Use of GEANT4 in atmospheric physics

Zemlianskaya Daria

zemlianskay.d@phystech.edu

Why Geant4?

- Nobody knows how lightning starts.
- Measurements in thunderclouds are difficult to make.
- Simulation allows you to quickly get data that is difficult to get from the experiment

Normal breakdown	$E > 3000$ kV/m
Field in thunderstorm	$E < 300$ kV/m

zemlianskay.d@phystech.edu

What are we studying?

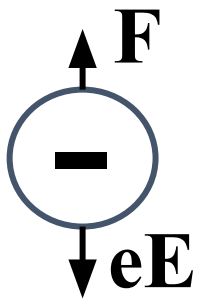
Mostly, **RREA** (Relativistic runaway electron avalanche)

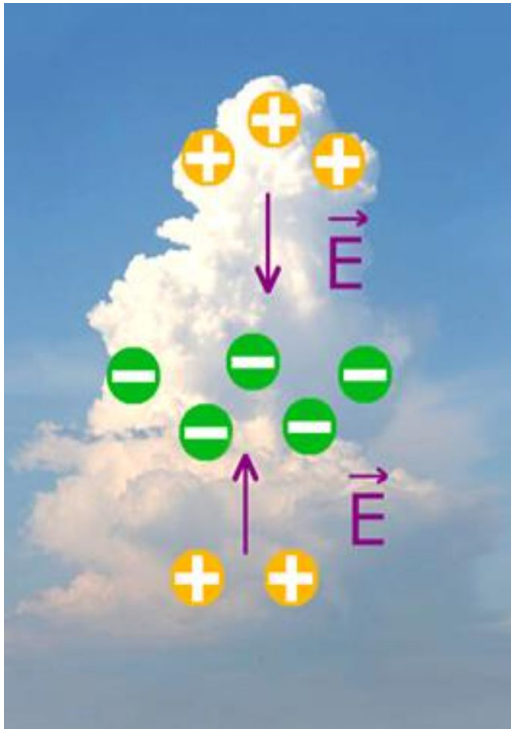
If $F < eE$

then the electrons are accelerated.

The electric field in a thundercloud can accelerate electrons.

But they are slowed down by the effective “friction force” against the air.



