

# Working Group: Cosmology

Chiara Caprini

*Institut de Physique Théorique*

CEA - Saclay

work topic: early universe cosmology and stochastic backgrounds of GWs

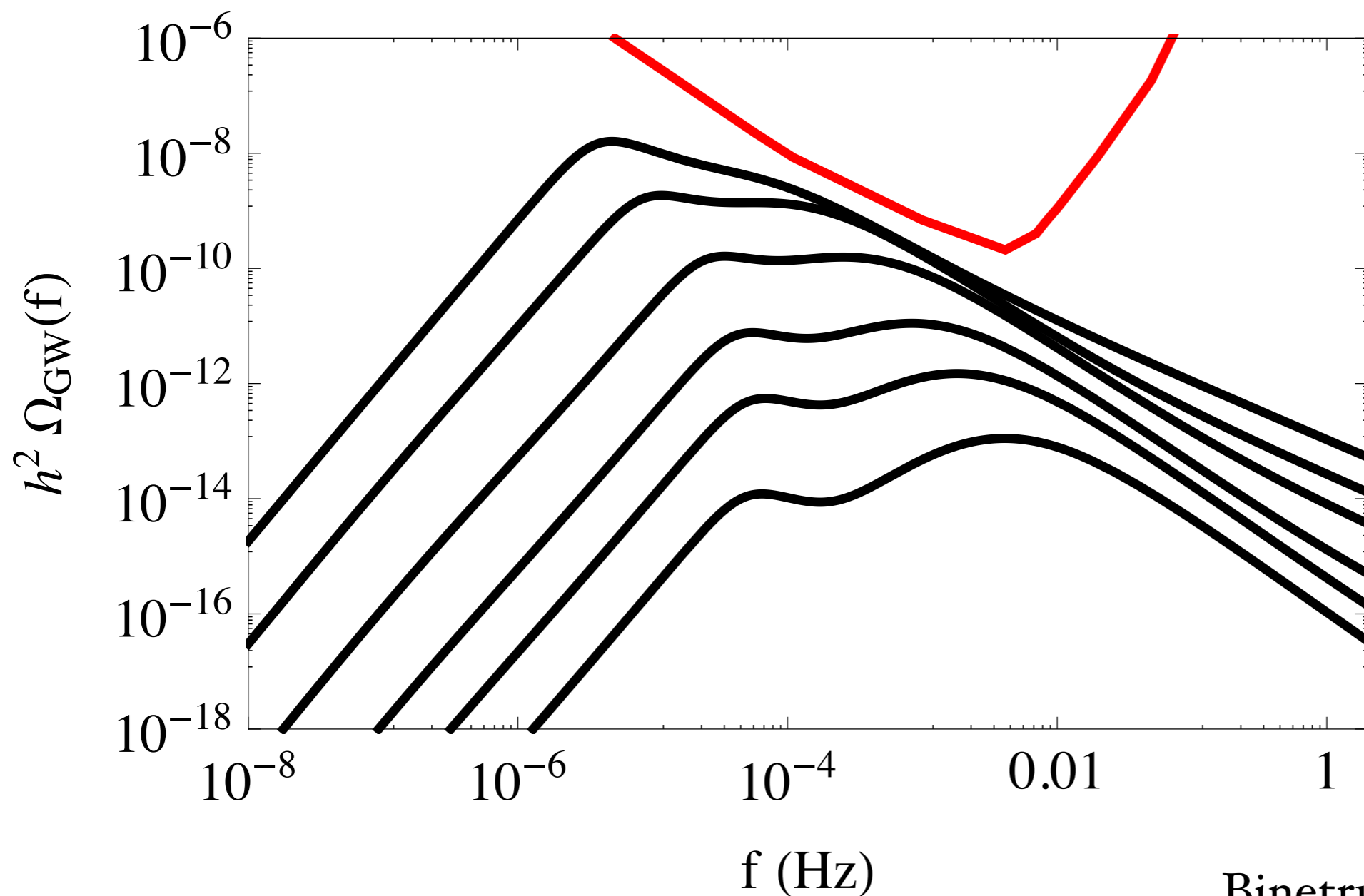
# Relevant topics for the working group

- Stochastic GW backgrounds from cosmological sources
- Measure of the cosmological parameters using standard sirens
- Testing the  $\Lambda$ CDM paradigm through information on structure formation ?
- Testing modifications of General Relativity which might be relevant at cosmological scales ?

