Stray light in the LISA mission: perturbation of an interferometer due to back-scattered light

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Stray light

Stray light can affect a system in various ways:

- by coupling into an interferometer
- added radiation pressure (e.g. to the test mass)
- blinding a camera (e.g. the "Constellation Acquis. Sensor")
- heating (e.g. the beam dumps)

Stray light can be generated by

- scattering (roughness, contamination)
- imperfect polarization
- diffraction
- stray reflection or transmission ("ghost beams")
- ambient light (incoherent): stars, ...

=> the "stray light work group" of the LISA Consortium

Coupling of back-scattering into an interferometer

Characterization of back-scattering into an interferometer

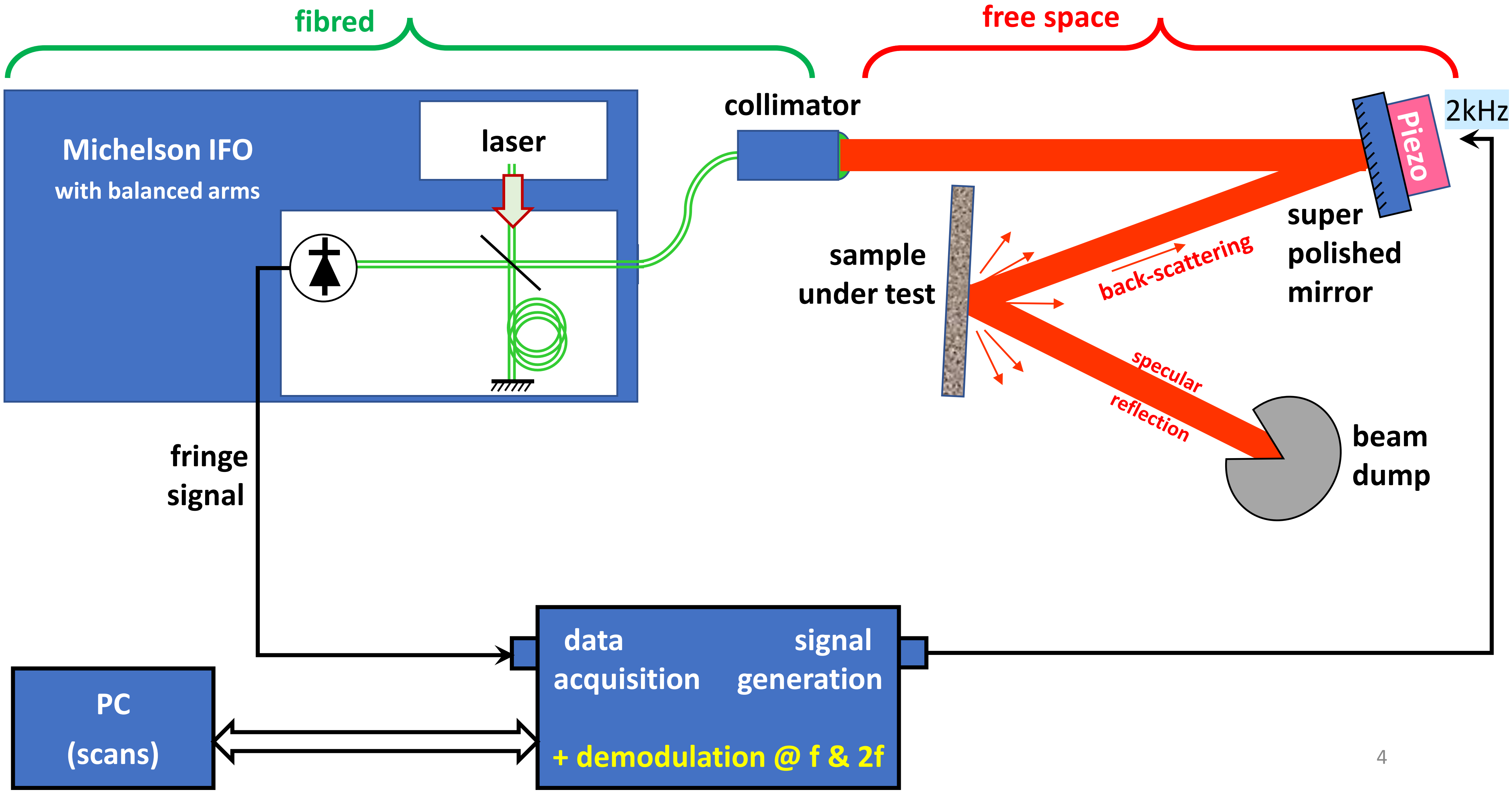
speckle properties

Approximate calculation of the back-scattered power fraction

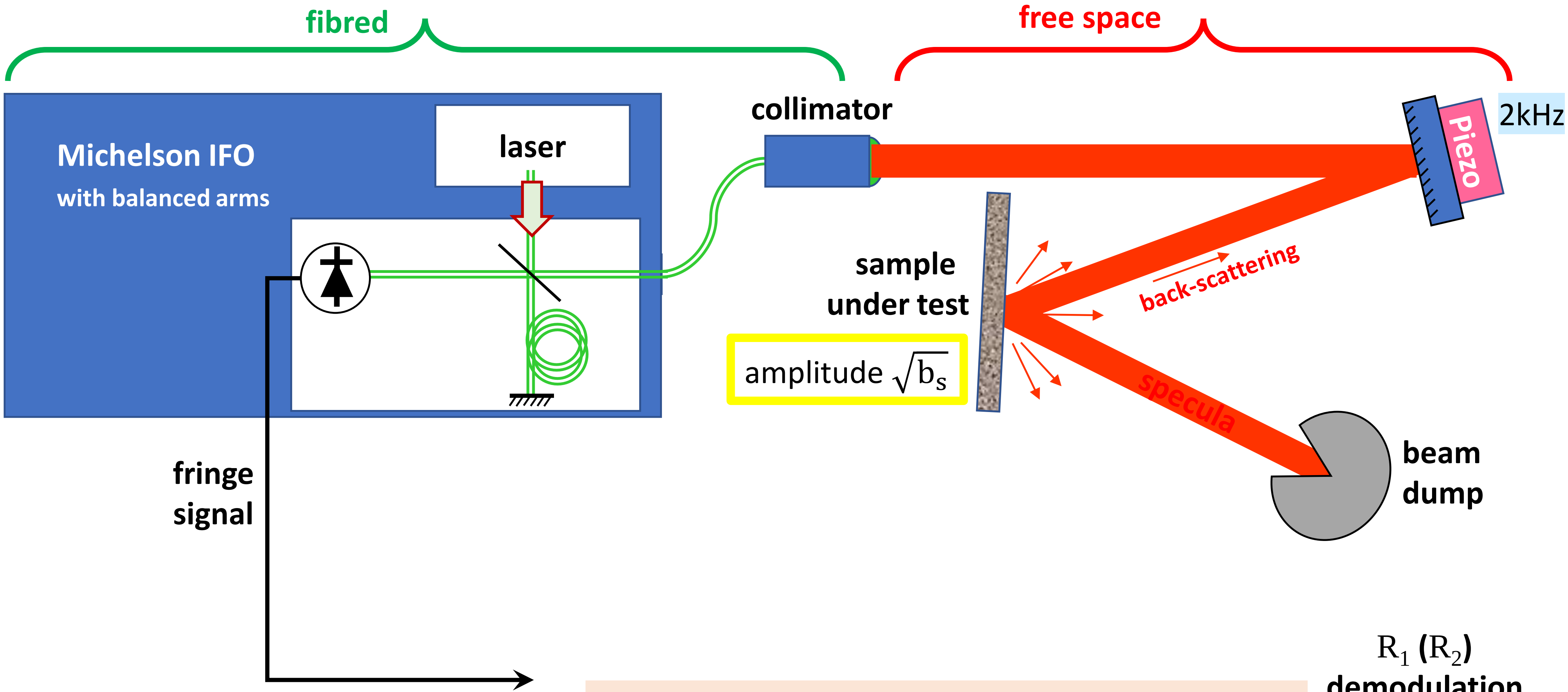
without use of a software

Rayleigh back-scattering in the "back-link" fiber

Study of the back-scattering from a surface (see V. Khodnevych's PhD)



