PIERRE AUGER OBSERVATORY

FAST
Fluorescence detector Array of Single-pixel Telescopes

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Potential for atmospheric monitoring using FAST telescopes

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AtmoHEAD 2022, 13.-15. 7. 2022

Outline

Fluorescence detector Array of Single-pixel Telescopes

Introduction of the FAST telescopes

Optical properties of atmosphere

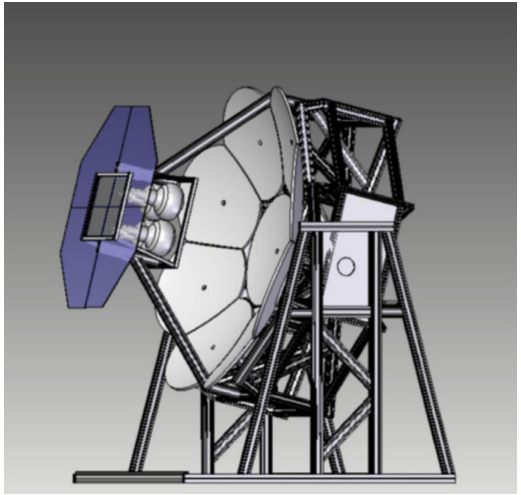
Comparison of the detected events

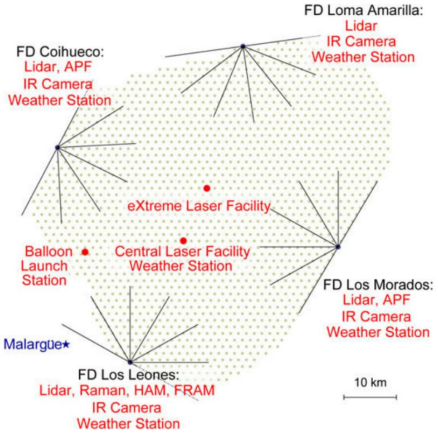
Analysis of vertical CLF shots detected by FAST

Future plans

Introduction of the FAST telescopes

- FAST telescope
  - 3 at TA
  - 2 at PAO
- Distance between CLF and LL
  - L = 25 987 m
  - time of light traveling
    - approximately 8.67.10−5 s
  - FAST is located within hundreds of meters from LL





Picture 1: Design of the prototype the FAST telescope [1] and map with positions of the Fluorescent detectors, laser facilities and other scientific stations at Pierre Auger observatory [2].

