PASAIG - Physics case:

40 GeV lepton collider at Berkeley Lab

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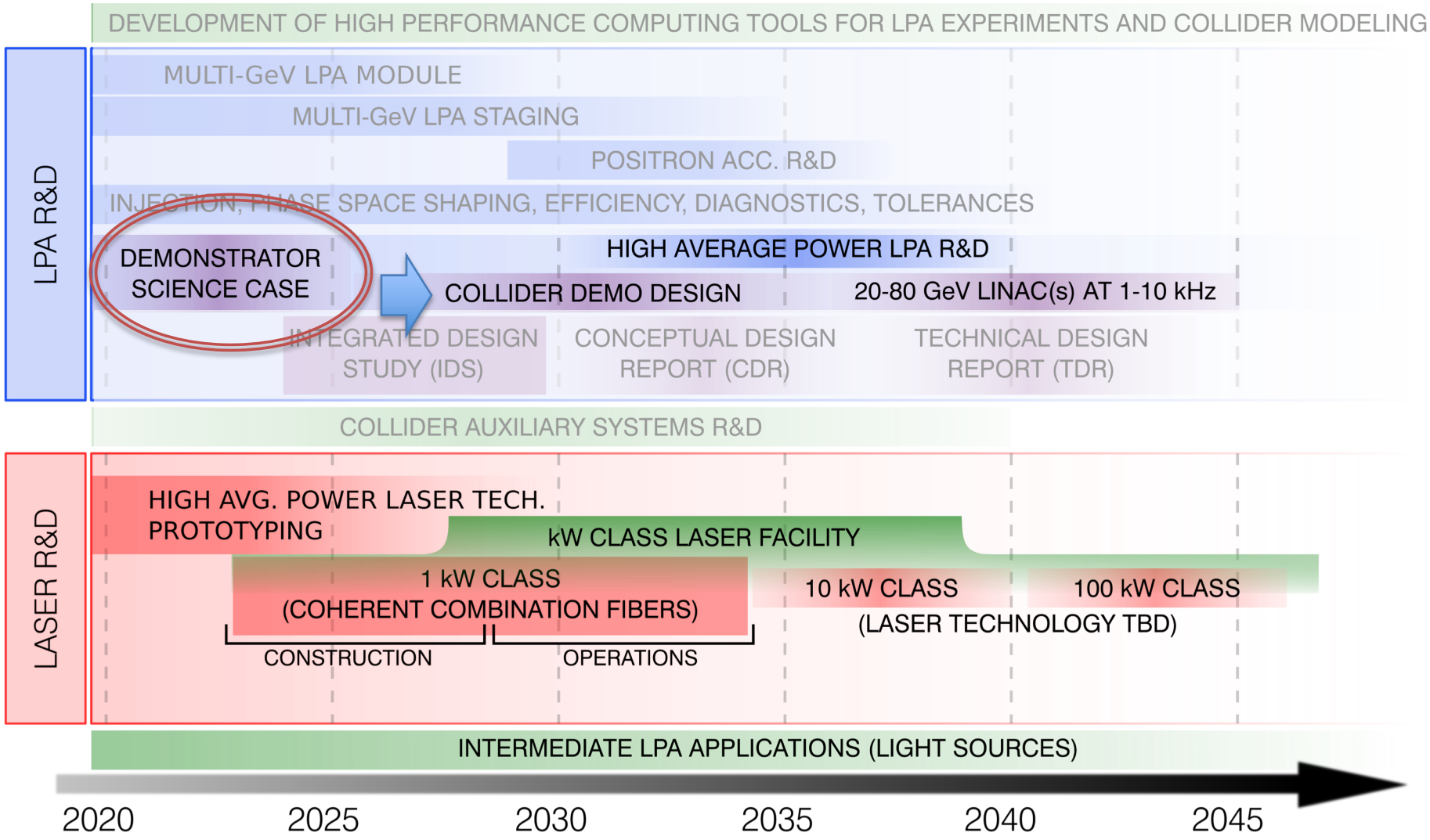
40 GeV lepton collider is a part of the high-level laser-plasma-accelerator-based collider R&D roadmap



Outline of White Paper

Whitepaper submitted to Snowmass21:

40 GeV lepton collider at Berkeley Lab

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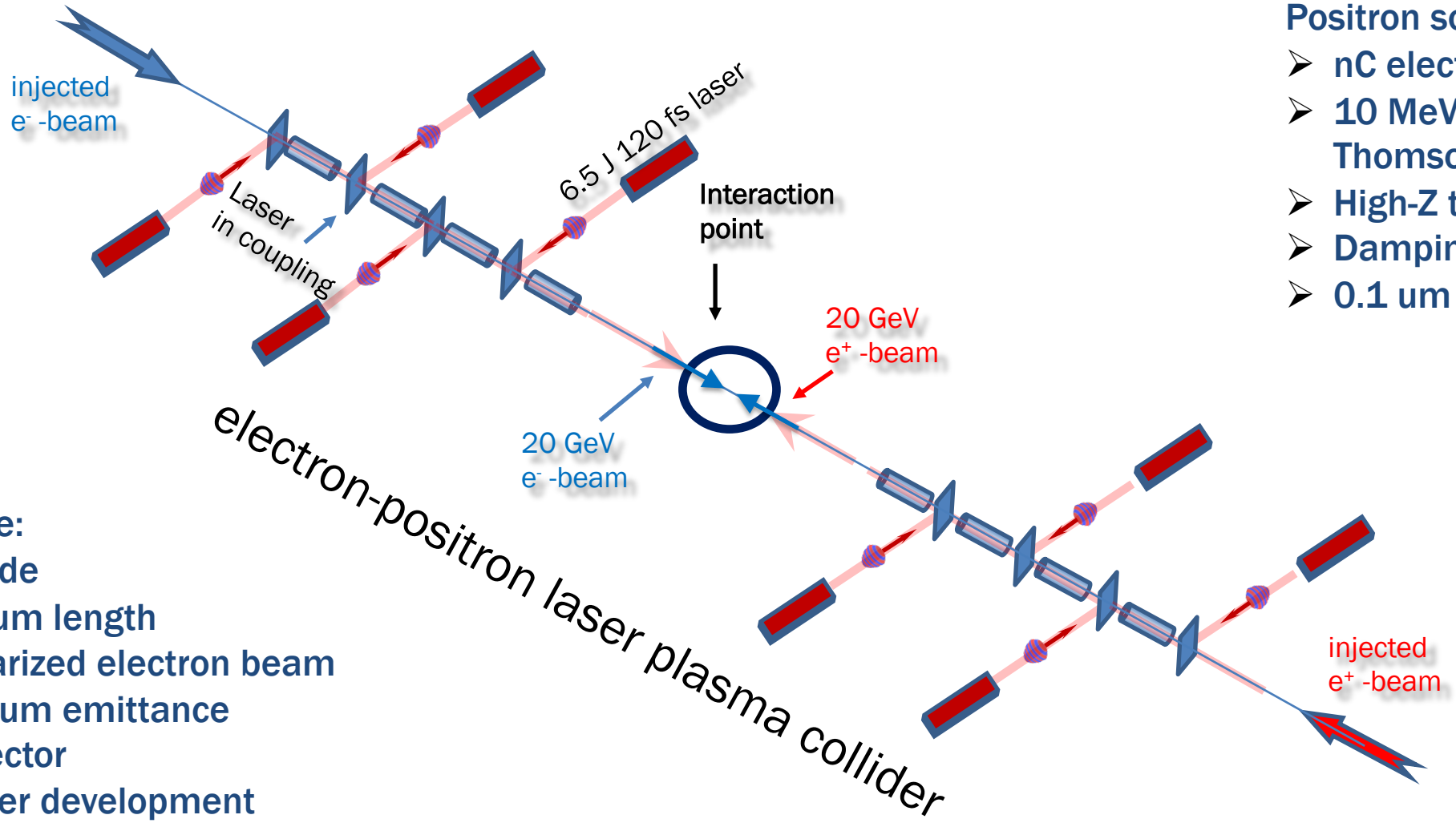
- Distribute to broader laser-plasma and HEP community
- More input and authors are welcome
- Integrate feedback into the white paper

CONTENTS

40 GEV LPA-BASED COLLIDER DESIGN



Positron source:

- nC electron beam
- 10 MeV photons via Thomson scattering
- High-Z target
- Damping ring
- 0.1 um emittance

Electron source:

- Photocathode
  - 15 um length
  - Polarized electron beam
  - 0.1 um emittance
- Plasma injector
  - under development

TABLE I. : High-level IP parameters for $\sqrt{s} = 40$ GeV e^+e LPA-based collider.

