# L. Volpe

"Centro de Laseres Pulsado CLPU " Salamanca, Spain


## The VEGA system at CLPU

LULI laboratory, Paris 23 April 2015

# Outlook

» CLPU an introduction
» CLPU the uniqueness of  VEGA
» CLPU scientific goals
» Conclusions and remarks …

# CLPU an Introduction

CLPU CENTRO DE LÁSERES PULSADOS

- Constituted: December 2007 -> Validity until : 31 December 2021
- Singular Scientific and Technological Installations


| | | |
|---|---|---|
| MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD | 50 % | Ministerio de Economía v |
| | | + |
| Junta de Castilla y León | 45 | Comunidad de Castilla v León* |
| | | + |
| VNIVERSIDAD DSALAMANCA | 5 % | Universidad de Salamanca |

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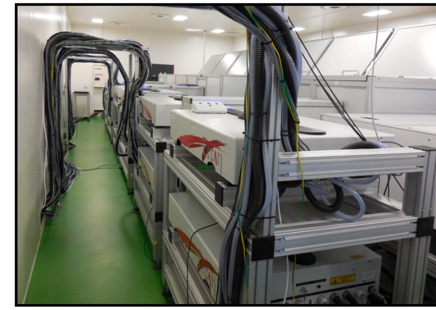
LAB VEGA
High power < 1PW

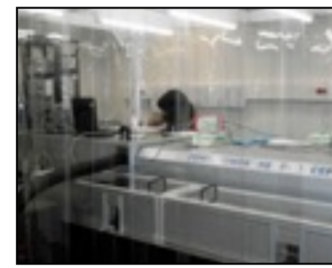
| | Pulse duration | Energy per shot | Peak power | Rep. Rate |
|---|---|---|---|---|
| VEGA-1 | 25 fs | 600 mJ | 20 TW | 10 Hz |
| VEGA-2 | 25 fs | 6 J | 200 TW | 10 Hz |
| VEGA-3 | 30 fs | 30 J | 1 PW | 1 Hz |



+

Auxiliary Laboratories

| | Pulse duration | Energy per shot | Rep. Rate |
|---|---|---|---|
| HHR | 100 fs | 7 mJ | 1 kHz |
| CEP | 25 fs/5 fs | 6 mJ/ 1 mJ | 1 kHz |



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- Oscillator Unit
- Microscopy unit
- Mechatronics

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**M5 building:**
PW VEGA laboratory
from Sep-Oct 2015

**M3 building:**
Auxiliary Laboratories
+ VEGA-1,2 until May 2015


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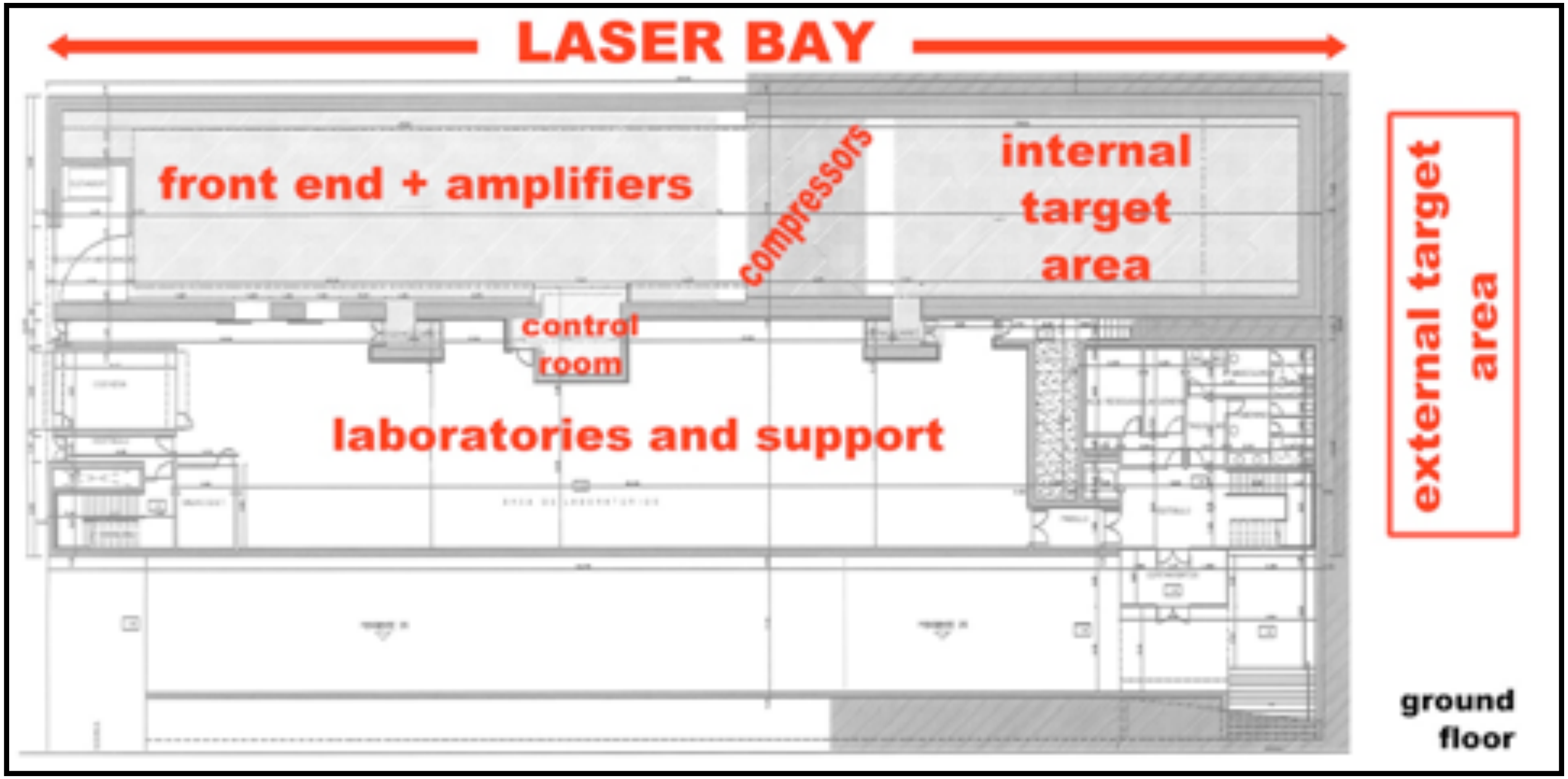
LASER BAY
front end + amplifiers
compressors
internal target area
control room
laboratories and support
external target area
ground floor