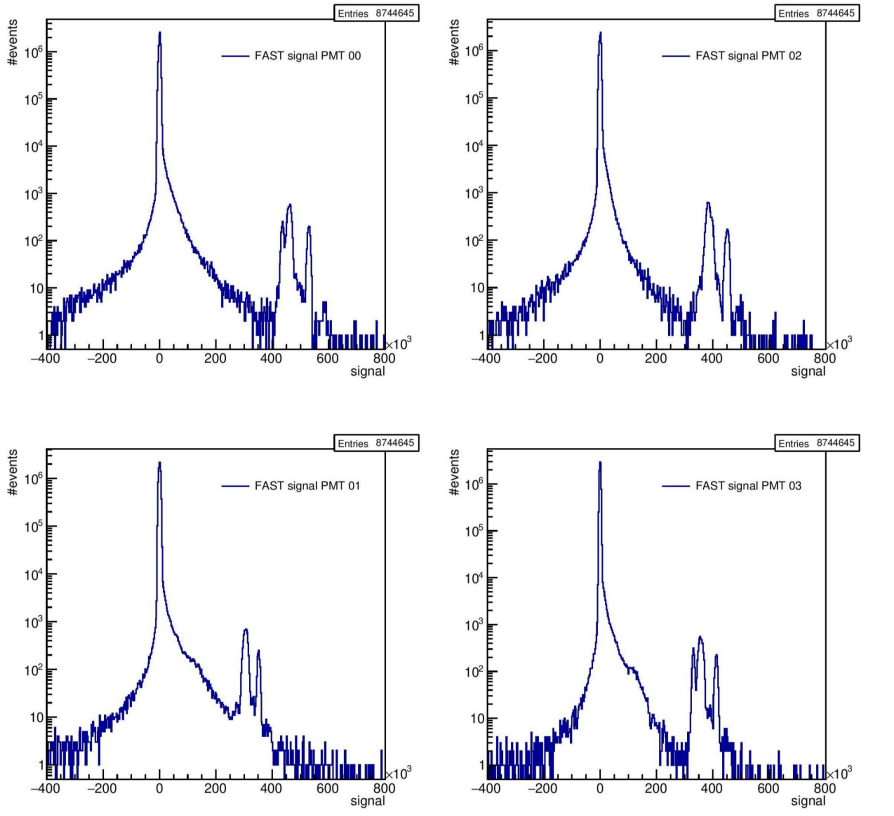
Optical properties of atmosphere

- Important to know transmission properties of atmosphere
  - absorption
  - scattering - Rayleigh scattering and Mie scattering
- Wavelength band of interest 300 nm - 400 nm
- For the first approximation used Beer-Lambert's law

$$I = I_0 \, e^{-\beta L}$$

Comparison of the detected events

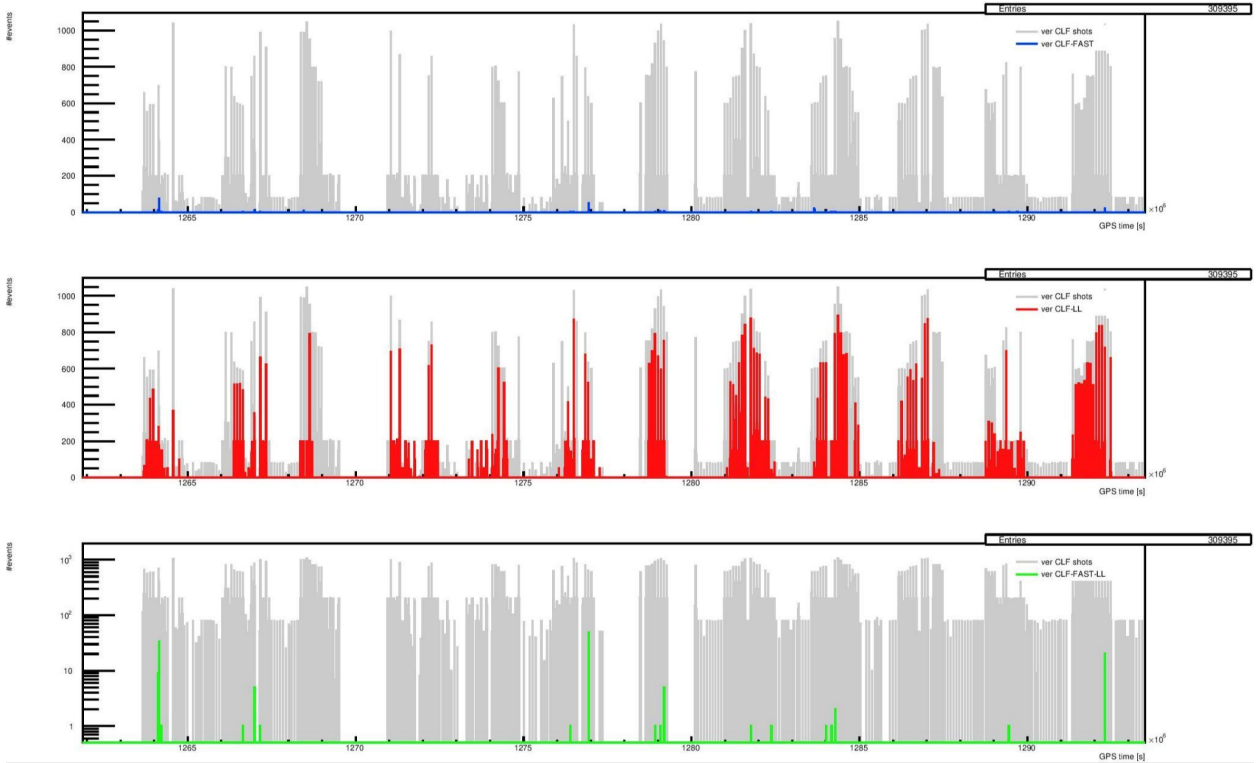
- CLF has 2 types of shots:
  - vertical:
    - fired at 0.25 s
    - azimuth: 0°
    - zenith: 90°
  - horizontal:
    - fired at 0.5 s
    - azimuth: 141°
    - zenith: 2°, 3° or 4°



Picture 2: Sum of the signal detected at all PMTs on FAST for 2020.

