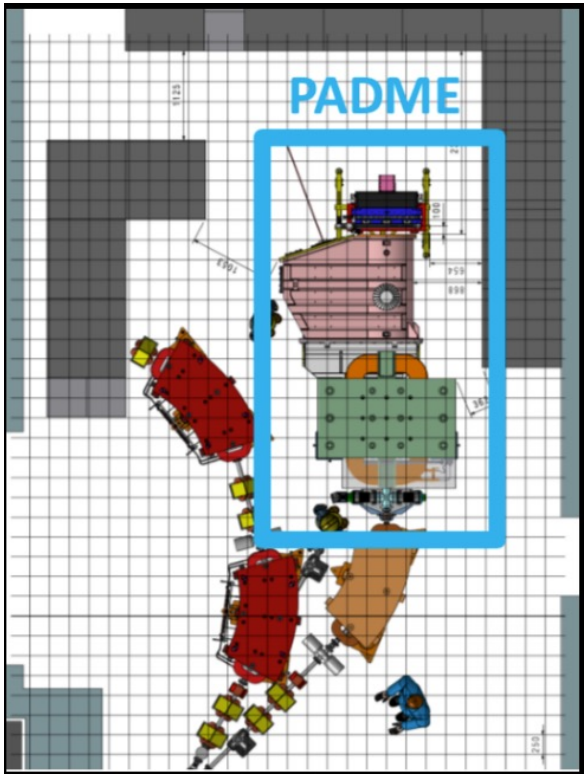
Searching for the Dark Photon at the PADME Experiment

