EURADOS

Radiation measurements using stratospheric balloons and drones

Iva Ambrožová on behalf of the CRREAT team
Nuclear Physics Institute of the Czech Academy of Sciences
ambrozova@ujf.cas.cz

CRREAT

EUROPEAN UNION
European Structural and Investing Funds
Operational Programme Research,
Development and Education

MINISTRY OF EDUCATION, YOUTH AND SPORTS

CTU CZECH TECHNICAL UNIVERSITY IN PRAGUE

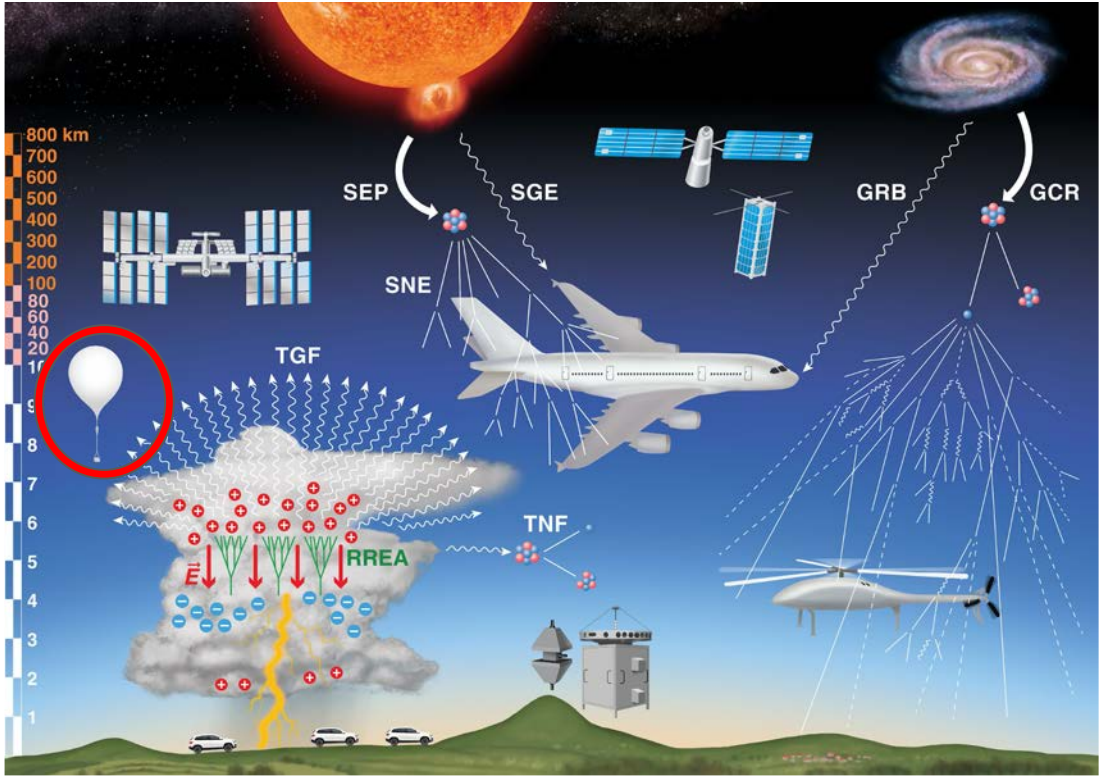
INSTITUTE OF ATMOSPHERIC PHYSICS CAS

Nuclear Physics Institute of the CAS
public research institution

Motivation

CRREAT
RESEARCH CENTRE OF COSMIC RAYS
AND RADIATION EVENTS IN THE ATMOSPHERE

- Platform for measurements of atmospheric phenomena and secondary cosmic radiation at high altitudes
- Verification of procedures and methods for atmospheric measurements
- Testing of new devices in challenging conditions

