

# 21GRD02 BIOSPHERE

01.10.2022 – 30.09.2025

## Metrology for Earth Biosphere: Cosmic Rays, Ultraviolet Radiation and Fragility of Ozone Shield

F. Krasniqi (PTB), Coordinator

*The project 21GRD02 BIOSPHERE has received funding from the European Partnership on Metrology, co-financed by the European Union's Horizon Europe Research and Innovation Programme and by the Participating States.*



## Need: Disturbance of natural equilibrium

**Cosmic rays**

**Air shower**

Source: flickr

**Solar Particle  
Events**

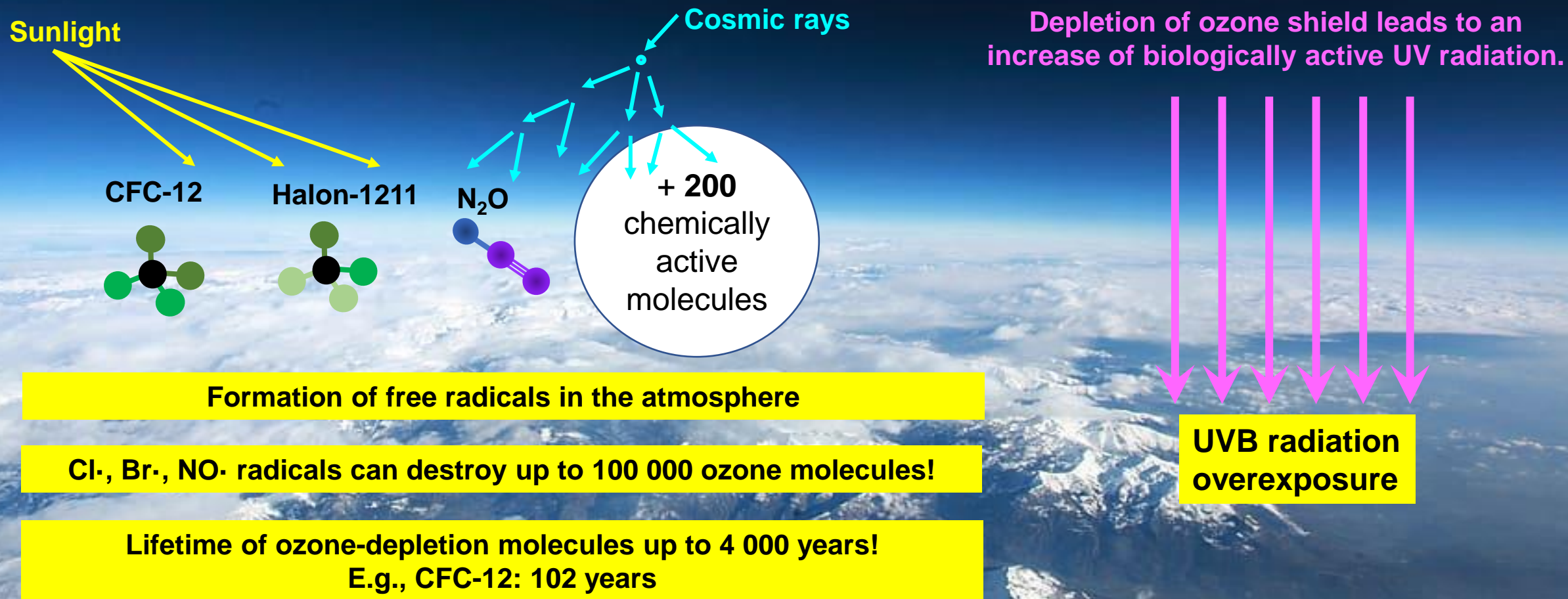
Cosmic rays and solar UV  
radiation are the main sources  
of atmospheric ionization



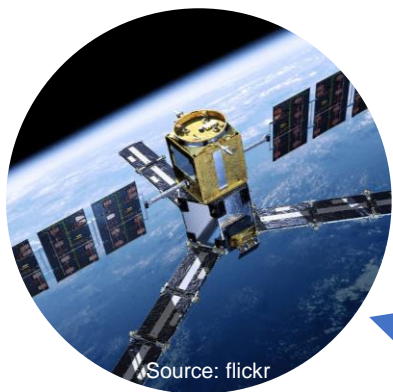
Implications for the  
**climate** and **health**

**UV radiation**

## Need: Ozone chemistry

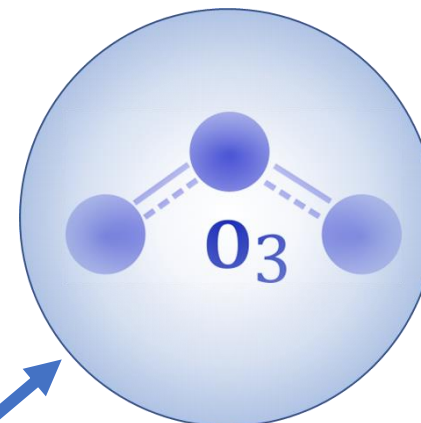


# Need: Metrology for the Earth biosphere



## Extraterrestrial radiation in space

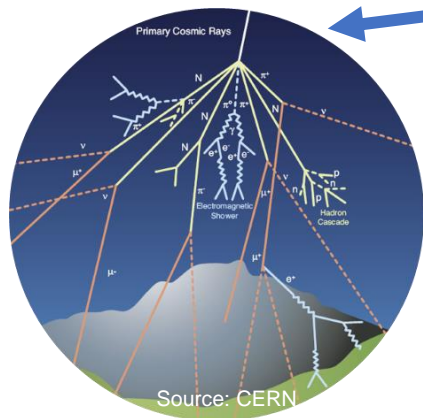
- Solar particle events
- Galactic cosmic rays
- Solar radiation



