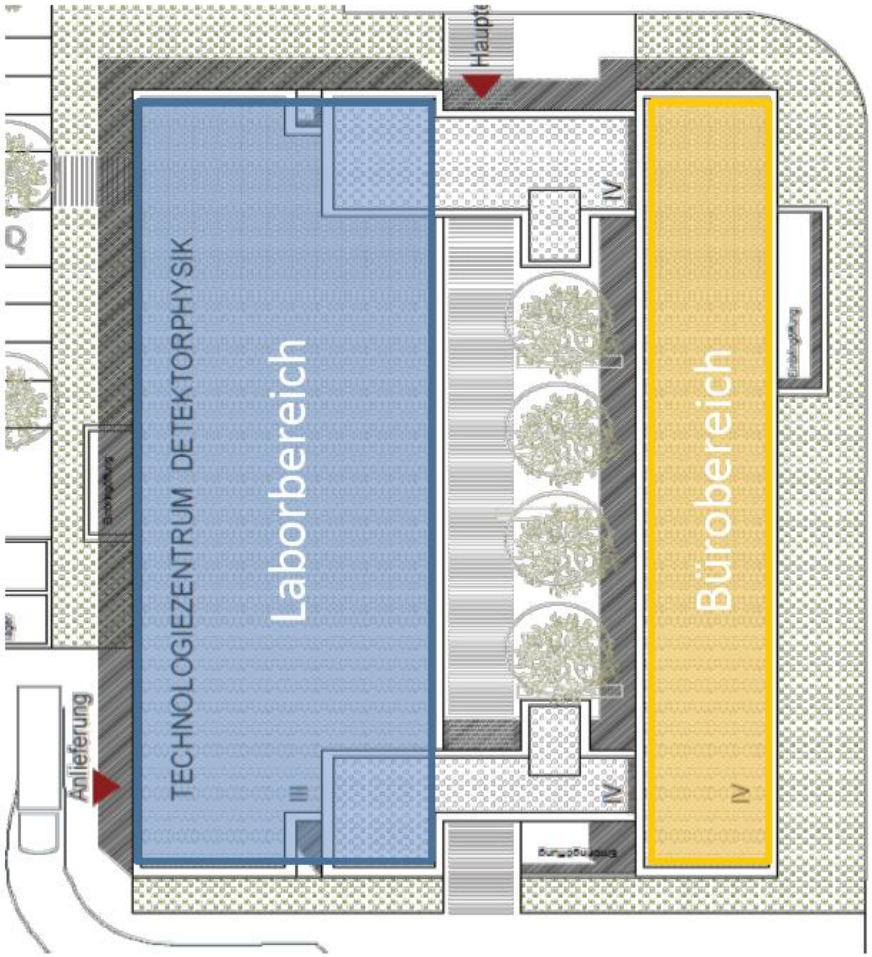
The Forschungs und Technologiezentrum Detektorphysik (FTD) at Bonn

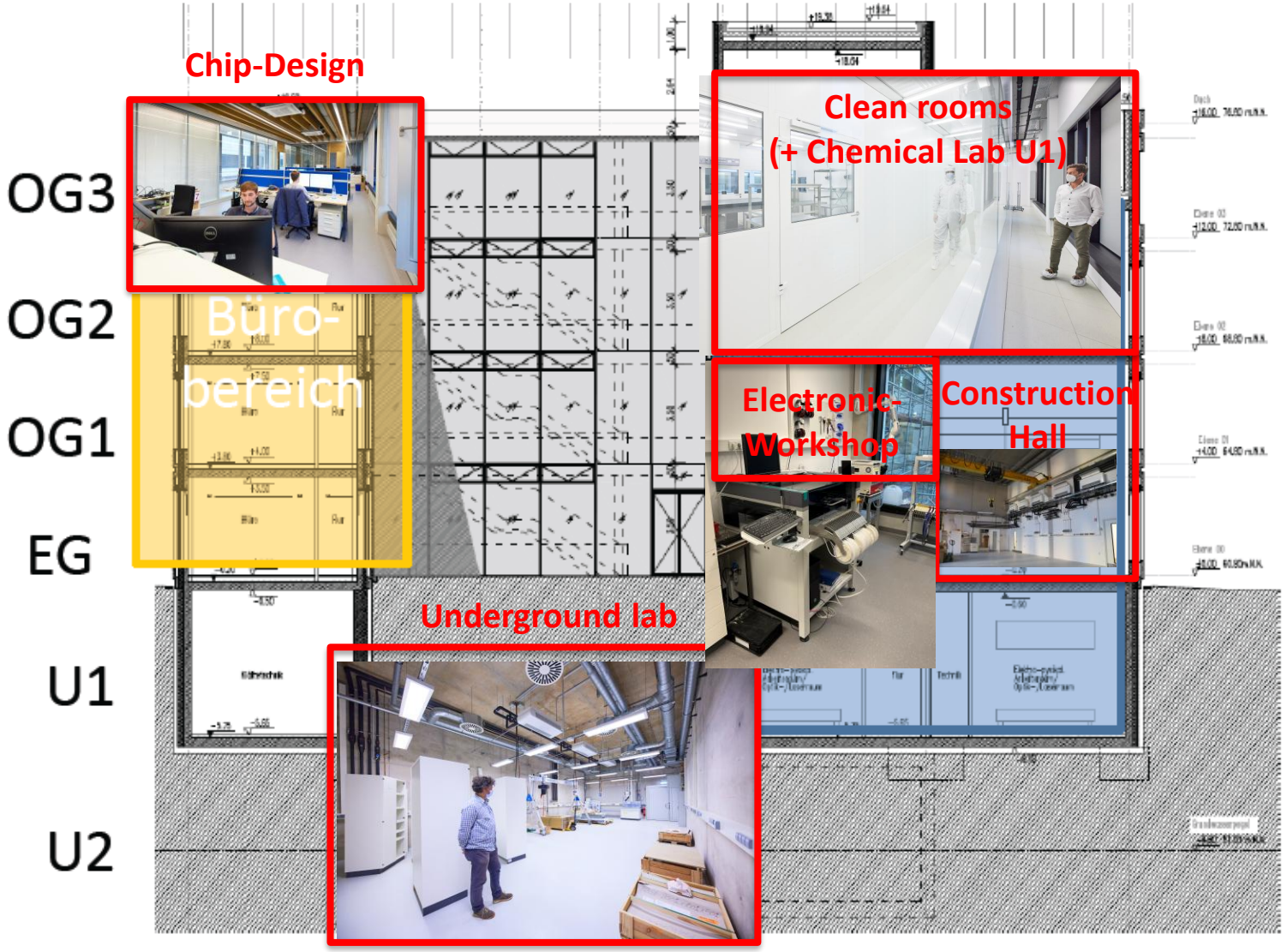
Markus Ball

The FTD

FTD is short for Forschungs- und Technologiezentrum Detektorphysik (FTD) at the university of Bonn

