# Processing of Radiation Data from the Timepix Sensor on the VZLUSAT-1 Satellite

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## Motivation

- Space dosimetry is important for protecting both health of astronauts and space technology.
- **Timepix** detector is promising technology for this application (and used by ESA [1], NASA [2]).
  - It captures traces of ionizing particles in silicon detector while measuring the dissipated energy.
  - It is lightweight, small (~cm) and has low power requirements.

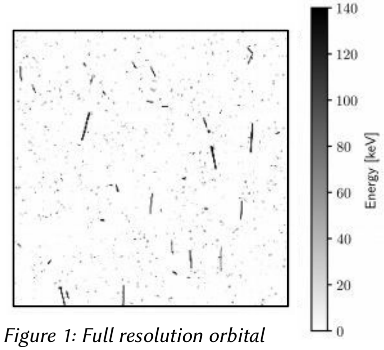


*Figure 1: Full resolution orbital image from the Timepix detector*

## The problem

- Nanosatellite **VZLUSAT-1** has on-board Timepix sensor, but almost all incoming data are **lossy compressed** by on-board computer with binning algorithm which was designed specifically for X-ray astronomy observations. The data are also **sampled sparsely in space** because of a limited transfer channel capacity.

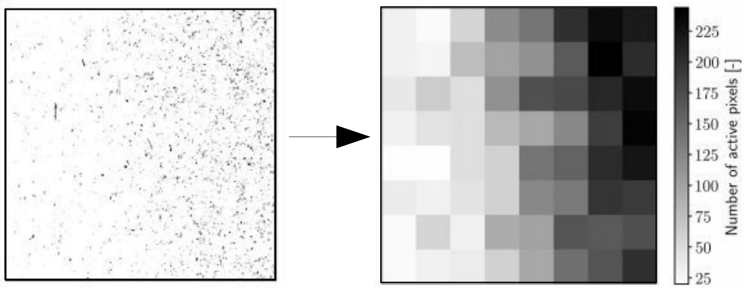


*Figure 2: Frame before and after compression. It is clear that direct morphological information about shape of tracks is lost.*

- Is it possible to **recover sufficient information** from compressed images to estimate **fluxes of different particles** and to generate **orbital dosimetry maps** from these data?

## The solution

- Pipeline combining **classification**, **regression** and **generative model** based on random forests, neural networks and kernel density estimator predicting **counts of particle traces** on compressed images.
- Modification of methods used in geography for final interpolation/regression of maps (kriging, IDW…).

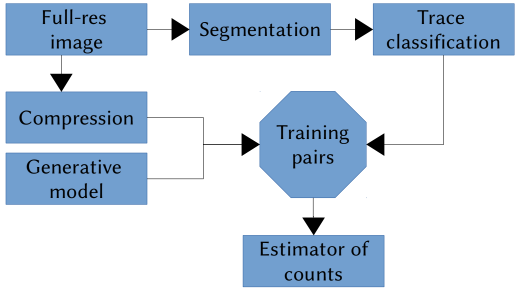


*Figure 3: Pipeline for training estimator of particle counts*

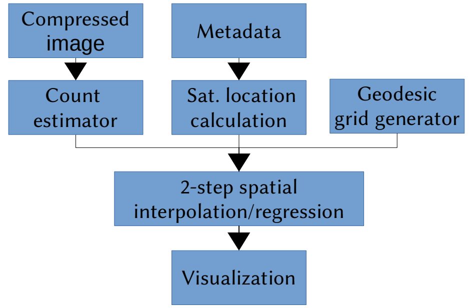


*Figure 4: Pipeline for prediction of counts of particles from compressed images*

## Results

- Performance of trained models was evaluated qualitatively and quantitatively (RMSE for regression, Matthews correlation coefficient for classification).
- Dosimetry maps were generated from all available data for 5 types of particles.

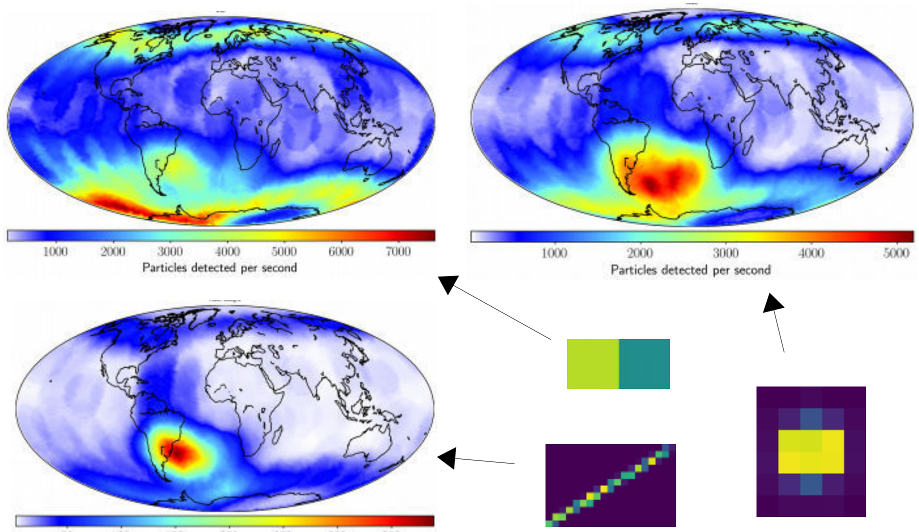


*Figure 5: Example of maps for three types of particles: dot, blob, straight track*

## Contributions

- Extension of the functionality of the satellite with methods on **edge of published state-of-the-art.**
- Results presented on iWoRiD 2018 as a part of larger contribution.
- **Universal particle track classifier** usable also in non-space scenarios-

*[1] C. Granja, S. Polansky, Z. Vykydal, S. Pospisil, A. Owens, Z. Kozacek, K. Mellab, and M. Simcak, "The SATRAM Timepix spacecraft payload in open space on board the PROBA-V satellite for wide range radiation monitoring in LEO orbit," Planetary and Space Science, vol. 125, pp. 114–129, 2016.; [2] N. Stoffle, L. Pinsky, M. Kroupa, S. Hoang, J. Idarraga, C. Amberboy, R. Rios, J. Hauss, J. Keller, A. Bahadori, E. Semones, D. Turecek, J. Jakubek, Z. Vykydal, and S. Pospisil,"Timepix-based radiation environment monitor measurements aboard the International Space Station," Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, vol. 782, pp. 143–148, 2015.48, 2015.*