Summary "R & D Plans 2

Swapan Chattopadhyay (CI)
Andrei Seryi (JAI)

EuCARD, EuroNNAc Workshop, 3 - 6 May'11

Contributions

Wed 4/5

Plans at Duesseldorf	*WILLI, Oswald*	
Kjell Johnsen Auditorium, CERN	12:20 - 12:35	
Helmholtz Activities	*COWAN, Thomas*	
Kjell Johnsen Auditorium, CERN	14:00 - 14:20	
UK Plans 1 + overview	*JAROSZYNSKI, Dino*	
Kjell Johnsen Auditorium, CERN	14:20 - 14:40	
UK Plans 2	*HOOKER, Simon*	
Kjell Johnsen Auditorium, CERN	14:40 - 14:55	
UK Plans 3	*NAJMUDIN, Zulfikar*	
Kjell Johnsen Auditorium, CERN	14:55 - 15:10	
Plans Sweden	*WAHLSTRöM, Claes-Göran*	
Kjell Johnsen Auditorium, CERN	15:10 - 15:25	
Plans Portugal	*SILVA, Luis*	
Kjell Johnsen Auditorium, CERN	15:55 - 16:10	
Plans Russia	*KOSTYUKOV, Igor*	
Kjell Johnsen Auditorium, CERN	16:10 - 16:25	
Plans Netherlands	*BRUSSAARD, Seth*	
Kjell Johnsen Auditorium, CERN	16:25 - 16:40	
ELI-PP science & technology: beamlines	*KORN, Georg*	
Kjell Johnsen Auditorium, CERN	16:40 - 16:55	

Plans at Duesseldorf

Oswald WILLI

University of Düsseldorf, Laser & Plasma Physics

Present laser specifications at the HHU Düsseldorf

	Beam 1	Beam 2	Beam 3
Energy before compression	3.2 J	6 J	100 mJ
Pulse duration is variable	>25 fs	>30 fs	>30 fs
Options	adaptive mirror plasma mirror 10Hz	adaptive mirror 10Hz	2ω 10Hz

Open and free access to the facility on a collaborative basis

Laser driven electron acceleration at the HHU Düsseldorf

- Development and characterisation of new targets
- Optimization of laser parameters for LWFA to obtain small energy bandwidth, stability, divergence, reproducibility
- Multi-stage acceleration (B. Hidding et al., PRL 104, (2010))
- e-beams as seeder for classical accelerators
- Beam driven wakefields with laser accelerated electrons
- X-ray sources: Betatron and Thomson scattering

Helmholtz Activities

Thomas COWAN

Helmholtz-Zentrum Dresden-Rossendorf

R&D Plans: Helmholtz Activities (1/2)

Helmholtz Accelerator Research & Development (ARD):
Electrons: DESY, HZDR, HI-Jena (& Ions: HZDR, GSI, HI-Jena)

Facilities:
- Jena Ti:Sa JETI (10 Hz 30 TW → 100 TW in 2012)
- HZDR Draco @ ELBE (10 Hz 150 TW → 500 TW 2012 → 1 PW 2013)
- HZDR Penelope @ ELBE (→ 1 Hz, 200 J/150 fs, >PW, 2014)
- DESY planned 100 TW @ 1.25 GeV FLASH II (& standalone 5-20 MeV gun)

5 Year Perspectives:
- JETI: HI-Jena (~20% of 5 M€ / yr) + FSU-Faculty + IOQ groups
- HZDR: (~60% of 56 M€ upgrade) + operating (~1-2 M€ / yr) + staff (~20)
- DESY: ~8 M€ + 12 dedicated faculty/staff/students + DESY infrastructure

Motivation & Objectives:
- Laser Wakefield + staging + external injection
- Beam-driven Wakefield with shaped electron drive bunches
- Laser ion acceleration & applications
- Laser coupling with Accelerators: technology & radiation sources
- High intensity, high rep-rate laser development
- Advanced simulations
- fs bunch diagnostics & synchronization

DRESDEN concept HZDR

Mitglied der Helmholtz-Gemeinschaft

R&D Plans: Helmholtz Activities (2/2)

Acceleration goals:

- Injection & Staging (Jena, HZDR, DESY)
- Injection from RF accelerators (ELBE, PITZ REGAE, FLASH)
- Shaped-pulse beam-driven wakefield (DESY)
- Electron bunch characterization (Jena, DESY, HZDR)

