Progress of ILPS in 2007

D. Schulte for the ILPS team

ILPS Tasks

- LAST, luminosity and alignment studies
  - Develop codes, understand imperfection models, develop alignment, feedback and tuning strategy, integrate studies
- COLSIM, collimation simulations
  - Develop codes and study/optimise collimation
- FMSIM, failure mode simulations
  - Determine relevant modes and study them
- BBSIM, beam-beam simulation code developement
  - Benchmarking/improvement, e.g. spin tracking
- HTGEN, halo and tail generation
  - Provide realistic tail/halo models
- BCDES, bunch compressor design (CLIC)
- PCDL, post collision diagnostics line
  - Diagnostics potential in post collision line
  - Develop line for CLIC

Some Comments

- The work of ILPS is fully integrated in the GDE and in the CLIC beam physics meetings
- A good part of the RDR chapter on accelerator physics has been contributed by ILPS
  - Even most of the editing
  - Organisation changes made work a bit difficult
- CLIC parameters changed
  - From 30 GHz to 12 GHZ
  - From 150MV/m to 100MV/m
  - Driven by beam physics, RF structure design and cost optimisation
  - Large input from ILPS
  - CTF3 collaboration extended to cover CLIC as well
- Due to the expected prolongation of EUROTeV people have been preparing to finish in 2008

BCDES

M. Pedrozzi (PSI)

Main Beam Bunch Compressors and Turn Around

Main Beam BC1 and BC2:

-> design BC1/BC2 using a Gaussian charge distribution and linear energy chirp, optimize with respect to CSR using a 1D CSR model ✓

-> confirm results using 3D CSR model
...almost finished for BC2, to be done for BC1 ✓

-> investigate CSR micro-bunch instability ✓

-> use a more realistic charge distribution including effects of wakefields, RF curvature, etc.
...RF curvature included, wakefields missing
...but details have to be studied within start-to-end simulations ✓

-> study influence of imperfections (energy jitter, alignment errors, ...)
..will be finished soon ✓

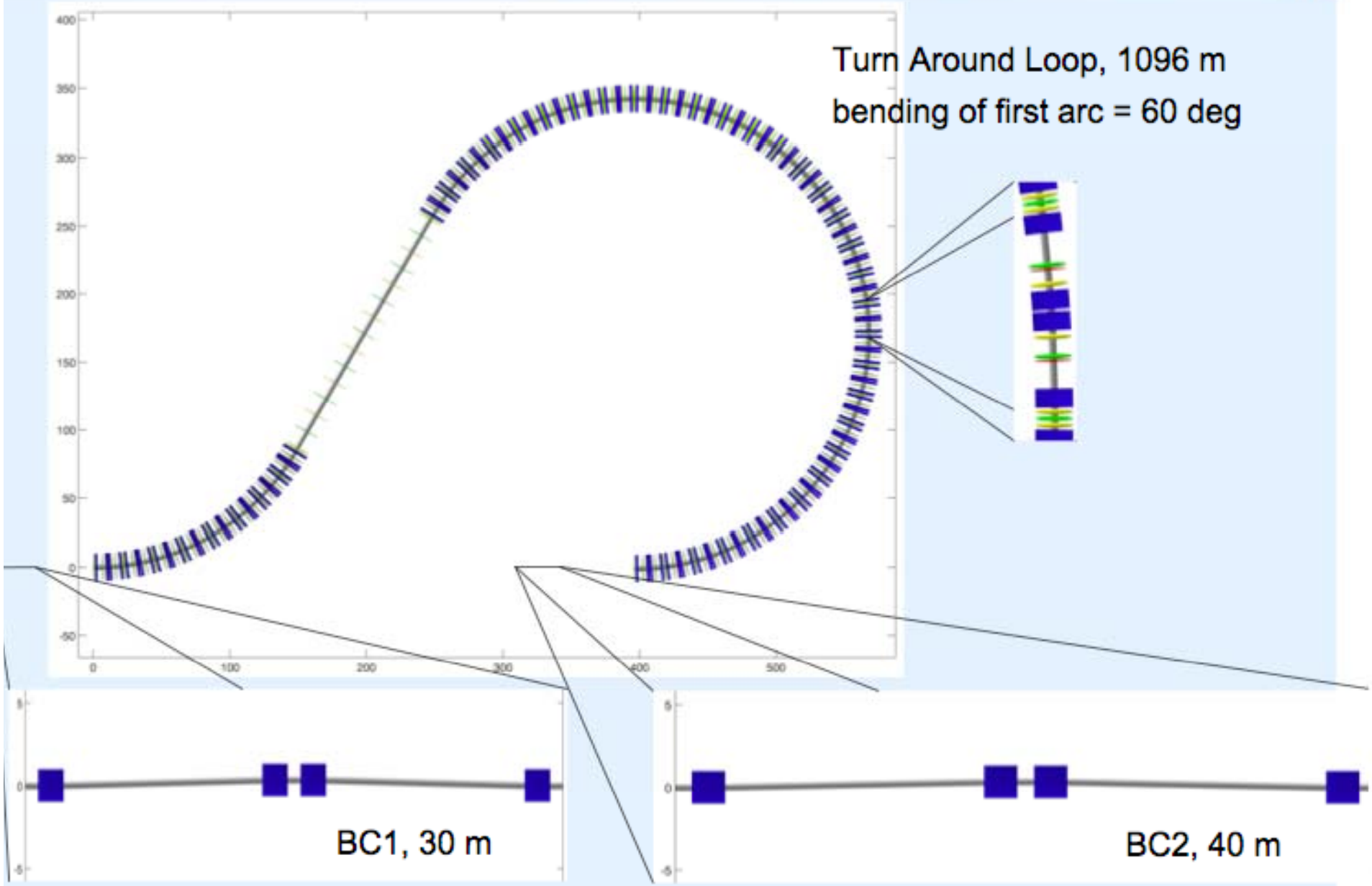
Main Beam 9GeV Turn Around Loop:

-> design a loop using a Gaussian charge distribution and linear energy chirp, optimize with respect to ISR and CSR using a 1D CSR model
...last check using newest CLIC parameters still missing ✓

-> study influence of imperfections (energy jitter, alignment errors, ...)
...will be started soon

F. Stulle (PSI)

Overview of Main Beam Chicanes and Loop



Drive Beam Bunch Compressors and Turn Around

Drive Beam Chicanes and Turn Around Loop:

-> design of loop and chicanes for bunch compression and phase feed-forward using a Gaussian charge distribution and linear energy chirp, optimize with respect to CSR using a 1D CSR model
...last check using newest CLIC parameters still missing

-> confirm results using 3D CSR models
...some 3D simulations of chicanes still need to be done,
...not possible for loop due to computational constraints

-> investigate CSR micro-bunch instability

-> use a more realistic charge distribution including effects of wakefields, RF curvature, ...
...partly done, but details have to be studied within start-to-end simulations

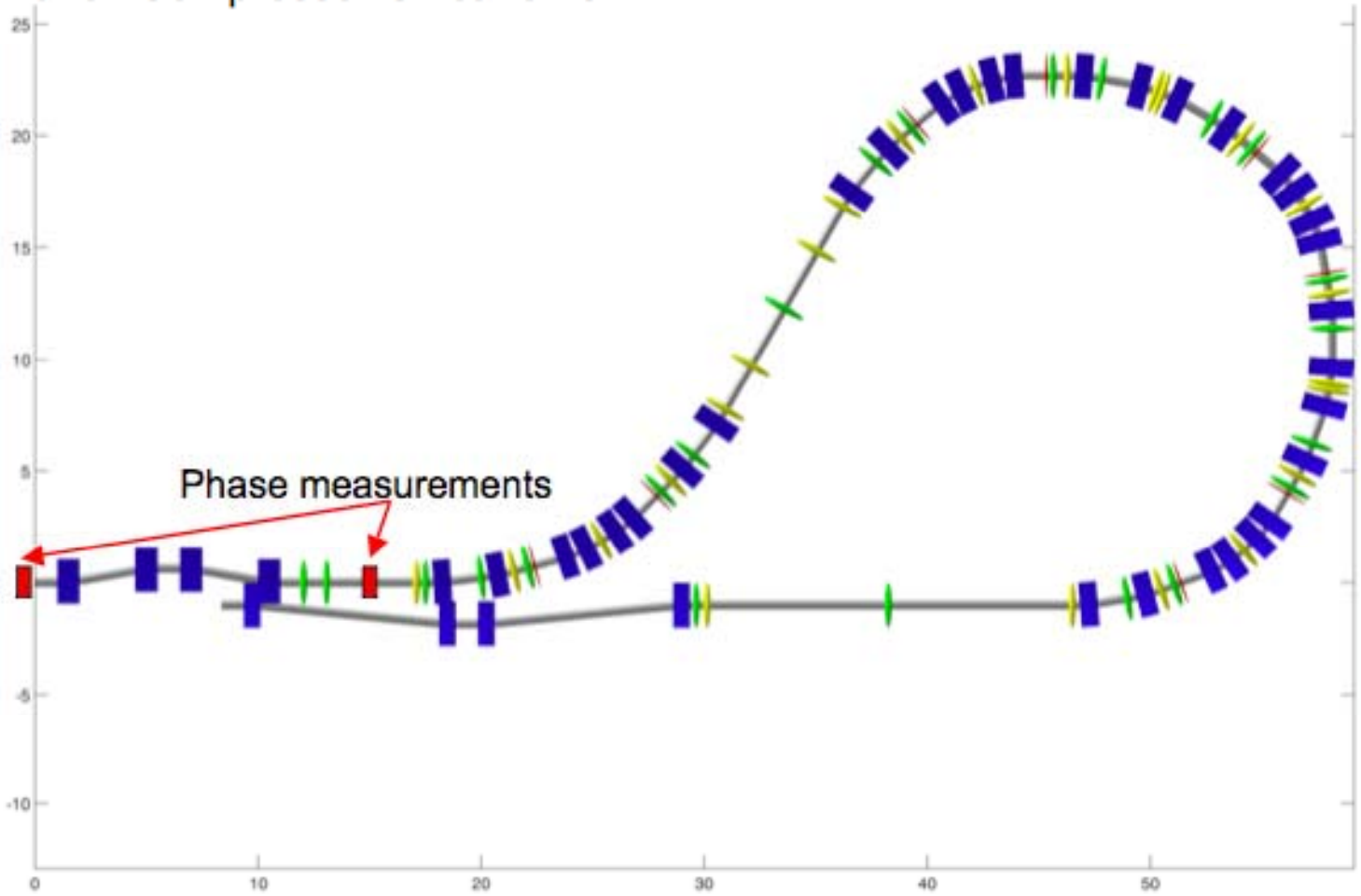
-> study influence of imperfections (energy jitter, alignment errors, ...)
...will be started soon, easy for chicanes, more complicated for loop

Overview of Drive Beam Chicanes and Loop

Bunch Compressor Chicane 10 m

Turn Around Loop 77 m = 1x 60deg arc + matching + 3x 80deg arc

Bunch Compressor Chicane 20 m

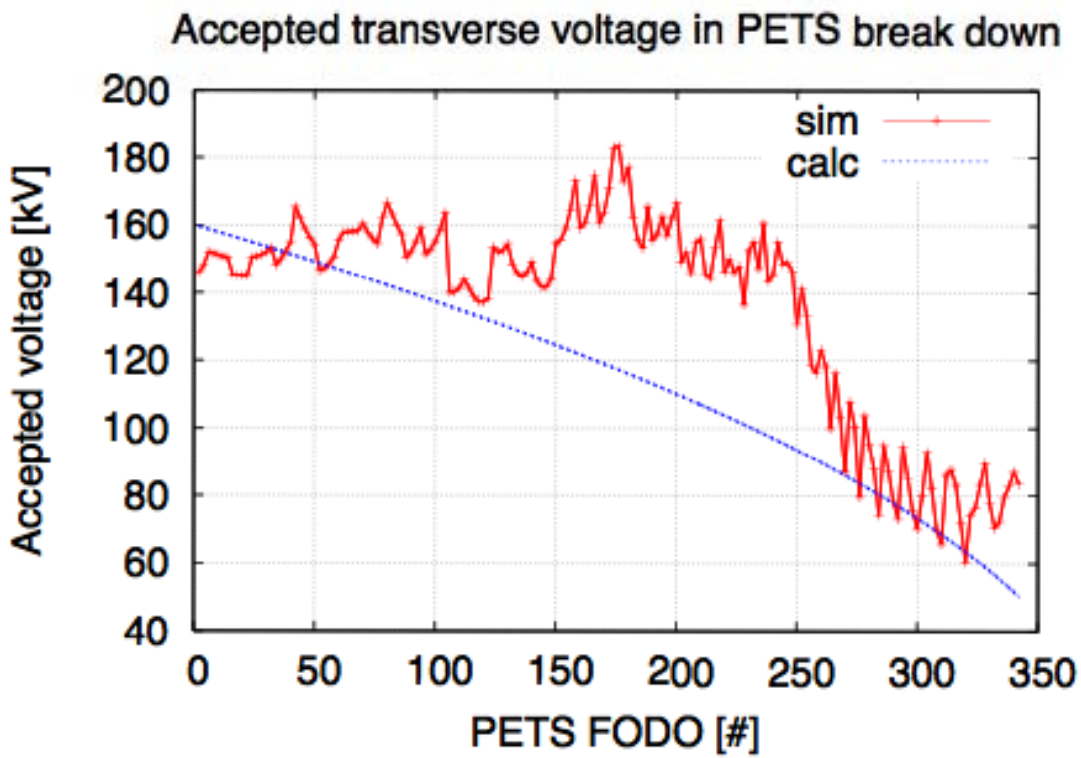


FMSIM

N. Walker (DESY)

CLIC Drive Beam Machine Protection (CERN/Oslo)

- High-current drive beam is an important machine protection issue
  - $I = 100\,\mathrm{A}$
  - hugh energy spread
- We defined the allowed kick as one that does not increase the centroid envelope by more than 1mm
- More studies to be done to determine actual RF kick



E. Adli, D.S. (CERN/Oslo)

HTGEN

H. Burkhardt (CERN)

HTGEN : Halo estimates and simulations for linear colliders

by H. Burkhardt, L. Neukermans[1], A. Latina, I. Ahmed ; CERN

Done 2007 :

htgen software package with installation instructions, interfaces to tracking codes and examples made available (and started to be used by people other then the authors)

provides simulation and estimates of main halo production processes ; applied to ILC & CLIC

Ongoing and future work :

- **provide an online manual for the htgen software package**
- **improve the HTGEN package**

simplify HTGEN commands and provide control and diagnostics output
implement further halo production mechanisms
reduce dependence on external libs (CLHEP, GS in case of placet)
cleaner interfaces -- less globals and copying of structures
update to recent synchrotron radiation code

- **work with HTGEN users, provide help and follow up on requests**
- **tests and benchmarking : measurements (ATF, CTF3) and with other codes -- Geant4, BDSIM**

[1] EuroTeV fellow until 28 Feb 2007

Reports and Presentations

Reference to all material, software package for download, installation instructions, answers to frequently asked questions:
HTGEN page http://hbu.home.cern.ch/hbu/HTGEN.html

