Axion Polarimetric Experiment (APE)

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The 20th Patras Workshop on Axions, WIMPs, and WISPs

23.September.2025

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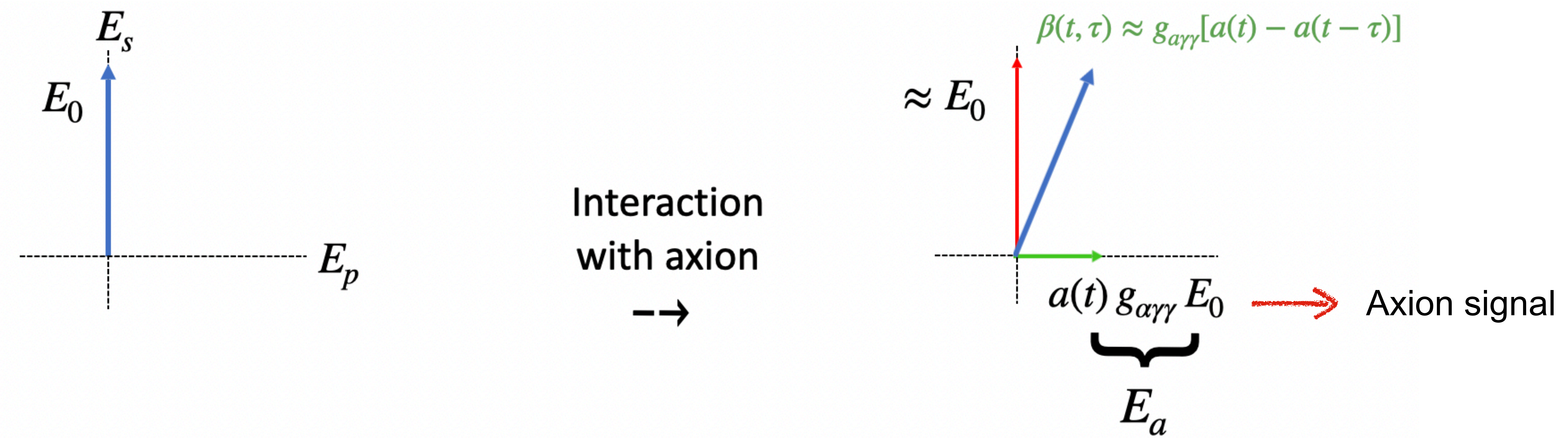
Effect of Axion Field on Polarisation of Light

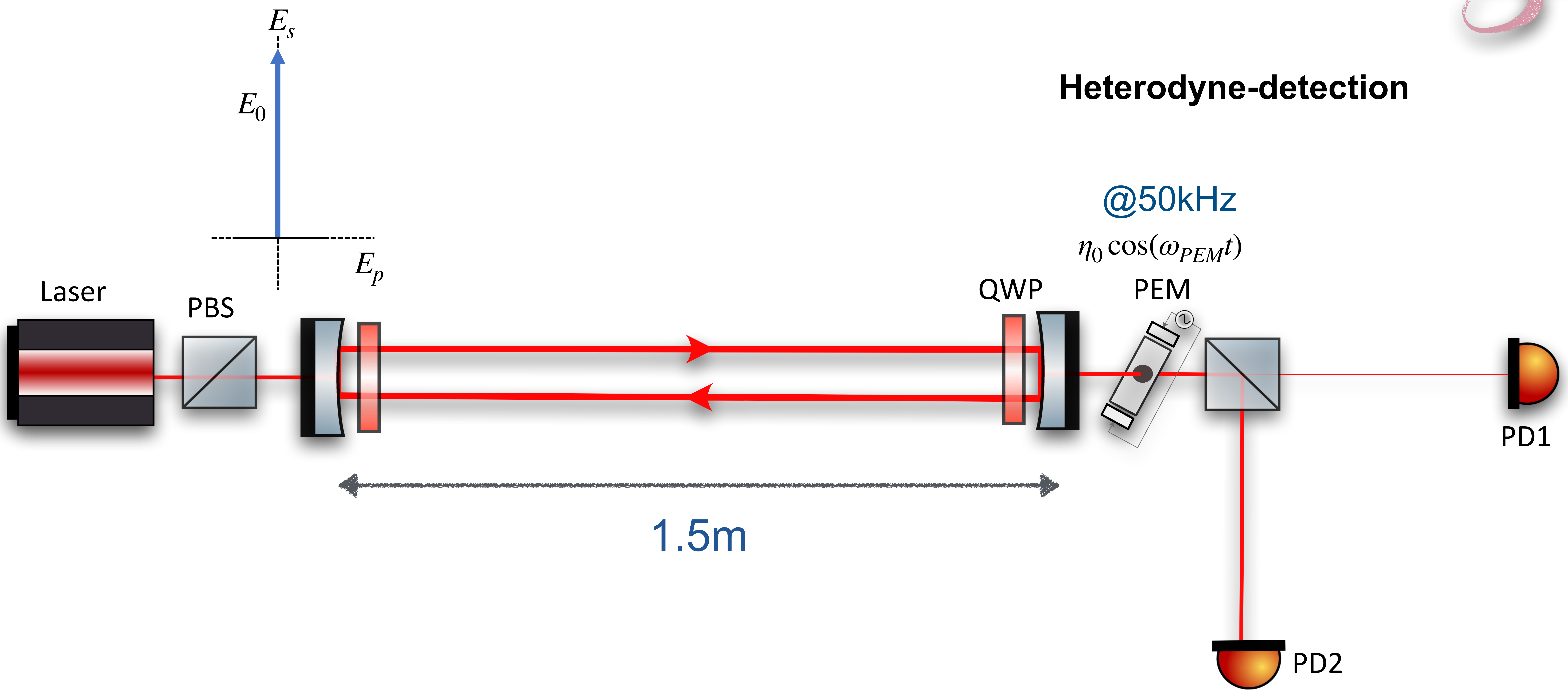
- Axion DM appears as oscillating classical fields:
- Axion field rotates the polarisation of linearly polarised light
- Angle of rotation oscillates with the frequency of Axion field

