



FLAP



Fundamental and applied Linear Accelerator Physics collaboration

Pavel Karataev (Spokesperson)

*John Adams Institute for Accelerator Science at
Royal Holloway, University of London*

RREPS-19, Belgorod, 2019



It all started in Belgorod in 2019 at the XIII International Symposium RREPS-19 (“Radiation from relativistic electrons in periodic structures”) organized by Belgorod State University, National Research Nuclear University "MEPhI" and Tomsk Polytechnic University. Scientists from Russia, Great Britain, Germany, Japan, China, and other countries participated in the Symposium.

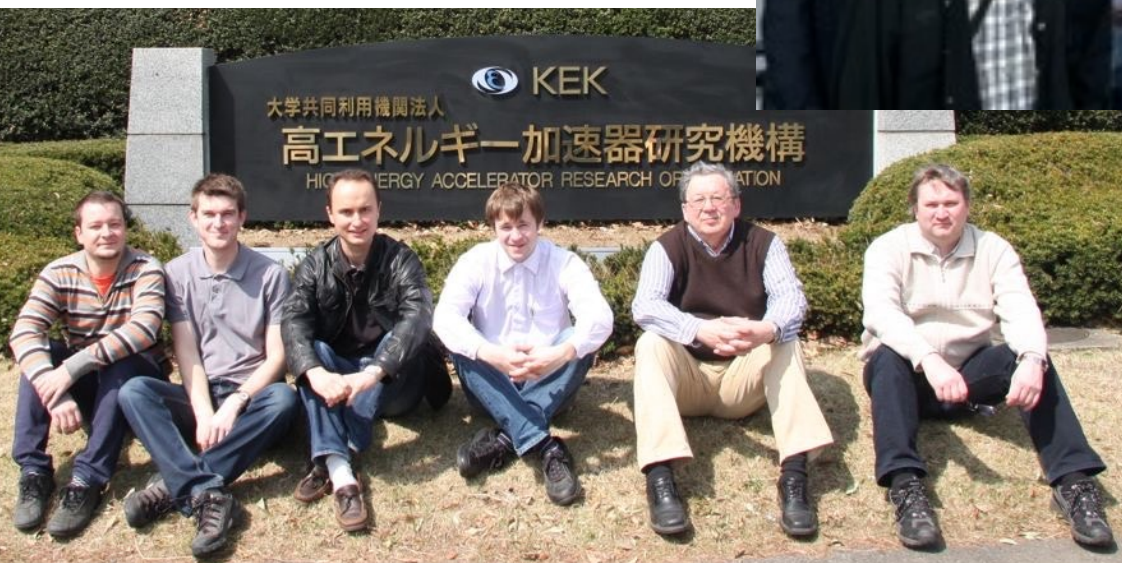
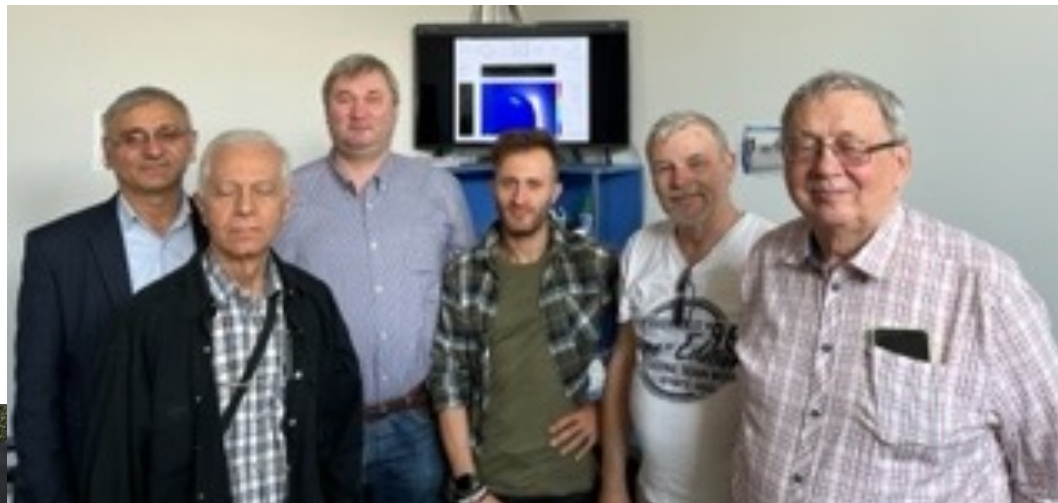
FLAP Collaboration Composition

- Founded in 2020 just before the pandemic;
- Spokesperson: **Pavel Karataev (RHUL)**
- Co-ordinator: **Anton Baldine (JINR)**
- Accounts for **19** organizations from **7** countries



FLAP Collaboration Expertise

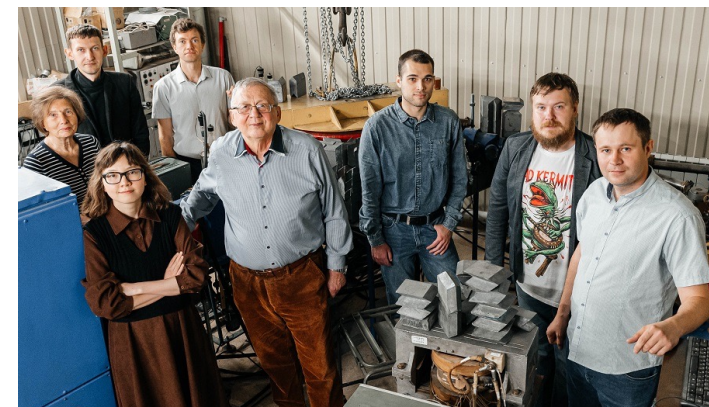
Tsukuba, Japan:
Advanced accelerator
operation, beam
instrumentation, feedback,
fs synchronization



Armenia: EM
processes in
condensed media



TPU: Polarization radiation
Advanced diagnostics
Medical Physics
Detection systems



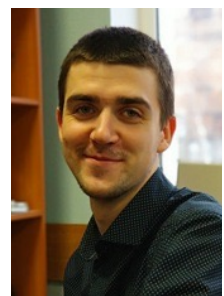
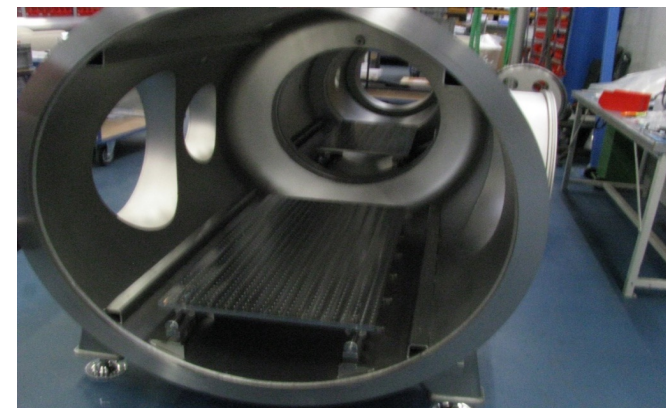
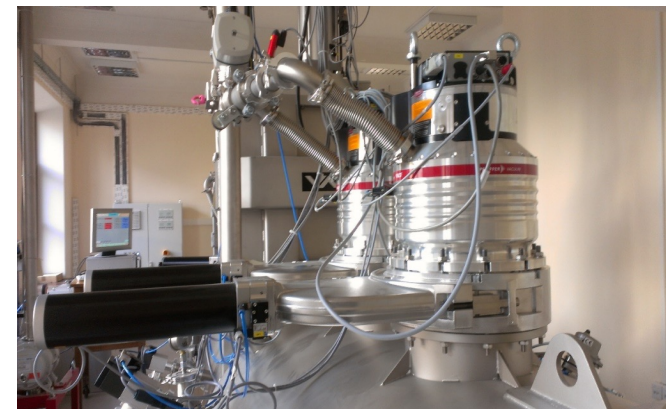
Minsk, Belarus: condensed media, EM
processes, advanced theory

Radiation Physics Laboratory

Belgorod National Research University

Group of Prof. Aleksandr Kubankin

- 1) Compact radiation sources
- 2) Electron beam optics elements
- 3) THz sources and sensors
- 4) Vacuum systems
- 5) New mechanisms for generation of X-rays
- 6) New sources of ions based on nano-tubes



ADJUNCT RESEARCH PROFESSORSHIP PROGRAM – 2023

X-ray and giga-terahertz tomography and spectroscopy

Leading by Pavel Karataev (RHUL)

In Collaboration with Sultan Dabagov (INFN)

And Vardan Margaryan (IAPP NAS RA)

1) Development of an X-ray tomographic stand with micron resolution;

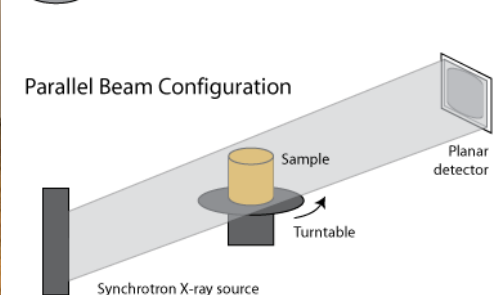
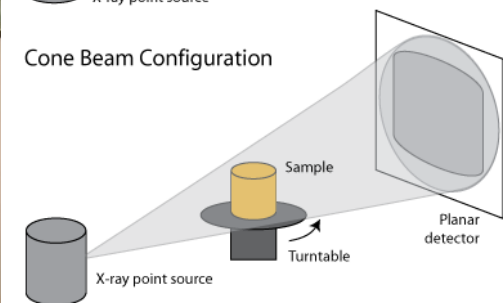
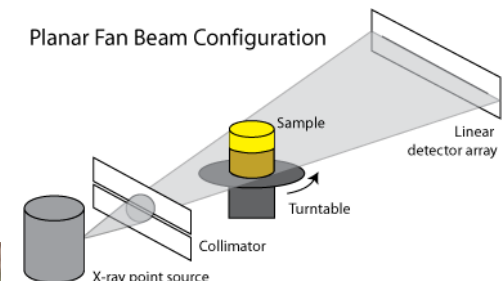
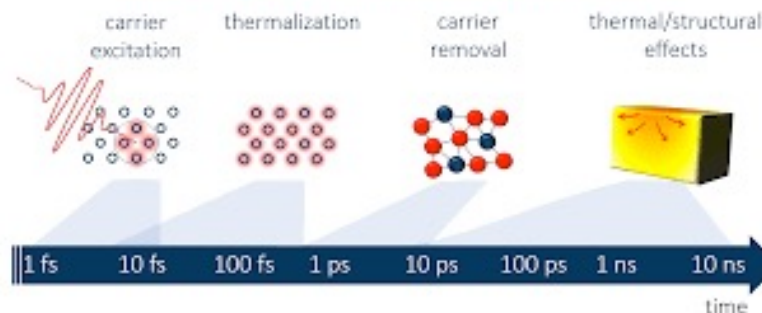
2) Development of a non-destructive sub-THz technology for table-top tomography;

