MIPT
NUCLEAR PHYSICS METHODS TEAM

CURRENT STATE AND PROSPECTS

TEAM

- **Lev Inzhechik** – team leader, ph.d, MIPT staff. Leads all low background experiment tasks.
- **Alexander Nozik** – ph.d, senior researcher at INR, junior MIPT staff. Software development and mathematical methods tasks.
- **Alexey Khudyakov** – researcher at INR. Mathematical methods task leader.
- **Grigory Koroteev** – phd student at INR, junior MIPT staff.
- **Mikhail Zelenyy** – phd student at INR.
- **Almaz Fazliakhmetov** – master student at MIPT and INR. Muon monitor task leader.
- **Olga Matveeva** – master student at MIPT and INR.
- **Maria Nelyubina** – student at MIPT (4^{th} year).
- **Timofey Glukhih** – student at MIPT (4^{th} year).
- 3^{rd} year students

General physics department
MIPT

High energy physics laboratory
MIPT

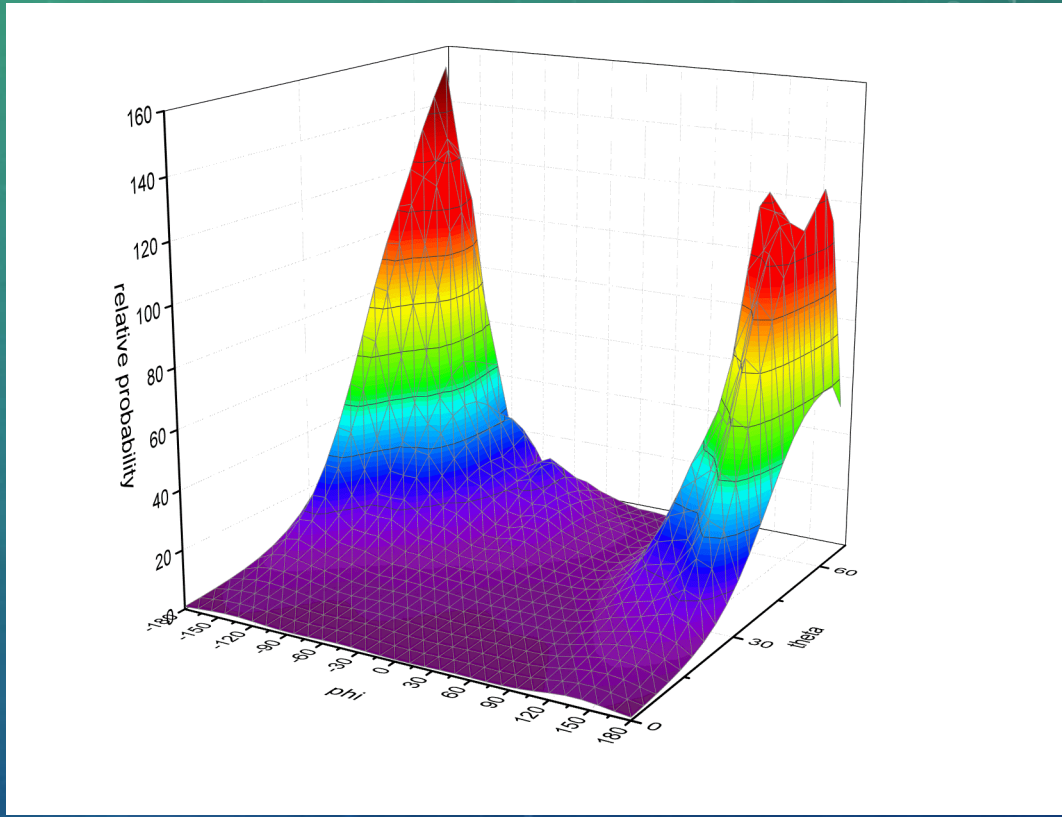
Baksan neutrino observatory
INR RAS

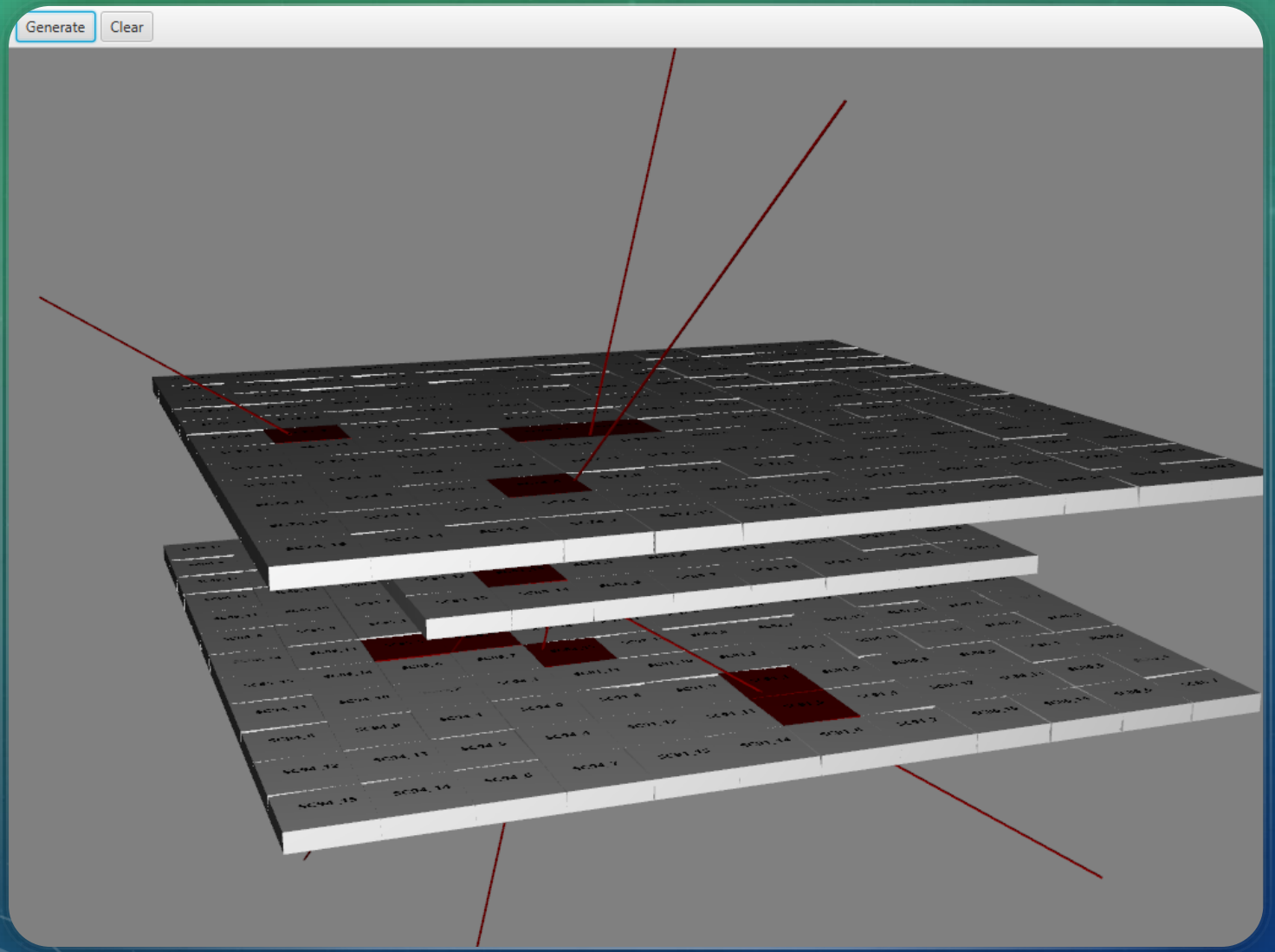
MIPT-npm

Bunch laboratory
Troitsk linear accelerator
INR RAS

Sector for
mathematical support
INR RAS

PROJECTS – PHYSICS





MUON MONITOR

- Measurement of deep underground muon flux via scintillation detector.
- Methods for angle distribution reconstruction.
- Possible geological applications?

GERDA ISOTOPE GERMANIUM RECTIFICATION

- On-site purification of residual Germanium for GERDA collaboration.

- Actual work being performed at Dmitry Mendeleev University of Chemical Technology.

