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# EuPRAXIA 2nd site options

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**for providing information, input, material, slides**

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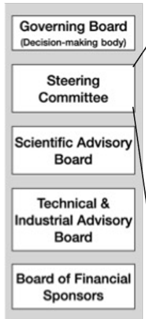
# Why us?

Funded by the European Union

**WP3 : "Organization and Rules" coordinators: Andrea GHIGO (INFN) Arnd SPECKA (CNRS)**




**WP1 - Coordination & Project Management**
R. Assmann, INFN & DESY
M. Ferrario, INFN

**WP2 - Dissemination and Public Relations**
C. Welsch, U Liverpool
S. Bertellii, INFN

**WP3 - Organization and Rules**
A. Specka, CNRS
A. Ghigo, INFN

**WP4 - Financial & Legal Model. Economic Impact**
A. Falone, INFN

**WP5 - User Strategy and Services**
F. Stellato, U Tor Vergata
E. Principi, ELETTRA

**WP6 - Membership Extension Strategy**
B. Cros, CNRS
A. Mostacci, U Sapienza

*WP's on coordination & implementation as ESFRI RI (organization, legal model, financing, users)*

**WP7 - E-Needs and Data Policy**
R. Fonseca, IST
S. Pioli, INFN

**WP8 - Theory & Simulation**
J. Vieria, IST
H. Vincenti, CEA

**WP9 - RF, Magnets & Beamline Components**
S. Antipov, DESY
F. Nguyen, ENEA

**WP10 - Plasma Components & Systems**
K. Cassou, CNRS
J. Osterhoff, DESY

**WP11 - Applications**
G. Sarri, U Belfast
E. Chiadroni,U Sapienza

**WP12 - Laser Technology, Liaison to Industry**
L. Gizzi, CNR
P. Crump, FBH

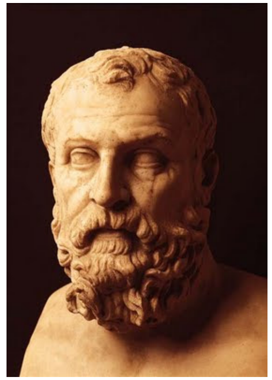
**WP13 - Diagnostics**
A. Cianchi, U Tor Vergata
R. Ischebeck, EPFL

