Microsystems Engineering

Alessandro Mapelli

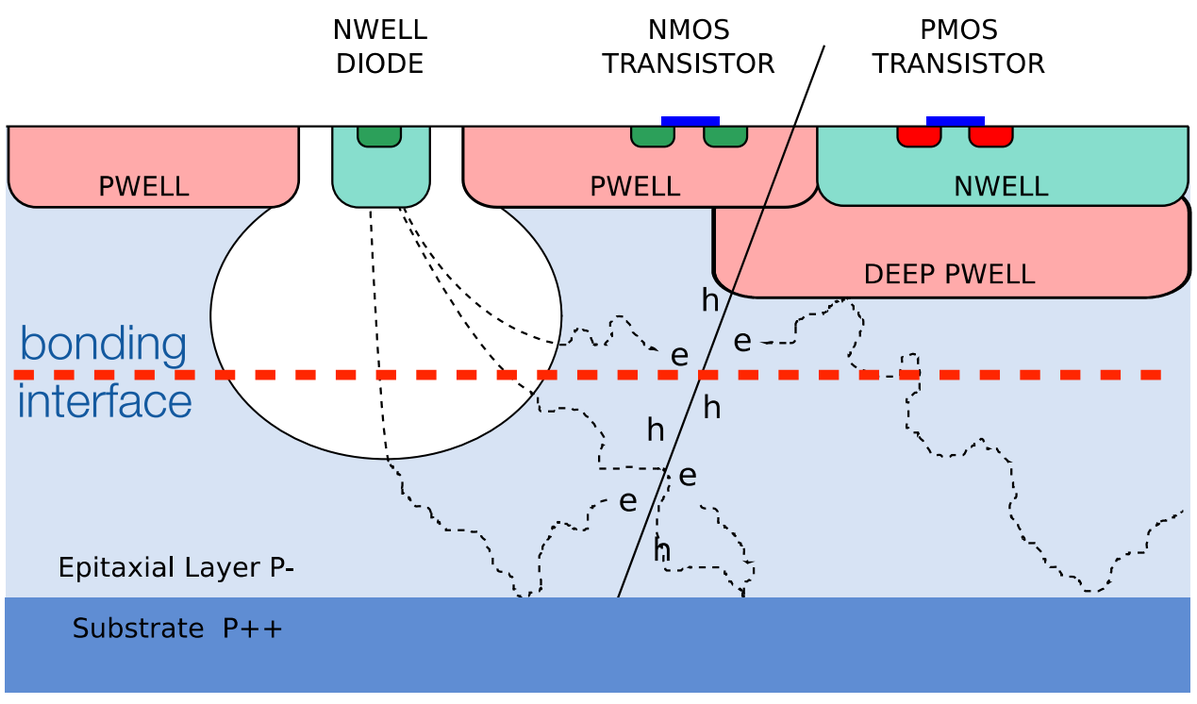
DD Section Meeting, 27 November 2015

- **novel types of detectors**
  - monolithic silicon pixel detectors obtained by low temperature bonding
  - microfluidic scintillation detectors
- **alternative approaches to on-detector services**
  - silicon microchannel cooling
- **micro-engineered solutions for particle detectors**
  - microfluidic connections and interconnections
  - silicon fracture mechanics

Microsystems are investigated since 2010 in the CERN Physics Department (PH) by the Detector Technologies Group (PH-DT) in close collaboration with the EPFL Microsystems Laboratory (LMIS4).

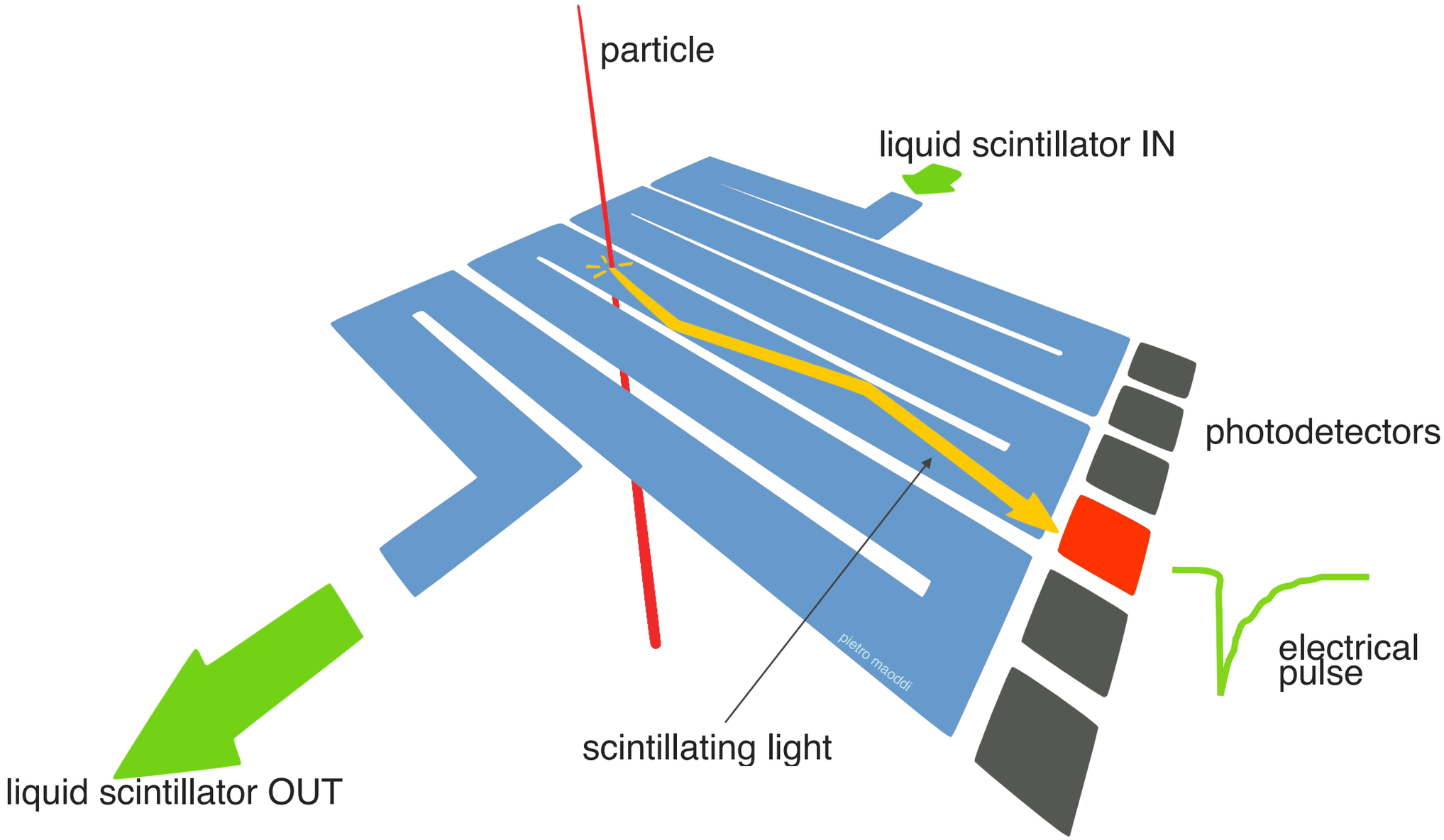
monolithic detectors obtained by low temperature bonding