Reports

Monte Carlo generation of the energy spectrum of synchrotron radiation, by. H. Burkhardt, 8 June 2007, CERN-OPEN-2007-018; CLIC-Note-709; EUROTEV-Report-2007-018

Halo Estimates and Simulations for Linear Colliders, PAC'07 Proc. WEOCC03 ; CLIC-Note-714, CERN-AB-2007-045, EUROTeV-Report-2007-064

Presentations

LC workshop Daresbury : 8-11 Jan 2007, Halo and Tail Generation Studies, by L Neukermans

PAC June 2007 : Halo Estimates and Simulations for Linear Colliders, by H.Burkhardt

CLIC'07 workshop : Halo and Tail Generation, by H.Burkhardt on 17 Oct. 2007

COLSIM

G. Blair (RHUL)

COLSIM Report CERN/IFIC activities 2007

- Design and optimization of an alternative nonlinear collimation system for CLIC (protection against energy failure scenarios)
- Now two available designs: linear vs nonlinear
  - Performance and cleaning efficiency comparison

    ["Study of the CLIC BDS: Linear versus Nonlinear Collimation", Javier Resta Lopez et al. European LC Workshop, Daresbury, 8-9 January 2007]
- Study of the collimator wakefield impact on the luminosity
  - Tracking studies using the code Placet
  - Analytical calculations (Stupakov's regimes)
- General design: nonlinear collimation system can be adapted to circular colliders (nonlinear collimation system for the LHC)
- PhD thesis made in the framework of this studies ["Design and Evaluation Performance of Nonlinear Collimation Systems for CLIC and LHC", Javier Resta Lopez, PhD Thesis, University of Valencia, October 2007]

J. Resta Lopez, A. Faus-Golfe (Valencia)

Milestones

- Design and evaluation performance of alternative optics for collimation in the colliders: nonlinear collimation systems

- General conceptual design of nonlinear collimation systems for linear colliders and adaptation to circular colliders

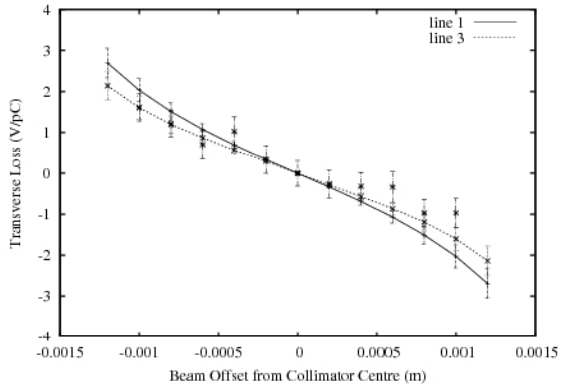
- Two available optics designs for collimation in CLIC BDS: a baseline linear collimation systems and a competitive nonlinear collimation system

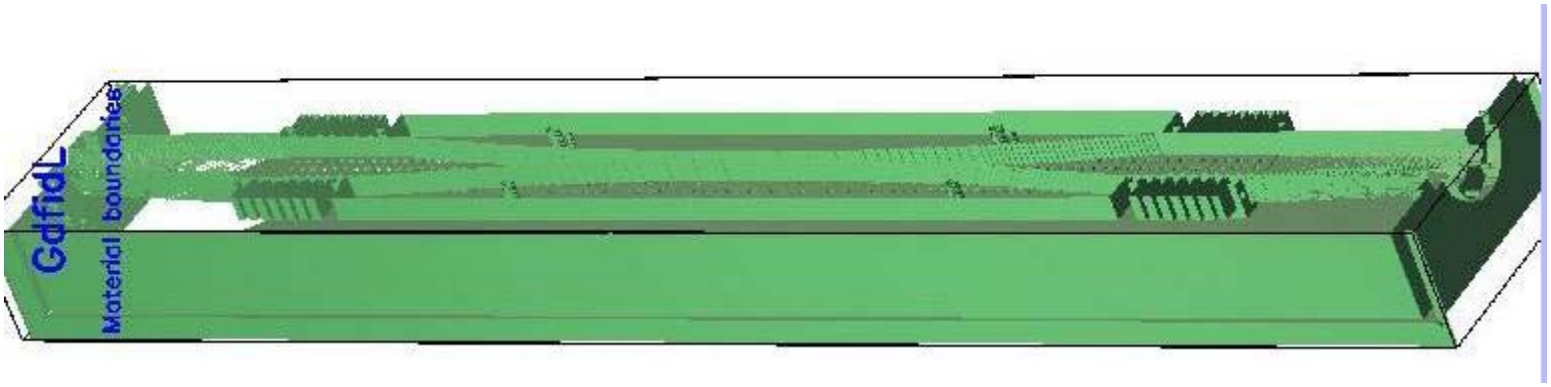
Jonny Smith
Lancaster

Gdfidl

Gdfidl EM simulations predict kick factors measured for simple tapered collimator by the SLAC ESA experiment

Now being extended to simulate fields in real collimators with all the added hardware: bellows, flanges, etc.

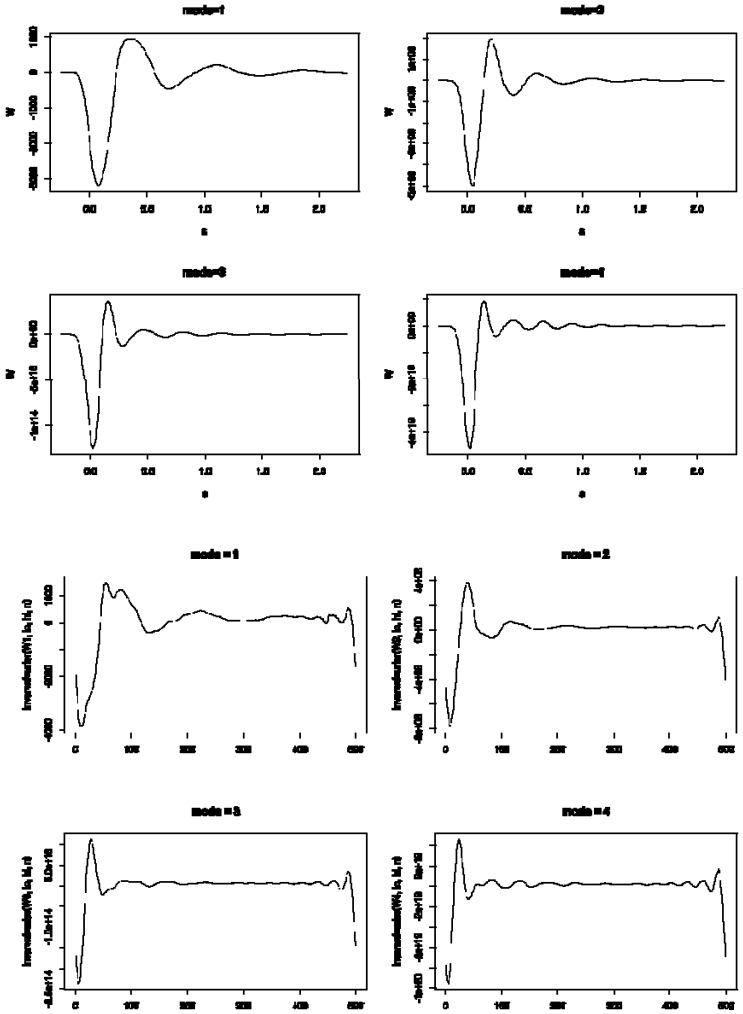




Delta wakes from Bunch wakes

Roger Barlow
Manchester

- Gdfidl provides the EM wakefield due to a specific bunch (Gaussian with some σ_z)
- Tracking simulations need EM wakefield of single particle (to be summed over in an arbitrary bunch: different σ_z or even non-Gaussian)
- Deconvolute using Fourier Transforms for angular modes



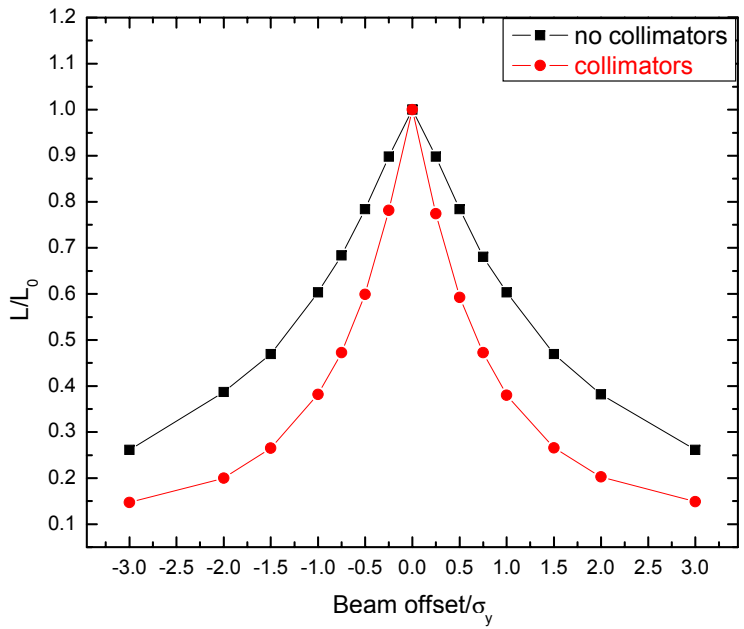
ECHO2D simulation of wakes from a bunch

(Modes 1-4)

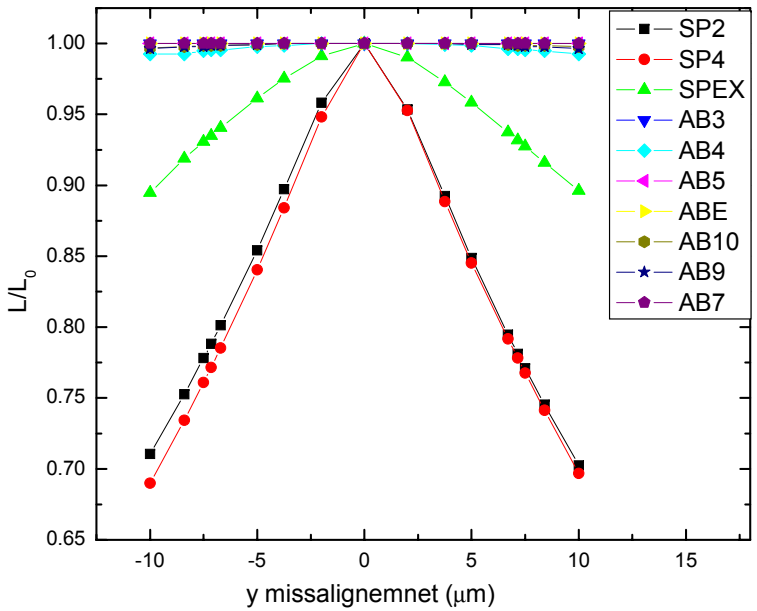
Reconstructed wakes from a point particle

PLACET Simulations of Collimator Wakefields in the ILC BDS

Adina Toader
Manchester



a)



b)

Fig. a) ILC Luminosity versus initial beam jitter. For a vertical beam offset at the beginning of BDS of $1/2\sigma_y$ the luminosity at IP is reduce by 40% due to the collimators.

b) ILC Luminosity versus vertical collimator offset. The main cause to the luminosity loss is due to the wakefield effects in the spoilers (SP), while the absorbers (AB) have very little influence. For instance an offset of $1/2\sigma_y$ of SP4 (red dot line) gives a reduction in luminosity of 25%.

Wakefield effects with MERLIN

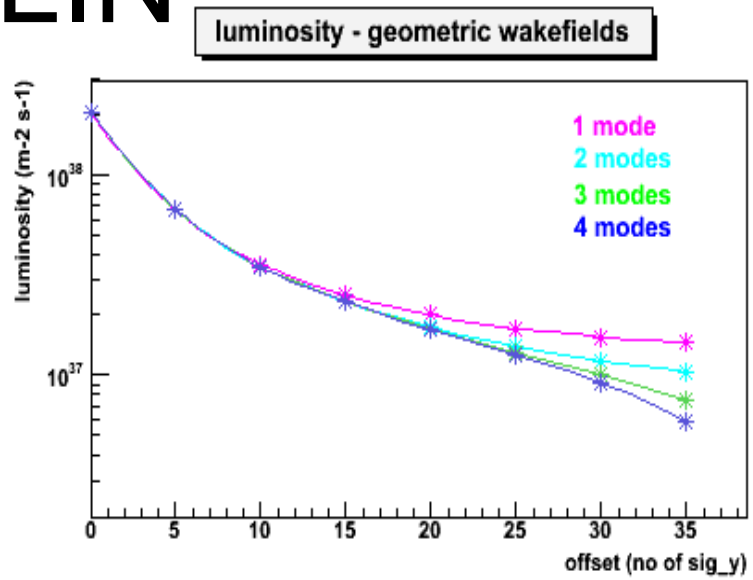
Adriana Bungau
Manchester

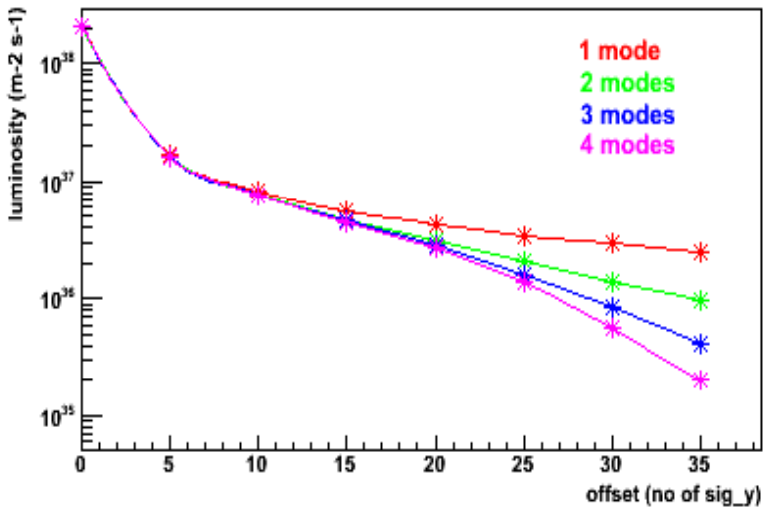
Code adapted to include angular modes of arbitrary order

Effect beams that go very near the edge of the collimator

Can conclude that high-order modes only matter for unrealistically large offsets

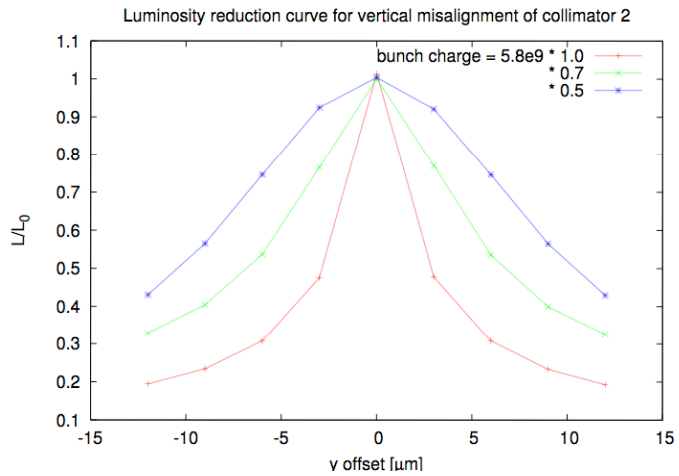
Must get the two sets of results on comparable plots…

