



## TSU HEPI Computer Server for Nuclear and Particle Physics

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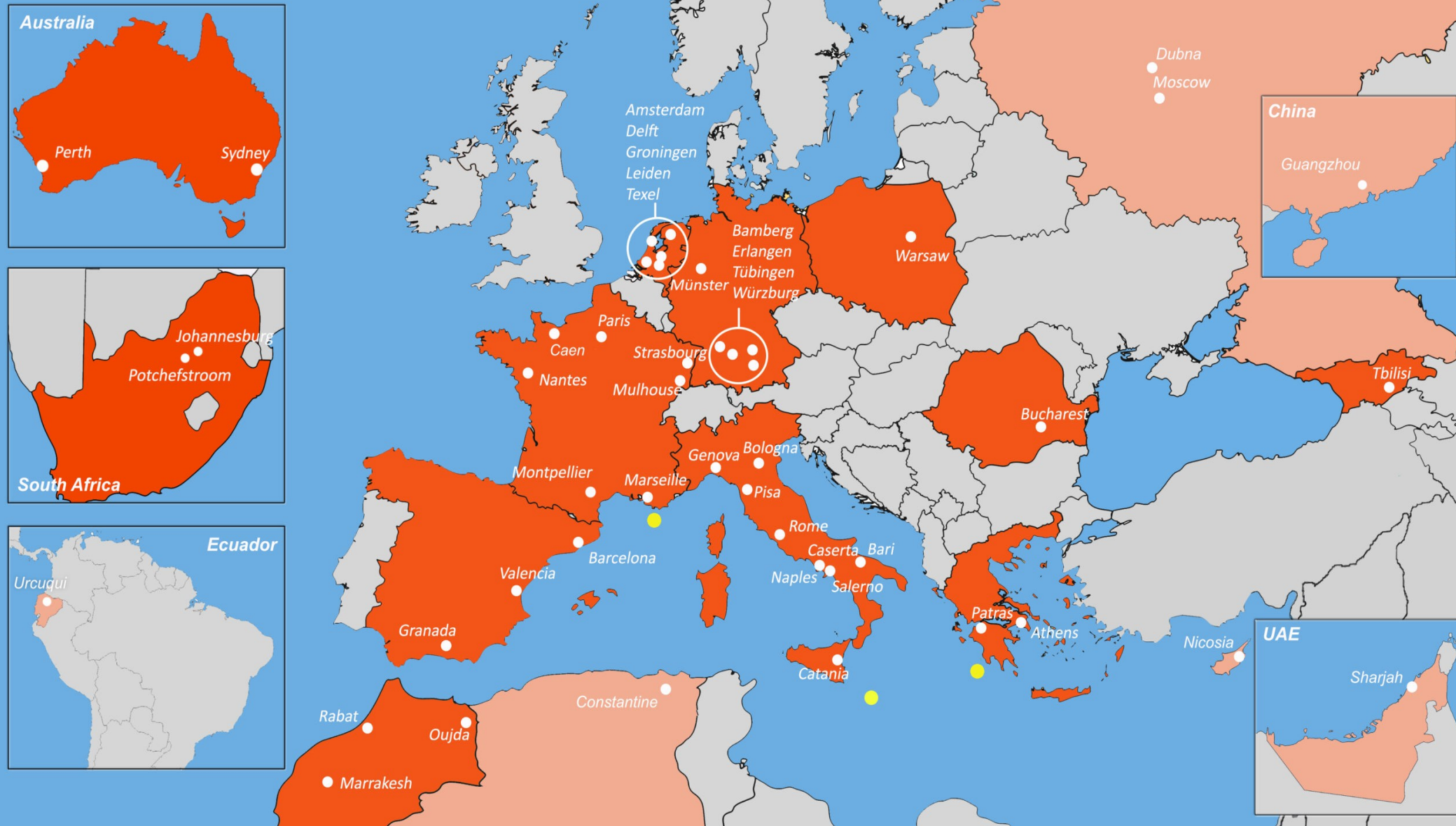
High Energy Physics Institute  
Tbilisi State University