Jacopo Bronuzzi, PhD Student



- direct bonding of silicon to silicon at CMOS-compatible temperatures
- manufacture devices
- investigate the charge collection efficiency across the bonding interface

microScint - microfluidic scintillation detector



- Low material budget - Thin microfluidic device
- High spatial resolution - Photolithography patterning
- Increased radiation resistance - Circulation (and renewal) of detecting medium

Single layer and doubler layer microScint fabricated in silicon or SU-8

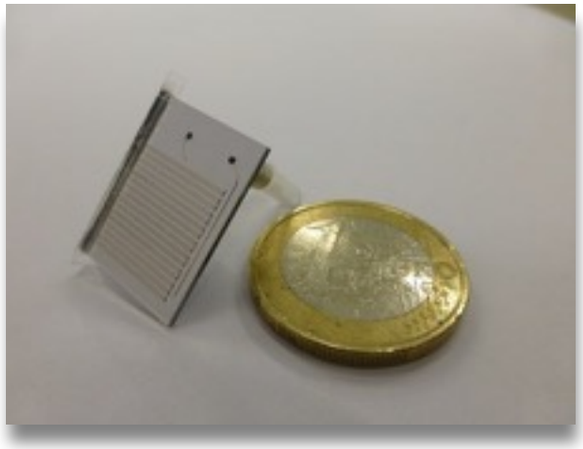
Pietro Maoddi, EPFL PhD Thesis No. 6620 (2015)

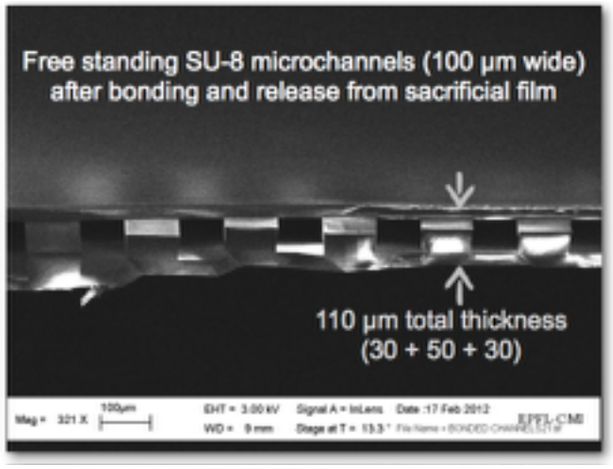
https://infoscience.epfl.ch/record/208830?ln