3) Train next generation of scientist;

4) Develop light source user community;

5) Advanced X-ray and THz instrumentation

ultrafast dynamics in materials



НОВЫЙ УСКОРИТЕЛЬ ОИЯИ
ЛИНАК-200 ГОТОВИТСЯ
К ВВОДУ В ЭКСПЛУАТАЦИЮ



NEW JINR ACCELERATOR
LINAC-200 BEING
PREPARED FOR COMMISSIONING



Energy: 400keV, 20MeV,
200 MeV

Planned energy: 80MeV,
800MeV (1 GeV?)

Pulse Current: 80mA

2856 GHz bunch sequence



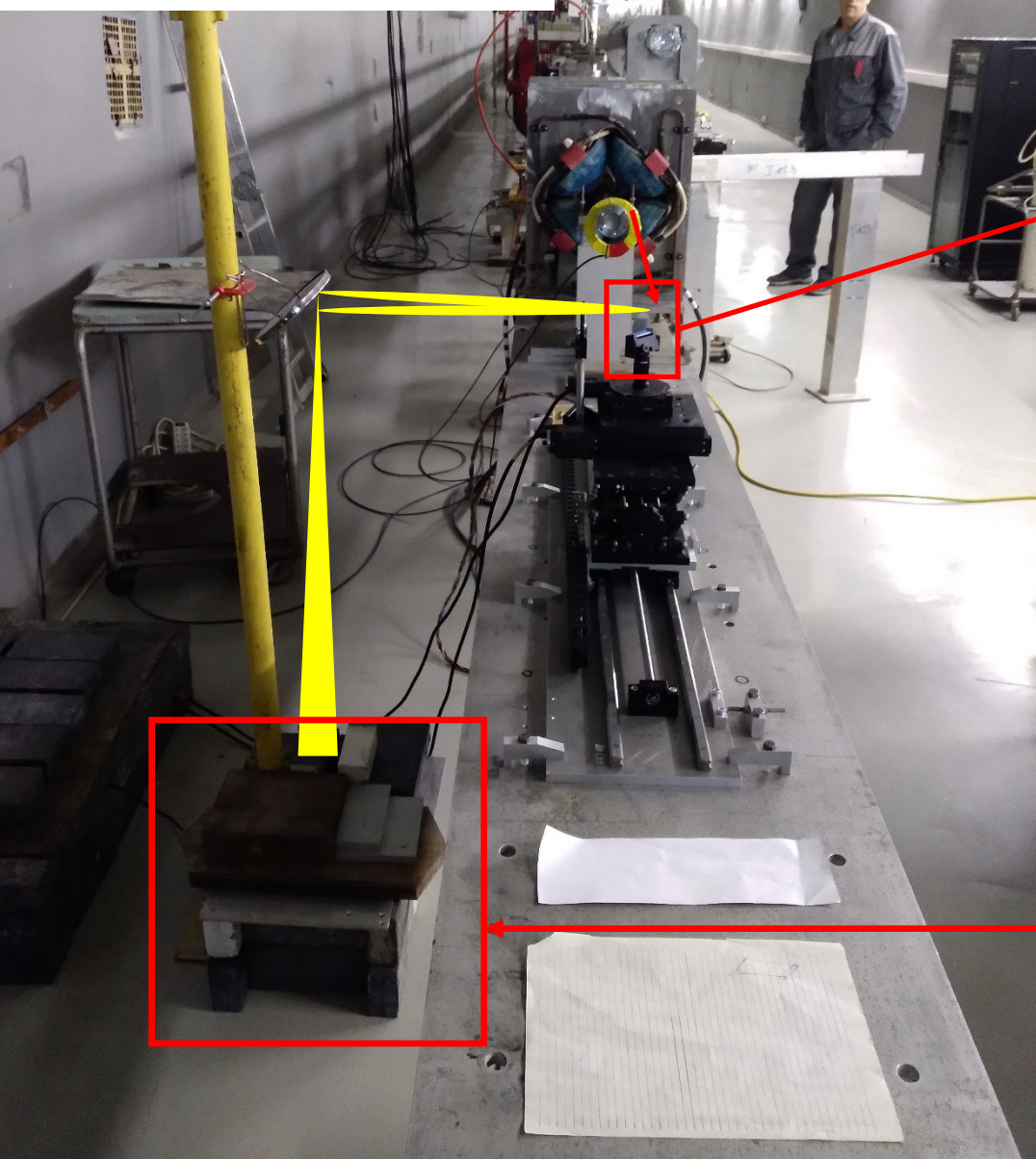
- **Commissioning has begun;**
- **FLAP collaboration actively participates;**
- **Individual group experiments are planned;**
 - **Grant applications, hardware preparation, automation, calibration, etc.**

LINAC200 Commissioning and Start-up

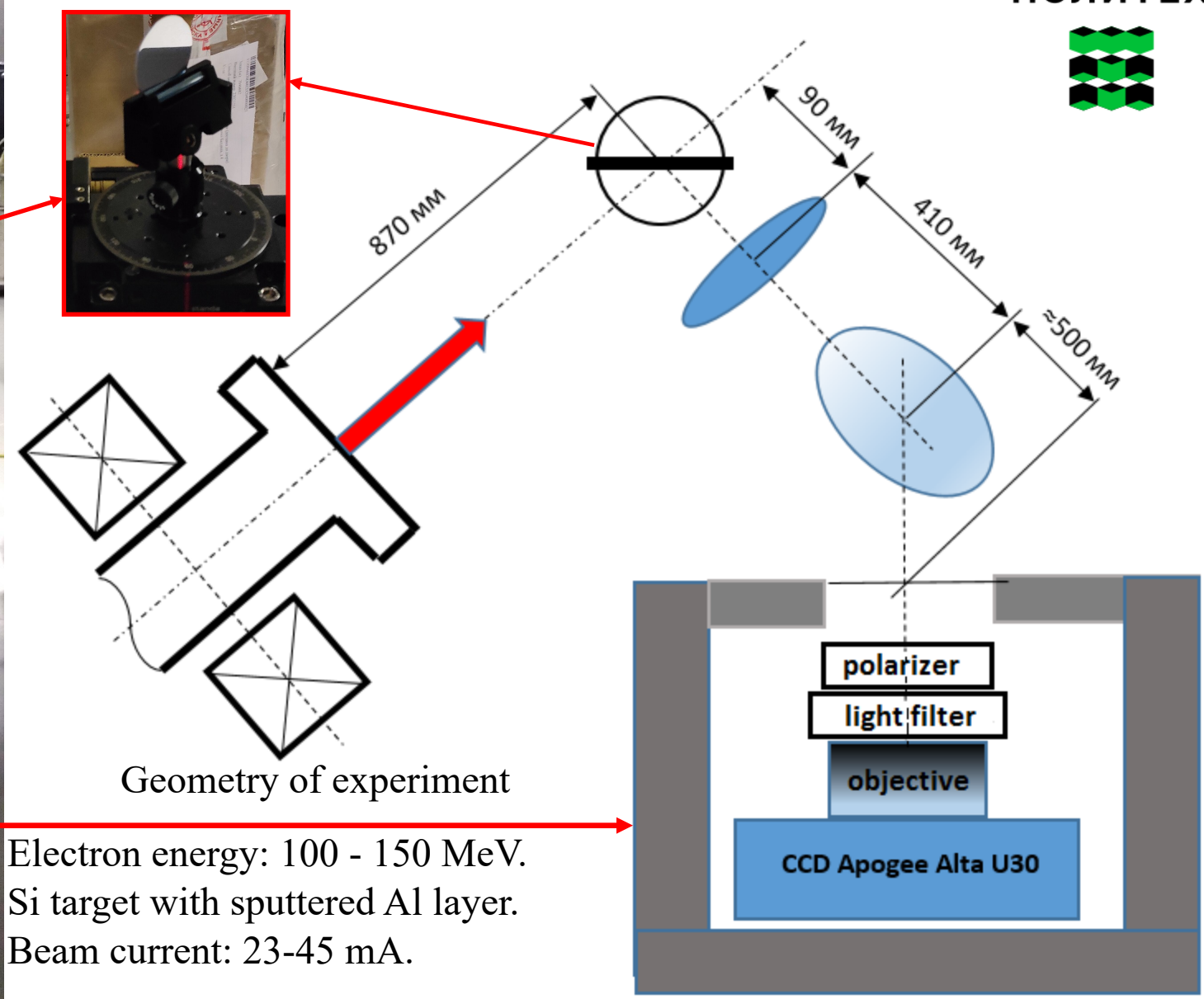


- **Beam parameter control;**
- **Transverse beam size and emittance measurement;**
- **Single bunch and train length monitoring;**
- **Arrival time and fast synchronization issues.**

