Baffle simulation by SIS status

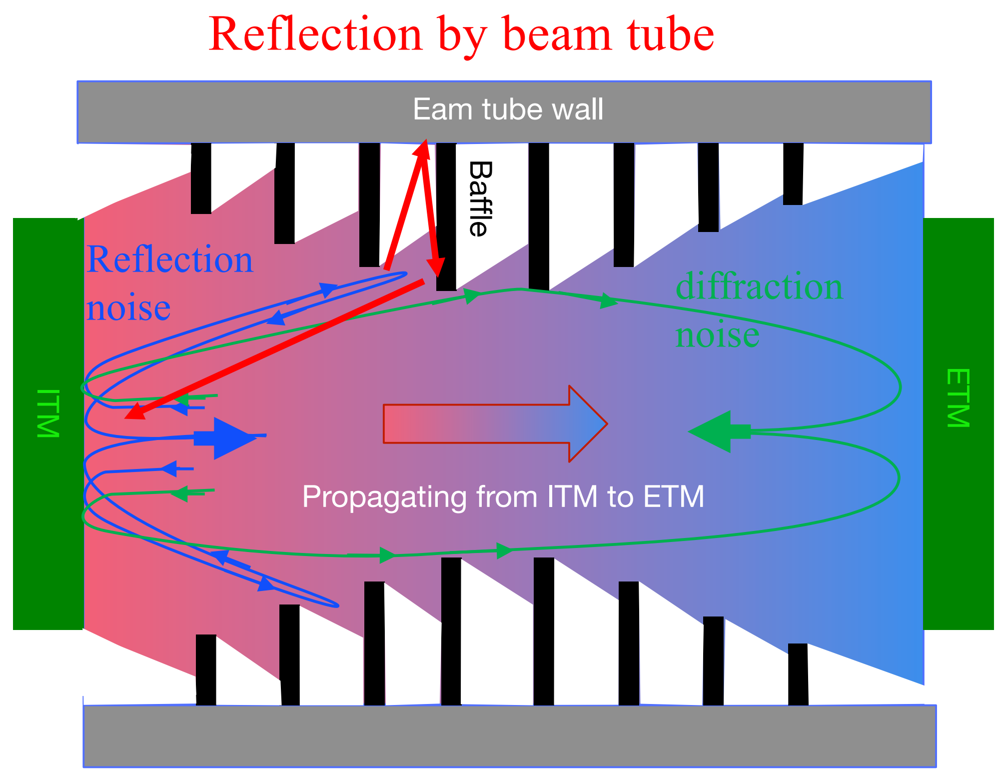
- Baffle modeling by SIS
- General power deposit views
- Low pass filter
- NbafShield dependence
- Resolution
- BRDF

CE arm tube baffle design by SIS

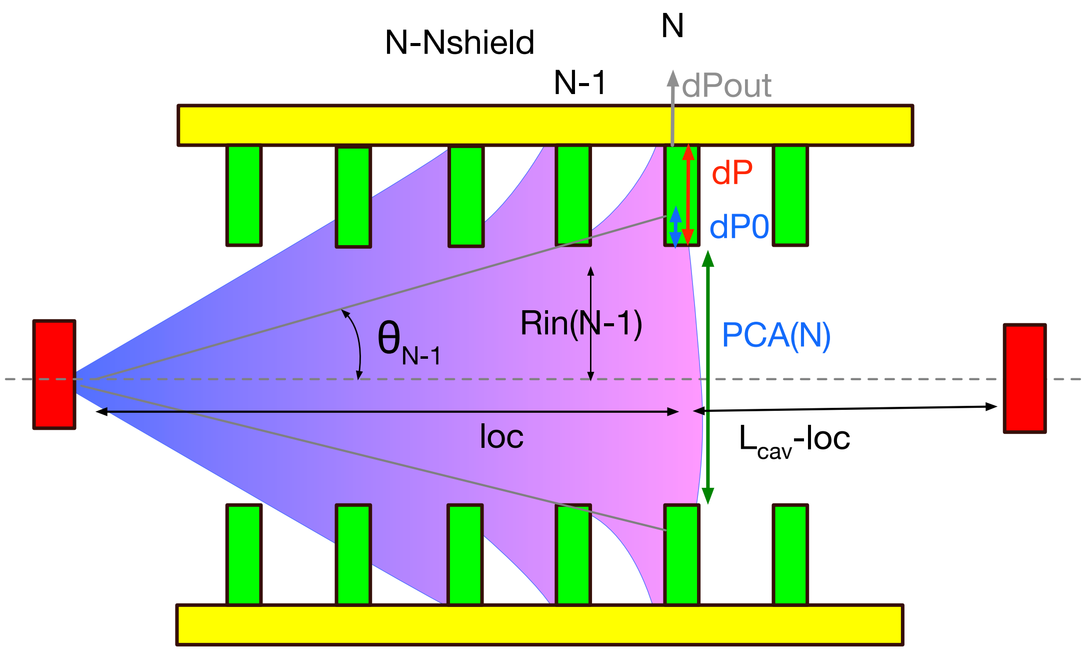
- Goal : Quantitative and flexible noise estimation by beam tube baffles in Cosmic Explorer
- Physics :
  - » Eanna Flanagan and Kip Thorne. “Light Scattering and Baffle Configuration for LIGO”, LIGO-T950101-00-R, 1995.
  - » Proper inclusion of scattering by mirror surface map and BRDF data for large angle scattering
  - » Noise by reflection by beam tube
- Tool : SIS (Stationary Interferometer Simulation) with extensions for CE and baffle scattering
  - » Documentations : https://dcc.ligo.org/LIGO-T2000311
  - » Source code and examples : https://git.ligo.org/IFOsim/SIS
- To be studied
  - » Optimal design of the baffle, locations, geometry, material, etc
  - » Dependence on the mirror phase map

