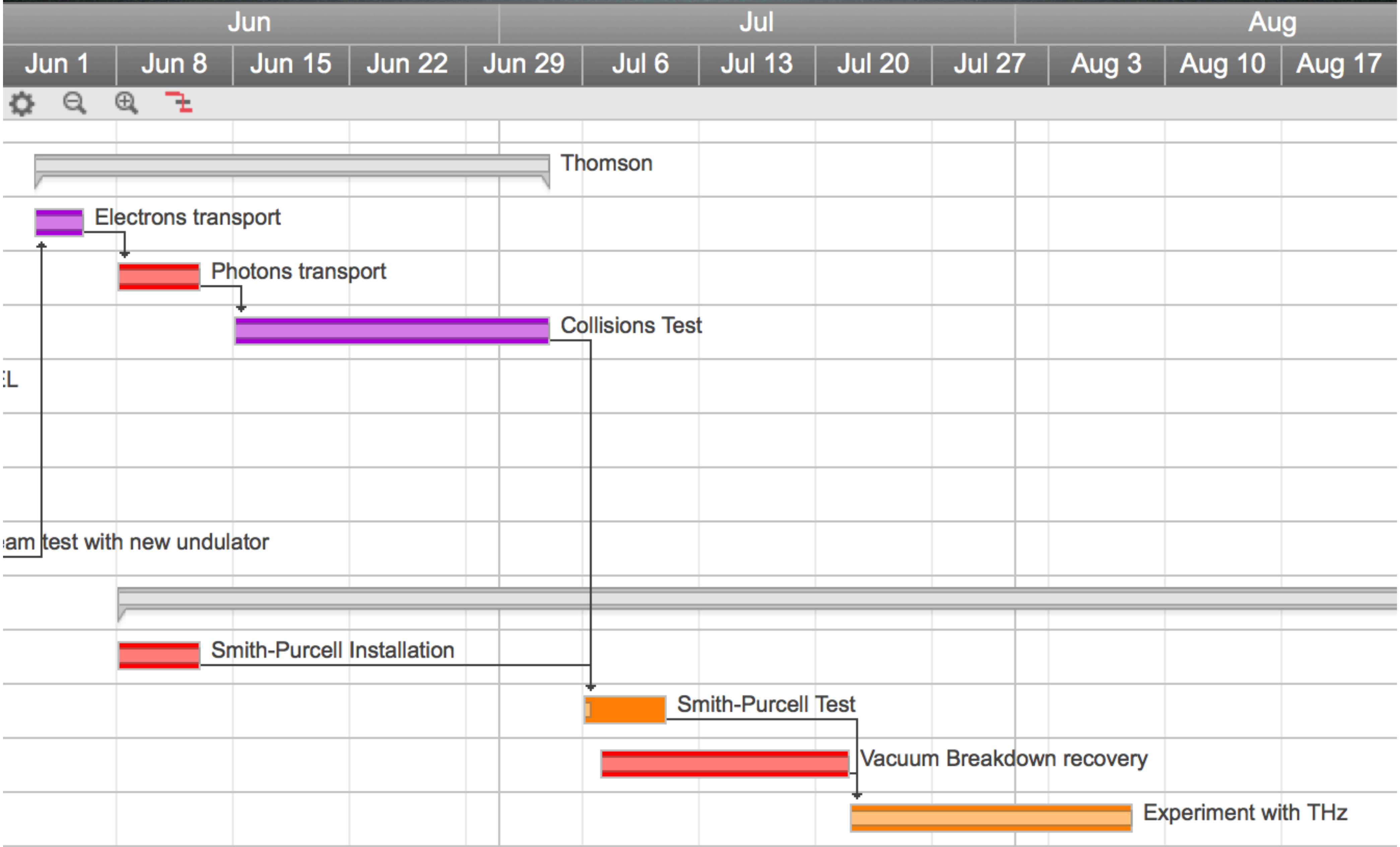
Summary of the SPARC_LAB activities

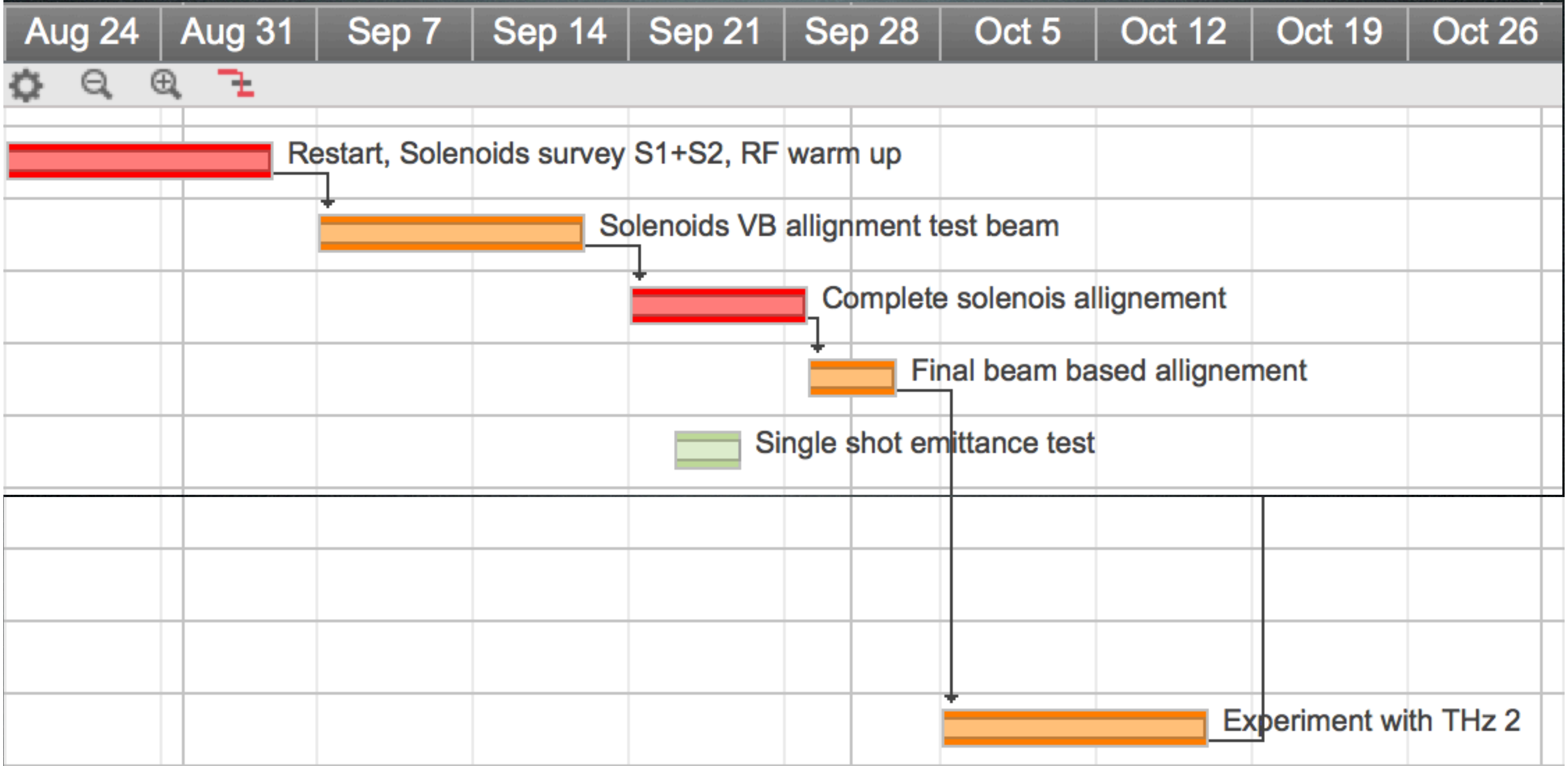
Massimo.Ferrario@LNF.INFN.IT
On behalf of the SPARC_LAB collaboration

LNF Scientific Committee Meeting - November 23, 2015

June 1– August 10

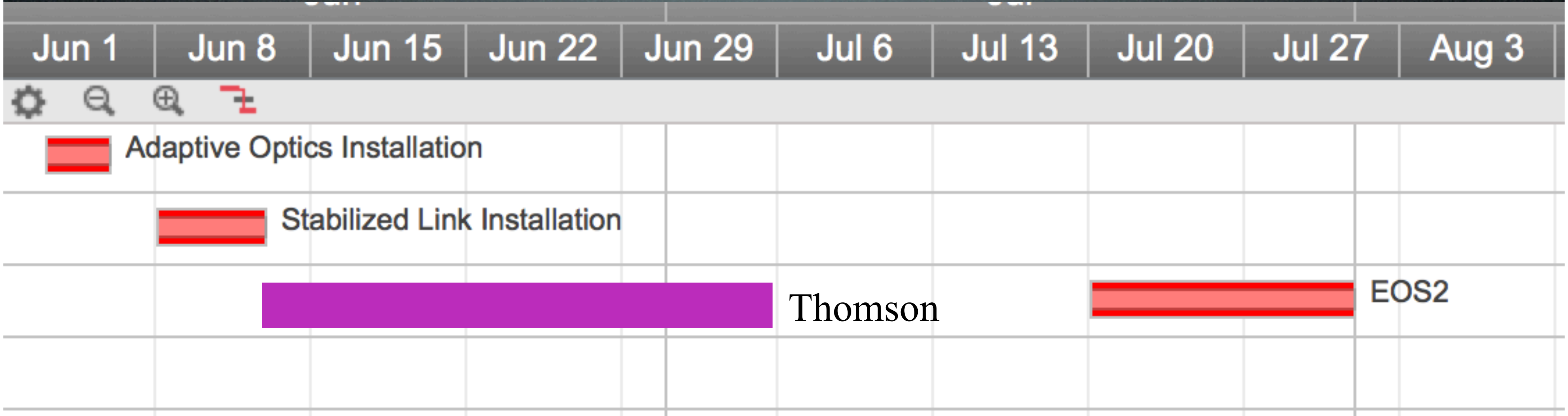


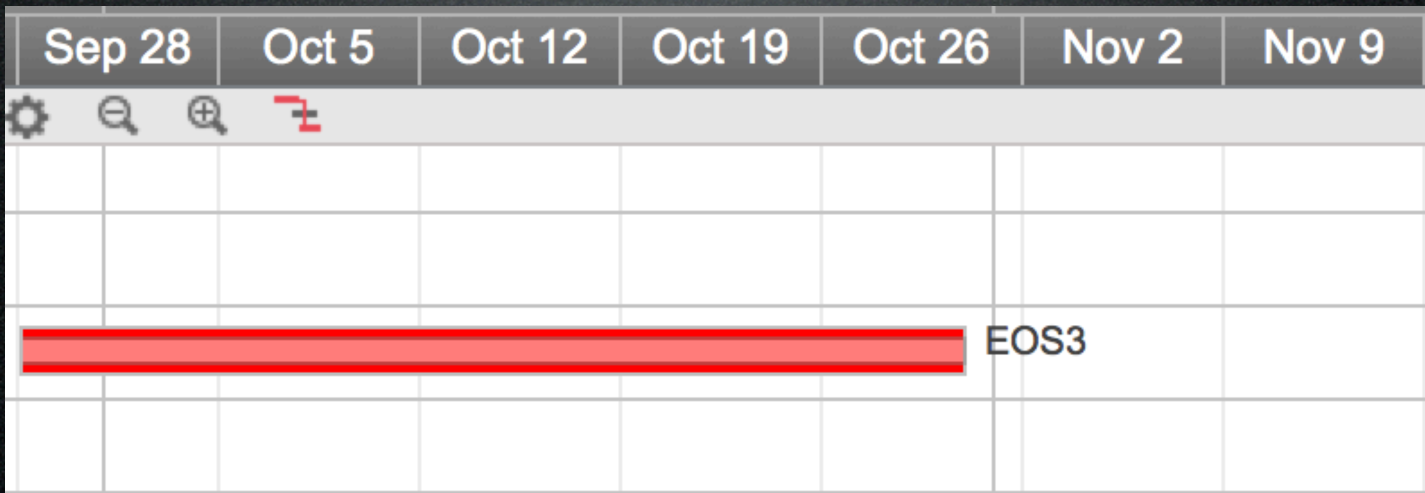
August 24 – October 20



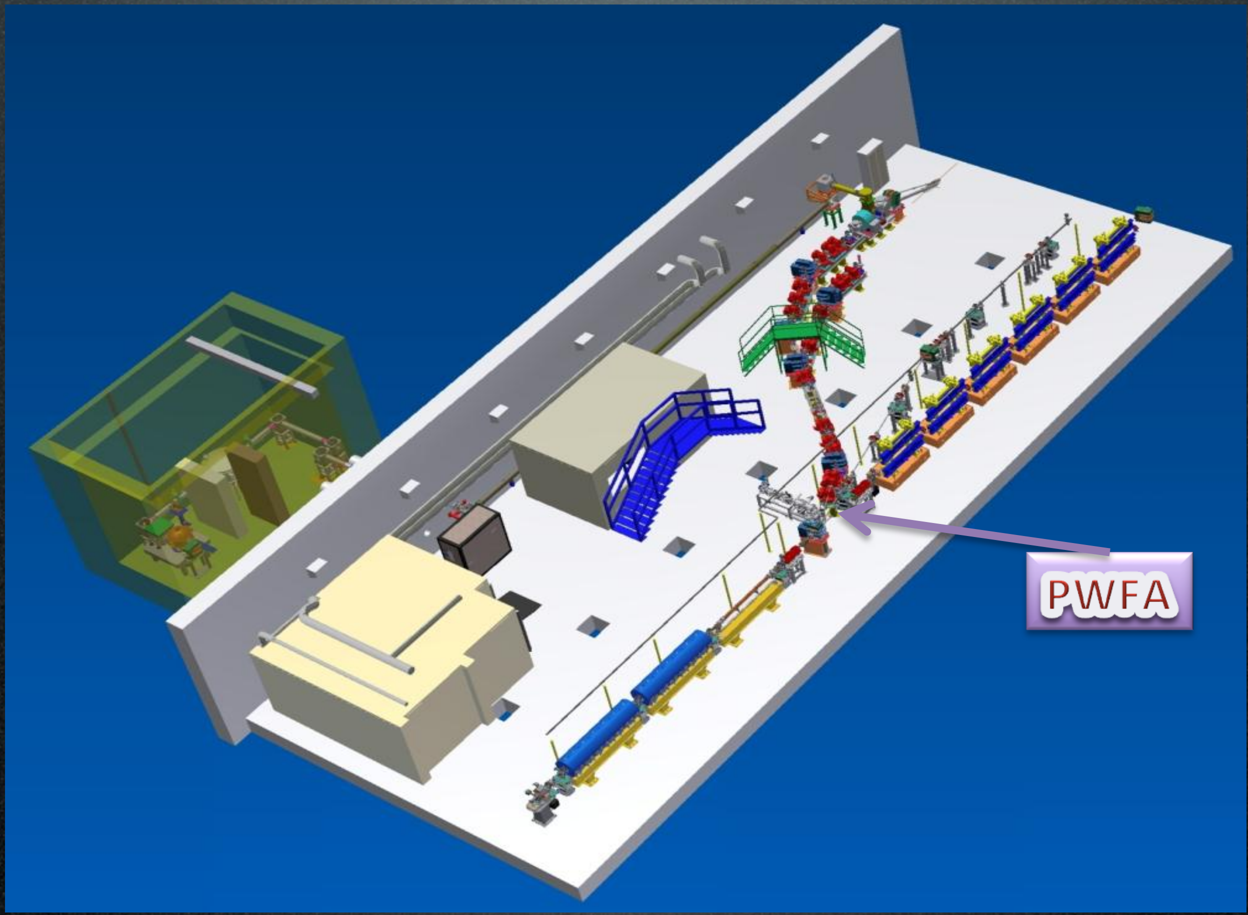
Installations from October 20 up to December 23

FLAME operation

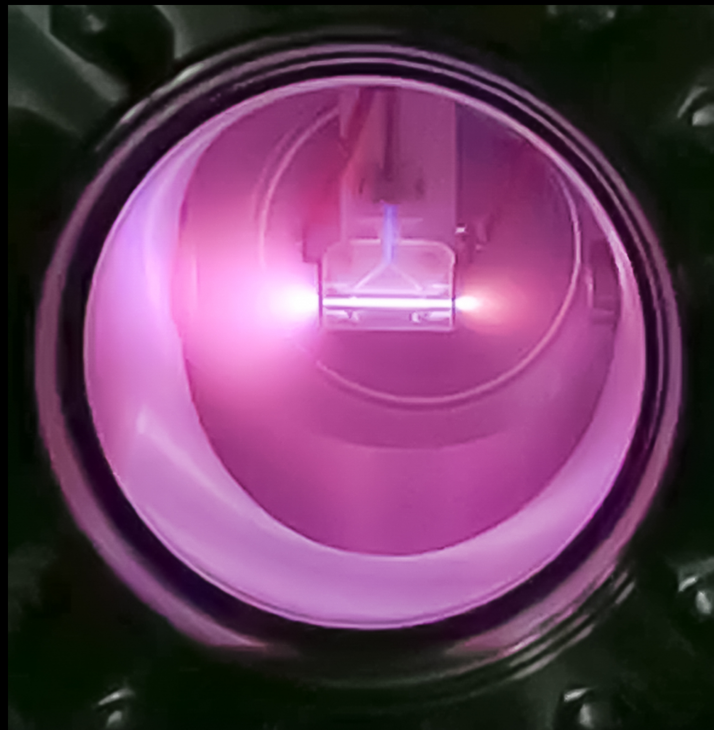




SL_COMB: Beam Driven Plasma Wake Field Acceleration

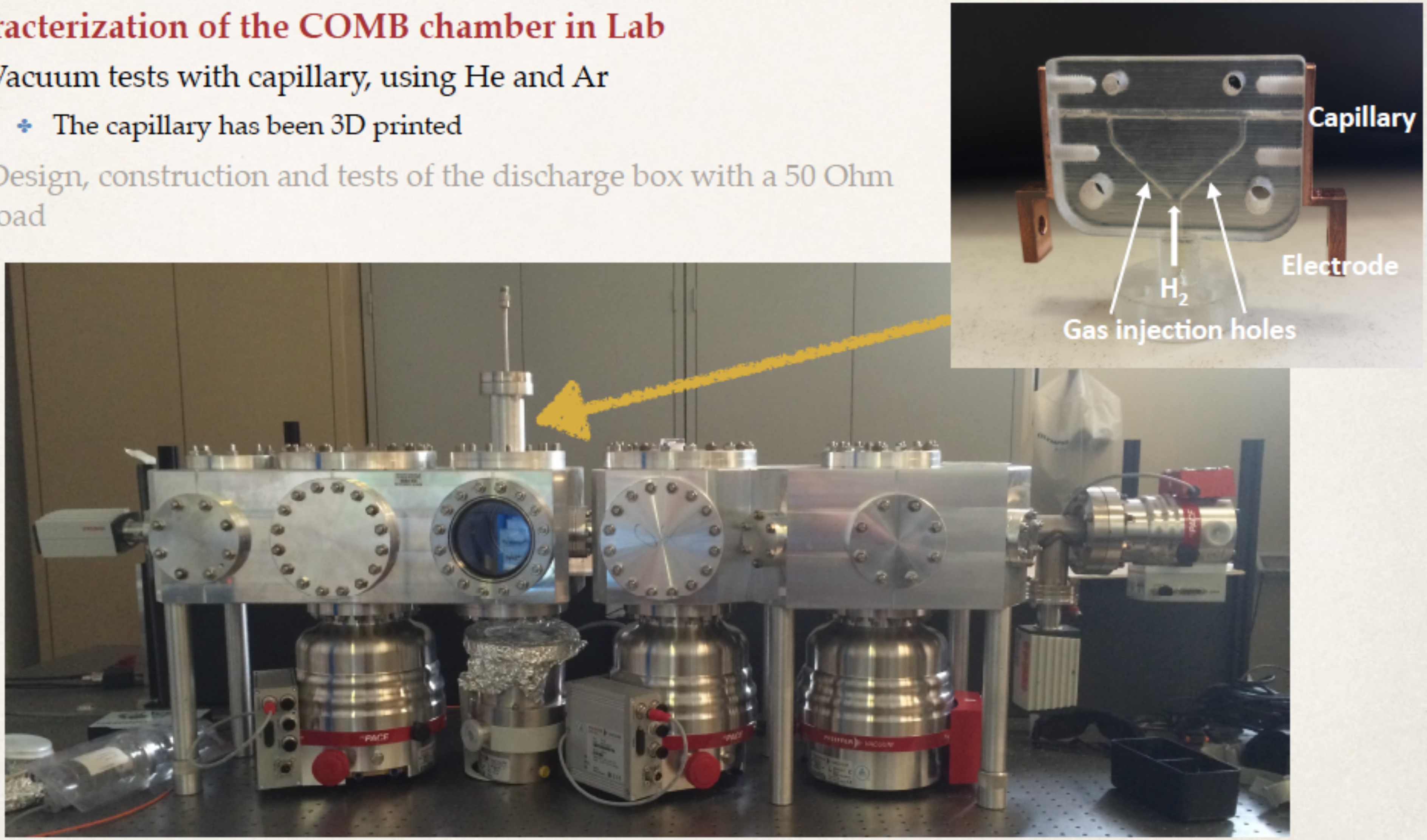


First Capillary Discharge (Oct. 23)