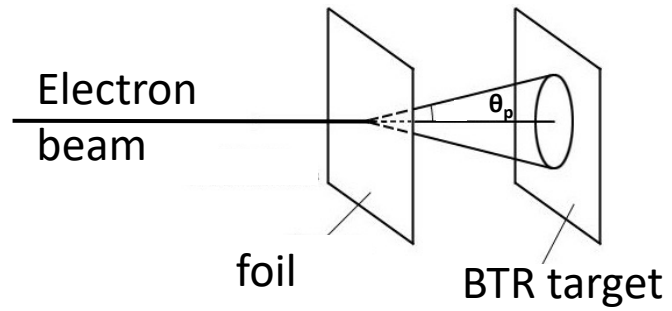
Task № 1: Measurement of transverse profile, energy, and divergence of electron beam



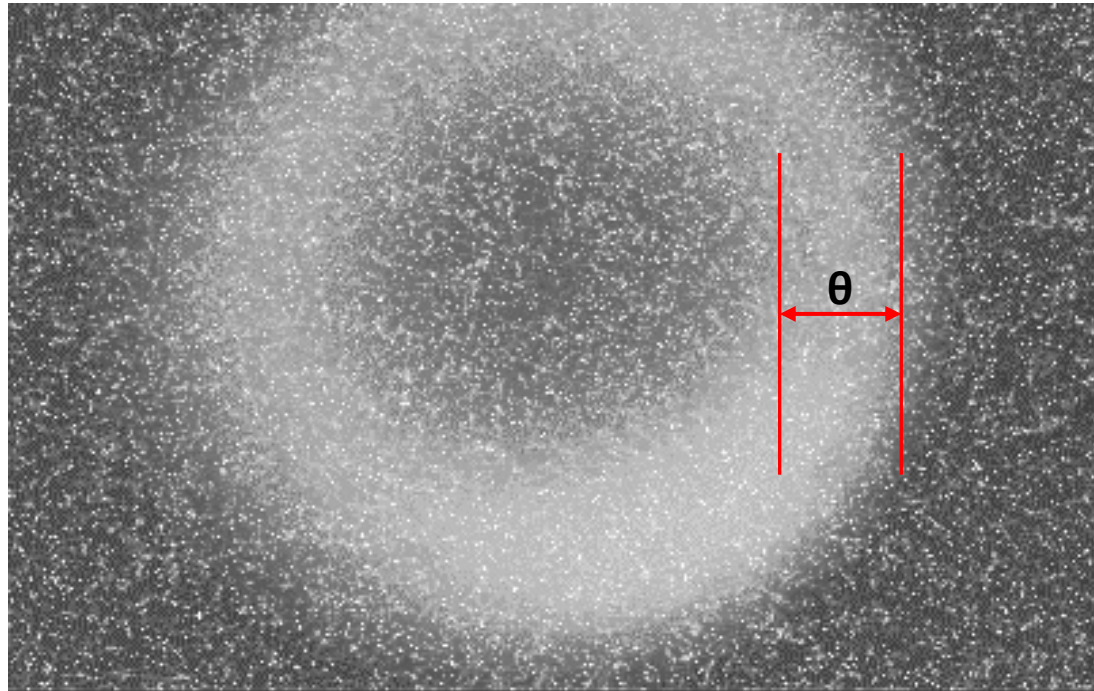
Measurement of backward transition radiation at LINAC-200



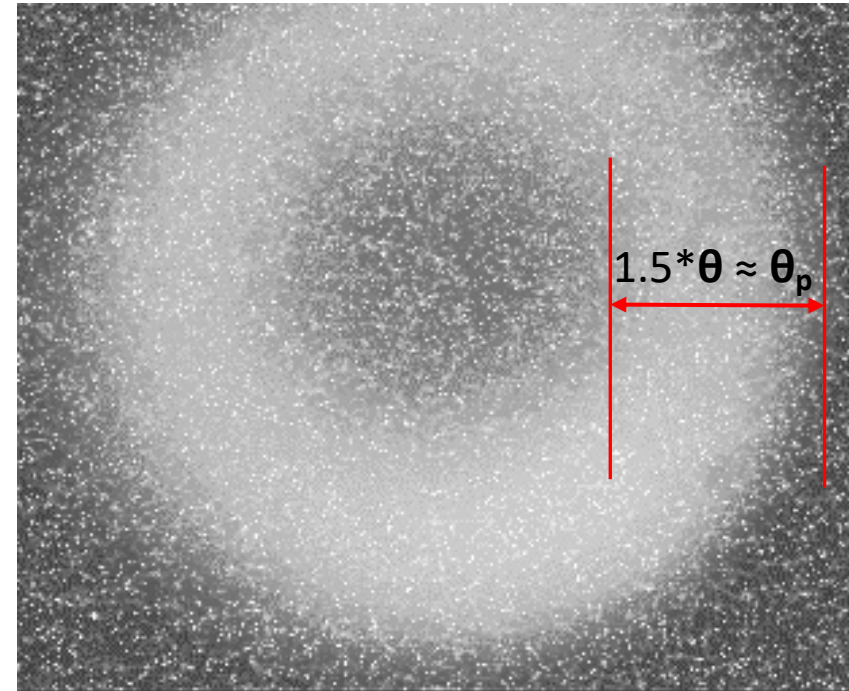
Estimation of electron beam scattering



Scatterer: Aluminum foil
 $\approx 9 \text{ mkm} * 8 \text{ layers} \approx 72 \text{ mkm}$.

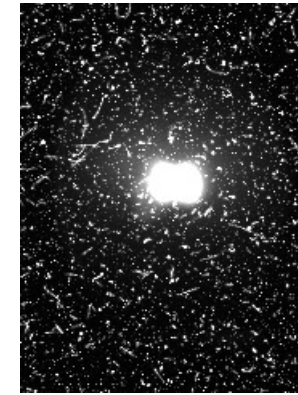
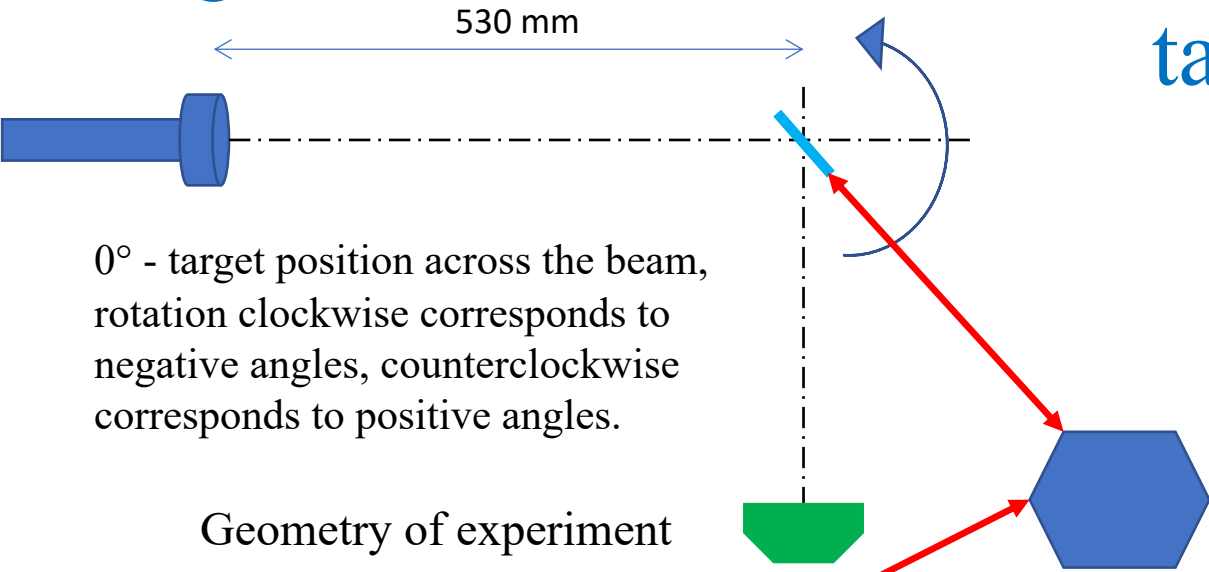


Without scatterer

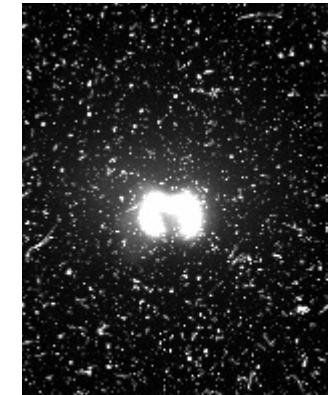


With scatterer

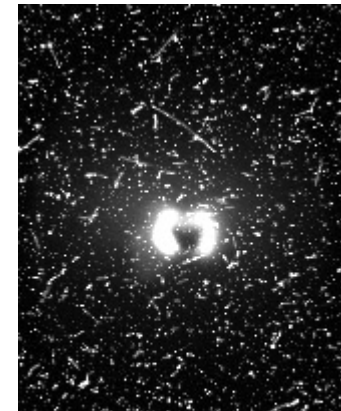
Registration of Vavilov-Cherenkov radiation from a diamond target



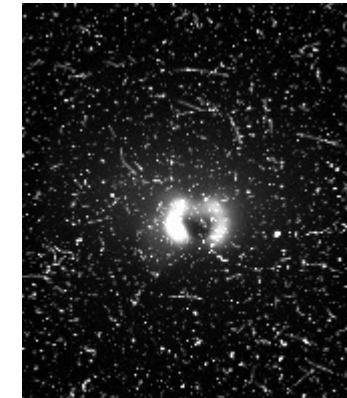
VCR from diamond, target angle 53.50°.