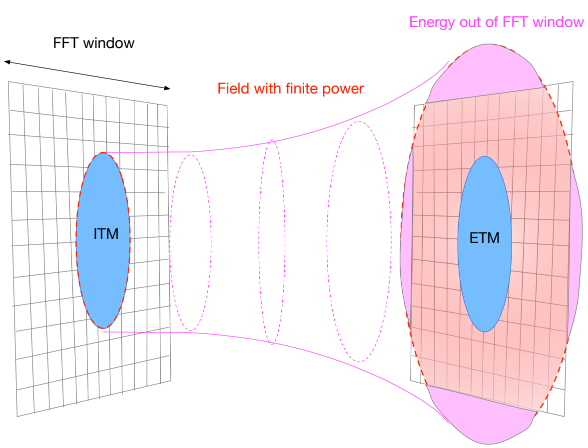
CE arm tube baffle simulation by SIS

- Fields in the cavity is calculated including the clipping by all preceding baffles
  - Field passing through a baffle propagates to the next baffle using FFT propagation
- The noise calculation of reflection and diffraction by baffles discussed in T950101
  - Updated by including new information, without approximation needed for numerical calculation, and better methods
- Noise by the reflection of the field off the beam tube



General power deposit views





Variables in baffleManager.m and are available in the output of getBaffData

- loc : distance to source
- dP : power on baffle using FFT propagation
- dP0 : power on baffle using geometrical prop
- PCA : power going through clear aperture
- dPout : power out of baffle or on beam tube

dPout(N) = PCA(N-1) - dP(N) – PCA(N)

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Low pass filter

$$E[x_2, y_2, L] = \iint K_1[x_2 - x_1]\, K_1[y_2 - y_1]\, E[x_1, y_1]\, dx_1\, dy_1$$

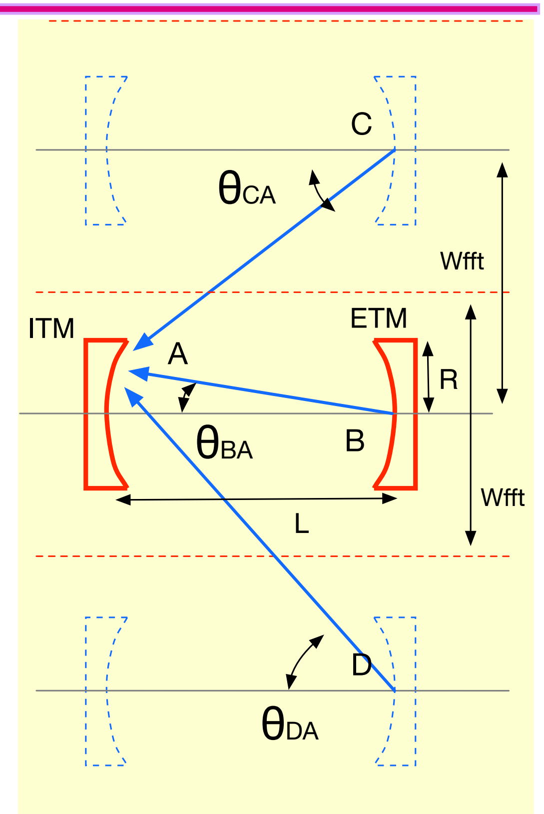
$$K_1 = \mathrm{Exp}\left[-i 2\pi \frac{(x_2 - x_1)^2}{2L}\right] \sim \mathrm{Exp}\left[i\, 2\pi \frac{x_2}{L\lambda} x_1\right] = \mathrm{Exp}[i\, 2\pi\, p\, x_1];$$

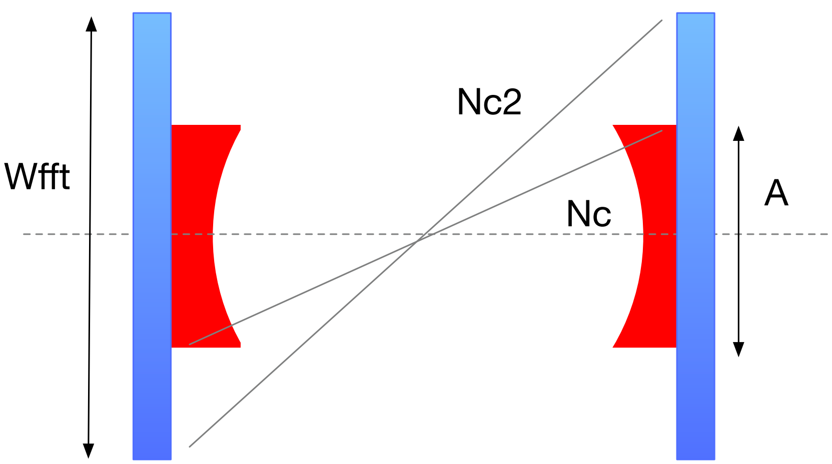
$$\tilde{E}[p, q, L] = \mathrm{prop}[p, q, L] \times \mathrm{FFT2}[E(x1, y1)];$$

$$p_n = \left(-\frac{N}{2} \sim \frac{N}{2}\right) \frac{1}{W};\; p = \frac{x_2}{\lambda L};$$

$$x_2 = \lambda L p = \frac{\lambda L}{W} \left(-\frac{N}{2} \sim \frac{N}{2}\right);$$

$$E[x2, y2, L] = \mathrm{iFFT2}[\mathrm{lowPass}[p, q] \times \mathrm{prop}[p, q, L] \times \mathrm{FFT2}[E(x1, y1)]];$$





