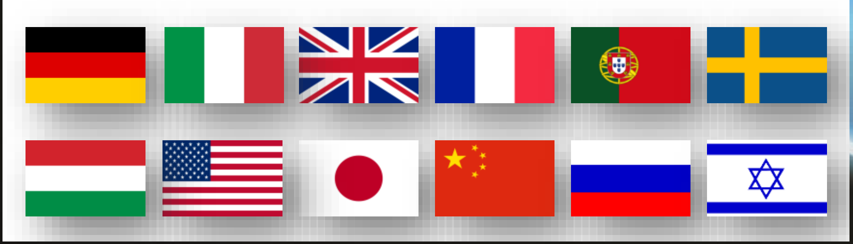
EUROPEAN
PLASMA RESEARCH
ACCELERATOR WITH
EXCELLENCE IN
APPLICATIONS

EuPRAXIA Machine Design

Eva Panofski, DESY Hamburg



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

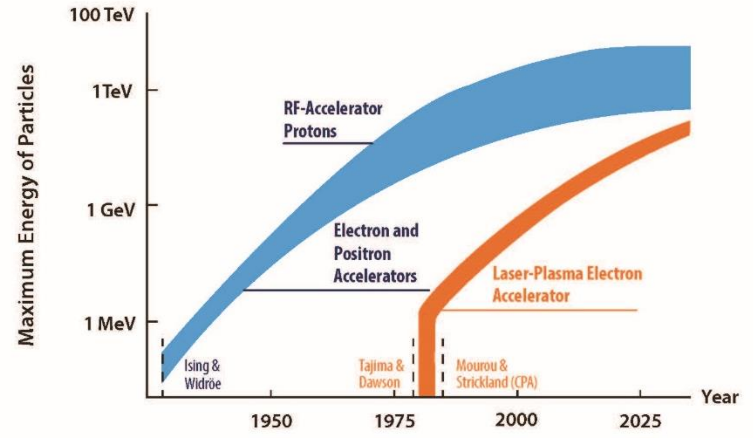
LWFA for future linear colliders

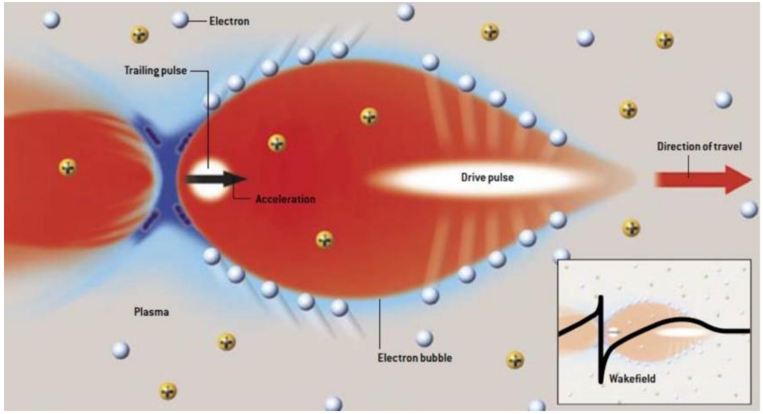
- The collision energy in particle colliders increased exponentially in time over decades
- Increase leveled off since the 1980s:
  → limits in conventional accelerators (electrical breakdown, max fields in sc magnets, accelerator size, accelerator costs, …)

- Plasma based acceleration proposed by Tajima and Dawson in 1979 and enabled by the invention of chirped pulse amplification (Mourou and Strickland 1985) offers:

  → High beam energies
  → Highest acceleration gradients on a short acceleration length (up to 160 GeV/m)

Produce high beam quality and prove operational reliability





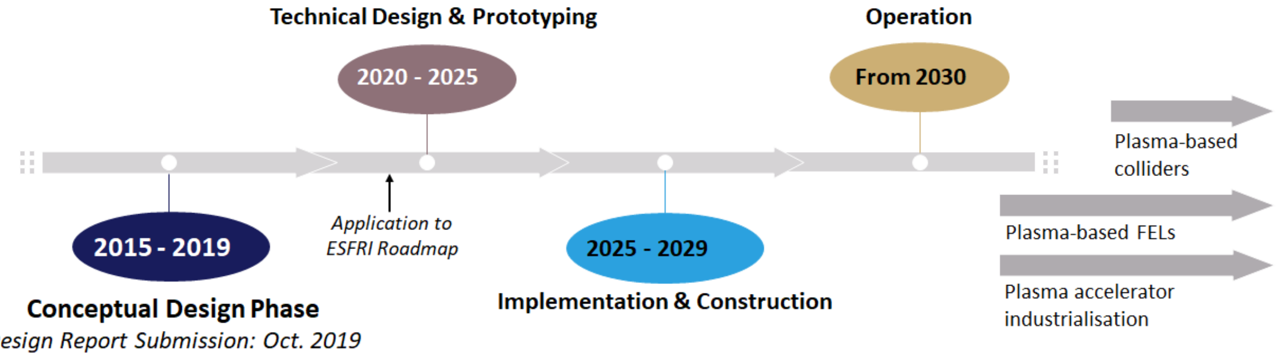
Outline

- Project overview - EuPRAXIA
- EuPRAXIA implementation at DESY Hamburg
- Beamline design and beam dynamic simulations
- Electron beam diagnostics
- Plasma acceleration
- EuPRAXIA as a particle collider
- Conclusion

EuPRAXIA - Project Overview

Horizon 2020

- EuPRAXIA (European Plasma Research Accelerator with eXcellence In Application) is an **EU design study**.
- EUPRAXIA is **one of two accelerator-related design studies** funded by **Horizon 2020**.
- First European research infracture dedicated to **demonstrate usability of plasma accelerators ready for user applications**.
- **Project time line**:



Technical Design & Prototyping

2020 - 2025

Operation

From 2030

2015 - 2019

Application to ESFRI Roadmap

2025 - 2029

Conceptual Design Phase

Design Report Submission: Oct. 2019

Implementation & Construction

Plasma-based colliders

Plasma-based FELs

Plasma accelerator industrialisation

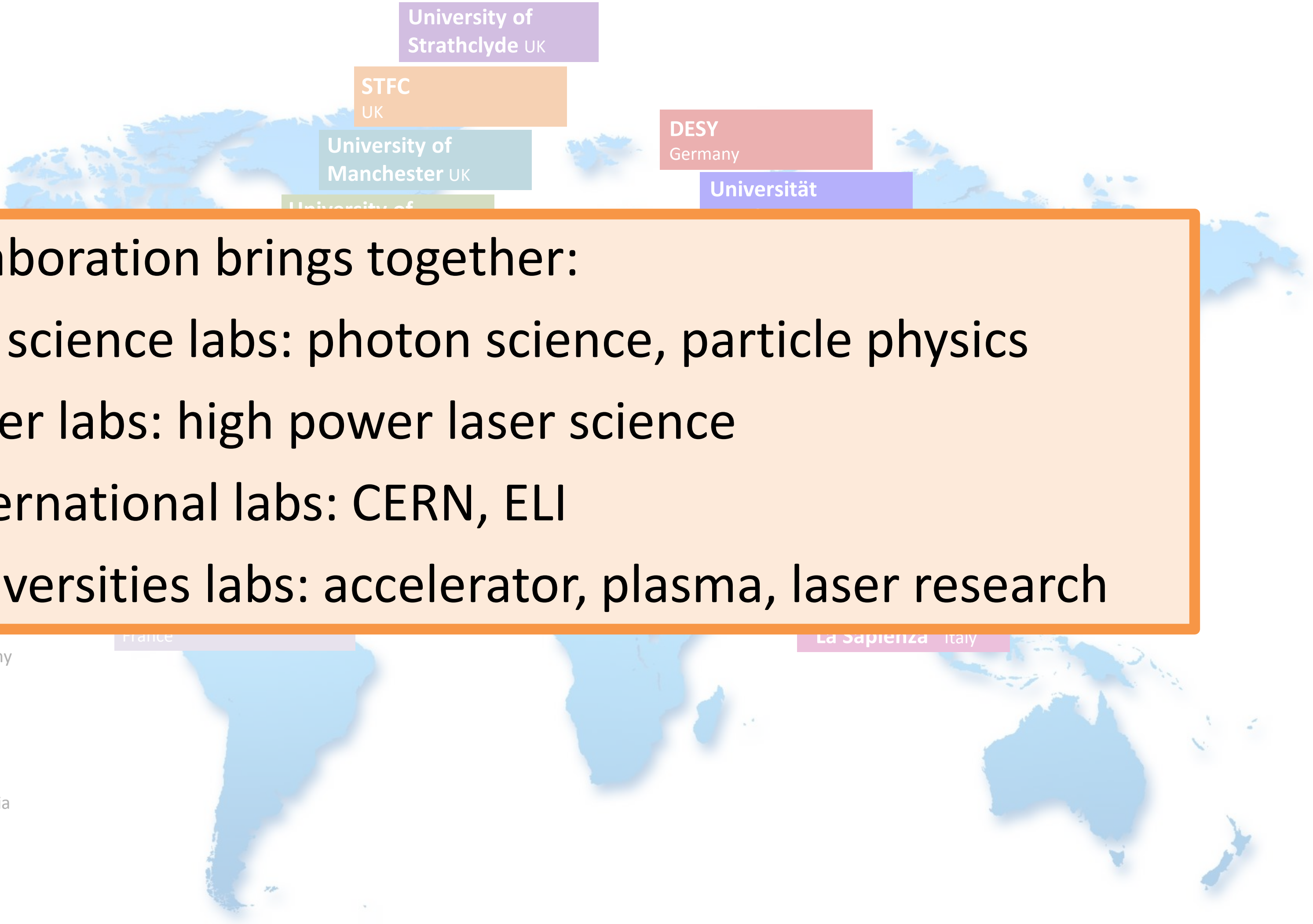
Participating Institutions

Horizon 2020

25 Associated Partners
(as of December 2018)

1 **Shanghai Jiao Tong-University**, China
2 **Tsinghua University Beijing**, China
3 **ELI Beamlines**, International
4 **PHLAM, Université de Lille**, France
5 **Helmholtz-Institu**
6 **HZDR (Helmholtz**
7 **LMU München**, G
8 **Wigner Fizikai Ku**
9 **CERN**, Internation
10 **Kansai Photon Sc**
11 **Osaka University**
12 **RIKEN SPring-8**, J
13 **Lunds Universitet**
14 **Stony Brook Univ**
15 **LBNL**, USA
16 **UCLA**, USA
17 **Karlsruher Institut für Technologie**, Germany
18 **Forschungszentrum Jülich**, Germany
19 **Hebrew University of Jerusalem**, Israel
20 **Institute of Applied Physics**, Russia
21 **Joint Institute for High Temperatures**, Russia
22 **Università di Roma "Tor Vergata«**, Italy
23 **Queen's University Belfast**, UK
24 **Ferdinand-Braun-Institut**, Germany
25 **University of York**, UK

16 laboratories and universities from 5 EU member states



Collaboration brings together:

- Big science labs: photon science, particle physics
- Laser labs: high power laser science
- International labs: CERN, ELI
- Universities labs: accelerator, plasma, laser research

EuPRAXIA - Project Overview

Horizon 2020

Goal: Compact facility producing multi-GeV electron beams based on plasma acceleration

➡ Demonstrate plasma accelerator technology is able to provide **high beam quality**

- Incorporate established (RF) accelerator technology
- Combine expertise from accelerator & laser labs, industry, international partners
- Develop new technical solutions

➡ Show **benefit in size** versus established RF technology

➡ Up to 5 GeV high brightness electron beams for **various user applications**: Photon science, high energy physics, FEL radiation in the X-ray regime

➡ Milestone towards plasma driven **future linear collider**

Integration of high gradient plasma modules to short wavelength FEL

EuPRAXIA - Experimental Sites

Design study is site-independent. Potential sites are:

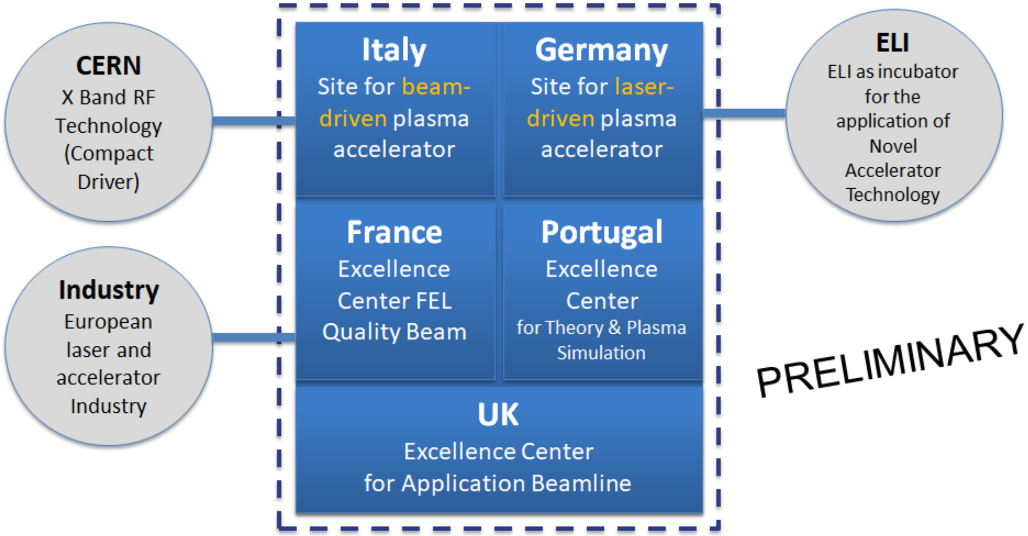
- EuSPARC (Frascati, Italy)
- SINBAD at DESY (Hamburg, Germany)

SINBAD

Facility for Short INnovative Bunches and Accelerators at DESY (ex DORIS collider)

- dedicated acc. R&D facility
- 280 m beam tunnel
- accelerator science programs
- adjacent laser laboratories
- photon science labs
- central campus location
- home for future ATHENA facility, if funded by Helmholtz

Pan-European concept with 2 experimental sites:



CERN
X Band RF Technology (Compact Driver)

Industry
European laser and accelerator Industry

Italy
Site for beam-driven plasma accelerator

Germany
Site for laser-driven plasma accelerator

France
Excellence Center FEL Quality Beam

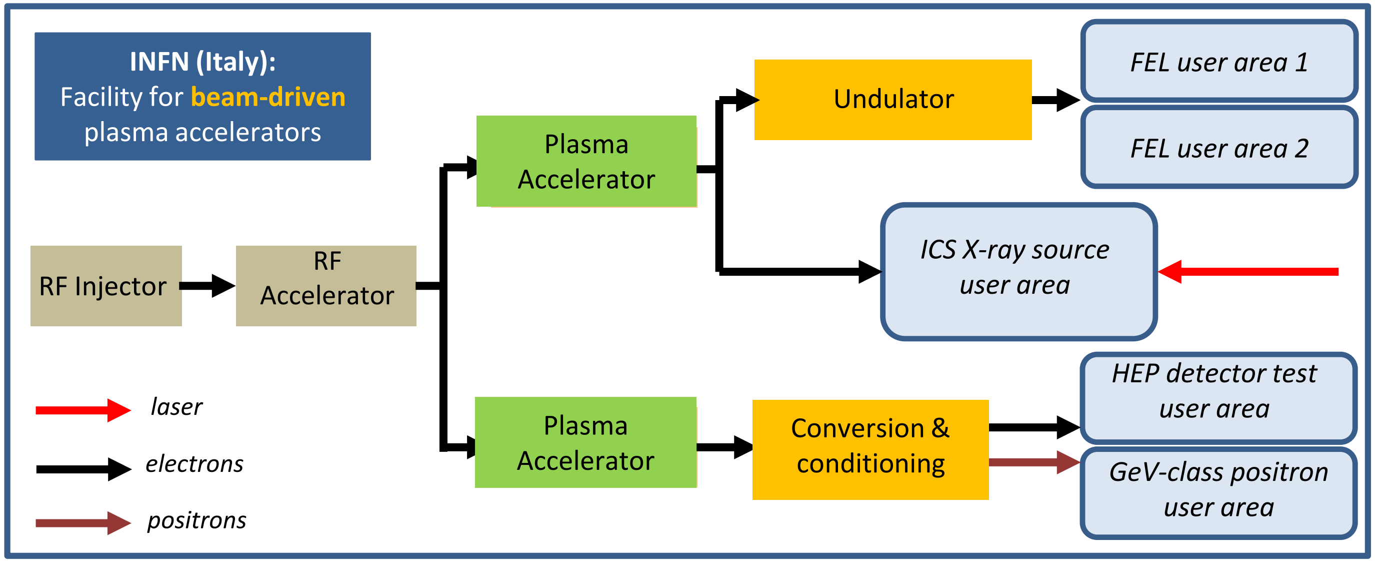
Portugal
Excellence Center for Theory & Plasma Simulation

UK
Excellence Center for Application Beamline

ELI
ELI as incubator for the application of Novel Accelerator Technology

PRELIMINARY

Beamline Layout



INFN (Italy):
Facility for **beam-driven**
plasma accelerators

RF Injector → RF Accelerator → Plasma Accelerator → Undulator → FEL user area 1 / FEL user area 2

Plasma Accelerator → ICS X-ray source user area

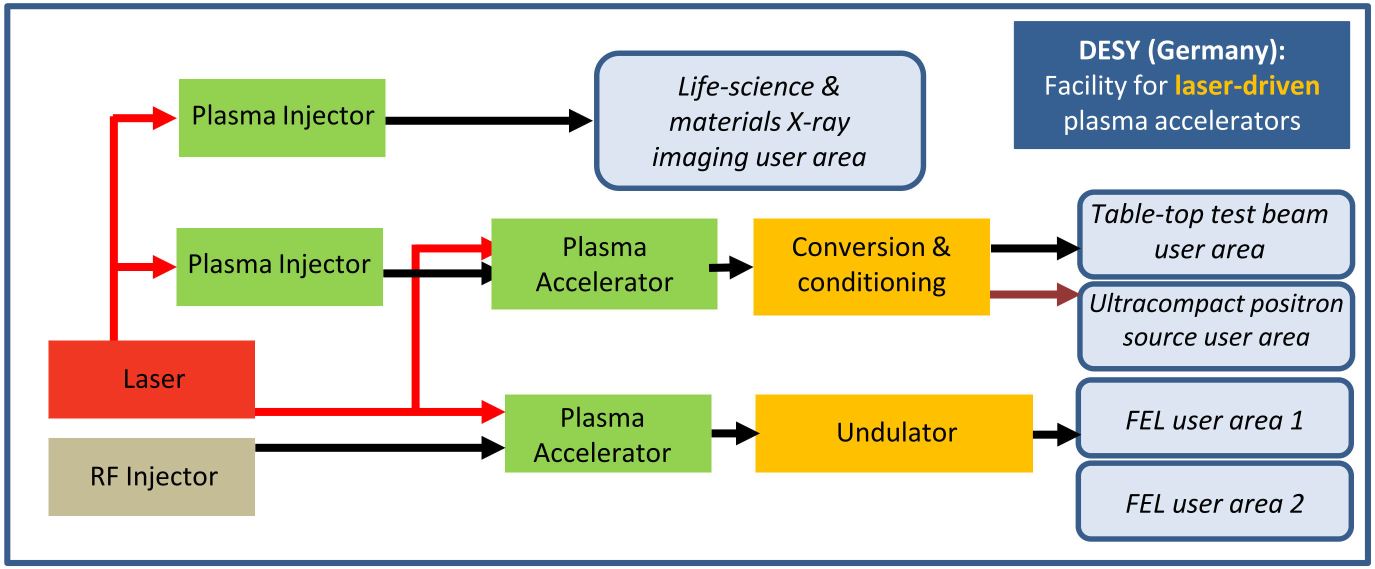
RF Accelerator → Plasma Accelerator → Conversion & conditioning → HEP detector test user area / GeV-class positron user area

→ *laser*

→ *electrons*

→ *positrons*

Current version of layout for Frascati and Hamburg machine sites



DESY (Germany):
Facility for **laser-driven**
plasma accelerators

Laser → Plasma Injector → *Life-science & materials X-ray imaging user area*

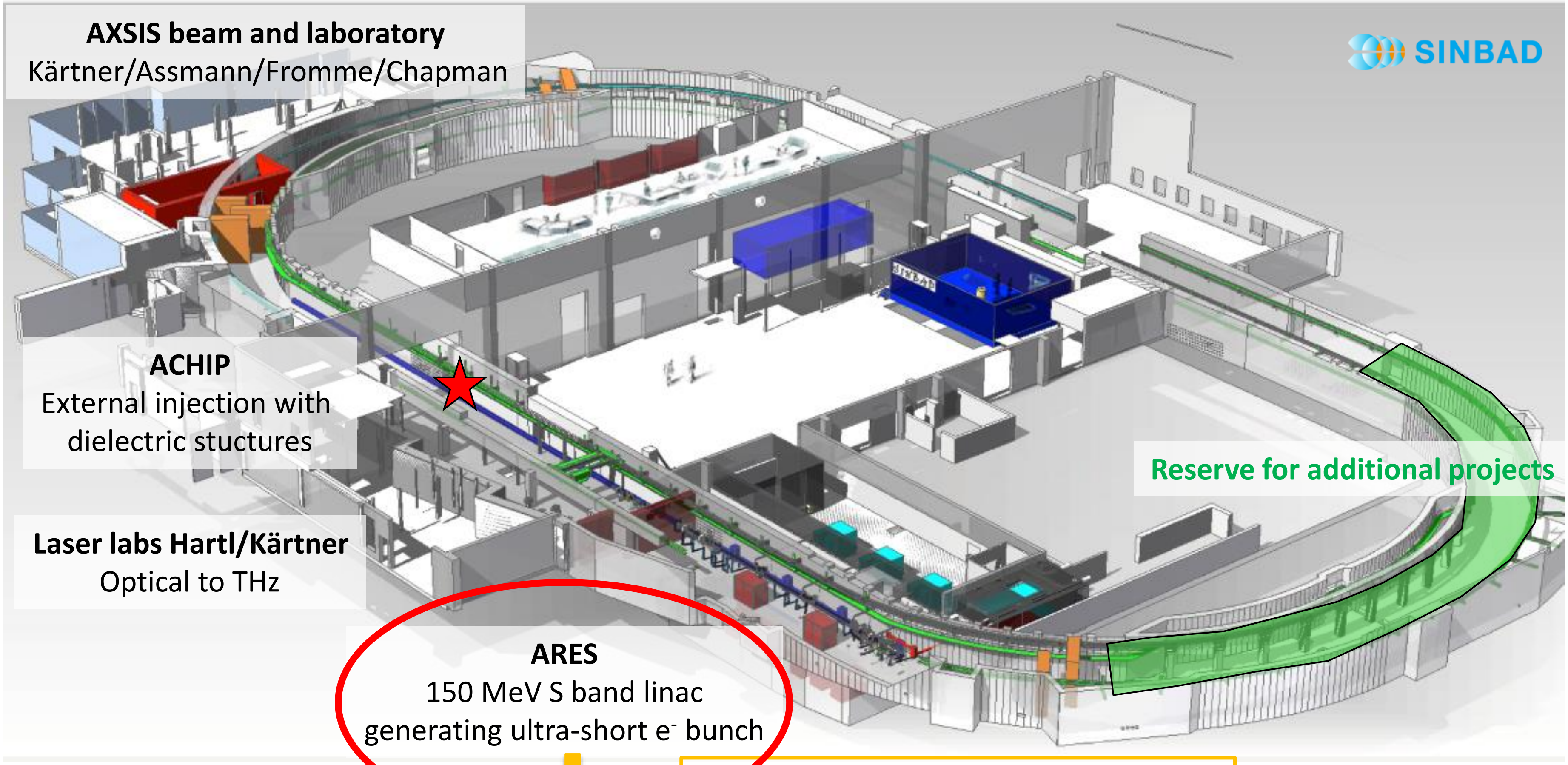
Laser → Plasma Injector → Plasma Accelerator → Conversion & conditioning → *Table-top test beam user area* / *Ultracompact positron source user area*

Laser, RF Injector → Plasma Accelerator → Undulator → *FEL user area 1* / *FEL user area 2*

Credit: A. Walker

SINBAD @ DESY Hamburg

New accelerator concepts will be tested at DESY within the SINBAD facility (former DORIS ring)



