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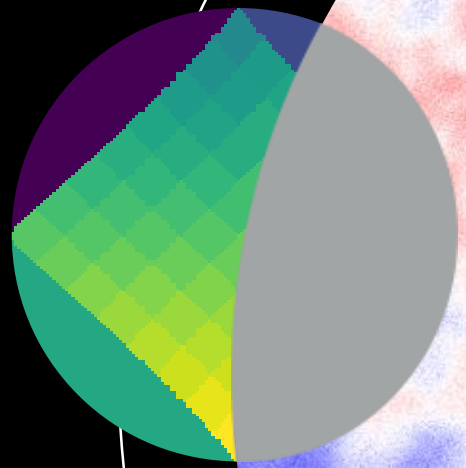
Small Scale CMB Lensing with Local Map-Space Statistics



Victor Carl Chan
Renée Hložek (Dunlap)
Alex van Engelen (CITA)
Joel Meyers (SMU)

The CMB in HD: the low noise high-resolution frontier

CMB lensing at small angular scales ($\boldsymbol{\ell} >> 3000$)

$$T_{lens}(\hat{n}) \approx T_0(\hat{n}) + \vec{\nabla} T_0(\hat{n}) \cdot \vec{\nabla} \phi$$

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Diffusion Damping

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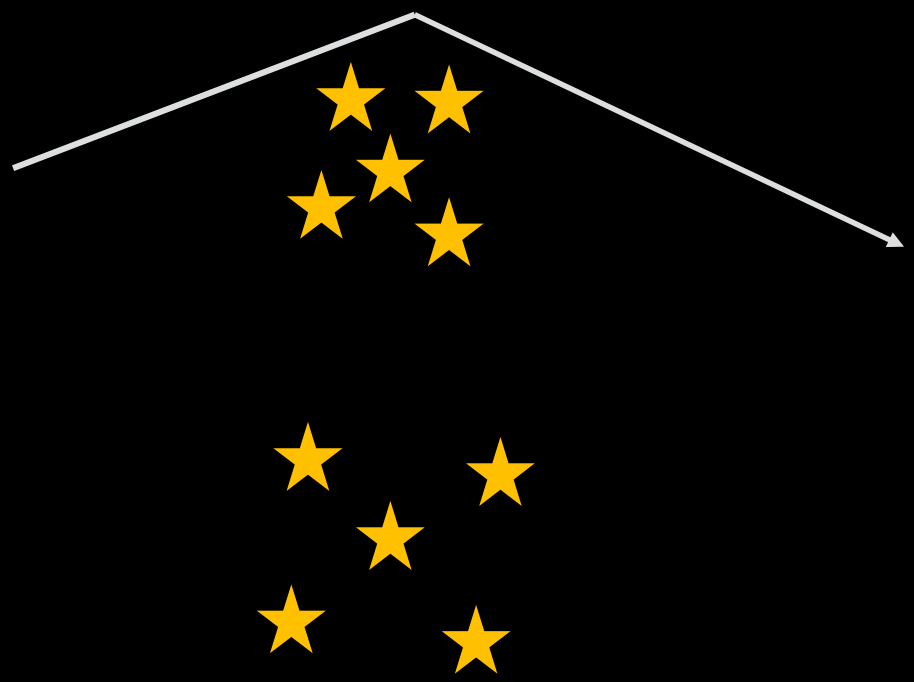

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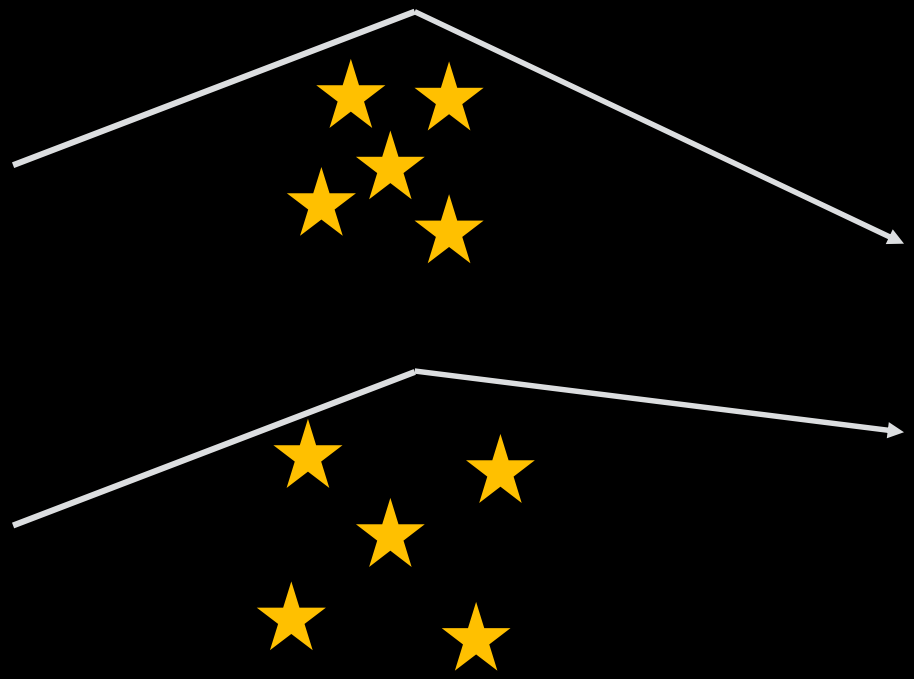

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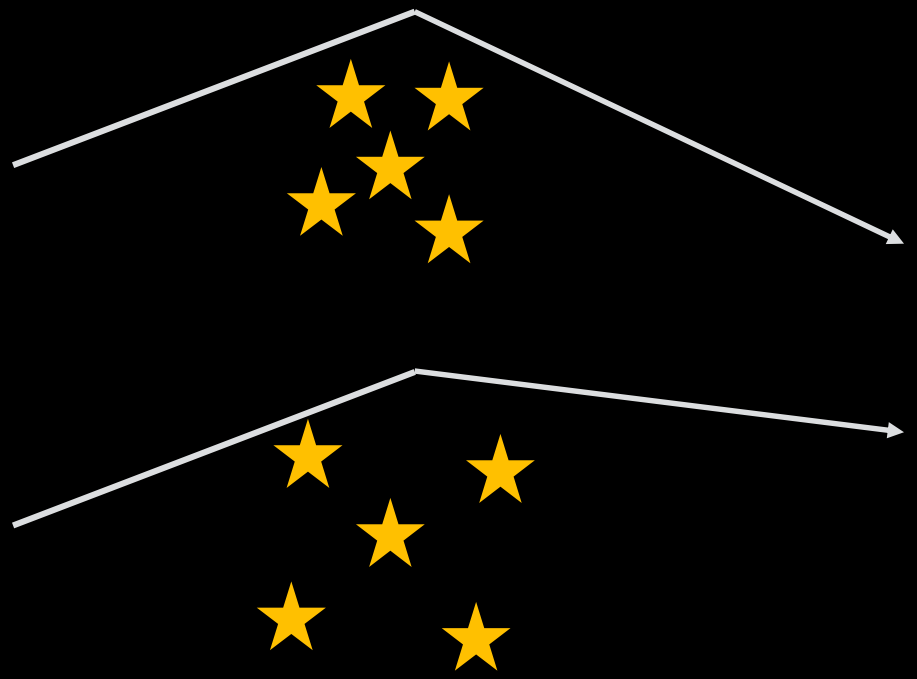

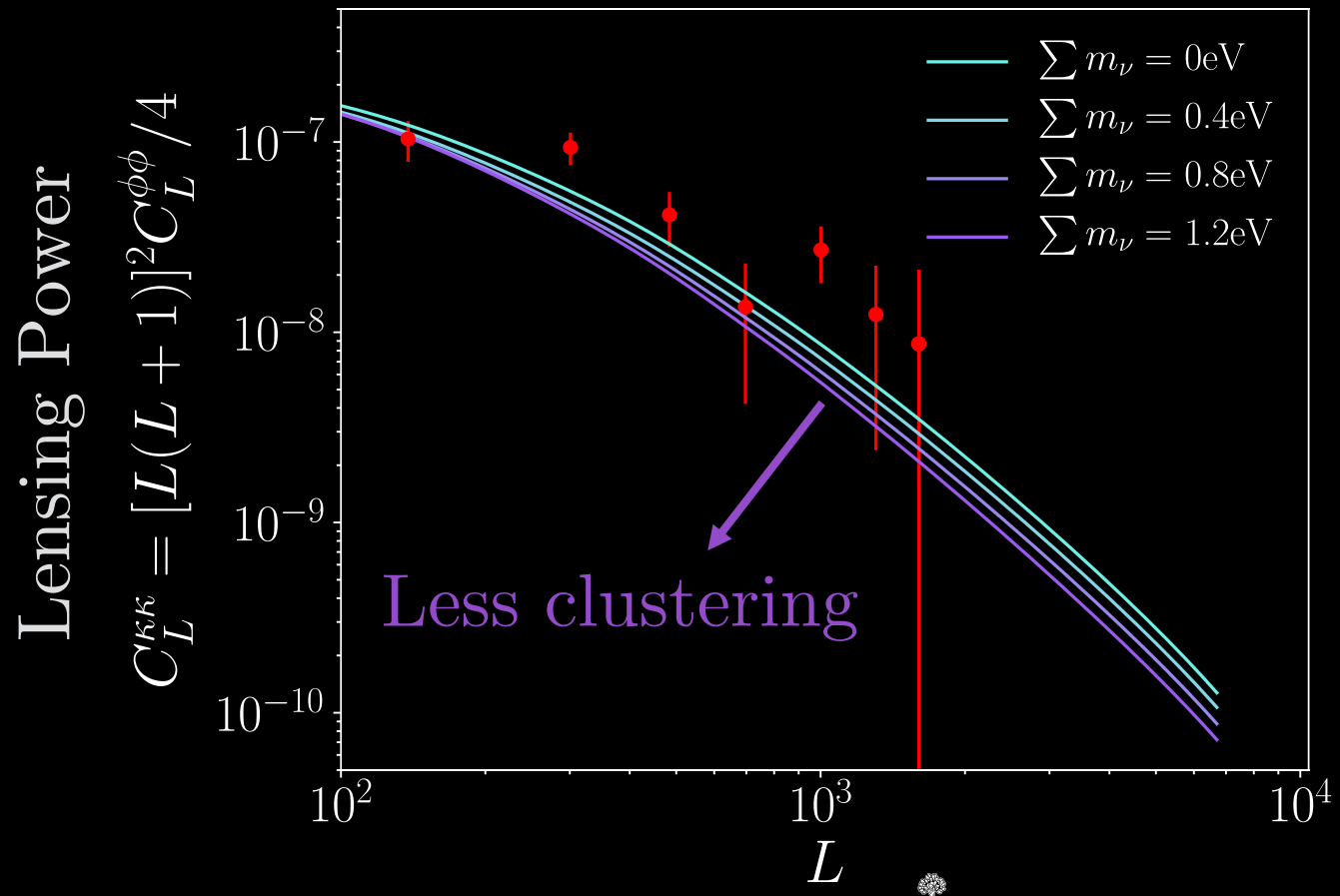

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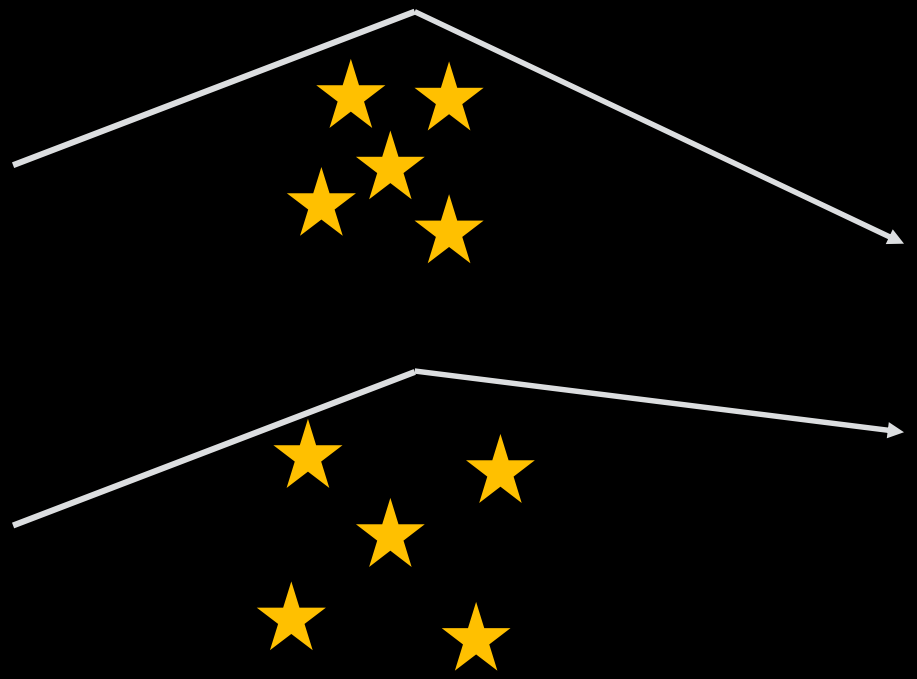

