EBERHARD KARLS UNIVERSITÄT TÜBINGEN

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Institut für Astronomie und Astrophysik

Experimental UV Astronomy

Development of Microchannel Plate Detectors for the Ultraviolet

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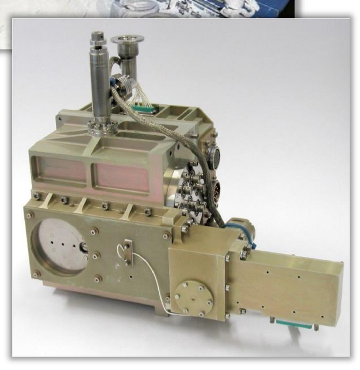
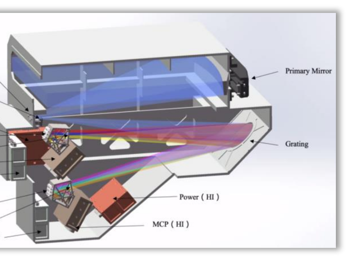
Background and heritage

- Ultraviolet (UV) radiation is strongly absorbed in the Earth's atmosphere. Therefore, spaceborne observatories are crucial for UV astronomy.
- The group for Experimental UV Astronomy at IAAT developed and built the detector of the ORFEUS SPAS mission, which was flown twice.


