Empowering Underrepresented Communities Through Julia

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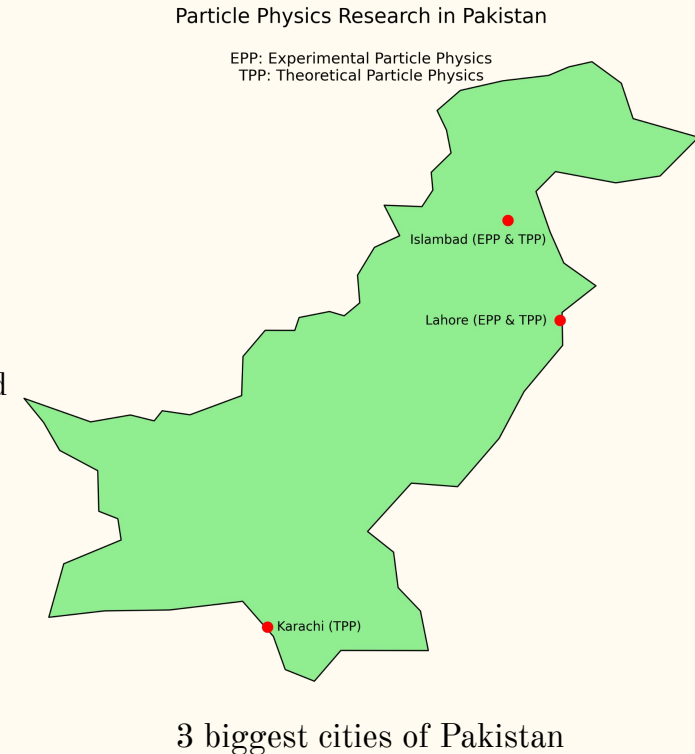1 shahzaib.abbas2001@gmail.com
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Experimental Particle Physics in Karachi

- **Karachi: One of Pakistan's Largest Cities**
  - Significant urban population and academic institutions.

- **Lack of EPP Research in Karachi Universities**
  - No active Experimental Particle Physics (EPP) research in local institutions.

- **Knowledge Gap Among Students**
  - Students in Karachi are less aware of ongoing EPP research compared to students in Lahore and Islamabad.
  - Possible contributing factors:Lack of strong research linkages among intra-cities,Long distances between universities and research centers from Karachi to Islamabad and Lahore
  .

- **Research Focus in Karachi**
  - Current research in Karachi predominantly focuses on Nanophysics, Molecular Physics, Medical Physics, TPP

Particle Physics Research in Pakistan

EPP: Experimental Particle Physics
TPP: Theoretical Particle Physics

Islambad (EPP & TPP)

Lahore (EPP & TPP)

Karachi (TPP)

3 biggest cities of Pakistan

Workshop

A workshop arranged to give a flavour of Experimental Particle Physics at the LHC and Julia language

- Arranged at NED University, Karachi (Pakistan)
- No of Participants: 15
- Study year of Participants: 2nd-4th Year of BS Physics

It's the first-ever workshop on Julia programming in Pakistan

Workshop - Selection of students

We selected 15 students, with a focus on underrepresented communities (such as women, racialized groups, and other minorities), with the following goals:

- To encourage them to pursue higher education, ultimately empowering their communities in the future.

- To introduce them to Physics at the Large Hadron Collider (LHC) to spark interest in further studies and/or a career in Experimental Particle Physics (EPP).

- To provide insight into how various physics analyses are conducted at CERN and highlight the critical role of programming in these processes.

- To familiarize them with Julia programming and its high performance, enabling them to use it in their current or future research for maximum efficiency.

Workshop

A workshop arranged to give a flavour of Experimental Particle Physics at the LHC and Julia language

- **Three talks:**
  - **Introduction to Particle Physics** - Dr. Shabbar Raza (Associate Professor at FUUAST, Pakistan)
  - **Introduction to CMS Experiment** - Dr. Muhammad Ansar Iqbal (Postdoctoral fellow at UCLA, USA)
  - **Introduction to Julia** - Shafiq Ur Rehman (Instructor at Aligarh Institute of Technology)

- **Two Tutorials**
  - Basics of Julia Programming
  - Short tutorial of Julia Programming in High Energy Physics

Workshop - Tutorials

The tutorials on Julia Programming and its applications in High Energy Physics (HEP) were presented by Ali and me, both master's students at the University of Karachi with a strong passion for HEP.

- We are self-taught in Julia Programming and, through various tutorials (referenced in the following slides),
- We explored how to use Julia as a tool for HEP research.

