ICRR
Institute for Cosmic Ray Research
University of Tokyo

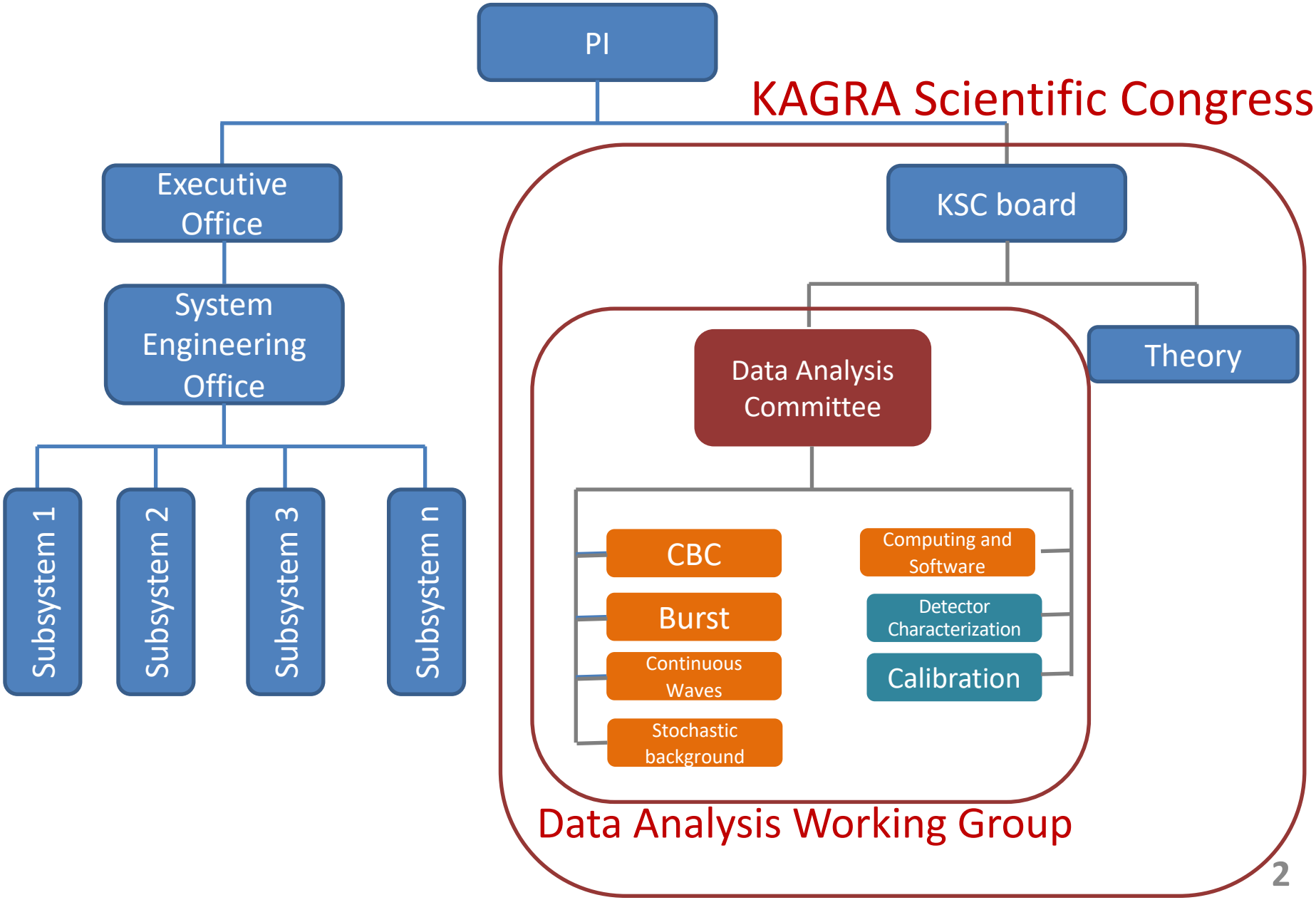
KAGRA Data Analysis Working Group

Hideyuki Tagoshi

(ICRR, U Tokyo)

