

Thesis status updates: Activities in past months

Notes on ASTRA simulations

Beam modulation method

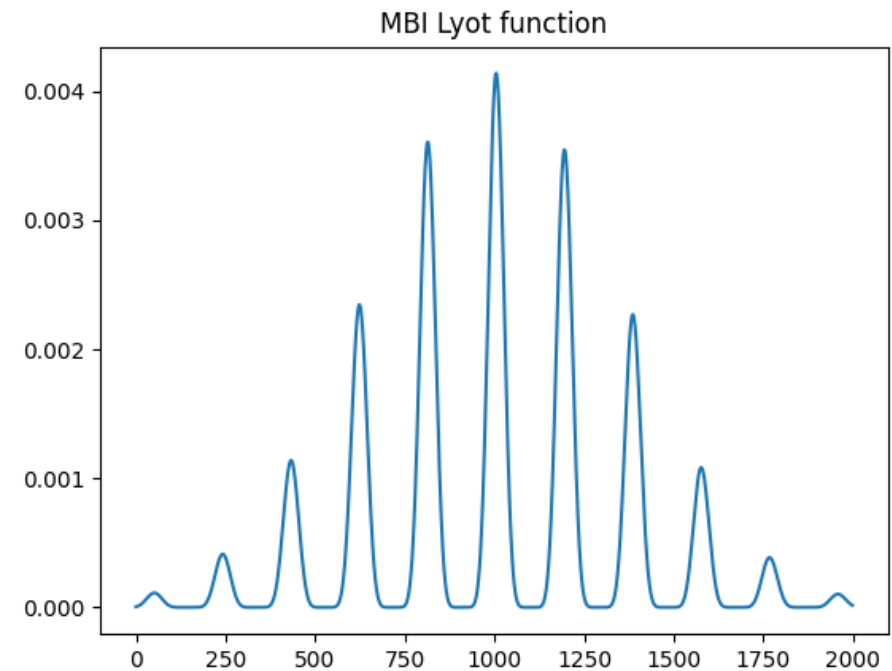
Genesis V4

Ocelot with Genesis V4

G. Georgiev
PPS
30.07.2020

Introduction

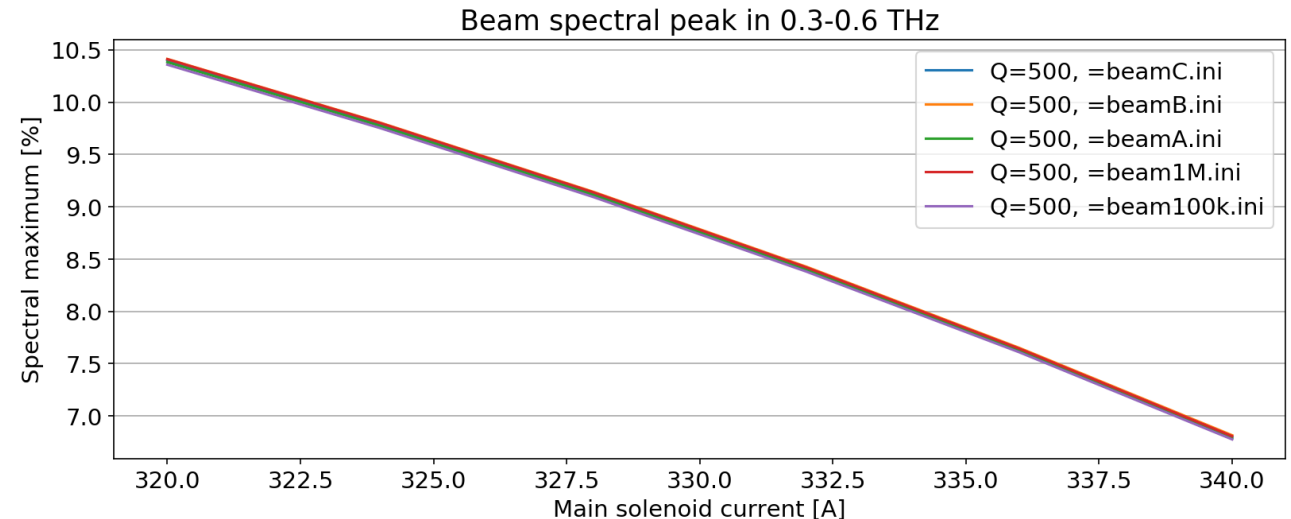
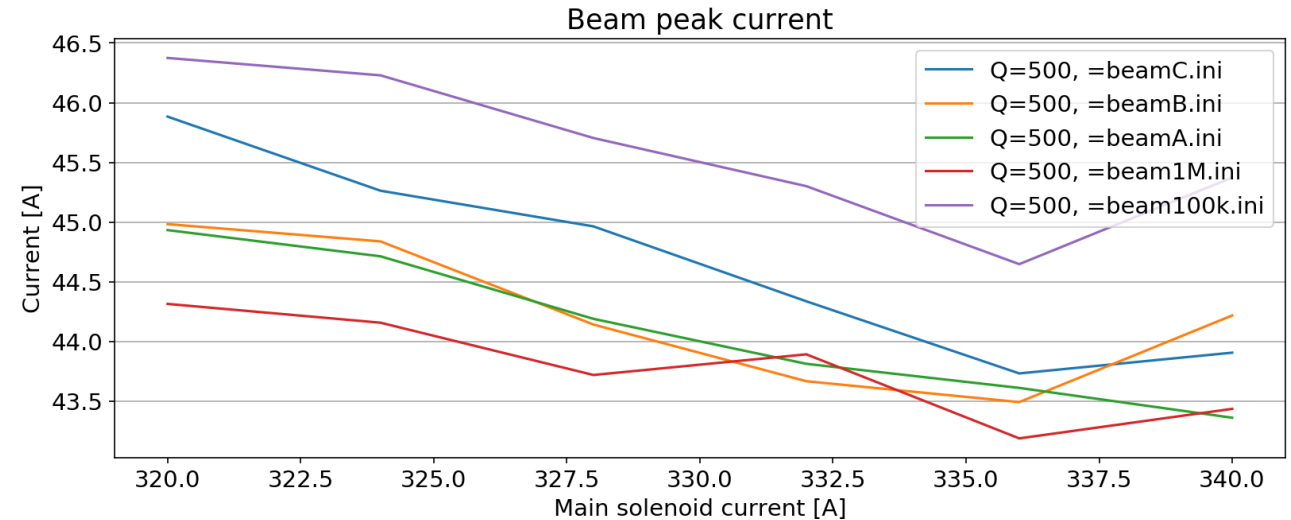
- Simulation of seeded FEL
- Two codes: ASTRA and Genesis
- ASTRA setup
 - Modulated beam @ 0,4 THz
 - Parameter scans
 - Monitor at **PST.Scr2**
- Genesis
 - Focus on version 4
 - Ocelot toolkit



