



## Laboratori Nazionali di Frascati: present status and future plans

P. Campana – CVI – 19.10.2015

## LNF mission

Accelerator Science for Particle Physics has been always an asset of LNF, **and such a characterization should remain**, within INFN and outside.

Photonics and related technologies are also considered strategic (although the Frascati and INFN context is different from that of SLAC or DESY)

The R&D on new accelerating techniques and the preservation of the capability of conceiving, building and operating large complex **are key elements of Lab's future**

Moreover, there is **a long tradition in building large detectors**, together with an experience in detector R&D: in this area, a strategic focus is needed to keep excellence and international visibility

A technological hub for INFN in view of LHC phase 2 upgrades

Keep an eye to “societal benefits” coming from our activities

Making use of our infrastructures to attract external resources (EU funds, etc...)

Our fundamental research **is highly fascinating for the public** and the young generation: it is among the driving subjects for the general interest in science. The Lab should foster its engagement in a **strong effort in dissemination and outreach**



## Accelerator Science

Accelerator Division and Technical Division (~120 staff) are focused on 3 strategic activities:

- 1) The DAFNE operation to complete the scientific program
- 2) The construction and the commissioning of ELI-Nuclear Physics in Romania
- 3) The operation and the upgrade of SPARC\_LAB

Other activities:

- Participation to study groups for HL-LHC and FCC
- Commissioning of KEK beams (crab waist scheme)
- Collaboration with ESRF
- STAR project at Univ. of Calabria (a small Thomson X-ray machine)
- Future ideas (mumu collider, compact accelerators, ...)

Key point: guarantee enough resources for the strategic activities

Points 2) and 3) are possible thanks to external funds

Due to the large number of retirements and to hiring difficulties, without external funds, **not only activities 2) and 3) would not be possible, but also 1)**

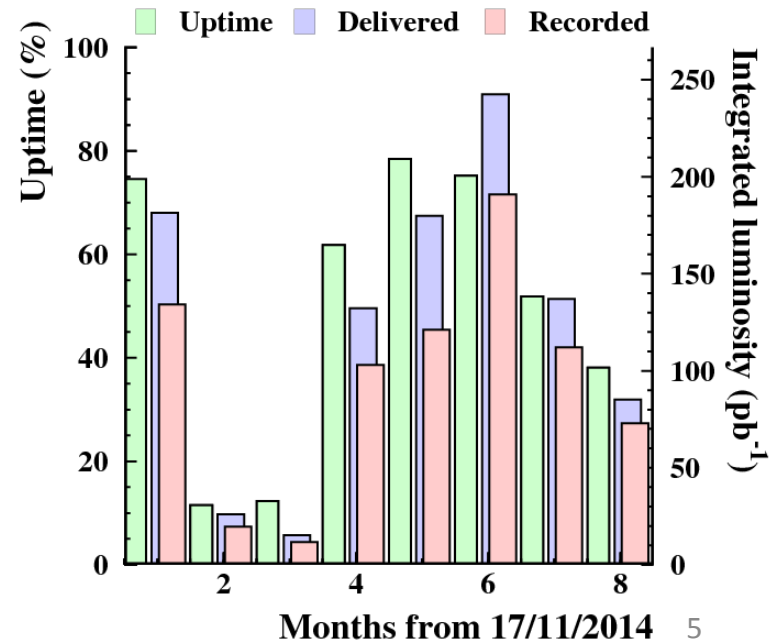
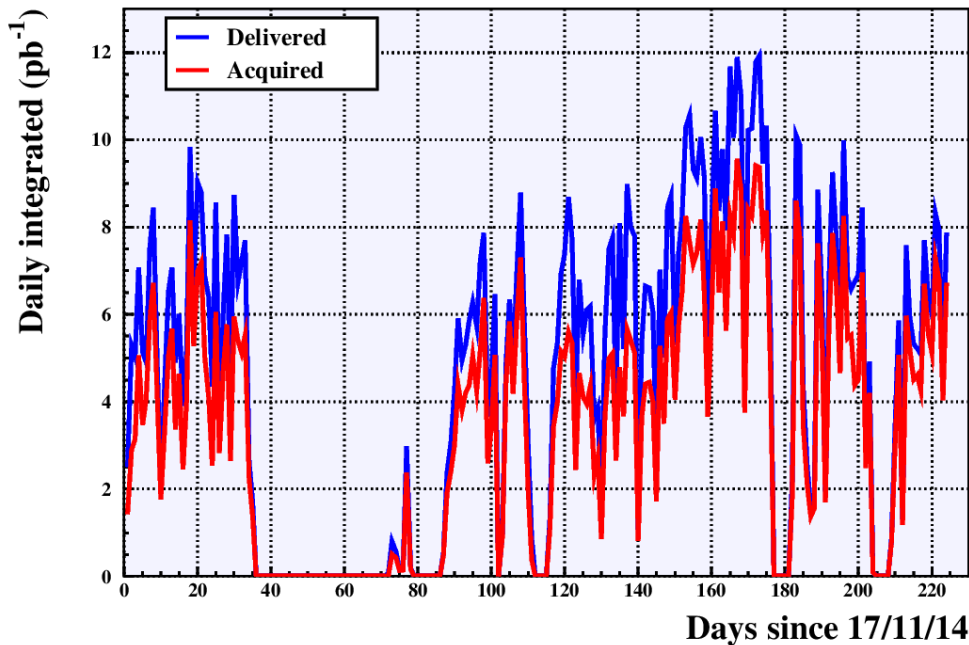
In 2015, 26 active projects on external funds (the majority in Accel. Div., but not only), for a total initial budget of **12.3 ME**