**WP14 - Transformative Innovation Paths**
B. Hidding, U Strathclyde
S. Karsch, LMU

**WP15 - TDR EuPRAXIA @SPARC-lab**
C. Vaccarezza, INFN
R. Pompili, INFN

**WP16 - TDR EuPRAXIA Site 2**
A. Molodozhentsev, ELI-Beamlines
R. Pattahil, STFC

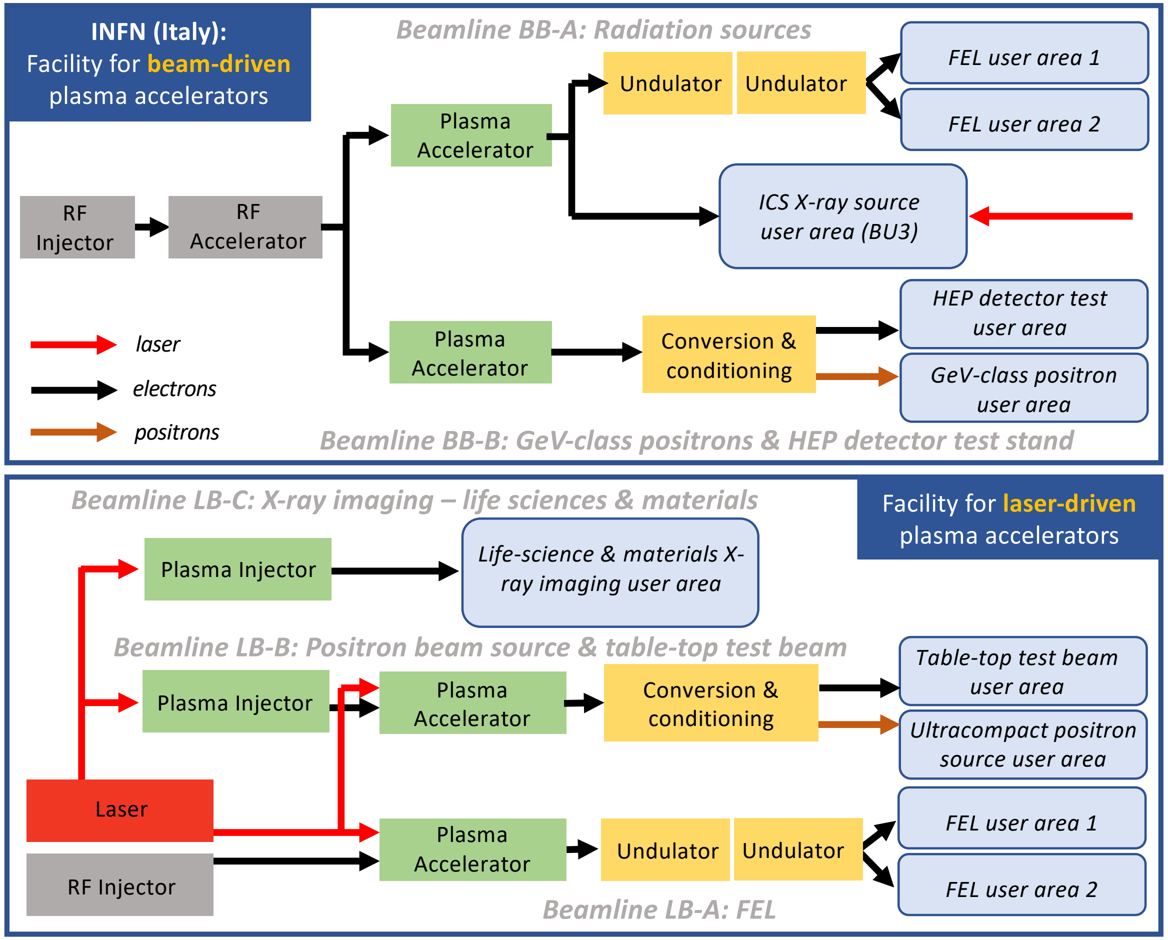
*WPs on technical implementation and sites*




2nd site

# Phased Implementation of Construction Sites

| | Laser-driven | Beam-driven |
|---|---|---|
| **Phase 1** | ✓ FEL beamline to 1 GeV + user area 1<br>✓ Ultracompact positron source beamline + positron user area | ✓ FEL beamline to 1 GeV + user area 1<br>✓ GeV-class positrons beamline + positron user area |
| **Phase 2** | ✓ X-ray imaging beamline + user area<br>✓ Table-top test beams user area<br>✓ FEL user area 2<br>✓ FEL to 5 GeV | ✓ ICS source beamline + user area<br>✓ HEP detector tests user area<br>✓ FEL user area 2<br>✓ FEL to 5 GeV |
| **Phase 3** | ✓ High-field physics beamline / user area<br>✓ Other future developments | ✓ Medical imaging beamline / user area<br>✓ Other future developments |



# Baseline Scenario for 2nd Site Assessment (proposal R.A.)

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- EuPRAXIA CDR contains various options and scenarios, also for second site.
- Baseline scenario to be defined. Here (my) first thoughts on possible approach:
  - Assessment on operational **laser-driven 1 GeV plasma FEL (20 Hz, 30 pC) as requirement for initial operation**: space, investment cost, person-power, brilliance, space & time for users, … Choose your favorite scheme (1 or 2 stage, all optical or plasma plus RF, injection scheme, …).
  - **Beneficial in review**: Additional applications & user beamlines (time plan & resource needs), test plan for 2 stage plasma acceleration
  - **Outlook**: Upgrade plan to 100 Hz, to 5 GeV FEL, … including eventually required R&D, personnel cost, invest budget for implementation

| | Laser-driven |
|---|---|
| **Phase 1** | ✓FEL beamline to 1 GeV + user area 1<br>✓Ultracompact positron source beamline + positron user area |
| **Phase 2** | ✓X-ray imaging beamline + user area<br>✓Table-top test beams user area<br>✓FEL user area 2<br>✓FEL to 5 GeV |
| **Phase 3** | ✓High-field physics beamline / user area<br>✓Other future developments |

