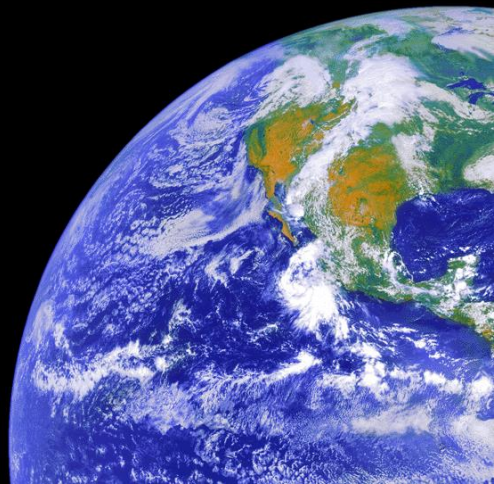
Summary of the Town Hall meeting and next steps

(a personal view)

Peter Shawhan
U. of Maryland / Joint Space-Science Institute

OpenLVEM Town Hall Meeting
MIT — March 17, 2018



LIGO-G1800408-v2

GOES-8 image produced by M. Jentoft-Nilsen, F. Hasler, D. Chesters (NASA/Goddard) and T. Nielsen (Univ. of Hawaii)

Goals of the Meeting

(David Shoemaker's talk)

To share LVC's expectations for how the GW detectors will operate during the O3 run

- And what it implies about expected event rates

To talk about the new direction we are going with the follow-up program for O3 and beyond

- Open Public Alerts: long promised, now will be the norm!
- Philosophy and mechanics of selecting event candidates and sharing information about them
- Preliminary (un-vetted) GCN Notices; GCN Circulars & Notices after vetting

To allow observers to discuss plans for taking advantage of this

- Acting on low-latency alerts
- Doing science with multi-messenger observations

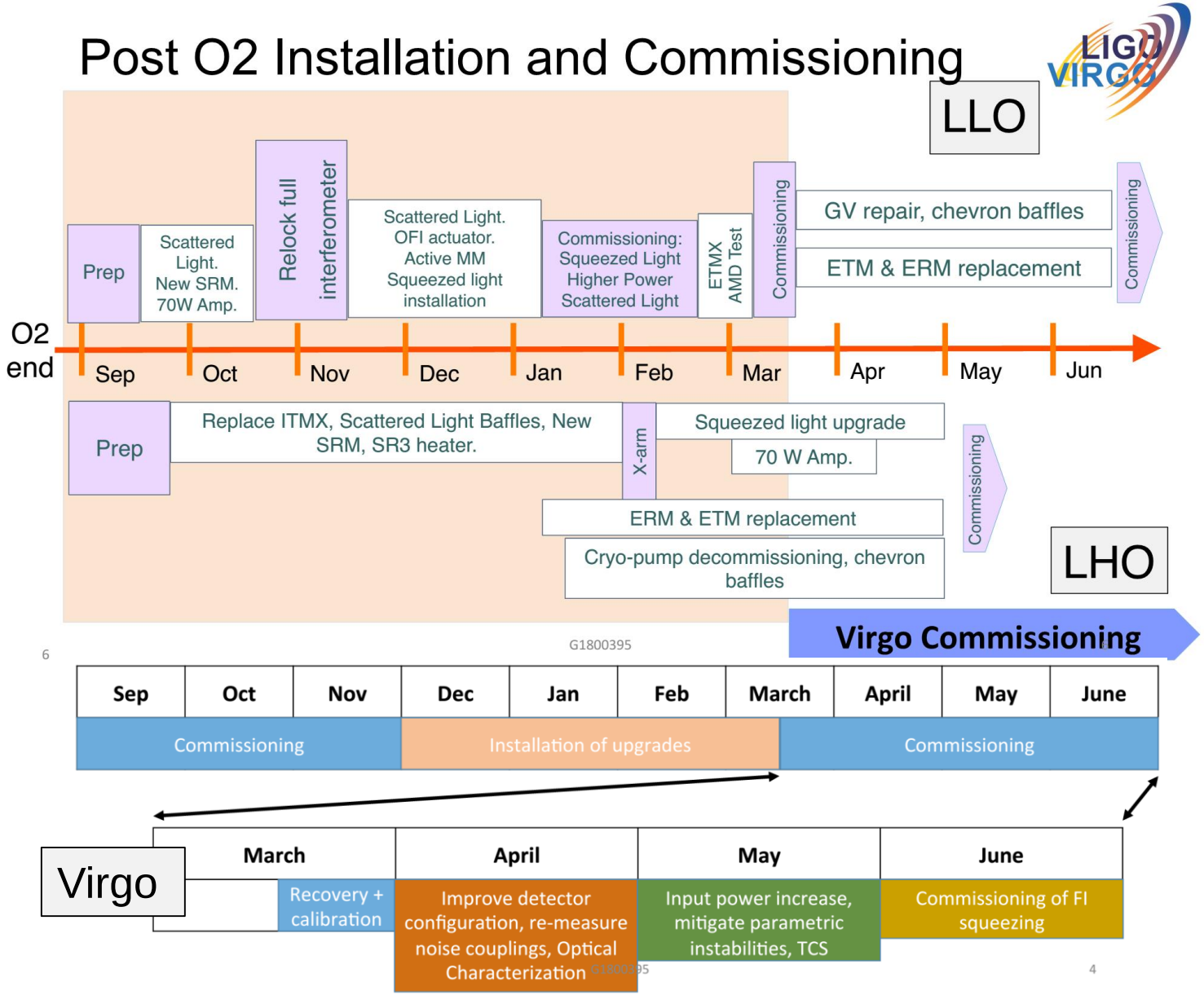
To discuss whether some science investigations will require more