ORFEUS, 1st flight with the Discovery


FUV MCP detector of the TUES spectrograph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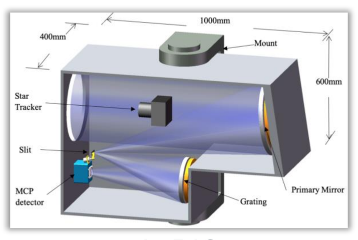
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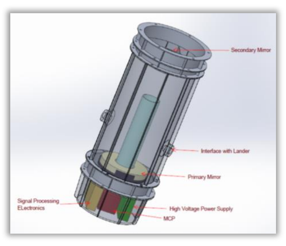
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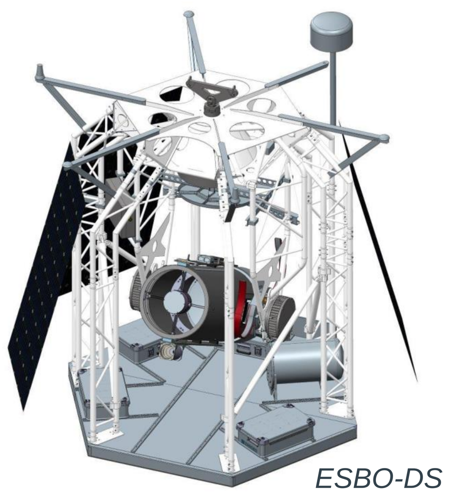
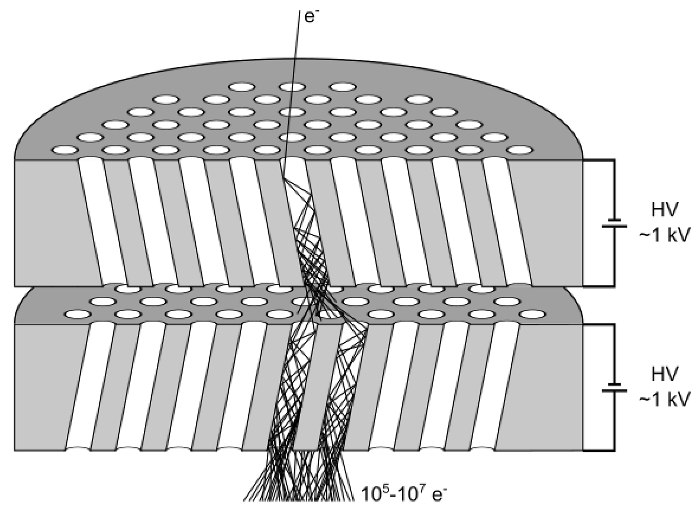
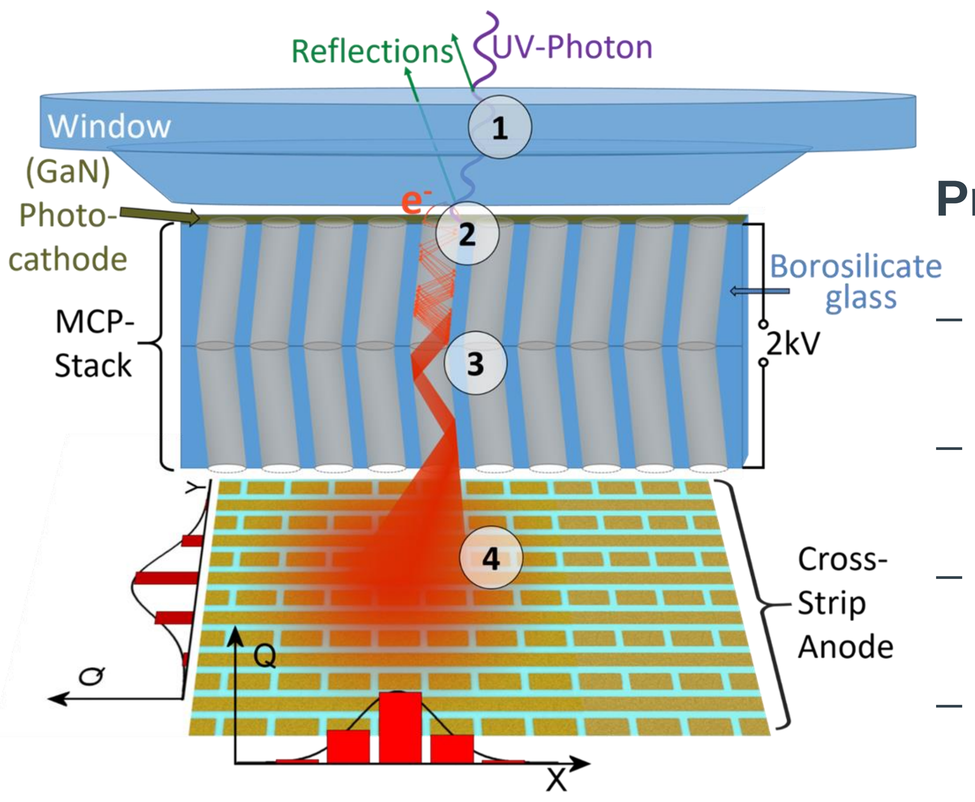

ESBO-DS

- Future UV missions require advanced detectors with higher sensitivity, increased lifetime and a low power dissipation.
- Our group participates in several small UV space missions and a stratospheric balloon project. We have collaborations over Europe as well as in India and China.

Microchannel plate (MCP) technology

MCPs are thin (~1 mm) glass plates with microscopic channels of about 10 µm diameter. By applying a high voltage the channels act as continuous dynodes so that incident ionizing radiation triggers the release of an electron cloud.



