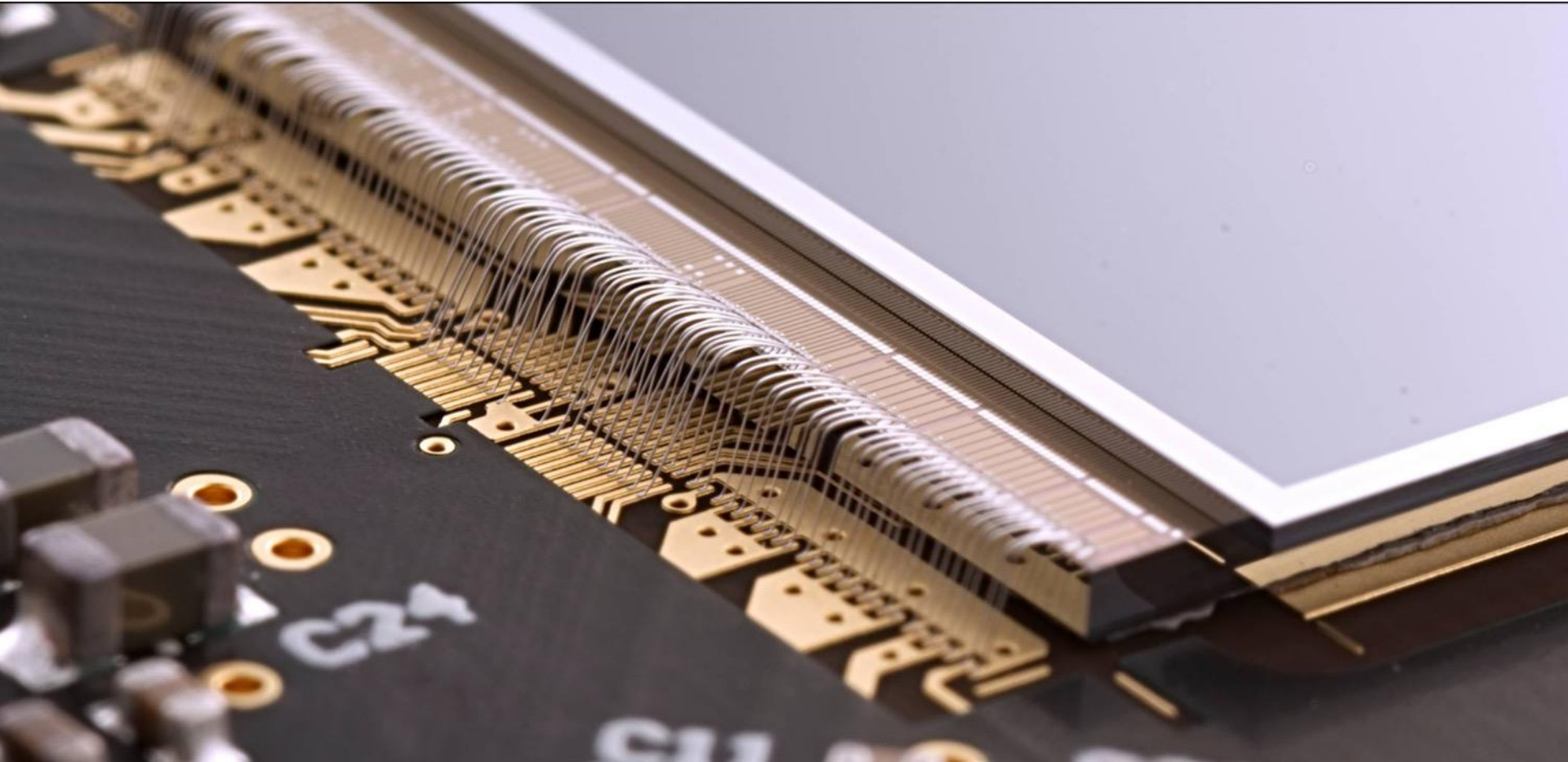


Bond/QART Lab and Pixel R&D

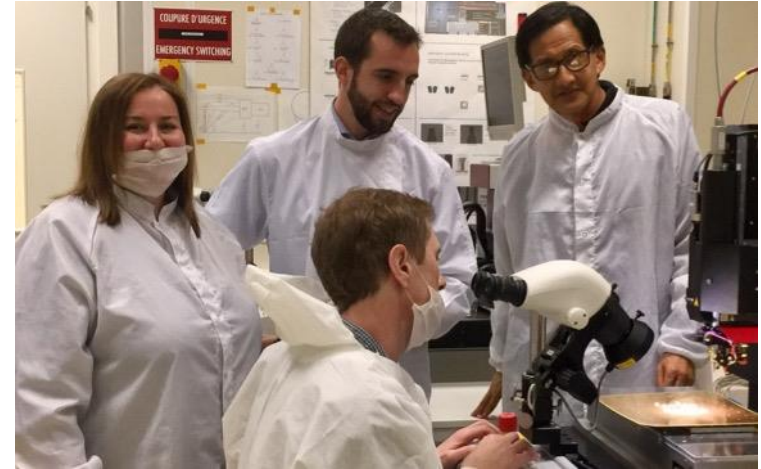
Petra Riedler, EP-DT-DD

June 22, 2017



Bond & Quality Assurance and Reliability Testing Lab

- Provides **services** in the area of **micro-connections and quality and reliability testing**.
- **Bond lab** founded in mid-1990's, inherited from OPAL and evolved into a CERN service.
 - Main equipment: 3 Delvotec G5 automatic wedge wire bonding machines.
- **QART lab** founded in 2008 to help with the LHC silicon detector upgrades.
 - Main equipment: 2 fast cycling climatic chambers, electromagnet, vibration system
- The Departmental Silicon Facility (DSF) houses both labs including a cleanroom with a common area.



Florentina Manulescu
