ITS OB module telescope

for educational activities

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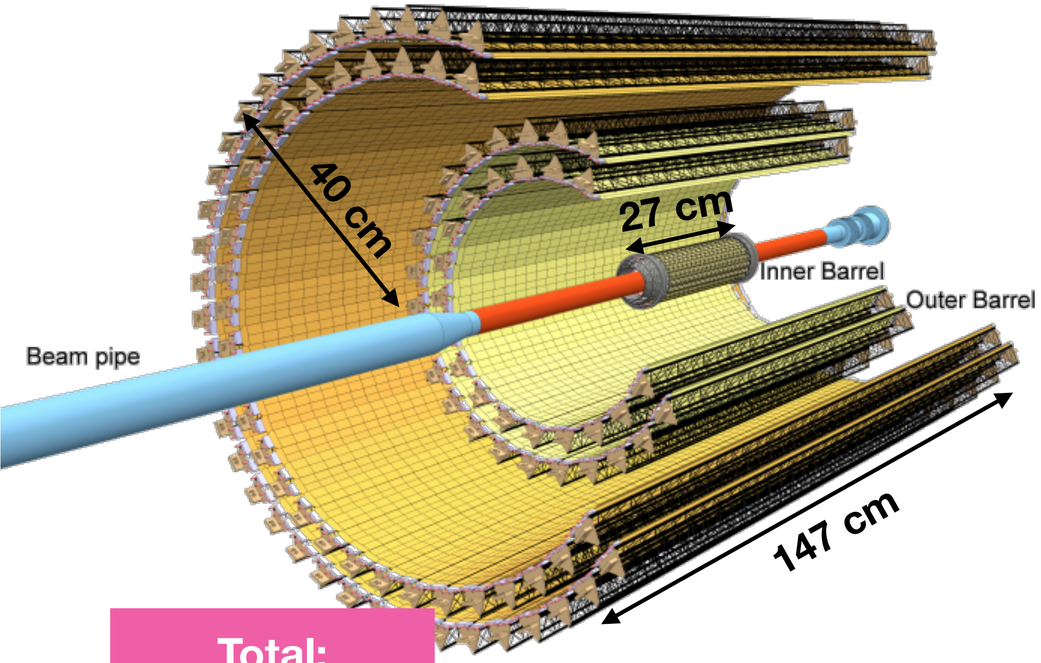
Scope: ITS2

Layout



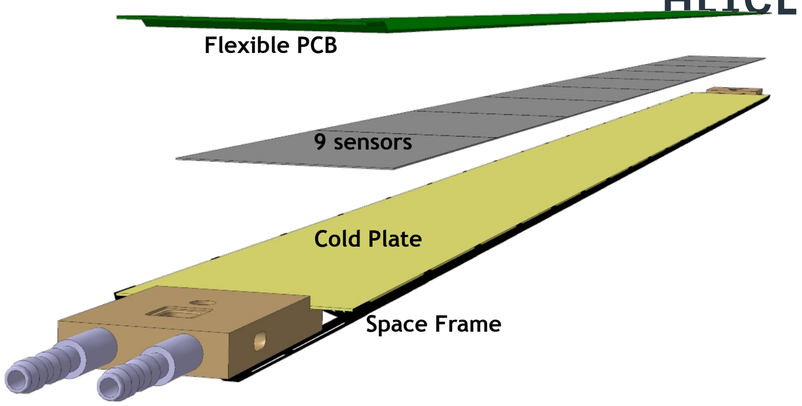
Total:
- 24k chips
- 10 m²
- 12.5 GPixel

Inner Barrel (IB)

3 Inner Layers: 12+16+20 Staves
1 Module / Stave

9 sensors per Module

96 Modules to be produced

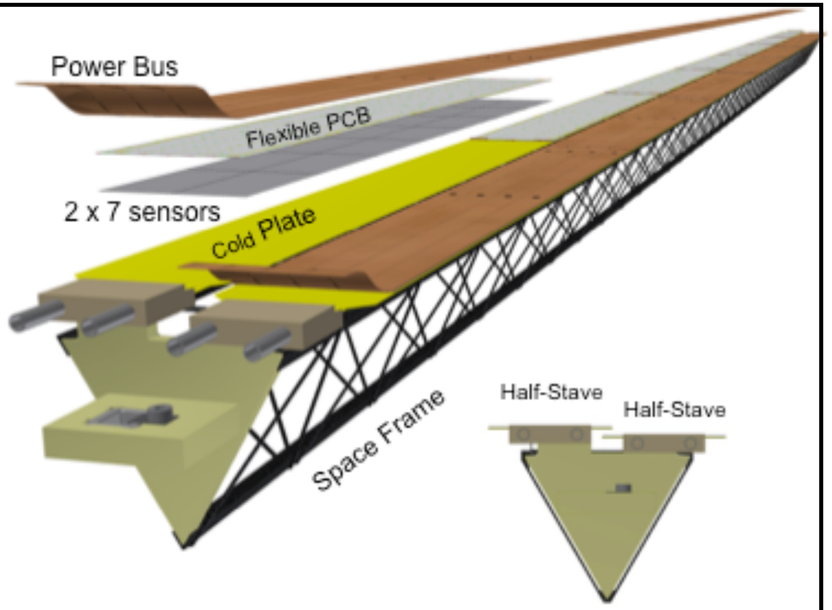


Outer Barrel (OB)

