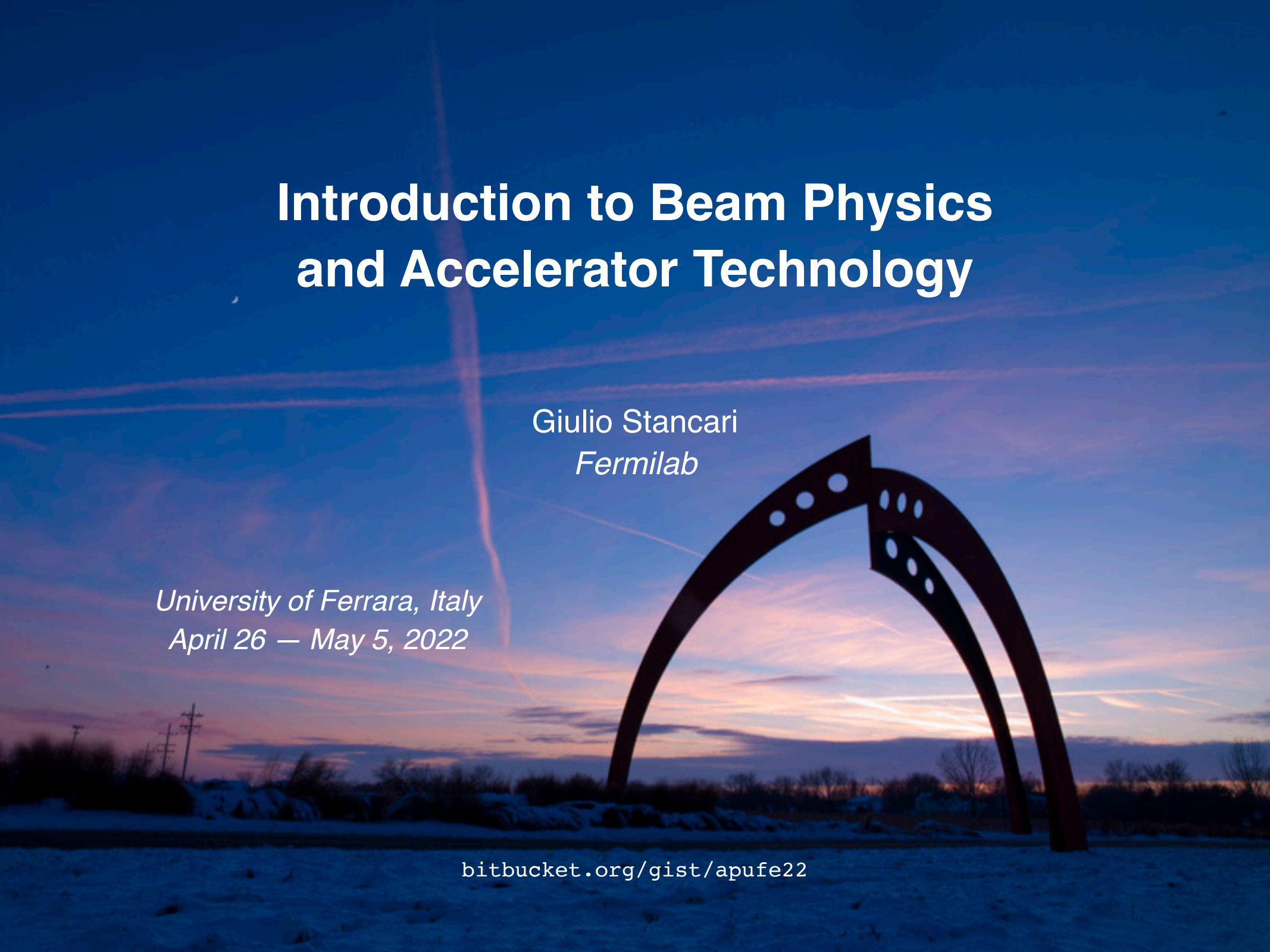
Introduction to Beam Physics and Accelerator Technology