AXSIS beam and laboratory
Kärtner/Assmann/Fromme/Chapman

ACHIP
External injection with
dielectric stuctures

Laser labs Hartl/Kärtner
Optical to THz

ARES
150 MeV S band linac
generating ultra-short e$^-$ bunch

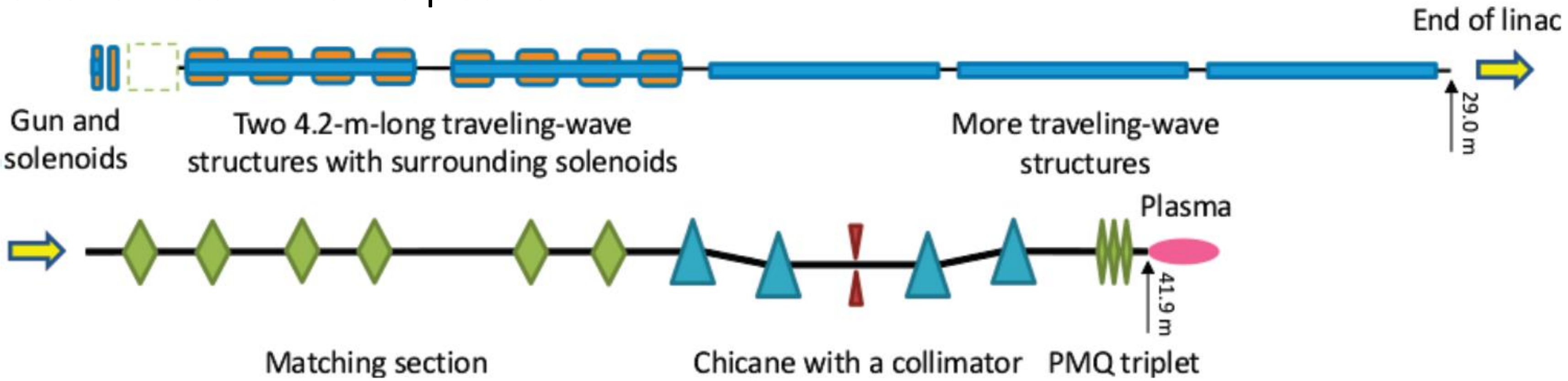
Reserve for additional projects

Testing site for LPWA (target energy 1 GeV)
1GeV FEL driven by LPWA

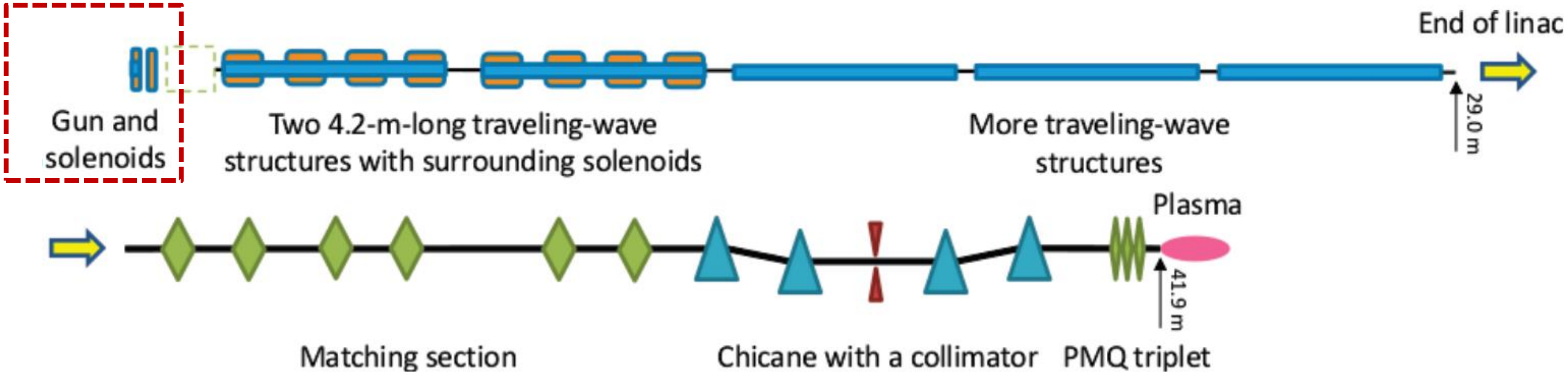
Eupraxia @ DESY Hamburg

Proposal: Host EuPRAXIA under the infrastructure of the SINBAD facility at DESY

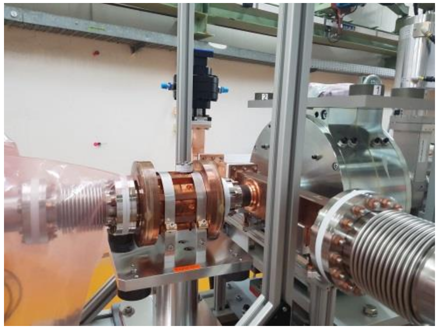
For Configuration 2 (LPWA with external RF injector) setup **close to ARES linac @ SINBAD** is planned based on 3 additional TWS and an adjusted PMQ triplet for matching the electron beam into the plasma



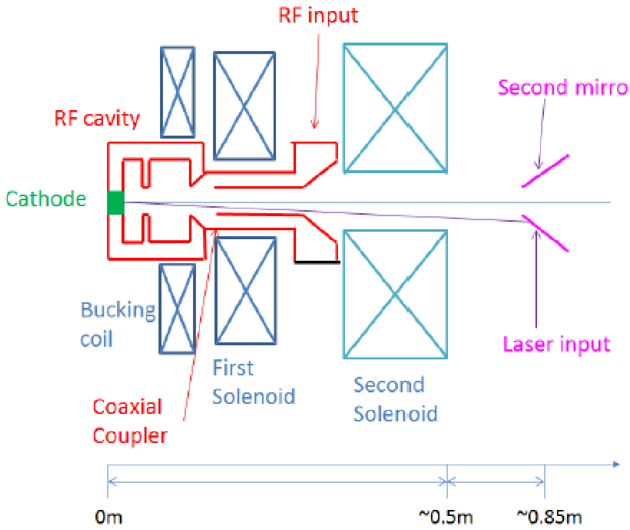
EuPRAXIA Beamline Design



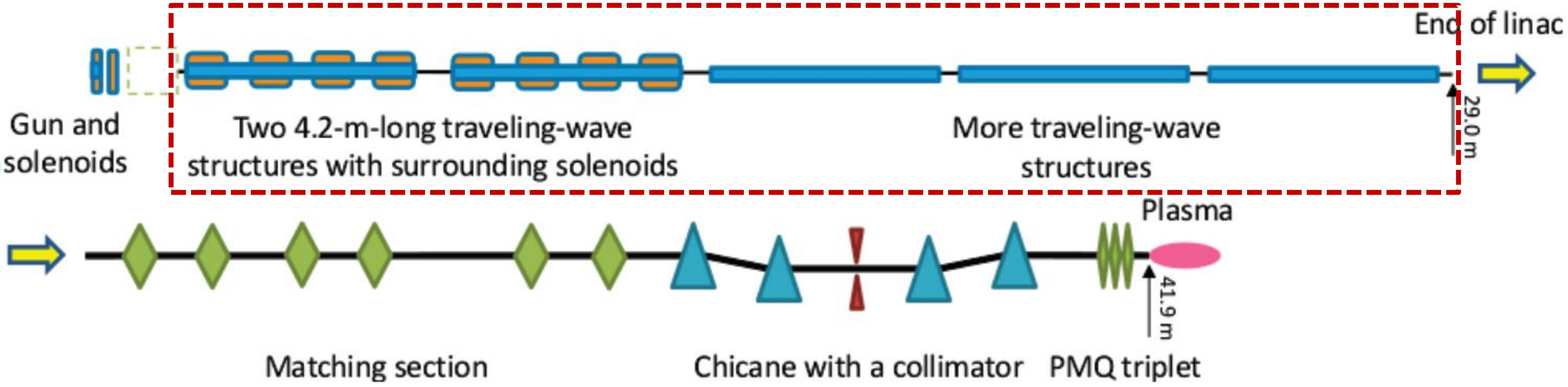
1.5 cells standing wave



Peak gradient: 117 MV/m for 6MW input power
RF pulse length: 6μs



EuPRAXIA Beamline Design



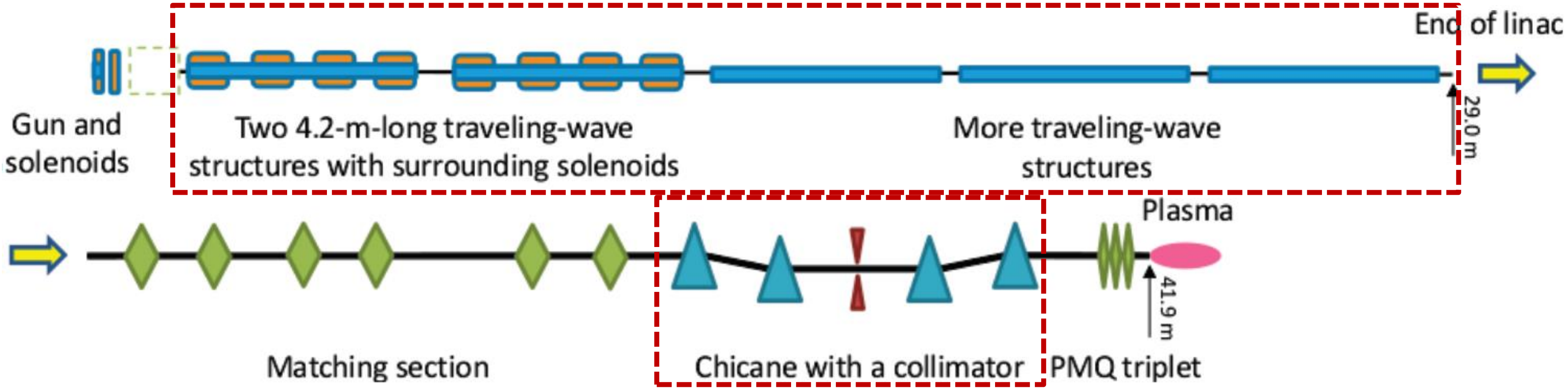
Normal conducting S-band technology:

- **2.998 GHz** normal conducting linac
- **10-50 Hz** rep. rate, single bunch mode

- RF cavities embedded in solenoids
- RI design, similar to SwissFEL injector cavities
- 4.15m long
- 20 MV/m for 45MW input power

→ About **50 MeV energy gain per cavity** expected with our RF station

Bunch Compression



End of linac

Gun and solenoids

Two 4.2-m-long traveling-wave structures with surrounding solenoids

More traveling-wave structures

29.0 m

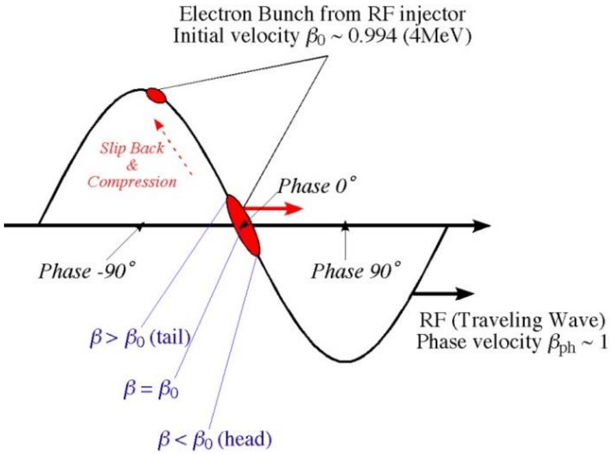
Plasma

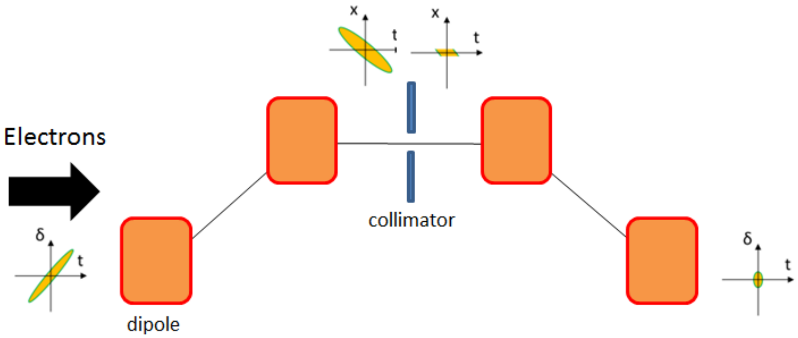
41.9 m

Matching section

Chicane with a collimator

PMQ triplet



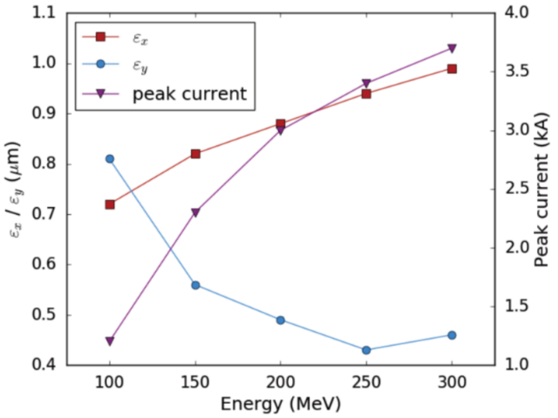


Simultaneous **compression** and **acceleration** of a *non-yet-relativistic beam*