## Atmospheric chemistry

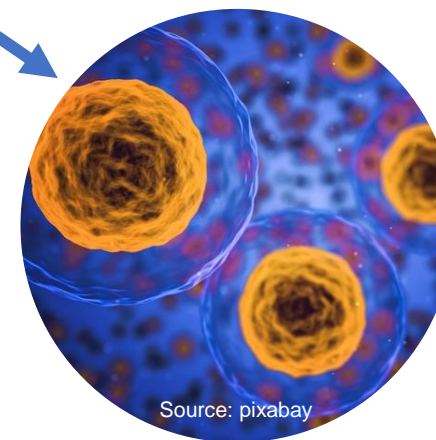
- Anthropogenic activities
- Ionization
- Molecular dissociation
- Ozone depletion

Novel metrological methodologies are needed to establish correlations between them



## Extraterrestrial radiation on the ground

- Muons
- Neutrons
- UVB radiation



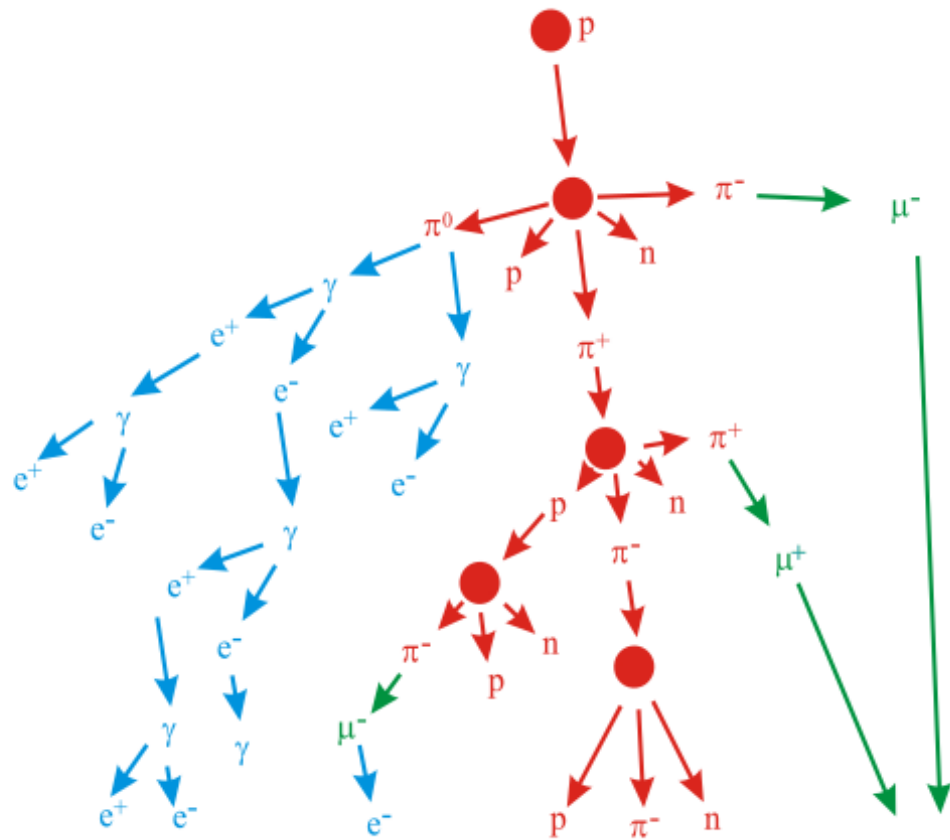
## Biology

- DNA damage
- Genomic instability
- Cell death

# WP1: Instrumentation for determining the dependence of SCR on PCR and atmospheric parameters

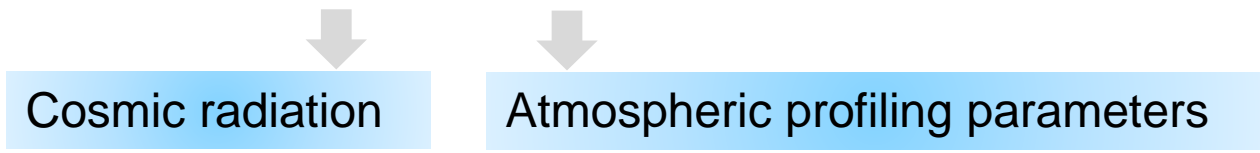
**WP 1 Leader:  
B. Rapp**

 **Laboratoire National  
Henri Becquerel**  
