EUROPEAN
PLASMA RESEARCH
ACCELERATOR WITH
EXCELLENCE IN
APPLICATIONS

WP1

Ralph Assmann, DESY

Arnd Specka, Ecole Polytechnique

Thanks to Andreas Walker and Maria Weikum for crucial help, work and slides

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

EuPRAXIA Project Progress

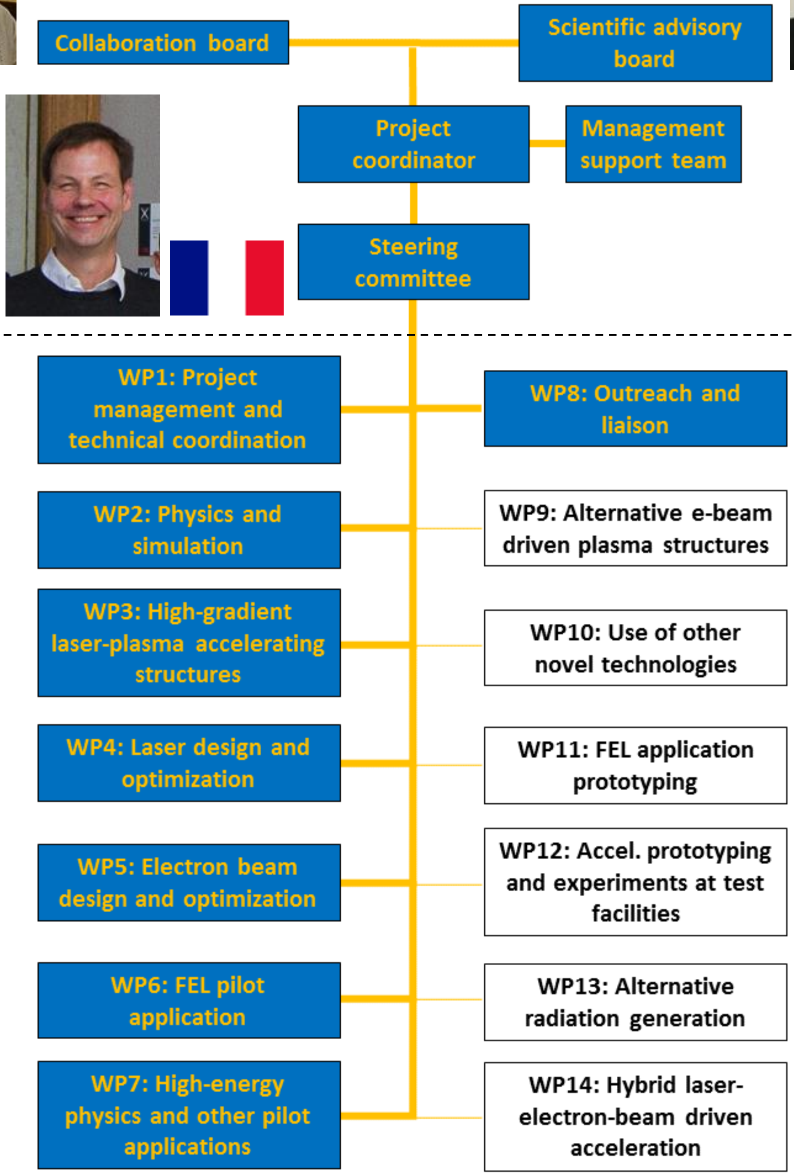
- EuPRAXIA is in its 3rd year and going strong:
  16 beneficiaries and 24 associated partners
- Excellent outreach, picking up speed to have maximum impact at end of project.
- Various talks to the community and users (*many EuPRAXIA but also general plasma accelerator talks mentioning EuPRAXIA*):
  - P. Ngie, M. Ferrario, L. Gizzi, A. Walker, A. Specka, R. Assmann, B. Cros, M. Weikum, …
- It is a marathon race: **31.10.2019**

#EuPRAXIA
#plasma
#accelerator

Committee Structure

Heads of Project and of Supervisory Boards





Steering Committee

All credits for the progress achieved must go to the WP leaders and members of the steering committee.
Many thanks from WP1!

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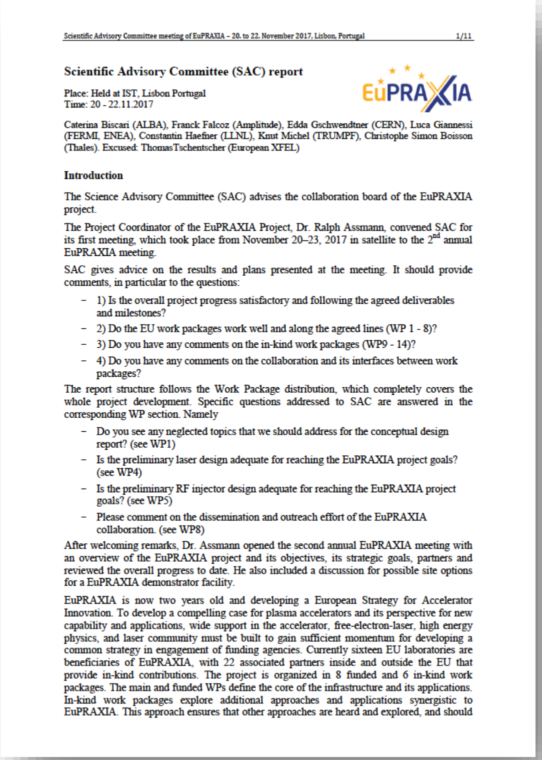
EuPRAXIA Project Progress

- Passed very successfully the **mid-term review at the EU** in Brussels in last November
- First report of **Scientific Advisory Committee** in February:
  - Extremely useful external view from
  - Good remarks and some homework for us.
- Activities, milestones and deliverables:
  - All **reporting** (milestones and deliverables) is on track
  - We have an **outline of the CDR** with names attached to all chapters and sections → executive editor M. Weikum (please contact her if you want to contribute)
  - **User survey** initiated and ongoing
  - **ESFRI roadmap** preparation
- Our aim: Compact and cost-efficient plasma accelerator with usable beams
- Not our aim: Efficiency of driver technology (rely on ongoing progress in field)



Scientific Advisory Committee meeting of EuPRAXIA – 20. to 22. November 2017, Lisbon, Portugal 1/11

Scientific Advisory Committee (SAC) report

Place: Held at IST, Lisbon Portugal
Time: 20 - 22.11.2017

Caterina Biscari (ALBA), Franck Falcoz (Amplitude), Edda Gschwendtner (CERN), Luca Giannessi (FERMI, ENEA), Constantin Haefner (LLNL), Knut Michel (TRUMPF), Christophe Simon Boisson (Thales). Excused: ThomasTschentscher (European XFEL)

Introduction

The Science Advisory Committee (SAC) advises the collaboration board of the EuPRAXIA project.

The Project Coordinator of the EuPRAXIA Project, Dr. Ralph Assmann, convened SAC for its first meeting, which took place from November 20–23, 2017 in satellite to the 2nd annual EuPRAXIA meeting.

SAC gives advice on the results and plans presented at the meeting. It should provide comments, in particular to the questions:

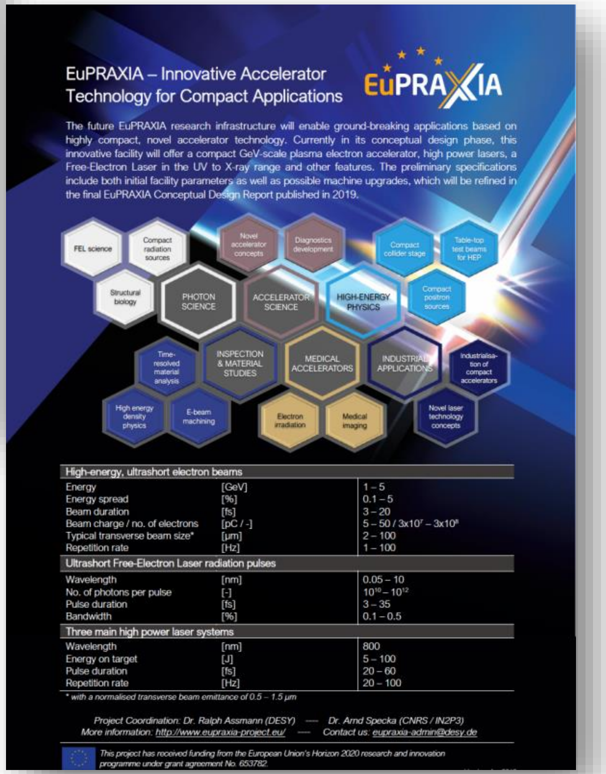
- 1) Is the overall project progress satisfactory and following the agreed deliverables and milestones?
- 2) Do the EU work packages work well and along the agreed lines (WP 1 - 8)?
- 3) Do you have any comments on the in-kind work packages (WP9 - 14)?
- 4) Do you have any comments on the collaboration and its interfaces between work packages?

The report structure follows the Work Package distribution, which completely covers the whole project development. Specific questions addressed to SAC are answered in the corresponding WP section. Namely

- Do you see any neglected topics that we should address for the conceptual design report? (see WP1)
- Is the preliminary laser design adequate for reaching the EuPRAXIA project goals? (see WP4)
- Is the preliminary RF injector design adequate for reaching the EuPRAXIA project goals? (see WP5)
- Please comment on the dissemination and outreach effort of the EuPRAXIA collaboration. (see WP8)

After welcoming remarks, Dr. Assmann opened the second annual EuPRAXIA meeting with an overview of the EuPRAXIA project and its objectives, its strategic goals, partners and reviewed the overall progress to date. He also included a discussion for possible site options for a EuPRAXIA demonstrator facility.

