This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement No 730871.

The ARIES WPs on New Acceleration Technologies (Network, TA, JRA)

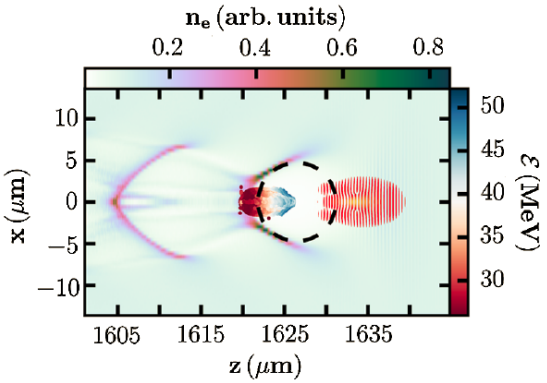
Brussels / September 25th, 2019/ mid-term Review

Brigitte CROS / CNRS - LPGP

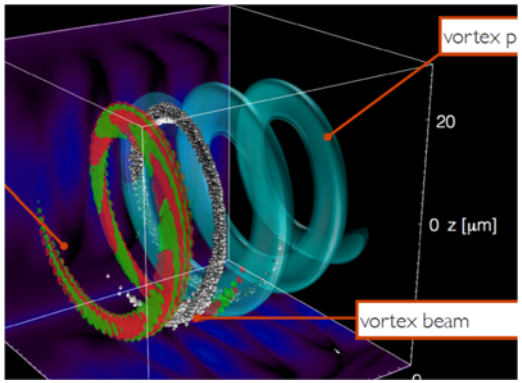
New high gradient acceleration concepts in ARIES

- Characterized accelerating gradients >1 GeV /m and short particle bunches >>> GeV electron bunches can be accelerated over cm scale
- ARIES includes electron acceleration in laser driven wakefield in plasmas and dielectric structures

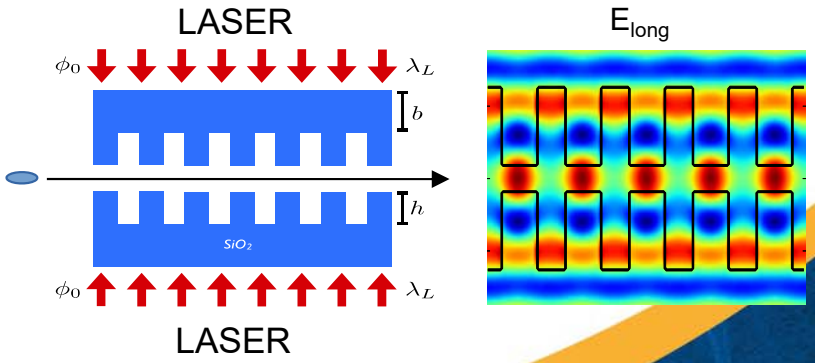
Non linear interaction of the laser pulse with a plasma generates relativistic electrons over mm scale



A light spring to drive a vortex shape electron beam



Transverse Laser driven eigen modes in the dielectric structure, external electron bunch gains energy during its propagation



Overview

- Using new accelation concepts for the construction of accelerators requires developments through the joint effort of advanced acceleration physicists and accelerators experts
- **ARIES is an ideal frame to foster these activities**

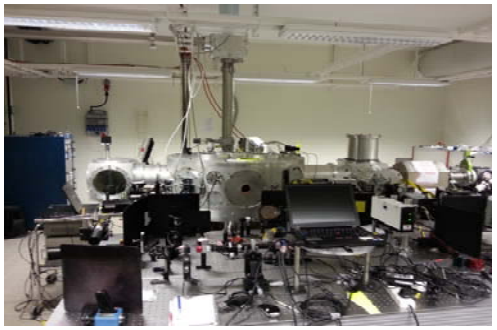
- Within ARIES it is implemented as
  - **NA**: Networking activities to shape the future of the field, EuroNNAC (WP5)
  - **JRA**: R&D efforts to propose disruptive concepts and study implementation of the state of the art concepts (WP18)
  - **TA:** Access to beam plasma facilities to provide the accelerator community opportunities to test or improve these facilities (WP13)

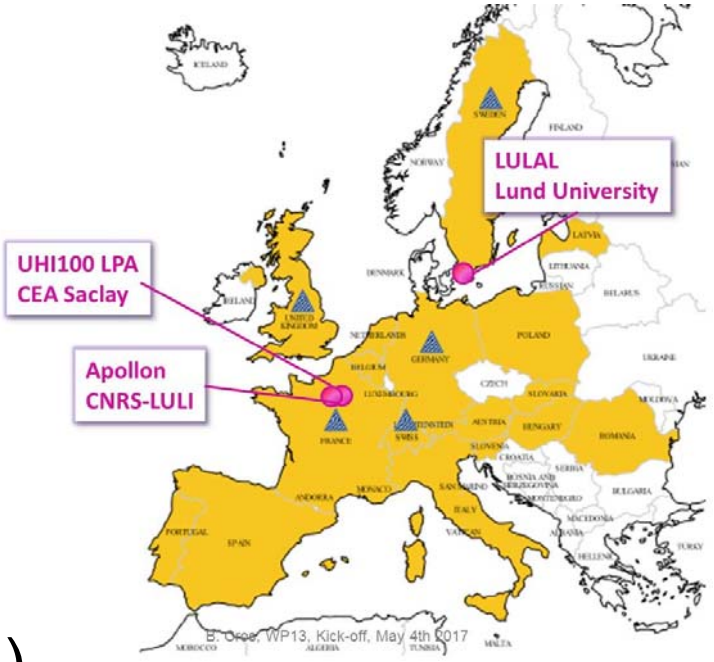
TA to electron beams generated by Laser driven wakefield in plasma

- In the frame of ARIES Transnational Access Users are contributing to the characterisation and improvement of these beams

