Some drawings and musings about Optical Bench to Telescope alignment requirements

(Largely for our own benefit to visualize the various possible misalignments and how they lead to requirements, but maybe useful as a reference point for discussions in the TMWG.)

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Some notation definitions (tried to match PDD)

Δy = **“static” OB/Tel small pupil offset in lateral position in constellation plane, perp. to LOS.**

Δz = **“static” OB/Tel small pupil offset in lateral position normal to constellation plane.**

Δx = **“static” OB/Tel small pupil offset in longitudinal position, along line of sight.**

$\Delta\Theta$ = **“static” OB/Tel roll angle offset, about line of sight (origin unclear, two options drawn).**

$\Delta\eta$ = **“static” OB/Tel small pupil angular offset out of constellation plane, pivot is OB pupil (?)**

$\Delta\varphi$ = **“static” OB/Tel small pupil angular offset in constellation plane, pivot is OB pupil (?)**

δx = **“noisy” error in optical path length along line of sight.**

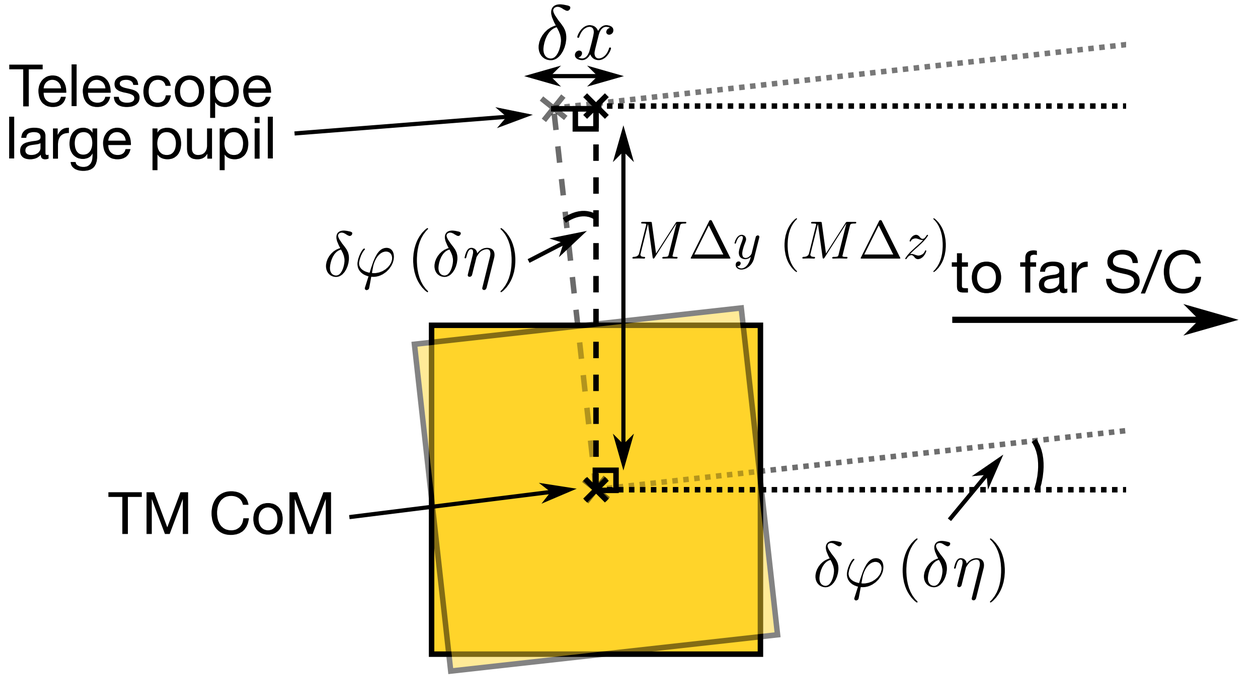
$\delta\eta$ = **“noisy” spacecraft jitter angle out of constellation plane, pivot assumed to be TM CoM.**

$\delta\varphi$ = **“noisy” spacecraft jitter angle in constellation plane, pivot assumed to be TM CoM.**

y_{off} = **fixed (design) offset between small and large pupil, transverse to line of sight.**

