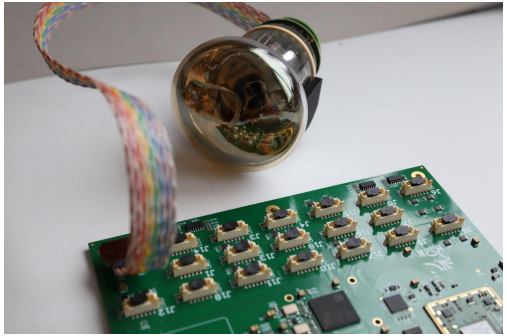
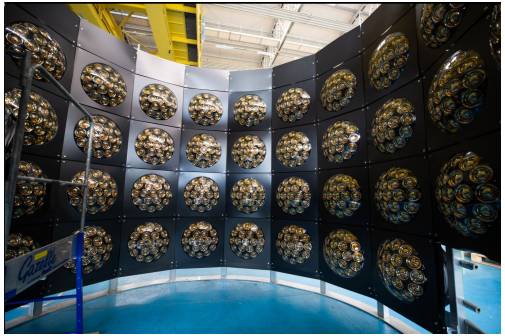
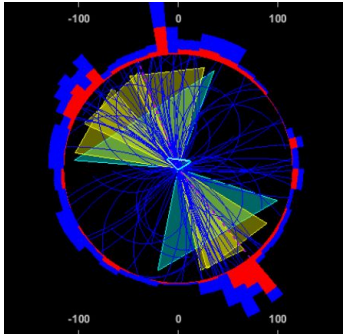
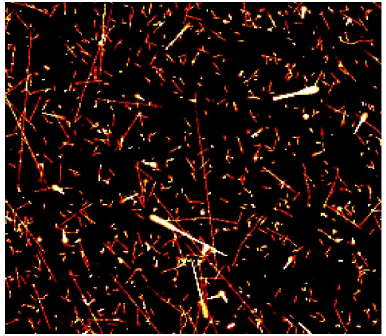


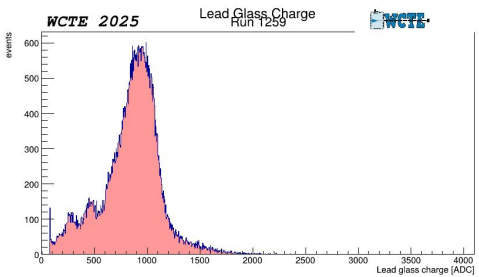


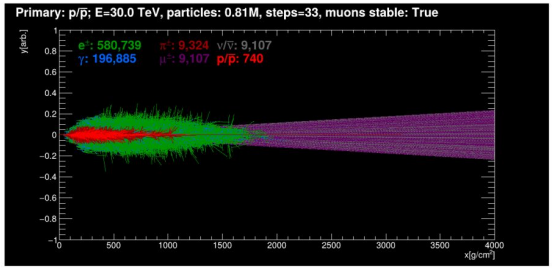


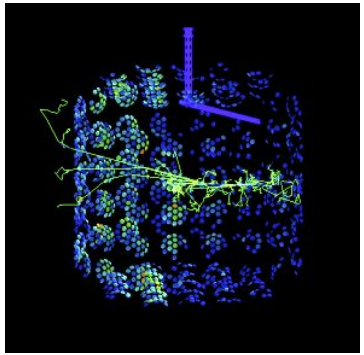


Témata prací částicové a neutrinové fyziky

Jiří Kvita
jiri.kvita@upol.cz
duben 2025



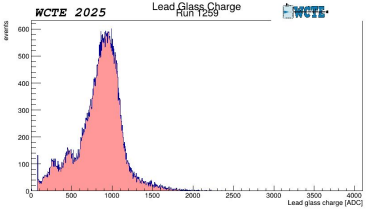


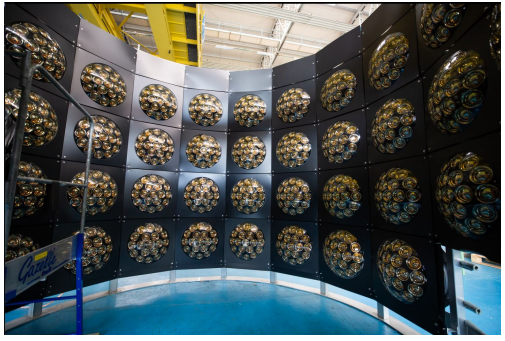


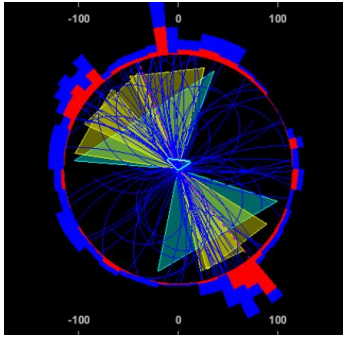
Links

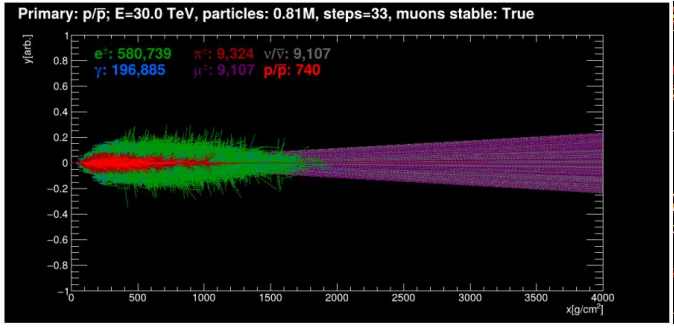
- Možnost pochopit procesy
  - ve srážkách částic na urychlovači LHC v experimentu ATLAS.
  - interakcí částic v testovacích svazcích pro neutrinové experimenty.
  - generování atmosférických sprškek kosmického záření.
  - interakce částic v částicové kameře.
  - ve srážkách těžkých iontů v experimentu ATLAS, kdy je produkován top kvark.
- Možnost zapojit se do
  - analýzy dat v jazycích Python či C++
  - simulací částicových procesů
  - testování fotonásobičů.
- Pochopit něco ze statistiky, zpracování dát, částicové fyziky a detektorů částic.

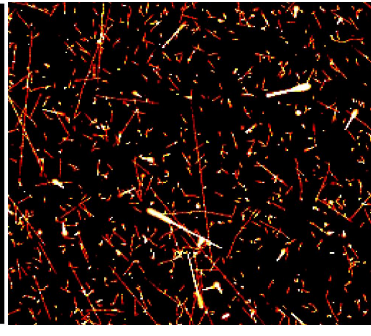
```python
#/usr/bin/python3

# jk
# 20/09/2022
# 14.7.2023
# 5.3.2024
# 6.3.2024

#from __future__ import print_function

import ROOT
from math import sqrt, pow, log, exp
import os, sys, getopt

from labelTools import *
from tofUtil import *

cans = []
stuff = []
lines = []

######################################

def makeLine(x1, x2, y1, y2):
    line = ROOT.TLine(x1, y1, x2, y2)
    line.SetLineColor(ROOT.kGreen)
    line.SetLineWidth(2)
    line.Draw()
    return line

######################################

def PrintUsage(argv):
    print('Usage:')
    print('{} filename_plots.root [-b]'.format(argv[0]))
    print('Example:')
    print('{} output_300n_plots.root -b'.format(argv[0]))
    return
######################################
```