JGW-G1909833

Image of new organization structure of KAGRA



Working group chairs

	Chair	Vice-chairs
CBC	Hideyuki Tagoshi	Hyung Won Lee Kipp Cannon Tjonnie Li
Burst	Kazuhiro Hayama	
Continous Waves	Yousuke Itoh	
Stochastic Background	Guo-Chin Liu	Sachiko Kuroyanagi
Computing and Software	Ken-ichi Oohara	Kazuki Sakai
Detector Characterization	TBD	
Calibration	Yuki Inoue	

Data Analysis Committee

Chair: Hideyuki Tagoshi (also CBC chair)

Members: Kazuhiro Hayama (Burst chair)
Yousuke Itoh (CW chair)
Guo-Chin Liu (Stochastic chair)
Ken-ichi Oohara (Computing and Software chair)
Yuki Inoue (Calibration chair)
TBD (Detchar chair)

Observers: Nobuyuki Kanda (DMG chief)
Kazuhiro Hayama (DET chief)
Hisaaki Shinkai (KSC board)

- Chair of Data Analysis Committee
- Chairs of working groups
  (CBC, Burst, CW, Stochastic, Computing and Software, Calibration, Detchar)
- Observers: DET chair, CAL chair, DMG chair
- One or two KSC board members

Data Analysis Reserach Unit

Individual research groups for data analysis in KAGRA

37 Research Units
115 members

Summary of groups

CBC	Burst	CW	Stochastic	Comp&Soft	Em Follow up	Others
24	13	2	5	20	2	3

CBC

CBC-TGR	CBC-PE	CBC-Online	CBC-Offline	CBC-Theory	CBC-others	CBC total
12	10	4	4	7	5	25

Burst

Burst-Search	Burst-PE	Cosmic String	Burst total
7	6	2	13

Computing and Software

Computing & Software	Machine learning	Statistics, Data science
13	9	2

Data transfer, Computer, Software

These are managed by

- DMG (Data management subsystem, chief: Nobuyuki Kanda)

  detector-side tasks

- Computing and Software working group

(chair: Ken-ichi Oohara, vice-chair: Kazuki Sakai)

