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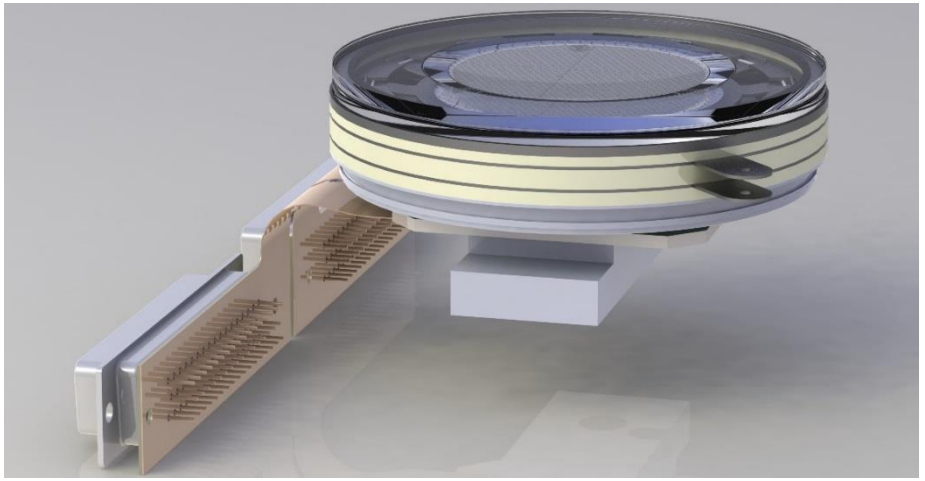
FACULTY OF
SCIENCE
Kepler Center for Astro and Particle Physics
Institute for Astronomy and Astrophysics

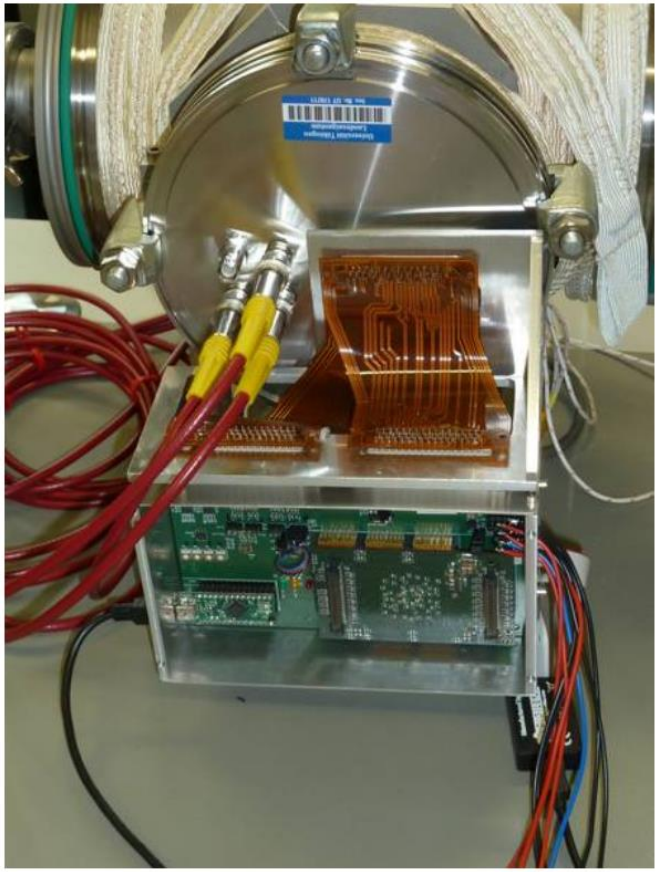
ESBODS
European Stratospheric Balloon Observatory
Design Study



UV-Detector Development and Application

Lars Hanke, J. Barnstedt, L. Conti, N. Kappelmann, C. Kalkuhl, T. Rauch, T. Schanz, B. Stelzer, K. Werner

Outline



Detector electronics at the Laboratory

General UV Part

1. Ultraviolet Astronomy
2. ESBO-DS

Detector part

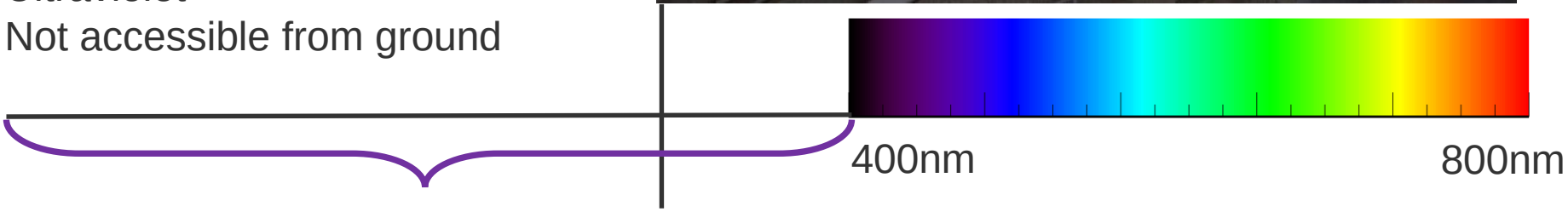
1. The UV Detector
2. Single parts and active research
3. Balloon vs. Space

