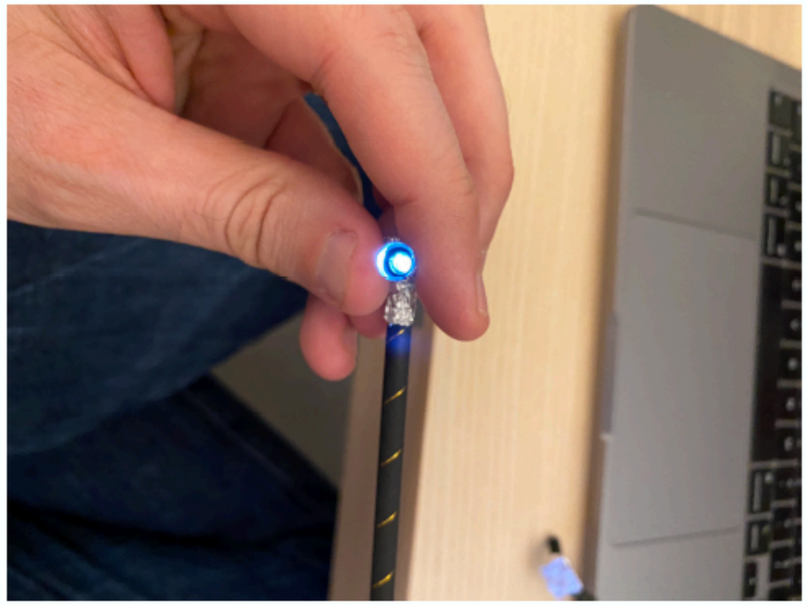


- TRT straws (left over from CERN open day)
- 3D-printed corner connectors
- wrapped in aluminum foil