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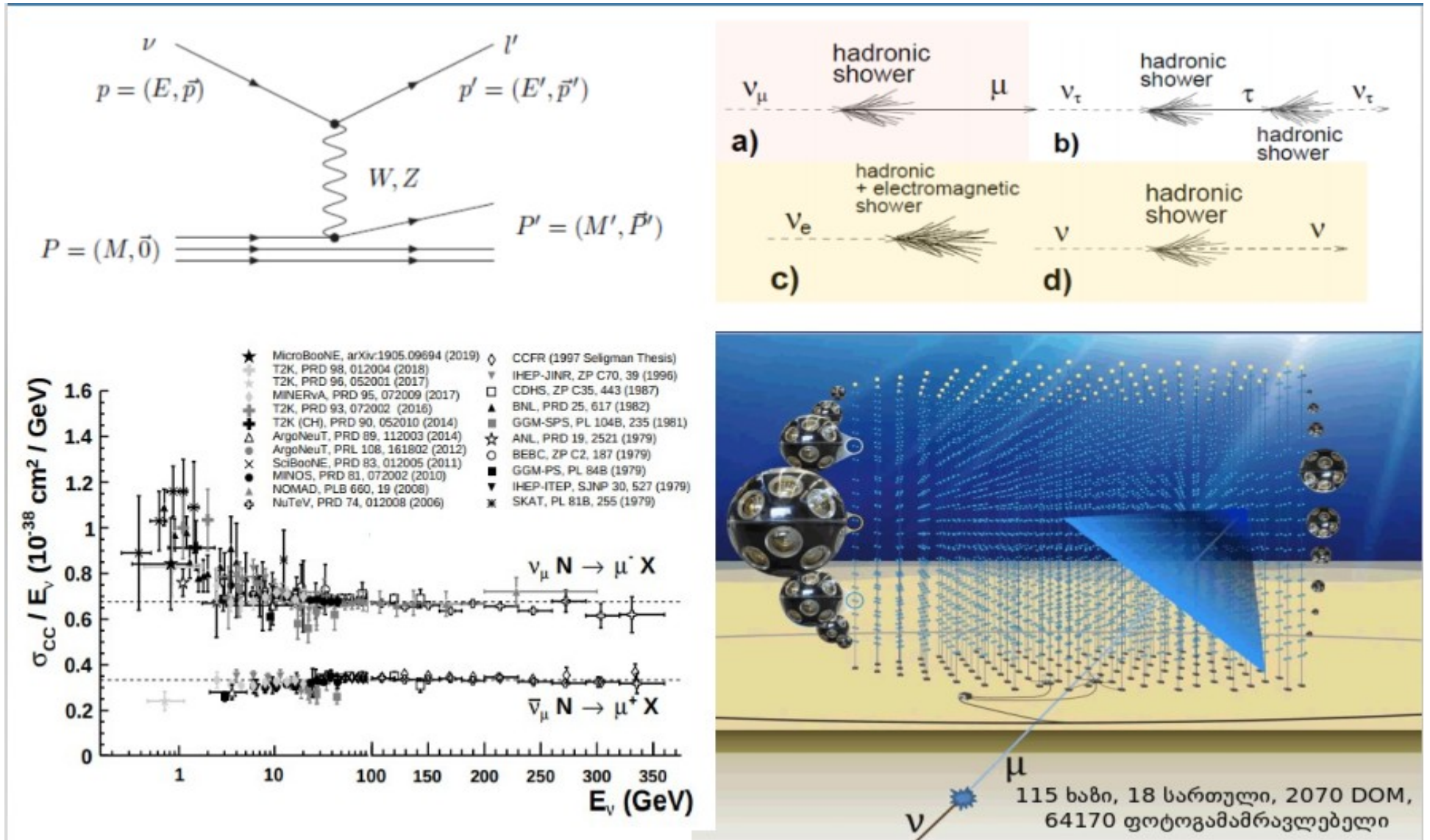
- ✓ Introduction
- ✓ TSU HEPI computer server specifications
- ✓ Installed software and examples of usage
- ✓ Summary and Outlook