M = **telescope magnification.**

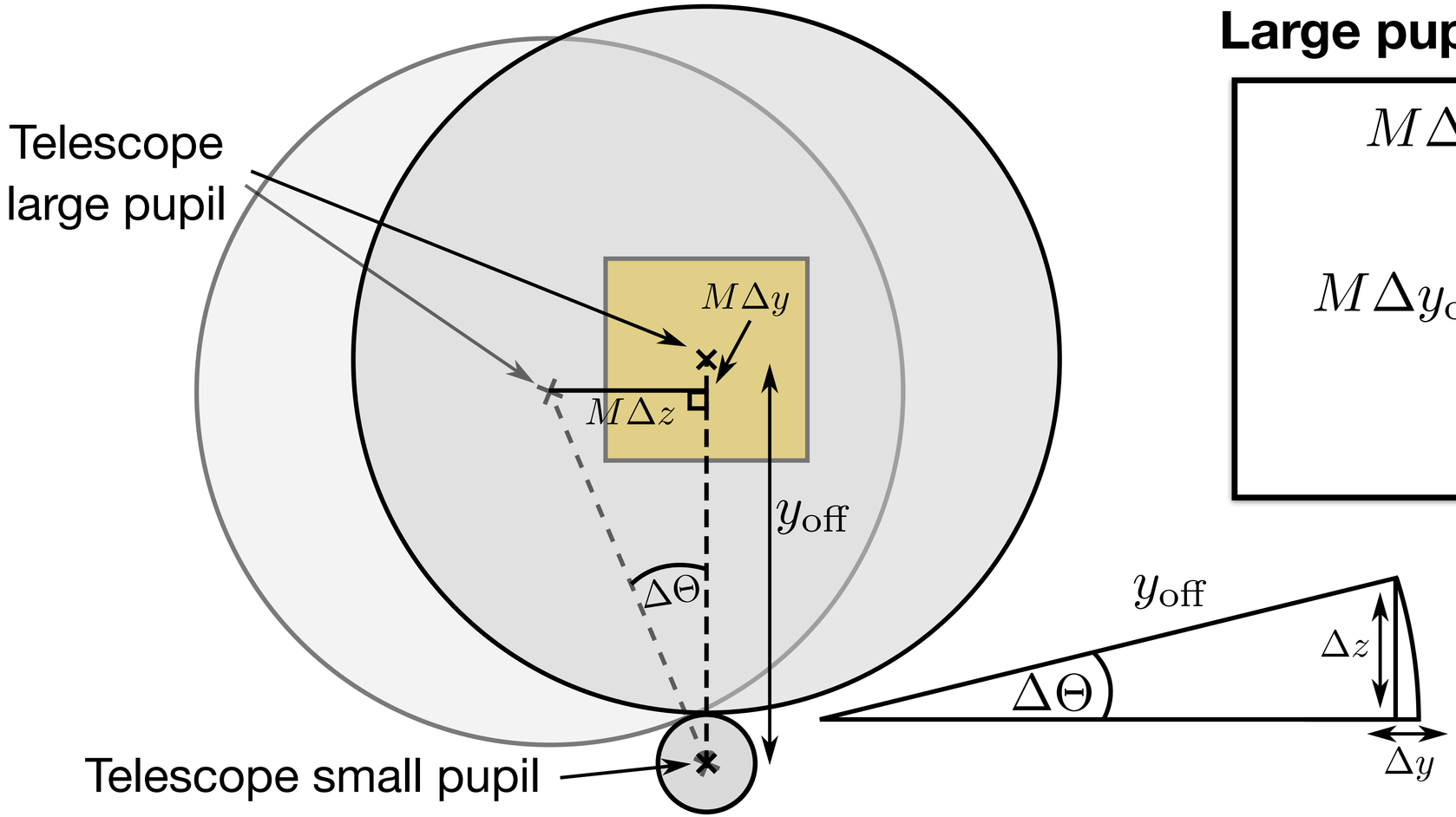
Lateral offset of large pupil



Optical path length noise from S/C jitter, coupled via lateral offset

$$\delta x = M\Delta y \sin(\delta\varphi) + M\Delta z \sin(\delta\eta)$$
$$\simeq M\Delta y\,\delta\varphi + M\Delta z\,\delta\eta$$