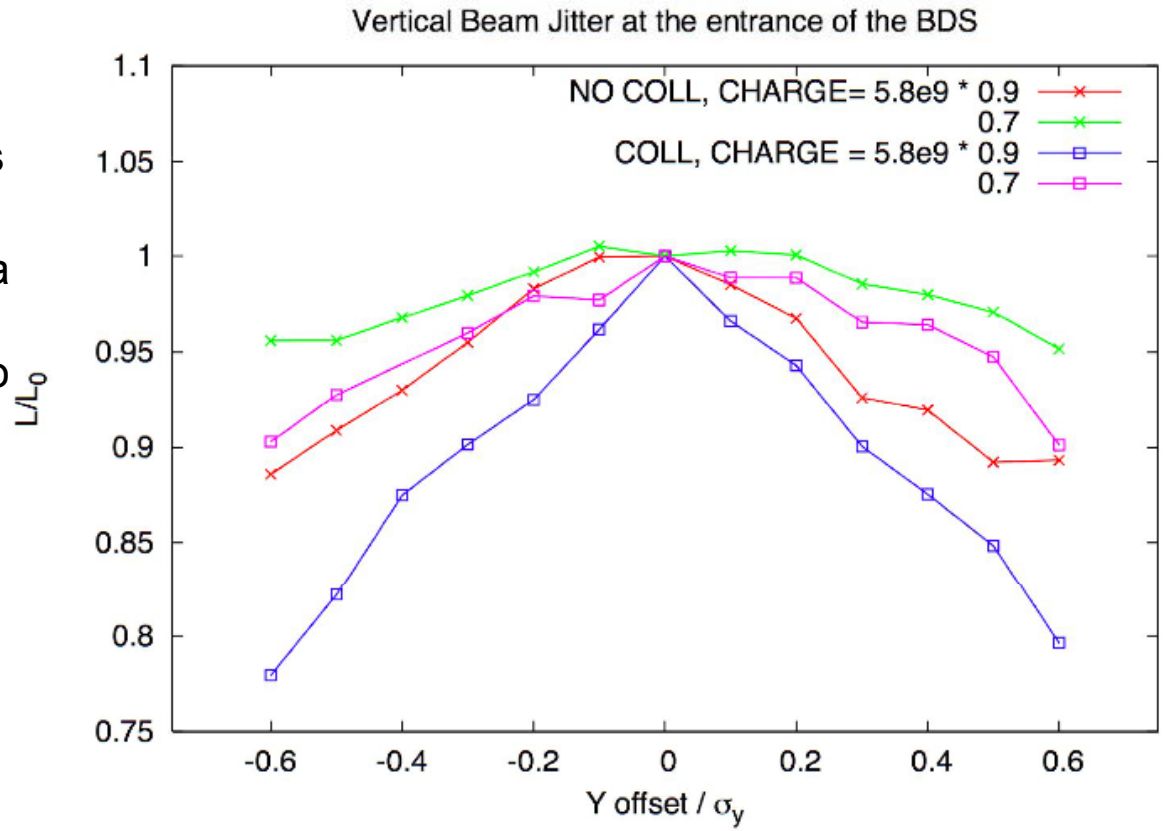




CLIC Collimator Wakefield Effects

- For perfect BDS little amplification of initial jitter exists
- But alignment of collimators to beam is important
  - Moving collimators by a few micrometres reduces luminosity if no trajectory correction is applied

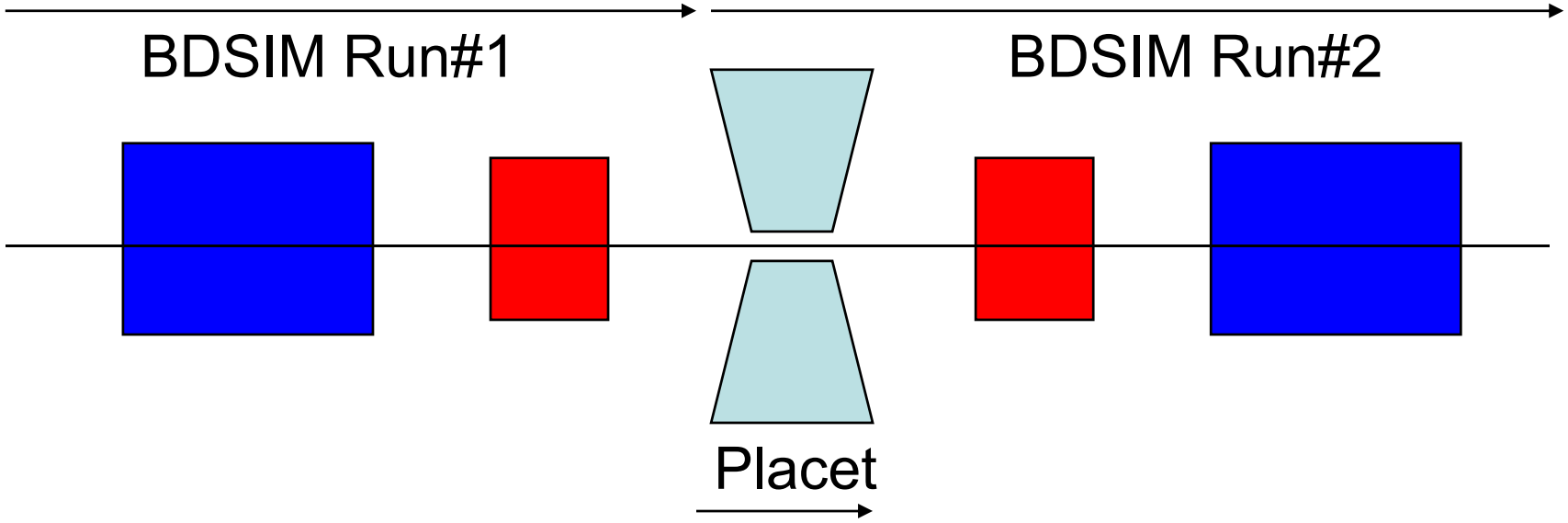




A. Latina, D.S. (CERN)

BDSIM-Placet Integration

- BDSIM tracks halo particles up to collimator
- Placet tracks core beam
- BDSIM passes halo description to Placet
- Placet tracks combined beam through collimator to calculate wakefield kicks
- Placet passes kicked halo back to BDSIM
- BDSIM applies kicks and continues tracking halo



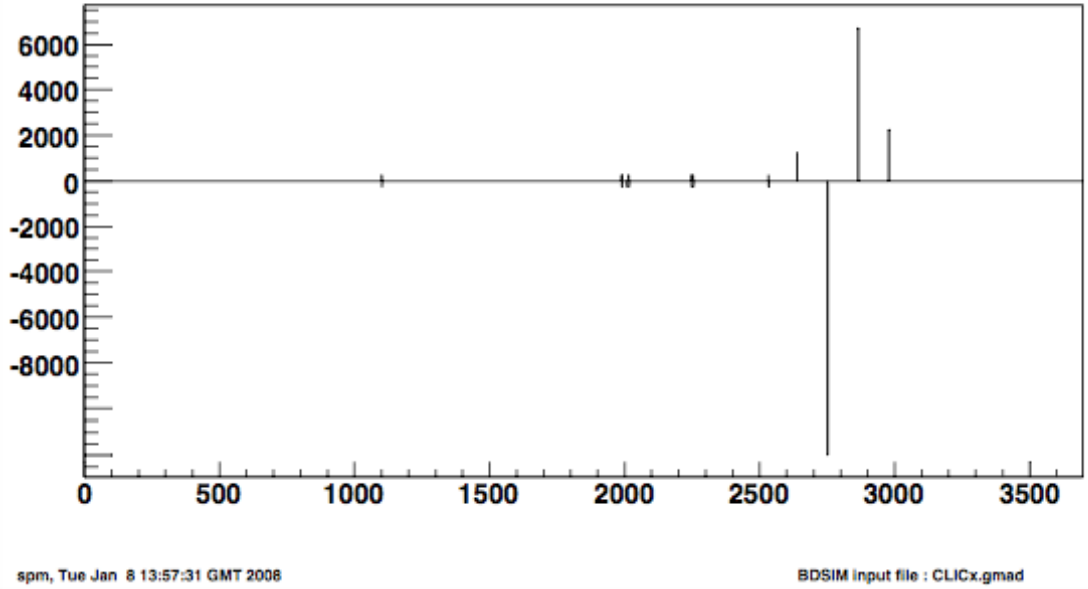
S. Maton (RHUL), A. Latina (CERN)

BDSIM-Placet Integration

- 1000 halo particles tracked through CLIC BDS
- 1/r distribution in x,xp space
- A_x=[5.7-14.2]σ_x
- A_y=[54-162]σ_y
  cf: CLIC Note 555, CERN
- dE/E = 0.01%

- Tested with CLIC
- Plan to apply to ILC

Difference in energy losses along beamline between Placet-BDSIM tracking and BDSIM-only tracking



BDSIM Recent Upgrades

- Define new materials in gmad file
- Kicker magnets implemented
- Parser correctly reads lines, inverted lines and nested combinations of these
- Added global coordinates, time of flight and arc path length to sampler output
- Multiple laserwires with varying wavelength and crossing angle now possible
- Upgrade for compatibility with Geant4.9, CLHEP2.0 and gcc4.0
- Numerous bugfixes

S. Malton (RHUL)

Future Upgrades to BDSIM

- Category A: Must have:
  - Beam gas scattering
  - Neutron transport
  - Realistic magnet geometries
- Category B: Would like:
  - Dosimetry and activation
  - Polarisation tracking
  - AML/XML input
- Category C: Wouldn’t mind:
  - Better visualisation: Interactive pan and zoom
  - Better format conversion tools: Update mad2gmad. Make sad2gmad? placet2gmad?

BBSIM

Ph. Bambade (LAL)

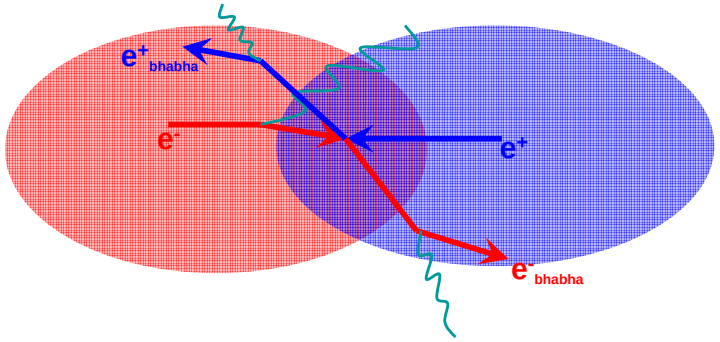
BBSIM1 - Study of Impact of beam-beam effects on precision luminosity measurements using Bhabha scattering at ILC

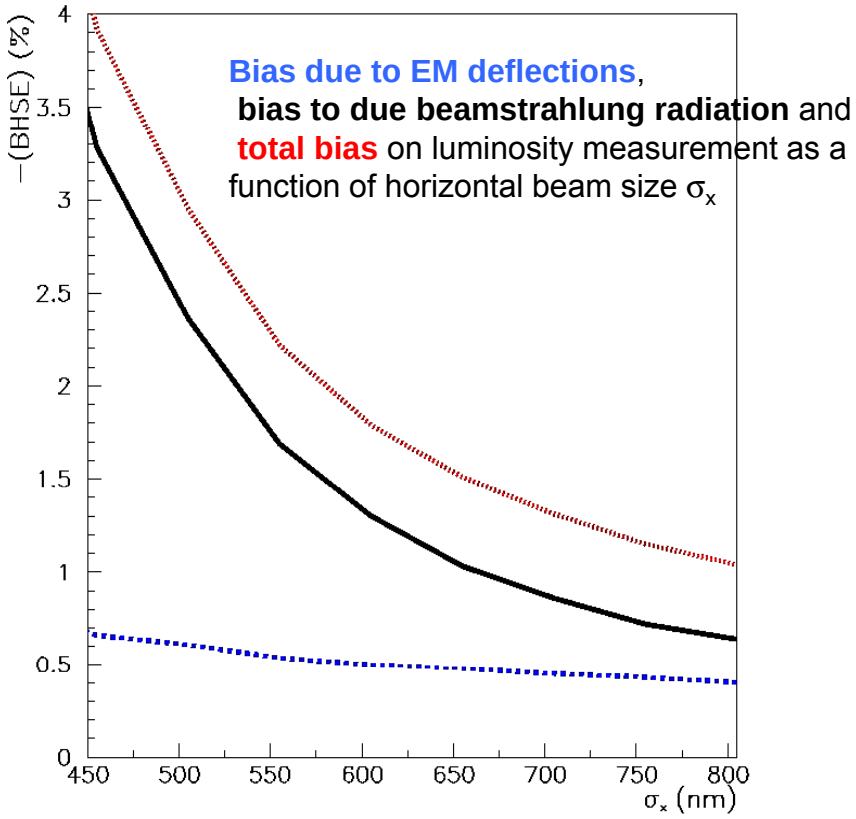
C. Rimbault, P. Bambade, K. Mönig, D. Schulte

- **Kinematics of the Bhabha process is modified by the collective space charge effect (beamstrahlung + electromagnetic deflections) ➔ Number of detected Bhabha in a given angular acceptance is lower than the theoretical predictable one**
- **This leads to a bias of the order of 10^{-2} (for nominal case) in the luminosity measurement. But the bias depends on the parameters of the beams (energy, sizes, intensity)**
- **Beam parameters must be controlled at better than 20% to reach a precision of 10^{-3} on the luminosity measurement**

