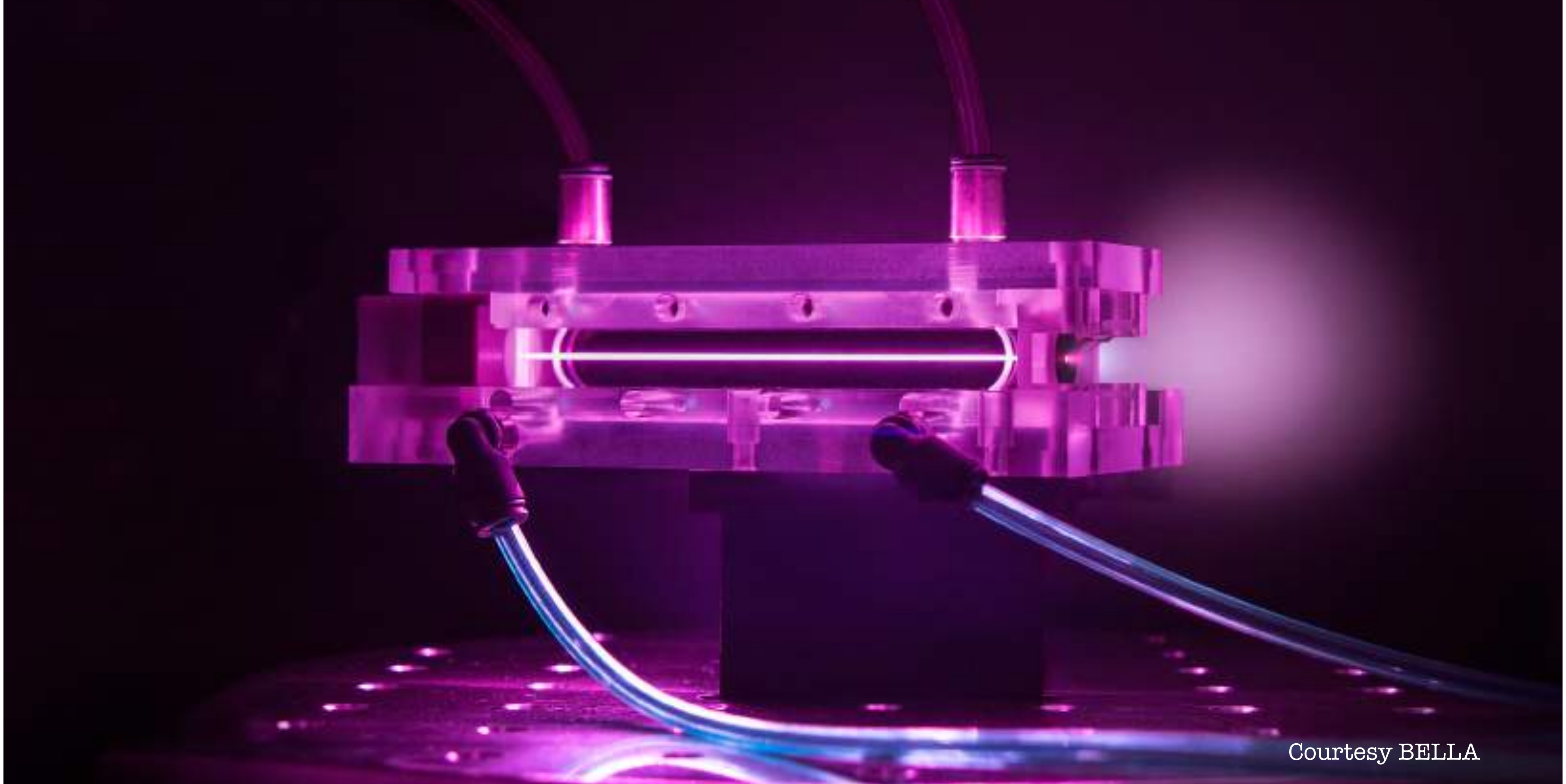
# EuPRAXIA@SPARC_LAB

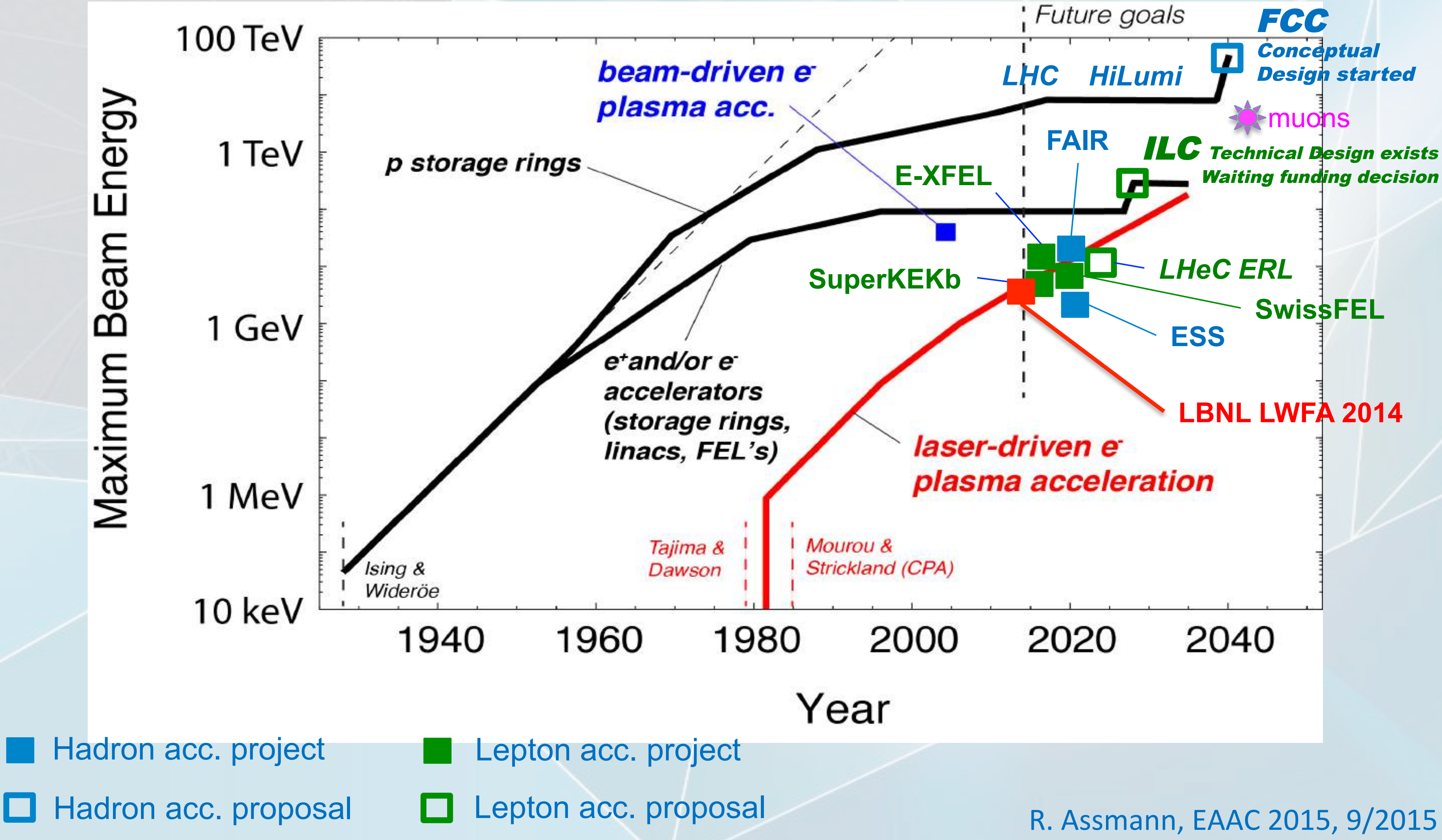
Massimo.Ferrario@LNF.INFN.IT
**On behalf of the EuPRAXIA@SPARC_LAB collaboration**



Courtesy BELLA

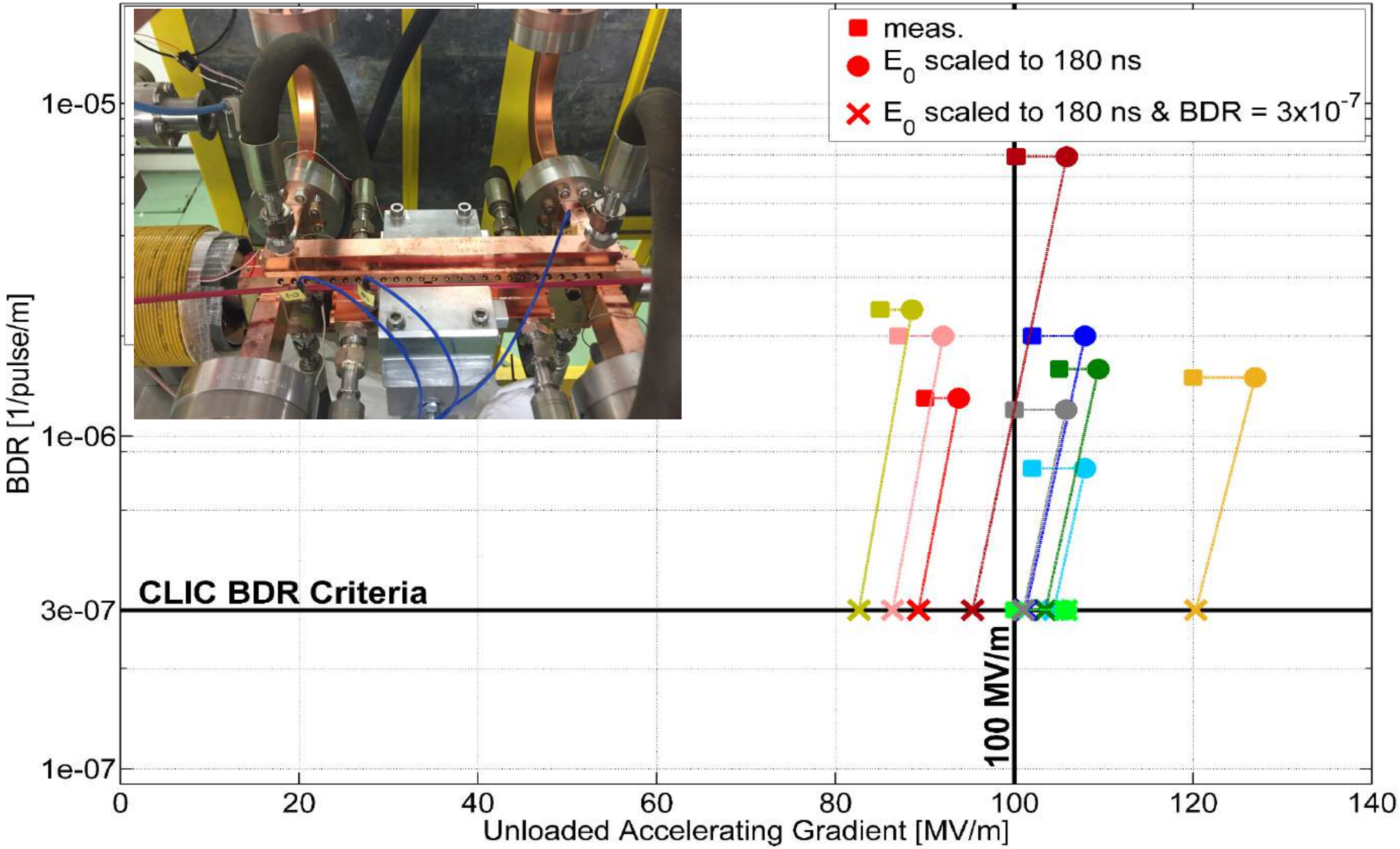
**Pre-Direttivo INFN – 26 October 2017**

# Future of Accelerators




R. Assmann, EAAC 2015, 9/2015

# X-band RF structures best performances



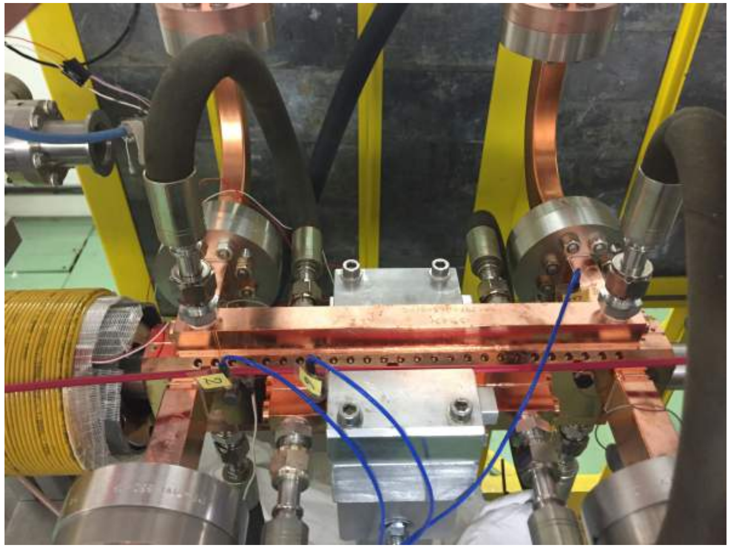
Compact

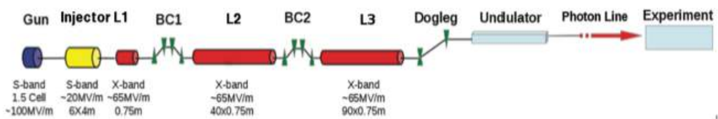
# New EU Design Study Approved

3 years – 3 MEuro

(➔212 kEuro INFN)

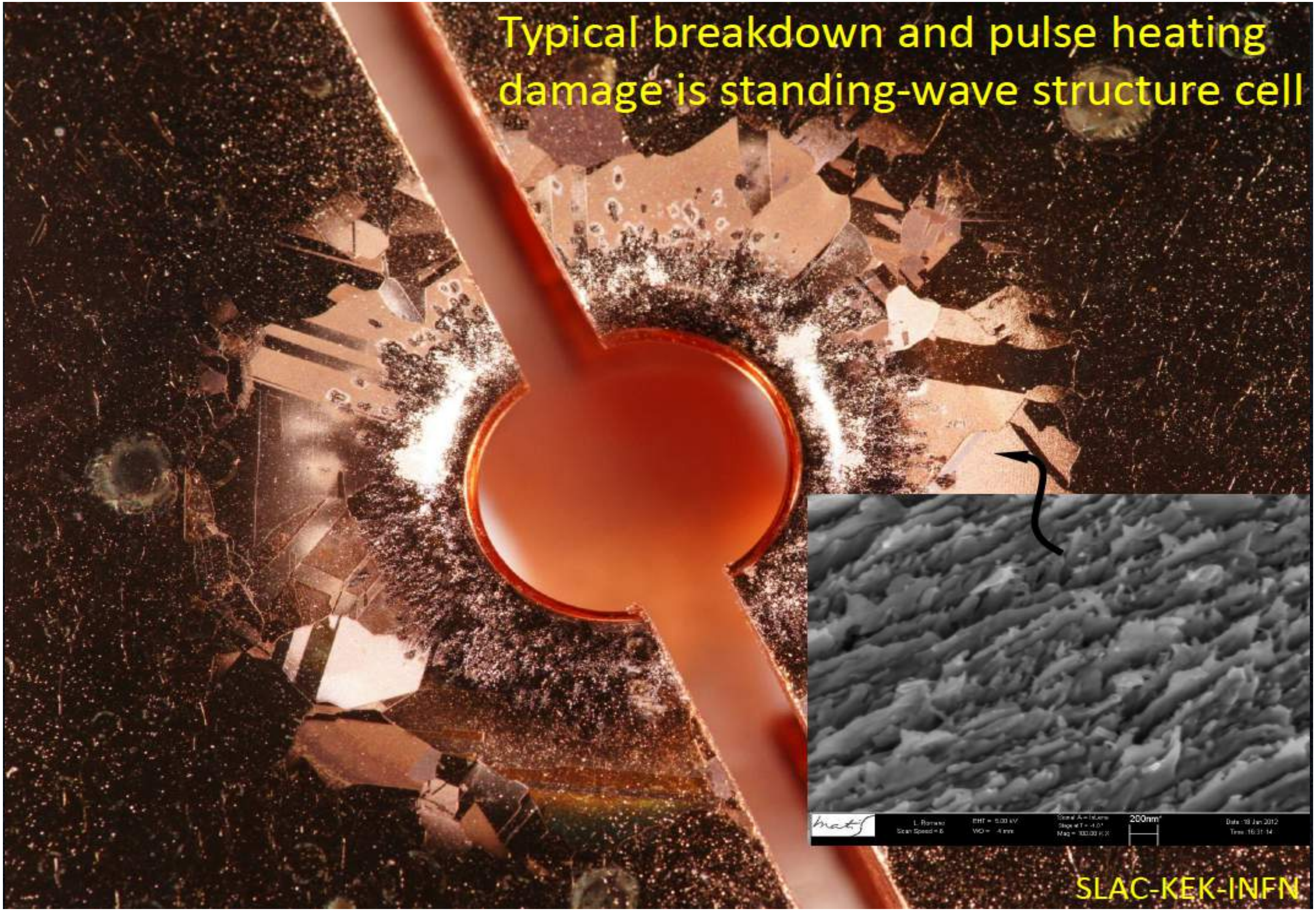
Coordinator: G. D'Auria (Elettra)



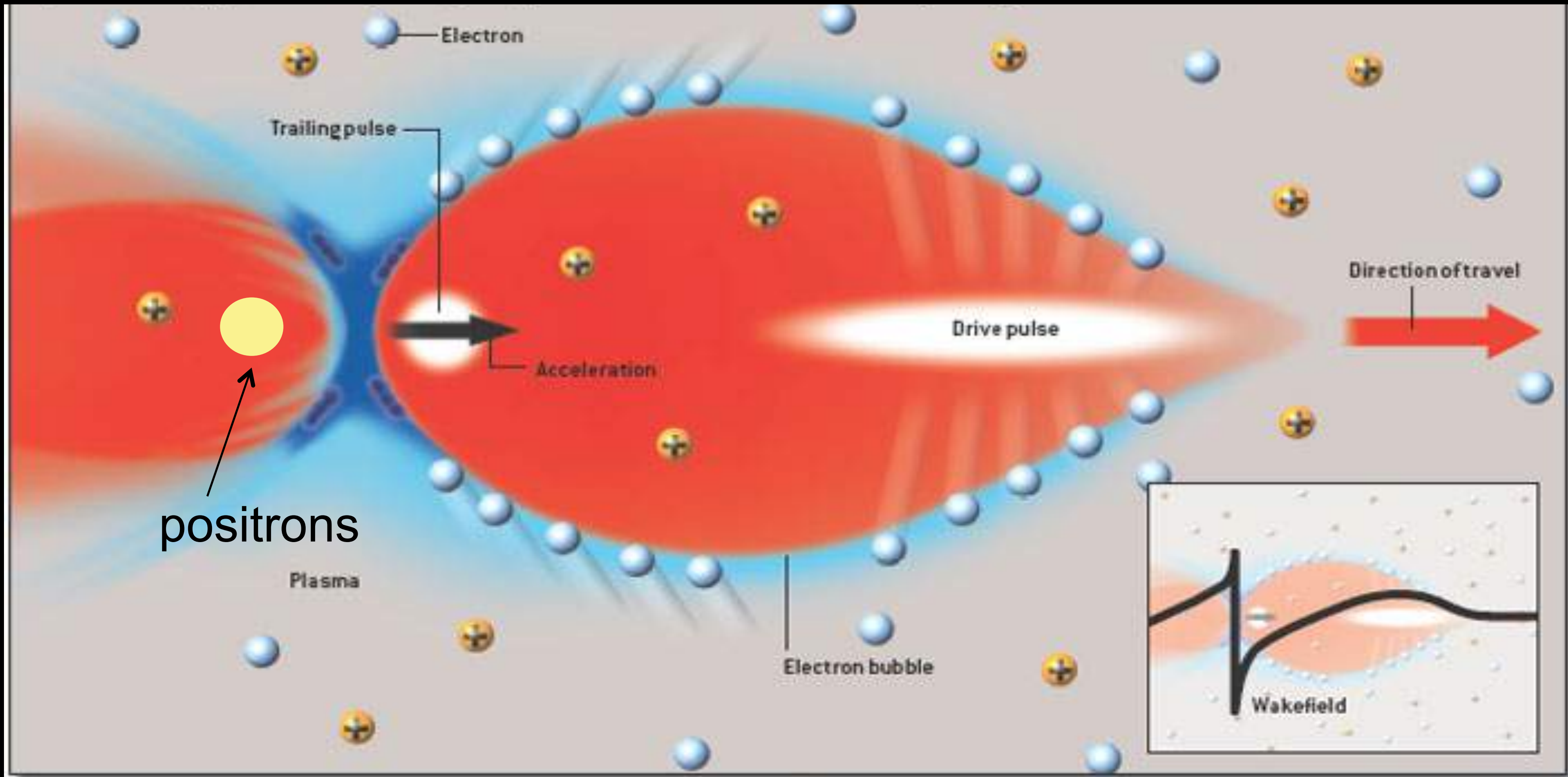




**The key objective of the CompactLight Design Study is to demonstrate, through a conceptual design, the feasibility of an innovative, compact and cost effective FEL facility suited for user demands identified in the science case.**