 **LNE-LNHB**



*Cosmic air shower  
(Source: Wikimedia Commons)*

**New metrological method** to determine the relationship between:



**Muons**  
 $\mu$

**Neutrons**  
 $n$



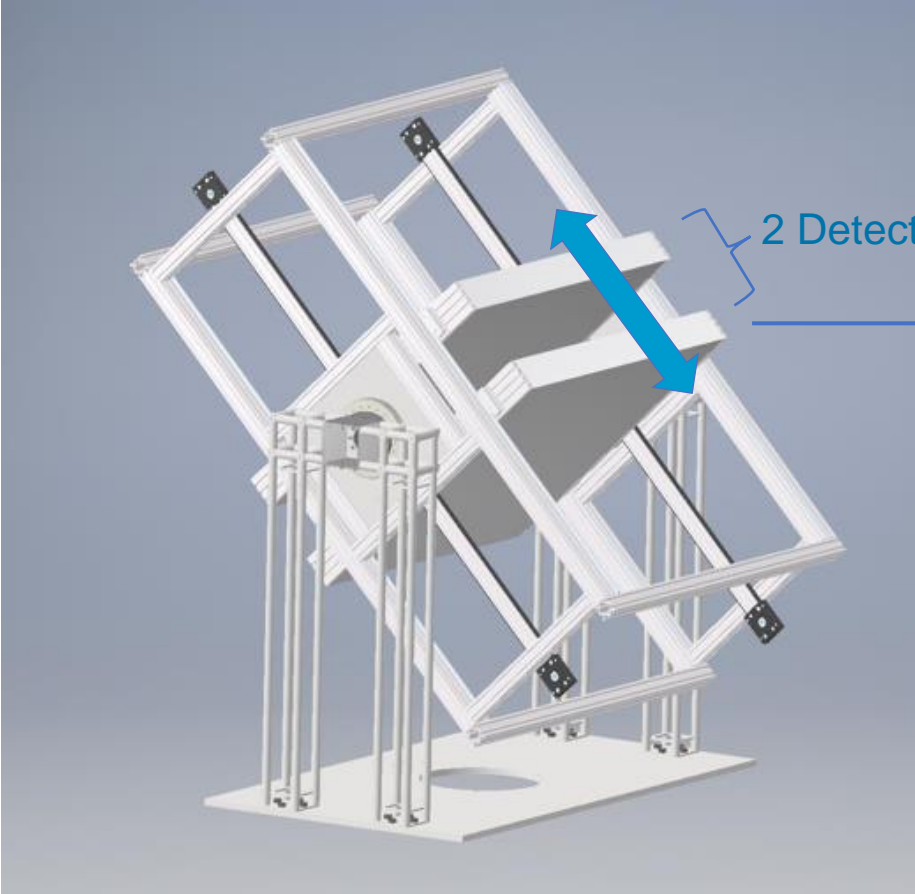
**Raymetrics+NTUA  
LIDAR**

# WP1: Instrumentation for determining the dependence of SCR on PCR and atmospheric parameters

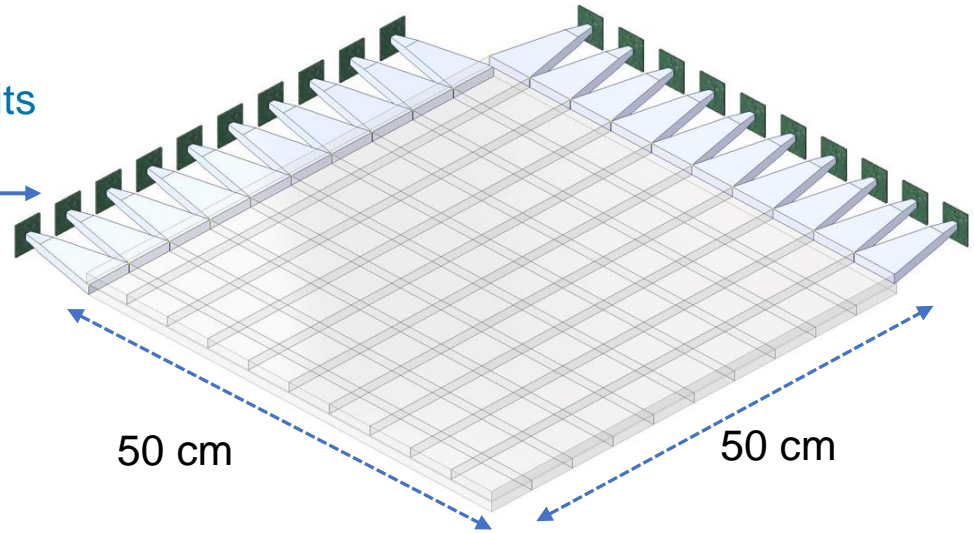
Novel detector for cosmic muons



- Solid angle adjustment ( $\Omega/(2\pi)$ : 0.1 to 0.6)
- Angular distribution of muons ( $\theta$ :  $0^\circ$  to  $90^\circ$ ,  $\varphi$ :  $0^\circ$  to  $360^\circ$ )
- Pixelated ( $5 \times 5 \text{ cm}^2$ )
- Mobile