EuPRAXIA is now two years old and developing a European Strategy for Accelerator Innovation. To develop a compelling case for plasma accelerators and its perspective for new capability and applications, wide support in the accelerator, free-electron-laser, high energy physics, and laser community must be built to gain sufficient momentum for developing a common strategy in engagement of funding agencies. Currently sixteen EU laboratories are beneficiaries of EuPRAXIA, with 22 associated partners inside and outside the EU that provide in-kind contributions. The project is organized in 8 funded and 6 in-kind work packages. The main and funded WPs define the core of the infrastructure and its applications. In-kind work packages explore additional approaches and applications synergistic to EuPRAXIA. This approach ensures that other approaches are heard and explored, and should



Dates Towards CDR Completion

M 1.2 Report: Outline CDR & Contributions Defined	30.06.2018
ESFRI Roadmap Application – first draft	31.12.2018
Input to pre-construction R&D activities received	31.12.2018
Input to site studies received	31.01.2019
CDR contributions – first draft	**Jan 2019**
5th Collaboration Week (Retreat in the Alps)	25.02. – 01.03.2019
M 1.3 Report: Draft Contributions for the CDR Received	30.04.2019
First revision of CDR draft version	mid-May to mid-July 2019
Second revision of CDR draft version	mid-July to end-August 2019
Final CDR draft	**30.09.2019**
D 1.7 Report: Final Design Report	30.10.2019

Official EU Reporting *Major CDR deadlines*

CDR Chapter Editorial Teams Defined

Horizon 2020

Chapter Titles	Editorial Team	Main WPs Involved
8 Resource & Financial plan		
8.1 EuPRAXIA Technical Design & Pre-Construction	R. Assmann, A. Specka, P. M. Weikum	
8.2 EuPRAXIA Construction & Operation	R. Assmann, A. Specka, P. M. Weikum	
9 Cost-Benefit Analysis	R. Assmann, A. Specka, P. M. Weikum	
10 Site Studies		
10.1 Introduction and Common Assumptions	R. Assmann, A. Specka, P. M. Weikum	
10.2 Site A: CILEX (prelim.)	F. Mathieu, A. Spe	
10.3 Site B: CLF (prelim.)	R. Pattathil	
10.4 Site C: DESY (prelim.)	R. Assmann, A. Wa	
10.5 Site D: ELI-Beamlines (prelim.)	L. Pribyl	
10.6 Site E: SPARCLAB (prelim.)	M. Ferrario	
11 Additional Information and Statements from Revie		
11.1 Outreach and Public Response	B. Hidding, R. Torres, C. W Walker, M. Weiku	
11.2 Review 1	R. Assmann, R. Torres, C. A. Walker, M. Weik	
11.3 Review 2	R. Assmann, R. Torres, C. A. Walker, M. Weik	
12 Expressions of Commitment	R. Assmann, A. Specka, P. M. Weikum	
13 Expressions of Political Support	R. Assmann, A. Specka, P. M. Weikum	
14 References	P. A. Walker, M. Wei	
15 List of Institutes & Principal Investigators	P. A. Walker, M. Wei	
16 Appendix I: EuPRAXIA Publications & Conference Contributions	B. Hidding, R. Torres, C. W Walker, M. Weiku	
17 Appendix II: Press Articles	B. Hidding, R. Torres, C. W Walker, M. Weiku	
18 Appendix III: Letters of Support from Peers	R. Assmann, R. Torres, C. A. Walker, M. Weik	
19 Appendix IV: Letters of Support from Industry	R. Assmann, R. Torres, C. A. Walker, M. Weik	

Chapter Titles	Editorial Team	Main WPs Involved
5.10 Electron-Based Beam Diagnostics & Controls	A. Chance, A. Cianchi, E. Chiadroni, P. A.	WP5
5.11 Beam Distribution Concept	M.-E. Coupr A. Specka,	
5.12 FEL & Photon Science Facility	M.-E. Coupr P. A.	
5.13 HOPA Science Facility	A. Specka,	
5.14 EuPRAXIA Operational Model	R. Assmann	
5.15 Environmental Impact	R. Assmann	
5.16 Safety Aspects	R. Assmann	
5.17 Project Risk Assessment	R. Assmann A. V	
5.18 Tables of Parameters & Technical Data	P. A.	
5.19 Impact Assessment	R. Assmann	
6 EuPRAXIA Pre-Construction R&D an		
6.1 List of Required R&D and Protoyping	L. Gizzi, F. Pattathil,	
6.2 Use of EuPRAXIA Consortium Facilities	A. Mostacci	
7 Project Organization and Implementati		
7.1 Structure & Governing Model	R. Assmann	
7.2 Project Schedule	R. Assmann	
7.3 User Support	R. Assmann	
7.4 Safety Organization	R. Assmann	
7.5 Quality Assurance	R. Assmann	
7.6 Proposed Financial Model	R. Assmann	
7.7 Outreach & Communication	R. Assmann A. V	

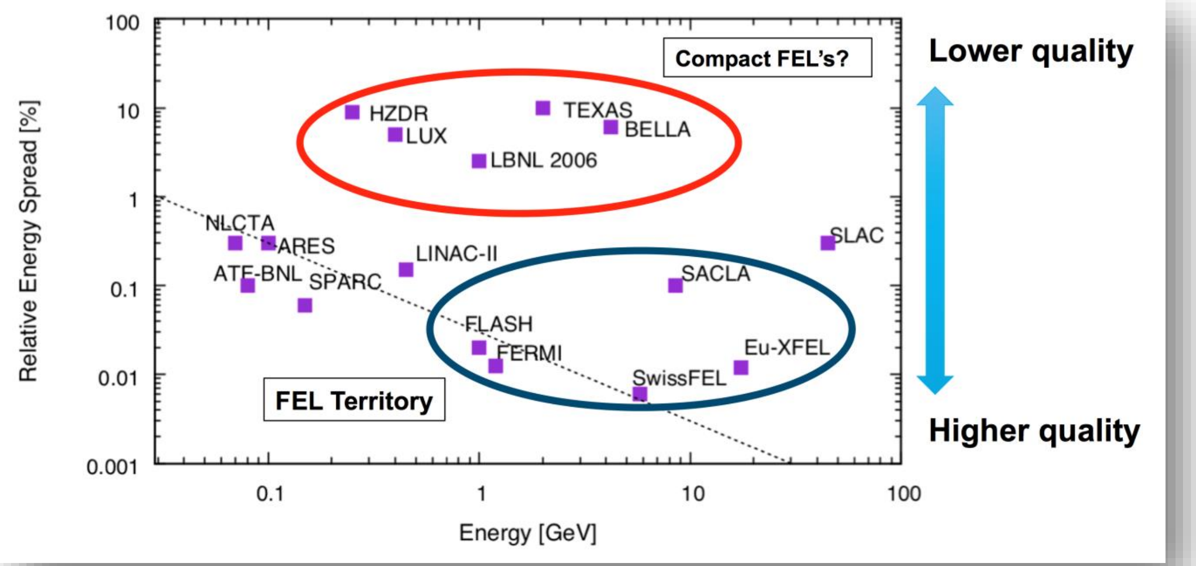
Chapter Titles	Editorial Team	Main WPs Involved
1 List of Authors & Contributors	P.A. Walker, M. Weikum	/
2 Executive Summary	R. Assmann, P.A. Walker, M. Weikum	/
3 Introduction	R. Assmann, A. Specka, P.A. Walker, M. Weikum	WP1
4 Scientific Case Study		
4.1 Flagship Science Goals	R. Assmann, A. Specka, P. A. Walker, M. Weikum	WP1
4.2 Need for External Users	M.-E. Couprie, A. Specka, P. A. Walker, M. Weikum	WP6, WP7, WP1, WP4
4.3 User Access	M.-E. Couprie, A. Specka, P. A. Walker, M. Weikum	WP6, WP7, WP1
4.4 Added Value for European Research & Technology Landscape	R. Assmann, A. Specka, P. A. Walker, M. Weikum	WP1
4.5 Scientific Background	R. Assmann, R. Torres, C. Welsch, P. A. Walker, M. Weikum	WP1, WP8
5 EuPRAXIA Conceptual Design		
5.1 Performance Goals	R. Assmann, A. Specka, P. A. Walker, M. Weikum	WP1
5.2 Overall Facility Layout & Major Parts	R. Assmann, A. Specka, P. A. Walker, M. Weikum	WP1
5.3 Laser Technology	L. Gizzi, F. Mathieu, P. A. Walker, M. Weikum	WP4
5.4 RF Technology	A. Chance, E. Chiadroni, P. A. Walker, M. Weikum	WP5, WP9
5.5 Electron Injector	B. Cros, P. Nghiem, P. A. Walker, M. Weikum	WP2, WP3, WP5, WP14
5.6 Electron Accelerator to 1 GeV	B. Cros, P. Nghiem, P. A. Walker, M. Weikum	WP2, WP3, WP5, WP14
5.7 Electron Accelerator to 5 GeV	B. Cros, P. Nghiem, P. A. Walker, M. Weikum	WP2, WP3, WP5, WP14
5.8 Beam Transport & Handling Systems for the 1 GeV Beam	A. Chance, E. Chiadroni, P. A. Walker, M. Weikum	WP5
5.9 Beam Transport & Handling Systems for the 5 GeV Beam	A. Chance, E. Chiadroni, P. A. Walker, M. Weikum	WP5

Full list available in **EuPRAXIA Milestone Report M25 (1.2): Outline Conceptual Design Report & Contributions Defined**

(see Sharepoint → Milestones → Reports)