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# Today !!


from the CLPU website www.cpu.es

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# More on VEGA

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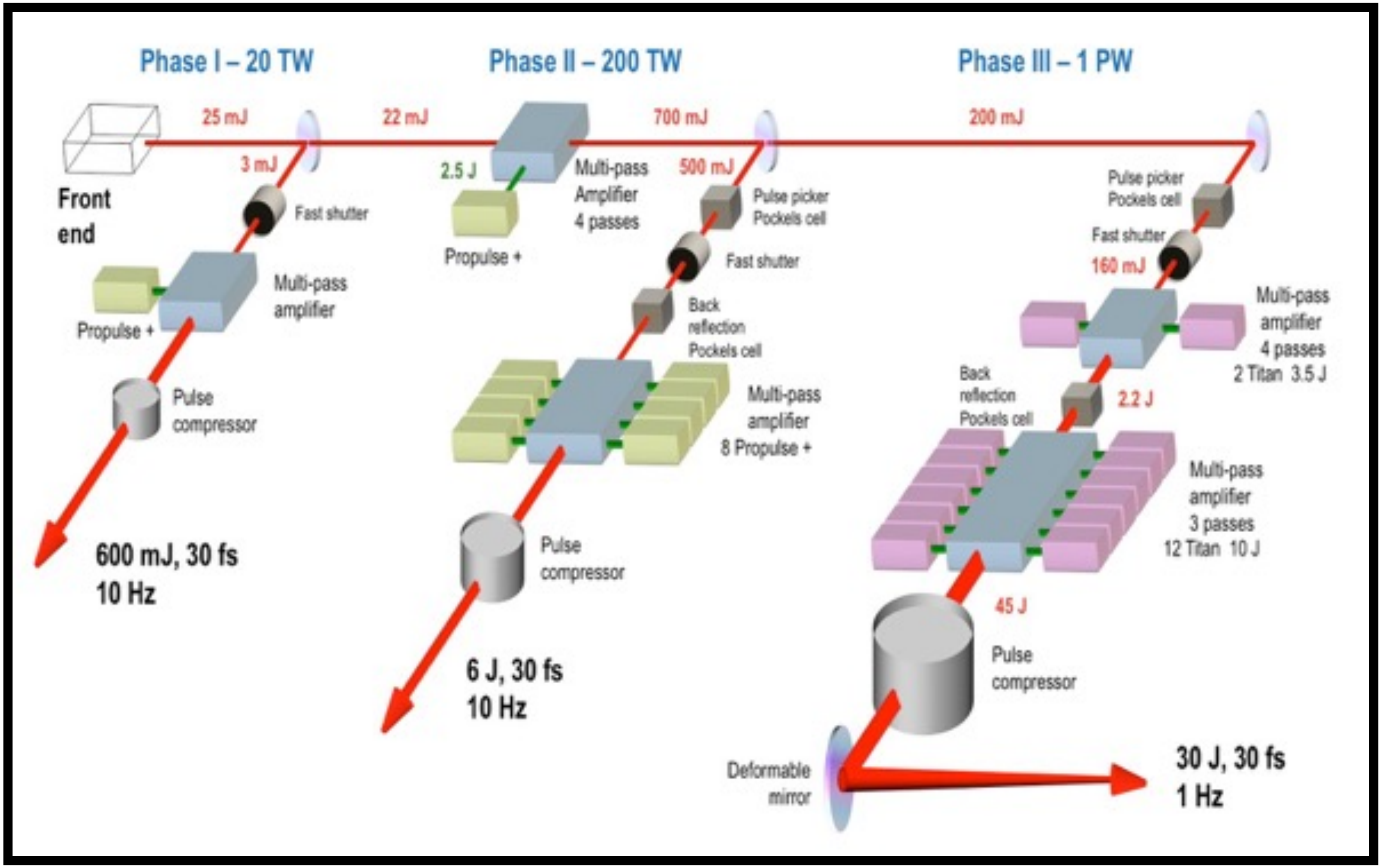