Julien Bonnaud
Ian McGill
Alan Honma (lab manager)



G5 Bonding machines

Bond Lab

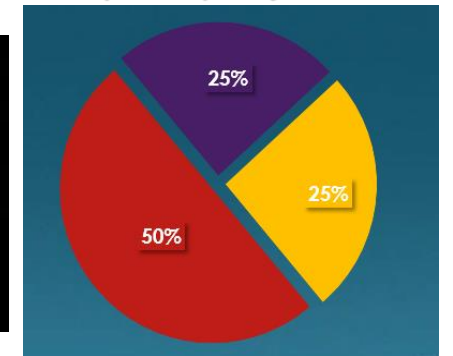
Large variety of work:

- From gluing of newly developed **ASICs** to a test PCB and provide wire bonding connections between chip and PCB to **full module bonding**.
- Connections between solid state sensors, fan-out circuits, PCBs, and read-out chips in any combination
- **Very experienced team, that can handle unusual and difficult geometries** as well as **complex combinations of materials**.

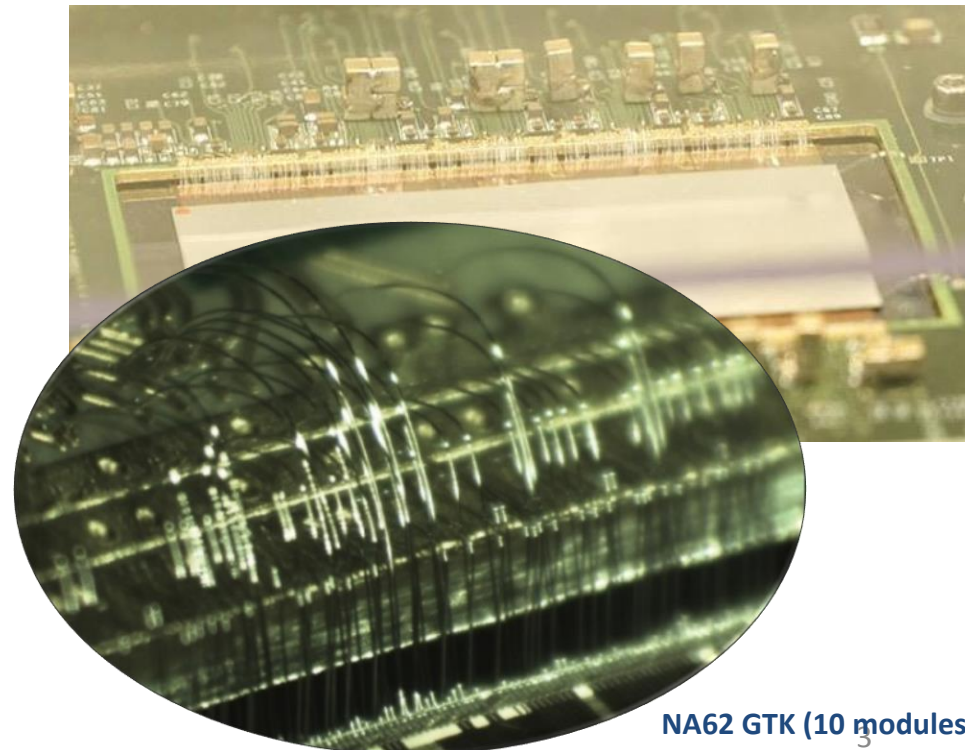


ALICE ITS module

Complexity of jobs



low complexity high



NA62 GTK (10 modules)
3

Bond Lab

Providing service to all experiments and the community (selection 2016/17):