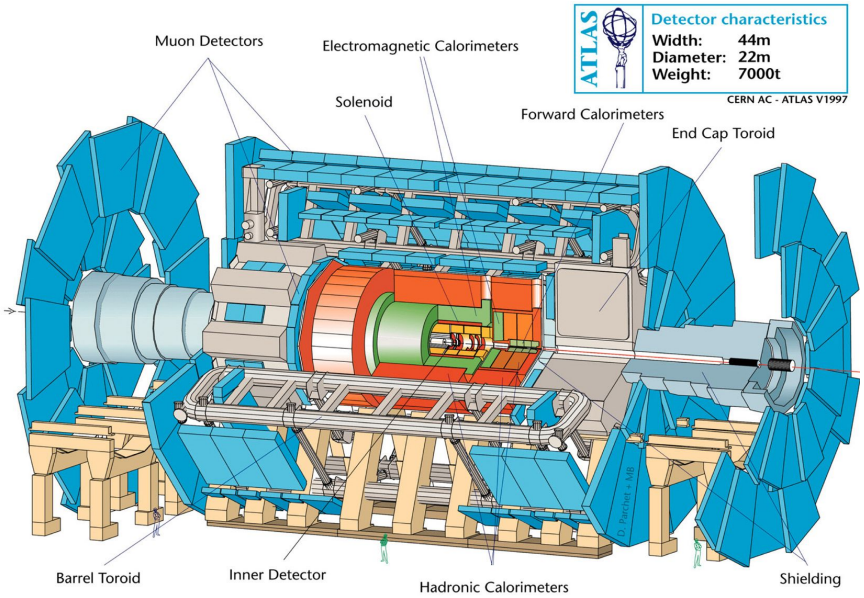


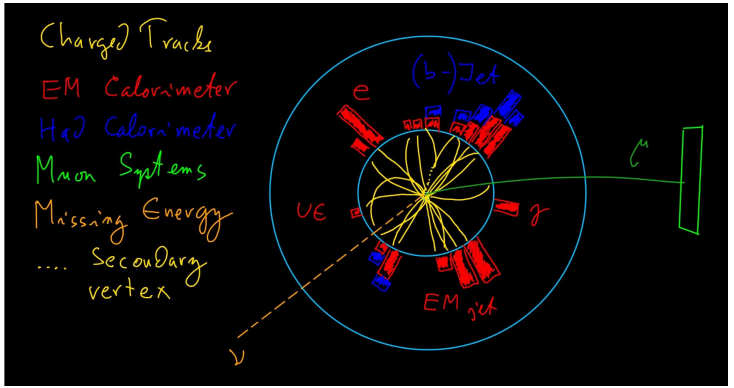


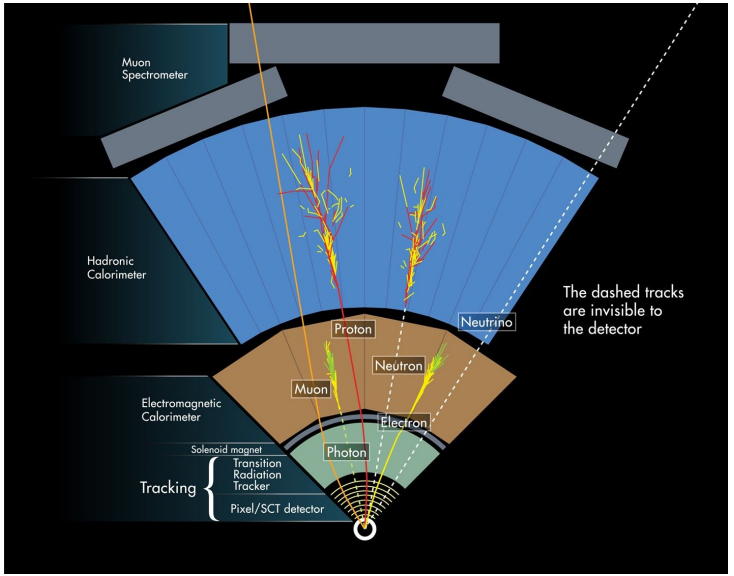


Experiment ATLAS – CERN

```
15  //
16
17  double computeneutrinopz(const TMyLorentzVector lepton, double metx, (
18    //computing z component of neutrino momentum given lepton and met
19    double pzneutrino;
20    double met = sqrt ( sqr(metx) + sqr(mety) );
21    double m_W = 80.399; // in GeV, given in the paper
22    double k = (( sqr( m_W ) - sqr( lepton.M() ) ) / 2 ) + (lepton.Px()
23    double a = sqr ( lepton.E() )- sqr ( lepton.Pz() );
24    double b = -2*k*lepton.Pz();
25    double c = sqr( lepton.E() ) * sqr( met ) - sqr( k );
26    double discriminant = sqr(b) - 4 * a * c;
27    double quad[2] = { (- b - sqrt(discriminant)) / (2 * a), (- b + sqr
```

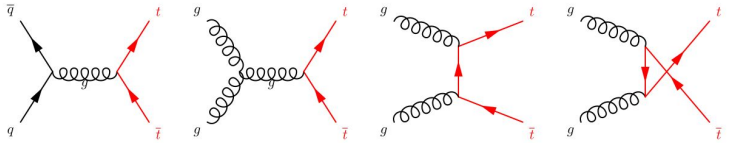


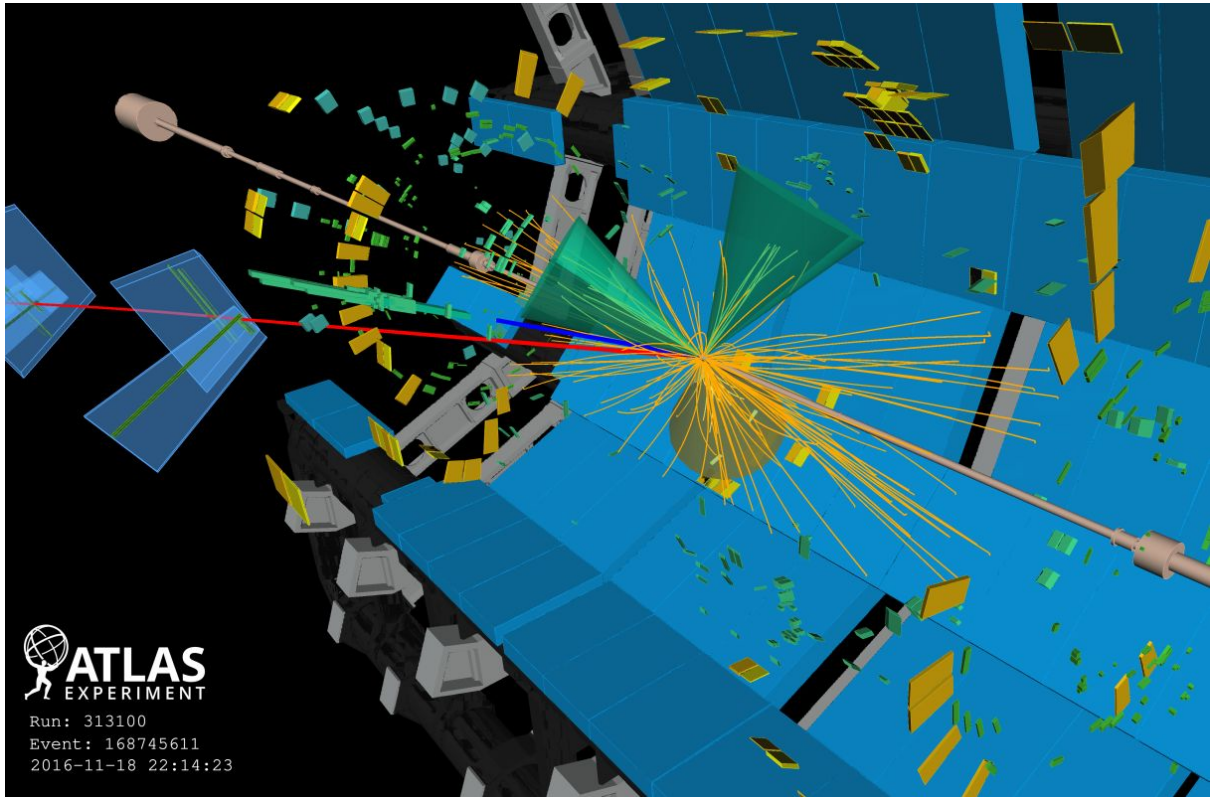




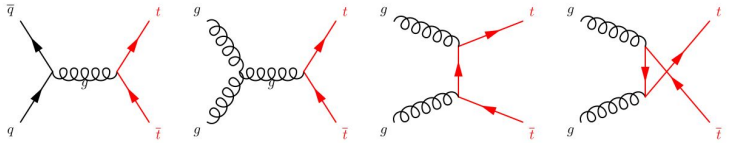
Fyzika top kvarku

- Simulace srážek proton-olovo či proton-proton
- Produkce párů top kvarků.

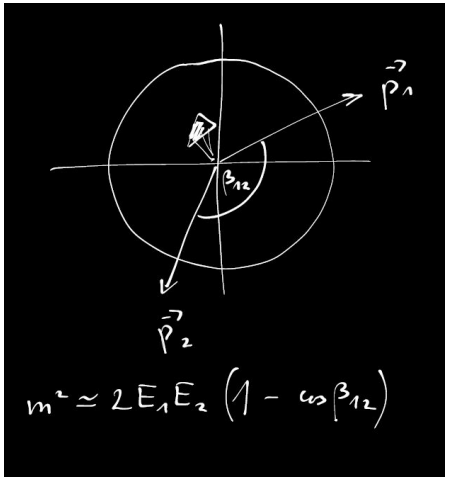


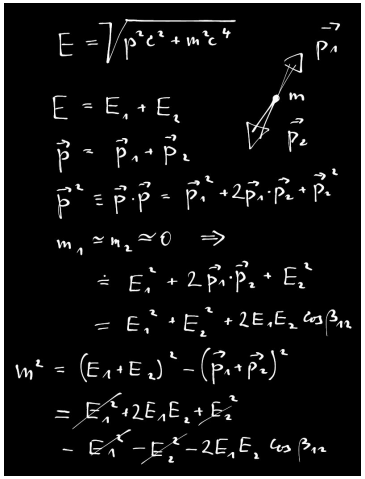


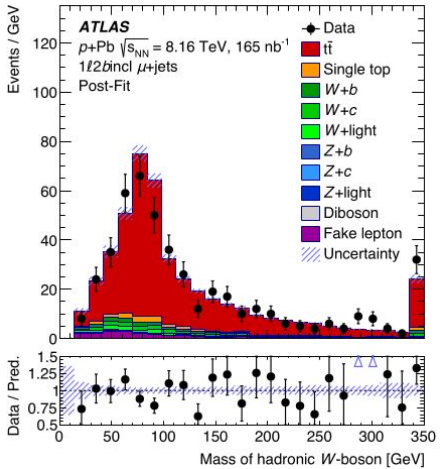
Fyzika top kvarku

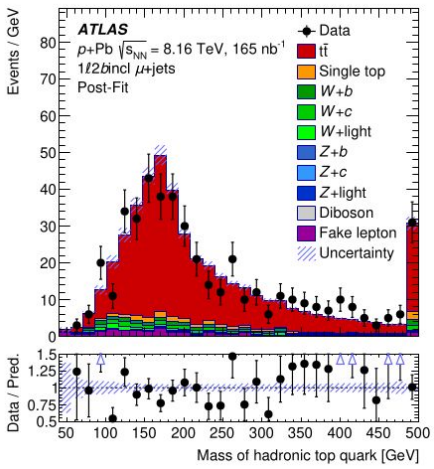


- Simulace srážek proton-olovo či proton-proton
- Lze studovat
  - produkci top kvarku v těchto různých srážkách.
  - studovat vliv různých srážek na energetická spektra top kvarku.
  - Možnost předpovědět měřitelnost pozorovatelných veličin v dalším běhu urychlovače LHC.
- https://jointlab.upol.cz/jlo/cs/content/experiment-atlas-pozoroval-nejtezsi-kvarky-typu-t-top-ve-srazkach-proton-olovo



