Accelerator R&D: view on future accelerators / concepts

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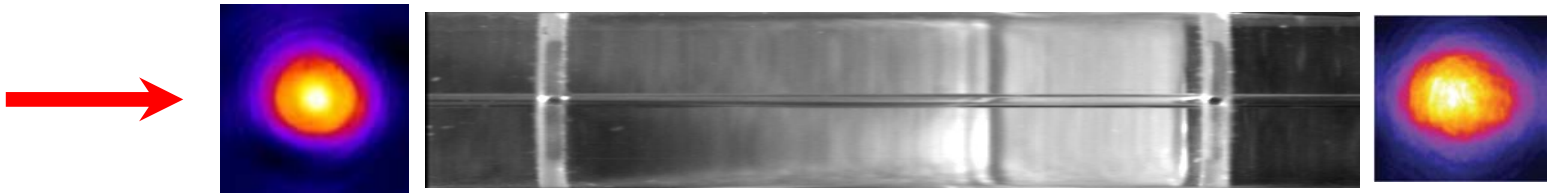
Outline

- Plasma based linac for e- and e+: main features
- First steps towards accelerator R&D: get organized
- Main challenges to address

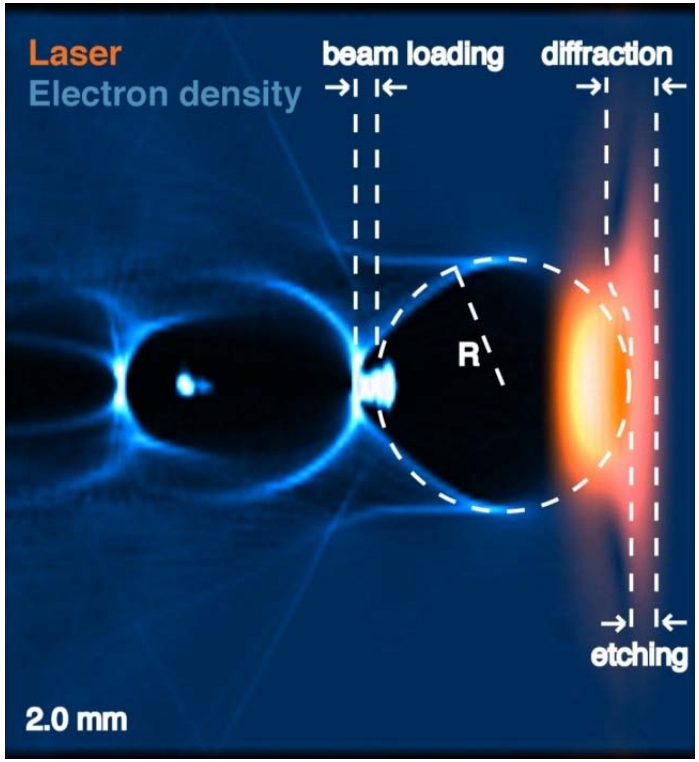


