EUROPEAN
PLASMA RESEARCH
ACCELERATOR WITH
EXCELLENCE IN
APPLICATIONS

EuPRAXIA

Horizon 2020 EuPRAXIA Design Study

Ralph Aßmann (DESY)

on behalf of the EuPRAXIA collaboration

3rd European Advanced Accelerator Concepts Workshop

September 28th, 2017, Elba

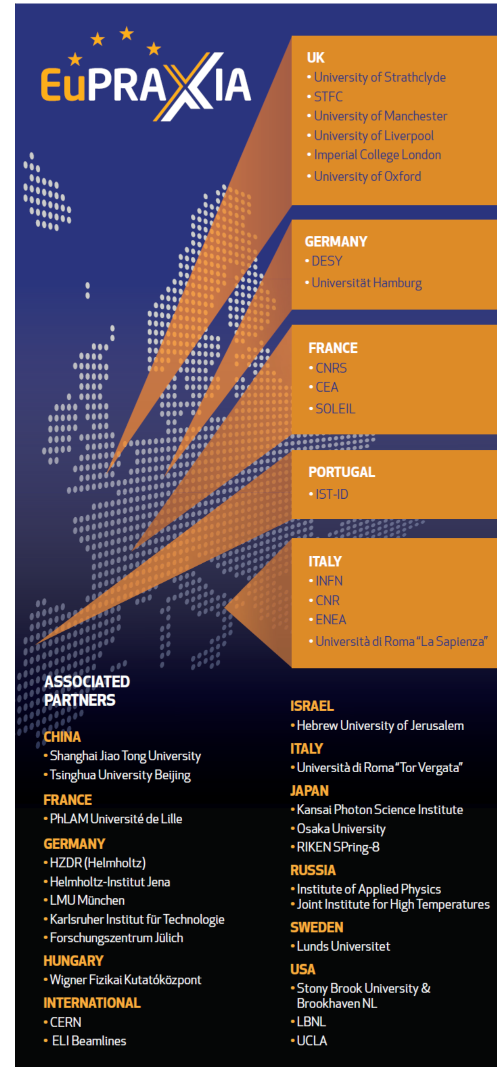
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 653782.

http://eupraxia-project.eu

European Plasma Research Accelerator with eXellence In Applications

Horizon 2020

- EuPRAXIA is a **conceptual design study** for a **5 GeV electron plasma accelerator** as an European research infrastructure
- 125 scientists work in **38 international partners**
  - 16 EU laboratories are beneficiaries
  - 22 associated partners contribute in-kind
  - DESY is coordinator laboratory (R.W. Assmann)
- EuPRAXIA is an **EU Horizon 2020** project
  - Is an accelerator related design study, as EuroCirCol (FCC) from CERN
  - Final CDR will be published in October 2019
- Develop **plasma technology for user readiness**:
  - Incorporate established accelerator technology for optimal quality
  - Combine expertise from accelerator and laser labs, industry, and international partners



A European Strategy for Accelerator Innovation

EuPRAXIA

Horizon 2020

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

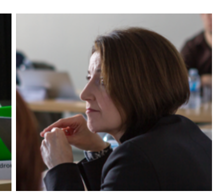
Pilot users from FEL, HEP, medicine, ...

PRODUCTION FACILITIES

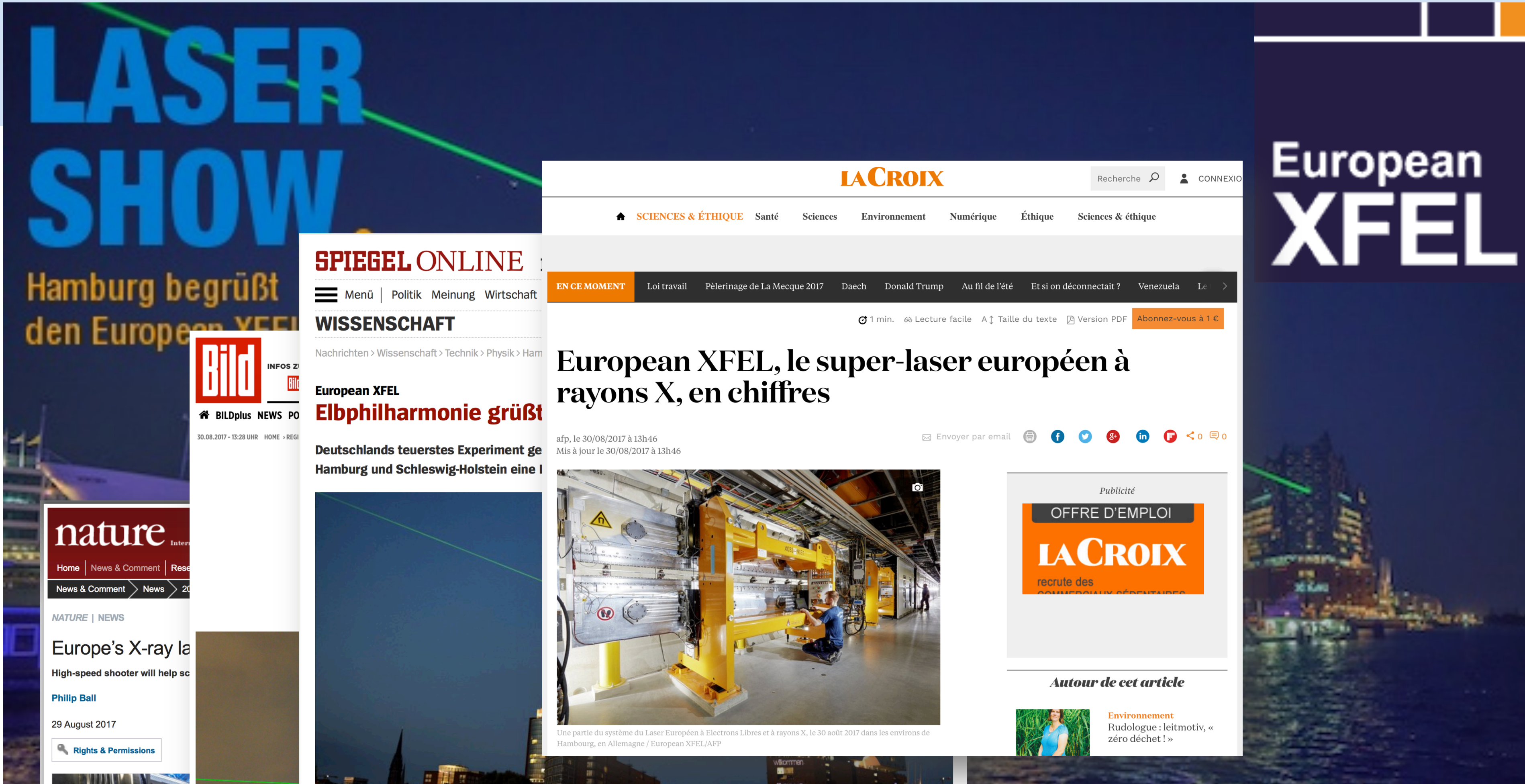
Plasma-based **linear collider** in 2040's

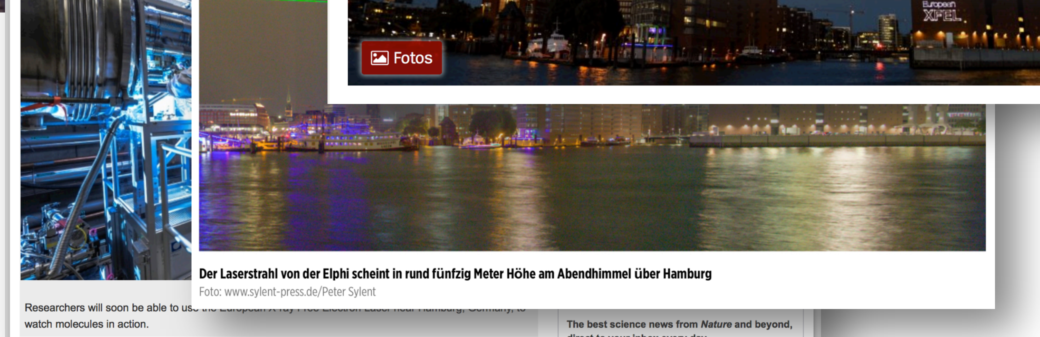
Plasma-based **FEL** in 2030's

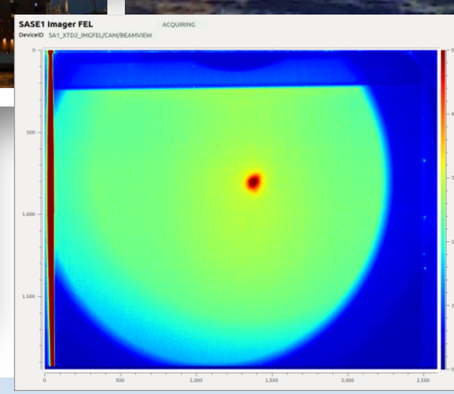
Medical, industrial applications soon



Free-electron lasers conquering Hamburg and European Photon Science...







June 23rd
lasing at 1.5 Å

EuPRAXIA Expertise

- **Accelerator scientists** (LHC, SLC, LEP, PEP-2, MedAustron, FLASH, Soleil, SPARC, ...)
- **Laser scientists**
- **Plasma scientists**
- **Universities** with great ideas and enthusiastic **students**
- **National labs** with expert technical groups (EU-XFEL)
- Access to **engineers** from all specialties (building, mechanical, electrical, ...)
- Access to highly trained **technicians**

The Power of Collaboration

Adapted from P. Schmüser

The Power of Collaboration

Horizon 2020

Why use plasma accelerators?

Horizon 2020

Plasma accelerator techniques offer an innovative path to new parameters and to reduced size and cost with **novel applications** such as:

1) **FEL's with new properties for research centers** (complimentary to high power FEL's): *ultra-short pulses, pump-probe, excellent synchronization with low power (at least initially)*

2) **Ultra-compact FEL's at universities** (fit available space)

3) Laser-driven electron beams as **medical imaging sources** in hospitals

4) Compact **electron irradiation**

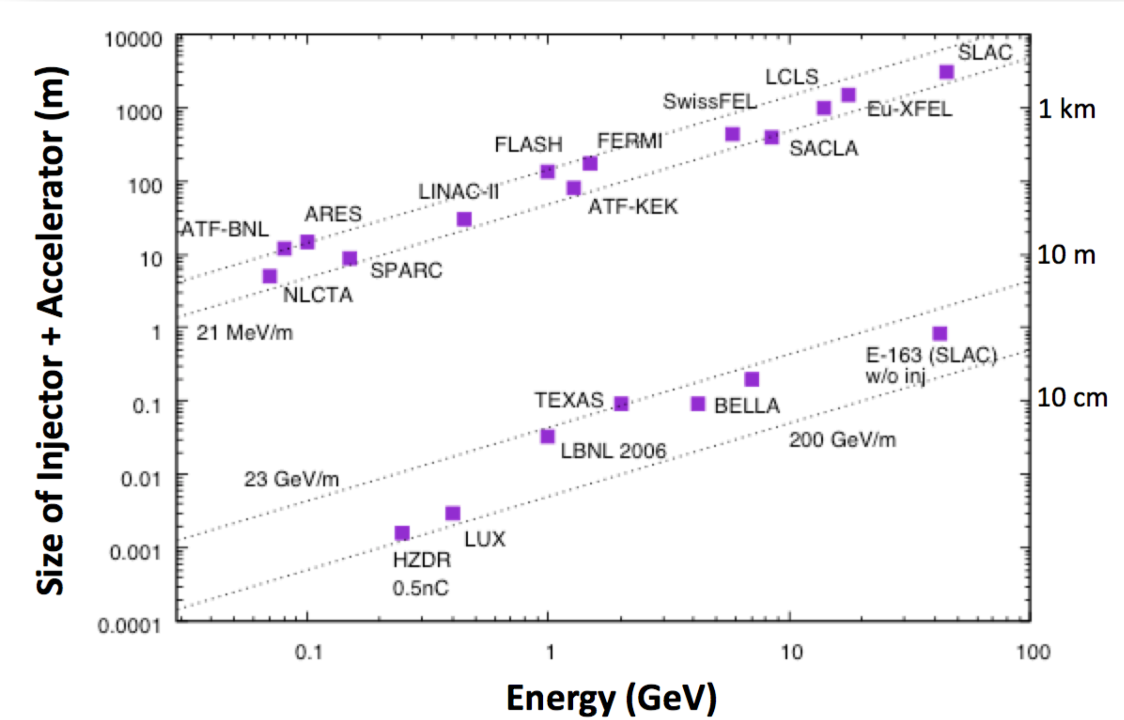
5) Portable industrial applications for **X-ray inspections**

6) New **HEP table-top test beams**

7) Compact plasma **HEP collider**

Size versus Energy

electron linear accelerators

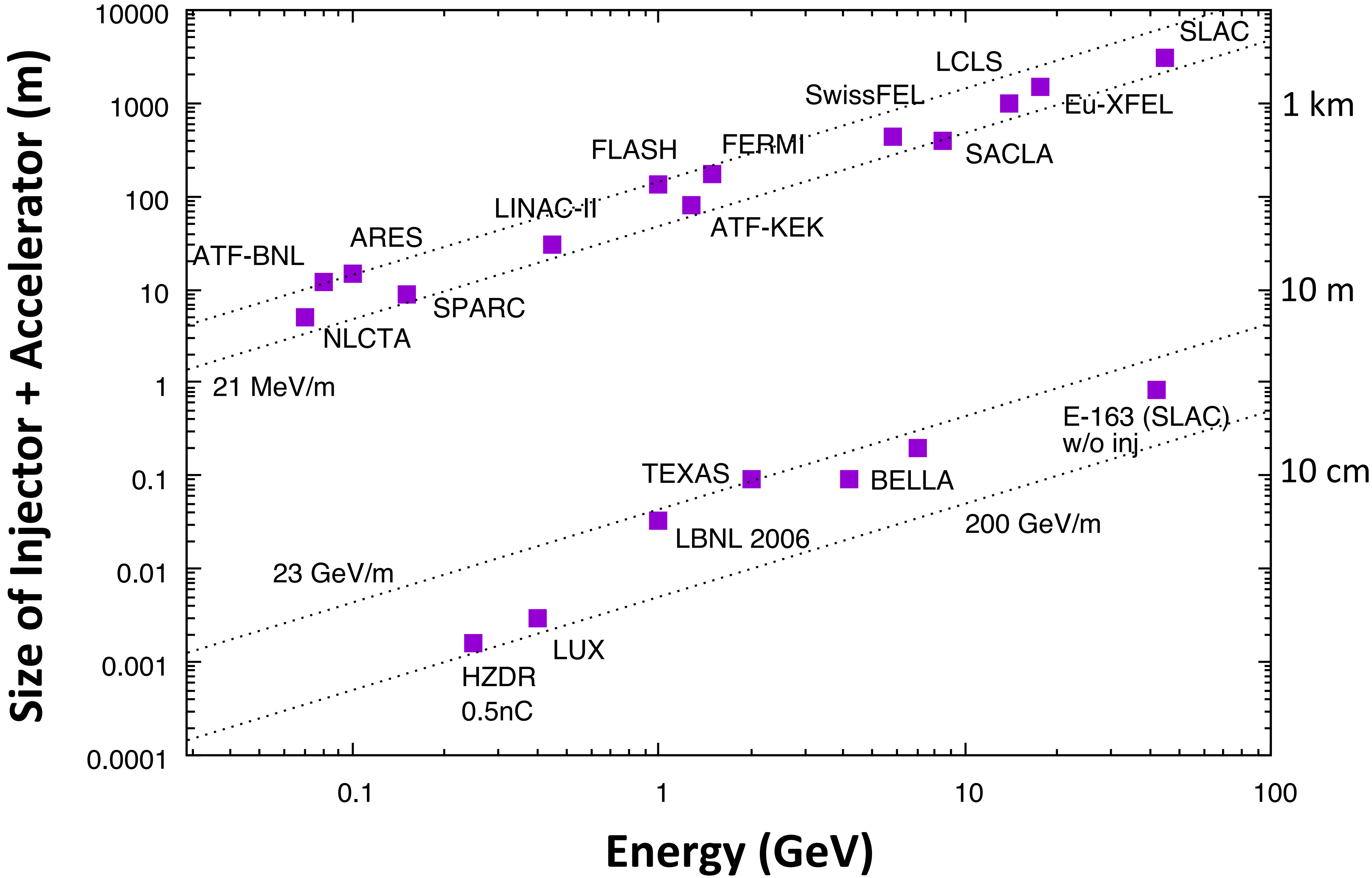


Some remarks:

- Various **electron linear accelerators** are included
- Size includes size of injector (except beam-driven plasma E-163)
- **Not included are beam delivery or undulators**
- Energy gain is NOT peak RF field but **average energy gain**
- **Not complete list** of experiments or facilities − many more exist
- Example WP's: HZDR, LUX, ... can also produce GeV beams

