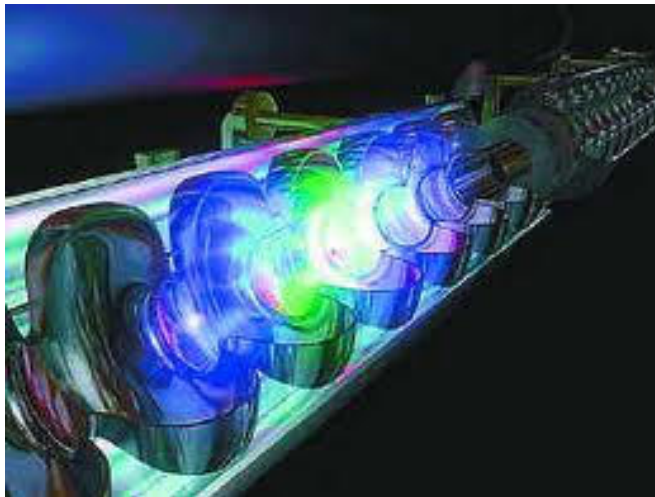


# Numerical Modeling of FLASH and the European XFEL

## Start-to-End Simulations



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S2E Meeting, DESY  
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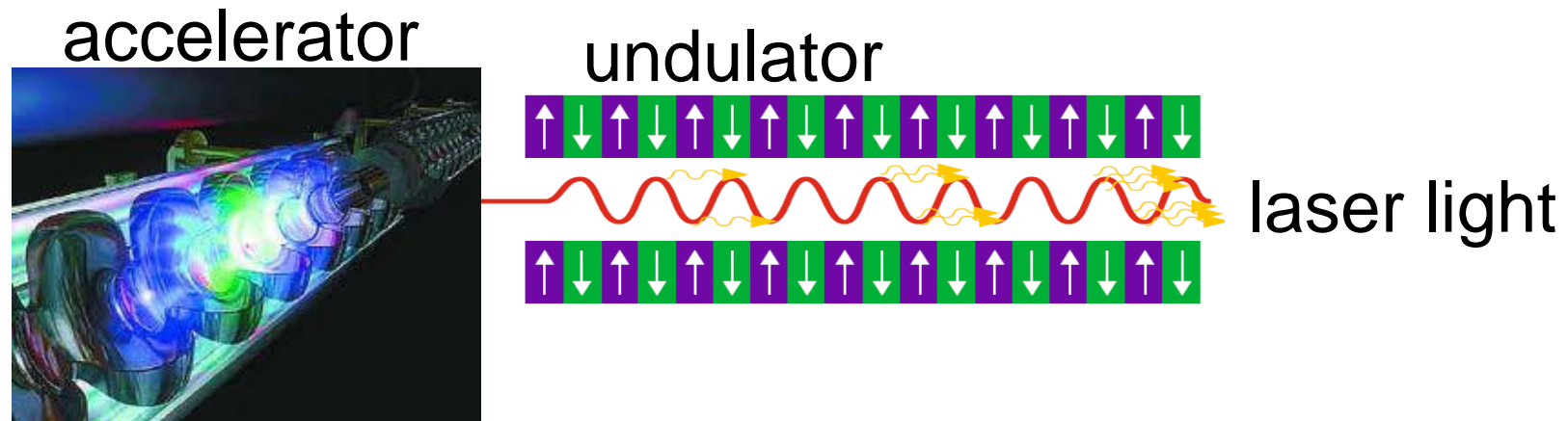
# Content

- ❑ motivation
- ❑ FLASH simulations
- ❑ XFEL simulations
- ❑ tools, internet presence and publications
- ❑ challenges



