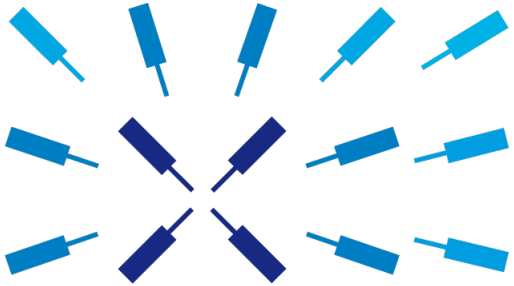

Zurich Instruments

Advanced Measurement tools for nonlinear optics

Dr Paolo Navaretti
Product Manager Lock-in Amplifiers

ZI Marketing & Sales
www.zhinst.com

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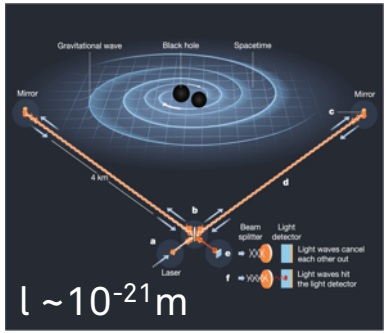
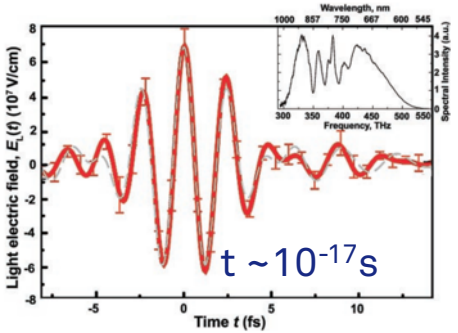
Why signal recovery is necessary for optical signals?



M.Miller et al.Nature **568**, 469-476 (2019)



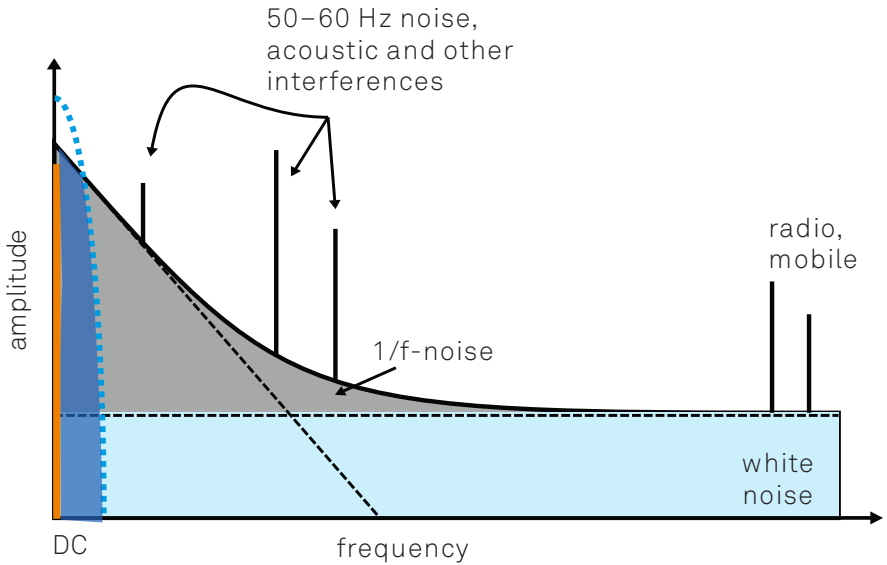
Goulielmakis et al. Science **305**, 1267-1269 (2004)