# DAFNE

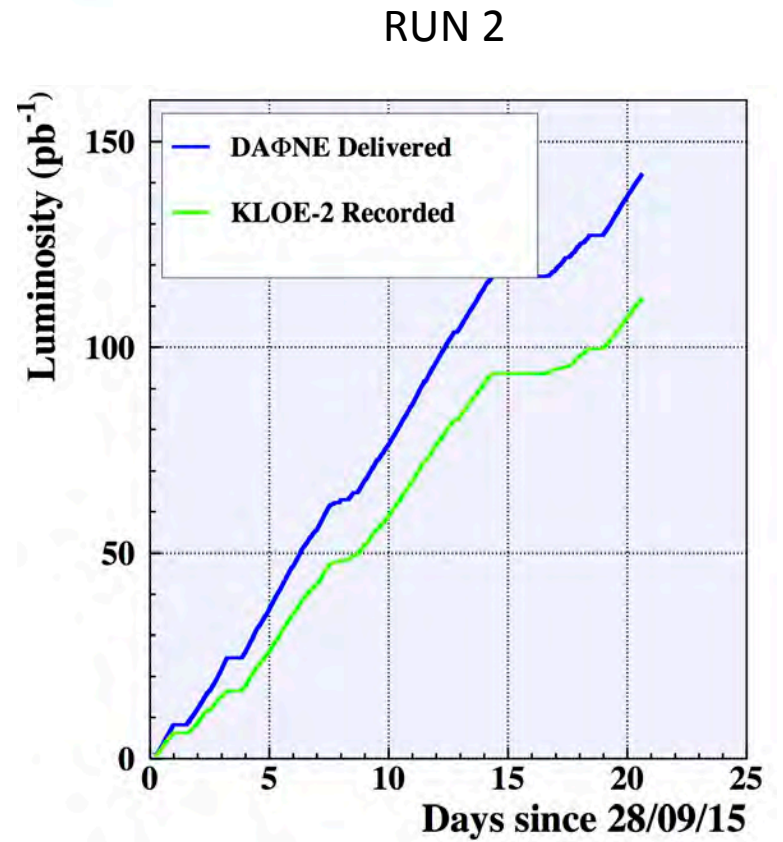
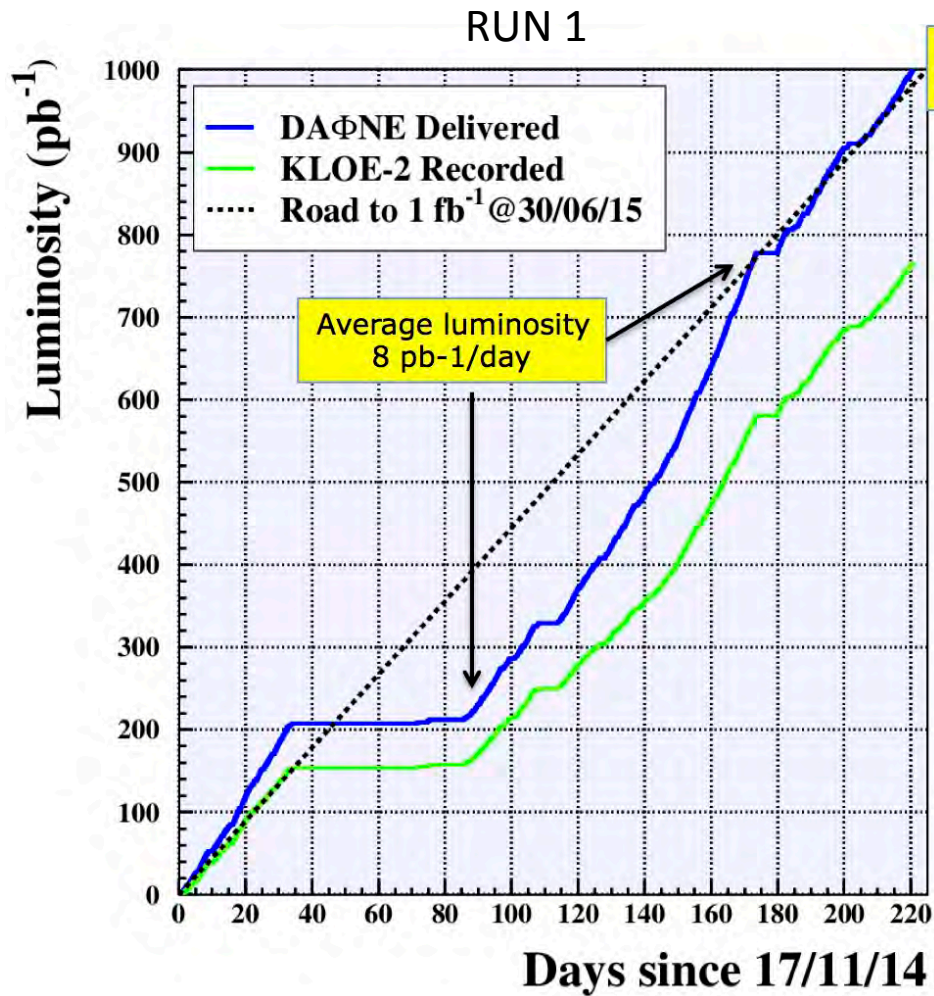
Operating DAFNE at high efficiency to complete the physics program (KLOE2 & Siddharta) is a priority of the Lab to show that commitments can be fulfilled

DAFNE has shown to be able to provide  $\sim 200 \text{ pb}^{-1}/\text{month}$  and there are the conditions to deliver the  $5 \text{ fb}^{-1}$  required by KLOE2 by the end of 2017

DAFNE - after an intense consolidation in 2013/14 - has operated [Nov 2014-July 2015 \(Run 1\)](#) delivering  $\sim 1 \text{ fb}^{-1}$  and it is in data taking now for Run 2 ([Sept 2015-July 2016](#))  
The target is to collect  $\sim 1.5 \text{ fb}^{-1}$  more in one year from now







In June DAFNE reached a record luminosity of  $2 \cdot 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$  with  $1.0 \times 1.0 \text{ A}^2$   
Machine physicists believe that there are still margins to achieve better performance

