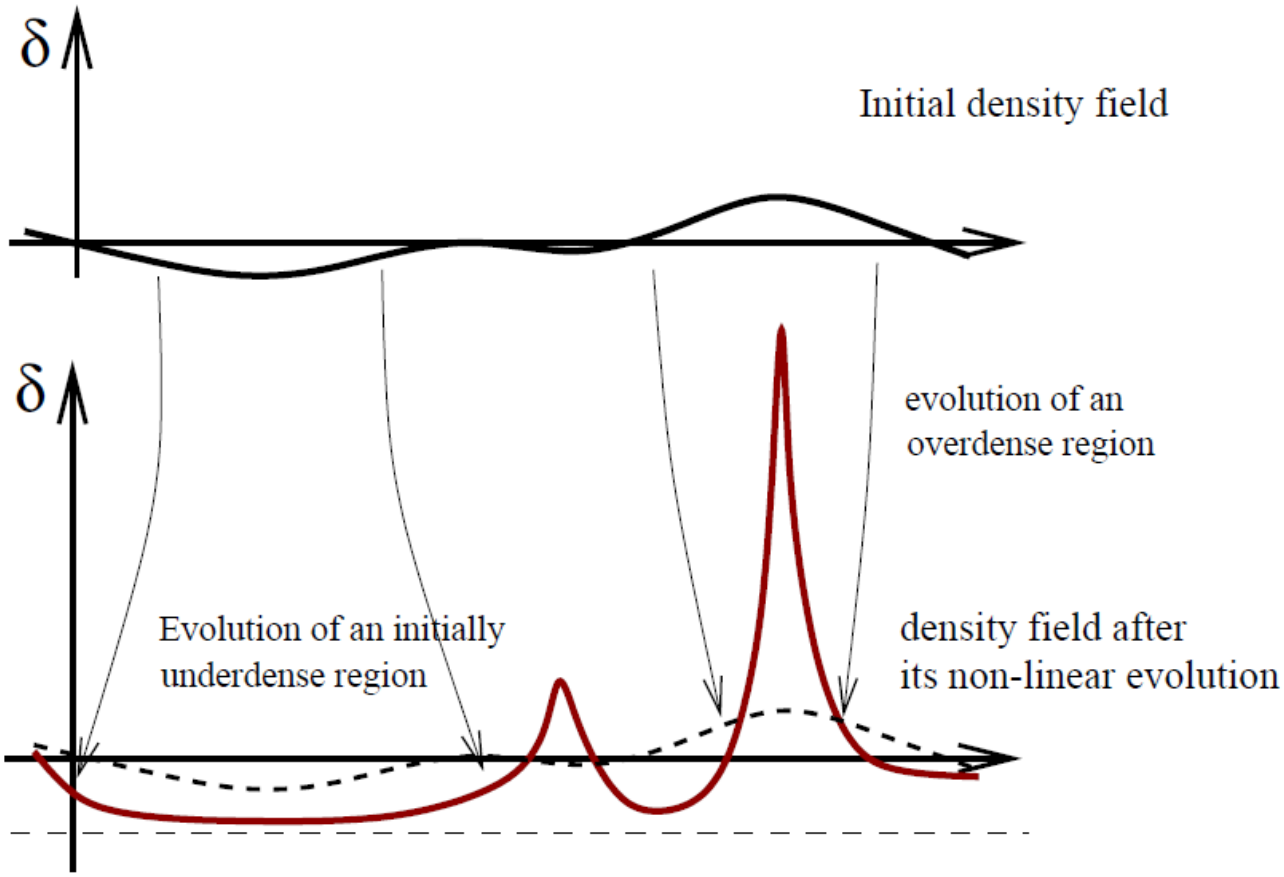
Trough Lensing

probing differences between the under- and overdense universe

Oliver Friedrich – LMU Munich

together with
Daniel Gruen, Elisabeth Krause, Kyle Story, Joe DeRose, Risa Wechsler, Stella Seitz

Evolution of the cosmic density field



Bernardeau et al. (2002)

- Initially Gaussian fluctuations
- evolve into few highly overdense regions
- most of the volume becomes underdense

Probing the non-linear density field

- 2-pt. statistics *(amplitude of density field)*
- Cluster counts *(highly NL-regime)*
- Void statistics (hard to identify in photo-metric surveys)
- …
- Trough Lensing *(mildly NL and high SN)*

Splitting the sky

1.) Pixelize the sky

2.) Around each pixel:

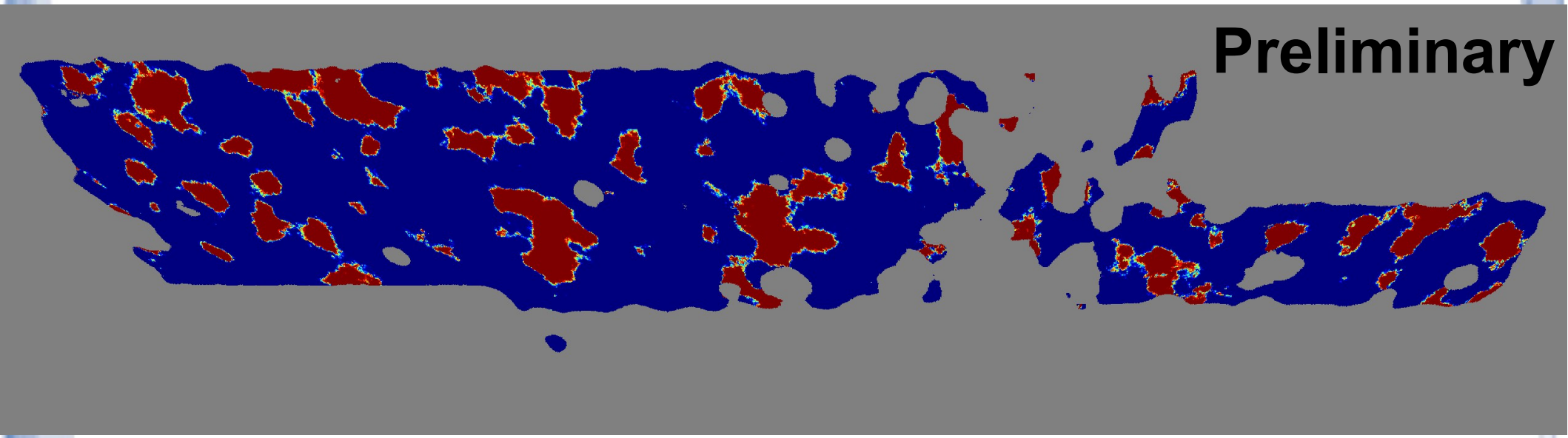
count foreground galaxies within fix radius θ

3.) Order pixels in terms of galaxy counts

4.) Divide pixels Into different Density quantiles

Splitting the sky

courtesy of Daniel Gruen



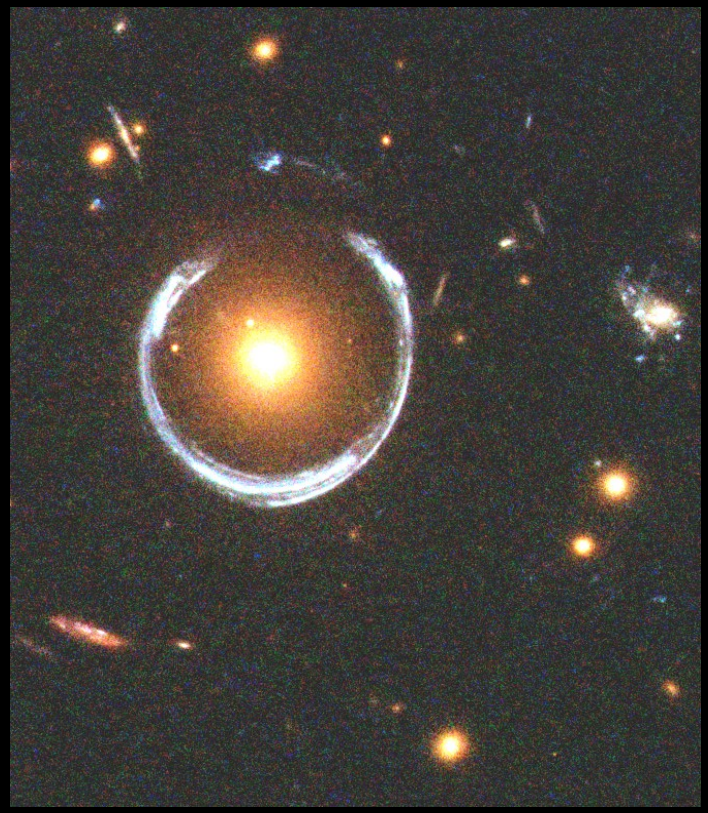
- Quantiles of galaxy density in DES year-1 data after smoothin of 1deg.
- Foreground galaxy catalog: redMaGiC (see Rozo, Rykoff et al. 2016 for early DES data)

What can you do with that??

