Broad impact of the Energy Frontier towards BSM searches in synergy with the other frontiers: Axion and ALP example

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P5 Town Hall Meeting
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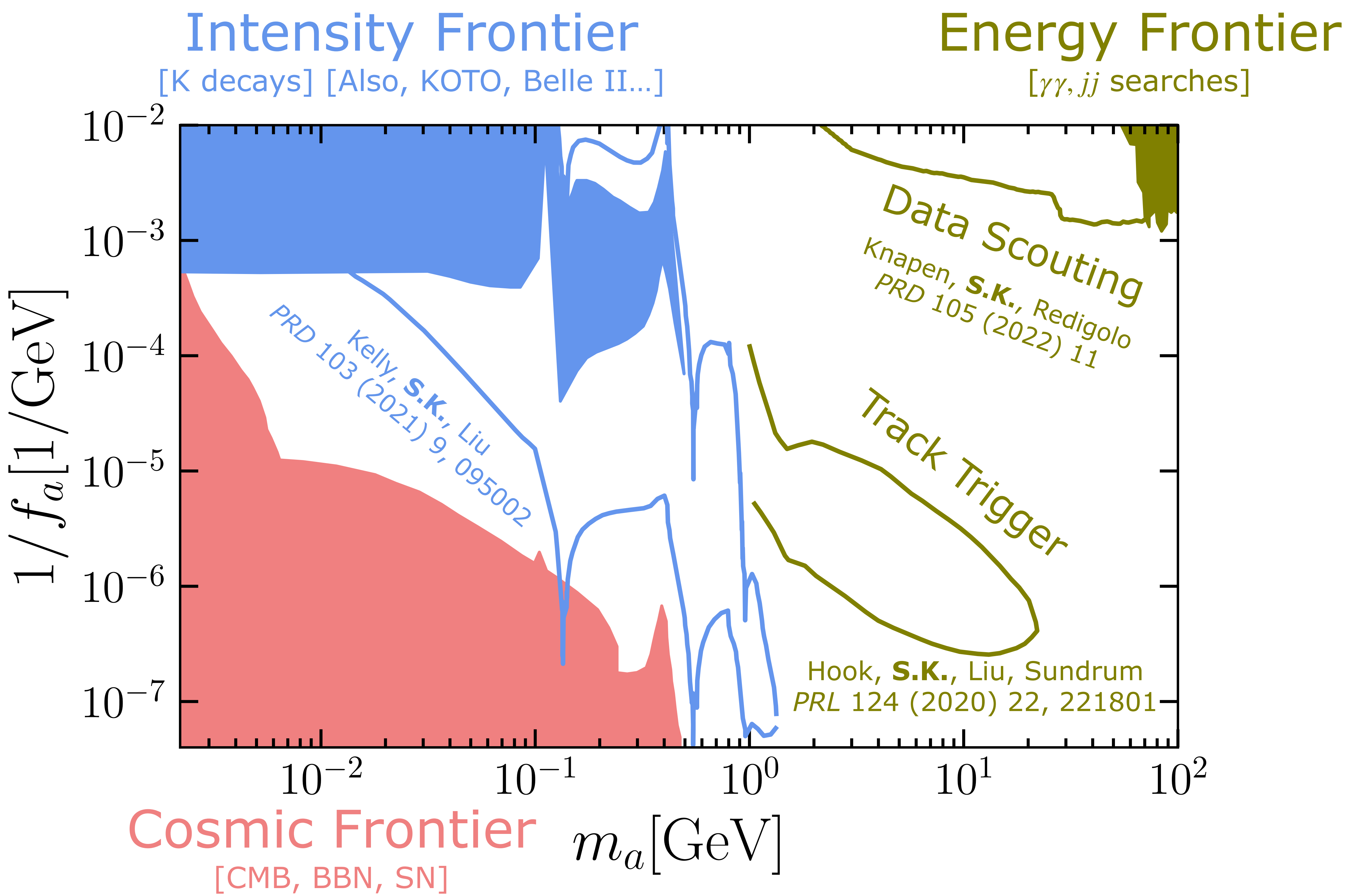
Hidden Sectors

- Very well motivated: Dark Matter, Strong *CP* Problem…

- Cosmic Frontier and Intensity Frontier provide excellent probes, especially for MeV-GeV scale masses [*e.g.*, CMB, BBN, rare meson decay]

- Energy Frontier can play a complementary and powerful role: lots of room for progress!
    - Theory predictions and model building
    - Detection strategy and upgrades

Energy Frontier Probes of Axion/ALP



Back-up Slides

Low-Mass Diphotons

Knapen, **S.K.**, Redigolo: *PRD* 105 (2022) 11

$$m_{\gamma\gamma} \simeq \sqrt{p_{T_1}^{\gamma} p_{T_2}^{\gamma}} \Delta R_{\gamma\gamma}$$