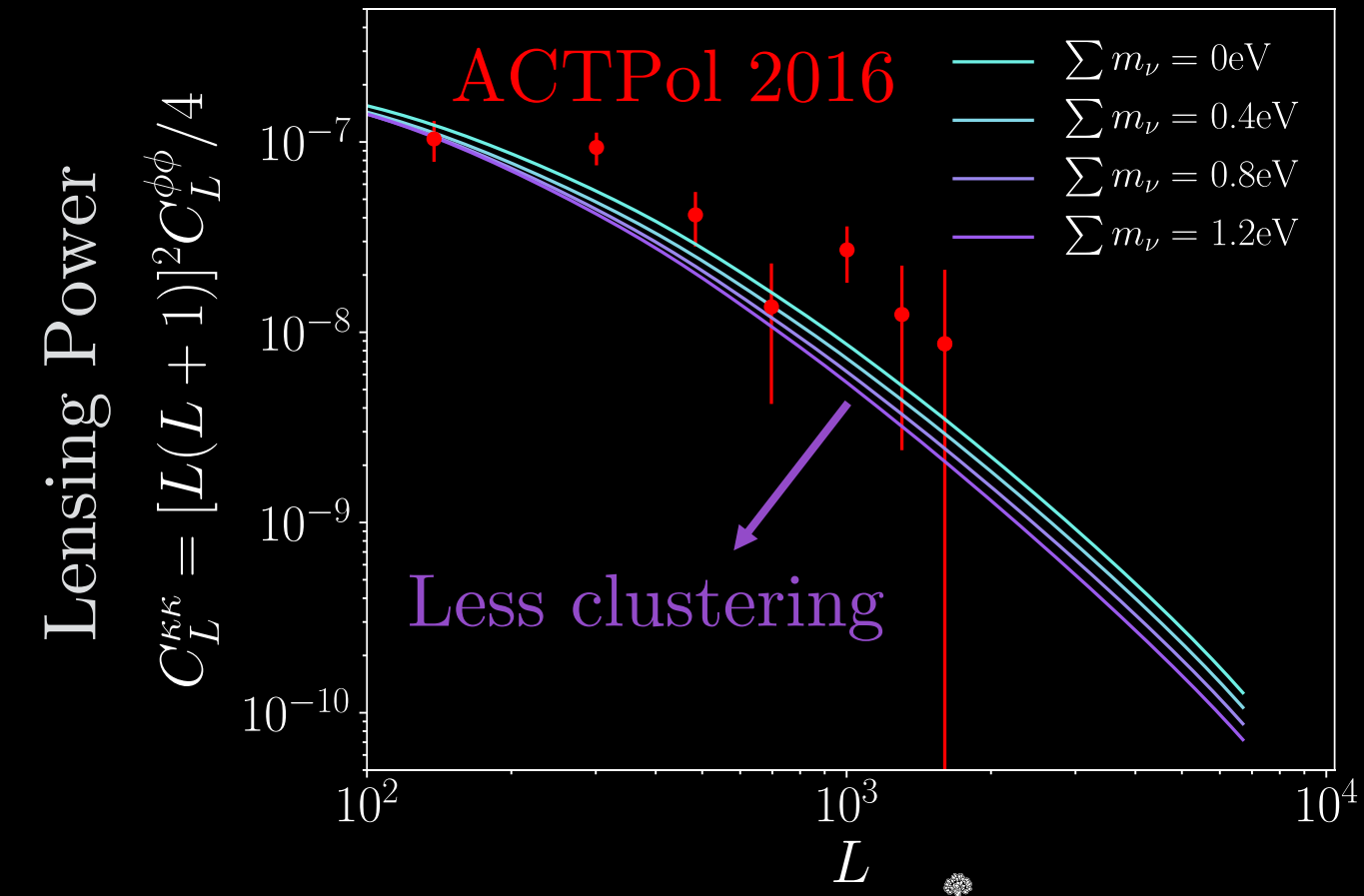

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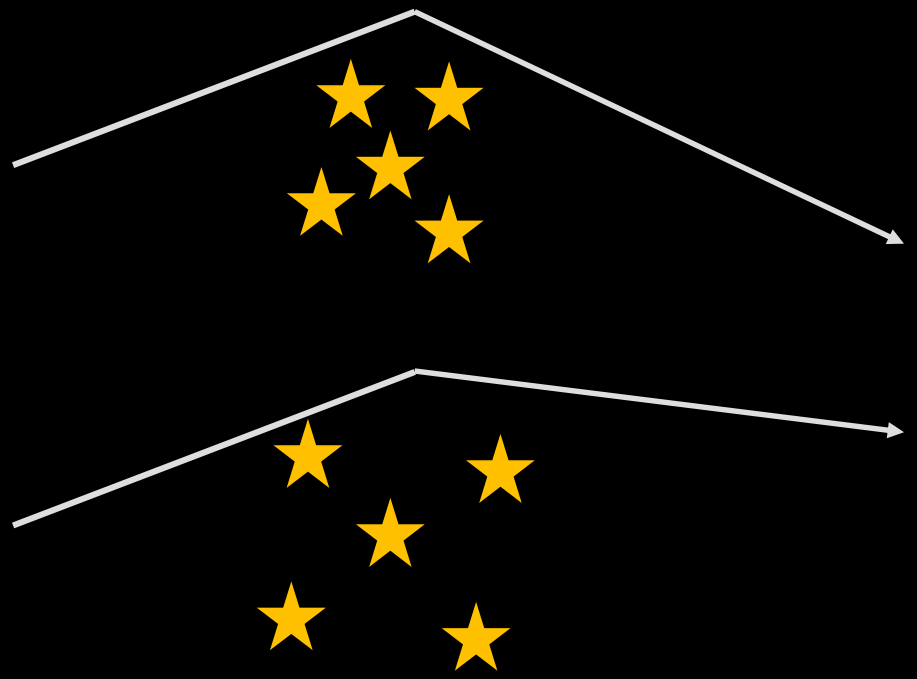

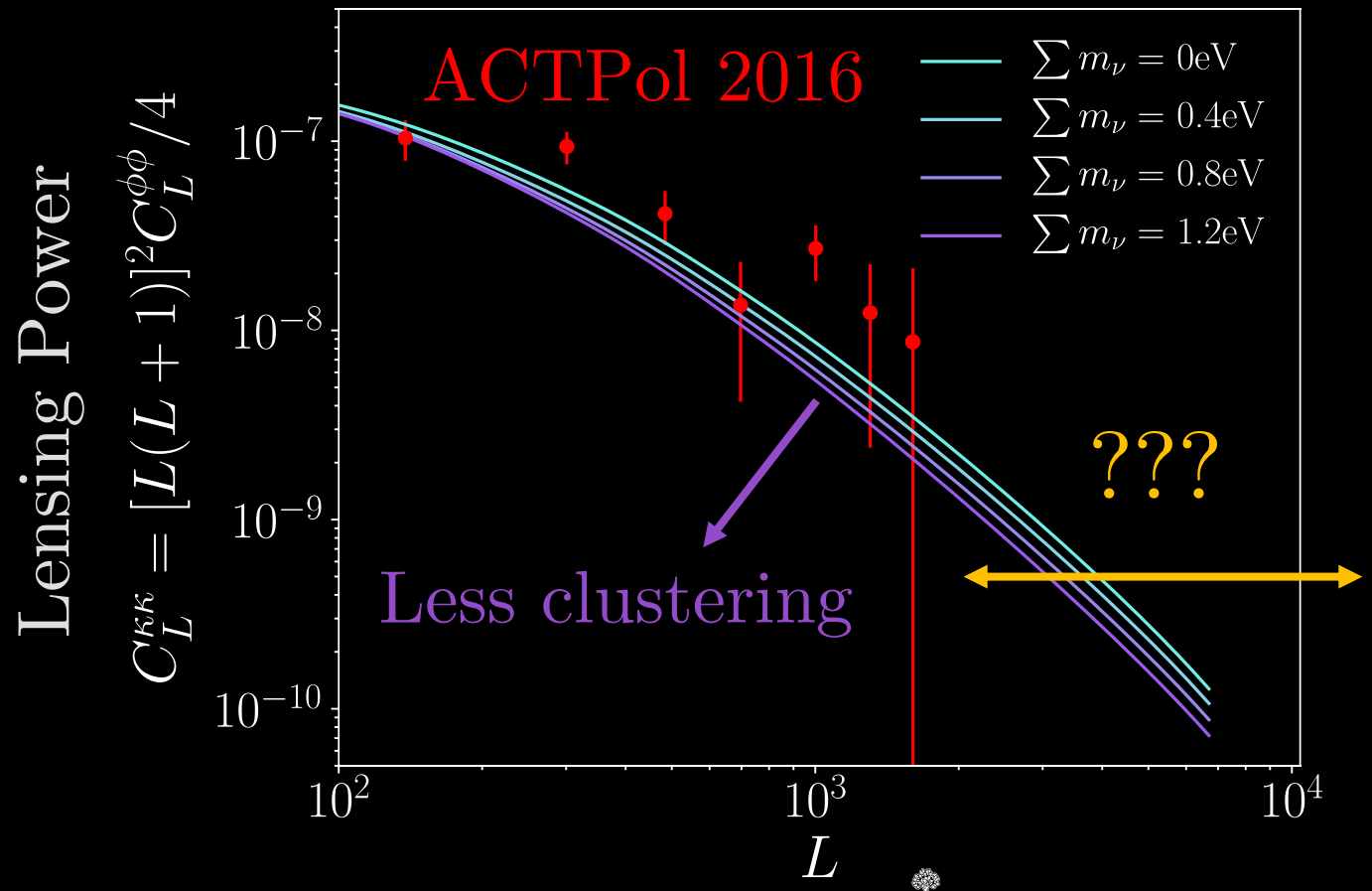

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Taking advantage of lensing dominated scales

$$\tilde{T}^{SS} \approx \vec{\nabla} T \cdot \vec{\nabla} \phi$$

Taking advantage of lensing dominated scales $\tilde{T}^{SS} \approx \vec{\nabla} T \cdot \vec{\nabla} \phi$

Reconstruct lensing potential?

$$\nabla \phi \approx T / \nabla T$$

See Simone/Blake!

Taking advantage of lensing dominated scales

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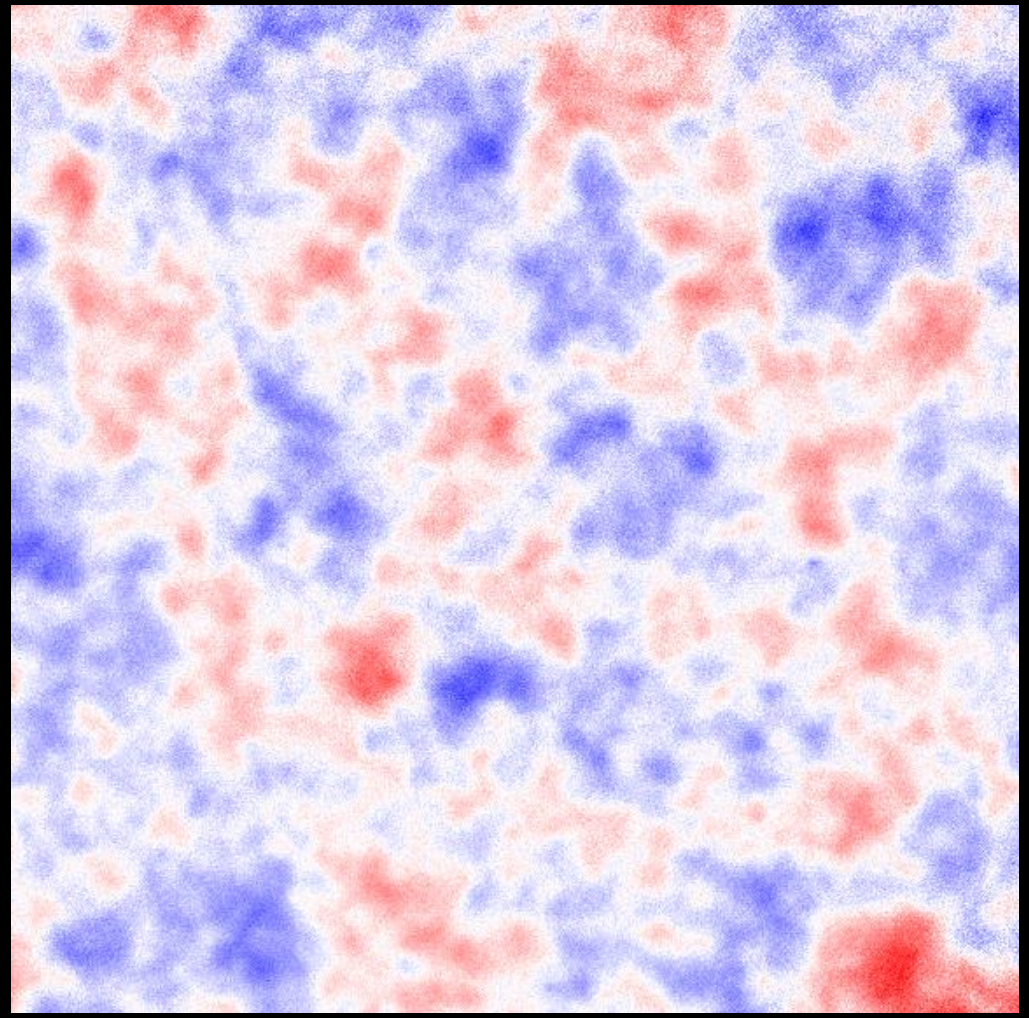

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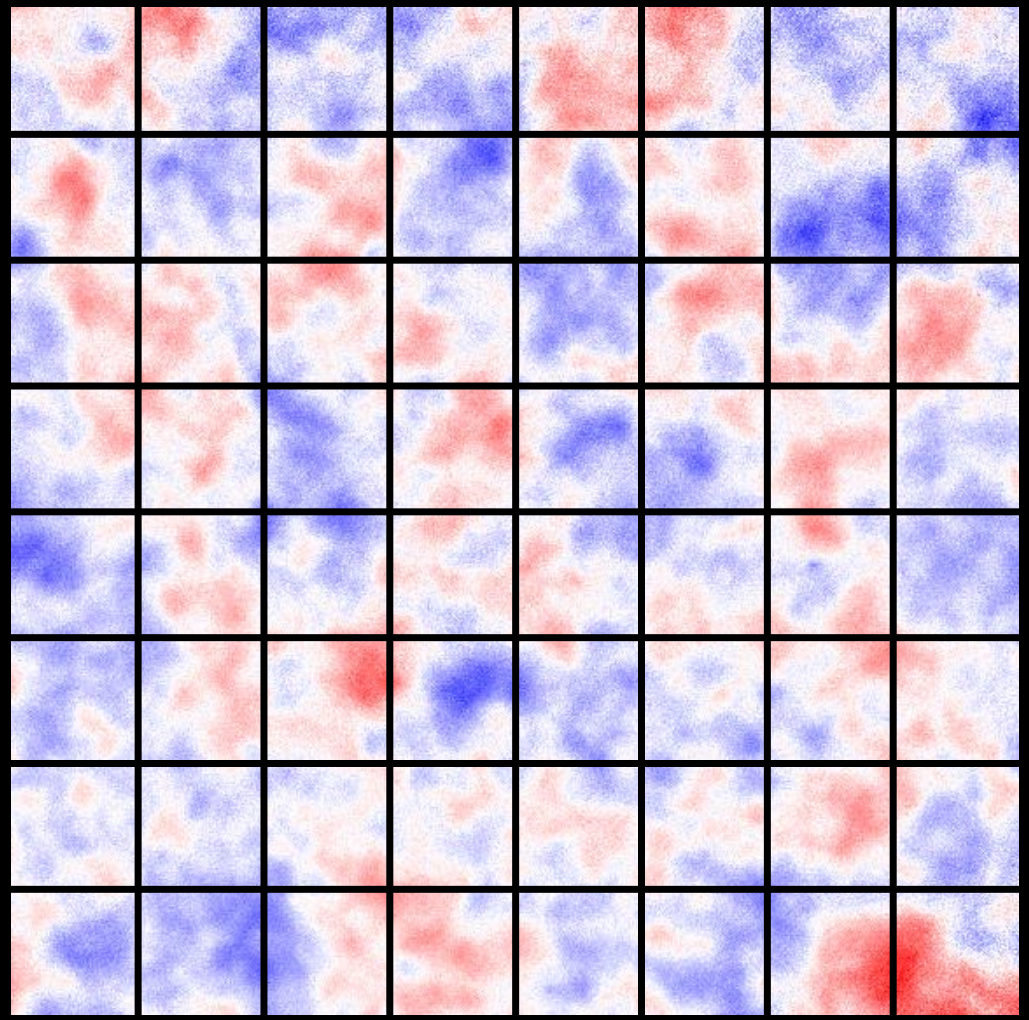