- ATLAS pixel upgrade, Itk
- ALICE ITS, MFT
- CMS upgrade, HCAL, ECAL, opto-hybrid
- EP-ESE: prototypes
- LHCb SciFi, VELO, VeloPix, UT upgrade
- LINAC4
- Medipix, NASA, TMPX, CLICpix
- NA62 GTK
- RADMON
- Prototypes and R&D test structures, e.g. RD50, RD51

Bond Lab 2016:

- Number of pieces: ~1200 with about 100 pieces per month
- Number of projects: 48 (30 for test-beams and 18 others)



QART Lab

Climatic chambers

- **Guidance and support regarding QA (quality assurance) planning:**
 - methods & processes, risk analysis, standards, specifications, quality control
 - technology development and design feed-back
- **Consulting regarding reliability testing:**
 - ageing tests, failure analysis, evaluation & qualification of component or assemblies
- **Many users:** ALICE ITS, CMS Si Tracker Upgrade Phase II, CMS Hcal, CMS Ecal, ATLAS NSW (GEM foils), EP-ESE and more.

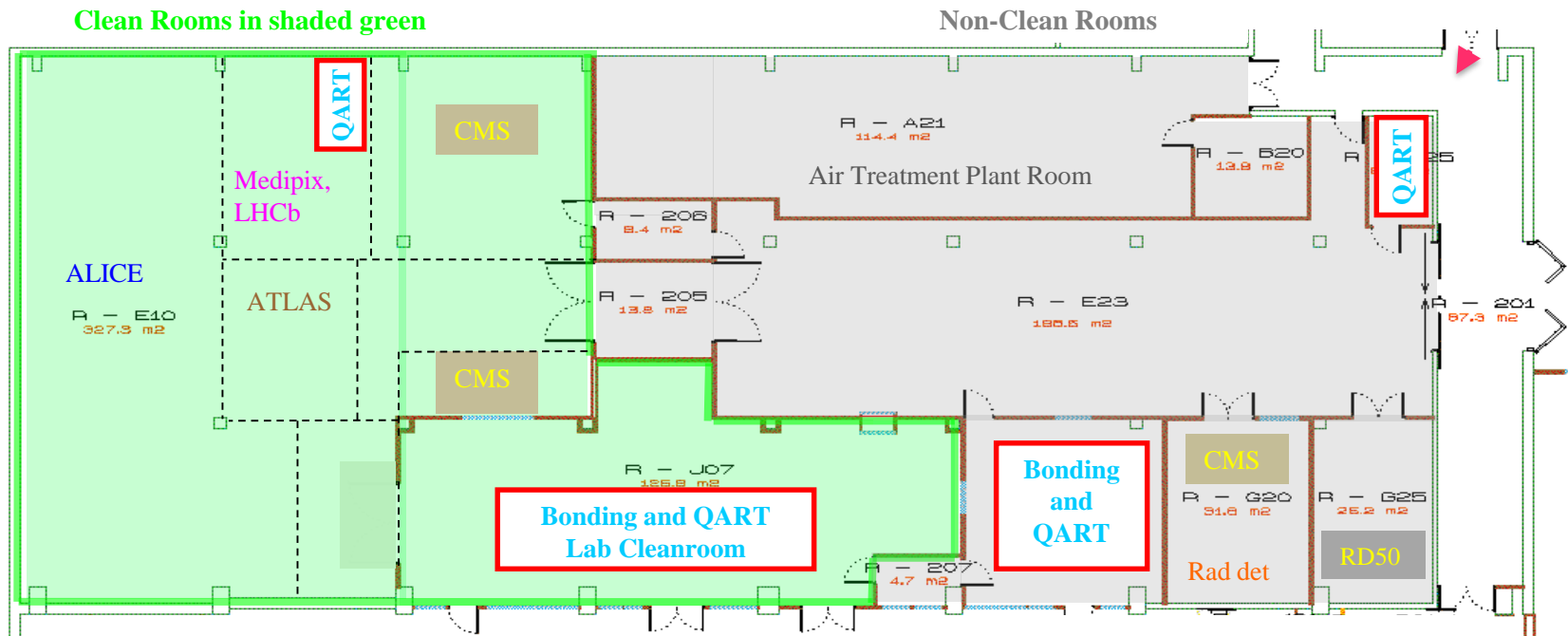


800 DC-DC converters for LHC upgrades

Departmental Silicon Facility (Bat. 186)

