Introduction to beta-delayed particle spectroscopy by the OTPC technique

MARTA KLEPACKA, POZNAN UNIVERSITY OF TECHNOLOGY

MARTA LISOWSKA, WROCLAW UNIVERSITY OF SCIENCE AND TECHNOLOGY

FLEROV LABORATORY OF NUCLEAR REACTIONS

SUPERVISOR: DR GRZEGORZ KAMIŃSKI

Summer Student Practice, JINR, Dubna, 2018

Outline

1. Aim of the project
2. What is OTPC?
3. Scheme and principle of operation
4. Our practice

Aim of the project

The purpose of the project was to get familiar with new detection technique.

The first part of practice was theoritical introduction to the physics of detection, beam preparation, ion identification, and the second part were activities that included practical experience of work with detection setup.

What is OTPC?

OTPC = Optical Time Projection Chamber
It was the concept of prof. Wojciech Dominik from Warsaw University.

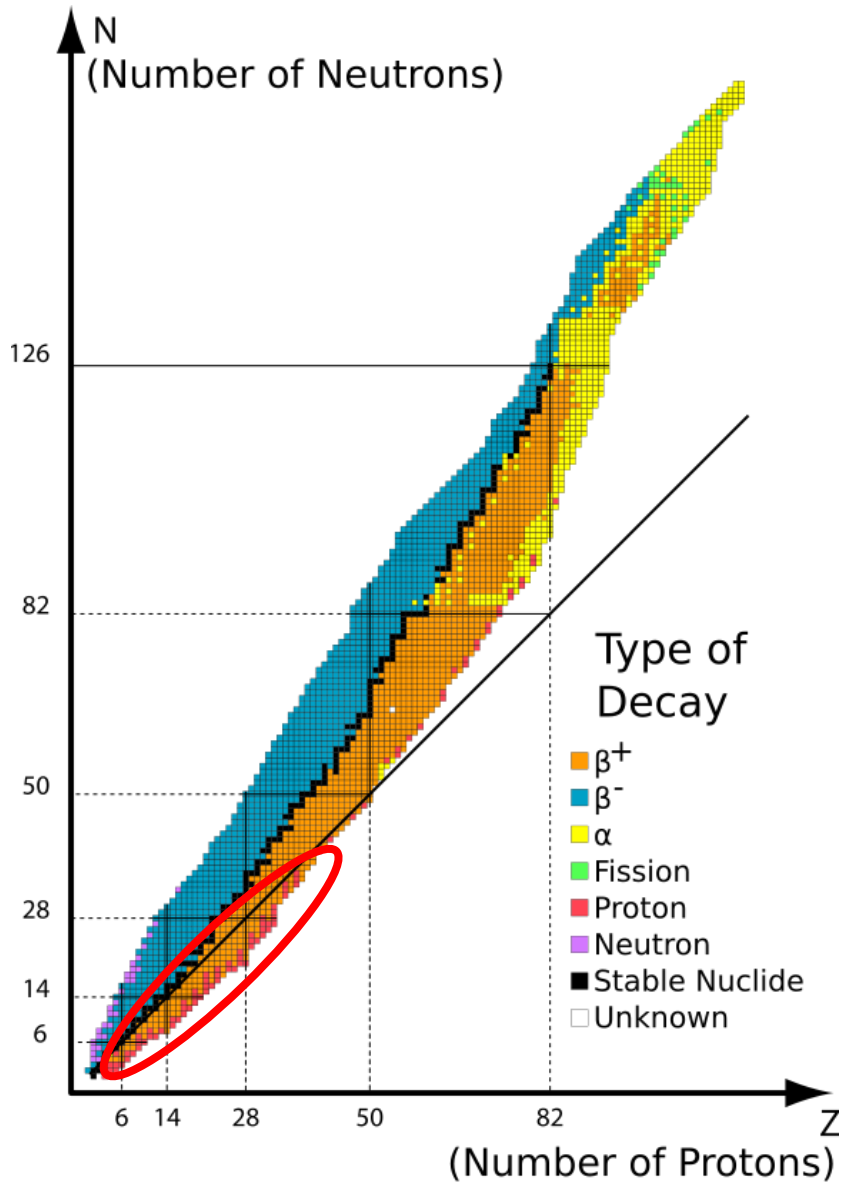
OTPC is a detector that measures radioactive decay events.

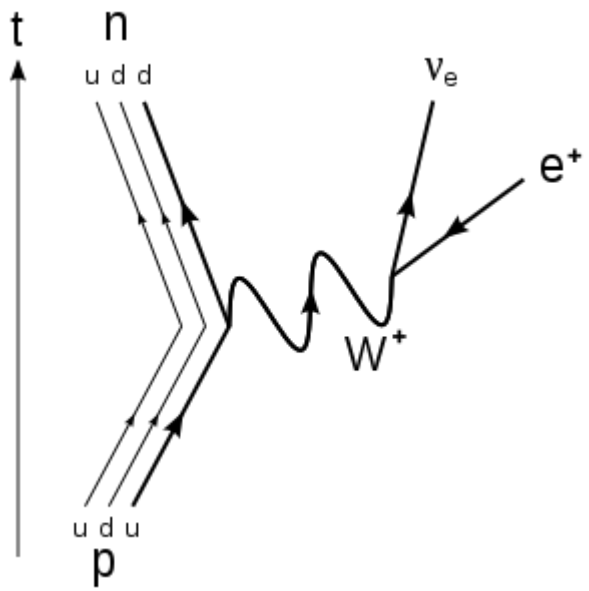
It gives us information about:

-the intensity of event,

-the path of particles.

It is used for β delayed particle emission spectroscopy of proton-rich nuclei.

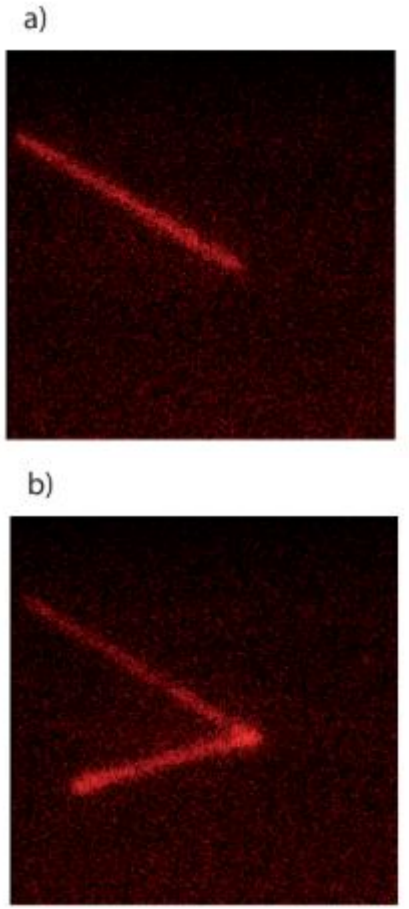




Feynmann diagram for β+ decay

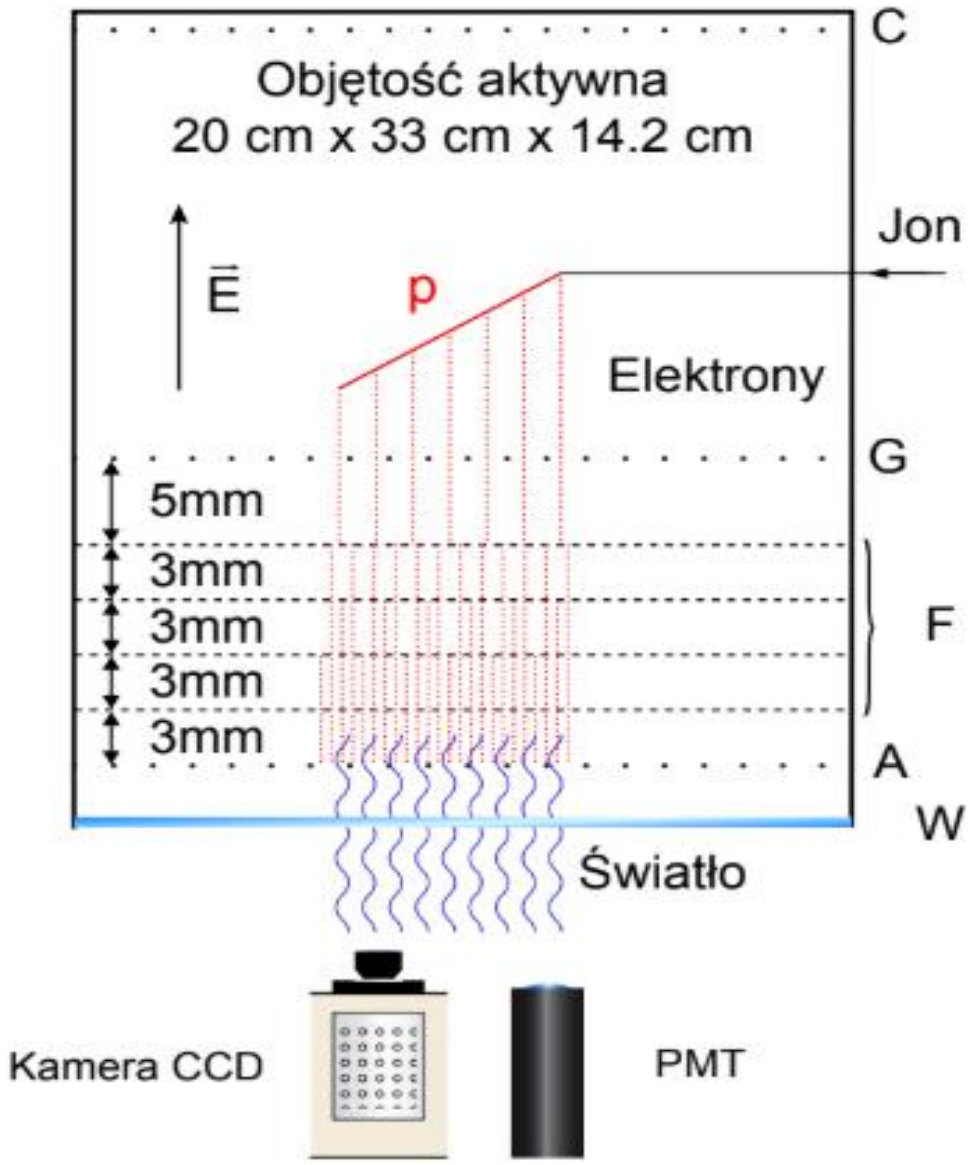
$$ {}^{A}_{Z}X \rightarrow {}^{A}_{Z-1}X' + e^{+} + \nu_e $$