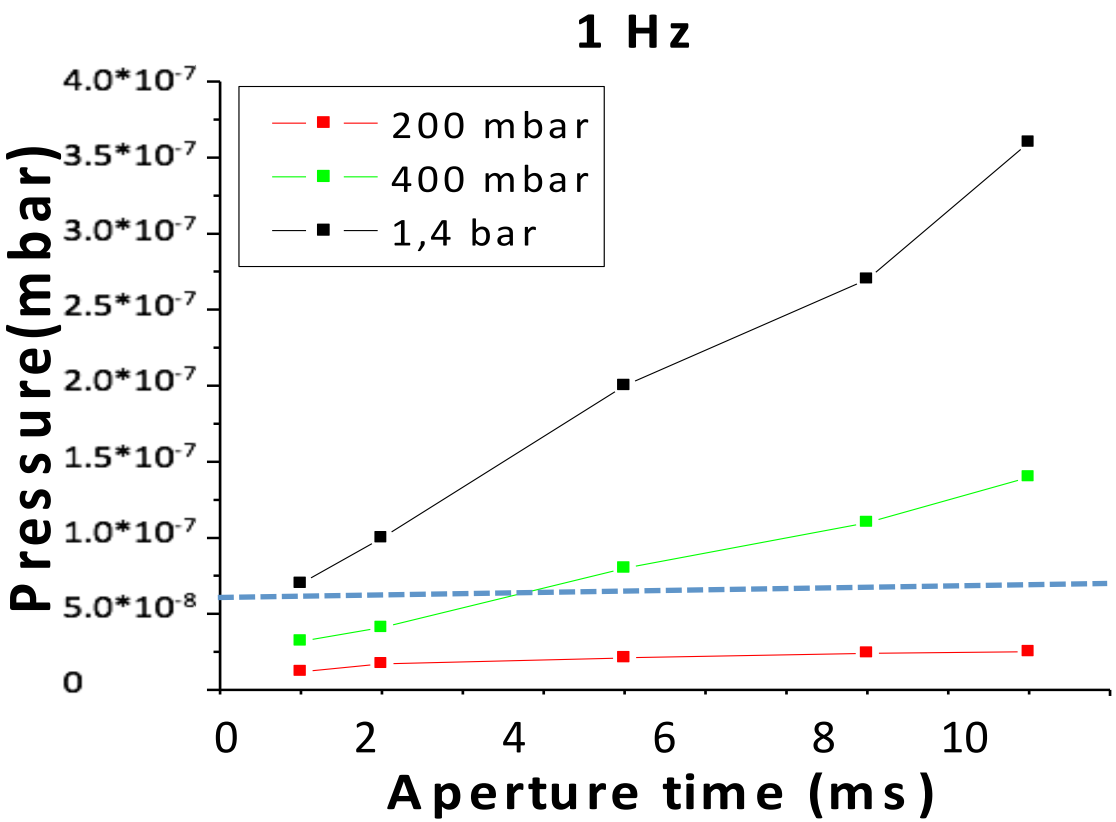
Vacuum Chamber ready to be installed

- **Characterization of the COMB chamber in Lab**
  - Vacuum tests with capillary, using He and Ar
    - The capillary has been 3D printed
  - Design, construction and tests of the discharge box with a 50 Ohm load



Vacuum tests

- ✓ **Characterization of the COMB chamber in Lab**
  - ✓ Vacuum tests with the 3D printed capillary using H_2
    - ✓ **GOAL**: Keep vacuum pressure below $6*10^{-8}$ mbar
  - ✓ Design, construction and operation of the discharge box with a 50 Ohm load



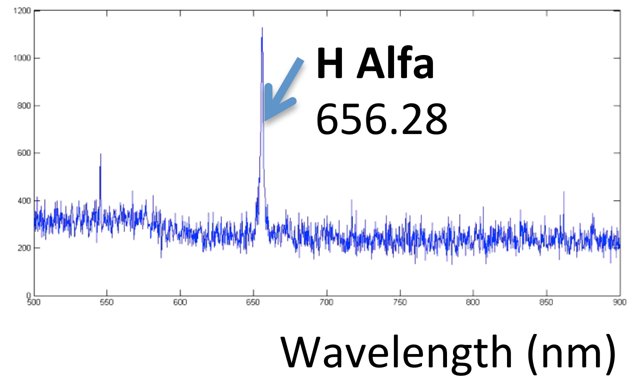
These results are obtained with one skroll as retro-pump for every turbo pumps at different input gas pressure.

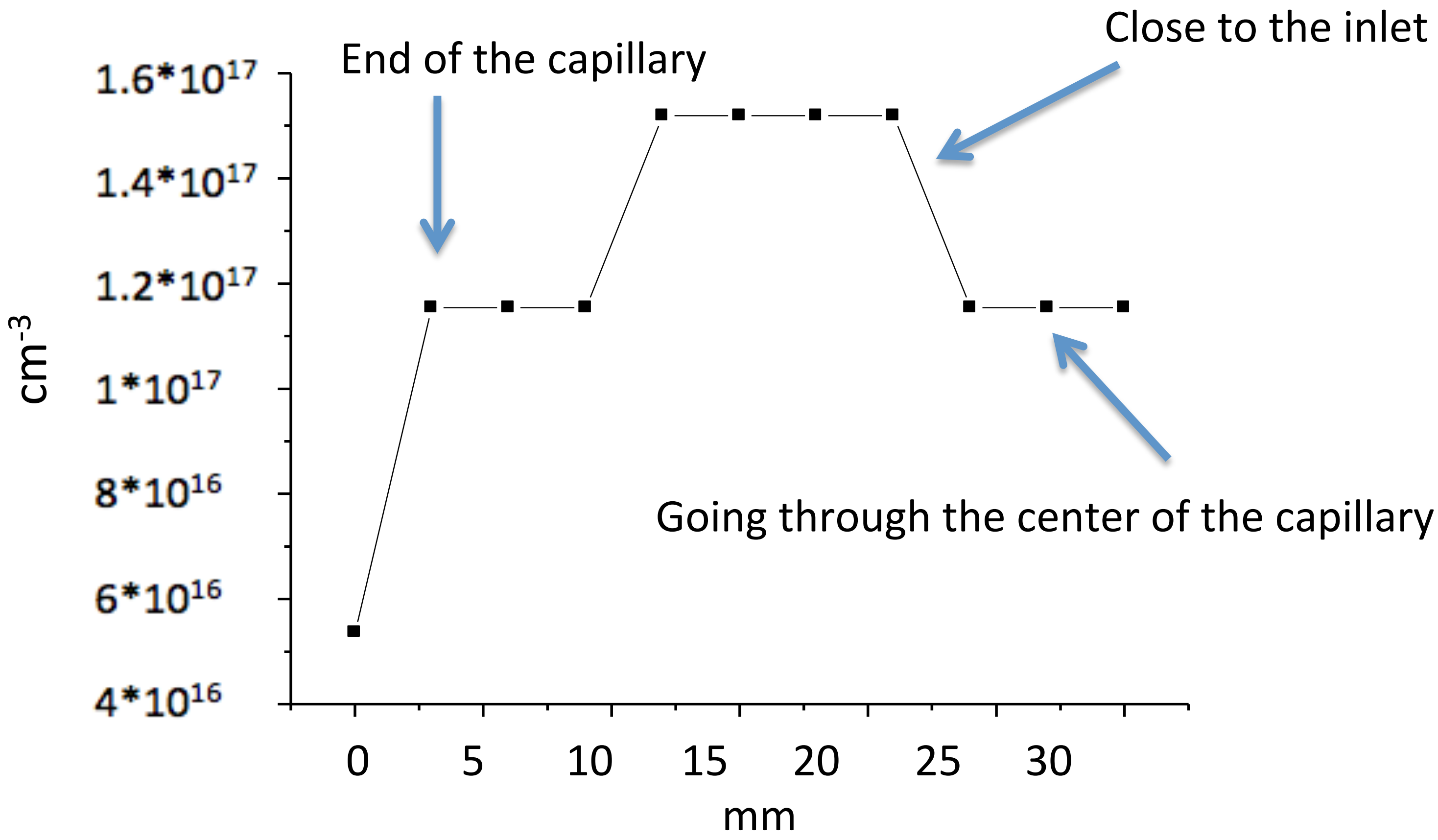
Recent tests with more than a retro-pump have shown the possibility to sustain up to 5 Hz rep rate with 400 mbar input gas pressure

M. P. Anania, A. Biagioni, F. Filippi

Plasma Diagnostics along the Capillary

- ✓ Measurements were performed varying:
  - ✓ Inlet pressure
  - ✓ Valve aperture time
  - ✓ Position of the fiber respect to capillary

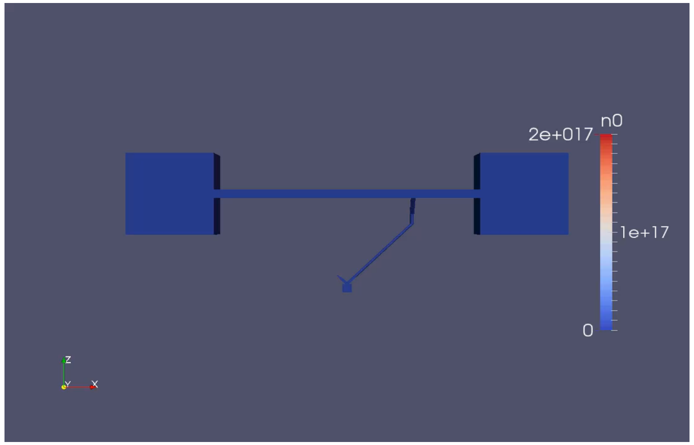




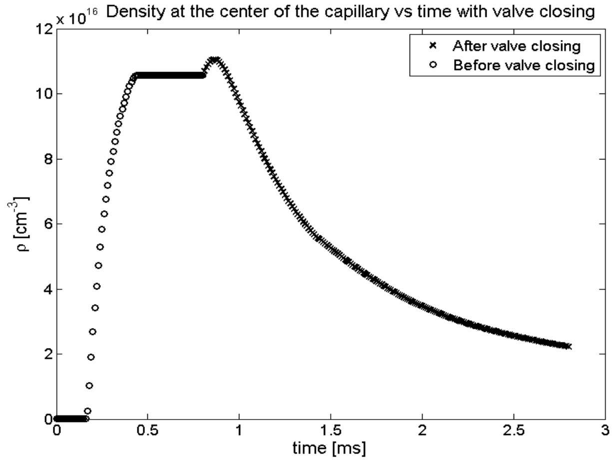
F. Filippi, M. P. Anania, A. Biagioni, A. Zigler

Gas Flow Simulations with OpenFoam code

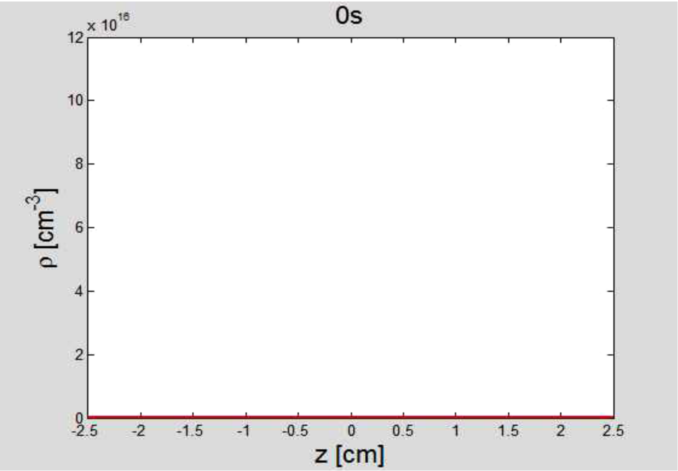
Gas Flow inside capillary



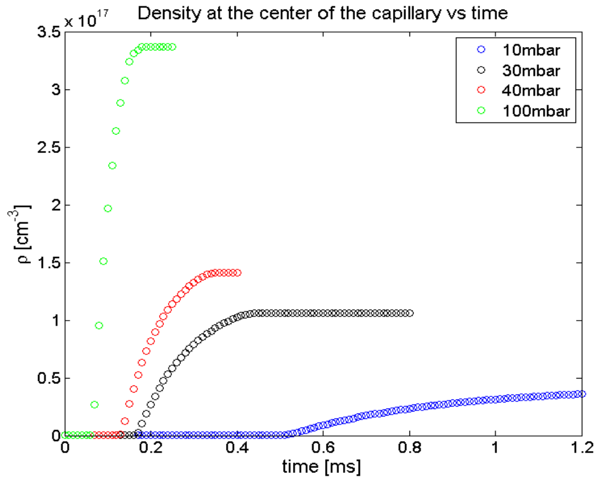
Valve closing at 800μs



Variable density ramp

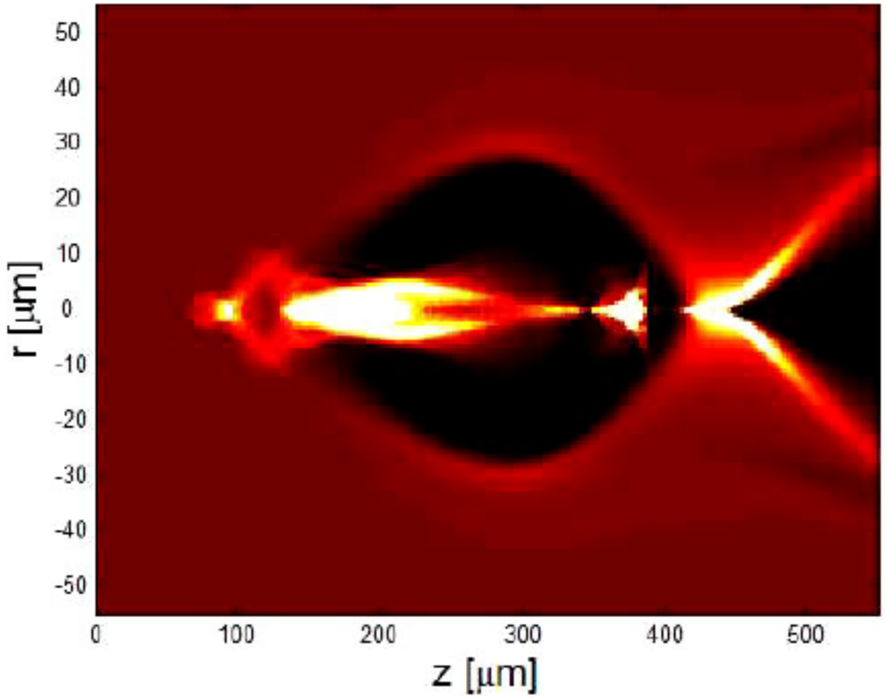


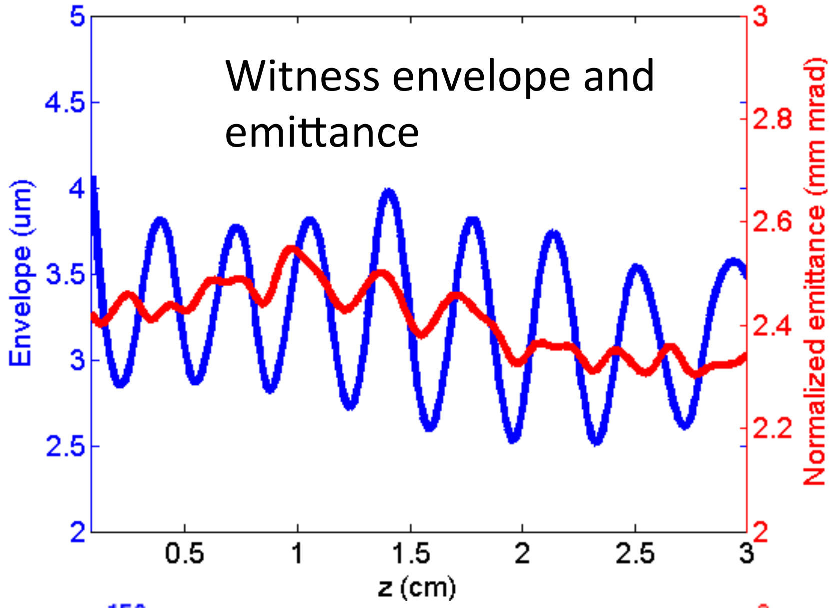
Filling time simulations

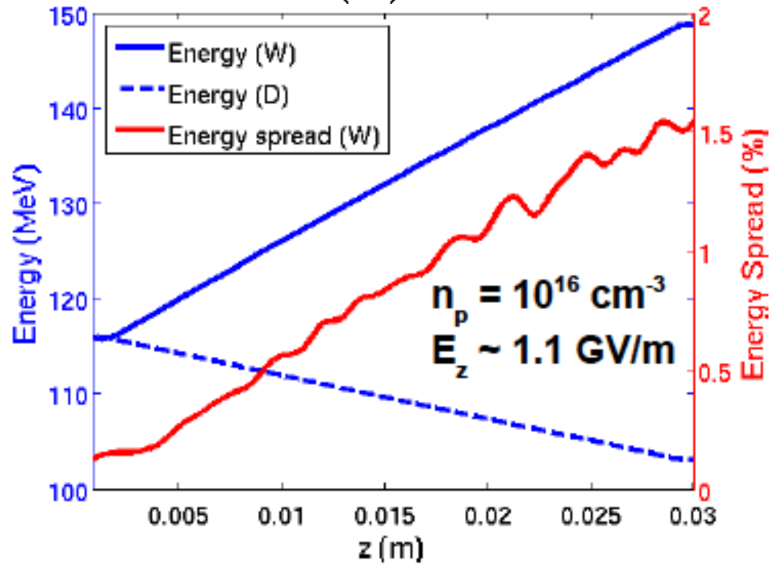


S. Romeo

Acceleration in plasma - Simulations







- *Hybrid kinetic-fluid simulation by* ***Architect***
  - ***PIC*** *(bunch),* ***fluid*** *(plasma), 3-5 hours for 3 cm*
  - *Cross-checked with full PIC codes (ALaDyn)*