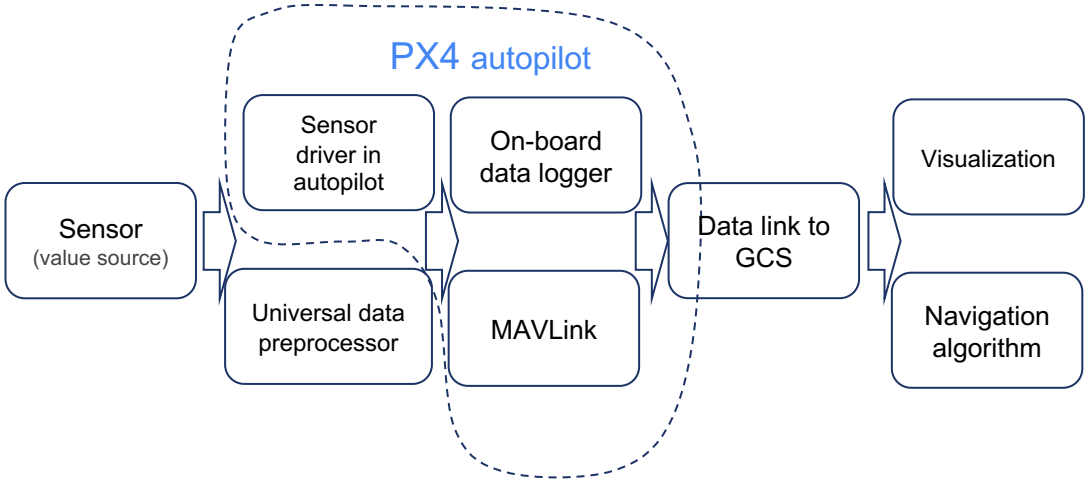


Flight	**FIK-1**	**FIK-2**	**FIK-3**	**FIK-4**	**FIK-5**	**FIK-6**	**FIK-7**
Location	CZ (2015)	CZ (2017)	CZ (2018)	SE (2019)	CZ (2019)	CZ (2020)	CZ (2021)
Payload	Candy detector Web camera	Candy detector, 360 deg camera	AIRDOS	AIRDOS C, SPACEDOS, GM, Socrat-R	AIRDOS C, SPACEDOS, GM, 360 deg camera	AIRDOS C, SPACEDOS, GM, Ionmeter, 360 deg camera	SPACEDOS, PiTED, 360 deg camera
Landing site	vineyard Austria	rapeseed field	Poland	swamp	forest	railway corridor	Poland
Power source	Li-ion 18650 accu	Li-ion 18650 and li-pol accu	Lithium primary cells and li-pol accu	Lithium primary cells	Lithium primary cells	Li-ion 18650 accu	Lithium primary cell and LiIon Power Bank
Telemetry system	GSM	GSM 868 MHz Proprietary Modem	SigFox Proprietary Modem	Outsourced	1x LoRa 1x SigFox 1x SiK 433 MHz	2x LoRa 1x SiK 433 MHz	1x LoRa
Rescue beacon	433 MHz CW	433 MHz CW	433 MHz CW	Outsourced	433 MHz CW	433 MHz CW	433 MHz CW
Flight control computer	Odroid-U2	Odroid-U2	Not used	Outsourced	PX4, FMU v5	PX4, FMU v5	DATALOGGER R01A

Challenges

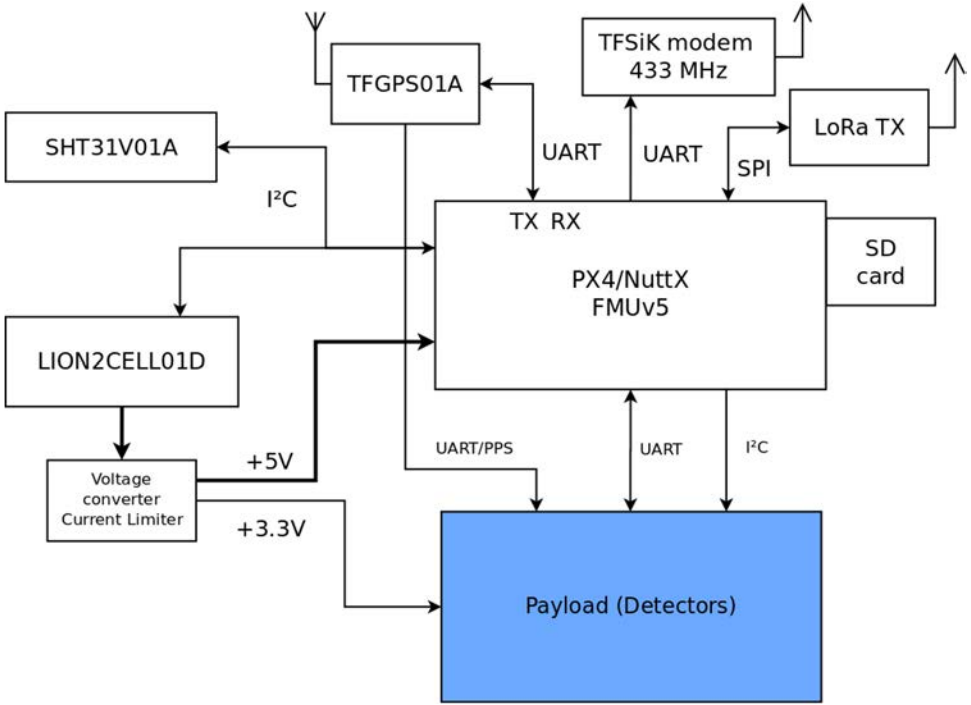
- Flexible system or system easily specialized on one task
  - Electric field measurement
  - Secondary cosmic radiation
  - Concentration of ions
- Measurements under unfavourable or even extreme weather conditions
- Use of real-time data to adjust the measuring process