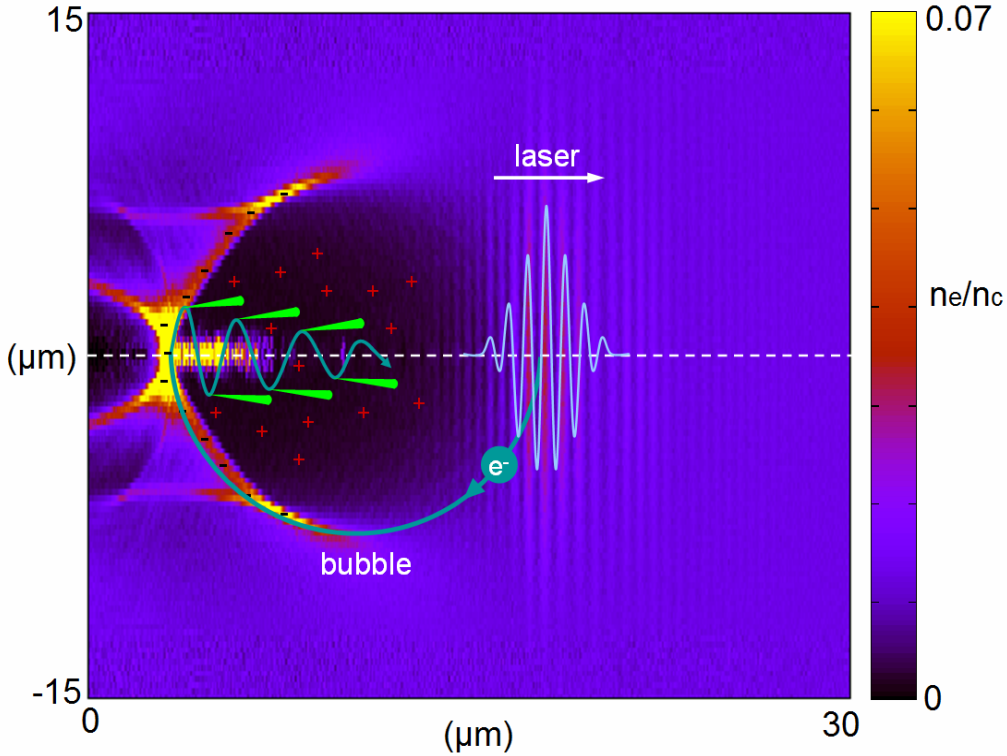
Plasma contribution to accelerators

- Electron source
- Emittance determination and control
- Acceleration
- Focusing
- Pulse structure
- Polarisation ?

A plasma wave is more than a pure accelerating field

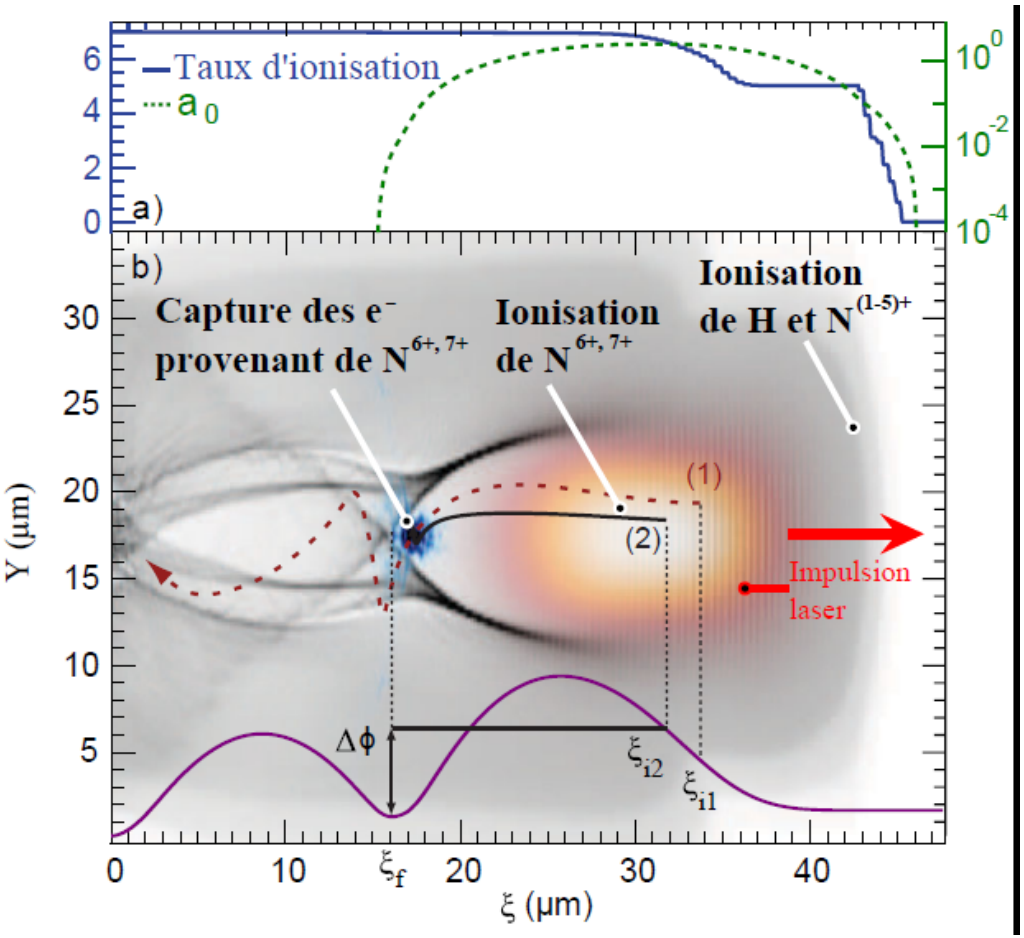
- Electron source (injector)
- Self-injection of e-, betatron radiation