	Q (pC)	σt (fs)	σx (μm)	E (MeV)	ε (μm)
Driver	200	180	5.5	116	4.5
Witness	20	35	3	116	2.4

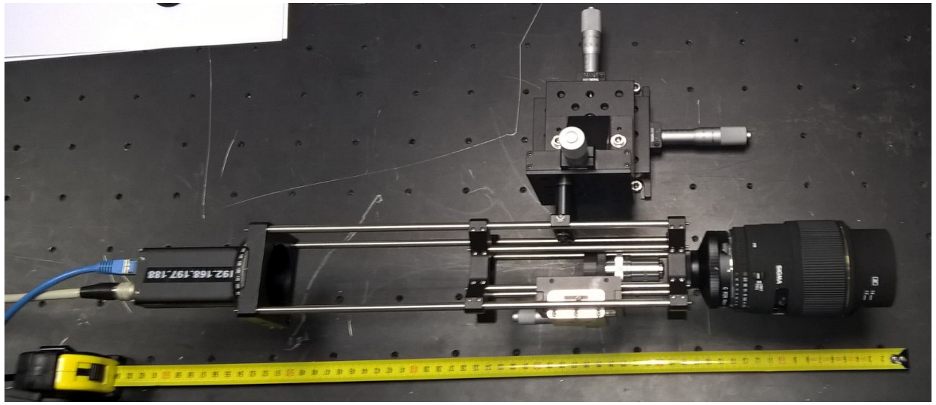
A. Marocchino, F. Massimo

Electron beam diagnostics

Longitudinal diagnostics for the input beam, both drivers and witness, **based on EOS** technique to characterize single bunch length and temporal separation, needed for optimize the plasma acceleration performance (*R. Pompili*)

Transverse diagnostics for the input beam at the injection into the capillary (*V. Shpakov*)

- High resolution needed to measure **micrometer size** beam spot at the capillary entrance
- Micro-objective (20x), 105 mm objective lens, Basler camera

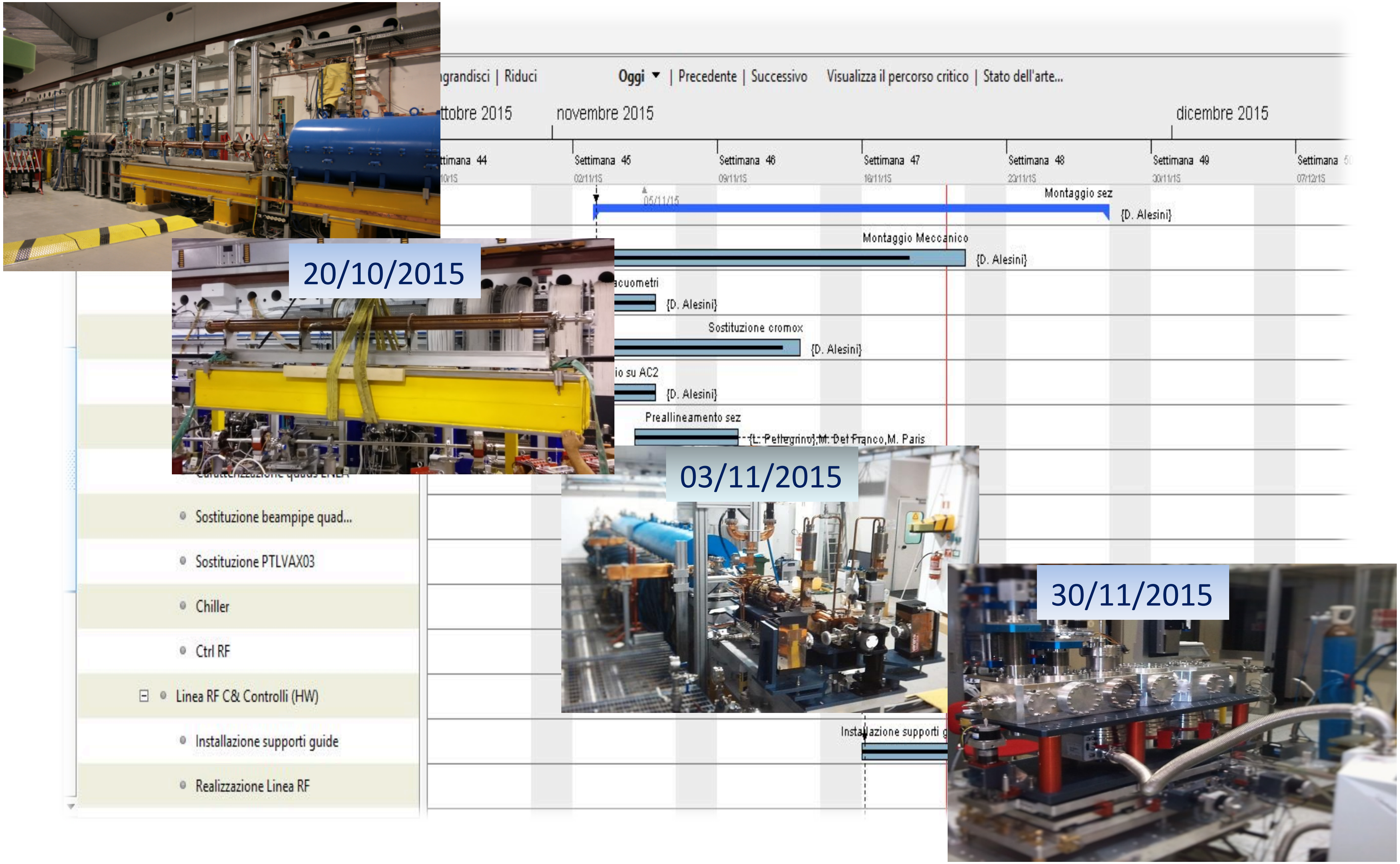


50 cm

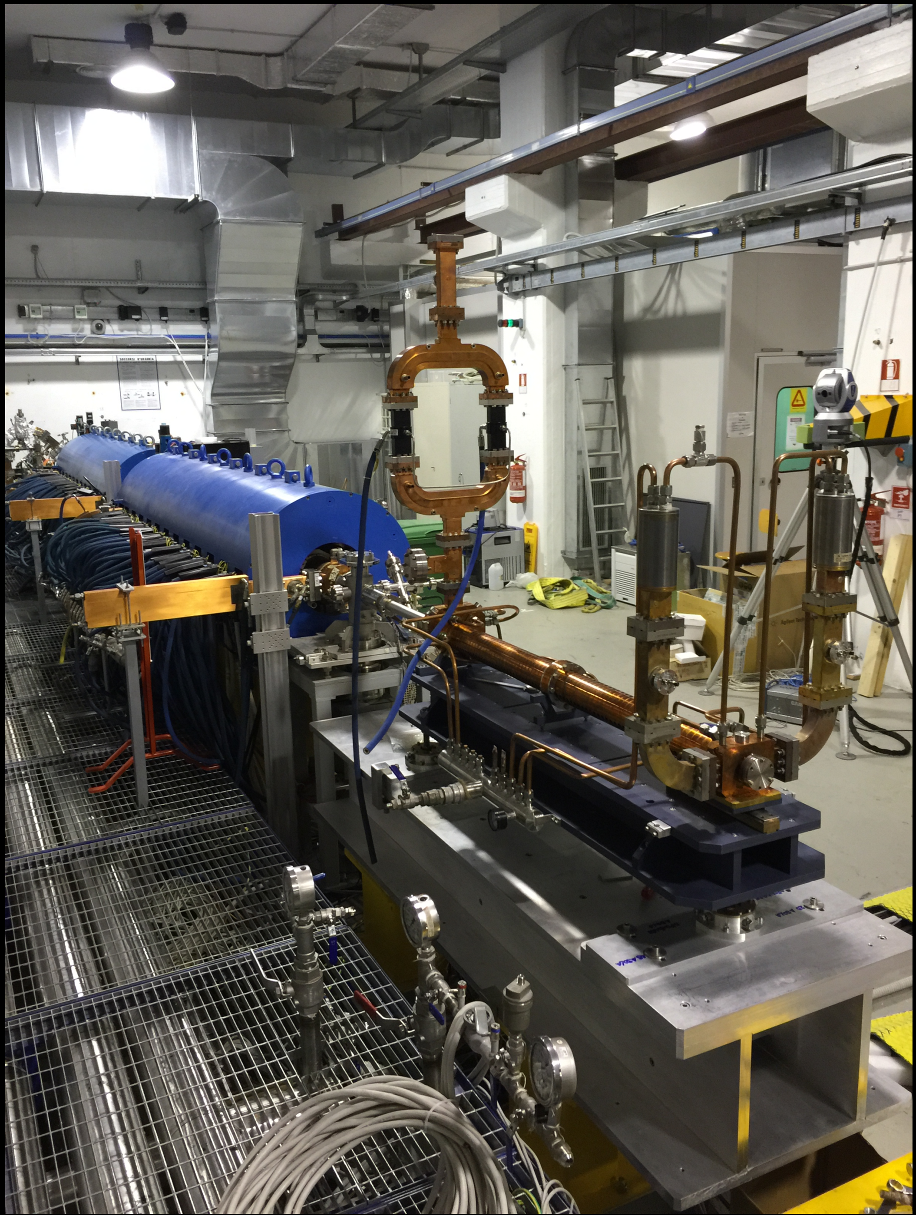
Longitudinal diagnostics for the output witness beam based on THz radiation (*F. Giorgianni*)

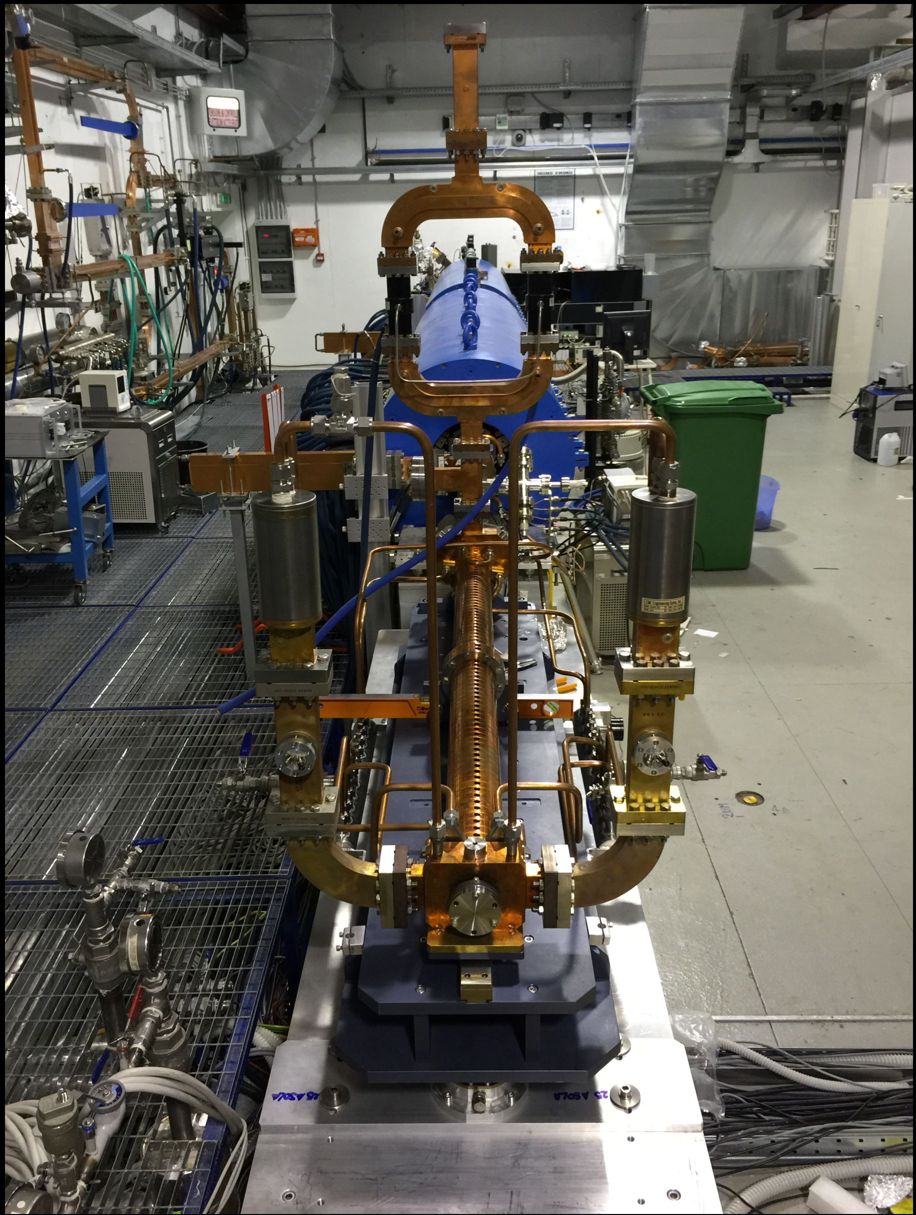
- The system is able to measure radiation from a 10-20 pC charge beam, but sofar it is multi-shot
- Further implementation, in combination with EOS technique, would allow for single-shot measurement

On going Installations from Oct. 20

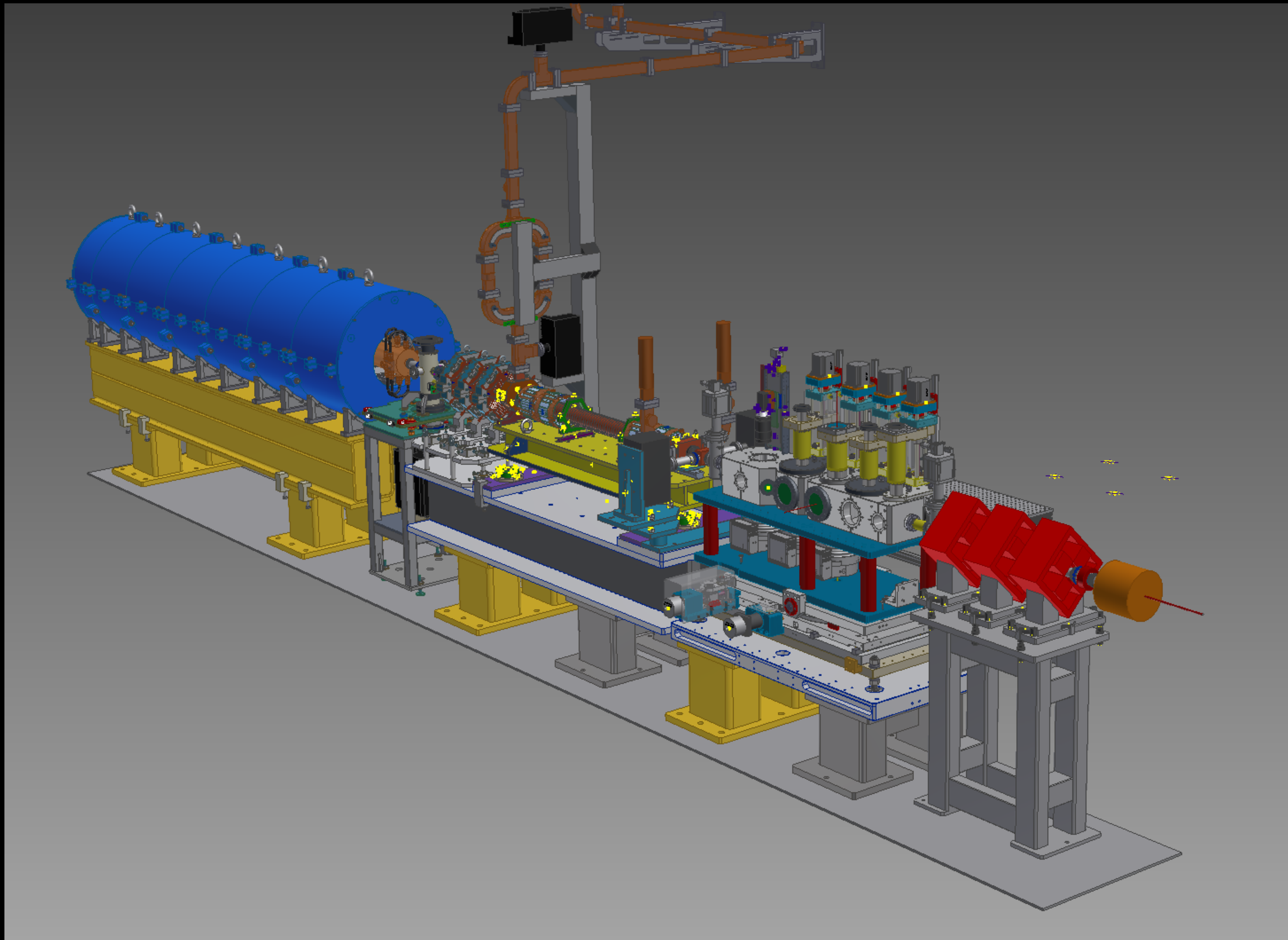


C-band structure already installed



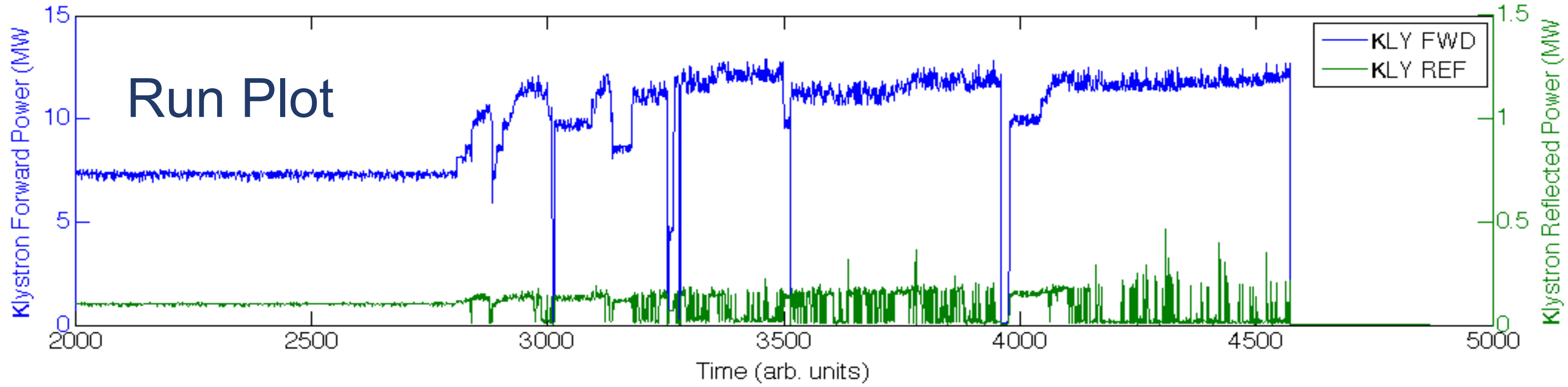


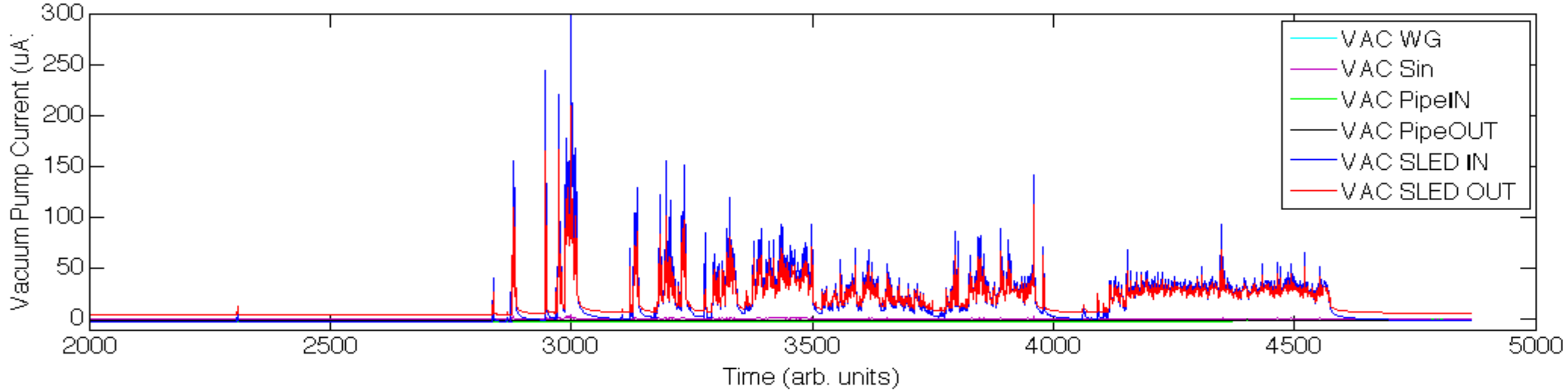
Final layout as expected by December 2015



2015 significant fault at C-band Klystron - Vacuum Interlock

After 54 hours of High Voltage a Vacuum Interlock occurred again. During a smooth conditioning run a Vacuum Interlock occurred again.