TF-ATMON system architecture



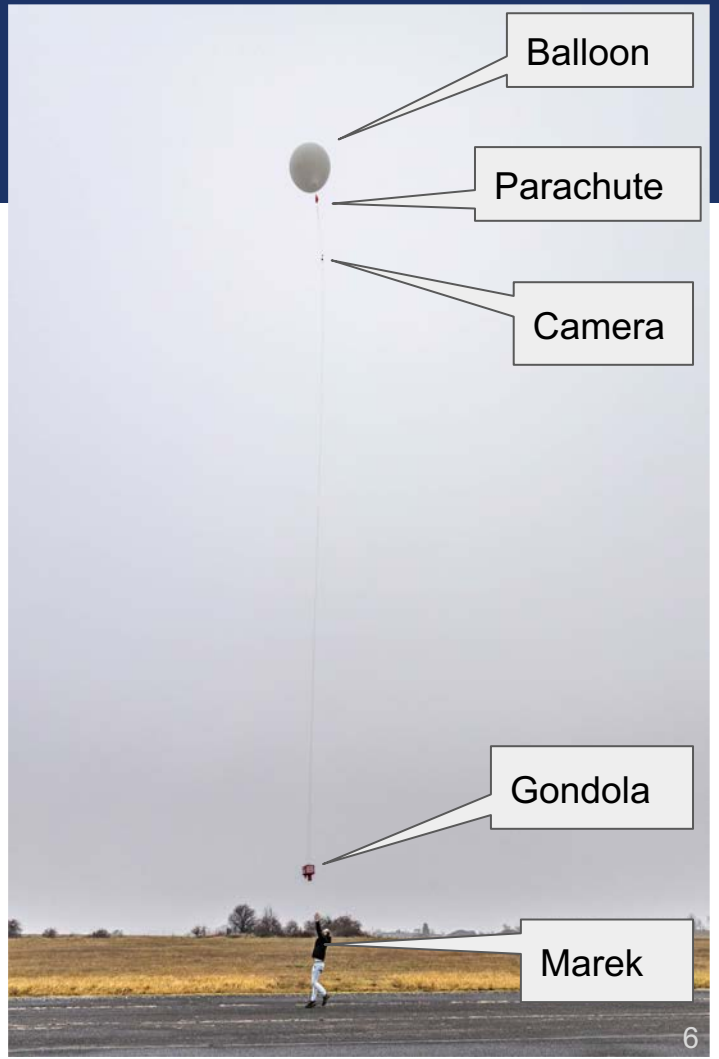
TF-ATMON

- Universal
  - fast implementation of new sensors
- Platform independent
  - Autogyro, Multicopter, Balloon
- Realtime measured data visualisation
- Features of balloon design
  - Simplification of payload integration
  - Possible of use relative high-power payloads
  - Redundant telemetry link
  - Gondola orientation tracking and logging
  - Power monitoring and maximal uptime calculation relevant to actual situation
  - Real-time pre-flight payload diagnostic



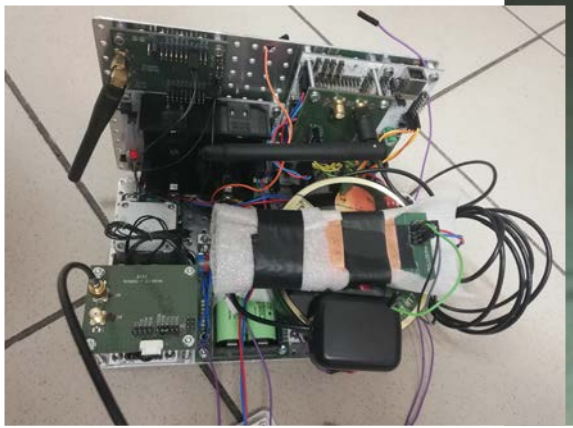
Balloon flight FIK-6

- 18th December 2020
- Balloon type: Hwoyee 1600
- Balloon gas: Helium
- Expected maximum altitude: 33 km
- Expected climbing rate: 5 m/s
- Total time of flight: 1 h 40 min
- Payload mass: 2 kg