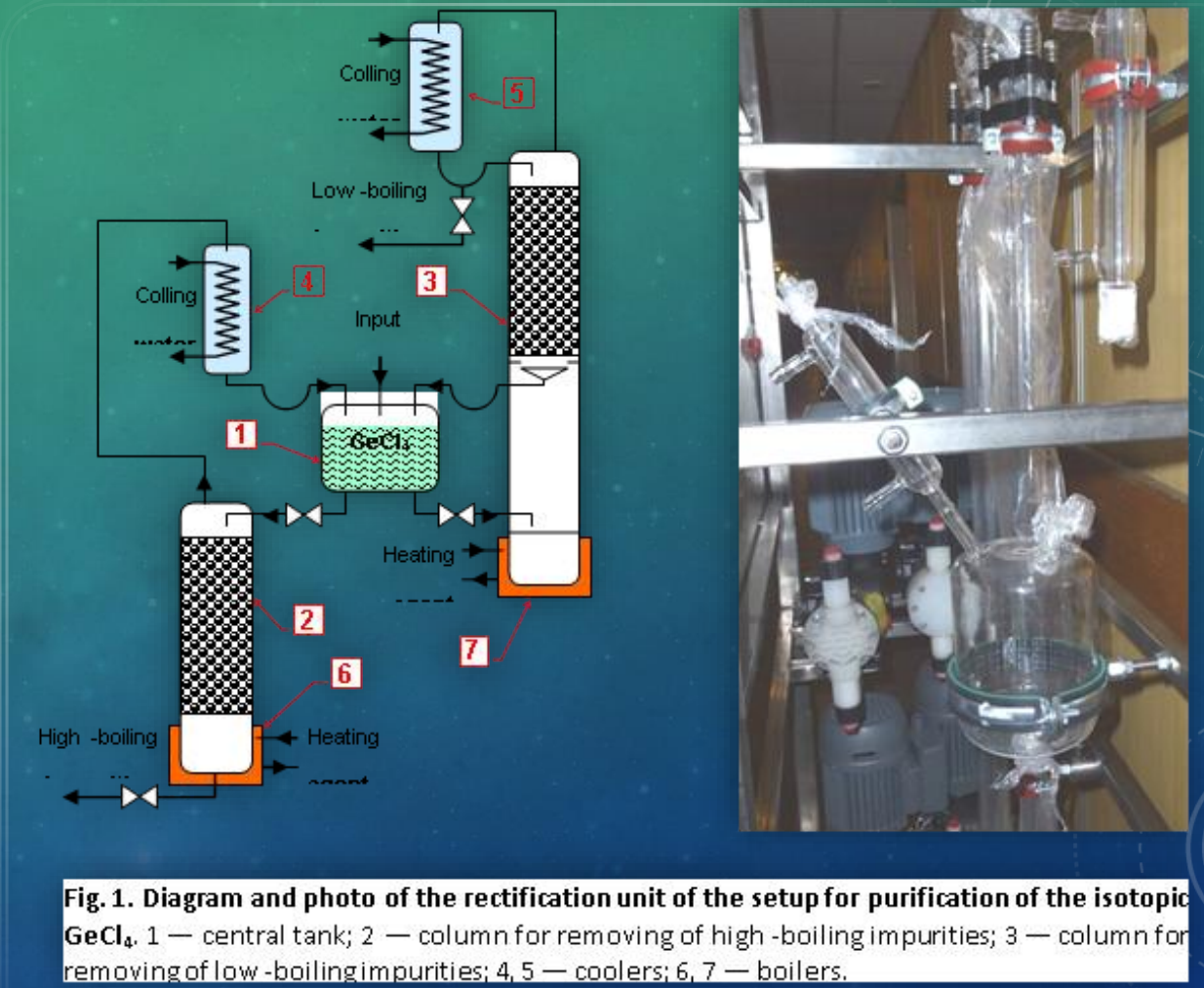


Fig. 1. Diagram and photo of the rectification unit of the setup for purification of the isotopic $GeCl_4$. 1 — central tank; 2 — column for removing of high -boiling impurities; 3 — column for removing of low -boiling impurities; 4, 5 — coolers; 6, 7 — boilers.

TROITSK NU-MASS

Search for sterile neutrinos in Troitsk nu-mass experiment.

- DAQ software
- Data storage
- Simulation
- Analysis

PHYSICS

- **Muon monitor – analysis of data obtained from muon monitor at LSC.**
- Solar neutrinos in $2\beta 0\nu$ – investigation of impact of solar neutrinos capture on double beta-decay experiments.
- Ge rectification for GERDA.
- Solar neutrino flux variation – investigation of SAGE experiment data in search for neutrino flux variations.
- Troitsk nu-mass experiment – search for sterile neutrinos with masses up to 4 keV in tritium beta-decay.