Ultraviolet Astronomy

wikipedia.org

Very Large Telescope (VLT) from: wikipedia.org

Ultraviolet
Not accessible from ground



Ultraviolet

Visible regime
accessible from ground

Ultraviolet Astronomy

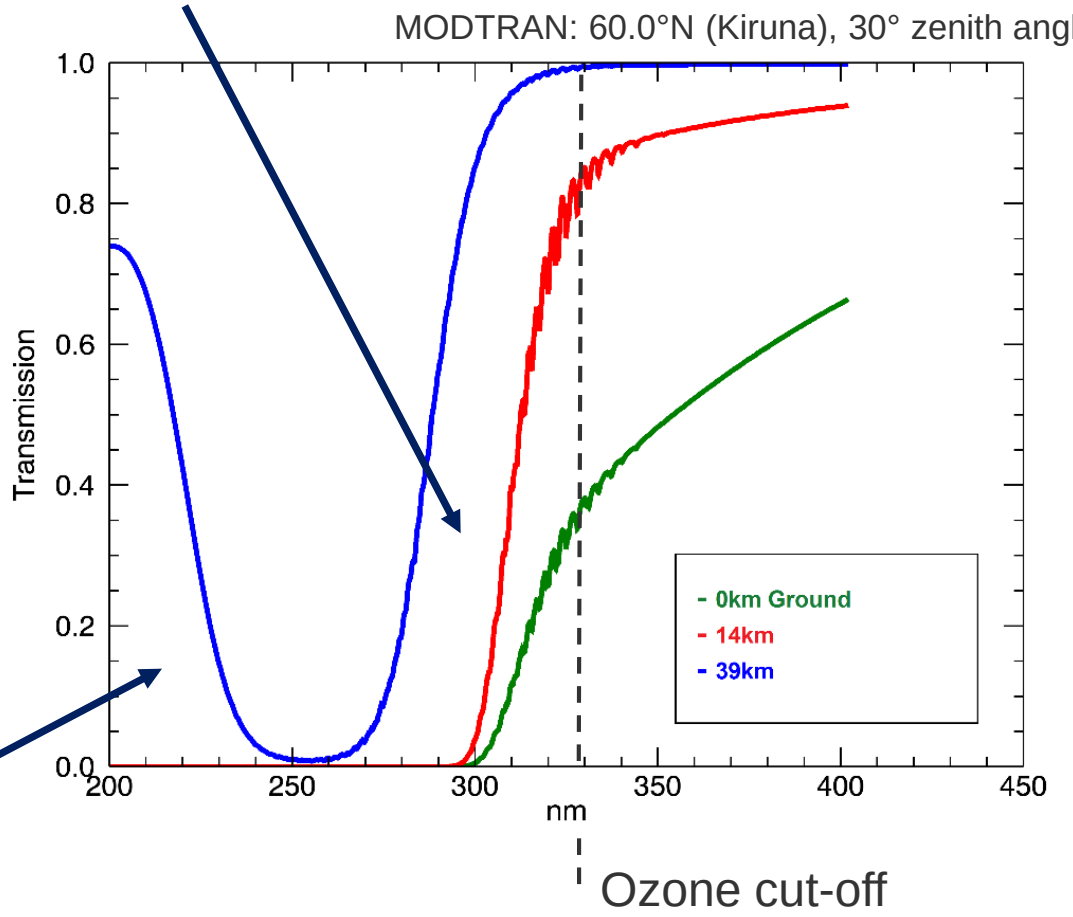
Window: 280nm - 330nm

1.) UV radiation is absorbed by ozone layer (20-30km) and oxygen.

2.) UV radiation suffers from Rayleigh scattering

$$\sim 1/\lambda^4$$

3.) λ < 180nm oxygen absorbs all light.



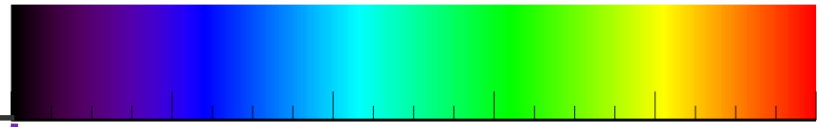
Window: 180nm - 230nm

Ultraviolet Astronomy

Very Large Telescope (VLT) from: wikipedia.org

Credit: SSC

Ultraviolet
Not accessible from ground



400nm

800nm

180nm

≈300nm

Ultraviolet

Visible regime
accessible from ground

European Stratospheric Balloon Observatory Design Study

ESBO DS
European Stratospheric Balloon Observatory
Design Study

University of Stuttgart Germany
Institute of Space Systems

SSC

Telescope mirror: 50cm

Visible channel: 300nm - 1000nm

UV channel: 180nm – 330nm

MAX-PLANCK-GESELLSCHAFT

INSTITUTO de ASTROFISICA de ANDALUCIA
CSIC
I·A·A

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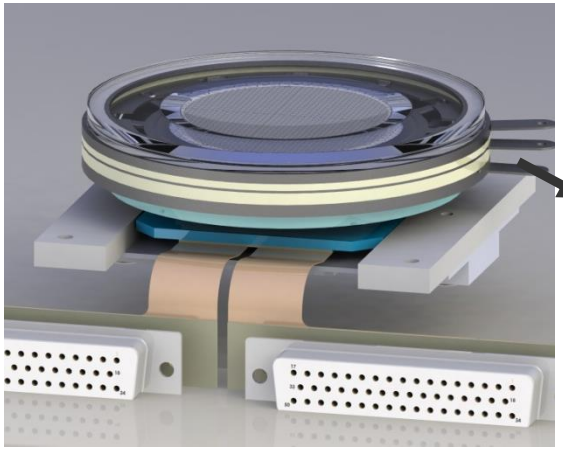
The UV Detector