# Motivation

## Why do we need S2E simulations?



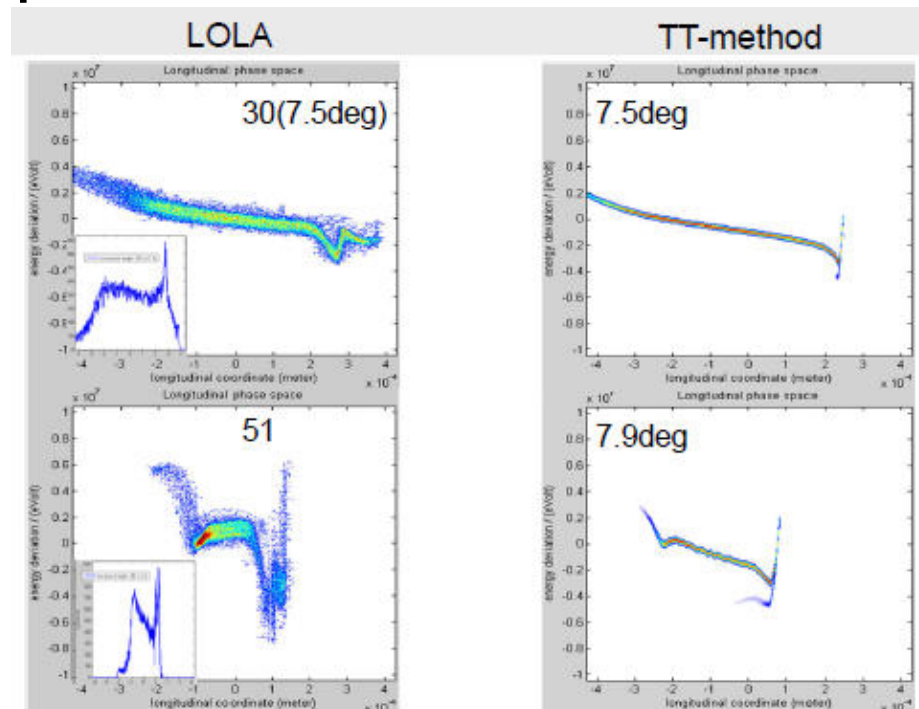
- to verify the facility design and to improve it
- to explain facility performance and to improve it
- to develop new ideas, facilities etc.

# Motivation

Can we trust the S2E simulations?

Yes! If we are able

- ❑ to reproduce the measurements
- ❑ to predict the measurements



# FLASH Simulations

gun



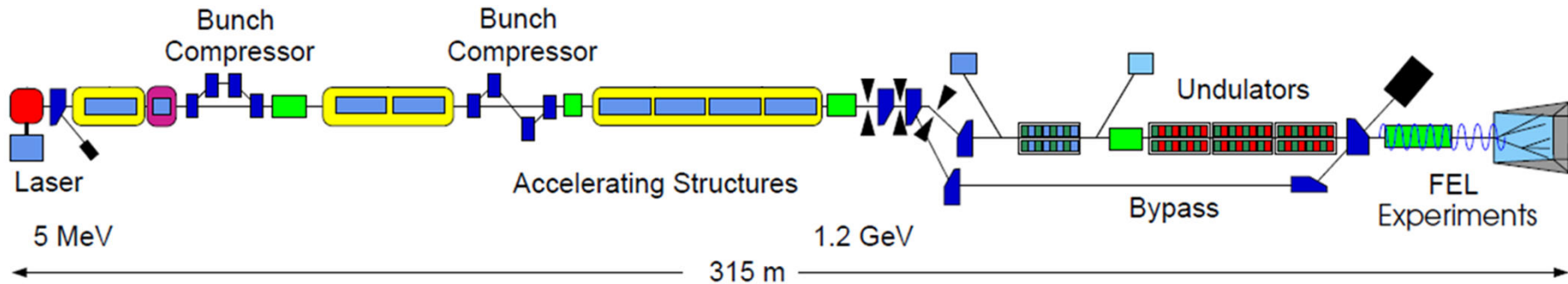
accelerator



undulator



laboratory



# FLASH Simulations

## Already done

- detailed simulation of the whole facility
- simulation of experiments (triangular profile)
- simulations of measurements (weak compression, spike mode)
- longitudinal wakes are included
- BBA, microbunching, trajectory jitter etc?