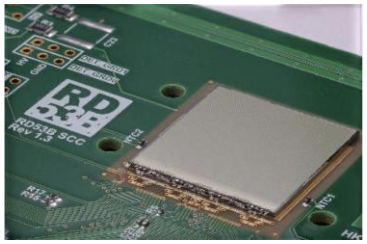
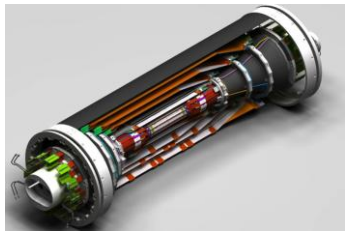


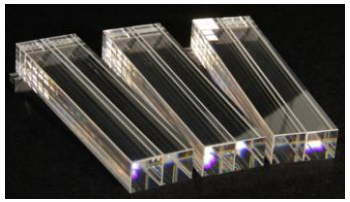
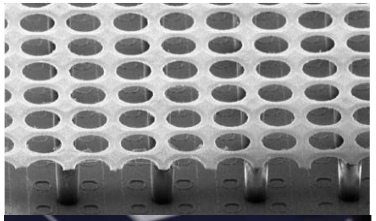
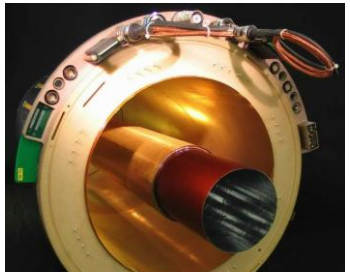
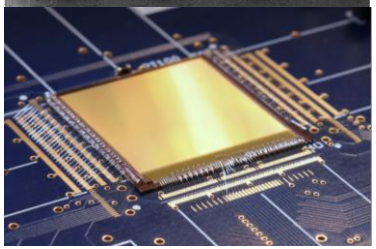
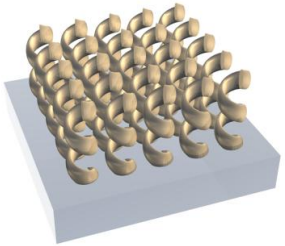
The FTD


Chip-Design
Clean rooms
(+ Chemical Lab U1)
OG3
OG2
Büro-
bereich
OG1
Electronic-
Workshop
Construction
Hall
EG
Underground lab
U1
U2

Projects of the FTD

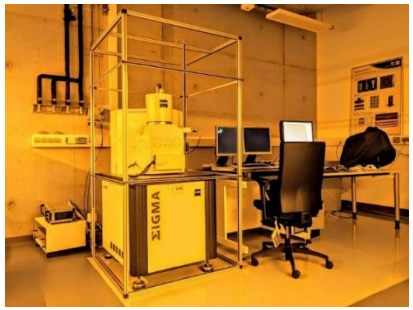
- ATLAS (CERN): Inner Tracker Upgrade: 13m^2 Hybrid Pixel detector
- Belle II (KEK): DEPFET Pixel detector and upgrade with monolithic CMOS detectors
- ALICE (CERN): ALICE 3 complete redesign with only silicon detectors
- AMBER (CERN): Planar GEM detectors with triggerless readout
- LHC-B: Mighty Tracker upgrade
- PANDA/INSIGHT (FAIR/Bonn): high-resolution electromagnetic calorimeter (20'000 crystals)
- IAXO (axion search at DESY/CERN): InGrid detectors
- ILC: TPC readout with pixelized gaseous detectors
- ELSA:
  - INSIGHT: upgrade with charged-particle tracking and forward detectors
  - Lohengrin: dark photon search
  - Bethe-Heitler experiment: form factors
- Nanodetectors for photonics
- Chip design for readout and control of detectors
- Generic R&D on detectors: semiconductors, micropattern gaseous detectors
- Electronics for particle detectors
- Connection to Quantum Optics: Fibre Lab
- Cooperations with external partners

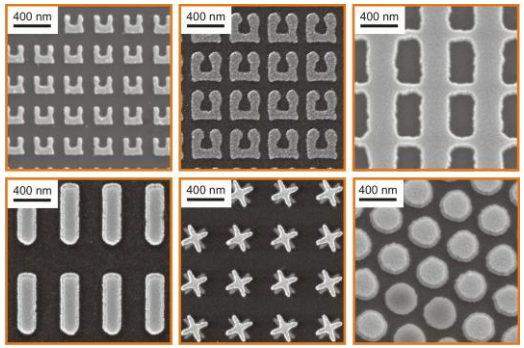



Nano- and Micro-Fabrication

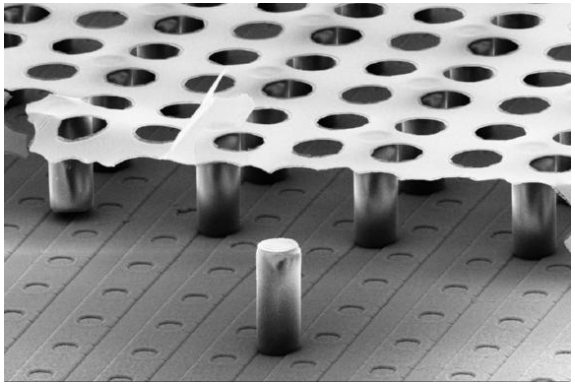
Electron beam + optical lithography





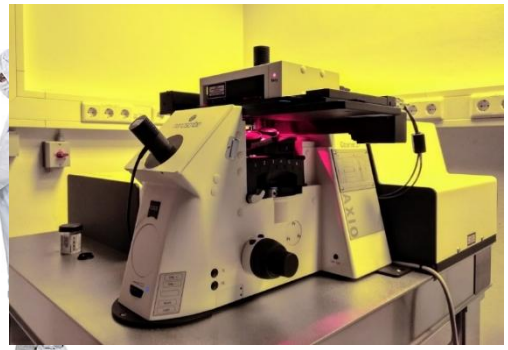
- Planar nanostructures with feature sizes down to 50 nm

