

Towards a Proposal for an Advanced Linear Collider

Report on the Advanced and Novel Accelerators
for High Energy Physics Roadmap Workshop

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On behalf of ICFA ANA Panel

<http://www.lpgp.u-psud.fr/icfaana/ana-publications-2017>

Advanced and Novel Accelerators for High Energy Physics Roadmap Workshop 2017

- ❖ Was held at CERN 25-28 April 2017
- ❖ ~80 participants, 4 Working Groups



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<https://indico.cern.ch/event/569406/>



European Organization for Nuclear Research
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Organised at the initiative of the ICFA panel for Advanced and Novel Accelerators (ANA)



Organizing Committee (OC)

ICFA ANA Panel members

- **Brigitte Cros (chair)**, CNRS- U PSud, France
- Patric Muggli, MPP, Germany
- Bruce Carlsten, LANL, USA
- **Massimo Ferrario**, INFN, Italy
- **Brian Foster**, U Hamburg, Oxford, DESY, Germany
- **Ryoichi Hajima**, NIQRST, Japan
- **Dino Jaroszynski**, U Strathclyde, UK
- Philippe Piot, NI U (USA), Fermi Lab.
- **James Rosenweig**, UCLA, USA
- **Carl Schroeder**, LBNL, USA
- Chuanxiang Tang, Tsinghua U, China
- **Mitsuru Uesaka**, U Tokyo, Japan
- **Mitsuhiro Yoshida**, KEK, Japan

Other members

- **Ralph Assmann**, DESY, Germany
- **Edda Gschwendtner**, CERN, Switzerland
- **Bernhard Holzer**, CERN, Switzerland

<http://www.lpgp.u-psud.fr/icfaana/front-page>

Goal of the workshop

- ❖ To define an **international roadmap towards colliders based on advanced accelerator concepts**, including intermediate milestones, and to discuss the needs for international coordination.
- ❖ Slides available at
- ❖ <https://indico.cern.ch/event/569406/overview>

Outline

- ❖ Scientific frame
- ❖ Challenges and global roadmap items
- ❖ Review of strategy worldwide
- ❖ Next steps toward a collider roadmap

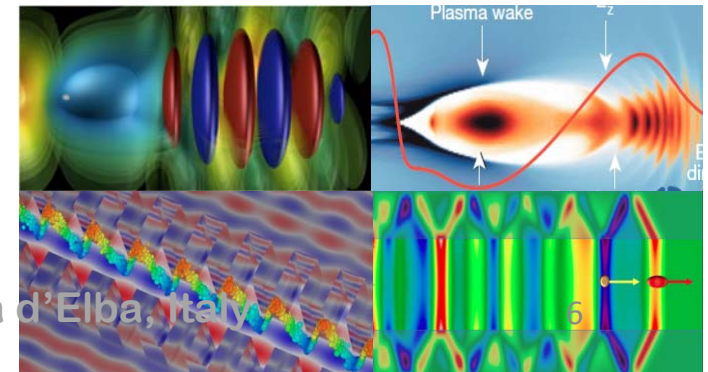
Challenging question for the community of ANA



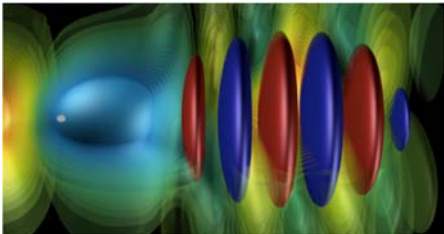
❖ Can we envisage the delivery of an **Advanced Linear Collider design** at $>1\text{TeV}$ (10 TeV) in 2035?

