Start to End Simulations for FLASH2020+

Pardis Niknejadi
on behalf of the FLASH2020+ simulation team

TU Dortmund, Feb 22nd 2023
FLARE 1st Project Meeting

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

DESY.

Outline

Status of past work when we started

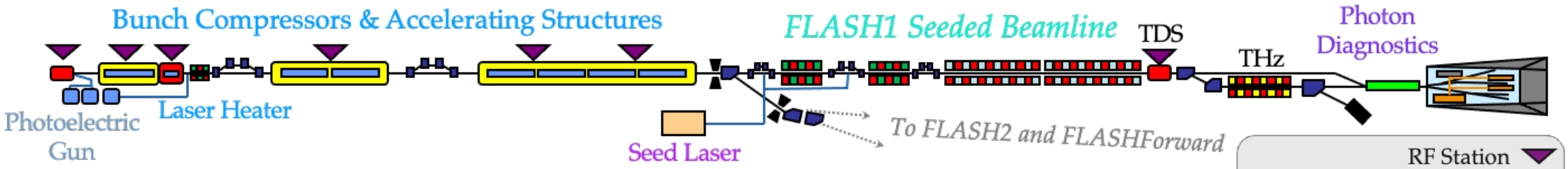
Status of Handshaking Scripts Now

Some Highlights

Outlook

FLASH2020+ Start to End Simulations and Categories

Initial Focus was on Benchmarking and handshaking between the 3 Categories to produce the first example of reliable S2E



Add compression and tweak optics

Start with an on crest file with design optics

Tracking in Elegant

Design File in MAD

Seed1 and Seed2

Chi2 3D

Intermediate step for tool development

Resolving issues with integration

Impact-Z

SelaV

Start with a realistically modeled beam from the Gun

Genesis/Puffin

(a) Genesis

(b) SelaV

Radiators

Chicane 1

Elegant

Chicane 2

(c) Tracking Single Particle in Elegant

Beam & Seed1 in Mod 1

Beam & Seed2 in Mod 2

End with Transport to Photon BL

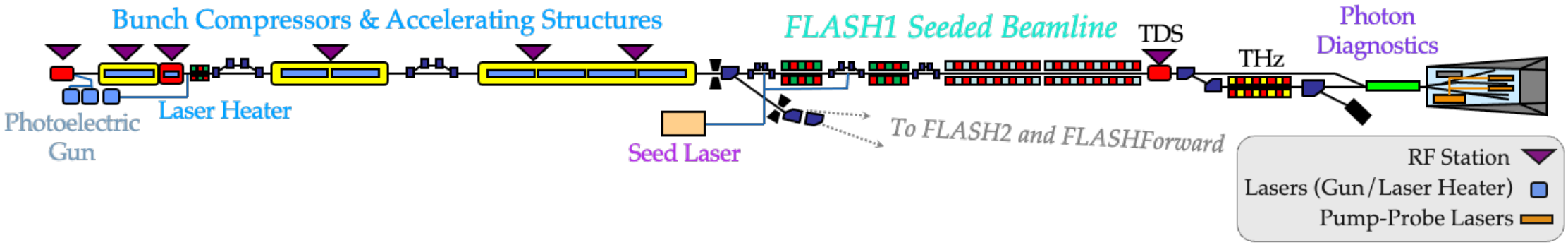
Synchrotron Radiation Workshop

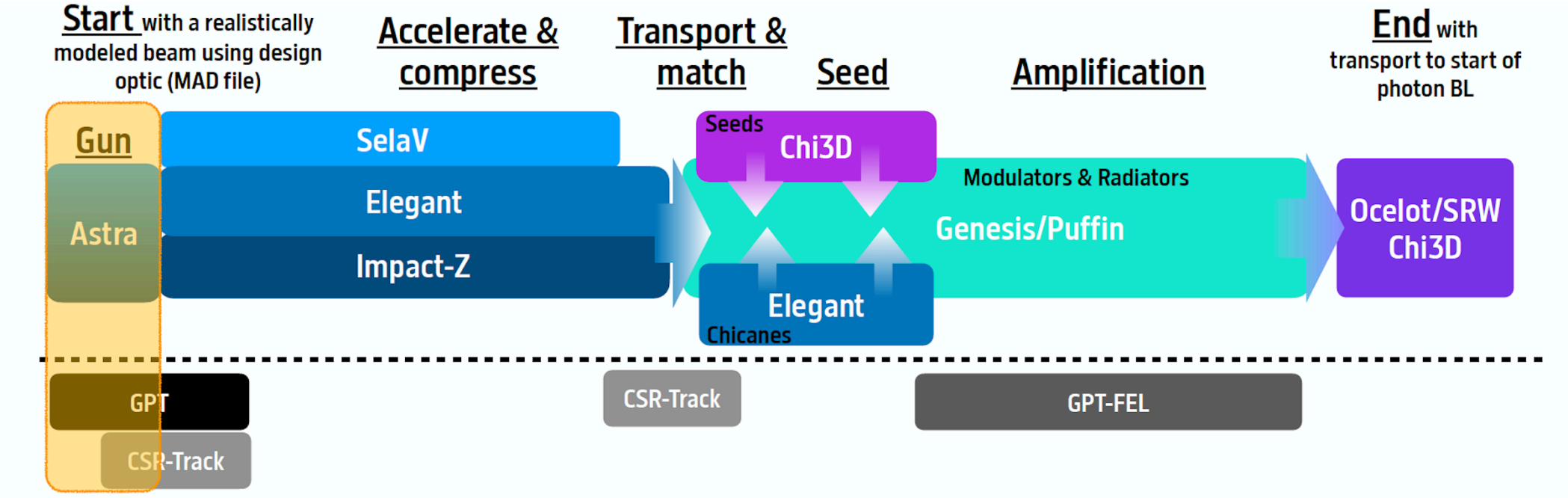
Benchmarking and comparing three approaches (a-c) for Seeded Beamline

