EuPRAXIA

EUROPEAN PLASMA RESEARCH ACCELERATOR WITH EXCELLENCE IN APPLICATIONS

WP2
Theory and Simulations

Alban Mosnier – Luis O. Silva (Jorge Vieira)

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WP2 meetings

Plan for Collaboration Week

- Update the results
- Review the LP injectors
- Review the LP accelerating sections
- Discuss next simulations
  - ✓ Focus on most promising schemes
  - ✓ Tuning of the individual stages
  - ✓ Simulations with errors
  - ✓ End-to-end simulations (in close collaboration with WP5)

Collaboration Week - tentative WP2 agenda		
Wednesday 21st June 14:00 -15:30		
LP Injectors (Low-energy and High-energy)		
20'	New injection method	Paolo Tomassini (CNR)
15'	Effect of density gradient and laser spot size on energy gain, energy spread and total charge	Ujjwal Sinha (IST)
15'	Plasma density parameter scan for the laser wakefield injector using OSIRIS	Thales Silva (IST)
20'	Optimization of the ionization injection in tailored density profiles	P. Lee et al (LPGP)
20'	Self-injection study with Calder-Circ	Francesco Massimo (LOA)
Wednesday 21st June 16:00-18:00		
LP accelerating module (linear and non-linear regimes)		
30'	5 GeV accelerating module with beam loading	Xiangkun Li (CEA)
20'	Preserving the quality of an electron beam externally injected into LPA	Elena Svystun (DESY)
20'	External injection in the context of SINBAD facility	Maria Weikum (DESY)
20'	External injection with sub-femtosecond timing jitter	Angel Ferran Pousa (DESY)
20'	Data transfer between codes for end-to-end simulation	Maria Weikum (DESY)
Thursday 22nd June 9:00-10:30		
Joint WP2/WP3/WP4 meeting		
Discussion on laser requirements and specifications :		
	pulse duration, pulse trains option in the laser	
	laser beam quality at focus and coupling to plasma	
	energy requirements for injector/accelerator	
Thursday 22nd June 11:00-12:30		
Joint WP2/WP5/WP9 meeting (11:00 - 11:45)		
	discussion on code benchmarking	
	discussion on possible common (WP2/WP9) PIC simulation work	
WP2 meeting (11:45 - 12:30)		
	Simulation work : next steps, main goals (injector, accelerating module, end-to-end)	

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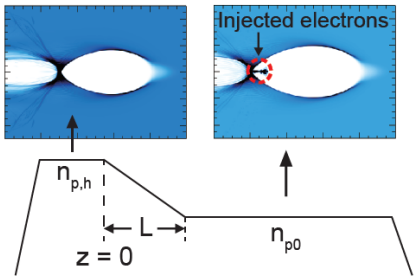

Soft density down-ramp

Best result to date

Extracted beam	
Energy	236 MeV
Charge	80 pC
E spread FWHM	9 %
$\varepsilon_{N\,x,y}$ (mm.mrad)	?

Next step

- ➢ Understand why a mismatched laser pulse provides lower energy spread
- ➢ Estimate the emittances !

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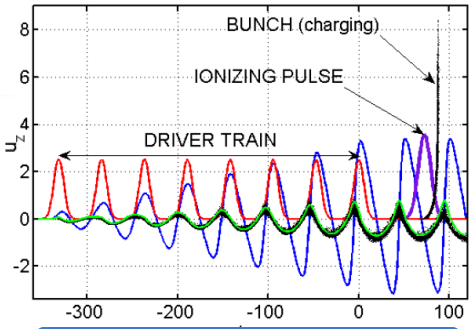

Resonant multi-pulse ionization

Best result to date

Extracted beam	
Energy	265 MeV
Charge	~ 4 pC
E spread rms	0.5 %
$\varepsilon_{N\,x,y}$ (mm.mrad)	0.08 , 0.02

Next step

- ➢ Increase the charge to the cost of energy spread and emittance
- ➢ Look for longer plasma capillary to achieve 1 - 2 GeV

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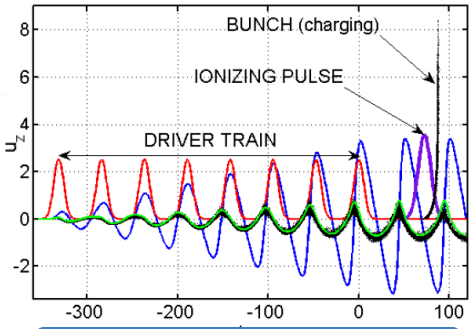

