21cm - optical correlation measurement at Nancay

R. Ansari - July 2012

21cm - optical correlation signal

– $T_{21}(\alpha,\delta,\nu) \sim\propto n_{gal}(\alpha,\delta,\nu)$. At $z \sim 0.25$, mean 21 cm $T_{21} \sim 0.1$mK, we expect RMS fluctuations for $\sigma_{21} \simeq 0.1\text{mK}$
– Noise impact on measured temperatures $T_{mes} = T_{21} + T_{sys}$
– 3D-pixel defined by the instrument beam, frequency interval $\delta\nu$ and integration time t_{int}.
– Assuming $T_{sys} = 30$ K, $\delta\nu = 900$kHz, $t_{int} = 1000$s

$$\sigma_{noise} \sim \frac{T_{sys}}{\sqrt{\delta\nu t_{int}}} \simeq 1\text{mK}$$

– Assuming a total bandwidth $\Delta\nu \longrightarrow N_\nu = \frac{\Delta\nu}{\delta\nu}$, and a 2D map with $N_\alpha \times N_\delta$ pixels, there would be a total number $N = N_\alpha \times N_\delta \times N_\nu$ of pixels, with total observation time $t_{tot} = N_\alpha \times N_\delta \times t_{int}$
– Compute the correlation between the radio signal and the optical signal :

$$\chi = < T_{mes}.T_{21} > = \frac{1}{N}\sum_{i=1}^{N} = T^i_{mes} T^i_{21}$$

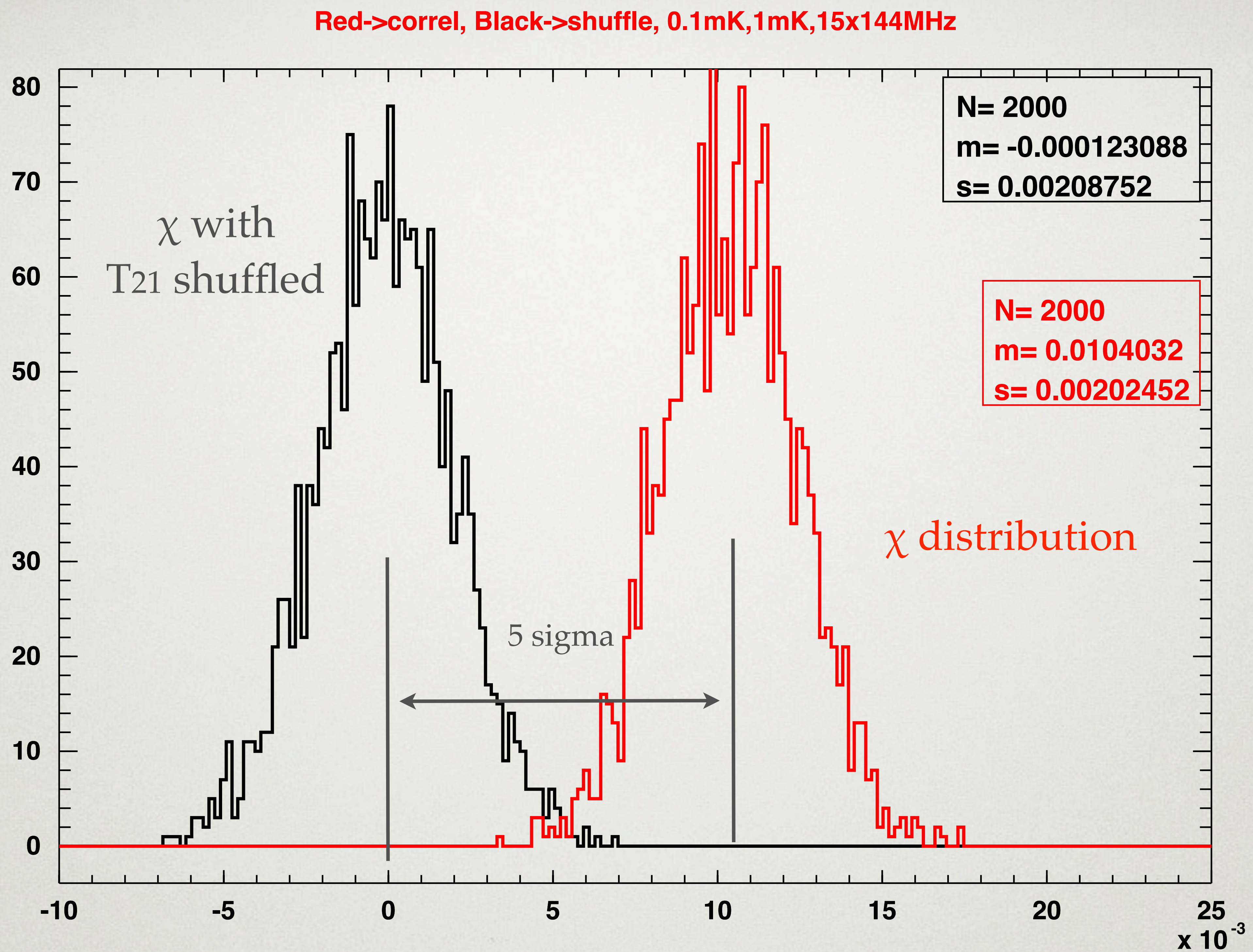
– χ expectation value and RMS :

$$< \chi > = \sigma_{21}^2 \qquad \sigma_\chi^2 = \frac{1}{N}\sigma_{21}^2\sigma_{noise}^2$$

– Bandwidth is the key

$$\sigma_\chi = \sigma_{21}\frac{T_{sys}}{\sqrt{N_\alpha N_\delta N_\nu}\sqrt{t_{int}\delta\nu}} = \sigma_{21}\frac{T_{sys}}{\sqrt{t_{tot}\Delta\nu}}$$

Bandwidth is the key



- 144 MHz of usable band (160x900kHz)
- 3 x 5 = 15 NRT pointings (120 x 40 arcmin^2)
- 2400 pixels, 15 000 seconds (4 hours) total observation time

- Test for drift-scan mapping with NRT
- Select drift-scan of tracking mode
- Optimize frequency (redshift range) and sky region
- Adapt the electronic (filters)
- Enhance the acquisition control software