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### **Measurement and Instrumentation Challenges at X-ray Free Electron Lasers<sup>1</sup>**

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X-ray Free Electron Laser sources based on the Self Amplified Spontaneous Emission process are intrinsically chaotic, giving rise to pulse-to-pulse fluctuations in all physical properties, including intensity, position and pointing, spatial and temporal profiles, spectral content, timing, and coherence. These fluctuations represents special challenges to users whose experiments are designed to reveal small changes in the underlying physical quantities, which would otherwise be completely washed out without using the proper diagnostics tools. Due to the X-ray FEL's unique characteristics such as the unprecedented peak power and nearly full spatial coherence, there are many technical challenges in conceiving and implementing these devices that are highly transmissive, provide sufficient signal-to-noise ratio, and most importantly work in the single-shot mode.

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