# Selection Criteria 2nd EuPRAXIA Site

*(from CDR, fulfilled by 1st Site LNF/INFN)*

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| Legal/Political | Technical | Financial |
|---|---|---|
| Compliance of host institution with **EuPRAXIA Access** Policy | Site provides sufficient **space** (about 175 m x 35 m) | Commitment to **sustainability** of EuPRAXIA (host lab covers site operation costs) |
| Compliance of host institution with **EuPRAXIA Open Innovation** and **Open Science** Policy | Laboratory has **infrastructures** in one or several of RF accelerators, laser installations, user access. | **Previous investments** into local infrastructures of relevance for EuPRAXIA (leverage effect) |
| Agreement of host institution with the **long-term scientific agenda** of EuPRAXIA | Site provides required **services** and facilities for support of external users, including E infrastructure | Existence of one or a mix of **funding sources** able to finance implementation of the site |
| Laboratory has existing groups in place to guarantee **safety** requirements (laser, radio-protection, access control) and rules | | |

*Note: approach reduces cost (pre-invest) and risks of cost-overun.*

# Assessment criteria: Infrastructure

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- **Infrastructure and Facilities**: power supply, cooling systems, access to water, and available land area.
- **Geographic Location:** accessibility for researchers, collaborators, and users. proximity to transportation hubs, on site or close accommodation
- **Local Support and Expertise:** local expertise in accelerator science, engineering. Presence of universities, research institutions, and industry.
- **Environmental Considerations:** environmental impact, potential risks to the local ecosystem or population.
- **Collaborative Opportunities:** synergy with existing scientific communities, research projects, and facilities in the vicinity.
- **Funding and Cost Considerations:** availability of funding sources, potential construction costs, and the overall cost of operations and maintenance
- **Legal and Regulatory Factors:** legal and regulatory framework of the host country or region. factors such as Licensing requirements, permitting processes, and any potential restrictions
- **Defense/National Security connection** (if any) : How well is the separation drawn out? Are there access restrictions?
- **Political Stability:** long-term commitment to scientific infrastructure development
- **Safety and Security:** including emergency response capabilities, physical security systems
- **Future Expansion Potential:** potential for future expansion and upgrade of the accelerator facility at the selected site.

# Assessment criteria: LPA specific

- **Laser Infrastructure**: existing laser infrastructure capable of driving the LPA: energy, repetition rate, pulse duration, and beam quality
- **Beam Quality and Stability:** pointing stability, beam profile, energy stability, temporal characteristics
- **Laser Synchronization:** with the electron beam generation and acceleration processes.
- **Beam Diagnostics and Control:** of the accelerated electron beams, including parameters such as energy, emittance, charge, and divergence.
- **Experimental Infrastructure:** readiness of beamlines, vacuum systems, target systems, and radiation shielding
- **Radiation Safety:** shielding measures, personnel protection protocols, and monitoring systems
- **Data Acquisition and Analysis:** data acquisition, storage, and analysis, high-speed, computational and network resources, data volume
- **Collaboration Potential:** opportunities to leverage complementary expertise and resources
- **Future Upgrade and Scalability:** potential for future upgrades and scalability. Flexibility of the existing infrastructure, accommodate technological advancements
- **Technical Support:** availability of skilled technical staff and support services at the site. Experienced engineers, physicists, and technicians.

