



Progress in the IZEST Projects:

4th IZEST Conference
French Embassy, Tokyo
November 20, 2013

T. Tajima
Norman Rostoker Professor, UCI
Deputy Director, IZEST
Guest Professor, KEK

Acknowledgments for Collaboration: G. Mourou, C. Barty, W. Brocklesby, K. Nakajima, R. Hajima, T. Hayakawa, S. Gales, K. Homma, M. Kando, S. Bulanov, B. Holzer, T. Esirkepov, F. Krausz, D. Habs, B. LeGarrec, J. Miquel, W. Leemans, D. Payne, P. Martin, R. Assmann, R. Heuer, M. Spiro, B. Holzer, W. Chou, M. Velasco, J.P. Koutchouk, M. Yoshida, T. Massard, G. Cohen-Tannoudji, V. Zamfir, T. Ebisuzaki, R.X. Li, X. Q. Yan, K. Abazajian, S. Barwick, J. Limpert, D. Payne, K. Koyama, A. Suzuki, Y. Okada, K. Ishikawa, N. Rostoker



IZEST Associate Laboratories



- | | | | |
|-----------------------------------------------------------------------------------------------|----|----|----------------------------------------------------------------------------------------|
| Ecole Polytechnique - Palaiseau, France | 1 | 12 | IAP - Institute of Advanced Physics, Nizhy Novgorod, Russia |
| CEA - Commissariat à l'Énergie Atomique et aux énergies alternatives, Bordeaux, France | 2 | 13 | GIST - Gwangju Institute of Science and Technology, Gwangju, Republic of Korea |
| PPPL - Princeton Plasma Physics Laboratory, Princeton, New Jersey, USA | 3 | 14 | KEK - High Energy Accelerator Research Organization, Tsukuba, Japan |
| FERMILAB - Fermi National Accelerator Laboratory, Chicago, Illinois, USA | 4 | 15 | KPSI - Kansai Photon Science Institute, Kansai, Japan |
| LLNL - Lawrence Livermore National Laboratory, Livermore, California, USA | 5 | 16 | LeCosPa - Leung Center for Cosmology and Particle Astrophysics, Taipei, Taiwan |
| CUOS - Center for Ultrafast Optical Science, Ann Arbor, Michigan, USA | 6 | 17 | CLPU - Centro de Láseres Pulsados Ultracortos Ultraintensos, Salamanca, Spain |
| ALLS - Advanced Laser Light Source, Montreal, Canada | 7 | 18 | CERN - Organisation Européenne pour la Recherche Nucléaire, Genève, Switzerland |
| JAI - John Adams Institute for accelerator science, Oxford, UK | 8 | 19 | SIOM - Shanghai Institute of Optics and Fine Mechanics, Shanghai, China |
| TOPS - TeraHertz to Optical Pulse Source, Strathclyde, UK | 9 | 20 | Kyoto University - Kyoto, Japan |
| HHU - Heinrich Heine Universität, Düsseldorf, Germany | 10 | 21 | ELI-NP - Extreme Light Infrastructure - Nuclear Physics, Magurele, Romania |
| MEPhi - Moscow Engineering Physics Institute, Moscow, Russia | 11 | 22 | Beijing University - Beijing, China |
| | | 23 | TCHILS - Texas Center for High Intensity Laser Science, Austin, USA |



IZEST Inaugurating Confenrece (Nov., 2011, Palaiseau, France)

IZEST: a New Paradigm in **Laser** and High Energy Physics

- Integrate two communities of **laser** and HEP (ICUIL x ICFA, JTF ongoing)
- Jump-start on existing large energy **lasers**
- new initiative = High Field Science x High Energy x Astrophysics (WG: Darkfields)
- Highest intensity frontier = material breakdown → plasma (accelerator, mirror, compressor, beam dump)
- CAN (Coherent Amplification Network) **laser**
- Its applications to science and society

IZEST:

Laser Technology Driver

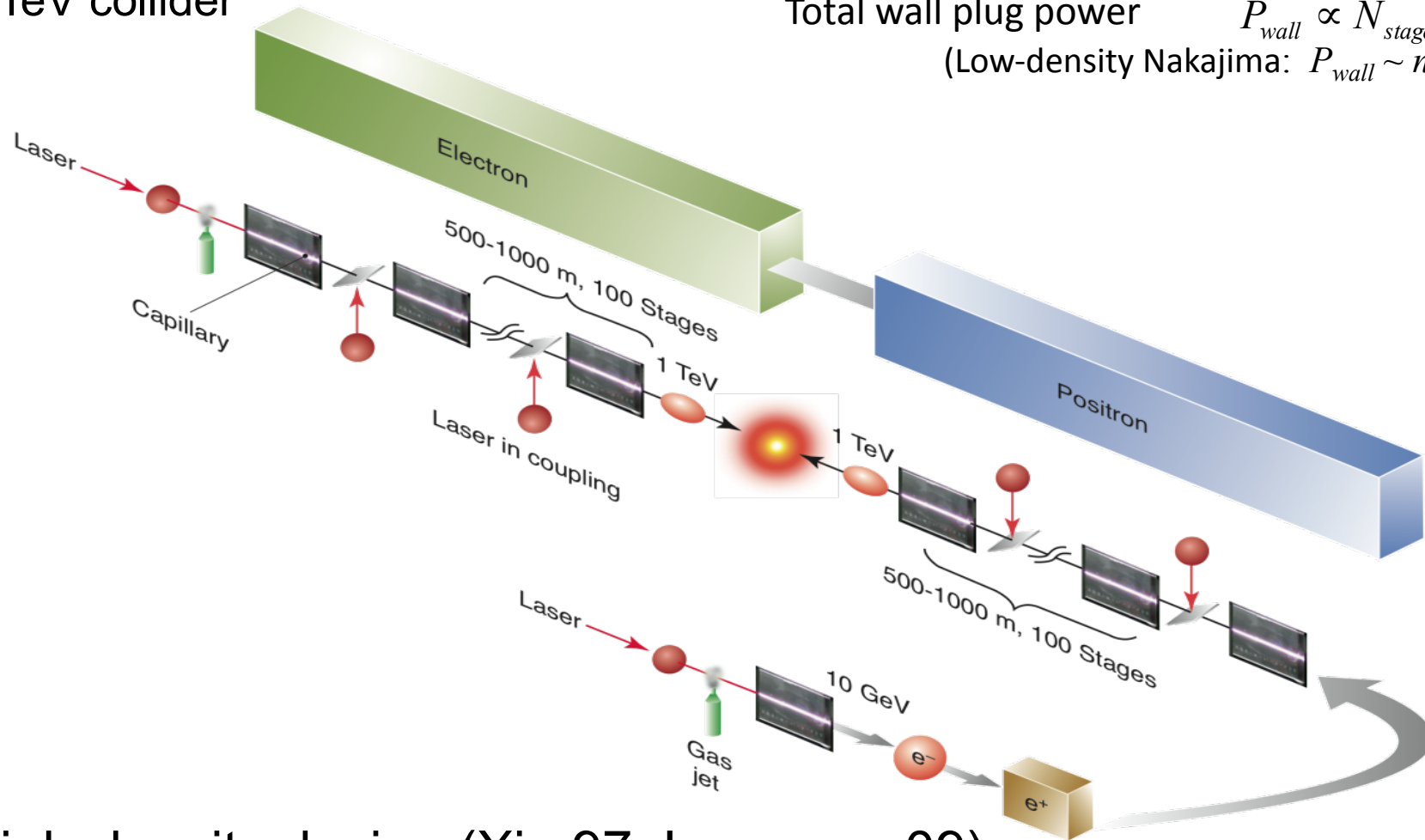
- Employment of 10kJ large energy **laser** applications to fundamental physics
- Highest peak power demands higher damage components and Plasma **Optics**.
Project C3 from J/cm^2 to 10kJ/cm^2 (WG:C3)
- **Laser** Acceleration: 100GeV single stage to ascend toward TeV-PeV level (WG: 100GeV). Needs ascending series of experiments toward largest energy **lasers** (to cover limited number of shots and find sweet spots----- the roles of Associate Labs)
- Dark field search: Testing the concept with high rep rated lower energy **lasers** to eliminate noise and identify the nature of nonlinearities of the background
- Scientific and Societal Applications need much higher and efficient average-power (WG:App): Project **ICAN** from single Watt to MW
(again, the Associate Labs play in covering the broad spectrum of parameters and configurations)