Application goals:

- Undulator radiation, THz, SC undulators
- Thomson x-rays for pump-probe, HEDP driver at XFEL
- Research on matter under extreme conditions, HEDP, WDM, ultrafast materials
- Plasma-accelerator-driven FELs
- Medical & accelerator applications of laser-driven ions

Possibilities for Open Access:

- "Collaborative Access" for all facilities
- Distributed Test Beams within Helmholtz ARD

Expectations for Network:

- Trans-national access for ELBE- and FLASH-based experiments
- Participation in EuroNNAc "Distributed Test Beams"
- Identify & promote collaborations
- Contribute to development of future dedicated facility in Europe

DRESDEN concept

HZDR

UK Plans 1 + overview

Dino JAROSZYNSKI

University of Strathclyde

Plans of UK groups, and the Scottish Universities Physics Alliance, SUPA, and collaborators

Dino Jaroszynski, University of Strathclyde
Guenther Rosner, University of Glasgow
Phil Woods, University of Edinburgh
Allan Gillespie, University of Aberdeen
John Smith, University of the West of Scotland
John Wilson, Heriot Watt University

dino@phys.strath.ac.uk

UK programme builds on main UK results

- Improve control of acceleration
- Extend to multi-GeV beams
- Develop plasma media (capillaries, jets, cells and hybrids)
- Develop radiation sources (coherent and incoherent)
  - synchrotron sources
  - FEL
  - Betatron sources
  - Ion channel laser
  - CTR
- Extend to ultra-short bunches << 1 fs
- Decrease energy spread
- Control emittance - optimise beam transport
- Develop new injection techniques
- Investigate staging and understand beam transport
- Develop theory: PIC, reduced models, quantum models
- Continue developing new diagnostic techniques

Overview of the plans of the UK groups

- **Imperial College** – plasma media, betatron source, injection, multi-GeV, upgrade to 100 TW
- **Oxford University** – LWFA, X-ray sources, staging, upgrade laser to 50 – 100 TW
- **Strathclyde University/SUPA** – develop SCAPA, radiation source R&D, applications, FEL, new 200-300 TW laser and beam lines, training
- **Queens University Belfast** – ion acceleration, HHG

and facilities

- **STFC Daresbury laboratory** – accelerator and FEL development, undulators
- **STFC Central Laser Facility** RAL – 10 PW upgrade

Accelerator research institutes:

- **Cockcroft Institute** – accelerator R&D, cold beams, LWFA, training
- **John Adams Institute** – ASL, accelerator R&D, sources, LWFA, applications, training

Main cross-disciplinary areas ....

- Plasma Physics
- Free-electron lasers
- Accelerators
- Insertion devices
- High Power Lasers
- Plasma channels
- Electron beam diagnostics
- Terahertz techniques

..... combine R&D in laser-driven (and beam driven) accelerators with their application.

Applications as driver – focus on what needs to be developed – optimises effort and also helps drive new opportunities.

The Scottish Centre for the Application of Plasma Based Accelerators: SCAPA

SCAPA in basement 500 m^2 shielded area

Funded 1000 m^2 laboratory: 200-300 TW laser and up to 10 “beam lines” including undulators for producing particles and radiation sources for applications: nuclear physics, health sciences, plasma physics, biology etc.

SUPA-SCAPA topics of research generalised compact synchrotron-like source: particles + radiation

- Detector development
- Free-electron laser : CSE and superradiant regime
- Imaging
- Holography
- Diffraction
- Nuclear physics (aligned with ELI)
- Fusion: application of electron and ion beam
- High field physics and warm dense matter
- Medical applications: imaging, oncology
- Biology
- Plasma physics
- Material sciences and surface physics
- Homeland security

Collaboration and Access to SCAPA

- Access is as part of collaborative projects
- Support through collaborative grants
- Emphasis is on long term projects
- Up to 10 beam lines
- Emphasis on applications
- Exchange with ELI, Laserlab, EURONNA, CERN ion driven wakefield project, HiPER
- Linked into the UK community – part of UK R&D and applications roadmap
- Strong links with Cockcroft Institute, John Adams Institute and STFC.
- Joint appointments
- Doctoral training programme – students get access
- SUPA Graduate school provides excellent distance training