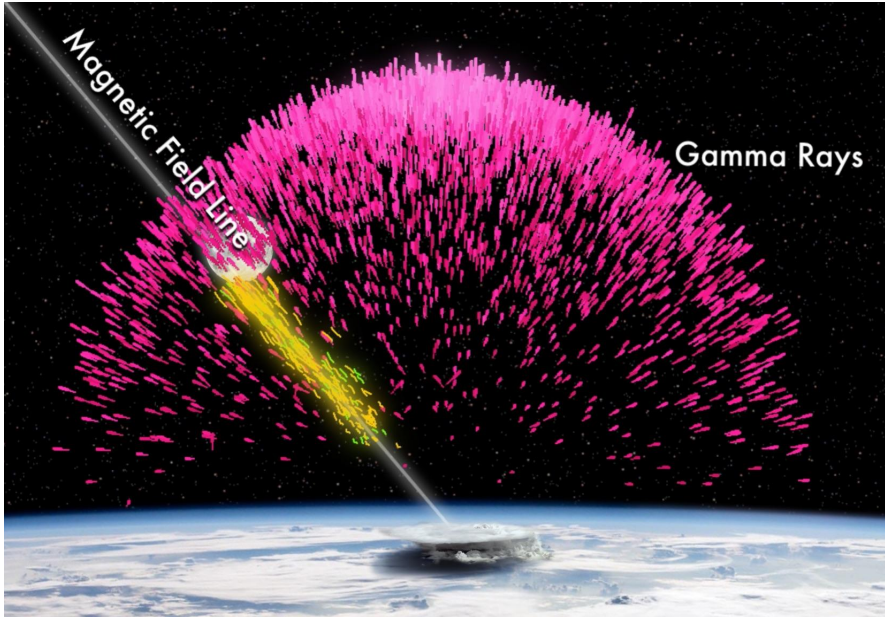


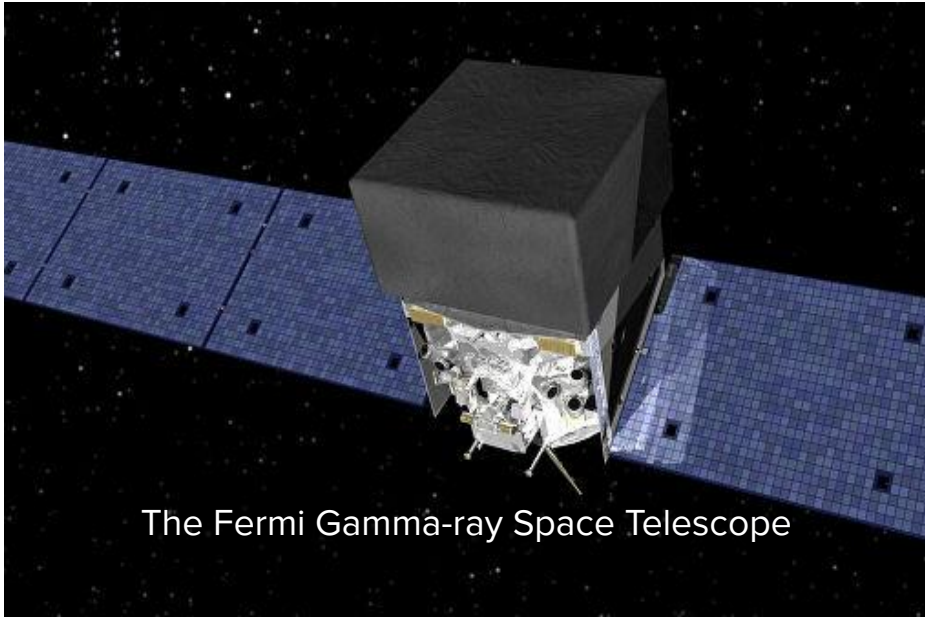
Accelerating relativistic electrons are called **runaway relativistic electrons**.

zemlianskay.d@phystech.edu

What are we studying?

TGF (Terrestrial gamma-ray flashes)