Postprocessing



- Etching (chemical, plasma)
- Deposition (metals, dielectrics)

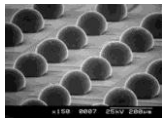
3D Direct laser writing

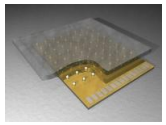


Mer han d'r Dom och en Bonn!
Translation provided by
https://mingsprooch.de/

Interconnect and Characterization

Solder Ball Placer





CR: Nikon

X-ray Inspection Device

X-ray Irradiation Device

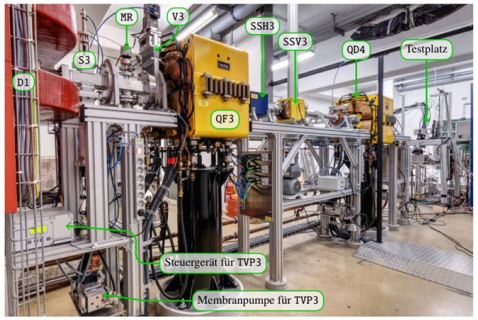
Scanning Electron Microscope

Flip Chip Bonder

Wire Bonder

Wafer Probe Station

3D Laser Tracker



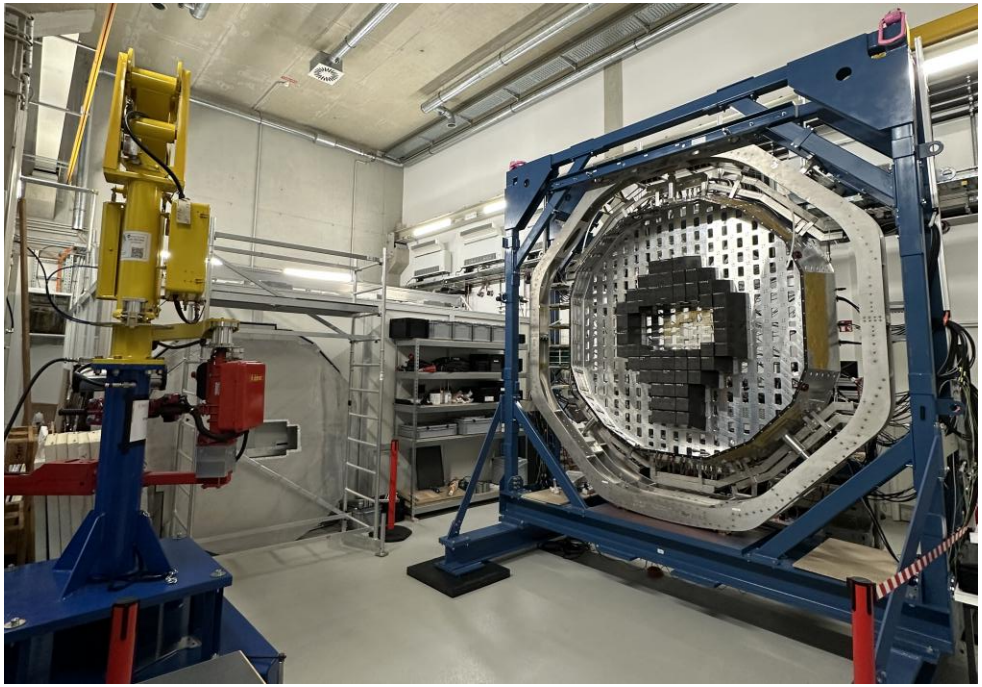
Dissertation N. Heurich (2017)

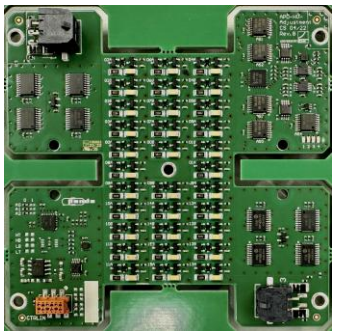
In-beam testing and irradiation

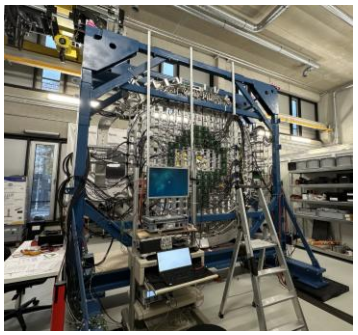
- Cyclotron
- ELSA

PANDA FWEC

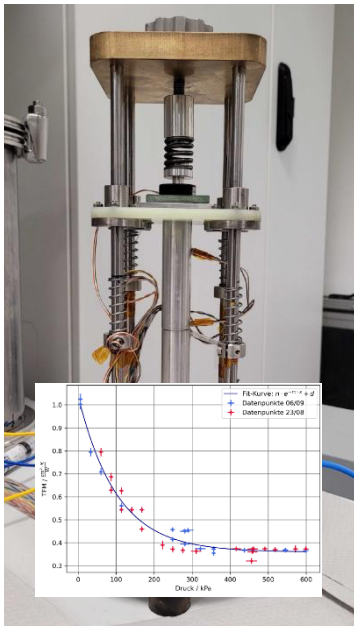
- 3856 PbWO-Crystals
- Length of 20cm = $22X_0$
- Weight: ≈ 8 Tons
- Energy resolution: 3% @ 1GeV
- Operated @ -25°C and cooled with water-methanol mixture
- Installation of modules with high precision
- 14-bit 80MHz sampling ADC with 64 channels



