

WP3: High Gradient Laser Plasma Accelerating Structure

CNRS, ICL,

CEA, DESY, USTRATH, STFC, UHH, ULIV

- Design plasma accelerating structures and elements linked to laser plasma coupling issues:
 - (i) to achieve **an injector**, by generating a source of electrons, producing bunches of short **duration with reliable parameters**, suitable for injection into a laser plasma accelerating structure;
 - (ii) to achieve a **high gradient accelerating structure** with controllable plasma parameters, compatible with laser propagation over the acceleration length, and **scalable to high electron energy** requirements.

- Tasks
 - Task 3.1. Coordination and Communication
 - Task 3.2. Design plasma structures (injector & accelerator) **CNRS, JAI, ULIV**
 - Task 3.3. Design plasma chamber & environnement (beam coupling...) **CNRS, JAI, CEA, DESY**
 - Task 3.4. Diagnostics for plasma, wakefield and electron parameters **CNRS, JAI, ULIV, USTRATH**
 - Task 3.5. Staging plasma structures **CNRS, JAI, USTRATH, CEA, DESY, UHH**

M or D number	Milestone or Deliverable title	Lead beneficiary	Due Date (months)	Means of verification
MS14	M3.1 Design for electron injector and laser plasma stage proposed	4 - CNRS	18	Published on intranet
MS20	M3.2 Design for interaction chambers proposed	4 - CNRS	24	Published on intranet
MS21	M3.3 Design for implementation of diagnostics proposed	4 - CNRS	24	Published on intranet
MS26	M3.4 Design for multi stage coupling proposed	4 - CNRS	33	Published on intranet
D3.1	Report on the design of plasma structure	4 - CNRS	36	Report

To do urgently:

- Identify people who will contribute
- Establish a detailed task list
- Distribute work

WP3 meeting before june2016?

Questions:

Access to facilities for testing concepts and prototypes versus

Facilities select users on « new physics » criteria:
on which basis do the Eupraxia partners access test facilities for design purposes? Can we handle this on « internal » beam time?

Table from the proposal

Beam Parameter	Unit	Value
Particle type	-	Electrons
Energy	GeV	1 – 5
Charge per bunch	pC	1 – 50
Repetition rate	Hz	10
Bunch duration	fs	0.01 - 10
Peak current	kA	1 – 100
Energy spread	%	0.1 – 5
Norm. emittance	mm	0.01 – 1
FEL wavelength	nm	1 - 15

Additional properties to be defined:

reliable laser system,
 plasma based accelerator structures
 that can be cascaded,
reliable, compact beam source for
 HEP and for FEL for photon science.

A two stage scheme studied for reliability and scalability (cascade of accelerator structures) :
Injector in the range 100 to 200 MeV
coupled to an accelerator
to obtain an energy from 1 to 5 GeV

- Plasma based injector:** The best method of injection should be determined for **bunch charge in the range 10-20 pC, and 50-100 pC at the output of the injector**, allowing the achievement of other parameters:
 - Energy spread $\leq 5\%$ at the injector exit
 - Normalized emittance ≤ 1 mm mrad
 - Repetition rate 10 Hz or more (if useful for beam steering, positioning with feed back loop, switching between two beam lines - to be discussed)

- Plasma based acceleration structure**
 - **Define regime of acceleration:** non-linear with self-focusing versus quasi-linear with external guiding. The two options should be studied in a preliminary phase.
 - **For each option describe** plasma creation, guiding, depletion and dephasing, acceleration distance. Evaluate reliability at 10Hz and scalability.

- The interstage section should include a **compact (TBD) injection/extraction system** for the laser beams, using conventional or plasma mirrors
- The interstage section should include a **transport line** which, in addition to be compact, has to fulfil the following properties:
 - Beam matched to plasma structure (beam size \sim a few tens of μm)
 - small bunch lengthening ($< \frac{1}{4}$ of the plasma wave period)
 - Small dispersion and chromaticity (TBD)
- The transport line can be made of conventional magnets or plasma lenses, while plasma structure ends can include longitudinal density gradients to ease the matching.

Task	Description	Contributing institutions	people
3.1	Science Input	CNRS ICL	B. Cros, Z. Najmudin,
	Monitoring	CNRS ICL	B. Cros, Z. Najmudin,
	Reporting	CNRS ICL	B. Cros, Z. Najmudin,
3.2:	I &A Plasma design		
	Injector 100-200 MeV		
	Injection 1-3 GeV		
	Target design - gas cell		
	Target design - capillary		
	Target design - discharge		
	Target tests		
3.3	Plasma Chamber design		
	Beam combining tests		
	Beam focussing test- capillary		
	Beam focussing test- magnets		
3.4	Diagnostics		
	Diagnostics injector		
	Diagnostic - accelerator		
3.5	Staging		
	Identify scalability parameters		
	Compact laser Plasma coupling plasma mirror...		
	Stability space/time		