$$a(t, \vec{r}) = [\frac{\hbar\sqrt{2\rho_{Local}}}{m_a c}] \cos(\omega_a t - \vec{k_a} \cdot \vec{r})$$

$$\omega_a = m_a \frac{c^2}{\hbar}$$

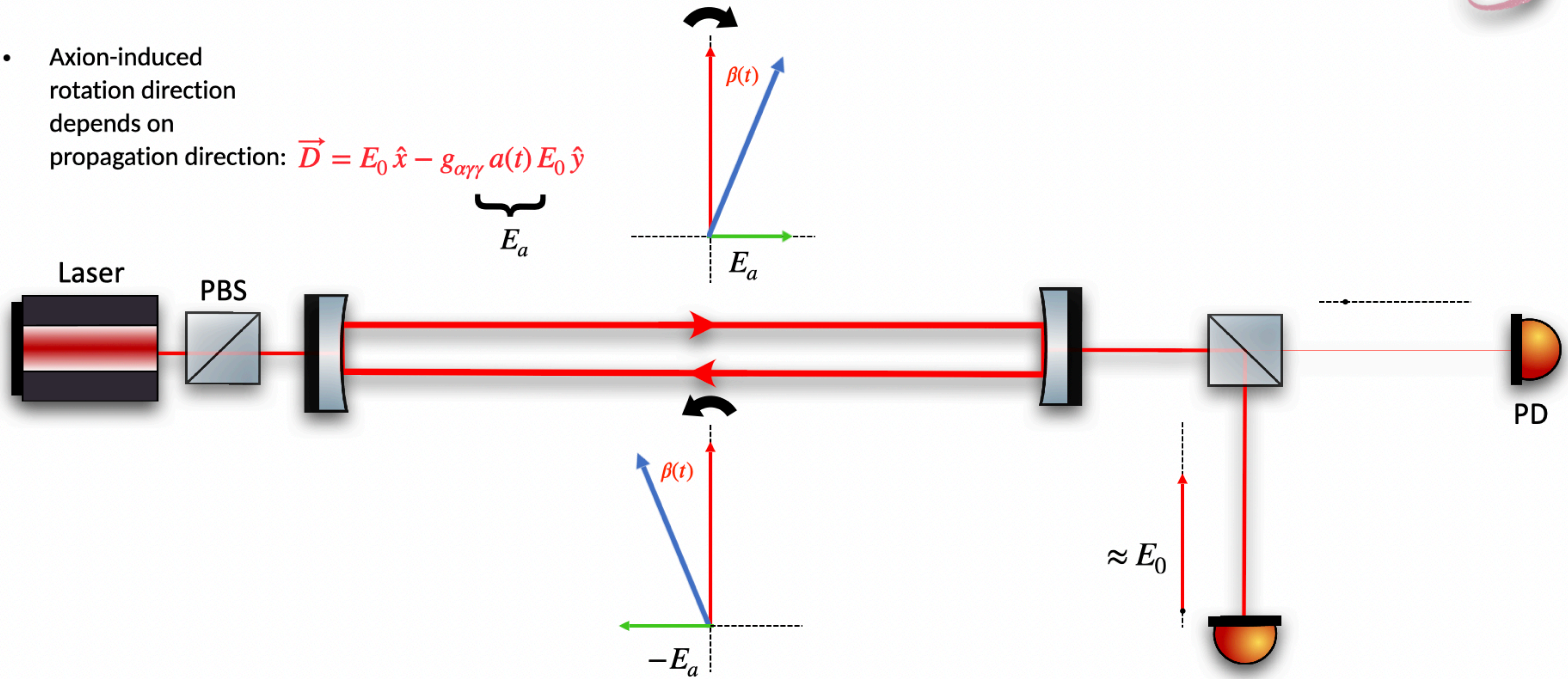


Optical Setup of APE



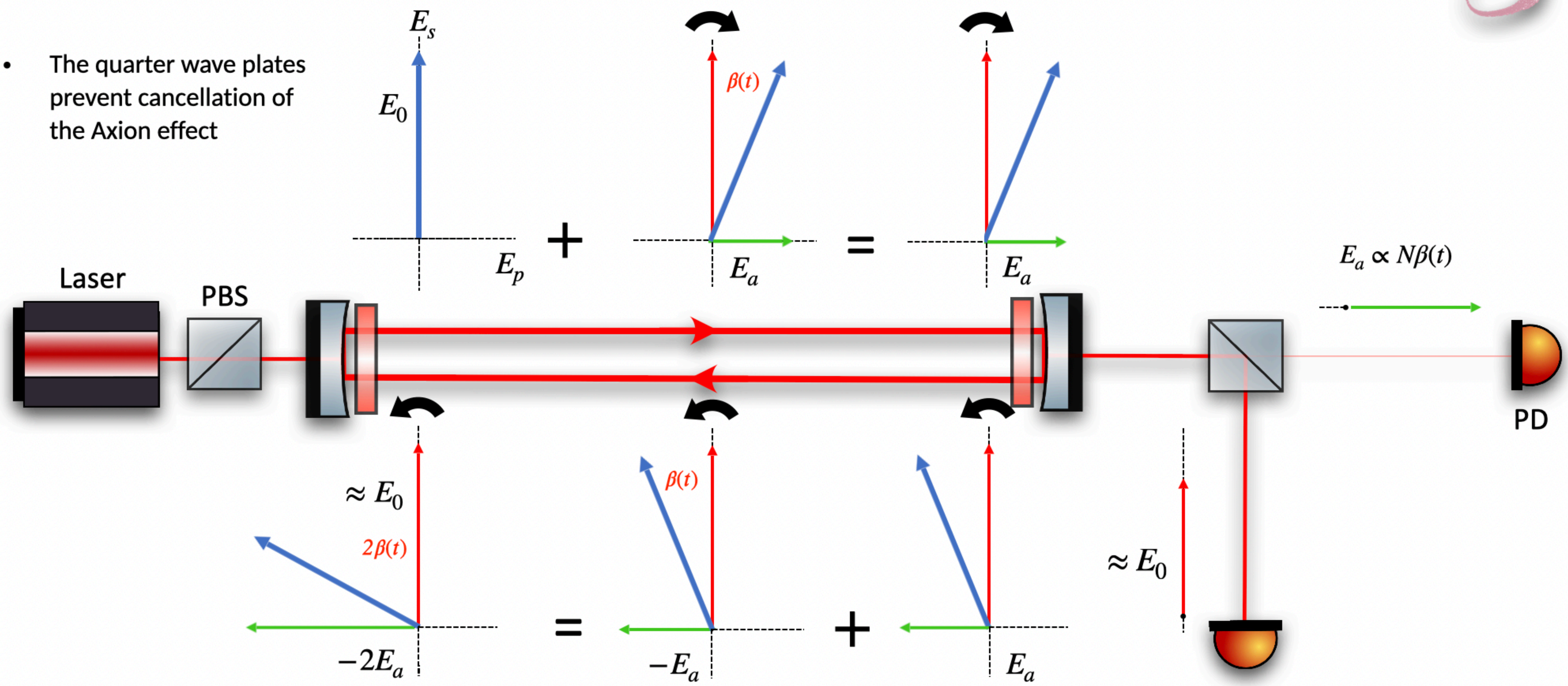
Mechanisms of Signal Cancellation in Cavity

- Axion-induced rotation direction depends on propagation direction: $\vec{D} = E_0\,\hat{x} - \underbrace{g_{a\gamma\gamma}\,a(t)\,E_0}_{E_a}\,\hat{y}$

