FCC BACKGROUND STUDIES

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Including information from:

OVERVIEW

FCC precision will be influenced by background

- Background can cause mis-reconstructions and issues with detector triggering
- The importance of background varies with beam energies, emittance, bunch particle type etc.

Understanding beam configuration and background at FCC will allow us to optimize detector placement and reduce the influence of background events

GENERATING EVENTS WITH GUINEA-PIG

https://gitlab.cern.ch/clic-software/guinea-pig

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Generator of Unwanted Interactions for Numerical Experiment Analysis

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Generator of Unwanted Interactions for Numerical Experiment Analysis

- Simulates the interaction of two colliding ultra-relativistic beams containing electrons, positrons and photons (others can be approximated using tricks)
- Made for single collisions, can be used for repeated collisions at some level

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Includes:

Pinching of the beams • Emission of beamstrahlung • Initial state radiation • Production of incoherent pair background • Bremsstrahlung • Beam size effect • Production of coherent pair background • Production of hadronic background (also minijets)

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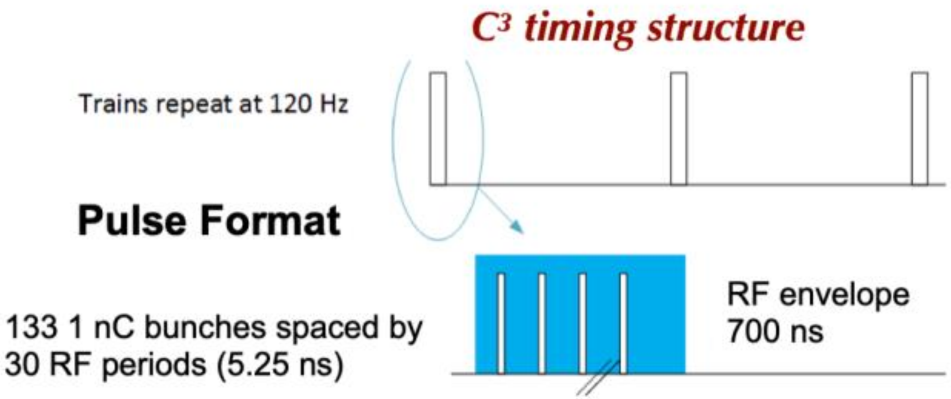
C3 PARAMETERS [250 GEV COM]

