Understanding basic principles of particle accelerators

12th- 17th June 2017

Monday 12th June:
9h-12h History and basic principles of accelerators - Nicolas Delerue - LAL – Bât 200, salle 101
12h15-12h45: Visit of ACO (Orsay Collider Ring) – Bât 201

Tuesday 13th June:
9h-12h: Related technologies : Radiofrequency and Cryogenics - Guillaume Martinet et David Longuevergne – IPN Bât 102 – salle de réunion
12h15-12h45: Visit of Supratech – IPN

Wednesday 14th June:
9h-12h: Optics and beam dynamics - 3h - Jean-Luc Biarotte et Luc Perrot – IPN Bât 102 - salle de réunion

Thursday 15th June:
9h-10h20: Zoom on the LHC - Nicolas Delerue – LAL – Bât 209A, salle verte
10h30-12h: Zoom on SPIRAL2 – Luc Perrot – LAL – Bât 209A, salle verte
12h15-12h45 Visit of Tandem/ALTO – IPN – Bât 109.

Friday 16th June:
9h-10h30: [In French] Technologies associées: Ultra-Vide - Bruno Mercier ;
10h45-12h: [In English] Machine detector Interface and applications of accelerators - Nicolas Delerue - LAL – Bât 208, salle 100
12h15-12h45: Visit of the Photoinjector PHIL – LAL, Bât 200

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

a. RF systems : fundamental technology for modern accelerators
   i. Why RF structures for particle acceleration?
   ii. Basics concept of RF structures
   iii. Description of different RF structures and their applications

b. Integration of RF structures
   i. Choice of RF Frequency
   ii. RF Components
   iii. Command and control accelerating RF structures under beam loading

2. Superconductivity/Cryogenics (David Longuevergne) 1h

a. Why superconductivity for acceleration ?
   i. Magnets

        ii. Accelerating Cavities
    b. Superconductivity : models and limitations
        i. 2 fluids model (London theory)
        ii. Ginsburg-Landau theory
        iii. BCS theory (Bardeen Cooper Schrieffer)
    c. Superconducting materials (properties and what they are good for)
    d. Cryogenics
        i. Cryostat and interfaces
        ii. What's the right temperature of operation?

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

    a. Perturbation during operation
        i. Frequency perturbations (Microphonics, Lorentz detuning)
        ii. Multipacting
        iii. Field emission
        iv. Q-disease
    b. Failures during operation
        i. Leaks
        ii. Breakdown (or Quench)
        iii. Others
    c. Reliability (statistics)

4. 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** Vacuum in accelerators.

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