→ EUROTeV-Report-2007-017, JINST 2 P09001

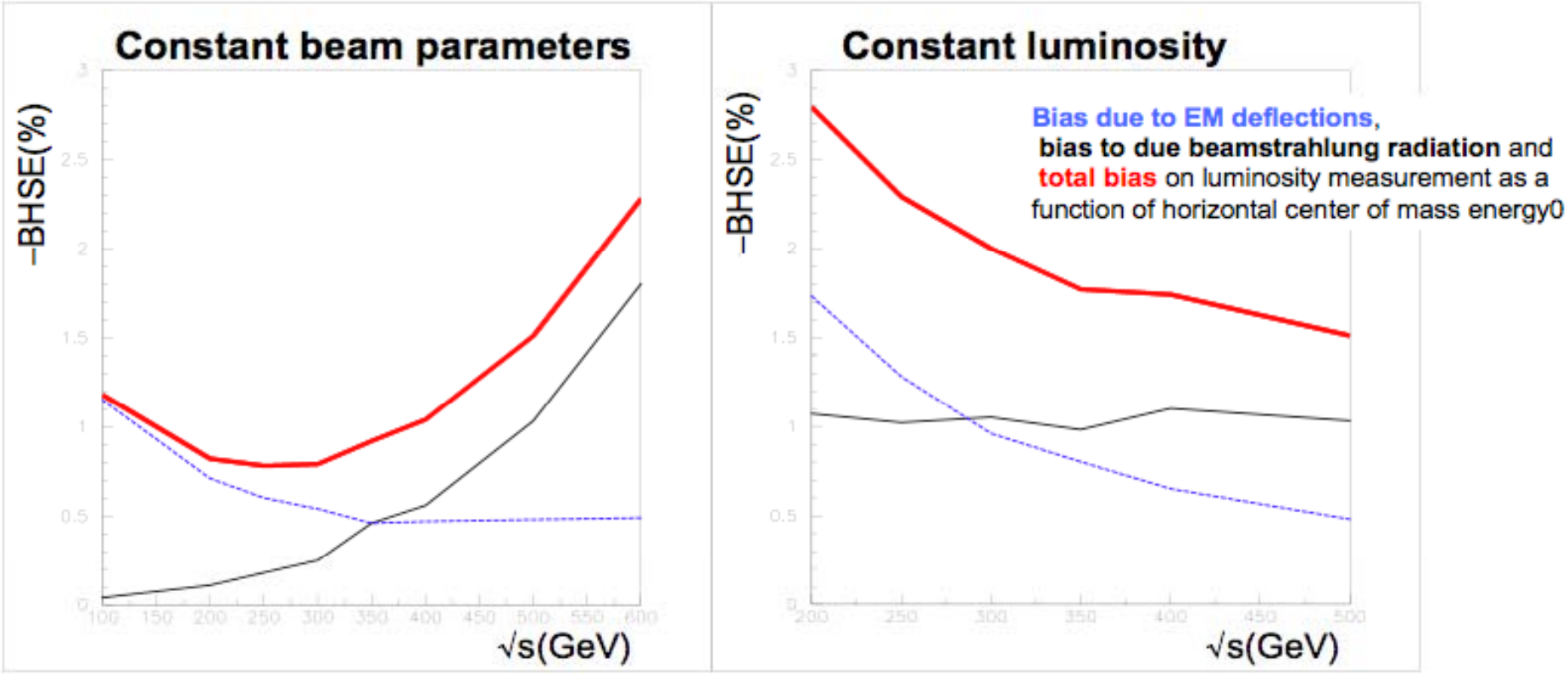
•Contribution to ILC Detector R&D Panel Report, FCAL Collaboration, 2007





BBSIM2 - Sensitivity of the bias to energy: Problem for GigaZ option

ILC should enable physics runs initially for energies from the Z boson mass to 500 GeV ➔ In this energy range beam-beam effects are strongly modified



For the GigaZ option, a precision of 10^{-4} is needed for the luminosity, while the bias from EM deflections is >100 x 10^{-4}... ➔ need more complete studies.

BBSIM3 - Status of GUINEA-PIG++ Simulation

G. Le Meur, F. Touze, P. Bambade, C. Rimbault

- GP++ use configuration management environment **CMT** ➔ easy compilation

- GP++ versioning, updating and releasing achieved with **SVN**

- GP++ is distributed on the web software development tool **TRAC**:
  https://trac.lal.in2p3.fr/GuineaPig

- GP++ code can be run both on 32-bit and **64-bit** computers.

- New keyword **rndm_seed** allows to choose the random generation seed.

- Physics simulation improvement: easy interface to apply beam-beam effects on Bhabha event input files and associated photons. See documentation
  http://flc.web.lal.in2p3.fr/mdi/BBSIM/bbsim.html

- Automatic GRID sizing option: auto-computation of the grid sizes and number of cells based on the input beam parameters or loaded beams and disruption angle calculation (EuroTeV memo drafted) → very useful for feedback studies.

- All results are now in the main output file, with units and few comments.

Future of Beam-Beam SIMulation task

- Implement and study spin depolarization in GP++ (Spring 2008)
  - Check theory (Autumn 2008)
- Extend hadronic mini-jet phase space (Fall 2008)
  - Could be late (priority was on luminosity measurement)
- Time performance improvements:

  parallel computation is under development/investigation

  research on pair production optimization
- Technical paper on GP++ developments

Involved persons at LAL: P. Bambade, G. Le Meur, C. Rimbault, F. Touze, + ?

At CERN: D. Schulte

PCDL

V. Ziemann (Uppsala)

The CLIC Post-Collision Line

A conceptual design of the extraction line for CLIC was completed and published in 2007:

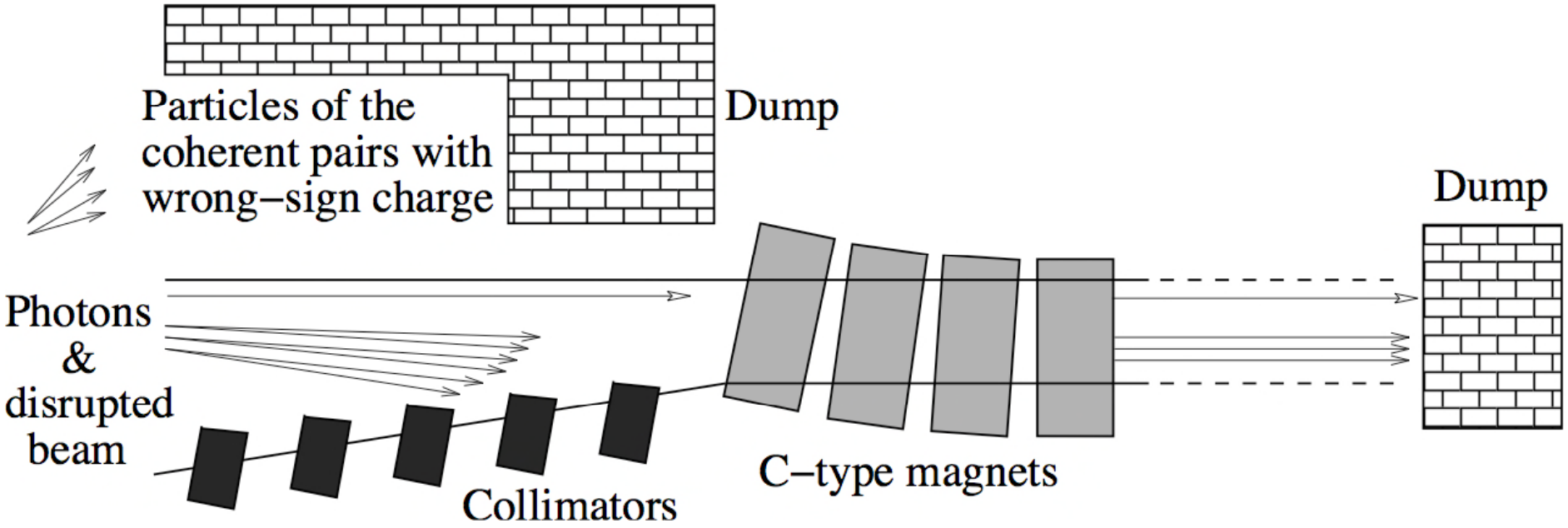
1. *magnetic separation of the wrong-sign charged particles of the coherent pairs from the other outgoing beams (two beam pipes after 38 m) + early measurement of the beam profile (energy spectrum) for the wrong-sign charged particles of the coherent pairs,*

2. *transport of the disrupted main beam through a vertical magnetic chicane, a refocusing region (quadrupoles) to bend back the low-energy tail and a long drift (total length = 250 m),*

3. *beamstrahlung photons in the same pipe as the disrupted beam.*

A. Ferrari, V. Ziemann (Uppsala)

CLIC Post Collision Line Layout



CLIC Post-Collision Line (cont.)

A design of the dump window was done (report in preparation):

The most severe constraints come from the undisrupted beam (spot size of 1 mm^2, 20 MW). The window must have a thickness smaller than a radiation length, low elastic modulus and thermal expansion coefficient (to have small mechanical and thermal stresses).

Similarly to the LHC dump window, use a 1.5 mm thick layer of C-C composite (SIGRABOND 1501G) with a thin 0.2 mm leak-tight layer (Cu or Al) on the high-pressure side.

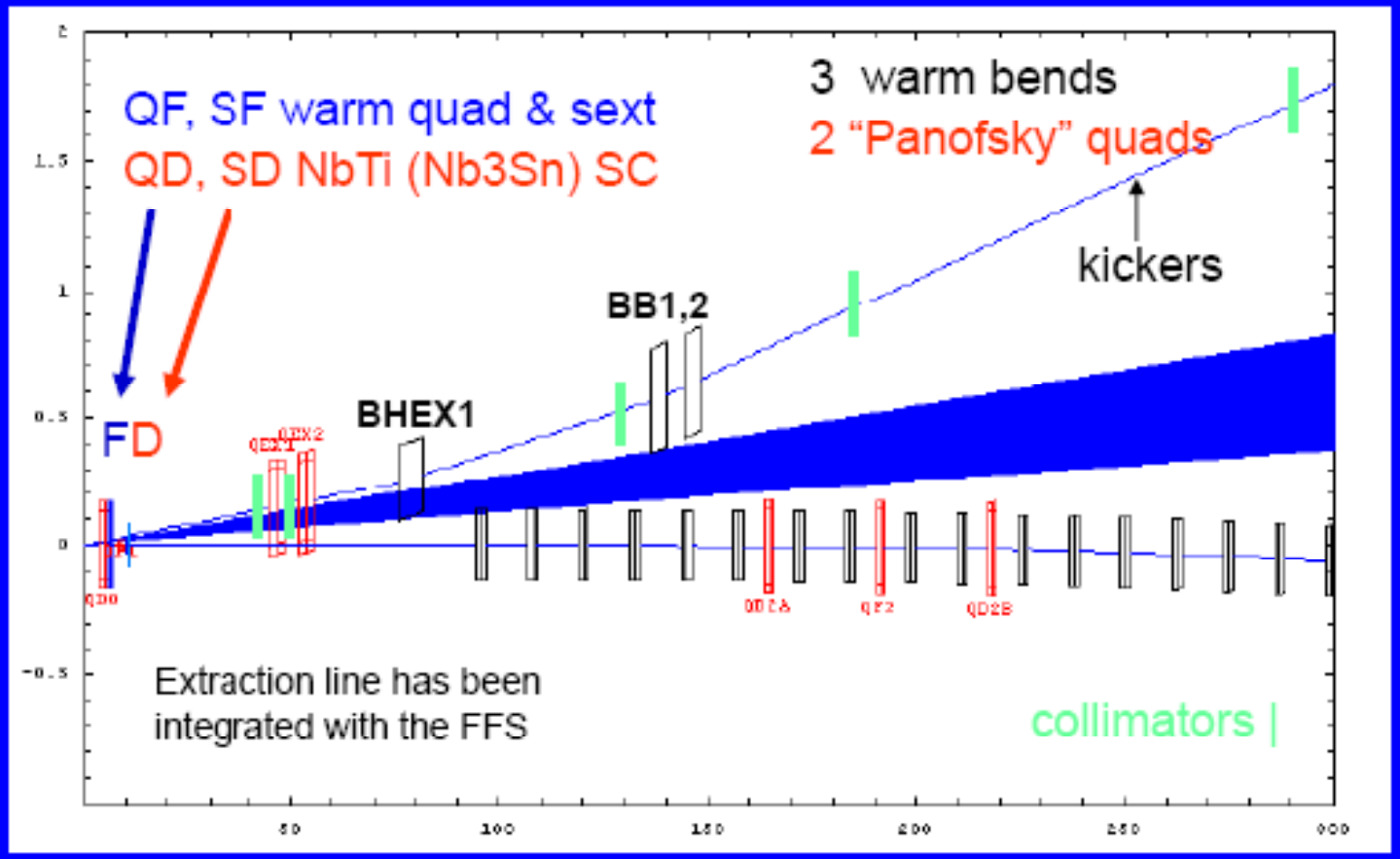
Temperature increase of 1 K after beam impact, thermal stress below 1 MPa, displacement below 0.1 mm for a pressure difference of 1 atm and maximal mechanical stress of 15 MPa.

New “minimal” extraction line concept

D.Angal-Kalinin, R.Appleby, P.Bambade

➔ Explicit goals : short & economical, as few and feasible magnets as possible, more tolerant and flexible

EUROTEV-REPORT-2007-022
EUROTEV-MEMO-2007-1,4,5



dump(s): 0.5 m

flexible

3 m

Beam rastering kickers can be placed to prevent water boiling and window damage

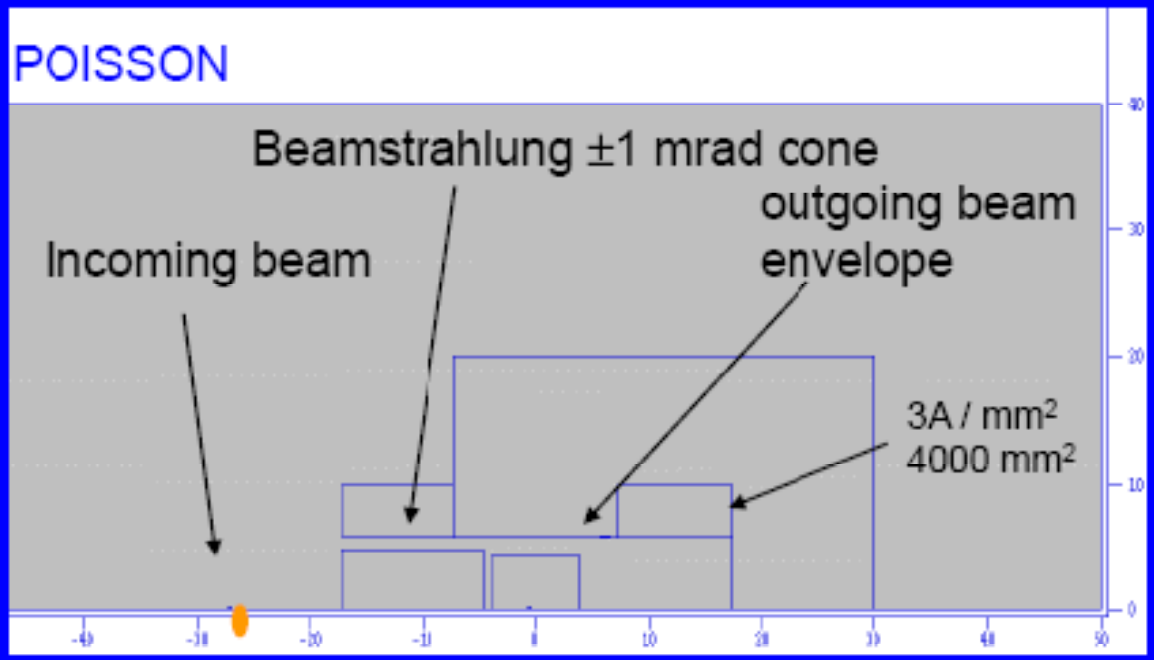
Length ~ 300 m

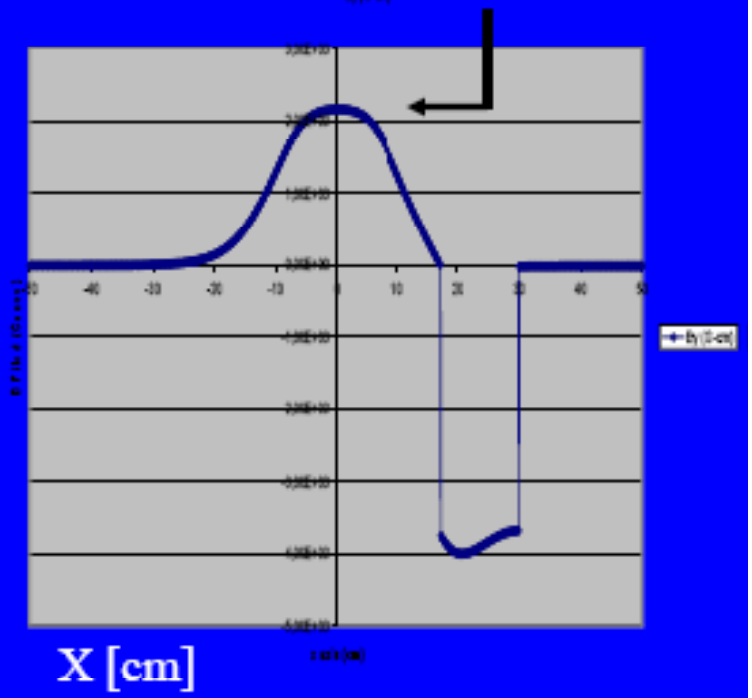
S.Cavalier → F.Touze
EUROTEV-MEMO-2008-xx