Beam energy	20 GeV
Bunch charge	200 pC
Bunch length (rms)	15 μm
Repetition rate	1 kHz (upgrade to 25 kHz)
Spot size at IP	50 nm
Luminosity	4×10^{30} cm^{-2}s^{-1} (upgrade to 1×10^{32} cm^{-2}s^{-1})

Applications

QCD:

(i) Precision α_s measurement

(ii) Measurements to improve simulation modeling

(iii) New QCD measurements that were not on the radar previously

Beyond SM:

(i) Milli-charged particles

(ii) Axion-like particles

(iii) Low mass resonances decaying to hadronic final states

Revisiting old measurements:

(i) Detectors could be designed to do physics that was not possible at the older experiments

(ii) Redo some analysis with lower uncertainties

Strong Field QED:

(i) High energy electron/positron/photon interactions with intense EM fields

(ii) Final focusing and interaction point limitations due to strong fields

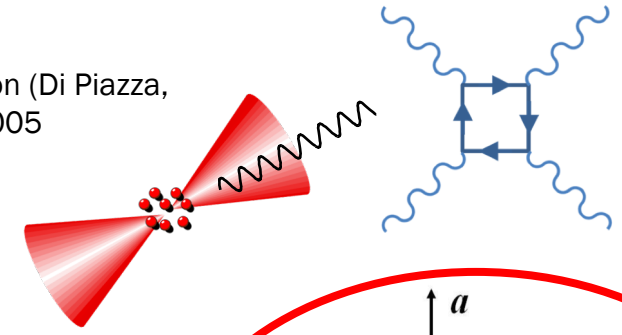
γγ collider

Thank you!

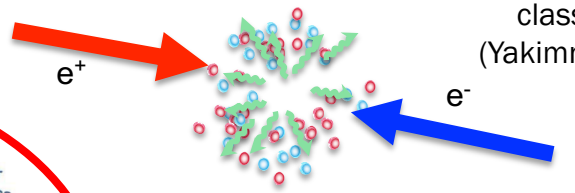
Extra slides

High Intensity Particle Physics describes the phenomena in strong EM fields in the environments where the field strength is comparable to the QED critical field

High order harmonic generation (Di Piazza, Hatsagortsyan, C. H. Keitel, 2005 Fedotov & Narozhny, 2006)



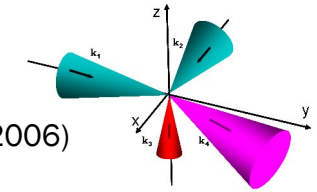
Photon-photon scattering via relativistic mirrors (Koga et al (2012))

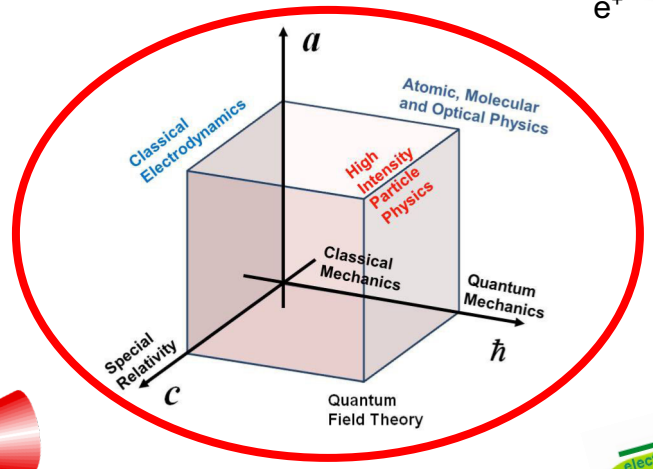


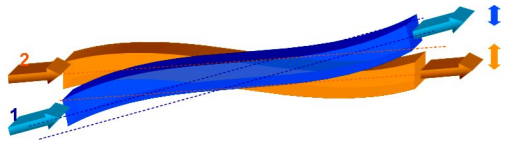
Interaction point physics at future TeV-class lepton colliders (Yakimneko et al, 2019)

4-wave mixing

(Lundström et al, 2006)

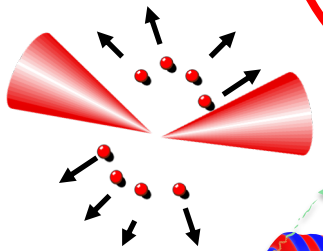


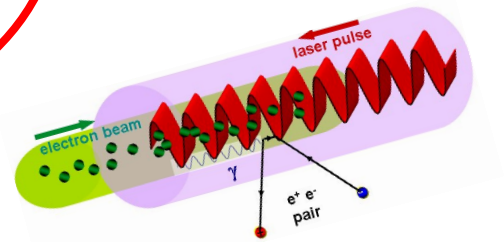




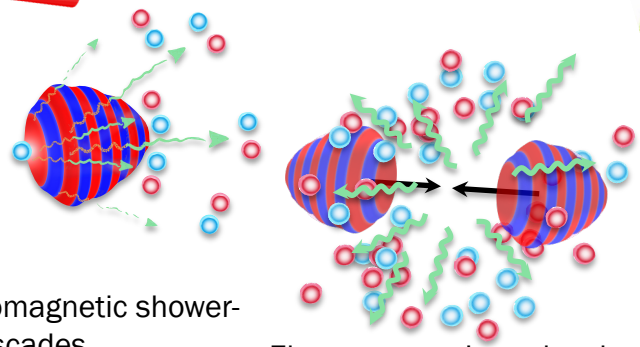
Birefringent e.m. vacuum (Rozanov, 1993)