2015 significant fault at LNF-SPARC Facility
Klystron E37202 Vacuum Interlock

Picture taken from the tank side window

July 21, 2015   Klystron E37202

Phenomenon and causes:

As a result of the investigation, it is likely that energy passed from the outside to the inside of the tube and caused a damage to the gun ceramic. Although the cause of the leak was not identified in this investigation (last TOSHIBA report October 2015) .

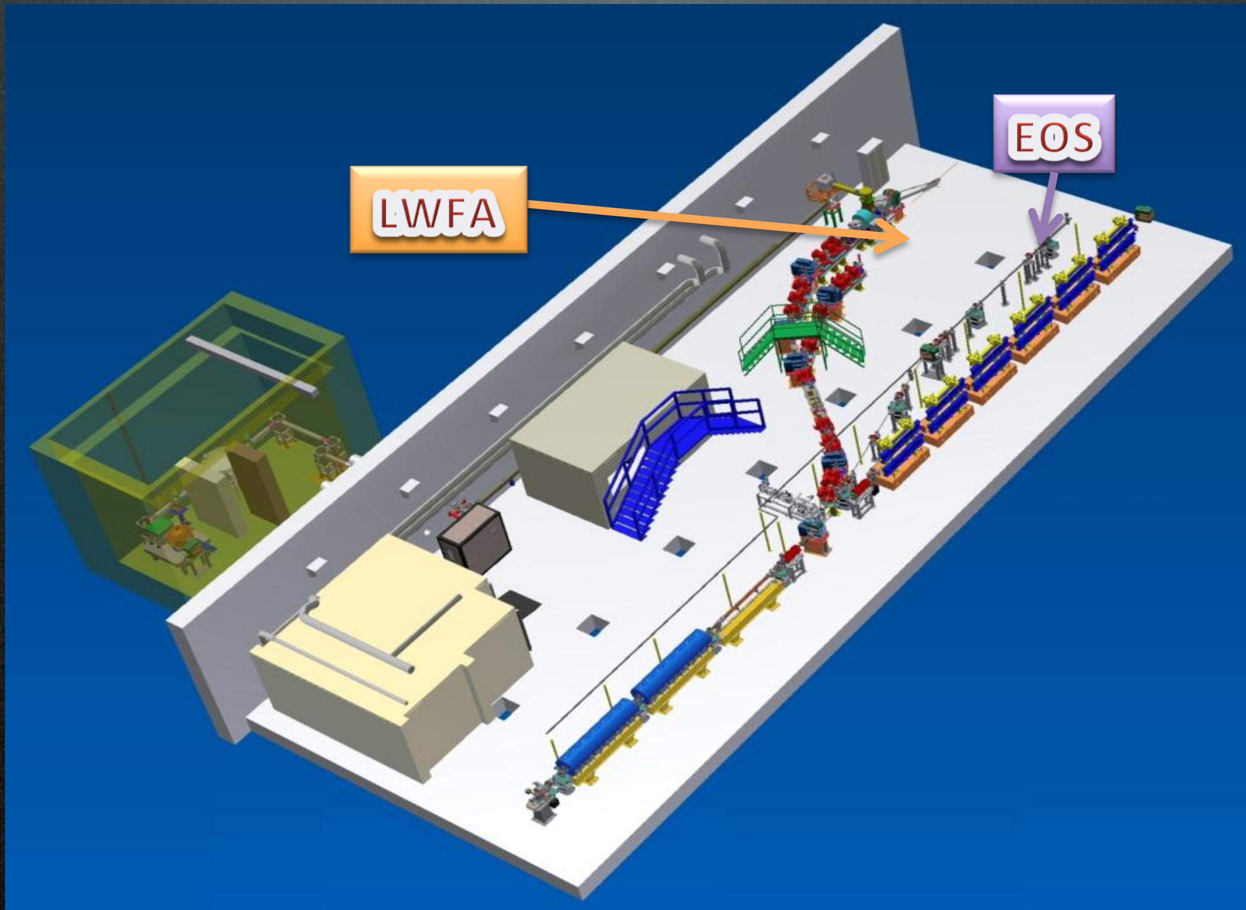
Same type of fault at PSI:
We have shared all the Information during a collaboration meeting (September 2015)

We are still waiting for the repaired Klystron, the negotiation with Toshiba is still in progress

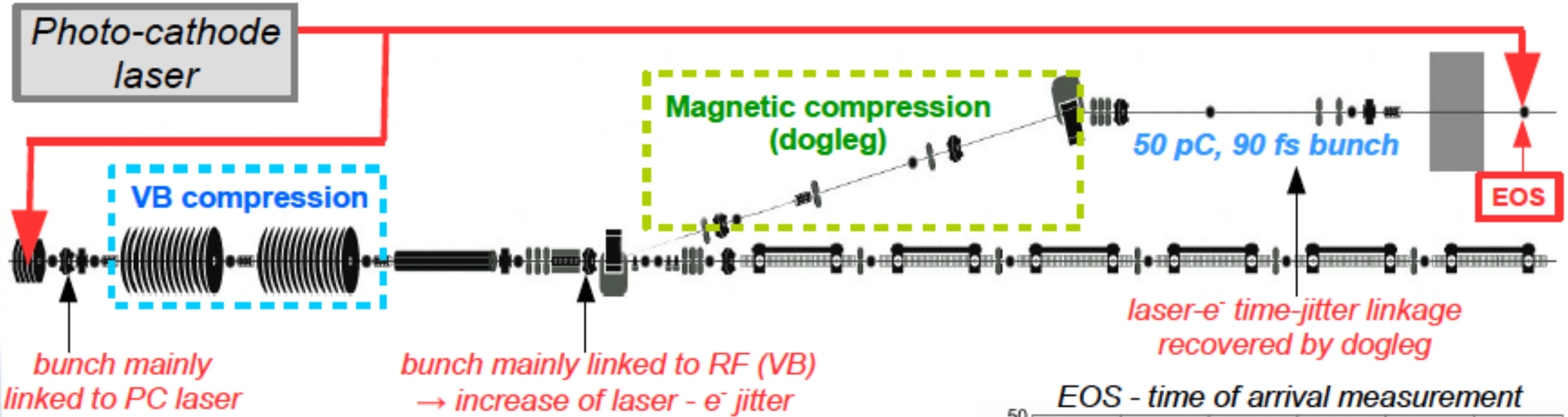
SL_COMB Milestones 2016 (depending on C-band Klystron availability)

- Commissioning of the COMB chamber installed on the SPARC main line (end of February)
- Setup of the online plasma diagnostics based on Stark effect and measure the plasma density profile in the capillary
- Start-to-End simulation to characterize two working points
  - with 2 and 5 bunches to demonstrate the resonant excitation of the plasma wave
- Experimental study of the fringing effects on the capillary (plasma lens) (March)
  - adiabatic plasma lens
- Beam loading studies and energy spread correction (plasma dechirper)
- **Experimentally characterization of the driver/witness bunch interaction with the plasma**
  - **single bunch study**
  - **Multi-bunch study**
- Transport of the plasma accelerated beam
- Test the electron beam diagnostics at the plasma exit

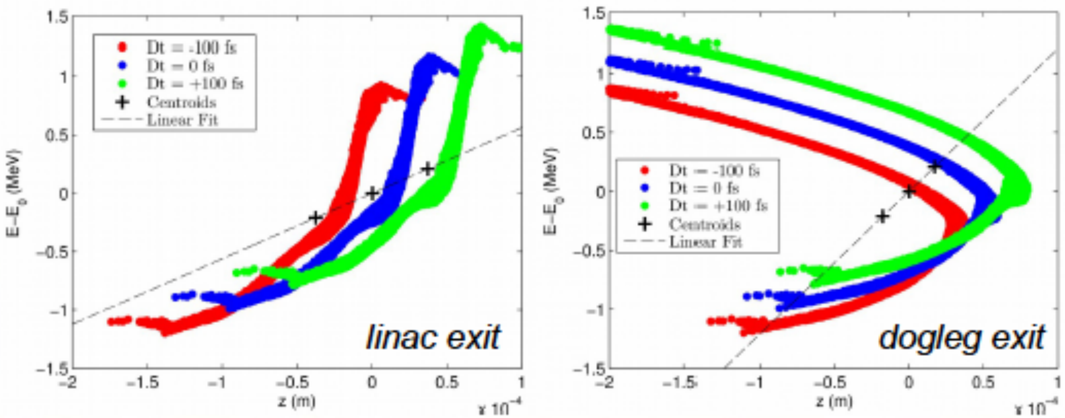
SL_EXIN: Laser Driven Plasma Wake Field Acceleration

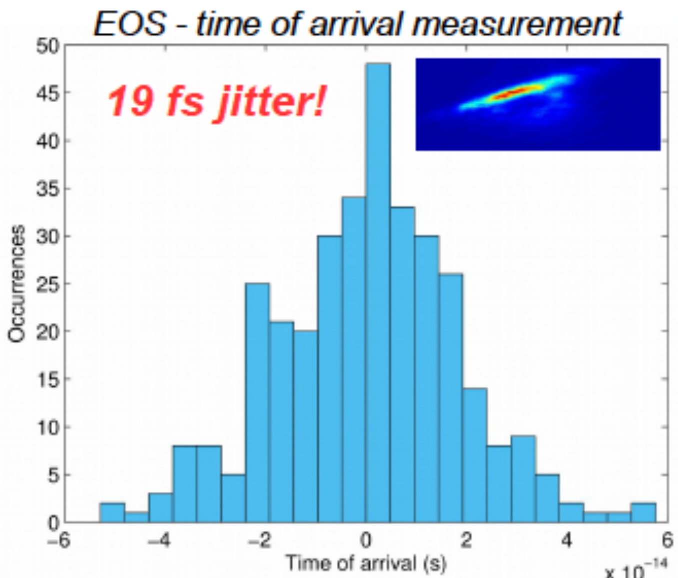


Laser vs e⁻ beam time-jitter reduction



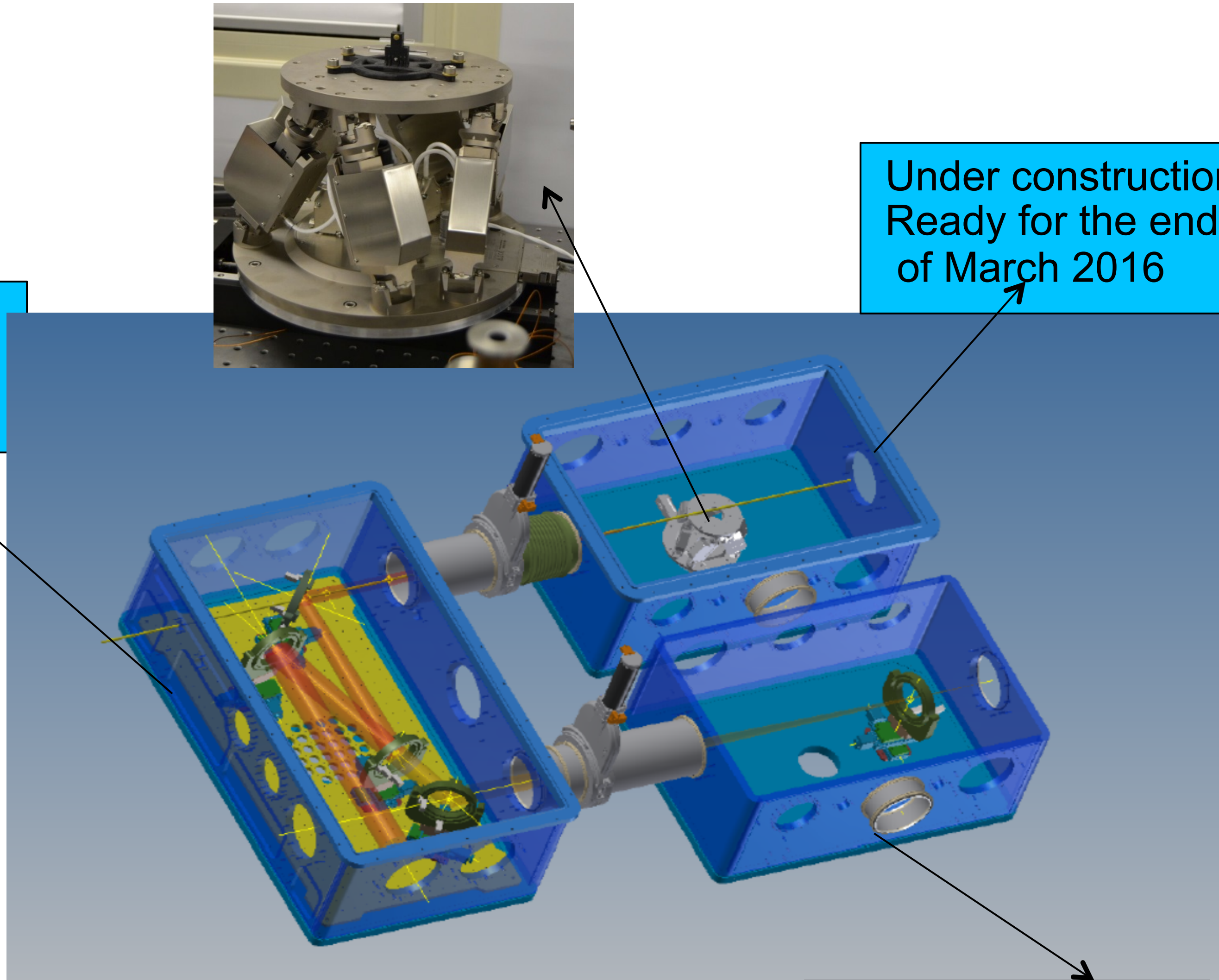
Hybrid compression: bunch shortening by **VB**, relative ATJ reduction by **magnetic compression**



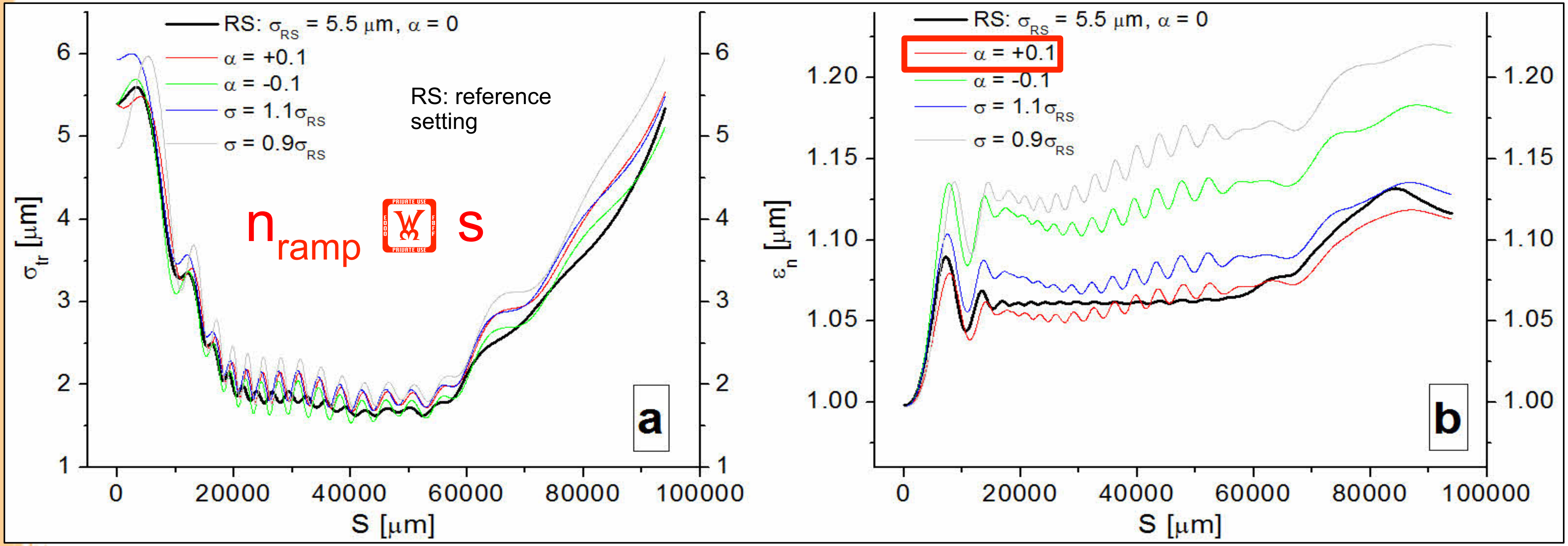


Pompili, R. et al. submitted to PRSTAB.