BHEX1 C-type bend

Accommodates the beamstrahlung, outgoing beam and proximity of incoming beam

$B_y = 0.215$ T





- $B_y(x)$ homogeneity < 4 % (with shims) within outgoing beam envelope → checked to be sufficient
- Residual B_y on incoming beam ~ 1% → 20 μrad (7.5 $\sigma_{x'}$)→use corrector
- Residual $B_x(y)$ dependence on incoming beam → only even powers sextupole absorbed refitting SD / SF, decapole → negligible effects

Vertex detector backscattered photon hits from extraction line losses

- BDSIM model of extraction line constructed to assess photon flux towards VD from charged beam losses on the main extraction line collimators
- MOKKA model of the LDC detector to compute hit probability in VD → ~ 2.2%

	D [m]	X [cm]	P [kW]	#γ's/bx	VD hits / BX
QEX1COLL	45	20	0.2	1.3	0.02
QE2COLL	53	-	0	0	0
BHEX1COLL	76	41	0.1	0.2	0.004
COLL1	131	85	52.3	40	0.8
COLL2	183	115	207.5	82	1.8
COLL3	286	-	0	0	0

Conclusion : VD hits negligible from this contribution compared to rate from incoherent beam-beam pairs ~ 250 hits / BX

Notes: γ's reach VD layers via direct lines-of-sight from Cu collimator, passing through BeamCal hole with radius 12 mm, assuming no reflections on beam pipe

O.Dadoun, LAL-RT-07-07

2 mrad specific

general issue

EDR plans

D.Angal-Kalinin
R.Appleby
P.Bambade

Aim of proposed EDR-phase 2 mrad tasks is to bring the design to the level of a credible alternative to the 14mrad baseline

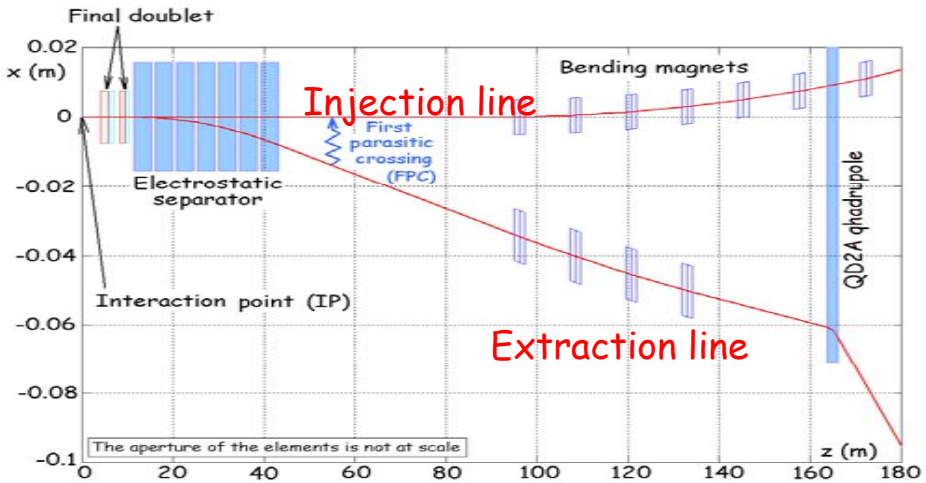
OK

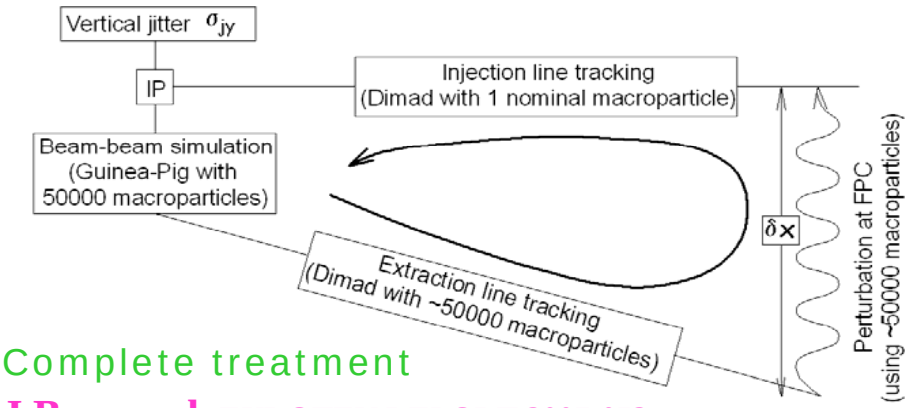
- Optics and beam transport
  - variable l* IR and extraction line layout (CI)
  - further study of extraction line aberrations on final focus beam(CI, LAL)
  - iteration of design and losses as magnet designs progress (LAL, CI)
  - iteration of integration of 2 mrad FD in final focus optics (CI)
- Magnet design studies
  - design of large aperture final horizontal bends BB1 and BB2 (LAL, CI)
  - design of standard warm FD magnets QF1 and SF1 (LAL)
  - design of a modified Panofsky quadruple magnets (exploring possibilities) [feasibility,cost]
  - engineering design of QD0 and SD0 [feasibility for compact SD0 size,cost]
- Other engineering and integration work
  - Integration of final doublet into detector, including
    - cryostat design and FD support / services
    - anti-solenoid or skew-quadrupoles for coupling correction, with appropriate integration
  - design of beam pipe in shared area (LAL) [detailed drawings critical]
  - design of beam pipe in extraction line (LAL) [detailed drawings critical]

Nov. 2007 : prel. design by Y. Iwashita (Kyoto) → seems OK

There is real flexibility in this scheme, with margins and adjustable parameters

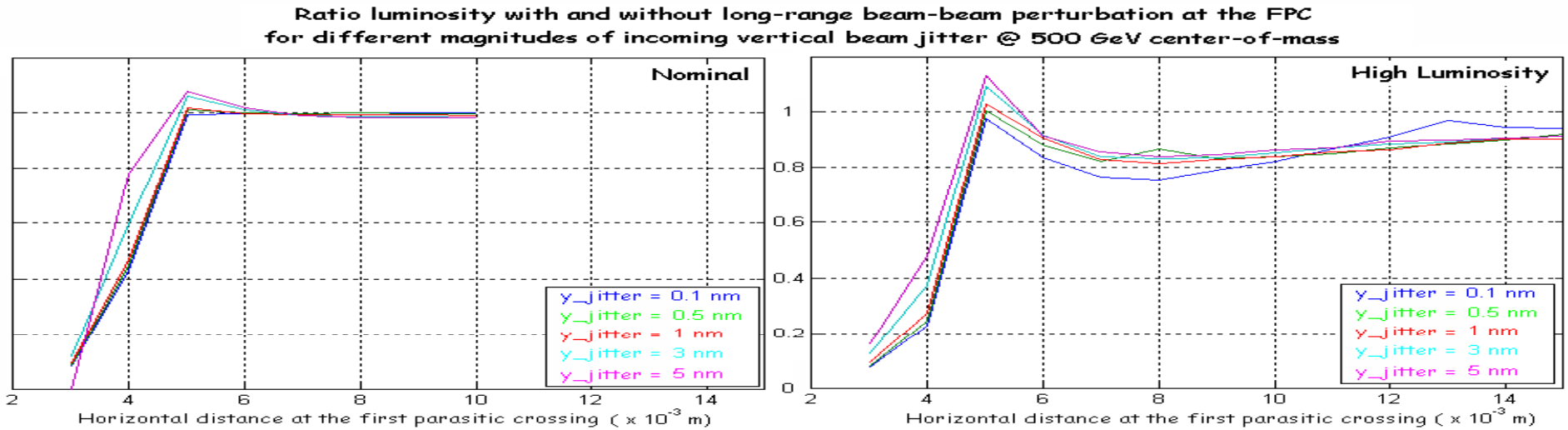
ILC head-on scheme : Luminosity reduction from amplification of vertical jitter due to long range beam-beam effect 60m after IP ?





Complete treatment

J.Brossard, EUROTEV-REPORT-2007-052



Nominal parameters → 6mm separation sufficient and OK with LEP E.S.

High Luminosity & Ecms ~ 200-350 GeV → further study under way

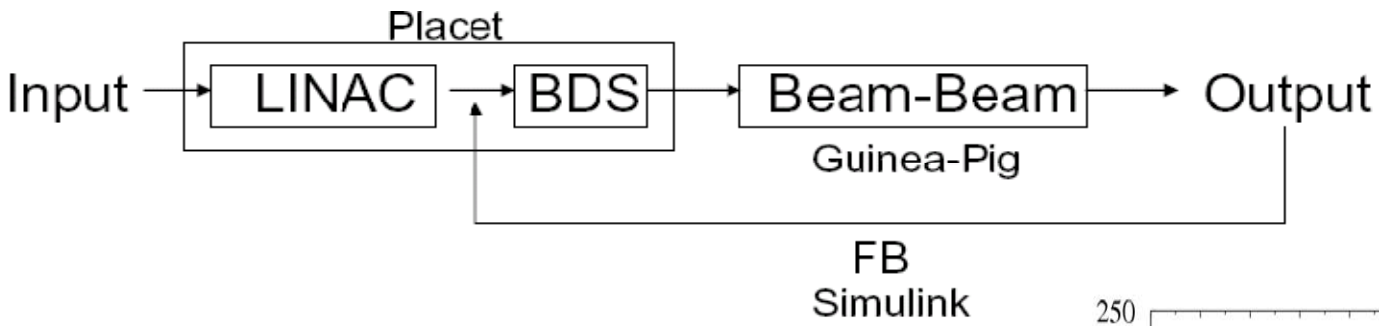
(Low Power → unfeasible due to reduced inter-bunch timing)

LAST

Ph. Burrows (Oxford)

Update of ILC integrated simulations (Oxford)

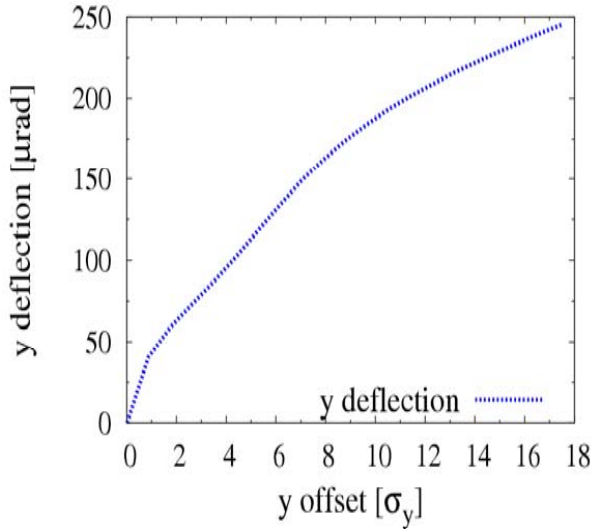
Realistic Placet based beam dynamics simulations:



FONT project:

Feedback On Nano-Second Timescales

- Operates at high frequency and acts within a bunch train
- Removes the relative offset jitter at the IP by measuring the beam-beam deflection angle and steering the beams back into collision

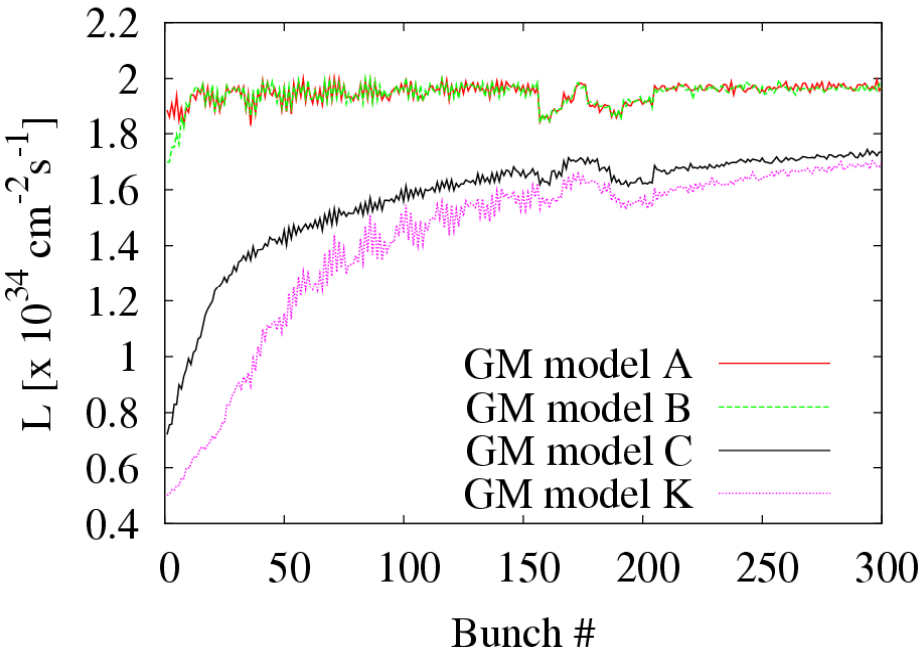


J. Resta Lopez (Oxford)

Fast feedback system

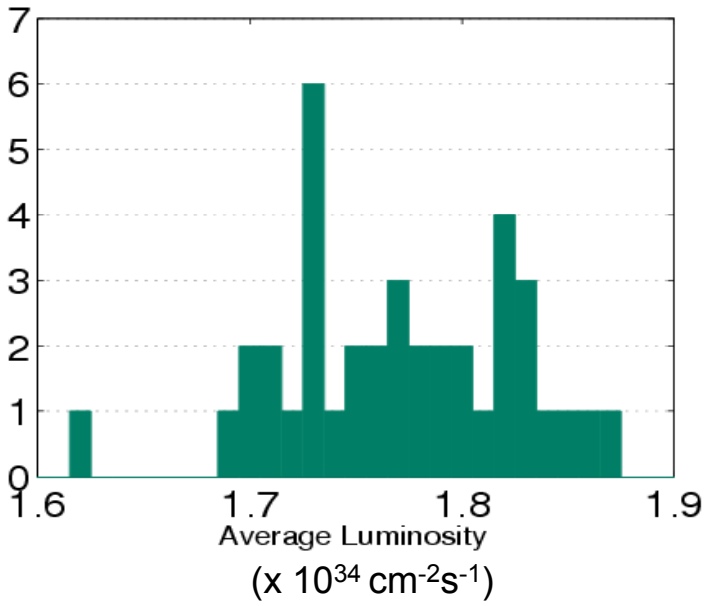
Luminosity result

Example for 1 single random seed



- Assuming 40 % emittance growth in the linac
- Applying 0.2 s of GM to the Linac +BDS
- Additional component jitter: 25 nm for the quads in the BDS; 50 nm for the quads in the Linac