2 Middle Layers: 30+24 Staves
2×4 Modules / Stave
2 Outer Layers: 42+48 Staves
2×7 Modules / Stave

2×7 sensors / Module
(Middle and Outer Layers are equipped with the same Module Type)

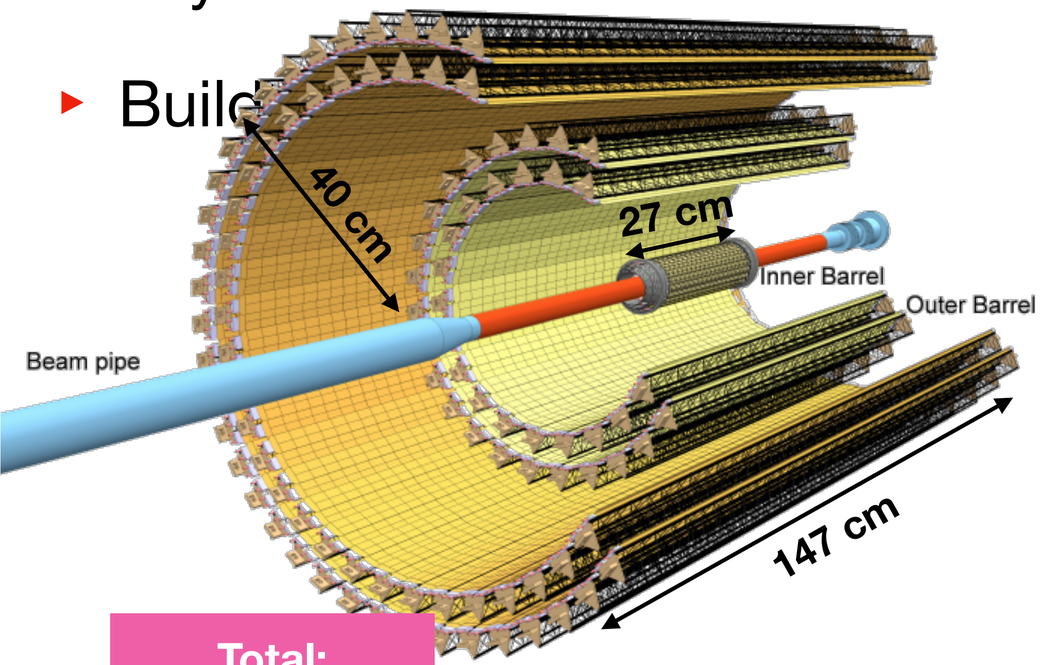
1880 Modules to be produced (including spares)



Scope: ITS2

- Layout
- Build

Layout



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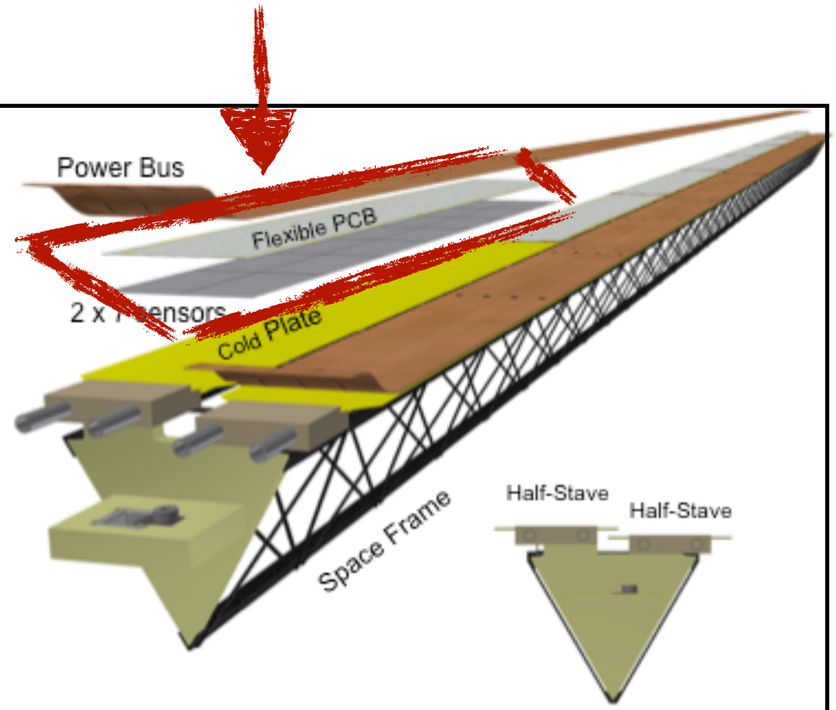
ITS OB module



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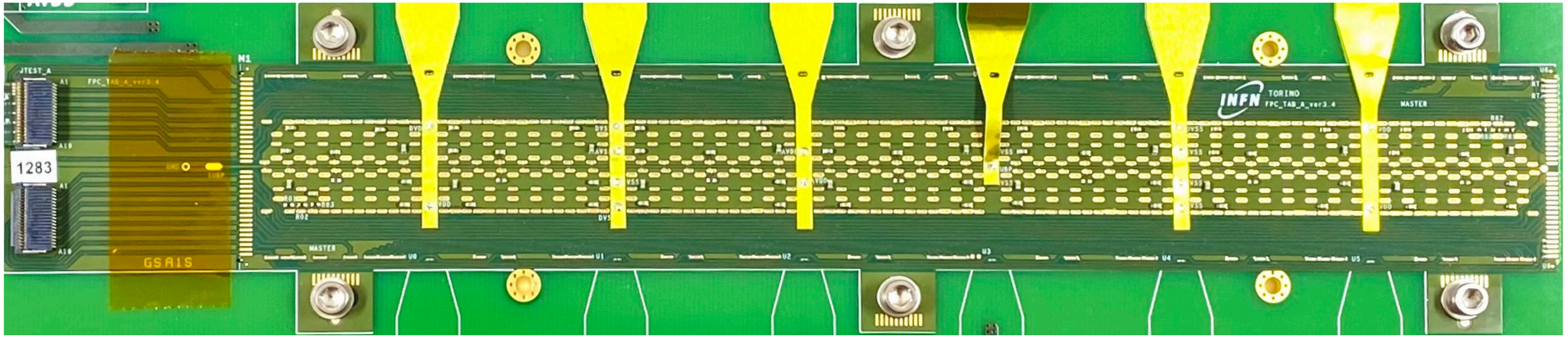
ITS2 OB module