- Electron- positron Collider at the energy frontier
- Parameters defined for/by HEP (Luminosity)

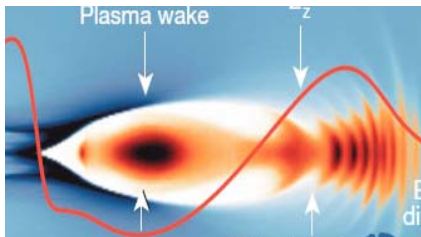
❖ Four different concepts of Advanced Accelerators were discussed



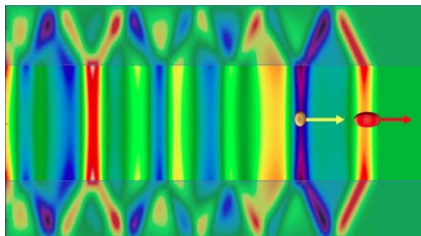
Advanced Accelerator concepts discussed in 4WGs



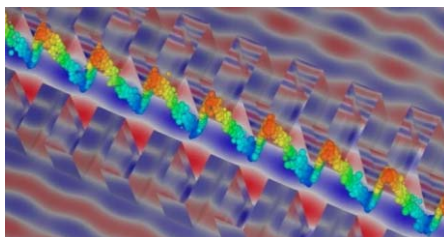
- ❖ Wakefields driven in **plasma** by **intense** laser beams : **LWFA**



- ❖ Wakefields driven in **plasma** by **particle** beams: **PWFA**



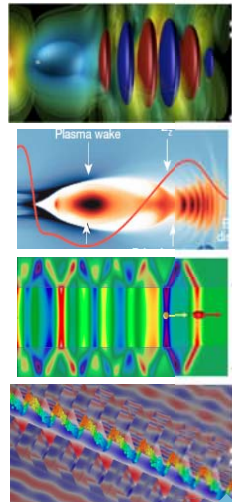
- ❖ Wakefields driven in **structures** (e.g. dielectric tubes) by **particle** beams: **SWFA**



- ❖ Wakefields driven in **dielectric structures** by **short-pulse** lasers: **DLA**

Status of ANAs

- ❖ Acceleration of electrons: strong peak gradient
- ❖ LWFA also for electron sources, short kA bunches



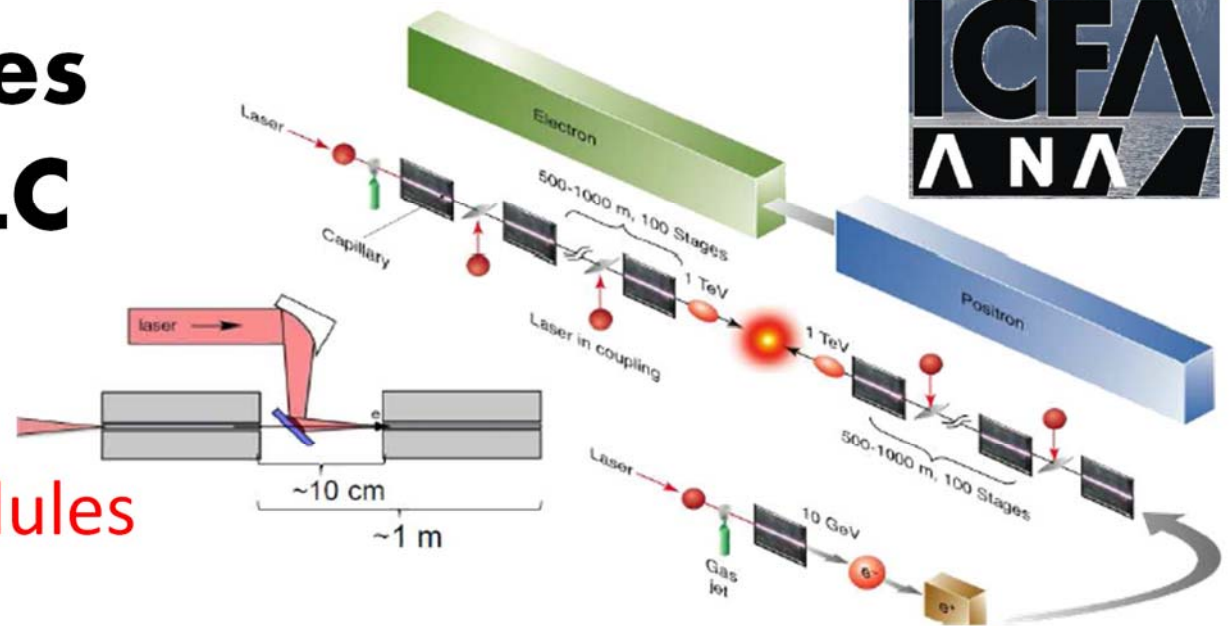
ANA	Energy Gain	$\Delta E/E$ %	Charge (pC)	Peak Gradient GeV/m	Efficiency %
LWFA	4.2 GeV	3	6	47	-
PWFA	42 GeV	100	-	53	-
	1.6 GeV	0.7	74	4.4	30
SWFA	30 MeV	0.7	944	0.32	80
DLA	24 keV	100	-	0.69	-