# Stochastic backgrounds from cosmological sources

- Phase transitions at the EW scale

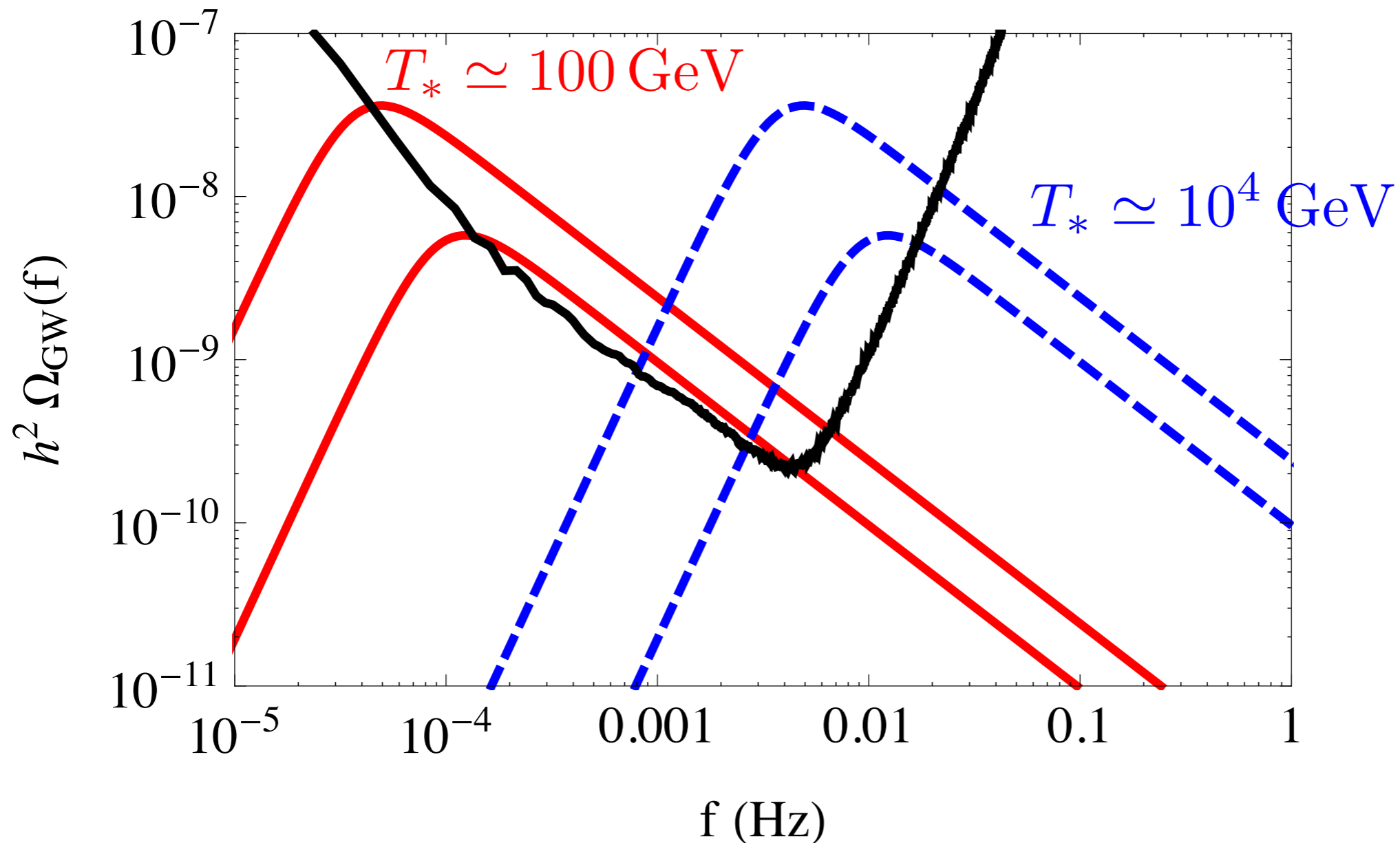
SM + dimension six operator,  $\eta=1$



# Stochastic backgrounds from cosmological sources

- Phase transitions at the EW scale

Holographic Phase Transition



# Stochastic backgrounds from cosmological sources

- Phase transitions at the EW scale

work topic:

- some improvement on the spectral shape
- which models will be still viable after LHC constraints?

