Second synchrotron instrumentation

JUAS Course 2

Group 4

24.02.2025

2nd synchrotron

Gamma [2.066, 107.6]
Beta [0.875, 0.999]

Beam current measurement

Proton energy: 1 GeV - 100 GeV

Beam current: 0.191 A - 0.219 A

→ no Faraday cups

→ non-invasive measurements are needed

Bandwidth: 6 MHz - 5.25 MHz = 0.75 MHz

→ we can use a Fast Current Transformer (FCT)

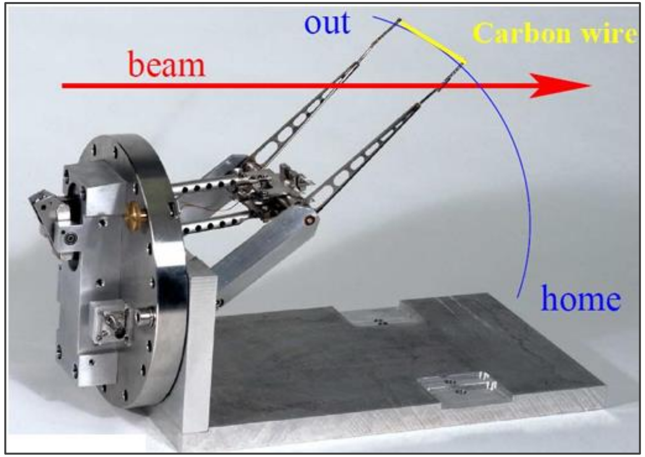
Rise time: 212 ns

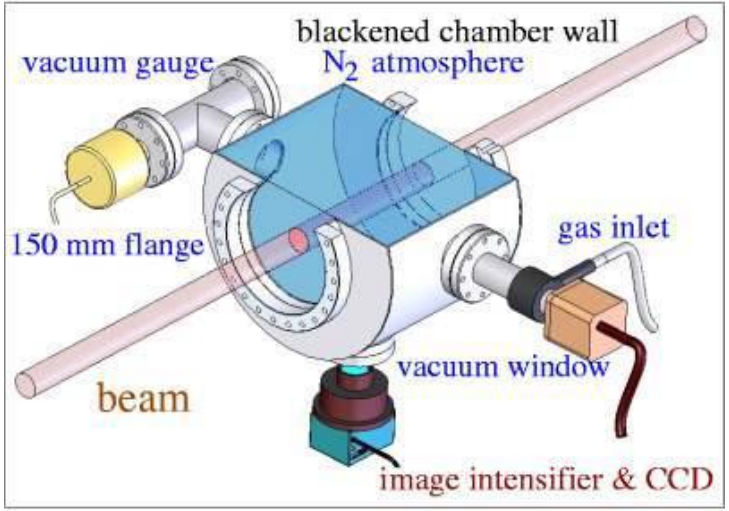
Beam transverse profile

Proton 1GeV-100GeV, 200 mA
=> few SR, heat

- **Optical** Transition Radiation: not enough synchrotron radiation
- **SEM-Grid**: Not fitted for synchrotron (heat)
- **Linear wire:** for low energy protons (because of heat)

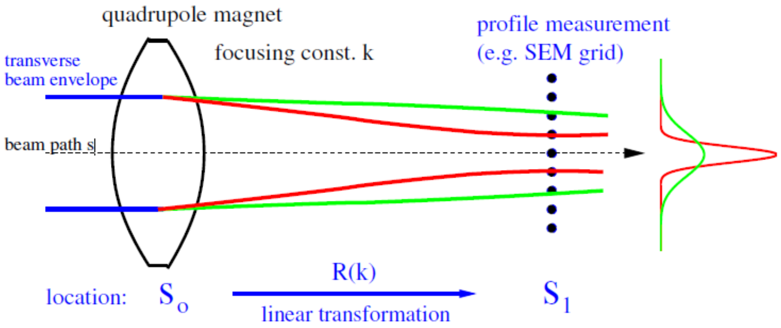
- **Fast wire scanner**
  - Possible it is for high E synchrotron and almost none destructive
- **Beam Induced Fluorescence Monitor**:
  - Easier to install than Ionization Profile Monitor
  - Drawback: sensitive to straylight and ionizing radiation
- **Scintillation screens**:
  - Invasive system
  - Damage with time
  - cheap (in case of malfunction)