- Active collaboration, joint papers, exchange of additional information, and/or lower-confidence event candidates

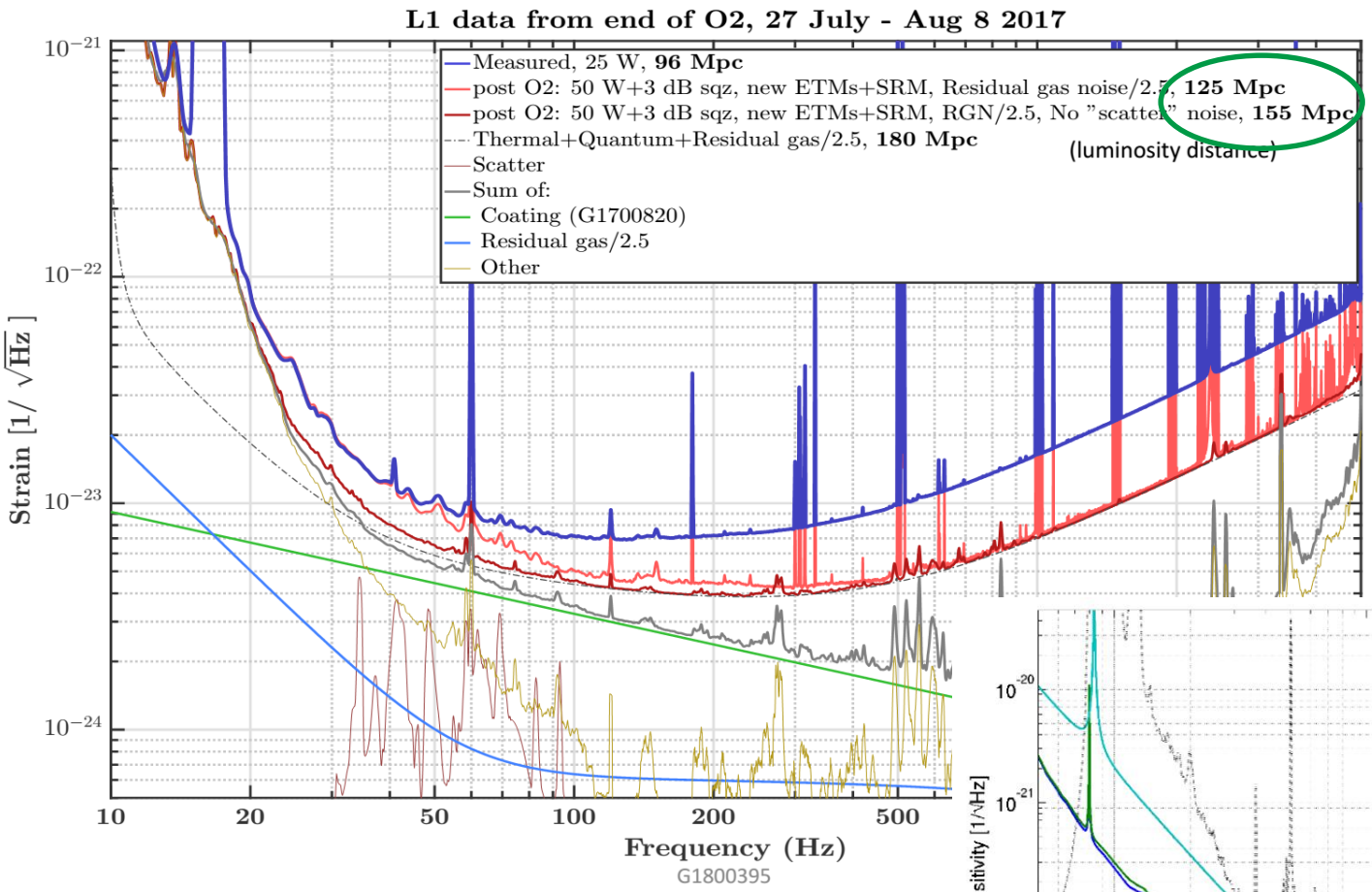
LIGO/Virgo instrument status & timeline

(Brian O'Reilly's talk)

Lots of work by Virgo and LIGO to achieve good sensitivity for O3

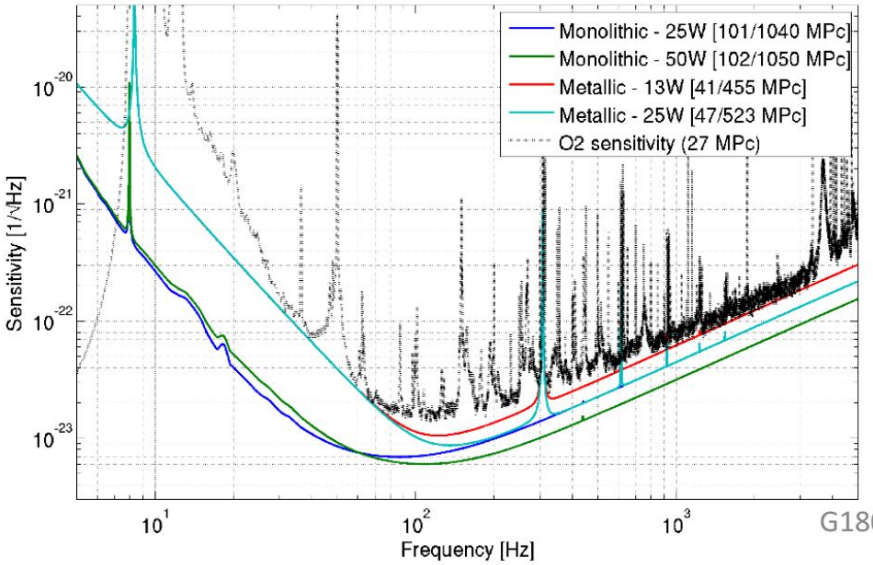


LIGO/Virgo expected sensitivities



Good reason to anticipate LIGO BNS range of 120 Mpc, at least

Somewhat greater improvements (vs. O2) for BBH and NS-BH (low f)



Virgo: aiming for 60–85 Mpc range

LIGO/Virgo run timeline

Virgo should make significant contributions to detection and localization of events

KAGRA now aims to join near the end of the run, but it's not yet known if their sensitivity will be sufficient to have a scientific impact

Single-detector searches are worth running

- To correlate with GRBs, at least

Date of beginning O3 run is not fixed, but expect Nov/Dec (/Jan?)

