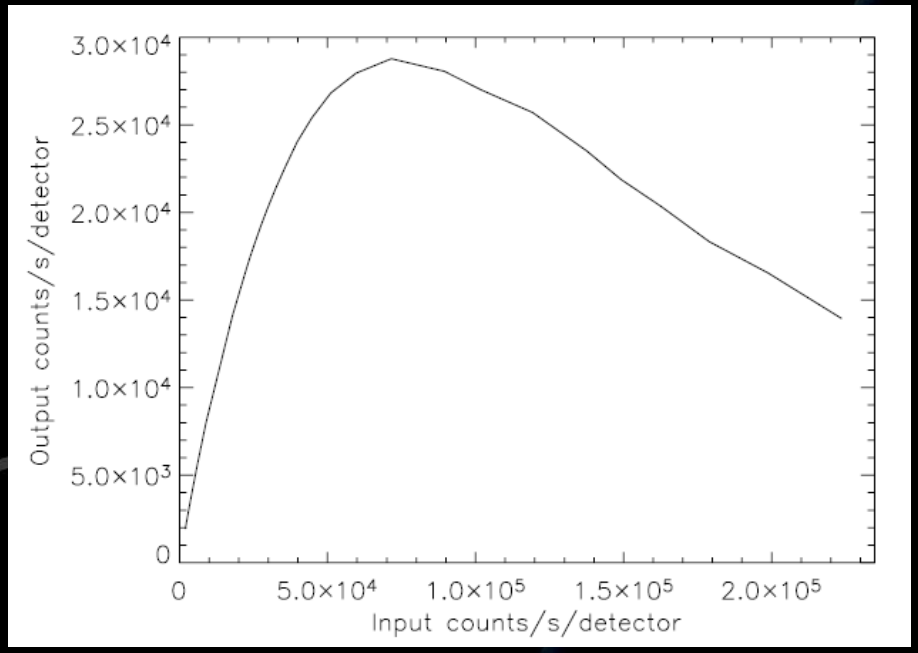
Cluster experiment for TGF investigation

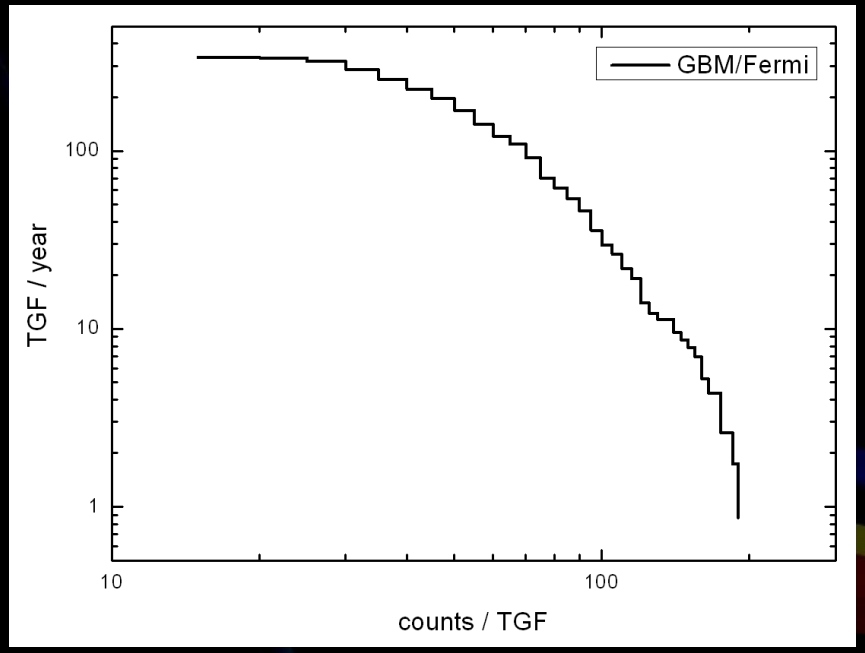
A. Pozanenko[1], N. Vedenkin[2], P. Kudryashov[2],
P. Minaev[1], A. Chernenko[1], V. Vybornov[1]

[1] – Space Research Institute (IKI), Russia
[2] – Dauria Aerospace, Technopark Skolkovo, Russia

Problems of TGF science

- Maximal fluence and true fluence distribution are unknown
- Distortion of spectrum and underestimating fluence of TGF due to dead time and pile-up effects