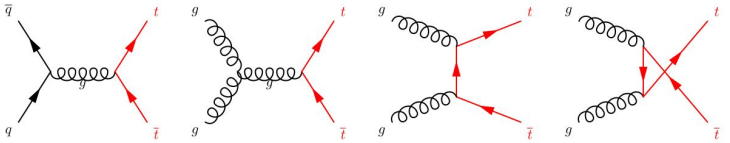


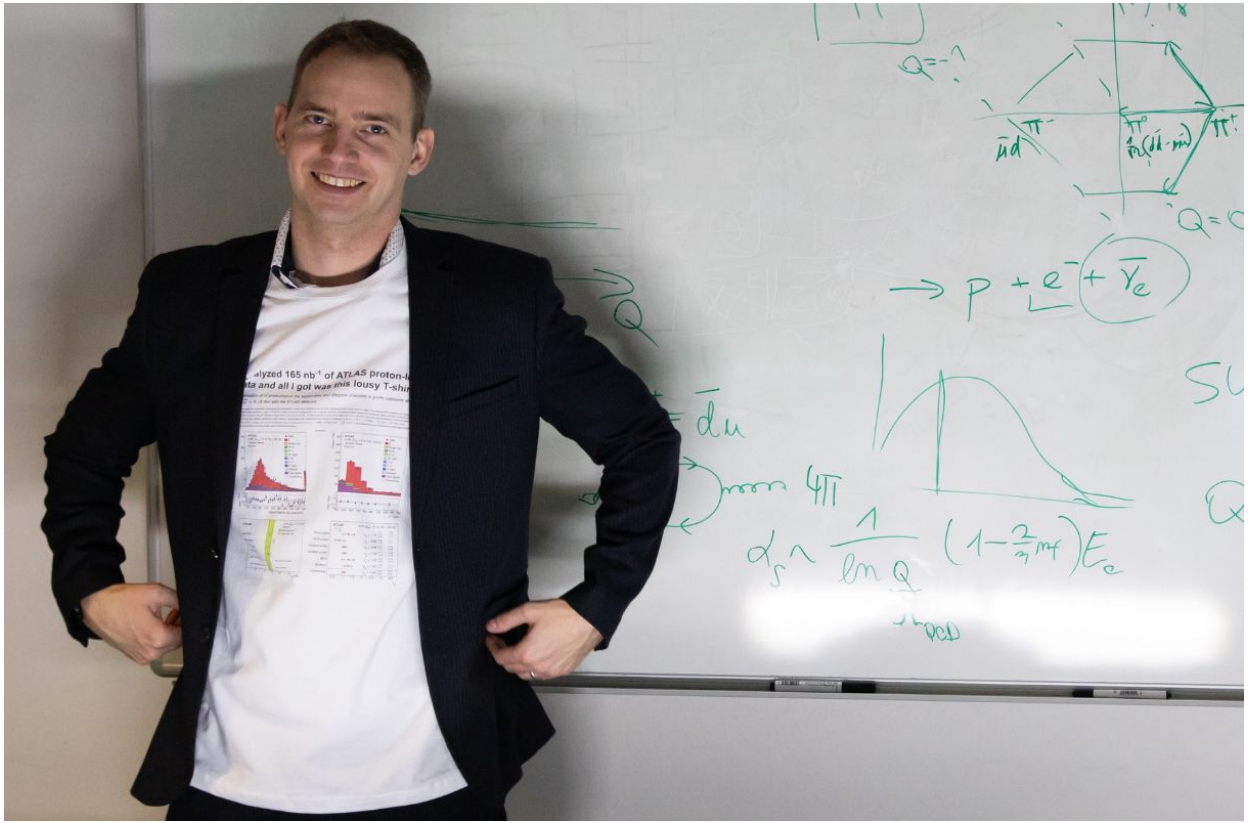




Fyzika top kvarku

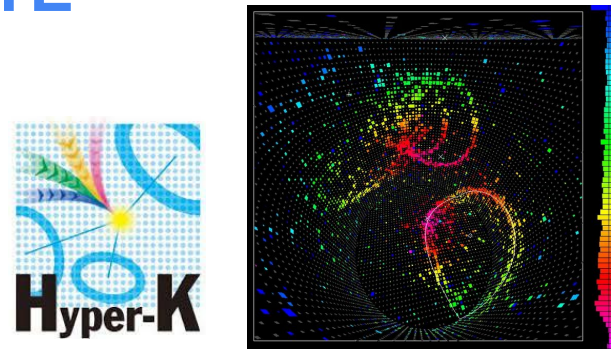
- Simulace srážek proton-olovo či proton-proton



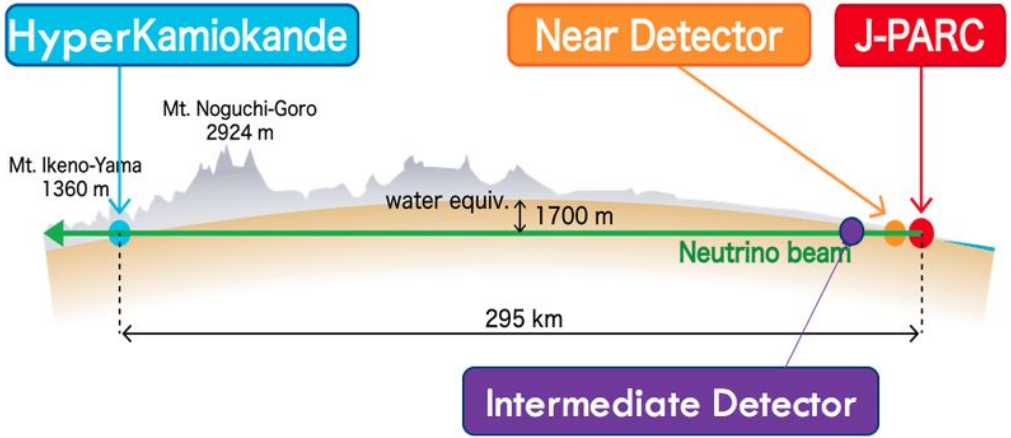


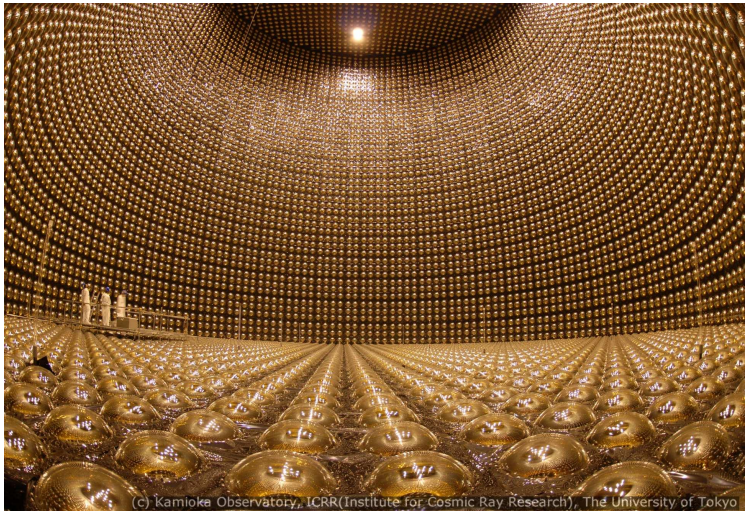
Experiment Hyper-Kamiokande a WCTE

- Nová generace neutrinových experimentů.
- Naše aktivity:
  - Testování fotonásobičů (PMTs)
  - Simulace a rekonstrukce druhu částic.
  - Měření na testovacích svazcích v CERN a analýza dat.