Laser driven collider concept

Laser energy: $U_L \sim n_0^{-3/2}$

a TeV collider

Total wall plug power $P_{wall} \propto N_{stage} P_{avg} \propto n_0^{1/2}$
 (Low-density Nakajima: $P_{wall} \sim n_0^{3/2}$)



High-density design (Xie,97; Leemans,09)

ICFA-ICUIL Joint Task Force on Laser Acceleration(Darmstadt,10)

CAN **Fiber Laser**

Average power
 rep rate x peak power
 Efficiency
 Smartness (digital control)
 Intensity

Collider requirements

→ luminosity
 → cost
 → emittance
 → gradient

γ - γ collider requirements

1-50kHz rep rate (other reqs are easier)

Dark matter search

average power → luminosity

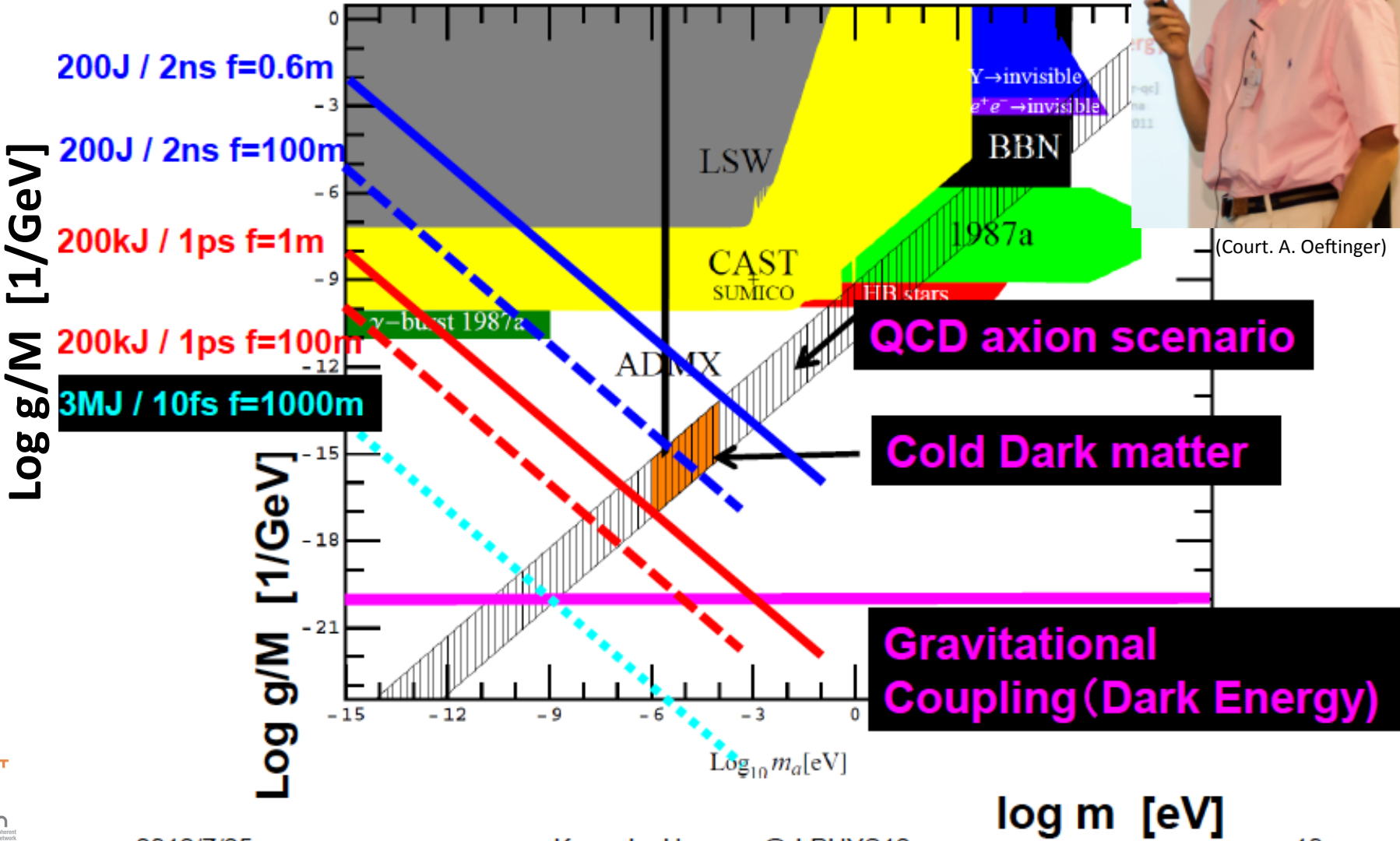
Proton acceleration

intensity (energy of beam), smartness
 (beam quality), average power (fluence)



R. Aleksan (Court. A. Oeftinger(CERN))

Photon mixer's road to unknown fields: dark matter and dark energy



K.Homma, D.Habs, T.Tajima
(2011)

Mountain of Radioactive Junk at Nuclear Facility



B. Carlucci
(Court. A. Oeftinger(CERN))



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CEA/DAM

France

Name of the IZEST
representative : J.L. Miquel

Topics related to IZEST :

- 1 – High intensity short pulse laser (PETAL)
- 2 – Plasma diagnostics (UV, X-ray, gamma, particles)



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Lab: Lawrence Livermore
National Lab

Country: USA

Representative : Edward Moses

Topics related to IZEST :

- 1 – High energy and ultrahigh-intensity lasers
- 2 – Laser-based particle accelerator
- 3 – X-ray and gamma-ray sources
- 4 – Relativistic Optics
- 5 – High Energy Density Science

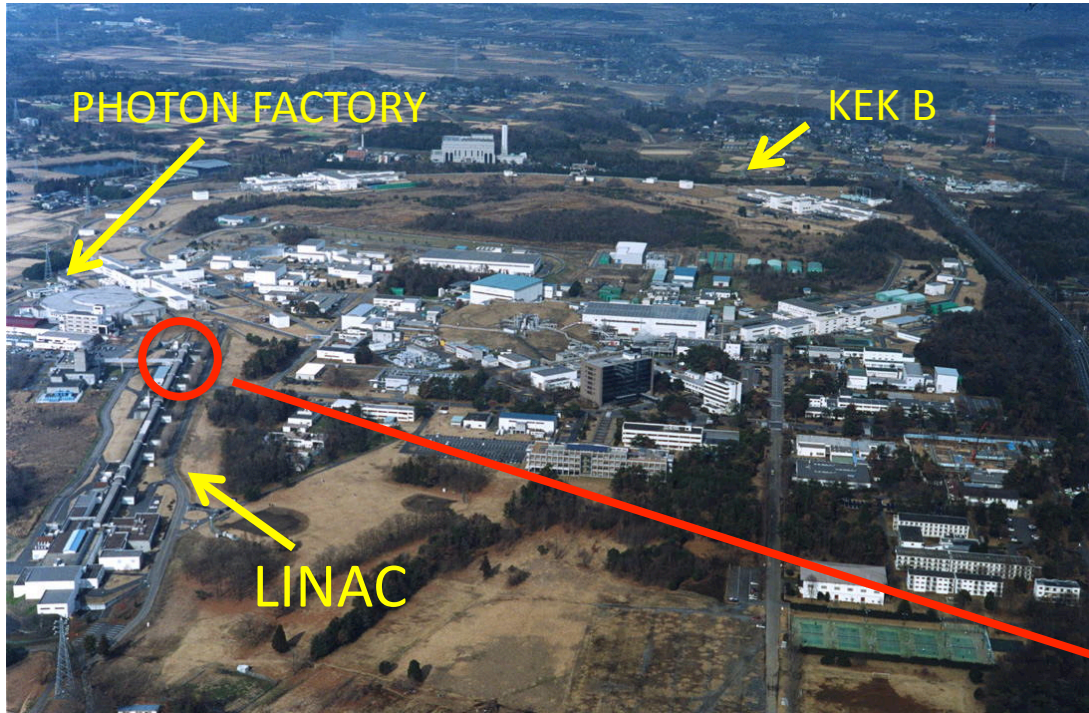
IZEST Could Benefit from the largest Pump Lasers Up to the MJ



