Searches for New Particles at DarkQuest

FERMILAB-POSTER-21-113-STUDENT

Meg Wynne, University of Michigan and Nikita Blinov, FNAL

What is DarkQuest?

- An updated fixed target experiment to detect Axion Like Particles (ALPs)
- Accelerates over 10^{18}protons per year (which allows detection of rare processes)
- An ALP is a meson like particle that couples to gluons (inducing coupling to photons and mesons)

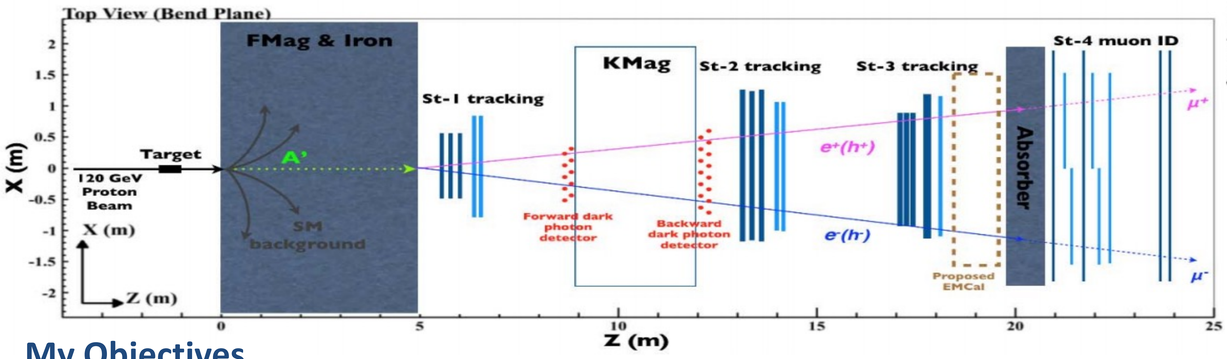


Fig: Dark Photon Experiment at DarkQuest

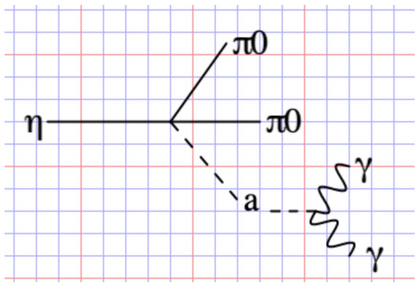
My Objectives

- Simulate ALPs via production and decay channels
- Compute the probability of detecting ALP decay products at the EMCal

Proton Beam Products	Daughter Particles
η	ALP, π, π
η'	ALP, π, π
κ	ALP & π
γ and Nucleus	ALP & Nucleus

Proton Beam Products	Daughter Particles
ALP	π, π, π (all neutral)
ALP	π, π, π (one neutral)
ALP	γ & γ

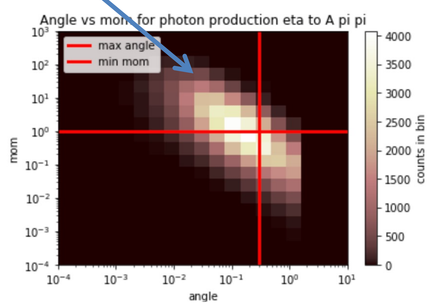
How ALPs are produced vs how ALPs decay



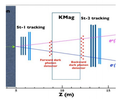
Methods:

- 2 & 3 body decay via Monte Carlo, Accept/Reject, & Special Relativity Kinematics
- ALP decay by lifetime ranges
- Filter ALPs by decay position
- Filter photons by separation, x and y position, and energy