Giulio Stancari
Fermilab

University of Ferrara, Italy
April 26 — May 5, 2022



bitbucket.org/gist/apufe22

Introduction to the course

About your lecturer

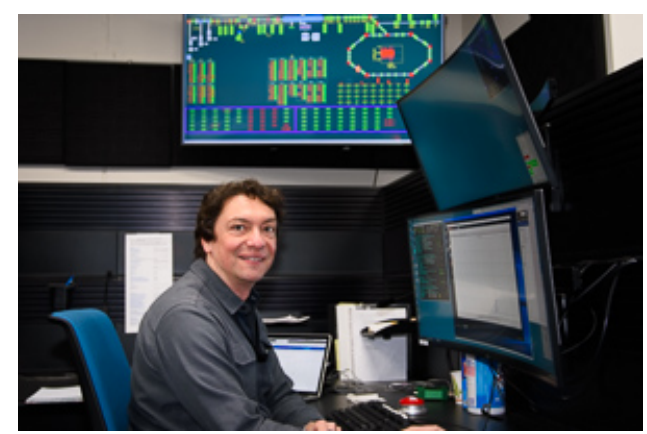
Senior scientist at Fermilab, Head of the Accelerator Research Department

Research

- Master and PhD at U. Ferrara / Fermilab in particle physics: charmonium spectroscopy, hadron form factors, scintillating-fiber detectors
- Post-doc at Fermilab: antiproton source, charmonium experiments
- Researcher at INFN Ferrara/Legnaro: production and trapping of radioactive francium for atomic spectroscopy and parity violation
- Professor at Idaho State U. / Jefferson Lab: positron source for CEBAF
- Scientist at Fermilab: beam dynamics in Tevatron, IOTA and LHC, electron lenses, nonlinear integrable optics, dynamics of single electrons, optical stochastic cooling, synchrotron-light detection

Teaching

electromagnetism, accelerator physics, seminars for high-school students and teachers



Interests and hobbies

playing music, photography, running, …

About you

What is your name?

Where are you from?

Where are you connecting from?

What is your course and year of study?

What branch of physics would you like to specialize in?

What do you expect from this course?

What are your other interests and hobbies?

Why study accelerator physics?

REWARDING: Connected to **fundamental science** (nuclear and particle physics, material science, biology, …) and **exciting applications** (medical diagnostics and treatment, industrial processes, …)

CHALLENGING and **DIVERSE**: You can find areas that match your interests in **applied math**, **physics**, **engineering**, **computing**, …

RELEVANT for many fields of science and technology. Essential to **design experiments**, **analyze data**, **explore new applications**

OPPORTUNITIES: If you like the subject, there may be a **career** path for you. Several **theses**, **internships**, **fellowships** and **jobs** are available.

Learning objectives

learn about the **historical evolution** and **applications**

become familiar with the main **concepts**

make quantitative estimates of basic phenomena and design parameters

locate and **critically review** relevant **journal articles**

All course activities are aimed at these learning objectives

Student evaluation for course credit

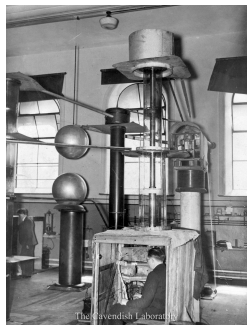
Attendance and Participation Be present to at least 5 of the 6 lectures. Participate in the group activities. Contribute to the discussions!

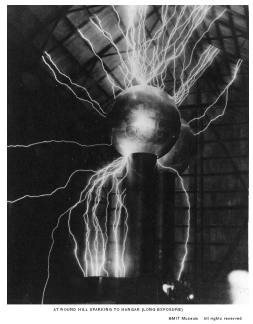
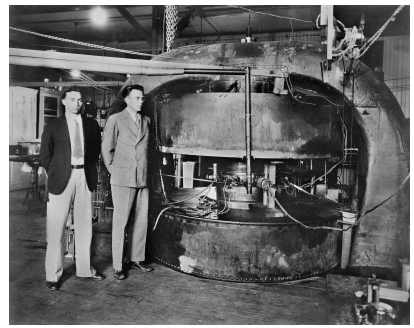
Homework A set of questions and problems. **Due before Tuesday, May 31**. Examples will be discussed in class. Can be done individually or as a group. Each student must send a scan of his or her own *handwritten* copy.

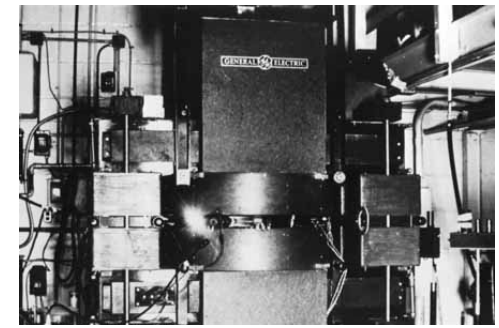
Critical Paper Review Choose a journal article from a list of landmark papers or propose one. Prepare a report according to the guidelines discussed in class. **Due before Tuesday, May 31**.