- ❖ Positron acceleration demonstrated by PWFA
- ❖ Response of dielectric structures (SWFA, DLA) symmetric to the charge of drive and witness bunches

Main challenges towards an ALC



- ❖ $e^- \rightarrow e^+$
- ❖ injector + accel modules



- ❖ Beam acceleration with small **energy spread**
- ❖ Preservation of small e-beam **emittance**
- ❖ Concepts for **positron acceleration** with high brightness
- ❖ **High efficiency** of acceleration for e^- and e^+
- ❖ **Staging** required to reach very high energies
- ❖ **Repetition rates** averaging 10s of kHz
- ❖ Beam **stability and reproducibility**

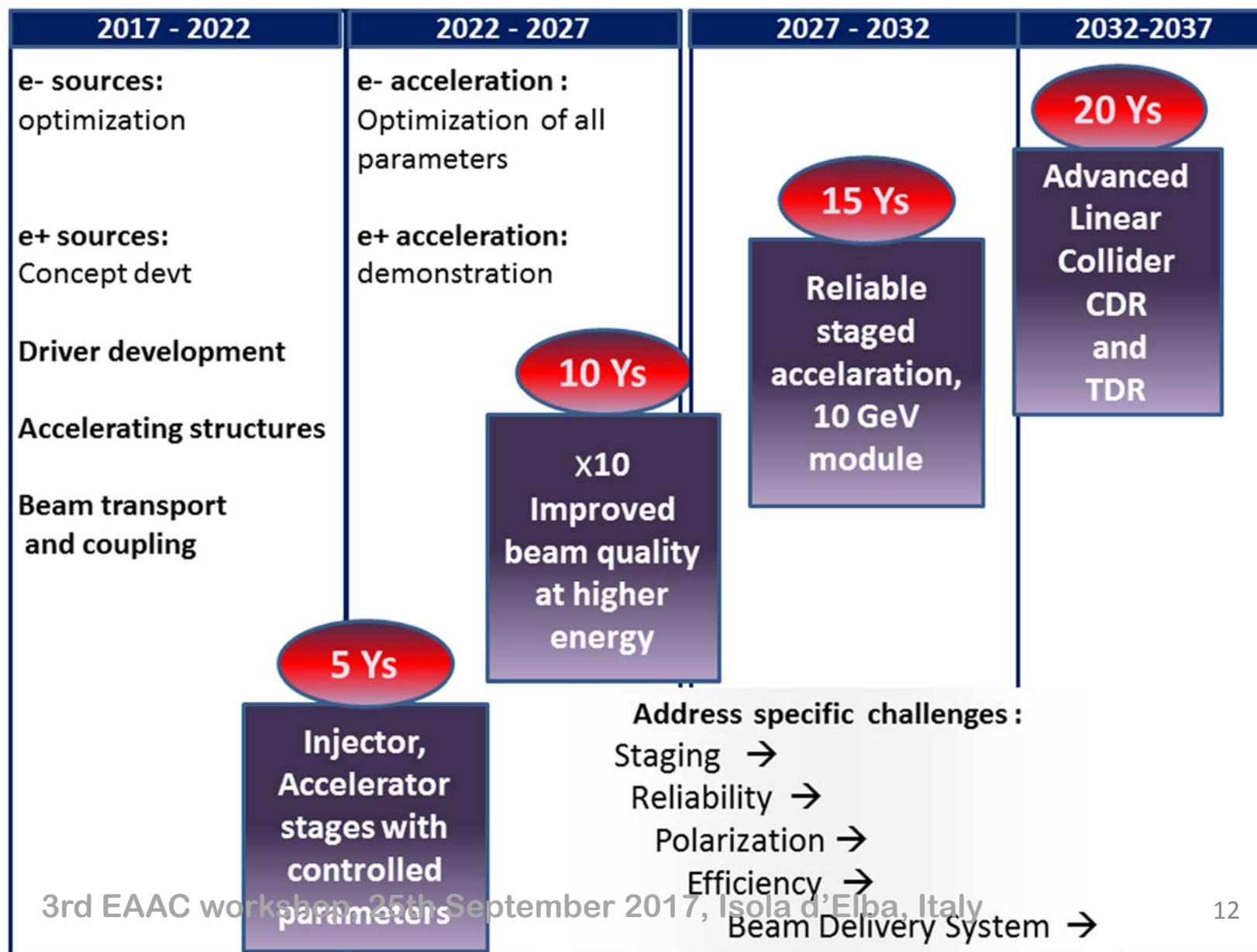
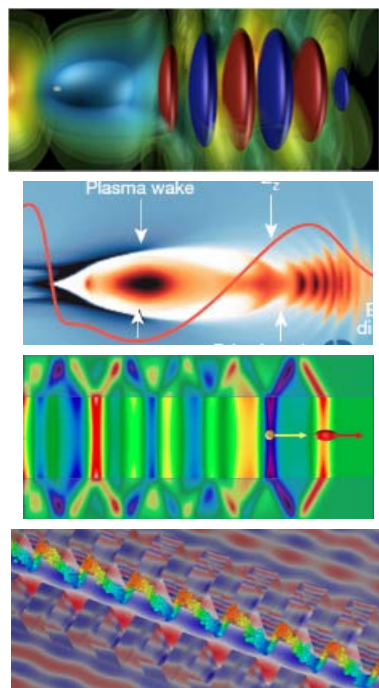
Challenges related to novel accelerator components