Simulation with ASTRA – accuracy

Effect of number of macroparticles

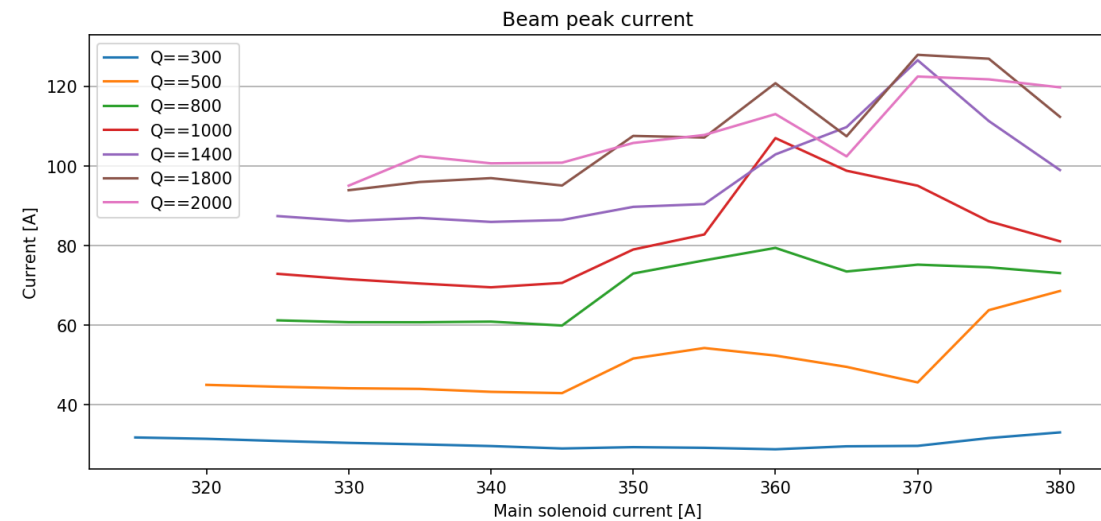
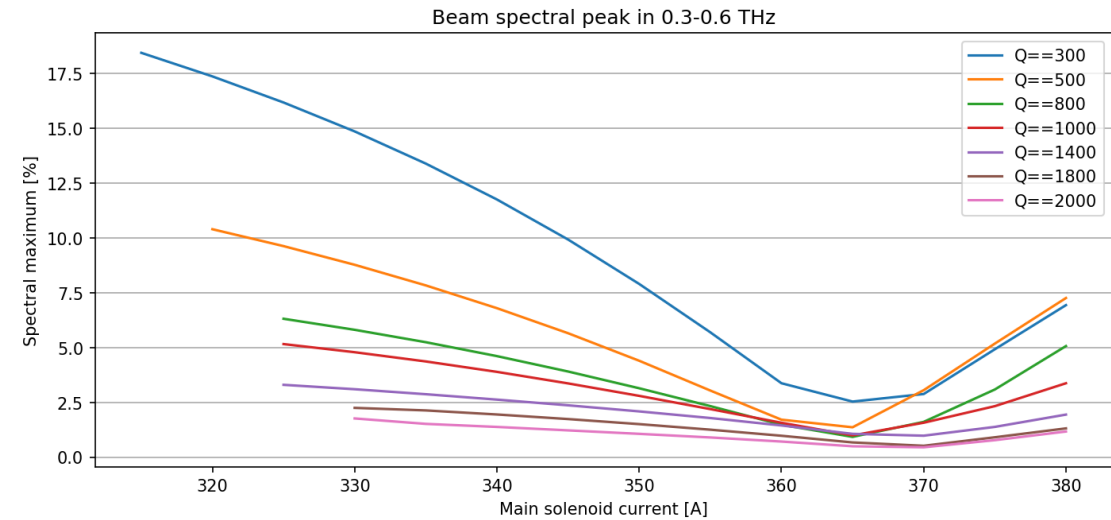
- Verification of simulation accuracy
 - Check if improvement is needed
- Focus on macroparticle count
- Three cases
 - 500k with statistics (A, B and C)
 - 100k
 - 1M
- Modulated beam of 500 pC, Gun, Booster MMMG
- 500k vs 1M
 - Not far from statistical fluctuations
- 500k vs 100k
 - Only some properties differ noticeably
- **500k provides sufficient accuracy**



