Study of spatial and energy characteristics of relativistic electron bursts in magnetosphere with robust methods

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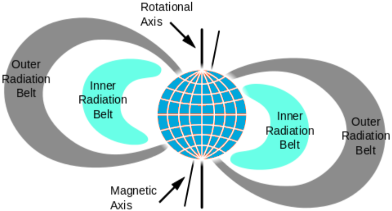
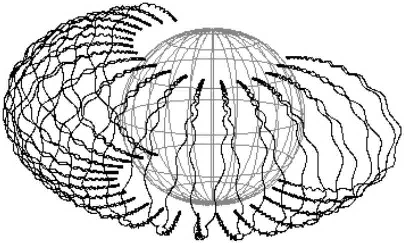
ICCPA - 2015, Moscow

Introduction

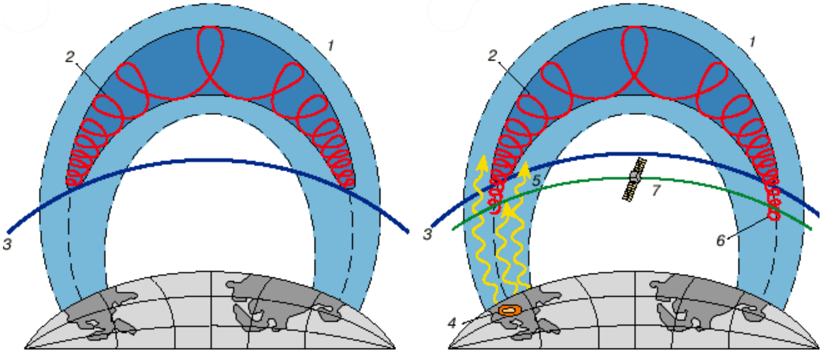
Radiation belt



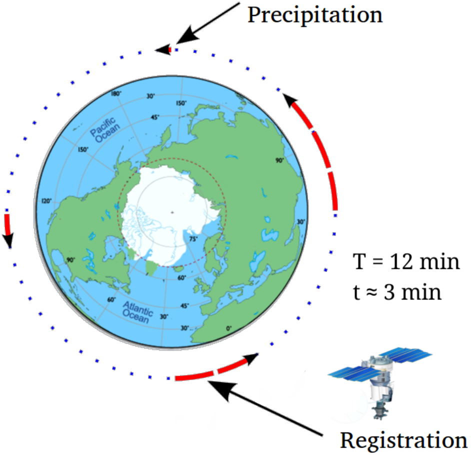
Charged particle movement in dipole magnetic field



Model of particle burst formation



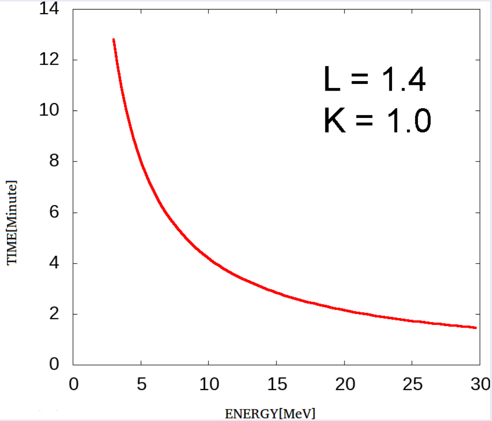
Precipitated paritcles registration on board the satellite



Cloud of precipitated paritcles may be crossed by satellite in random moment, registered burst parameters would vary a lot.

Model of longitudal particle drift

The expected curve of energy-time dependency



$\tau = \frac{88(1+E/E_0)}{2+E/E_0}\frac{K}{LE}$,

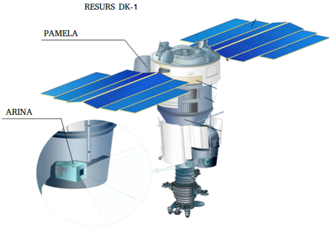
$K = 1.25 - 0.25\cos^2\lambda_m$

λ_m- geomagnetic latitude of mirror points

E – particle energy,

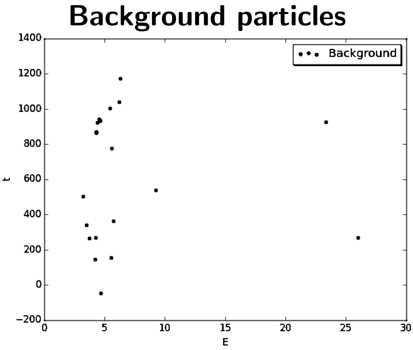
E_0 – rest energy

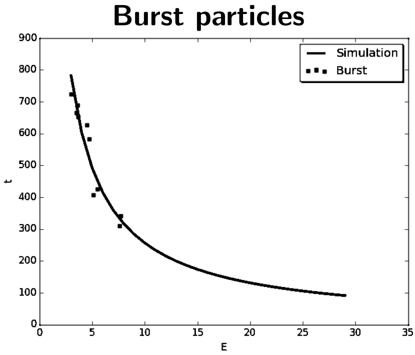
Experiments on orbit - ARINA and VSPLESK