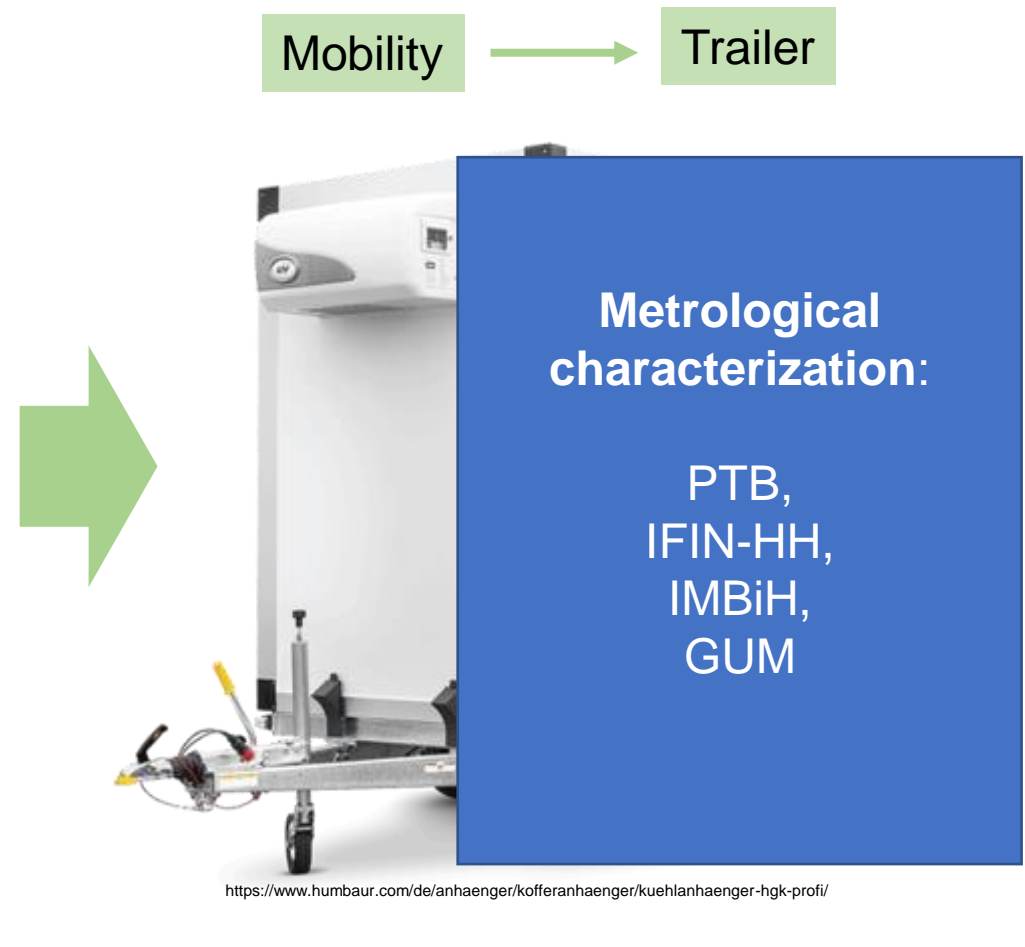
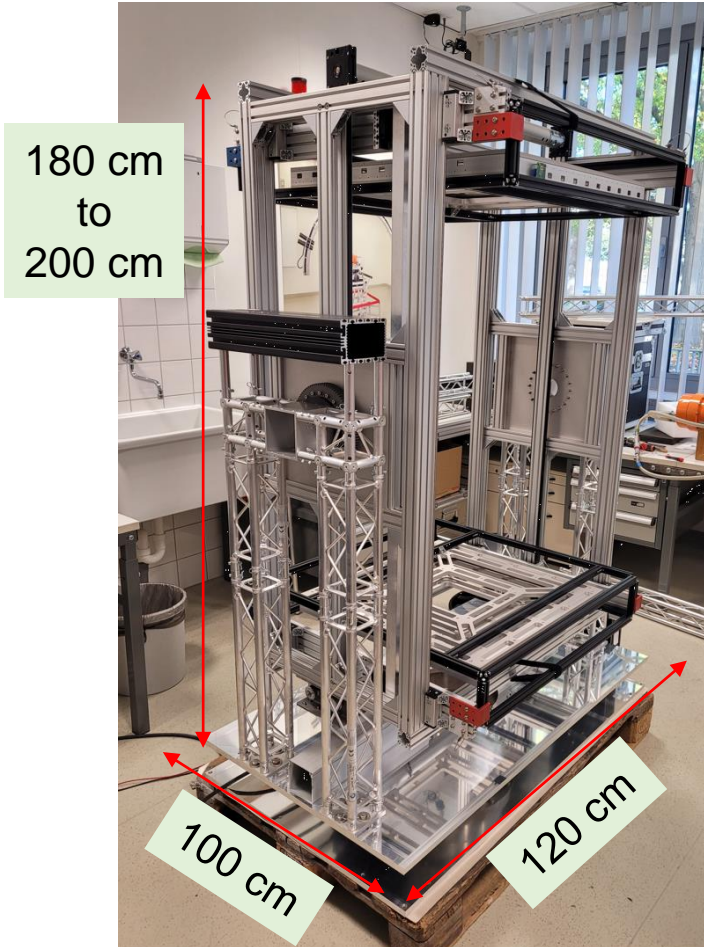


2 Detector units



M. Weierganz, B. Pullner, G. Winterbottom, M. Reek, K. Kahnt, T. Weidner, V. Dangendorf, F. Krasniqi (PTB)

# WP1: Instrumentation for determining the dependence of SCR on PCR and atmospheric parameters



# WP1: Instrumentation for determining the dependence of SCR on PCR and atmospheric parameters

## Novel mobile detector for cosmic neutrons

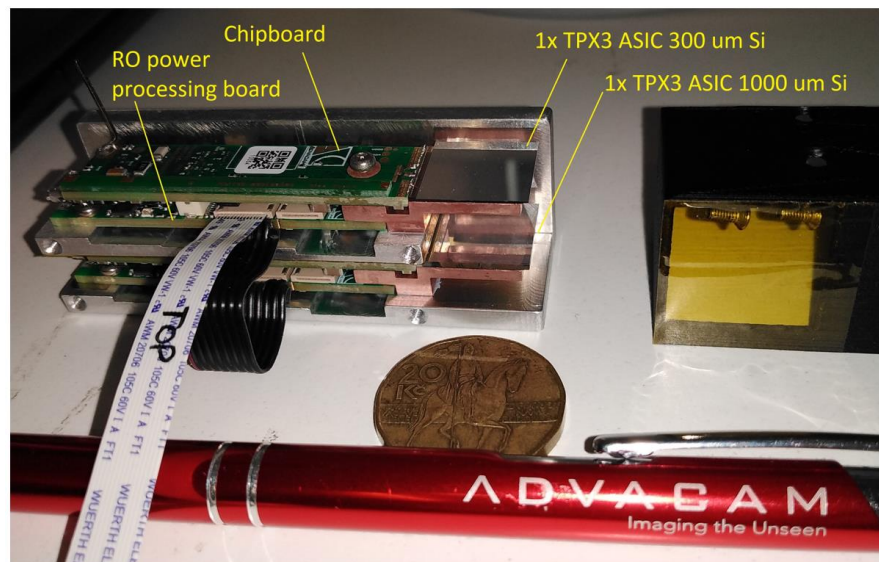


UJF CAS: Iva Ambrožová

### Detection:

- fast neutrons,
- thermal neutrons, and
- photons

## Timepix3



ADVACAM: Carlos Granja

**Radiation imaging, particle tracking:**  
charged particles, neutrons, gamma rays

Development and validation of Monte Carlo models for the detectors  
+  
Metrological characterization