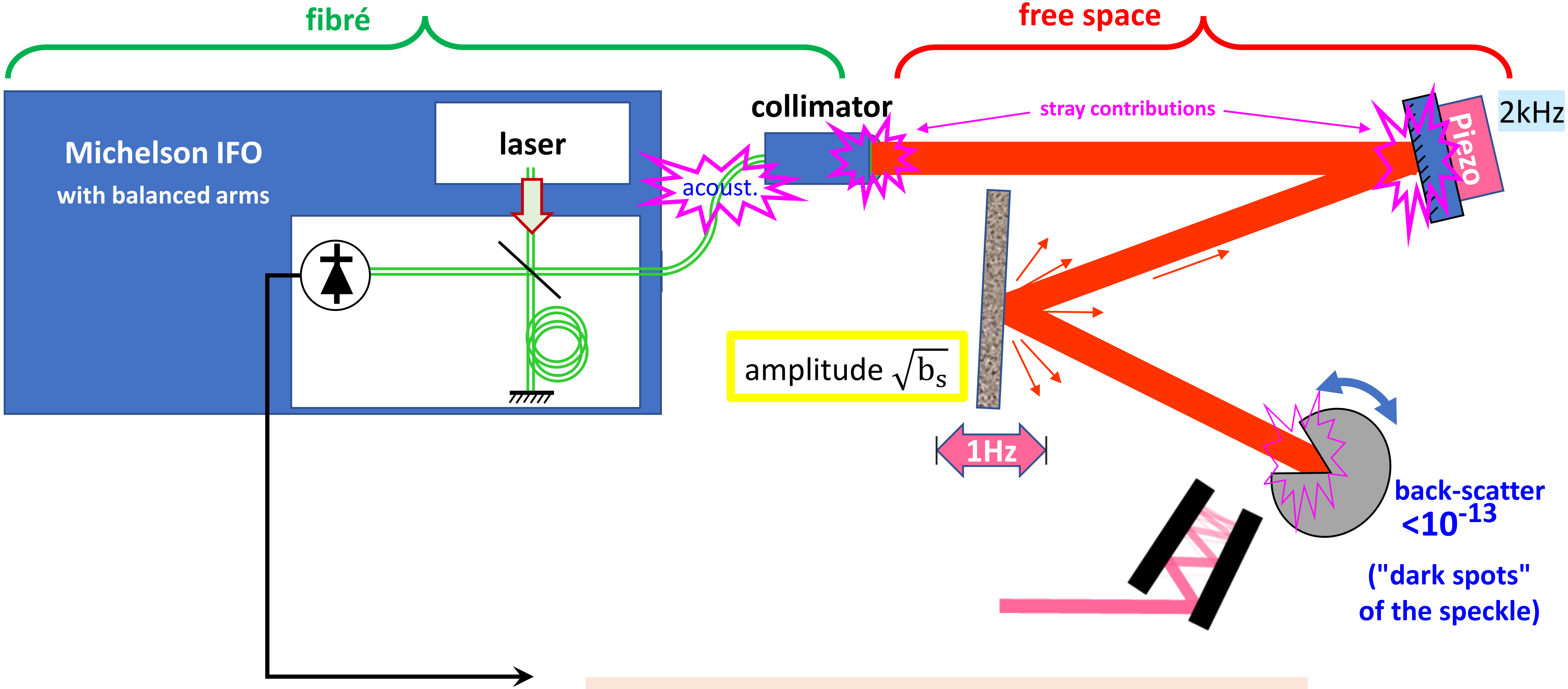
Michelson IFO: demodulation scheme



$$\sqrt{b_s} = \sqrt{\left(\frac{R_1}{2J_1(2\pi\delta_{PM})}\right)^2 + \left(\frac{R_2}{2J_2(2\pi\delta_{PM})}\right)^2 \frac{1}{I_L/2}}$$