Parameter scans with ASTRA

Bunch charge

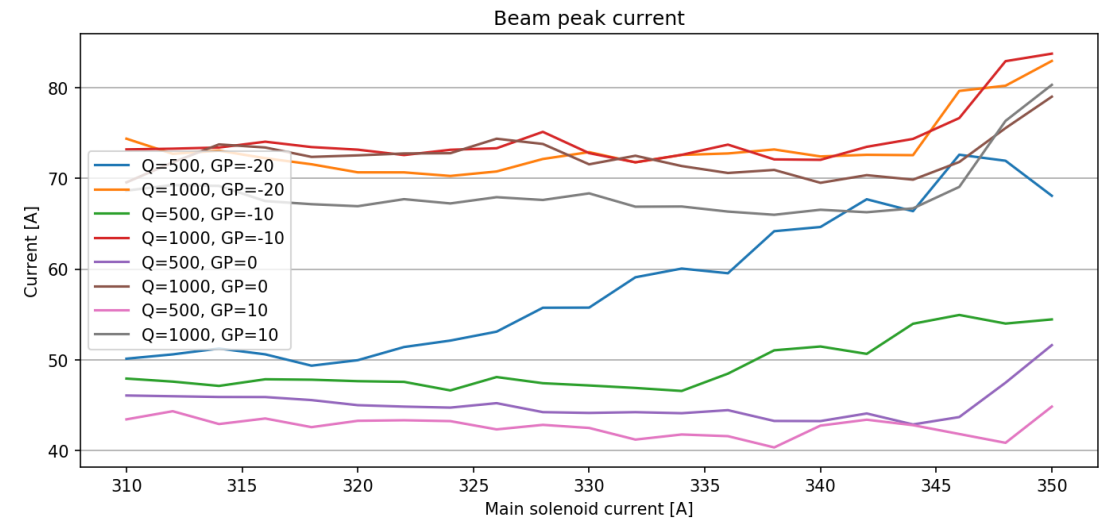
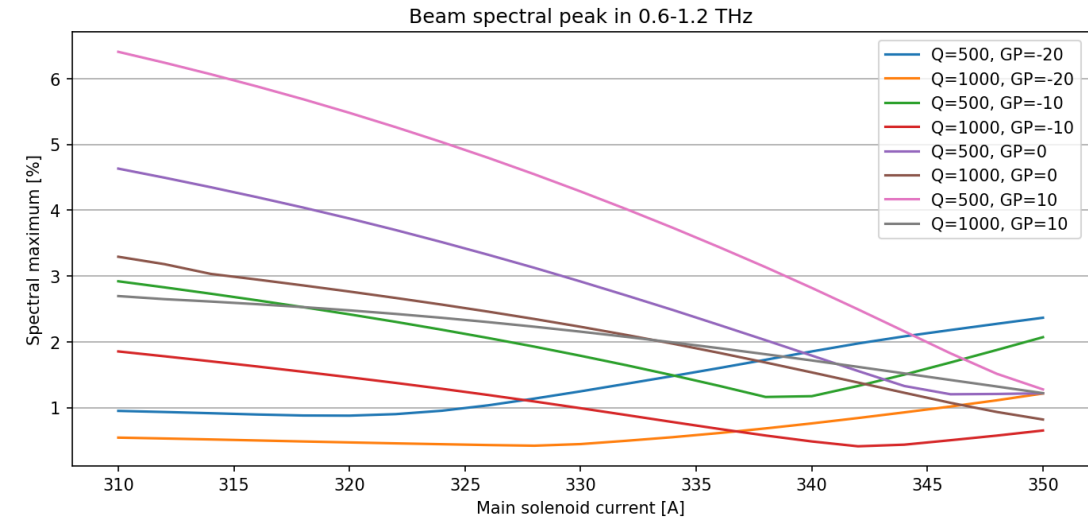
- Bunch charge limits
 - Peak current
 - Modulation amplitude kept
- Modulated beam, nominal fields
 - Gun+Booster@MMM
 - Solenoid scan with many charges
- After 1.4 nC
 - Slow peak current rise
- Stronger solenoid focusing
 - Increases SC smearing
- *Solenoid overfocusing*
 - Effect on peak current
 - Brings high freq. component



