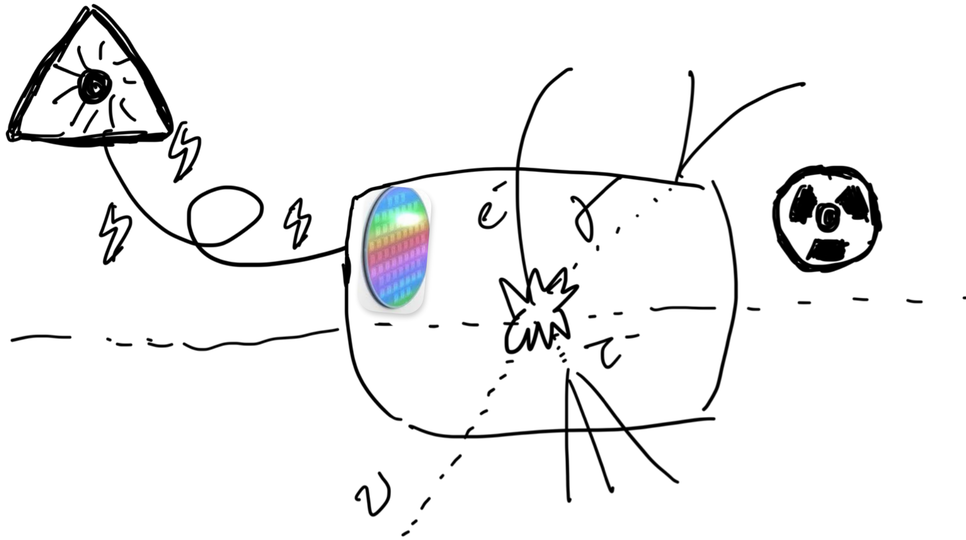
1 Radboud University
2 Nikhef

Develop an Optical Powering Demonstrator

for High-Granularity Detectors at Future Colliders



Mengqing Wu[1,2], Mike Kruis[1], Daniel Szalas-Motesiczky[1], John Schermer[1] and Jeroen Maasen[1]



Hefei, Oct. 16, 2026



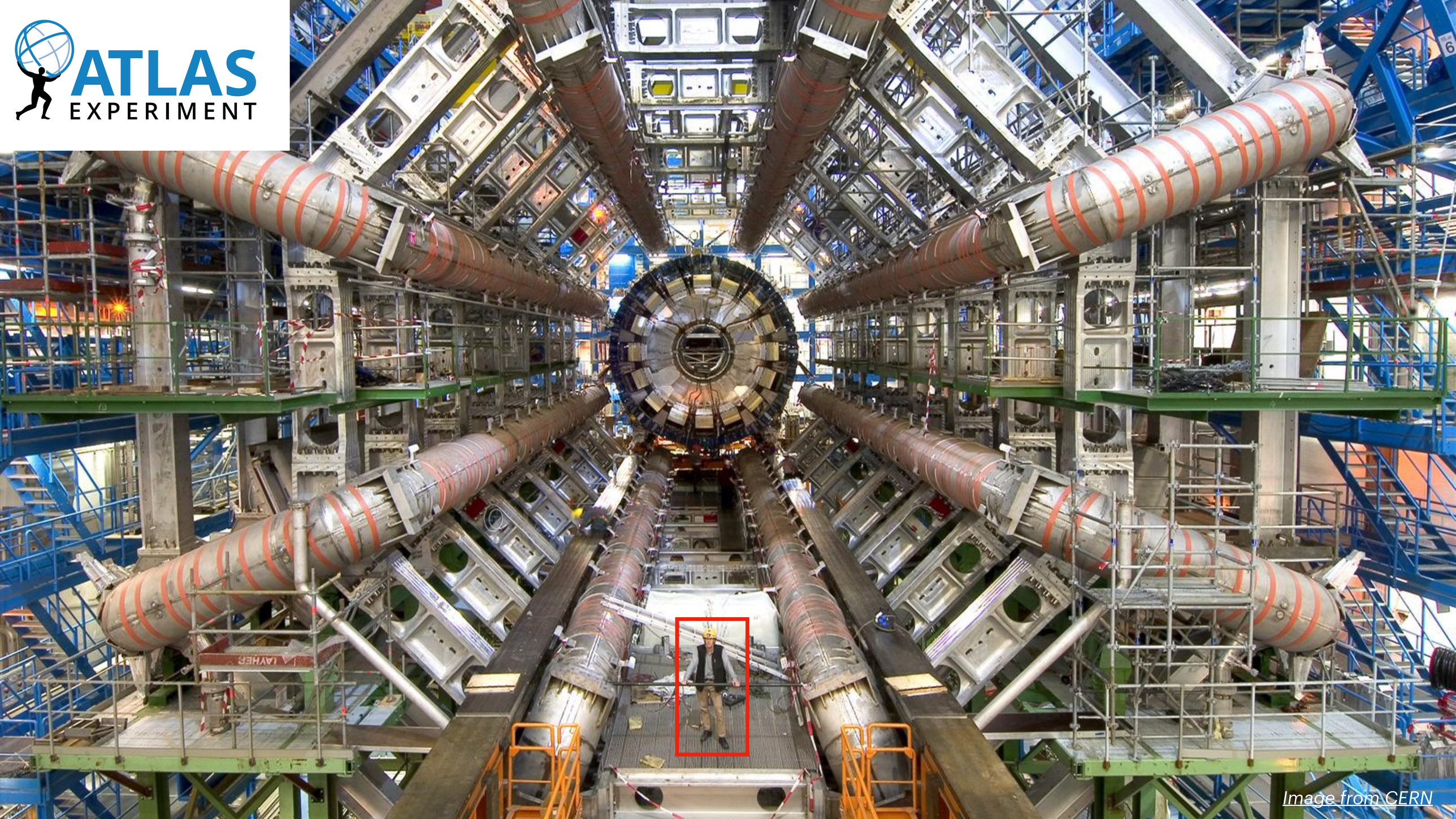


Image from CERN

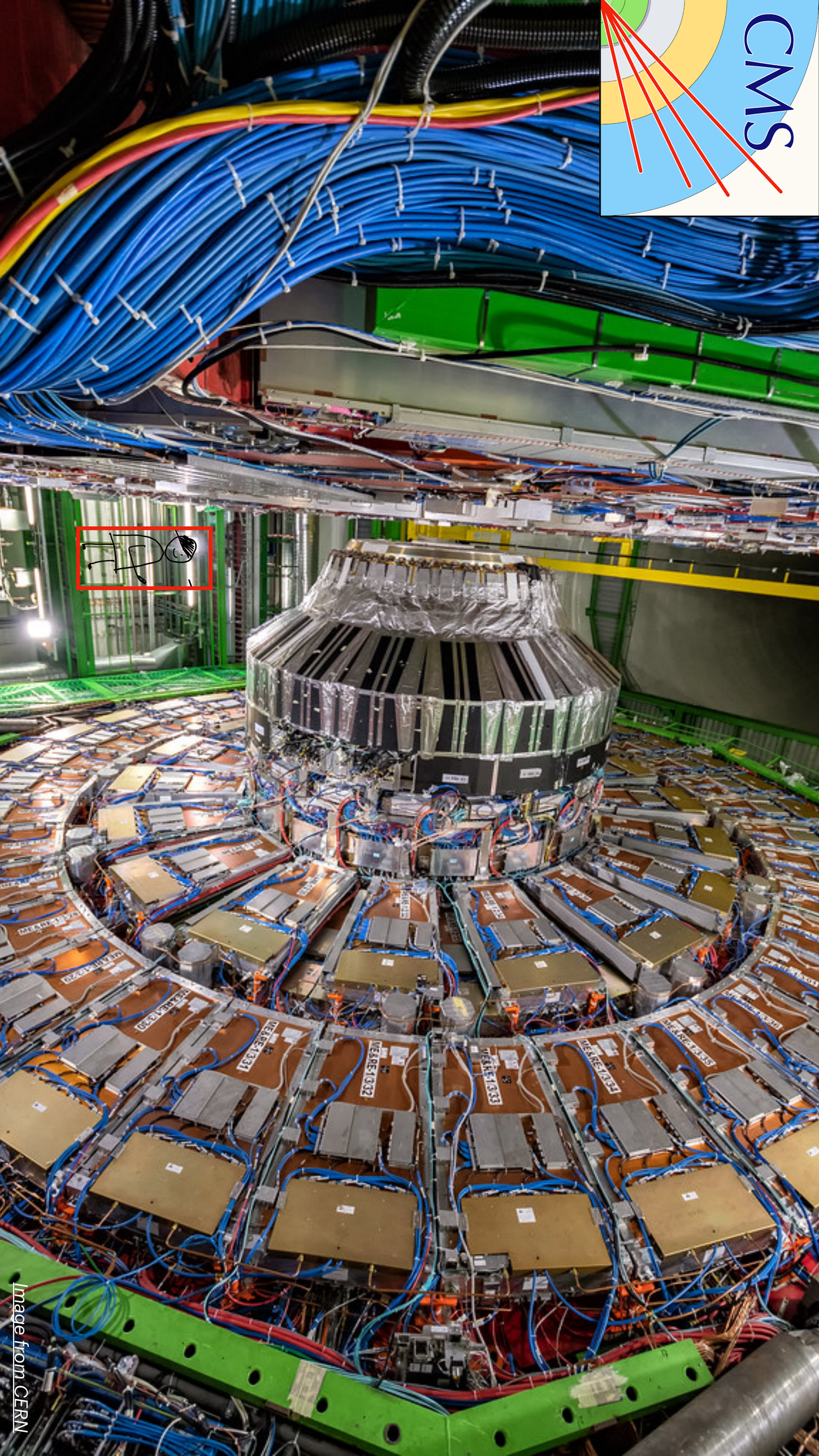
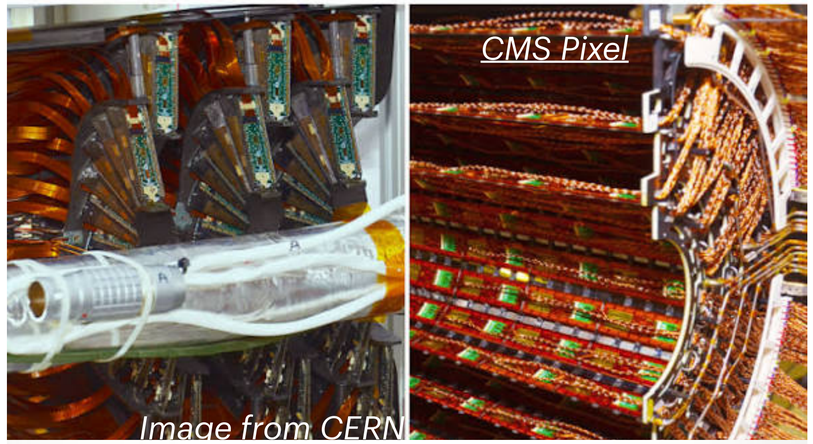