Operational **Work in progress**

FLASH2020+ Start to End Simulations

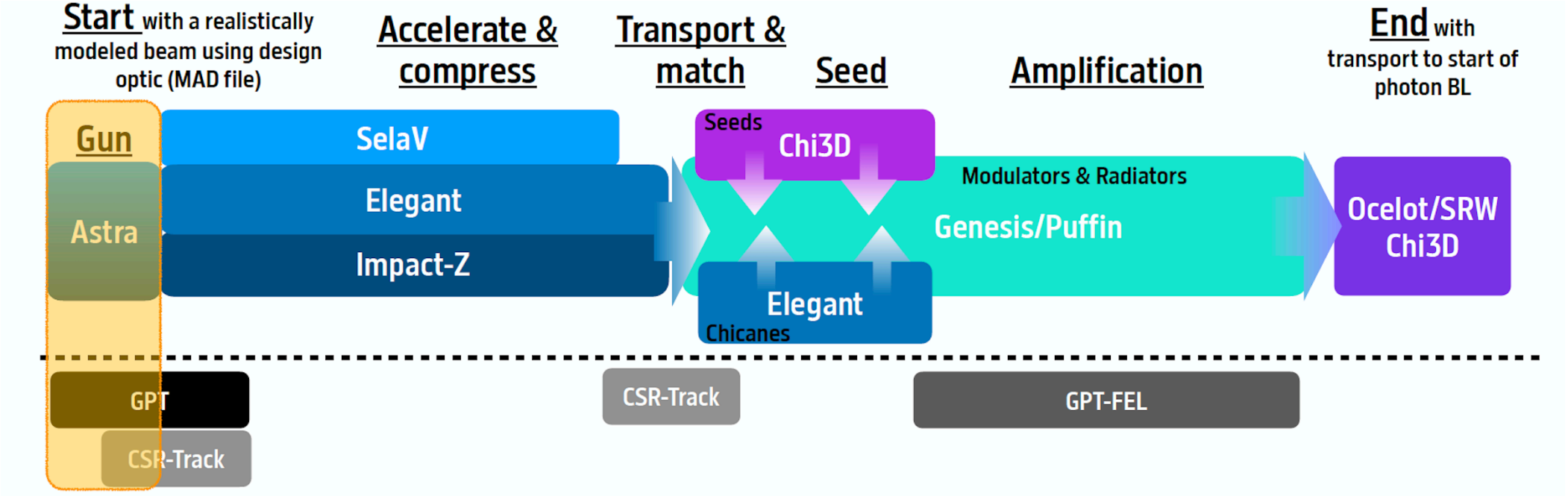
Final main working flow and a few additional planned benchmarking





FLASH2020+ Start to End Simulations

Status of handshaking scripts



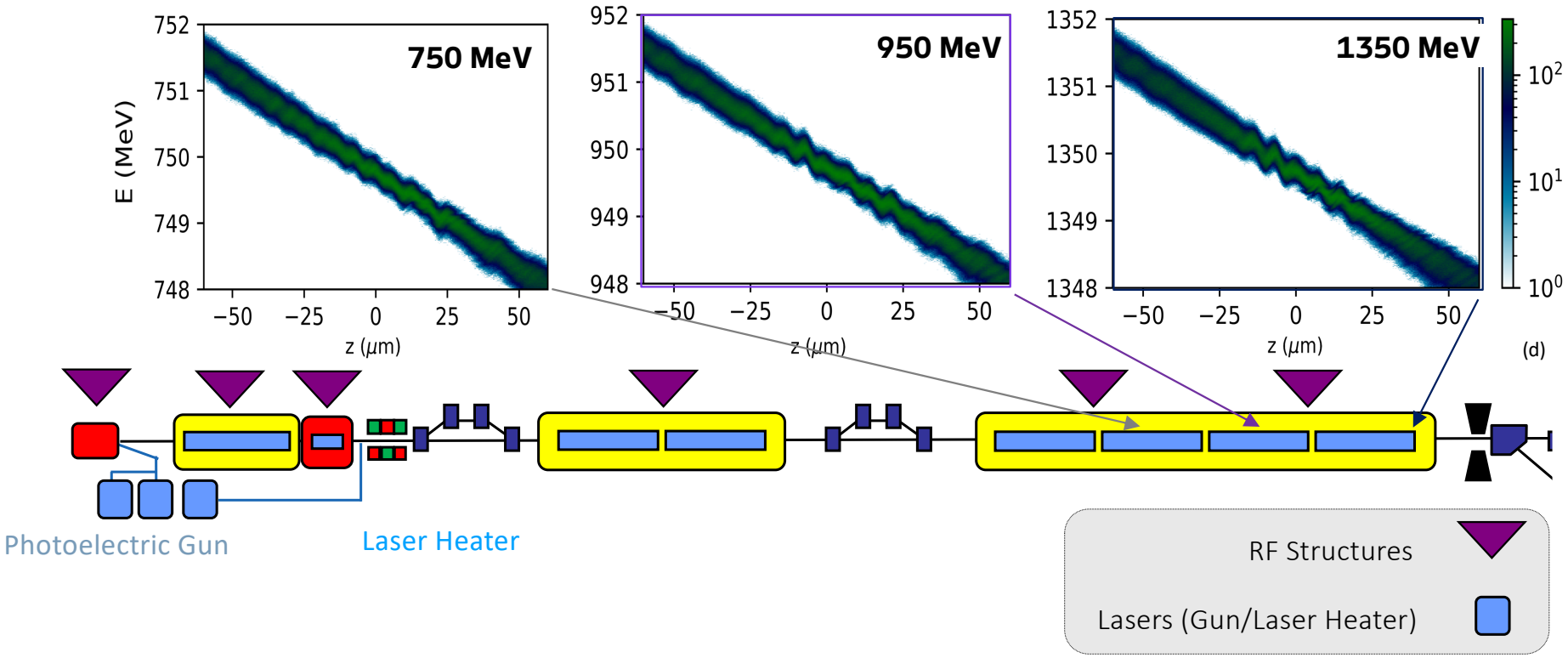
Impact-Z 2 SU	Resampler**	SU 2 Elegant	Genesis 2 Chi3D*
Elegant 2 SU	Chi3D 2 Genesis	Genesis 2 SU	
SelaV 2 Genesis**	SU 2 Genesis	SU 2 Genesis	