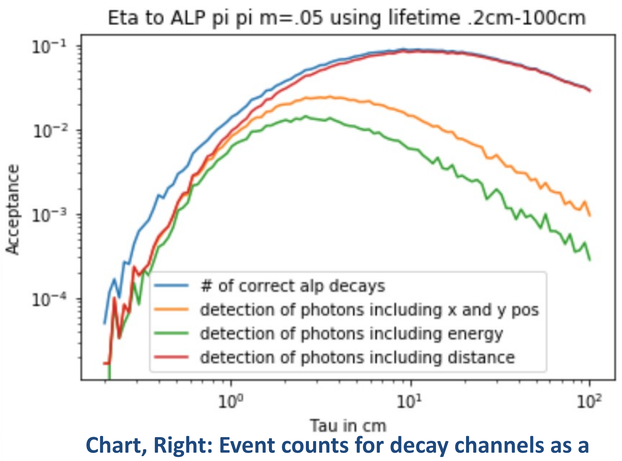
Photons in this region will be detected



Feynman Diagram, Left: Eta decay into two pions and an ALP, which decays into two photons to be detected at the EMCal. Histogram, Right: Maps the number of photon pairs with an angle normal to the z-axis and the magnitude of momentum in units of GeV. Photons in the upper left quadrant will be detected.



This manuscript has been authored by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the U.S. Department of Energy, Office of Science, Office of High Energy Physics.



Chart, Right: Event counts for decay channels as a function of cgg/f (value related to ALP mass and lifetime) Chart, Above: Acceptance as a function of lifetime at various cuts to produce number of events. Chart, Low Right: Testing the impact of mass on total events. Large mass is less favorable and has a smaller lifetime window to produce acceptable events.

Meson	Probability of Production
η	0.30
η'	0.034
K Short	0.18

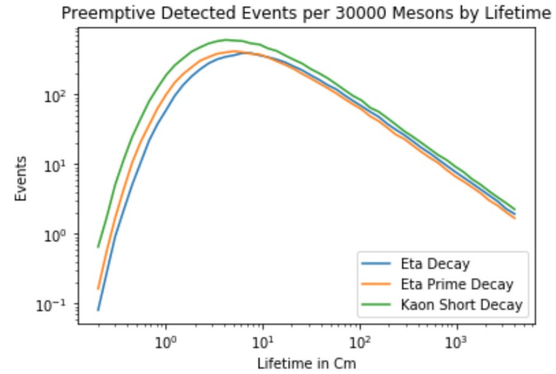
Chart, Above: Probability of meson production per proton interaction. Values computed using Pythia 8

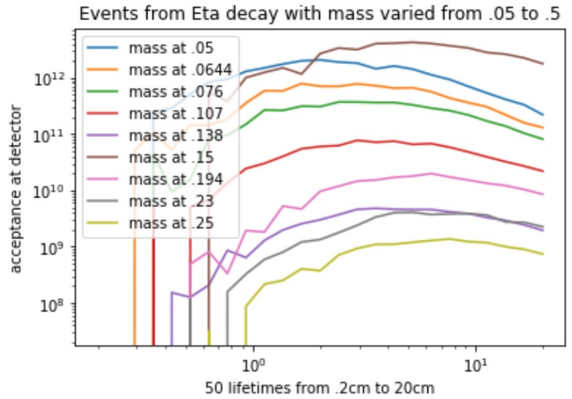
Conclusion & Future Goals

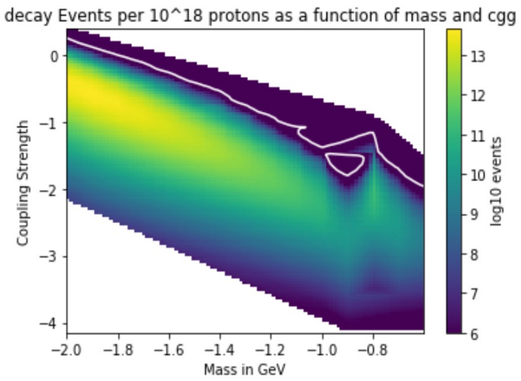
- Eta decay is most favorable by factor of at least 1000
- Lower masses & short lifetimes is the best combination
- Investigate high mass event spike
- Repeating Analysis with ALP decay channels

Methods, Cont:

- Simulate over a range of ALP masses
- Determine meson production
- Probability of meson decaying into ALP
- Find total number of events by production channel







Heat Map, Above: Plotting events as a function of coupling strength and mass.

Fermilab U.S. DEPARTMENT OF ENERGY