Understanding particle beam dynamics in the LHC

UMICH CERN REU

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Probes of the sub-microscopic world

- Particles accelerators have played an instrumental role in advancing our understanding of matter and energy at the smallest scales
- Making accelerators into precision tools for scientific investigation requires a detailed understanding and control of the dynamics of particle bunches
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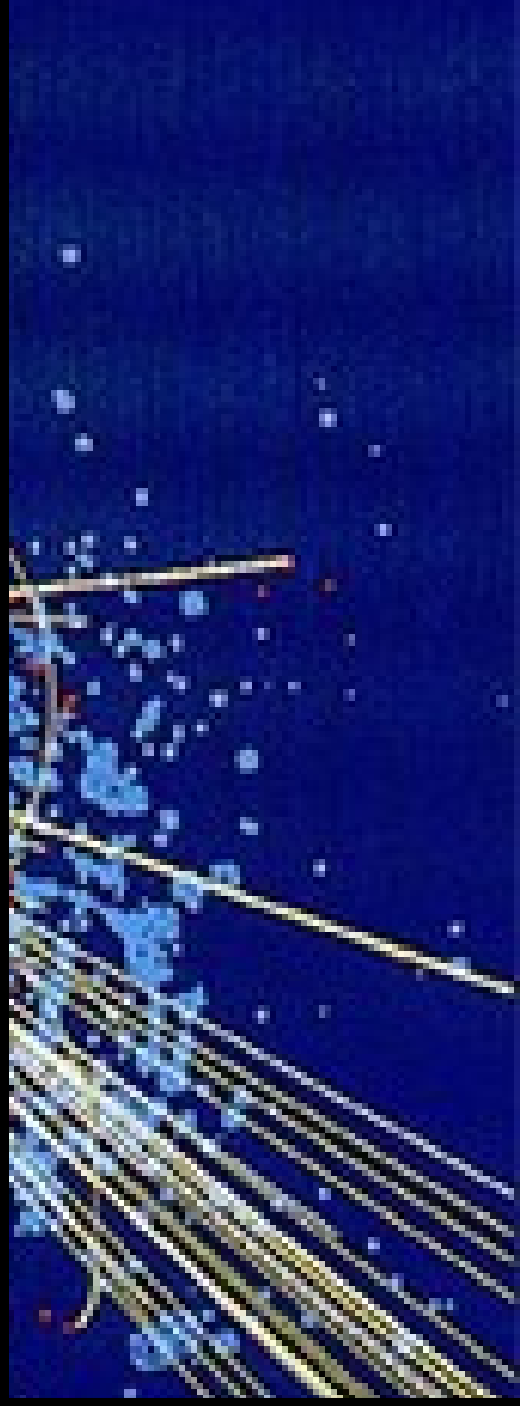
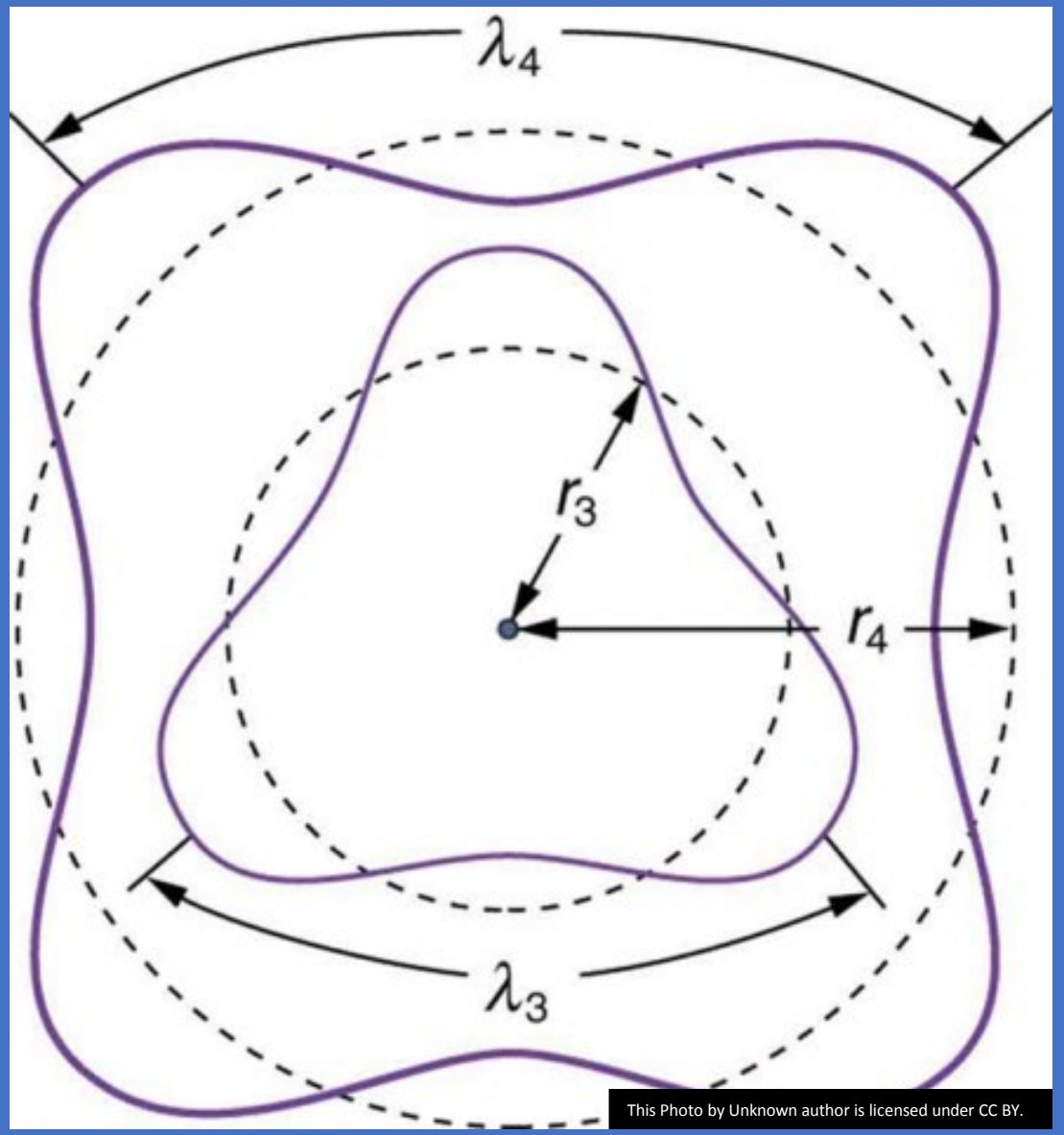


