WaveBurst simulation

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- **Simulation engine**
- **sine-Gaussian**
- **BH-BH mergers**
- **Summary & Plans**

http://www.phys.ufl.edu/LIGO/bursts/waveburst/S2

Simulation

- **injection into all three interferometers:**
  - **waveform name**
  - **GPS time of injection**
  - **{θ, φ,Ψ} - source location and polarization angle**
  - **T {L1,H1,H2} - LLO-LHO delays**
  - **F+{L1,H1,H2} - + polarization beam pattern vector**
  - **Fx {L1,H1,H2} - x polarization beam pattern vector**
- **prepare waveforms in datacondAPI and send to DSO**
- **multiple injection in the same data with different hrss**

injected waveforms

- sine-Gaussian injections
  - 16 waveforms: 8-Q9 and 8-Q3
  - frequencies 100 – 2000 Hz
  - F+ {1,1,1} , Fx {0,0,0}
- BH-BH mergers (10-100 Mo)
  - 10 pairs of waveforms {h+,hx}
  - all sky uniform distribution with calculation {F+,Fx} for LLO,LHO
  - 1.1 millions waveforms injected
- use exactly the same pipeline for processing of GW and simulation triggers → realistic estimation of detection efficiency including all selection cuts

optimal time coincidence window (w)

- **depends on ETG time resolution and LHO-LLO delay**

S2 SG simulation sample

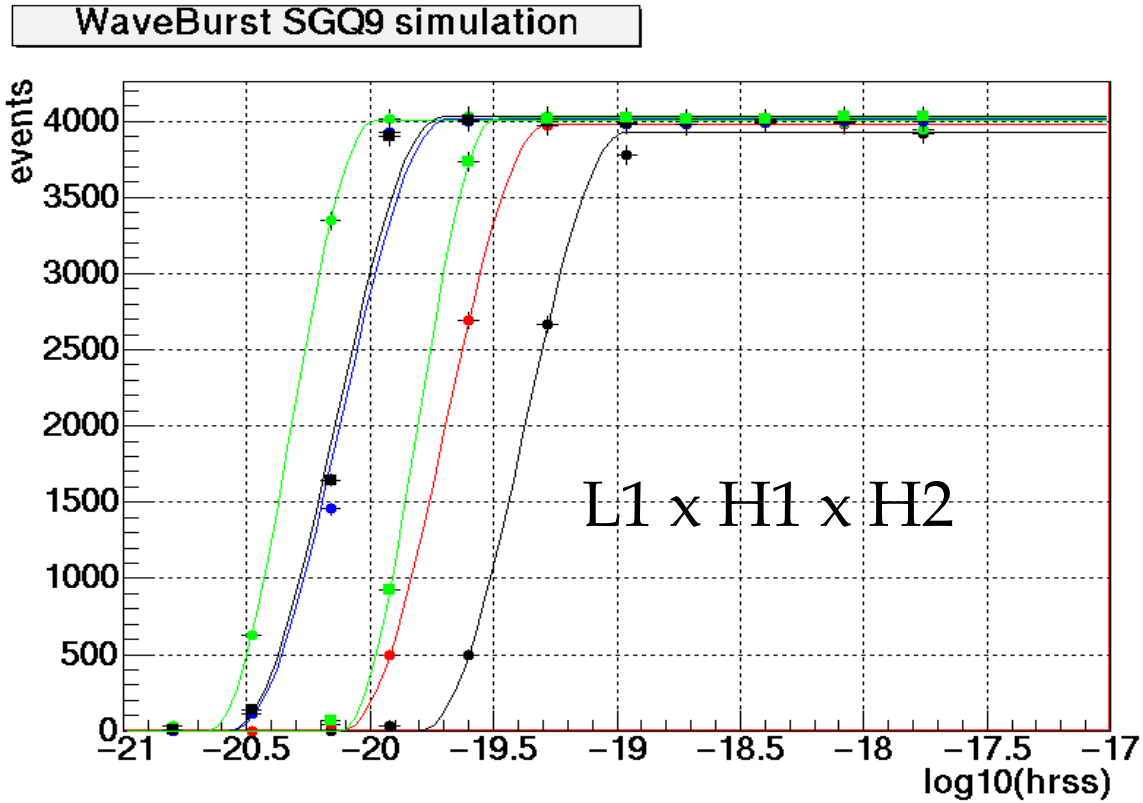
resolution, ms	10	20	30	50	100
total number of events	405511	464584	476437	489018	520294
estimated background	9.9 ±0.4 k	18.9 ±0.5 k	26.8 ±0.7 k	39.3 ±0.8 k	71.8 ±1.1 k
detected injections	395.6 k	445.7 k	449.6 k	449.7 k	448.5 k

