

Development of Energy Recovery Linacs

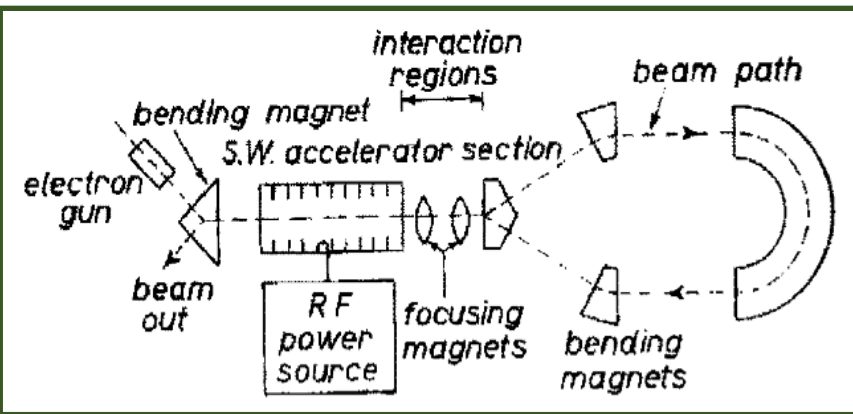
A Contribution to the European Strategy of Particle Physics

Introduction to a Symposium, June 4, 2021

Max Klein



on behalf of the ERL panel



Performance of a 55 year old idea with the technology of today and tomorrow:
M Tigner A Possible Apparatus for Electron Clashing-Beam Experiments, N.Cim 10(1965)1228

Recirculation lattice to recycle kinetic beam energy of a decelerating beam for acceleration of a newly injected low energy beam. Avoid synchrotron loss initiated emittance growth as in storage rings. Minimize power consumption (by an order of magnitude) and dump at E_{inj} :
a high luminosity (1000 ELI, 1000 HERA), 'powerful' green accelerator concept for 21st century

DRAFT

The Development of Energy Recovery Linacs

A Contribution to the European Strategy for Particle Physics

The ERL Study Group

ERL Panel Members

Deepa Angal-Kalinin⁶, Kurt Aulenbacher¹⁰, Alex Bogacz¹⁵, Georg Hoffstatter⁵, Andrew Hutton¹⁵ (Co-Chair), Erk Jensen⁴, Walid Kaabi¹¹, Max Klein⁹ (Chair), Bettina Kuske¹, Frank Marhauser¹⁵, Dmitry Kayran³, Jens Knobloch¹, Olga Tanaka¹⁴, Norbert Pietralla⁷, Cristina Vaccarezza⁸, Nikolay Vinokurov², Peter Williams⁶, Frank Zimmermann⁴

Guest Authors

Michaela Arnold⁷, Steve Benson¹⁵, Jan Bernauer¹³, Maarten Boonekamp¹², Oliver Brüning⁴, Max Bruker¹⁵, Patxi Duthill¹¹, Oliver Fischer⁹, Bernhard Holzer⁴, Geoff Krafft¹⁵, Julius Kühn¹, Boris Militsyn⁶, George Neil¹⁵, Axel Neumann¹, Vladimir Litvinenko¹³, Bob Rimmer¹⁵, Oleg A. Shevchenko², Nick Shipman⁴, Hubert Spiesberger¹⁰, David Verney¹¹, Valeri Telnov², Chris Tennant¹⁵ and others

Incomplete

Abstract (DRAFT)

Energy recovery linacs (ERL's) have been emphasised by the recent (2020) update of the European Strategy for Particle Physics as one of the most promising technology for the accelerator base of future high energy physics. They are indeed beginning to assert their potential as game changers in the field of accelerators and their applications. Their unique combination of bright, linac-like beam quality with high average current and extremely flexible time structure, unprecedented operating efficiency and compact footprint opens the door to previously unattainable performance regimes. This paper

A White Paper [work in progress] on

1. ERL Magics and Particle Physics
2. Facilities – Past and Current
3. New ERL Facilities in the Twenties
4. Key Technical Challenges
5. Energy and Intensity Frontier Physics
6. Applications
7. ERL and Sustainability

A Overview on Facilities

B Sub-Panel Report on e⁺e⁻ ERLs

For publication (~250 pages)
and baseline information for the
development of an ERL Roadmap
concept in the summer/fall 2021

Key issues presented in today's meeting

Particle Physics: The Challenge Ahead

Principally new theories would be required to “turn the SM on its head” while, as Steven Weinberg also stated not long ago: “There isn’t a clear idea to break into the future beyond the Standard Model” [15], it remains the conviction, as Gian Giudice described it in his eloquent “imaginary conversation” with the late Guido Altarelli, that “A new paradigm change seems to be necessary” [17] in the “Dawn of the post naturalness era”.

The Development of ERLs. draft

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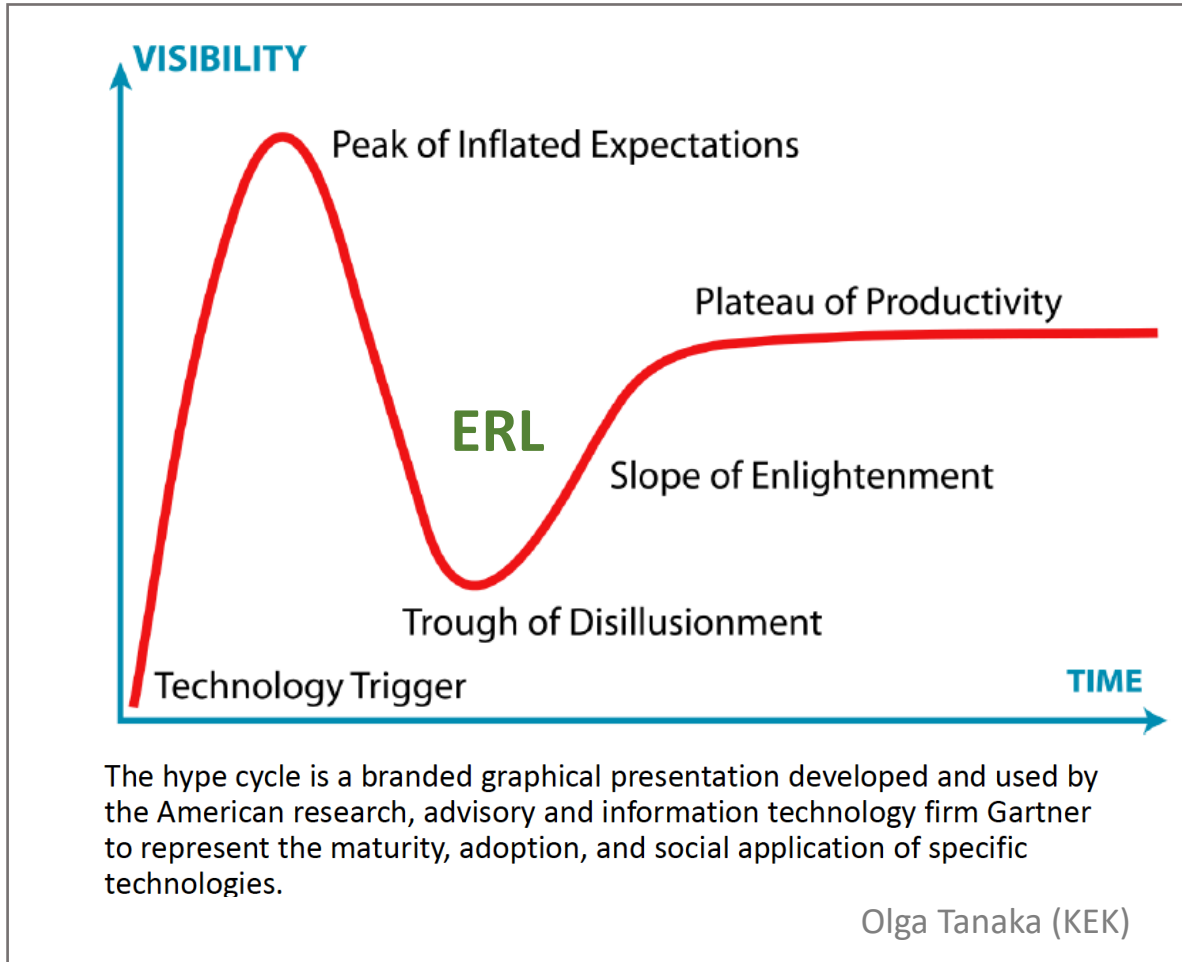
Apparently, particle physics is as interesting, challenging and far reaching as it ever was in recent history. It yet needs revolutionary advances in insight, observation and technologies, not least for its accelerator base. It demands that new generation hadron-hadron, electron-hadron and pure lepton colliders be developed and realised. Hardly a new paradigm can be established with just one type of collider in the future. The field needs global cooperation, trust and complementarity of its techniques, a lesson learned from the exploration of the Fermi scale with the Tevatron, HERA and LEP/SLC,

High field magnets, SRF, ERL, Muon Collider, and Plasma Wakefield

The five acc. technology pillars identified last year and by Council/SPC/LDG.

*) cf backup slide

ERLs - a Progressing, Revolutionary Technology



Based on decades of SRF, FEL, ERL, Facility.. developments*) :

The debate now is about the conditions for ERLs to reach their productivity plateau and the demands implied on R&D, financial, intellectual and technical support.

An initial observation (not only) by the panel:

ERLs are more than an appealing technology:

They (cor)respond to **A NEW ERA** in particle and several other fields of physics, industry, accelerators .. in a world that cannot proceed without renewed care for our planet.

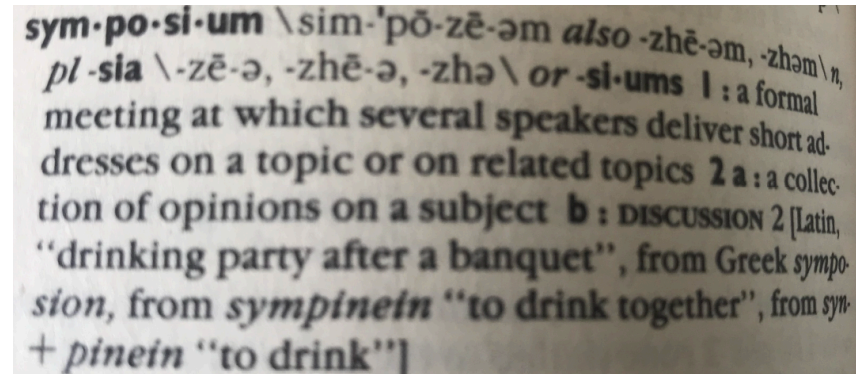
ERLs, as will come out today, are technologies with far reaching impacts on science + society.

*) e.g. Ilan Ben-Zvi 2016 *Supercond. Sci. Technol.* **29** 103002
Chris Tennant, ERLs, in "Challenges and Goals for Accelerators in the XXI Century", O Bruening, S Myers, World Scientific, 2019

ERL Symposium

Friday 4.6. 1-5pm CEST

Webster's New Encyclopedic Dictionary



sym·po·si·um \sim-'pō-zē-əm *also* -zhē-əm, -zhəm \n, pl -sia \-zē-ə, -zhē-ə, -zhə \ *or* -si-ums | : a formal meeting at which several speakers deliver short addresses on a topic or on related topics 2 a : a collection of opinions on a subject b : DISCUSSION 2 [Latin, "drinking party after a banquet", from Greek *symposion*, from *sympinein* "to drink together", from *syn-* + *pinein* "to drink"]

- Presentations of key issues for information and further input
- Towards possibly common understanding to advance the field
- More consultation at Future Accelerator Workshop and EPS

Today: Questions please on the chat or/and raise hand

<https://indico.cern.ch/event/1040671/>

If your link to indico is not working, copy the address directly into the browser [sorry for inconvenience]

Chair: Bettina Kuske (HBZ, Berlin)

13:00 **Welcome by the Lab Directors Group** 10m

Dave Newbold (STFC RAL, Chair LDG)

13:10 **Introduction** 5m

Max Klein (University of Liverpool)

13:15 **ERL Facilities** 25m

Andrew Hutton (Jefferson Laboratory)

13:40 **High Current Electron Sources** 20m

Boris Militsyn (STFC Daresbury)

14:00 **SRF Developments for ERLs** 25m

Robert Rimmer (Jefferson Laboratory)

14:25 **ERL Prospects for High Energy Colliders** 25m

Oliver Bruening (CERN)

14:50 **Coffee/tea Break** 10m

Chair: Olga Tanaka (KEK)

15:00 **Low Energy Physics with ERLs** 20m

Jan Bernauer (Stony Brook University)

15:20 **Industrial ERL Applications** 20m

Peter Williams (Daresbury Laboratory)

15:40 **Energy Recovery and Sustainability** 20m

Erk Jensen (CERN)

Chairs: Andrew Hutton and Max Klein

16:00 **Discussion** 55m

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Future of Particle Physics

much now resembles the fifties - theory provides questions, but no firm answers. Specifically, the SM has known, fundamental deficiencies: a proliferation of too many parameters, a missing explanation of the repetitive quark and lepton family pattern, an unresolved left-right asymmetry in the neutrino sector related to lepton-flavour non-conservation, an unexplained flavour hierarchy, the intriguing question of parton confinement and others. The Standard Model carries the boson-fermion asymmetry, it mixes the three interactions but has no grand unification, the proton is stable, it needs experiment to determine the parton dynamics inside the proton, has no prediction for the existence of a yet lower layer of substructure, and it does not explain the difference between leptons and quarks. Moreover, the SM has missing links to Dark Matter, possibly through Axions, and Quantum Gravity, while string theory still resides apart. The Standard Model is a phenomenologically successful theory, fine tuned to describe a possibly metastable universe [16].