Good vibes

- As a result of being perturbed by the electromagnetic components of the accelerator, the particle bunches will oscillate about their main tragectory.
- The period of this oscillation is known as the Tune of the accelerator.
- My project is concerned with testing novel techniques to predict this parameter via simulations and experimental data.



Methods of Attack

- The Techniques that have been explored to extract the Tune include:
- Average Phase Advance (APA)
- Interpolated Fast Fourier Transform (FFT)
- Hanning Filtered FFT
- Signal padding (Common method to make the FFT applicable to signals of short duration)
- Weighted Birkhoff average (a technique borrowed from integrable systems theory)

Intellectual Nepotism

- And then, of course, there is my favorite idea, (which I also just so happened to come up with), Is to bring deep Learning into the fold.
- AI Feynmann is a physics inspired software tool which was develop to discovery "physical laws" which describe the relationship between some input/output data.
- In our case, the hope is to use AI Feynmann to discover an expression for the Tune of the particle bunches for a given set of experimental parameters
- This idea is very preliminary, don’t assault me with questions just yet!

THE ROAD SO FAR

- Familiarized myself with the use of Linux
- Learned the basics of Accelerator Physics
- Learned the inner workings of the simulation codes
- We are currently in the process of testing techniques developed by a collaborator for measuring the tune of the particle bunches.

Stay tuned for more information!

Slide 4

The two figures on the left depicts the plot of the average positions of the particle bunches in the LHC as a function of turns and its Fourier Transform.