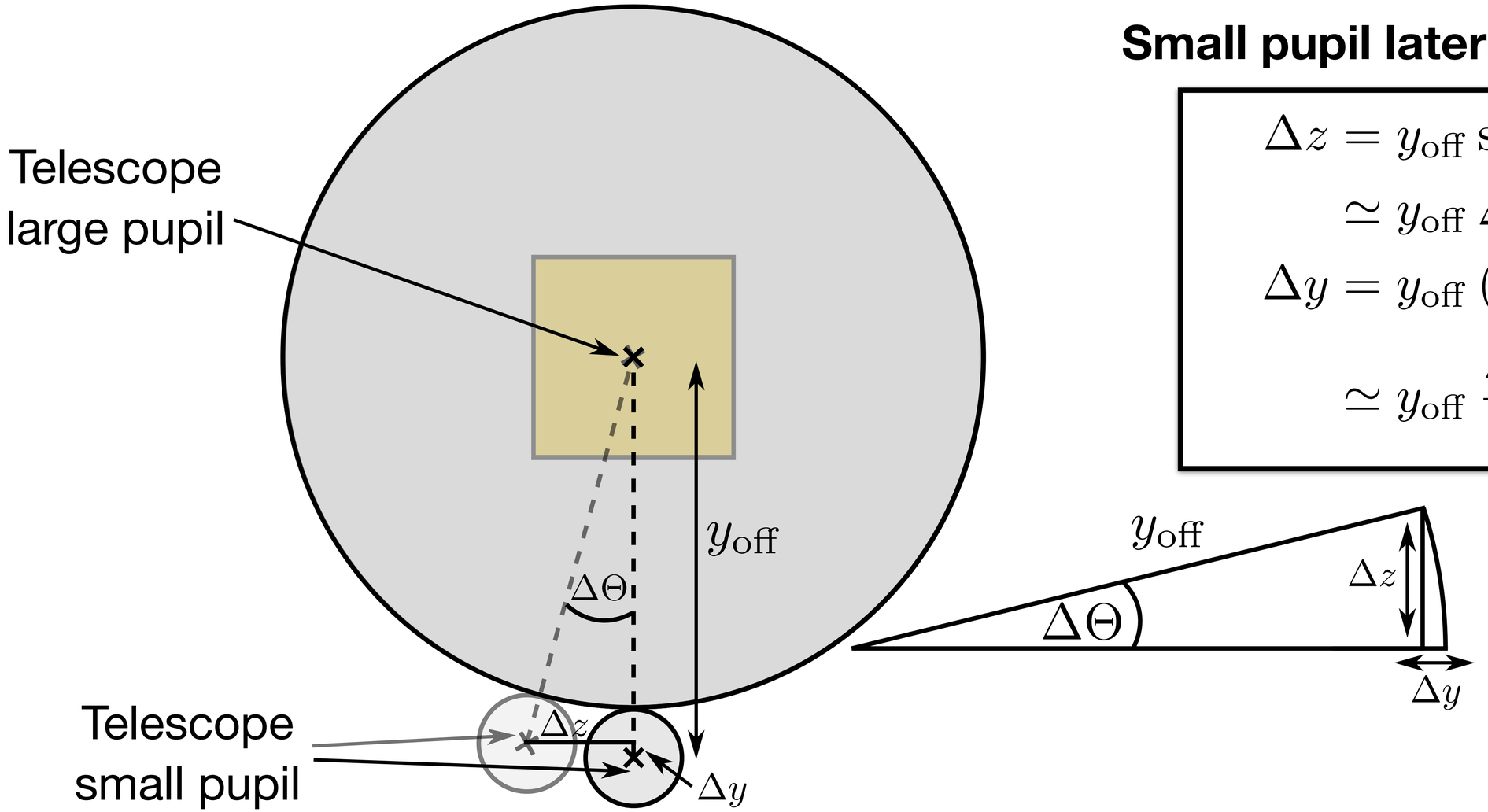
Roll about small pupil



Large pupil lateral offsets from roll:

$$
\begin{aligned}
M\Delta z &= y_{\rm off}\,\sin(\Delta\Theta) \\
&\simeq y_{\rm off}\,\Delta\Theta \\
M\Delta y_{\rm off} &= y_{\rm off}\,(1-\cos(\Delta\Theta)) \\
&\simeq y_{\rm off}\,\frac{\Delta\Theta^2}{2}
\end{aligned}
$$