Typical breakdown and pulse heating damage is standing-wave structure cell
L. Romano
Scan Speed = 6
EHT = 5.00 kV
200nm
Date :18 Jan 2012
Time :16:31:14
SLAC-KEK-INFN

# Plasma Accelerator

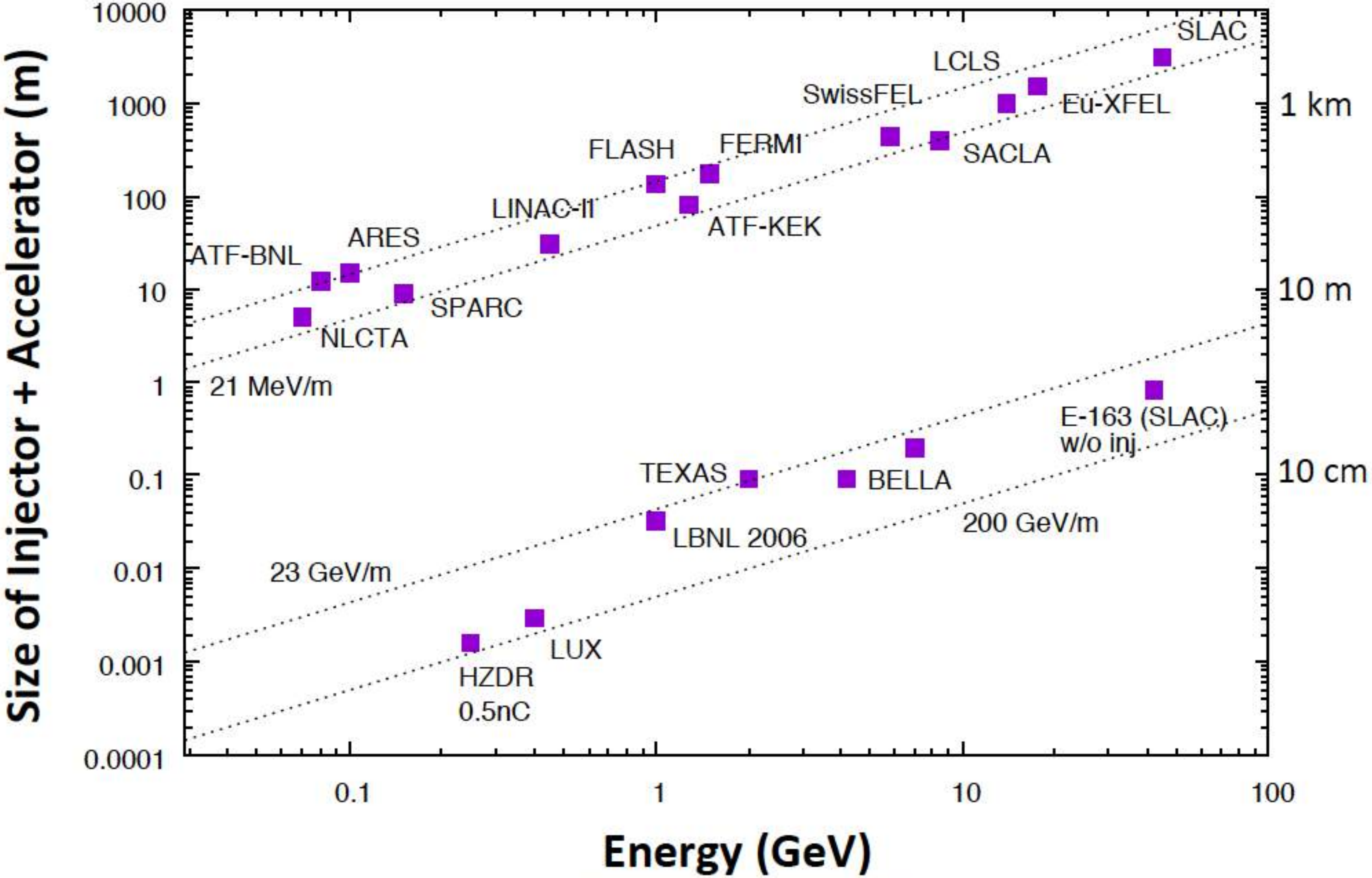



## Breakdown limit?

$$E_0 = \frac{m_e c \omega_p}{e} \approx 100[\frac{GeV}{m}] \cdot \sqrt{n_0[10^{18} cm^{-3}]}$$

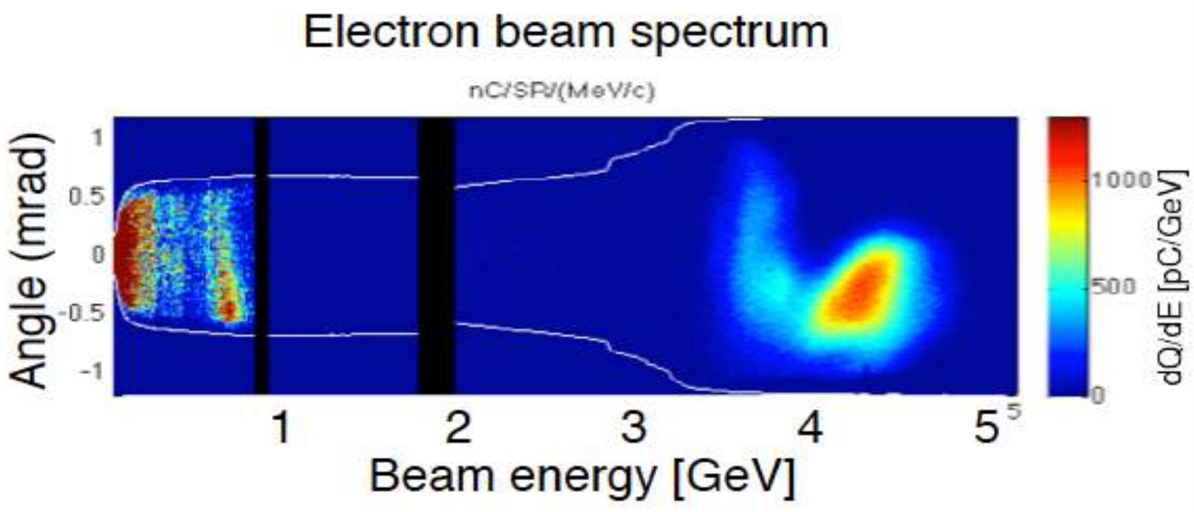
# Size versus Energy

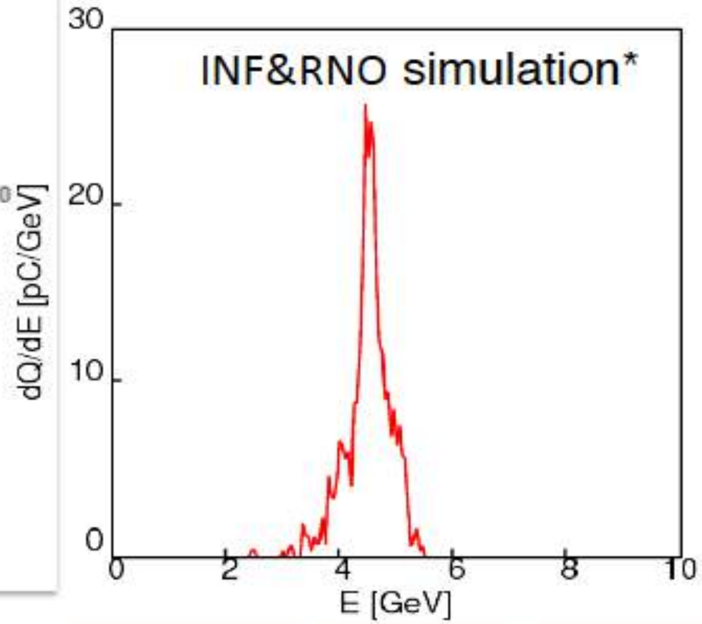
*electron linear accelerators*



# 4.25 GeV beams have been obtained from 9 cm plasma channel powered by 310 TW laser pulses (15 J)

*C. Benedetti et al., proceedings of AAC2010, proceedings of ICAP2012




- **Laser** (E=15 J):
  - Measured) longitudinal profile ($T_0$= 40 fs)
  - Measured far field mode ($w_0$=53 µm)
- **Plasma:** parabolic plasma channel (length 9 cm, $n_0$~6-7x$10^{17}$ $cm^{-3}$)

| | Exp. | Sim. |
|---|---|---|
| Energy | 4.25 GeV | 4.5 GeV |
| ΔE/E | 5% | 3.2% |
| Charge | ~20 pC | 23 pC |
| Divergence | 0.3 mrad | 0.6 mrad |

W.P. Leemans et al.,PRL 2014

# EUROPEAN PLASMA RESEARCH ACCELERATOR WITH EXCELLENCE IN APPLICATIONS

## EuPRAXIA Design Study

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

Coordinator: Ralph Assmann (DESY)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 653782.

# Motivations

Horizon2020

## PRESENT EXPERIMENTS

Demonstrating **100 GV/m** routinely

Demonstrating **GeV** electron beams

Demonstrating basic **quality**

## EuPRAXIA INFRASTRUCTURE

**Engineering a high quality, compact plasma accelerator**

**5 GeV electron beam for the 2020's**

**Demonstrating user readiness**

**Pilot users from FEL, HEP, medicine, ...**

## PRODUCTION FACILITIES

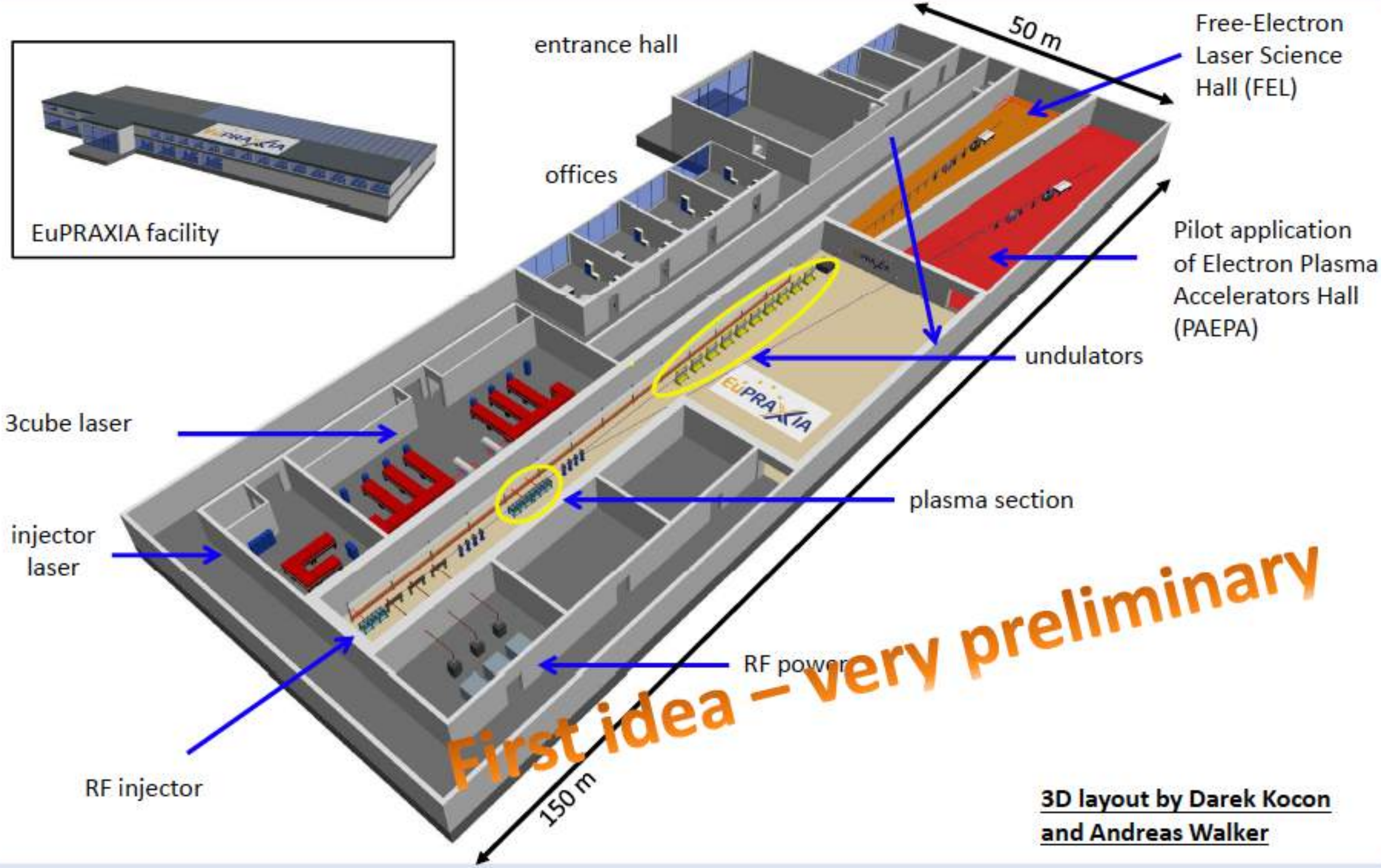
Plasma-based **linear collider** in 2040's

Plasma-based **FEL** in 2030's

**Medical, industrial** applications soon

Courtesy R. Assmann

# draft of facility layout



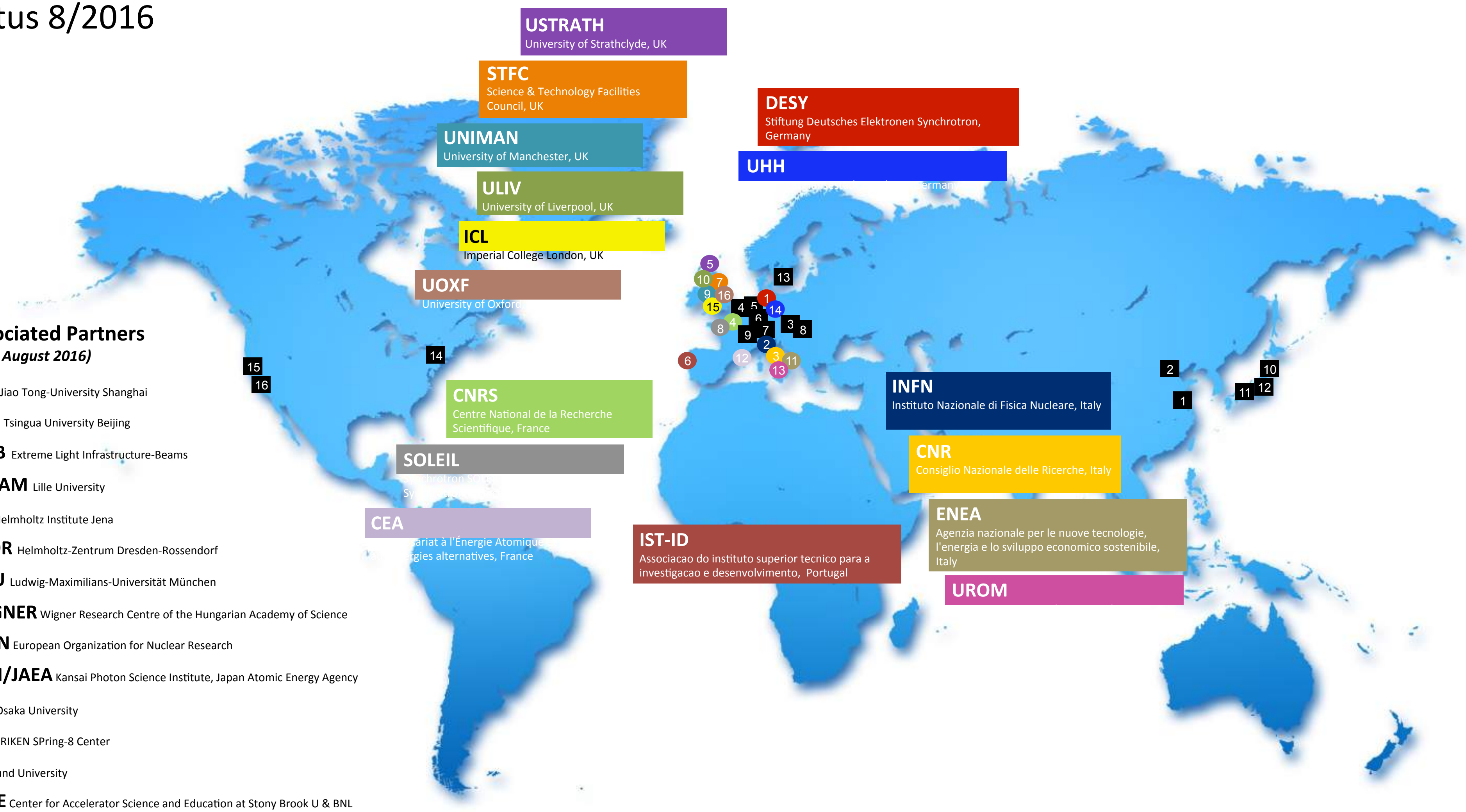

**3D layout by Darek Kocon and Andreas Walker**

# Participating Institutions

*16 beneficiaries, 16 associated partners*

Horizon2020

Status 8/2016




## Associated Partners

*(as of August 2016)*

1 **JUS** Jiao Tong-University Shanghai

2 **TUB** Tsingua University Beijing

3 **ELI-B** Extreme Light Infrastructure-Beams

4 **PHLAM** Lille University

5 **HIJ** Helmholtz Institute Jena

6 **HZDR** Helmholtz-Zentrum Dresden-Rossendorf

7 **LMU** Ludwig-Maximilians-Universität München

8 **WIGNER** Wigner Research Centre of the Hungarian Academy of Science

9 **CERN** European Organization for Nuclear Research

10 **KPSI/JAEA** Kansai Photon Science Institute, Japan Atomic Energy Agency

11 **OU** Osaka University

12 **RSC** RIKEN SPring-8 Center

13 **LU** Lund University

14 **CASE** Center for Accelerator Science and Education at Stony Brook U & BNL

15 **LBNL** Lawrence Berkeley National Laboratory

16 **UCLA** University of California, Los Angeles

# Industrial Participation

Horizon 2020

**Industry:** involved through workshops and Scientific Advisory Board

Contacts still evolving, several cooperations under discussion

**Thales group (France)**: Number of employees: 62,194 (2015)
Sales 14.06 B€ (2015)

**Amplitude (France)**: Number of employees: 80 (2015)
Sales 17.4 M€ (2015)

**Trumpf group (Germany)**: Number of employees: 11,181 (2016)
Sales 2.81 B€ (2016)

# Officially started on November 1, 2015

EuPRAXIA

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€

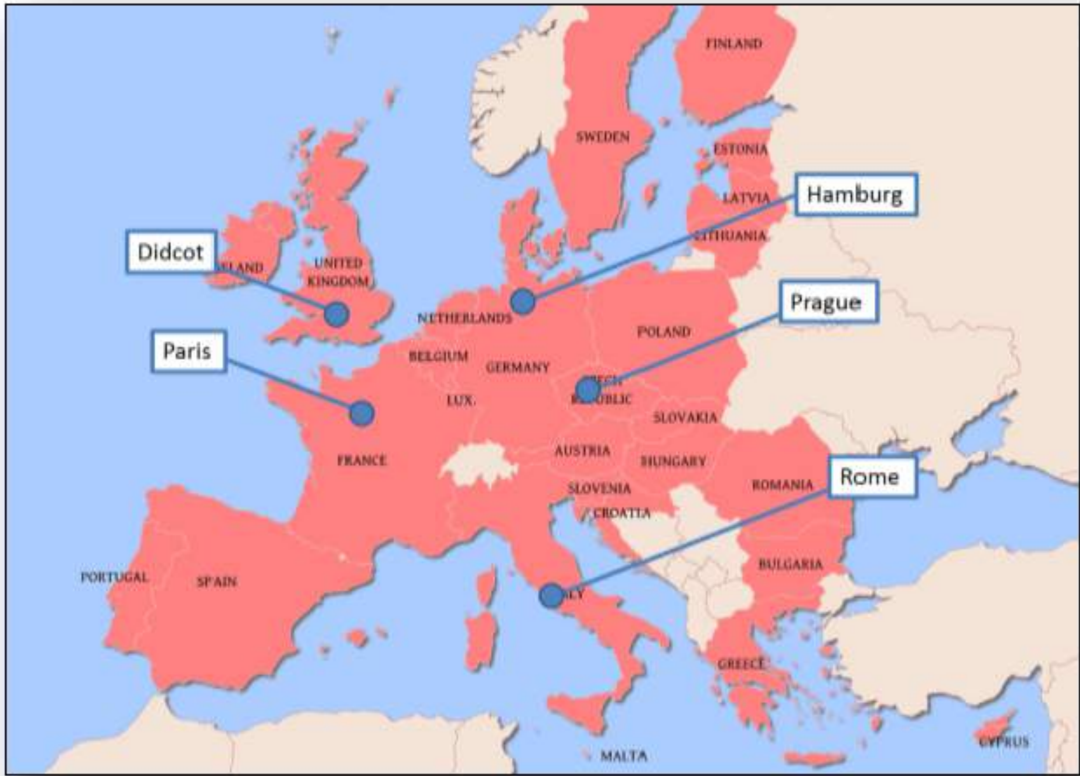
- Design Studies with at least 3 Countries,
- Cost. Schedule?
- What is the governance model?
- What is the intended user community?
- Will it be open access?
- Apply for H2020 preparatory phase (PP)?