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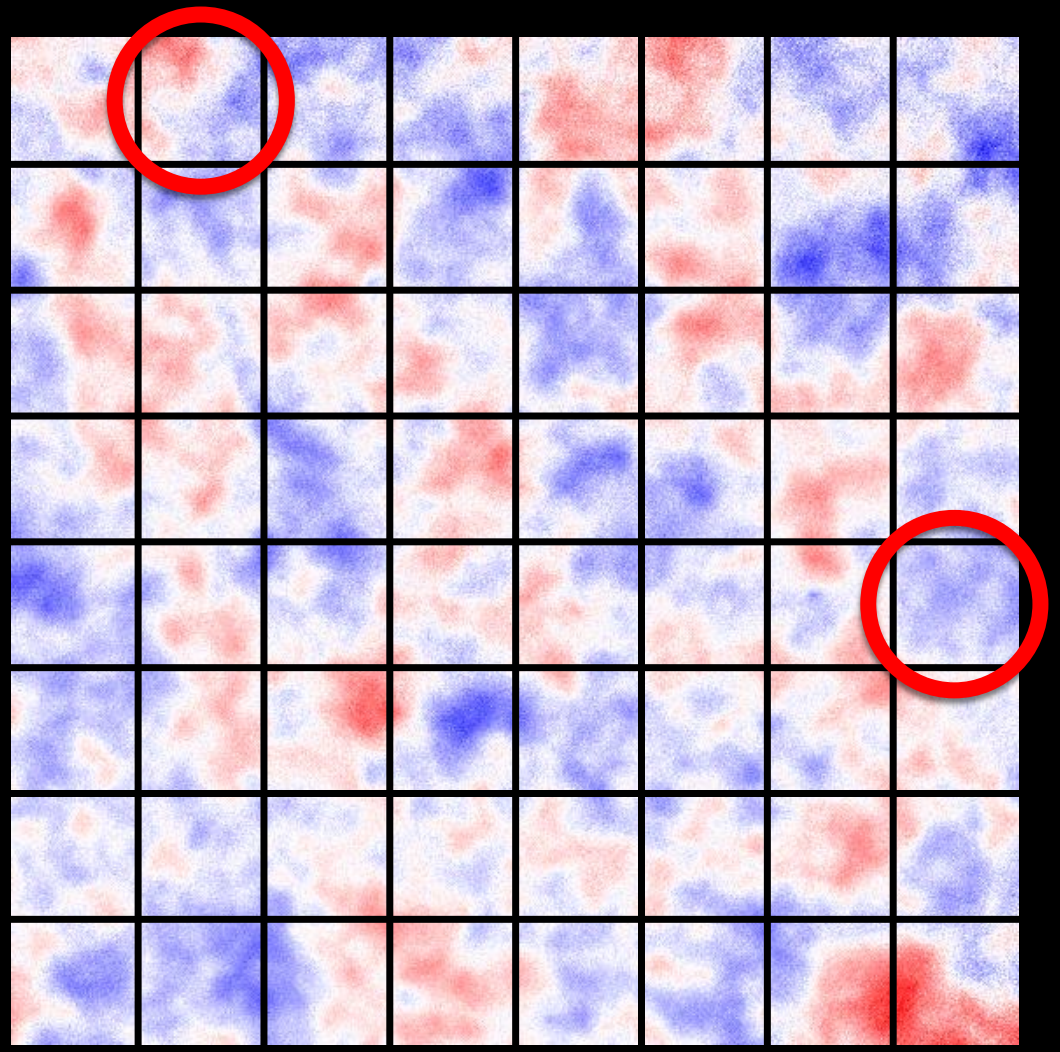

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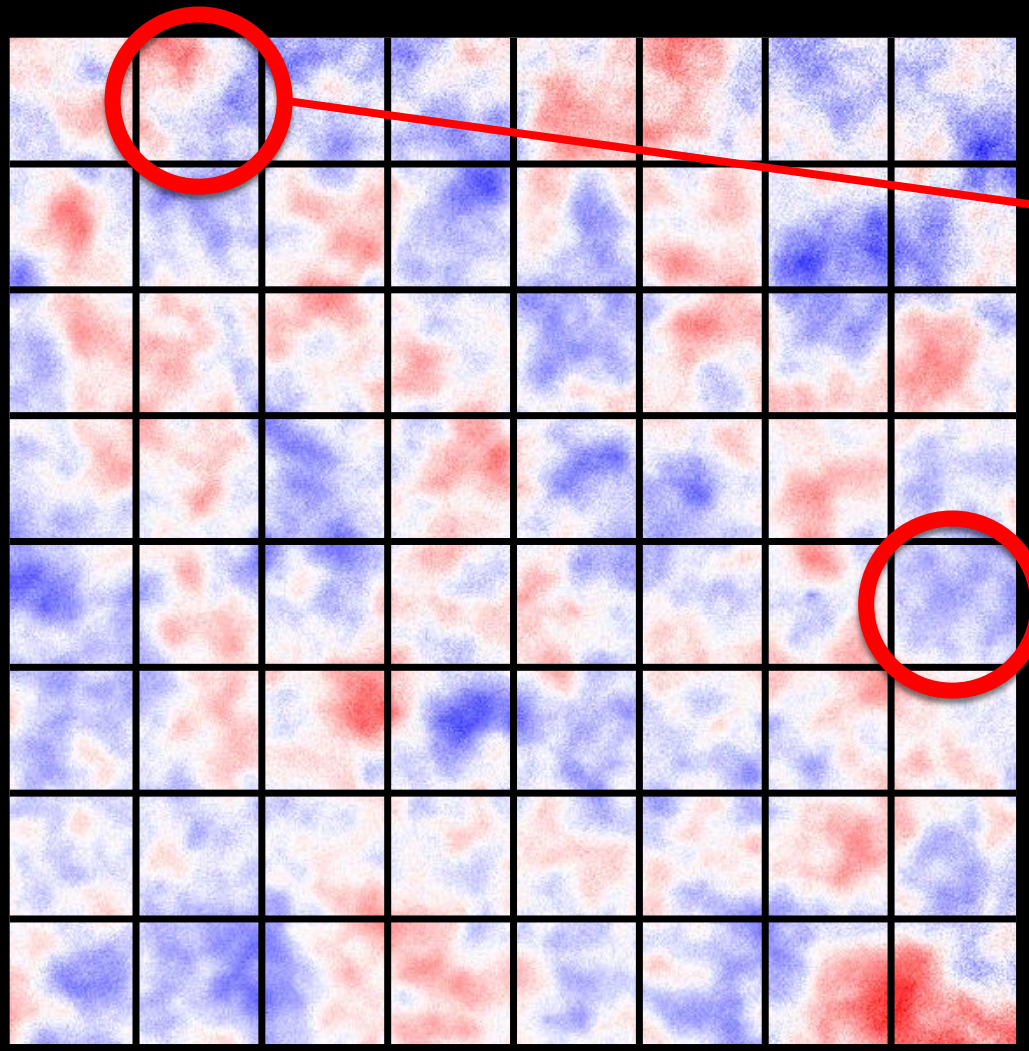

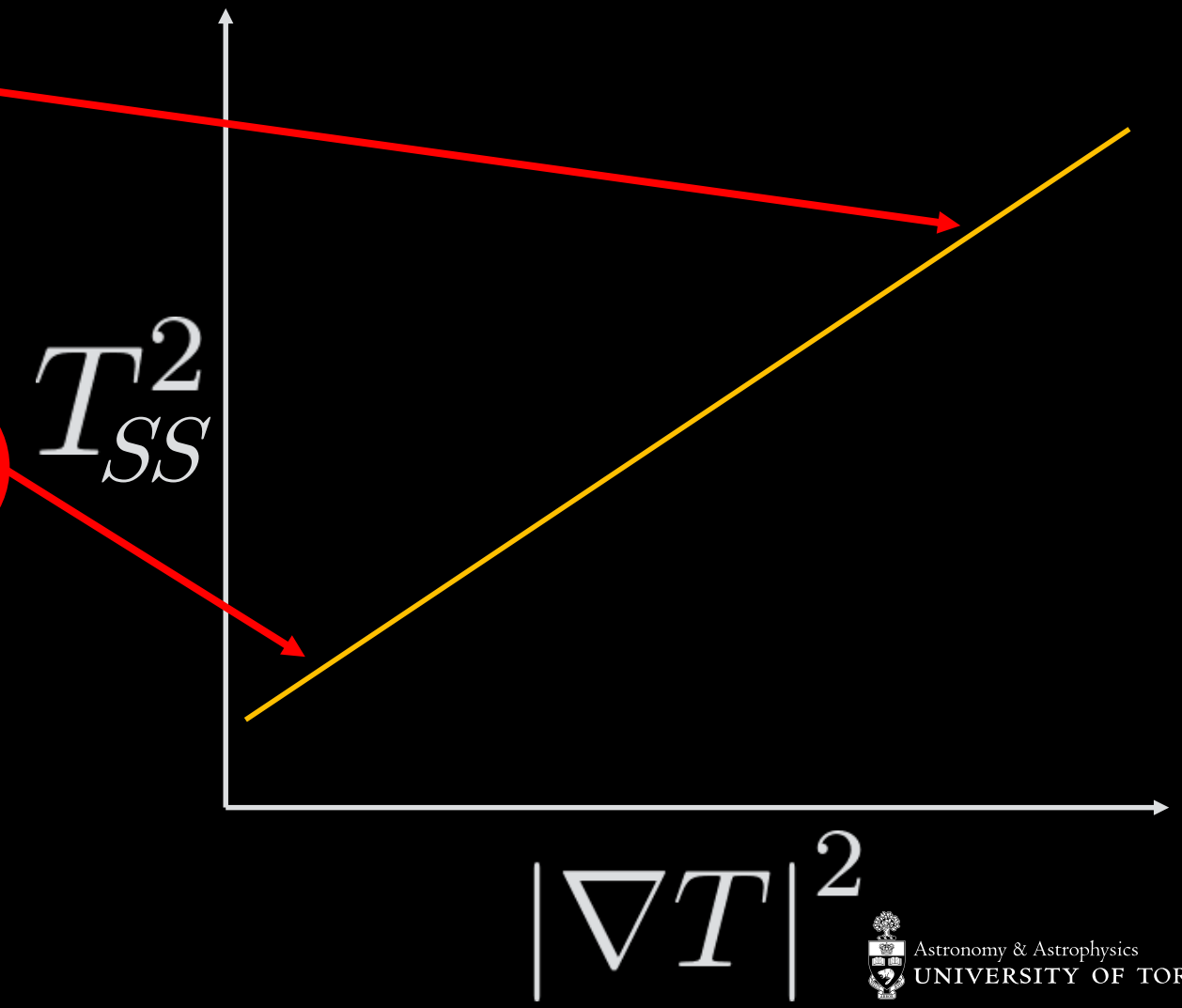

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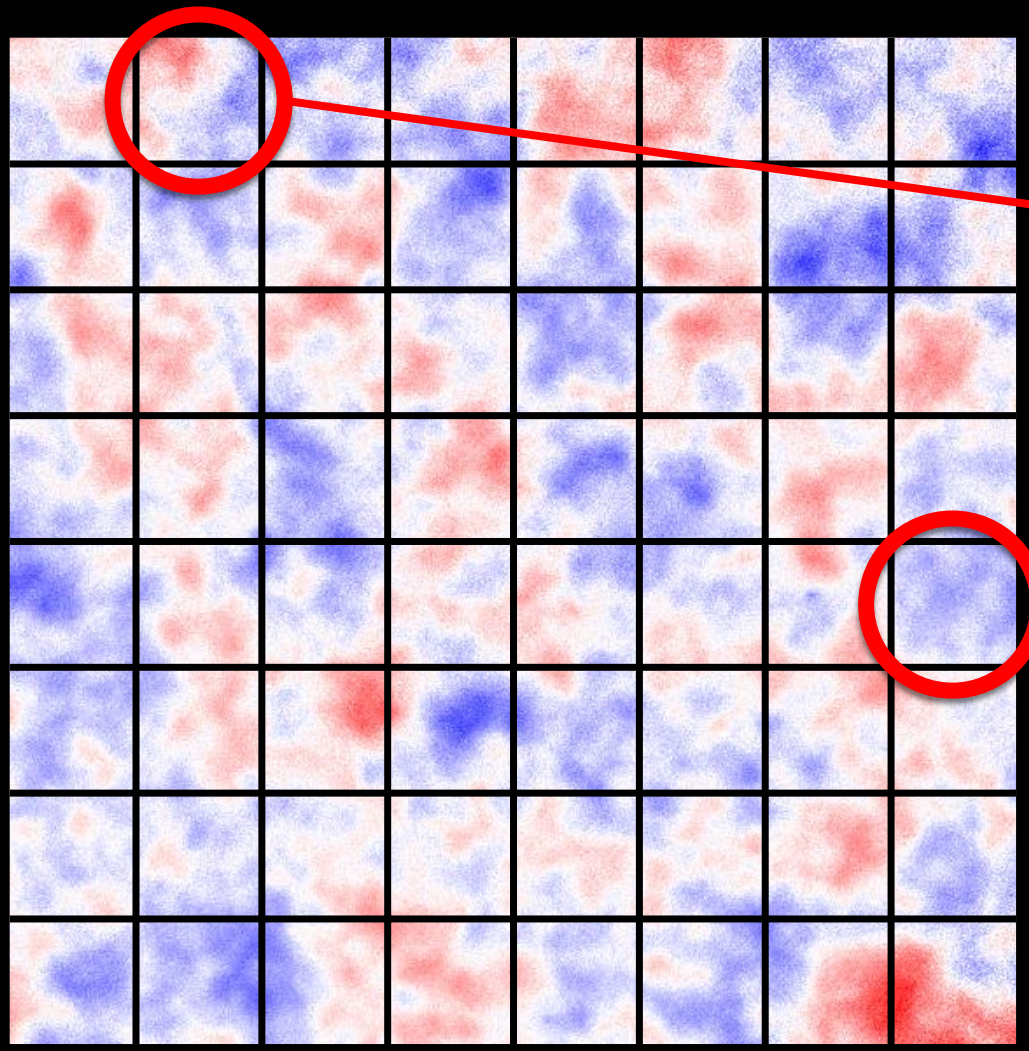

