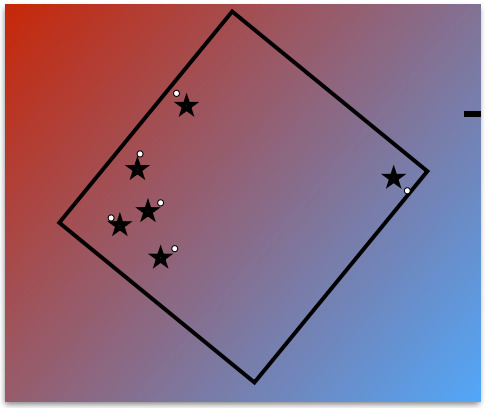
Sub-pixel effects and pointing error

- 2 effects due to non-uniform sky signal at scales < pixel size, both described as extra “noise” terms = offset * gradient of signal, (same formalism as Gravitational Lensing + leakage T → P)
  - **Sub-pixel effects and pixelized map**:
    - signal *usually* assumed uniform in pixel during map making (NGP),
    - but samples distributed all over pixel, far (~ 60”) from pixel nominal center ,
    - for Planck-HFI frequency maps (averaged over many samples, several detectors):
      - ★ hits center of mass ~ 6” from pixel center,
      - ★ offset weakly correlated between pixels (~ white noise)



  - **Pointing error**:
    - small (~ 3”) offset between real and measured sample position,
    - how does it averages in each pixel over samples and detectors ?

Sub-pixel effects and pointing error

Measured power spectra (X,Y in {T,E,B}):

$$\widetilde{C}_\ell^{XY} = W_\ell^{\rm pix} \sum_{X'Y'} W_\ell^{XY,\,X'Y'} C_\ell^{X'Y'} + N_\ell^{XY}$$

Sky spectra

pixel smearing

(Non circular) beam

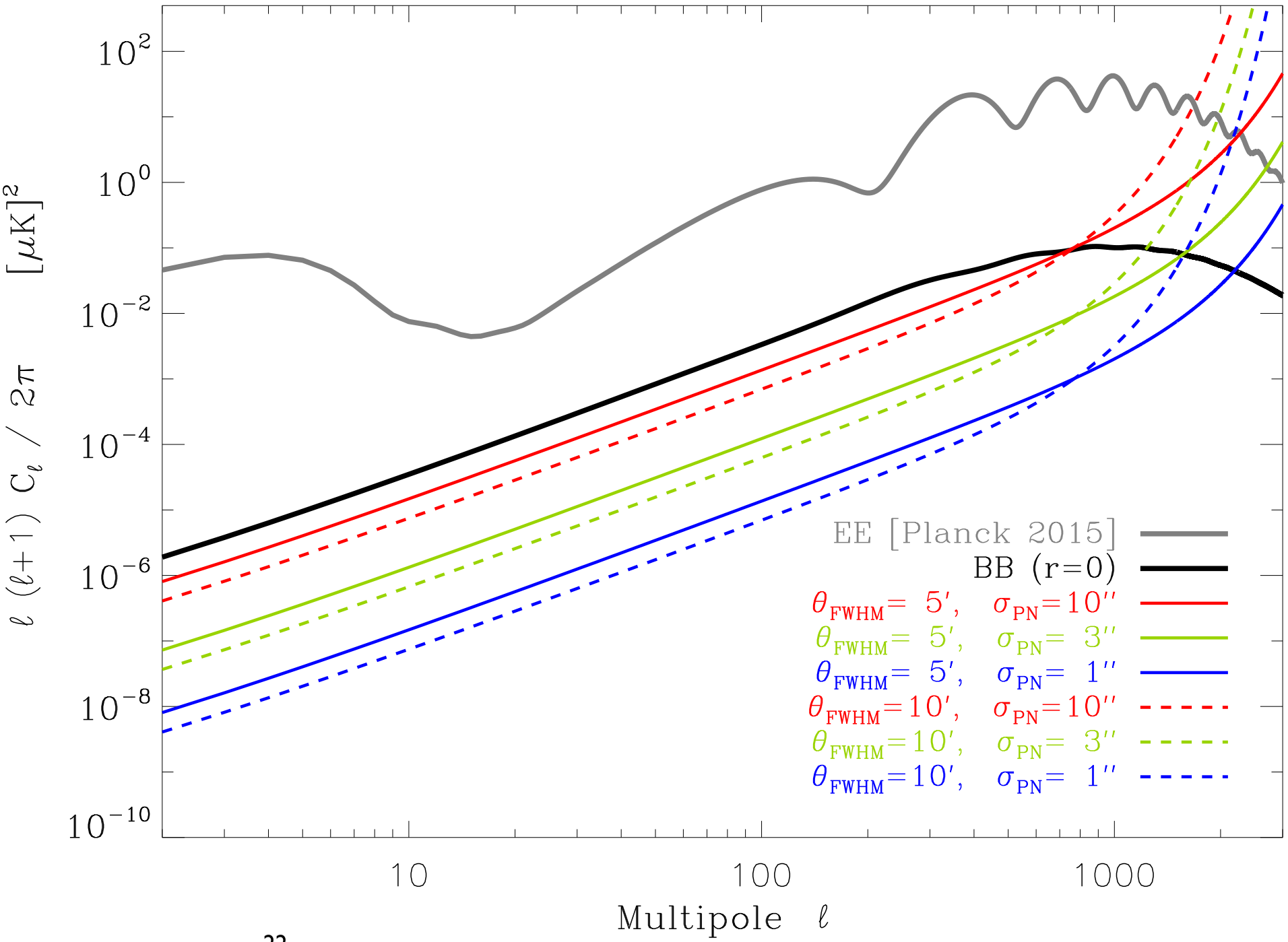
sub-pixel "noise"