CMI: Jaroslav Šolc



**New metrological method to quantify correlations between**



*Cosmic rays*

*Solar UV radiation*

*Anthropogenic emission*

## Measurement campaigns

(cosmic ray detectors, LIDARS, UV Spectroradiometers)



National Technical  
University of Athens

**Greece**

A. Papayannis



**Belgium**

R. van Malderen,  
D. Bolsée



**Czech Republic**

Iva Ambrožová

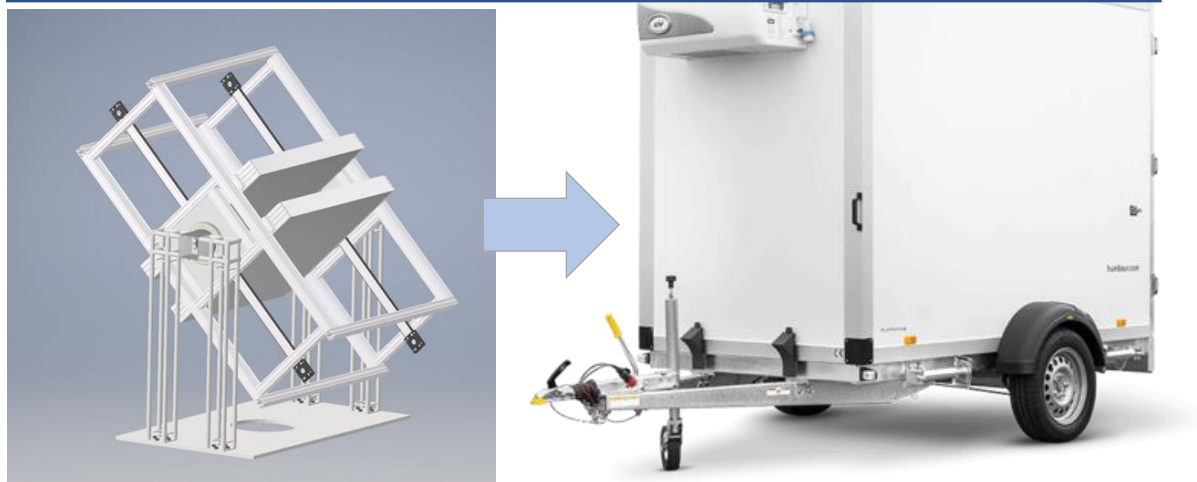


**Germany**

L. Doppler

June –September (2023)

PTB: Muon detector

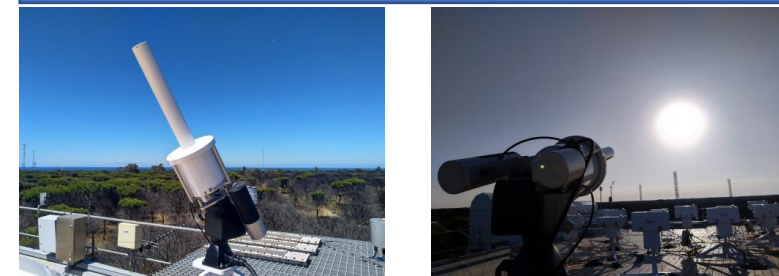


<https://www.humbaur.com/de/anhaenger/kofferanhaenger/kuhlanhaenger-hgk-profi/>

NTUA & Raymetrics:  
LIDAR



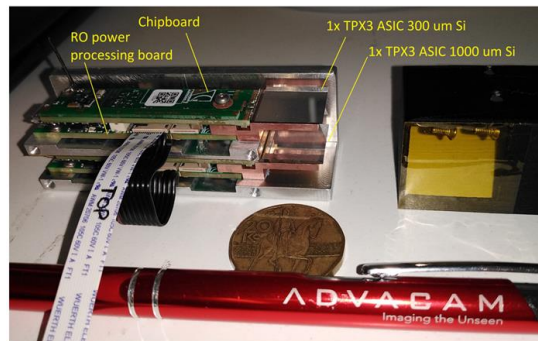
GGO:UV Spectroradiometer BTS-Solar



UJF CAS:  
Neutron detector



ADVACAM: Timepix 3



BFKH: Neutron  
detector

<sup>3</sup>He detector  
(SP9 type)

BIRA-IASB: UVB pyranometer and GUV-511 multichannel filters radiometer



*(Relevant for WP2 & WP3)*

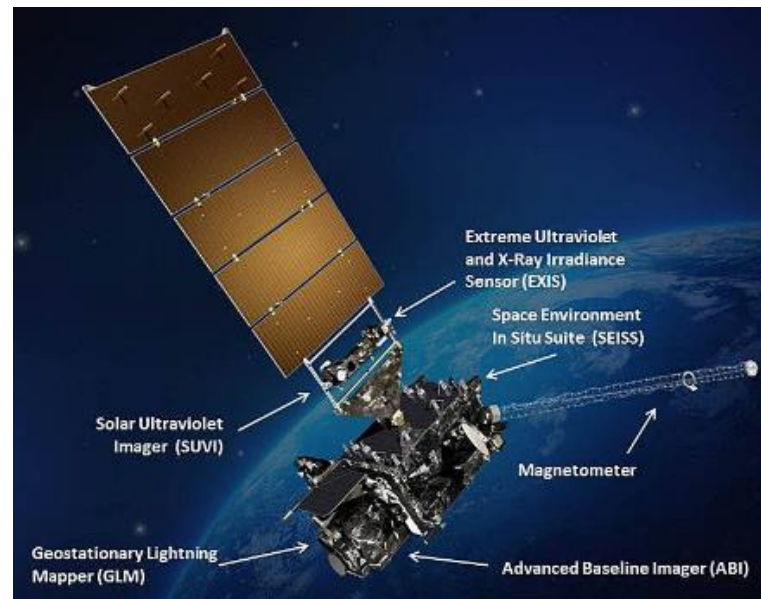
## PROBA-V Satellite

Data on electron, proton and helium ion fluxes to investigate flux increases during SEP (Solar Energetic Particles) events and geomagnetic storms