Lu (2007), Pukhov (2002)

Emittance controlled by e-injection mechanism

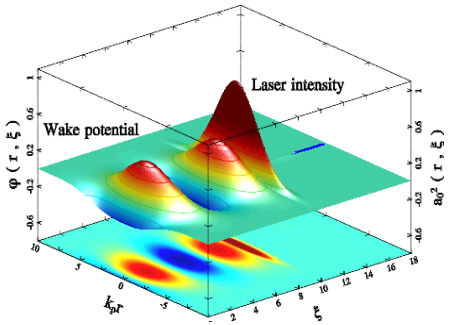


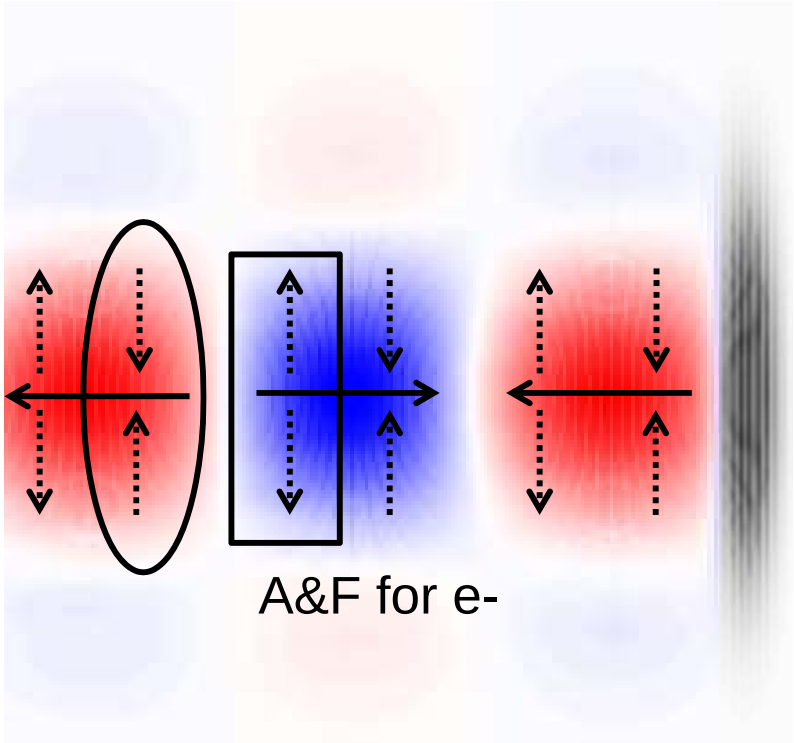
- Ionisation assisted injection can help to control injector emittance

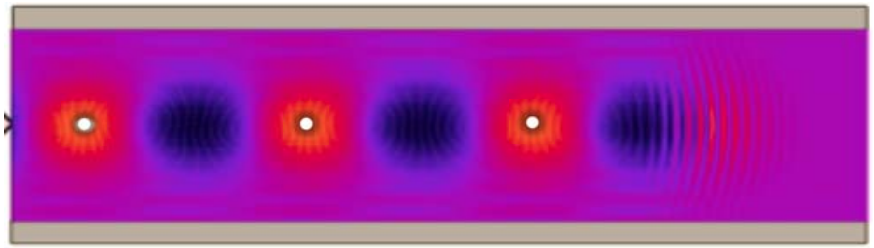
Pak (2010), Chen (2002)

Several phases of plasma wave can be exploited

- Acceleration in QL regime
- Focusing (e- or e+ in different phases)
- Pulse structure (multi-bunch)





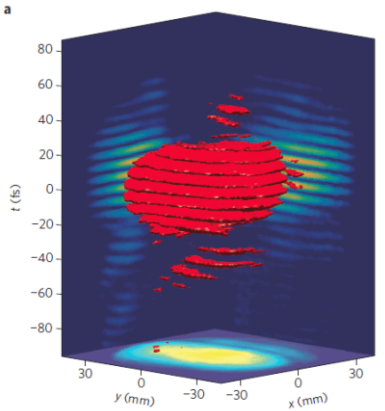


A plasma wave is more than a pure accelerating field

- Electron source
- Emittance determination (injector)
- Acceleration
- Focusing
- Pulse structure
- Polarisation ?
- **Plasma accelerator should operate in the most suitable regime to take advantage of these properties**