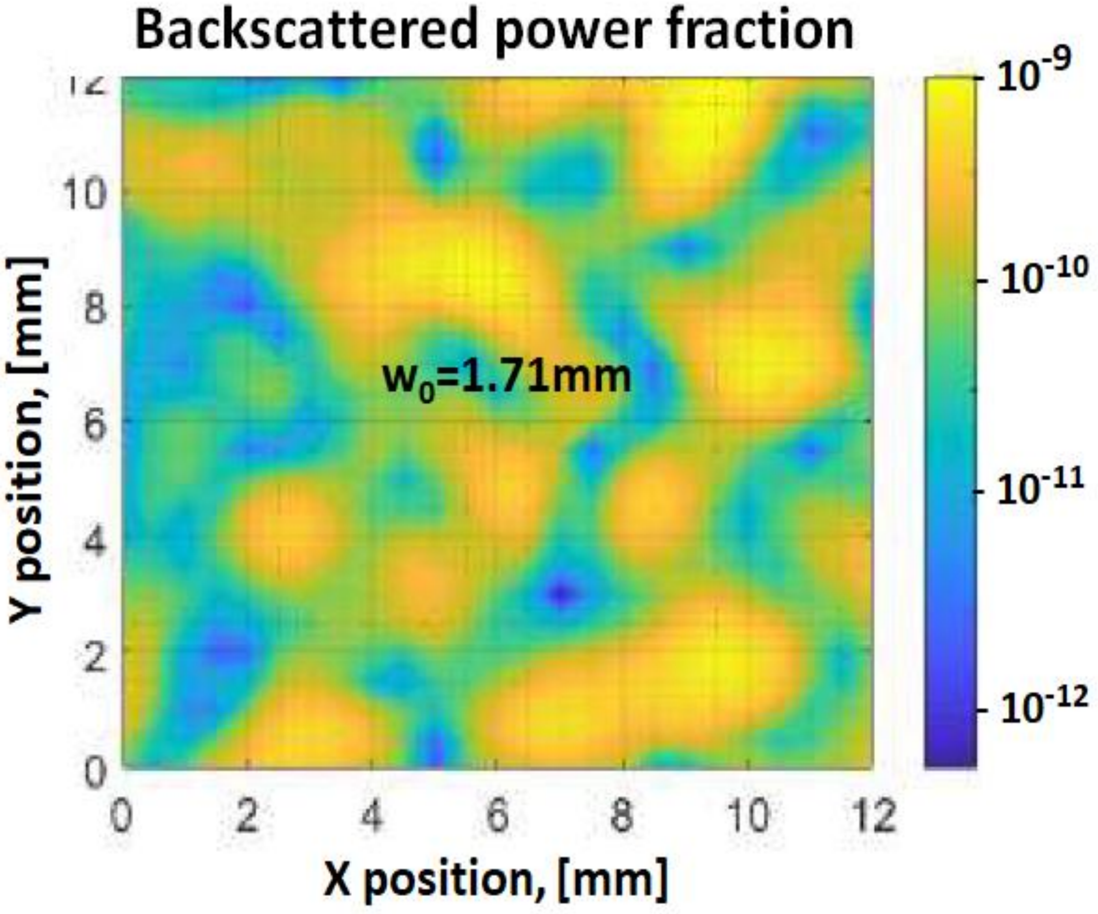
R_1 (R_2) **demodulation @ f and @ 2f**

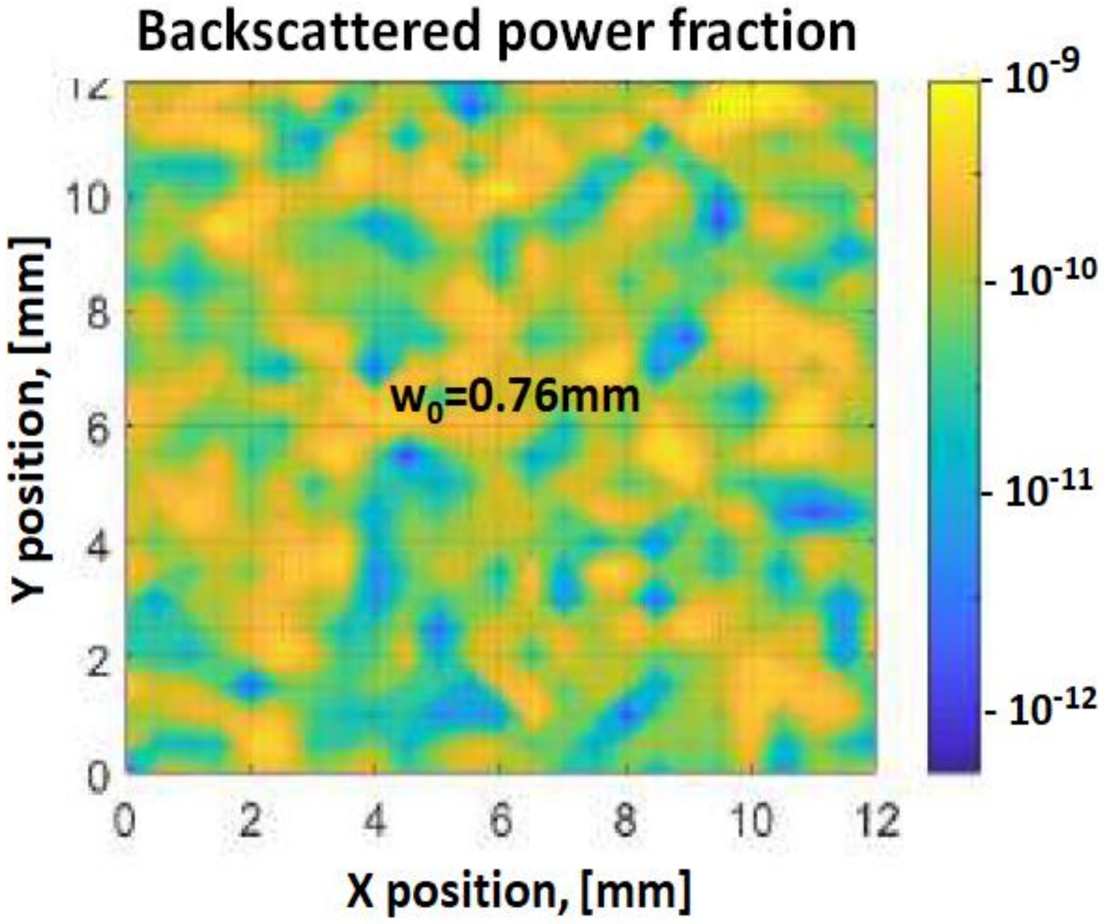
Nominal and stray contributions



$$\sqrt{b_s} = \sqrt{\left(\frac{R_1}{2J_1(2\pi\delta_{PM})}\right)^2 + \left(\frac{R_2}{2J_2(2\pi\delta_{PM})}\right)^2} \frac{1}{I_L/2}$$