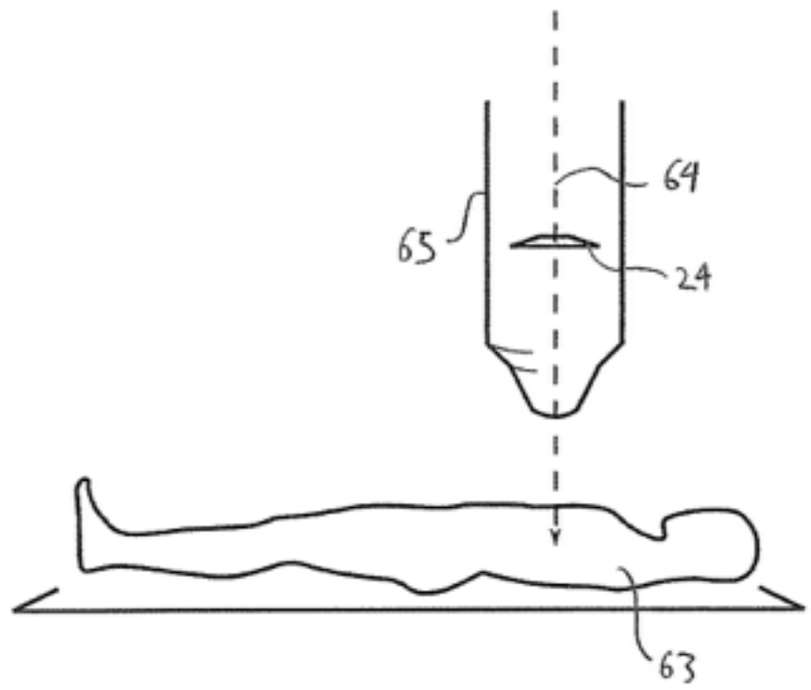
Silicon

SU-8

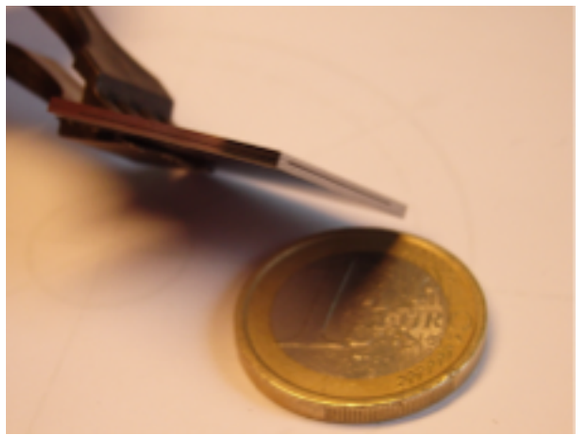
Single Layer

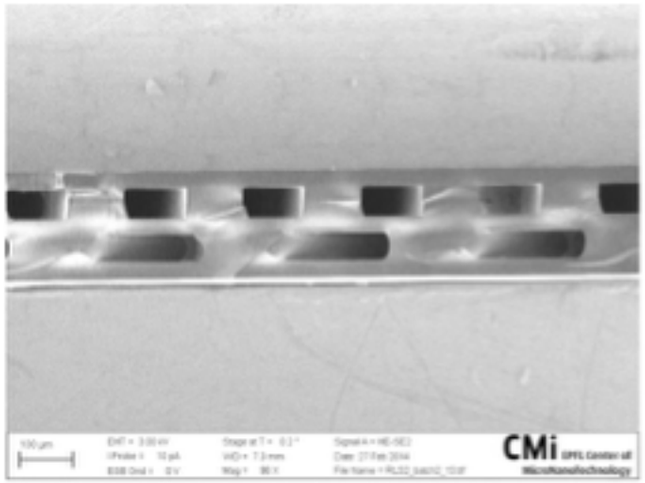


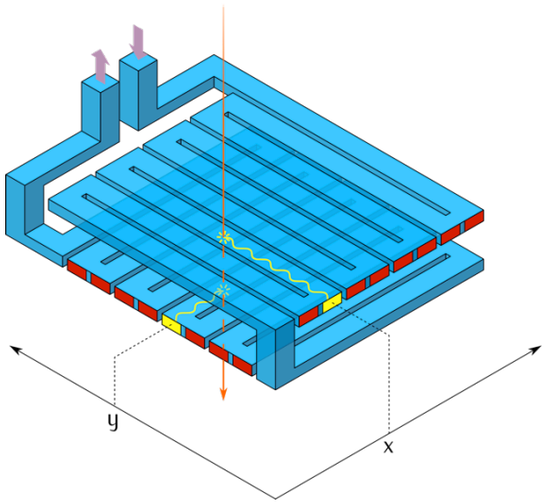




Double Layer





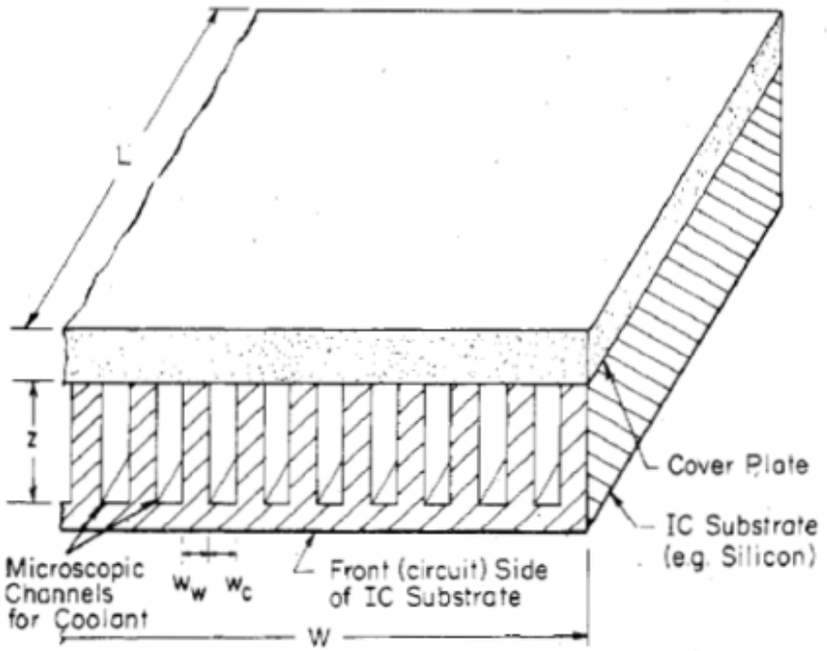


(10) International Publication Number
WO 2013/167151 A1

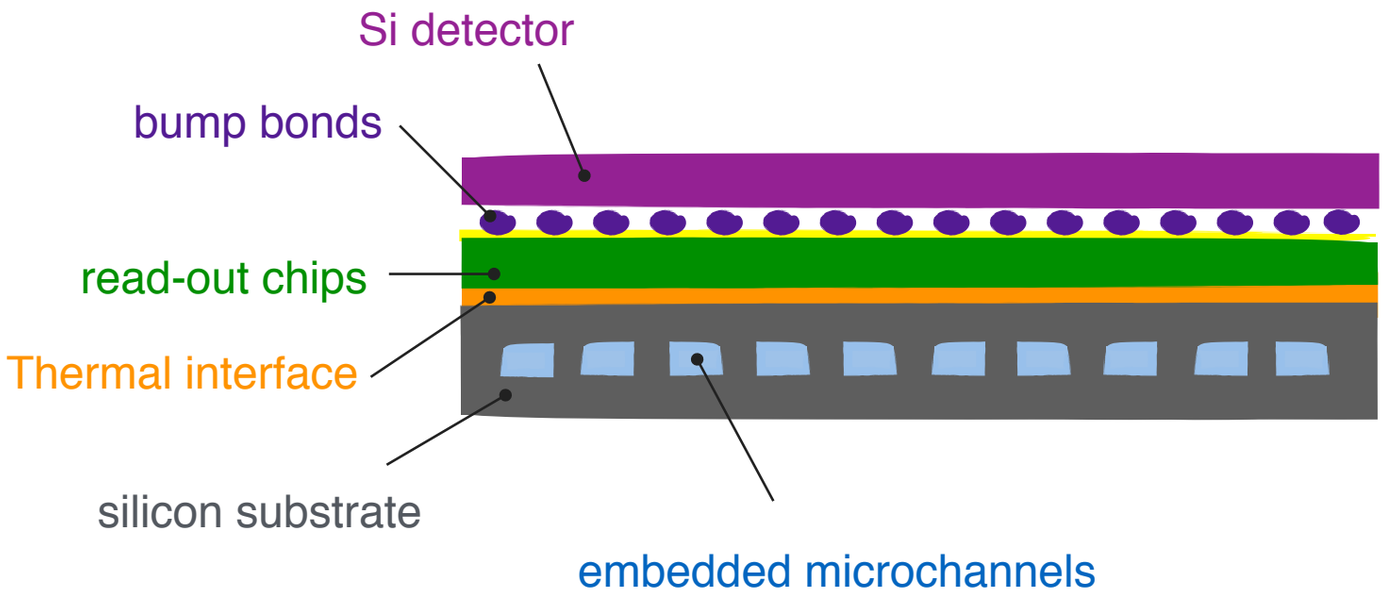
microScint - microfluidic scintillation detectors

- Single layer and doubler layer devices fabricated in silicon or SU-8
  - Pietro Maoddi (PhD, 2012-2015)
- Integration of photodetectors in microfluidic scintillation channels
  - Rosalia Moreddu (MSc Thesis 2015, now COAS)
- Microchannels embedded in substrates with good optical properties (PMMA microchannels)
  - Jacopo Bronuzzi (MSc Thesis, 2015)