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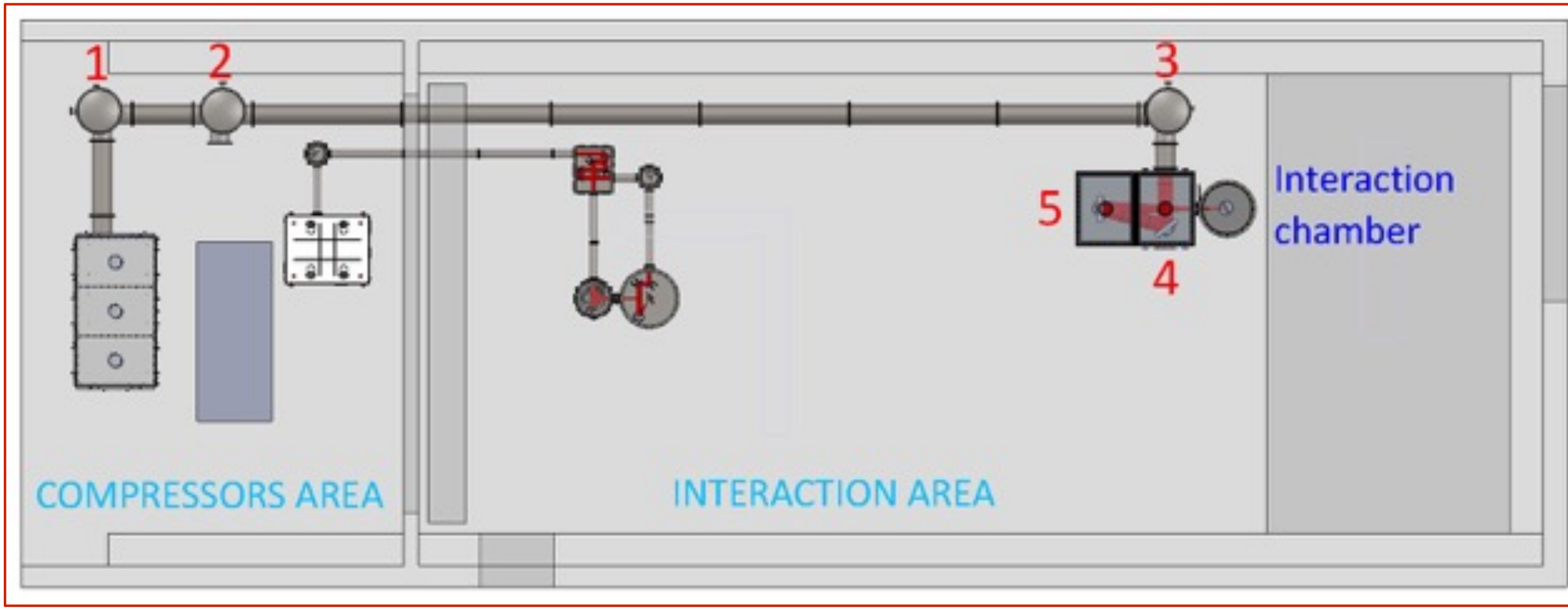
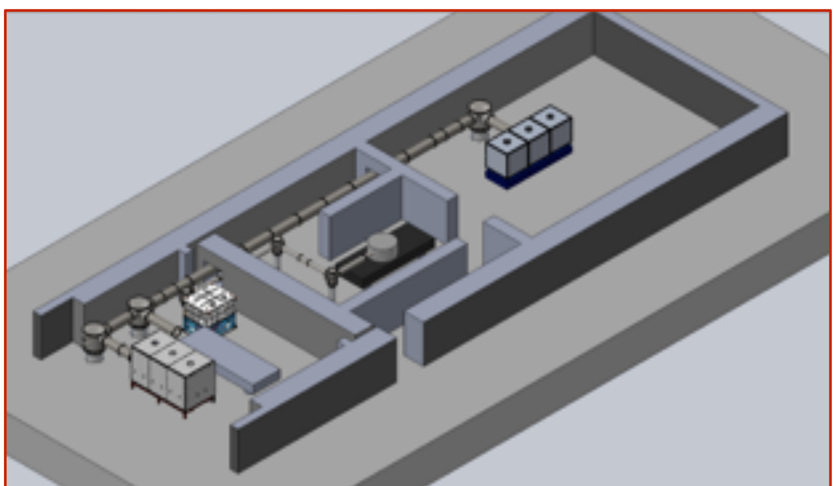
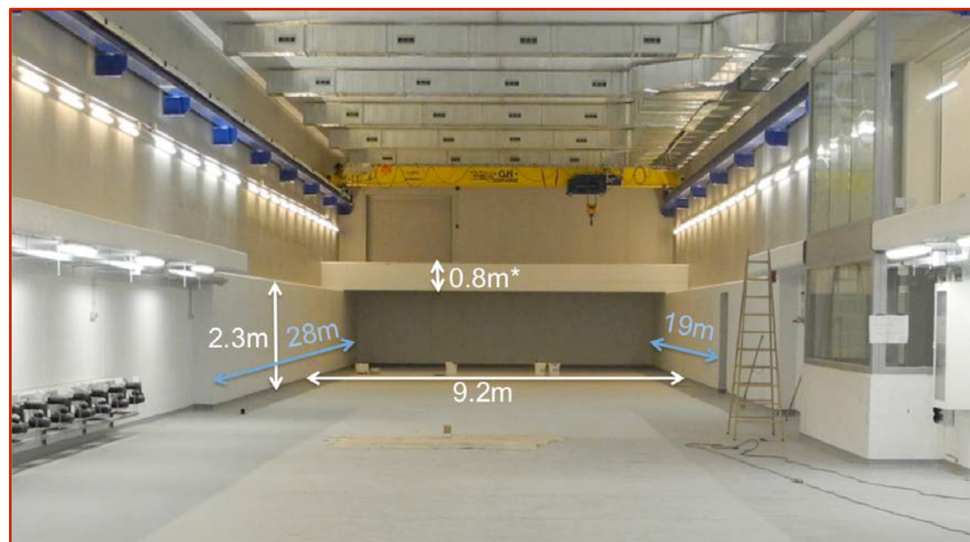