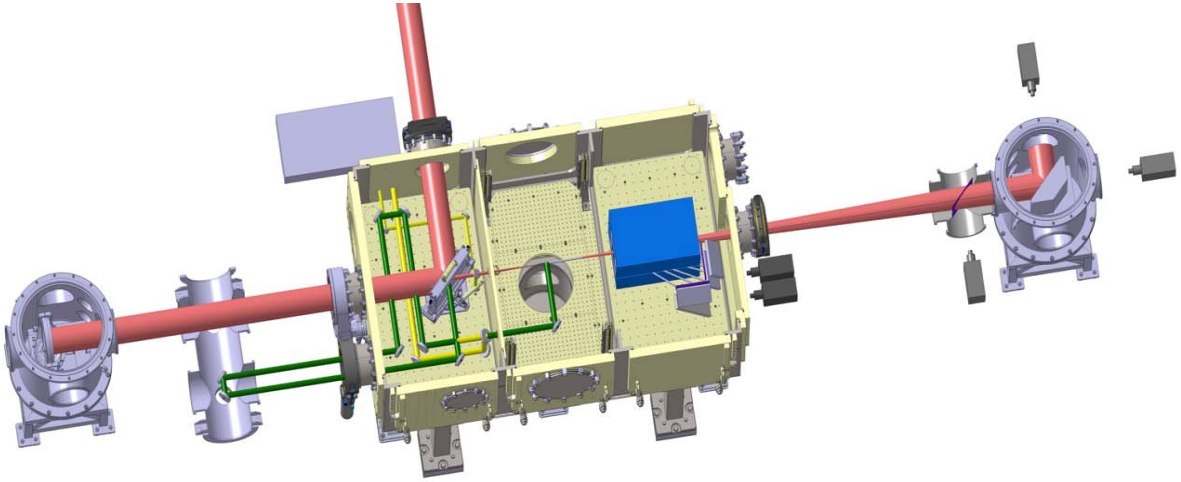
- Typical parameter range for WP13 facilities
- Energy: 50 MeV – 300 MeV
- DE/E: 5 % -100%
- Charge: 1- 100pC
- Duration: 10-100fs

3 facilities offering TA in WP13

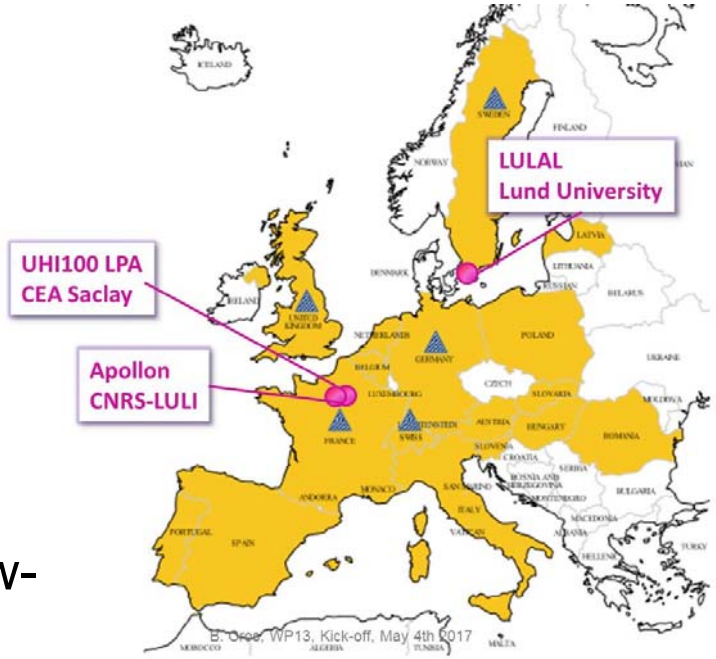




- LULAL (Lund University)
- UHI100 LPA (CEA LIDYL)
- APOLLON MUST-LPA (CNRS LULI)

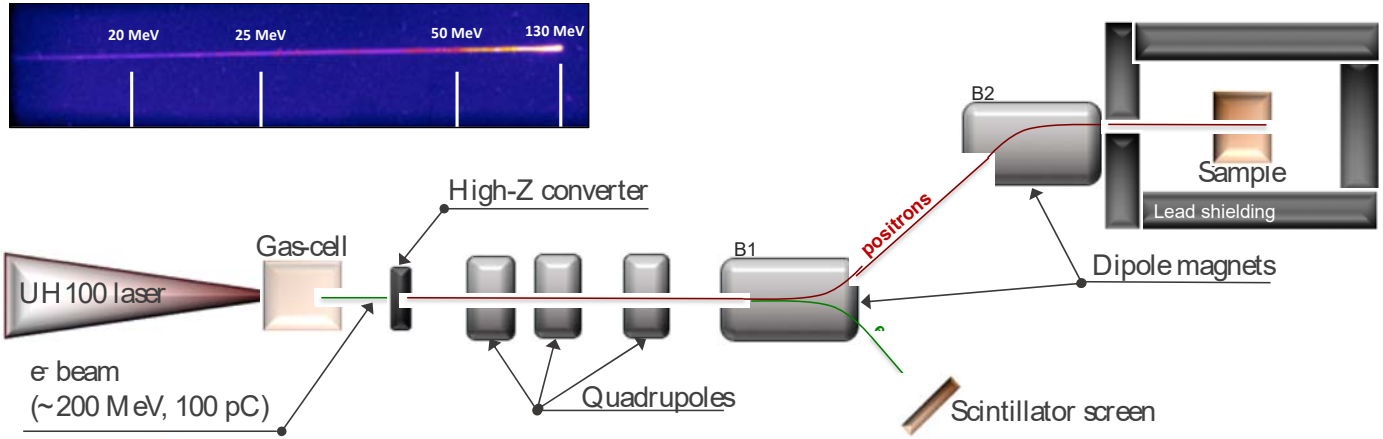


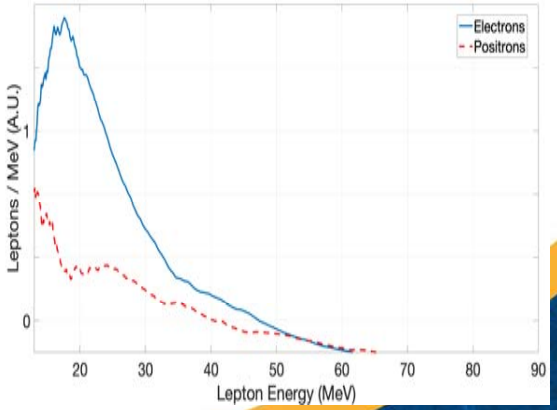
UHI100 : Queens Univ. Belfast, Positron generation and characterisation