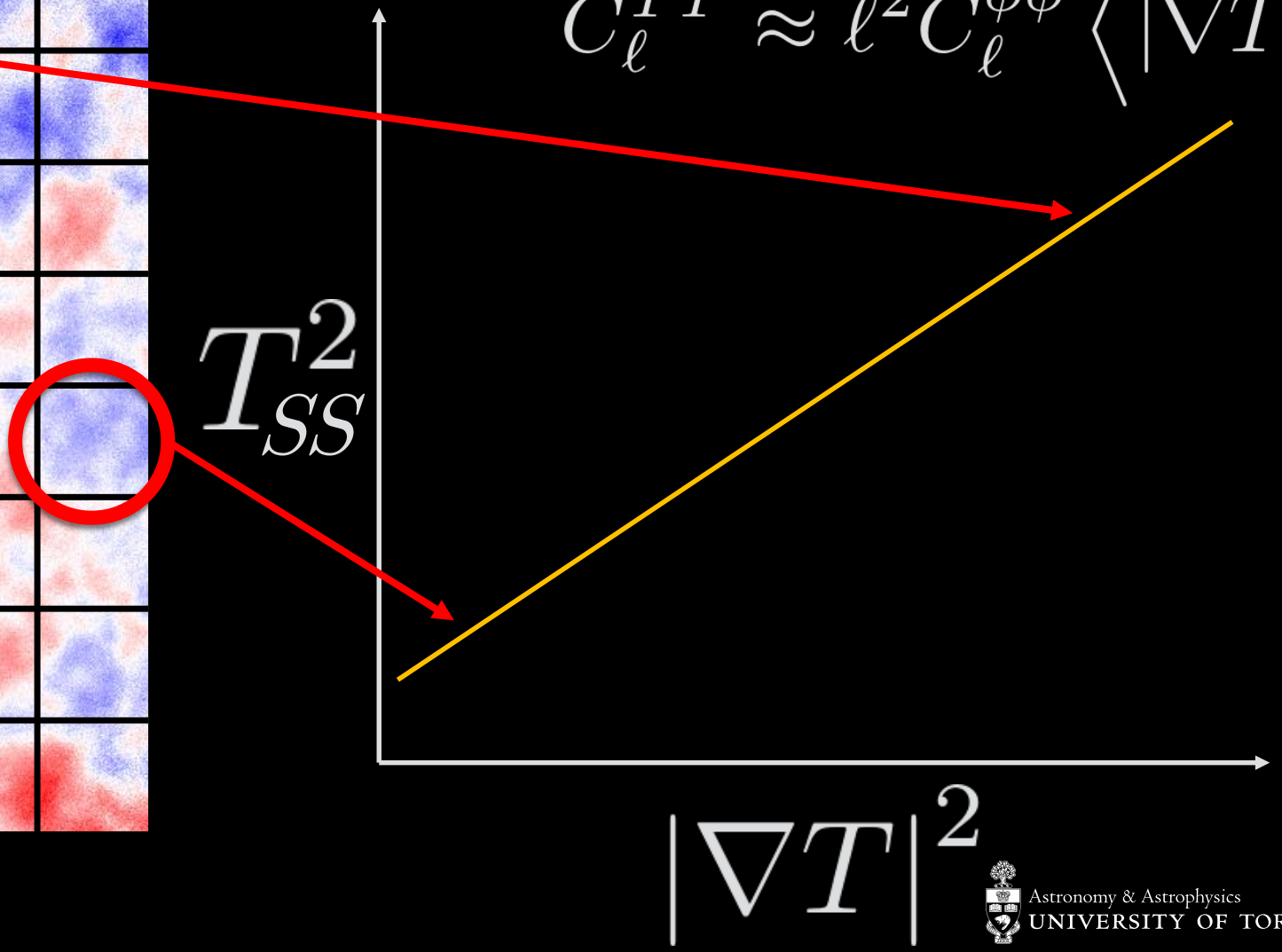

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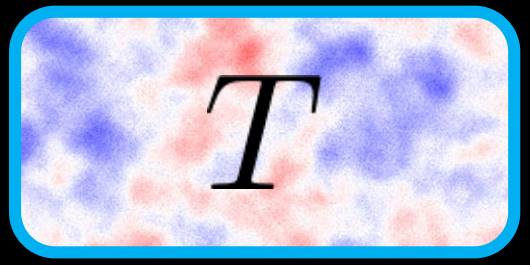
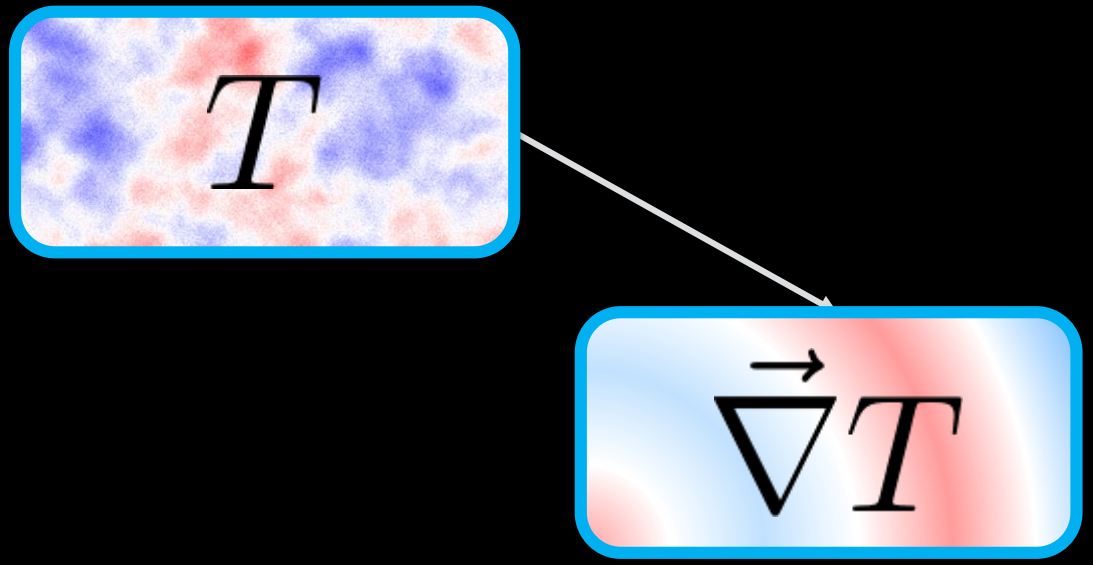
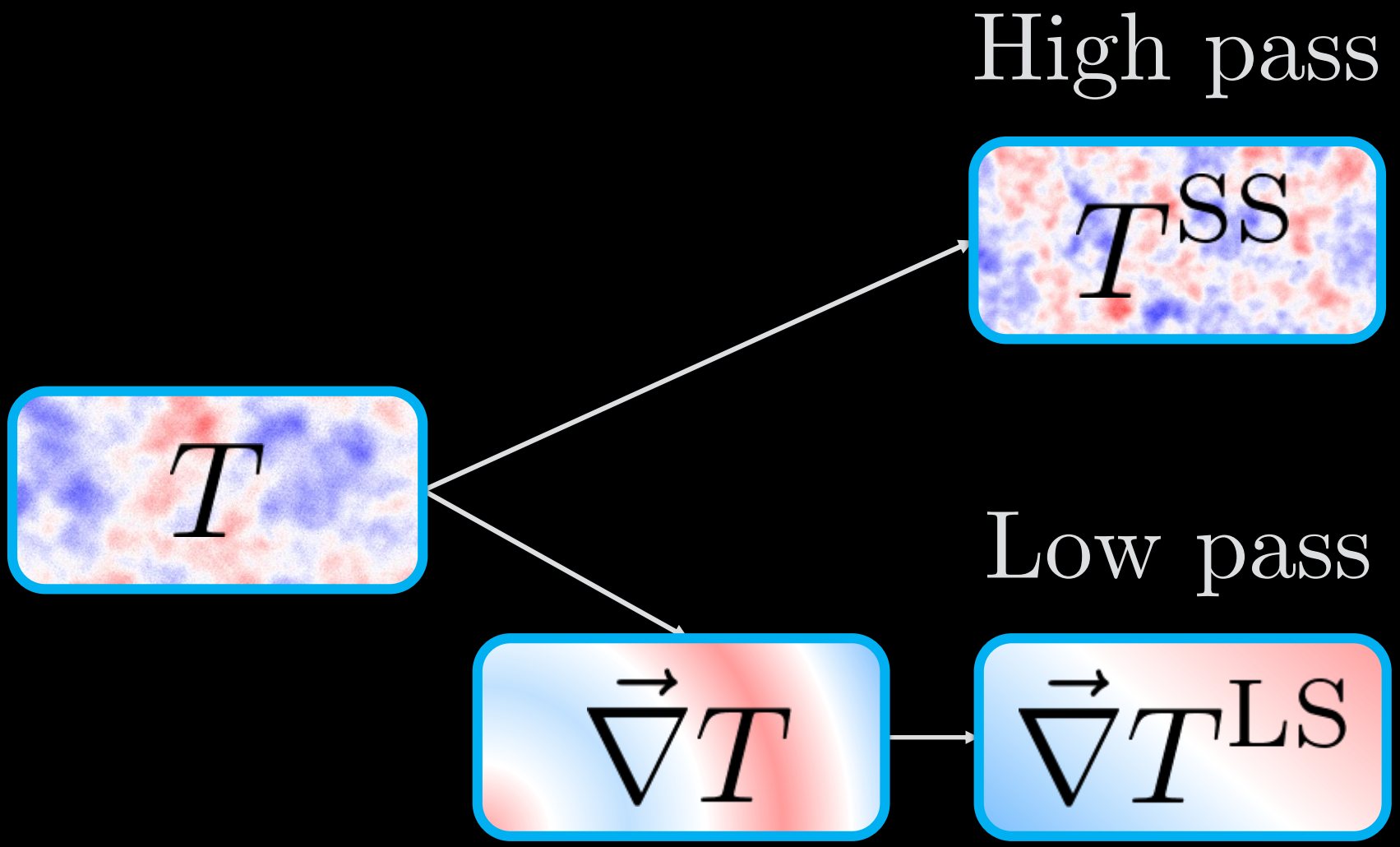
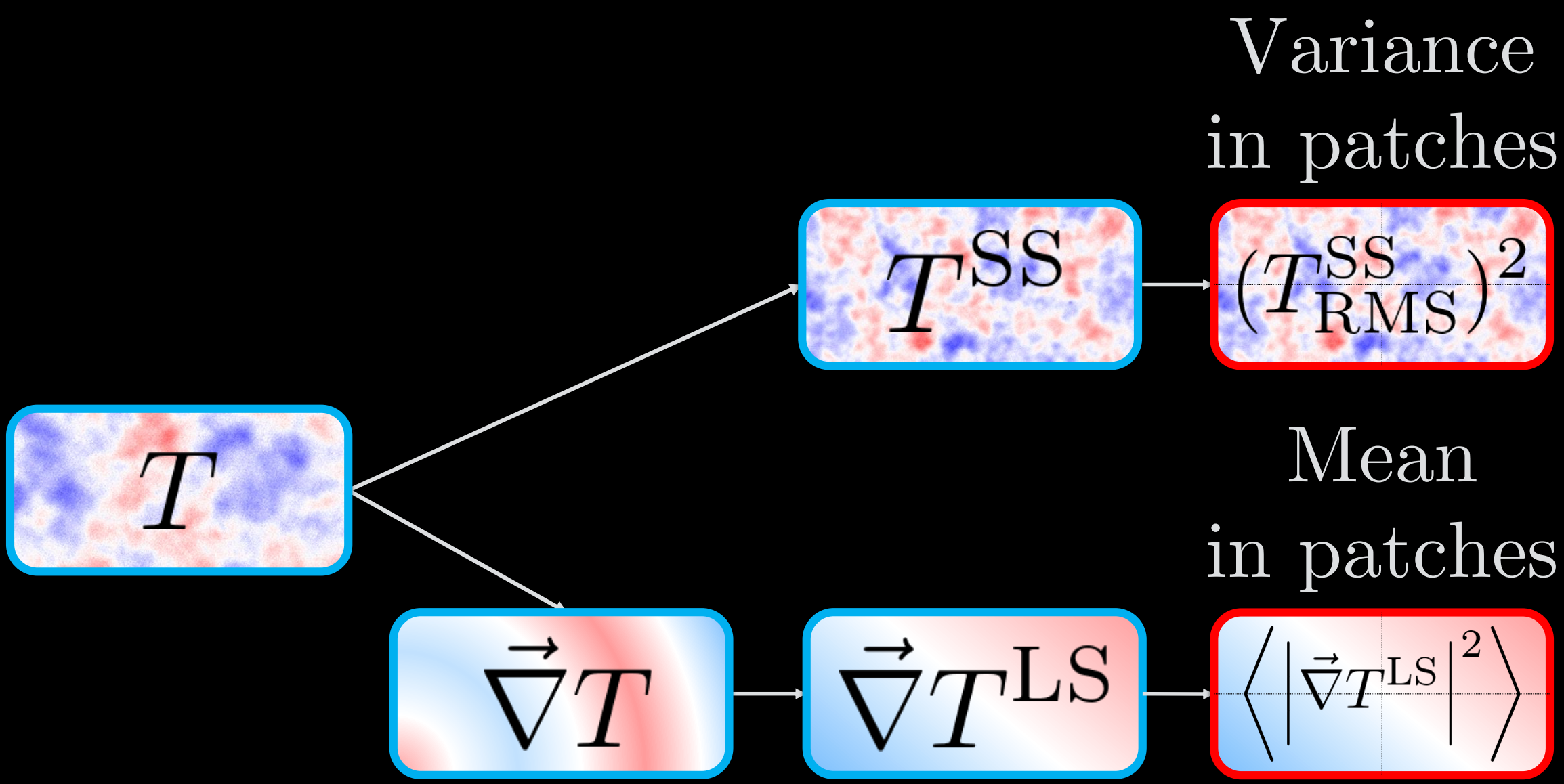

