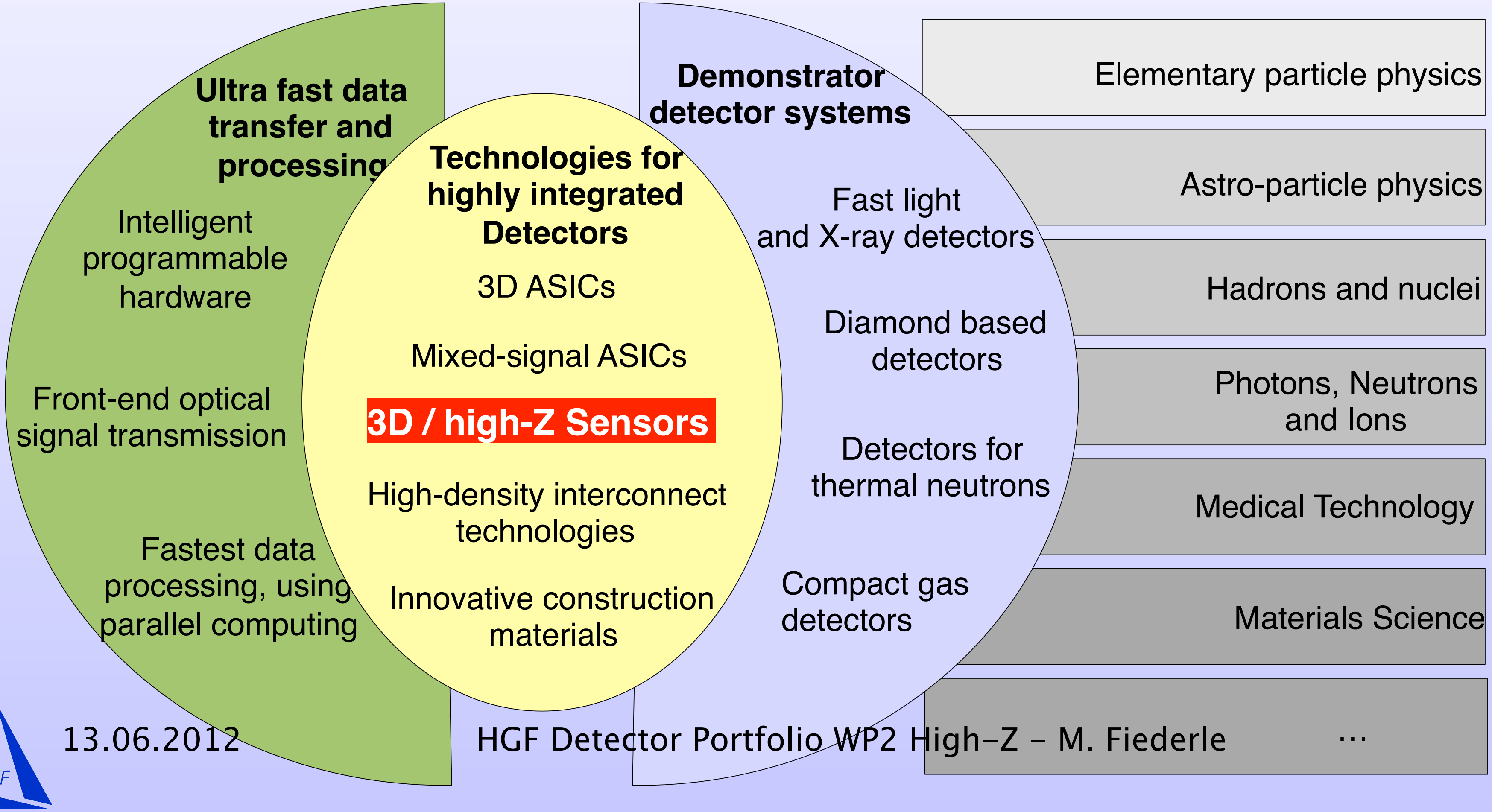
HGF - Detector Technology and –Systems:

WP 3D / High-Z detectors

Michael Fiederle



Ultra fast data transfer and processing

Intelligent programmable hardware

Front-end optical signal transmission

Fastest data processing, using parallel computing

Technologies for highly integrated Detectors

3D ASICs

Mixed-signal ASICs

3D / high-Z Sensors

High-density interconnect technologies

Innovative construction materials

Demonstrator detector systems

Fast light and X-ray detectors

Diamond based detectors

Detectors for thermal neutrons

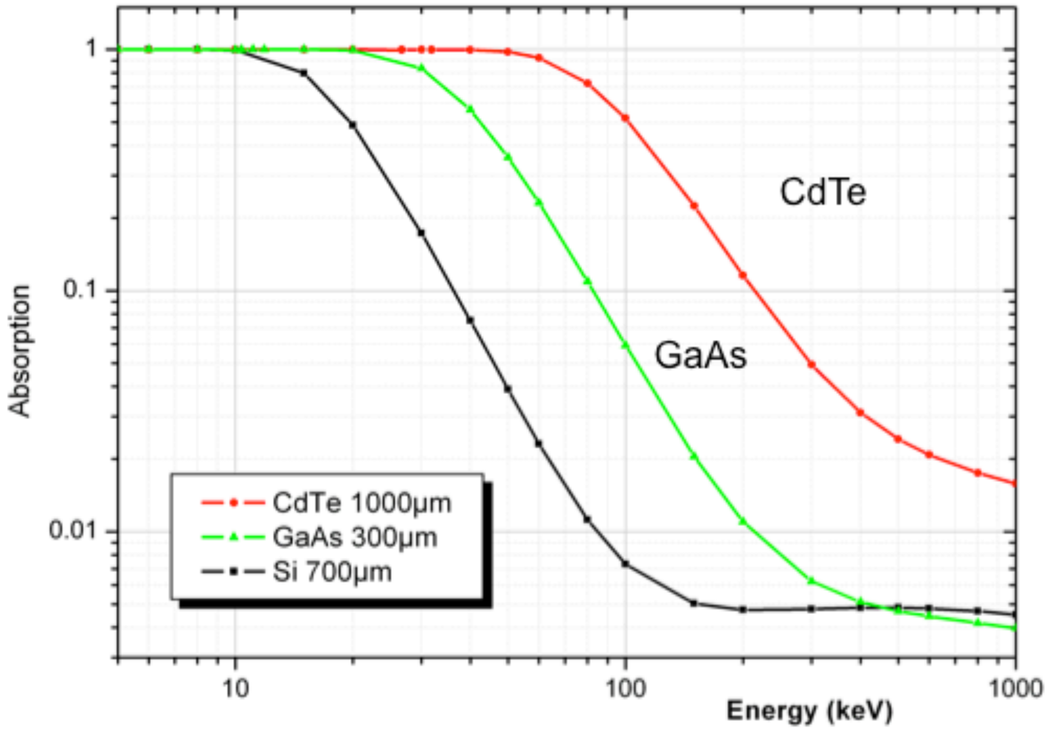
Compact gas detectors

Application areas

- Elementary particle physics
- Astro-particle physics
- Hadrons and nuclei
- Photons, Neutrons and Ions
- Medical Technology
- Materials Science
- …

High Z semiconductor detectors

- Direct converter => **semiconductor material**
- semiconductors:
  - **CdTe**
  - **GaAs**
  - **Ge(?)**
  - **CdZnTe**



Absorption

@ 40keV:

Si: 7.5%

GaAs: 55%

CdTe: 100%

@ 60keV:

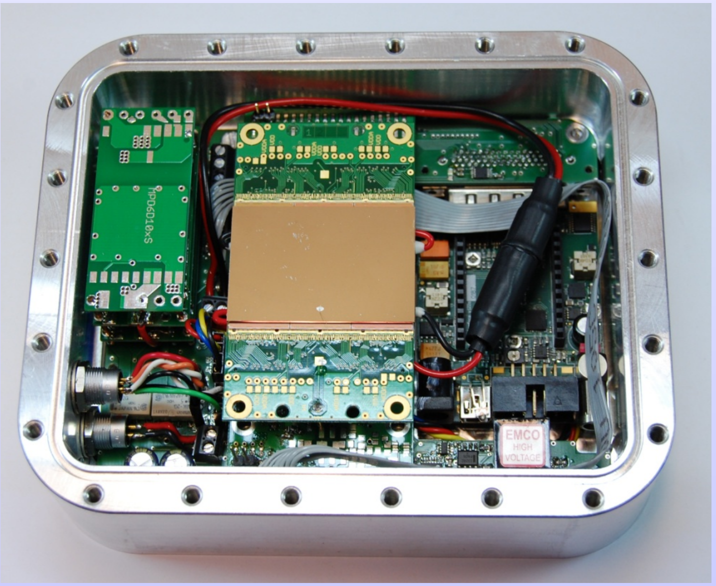
Si: 2.2%

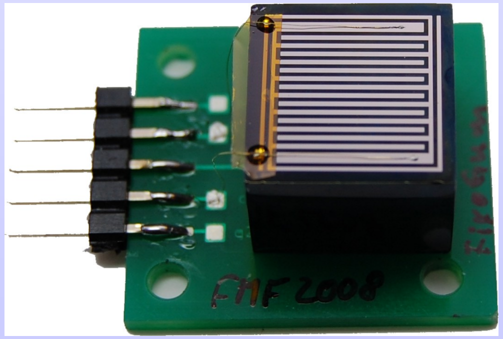
GaAs: 22%

CdTe: 90%

Radiation detectors CdZnTe

- Single detectors with high energy resolution
- Pixel detectors: combination with electronics
  - Spatially resolving systems
  - Tracking of charged particles





Potential applications of high Z pixel detectors

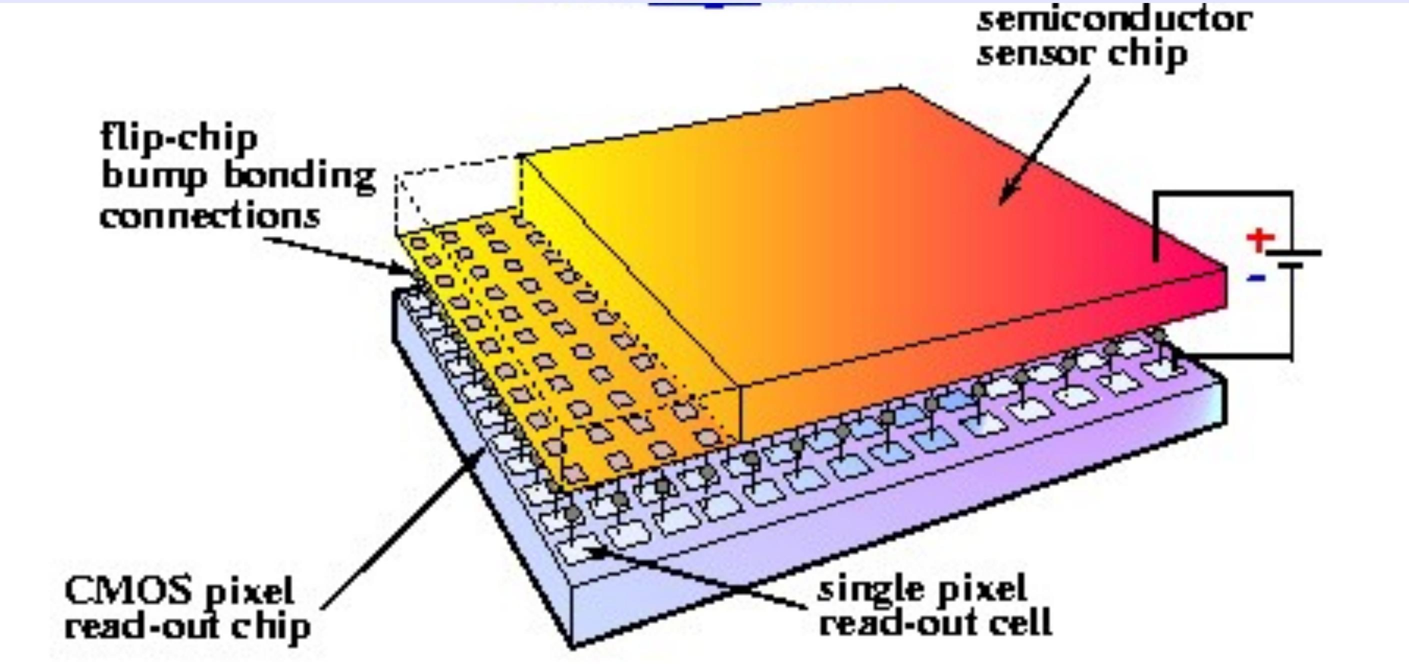
- X-ray Imaging (2D imaging):
  - Pixel detectors with µm resolution
- X-ray Diffraction:
  - Large areas detectors
- High flux X-ray CT applications:
  - Pixel detectors with 200 µm and higher spatial resolution
  - High photon fluxes: 10^9 mm^2/s and higher
  - Medical CT
- Gamma-Ray detectors for Medical and Security applications