## GOES Satellite

Satellite observations of energetic electron and proton fluxes



Credits: NASA

## AtRIS

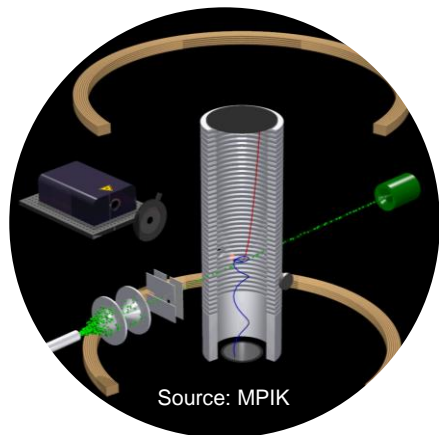
Atmospheric Radiation Interaction Simulator

Analyse the impact of Solar Energetic Particles (SEP) and Cosmic primary and secondary radiation on atmospheric dynamics.

**BIRA-IASB:**  
V. Pierrard,  
A. Winant,  
E. Botek

## WP3: Molecular processes affecting ozone depletion and atmospheric dynamics

WP 3 Leader:  
A. Dorn



Reaction microscope

For the first time, **fundamental data** on the interaction of low-energy electrons with atmospheric gases of both natural and anthropogenic origin

Molecular ionization

Molecular fragmentation

Dissociative electron attachment

Development of a **complete data base of collision cross sections** for natural atmospheric and anthropogenic gases

CFCs, CFC/CH<sub>2</sub>Cl<sub>2</sub>, N<sub>2</sub>, O<sub>2</sub>, NO, NO<sub>2</sub>, CFC/CH<sub>2</sub>Cl<sub>2</sub>, HCl, HF, HBr, SF<sub>6</sub>

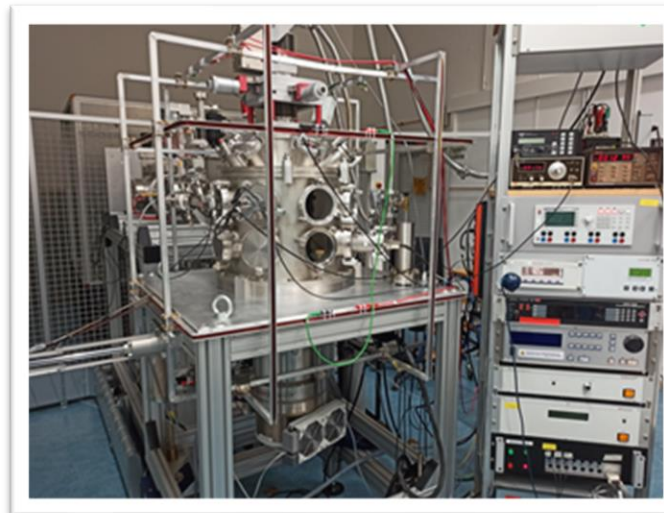
WP3 Partner: MPG, PTB, TUBITAK, BIRA-IASB, CSIC, NOVA



Proba-V satellite

Biofuels such as ethanol are increasingly replacing traditional fossil fuels, which leads to an elevation of volatile organic compounds in the earth atmosphere.

- Elastic electron scattering cross sections of ethanol have been measured and submitted for publication (accepted)
- Total ionization cross sections of ethanol have been calculated