$$ p \rightarrow n + e^{+} + \nu_e $$

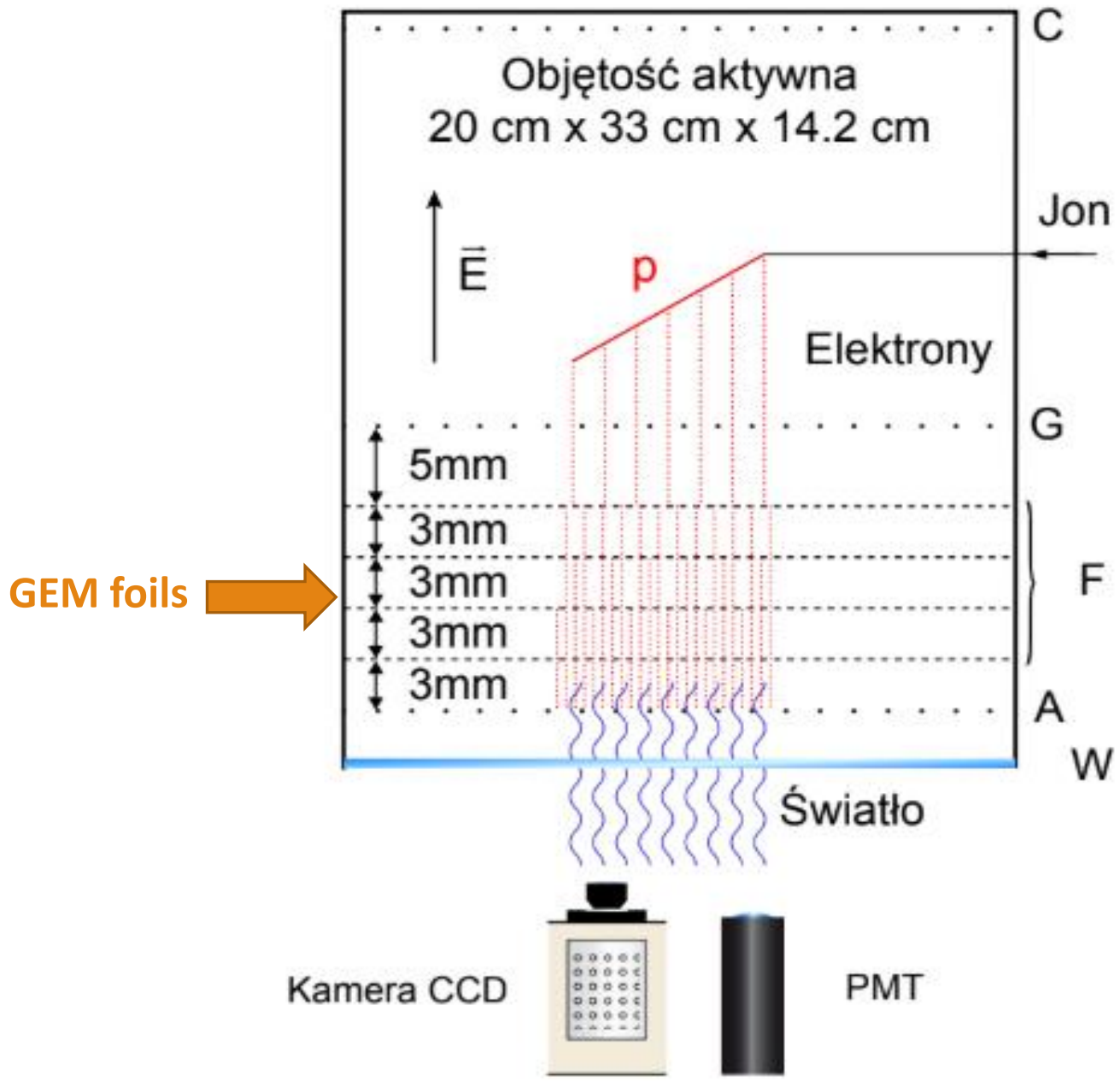


a) Emission of 1 proton
b) Emission of 2 protons

Scheme

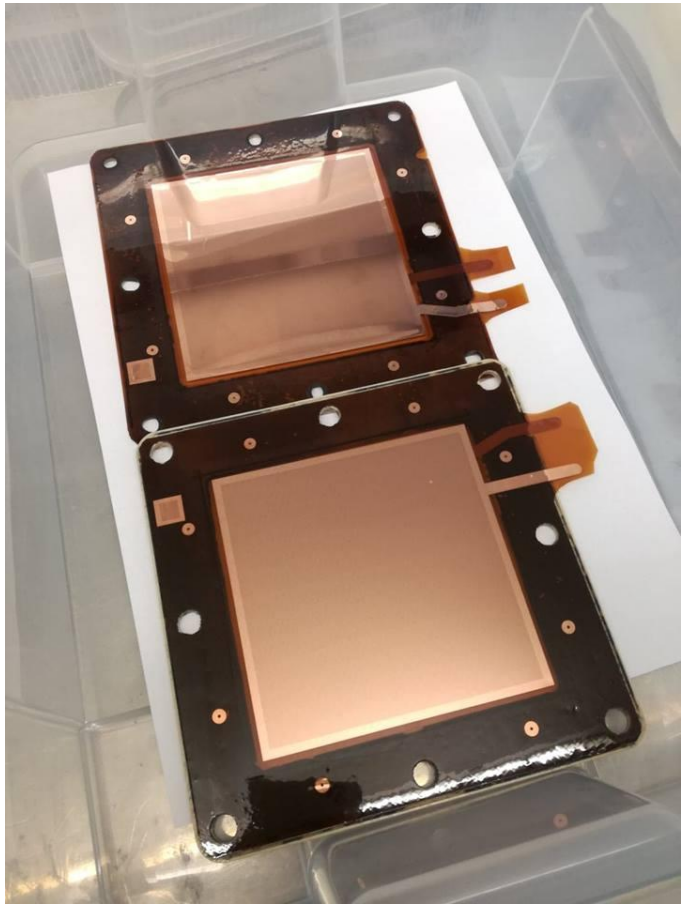


Optical Time Projection Chamber scheme

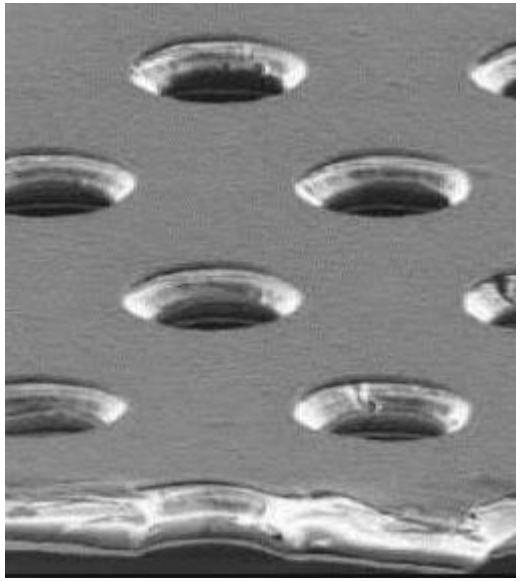

C
Objętość aktywna
20 cm x 33 cm x 14.2 cm
Jon
$\vec{E}$
p
Elektrony
G
5mm
3mm
3mm
3mm
F
GEM foils
A
W
Światło
Kamera CCD
PMT

