Beam Dynamics Studies to Prove Feasibility of CLIC

- many components are critical
- some look more difficult than others
- but misjudgment of difficulties existed (even in other projects)
- there are CLIC specific items

  e.g. drive beam
- others are "just" more difficult for CLIC

  e.g. DR, alignment etc.

three work areas exist

- drive beam complex
- main beam complex
- CTF3

$\Rightarrow$ collaboration is needed

- e.g. Frascati for CLIC combiner ring?

Drive Beam Complex

- individual components
  - drive beam injector
  - drive beam accelerator
  - bunch compressors
  - combiner ring
  - transport lines
  - decelerator
  - beam dumps
  - special lines (feedback, collimation)
- studies across the whole complex
  - timing and amplitude error of RF produced by drive beam
  - losses and machine protection
  - beam physics (e.g. fast beam-ion instability)

Drive Beam Injector *

- update of PARMELA studies
- evaluation of beam stability
- update of lattice design
- contribution to studies across the whole complex

Drive Beam Accelerator *

- update of beam stability studies
- update and improvement of lattice design
- contribution to studies across the whole complex

Bunch Compressors *

- update and improve current design
- new design as needed
- tolerance estimation
- contribution to studies across the whole complex

Combiner Ring **

- evaluate effects of static and dynamic imperfections
- stability is a bit marginal (RF-deflector and phase advance)
- many effects to be followed (synchrotron radiation etc.)
- improve and update lattice design
- contribution to studies across the whole complex

Transport Lines *

- design missing lines
- evaluate tolerances
- contribution to studies across the whole complex

Drive Beam Decelerator **

- improvement of modelling
- update of stability simulations
- update and improvement of lattice design
- contribution to studies across the whole complex

Beam Dump *

- develop and verify design

Special Lines **

- update and improve existing designs
- make new designs when and where required by study of the whole complex
- contribution to studies across the whole complex

Drive-Beam Timing and Intensity***

- timing and intensity errors of the drive beam can significantly affect the main beam
- the error can be quite coherent (unlike klystron)
- main linac studies are needed to determine tolerances

Tasks

- Identify important sources of drive beam timing jitter

  some work has already been done

  but needs to be redone and extended

- Identify possible cures (e.g. feedback) and evaluate their potential performance

  some ideas exist
  (e.g. longitudinal feedback before decelerator)

  but even first order evaluation remains to be done

  how well can we measure the interesting parameters?

  how fast can we feed back?

Drive-Beam Losses ***

Main problems are permanent and accidental beam losses

- identify and investigate sources of tails
- investigate acceptance (sofar looked at core)
- establish limits for acceptable losses
- define means to ensure acceptable loss levels (collimation, etc.)
- make sure they basically work (heat load in collimators, etc.)
- identify accidental loss scenarios
- identify strategies of machine protection

this calls for

- multi-headed effort to make sure we do not miss something important
- core people to keep things coherent
- development of new and/or significant extention of existing tools to study losses and their impact
- we may profit from collimation studies etc. of other projects

General Beam Physics **

- a number of topics need to be looked at or followed up

  space charge

  fast beam ion instability

  external fields

  steering via loss monitors?

  etc.

Main Beam

- a number of beam lines remain to be designed or improved
  - injector linacs
  - beam delivery system
  - spent beam line
  - damping ring
  - everything else
- some topics need to be studied across the machine
  - tuning in dynamic environment
  - luminosity monitor
  - experimental conditions at IP
  - multi-bunch effects
  - electron cloud
  - FBII
  - impedances (collimators etc.)
- experience shows that we need an integrated modelling of the main beam complex

Injectors *

- looks less difficult for us than for the other projects
- can learn from polarised positron experiments (shall we contribute?)
- essentially need to follow the developments

Damping Ring **

- include static and dynamic imperfections
- evaluate electron cloud and beam-ion effects
- improve performance to reach design values (or substantiate that the goal cannot be met and parameters must be changed)
- demonstrate effectiveness of the concept including wigglers
- update design to stay consistent with developements
- contribute to overall modelling

Transport Lines and Turn Arounds *

- complete, update and improve design
- establish tolerances
- contribute to overall modelling

Bunch Compressor *

- design and evaluate lattice of compressor linacs
- evaluate effect of coherent synchrotron radiation in compressor
- evaluate emittance growth in booster linac and bunch compressor
  likely need dispersion bump
- update design to stay consistent with developments
- contribute to overall modelling

Main Linac **

- support structure developments
    - short range wakefields
    - long range wakefields
- update and improve design to stay consistent with developments
- strongly contribute to overall modelling

Collimation System **

- critical for machine protection
- a not well solved problem for everybody
- understand the wakefields of collimators
- evaluate impact of imperfections
- update and improve design
- strongly contribute to integrated modelling

Final Focus System *

- evaluate impact of imperfections
- update and improve design
- strongly contribute to integrated modelling

