Brainstorming for the Hungarian contribution to the Proposal for a Horizon 2020 Design Study on the „European Plasma Research Accelerator with eXcellence in Application” EuPRAXIA

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Outline

What is EuPRAXIA
(technical details)

Speculation on the possible WIGNER contributions experimental and theoretical
(plasma source, diagnostics etc.
just run through the workpackages)

European Plasma Research Accelarator with eXcellence in Application” EuPRAXIA

Aim: Conceptual design report for the worldwide first 5 GeV plasma based accelerator
Two user areas will be developed for a novel Free Electron Laser and High Energy Physics detector science.
EuPRAXIA will be a new large research infrastructure
with an estimated footprint of about 250 m. If the design study is approved it will lay the foundation for a possible decision on construction in 2020.

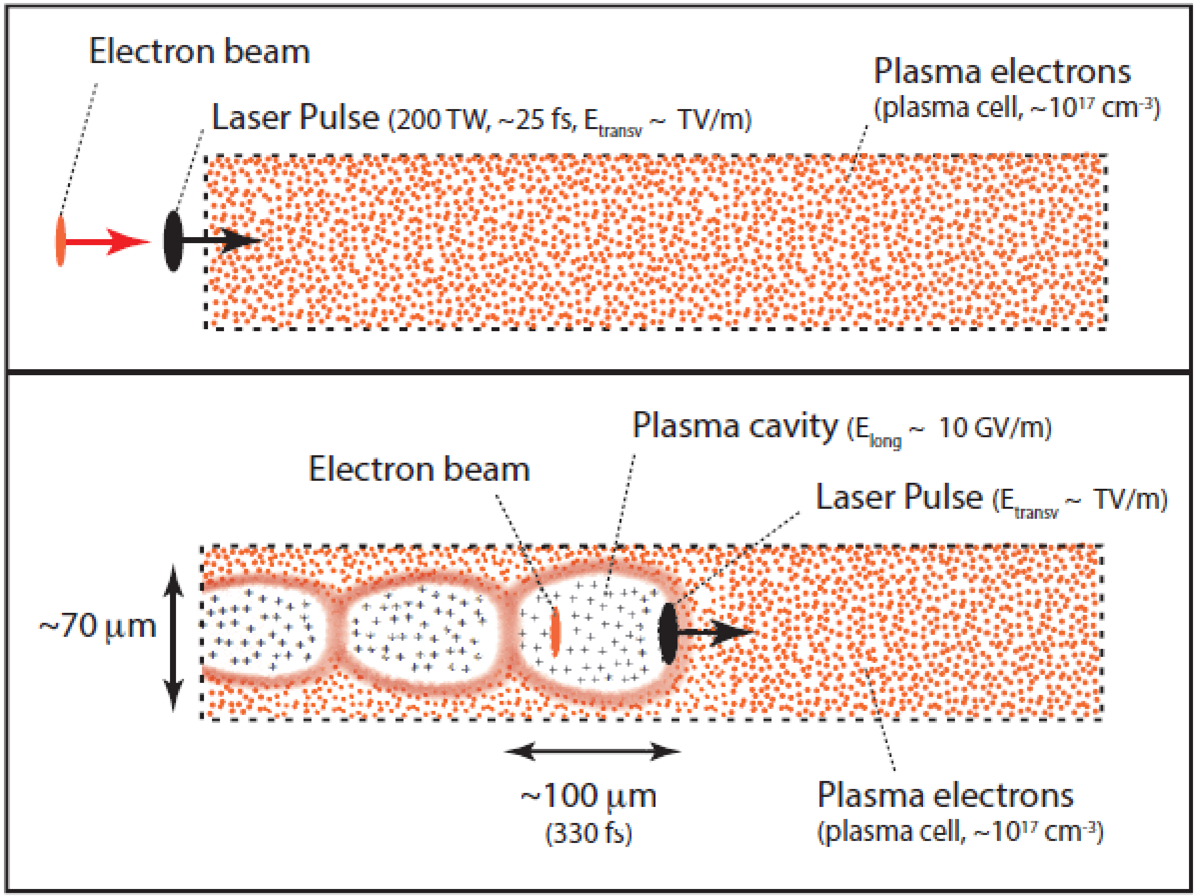
Consortium 16 laboratories and 5 unis from 5 EU states, and 18 partners from 8 countries

Our proposal EuPRAXIA was finally submitted to the European Union Horizon 2020 Program. You will find the submitted version under:

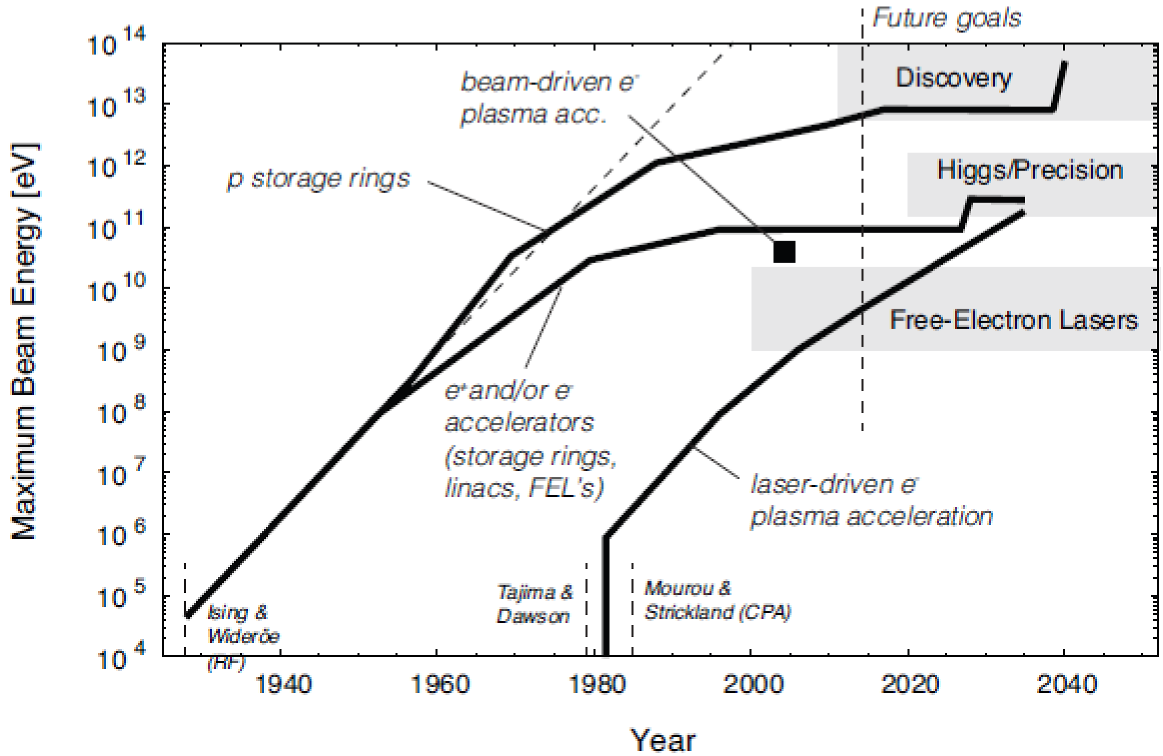
https://ard.desy.de/login_form?lang=eng&destination=https://ard.desy.de/e178196/@@siteview
the requested name is : eupraxia
the password is: Horizon2020