GEM

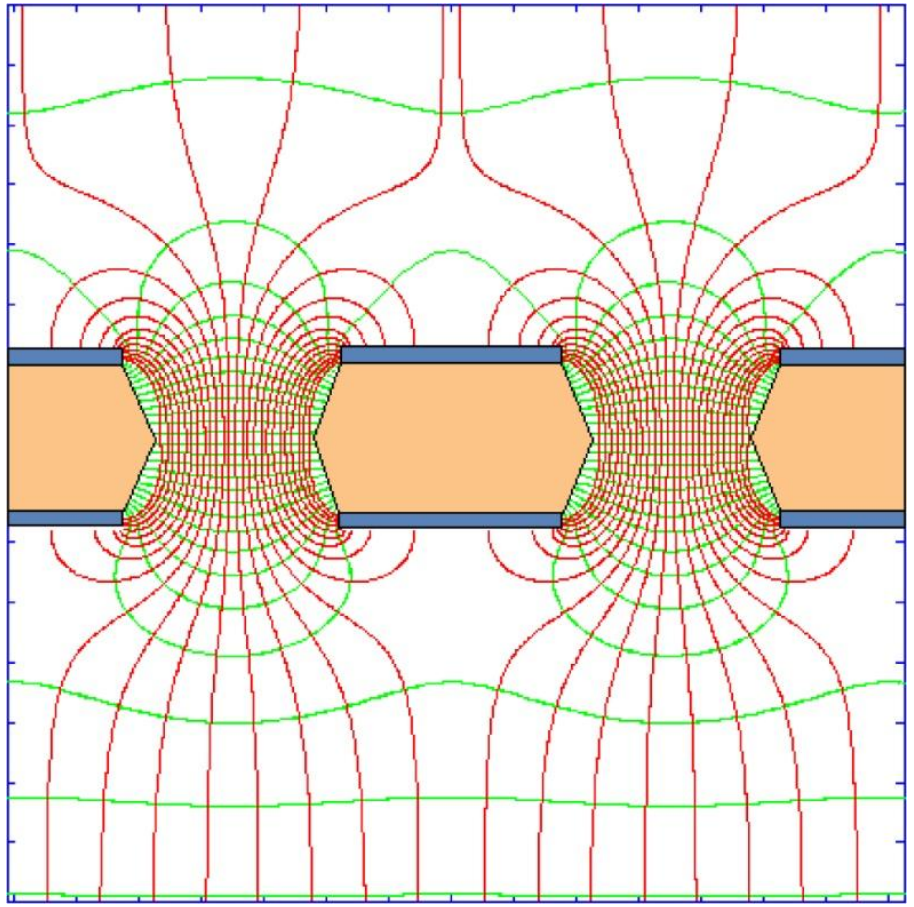
Gas Electron Multiplier



GEM foils

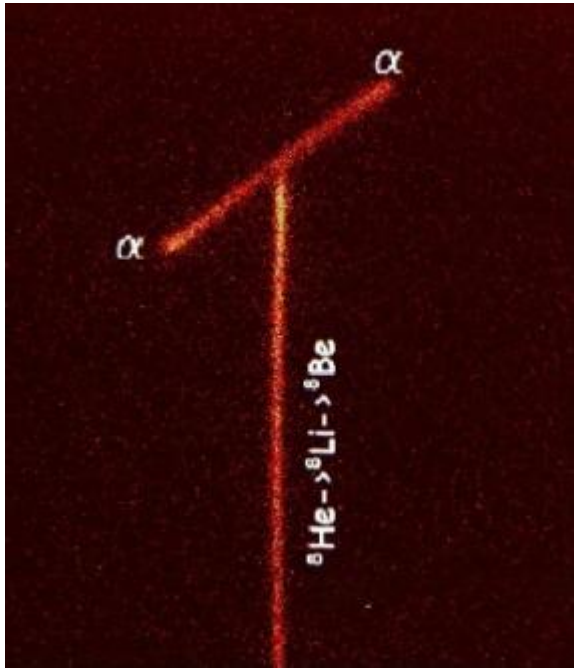


Porous structure of GEM foils

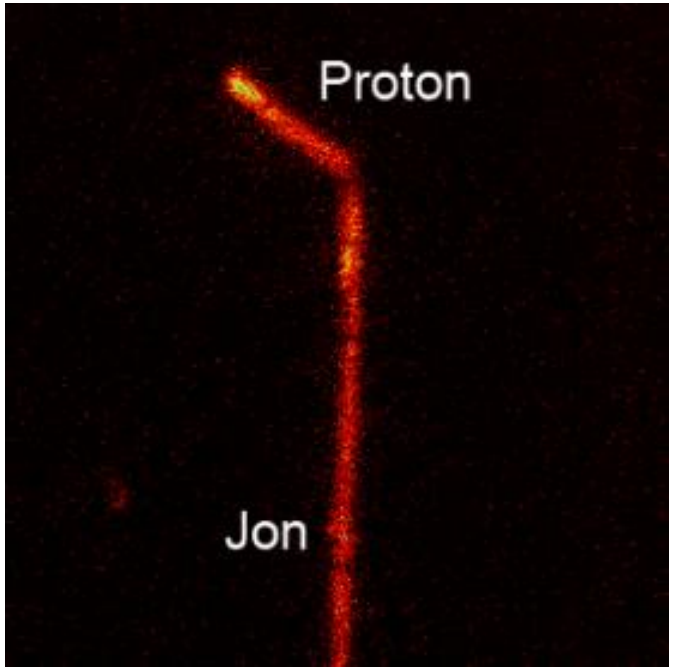


Lines of electric field in pores

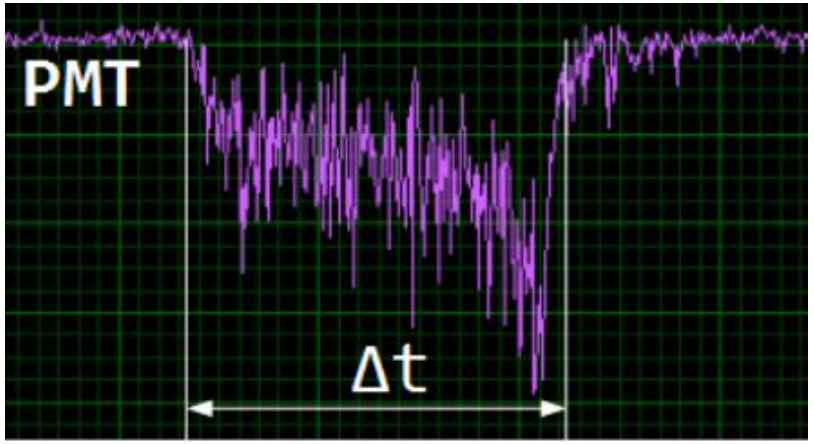
Results



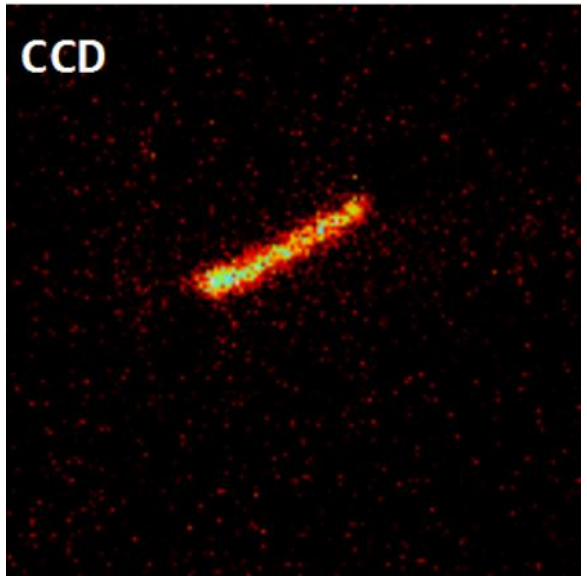
8He decay into 2 alpha particles



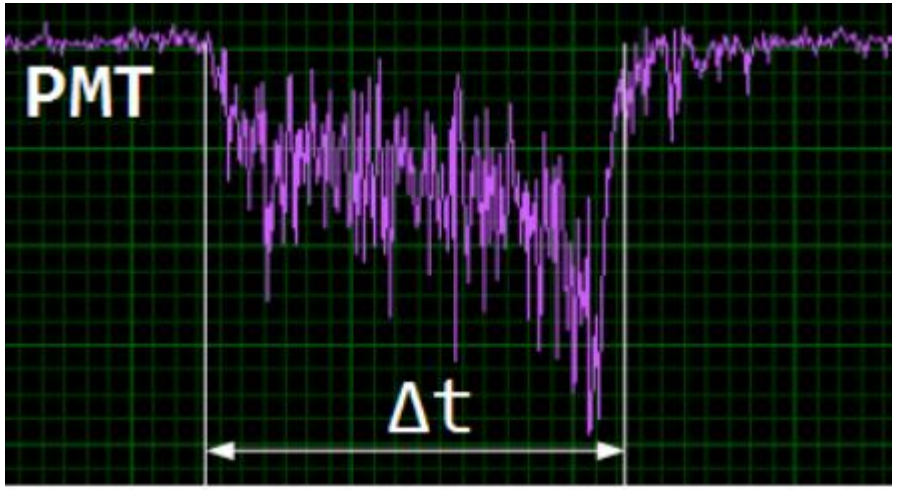
44Cr beta-delayed proton emission



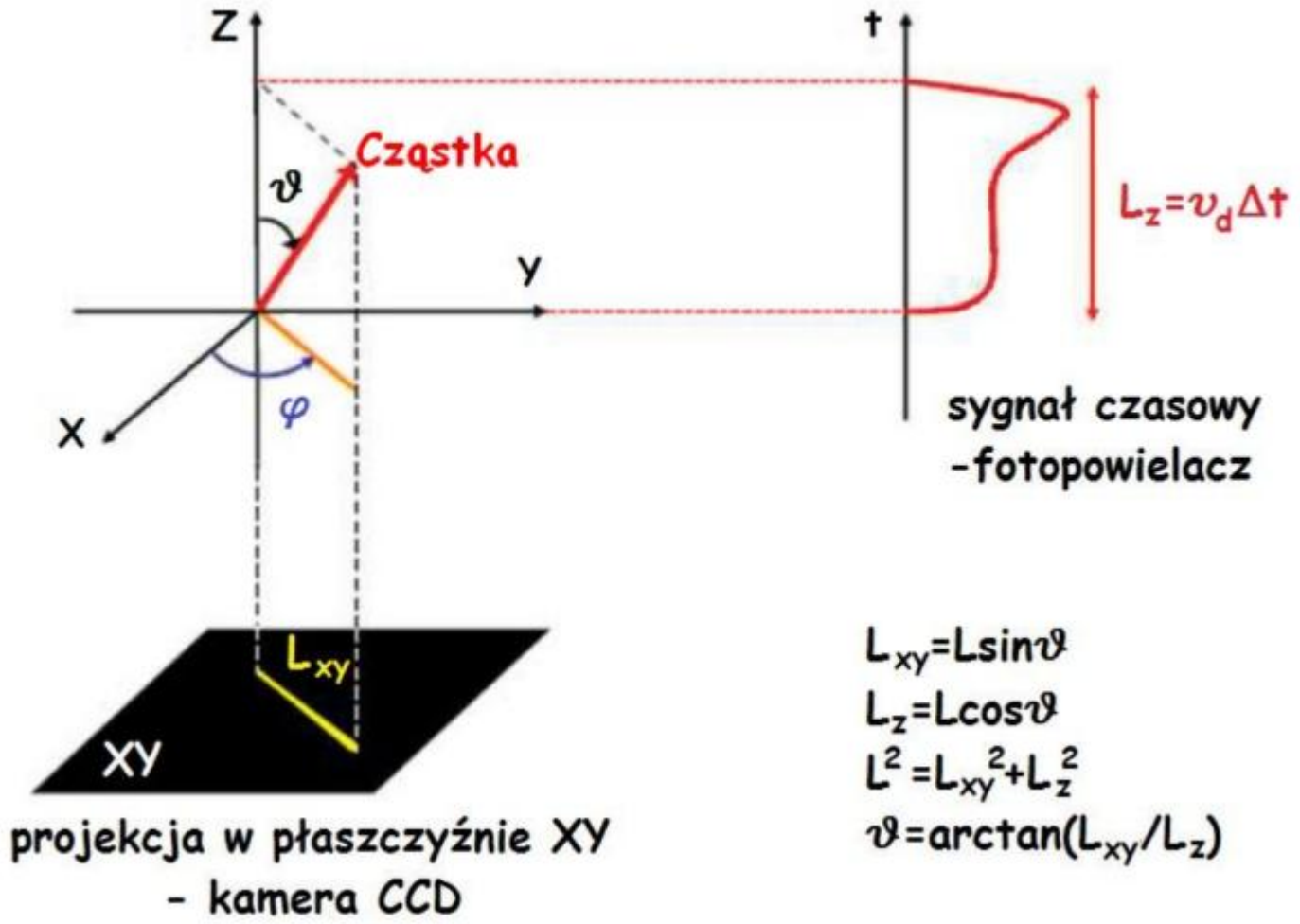
Oscilloscope graph corresponding to ionization curve generated by emitted proton