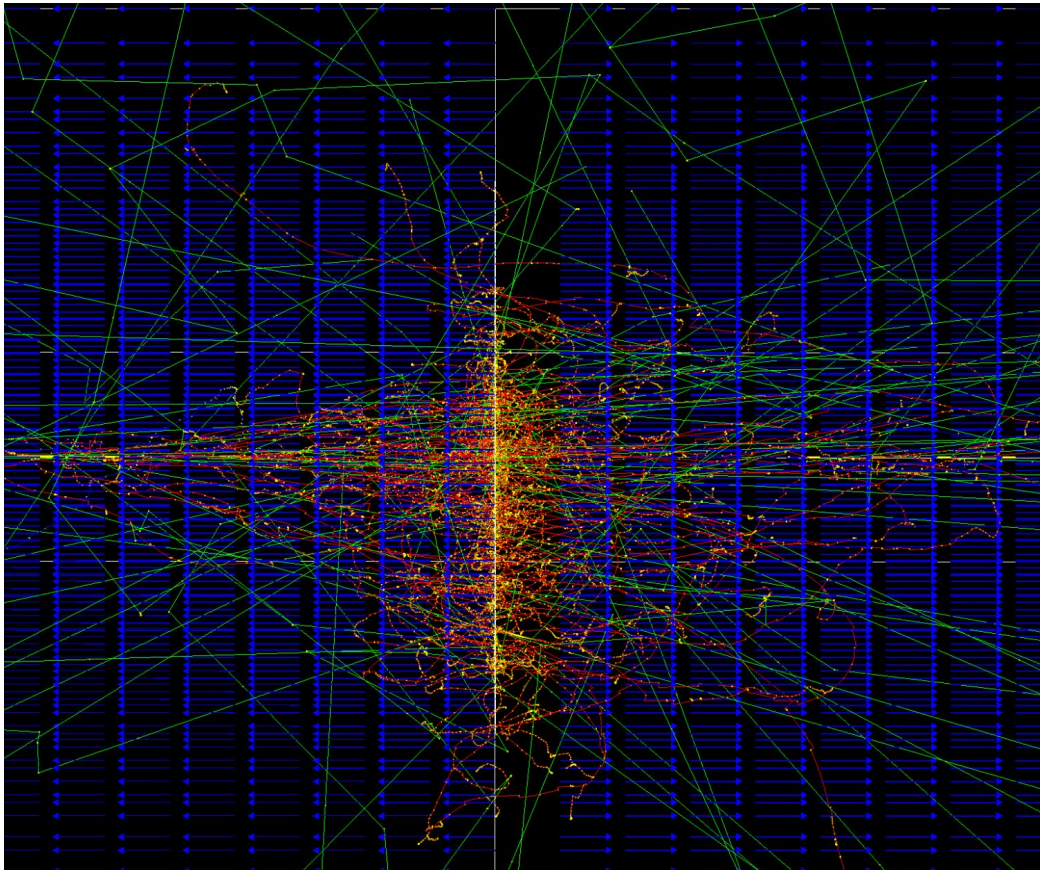


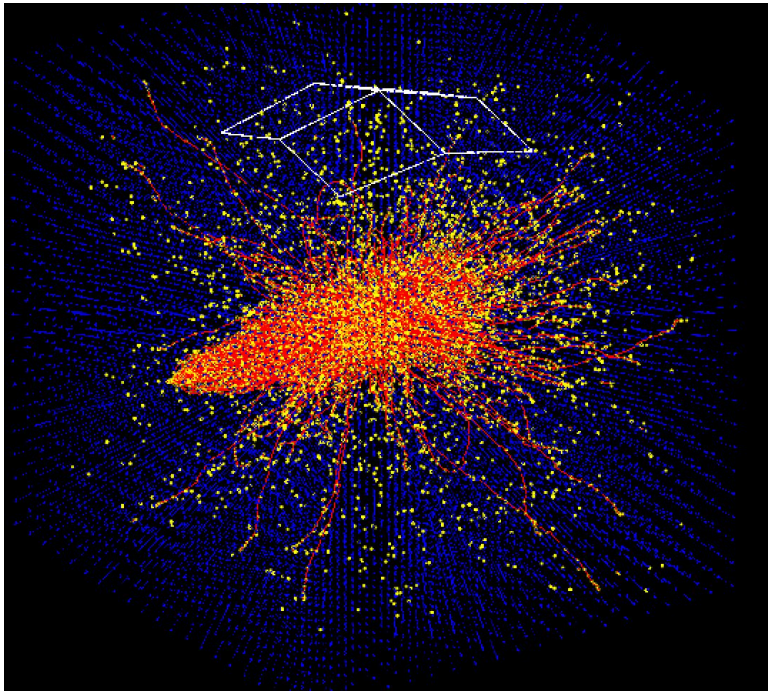


zemlianskay.d@phystech.edu

Researched physics

- Electromagnetic physics.
- Energy around 0.5-50 MeV
- Beams of gamma, e-, e+
- Electric fields up to 300 kV/m





zemlianskay.d@phystech.edu

Researched physics

Reactor model

The models assume the dynamics of electron avalanches inside one region with a uniform electric field.

Infinite feedback in a cell, that is, when the movement of particles in such a cell does not fade, creates an infinite loop that triggers the generation of TGF and communication between the cells in the cloud.

Infinite feedback can appear in a system with a large number of separate fields - cells with a uniform field.

