

Emittance measurement section design and related studies

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Energètiques

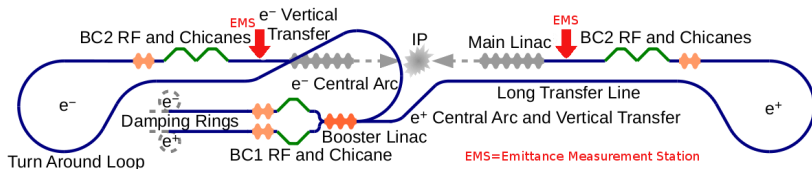
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Emittance measurement at the exit of the RTML

Previously a LW emittance measurement section at the exit of the RTML beamline was designed and proposed for the CDR.

| Property | Symbol | Value | Unit |
|----------------------|-------------------------------------|---------|---------------|
| Energy | E_0 | 9 | GeV |
| Bunch length | σ_s | 44 | μm |
| Total energy spread | σ_E | < 1.7 | % |
| Normalised emittance | $\varepsilon_{n,x}$ | < 600 | nm rad |
| | $\varepsilon_{n,y}$ | < 10 | nm rad |
| Emittance error | $\delta\varepsilon_x/\varepsilon_x$ | < 10 | % |
| | $\delta\varepsilon_y/\varepsilon_y$ | < 10 | % |



Measurement beamline

- The transverse emittance is reconstructed from the beam size measurements of 3+1 monitors.
- The designed measurement beamline is based on a 4-FODO of a total length of 81 m.

$$\sigma = \begin{pmatrix} \Sigma_{xx} & 0 \\ 0 & \Sigma_{yy} \end{pmatrix}$$

$$\varepsilon_x = \sqrt{\det \Sigma_{0,xx}}$$

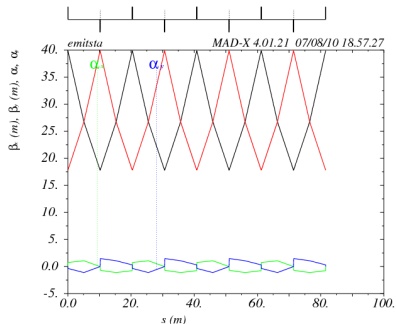
$$= \sqrt{(\sigma_0)_{11}(\sigma_0)_{22} - (\sigma_0)_{12}^2}$$

$$= \sqrt{\langle x^2 \rangle \langle x'^2 \rangle - \langle xx' \rangle^2}$$

$$(\sigma_i)_{11} = (R_i)_{11}^2 (\sigma_0)_{11} - 2(R_i)_{11}(R_i)_{12} (\sigma_0)_{12} + (R_i)_{12}^2 (\sigma_0)_{22}$$

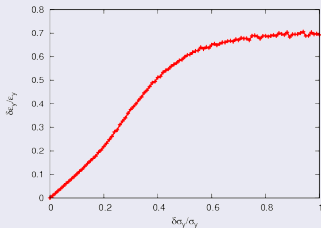
$i = x, y$

(PAC 2011 paper in collaboration with D.Schulte and F.Stulle.)



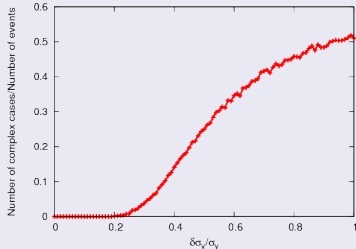
Error simulation studies

Measurement error



- The maximum acceptable error in the emittance measurement is $< 10\%$
- From the plot, this implies a beam size error $< 10\%$
- The required vertical beam size precision is $< 0.5\mu\text{m}$

Non-physical cases ($\epsilon_{x,y}^2 < 0$)



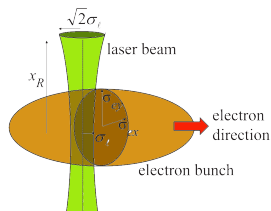
- The number of non-physical solutions is zero if the beam size error is $< 20\%$

Laser Wire System

The laser wire is a suitable and non-invasive method of beam size measurement, since it provides:

- Possibility of beam size measurements as small as $0.5 \mu\text{m}$.
- High precision of the beam size measurement.
- Based on the inverse Compton scattering of laser photons on electrons or positrons of the collider beam.

| Parameter | Mode locked | Q-switched |
|--|------------------|-------------------|
| Laser wavelength | 532 nm | 532 nm |
| $f\#$ | 6 | 6 |
| Mode quality factor M^2 | 1 | 1.5 |
| Rayleigh range z_R | $90 \mu\text{m}$ | $820 \mu\text{m}$ |
| Laser spot size σ_l | $3 \mu\text{m}$ | $5 \mu\text{m}$ |
| Instantaneous laser power P_l | 440 MW | 4 MW |
| Laser pulse duration τ_l | 0.15 ps | 5 ns |
| Pulse repetition frequency f_l | 2 GHz | 50 Hz |
| Compton photons per laser pulse N_γ (for $\Delta = 0$) | 3200 | 250 |



(IPAC 2011 paper in collaboration with D.Schulte, F.Stulle, G.Blair and T.Aumeyr.)

Future CLIC - UPC - JAI RHUL collaboration

Planned work in the Working Package-Clic Design (WP-CD):

- Study on location of LW monitors throughout the machine. After RTML and entrance of BDS.
- Design of magnetic lattice of the emittance measurement section.
- Simulation of statistical and machine-related errors.
- Estimates of backgrounds.
- Proposal of laser schemes (mode seed locked laser, Q-switched laser) and estimates of laser parameters.

Participants of the collaboration:

- from UPC: Yuri Kubyshin, Hèctor Garcia (partially), perhaps a future student.
- from JAI-RHUL: Grahame Blair, Thomas Aumeyr.

(more details given in talk: RHUL-BDS optics, background and emittance measurement)

Collaboration working information sheet

Collaborators: general information and resource estimate

(31/10/2011)

Institute: UPC - Universitat Politècnica de Catalunya
(Technical University of Catalonia)

Main contacts: Yuri Kubyshin

CERN responsible: Rogelio Tomás, Daniel Schulte

Activity/work package/task: Beam Physics (???); intersection with WP CTC-006-beam instrumentation Task 3

Technical subject: Proposal of lattices and LW systems of emittance measurement sections throughout the machine, simulation of errors

Working arrangement: Work in collaboration with the CERN BD group and JAI-RHUL (Grahame Blair), PhD student at CERN, visits and common meetings

Funding status: No secured funds at the moment, applying for 2012-13

Formal agreement: ???

Expected resources

| | 2012 | 2013 | 2014 | 2015 | 2016 |
|---------------------------------------|------|------|------|------|------|
| Material budget [CHF at current rate] | 4000 | 5000 | 4000 | 4000 | 4000 |
| Manpower at institute [FTEyears] | 0,5 | 0,5 | 1 | 1 | 1 |
| Manpower at CERN [FTEyears] | 0,5 | 0,5 | 0,5 | 0,5 | 0 |