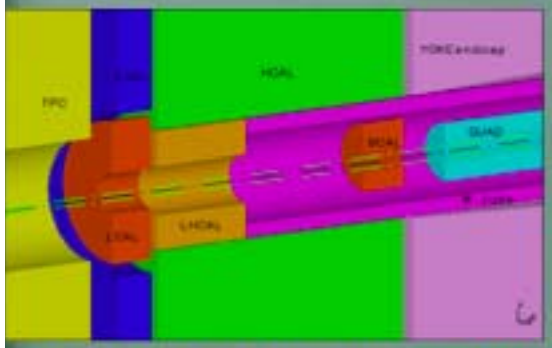
Example of 40 random seeds GM model C

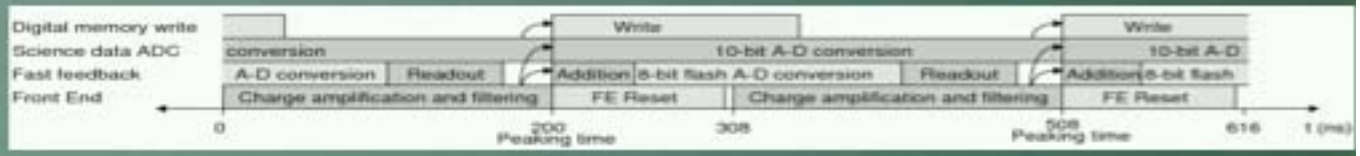


Mean value=1.7698 +/- 0.0539
(88.5 % of the nominal Luminosity)

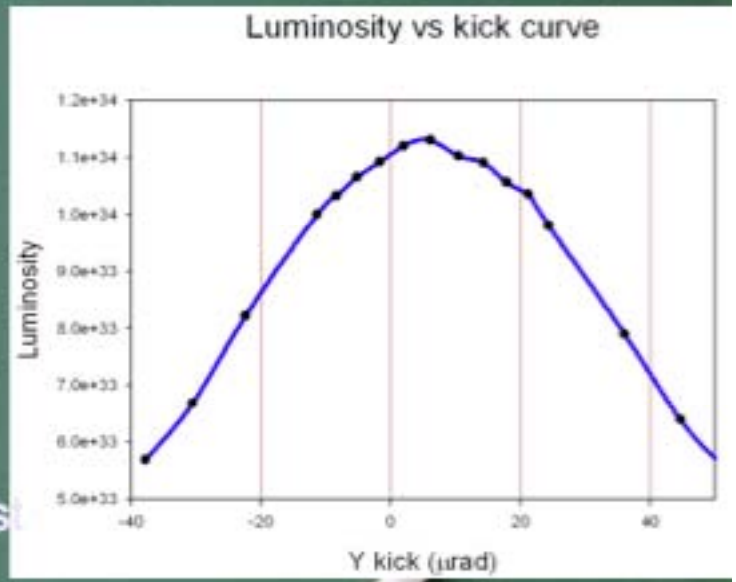
J. Resta Lopez (Oxford)

Feedback with Luminosity signal

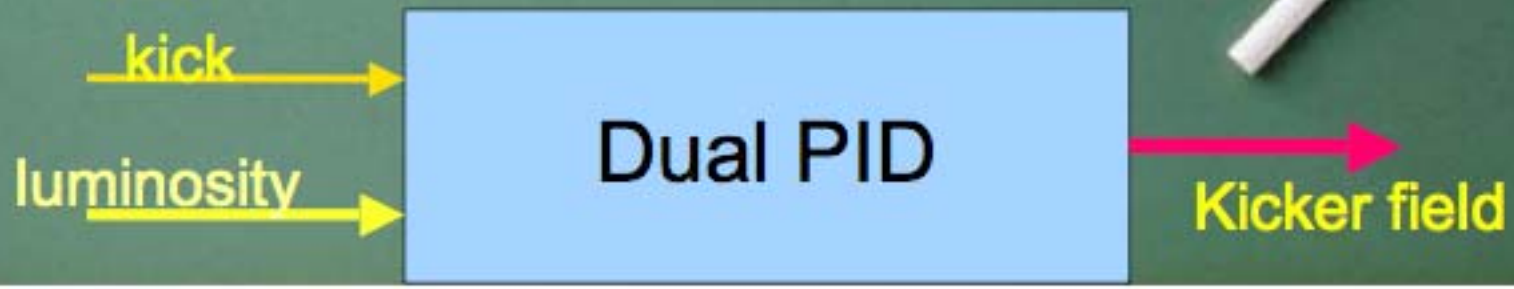




Lumi signal available within 3 bunches

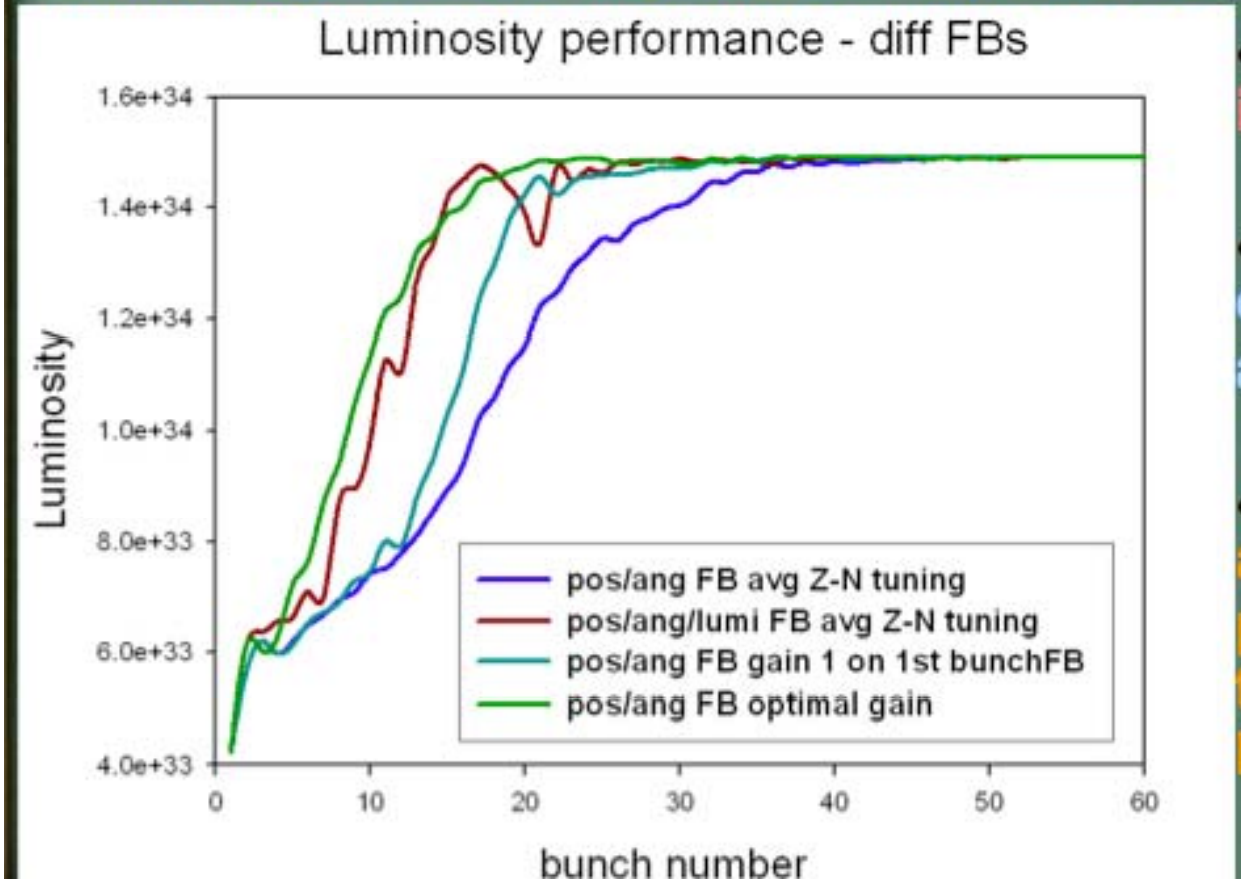


- Two input signals – Y kick and lumi
- Luminosity is max when lumi-kick gradient zero
- So try to minimise gradient using PID controller and use output as set point for the position feedback
- Feedback on differential signal difficult so constrain max gradient
- Turn off after 20 bunches and let position fb do the res



Early Luminosity recovery

1. Slow convergence with only nominal Position/Angle feedback
2. Aggressive Gain on 1st bunch leads to improvement
3. optimising gain and adding lumi feedback provide the best lumi gain, but..

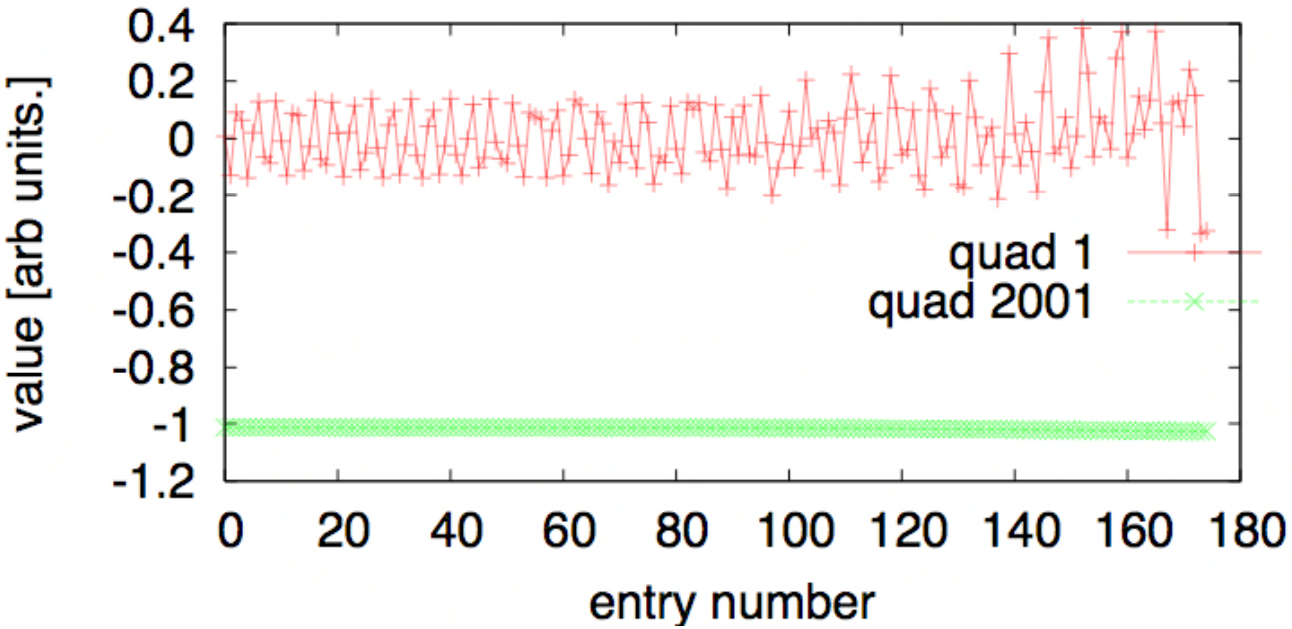


- feedback on lumi signal is unstable
- would be best to optimise the gain adaptively train-to train
- will look for a way to adaptively set gain on pos/ang feedbacks using the luminosity signal from bunch 3 in the train

Optimised Bumps (Uppsala and CERN)

- The method to automatically design optimised bumps has been further developed
  - Accepted for publication in PRST

- Main idea is to
  - –represent beam at the end of the linac by a vector
  - –Simulate a number of machines with imperfections and analyse the space they span
  - –With the same method design bumps that can correct this space



•Method has been adopted by Fermilab

P. Eliasson, D. S.

ILC Static Imperfections

- Bunch Compressor alignment using DFS has been investigated
  - Differences between SLAC and KEK simulations existed
  - Good agreement KEK/CERN found after detailed comparison
  - Final emittance growth (both stages) $\otimes\sum_{\psi} < 3$ nm
- BC for DFS alignment of the Main Linac
  - Suggested by CERN earlier as solution to produce different energy beams before main linac
  - Full simulation of BC and main linac performed
  - Final vertical emittance growth (for misaligned ML) $\otimes\sum_{\psi} < 2$ nm
  - Slightly better than simplified simulations
- Main Linac tolerances for RDR
- Identified helical undulator as problematic
  - Confirmed by DESY
- Cross talk between RF dynamic effects and cavity tilt identified as potential error source

A. Latina, D.S. (CERN)

ILC – Dynamic Imperfections

- Dynamic effects during beam-based alignment studied
  - Criterion: direct emittance growth due to dynamic imperfection must be larger than indirect effect
    - In this case indirect effect will be acceptable
  - Imperfections applied during DFS
  - Quadrupole jitter

    $\int_{quad}$= 500 nm jitter $\otimes\sum_{\psi}$~6 nm (direct) 3nm (indirect)
    - Using both energies in one pulse reduces this to about 1nm
  - RF gradient jitter (indirect growth)
    - very large gradient jitter = 5% leads to $\otimes\sum_{\psi}$< 3 nm
    - smaller gradient jitter = 1.5% leads to $\otimes\sum_{\psi}$< 0.2 nm
- Impact of crab cavity studied (with Cockroft)
  - Control of transverse mode frequencies is important
- Comparison between different main linac feedback systems
  - One-to-one
  - Local feedback
  - MICADO
- Integrated simulation of ILC showed luminosity loss with GM model C
  - Need element stabilisation

A. Latina, D.S.(CERN)

Beam Delivery System Alignment

- Static Alignment (CLIC)
  - Few-to-few and DFS used
  - DFS is problematic since response to energy deviation is not linear
  - Collimations system can be aligned using DFS
  - FFS alone does not work in all cases
  - No final solution yet – synergy with ILC BDS alignment study
- Dynamic Alignment (CLIC)
  - Choice of orbit feedback gain and tolerance on BPM resolution
    - 100nm BPM resolution seems acceptable
  - Very tight quadrupole stability requirements (fractions of nm for final doublet, need to use stabilization)
- Method for ATF2 developed
  - First iteration
  - But seems to work
  - Reasonable agreement with SLAC findings
  - Is already being used in Oxford ATF2 dynamic studies

A. Latina, R. Tomas, D.S. (CERN)

Other CLIC Main Beam Studies

- Main linac lattice for new parameters developed
  - Survey/stability tolerances specified
  - More relaxed beam parameters introduced
- RTML : BC's, booster, pre-injector linac have been simulated
- BC for DFS in the main linac
  - Confirms previous simplified studies
- Dynamic effects during alignment (DFS)
  - Quadrupole and beam jitter
  - Indirect effect somewhat smaller than direct effect
- Orbit correction feedback
  - Specifications of components, e.g. corrector step size, BPM resolution
- DFS used for drive beam alignment
  - Method seems to work fine
- Multi-bunch studies to confirm long-range wakefield limit