UK Plans 2

Simon HOOKER

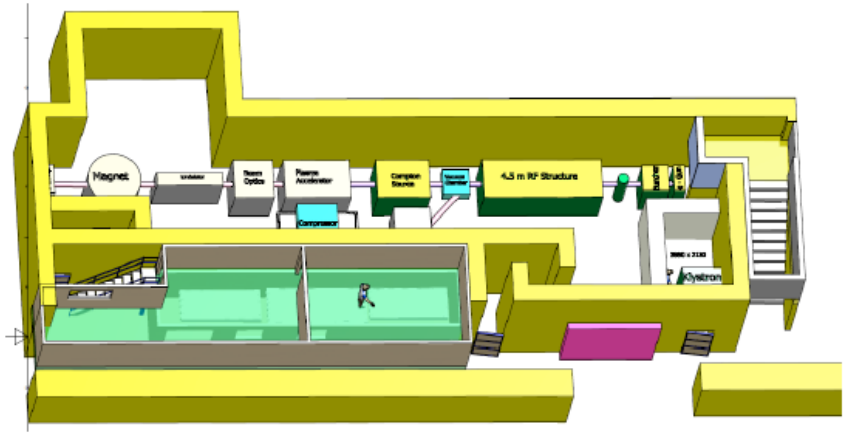
Clarendon Laboratory, Oxford

Plasma accelerator research at JAI

- Strong cross-fertilisation between expertise in conventional accelerators, plasma accelerators, and beam-driven light sources
- Plan to build new Accelerator Science Lab (ASL) in Oxford Physics
  - to develop improved laser-driven plasma accelerators
  - to develop x-ray sources driven by laser-accelerated electrons

Research focus

- Techniques for controlling electron injection
  - ionization-induced injection, density ramps
- Techniques for staging plasma accelerators
  - coupling of stages by plasma mirrors
- Development of electron beam diagnostics
  - pepper-pots, OTR screens, Smith-Purcell radiation
- Application to radiation generation
  - undulator experiments
  - numerical studies of HHG seeding



UK Plans 3

Zulfikar NAJMUDIN

Imperial College

Imperial College London

Laser developments

Vulcan 10 PW upgrade: OPCPA: 300 J in 30 fs approved awaiting funding

Acceleration to 10 GeV scale predicted

Laser developments at Imperial College

Laser	Energy (now)	Pulse Length (now)	Rep-rate	Energy planned	Pulse Length planned
Cerberus	10 J	500 fs	minutes	300 J	150 fs
Femtosecond	~ mJ	10 fs	kHz	30 mJ	10 fs

Plans

High energy :

Gemini experiments with improved laser characteristics over longer lengths (RAL).

10 PW experiments should approach 10 GeV. (RAL)

Proton driven wakefield experiments

"Controlled" experiments:

kHz short-pulse laser development for low energy high-rep rate source. (IC)

Higher energy long pulse development for higher charge higher energy beams. (IC)

Collaborative experiments at Lund, Michigan ...

Collaborations :

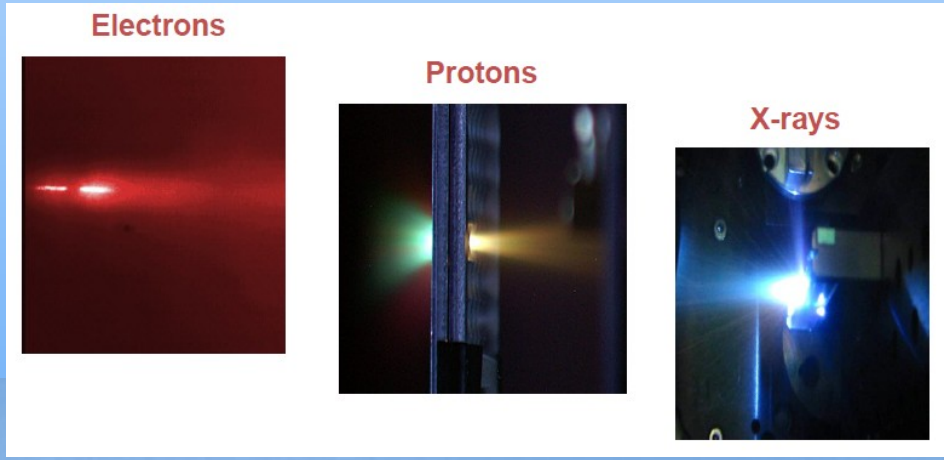
Diagnostic development, use of facilities, joint positions... with Cockroft Institute and John Adams Institute.