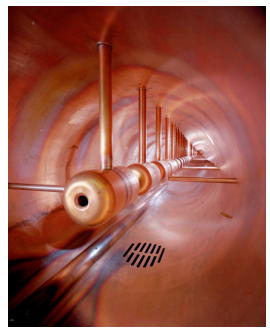
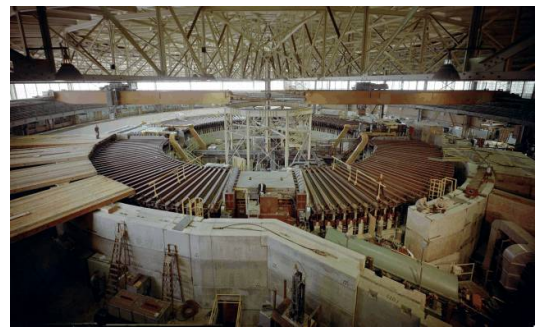
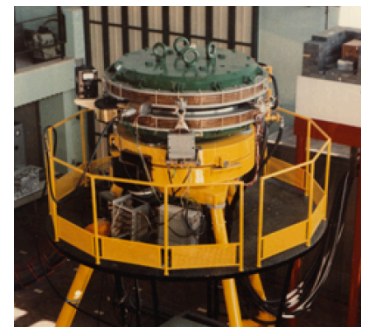
Oral Exam (for undergraduate students only) Answer questions about the course contents. Summarize your paper review.

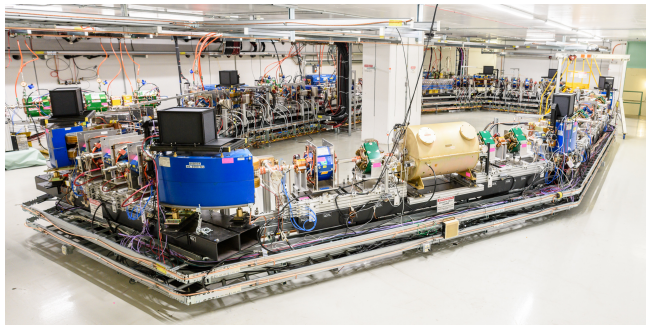
Overview: evolution of particle accelerators