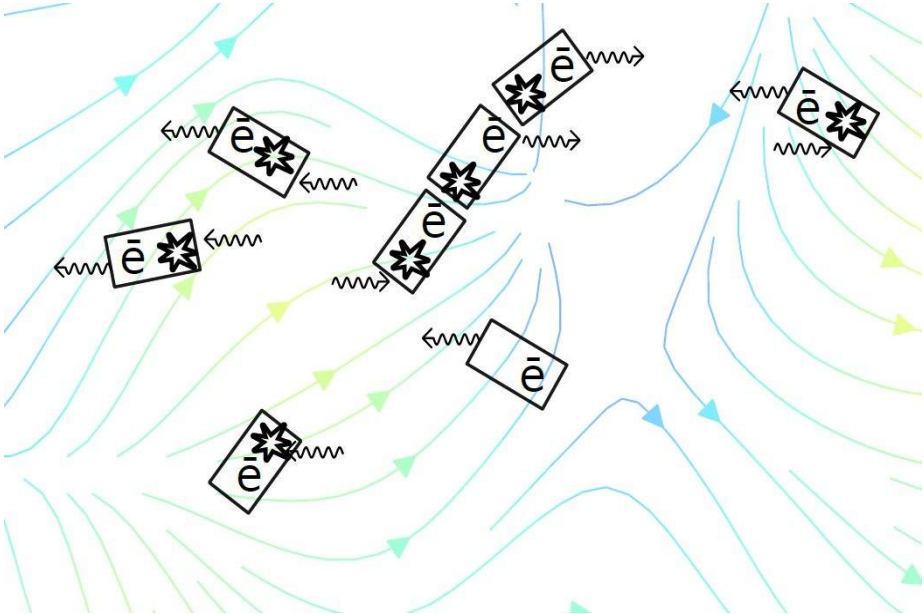
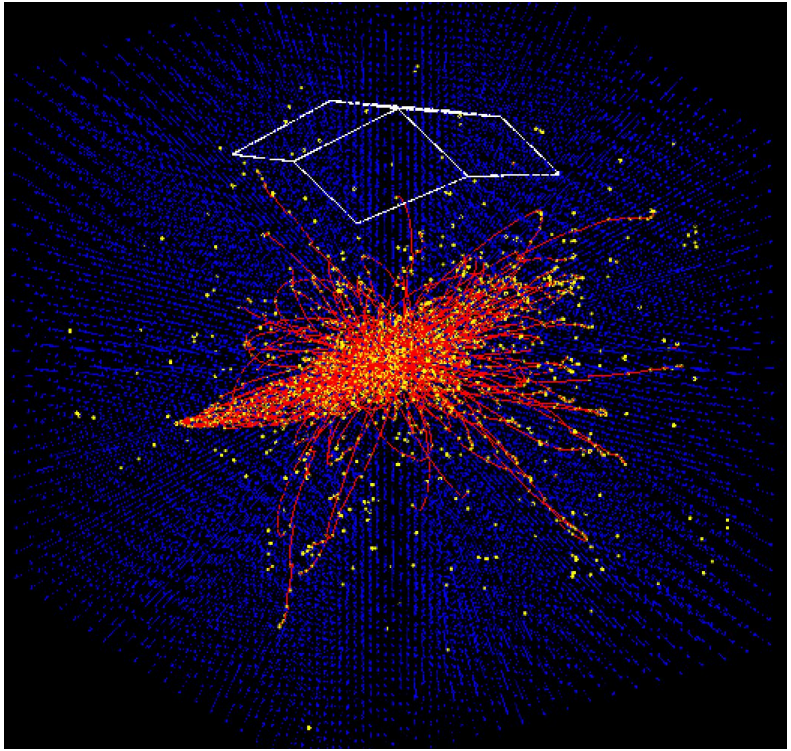


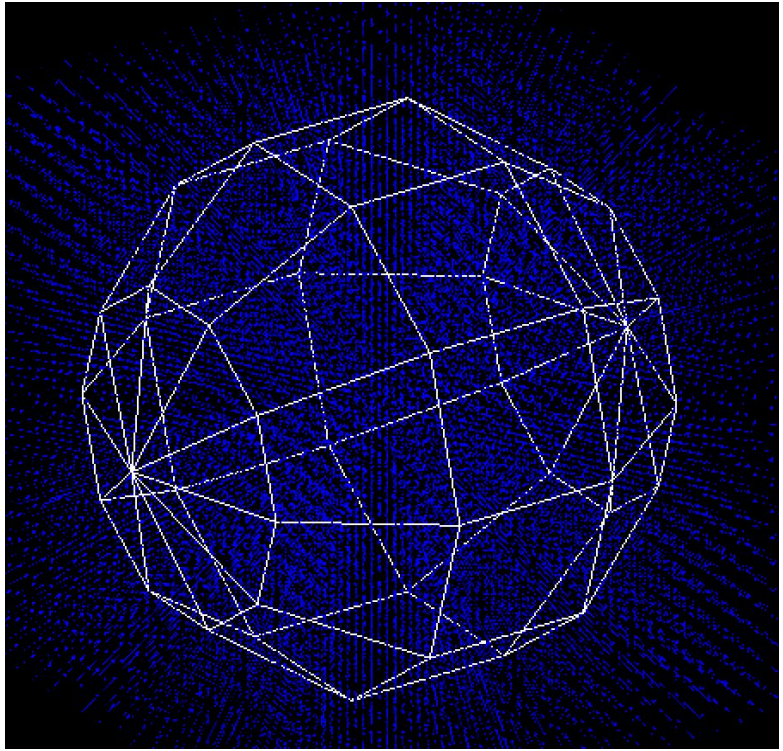
Illustration of the operation of a lightning reactor.