Collaborative experiments at Lund, Michigan ...

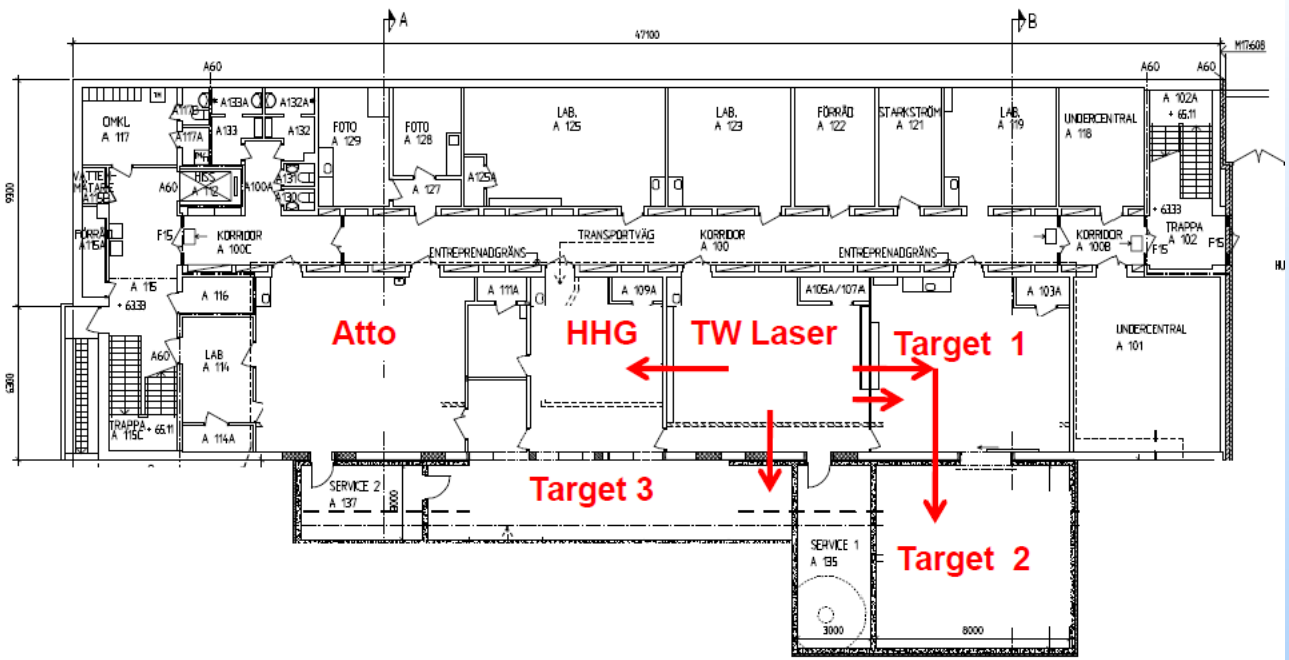
Plans Sweden

Claes-Göran WAHLSTRöM

Lund University



High-Power Laser Facility Laboratory Upgrade 2011



Laser Upgrade 2011-2013

"Only " to 60 TW + 5 TW + 3 TW
(Three separate compressors)

Emphasis on:

- Stability (pulse-to-pulse)
- Reliability (day-to-day)
- Contrast (ex. plasma mirrors)
- Beam pointing (active control)
- Wavefront (adaptive optics)