The tutorials were conducted using Google Colab

- We utilized a template to run Julia.
- We provided participants with self-guided Jupyter notebooks that covered the basic syntax of Julia and the simulation of Higgs boson decay channels.

```julia
1  using Random
2
3  # Define the decay channels and their probabilities
4  decay_channels = Dict(
5      "bb" => 0.60,
6      "cc" => 0.03,
7      "ττ" => 0.06,
8      "WW" => 0.19,
9      "ZZ" => 0.12
10 )
11
12 # Ensure the probabilities sum to 1 with a tolerance
13 total_probability = sum(values(decay_channels))
14 tolerance = 1e-10  # Define a small tolerance
15
16 # Missing line(s): Complete the probability validation check
17 if abs(total_probability - 1.0) > tolerance
18     # Complete this line to handle the error
19 end
20
21 # Function to simulate a Higgs boson decay
22 function decay_higgs()
23     rand_value = rand()
24     cumulative_probability = 0.0
25
26     for (channel, probability) in decay_channels
27         cumulative_probability += probability
28         if rand_value < cumulative_probability
29             return channel
30         end
31     end
32
33     return "Invalid Decay"  # This should never be reached
34 end
35
36 # Simulate multiple Higgs boson decays
37 num_decays = 100000
38 results = Dict(channel => 0 for channel in keys(decay_channels))
39
40 for _ in 1:num_decays
41     decay_channel = decay_higgs()
42     results[decay_channel] += 1
43 end
44
45 # Print the results
46 println("Decay Channel Results after $num_decays decays:")
47 for (channel, count) in results
48     percentage = count / num_decays * 100
49     println("H -> $channel: $count ($(round(percentage, digits=2))%)")
50 end
```

Reference Material used for the tutorials

- [UnROOT Tutorial · HSF_Julia_Tutorial](#)

- [Julia Documentation · The Julia Language](#)

- [Potential of the Julia Programming Language for High Energy Physics Computing - INSPIRE (inspirehep.net)](#)

- [Performance of Julia for High Energy Physics Analyses - INSPIRE (inspirehep.net)](#)

Survey from the students

Student Knowledge Before and After Workshop: Julia & HEP
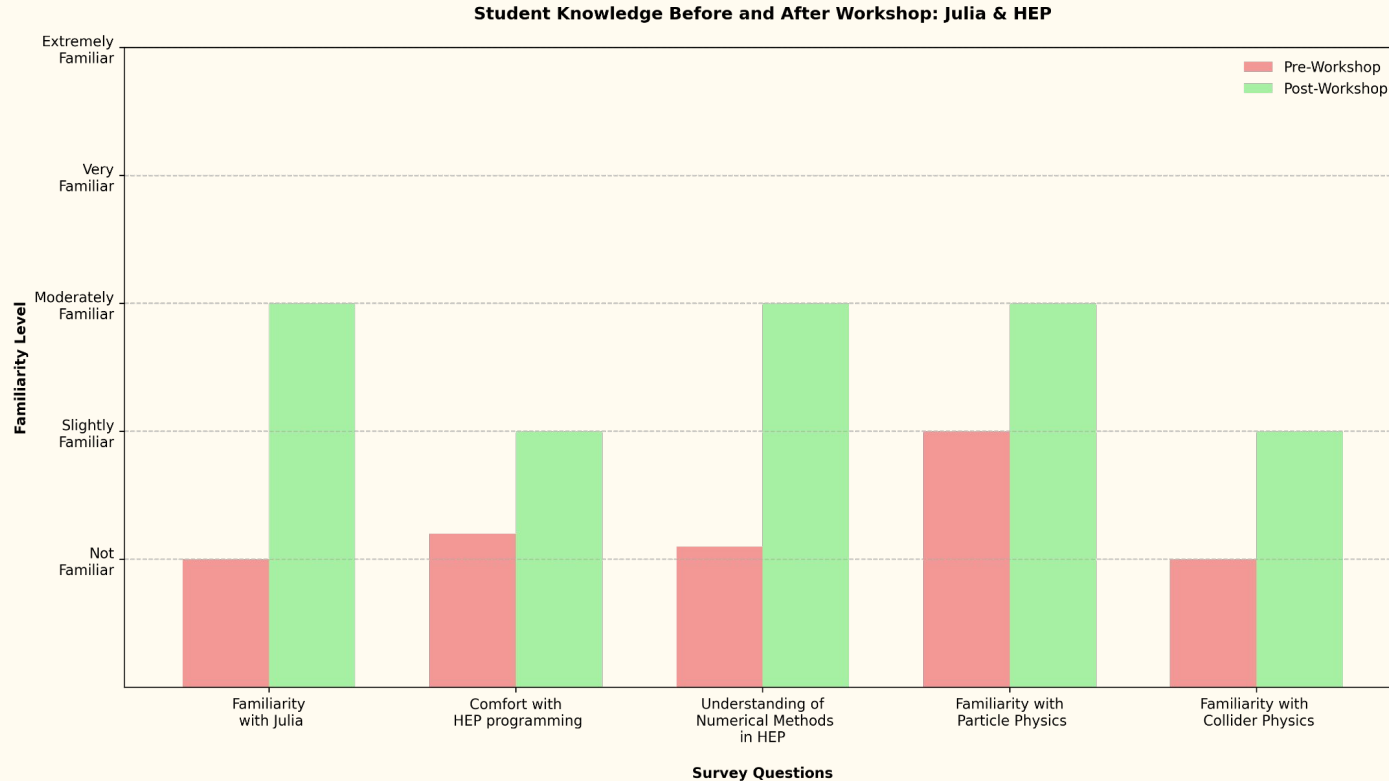
Some Images of Workshop

Conclusion

- Julia programming boosts STEM access for underrepresented communities.
- Integrating Julia with CMS Open Data engages students in particle physics and STEM.
- Diverse expert speakers enhance learning and networking.
- The workshop fosters community, inspiring collaboration in particle physics and coding.

Seeking short research opportunities
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Acknowledgement