Single particle captured by CCD camera

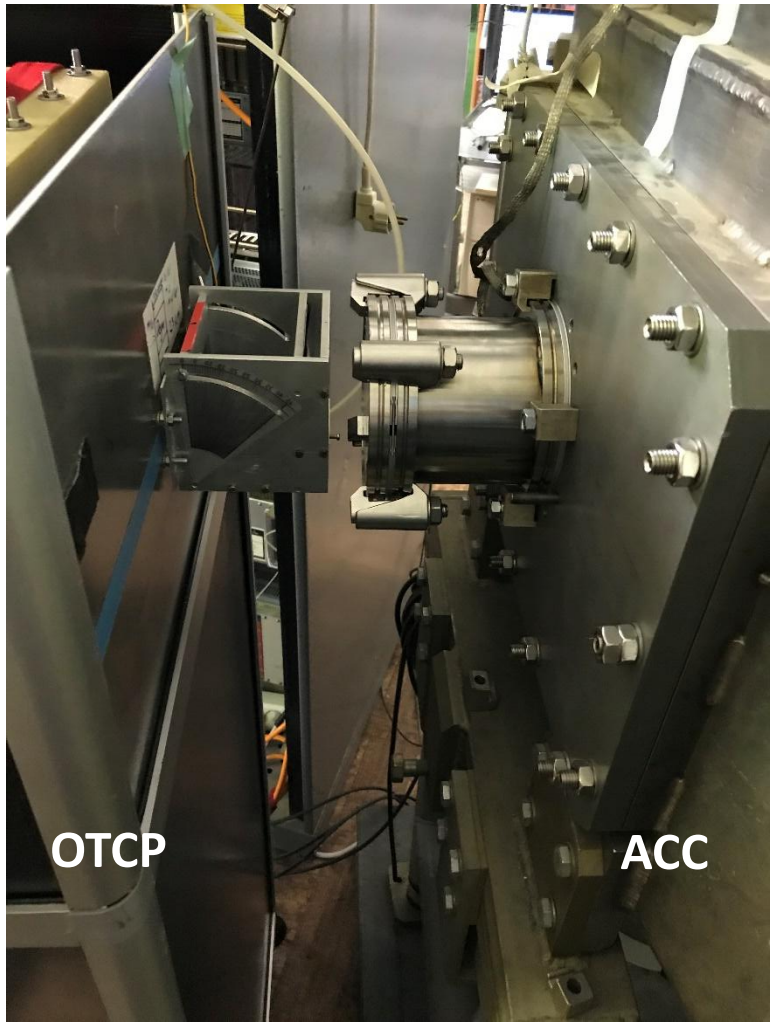


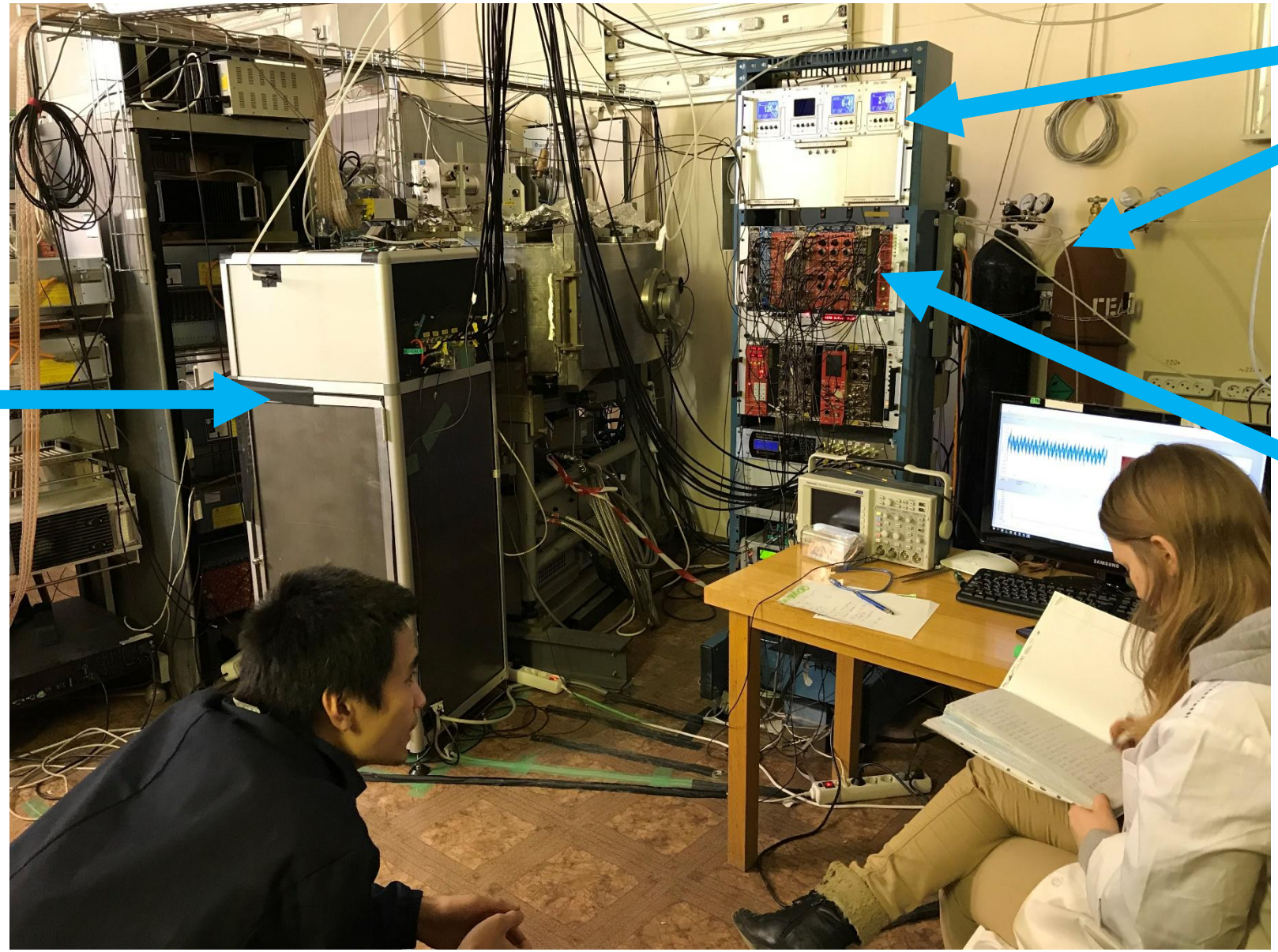
Oscilloscope graph representing detection of particle



Active part

Camera chamber




Gas mixing system
Bottles with helium and nitrogen gas
OTPC
Data acquisition system

Practical part

Constructing a vacuum chamber

We constructed a vacuum chamber that included:

tubes, valves, joints, pressure measuring instruments

(for low and high vacuum).

At first, we attached external pump, which allowed us to gain low vacuum (10^-2 hPa) in the chamber.

Then we could use the turbomolecular pump to reach high vacuum (10^-7 hPa).

Assembling a vacuum chamber

Working with gases

During our practice we learned how to:

- design and construct the whole system together: gas bottles, pressure regulator, flow measurement, vacuum pump and spectrometer
- prepare and connect all the elements using plastic pipes, valves, cables…

Gas bottles

Pressure regulator

Working with gases

During our practice we learned how to:

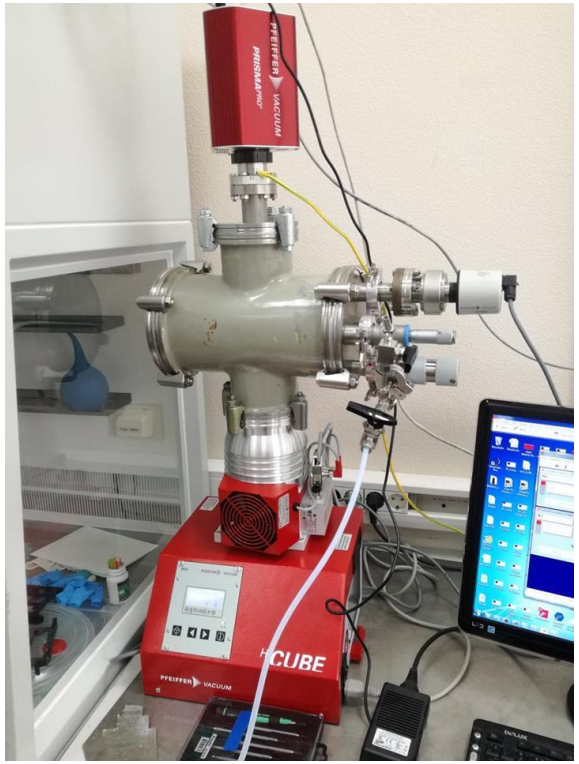
- handle with the flow measurement
- set up values of flow
- control the gas flow using a computer software
- prepare the gas mixture, e.g. 95% He and 5% N_2 (gas purity 99.9999)

Operating the flow measurement and connecting it with computer software

Working with gases

During our practice we learned how to:

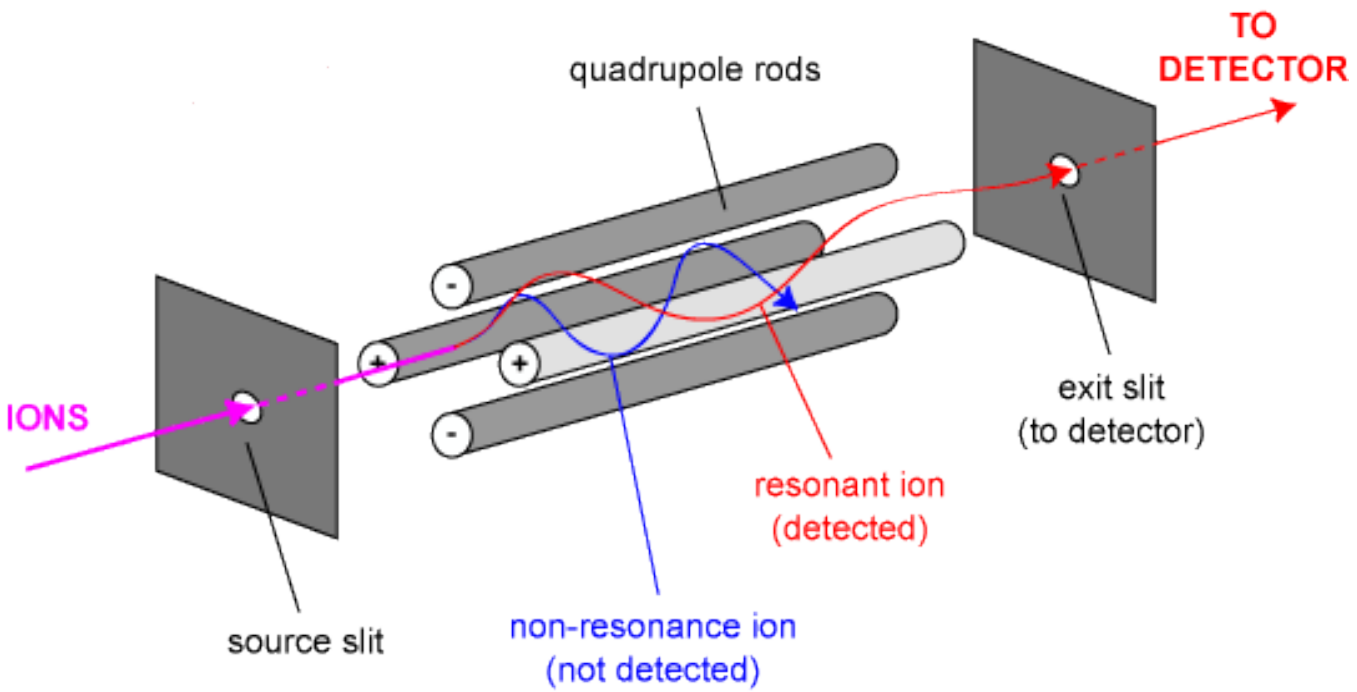
- use the vacuum pomp and mass spectrometer (Pfeiffer Vacuum Prisma Pro 200)
- analise data from the experiment