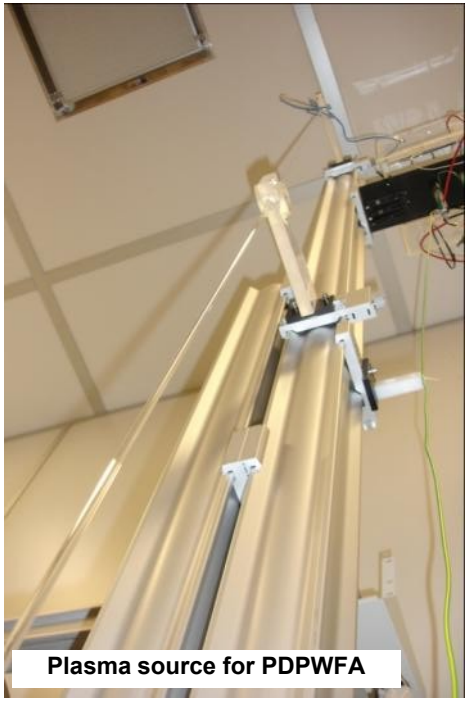
Plans Portugal

Luis SILVA

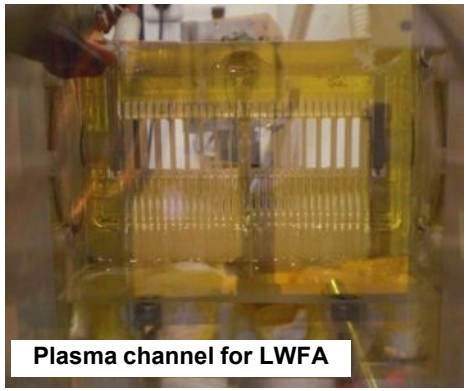
Instituto Superior Tecnico de Lisboa

Summary for IST, Lisbon, Portugal

Two areas where IST can contribute for the EU effort & next generation of experiments/facilities/developments in electron acceleration:

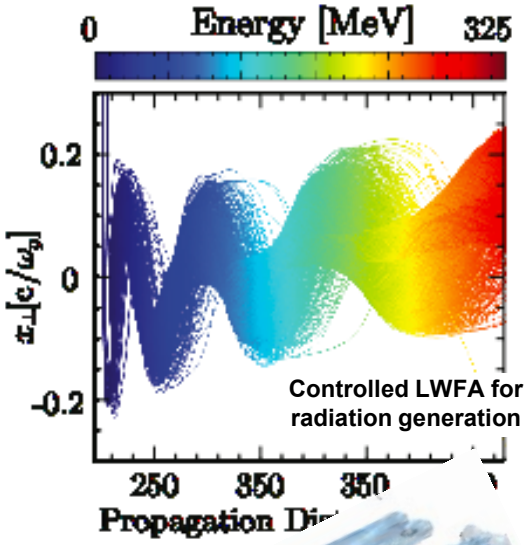


Plasma source for PDPWFA

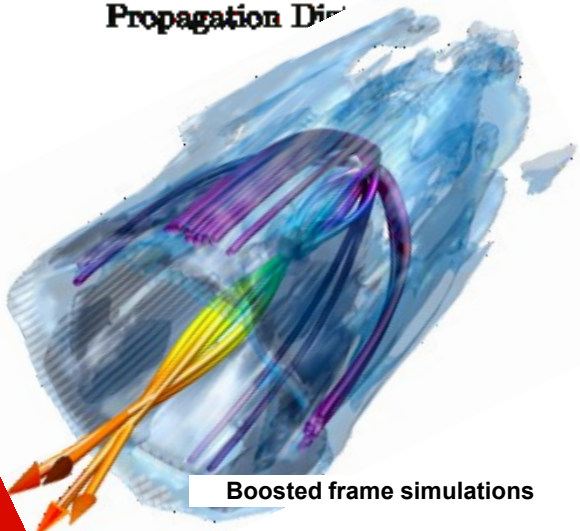


Plasma channel for LWFA

Numerical simulations to explore new ideas, to design experiments, to interpret experimental results



Long plasma sources/channels to fully explore potential of future laser/beam facilities for electron acceleration



Boosted frame simulations

EuroNACC should contribute for a coordinated integration of the efforts and **link with other communities** (e.g. LaserLab - JRAs LAPTECH & CHARPAC)

Plans Russia

Igor KOSTYUKOV

IAP *Nizhny Novgorod*

- NUMBER OF GROUPS INVOLVED IN RESEARCH RELATED TO PLASMA-BASED ACCELERATORS INCREASES IN RUSSIA

- STATUS:

• LWFA has been experimentally studied at PEARL facility.
• Plasma wakefields excited by low-power laser have been observed in gas-filled capillary tube.