Image from CERN

Cable Mass







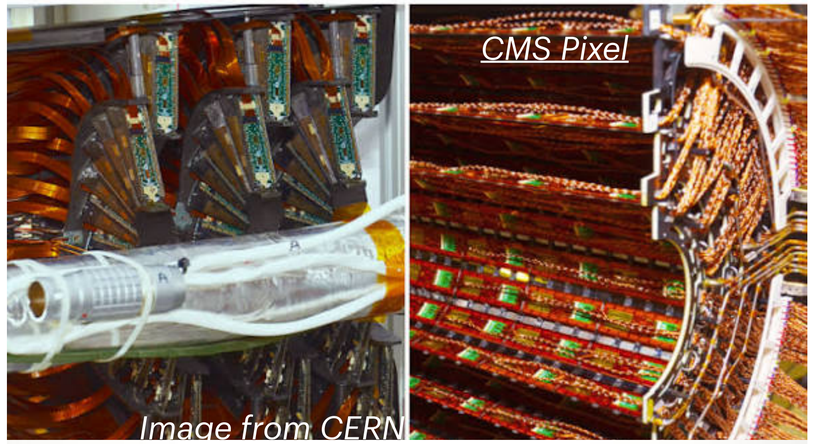




In order to upgrade the Large Hadron Collider, engineers need to identify and unplug 9,000 useless cables

From EDN. Jan 2016

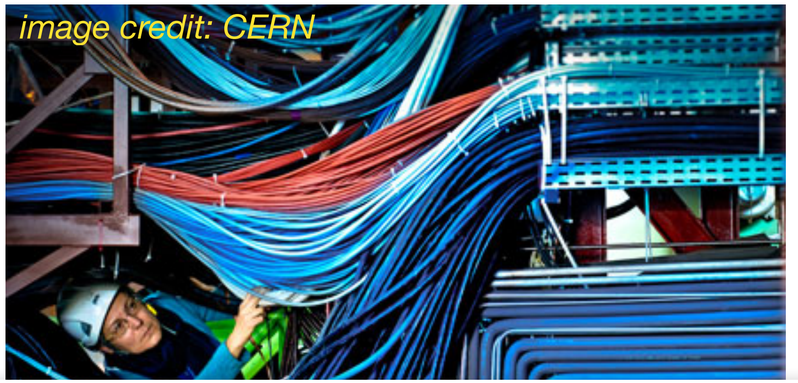
Cable Mass





atlasexperiment 35w
Science is about 80% cable management, at least when looking at the smallest components of matter!





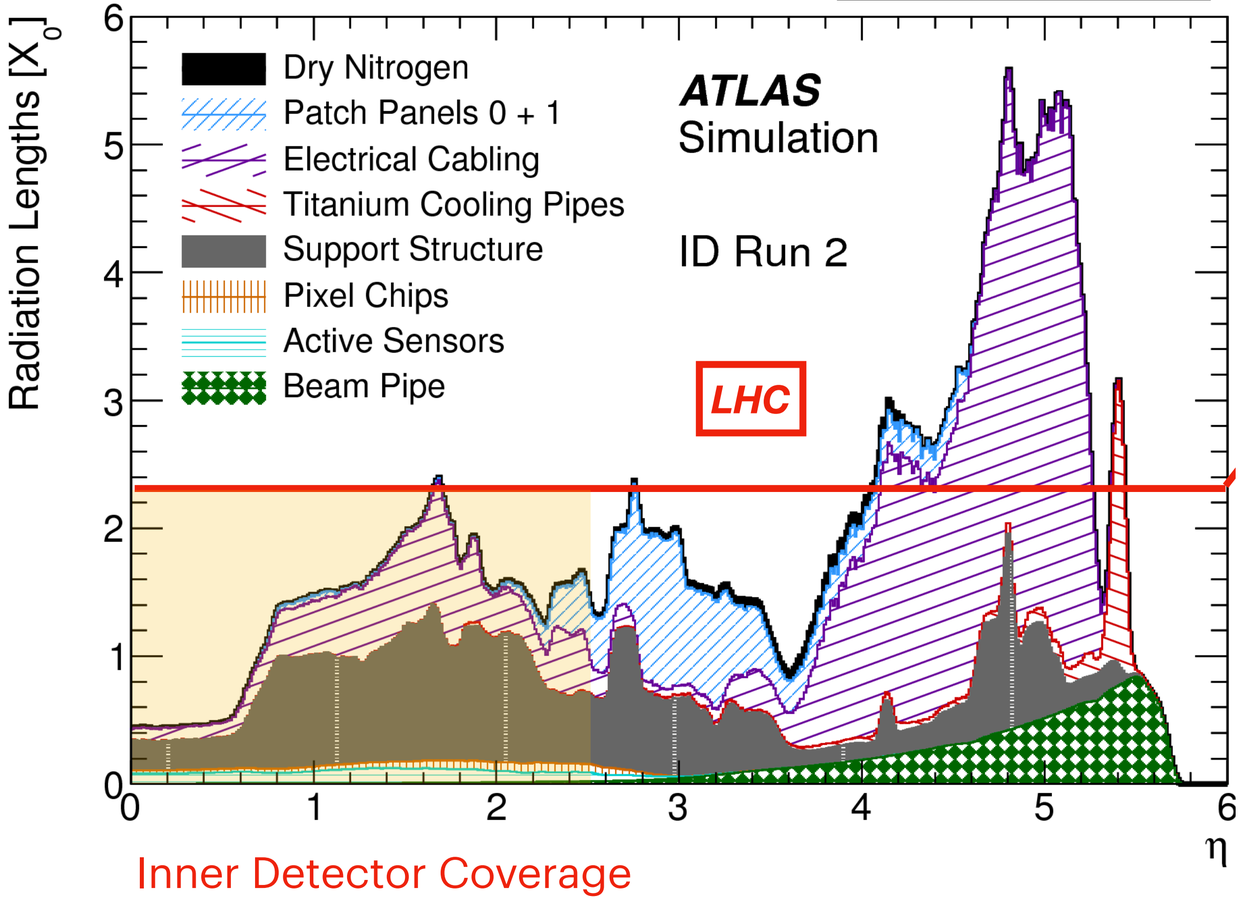


In order to upgrade the Large Hadron Collider, engineers need to identify and unplug 9,000 useless cables

From EDN. Jan 2016

Just a reminder – material budget with copper power in parallel

ATL-PHYS-PUB-2021-024



Powering schemes, a state-of-the-art

- **Serial powering:** adopted now by both CMS & ATLAS for HL-LHC inner tracker upgrades
  - Its proposal and development dated back to 2003 *(NIMA 511 (2003) 174–179)*
  - Requiring shunt-LDOs, offloaded to FE chips, to generate a local supply voltage from the current supply

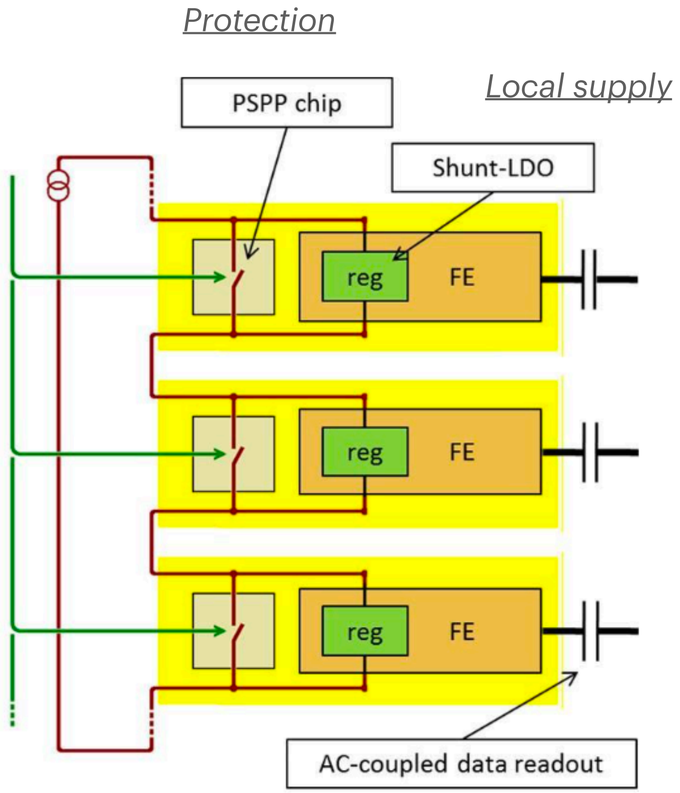
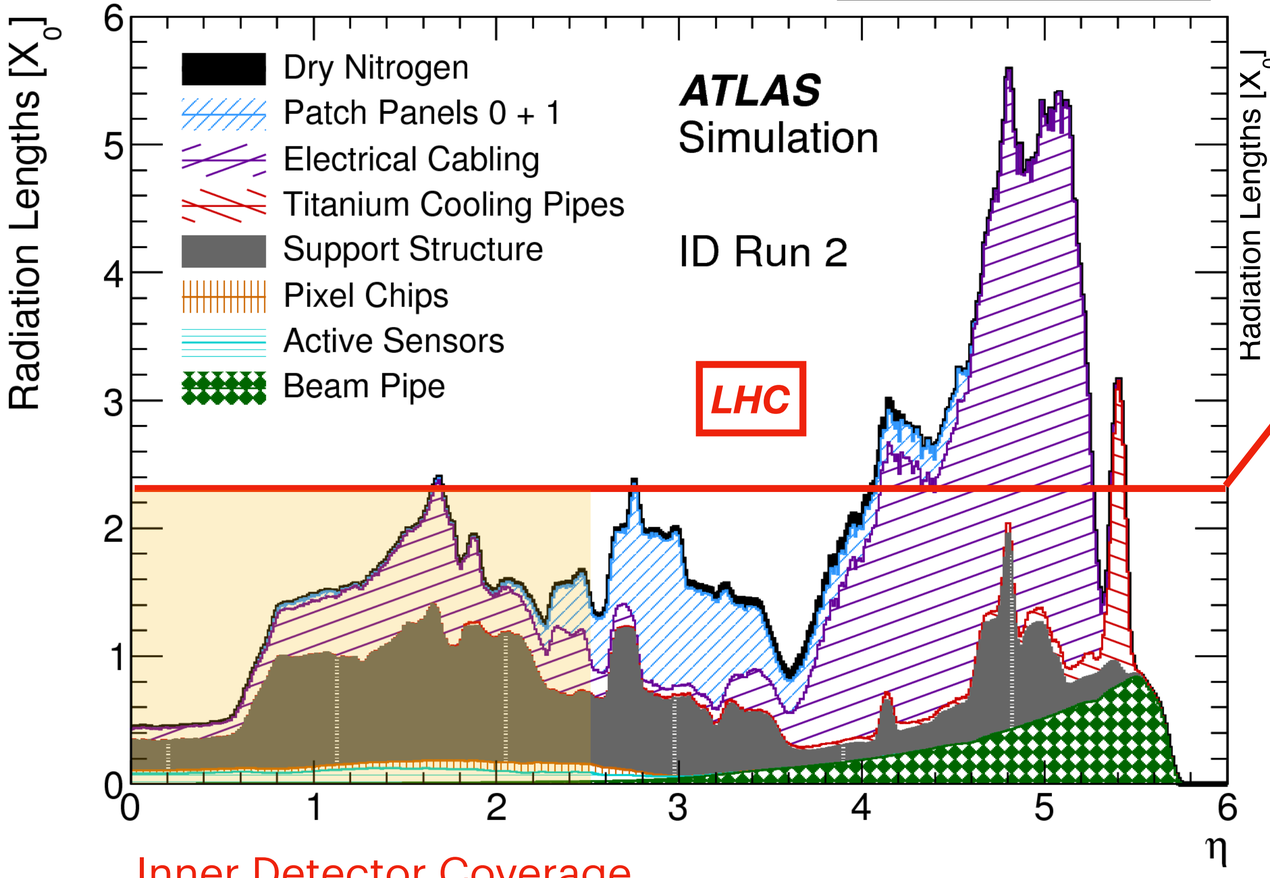