Interaction Chamber



Transport stability vs beam parameters at injection

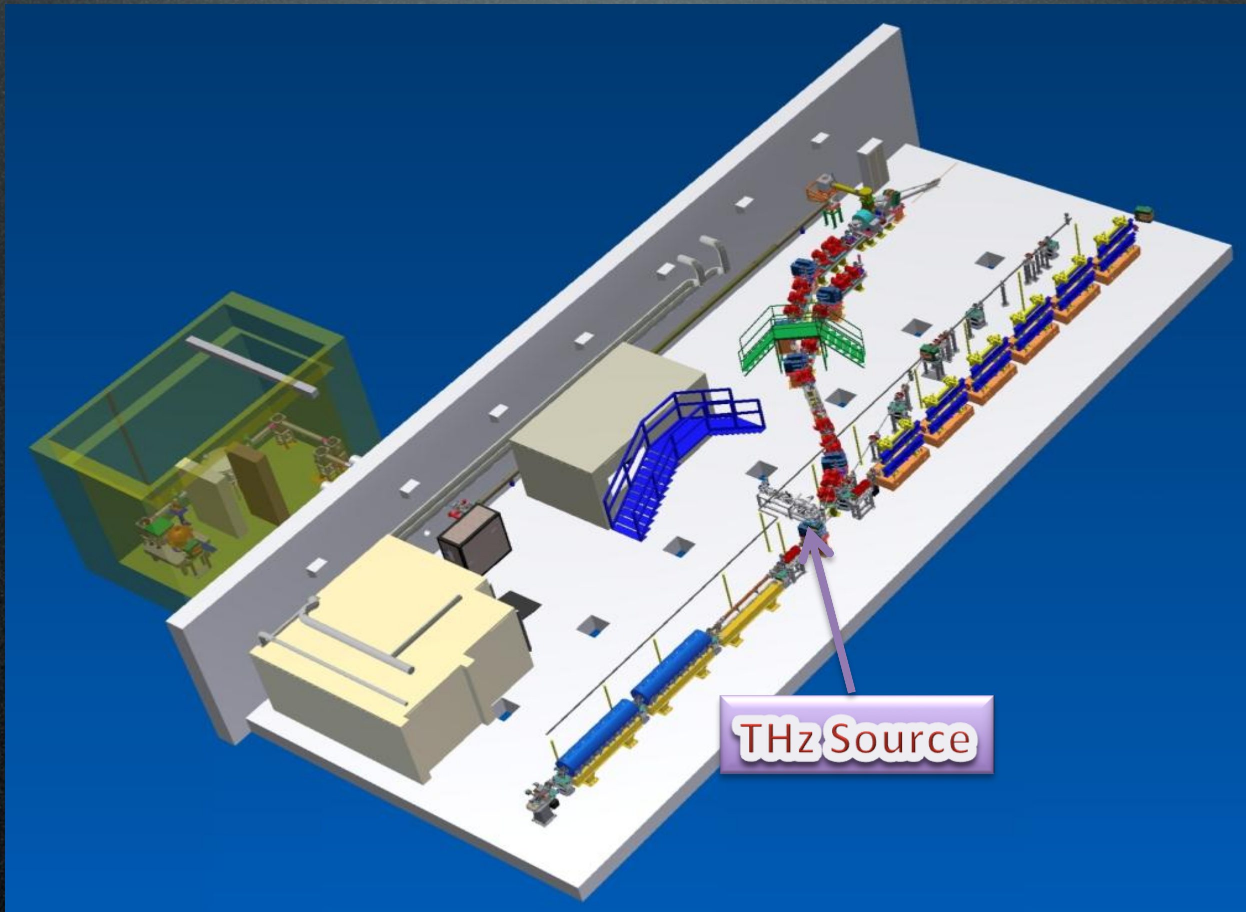


- Asymmetry in the jitters
- Robustness in some directions (for emittance)
- Overall robustness in output transverse dimension

Unexpected: improved results if $\alpha_T > 0$
Educated guess: beam loading effect?

These results were submitted for EAAC 2015 proceedings on NIM A

THz Source



Comments

The THz run was scheduled starting from July 7th for 5 weeks till August 7th .
The first week was dedicated to Smith-Purcell alignment and preliminary tests with beam, but a vacuum leak in the Smith-Purcell chamber together with a control/ion pump system failure caused the vacuum break with pressure of 100 mbar in the gun.

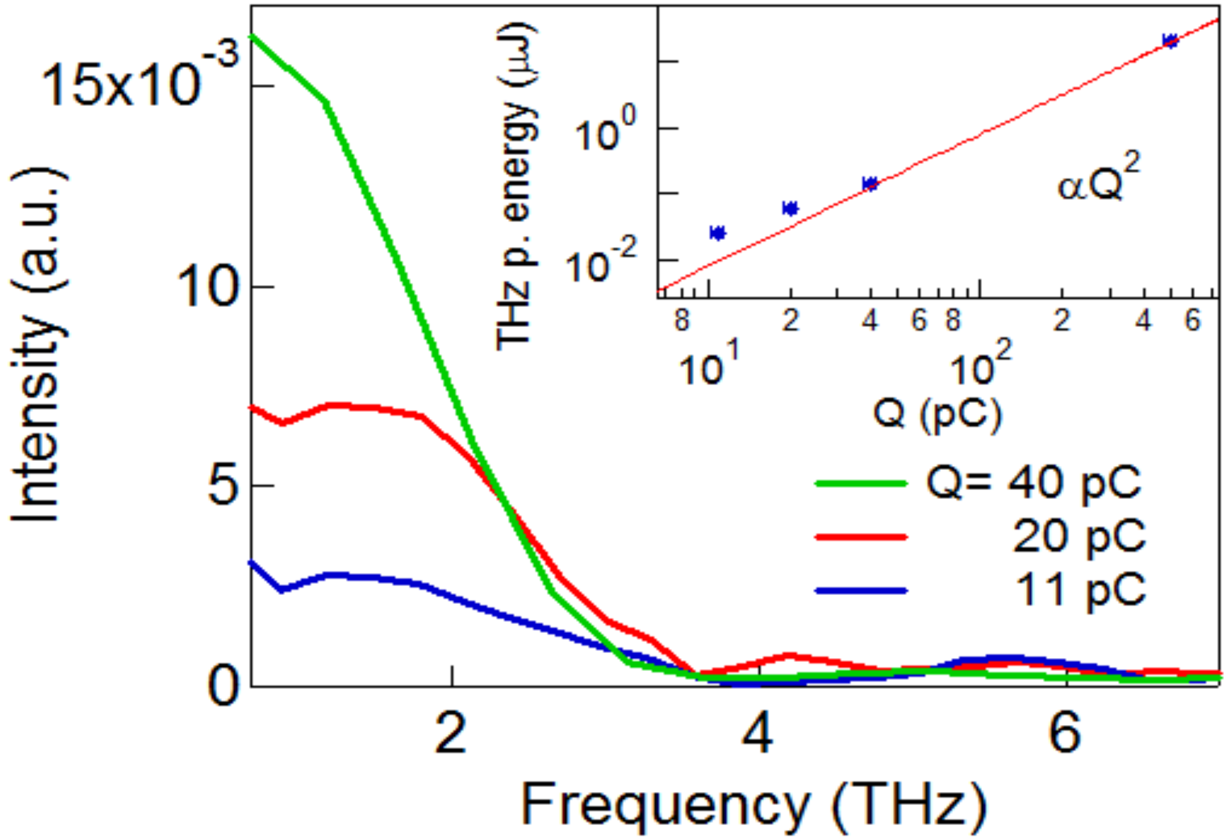
The vacuum pumping re-started immediately and UHV level restored in a couple of days, but gun and traveling section needed a slow conditioning with RF, which caused a shift of two weeks in the THz program. The cathode QE was however reduced because of air contamination, resulting in a lower extracted charge for a given laser energy. However the minimum 500 pC beam for THz experiments was guaranteed.

Machine setup for THz studies started on July 23rd (2 days) and the run with THz users started on July 28th till August 7th .

One more week in October was dedicated to THz user shifts.

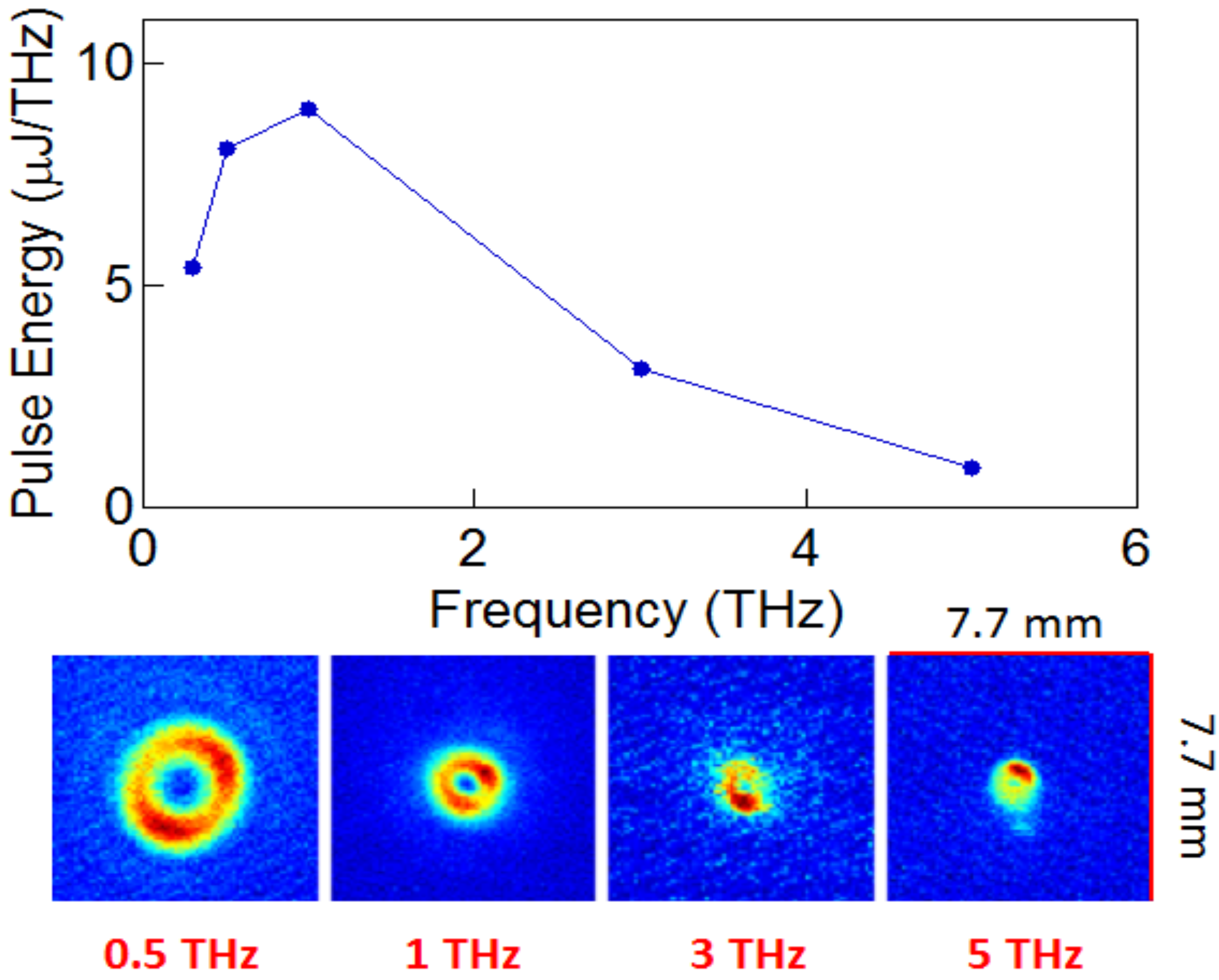
Improvement of the experimental setup

- Dry air system to reduce water absorption allowed to measure radiation from very low charge bunches, of the order of 10 pC
  - Coherent THz radiation from the ultra-short witness bunch can be used to retrieve its duration
  - Preliminary measurements show that the system allows to detect pC scale beam, but still dedicated tests at such low charge are needed



Broad-band THz Emission

- 500 pC, ~ 100 fs (rms), 115 MeV



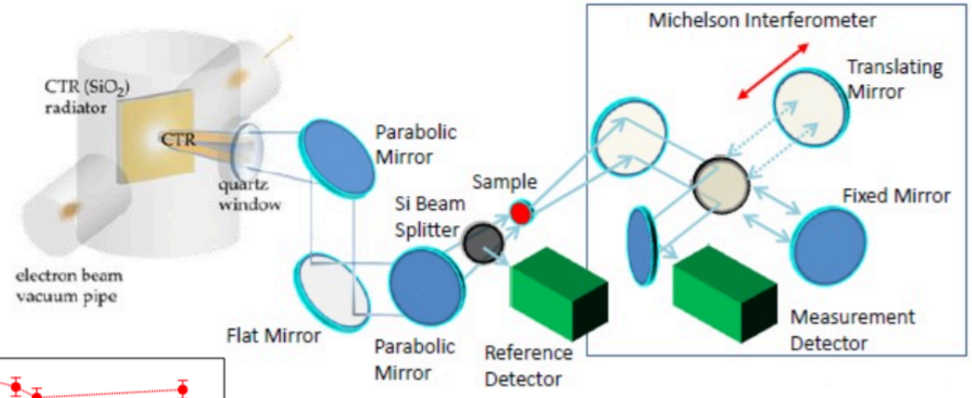
Spatial distribution of CTR radiation in the focus of a parabolic mirror as measured by means of a Pyrocam

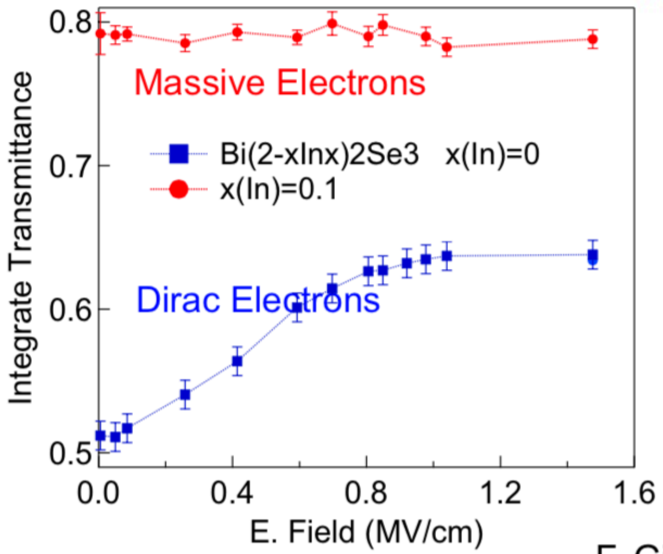
Nonlinear THz response of Bi_2Se_3 Topological Insulator

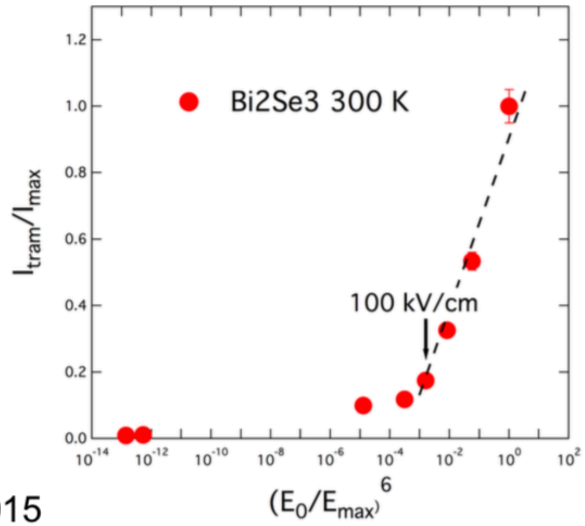
A Topological Insulator is an exotic electronic material showing an insulating bulk and intrinsic metallic surfaces.

The metallic surfaces are characterized by a gas of Dirac electrons, *i.e.* having a relativistic dispersion: $E(k)=v_F k$ where v_F is the Fermi velocity.

In this experiment we observe a nonlinear optical behavior of Dirac electrons over 6 orders of megnitude of the THz electric field and characterized by THz harmonic generation





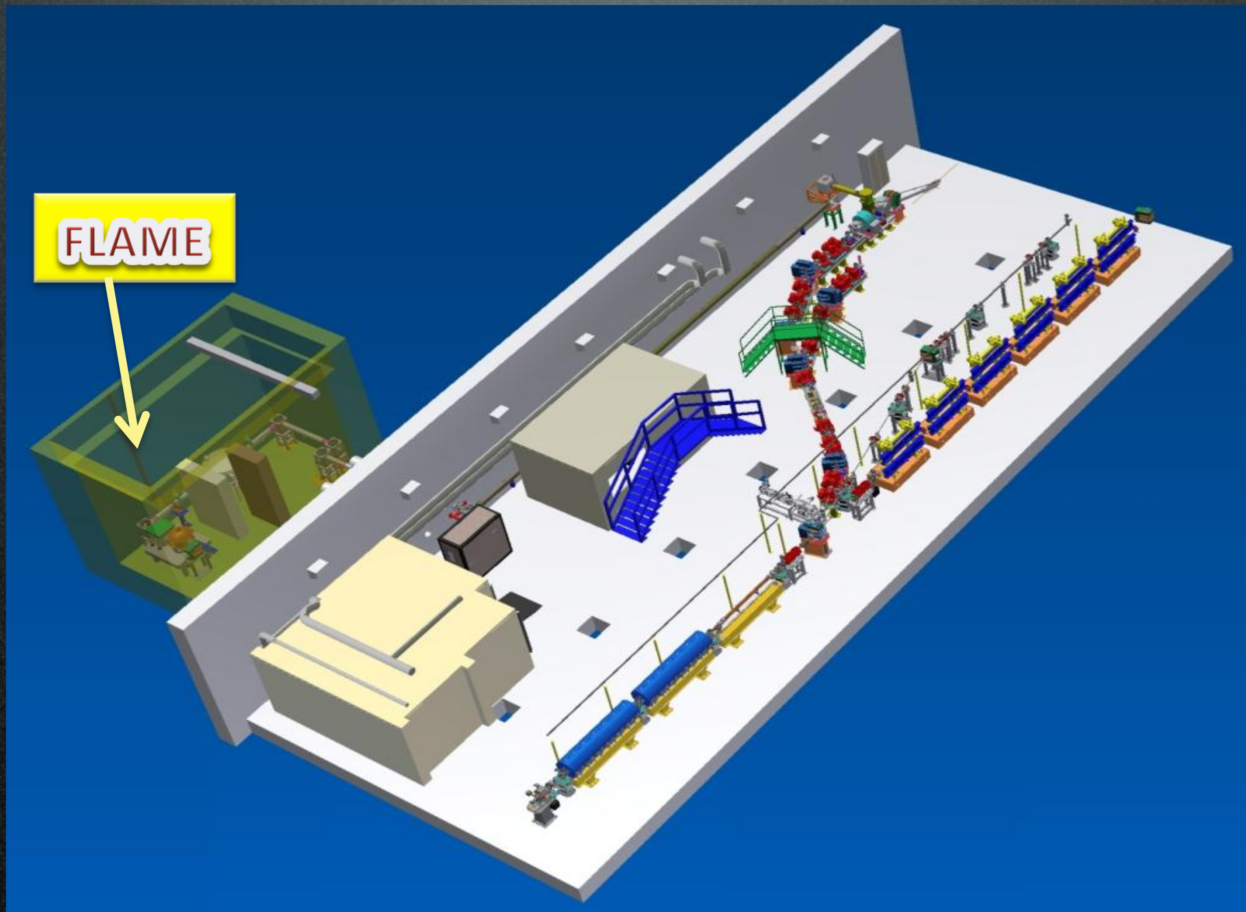


F. Giorgianni et al, NC submitted 2015

Milestones 2016

- THz radiation studies for the low charge regime in order to use coherent radiation methods for bunch length measurements
- Implementation of EO technique to allow for single-shot measurements
- Project of the THz beamline
- THz user experiments