Line for the Spent Beam *

- design a system
- evaluate tolerances, losses and background
- identify possible instrumentation and steering

Emittance Tuning Bumps **

- design measurement station
- perform realistic background evaluation
- evaluate and improve measurement procedure
- strongly contribute to overall modelling

Diagnostics Section **

- establish required performance
- design a system (may be integrated into BDS)
- evaluate performance
- update design to stay consistent with developments
- strongly contribute to overall modelling

Other Diagnostics Section *

- identify needs and possibilities
- design systems
- strongly contribute to overall modelling

Interaction Point **

- evaluate luminosity and luminosity spectrum for different conditions
- evaluate crab crossing cavity effects
- verify integration of quadrupoles into the detector
- intra-pulse interaction point feedback
- update design to stay consistent with developments
- provide luminosity and background data for the CLIC Physics Study
- strongly contribute to overall modelling

Luminosity Monitor ***

- crucial for machine tuning
- the low energy solution does not work for us
- identify potential signals.
- make conceptual detector design taking into account the background conditions.

Other Tuning Signals **

- identify potential signals
- identify tuning knobs
- make conceptual design

Overall Tuning and Luminosity ***

- continue integration of different subsystems in overall modelling
- evaluate luminosity performance

  static effects

  dynamic effects

  noise sources

  time needed for tuning
  (this is critical
  in particular for complex precedures)

  extension to multi-bunch effects

  cross talk of machine components
- improve trade-offs (e.g energy spread: linac vs. BDS)
- machine protection and failures

Beam Physics Matters ***

- verification of coherent synchrotron radiation modelling
- multi-bunch effects
  - identify multi-bunch problems all across the machine
  - complete solution of beam-loading problem in main linac
  - evaluate multi-bunch transverse wakefield effects in main linac
  - evaluate effect on emittance tuning bumps
  - continue intra-pulse feedback studies
  - etc.
- electron cloud
  - maybe a problem in BDS (SLAC)
  - verification of modelling
  - counter measures (also LHC)
  - improved simulations
- fast beam ion instability
  - where is it a problem (e.g. main linac)
  - verification of modelling

anomalous skin effect

- also interesting for LHC
- but may be different (high frequency vs. low temperature)

non linear collimation

CTF3

Two main tasks

- help CTF3
- get help from CTF3

this requires

- provide simulation tools for CTF3
- integrate tools into control environment
- verify that tools are consistent with findings
- identify dedicated experiments to verify tools
- design new components
  (e.g. decelerator)
- example studies

  instability in combiner ring

  new instrumentation (measure dipoles at coupler)

  can we measure wakes with the beam?

  halo generation

  beam stability in decelerator

  invent and test feedback loops

  interaction with instrumentation experts

Potential Demonstrations at CTF3

- drive beam injector
  - comparable current
  - different frequency, bunch parameters
  - can gain confidence
- drive beam accelerator transverse stability
  - comparable current
  - can run at higher current
  - machine is shorter
  - but starts at lower energy
  - can gain confidence
- drive beam accelerator longitudinal stability
  - higher frequency
  - fewer units
  - could establish stability but may be too hard
- combiner ring
  - very different current
  - but right frequency (3GHz vs.3.75GHz)
  - and lower energy
  - strong prediction from the simulation can be tested (RF deflector wakefield)
  - can some gain confidence

- halo formation

  lower energy

  shorter machine

  need to make tails visible (e.g. chicane)

  can gain some confidence

- drive beam decelerator transverse stability

  current way lower

  energy lower (start in CTF3 where CLIC ends)

  will be challenging to find experiments which give confidence

  can gain some confidence

- drive beam decelerator longitudinal stability

  maybe can gain some confidence

- potential test of kicker flatness

  could gain confidence

- instrumentation

- feedbacks

  CTF3 may prove a value testbed for different feedbacks

  can we test drive beam timing feedback?

- main linac

  maybe can do a bit

  e.g. a rough test of beam loading compensation

  but transverse emittances are much larger, so many effects cannot be tested

Conclusion

- most of drive beam generation can be tested

  some work is needed to cover more topics (feedbacks, longitudinal stability, halo, etc)

  some topics may remain

- testing the drive beam decelerator will be though

  can try to do our best

- only few main linac can be adressed

  maybe beam loading

  maybe RF timing

$\Rightarrow$ CTF3 meeting(s) to help defining a programme for maximum exploitation of CTF3

- e.g. decelerator design

$\Rightarrow$ few items that cannot be addressed at CTF3 can be adressed elsewhere (e.g. ATF)

$\Rightarrow$ theoretically investigate in particular

- drive beam phase and amplitude stability
- drive beam losses
- main beam tuning

  the other topics should be integrated into this

$\Rightarrow$ these studies must be in very close collaboration

  some topics are OK for other collaboration

$\Rightarrow$ maybe low energy CLIC1