EuPRAXIA Concept that has Emerged

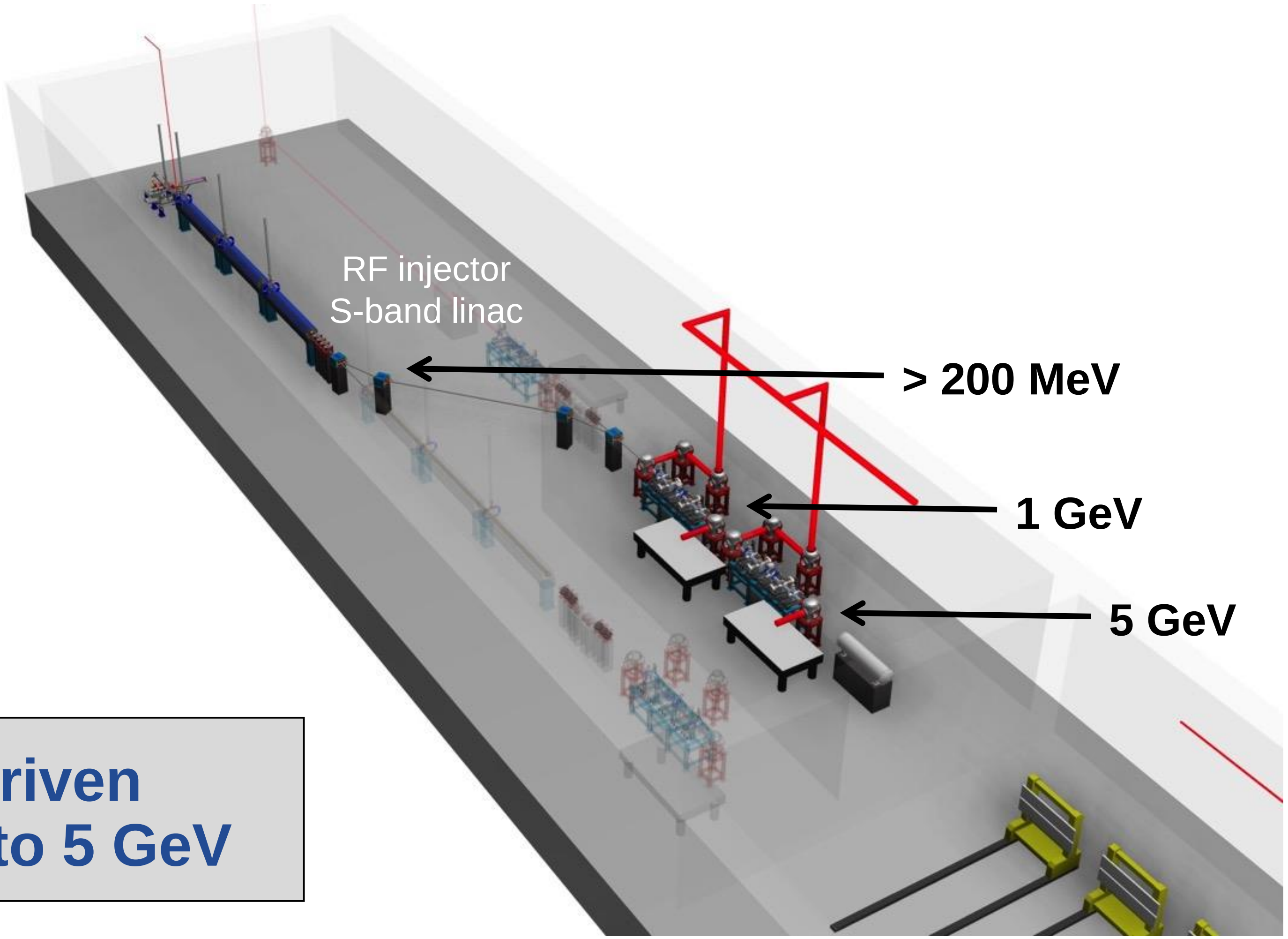
- A technically convincing concept is critically important. We must explain why we can build a usable plasma accelerator.
- Components of EuPRAXIA concept:
  - **High brilliance photo injectors**, both photocathode and plasma based
  - State of the art **matching and beam transport**, based on RF accelerator high tech
  - Latest and new **instrumentation** for electron beam, laser, plasma
  - An outstanding **laser program** to move to the next level with industry
  - **X band RF technology** for building compact plasma drivers
  - Complete **theory and simulation** capabilities with predictive capability
  - Several paths to **minimize correlated energy spread** (beam loading, plasma modulation, sub-fs bunches)
  - Understanding of **uncorrelated energy spread**
  - New concept to **suppress timing jitter** (e- beam to laser) to sub-fs
  - Ideas on **7/7 24h** operation (multiple laser operation)



- Versatile concept of parallel plasma accelerators feeding parallel user lines but keeping central powering scheme
- A hybrid scheme offering potentially much better brilliance

EuPRAXIA

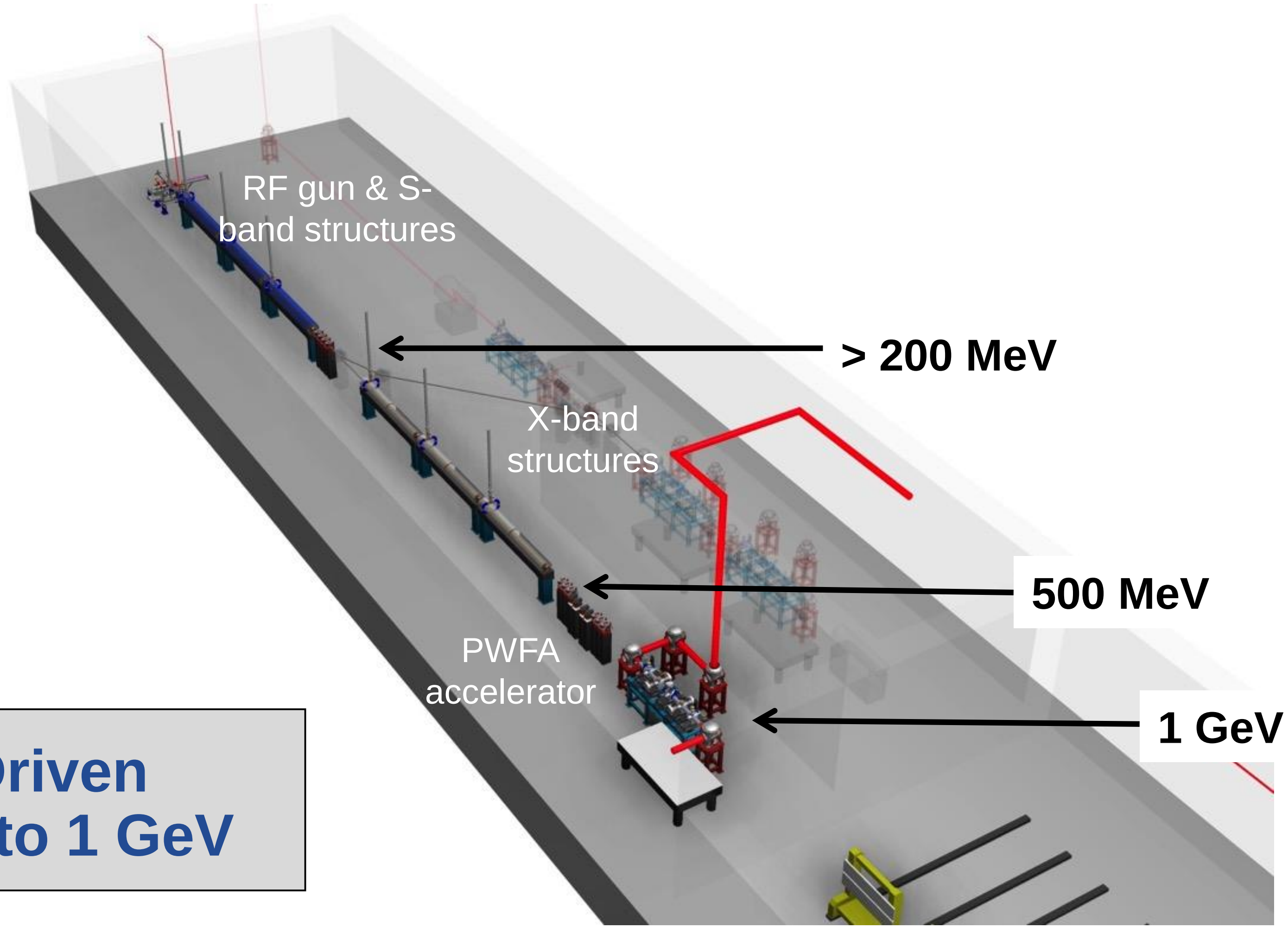
The 50 Billion Volt per Meter Linear Accelerator



A **Laser-Driven Stages to 5 GeV**

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

The 50 Billion Volt per Meter Linear Accelerator



B **Beam-Driven Stages to 1 GeV**

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EuPRAXIA

Targets in Facility Parameters

Overview of EuPRAXIA technical goals. Not self-consistent cases. Detailed and self-consistent parameter tables are available upon request.

High-energy, ultrashort electron beams		
Energy	[GeV]	1 – 5
Energy spread	[%]	0.1 – 5
Beam duration	[fs]	3 – 20
Beam charge / no. of electrons	[pC / -]	5 – 50 / 3x10^7 – 3x10^8
Typical transverse beam size*	[µm]	2 – 100
Repetition rate	[Hz]	1 – 100
Ultrashort Free-Electron Laser radiation pulses		
Wavelength	[nm]	0.05 – 10
No. of photons per pulse	[-]	10^{10} – 10^{12}
Pulse duration	[fs]	3 – 35
Bandwidth	[%]	0.1 – 0.5
Three main high power laser systems		
Wavelength	[nm]	800
Energy on target	[J]	5 – 100
Pulse duration	[fs]	20 – 60
Repetition rate	[Hz]	20 – 100

** with a normalised transverse beam emittance of 0.5 – 1.5 µm*

More technical and self-consistent tables have been prepared by Maria Weikum

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Technical Assessment and Prioritization

1. Develop a comprehensive list of technical decisions to take for EuPRAXIA design and, for each case, the available options (→ ongoing)

