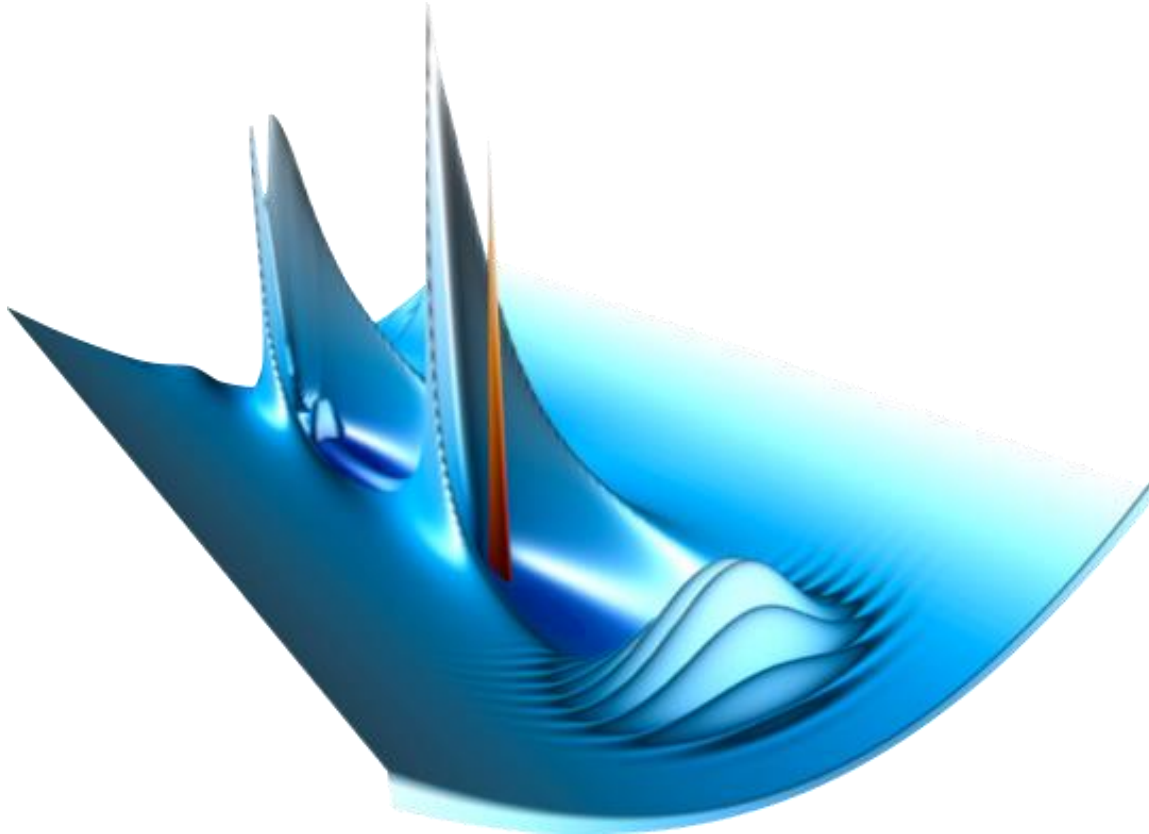


# WP2: Physics and Simulation



## Extensive simulations

- to optimize the plasma, laser and electron beam parameters
- for both, the plasma injector and the accelerating modules
- including injection from a conventional linac and internal injection from a laser-driven plasma cell

## Start-to-end simulations

- to determine optimum sets of plasma modules and beam parameters
- target achievable final energy and bunch charge, but also energy spread and transverse emittance of the electron bunches

## Acceptable tolerance levels

- Study of the effects from various error sources including laser parameters (intensity, wavefront defaults, etc) plasma density, spatial and temporal tolerances

<b>CEA</b>			
	Alban Mosnier	WP Leader	<a href="mailto:alban.mosnier@cea.fr">alban.mosnier@cea.fr</a>
	Phi Nghiem		<a href="mailto:phu-anh-phi.nghiem@cea.fr">phu-anh-phi.nghiem@cea.fr</a>
	Xiangkun Li	from Sept 2016	
<b>IST (Instituto Superior Técnico)</b>			
	Luis Oliveira e Silva	WP Co-Leader	<a href="mailto:luis.silva@ist.utl.pt">luis.silva@ist.utl.pt</a>
	Jorge Vieira	WP Expert	<a href="mailto:jorge.vieira@ist.utl.pt">jorge.vieira@ist.utl.pt</a>
	Ricardo Fonseca		<a href="mailto:ricardo.fonseca@tecnico.ulisboa.pt">ricardo.fonseca@tecnico.ulisboa.pt</a>
	Joao M. Dias		<a href="mailto:joao.m.dias@tecnico.ulisboa.pt">joao.m.dias@tecnico.ulisboa.pt</a>
	Ujwall Sinha		<a href="mailto:ujjwalsinha@tecnico.ulisboa.pt">ujjwalsinha@tecnico.ulisboa.pt</a>
	Joana Martins		<a href="mailto:ilmartins@ist.utl.pt">ilmartins@ist.utl.pt</a>
<b>DESY</b>			
	Ralph Assmann		<a href="mailto:ralph.assmann@desy.de">ralph.assmann@desy.de</a>
	Elena Svystun		<a href="mailto:elena.svystun@desy.de">elena.svystun@desy.de</a>
	Angel Ferran Pousa		<a href="mailto:angel.ferran.pousa@desy.de">angel.ferran.pousa@desy.de</a>
	Thomas Heinemann		<a href="mailto:thomas.heinemann@desy.de">thomas.heinemann@desy.de</a>
<b>ICL (Imperial College London)</b>			
	Aakash Sahai	PDRA	<a href="mailto:a.sahai@imperial.ac.uk">a.sahai@imperial.ac.uk</a>
<b>INFN</b>			
	Massimo Ferrario		<a href="mailto:massimo.ferrario@Inf.infn.it">massimo.ferrario@Inf.infn.it</a>
	Alberto Marocchino		<a href="mailto:alberto.marocchino@Inf.infn.it">alberto.marocchino@Inf.infn.it</a>
<b>CNRS-LPGP</b>			
	Gilles Maynard		<a href="mailto:gilles.maynard@u-psud.fr">gilles.maynard@u-psud.fr</a>
<b>JUS (Jiao Tong University Shanghai)</b>			
	Min Chen		<a href="mailto:minchen@sjtu.edu.cn">minchen@sjtu.edu.cn</a>
	Lule Yu		<a href="mailto:luleyu@sjtu.edu.cn">luleyu@sjtu.edu.cn</a>
<b>USTRATH (University of Strathclyde)</b>			
	Zheng-Ming Sheng		<a href="mailto:zhengming.sheng@strath.ac.uk">zhengming.sheng@strath.ac.uk</a>
	Feiyu Li		<a href="mailto:feiyu.li@strath.ac.uk">feiyu.li@strath.ac.uk</a>
	Maria Weikum		<a href="mailto:maria.weikum@strath.ac.uk">maria.weikum@strath.ac.uk</a>
<b>ELI-Beamlines</b>			
	Danila Khikhlukha	plasma physicist	<a href="mailto:Danila.Khikhlukha@eli-beams.eu">Danila.Khikhlukha@eli-beams.eu</a>