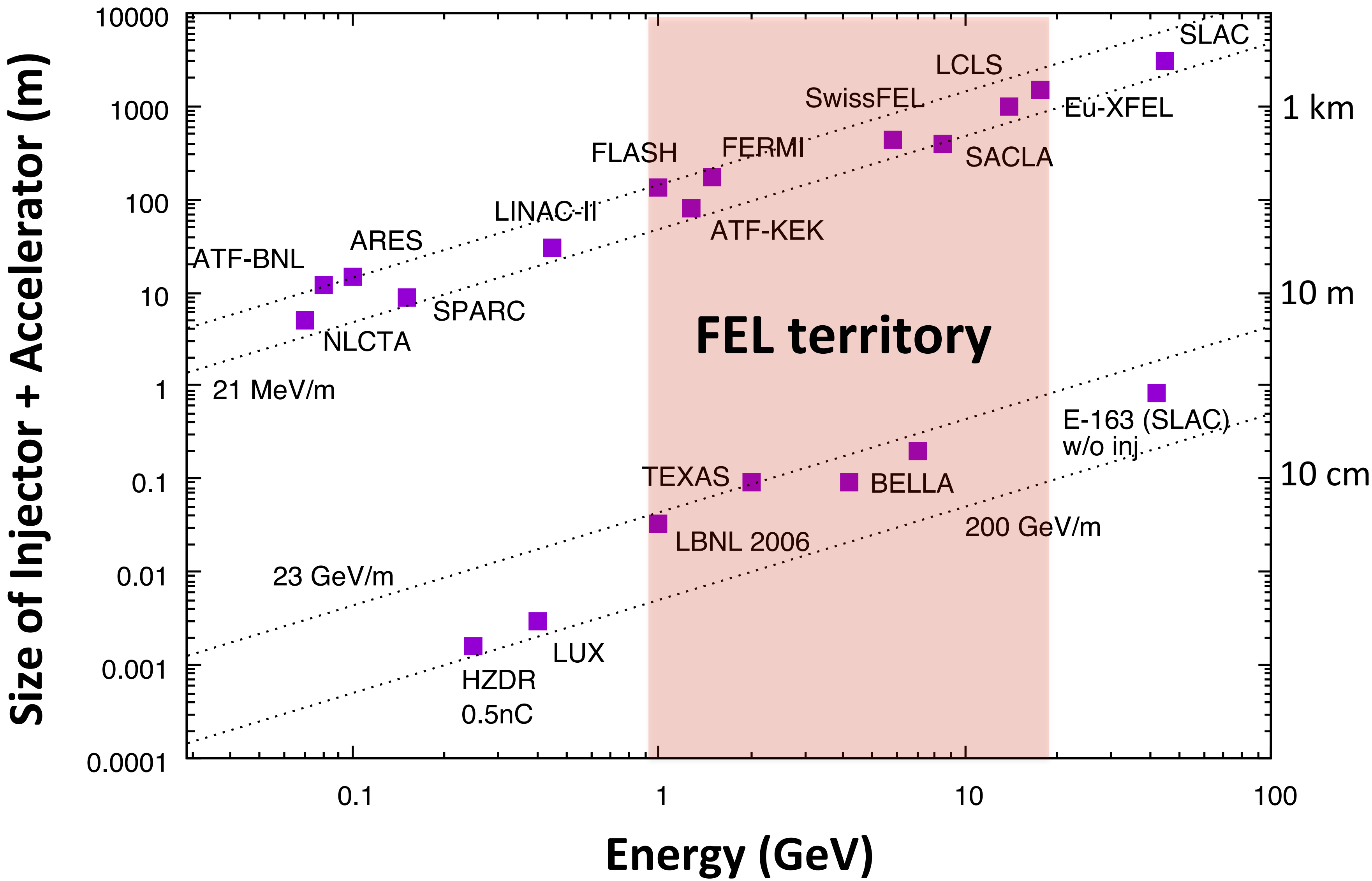
Size versus Energy

electron linear accelerators



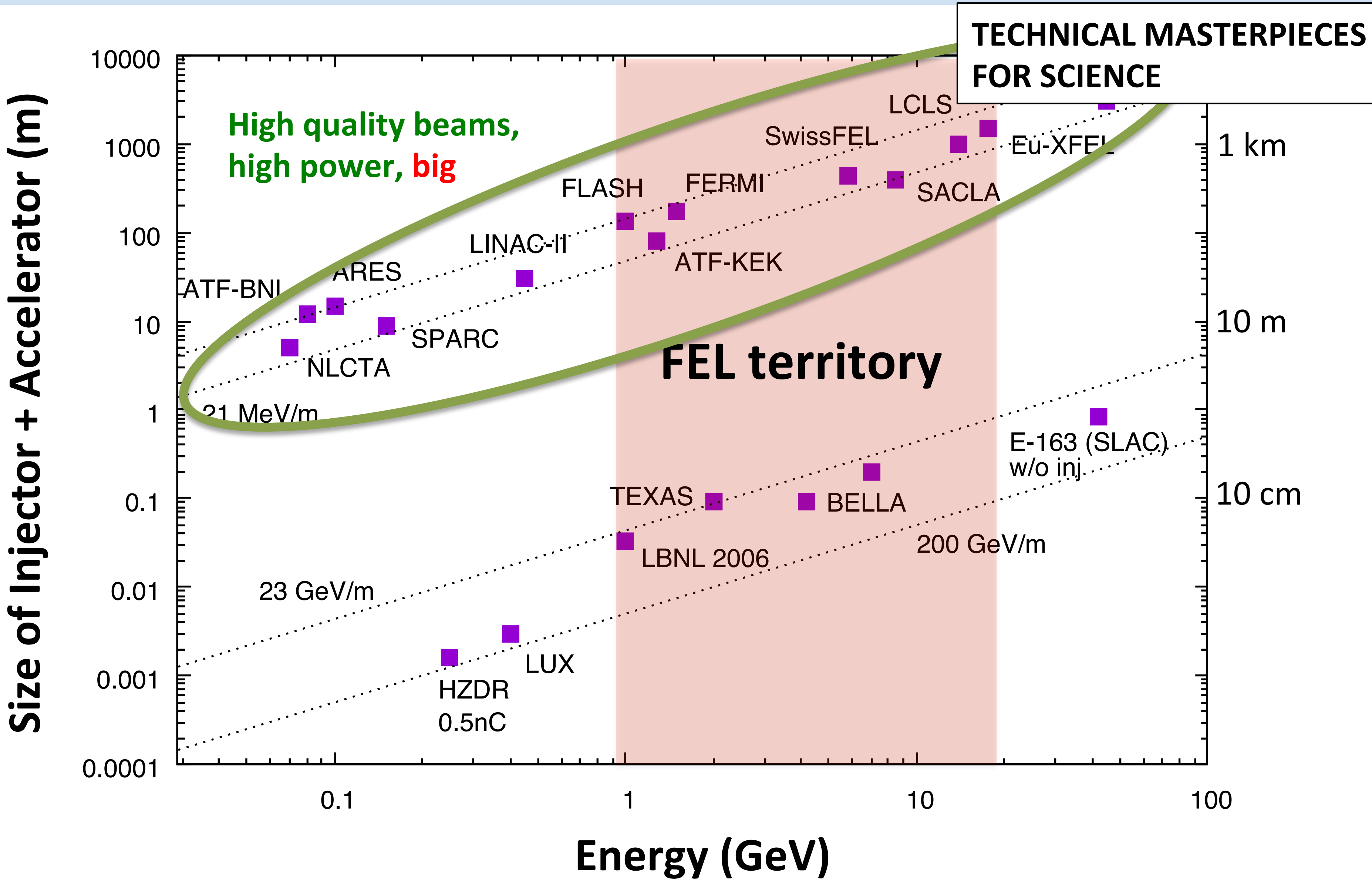
Size versus Energy

electron linear accelerators



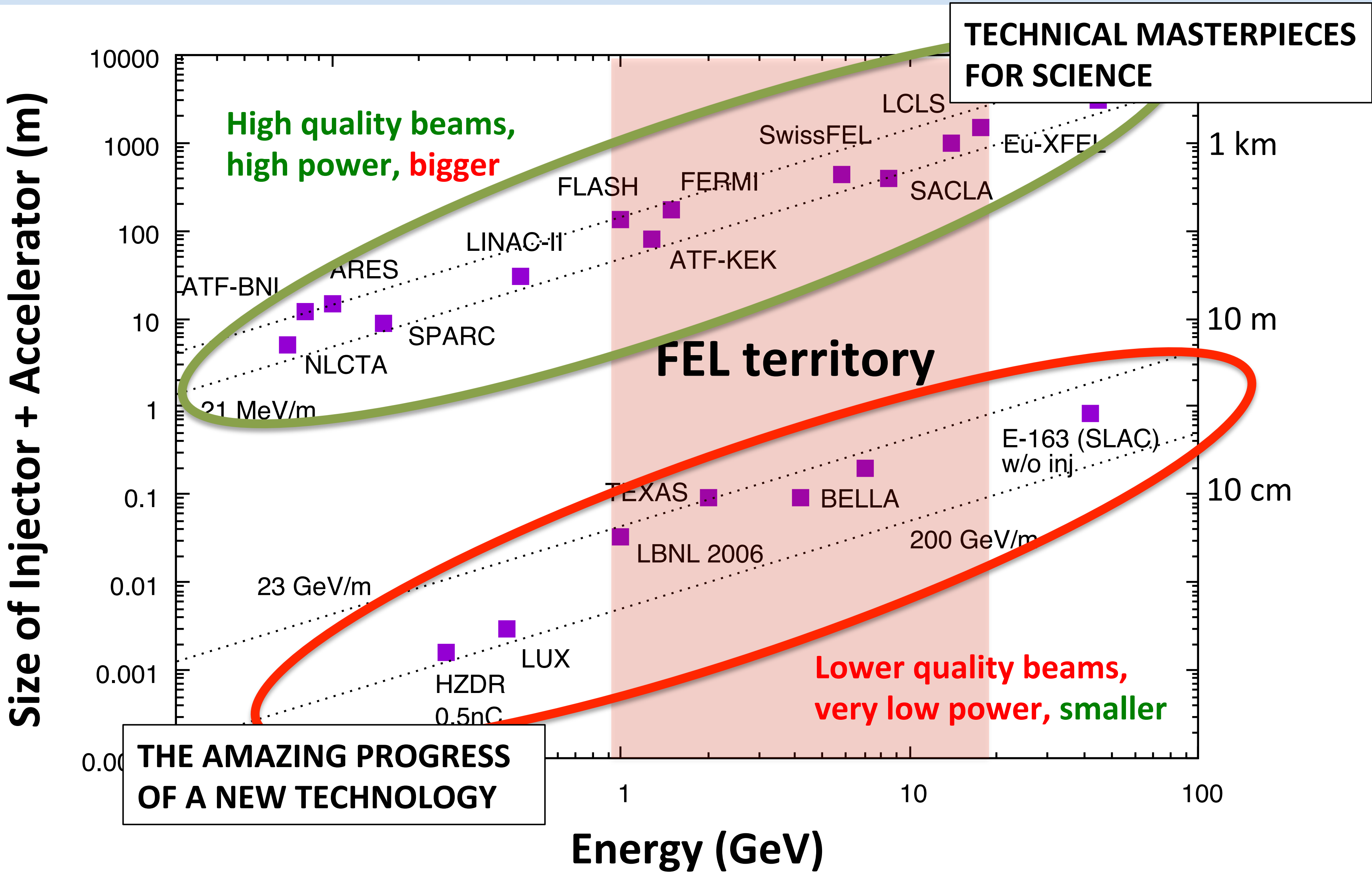
Size versus Energy

electron linear accelerators



Size versus Energy

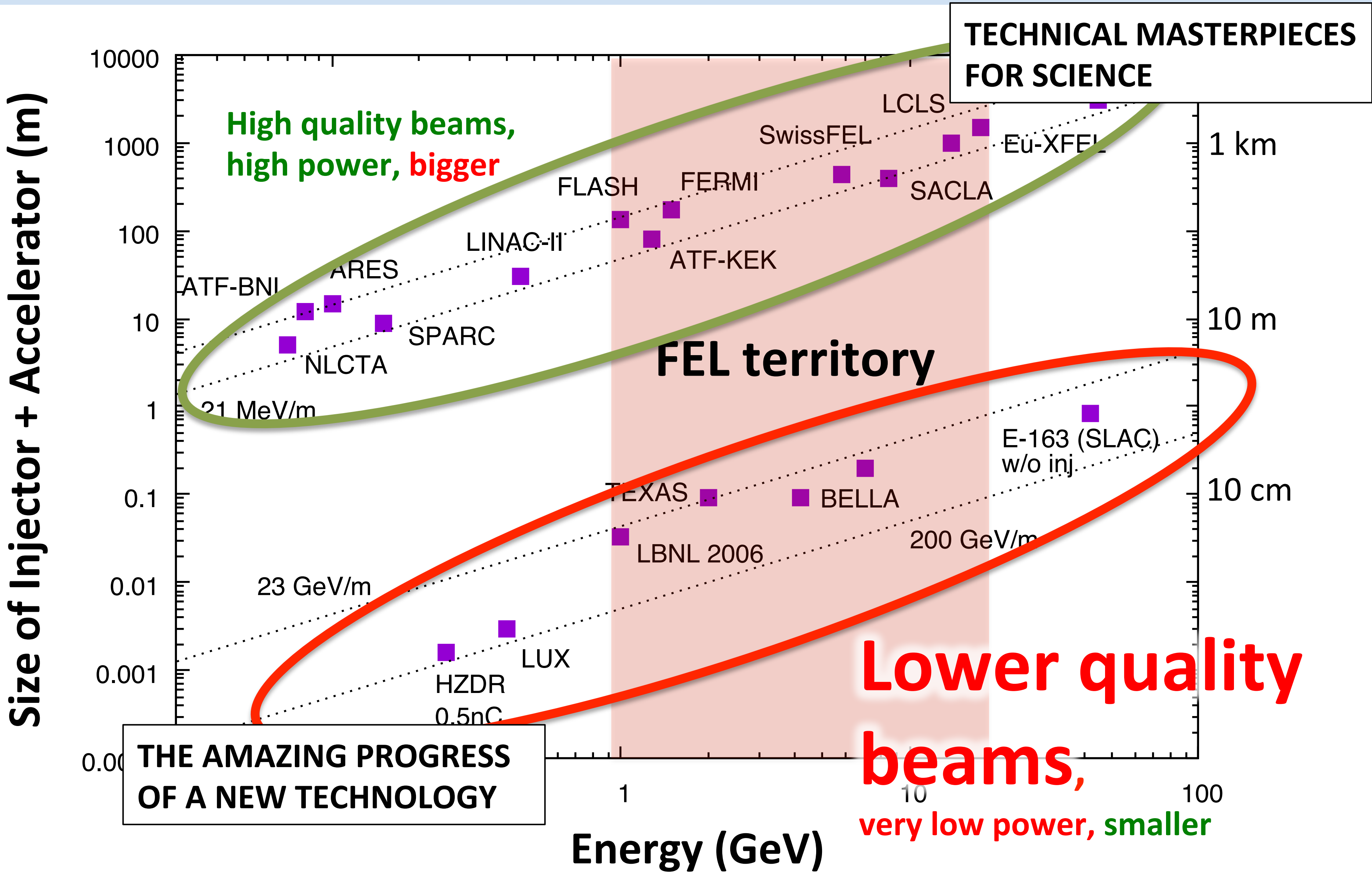
electron linear accelerators



Size versus Energy

electron linear accelerators

Horizon 2020



Addressing Quality

EuPRAXIA aims to **address the quality problem**. How (easy said – everybody wants to do this)?

1. Improve **technical components and approaches in plasma accelerator** concepts producing already GeV class beams:
   - Improved laser technology
   - Feedbacks
   - New and old concepts for solutions in one stage all plasma facility

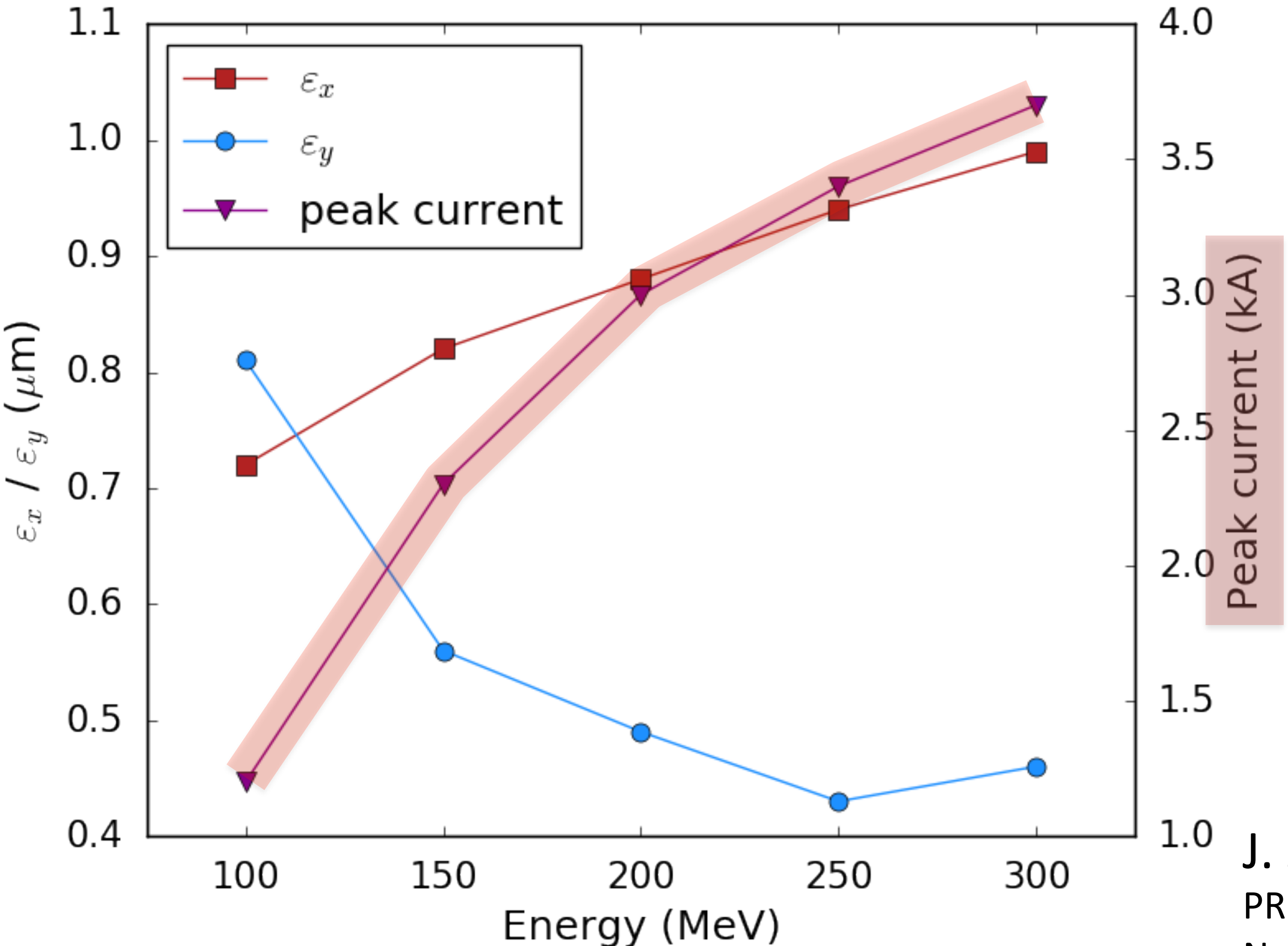
More resources will allow focused R&D

2. Start with a **high quality beam from a small RF injector** and boost it to high energy:
   - Starting point quality is assured (start with FEL quality beam)
   - Solve new issues, e.g. timing: new solutions needed
   - Fully stageable → path to high energy