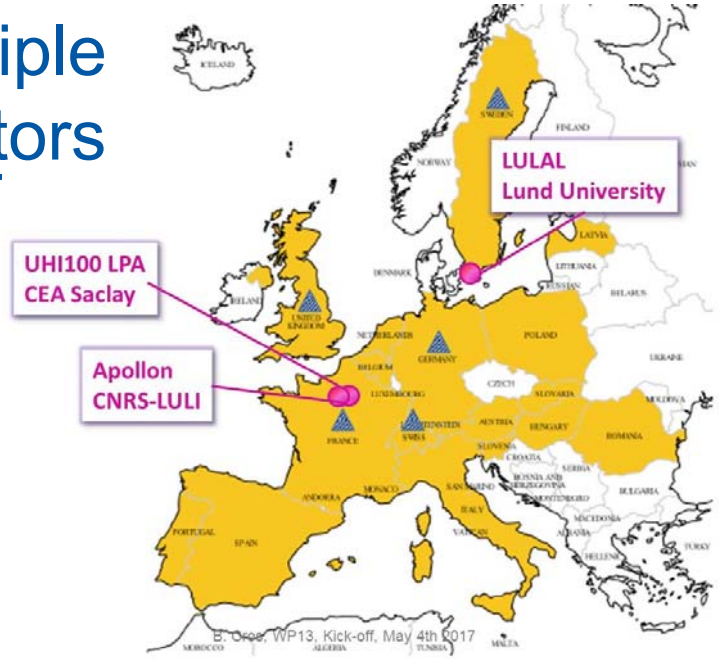
Generation and characterisation of dense populations of low-energy (sub-MeV) and ultra-short duration (~ps) positrons to be used for advanced non-destructive inspection of materials.

LYDIL @ CEA: Jan-Feb 2019





LULAL: FTMC &VDU Vilnius, Testing multiple micro nozzle for profiling plasma accelerators

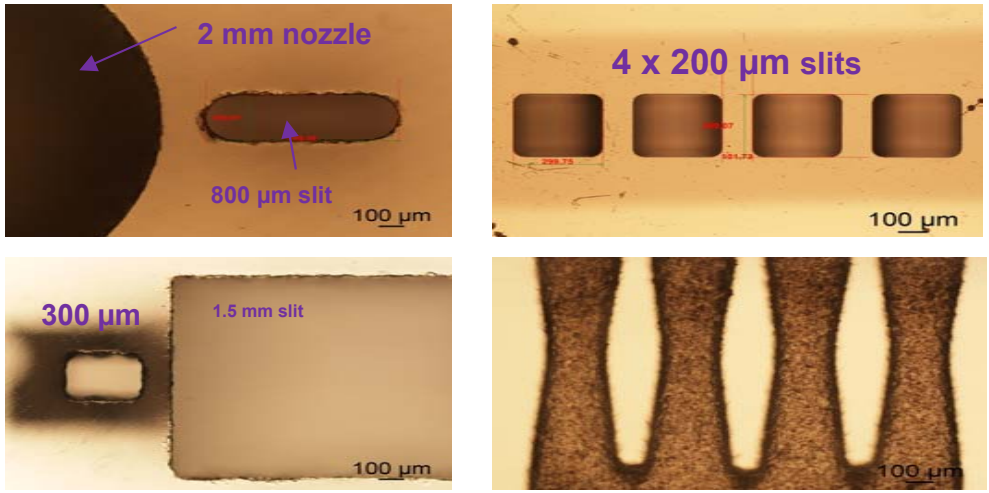


Testing of femtosecond laser micro-machined supersonic gas jets for LWFA and X-ray emission

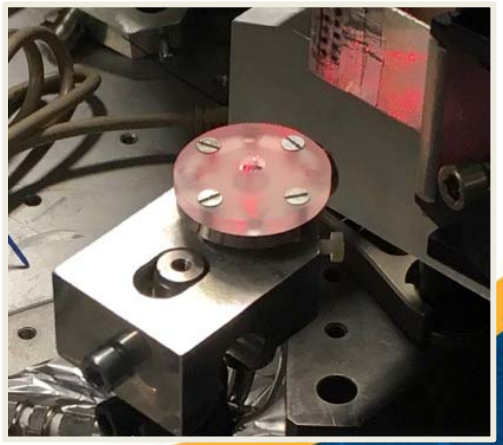
Performed Feb 2019 (120 hours, 3 weeks)

User team: V. Tomkus[1], V. Girdauskas[2], G. Raciukaitis[1] (PI), V. Stankevic[1], J. Dudutis[1]

[1]Center For Physical Sciences and Technology (FTMC), Vilnius, [2]Lithuanian University of Educational Sciences (VDU), Vilnius, Lithuania