Engineering runs

- Virgo will start short engineering runs in April, but LIGO will be down
- First possible date of a joint engineering run: August
- Plan to have a one-month engineering run leading into O3
- Time for shaking down systems; may issue (open) alerts on best-effort basis
- Need to be clear about when we may send alerts – status display / API ?

Rate estimates

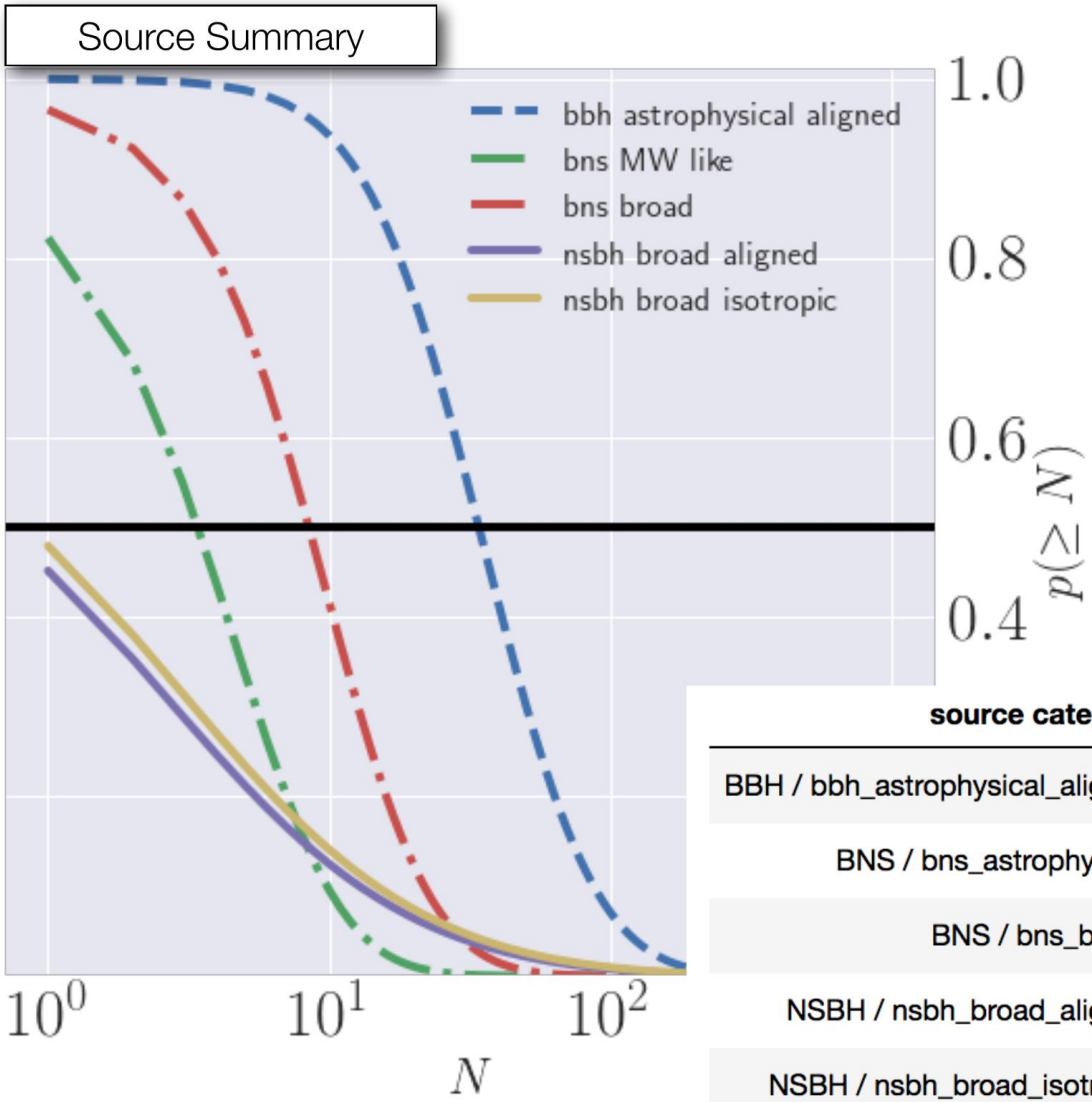
(Chris Pankow's talk)