** Still In development

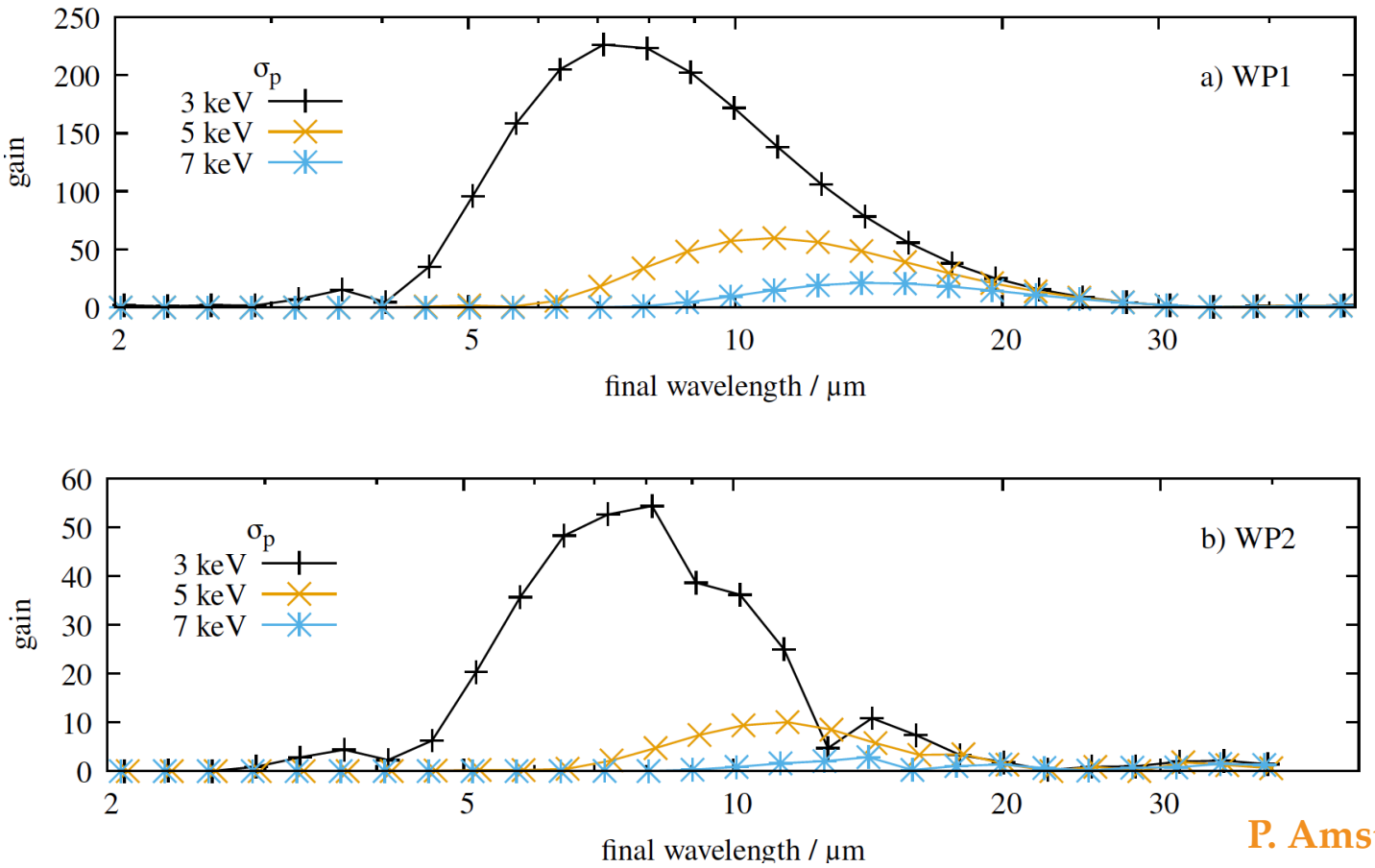
* Not tested yet

FLASH2020+ Start to End Simulations

Example of workflow Part 1 (New working Point)



WP2: Reducing the Micro-bunching Gain (SelaV)