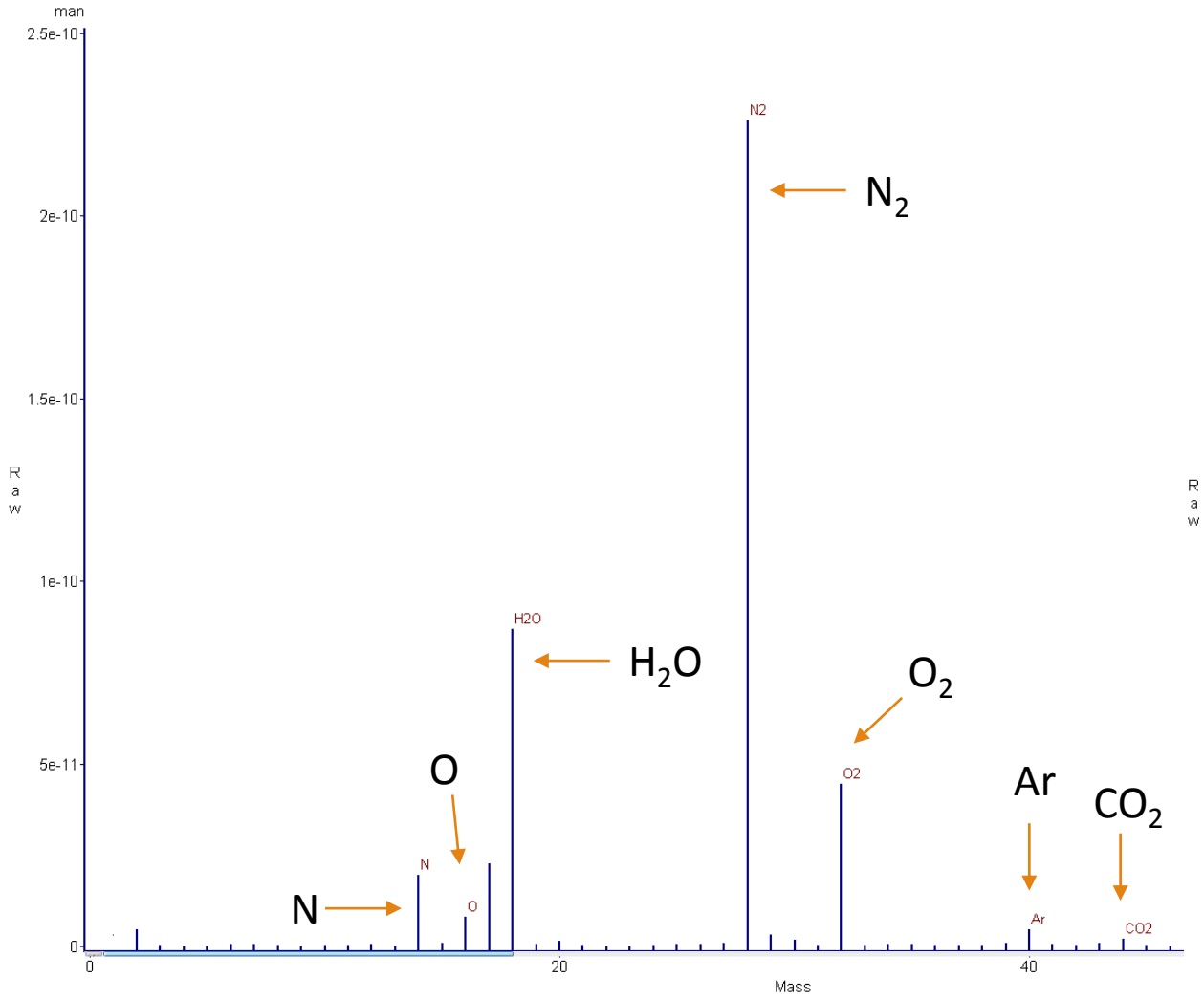


Vacuum pump with spectrometer

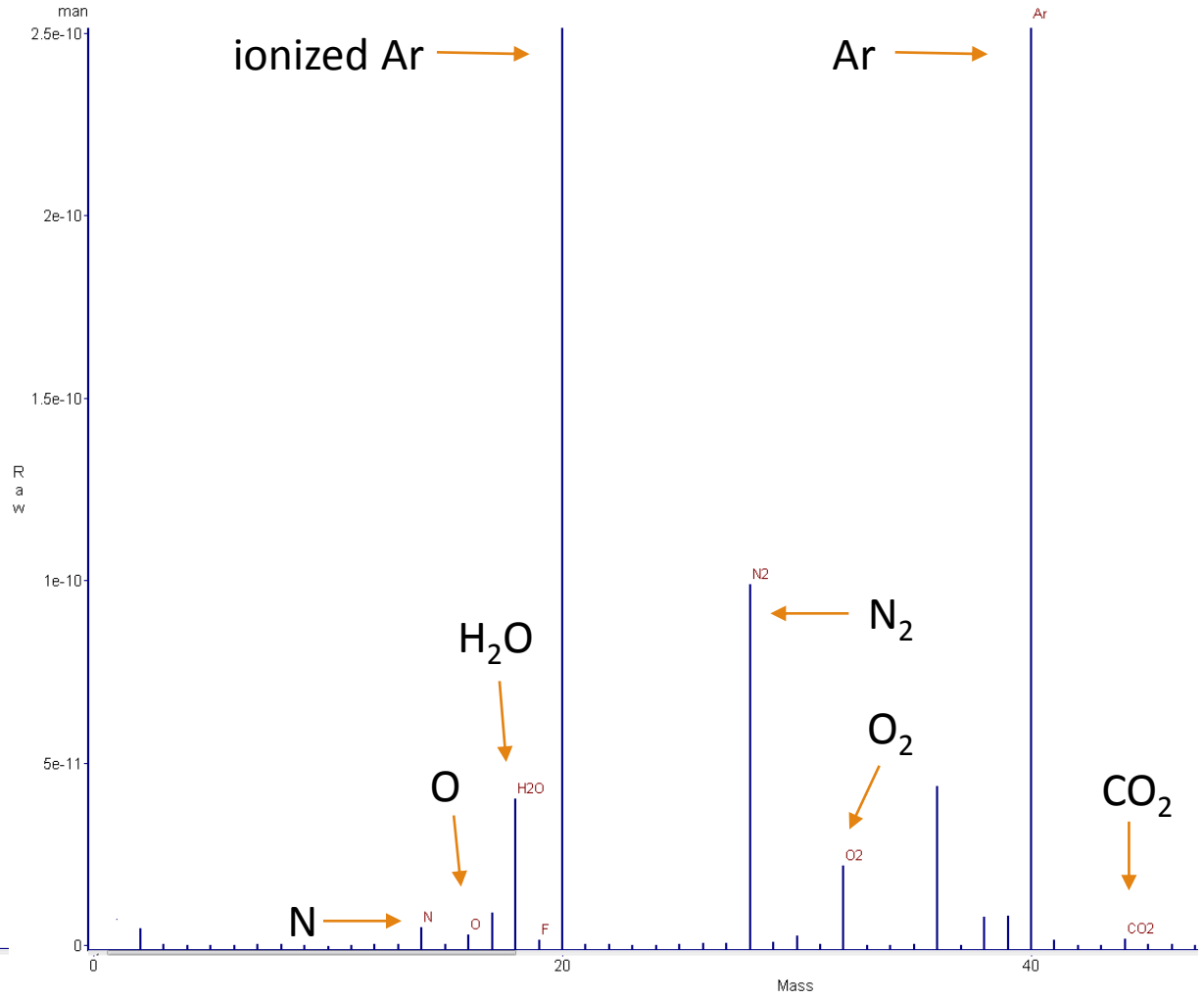
Assembling of the system

Quadrupole mass analyser



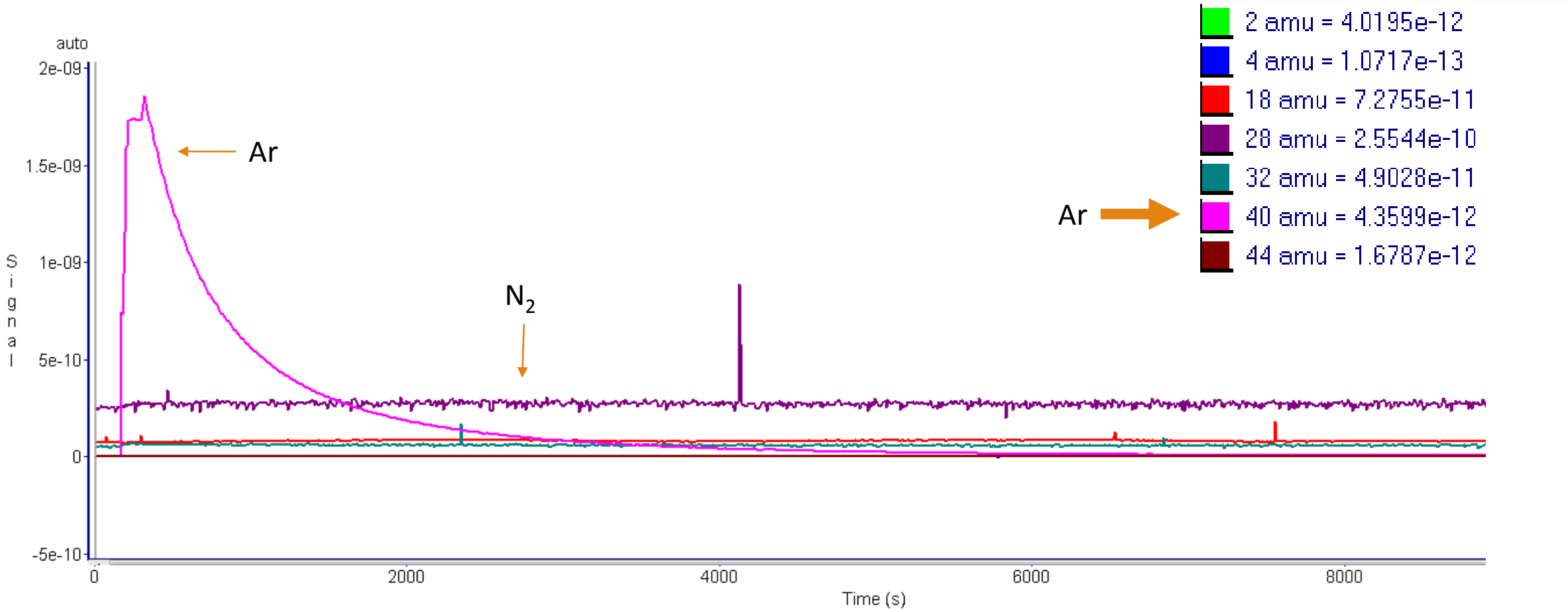


Mass spectrum before Ar injection

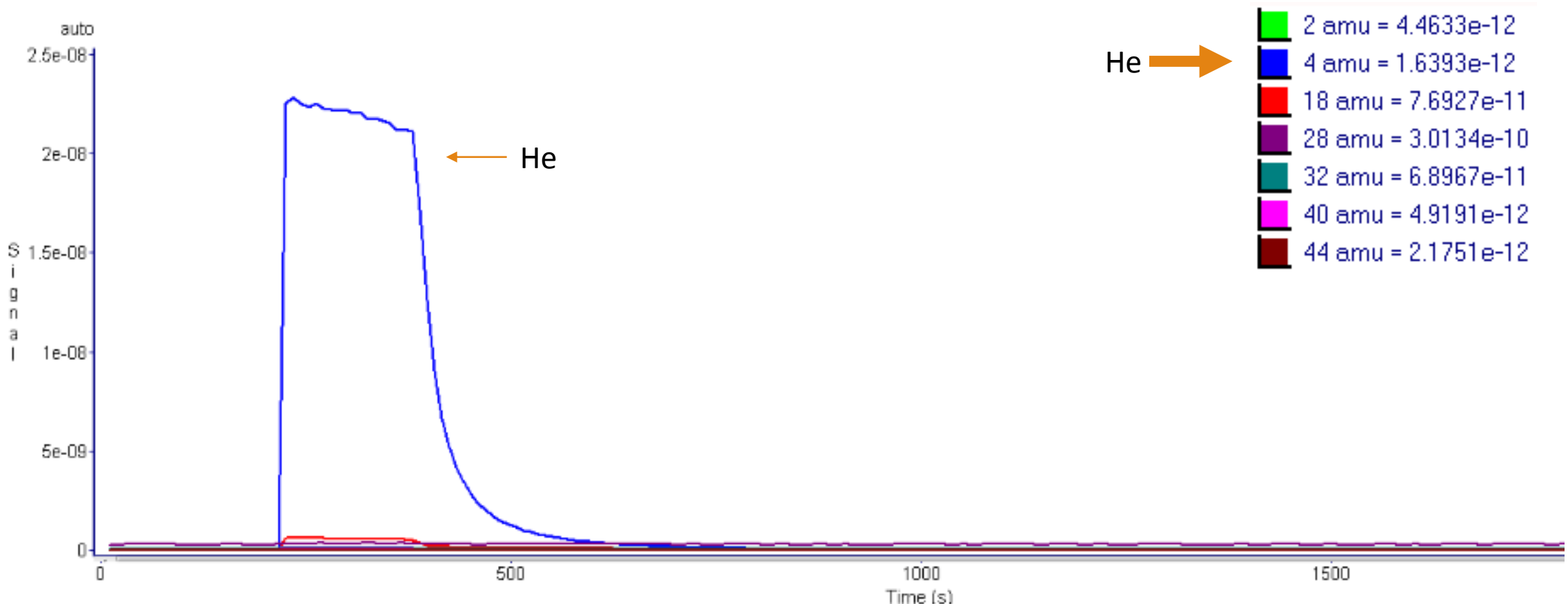


