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PE Mini Lectures #5
Introduction

18.09.2019
 Beam & Accelerator physics

1) How to describe a particle beam?
   - Phase-space, Liouville theorem, emittance, optical functions (α, β, γ, σ)

2) How do accelerators work?
   - Beams production: ion sources
   - Beam transport, FODO lattice
   - Beam acceleration: linacs and acc. cavities
   - Acc. hardware: beam dump, cavities, ...

3) What types of magnets do we need? And how do we get them?
   - Dipoles, quadrupoles, and more: beam-dynamics and hardware realization
   - Kicker and septa

4) How do superconducting acc. magnets work?
   - Basics of superconductivity
   - Basics of superconducting magnet and cable design
   - Why use superfluid helium?

Magnets

5) Why and how to protect a s.c. magnet?
   - How to quench a s.c. magnet?
   - How to protect a s.c. magnet?
   - Quench/damage limits

6) Reliability and availability
   - Basic definitions (for CERN and other accelerators)
   - Introduction to risk assessment
   - Lifetime distributions and bathtub curve

What can go wrong? Beam-related failures
- Failure classification (risk, slow/fast/ultrafast failures)
- Failure examples: magnet powering, injection/extraction failures, UFOs, QH firing
- Failure criticality for different machines

How does the CERN accelerator complex work?
- Injectors: LINACs, PSB, PS, SPS
- LHC operation and cycle
- LHC availability and faults

What happens if the beam is lost?
- Beam-matter interaction
- Hydrodynamic tunnelling

MP Systems
- Main MP systems at LHC (BIS, PIC, WIC, QPS, LBDS, COLL)
- Electronics for MP

Machine Protection

Computational Methods
- Coding conventions and good practice / Object-oriented programming
- Basics of co-simulation
- Introduction to machine learning
- How to simulate a particle beam? How to simulate a magnetic field?
Where are we?

1) Coding convention and good practice
   - Concept of phase space/Liouville theorem
   - Emittance
   - Beta function and Twiss parameters

2) How to describe a particle beam?
   - Concept of phase space/Liouville theorem
   - Emittance
   - Beta function and Twiss parameters

3) How to produce a particle beam?
   - Ion sources
   - Space charge

4) How to accelerate a particle beam?
   - RF acceleration (LINACS and RF cavities)

5) SWAN Notebooks
   - Using SWAN for scripting and documentation

- How to transport a particle beam?
  - How to deflect a beam?
  - How to focus a beam?
  - Magnet types and their beam-dynamics functions

Computational Methods
Beam & Accelerator Physics

- Next (?)