  - Luca Muller (internship then MSc Thesis in 2016)
  - Ruben Ricca (internship)

microCool - silicon microchannel cooling



Tuckerman and Pease, IEEE Elec. Dev. Letters, Vol. 2, 5, 1981



- No CTE mismatch
- Low material budget
- Active/distributed cooling
- Radiation resistance
- Great integration potential

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A VERY COOL COOLING SYSTEM

The NA62 Gigatracker is a jewel of technology: its sensor, which delivers the time of the crossing particles with a precision of less than 200 picoseconds (better than similar LHC detectors), has a cooling system that might become the precursor to a completely new detector technique.

The 115 metre long vacuum tank of the NA62 experiment.

The NA62 Gigatracker (GTK) is composed of a set of three innovative silicon pixel detectors, whose job is to measure the arrival time and the position of the incoming beam particles. Installed in the heart of the NA62 detector, the silicon sensors are cooled down (to about -20 degrees Celsius) by a microfluidic silicon device. "The cooling system is needed to remove the heat produced by the readout chips the silicon sensor is bonded to," explains Alessandro Mapelli, microsystems engineer working in the Physics department. "For the NA62 Gigatracker we have designed a cooling plate on top of which both the silicon sensor and the readout chip are bonded."

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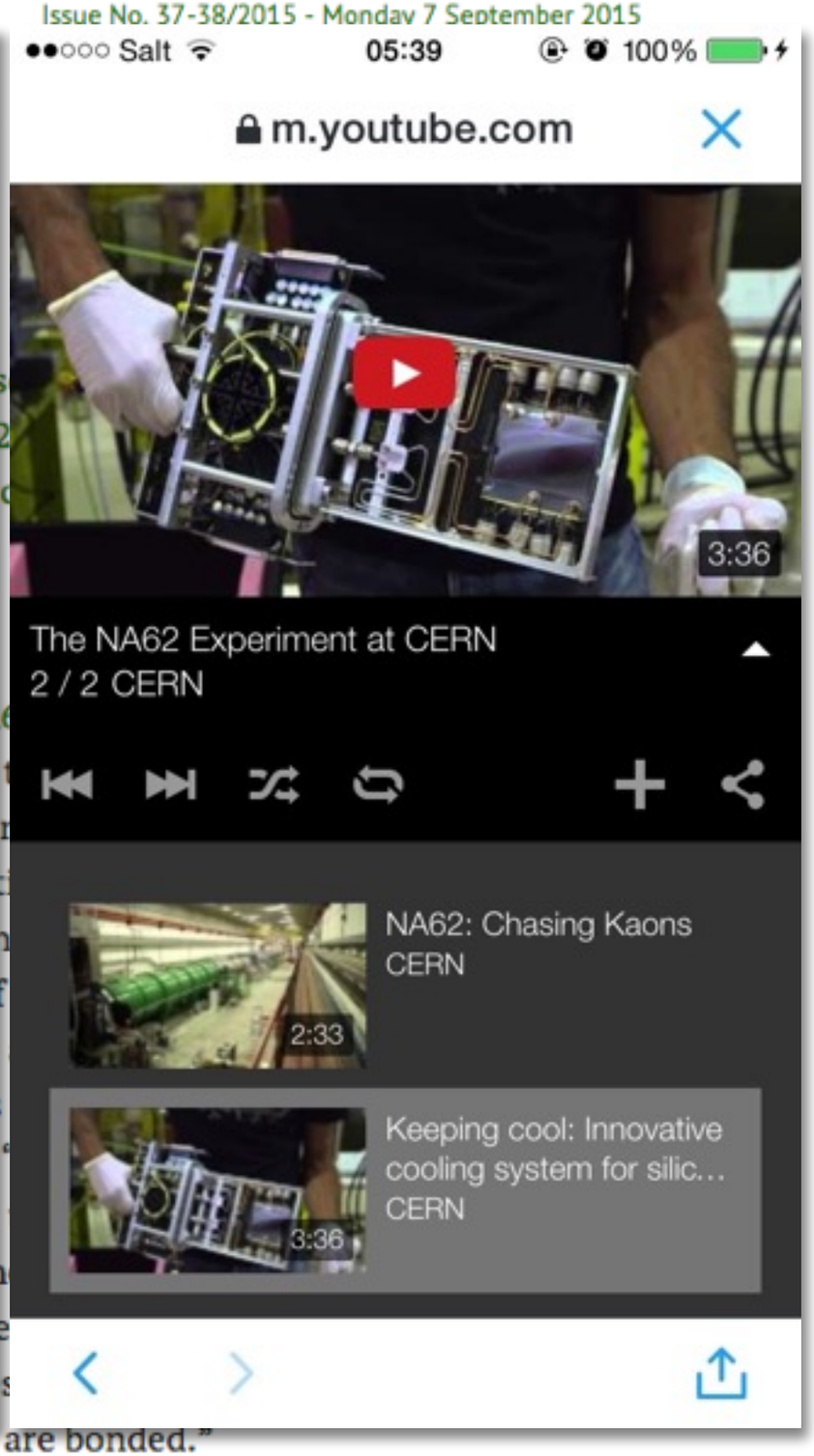