2. Assessment of each technical option based on a pre-defined set of criteria (tbd)

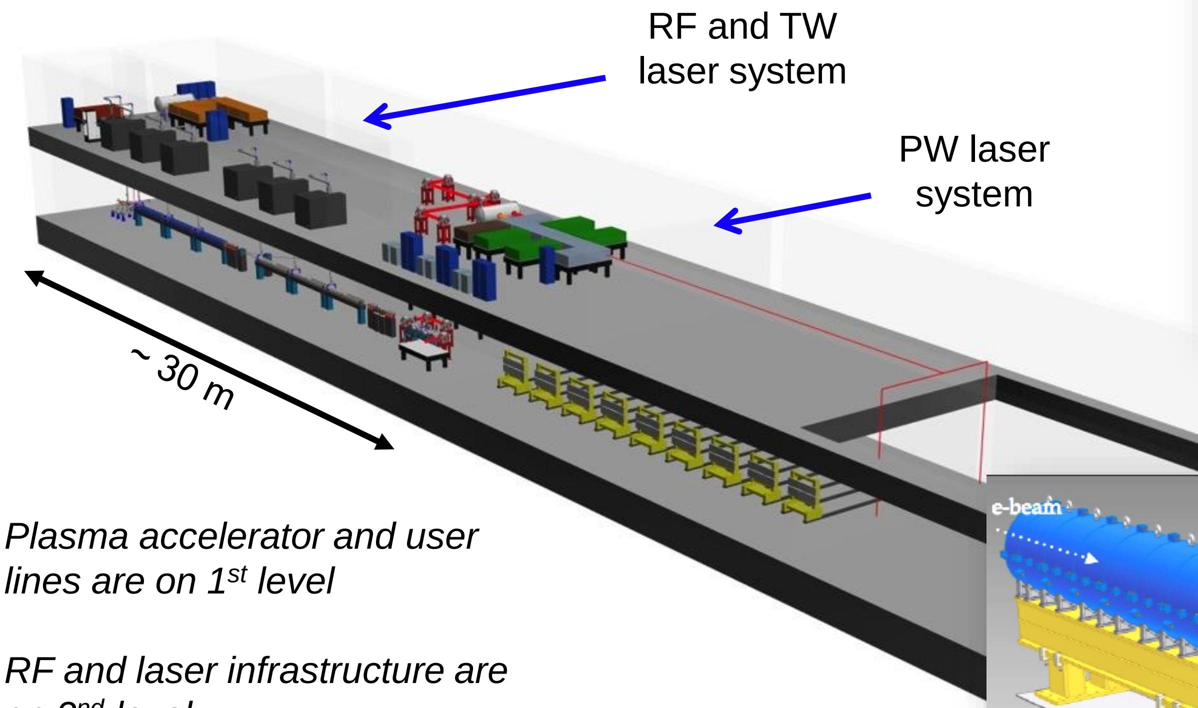
3. Prioritization of one or several technical options, where necessary, into three main categories by Steering Committee:

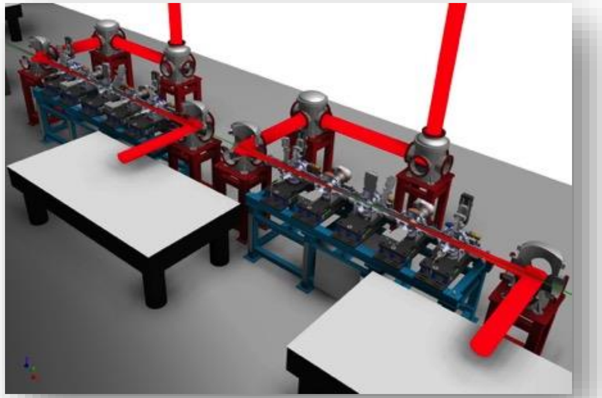
Baseline - Development Path - Backup Option

Main goals:

- **Better understanding of available technical options, especially for more general aspects, like cost, technical readiness, upgradability, etc.** *→ Recommended by SAC (this is also what reviewers will ask!)*
- **Focus work efforts and resources on bringing results together into a coherent, excellent conceptual design**

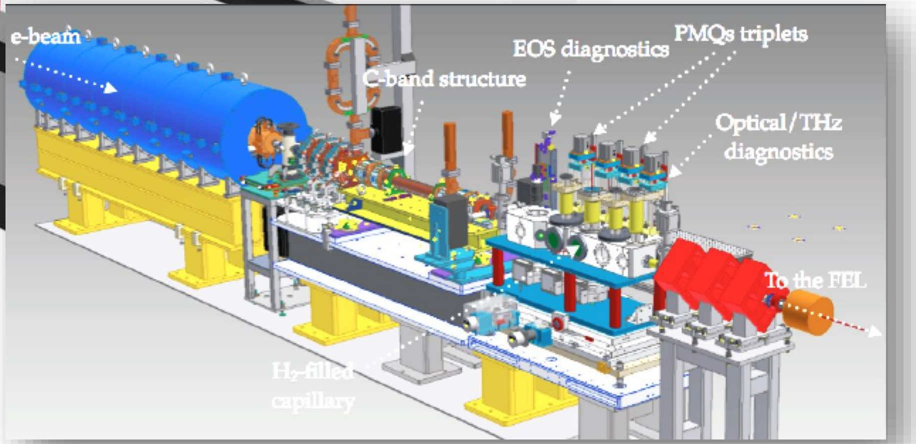
The EuPRAXIA Facility (Under Design)

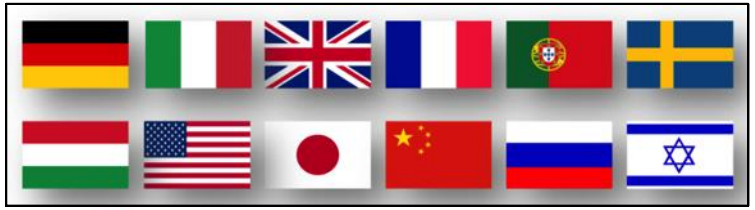




Plasma accelerator and user lines are on 1st level

RF and laser infrastructure are on 2nd level





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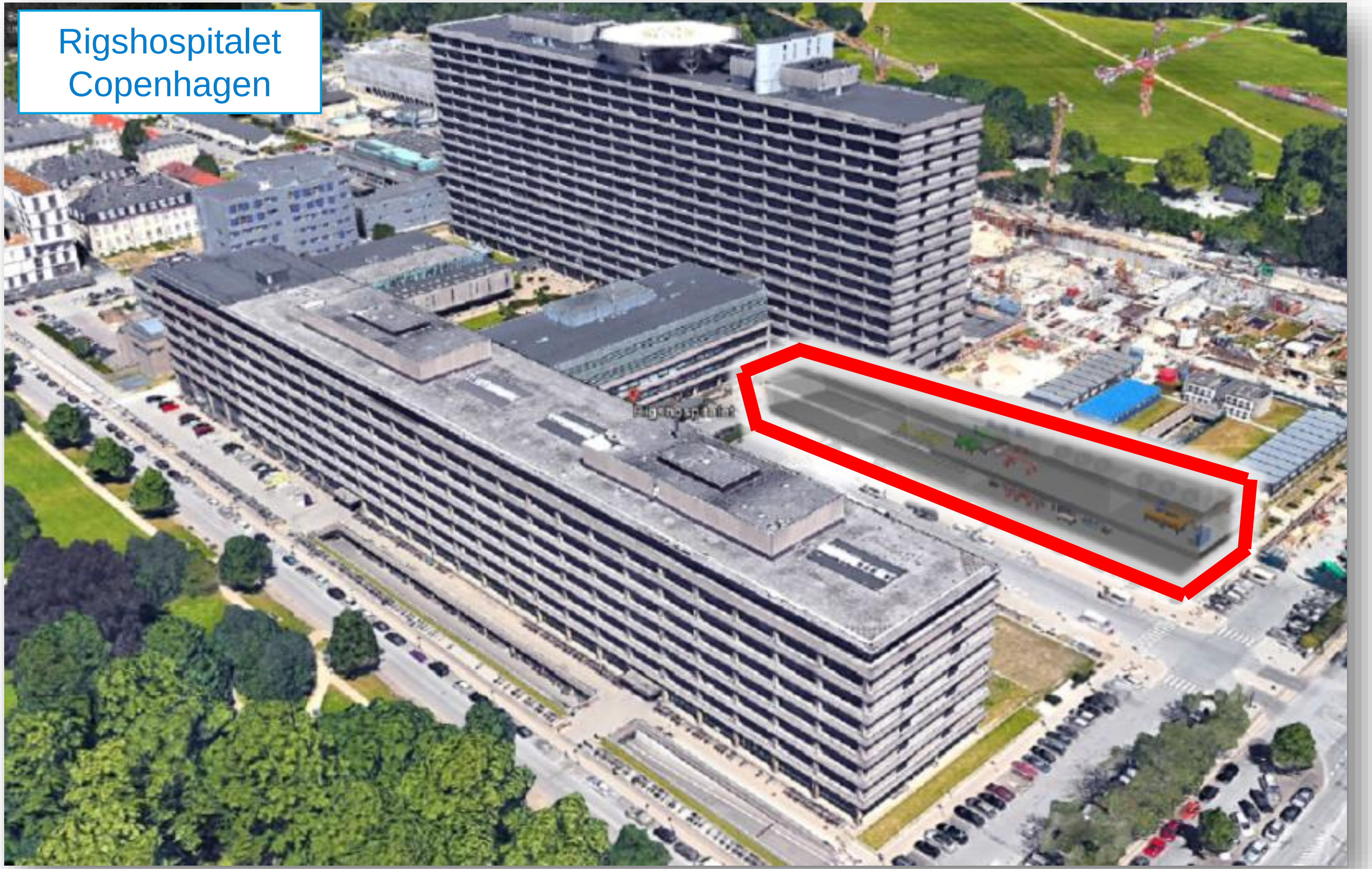
Fits on the Parking Lot of the Hospital Copenhagen



Illustrative example prepared for IPAC17 talk in Copenhagen

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

How and where to build it?

Working and building together

- Build EuPRAXIA in a similar way a **High Energy Physics experiment** is built.
- **Consortia** address the relevant topics in design, construction and commissioning. Budget defined by responsibility...
- Work by Pierluigi Campana: short document describing how it works at CERN

A scheme of how HEP Collaborations work at CERN

CERN is the hosting institution.
Typically it takes care of resources needed to run the machines (e.g. LHC): buildings, power, technicians, general services, part of the computing, etc...

Each collaboration (= organized ensemble of international groups) makes an agreement with CERN (Memorandum of Understanding, MoU) on how to operate the experiment and which kind of support is obtained. CERN binds the experiment to a certain set of rules: safety, publications, outreach, management, etc... MoUs are not legally binding, although an arbitration procedure is defined.