- Compare cluster mass function in different regimes
- Measure correlation between density quantiles and SZ or ISW
- … *(ask Daniel, Kyle or me for more)*

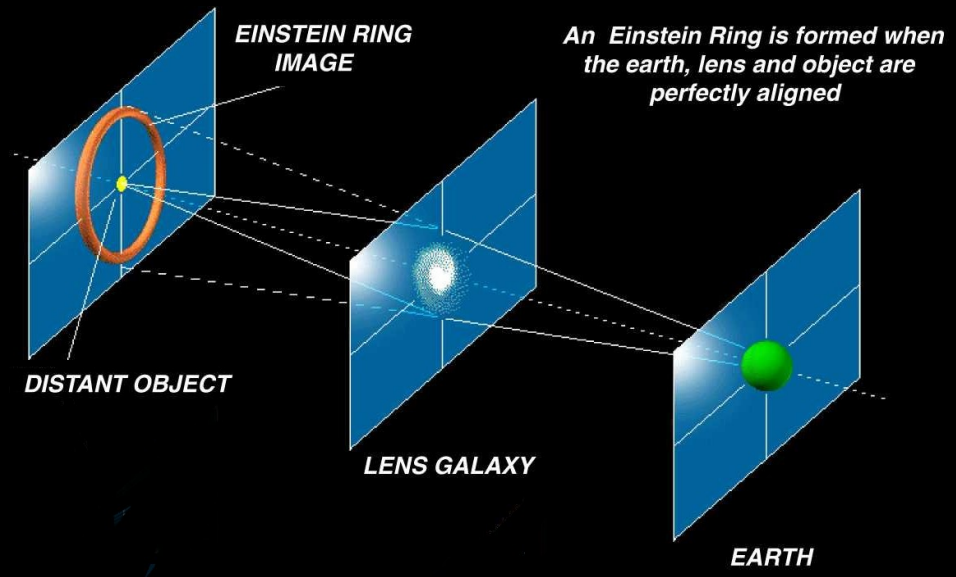
- Trough Lensing *(this talk)*

Gravitational Lensing – the very basics



γ: shear

κ: lensing convergence



Einstein ring around a giant elliptical galaxy,

image credits: apod:nasa:gov=apod=ap111221:html (l), Jodrell Bank Observatory (r).

Lensing by overdensity:

$\kappa > 0, \gamma > 0$

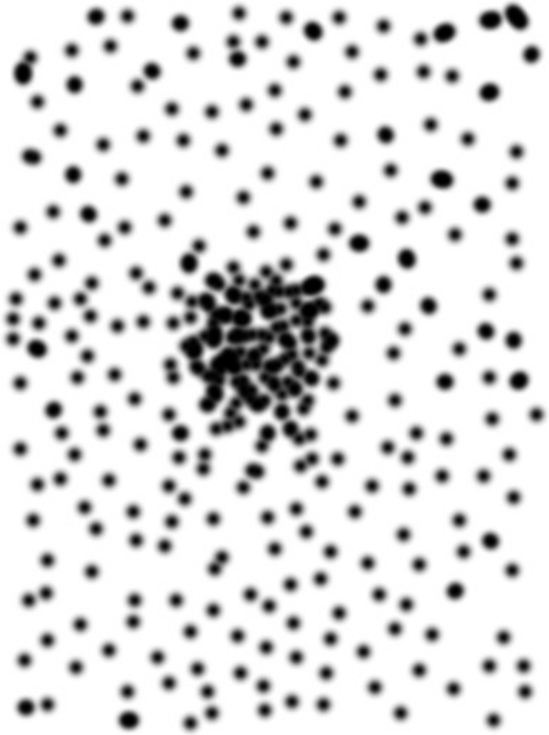
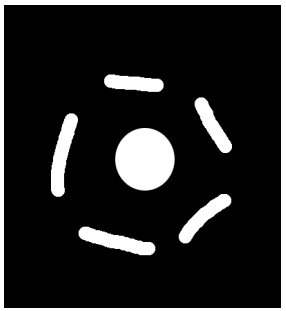
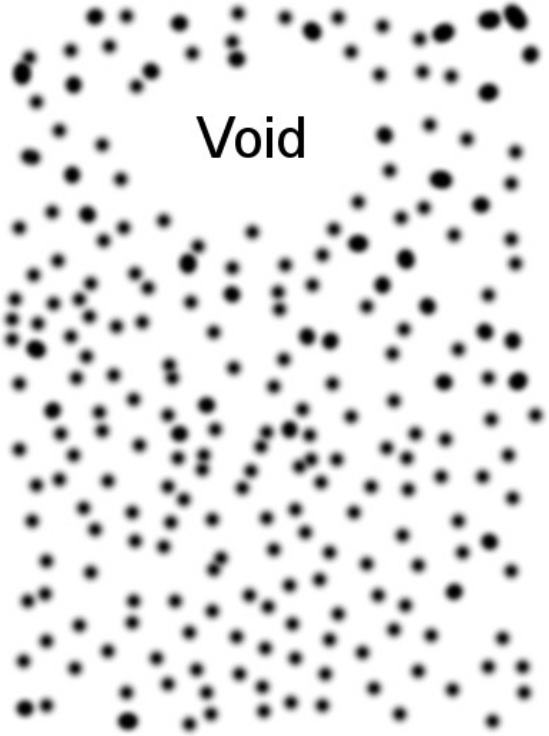


Image:



Lensing by underdensity:

$\kappa < 0, \gamma < 0$



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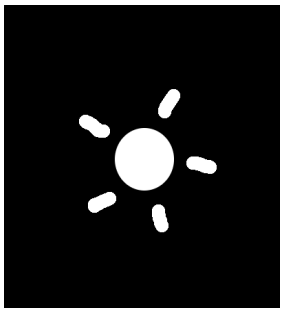


Line of Sight

Lensing by overdensity:

$\kappa > 0, \gamma > 0$

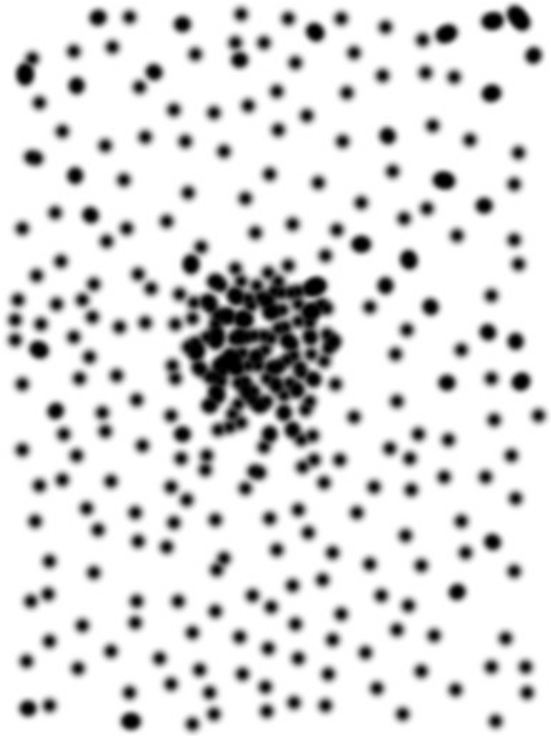
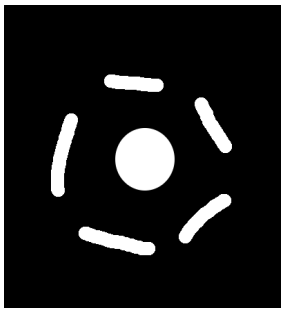