# $2^{nd}$ site candidates

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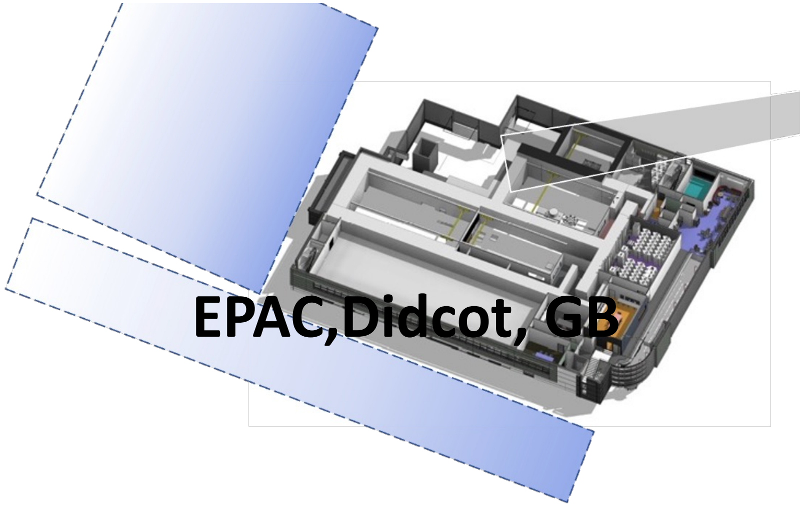
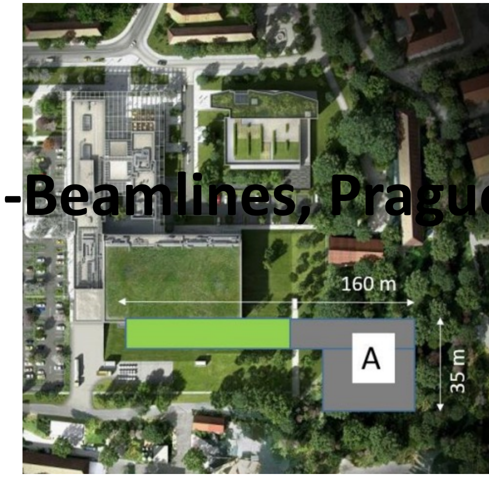
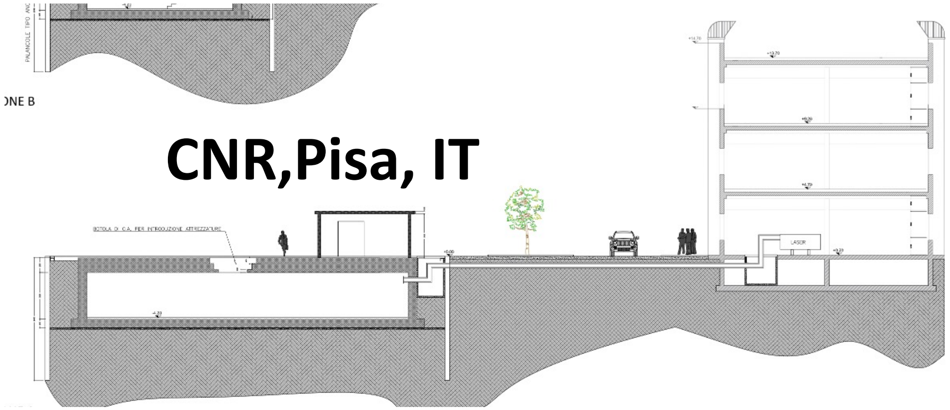
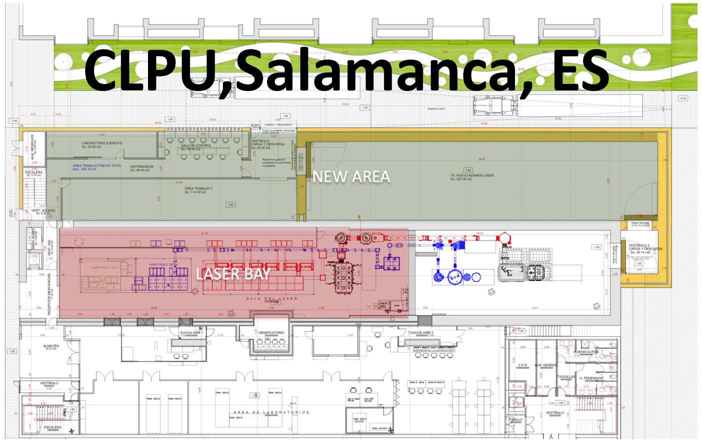
# Ground area for extensions identified



# Wishlists from 2nd site proponents

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## EPAC,Didcot, GB

| Key systems | | | R@D |
|---|---|---|---|
| 1 High power High rep-rate Laser system<br>L2-DUHA: 3-5 J / 30 fsec / 50-100 Hz | ◯ | 1 | YES<br>upgrade to 100Hz |
| 2 Laser-Plasma compact accelerator | ◯ | 2 | YES -> high quality e-bunch |
| 3 Electron beam line with relevant diagnostics | ◯ | 3 | YES<br>Active plasma lens @ 100 Hz |
| 4 Undulator line with relevant diagnostics | ◯ | 4 | - |
| 5 Photon beam line @ User stations | ◯ | 5 | - |
| 6 Control system | ◯ | 6 | - |
| Extra: Betatron and Position source | ◯ | Extra | YES -> positron |