# FLASH Simulations

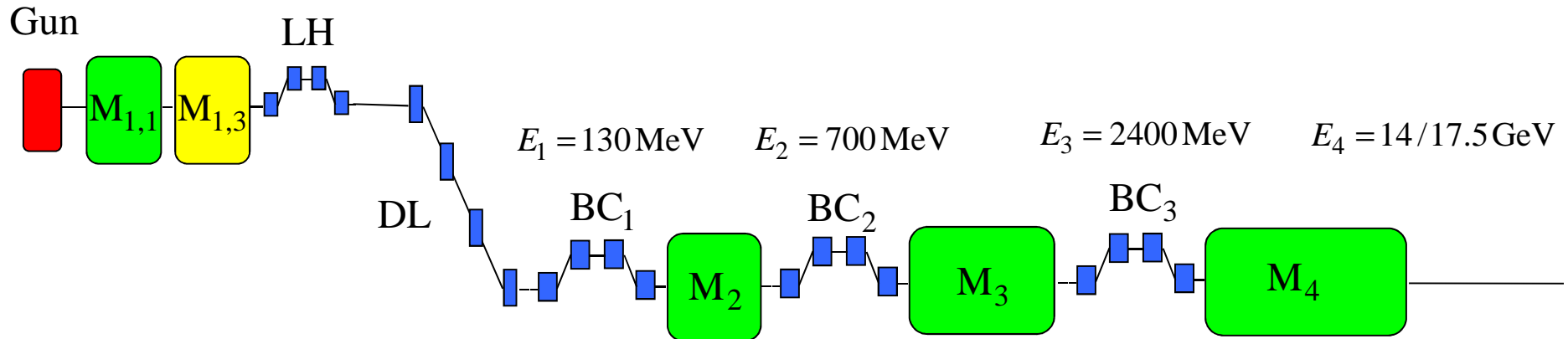
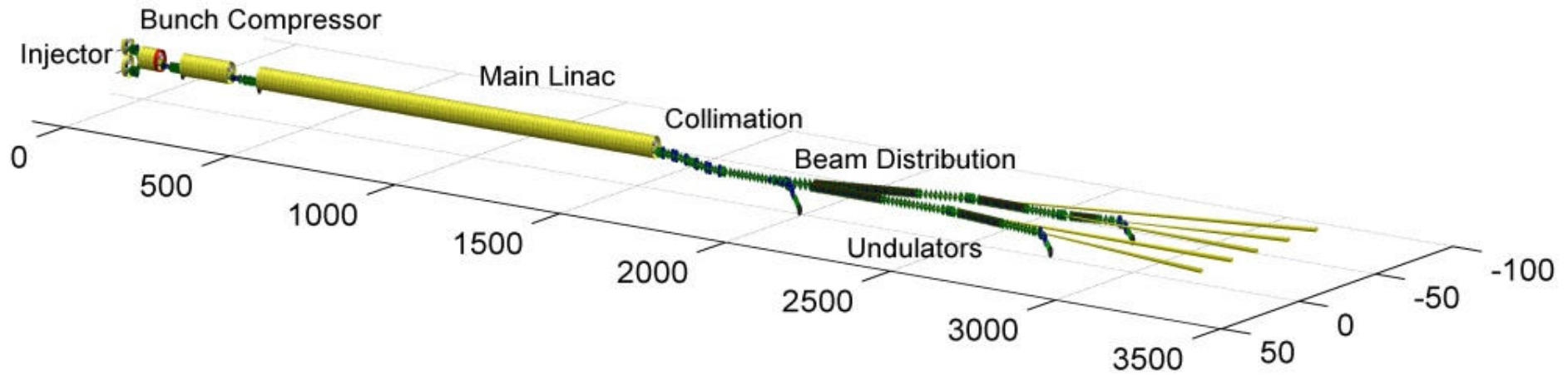
## Has to be done (short term)

- more accurate simulations without suspicious steps (matching, shifting of slice centers etc.)
- to reproduce the LOLA measurements at FLASH for average and strong compression
- to explain the SASE dependence on ACC1 gradient
- to include the transverse wakes



# XFEL Simulations

## Layout





# XFEL Simulations

## Already done

- detailed simulation of the facility up to the collimation section
- simulation of different compression scenarios
- longitudinal wakes partially included
- BBA, microbunching, quad errors, etc?



# XFEL Simulations

## Has to be done (short term)

- simulations of the whole facility
- more accurate simulations without suspicious steps (matching, shifting of slice centers etc.)
- simulations of non-standart scenarious (different charges in the train etc.)
- tollerance studies



# Tools, Internet Presence and Publications

## Tools

- convertors
- fast trackers
- manuals, **tests**, examples

## Internet Presence

- tools
- results documented
- reproducibility** of the results

## Publications

- internal reports
- in referred journals



# Challenges

- ❑ the simulations has to checked through experiments
- ❑ we have to be able to reproduce the measurements
- ❑ we have to be able to predict the measurements
  
- ❑ simulation of FLASH II
- ❑ simulation and explanation of XFEL performance
- ❑ plasma experiments at FLASH

**We have to continue the accelerator code development!**



# Challenges

## The European XFEL Machine FAQ?

See, for example, LCLS Machine FAQ

[https://slacportal.slac.stanford.edu/sites/lclscore\\_public/Lists/LCLS\\_FAQ/FAQ.aspx](https://slacportal.slac.stanford.edu/sites/lclscore_public/Lists/LCLS_FAQ/FAQ.aspx)

- What is the photon energy range and how long does it take to switch?
- What is the highest pulse energy available (number of photons in the pulse) and how does it vary with photon energy and pulse length?
- What is the x-ray pulse length, how long does it take to change it, and how does the pulse energy and peak power vary with pulse length?
- How does the x-ray transverse beam size vary with photon energy and electron peak current settings?
- What are the temporal characteristics of the x-ray pulse, including number of spikes, spike duration, peak power in each spike, and how does this vary with photon energy and peak current?