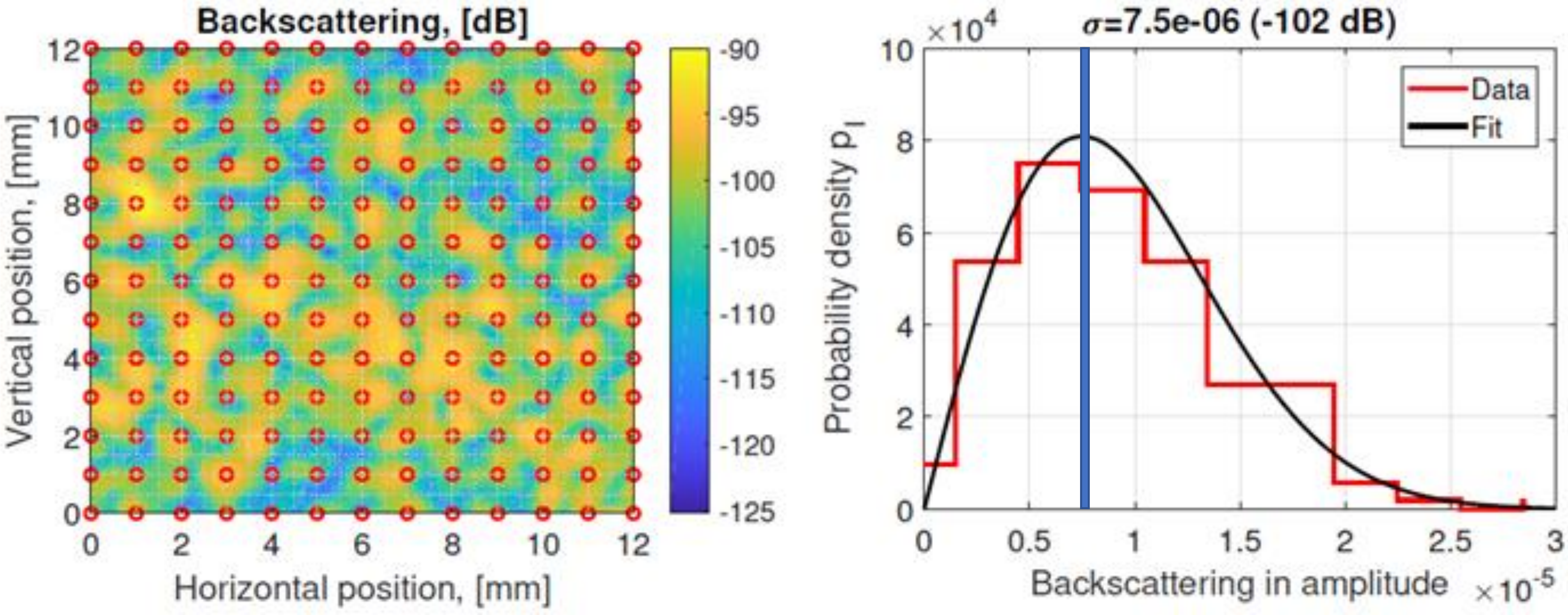
Speckle properties: X-Y scans in the plane of the sample