T


T
$\vec{\nabla} T$


High pass
$T^{\rm SS}$
T
Low pass
$\vec{\nabla} T$
$\vec{\nabla} T^{\rm LS}$



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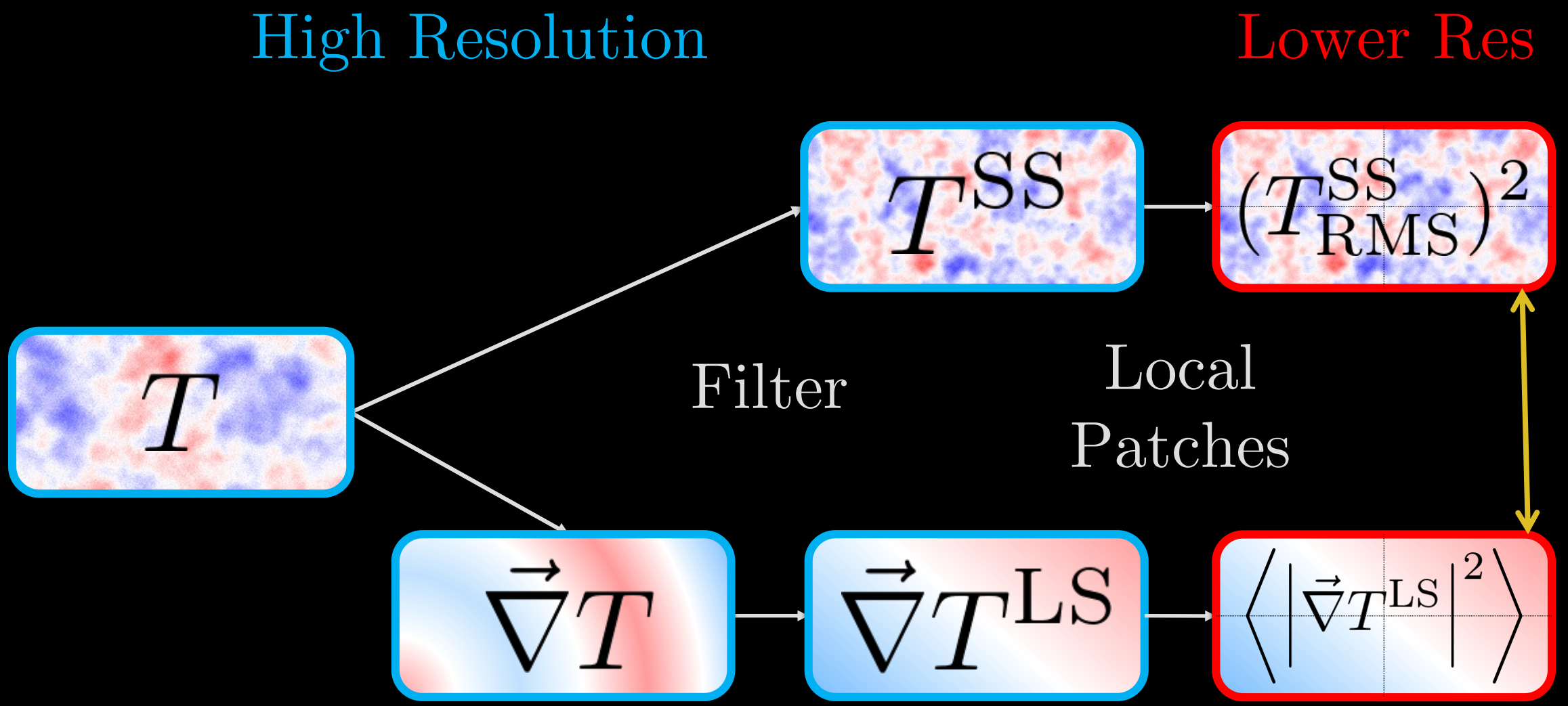
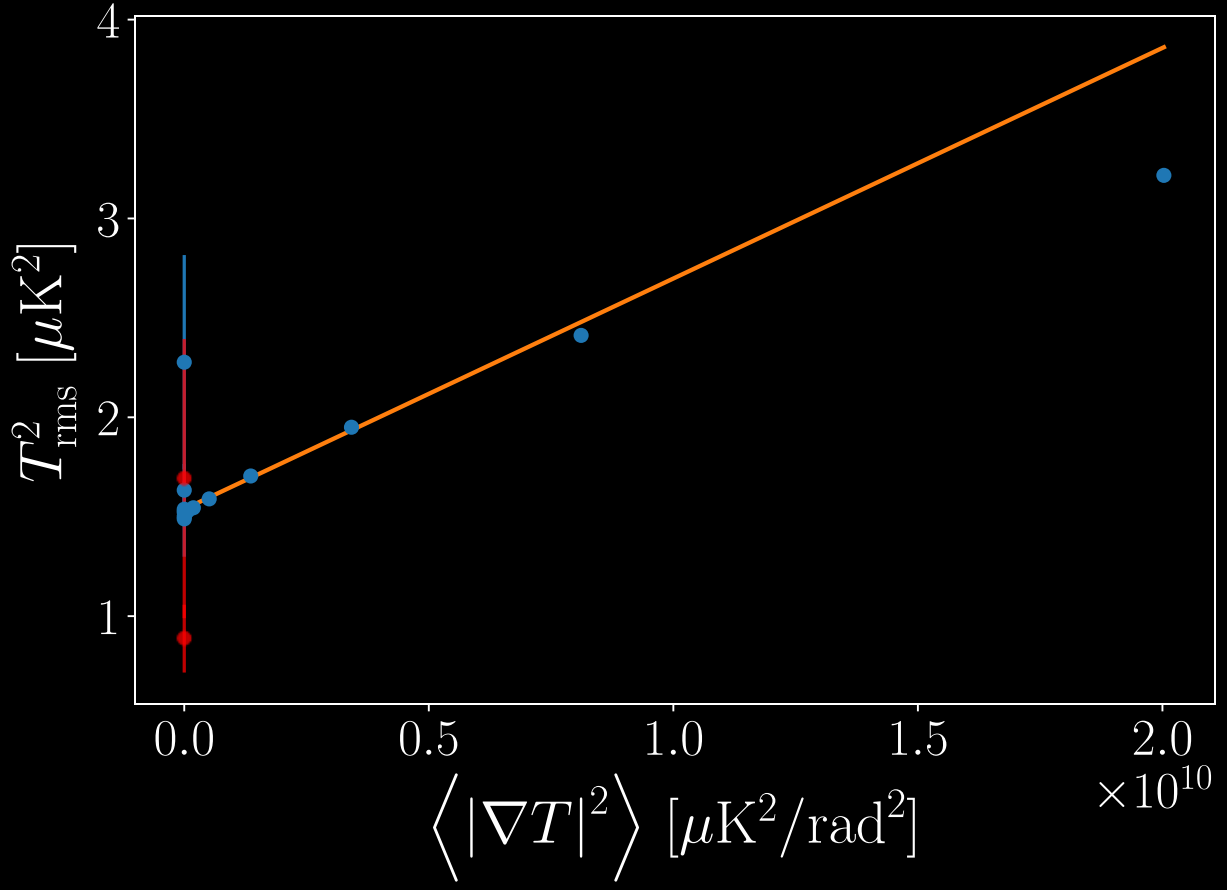
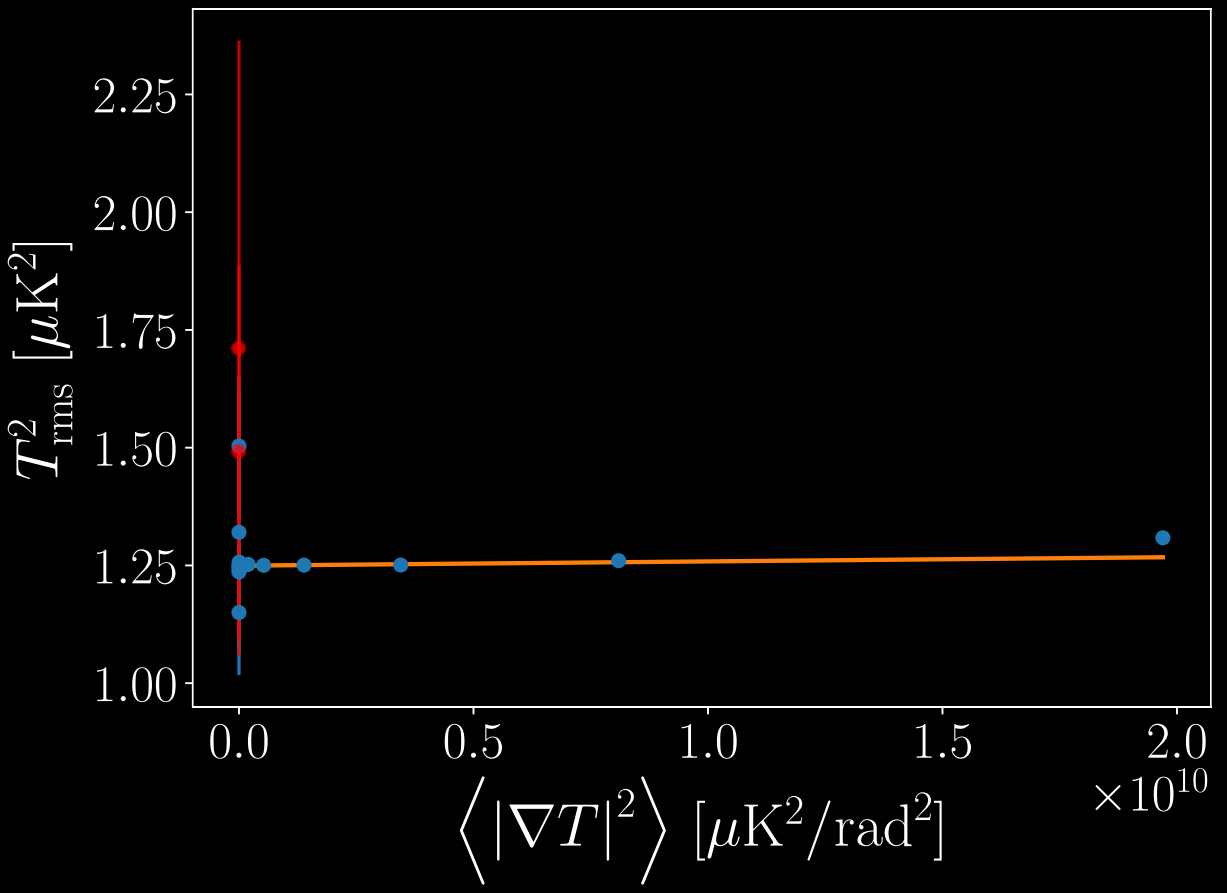

High Resolution
Lower Res
$T^{\rm SS}$
$(T^{\rm SS}_{\rm RMS})^2$
T
Filter
Local
Patches
$\vec{\nabla}T$
$\vec{\nabla}T^{\rm LS}$
$\left\langle \left| \vec{\nabla}T^{\rm LS} \right|^2 \right\rangle$

Lensed Map



Unlensed Map



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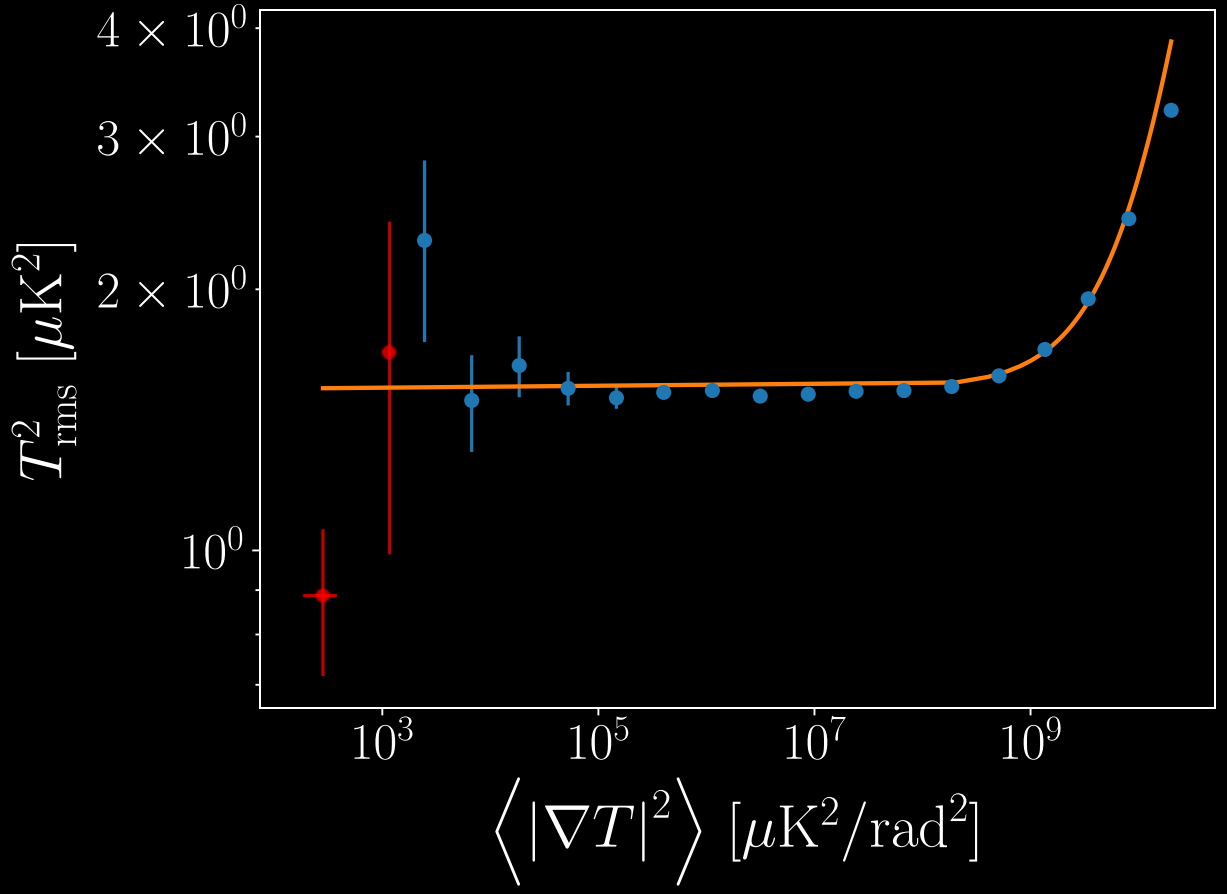
Log-space

Lensed Map



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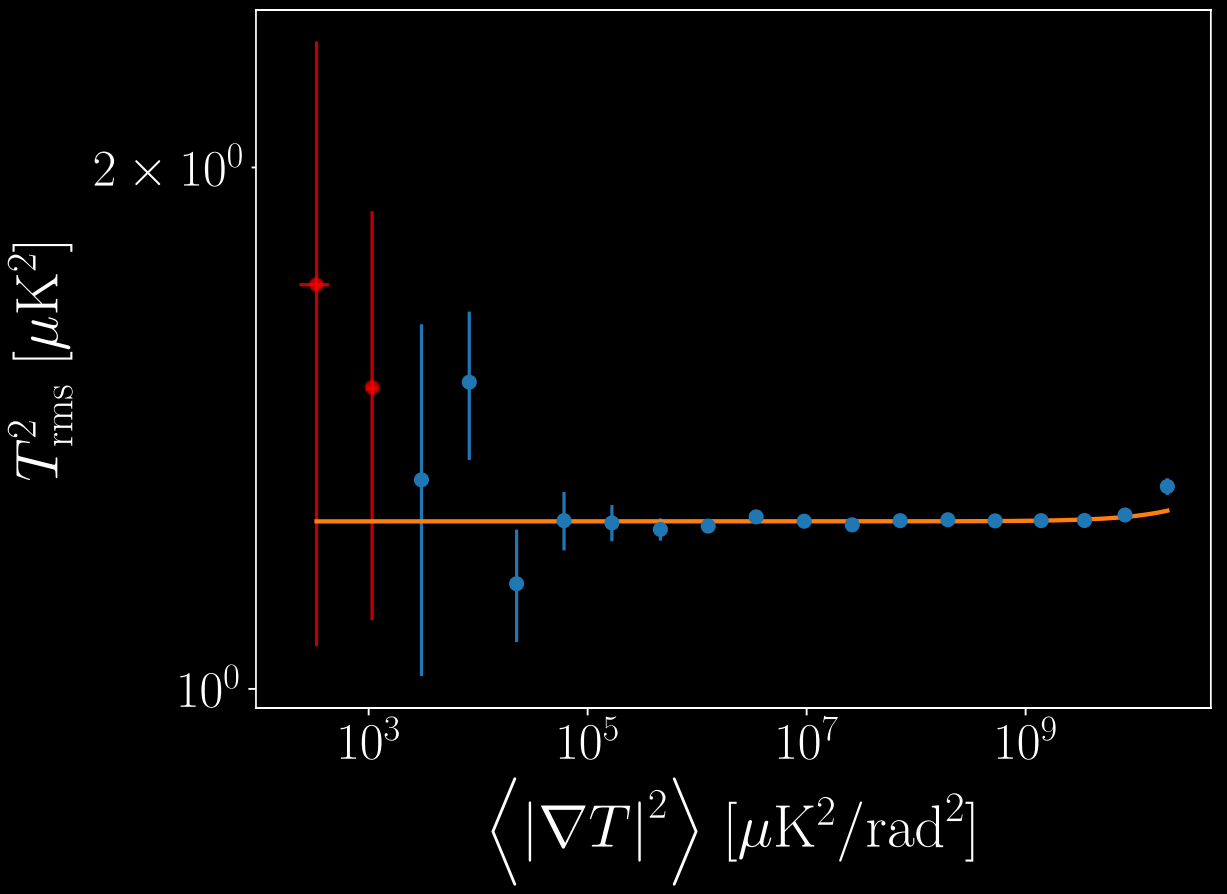