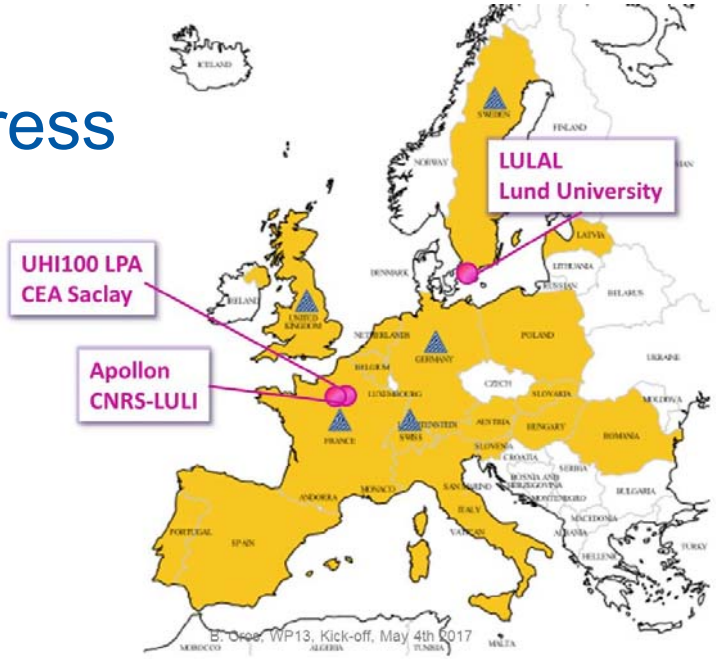


De Laval nozzle shapes



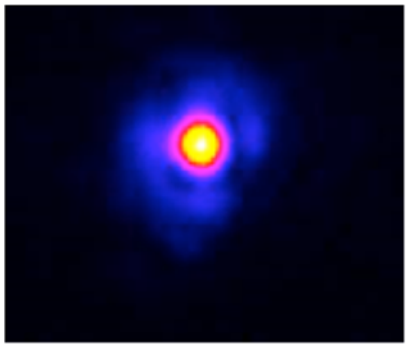
APOLLON facility commissioning in progress

Apollon



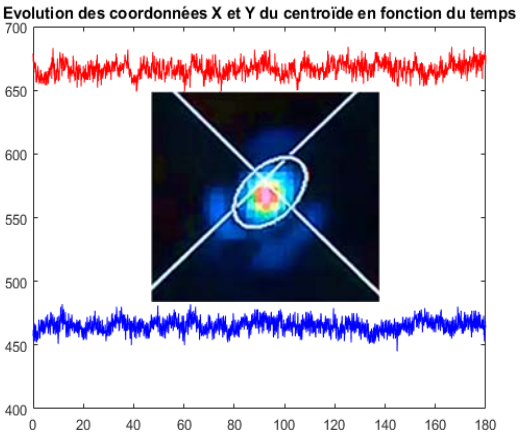
⇒ About 18J available in the experimental hall.
⇒ Pulse duration around 22 fs.

⇒ Strehl ratio of ~0.5 measured at the experimental chamber centre using the 10 Hz alignment laser.



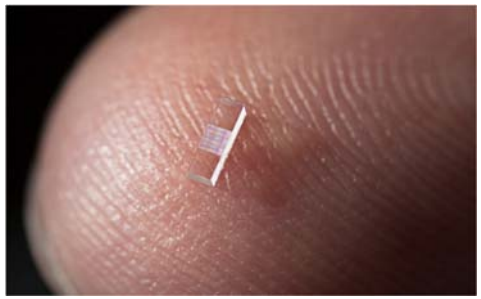
⇒ Strehl ratio of ~0.6 measured at the end of the last amplifier running at full energy (30J).

⇒ Shot-to-shot stability measured over 3h to be around 15 µrad (real values are expected to be better due to the low dynamic of the camera. Extra measurements under way).

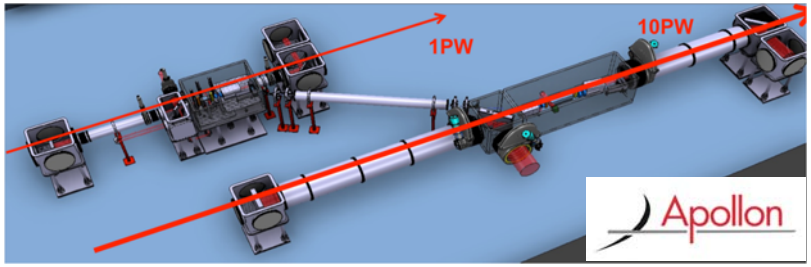


ARIES

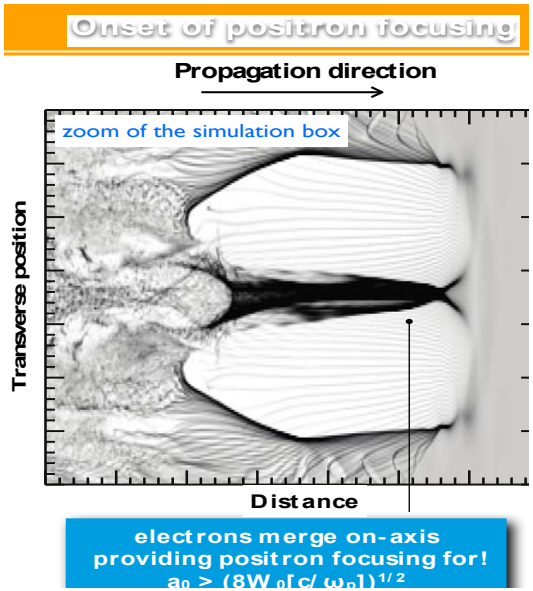
A JRA for R&D and implementation of new accelerator concepts Coordination (**A.Specka**, **CNRS)**



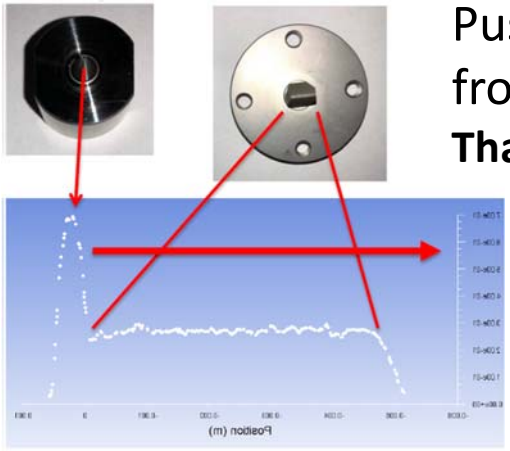
Laser driven dielectric accelerator (DLA)
in vacuum **(U. Dorda, DESY,** U. Erlangen)



Enabling multi-stage LWFA (**A. Chancé**, **CEA**, CNRS)



LWFA with exotic laser beams (**J. Viera**, **IST**, CEA)



Pushing back the charge frontier ***in plasma*** *(LWFA)* (**C. Thaury**, **CNRS**, U Lund)