It is a 155 pages .pdf document

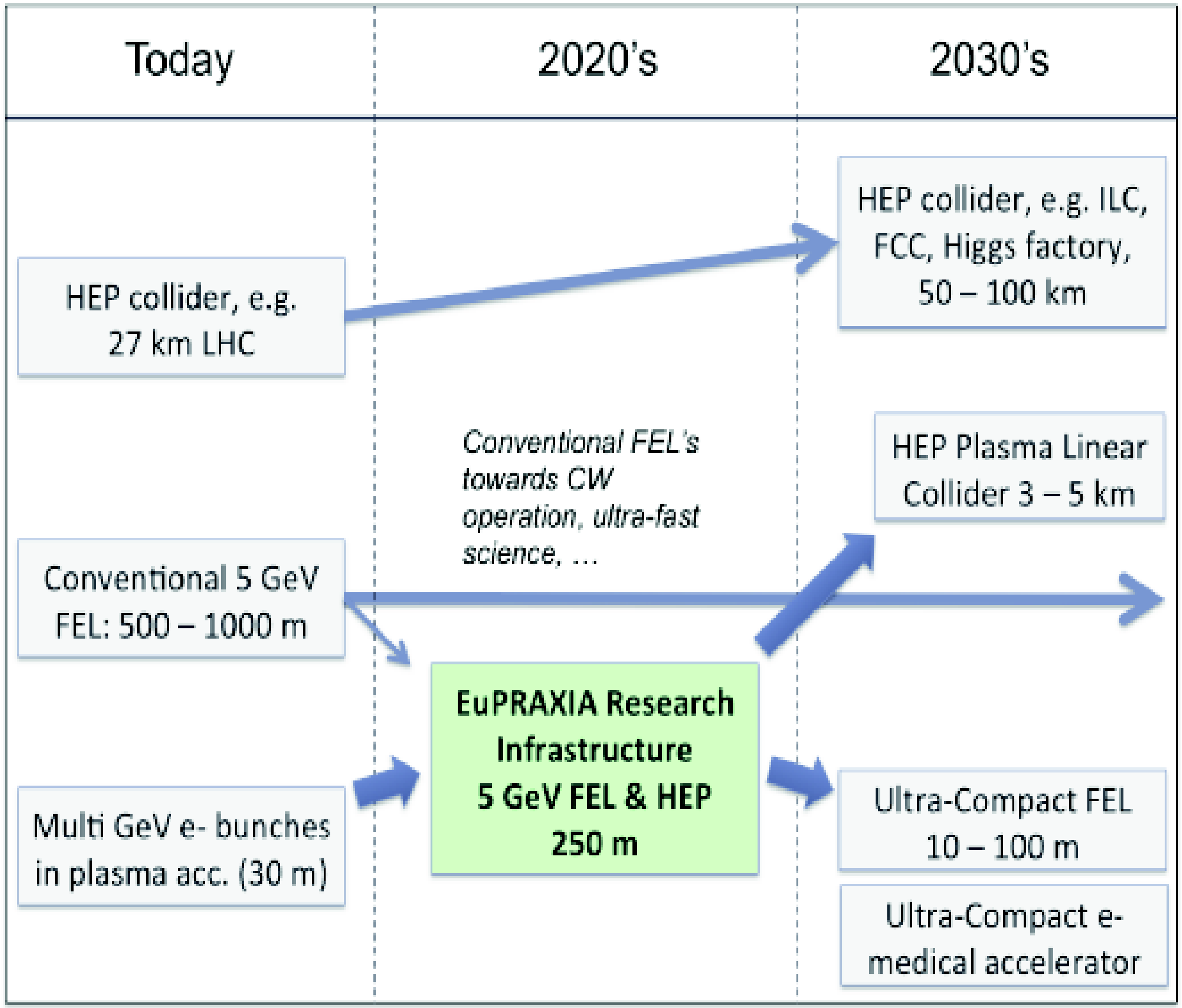
dea of Laser Wake Field in Plasma

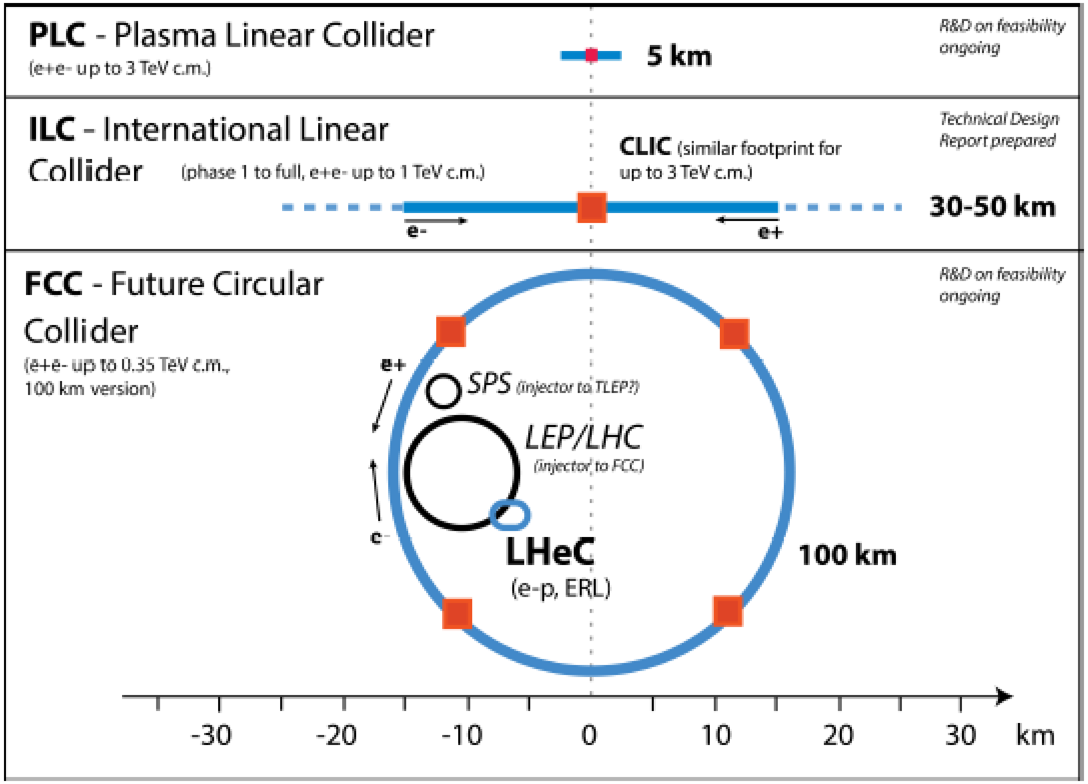


200 TW laser exciting a wake in a plasma of 10^{17} cm^{-3}



Livingston curve for accelerators, showing the maximum reach in beam energy versus time.


