International
UON Collider
Collaboration

Collider Ring Parameters

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- Luminosity
- Collider Ring Parameters
- Not (yet) in List of Collider Parameters or in other Presentations

Luminosity

- Luminosity per IP given by: $L = \frac{N^2}{4\pi\ \varepsilon_{ph}\beta^*} f_{hg}\ f_r \frac{\gamma\ T_\mu}{2T_{rev}}$

  for round muon beams and one bunch per beam and with
  - f_r the complex repetition rate, N the number of muons in bunch
  - $\varepsilon_{ph} = \varepsilon_n/\gamma$ the physical rms emittance with $\varepsilon_n = 27.5\ \mu\mathrm{m}$ the normalized rms emittance and γ the relativistic Lorentz factor
  - β^* the Twiss betatron function at the IP, σ_z the rms bunch length
  - $T_\mu \approx 2.2\ \mu s$ the muon life-time at rest, T_{rev} the revolution time
  - f_{hg} the "hourglass" luminosity reduction factor a function of σ_z/β^* (for short bunches $f_{hg}(\sigma_z \ll \beta^*) \approx 1$)
- Assumptions
  - Bunch length $\sigma_z = \varepsilon_L/(\gamma\ \sigma_\delta)$ expressed by geometric longitudinal rms emittance ε_L and rms relative momentum spread
  - $\beta^* = \sigma_z$ giving moderate luminosity loss due to hourglass effect $f_{hg} = 0.758$
  - Revolution time $T_{rev} = 2\pi \frac{\gamma\ E_\mu}{e\ c^2\ \bar{B}}$ with $E_\mu = 105.658\ \mathrm{MeV}$ the muon rest energy and $\bar{B}$ the average bending field

→ gives luminosity per IP $L = \frac{e\ c^2\ T_\mu}{16\ \pi^2\ E_\mu} \frac{f_r\ N^2\ \gamma^2\ \sigma_\delta\ \bar{B}\ f_{hg}}{\varepsilon_n\ \varepsilon_L}$

Luminosity

Incoming beam
- Emittances determined by ionization cooling
- Luminosity per beam power increase with beam power ∝ $(f_r\, N\, \gamma)$ under assumptions made
- Large bunch population N gives higher lumi and corresponds to lower repetition rate for given beam power => nominal N/ε_n close to beam-beam limit

Constant $11.83\ \mathrm{T}^{-1}$

$$L = \frac{e\, c^2\, T_\mu}{16\, \pi^2\, E_\mu} \frac{(f_r\, N\, \gamma)\, N\, \gamma}{\varepsilon_n\, \varepsilon_L} \sigma_\delta\, \bar{B}\, f_{hg}$$

Few collider parameters to maximise luminosity
- Large (average bending) magnetic field helps
- Large longitudinal acceptance to operate with large rms momentum spread σ_δ => corresponds to small $\beta^* = \sigma_z$ - both a challenge for lattice design
- Consequence of assumption and optimizations made:
  - Bunch length σ_z and β^* decrease with energy
  - Divergence at IP independent of energy!
  - Lattice design becomes more difficult for higher energies (higher beam rigidity, longer innertriolet, more chromatic effects …)

Nominal 10 TeV com Collider Parameters

Parameter	Symbol	Value
Beam energy	E	5000 GeV
Relativistic Lorentz factor	γ	47 322
Circumference	C	$\approx$ 10 000 m
Magnetic (average bending) field	$\bar{B}$	$\approx$ 10.48 T
Repetition rate	f_r	5 Hz
Bunch intensity (one bunch per beam)	N_μ	$1.8 \cdot 10^{12}$
Beam power for both beams together	P_B	14.4 MW
Power from muon decays to W absorber	P_L	$\approx$ 5 MW
Power from decays to cold mass (40 mm W)		$\approx$ 5 W/m
Normalized transverse rms emittance	ε_n	27.5 μm
Physical transverse rms emittance	ε_{ph}	0.581 nm
Long. geometric rms emittance $\gamma\ \sigma_z\ \sigma_\delta$	ε_L	77 mm
Rms relative momentum spread	$\sigma_\delta = \sigma_p/p$	$1 \cdot 10^{-3}$
Rms bunch length	σ_z	1.65 mm ($\approx$ 5.5 ps)
Twiss betatron function at the IP	β^*	1.65 mm
Rms beam size at IP	$\sigma_{\perp,IP}$	0.98 μm
Luminosity	L	$17.2 \cdot 10^{34}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}$
Beam-beam tune shift per IP		0.071

Not (yet?) in List of Collider Parameters or covered in other Presentations

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CERN

- Details on optics as Twiss functions, (maximum) chromatic aberrations, working point .. .
- Radial built in presentation on MDI
- Assumptions on maximum magnetic fields and gradients
  - $$\left(\frac{1}{\rho} + k\left(5\sqrt{\beta\,\varepsilon_{ph} + (\sigma_\delta\, D)^2} + d\right)\right)\frac{p}{q}\ \begin{cases} < 20\ \ \mathrm{T\ \ for\ region\ close\ to\ IP} \\ < 16\ \mathrm{T\ for\ other\ regions\ (arc)} \end{cases}$$
  - Similar relation for sextupoles
  - To be discussed and coordinated further (aperture in arc, maximum fields, mechanical stress management)
- Parameters relevant for neutrino radiation
  - Maximum equivalent dose at Earth's surface ($10\ \mu\mathrm{Sv/year}$ for site in Europe)
  - Computations (FLUKA results, analythical estimates and folding integrals …)
  - Longitudinal magnetic field profile around interconnects (now hard edge model with 30 cm between magnets) – input from magnets working group required
  - Parameters for machine wobbling: 1 mrad amplitude ….. (feasibility?)
  - Depth of tunnel
- Impedances
- Cryogenic system
- Vacuum system and needs