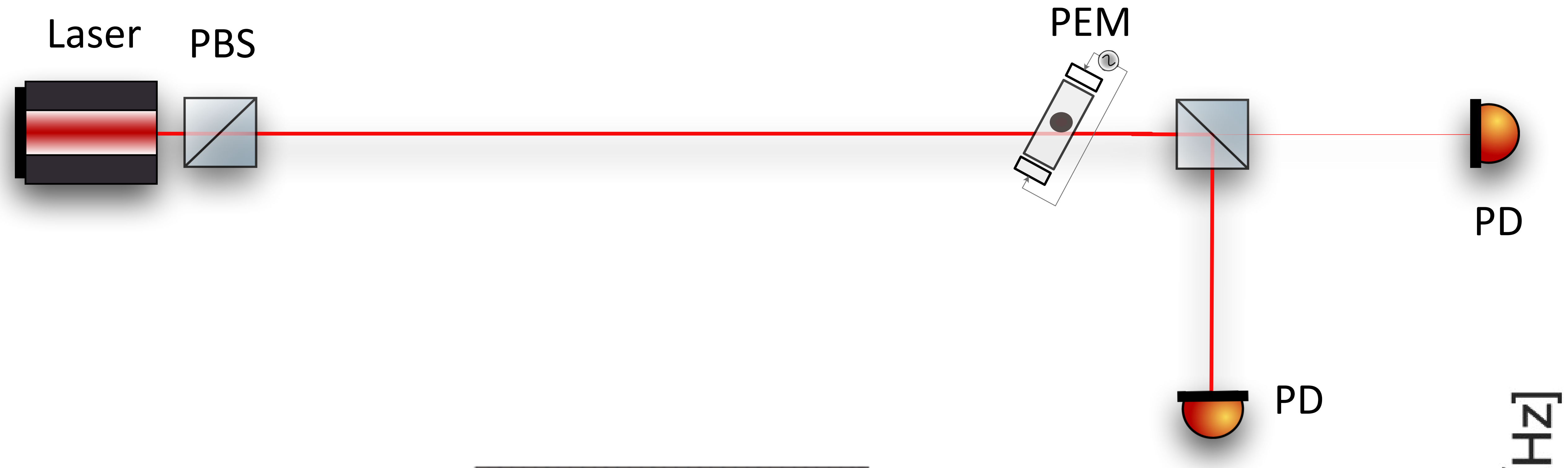


Function of the Quarter Wave Plates

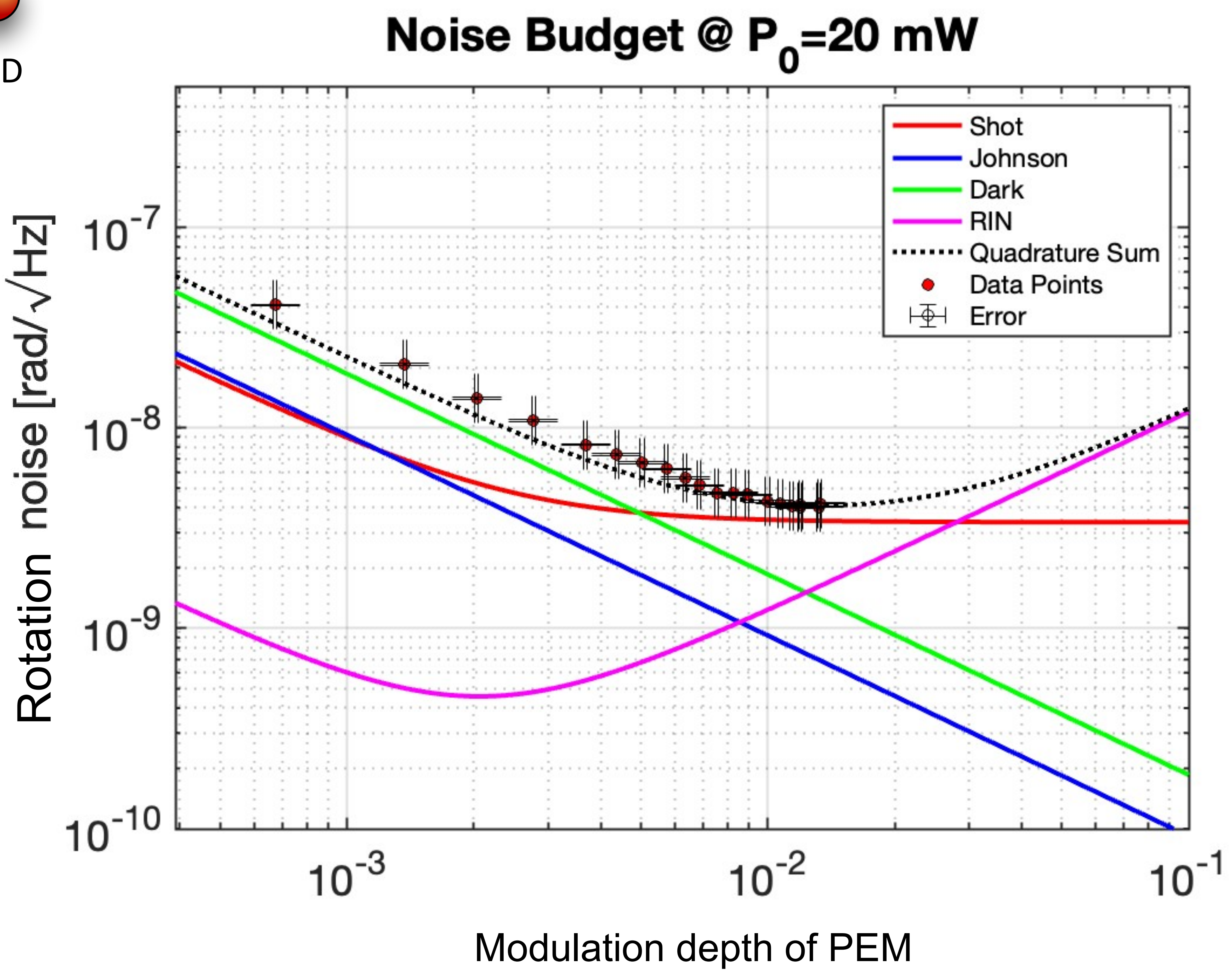
- The quarter wave plates prevent cancellation of the Axion effect



Measured Noise Budget without FP cavity



- Shot noise $= \sqrt{\frac{2e}{qI_0}\left(\frac{\sigma^2+\eta_0^2/2}{\eta_0^2}\right)}$
- ~~Dark noise~~ $= \frac{i_{\text{dark}}}{qI_0\eta_0}$
- ~~Thermal Johnson noise~~ $= \sqrt{\frac{4k_BT}{G}}\frac{1}{qI_0\eta_0}$
- ~~RIN~~ $= N_{\nu_m}^{(\text{RIN})}\frac{\sqrt{(\sigma^2+\eta_0^2/2)^2+(\eta_0^2/2)^2}}{\eta_0}$