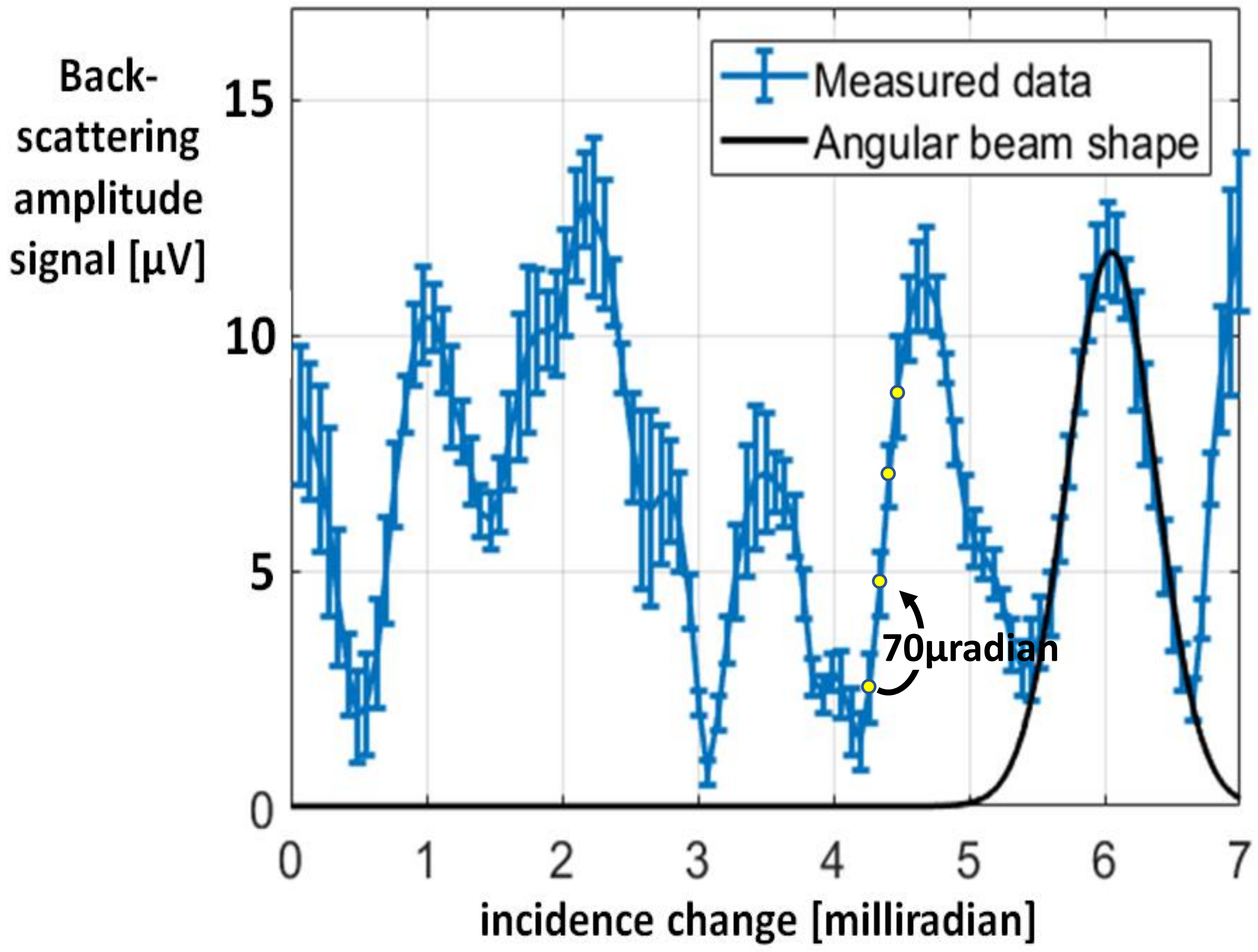
Size of a speckle grain ~ beam size

Speckle properties: statistics



Observed statistics: Rayleigh distribution, $\frac{A}{\sigma^2} exp\left(-\frac{A^2}{2\sigma^2}\right)$