some specifications



- **14** ALPIDEs
- Active area: **~57.7 cm²**
- **7.3 Million** channels

These are beautiful objects!

… just a bit fragile (low material budget!)

… not too user friendly (not mean to be used stand alone)

ITS2 OB module

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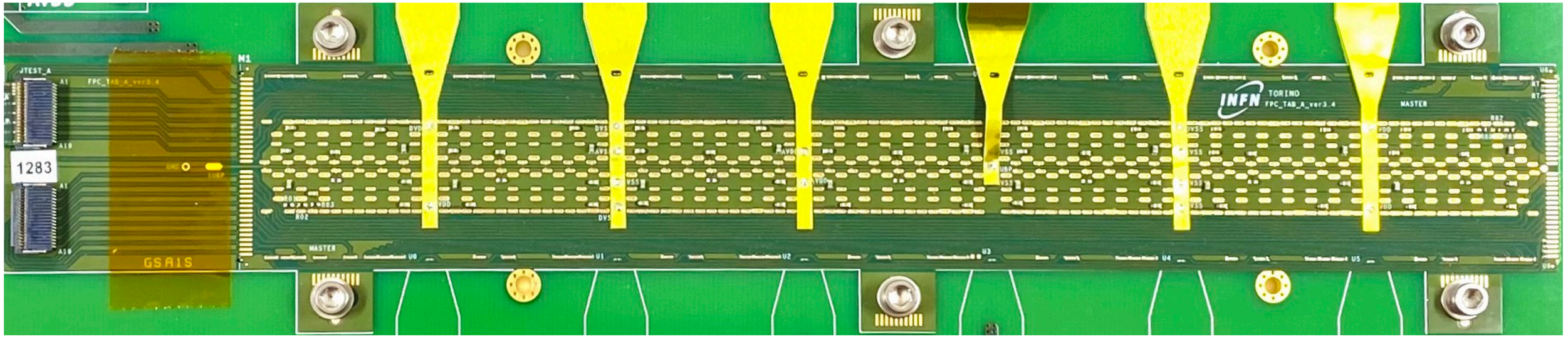

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^^ this we will target!

Background & Motivation

- In the production of the ITS Outer Layers, a number (small in relative terms, sizeable in absolute terms) of non-working modules have accumulated
  - Many of them have single problematic chips (i.e. 1 out of 14)
  - Bad for the detector, but still very good for educational/outreach applications
- Modules need quite some infrastructure to be operated
  - mechanically and electrically
- *If one can operate them,* they are beautiful objects with bleeding edge technology
  - they would allow to study a lot of things: electronics, detector physics, reconstruction, …

Idea

- Interface the leftover ITS OB modules to a broad audience!
  - *electrically* (use standard connectors, voltage levels, pinouts)
  - *mechanically* (give the fragile modules a rigid support and protection)
  - *intellectually* (provide support, examples, instructions, courses)