In-press at Living Reviews, now posted at arXiv:1304.0670v5 :

Epoch			2015 – 2016	2016 – 2017	2018 – 2019	2020+	2024+
Planned run duration			4 months	9 months	12 months	(per year)	(per year)
Expected burst range/Mpc		LIGO	40 – 60	60 – 75	75 – 90	105	105
		Virgo	—	20 – 40	40 – 50	40 – 70	80
		KAGRA	—	—	—	—	100
Expected BNS range/Mpc		LIGO	40 – 80	80 – 120	120 – 170	190	190
		Virgo	—	20 – 65	65 – 85	65 – 115	125
		KAGRA	—	—	—	—	140
Achieved BNS range/Mpc		LIGO	60 – 80	60 – 100	—	—	—
		Virgo	—	25 – 30	—	—	—
		KAGRA	—	—	—	—	—
Estimated BNS detections			0.05 – 1	0.2 – 4.5	1 – 50	4 – 80	11 – 180
Actual BNS detections			0	1	—	—	—
90% CR	% within	5 deg^2	< 1	1 – 5	1 – 4	3 – 7	23 – 30
		20 deg^2	< 1	7 – 14	12 – 21	14 – 22	65 – 73
	median/deg^2		460 – 530	230 – 320	120 – 180	110 – 180	9 – 12
Searched area	% within	5 deg^2	4 – 6	15 – 21	20 – 26	23 – 29	62 – 67
		20 deg^2	14 – 17	33 – 41	42 – 50	44 – 52	87 – 90

O3

Range of likely rates – BBH, BNS, NSBH(?)



There are caveats, but the general picture is:

BBH: at least a few per month, maybe more

BNS: 1–10, possibly up to ~1 per month

NSBH: Could detect one or more during O3, but uncertain. We'll see!

source category	full year VT	N_d
BBH / bbh_astrophysical_aligned	6.8×10^8 Mpc^3 yr	34^{+79}_{-25}
BNS / bns_astrophysical	3.2×10^6 Mpc^3 yr	4^{+9}_{-4}
BNS / bns_broad	7.3×10^6 Mpc^3 yr	9^{+19}_{-7}
NSBH / nsbh_broad_aligned	5.0×10^7 Mpc^3 yr	1^{+24}_{-1}
NSBH / nsbh_broad_isotropic	5.7×10^7 Mpc^3 yr	1^{+28}_{-1}

Implications of these rates

Those estimates are for 3-detector events; will also have some 2-detector events (and potentially 1-detector, if validated by a counterpart)

Handling these rates will present challenges

- Will you still follow up on all the BBHs you can?
- There will be times with more than one event "in play" – we will need to keep the identities clear
- Unlikely (not impossible) to get another BNS event as close as GW170817
- Nearby core-collapse supernova? Better be ready for one

Publishing schedule?

- Notable individual events will still be published individually, including at least the next few BNS
- Expect to publish "routine" events periodically in catalog papers; maybe 6-month cadence, but this is under discussion. Could coordinate.
- Issue: delay in getting parameter results out could negatively impact EM observers publishing about the event

Open public alerts

(Leo Singer's talk)

LIGO-Virgo alerts in O3 will all be public

- We will set CBC FAR threshold to try to get an *overall* purity of 90%
- We will tell you the FAR so that you can be more selective if you want
- CBC alerts will include type classification
- We'll issue an alert for a sufficiently high-confidence GW burst detection
- We will "promote" a weaker event to a public alert if it is compellingly associated with a multimessenger signal
- Alerts will be communicated using (regular) GCN Notices and Circulars, starting with one or more *Preliminary* Notices before vetting
- ➔ Users should be prepared to handle *Retraction* Notices too