PETAL-LMJ



NIF LLNL



KEK

Japan

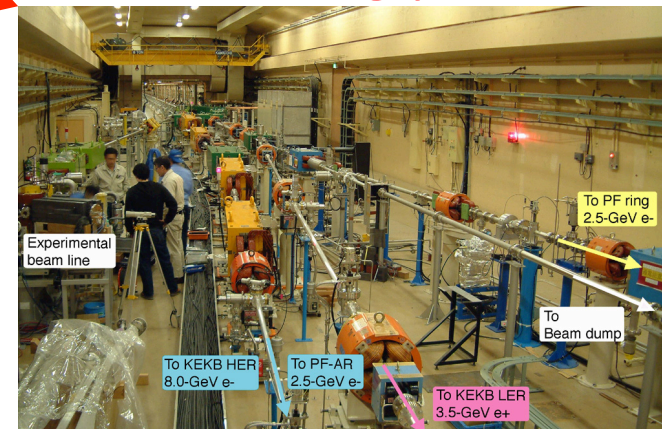
Kazuyoshi Koyama

(Mitsuhiro Yoshida)

(Mitsuaki Nozaki)

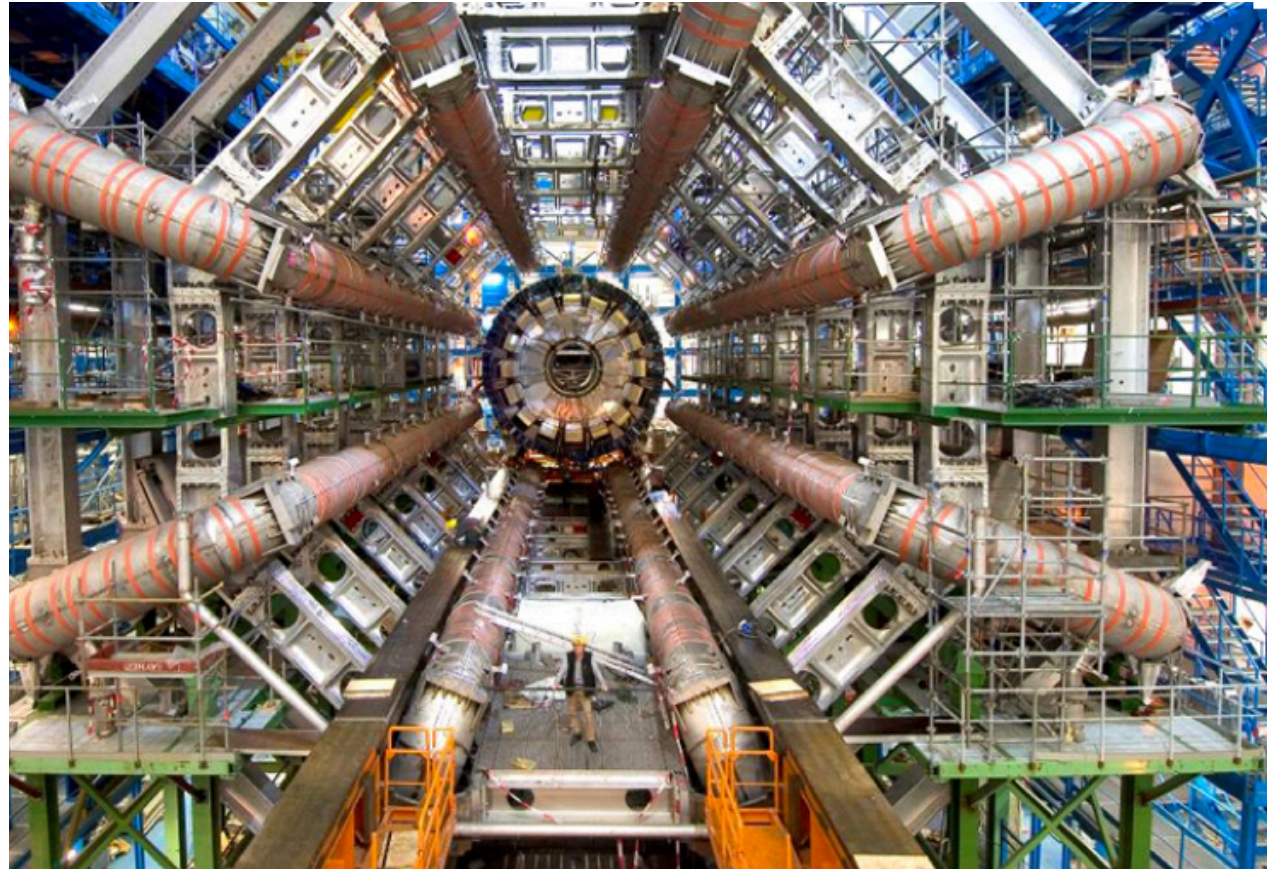
Switching yard

- 1 – Laser-driven Electron Injector
- 2 – Long Plasma Channel





High Energy Physics Supporters: CERN



Ralph Heuer
CERN Director General



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A view of GSI and the upcoming FAIR accelerator

GSI Darmstadt

Germany

Name of the IZEST
representative : T. Kühl

Topics related to IZEST :

- 1 – Plasma amplification (Raman and Brilloin)
- 2 – Particle acceleration
- 3 – Laboratory astrophysics
- 4 –
- 5 max –

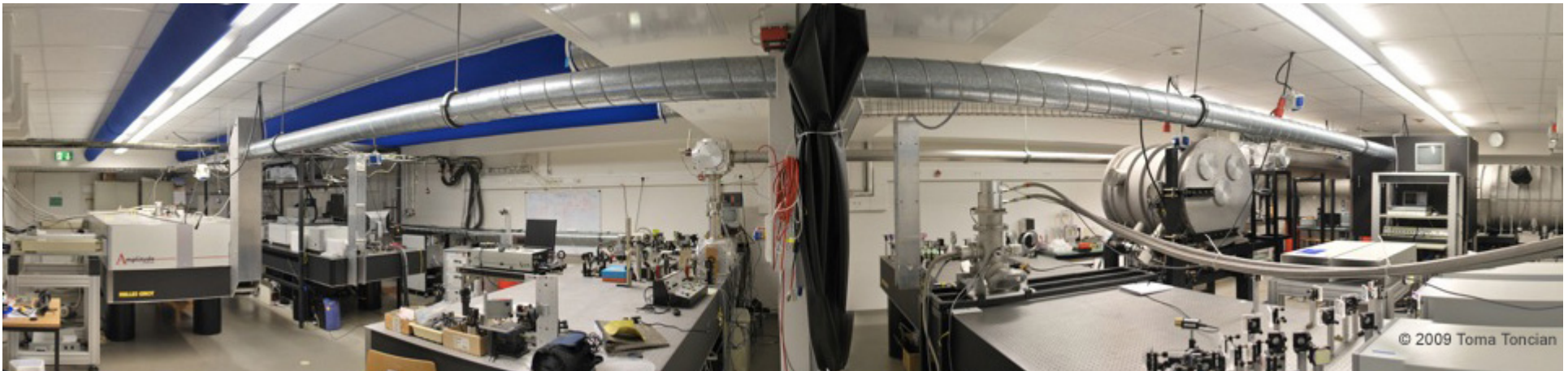


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Arcturus (HHU Düsseldorf) Germany
Representative : O. Willi