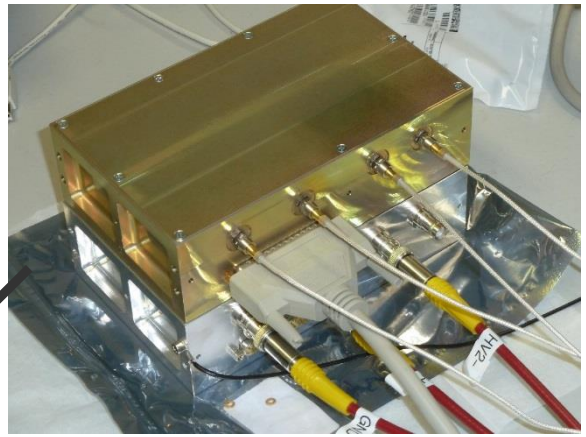


Detector head

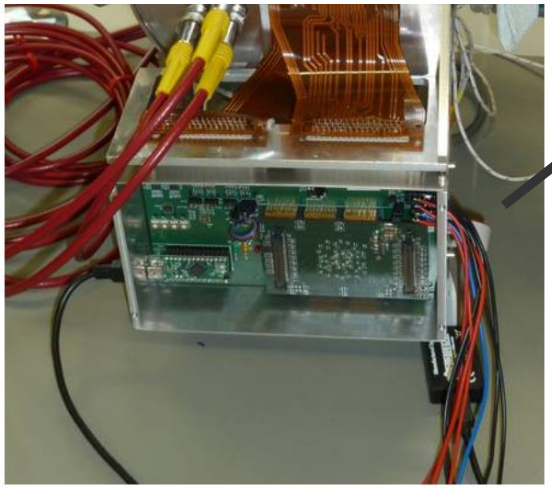
The Detector parts

Detecting single photons
Producing raw data

Supplying the microchannel plates + cathode



High-Voltage Supply

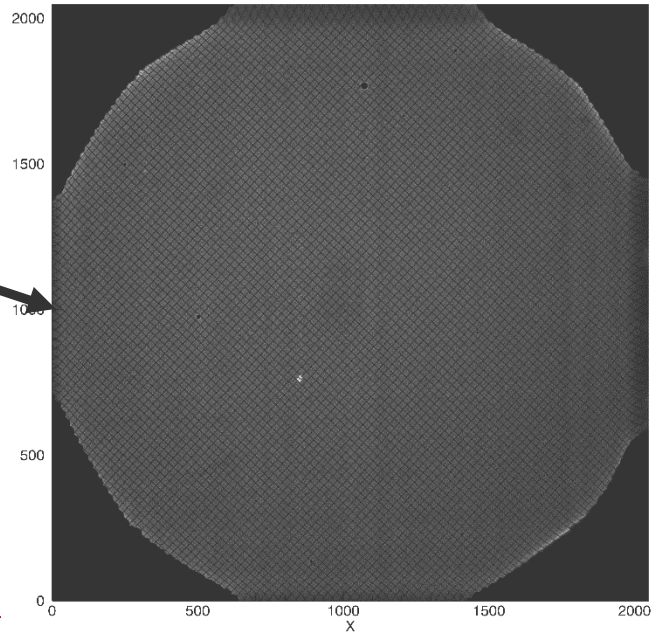


Front-end electronics

Controlling the detector
Processing the raw data

Mode 1: normal image

Mode 2: single photon
+ arrival time



The UV Detector

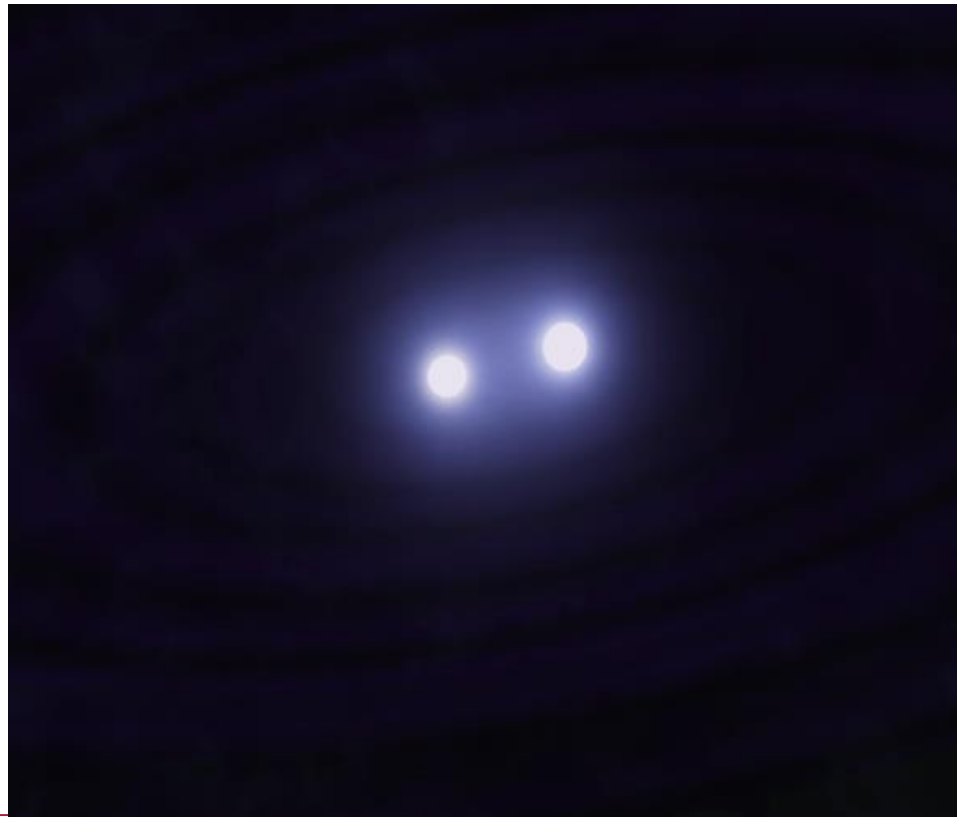
The UV detector is a single-photon-counting device.

Suitable for the observation of faint variable sources

Two Modes

1. *Image integration:* All photons detected within obs. time are saved in an image.

2. *Photon by photon:* Every photon is stored with its position and time.



- Low power consumption
- Low weight
- No readout noise
- Only dark counts and Poisson noise