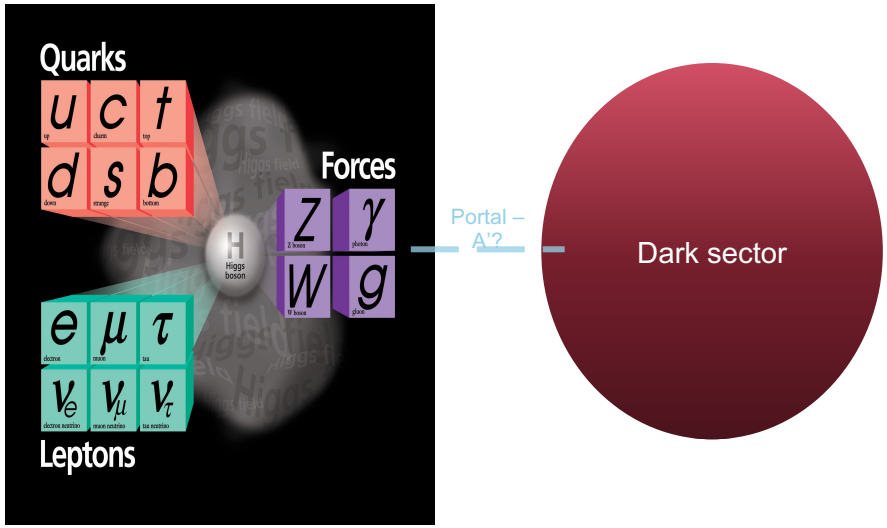
Invisibles21 Workshop

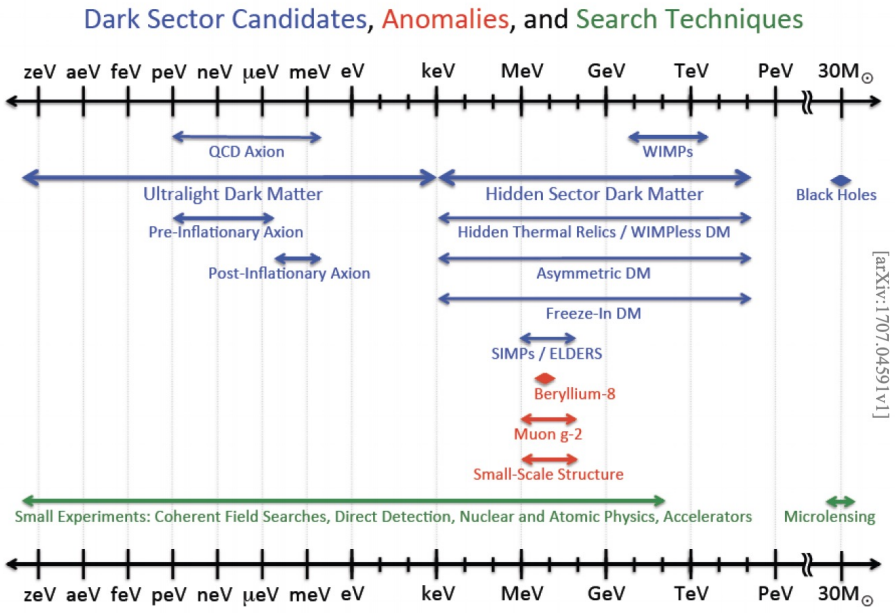


Elizabeth Long - Sapienza Università di Roma

The Dark Photon

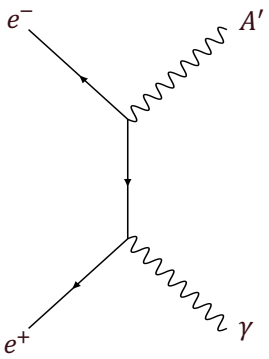
- The dark photon (A') is a portal between the Standard Model & the Dark Sector
- It's a massive vector boson
- SM-A' coupling $\epsilon \ll 1 \Rightarrow$ hidden
- Certain parameters could also explain other anomalies