Inside each Collaboration, groups agree on:
1) list of collaborating institutes and management

Pierluigi Campana

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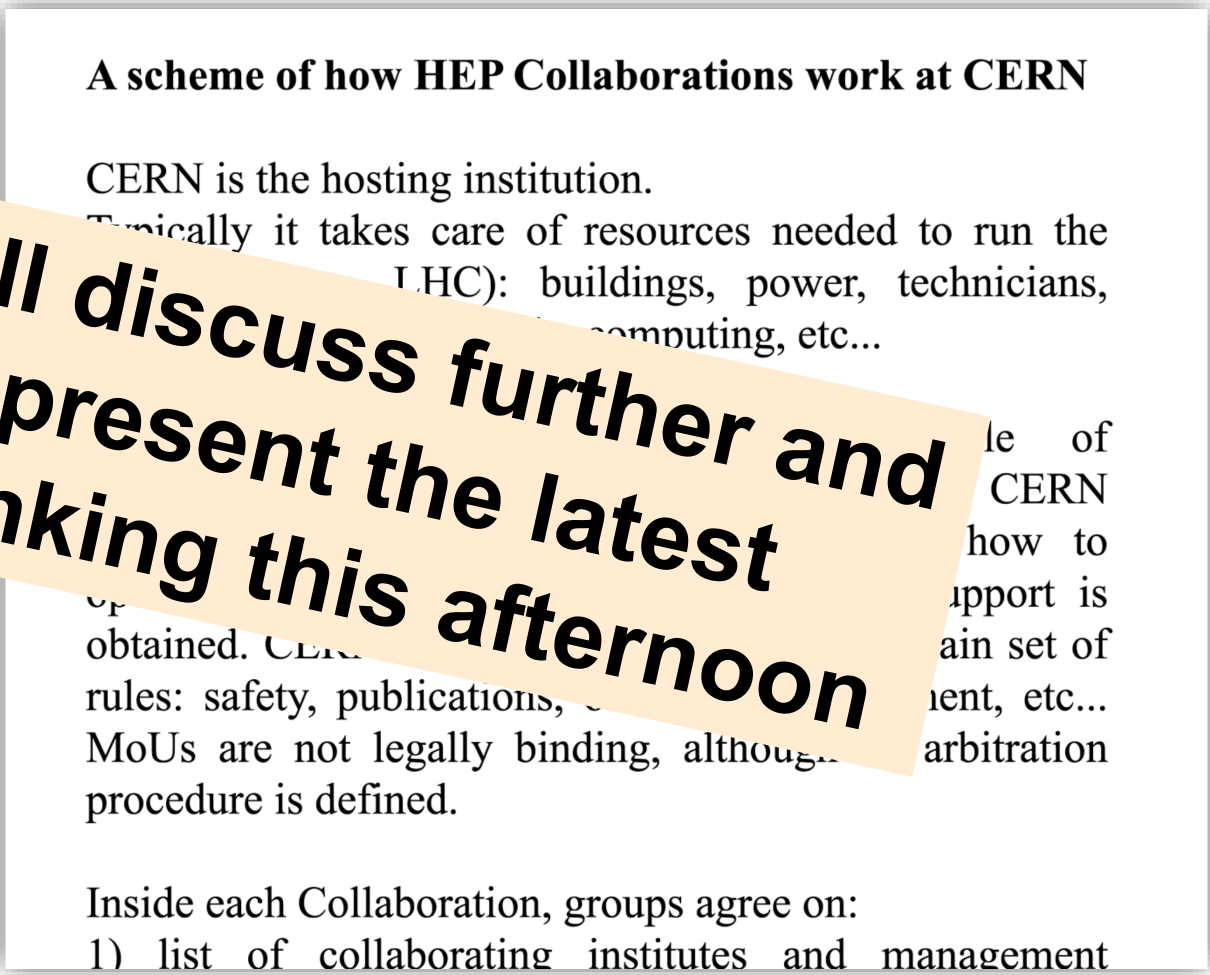
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Will discuss further and present the latest thinking this afternoon

Pierluigi Campana

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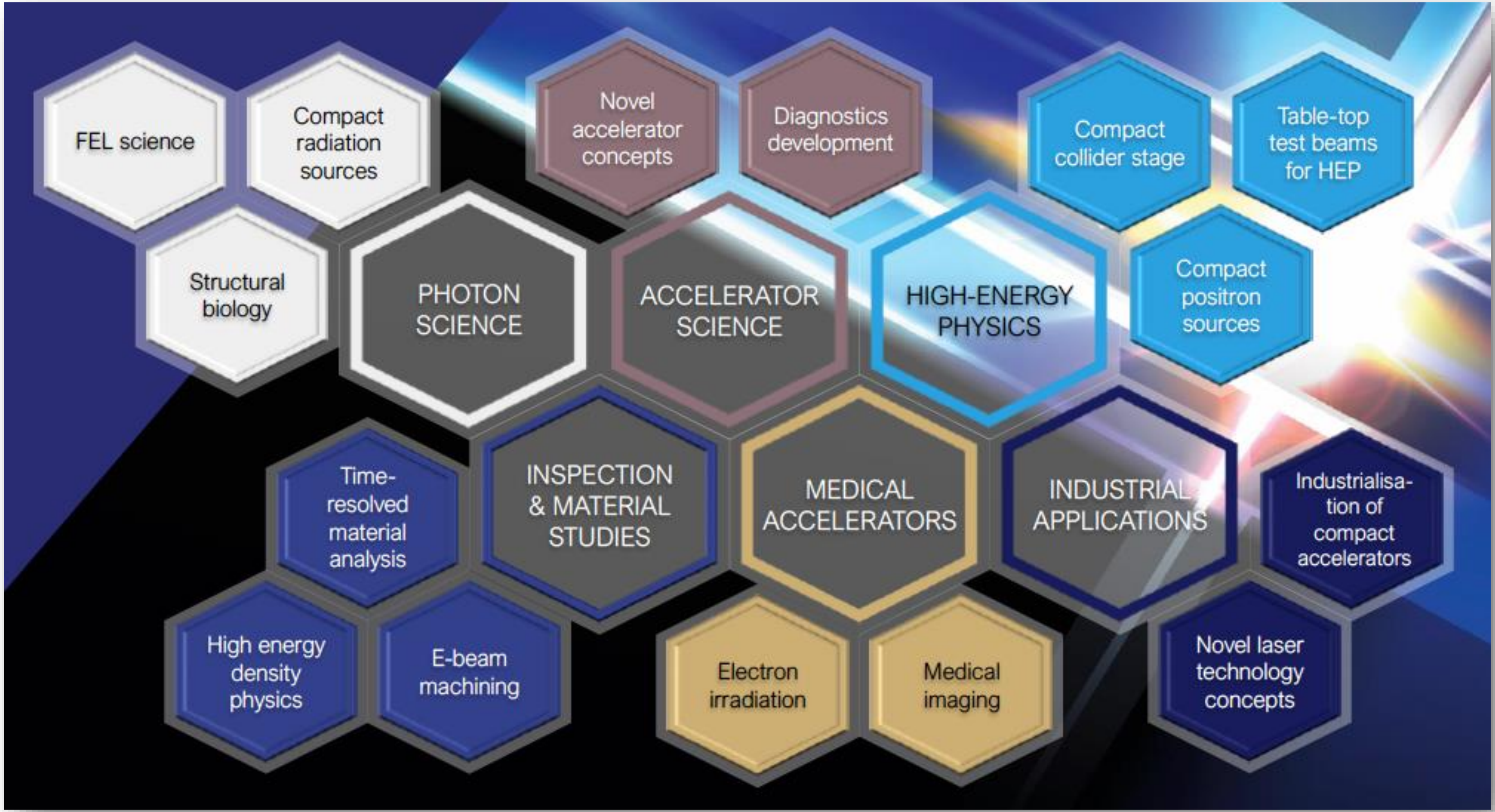
Versatile – Designed for Multiple Applications

High Energy – Accelerator R&D – Photon Science – Material – Medical – Industrial



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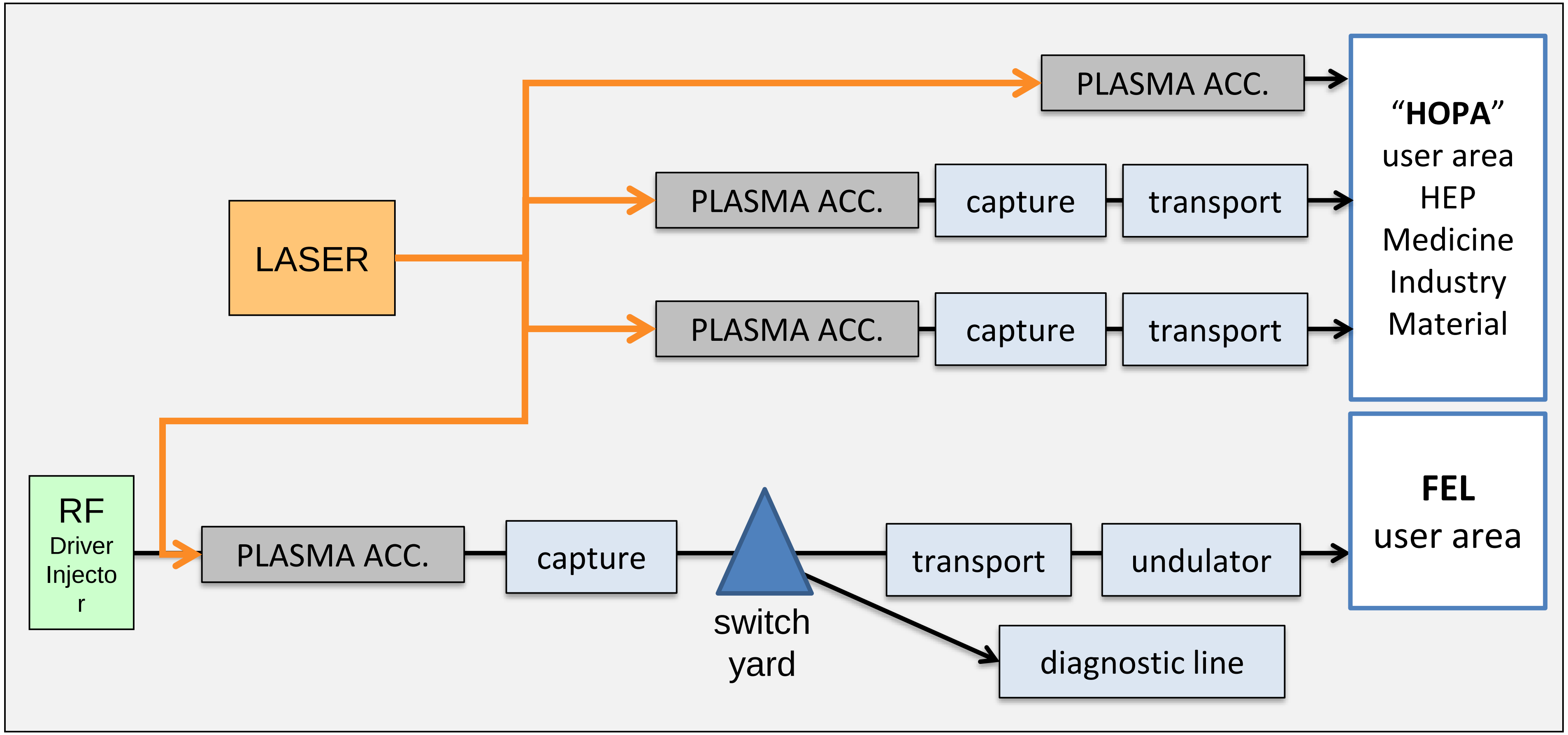
EuPRAXIA

Can the Facility REALLY Do ALL of This?