- ❖ **Injectors:** e-/e+ high 6D brightness (RF PI, Plasma bubble, nanotips)
- ❖ Accelerating **structures:** dielectrics or plasma, sustaining high rep rate, stable m-long media
- ❖ **Diagnostics:** for micron x fs resolution
- ❖ **Staging:** in- out-coupling, drive-witness beams management, alignment, imaging, compact transport
- ❖ **Stability, reproducibility, reliability:** feedback and control system, dedicated facilities

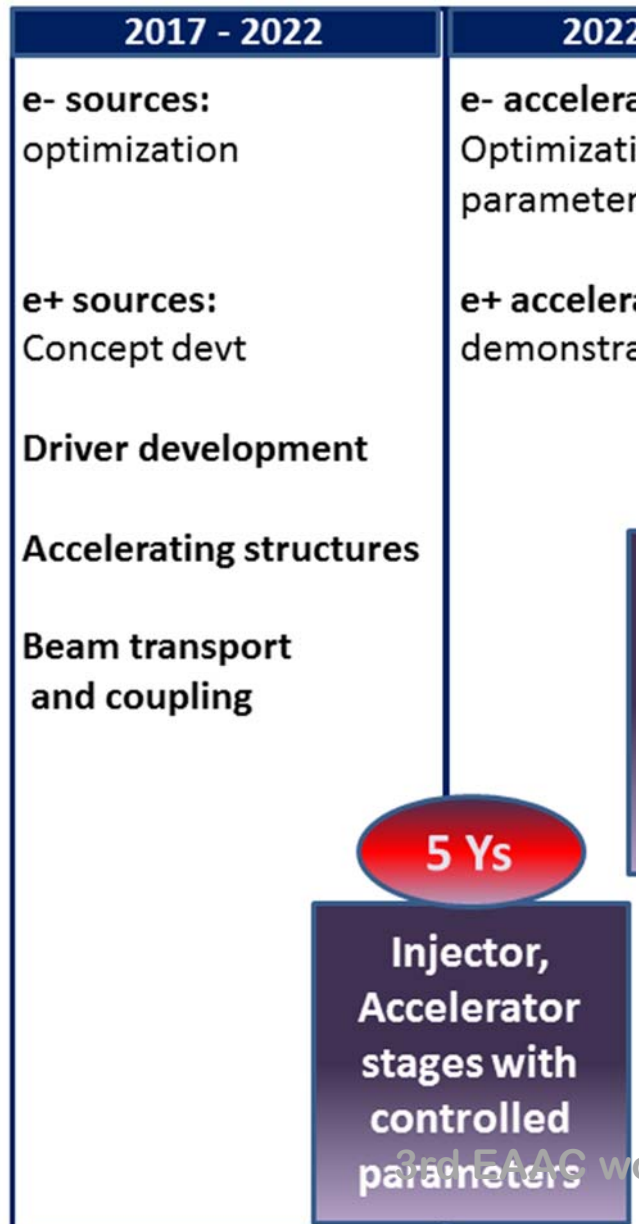
Challenges related to beam dynamics at high energy