High-Z detectors / 3D

- Hybrid Pixel detectors
- **Medipix3 => Electronics platform**
- Pixel layouts:

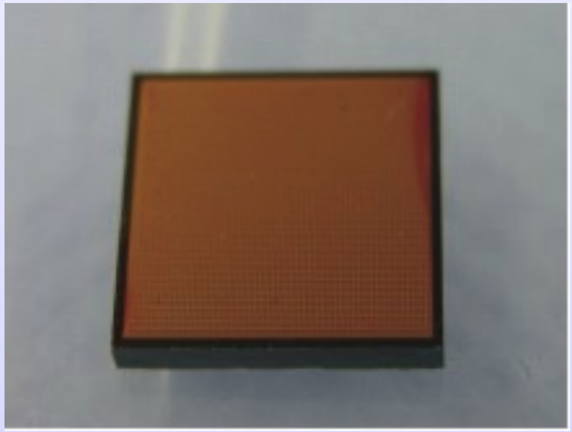
Fast lane **pixels 55 µm with 1 mm / 600 µm sensors**

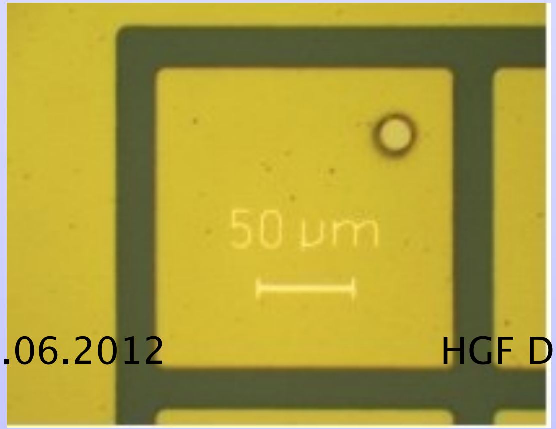
  - **Large pixels 550 µm with 3 – 5 mm sensors**

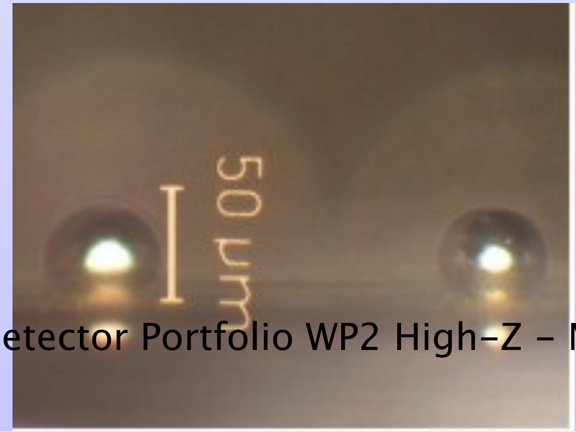


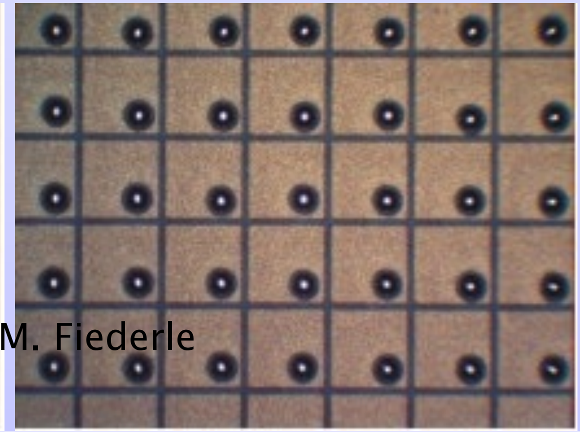
Key technologies

- Processing of high-Z sensors
- Flip-chip technology at low temperatures for pixel detectors:
  - 65000 with 55 µm pixels (HD)
  - 100 with 550 µm pixels
- integration into detector systems