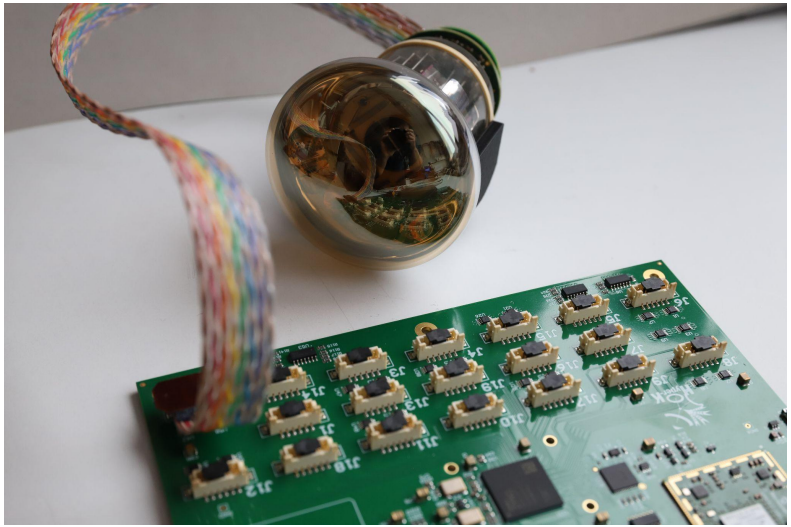
Super-Kamiokande

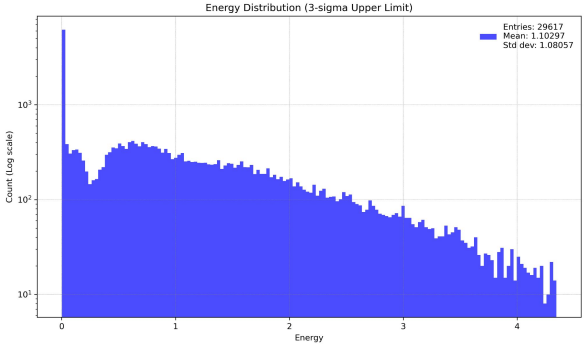


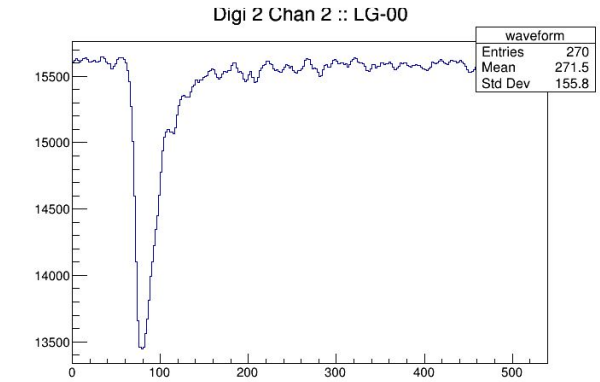


Fotonásobiče pro projekt Hyper-Kamiokande

- Testování v temné laboratoři
- Co se můžete naučit?
- Práce a HW, elektronikou, Laserem, zpracování dat v Python/C++
- Budeme testovat cca 300ks!:)

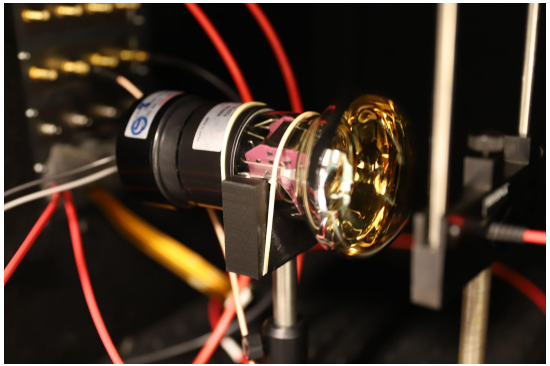
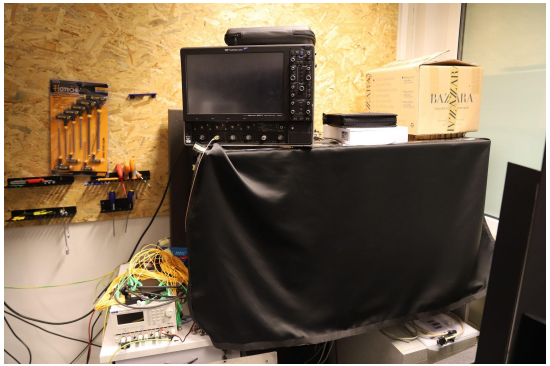
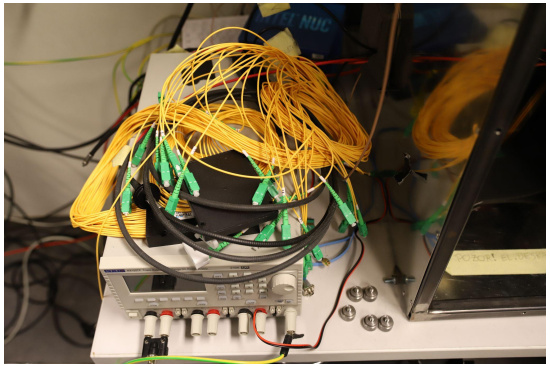
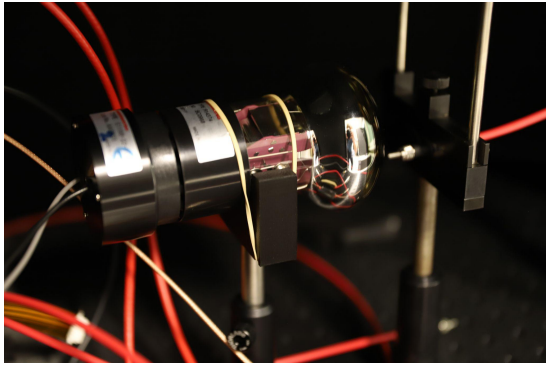
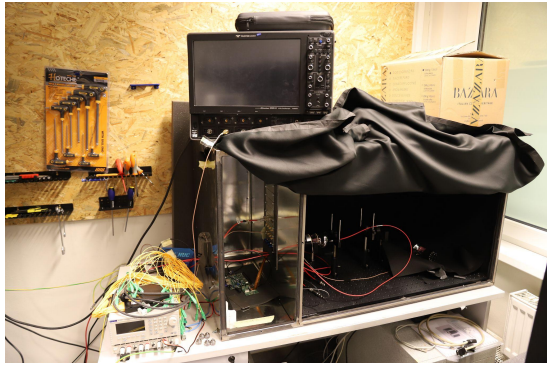
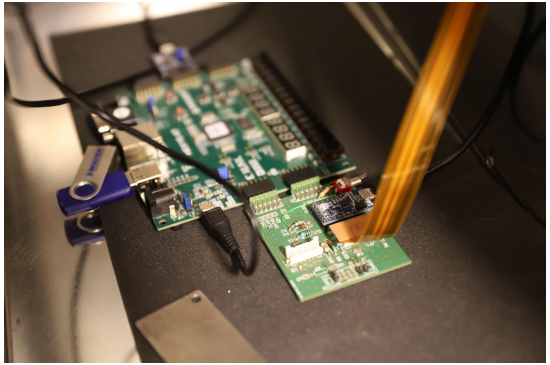






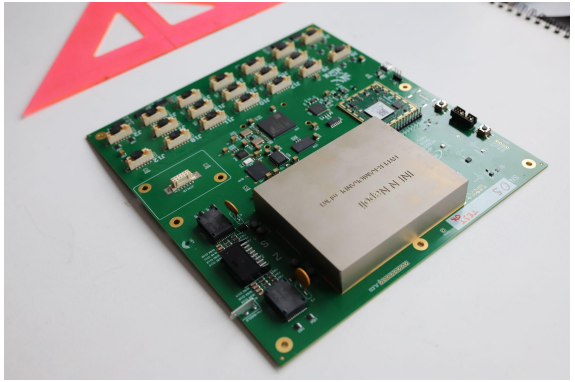
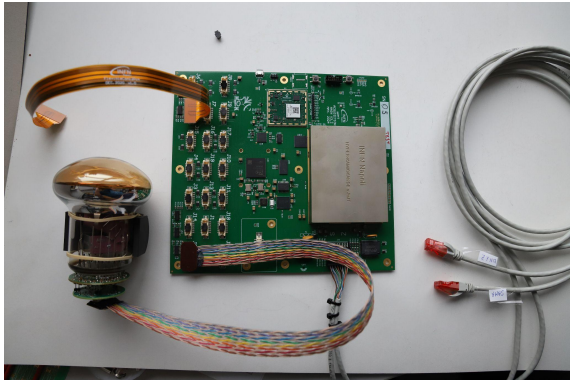
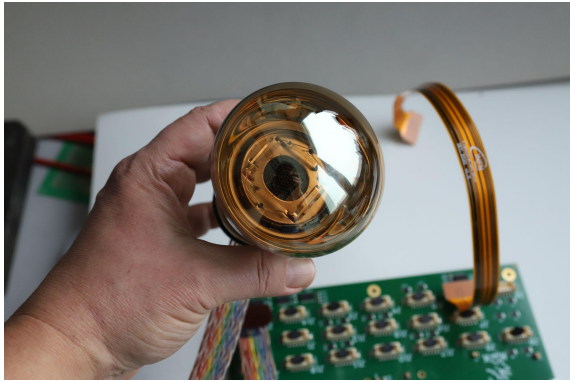
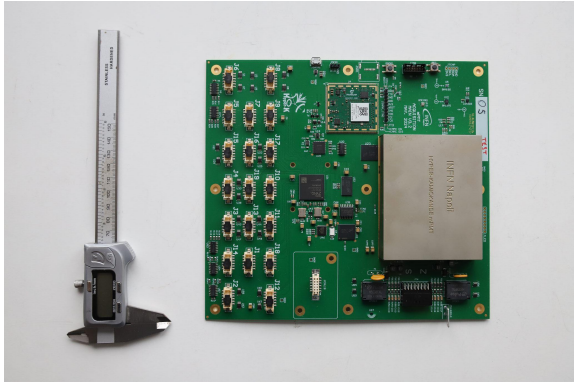
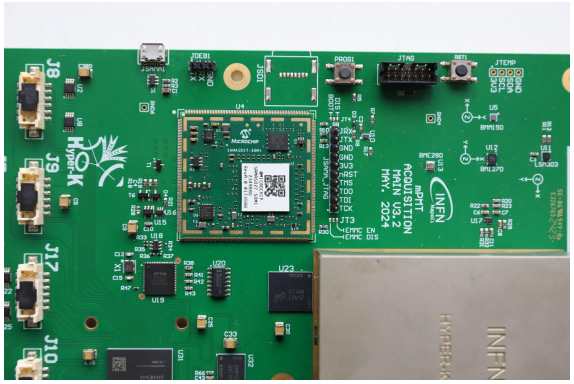
Current Setup