Figure from V. Filimonov thesis (BONN-IR-2017-06)

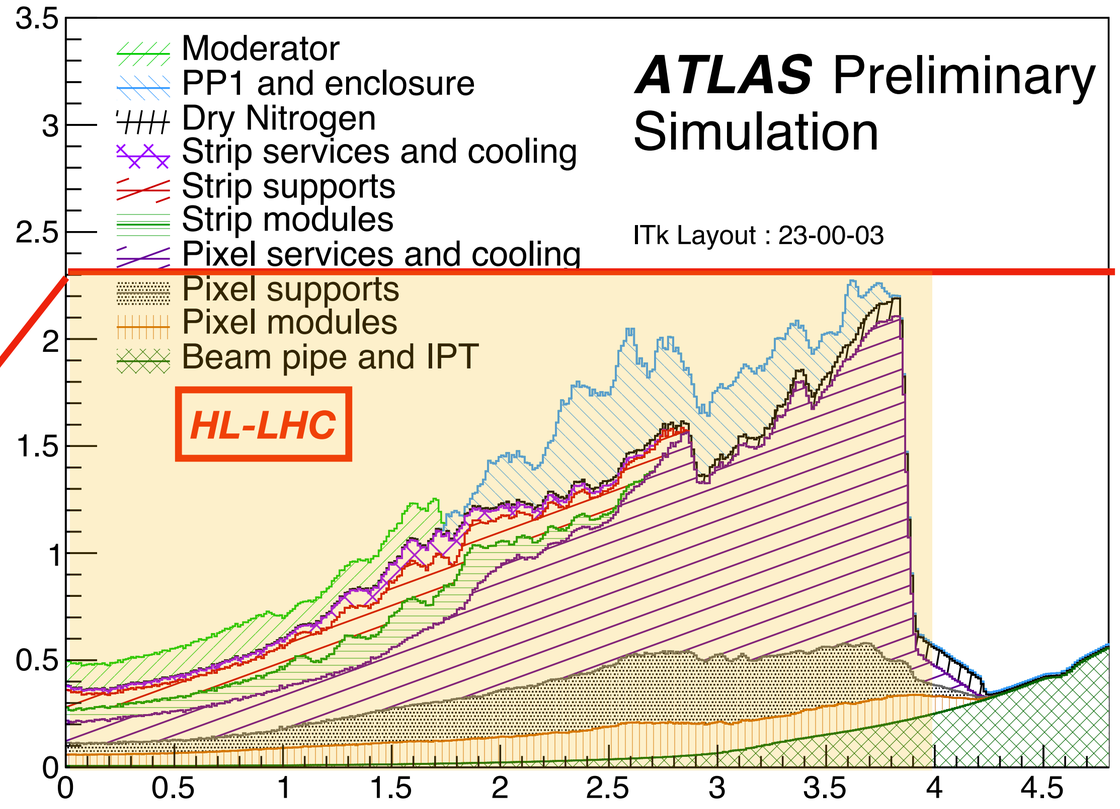
Parallel vs Serial with Copper

ATL-PHYS-PUB-2021-024



Inner Detector Coverage

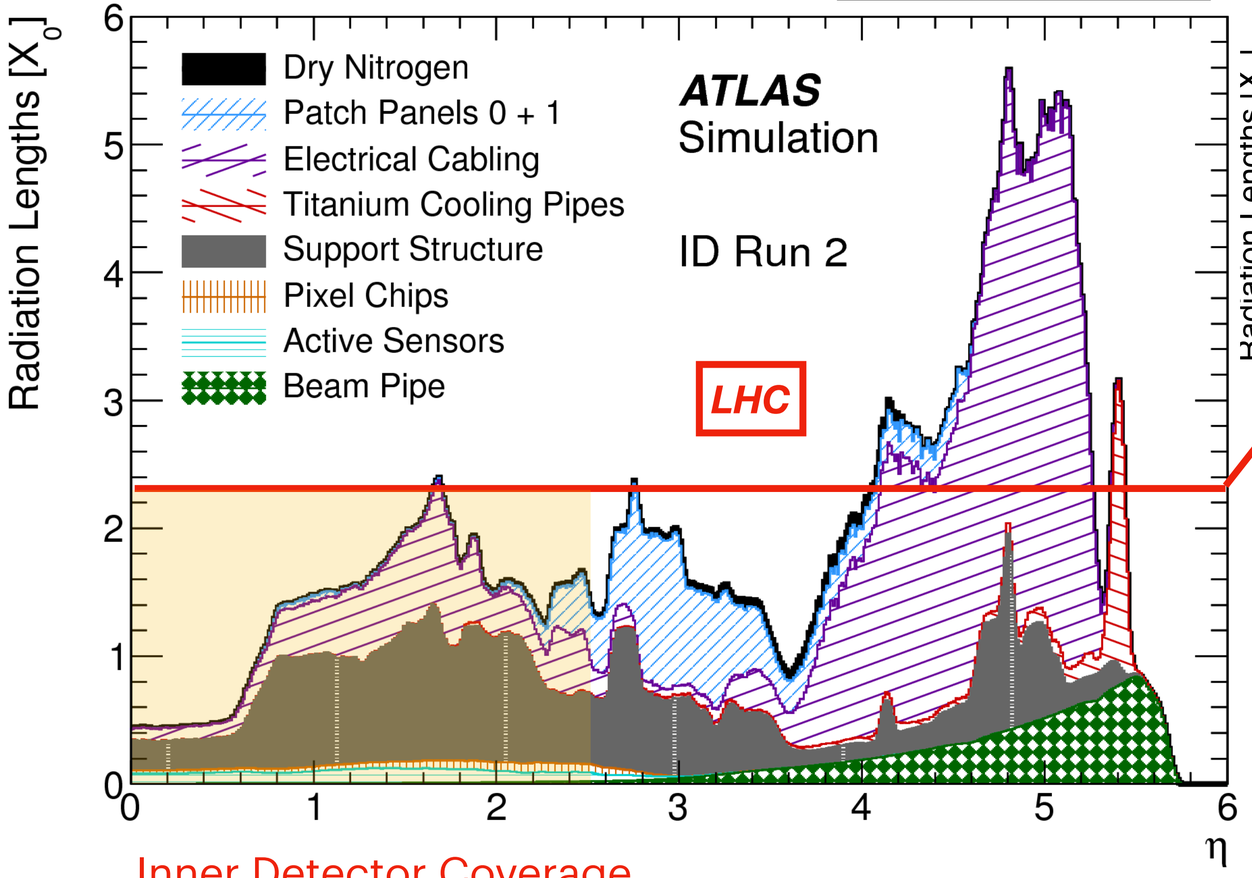
See X's talk on Y



New Inner Tracker Coverage

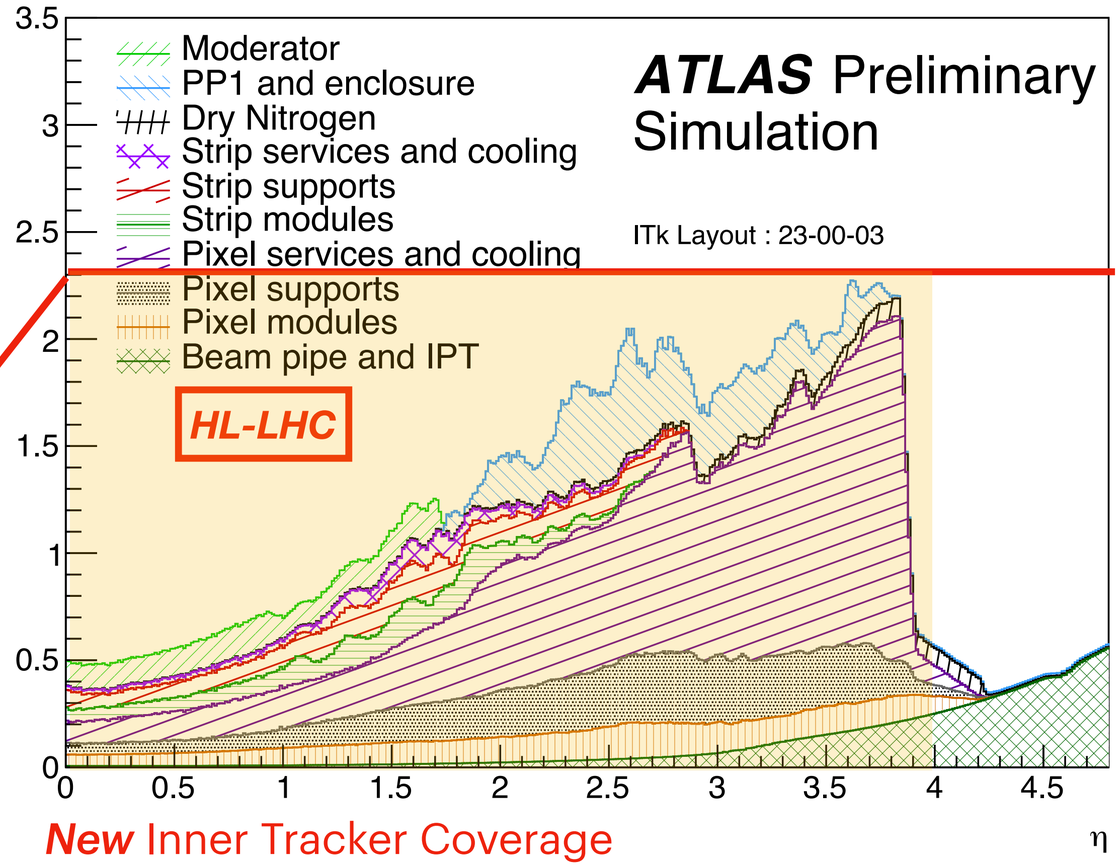
Parallel vs Serial with Copper

ATL-PHYS-PUB-2021-024



Inner Detector Coverage

~80M Pixel channels
+ ~6.3M microstrip channels

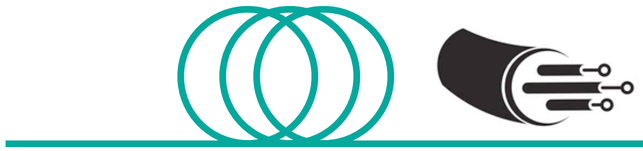


New Inner Tracker Coverage

~5000M Pixel channels
+ ~60M microstrip channels

A *light-in light-out* detector concept

Pick your favorite detector here

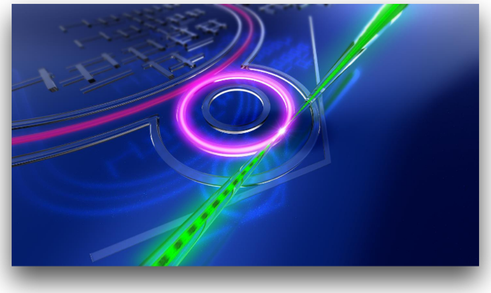


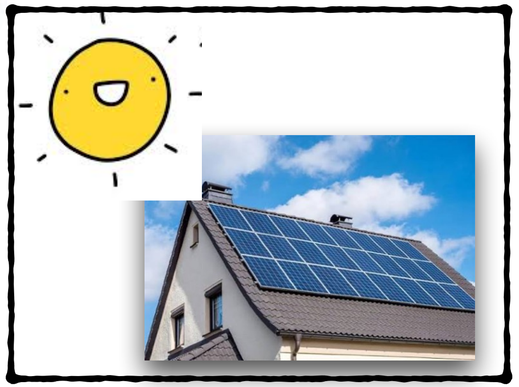
Fibre goes in
Power + Commands (DAQ)





Fibre goes out
Power + Data (DAQ)

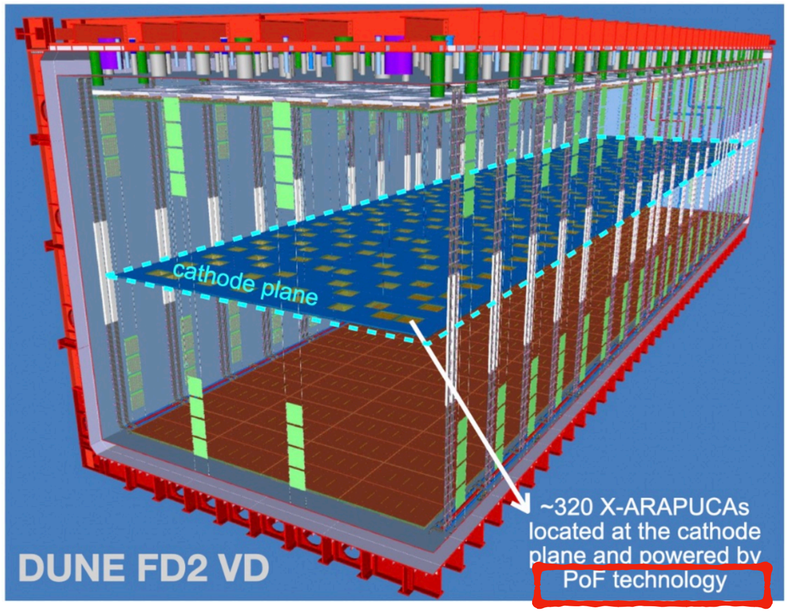




Powering schemes, a state-of-the-art [Continue]

- **Serial powering:** adopted now by both CMS & ATLAS for HL-LHC inner tracker upgrades