Images with GaAs assemblies

MPX3 assembly
25 kV – 200 V
TH0 6 keV

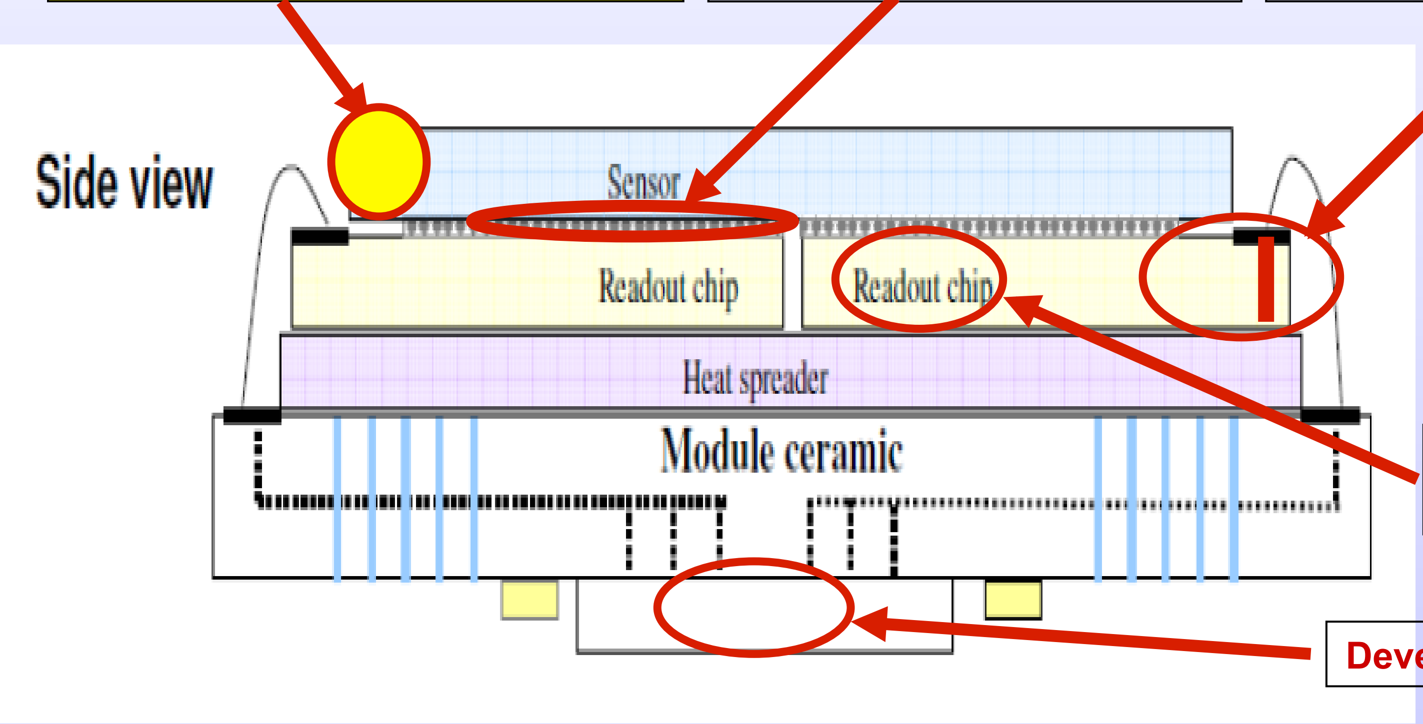
Task 0 fields of applications

- Identification of fields of applications for high-Z sensors
- Contribution of all partners
- Applications limited to
  - Small pixel systems: 55 µm / 1 mm
  - Large pixel systems: 550 µm / 3 mm
- Inputs required in the first 6 months