- 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.

what NEXT?

**EuPRAXIA site studies**:

- Design study is site independent
- Five possible sites have been discussed so far
- We invite the suggestions of additional sites








Central Laser Facility
Didcot, United Kingdom


Eli Beamlines
Prague, Czech Republic

# EuPRAXIA@SPARC_LAB

- D. Alesini, M. P. Anania, R. Bedogni, M. Bellaveglia, A. Biagioni, F. Bisesto, E. Brentegani, B. Buonomo, P.L. Campana, G. Campogiani, S. Cantarella, F. Cardelli, M. Castellano, E. Chiadroni, R. Cimino, R. Clementi, M. Croia, A. Curcio, G. Costa, S. Dabagov, M. Diomede, A. Drago, D. Di Giovenale, G. Di Pirro, A. Esposito, M. Ferrario, F. Filippi, O. Frasciello, A. Gallo, A. Ghigo, A. Giribono, S. Guiducci, S. Incremona, F. Iungo, V. Lollo, A. Marcelli, A. Marocchino, V. Martinelli, A. Michelotti, C. Milardi, L. Pellegrino, L. Piersanti, S. Pioli, R. Pompili, R. Ricci, S. Romeo, U. Rotundo, L. Sabbatini, O. Sans Plannell, J. Scifo, B. Spataro, A. Stecchi, A. Stella, V. Shpakov, C. Vaccarezza, A. Vannozzi, A. Variola, F. Villa, M. Zobov.
- **INFN - Laboratori Nazionali di Frascati**
- A. Bacci, F. Broggi, C. Curatolo, I. Debrot, A. R. Rossi, L. Serafini. **INFN - Sezione di Milano**
- D. Cirrincione, A.Vacchi. **INFN - Sezione di Trieste**
- G. A. P. Cirrone, G. Cuttone, V. Scudieri. **INFN - Laboratori Nazionali del Sud**
- M. Artioli, M.Carpanese, F.Ciocci, D.Dattoli, S.Licciardi, F.Nguyen, S. Pagnutti, A.Petralia, E. Sabia. **ENEA – Frascati and Bologna**
- L. Gizzi, L. Labate. **CNR - INO, Pisa**
- R. Corsini, A. Grudiev, N. Catalan Lasheras, A. Latina, D. Schulte, W. Wuensch. **CERN, Geneva**
- C. Andreani, A. Cianchi, G. Festa,V. Minicozzi, S. Morante, R. Senesi, F. Stellato. **Universita' degli Studi di Roma Tor Vergata and Sezione INFN**
- V. Petrillo, M. Rossetti. **Universita' degli Studi di Milano and Sezione INFN**
- G. Castorina, L. Ficcadenti, S. Lupi, M. Marongiu, F. Mira, A. Mostacci. **Universita' degli Studi di Roma Sapienza and Sezione INFN**
- S. Bartocci, C. Cannaos, M. Faiferri, R. Manca, M. Marini, C. Mastino, D. Polese, F. Pusceddu, E. Turco. **Università degli Studi di Sassari, Dip. di Architettura, Design e Urbanistica ad Alghero**
- M. Coreno, G. D'Auria, S. Di Mitri, L. Giannessi, C. Masciovecchio. **ELETTRA Sincrotrone Trieste**
- A. Ricci. **RICMASS, Rome International Center for Materials Science Superstripes**
- A. Zigler. **Hebrew University of Jerusalem** J. B. Rosenzweig. **University of California Los Aangeles**

CDR.0 delivery expected by Autumn

WG 0 – Project Management
- 0.1 Executive summary (M. Ferrario)

WG 1 – Electron beam design and optimization
- 1.1 Advanced High Brightness Photo-injector (E. Chiadroni)
- 1.2 HB Linac technology, (A. Gallo)
- 1.3 Linac design and parameters (C. Vaccarezza)

WG 2 – Laser design and optimization
- 2.1 FLAME upgrade (M. P. Anania)
- 2.2 Advanced Laser systems (L. Gizzi)

WG 3 – Plasma Accelerator
- 3.1 PWFA beam line (A. Marocchino)
- 3.2 LWFA beam line (A. R. Rossi)
- 3.3 Plasma and Beam Diagnostics (A. Cianchi)

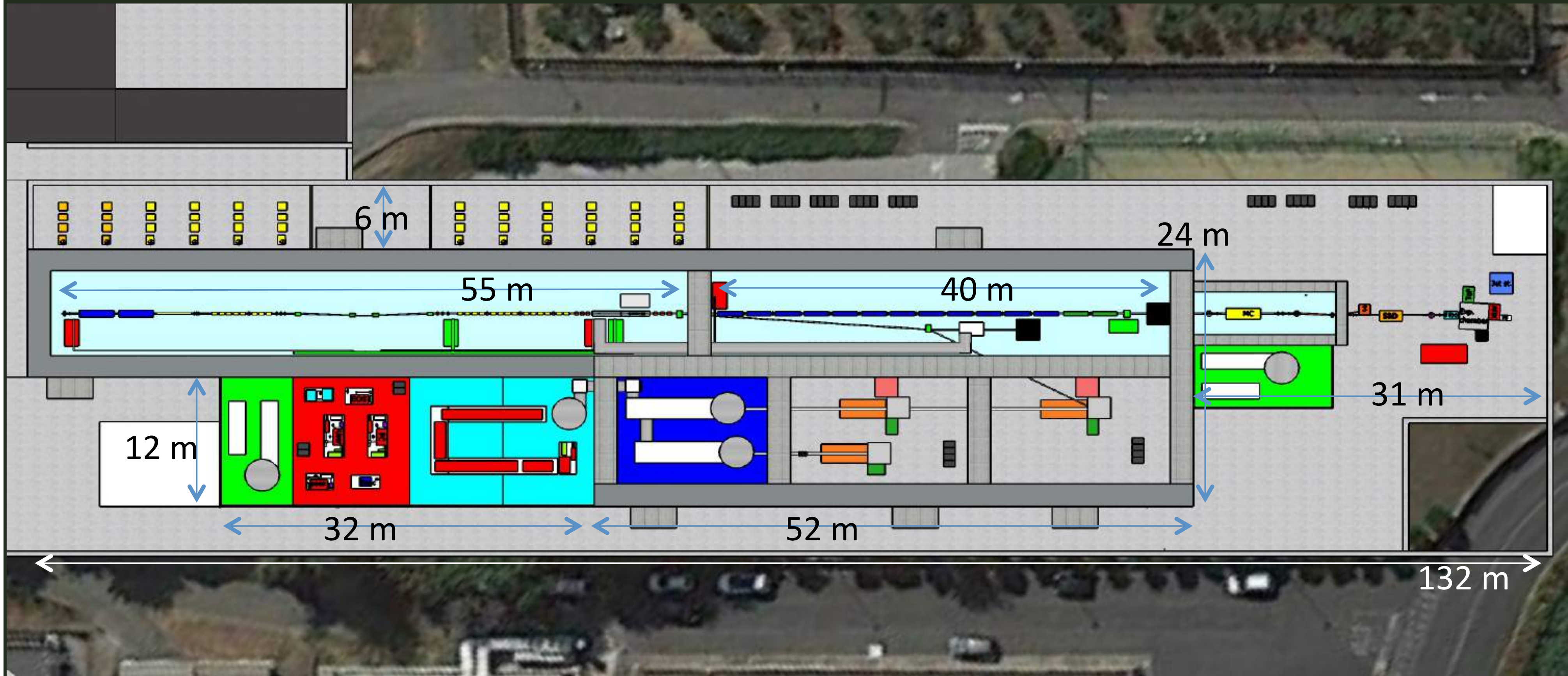
WG 4 – FEL pilot applications
- 4.1 Conventional and Plasma driven FEL (V. Petrillo)
- 4.2 Advanced FEL schemes (G. Dattoli)
- 4.3 Photon beam lines (F. Villa)
- 4.4 FEL user applications (F. Stellato)

WG 5 – Radiation sources and user beam lines
- 5.1 Advanced (dielectric) THz source (S. Lupi)
- 5.2 Compton source (C. Vaccarezza)
- 5.3 Secondary Particle Sources (LNS)?
- 5.4 Laser-driven neutron source (Cianchi)
- 5.4 User beam lines (P. Valente)

WG 6 – Low Energy Particle Physics
- 6.1 Advanced positron sources (A. Variola)
- 6.2 Fundamental physics experiments , LabAstro (C. Gatti)
- 6.3 Plasma driven photon collider (L. Serafini)

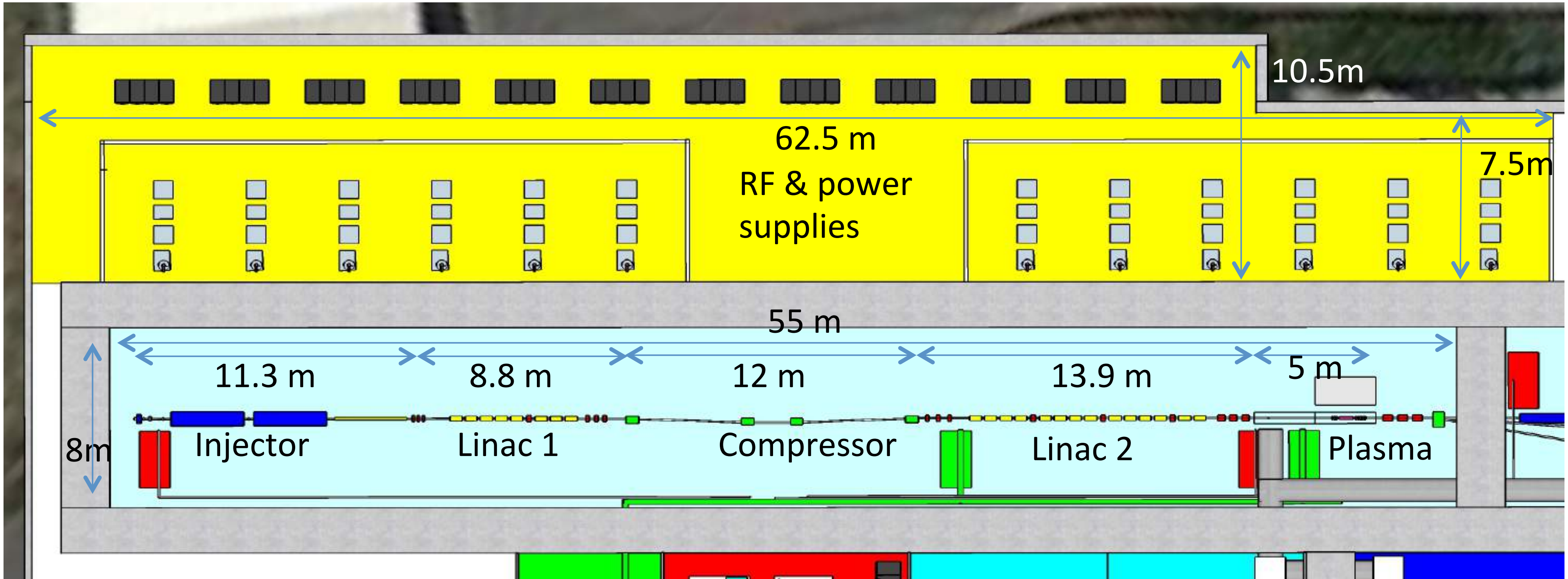
WG 7 – Infrastructure
- 7.1 Civil Engineering and conventional plants (U. Rotundo)
- 7.2 Control system (G. Di Pirro)
- 7.3 Radiation Safety (A. Esposito)
- 7.4 Machine layout

- Candidate LNF to host EuPRAXIA (1-5 GeV)
- FEL user facility (1 GeV – 3nm)
- Advanced Accelerator Test facility (LC) + CERN



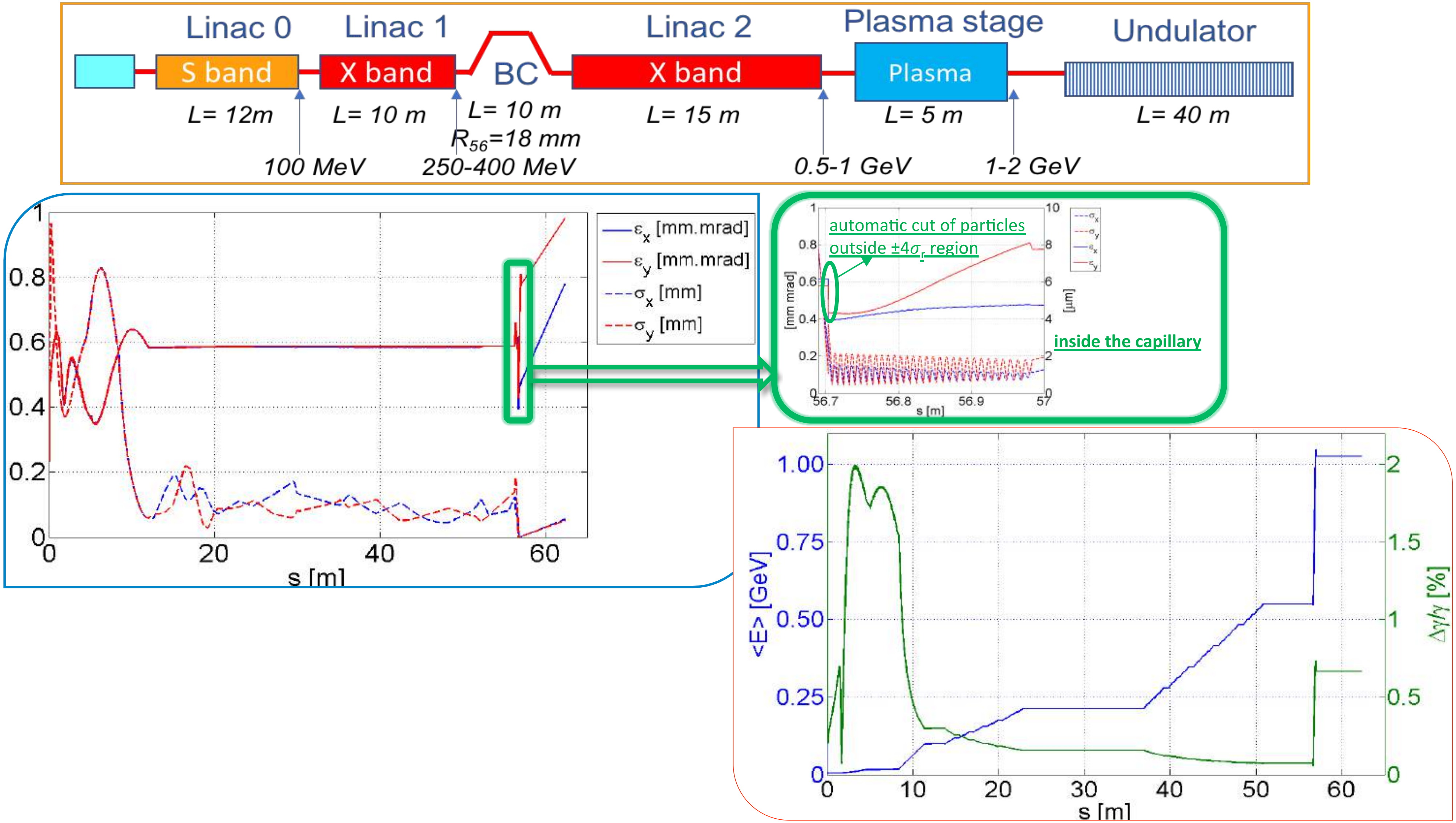

- 500 MeV by RF Linac + 500 MeV by Plasma (LWFA or PWFA)
- 1 GeV by X-band RF Linac only
- Final goal compact 5 GeV accelerator