Mass spectrum after Ar injection

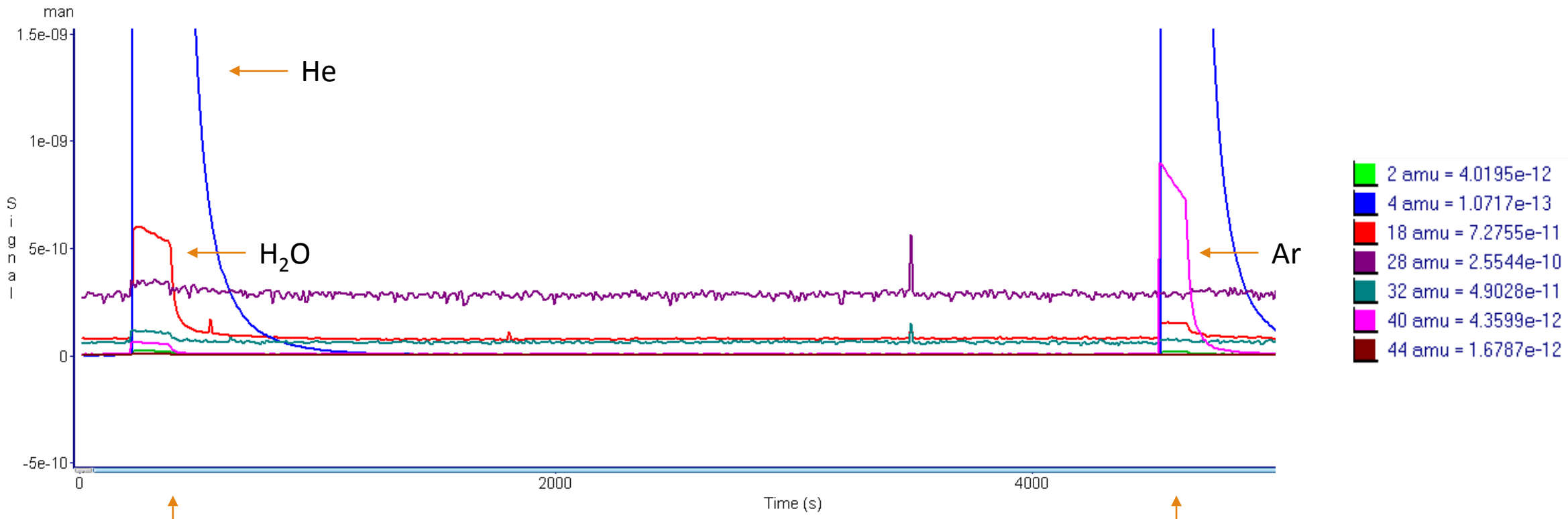
Time spectrum after Ar injection



Time spectrum after He injection



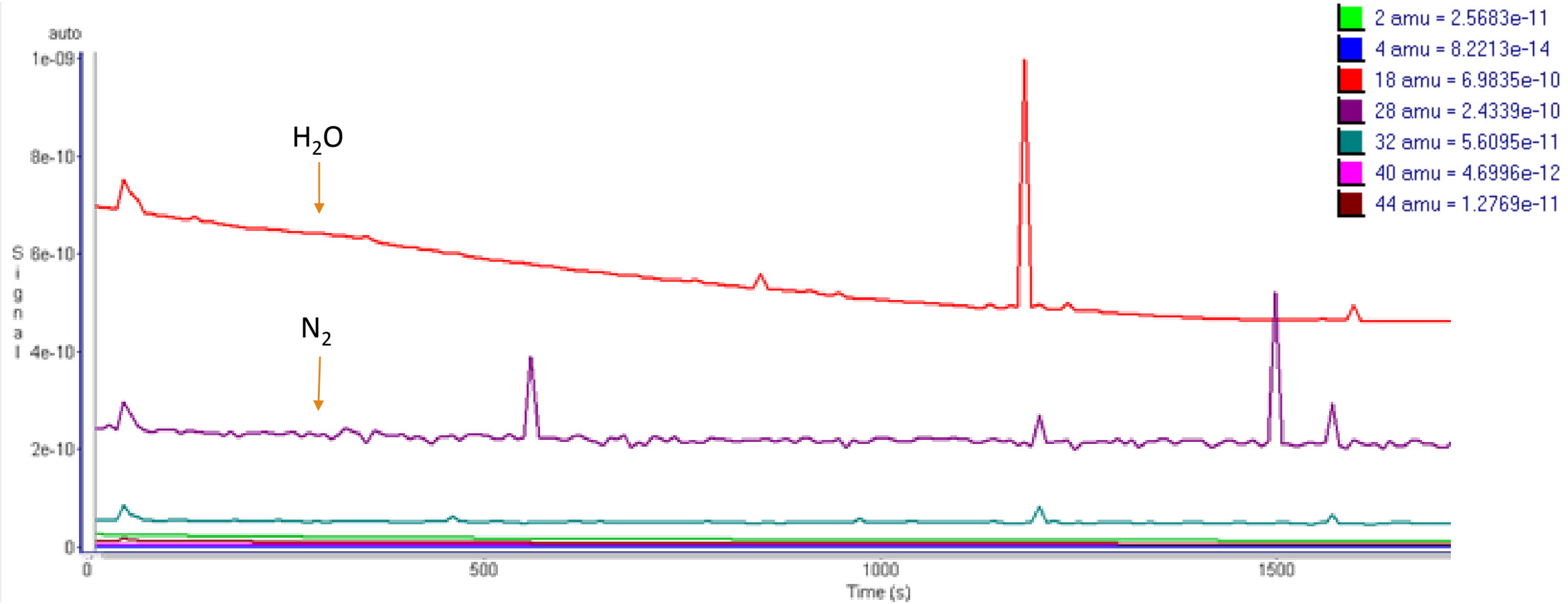
Time spectrum after He injection using pipe contaminated with Ar (zoom)