- **Optical powering:** first deployment in HEP is @*DUNE* - power cold electronics & SiPM
  - Different challenges: radiation level, signal noise requirement, and temperatures
  - Though, synergies on stress tests on fibres and system long-term stability
  - Challenge ahead:
    - Small (nA-level) signal, aka stringent noise requirement
    - Strong radiation ☢☢☢

arXiv:2405.16816v1

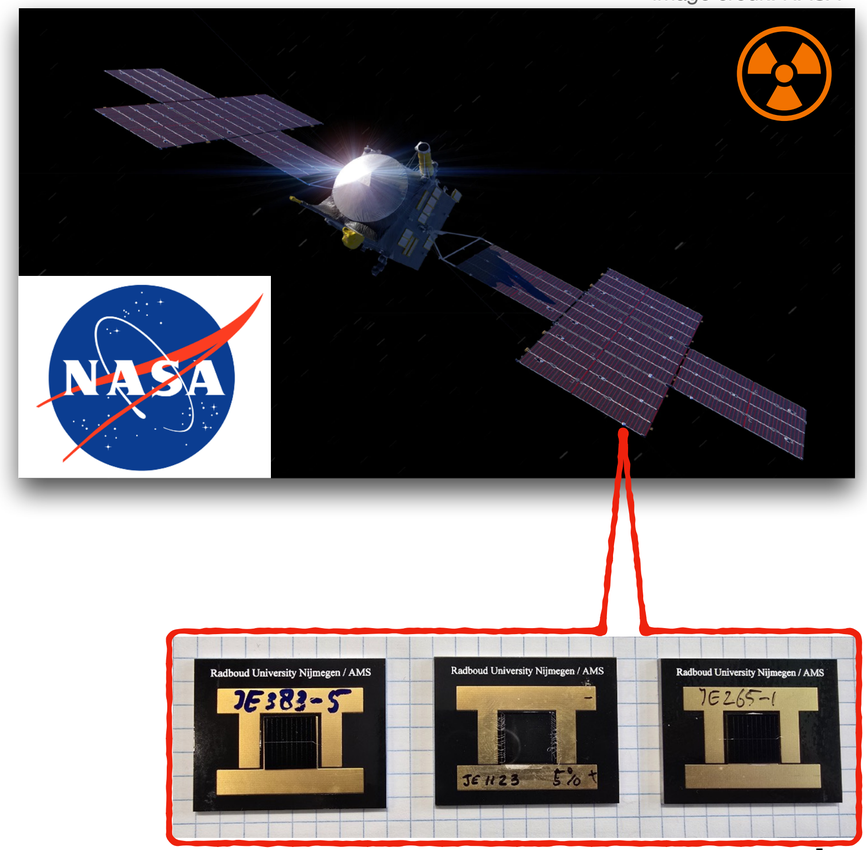


Cryogenic temperature @−196° *(Liquid Nitrogen)*

Powering schemes, a state-of-the-art [Continue]

- **Serial powering:** adopted now by both CMS & ATLAS for HL-LHC inner tracker upgrades
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    - Strong radiation ☢☢☢

image credit: NASA



Radboud University

Power a Particle Detector with Solar Cells

Baseline Setup





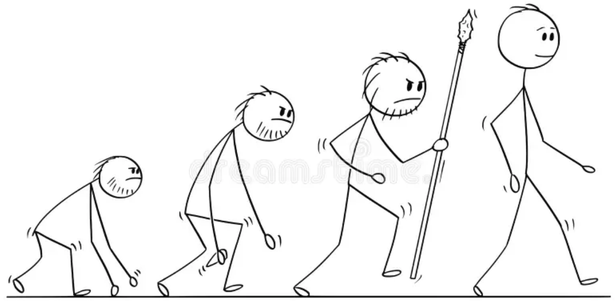
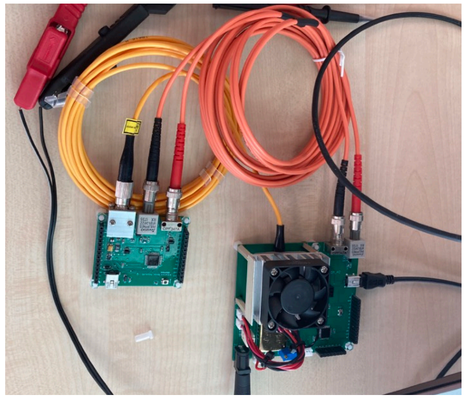
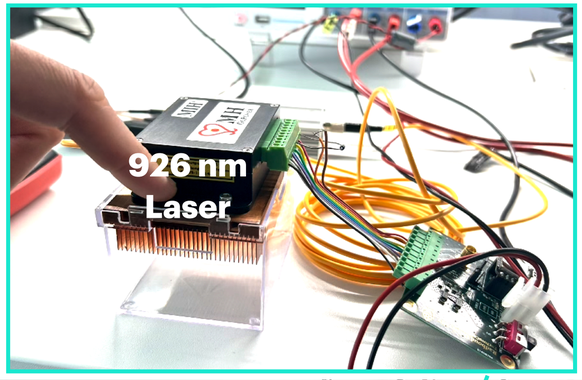
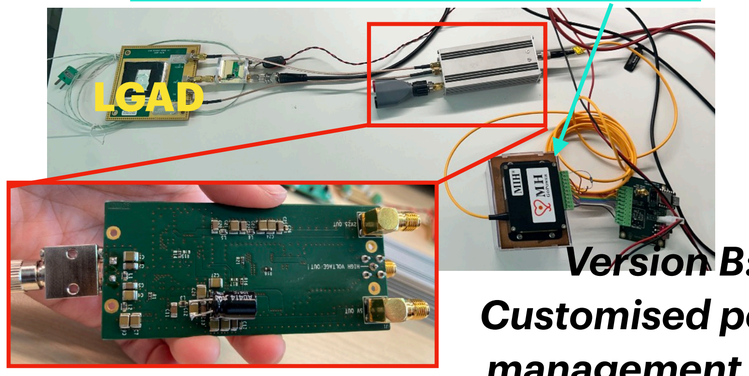