Comparison of the detected events

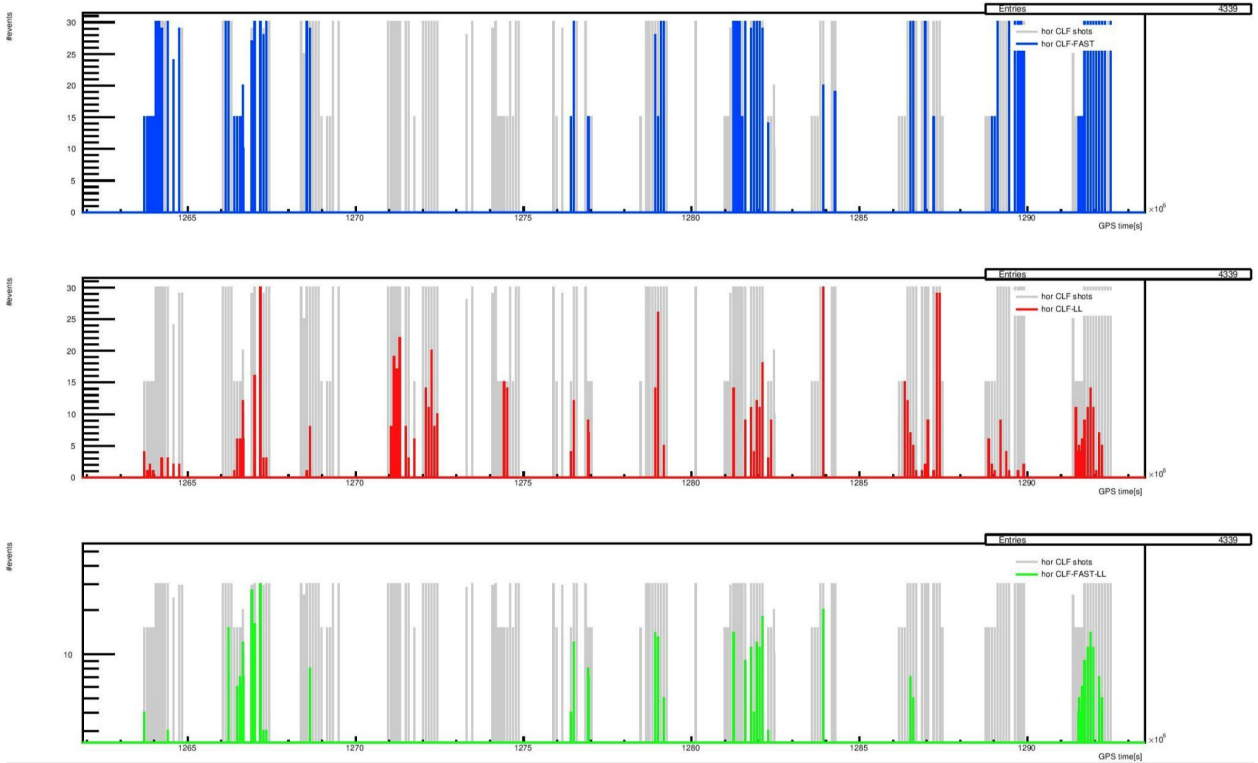
- Vertical CLF shots: 309 395
  - CLF-FAST: 280
  - CLF-LL: 146 715
  - CLF-LL-FAST: 137



Picture 3: CLF vertical shots and their detection on FAST and LL.