Laser wakefield acceleration to go beyond conventional accelerators

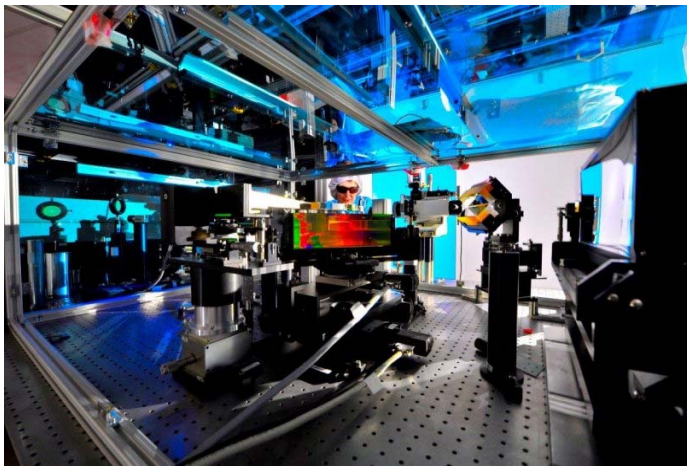
- State-of-the- art: High field gradient: 1-100 GV/m
- Room for exploration
  - complex NL physics: interaction of particles with plasma waves (3 players laser driver, plasma, particle),
  - beam polarisation, focusing
- New physics driven by innovative tools
  - develop more 3D diagnostics and simulations
- Multi-stage (laser) plasma acceleration as the basis of future high energy accelerators? Increases the number of independant control of parameters

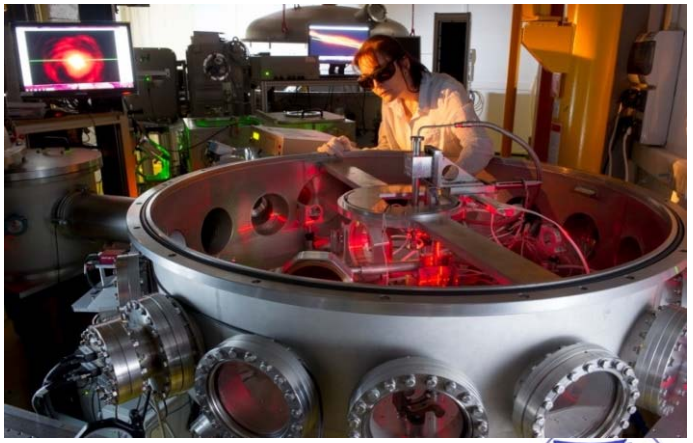


Pariente 2016

First steps towards laser plasma accelerator R&D

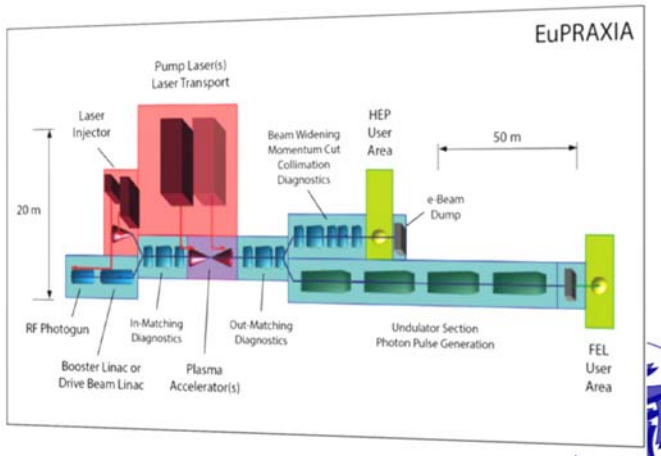
- Is the field ready to go beyond physics into the machine world?
  - LWFA developped at laser (research) facilities by plasma physicists
- Who should do it?
  - Change of culture and environment is needed: involvement of engineers necessary to build a reliable, user friendly, accelerator facility
  - Industry involvement to build industrial accelerator





