Development of a large-area, light-weight module using the MALTA monolithic pixel detector

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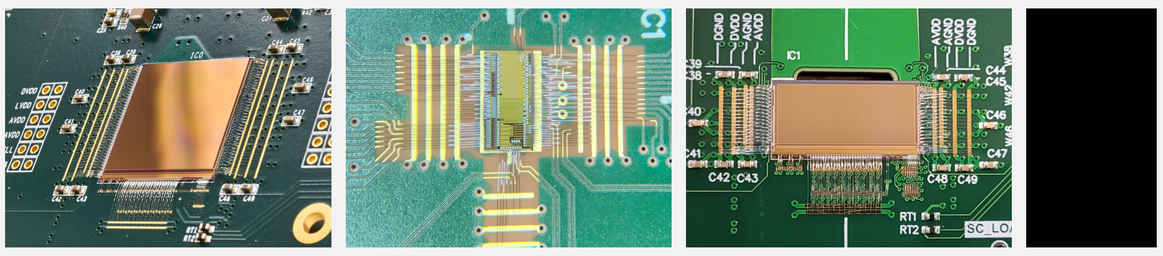
The MALTA detector family

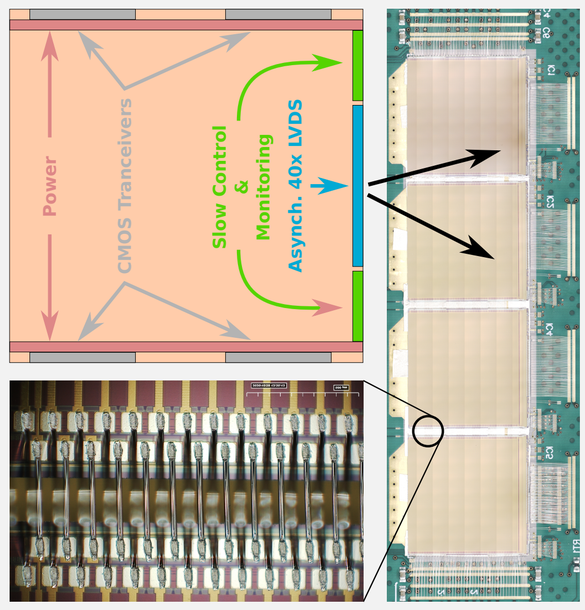


MALTA → MiniMALTA → MALTA2 → MALTA3

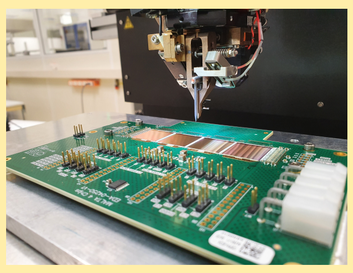
The goal for MALTA is to develop a radiation hard large-area DMAPS with high-granularity and ~1ns timing precision produced with an industrial standard CMOS process (180nm TowerJazz) for environments such as the outer layers of the ATLAS ITK.

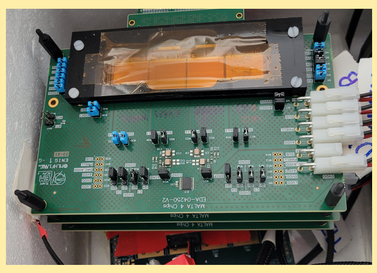
MALTA module capability

MALTA and MALTA2 can send data as 40x parallel signals either from the default LVDS output or **transmit to a neighbor via redundant CMOS transceivers**. Both, transceivers and powering pads are located on the chip to allow **chip-to-chip data and power transmission** in a module structure.