Complementary approach will bring in RF excellence

FEL Class Beam from RF acc.

with required short bunch length



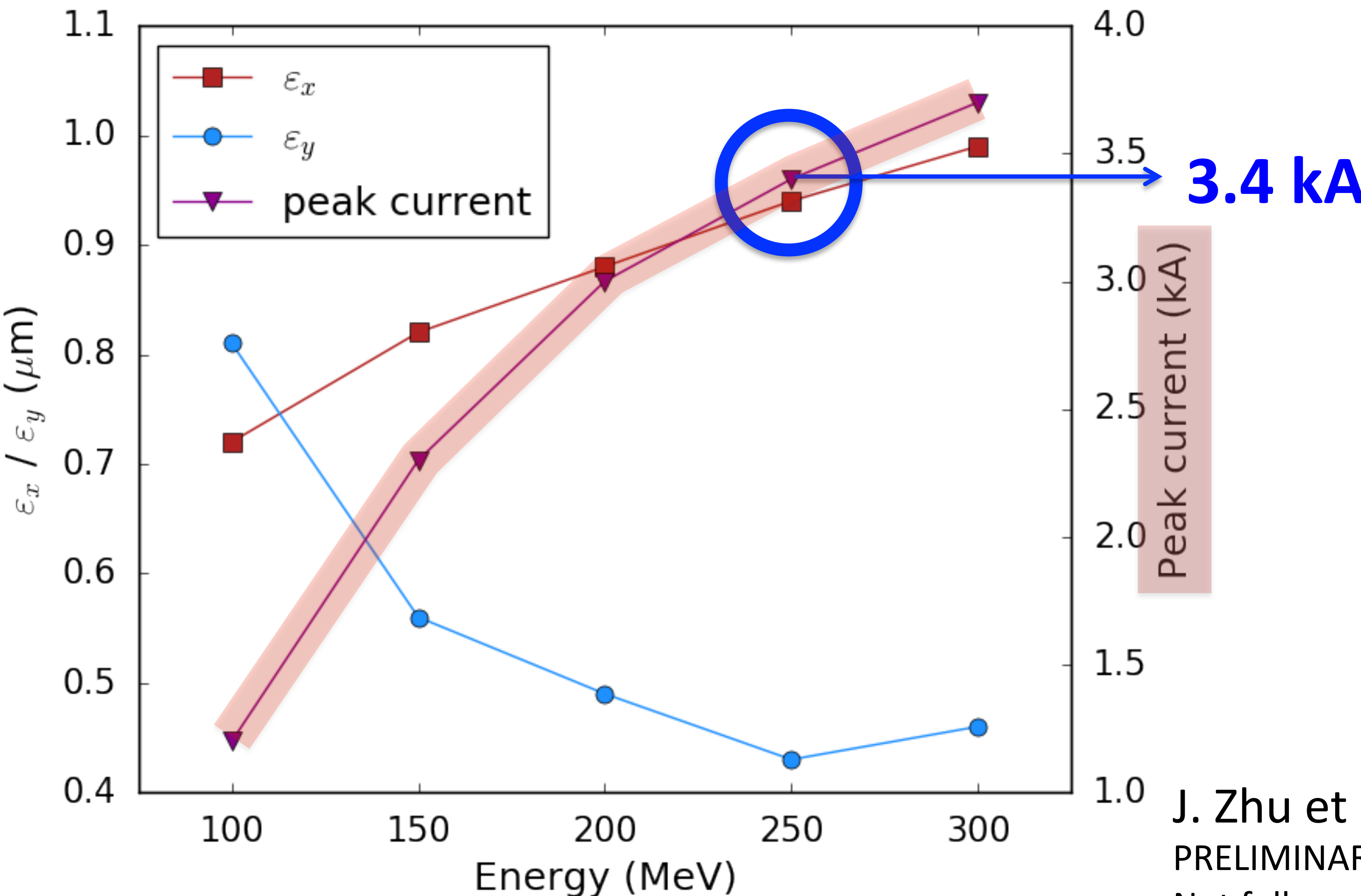
J. Zhu et al

PRELIMINARY

Not fully optimized

FEL Class Beam from RF acc.

with required short bunch length



J. Zhu et al

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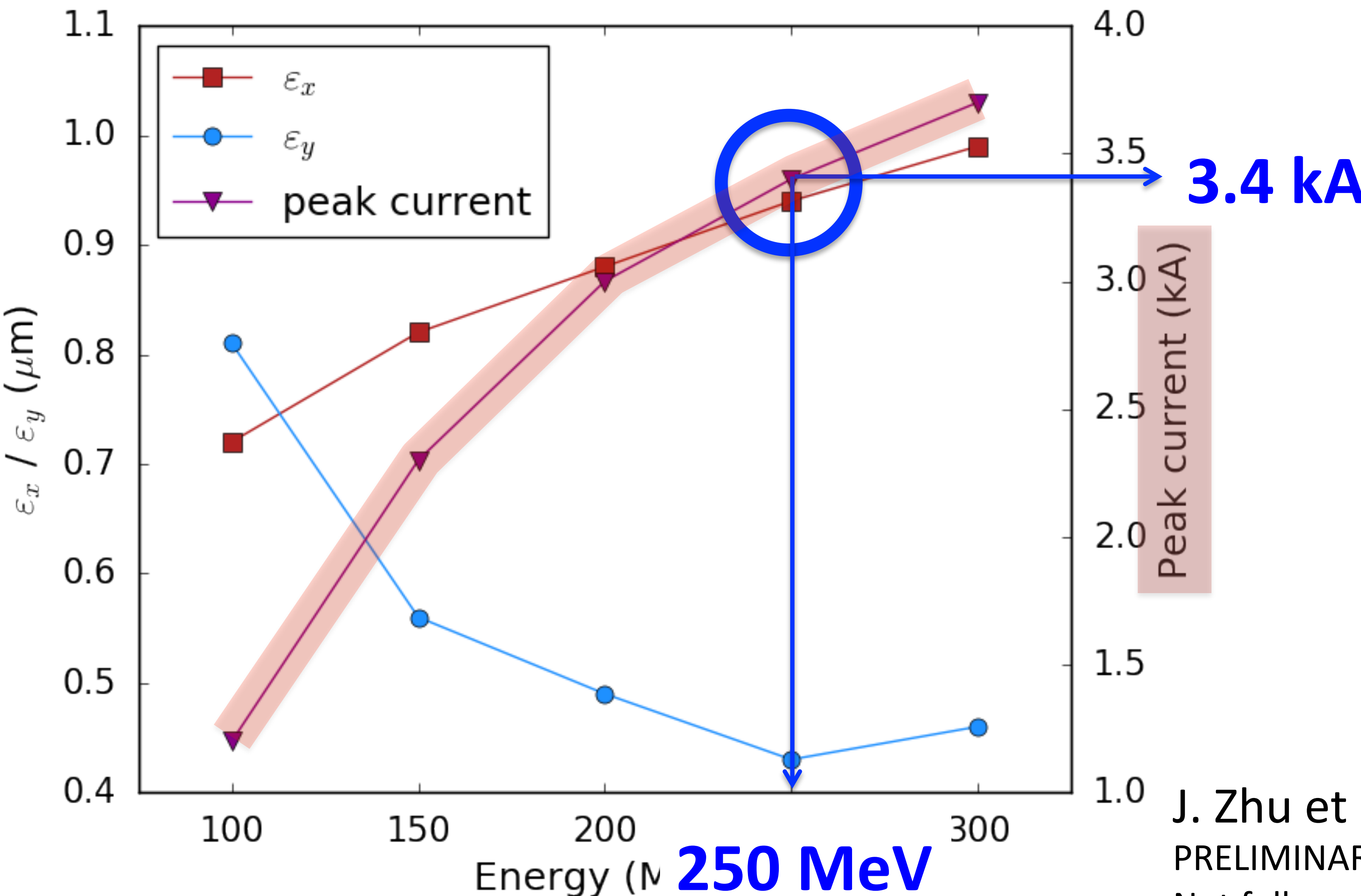


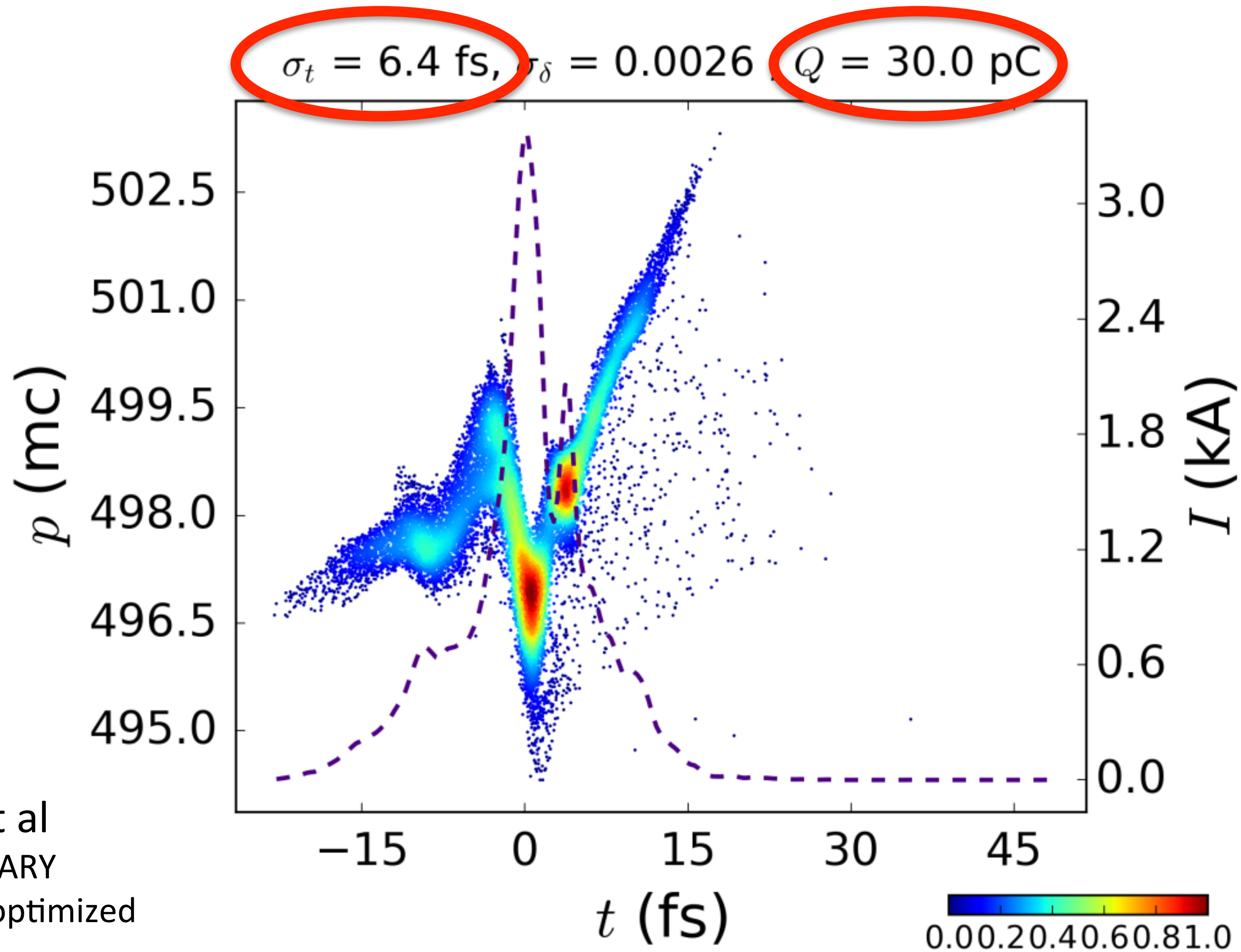
J. Zhu et al

PRELIMINARY

Not fully optimized

Short Bunch Length

bunch must fit into plasma wavelength



J. Zhu et al
PRELIMINARY
Not fully optimized

INFN PWFA Ansatz: 536 MeV → 1 GeV

See talk Massimo Ferrario and A. Mosnier

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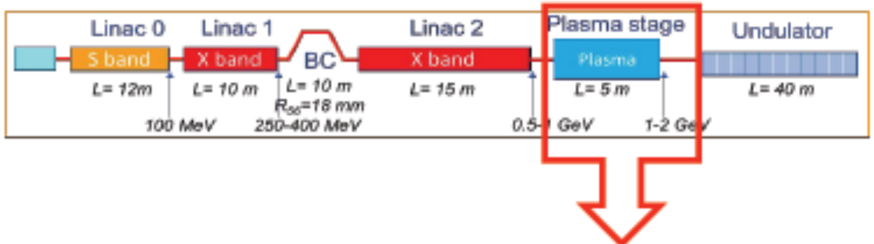


In the plasma capillary

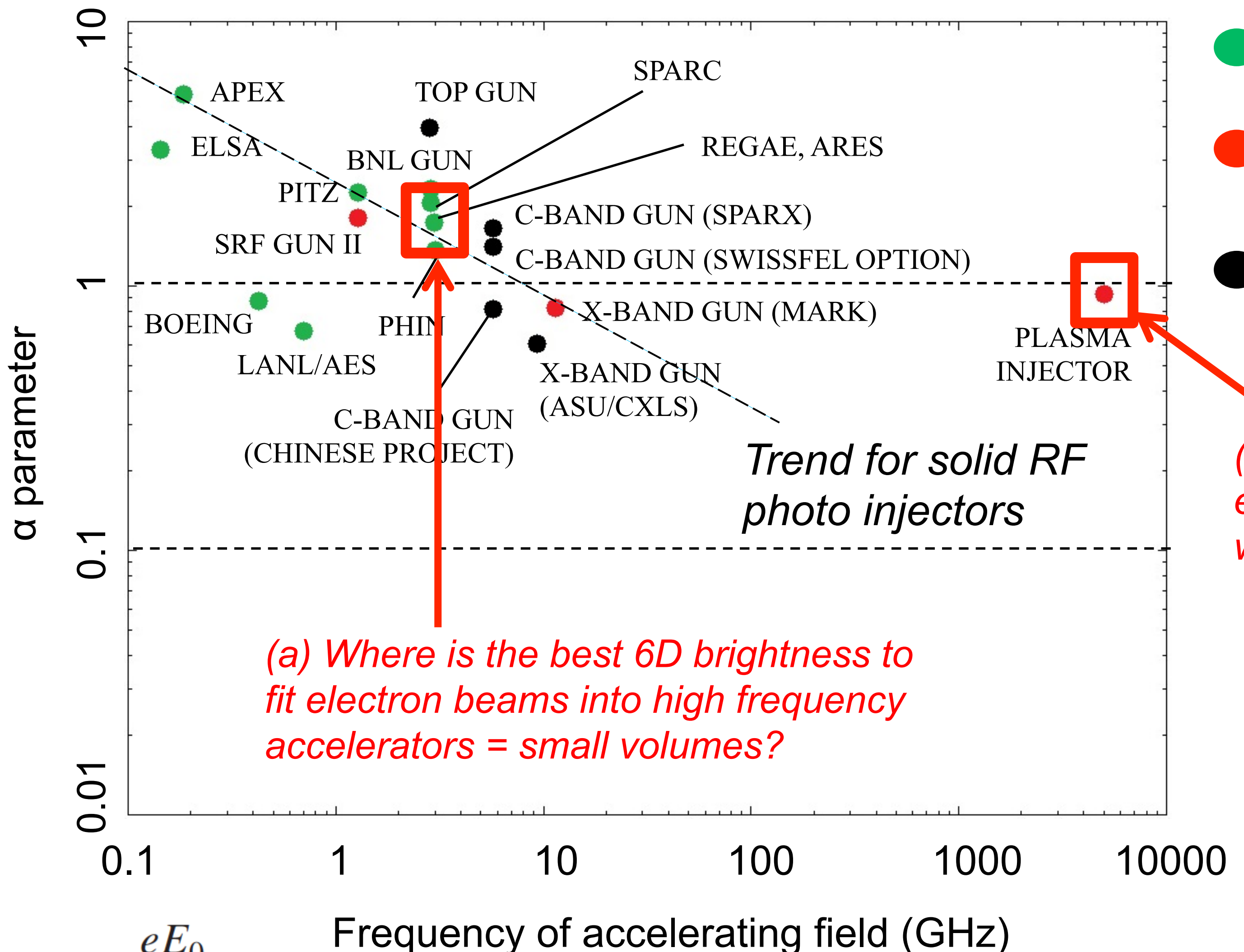
- Simulations with QFluid[1]
- Plasma density: 10^{17} cm^{-3}
- Plasma plateau length: 6 cm

Q-Fluid simulations of LWFA external injection

	Input	Output w/o ramp	Output with ramp
E [MeV]	536	1060	1035
ΔE/E	7 10^{-4}	1.2 10^{-2}	7 10^{-4}
$I_{peak\ FWHM}$ [kA]	1,8	1,8	1,8

	Input	Output w/o ramp	Output with ramp
E [MeV]	536	1060	1035
ΔE/E	7 10^{-4}	1.2 10^{-2}	7 10^{-4}
$I_{peak\ FWHM}$ [kA]	1,8	1,8	1,8
Q [pC]	30	27	27

Electron Gun



Routinely working

Under development

Under design

(b) Most compact electron generation with high alpha?

$$\alpha \geq 1$$

Required!? E.g. Rosenzweig et al, Flöttmann et al, ...