Laser driven dielectric accelerator (T18.4)

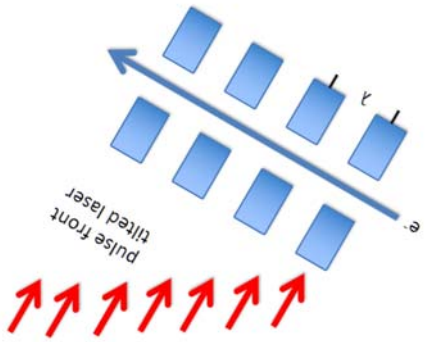
- Task leader: **Ulrich Dorda** (DESY)
- Partners: DESY 72 p.m
  Friedrich-Alexander-Uni Erlangen 4 p.m
- Milestone *(MS18.3)*:
  M30: *Final design of the ARIES dielectric structure for relativistic beams*
- Deliverable (D18.4):
  M35: *Design & construction of an ARIES dielectric structure for acceleration of relativistic electron beams*

Dielectric Laser Acceleration experiment in preparation

Commissioning of **ARES linac** started

DLA-experimental Area:

most components in final stages of production, 2µm laser being installed, laser beam line ordered, components for microbunching experiment (stage 2)



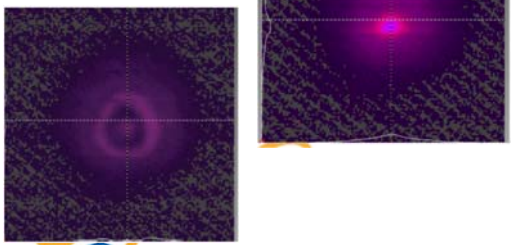
DLA components:

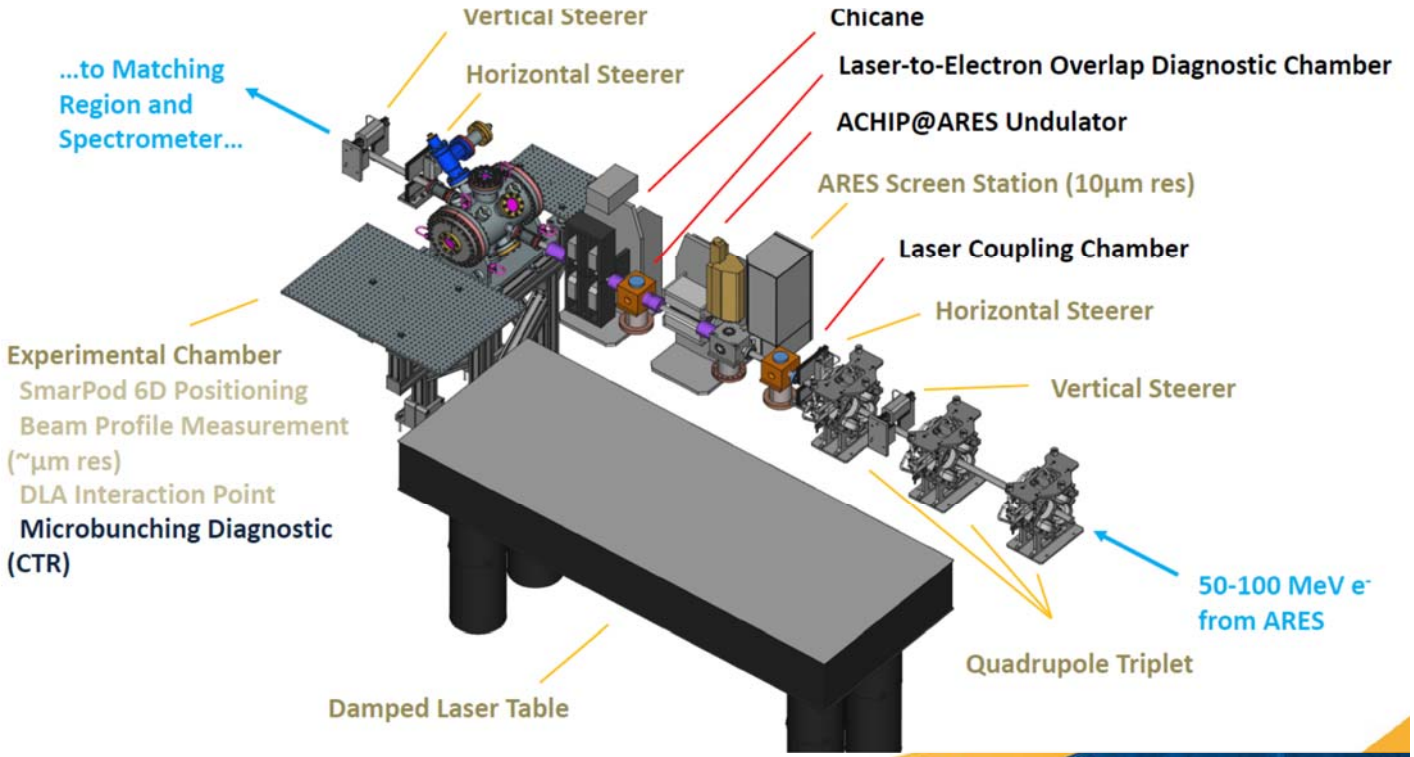
Design done

First DLA structures received

Damage tests started

0.2J/cm²



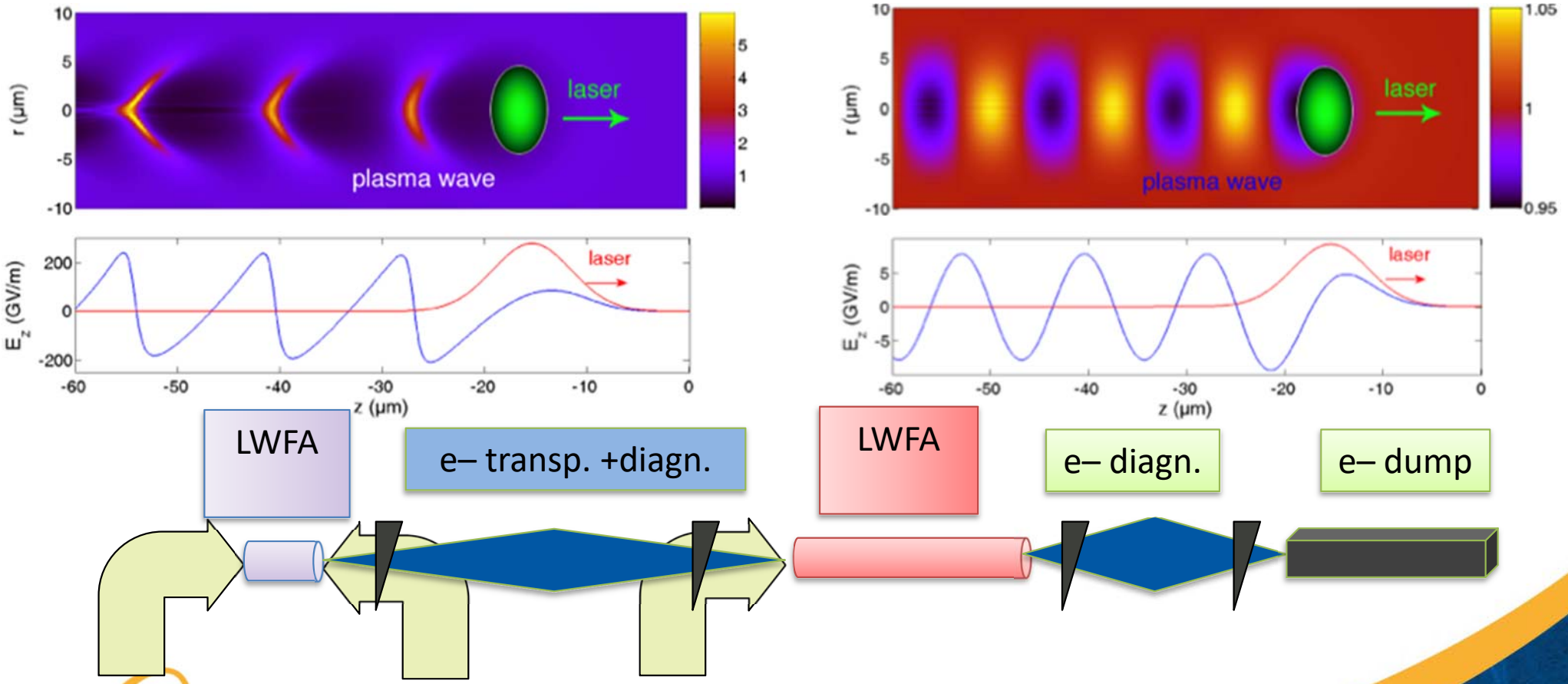


Enabling multi-stage LWFA (T18.2)

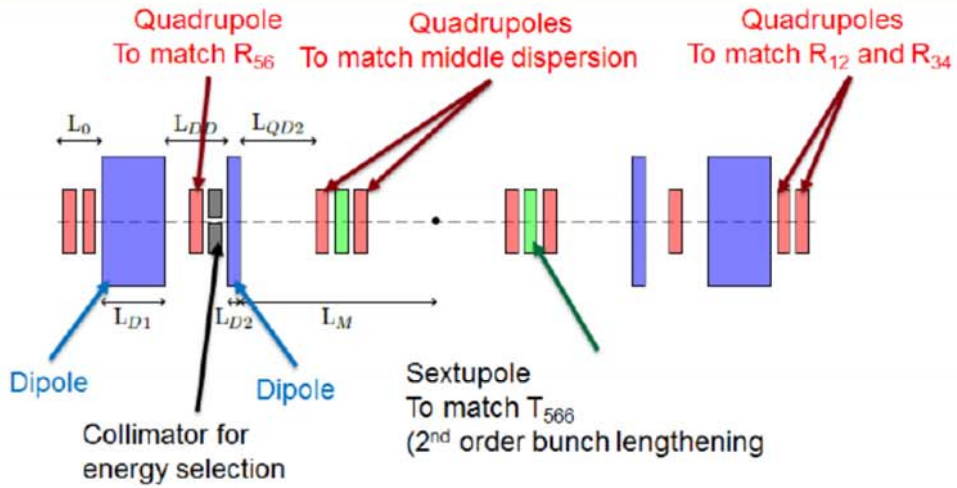
- Task leader: **Antoine Chancé**,
- Partners: CEA (IRFU) 10 p.m
- CNRS (LLR, LULI, LPGP) 19 p.m
- Milestone (MS18.4):
  - *M36: Start of commissioning inter-stage line*
- Deliverables (D18.1 D18.2):
  - ✓ *M18: Report containing a detailed design of a compact dogleg transport systems for use in plasma accelerators*
  - *M46: Component procured, inter-stage transport line assembled, elements tested characterized and integrated in the CILEX facility, first beam tests completed*

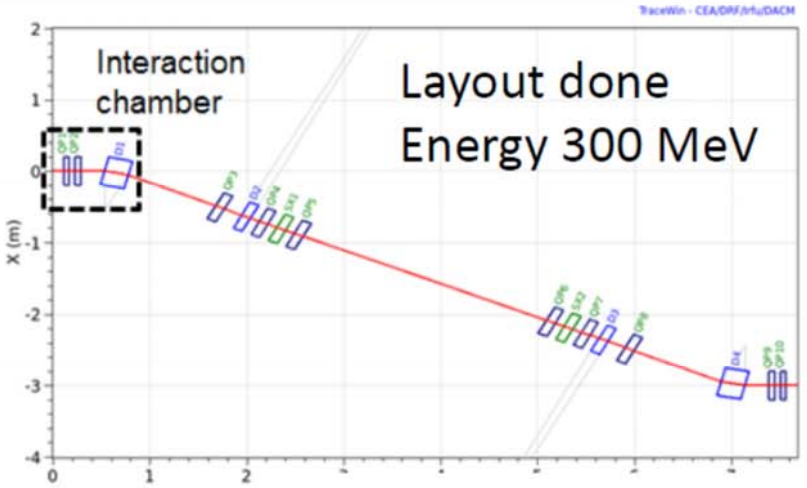
Enabling multi-stage LWFA (T18.2)