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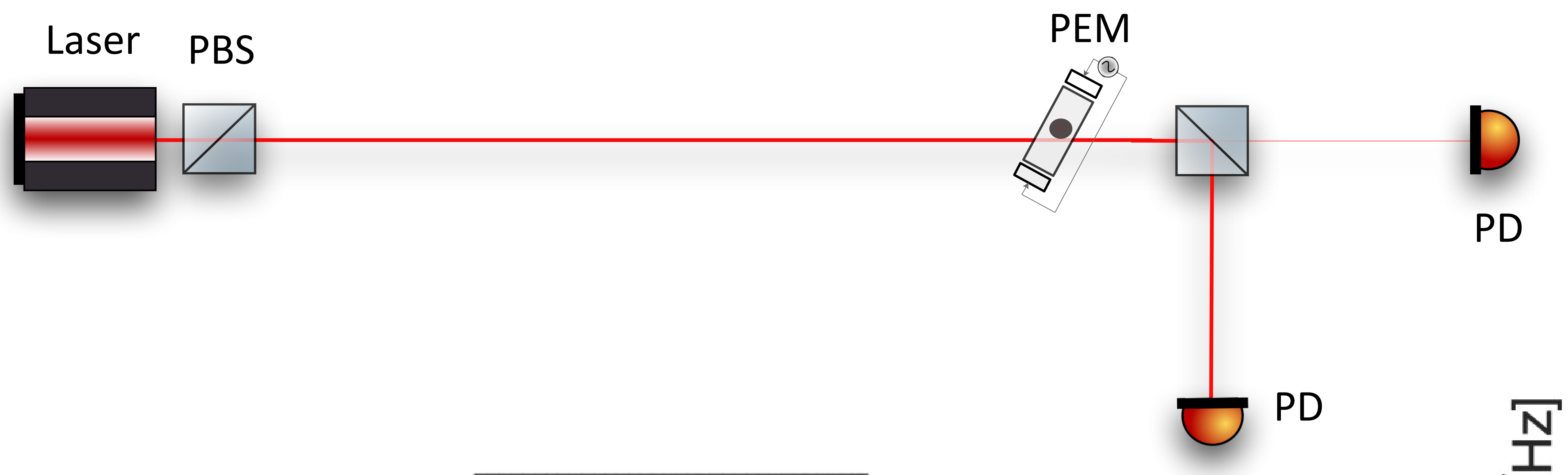