# KM3NeT Collaboration

## Cities and Sites of KM3NeT



## Neutrino physics and astrophysics in the Mediterranean Sea



# TSU HEPI Computer Server Specifications



## Main Hardware specifications Dell PowerEdge T40

- Intel Xeon E-186G
- 3.8GHz (upto 4.7GHz) 6 core, 12 Threads
- 12MB cache memory
- 32GB RAM
- 10 TB hard disk



## CentOS 7

The Community ENTERprise Operating System

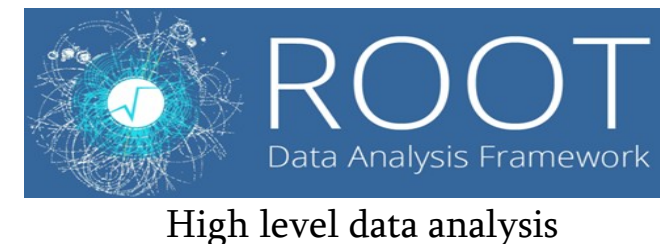
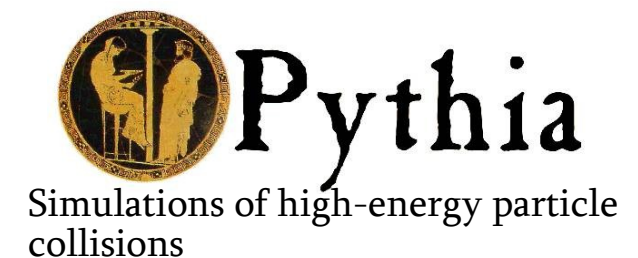
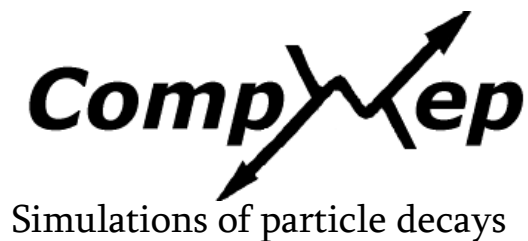
Address: [t2.km3net.tsu.ge](http://t2.km3net.tsu.ge)