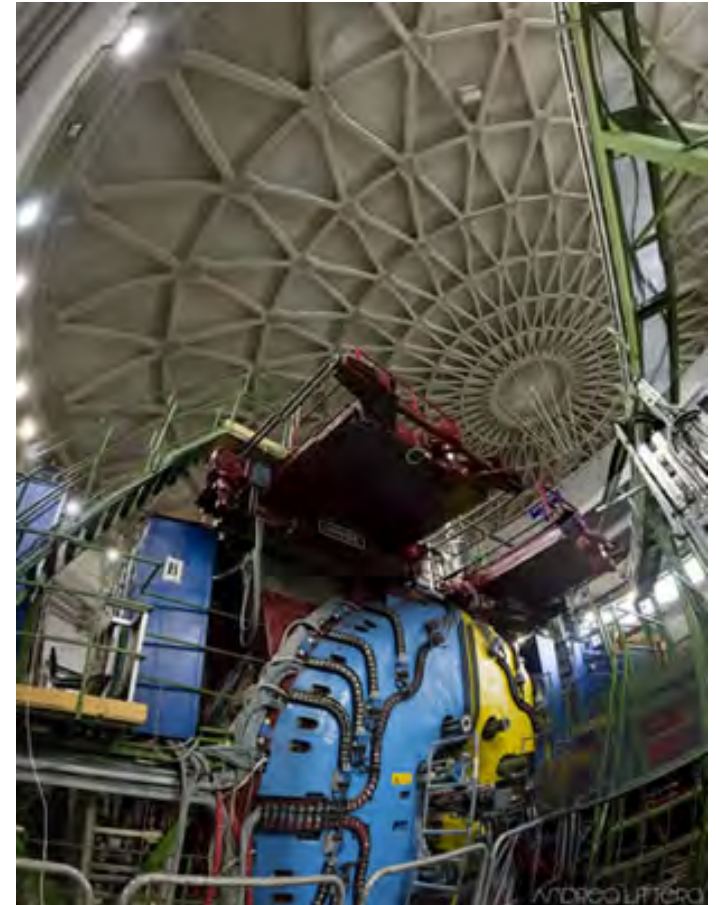
The crab-waist scheme (invented in Frascati and to be used in KEK) gives a better luminosity (factor  $\sim 3$ ) with higher backgrounds.

KLOE2 data are of enough good quality to perform the physics program ( $\pi^0$  width, U-boson searches, quantum interferometry,  $K_s$  rare decays, ... )

The machine restarted after a summer shutdown, to do a series of maintenance interventions on cooling systems, on LINAC and on cryogenics

DAFNE is in data taking mode since the end of September and Run2 will lasts until  $\sim$ July 2016.

So far  $\sim 140 \text{ pb}^{-1}$  have been delivered in 21 days (with a programmed stop of 2 days)



## ELI-NP Infrastructure

A state-of-art accelerator to produce high intensity 20 MeV photons, to be built in Romania, using EU structural funds.

A consortium of Rome University/INFN/STFC/CNRS and several European industries.  
Makes use of many R&D performed within SPARC\_LAB activities at LNF  
A truly interdisciplinary photon infrastructure with challenging performance

Target: complete the construction and the commissioning by 2019.

A pivotal commitment that guarantees external funds and human resources to INFN and to Frascati





Frascati is the main contractor and has several Working Package responsibilities: machine physics, diagnostics, radio-frequency and feedback systems, module integration, beam dump, radio-protection, safety.

Personnel of Accelerator and Technical Divisions is strongly involved

Status of module assembly is very advanced: however the building in Romania has a big delay (> 6 months). Careful monitor on the effects on the overall project

All technical issues of INFN responsibility are so far under control



## SPARC\_LAB

A Laboratory for advanced R&D on plasma accelerating structures (PWFA and LWFA) and photonic sources. A large platform of facilities:

- a power laser (0.2 PW),
- a plasma accelerating cell,
- a linear accelerator for  $e^+/e^-$  (180 MeV),
- a FEL,
- a Thomson source,
- a THz source.

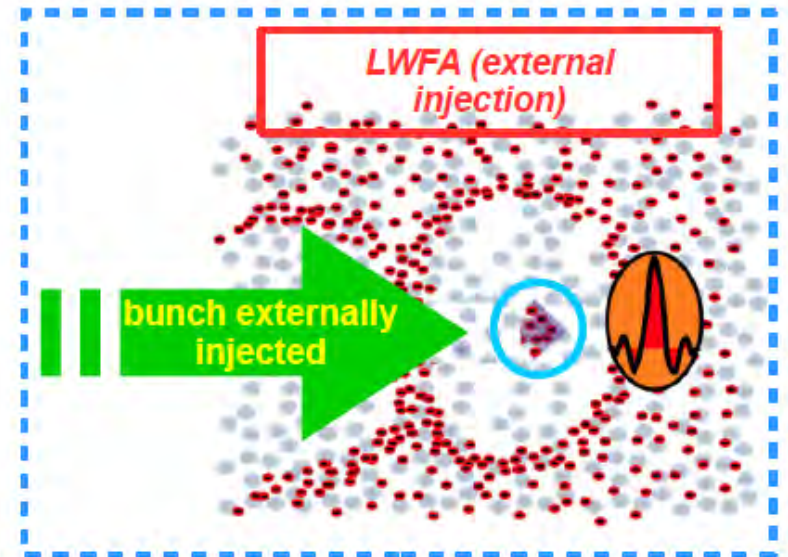
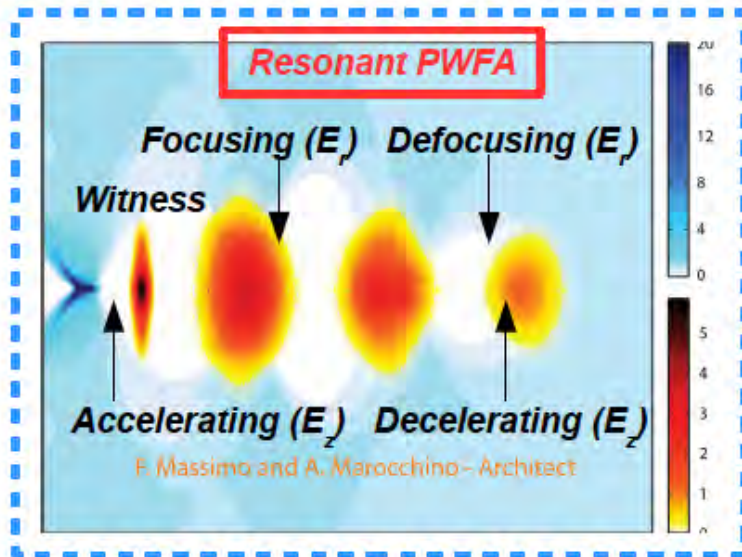
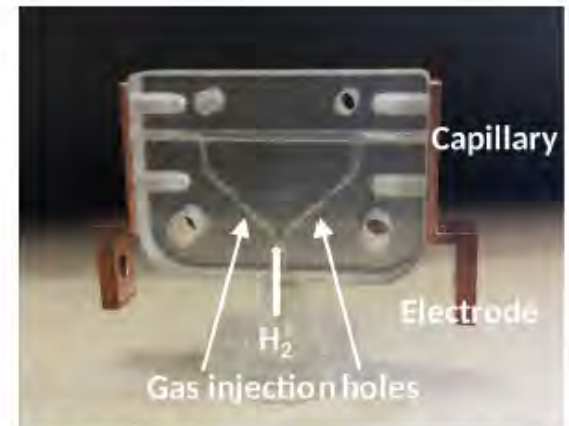
The LNF group is a leader in this field, with several original contributions (e.g. the COMB technique)