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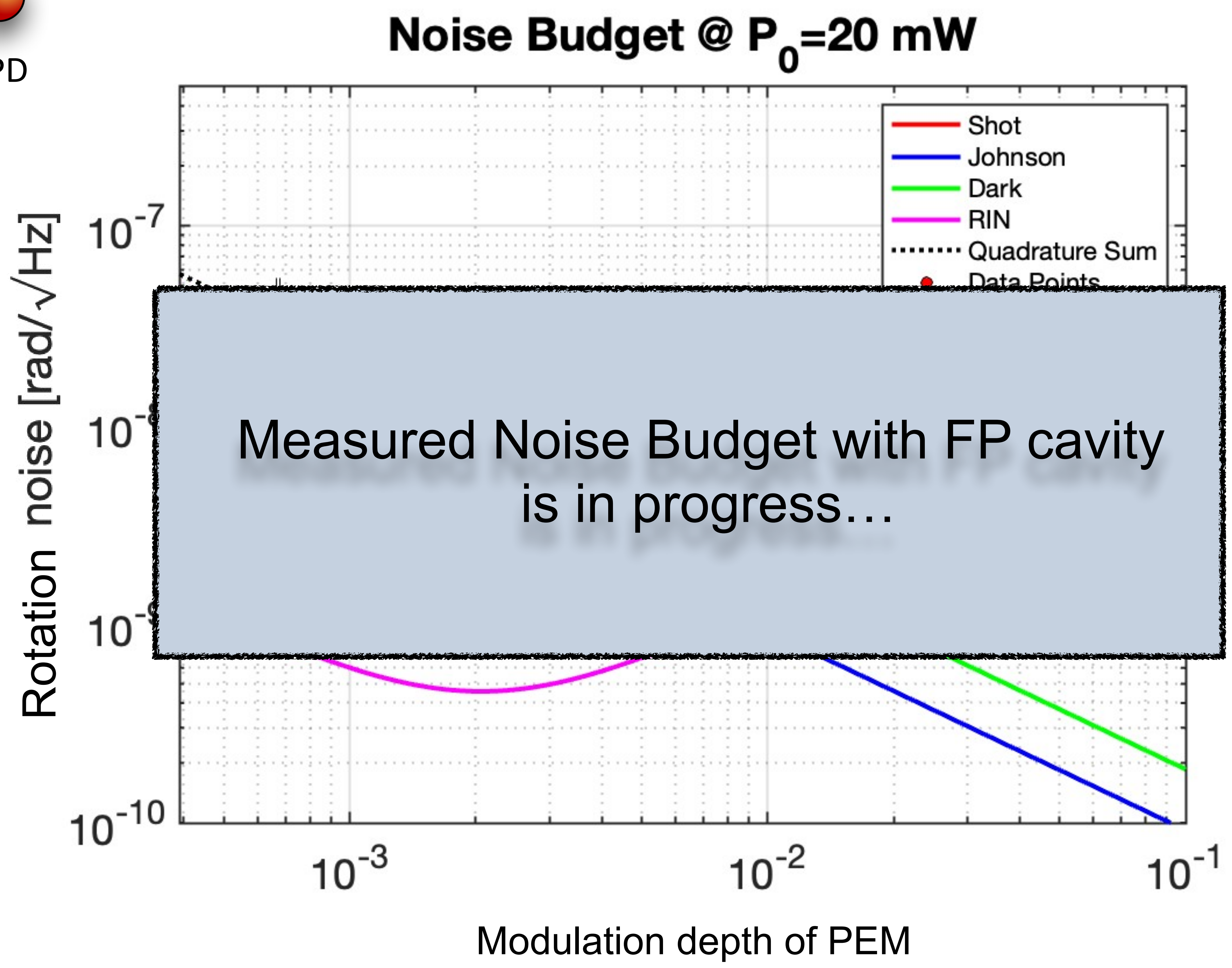
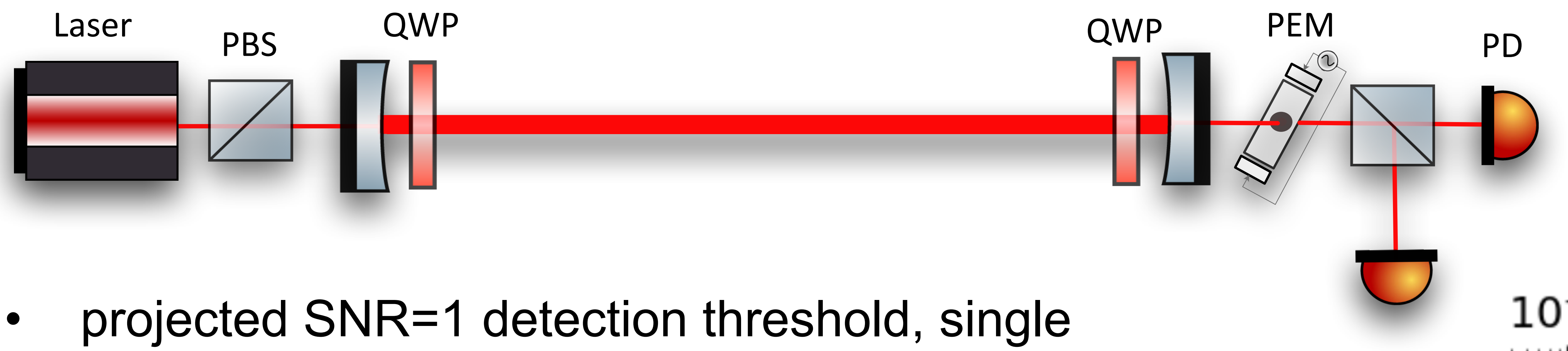