## Uniqueness of VEGA

High Power 20-200-1000 TW
Short duration 30 fs
High rep. rate 1-10 Hz
High contrast ratio > $10^{10}$:1
High beam quality (wave front 0.75-0.9)
High flexibility (pump & probe)

## key words

Solid & fluid targets
short & long focalisation
small & large interaction volume

## CLPU primary goals (laser-plasma only)

| | | | |
|---|---|---|---|
| laser-driven protons/ions | **solid** | **gas** | **liquid** |
| laser-driven electrons | **solid** | **gas** | **liquid** |
| High harmonic generation | **solid** | **gas** | **liquid** |
| coherent X-rays (Ka) | **solid** | **gas** | **liquid** |
| WDM and HEP | **solid** | **gas** | **liquid** |

# Laser-plasma driven protons beam first experiment at CLPU in collaboration with CELIA Bordeaux (Emannuel d'Humieres)

# Laser-plasma driven protons beam

- laser-accelerated ions can also be obtained in the low-plasma-density regime (near-critical)
- In such regime, volume effects are expected to dominate.
- Simulations show that it is possible to reach high ion energies with a high number of accelerated ions and a high conversion efficiency

## Why gaseous targets ?

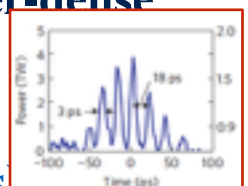
1. solid targets need to be aligned precisely for each shot,
2. laser temporal contrast needs to be controlled
3. debris is produced,
4. repetition rate is limited
5. volume Vs surface interaction

## how produce it ?

1. gas jet close near-critical densityas laser interaction medium
2. ion acceleration needs very thin plasma medium FWHM ~ 100 microns
3. it is also possible to obtain plasma density profiles by exploding thin foils with energetic long (few hundred of ps) pulses.

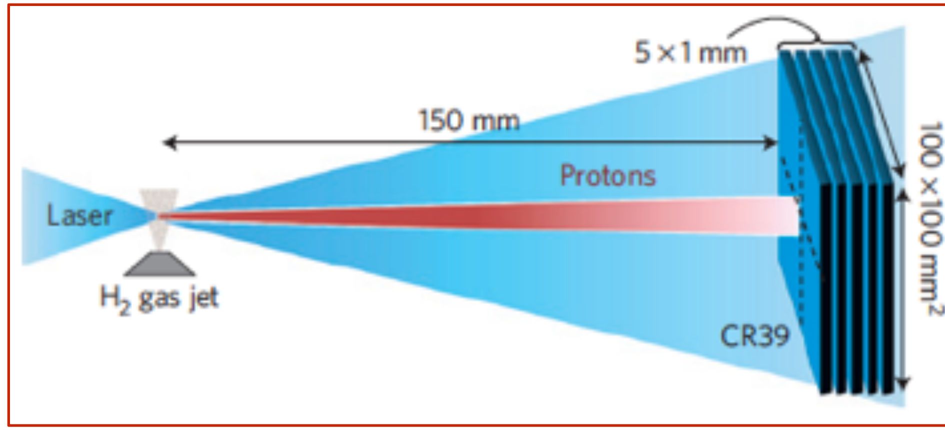
# previous works

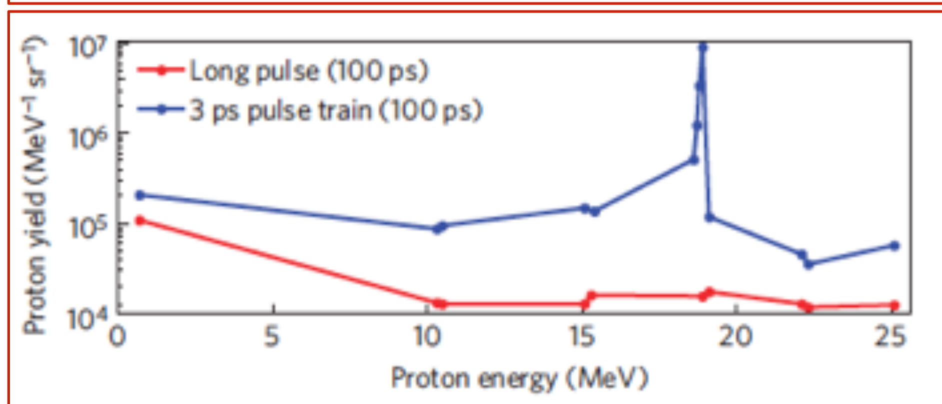
- **Laser-plasma ion acceleration in the longitudinal direction, has been demonstrated by focusing $CO_2$ Neptun laser (Los Angeles) in over-dense gas jets.**



- **$CO_2$ laser (l~ 10 microns)**
- **$E_L$~ 60 joules; d= 1mm**
- **near critical plasma jet $w_0$=60 microns, $n_e$~ $10^{19}$ part/cc**