image credit: Dreamstime



Version A:
Completely Off-shelf

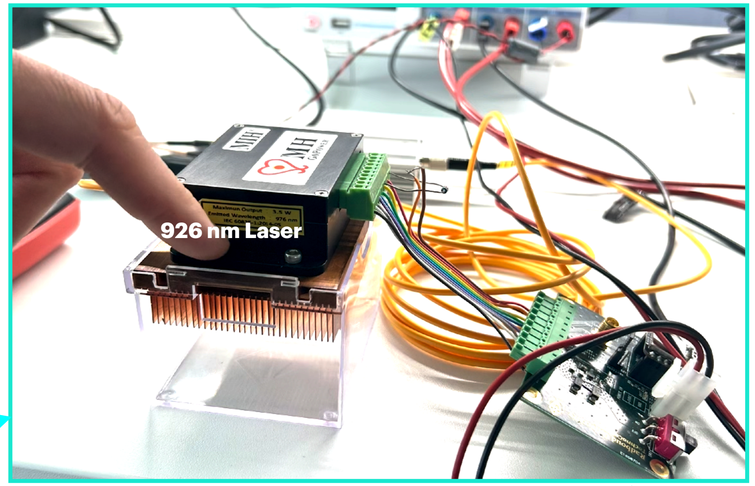


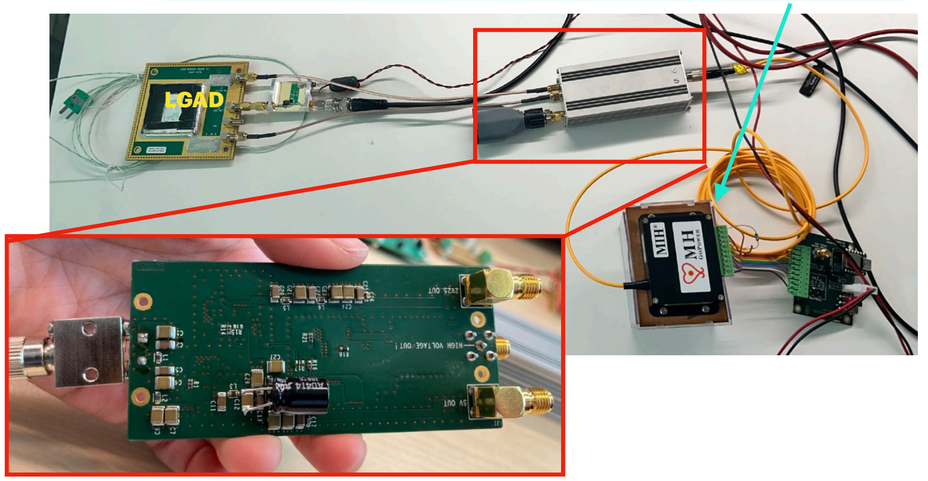


Version B:
Customised power management with
off-shelf Si Solar Cell

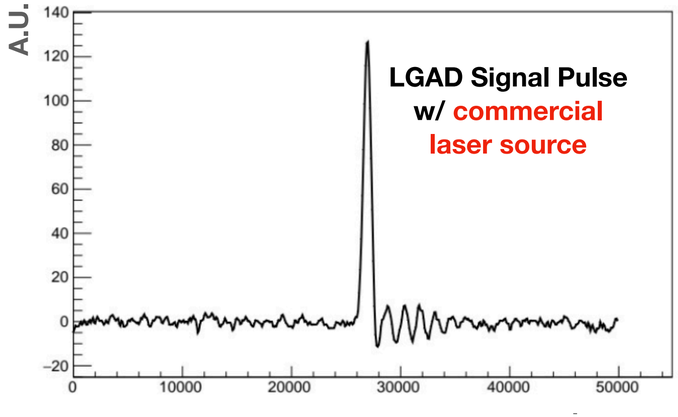
From off-shelf to customised power management

- From version A to B:
  - A customised PV cell power board
  - A customised laser source board (power configurable): modular concept to adapt to changes (for different laser driver wavelengths)
- Ripple noise on signal pulse disappeared after deploying *customised laser driver boards*

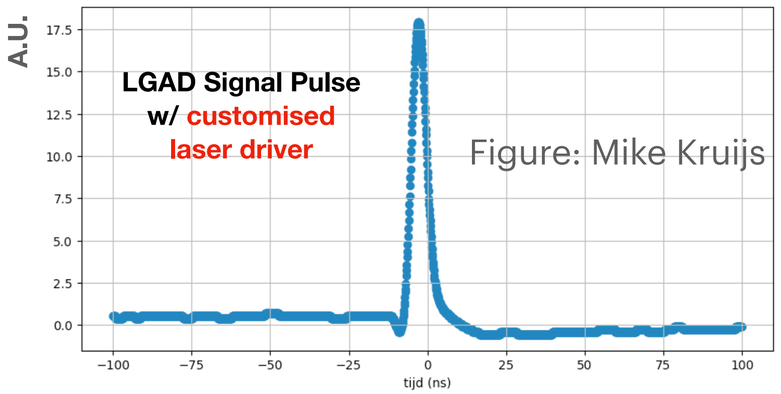




DOI: 10.22323/1.485.0471



Presented in CEPC2026



Power a Particle Detector with Solar Cells

Baseline Setup





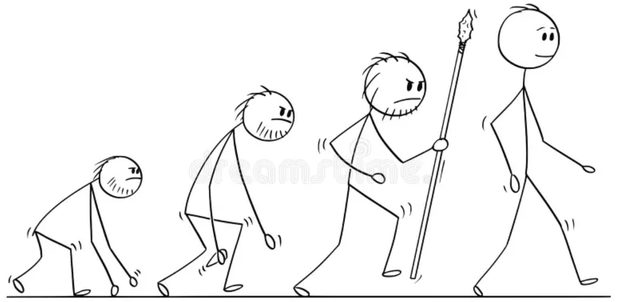
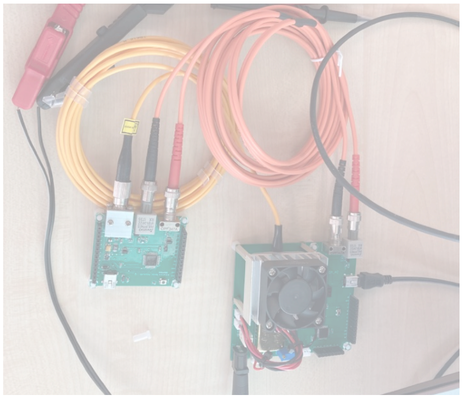
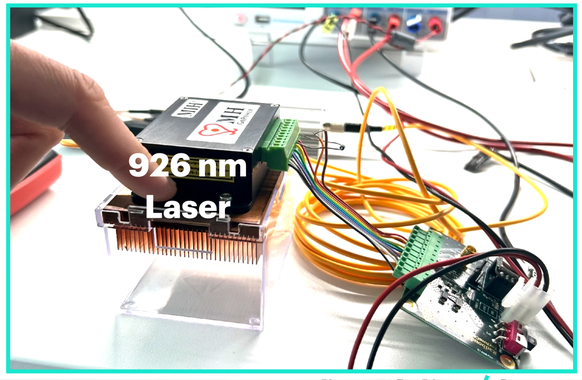
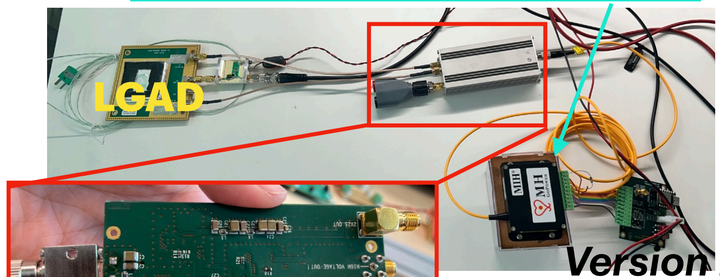