Collected from WP Contacts List on Wikipraxia  
<https://vocal-external.liv.ac.uk/sites/eupraxia/wikipraxia/Wiki%20Pages/WP%20Contacts%20List.aspx>

+ additions from IST and NFN

## ☐ LWFA Injector

Zero order parameter reminder: Charge 10-100 pC, Energy 0.1-0.2 GeV,  $\sigma E/E < 5 \%$

- Which plasma structure to consider ?  
→ gas jet, gas cell, etc
- Which internal injection methods to select ?  
→ Self-injection, optical injection, density gradient (smooth, shock-front), ionization (gas mixture) and variants, or more sophisticated: shock front assisted by ionization, self-truncated ionization injection, etc
- Matching to interstage beamline:  $a_0$ /density gradient

## ☐ LWFA Acceleration

Zero order parameter reminder (FEL application): Energy from 1 to 5 GeV

- Quasi-linear regime ?
- Which plasma structure to consider ? gas cell, capillary, etc
- Matching to input beamline (from RF injector or LWFA injector) and output beamline:  $a_0$ /density gradient

## □ Criteria for a good internal injection

- to control start and stop trapping, the charge

## □ Ionization injection with all variants looks very attractive

- Ionization + density down-ramp with controllable 2-stage gas target

*G. Golovin et al., Phys. Rev. STAB 18, 011301 (2015)*

- Self-truncated ionization injection

*M. Mirzaie et al, Nature Scientific Reports (2015)*

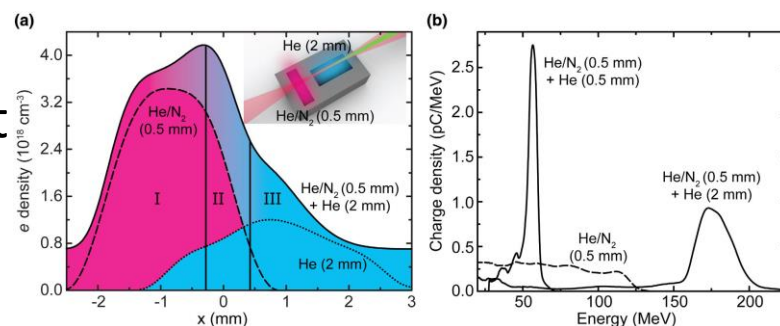
- Two-colour Laser-Ionization Injection

*L-L Yu et al, PRL 112, 125001 (2014)*

- Two-Pulse Ionization Injection

*N. Bourgeois et al, PRL 111, 155004 (2013)*

- etc



- ❑ **OSIRIS** (Joana Martins)
- ❑ **ALaDyn & Architect** (Alberto Marocchino)
- ❑ **SMILEI** (Arnaud Beck)
- ❑ **CALDER-CIRC** (Francesco Massimo)
- ❑ **PICon GPU** (Ashutosh Sharma)
- ❑ **WARP**
- ❑ **EPOCH**
- Hybrid codes or 2D option of PIC codes (cylindrical geometry) could give also a good starting point on the job  
**LCODE, QFLUID, Architect (PWFA), WAKE, ...**
- But need at the end full 3D PIC codes, very time consuming  
**Idea: EuPRAXIA consortium could apply to PRACE call**
- **Coupling** of PIC codes with conventional beam dynamics codes discussed (ex. OSIRIS-ASTRA coupling, Timon Mehrling)
- But also with FEL analytical codes (G. Dattoli)

# PIC codes used and Labs

Institution	PIC code used	Area of Interest
IST	OSIRIS	plasma Injector
DESY	PICon GPU OSIRIS	external injection LWFA acceleration (low density)
INFN _ SparcLab	ALaDyn Architect	ionization injection beam-driven (WP9)
PISA_ILIL	ALadDyn	channel propagation, self injection & ionization
CNRS/LLR	SMILEI	self injection, wavefront defaults
LOA	CALDER-Circ	plasma Injector WP6-WP11 oriented (FEL + prototyping)
CEA	WARP	plasma Injector + acceleration
CNRS/LPGP	WARP	plasma Injector (ionization injection)
ELI_Beamlines	PICon GPU	FEL application, self injection, LWFA
ELI_ALPS	PICon GPU EPOCH	LWFA