Today
2020's
2030's
HEP collider, e.g. 27 km LHC
HEP collider, e.g. ILC, FCC, Higgs factory, 50 – 100 km
Conventional FEL's towards CW operation, ultra-fast science, …
HEP Plasma Linear Collider 3 – 5 km
Conventional 5 GeV FEL: 500 – 1000 m
EuPRAXIA Research Infrastructure 5 GeV FEL & HEP 250 m
Multi GeV e- bunches in plasma acc. (30 m)
Ultra-Compact FEL 10 – 100 m
Ultra-Compact e- medical accelerator



PLC - Plasma Linear Collider
(e+e- up to 3 TeV c.m.)
5 km
R&D on feasibility ongoing
ILC - International Linear Collider
(phase 1 to full, e+e- up to 1 TeV c.m.)
CLIC (similar footprint for up to 3 TeV c.m.)
Technical Design Report prepared
30-50 km
e-
e+
FCC - Future Circular Collider
(e+e- up to 0.35 TeV c.m., 100 km version)
R&D on feasibility ongoing
e+
SPS (injector to TLEP?)
LEP/LHC
(injector to FCC)
e-
LHeC
(e-p, ERL)
100 km
-30
-20
-10
0
10
20
30
km

The Facility

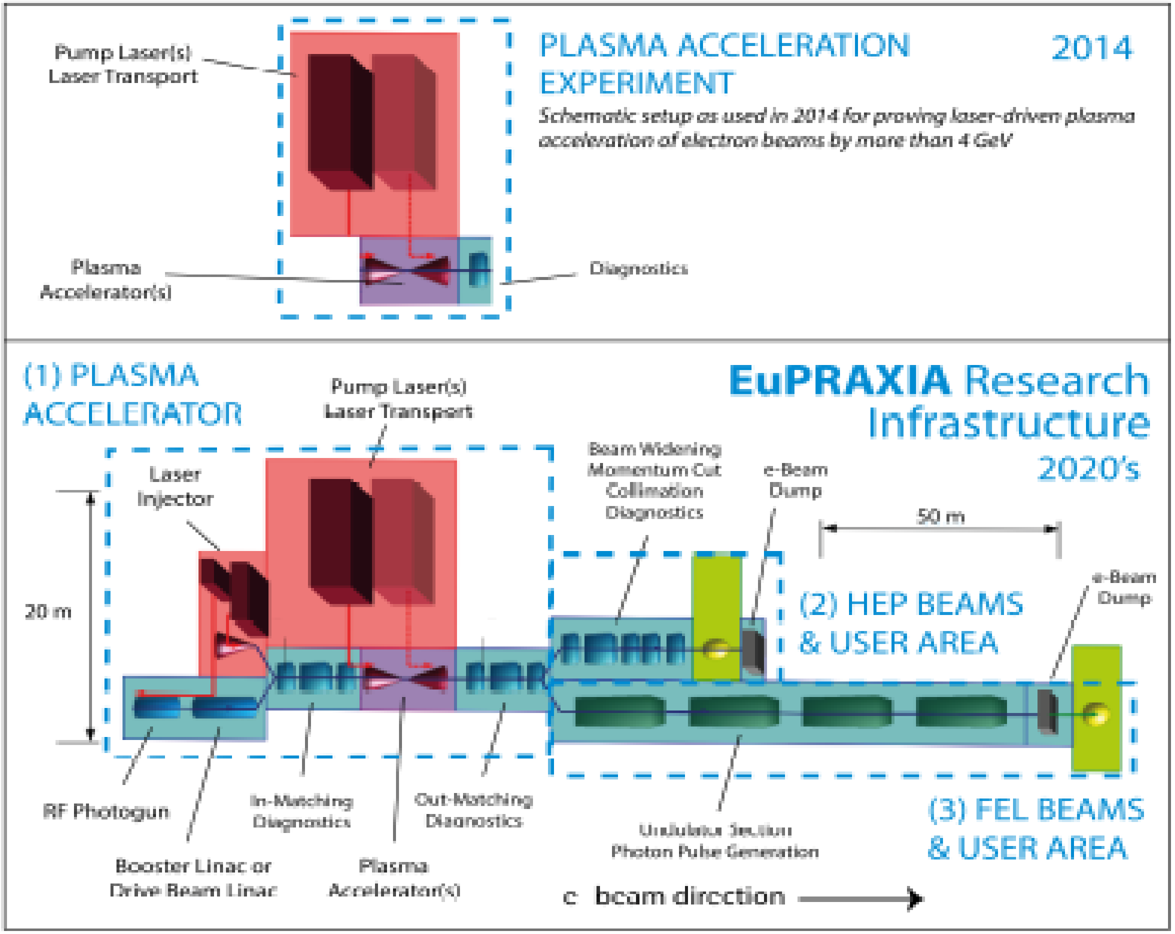


Figure 1.1: An illustration of the EuPRAXIA concept for designing a European Research Infrastructure consisting of (1) a plasma accelerator for providing 5 GeV e- beam, (2) a high energy physics user area and (3) an FEL user area. For comparison, the schematic setup of a state-of-the-art multi GeV plasma acceleration experiment is shown in the upper part of this Figure. Many major building blocks of EuPRAXIA are shown. Indicative lengths scales are given for the longitudinal and transverse ground footprint.

