Subsection 4.4

Some proposed changes

- Notation is not always fully consistent with other parts, for example with Section 2.1. It should be good to try to make it fully compatible.
- Add a new subsubsection covering the combination of photon counting experiments.
- Subsubsection 4.4.6 (Issues related to data acquisition and long term storage) should be updated to cover frequencies up to the GHz regime
- A subsection with a discussion about synergy with other detectors could be added

Addition to Sec. 4.4: Coincidence Counting Experiments

- Assuming single photon detection, narrow band experiments, each photon time-stamped

- **Globally distributed** detectors can be combined in a **coincidence experiment**
  - Can allow for **different detector designs / technologies**, even **different frequencies** (in limited range)
    - Combining detectors operating at various frequencies requires models of the time evolution of the GW signals

- Overall signal efficiency dependent on detector efficiency, coincidence window and signal photon flux
  - Neglected dead-time here

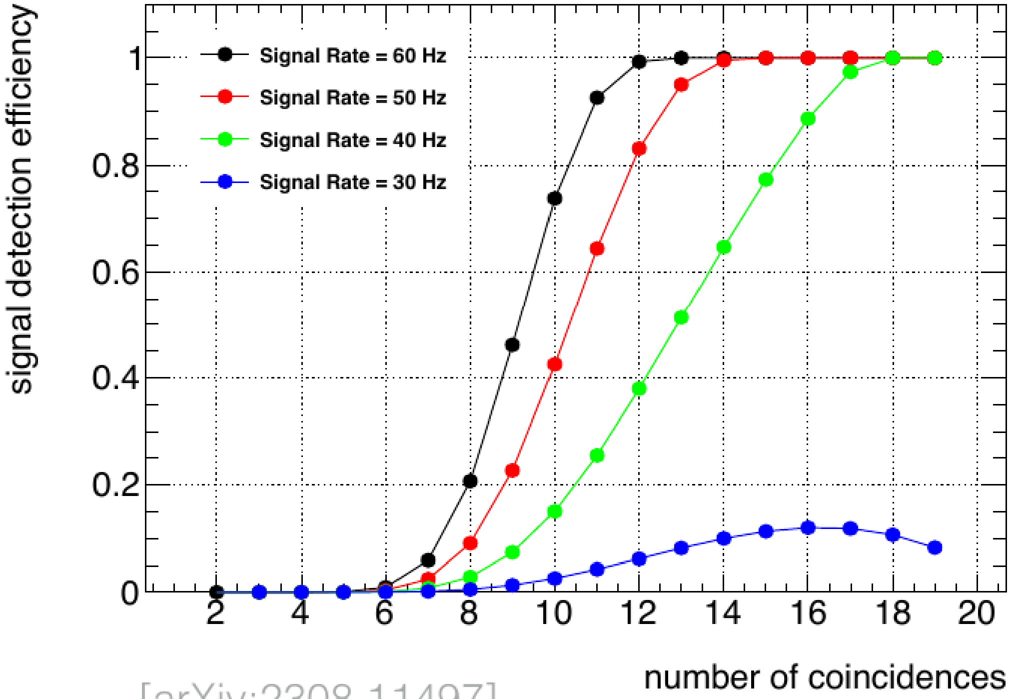
- $\epsilon_{single} = \epsilon_{det} \Delta t_{coincidence} \Phi_{sig}$ Φ_{sig} = signal photon flux

- $\epsilon_{tot} = \sum_{i>k} \binom{N}{k} p^k (1-p)^{N-k}, p = \epsilon_{single}$,

k = number of required coincidences, N = number of detectors

- Parameter used for Calculation:
  - Allowed accidental coincidence rate: <= 1/year
    - Determining coincidence window
  - Background rate: 10 Hz
  - N detectors: 20
  - ϵ_{det}: 0.5

- With **20 detectors** a photon flux of **40 Hz** can be detected with an efficiency of 1 within a coincidence interval of **32ms**



[arXiv:2308.11497]

Additions to Section 4.4

4.4.7 Coincidence counting experiments

With the prospects of single photon detectors in the GHz regime and above, spatially separated UHFGW detector signals can be combined in a simple coincidence counting experiment. Technically every detected photon can be associated to a timestamp with ns resolution and combined offline with any number of experiments. Low event rates of 100Hz allow for easy processing and storage. This approach is in particular interesting for short transient signals like those from PBH merger events. Using a sufficiently large number of detectors (order of 10) the detection efficiency and rate of accidental coincidence can be adjusted by varying the coincidence window, given the detector dependent dark count rate. The efficiency of the detector network is given by $\epsilon_{tot} = \sum_{i>k} \binom{N}{k} p^k (1-p)^{N-k}$, where N is the number of participating detectors, k ist the number of required coincidences and $p = \epsilon_{det}$ is the individual detector efficiency. ϵ_{tot} can be adjusted to be close to 1 with a negligible accidental coincidence rate, making this approach ideal for the detection of transient signals. As an example, using N = 20 independent detectors and requiring k = 14 coincidences, assuming $\epsilon_{det} = 0.5$ and a dark count range of 10 Hz, an accidental coincidence rate of < 1 per year is reached for a coincidence window of 30ms with an efficiency of ≈ 1.

