EUROPEAN
PLASMA RESEARCH
ACCELERATOR WITH
EXCELLENCE IN
APPLICATIONS

EuPRAXIA

Use of Other Novel Technologies (WP10)

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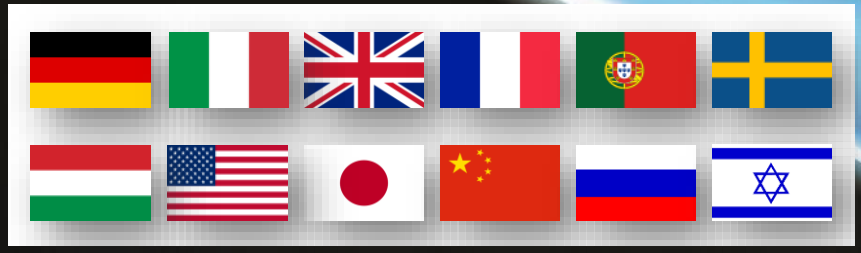


This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 653782.

Contents

- Fiber lasers
- Dielectric-based accelerators
- Plasma beam dumps

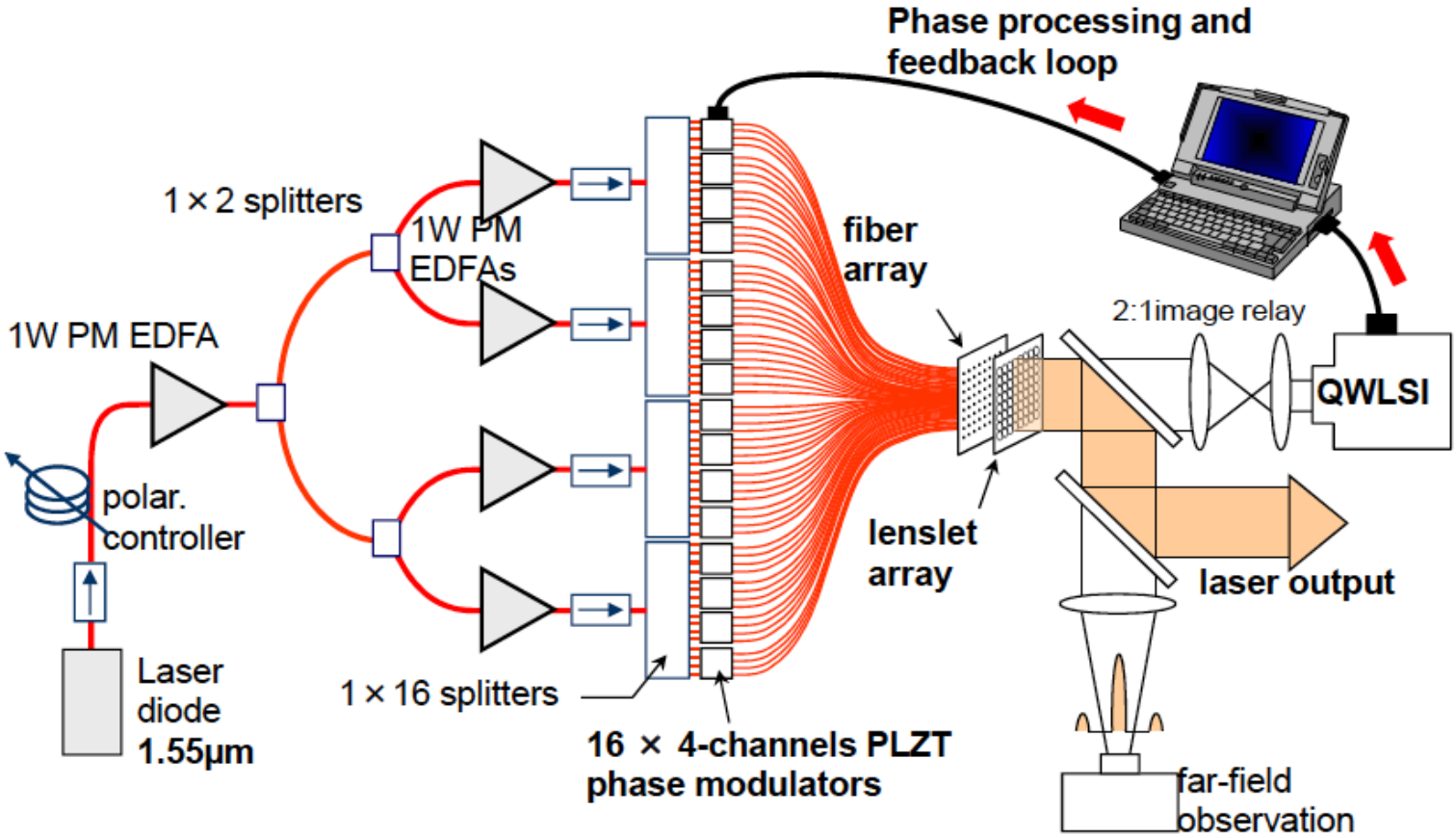
Fiber lasers

- Fiber lasers (advantages: high efficiency, high repetition rate, low loss, heating is not an issue)
- 10 GW per stage, need 100s fiber lasers combined to achieve TW level, even more for achieving hundreds TW or PW level laser for EuPRAXIA
- ICAN and XCAN (Gerard Mourou)
  - 61 pulsed fibers combined (CW), with each beam controlled separately on phase (adding flexibility), 91 next step, 500 fibers for future (1 µm precision core to core)
  - 10,000 fiber lasers can be combined in principle, 10s of Joules, more than 10 kHz repetition rate)
  - Combination of two high power Ti: Sapphire lasers planned
- Status, problems, limitations, potentials
- Industry involvement, Thales and others

