International Landscape: Facilities, projects, initiatives

M. J. Hogan (SLAC) on behalf of:
C. Geddes (LBNL), M. Kando (QST), W. Lu (Tsinghua) , and P. Musumeci (UCLA)

EUROPEAN NETWORK FOR NOVEL ACCELERATORS
EuroNNAc4
NPACT supported by EU via I-FAST

September 19, 2022

Some context for this session

- Since the birth of AAC the driving force behind much of the research (and funding) has had an eye towards applying the large accelerating gradients we create to enable particle physics at the energy frontier
- Current facilities are monuments to human design and engineering
- Even with aggressive magnet development there are limits to the reach of existing p-rings like the LHC
- The last e^-e^+ linear collider (SLC) turned off 25 years ago
- Size, timescale, CO_2 footprint, power consumption… of proposed next generation facilities is daunting
- Every 5-10 years there are planning processes that survey the desires of the particle physics community and the options coming from the accelerator community
- Two important activities since we last gathered in person: European LDG Expert Panels and 'Snowmass' in the US

Courtesy R. Assmann

European Particle Physics Roadmap High-Gradient Novel Accelerators
(1/2021 – 2/2022)

Expert Panel – Panel chairs:
Chair: Ralph Assmann (DESY/ INFN)
Deputy Chair: Edda Gschwendtner (CERN)

Panel members:
Kevin Cassou (IN2P3/IJCLab), Sebastien Corde (IP Paris), Laura Corner (Liverpool), Brigitte Cros (CNRS UPSay), Massimo Ferarrio (INFN), Simon Hooker (Oxford), Rasmus Ischebeck (PSI), Andrea Latina (CERN), Olle Lundh (Lund), Patric Muggli (MPI Munich), Phi Nghiem (CEA/ IRFU), Jens Osterhoff (DESY), Tor Raubenheimer (SLAC), Arnd Specka (IN2PR/LLR), Jorge Vieira (IST), Matthew Wing (UCL).

Panel associated members:
Cameron Geddes (LBNL), Mark Hogan (SLAC), Wei Lu (Tsinghua U.) , Pietro Musumeci (UCLA)

Yellow Report
CERN-2022-001

Three pillar R&D roadmap defined, including resources

FEASIBILITY, PRE-CDR STUDY

Scope: 1st international, coordinated study for self-consistent analysis of novel technologies and their particle physics reach, intermediate HEP steps, collider feasibility, performance, quantitative cost-size-benefit analysis

Concept: Comparative paper study (main concepts included)

Milestones: Report high energy e^- and e^+ linac module case studies, report physics case(s)

Deliverable: Feasibility and pre-CDR report in 2025 for European, national decision makers

TECHNICAL DEMONSTRATION

Scope: Demonstration of critical feasibility parameters for e^+e^- collider and 1st HEP applications

Concept: Prioritised list of R&D that can be performed at existing, planned R&D infrastructures in national, European, international landscape

Milestones: High-rep rate plasma module, high-efficiency module with high beam quality, scaling of DLA/THz accelerators

Deliverable: Technical readiness level (TRL) report in 2025 for European, national decision makers

INTEGRATION & OUTREACH

Synergy and Integration: Benefits for and synergy with other science fields (e.g. structural biology, materials, lasers, health) and projects (e.g. EuPRAXIA, ...)

Access: Establishing framework for well-defined access to distributed accelerator R&D landscape

Innovation: Compact accelerator and laser technology spin-offs and synergies with industry

Training: Involvement and education of next generation engineers and scientists

Next step: Implementation – see several discussions at workshop

European Plasma Research Accelerator with eXcellence In Applications

European High-Tech Project on Accelerator Innovation

Courtesy R. Assmann

New kind of **C O M P A C T** Distributed Research Infrastructure Involving 50 Institutes from **15 Countries** – see full CDR published in 2020

Selected for 2021 Update **ESFRI Roadmap** *as first ever plasma acc. project, first accelerator project since HiLumi LHC*

569 M€ total cost: ~150 M€ already financed

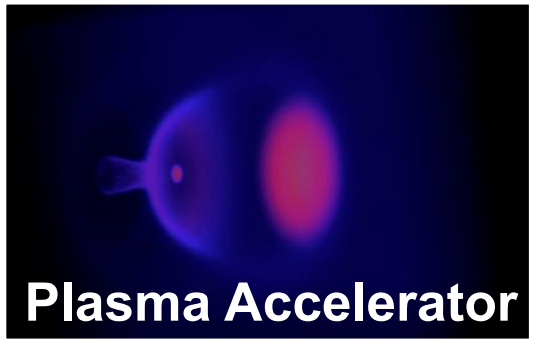
EU Preparatory Phase project 11/2022 – 2026 to define full implementation: financial, legal, technical