- **negligible loss of simulated events for** $w \geq 20ms$
- **can use window of 20 ms without loss off efficiency**

triple detection efficiency vs hrss

$hrss(50\%)/\sqrt{Hz}$

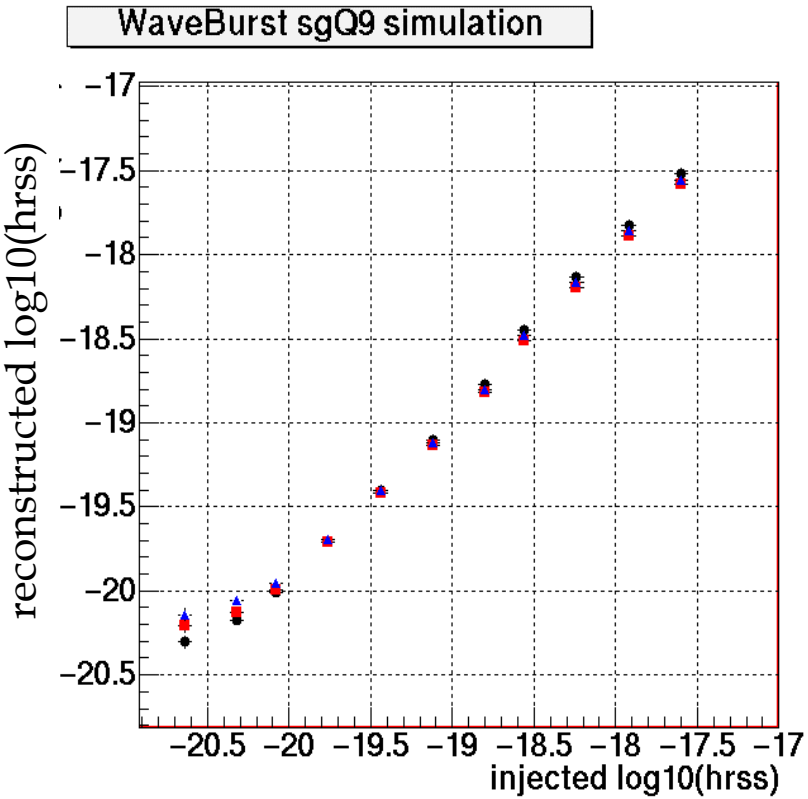
5-6 10^{-21}
@235 Hz
robust
with respect
to waveform

