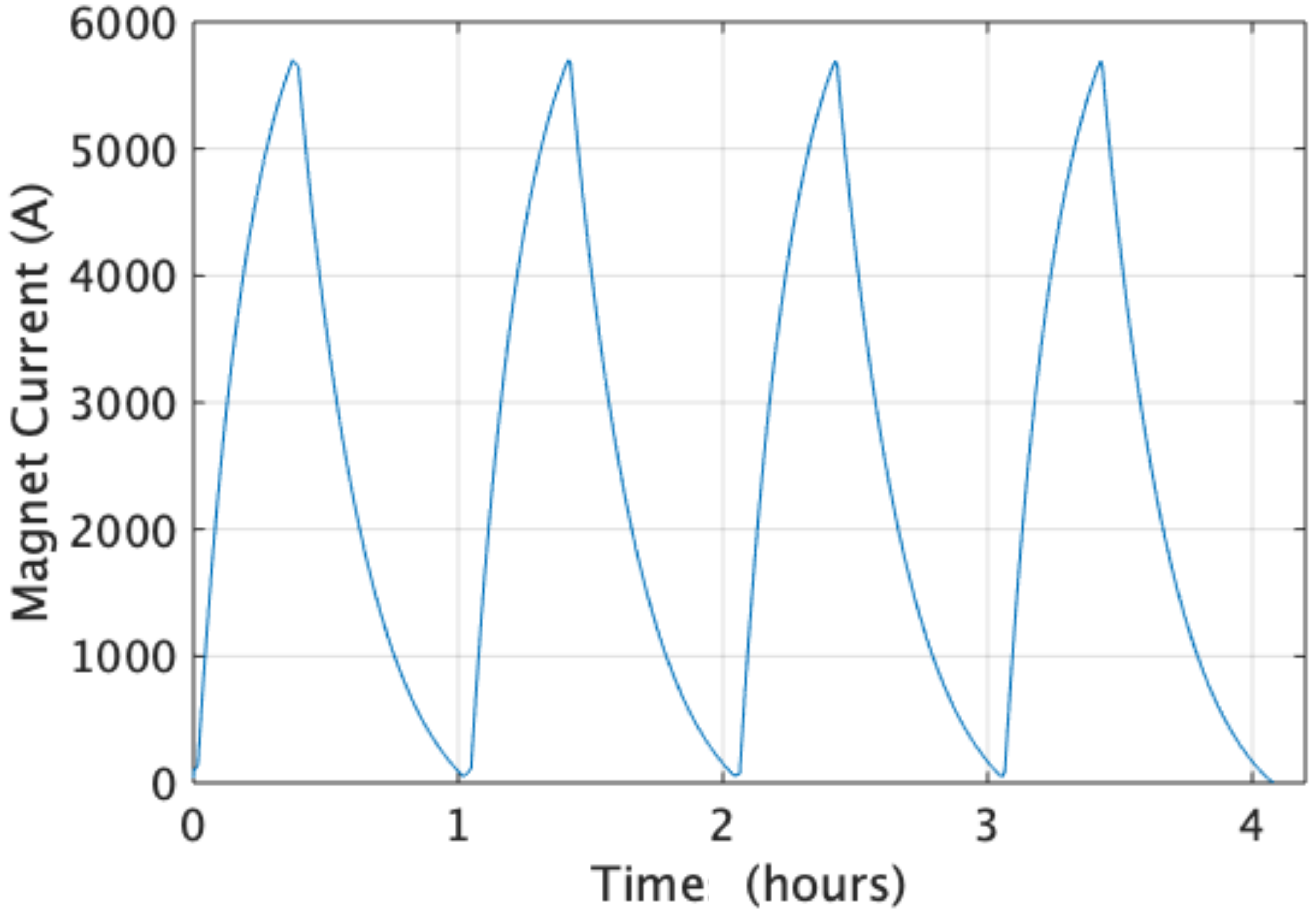
Measuring VMB with the ALPS II Magnet String

Orders of magnitude higher FOM

Figure of merit: $\Delta B^2 L$

- Differential index of refraction : $\Delta n = 3\,A_e B^2$ $\quad (A_e = 1.32\times10^{-24}\,T^{-2})$
- Phase retardation: $\Gamma = 3\,A_e (2\pi/\lambda)\,B^2 L$
- ALPS II has $\Delta B^2 L$ 600x larger than leading experiment
  - Challenge: much lower magnet modulation frequency