Extremely faint signals

The different noise sources

Source | Experiment | Detector | Signal Analysis

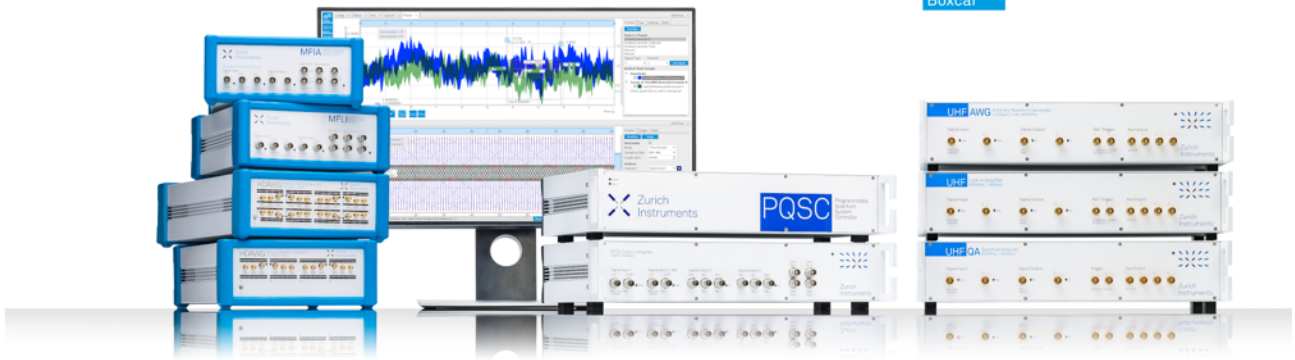
- 1/f noise
- White noise
- Interference and other environmental noise