Parameter scans with ASTRA (continued)

Gun phase

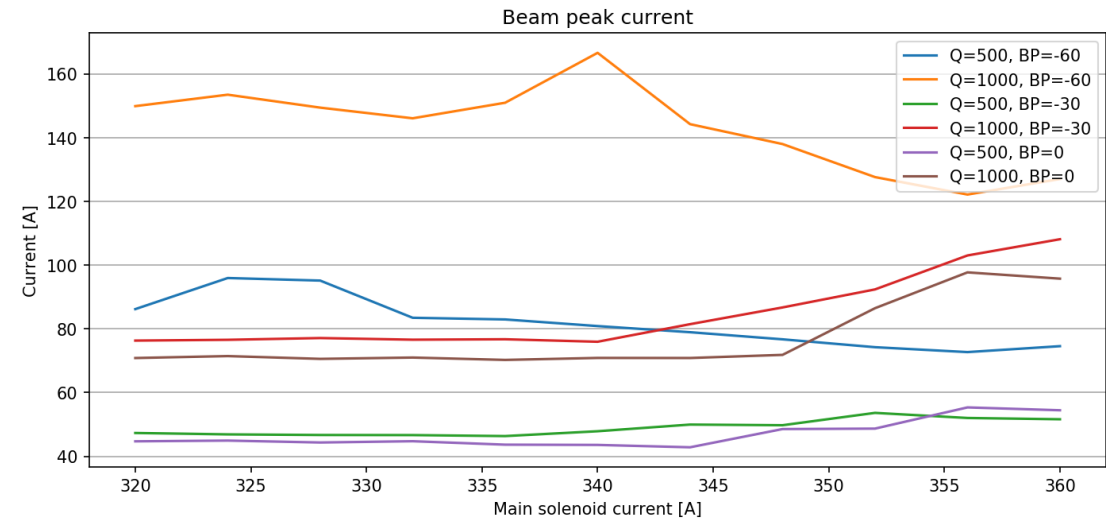
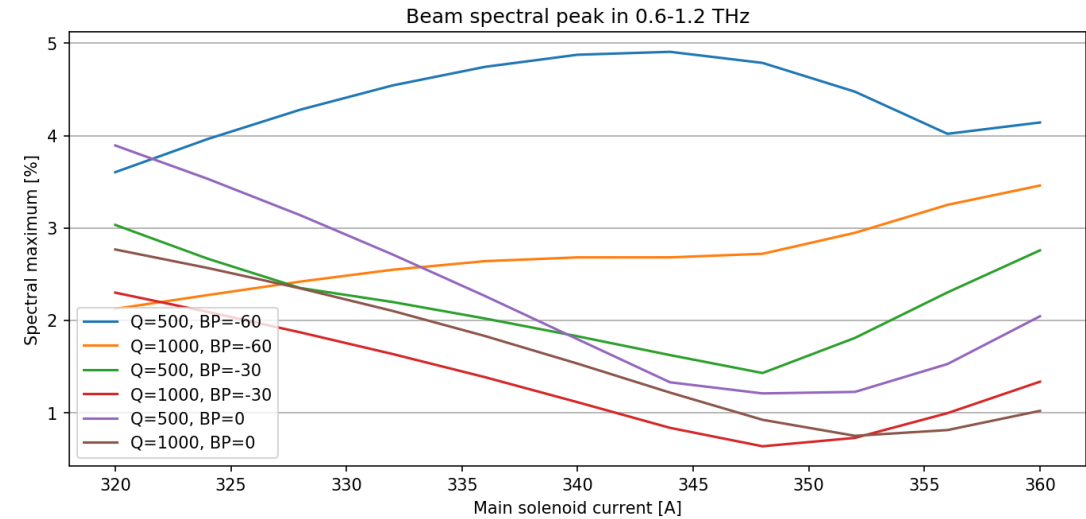
- Gun phase effect on selected beam properties
 - Longitudinal compression → peak current
 - Modulation amplitude kept
- Modulated beam, nominal fields, Booster@MMMG
 - Solenoid scan with 500 pC and 1 nC
- Gun compression
 - Loss of current modulation
 - Not above 0.5 THz
 - Small increase of peak current
- *Solenoid overfocusing*
 - Effect on peak current
 - Brings high freq. component