Will serve users (FEL, e+, e-) in biology, health, physics, materials, … at end of decade

LNF-INFN Frascati, Rome, Italy:

1st construction site & Headquarter in progress

2nd construction site in Europe for a laser-driven plasma accelerator facility to be decided in June 2024



600+ page CDR, 240 scientists contributed

ESFRI

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

EUPRAXIA

Summary & Conclusions

See talk by M. Turner

- Snowmass is a **Particle Physics Community Planning Exercise**, provides input to P5 to produce scientific vision for the future of particle physics in the U.S. and happens every ~8 years (Originally scheduled for 2021, delayed for 1 year to 2022 due to COVID).
- http://snowmass2021.org
- P5 will prioritize
- Interest has shifted from a TeV-Scale Collider to a **10+ TeV Scale Collider**
- AF Report **encourages R&D on AAC** technologies but does not acknowledge them as being promising 10+ TeV collider options yet
- To be included they asked the AAC Community to develop **consistent collider parameters sets**, that include detector considerations and to document them together with the technology gaps

See talk by M. Turner

AF WG Conveners

Link to reports: https://snowmass21.org/accelerator/start

AF 6: Advanced Accelerator Concepts

Interchange between snowmass and the European LDG activity

Cameron Geddes
Lawrence Berkeley National Lab

Mark Hogan
SLAC National Accelerator Lab

Pietro Musumeci
University of California, Los Angeles

Ralph Assmann
Deutsches Elektronen-Sychrotron

AF 4: Multi-TeV Colliders

e+e- collider forum: Maria Chamizo Llatas, Sridhara Dasu, Ulrich Heintz, Emilio A. Nanni, John Power, Stephen Wagner

Implementation Task Force

Steve Gourlay
(LBNL)

Philippe Lebrun
(CERN)

Thomas Roser
(BNL, Chair)

John Seeman
(SLAC)

Tor Raubenheimer
(SLAC)

Katsunobu Oide
(KEK)

Jim Strait
(FNAL)

Reinhard Brinkmann
(DESY)

Marlene Turner
(LBNL)

Spencer Gessner
(SLAC)

Sarah Cousineau
(ORNL)

Vladimir Shiltsev
(FNAL)

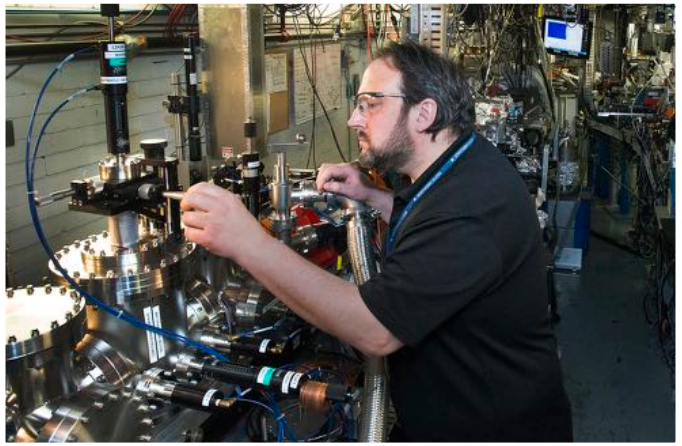
See talk by S. Gessner

Test Facilities at DOE Laboratories

FAST/IOTA Fermilab

AWA Argonne

ATF Brookhaven



FACET-II SLAC

BELLA Berkeley

Beam Test Facilities at DOE Laboratories provide unique and world-leading capabilities for research on Advanced Accelerator Concepts fueled by collaboration with University groups