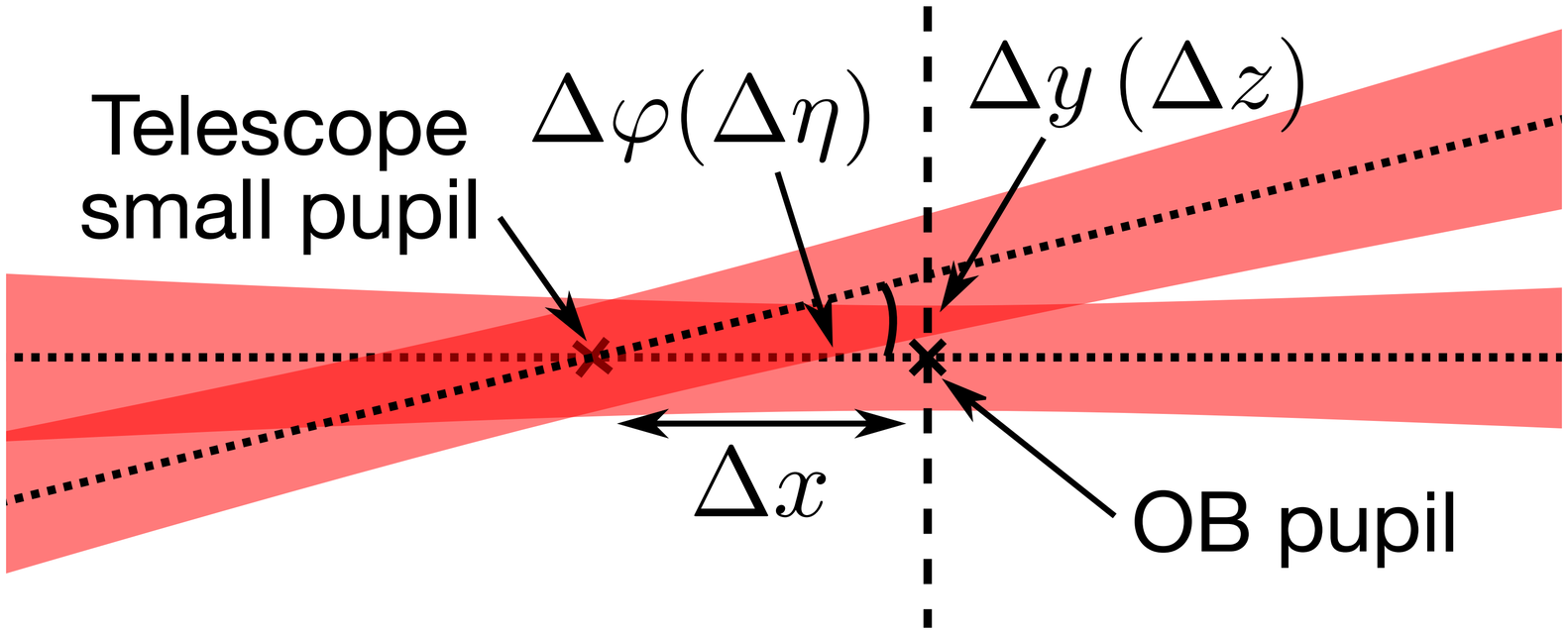
Roll about TM CoM



Small pupil lateral offsets from roll:

$$\begin{aligned}\Delta z &= y_{\mathrm{off}}\,\sin(\Delta\Theta)\\ &\simeq y_{\mathrm{off}}\,\Delta\Theta\\ \Delta y &= y_{\mathrm{off}}\,(1-\cos(\Delta\Theta))\\ &\simeq y_{\mathrm{off}}\,\frac{\Delta\Theta^2}{2}\end{aligned}$$