wide variety of tasks

Data flow and distribution

Data transfer : Construct stable path to Tier-1 and Tier-2,3

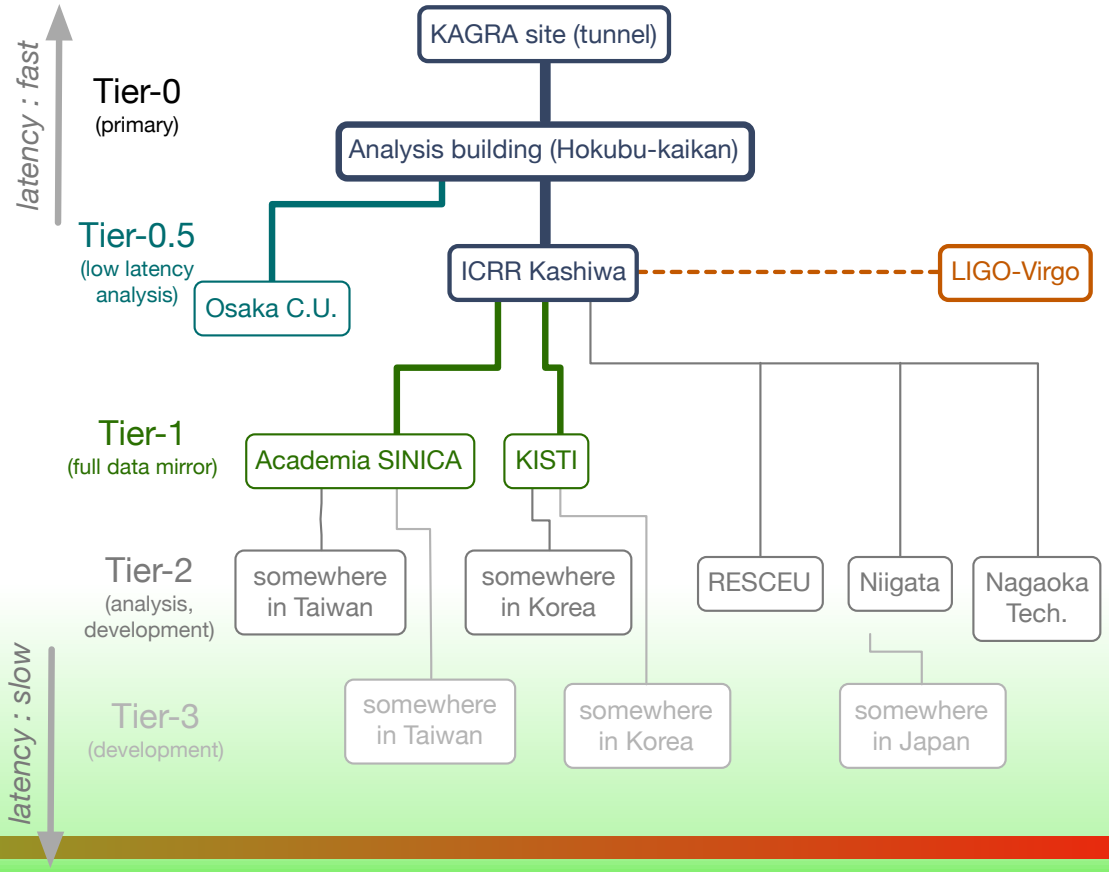
Tier-0 (primary)
: Kashiwa main storage system

Tier-1 (full data mirroring)
: Academia SINICA, KISTI
Recently some network troubles occurred, but now it's resolved.

Tier-2 (delayed automatic transfer)
: Niigata U., Nagaoka U. Tech., RESCEU U.Tokyo., etc…
Each site can decide their policy about the period and kind of data.
Software tests of Tier-2 are planned to be done this winter.

Tier-0.5 (Low latency transfer)
: Osaka City U. (RESCEU will be.)

KAGRA data tree (unfinished)



