ILC Software and Tools Workshop

GUINEA-PIG: Beam-beam interaction simulation status

Orsay, 2-4 May 2007

M. Alabau, P. Bambade, O. Dadoun, G. Le Meur, C. Rimbault, F. Touze
LAL - Orsay

D. Schulte
CERN - Genève

GUINEA-PIG:
Beam-beam interaction simulation status

Beam-Beam effect overview:

why a beam-beam simulation tool is needed

GUINEA-PIG Simulation Principle

GUINEA-PIG Improvement at LAL: GP++

Beam-Beam effects overview

When beams collide: mixing of classical and quantum effects

- **Bunches are deformed by electromagnetic attraction: *Disruption + pinch effect* ➔ enhancement of luminosity**
- **High beam-beam field (kT for ILC) ➔Energy loss in the form of synchrotron radiation: *beamstrahlung* (~3%)**

- **Secondary backgrounds**
  - **Electromagnetic : $e^+ + e^- \rightarrow \gamma\gamma \rightarrow e^+e^-$ ...**
  - **Hadronic : $e^+ + e^- \rightarrow \gamma\gamma \rightarrow$ hadrons**
- **Electromagnetic deflections**
  - **Effect on backgrounds (pairs ...)**
  - **Effect on luminosity measurements (Bhabha scattering)**
- **$e^+ e^-$ spin depolarisation effects...**

➔ need beam-beam simulation tool:
GUINEA-PIG* C code from D. Schulte

**Generator of Unwanted Interactions for Numerical Experiment Analysis -- Program Interfaced to Geant*

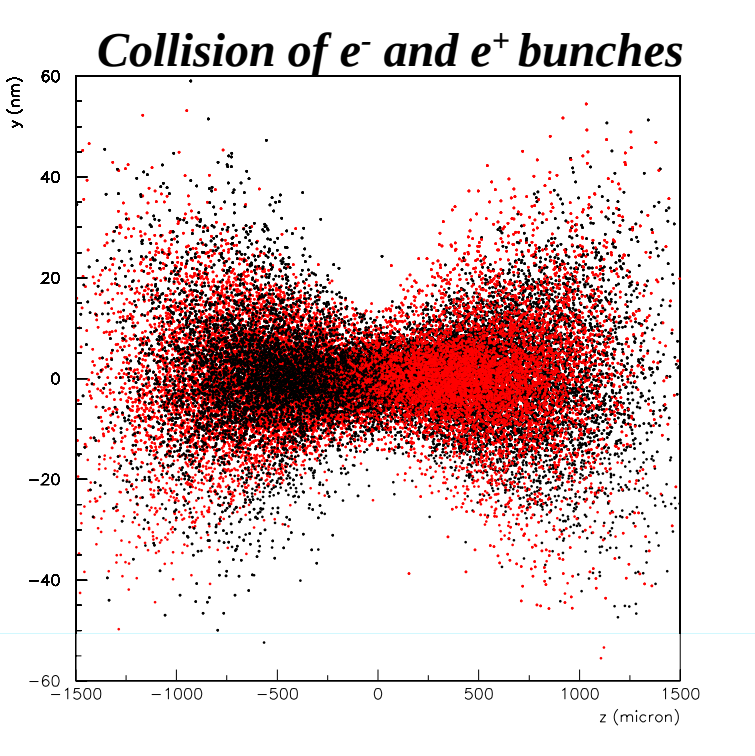
GUINEA-PIG simulation

• GP simulates the collision of two bunches (e^-e^+ or e^-e^-) *for a given set of input parameters: bunches sizes, emittances, energy, offset... or of two input files.*

+ computation parameters... specified in an ascii input file acc.dat

➔ *luminosity, distributions of beam particles after collision...*

• GP generates backgrounds *(bstrahlung γ, e^+e^- pairs, comptons ,hadrons...) ascii output files*