Number of users > 30  
Used storage > 4TB

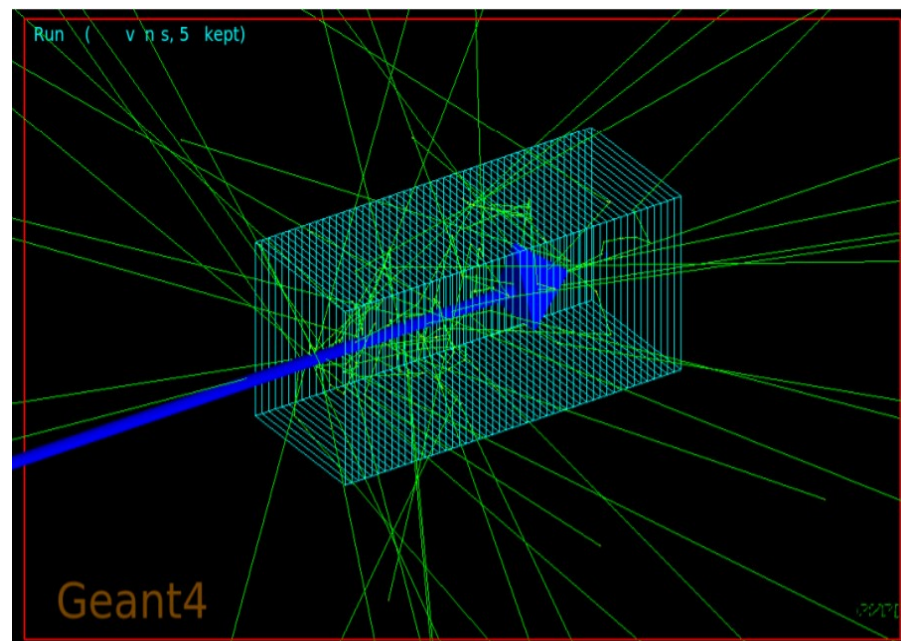
# Available software at TSU server

## KM3NeT Software

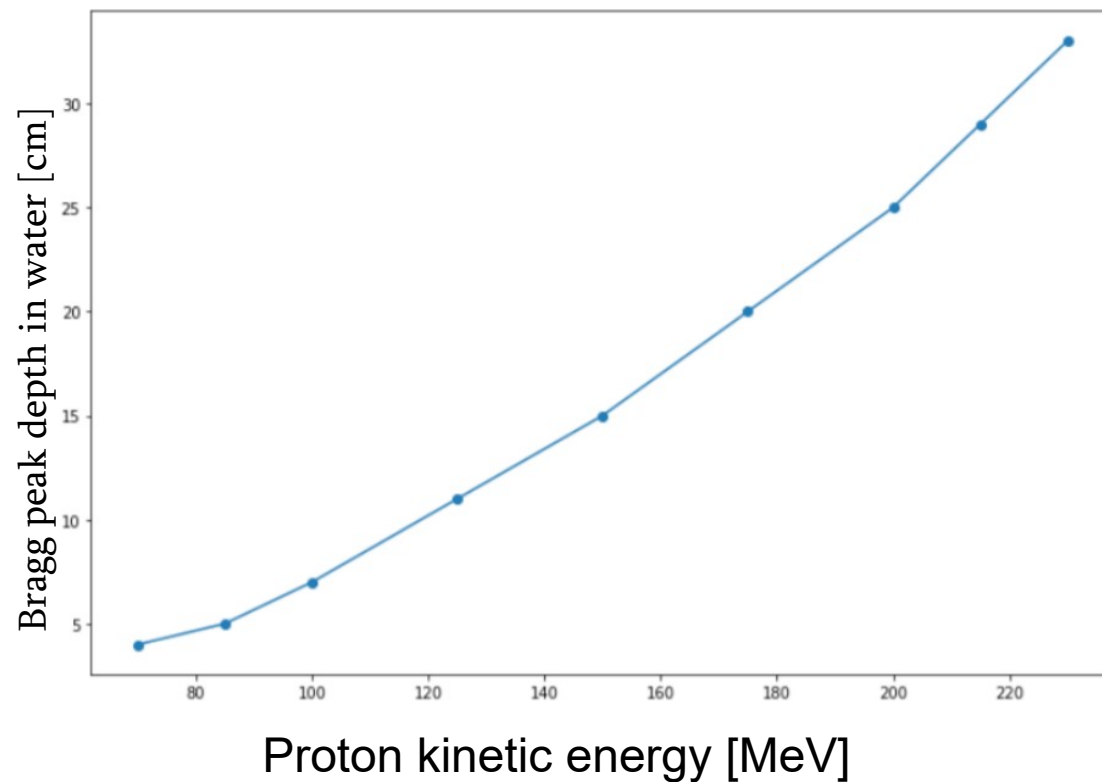
Software	Programming Language	Main Functions
gSeaGen	C++	Simulations of neutrinos
MUPAGE	C++	Simulations of atm. muons
JPP	C++	Simulations of light and detector data analysis...
AANET	Python	data analysis
km3py	Python	Accessing and analysis of the data