Between LIGO-Virgo and KAGRA

Low latency data sharing with LV

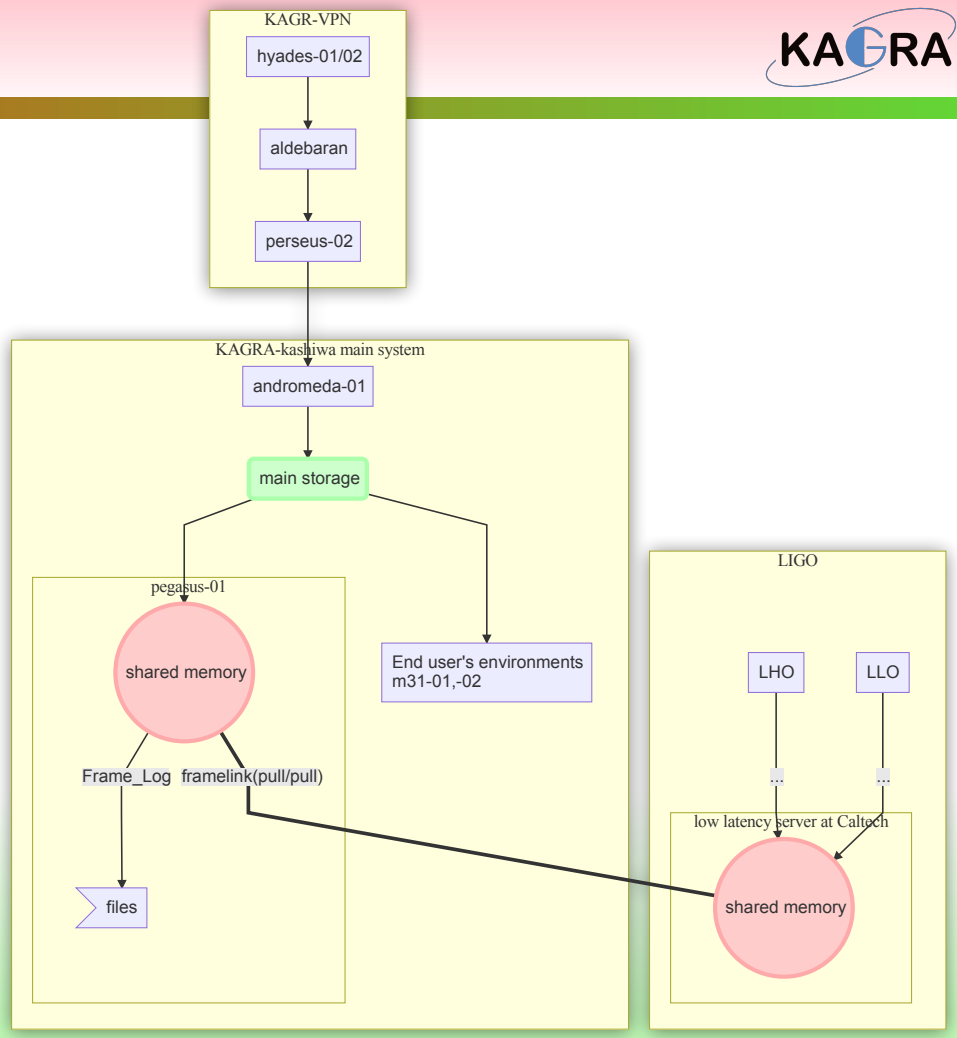
KAGRA will send short (1sec) frame data from IFO site to Kashiwa.

Data sharing dedicated server will put it on the 'shared memory'.

Shared memory of servers at LIGO (Caltech) and at KAGRA will be synchronized.

Each site can read/extract h(t) in very low latency.

[Current latency]
from* LHO to Kashiwa : about 6.4 sec
from* LLO to Kashiwa : about 9.6 sec
(*from the A/D converter=beamsplitter)



Kanda

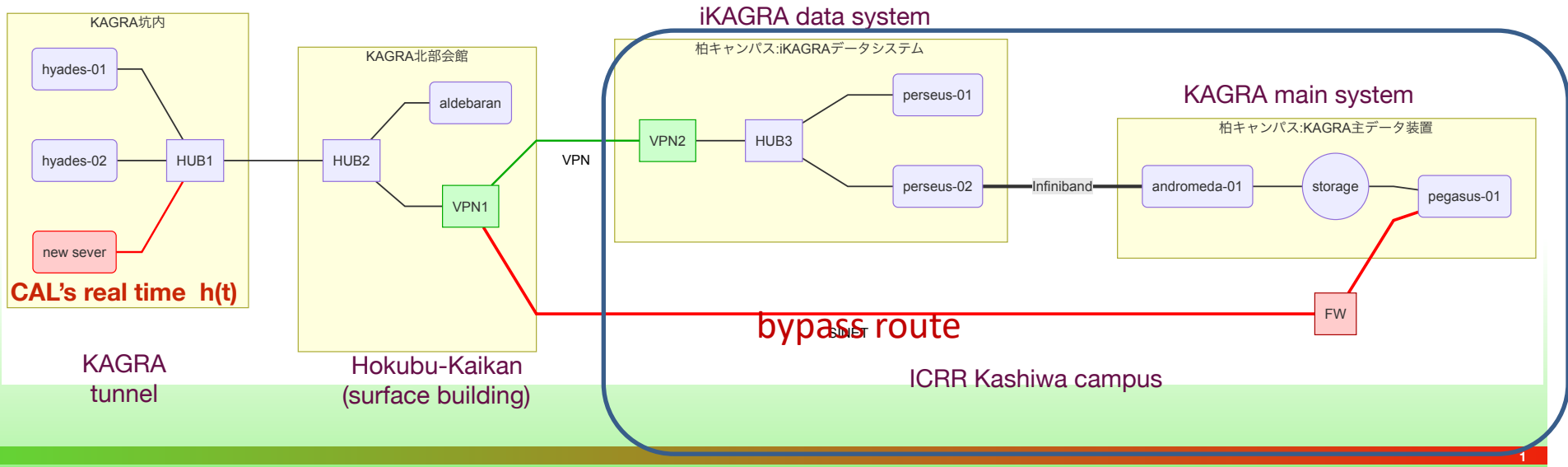
The status of the transfer can be viewed at the LIGO monitor site.