- Built in 2002 for the LHC silicon detector development and construction (~800 m²) with cleanroom space for experiments close to the bond lab.
- DSF cleanroom:
 - Shared clean room: 330m²
 - Bond/QART lab clean room: 130m²

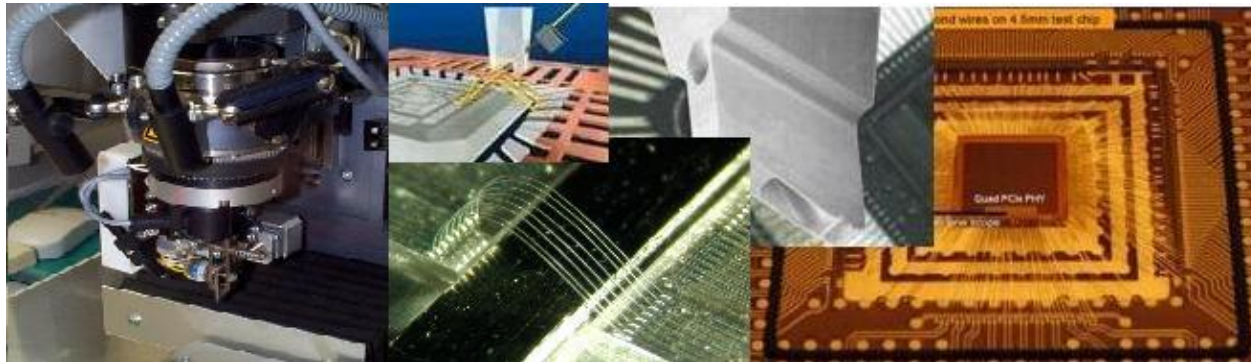
Clean Rooms in shaded green



Users in 2017: ALICE ITS, ALICE MFT, LHCb upgrades (chip R&D), Medipix, ATLAS ITK (pixel), CMS phase 2 tracker upgrade, CMS silicon forward ECAL phase 2 upgrade, LCD silicon calorimeter R&D

Summary Bond/QART Lab

- **Essential and unique service** providing a point of reference for the many users in the community.
- **Increasing demand**, with LS2 and LS3 upgrades coming up.
- **Investment in expertise and equipment/infrastructure to continue to provide high-tech service.** Equipment and infrastructure needs to be maintained and upgraded in order to meet the clients needs (e.g. new bonding machine installed in 2016).
- **Follow closely technological developments** for new trackers and detectors.