Another Advantage of Plasma Accelerators



Laser pulses distributed to “small” plasma accelerators to drive many applications!

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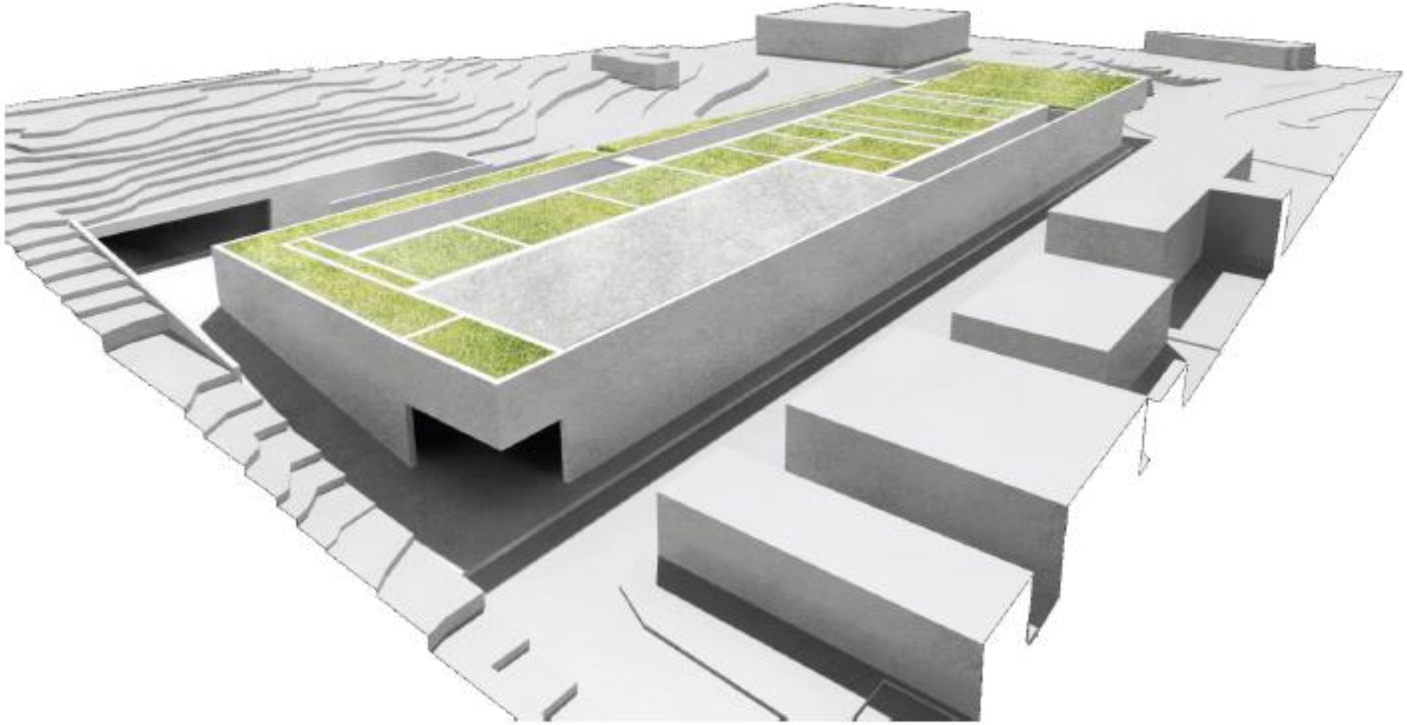
News from Italy




INFN
Istituto Nazionale di Fisica Nucleare

CDR-1, April 2018

EuPRAXIA@SPARC_LAB

Conceptual Design Report

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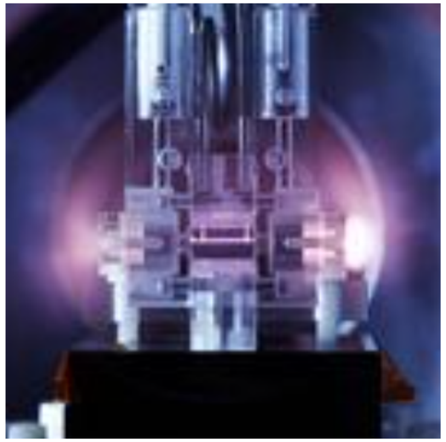
News from Germany

Latest press releases



18/06/14 · Press-Release

Helmholtz Association supports ATHENA with 29.99m euro grant

ATHENA ("Accelerator Technology HElmholtz iNfrAstructure") is a new research and development platform focusing on accelerator technologies and drawing on the resources of all six Helmholtz accelerator...

The work on ATHENA is closely embedded in the wider context of European research through the EU-sponsored design study EuPRAXIA, with its 40 partner institutes, which is also coordinated by DESY. Hence the top German research project ATHENA has had a clear European perspective and orientation right from the start.

Conclusion WP1

- EuPRAXIA is **on track** both formally and content-wise.
- We believe that we are developing an **attractive concept with a number of innovative/new design features**: many thanks to all WP leaders from WP1
- **European context is developing very well** with exceptionally good news for plasma accelerators from Germany and Italy.
- **Need** for plasma accelerators is recognized and **European collaboration** between members of EU strongly acknowledged (and more important than ever)!
- Strong interest and support from **European laser industry**.
- It seems that from **scientific, user and political context** there is a reasonable chance to get EuPRAXIA funded.
- **Need to be ready** with detailed spending proposals to grasp the opportunity: means a busy year ahead of us!

EUROPEAN
PLASMA RESEARCH
ACCELERATOR WITH
EXCELLENCE IN
APPLICATIONS

Site Studies
Plenary Discussion

Ralph Assmann, DESY

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How to build it?

We must deliver what we promised to EU

- EuPRAXIA: proposal for **site independent conceptual design study** for a European Research Infrastructure that
  (a) can produce **high quality electron beams** from plasma accelerators
  (b) advance several **applications for pilot users**.
- **Deliverables** in CDR:
  (a) Technical concept(s) and major components of EuPRAXIA facility
  (b) Cost
  (c) Schedule
  (d) Concept of usage
  (e) Governance model
  (f) Site studies

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How to build it?

Distributed construction of central infrastructure

- EuPRAXIA: **Build EuPRAXIA similar to a particle physics detector – many labs together build a central infrastructure**
- We need to collect interests and proposals. For example:
  - Who does prototyping, testing and building of EuPRAXIA laser(s)?
  - Who does prototyping, testing and building of RF injector/linac?
  - Who does prototyping, testing and building of plasma accelerator(s)?
  - Who does prototyping, testing and building of undulators?
  - Who does prototyping, testing and building of instrumentation?
  - Who does project management?
- **Can and should be consortia of labs, using their local expertise and infrastructure**! Budget follows from responsibility!

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How to build it?

Horizon 2020

- Build EuPRAXIA in a similar way a **High Energy Physics experiment** is built.
- **Consortia** address the relevant topics in design, construction and commissioning. Budget defined by responsibility...
- Work by Pierluigi Campana: short document describing how it works at CERN
- Take into account boundary conditions:
  - Excellent beam-driven approach
  - Excellent laser-driven approach
  - Frascati with impressive progress and plans
  - Very good news from Germany

A scheme of how HEP Collaborations work at CERN

CERN is the hosting institution.
Typically it takes care of resources needed to run the machines (e.g. LHC): buildings, power, technicians, general services, part of the computing, etc...

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Inside each Collaboration, groups agree on:
1) list of collaborating institutes and management

Pierluigi Campana

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How to build it?

- Working and building it together, using our local infrastructure and facilities!
- Consortia address the relevant topics in design, construction and commissioning. Budget defined by responsibility...

Laser
Pisa, CNRS, CLF, ELI, FBI, ...

RF Tech
DESY, INFN, CERN, Daresbury, ...

FEL
SOLEIL, Roma, DESY, Daresbury, ...

Applica-tions
Oxford, CNRS, UB, Strathclyde, ...

Plasma
U. Paris, DESY, Oxford, ...

Theory/Sim
CEA, IST, DESY, INFN, HZDR, ...

Instrumen-tation
INFN, KIT, SOLEIL, DESY, ...

xxx
...

Not complete, just examples...