zemlianskay.d@phystech.edu

Researched physics

Spherical reactor

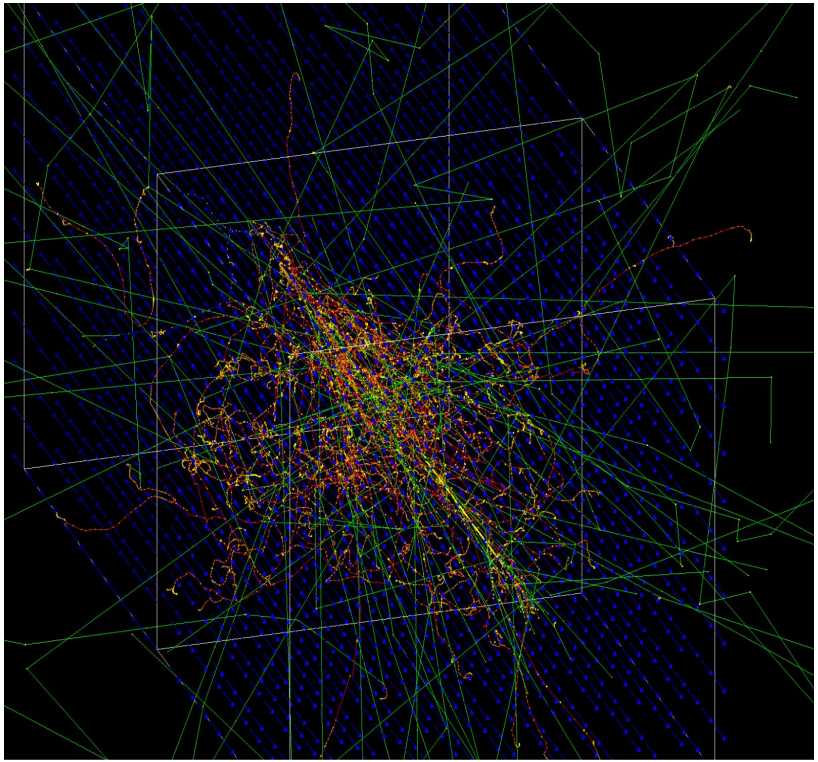


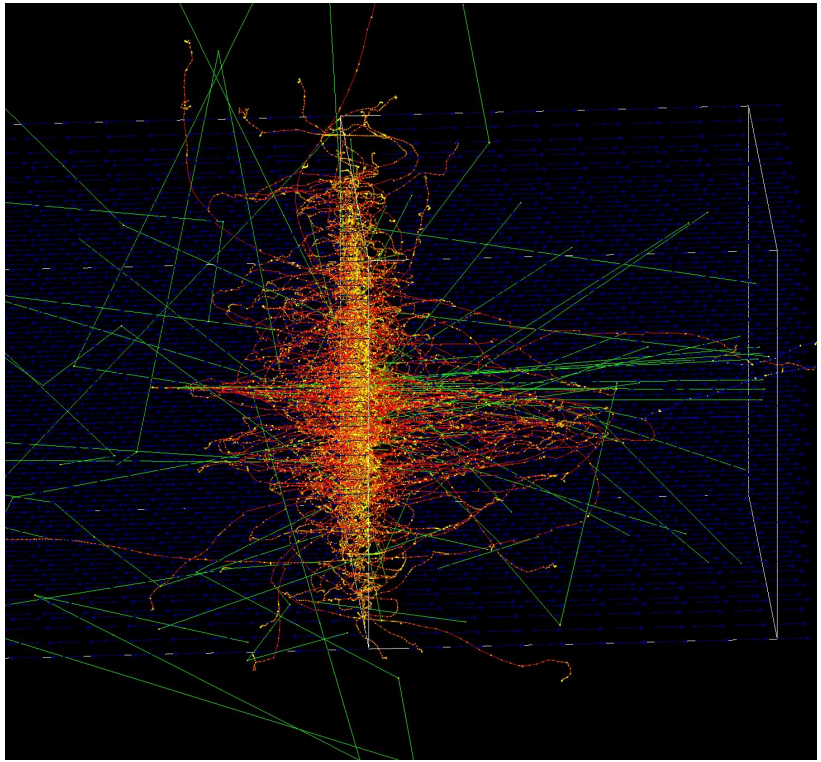


zemlianskay.d@phystech.edu

Researched physics

Simple reactor

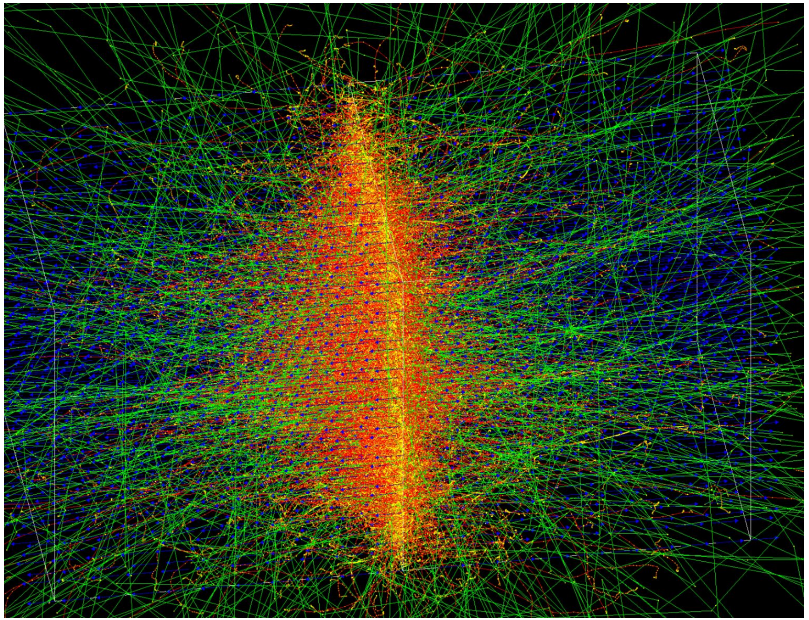


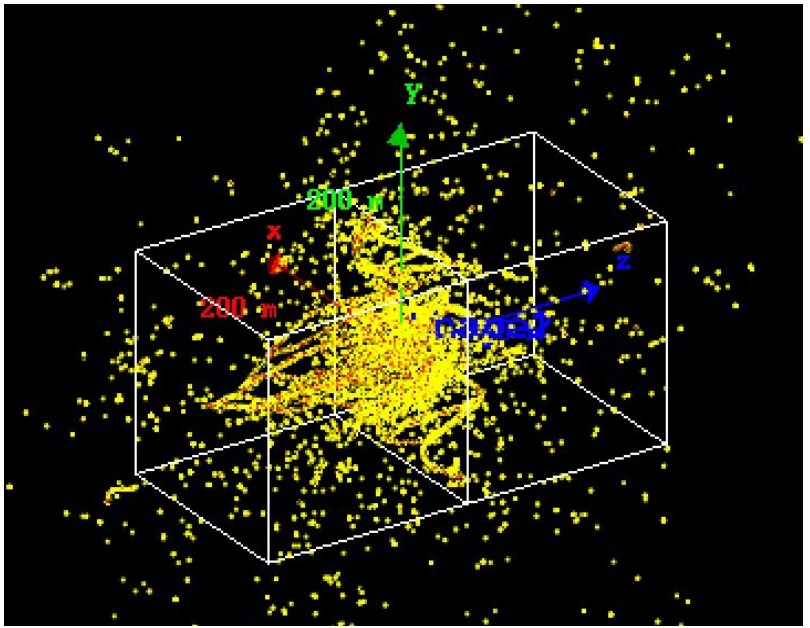


zemlianskay.d@phystech.edu

Problems solved by modeling on GEANT4

- Found electron feedback in simple reactor
- Found the coefficients for the probability of electron reversal for different cell parameters
- Found the dependences of the parameters of avalanches of relativistic runaway electrons