## ELI-Beamlines, Prague, CZc

| Internally developed/coordinated key components | |
|---|---|
| Building design and construction with radiological modeling (CLF) | • Prototypes of amplifier head, solutions for heat management<br>• Test compressors with gratings with appropriate damage thresholds and heat management solutions |
| EPAC 10Hz, 30J system, 100Hz – few 100TW system (CLF) | |
| Laser beam transport (CLF) | • Solutions for wavefront and pointing corrections |
| Plasma accelerator (UK CoE) | • Diagnostics, Targets, Gas flow control, feedback systems, ML control, plasma lens |
| Electron beamline, undulators (ASTeC) | • Inputs to end-to-end FEL simulations with laser-driven electrons, undulator design, electron beam transport, photon beamline, diagnostics |
| User areas (UK CoE) | • Input to design of user stations, rigs, diagnostics |
| Betatron beamline (UK CoE) | • Physics simulations of LWFA and optimisation of secondary sources for various applications, diagnostics |
| Positron beamline (UK CoE) | • Advanced Accelerator schemes (eg. Trojan Horse) |

## CNR,Pisa, IT

**Wish list for 2nd Site PISA**

The construction of the 2nd site in Pisa would be based on the experience gained by the CNR group over more than 20 years of operation of the Intense Laser Irradiation Laboratory (ILIL) and including the commissioning of the FLAME laser facility at LNF-INFN.

The Site 2 of the EuPRAXIA infrastructure, namely the LASER-driven site, is unique in its kind for the scientific mission, for the scale and for the advanced science and technology of the proposed laser and plasma components.

**Building design and construction**: the construction or the Pisa 2nd site is foreseen to be designed as a new building, starting from the green field, to ensure proper construction and full architectural compliance with sustainability and environmental guidelines. Such conditions would be difficult to attain with adaptation ad extension of existing lab space and would require stop of operations of the existing facility. Collaboration with experts of infrastructures and facility design (e.g. INFN, STFC, ELI, ESS etc.) is expected to deliver the first concept of 2nd Site.

**Laser driver**: based on the existing conceptual design, a path for construction and commissioning is being identified. A first step is already being taken with the definition of the laser front-end specifications of a 100 Hz repetition rate system that is currently being procured (EUAPS). The following steps include technical design of the amplification chain, compression, transport and focusing to target and will require strong contribution from many EuPRAXIA partners.
A list of R&D items (and possible EUPRAXIA partners/contributors) include 100 J amplifier design (STFC), kW average power beam transport (ELI-BL) and compressor gratings (DESY), passive and active mechanical stabilization (CNRS), pump laser design (AMPLITUDE, THALES, STFC), high efficient laser diodes (FBH), components lifetime test bed ELI-BL), cryo lab development (AMPLITUDE) etc.
Specifically for the Multi pulse driver concept (REMPI), main contribution is expected from ELI-NP and from OXFORD, possibili with in-kind contributions.

**Plasma components**: The required plasma components will be defined according to the selected acceleration scheme (jet, cell, capillary etc ..). Here delivery is expected from leading partners in this areas, including industrial partners (e.g. SOURCELAB) that have developed engineered components for user operation.

**Plasma diagnostics**: The Pisa group has an extensive experience in the development and fielding of plasma diagnostics, including data acquisition and analysis. On line plasma diagnostics for the 2nd site will be designed and developed based on this this expertise and taking advantage of unique capabilities of selected partners (CNRS, STFC etc ).

**Electron beam diagnostics**: Main contribution to beam diagnostics is expected from INFN and DESY.

**Undulators**: Main contribution to beam diagnostics is expected from INFN and DESY.

**Strength:**
- Strong motivation;
- Solid expertise with commissioning and operation of intense laser lab;
- Established experience as user of laser-plasma expts;
- Positive feedback from CNR headquarters.