LIGO/Virgo are looking forward to seeing the fruits of open alerts

- This plan for the program was the result of extended discussions, endorsed by votes of the LSC Council and Virgo Steering Committee

Information in open public alerts

General LVC philosophy: provide information relevant to identifying a counterpart to a GW candidate

CBC type classification

Will continue to provide probabilities as in O2; developing other things too

This is not trivial to do well with low-latency analysis, but

we should provide this as soon as it's available, in *Preliminary* Notices

p_{astro} : we'll calculate it to the extent we can

But this is nontrivial – depends on our understanding of the population of real events, which evolves – and we don't currently have someone to do it

Updates

LVC will provide updated information when it becomes available, if it's measurably different (criteria TBD) from what was sent earlier and if it could help identify or confirm an unambiguous counterpart

LVC challenge in the past has been deciding when we have a better map

Timeline for alerts

***Preliminary* Notices: as soon as automated processing is done**

Vetting for confirmation (*Initial* Notice + Circular) or retraction

- Understand that BNS and NS-BH are priorities to complete vetting ASAP
- Current thought is to be more relaxed for BBH events (unless they are obviously real), to reduce middle-of-night obligation on scientists & staff

Timing of alerts

- We can control this to some extent, e.g. aim to provide an intermediate skymap update after a certain number of hours, if that would be helpful

When do final results of LVC analysis become available?

- For notable events: as soon as we can complete them and publish a paper
- For routine events (vanilla BBH for now): planning to just report in catalog paper. Could maybe provide some public information before that, e.g. confirming type of CBC event. Also something like total mass?

Provide wide access to phone / text alerts, besides GCNs?

Other information

Data quality caveats, when known

Unclear exactly what form this will take, what we can say about impact

Calling out interesting events will help prioritize follow-up observing

Including interesting BBH, to the extent we can determine that in low latency

Provide information about inclination?

LVC can't say measure well if close to on-axis, especially in low latency

GW instrument status information

Can LVC report for every GRB even if no GW candidate is found?

Not sure we'd issue a Circular for *every* reported GRB, but can set criteria, e.g. short GRBs, nearby/bright GRBs. Planned to start near end of O2.

Combined localization region with Fermi GBM, others?

Useful, but unclear how they can be delivered

Candidate event vetting

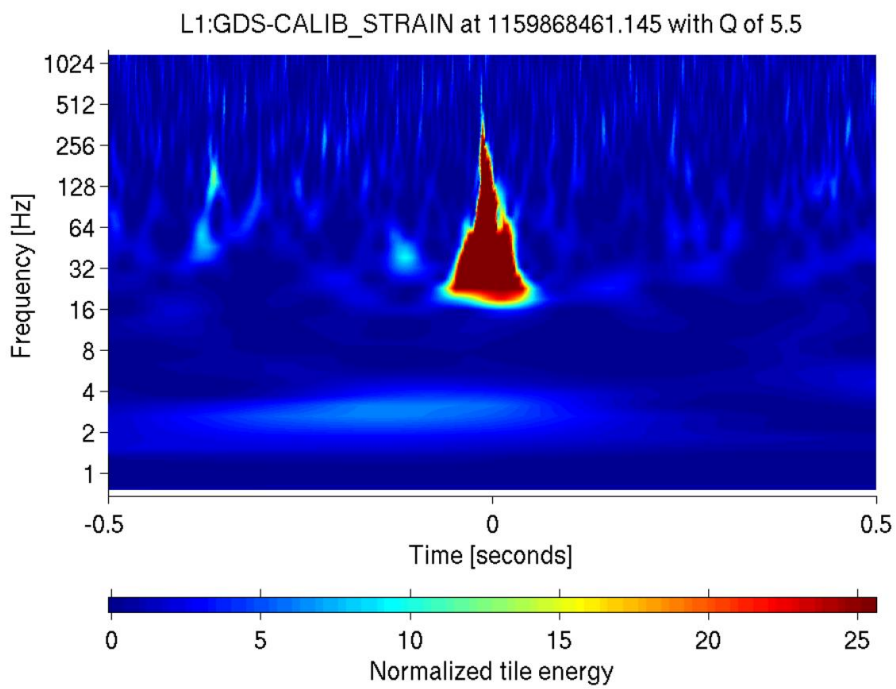
(Brian O'Reilly's talk)