Eupraxia: a bridge between physics labs and industrial accelerators

- The design phase will define the kind of accelerator that can be build relying on existing knowledge
- Its construction will provide a test facility for accelerators R&D
  - Should be a milestone: 1st unit block for multi-stage electron accelerators to high energy
  - Test bench for beam manipulation

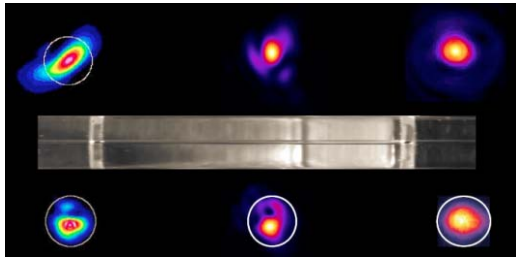


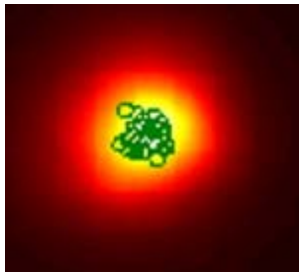
Main challenges of Laser plasma linac / collider development

- Laser system efficiency
- Quality and efficiency of laser plasma coupling
- Stability of the whole accelerator
- Compact particle beam transport and shaping
- Positron acceleration
- Collider elements adpated to LPA

Addressing main challenges 1/2

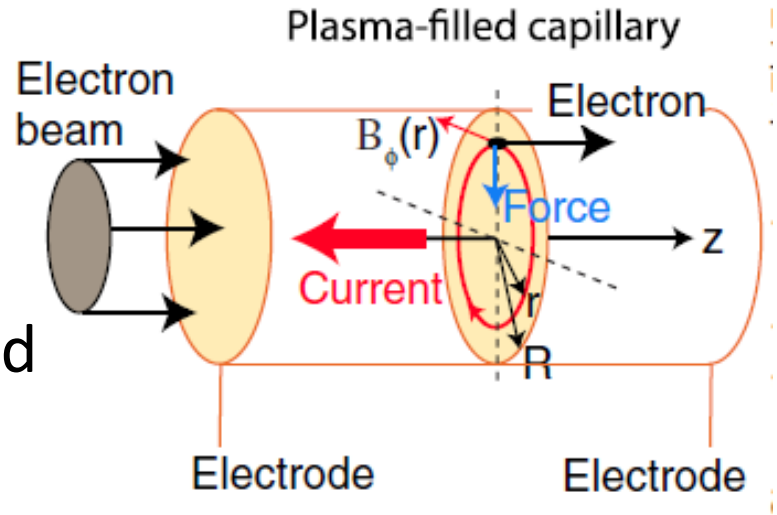
- Laser system efficiency : industry R&D
- Quality and efficiency of laser plasma coupling
  - Laser pulse shaping and cleaning, guiding , recycling: non linear optics in plasma and/or in waveguides
  - Plasma control and tailoring : fluids dynamics and plasma physics, target design
- Stability of the whole accelerator:
  - Global view, engineering know-how and methods necessary





Addressing main challenges 2/2

- Compact particle beam transport and shaping
  - Beam optics based on plasmas?
  - Plasma or laser/plasma design
- Positron acceleration
  - Feasible in QL regime, should be tested experimentally
  - Need to develop positron sources



Van Tilborg (2015)

- Collider elements adpated to LPA
  - Final focusing, cooling
  - Need for expertise and new ideas

Summary

- A test facility in the multi-GeV range should be build asap
  - To address main challenges
  - To identify unpredicted issues
  - to foster collaborations worldwide and form an active group for accelerator development
  - To propose technical design for colliders/new machines
- In parallel massive efforts are necessary to build numerical tools to achieve fast and realistic simulations

25-28 April 2017, CERN

ANAR2017: Advanced and Novel Accelerators for High Energy Physics Roadmap Workshop 2017

https://indico.cern.ch/event/569406/

The general goal is to define an international roadmap toward colliders based on advanced accelerator concepts, including intermediate milestones, and to discuss the needs for international coordination.

4 working groups
to define a scientific roadmap
LWFA, PWFA, DWA, DLA
Plenary sessions
to discuss strategy and international coordination

Organized at the initiative of the ICFA panel for Advanced and Novel Accelerators
(http://www.lpgp.u-psud.fr/icfaana)