

# Development of LAMBDA: Large Area Medipix-Based Detector Array





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- > Detector design and current status of system
- Further developments
- > Germanium pixel detector development



# **PETRA-III** synchrotron

- New 3<sup>rd</sup> generation light source (2009)
- > Aims of detector development
  - Improve on successes with silicon hybrid pixel detectors
  - Replace silicon with high-Z material for high energy beamlines





# Medipix3 readout chip

- > 21 groups in collaboration
  - Chip design at CERN
- Photon-counting chip
- > 256 \* 256 pixels, 55µm
- Continuous read-write (2000 fps with 12 bit counter depth)
- Charge summing using interpixel communication





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# LAMBDA detector head

### > 6-by-2-chip layout

- Set by typical silicon and high-Z wafer sizes (6", 3")
- > Tilable layout
  - Electronics behind sensor
- > High-speed readout
  - All 8 readout pairs per chip used
- Cooling
  - Compatible with lowtemperature operation (-60°C for germanium)



Heat spreader



# System design



**Initial readout board** – USB2 readout, allows chip testing and firmware development

**Final board** – Board based on XFEL (AGIPD) developments with 10 GBE readout



### **Detector assembly and module ceramic PCB**



Heat spreader to improve temperature uniformity

- Low-Temp Co-fired Ceramic (LTCC) board KOA, Japan
  - Matching of CTE to sensor materials (6 ppm / K)
  - Heat coupling through board under each chip with thermal vias
- > 500-pin Samtec high density right-angle connector



### **Current readout board**

- > Virtex-5 FPGA
  - Same series as FPGA for high-speed readout board
- > USB2 readout
- > PC control with C++ (functions called by simple GUI)

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### **Current system**

- Si Medipix3 2\*2-chip assembly (300µm thick)
- > Flat connector used, rather than right-angle





### **Detector test**

#### Detector is working

- Standard functions implemented
- Threshold equalisation running (but needs improvement)
- Test mask image taken with Mo X-ray tube







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### Large-area silicon modules

- > 6" wafers with large Medipix3-layout sensors ordered from Canberra
  - Masks in production
- Working on assembly process and single module mechanics





# **High-speed readout system**

- > Will modify board and firmware from XFEL
  - Collaborating with TUM on firmware
  - See Franz M. Epple's poster
- Virtex-5 FPGA with PowerPC core
- RAM for data re-ordering and burst mode
- > 4 \* 10 Gbit Ethernet to allow maximum readout rate
  - Maximum data rate from module is ~ 25 Gbit/s!





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# **Germanium pixel development**

Canberra (Lingolsheim): M Lampert, M Zuvic, J Beau

Fraunhofer IZM (Berlin): T Fritzsch, R Jordan, H Oppermann, O Ehrmann





- > High-purity, high uniformity 90 mm Ge wafers available
- Cooled operation needed to reduce leakage current
  - Per pixel current must be within ROC limits (order of nA per pixel)
  - Est. -60°C operation with Medipix3 (55µm)
    - Measured transport and depletion fine at this temperature
  - Thermal stresses are biggest problem
- Fine pixellation and bump-bonding must be developed



### **Bump bonding and sensor processing**

- ~3.5µm max displacement during cooling
- Indium bump bonding
  - Indium remains ductile at low temperatures
  - Already used for IR hybrids at -196 °C
- > Ge diodes used for processing tests
  - Passivation and processing optimised to avoid sensor damage
  - Bumps will be electroplated on sensor and ROC
  - Bonding will use thermocompression at 80°C

Ge		
Si		



### **Pixel detector production at Canberra**

#### Detector structure:

- Thinned germanium wafer (700µm)
- Boron implanted on back contact
- New pixel architecture
- > Test wafer produced (55µm pixels)
- Medipix3 90 mm mask produced
  - 16 singles per wafer
- > Optical Ge dummies in production
  - Optimization of flip chip at IZM
- > 2 high-purity wafers will be produced
  - Expect sensors later this year







### Summary

- > Goal is to provide improved hybrid pixel detectors for PETRA-III
- > Prototype Medipix3 module is complete
- Continuing to produce full Si sensors and high-speed readout
- Developing pixellated Ge sensors for high-energy beamlines