- **$E_p$~ 20 Mev: dE/E~1 %**



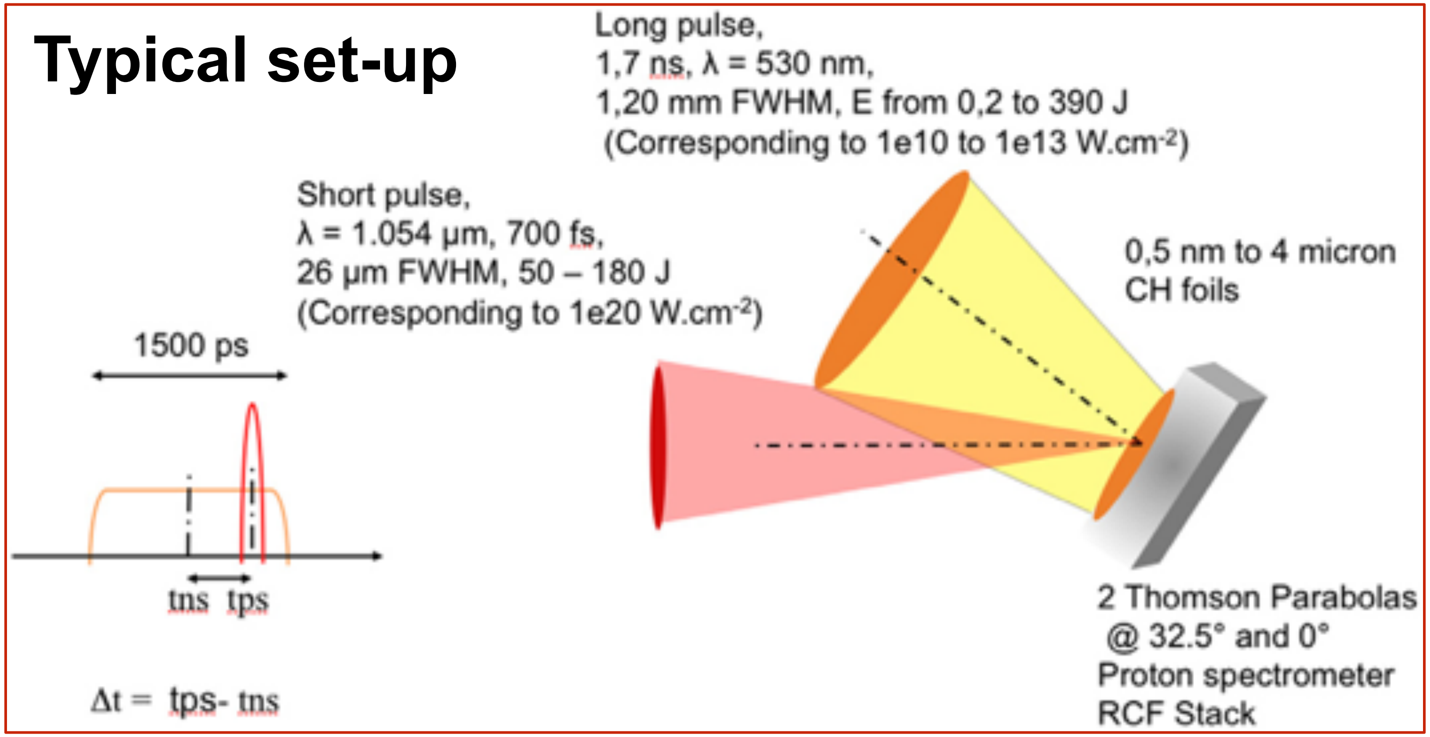

**[Dan Haberberger, Nature Physics 8, 95–99 (2012)]**

**also C. A. Palmer, et al,., Phys. Rev. Lett. 106, 014801 (2011).**

# previous works

This accelerating scheme has also started to be investigated at shorter laser wavelengths (l ~ 1 microns) at **LULI [M. Gauthier et al. PoP 2014]** and on the Titan laser facility at Livermore **[E. D'Humières et al. PPCF 2013].**