Zurich Instruments Mission

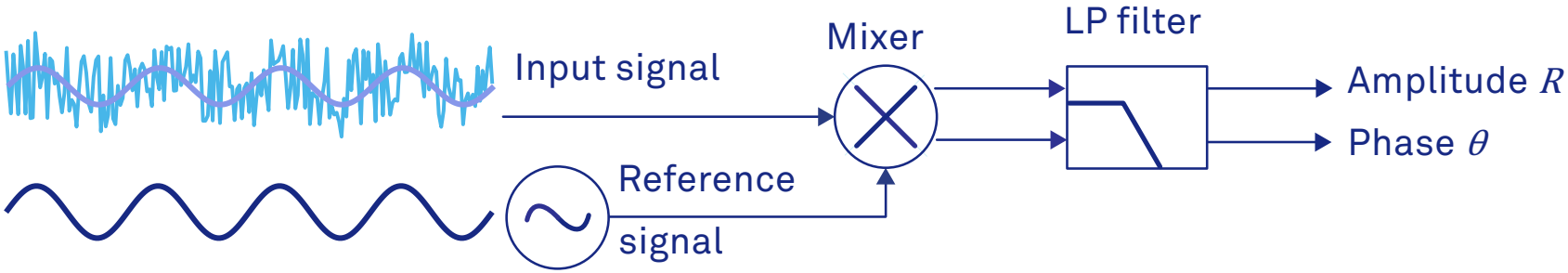
Lock-in Amplifiers

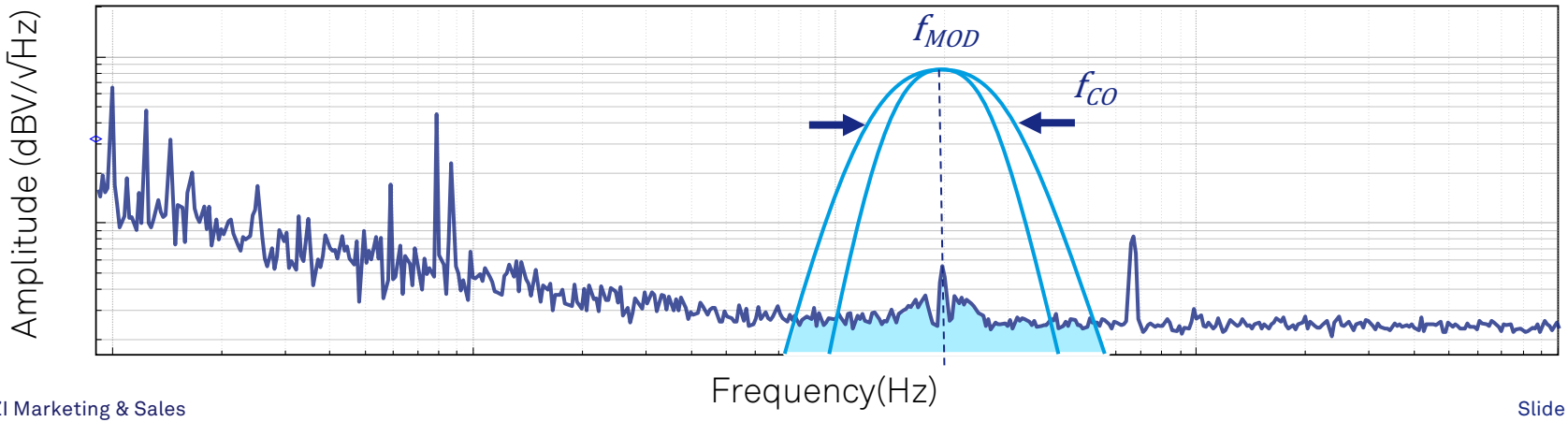
Boxcar averagers



Provide best-in-class dynamic-signal instruments for advanced R&D labs.

Lock-in amplifiers



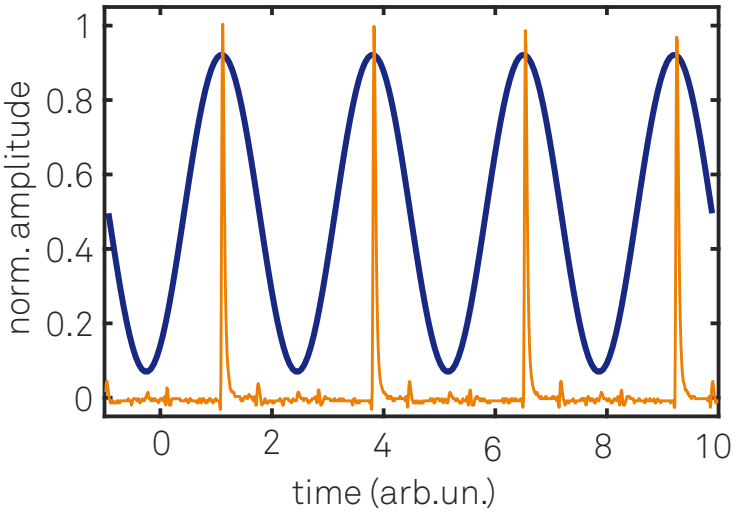


Choose the right Lock-in amplifier

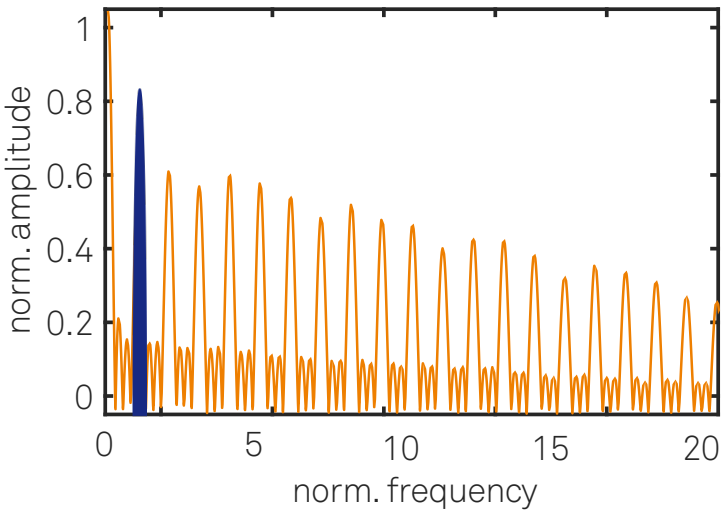
Instrument	Input Bandwidth
MFLI	DC – 500 kHz/5 MHz
HF2LI	DC – 50 MHz
UHFLI	DC – 600 MHz Boxcar Averager

What if the periodic signals are not sinusoidal?