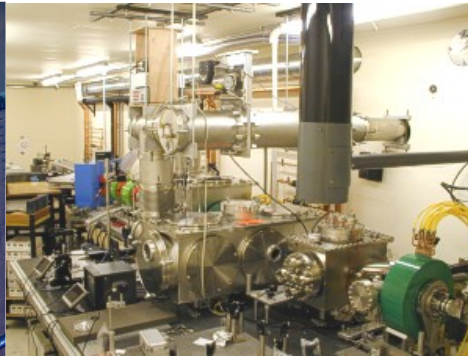
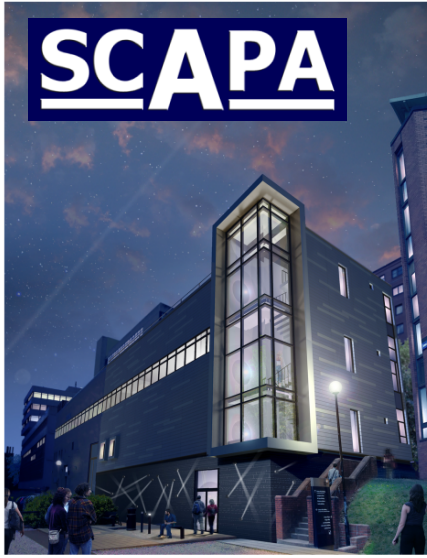
Topics related to IZEST :

- 1 –Novel sources of high energy radiation and particles
- 2 –Pulse amplification by stimulated Raman and Brillouin scattering
- 3 –Theory (SRS, SBS)



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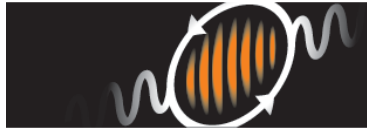


ALPHA-X
@ Strathclyde

SCAPA – ALPHAX
Scotland
United Kingdom
Dino Jaroszynski

Topics related to IZEST:

- 1 – Laser-plasma acceleration: electrons and ions
- 2 – Raman amplification in plasma
- 3 – Pulse compression and beam combination in plasma
- 4 – Radiation reaction + coherent x-ray production using plasma
- 5 – Plasma, beam and radiation diagnostics and media



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Imperial College
London

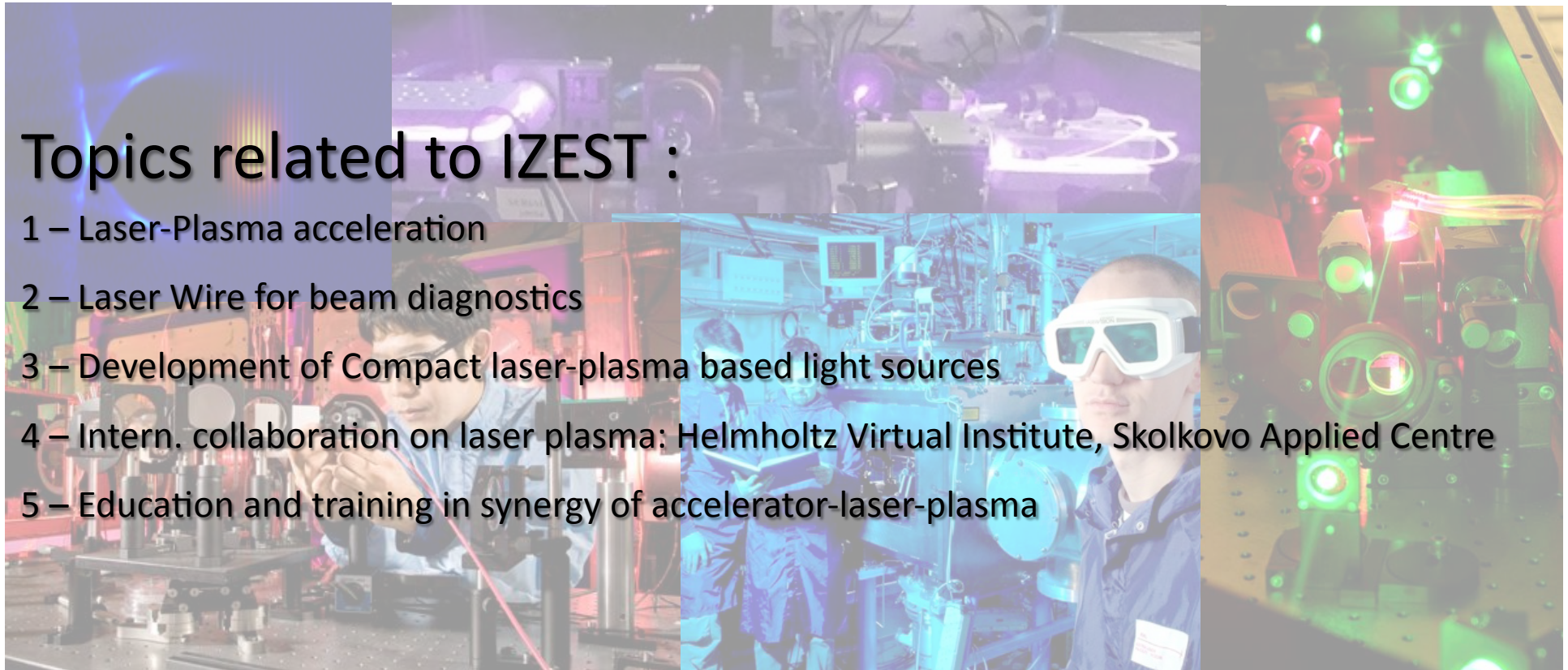


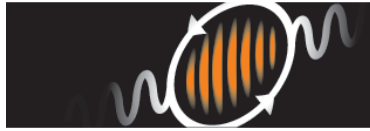
The John Adams Institute (UK) is jointly hosted by the physics departments of the University of Oxford, Royal Holloway, University of London and Imperial College London.

IZEST representative : Prof. Andrei A. Seryi

Topics related to IZEST :

- 1 – Laser-Plasma acceleration
- 2 – Laser Wire for beam diagnostics
- 3 – Development of Compact laser-plasma based light sources
- 4 – Intern. collaboration on laser plasma: Helmholtz Virtual Institute, Skolkovo Applied Centre
- 5 – Education and training in synergy of accelerator-laser-plasma





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Centro de Láseres Pulsados
Spain

Name of the IZEST
representative :

Luis Roso / Ricardo Torres

Topics related to IZEST :

- 1 – Theory of Vacuum Polarisation
- 2 – Relativistic Optics
- 3 – Laser Plasma Acceleration



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www.ifin.ro



IFIN-HH / ELI-NP

“Horia Hulubei” National Institute of Physics and
Nuclear Engineering
Extreme Light Infrastructure – Nuclear Physics

ROMANIA

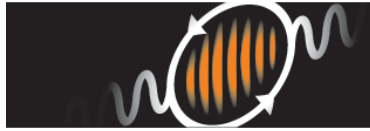
IZEST representative :