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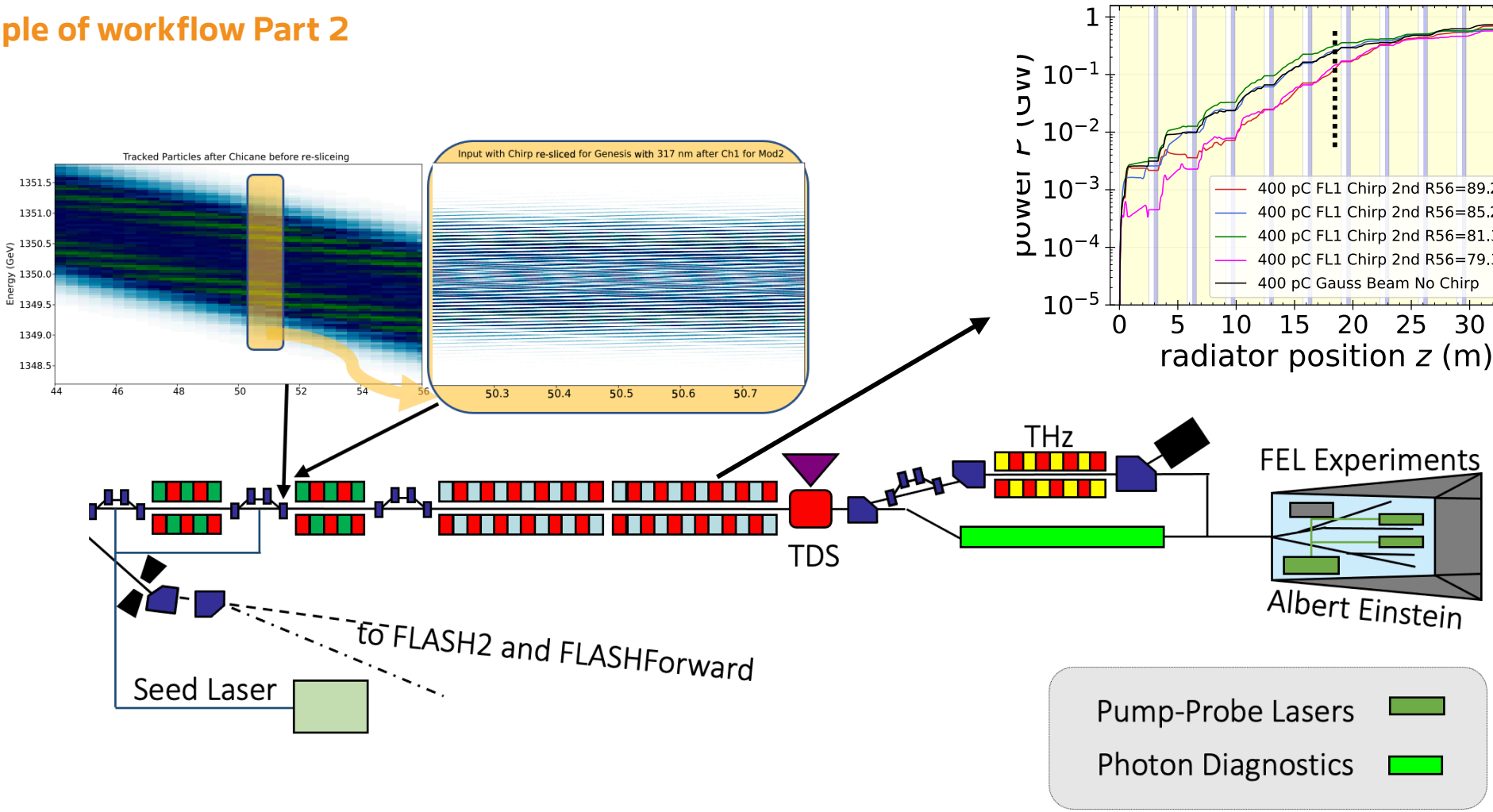
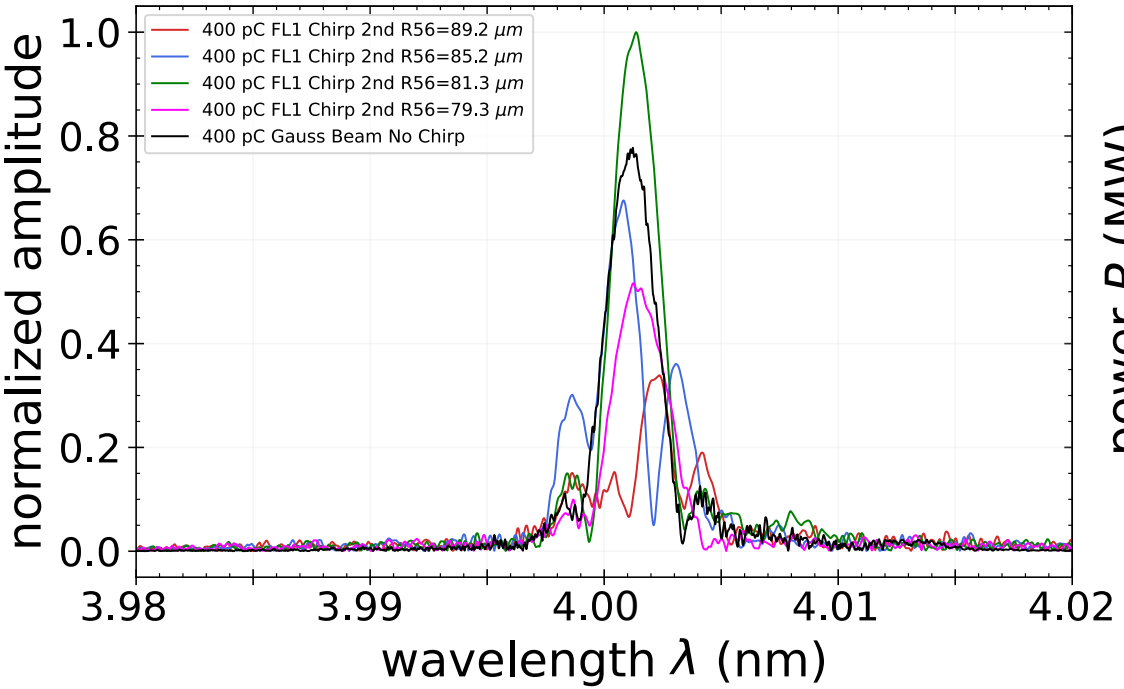
Example of workflow Part 2