Technical Parameters

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

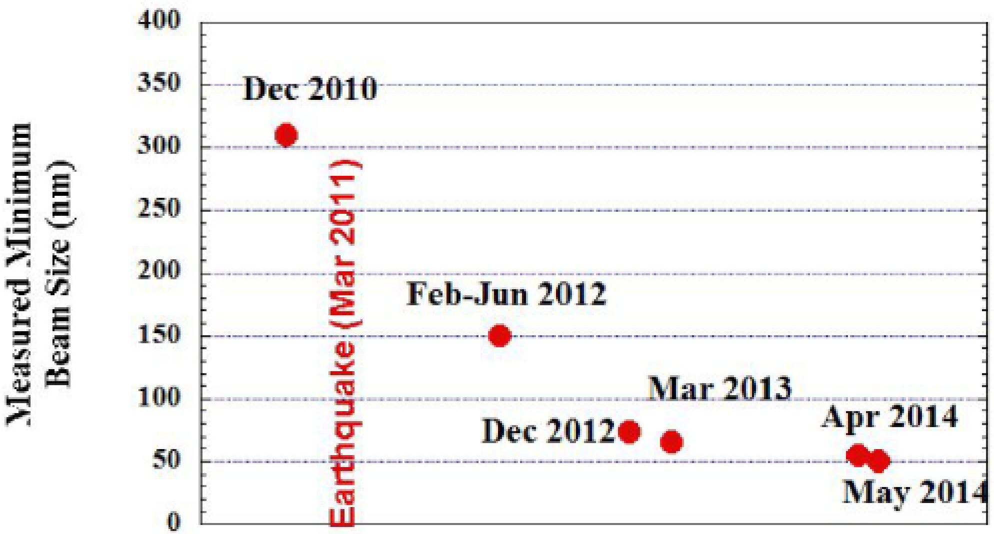
1 PW laser is needed
THALES, Amplitude Technology show interest

The whole costs will be 200 Meuro
Single countries UK, Germany have 30 – 50 Meuro for such facilities

The aim is to reduce the beam size

time.

3. Latest accelerator technology has shown the feasibility of generating and controlling **small beam sizes** (down to 45 nm, see Figure 1.2) and **short electron pulses** (down to several 10 fs, less than 10 μm). At the same time it is now possible to achieve **synchronization accuracies at the 10 fs level** and to keep this over 24 hours (see Figure 1.3). This progress is fundamentally important for turning plasma accelrators into a realistic option for users.
4. Laser technology has reached and surpassed the **1 PW peak power level**, which is required for GeV-class plasma acceleration. It is now realistic to focus technical work on improving the stability and reproducibility of laser beams and efficiency and scalability of laser installations.



