

# Strategy Towards Ultimate Limits

*M. Bai (GSI), S. Brooks (BNL), G. Franchetti (GSI), Z. Huang (SLAC),  
V. Lebedev (FNAL), V. Shiltsev (FNAL), G. Stupakov (SLAC), U.  
Wienands (ANL), F. Zimmermann (CERN)*

We propose a joint global brainstorming and R&D effort to identify and quantify, in a structured way, the ultimate limits for extreme beams, such as limits on high-gradient acceleration, high-field bending, beam size, beam brightness, and luminosity.

Hadron beam brightness, if, e.g., limited by space-charge effects, could be boosted by various approaches to space-charge compensation, by various types of cooling (including coherent electron cooling, optical stochastic cooling, enhancement of synchrotron radiation), and by exploring the wider production and use of crystalline beams.

Technology-dependent limits on the magnetic field may be set by material properties (critical current, tensile properties, ...) or by physics (break-up of the proton, or breakdown of the QED vacuum).

In the framework of the proposed initiative, an overall assessment and roadmap could be developed, in which various relevant limits will be discussed, ranked and analyzed.

Other degrees-of-freedom relate to the societal imprints of future frontier accelerators: energy consumption, length, cost, technology transfer and increasing the “human capital” of the world.

The overcoming of the present limits will be assessed through “ultimate scenarios”, for example ones based on nanotubes or crystals.

Even an extremely-long-term vision could be developed on hypothetical options to go beyond the Schwinger critical field, such as a quantum plasma accelerator and acceleration using a different force, e.g. “black hole acceleration”.

Finally, the feasibility and potential of all proposed options will be reviewed, ranked, clustered and structured into a long-term “Ultimate R&D plan” (R&D towards ultimate beams).

The proposed effort can profit from the results of the past and ongoing European projects EuCARD-2 WP5 XBEAM [1] and ARIES WP6 APEC [2]. It would be synergistic with the future IFAST project [3] and, especially, with the widening of IFAST, as proposed in a separate Snowmass2021 LOI [4].

## References

1. <http://xbeam.web.cern.ch/>
2. <https://aries.web.cern.ch/wp6>
3. M. Vretenar et al., “Innovation Fostering in Accelerator Science and Technology (IFAST)”, proposal no. 101004730, submitted to the European Commission’s H2020 Call H2020-INFRAINNOV-2019-2020 (Demonstrating the role of Research Infrastructures in the translation of Open Science into Open Innovation) on 17 March 2020.
4. G. Franchetti et al., “Exploiting Global Accelerator Network Synergies”, LOI submitted to Snowmass2021