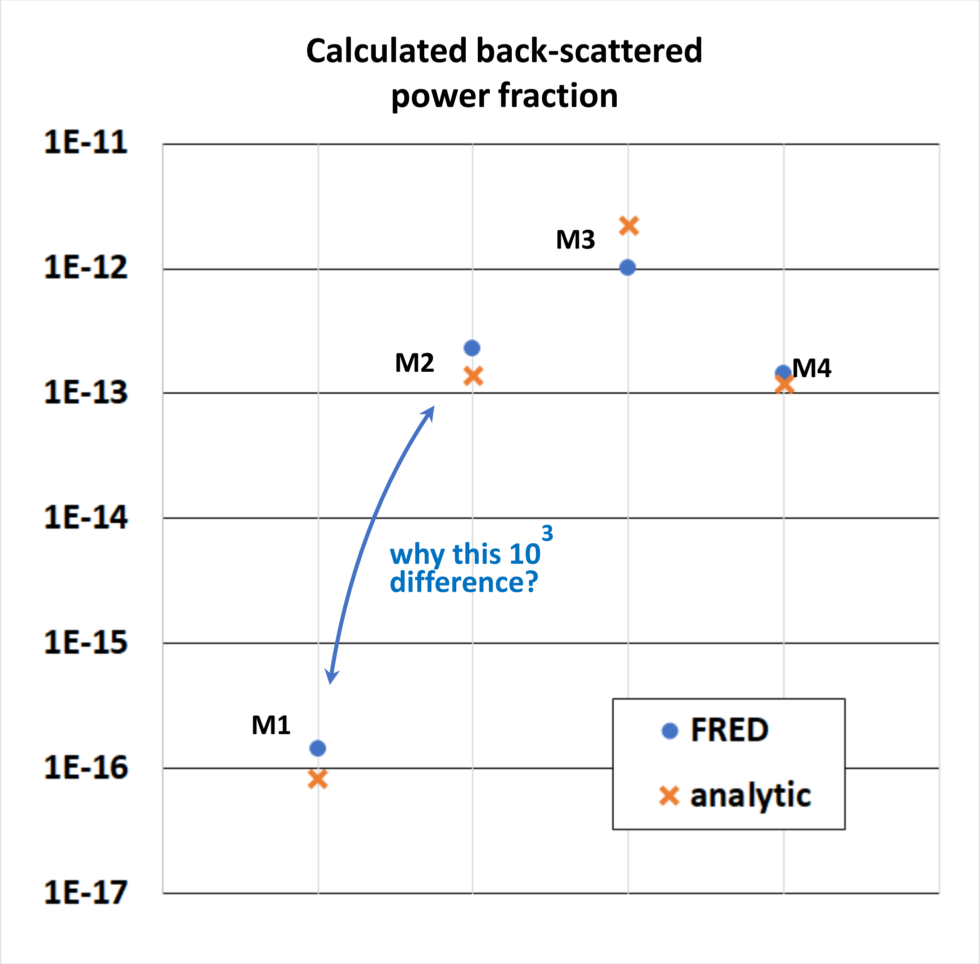
Speckle properties: angular scans *(at milliradian scale)*