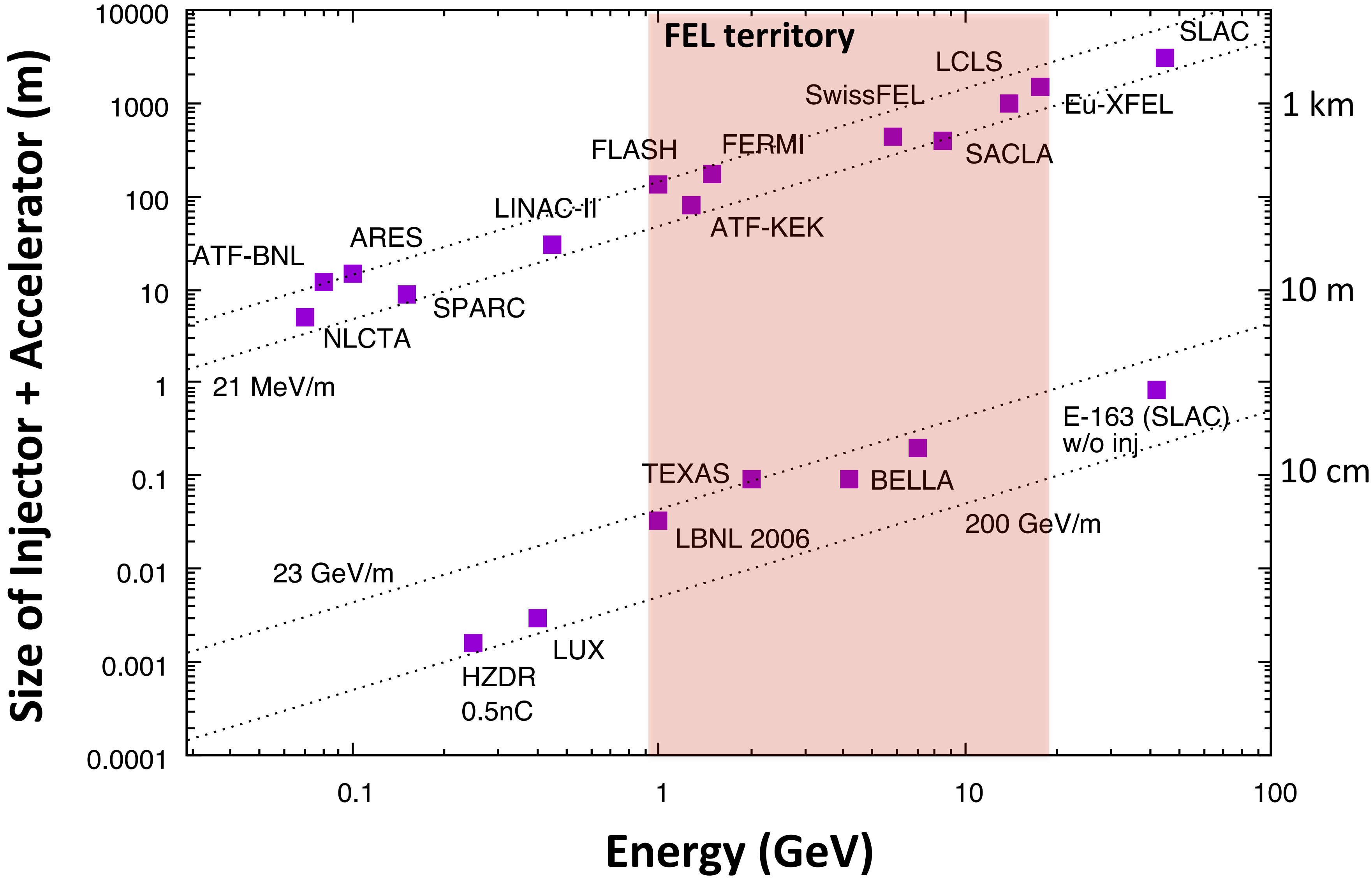
$$\alpha = \frac{eE_0}{2m_e c^2 k}$$

Analysis and graph: T. Vinatier, R. Assmann et al (July 2017)

EuPRAXIA Development Paths

towards high quality electron beams

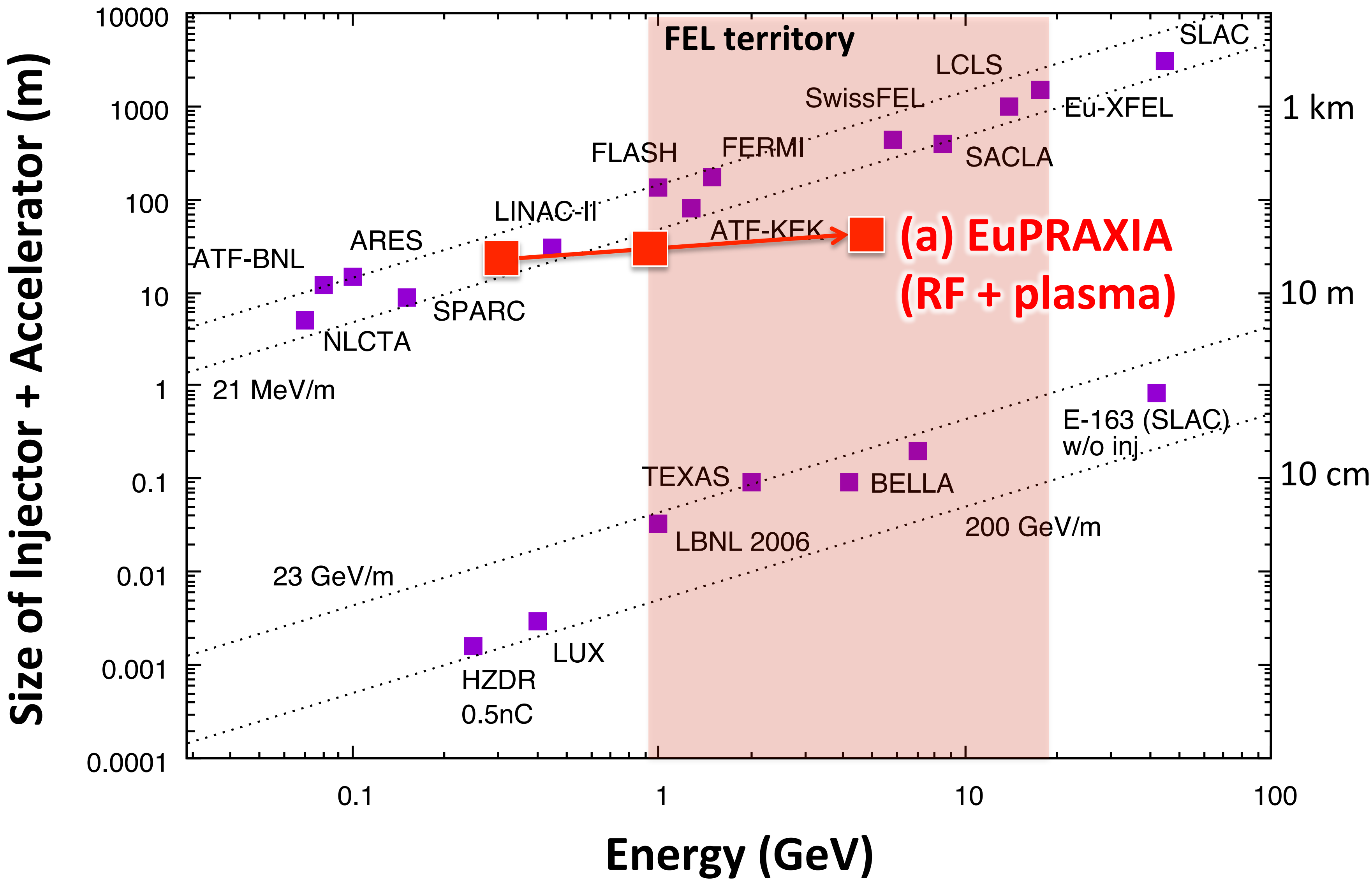
Horizon 2020



EuPRAXIA Development Paths

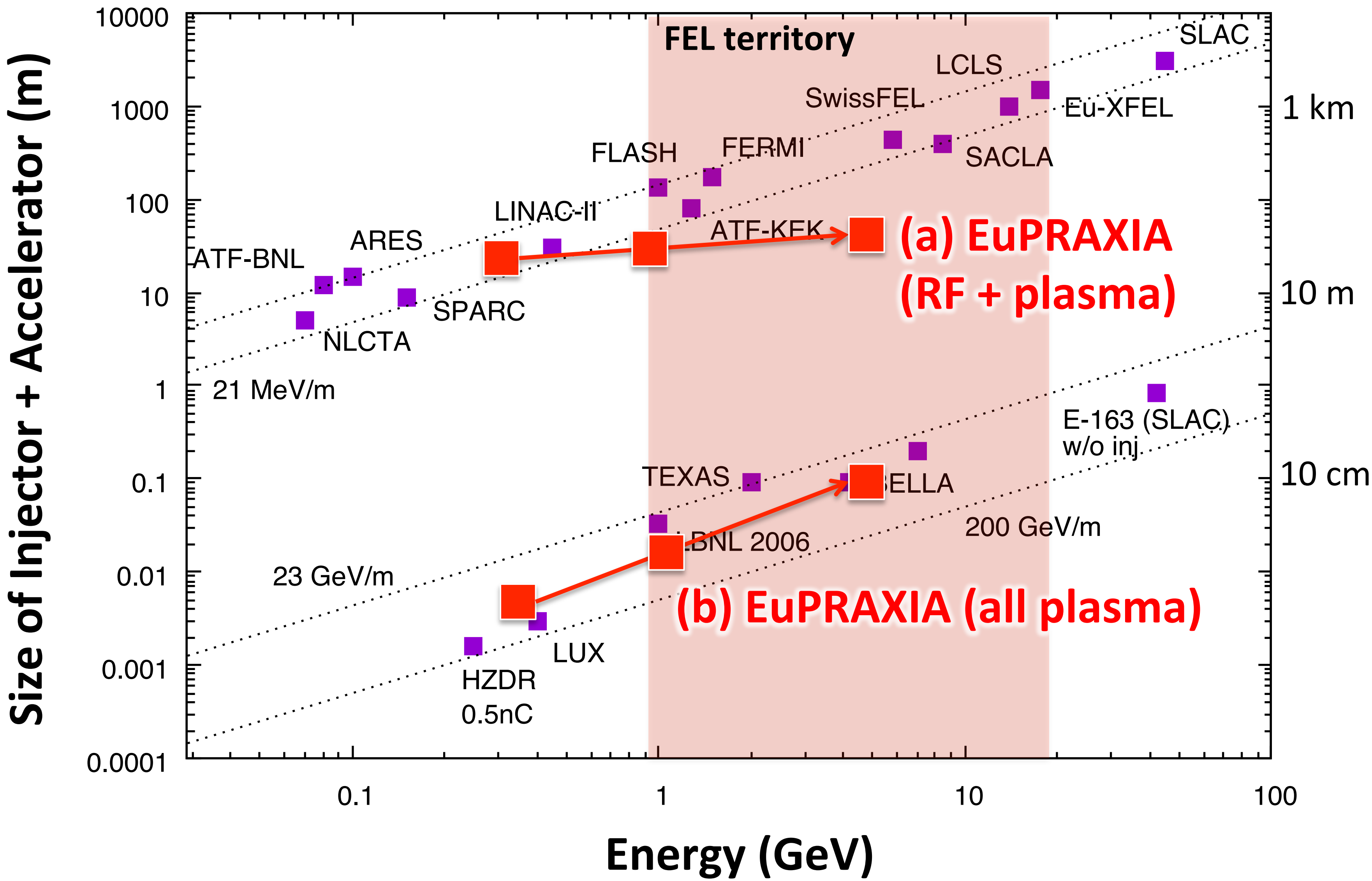
towards high quality electron beams

Horizon 2020



EuPRAXIA Development Paths

towards high quality electron beams



Old Solutions

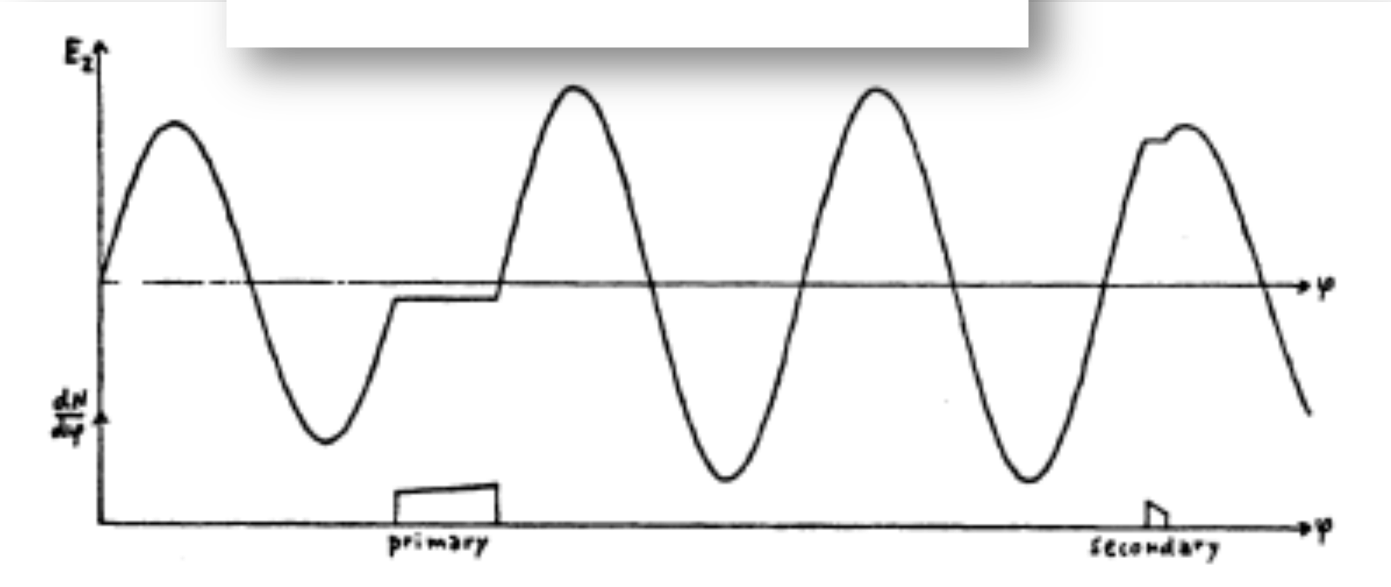
CERN/PS/85-65 (AA)
CLIC Note No. 3

1985 van der Meer

IMPROVING THE POWER EFFICIENCY OF THE PLASMA WAKEFIELD ACCELERATOR

S. van der Meer

Beam loading, energy spread and efficiency



External injection into a laser-driven plasma accelerator with sub-femtosecond timing jitter

A Ferran Pousa[1,2], R Assmann[1], R Brinkmann[1] and A Martinez de la Ossa[1,2]

[1] DESY, 22607 Hamburg, Germany
[2] Universität Hamburg, 22761 Hamburg, Germany

E-mail: angel.ferran.pousa@desy.de

External injection: timing

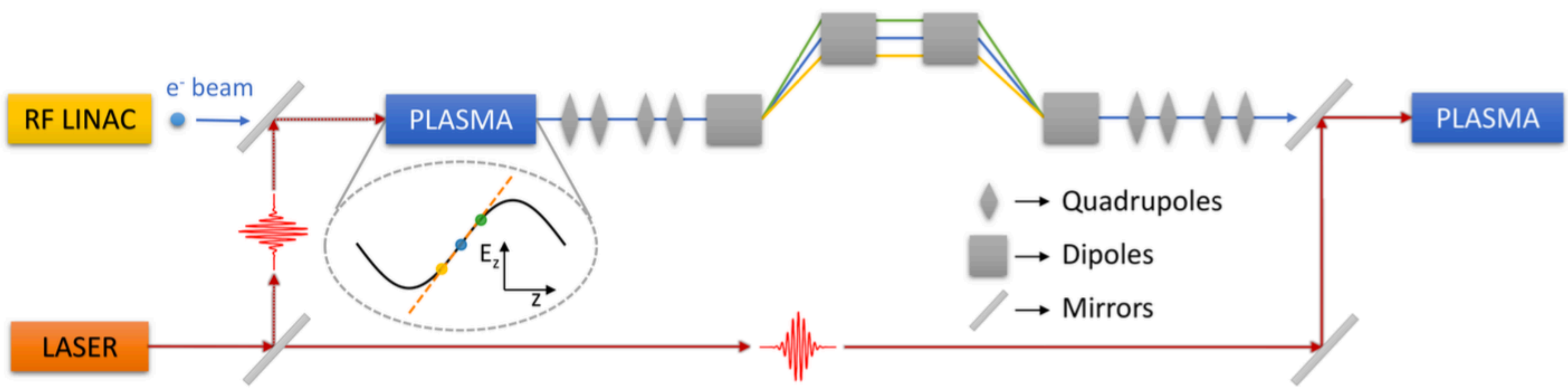


Figure 1. Schematic view of the synchronizing stage.