FLAME Laser



FLAME status

In general the laser is working fine, **delivering 5-6 J in 35-40 fs.**

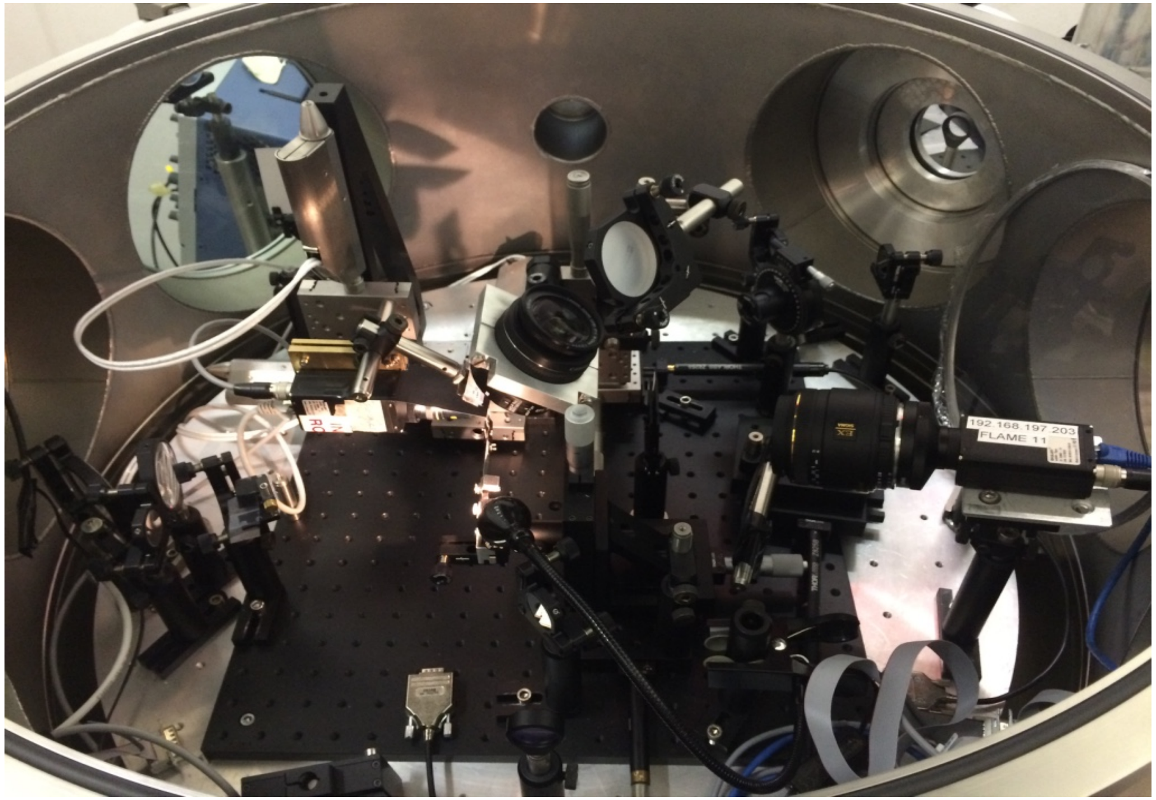
The final transport section (between the laser clean room to the compressor entrance) has been updated: now it's **fully closed in pipes** so to have small variation in the focal spot due to turbulences. Also lots of CCD cameras have been installed enabling us to check the beam status and alignment both in air and in vacuum.

The compressor chamber has been fixed to the floor, so the problem of alignment in vacuum has been solved (before we were completely loosing the beam while going in vacuum; now the focal spot is moving of microns, which is normal).

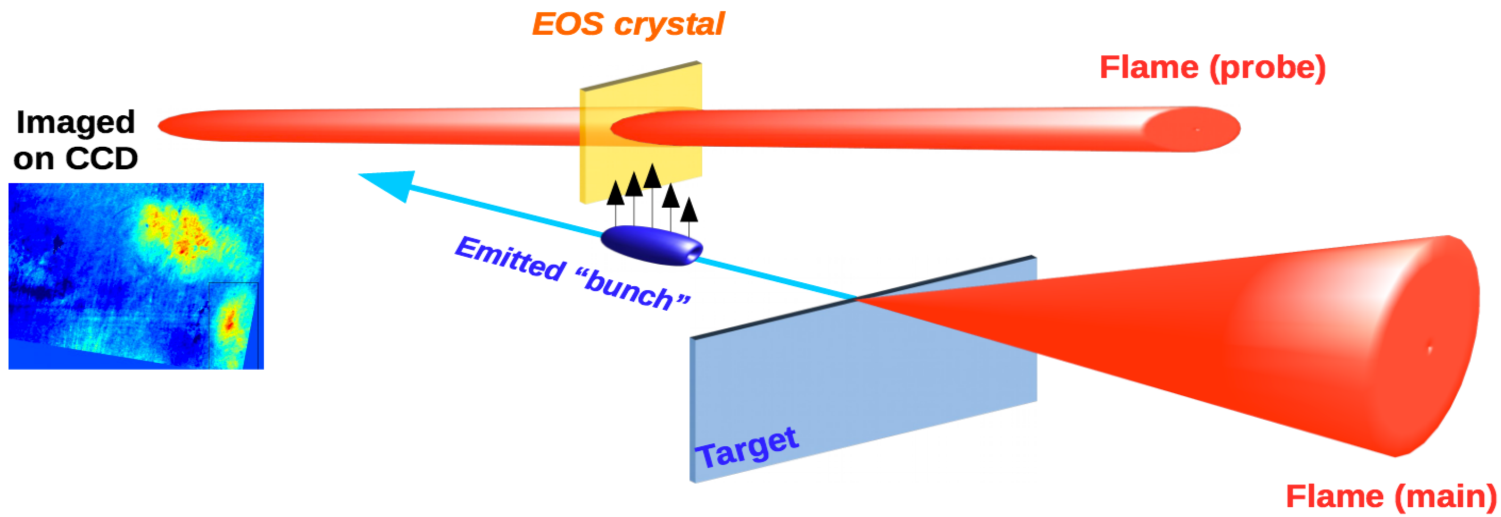
As far **as the adaptive optics, it is working well giving us almost 60% of energy in the focal spot**. In order to be able to reach a higher percentage of energy in the spot, we have bought a larger achromatic doublet which will allow us to have the whole beam on the diagnostic bench and make sure that the corrections of the phase front are done on the whole beam and not just on a smaller part of it.

Experiments with the FLAME laser

The **goal** of the experiment is to measure electric field emitted by generated particles (both electrons and ions) by means of Electro-Optical Sampling. We wish to demonstrate that acceleration of light ions can be optimized by shaping opportunely the solid target.



Experiments with the FLAME laser

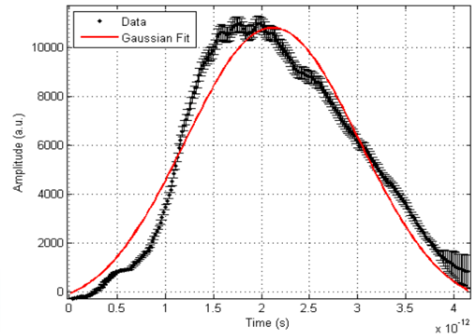


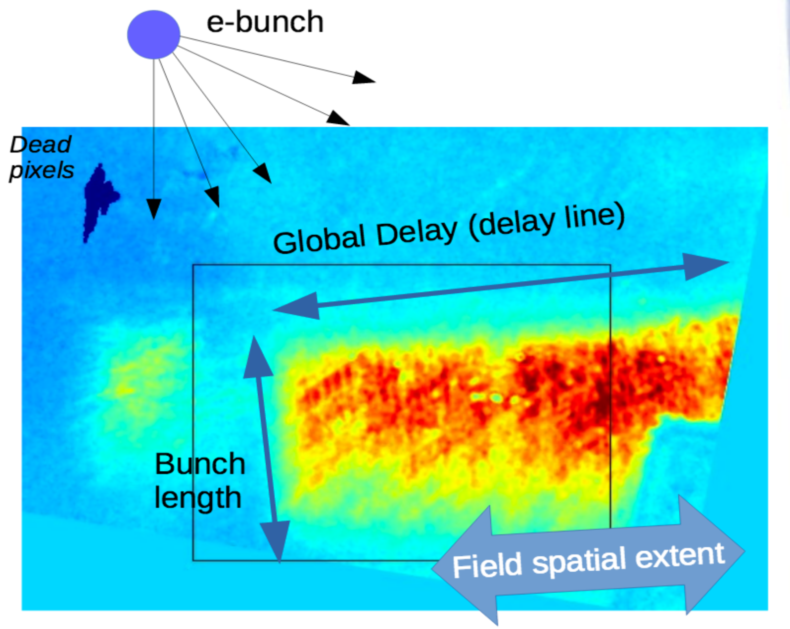
Why EOS?

- Non-intercepting and single-shot
- Use a «probe» laser to monitor the changing on the optical properties of a nonlinear crystal placed near the emitted particles
  - The high electric field produced by the interaction of the FLAME laser with the target make the crystal birefringent
  - Two different refractive indices appear in the crystal
  - The polarization of the probe laser rotates because it feels the two refractive indices

Experiments with the FLAME laser

- **Crystal: ZnTe (1 mm)**
- Shot # 8
- Phase shift: 3.47°
- sigma: 1.38e-12 s
- Electric Field: 46.5 MV/m





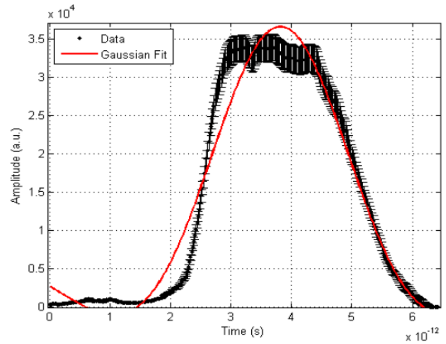
Data taken with lower laser intensity (due to large spatial chirp).

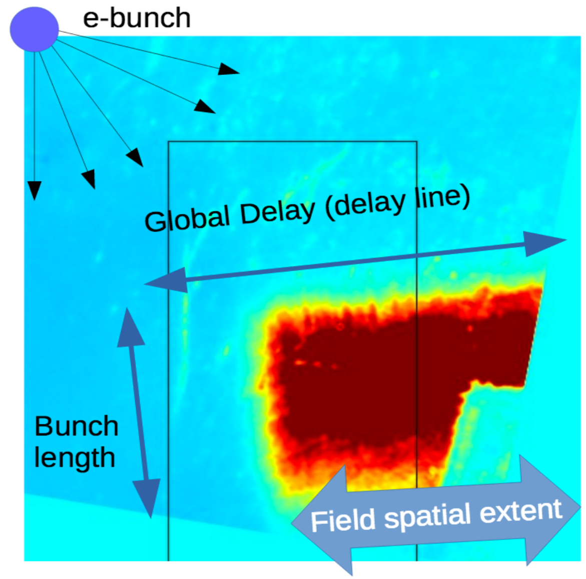
Field measured: 46.5 MV/m.

Data taken with higher laser intensity (4 times higher - after realigning the compressor).

Field measured: 105.7 MV/m.

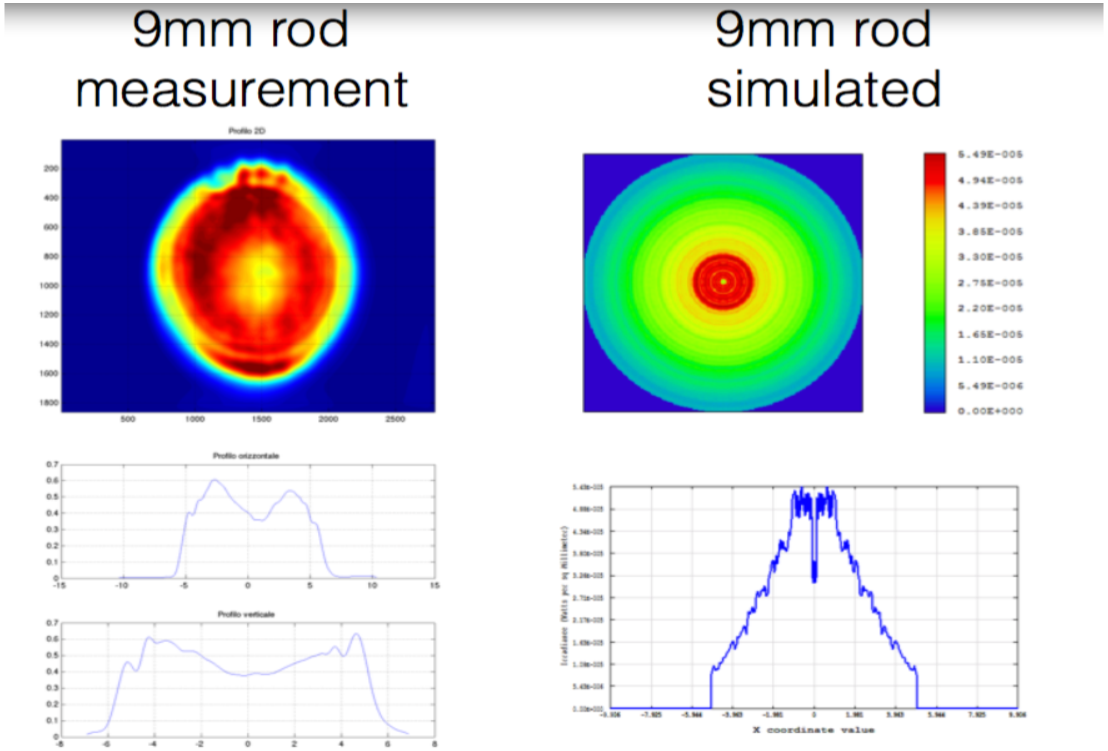
- **Crystal: ZnTe (1 mm)**
- Shot # 7
- Phase shift: 4.1°
- sigma: 1.84e-12 s
- Field @ 1mm: 54.3 MV/m
  - *NB: signal saturated: real amplitude is about 1.95x larger!*





FLAME status

However, since we are using the full power continuously, **high power parts (YAGs) get damaged easily.** Measurements have been done and ZEMAX simulations have been performed in order to understand how to solve the problem.



The images show **that the road of the YAGs' oscillator is too small respect to the size of the beam at the last pass inside the cavity** and therefore the beam is cut at the edges by the rod itself.

After this cut, the beam is sent to the two following amplifiers which will amplify the diffraction pattern at the side of the beam and which will eventually damage the coating of the last surface of the last rod at the beginning and the rod itself at the end.

FLAME status

The main problem is the magnification inside the amplifier of the YAG; we have mainly two options to try:

1. **Change the size of the rod, so not to cut the beam;**
2. **Change the magnification of the beam by changing the reflectivity profile of the output gaussian mirror.**

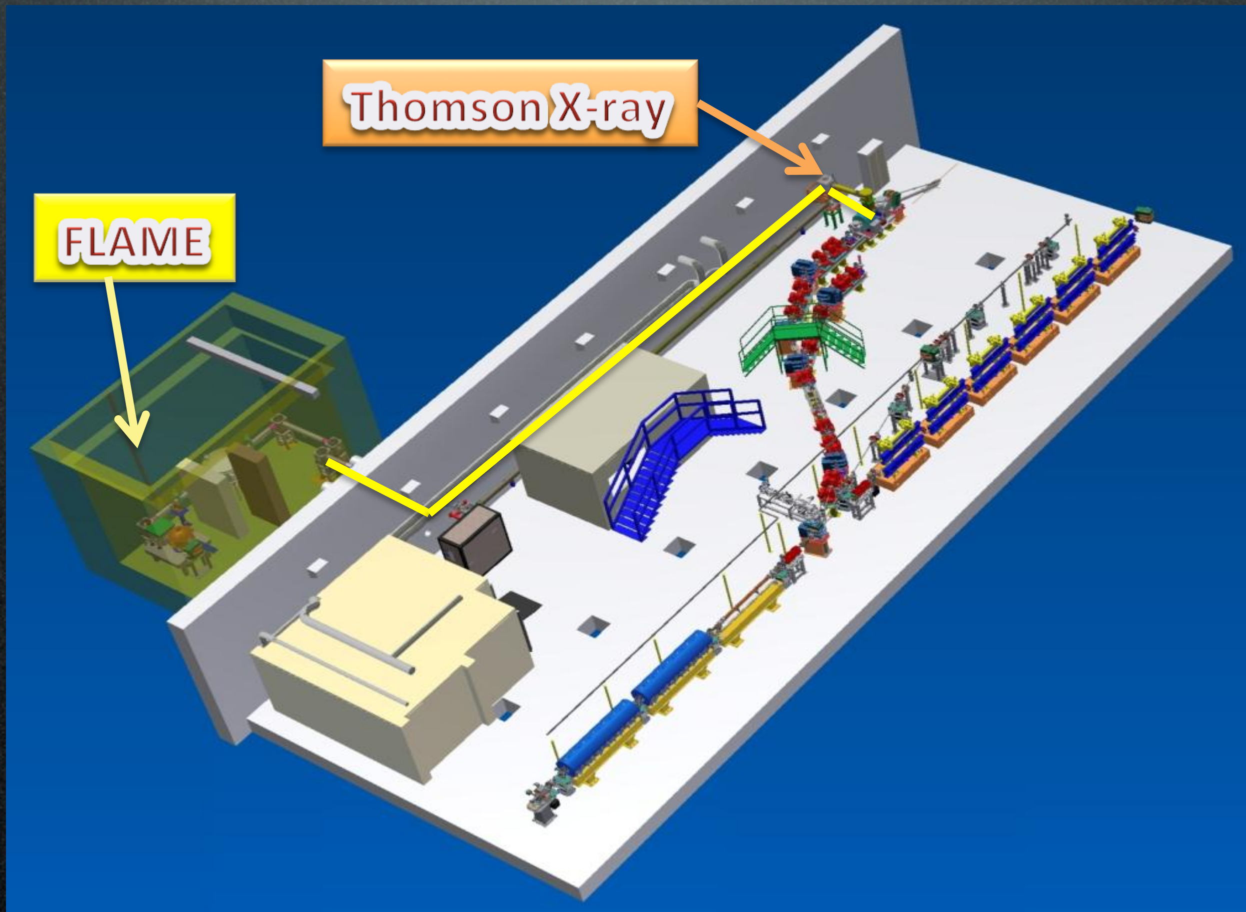
Both solutions will give us less energy for the output beam, so in order to have again the some output energy from each YAG, we will also change the second harmonic crystal from BBO to LBO (the last one has 70% conversion efficiency instead of 50% of BBO crystal).

The program to make these changes to sacrifice one of the YAG to make the changes and test the two different options (2 weeks) and then chose the best solution, buy the optics/goods to make the changes to all the 11 YAGs and dedicate 2 weeks to upgrade all the YAGs.