image credit: Dreamstime

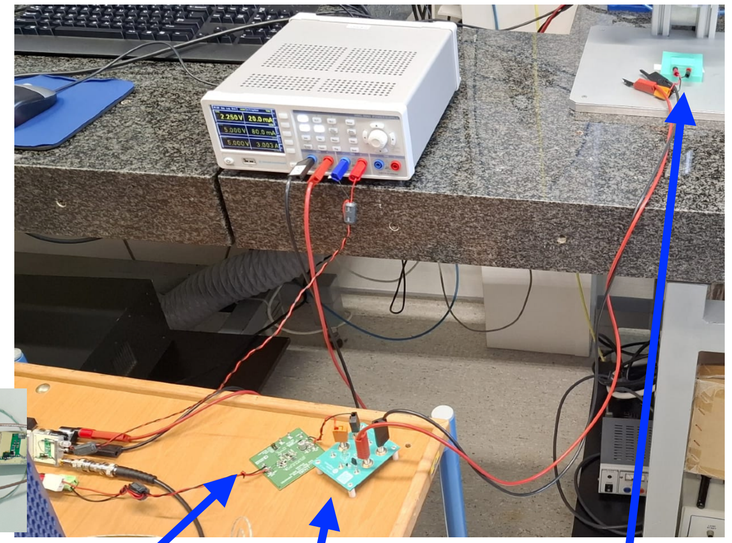


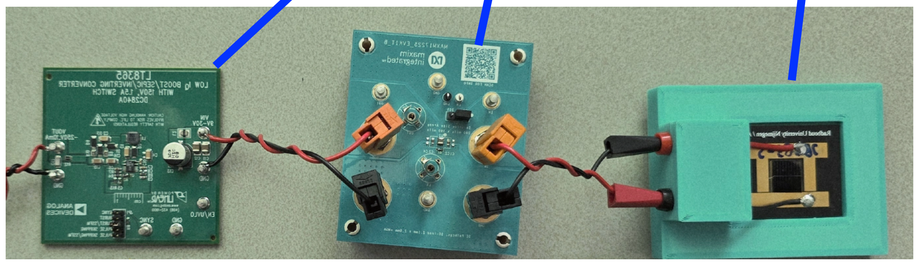
Version A:
Completely Off-shelf





Version B:
Customised power management with off-shelf Si Solar Cell





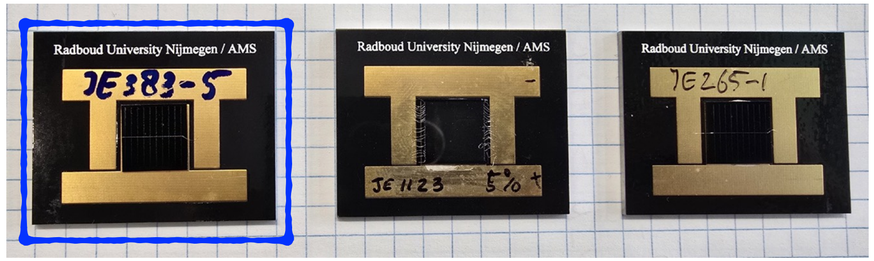
Version C:
moving to research-grade GaAs Solar Cell

New Results Today!

Moving to Research-grade GaAs Solar Cells

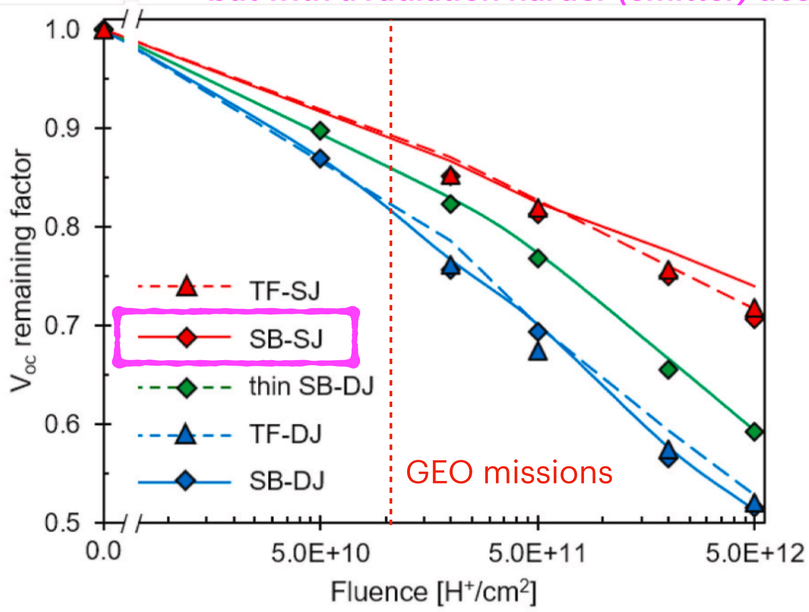
Radboud University

- Group III-V so far scores the highest single-wavelength conversion efficiency
  - Unprecedented efficiency record at 74.7% at 808 nm *[Photonics 2022, 9(8), 579]*
- Thin-film Group III-V solar cells designed primarily for space missions, studied against
  - Electron up to $1 \times 10^{15} \mathrm{cm}^{-2}$ (1MeV) *DOI: 10.1002/pip.3224*
  - Proton up to $5 \times 10^{12} \mathrm{cm}^{-2}$ (1MeV) *10.1016/j.solmat.2021.110971*
- Performance degradation of the solar cells mainly due to *reduction of the minority carrier lifetimes*.
- Identified radiation-hard cell structures
- Nijmegen group is experienced in design, simulation & fabrication of radiation hard cells
  - Our collaboration aims to identify and develop cells for collider applications

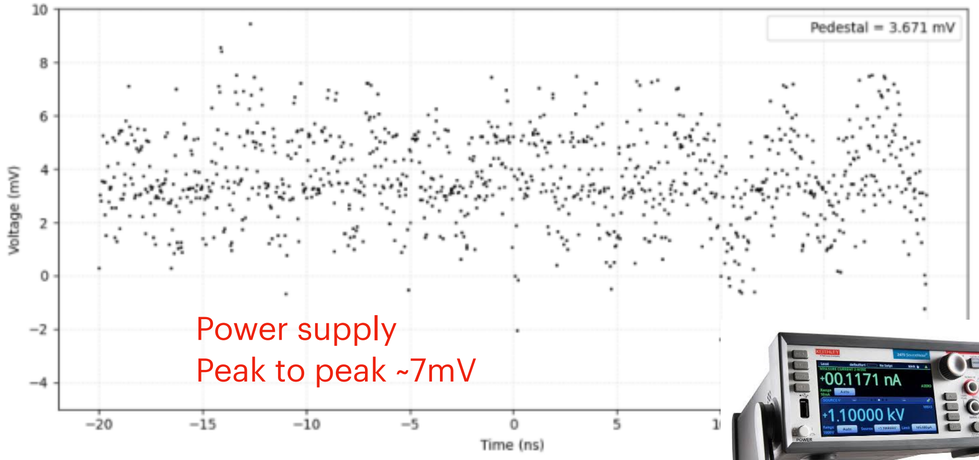


Used in the study presented here.