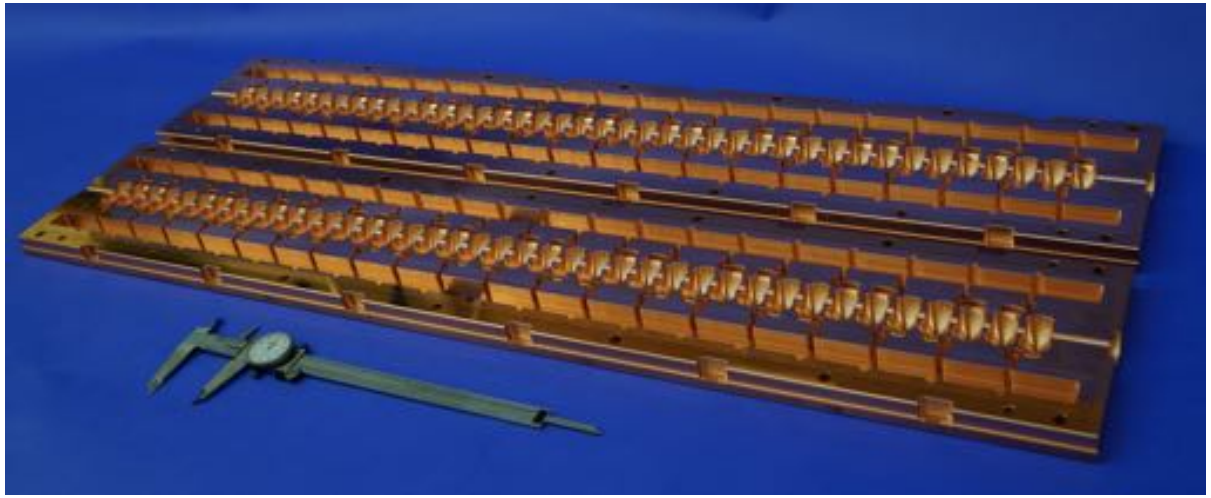
See talk by A. Dhar

Cool Copper Collider

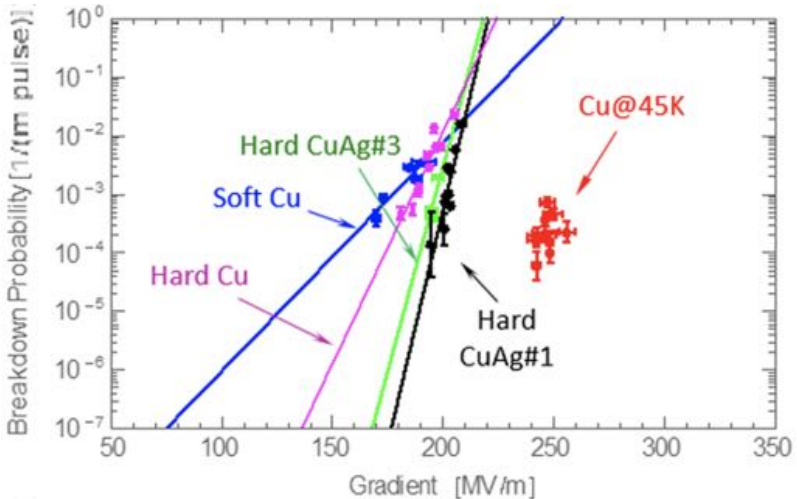
C³ is based on a new rf technology

- Dramatically improving efficiency and breakdown rate
- Distributed power to each cavity from a common RF manifold
- Operation at cryogenic temperatures (LN_2 ~80 K)
- Robust operations at high gradient: 120 MeV/m
- Scalable to multi-TeV operation