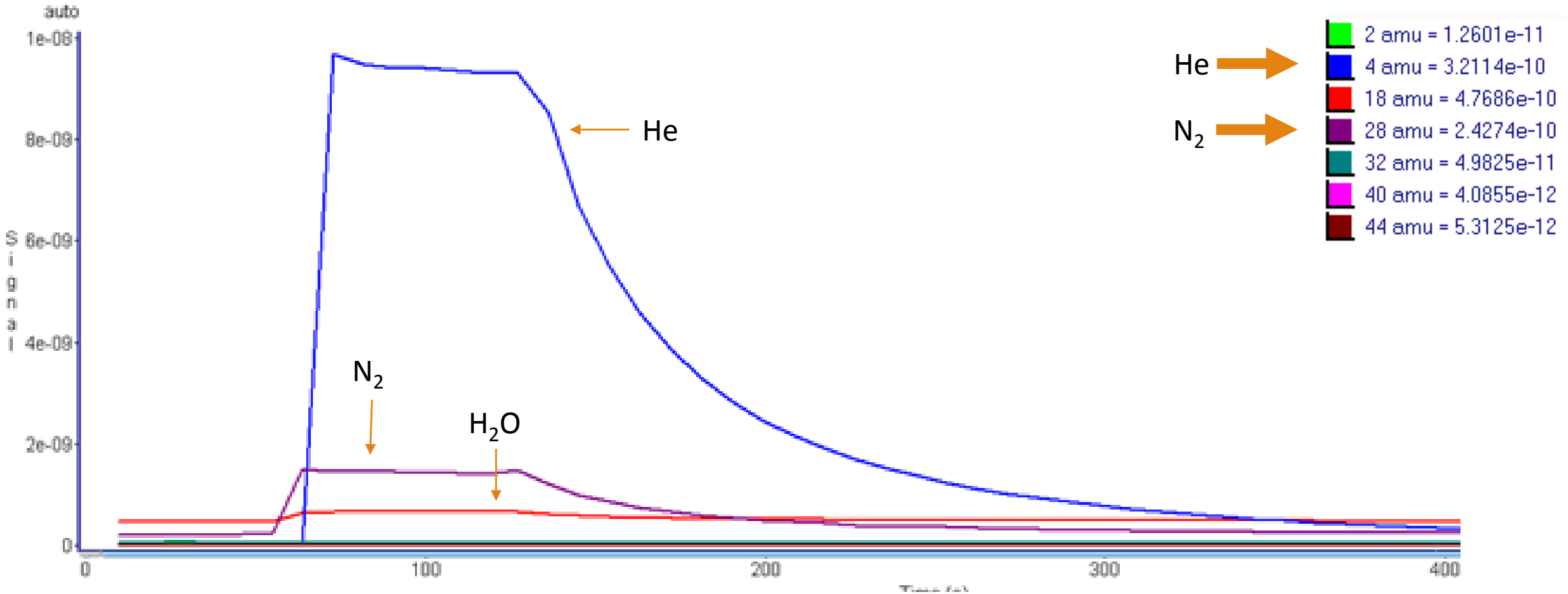
He in He pipe

He in Ar pipe

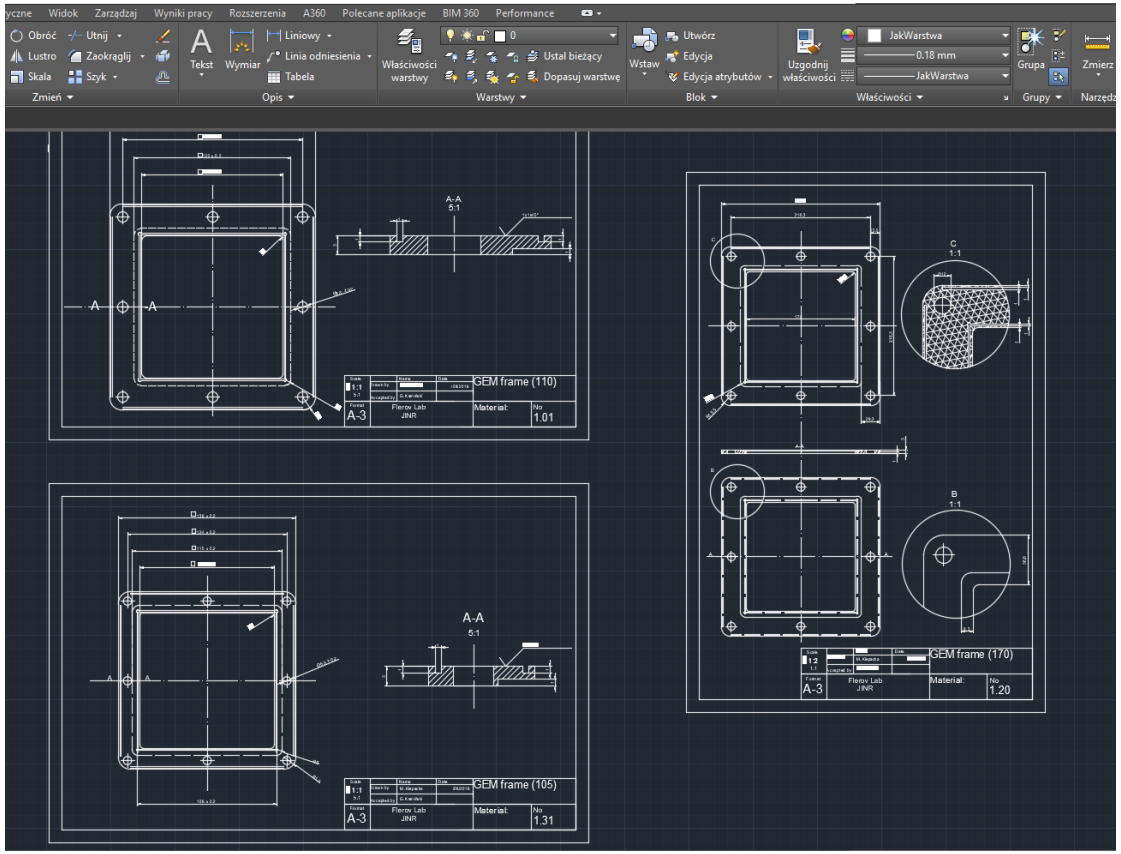
Testing flow measurement
Spectrum before gases flowed through the pipe to the pump (background)