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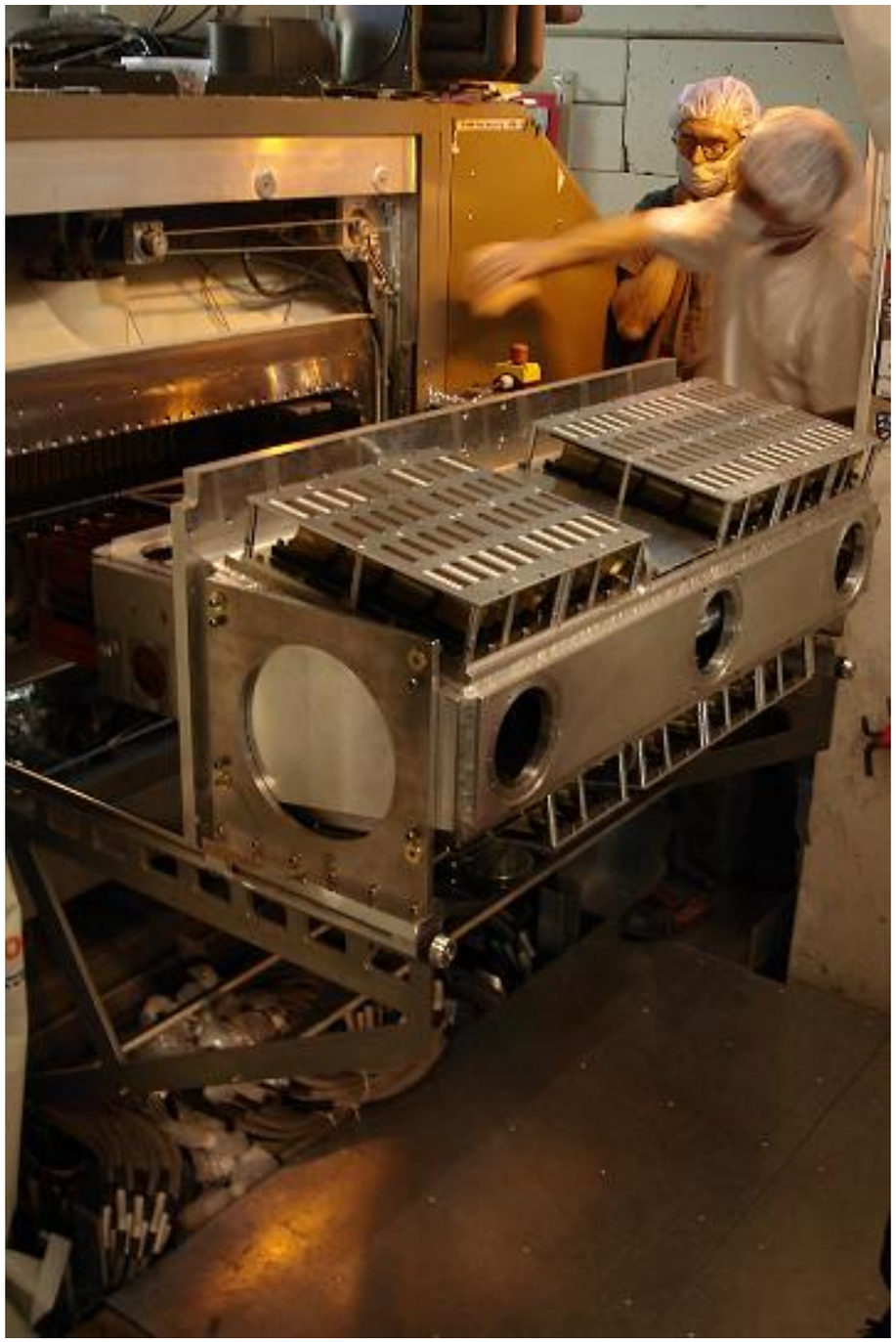
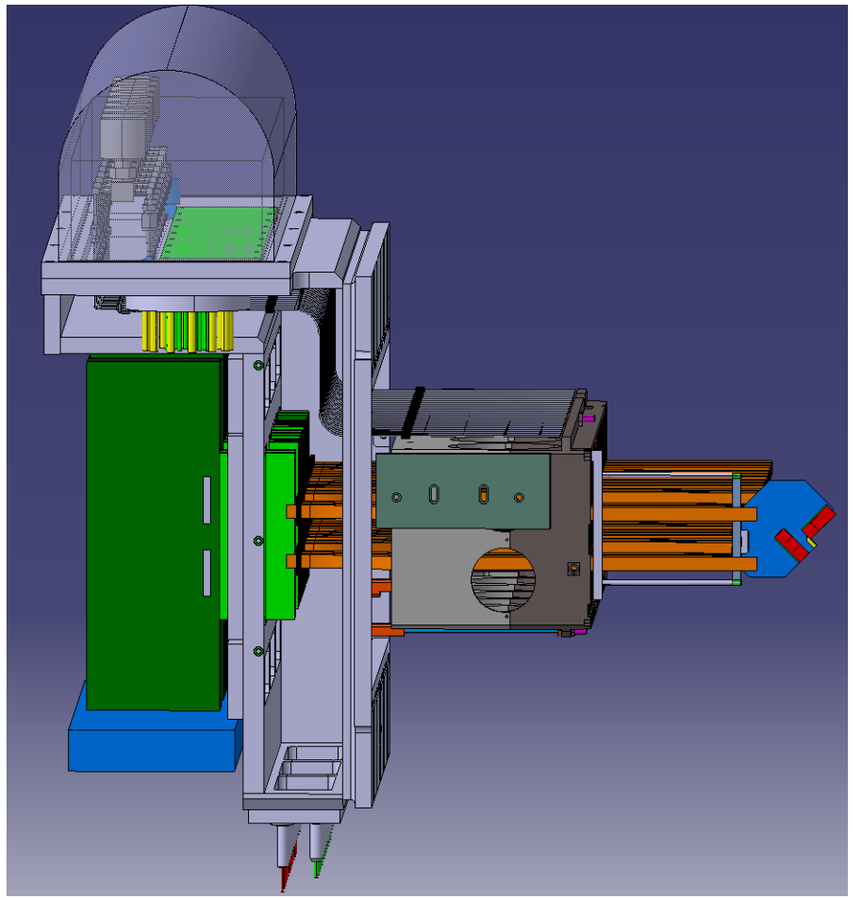
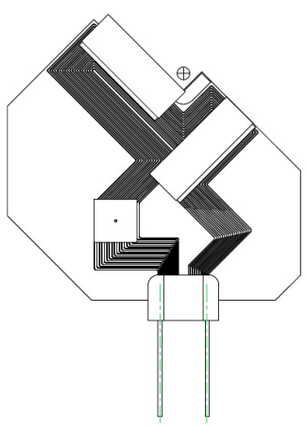
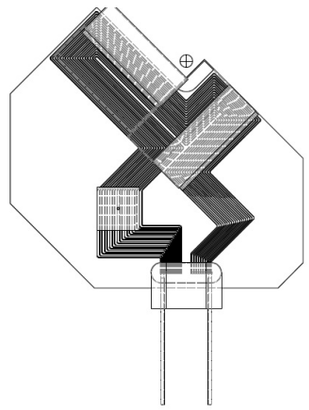
LHCb VeLo Upgrade