New Solutions

Horizon 2020

PRL 118, 214801 (2017) PHYSICAL REVIEW LETTERS week ending 26 MAY 2017

Chirp Mitigation of Plasma-Accelerated Beams by a Modulated Plasma Density

R. Brinkmann,[1] N. Delbos,[2] I. Dornmair,[2] M. Kirchen,[2] R. Assmann,[1] C. Behrens,[1] K. Floettmann,[1] J. Grebenyuk,[1] M. Gross,[3] S. Jalas,[2] T. Mehrling,[1] A. Martinez de la Ossa,[4] J. Osterhoff,[1] B. Schmidt,[1] V. Wacker,[1] and A. R. Maier[2,*]

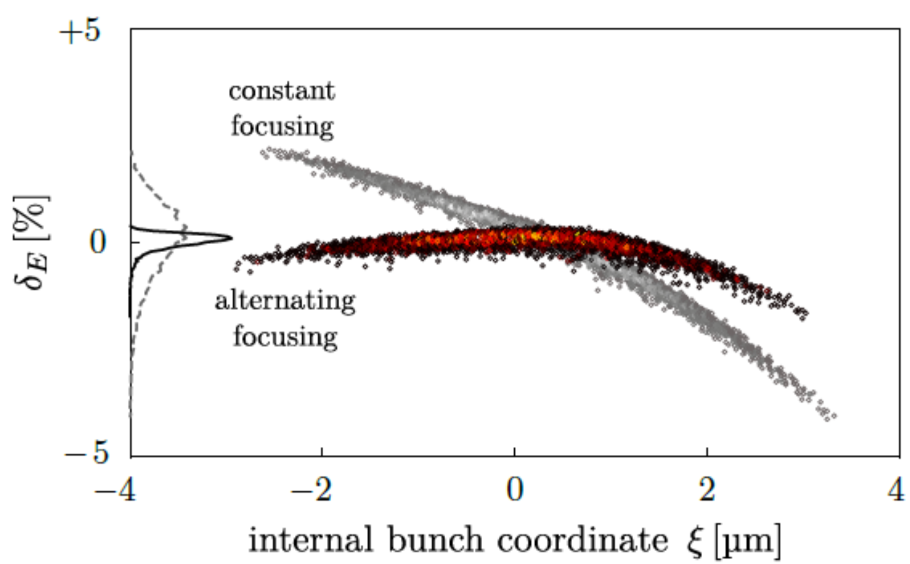
[1]*Deutsches Elektronen-Synchrotron DESY, Notkestrasse 85, 22607 Hamburg, Germany*

[2]*Center for Free-Electron Laser Science and Department of Physics, University of Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany*

[3]... *nenallee 6, 15738 Zeuthen, Germany*

... *mburg, 22761 Hamburg, Germany*

... lished 23 May 2017)



Energy spread, focusing and defocusing stabilization

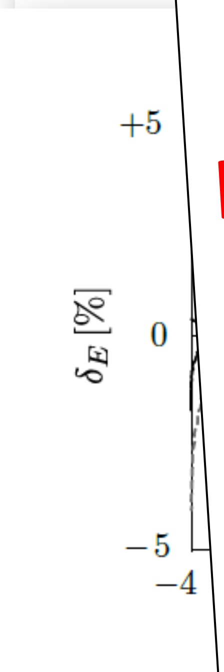
New Solutions

Horizon 2020

PRL 118, 214801 (2017) week ending 26 MAY 2017

ity

R. Br ... ebenyuk,[1]
M. Gr ... R. Maier[2,*]



... and many more good ideas and concepts in- and outside of EuPRAXIA

See talk A. Mosnier and talks from EAAC participants:

kHz beams, long guiding, plasma lenses, high charge, improved quality, hybrid nano-emittance guns, application development, undulator radiation, novel undulators, theory advances, better and faster simulations, ...

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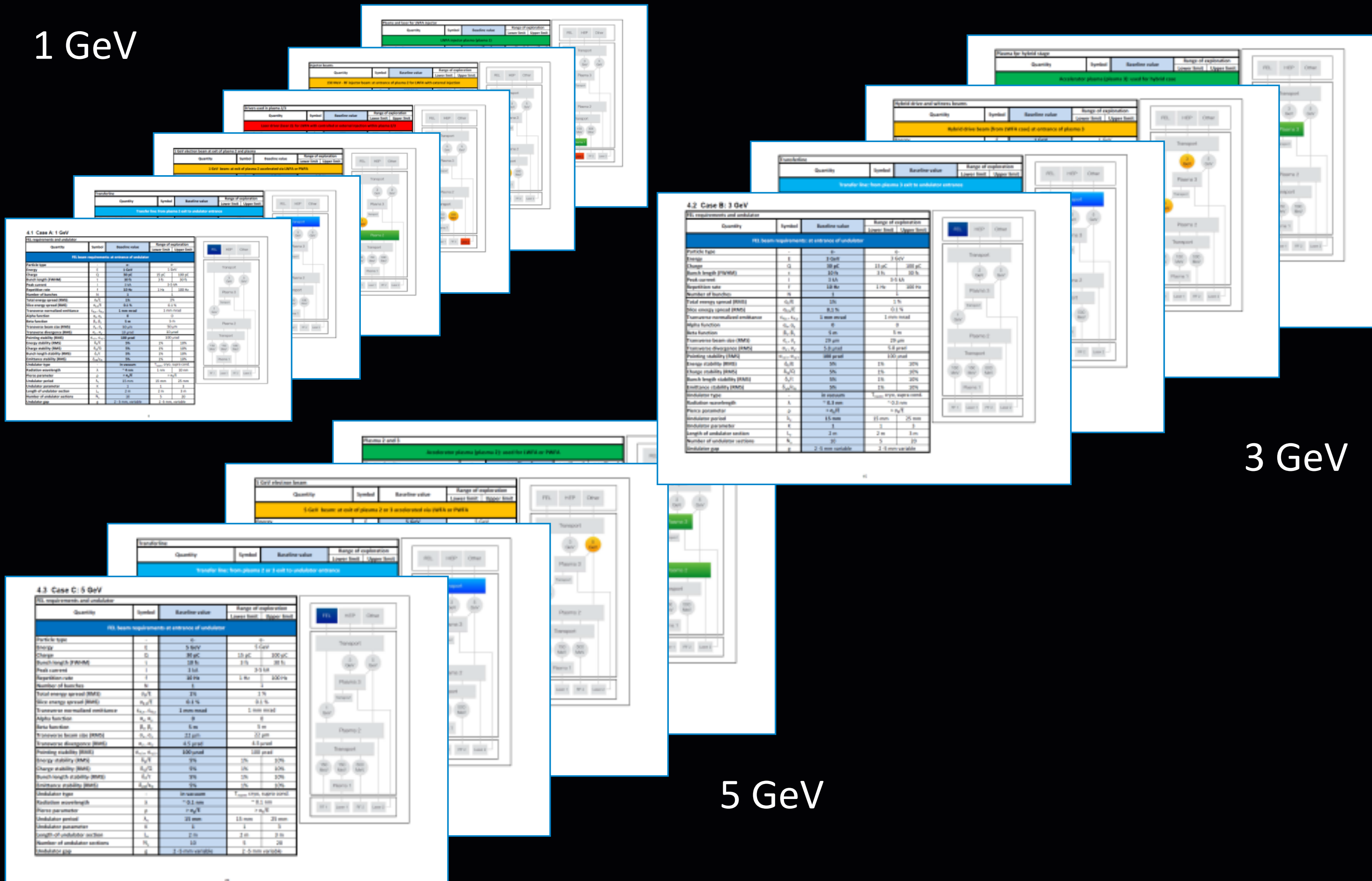
EuPRAXIA

Parameter Tables
Study Version 2016

Horizon 2020



Configuration B: Plasma & Beam Movie

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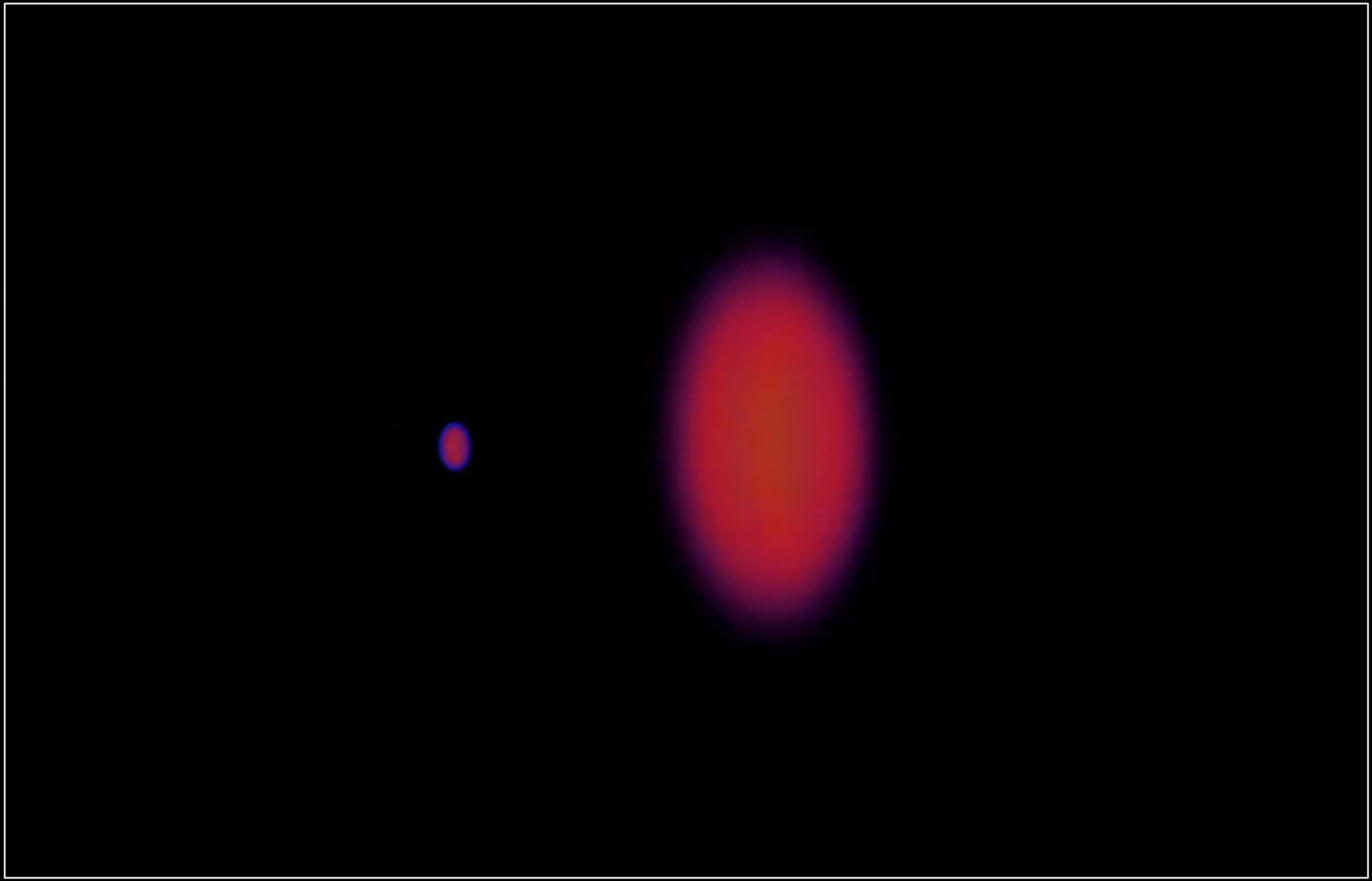
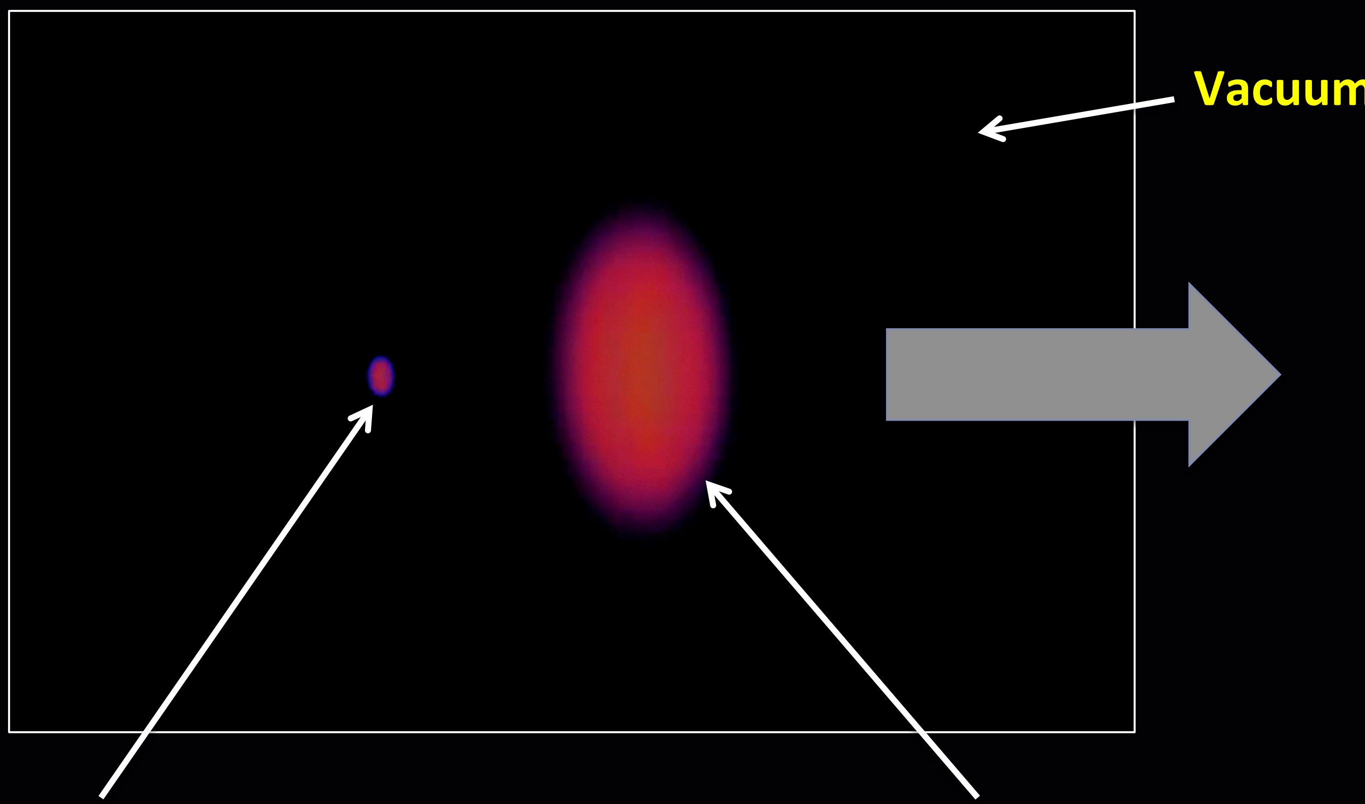
A. Ferran Pousa et al: "**Visualpic** Data Visualizer and Post-Processor for PIC Codes"



Á. Ferran Pousa, A. Aschikhin, R. Assmann ,A. Martinez de la Ossa. IPAC17 paper TUPIK007.

Configuration B: Simulation I

From
A. Ferran-Pousa



Electron pulse:
Gaussian beam, 1 pC, 100 MeV, relative energy spread = 0.1%, 3.3 fs length (rms), 1.26 micron transv. size (rms),norm. emittance 0.99 mm mrad

Laser pulse:
a_0 = 3.1, λ = 800 nm, 100 fs (FWHM in intensity), w_0 = 54 μm, 100 J energy, 1 PW peak power, laser and plasma parameters adjusted for self guiding.

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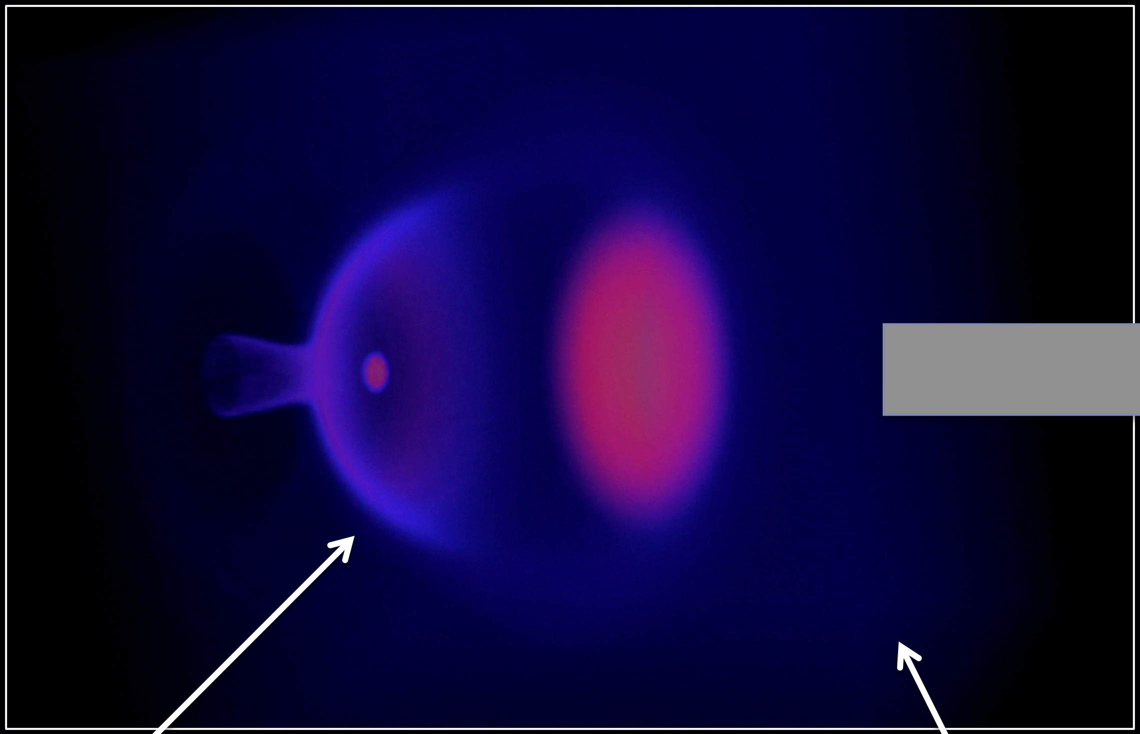
Configuration B: Simulation II

From
A. Ferran-Pousa

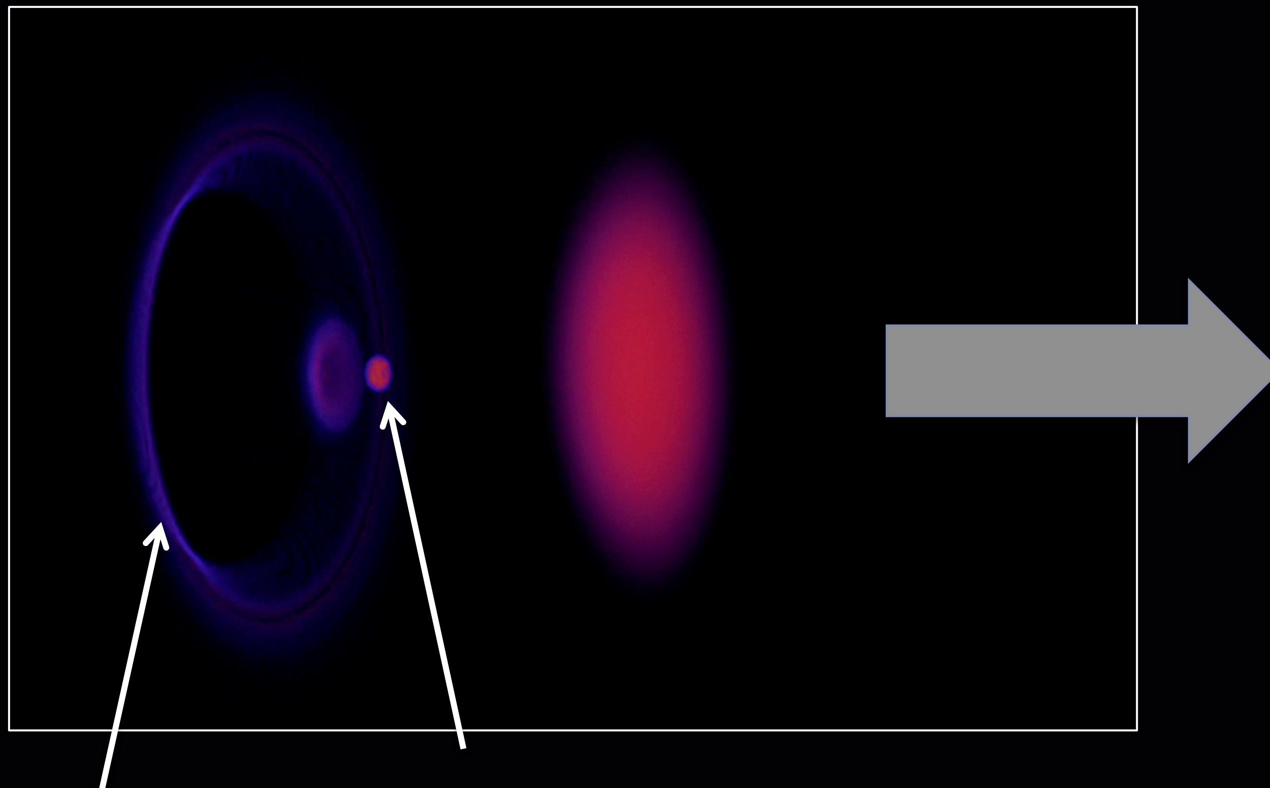


The acceleration regime:
close to blowout. 2D simulation: the 3D animation was made assuming cylindrical symmetry and reconstructing a 3D field.