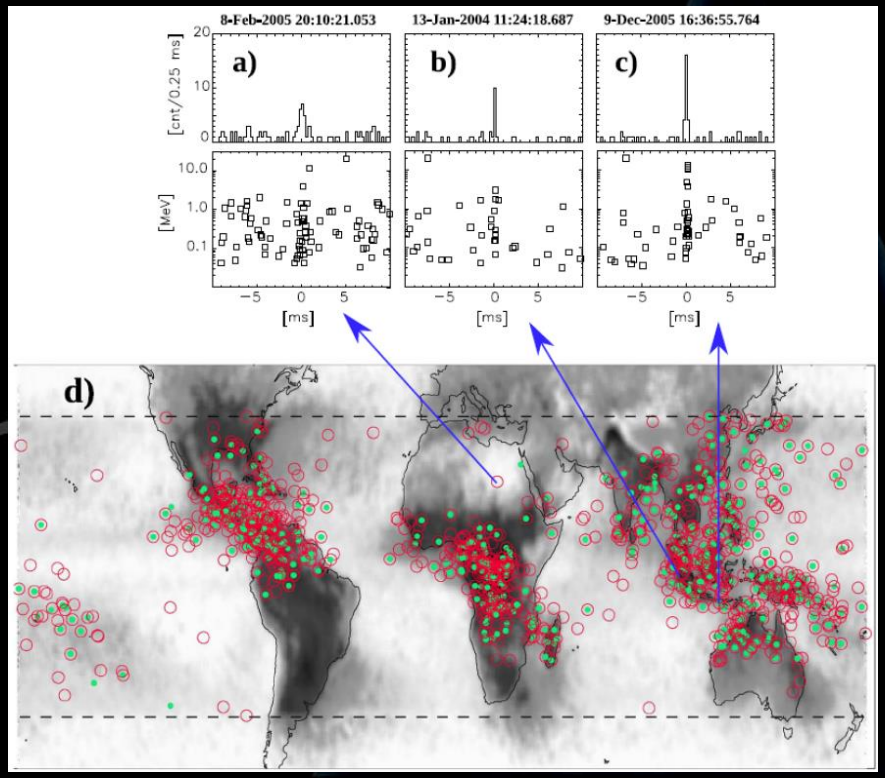




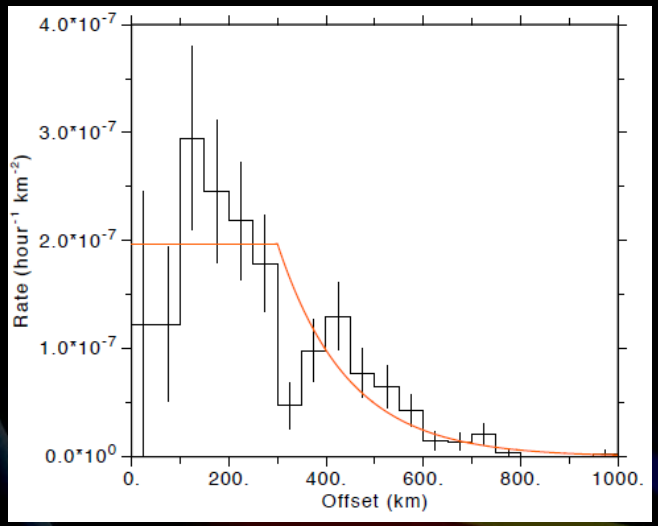
Grefenstette+ 2009

Problems of TGF science

- Two-thirds of events are not identified with lightning
- Localization in gamma-ray domain is impossible
- Till now only one TGF was observed in both gamma- and visible light (Ostgaard+ 2013)



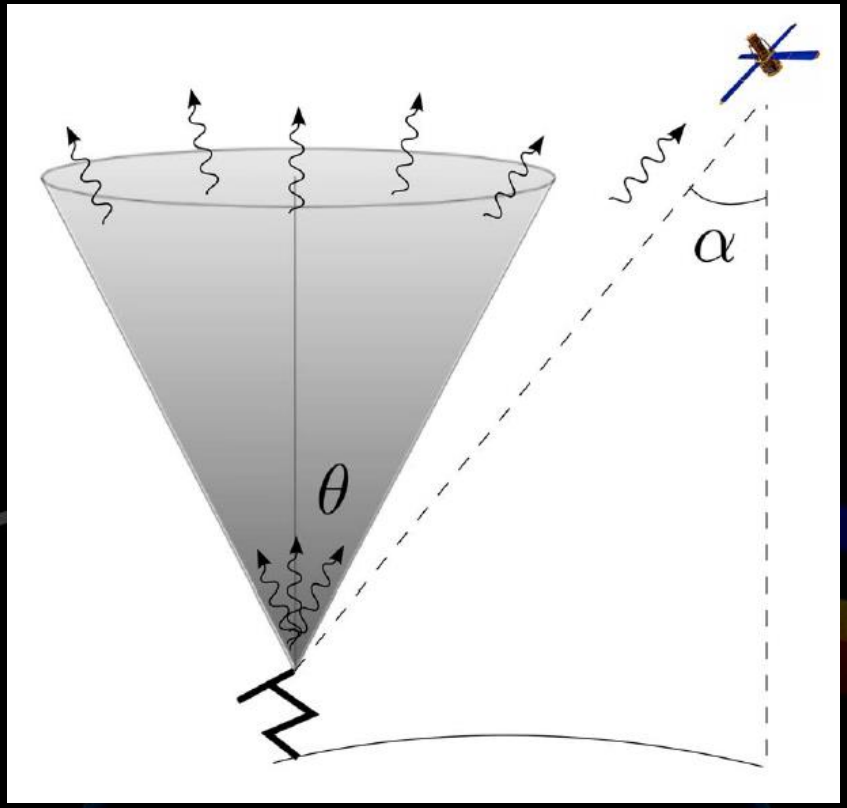
Gjesteland+ 2012



Briggs+ 2012

Problems of TGF science

- Cone angle of gamma-emission is unknown (~ 40 deg or greater, Gjesteland+ 2011)