Comparison of the detected events

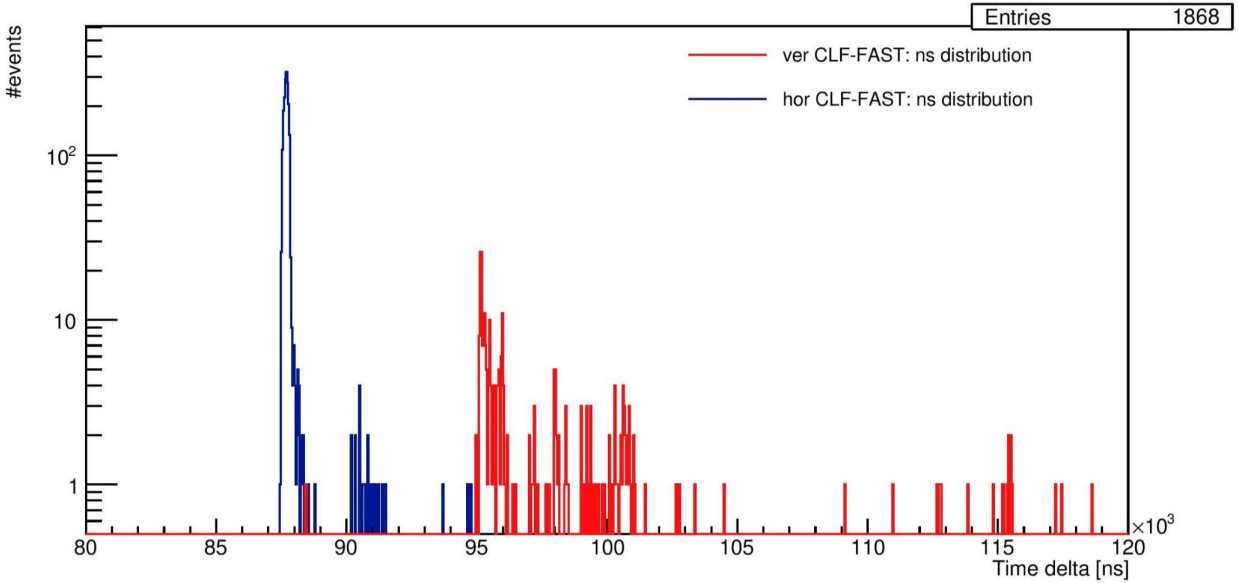
- Horizontal CLF shots: 4 350
  - CLF-FAST: 1868
  - CLF-LL: 762
  - CLF-LL-FAST: 434



Picture 4: CLF horizontal shots and their detection on FAST and LL.

Comparison of the detected events

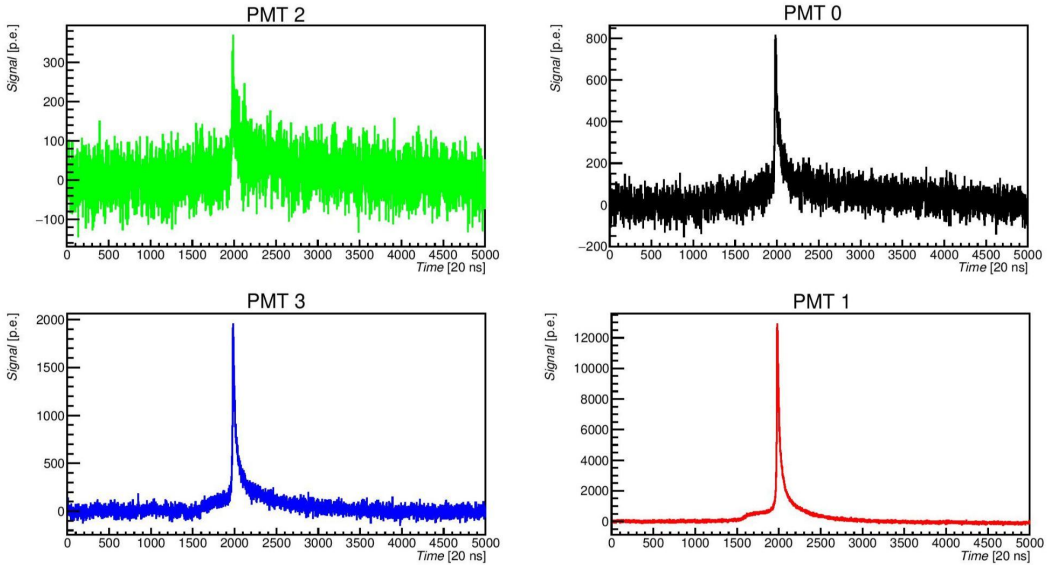
- Distribution of ns part:
- Horizontal shots:
  - aim straight
- Vertical shots:
  - light scattering



Picture 5: Distribution of the ns part of time between CLF and FAST for 2020.