- PLANS:

• PEARL-10 will provide power up to 5 PW (2014).
• The first experiments with power level ~0.5PW will start before the end of 2011.

- GOALS:

• several GeV electron beam in gas jet in 5 PW regime,
• high-quality GeV electron beam in the regime with external injection,
• 100-200 MeV electron beams in gas-filled capillary tubes with low-power, high-repetition-rate (>1kHz) laser system (+ injector)

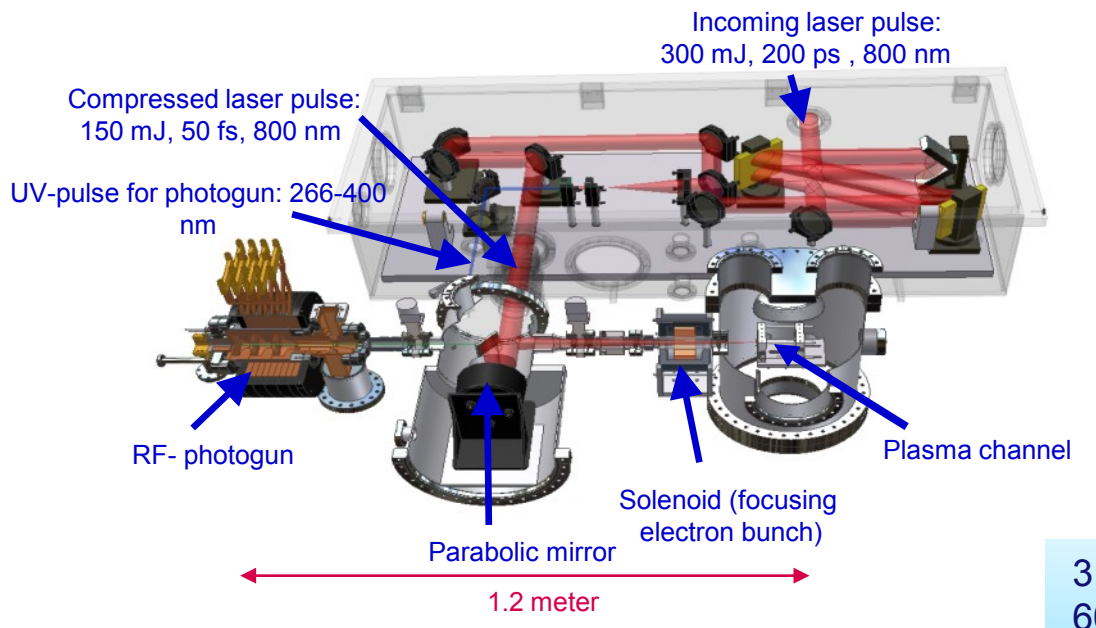
Plans Netherlands

Seth BRUSSAARD

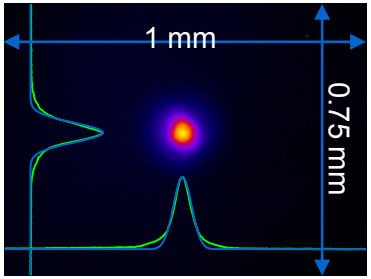
EINDHOVEN University of Technology

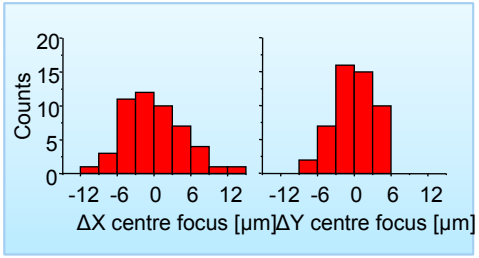
Laser Wakefield Acceleration in The Netherlands

External Injection of electrons



Experimental Results at entrance of plasma channel





3.71 ± 0.03 MeV, σ_E 2 keV
60 μm (fwhm) @ 10 pC
5 μm focus stability (laser and e-bunch)
100 fs Synchronization

Approach:
- Control input = Control output
- Table-Top for Applications

Acceleration Goals:
- Twente: 3.5 MeV electrons + 15 TW laser: Nonlinear regime, GeV level
- Eindhoven: 6 MeV electrons + 3 TW laser: Linear regime, 100 MeV level