FLAME program for 2016

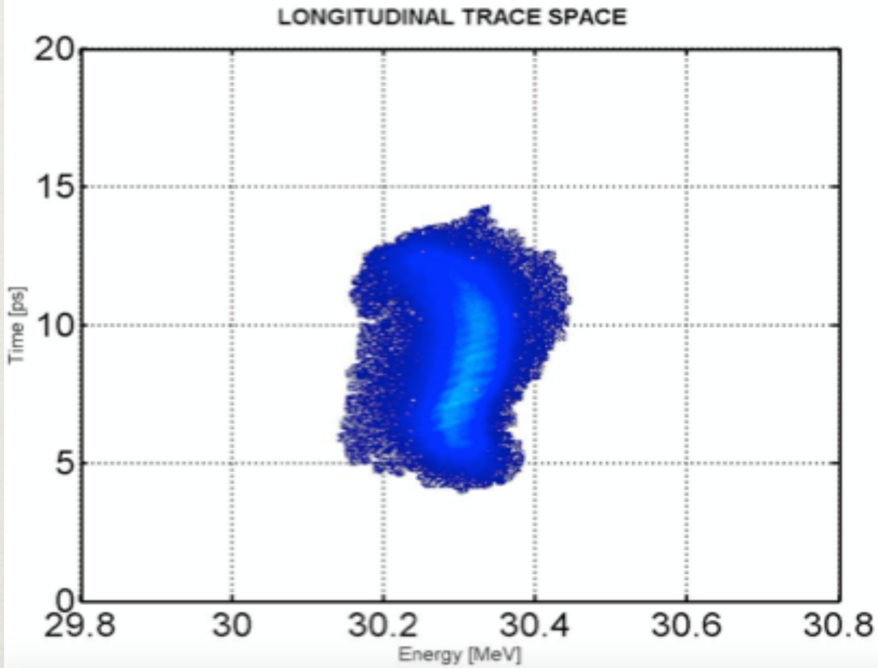
Activity	Start date	End date
Restart after Christmas	11/01/2016	22/01/2016
Single shot emittance measurement	25/01/2016	11/03/2016
Laser maintenance	14/03/2016	18/03/2016
Amplitude visit and compressor optimization	21/03/2016	08/04/2016
Optimization of one of the YAGs (Bisesto's solution)	21/03/2016	08/04/2016
EOS experiment (A. Zigler)	11/04/2016	06/05/2016
Laser maintenance	09/05/2016	13/05/2016
Optimization of all the YAGs (Bisesto's solution)	16/05/2016	27/05/2016
Laser maintenance	30/05/2016	03/06/2016
Capillary guiding and acceleration for EXIN in FLAME bunker	06/06/2016	29/09/2016
Restart after summer holidays	05/09/2016	16/09/2016
Thomson experiment @ SPARC	19/09/2016	28/10/2016
Laser maintenance	31/10/2016	04/11/2016
Plasma mirror experiment	07/11/2016	02/12/2016
Filamentation experiment (M. Petrarca)	05/12/2016	23/12/2016

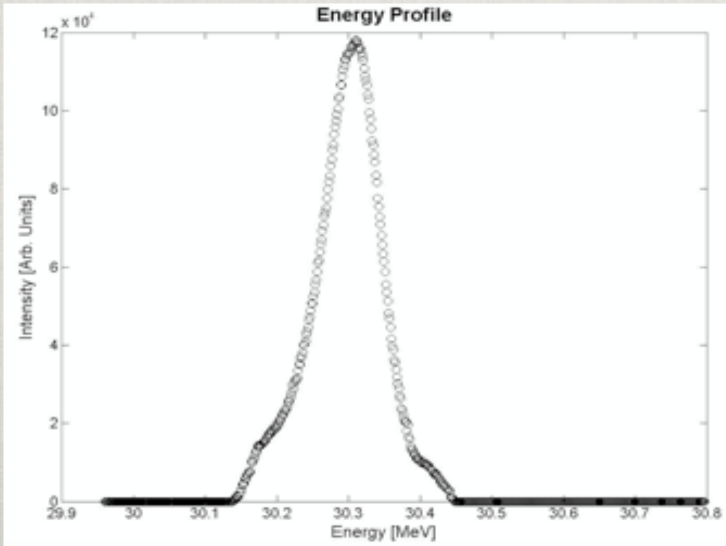
SL_Thomson backscattering

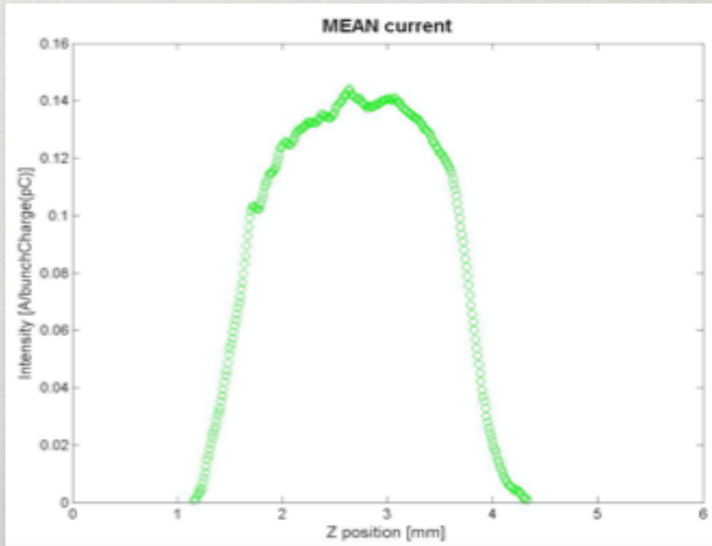


2^{nd} comm. phase (3 weeks shift on Jun 2015): 30 MeV Working point

- Charge = 100-200 ± 20 pC
- Energy = 29-31 ± 0.2 MeV
- Launch phase: Φ = + 30°
- Laser pulse length = 4.0 ps
- 1^{st} TW S1 phase: Φ = +32°
- 2^{nd} TW S2 phase: Φ = - 72°
- 3^{rd} TW S3 phase: Φ = - 134°
- Bunch length rms = 2.2 ps







Radiation measurements

1. Measurement of the **charge produced in a Si PIN diode** (Hamamatsu, 28mm x 28mm x 0.3mm), by an electrometer (Keithley)
    1. No polarisation, low dark current -> high sensitivity
    2. Wide linear dynamic range
    3. Low efficiency -> low background radiation signal

2. Charge Vs flux estimation, for a known incident spectrum, **previously calibrated** using monochromatic source (Elettra synchrotron)

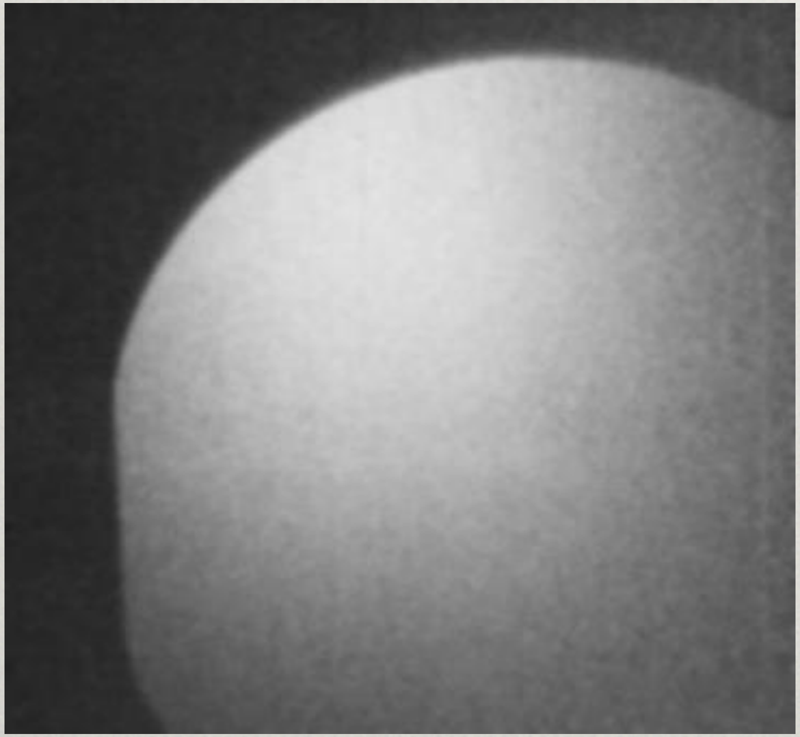
3. **The measured charge** (depends on conditions, around 10 pC per pulse) **is compatible with 10^4 photons (@ 20 keV) per pulse** on the detector sensitive volume, instead of:

$$N_\gamma = 4.8\times10^8 \frac{U_L[J]Q[pC]\delta_\phi}{h\nu[eV]\left(\sigma_x^2[\mu m]+\frac{w_0^2[\mu m]}{4}\right)} \approx 1.4\times10^6\ /\ shot$$

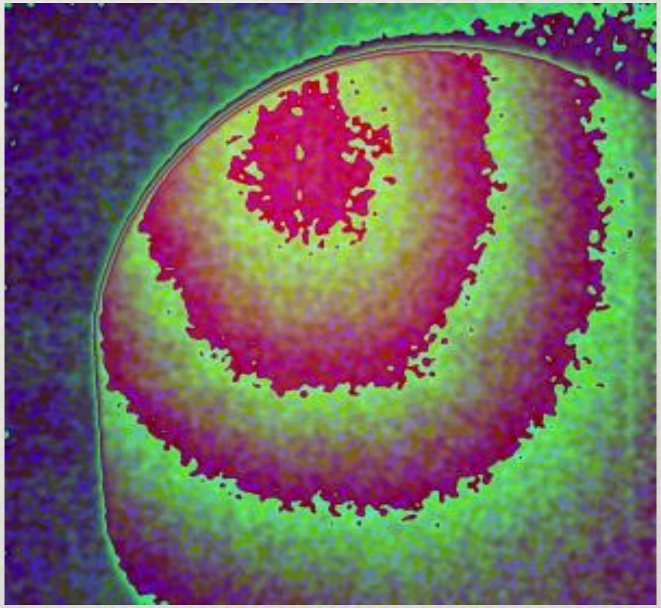
for $U_L \approx 2$ *J*, $Q \approx 200$ *pC*, $\delta_\Phi = 0.2$, $h\nu = 1.55$ *eV*, $\sigma_{x,y} \approx 110\,\mu m$, $w_o \approx 150\,\mu m$

Radiation measurements from imager

- Hamamatsu imager Flat Panel C9728DK-10
    - CMOS + 165 micron CsI
    - Pixel pitch 50 micron, 1032 x 1032



Exposure time 1 s, average over 100 images



Conclusions

- The 2^{nd} Commissioning phase of the SL_Thomson source took place in the June 2015 dedicated shift.
- The 30 MeV e^- beam energy WP has been addressed as foreseen for the first imaging experiment.
- With the available hw (phase shifters on 3 TW's) the applied acceleration/deceleration scheme worked well enough to produce a low energy spread e^- beam at 30 MeV, even though resulting in a strong sensitivity for the e^- beam to the machine imperfections/stability.
- The measured photon flux is still below the foreseen value (10^4 vs 10^6 photons/pulse)

Next: Collision Optimization

- 4-button BPM installation downstream the IP and on the dumping pipe to control the e^- beam trajectory inside the solenoid

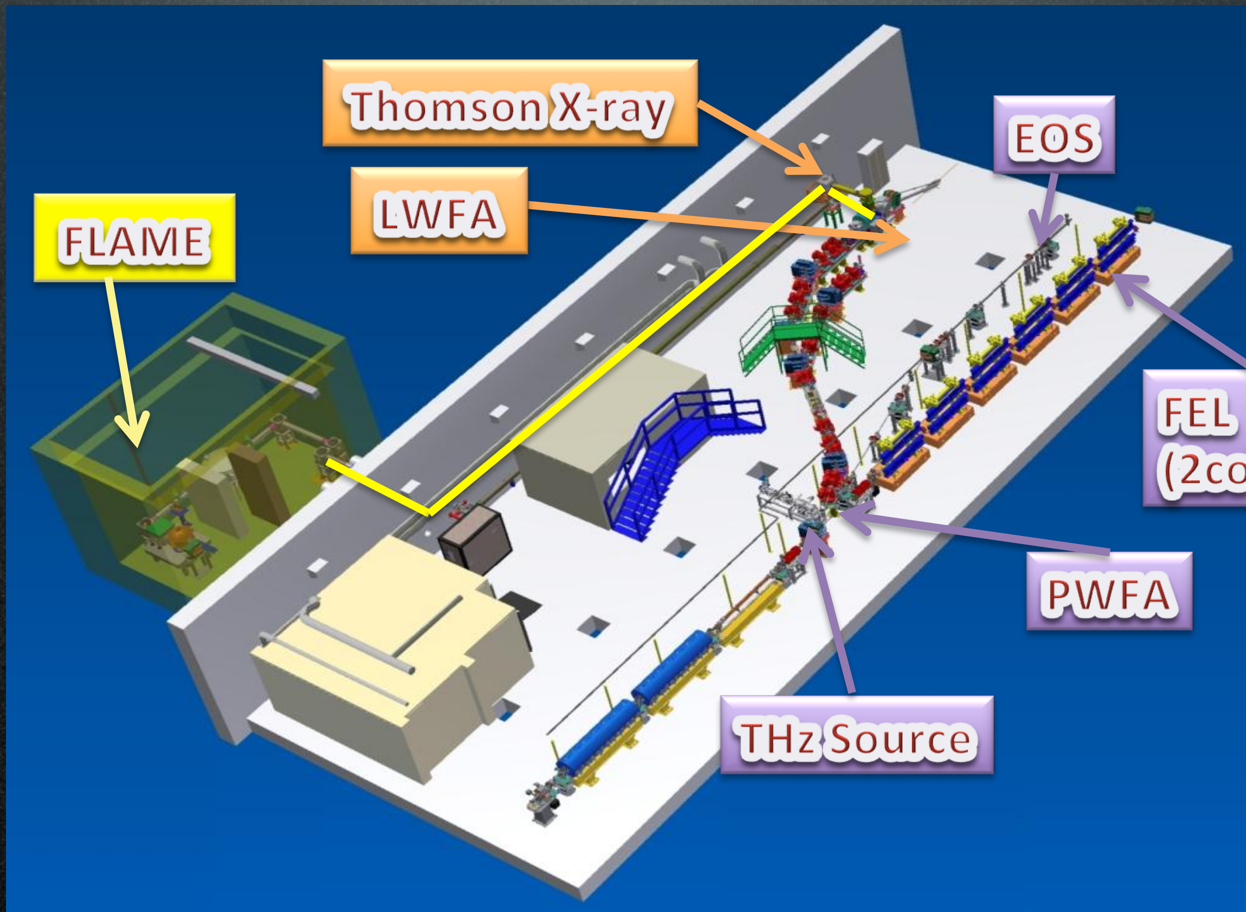
- Referenced Pinhole insertion upstream and downstream for FLAME laser beam alignment to increase the realignment precision)

- Radiation exit window replacement DN100 vs DN40 (done)

- Tapered pipe replacement w straight one (DN100) (done) to reduce background and allow to squeeze the e-beam down to nominal size

- 1 cm shift (vs lattice model) in one 2nd dogleg quad (recovered)

Publications 2015



Analogical optical modeling of the asymmetric lateral coherence of betatron radiation
B Paroli, E Chiadroni, M Ferrario, MAC Potenza
Optics Express 23 (23), 29912-29920

Resonant interaction between laser and electrons undergoing betatron oscillations in the bubble regime
A Curcio, D Giulietti, G Dattoli, M Ferrario
Journal of Plasma Physics 81 (05), 495810513

New technology based on clamping for high gradient radio frequency photogun
D Alesini, A Battisti, M Ferrario, L Foggetta, V Lollo, L Ficcadenti, ...
Physical Review Special Topics-Accelerators and Beams 18 (9), 092001

Asymmetric lateral coherence of betatron radiation emitted in laser-driven light sources
B Paroli, E Chiadroni, M Ferrario, V Petrillo, MAC Potenza, AR Rossi, ...
EPL (Europhysics Letters) 111 (4), 44003

Six-dimensional measurements of trains of high brightness electron bunches
A Cianchi, D Alesini, MP Anania, A Bacci, M Bellaveglia, M Castellano, ...
Physical Review Special Topics-Accelerators and Beams 18 (8), 082804

Novel schemes for the optimization of the SPARC narrow band THz source
B Marchetti, A Bacci, E Chiadroni, A Cianchi, M Ferrario, A Mostacci, ...
Review of Scientific Instruments 86 (7), 073301

Two-Color Radiation Generated in a Seeded Free-Electron Laser with Two Electron Beams
A Petralia, MP Anania, M Artioli, A Bacci, M Bellaveglia, M Carpanese, ...
Physical review letters 115 (1), 014801

Intense terahertz pulses from SPARC LAB coherent radiation source
F Giorgianni, M Bellaveglia, M Castellano, E Chiadroni, A Cianchi, ...
SPIE Optics+ Optoelectronics, 95090O-95090O-6

Operational experience on the generation and control of high brightness electron bunch trains at SPARC-LAB
A Mostacci, D Alesini, MP Anania, A Bacci, M Bellaveglia, A Biagioni, ...
SPIE Optics+ Optoelectronics, 95121Q-95121Q-8

Segmented undulator operation at the SPARC-FEL test facility
F Ciocci, MP Anania, M Artioli, M Bellaveglia, M Carpanese, E Chiadroni, ...
SPIE Optics+ Optoelectronics, 951203-951203-8

Seeded FEL with two energy level electron beam distribution at SPARC_LAB
F Villa, D Alesini, MP Anania, M Artioli, A Bacci, M Bellaveglia, ...
SPIE Optics+ Optoelectronics, 95120T-95120T-7

6D electron beam diagnostics at SPARC_LAB
A Cianchi, MP Anania, A Bacci, M Bellaveglia, M Castellano, E Chiadroni, ...
SPIE Optics+ Optoelectronics, 95120E-95120E-7

Coherence properties and diagnostics of betatron radiation emitted by an externally-injected electron beam propagating in a plasma channel
B Paroli, E Chiadroni, M Ferrario, A Mostacci, V Petrillo, MAC Potenza, ...
Nuclear Instruments and Methods in Physics Research Section B: Beam ...

Pre-wave zone studies of Coherent Transition and Diffraction Radiation
V Shpakov, M Bellaveglia, M Castellano, E Chiadroni, A Cianchi, ...
Nuclear Instruments and Methods in Physics Research Section B: Beam ...

From SPARC_LAB to EUPRAXIA
(via EUSPARC?)