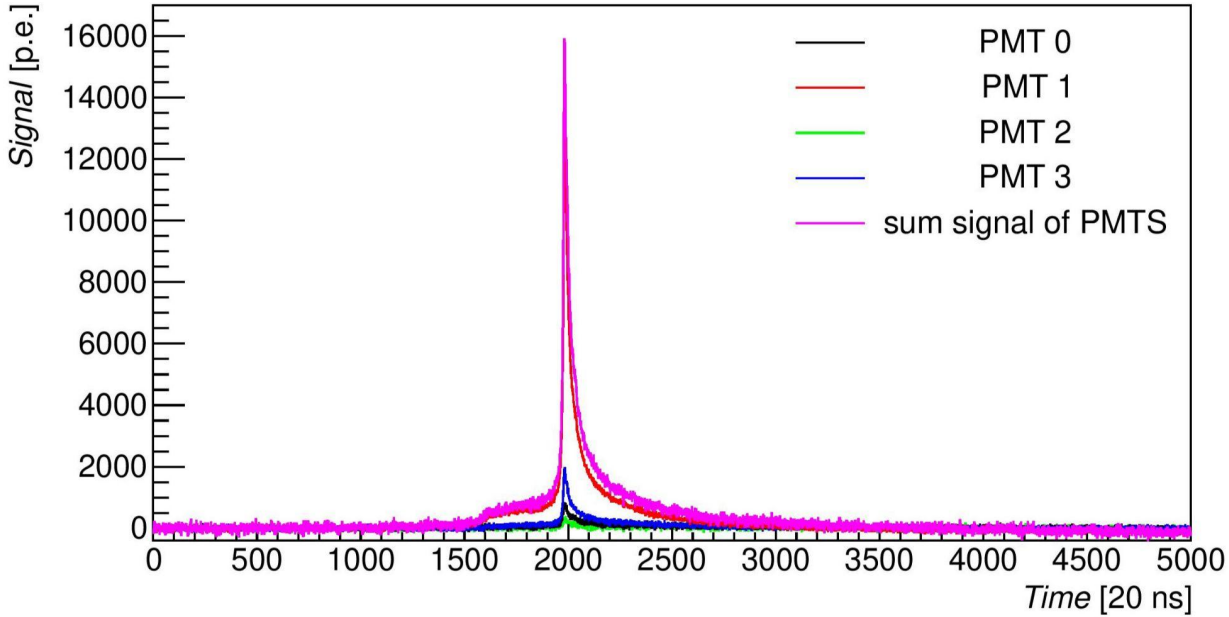
Analysis of vertical CLF shots detected by FAST

- Time and signal condition for selecting events
- Impact of position of the FAST telescope
- The CLF in lower-left part of the FOV



Picture 6: Integrated signal from vertical CLF shots for period from December 2019 to December 2020 for individual PMTs, it contains 358 detected events.

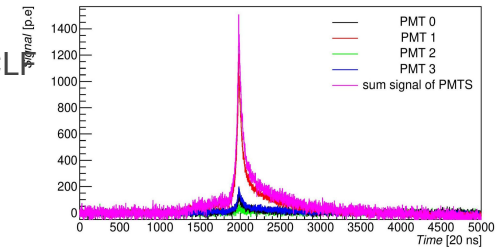
Analysis of vertical CLF shots detected by FAST



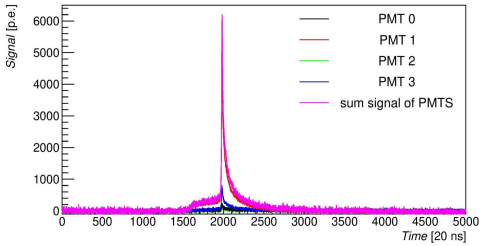
Picture 7: Integrated signal from vertical CLF shots for period from December 2019 to December 2020 for individual PMTs and sum of all PMTs in one histogram.

Analysis of vertical CLF shots detected by FAST

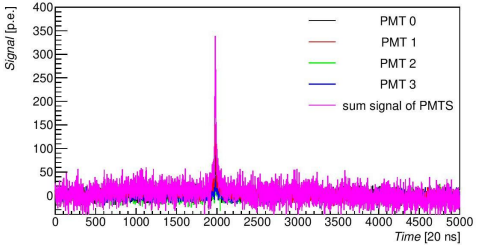
- Impact of year period on signal of CLF shots.
- Periods are named according to weather periods in Argentina.



