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):
 - \star 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}):

$$\begin{split} & \bigvee_{\widetilde{C}_{\ell}^{XY}} = W_{\ell}^{\text{pix}} \sum_{X'Y'} W_{\ell}^{XY, X'Y'} C_{\ell}^{X'Y'} + N_{\ell}^{XY} \\ & \downarrow_{\text{pixel}} & \bigvee_{X'Y'} (\text{Non circular}) & \text{sub-pixel} \\ & \text{smearing} & \text{beam} & \text{"noise"} \end{split}$$

one finds

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

If Pointing Noise is white with variance/pixel $\sigma_{\rm PN}^2$ then $N_{\ell}^{EE} = N_{\ell}^{BB} \simeq \sigma_{\rm PN}^2 \sum_{\ell'} \ell' (\ell'+1) \frac{2\ell'+1}{4\pi} C_{\ell'}^{TT} B_{\ell'}^2$





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)
 - ◆ <u>Analytical</u> 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)