Image:



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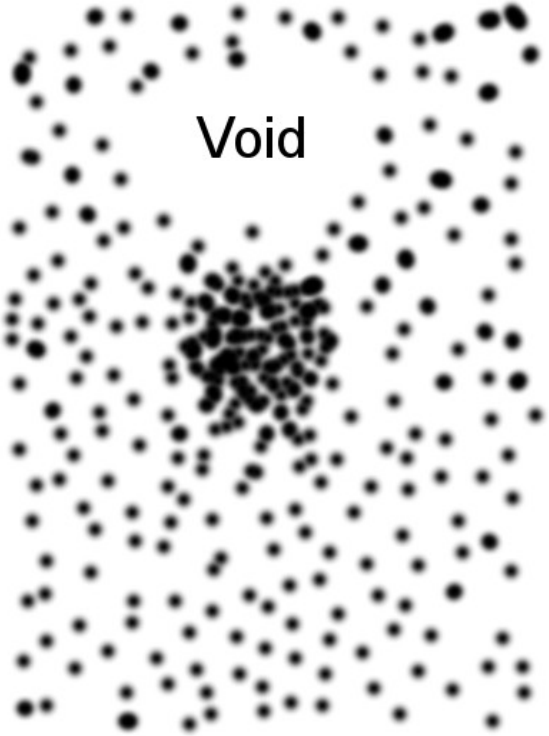

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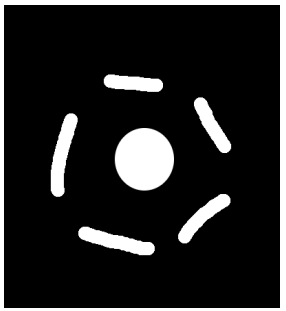
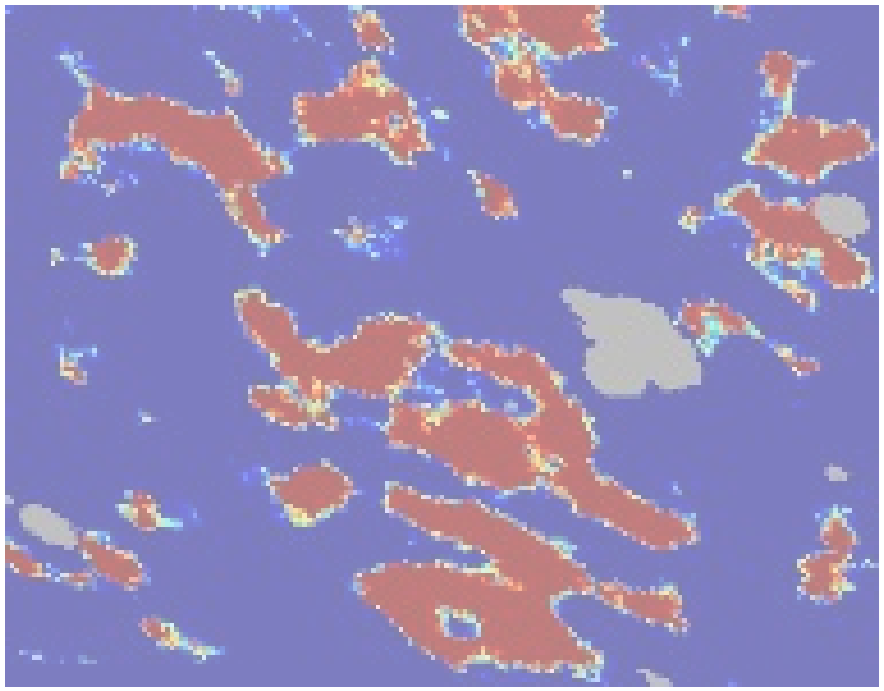
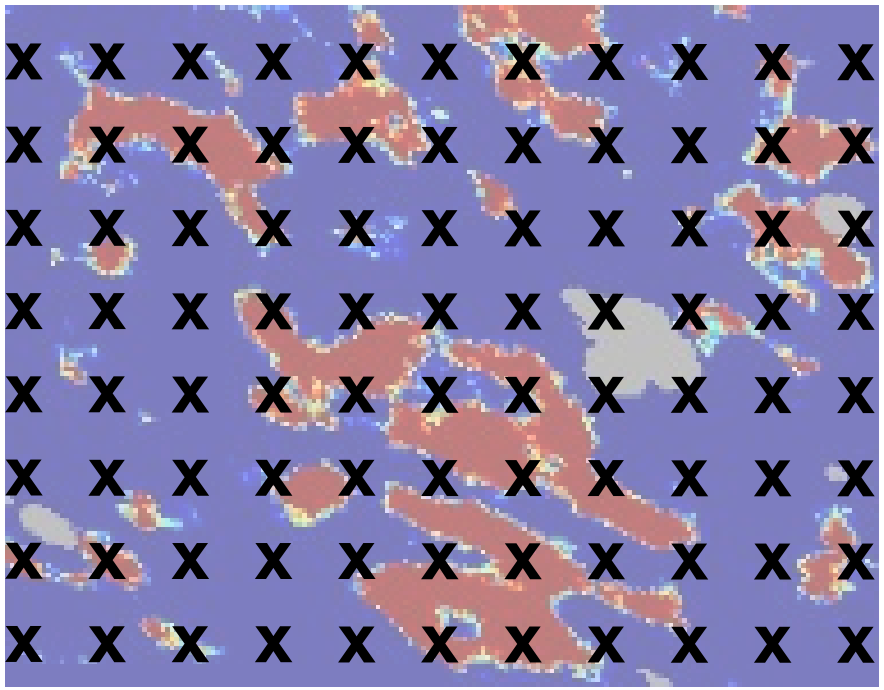


Line of Sight

Lensing around Troughs



Lensing around Troughs



- Lensing signal around arbitrary line of sight:

$$\langle \gamma \rangle = 0$$

Lensing around Troughs

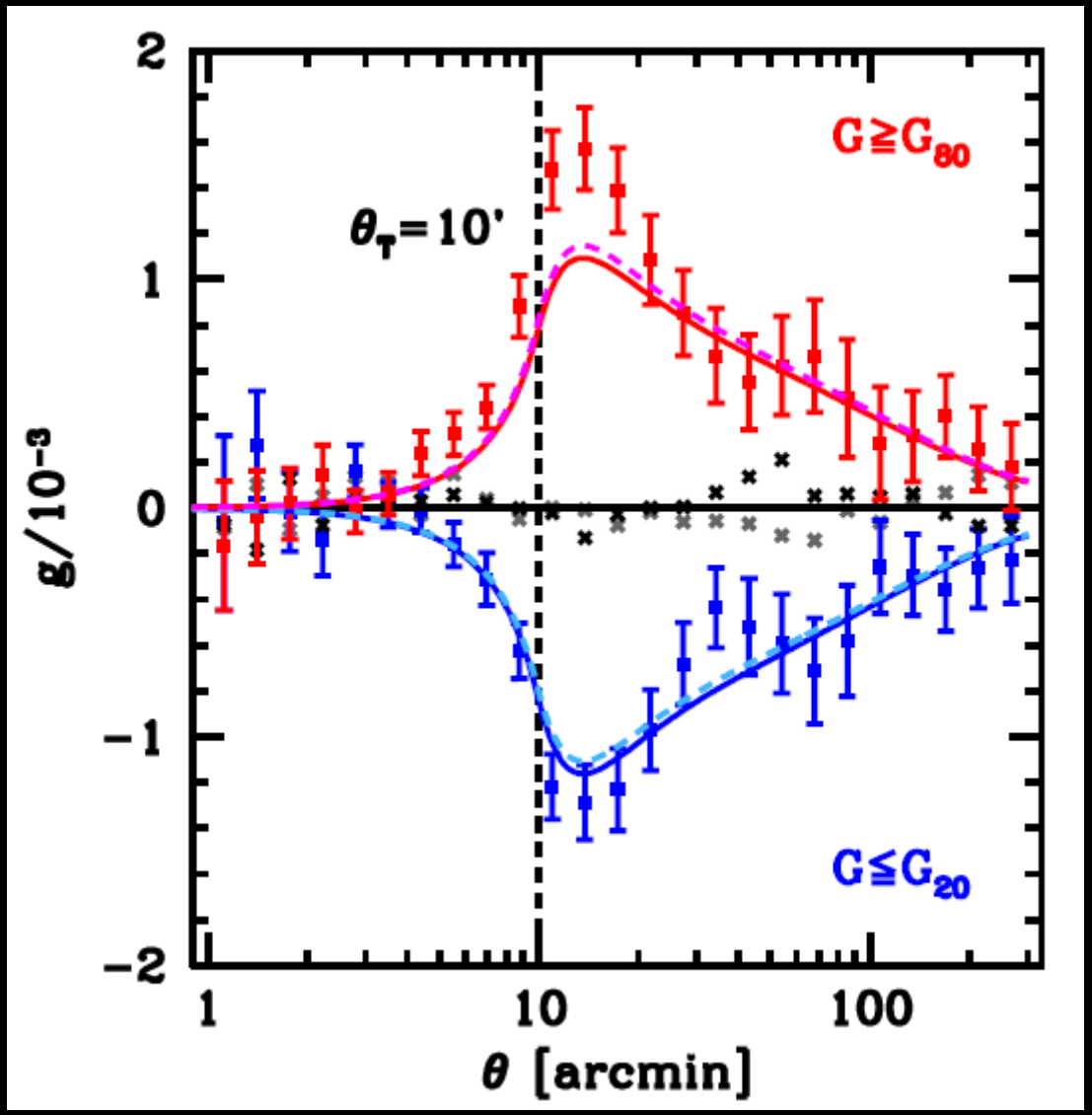
- Lensing signal around arbitrary line of sight:

  $\langle \gamma \rangle = 0$

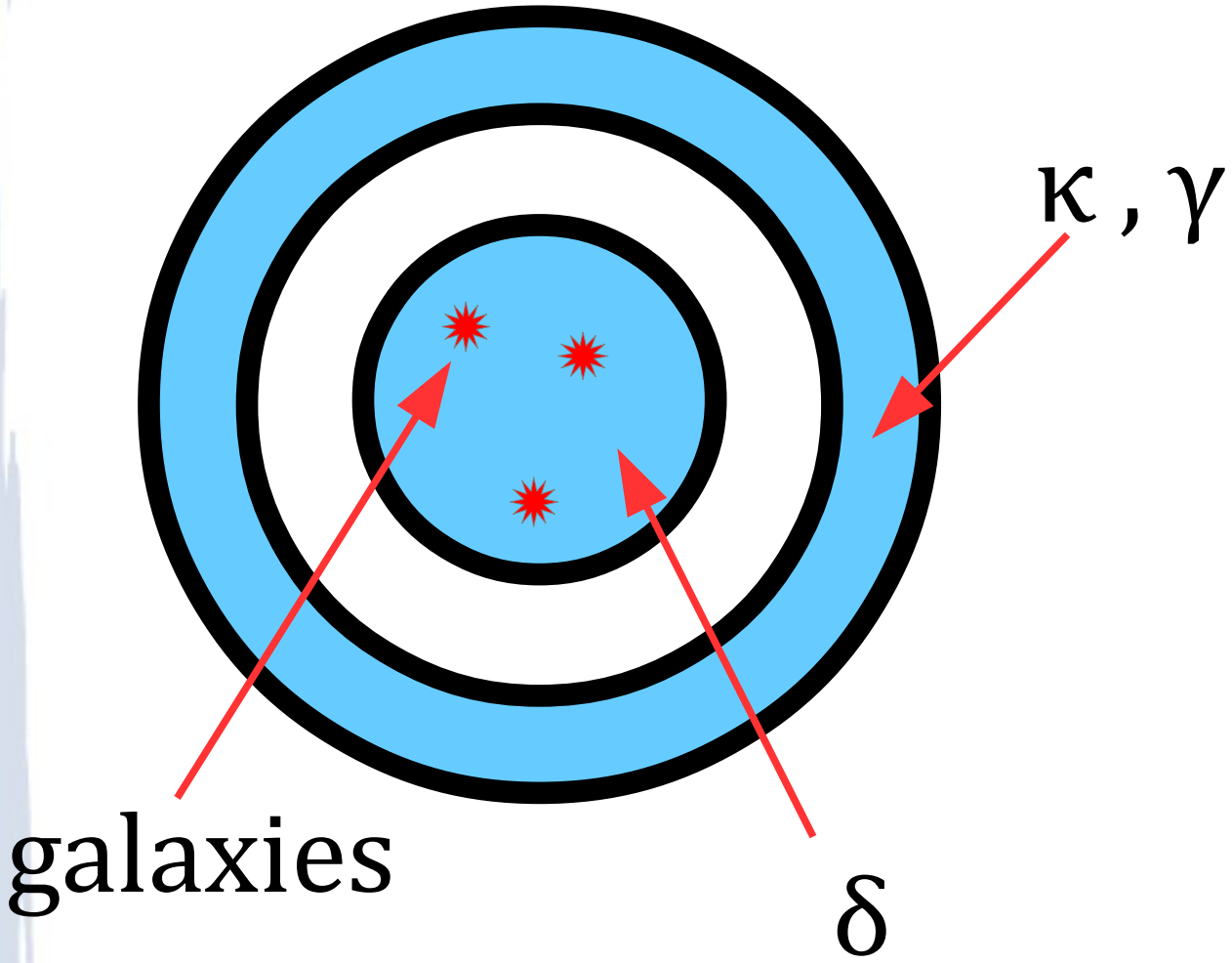
- Lensing signal around underdense lines of sight:

  $\langle \gamma \rangle < 0$

Measurement in DES-SV (Gruen, Friedrich et al. 2016)