Magnetic chicane with a collimator

e-Bunch Requirements to Address LWFA Challenges

- **Bunch duration shorter** than a **few fs** → reduce the impact field curvature → reduce energy spread;
- **Bunch arrival time jitter** significantly smaller than the **field wavelength** (e.g., smaller than 10 fs for 1 ps field period) → acceptable shot to shot energy variation;
- **Beam transverse size** of the **µm level** → transverse beam **matching**;
- **Beam emittance** as **small** as possible
- **Pointing stability** needs to be limited to a **few µm** → strong **focusing of the fields** inside the plasma bubble.
- **Maximum bunch charge** and its **stability** limited by the maximum **tolerable beam loading effect** and by the requirements above;
- **Beam energy** chosen to reduce the **space charge effect**, thus allowing shorter bunch lengths for a fixed bunch charge



J. Zhu et al., "Simulation Study of an RF Injector for the LWFA Configuration at EuPRAXIA", in Proc. IPAC'18, Vancouver, Canada (2018), paper THPAF032 .

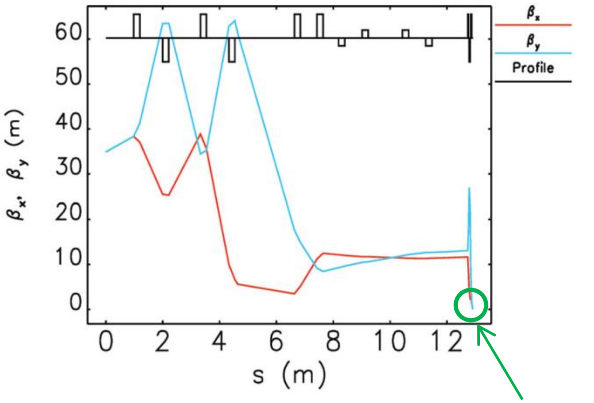
Beam dynamic simulations - Plasma injection point

	Plasma injection point
Energy (MeV)	240.8
Bunch charge (pC)	29.8
rms bunch length (fs)	7.5
Peak current (kA)	4.0
Projected $\varepsilon_x/\varepsilon_y$ (µm)	0.81 / 0.46
Slice $\varepsilon_x/\varepsilon_y$ (µm)	0.59/0.34
β_x/β_y (mm)	3.1/3.0
rms energy spread (%)	0.27
Slice *rms* energy spread (%)	0.23

ultra-short bunch

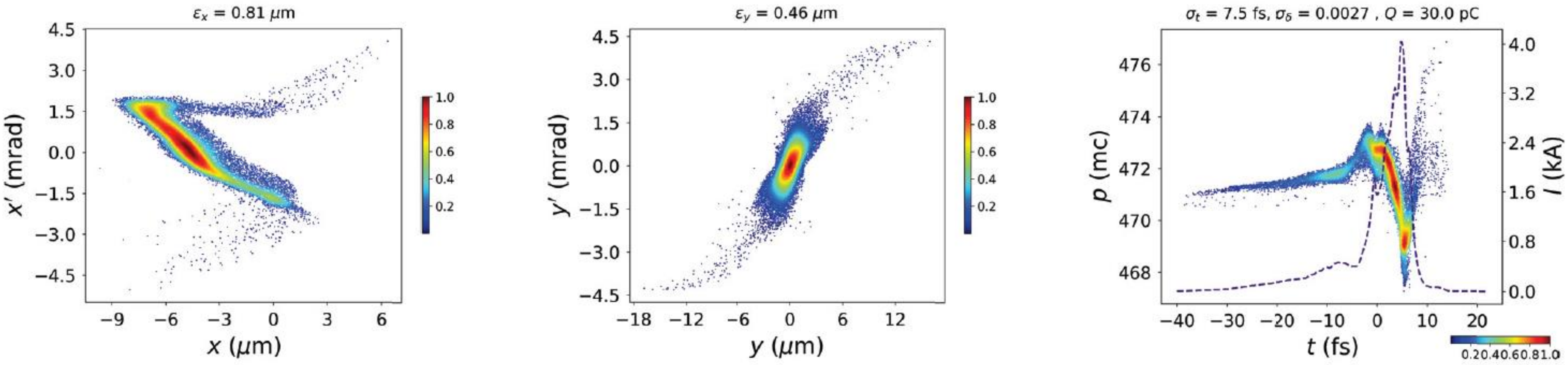
high peak current

Increased transv. emittance due to sc effects and chromatic abberation



small β-function

Transverse and longitudinal phase spaces at the plasma injection point



Beam diagnostics

Goal:
Complete characterization of the fs beam injected in plasma

- **Transverse** measurements in the **µm** (*rms*) range

  → Scintillating screen, OTR (transverse beam size)

  → Pepper pot, perm. quade scan, betatron-radiation,… (transv. emittance)

- **Longitudinal** measurements in the order of a **few fs** (FWHM)

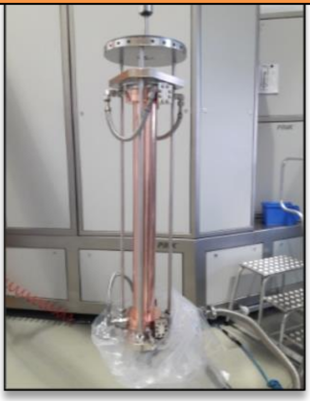
  → X-band TDS

fs Bunch Length Diagnostics - Polarizable Transverse Deflecting Structure

Horizon 2020

- Novel design of TDS with **tunable direction of the streaking field** invented at **CERN** [1]
- First prototype cavity [2] has been **produced** and **characterized** at **PSI**
- **High power conditioning at CERN** ongoing
- Prototype cavity **will be tested with beam at DESY** (FLASHForward beamline) in **2019**
- Novel beam diagnostics techniques will be tested: e.g. **3D beam charge distribution reconstruction** through tomography [3]

Prototype manufactured at PSI

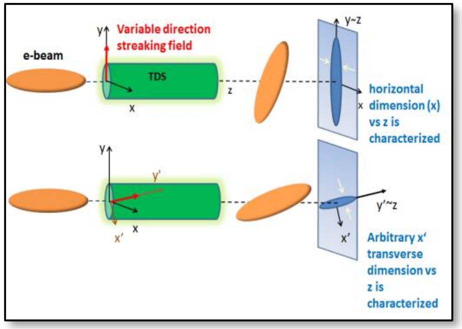


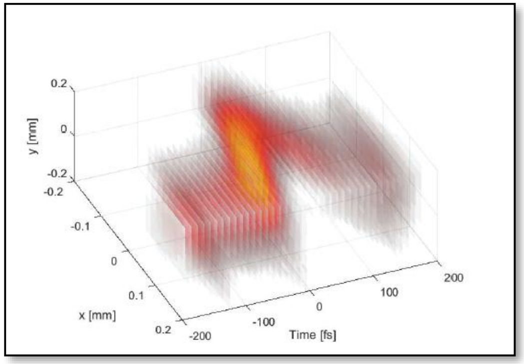
Collaboration between:

DESY
PAUL SCHERRER INSTITUT
CERN

DESY-experiments involved:

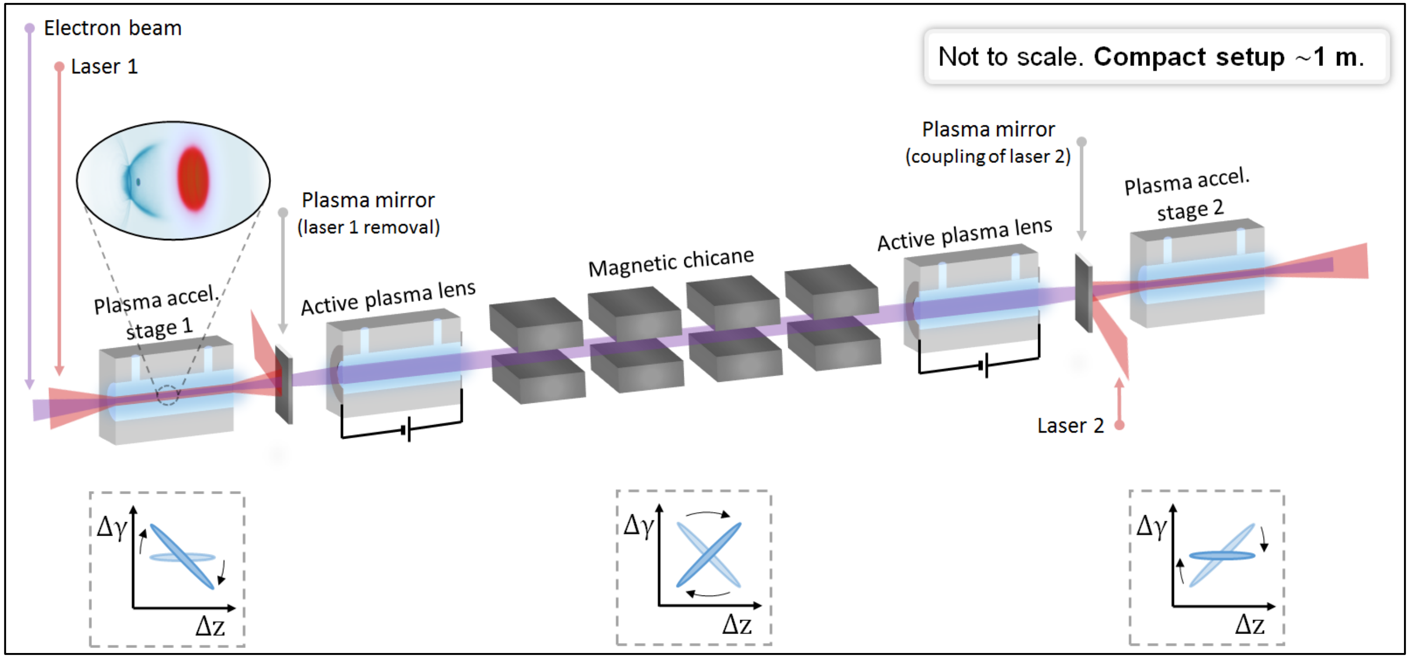
SINBAD, FLASHForward, FLASH2, possibly in the future XFEL





References: [1] CLIC - note - 1067 (2016)
[2] doi: 10.18429/JACoW-IPAC2018-THPAL068
[3] doi: 10.18429/JACoW-IPAC2018-WEPAF05

Plasma Acceleration - New concept: 5GeV stage




arXiv:1811.07757v1 [physics.acc-ph] 19 Nov 2018

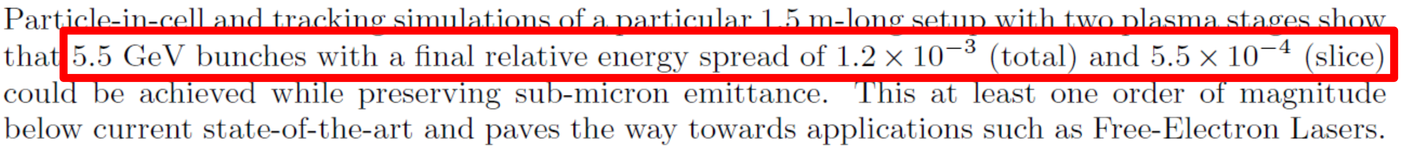
Correlated Energy Spread Compensation in Multi-Stage Plasma-Based Accelerators

A. Ferran Pousa,[1,2,*] A. Martinez de la Ossa,[1] R. Brinkmann,[1] and R. W. Assmann[1]
[1]Deutsches Elektronen-Synchrotron DESY, 22607 Hamburg, Germany
[2]Institut für Experimentalphysik, Universität Hamburg, 22761 Hamburg, Germany
(Dated: November 20, 2018)

The extreme electromagnetic fields sustained by plasma-based accelerators allow for energy gain rates above 100 GeV/m but are also an inherent source of correlated energy spread. This severely limits the usability of these devices. Here we propose a novel compact concept which compensates the induced energy correlation by combining plasma accelerating stages with a magnetic chicane. Particle-in-cell and tracking simulations of a particular 1.5 m-long setup with two plasma stages show that 5.5 GeV bunches with a final relative energy spread of 1.2×10^{-3} (total) and 5.5×10^{-4} (slice) could be achieved while preserving sub-micron emittance. This at least one order of magnitude below current state-of-the-art and paves the way towards applications such as Free-Electron Lasers.