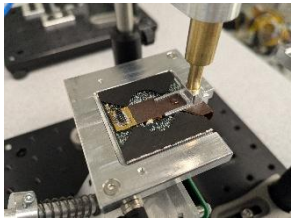


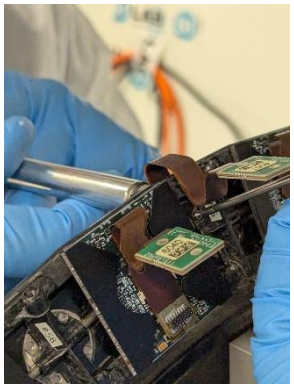


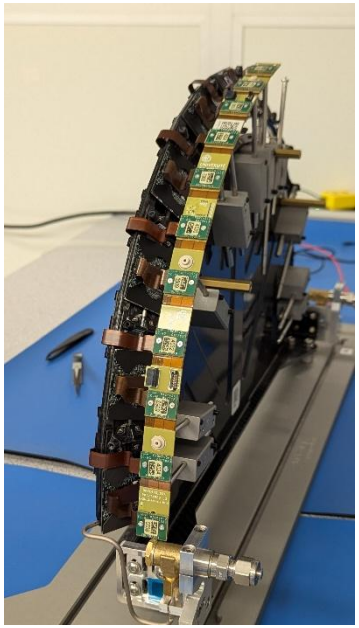
Integration of the ATLAS ITK Pixel Detector



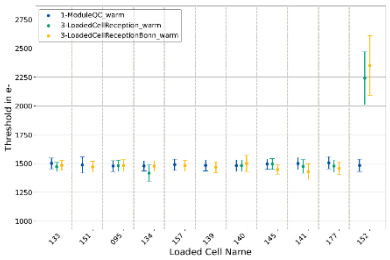
quality control for bare local supports

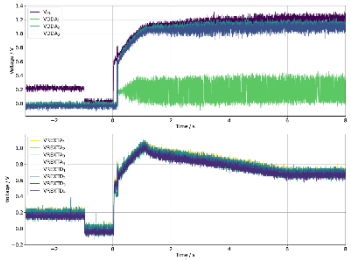






integration of loaded local supports



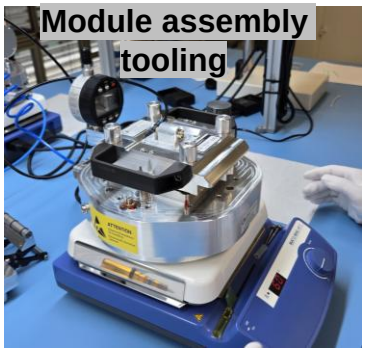


system testing and quality control of loaded local supports

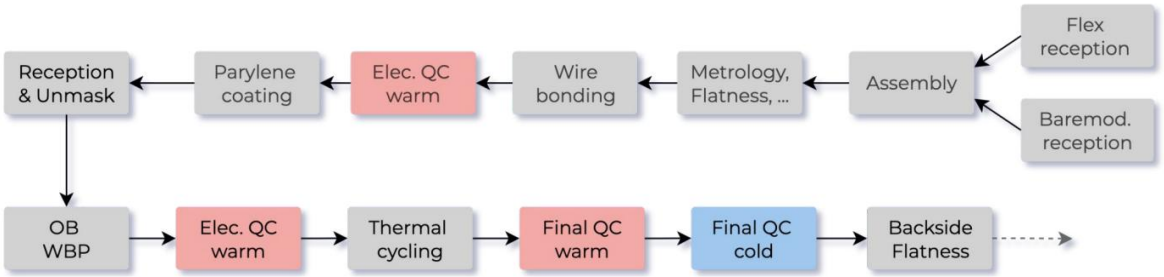
- production of the ITk Pixel Detector (just Bonn)
  - 6.000 bare cells and base blocks
  - 30-50 Loaded Local Supports
  - 850 Modules

ATLAS Module Production (at FTD)

- The new ATLAS ITk pixel detector requires in total the production of ~11 000 pixel detector modules
- Collaborative effort across the whole world (not only in germany)
- 1600 of these modules will be built in the FTD cleanroom until the end of 2026
- Extensive QC measurements after each production step are required to ensure good quality along the full chain of production
- Production has started already: we have assembled ~120 production modules so far at the FTD

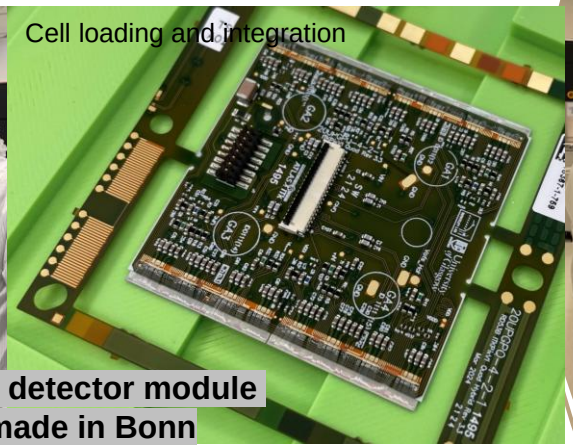


Module assembly tooling



ATLAS module assembly in the FTD cleanroom

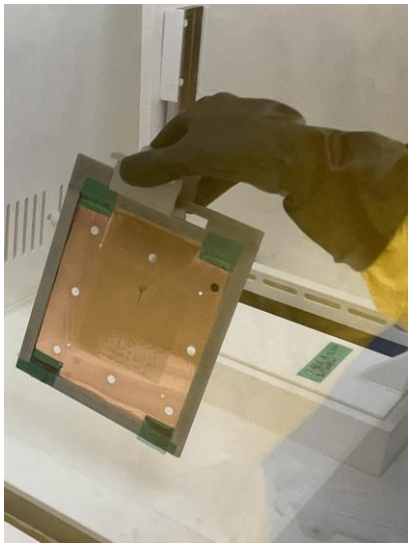
Part of the whole team (not a one-man-show)