Possible activities

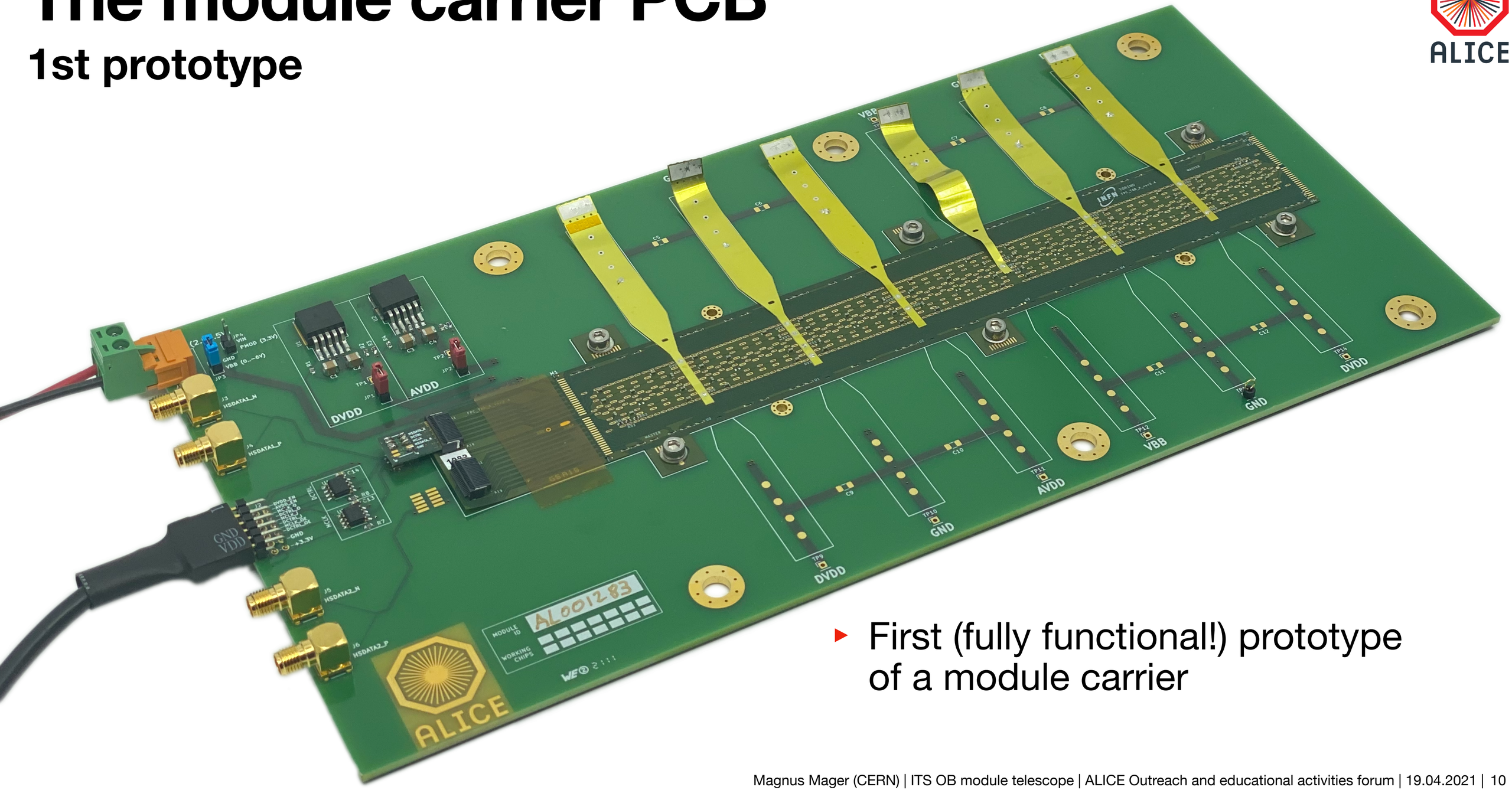
- Cosmic data taking and analysis
- Development of readout soft- and firmware
  - supporting a variety of development boards is supported:
    - microctroller-based (Arduino and alike)
    - microprocessor-based (Rasperrry Pi and alike)
    - FPGA-based (Lattice, Xilinx, Altera/Intel etc.)
    - SoC-based
- Study principles of data transmission
- Instrumentation of student experiments (e.g. beam line for schools)
- *Likely more…*

Target audiences

- General public
  - e.g. international cosmics day, science fairs
- Highschools
  - classes, competitions
- University courses
  - lab courses
- PhD schools