Gjesteland+ 2011

The idea of Cluster experiment

- Several identical micro satellites on the same low orbit with distance ~ 50 km between them:

- Can improve statistics without increasing of dead time effects

- Can provide localization in gamma-rays using triangulation method in case of registration of the same TGF by two or more satellites

- Can provide estimation of gamma-radiation beam angle and its structure

- Can provide full coverage of thunderstorm areas for multiple TGF registration

Cluster experiment

●Objectives:
●TGFs: registration, localization, estimation of radiation beam angle, registration of several TGFs from one thunderstorm area
●Registration of GRBs and Solar flares

●Orbit ~350 km (LEO) with inclination of 51 deg
●4 identical satellites
●Distance between satellites ~ 50 km
●GPS controlled and synchronized with accuracy of time acquisition better ~ 1μs
●Lifetime ~ 1-3 yr
●Expected launch date of the first 4 satellites – 2017
●Expected launch date of the next 4 satellites – 2019, 2020, …
●Current status of the project – under investigation of international collaboration

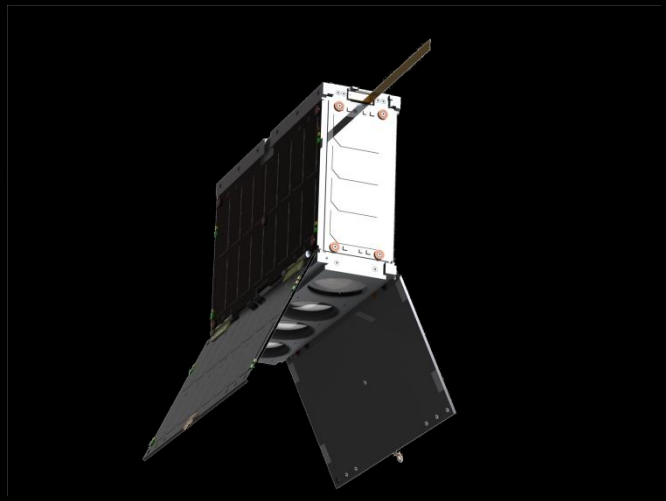
●Detectors:
●BGO crystal with diameter of 3 inches
●Energy range – 0.1-10 MeV
●Photon-by-photon registration
●Time accuracy of photon registration ~ 1μs

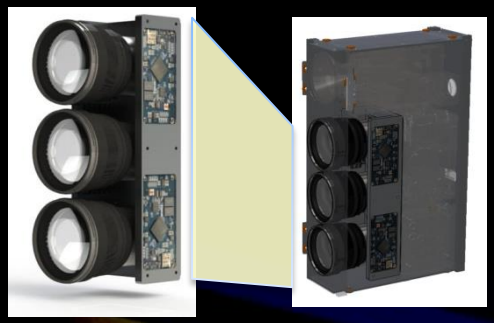
●Triangulation:
●Time delay ~ 0.2 ms for 350 km orbit and distance between satellites of 200 km
●Time accuracy of TGF profiles alignment is ~ 10 μs for bright events
●Time accuracy synchronization with UT ~ 1μs

Sensitivity to TGFs is like GBM/Fermi one (smaller detectors but lower orbit)

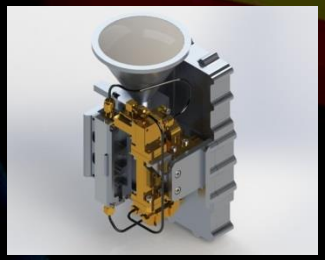
Dauria space platform

Parameter	
Possible payload	Earth Observation, Disaster monitoring, AIS, Science, M2M, GPS/Glonass occultation
Total Mass	10-13 kg
Payload	5 kg
Orbit	LEO, SSO
Size	6U (240x370x115) **244x89x116 for payload**
Lifetime	1-3 years
Maximum power output	30 W
Battery capacity	12.1 Ah
GPS /Glonass	GPS/Glonass
Accuracy of 3-axes stabilization	$<1^0$
Target information transmitter	Ka-band





Example: Framing Imager – 3 channel – 22m GSD



Ka-band Transmitter

Expected results

- TGF registration rate ~ 300 / yr (Briggs+ 2013)
- TGF registration with localization ~ 10 / yr
- Ground localization is grazing belts of ~ 15 km width
- Gamma Ray Burst registration rate ~ 50 / yr

Thank you for your attention!