The UV Detector

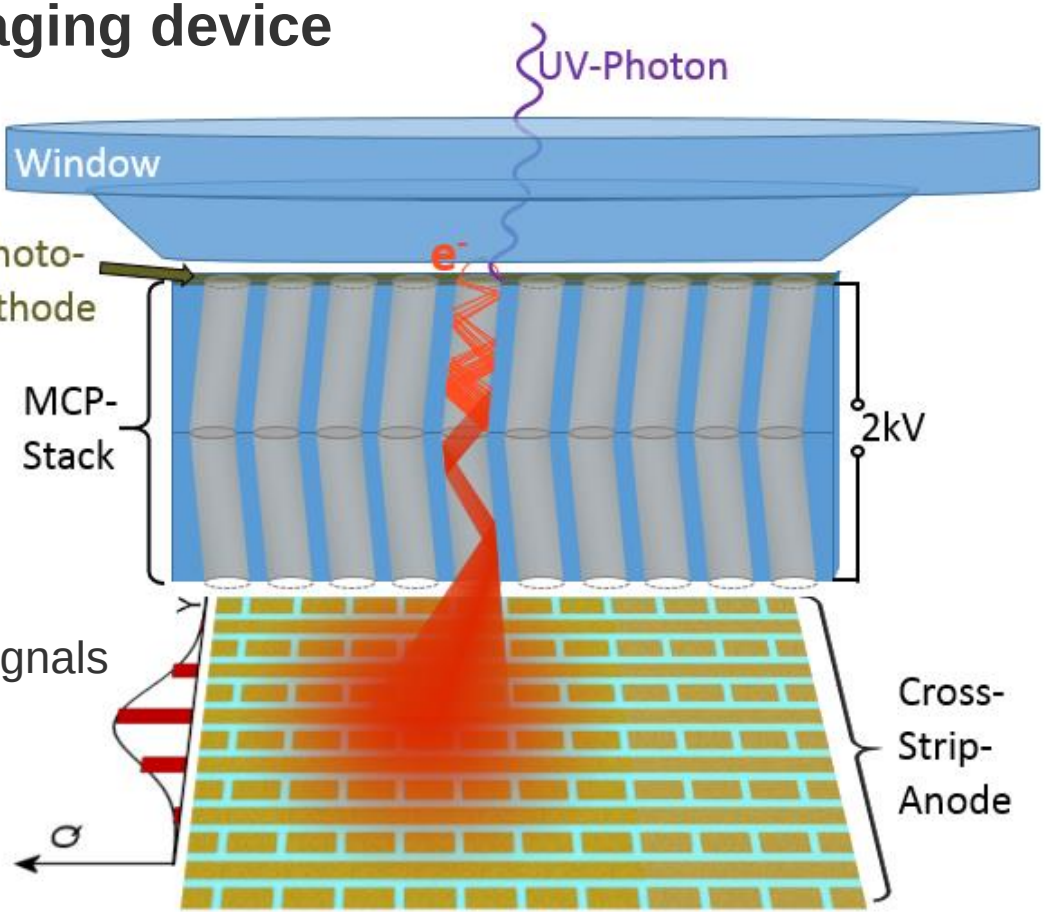
Single-photon-counting, imaging device

Cathode
1 Photon ⟶ 1 Electron

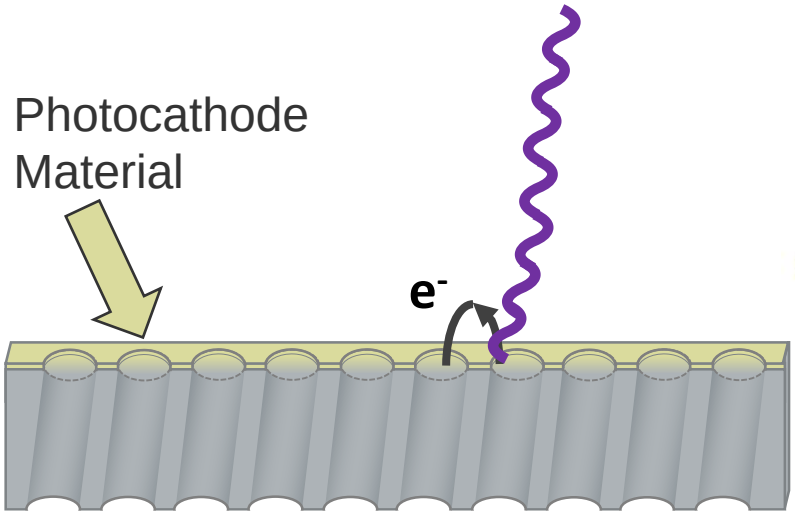
Micro channel plates (MCP)
1 Electron ⟶ $10^5 - 10^6$ Electrons

Cross strip anode
10^6 Electrons ⟶64 X + 64 Y charge signals

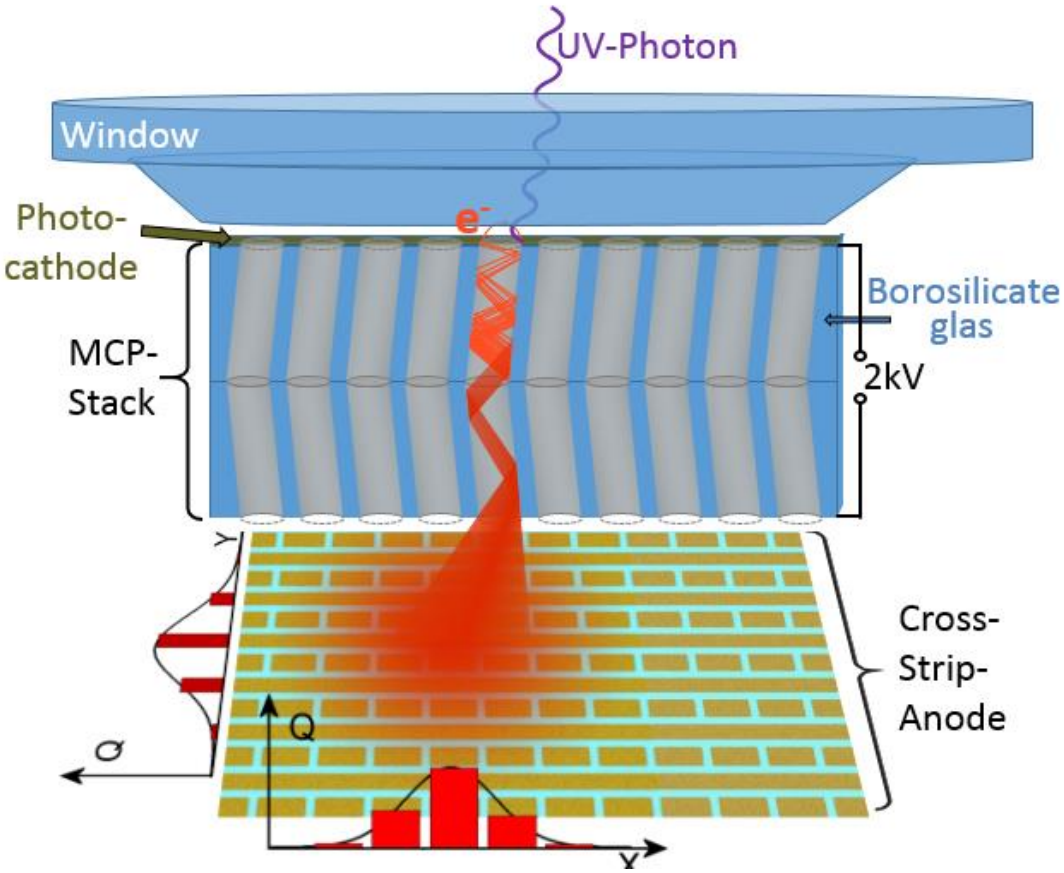
Readout
Charge signals ⟶ photon location
2048 x 2048 pixel