Status:
Searching for overlap electrons/laser pulse

TU/e Technische Universiteit Eindhoven University of Technology

ELI-PP science & technology: beamlines

Georg KORN

Max-Planck-Institut für Quantenoptik

ELI-Beamlines: one of the designed ELI pillars

ELI-ALPS, Hu → Attosecond XUV/X-ray physics
Applications in material sciences and biology

ELI-Beamlines, Cz → High-brightness sources of X-rays & particles
Molecular & biomedical sciences, particle acceleration, dense plasma physics, exotic physics

ELI-NP, Ro → Laser-induced nuclear physics
Photonuclear science and applications

Site to be determined **High-intensity development** → Exawatt-class laser technology
High-intensity laser technologies for frontier physical research

ELI-Beamlines mission

1. Generation of femtosecond secondary sources of radiation and particles
   - XUV and X-ray sources (monochromatic and broadband); ELI Betatron beamline
   - Accelerated electrons (2 GeV 10 Hz rep-rate, >100 GeV low rep-rate),
     protons (200-400 MeV 10 Hz rep-rate, >3 GeV low-rep-rate)
   - preparation for a future laser driven X-FEL
   - Gamma-ray sources (broadband);

2. Programmatic applications of the femtosecond secondary sources
   - Medical research including proton therapy (1 PW-Laser, 10 Hz)
   - Molecular, biomedical and material sciences
   - Physics of dense plasmas, WDM, laboratory astrophysics

3. High-field physics experiments with focused intensities 10^{23}-10^{24} Wcm^{-2}
   - Exotic plasma physics (e.g. electron-positron pair plasma), non-linear QED
     proton and electron acceleration at high intensities and high energies

4. Participation in prototyping technologies for the high-intensity pillar
   Compression & coherent superposition of multi-10-PW ultrashort pulses

The real challenge

The real challenge is NOT to overcome the technological barriers towards multi-ten PW or even multi-hundred PW systems

Nor is it the challenge to achieve high repetition rates of such lasers for applications („*The next challenge after the PW is the kW*“ *)

Nor is it funding, due to an innovative ELI funding scheme

The real challenge is to build ELI under the temporal constraints of the Structural Funds within an environment that **has not kept up developing human resources at a rate which is needed**