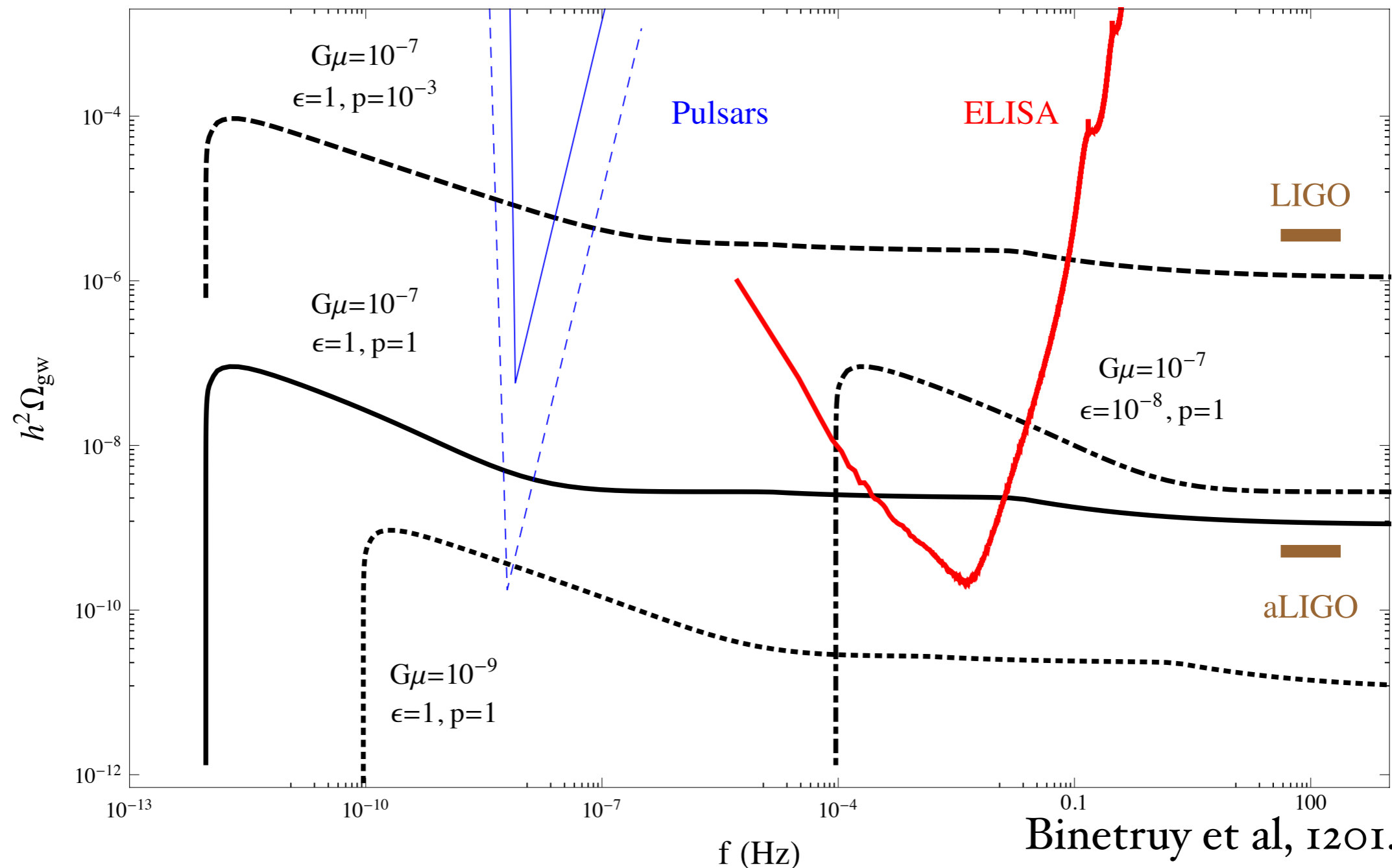
possible connection with data analysis group:

- detection of spectral shapes which are not flat
- (simulate them for a mock data challenge?)