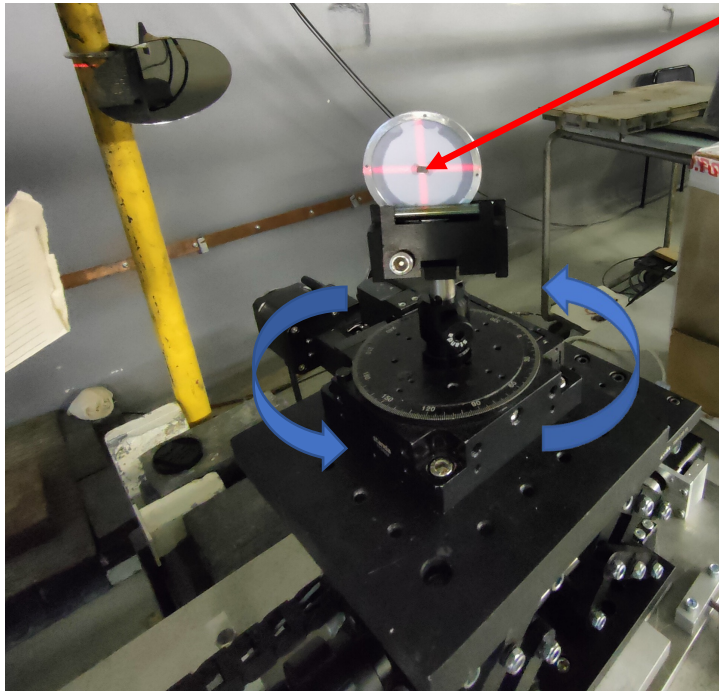
VCR from diamond, target angle 54°.



VCR from diamond, target angle 55°.

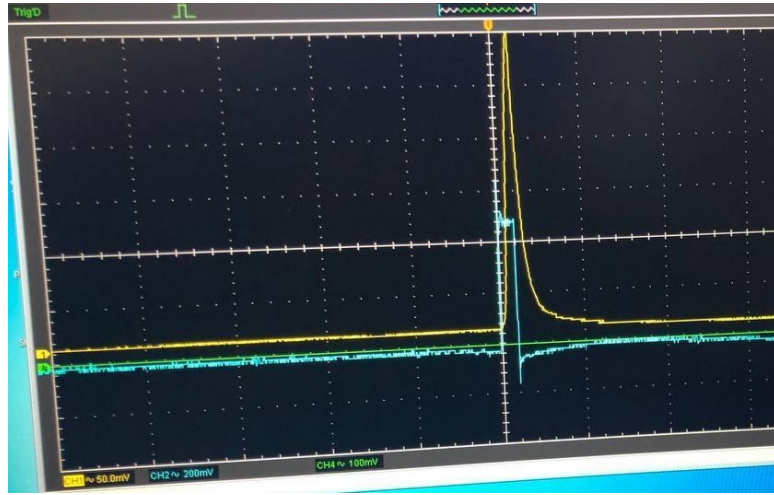


VCR from diamond, target angle 56°.

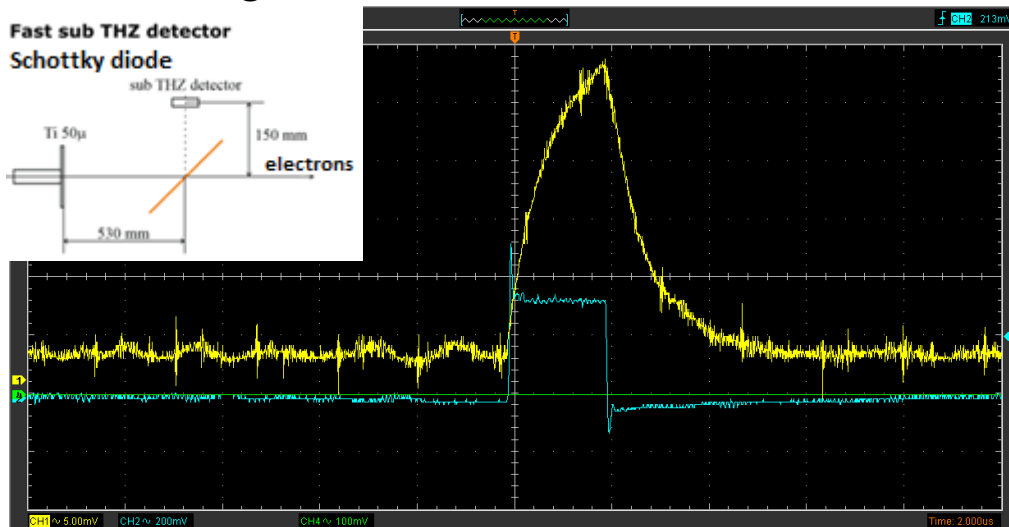


Target:
diamond
5 mm, 3 mm,
300 mkm

Registration and measurement of orientation dependence of coherent transition radiation in GHz and sub-THz frequency ranges



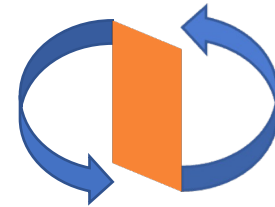
Oscillograms from ДП-ММ detector



Oscillograms from THz detector

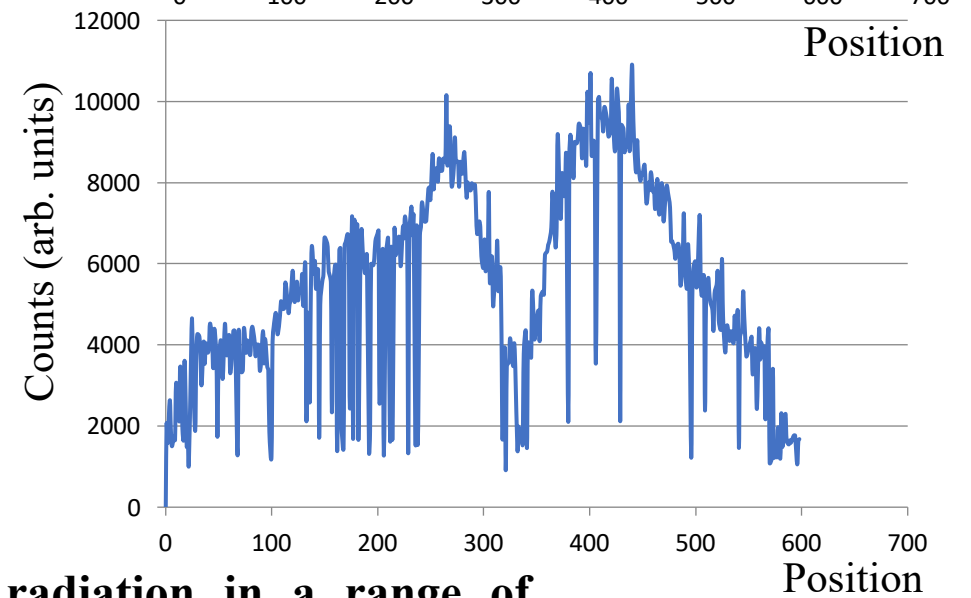
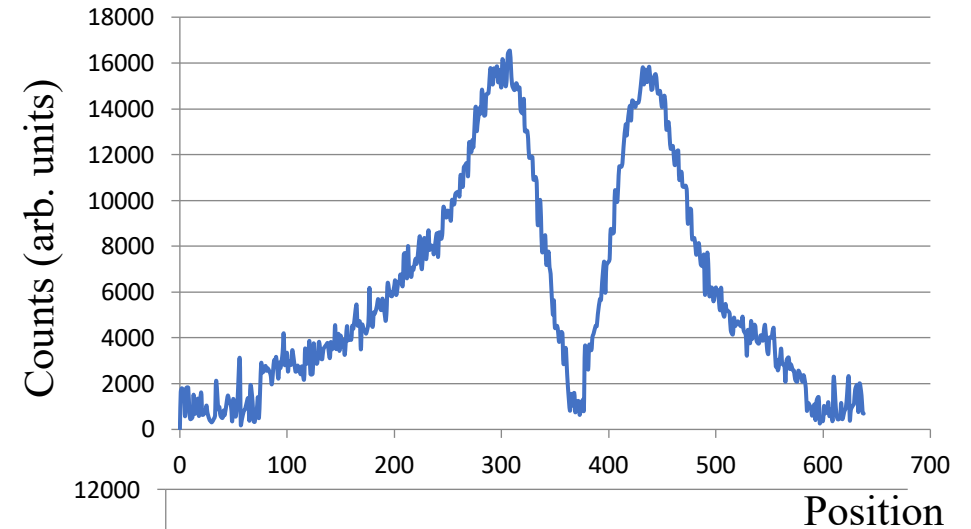


Low-barrier semiconductor
Si detector



Fast sub-THz detector.