The UV Detector



Credit: Lauro Conti

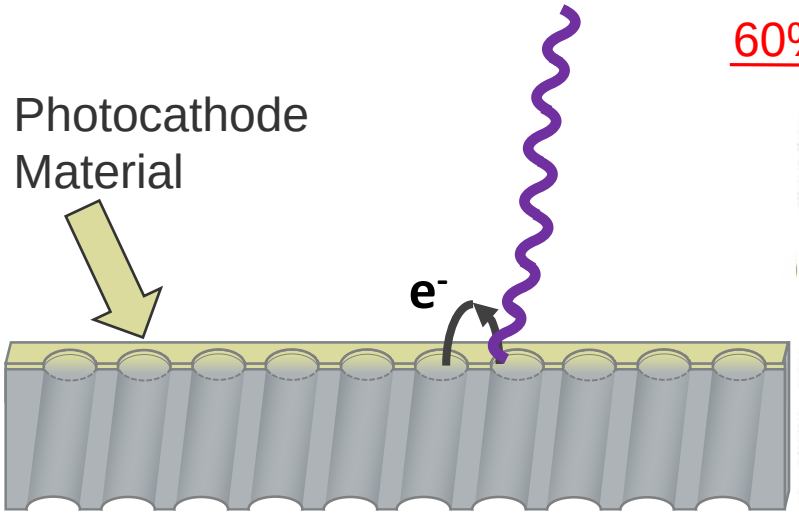


Quantum efficiency

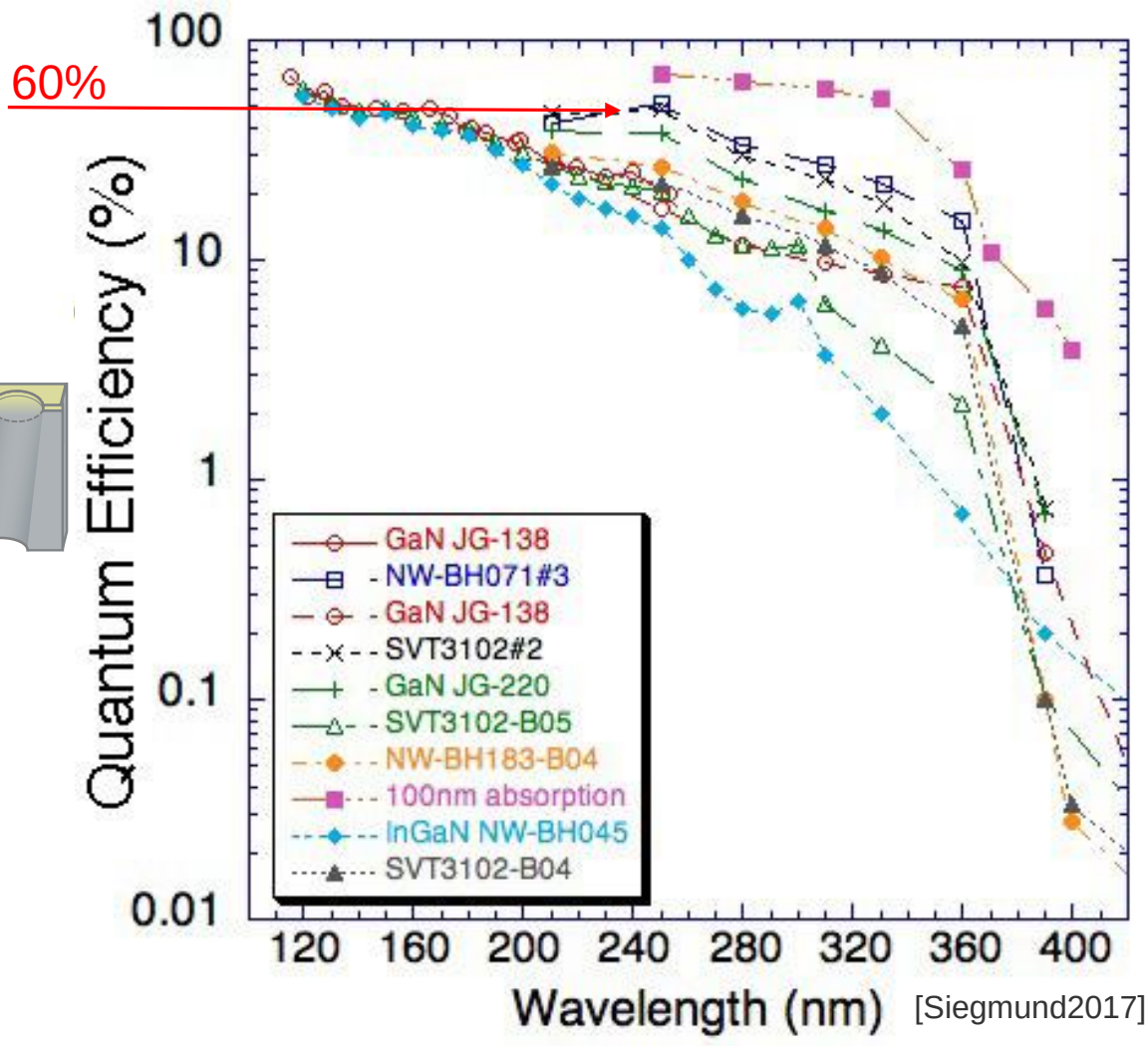
Cesium-Telluride (CsTe) can reach about 10%

Gallium-Nitride (GaN) might reach up to 60- 70%

The UV Detector



Credit: Lauro Conti



[Siegmund2017]