First tests

LED

LED through the straw

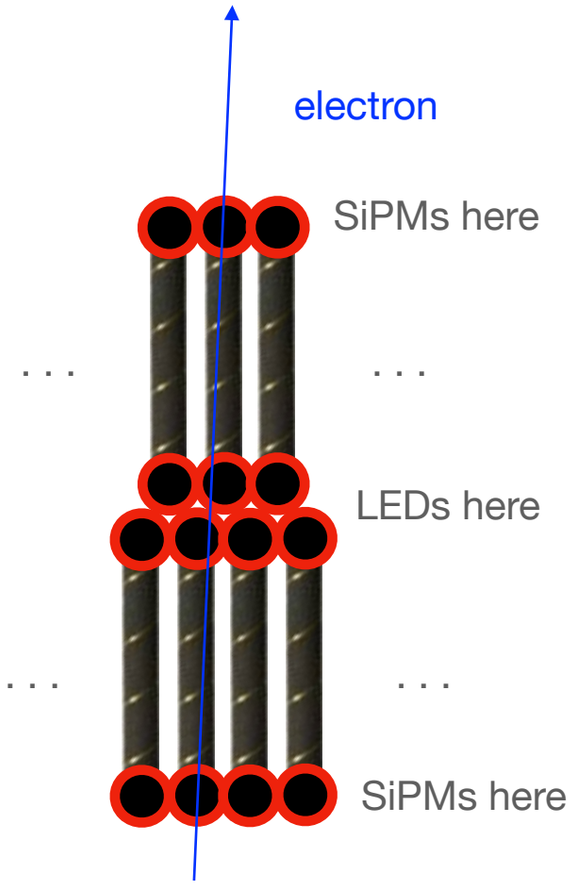


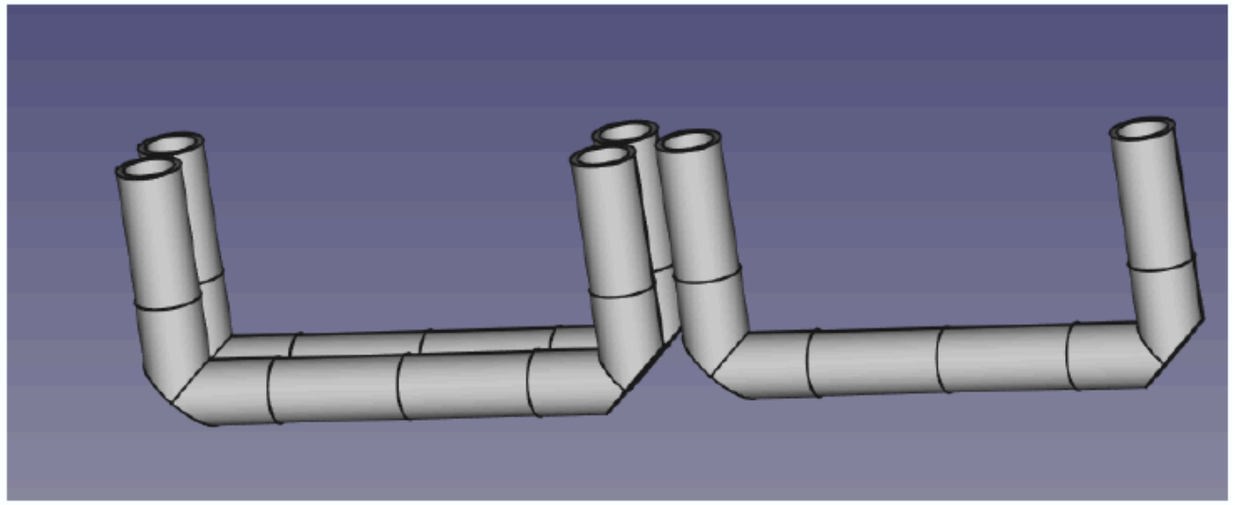
LED through 2 straws with 1 reflection on aluminium foil

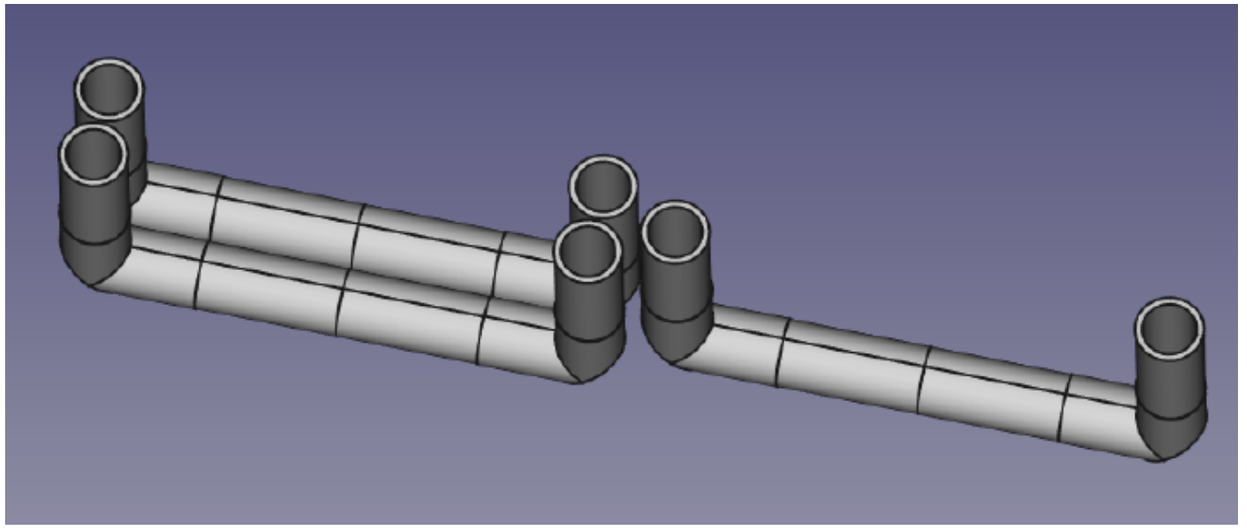
LED through the 3 straws with 2 reflection on aluminium foil

- seems we get enough light out
- a lot of handles to increase light yield (channel length, mirror, ND filter)
- in LUXE high-rate environment, need to worry more about “too much light” rather than “not enough light”

Segmentation & Design







- Corner Connectors have to have a certain wall-thickness to give rigidity
  → “gap” between straws
- available straw tubes have ~3mm diameter, we need 1.5mm
  → multi-layer design can help!
- recover segmentation information and acceptance due to gap
  → price to pay: more SiPMs and LEDs needed
- on the outer part of the detector single layer is enough

Radiation Tolerance?