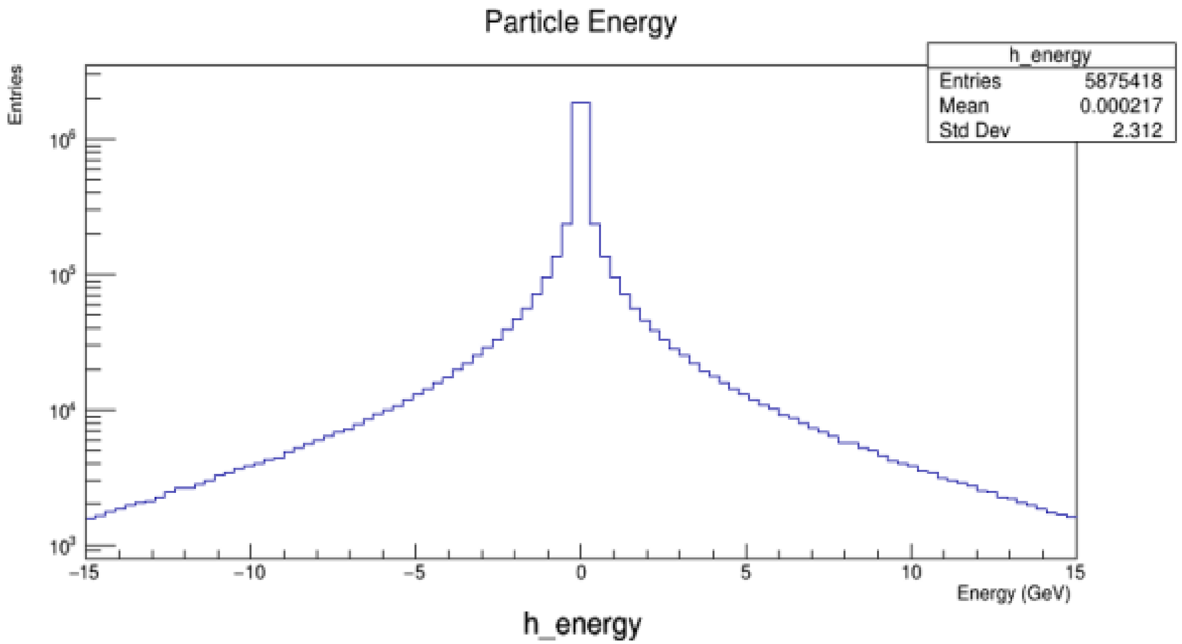


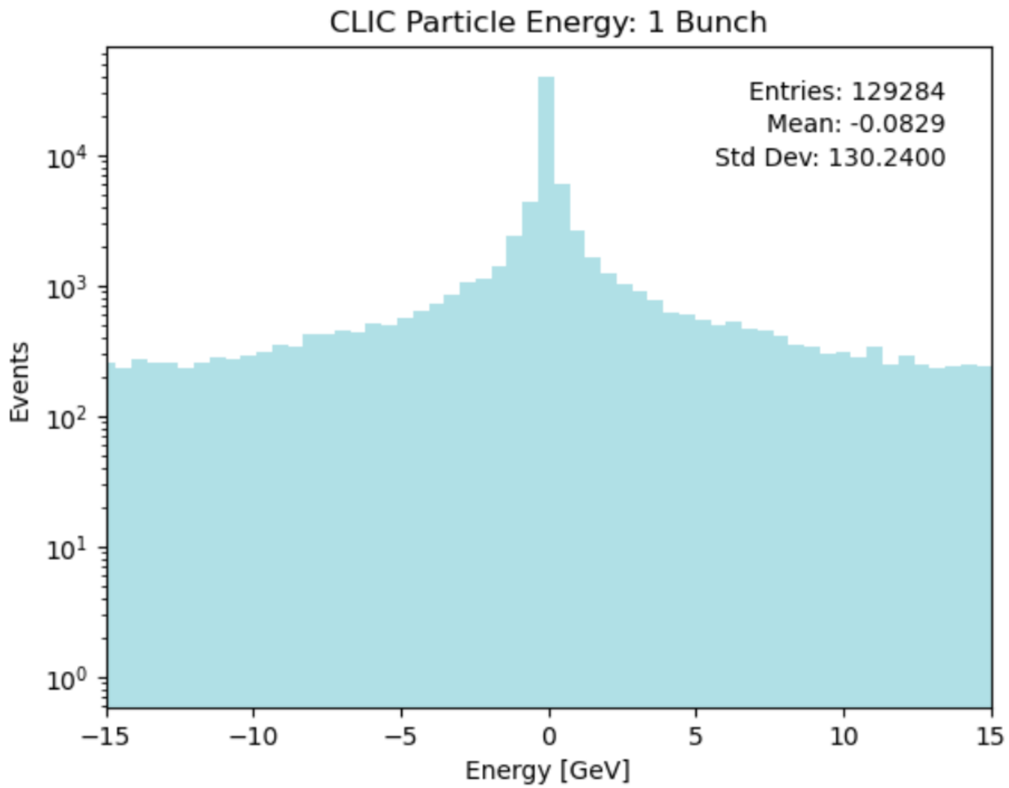
Parameter	Units	Value
β_x^*	mm	12
β_y^*	mm	0.12
$\epsilon_{N,x}^*$	nm	900
$\epsilon_{N,y}^*$	nm	20
σ_x^*	nm	210.12
σ_y^*	nm	3.13
σ_z^*	µm	100
n_b		133
f_{rep}	Hz	120
N		$6.25 \cdot 10^9$
θ_c	rad	0.014

	Initial Tests	Emilio's Values
Energy spread	0.1%	0.3%
Energy spread distribution	Gaussian	Flat
Offset in x direction (nm)	0	5
Offset in y direction (nm)	0	0.2
Waist shift in x direction (µm)	0	0
Waist shift in y direction (µm)	0	0
Crossing angles (not compensated by crab scheme)	0	0