A. Latina, D.S. (CERN)

CLIC Structure Model and Tolerances

- CLIC parameter optimisation has been using wakefield models based on a previous fit to RF structure simulations
  - Fit not valid in whole explored region
  - New study has been performed to extend range of validity and to confirm results
  - Model has been improved
  - Rounded irises have been included in model
- Mechanical structure tolerances have been calculated based on beam dynamics requirements
  - Particularly tight is the longitudinal shift tolerance for CLIC structures

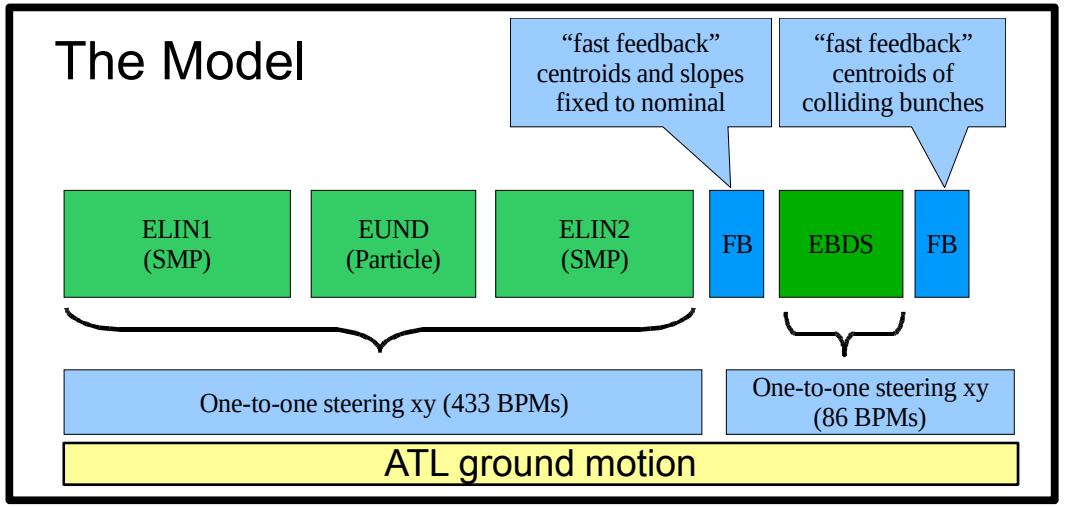
PLACET Tracking Code

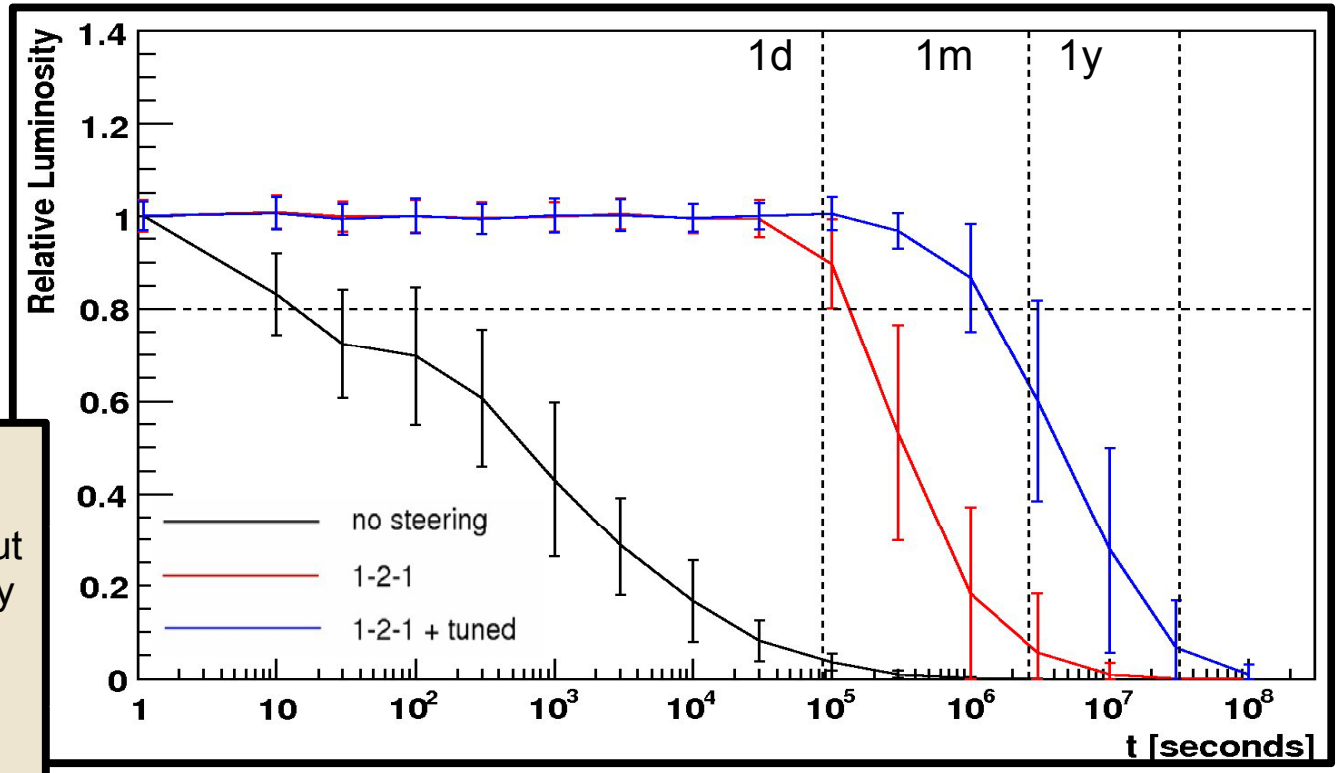
- OCTAVE interface greatly extended (MATLAB like code)
  - Started to exploit OCTAVE capabilities
- Dynamic libraries
- AML interface (with Y. Renier (LAL))
- Defined step sizes for movers
- Collective effects
  - Coherent synchrotron radiation
  - Improved (non-linear) collimator wakes (GdfidL in preparation)
- Halo and tail generation module has been integrated
- Some reference manual available – tutorials on the web
- BDSIM-PLACET interface
  - BDSIM is a vital code for BDS studies
  - Alignment and tuning studies with PLACET
- Standard unix/macintosh/linux distribution installation procedure
- Used at a number of institutes

A. Latina, E. Adli, H. Burkhardt, G. Rumolo, D.S. (CERN)

1. Luminosity Stability

- $\gamma\varepsilon_x$ = 10 µm
- $\gamma\varepsilon_y$ = 0.02 µm
- ATL in x and y
  A = $4\cdot10^{-18}$ m/s
- 1-2-1 steering
- Idealistic feedback and beam tuning
- 5 linear "tuning knobs"
  w_x, w_y, d_x, d_y, c_{xy}
- Cross section by GUNIEAPIG with 40 collision / point



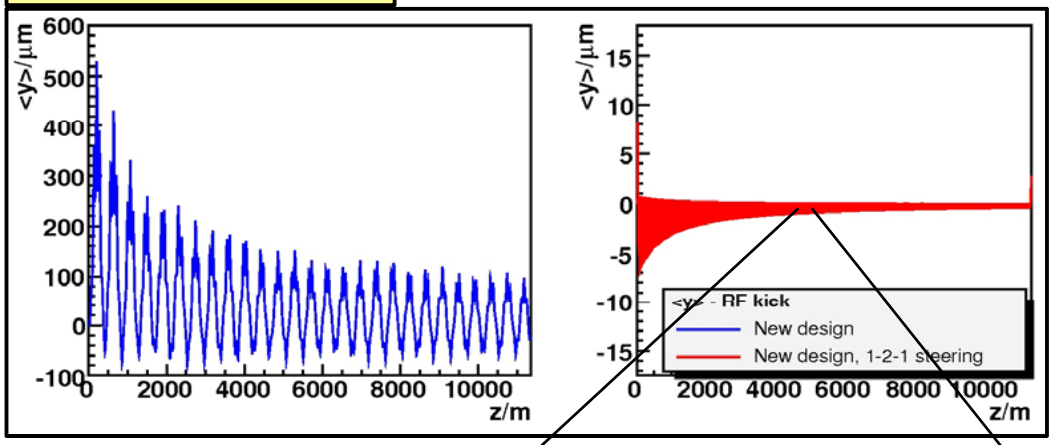


In our model the luminosity can be kept above 80% of the nominal values for about 15 (-7+15) days. Luminosity needs to be re-established then by a re-application of beam-based alignment.

2. Coupler Wake Fields and RF Kicks in MERLIN

- Coupler wake fields and RF kick has been implemented in **MERLIN** based on Zagorodnov/Dohlus
- HOM coupler rotated by π/2 → wake field kick negligible
- RF kick ~ 1KV/cavity, similar to a 100 μrad cavity tilt
- Emittance growth in ML 1.5 nm – mainly dispersive

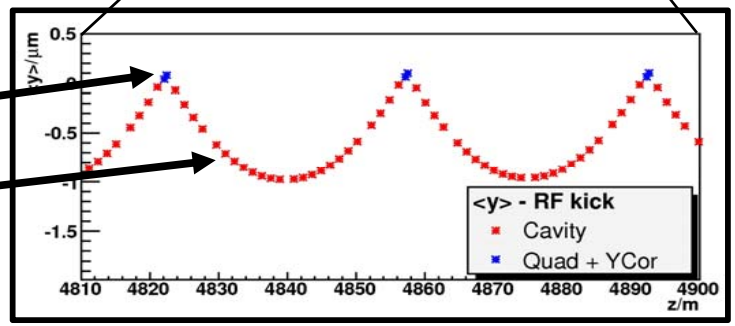
Trajectory in ML



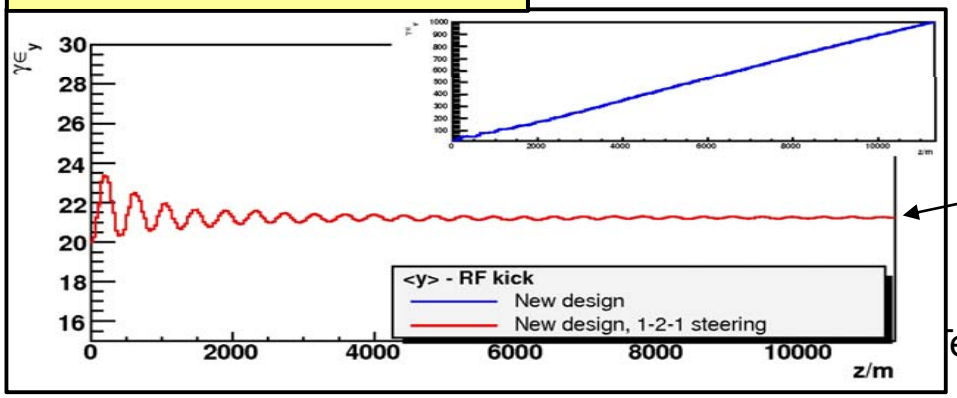
Lattice w/o undulator bypass

corrector

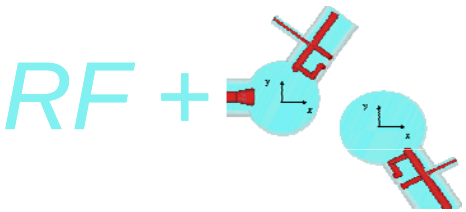
cavities



Projected Emittance ML



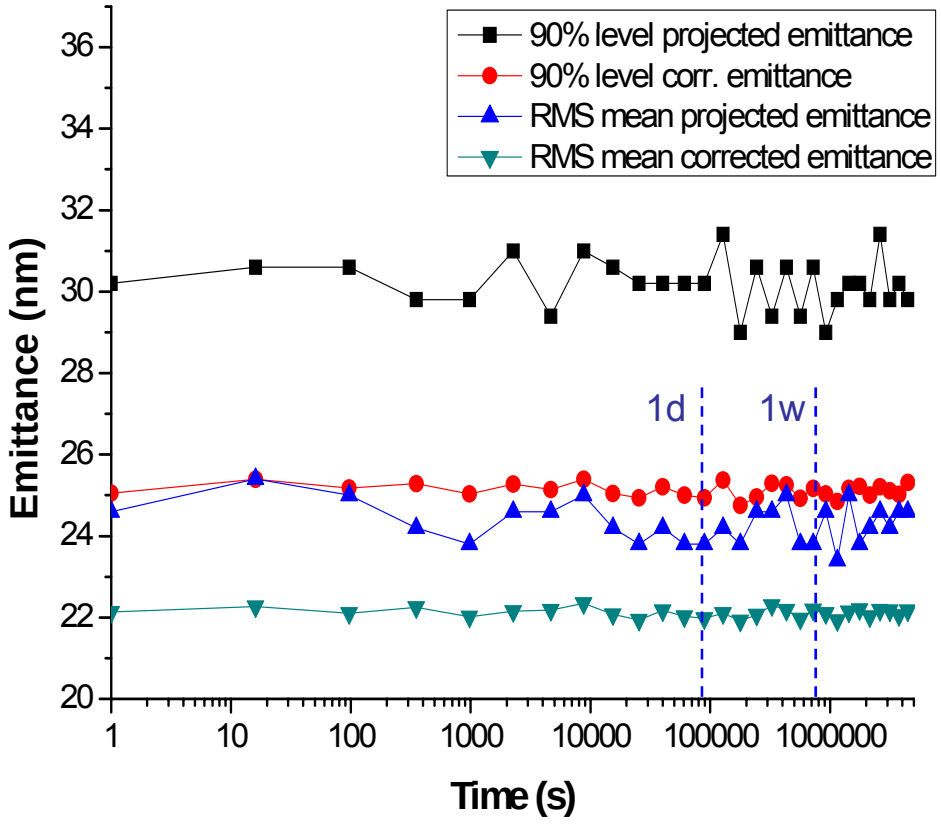
21.5 nm



Dynamic Studies on Main Linac

DFS after ATL on ML:

- **Start with a misaligned linac (positron)**
  - Std random errors on elements
  - 100 Rnd Seeds
- **Apply DFS (DMS**)**
  - Differential Weight fixed (=40)
  - Energy modification strategy:
    - -20% gradient
    - -20% initial beam
  - Segmentation (40 quad, 20 overlap)
  - Final (energy corrected*) mean Emittance = ~22 nm
- **Apply random walk** (ATL) A=4 10^-18 m/s
- Then **apply DMS algorythm**
  - Over the time scale (up to 6 weeks) studied, the vertical emittance is flat.
  - Final (energy corrected*) mean Emittance = ~22 nm



Vertical emittance value stable over studied time scale.