- Corner Connectors and lower part of straw tube would be exposed to O(10^8 electrons/shot)
- Polyimide/Kapton is known to be radiation hard
- we need the tubes to maintain: mechanical stability, reflective properties and light tightness
- Study on ageing of ATLAS TRT tubes found no “visible change” on the cathode surface : Akesson et al: Aging studies for the ATLAS Transition Radiation Tracker (TRT)
- would be good to test reflective properties before/after irradiation in more detail
- for 3D-printed parts, Nylon seems to be a robust filament material: P. Wady et al: Effect of ionising radiation on the mechanical and structural properties of 3D printed plastics

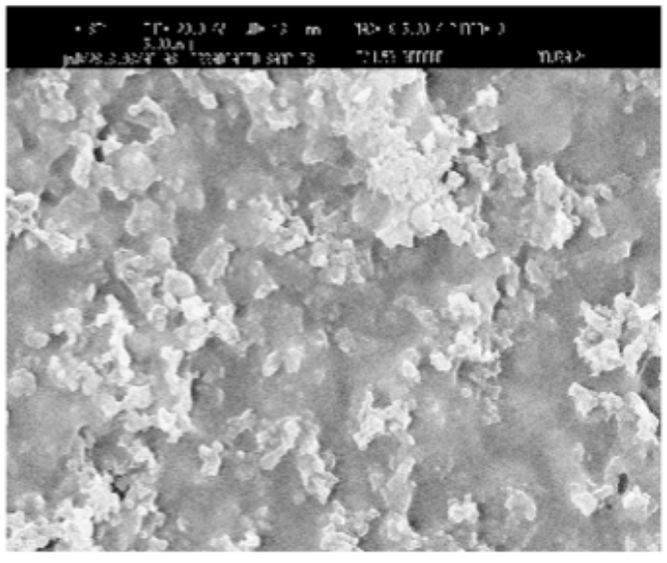


Fig. 1. Micro-photograph of the cathode surface before irradiation (25×20 μm).

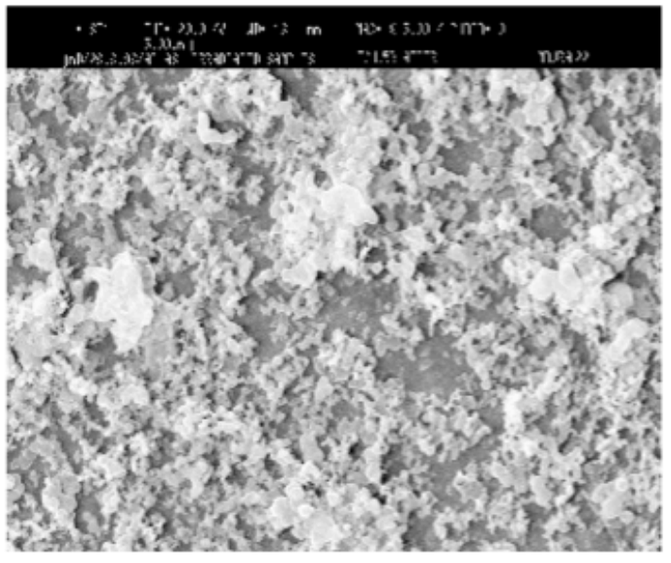


Fig. 2. Micro-photograph of the cathode surface after irradiation (25×20 μm).

inside of ATLAS TRT straw tube before and after 18C/cm irradiation (a lot! 18 yr LHC operation)

Summary

- Cerenkov U-channel design with fine segmentation
- propose to use Al-coated Kapton Straw tubes instead of metal channels
- reflective enough, less material, lighter, easy to mount
- radiation hardness seems to be sufficient
- first tests by Louis with some spare straws look promising
- in contact with ATLAS TRT group at CERN, they have a lot of “left-over” straws