- dark box, demo board, splitter, simple holder, optical fibre from laser

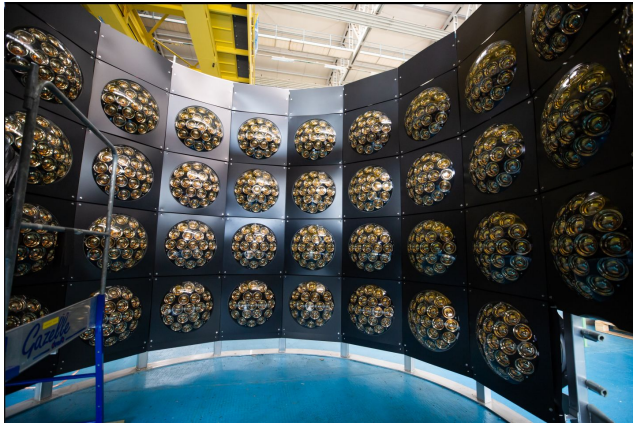







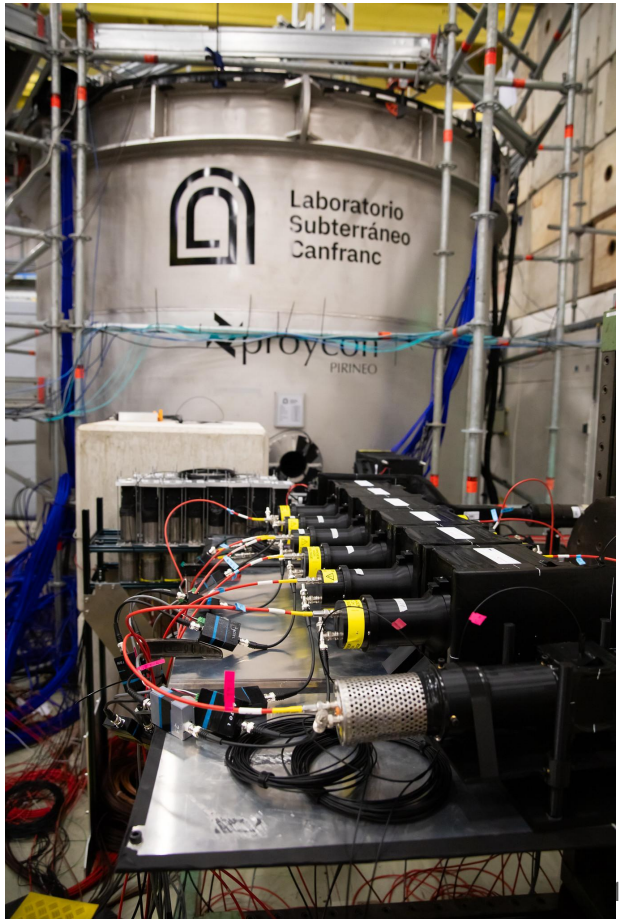
Main Board

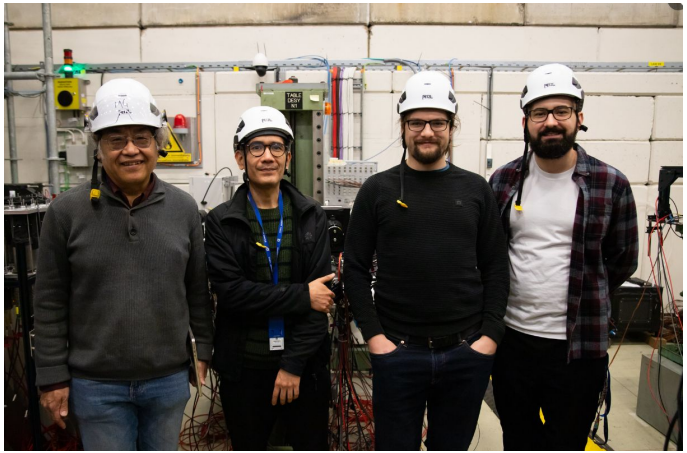
- from Napoli

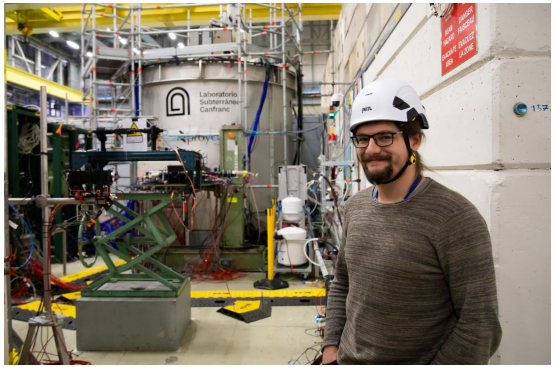






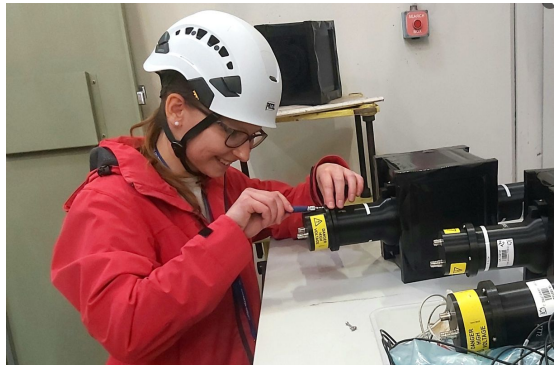

- Water Cherenkov Test Experiment, CERN
- Stavba, testování komponent 2022, 2023.
- Ostré nabírání dat 2024 a 2025:)

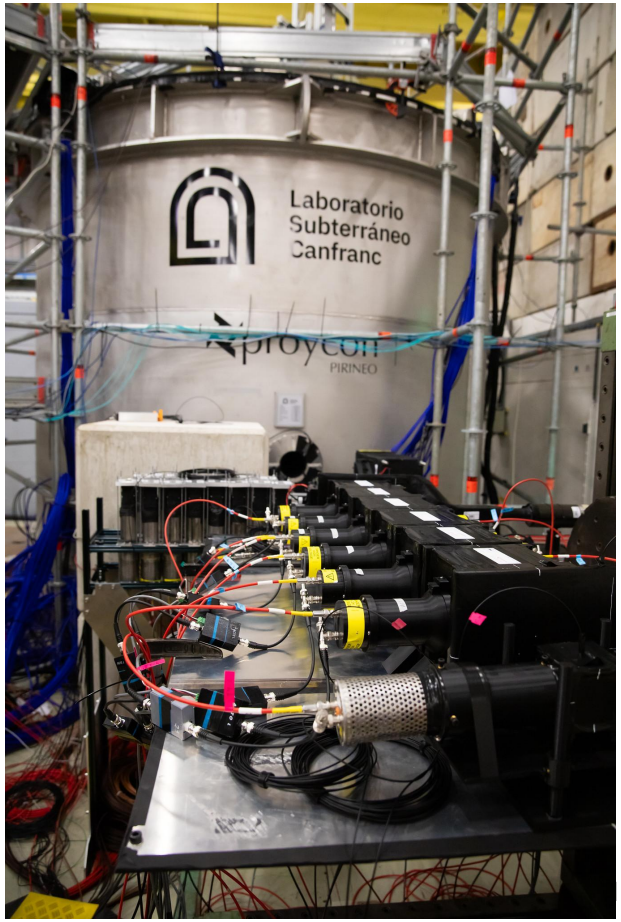






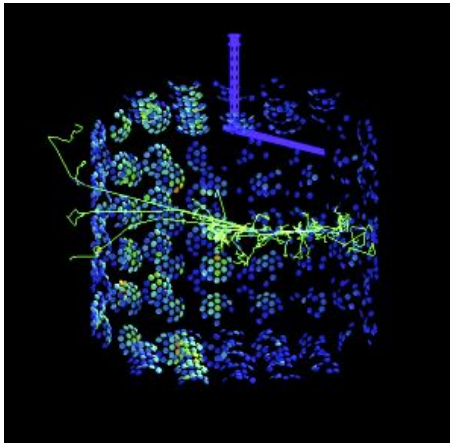

Laboratorio
Subterráneo
Canfranc



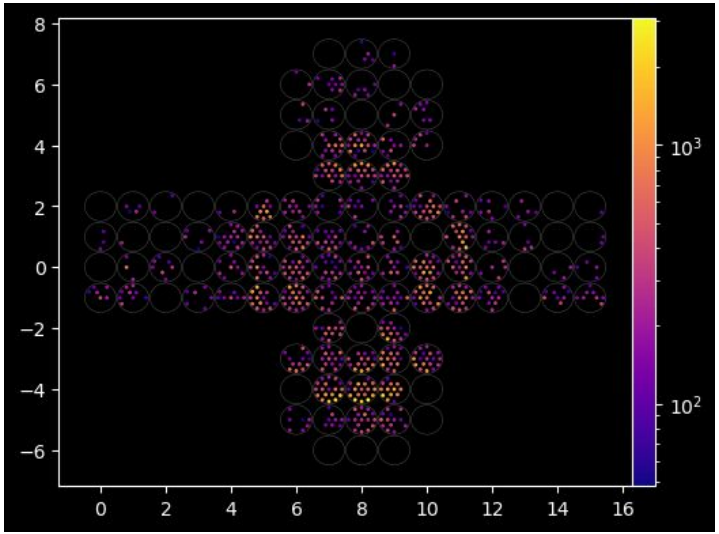

Laboratorio
Subterráneo
Canfranc
PIRINEO

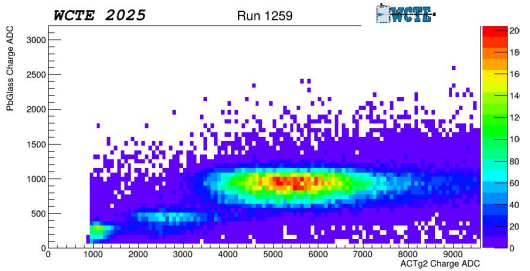
- Water Cherenkov Test Experiment, CERN.
- Analýza dat z detektorů
  - aerogelové Čerenkovské detektory
  - kalorimetr z olovnatého skla
  - scintilátory a měření doby letu částic
  - WCTE data
- Simulace WCTE experimentu
  - částice ze svazku
  - miony z kosmického záření – pozadí