Measured Noise Budget with FP cavity is in progress…

Sensitivity to the Axion-photon Coupling Coefficient



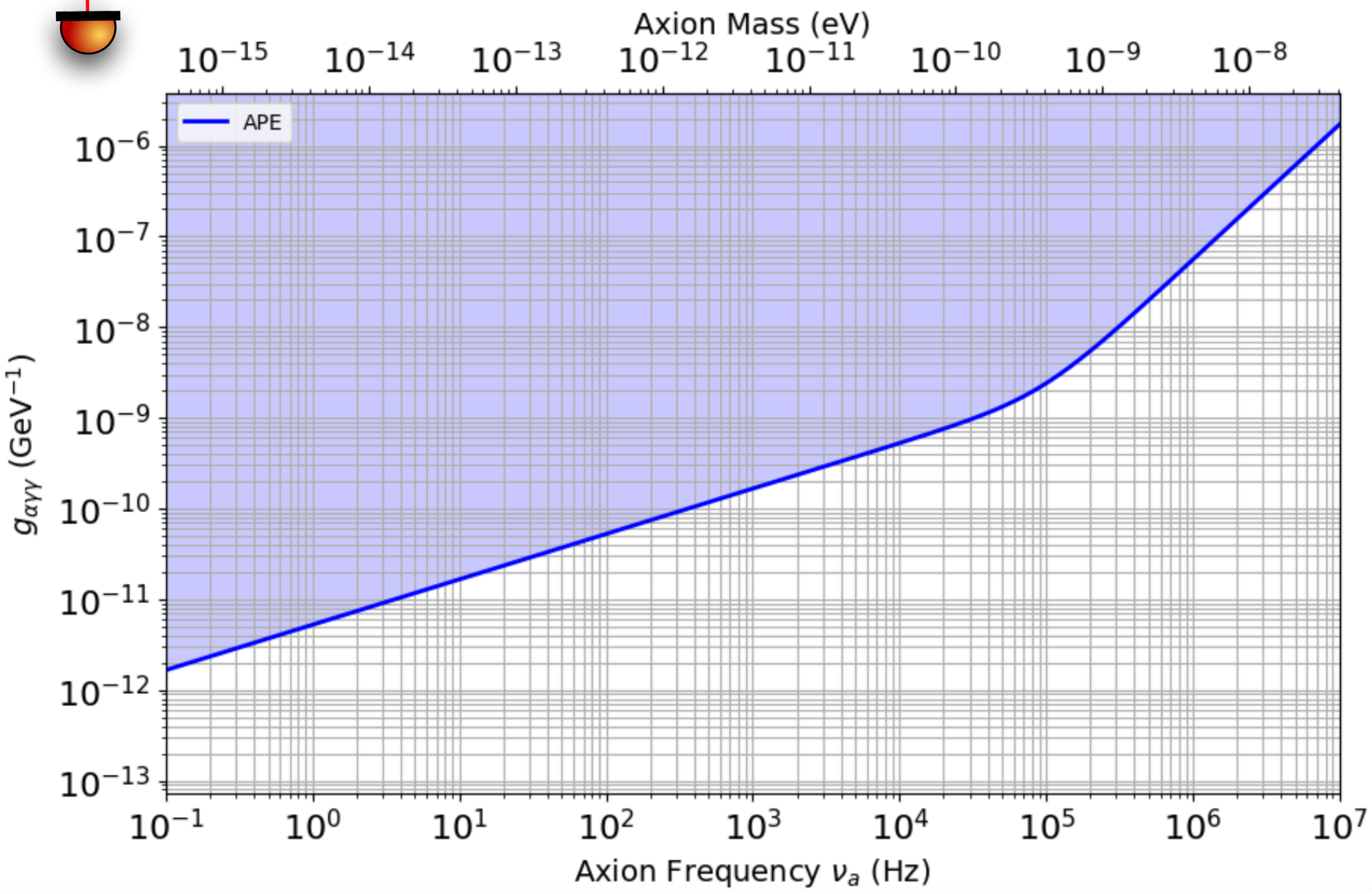
$$g_{a\gamma\gamma} = \frac{1}{\sqrt{t_{int}}} \frac{S_\beta^{shot}}{2\tau} \sqrt{\frac{(l_{int,rt})^2 + 4\sin^2(\pi \nu_a \tau)}{2\rho_{Local}}}$$