Parameter scans with ASTRA (continued)

Booster phase

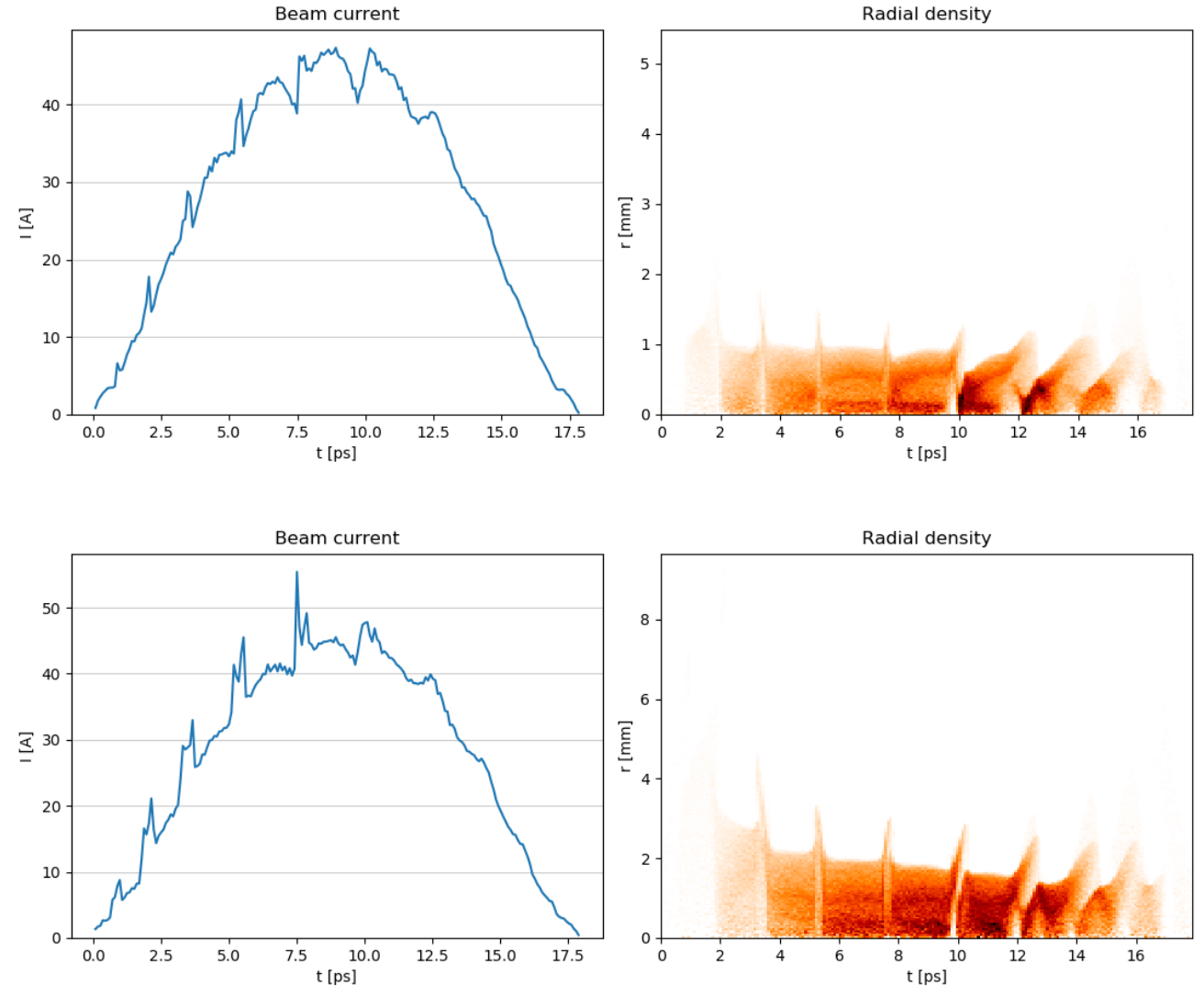
- Booster phase effect on selected beam properties
 - Longitudinal compression → peak current
 - Modulation amplitude kept
- Modulated beam, nominal fields, Gun@MMMG
 - Solenoid scan with 500 pC and 1 nC
- Booster compression
 - Smaller decrease of current modulation vs gun
 - Above 0.5 THz @ -60 deg
 - Almost double peak current @ -60 deg
- Stronger solenoid focusing
 - Odd trend @ -60 deg
- *Solenoid overfocusing*
 - Brings high freq. component