Dr. Nicolae Victor Zamfir

Director General IFIN-HH
ELI-NP Project Leader

Topics related to IZEST :

- 1 – photonuclear reactions
- 2 – synthesis and investigation of neutron rich nuclei of astrophysical interest
- 3 – material behaviour under strong irradiations
- 4 – development and optimization of nuclear diagnostics for laser-target interaction
- 5 – fast electronics and data acquisition



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Institute of Applied Physics of Russian Academy of Sciences

IZEST representative :
Prof. Alexander Litvak

Topics related to IZEST :

- 1 – Construction of multipetawatt and exawatt laser systems
- 2 – Development of compact laser-plasma based accelerators and X-Ray sources
- 3 – Interaction of laser radiation with matter under ultrarelativistic intensities
- 4 – QED phenomena in the presence of ultraintense laser fields



Name of the Lab: **National
Research Nuclear University
MEPhI**

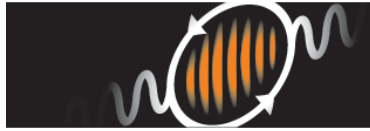
Country: **Russia**

Name of the IZEST
representative :

Nikolay Narozhny

Topics related to IZEST :

- 1 – development of very high intensity lasers (participation in XCELS - IAP RAS, UFL-2M - RFNC VNIIEF)
- 2 – high energy fundamental physics, physics beyond the Standard Model (high energy QED processes in superstrong laser field, QED cascades, etc.)
- 3 – vacuum structure (vacuum polarization, pair creation from vacuum)
- 4 – dark matter search (PAMELA experiment)



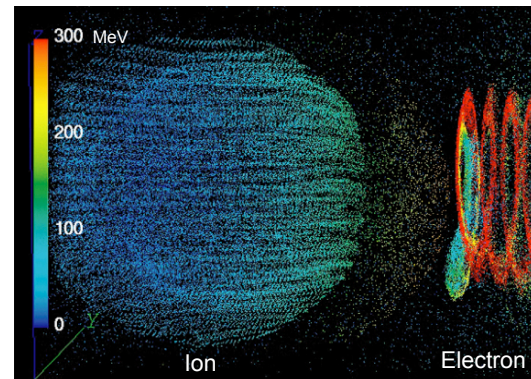
10 PW laser - LFX

Institute of Laser Engineering (ILE)
Osaka University
JAPAN
Masa MURAKAMI

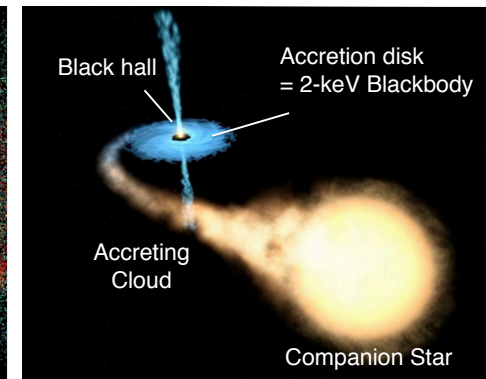
LFX laser at Osaka (10 PW / 10 kJ / 1 ps)
is used for such studies as Fast Ignition
(laser fusion) and laboratory astrophysics.

Topics related to IZEST :

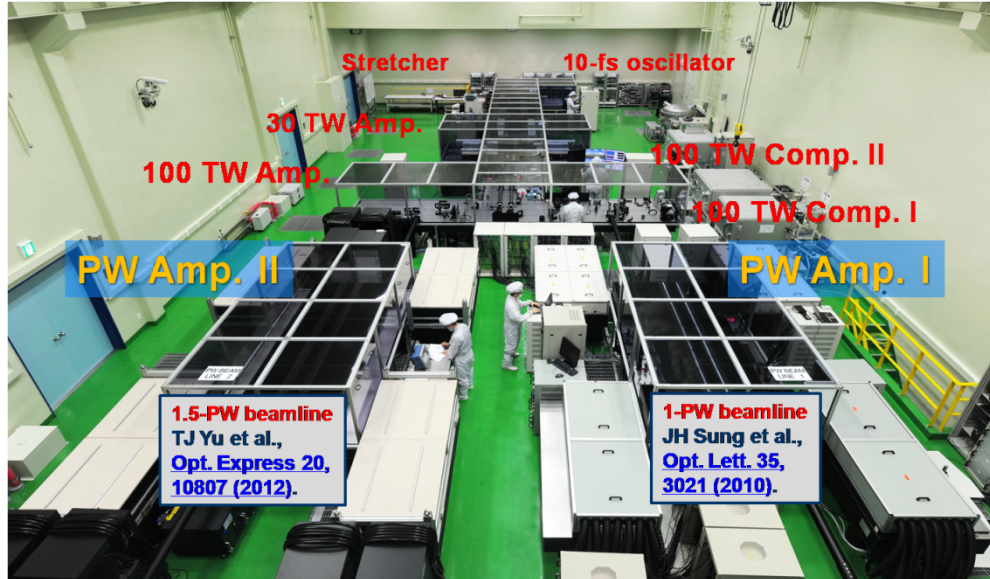
- 1 – Generation of positrons
- 2 – Relativistic Coulomb explosion
- 3 – Generation of extreme environment relevant to blackhole
- 4 – Nuclear transmutation



Relativistic Coulomb explosion



Environment for blackholes



Name of the Lab: APRI/GIST

Country : Republic of Korea

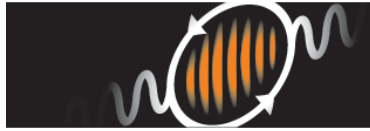
Name of the IZEST
representative :

- Prof. Jongmin Lee

- Dr. Tae Moon Jeong

Topics related to IZEST :

- 1 – Femtosecond High-Power Laser
- 2 – Electron Acceleration
- 3 – Proton Acceleration
- 4 – X-ray/ γ -ray generation
- 5 max –



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Kansai Photon Science
Institute (KPSI), Japan
Paul R. Bolton, KPSI
Deputy-Director-General

Topics related to IZEST :

- 1 – high peak power laser development
- 2 – laser-driven particle acceleration
- 4 – x-ray/gamma-ray source development



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Laboratory for Laser Matter Science
Advanced Research Center for Beam Science
Institute for Chemical Research
Kyoto University, Japan
Professor Shuji SAKABE



Topics related to IZEST :

- 1 – Generation of energetic electrons and ions by intense femtosecond laser pulses
- 2 – Ultrafast electron diffraction using electrons accelerated by femtosecond laser pulses
- 3 – Guide and transportation of laser-generated electrons
- 4 – Plasma mirrors



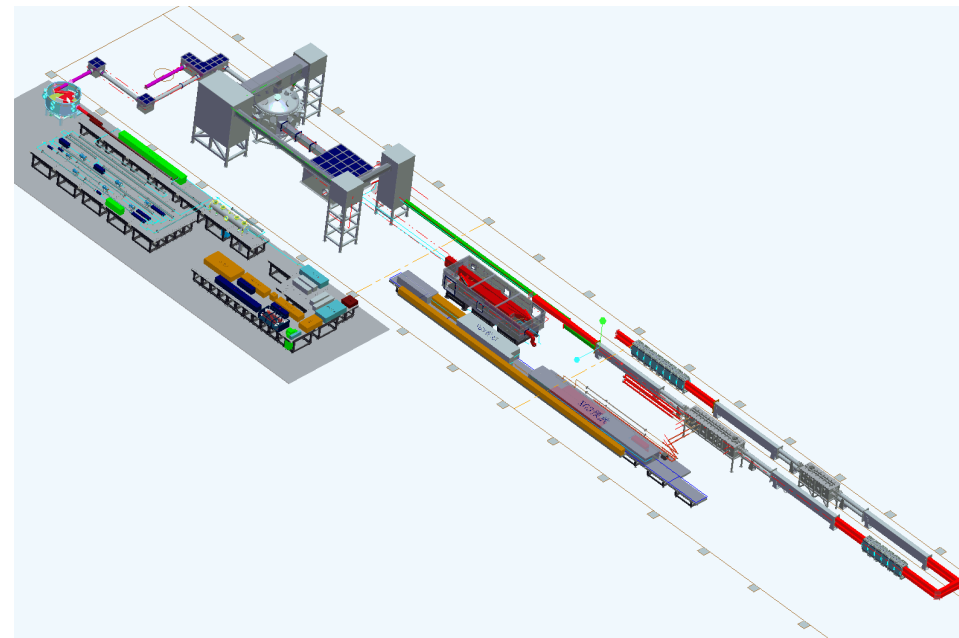
500TW/30fs Laser: SILEX-II



**Science and Technology on
Plasma Physics
Laboratory, China**
Name of the IZEST
representative : **Yuqiu Gu**

Topics related to IZEST :