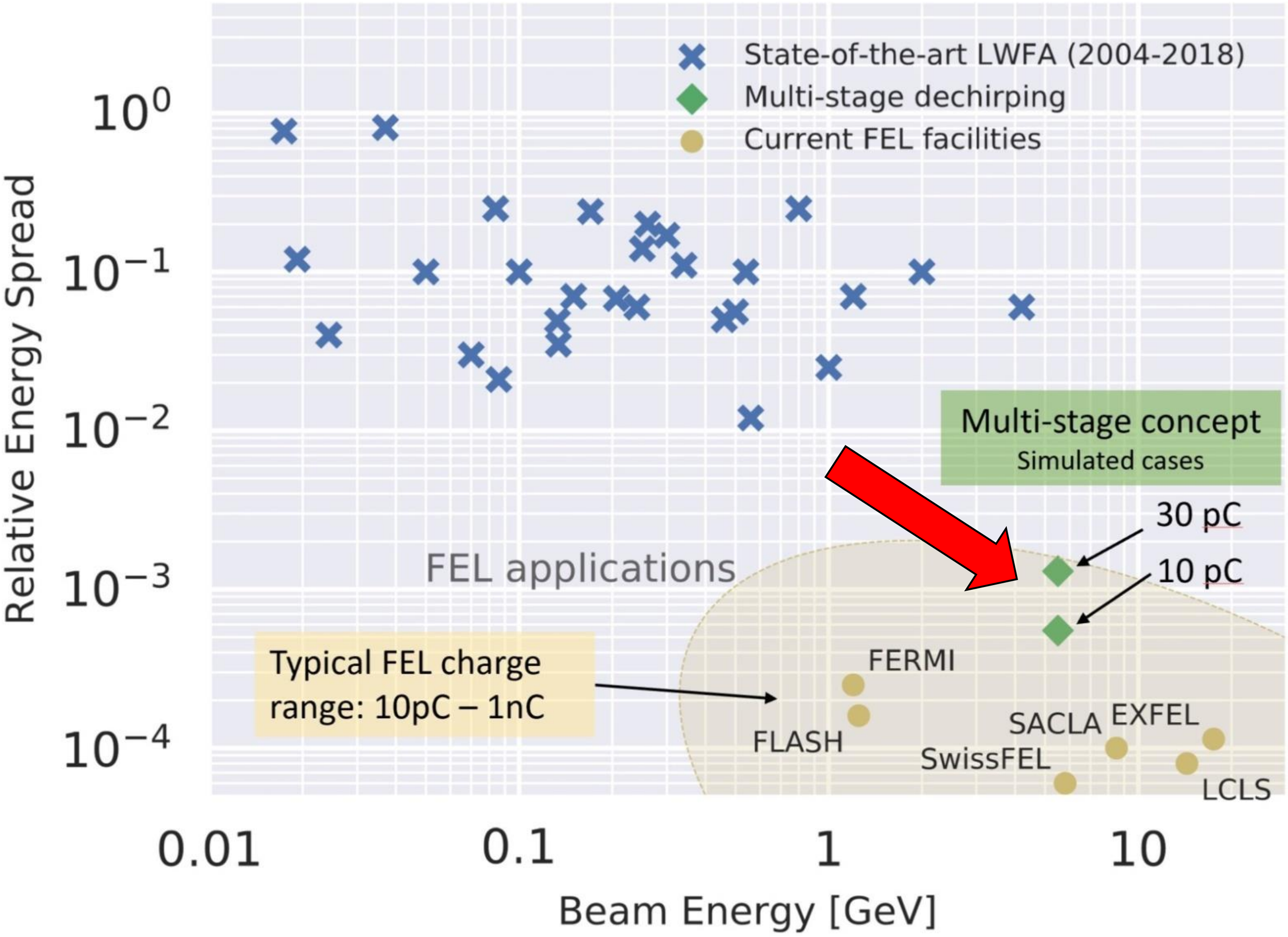
Submitted for publication
Available on arXiv

Ref.: Ferran Pousa, Martinez de la Ossa, Brinkmann, Assmann, **arXiv:1811.07757**


Particle-in-cell and tracking simulations of a particular 1.5 m-long setup with two plasma stages show that 5.5 GeV bunches with a final relative energy spread of 1.2×10^{-3} (total) and 5.5×10^{-4} (slice) could be achieved while preserving sub-micron emittance. This at least one order of magnitude below current state-of-the-art and paves the way towards applications such as Free-Electron Lasers.

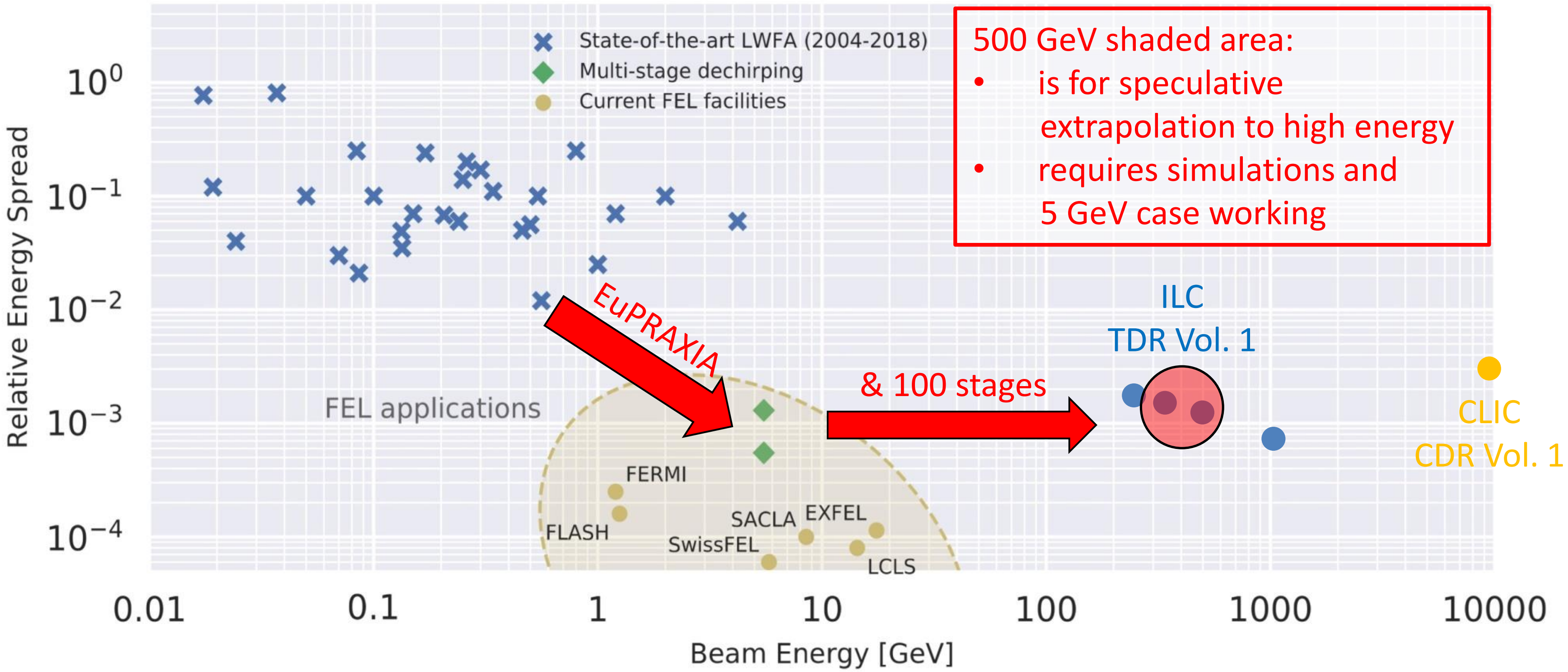
Plasma Acceleration - New concept: 5 GeV stage

Plot courtesy Angel Ferran Pousa



ATHENA can prove this concept at lower energy (1 GeV) and lower charge. Then EuPRAXIA for the 5 GeV case!

Plasma Acceleration for Colliders- Future concept: 500 GeV



500 GeV shaded area:

- is for speculative extrapolation to high energy
- requires simulations and 5 GeV case working

Conclusion

- EuPRAXIA is a **conceptual design study for a 5 GeV electron accelerator**
- Based on **laser and beam driven plasma acceleration**
- Pan-European concept in Italy, Germany, France, Portugal and the UK with two experimental sites
- EuPRAXIA is **addressing the quality issue of plasma accelerators**
- Several **new concepts** (reduce energy spread, synchronization, …) have been developed over the last years
- Provide high quality beams to multiple **user areas**:
  - Electron beams at 1 - 5 GeV
  - Positrons at 1 MeV - 1 GeV

Dissemination

Horizon 2020

NOVEL FUNDAMENTAL RESEARCH

COMPACT EUROPEAN PLASMA ACCELERATOR WITH SUPERIOR BEAM QUALITY

Find Out More

OUR TECHNOLOGY
EuPRAXIA brings together novel acceleration schemes, modern lasers, the latest correction technologies and large-scale user areas.
LEARN MORE

PARTICIPANTS
A consortium of 16 laboratories and universities from 5 EU member states has formed to produce a conceptual design report.
LEARN MORE

WORK PACKAGES
The project is structured into 14 work packages of which 8 are included into the EU design study.
LEARN MORE

MANAGEMENT
The management bodies will organise, lead and control the project's activities and make sure that objectives are met
LEARN MORE

www.eupraxia-project.eu

#EuPRAXIA
#plasma
#accelerator

EUROPEAN PLASMA RESEARCH ACCELERATOR WITH EXCELLENCE IN APPLICATIONS

DESIGNING THE FUTURE

The EuPRAXIA Consortium is preparing a conceptual design for the world's first multi-GeV plasma-based accelerator with industrial beam quality and dedicated user areas.

ADVANCED TECHNOLOGIES

EuPRAXIA joins novel acceleration schemes with modern lasers, the latest correction technologies and large-scale user areas. The consortium offers unique training opportunities for researchers in a multidisciplinary field.

OPENING NEW HORIZONS

The project will bridge the gap between successful proof-of- principle experiments and ground-breaking, ultra-compact accelerators.

With a smaller size and improved efficiency, plasma-based technologies have the potential to revolutionize the world of particle accelerators multiplying their applications to medicine, industry and fundamental science.

INTERNATIONAL COLLABORATION

EuPRAXIA brings together a consortium of 16 laboratories and universities from 5 EU member states. The project, coordinated by DESY, is funded by the EU's Horizon 2020 programme.

The consortium holds open international events to strengthen collaborations, to connect to interested users from FEL's, high-energy physics, medicine and industry, and to assess the development of the project.