Development of sharp modulations

ASTRA simulation

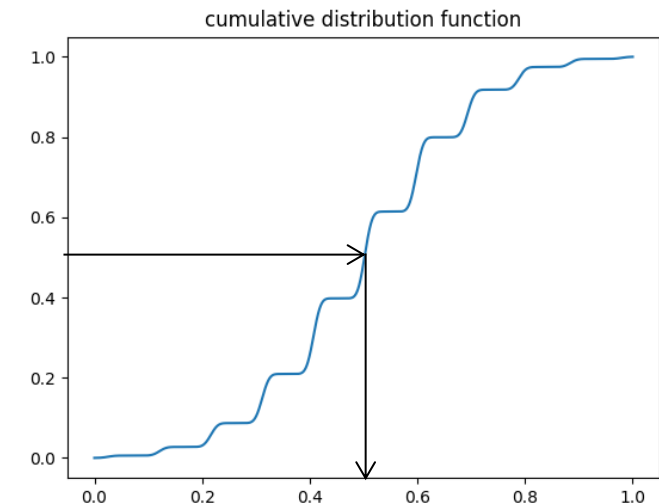
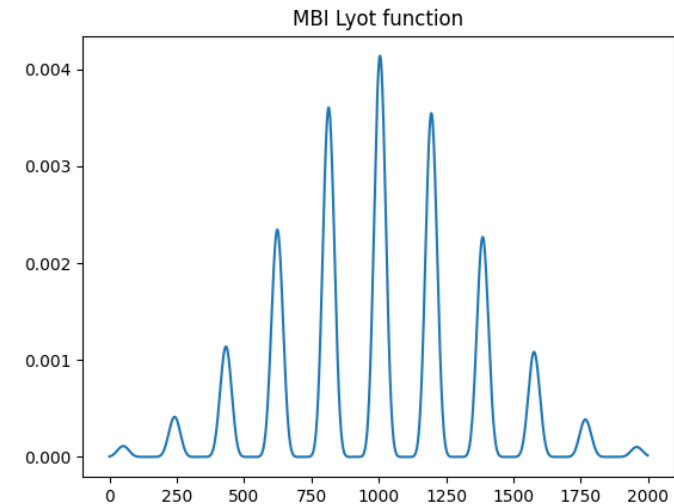
- Very strong solenoid focusing – odd trends
- Plotted two cases from gun phase scan @ -20 deg
 - 500 pC @ -20 deg, $I_{\text{main}}=320\text{A}$ (top plots)
 - 500 pC @ -20 deg, $I_{\text{main}}=340\text{A}$ (bottom plots)
- Development of sharp modulations
 - Dips between peaks smeared
 - Overlap between peaks
 - Longitudinal and transverse effect
- Notes
 - Better with booster off-crest
 - Noticed rather late
 - Needs dedicated simulations
 - Usable in FEL?