*Comparable to **SB-SJ**, but with a radiation harder (emitter) design*

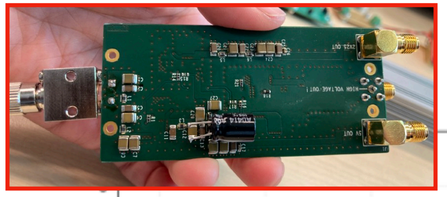


Power Example Detector Optically - *noise performance*

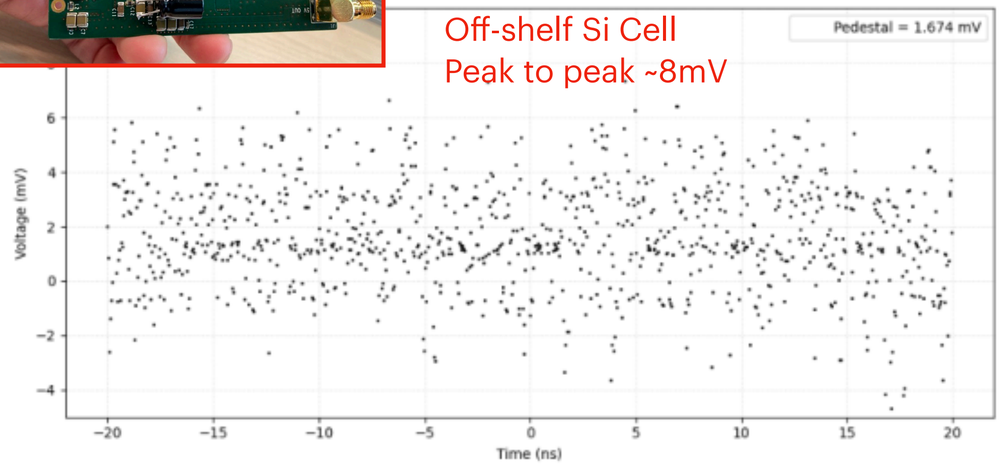


Power supply
Peak to peak ~7mV

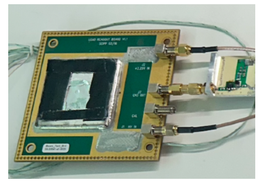


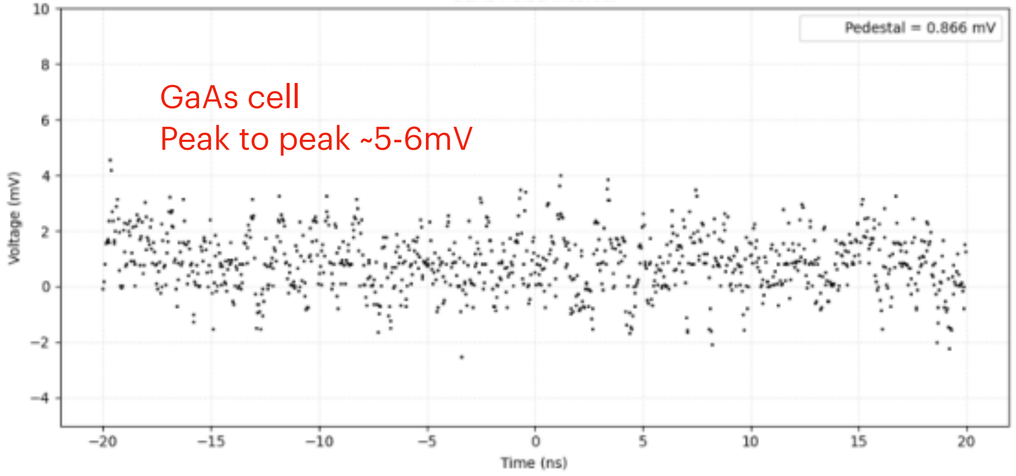


Off-shelf Si Cell
Peak to peak ~8mV

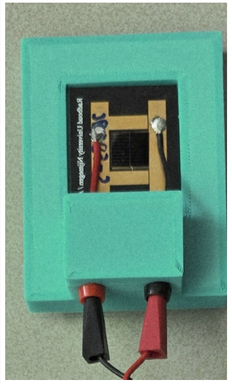


Detector readout without Sr90



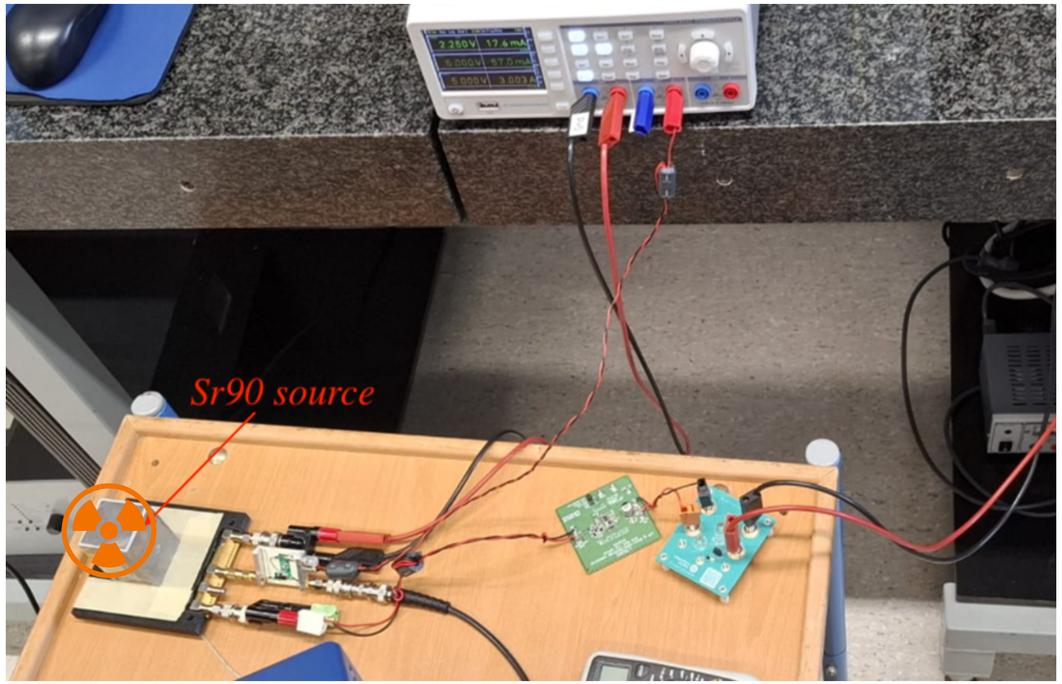


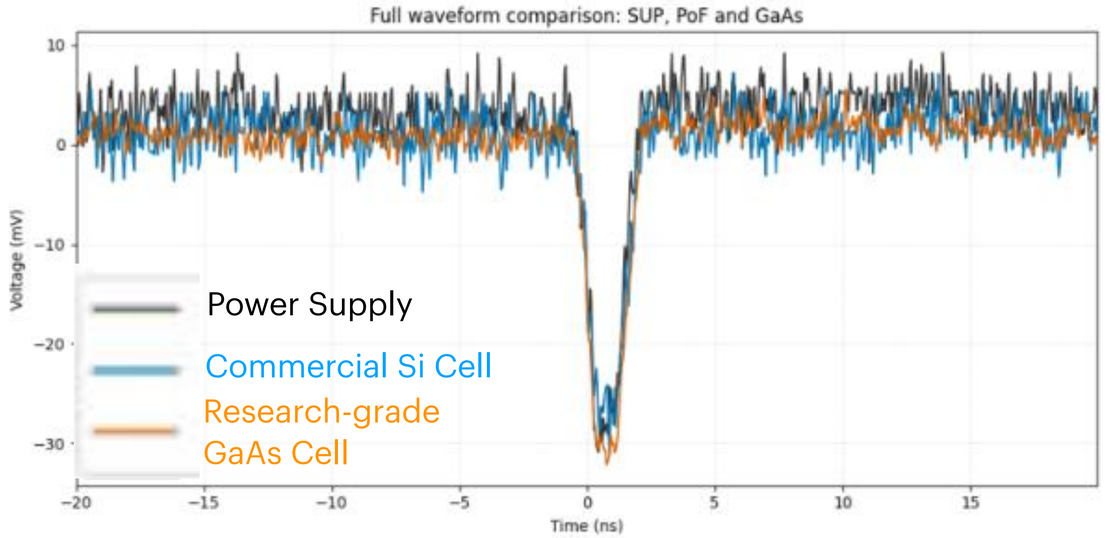
GaAs cell
Peak to peak ~5-6mV

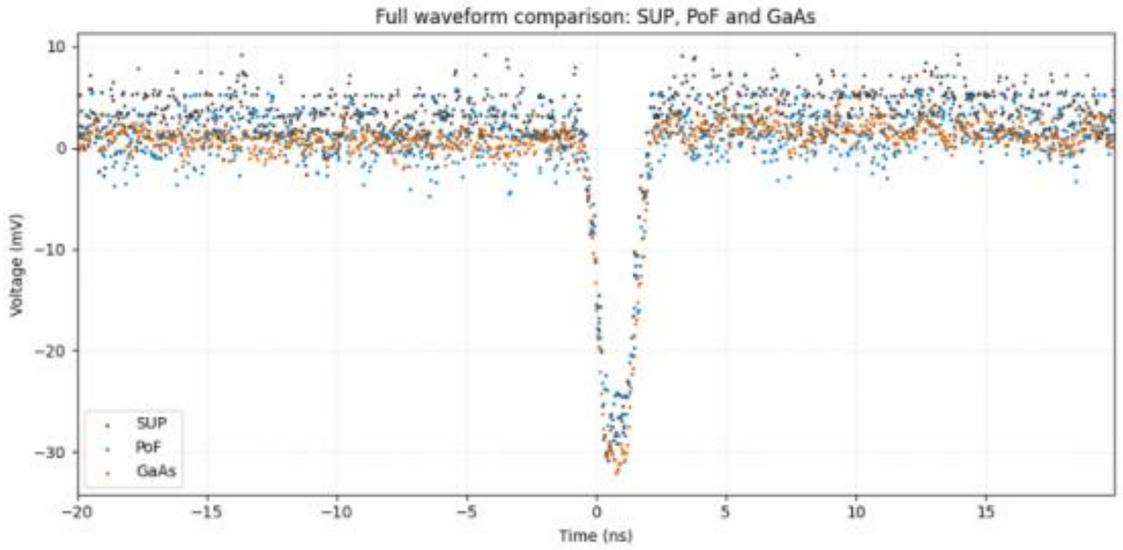


- The example detector front-end requires 5mV peak-to-peak noise *(0-20MHz)*
- The 5mV is used as a target - though the relevant front-end is not used.
- GaAs cell is so-far the most quiet - both open-circuit and with loads (without and with signal)