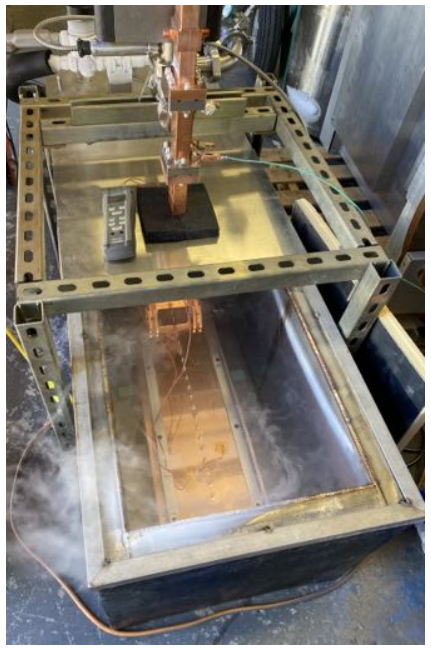
C³ Prototype One Meter Structure



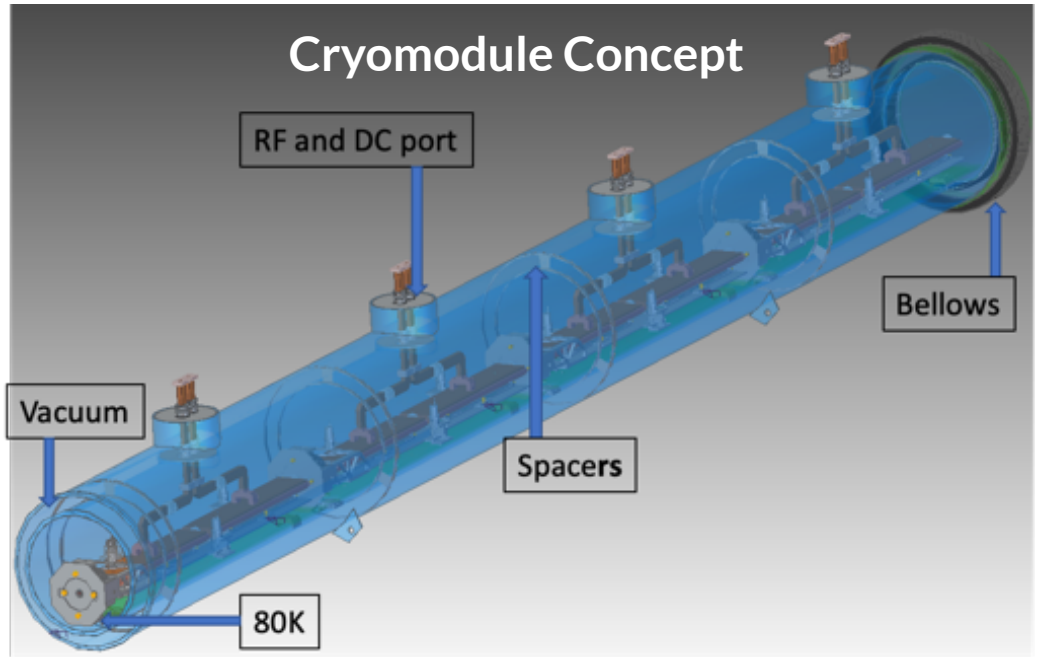
High Accelerating Gradients at Cryogenic Operation



C³ Cryo Test



Cryomodule Concept

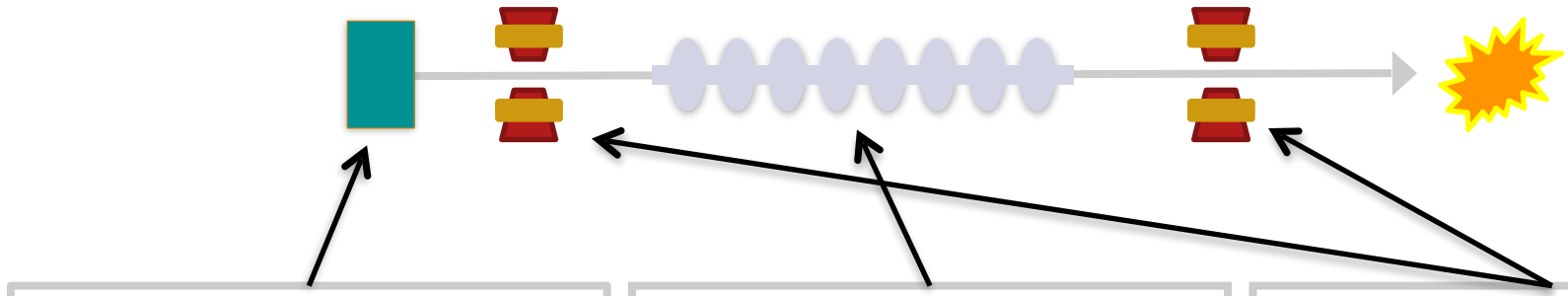


See talk by J. Maxon

The Center for BRIGHTBEAMS
A National Science Foundation Science & Technology Center

In Introduction the Center For Bright Beams and its Research

J. Maxson, Cornell University



Beam Production

Goal: Methods for x100 brighter photocathodes

Beam Acceleration

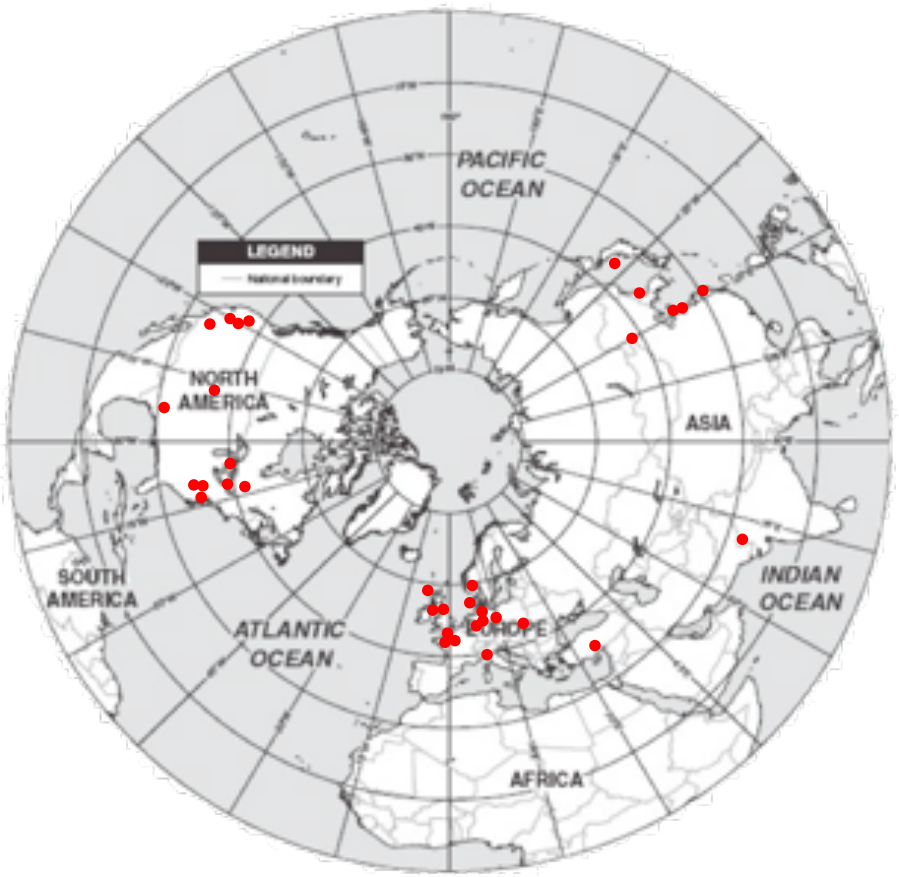
Goal: Methods for superconducting RF accelerating cavities with x10 lower losses and x2 higher gradient

Beam Dynamics and Control

Goal: Methods for beam transport that preserve and optimize brighter beams

Integration of these methods in order to optimize high performance accelerator systems.

Global Landscape for Plasma Acceleration R&D (an incomplete list)



International LWFA R&D Laboratories:

- ELI-Beamlines (Czech)
- ELI-NP (Romania)
- U. Lund (Sweden)
- HZDR (Germany)
- DESY (Germany)
- LMU (Germany)
- Jena (Germany)
- RAL (UK)
- SCAPA (UK)
- U. Oxford (UK)
- LOA (France)
- Apollon (France)
- LULI (France)
- INFN (Italy)
- CoReLS (Korea)
- KPSI (Japan)
- Tsinghua U. (China)
- SIOM (China)
- SJTU (China)
- TIFR (India)
- IAMS (Taiwan)
- ALLS (Canada)
- Weizmann Inst. (Israel)

US LWFA R&D Laboratories:

- LBNL – BELLA
- LLNL – JLF
- BNL – ATF
- SLAC – MEC
- U. Texas
- U. Michigan
- LLE (Rochester)
- U. Nebraska
- NRL
- UCLA
- U. Maryland

PWFA/SWFA Laboratories:

- ANL – AWA
- BNL – ATF
- DESY – FLASHForward
- INFN – SPARC_Lab
- SLAC – FACET-II
- CERN – AWAKE (proton)

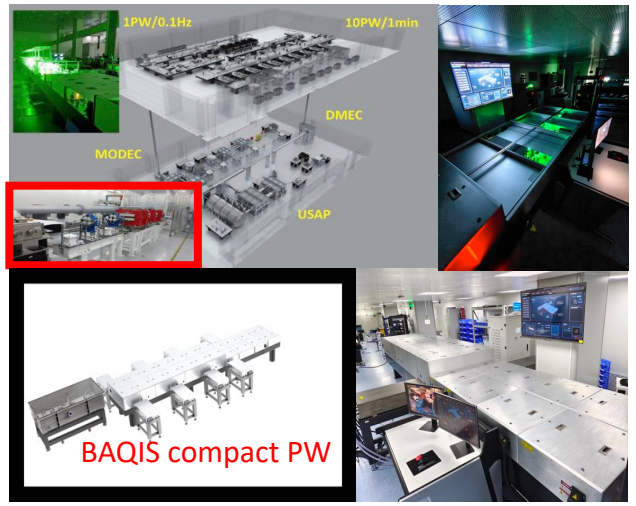
Compactness of laser systems has led to proliferation of plasma accelerator R&D in laboratories and universities world-wide with activities in Europe, U.S. and Asia

Updates of Plasma Acceleration in China by Wei Lu

See talk by W. Liu

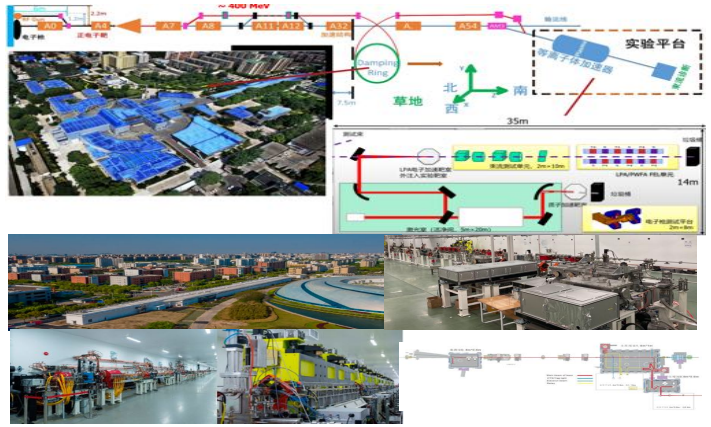
Major Laser Facilities: 6 PW+ systems in 1-3years

Institute	Peak Power	rep rate	main research	timeline
SIOM	10PW	1shot/min	extreme light physics	laser ready
LFRC	5PW	1shot/hour	extreme light physics	laser ready
IOP	1PW	1shot/min	X ray source (Betatron)	in 1 year
BAQIS+THU	1PW	1Hz	Electron accelerator	in 2 years
PKU	2PW	1Hz	Ion accelerator	in 2 years
SJTU	2PW	1shot/min	Lab Astronomy	in 3 years



Two major initiatives on PWFA

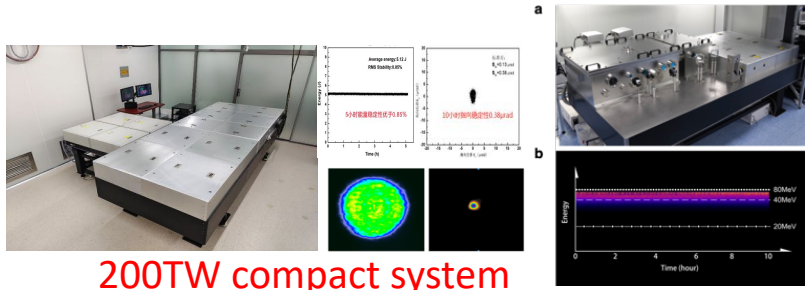
Institute	Facility	Energy	Research
IHEP	BECP	2.5GeV	e-/e+ for collider
SARI	SXFEL	1.5GeV	e- for FEL



Laser development towards applications:

BAQIS + Qi-NLS + THU

- 7+ years effort on compact industry level TW-PW lasers
- Lasers with much reduced size, enhanced long term performance
- Table top ultrafast synchrotron light sources demonstrated (with very compact 20-40TW systems)

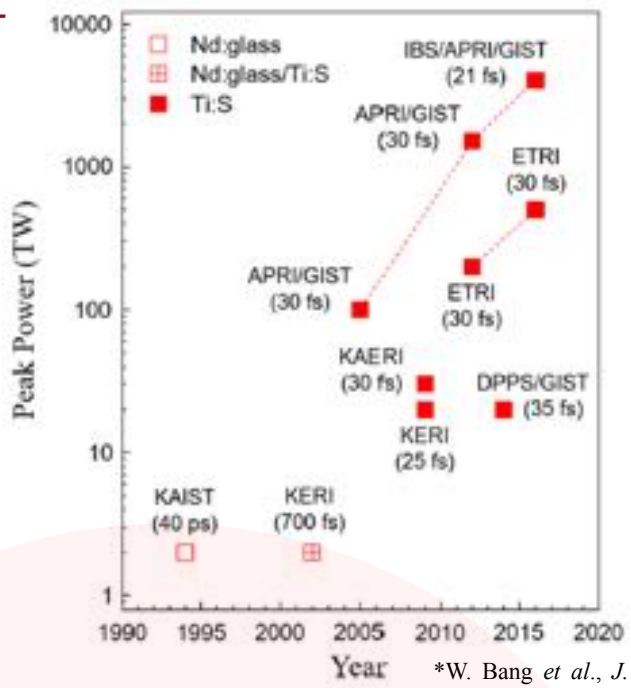


200TW compact system

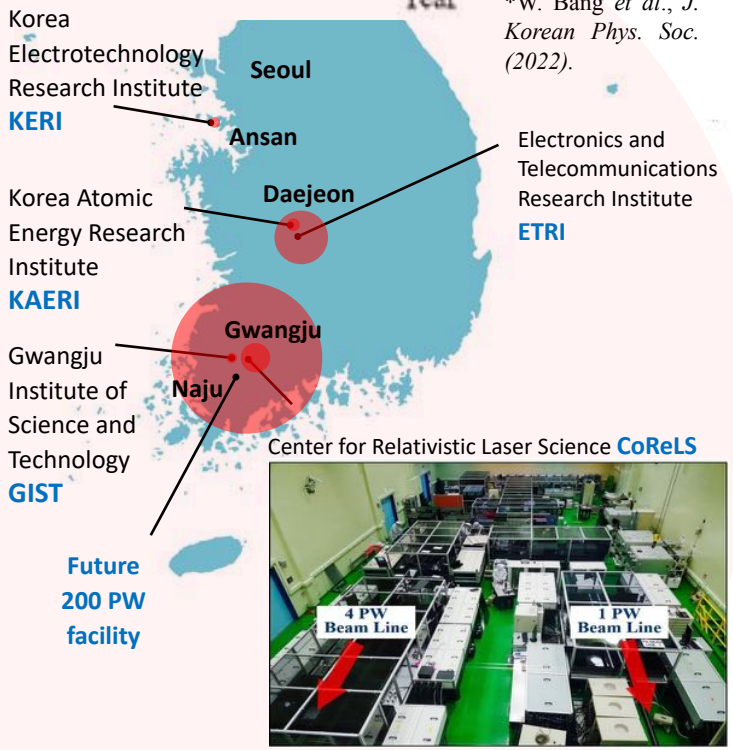
Courtesy K. Masaki and Prof. Kim and Prof. Nam of GIST

TW and PW laser facilities in Korea

Facility	Location (city)	Peak power (PW)	Energy (J)	Pulse width (fs)	Rep rate (Hz)	Year ops.	Research
KERI	Ansan	**0.02**	0.5	25	10	2009	Electron acceleration
GIST	Gwangju	**0.02**	0.7	35	10	2014	Electron acceleration, X-ray/ THz generation
KAERI	Daejeon	**0.03**	0.9	30	10	2009	Electron/ion acceleration, X-ray/THz generation
CoReLS (IBS)	Gwangju	**0.15**	3.8	25	5	2017	Electron/ion acceleration, X-ray/THz generation, HEDP studies
ETRI	Daejeon	**0.5 (0.2)**	15 (5)	30 (25)	0.1 (10)	2016 (2012)	Electron/ion acceleration
CoReLS (IBS)	Gwangju	**4 + 1**	80 + 20	20	0.1	2017	Electron/ion acceleration, X-ray/γ-ray generation, Strong-field QED studies
Initiative	Naju	**200**	4000	20	Single-shot	2034	Ultra-intense laser-matter interactions

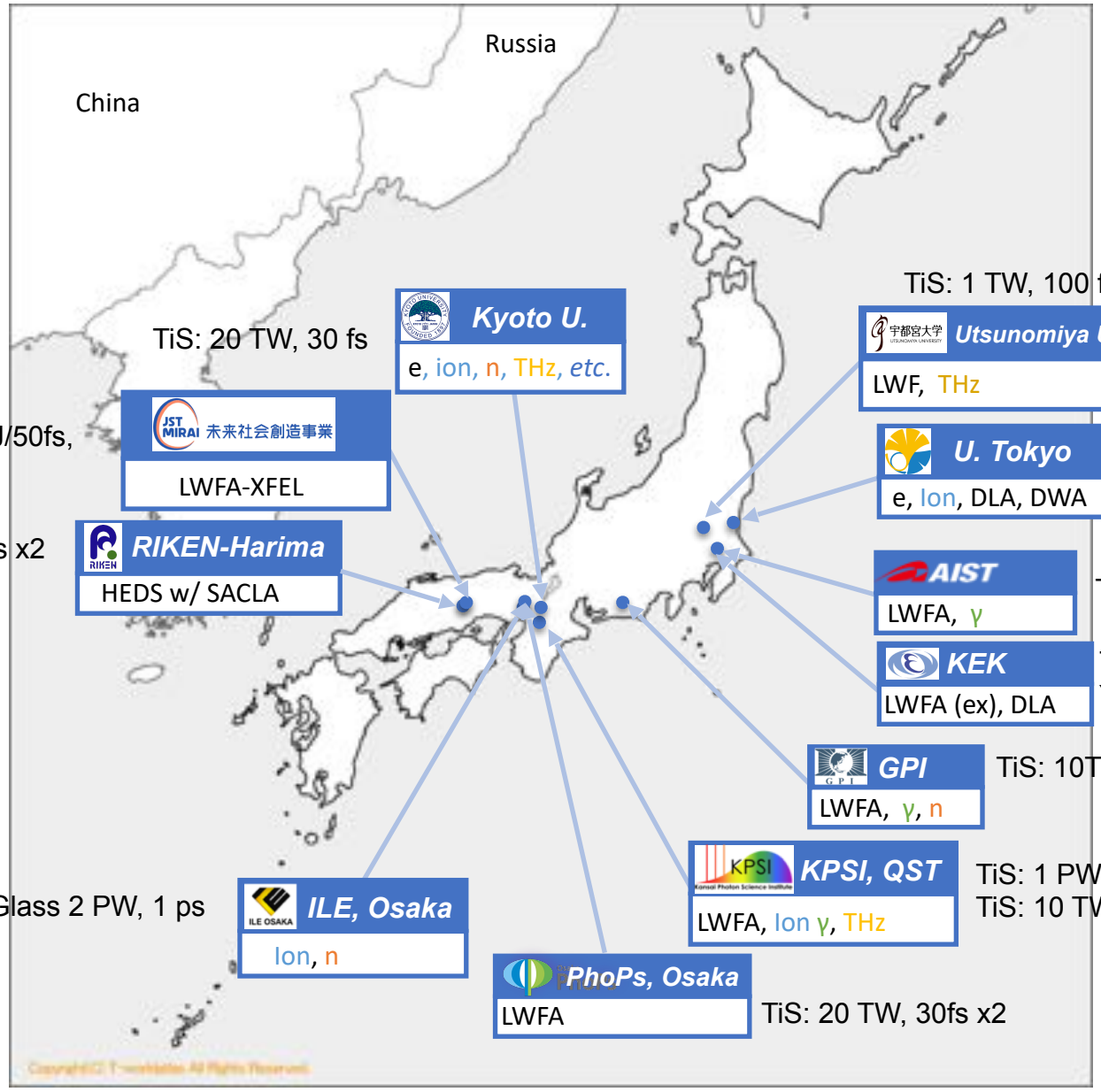


*W. Bang *et al.*, *J. Korean Phys. Soc.* (2022).



Courtesy K. Masaki

Laser-Acceleration facilities in Japan

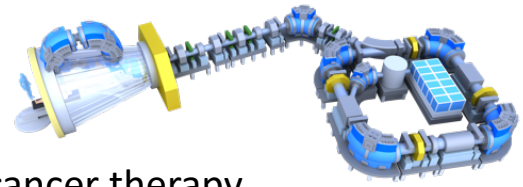


Project (MIRAI, 2017-2026)

Osaka U, QST, KEK, RIKEN, JASRI, IMS

- LA based FEL
- LA based carbon injector for cancer therapy
- Related laser development (100J, 100 Hz pump, 2J, 50 Hz pump)

Laser electron Platform (RIKEN)



Future cancer therapy system based on LA

Planned : J-EPoCH laser facility

Osaka U, QST

- 1 PW, 100Hz
- 20 PW, 10 Hz

Multi-beam, Multi-function for various scientific fields

International Landscape: Facilities, projects, initiatives

- Exciting to re-engage with larger AAC community as we climb out of the COVID cocoon
- In AAC we need to engage broader communities of particle physicists and accelerator builders
- Parameter sets/IDS, deliver on commitments for R&D
- First applications are a strength
- Advocate for all
- Looking forward to interesting discussions - how can we engage across regions on these topics that are international in scope?