Plasma:
Density = 1.2 x 10^{17} cm^{-3}
Length = 2.5 cm

Configuration B: Simulation III

From
A. Ferran-Pousa



Just after exiting plasma:
Back in vacuum.

Electron beam:
Energy = 1 GeV
Relative energy spread = 1.5%
Normalized emittance = 0.995 mm mrad

Overall layout status (ongoing)

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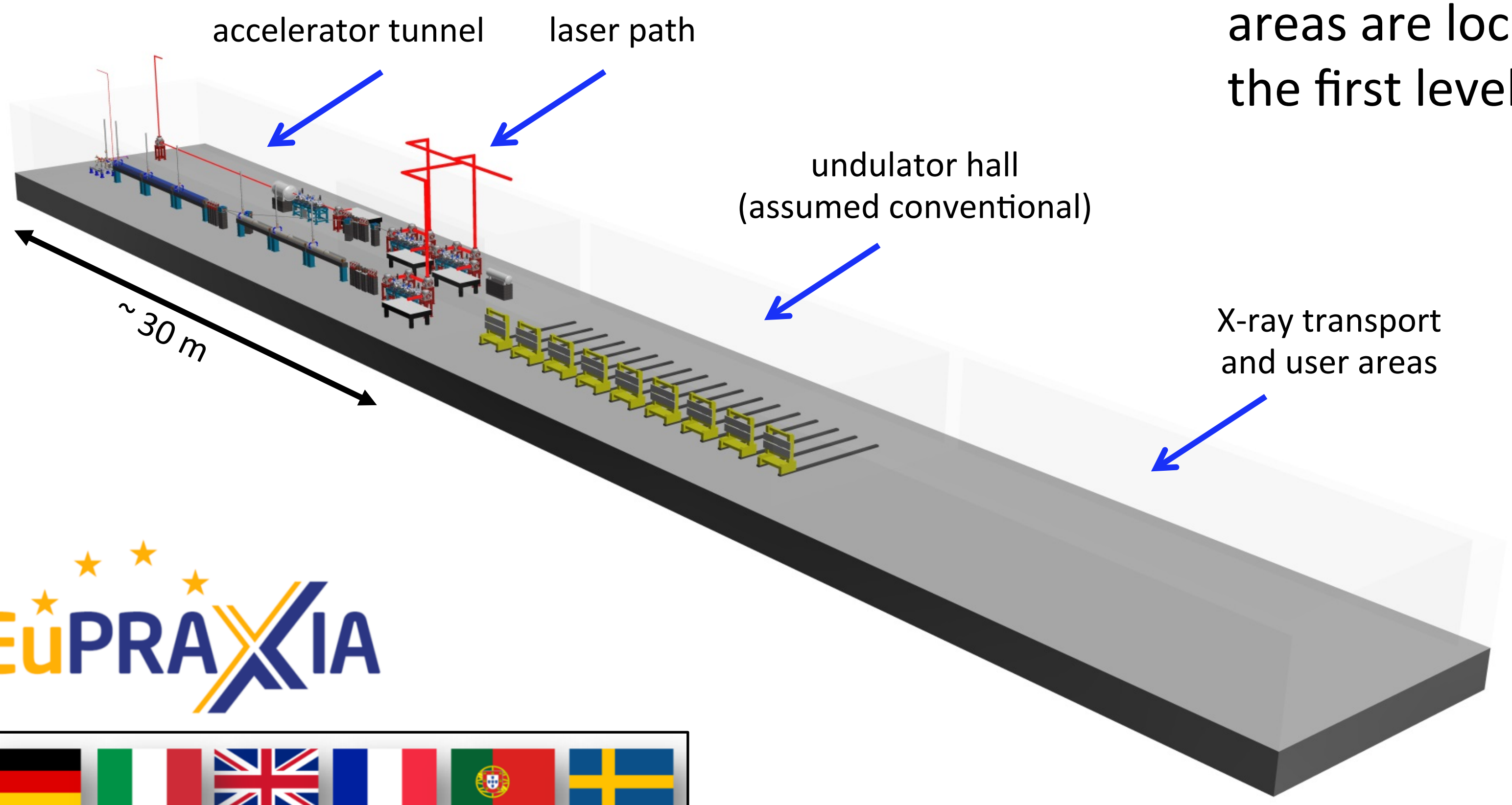
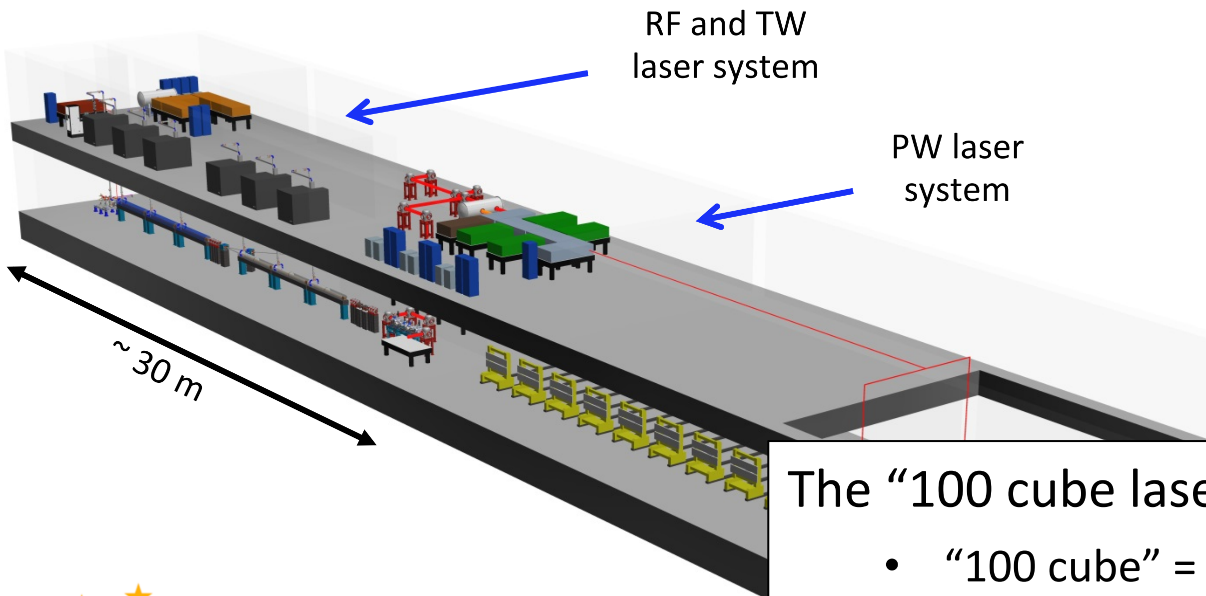
Accelerator research, undulators and user areas are located on the first level



Design by A. Walker (DESY) and Dariusz Kocoń (ELI-Beams)

… with 1st floor for laser infrastructure

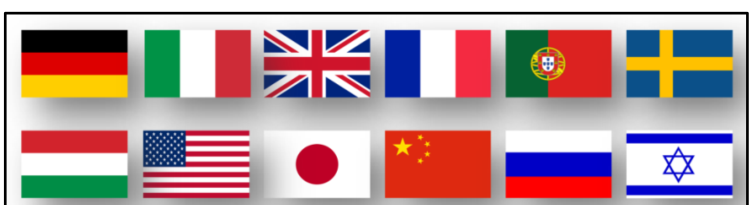
RF and laser infrastructure on second level



The "100 cube laser challenge":

- "100 cube" = 100 J, 100 fs, 100 Hz
  => 1PW @ 100Hz
- Not a complete Ti:Sa laser system
- Diode-pumped solid-state laser scheme
- 2nd laser system (Ti:Sa) operates at lower energy and shorter pulse length

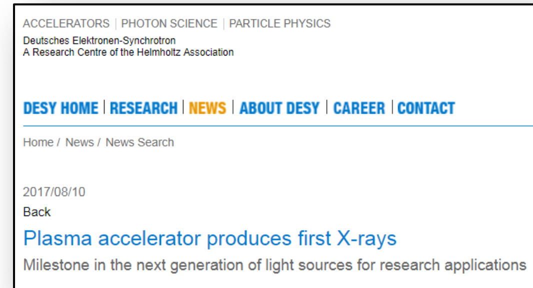
EuPRAXIA



Ongoing experiments and site study

Demo-FEL projects ongoing:

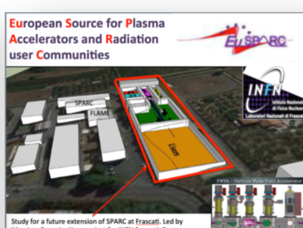
- X-ray produced after undulator in August 2017 at DESY by LUX group (A.R.Maier et al.)
- Beamtime in Paris planned for November 2017 by COXINELLE (M.E. Couprie & V. Malka et al.)



DESY news (10th August 2017)

EuPRAXIA site studies:

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



Possible footprint for 5 GeV FEL

Design by A. Walker and Dariusz Kocoń (ELI-Beams). Photo credit: google.

Possible footprint for EuPRAXIA

Design by A. Walker and Dariusz Kocoń (ELI-Beams). Photo credit: google.

Political Landscape: Helmholtz Association in Germany

Horizon2020

HELMHOLTZ GEMEINSCHAFT

Stand: 26. September 2016

AGENDA des Präsidenten der Helmholtz-Gemeinschaft

Zu den inhaltlichen Herausforderungen zählen aus heutiger Sicht:

From today's perspective the following challenges are identified

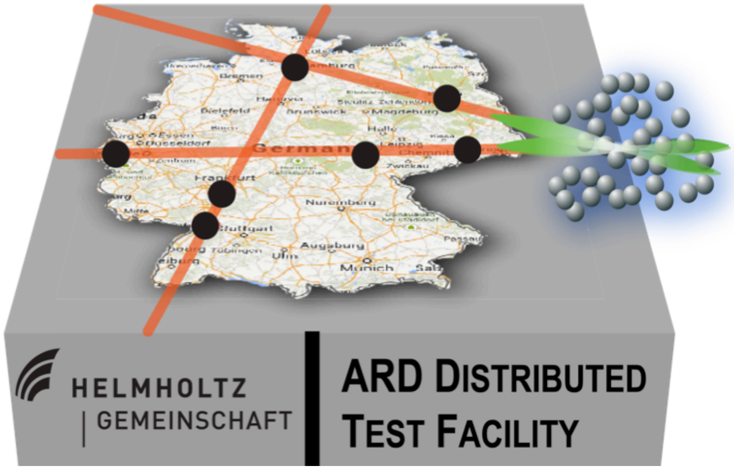
- Energiesysteme der Zukunft — ***energy systems***
- Information und Data Science — ***information and data science***
- Integrierte Erforschung des Erdsystems — ***research earth system***
- Neuartige Materialien und Wirkstoffe — ***new materials and agents***
- Entwicklung neuer Mobilitätskonzepte — ***new mobility concepts***
- Psychische Erkrankungen und Translation für eine individualisierte Medizin — ***psych. disease indiv. medicine***
- Neue Generationen von kompakten Beschleunigersystemen. — ***New generations of compact accelerators.***

In den nächsten Jahren werden wir diese und andere Themen auf vielfältige Weise unterstützen.

In the next years we will support these and other themes in multiple ways.

ATHENA:

Development of ultra-compact* accelerators and radiation facilities for science and medicine



and highly cost-efficient

ATHENA shall allow the Helmholtz centers to keep and expand their world-wide leading competence in designing and building cutting-edge accelerators with a multitude of applications in science, technology, medicine and industry.

<u>ATHENA = Acc. Technology HElmholtz iNfrAstructure</u>


Details on included facilities see presentations on the Helmholtz ARD web site or contact PI's!
SINBAD Short INnovative Bunches & Accelerators at DESY
ARD Spitzenforschung im alten DORIS Komplex
durch optimale Nutzung der Infrastruktur
Kompakte Atto-Sekunden Lichtquelle
50 as, ICS
ERC Synergy Grant, DESY, Uni HH, Arizona
Ultrakurzer Elektronenpuls
< 1 fs mit konventioneller Technologie
ARD, DESY, Uni HH, KIT
Nutzbarkeitsstudien Plasma-beschleuniger, Skalierbarkeit
> 1 GeV/m, nutzbare Strahlqualität, FEL?
LAOLA, ARD, DESY, Uni HH
Raum für weitere Phasen und Nutzer
Drittmittel
Interessensbekundung ELI
PIER
Coordinating PI
bERLinPro centre for high power cw beams in sc accelerators
bERLinPro = Berlin Energy Recovery Linac Project
100 mA / low emittance technology demonstrator
bERLinPro
Helmholtz-Zentrum Berlin
beam dump
6.5 MeV, 100 mA = 650 kW
linac module
44 MeV
booster
4.5 MeV
srf-gun
1.5-2 MeV
merger
dogleg
50MeV, 100mA, 2ps (5 MW of virtual beam power)
50MeV, 10mA, <100fs (500kw of virtual beam power)
both modes normalized emittance < 1mm mrad
JÜLICH
Jülich Short-Pulse Particle and Radiation Centre
Particle physics
Synchrotron radiation
JuSPARC
Material research
Markus Büscher
ELBE center for high power radiation sources
Dual beam Petawatt / 150 TW ultrashort pulse laser facility
Diode pumped Petawatt laser development
Synchronized operation with ELBE accelerator
Dedicated shielded target areas (~1000m² laser lab space)
Beam driven sources (THz, FEL, ...) at ELBE
ELBE
150TW
Draco PW
HZDR
The LIGHT test-stand at GSI: coupling of laser-accelerated ions into conventional accelerators
Principle: manipulation of laser-accelerated ions
HI Jena
GSI
HZDR
ion source (TNSA)
solenoid/ quadrupols
spiral resonator
1. Laser-driven ion acceleration
2. beam conditioning (collimation)
3. drift line and phase-space rotation
Current results:
proton spectrum
proton beam
FLUTE: ARD-Forschung am KIT
KIT
Ultrakurze Elektronenpulse (1 fs bis 300 fs)
Grosser Bereich an Ladungen (1 pC bis 3 nC)
Kohärente Strahlung für Materialwissenschaften und biologische Anwendungen
Entwicklung/Tests von Kurzpuls-Strahldiagnose und Instrumentierung
Kooperation KIT, PSI, DESY
Ferninfrarot Linac-
FLUTE
FLUTE, a Linac-Based THz Source at KIT
Helmholtz-Institute Jena
relative z-position (µm)
Development and application of novel plasma diagnostics:
few-fs and 1-µm resolution,
first direct visualization of the laser-driven plasma wave in a laser-electron accelerator.
M. Schwab et al., Applied Phys. Lett (2013)
A. Sävert et al., submitted (2013)
Germany
Hamburg
Berlin
Dresden
Frankfurt
Stuttgart
Munich