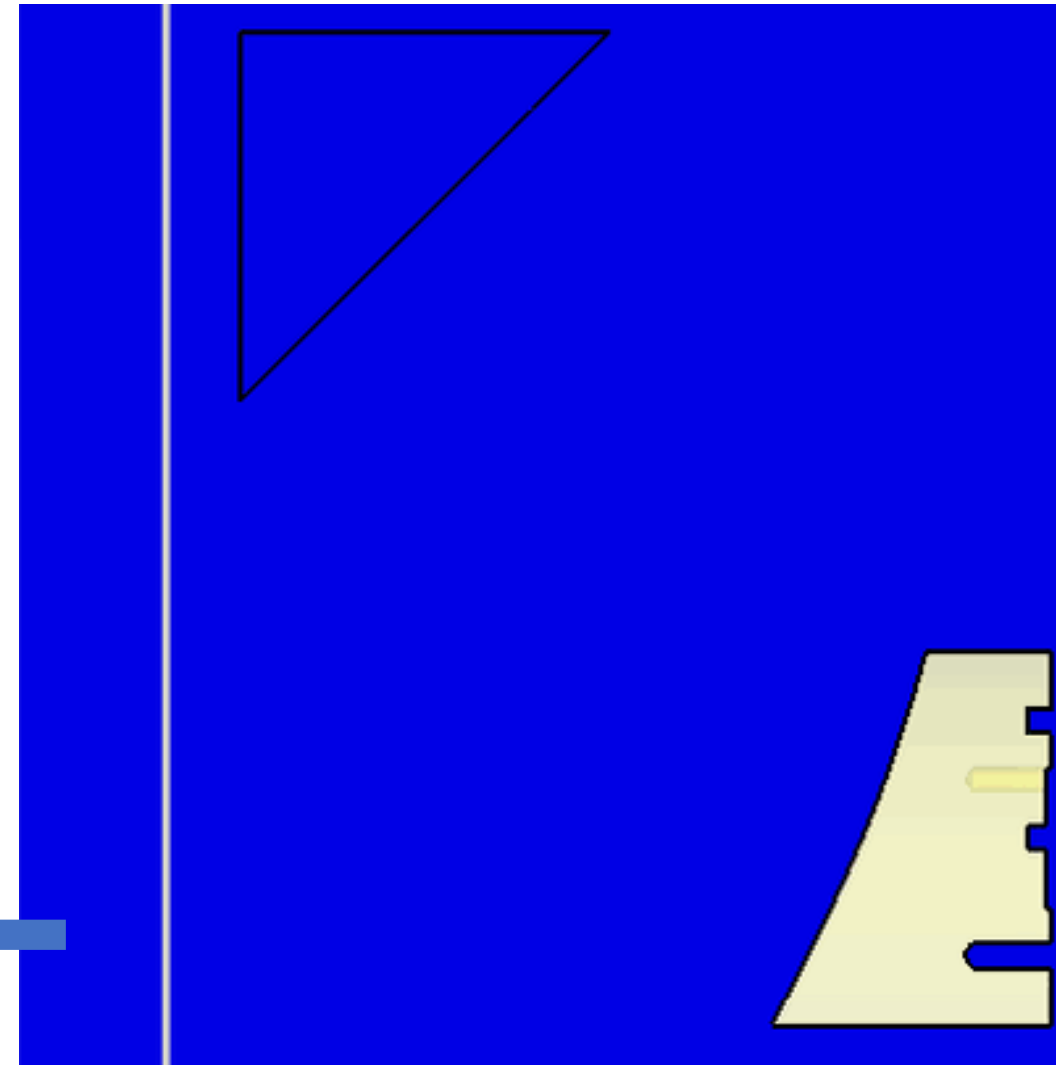
Coherent transition radiation in a range of about 100 GHz was registered.



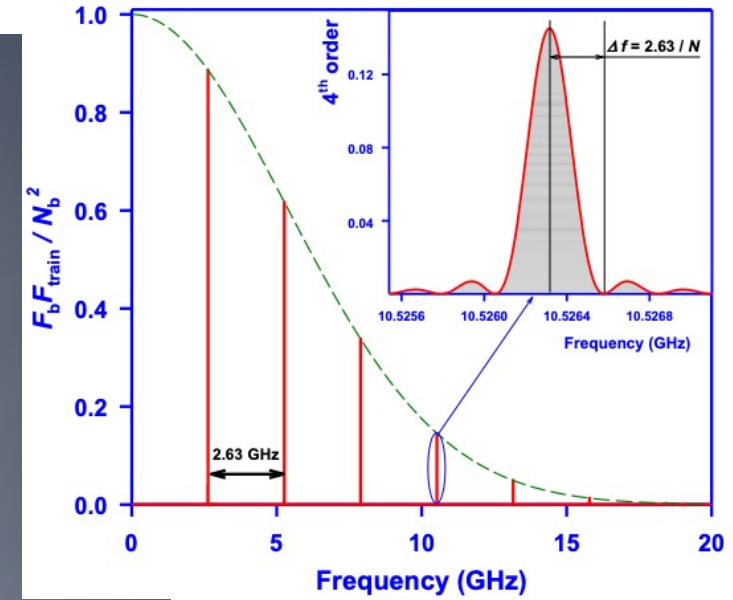
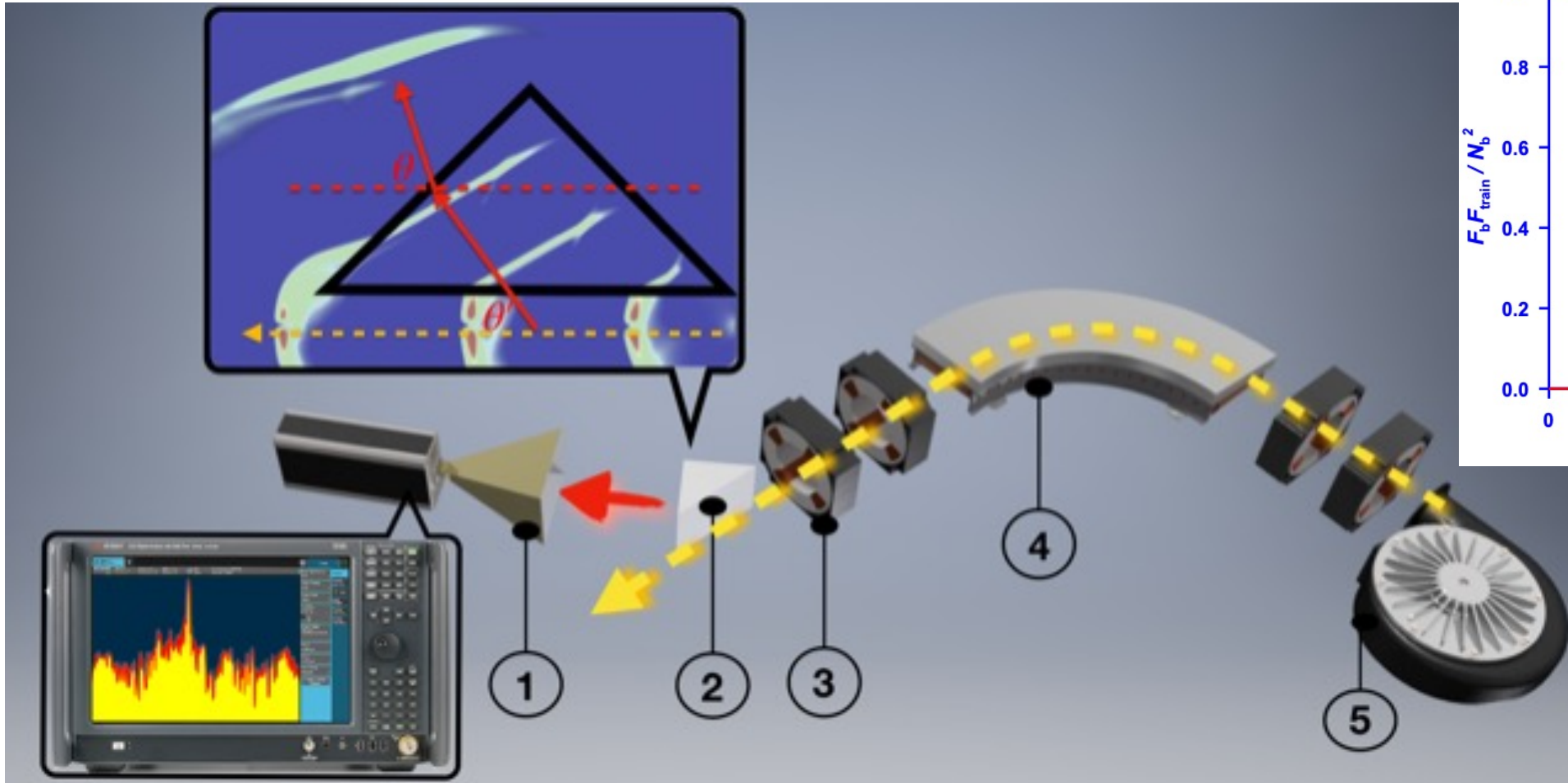
Program for Polarization Radiation studies and its applications

- ❑ Radiation processes (Cherenkov, Transition, Diffraction, Smith-Purcell radiation) from charged particles
- ❑ Generation of surface polaritons by beams of charged particles on curved interfaces
- ❑ Influence of periodic superlattices generated by acoustic waves on various radiation processes in media
- ❑ Superradiant and Stimulated regimes