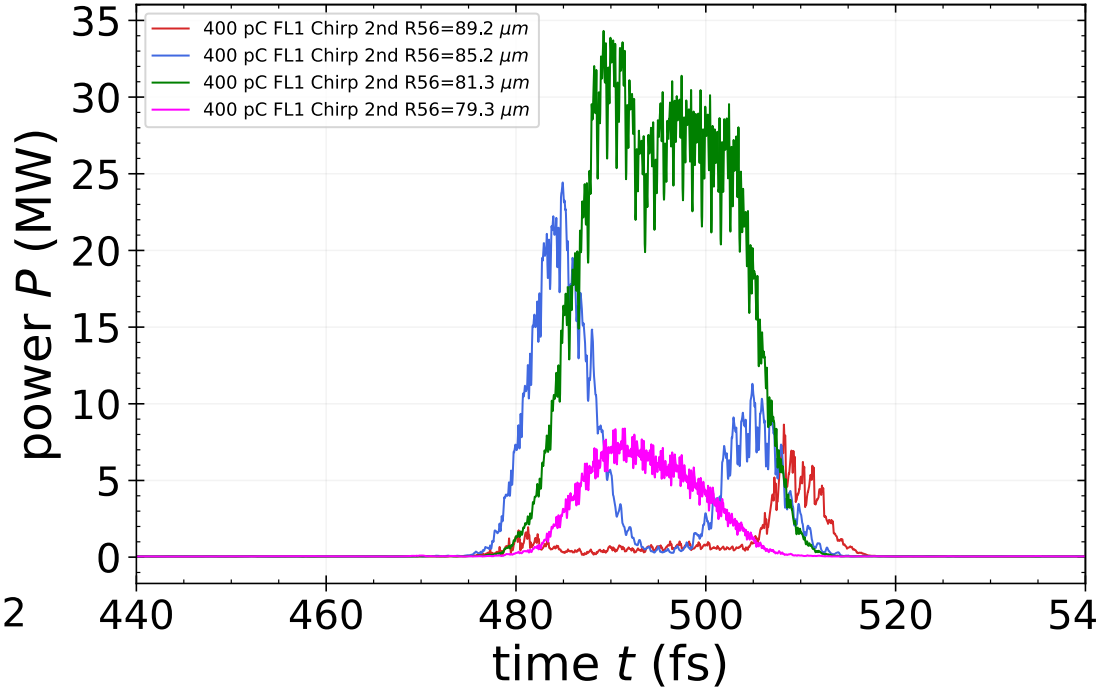


Results of R54 Scan in the Second Chicane for Chirped Beam

Example of workflow Part 2 (Cont.)

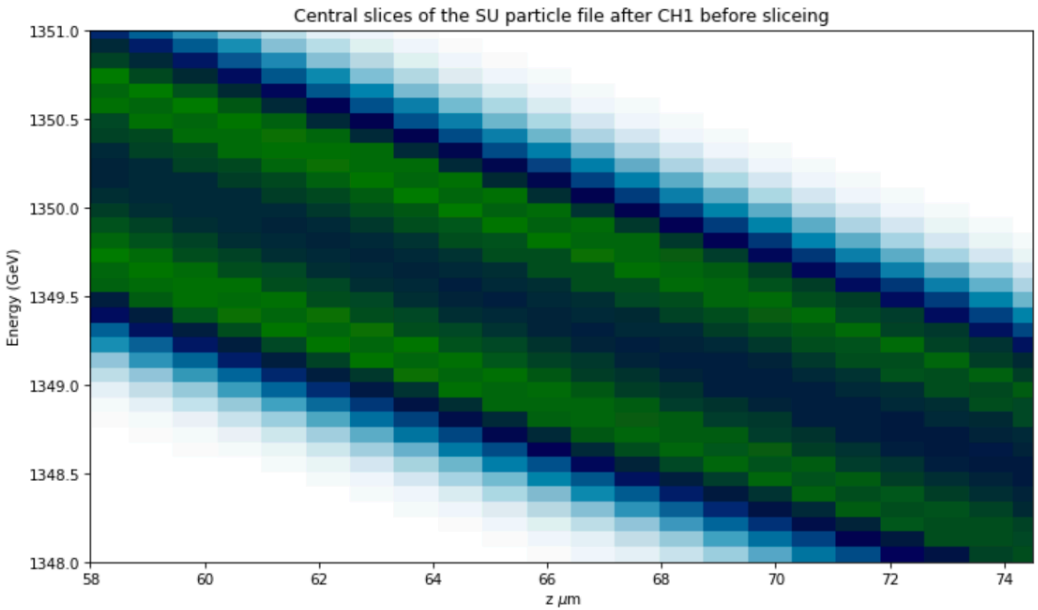
Only 6 Radiators Closed

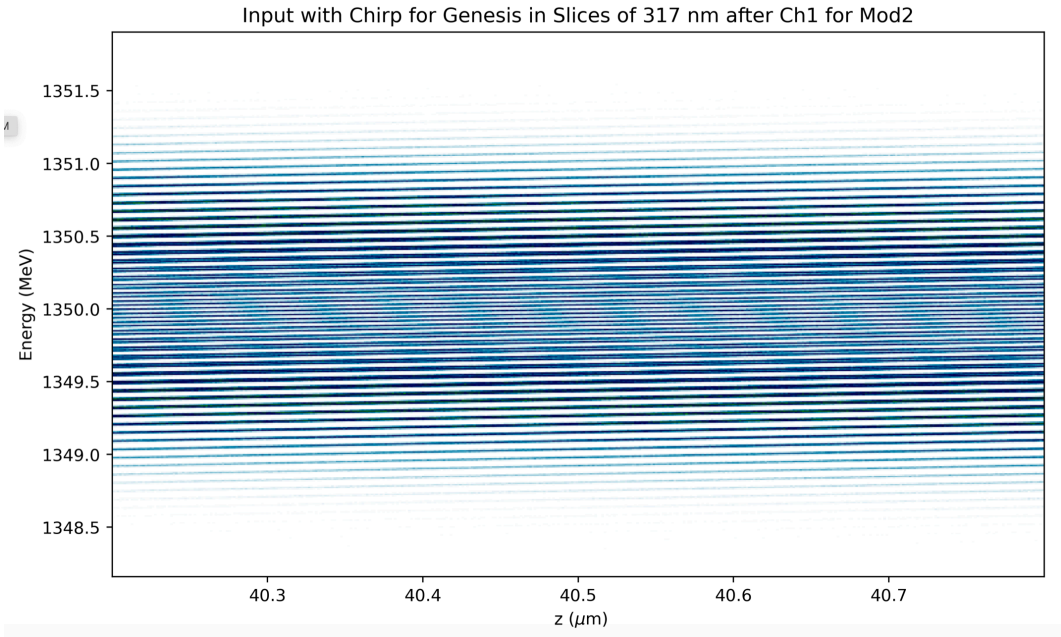




SU to Genesis for two different cases:

Case 1: EEHG Chicane





Need to make sure peak current is more or less in center of slice

Might need to cut the beginning of the beam

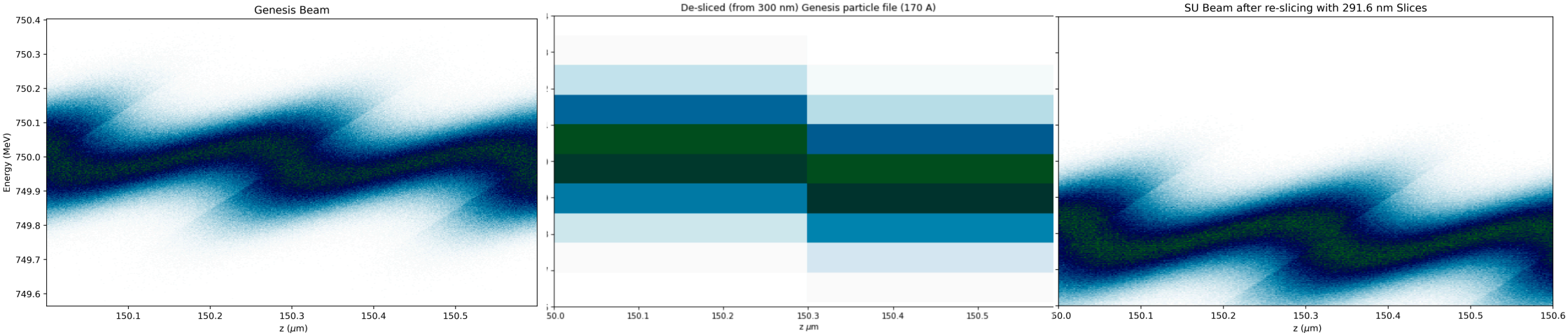
Consistent bunching needs to be checked

Iterative process

SU to Genesis for two different cases:

Case 2: (testing script with relatively low R56)

Optical klystron beam from Genesis is de-sliced after the chicane



The beam is re-sliced with a different slice length

Laser Start 2 End simulations

Short intro to Chi3D

Propagation of ultra-short laser pulses in isotropic and birefringent media

- rely on a new concept utilizing the fact that all second-order conversion processes of practical use are realized in birefringent nonlinear crystals
- Super fluorescence cone / cascaded frequency generation in chirped pulse parametric amplifiers

Output intensity distribution in space and time as well as peak power and phase

- Used for Study of impact of Laser chirp on Seeded FEL is in progress

Laser Start 2 End simulations

Chi3D Output Flexibility

convert from chi3D to Genesis

```
function chi3DtoGen(obj,Eftfxfy)

clear all
load ccSFG_compressed.mat
Eftfxfy = E_ftfxfy;

%%
% tWindow -> z-window & Nt -> number of slices because dt = wavelength
N_slices = 4000;  %z_window = wavelength * (N_slices + 1)

% position x y % GD -> z position of the laser pulse
% pointing x y
% chirp
EorI=16e-6; %pulse energy if smaller 1 or intensity if larger 1
alpha_x=0   ; %pointing x
alpha_y=0   ; %pointing x
GD=0    ; %postion along z = t*3e8 -> GD = z/3e8
GDD=0   ; %linear chirp
TOD=0   ; %nonlinear chirp
radiusOfCurvature_x=0   ; %focussing
radiusOfCurvature_y=0   ;
shift_x=0   ; %position x
shift_y=0   ; %position y
slant_x=0   ; %angular chirp x
slant_y=0   ; %angular chirp y
% Phase=    0; %can be scalar, wavefront, or whole pulse

```

Bridging S2E simulations and Machine Operations (work in progress)