# Accelerator (X-band EU frequency – 100 Hz?)

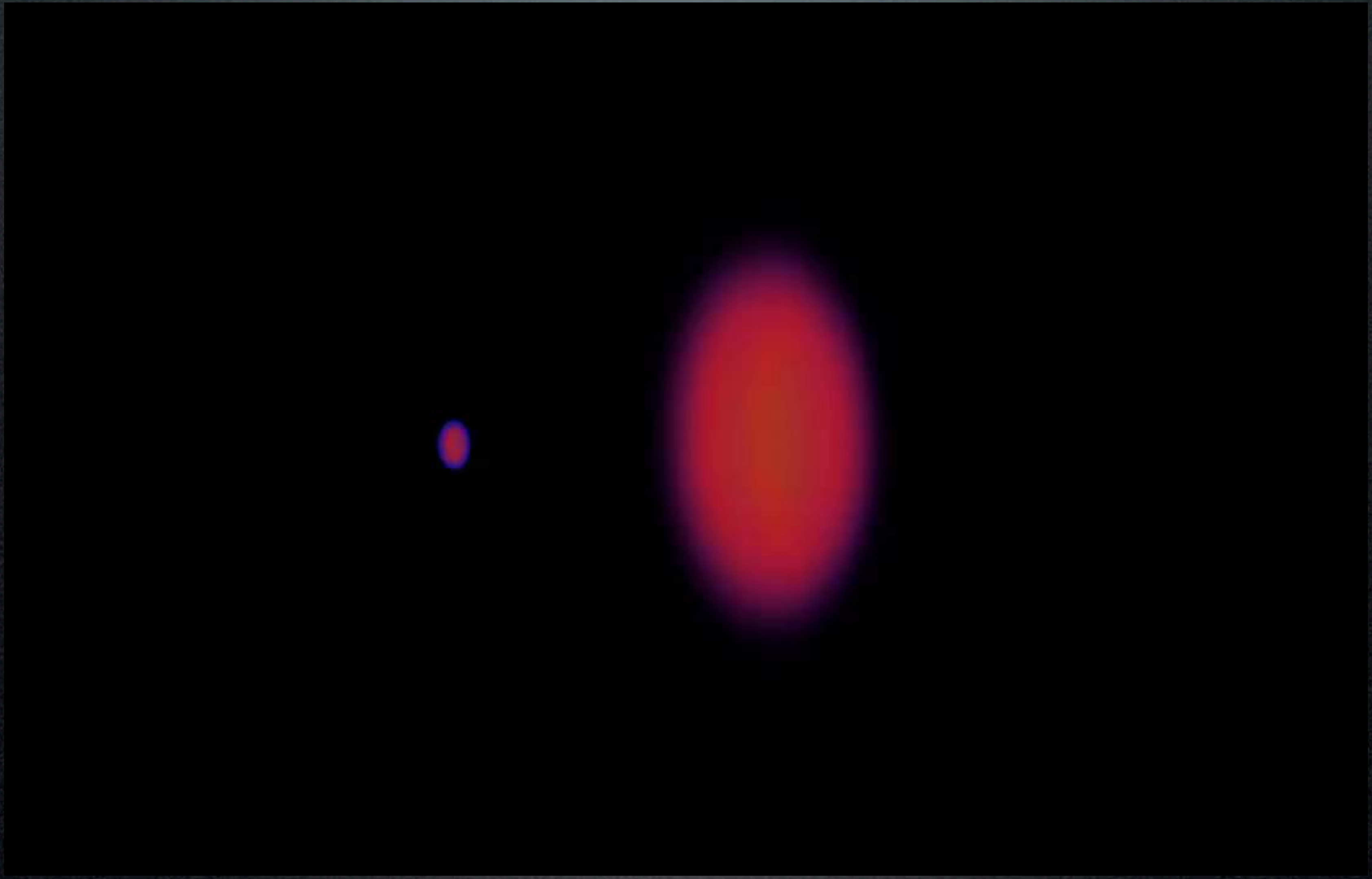



- Injector:
  - Gun+solenoid
  - 3x 3m s-band sectons
- Linac 1:
  - 8x 0.5m x-band sections
  - Matching Quads
- Compressor:
  - 2.19° deflection
- Linac 2:
  - 14x 0.5m x-band sections
  - Matching Quads
- Plasma:
  - PMQ matching
  - 0.6 m capillary

# 30 pC beam Start To End Simulations

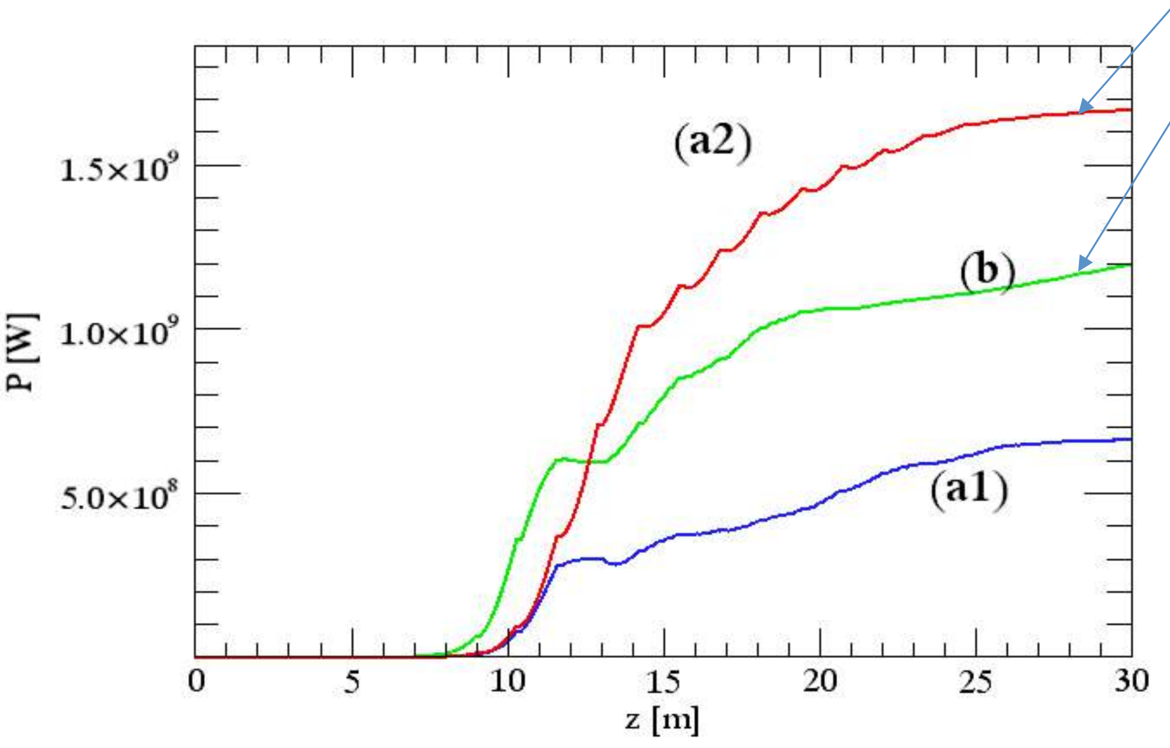


# External Injection (LWFA or PWFA)



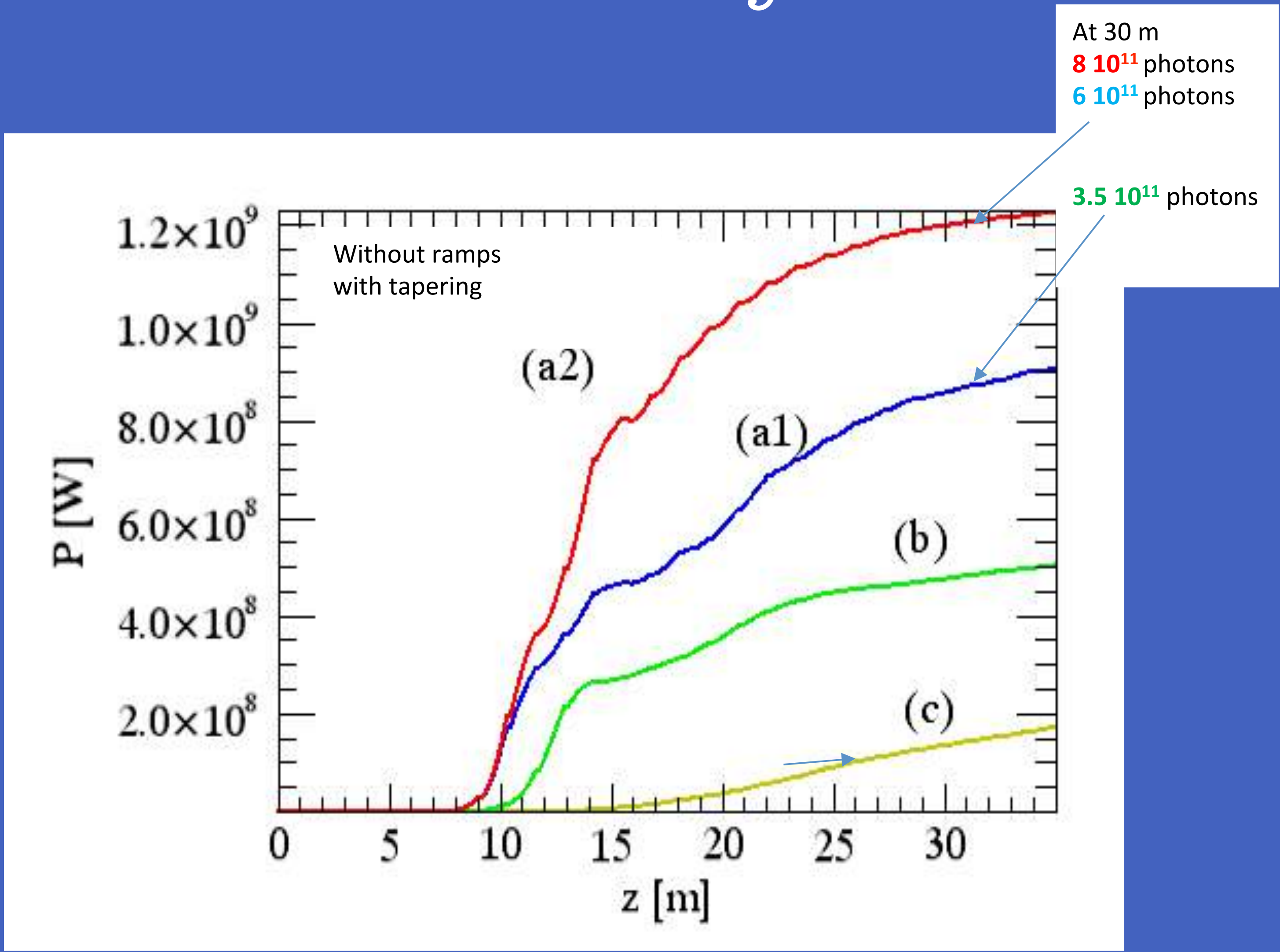
# FEL driven by LWFA

At 30 m
**6.4 $10^{11}$** photons
**5.2 $10^{11}$** photons
**3.6 $10^{11}$** photons




Growth of the radiation along the undulator

# FEL driven by PWFA



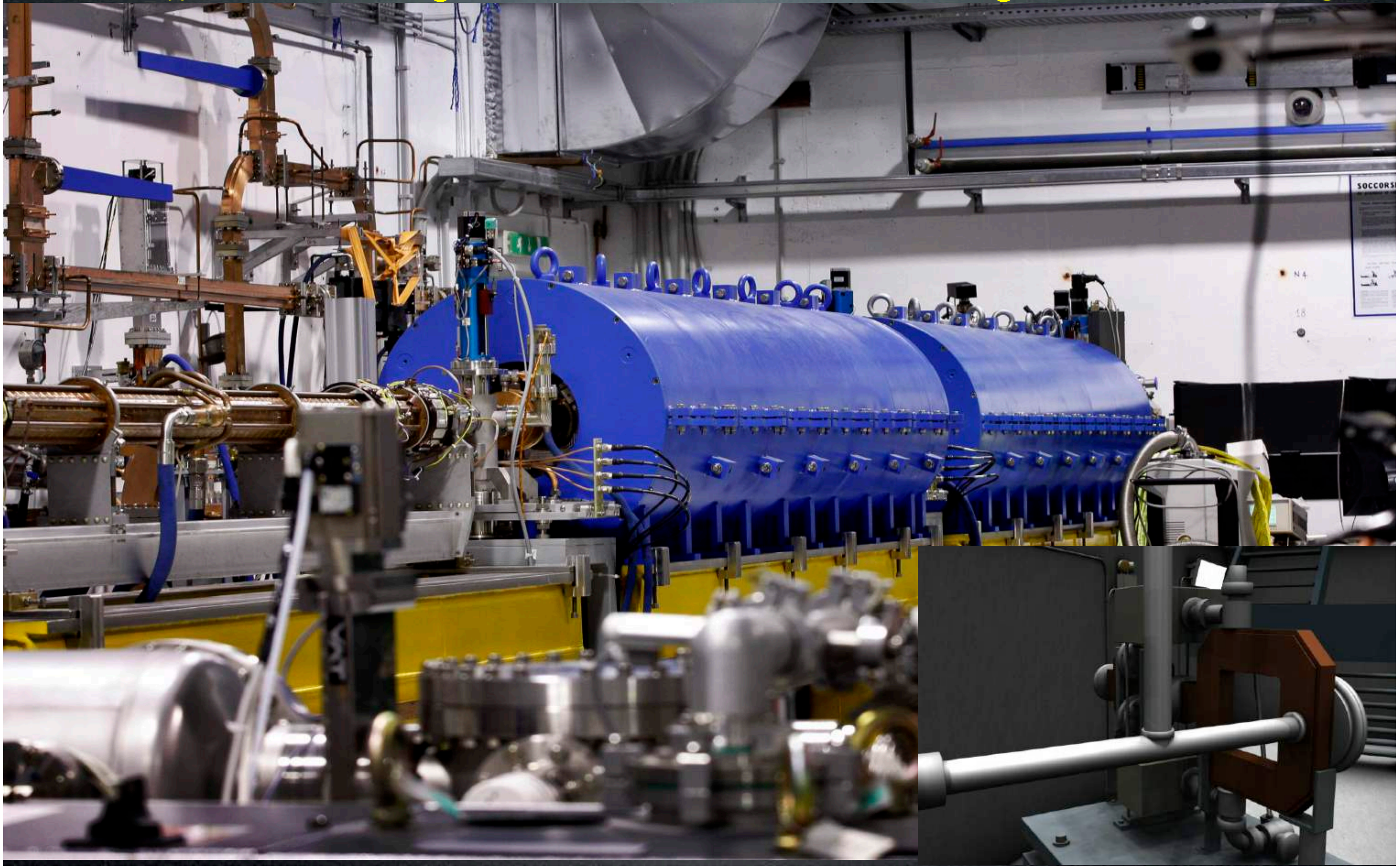
# FEL driven by PLASMA

| | Units | 1 GeV PWFA with Undulator Tapering | 1 GeV LWFA with Undulator Tapering |
|---|---|---|---|
| **Bunch charge** | pC | 29 | 26.5 |
| **Bunch length rms** | fs | 11.5 | 8.4 |
| **Peak current** | kA | 2.6 | 3.15 |
| **Rep. rate** | Hz | 10 | 10 |
| **Rms Energy Spread** | % | 0.73 | 0.81 |
| **Slice Energy Spread** | % | 0.022 | 0.015 |
| **Average Rms norm. emittance** | μm | 0.6 | 0.47 |
| **Slice norm. emittance** | μm | 0.39-0.309 | 0.47 |
| **Slice Length** | μm | 1.39 | 1.34 |
| | | | |
| **Radiation wavelength** | nm | 2.79 | 2.7 |
| **ρ** | x $10^{-3}$ | 2 | 2 |
| **Undulator period** | cm | 1.5 | 1.5 |
| **K** | | 0.987 | 1.13 |
| **Undulator length** | m | 30 | 30 |
| **Saturation power** | GW | 0.850-1.2 | 1.3 |
| **Energy** | μJ | 63 | 63.5 |
| **Photons/pulse** | | 8.8 x $10^{11}$ | 8.6 x $10^{11}$ |
| **Bandwidth** | % | 0.35 | 0.42 |
| **Divergence** | μrad | 49 | 56 |
| **Rad. size** | μm | 210 | 160 |
| **Brilliance per shot** | (s $mm^2$ $mrad^2$bw (‰)$)^{-1}$ | 0.83 x $10^{27}$ | 1.22 x$10^{27}$ |

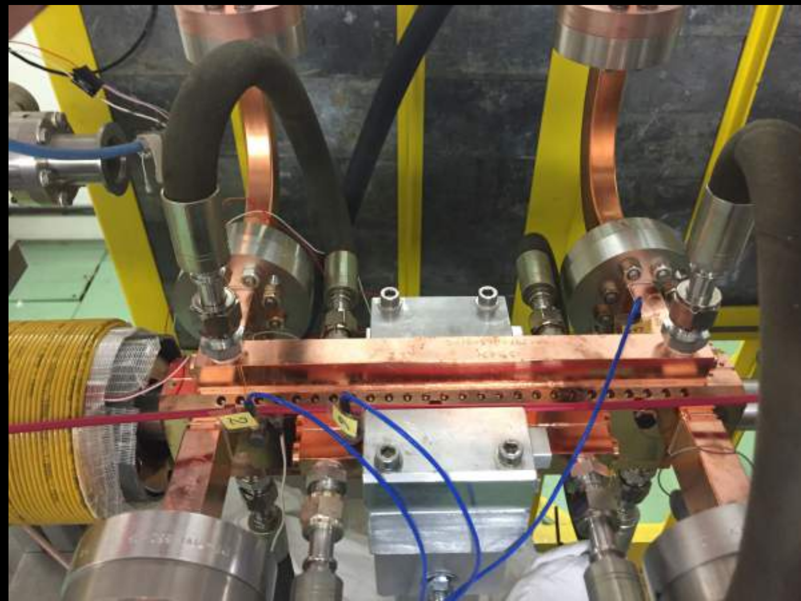
# FEL driven by X-band only

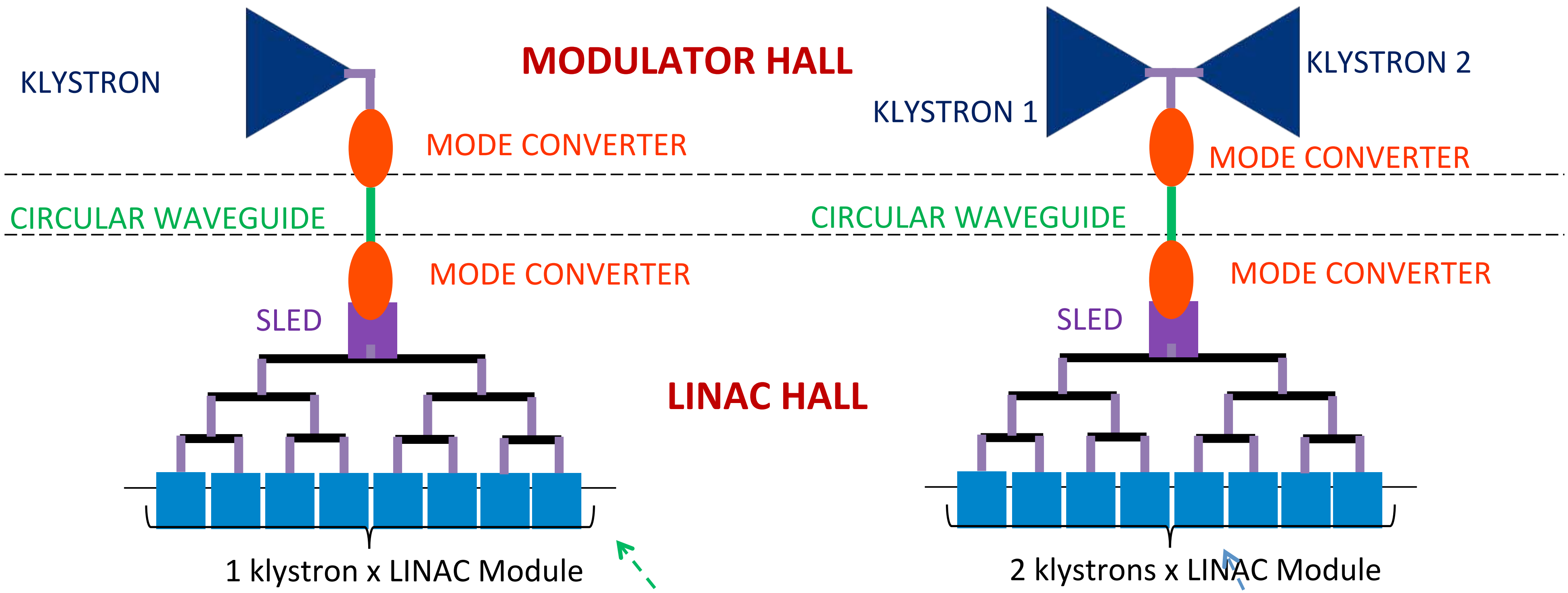
| | Units | 1 GeV with X-band linac only 100 pC | 1 GeV with X-band linac only 200 pC |
|---|---|---|---|
| **Bunch charge** | pC | 100 | 200 |
| **Bunch length rms** | fs | 38.2 | 55.6 |
| **Peak current** | kA | 2. | 1.788 |
| **Rep. rate** | Hz | 10 | 10 |
| | | | |
| **Rms Energy Spread** | % | 0.1 | 0.05 |
| **Slice Energy Spread** | % | 0.018 | 0.02 |
| **Average Rms norm. emittance** | μm | 0.5 | 0.5 |
| **Slice norm. emittance** | μm | 0.35-0.24 | 0.4-0.37 |
| **Slice Length** | μm | 1.25 | 1.66 |
| | | | |
| **Radiation wavelength** | nm | 2.4 (0.52 keV) | 2.87(0.42 keV) |
| **ρ** | $x\ 10^{-3}$ | 1.9(1.7) | 1.55(1.38) |
| **Undulator period** | cm | 1.5 | 1.5 |
| **K** | | 0.987 | 0.987 |
| **Saturation length** | m | 15-25 | 16-30 |
| **Saturation power** | GW | 0.361-0.510 | 0.120-0.330 |
| **Energy** | μJ | 48-70 | 64-177 |
| **Photons/pulse** | | $5.9\text{-}8.4\ x\ 10^{11}$ | $9.3\text{-}25.5\ x\ 10^{11}$ |
| **Bandwidth** | % | 0.13-2.8 | 0.24-0.46 |
| **Divergence** | μrad | 17.5-16 | 28-27 |
| **Rad. size** | μm | 65-75 | 120-200 |
| **Brilliance per shot** | $(s\ mm^2\ mrad^2 bw\ (‰))^{-1}$ | $Fx3.8\text{-}2.2\ 10^{28}$ | $Fx2.5\text{-}1.4\ 11^{27}$ |