- electron dephasing, laser depletion -> staging of plasma accelerators
- plasma injector O(200MeV) and plasma booster (5-20GeV)
- **coupled by interstage e- transport and diagnostics line**
- part of CILEX e- acceleration program (>2018) at APOLLON



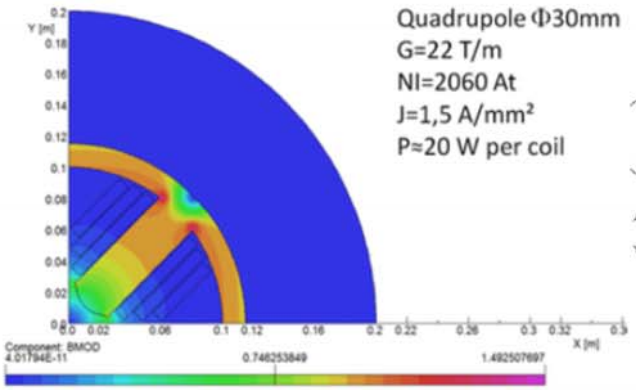
Enabling multi-stage LWFA : Status





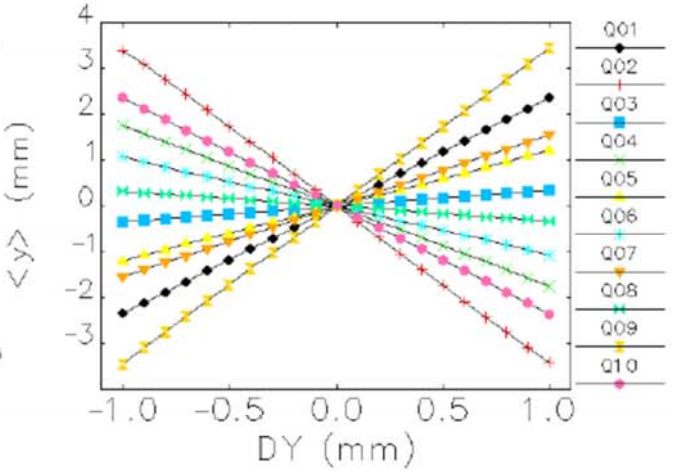
Magnet	Length	Max Strength
D1	250 mm	1,7 T/26°
D2	100 mm	0.15 T/1°
QP1	60 mm	206 T/m (PM)
QP2	60 mm	102 T/m (PM)
QP3/4/5	100 mm	15 T/m (EM)
SX1	100 mm	100 T/m² (EM)

List of magnets fixed

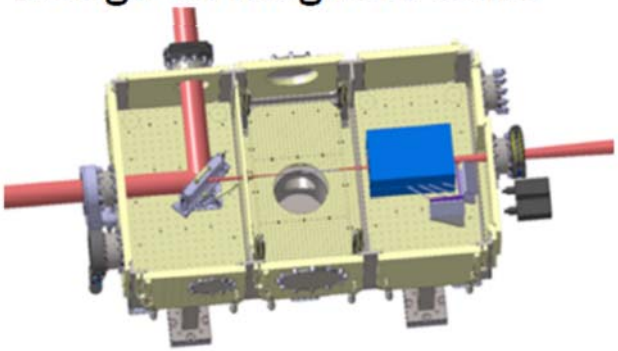


Quadrupole Φ30mm
G=22 T/m
NI=2060 At
J=1,5 A/mm²
P≈20 W per coil

Design of magnets done

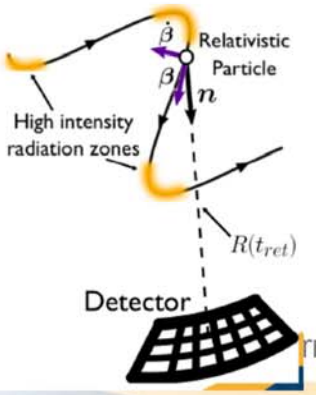


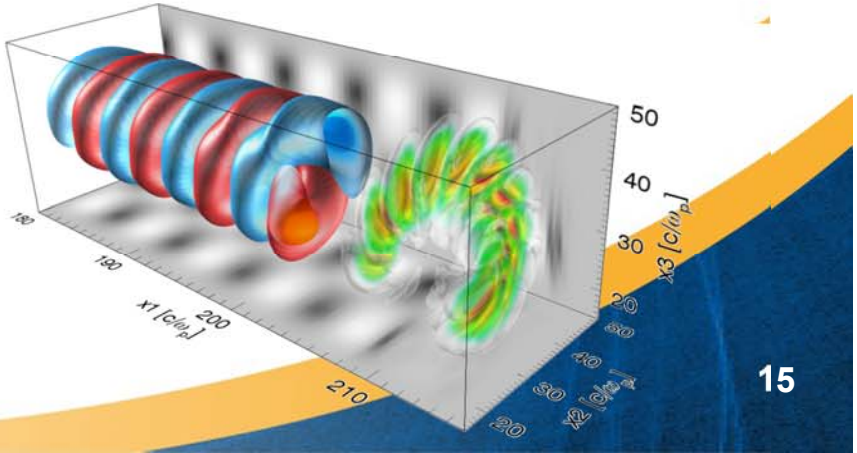
Tolerance analysis begun



LWFA with exotic laser beams (T18.3)

- Task leader: **Jorge Vieira** (IST Lisbon) 36 p.m
- Partners: CEA/LIDYL 10 p.m
- Milestones (MS18.2, MS18.3)
  - ✓ *M6: Setup simulation framework for acceleration and radiation generation in wakefields driven by lasers with orbital angular momentum (Lisbon)*
  - ✓ *M12: Setup of experimental facilities for laser wakefield acceleration experiments using laser drivers with orbital angular momentum*
- Deliverable (D18.3)
  - *M36: Report on simulations of particle acceleration in plasma waves driven by exotic lasers with orbital angular momentum with corresponding radiation signatures and experiments on particle acceleration and radiation generation using intense vortex light beams*