# Stochastic backgrounds from cosmological sources

- Cosmic strings and superstrings

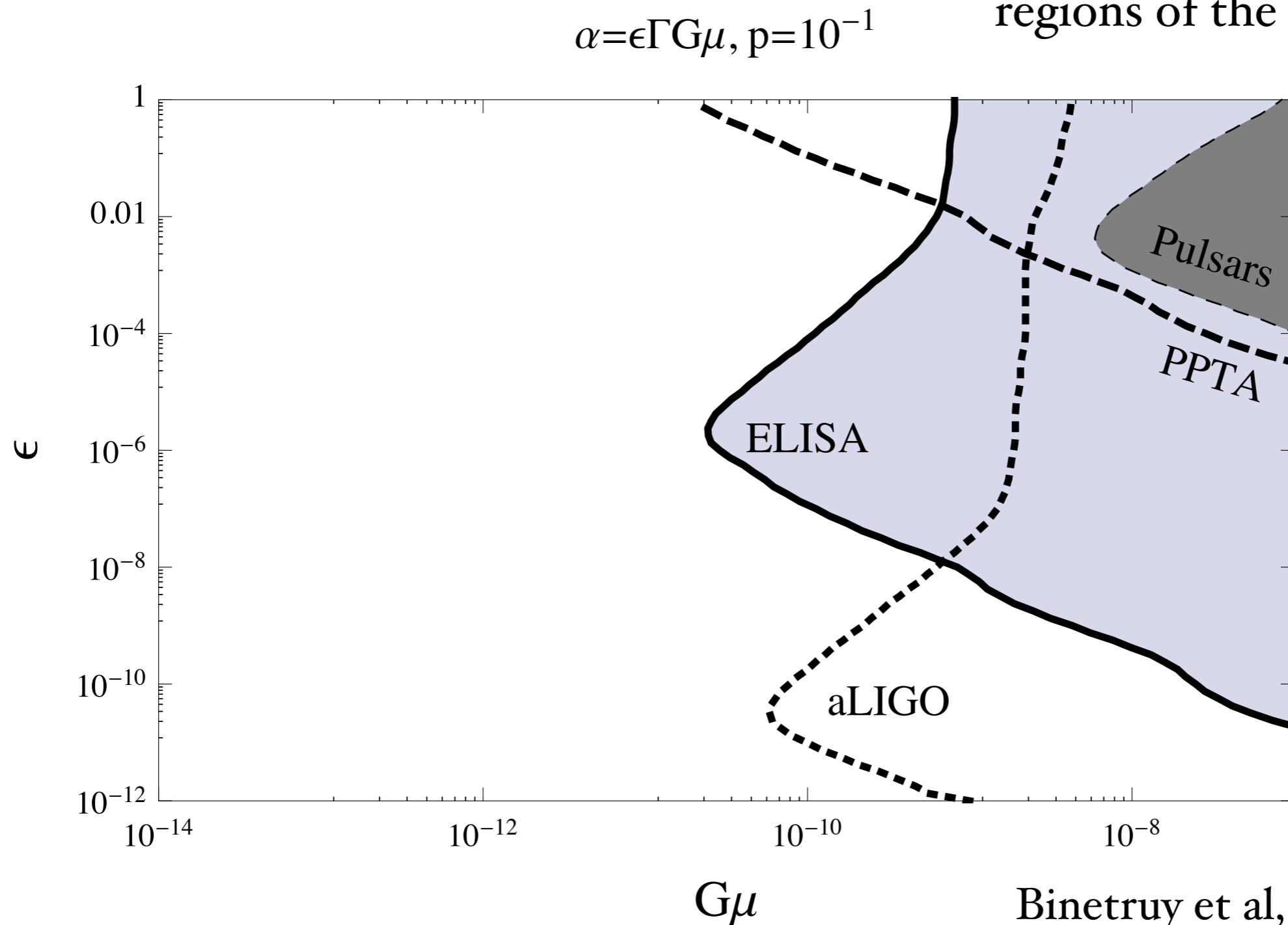
parameters: tension, loop size, reconnection probability (small loops)