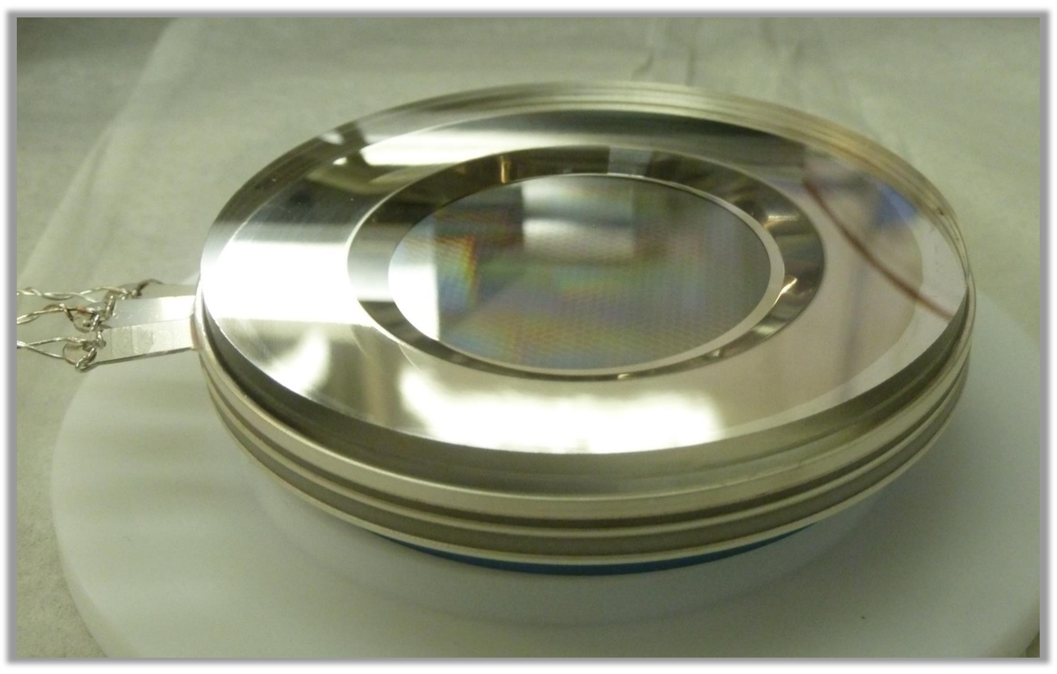


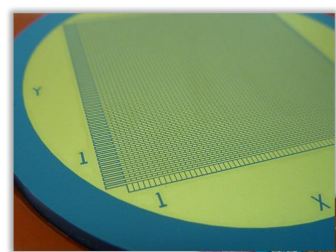
Principle of a UV MCP detector

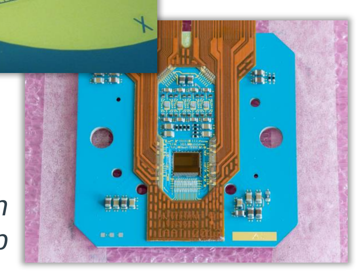
- UV photons release photo-electrons from a photocathode
- The photoelectrons are multiplied in a stack of MCPs
- The charge cloud is detected on a position-sensitive anode
- The anode signals are digitized and processed in the attached readout electronics