Quantum efficiency

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The UV Detector

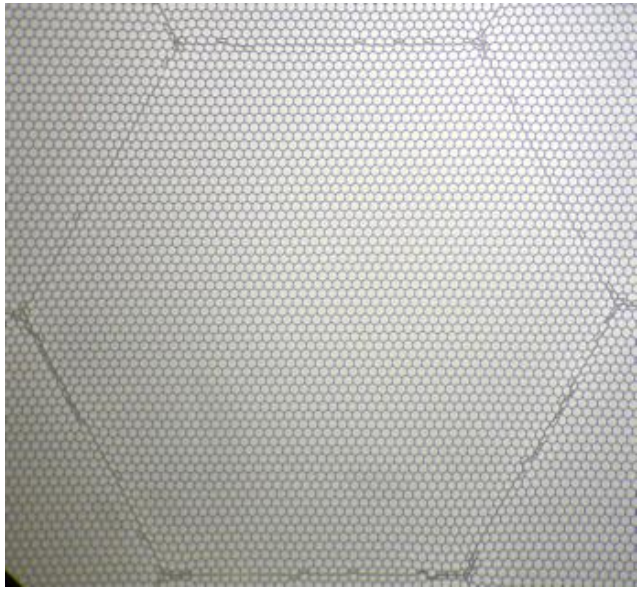
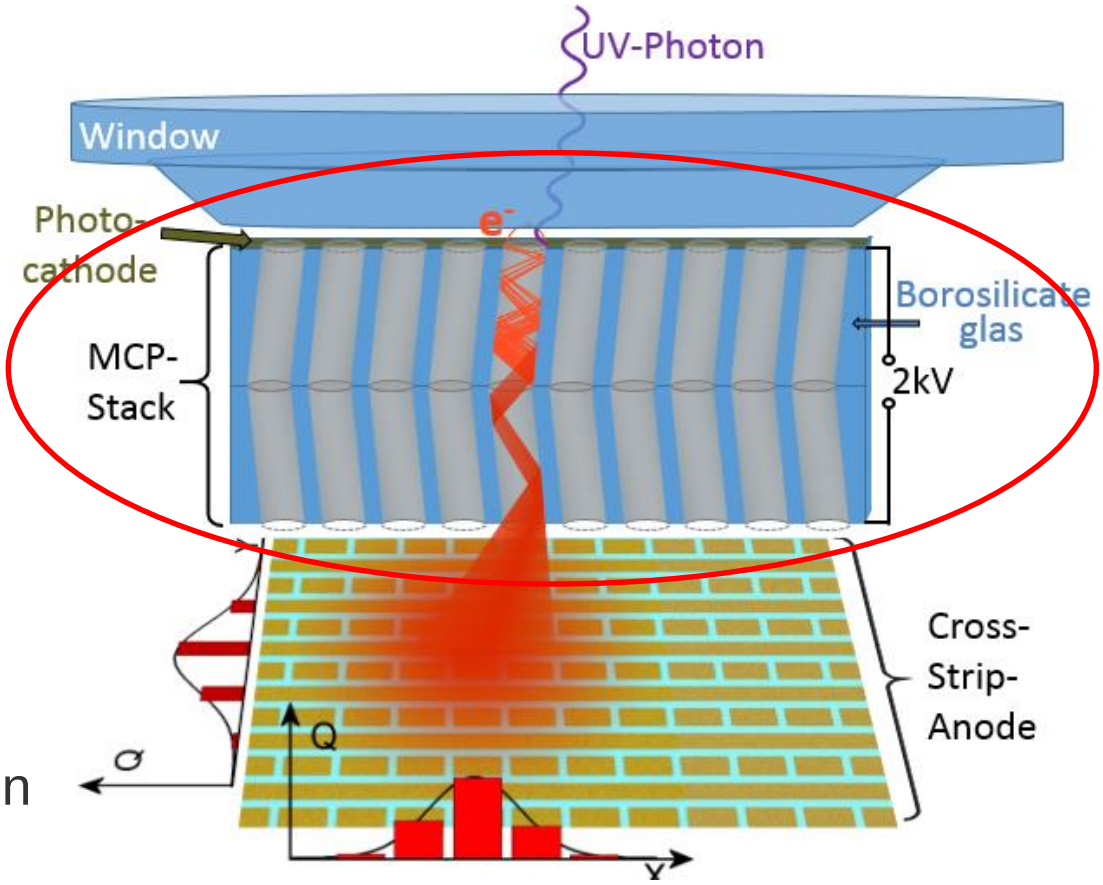
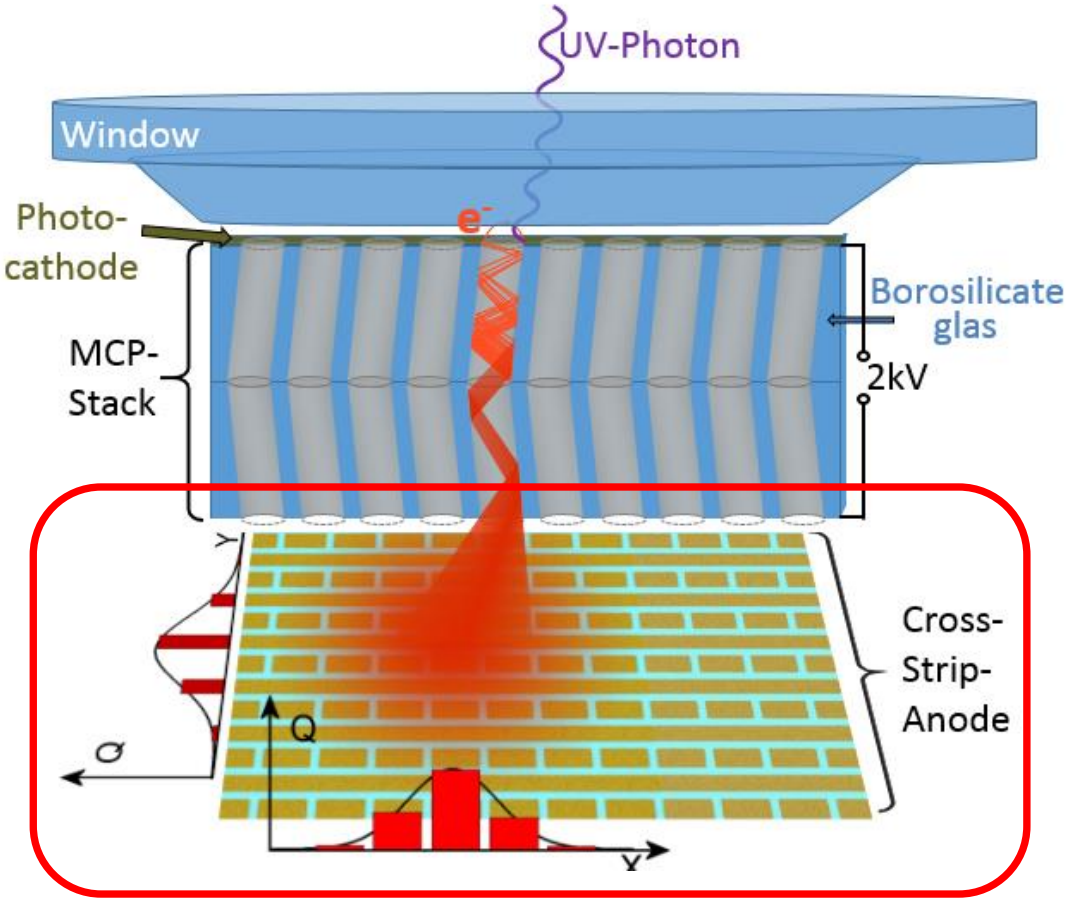