EuPRAXIA

Officially started on November 1, 2015

Excellent Science
Developing new world-class research infrastructures
H2020-INFRADEV-1-2014-1

Deadlines: 02/09/2014
Opening Date: 11/12/2013

ESFRI European Strategy Forum on Research Infrastructures

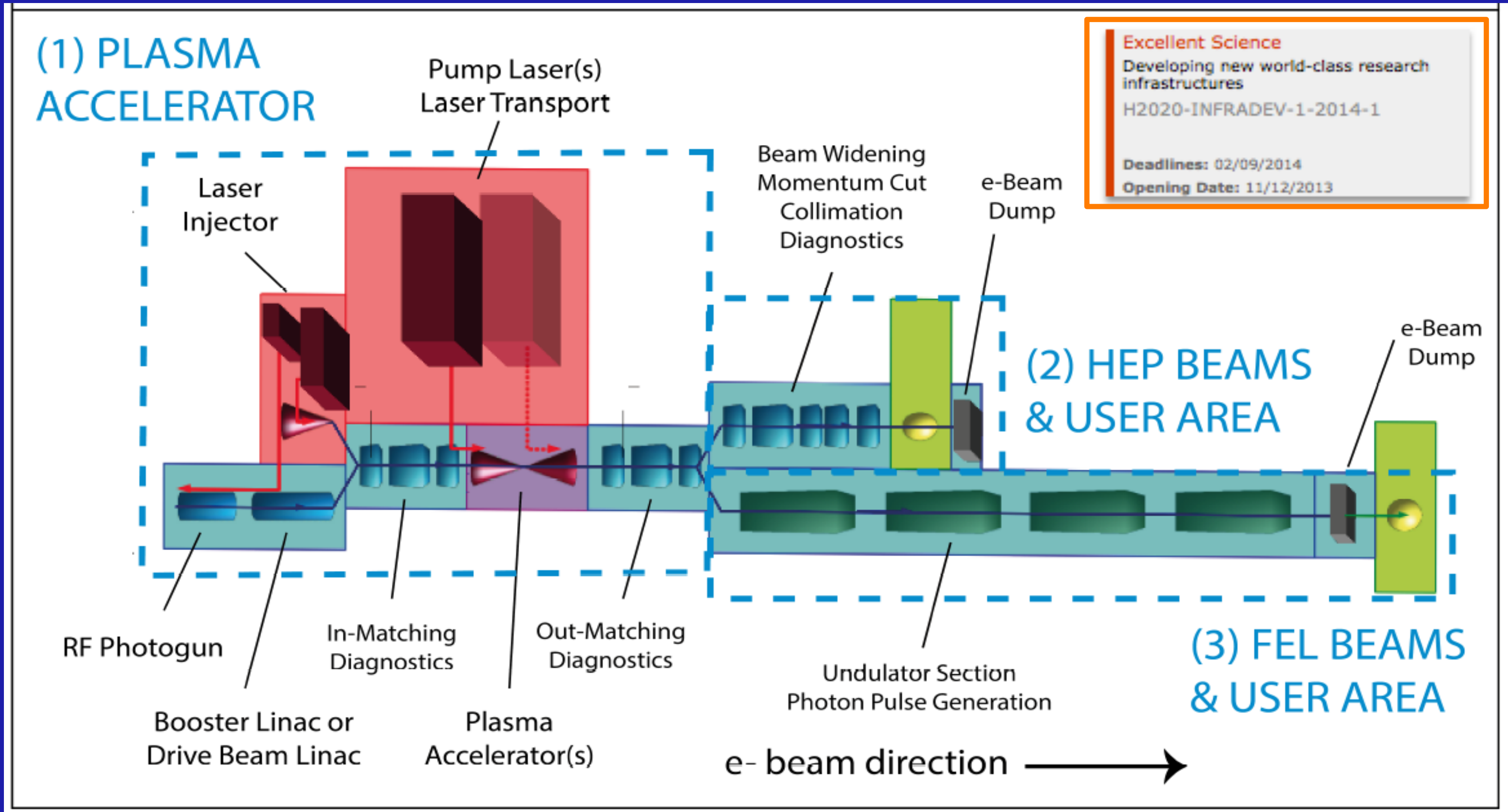
~200 M€

- Design Studies with at least 3 Countries,
- Cost. Schedule, Siting?
- What is the governance model?
- What is the intended user community?
- Will it be open access?
- Apply for H2020 preparatory phase (PP)?

- Support will be provided by Horizon2020 and MIUR for the implementation (PP) and operation of the research infrastructures listed on the ESFRI Roadmap and ERIC.

Design Study on the "European Plasma Research Accelerator with eXcellence In Applications" (EuPRAXIA)

Approved as HORIZON 2020 INFRADEV, 4 years, 3 M€



A commercially available 1 PW Ti: Sa laser laser driver or a high brightness 1 GeV electron beam linac could be adequate drivers for the EUPRAXIA plasma accelerator.

The foreseen parameters give access to:

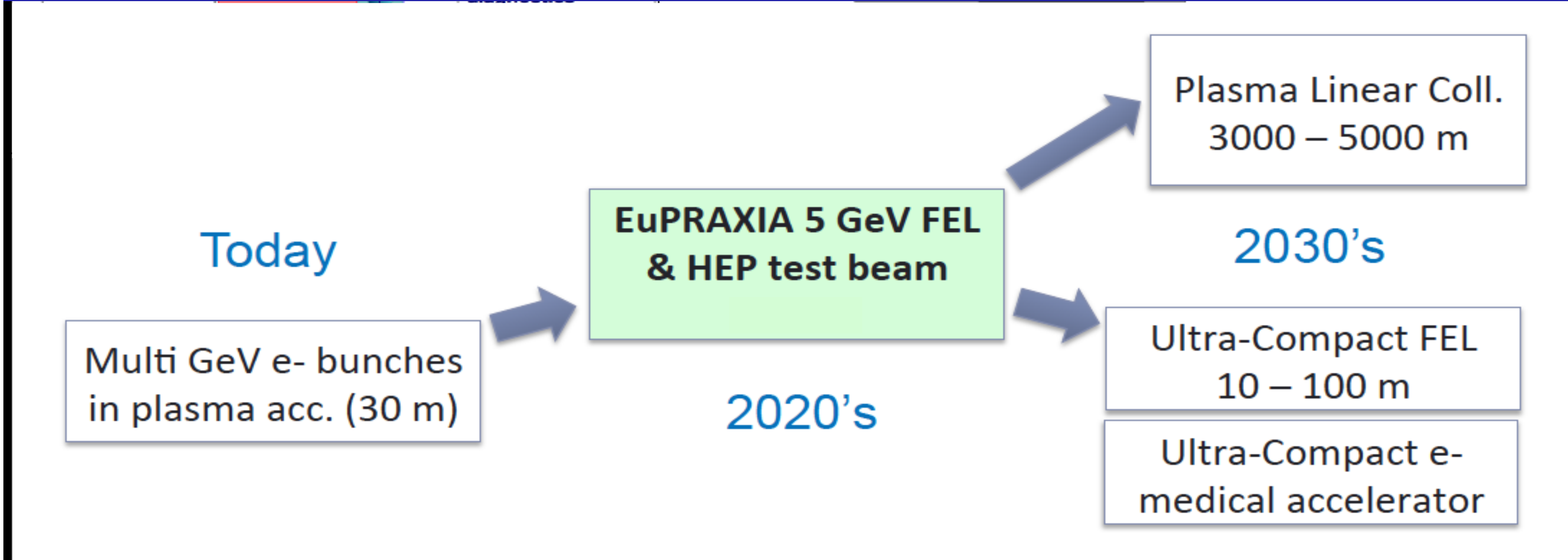
(1) to an FEL in the EUV to X-ray regime (1 – 15 nm) and

(2) to short electron pulses with high brightness for HEP detector tests, material tests and other applications.

Beam Parameter	Unit	Value
Particle type	-	Electrons
Energy	GeV	1 – 5
Charge per bunch	pC	1 – 50
Repetition rate	Hz	10
Bunch duration	fs	0.01 - 10
Peak current	kA	1 – 100
Energy spread	%	0.1 – 5
Norm. emittance	mm	0.01 – 1
FEL wavelength	nm	1 - 15

Positioning of the Project

The **EuPRAXIA project will bridge the gap between successful proof-of-principle experiments (today) and a reliable technology with many applications (end of the 2020's)**. It should be considered as a ground-breaking, full-scale demonstration facility with pilot users and unique ultra-fast science features. EuPRAXIA would solve several technical shortcomings with known solutions and prove the potential of plasma accelerators for users. It would establish the basis for applications in industry, medicine, photon science and HEP.

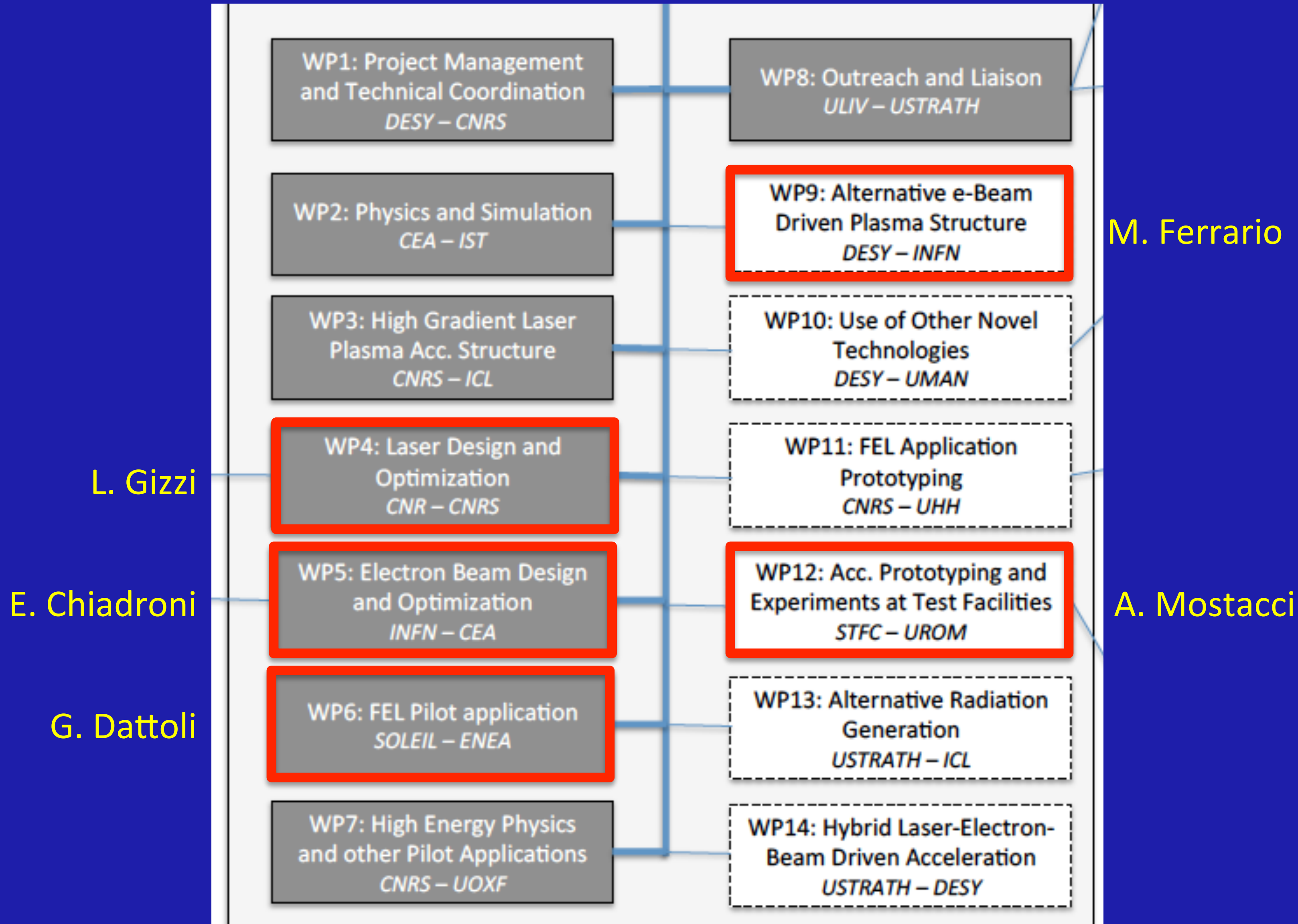


EuPRAXIA Participants

Participant no.	Participant organisation name	Short name	Country
1 (Coordinator)	Stiftung Deutsches Elektronen Synchrotron	DESY	Germany
2	Istituto Nazionale di Fisica Nucleare	INFN	Italy
3	Consiglio Nazionale delle Ricerche	CNR	Italy
4	Centre National de la Recherche Scientifique	CNRS	France
5	University of Strathclyde	USTRATH	UK
6	Instituto Superior Técnico	IST	Portugal
7	Science & Technology Facilities Council	STFC	UK
8	Synchrotron SOLEIL – French National Synchrotron	SOLEIL	France
9	University of Manchester	UMAN	UK
10	University of Liverpool	ULIV	UK
11	Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenible	ENEA	Italy
12	Commissariat à l'Énergie Atomique et aux énergies alternatives	CEA	France
13	Sapienza Universita di Roma	UROM	Italy
14	Universität Hansestadt Hamburg	UHH	Germany
15	Imperial College London	ICL	UK
16	University of Oxford	UOXF	UK

SPARC LAB
SPARC LAB
SPARC LAB
SPARC LAB

EuPRAXIA WPs and SPARC_LAB responsibilities (SPARC_LAB WG leaders or deputy leaders)



An upgraded (<1 GeV, <1 PW) SPARC_LAB facility could be a strong candidate for the EuPRAXIA site

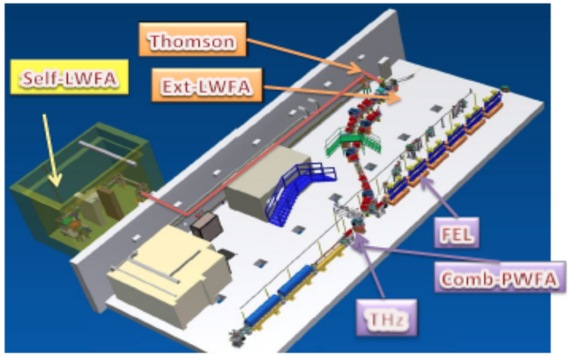
WHAT NEXT AT SPARC_LAB ?

M. Ferrario on behalf of the SPARC_LAB Collaboration

April 24, 2014

1- INTRODUCTION

SPARC_LAB [1] (Sources for Plasma Accelerators and Radiation Compton with Lasers And Beams) is an inter-disciplinary laboratory with unique features in the world. Born from the integration of a last generation photo-injector (SPARC)[2-7], able to produce electron beams up to 200 MeV energy with high peak current (> 1 kA) and low emittance (<2 mm-mrad), and of a high power laser (> 200 TW) (FLAME) [8,9], able to produce ultra-short pulses (<30 fs), SPARC_LAB has already enabled the development of innovative radiation sources and the test of new techniques for particle acceleration using lasers.

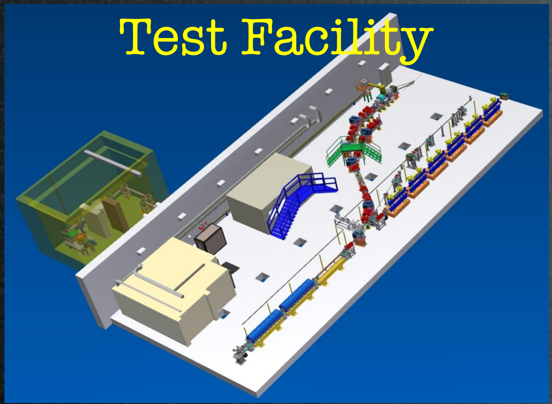


Layout of SPARC_LAB beam lines

In particular the following highlight results have been achieved:

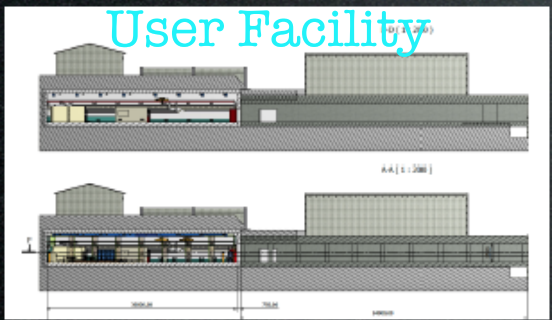
- a Free Electron Laser has been commissioned producing coherent radiation tunable from 500 nm down to 40 nm and new regimes of operation like Seeding, Single Spike, Harmonic Generation and Two Colors have been observed [10-14];
- a source of both broad band, narrow band (<30%) and high energy (> 10 μJ) THz radiation has been tested, first experiments with users are underway [15,16];
- electrons have been accelerated up to 100 MeV in 4 mm long plasma wave excited by the high power laser FLAME [9];

From SPARC_LAB to EUPRAXIA



SPARC_LAB Consolidation: on going, ~3 years

- FLAME maintenance
- Injector upgrade (C-band, X-band)
- THz user beam line upgrade
- Thomson and Plasma beam lines final commissioning
- FEL new short period undulator



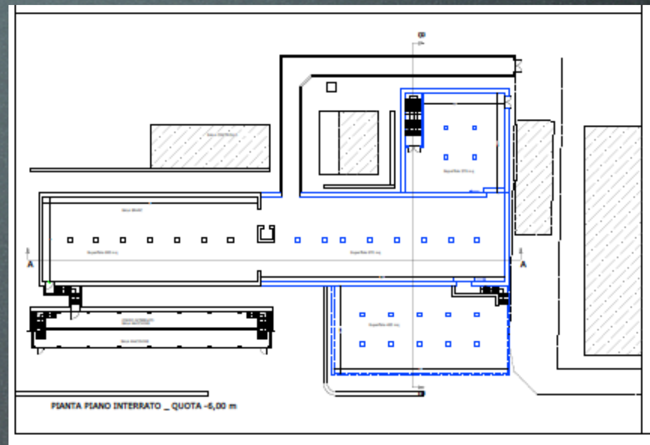
EUSPARC: proposed, ~5 years

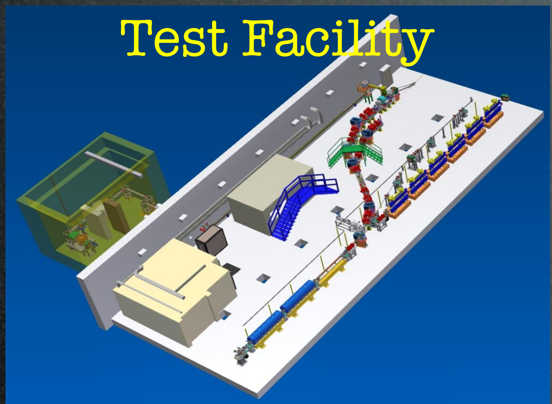
- Infrastructure extension
- Linac upgrade <1 GeV (L-S-C-X-band, multi-bunches)
- FLAME upgrade towards 1 PW
- Plasma, dielectric and high frequency acceleration
- Positron production and acceleration with plasma
- Advanced FEL schemes (oscillator, optical,QFEL?)
- THz, Compton and FEL user beam lines
- AND RELIABILITY !!!!

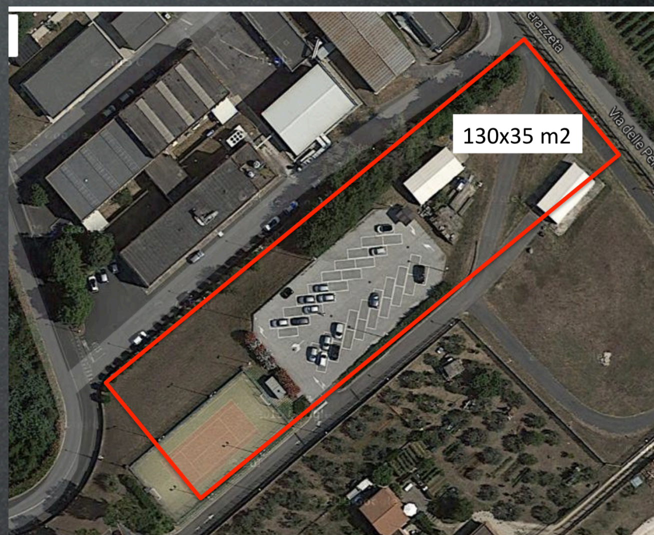
EUPRAXIA, ~10 years, ~200 M€

- Plasma based FEL Pilot User Facility
- Plasma based HEP beam line

Civil Engineering options







EUSPARC Working Groups Organization

WG 1 – Injector and Linac (E. Chiadroni, A. Gallo)

WG 2 – Laser system (L. Gizzi, M. P. Anania)

WG 3 – LWFA and PWFA beam lines (A. Cianchi, A. R. Rossi)

WG 4 – Plasma driven FEL, advanced FEL schemes (G. Dattoli, F. Villa)

WG 5 – Advanced positron sources, fundamental physics experiments

WG 6 – Advanced THz, Compton and FEL sources with user beam lines (....., C. Vaccarezza)

WG 7 – Civil Engineering, Plants, Controls and Radiation Safety (U. Rotundo, G. Di Pirro)


Thank you