Low pass = 1 : n < Nc

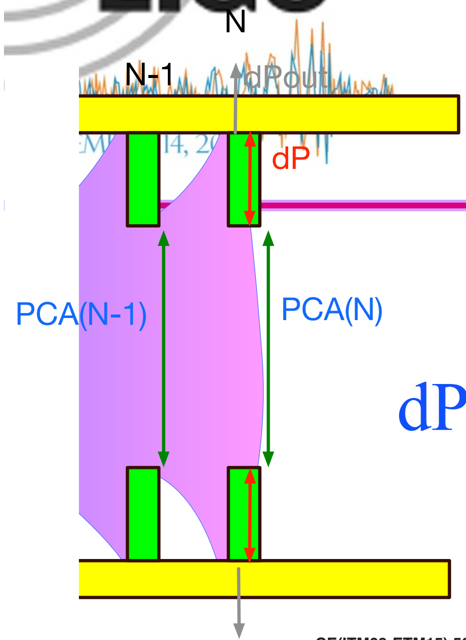
smoothly connected in between

Low pass = 0 : n > Nc2

Nc is scaled by lowPassVal

Default lowPassVal = 1

Low pass filter

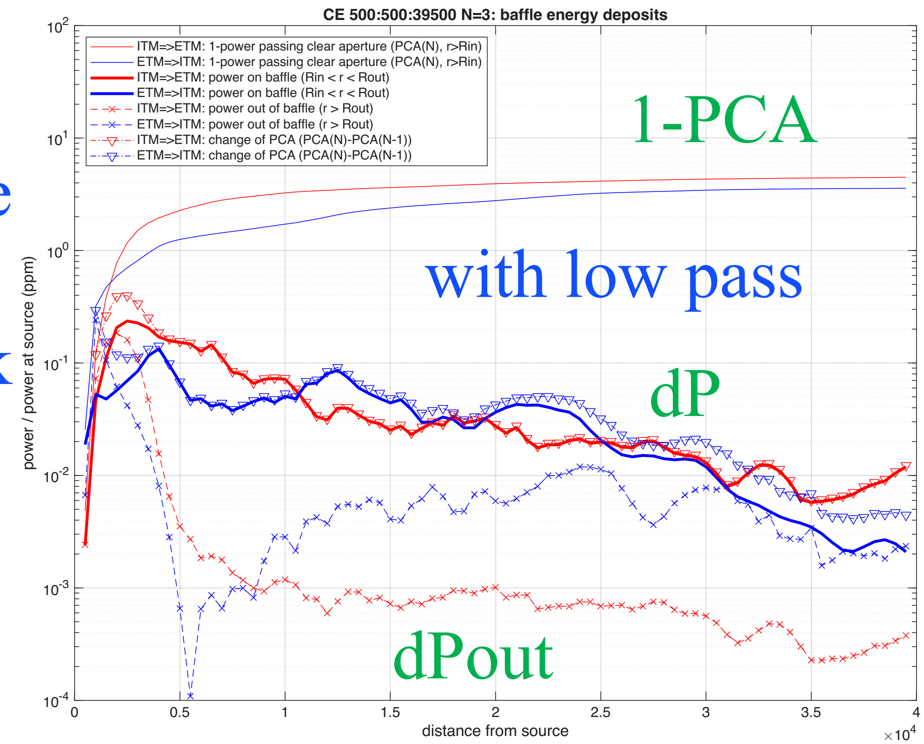


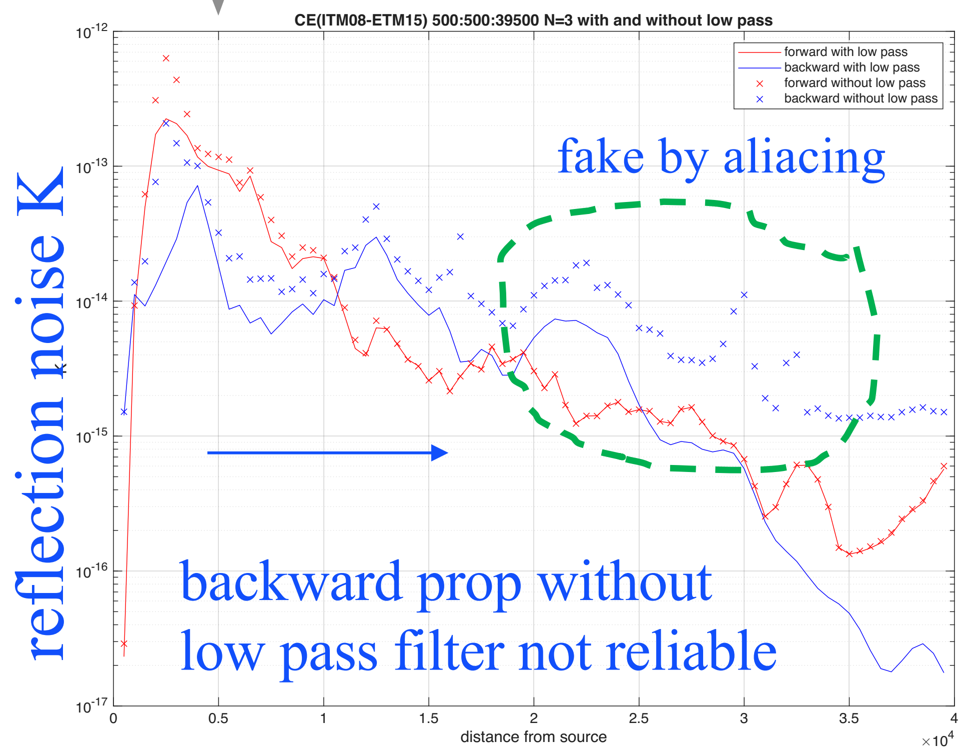
aLIGO : no difference

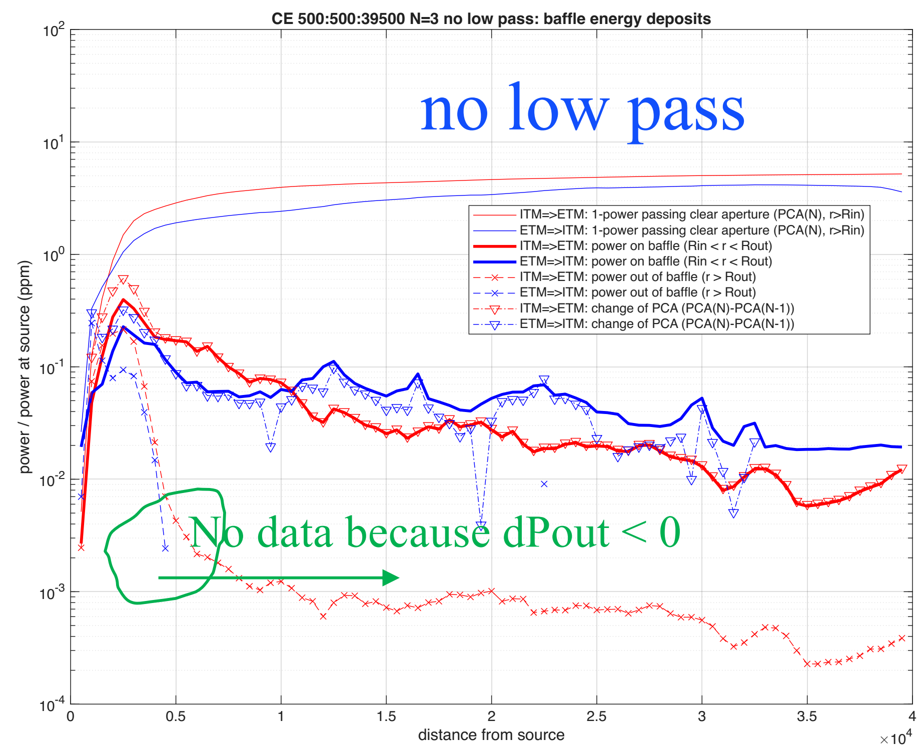
CE :