To
detector ←



Experiment at Tomsk 6.2 MeV microtron

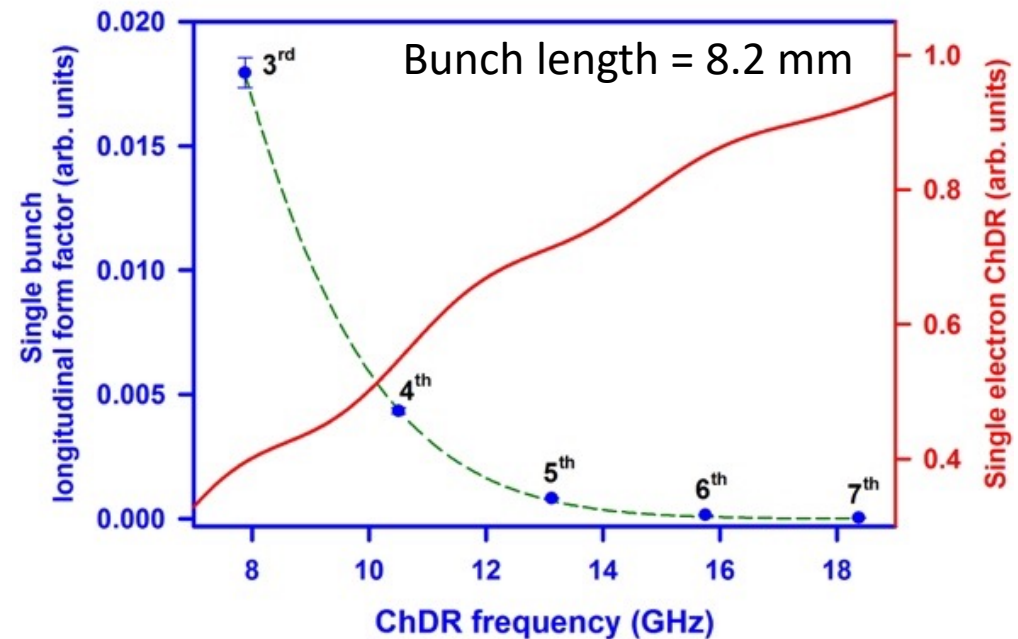
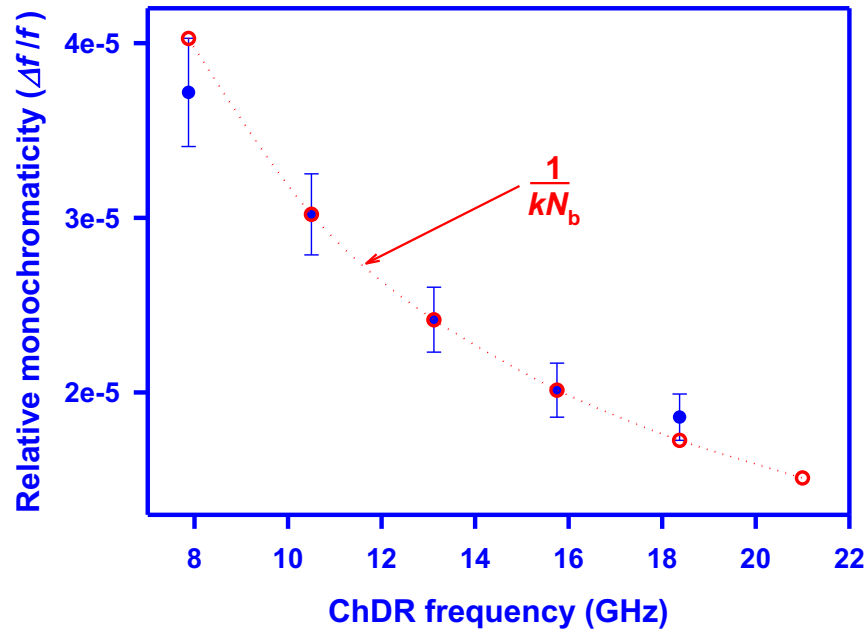
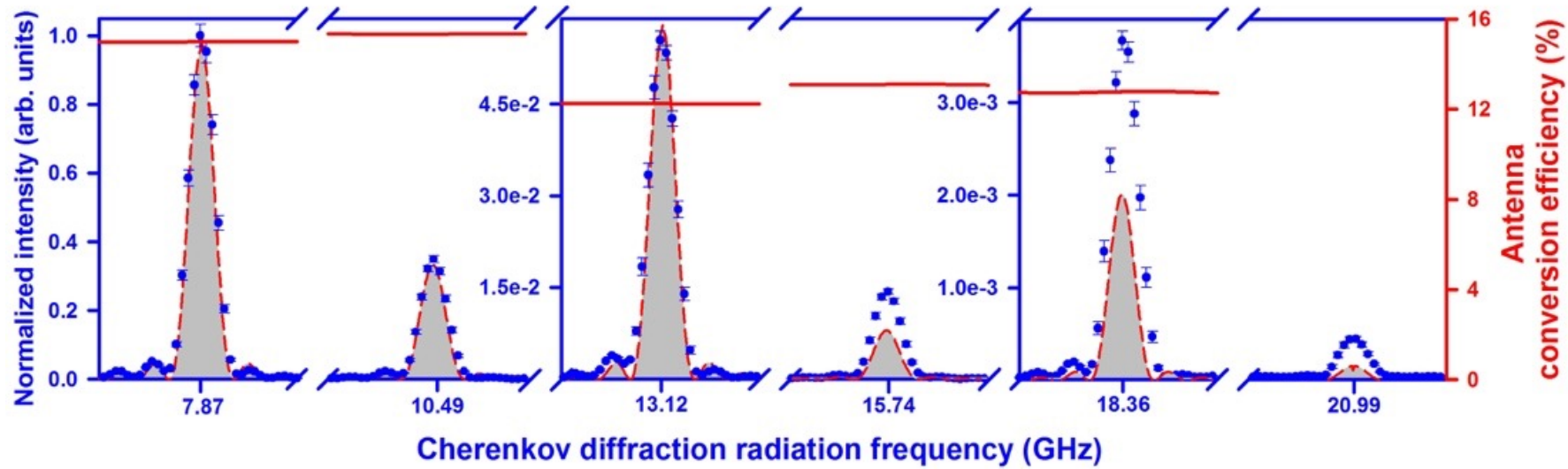


$$N_b = 8416$$

$$f_{\text{RF}} = 2.63 \text{ GHz}$$

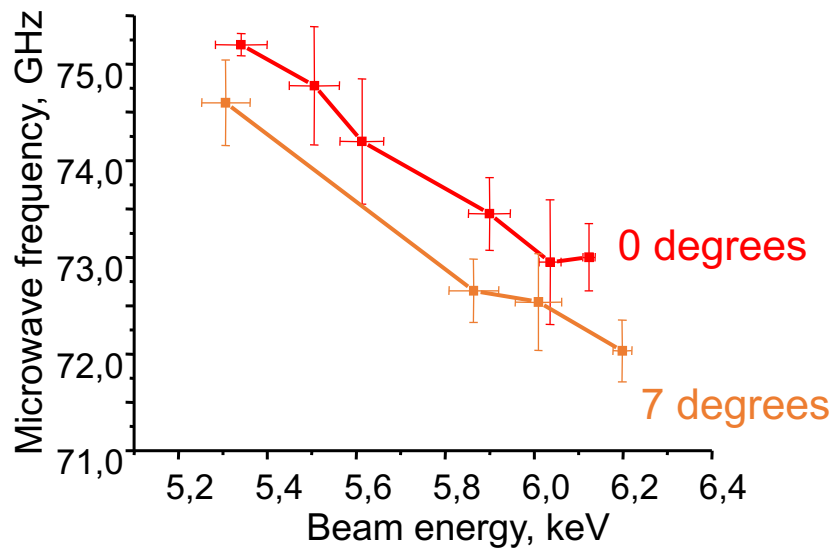
$$\text{Bunch length} = 8.2 \text{ mm}$$

Cherenkov diffraction radiation in super-radiant regime

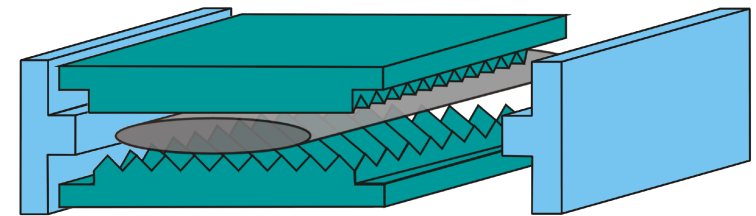
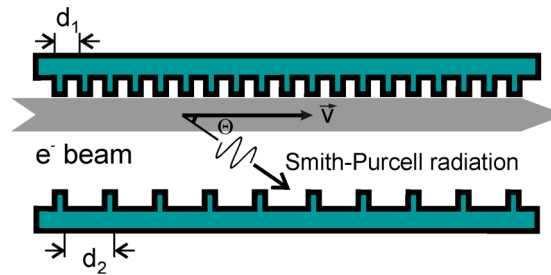


Volume FEL in mm and THz-wavelength range at LINAC-200 (JINR)

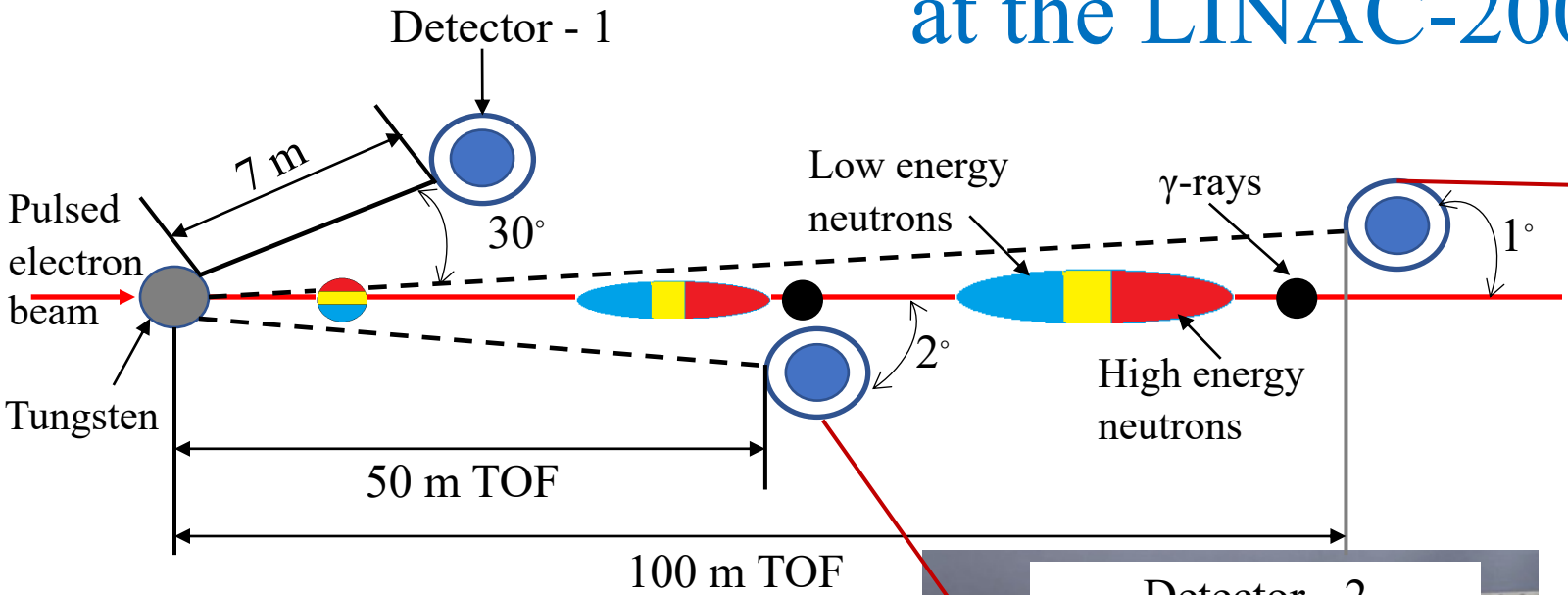
The first Volume FEL (Institute for Nuclear Problems, Minsk, 2001)