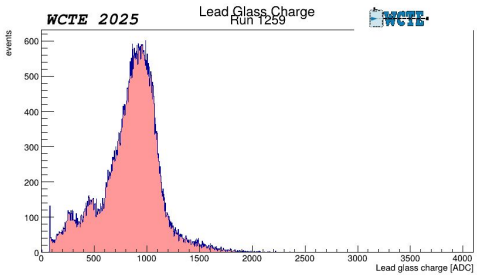
Simulace

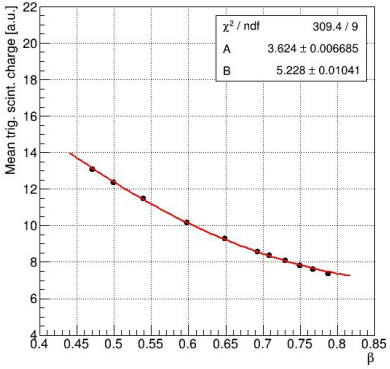


Data

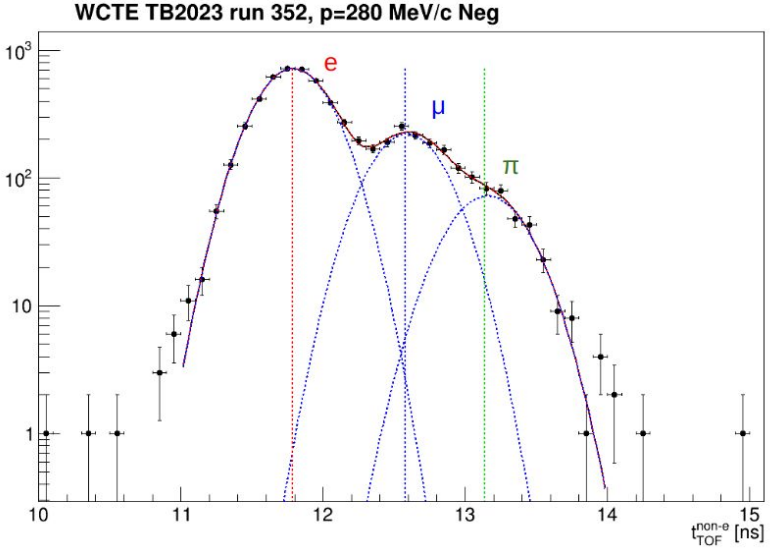


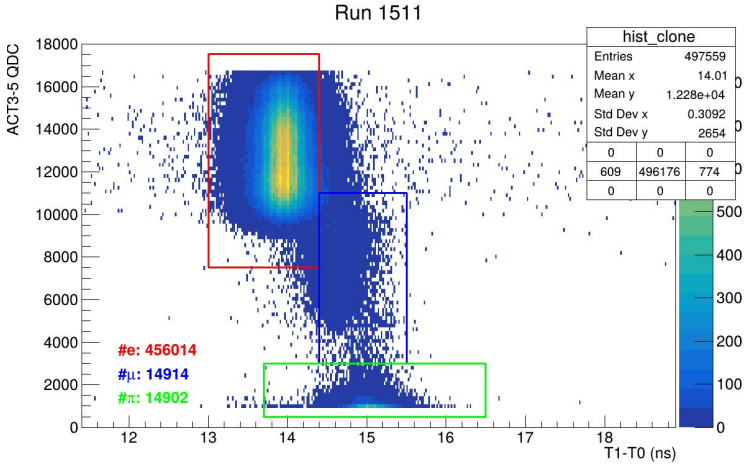






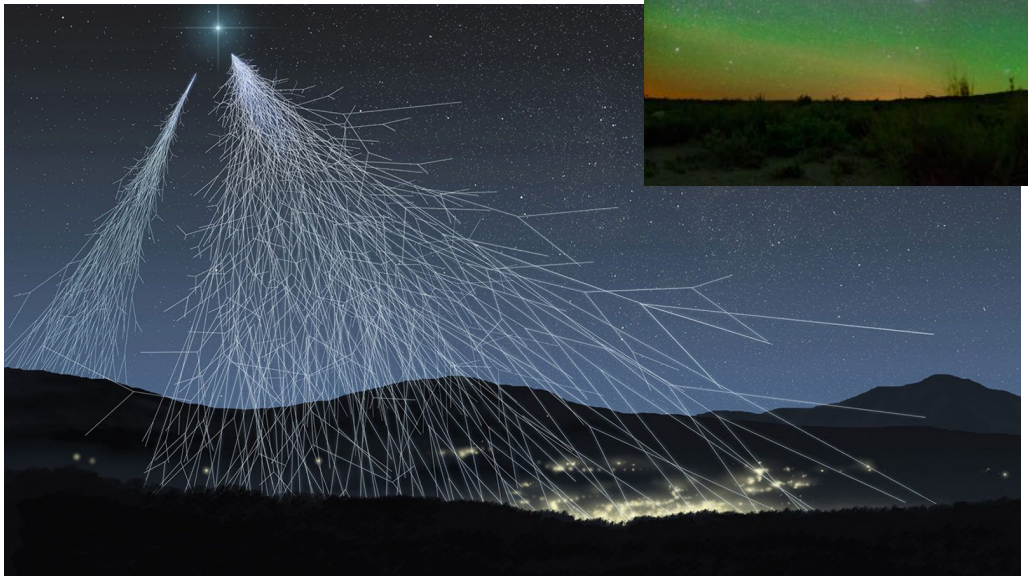
$$f(\beta|A,B) = \frac{A}{\beta^2}\left(\log\frac{B\beta}{\sqrt{1-\beta^2}} - \beta^2\right)$$





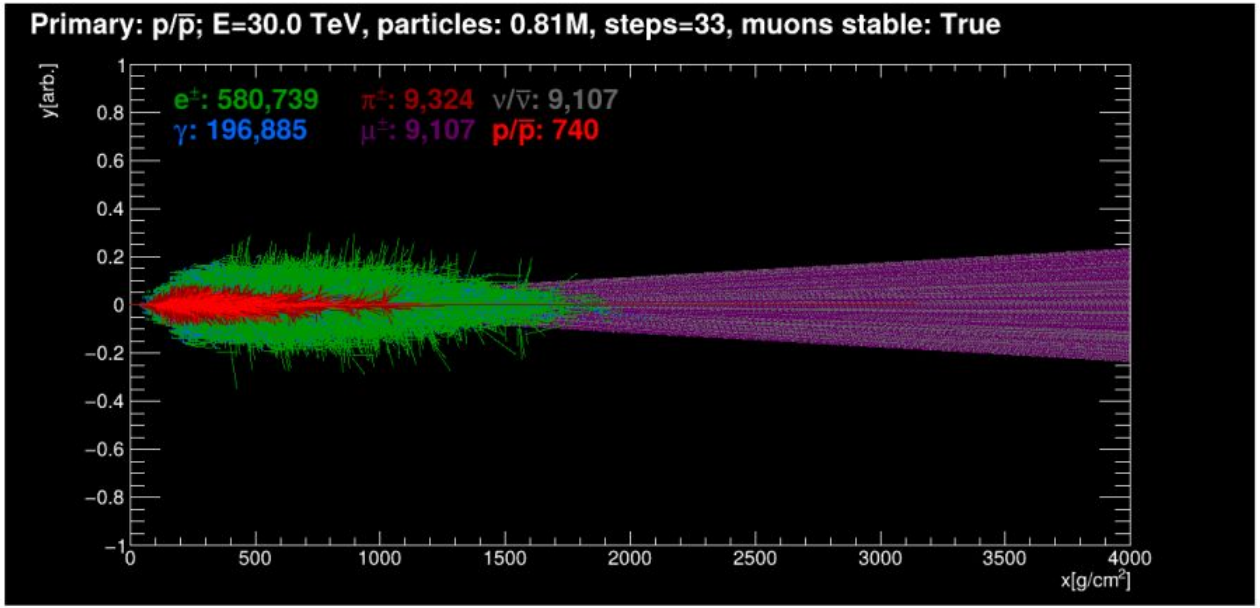

```
this -> ComputeChargesAndAmplitudes();
_histos2d["hRef_TOFACT1C"]->Fill(_tof, _act1c);
_histos2d["hRef_TOFACT2C"]->Fill(_tof, _act2c);
_histos2d["hRef_TOFACT3C"]->Fill(_tof, _act3c);

_histos2d["hRef_TOFACT23A"]->Fill(_tof, _act23aAver);
_histos2d["hRef_PbAT0F"]->Fill(_pba, _tof);
_histos2d["hRef_TOFPbA"]->Fill(_tof, _pba);
_histos2d["hRef_TOFPbC"]->Fill(_tof, _pbc);

this -> FillPIDHistos("");

// cout << " momentum: " << _momentum << " tof=" << _tof << " ptofExp="
if ( fabs(_tof - ptofExp) < tsigma) {
  // protons
  this -> FillTrigScintHistos("_p-like");
} else {
  // non protons
  this -> FillPIDHistos("_nonp-like");

  if ( fabs(_tof - DtofExp) < tsigma) {
this -> FillTrigScintHistos("_D-like");
  } else if ( fabs(_tof - TtofExp) < tsigma) {
this -> FillTrigScintHistos("_T-like");
  } else
// JK 10.4.2024
// require also 2*sigma around the electron peak in PbG charge
```