*Correction throughout this study: Energy correlation numerically removed

**DMS: Dispersion Matched Steering (as dealing with a curved machine)

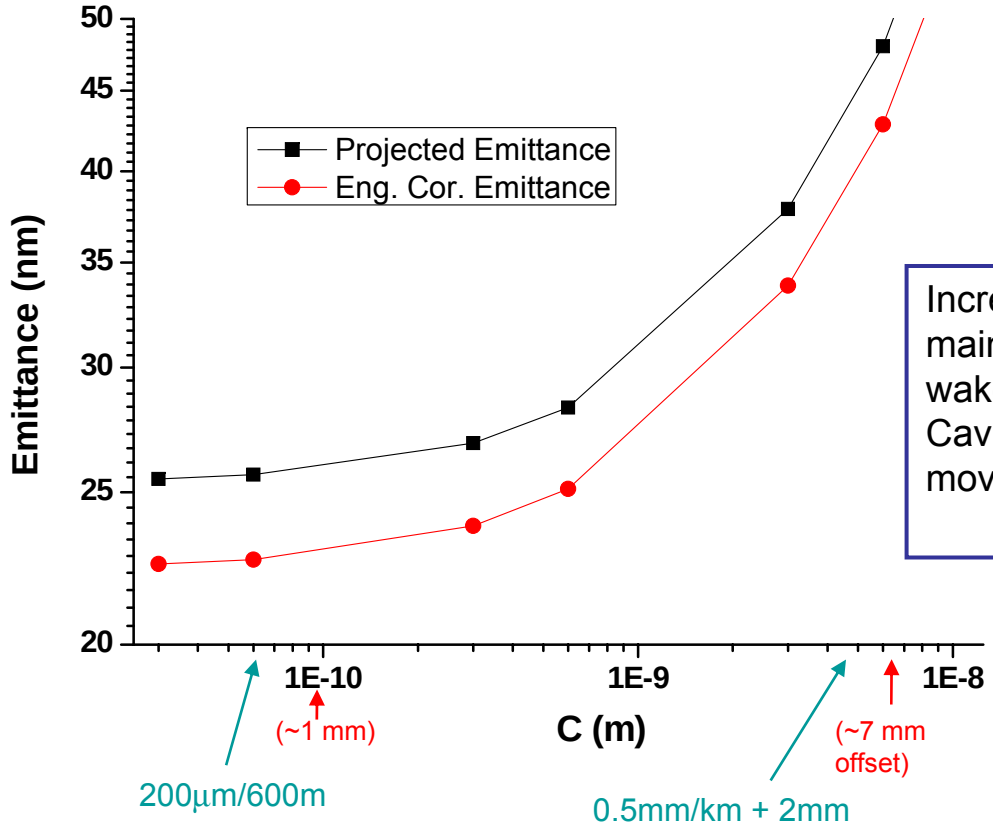
N. Walker

Static Misalignment in ML

Rnd-walk-like misalignement:

Apply vertical misalignment with a simple random-walk-like correlation: $\sigma^2 = C\,L$

- Mean Vertical Emittance (100 seeds)
- Curved machine, with wakefields.
- Misalignment errors have been applied prior to this study
- Apply CL model
- Apply Dispersion Match Steering



Increase due mainly to wakefields as Cavities are moved away.

A misalignment of 200 µm vertical over 600 m along the linac corresponds to C= 6.7 10^-11 m

With the simple CL model and misalignment of 200µm/600m, no significant impact on the vertical emittance.

Impact of misalignment non negligible if misalignment worse (eg. 0.5mm/km + 2mm).

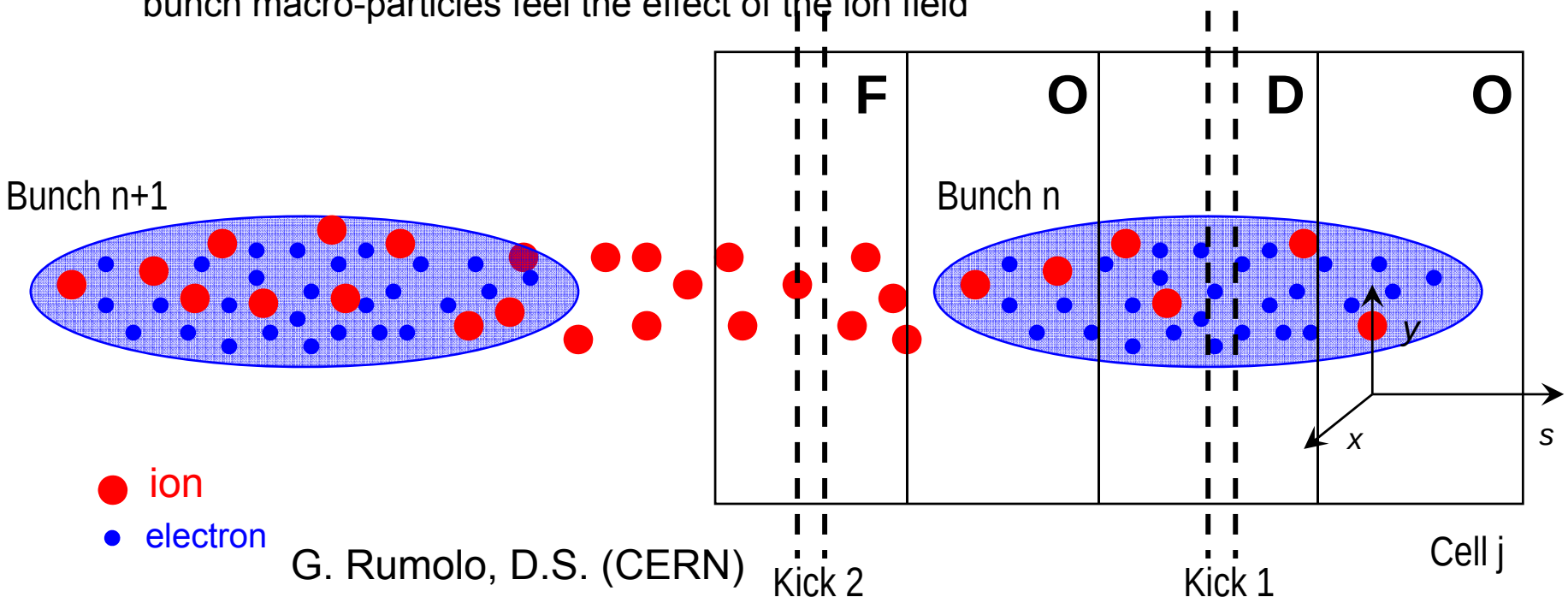
N. Walker

FASTION: A code to study the fast ion instability in a line (with acceleration or not)

- Multi-bunch code, ions and electrons are macro-particles
- Ions of an arbitrary number of species are created at each bunch passage and propagated through the train
- Line can be made of

  → a sequence of FODO cells, two kicks per FODO cell.

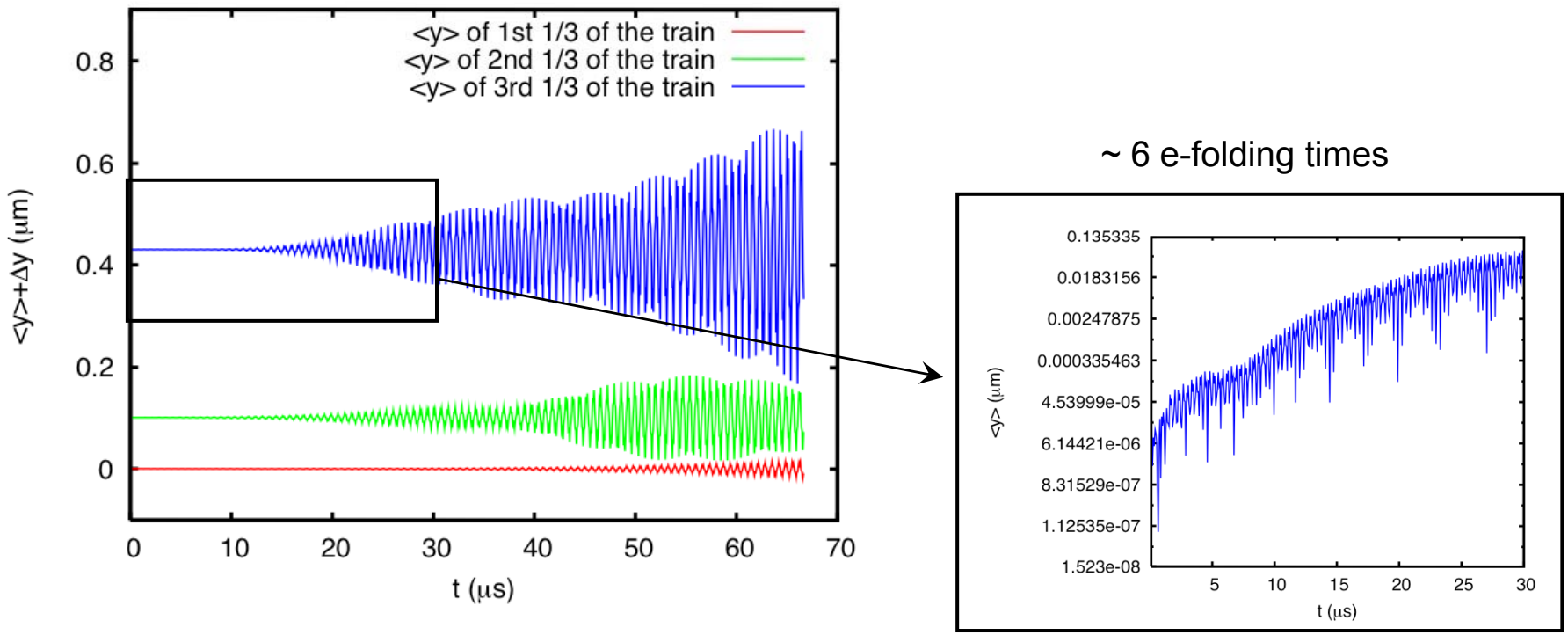
  → a given lattice, which is passed through a twiss file
- Electromagnetic interaction: the ions are kicked by the passing bunches and the bunch macro-particles feel the effect of the ion field



G. Rumolo, D.S. (CERN)

Application to CLIC Transport Line

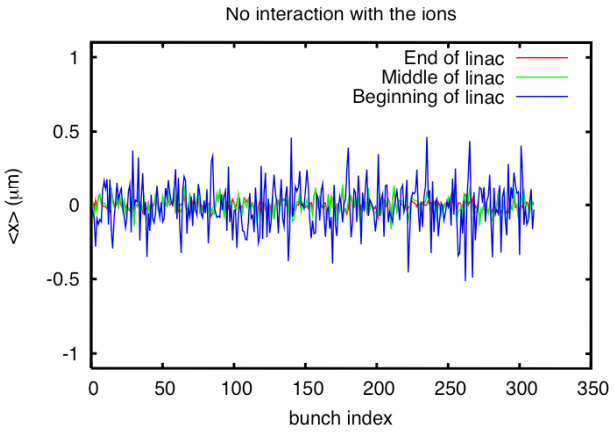
⇒ **If we look at the time evolution of the instability at the head, middle and tail of the batch, we clearly see a strong growing coherent signal mainly affecting the last part of the train (p = 1 nTorr)**

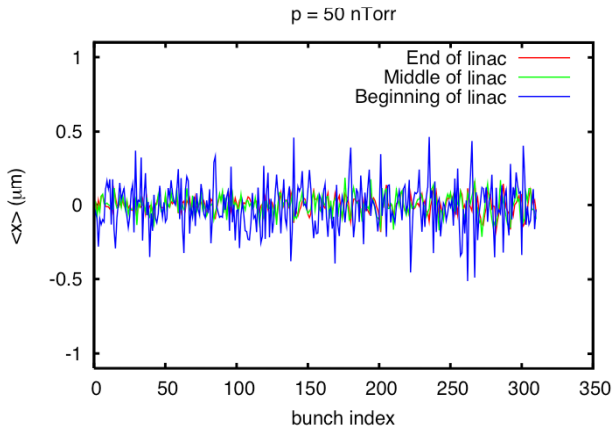


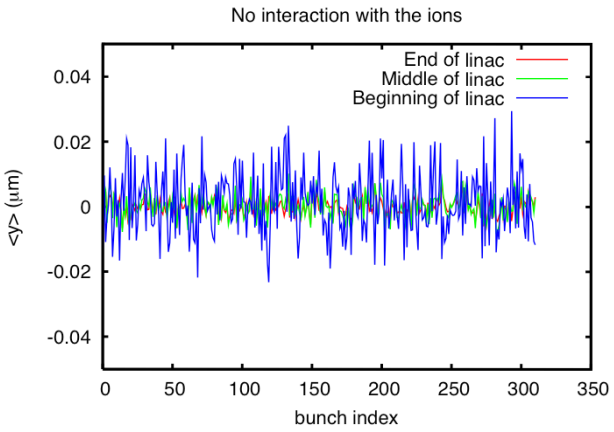
G. Rumolo (CERN)

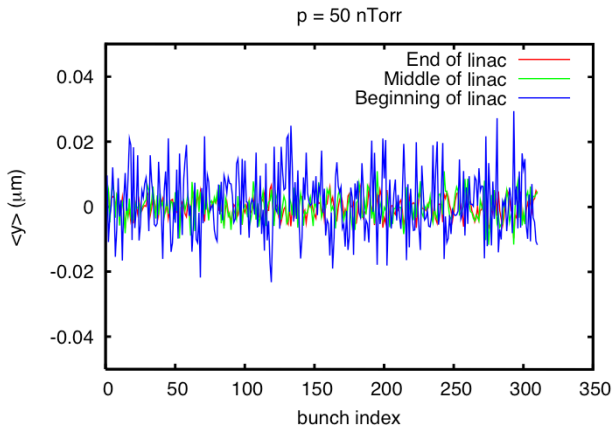
Application to CLIC Main Linac

Up to p = 50 nTorr no coherent instability appears and noise amplification does not cause large centroid motion (nor emittance growth). The reason is the absence of trapping and the consequent drift of ions to the large amplitudes, while the bunch train is passing through.









ILPS Objectives

- Conceptual design of a bunch compressor system, and a chicane system for tuning the beam path length, compatible with multi-TeV operation
- Inclusion of spin in the simulation code GUINEA-PIG, and benchmarking of physics processes
- Evaluate (model) the performance of various post-LINAC collimation systems for given halo models, and evaluate the impact on the detector. Investigate the impact of luminosity tuning and errors on background performance
- Identification of key failure modes, and evaluation of their impact on the machine design
- Develop and optimise beam-based alignment algorithms and feedback systems to optimise the luminosity performance in the bunch compressor, main linac and beam delivery systems
- Conceptual design of a post-collision extraction lines; studies on the feasibility of post-collision diagnostics.

Deliverables

- Software package to model luminosity performance
  - Two essentially ready, documentation improvements needed
- Report on luminosity tuning
  - Needs to be collected, not everything is done in Europe
- Report on failure modes
  - Reduced in priority, a bit exists
- New version of GUINEA-PIG
  - Polarisation missing, foreseen in 2008, but important effect found for luminosity spectrum reconstruction
- Report on multi-TeV BC
  - Work almost done, final report is needed
- Report on possible performance of post collision diagnostics
  - Beam line designs exists (referenc for CLIC), diagnostics potential needs to be documented
- Computer models for halo and tail generation
  - Exist, are being documented
- Report on performance of collimation system
  - Parts exist, summary to be written, impact of tuning not addressed

Conclusion

- Strong activity in 2007
  - Significant impact on ILC
    - See RDR
  - Significant impact on CLIC
    - New parameters
- Need to finalise in 2008
  - Consolidation of codes
    - In particular documentation
  - Documentation of results