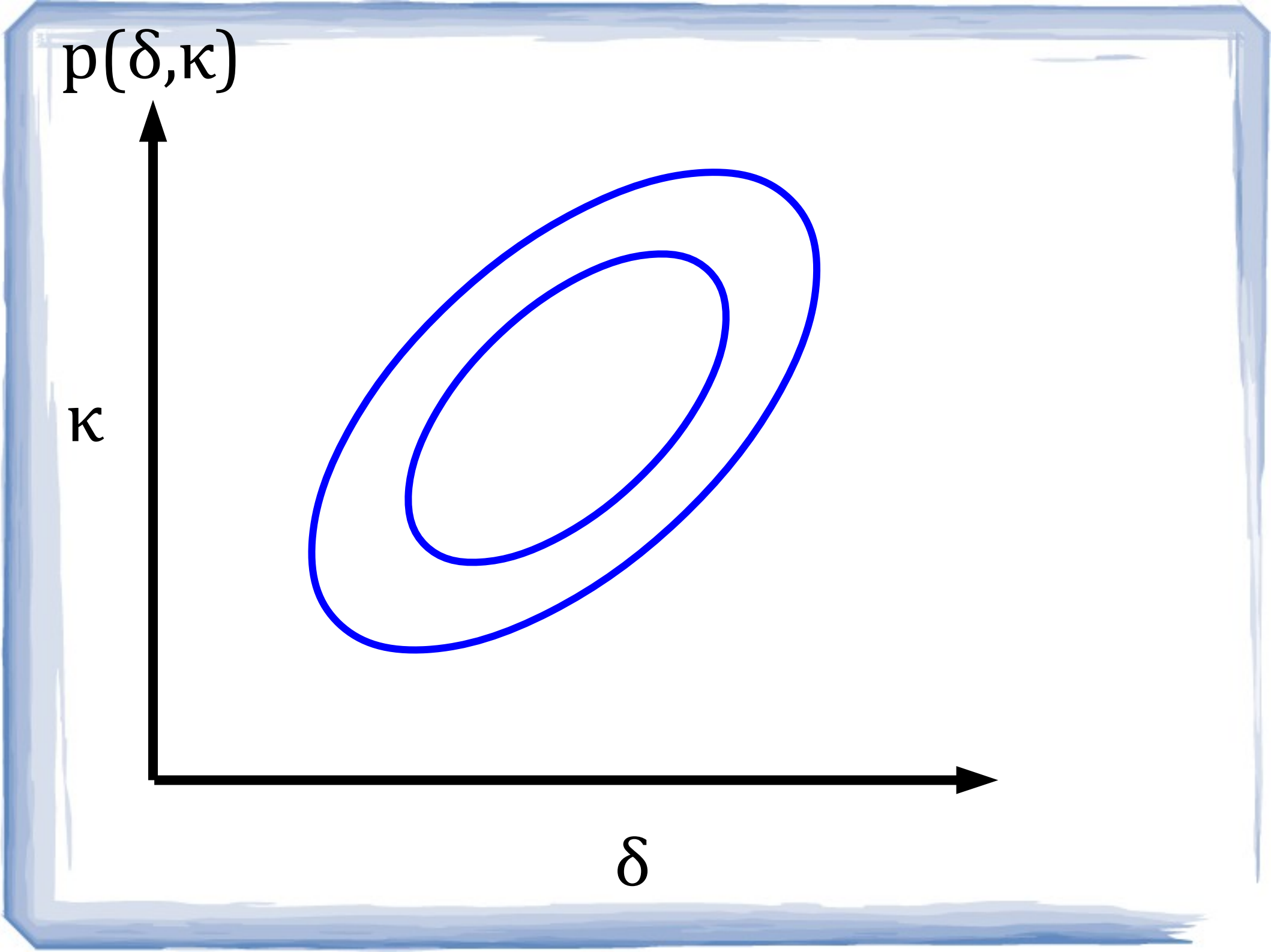


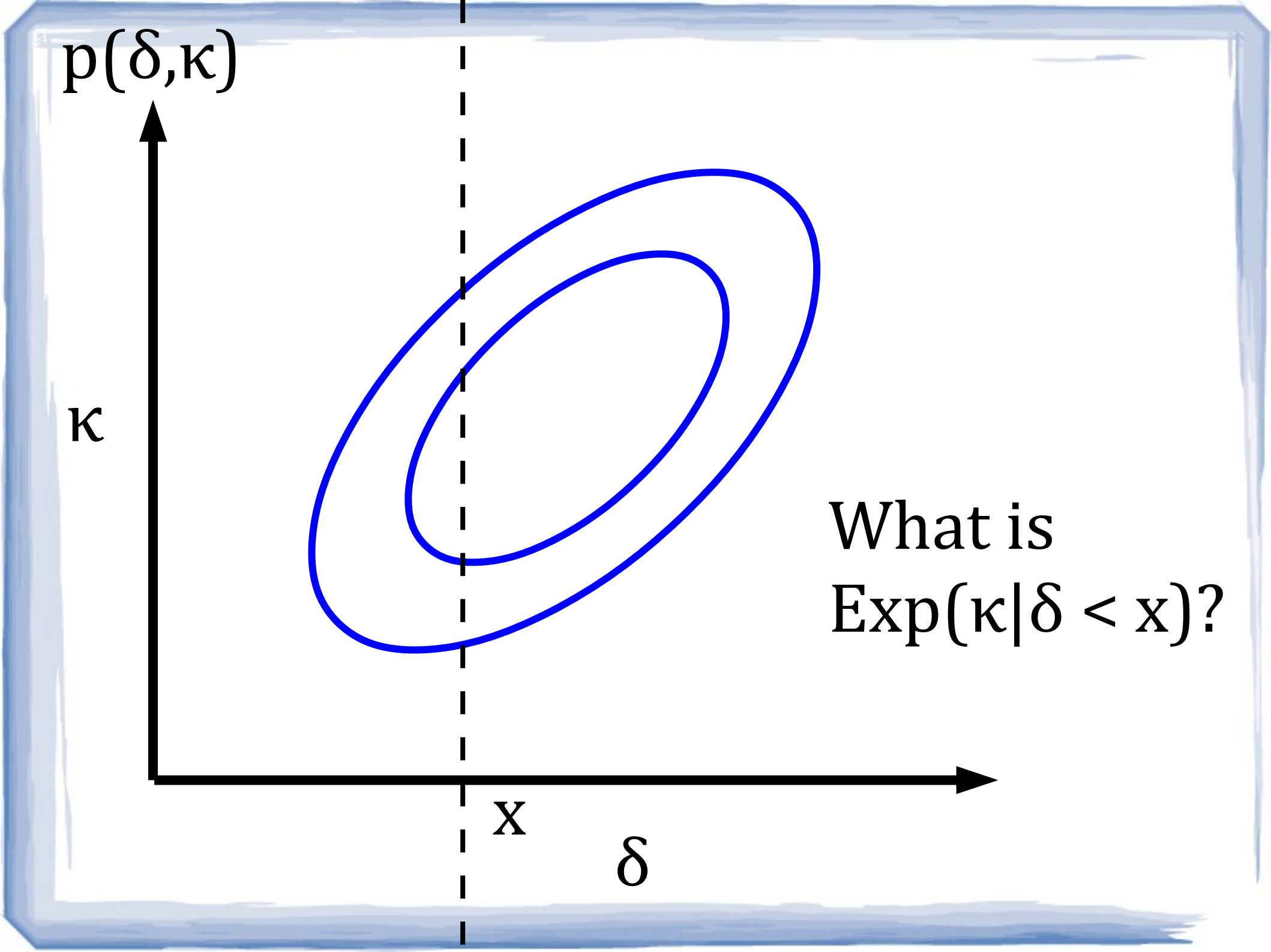
- trough lensing signal for underdense and overdense lines of sight
- model:
  κ and δ Gaussian random fields
  +
  Poissonian shot noise of galaxies