MS: Fields of application for pixel detectors

The “Helmholtz-Cube”

Vertically Integrated Detector Technology



Replace standard sensor with: 3D and edgeless sensors, as well as High-Z

Replace standard bump-bonds with new interconnect techniques

Replace standard ASIC and wire bonds with thinned ASICs and TSV as well as ball-grid arrays

Replace standard ASIC with 3D-ASICs

Develop new high speed IO’s

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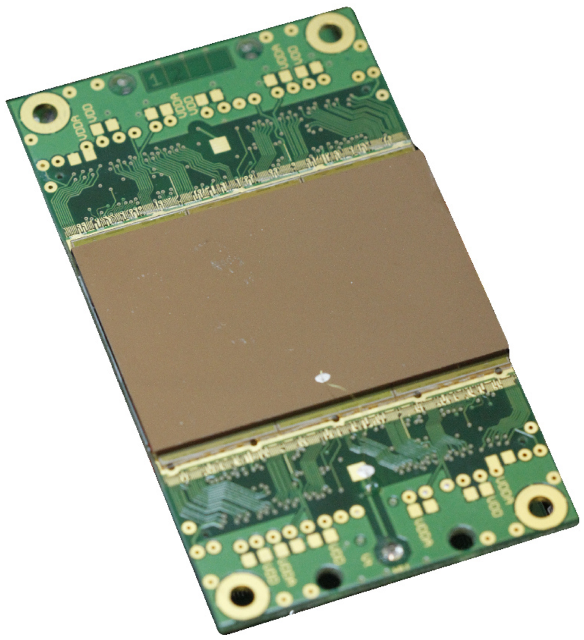
T1 pixel detectors

Task 1

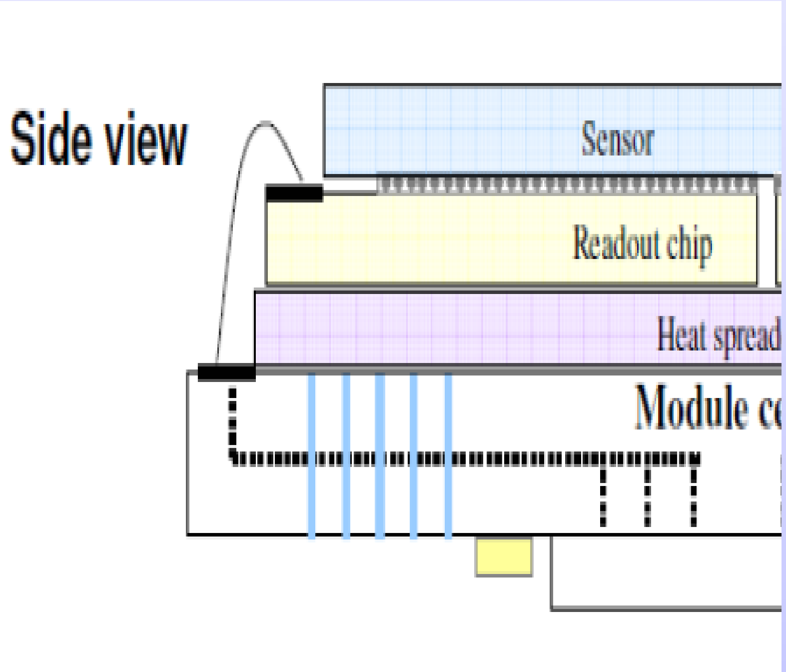
- sensor material: CdTe
- detector layout: 55 µm pixels
- active area: 28x43 mm^2
- Flip-chip bonding
- Hexa modules: 4 modules
- groups: KIT/FMF



T2 Integration HGF Cube

Task 2

- Detector boards provided by DESY
- Assemblying CdTe modules
- Wirebonding
- Backside contact wire
- Groups: KIT/FMF, DESY



MS: CdTe HGF cube

T3 Tests with HGF Cube

Task 3

- Integration of CdTe module into HGF Cube by DESY
- Tests with CdTe modules with X-ray tubes and at ANKA and DESY
- Report on CdTe modules
- Groups: KIT/FMF, DESY