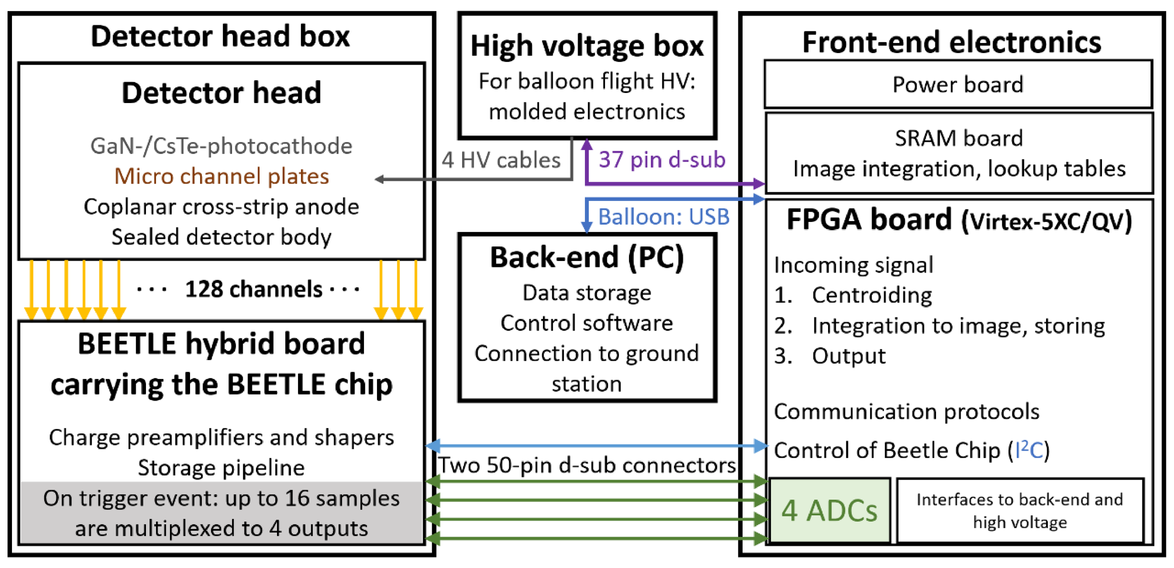
Concept for an advanced MCP detector

- High quantum efficiency (QE) $Al_xGa_{1-x}N$ photocathode:
  - coated on the inner side of an MgF_2 entrance window (120 – 380 nm)
  - coated directly on the first MCP (90 – 380 nm), in combination with a shutter mechanism
- Novel borosilicate MCPs functionalized via atomic-layer deposition (longer lifetime, less background)
- Cross-strip (XS) anode with 128 channels (lower MCP gain, increased position resolution)
- FPGA-based readout electronics


Sealed detector head with ALD-MCPs and cross-strip anode

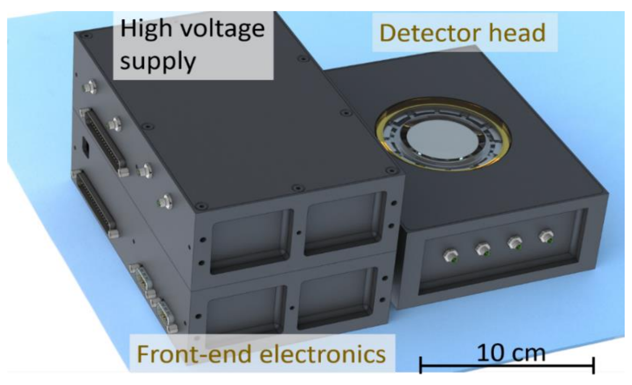

Cross-strip anode


Hybrid board with BEETLE chip



Comparison MCP vs. silicon detectors

- Photon-counting (time resolution <1 s)
- No readout noise, but finite dark current
- Lower QE, particularly in the NUV
- Solar-blind (reduced straylight issues)
- High voltage required
- No cooling necessary