baffle at 500:500:40k

$$dPout = PCA(N-1) - PCA(N) – dP(N)$$

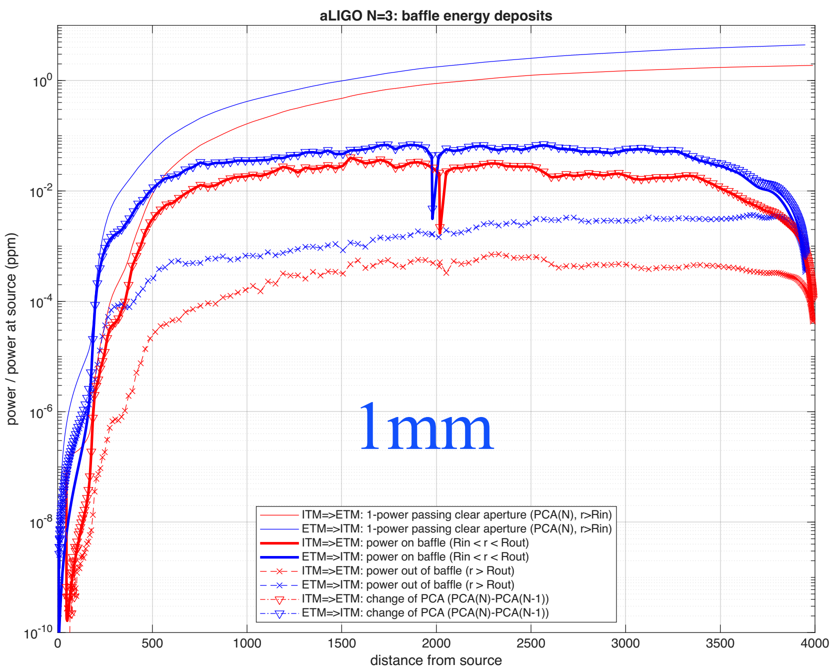


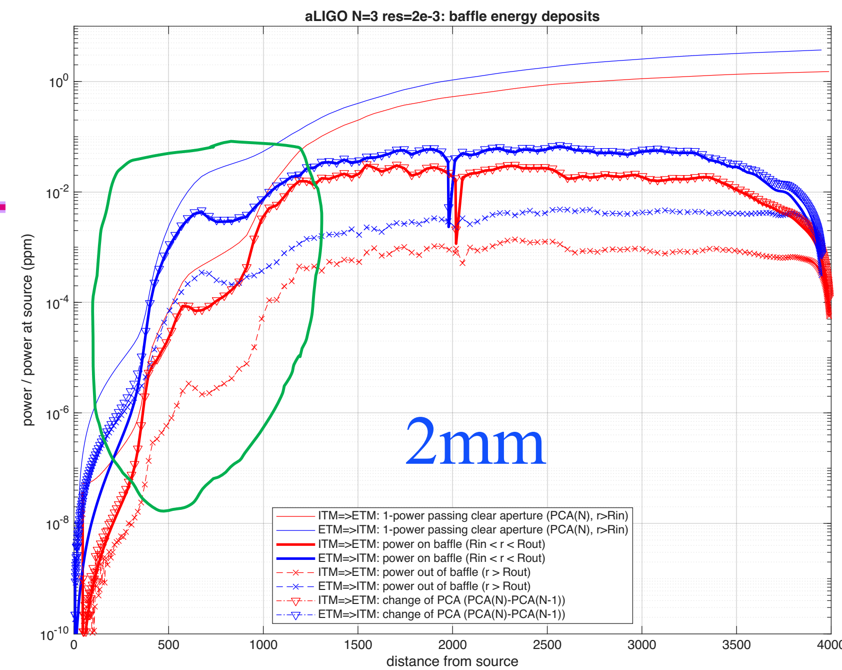




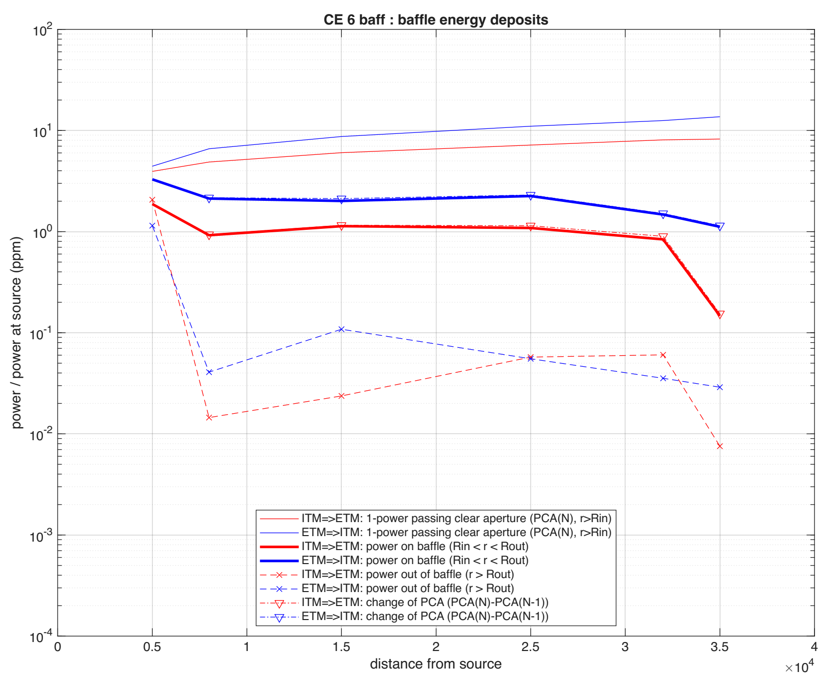
Resolution : 1mm vs 2mm

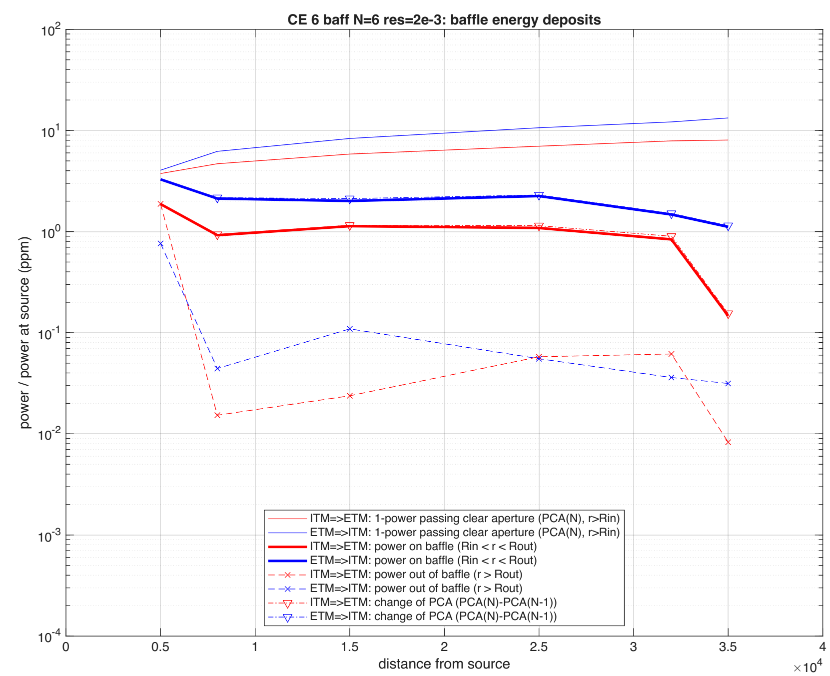
aLIGO
Rin = 53cm