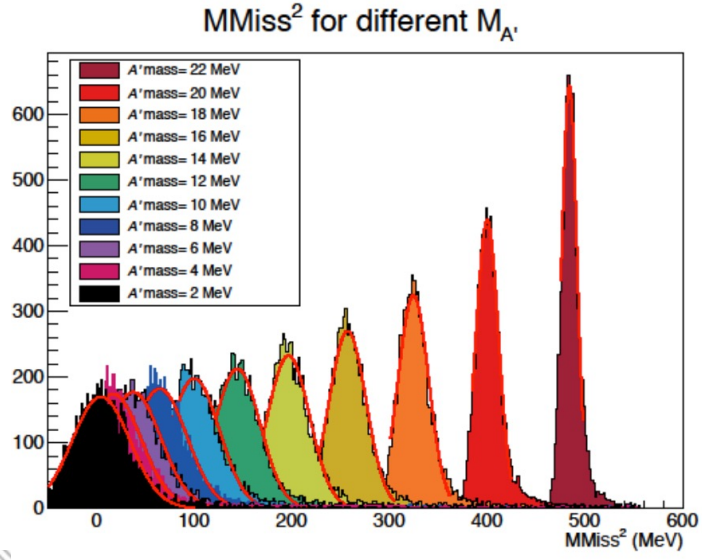


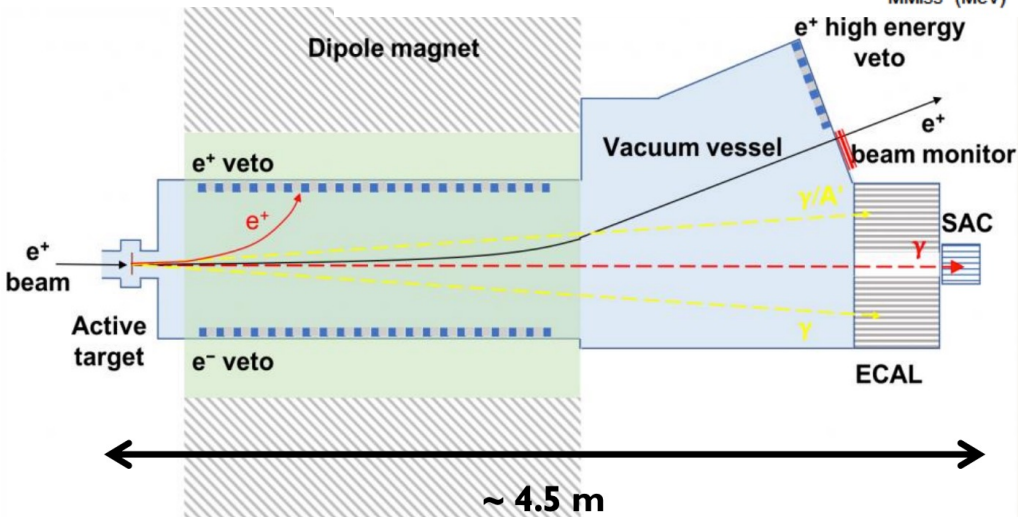


Dark photon production and detection at PADME

- Positron Annihilation to Dark Matter Experiment:
  - $e^+e^- \rightarrow \gamma A'$
- Up to 550 MeV e^+ beam on diamond target
- Signal: 1 γ in Electromagnetic Calorimeter & nothing elsewhere
- ΔM^2_{miss} then gives access to $M_{A'}$