- ❖ Narrow **energy spread**
- ❖ **Efficiency** and beam loading
- ❖ **Emittance** preservation
- ❖ Scattering (*plasma*)
- ❖ Beam break-up and hosing instabilities
- ❖ Spin polarization preservation
- ❖ Ion motion (*plasma*)
- ❖ Structure charging and radiation damage
- ❖ **Numerical simulation**

4ANAs scientific roadmap up to design report delivery

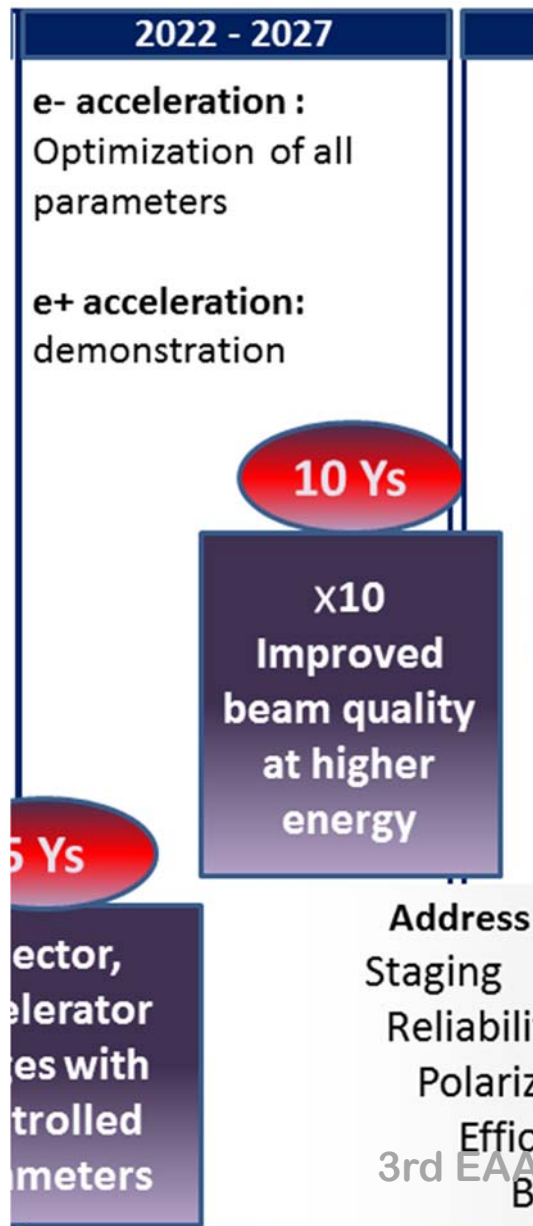


5-year milestone



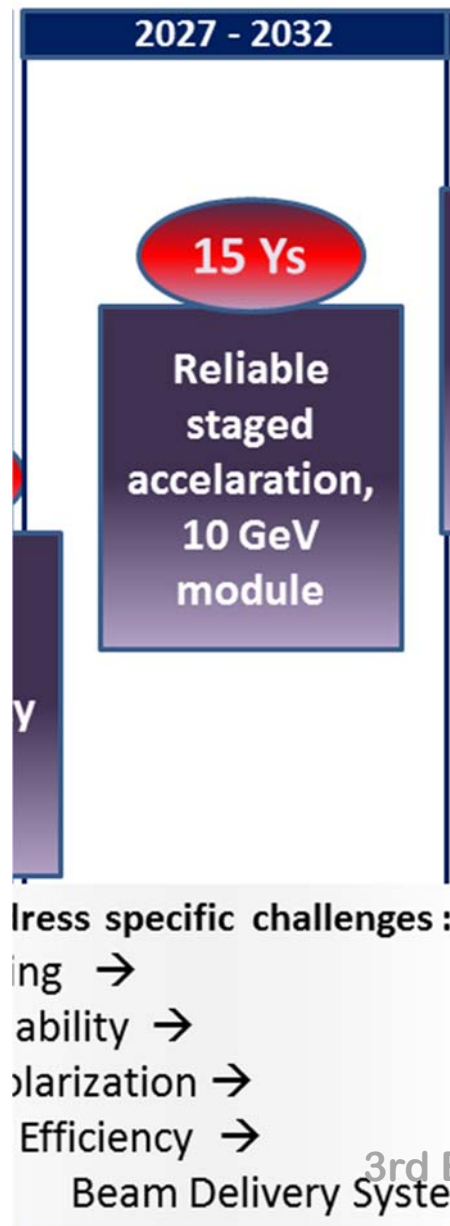
- ❖ **5-10 GeV ANA stage
producing stable, good
quality e- beam**
- ❖ **Sustained efforts on all
accelerator components
needed**
- ❖ **Increase of drivers stability
and efficiency should be
addressed**

10-year milestone



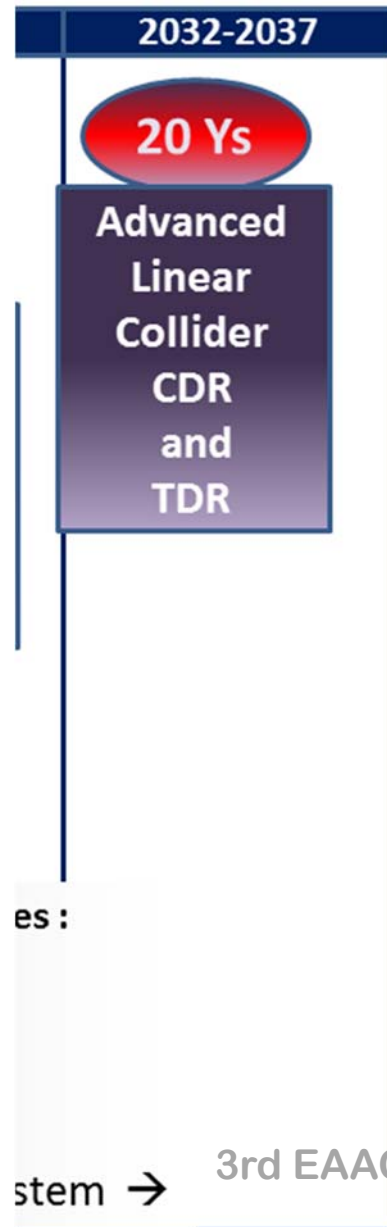
- ❖ Improved bunch quality at high energy and staging of two structures
- ❖ Optimize all beam parameters e^- , test e^+
- ❖ Start addressing in detail specific collider challenges : reliability, compact staging, polarization, efficiency, BDS