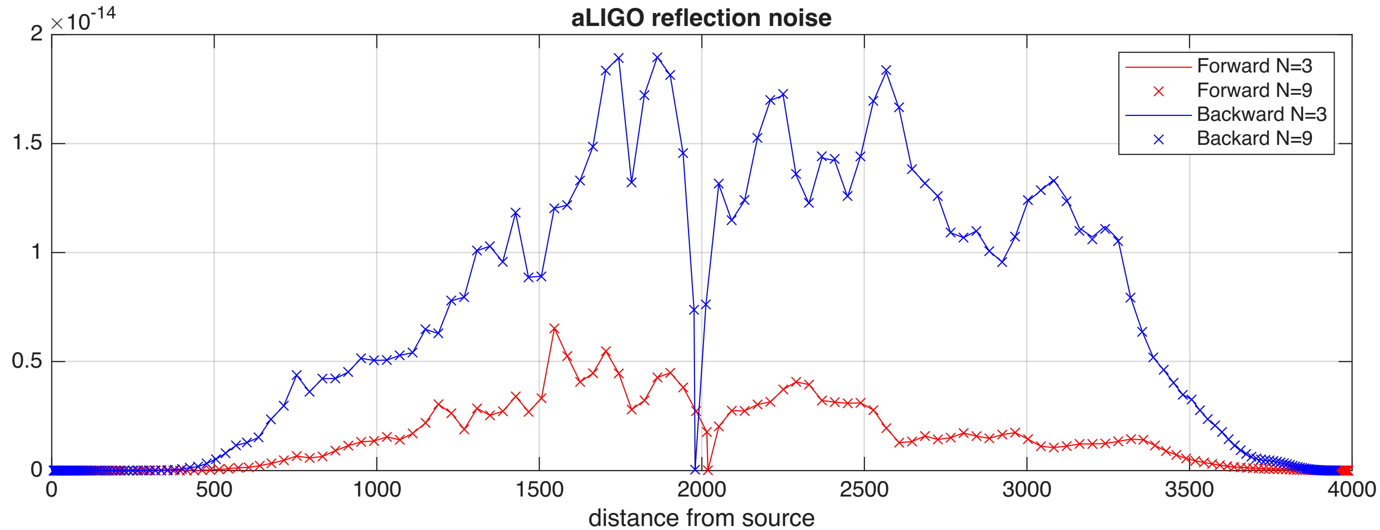


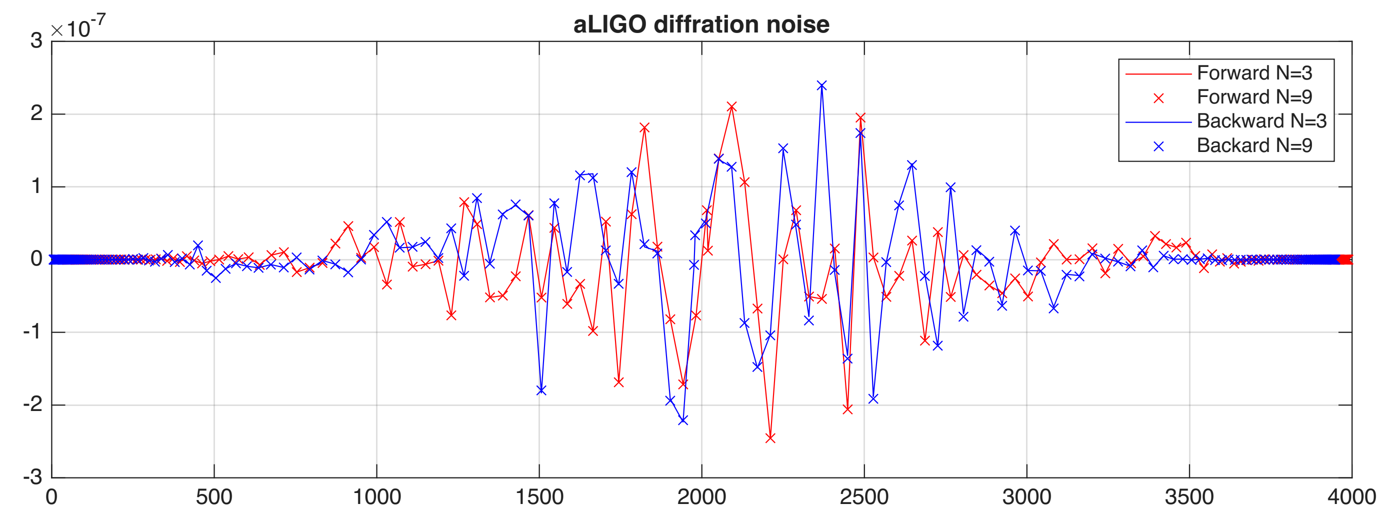
CE 6 baffles
Rin = 30cm





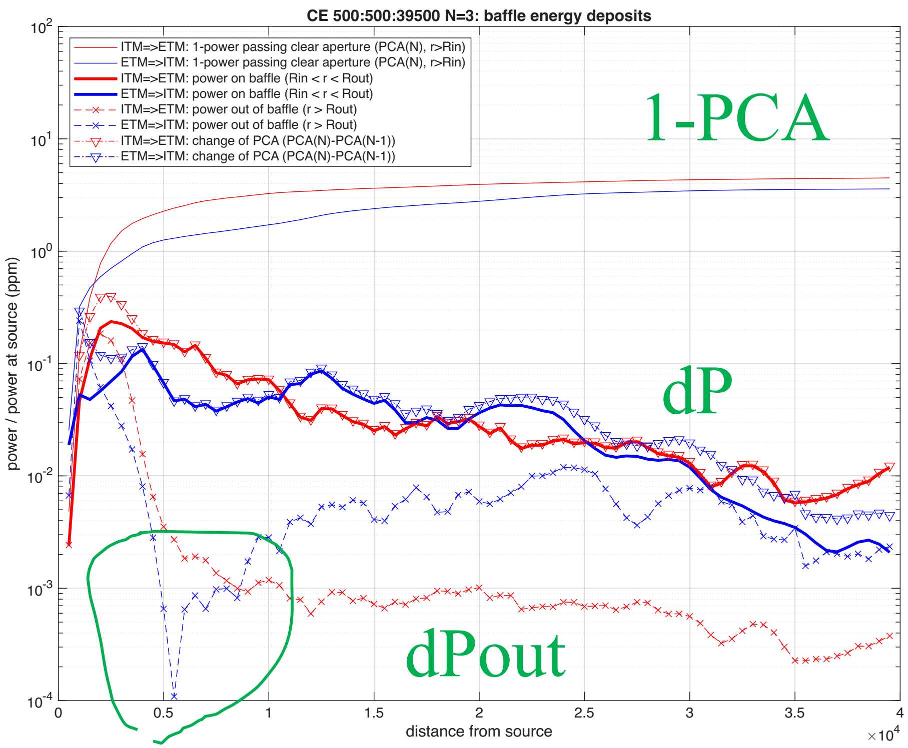
NbafShield dependence aLIGO signal



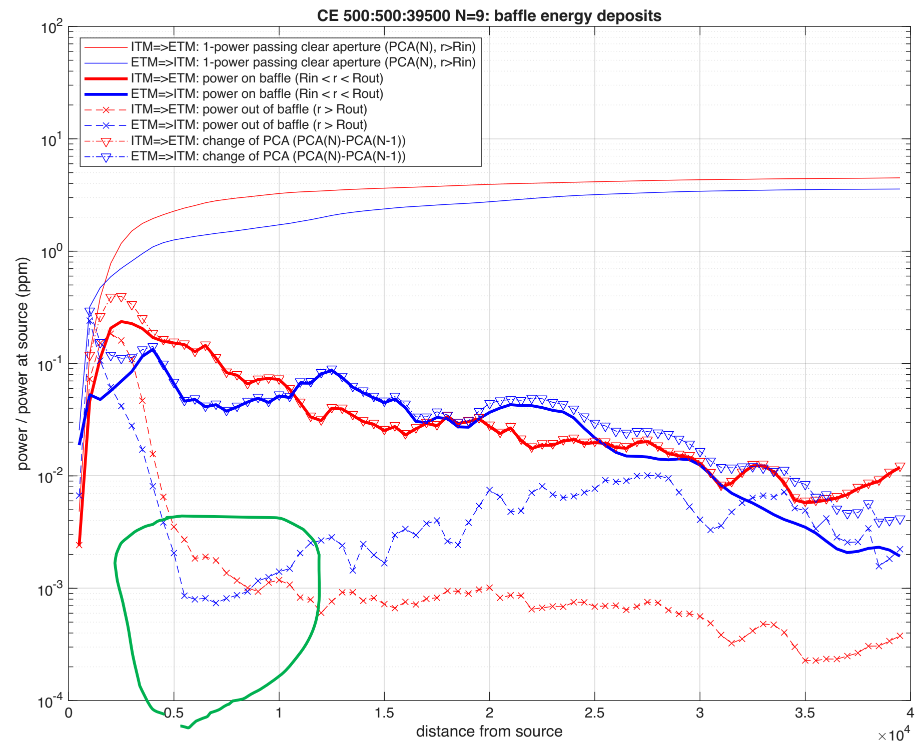


NbafShield dependence CE power

N=3



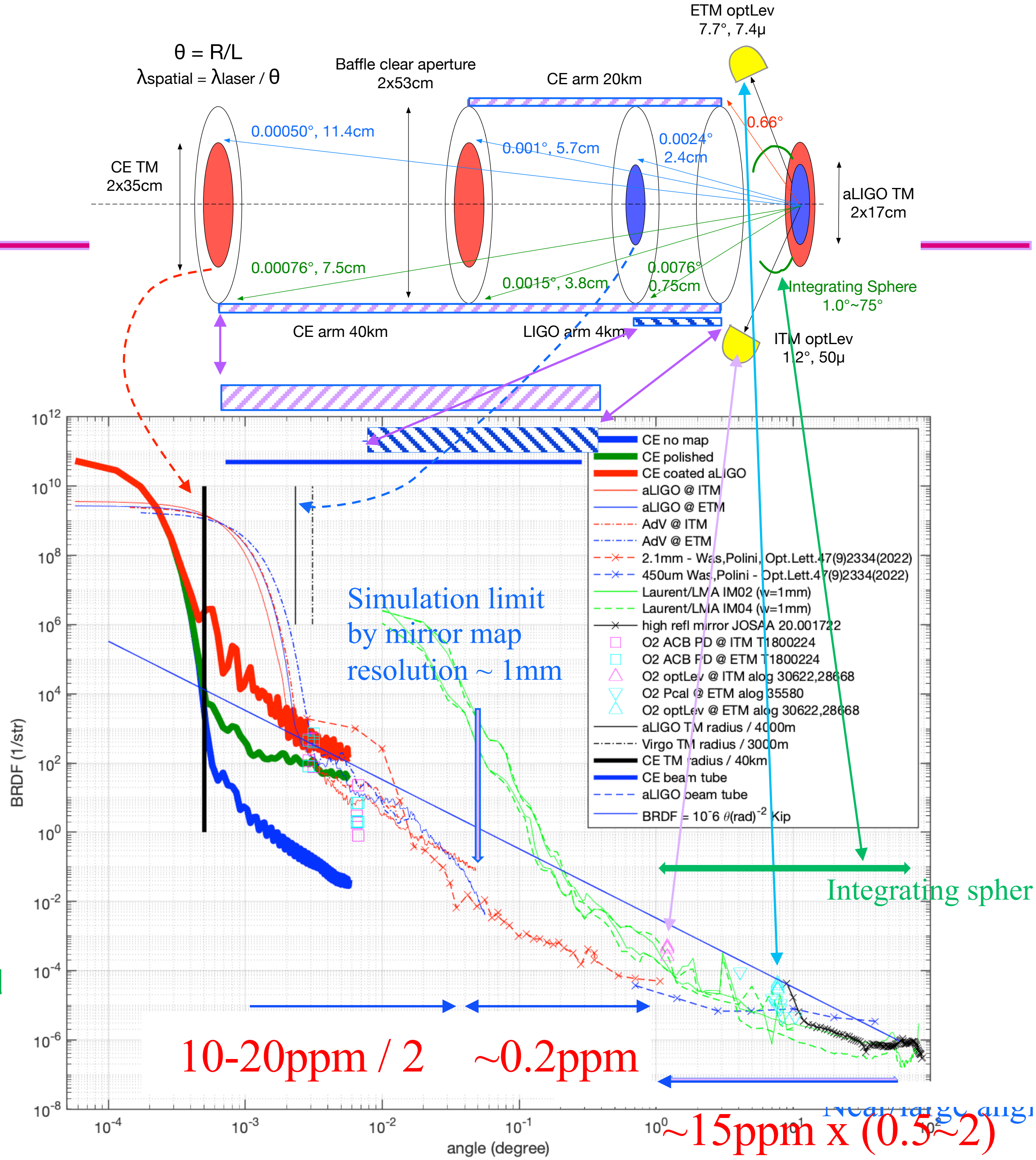