# HB photo- injector with Velocity Bunching



# X-band Linac






| X-Band LINAC parameters | | | |
|---|---|---|---|
| total active length $L_t$ | 16 m | | |
| Number of sections $N_s$ | 32 (4 modules x 8 sections) | | |
| available RF power | 50 MW (@klystron output coupler)<br>40 MW (@ section input couplers) | | |
| | Injection in the plasma | Injection in the undulator | Ultimate |
| linac energy gain $\Delta W_{linac}$ | 480 MeV | 910 MeV | 1280 MeV |
| average acc gradient $<E_{acc}>$ | 30 MV/m | 57 MV/m | 80 MV/m |
| total required RF power $P_{RF}$ | 44 MW | 158 MW | 310 MW |

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
**CERN** EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

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GENEVA, SWITZERLAND

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Central/Exchange : +41 22 767 6111

E-mail : steinar.stapnes@cern.ch

Votre référence/Your reference:
Notre référence/Our reference:

Dr Pierluigi Campana
Director
**INFN**
Via Enrico Fermi 40
00044 Frascati RM
Italy

Geneva, 23 June 2017

Dear Dr Campana,

We wish to provide our very strong support for the EuSPARC project being proposed by INFN Frascati. We sincerely believe that this is an excellent choice for the future of the laboratory.
It is also very important for the CERN and the CLIC collaboration. We have discussed with INFN leaders and elaborated a mutually beneficial program of exchange of hardware and staff to advance both the EuSPARC and CLIC projects.

One of the key areas of the CLIC is the high-gradient, X-band radio frequency accelerator of the main linac. Significant resources have been invested to develop the necessary technology and considerable progress has been made and demonstrated by testing prototype systems in test stands at CERN. The EuSPARC proposal is an opportunity to now implement this accelerator technology on a much larger scale than is possible in our test facilities. EuSPARC will provide important benefits for high-gradient X-band technology including industrialization, larger-scale series production and long-term user operation.

For these reasons, we have identified an initial set of collaboration activities. At the core is the loan to Frascati of a 50 MW X-band klystron in order to jointly set up a local high-gradient testing facility. INFN would complete the test stand including the modulator and supporting infrastructure and then carry out high-gradient testing. Preparation for the test stand in Frascati would involve training INFN staff at CERN on the existing test stands. The experts would return to Frascati to build and operate the test stand there, experience which is directly applicable to EuSPARC linac. Overall this would be part of the strategy to introduce this innovative accelerator technology which will become a core component of the EuSPARC facility.

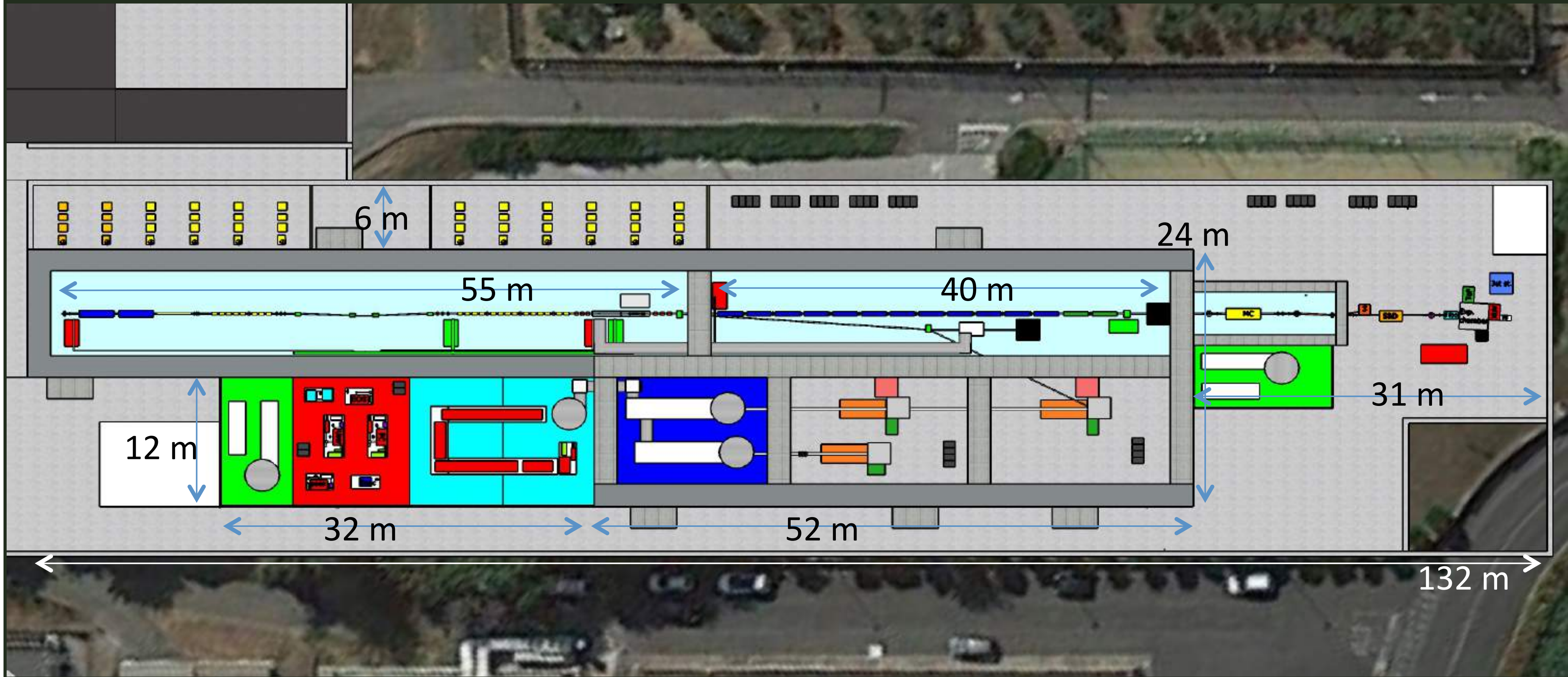
EuSPARC, with its high-gradient accelerator and very low emittance beam, will in the longer term provide a unique and important opportunity for the CLIC study for beam testing. This includes experiments and tests in a number of areas including beam dynamics, rf systems and beam instrumentation. Finally, the Frascati-based test stand and then the EuSPARC facility will provide important continuity for a long-standing and very productive collaboration which extends back to the early days of CTF3.

Sincerely,

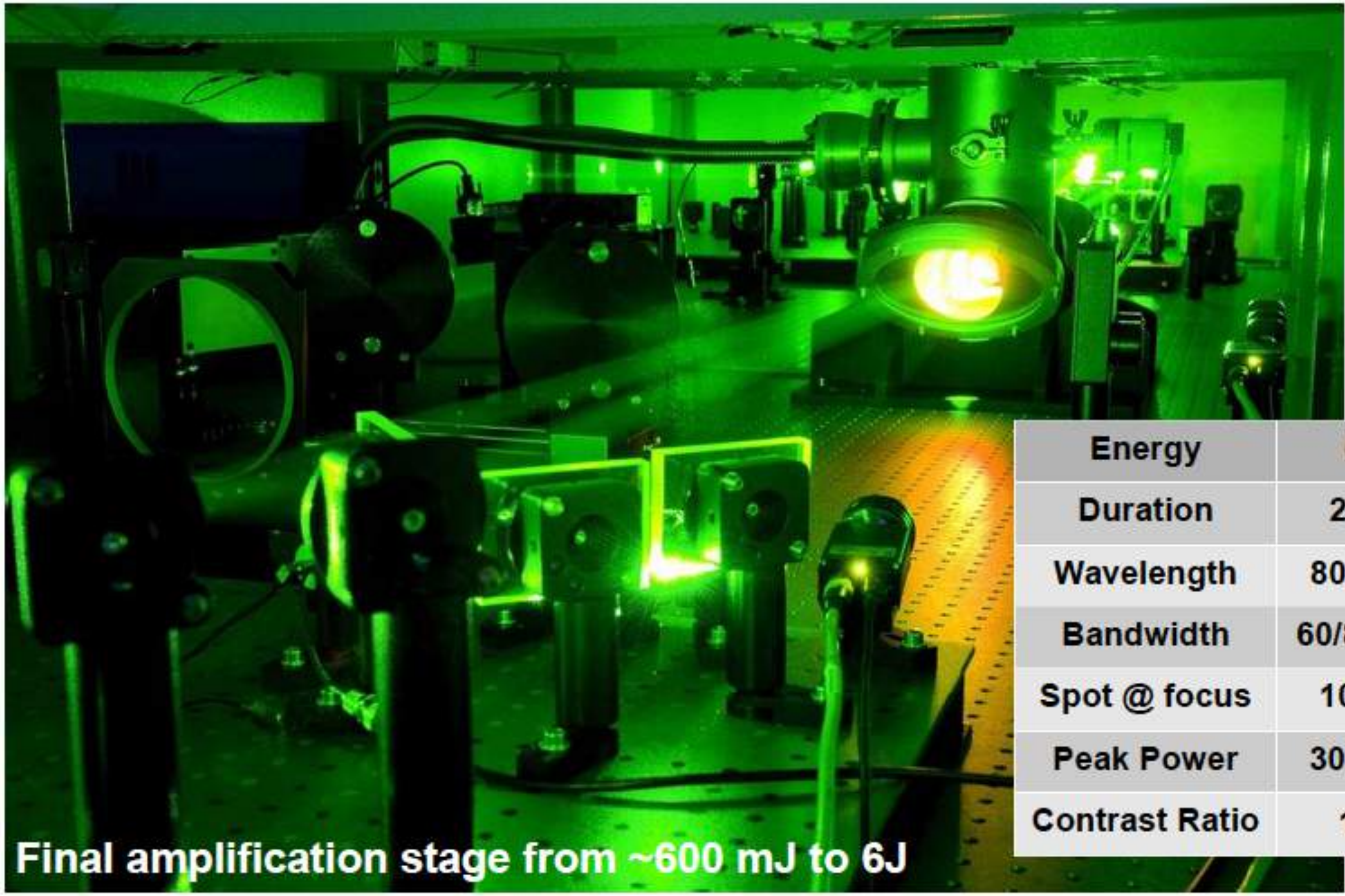
Prof. Steinar Stapnes
CERN Linear Collider Study Leader

Dr Walter Wuensch
CLIC X-Band Activity Leader

- The High Power Laser system



# Ti:Sa FLAME laser



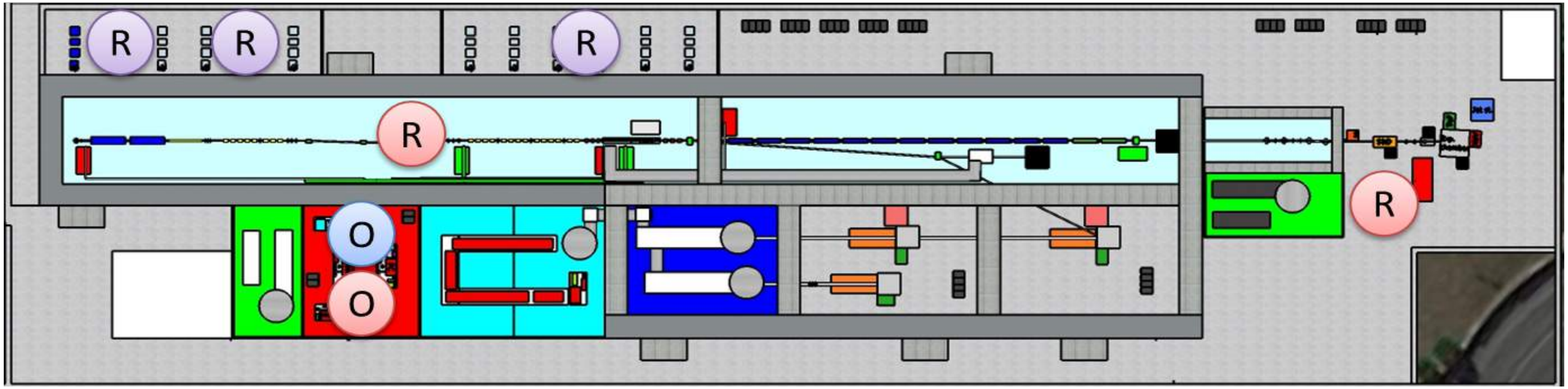

| | |
|---|---|
| Energy | 6 J |
| Duration | 23 fs |
| Wavelength | 800 nm |
| Bandwidth | 60/80 nm |
| Spot @ focus | 10 µm |
| Peak Power | 300 TW |
| Contrast Ratio | $10^{10}$ |

# Parameters of the 500 TW laser

| Parameters | FLAME today | FLAME upgrated |
|---|---|---|
| Wavelength [nm] | 800 | 800 |
| Bandwidth [nm] | 60-80 | 60-80 |
| Repetition rate [Hz] | 10 | 1-5 |
| Max energy before compression [J] | 7 | 20 |
| Max energy on target [J] | 4 | 13 |
| Min pulse length [fs] | 25 | 25 |
| Max power [TW] | 250 | 500 |
| Contrast ratio | $10^{10}$ | $10^{10}$ |

Comparison between the parameters of the actual FLAME system and the upgraded FLAME system.

# Eupraxia@SPARC_LAB synchronization system

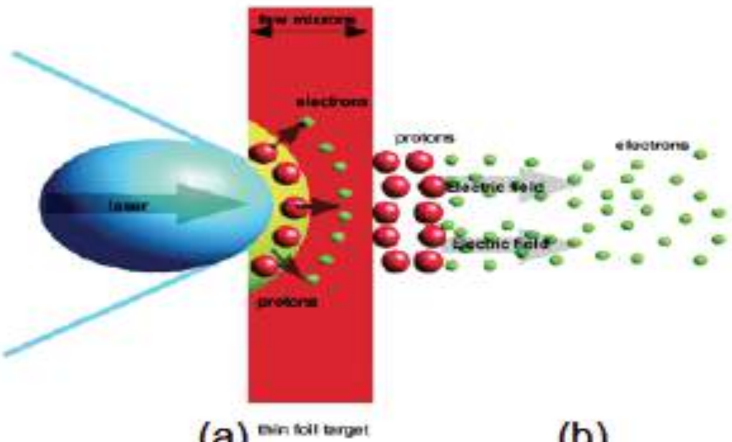


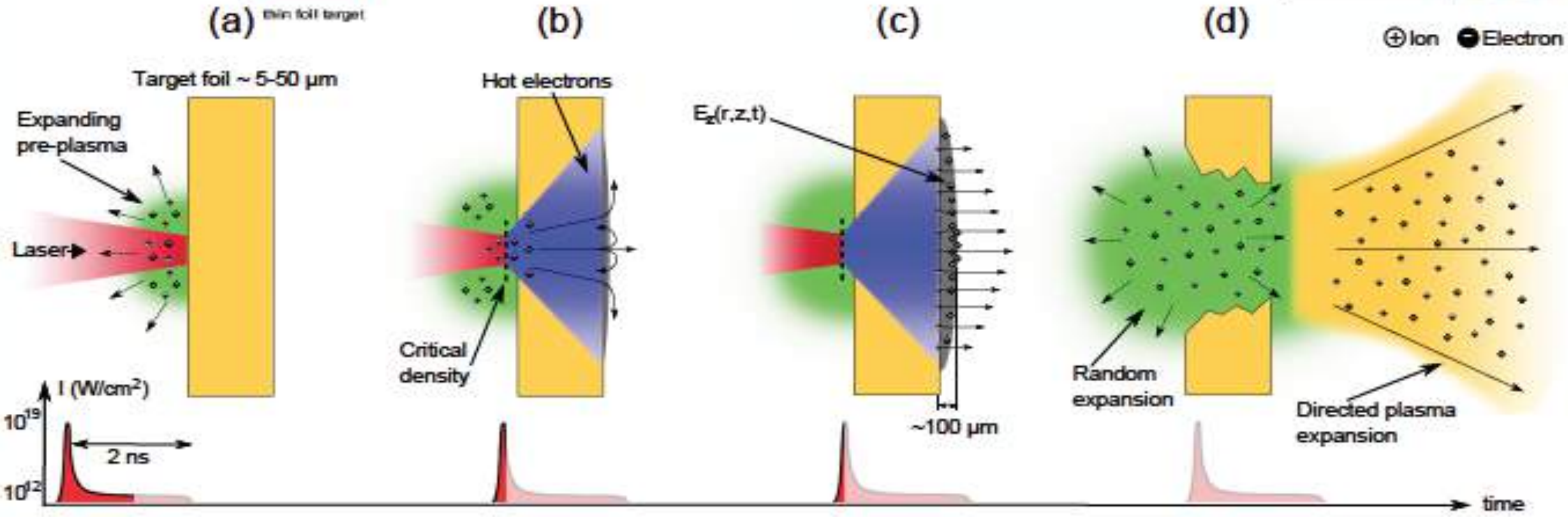

**Synchronization system:** A fine temporal alignment among all the relevant sub-system oscillators that guarantees temporal coherence of their outputs (**precision ~10fs**)