**Weakness:**
- Significant scalup compared to existing facility
- High cost
- Timescale for commitment

**Opportunity:**
- Engaged national matching funds for existing facility/lab
- Link with LASERLAB
- Strengthen national collabotation (CNR-INFN-UNI)

**Threats/Risk:**
- Community scale
- Training
- User operation funding
- Future EuPRAXIA plans

## CLPU,Salamanca, ES

- Start to end simulations (plasmas, FEL)
- Laser to laser and laser to electrons synchronization
- Laser upgrade (from 1 to 10 Hz)
- Electron and plasma diagnostics (partial support)
- FEL beamlines (design, implementation, diagnostics)
- Control System and Machine Learning
- Plasma Targets
- Staging
- Undulators development (construction and characterization)
- Positron Source
- Accelerator & beamlines installation/alignment (references, laser tracker etc.)
- Magnets (partial support)
- Outreach
- Training

# Wishlists from 2nd site candidates: first impressions

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- Thanks to impressive pre-investment (existing infrastructures, human resources, and technological expertise) all candidates appear to have in hand many (if not all) key components for achieving phase 1!
- Desired contributions from CoE are not identical for each candidate. (e.g. betatron, positrons for ELI-BL) -> complementarity
- Potential synergies between 1st site (LNF) and 2nd site should be explored more deeply. (e.g. Control systems, design of user areas, photon line, ML beam optimization, plasma lenses)
- Strong transverse needs identified, e.g. start-to-end simulations

# Towards an unified qualitative assessment criteria 0-order draft

- How long-standing/strong is the lab's **expertise** in:
  High power laser, Electron beam , X-ray optics, FEL  operation , synchrotron radiation users, user management
- Does the lab have **equipment** that can be partly or fully dedicated to EuPRAXIA?
  High power (PW) laser, Interaction plasma chamber, Electron /photon transfer lines, undulator, X-ray transfer line, User end station
- What is the **available space**, as building or as construction grounds, for laser, undulator, transport line, user areas
- Are there conflicts with the operation of the existing facility (space, HR,..) and how can they be circumvented?



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# Towards an unified qualitative assessment criteria 0-order draft

- What is the labs evaluation of pre-investment and require extra- investment for :
  - infrastructure construction  (building, shielded area….)
  - equipment (laser, electron and photon beam lines, undulators)
  - operational cost (HR, spares, consumables
- Operation
  - number of hours dedicated to users per year
  - number of hours dedicated to machine development per year
  - operation scheme (beam hours/day, development or maintenance days/month)
- Human ressources
  - Number of people dedicated to Laser maintenance
  - Number of people dedicated to equipment user operation
  - Number of people dedicated to Beam lines