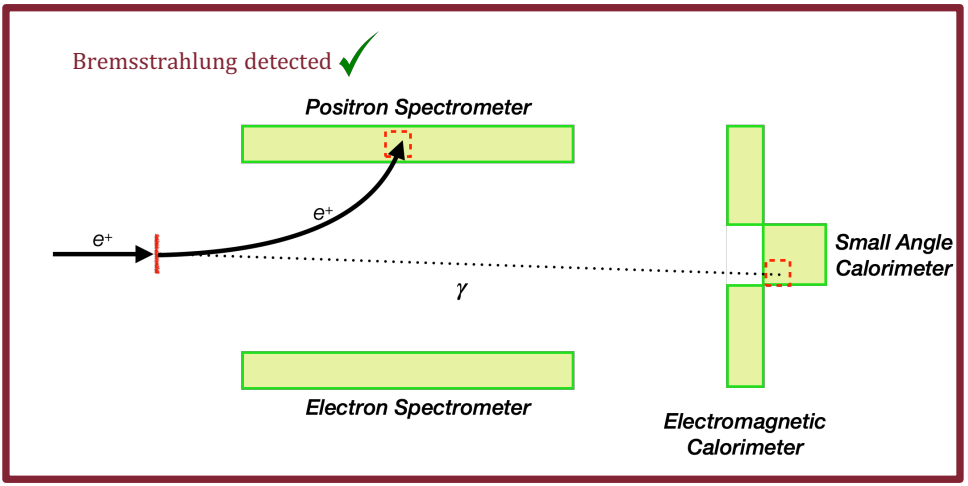


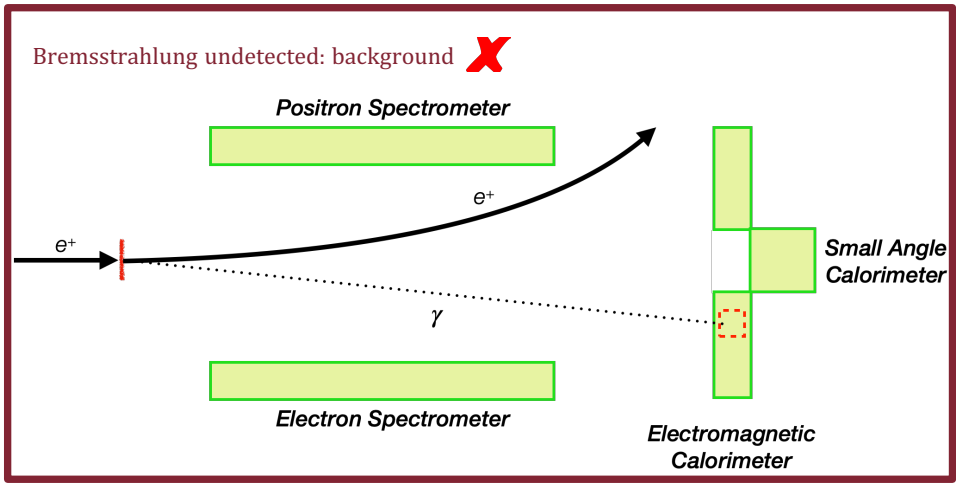




Background sources and rejection

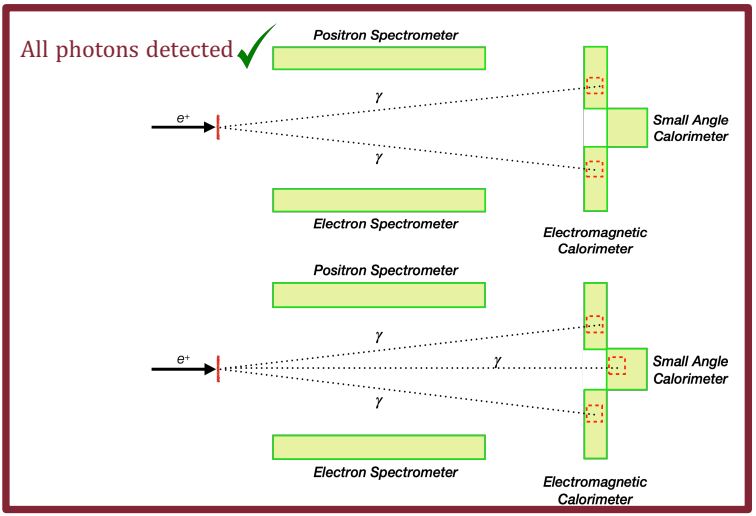
- Main backgrounds:
  - Bremsstrahlung $e^+N \rightarrow e^+\gamma N$
  - 2 or 3 photon annihilation with 1 or 2 undetected photons
- Background rejection:
  - Bremsstrahlung:
    - Detect irradiating e^+ in Positron Veto detector
    - Cut on photon energy