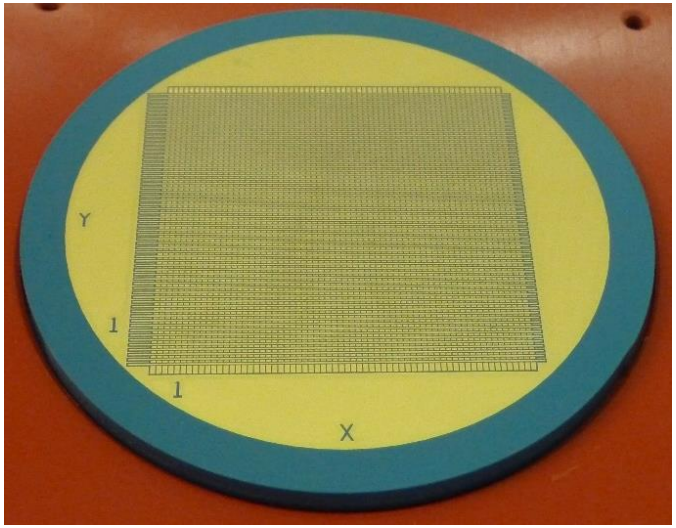
Image of a MCP [Siegmund2017]



The MCPs multiply the electron to obtain an electron cloud

The UV Detector



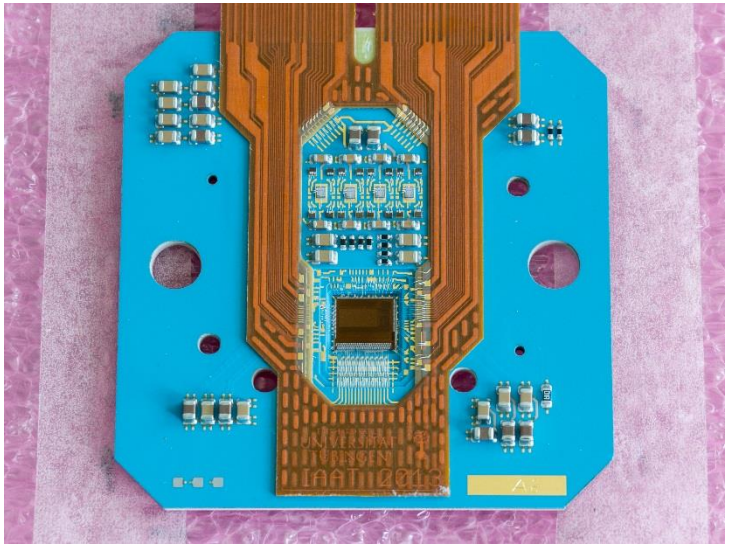


64 + 64 Strips measure the charge from the electron cloud.