**Tasks:** triggers to sub systems (RF pulses, laser amplifiers, BPM, injection/extraction kickers), event tagging

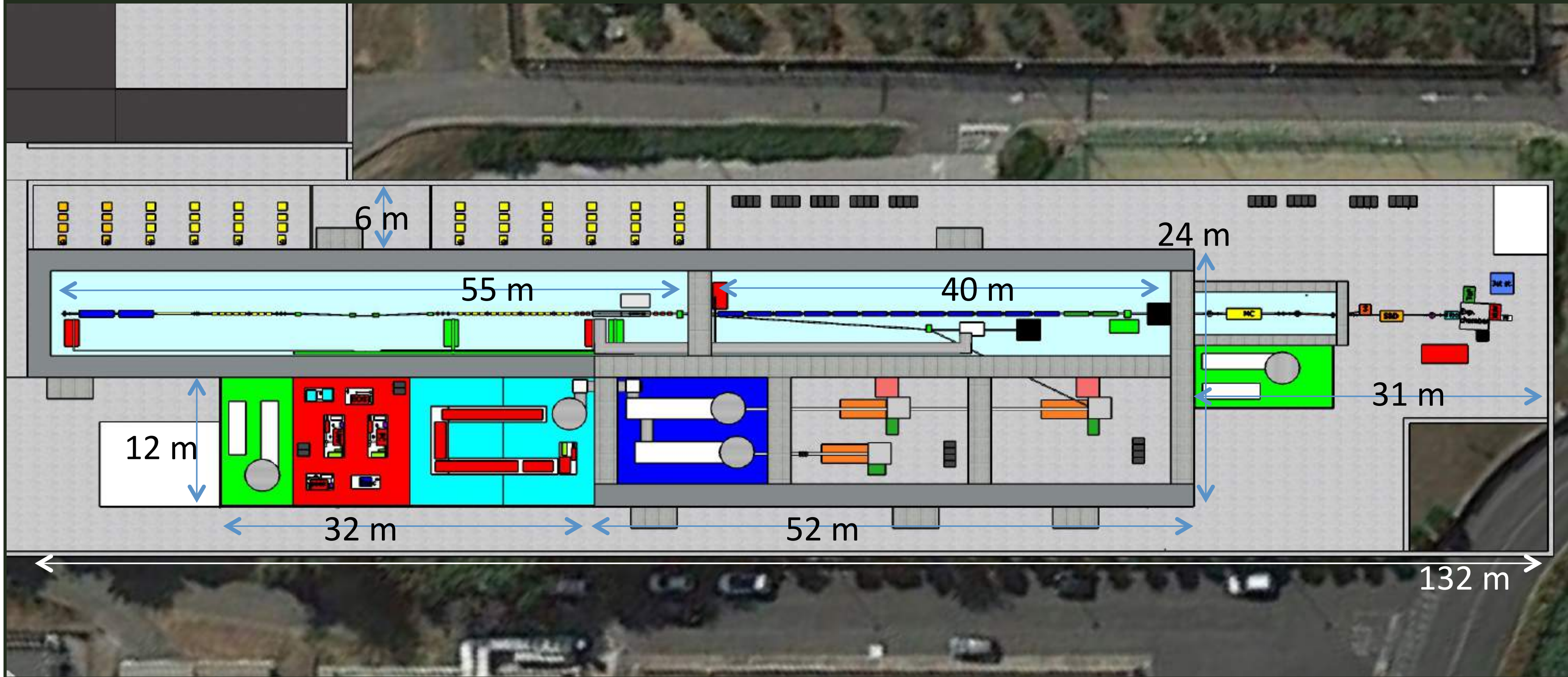
**Layout:** 1 Electrical and 1 Optical Master Oscillator, 3 RF extractors, 2 optical link ends (diagnostics and users)

# Target Normal Sheath Acceleration



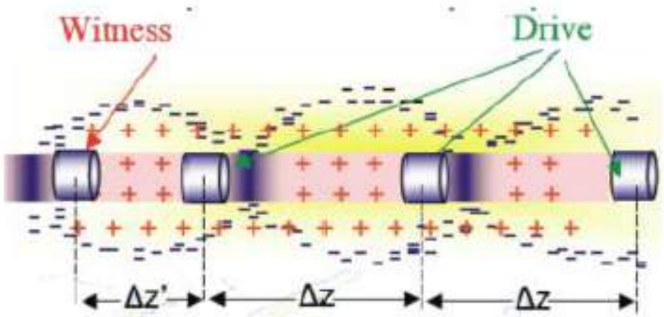



- The Plasma Accelerator Complex



# Plasma-based acceleration techniques

**resonant-PWFA**



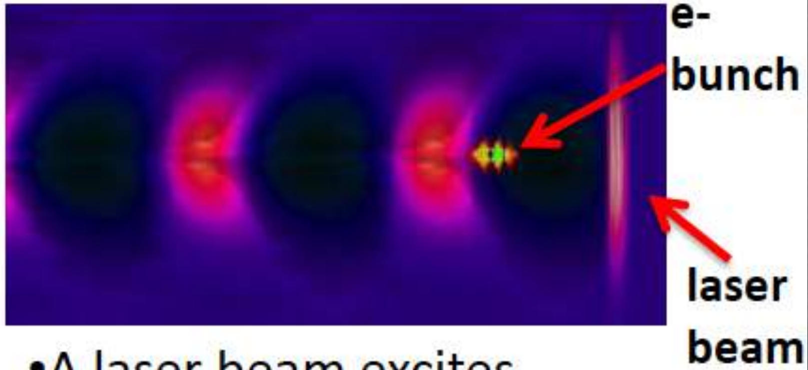

•A train of three electron bunches (driver bunches) is sent through a capillary discharge

•A resonant plasma wave is then excited in plasma

•A fourth electron beam (witness beam) uses this wave to be accelerated

$n_e = 2x10^{16}$ $cm^{-3}$
$\lambda_p = 300\mu m$
Capillary 1mm
Hydrogen

**external injection LWFA**

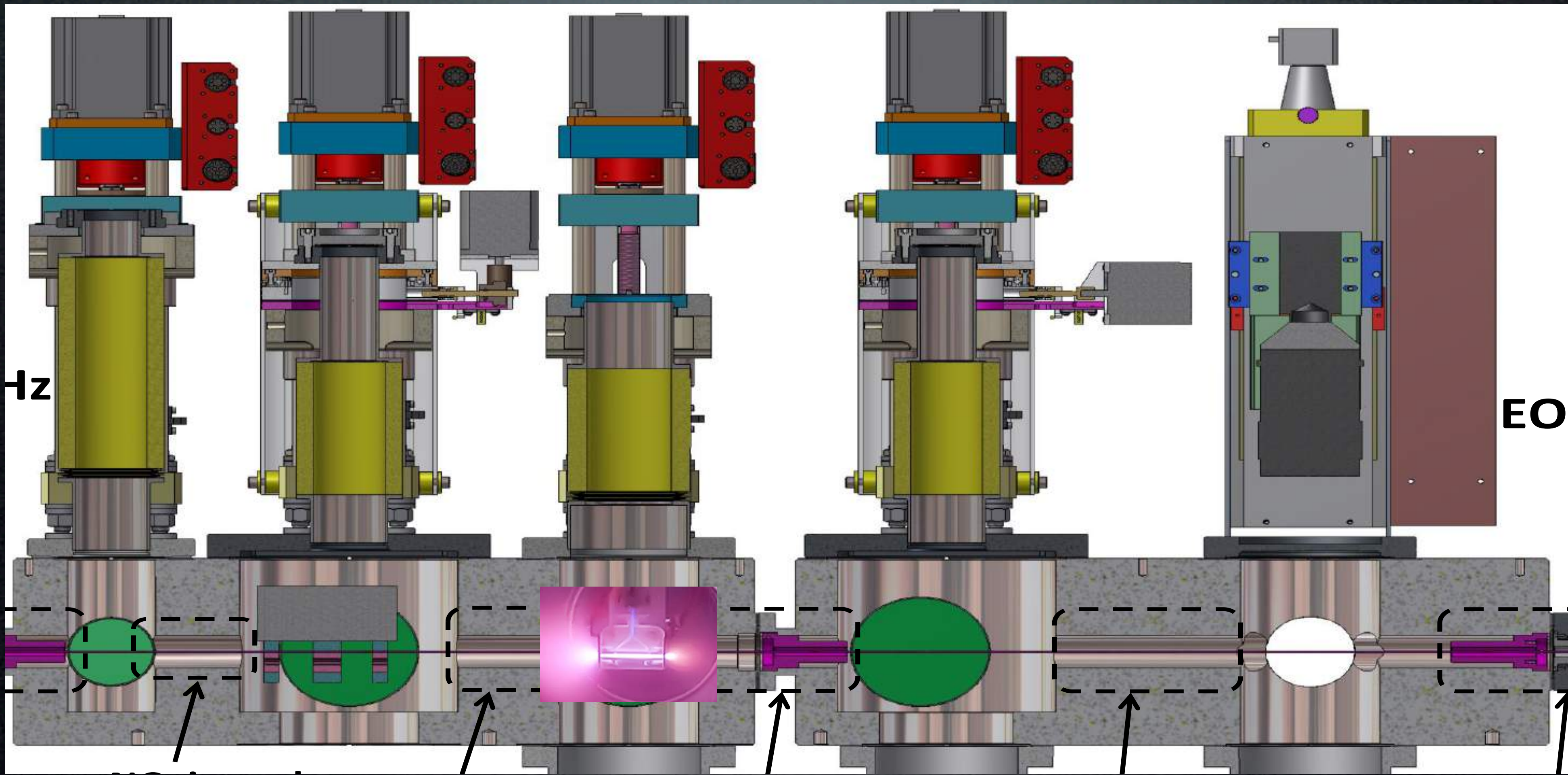



•A laser beam excites plasma waves in a capillary filled with gas

•A high brightness electron beam uses this wave to be accelerated

$n_e = 1x10^{17}$ $cm^{-3}$
$\lambda_p = 100\mu m$
Capillary 100 µm
Hydrogen

# SPARC_LAB Plasma Vacuum Chamber

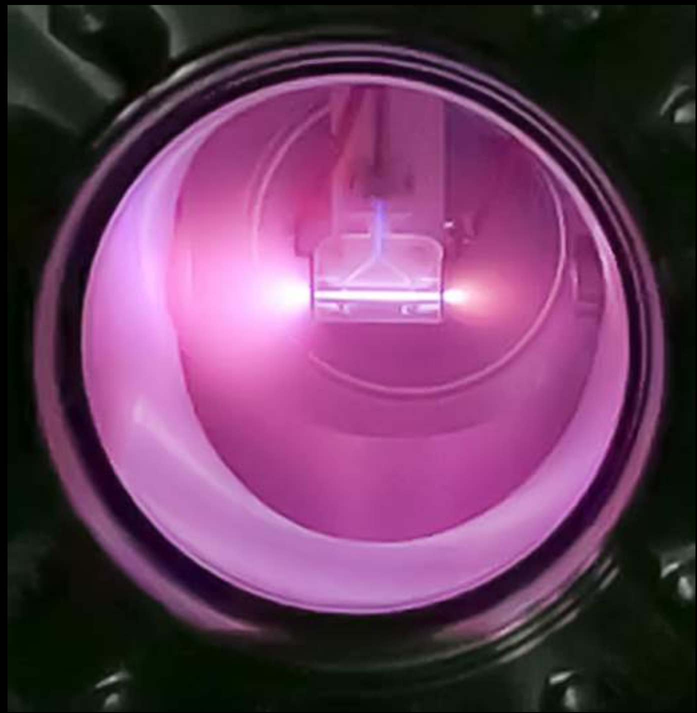



Focusing PMQ

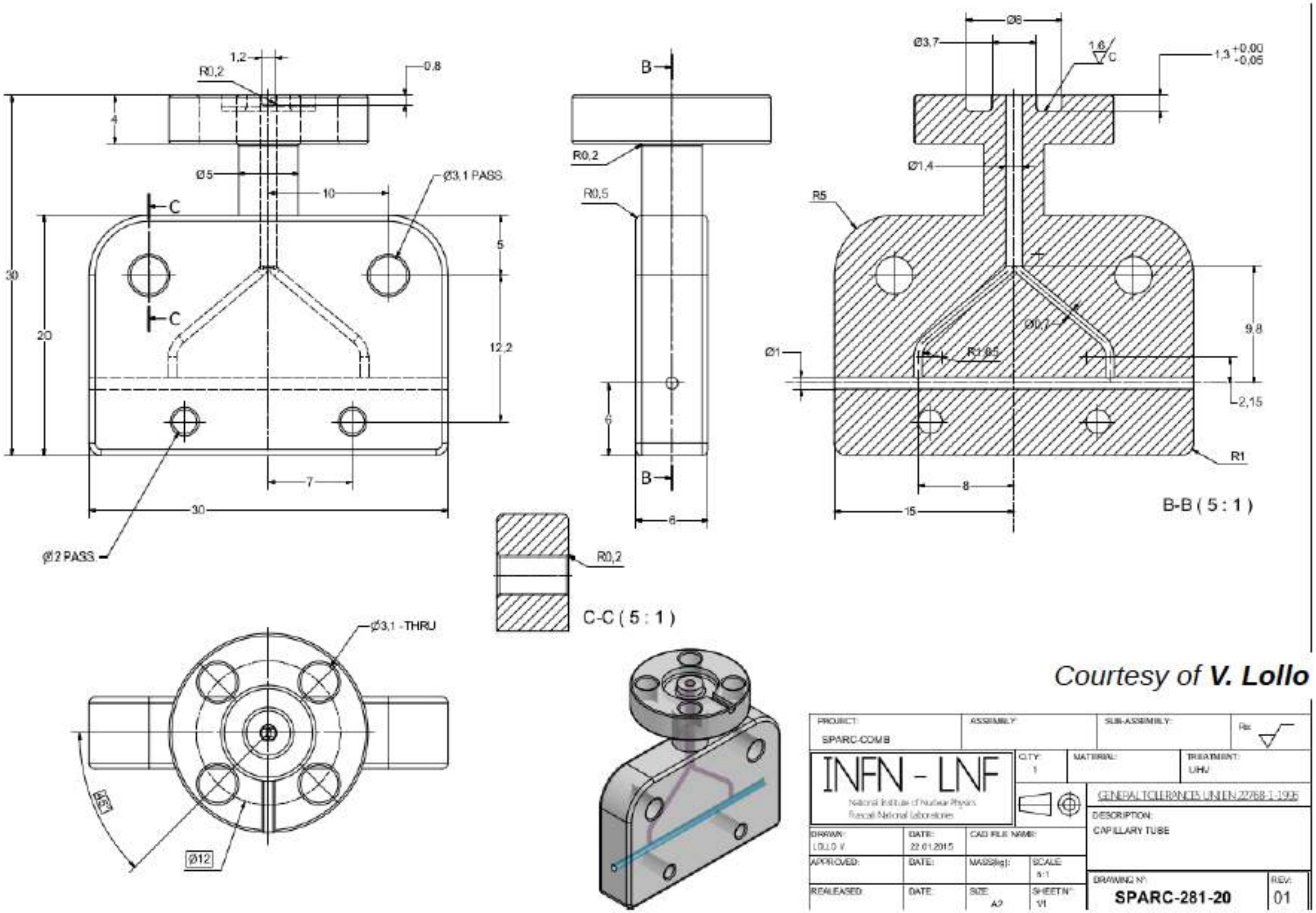
PWFA module

Capture PMQ

# Capillary Discharge at SPARC_LAB



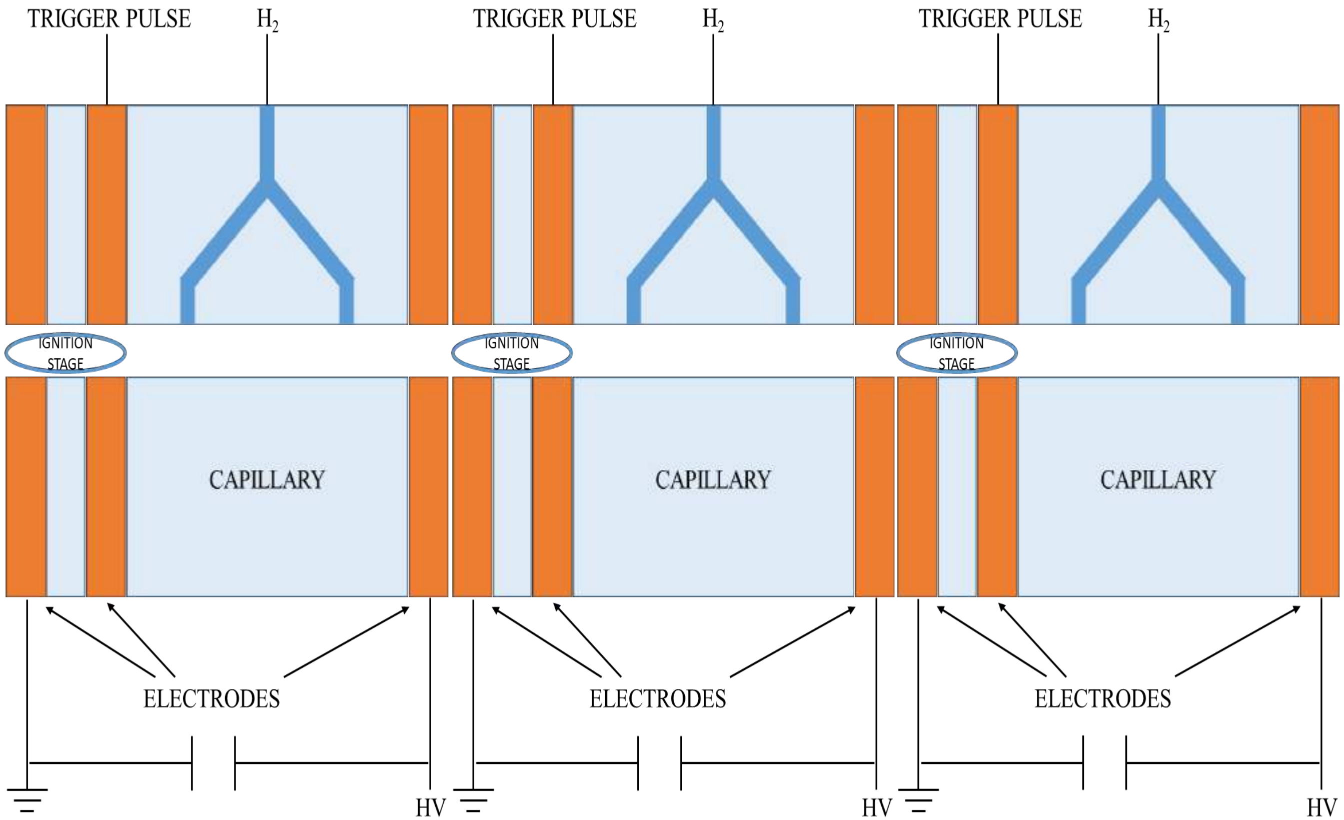
# Plasma capillary



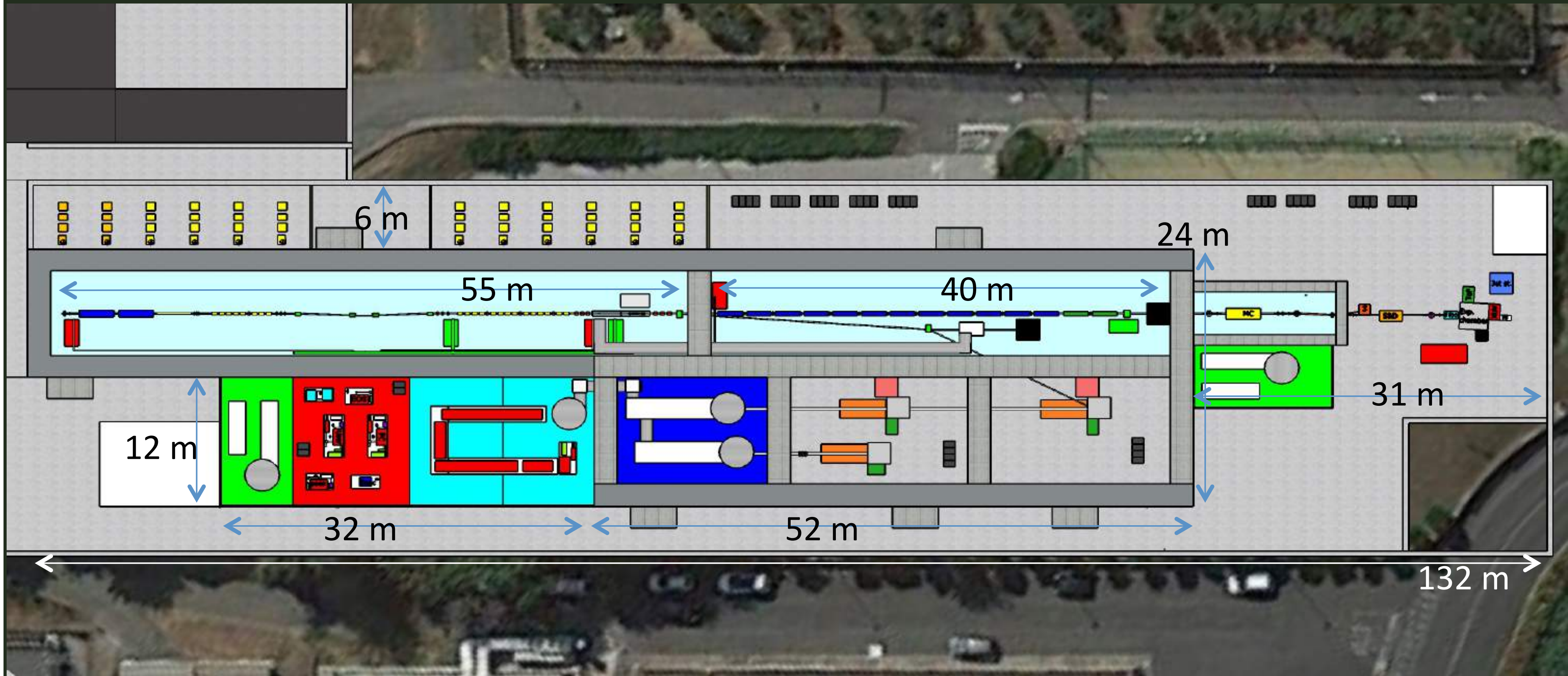

*Courtesy of* ***V. Lollo***

# Plasma source

This scheme can be reproduced for tens-of-centimetre capillaries. This single unit can be integrated simply by adding more units obtaining up to tens of centimetre capillaries homogenously ionized and controlled independently one to each other, leading to the desired length of plasma (almost 30 cm) with the proper density ($10^{17}$ $cm^{-3}$) required for this project.