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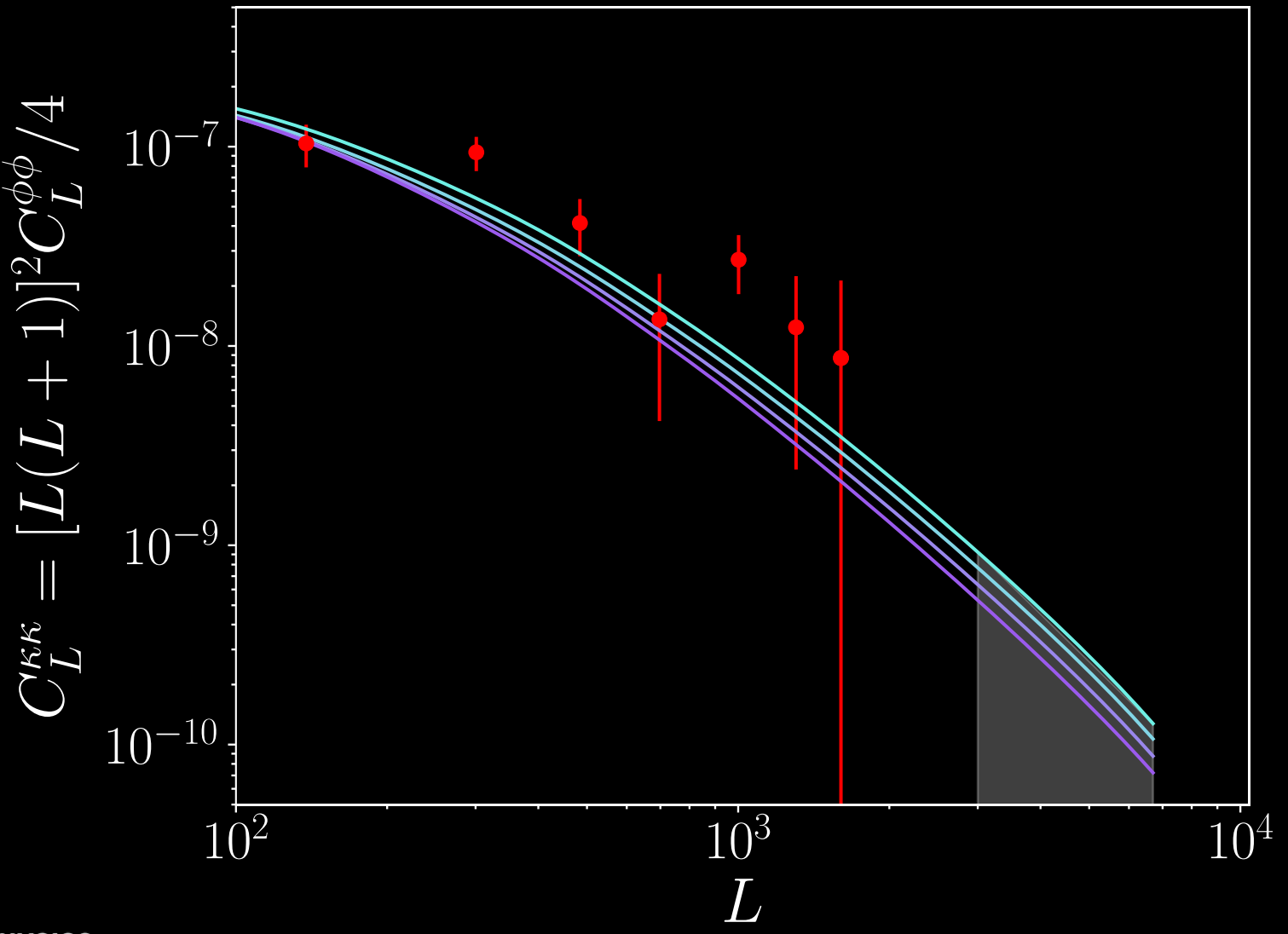
Ability to constrain small scale lenses

$$\tilde{C}_\ell^{TT} \approx \ell^2 C_\ell^{\phi\phi} \left\langle |\nabla T|^2 \right\rangle$$



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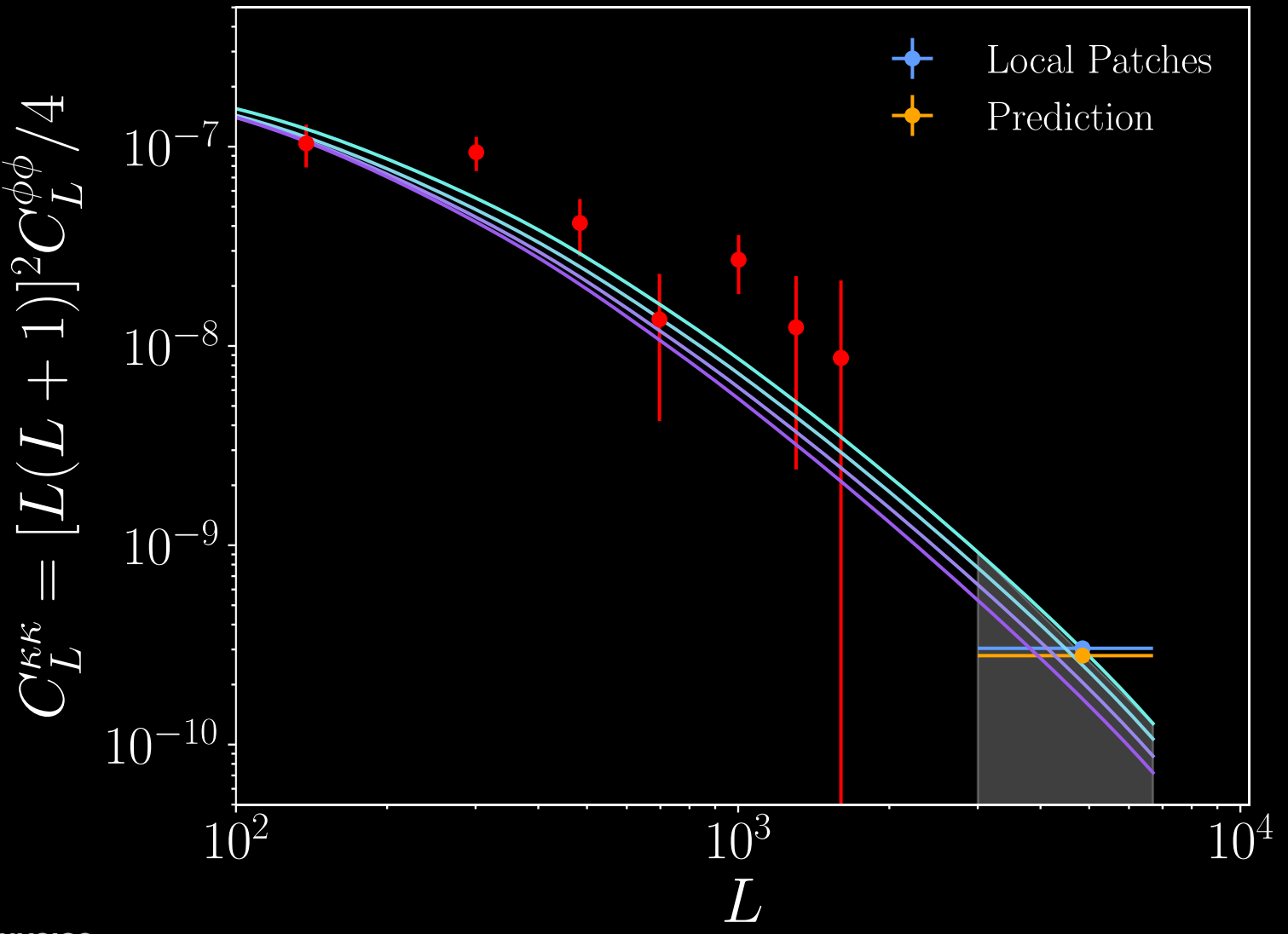

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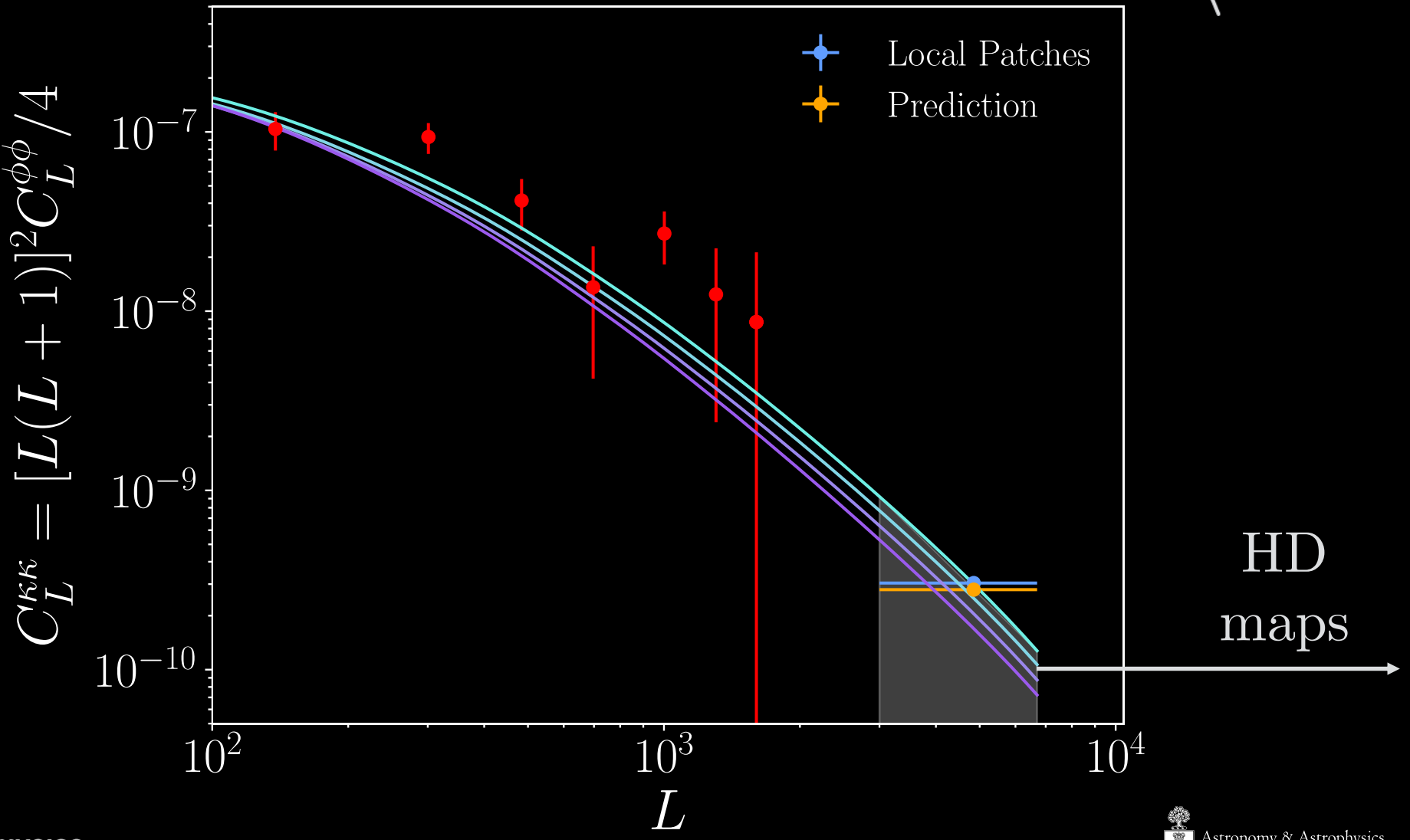

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Gradient direction?

$$\tilde{T}_{SS} \approx \vec{\nabla} T \cdot \vec{\nabla} \phi$$

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See Simone/Blake

Adding kSZ at small scales

$$\tilde{T}_{SS} \approx \vec{\nabla} T \cdot \vec{\nabla} \phi + \sum_z \tau_z v_{r,z}$$

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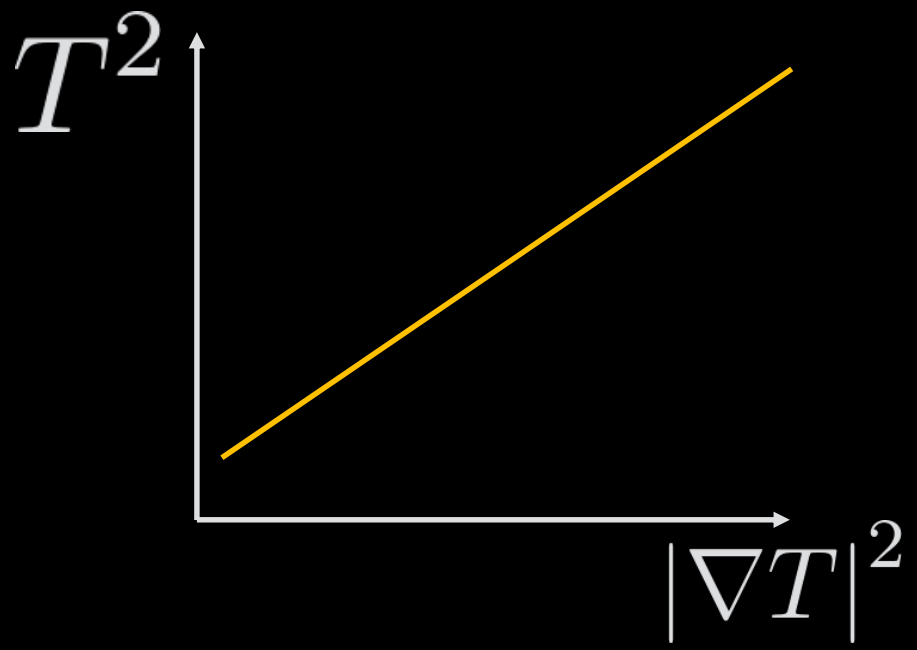