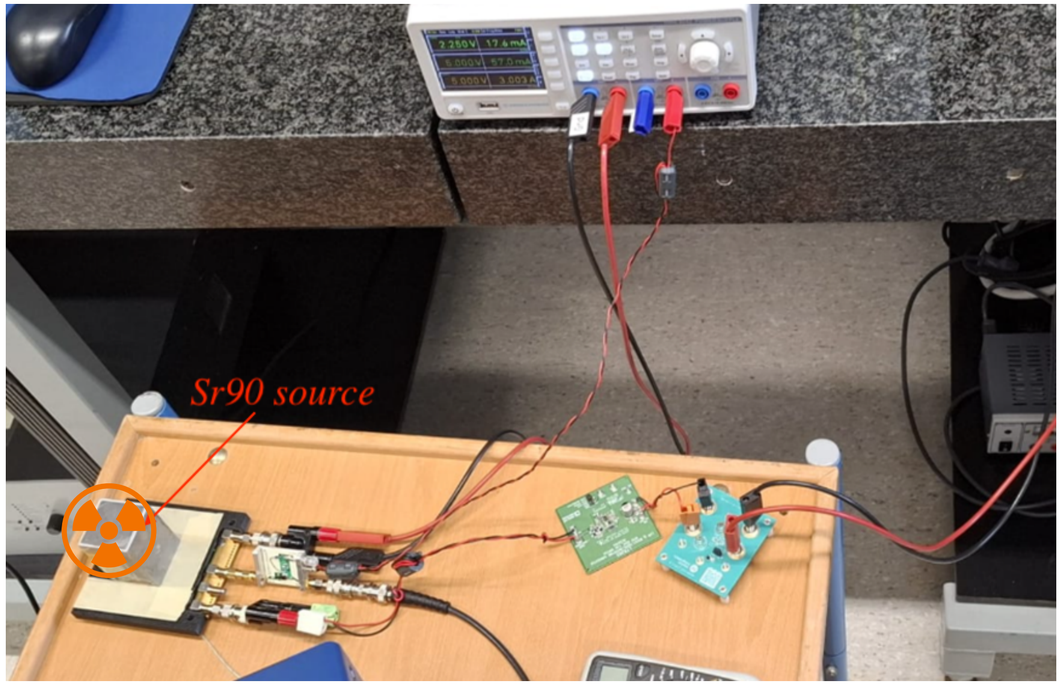
Power Example Detector Optically

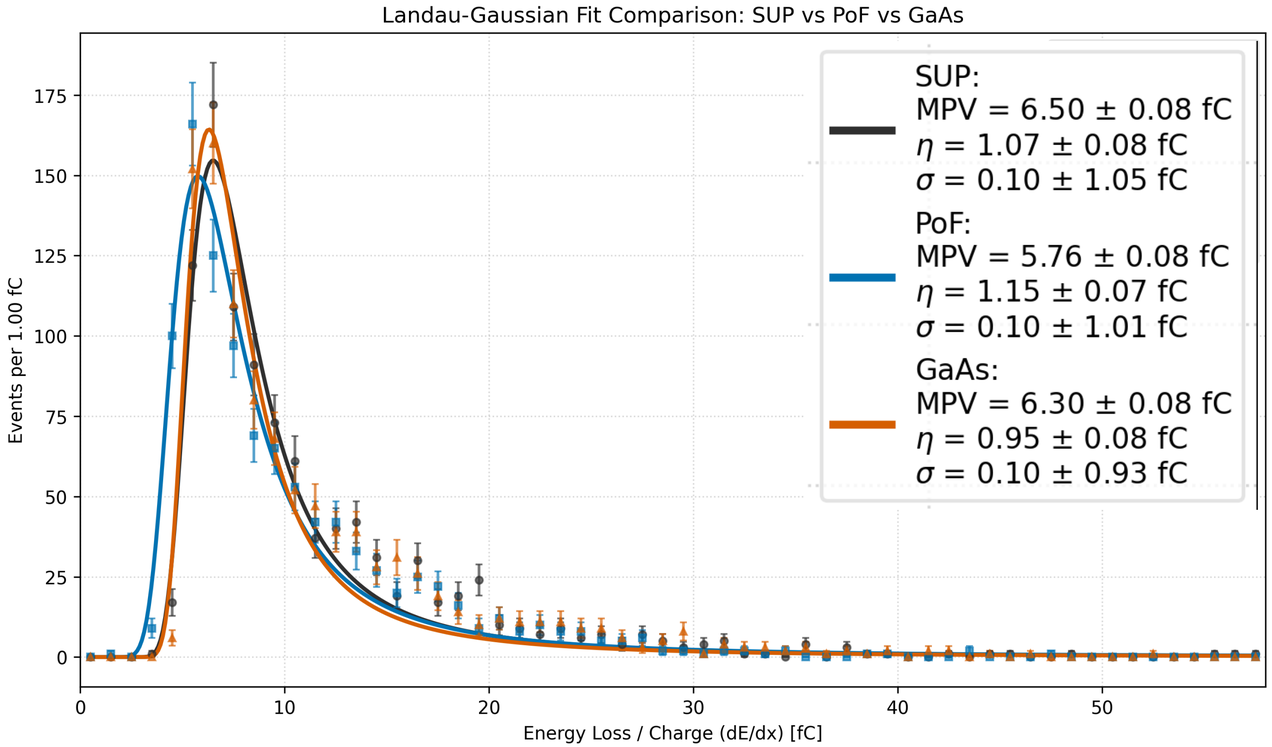




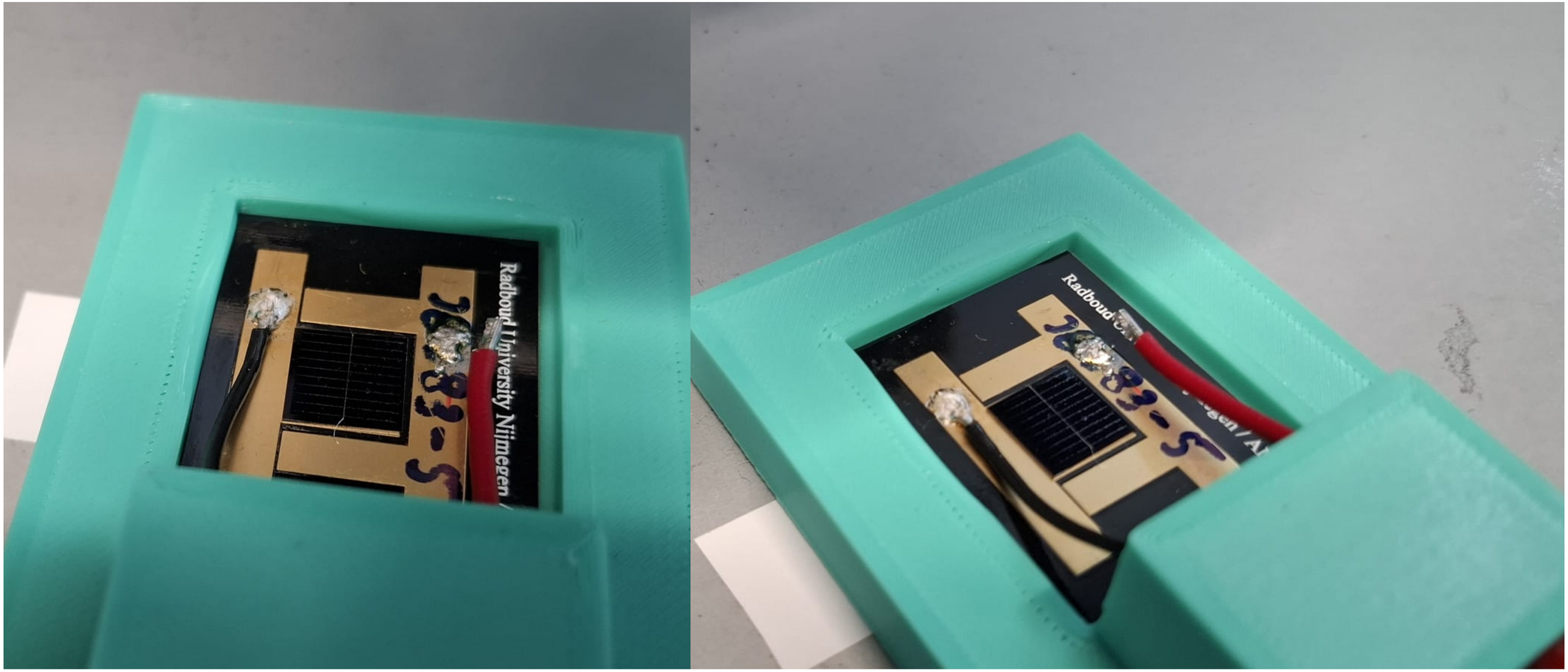


Power Example Detector Optically

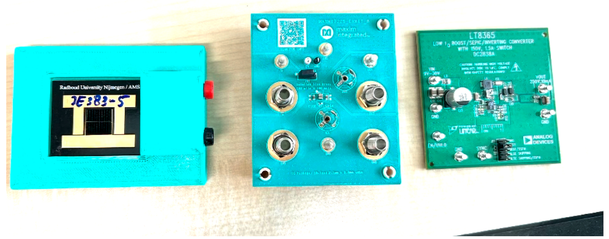


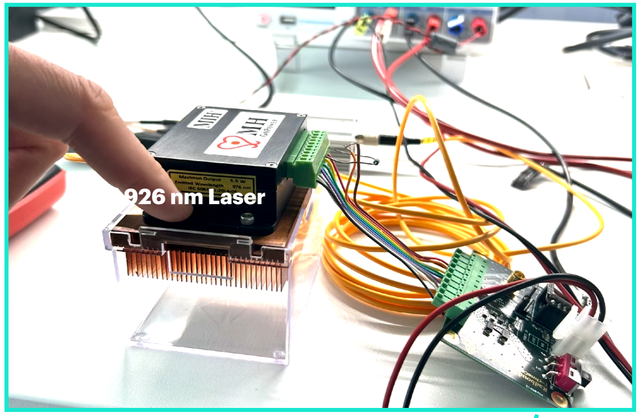


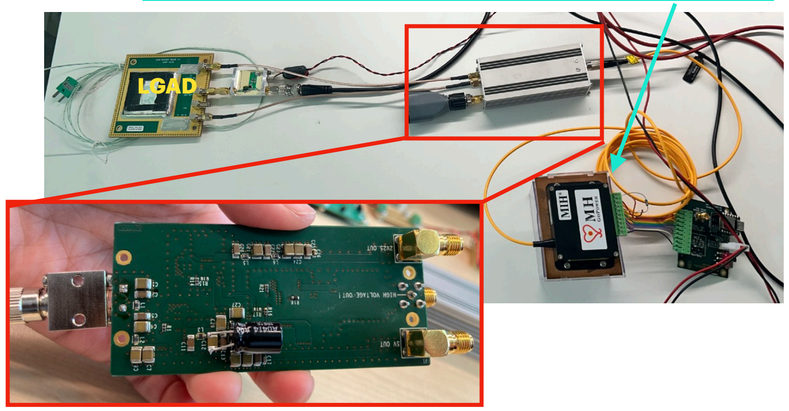
Anecdotes



Thanks and Stay tuned







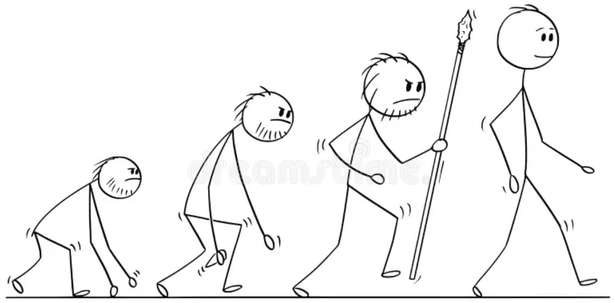
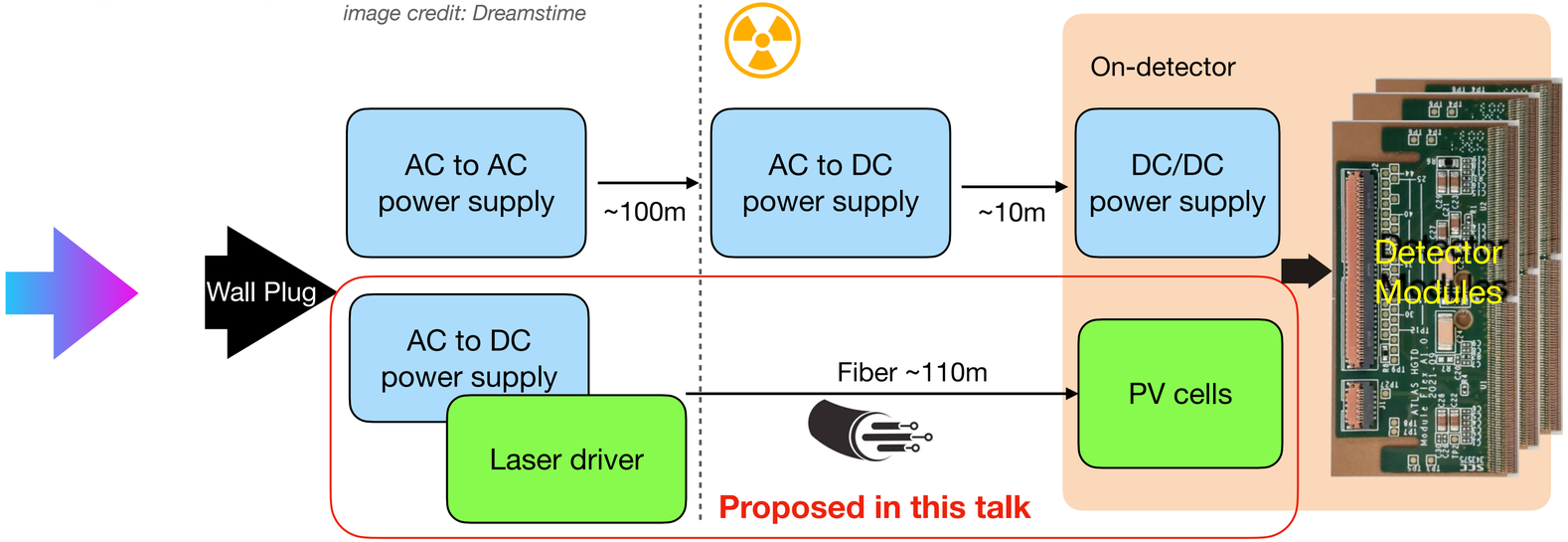


image credit: Dreamstime



Radboud University