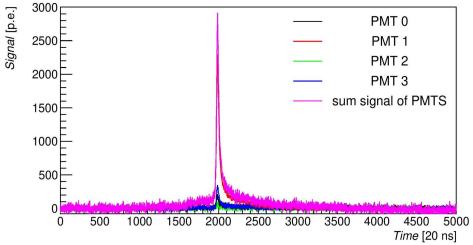
a)



b)



c)

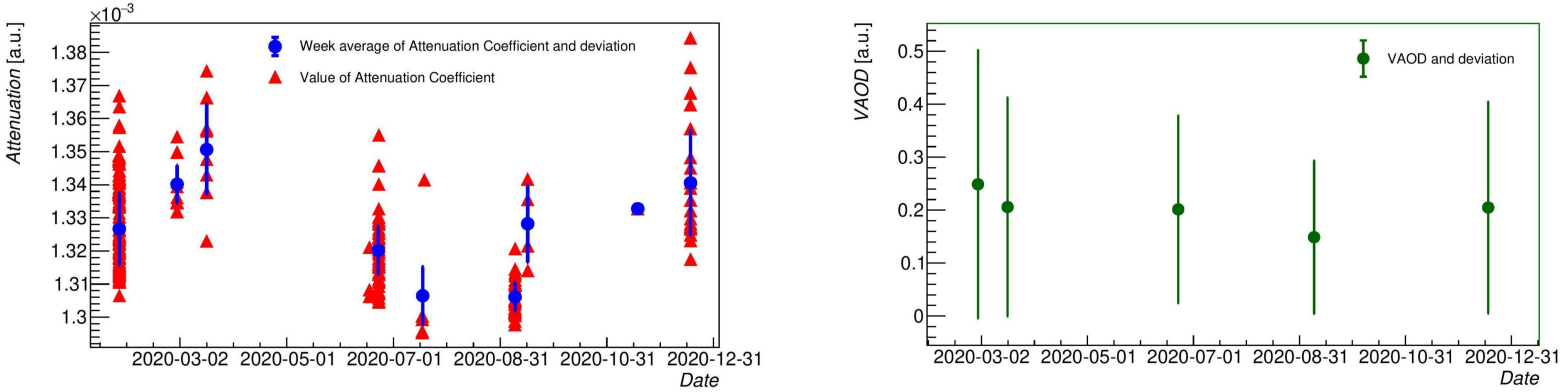


d)

Picture 8: Sum of signal from all detected vertical CLF shots from (a) spring (37 events detected), (b) summer (259 events detected), (c) autumn (8 events detected) and (d) winter (54 events detected) in Argentina.

Analysis of vertical CLF shots detected by FAST

- For the first approximation of the optical properties of the atmosphere, the attenuation coefficient calculated from Beer-Lambert's law was used, the time dependence of the attenuation coefficient was plotted.
- For comparison was plotted alse time dependence of vertical optical depth of atmosphere measured by Raman lidar.

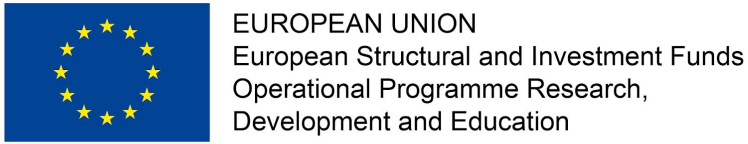


Picture 9: Time dependence of attenuation coefficient determinate from the FAST detection of vertical CLF shots and time dependence of VAOD measured by Raman Lidar.

Future plans

- Expanding the effectiveness of observing vertical and horizontal shots
- Investigate deeply properties of atmosphere and how to determinate them from detecting CLF shots
- Correlate the results obtained from FAST with the results from the fluorescence detector at Los Leones
- Based on results, simulate optical properties and create model of atmosphere

Acknowledge



This work was supported by the Ministry of Education, Youth and Sports (MEYS) of the Czech Republic, within the projects LM2018102, LTT18004, EU/MEYS CZ.02.1.01/0.0/0.0/17 049/ 0008422 and CZ.02.2.69/0.0/0.0/16 018/0002424. Also the authors gratefully acknowledge the support from the projects IGA PrF 2022 004 of Palacky University in Olomouc and ITI EU/MEYS CZ.02.1.01/0.0/0.0/17 049/0008422.