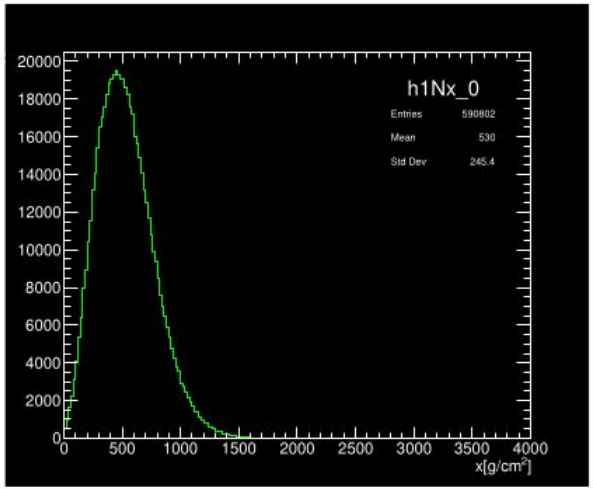
Simulace sprškek kosmického záření



Simulace sprškek kosmického záření

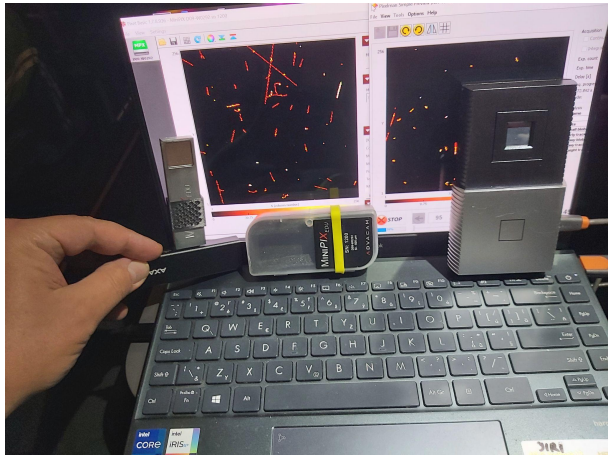
- Vývoj vlastních simulací
- Porozumění procesům průchodu částic látkou
- Možnost analýzy a rekonstrukce energie a dalších vlastností sprškek pomocí AI.
  - https://github.com/jirikvita/myStatsToys/tree/main/AirShowers

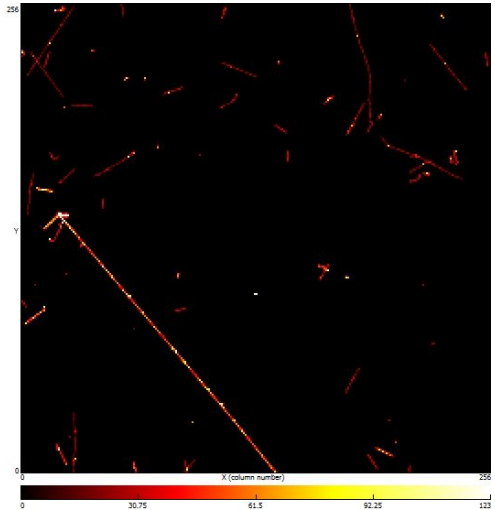


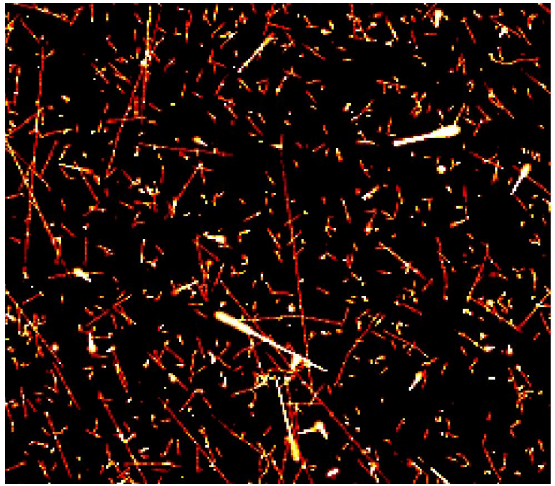


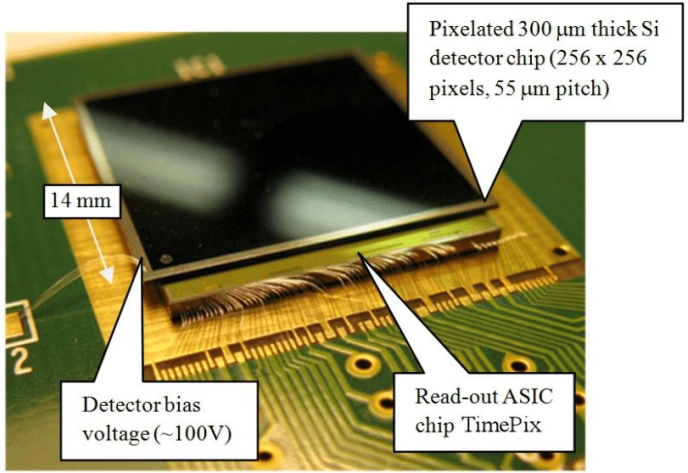
Částicová kamera

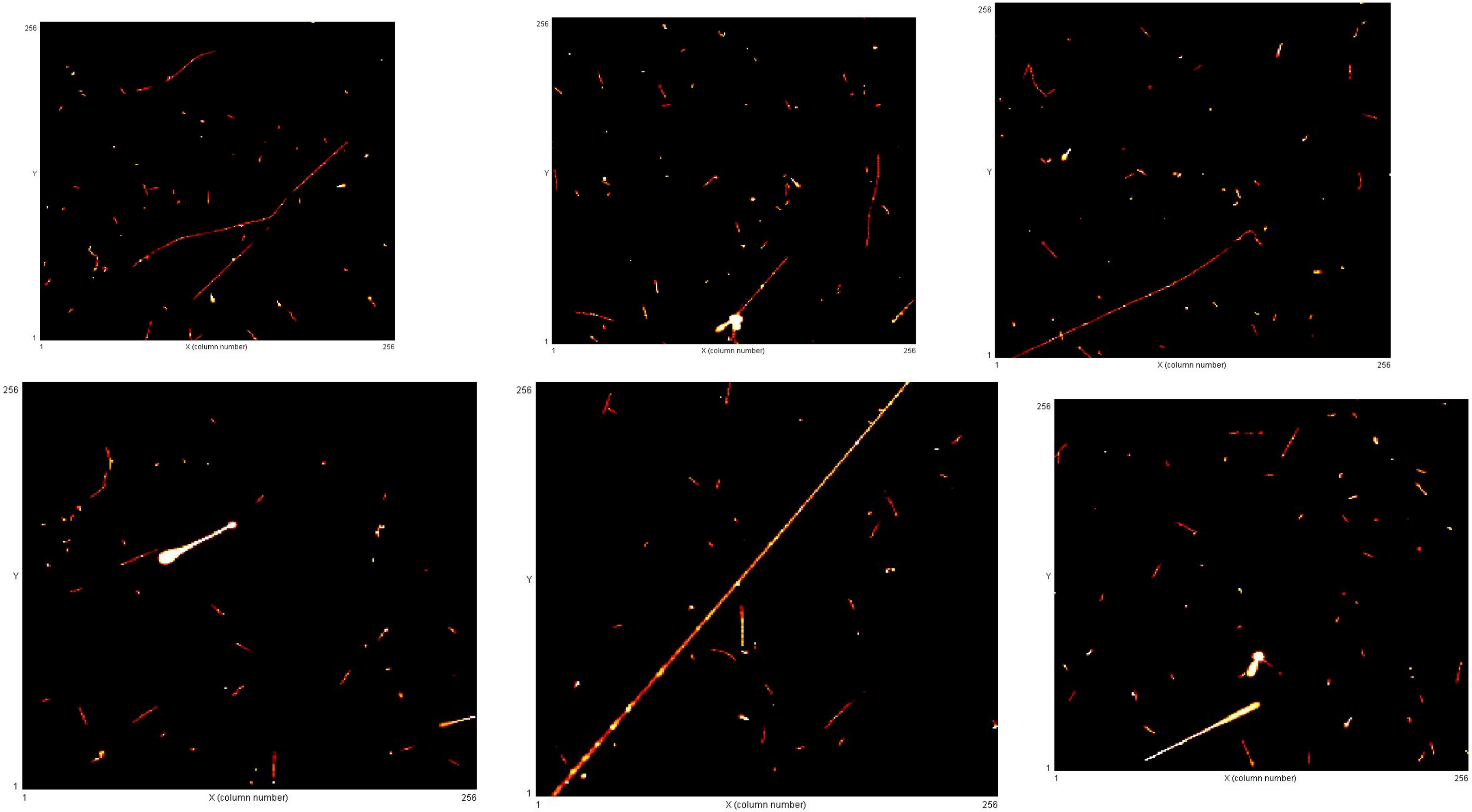
- MiniPix / TimePix
  - https://vnuf.cz/sbornik/prispevky/18-33-Vicha.html
- Image analysis, particles selection
- Energy spectrum analysis
- Python