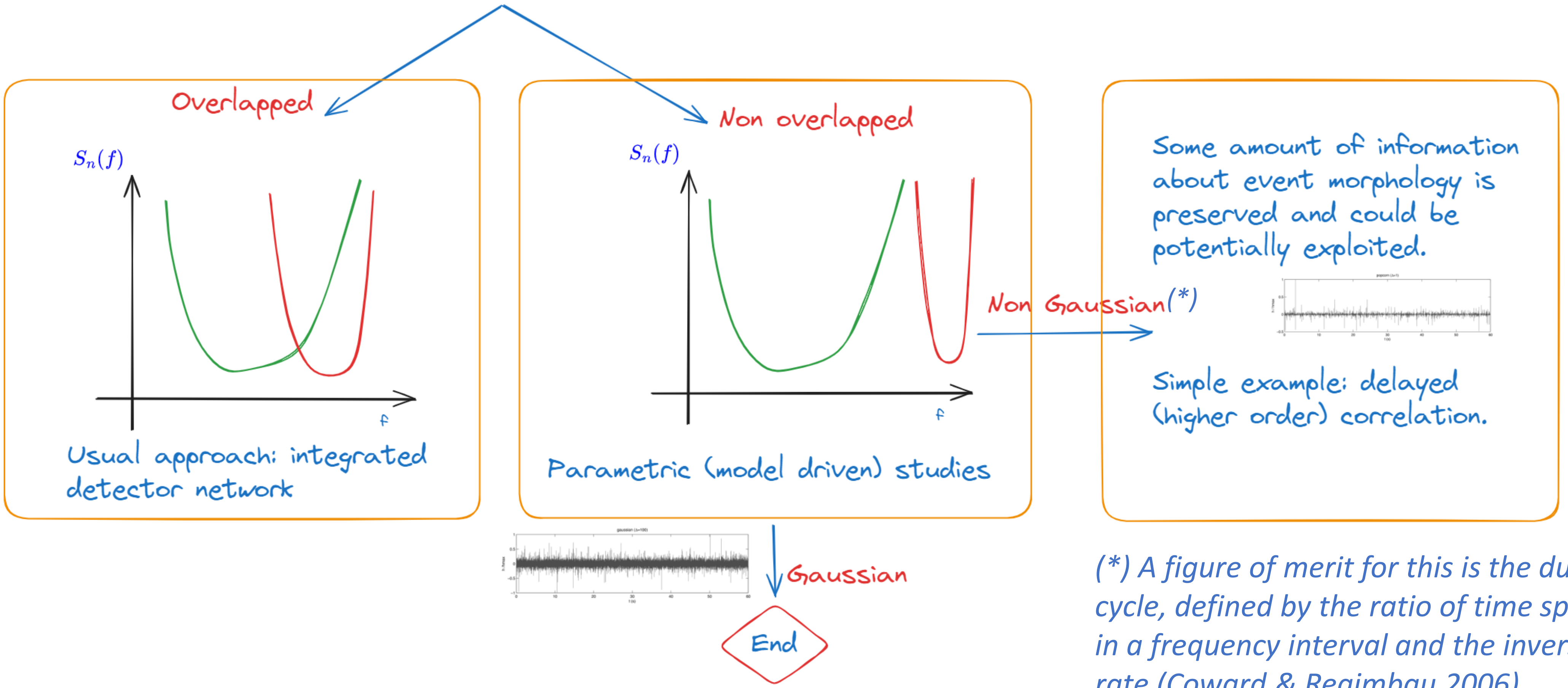
It is even possible to combine information from narrow band detectors operating at different frequencies. In this case the time dependent evolution of the frequency of the signals needs to be know requiring reliable models. Alternatively the model parameters could be fitted to the data.

Additions to Section 4.4

Updates to Sec. 4.4.6 Issues related to data acquisition and long term storage

This section only refers to signal up to 1MHz. Today several experiments (originating in the axion community) operate in the GHz regime, increasing the requirements on processing and storage of time-series data significantly, which should be mentioned in this section. While web 2.0 is mentioned, it should rather be noted that plenty of experience in handling huge amounts of data exists in the LHC community. We can profit from those experiences and even try to get access to the available resources to facilitate the time series correlation of UHFGW searches.

Synergies with other detectors



(*) A figure of merit for this is the duty cycle, defined by the ratio of time spent in a frequency interval and the inverse rate (Coward & Regimbau 2006)

This could evolve to a more detailed consideration of the scenario for given source and detector. Probably too premature (investigation needed) for this WP version. Some work is in progress.