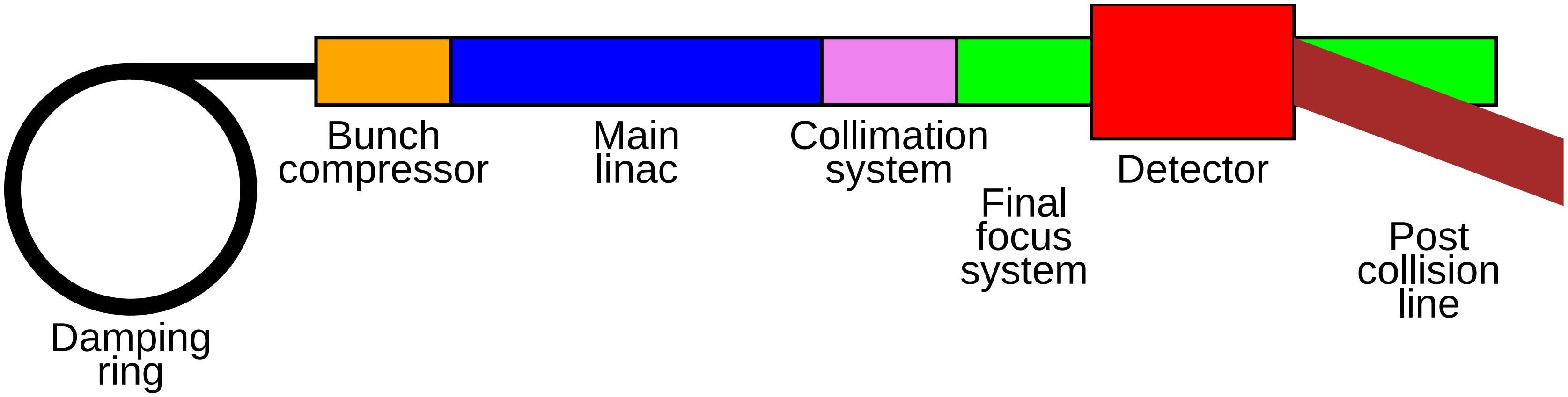
Workpackage on Integrated Luminosity Performance Studies (ILPS)

D. Schulte

"Core beam dynamics work package studying the impact on integrated luminosity of tuning and feedback systems in the collider systems downstream of the damping ring (bunch compression, main linac, beam delivery); analysis (simulation) of failure modes; simulations of the efficiency and related background from beam halo collimation; development and benchmarking of beam-beam simulation codes; simulation of the extraction line diagnostics performance."


Bunch compressor
Main linac
Collimation system
Final focus system
Detector
Post collision line
Damping ring

Motivation of the Workpackage

Two very critical challenges

- Achievement of luminosity goal
- Protection of machine

- Luminosity can be harmed by
  - static imperfections
    ⇒ beam-based alignment and tuning
  - dynamic imperfections
    ⇒ feedback
  - too high background
    ⇒ e.g. collimation
- Interaction of sub-systems can be important (e.g. banana effect)
- Interaction of differemt feedback systems can be important (fast vs. slow)
- Interaction between tuning procedure and dynamic effects can be important
- Achievement of instrumentation/diagnostics performance is vital (e.g. spent beam line)
- Machine protection may affect machine design and hence luminosity (e.g. collimation)

Charge

The workpackage aims to demonstrate through full simulations that the accelerator luminosity performance goal can be reached, even in presence of a wide variety of dynamic and static errors. It will also study the strategy to deal with failures and the impact of background on the luminosity and design.

To fulfill this task the following is included

- development of luminosity tuning strategy
- develop imperfection/instrumentation model
- development of simulation tools
- code benchmarking
- design of important beam lines that have not yet been designed
- conceptual study of potential special instrumentation
- impact of machine background on the luminosity limitations

External Constraints

- A recommendation has been issued to use superconducting RF technology for the next linear collider
- The machine design has not yet been fixed and can be quite different from the TESLA design
- We will contribute to the choices made
- Other regions will also contribute

$\Rightarrow$ We will need to be flexible to adjust to new challenges

$\Rightarrow$ We will have to strongly interact with the other regions and try to limit the duplication of work to the minimum required for healthy competition

Task Overview

- Bunch compressor design (BCDES): 4 person-years
- Post-collision Diagnostics line (PCDL): 8py
- Beam-beam simulation code development (BB-SIM) 4 py
- Halo and tail generation (HTGEN) 4 py
- Failure mode simulations (FMSIM): 4 py
- Collimation simulation (COLSIM): 9.5 py
- Luminosity and alignment studies (LAST): 14 py
- above are round numbers, total: 570.8 person months of which Europe contributes 212.5

Schedule and Remarks

- ILPS is a research project so needs flexibility
- Good part of the work is creative and not easy to plan
- Schedule should support the required strong interaction between the tasks

⇒ Simple milestone plan

- Main milestones
  - detailed planning ready, personal hired: after 6 months
  - work that is input for further studies is ready (for exchange between tasks): after 18 months
  - first version of final reports, deliverables: after 30 months
  - integration, review, improvement of deliverables done: after 36 months
- Interaction between tasks all the time

Bunch Compressor Design (BCDES)

M. Pedrozzi (PSI)

- Design a bunch compressor compatible with multi-TeV centre-of-mass energies
- Design a path length tuning chicane

- Design compressor and tuning chicane
- Evaluate system performance, e.g. coherent synchrotron radiation
- Improve design as appropriate/possible

- First design ready for evaluation

- Bunch compressor lattice suited for multi-TeV operation
- Evaluation report on compressor performance
- Tuning chicane lattice