At the beginning of 2016, crucial tests on a PWFA plasma capillary cell will start to accelerate electrons in the wake field of other electrons



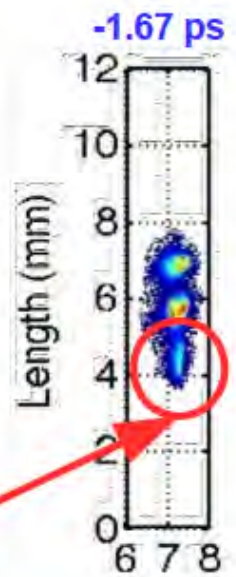
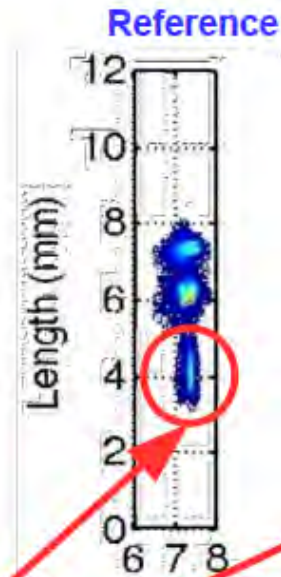
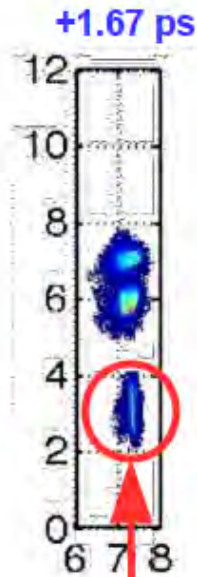
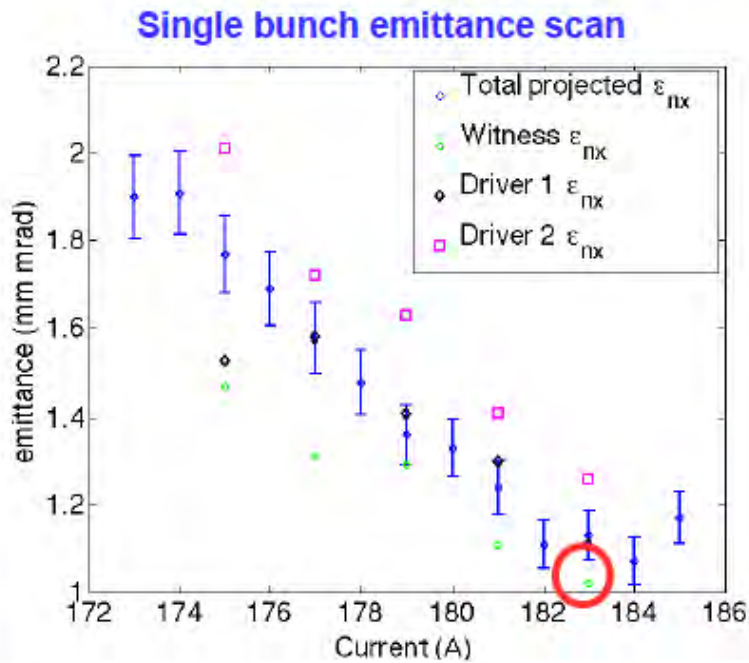
# Plasma-based acceleration activities

- Several plasma-based schemes will be tested
  - **PWFA resonant scheme** → 1-2 GV/m expected
    - $n_e \sim 10^{16} \text{ cm}^{-3}$ , 1 mm diameter capillary, Hydrogen
  - **LWFA, external injection** → 5-10 GV/m expected
    - $n_e \sim 10^{17} \text{ cm}^{-3}$ , 100  $\mu\text{m}$  diameter capillary, Hydrogen
- Goal: **high quality** accelerated beams
  - Maintain the high brightness of injected beams