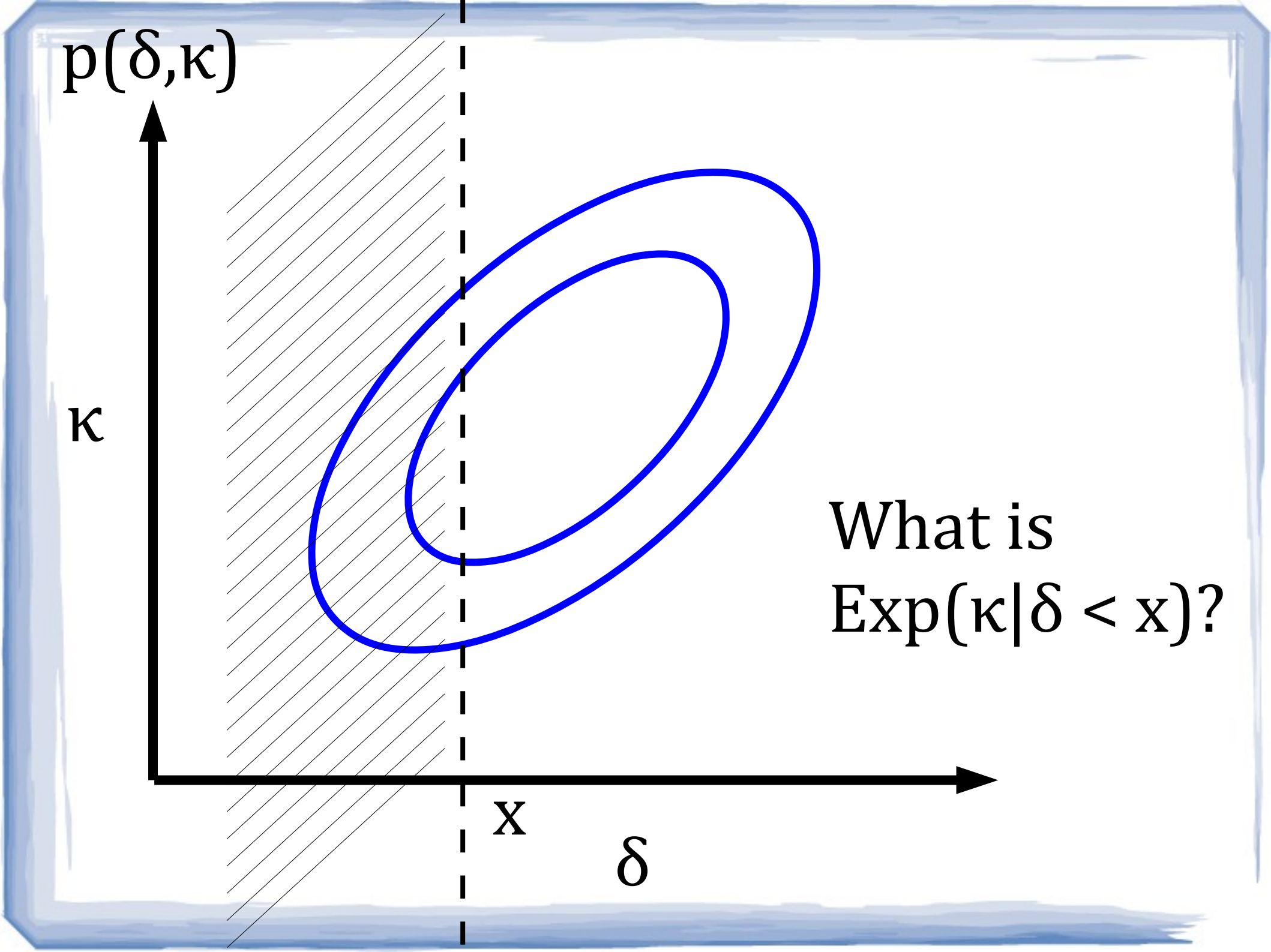


Need to model:

- relation of galaxies and matter
- relation of δ and κ


p(δ,κ)
κ
δ


p(δ,κ)
κ
x
δ
What is
Exp(κ|δ < x)?


p(δ,κ)
κ
x
δ
What is
Exp(κ|δ < x)?

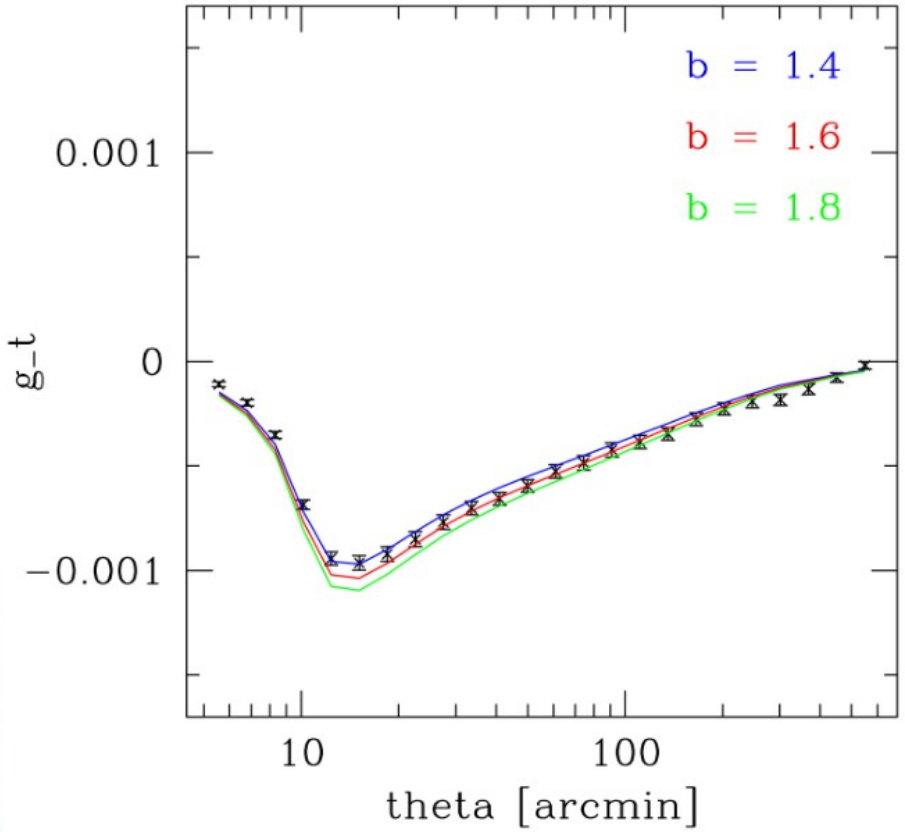
Possible ansatzes:

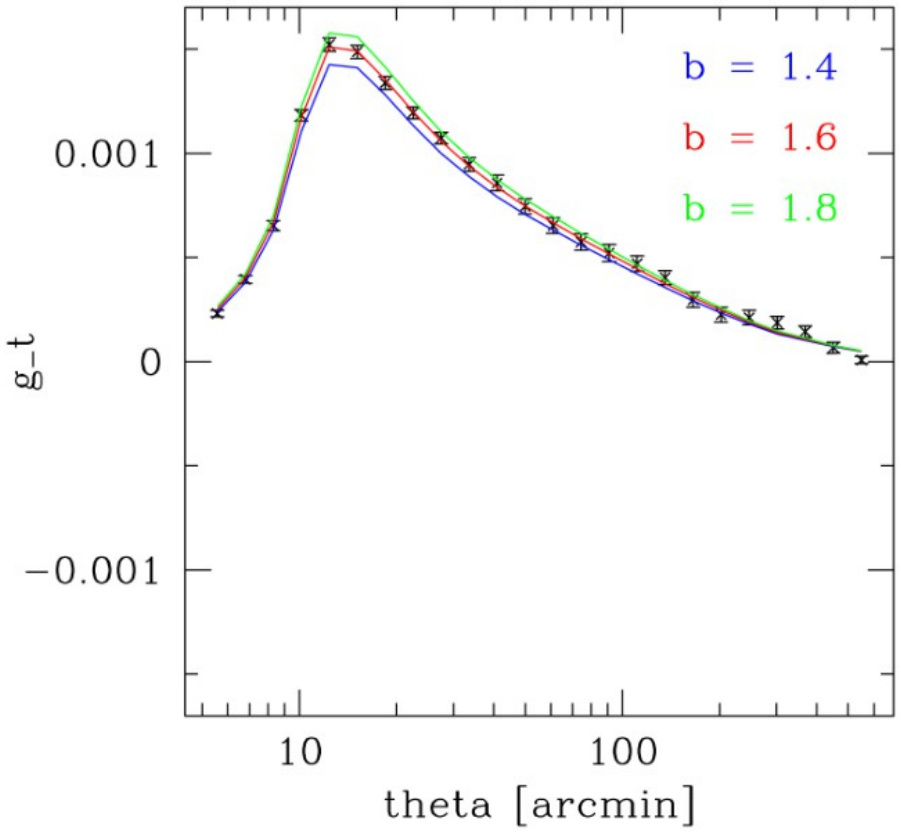
- Gaussian PDF ✓
- log-normal PDF ✓
- model PDF by assuming cylindrical collapse along line of sight (✓)

  for details see Valageas et al. (2002), Bernardeau et al. (2014) or Friedrich et al. (in prep.)

