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