T4 Production of further HGF Cubes

Task 4

- Production of CdTe Hexa modules
- Integration into HGF Cubes
- Providing of Cubes to partners
- Tests in different fields of applications
- Groups: KIT/FMF, DESY + all

Funding of Cubes by partners
Ownership of Medipix3 systems by KIT, FMF and DESY

T5 GaAs HGF Cubes

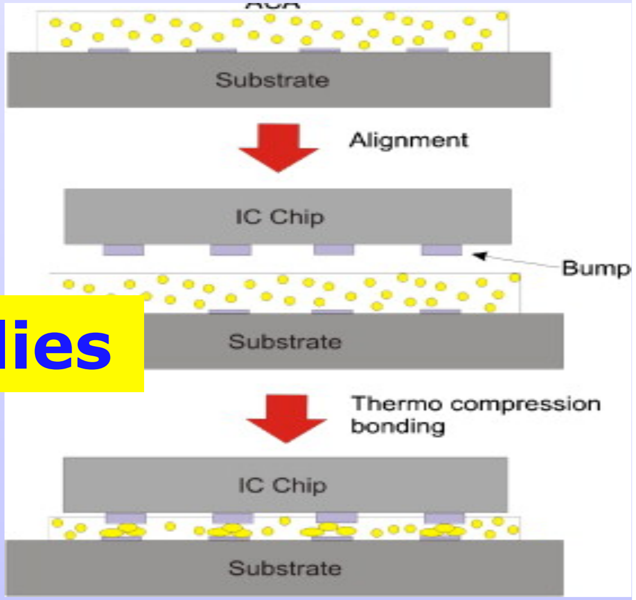
Task 5

- Production of GaAs Hexa modules
- Integration into HGF Cube
- Tests with GaAs HGF Cube
- Groups: KIT/FMF, DESY

T6 Large pixel sensors

Task 6

- Processing of 3 – 5 mm thick CdZnTe
- Detector layout: 550 µm pixels, 14x14 mm^2
- Flip-chip bonding with Gold-stud and conductive polymer to Medipix3 (t.b.d.)
- Groups: KIT/FMF, KIT IPE

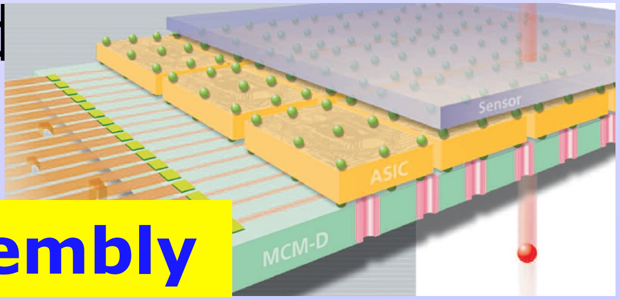


MS: CdTe – Large pixel assemblies

T7 3D technologies

Task 7

- Use of technology of Open-3D TSV for electronic chip
- 3D sensors processing: Si, GaAs and CdTe
- Flip-chip bonding of CdTe and GaAs sensor to TSV thinned Medipix3 chips (Open-3D)
- Integration into detector system with tiling of assemblies
- Investigation of edge-less Cd
- Groups: KIT-FMF, DESY



MS: CdTe - MPX3 with TSV assembly

WP high-Z summary

Task	Duration	Milestone	MS Date	Groups
T0 Fields of applications	3 Months	List of applications	October-12	All
T1 Pixel detectors	6 Months	CdTe sensors	November-12	KIT-FMF
T2 CdTe HGF Cube	9 Months	CdTe Cube	January-13	KIT-FMF, KIT-IPE, DESY
T3 Tests with HGF Cube	3 Months	Report	March-13	KIT, DESY
T4 Production HGF Cubes	9 Months	Cubes	September-13	KIT-FMF
T5 GaAs Cube	9 Months	GaAs Cube	September-13	KIT-FMF, DESY
T6 Large Pixel Sensors	15 Months	Large Pixel Assemblies	January-14	KIT-FMF, KiT-IPE
T7 3D Technologies	15 Months	CdTe-MPX3-TSV	January-14	KIT-FMF, DESY