Fiber lasers

J. Bourderionnet, A. Brignon (Thales), C. Bellanger, J. Primot (ONERA)

Coherent Fiber Combining



Achievement 2011
→ 64 phase-locked fibers

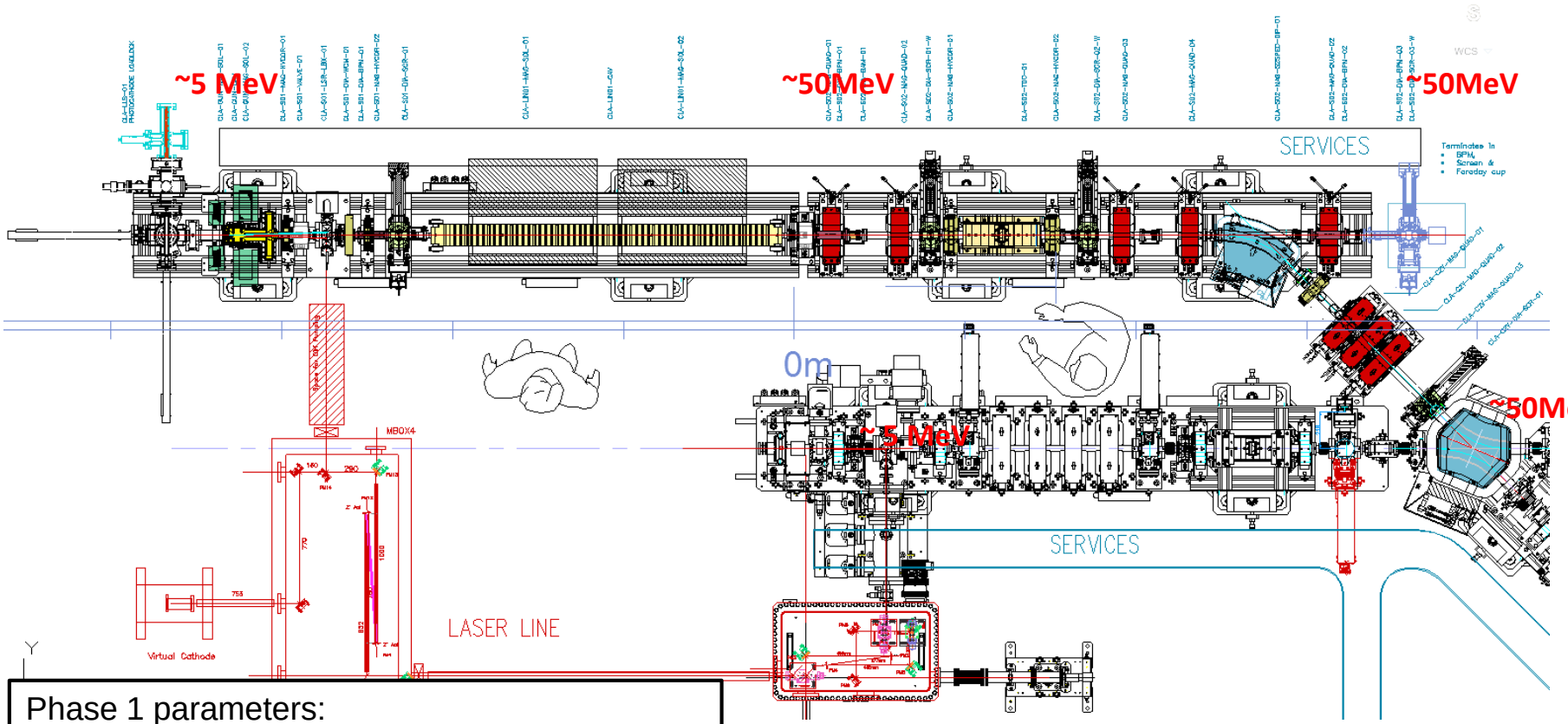
Dielectric based accelerators

- Current status of dielectric laser accelerators, THz driven dielectric accelerators and compact electron gun setup based on dielectric accelerators are reviewed.

- Updates from ACHIP project
  - ANL/UCLA/SLAC/
  - DESY
  - PSI
  - SLAC
  - …

- Update from DATA program at Cockcroft Institute
  - DLW as energy dechirper (for FELs)
  - DLW as THz source
  - DWA for two beam acceleration

CLARA front-end

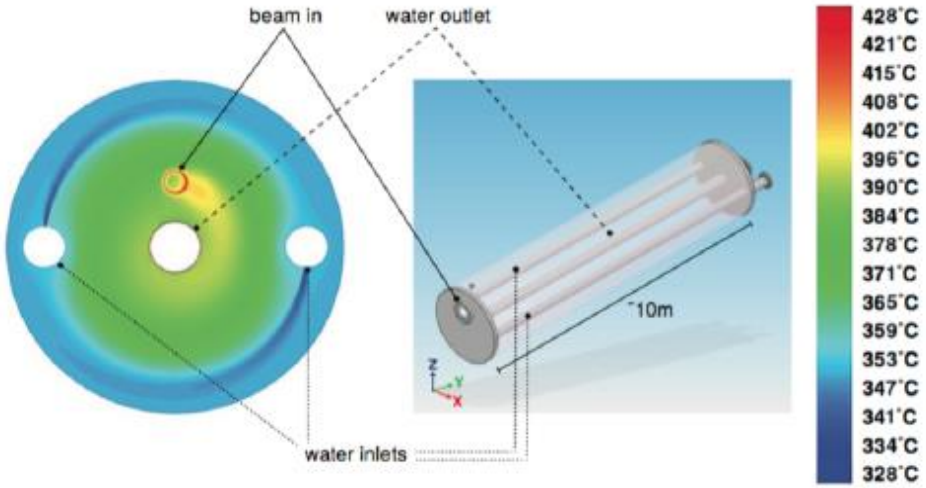


Phase 1 parameters:	
Max energy	~50 MeV
Max charge	250 pC
Norm. emitt.	< 1 mm mrad
Min bunch length	50 fs (rms)
Max peak current	2 kA
Bunches/RF pulse	1
Pulse rep. rate	10 Hz (400Hz later)

Plasma beam dump

Conventional beam dumps use high density materials – metal, water etc. They require high power density cooling, can produce radionuclides and (for water) explosive gasses through decomposition.

Stopping a beam with a low density material could have advantages.



Plasma beam dump

H.C. Wu, T. Tajima et al. PR-STAB 13, 101303 (2010)

- **High decelerating gradients with low density dump medium.**
- **Effectiveness depends on bunch parameters.**
- **Possibility for electrical energy recovery.**

Plasma beam dump

Plasma beam dump for EuPRAXIA 1 GeV beam

Parameter	EUpraxia Beam	Simulation Beam
Mean beam energy, T_0	1-5 GeV	1 GeV
RMS energy spread	$\sim$5%	$\lesssim 1\%$
RMS bunch length, σ_z	$\sim 1.5\mu$m (5 fs)	1.5 μm (5 fs)
RMS transverse beam size, $\sigma_{x,y}$	$\sim$0.3 μm	0.3μm
Bunch charge	100 pC	100 pC
Peak bunch density, n_b	10^{23} m^{-3}	10^{23} m^{-3}