ATF2 result from KEK (Japan) s

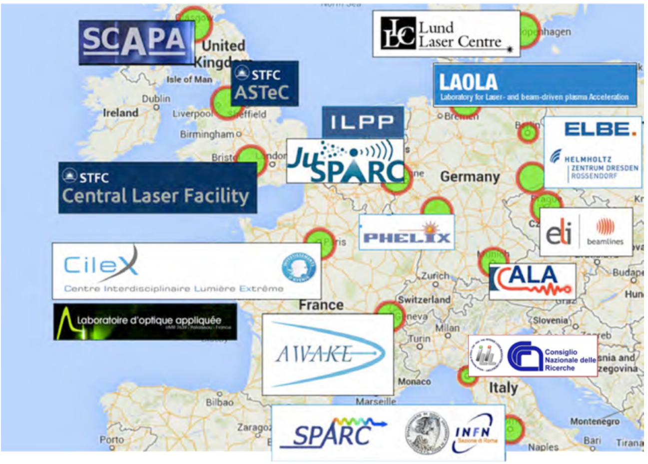
Now from the proposal

Date of preparation:
2nd September 2014
Coordinator: Ralph W. Aßmann, e-mail: ralph.assmann@desy.de
They ask 3.000.000 Euro for the proposal for the design study (2015-2019)

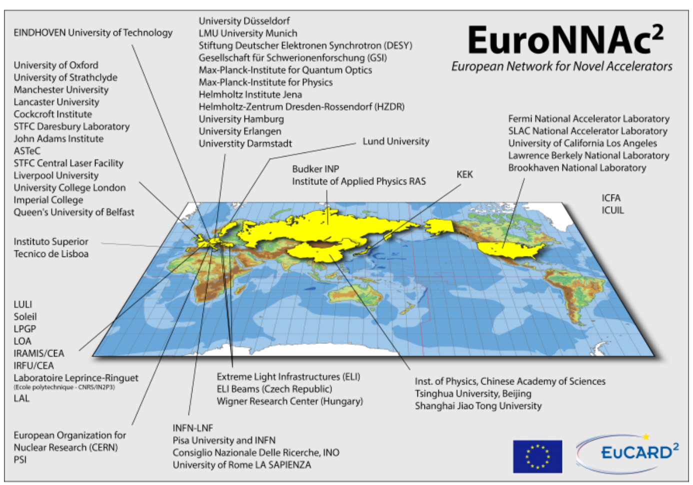
- pp. 1—57: list of participants, general statements
- pp. 58—125: technical description, Work Packages, tasks, schedule gant chart
- pp. 26—155: clarification of proficiencies of the participants, relevant publications, contact people (Wigner RCP listed on p. 152)

Associated Partner No 8	Wigner Research Center of the Hungarian Academy of Science
General Description	The Research Centre was founded on 1st January, 2012, by the merging of two former research institutes, the Research Institute for Particle and Nuclear Physics, and the Research Institute for Solid State Physics and Optics of the H.A.S. It has expertise in High energy physics, plasma physics, applied optics and quantum optics, matching several required key expertises for EuPRAXIA.
Contact Scientist and Involvement	The contact scientist for EuPRAXIA is Dr. Imre F. Barna. Detailed participation remains to be defined.

International Activities



Overview on National Eur. Projects in the field of plasma accelerators



Participants of 1st European Advanced Accelerator Workshop (2013, Island of Elba)

List of participants:

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

List of associated partners:

Associated partner no.	Associated partner organisation name	Short name	Country
1	Jiaotong-Universität Shanghai	JUS	China
2	Tsingua University Beijing	TUB	China
3	Extreme Light Infrastructures - Beams	ELI-B	Czech Republic
4	Lille University	PHLAM	France
5	Helmholtz Institute Jena	HIJ	Germany
6	Helmholtz-Zentrum Dresden-Rossendorf	HZDR	Germany
7	Ludwig-Maximillians-Universität München	LMU	Germany
8	Wigner Research Center of the Hungarian Academy of Science	WIGNER	Hungary
9	European Organization for Nuclear Research	CERN	IEIO[1]
10	High Energy Accelerator Research Organization	KEK	Japan
11	Kansai Photon Science Institute, Japan Atomic Energy Agency	KPSI-JAEA	Japan
12	Osaka University	OU	Japan
13	RIKEN SPring-8 Center	RSC	Japan
14	Lund University	LU	Sweden
15	Center for Accelerator Science and Education at Stony Brook U & BNL	CASE	USA
16	Lawrence Berkeley National Laboratory	LBNL	USA
17	SLAC National Accelerator Laboratory	SLAC	USA
18	University of California, Los Angeles	UCLA	USA

Hungary will get 12000 EUR for travel costs for the next 3 years ??