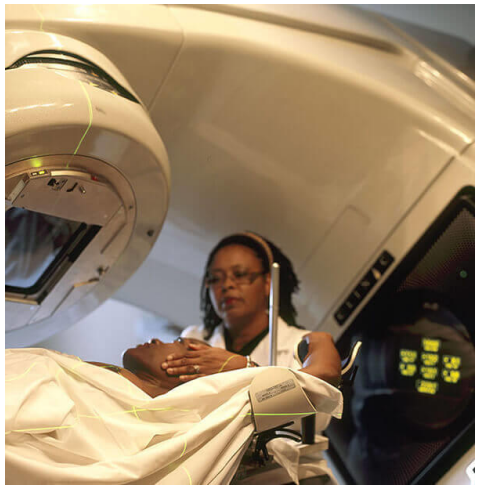


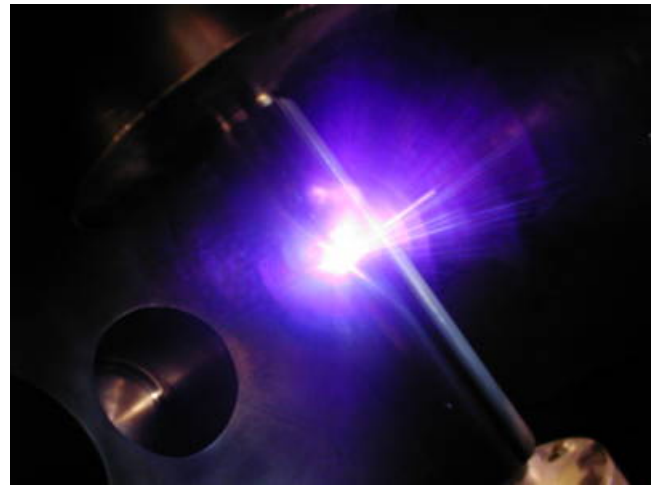




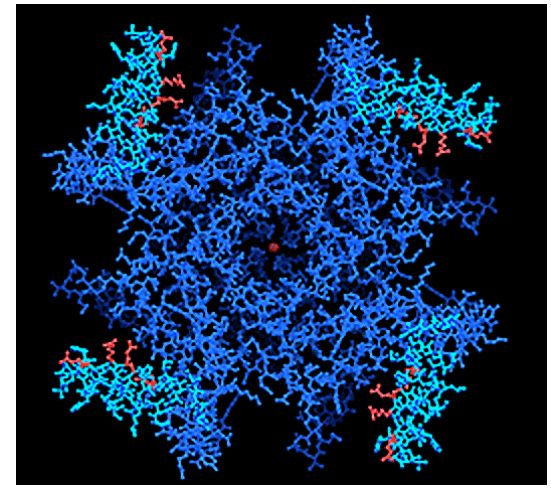



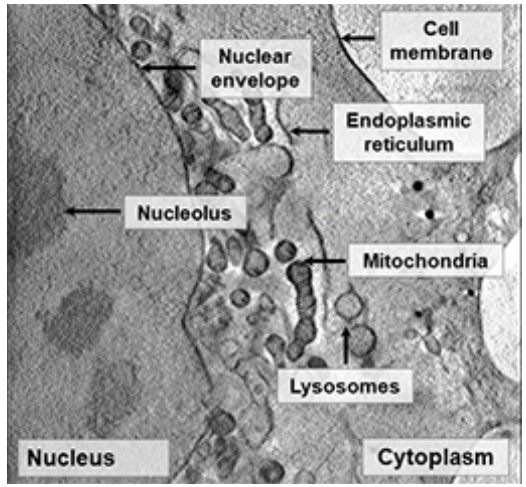
Physical principles and technologies

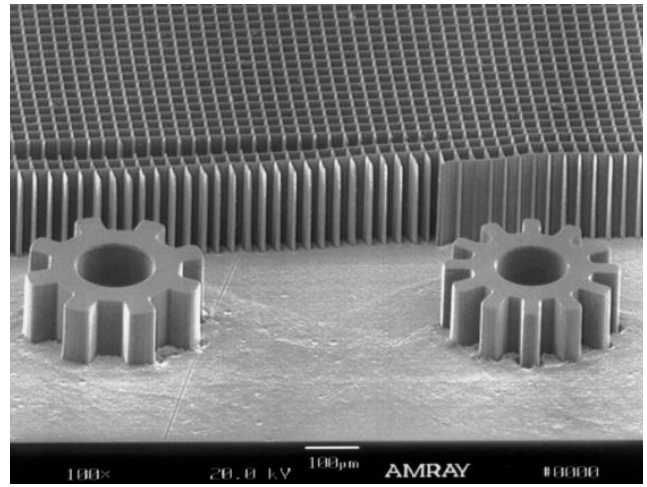
Overview: applications of particle accelerators