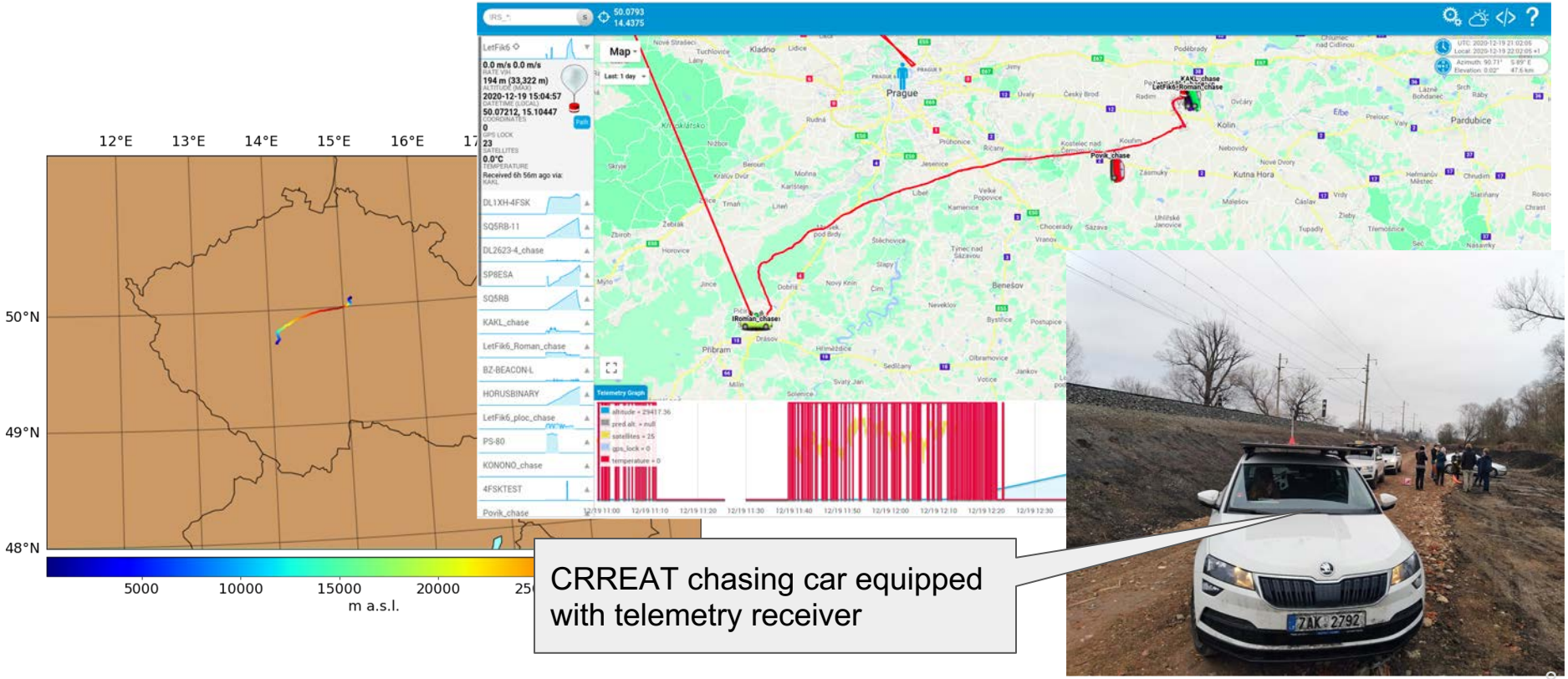


Balloon flight FIK-6

- Scientific experiment for measuring secondary cosmic radiation
- Testing and verification of the platform
  - 3D trajectory and gondola attitude logging
  - telemetry radio link
  - system reliability to use for controlled descent through thunderstorm in future experiments
- Gondola equipment:
  - 3 types of radiation detectors
  - 2 ion-meters
  - 3 telemetry systems
  - camera
  - Pixhawk Autopilot