- projected SNR=1 detection threshold, single detector and coherence-limited $t_{int} = 10^6/\nu_a$
- The current sensitivity analysis does not include the effect of seismic noise
- Sensitivity is proportional to the length of cavity
- Critically coupled cavity:

$$T_1 = T_2 + l_{int,rt}$$

$$T_2 = l_{int,rt}$$

Input power	300 mW
Finesse	~1000
Round-trip internal loss	~1,500 ppm
Length	1.5 m



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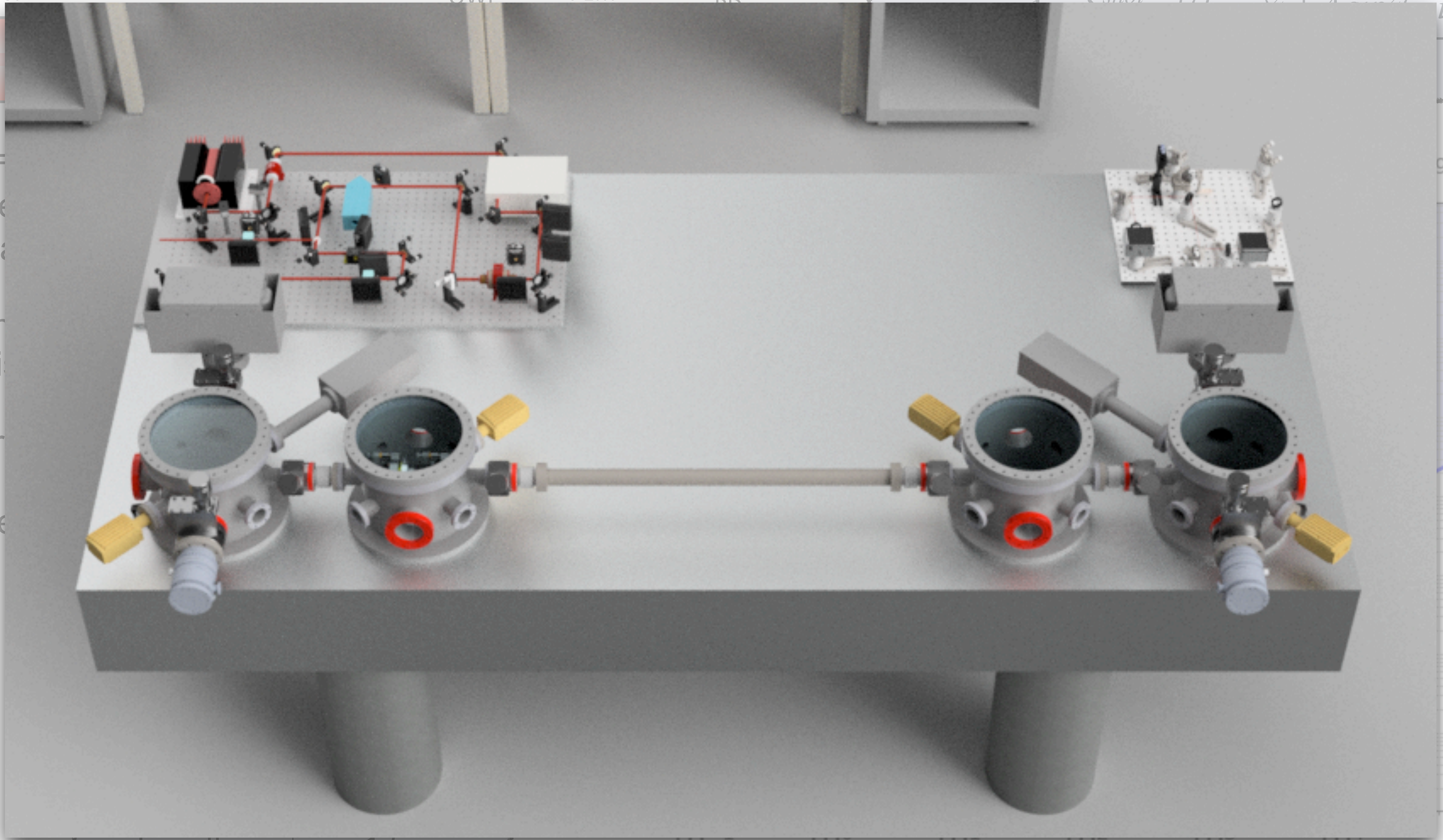
Sensitivity to the Axion-photon Coupling Coefficient

Laser PBS QWP QWP PEM PD



- projected SNR=
  detector, cohere
  assumptions st
- The current ser
  the effect of sei
- Sensitivity is pr
- Critically couple

$$T_1 = T_2 + l_{int,rt}$$

$$T_2 = l_{int,rt}$$

Length	1.5 m

10^{-8} 10^{-7}

10^5 10^6 10^7

Axion Frequency ν_a (Hz)