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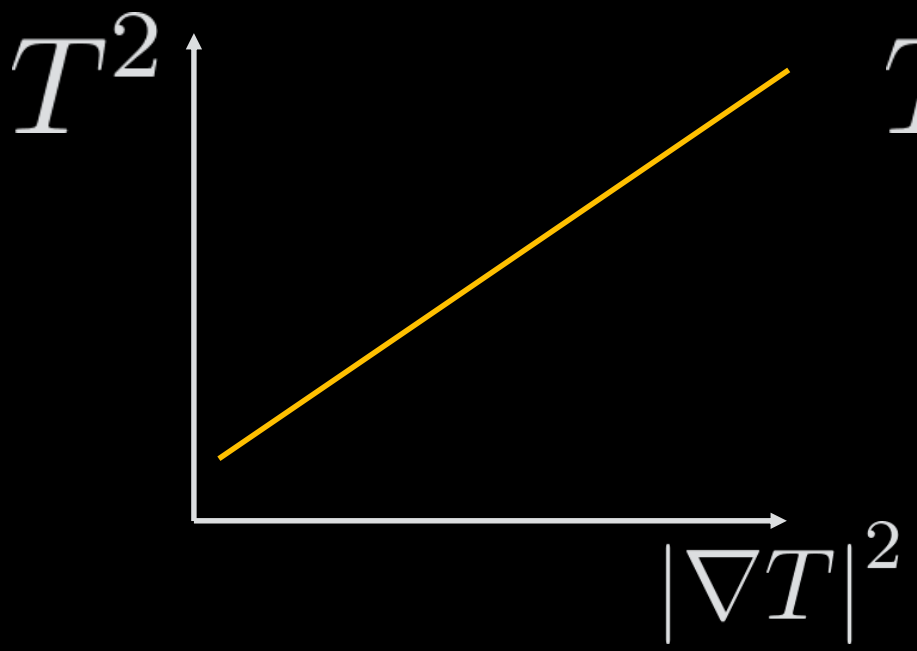

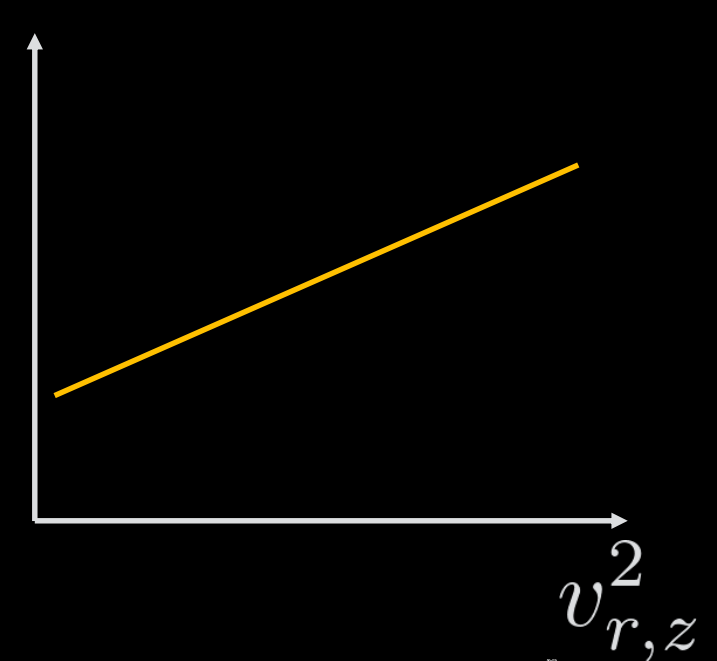

Thank you!

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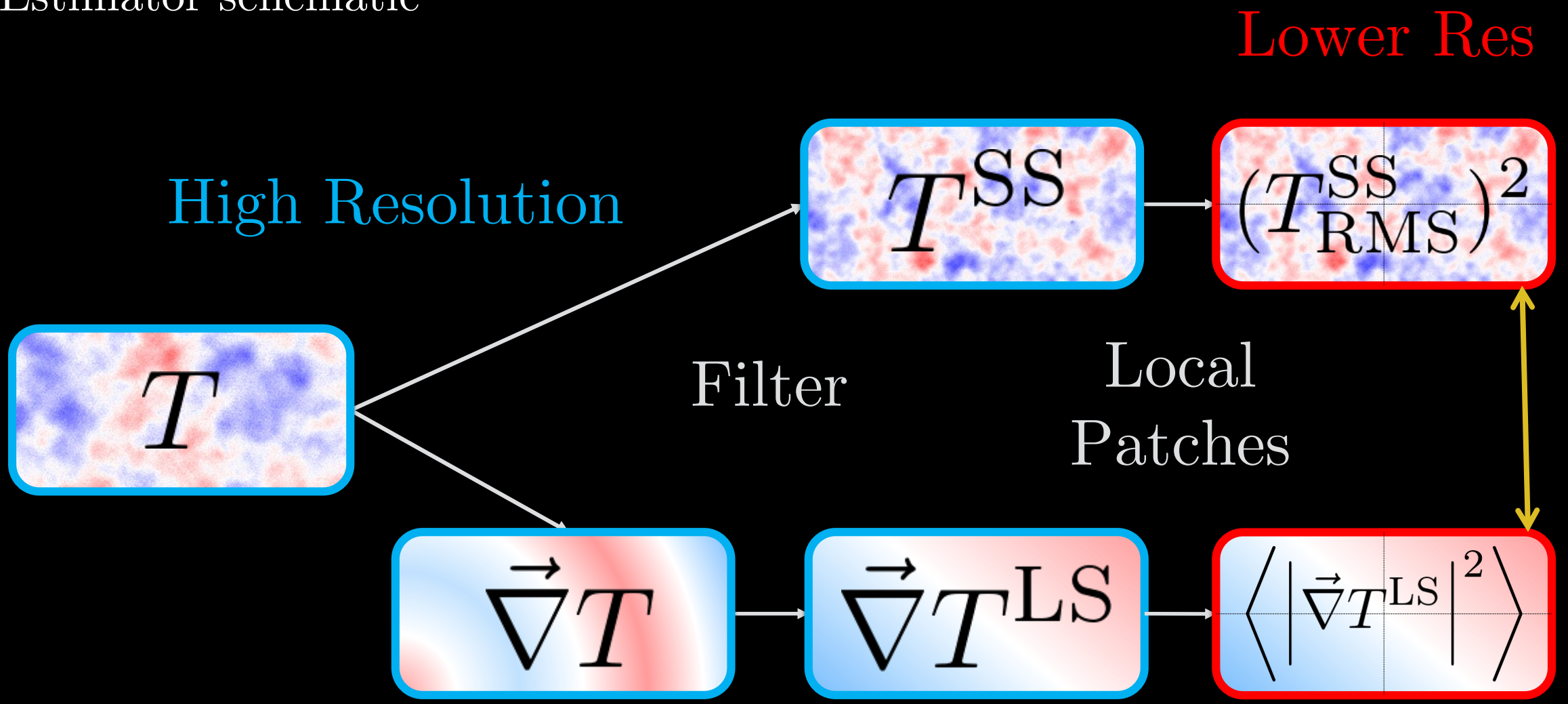
Estimator schematic

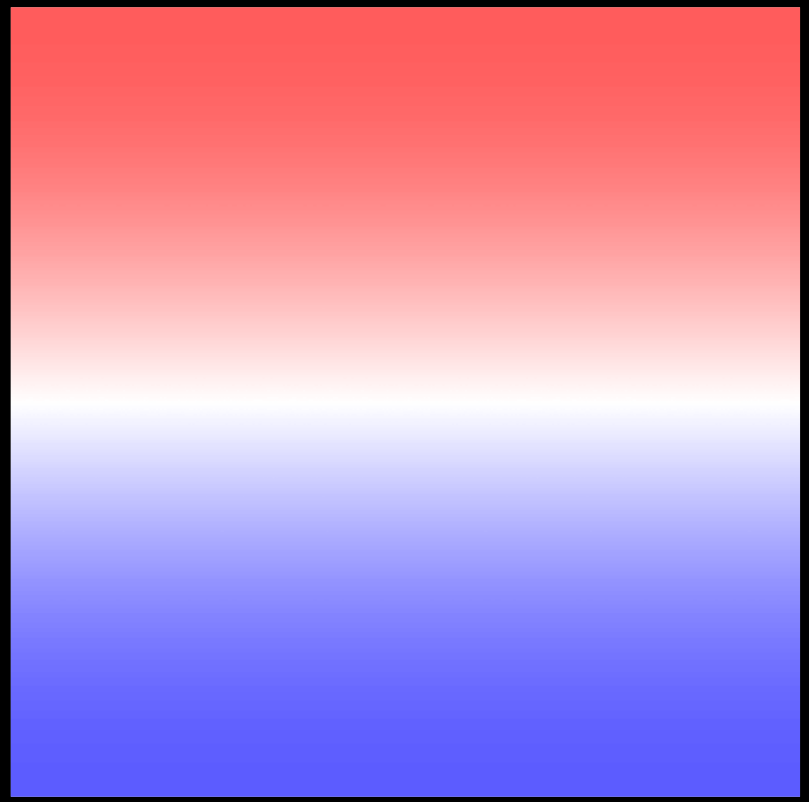


$$\tilde{C}_\ell^{TT} \approx \ell^2 C_\ell^{\phi\phi} \left\langle |\nabla T|^2 \right\rangle$$

$$\underbrace{T^2_{\rm RMS}}_{\text{Y-axis}} = \int_{\ell_{\rm min}}^{\ell_{\rm max}} \ell \tilde{C}_\ell^{TT} \, {\rm d}\ell \approx \underbrace{\left\langle |\nabla T|^2 \right\rangle}_{\text{X-axis}} \underbrace{\int_{\ell_{\rm min}}^{\ell_{\rm max}} \ell^3 C_\ell^{\phi\phi} \, {\rm d}\ell}_{\text{Slope}}$$

Choosing patches

T



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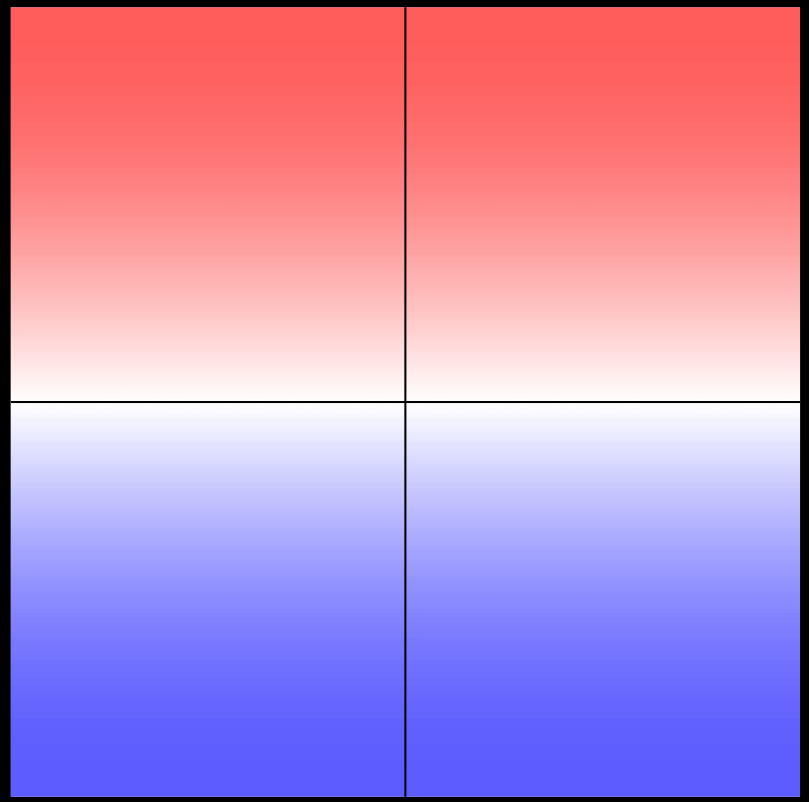

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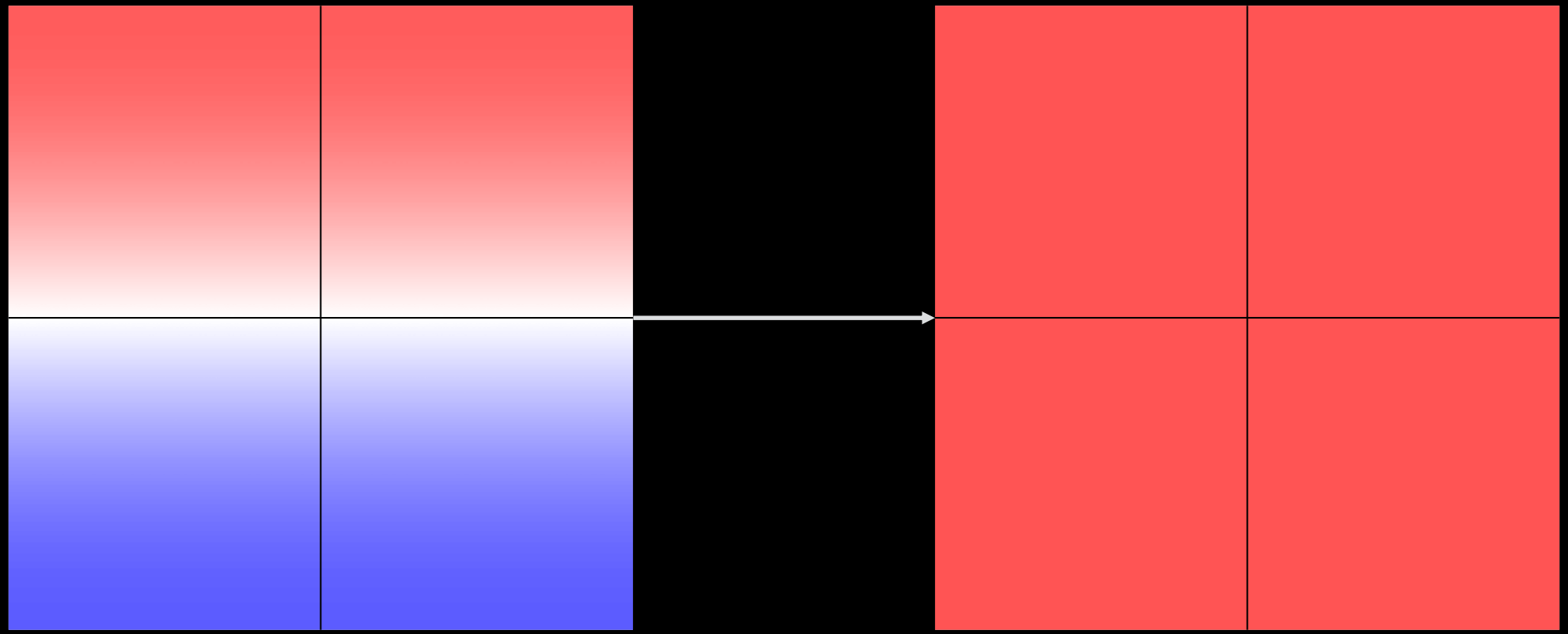
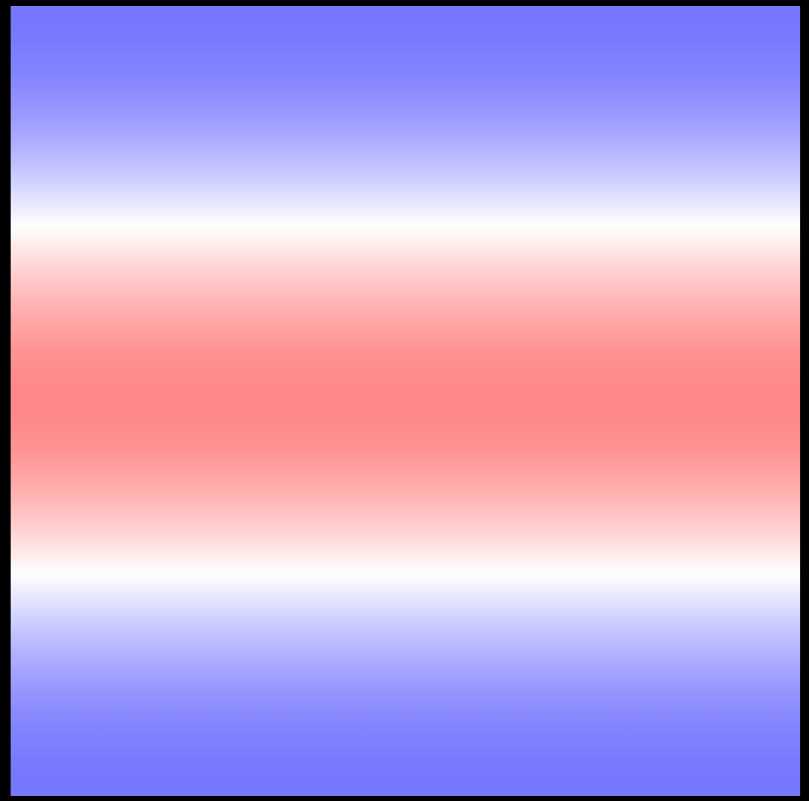