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DESY (Coordinator)
Dr. Arnd Specka,
CNRS/IN2P3 (Deputy)

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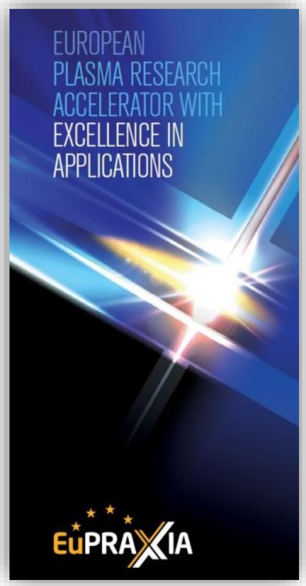

EUROPEAN PLASMA RESEARCH ACCELERATOR WITH EXCELLENCE IN APPLICATIONS

THE EuPRAXIA FILES

ISSUE I – May 2016

Foreword

Dr Ralph Aßmann
EuPRAXIA Coordinator

Novel accelerators have seen strong advances not only in achievable beam energy but also in beam quality. This success story is still developing, as you can see from the publications that we collect in this first edition of "The EuPRAXIA Files". As many of you are aware, the Horizon2020 Design Study EuPRAXIA aims at a conceptual design for a European plasma accelerator with usable beams. Instead of another newsletter we will regularly provide you with summaries of recent publications, letting the science speak for itself. EuPRAXIA has meanwhile had an excellent project start and is gearing up to a workshop in Pisa at the end of June, organized together with the European Network for Novel Accelerators EuroNNAc2 and EuCARD2. For further news on EuPRAXIA please visit our website or read regular updates in "Accelerating news". We wish you some inspirational science readings in this edition of "The EuPRAXIA Files", prepared by the EuPRAXIA outreach team in Liverpool with Ricardo Torres as lead editor.

Research Highlights

Berkeley Lab Scientists Create the First-ever, 2-stage Laser-plasma Accelerator Powered by Independent Laser Pulses

Researchers from the Lawrence Berkeley National Laboratory in the US have made an important breakthrough in the development of ultra-compact high-energy plasma-based accelerators.

In a paper recently published in Nature, they demonstrate for the first time the technique of staging, or sequencing multiple plasma accelerators independently powered. Staging is critical for high-energy physics applications of laser-plasma accelerators, as it enables to achieve higher beam energies, while maintaining accelerating gradients orders of magnitude above conventional technology.

In these experiments, electrons from one laser-plasma accelerator were transported into a second laser-plasma accelerator, powered by a second laser pulse, and accelerated. What was particularly novel about this experiment is that a plasma-based lens was employed to transport the beam between stages and a plasma mirror was used to couple in the second laser pulse. These plasma-based components allowed the system to remain extremely compact.

Members of the BELLA Center staging experiment team, from left, are Eric Esarey, Wim Leemans, Jeroen van Tilborg, Carlo Benedetti, Kelly Swanson, Anthony Gonsalves, Joost Daniels, Sven Steinke, and Kei Nakamura. Not pictured are Cameron Geddes, Carl Schroeder, Nicholas Matlis, and Brian Shaw. (Photo credit: Roy Kaltschmidt/Berkeley Lab)

With this result, one can envision scaling to beam energies of interest for high-energy physics applications in a compact footprint. However, these results are a first step toward that vision—experiments at higher beam energy, with higher efficiency and improved beam quality, will need to be performed to further develop plasma-based technology for next-generation colliders.

Read more at: http://newscenter.lbl.gov/2016/02/01/2-stage-laser-plasma-accelerator/

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Thank you for your attention!

Horizon 2020

16 Participants

DESY
INFN
Consiglio Nazionale delle Ricerche
cnrs
University of Strathclyde Glasgow
IST-ID Associação do Instituto Superior Técnico para a Investigação e Desenvolvimento
Science & Technology Facilities Council
SOLEIL SYNCHROTRON
MANCHESTER 1824 The University of Manchester
UNIVERSITY OF LIVERPOOL
ENEA Italian National Agency for New Technologies, Energy and Sustainable Economic Development
cea
SAPIENZA UNIVERSITÀ DI ROMA
UH Universität Hamburg
Imperial College London
UNIVERSITY OF OXFORD

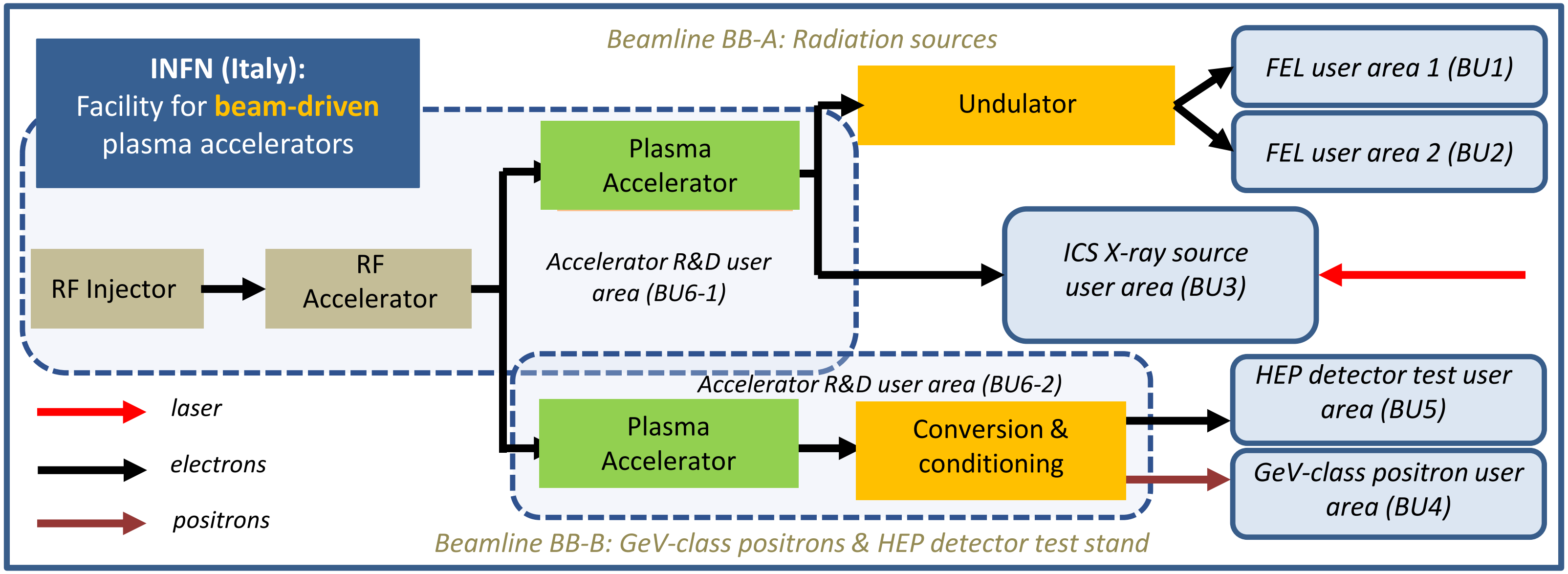
25 Associated Partners

(as of December 2018)

上海交通大学 SHANGHAI JIAO TONG UNIVERSITY
Université de Lille 1 SCIENCES ET TECHNOLOGIES
eli beamlines
HI Jena Helmholtz Institute Jena
清華大学 Tsinghua University
HZDR HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF
LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN
wigner
KPSI Kansai Photon Science Institute
大阪大学 OSAKA UNIVERSITY
RIKEN
Stony Brook University CASE
CERN
LUND UNIVERSITY
BERKELEY LAB
UCLA
JAEA
KIT Karlsruhe Institute of Technology
Università di Roma Tor Vergata
האוניברסיטה העברית בירושלים THE HEBREW UNIVERSITY OF JERUSALEM
ОБЪЕДИНЕННЫЙ ИВТАН
ИПФ РАН
JÜLICH FORSCHUNGSZENTRUM

Backup Slides

Beamline Layout - INFN Italy



INFN (Italy):
Facility for **beam-driven**
plasma accelerators

Beamline BB-A: Radiation sources

RF Injector

RF Accelerator

Plasma Accelerator

Accelerator R&D user area (BU6-1)

Undulator

FEL user area 1 (BU1)

FEL user area 2 (BU2)

ICS X-ray source user area (BU3)

Accelerator R&D user area (BU6-2)

Plasma Accelerator

Conversion & conditioning

HEP detector test user area (BU5)

GeV-class positron user area (BU4)

Beamline BB-B: GeV-class positrons & HEP detector test stand

laser

electrons

positrons

Credit: A. Walker

1. FEL with initial focus on application *X1*

Towards attosecond sources with pump-probe capability.
Two-colour FEL scheme.

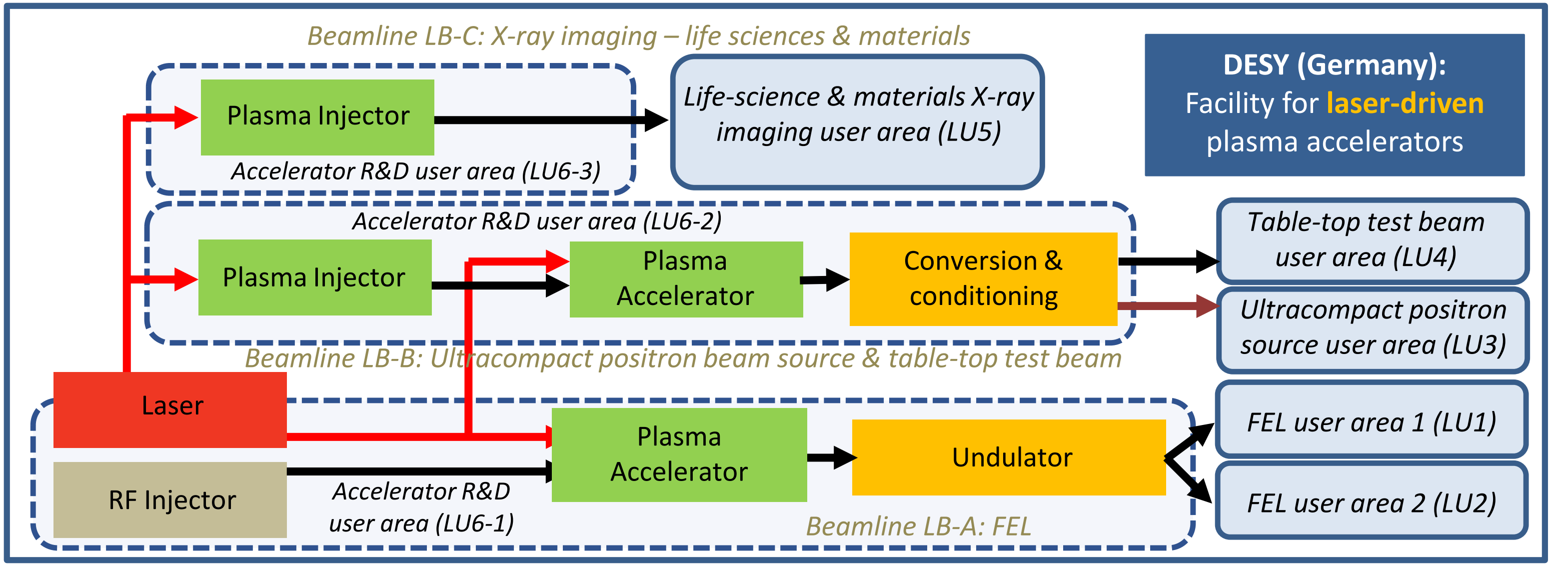
2. *GeV-class* positrons & HEP detector tests

Best exploitation of the 500 MeV PWFA beam driver.
Outstanding temporal and spatial resolution.

3. Compton source

Less complex with PWFA (1 laser 1 e-beam).

Beamline Layout - DESY Germany



Credit: A. Walker

1. FEL with initial focus on *X2 (e.g. medical)*

Towards attosecond sources with pump-probe capability

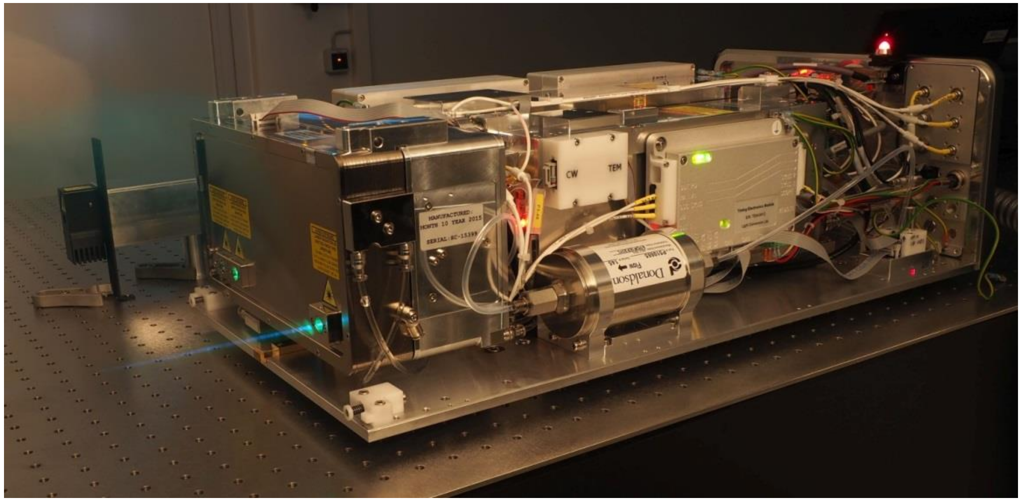
2. *Ultracompact* positrons beam source & table-top test beam

LWFA compact and efficient to produce low energy e- . High repetition capability. Outstanding temporal and spatial resolution.