# COMB Experimental results (LNF)

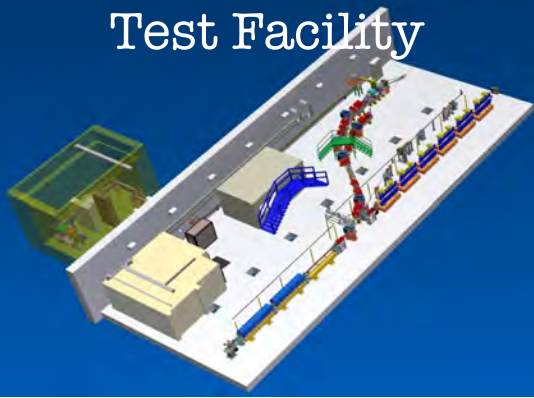


**Witness position tuning with laser delay line!**



# Future scenarios

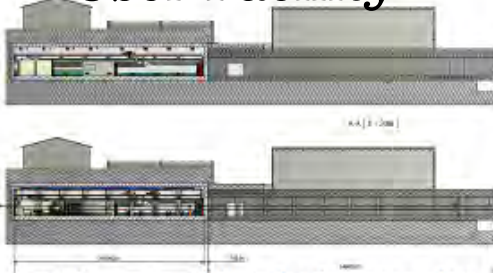
## Test Facility



Consolidation: on going,  $\sim 3$  years

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

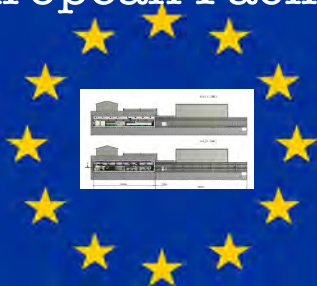
## User Facility



Upgrade: proposed,  $\sim 5$  years

- Infrastructure extension
- Linac upgrade  $\sim 1$  GeV (C-X-band, multibunch)
- THz, X-ray Compton and FEL user facility
- Advanced FEL schemes (oscillator?)
- FLAME Laser upgrade towards 1 PW
- Plasma, dielectric and high frequency acceleration
- Positron production and acceleration with plasma
- USER FACILITY !!!!

## European Facility

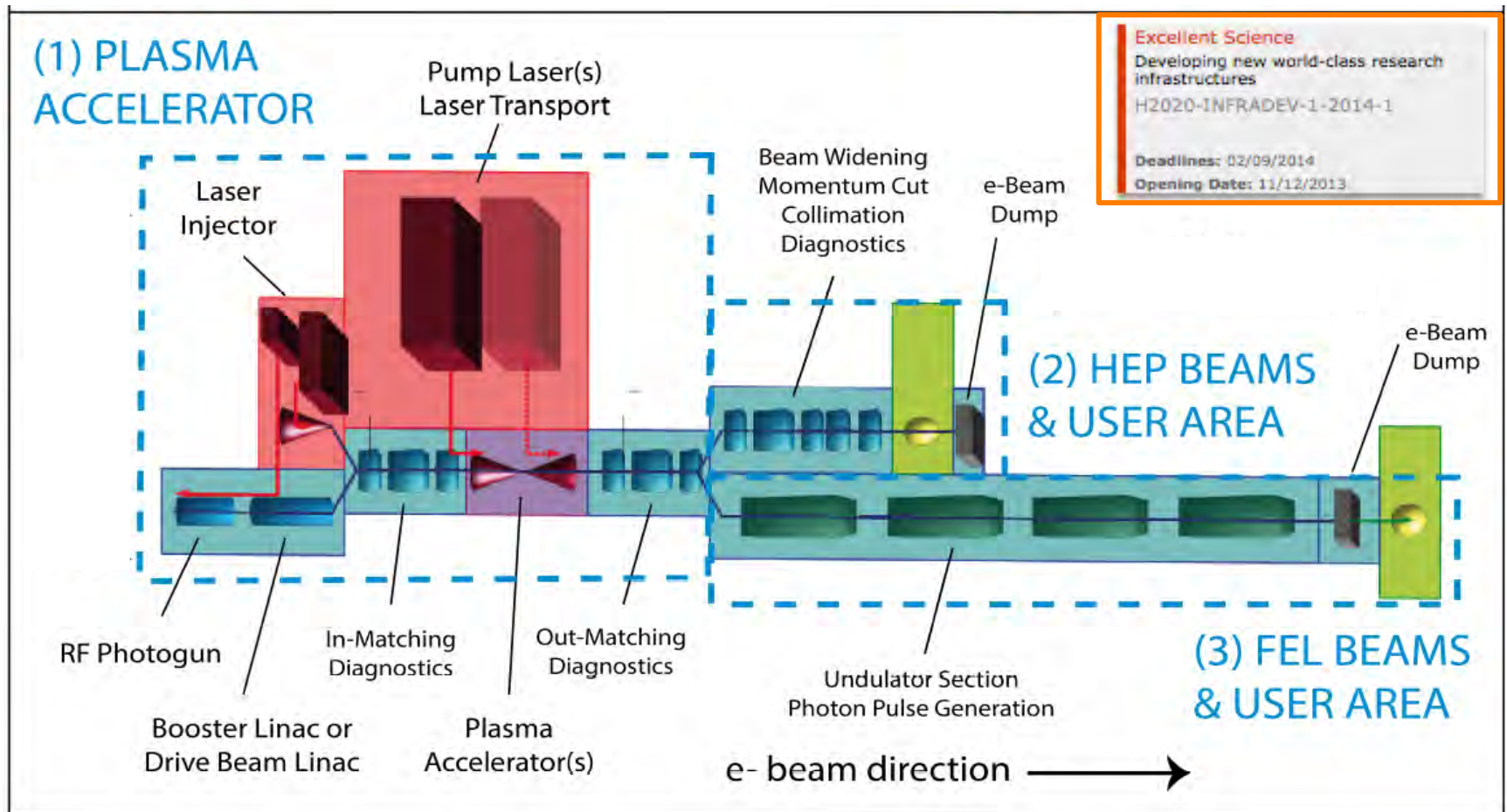


European Facility,  $\sim 10$  years,  $\sim 200$  M€

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

# Design Study on the "European Plasma Research Accelerator with eXcellence In Applications" (EuPRAXIA) - Approved in HORIZON2020 INFRADEV, 4 years, 3 M€

(Desy-INFN-CNR-ENEA-CNRS-CEA-STFC-LaSapienza + other universities)