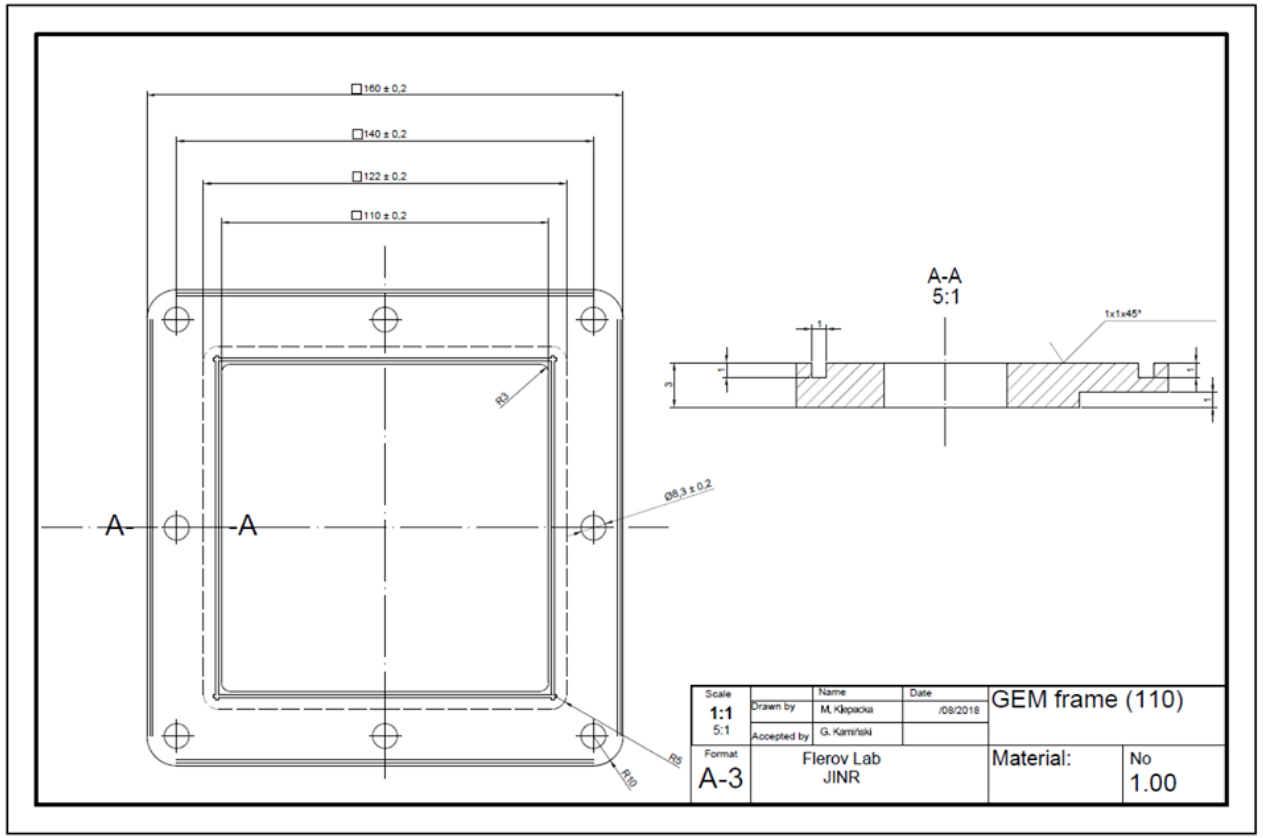


Testing flow measurement
Spectrum of mixture containing 95% He and 5% N

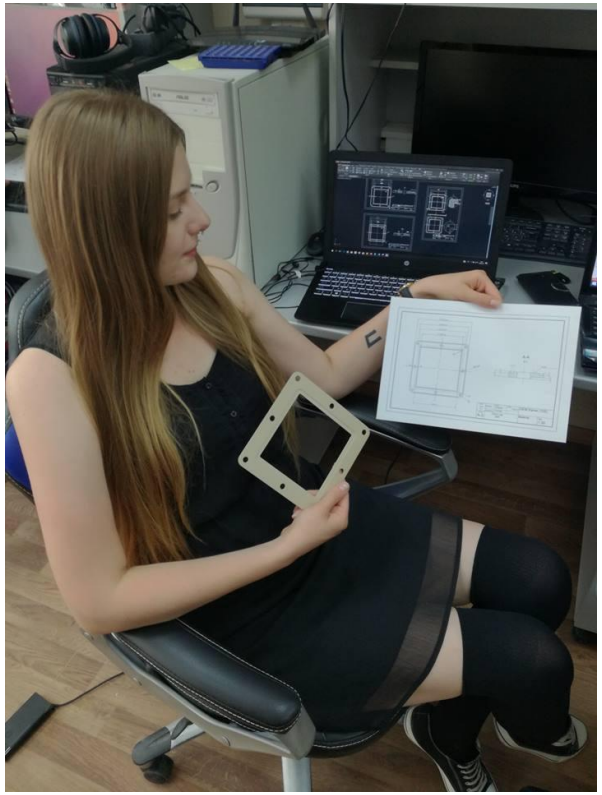


Project of the frame for GEM in AutoCAD

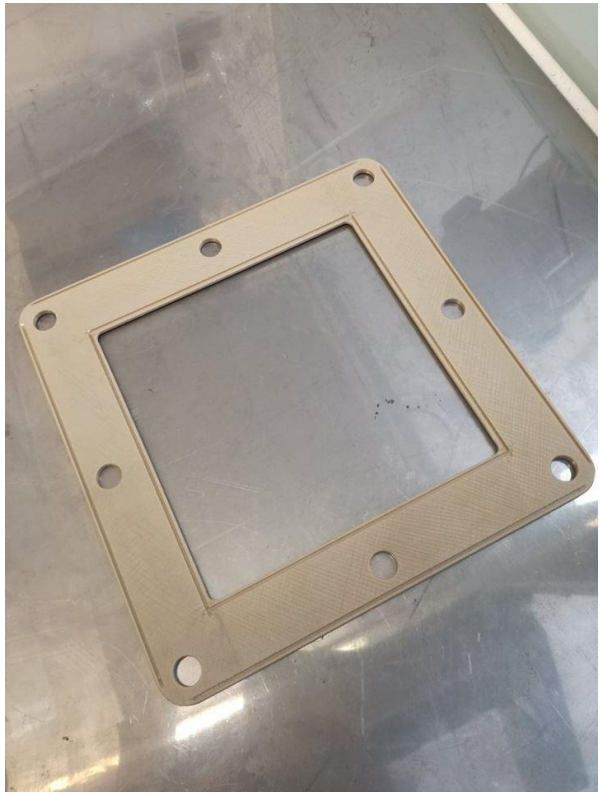




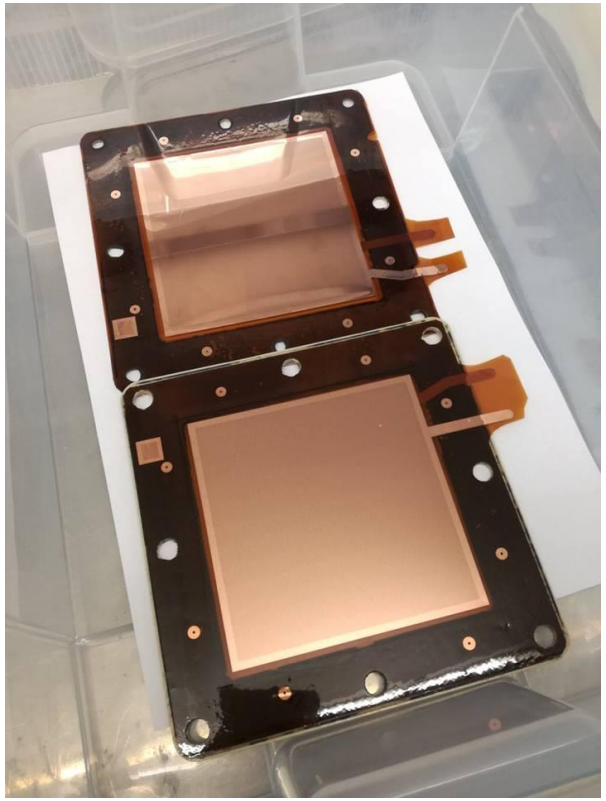
Project of the frame for GEM in AutoCAD



Marta with her project

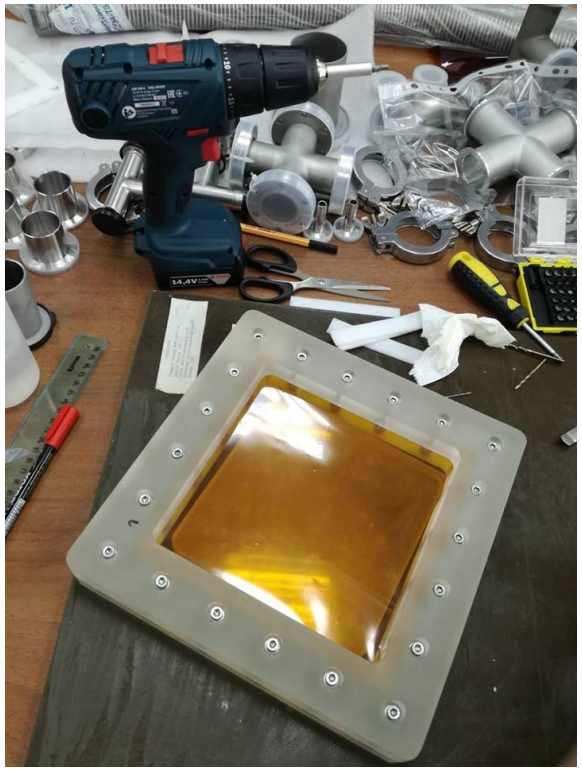


The frame from the project

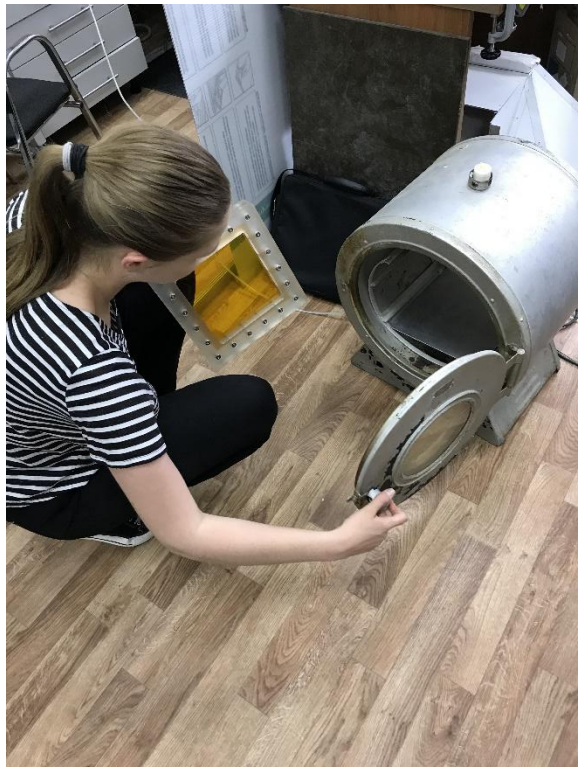


The frame with GEM foil

Preparing GEM foil for the detector



Attaching kapton to the frame



Heating foil in an oven

Applying glue on the frame

Putting foil on the frame

Other activities during practice

Preparing cables

Soldering

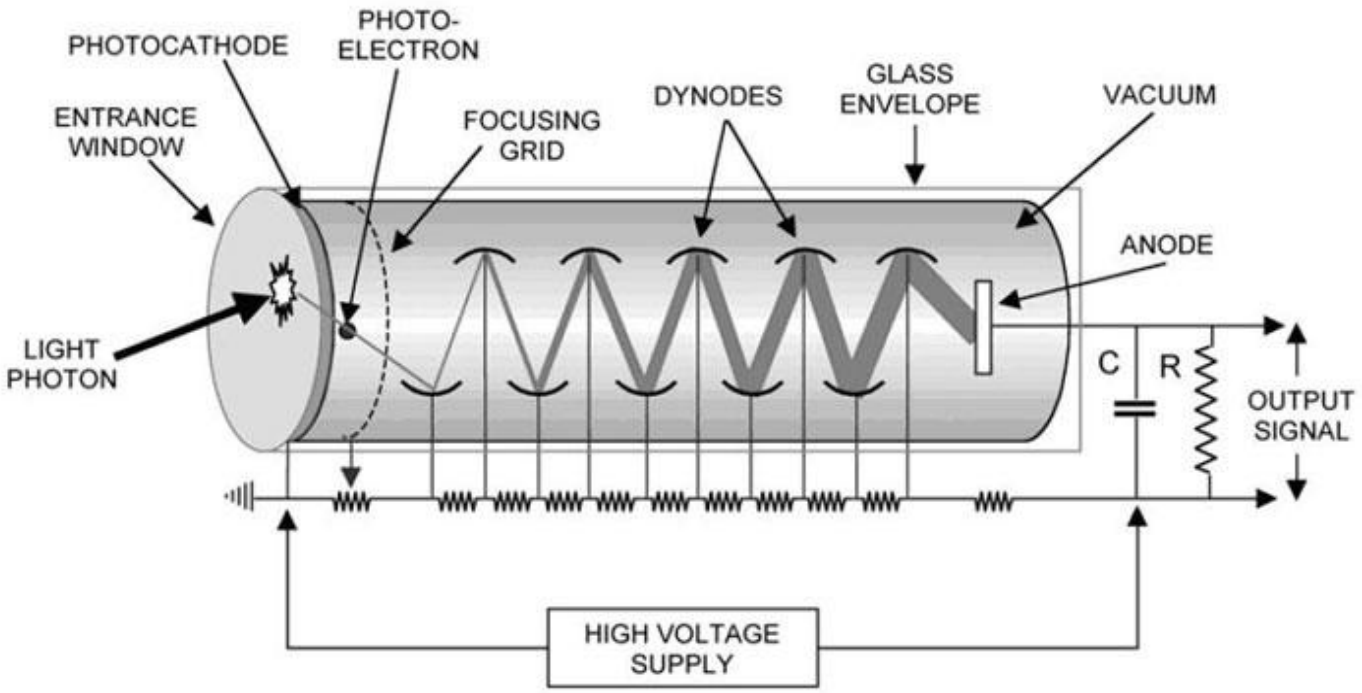
Exploring detectors

Using drill-driver

THANK YOU FOR YOUR ATTENTION ☺

ANY QUESTIONS?

PMT


PHOTOCATHODE
PHOTO-
ELECTRON
ENTRANCE
WINDOW
FOCUSING
GRID
DYNODES
GLASS
ENVELOPE
VACUUM
ANODE
LIGHT
PHOTON
C
R
OUTPUT
SIGNAL
HIGH VOLTAGE
SUPPLY