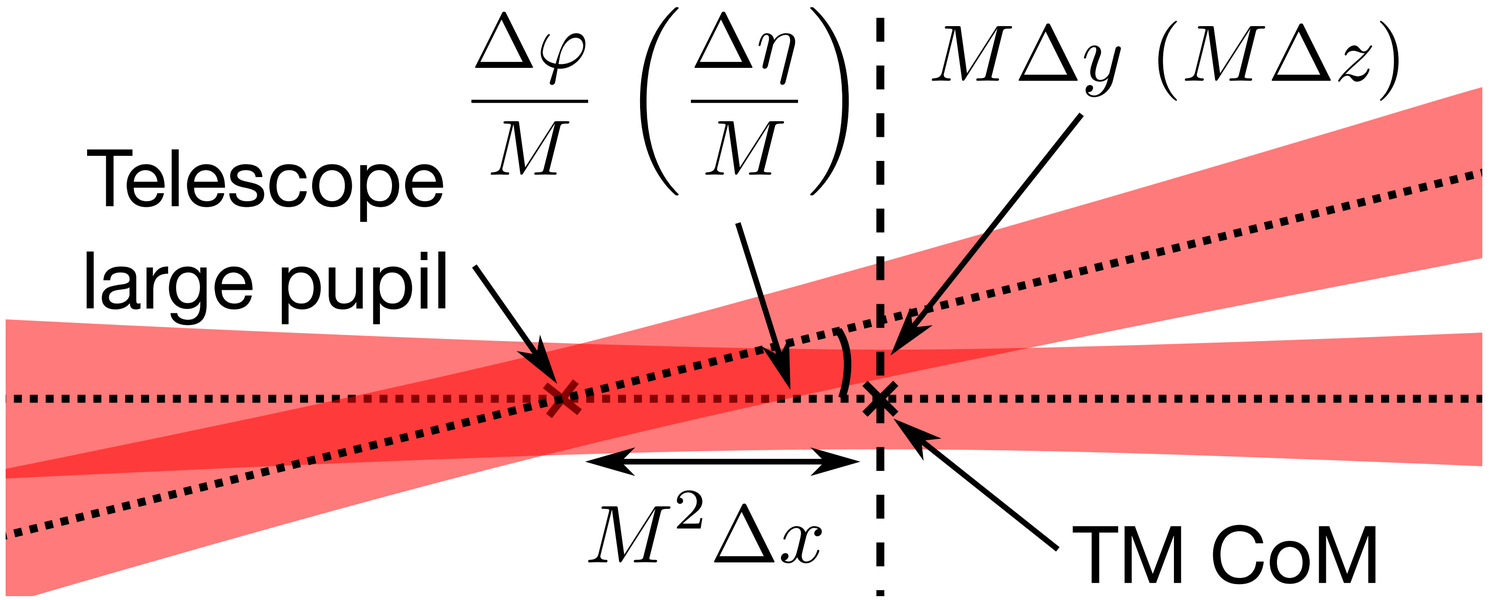
Longitudinal small pupil offset



Cross coupling from angular to lateral offset via longitudinal offset

$$\Delta y = \Delta x \tan(\Delta\varphi) \simeq \Delta x\,\Delta\varphi \qquad \Delta z = \Delta x \tan(\Delta\eta) \simeq \Delta x\,\Delta\eta$$

Longitudinal large pupil offset



Cross coupling from angular to lateral offset via longitudinal offset

$$M\Delta y = M^2\Delta x \tan\left(\frac{\Delta\varphi}{M}\right) \simeq M\Delta x\,\Delta\varphi \qquad M\Delta z = M^2\Delta x \tan\left(\frac{\Delta\eta}{M}\right) \simeq M\Delta x\,\Delta\eta$$

Still to be done (not an exhaustive list)

- Define coordinate system for OB/Telescope interface.
    - Roll about what axis? Pivot about what point? Etc.
- Investigate effects of combinations of pupil misalignments/offsets.
- More detail on how well the TTL coupling from lateral offset can be subtracted, since it seems to factor directly into the key alignment requirement.
    - Is a percentage really the way to approach this, or does it e.g. get harder to measure and subtract TTL couplings anyway?
    - How reliable are LISA pathfinder measurements for this?
- Calculate TTL from wavefront error (in both directions through the telescope?).
- What about in band “noisy” motion of telescope pupil w.r.t. OB pupil?