PTB: M. Dinger, W. Y. Baek

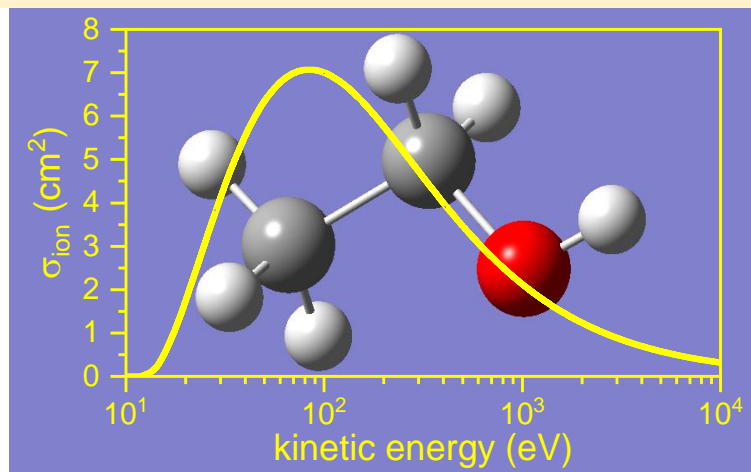
Collaboration with



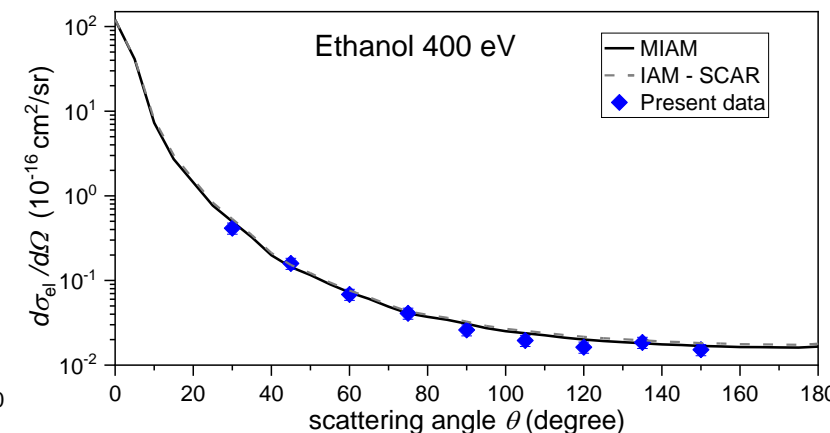
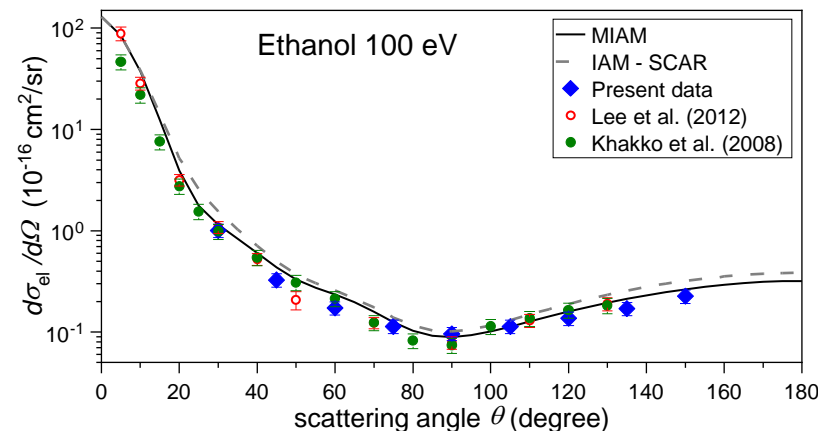
Korean Institute of Fusion Energy

Y. S. Park, M. -Y. Song

## Ionization cross sections of ethanol

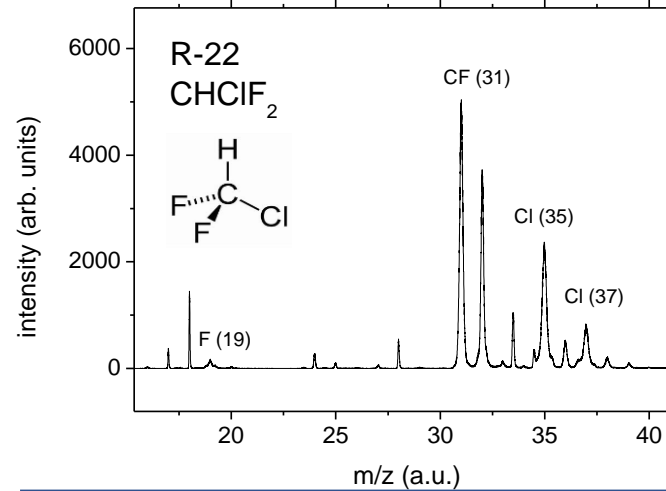
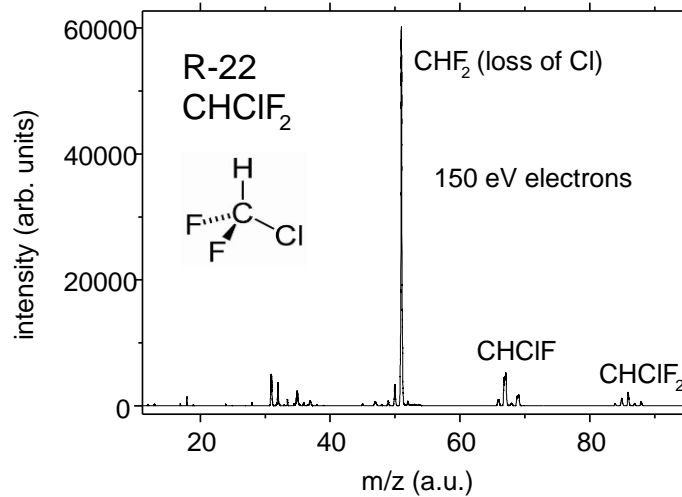


M. Dinger et al, Combined experimental and theoretical study on the elastic electron scattering cross sections of ethanol, EPJD accepted



Example of a fragmentation spectrum of  $\text{CHClF}_2$  (R22), measured with a Reflection Time-of-Flight Mass Spectrometer for an electron impact energy of 150 eV

## Dominant process: the loss of the Cl - ion



PTB: V. Dangendorf

In collaboration with

UNIVERSIDADE FEDERAL DO RIO DE JANEIRO

W. Wolff

## CFC, HFC and related substances to be evaluated:

### CFCs

CCl3F	Trichlorfluormethan	R11
CCl2F2	Dichlordifluormethan	R12
CClF3	Chlortrifluormethan	R13
CHCl2F	Dichlorfluormethan	R21
CHClF2	Chlordifluormethan	R22
CClF2-CClF2	1,2-Dichlor-tetrafluorethan	R114
C2ClF3	Chlortrifluorethylen	R1113

### HFCs:

CF4	Tetrafluorkohlenstoff	R14
CHF3	Trifluormethan	R23
CH2F2	Difluormethan	R32
CF3CF3	Hexafluorethan	R116
CF3CHF2	Pentafluoroethane	R125
CF3CH2F	1,1,1,2-Tetrafluorethan	R134a
C2H3F3	1,1,1-Trifluorethan	R143a
CF3CF2CF3	Octafluormethan	R218

### Others:

CH3Cl	Chlormethan	R40
CHCl3	Chloroform	R20
CH2Cl2	Dichlormethan	R30
CH2Br2	Dibrommethan	
CBrF3	Bromtrifluormethan	H1301
SF6	Schwefelhexafluorid	
N2O	Distickstoffmonoxid, Lachgas	

available | already measured

## WP4: Effects of combined SCR and UV radiation fields on biological systems

WP 4 Leader:  
A. Georgakilas



National Technical  
University of Athens

Investigation of **structural** and **functional damages** inflicted by combined cosmic and UV exposure in human primary cells