Improved method for beam modulation

ASTRA simulation

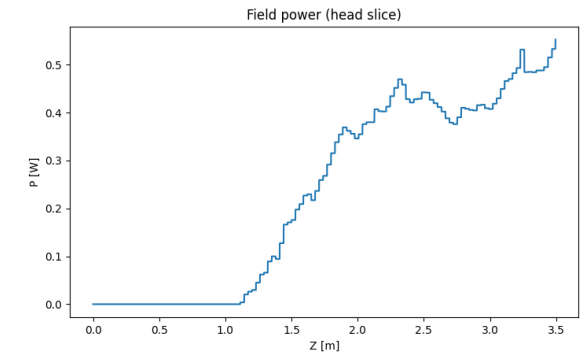
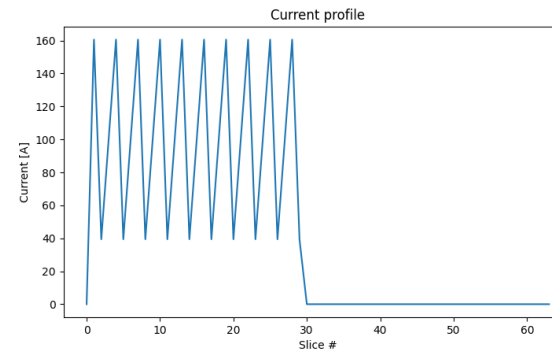
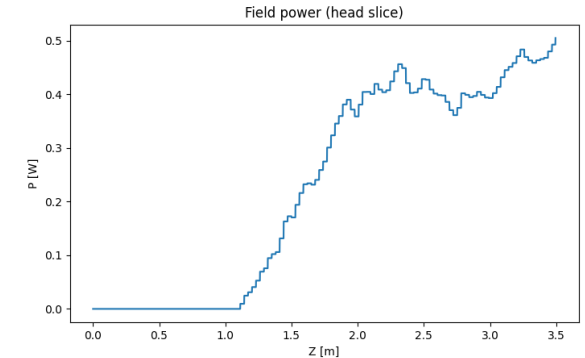
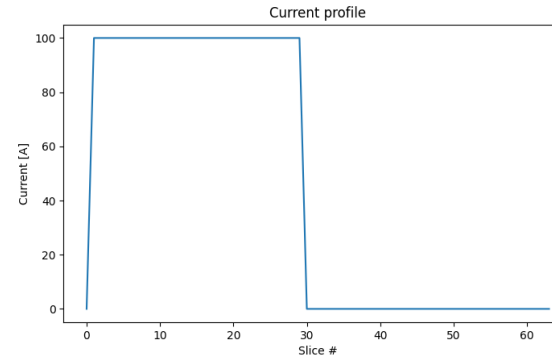
- Simulations require long. modulated beam
- Modulation by macro particle charge modulation
 - Uniform particle positions
 - Charge dependent on position
 - Some particles have very low charge
 - Effectively reduces number of particles
- Modulation by macro particle position
 - Using method for 'perfect' sampling in Monte-Carlo
 - Given probability density (PDF) \rightarrow cumulative density (CDF)
 - Passing uniform distribution in the inverse CDF \rightarrow distribution with PDF
 - Equal particle charge, changed position
- Difficulties
 - Surprisingly hard to develop
 - Achieved by fine binning of position (non continuous)



Genesis 1.3 Version 4

Installation and first simulations

- New to PITZ
 - Expertise on V2
- Installation
 - Requires several extra modules
 - Xiangkun compiled more portable executable
 - Runs on batch
- Setup
 - Differently organized from V2
 - V2 to V4 parameter table in Confluence by me
 - PITZ like FEL with the help of G. Paraskaki (PhD @ Hamburg) and Xiangkun
- Challenges
 - There are known bugs
 - Still no V2 equivalent setup for PITZ → TBD



Ocelot: multiphysics simulation toolkit

Python package

- Toolkit to ease FEL simulations
 - Numerous components simulated
 - Internal simulation code
 - Backends, including ASTRA, Genesis V4
- Ocelot-Genesis interface in development
 - Preprocessing, simulation, postprocessing in one script
 - Not officially released – development branch in latest git
 - Idea to test it with PITZ
 - In contact with main developer
- What was done?
 - Installed and running
 - Loaded ASTRA distribution
- Difficulties
 - Lack of documentation