## Typical set-up



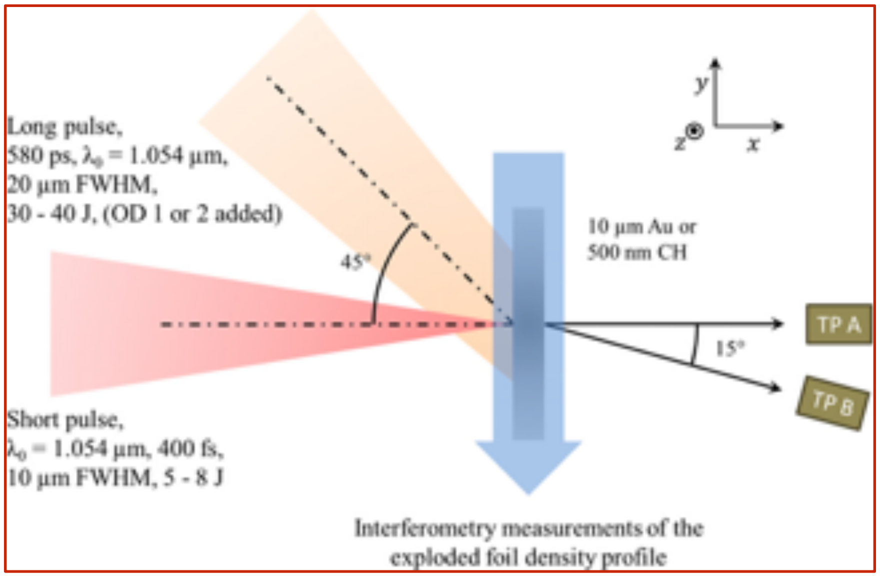
# LULI experiment

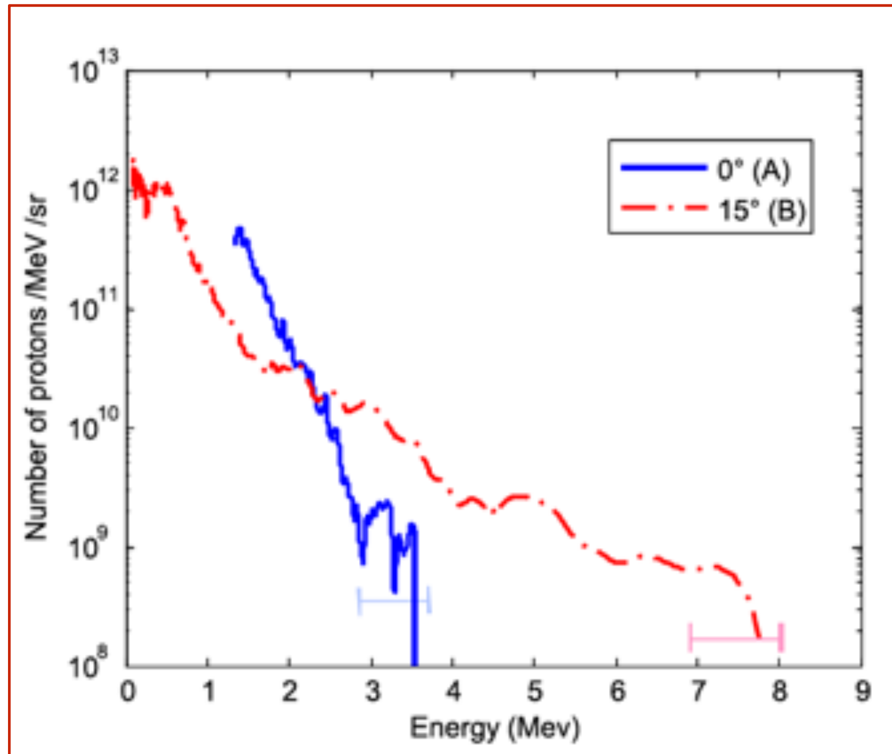
**long pulse**

- $E_L$~ 30-40 joules
- $t_L$~580 ps
- d=20 microns
- $I_L$~ $3x10^{15}$ W/cm$^2$

**short pulse**

- $E_L$~ 5-8 joules
- $t_L$~400 fs
- d=6 microns
- $I_L$~ $10^{18}$ W/cm$^2$



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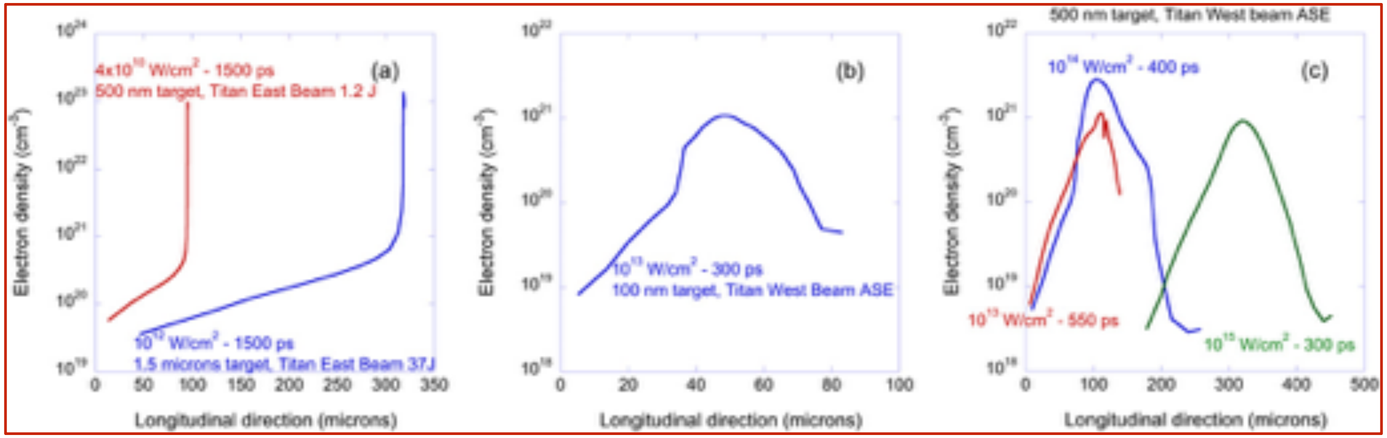
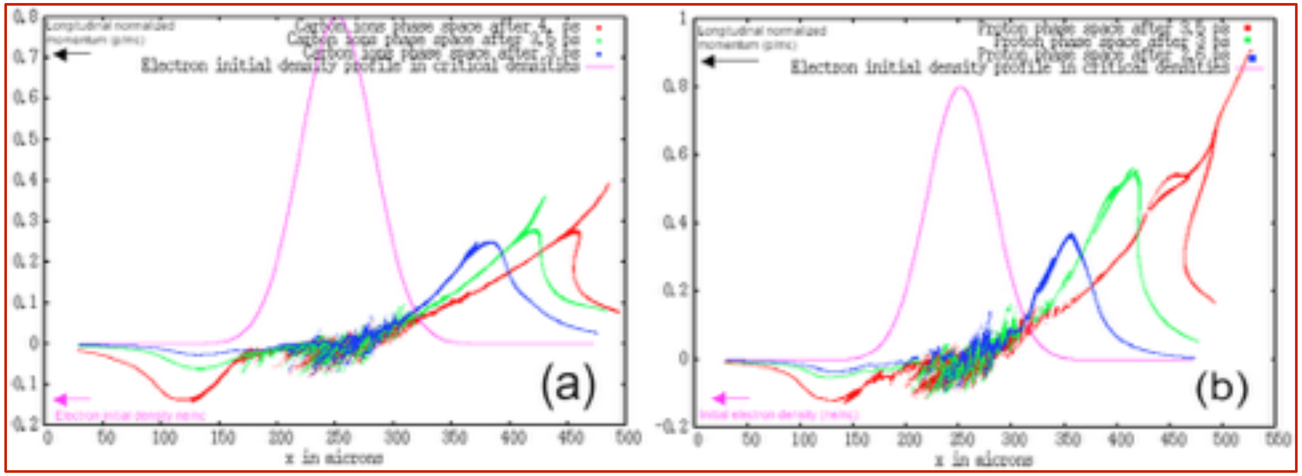
# TITAN parameters simulations