PROJECTS – SOFTWARE AND MATHEMATICS

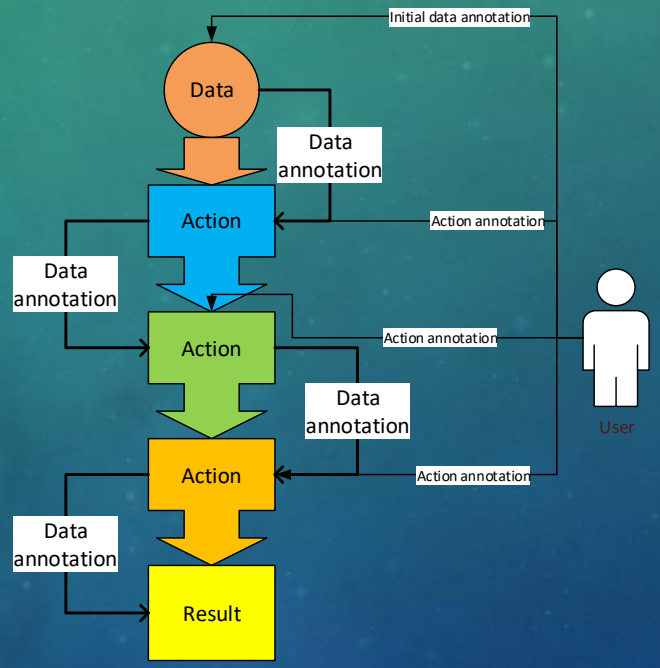
```
class Cos2TrackGenerator(val power: Double = 2.0,
             val maxX: Double = 4 * PIXEL_XY_SIZE,
             val maxY: Double = 4 * PIXEL_XY_SIZE) : TrackGenerator {
    override fun generate(rnd: RandomGenerator): Track {
        val x = (1 - rnd.nextDouble() * 2.0) * maxX;
        val y = (1 - rnd.nextDouble() * 2.0) * maxY;
        val phi = (1 - rnd.nextDouble() * 2.0) * Math.PI;


        for (i in 0..500) {
            val thetaCandidate = Math.acos(rnd.nextDouble());
            val u = rnd.nextDouble();
            val sin = Math.sin(thetaCandidate);
            if (u < Math.pow(sin, power) / sin) {
                return makeTrack(x, y, thetaCandidate, phi);
            }
        }
        throw RuntimeException("Failed to generate theta from distribution");
    }
}
```

DATAFORGE

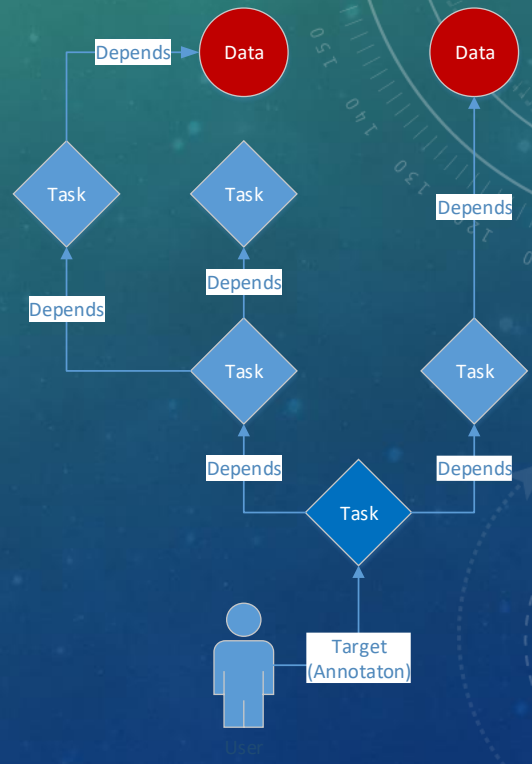
Modern framework for data processing:

- Cross-platform
- Modular
- Scalable
- Fast
- Environment independent
- Declarative
- Flexible without scripts