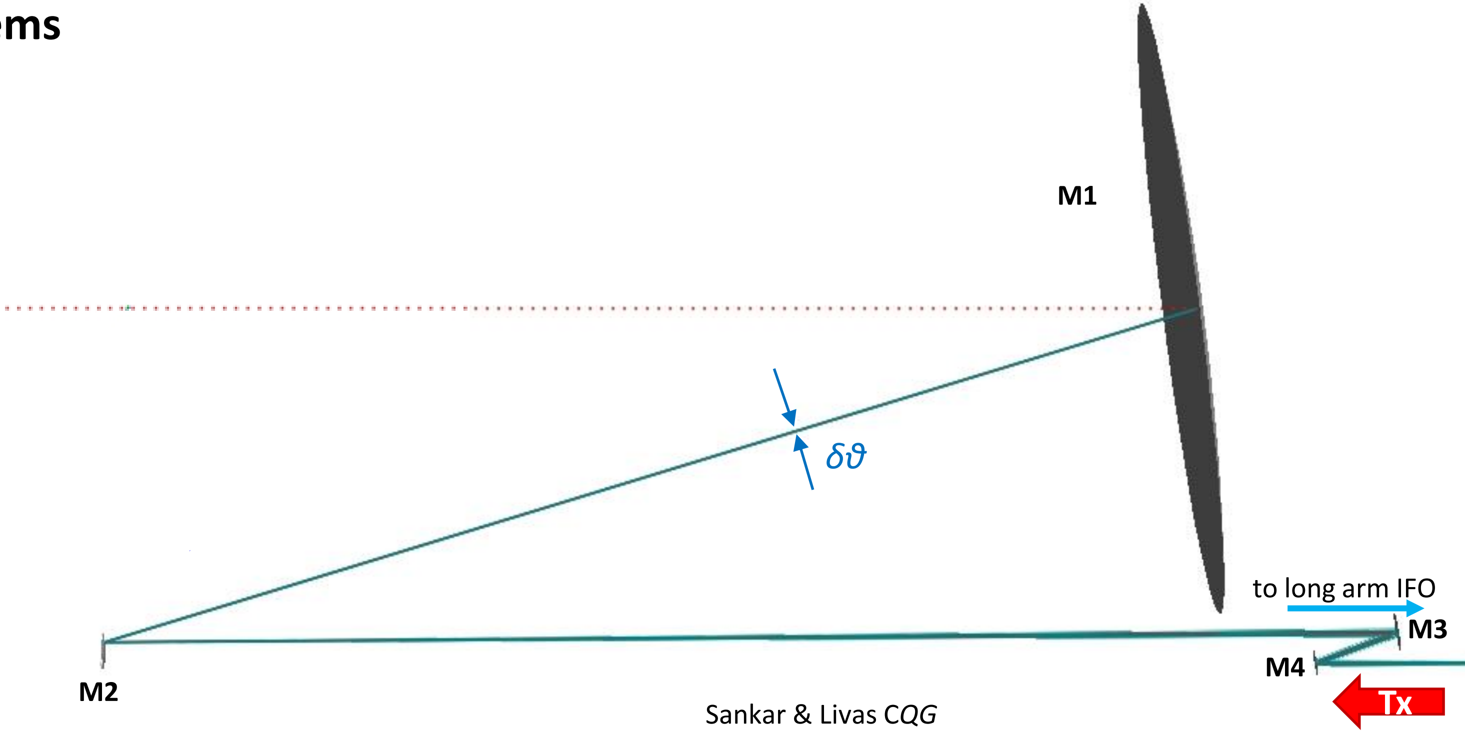


Fast angular dependance: grains with angular size ≈ $\lambda/\pi D$

Calculation of the recoupled power fraction (see M. Nardello's presentation at ICSO)

Use of sofwares (FRED, Zemax,...) is often necessary to obtain the SL fraction reaching a detector in complex systems





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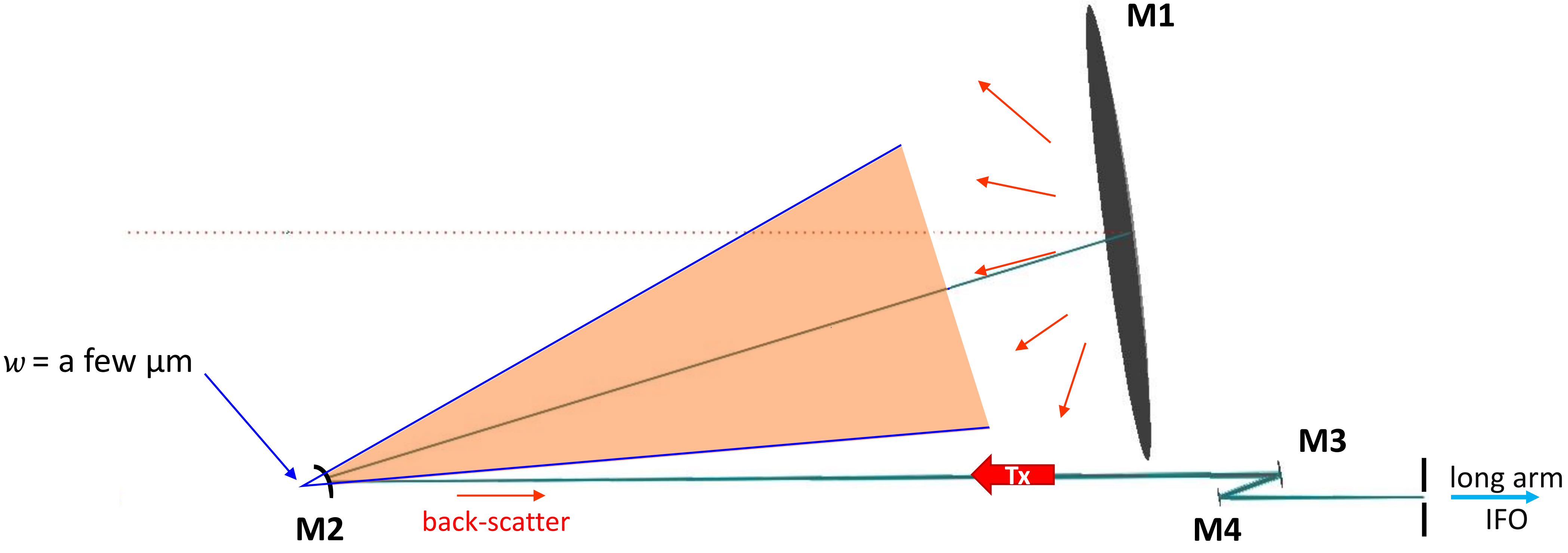
beta.sam.gov/opp/72d6f9eaf7308681d44a4391e73ad57b/view#attachments-links

Calculation of the recoupled power fraction (see M. Nardello's presentation at ICSO)

The difference lies in the very small size of the (virtual) waist behind M2

=> the solid angle of the spot, as seen from M1, is very small



Calculation of the recoupled power fraction (see M. Nardello's presentation at ICSO)

Using the estimated solid angle for each of the 4 mirrors allows quick and analytic estimate of BS into the "Long arm" interferometer

Agrees within factor ≈ 2 with software predictions

- **Very convenient estimate of the recoupling factor**
- **Conversely, the same considerations can be used to improve the choice of the "importance sampling" parameters of optical sofwares**