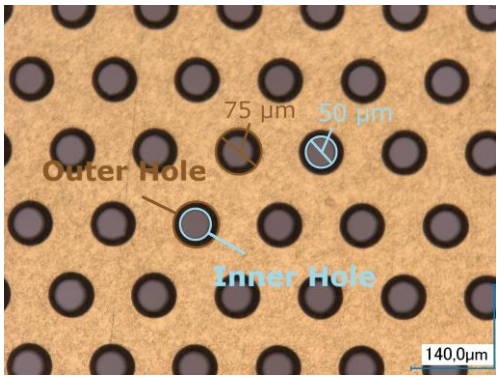


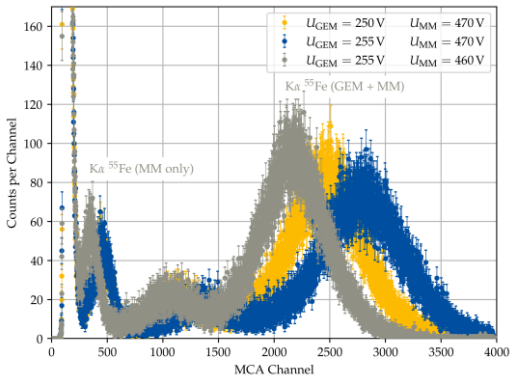
Cell loading and integration

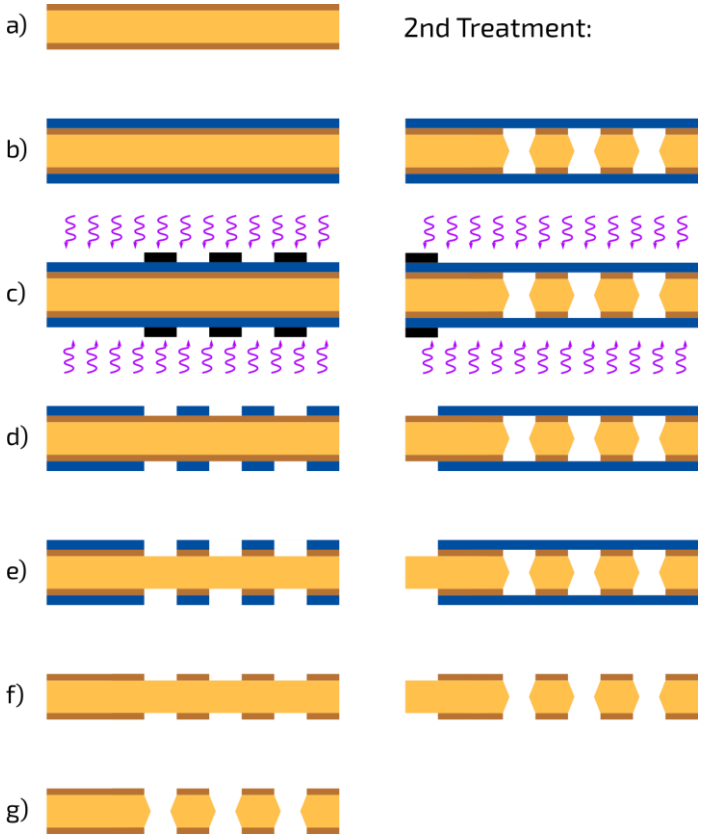
Pixel detector module made in Bonn

GEM Production (at FTD)

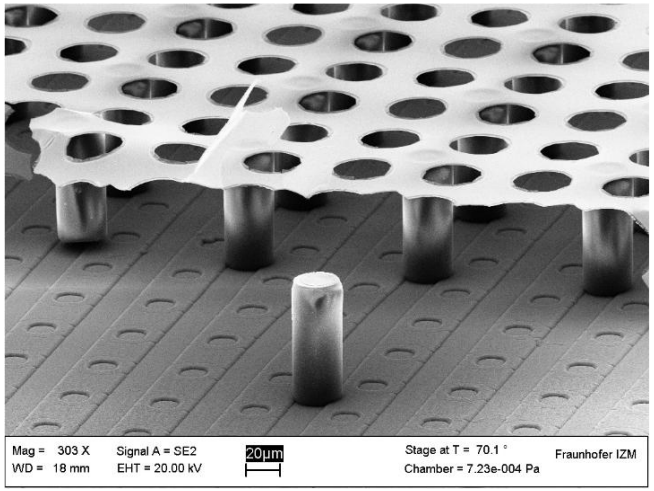


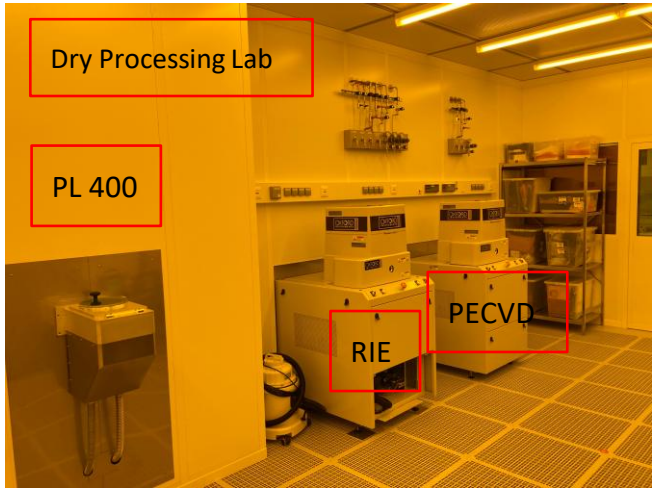




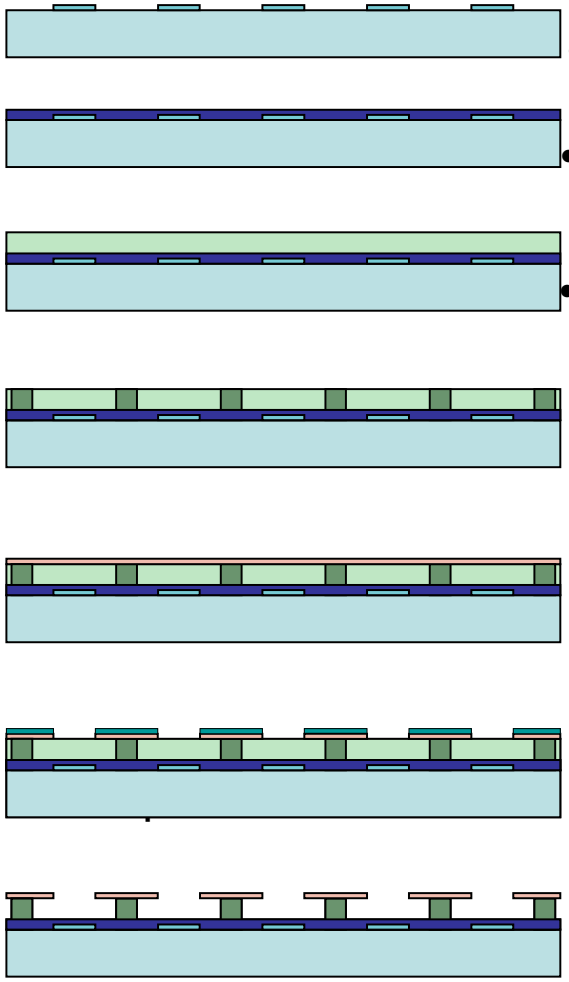


PixGrid Production (at FTD)