Structure and Work Packages

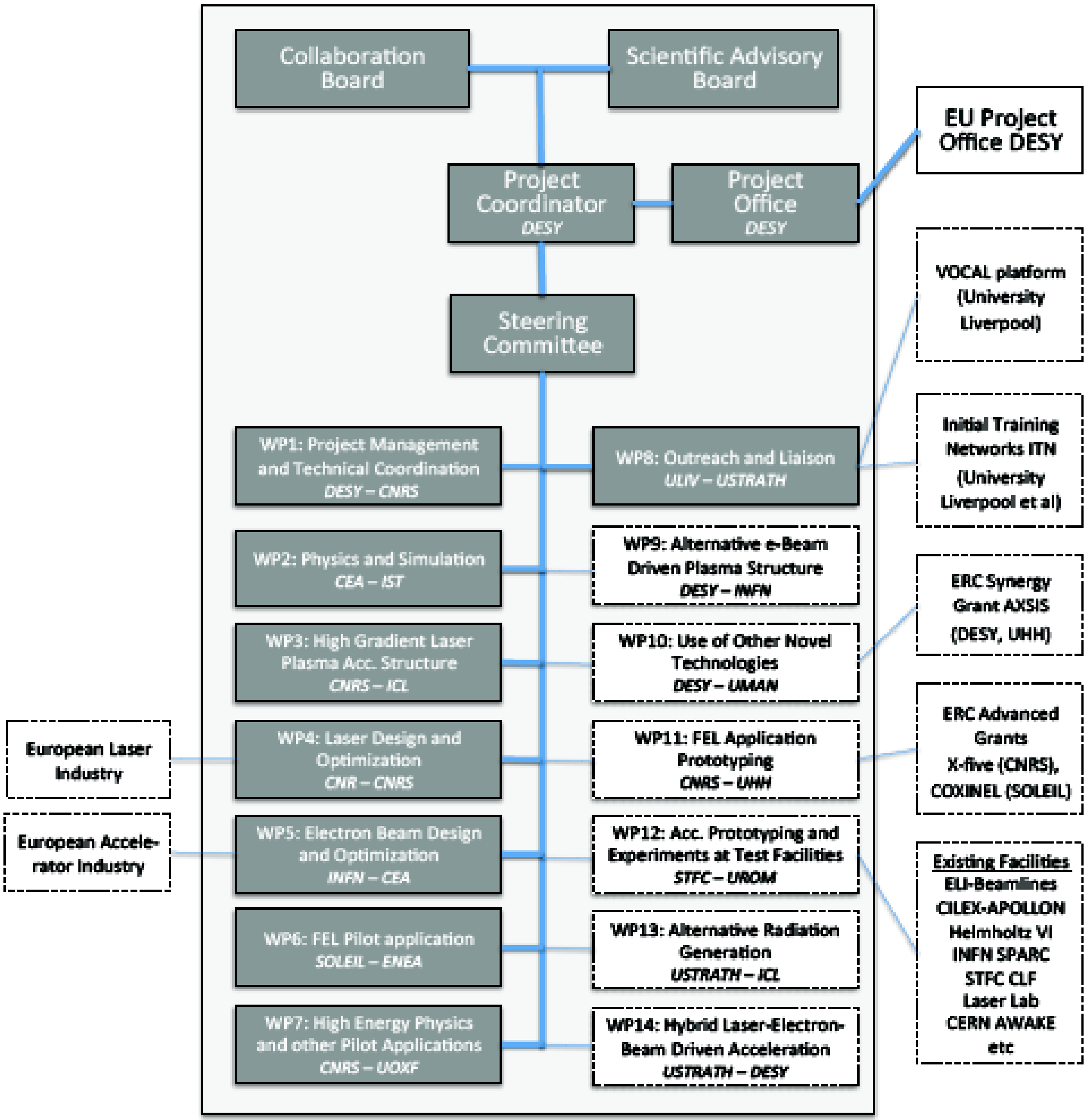


Table 3.1b: List of EuPRAXIA Work **Packages included in the EU design study. Person-months list the man-power requested from EU as well as the total manpower (in brackets) per WP.**

WP No	Work package title	Type of activi-ty[14]	Lead patici-pant No	Lead participant short name (depu-ty in brackets)	Person-months[15]	Start month	End month
1	Project Management, Technical Coordination	MGT	1	DESY (CNRS)	24 (96)	M1	M48
2	Physics and Simulation	RTD	12	CEA (IST)	88 (290)	M1	M48
3	High Gradient Laser Plasma Accelerating Structure	RTD	4	CNRS (ICL)	42 (142)	M1	M48
4	Laser Design and Optimi-zation	RTD	3	CNR (CNRS)	57 (83)	M1	M48
5	Electron Beam Design and Optimization	RTD	2	INFN (CEA)	78 (218)	M1	M48
6	FEL Pilot Application	RTD	8	SOLEIL (ENEA)	126 (266)	M1	M48
7	High Energy Physics, other Pilot Applications	RTD	4	CNRS (UOXF)	36 (54)	M1	M48
8	Outreach and Liaison	MGT	10	ULIV (USTRATH)	50 (60)	M1	M48
		TOTAL			501 (1209)		

Table 3.1b-non-EU: List of EuPRAXIA Work Packages that are not included in the EU design study. The in-kind contributions for these WP's are listed in Table 3.4a-total-project.