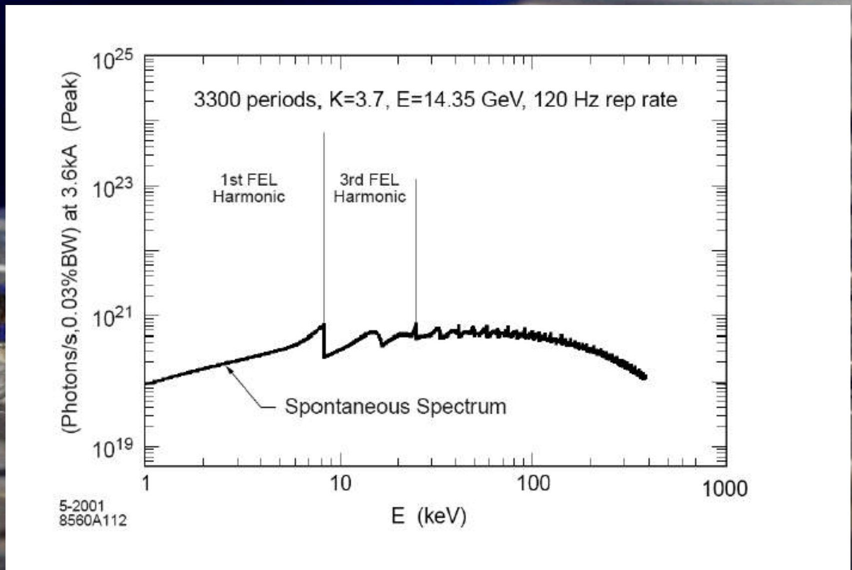


- The FEL




- 500 MeV by RF Linac + 500 MeV by Plasma
- 1 GeV by RF Linac only (EuSPARC)

# SASE FEL studies



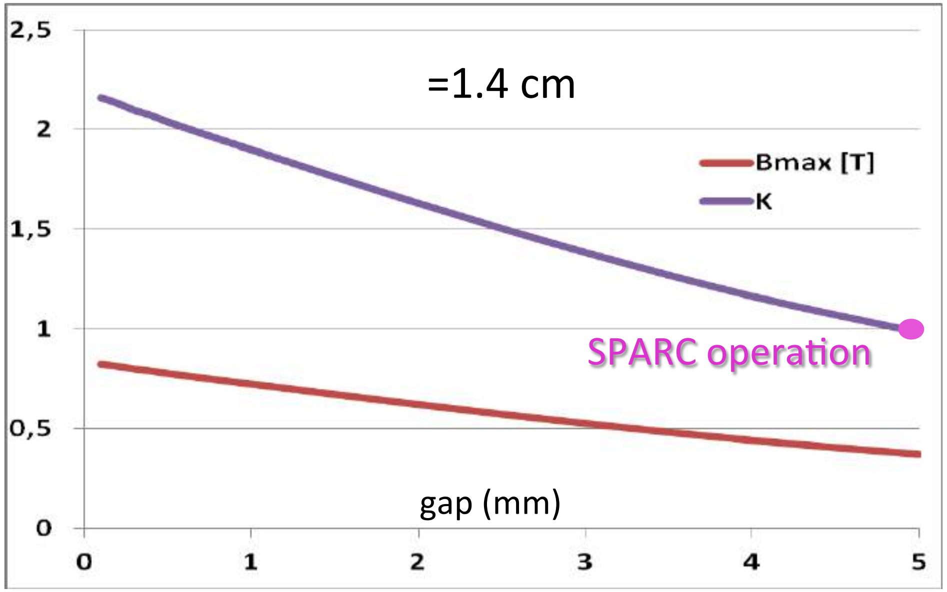

$$\lambda_{rad} \approx \frac{\lambda_u}{2\gamma^2}\left(1 + \frac{K^2}{2} + \gamma^2\vartheta^2\right)$$

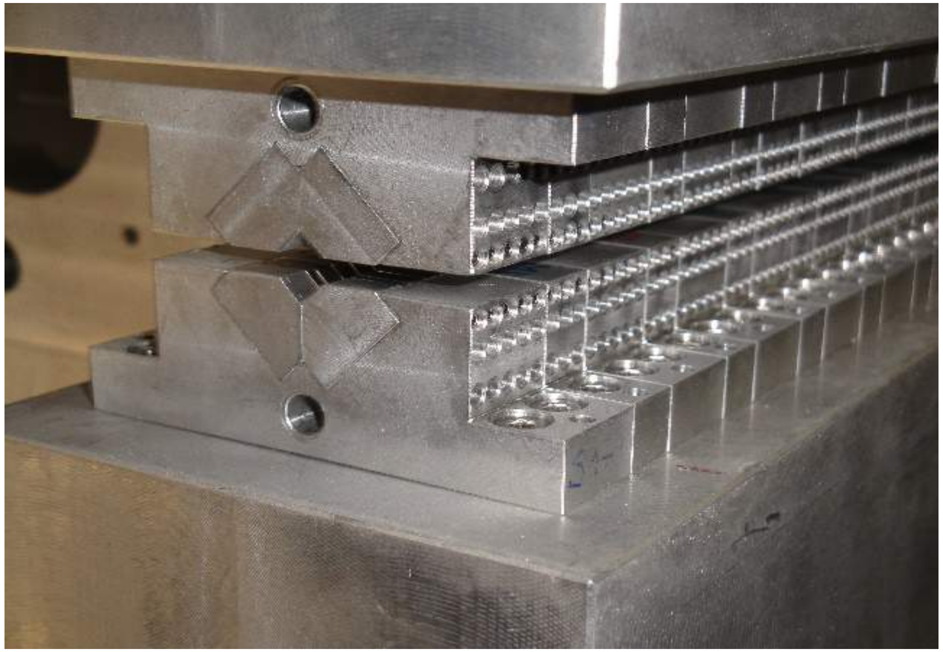
## **KYMA Δ undulator:**
designed by ENEA Frascati,
constructed by Kyma Trieste,
tested on beam at SPARC_LAB

- DELTA like undulator

  $\lambda_u$ = 1.4 cm, gap g = 5mm, Br = 1.22T.

Undulator tested in two stage SASE-FEL:
630nm to 315 nm



L'iniziativa EuPRAXIA@SPARC_LAB è valutata, quindi, di grande rilevanza scientifica per Elettra, che la considera sinergica con le proprie attività di ricerca.

Con la presente lettera Elettra intende esprimere, perciò, il proprio interesse a collaborare con INFN alla preparazione del TDR di EuPRAXIA@SPARC_LAB, con particolare attenzione allo sviluppo del linac in banda X, alla concezione di ondulatori compatti, allo studio degli schemi FEL più adatti allo scopo e alla progettazione delle relative linee di luce. Allo scopo di favorire la collaborazione con INFN in questi campi, Elettra potrà rendersi disponibile ad ospitare giovani ricercatori per brevi periodi di training.

