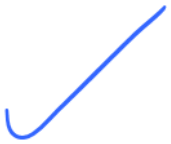
Paul Allen Y362220
S284 TMA_06

Question 2



A Mass-Gap Merger in O4

- Detected 29 May 2023, Livingston only
- Primary 2.5–4.5 M⊙ ⇒ “lower mass gap”
- Secondary 1.2–2.0 M⊙ neutron star
- Adds new evidence the gap isn’t empty

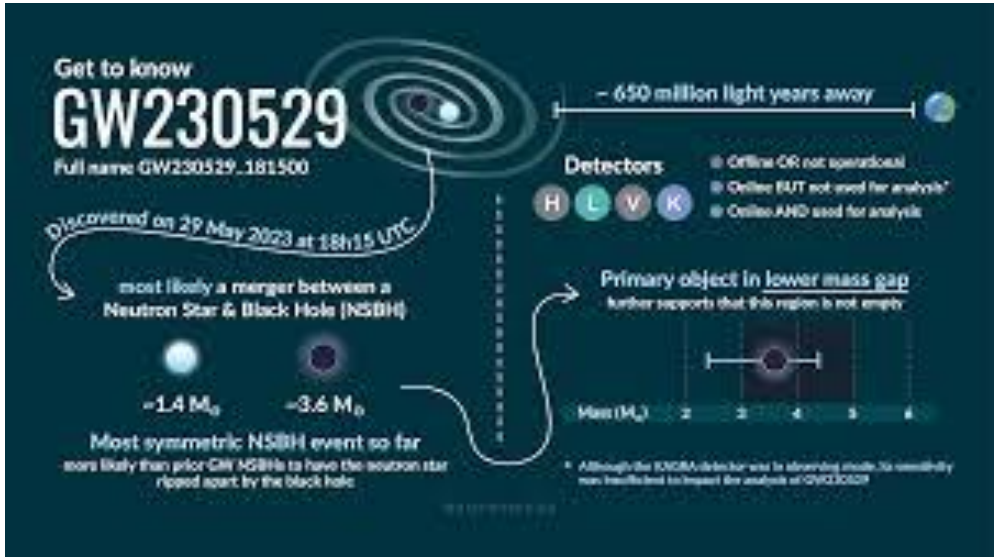


Image from:https://ligo.org/detections/gw230529/, accessed:28:03/25

Signal Stands Out from Noise

- Three matched-filter pipelines
  → **FAR < 1 in 1000 yr**
- S/N ≈ 11; strong single-detector event
- Livingston only ⇒ poor sky-map
  (~2×10^4 deg^2)
- Waveform = asymmetric NS-BH chirp

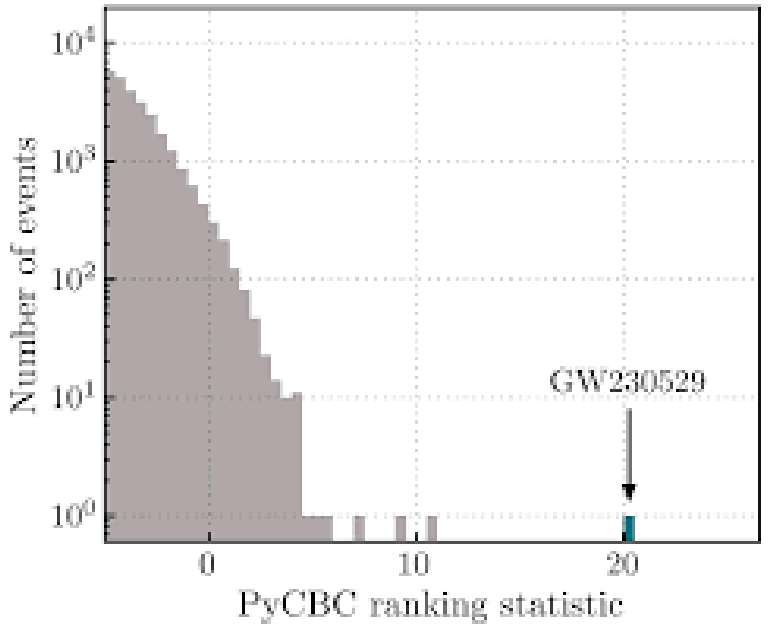


Image from: https://dcc.ligo.org/public/0190/P2300352/009/gw230529-discovery-8.pdf, acessed: 28/03/2025

Component Masses & Spins

- $m_1 \approx 3.6\ M\odot$ in mass gap
- $m_2 \approx 1.4\ M\odot$ – consistent NS
- Chirp mass 1.94 $M\odot$; total 5.1 $M\odot$
- Distance ~200 Mly ($z \approx 0.04$)
- Little evidence for spin-induced precession

No Confirmed EM Counterpart

- Single detector → wide sky area
- Multiple GRB / optical / neutrino searches → null
- Models: NS disruption unlikely (low ejecta $\lesssim 0.05\ M_\odot$)
- Faint or off-axis kilonova not ruled out

Re-thinking the Lower Mass Gap

- Shows 3–5 $M_\odot$ region **is populated**
- Low-mass BHs challenge core-collapse models
- Updates NS-BH merger-rate estimates (~60 yr^{-1} Gpc^{-3})
- O4 could exceed 200 GW events (Pratten 2024)

- “In addition to GW230529, we have identified about 80 other significant event candidates to investigate. We expect that by February 2025, when the fourth observing run ends, we will have observed more than 200 gravitational-wave signals. Future detections of similar events, especially those accompanied by bursts of electromagnetic radiation, could hold the key to solving this cosmic mystery of mass-gap and further our understanding of the universe.— BofB news, Apr 2024 .”

UofB News, Apr 2024, https://www.birmingham.ac.uk/news/2024/mass-gap-gravitational-wave-signal-discovered-by-international-scientists