256
Y
1
1
X (column number)
256

July 11th 2022

Advacam t=500μm

Stopped muon? Even decayed?

https://www.daviddarling.info/encyclopedia/P/pion.html

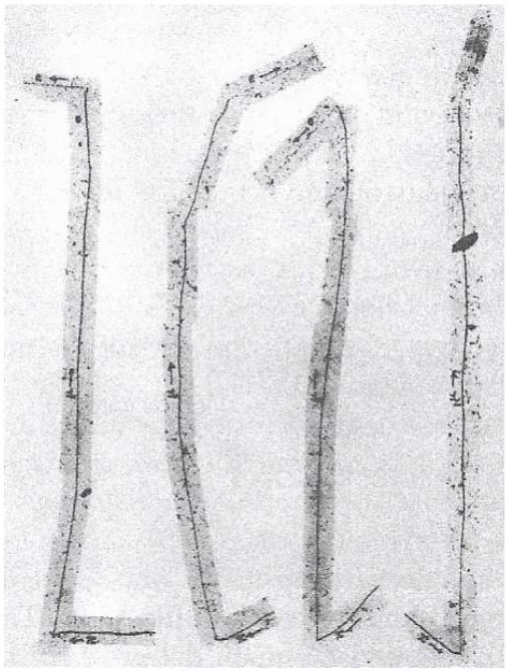
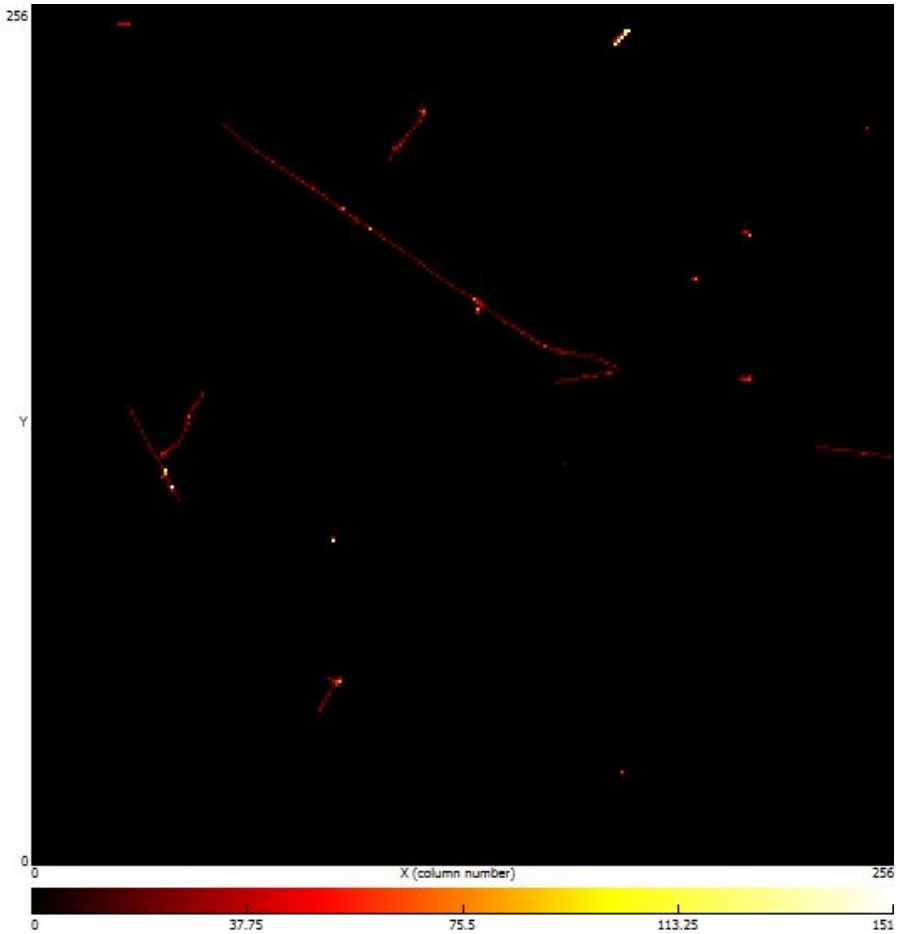
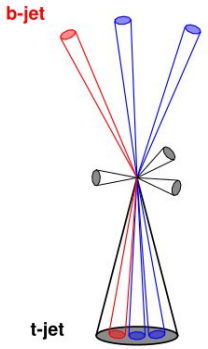


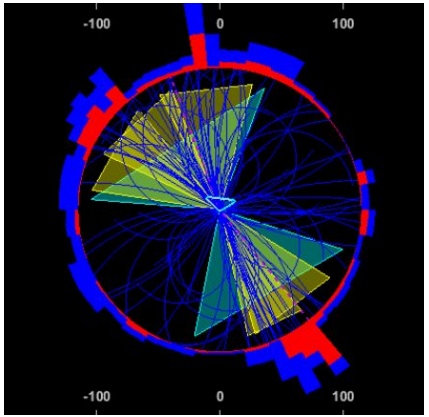
Figure 1. Some early examples of pion decays observed in a photographic emulsion in 1947. The positive pions come to rest before decaying by the reaction $\pi^+ \rightarrow \mu^+ + \nu_\mu$ to give monoenergetic muons. These travel about 600 mm in the emulsion before coming to rest and decaying by the reaction $\mu^+ \rightarrow e^+ + \nu_e + \bar{\nu}_\mu$ to give a positron.

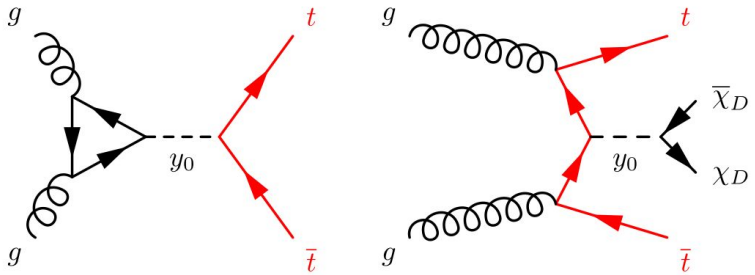


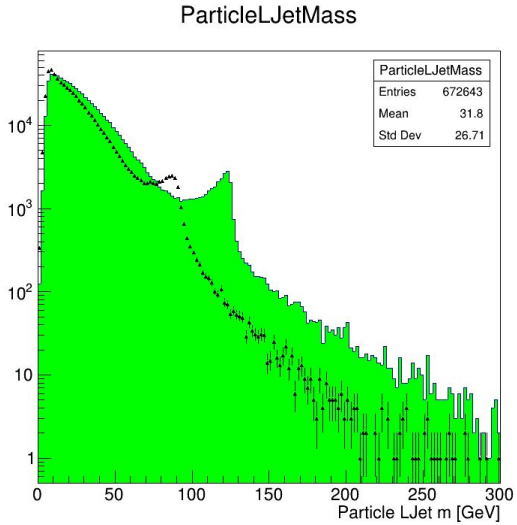
Rozpoznávání podstruktury jetů pomoci AI

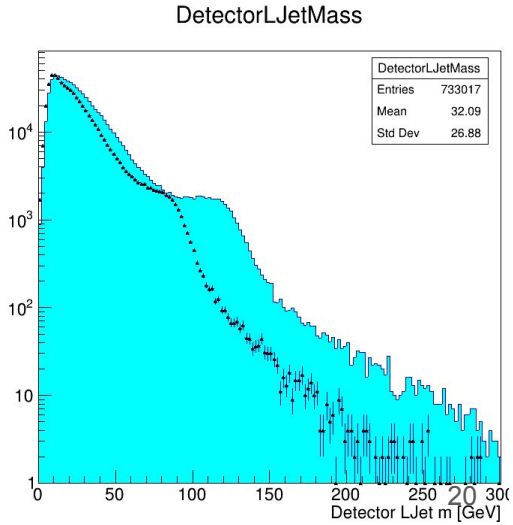
- Generování procesů v proton-protonových srážkách, kdy vznikají spršky částic (jety) pocházející z různých těžkých částic jako je top kvark, Higgsův boson atd.
- Rozlišení typu mateřské částice na základě struktury sprškek.
- Python, C++.











Links

- 2024, JK:
  - https://jointlab.upol.cz/kvita/outreach/UpoutavkaBcPraciSLO2024_JK.pdf
- 2021:
  - https://jointlab.upol.cz/kvita/AstroTemata2021.html
- Outreach:
  - https://jointlab.upol.cz/kvita/outreach/