Wolfgang Sandner
Max Born Institute
and
LASERLAB-EUROPE

Plans Cockcroft Institute

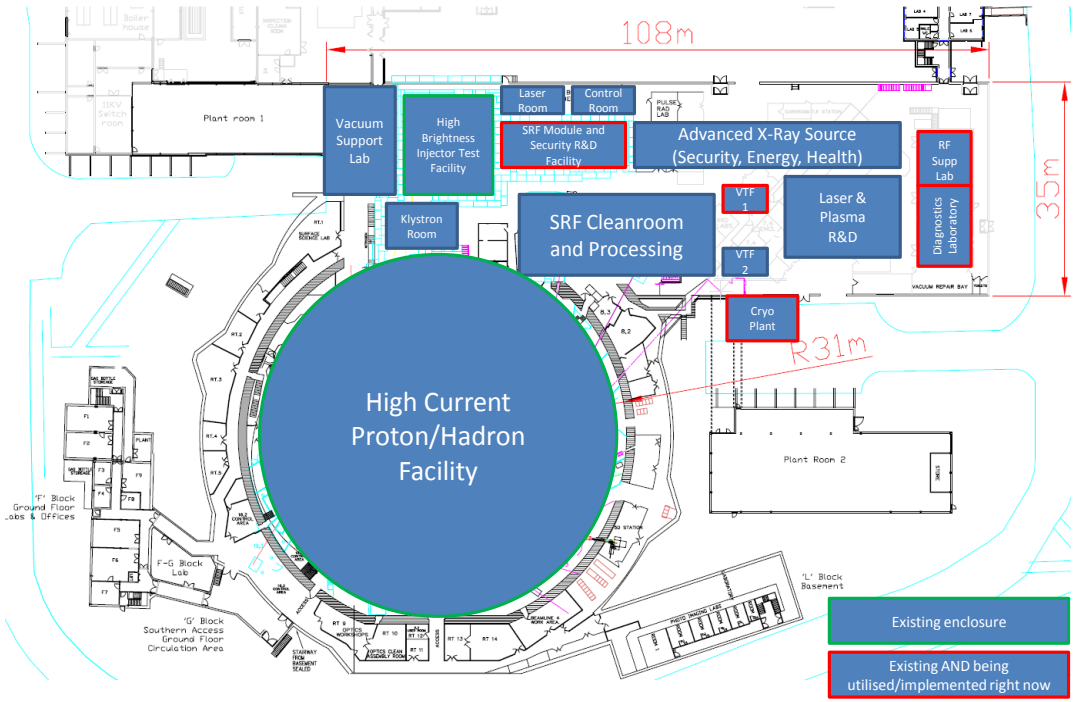
Swapan Chattopadhyay

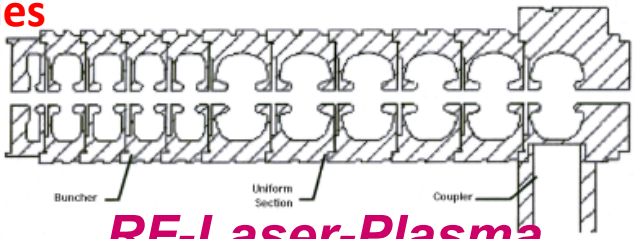
Cockcroft Institute

Advanced Laser-Plasma-Beam R&D and Facility Plans at Cockcroft Institute for Particle Physics, X- ray FELs and Electron Diffraction

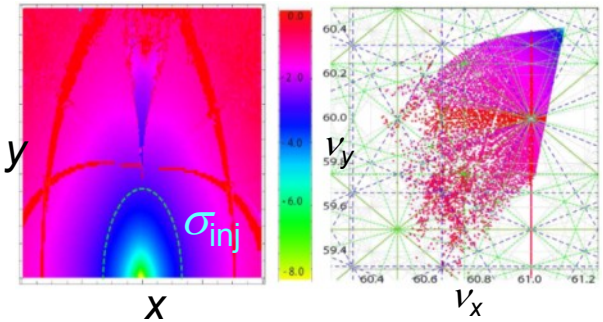
→Proton Wakefield Experiment at CERN (electron injector)
→Electron Wakefield Experiment at DESY (diagnostics & instrumentation)
→Development of "ultra-cold" electron source (collab. w/Eindhoven and Lund)
→Laser-Beam-Plasma facility combining various technologies

Accelerator R&D @ Daresbury
(RF, SRF, High Brightness E-Gun, Laser, Proton, Vacuum, Cryogenics, Diagnostics)

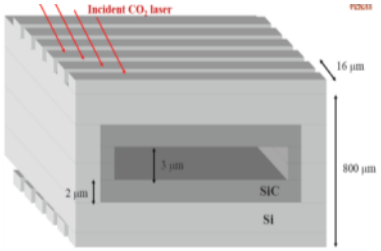


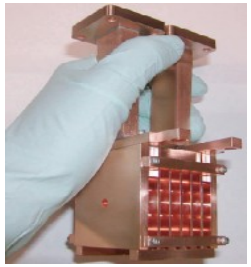


RF-Laser-Plasma



Meta-materials?





Plans John Adams Institute

Andrei Seryi

John Adams Institute

JAI New Directions

Several illustrations, not a complete portfolio

Advanced instrumentation

Feedback on ns time scale & BPMs — BPMs & FONT for CLIC, Super-B ...

Coherent Smith-Purcell radiation — S-P extended to fs regime

Laser wire — Laser wire for e+e- & proton facilities; Laser wire with fibre laser; L4A

Next Generation Compact Light Sources and laser-plasma FEL

Enabling Acc. Techniques

Diamond, Next (SC) Light Source — Diamond Options R&D; Future Light Source

FFAG, EMMA, PAMELA, PTCRi — EMMA Explore options integr. optics; PTCRi & Intern Collab.

MICE/NF — MICE/NF FETS, H- src; ESS, prj.-X, MW p..

MDI & FF: ILC — MDI & FF: CLIC/ILC; Super-B, c-τ, e-ion, ...

Training: Accelerator Science

Training: Acc. Sci. & Laser & Plasma

Now

Summary

- Plasma acceleration –
- - very active field of science and technology
- - growing activities all over the world
- -increased synergy and joint efforts between RF accelerator labs & plasma & lasers
- We hope that EuroNNAc will help in developing the novel electron accelerators based on plasma acceleration