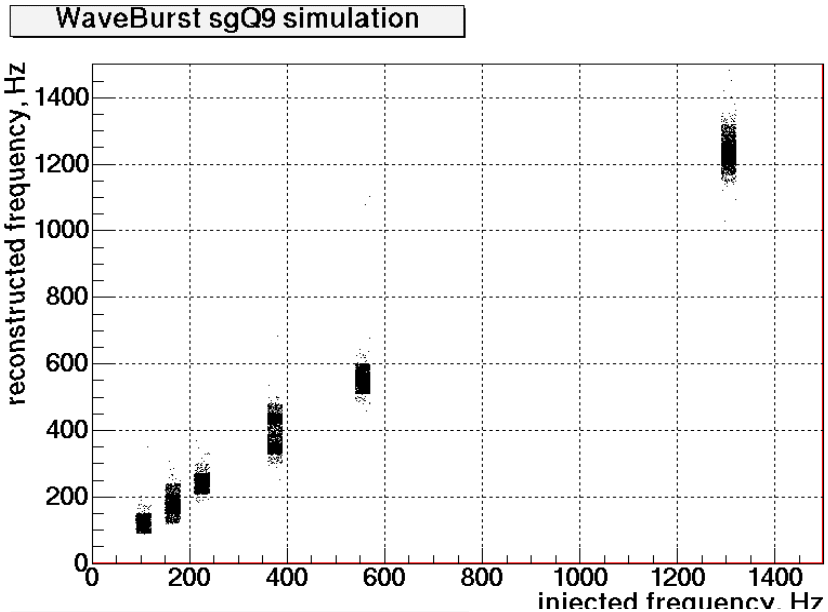


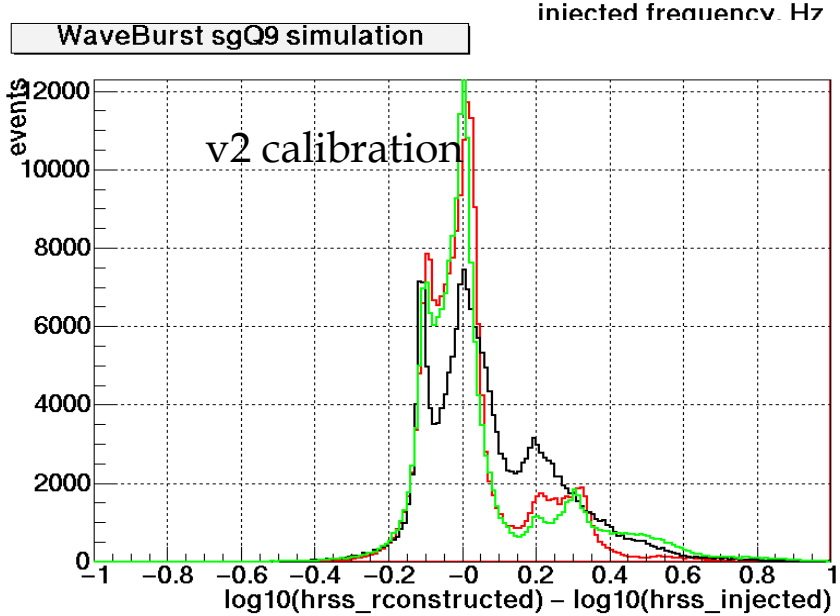
freq., Hz	100	153	235	361	554	850	1034	2000	
h50%, Q9	40.	20.	4.8	7.5	7.2	-	16.	-	x10^{-21}
h50%, Q3	36.	14.	6.0	6.6	8.6	10.	17.	30.	x10^{-21}

reconstruction of signal parameters

few ms time reconstruction accuracy







BH-BH merger injections

- **BH-BH mergers** **(Flanagan, Hughes: gr-qc/9701039v2 1997)**

start frequency: $$f_{start} \approx \left(\frac{0.02}{M}\right) = 205Hz \cdot \left(\frac{20M_o}{M}\right)$$

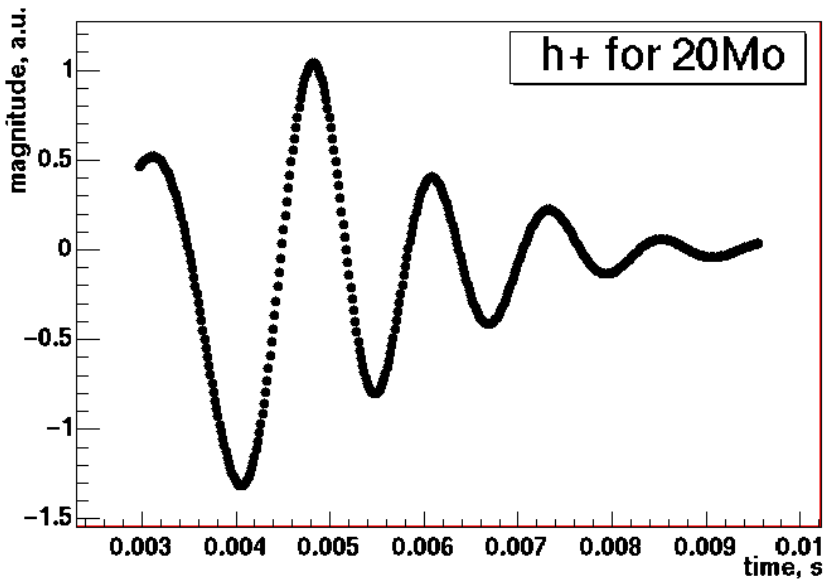
duration: $$\tau \approx 50M = 5ms \cdot \left(\frac{M}{20M_o}\right)$$

bandwidth: $$\Delta f \sim f_{qnr} \approx \left(\frac{0.13}{M}\right) = 1300Hz \cdot \left(\frac{20M_o}{M}\right)$$