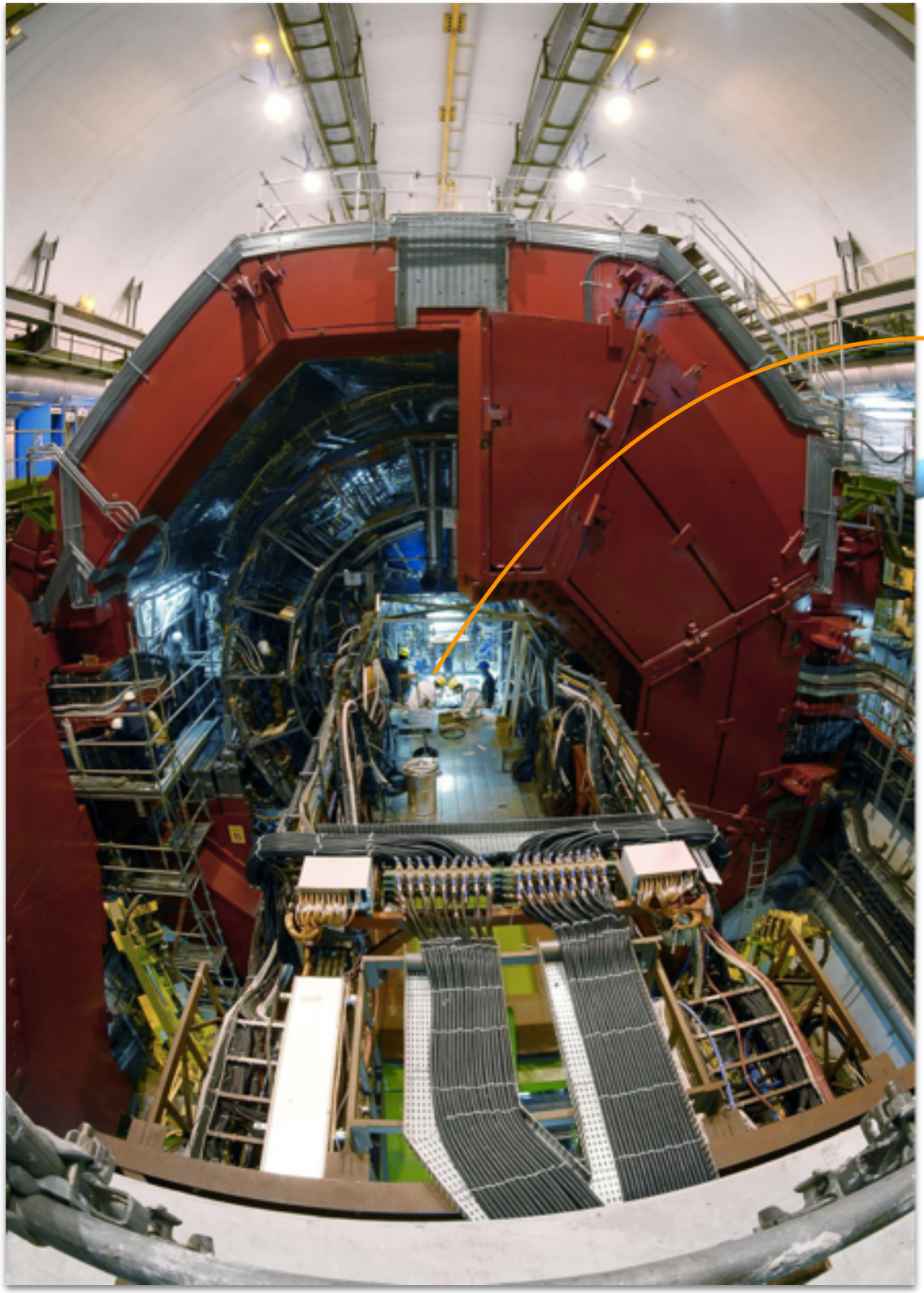


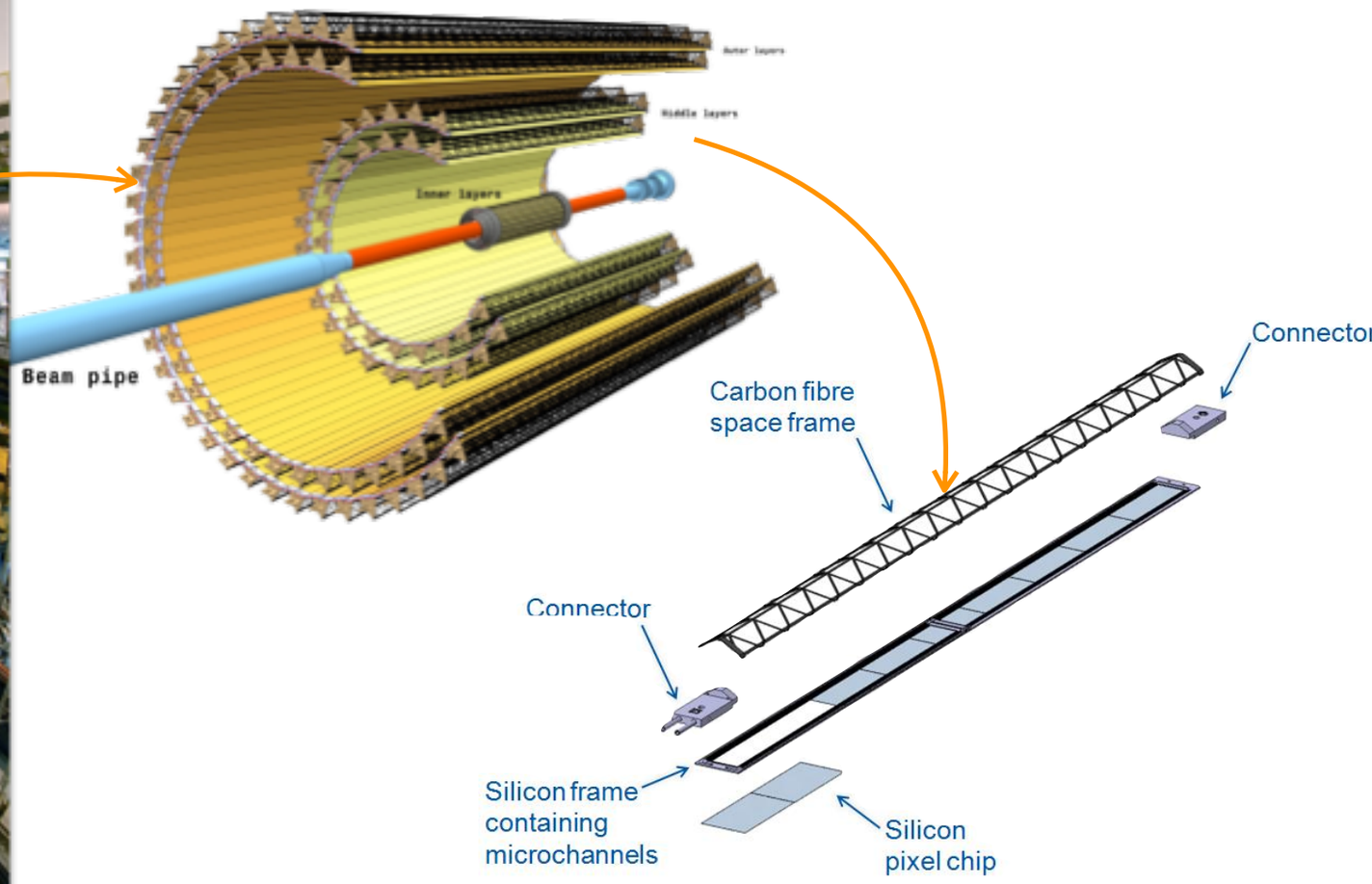




ALICE Inner Tracking System Upgrade

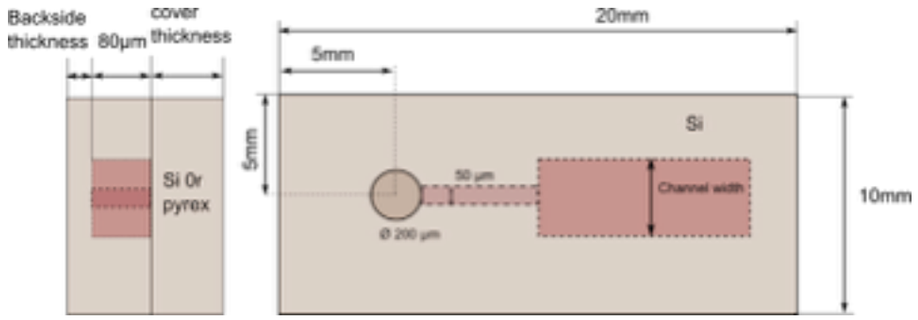
Andrea Francescon, PhD Student, now Fellow
Tiago Morais, MSc Student