The module carrier PCB

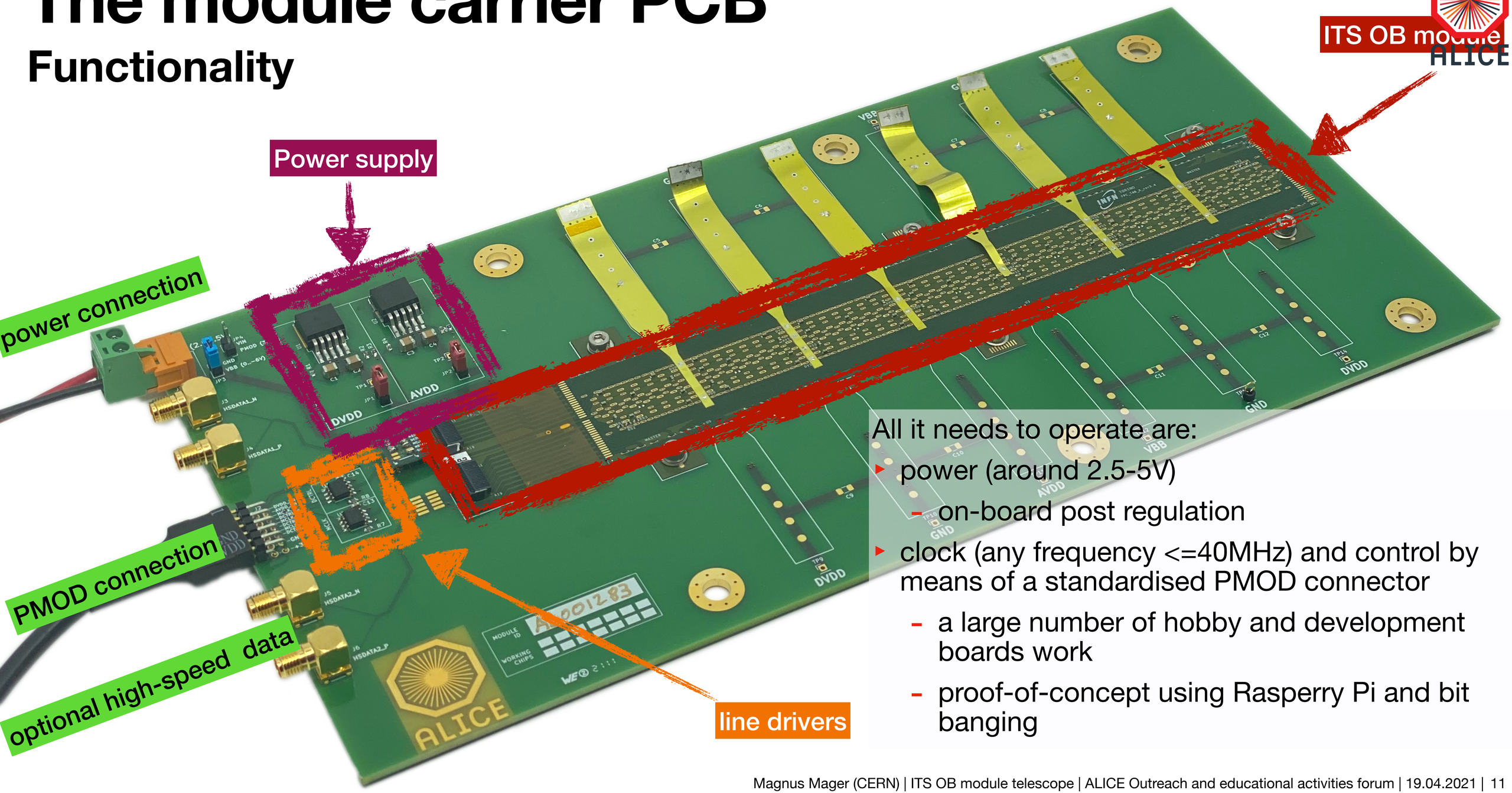
1st prototype



- First (fully functional!) prototype of a module carrier

The module carrier PCB

Functionality

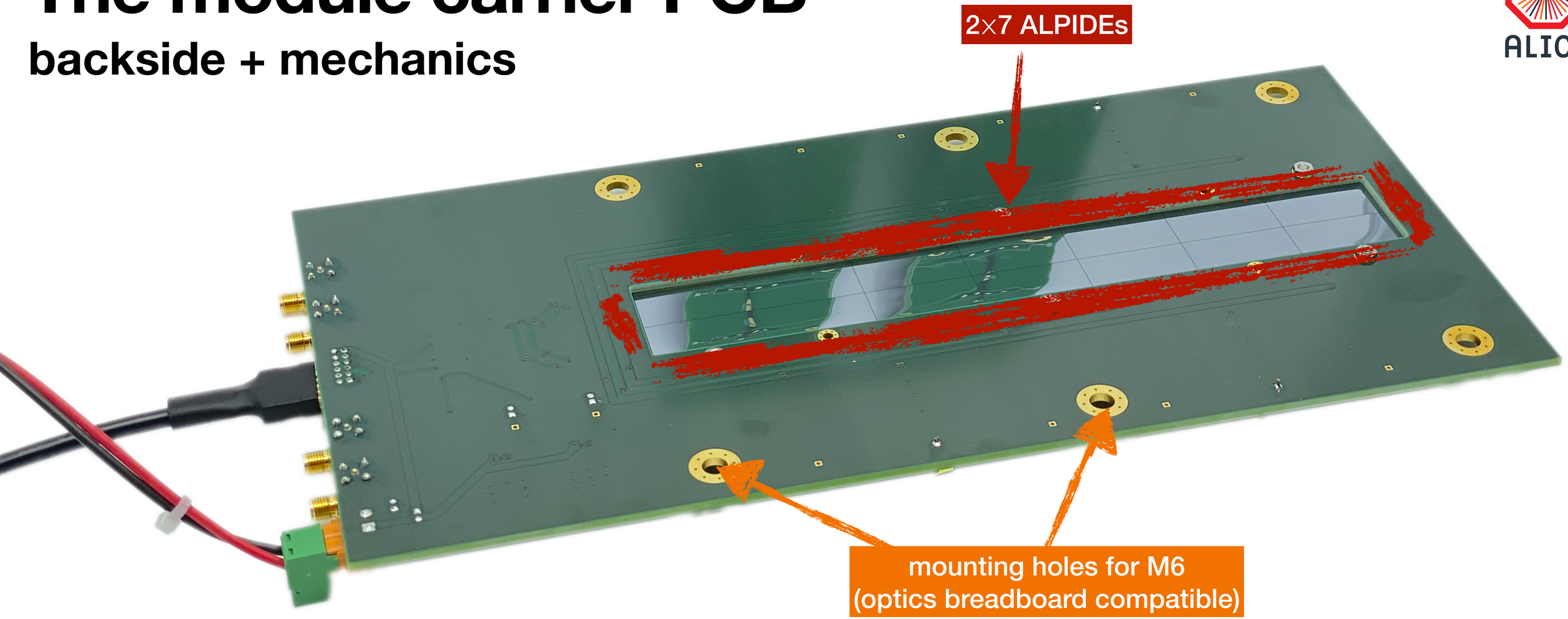


All it needs to operate are:

- power (around 2.5-5V)
  - on-board post regulation
- clock (any frequency <=40MHz) and control by means of a standardised PMOD connector
  - a large number of hobby and development boards work
  - proof-of-concept using Rasperry Pi and bit banging