Low latency transfer

Low latency transfer from the KAGRA site (tunnel) to Kashiwa

CAL subsystem will generate real time h(t) generation by 'gstlal', i.e. 1sec or 4sec data chunks. h(t) data will be pushed to Kashiwa via the network, and will be stored in the shared memory.

- Some modification of the routing of VPN had already done.
- Both CAL's server and KAGRA main system's server are installed/tested 'framelink' for the shared memory transfer/receive.
- This connecting is planned to be available by the end of Feb.2019.



Kanda

Data transfer: remaining tasks

1. Bulk data transfer between LIGO-Virgo and KAGRA

2. Low latency h(t) transfer from Kamioka to Kashiwa
   - Connection to calibration system, bypass transfer

3. Plan to start steady operation of data transfer system including the connection with LIGO-Virgo in this month.

4. Data distribution environment for Tier-2,3
   - Software, disk management, etc.

Computing resources in Japan

Site	Nodes	Cores (clock)	Memory/core (GB)	Storage	Misc.
Kamioka (surface)				200 TiB	Spool, On-site analysis
iKAGRA				100 TiB	Spool
KAGRA Main	12	336 (2.4GHz)	9.14	2.5 PiB	dedicated
ICRR (Tagoshi)	7	224 (2.1GHz)	3	11 TiB	dedicated
ICRR (Hayama)	8	224 (2.6GHz)	16	48 TiB	dedicated, GPU(GTX1080Ti)x4
ICRR-Center	1	20 (2.2GHz)	6.4	122TiB	shared, total 2060 cores, 1 node dedicated for KAGRA
OCU	28	~~760~~ 920 (2.6GHz)	4.57	304 TiB	dedicated
RESCEU (Kambai)		540		100 TiB	dedicated
Niigata	4	60 (2.6,3.2)	3.2,4,8	92TiB, 64TiB	dedicated
Nagaoka	3	40 (3.1,3.2)	16,8,16	92TiB	dedicated, GPU(GTX1080Ti)x2

Computing resources in abroad

Site	Nodes	Cores (clock)	Memory/core (GB)	Storage	Misc.
KISTI-GSDC		404	7.1	65TB (100TB after 2019)	Tier-1 mirroring etc. shared btw LIGO and KAGRA
Shanghai Astronomical Observatory		~67 (2.44GHz)	4	2TiB	shared system (total:1344cores, 5%available)
Academia SINICA				220 TiB (will be ~PB)	Tier-1 mirroring, etc.
Taiwan (Lin, Liu)		7-8Million CPU hours or 2.9-3.3 x 10^5 GPU hours			billing system

KAGRA Main System

System-B is planned in 2020

Software

KAGALI: KAGRA Algorithmic LIbrary
current version: 0.0.5a

- Common data analysis framework for KAGRA group
- Primary language: C
- Managed by git repository
- Can depend on LAL