WP No	Work package title	Type of activity[2]	Lead participant No	Lead participant short name (deputy in brackets)
9	Alternative e-Beam Driven Plasma Structure	RTD	1	DESY (INFN)
10	Use of Other Novel Technologies	RTD	1	DESY (UMAN)
11	FEL Application Prototyping	RTD	4	CNRS (UHH)
12	Accelerator Prototyping and Experiments at Test Facilities	RTD	7	STFC (UROM)
13	Alternative Radiation Generation	RTD	5	USTRATH (ICL)
14	Hybrid Laser-Electron-Beam Driven Acceleration	RTD	5	USTRATH (DESY)

Kapcsolódási pontok:

WP1 Project Management and Technical Coordination

1. Management
2. Parameter, Layout and Cost Committee
3. Quality Assurance Plan
4. Implementation Model and Site Study (?EK Török Szabina, Zagyvai Péter)
5. Radiological Impact (?EK Török Szabina, Zagyvai Péter)

WP2 Physics Simulation

1. Coordination and Communication
2. Machine model
3. Start-to-End simulation PIC Donkó Zoltán and Co. ???
   AWAKE Rb ionizáció, propagation számolás Gagik and Co.
4. Tolerance Budget
5. Final performance

WP3 High. Grad. Las. Plasm. Accel. Structure

1. Design plasma acceler. Structure elements linked to laser. Plasm coupling
2. Design the plasma structures required ,
3. Plasma chamber design (Rb kísérlet eredményei ?)

WP4 Laser Design and Optim.

1. System engineering
2. Laser design study
3. Transverse function
4. Laser control system

WP5 Electron Beam Design and Optimization

1. Coordination and Communication
2. Electron beam for injection
3. Electron beam manipulation
4. Electron beam
5. Final performance

WP6 FEL Pilot application (?Faigel Gyula and Co)

1. Coordination and Communication
2. FEL Baseline cases
3. Undulators and technological developments of equipments
4. Towards scientific applications
5. Operational model

WP7 High Energy Physics and other Applications (? Siklér and Co)

1. Coordination and Communication
2. Identification of pilot application for LWFA electron beams
3. Specif. of electron beam parameters for selected pilot application
4. Beam Line conceptual design
5. User experimental area conceptual design

WP8 Outreach and Liaison

1. Coordination and Communication
2. Liaison with FEL and HEP Sciences
3. Dissemination of Information and Industry outreach
4. Training of required experts

Work packages not supported by the EC

WP9 Alternative e-Beam Driven Plasma Structure

1. e-beam driver option and beam preparation
2. Plasma target and vacuum system
3. Plasma diagnostics
4. Beam tailoring and release into vacuum
5. Staging of acceleration modules
6. Engineering issues and stability

WP10 Use of Other Novel Technologies

1. Novel cold injectors
2. Dielectric structures
3. Fibre Laser (?Szipőcs R. and Co.)

WP11 FEL Application Prototyping

1. Optimization of LWFA for FEL application

WP12 Accelerator Prototyping and Experiments at Test Facilities

1. Testing laser-driven plasma source, staging, diagnostics and mode coupling
2. Testing laser feedback and correction methods and two plasma module laser acceleration
3. Testing and optimizing electron beam properties before and after injection
4. Testing FEL parameters and performance
5. Testing application of Particle beams

WP13 Alternative Radiation Generation

1. Investigations of injection schemes for high quality electron bunches
2. Extension of spectral range of plasma-based radiation sources to gamma-rays and the far infra-red
3. Investigations of coherence development in plasma-based radiation sources
4. Development of diagnostic systems for investigating plasma-based radiation sources

WP14 Hybrid Laser—Electron—Beam Driven Acceleration

1. Selective ionization os plasma components
2. Trojan Horse underdense photocathode witness bunch generation
3. Wakefield-induced ionization injection
4. Exploiting LWFA-generated electron bunches as drivers for PWFA
5. Integration of resutls of tasks 14.1—14.4. into the EuPRAXIA Design Report

Thank you for your attention!