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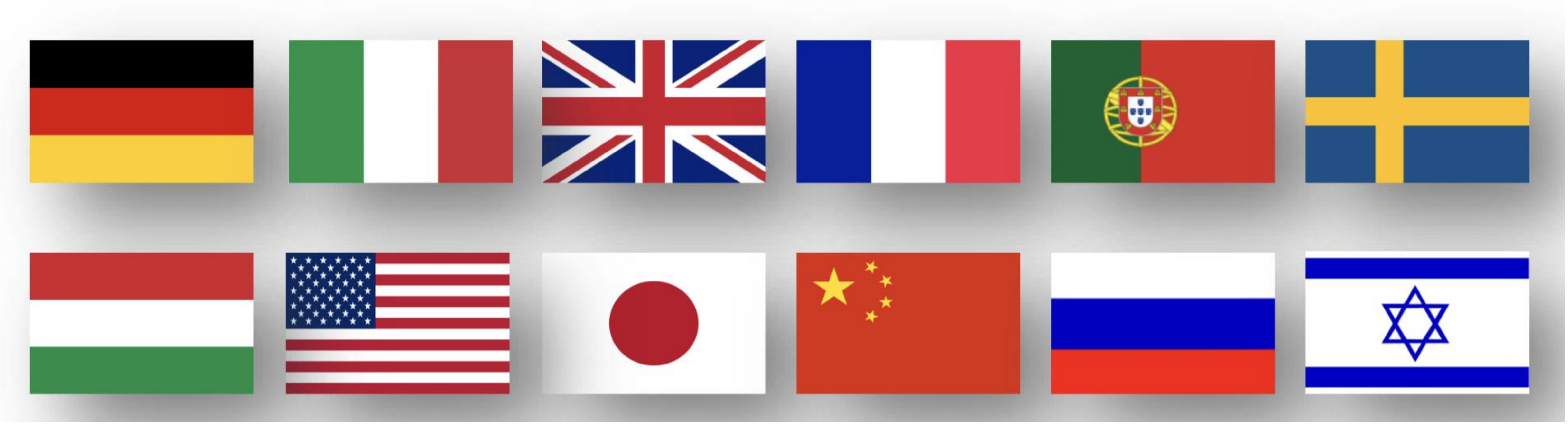
Where to build it?

- Site-independent proposal will require a **site selection process**. Who will do this? How long will it take? We will be faster and more immediately be ready for funding if we can **make a proposal ourselves**!
- Take into account **boundary conditions**:
  - Excellent beam-driven approach and excellent laser-driven approach
  - Frascati with impressive progress and plans and very good news from Germany



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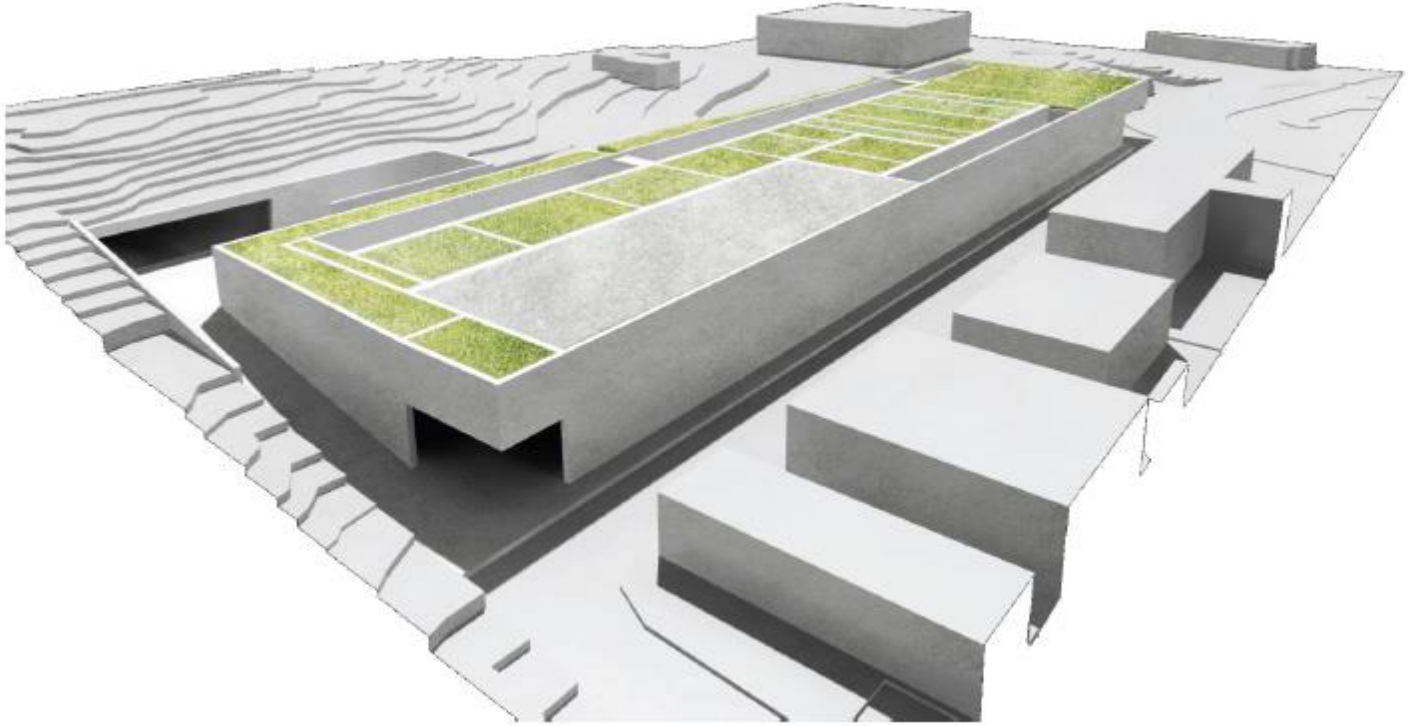
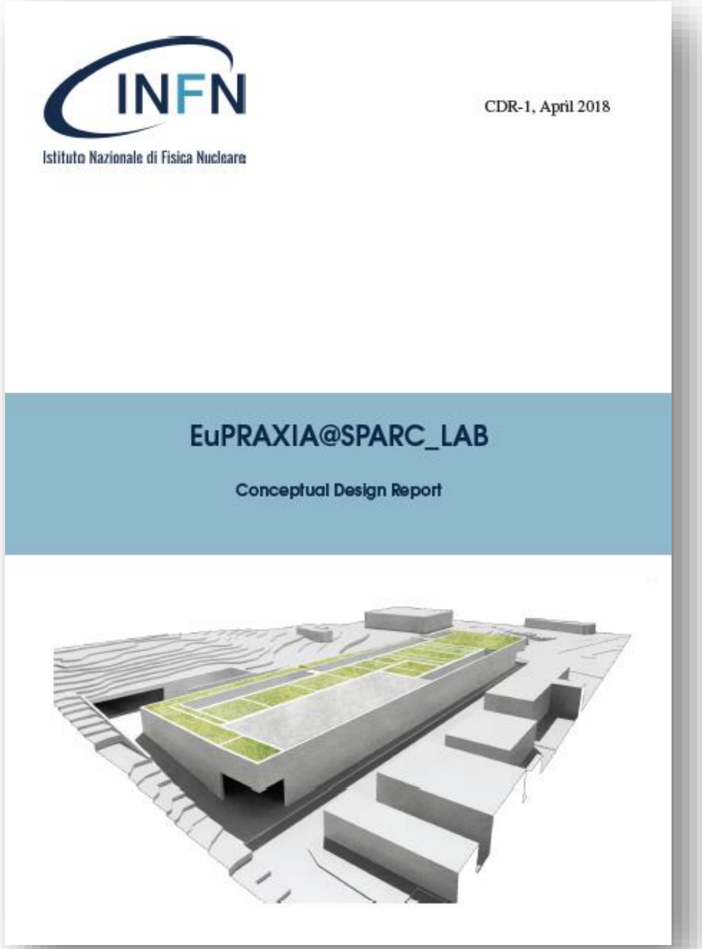
News from Italy





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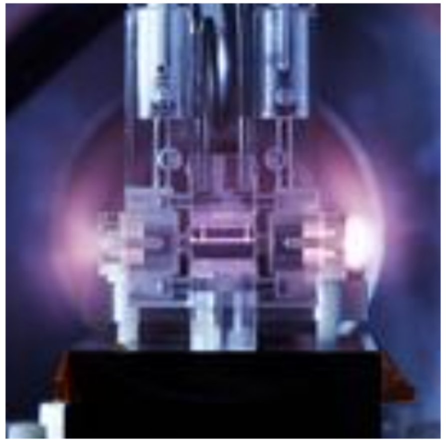
News from Germany

Latest press releases



18/06/14 · Press-Release

Helmholtz Association supports ATHENA with 29.99m euro grant

ATHENA ("Accelerator Technology HEImholtz iNfrAstructure") is a new research and development platform focusing on accelerator technologies and drawing on the resources of all six Helmholtz accelerator...

The work on ATHENA is closely embedded in the wider context of European research through the EU-sponsored design study EuPRAXIA, with its 40 partner institutes, which is also coordinated by DESY. Hence the top German research project ATHENA has had a clear European perspective and orientation right from the start.

Where to build it?

Site wishes

- **Possible sites** for EuPRAXIA research infrastructure being pushed strongly and clear site studies:
  - **Frascati, Italy** (first few M€, aiming for 50 M€ Italian project)
  - **DESY, Germany** (electron site for ATHENA a 30M€ invest laser plasma project)
- **Other possible sites** which have been discussed:
  - **CILEX, France** (political support not yet clear)
  - **CLF, UK** (impact from BREXIT unclear)
  - **ELI** (laser infrastructure with important milestones ahead – happy to connect to EuPRAXIA without being the EuPRAXIA site)
  - ... (?)
- In this situation, have been thinking about best way forward...