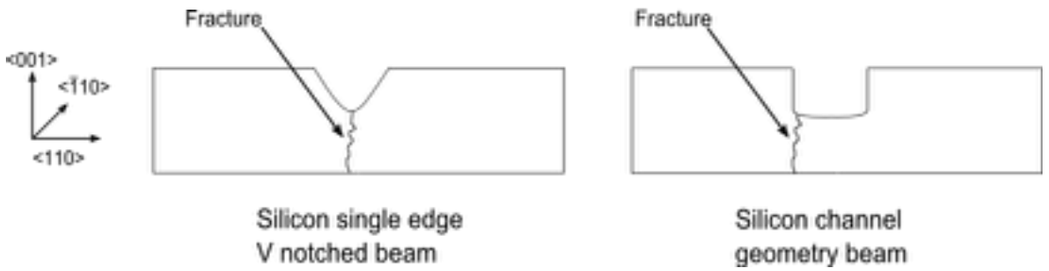


silicon fracture mechanics

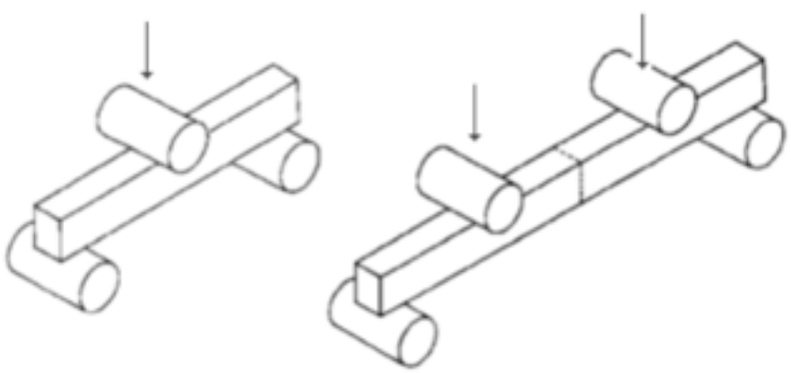
with PH-DT-EO



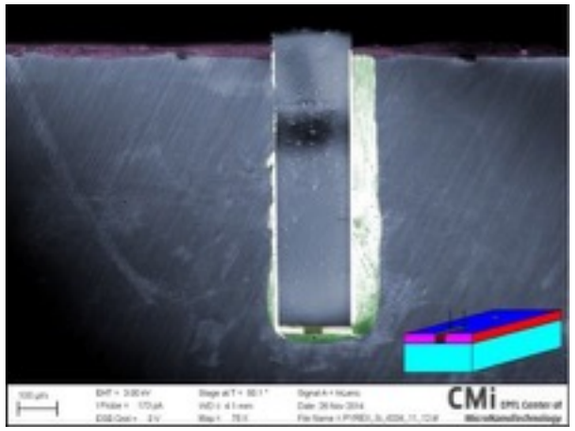
embedded microchannels for pressure tests

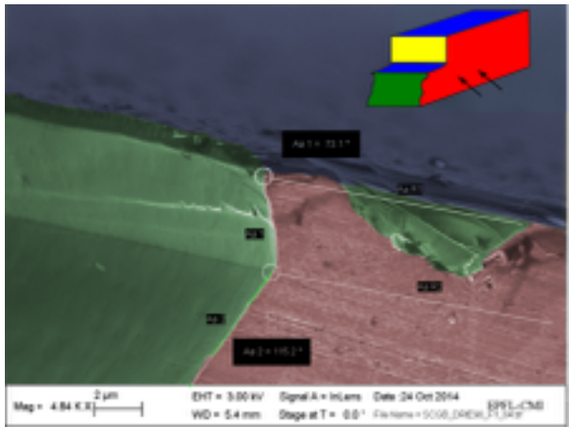


silicon samples obtained with different etching methods (RIE, DRIE, KOH)

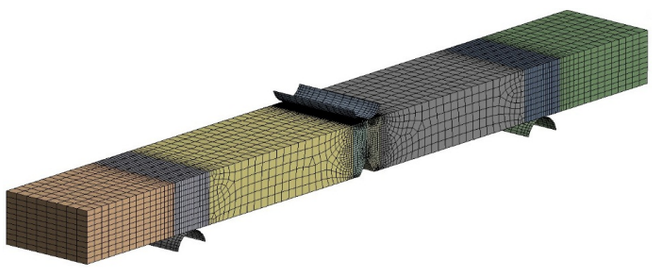


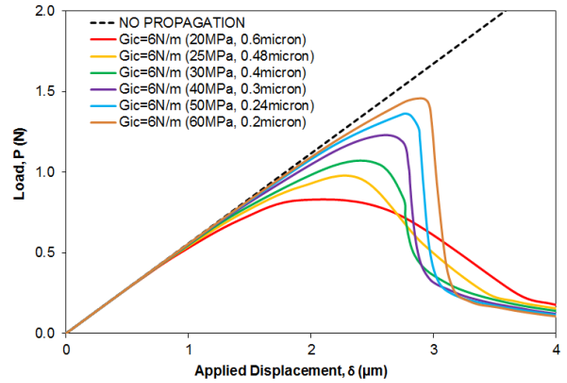
3-point bending and 4-point bending tests





SEM images analysis of rupture samples.





FEA parametric studies