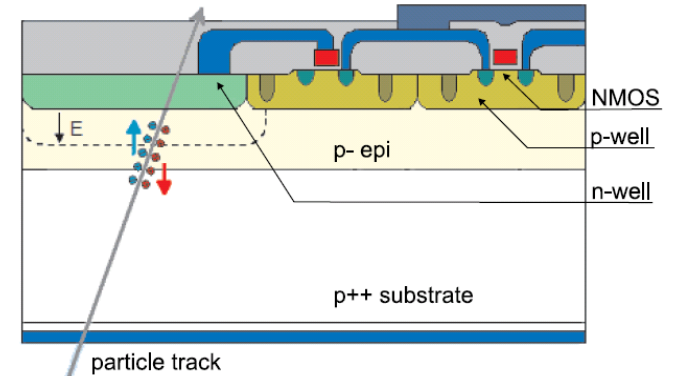


http://bondlab-qa.web.cern.ch/bondlab-qa/bondlab_home.html

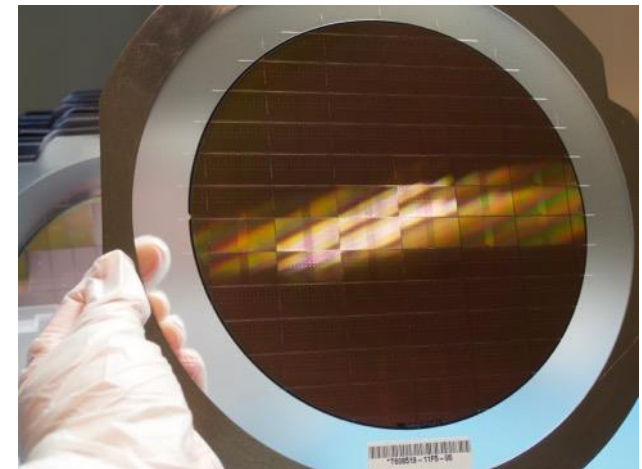
Pixel R&D



- Silicon pixels will be used in all LHC experiments with **two projects using monolithic pixels** (ALICE ITS and MFT).
- Started generic, early-phase pixel R&D activity in DT-DD for future detectors in 2016 to anticipate possible solutions for the upcoming trackers. Centered around module concepts and assembly.
- Via **STREAM (EU Marie Curie Training Network)** activity with special emphasis on **CMOS pixels** and how they can be integrated into future trackers.
- Petra Riedler (0.15 FTE)
Roberto Cardella/DOCT (1 FTE)



CMOS pixel (schematic)



Silicon wafer with CMOS pixel chips (ALICE)

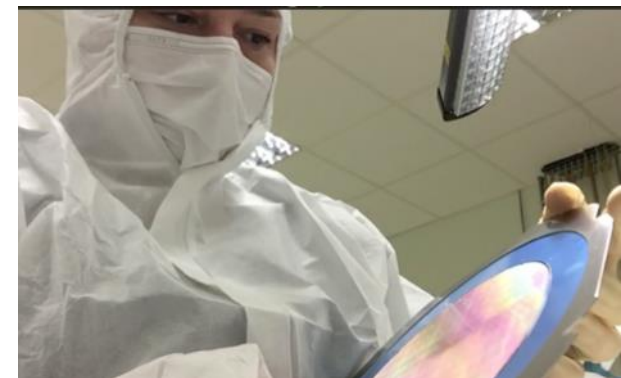
Pixel R&D



- **STREAM:** 3 ESRs (students) at CERN (DT, ESE, ADE) for 3 years
- Within STREAM, started to work on a **design of a novel CMOS pixel sensor** in the TowerJazz technology (used by ALICE) in autumn 2016.
- Design uses a **process modification** developed by ALICE which **enhances the radiation tolerance** of the CMOS sensors (e.g. ATLAS pixel L4: $1.5 \times 10^{15} n_{eq} \text{ cm}^{-2}$).*
- Team composed of ESRs, EP-ESE members (design team lead by W. Snoeys), ATLAS (ADE) members, MIND and close collaboration with outside institutes working in the ATLAS CMOS team.