High-energy injector

Best result to date

Extracted beam	
Energy	1.0 GeV
Charge	~ 600 pC
E spread rms	6.6 %
$\varepsilon_{N\,x,y}$ (mm.mrad)	1.5

Next step

- ➢ Increase the number of particles per cell (≥100)
- ➢ For FEL analysis

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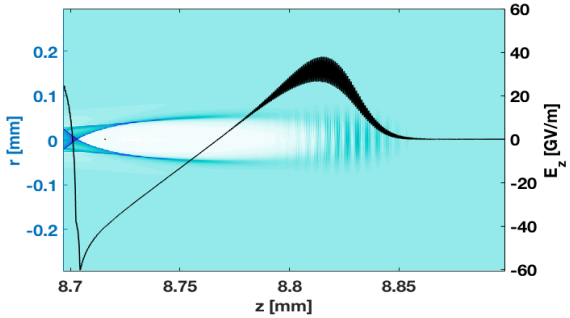

From RF Injector 83.5 MeV

Best result to date

Extracted beam	
Energy	1.0 GeV
Charge	0.74 pC
E spread rms	0.34 %
$\varepsilon_{N\,x,y}$ (mm.mrad)	0.15

Next step

- ➢ Increase the bunch charge (EuPRAXIA working point)
- ➢ Decrease the laser pulse energy (50 J) *instead of 100 J, 100 fs*

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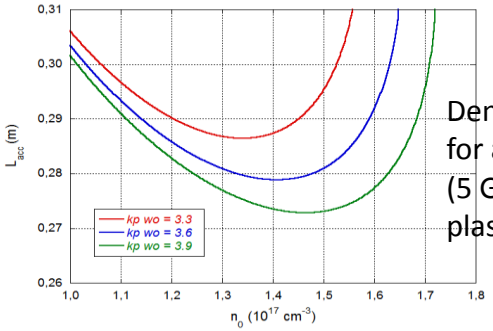

Density optimization for a given energy gain (5 GeV) and minimal plasma length

From LP Injector 150 MeV

Best result to date

Extracted beam	
Energy	5.0 GeV
Charge	30 pC
E spread rms	4 %
$\varepsilon_{N\,x,y}$ (mm.mrad)	No ε growth for matched beam

Next step

- ➢ Energy spread dominated by uncorrelated energy spread induced by the transverse gradient of beam driven wakefield
- ➢ Check with full WARP simulations !

Plan for Collaboration Week

- **Compensation of time jitter to sub-fs level for external injection**

✓ Focus on most promising schemes
✓ Tuning of the individual stages
✓ Simulations with errors
✓ End-to-end simulations
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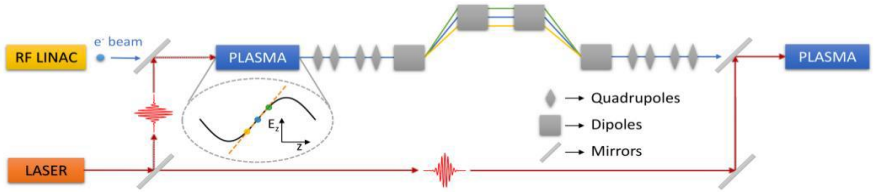

From RF Injector 100 MeV

Best result to date

Time jitter of 10 fs reduced to sub-fs level with charge of 0.1 pC

Next step

- Consider also higher charge (10's pC)
- Improve beam transport to preserve the emittance (chromatic effects)
- Tolerance

WP2 meetings

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➢ Laser imperfections were clarified in the joint meeting WP2-3-4

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Codes	Users	Format	Interface to other codes?
OSIRIS	IST, DESY	hdf5	Yes
WARP	CNRS / LPGP, CEA	openPMD, hdf5	
CALDER-Circ	LOA		No (?)
SMILEI	CNRS / LLR	openPMD	
ALaDyn, Architect	INFN_SparcLab (PISA_ILIL)	ascii file with xml metadata	Yes
HiPACE	DESY		
PIConGPU	DESY	hdf5	No (?)

+ particle tracking codes (ASTRA, ELEGANT, ...)
+ FEL codes (Genesis, Puffin,..?)
+ etc.

- ➢ Data transfer between codes issue
- ➢ A standard format for all codes would help a lot !
- ➢ Angel Ferran Pousa will make a proposal

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+ particle tracking codes (ASTRA, ELEGANT, ...)
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+ etc.

- ➢ Possible code benchmarking discussed in the joint meeting WP2-5-9
- ➢ 1st step : exchange 2-3 reference cases (beam-driven and laser-driven PA)

- ➢ Data transfer between codes issue
- ➢ A standard format for all codes would help a lot !
- ➢ Angel Ferran Pousa will make a proposal