[Lindsey Gray, Collider Background Studies, 2024]

GP RESULTS: ENERGY

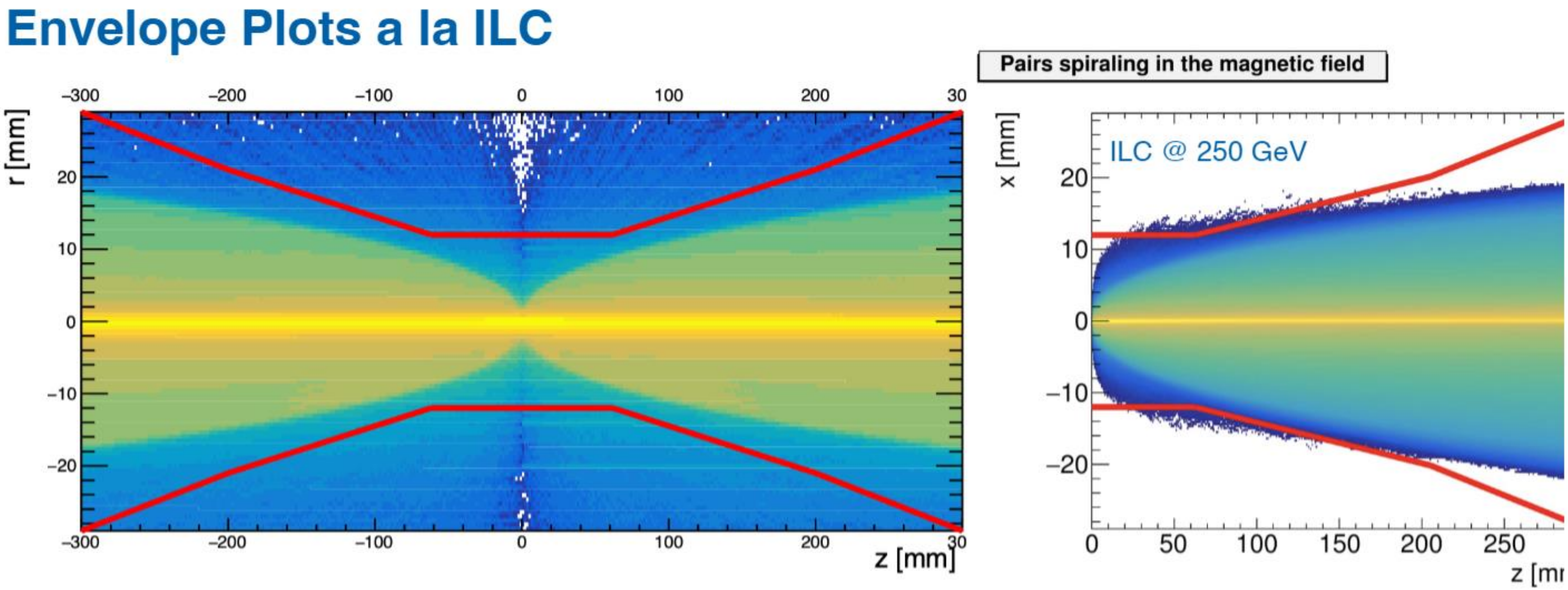




133 bunches configured with C^3 parameters

[Lindsey Gray, Collider Background Studies, 2024]

PRODUCING ENVELOPE PLOTS



[Lindsey Gray, Collider Background Studies, 2024]