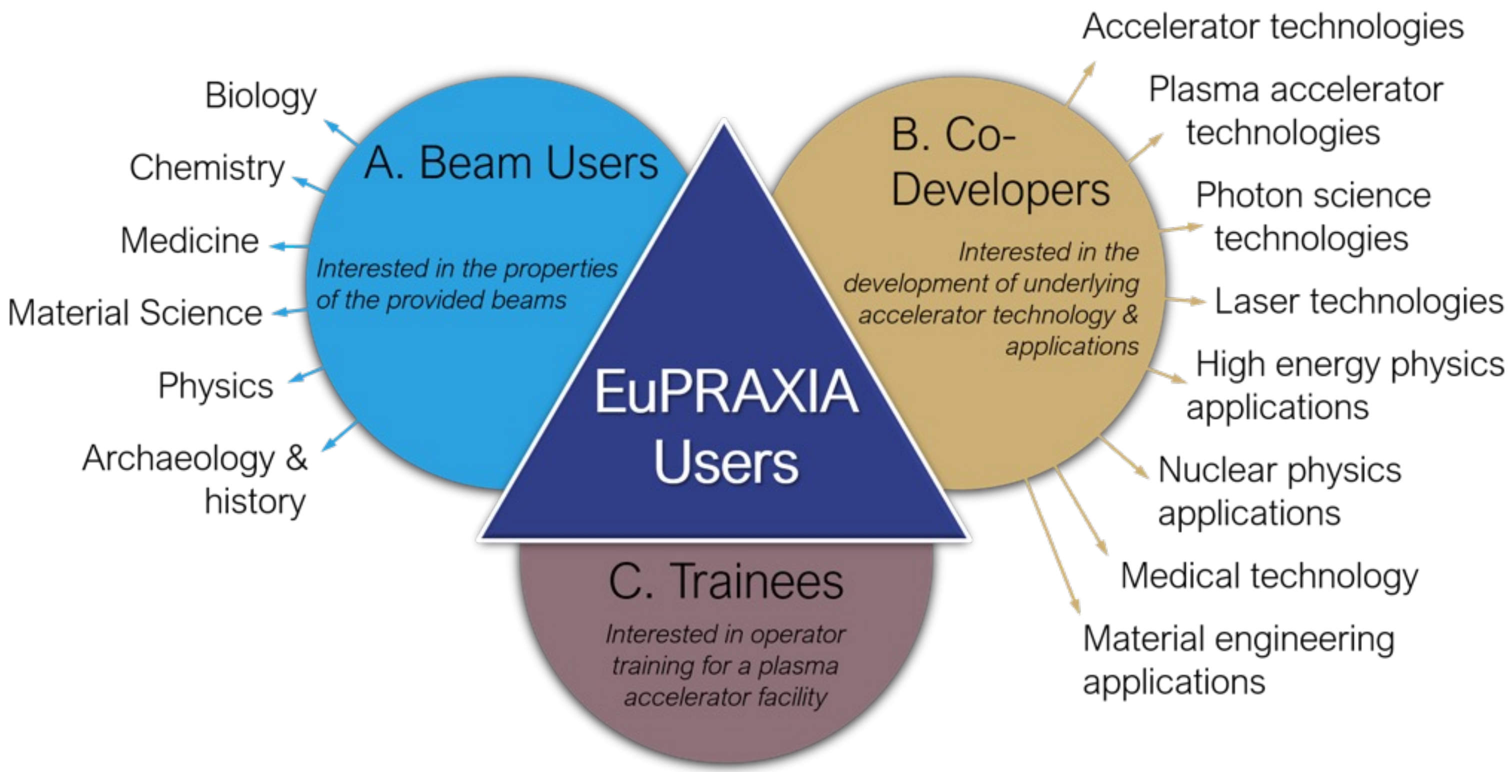
# Managerial concept

**quoted from the ESFRI proposal**

The overall managerial concept of EuPRAXIA therefore implements the scenario where the European field comes together for common design and construction of a European plasma accelerator facility, which shall be installed in two central locations for two complementary driver technologies (one for beam and one for laser drivers). Both sites share common technical designs, prototyping and production for many components. The model applied here takes the example of a large High Energy Physics detector, that is designed and constructed by a wide collaboration

# User Categories






WP5 "User Strategy & Services" (D. Bleiner ,E. Principi , G. Sarri, F. Stellato)

**Please fill out Users' requirements survey** https://surveys.infn.it/index.php/718177

# Collaboration models: “HEP detector”

Many other models exist: observatories (ELT, CTA, KM3NET) , supercomputers (PRACE), radiation facilities (XFEL,ESS, ESRF), accelerators (HL-LHC, FAIR, SPIRAL2)

- Collaboration agreement, bodies, in/out criteria
- Contributed parts: subdetectors + Trigger + DAq/Control + Computing + Spares
- Construction funding: institute salaries, national funding (e.g. France: TGIR)
- Integration closely supervised and coordinated by host lab
- Members: “builders and users” (the builders are the users)
- Competing detector technologies: arbitration by collaboration (not painless )
- Reward: perennial (and - so far - exclusive) access to the data
- Physics publication signed by all (active) members (shifts, M&O cost paid)
- Technical publications signed by the actual development teams
- No country-wise attribution of competences/purview

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# What is needed now? (personal view)

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- Set up *working* working group for defining 2nd site candidate assessment criteria. Should contain:
  WP1Project leaders (MF, RA->NN), financial and legal expert (AF), WP3 coordinators, ≥1 representative of candidate site.
- Refine **uniform assessment criteria** list (comparability) -> WP1,3,4
- Each candidate site should **identify one (or two) preferred** international/european **collaboration models** (ideally distributed ESFRI project or landmark).
- Identify a very **restricted number of** phase 1 scenarios for **start-to-end simulations** -> WP Theory and simulation
- Reinforce the appearance as a single RI (with two sites): identify **concrete common developments** for (but not necessarily done by) Site 1 and Site 2.
- Implementation engineering team in each site

# Summary

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- We are lucky! There are 4 good and motivated candidates for the 2nd site.
- Visits to candidate sites and (possibly meeting with officials) are scheduled.
- Original 2nd site decision time was unfeasible
  -> amendment of deliverable dates must happen now!
- Choice of an appropriate*) collaboration model is crucial.
  *) familiar and appreciated by the funding agencies of all partners.

**EuPRAXIA will have the organizational model that YOU will shape, and follow rules that YOU will have set. YOUR input is required and will be requested.**