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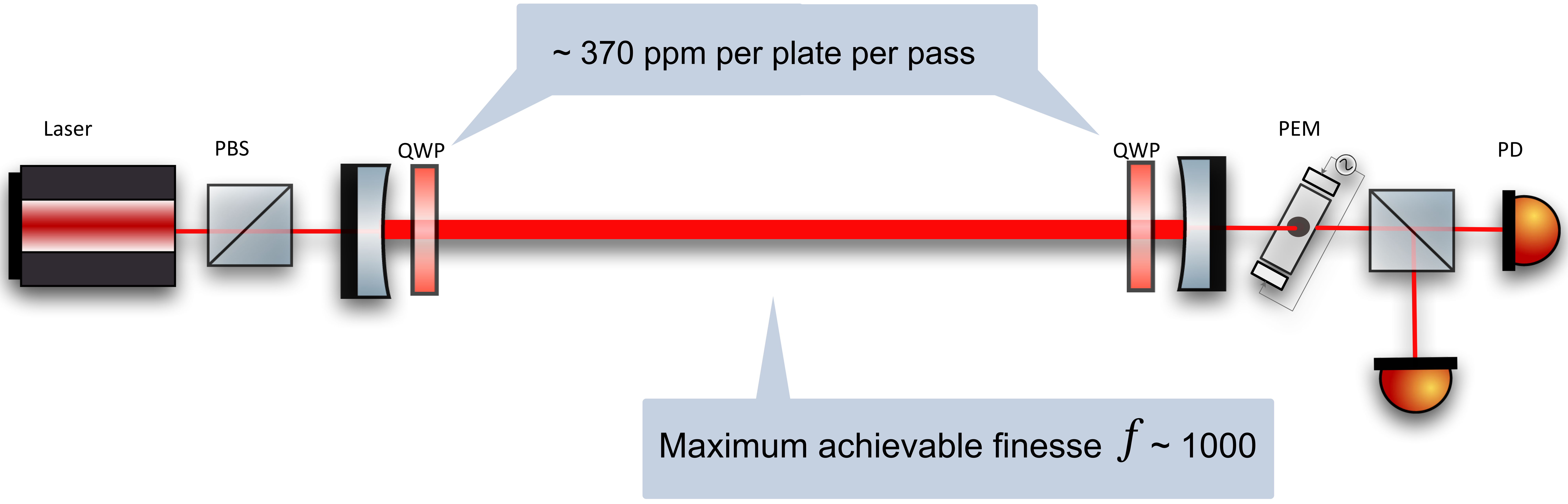
What is next?



Sensitivity :

$$g_{\alpha\gamma\gamma} = \frac{1}{\sqrt{t_{int}}} \frac{S_{\beta}^{shot}}{2\tau} \sqrt{\frac{(l_{int,rt})^2 + 4\sin^2(\pi\,\nu_a\,\tau)}{2\rho_{Local}}}$$

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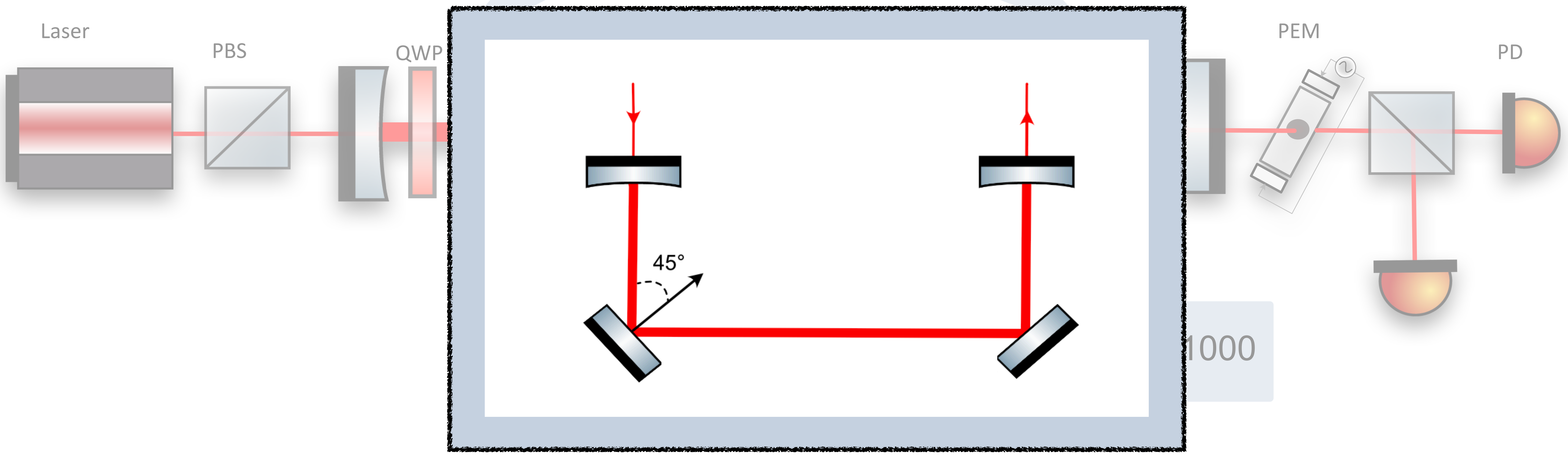
What is next?

~ 370 ppm per plate per pass



Sensitivity : $$g_{a\gamma\gamma} = \frac{1}{\sqrt{t_{int}}} \frac{S_\beta^{shot}}{2\tau} \sqrt{\frac{(l_{int,rt})^2 + 4\sin^2(\pi\,\nu_a\,\tau)}{2\rho_{Local}}}$$

Thank you!

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