Laser-driven electron LINAC

J. Vieira, B. Cros, M. Thévenet

web.ist.utl.pt/jorge.vieira

epp.tecnico.ulisboa.pt || golp.tecnico.ulisboa.pt

GoLP / Instituto de Plasmas e Fusão Nuclear
Instituto Superior Técnico, Lisbon *Portugal*

What are the requirements for a particle physics collider?

Parameter	Units	CLIC-like (e-/e+)	ILC-like (e-/e+)
bunch charge	pC	833	3200
polarization	-	80% e-	80% e- / 30% e+
initial energy	GeV	**175**	**235**
final energy	GeV	**190**	**250**
initial relative energy spread	%	0,6	1
final relative energy spread	%	0,35	0,1
initial bunch length	µm	70	300
final bunch length	µm	70	300
initial normalized emittance H/V	µm / nm	0.890 / 19	9.5 / 25
emittance growth budget H/V	µm / nm	0.010 / 1	0.5 / 5
final normalized emittance H/V	µm / nm	0.900 / 20	10 / 30
bunch separation	ns	0,5	554
number of bunches per train	-	352	1312
rep rate	Hz	50	5
beamline length	m	250	600
Efficiency: wall-plug to drive beam	%	58	-
Efficiency: drive beam to main beam	%	22	-
Luminosity	10^34 cm-2 s-1	1,5	1,8

Energy

- ✓ 15 GeV stages
- ✓ Up to 190 GeV
- ✓ High gradients have been established

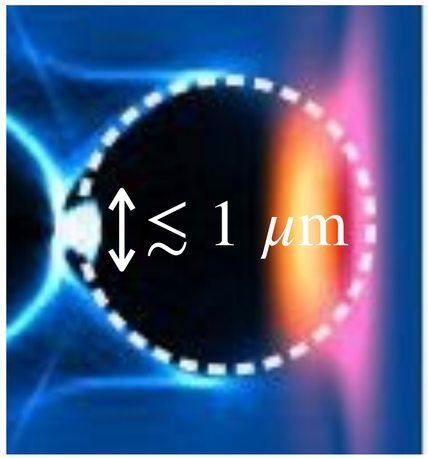
Energy spread

- ✓ Recent results are on track
- ✓ Recent experiments demonstrates $\Delta E/E \lesssim 0.01$

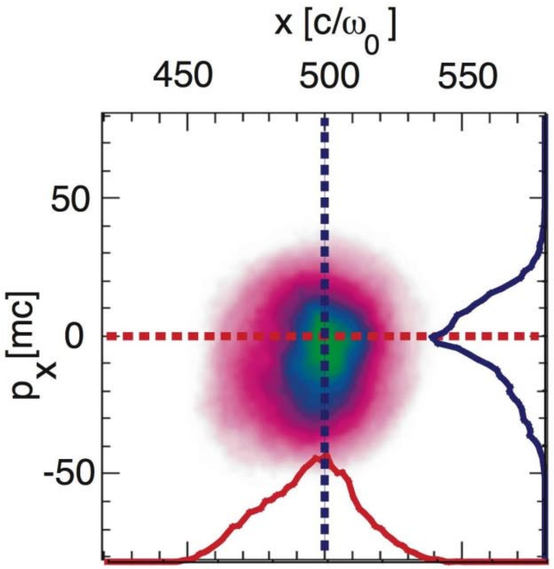
Emittance preservation is an open question

Electron acceleration in plasma

Typical e- acceleration modelling



$n_b/n_0 \lesssim 100$

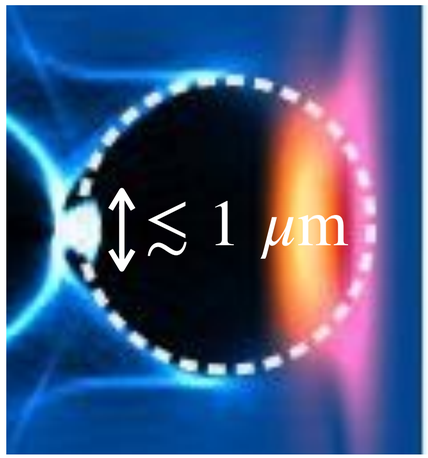


$\epsilon_N \lesssim 10\ \mu$m

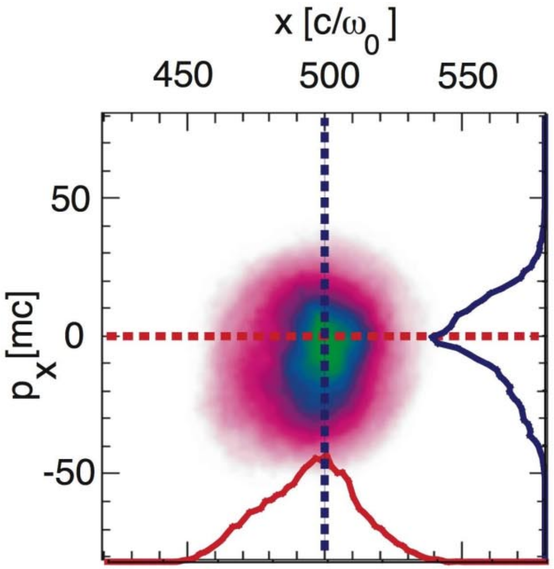
W. Lu et. al, Phys. Rev. ST-AB **10**, 061301 (2007)

Electron acceleration in plasma

Typical e- acceleration modelling



$n_b/n_0 \lesssim 100$



$\epsilon_N \lesssim 10\ \mu m$

W. Lu et. al, Phys. Rev. ST-AB **10**, 061301 (2007)

Eaccel [GeV/m]	100
Density [cm^{-3}]	1,00E+18
Q [nC]	0,833
Beam length [mm]	10

Energy [GeV]	ε_n [nm]	$\sigma_{x/y}$ [nm]	n_b/n_0
15	10	**21**	**1,20E+06**
15	100	**66**	**1,20E+05**
190	10	**11**	**4,27E+06**
190	100	**35**	**4,27E+05**

Main goal: (essential steps to) collider design

Collider-relevant parameters are difficult to simulate

Large scale disparity (cavity length/stage length, witness width/cavity radius)

Start from the plasma stage	Start from the collider design
Full-physics 3D EM PIC simulation: Ion motion, collisions, radiation reaction, realistic parameters	Reduced model to simulate a section Axisymmetric, quasi-static, reduced models
Scale up in number of stages	*Scale up in accuracy/physics*

Shake hands: ensembles of start-to-end accurate simulations

Next steps:

- Improve reduced models with additional physics
- Simulate 2 stages (e.g. 150 GeV - 190 GeV), starting reduced model & coupling
- Confirm with full-3D simulation

Main goal: (essential steps to) collider design

Resources:

- **Community** effort.
- (fraction of the) Work could be done with 3 post-docs for 3 years
- Access to dedicated computing time