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# Preliminary PIC simulations of ion acceleration in low density targets with Vega-2 and Vega-3

- 2D CALDER PIC simulations for plasma density profiles
- Exploded foil or supersonic nozzle gas jets: $\cos^2$ hydrogen near-critical density plasmas with FWHM from 65 to 130 microns and maximum density from 0.5 to 2 $n_c$.
- The plasma density profile can be obtained by using Uncompressed VEGA-2 (~ 7.5 joules) or VEGA-3 (~ 40 joules)
- Vega-2: compressed beam 30 fs, 6 joules, focal spot ~ 5 microns, intensity ~ $1\times10^{20}$ W/cm$^2$
- Vega-3: compressed beam 30 fs, 30 joules, focal spot ~ 5 microns, intensity ~ $1.5\times10^{21}$ W/cm$^2$

by E. d'Humierres CELIA Bordeaux

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# VEGA-2 simulations Proton phase space

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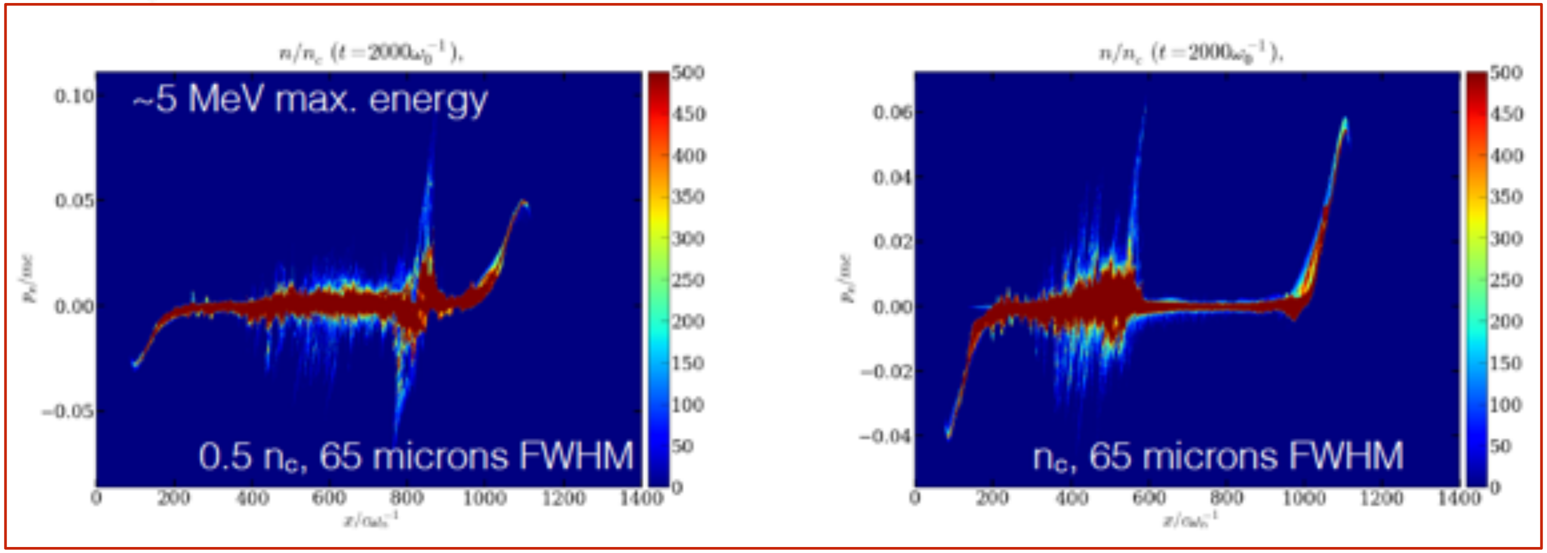