The module carrier PCB

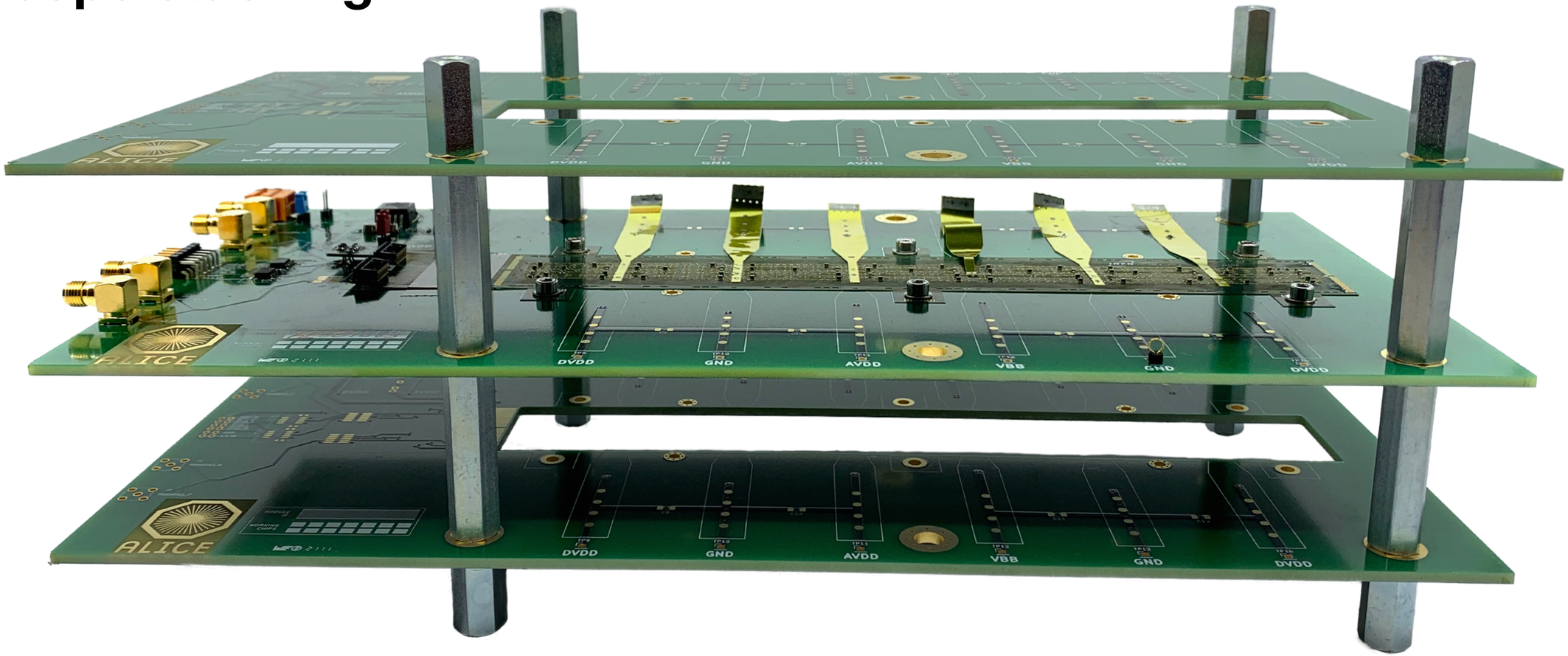
backside + mechanics



- Mounted on a thick, rigid PCB
- Opening in the centre to show off the ALPIDEs and to reduce material budget