3. X-ray imaging for life sciences & materials

Fully optical and most compact set-up. High repetition capability. Small source size combined with high flux capability.

Photocathode Laser System



- Yb doped laser
- Pulse energy ≥1mJ
- Central wavelength: 1030 nm (4th harmonic 257 nm)
- Pulse length range tunable: 180fs-10ps FWHM

- Laser setup tested in **I. Hartl's laboratory** (now being moved to the PC laser room).
- It is operated by **L. Winkelmann** and **S. Pumpe** for experiments on laser shaping.

→

- DESY-developed transverse flat-top shaping system
- Range for flat-top shaping: 20µm-0.2mm RMS

Transverse Deflecting Structures and Crab Cavities

The longitudinal distribution of the e-bunch is mapped into the transverse one thanks to the time dependent transverse deflecting field

Working Principle:

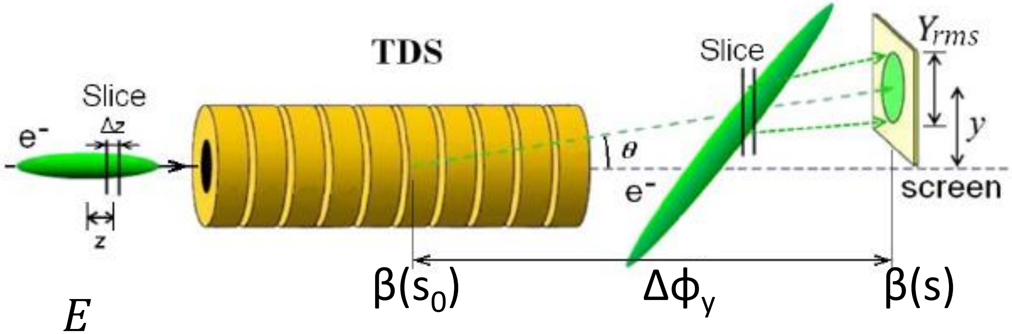


Fig. Credits: D. Malyutin PhD thesis

$$R_t = \frac{\sigma_{y,off}}{S_{y,t}} = \frac{\sqrt{\varepsilon_y \beta_y(s)}}{\sqrt{\beta_y(s)\beta_y(s_0)}\,sin(\Delta\varphi_y)}\,\frac{E}{\omega e V_0}$$

Frequency **~12GHz (X-band)** allows having 4 times higher resolution than **~3GHz (S-band)**

e-bunch:

- Kinetic Energy E
- Vertical geometric emittance ε_y

Magnetic Lattice:

- Phase advance in y plane $\Delta\phi_y$
- Beta function in the TDS $\beta_y(s_0)$

RF cavity:

- Frequency f = ω/(2π)
- Peak deflection voltage V_y

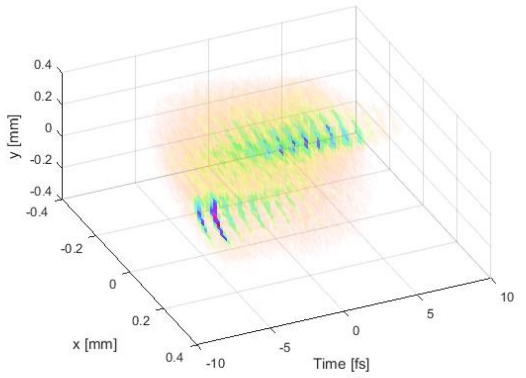
In this example streaking on y plane.

Cfr: P. Emma et al., LCLS-TN-00-12
M. Röhrs et. al., PRSTAB 12 050704 (2009)

Examples of beam characterization

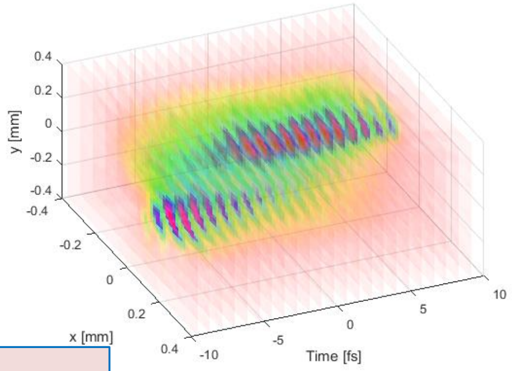
Simulations using Elegant (3D space charge effect not yet included)

Reconstruction of 3D charge density distribution



Original

Reconstructed



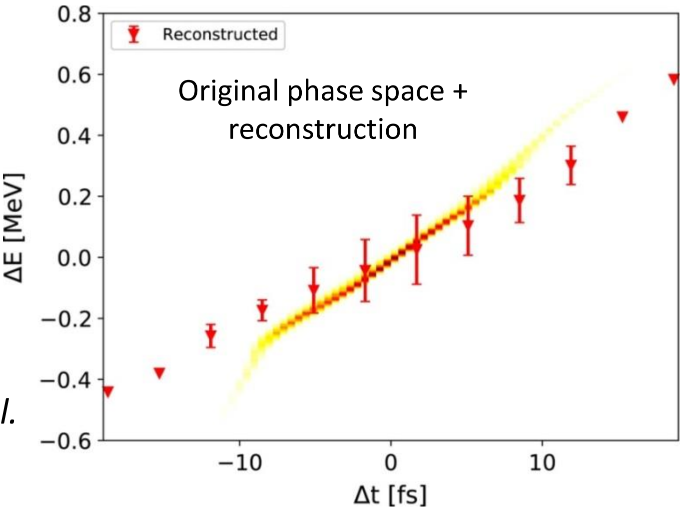
Longitudinal Resolution = 0.85 fs

Cfr: D. Marx et al., J. Phys.: Conf. Ser., vol. 874, p. 012077, (2017).

Longitudinal Phase Space

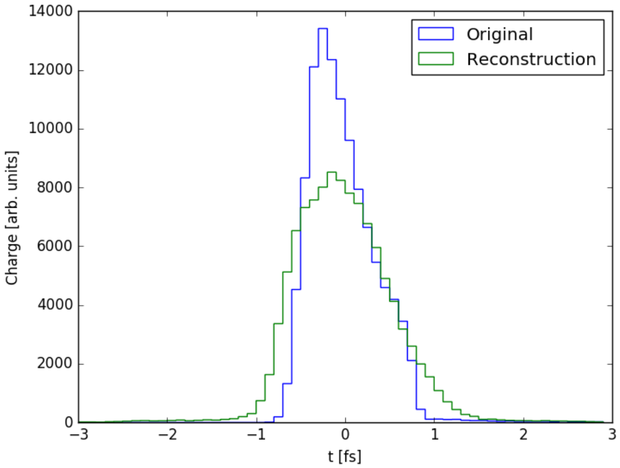
Longitudinal Resolution = 3.4 fs

Cfr: D. Marx et al., Nucl. Inst. And Meth, A (2018).



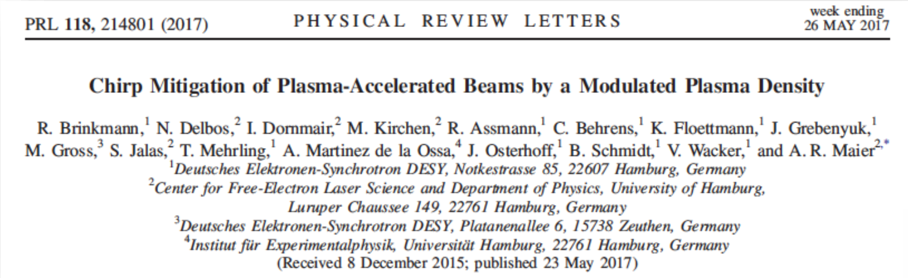
Longitudinal Charge Profile

Longitudinal Resolution = 0.42 fs



Plasma Acceleration -
Incorporate new concepts

Modulated plasma density: FODO type accelerator with electrons accelerated on both acceleration slopes



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

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

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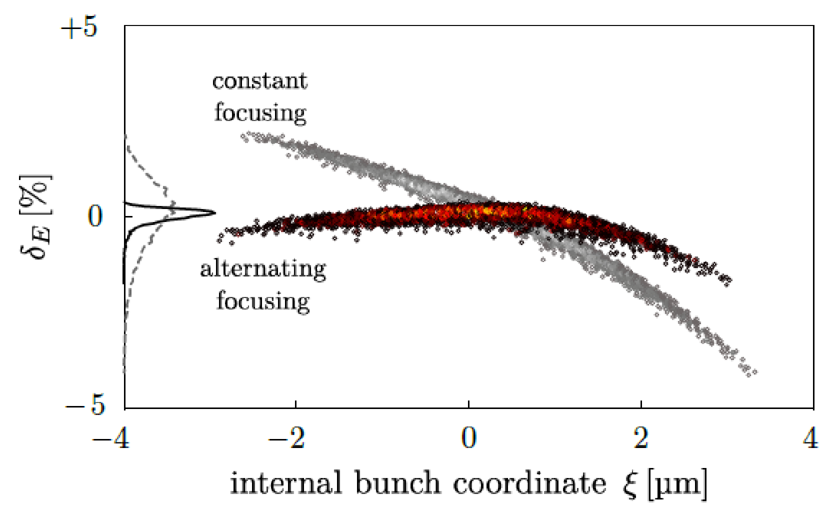
(Received 8 December 2015; published 23 May 2017)



Simulated energy spread reduced by factor 4

Plasma Acceleration - Incorporate new concepts

Solve external timing for laser driven plasma accelerators and achieve **sub-femtosecond timing jitter**

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

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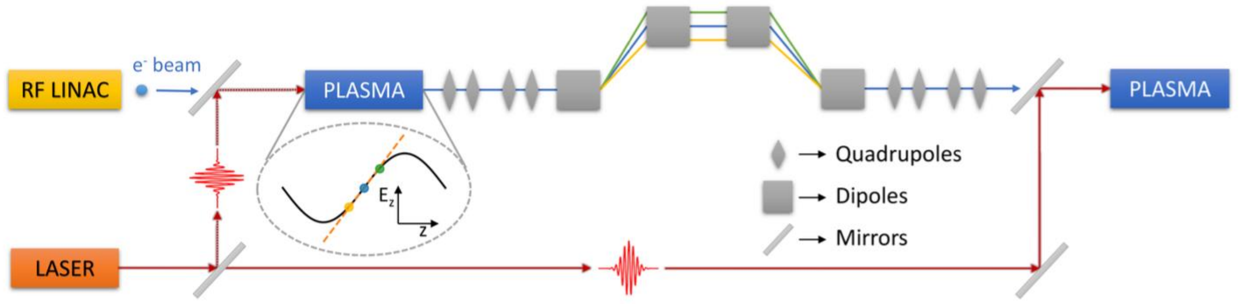


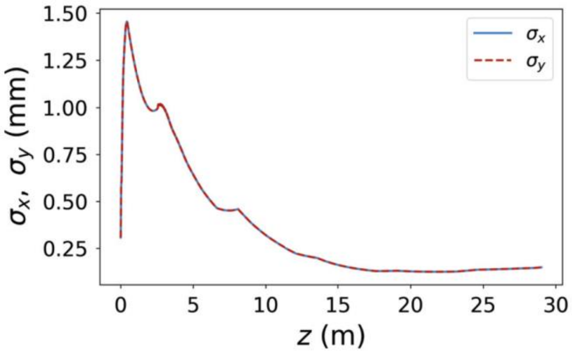
Figure 1. Schematic view of the synchronizing stage.