## SPARC\_LAB upgrade

The current space for SPARC\_LAB is not enough for any future upgrade

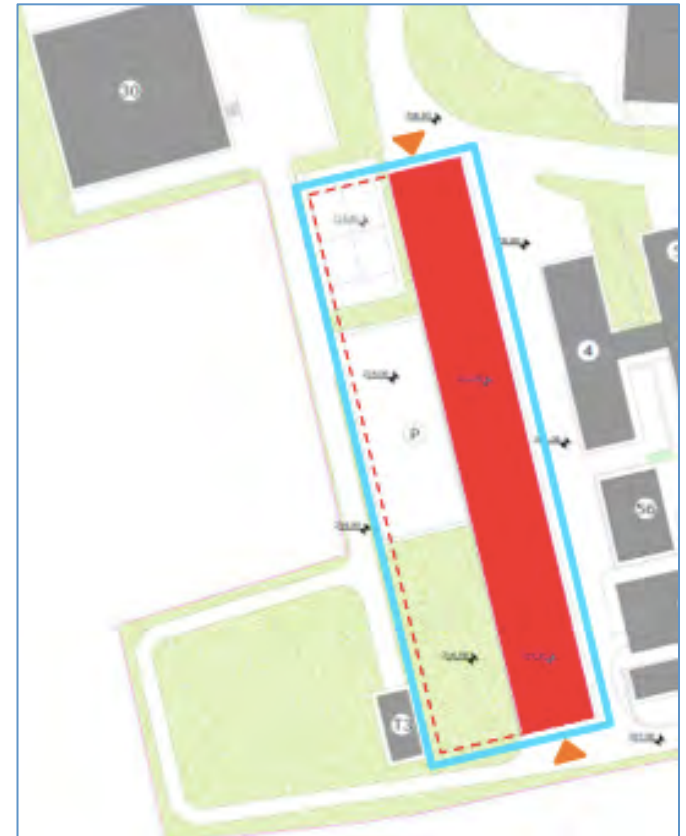
The Lab is planning to setup a new SPARC\_LAB facility to:

- to push Frascati as a possible site for a future European infrastructure
- to create a true facility open to users and to R&D in photonics (THz, FEL, Thomson scattering, etc ...)

All large laboratories are investing in this direction (SLAC, DESY, etc...)

We are currently studying an expansion of the bunker, the creation of space for users, etc... In near future, human resources currently committed to DAFNE-Light could converge to SPARC\_LAB

In the next months, prepare a plan which chooses the site (within LNF), evaluates the costs for the buildings and the facility infrastructures, and submit it to INFN



## What next

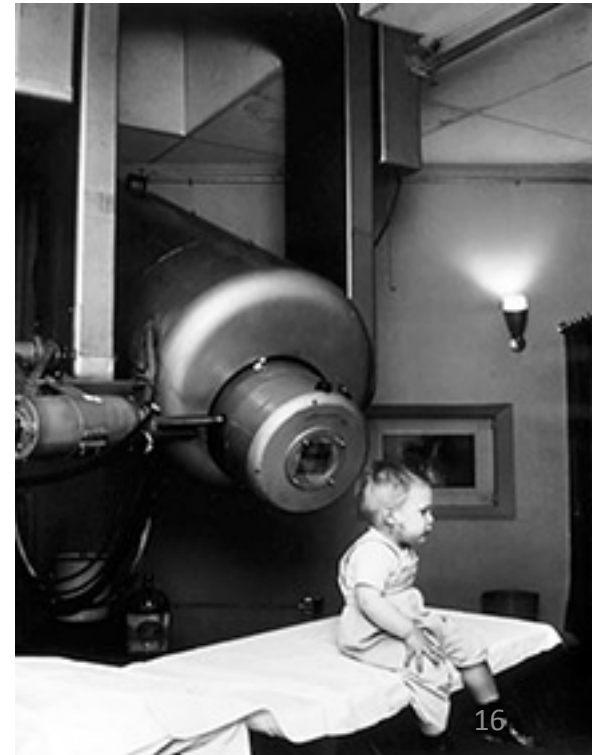
Looking forward, the Lab envisions a program – of European level – in the field of accelerators that can guarantee:

- resources, to maintain the competences
- international visibility and excellence
- technological transfer and return to Italian firms

The ELI-NP project has been very useful to fill a gap after the closing of Super-B project, and has allowed to maintain the competences

For several reasons, the EUPRAXIA design study represents an optimal initiative for the Lab: it has an accessible scale for LNF and can be built within its borders

If this *high value-high risk* program fails or is delayed, it is mandatory to identify other initiatives that will allow the Lab to maintain its characterization in the European Accelerator Science framework







LNf research  
infrastructures

## Beam Test Facility

A beam line (the DAFNE Linac) with  $e^-$ ,  $e^+$  and photons for a wide range of users (HEP, space, detectors, etc...)

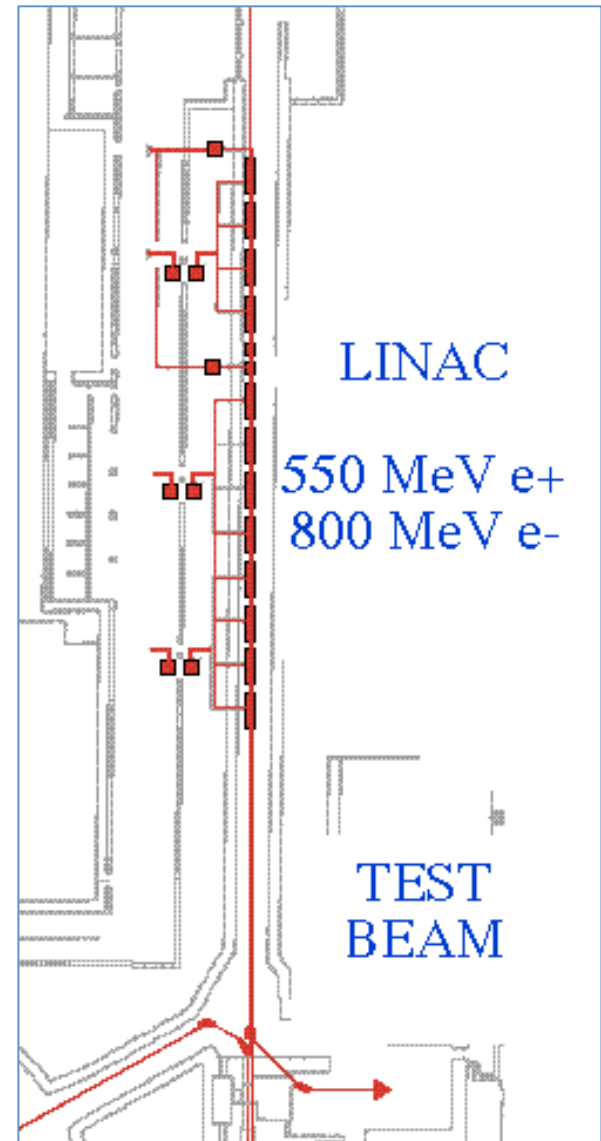
An increasing interest from other communities and industrial partners

Beam available for  $\sim 200$  days/year with high efficiency

A program of refurbishment/upgrade of the infrastructure:

- intensity increase for users and to run an experiment for the Search of Dark Photons, recently approved
- duplicate the lines to allow more independent users
- an area dedicated to space qualifications (strong interest from ESA and ASI)
- tagged photons, neutron source, etc...

