Fermilab U.S. DEPARTMENT OF ENERGY | Office of Science

In Support of Accelerator R&D Towards Superbeams: Three Points

Vladimir SHILTSEV (Fermilab)

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Need to Improve *MW/B$* of Future Machines → *R&D*

$$P_{beam} = \frac{N_{pulse} E}{T_{cycle}}$$

Cost = f(size, P_wall plug, RF, magnets, target, etc)

Point #1: Technology Progress is (Slow but) Needed

i) **Better RF:** "why so expensive?", improve klystron efficiency 55%→80%; tunable SC RF, *m*-harmonics, etc

ii) **Better magnets:** power efficiency, HTS rapid cycling, power storage/recovery, FFAG/nonlinear,etc

iii) **Better inj/extr/targets:** laser striping, clean & stable resonant or crystal assisted extraction, multi-MW target lifetime, maintenance, ops

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Point #2: Physics Progress is Needed

i) **Lower losses/emittance growth :** improve the beam dynamics with multiple harmonics RF, via clean transition crossing; by injection "painting" to make the SC force more uniform; via non-linear integrable optics or by SC compensation by e-lenses, also – AI/ML, etc

ii) **Improve collimation efficiency:** upderstand the limits, new ideas (electrostatic septa-assisted, etc)

iii) **Better physics understanding:** still "not-100% predictable" SC, need to advance beam diagnostics, better modeling and theory tools on major effects and instabilities, systematic beam studies at existing machines and test facilities (IOTA)

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Point #3: Forward thinking and "packaging"

i) **All intensity frontier high energy proton sources serve for over 40 years:** new ones should be *upgradable* (flexibility by design)

ii) **Given that the US HEP focus in US will be about neutrinos and rare processes for next several decades:** approach to corresponding R&D must be coherent ("packaged")

- long-term, with a roadmap and timeline
- better organized (than being scattered over multiple thrusts and teams)

Hope this Snowmass and P5 will move on that !