Post-Collision Diagnostics Line (PCDL)

V. Ziemann (University of Uppsala)
Ph. Bambade (LAL)

- Develop conceptual design of multi-TeV post collision line to ensure upgradability of linear collider
- Understand and possibly improve the potential for instrumentation with suitable performance in the post collision line at different energies

- Determination of spent beam characteristics (BBSIM, LAST)
- Collect/improve existing low energy designs
- Possibly develop new low energy design
- Develop multi-TeV design
- Tracking simulations with emphasis on location of post-IP diagnostics
- Conceptual instrumentation design
- Evaluation of instrumentation performance
- Make design choices based on results
- Give instrumentation performance to LAST

- Conceptual designs ready
- Conceptual multi-TeV post collision line design
- Report evaluating the potential instrumentation in the post collision line at different energies

Beam-Beam Simulation Code Development (BBSIM)

Ph. Bambade (LAL)
D. Schulte (CERN)

- Improve and verify beam-beam simulation code
- Benchmarking of physics processes in GUINEA-PIG against know and trusted physics generators
  - collect codes/data
  - compare
  - evaluate validity
- Implementation of spin transport into GUINEA-PIG
- First new version of code ready
- Most important benchmarking done
- New GUINEA-PIG version with spin transport
- Report on benchmarking of GUINEA-PIG

Halo and Tail Generation (HTGEN)

H. Burkhardt (CERN)

- Develop model of halo and tails in linear colliders
- Identify the potential to verify the model

- Identification of potential sources of halo/tails in LET
- For each source estimation of halo population
- Development of code modules for halo/tail generation
- Simulation studies of halo and tail generation
- Exploration of possible benchmarking

- Models developed/implemented

- Report on estimation of halo population due to different mechanisms
- Routines to include halo models in collimation simulations
- Report on potential benchmarks to verify predictions

Failure Mode Simulations (FMSIM)

N. Walker (DESY)
D. Schulte (CERN)

- Identify key failure modes and evaluate their impact on the machine design

- Determination of key failure modes
- Develop tools to simulate these failures
- Evaluation of the impact of key failure modes on the accelerator performance
- Explorative study of means to mitigate the effect of key failures

- Code ready, most important failures identified

- Report on most critical failure modes and their impact on machine performance
- Code package to simulate most critical failures

Collimation Simulation (COLSIM)

G. Blair (RHUL)
N. Walker (DESY)
R .Barlow (UMA)
D. Schulte (CERN)

- Improve understanding the impact of background on the collimation system design
- Improve understanding the interplay of tuning and background

- Further development of secondary particle simulation code (BDSIM)
- Further development of beam dynamics tracking codes
- Estimation of efficiency of removing beam tails
- Optimisation of the system
- Study of secondary backgrounds and their impact on the collimation system design, e.g.
  - synchrotron radiation
  - neutrons
  - muons

- Explore possibilities of benchmarking the simulation tools
- Investigation of impact of luminosity tuning on collimation efficiency
- Explore strategy of background tuning

- Studies ready with simple halo model
- Muon studies ready
- New BDSIM release (e.g. synchrotron radiation)

- Report on collimation system efficiency study
- New version of BDSIM
- Report on how the luminosity tuning affects the background
- Report on exploration of how the background can be reduced by tuning
- Report on exploration of benchmarking possibilities

Luminosity and Alignment Studies (LAST)

Ph. Burrows (QMUL)
N. Walker (DESY)
D. Schulte (CERN)

- Develop an alignment and feedback strategy for the low emittance transport system in order to optimise the luminosity performance of the linear collider
- Develop tools to evaluate the luminosity performance of the linear collider due to the effects in the low emittance transport system

- Development of simulation tools to study the beam transport from the damping ring to the interaction point including imperfections
- Development of beam-based alignment strategy in all subsystems (bunch compressor, main linac, BDS)
- Development of beam-based feedback strategy in all subsystems
- Development of emittance and luminosity tuning strategy (including beam-beam)
- Implementation of most relevant algorithms in codes

- Simulation performance of each algorithm with relevant set of machine errors
- Study of interplay of beam-based alignment, feedback and tuning in presence of relevant dynamic and static imperfections

- Studies ready for individual sub-systems, dynamic and static seperated
- Tracking codes ready

- Code package to simulate beam transport from damping ring to IP
- Report describing the alignment and feedback strategy and its expected performance

Milestone Plan

- After 6 months

- Detailed planning done

- After 18 months

- Subsystem alignment strategy defined (BC, main linac BDS) (LAST)
- Individual feedback systems defined (LAST)
- Tuning procdures explored (LAST)
- LET codes ready (LAST)
- Failure mode model ready (FMSIM)
- Beam-beam code ready (BBSIM)
- Halo code ready (HTGEN)
- BDSIM ready (COLSIM)
- Bunch compressor design ready (BCDES)
- Post-collision line design ready (PCDL)
- Collimation system efficiency evaluated (COLSIM)

- Following work
  - Study of tail generation and exploration of becnhmarking (HTGEN)
  - Analysis of failure mode impact (FMSIM)
  - Interaction of different alignment procedures (LAST)
  - Interaction of different feedback systems (LAST)
  - Interaction of dynamic/static effects (LAST)
  - Evaluation of bunch compressor performance (BCDES)
  - Evaluation of post collision line instrumentation (PCDL)
  - Further verification of beam-beam code (BB-SIM)
  - Evaluation of collimation system issues (COL-SIM)

Conclusion

- We know what we want to do
- We found some resources
- We got additonal resources from the European Union
- So let us go and do it