HELMHOLTZ GEMEINSCHAFT

ATHENA

Project

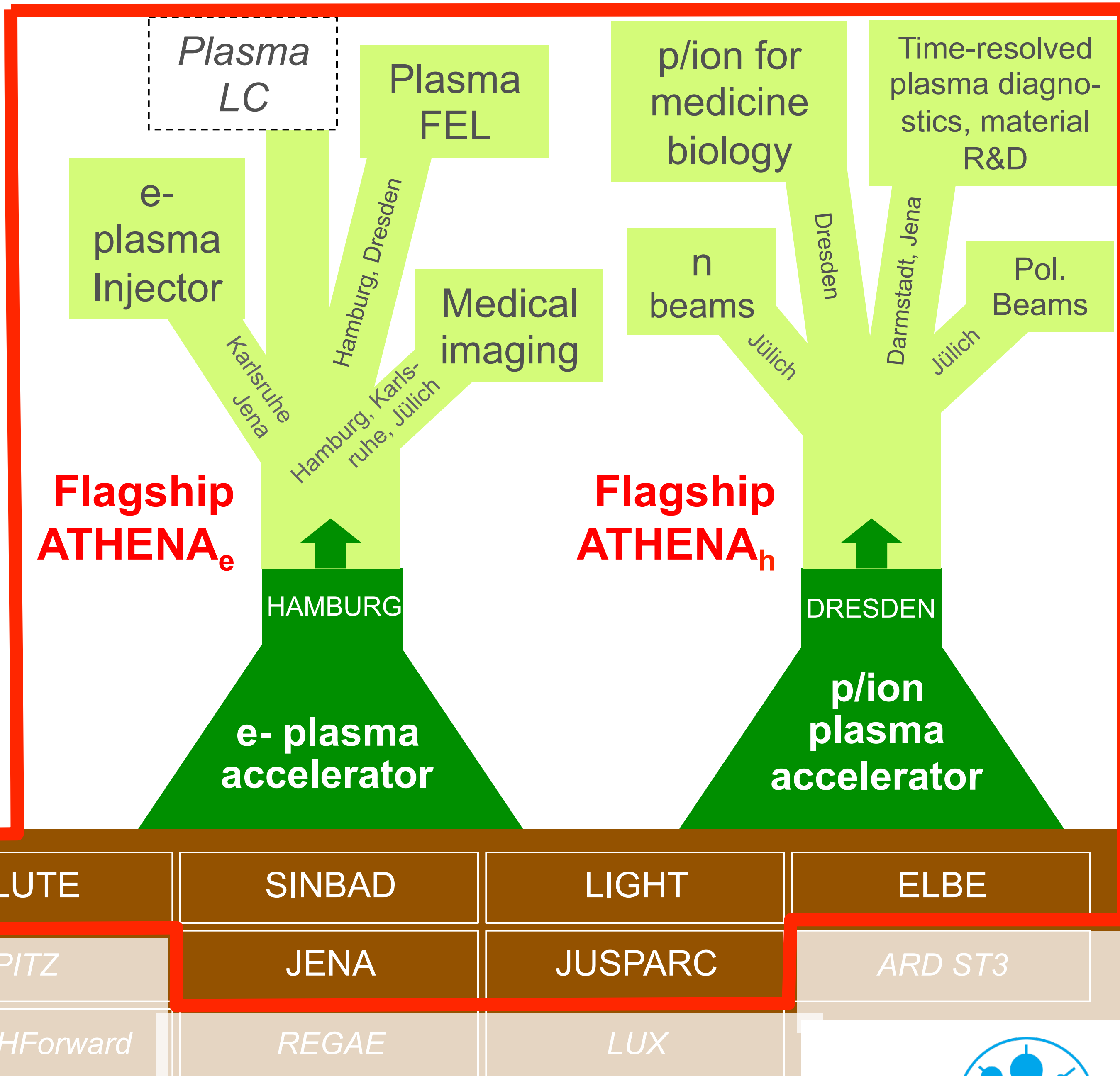
2018 – 2021, 30 M€

6 centers + 1 institute

Using infrastructures together

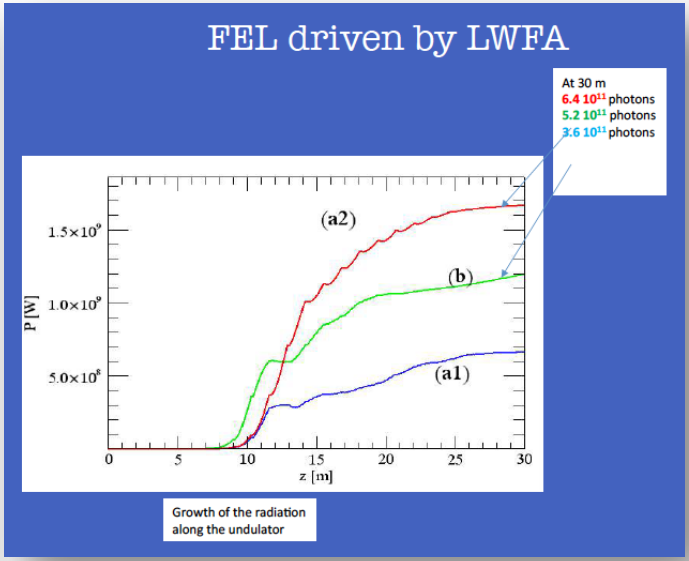
2 future technologies for the Helmholtz strategy

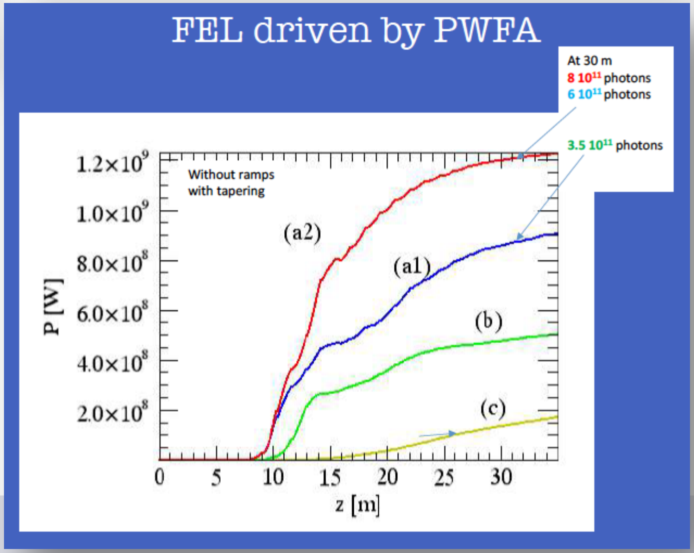
High relevance for applications in many centers.



JÜLICH FORSCHUNGSZENTRUM · GSI · KIT Karlsruhe Institute of Technology · HZB Helmholtz Zentrum Berlin · HZDR · HI Jena Helmholtz Institute Jena · DESY

Political Landscape: INFN Frascati in Italy





First start-to-end simulations plasma FEL

INFN strongly advancing scientific and political efforts towards an RF/plasma facility at Frascati that can host EuPRAXIA

Political Landscape: European Initiatives

Horizon2020

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LEAPS: devising a new era of accelerator-based photon science in Europe

By Carolin Hahn. Published on 22 May 2017 in:
May 2017, News, Europe, League of European Accelerator-based Light Sources, LEAPS, Light source, Particle Accelerator

The Directors of the European Synchrotron and FEL user facilities have decided to establish a strategic partnership – the League of European Accelerator based-Photon Sources (LEAPS)– which aims for an unprecedented level of cooperation and development and outreach to academic and industrial users as well as to the general public.

So far, 16 facilities have joined this initiative which is strongly encouraged by policy makers such as Robert-Jan Smits, the Director-General for Research and Innovation of the European Commission, who met with LEAPS representatives in Brussels on April 26, 2017.

LEAPS at Diamond Light Source in November 2016

The primary goal of LEAPS is to ensure the quality and impact of fundamental, applied and industrial research carried out at their facilities. The Partnership deploys its substantial collective knowledge, experience and expertise in Synchrotron and FEL science and technology, Research Infrastructure management, and service to scientific users to the greater benefit of European science and society. It also aims to play an integrating role for countries with less developed communities and infrastructure for research and innovation, in Europe and beyond.

Partners (PTB just joined and is still missing here)

The Partnership is currently preparing a roadmap document outlining the future of accelerator-based photon science in Europe, which will be handed over to DG research and innovation at the big international LEAPS roll-out meeting in November 2017.

LEAPS is aiming to get substantial funding from the EU in the 9th framework program based on its track record of more than three decades of accelerator based light sources and a community exceeding 30,000 users across Europe.

LEAPS is supported by ALBA, DESY, Diamond Light Source, Elettra, ESRF, European XFEL, FELIX, HZB, HZDR, INFN, ISA, MAX IV, PSI,SOLARIS, SOLEIL, and most recently PTB, and is collaborating with the European Synchrotron User Organization ESUO.

Find more information at www.leaps-initiative.eu

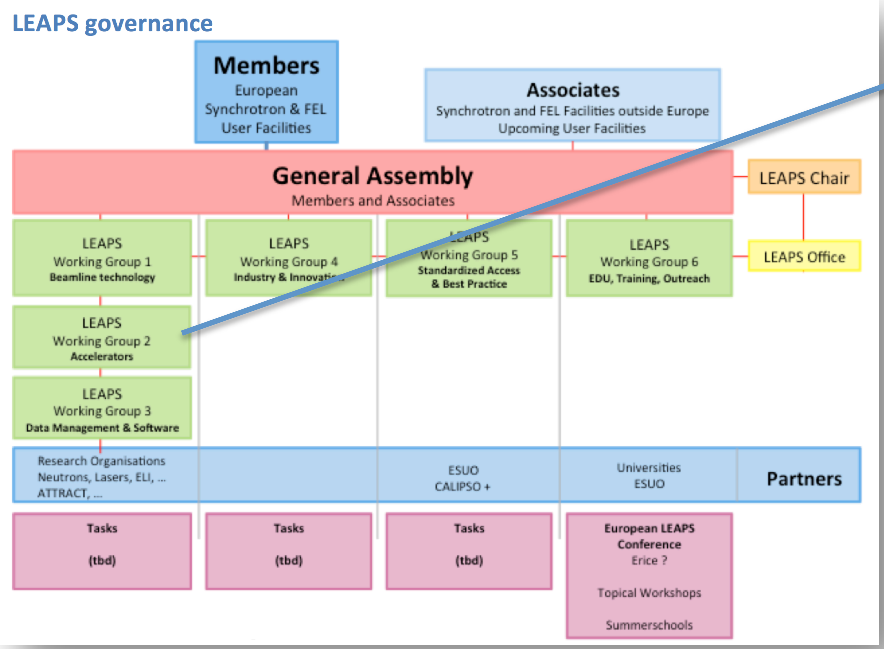
http://www.epsnews.eu/2017/05/leaps-devising-a-new-era-of-accelerator-based-photon-science-in-europe/

LEAPS: devising a new era of accelerator-based photon science in Europe

The Directors of the European Synchrotron and FEL user facilities have decided to establish a strategic partnership – the **League of European Accelerator based-Photon Sources** (LEAPS)– which aims for an unprecedented level of cooperation and development and outreach to academic and industrial users as well as to the general public.

Political Landscape: European Initiatives

Horizon2020



Brussels event: Nov 13, 2017

The accelerator WG2 is coordinated by **Hans Braun** (PSI).

Three topics have been defined with topic leaders:

1. **FEL developments**
   Thomas Tschentscher and Simone Di Mitri
2. **Storage rings**
   Andreas Jankowiak
3. **Future compact sources**
   Ralph Assmann

We hope for significant funding for accelerator R&D from the EU for LEAPS as the representative body of photon science in Europe.

Conclusion

- EuPRAXIA is a EU **design study for a novel European accelerator-based research facility** with applications in science, industry & medicine.
- Strongly linked major research centers and to leading European industry.
- Goal is to provide by Oct 2019 a design report for a **5 GeV electron beam facility** based on laser and/or beam driven **plasma acceleration**, which shall be compact and cost efficient.
- Design will include pilot user areas for **FEL radiation**, "table-top" **test beam for HEP detectors tests**, **compact X-ray source** for medical imaging, and other applications.
- New ideas and innovations make us more and more confident that **problems can be solved on the technical side**.
- Investment required to implement solutions. Very hopeful **progress in political landscape**: ATHENA, EuPRAXIA@SPARC, LEAPS, ...
- *This is a Horizon 2020 project and we acknowledge the support from the EU under grant agreement No. 653782.*

EuPRAXIA

Thank you for your attention

Horizon2020

The EuPRAXIA team

P. D. Alesini, A. S. Alexandrova, M. P. Anania, N. E. Andreev, R. W. Assmann, T. Audet, A. Bacci, I. F. Barna, A. Beaton, A. Beck, A. Beluze, A. Bernhard, S. Bielawski, F. G. Bisesto, J. Boedewadt, F. Brandi, O. Bringer, R. Brinkmann, E. Bründermann, M. Büscher, G. C. Bussolino, A. Chance, M. Chen, E. Chiadroni, A. Cianchi, J. Clarke, M. Croia, M. E. Couprie, B. Cros, J. Dale, G. Dattoli, N. Delerue, O. Delferriere, P. Delinikolas, J. Dias, U. Dorda, K. Ertel, Á. Ferran Pousa, M. Ferrario, F. Filippi, J. Fils, R. Fiorito, R. A. Fonseca, M. Galimberti, A. Gallo, D. Garzella, P. Gastinel, D. Giove, A. Giribono, L. A. Gizzi, F. J. Grüner, A. F. Habib, L. C. Haefner, T. Heinemann, B. Hidding, B. J. Holzer, S. M. Hooker, T. Hosokai, B. Imre, D. A. Jaroszynski, C. Joshi, M. Kaluza, O. S. Karger, S. Karsch, E. Khazanov, D. Khikhlukha, A. Knetsch, D. Kocon, P. Koester, O. Kononenko, G. Korn, I. Kostyukov, L. Labate, C. Lechner, W. P. Leemans, A. Lehrach, F. Y. Li, X. Li, A. Lifschitz, V. Litvinenko, W. Lu, A. R. Maier, V. Malka, G. G. Manahan, S. P. D. Mangles, B. Marchetti, A. Marocchino, A. Martinez de la Ossa, J. L. Martins, K. Masaki, F. Massimo, F. Mathieu, G. Maynard, T. J. Mehrling, A. Y. Molodozhentsev, A. Mosnier, A. Mostacci, A. S. Müller, Z. Najmudin, P. A. P. Nghiem, F. Nguyen, P. Niknejadi, J. Osterhoff, D. Papadopoulos, B. Patrizi, R. Pattathil, V. Petrillo, M. A. Pocsai, K. Poder, R. Pompili, L. Pribyl, D. Pugacheva, S. Romeo, A. R. Rossi, A. A. Sahai, Y. Sano, P. Scherkl, U. Schramm, C. B. Schroeder, J. Schwindling, J. Scifo, L. Serafini, Z. M. Sheng, L. O. Silva, C. Simon, U. Sinha, A. Specka, M. J. V. Streeter, E. N. Svystun, D. Symes, C. Szwaj, G. Tauscher, A. G. R. Thomas, N. Thompson, G. Toci, P. Tomassini, C. Vaccarezza, M. Vannini, J. M. Vieira, F. Villa, C.-G. Wahlström, R. Walczak, P. A. Walker, M. K. Weikum, C. P. Welsch, J. Wolfenden, G. Xia, M. Yabashi, L. Yu, J. Zhu, A. Zigler

www.eupraxia-project.eu

Dissemination

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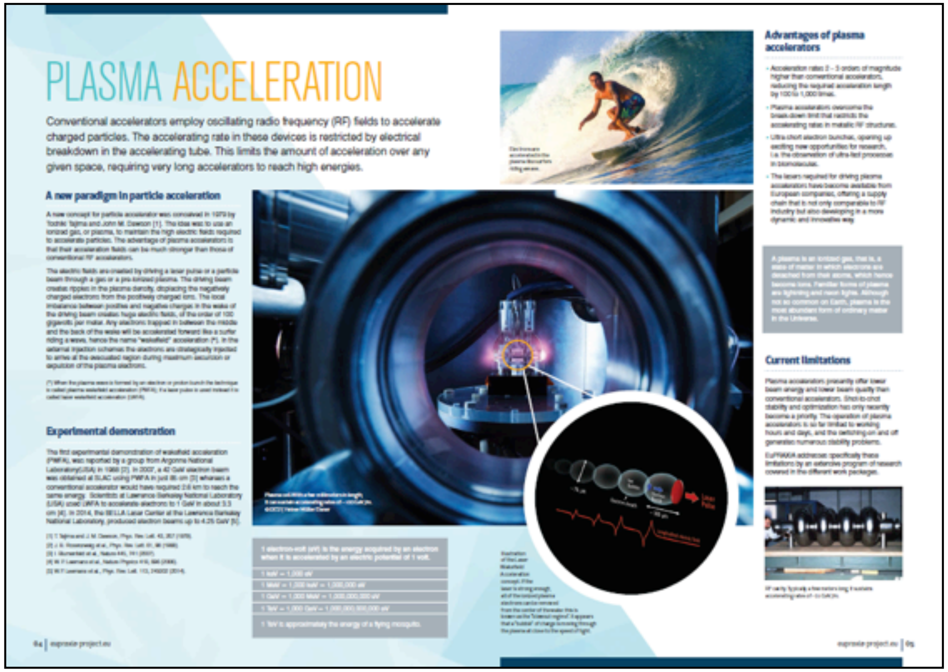

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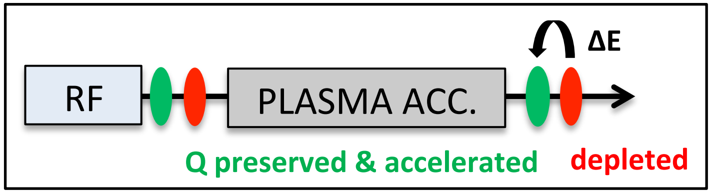
#EuPRAXIA
#plasma
#accelerator

Backup Slides

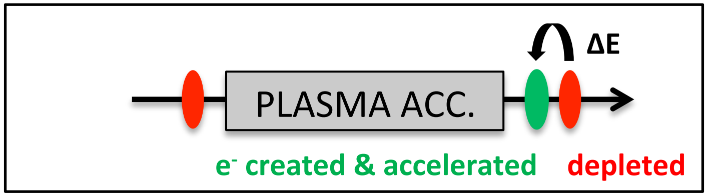
EuPRAXIA Plasma Accelerator Scheme

The 5 EuPRAXIA configurations

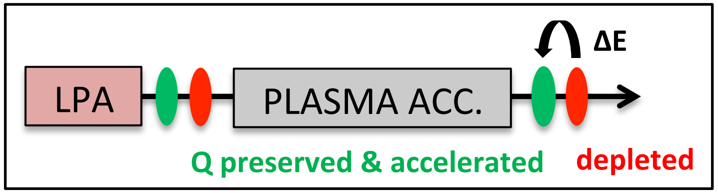
1) RF electron injector + laser plasma accelerator (LPA)
(LWFA with external injection from an RF accelerator)



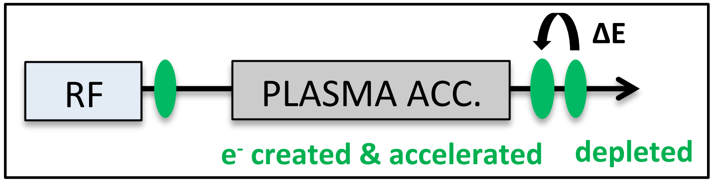
2) LPA with electron bunch created in plasma directly
(LWFA with internal injection)