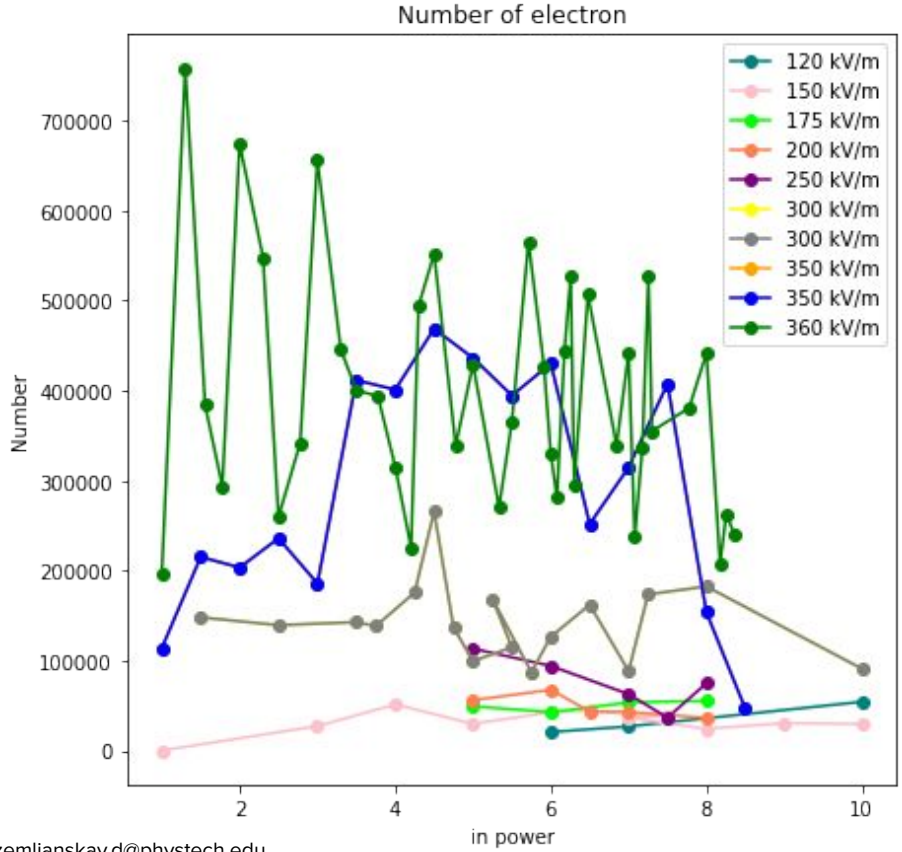


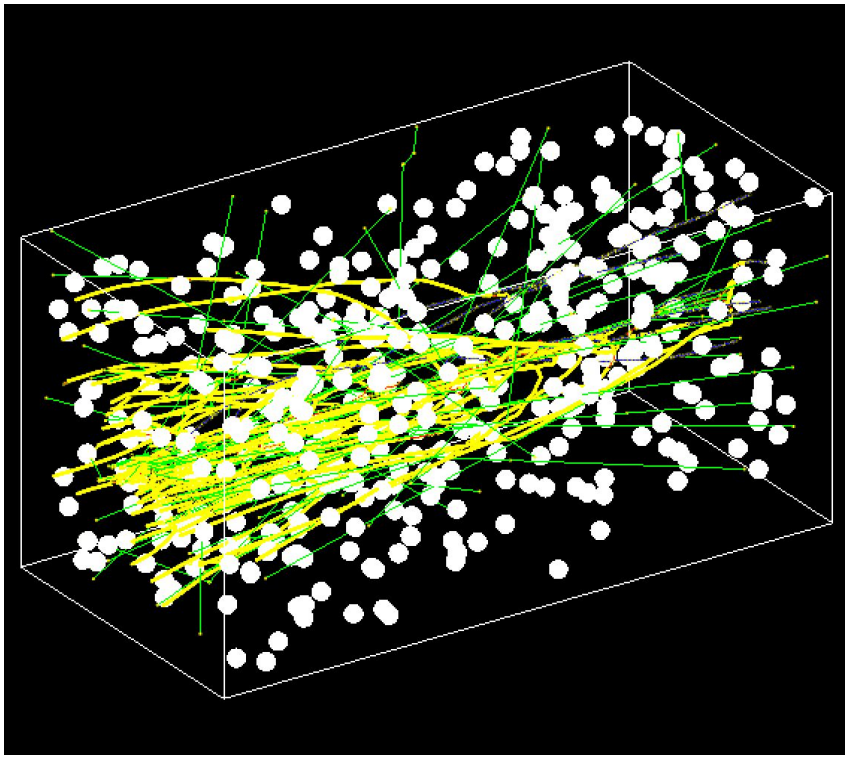


zemlianskay.d@phystech.edu

Suspicious result

Physics list: G4EmStandardPhysics_option4
Version: geant4.10.06.p01





zemlianskay.d@phystech.edu

Our plans for testing

- Comparison of RREA simulations with real data and various physical list.

- Checking for breaking areas on a lot of statistics.

zemlianskay.d@phystech.edu

Contacts

Zemlianskaya Daria

Email: zemlianskay.d@phystech.edu

Telegram: @drozena