Cordiali saluti

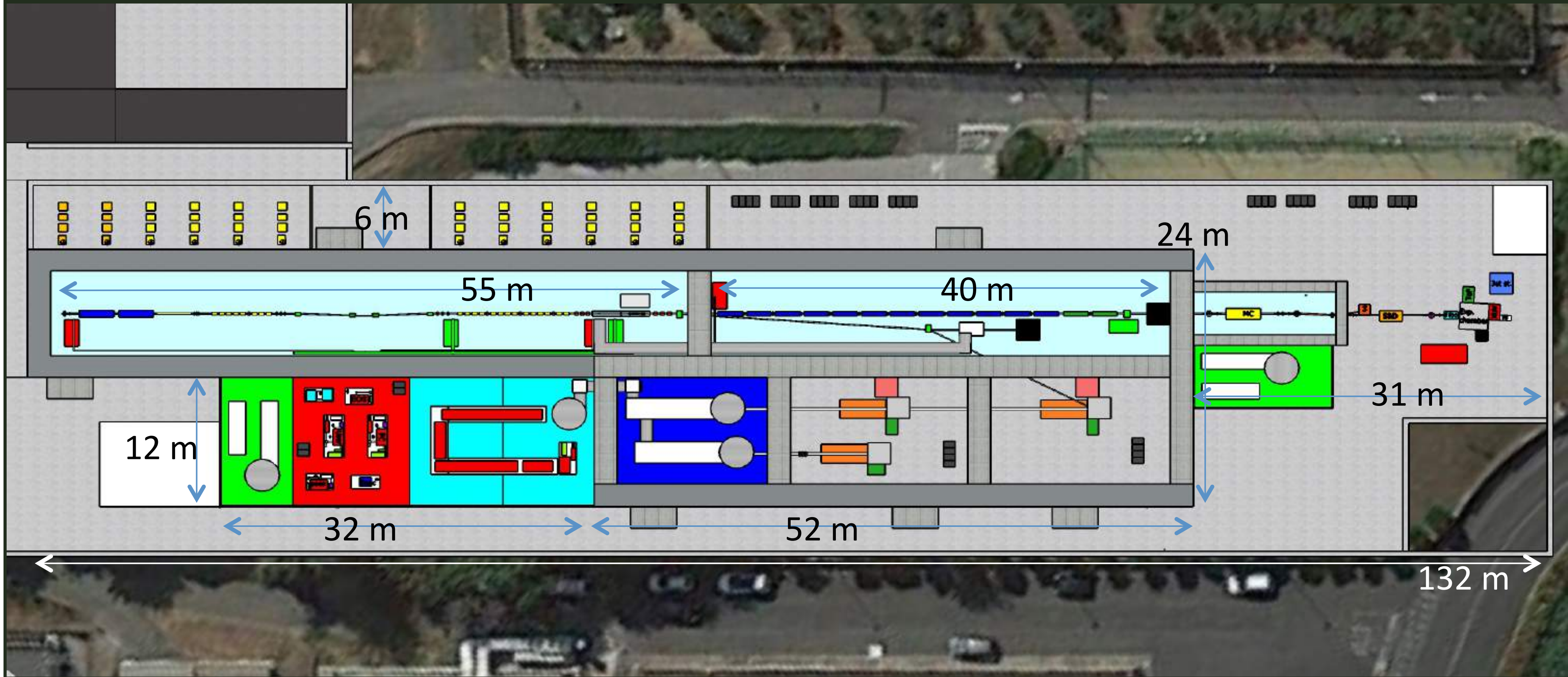
Elettra Sincrotrone Trieste

**LETTERA DI INTERESSE**

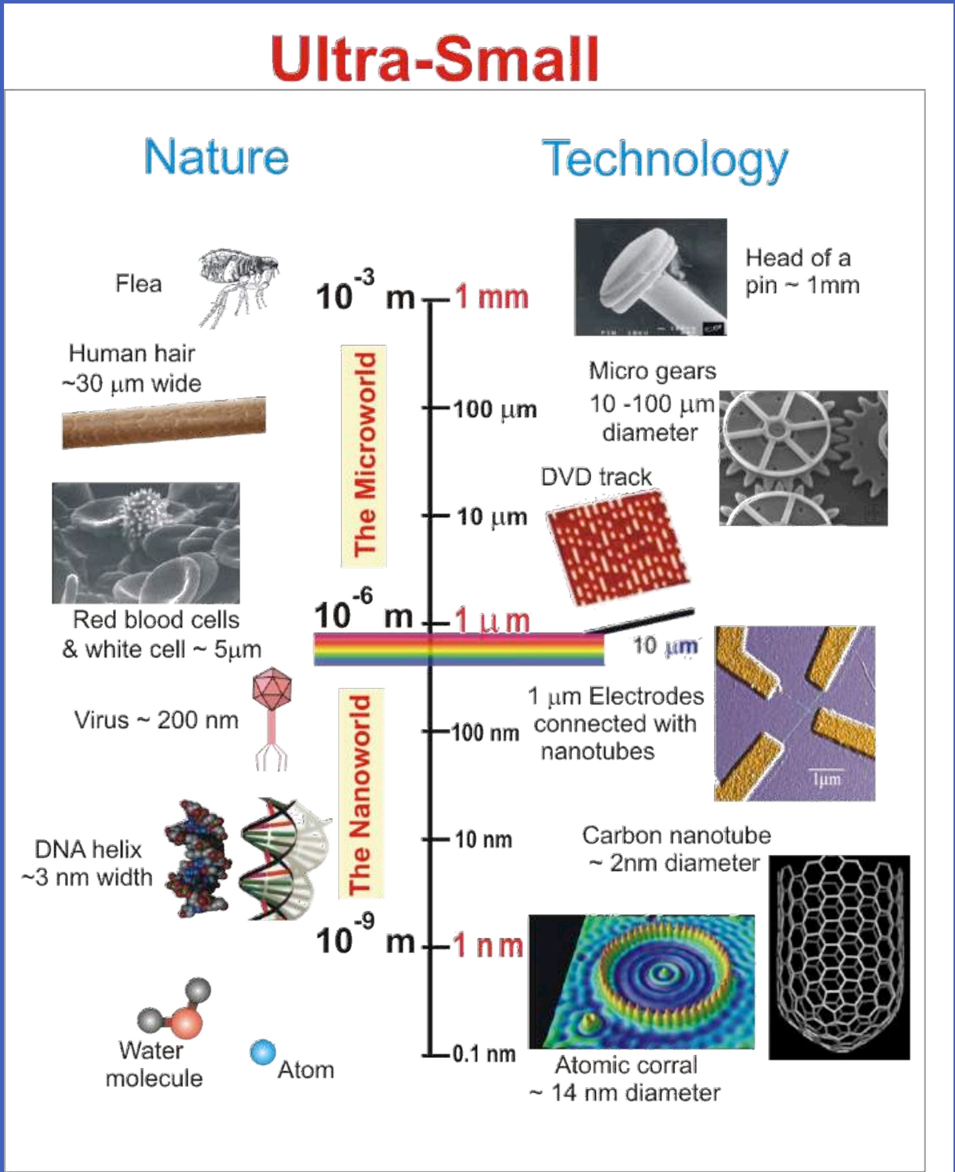
Il Presidente e Amministratore Delegato

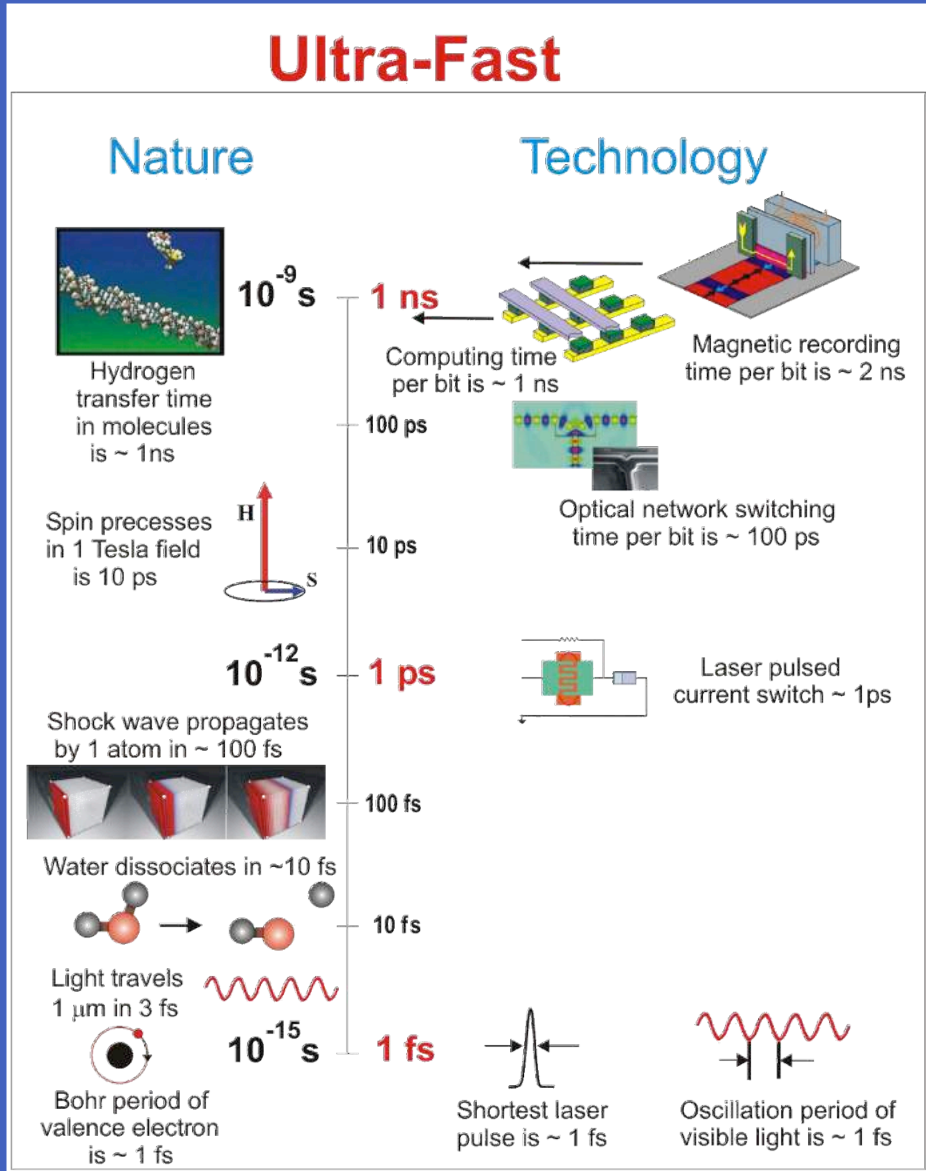
Prof. Alfonso Franciosi

- The User Beam Line

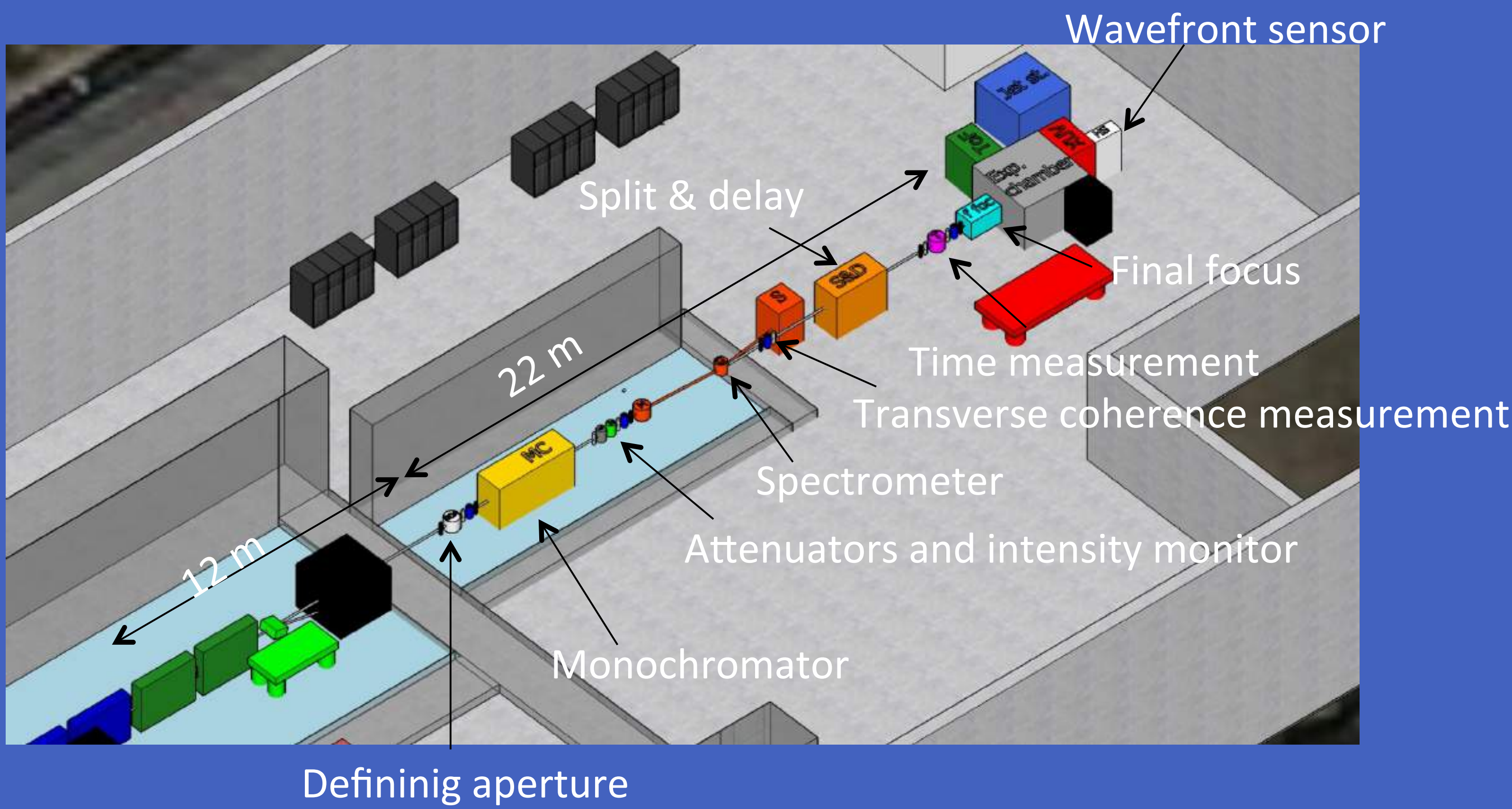


# Science with FEL



# Photon beam line

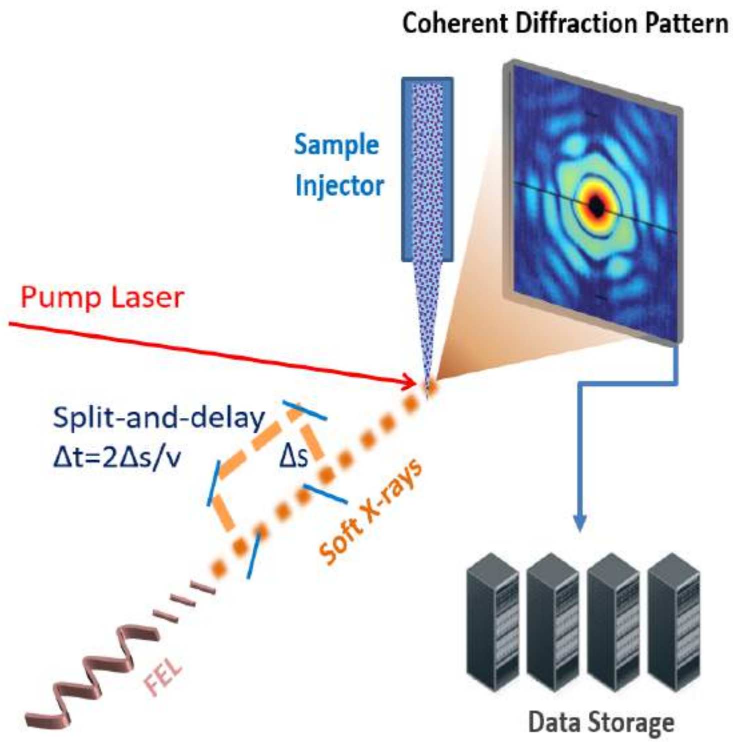


# Coherent Imaging @ EuSPARC/EuPRAXA

**2 key issues:** brilliance and coherence of the FEL radiation

**1 experimental station** performing coherent imaging experiments

**Many applications**, ranging from biological systems to condensed matter physics

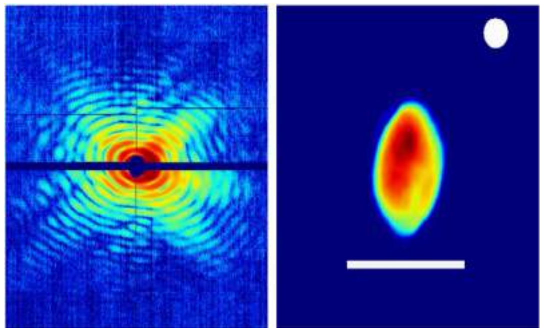


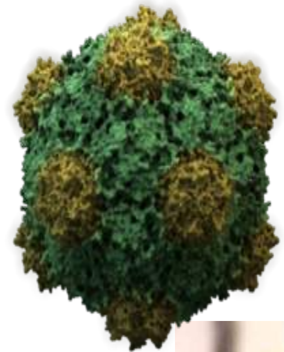

**Water Window Coherent Imaging of biological systems**

Energy region between oxygen and carbon K-edge

2D and 3D images of biological samples will be obtained

viruses, cells, organelles, protein fibrils…





**Condensed-matter**

High Temperature superconductors

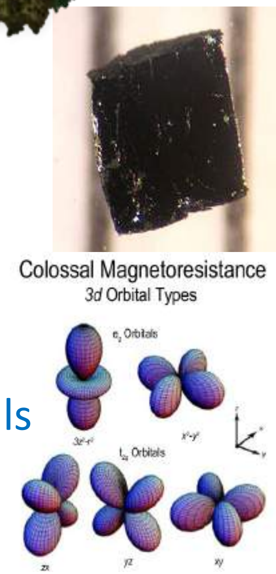
Metal-insulating transitions

Colossal magnetoresistance phenomena

Ferroelectrics & multiferroics materials

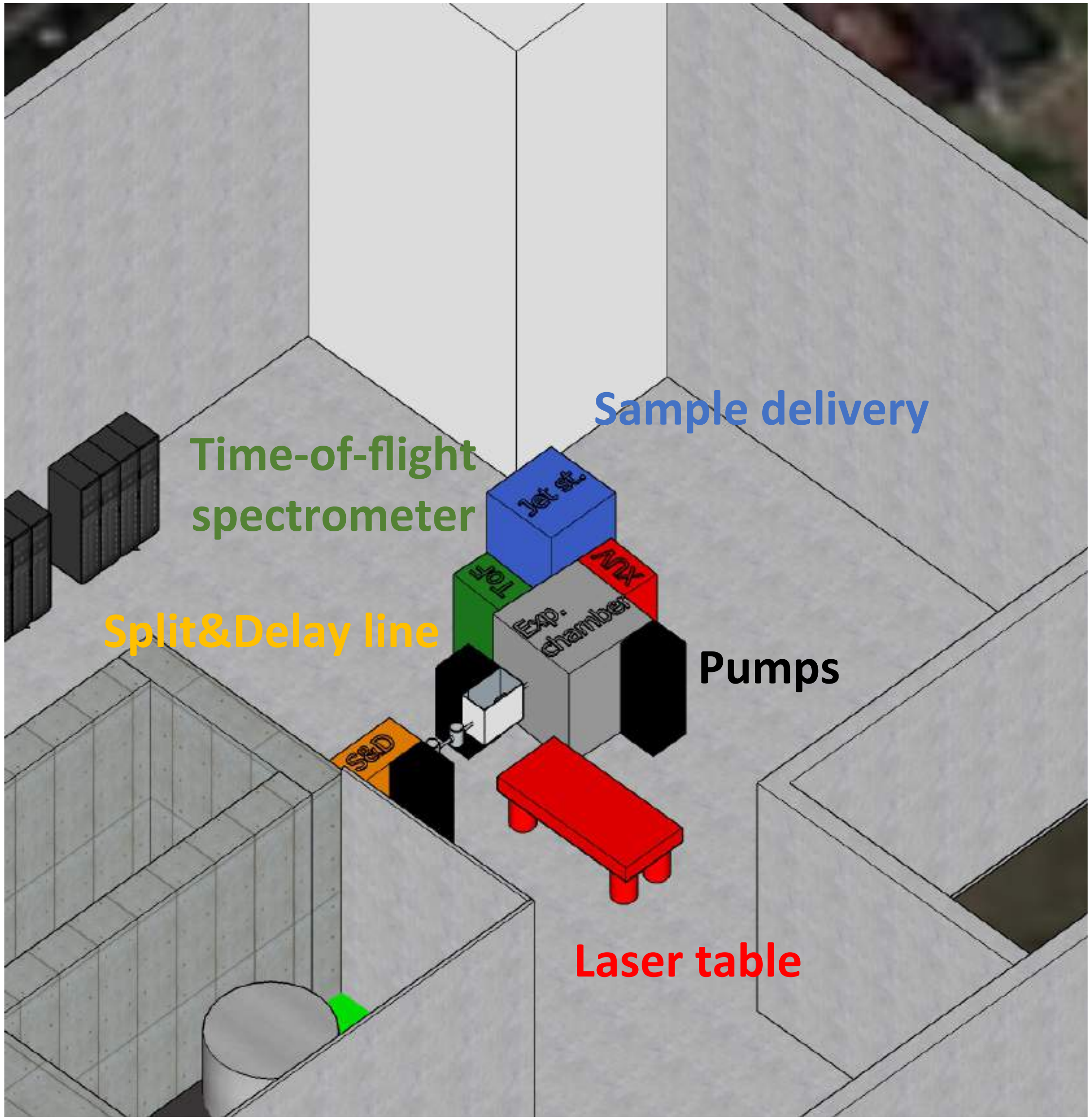
Skyrmions, spintronics

Nanoparticles and plasma



# The Experimental Endstation

| Parameters | Expected values |
|---|---|
| Radiation wavelength | 2-4 nm (310-620 eV) |
| Photons per pulse* | $1\text{-}7 \times 10^{11}$ |
| Pulse length (FWHM) | 10-50 fs |
| Repetition rate | 10-100 Hz |
| Bandwidth (FWHM) | 1 eV |




**A versatile, state-of-the art, fully equipped experimental station (and a transport line) will be necessary to exploit the brilliant, ultra-short and coherent FEL pulses**

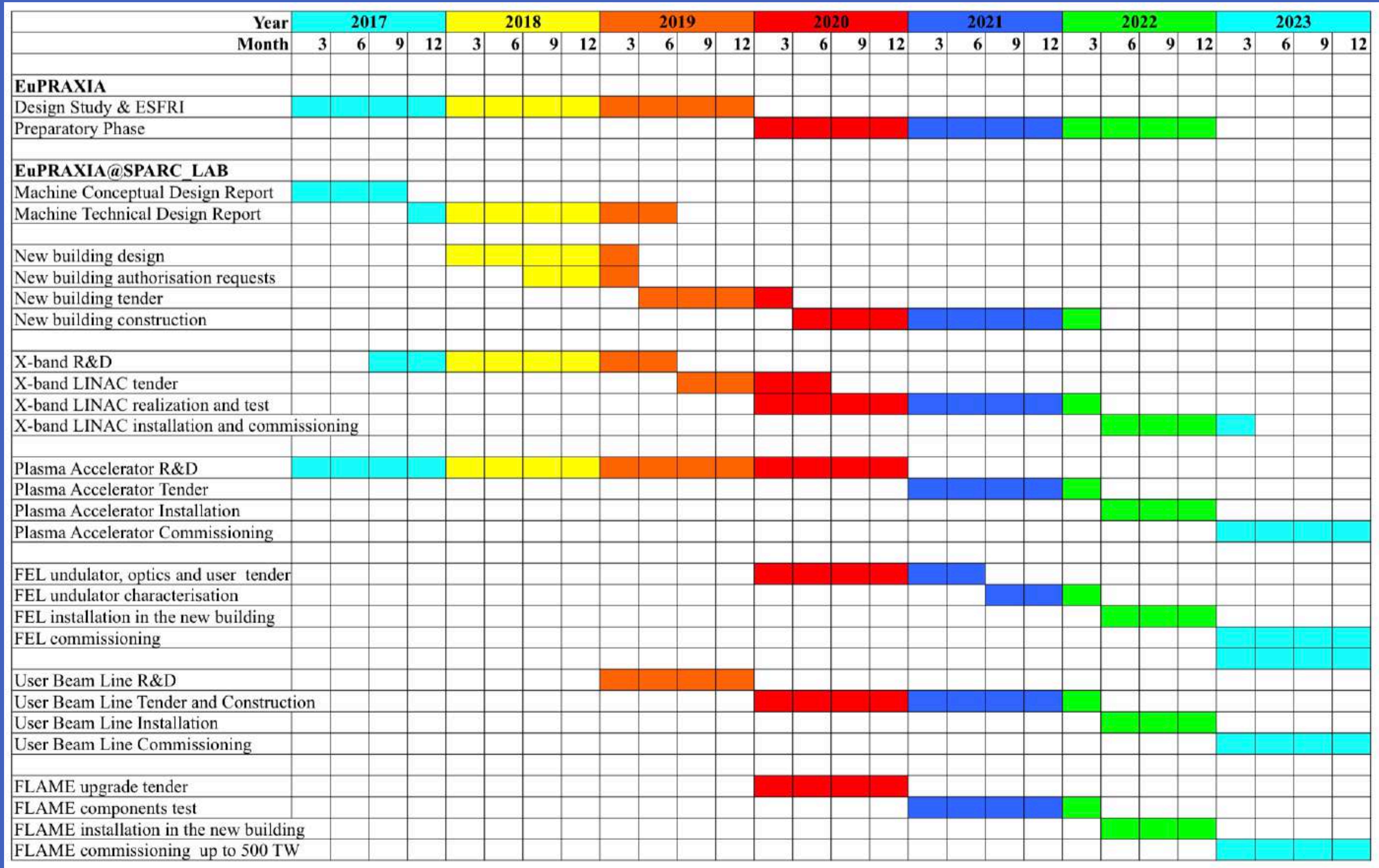
# EuPRAXIA@SPARC_LAB

# Project timeline

| | |
|---|---|
| 09.2014 | Proposal submission |
| 07.2015 | Approval |
| 11.2015 | **Start of EuPRAXIA project** |
| 2016 | Organization (collaboration agreements, …). Hiring dedicated personnel. Ten workshops on EuPRAXIA/EuroNNAc matters. Decision parameters for first study versions. |
| 08.2019 | Application to **ESFRI roadmap** for 2020 update |
| 10.2019 | Final **conceptual design report** and end design study |
| *2020* | *Construction decision* |
| *2021 – 2025* | *Construction* |
| *2025 – 2035* | *Operation* |

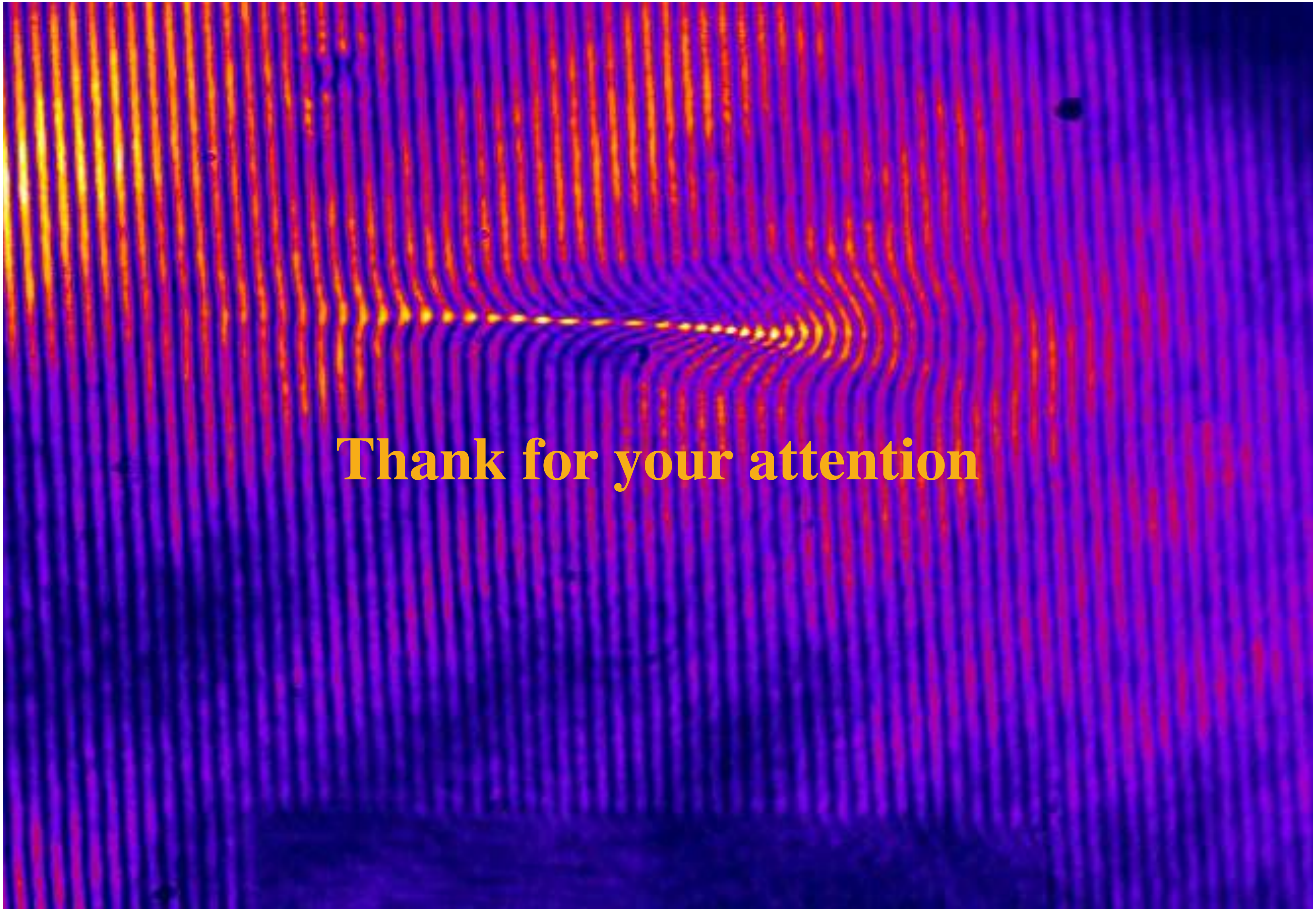
**ESFRI** = European Strategy for Future Research Infrastructures

# EuPRAXIA@SPARC_LAB timeline



# EuPRAXIA@SPARC_LAB

- X-band RF technology implementation, CLIC collaborations
- Science with short wavelength Free Electron Laser (FEL)
- Physics with high powerlasers and secondary particle generation
- R&D on compact radiation sources for medical applications
- Detector development for X-ray FEL
- Science with THz radiation sources
- Nuclear photonics with $\gamma$-rays Compton sources
- R&D on polarized positron sources
- Quantum aspects of beam physics, Quantum-FEL development
- R&D in accelerator physics and industrial spin – off


Thank for your attention