Major pipelines:
CBC offline search pipeline, CBC MCMC pipeline

Burst

Chair: Kazuhiro Hayama

1. Searches
   - All sky search
   - Triggered search
2. Post-processing of triggered burst signals
3. Characterization of burst signals

For O3:

1. Postprocess of the triggered events performed by all sky/triggered burst searches including BBHs.
   - Characterization of triggered events using time-frequency analysis
   - Stokes parameters

1. Searches for specific sources such as SNe, GRBs, FRBs, Cosmic strings etc.

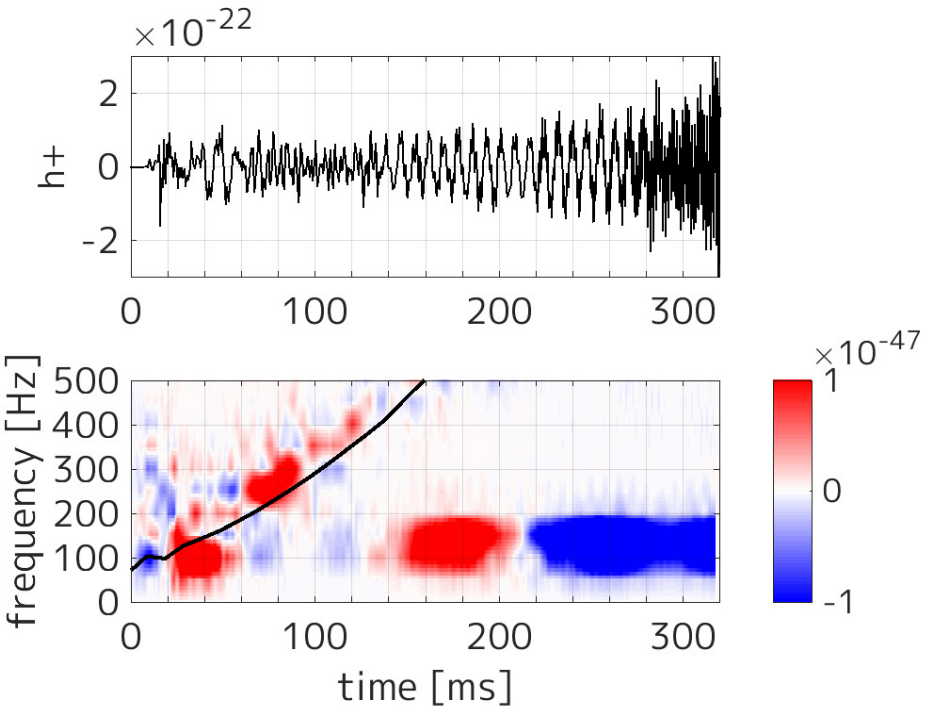
Burst: Collaboration with theory group

Supernova simulation

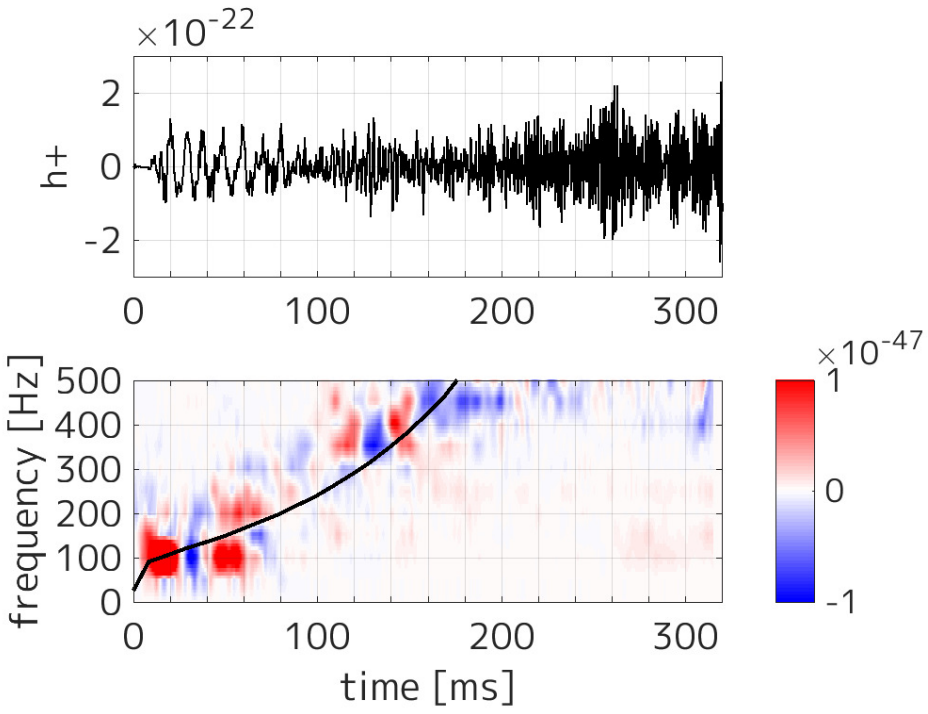
Kei Kotake (Fukuoka U), T. Takiwaki (NAOJ), T. Kuroda