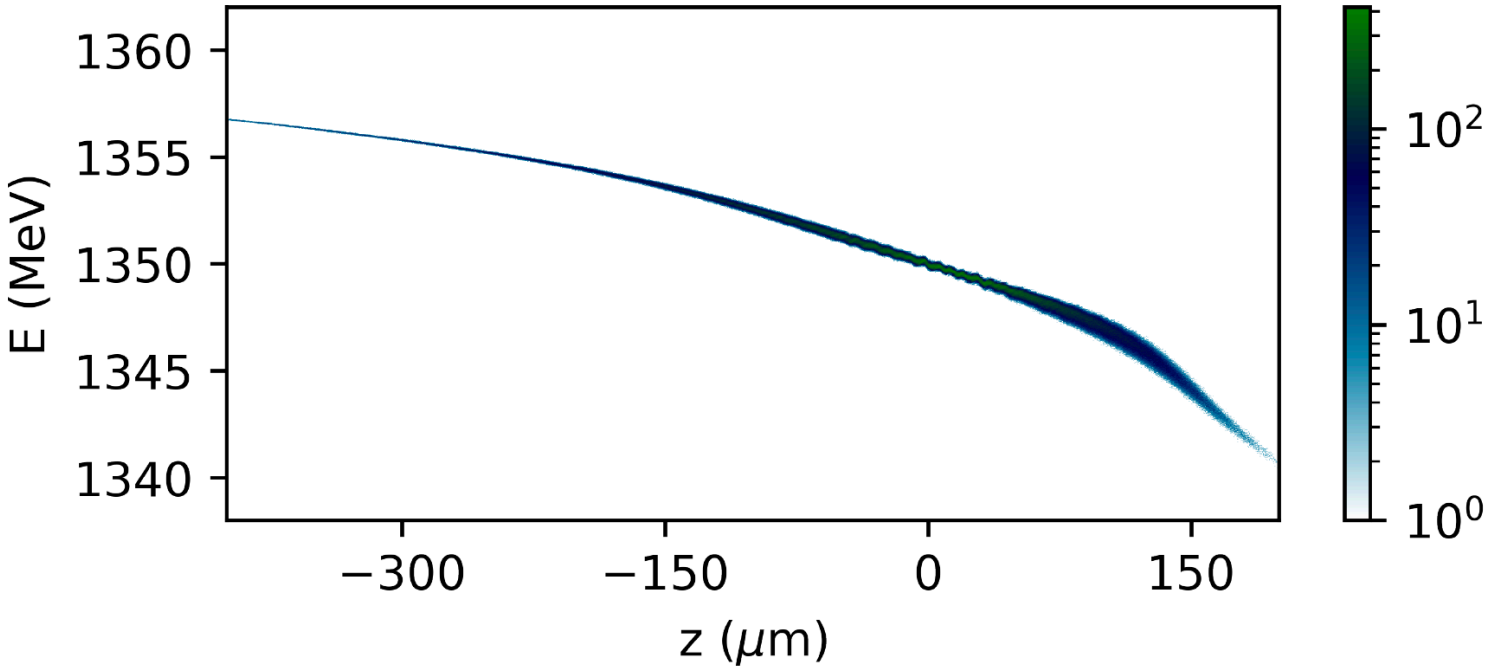
WP2: Impact-Z >> matched in elegant to Mod 1

Best of Impact-Z simulations

After scanning and optimizing number of particles, grid, …

One finals simulation takes about 3-5 days

SelaV is relatively instantaneous



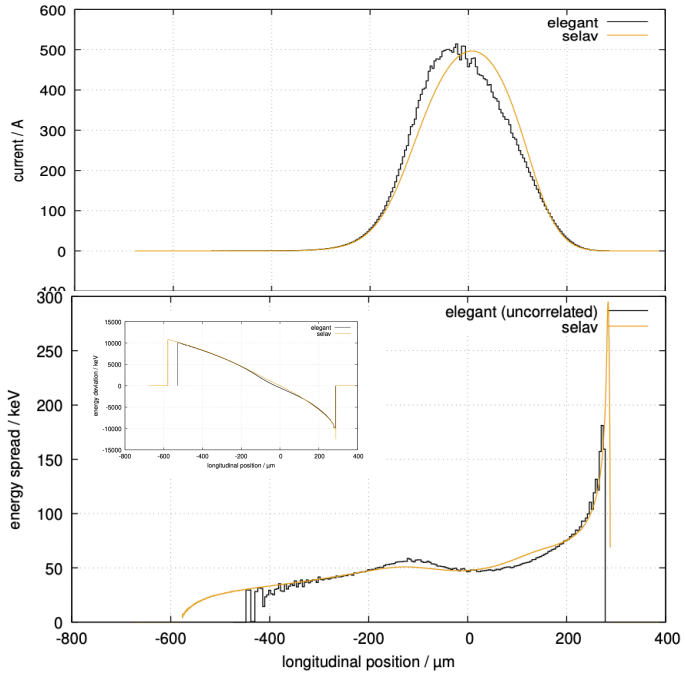
From FLASH2020+ Start to End to better Machine Operation

Acceleration and Compression stage, Results after BC2

Excellent agreement between Elegant & SelaV

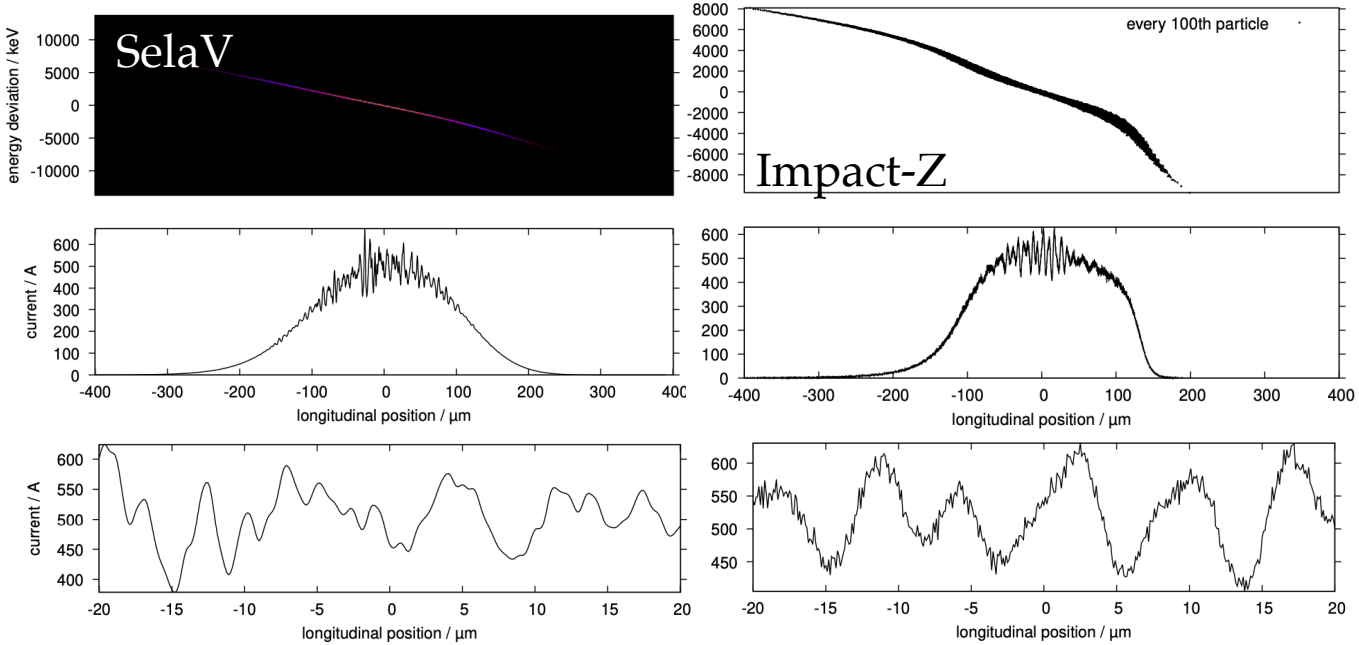
Good Agreement between SelaV and Impact-Z