- Rectangular resonator
- Two diffraction gratings with different periods
- Sheet electron beam 10 keV
- Wavelength range about 4 mm
- Radiation frequency changes at rotation of diffraction grating

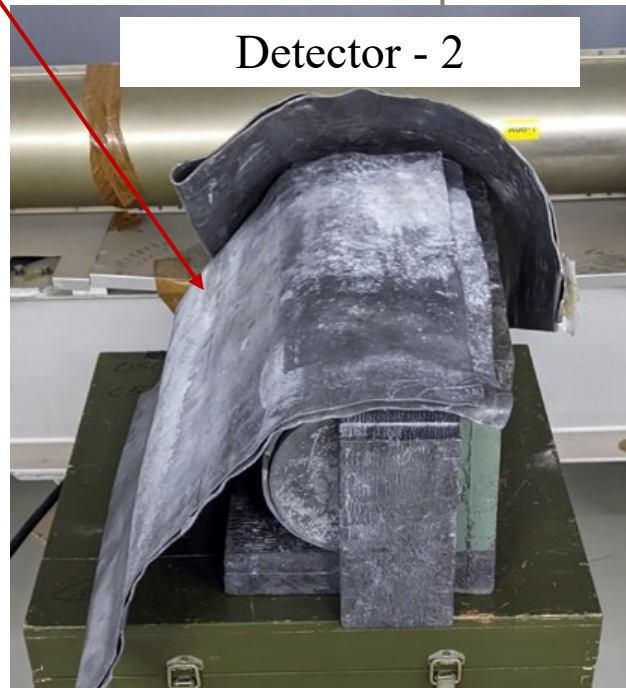


Scheme of the experimental setup for neutron generation at the LINAC-200



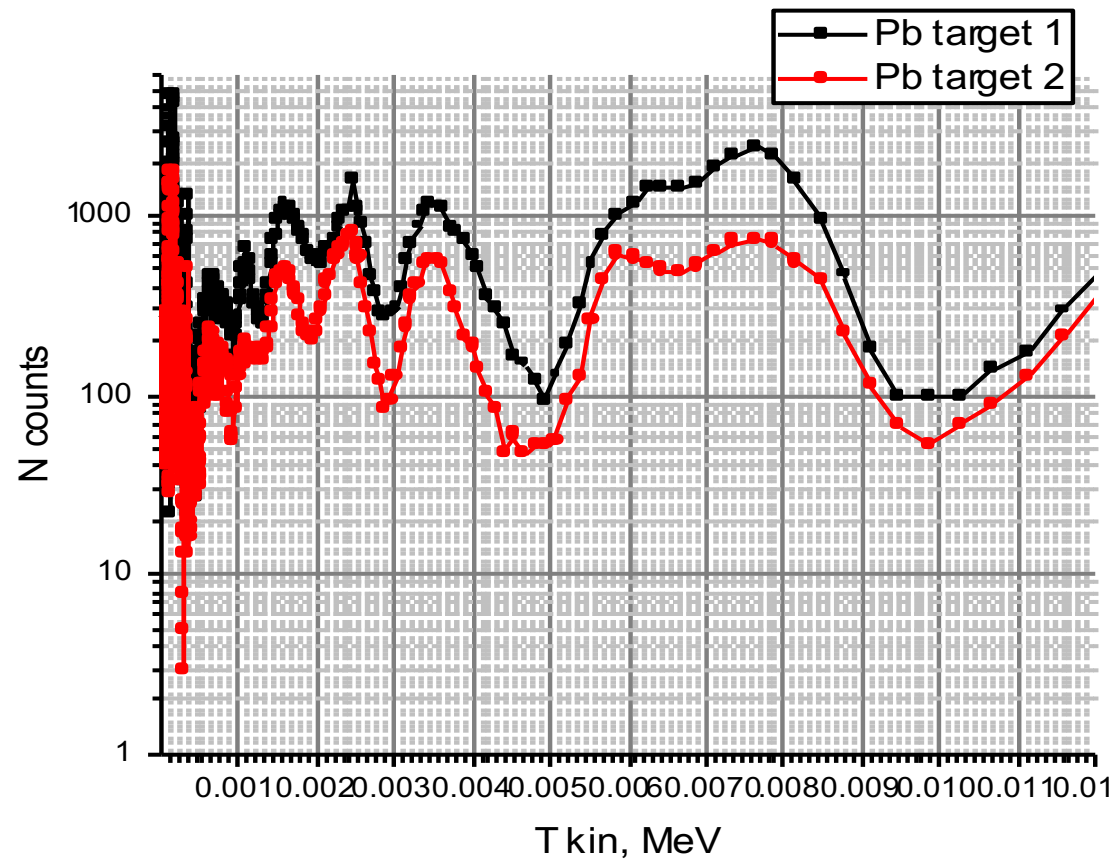
Main beam parameters:

Current beam 100 μ a,
Current pulse duration 100-300 ns,
electron energy 140 MeV.