15-year milestone



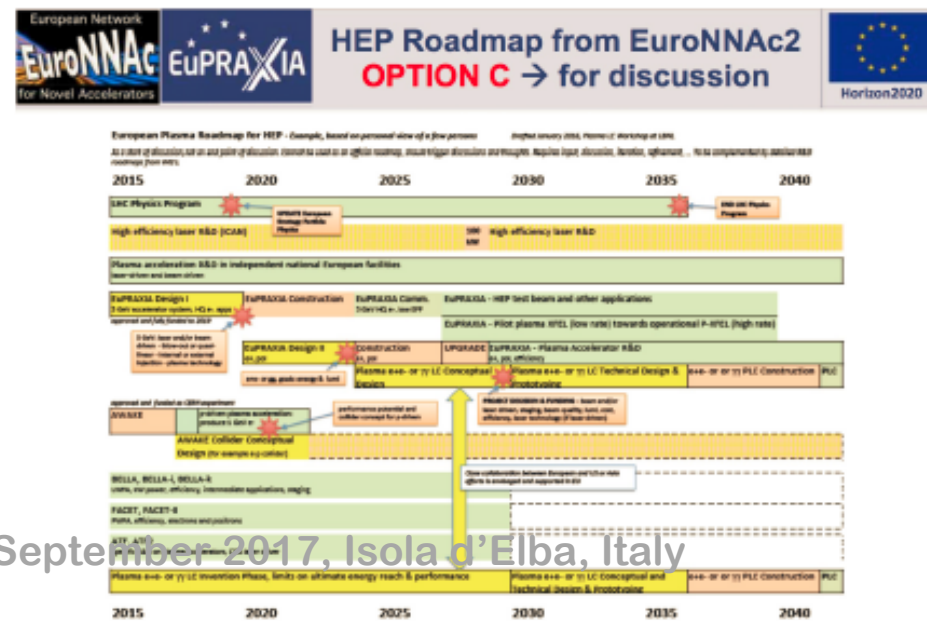
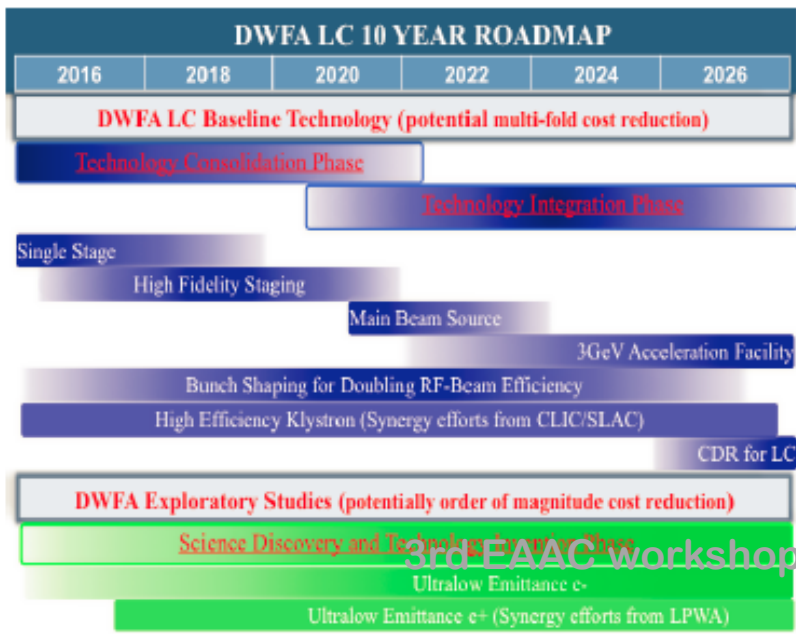
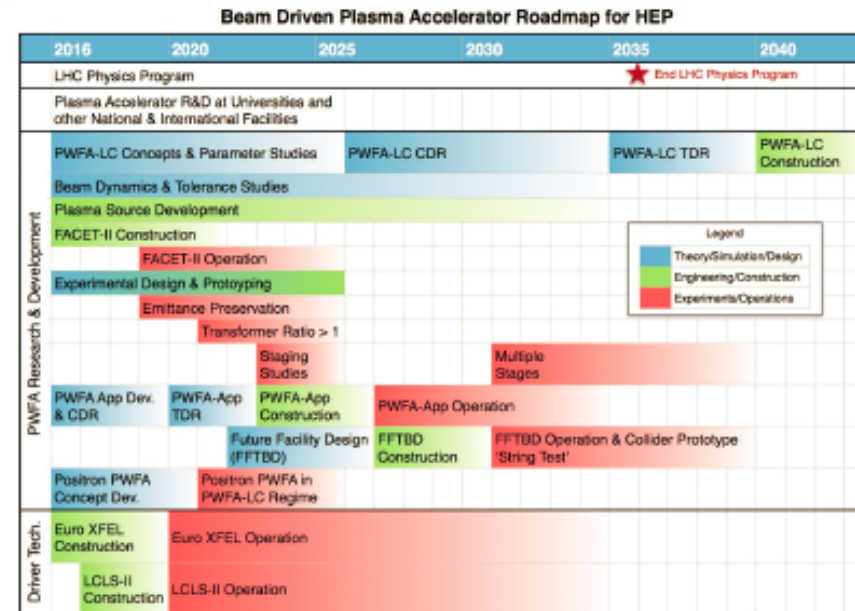
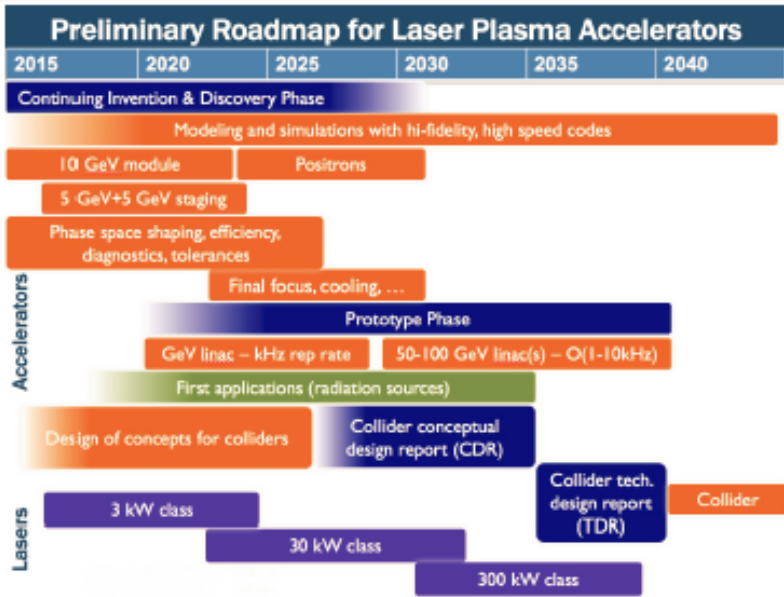
- ❖ E- beam with reliable parameters, collider quality level in a staged process multi-GeV range
- ❖ Large scale facilities needed to demonstrate staging and efficiency
- ❖ Multi-stage prototypes
- ❖ Strawman design of multi-TeV machines for 4 ANA concepts