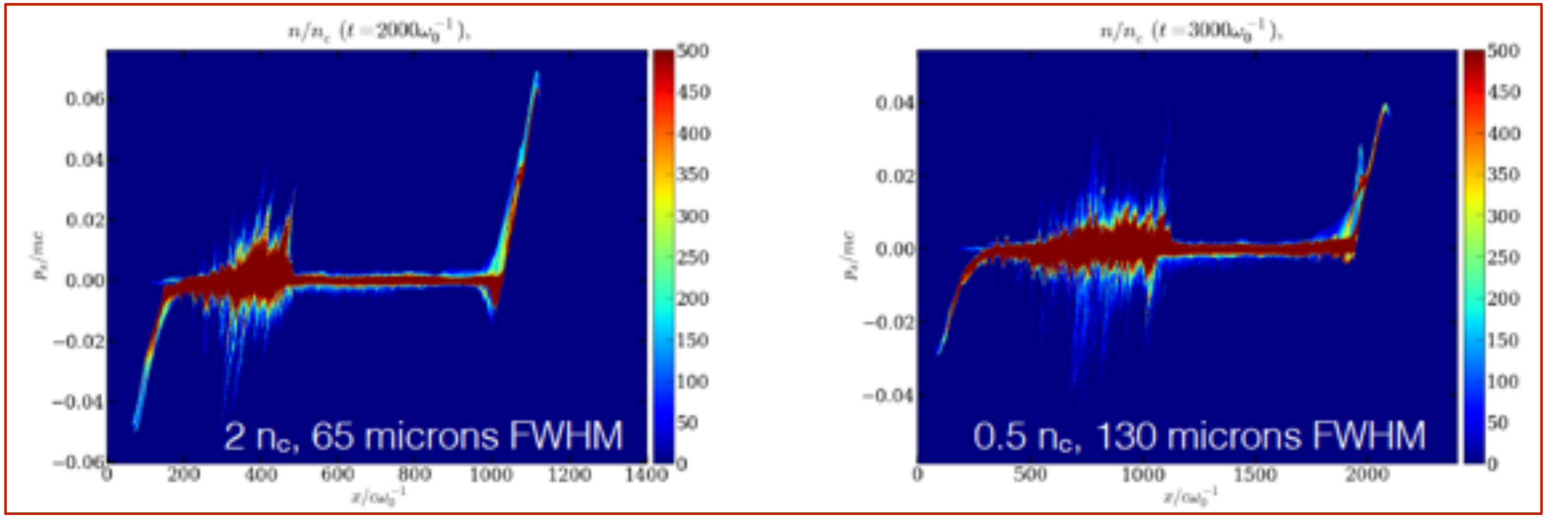


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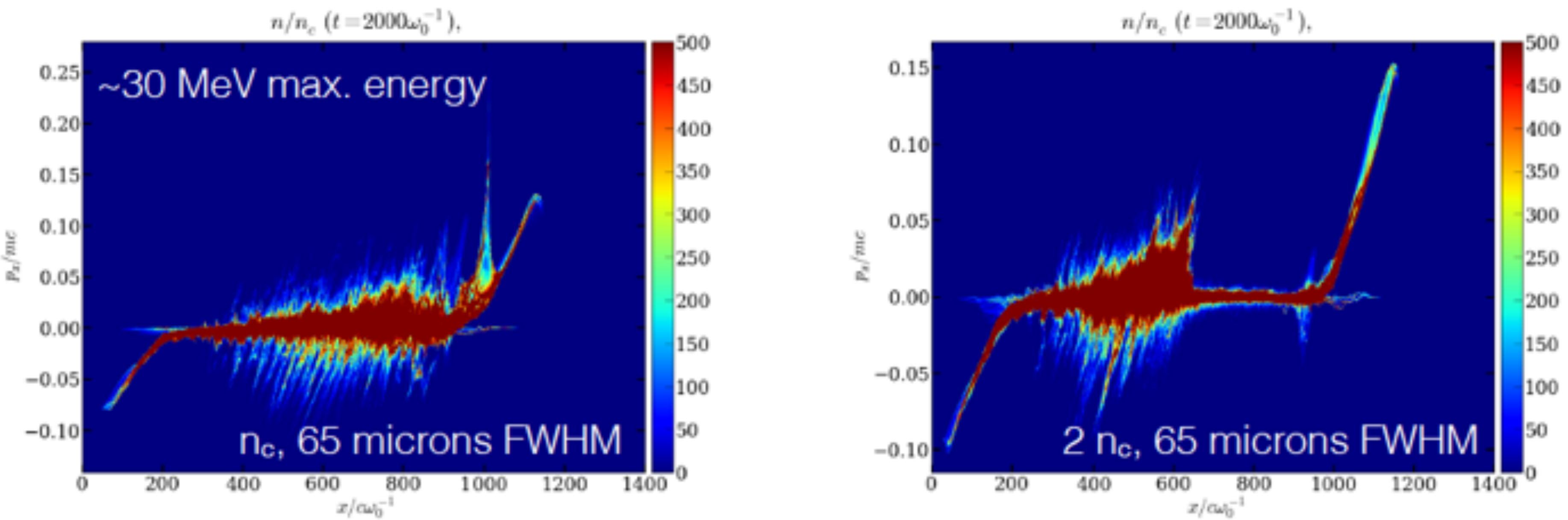
# VEGA-3 simulations Proton phase space



# Conclusions & remarks

- The VEGA system at CLPU in Salamanca is under construction and will be partially ready at the end of the year (2015)
- the first experimental campaign is mainly based on laser-plasma particle acceleration and the uniqueness of VEGA system permit to host both laser-solid/gaseous particle interaction
- The first experiment on laser-plasma driven proton acceleration is planned at CLPU in collaboration with the CELIA group in Bordeaux
- preliminary results shown that more optimisation is needed. But shock acceleration of protons is already observed in our simulations up to 5 MeV for Vega 2 and up to 30 MeV for Vega 3.
- Shorter plasmas are needed but will only be available using exploded foils in the near future.
- plasma densities should be reduced to allow the laser to propagate farther: for Vega 2 up to 0.1 nc and for VEGA-3 up to 0.5 nc
- simulations are on the way.

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Thank you for your attention !

Merci de votre attention !

Grazie per l'attenzione !


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