These upgrades will take place adiabatically in 2016-17 with a modest interference with DAFNE operations



## Space related activities

A facility (SCF\_LAB) to characterize reflectors for telecommunications, for laser ranging and tests of Gravitational Relativity

A certified clean room with 2 solar simulators.

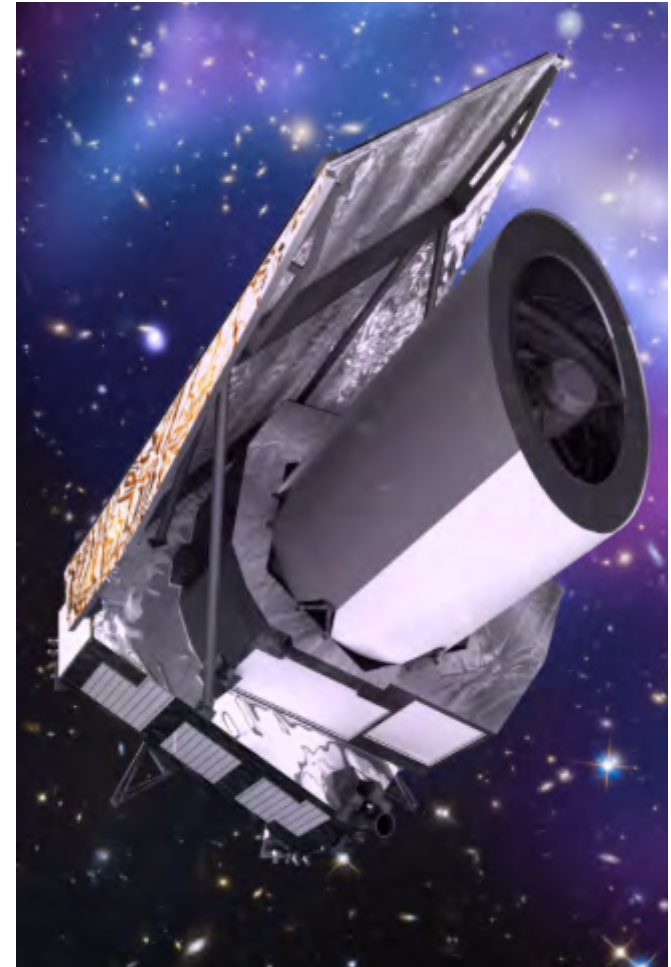
Support from ASI, ESA and NASA programs

The closing of the Nautilus gravitational antenna in mid 2016 will free a large cryostat and an assembly area to be possibly used for a facility dedicated to detector integration in balloons or small satellites

Initiative to be evaluated upon two requirements:

- Frascati astro-particle physicists are involved;
- external resources are made available