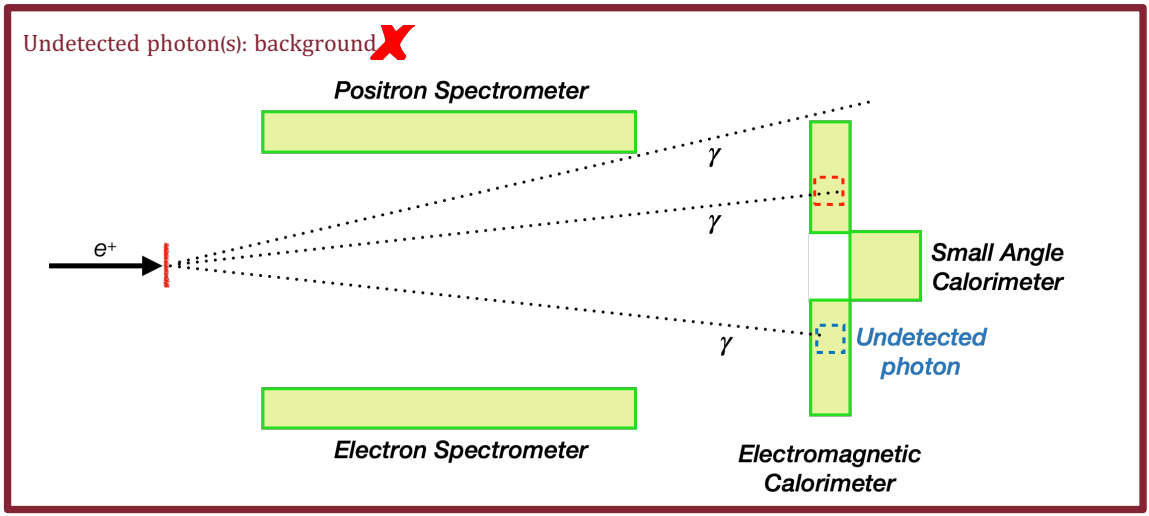




Background sources and rejection

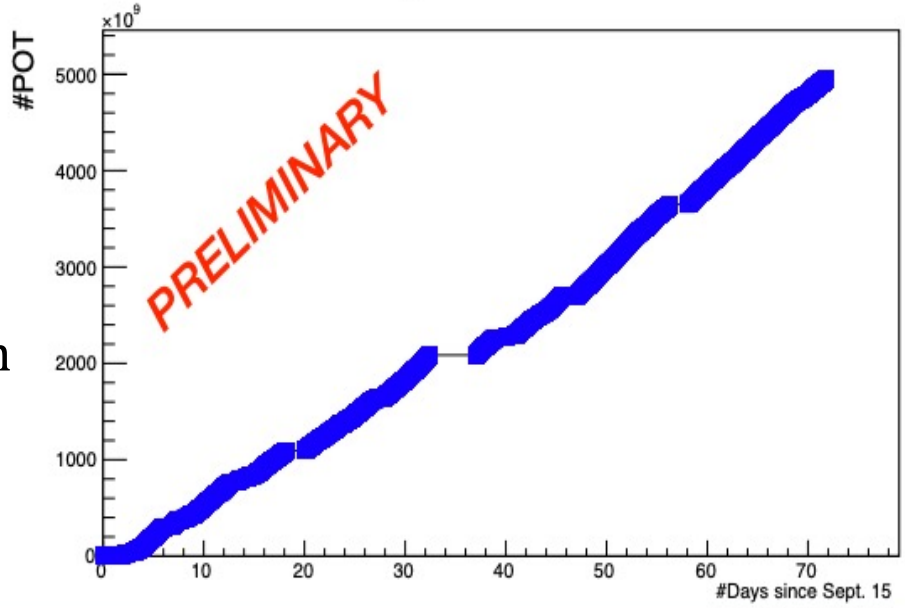
- Main backgrounds:
  - Bremsstrahlung $e^+N \rightarrow e^+\gamma N$
  - 2 or 3 photon annihilation with 1 or 2 undetected photons
- Background rejection:
  - Multiphoton annihilation:
    - Hermetic electromagnetic calorimeter detector
    - High granularity
    - Good energy resolution