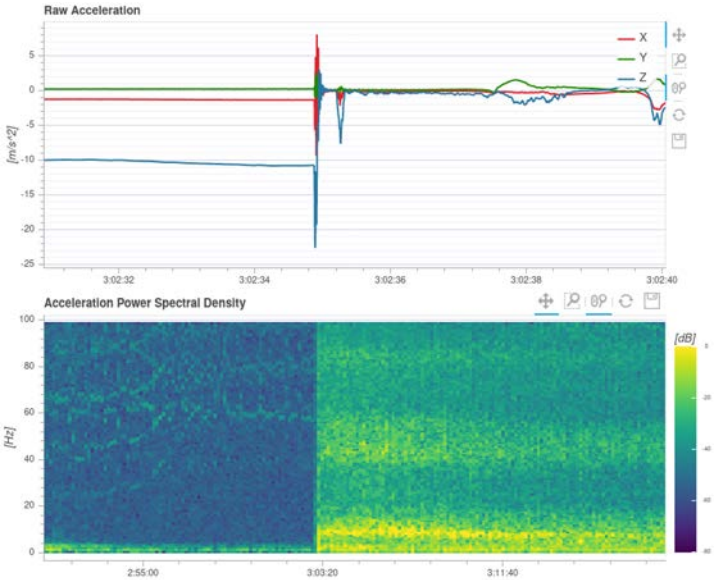
Balloon flight FIK-6

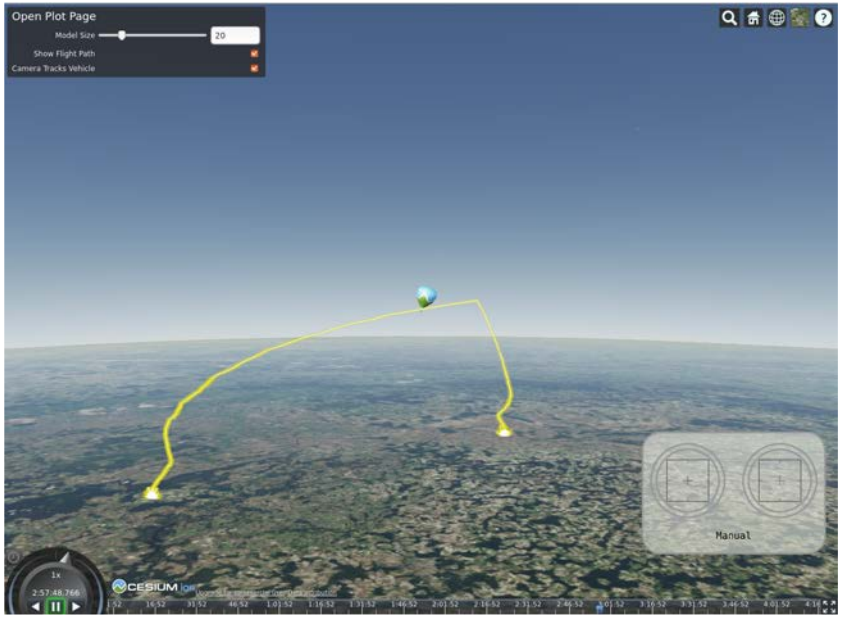


CRREAT chasing car equipped with telemetry receiver

Balloon flight FIK-6

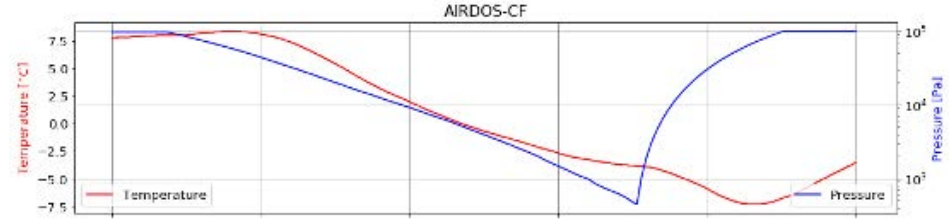
- Log analysis tool

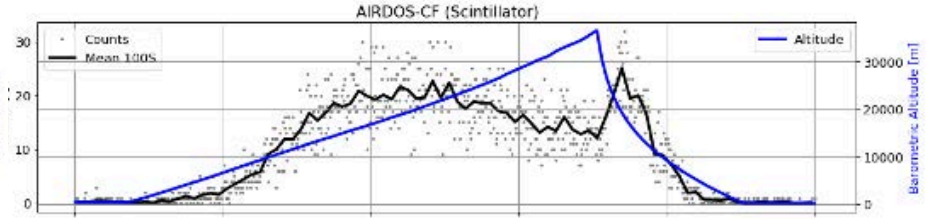


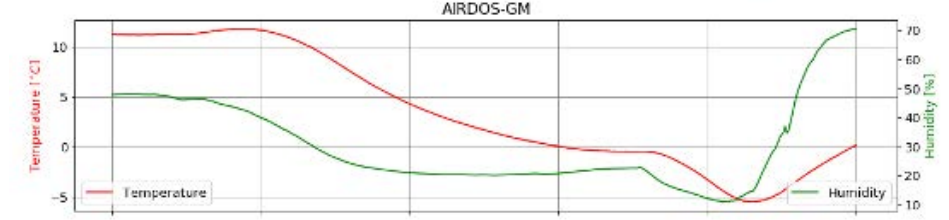


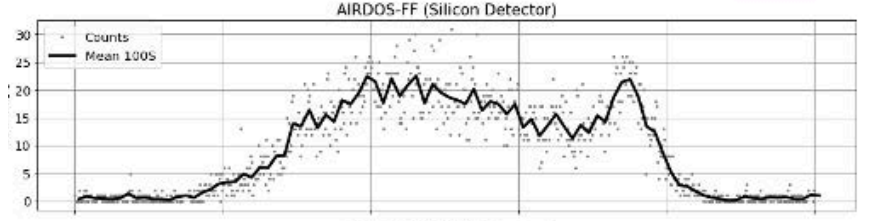
Video of recorded balloon burst https://youtu.be/E5B5rW-Sako