# Stochastic backgrounds from cosmological sources

- Cosmic strings and superstrings

different detectors are complementary for some regions of the parameter space



# Stochastic backgrounds from cosmological sources

- Cosmic strings and superstrings

work topic:

- possible to alleviate the strong dependence on the parameters and give a better prediction? (NO)

possible connection with external communities:

- combined detection with ground based interferometers and PTA



# Stochastic backgrounds from cosmological sources

- **Other sources**
  - fluid stiffer than radiation after inflation
  - preheating after inflation
  - phase transitions at the end or during inflation
  - unstable domain walls
  - primordial black holes
  - scalar field relaxation
  - ... ?

work topic:

- work is needed to better assess the detection prospects

# Stochastic backgrounds from cosmological sources

general questions for stochastic backgrounds  
in possible connection with data analysis group:

- is detection possible only if the signal overcomes the sensitivity curve,  
or can we dig the signal out of the noise ?

(see e.g. Adam and Cornish arXiv:1002.1291 - done for LISA)

- are astrophysical backgrounds (galactic and extragalactic) still an issue  
for detection, or the noise is too high ?

# Measure of the cosmological parameters through standard sirens

## advantages with respect to SNe :

- can probe cosmology at much higher redshift
- the systematic is different: provide an independent test of the cosmological paradigm
- avoid cross-calibration of different distance indicators: the luminosity distance is a direct observable

## problems :

- cannot disentangle chirp mass and redshift: need an electromagnetic counterpart (the nature and strength of which are still uncertain)
- the intrinsic precision would be phenomenal but in practice it is limited by weak lensing
- the event rate is poorly known, but certainly less than for SNe which are almost limited by systematics ?

# Measure of the cosmological parameters through standard sirens

work topic in connection with cosmology : correct for weak lensing

- inferring the matter distribution and therefore the magnification from other observations :

- luminous surveys plus a model for the dark matter haloes? Gunnarsson et al  
astro-ph/0506764
- retracing light-rays in the line of sight through a CDM simulation? Hilbert et al  
arXiv:1007.2468
- using directly shear maps? Holz and Wald  
astro-ph/9708036

possible connection with external communities :

Shapiro et al  
arXiv:0907.3635

- eLISA will come after EUCLID which will provide extremely precise shear maps (too low redshift?)

# Measure of the cosmological parameters through standard sirens

work topic in connection with cosmology : avoid the EM counterpart?

- use only statistical information on the redshift of the host, without identifying the host galaxy of every individual event:
  - place an error box in sky coordinates and redshift around a source
  - use a CDM simulation to measure the average redshift of potential host galaxies in the error box

possible to determine  $H_0$       MacLeod and Hogan arXiv: 0712.0618,  
Del Pozzo, arXiv: 1108.1317

or w assuming the other cosmological parameters (Petiteau et al, arXiv:1102.0769)

possible connection with external communities :

numerical simulations of large scale structure formation

# Measure of the cosmological parameters

work topic in connection with cosmology : strong lensing

multiple imaging of a source by an intervening lensing galaxy

- no need for EM counterpart: the lensing statistics depends directly on the cosmological parameters
- the main uncertainty is the knowledge of the formation history of the binary

Sereno et al, arXiv:1011.5238

potential work topic among the astrophysical BH  
and the cosmology group

## Testing the $\Lambda$ CDM paradigm through information on structure formation ?

- potential work topic among the astrophysical BH and the cosmology group
- possibility of involving the external cosmology community working on structure formation

## Testing modifications of General Relativity which might be relevant at cosmological scales ?

- example: in MOND - TeVes theories, gravitons and other massless particles propagate on different metrics : if they are emitted by the same source, there is a time difference between their detection at earth
- potential work topic among the tests of fundamental laws and the cosmology group

# Cosmology Working Group : practice

- we need a second convener, possibly with scientific knowledge complementary to the one of the first...
- up to now, different people have been working on stochastic backgrounds and issues related to cosmological parameters determination : people interested in joining the group should manifest themselves and possibly bring external collaborators
- we could set up a wiki website with ongoing discussions and maybe have regular telecons
- other ideas?