# Examples: GEANT4

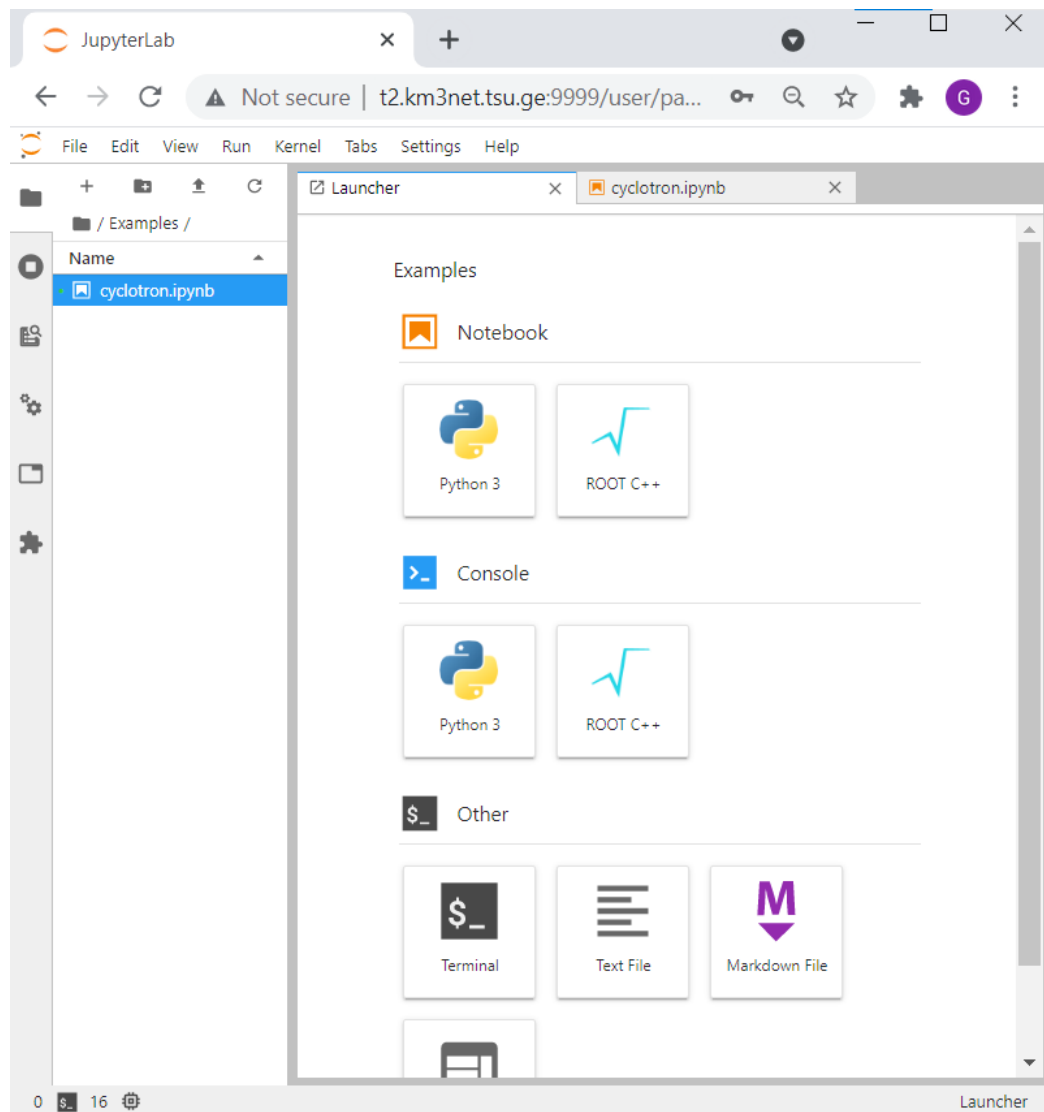


Proton beam interacting with matter



Example from master thesis of Giorgi Murvanidze

# Examples: JupyterHub



Screenshot from TSU HEPI web based JupyterHub Environment

Address: <http://t2.km3net.tsu.ge:9999/>



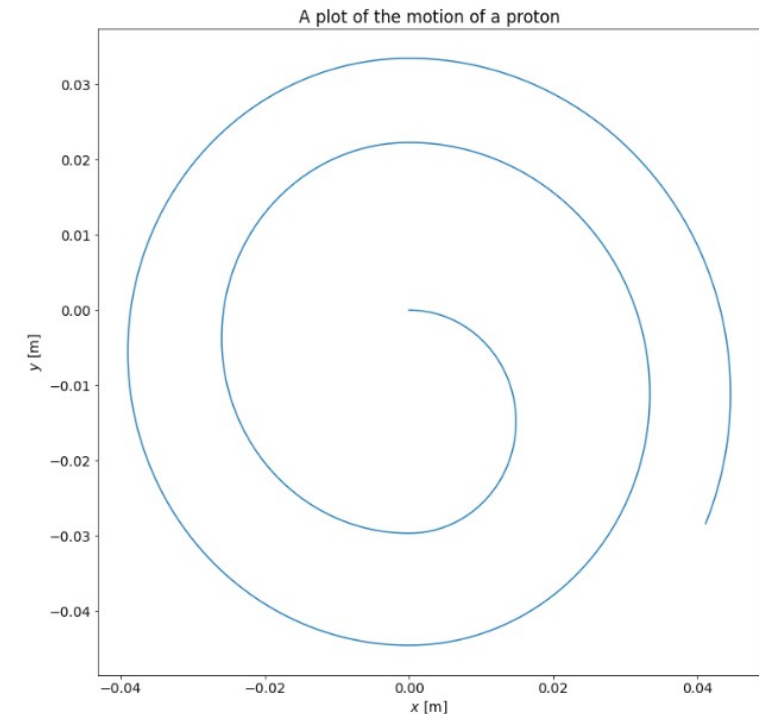
<https://jupyter.org/hub>



# Examples: JupyterHub Cyclotron Simulation

```
JupyterLab
x +
Not secure | t2.km3net.tsu.ge:9999/user/papalashvili/lab?
File Edit View Run Kernel Tabs Settings Help
/ Examples /
Name
cyclotron.ipynb
[1]: import sympy as sp
import numpy as np
import matplotlib.pyplot as plt
c = 299_792_458 #Speed of Light [m/s]
def F_net(r,v,t,B,q,m,V):
    d = 90e-6 #Set the separation between the plates to 90 micrometers
    E_0 = V/d #define the electric field based on voltage between the D's and separation
    w = q*np.linalg.norm(B)/m #define the cyclotron frequency
    F = np.zeros(3)
    if np.absolute(r[0]) < d/2: #if the particle is between the two D's calculate the electric force
        F[0] = q*E_0*np.cos(w*t)
    else: #if the particle is not, calculate the magnetic force
        F = q*np.cross(v,B)
    return F
def cyclotron(q,m,B,dt,T,V=50_000): #Set voltage between the plates to 50kV
    N = int(T/dt)
    r_cyclotron = .05 # set the radius of the D's to 5cm
    r = np.zeros((N,3)) # create a array for the position of the particle.
    v = np.zeros((N,3)) # create a array for the velocity of the particle.
    t = np.zeros(N)
    F = np.zeros((N,3)) # create a array for the net force on the particle.