Courtesy of Y. Bilevych



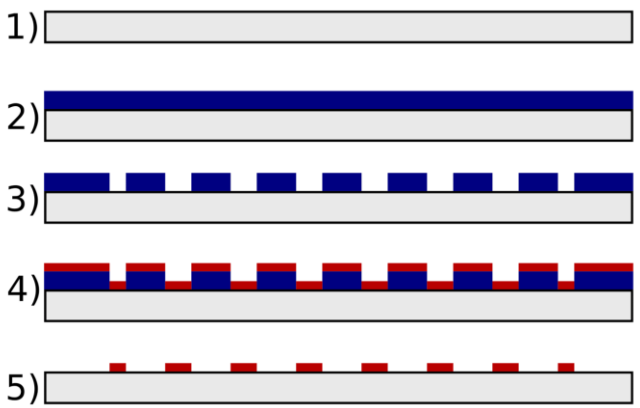
- 1. Surface preparation
- 2. Protection layer (SixNy)
- 3. Spacer layer (SU-8)
- 4. Patterning of SU-8
- 5. Deposition of Al
- 6. Grid formation
- 7. Detector releasing

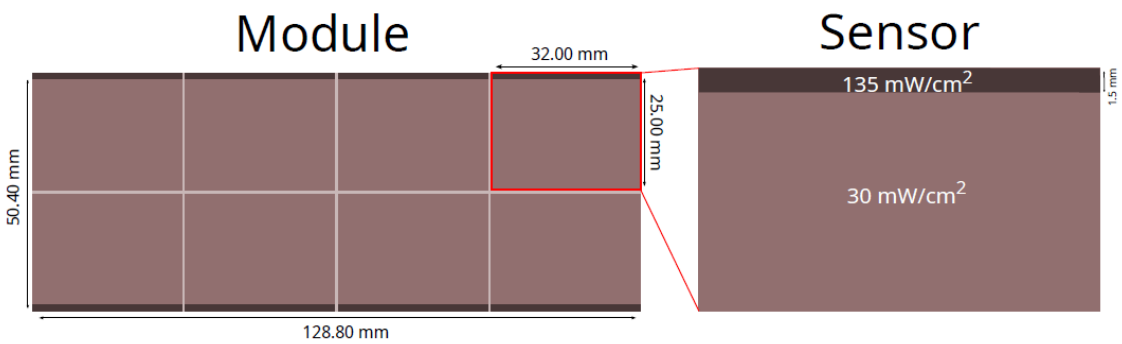
ALICE 3 (at FTD)

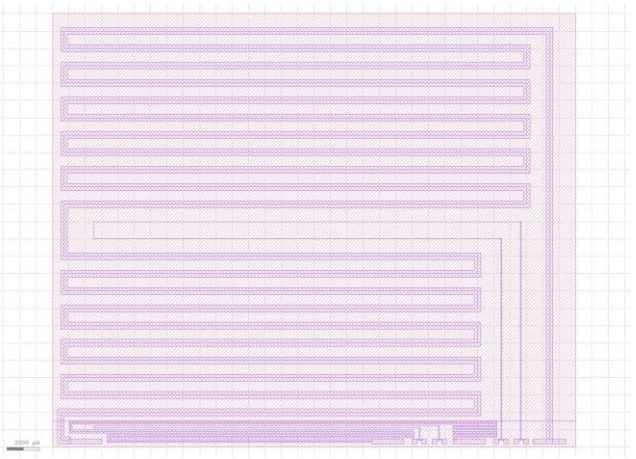
MADHAT: Mechanical **A**ssessment **D**esign for **H**eat **A**nd **T**hermal Solutions

1. Clean and dehydrate silicon wafer
2. Apply liquid photoresist via spinner
3. Pattern resist using maskless aligner
4. Apply 500 nm of aluminium via electron beam evaporation
5. Remove access resist with aluminium on top