- 1 – laser particle acceleration
- 2 – Advanced X ray sources
- 3 – laser nuclear physics
- 4 – fast ignition



**XingGuang III: Combined fs/ps/ns 3
beams**



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**State Key Laboratory of High
Field Laser Physics**

**Shanghai Institute of Optics
and Fine Mechanics (SIOM)**

China

Prof. Ruxin Li

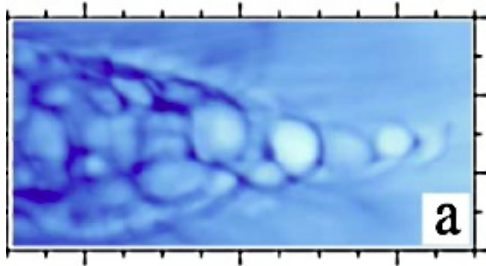
Prof. Yuxin Leng

Topics related to IZEST :

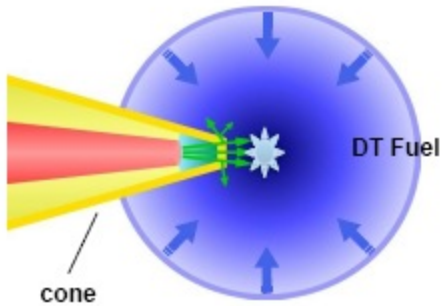
- 1 – Multi petta watt laser: CPA and OPCPA**
- 2 – Laser particles acceleration (electron, proton and carbon ion etc.);**
- 3 – Attosecond science**

Institute of Heavy Ion Physics @ Peking University, China

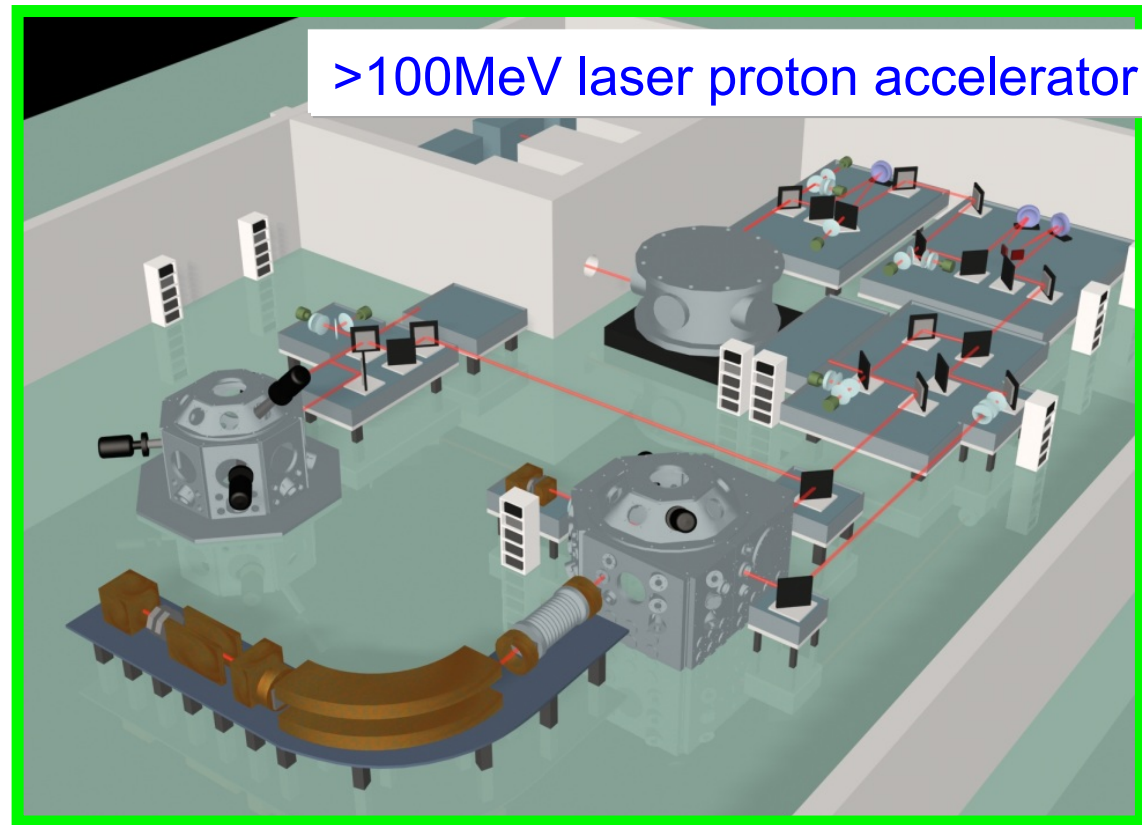
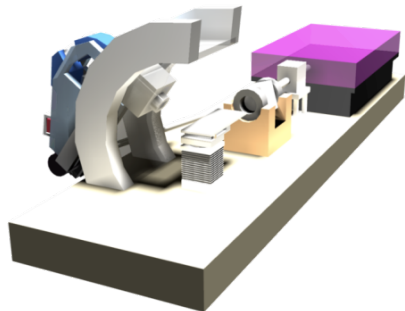
1) Proton imaging