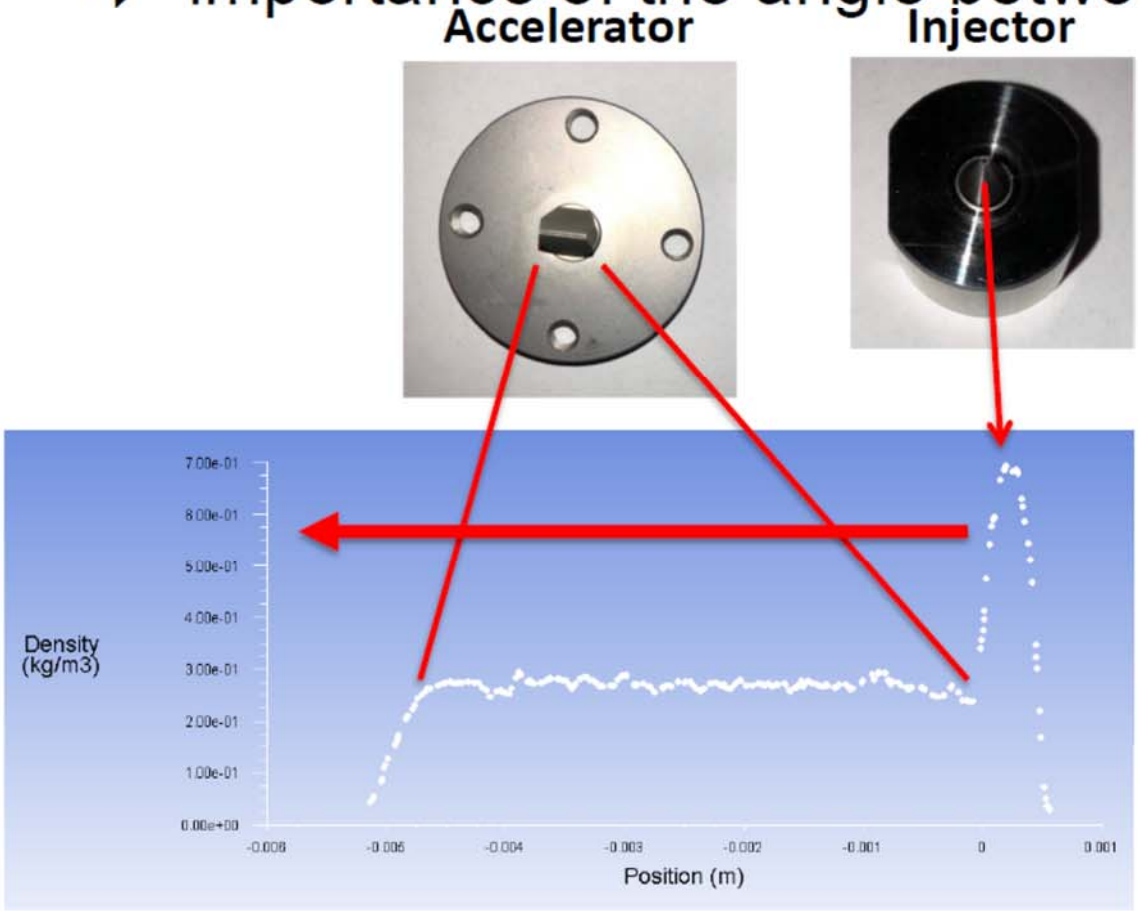


Pushing back the charge frontier (T18.5)

- Task leader: **Cédric Thaury** ,CNRS (LOA) 15 p.m
- Partner: Lund Laser Center 2 p.m
- Deliverable (D18.5):
  M45: Experimental demonstration on a plasma acceleration test stand of a substantial charge density increase obtained by improving injection techniques, and/or develop new techniques for increasing the beam charge.

Pushing Back the Charge Frontier: Status

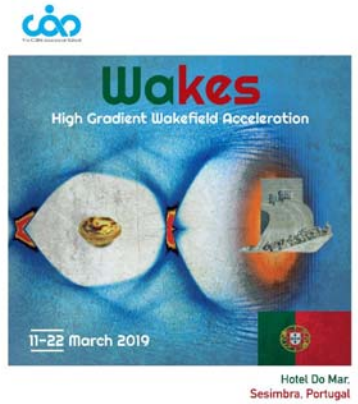
- 3D simulations of the two-nozzle setup
  - ➡ importance of the angle between the two nozzles



- density can be varied independently.
- dens. gradient length of injector is ~ 150µm
- nozzles experimentally tested (separately)
- first test of the complete setup done

European Network for Novel Accelerators (EuroNNAc) , https://www.euronnac.eu/

- Coordinated by R. Assmann, DESY, includes representatives from 66 institutes, 18 countries world-wide
- Prepared an input to the European Particle Physics Strategy
- Specialized Accelerator School Novel Acc. http://cas.web.cern.ch/schools/sesimbra-2019 https://indico.cern.ch/event/759579/



70 students in 2019,
Proceedings in preparation

EAAC a very succesful workshop

- European Advanced Accelerator Concepts Workshop

- Workshop series started in 2013, then organized in 2015, 2017 and the latest one in 2019 supported by ARIES
- **267 participants, 300 contributions, 49 students funded, 3 poster prizes**

- Simon van der Meer Early Career Award in Novel Accelerators

Summary

- **JRA: Milestones and deliverables achieved in time**
  - **Dielectric laser acceleration:** DLA experiment in preparation
  - **Multistage** (commissioning delayed): conceptual design ready,detailed technical started; special report on diagnostics
  - **Charge frontier:** nozzle designed, experiments in preparation
  - **Exotic laser beams:** Numerically studying experimental signatures: radiation and electrons
- **TA: beam time delivered to users** at UHI100 CEA and Univ Lund, start of access delayed for Apollon
- **NA: very active and highly visible network,** brings together an increasing community, produces documents, workshops and prizes

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement No 730871.

Thank you for your time