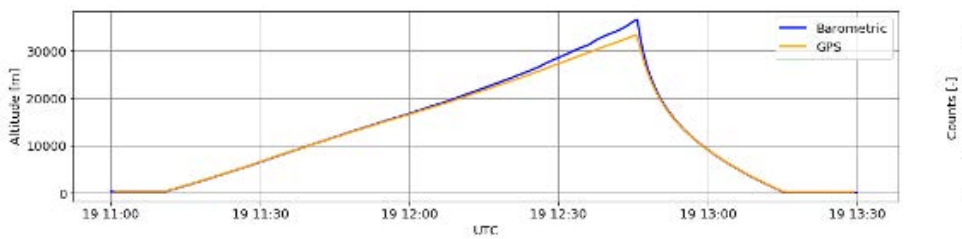
Balloon flight FIK-6

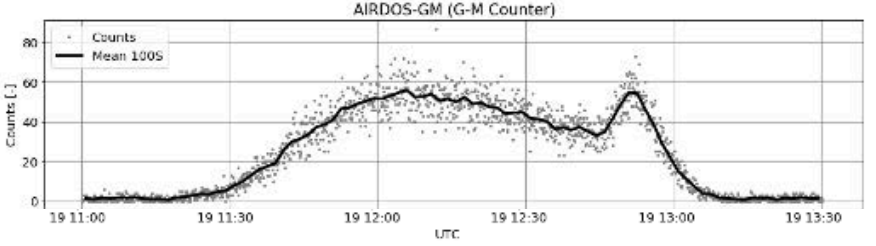






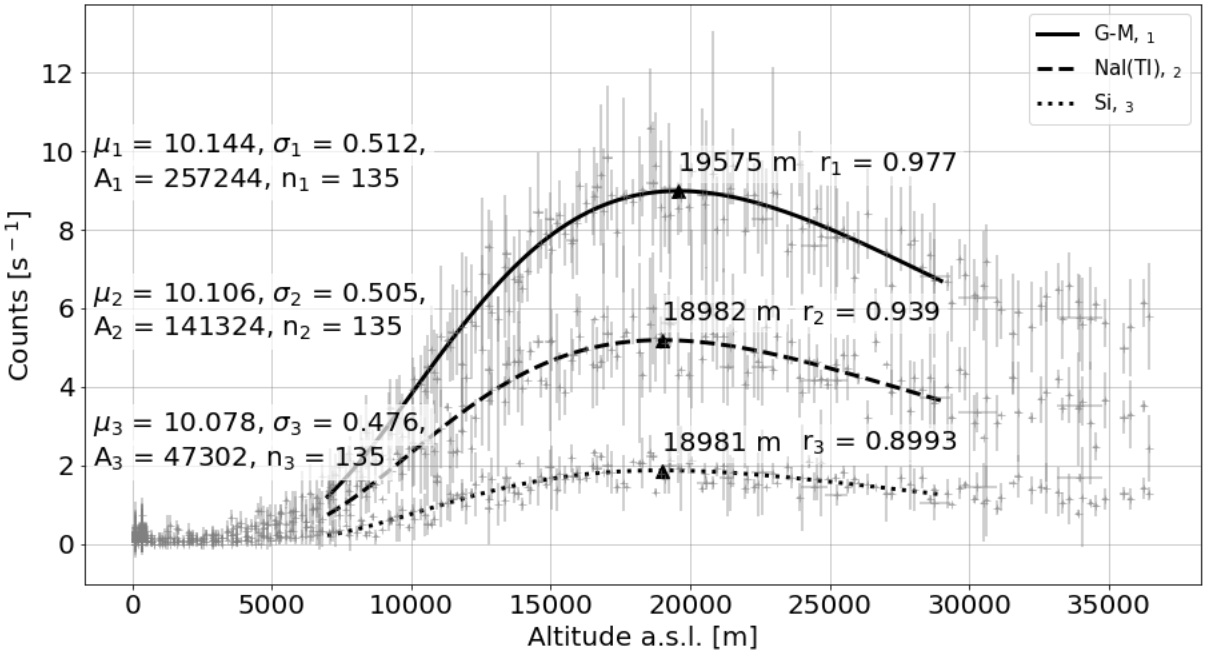






Balloon flight FIK-6

- SPACEDOS (AIRDOS FF)
  - Silicon detector
  - 300 µm x 10 mm x 20 mm
  - 180 keV – 7.8 MeV
- AIRDOS C (AIRDOS CF)
  - NaI(Tl) + SiPM
  - D 10 mm x 20 mm
  - 100 keV – 28 MeV
- G-M counter (AIRDOS GM)
  - STS-5
  - D 10 mm x 76 mm