Roberto Cardella (STREAM ESR), DT-DD



Petra Riedler, DT-DD

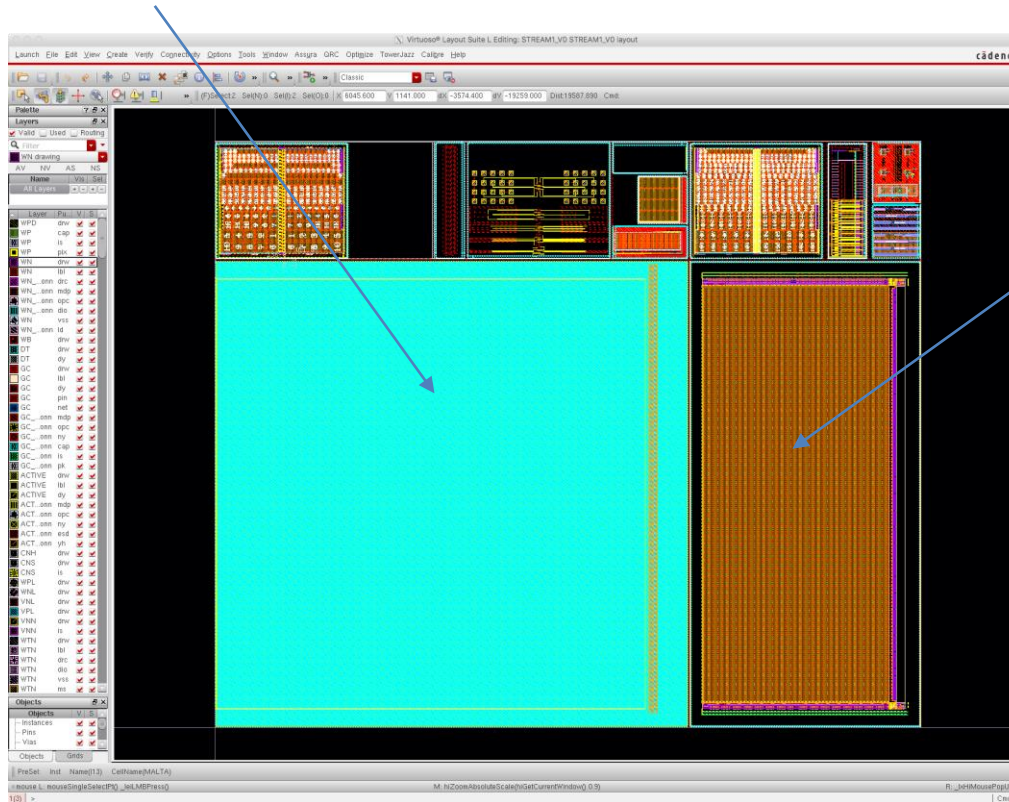
Pixel R&D



STREAM submission to TowerJazz composed of **2 large CMOS pixel sensors (meeting ATLAS specs, e.g. correct 25 ns BC identification, hit rates up 0.11 hits/mm²/BC) available for module assembly studies** and several smaller test structures

MALTA (Monolithics from ALice To Atlas): 2 cm x 2 cm

Pixel size: 36.4 μm x 36.4 μm , low power design with hits transmitted asynchronously



Monopix (version for TowerJazz): 1 cm x 2 cm
Pixel size: 36.4 μm x 40 μm

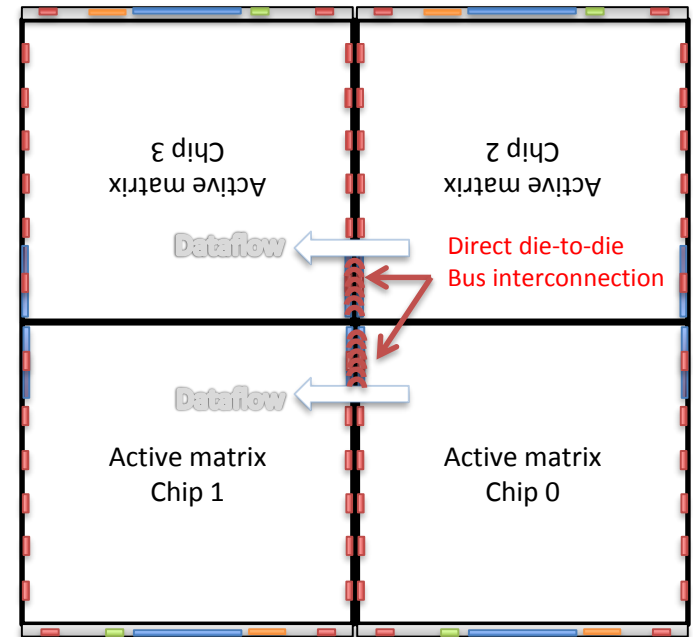
Interconnection test-structure (compatible with MALTA connection pads)

16 channel LVDS/CMOS I/O test chip (also integrated into MALTA) for signal transmission tests

Pixel R&D



- STREAM submission will receive **pad silicon wafers in summer and full CMOS wafers at the end of the summer.**
- **Module assembly using MALTA's chip-to-chip data transfer** (reduces need of a flex cable)
 - Study prototype modules with direct chip-to-chip wire bonding
 - Study alternative interconnections using the small interconnection structure
- **Thinning, dicing and module assembly study using pad wafers.**
 - Interconnection and mechanical tests
- **Functional tests of the CMOS chips** (including lab tests and testbeam before and after irradiation) planned for autumn



Pixel R&D Summary



- There is an increasing interest in CMOS pixel sensors as a possible solution for large tracker areas. This triggers also the **interest to study new module and interconnection concepts**.
- **Pixel R&D is a new activity in DT, which complements well the traditional rad-hard sensor R&D centered around RD50 and connects to the system aspects of tracking detectors.**
- The activity **builds on existing infrastructure and expertise, but adds the capability** of exploring new interconnection technologies, new module designs using new pixel detectors.