Parameter		Value
Geometrical factor		$10 cm^2 sr$
Aperture		± 30degree
Energy ranges	protons electrons	$30 - 100$MeV $3 - 30$MeV
Energy resolution	protons electrons	10% 15%
Time resolution		100ns
Mass		$8,6$kg
Power consumption		$13,5$W

Numerical model of longitudinal particle drift





Linear and Robust methods

$$R_{method} = \sum_{i=1}^{n} w_i \cdot \frac{(t_i - t_{dr}(E_i, \Delta\lambda))^2}{\sigma_i^2} \quad (1)$$

Linear

$$w_i = 1.0 \quad (2)$$

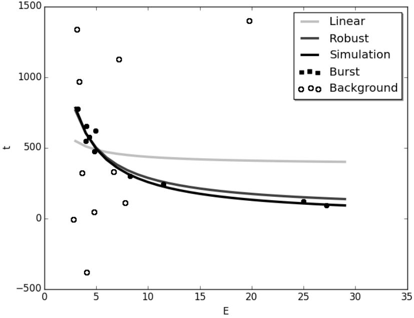
Robust

$$w_i = \frac{1}{1 + e^{-(\beta_0 + \beta_1 d_i)}} \quad (3)$$

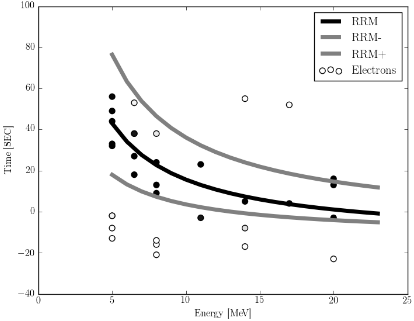
$$d_i = \sqrt{(E_i - E_{min})^2 + (t_i - t_{dr}(E_{min}, \Delta\lambda))^2} \quad (4)$$

Examples

Example 1 (Numerical simulation)

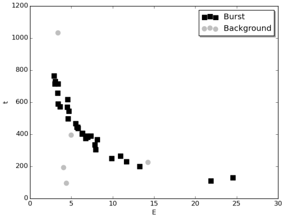


Example 2 (Experimental result)

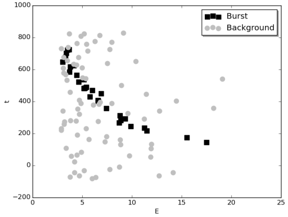


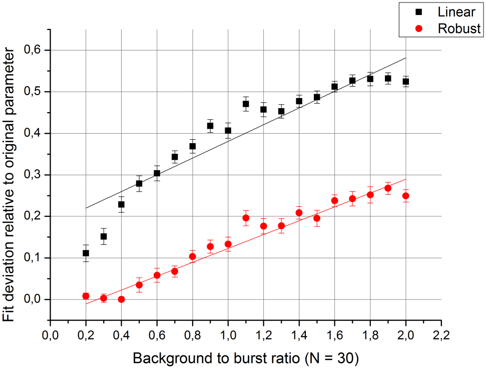
Background to burst ratio

Ratio $= 0.01$



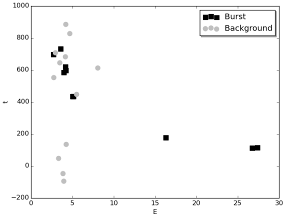
Ratio $= 2.0$



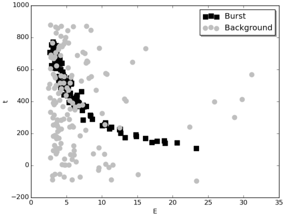


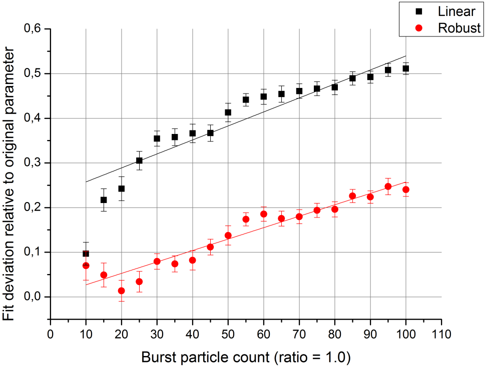
Number of events in burst

Count $= 10$



Count $= 100$





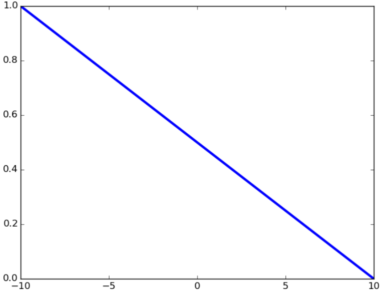
Conclusion

- The analysis of two methods of longitudinal distance determination of locally precipitated particles was conducted.
- Methods perfomance for various burst sizes and burst to background ratios was analyzed.
- Robust regression method is significantly more precise in comparison with linear method.
- Using burst to background ratio and particle number estimations from ARINA experiment ($N \sim 30, R \sim 0.5 \div 1.0$) the error of robust method is around $5 \div 10\%$.

THANK YOU!

Weight heuristics (Inverse distance)

$$w_i = 1 - \frac{d_i}{max(d_i)} \tag{5}$$



Weight heuristics (Logistic function)

$$w_i = \frac{1}{1 + e^{-(\beta_0 + \beta_1 d_i)}} \qquad (6)$$