Time domain



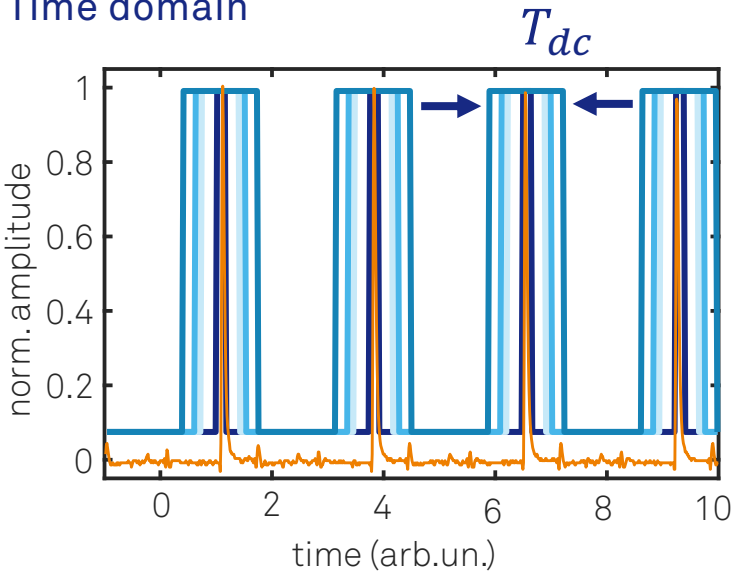
Frequency domain



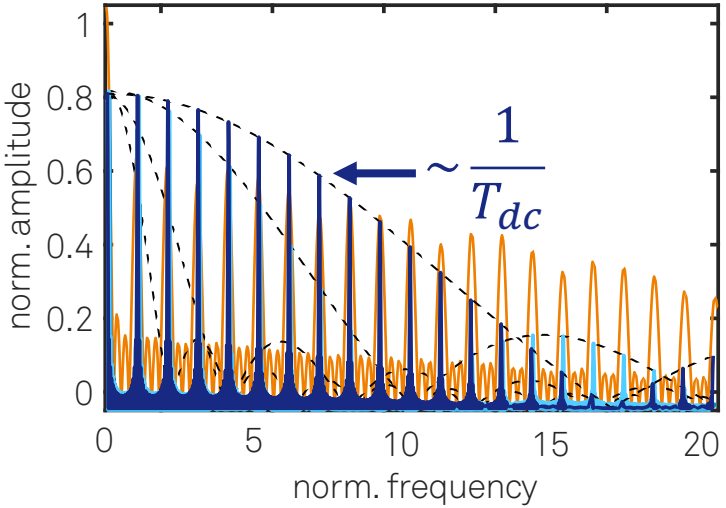
- Signal is confined in a short pulse – spread out in frequency
- Lock-in amplifier measures only one harmonic

Boxcar Averagers

Time domain



Frequency domain



- Measure only during the time with relevant signal
- The smaller duty cycle T_{dc} the broader the detection bandwidth $fco \sim \frac{1}{T_{dc}}$

LabOne® toolset and upgrade options

LabOne® toolset

→ Time analysis

→ Time evolution

→ Frequency analysis

→ Triggered acquisition/imaging

Upgrade options

→ Up to 8 independent frequencies

→ AM/FM modulation/demodulation

→ Integrated PID/PLL controllers

→ 2 Boxcar averager units

→ Arbitrary waveform generator

Why use a ZI Instrument in nonlinear optics?

- Choice of the best tool for the task: Lock-in or Boxcar
- Low time constant for fast measurement and imaging
- Tailor the instrument to your needs

Model	TC_{min}	BW	Settling Time	Scan time 512 x 512	Frame rate
UHFLI	30 ns	5.3 MHz	188 ns	49 ms	20 fps
HF2LI	780 ns	204 kHz	4.9 µs	1.28 s	0.78 fps
MFLI	336 ns	206 kHz	2.1 µs	0.55 s	1.82 fps

Zurich Instruments

Your application. Measured.