MCP detector system

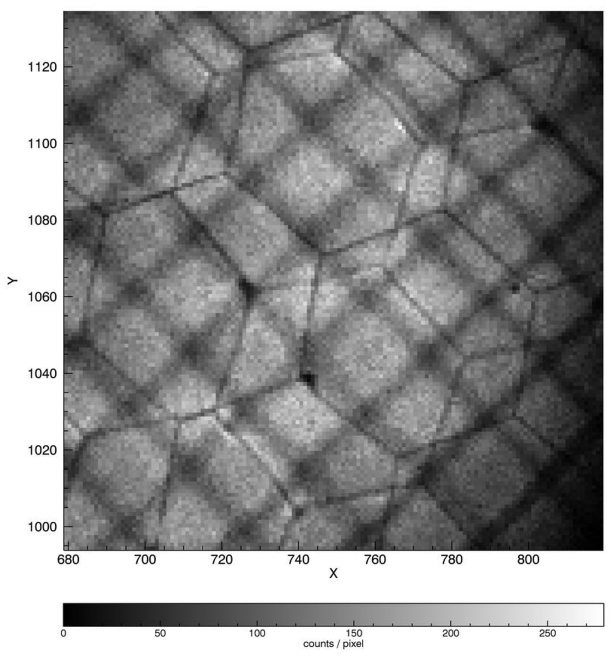
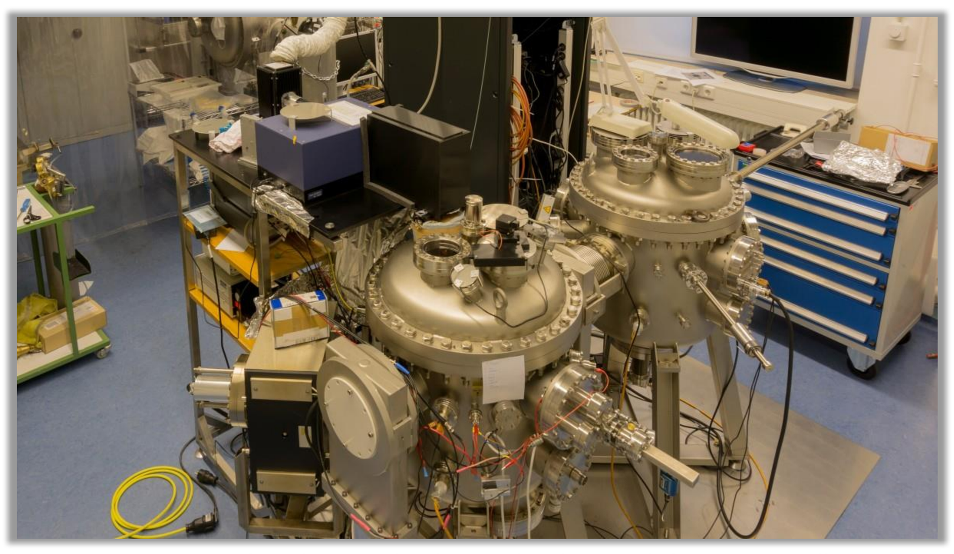


Image recorded with latest IAAT MCP detector

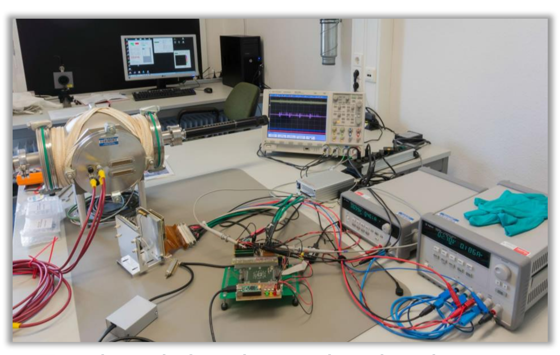
Bachelor and master theses in our group cover one or more of these topics

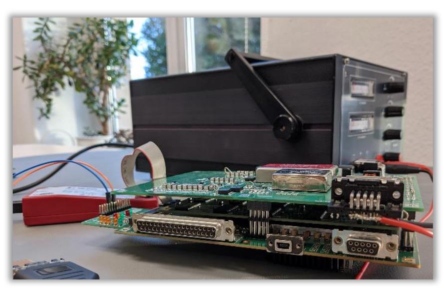
- Photocathode manufacturing and optimization (cleaning and thin film deposition techniques)
- Low current measurements
- QE determination (monochromator setups, photodiodes, channeltrons)
- MCP commissioning and operation
- Electronics development and operation
- FPGA programming in VHDL
- Software development in C/C++/C#, Python, IDL
- Computer simulations (photocathode, atmospheric absorption, signal-to-noise ratio etc.)
- Mechanical design with CAD software (detector parts, measurement setups etc.)
- Vacuum systems (UHV, various pumping technologies, different vacuum standards)
- Automation of measurement systems and laboratory equipment


UHV setup for photocathode production and detector sealing


Monochromator setup for FUV QE measurement


Thin film deposition system


Test bench for electronics development


Front-end electronics prototype

Bachelor- und Mastertag Physik

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Please scan for more information on the IAAT detector development: