

# Activities in France on Particle Wakefield Acceleration for leptons

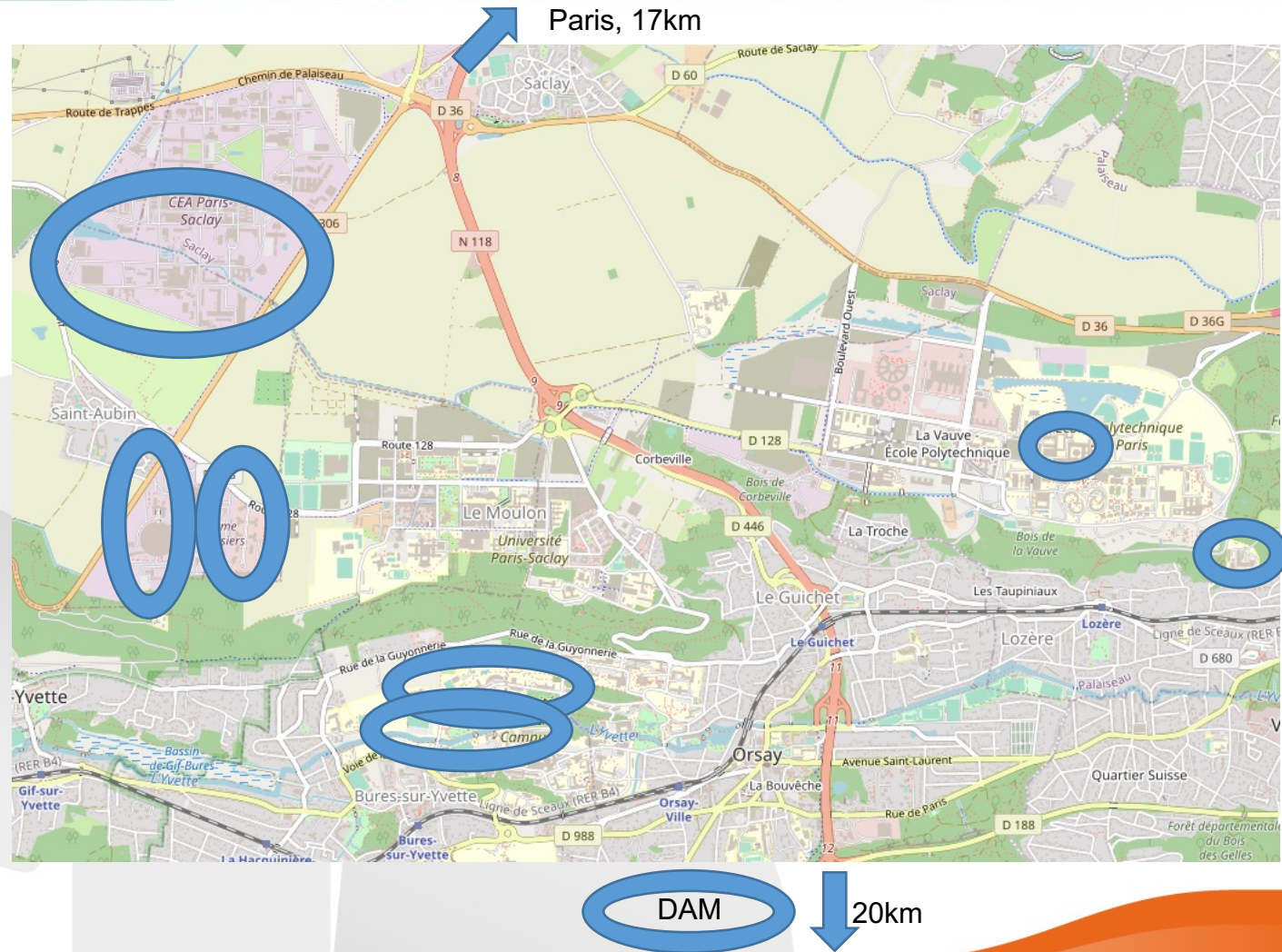
Nicolas DELERUE  
IJCLab (CNRS and Université Paris-Saclay)

1<sup>st</sup> DMLab meeting  
Decembre 2021

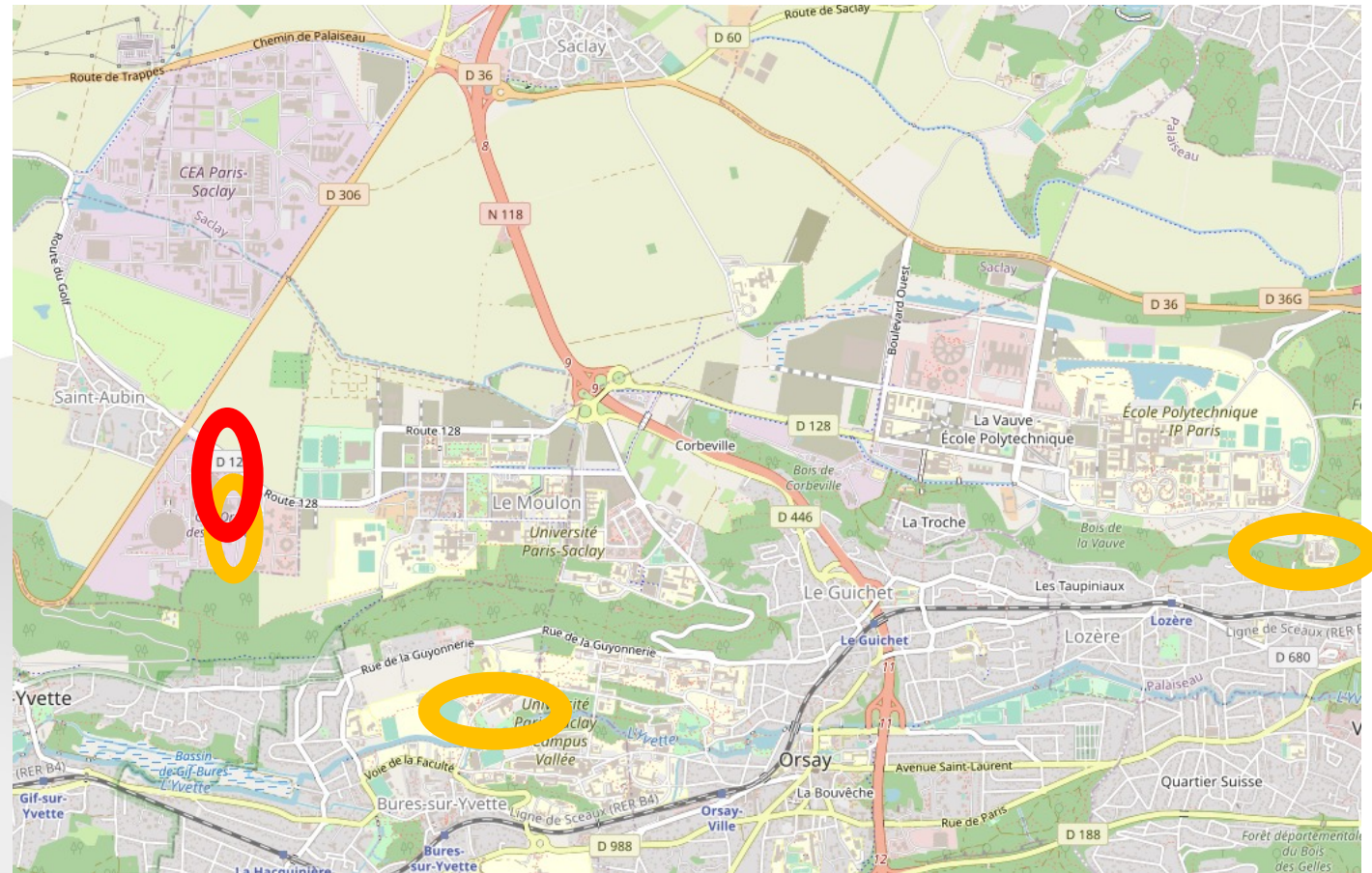


Laboratoire de Physique  
des 2 Infinis

- Most groups working on the acceleration of leptons in a wakefield are located in the “plateau de Saclay” area: Saclay, Gif, Orsay and Palaiseau (20km south of Paris).
- Two Universities...
  - Université Paris-Saclay (including former Université Paris-Sud)
  - Institut Polytechnique de Paris
- ... and 3 organizations:
  - CNRS including CNRS/IN2P3 and CNRS/INP
    - IJCLab (formerly LAL and IPNO), LLR, LPGP, LOA, LULI
  - CEA, Direction de la Recherche Fondamentale (DRF)
    - Lydil, IRFU/DACM.
  - Synchrotron SOLEIL
- Another group is located nearby, working mainly on simulations:
  - CEA, Direction des Applications Militaires (DAM)
- One structuring activity: GdR APPEL



- Several experimental facilities:
  - (Multi)-PW:
    - Laser APOLLON
  - 100's TW class:
    - LOA: salle Jaune
    - IJCLab: Laserix/PALAS
    - Lidyl: UHI-100
- + Simulation clusters





## Activities at CNRS/IN2P3

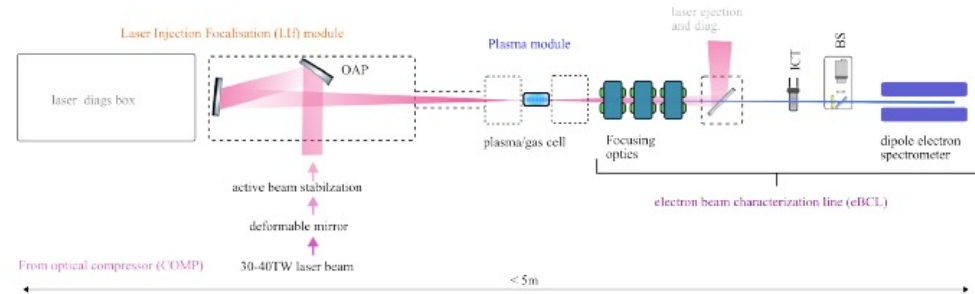
- Activities at CNRS/IN2P3 have been refocused around the PALAS facility using the Laserix laser (40TW) located at IJCLab.
- CNRS/IN2P3 is also a strong partner of the APOLLON laser facility (aiming for multi-PW beams) operated by école Polytechnique.
- Contributions to European and international activities such as EuPraxia, ALEGRO, ARIES, IFAST,... and to the European roadmap.



# PALLAS project



- Build an **accelerator test facility** to develop laser plasma accelerator with **reliability and control** performances comparable with RF standard
- First beam foreseen in 2023
- R&D axis :
  - laser advanced control
  - plasma target
  - electron beam transport
- Start with laser plasma injector @ 10 Hz with beam of **150-200MeV**, 10-30pC,  $\leq 1\text{mm.mrad}$



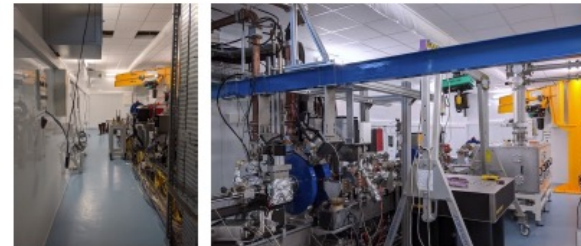
- At IJClab in Orsay based on :



40 TW, 10Hz laser driver system,  
LASERIX



70m<sup>2</sup> radiation shielded ISO7 cleanliness AC experimental area,  
NEPAL



08/12/2021

Mon exposé - Lieu - Titre

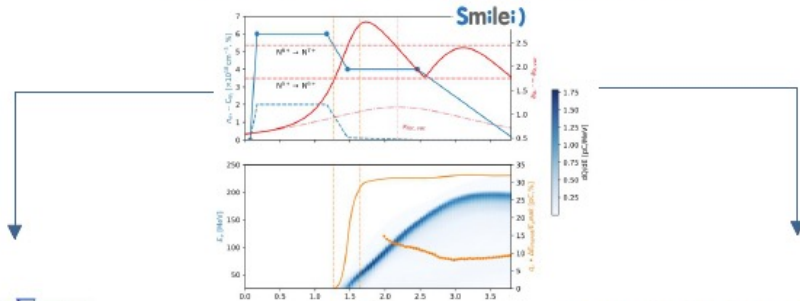
Courtesy of  
Kevin Cassou



# Current status

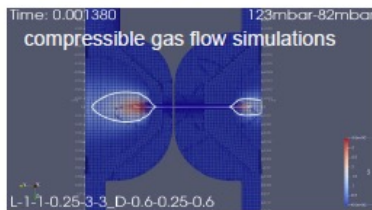
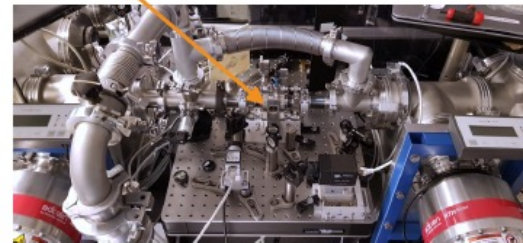
## Plasma target development

High speed PIC simulation for geometry optimization



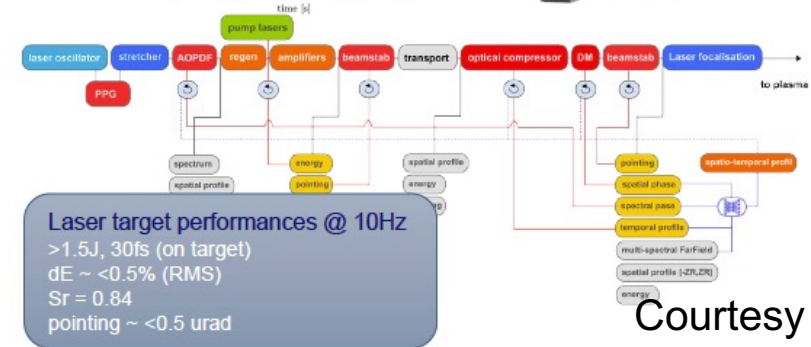
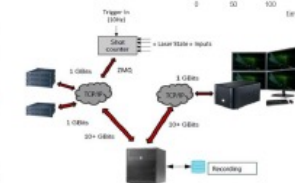
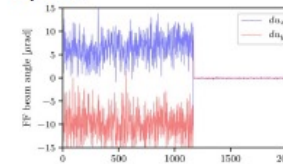
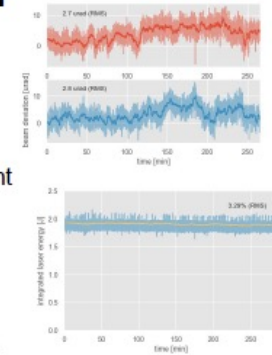
Dedicated test bench:

- e- density measurement with resolution of  $dn \sim 1.5e17 \text{ cm}^{-3}$
- laser endurance test
- continuous gas flow
- prototype multi-region gas cell



## Advanced laser control

- Laser driver characterization and optimization
- Full Datalogging and timestamping development
- Implementation of feedbacks
  - pointing (thermal drift + acoustic range)
  - energy
  - spatial



Laser target performances @ 10Hz

- >1.5J, 30fs (on target)
- dE ~ <0.5% (RMS)
- Sr = 0.84
- pointing ~ <0.5 urad

Courtesy of Kevin Cassou



08/12/2021

Mon exposé - Lieu - Titre



**APOLLON:** Infrastructure de Recherche, opérée par le LULI  
placée sous la tutelle du CNRS et de l'Ecole Polytechnique

- Un faisceau laser principal F1 –  $\phi=400\text{mm}$ , 15fs / 150J soit  $P_{\text{crête}} = 10\text{PW}$
- Un faisceau laser secondaire F2 –  $\phi=140\text{mm}$ , 15fs/ 15J soit  $P_{\text{crête}} = 1\text{PW}$
- Un faisceau laser de « création » F3, ns, E=250J
- Un faisceau laser sonde F4 – 20fs / 250mJ , soit  $P_{\text{crête}}=10\text{TW}$

2 salles expérimentales radioprotégées

Salle « courte focale »

Interaction laser intense – cibles solides

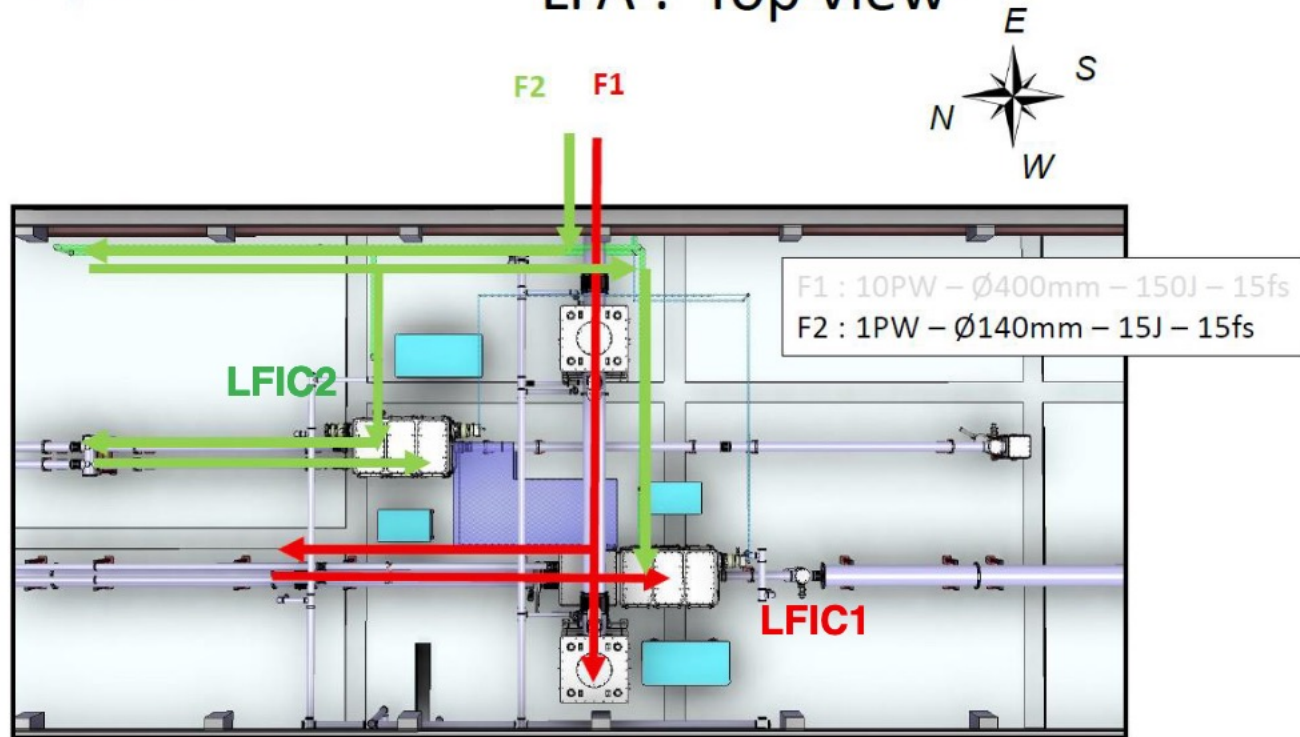
Salle « longue focale »

Interaction laser intense – cibles sous denses

Courtesy of S.  
Dobosz Dufrénoy



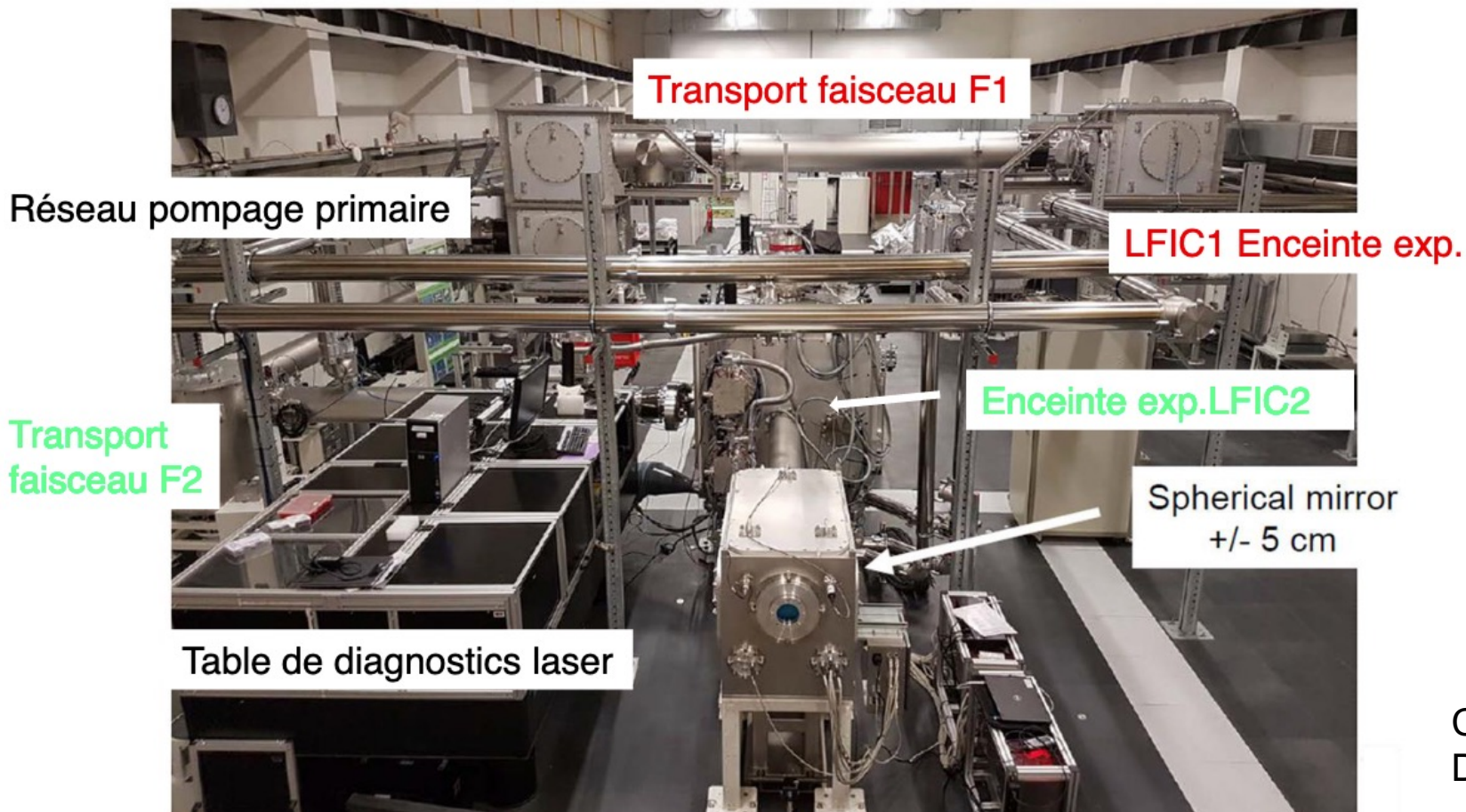
## LFA : Top view



- Two experimental laser/plasma interaction areas by using laser beams F1 and F2,
- Long focus distance (F1 : 8 up to 20m; F2 : 3 up to 9m),



## LFA : General view South direction

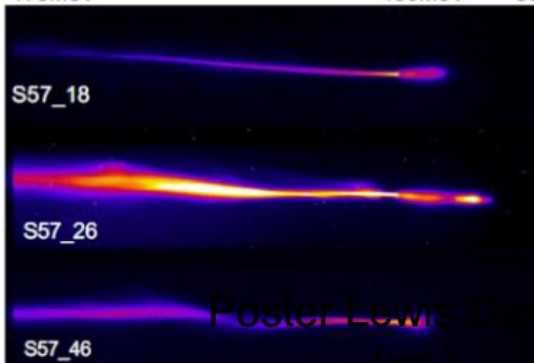


Courtesy of S.  
Dobosz Dufrénoy

Electron spectra observed in detection windows:

## 26/04 Spectra in 6mm long gas cell

175MeV 450MeV 800MeV



< 3 mrad at  
450 MeV

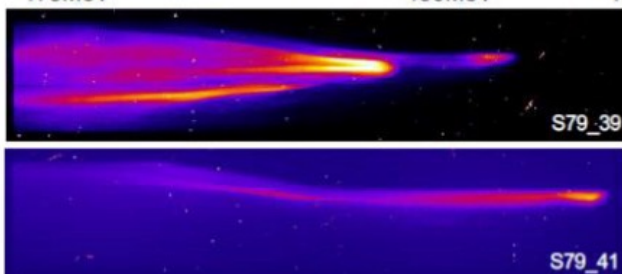
– 175 MeV – 750MeV (LANEX out vac)

– 450 MeV – 1.6 GeV (YAG in vac.)

Observed energy range and distribution in agreement with predictions, from simulations performed with focal spot measured in Nov. 2020 as input

## 30/04 Spectra in 13 mm long gas cell

175MeV 450MeV 1GeV



Larger shot to shot instability on the 30th of April, link to measured focal spot quality will be studied in future simulations

Courtesy of S.  
Dobosz Dufrénoy



- GdR = Research Group (gathering several laboratories working on the same topic).
- GdR APPEL: Aims at gathering the French community working on plasma acceleration.
  - Bi-weekly newsletter
  - Annual meeting
  - Topical meetings
  - Joint applications for beam time
- Important work in 2018-2019 to define the French contribution to the EuPraxia project.
- Currently working on a French roadmap for laser-plasma acceleration (both electrons and ions) to be released in 2022.
- Strong push to make the GdR evolve into an international research network (IRN) including international partners...





- French community on acceleration of electrons mostly located in the Saclay Area
- The laser APOLLON is most powerful facility available
- Several other facilities available for experiments in the 100-TW class, including the PALAS facility at IJCLab.
- GdR APPEL is gathering the community and preparing a roadmap on plasma acceleration in France.
- Looking forward to fruitful collaborations within the DMLab.

Thank you



Thank you