FCC-EE BEAM PARAMETERS

Beam energy	[GeV]	45.6	80	120	182.5
Layout		PA31-1.0			
# of IPs		4			
Circumference	[km]	90.836848			
Bending radius of arc dipole	[km]	9.937			
Energy loss / turn	[GeV]	0.0391	0.370	1.869	10.0
SR power / beam	[MW]	50			
Beam current	[mA]	1280	135	26.7	5.00
Bunches / beam		10000	880	248	40
Bunch population	[10^{11}]	2.43	2.91	2.04	2.37
Horizontal emittance ε_x	[nm]	0.71	2.16	0.64	1.49
Vertical emittance ε_y	[pm]	1.42	4.32	1.29	2.98
Arc cell		Long 90/90		90/90	
Momentum compaction α_p	[10^{-6}]	28.5		7.33	
Arc sextupole families		75		146	
$\beta^*_{x/y}$	[mm]	100 / 0.8	200 / 1.0	300 / 1.0	1000 / 1.6
Transverse tunes/IP $Q_{x/y}$		53.563 / 53.600		100.565 / 98.595	
Energy spread (SR/BS) σ_δ	[%]	0.038 / 0.132	0.069 / 0.154	0.103 / 0.185	0.157 / 0.221
Bunch length (SR/BS) σ_z	[mm]	4.38 / 15.4	3.55 / 8.01	3.34 / 6.00	1.94 / 2.74
RF voltage 400/800 MHz	[GV]	0.120 / 0	1.0 / 0	2.08 / 0	2.1 / 9.2
Harmonic number for 400 MHz		121648			
RF freuqeuncy (400 MHz)	MHz	400.793257			
Synchrotron tune Q_s		0.0370	0.0801	0.0328	0.0826
Long. damping time	[turns]	1168	217	64.5	18.5
RF acceptance	[%]	1.6	3.4	1.9	3.0
Energy acceptance (DA)	[%]	±1.3	±1.3	±1.7	-2.8 +2.5
Beam-beam ξ_x/ξ_y[a]		0.0023 / 0.135	0.011 / 0.125	0.014 / 0.131	0.093 / 0.140
Luminosity / IP	[10^{34}/cm^{2}s]	182	19.4	7.26	1.25
Lifetime (q + BS + lattice)	[sec]	840	–	< 1065	< 4062
Lifetime (lum)	[sec]	1129	1070	596	741

[a] incl. hourglass.

K. Oide, Nov. 2022

https://indico.cern.ch/event/1203316/timetable/#5-fcc-accelerator-status-and-r

FCC-EE BEAM SIZE

Parameter [4 IPs, 91.2 km]	Z	WW	H (ZH)	ttbar
beam energy [GeV]	45	80	120	182.5
horizontal beta* [m]	0.1	0.2	0.3	1
vertical beta* [mm]	0.8	1	1	1.6
horizontal geometric emittance [nm]	0.71	2.17	0.64	1.49
vertical geom. emittance [pm]	1.42	4.34	1.29	2.98
horizontal rms IP spot size [μm]	8	21	14	39
vertical rms IP spot size [nm]	34	66	36	69

[T.Lefevre, FCC Beam instrumentation workshop – CERN]

parameter (4 IPs, $t_{rev} = 304\ \mu s$)	value
circumference [km]	91.18
max. beam energy [GeV]	182.5
max. beam current [mA]	1280
max. # of bunches/beam	10000
min. bunch spacing [ns]	25
max. bunch intensity [10^{11}]	2.43
min. H geometric emittance [nm]	0.71
min. V geometric emittance [pm]	1.42
min. H rms IP spot size [μm]	8
min. V rms IP spot size [nm]	34
min. rms bunch length SR / BS [mm]	1.95 / 2.75

https://indico.cern.ch/event/1209598/timetable/#9-overview-of-bi-studies-for-f

FCC-EE VARIABLES

Definitions: https://gitlab.cern.ch/clic-software/guinea-pig/-/blob/master/doc/GuineaPigManual.pdf

Variable	Definition	Input FCC [Z]
energy	The energy of the particles in GeV.	45.6
particles	The number of particles per bunch in units of $[10^{10}]$	24.3
espread	The RMS value of the relative energy spread of the beam particles.	.038
charge_sign	The relative sign of charge of the two beams is -1 for an e+e- collider	-1
sigma_x	The horizontal beamsize in nm	8000
sigma_y	The vertical beamsize in nm.	34
sigma_z	The longitudinal beamsize in μm, the RMS value	4380
beta_x	The horizontal beta function in mm	.1
beta_y	The vertical beta function in mm	.0008

NEXT STEPS

1. Cross check results with past studies
   - Reproduce C^3 and LEP results with Guinea-Pig

2. Verify FCC Parameters

3. Produce pair envelope plots
   - Begin to study FCC background and detector configuration

THANK YOU

BACKUP

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