Understanding basic principles of particle accelerators

30th May – 3rd June 2022

Monday 30th May:

9h-12h History and basic principles of accelerators - Nicolas Delerue – IJCLab – Bât 108, Grande salle 108

12h15-12h45: Visit of ThomX – Iglex

Tuesday 31st May:

9h-10h30: Machine detector Interface and applications of accelerators - Nicolas Delerue - IJCLab – Bât 108, Grande salle 108

10h30-12h00: Zoom on the LHC - Nicolas Delerue – IJCLab – Bât 108, Grande salle 108

12h15-12h45: Visit of ACO (Orsay Collider Ring) – Bât 201

Wednesday 1st June:

9h-12h: Optics and beam dynamics - 3h - Luc Perrot – IJCLab – Bât 108, Grande salle 108

Thursday 2nd June:

9h-10h30: [In French] Technologies associées:  Ultra-Vide - Bruno Mercier ;

10h30-12h00: Related technologies : Radiofrequency and Cryogenics - Guillaume Martinet – IJCLab – Bât 108, Grande salle 108

12h15-12h45: Visit of SCALP

Friday 3rd June:

9h-10h30: [In English] Zoom on SPIRAL2 – Luc Perrot – IJCLab – Bât 108, Grande salle 108

10h30-12h00: Related technologies : Radiofrequency and Cryogenics - David Longuevergne – IJCLab – Bât 108, Grande salle 108

12h15-12h45: Visit of Supratech – IPN

1) History and basic principles of accelerators

A. History of particle accelerators

i Crookes tubes  
 ii Rutherford experiment

iii Van de Graaff generators, accelerators and tandem

iv Cockroft Walton generators  
 v Lawrence’s cyclotron

vi AdA

vii Accelerators since 1965 and Livingston charts

B. Basic principles

i Particle sources (electrons, protons, ions)

ii Acceleration of particle

iia Accelerating cavities for electrons

iib Alvarez structures

iic RFQ

iii Steering the particles : magnets

iv Rings

v Emittance

vi Beam diagnostics

via Beam-matter interaction

vib Radiation emitted by the beam

C. Challenges

i Energy

ii Intensity

iii Stability

iii Reliability

iv The future ? New acceleration techniques, plasma acceleration

2) Radiofrequency and Superconductivity/Cryogenics

1. **RF (Guillaume Martinet) 1h**
   1. RF systems : fundamental technology for modern accelerators
      1. Why RF structures for particle acceleration?
      2. Basics concept of RF structures
      3. Description of different RF structures and their applications
   2. Integration of RF structures
      1. Choice of RF Frequency
      2. RF Components
      3. Command and control accelerating RF structures under beam loading
2. **Superconductivity/Cryogenics (David Longuevergne) 1h**
   1. Why superconductivity for acceleration ?
      1. Magnets
      2. Accelerating Cavities
   2. Superconductivity : models and limitations
      1. 2 fluids model (London theory)
      2. Ginsburg-Landau theory
      3. BCS theory (Bardeen Cooper Schrieffer)
   3. Superconducting materials (properties and what they are good for)
   4. Cryogenics
      1. Cryostat and interfaces
      2. What’s the right temperature of operation?

# Operation of an accelerator (from perturbations to failures) 30 min

* 1. Perturbation during operation
     1. Frequency perturbations (Microphonics, Lorentz detuning)
     2. Multipacting
     3. Field emission
     4. Q-disease
  2. Failures during operation
     1. Leaks
     2. Breakdown (or Quench)
     3. Others
  3. Reliability (statistics)

# Visit of infrastructures (30 min)

3) Optics and beam dynamics

4) Zoom on the LHC and SPIRAL2

A. Zoom on the LHC

I LHC injection chain

(Ia) Linac 2

(Ib) PS and PSB ; Batch Compression and Merging and Splitting at the CERN PS

(Ic) SPS

(Id) RF frequency issues

II Injection chain limitations and upgrade

III The LHC

LHC performance during run 1

Issues : electron cloud, UFOs

Machine protection system

LHC Restart

B. Zoom on SPIRAL2

- Overview of SPIRAL2 accelerator

- Ion sources

- Low Energy Transport Lines

- RFQ

- Medium Energy Transport Lines

- Superconducting linac

- High-Energy Transport Lines

- NFS and S3

5) [In French] Technologies associées:  Introduction to **High** Vacuuminaccelerators**.**

I introduction

II vacuum basis

II-1 Kinetic behavior of gas molecules

II-2 impingement rate

II-3 Residence time/Mean free path

III vacuum in accelerators

III-1 interaction faisceau gaz

III-1-a Coulomb scattering

III-1-b Bremsstrahlung

III-1-C Ionization energy loss

III-1- ions accumulation

III-2 Interaction particules surface

III-2-a Synchrotron radiation and Photon stimulated desorption

III-2-b Ion stimulated Desorption

III-2-c Electron-cloud and Electron stimulated Desorption

III-2-d Other interaction

IV Technologie evolution

IV-1 Pressure distribution in accelerators

IV-2 Distributed pumping

IV-2-1 pumping Getter

IV-2-2 NEG coating

Some examples

6) Machine detector Interface and applications of accelerators

A. Machine detector-interface in particle physics

i Integration of the detector in the machine

ii Luminosity measurement

B. Applications of accelerators beyond HEP and Nuclear Physics

i Applications of synchrotron radiation

ii Medical applications  
 Cancer treatment, radioisotopes production, protein structure

iii Neutrons

iv Accelerator Mass spectrometry and radiocarbon dating

v An accelerator to burn nuclear waste