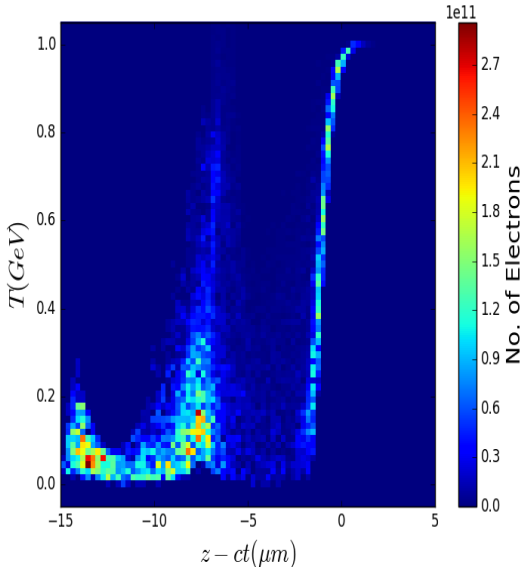
EPOCH code is used to model the energy loss of the electron beam

The results are very encouraging

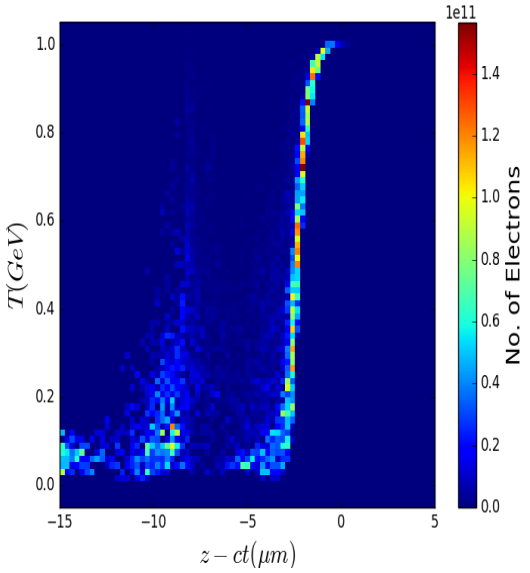
Results – Structured Plasmas

Example: Linearly Increasing Plasma Density

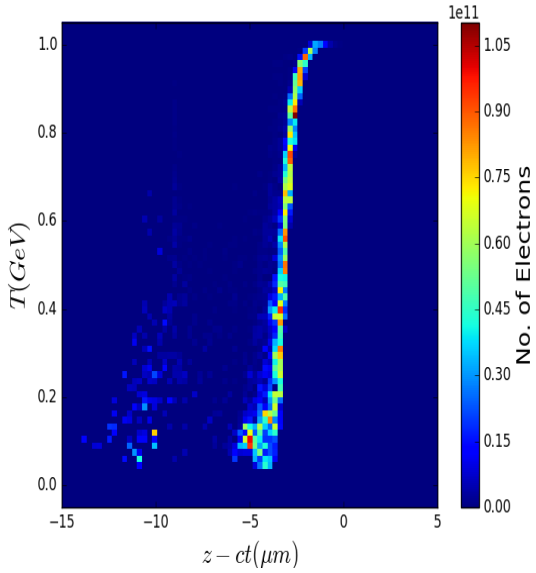
5cm



6cm



8cm



- Nearly all tail particles removed.
- Particles at the bunch head still remain.

Conclusions

- Latest development of fiber lasers is discussed (ICAN and XCAN)
- Latest development of the dielectric based acceleration program worldwide are reviewed. It might not be able to use as electron injector. However the dielectric structures, e.g. DLW might be used to improve the LWFA beam (energy dechirper), especially for FEL applications
- Plasma beam dump is very promising and will provide the key input to the EuPRAXIA novel beam dump design. The initial study shows that a 10 cm long plasma can dump ~90% of the 1 GeV EuPRAXIA beam energy
- Our next step is to optimize the design of the plasma beam dump for EuPRAXIA beam. Further experiment will be conducted at CLEAR and CLARA to verify this enabling technology

Workshop on Plasma Beam Dumps

- https://indico.hep.manchester.ac.uk/conferenceDisplay.py?confId=5343. (30-31 August 2018 in Manchester)
- Toshi Tajima (UCI), Alex Chao (SLAC), Kazuo Tanaka (ELI), Alex Bonatto (UFCSPA), T. Saeki (KEK), Denis Perret-Gallix (CERN), W. Lu (Tsinghua Univ.)
- With the aim to implement the plasma beam dump to the EuPRAXIA and other LWFA facilities