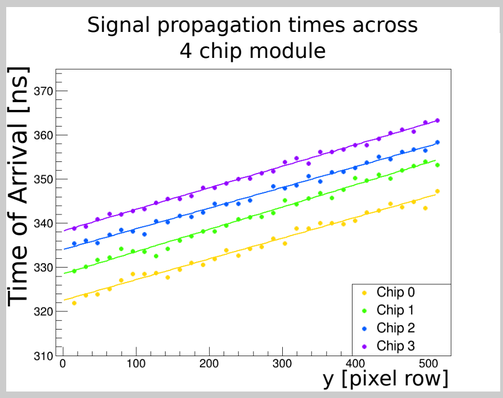


Readout tests on MALTA quad modules using an ^{90}Sr source

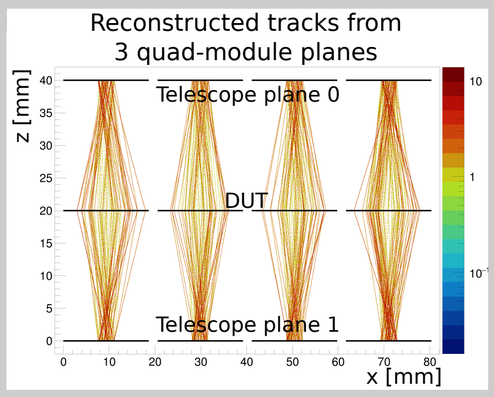




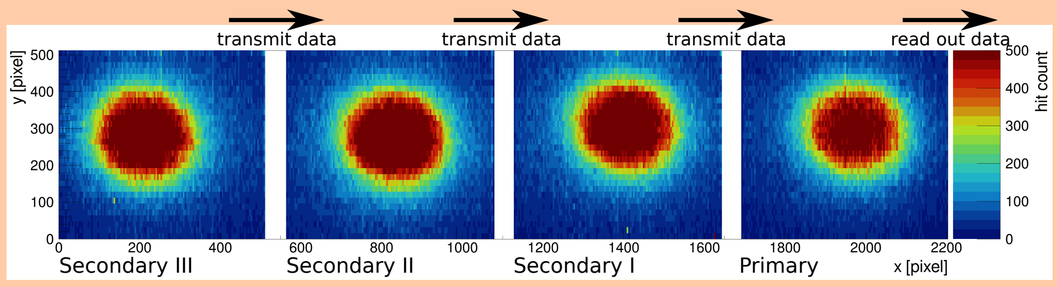
Three MALTA quad modules are installed in a desktop telescope setup. The top and bottom planes act as a telescope and provide a coincidence trigger, the middle plane acts as a DUT.
The **readout has been verified** and **preliminary tracking tests were carried out**. **High energy beam tests at the SPS are scheduled for summer 2022**



Right: Signal delay measurement across an individual quad-module. A delay is caused by signals propagating down the matrix to the periphery (slopes) and also during chip-to-chip data transmission (vertical shift).
Left: Reconstructed tracks from an ^{90}Sr source scan. A tight fiducial area constrains accepted tracks on the telescope planes while the DUT is read out across the entire sensor area to take scattering into account.