Center of the electron cloud ⇒ Position of photon

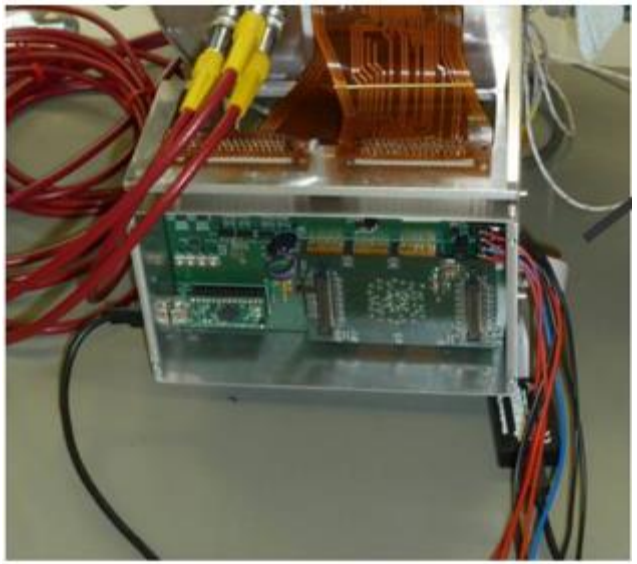
The UV Detector

Charge amplification ⟶ Analog digital conversion ⟶ Data evaluation



Beetle-chip

Beetle chip: 128 charge amplifiers
for 128 anode strips

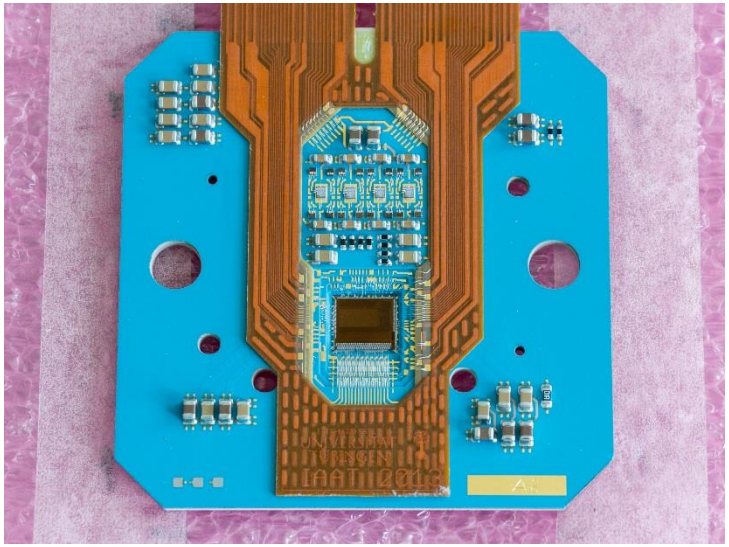


Custom developed electronics

Centroiding algorithm:
64 anode stripes into 2048 pixel

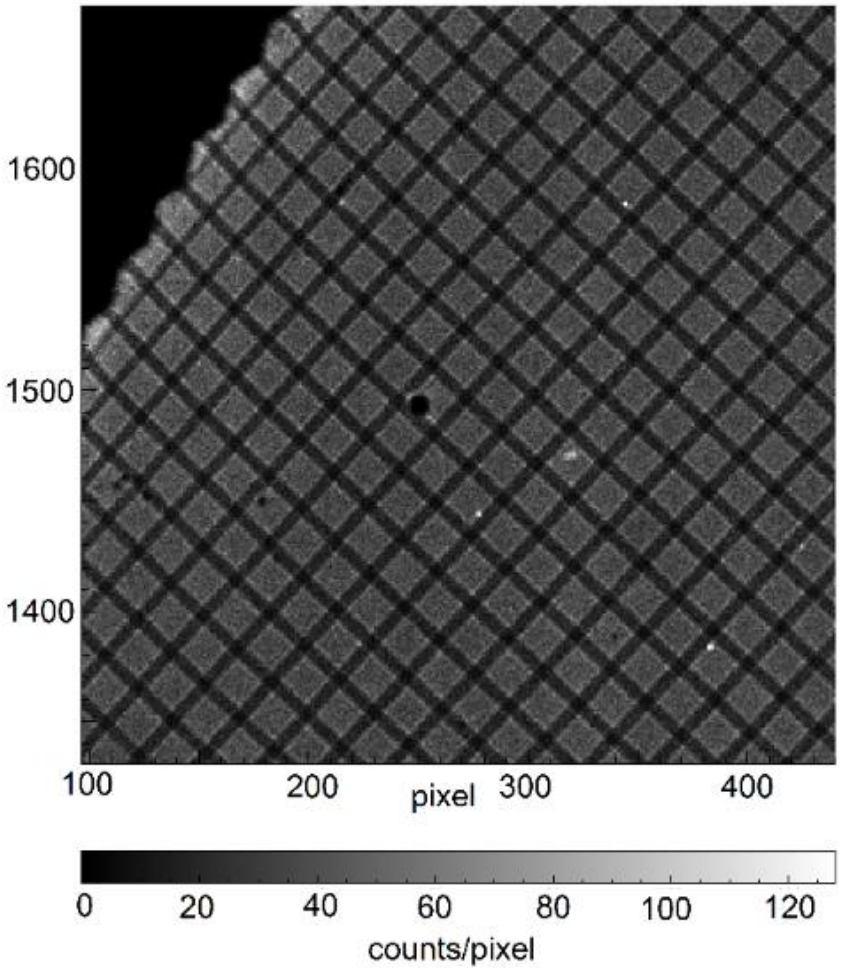
The UV Detector

Charge amplification ⟶ Analog



Beetle-chip

Final image



Balloon vs. Space

Low pressure environment. Not a vacuum!

→ ≈ few mbar at 40km

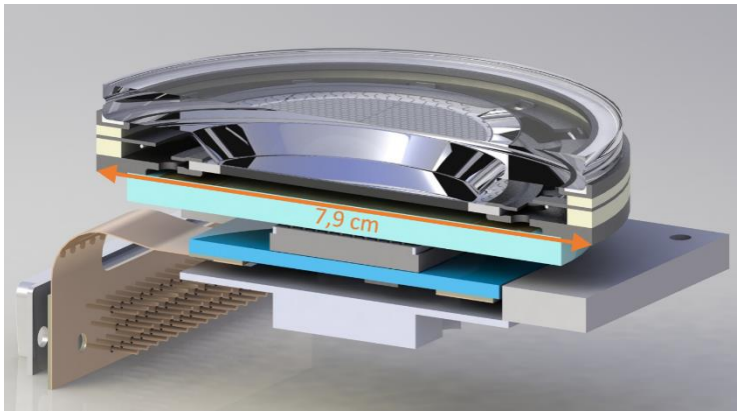
a)

High Voltage (HV) can build lightning arcs
- HV box purred with insulator
- Special coating inside
- Plastic connectors

Lightning arc: Deutsches Museum

b)

A sealed detector is necessary
- To prevent degrading of the cathode
- MgF_2 Window



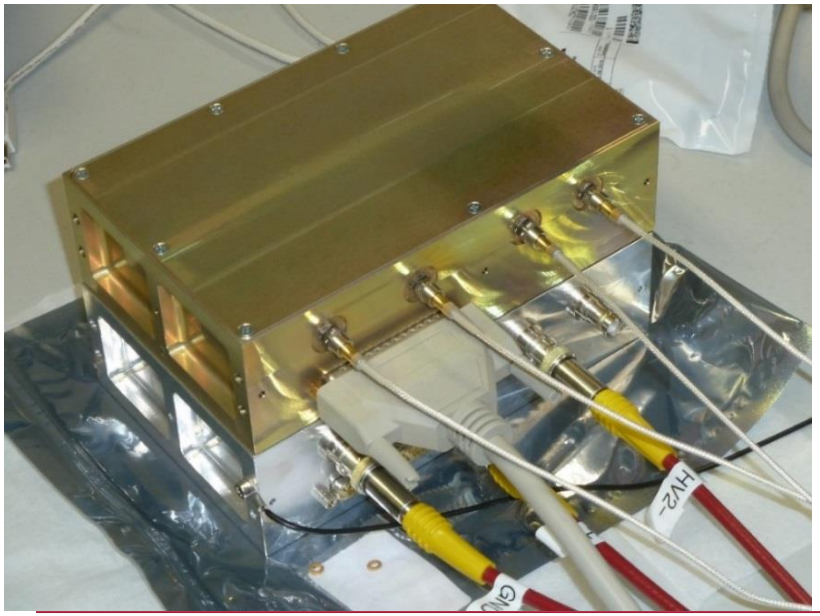
Balloon vs. Space

Advantages of a balloon flight

a) USB 2.0 Interface
⟶ high data rate
⟶ low cost

b) Radiation hardness of electronics not as crucial as in space
⟶ much cheaper
⟶ faster and easier to develop

HV box for space (on top), laboratory version (bottom)



Summary

Detector development at IAAT

- UV-MCP Detector
- Single-photon-counting
- Solar blind

- For Space and Balloon borne applications

Thank you!

The Laboratory