Electron positron pair production from vacuum (Schwinger, 1951)





Mulitphoton Compton and Breit-Wheeler processes
A. I. Nikishov, V. I. Ritus (1964);
Bula et al (1996); Burke et al (1997)
Cole et al (2018); Poder et al (2018)



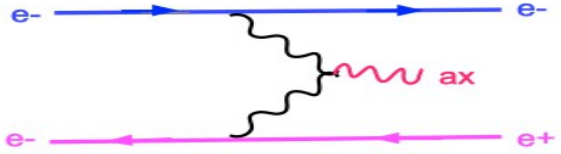
- Electromagnetic shower-type cascades

- Electromagnetic avalanche-type cascades (Bell&Kirk, 2008)

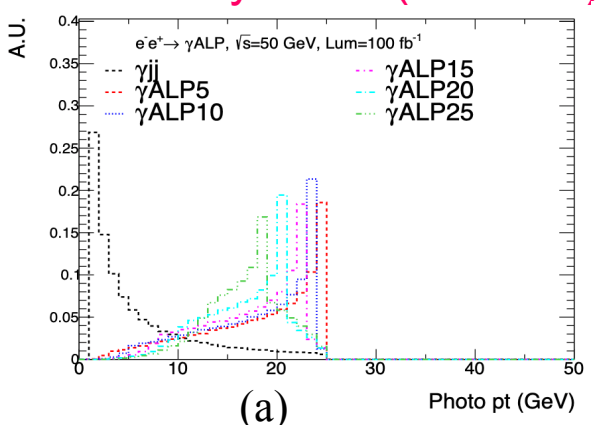
ALPs discovery potential at a e^+e^- 50 GeV collider

Wei-Ming Yao (LBNL)

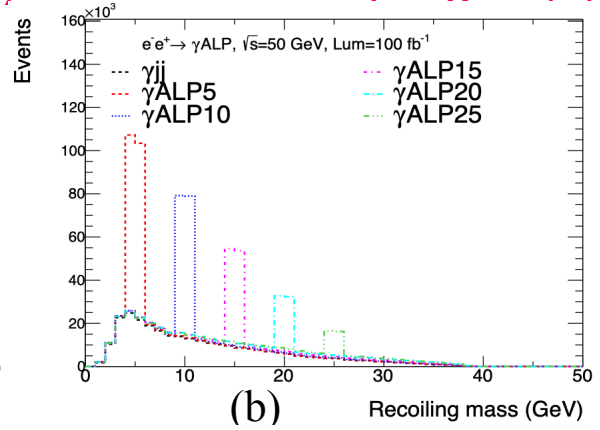
- Axion-like-particles (ALPs) are motivated in theories where new symmetries are broken spontaneously.
- ALPs can be produced with cross-section of 2.0–1.0 pb for mass (5-25 GeV).



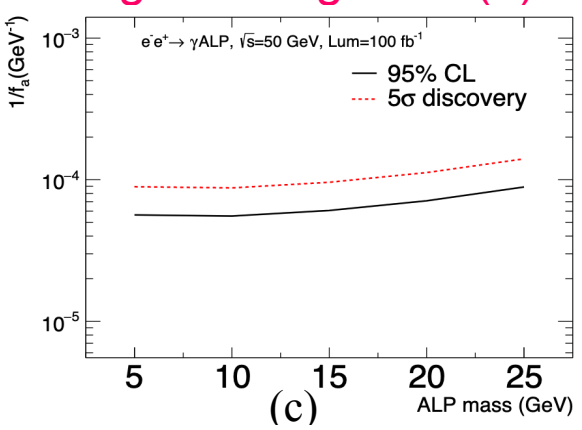
- Selecting one high pt isolated photon or two electrons and search for a bump in the recoiling mass for detection independently of ALPs decay modes.
- Events are generated in Madgraph 3.5.1 with ALP_linear model[1701.05379].
  - Pt of photon >10 GeV at truth level (a).
  - Mini dR between photon and rest particles >2.0
- Discovery limits (95% CL) on the ALP coupling fa (c) using recoiling mass(b).



(a)



(b)



(c)