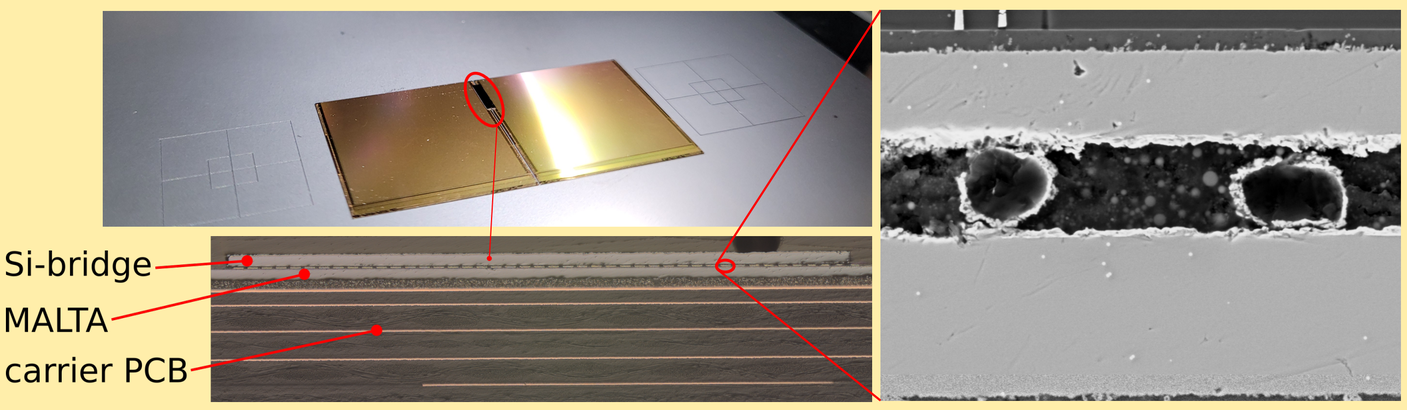


A first test to investigate the module's resilience to power contraints was done by routing all power through the primary chip alone and forwarding it from there chip-to-chip. A ground connection was kept for all chips.
The entire module stack remains fully functional as shown with a source scan where the middle module was operated in a continuous readout mode while the source was moved from chip to chip.



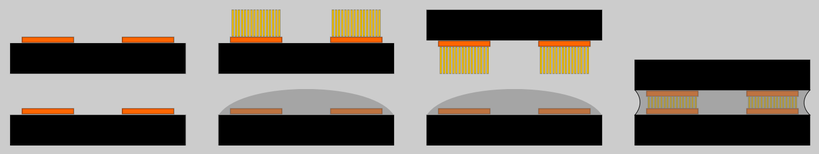
Alternative interconnection techniques

Anisotropic conductive films **offer a highly scalable and robust interconnection solution** for large area pixel detector modules. Several 2-chip modules with MALTA have been assembled and are mechanically intact. Electrical tests are ongoing.



Nano wires offer another promising alternative. The wires are grown on the substrate using a seed layer.

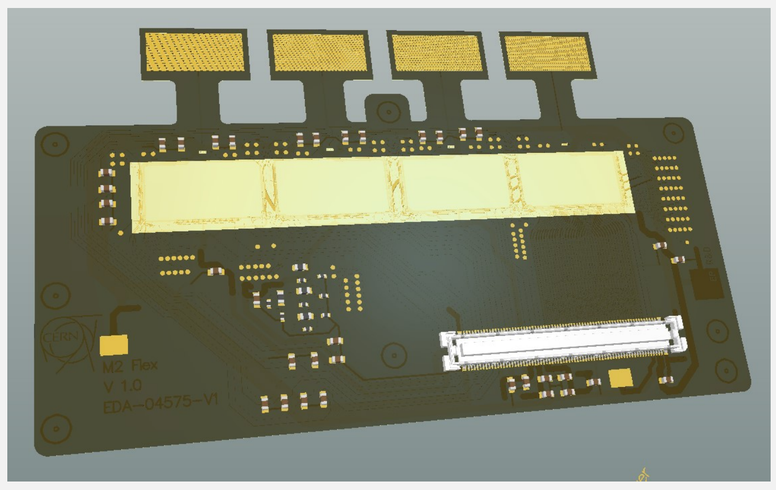
An interconnection process in combination with a glue layer offers high mechanical stability together with an electrical connection and is **the most likely candidate for interconnection on a planned quad flex board**.



Design of a super light-weight large area quad chip flex module

The characerisation of data and power transmission with wire bonded modules lays the ground work for the design of a much more advanced quad module using MALTA2 detectors.

The design of this module is completed. It will be assembled on an **ultra light-weight flex circuit with a thickness of 50µm, contact traces only 17µm wide and a layout that is designed to bond chips face down** either using ACF of nano wires.



Further reading on MALTA:

Measurement results of the MALTA monolithic pixel detector, Schioppa et al., https://doi.org/10.1016/j.nima.2019.162404,
A 1 µW radiation-hard front-end in a 0.18 µm CMOS process for the MALTA2 monolithic sensor, F. Piro et al., https://doi.org/10.1109/TNS.2022.3170729
Radiation hard monolithic CMOS sensors with small electrodes for High Luminosity LHC, H. Pernegger et al., https://doi.org/10.1016/j.nima.2020.164381