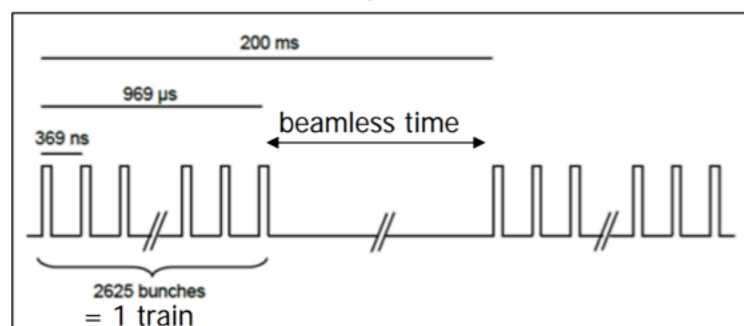# C3 Overlay Considerations

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ECFA Higgs Factories: 2nd Topical Meeting on Reconstruction

11 July 2023

Requirements for C3 Overlay (personal perspective)

- We must be able to overlay the primary components of machine and beam induced backgrounds with appropriate timing structure
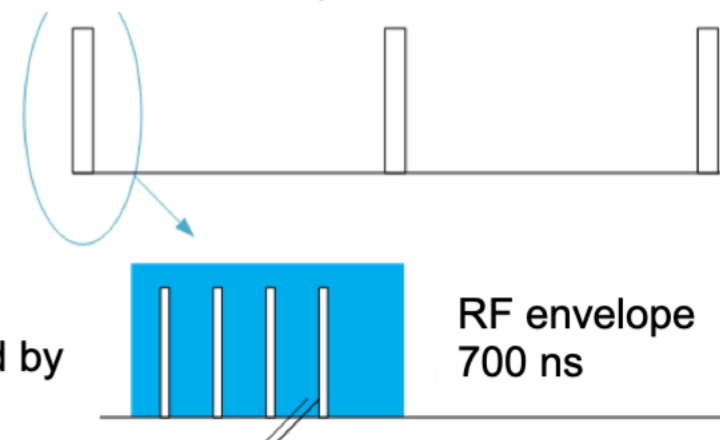

ILC timing structure

1 ms long bunch trains at 5 Hz
2820 bunches per train
308 ns spacing

C³ timing structure

Trains repeat at 120 Hz

Pulse Format

133 1 nC bunches spaced by 30 RF periods (5.25 ns)

RF envelope 700 ns

- C3 much more LHC or CLIC-like in bunch structure than ILC
- **This has impact on electronics design but overall C3 deals with 1/10th the per-train backgrounds of ILC, but they are the same constituency per bunch***
- Out of time pileup (OOTPU) is - comparatively - an issue

- We should endeavor not to engineer anything new, CLIC and LHC have solved this problem well, **C3 intends to use key4hep**
- We need to overlay backgrounds with correct rates and distributions in multiple bunches with correct timing structure to properly account for OOTPU
- LHC PU mixing solutions extremely robust to large data volume

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Requirements for C3 Overlay (and personal perspective)

- * The accelerator muon backgrounds are likely to be very different from ILC given much shorter BDS, again more similar to CLIC (but lower energy)

- We should also endeavor to make sure that the mixing in key4hep is scalable to any collider concept or experiment that wishes to use key4hep

- While the out-of-time overlay has been well trodden at CLIC it is probably worth it to take stock of what the LHC experiments have learned about doing this from the operational and software framework standpoint
  - Ignoring the lessons learned and code written is likely foolish
  - It has also been scaled to 200PU in hadron environments (and higher, privately) with high granularity calorimeters and modern tracker designs
  - Without blowing computing memory, disk, or networking budgets
  - These tools cover the entire range needed by Higgs Factories and well beyond, and may suggest a strategy for key4hep

Paths of Development

- Speaking for C3: We are curious to try the CLIC-style pileup overlay and anything else key4hep has to offer

- The primary aim is to get some first estimates of any deleterious effects from OOTPU on experiments @ C3
  - 1ns or better timing likely necessary to separate interesting physics suitably across bunch crossings - not a problem for modern electronics
  - Primary missing background is accelerator muons, but effort is started to calculate this

- Speaking for FNAL: we are also curious to pursue adding stitched to key4hep and bringing the LHC-style pileup mixing strategies into play
  - stitched is CMSSW without the experiment specific parts
  - Another useful take on an event data model in the modern heterogenous, parallel processing paradigm
  - Easily compatible with edm4hep
  - Longer term project

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Concluding Remarks

- C3 intends to use key4hep for further simulation studies and progression to full background simulations
  - Obviously it is very early days for us when it comes to background mixing

- C3 bunch structure closer to CLIC or LHC compared to ILC

- We are happy to collaborate, use, and contribute to any existing PU mixing scheme that is suitable for our task!
  - We are also interested in learning from the accumulated knowledge of CLIC and LHC to produce efficient, production quality, pileup mixing workflows

- If you're interested in joining the C3 effort we meet regularly on Fridays:
  - https://indico.slac.stanford.edu/category/58/

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