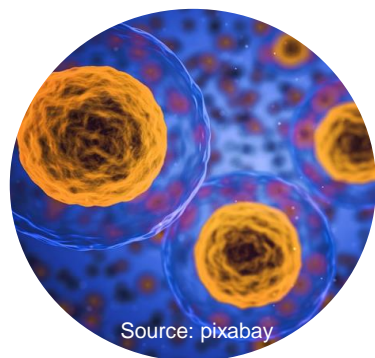
*Skin and lung fibroblasts*



*Proliferating human blood monocytes*



*Microvascular endothelial and normal epithelial brain cells*



*Human primary cell  
(artistic view)*

Correlation between irradiation parameters and changes of cellular parameters using **system biology** approaches.

NTUA: A. Georgakilas

IVB: G. Manda

IFIN-HH: M. -R. Ioan

### Collaborations:



BUNDESWEHR

Ch. Beinke



UK Health  
Security  
Agency

S. Barnard

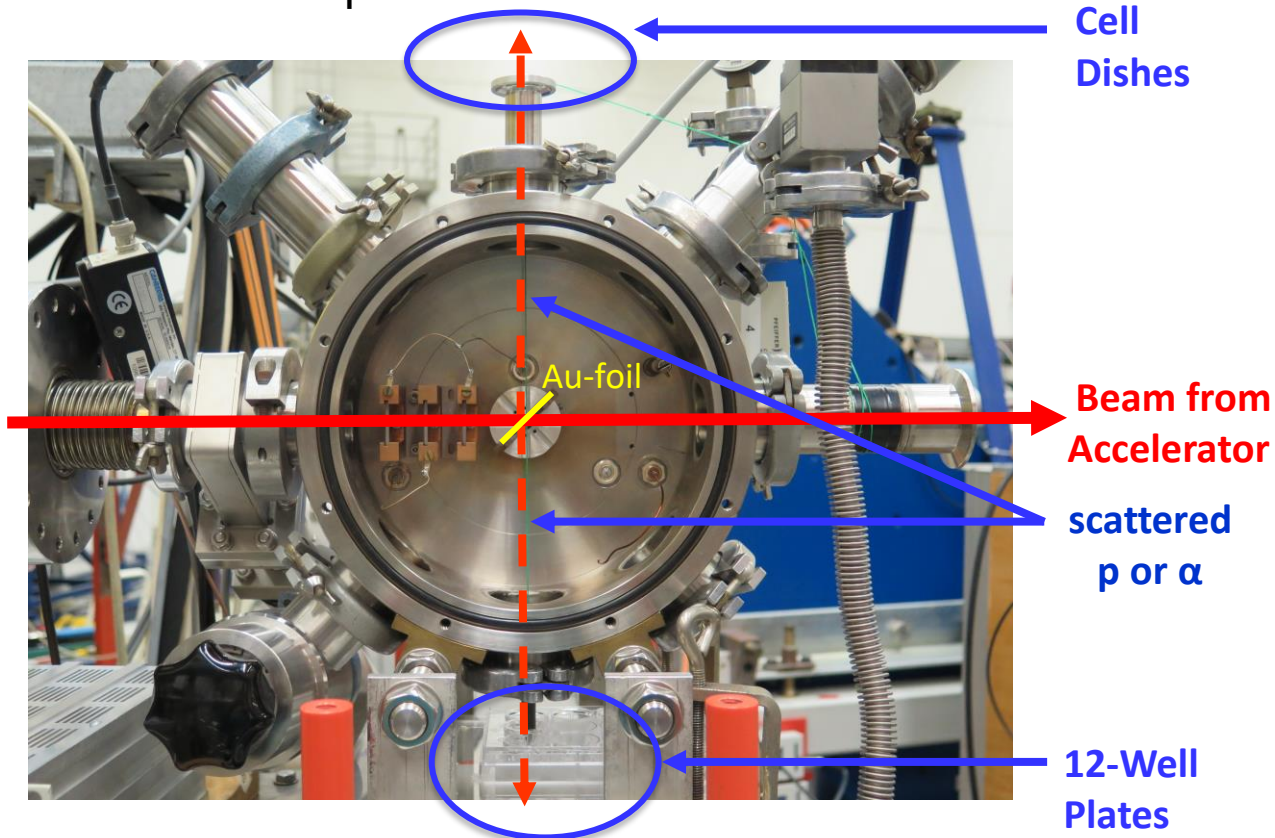


UNIVERSITÉ  
CAEN  
NORMANDIE

S. Haghdoost

## Experiments @ PTB Ion Accelerator Facility (July 2023) Simulate CR-Muons with low LET-protons

Protons of 10 MeV to 15 MeV  
LET ~ 4 keV/μm



## Solar Simulator based on 300 W Xe short arc lamp



### PTB Team:

U. Giesen (Department 6.4)

F. Krasniqi (Department 6.3)

with assistance from  
Working Group 4.11: Spectroradiometry



**WP1:** The cosmic ray detectors are being characterized metrologically.

**WP2:** The first measurement campaign to quantify the relationships between cosmic rays, UV-B radiation and the thickness of the ozone layer and the concentration of anthropogenic gases is in preparation. It will start on 01 June 2023.

**WP3:** Elastic electron scattering cross sections of ethanol were measured and submitted for publication (accepted). Fragmentation cross sections of 6 ozone depleting molecules have been measured (measurements with other molecules are ongoing).

**WP4:** Experiments at PIAF with human primary cells are in preparation. The first beam time is planned for July 2023.

# Thank you!

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