shear profile around 10' troughs: model vs. buzzard

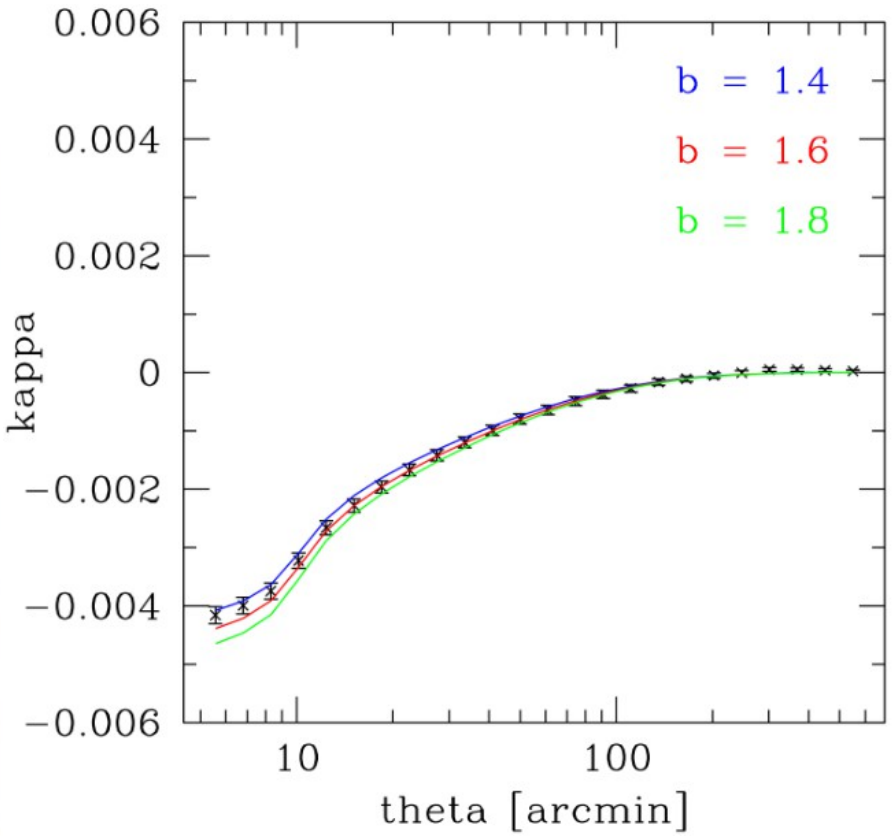
Simulations run by the group of Risa Wechsler, see Wechsler et al. (in prep.) and DeRose et al. (in prep.)

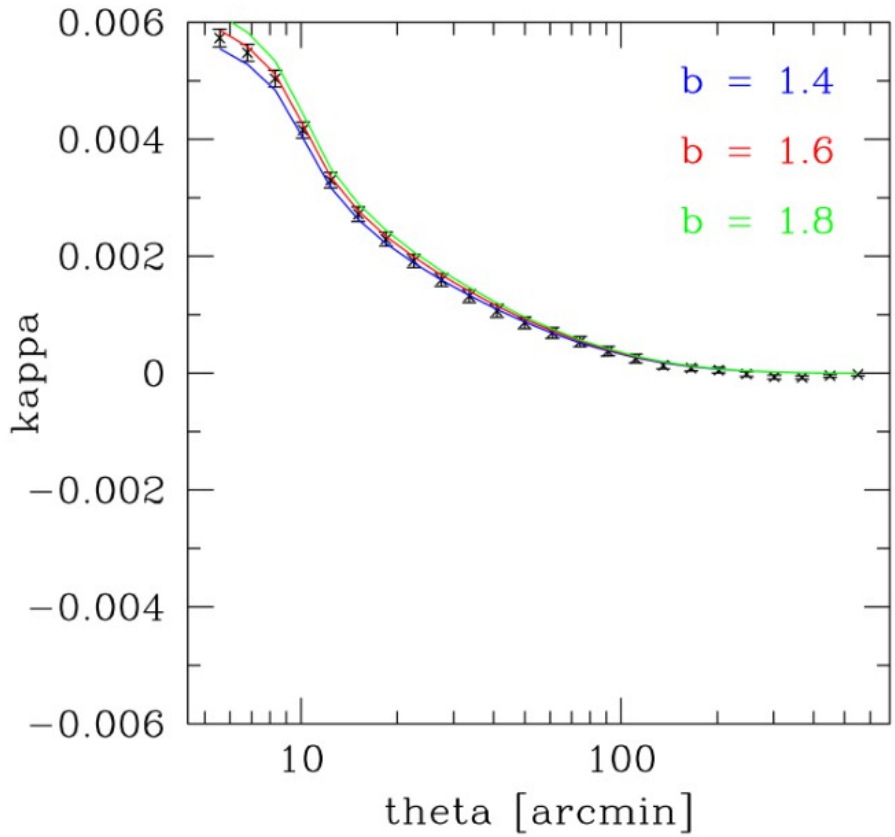




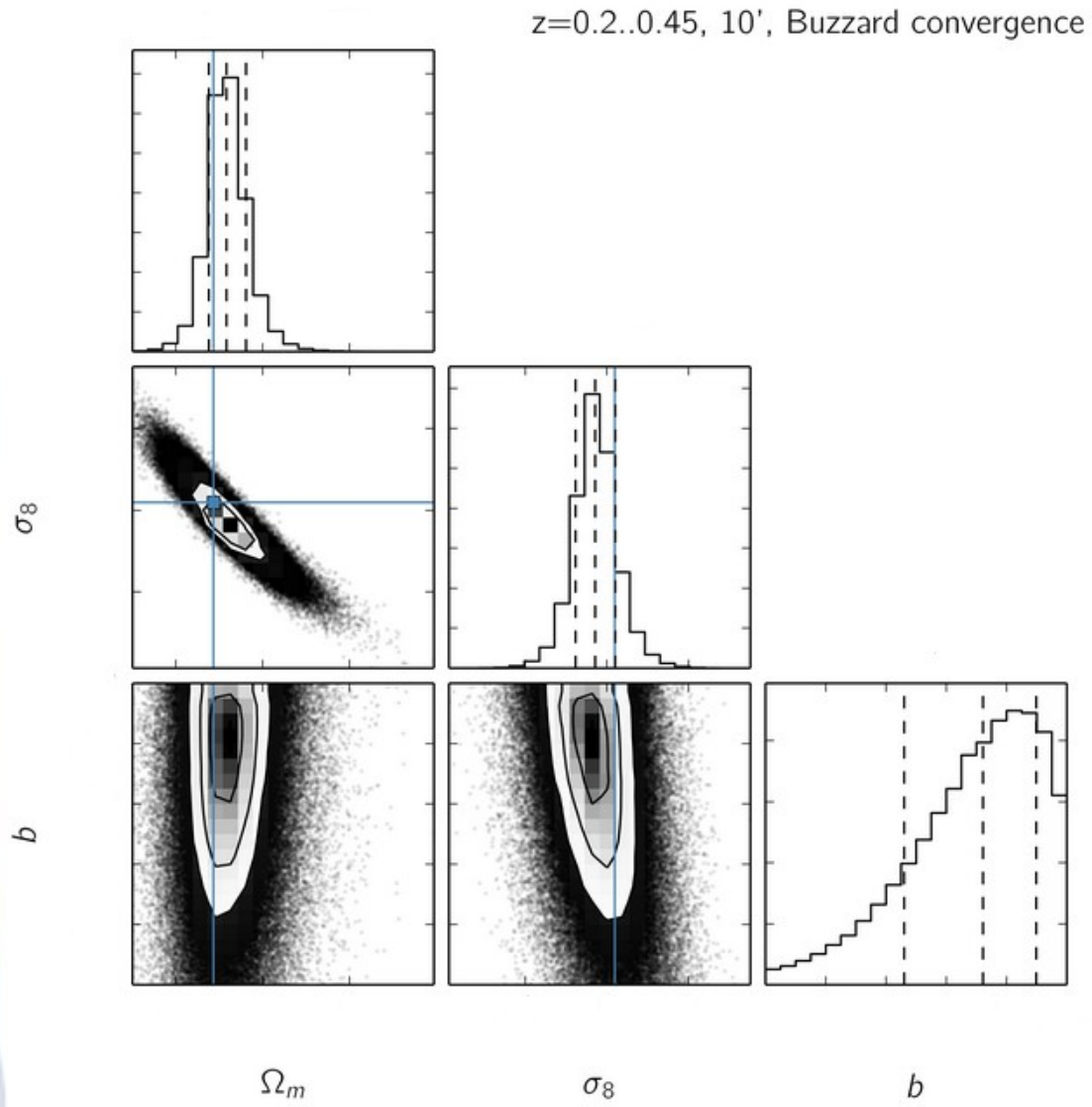
convergence profile around 10' troughs: model vs. buzzard simulations