Hayama et al. PRL116, 151102, 2016
Hayama et a. arXiv:1802.03842

Circular polarization of GWs from proto neutron star



Spectrogram of Stokes parameter V



Spectrogram of Stokes parameter V

Burst: Collaboration with LIGO-Virgo

Collaboration with LIGO-Virgo burst group started partially
(Sergey Klimenko, Marek Szczepanczyk)

Tasks:

- Imprement the polarization-reconstruction code in cWB
- Develop codes to compute stokes parameter for triggered events

Continuous Waves

Chair: Yousuke Itoh

1. Known pulsar search
   LAL-based analysis framework has been established
   iKAGRA analysis was done

2. Stochastic point source search
   Radiometer with GPGPU search code

Problem: manpower

Recently, a group from Taiwan joined. (Chia-Ming Kuo, NCU)
They will start working on blind search

Stochastic background

Chair: Guo-Chin Liu
Vice-chair: Sachiko Kuroyanagi

1. Isotropic stochastic gravitational-wave background search

   Parameter estimations with different theoretical models (power index, broken-power law, energy density)

2. All-Sky, all-frequency search or mapping

   Searching or modeling for different astrophysical sources
   Developing

CBC

Chair: Hideyuki Tagoshi
Vice-chairs: Hyung Won Lee, Kipp Cannon, Tjonnie Li

1. **Collaboration with LIGO-Virgo**
   - Operation of gstlal-inspiral during O3 to analyze KAGRA/LIGO/VIRGO data both for online and offline search
   - alert is included
   - Test operation will be done at Kashiwa soon.

2. **PE pipelines for CBC**
   - Project lead by Korean group (Hyung Won Lee)
   - MCMC (Metropolis-Hastings)
   - Other methods

3. **GPU acceralated PE for CBC**
   - Project lead by Taiwan group (Sadakazu Haino)
   - Nested sampling