- **BH-BH simulation**

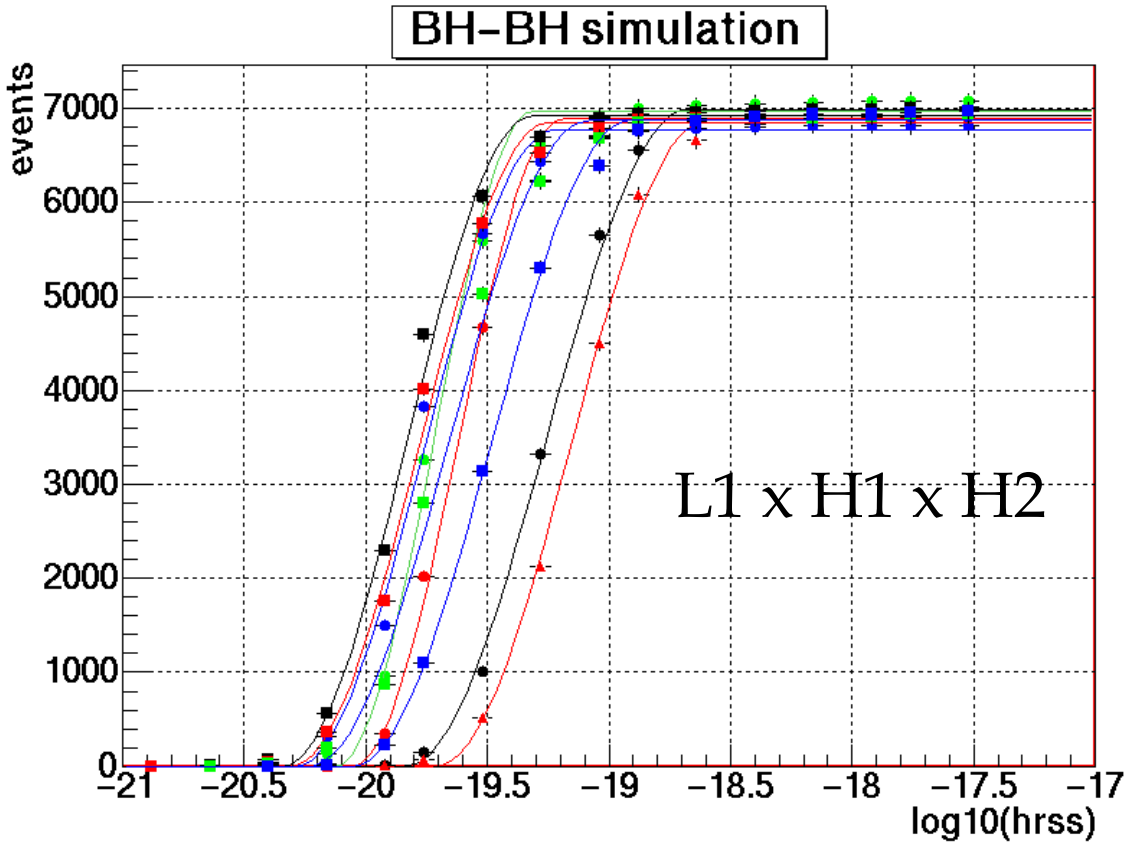
(J.Baker et al, astro-ph/0202469v1)