Rapid Response Team (RRT)

- Led by site advocates

Possible reasons to reject a trigger

- Issue with one of the instruments
- Issue with a data analysis pipeline
- Data quality issue



Caveat: Some instrumental artifacts may not have a good veto.
In this case we err on the side of accepting the event

- But need to be confident that the FAR estimation is valid

Contributed presentations

Precision standard siren cosmology *(Hsin-Yu Chen)*

Joint GW-GRB Localizations with Fermi GBM *(Adam Goldstein)*

GW Follow-up with the Full Suite of Steward Observatory Facilities *(Dave Sand)*

Observational implications of lowering the LSC-Virgo alert threshold *(Ryan Lynch)*

Importance of Early Optical and UV Observations for Constraining Kilonova Physics *(Iair Arcavi)*

The Astrophysical Multimessenger Observatory Network (AMON) in the LSC-Virgo era *(Hugo Ayala)*

IKI/Purdue-GW follow up network (EM counterpart search, modeling) *(Maxim Barkov)*

Just a sampling of some of the opportunities and science considerations

Opportunities for science-driven collaboration

(Erik Katsavounidis's talk)

We're delivering OPAs and we expect most multi-messenger science investigations to be based on those events

Some investigations may warrant sharing additional events; there are several existing MOUs

Regardless, we may need to collaborate to make best use of OPA events

How does an opportunity get proposed and discussed?

Some boundary conditions firm, others may be rethought (?)

Policy Fundamentals

Objectives must be part of the science program of the LIGO-Virgo Collaborations.

Agreements/collaborations with non-LIGO-Virgo partners should not be "exclusive" for any of the science topics pursued.

Data/information/results privacy to be maintained at all times.

Joint Publications of results upon mutual agreement and with the whole LIGO-Virgo author group.

?

Questions Re: science-driven collaboration

What is time-critical (i.e., relevant for low-latency)?

What is the added value in such science areas the collaborative effort will bring w/r/t what public data can offer? 7

How to start collaborative analyses?

- A written proposal that presents the idea, analysis, data (EM/nu/GW) and measurement/ publication?

How do we organize such collaborative efforts?

- Some MOU structure will be needed Peer-to-peer, broader group-structure?

What happens when multiple parties with overlapping interests/proposals materialize?

Do we set this up now or after observations/detections take place?

Need to strike a balance

Desire to do all possible science enabled by GW and other observations, and to do it optimally

Desire to get credit for doing / contributing to good science

versus

Effort required to make and fulfill commitments

LVC having to pay attention to many different projects

Sub-optimal analysis can still be worth doing

Notes from break-out sessions and discussion

Cosmology/Hubble constant

- Using EM observations can break inclination degeneracy, but requires careful modeling
- Should express needs even for “routine” observations, to help observers obtain the resources to make them

Fundamental physics/GRB (prompt HE emission)

- Push to identify additional counterparts
- The role of AMON, and possible MOU implications
- Archival search is underway, but caveats about selection criteria

NS physics/EM broadband modeling and interpretation

- “Coveted information”, principally **inclination**
- Combining data and modeling to get at physical properties of NS
- Two areas of motivation for MOUs: weak/subthresh kilonovae or faint supernovae; strongly lensed events (repeats)
- Centralized resources / software tools / planning ?

General themes

There are things which require deliberate collaboration to be done well

For any agreements, need to solicit participation equitably rather than selecting based on personal relationships, for instance

Theory / modeling is important for doing this science well, so need to engage those scientists too

Final notes

Many thanks to Erik Katsavounidis and the MIT LIGO staff for hosting this meeting!

Now, let's get ready for O3!