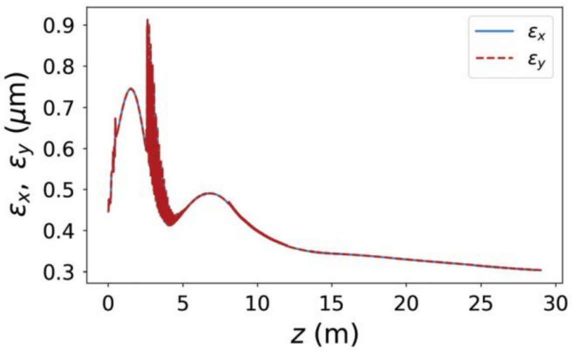
Start settings EuPRAXIA RF linac:

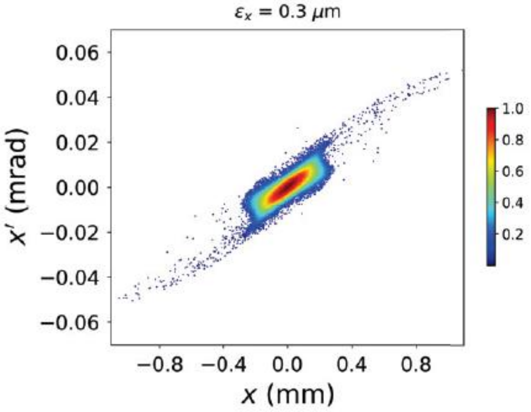
	WP4
Initial bunch charge (pC)	50
rms laser spot size (mm)	0.17
rms laser pulse length (ps)	2.9
Gun peak gradient (MV/m)	110
Gun phase (deg)	0.0
TWS 1-5 peak gradient (MV/m)	25.5
TWS 1 phase (deg) (rel. on crest)	-87.0
TWS 2 phase (deg) (rel. on crest)	-55.0
TWS 3 phase (deg) (rel. on crest)	-41.0
TWS 4 phase (deg) (rel. on crest)	-41.0
TWS 5 phase (deg) (rel. on crest)	-41.0
High charge gun solenoid field B_z (T)	0.24
Low charge gun solenoid field B_z (T)	0.11
TWS1 solenoids B_z (T)	0.037
TW2 solenoids B_z (T)	0.037
TW 3-5 solenoids B_z (T)	0.07

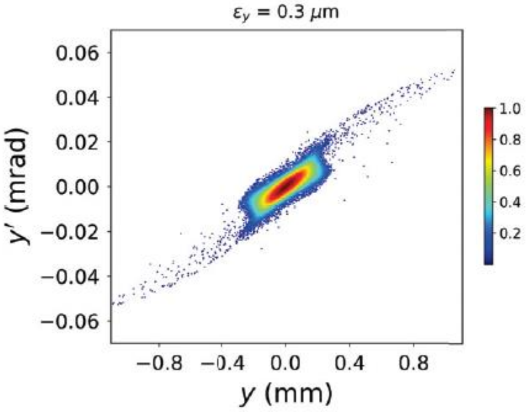
Beam dynamic simulations - Linac exit

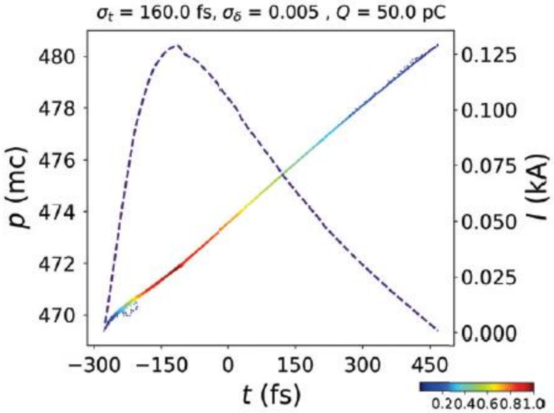
	Linac exit
Energy (MeV)	242.0
Bunch charge (pC)	50.0
rms bunch length (fs)	160.0
Peak current (kA)	0.13
Projected $\varepsilon_x/\varepsilon_y$ (µm)	0.30/0.30
Slice $\varepsilon_x/\varepsilon_y$ (µm)	0.28/0.28
β_x/β_y (mm)	\
rms energy spread (%)	0.50
Slice *rms* energy spread (%)	0.05



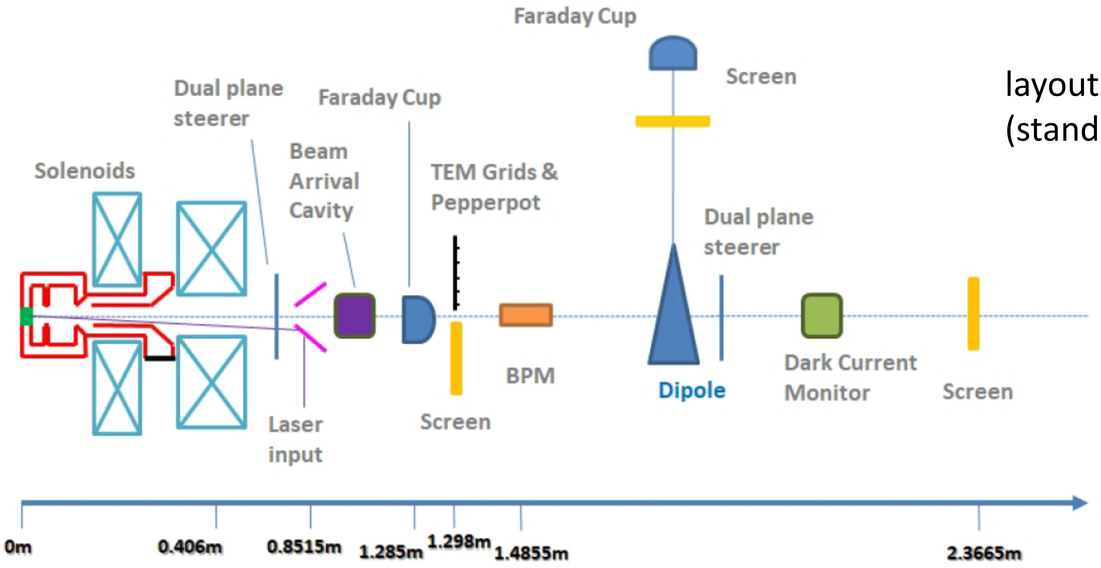




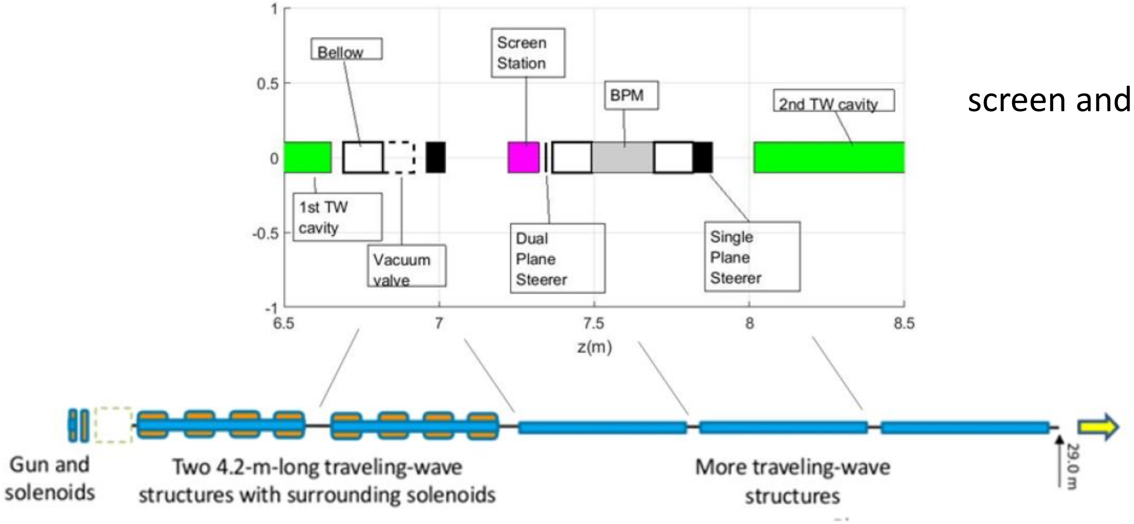




Beam Diagnostics

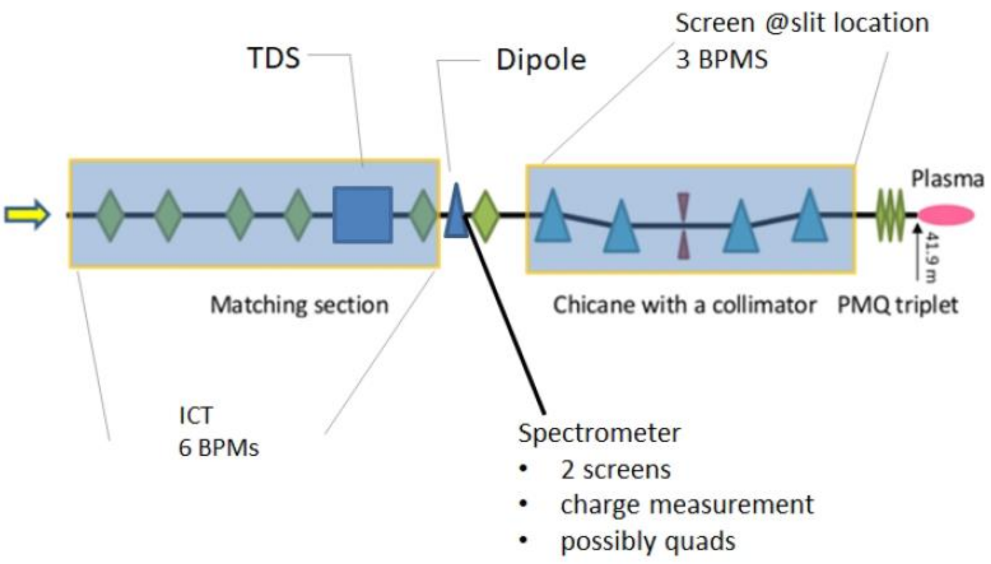


layout of the gun section ARES like diagnostics (standard diagnostics)



screen and BPM after each accelerating structure

Beam Diagnostics



TDS

Dipole

Screen @slit location

3 BPMS

Plasma

41.9 m

Matching section

Chicane with a collimator

PMQ triplet

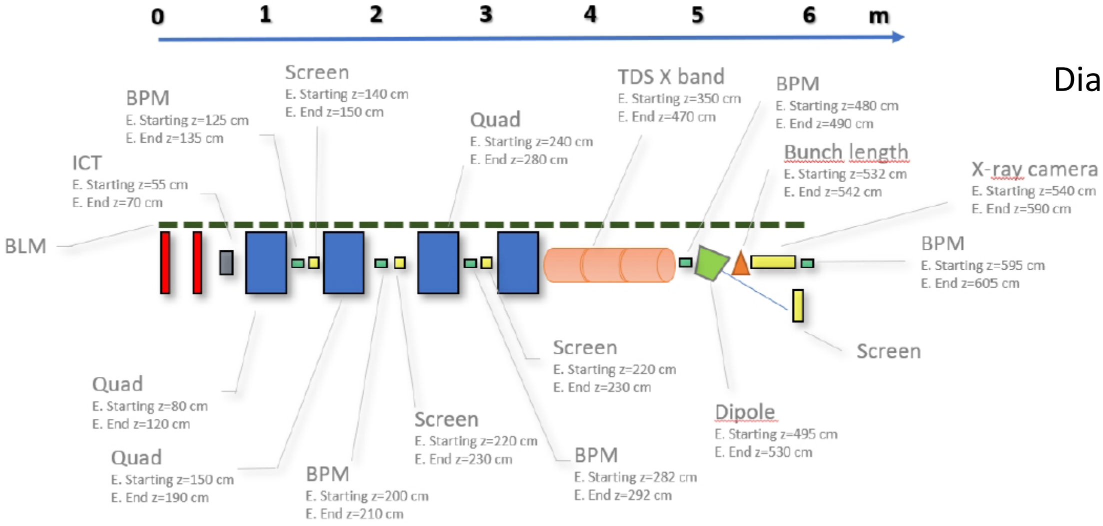
ICT

6 BPMs

Spectrometer

- 2 screens
- charge measurement
- possibly quads

Matching section: TDS to measure the full long. phase space, ICT, 6 BPMs
Dipole with 2 viewscreens and an ICT device
Collimation section: 3 BPMs in the chicane, screen at the slit location



Diagnostic beamline after the plasma booster