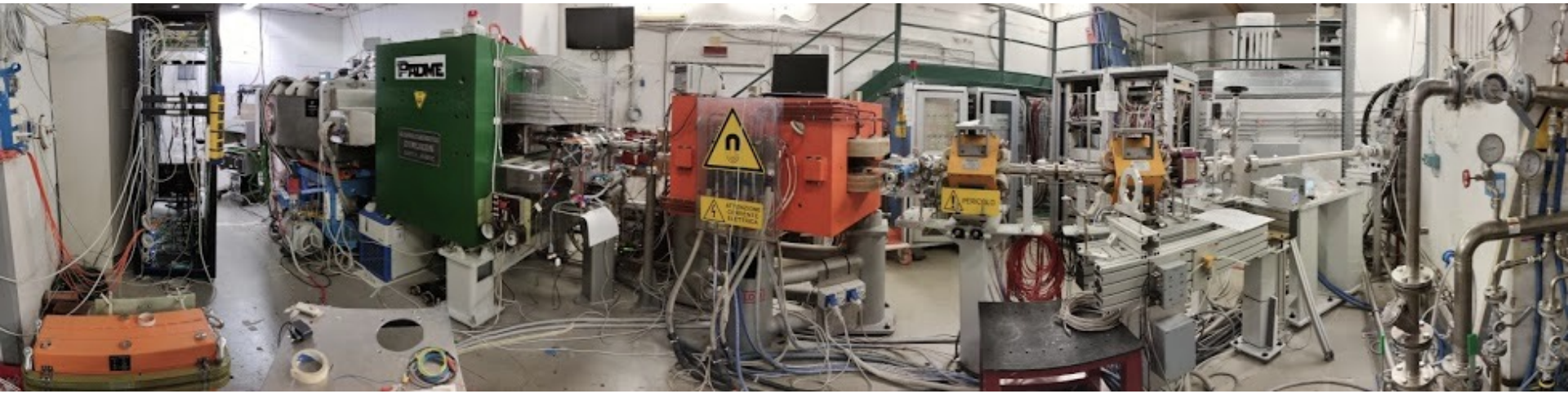




Current status

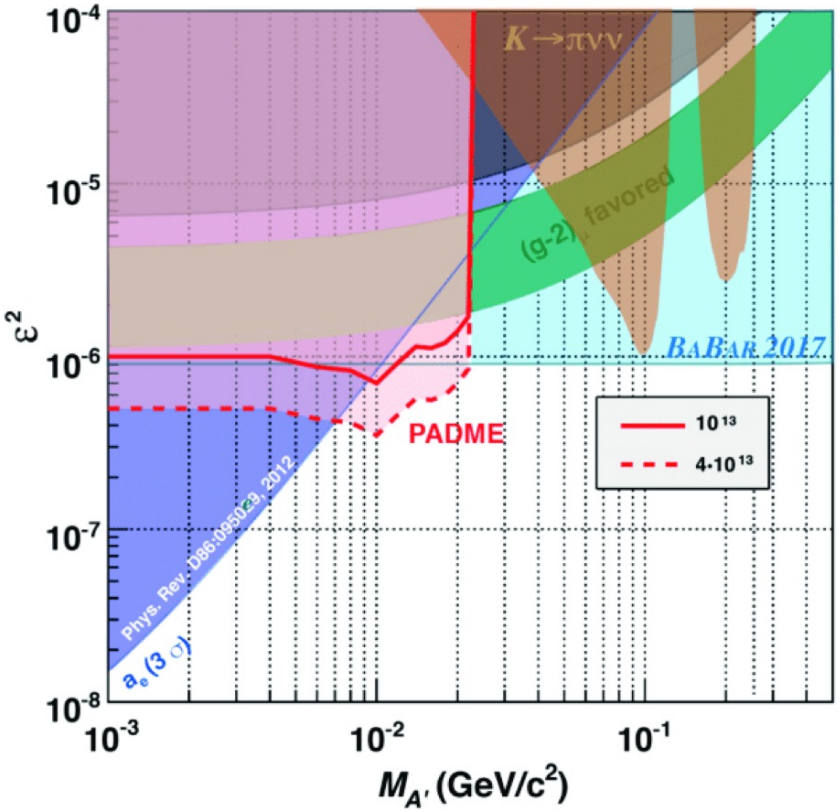
- Run2 was from September-December 2020
- We collected 5.6×10^{12} positrons on target
- Now in data analysis mode!