Application: Evaluate cooling and fabrication concepts for ALICE 3 Outer Tacker

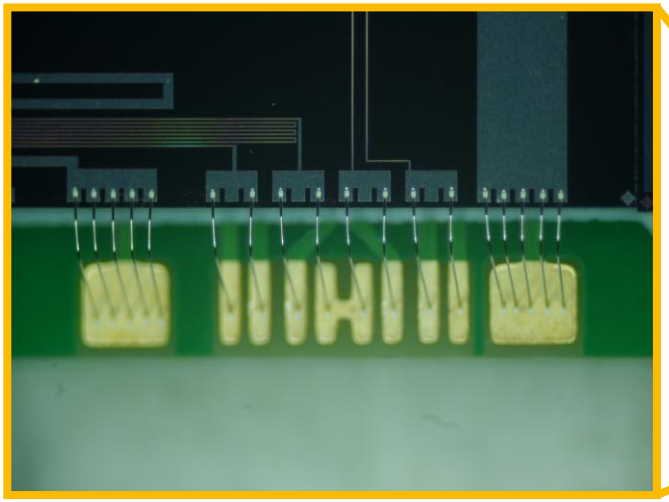


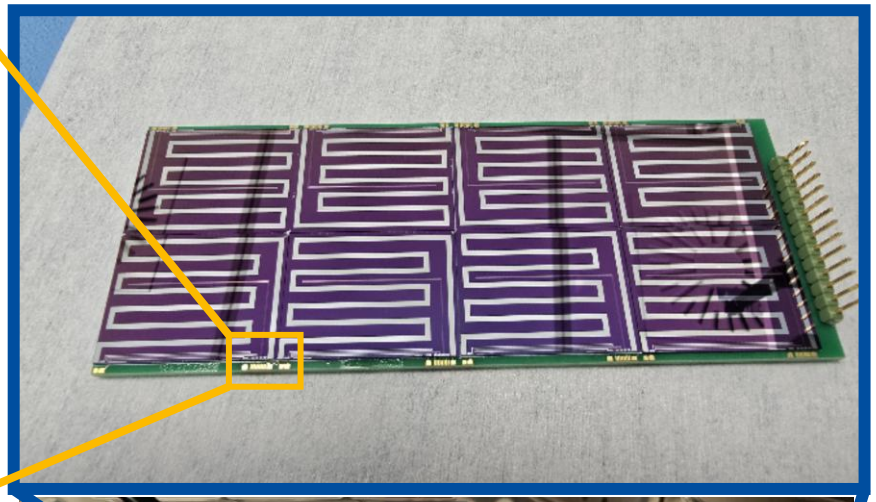


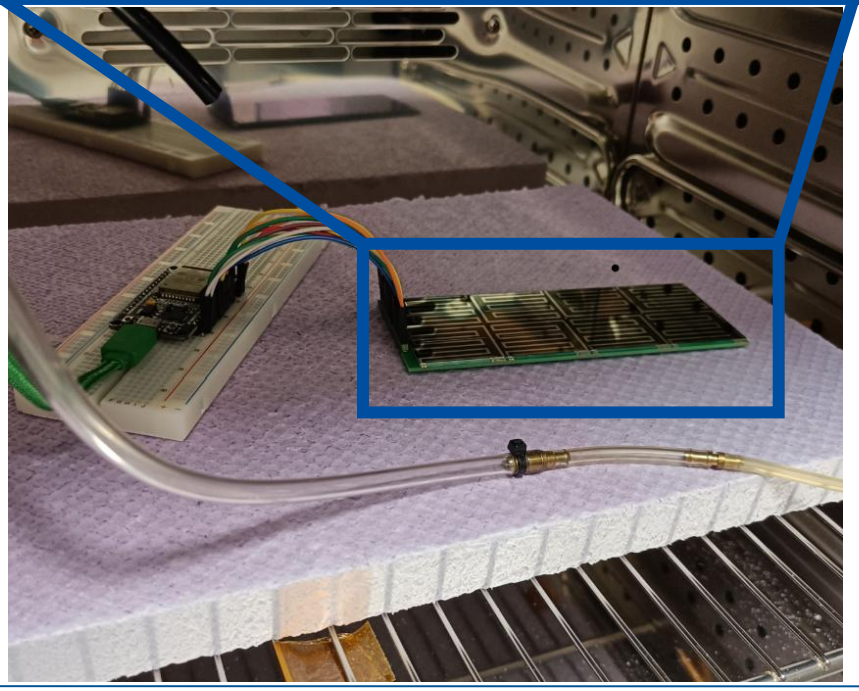


[Letter of Intent: ALICE 3]

ALICE 3 (at FTD)







Already done:

- Design of MADHAT
  - Emulates realistic heat dissipation
  - Used for testing the industrialization
- Production of 25 wafers

Plans for rest of this year:

- Production of O(10) dummy modules
  - (Assembly of components on backside)
  - Gluing of chips on front
  - Wire-bonding of MADHATs
  - Calibration

Machines for Microstructuring

Designation of the machine/device	Location of the machine	Status of the machine	Used for
Laminator	ISO6 – Yellow	in operation	GEM/Flex board production
LED Illuminator	ISO5 – Yellow	in operation	GEM/Flex board production
Wet bench – organic	ISO5 – Yellow	in operation	Multifunctional
Wet bench – anorganic	ISO5 – Yellow	in operation	Multifunctional
Wet bench – photoresist	ISO5 – Yellow	in operation	Multifunctional
Wet bench	ISO7	in operation	GEM/Flex board production
Dry Cabinet	ISO6	in operation	GEM/Flex board production
Heating Oven	ISO6	in operation	GEM/Flex board production
Spark Detection System (including pA)	ISO6	in operation	GEM/Flex board production
Maskless Aligner (MLA)	ISO5 – Yellow	in operation	Multifunctional
Filmetrics	ISO6 – Yellow	in operation	Optical Wafer resist uniformity inspection
Dektak	ISO6 – Yellow	in operation	Mechanikal structural Wafer inspection
PL 400 (aluminium sputterer)	ISO6 – Yellow	in operation	Metallization of Wafers
Reactive Ion Etching (RIE)	ISO6 – Yellow	in preparation	Dry etching of Wafer Post-processed
Plasma Enhanced Chemical Vapour Deposition (PECVD)	ISO6 – Yellow	in preparation	Deposition of protection layers (e.g. Siliconnitride)
Wafer saw	ISO7	in operation	Wafer cutting

The Staff of FTD

Technical Coordinator
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Detectordesign & -integration
Dr. Dmitri Schaab
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Secretary
Workshops, Guests, Web, Kommunikation, Outreach
Sarah Conee

Technician (Gases, Chemicals)
Chris Winter

Cleanroom-Technician
Jerome Laubner

Construction, CAD
N.N.