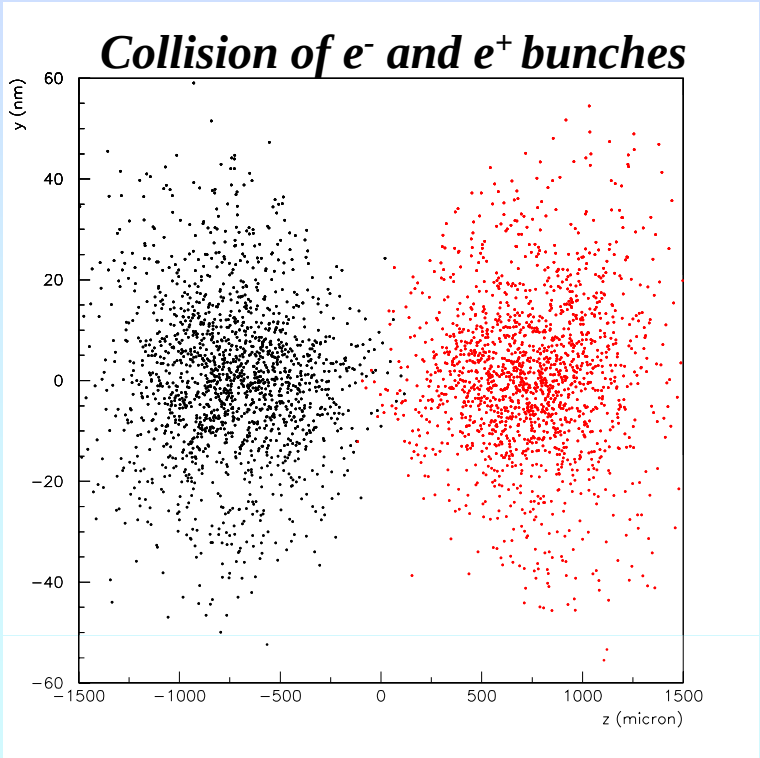
GUINEA-PIG simulation

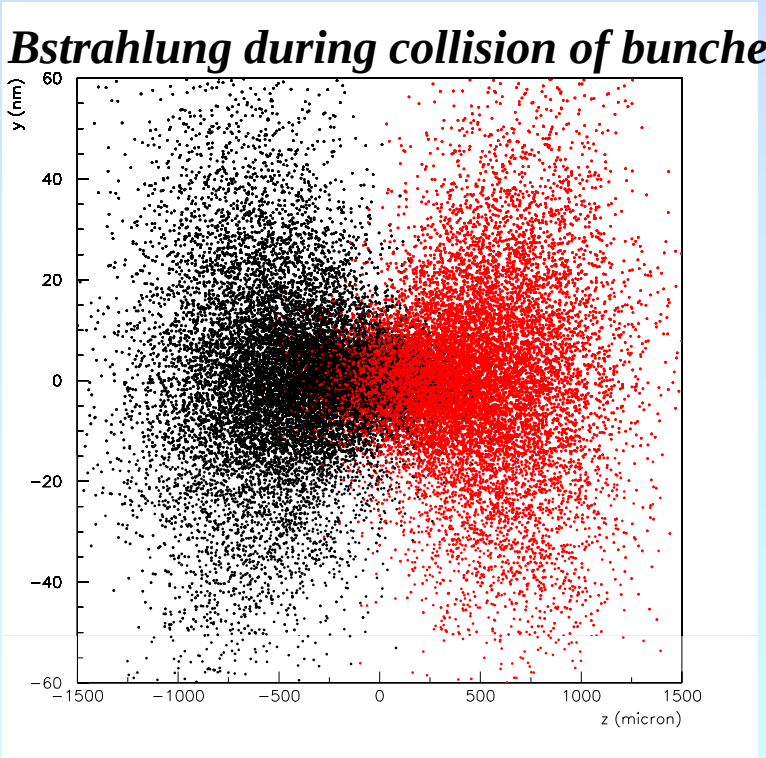
• GP simulates the collision of two bunches (e^-e^+ or e^-e^-) *for a given set of input parameters: bunches sizes, emittances, energy, charge, offset... or of two input files.*

+ computation parameters + options (espread, eloss, BG...)

➔ *luminosity, distributions of beam particles after collision...*

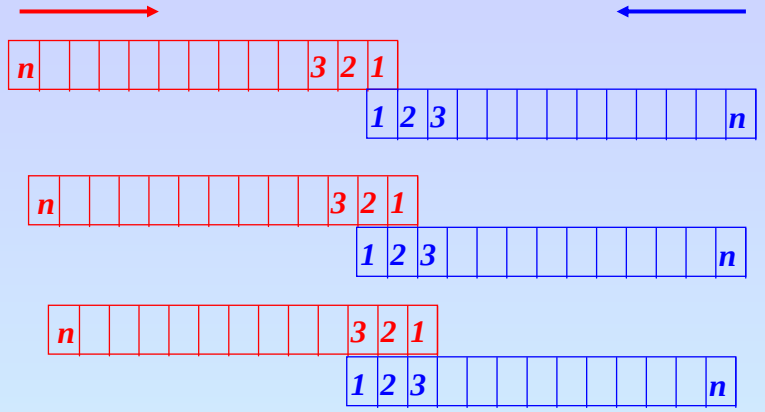
• GP generates backgrounds *(photons, e^+e^- pairs, comptons, hadrons...) ascii output files*





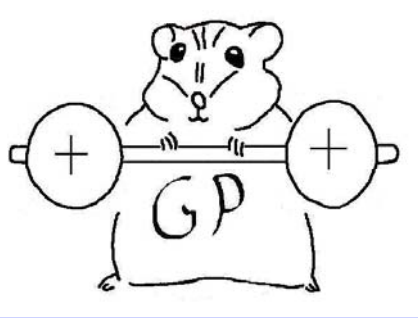
How does GUINEA-PIG work?

- Macro-particles replace particles (can be 10^5 Macro ⇔ 2 10^{10} part)
- Bunches cut into slices: a slice of one bunch interacts with a slice of the other bunch when they occupy the same transverse plan.
- Slices are moved longitudinally on a 3D grid



- For each slice-slice interaction:
  - Mpart distributed on the grid
  - Fields calculation
  - Mpart moved according to fields + photons generated
  - if photon asked:
    - photons distributed and moved on the grid
    - (if asked) pairs generated and moved.
  - e^-e^+ interaction: luminosity, bhabha ...
  - ...

GUINEA-PIG improvement: GP++



Open the Black Box...

- More safety and modularity
- To add new features: Bhabhas (done), depolarization, hadronic minijets (to be done)...
- To increase performance for high statistic simulation for ILC (GRID, parallelization?)

- GP++ can be run with a specified rndm seed: to perform independent runs on **GRID**
- Beam-beam effects on Bhabhas
- Work on an I/O interface which allows different formats
- Work on an automatic choice of the grid dimensions
- Work on feasibility of parallelization

To do: Implementation of all C version options in progress

Spin, hadronic minijets

rethink acc.dat...

See G. Le Meur presentation at ELC Workshop, 8-11 January 2007, Daresbury

Summary

- **Interaction Point: most important part of the machine and detector !**
- **GUINEA-PIG(++) is a nice tool to study backgrounds, beam-beam effects...**
- **Or can be used as a black box [e.g. PLACET-GP-BDSIM-MOKKA...]**

Recent progress on GP++ can be seen on: https://trac.lal.in2p3.fr/GuineaPig

GP Manual (extended to GP++): http://flc.web.lal.in2p3.fr/mdi/BBSIM/bbsim.html