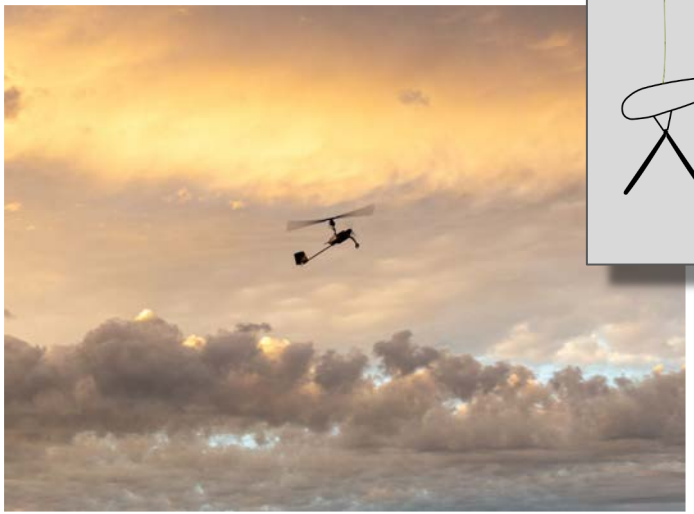


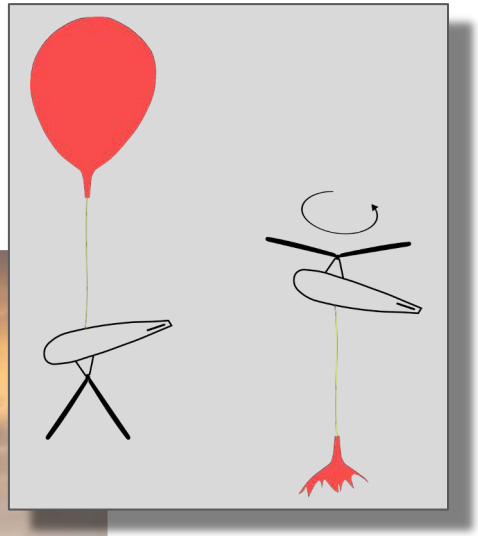
Conclusions and future improvements

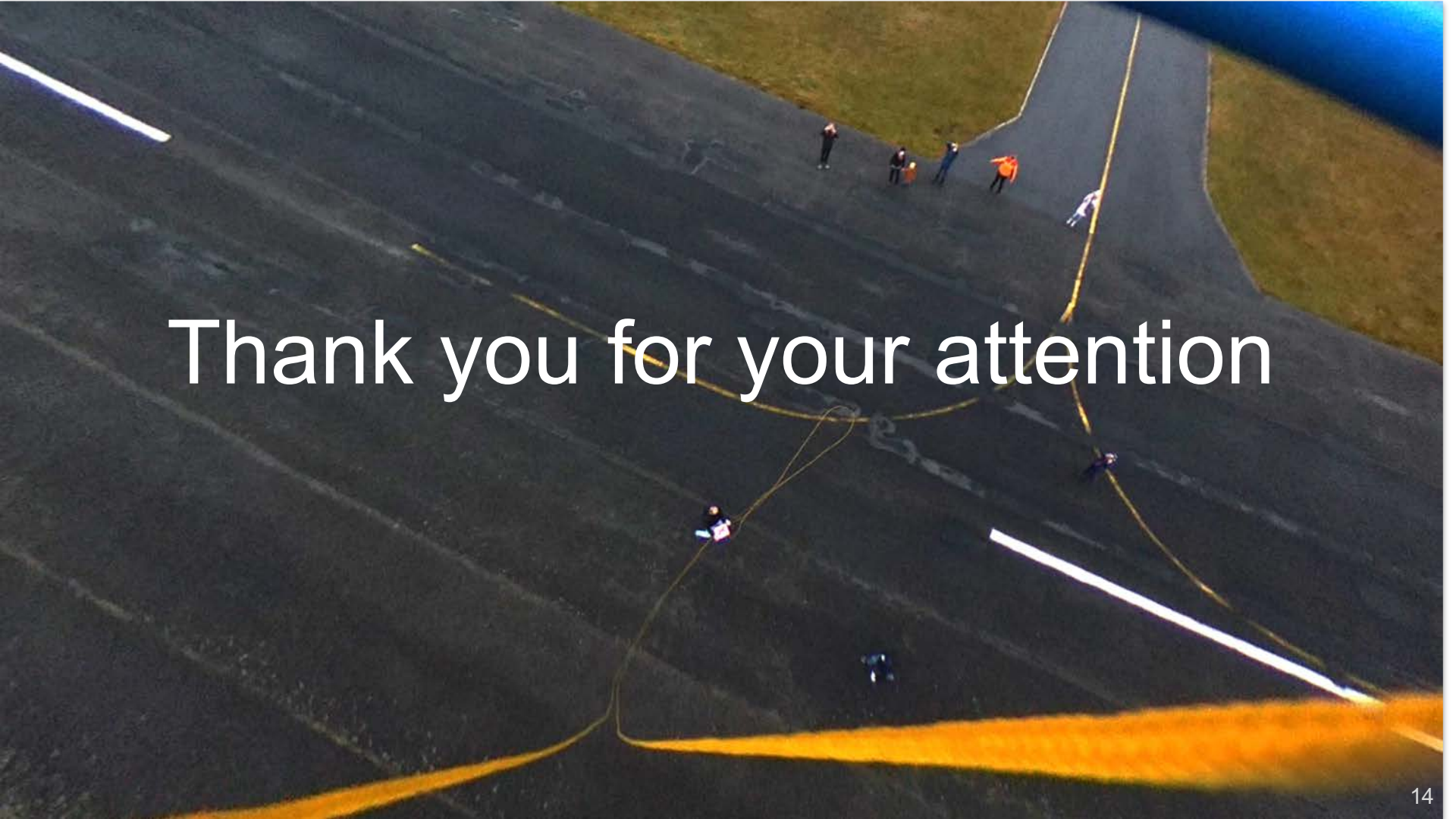
- Universal platform for atmospheric measurement using balloons and UAVs
- Data recording and monitoring
- Measured values
  - Electric field
  - Ionising radiation
  - Atmospheric aerosol particles
  - Supporting metadata - air pressure, humidity, temperature, vehicle acceleration, position, absolute time, etc.
- Different visualization techniques

Future improvements

- Improving quality and safety of balloon flights
  - Selective measurements of interesting layer in the atmosphere
  - Possible choice of safe landing area
- TF-G2 Autogyro
  - Takeoff and landing crosswind up to 15m/s
  - Wind gust resistance up to 10 m/s
  - 3D printed – Easily repairable
  - Open-source construction
  - Automatic flight support
  - Launch from hand or a car roof
  - Rotor diameter 0.8–1.05 m
  - Passive autorotation based safety mode
  - Airspeed flight range 7–25 m/s
  - Maximum takeoff weight 1.5 kg






Thank you for your attention