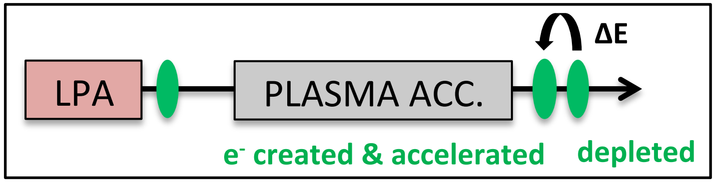
3) LPA electron injector + LPA
(LWFA with external injection from a LPA)



4) RF electron bunch as beam driver in LPA
(PWFA with an RF electron beam)



5) RF electron bunch as driver in a hybrid stage
(PWFA with LWFA produced electron beam or Trojan Horse scheme)

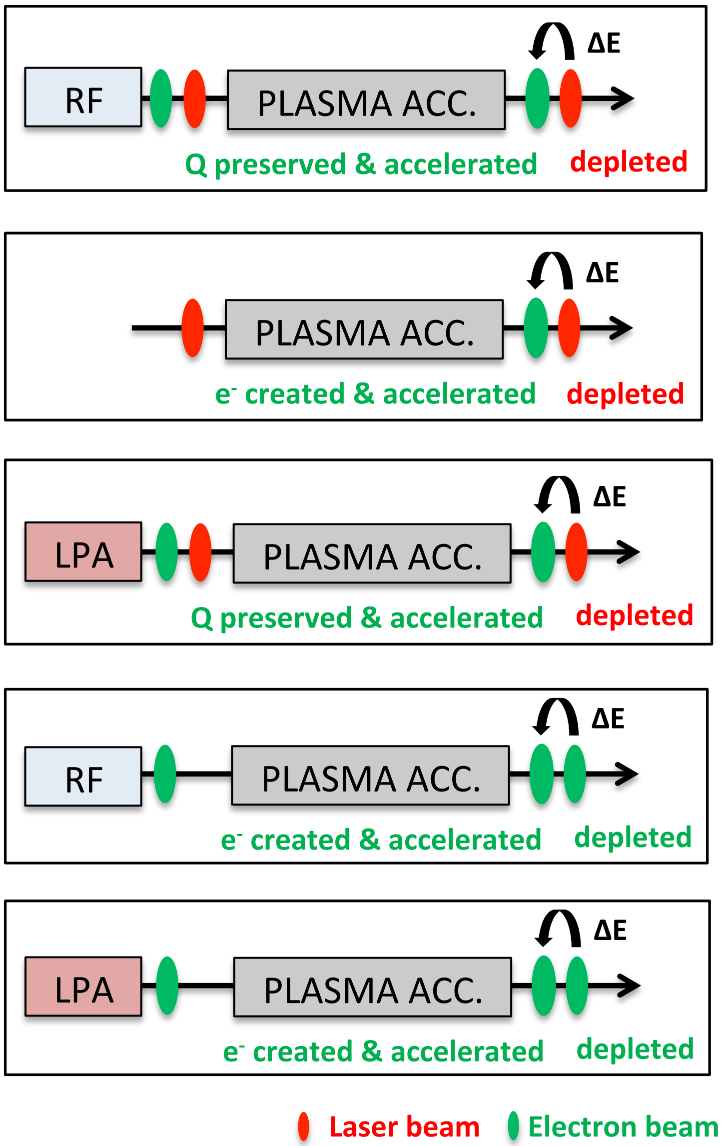


Laser beam   Electron beam

EuPRAXIA Plasma Accelerator Scheme

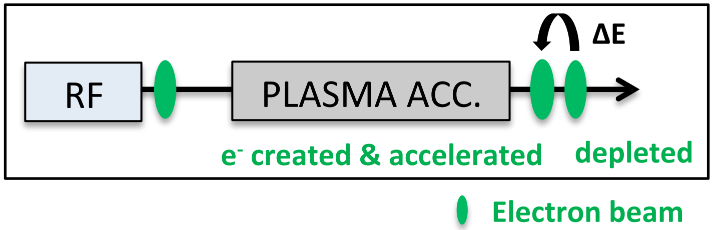
The 5 EuPRAXIA configurations

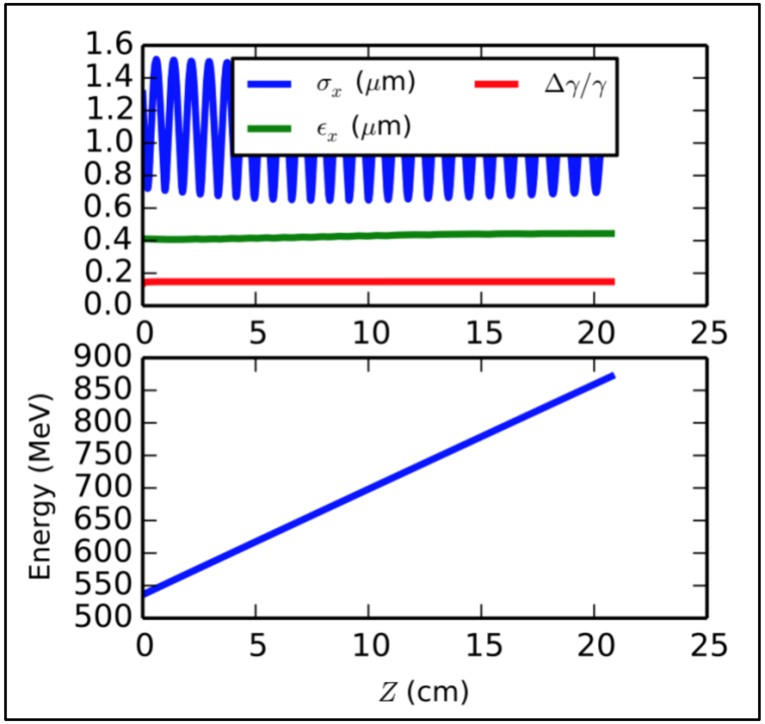
- Science & practical considerations will determine final choice of configuration(s)
- EuPRAXIA layout is being optimized for best synergy of lasers & RF technology



RF electron bunch as beam driver in laser plasma accelerator

- S-band gun and linac accelerate electron beam to E ~ 150 MeV
- X-band linac structures accelerate beam further to E ~ 500 MeV
- Plasma stage accelerates beam to E > GeV
- Low energy spread and emittance conserved in all stages



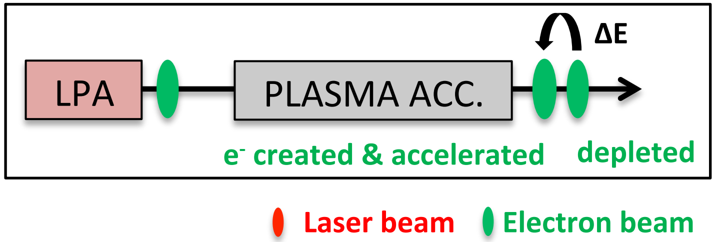


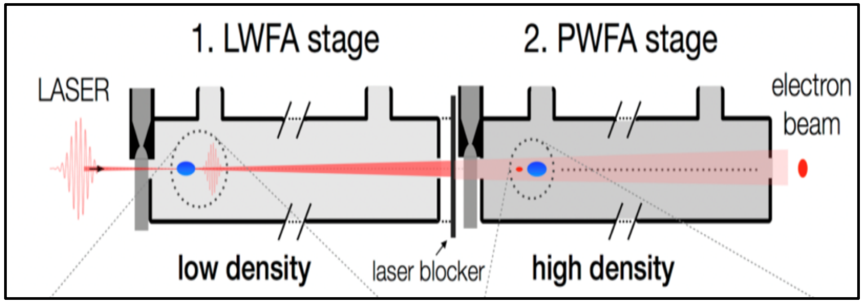
A. Marocchino et al., simulations with hybrid code Architect, Nucl. Instr. Meth. Phys. Res. vol. 829, 2016.

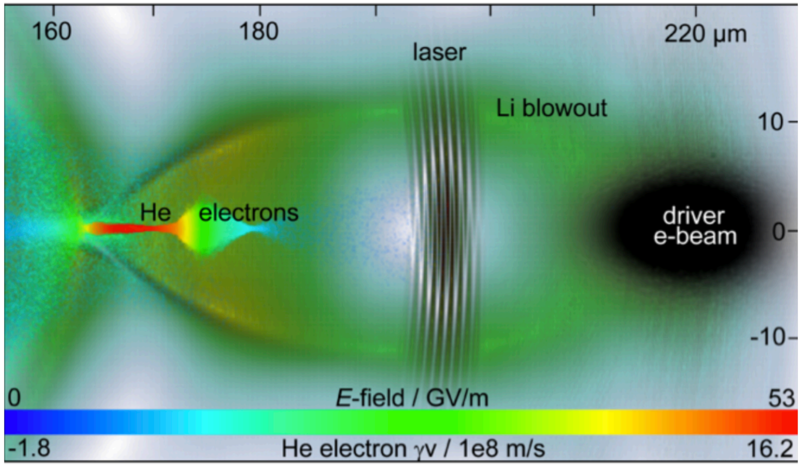
EuPRAXIA hybrid plasma acceleration ("Trojan Horse" and "L_2PWFA" schemes)

RF electron bunch as the driver in a hybrid stage:

- 1^{st} stage uses laser driver to accelerate electron beam
- 2^{nd} stage uses electron beam as beam driver to accelerate high quality electron beam







L_2PWFA scheme (pictured above): A. Martinez de la Ossa *et al.*, Phys. Rev. Lett. **111**, 245003 (2013)

Trojan Horse scheme (pictured above): B. Hidding *et al.*, Phys. Rev. Lett.**108**, 035001 (2012)

EuPRAXIA simulations
Imperfections of laser and plasma

- Of particular importance is the sensitivity to initial fluctuations
  - plasma density
  - alignment
  - particle beams
  - laser pulses

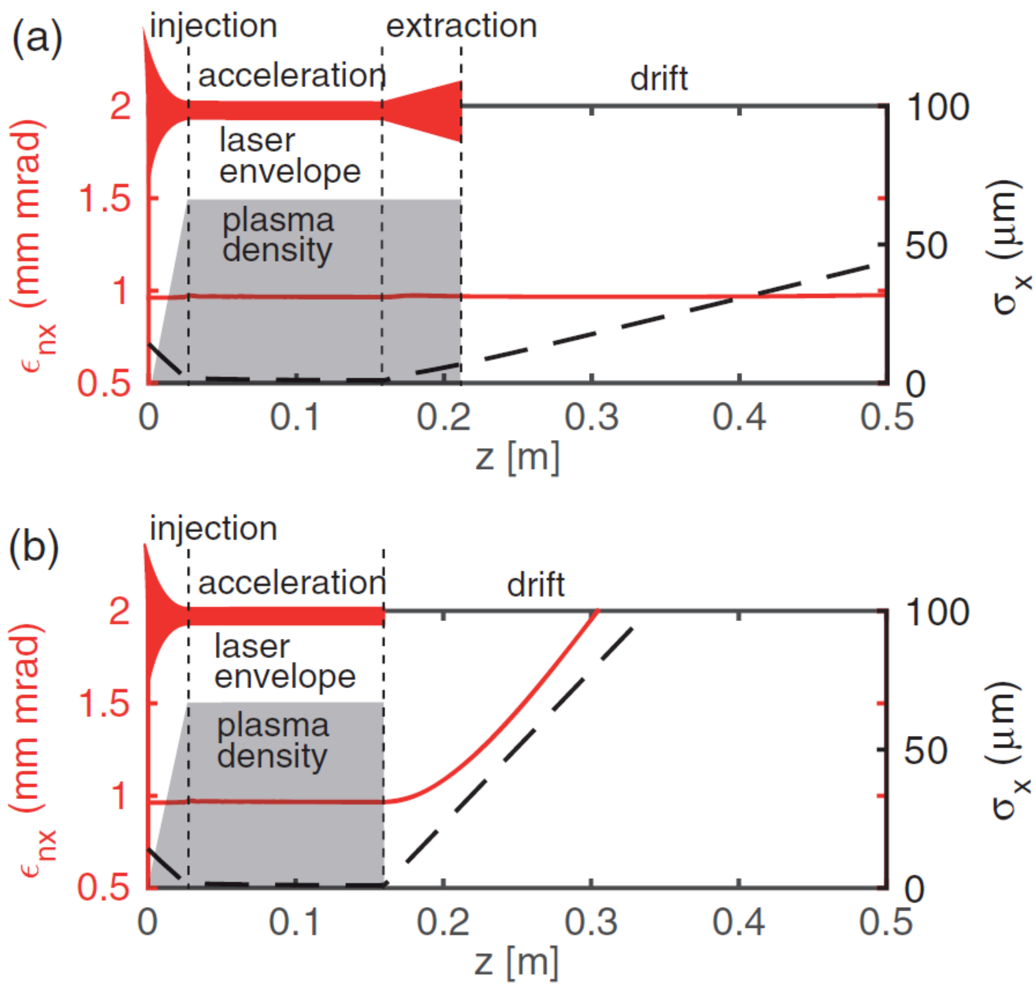
- Use of realistic profiles
  - Simulation work package is identifying the role of non-standard laser profiles such as non pure Gaussean beams:

		Min. Value (ex. jitter)	Max. Value (ex. slow drifts)
plasma			
	density	1%	10%
alignment error (plasma axis wrt e-beam and laser)			
	position [µm]	1	5
	angle [µrad]	1	10
e-beam and driver synchronization			
	Time shift [fs]	1	10
plasma lens			
	Magnetic field	1%	10%
Injected e-beam			
	charge	10%	20%
	energy	10%	20%
	emittance	10%	50%
	bunch length	10%	20%
Laser			
	Energy	5%	20%
	beam spot radius	10%	20%
	intensity	10%	20%
	focal plane position [mm]	0.1	1

Table 1: List of the main sources of errors.

$$A_L(z,\rho,\theta,t) = A_L^0(z,\rho,\theta)\exp\left[-(\tau/\tau_L)^2\right]\left\{1+\varepsilon_1\cos\left(2\pi\varepsilon_2(\tau-\tau_0)/\tau_L\right)\right\}$$

Emittance conservation by tailored plasma ramps



I. Dornmair et al., PRSTAB **18**, 041302 (2015)

EuPRAXIA is compact solution for (initially) low power accelerator to drive FEL

Horizon 2020

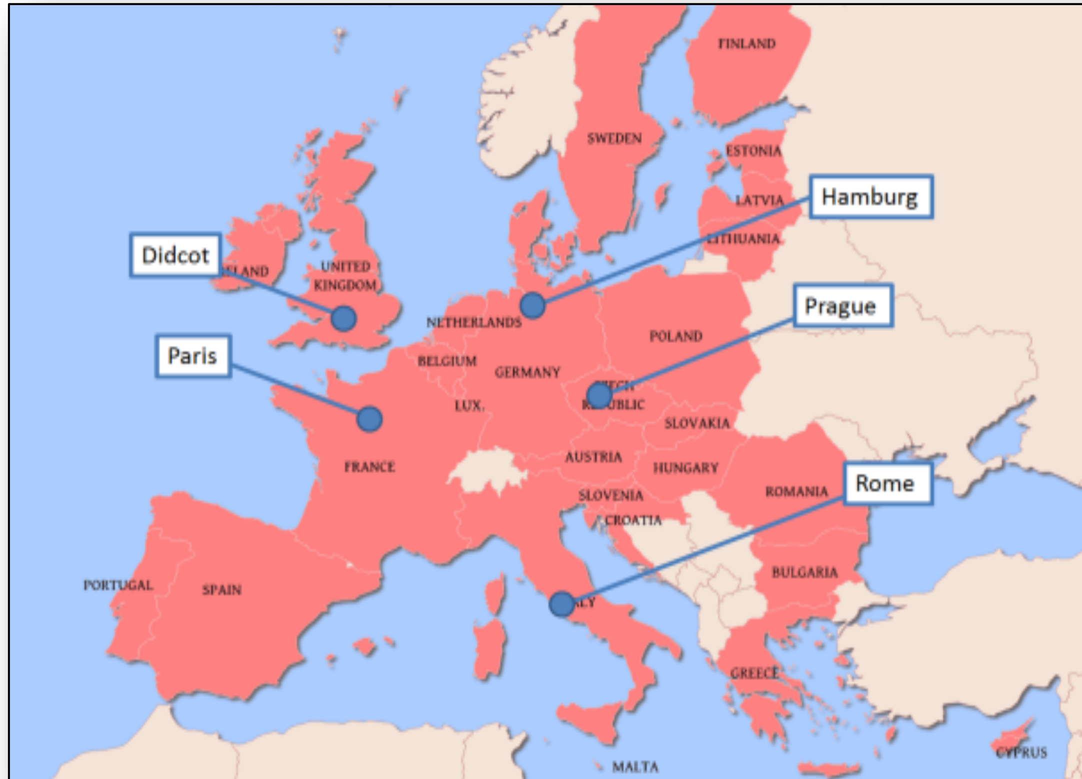
- Sufficient **beam quality is central goal** of EuPRAXIA
  - Improve energy spread (“beam loading” [1] or “modulated plasma density” [2])
- EuPRAXIA will initially be **low power** and **low wall-plug power efficiency**
  - Baseline (10 Hz): 10s of Watt with ~ 1 mJ/photon pulse energy
  - Dream scenario (1 MHz): kW - MW of power with diode-pumped solid-state laser (“100cube”) and/or concepts such as “kHz single cycle laser pulses” [3] or “resonant excitation of plasma waves” by trains of laser pulses [4]
  - Efforts with industry and laser institutes to improve rep. rate & efficiency of currently used laser systems (also incorporate fiber-based lasers with 30 % efficiency)
- EuPRAXIA report will be technical design report and project proposal:
  - Performance, required tolerances, footprint and cost will be assessed
  - We **hope for significant cost benefit** from this new technology

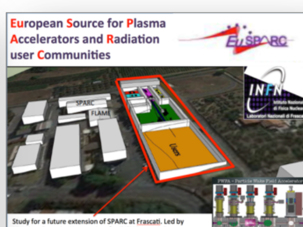
[1] S. Van der Meer, CLIC Note No. 3, CERN; PS, ‘85-65
[2] R. Brinkmann et al., PRL **118**, 214801 (2017)
[3] D. Guenot *et al.*, Nat. Photonics 11(5), 293-296 (2017)
[4] J. Cowley *et al.*, Phys. Rev. Lett. **119**, 044802 (2017)

Location of possible sites within EU

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

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