LNf may provide logistics and some engineering support

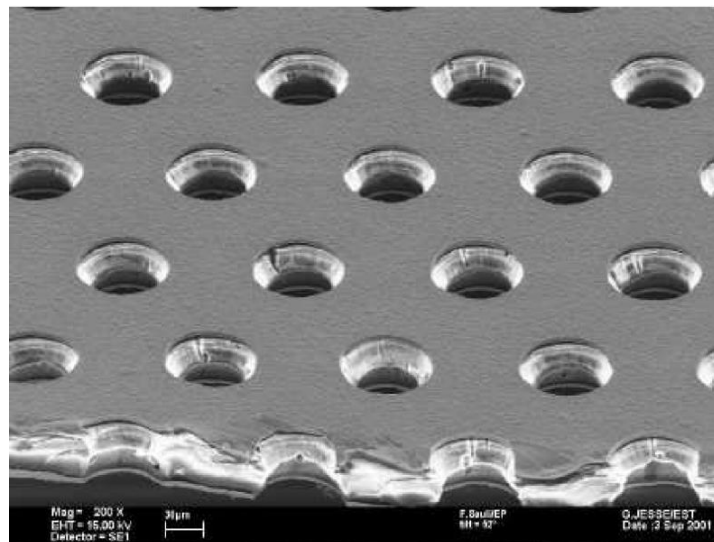


## $\mu$ Pattern Detector Laboratory

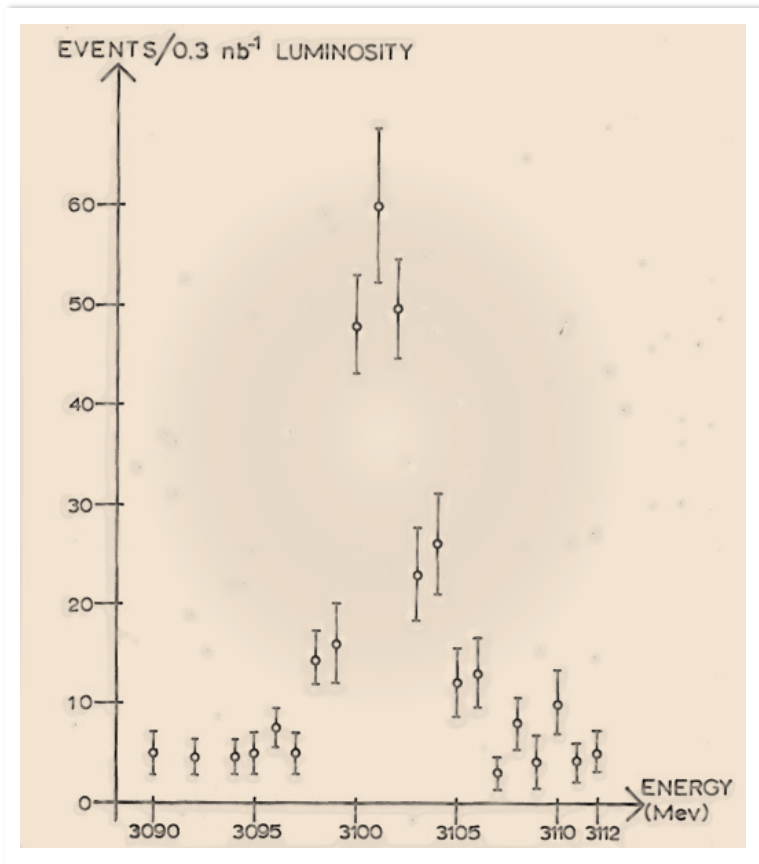
At LNF there is a strong know-how in this sector: GEMs present in LHCb, KLOE2, ATLAS, CMS, BES3 detectors and also for non HEP activities  
A wide interest in other INFN sections (Trieste, Bologna, Bari, etc...)

Currently, CERN is the only provider of such detectors. A semi-artisanal production.  
Working to setup an industrial collaboration with CERN and an Italian firm, to create a hub of production, test and R&D based in Frascati, to be available for all INFN requests and also from outside

In this frame, LNF could host  $\mu$ -pattern detector production for Phase2 LHC upgrades







Fundamental research

## Research Division Activities

INFN Research Division hosts 40% of Lab personnel (~160 staff)

Internal activities:

KLOE2 e Siddharta (at DAFNE),

PADME (dark photon search at BTF) ← new initiative

Moonlight (within SCF\_LAB)

Main research activities at outside Labs:

- the 4 LHC experiments and NA62 at CERN
- preparation for detectors at Fermilab muon campus (Muze, GMinus2)
- participation to JLAB (CLAS) e KEK (Belle2)
- astro-particle experiments (Juno, Jem-Euso, Km3) and several technological activities

In the next years, priority is given to the LHC-Phase 1 upgrades: ALICE (Si tracker)

LHCb (muon) ATLAS( $\mu$ -mega) CMS (GEM) constructions

Contributions are also foreseen for the preparation of PADME, Muze, Belle2, CLAS

A reorganization of Research Division technical support is on-going, to provide better support to experiment requests, and, preferably, also to other Lab activities



Outreach and  
dissemination

Commitment to foster and improve the on-going big effort.  
Some of the many activities in 2015:

- 1) OUTREACH SEMINARS for the Int. Year of the Light
- 2) OUTREACH SEMINARS at LNF and outside
- 3) GUIDED TOURS for the public
- 4) PROGRAM FOR KIDS
- 5) SCIENCE MATINEES
- 6) STAGES for high school students (also from abroad)
- 7) MASTERCLASS
- 8) OPEN DAY and RESEARCHERS' NIGHT
- 9) STAGES and TECHING for high school teachers
- 10) E-LEARNING on YOUTUBE CHANNEL
- 11) MULTIMEDIA MATERIAL
- 12) PARTICIPATION TO EU and ITALIAN EDUCATION MINISTRY FUND CALLS

~ 8,000 visitors and students in house

~14,000 contacts, including outside activities

Several challenges for the coming years: the effects of a recent high school reform, try to attract regional funds, e-learning and the new technologies

Here we need to inject resources and good ideas, to run the system optimally





Human resources

270 staff with indefinite contract (1.9.2015). LNF has **16%** of the INFN personnel

In 2002 they were **320** : - **16%** (in comparison with -**3%** to the rest of INFN )

**61** staff with short term hiring (2/3 on external funds: ELI-NP, SPARC\_LAB, ... )

A worrisome distribution >>>

The Lab is losing competences at increasing rate: we should intervene now, otherwise in 10 years human resources will be gone

Strong commitment to reinforce services (especially in Research Division) and to make more rational the access to them



A Lab with the capability of proposing research themes, with spots of excellence (a delicate balance between fundamental research and technology)

A difficult effort to reduce fragmentation, while keeping access to curiosity driven research. Not an easy task, also considering the environment ...

## LNF Personnel composition and distribution

|            |             |              |               |              |           |
|------------|-------------|--------------|---------------|--------------|-----------|
| DIV RIC    | 68+6 R      | 12+8 T       | 51+8 TT       | 8+3 A        | 27 B      |
| DIV ACC    | 7+3 R       | 18+12 T      | 41+7 TT       | 2+1 A        | 10 B      |
| DIV TEC    |             | 5+3 T        | 24+2 TT       | 3+0 A        | 1 B       |
| AMM        |             | 2+1 T        | 11+0 TT       | 18+7 A       |           |
| <b>TOT</b> | <b>75+9</b> | <b>37+24</b> | <b>127+17</b> | <b>31+11</b> | <b>38</b> |
| (270+61)   | 24%         | 18%          | 45%           | 13%          |           |

(Permanent+Short Term) staff

R=Researchers T=Technologists

TT=Technicians A=Administratives B=PostDocs

## Executive Summary

The short term priorities (with different timing) are on DAFNE+ELI-NP+SPARC\_LAB  
*Critical aspects: are we able to maintain all engagements at the needed levels ? How do we fight competence losses ?*

At medium-long term (Accelerator Science), investing in SPARC\_LAB  
*Critical aspects: is this technology far-reaching ? Are we able to assign timely human and economic resources to participate to the competition ? Can INFN guarantee enough resources for this plan ? **Do we have a backup option ?***

At medium-long term (Fundamental Research & Technology), focus the emphasis on detector developments, on infrastructures for research (BTF, may be space-related activities) and on experiments at CERN  
*Critical aspects: are we able to set-up an organization capable to focus on activities of excellence ? How do we fight competence losses ? Can we attract enough external resources to guarantee support ?*

**A Lab willing to maintain its role, to continue its mission within INFN, capable to react to a world which is very different from that of 60 years ago**