Addressing trigger threshold

Use "data scouting"

allows for smaller p_T

event rate increases, but event size is smaller

so can still write data on tape at $\ll$ 1 GB/s

Addressing photon isolation

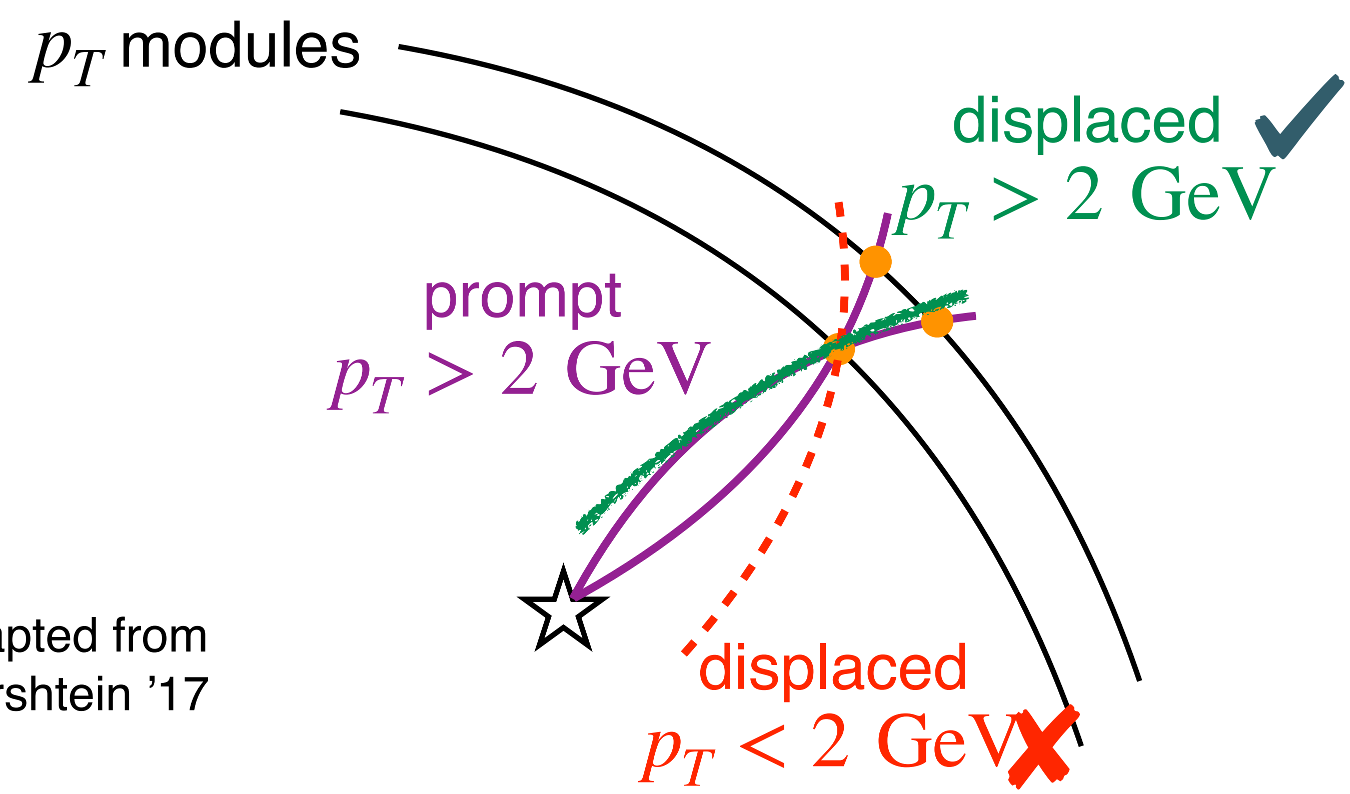
Use "modified isolation"

Light resonance: boosted & the photons overlap with each other

Subtract the subleading photon

Track Trigger

Hook, **S.K.**, Liu, Sundrum: *PRL* 124 (2020) 22, 221801



adapted from Gershtein '17

proposal to trigger on *displaced* tracks

Gershtein '17
CMS-PAS-FTR-18-018
Gershtein, Knapen '19

Vertex selection

1. The 2D tracks fit a common vertex with standard deviation $\Delta d_T < 1$ cm;
2. The 2D common vertex has a minimal distance to the interaction point of 0.5 cm and maximal distance of 35 cm, 0.5 cm $< d_T <$ 35 cm;
3. The 2D common vertex is significantly displaced away from the interaction point, $d_T/\Delta d_T > 5$;
4. The corresponding 4D vertex has a standard deviation in z direction $\Delta d_z < 5$ cm;
5. The corresponding 4D vertex has a z-direction location $d_z < 20$ cm;
6. The corresponding 4D vertex has a standard deviation in time $\Delta d_t < 500$ ps;
7. The corresponding 4D vertex has a time $d_t <$ 1000 ps;
8. The tracks are within 0.4 in pseudorapidity of the reconstructed displaced jet direction $|\eta_i - \eta_V| < 0.4$ for all the three tracks;
9. The tracks are within 0.4 in azimuthal angle of the reconstructed displaced jet direction $|\phi_i - \phi_V| < 0.4$ for all the three tracks,

Axions at DUNE

Kelly, **S.K.**, Liu: *PRD* 103 (2021) 9, 095002

$$\mathscr{L}_{\text{gauge}} \supset c_3 \frac{\alpha_s}{8\pi f_a} a G\tilde{G} + c_2 \frac{\alpha_2}{8\pi f_a} a W\tilde{W} + c_1 \frac{\alpha_1}{8\pi f_a} a B\tilde{B}$$

need a large distance between production and detector:
beam dump experiments