    i = 0
    while (np.linalg.norm(r[i]) < r_cyclotron): # Loop while the magnitude of the particle's position remains within the cyclotron radius
        F[i] = F_net(r[i], v[i], t[i], B, q, m, V)
        v[i+1] = v[i] + F[i] / m * dt
        r[i+1] = r[i] + v[i+1] * dt
        t[i+1] = t[i] + dt
        i=i+1
    print(f"The final speed of the particle is {np.linalg.norm(v[i]):.3e} m/s")
    return r[:i], v[:i], t[:i]
B = np.array([0,0,0,1.5]) #Set magnetic field to 1.5T in the +z directio
q = 1.6e-19 #Set the charge of the particle to the charge of a proton
m = 1.67e-27 #Set mass of the particle to the mass of a proton
dt = 5e-12
r,v,t = cyclotron(q,m,B, dt, 1e-5)
print(f"Total time in cyclotron: {t[-1]:.3e} s")
plt.figure(figsize=(12,12)) #create the figure
plt.rc('font', size=14)
plt.title("A plot of the motion of a proton")
plt.xlabel("$x$ [m]")
plt.ylabel("$y$ [m]")
plt.plot(r[:,0], r[:,1]) #create the plot
```

Total time in cyclotron: 1.012e-07 s  
[1]: [<matplotlib.lines.Line2D at 0x7f6a11c17e10>]



Simulating a relativistic cyclotron  
Computational Essay - Simulating a cyclotron  
A computational essay by Vebjørn Hallberg Bakkestuen



# Summary and Outlook

- HEPI TSU Server was created mainly for KM3NeT related projects
- KM3NeT software and other widely used software are available at HEPI TSU
- The server runs continuously and used by more than 30 users currently
- Students are welcome to use our resources
  
- Involving more students to do high level computing projects for their research
- Implementing new software and methods