ICRR
Institute for Cosmic Ray Research
University of Tokyo

KAGRA

JGW-G1809082
LIGO-G1802015-v2

On the KAGRA's sensitivity threshold at O3

Hideyuki Tagoshi
with
Sadakazu Haino, Tatsuya Narikawa, Soichiro Morisaki

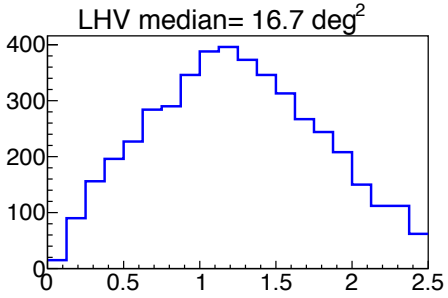
JGW-G1809082
LIGO-G1802015-v2

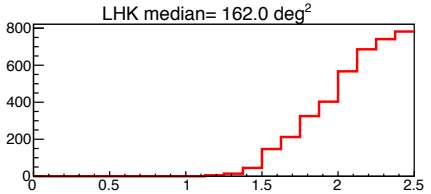
October 11, 2018, JRPC

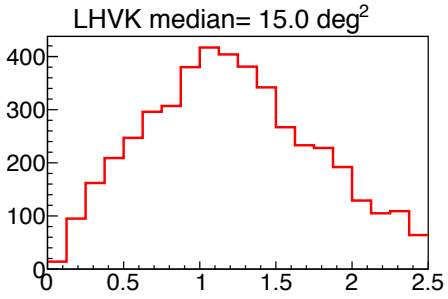
BNS range of 10 Mpc is the minimum sensitivity

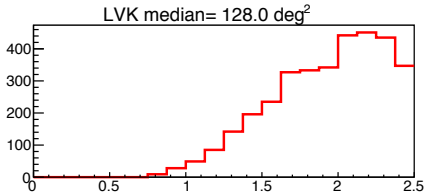
But more sensitivity is better, of course

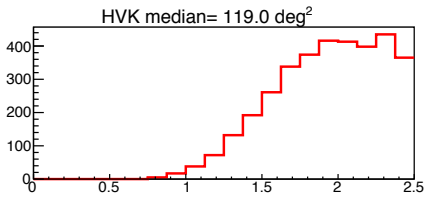
Nested Sampling Results











CBC

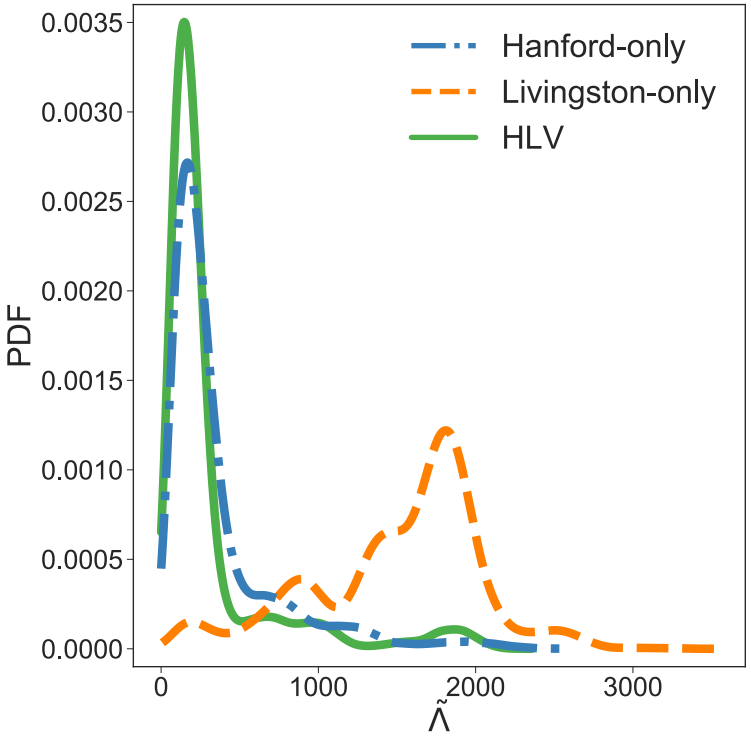
4. **Original CBC search pipeline**
   - One pipeline : iKAGRA data analysis
   - New pipeline

5. **Various Topics**
   - Tidal deformability
   - QNM
   - Echo
   - New method
   - etc.

Tidal Deformability of GW170817

Narikawa et al. arXiv:1812.06100

Re-analysis of GW170817 open data with LAL and
show the Hanford result and the Livingston result separately



Livingston's contribution
to the final result is small

Livingston's results is not
very stable.

However, lal PSD estimation was found to be the old one used by LV.
Data was also C01 not C02.
Now under investigation

Summary

We have to rush toward O3.