DF push data flow

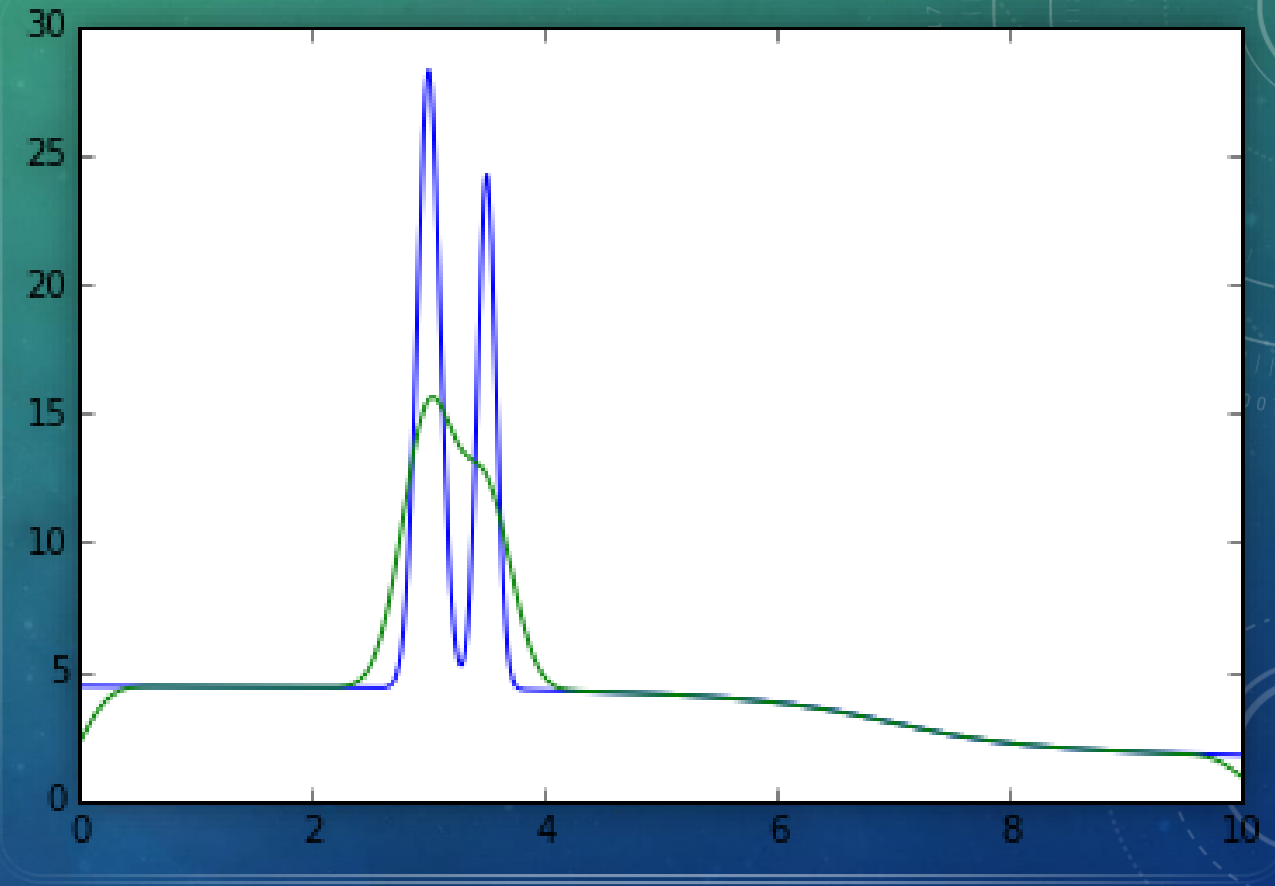


DF pull data flow



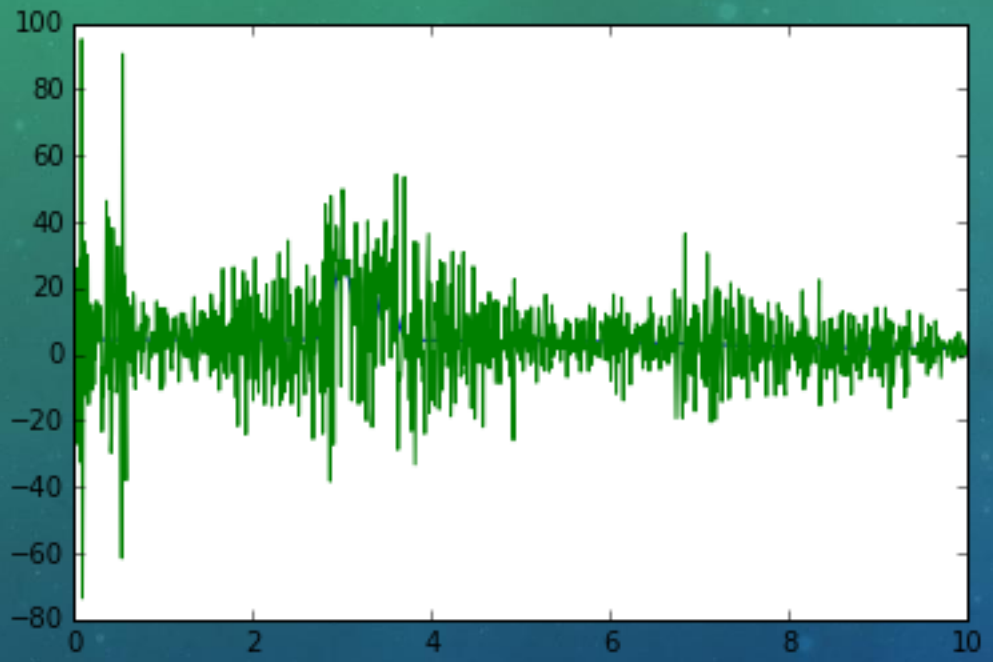
STATISTICAL REGULARIZATION

Consider one have an experimental apparatus with known resolution function and wants to derive initial function from the measurements.

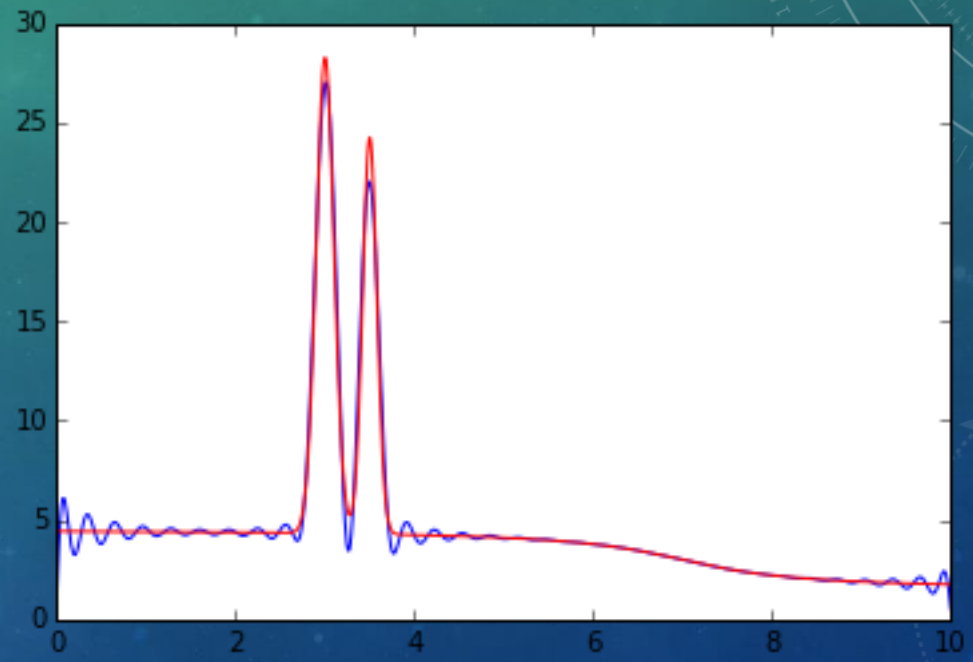


STATISTICAL REGULARIZATION

Naïve solution



Turchin statistical regularization



SOFTWARE AND MATHS

- DataForge – a modern software framework for scientific data processing automation.
- Statistical regularization of inverse problems.
- Optimal experiment planning – optimal measurement time distribution in physical experiments with systematic errors.
- Machine learning in particle physics.
- Laboratory practice modernization – development of modern software for MIPT general physics department.
- **Scientific software development**

CURRENT RESOURCES

- Basic staff positions at INR RAS
- Support from department of general physics at MIPT
- Minimal funding from High energy physics laboratory at MIPT
- A lot of students available at MIPT

PROSPECTS

- Rooms at new building at MIPT
- Funding from RFBR
- Funding from Science ministry of Russia (via MIPT)
- More students…

With additional projects we can invite new people and request additional funding.

We are open for any opportunities