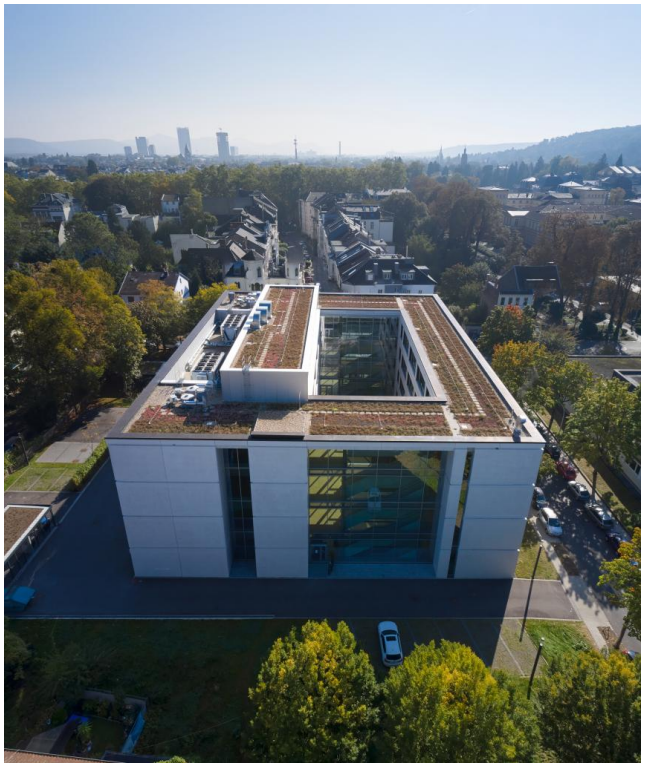
Common Electronic-Laboratory
Michael Henseler
Walter Honerbach
Alexander Konz
Alexander Ochs
Katharina Rosenthal
Candas Tezel

Radiation Protection Service
Dr. Christoph Wendel
Dr. Fabian Hügging
Dr. Marcus Grüner
Dr. Markus Ball
Dr. Dima Schaab

Laser Protection Service
Dr. Andrea Bergschneider

Enginers + Technicans
of the working groups

Summary



This is just a small glimpse of the capabilities & potential of the FTD

- Much more capabilities to come
- Some key machines are close to be put in operation
- Other machines are potentially in operation, but lack (still) manpower
- After the (ATLAS) upgrade is before the upgrade:
  - LHC-B
  - ALICE 3
  - INSIGHT
- As resources are always limited

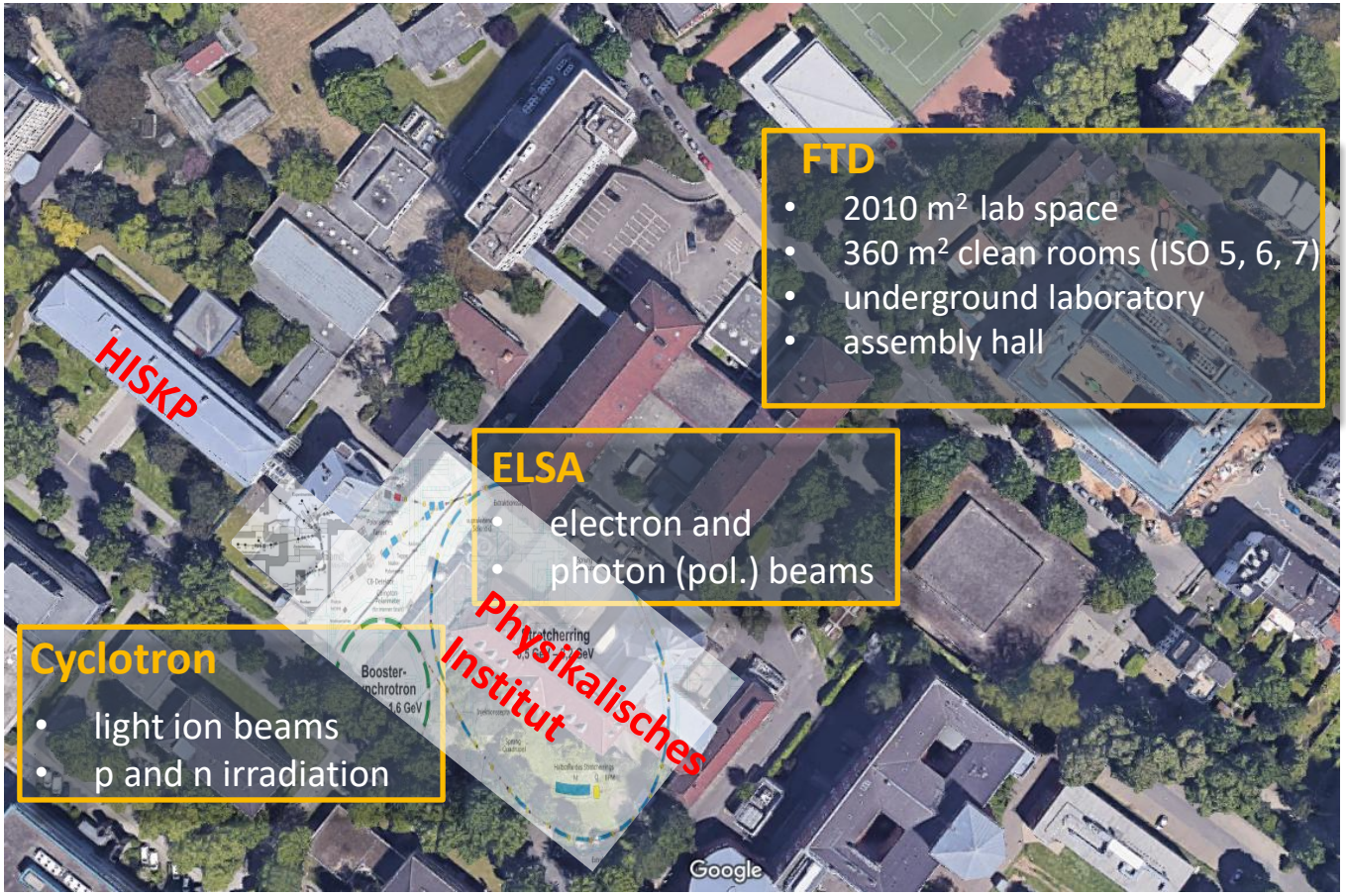
All activities of INSIGHT planning to use the FTD common facilities should be discussed in the FTD board !!!

Machines for Microstructuring

The Research Infrastructure at Bonn

Combined **Research Infrastructure**:

- FTD
- ELSA (Phys. Institut)
- Cyclotron (HISKP)



Timeline

Proposal

15.03.2012

Excavation

04.11.2014

Foundation ceremony

02.10.2015

Envelope closure

04.04.2016

Hand over to the University

02.11.2016 14.03.2017 28.02.2018 05.07.2018 05.07.2021 08.11.2021

Demolition Alte Pharmazie

Shell construction

Interior work

Clean room installation

Inauguration

ATLAS Stave Production (at FTD)