one finds

$$N_\ell^{\rm TT} \sim N_\ell^{\rm EE} \sim N_\ell^{\rm BB} >> N_\ell^{\rm TE} \sim N_\ell^{\rm TB} \sim N_\ell^{EB}$$

If Pointing Noise is white with variance/pixel $\sigma_{\rm PN}^2$ then

$$N_\ell^{EE} = N_\ell^{BB} \simeq \sigma_{\rm PN}^2 \sum_{\ell'} \ell'(\ell'+1) \frac{2\ell'+1}{4\pi} C_{\ell'}^{TT} B_{\ell'}^2$$


10^2
10^0
10^{-2}
10^{-4}
10^{-6}
10^{-8}
10^{-10}
$\ell\ (\ell+1)\ C_\ell\ /\ 2\pi \quad [\mu K]^2$
10
100
1000
Multipole ℓ
EE [Planck 2015]
BB (r=0)
θ_{FWHM}= 5′, σ_{PN}=10″
θ_{FWHM}= 5′, σ_{PN}= 3″
θ_{FWHM}= 5′, σ_{PN}= 1″
θ_{FWHM}=10′, σ_{PN}=10″
θ_{FWHM}=10′, σ_{PN}= 3″
θ_{FWHM}=10′, σ_{PN}= 1″

Conclusions

- Make identical circular small beams,
  and modulate polarisation by other means than scanning only !
  (eg, front-end rotating Half Wave Plates)
- **Otherwise**:
  - **T→P leakage** and **P↔P cross-talk** due to beam mismatch (and polar efficiency and inter calibration inaccuracy)
    can *not* be ignored (at least in Planck)
  - **Analytical tool to model them fully now available (QUICKPOL)**,
    - validated with simulations,
    - allowing extensive error propagation (no need for full focal plane simulations),
    - which seems to greatly improve TE inter-frequency consistency in Planck-HFI data (preliminary).
  - Applicable to other problems ?
    - HPW specific systematic problems
    - data mosaicking (heterogeneous data processing)