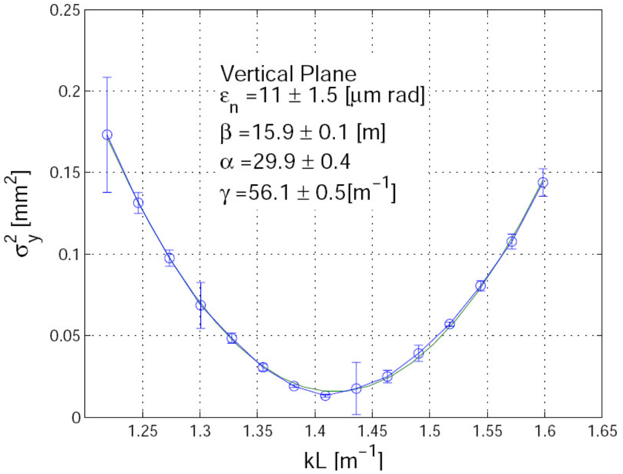
Transverse Emittance Measurement

- Quadrupole variation (non-destructive method)
- Expected emittance with betatron function 10 m using 3-1 mm transverse size -> 0.9-0.1 mm.rad
- Assumptions: well aligned beam, elliptical shape



$$\sigma_{11}(K) = a\,(K-b)^2 + c = aK^2 - 2abK + ab^2 + c.$$

$$\epsilon = \sqrt{\det \boldsymbol{\sigma}(0)} = \sqrt{\sigma_{11}(0)\sigma_{22}(0) - \sigma_{12}^2(0)} = \frac{\sqrt{ac}}{L^2}$$



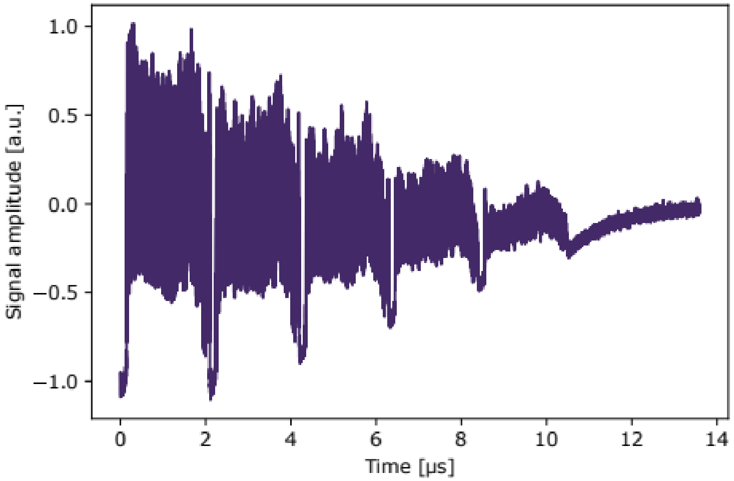
Measuring longitudinal parameters

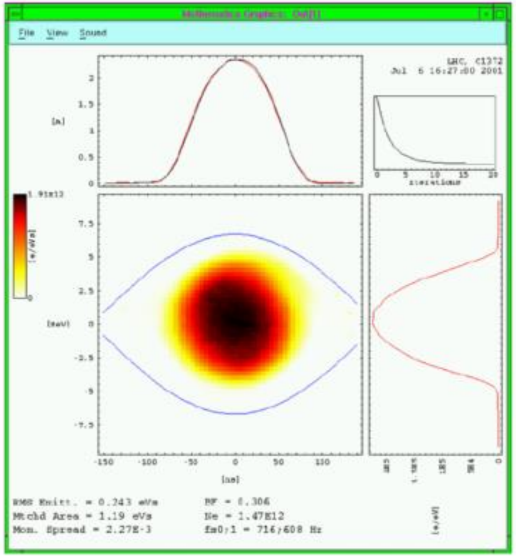
7.3 μs < t_{rev} < 8.4 μs

~ 120 kHz

High current : **Wall Current Monitors** (~ GHz bandwidth)

- **Bunch length + profile measurements, ns resolution** (bunch length 10 ns)
- Synchrotron freq ~ 100 Hz, beam stored ~ 3-4 s
  emittance by tomography





The Beam Position Monitor: Capacitive Linear Cut (Shoe Box)

- Frequency range compatibility, Linear position sensitivity, Non-destructive
- Cut-off frequency : 31.8 MHz

  ↓ **BPM operates in high pass regime**

- Transfer impedance : Zt (f = 5.25 MHz) = 0.175 Ω → Umin = 0.033 V

  Zt (f = 6.00 MHz) = 0.200 Ω → Umax = 0.044 V

  Expected Signal Strength

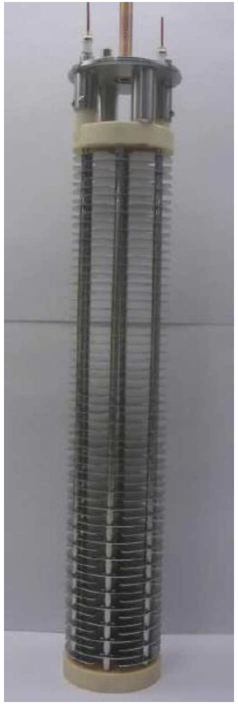
- Thermal Noise Voltage : 0.78 μV

Beam Loss

- Scintillators
  - fast response (ex: transition)
    - interlock signal
  - optical signals : chap and andy

- Ionization Chambers
  - accurate dose measurement
    - security
  - transverse beam emittance
    - fast wire

Scintillators



Ionization Chambers

Thanks for your attention