The module carrier PCB

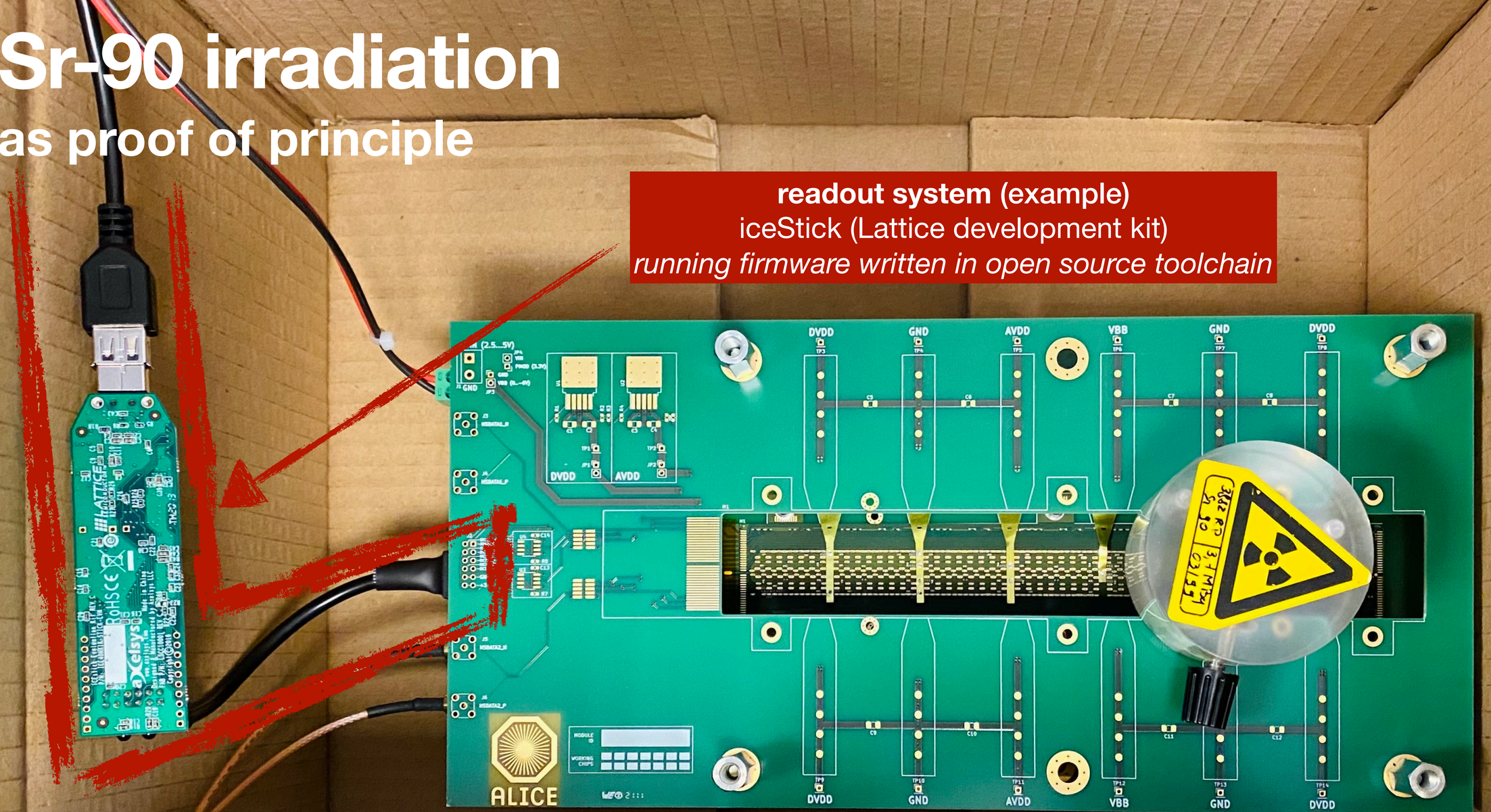
telescope stacking



- Planes can naturally be stacked
- This immediately makes them a large acceptance cosmic telescope

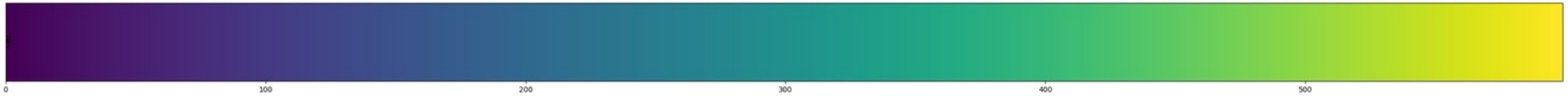
Sr-90 irradiation
as proof of principle

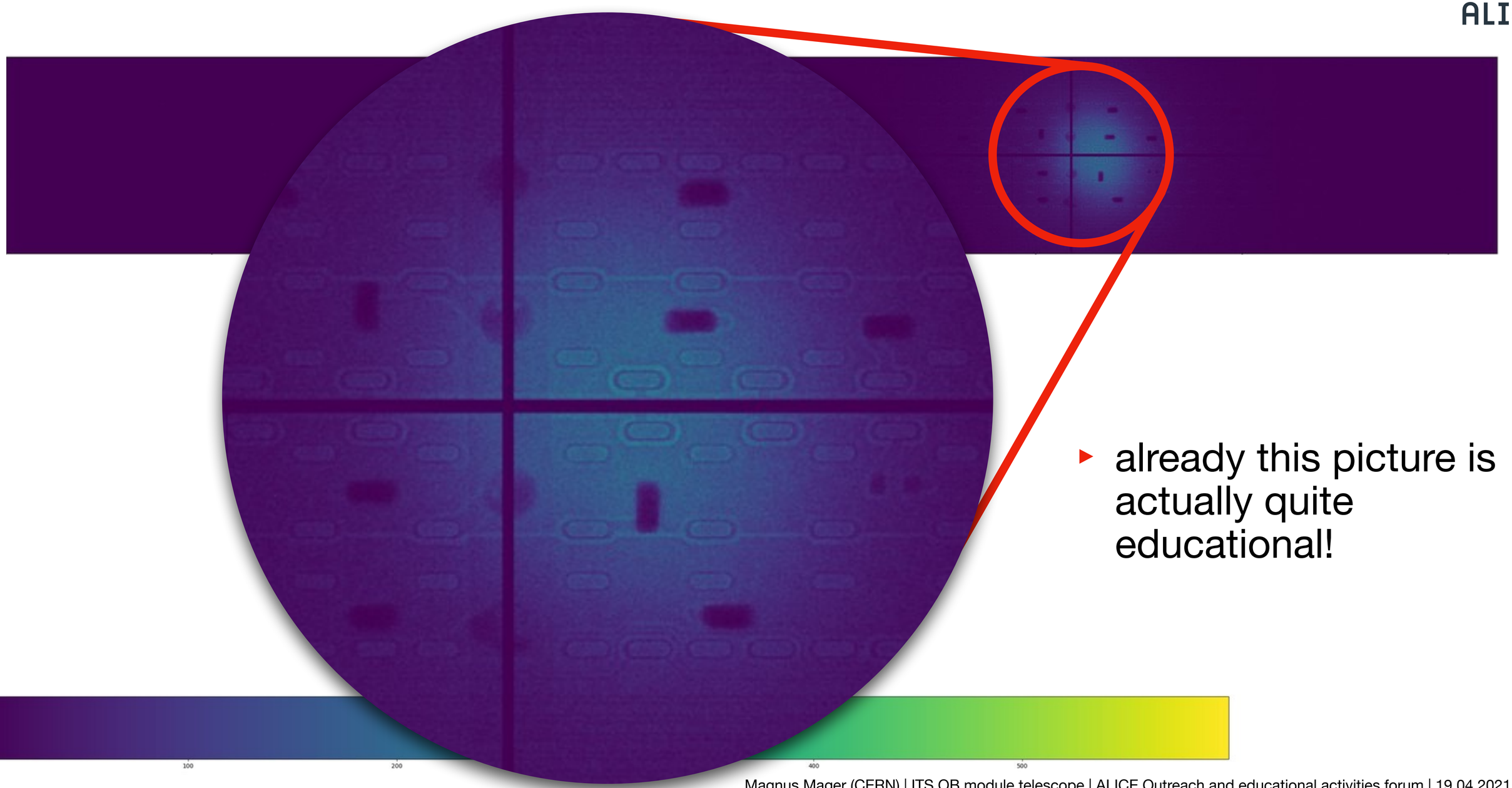
readout system (example)
iceStick (Lattice development kit)
running firmware written in open source toolchain