Simulations run by the group of Risa Wechsler, see Wechsler et al. (in prep.) and DeRose et al. (in prep.)





task: recovering buzzard cosmology



- likelihood run with help of cosmolike (Krause & Eifler 2016)
- in first test, true buzzard cosmology lies within 1-sigma (need more!!)

Conclusions / Summary

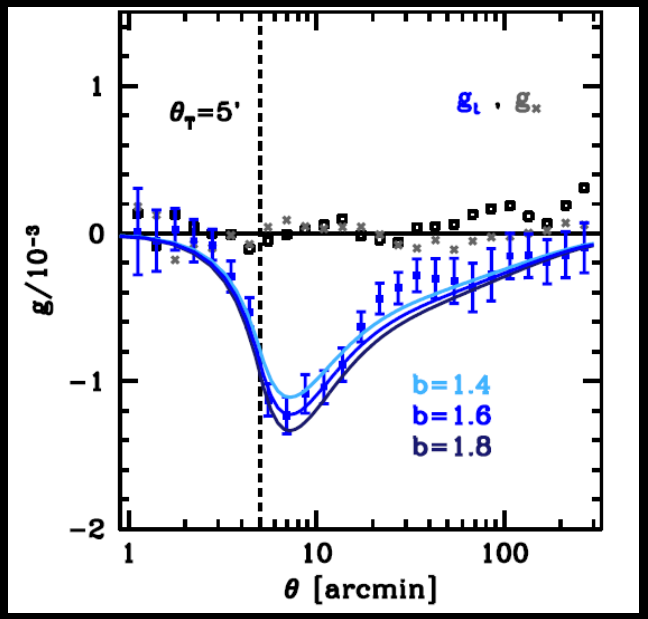
Trough Lensing sensitive to differences between over- and underdensities

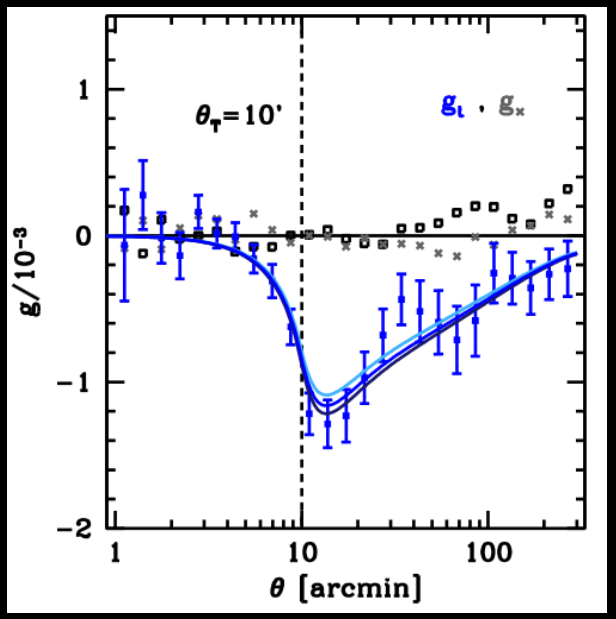
yields high signal-to-noise measurement of lensing around underdensities

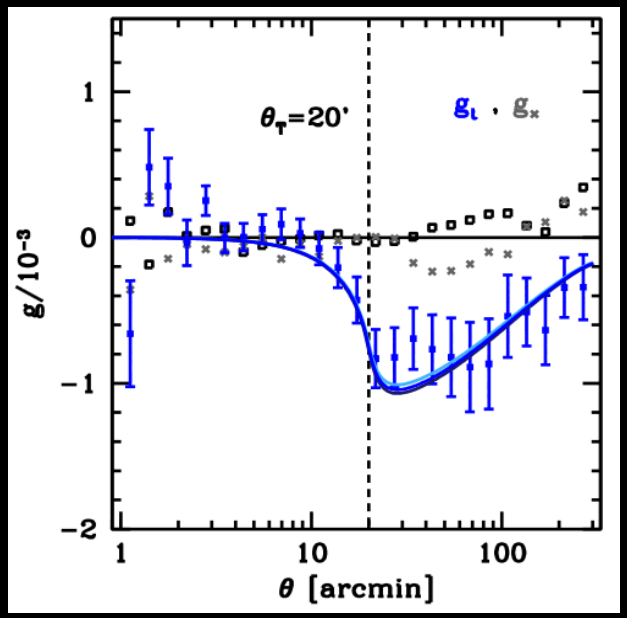
At first glance: modeling precise enough for use in DES year-1
need to perform further testing

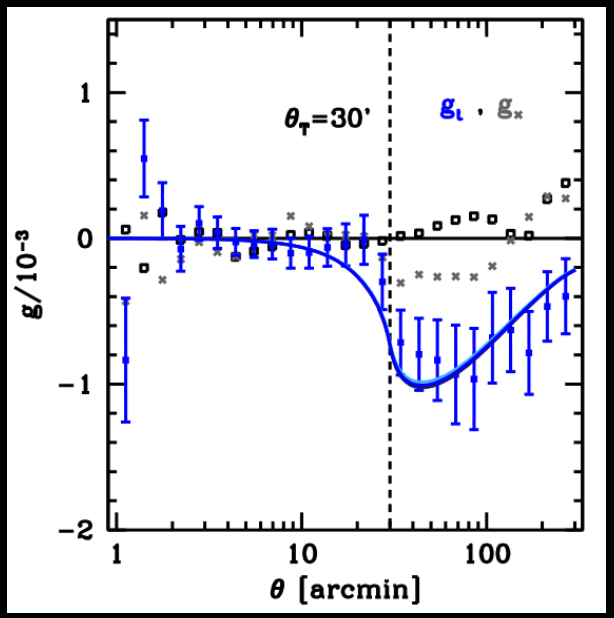
What kind of physics is this sensitive to?

Measurement in DES-SV (Gruen, Friedrich et al. 2016)









- trough lensing signal for different choices of smoothing radius
- model:
  κ and δ Gaussian random fields
  +
  Poissonian shot noise of galaxies

main idea:

- we know the PDF of the initial density field! (Gaussian)

- Radial symmetry $\Rightarrow$ $\delta_{NL} = \delta_{NL}[\delta_L]$

- The present day PDF can then be computed as

$$P(\delta_{\rm NL})\,{\rm d}\delta_{\rm NL} = P(\delta_{\rm L})\,{\rm d}\delta_{\rm L}$$

$$\Rightarrow P(\delta_{\rm NL}) = P(\delta_{\rm L}[\delta_{\rm NL}])\,\frac{{\rm d}\delta_{\rm L}}{{\rm d}\delta_{\rm NL}}$$

(very schematic and works only in Lagrangian coordinates...)