$\dfrac{\mathrm{d}T}{\mathrm{d}y}$

Choosing patches

T



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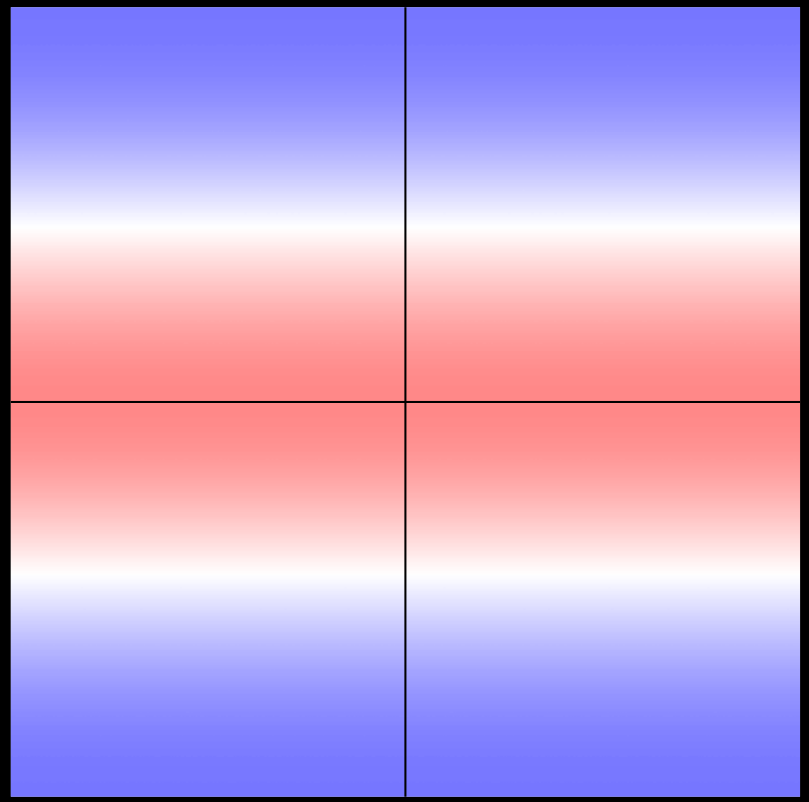

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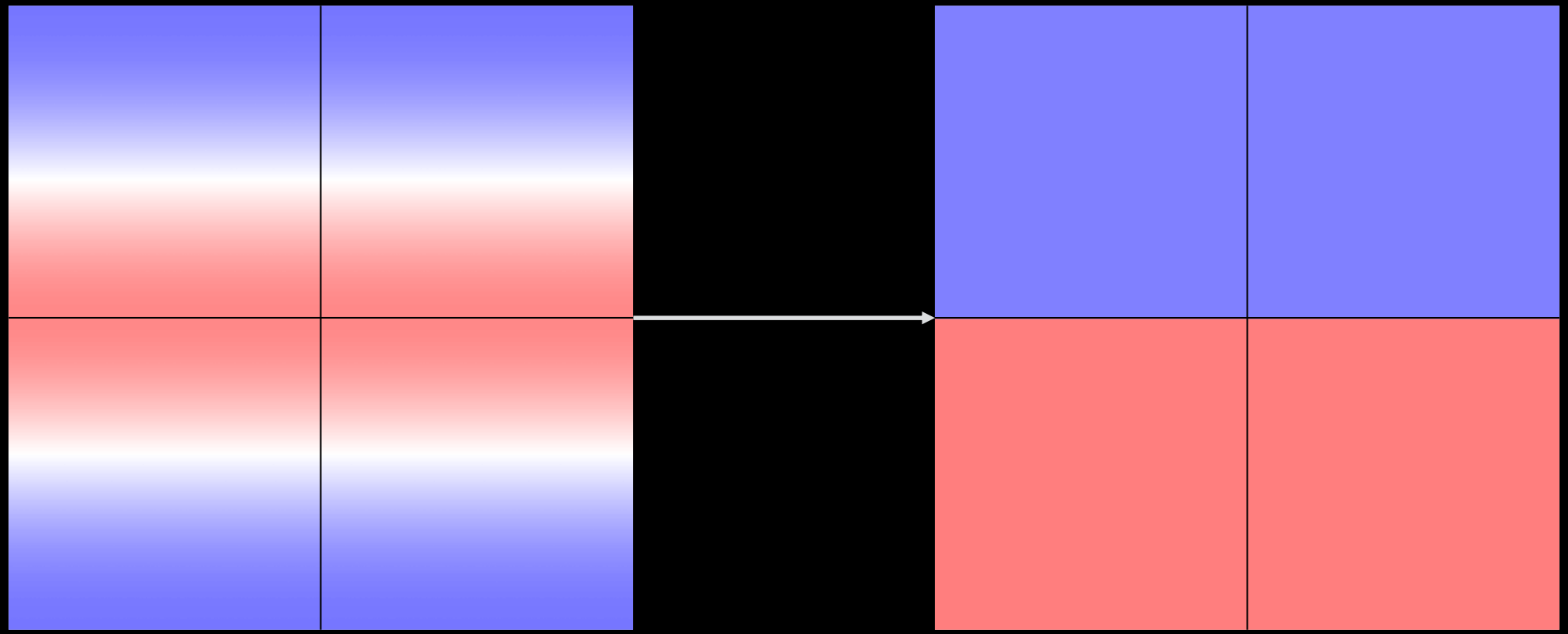
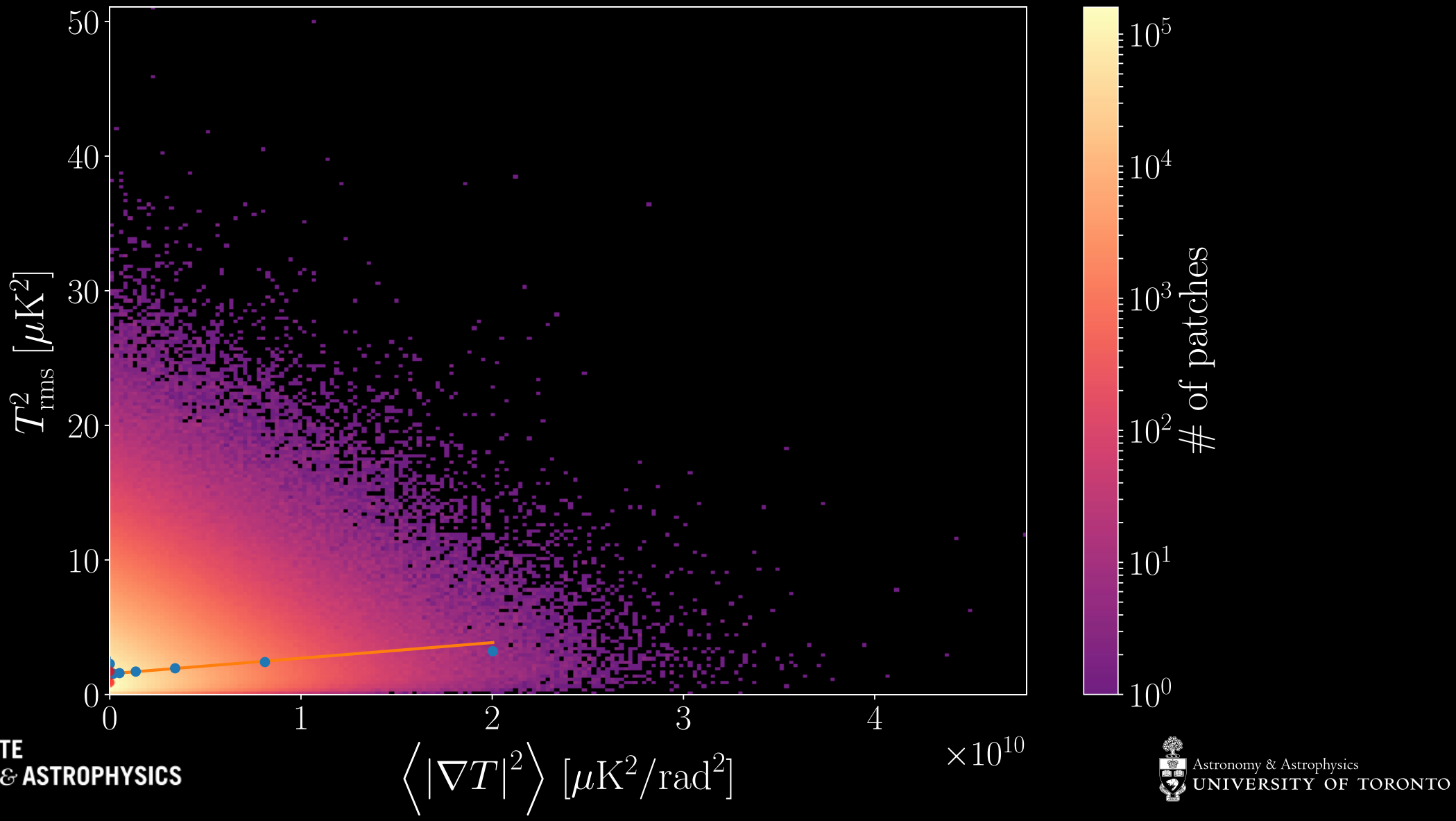


$\dfrac{\mathrm{d}T}{\mathrm{d}y}$

Lensed patch-patch matching



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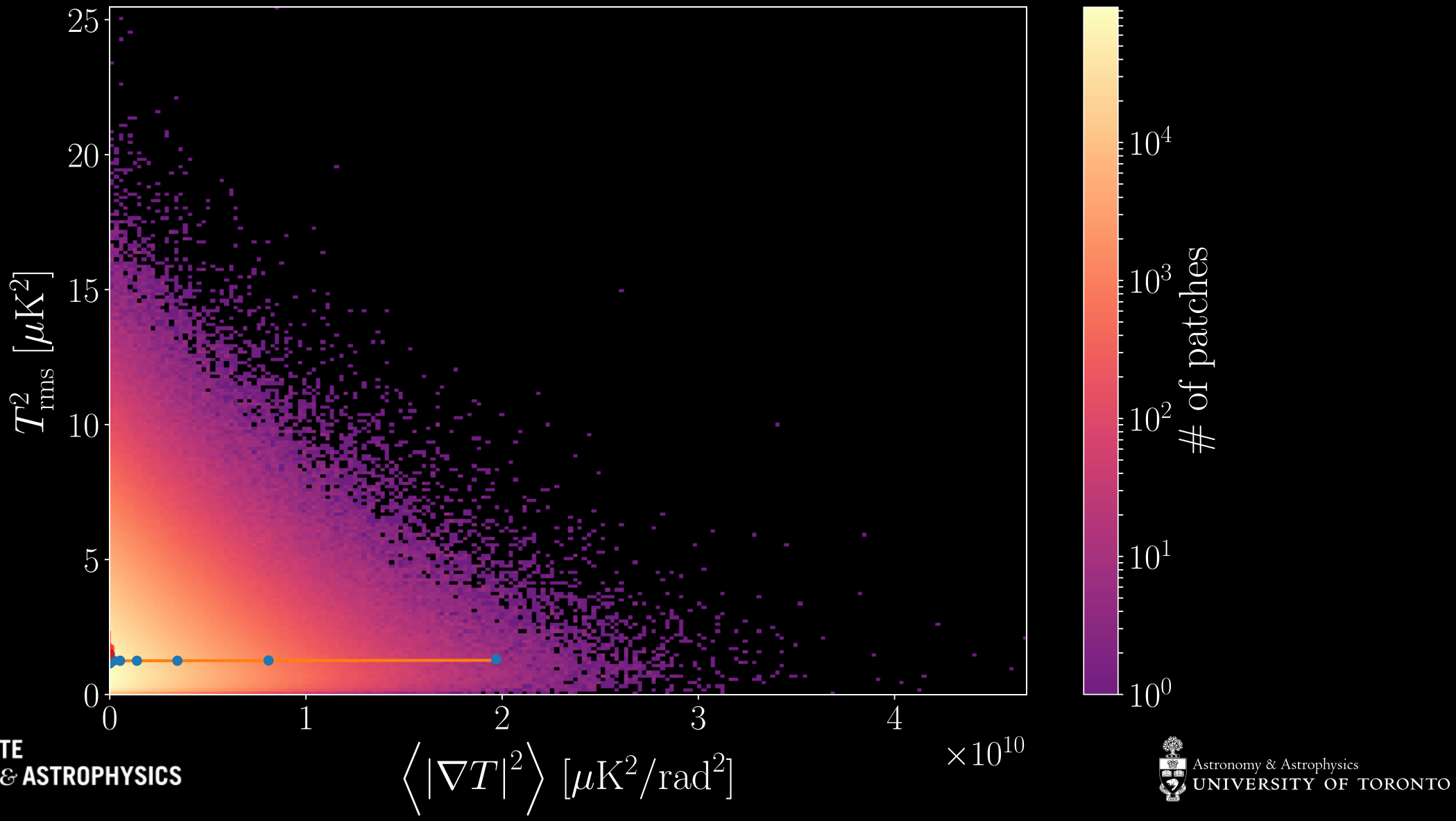
Unlensed patch-patch matching



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