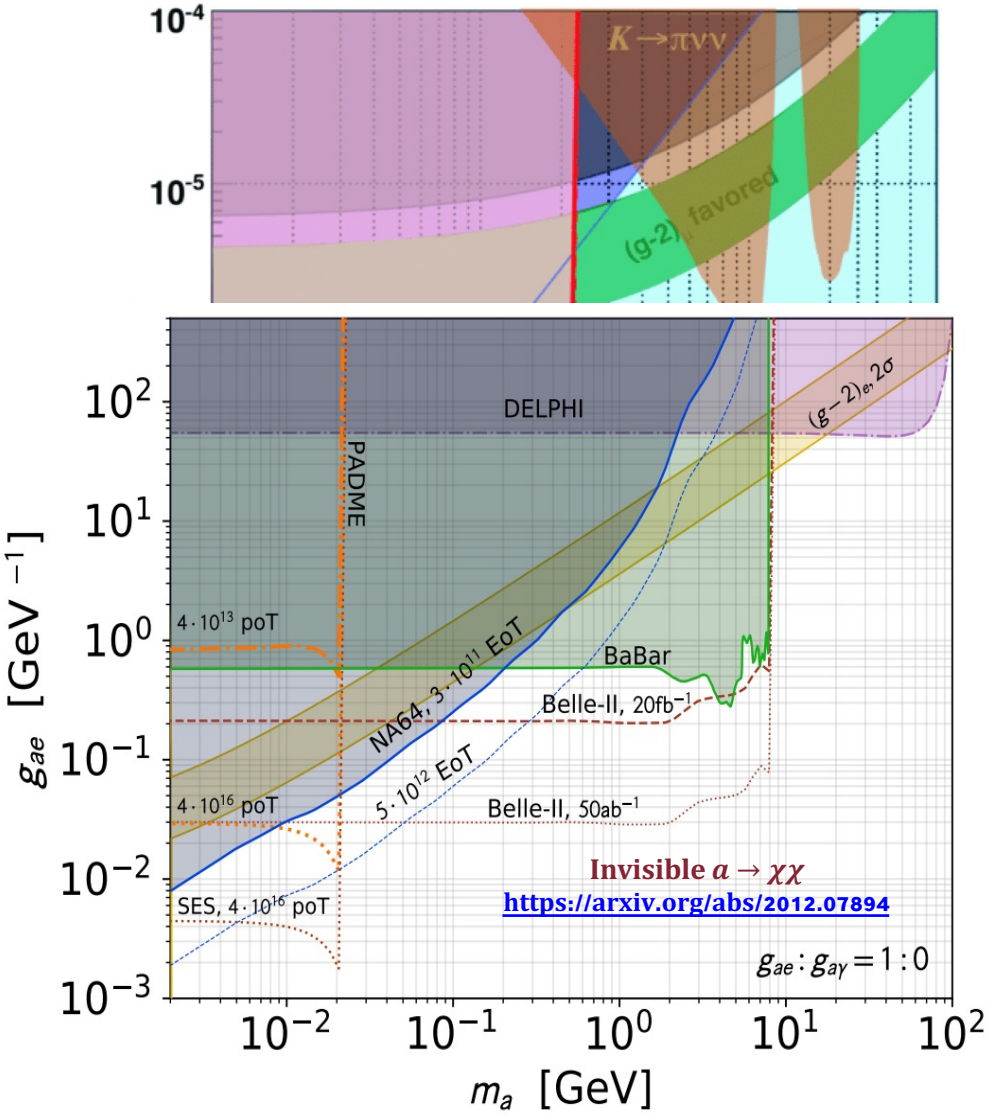
Physics goals

- Dark photons: $e^+e^- \rightarrow \gamma A'$
  - Final states:
    - Visible $A' \rightarrow e^+e^-$
    - Invisible $A' \rightarrow \chi\chi$



Physics goals

- Dark photons: $e^+e^- \to \gamma A'$
  - Final states:
    - Visible $A' \to e^+e^-$
    - Invisible $A' \to \chi\chi$
- Axion like particles (ALPS): $e^+e^- \to \gamma^* a$ or $e^+e^- \to e^+e^- a$
  - Final states:
    - Visible $a \to \gamma\gamma$ or $a \to e^+e^-$
    - Invisible $a \to \chi\chi$



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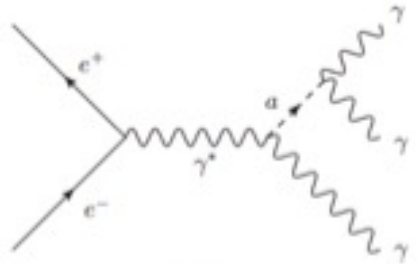
Thank you for your attention.

Backup

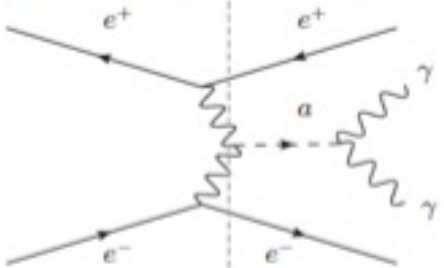
ALP production mechanisms

Coupling to photon only



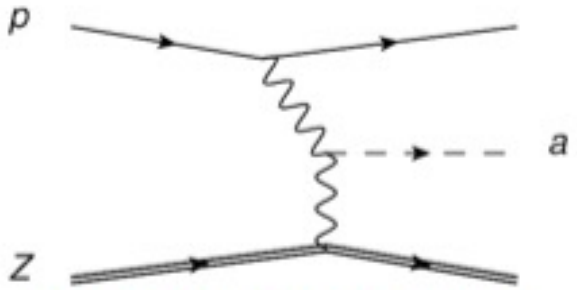
$(e^+e^- \to \gamma^* \to \gamma + a)$

ALPs production via ALPs-strahlung



$(e^+e^- \to e^+e^- + a)$

ALPs production via $\gamma\gamma$ fusion



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Coupling to electron only