Experiment	B_{max}	B_{min}	L	$\Delta B^2 L$	f	Sensitivity Δn
PVLAS	2.5 T	0 T	1.6 m	10 T^2m	16 Hz	2e-23 T^{-2}
BMV	6.5 T	0 T	0.14 m	5.8 T^2m	180 Hz	7e-21 T^{-2}
BFRT	3.9 T	2.6 T	8.8 m	71 T^2m	32 mHz	2e-19 T^{-2}
ALPS II	5.3 T	0.05 T	212m	6000 T^2m	< mHz	-



Challenges with Optical Cavities

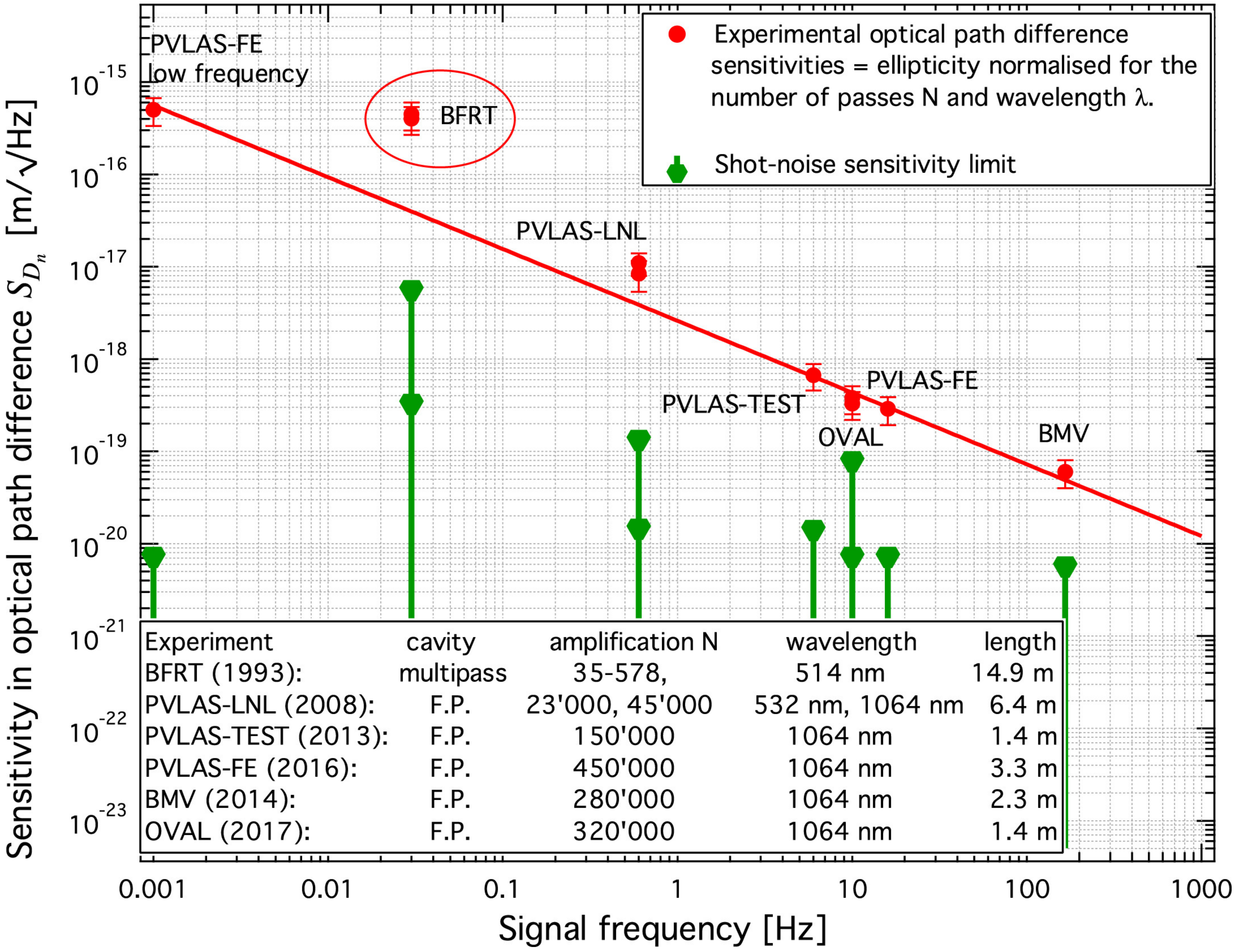
Sensitivity at low frequencies

Amplifying the signal

- Phase retardation with cavity: $\Gamma = (12 A_e/\lambda) \mathcal{F} B^2 L$
- Cavity finesse amplifies signal
  - Limit to SNR: dynamic birefringence of cavity

Challenge

- Birefringence noise appears to increase at lower frequencies



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Challenge

- Birefringence noise appears to increase at lower frequencies
- But we don't know what the birefringence noise spectrum will look like!