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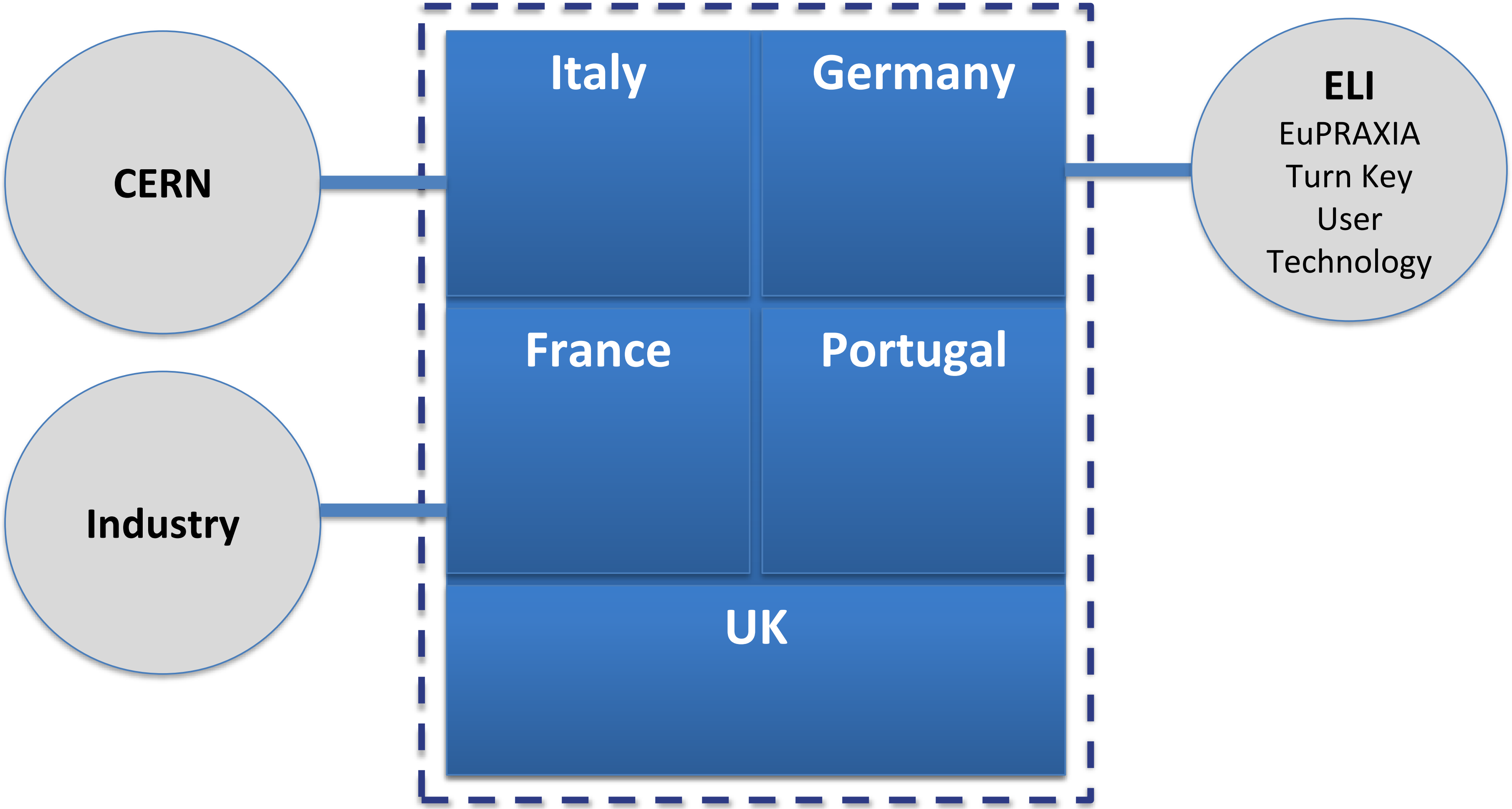
EuPRAXIA Concept: Alternative Site View?

Countries get their shares



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EuPRAXIA Concept: Alternative Site View?

Countries get their shares

CERN
X Band RF Technology (Compact Driver)

Industry
European laser and accelerator Industry

Italy
EuPRAXIA Site for beam-driven plasma acc.

Germany
EuPRAXIA Site for laser-driven plasma acc.

France
EuPRAXIA Center for Technology

Portugal
EuPRAXIA Center for Theory & Plasma Simulation

UK
EuPRAXIA Center for Industrial Applications

ELI
EuPRAXIA Turn Key User Technology

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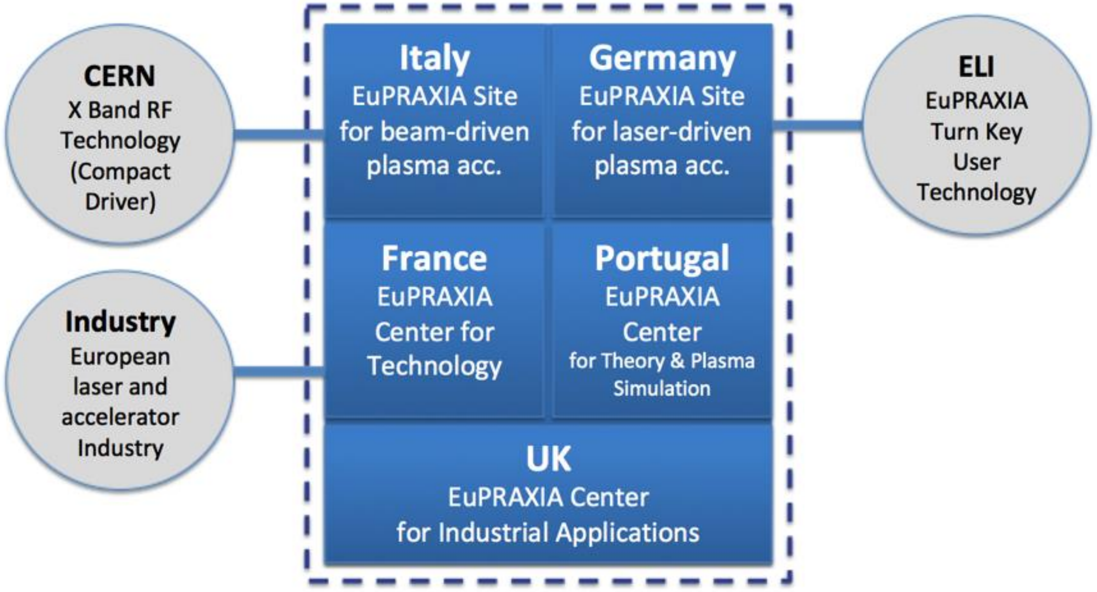
How and where to build it?

Project considerations

- Reflects ambitions known to us but integrates all into a common project.
- **Two sites reflect two driver technologies** – minimal duplications due to common project work!
- **Use of existing sites** use pre-invest and make sure OP costs are covered.
- Very visible roles to France, Portugal and UK without the need to propose a site.
- Connects to European industry, ELI and CERN.



- Simplifies discussion of radiation protection, safety, **OP costs**, ...: labs take care of it through existing structures.
- Easy to explain to people not interested in technical details.

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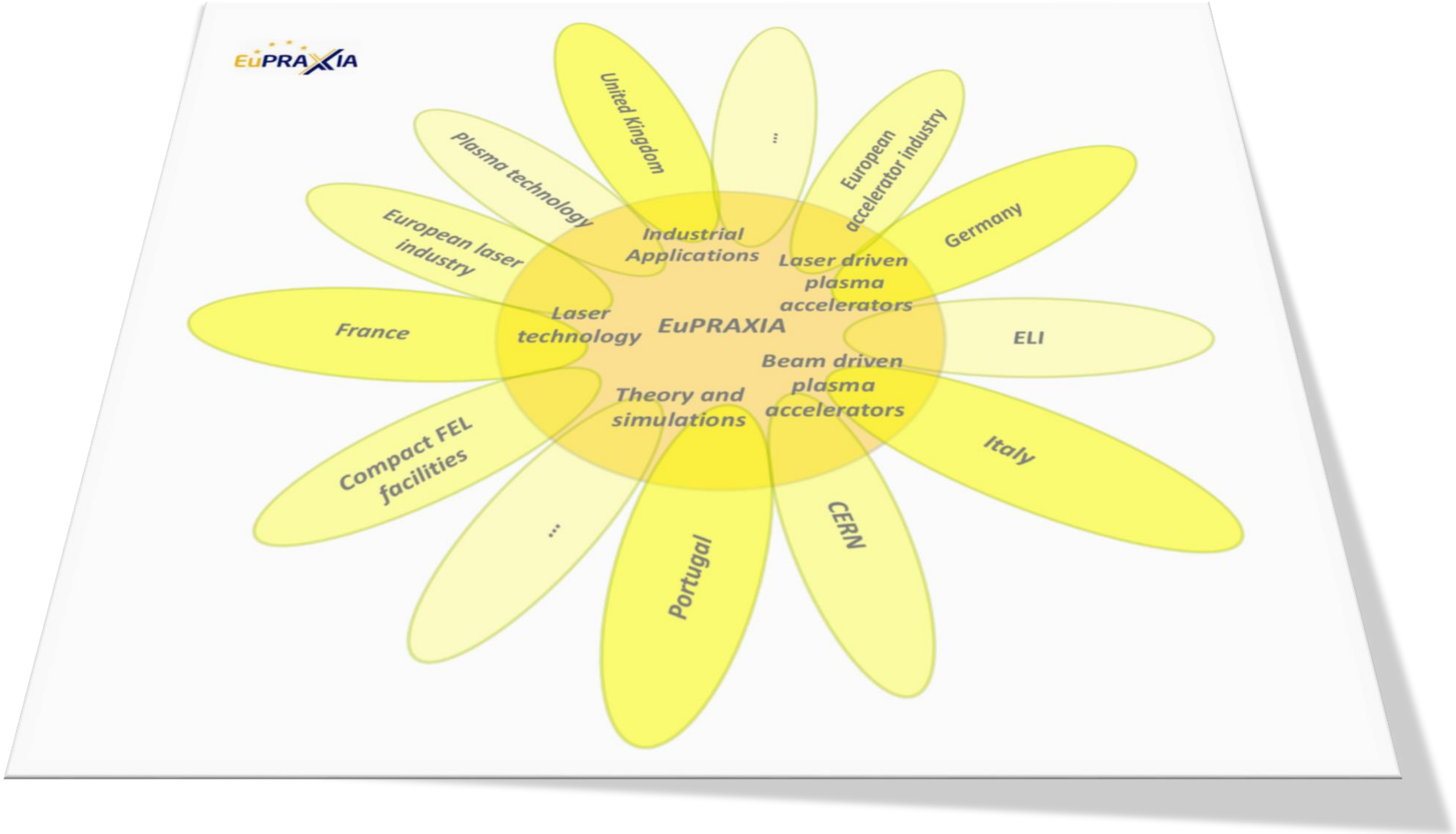
Alternative View



Andreas Walker

Conclusion

- We have interesting options to move faster with clear requests
- We would be ready for funding once funding becomes available
- We can still change and down-select when necessary, e.g. new insights, limited funding or new political boundary conditions

Now: PLENARY DISCUSSION

Consortium

16 Participants

24 Associated Partners

(as of December 2017)