all sky simulation using
two polarizations and
L & H beam pattern functions



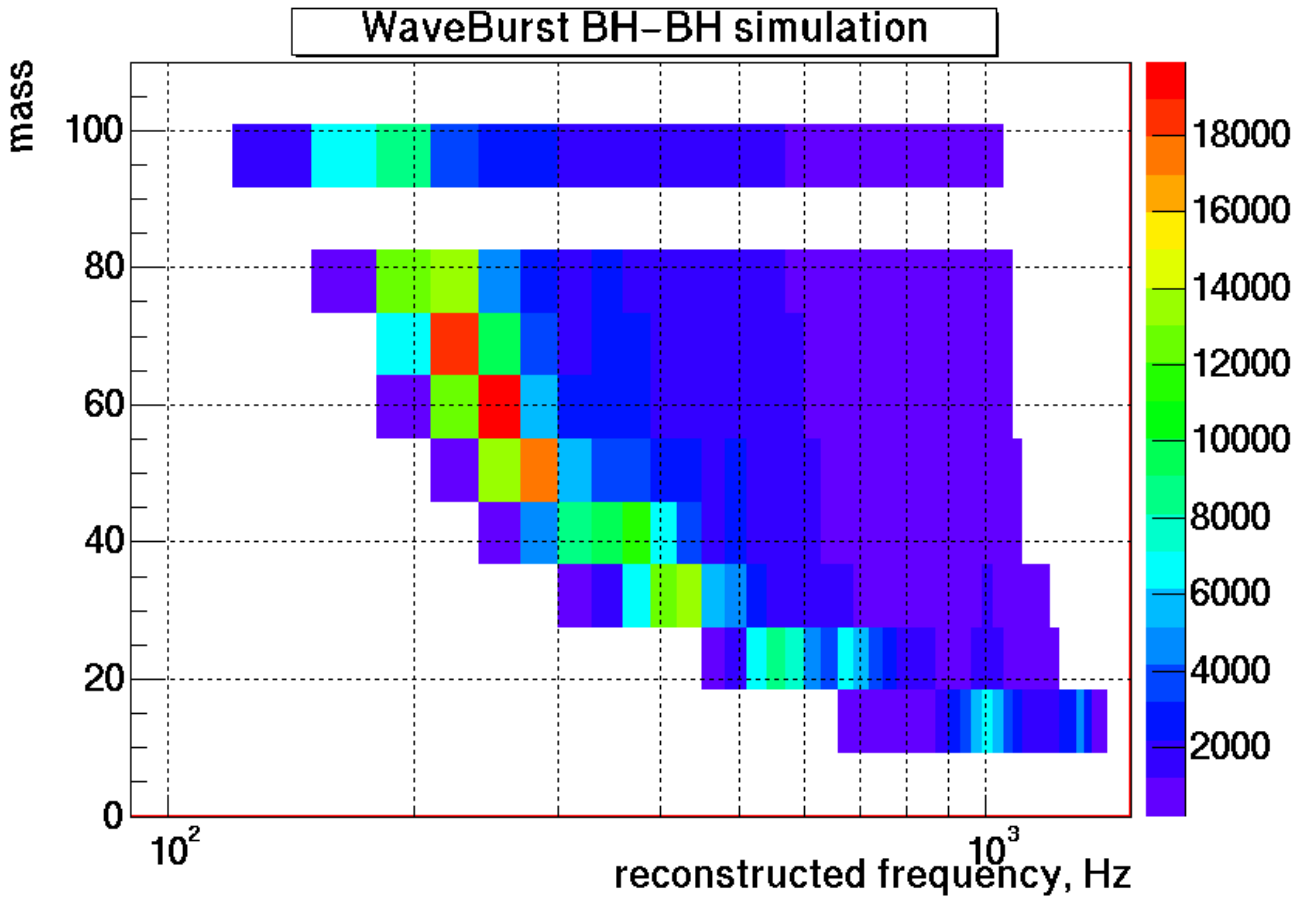
triple BH-BH efficiency

all sky search:
$hrss(50\%)/\sqrt{Hz}$
$\sim 2 \cdot 10^{-20}$



mass, Mo	10	20	30	40	50	60	70	80	100
hrss(50%) x 10^{-20}	4.5	2.4	2.0	1.8	1.5	1.7	2.2	3.4	7.1