Summary

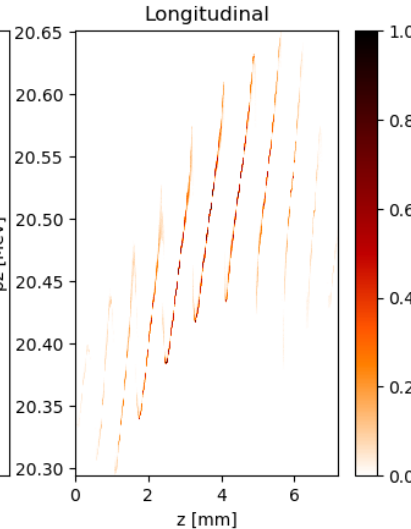
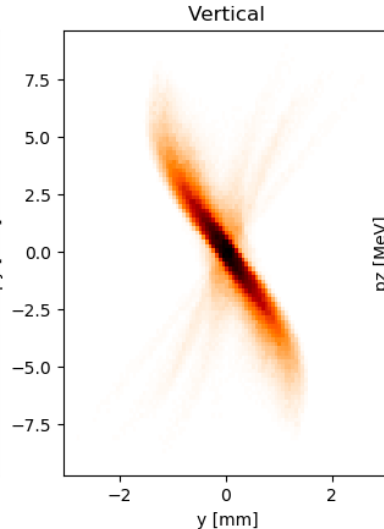
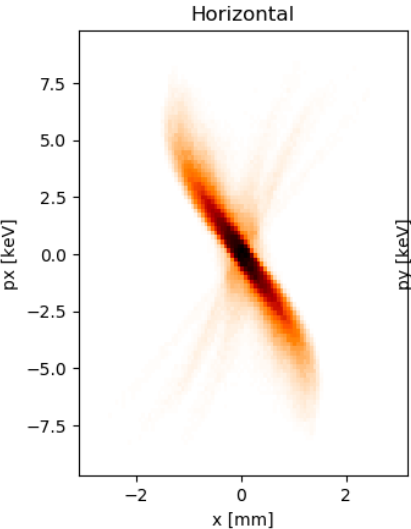
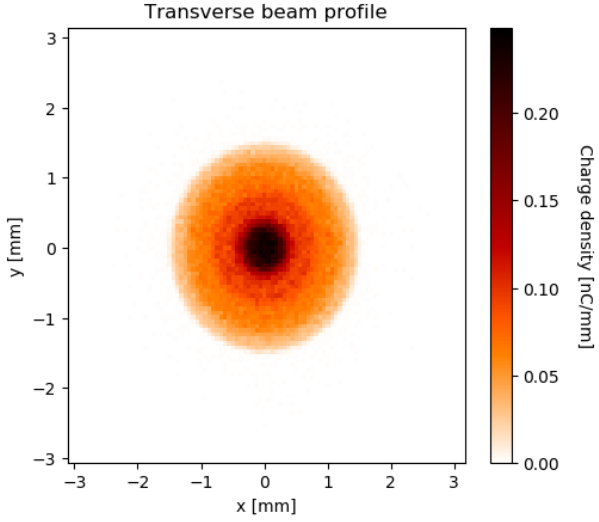
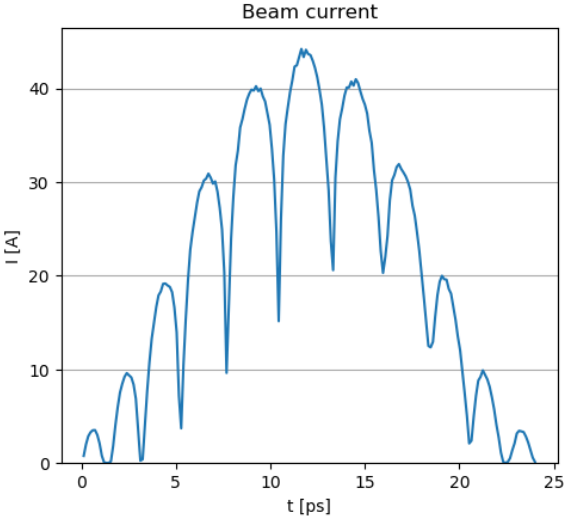
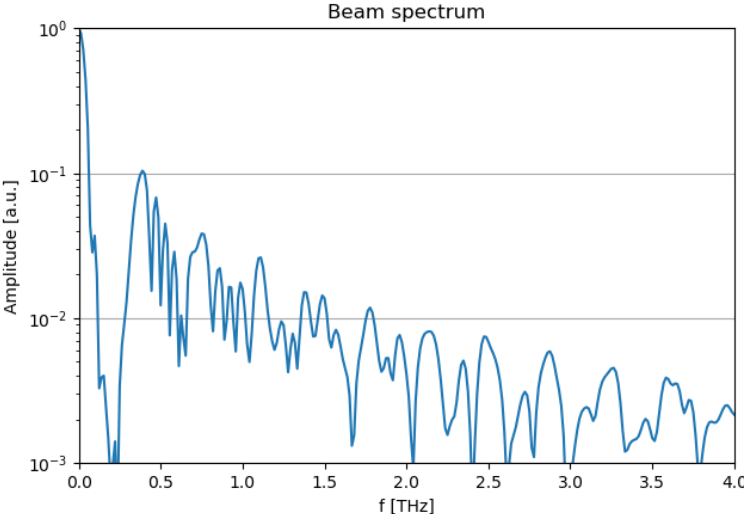
- Beam transport (ASTRA)
 - Compression with booster phase – preferable
 - Stronger solenoid focusing smears initial modulation
 - Sharp peaks develop in certain cases with overfocusing
- Genesis
 - Initial simulations
 - With Ocelot toolkit
- Outlook
 - Gun+Booster phases for best modulation amplitude
 - Sharp peaks for high freq. component
 - A detailed PITZ FEL setup for Genesis
 - ASTRA to Genesis bridge

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THANK YOU FOR YOUR ATTENTION

Backup



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