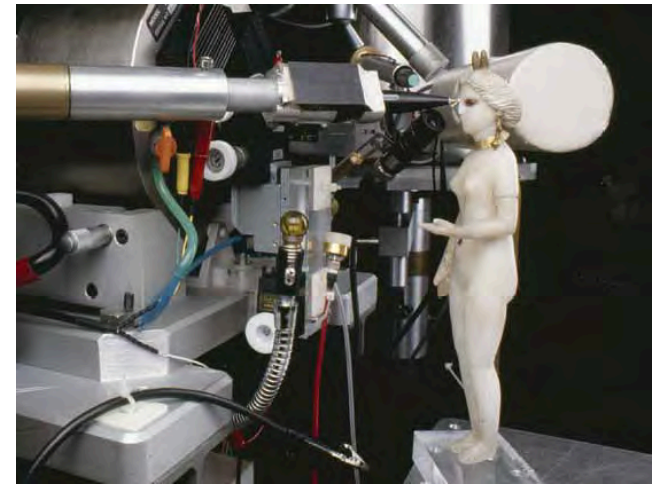




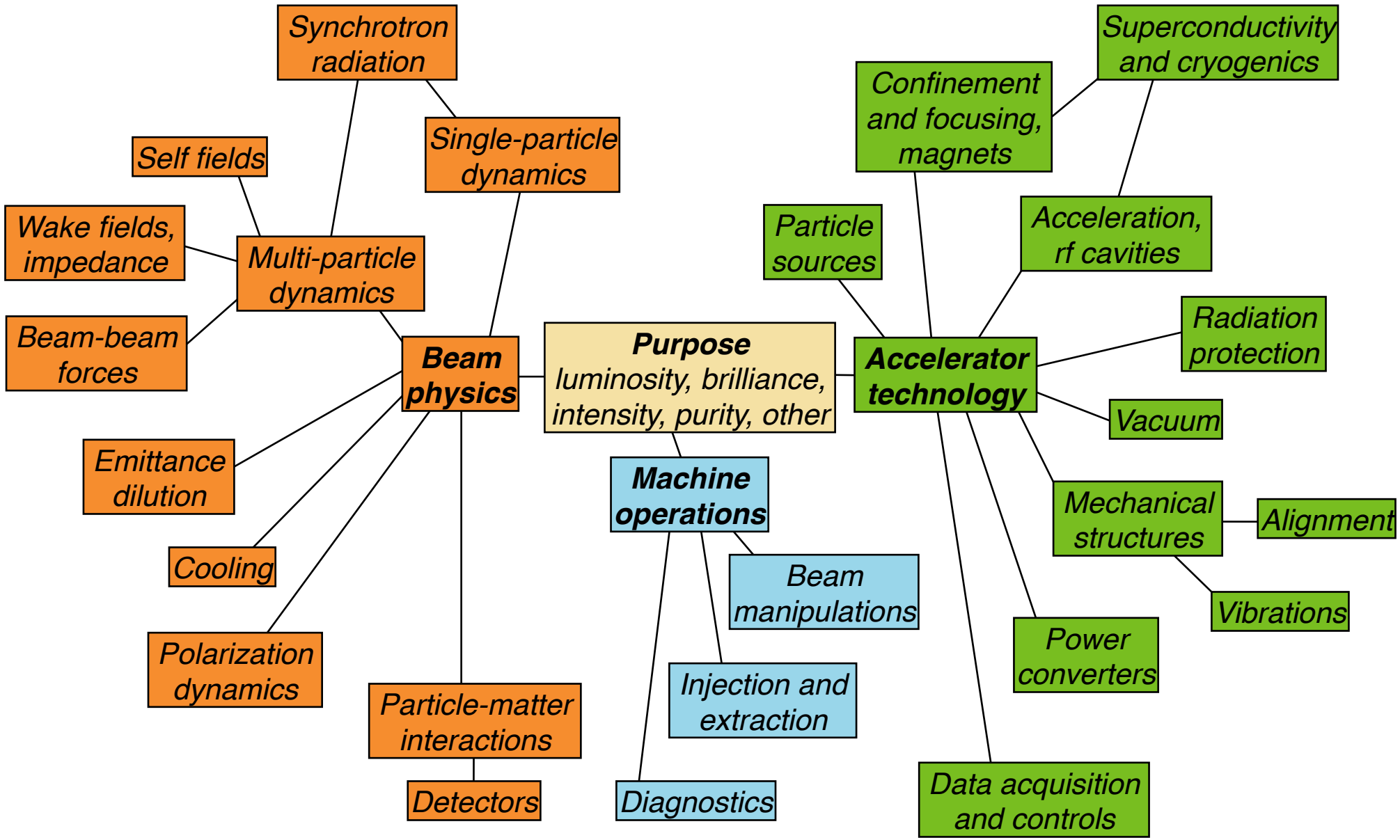








Overview: accelerator physics and technology concept map



Fermilab

Main course units

Review
dynamics, electromagnetism, relativity

Historical evolution
direct-voltage acceleration, cyclotron, linac, betatron, phase stability, synchrotron, strong focusing, colliders, …

Applications
physics, biology, medicine, industry, art, …

Experiment design and luminosity
cross sections, event rate, pulse structure

Longitudinal dynamics
acceleration, phase stability, buckets, synchrotron oscillations

Transverse dynamics
focusing, betatron oscillations, emittance, dispersion, chromaticity

Advanced topics
synchrotron radiation, current research areas, …

Practical matters

The **web site** bitbucket.org/gist/apufe22 is the main course hub. Updated with current information.

Large or non-public **files shared** on Fermilab Microsoft OneDrive or Google Drive

Lectures consist of
- Presentations
- Discussions in small groups
- Exercises and problems
- A few breaks

Please keep **microphone off** and **video on**, if possible. I would like to see you. **Show your name** in the window, so we can get to know each other better.

Raise electronic hand for **questions** or **comments**. However, please do not hesitate to interrupt for clarifications if I don't see it.

Please **turn off distractions** (e-mail, cell phone, etc.)

What technologies do you have available for **whiteboard sharing** (tablet, …)?

Questions?