Toward 3G detectors, input from SNe science
an outsider’s view

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Proposed 3G detectors

• Einstein Telescope
  – 10 Km long arms
  – Triangular shape
  – Underground
  – Sensitivity down to few Hz

• Cosmic Explorer
  – 40 Km long arms
  – L shaped
  – Over ground
  – Sensitivity down to ~8Hz
Getting to a science case

• When asking for that much money (~1 B$) there must be good and precise (astro)physical motivations.
• Interferometric GW detectors are delicate beasts: if you try to improve at some frequency you (typically) pay the price somewhere else
  – Trade-offs must be identified and justified (examples later)
• People will ask questions!

• This discussion is already quite advanced for binary black holes
Black holes everywhere!

- 3G detectors can observe BBH from most of the Universe
- Many loud signals
- Cosmological distances
- How well can BBH be characterized?

Horizon and 10, 50 and 75% confidence levels

3G detectors can observe BBH from most of the Universe

Many loud signals

Cosmological distances

How well can BBH be characterized?
Loud and clear

- BBH detected by 3G detectors will typically be loud
- Their inclination angle distribution will be isotropic
- Most events from redshift of a few

BBH with component masses in range [6,100]M
How many detectors do we need?
Extrinsic parameters

- With 3G detectors, distance estimation is needed to measure intrinsic masses -> need more than 2 instruments!
Masses

- Especially at large redshifts, having more than 2 sites is important to measure component masses
- Uncertainties of [few-10]% for z<3
- Factor 1.5-2 better with 4 IFOs w.r.t. 2 IFOs
Spins

- Due to larger SNR and isotropic orbital orientation, 3G will get much better spin estimation than 2G.

2G

3G

3/17/17

Vitale+, 1611.01122, on press PRD

S. Vitale

Vitale, Evans, 1610.06917, on press PRD
The stochastic background from unresolved BBH sources will totally dominate the stochastic background form inflation.

A significant fraction of it can be removed.

Regimbau+ 1611.08943, on press PRL
Back to SNe

• What must be done:
  – Develop and consolidate a science case with 3G detectors

• When?
  – ASAP. If SNe-driven requirements want to have any impact, they must be brought up and justified now
• So, we would like to know: to go where we want to go, where do we need to go? It’s a simple information...
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• If you want to the the mental hospital, I can bring you there.
• So, we would like to know: to go where we want to go, where do we need to go? It’s a simple information...

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To play a role in the preparation for 3G detectors, you must have answers (quantitative, if possible)
Detection range

• Should have precise (in the limits of possible) numbers for
  – How far can SNe be detected at 5-sigma? (please, do not use 3-sigma, great claims require great evidence!)
  – How does this number change requiring time ”coincidence” with neutrinos?
  – How does this number change requiring time, and sky and proto-NS mass and radius inferred from neutrinos? (Giulia’s talk)
Networks and such

• SNe are rare events.
  – One might be everything we get
  – Need to be sure we have at least two detectors continuously online (I’d argue one will not be enough for a first detection)

• If a choice is possible, would you
  – Renounce to some sensitivity in exchange for more reliability (high duty cycle)?

• Can/Should we try to keep old detectors online?
  – How much worse before they are useless
Detection is not enough

• Detection itself is not interesting. We know SNe exist and explode.
• We must learn something we don’t already know
How many?

• What can we learn with 1 SNe detection at threshold?
• What can we learn with 1 loud SNe detection?
  – Is either of these enough to excite the broad community? (i.e. people outside of this room)
  – Is this something we can only do with GWs?

• What if we have a second detection?
  – Would love a progression of science vs detections

• Can you learn more if you get have more instruments? Is polarization an asset?
Test of General relativity

- We all love GR but we would all love to see it violated
- Which GR violations can be tested with SNe?
  - Scalar-Tensor (Davide’s talk), dispersion relation (Quentin’s talk), extra polarizations
- Under which conditions we can actually test GR with SNe?
  - Are these tests competitive with what will be done in the next 20 years?
- Is one event (which might be the only thing we get) enough?
Frequencies

• Most people commonly associate SNe to kHz frequencies

• At this workshop, the role of low-frequency has been stressed
  – What can we learn if we start the analysis from 1Hz that we would not if we started at 10Hz?

• Not a random questions: the ET vs CE designs do differ in the low frequency cutoff.

• Neither side is sold to a design yet. If going to 1Hz would make SNe science dramatically better, we need to know (asap)