20-year milestone



- ❖ **Delivery of conceptual and technical reports**
- ❖ Following continuous developement of collider concepts
- ❖ **Performance** of each ANA assessed from **simulations and prototyping experiments**
- ❖ Proposed designs could be based on multiple ANA schemes

Connection with existing roadmaps in the US and Europe?



All roadmaps point to an ALC design by 2035



- ❖ Very important challenges remain, but **no show stopper**
- ❖ Proposed time frame achievable only with
 - ❖ **Intensive** and coordinated international **R&D**
 - ❖ **sufficient funding** for ANA technology with HEP application
- ❖ Common dedicated funding should support common roadmaps
- ❖ Coordination necessary to define common R&D objectives and propose future facilities

Summary and Next steps

- ❖ Advanced concepts offer promising options for colliders
- ❖ Key scientific milestones were identified
- ❖ Detailed program and resources need to be identified
- ❖ **Advanced LinEar collider study GROup (ALEGRO)** being created to foster and trigger ALC related activities
 - ❖ Provide a framework to **amplify international coordination**, broaden the community, involving accelerator labs/institutes
 - ❖ **Identify topics** requiring intensive R&D and **facilities** needed
 - ❖ 1st action : **Report** on ANA priorities as input for the European Research Strategy Group for HEP: due **end of 2018**
 - ❖ a series of workshops to discuss and finalize the roadmap and priorities is being planned (**WG8 EAAC this week, 26-29 March 2018 Oxford, AAC 2018**)

WG8 program this week

SALA ELENA (SE) meeting room

- ❖ Two sessions on **Tuesday afternoon** 16:00 to 19:30
 - ❖ Several topics addressed: BDS, energy spread, plasma lens, multistage, energy scaling in DLA, collider modelling tools
 - ❖ **Discussion of collider detailed roadmap , organisation of ALEGRO**

- ❖ Joint session WG1-WG8, **Wednesday** 18:00-19:45
 - ❖ Facilities for collider relevant R&D
 - ❖ Talks on some facilities
 - ❖ **Discussion about existing/needed facilities following our survey**

**Thank you to all ANAR 2017
workshop participants
and to CERN and EuCARD² for support**



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3rd EAAC workshop, 25th September 2017, Isola d'Elba, Italy