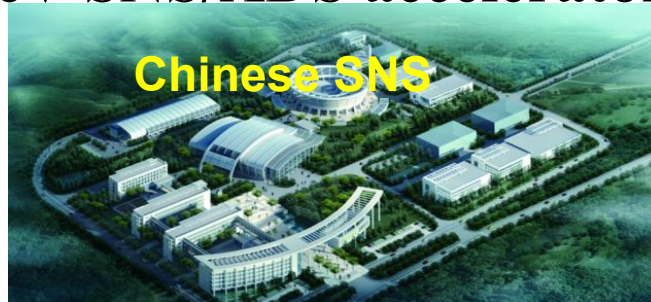
2) Fast Ignition



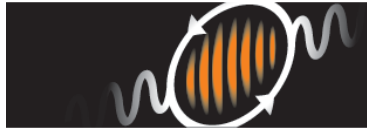
3) Proton therapy



4) GeV SNS/ADS accelerator



5) HEP accelerator



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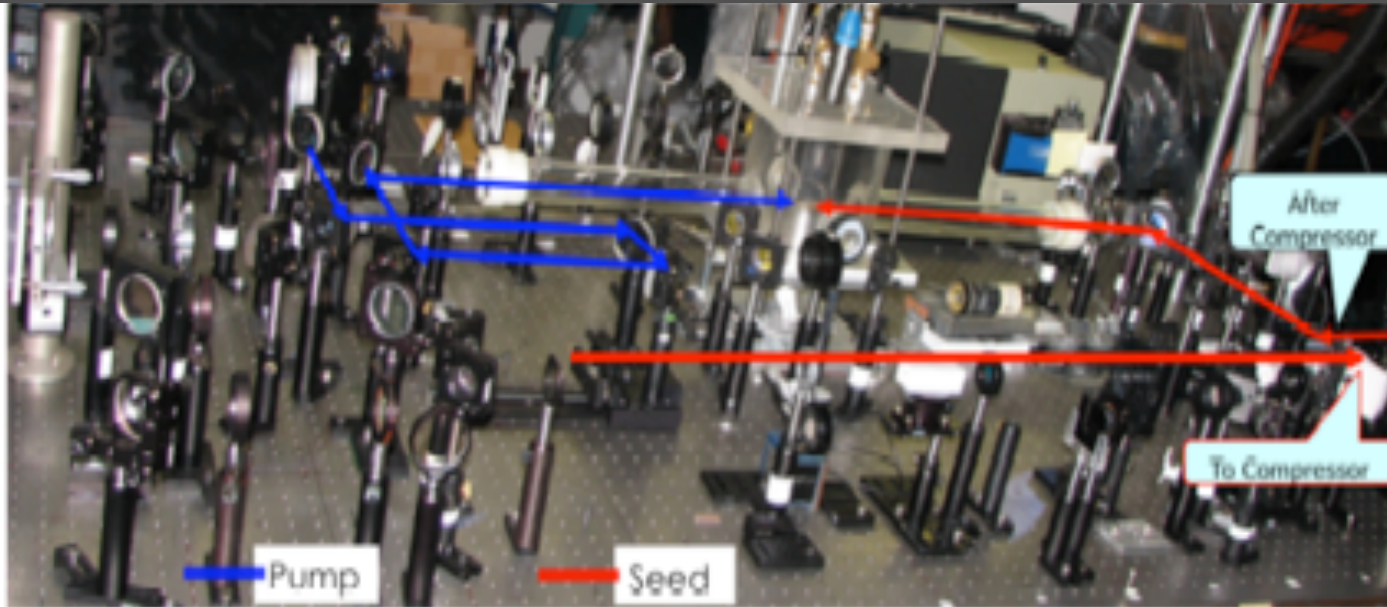


Center for Ultrafast Optical Science (CUOS)
University of Michigan
USA

Karl Krushelnick
Victor Yanovsky
Alec Thomas
Anatoly Maksimchuk

Topics related to IZEST :

- 1 – High field laser matter interactions
- 2 – Experimental Raman scattering/amplification
- 3 – Target development for Raman amplification
- 4 – Experiments on QED effects in high field interactions
- 5 – Diagnostic development



Picture of the Lab

**New SRBS Setup
for $I \sim 10^{20} \text{ W/cm}^2$
in Compact System**

Pump energy: 1.5J;
beam diameters of
pump & seed: 250 μm

Topics Related to IZEST:

1. Novel sources of high energy radiations and particles,
2. Laser in the relativistic lambda cubed
3. Fiber-based high peak power and high average power lasers.

Name of the Lab: PRINCETON
ULTRAHIGH LASER INTENSITY
PHENOMENA; **PULIP**,

Country: USA

IZEST representative :
Prof. Szymon Suckewer



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Picture of the Lab



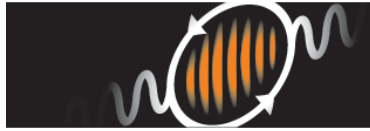
Name of the Lab: LeCosPA, NTU

Country: Taiwan

Name of the IZEST
representative : Pisin Chen

Topics related to IZEST :

- 1 – Laboratory Astrophysics
- 2 – Plasma wakefield acceleration for UHECR
- 3 – Probing Unruh effect with high intensity laser
- 4 – QED instability (boiling the vacuum)
- 5 – Vacuum instability of dark energy



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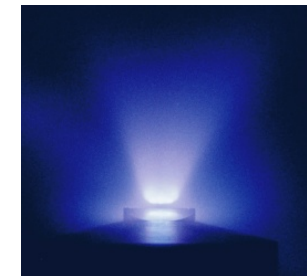
Military University of Technology –
Institute of Optoelectronics

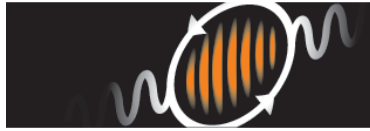
Poland

Name of the IZEST representative : Prof.
Henryk Fiedorowicz

Topics related to IZEST :

- 1 – interaction of high intensity lasers with matter,
- 2 – novel sources of high energy radiations and particles,
- 3 – target systems for high intensity laser interactions,
- 4 – solid state and fiber-based high peak power and high average power lasers.





Picture of the IMSLP-TUC



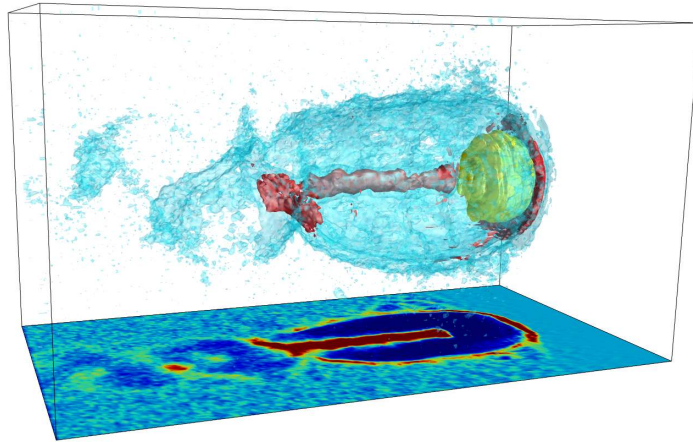
Name of the Lab : Institute of Matter Structure and Laser Physics [IMSLP], Technical University of Crete

Country : Chania – Crete - GREECE

Name of the IZEST representative : Prof. Stavros D. Moustazis

Topics related to IZEST :

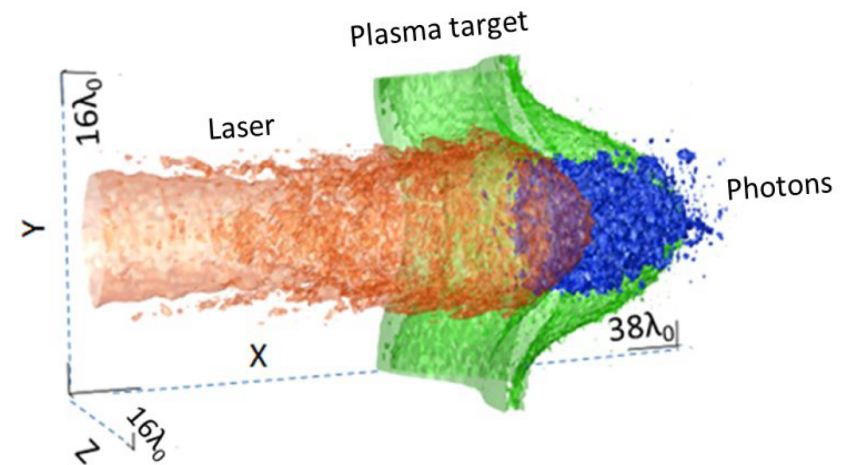
- 1 – high energy ion acceleration from interaction of ultrashort, ultrahigh laser beam interaction with thin solid targets
- 2 – Investigations on an alternative spallation source for high neutron flux production from interaction of relativistic protons with solid target. Important application to material test and potential collaboration with EURATOM for studies concerning the blanket and the first wall resistance for the Tokamak reactors (ITER and DEMO)
- 3 – Particle – antiparticle and meson production from vacuum breakdown or from ultrahigh intensity laser beam interaction with high relativistic electron beam

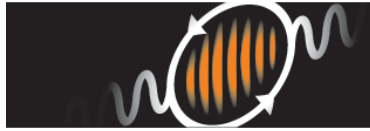


Alexander Pukhov
Institute for Theoretical Physics I
University of Düsseldorf
Germany