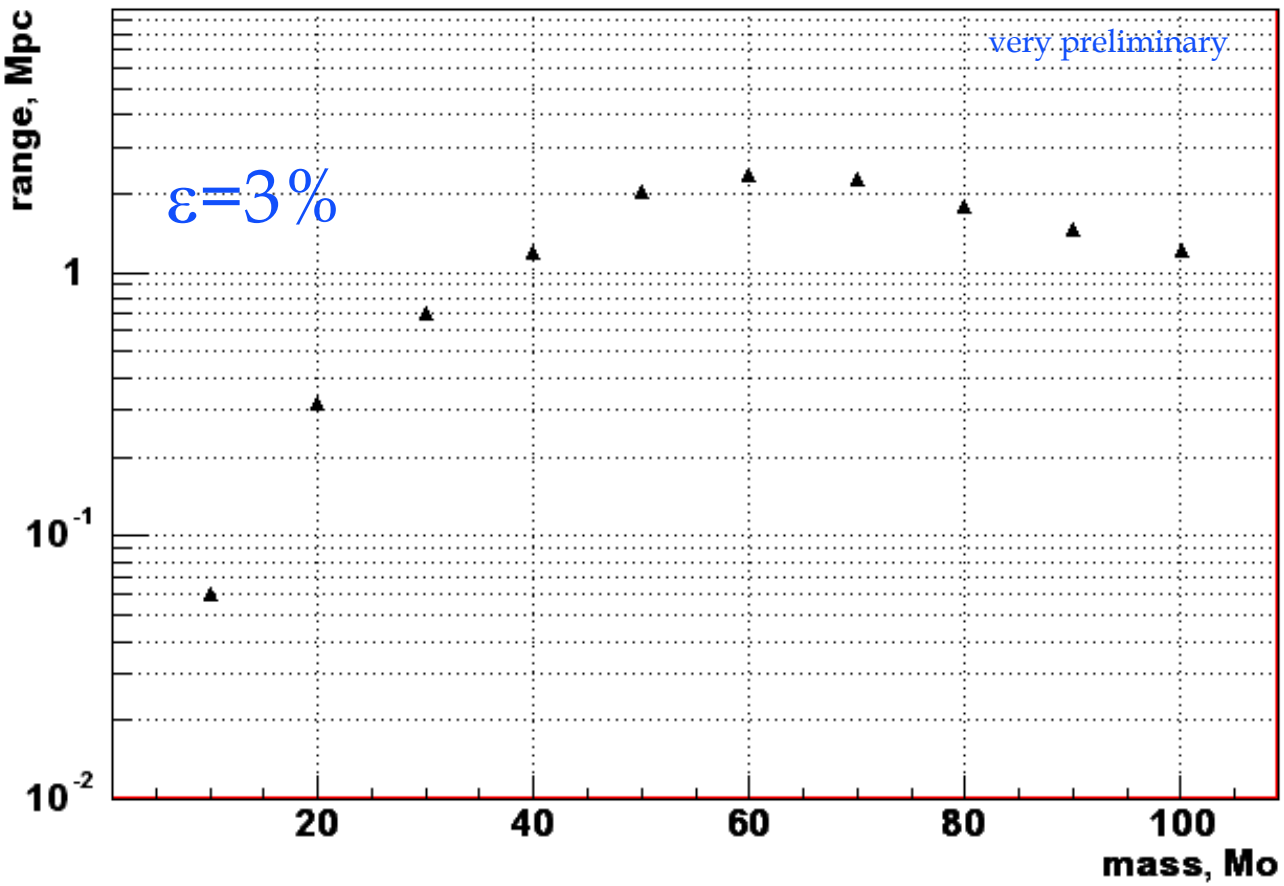
frequency vs mass



- **BH-BH frequency band – 100-1000 Hz**

triple BH-BH range

- triple coincidence of L1 x H1 x H2 for S2 noise
- average over all sky



Summary & Plans

- **WaveBurst pipeline sensitivity (low 3C rate @0.1 mHz)**
  - **(5-20) . 10^{-21} - optimal detection.**
  - **~2 . 10^{-20} - all sky BH-BH mergers search**
- **robust detection of different waveforms (SGQ9 vs SGQ3)**
- **Plans**
  - **study lower threshold case to increase sensitivity**
  - **do simulation of ZM supernova waveforms**