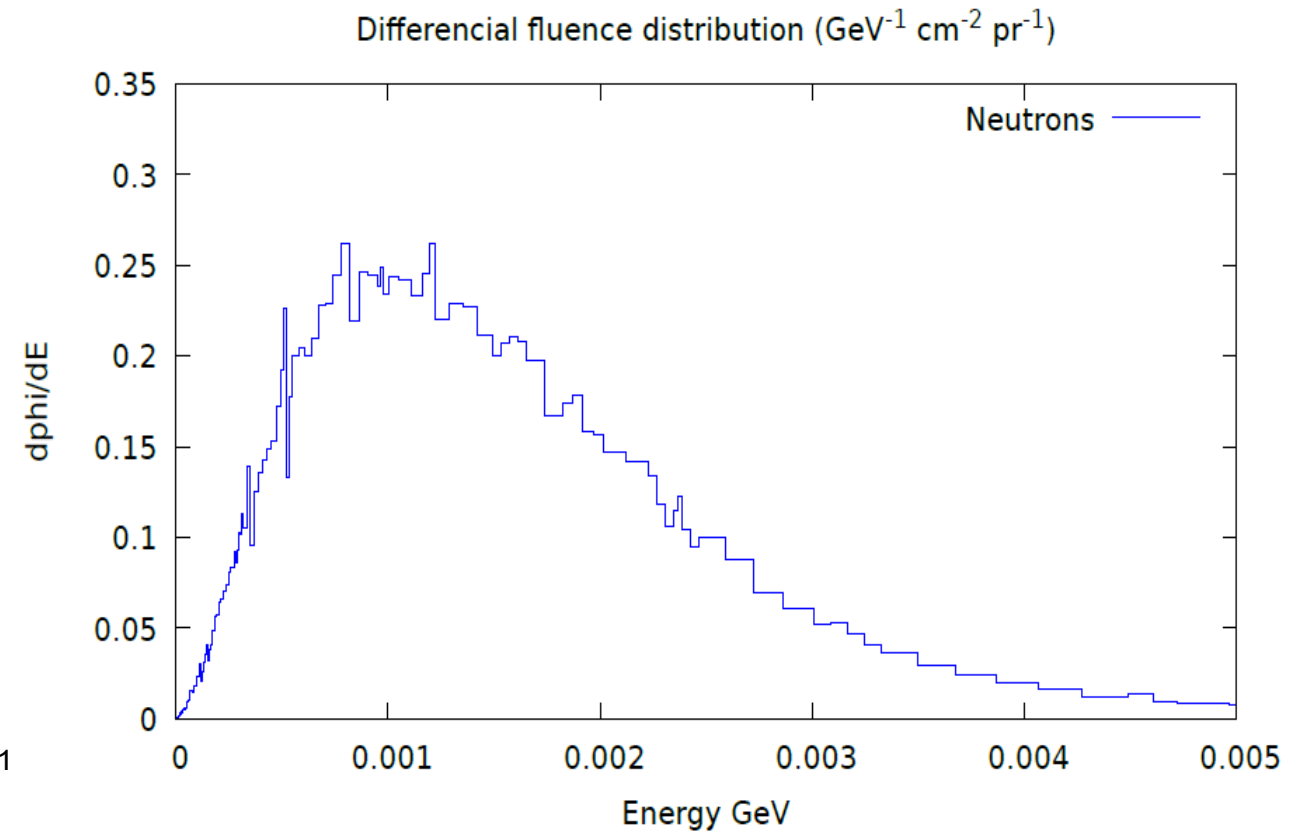


Neutron energy spectrum in Pb target

Experiment

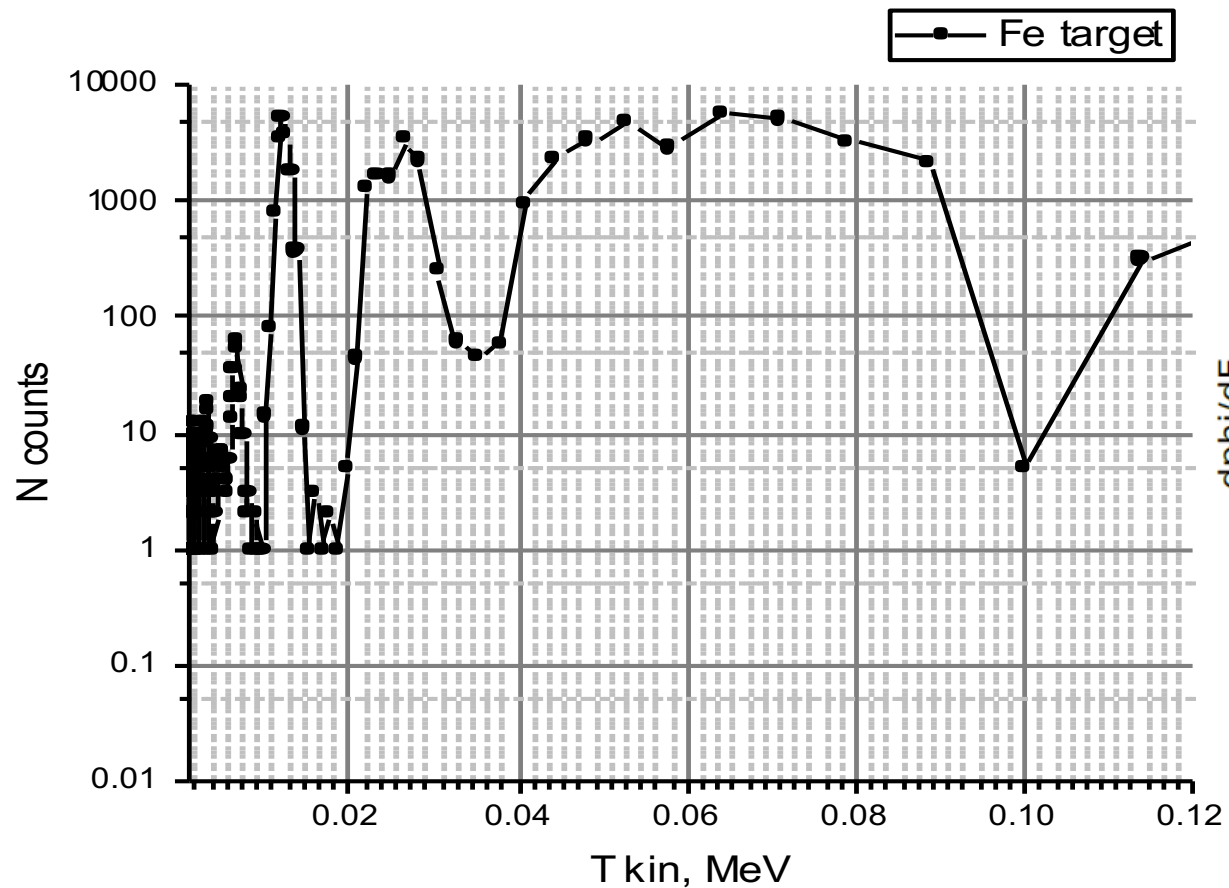


Simulation

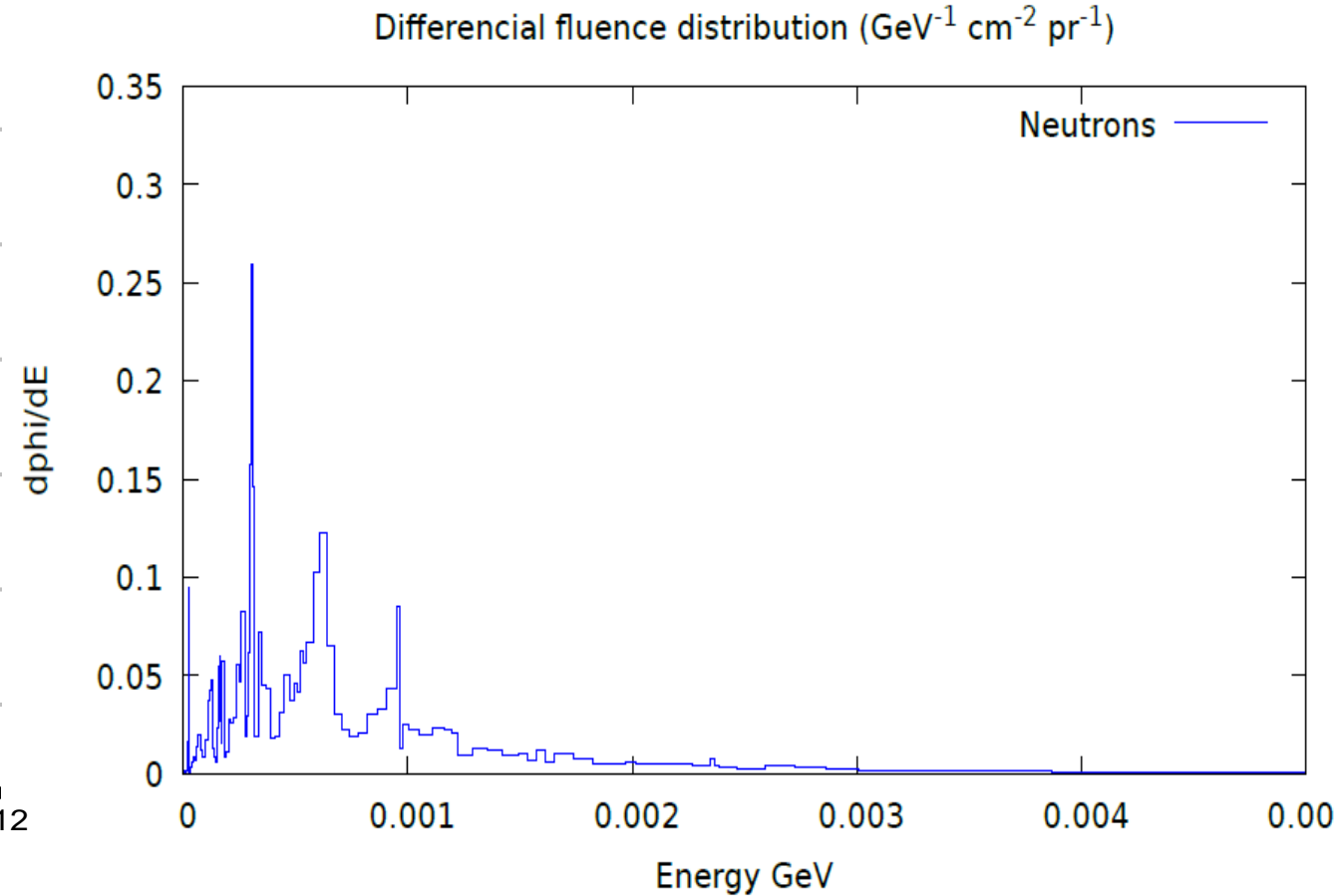


Neutron energy spectrum in Fe target

Experiment



Simulation



FLAP: research program at the linear electron accelerator LINAC-200 and beyond

- **Development of particle detectors for experiments at the NICA collider and other radiation facilities.**
- **Nuclear physics research – photonuclear reactions.**
- **Investigation of the mechanisms of electromagnetic interactions. Controllable generation of electromagnetic radiation of various types by relativistic electrons.**
- **Creation of neutron sources for neutronography and development and testing of neutron detectors.**
- **Applied studies in the field of radiation material research, radiobiology, radiochemistry.**
- **Search of new methods for charged particle diagnostics.**
- **Train the next generation of scientists for operation and exploitation of the novel accelerator and nuclear facilities**

Summary

- **LINAC200 commissioning work: beam size, emittance, length, diagnostics is planned;**
- **Online activity was reviewed via regular zoom seminars and conferences;**
- **Started applying for grants to fund our joint activities.**
- **Memoranda Of Understanding;**
- **Multiple research projects are being prepared;**
- **Express interest in further upgrade LINAC200 to higher energies: better radiators ultrarelativistic phenomena, potential FEL facility for research and education**

RREPS-23 merged with Meghri-23, Tsahgadzor, 2023, Armenia



Institute of Applied Problems of Physics

FLAP Presentations at RREPS'23 & Meghri'23 symposium

- Sultan Dabagov (2), Channeling X-rays for Tomographic Studies; and Coherent Radiation at Electron Channeling in OL as a Mechanism to Increase the Laser Intensity
- Alexander Potylitsyn (2), Monochromatic Cherenkov Radiation from Radiations with Frequency Dispersion; and Cherenkov Radiation and Transition Radiation from Tilted Corundum Plate
- Aram Saharyan, Generation of Surface Polaritons on Cylindrical Interfaces; and Quasidiscrete Spectrum Cherenkov Radiation from a Charge Moving inside a Dielectric Waveguide
- Veronika Bleko, Application of Optical Cherenkov Radiation for Ion Beam Diagnostics
- Mikhail Shevelev (3), Large-angular Emission of Quasi-Monochromatic Ultra-Soft X-ray from Multilayer Structure under Irradiation of 5.7 MeV Electrons; and Spectrum of Coherent VUV Radiation Generated by 5.7 MeV Electrons in the Periodic Structure of a Multilayer X-ray Mirror; and Coherent Transition Radiation from Finite-Size Screen in the Prewave Zone
- Yuri Cherepennikov, Prospects of Corundum Crystals Application as Cherenkov Radiators
- Mikhail Nozdrin, Project of the Source of Relativistic Electrons with Angular Momentum
- Sergey Stuchebrov (2), Evaluation of the Possibility of a Multichannel Detector Application for Electron Beam Profile Measurement by the Multi-Angle Scanning Method; and Electron Beam Profile Determination by Multi-Angle Scanning Using Scintillation Optical Fiber
- Artem Vukolov, Microtron Experimental Facility at Tomsk Polytechnic University
- Levon Grigoryan, Quasi-Coherent Radiation from a Train of Electron Bunches Inside a Waveguide Partially Filled with Dielectric
- Alexander Lobko (2), Generation of Superradiant Parametric X-rays (SPXR); and New Materials for Radiative Applications
- Andrey Oleinik, Quasi-Continuous Particle Generation in a Pyroelectric Accelerator
- Angelina Bulavskaya, The Electron Beam Propagation through 3D-Printed Plastic Samples with Different Infill Patterns
- Irina Miloichikova, Simulation and Experimental Results of Electron Beam Interaction with 3D-Printed Samples Made of Modified Plastics
- Vitold Bleko, Characteristics of a Neutron Source Based on an Electron Accelerator LINAC-200
- Lucine Aloyan, The Influence of Porphyrins on DNA Damage Induced by Electron Beam