Advancements and Challenges in Amplitude Analysis

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Who am I?

- **Masters & Ph.D.** at **PUC-Rio** (Pontifical Catholic University of Rio de Janeiro)
- **Posdoc** at **CBPF** (Brazilian Center for Research in Physics)
- Performed **Data Analysis** at **LHCb** (Large Hadron Collider beauty)
- Co-**Developer** of **Rio+** (a C++ tool for Amplitude Analysis)
- **Faculty** at **EAP-Zamorano** (Honduras)

Who am I?

- **Used Rio+** in Dalitz Plot Analysis
- $D \to hhh$ **specially** $D \to \pi^+\pi^+\pi^-$
- Performed a **Model Independent** Partial Wave Analysis for the first time in the $D \to \pi^+\pi^+\pi^-$ decay
- Also worked in $B \to hhh$
- Now, as a developer of Rio, I am striving to bridge the gap between C++ and Python, working towards porting my amplitude analysis code from C++ to Python.
- My ultimate aim is contributing to build a more accessible, flexible, and efficient tool for our community.

The Importance of Amplitude Analysis in HEP

AA plays a crucial role in our understanding of particle physics:

- It provides a fundamental tool in HEP to study complex particle decay phenomena.
- It grants us the ability to determine resonance properties and direct processes, including their masses, widths, and spin-parity assignments.
- It's a tool that aids us in validating or contesting theoretical models.
- It is key in uncovering potential new physics beyond the Standard Model.

However, the mathematical and computational nature of amplitude analysis poses unique challenges:

- The integration of the probability density function (PDF) in the likelihood calculation often exhibits slow convergence due to the high dimensionality of the problem space.
    - This is particularly true for the case of multi-body decays, where the number of dimensions of the integration can be very high.

The Importance of Amplitude Analysis in HEP

- Additionally, we are dealing with highly multi-dimensional phase spaces, intricate resonance structures, and background processes, which makes the computational aspect even more challenging.

- This is why we need effective tools and strategies to tackle these complexities.

Challenges with Current Tools

- While I've been working in the field of amplitude analysis and I've gained some familiarity with tools like GooFit, MINT and LAURA,
  - They come with their own set of challenges.
- GooFit, for instance, excels in performing maximum likelihood fits on large datasets and offers parallel processing capabilities using CUDA or OpenCL.
  - It's a powerful tool, but not without its complexities.
- There's a steep learning curve involved in fully understanding and leveraging these tools.

Challenges with Current Tools

- These complexities can act as barriers, making the process of navigating and adapting the codebase a challenging task.

- This highlights an important issue within our community:
  - the gap between the capabilities of these powerful tools and their usability for researchers.

- In my journey of transitioning from C++ to Python for amplitude analysis, I've come to realize the need for a more intuitive and accessible tool.
  - A tool that not only harnesses the power of GooFit-like packages but also presents a more user-friendly interface and a gentler learning curve.

Vision for a New Approach

- Another crucial aspect of this new approach is the generalization of fitting tools.
  - It's currently quite difficult to find a tool that can handle B decays and D decays simultaneously, or analyze decays of more than three bodies.
  - A more generalized tool would provide great benefits in terms of flexibility and broader application.
- Lastly, but most importantly, this new approach must prioritize user-friendliness and code readability.
  - Even without a deep understanding of CUDA or other complex technologies, users should be able to carry out their analysis efficiently.
  - A code that works on top of the existing codebase, similar to GooFit but with a simpler interface, could be a key part of this vision.

Call to Action and Workshop Expectations

- (This is why I'm here today:) I'm seeking feedback, suggestions, and partnership to drive forward my efforts in creating a more streamlined, user-friendly tool for amplitude analysis.

- I'm particularly interested in discussions around :
  - fitting tools
  - computational strategies
  - ways to improve code readability and user-friendliness.


thank you
danke
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merci
gracias
obrigado
dziękuję
bedankt
teşekkür ederim
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