N=9



Some difference, but small power

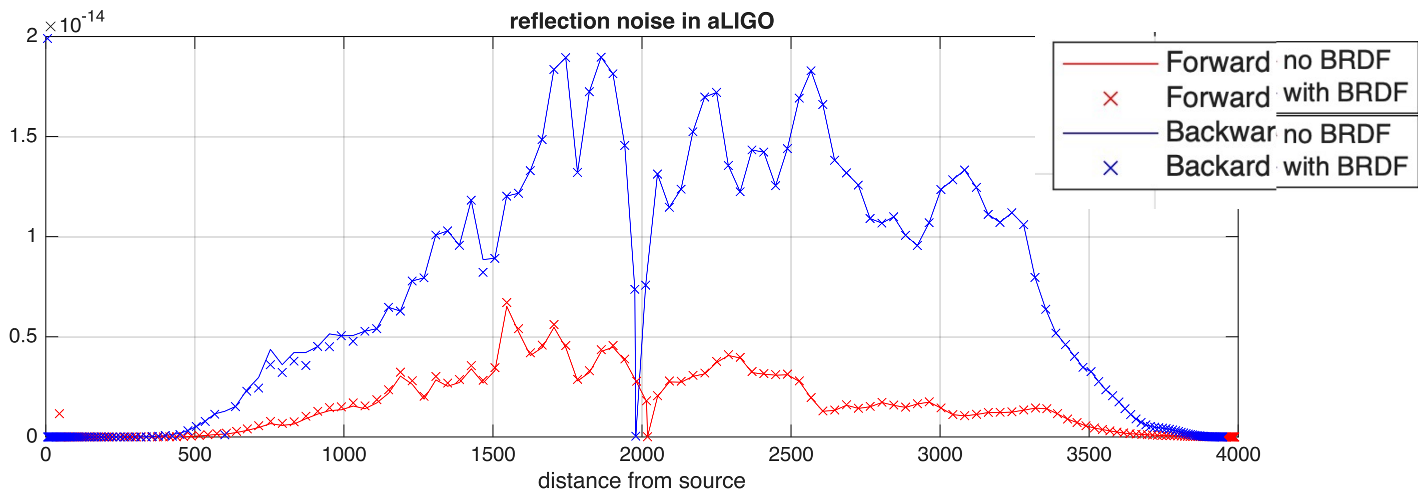
BRDF

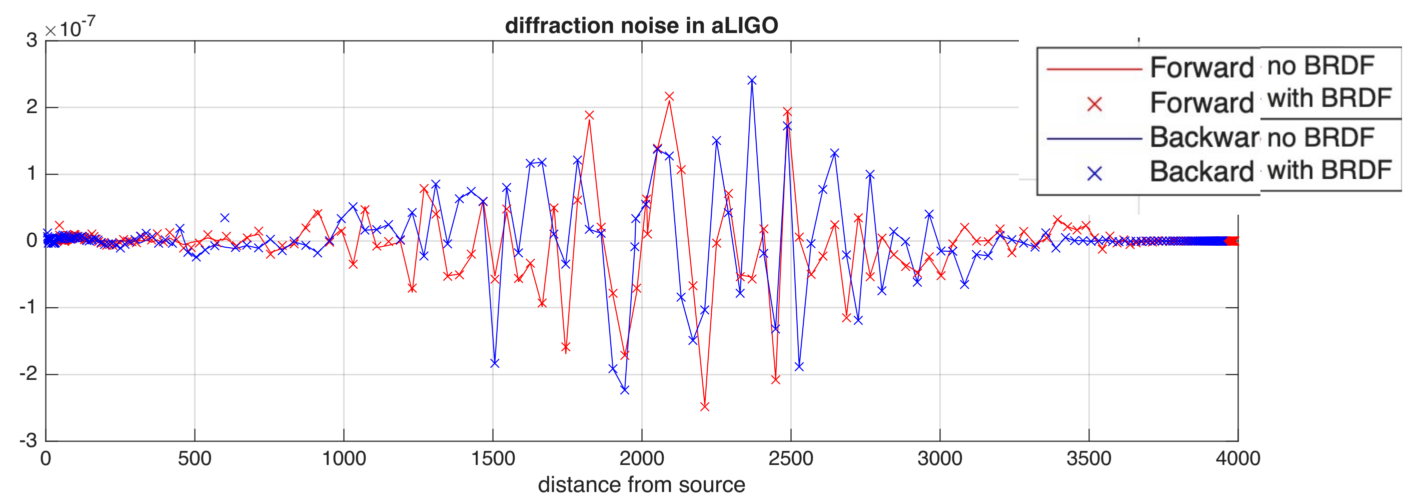
- Arm loss = 2 x $\int_0^{\pi} BRDF(\theta) d\theta$
- Measured arm loss ~ 50ppm
- Phase map resolution = 1mm (Nyquist frequency)
  $\theta_{map} < 10^{-3}$ rad = 0.06°
- Loss by phase maps up to θ_{map}
  = 10-20ppm (for two mirrors)
- Integral of BRDF fit between
  10^{-3} rad ~ 1° = 0.1 ~ 0.2 ppm
- Integral of BRDF fit between
  1° ~ 70° = 4~30 ppm
- Integrating Sphere covering
  1° ~ 70° ~ 9 ppm
- Total arm loss, 50ppm, should include BRDF to 90°
- Baffle noise calculations do not need to include BRDF correction – see next page



CE-G2500045

BRDF
aLIGO signal – not visible





BRDF
aLIGO powers

- Solid angle^2 x dP
- Effect of BRDF is observed in baffle location <300m
- Magnitude in this region is small