Topics related to IZEST :

- 1 – Bubble scalings for electron acceleration
- 2 – QED effects in particle-in-cell simulations
- 3 – Coherent particle acceleration



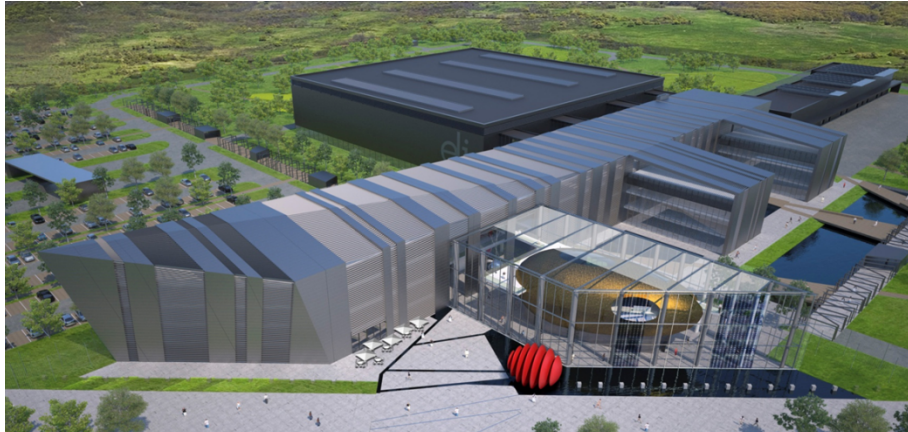


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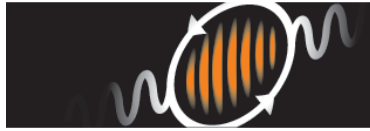
ELI Attosecond Light Pulse Source (ELI-ALPS), Hungary

D. Charalambidis

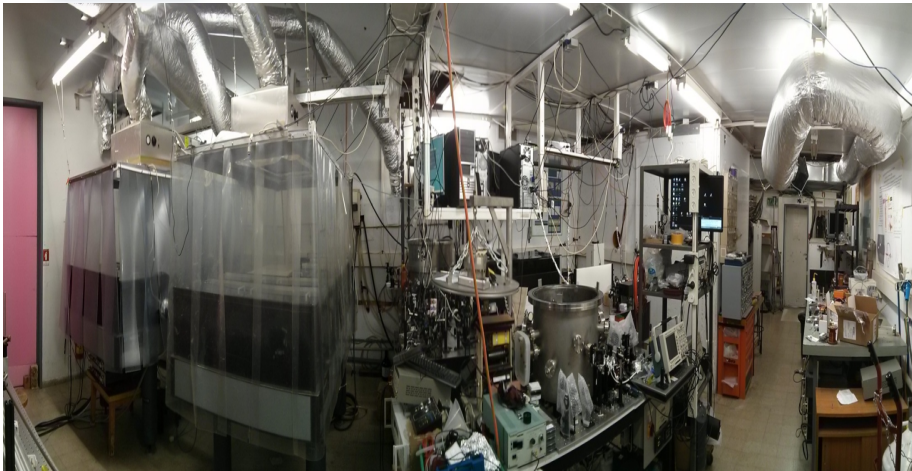
K. Osvay

Topics related to IZEST :

- 1 – Research at ultra-short time scales
- 2 – Research at ultra-relativistic intensities
- 3 – Ultrashort pulse laser technologies
- 4 – Measurement of ultrashort light pulses at extreme intensities
- 5 – Societal applications



HUHIL



Name of the Lab - **HUHIL**

Country - Israel

Name of the IZEST
representative : Arie Zigler
Hebrew Univ. of Jerusalem

Topics related to IZEST :

1. electron acceleration to 100 GeV energy levels and beyond,
2. proton and ion acceleration to GeV energy levels and beyond
3. novel intense sources of short wavelength radiation.



Name of the Lab: CUDOS Country: Australia

Centre for Ultrahigh bandwidth Devices for Optical Systems

National Center of Excellence by the Australian Research Council

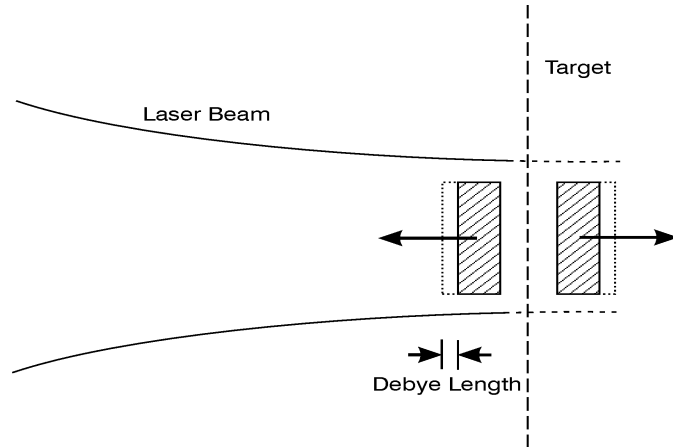
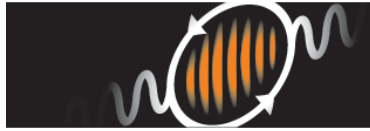
CUDOS is a research consortium between seven Australian Universities:

Director is Professor [Ben Eggleton](#), with Professor [Yuri Kivshar](#) as Deputy Director and Professor [Martijn de Sterke](#) as Associate Director at the School of Physics, Sydney University.

Name of IZEST Representative: [Ben Eggleton](#) (University of Sydney) in cooperation with [Heinrich Hora](#) (University of New South Wales and Royal Society of New South Wales)

Topics related to IZEST: (under preparation)

- 1- Fiber laser for low cost ICAN up to EXAWATT system (project proposal)
- 2- Clarifying plasma-block ultrahigh acceleration for ultrahigh current density ions in contrast to other mechanisms
- 3- Application to fast ignition for nuclear fusion and myonic fusion
- 4-Application to Hadron Cancer Therapy with very compact systems



Name of Lab: *Royal Soc. NSW with CUDOS
Nat. Lab & Assoc. Ctrs.*

Country: *Australia*

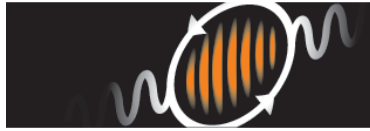
Name of the IZEST representative :

*Donald Hector, President of RSNSW, with
Executives: Benjamin Eggleton, Heinrich Hora,
Fred Osman*

(at stage of foundation)

Topics related to IZEST: (under preparation)

- 1) *Fiber laser for low cost ICAN up to EXAWATT system.*
- 2) *Clarifying plasma-block ultrahigh acceleration with ultrahigh ion current density with based on early stage collective hydrodynamics and later PIC and other mechanisms.*
- 3) *Application to fast ignition nuclear fusion and myonic fusion*
- 4) *Application to Hadron Cancer Therapy with very compact systems*



CoReLS PW Ti:Sapphire Laser



Center for Relativistic Laser
Science (CoReLS)

Korea

Representative : Chang Hee NAM

Topics related to IZEST :

1. Superintense laser-matter interactions
2. Laser electron acceleration
3. Energetic proton generation
4. Ultrahigh power laser technology
5. Theory of relativistic laser plasmas

Participant Council

20 November 2013

Hongo Campus -Tokyo University – Tokyo - Japan



Name of the Lab : CELIA

Country : France

Name of the IZEST representative :
Vladimir Tikhonchuk



**Centre Lasers Intenses et
Applications**

Topics related to IZEST :

- 1 – new schemes of amplification of electromagnetic radiation with plasmas
- 2 – energetic ion acceleration in intense laser-plasma interaction