Sr-90 irradiation

- Readout works
  - result is a nice beta-radiography
- This is the final proof of principle of this idea before building the full cosmic telescope
- *NB: software is python, firmware verilog, compiled using a fully open source toolchain – i.e. could be done by anybody!*

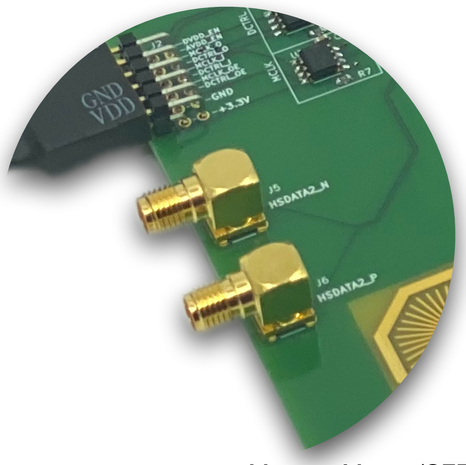




- already this picture is actually quite educational!

High-speed link

- The high-sped links of the module are made available using standard SMA connectors
- Can directly be connected to a scope
- High-speed drivers of ALPIDE are configurable (strength, pre-emphasis, line-rate)
  - one can learn a lot about serial data transmission here



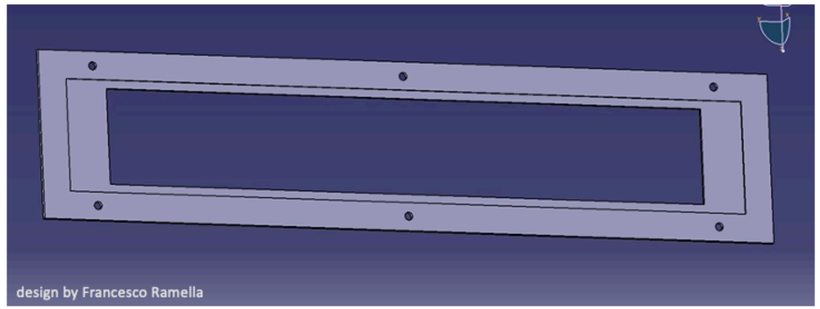
Plans

- Launch production of slightly updated carrier PCBs
- Adding mechanical chip protections to the planes
- Adding a battery power supply
- Build and operate a telescope for cosmics!

A. Zampieri

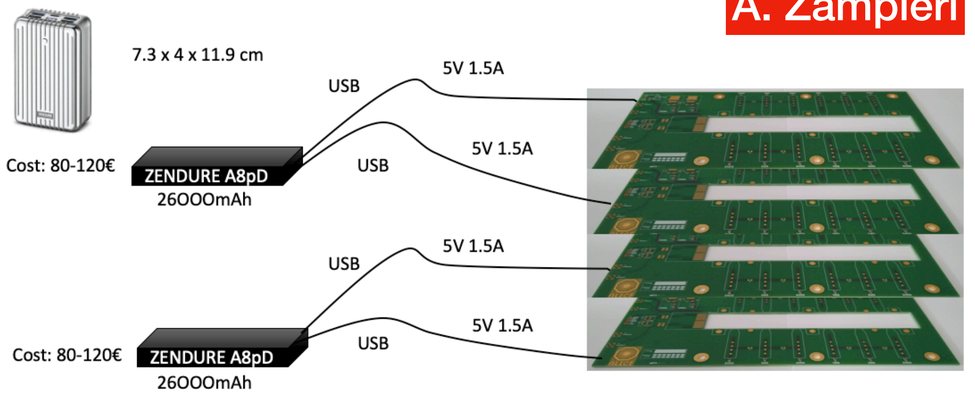
Idea for top protection:
- Aluminium frame + transparent polymide film
- fixed to HIC board using the same columns that are used to fix the FPC wings to the board.
- very thin, slightly wider than the HIC
- minimum column height: 0.5cm

Bottom Protection: polymide film glued to the board
This way each module is protected and can be assembled to others to form the telescope



A. Zampieri

Power supply for the tracker: compact/portable solution



battery pack duration:
- ~6 hours assuming maximum constant power consumption
- adding external switches we could increase the duration to 11h

Summary

- We propose to make use of left-overs from the ITS2 production for educational/outreach purposes
  - focussing on partially working Outer Barrel Modules
- Our goal is to make the technology easily accessible to a wide audience
  - relying on a de-facto standard “PMOD”, allowing to interface many different development platforms as well as SMA connections for high-speed signals
- We have built a first demonstrator of a single plane
  - it is fully functional and already took nice data
- The solution is relatively cheap (O(200 CHF) per plane excluding the module)
- We would like to continue by:
  - adding a mechanical support
  - producing more planes
  - writing demonstration/reference software/firmwares
- Last but not least, ITS has an interest in understanding the failure modes of partially working modules, and this work will serve this purpose, too