Includes Longitudinal space charge from quite start



Slight differences due to diff. In transverse beam size

Plotting one in every 1e4 particles for Impact-Z (one in every 100th is saved and one in every 100th of that is plotted)



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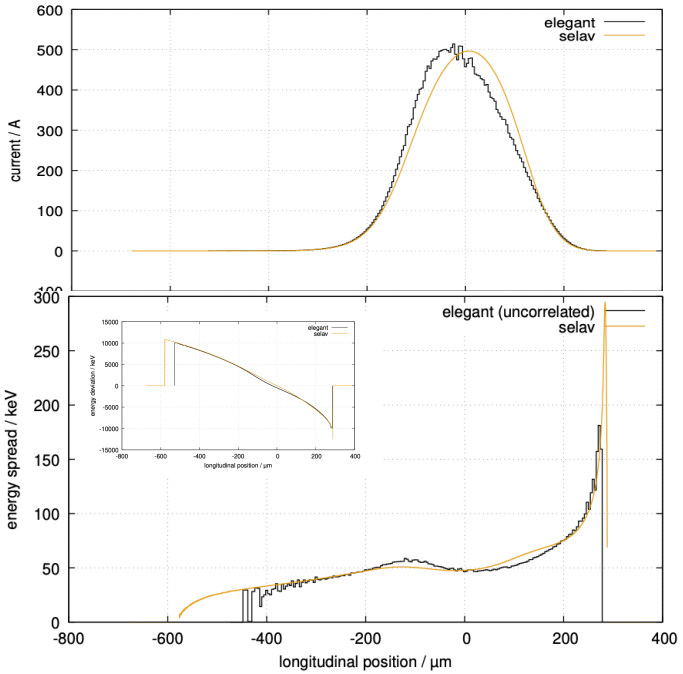

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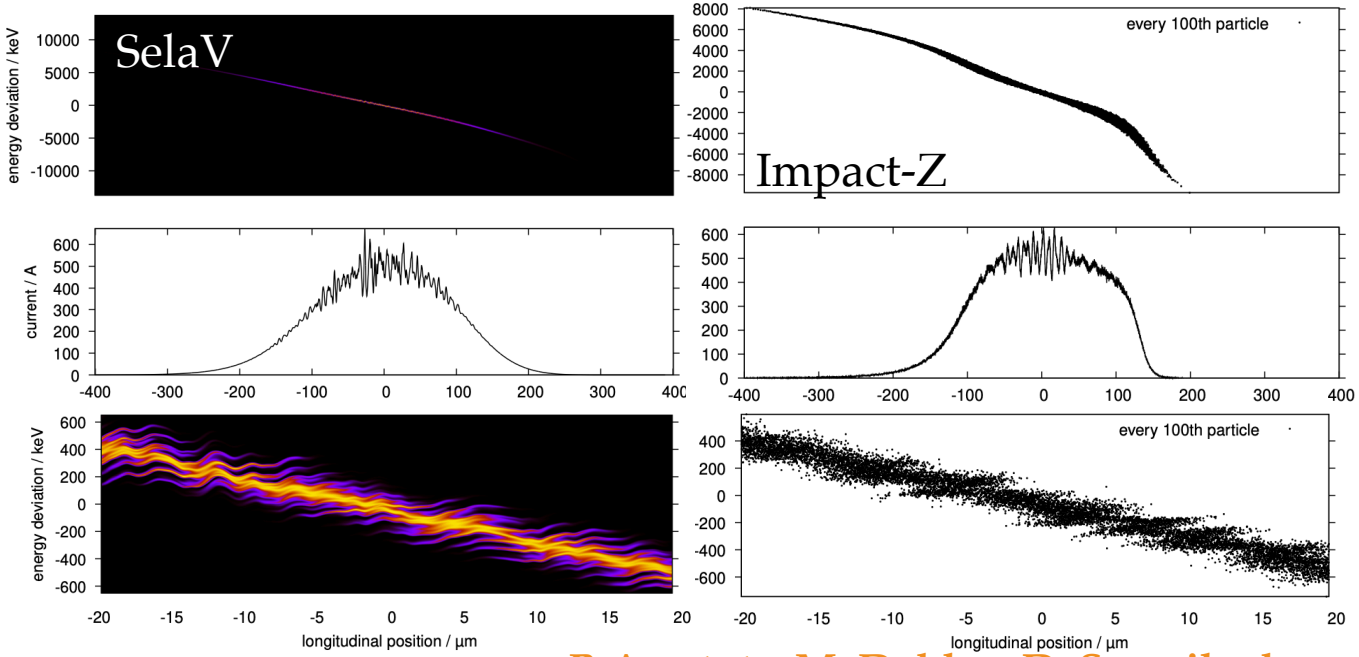

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Summary

Start to End simulations with Working point 2 in ongoing

Handshaking and full S2E workflow is nearly done

The S2E workflow is benefiting other studies (Advance modes for FLASH2020+)

In parallel work on having accessible simulations is also ongoing

Thank you

Back up (Grid Optimization)