Special working group for LCGT Roadmap

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On behalf of LCGT special working group

LCGT Roadmap Special working group

Roadmap special working group

- Ad-hoc working group to make recommendation on the LCGT commissioning schedule.
- Open for all collaborators, nominally ~20 participants.
- Brainstorm-type meeting with free discussions.
- 14 meetings since Oct. 25, 2010.

Original Scope

- To recommend the roadmap to realize bLCGT (after iLCGT), including design, research, development, performance test, installation, and shakedown procedures.

⇩ After the external review and establishment of the system engineering office.

Current Scope

- To recommend the roadmap to realize LCGT.
- Summarize the master schedule, considering basic concepts and schedule constrains.

Task flow

Working group task flow

- Collect information
  - Project: definition of LCGT, constrains form budget and schedule
  - Science: observation targets
  - Technical feasibility:
    - technology readiness, development plan, risk factors
- Decide basic policies
- Determine a master schedule of LCGT construction

- Break down to each subsystem schedule
  - ... several iteration ....
- Summarize a recommendation document

Target, constraint, and basic policies

Target and constraints

LCGT baseline concept

Purpose: detection of gravitational-wave signal

⇨ Primary target --- NS binary inspiral

3km cryogenic RSE interferometer at underground site

Constraints

- Financial constraints:

  First 3-year construction has been approved.

  Excavation cost has been approved.

- Uncertainties in the excavation schedule.

Basic policies

Basic policies

- First priority in schedule is to achieve the bLCGT observation.
  Additional tasks should be minimized.

- Tight schedule to start observation run in 2017.
  - Intensive preparations are required before installation,
    for efficient commissioning and for reduction of technical
    and schedule risks.
  - All the R&Ds should be completed before installation.
    LCGT should not be used as a R&D facility.

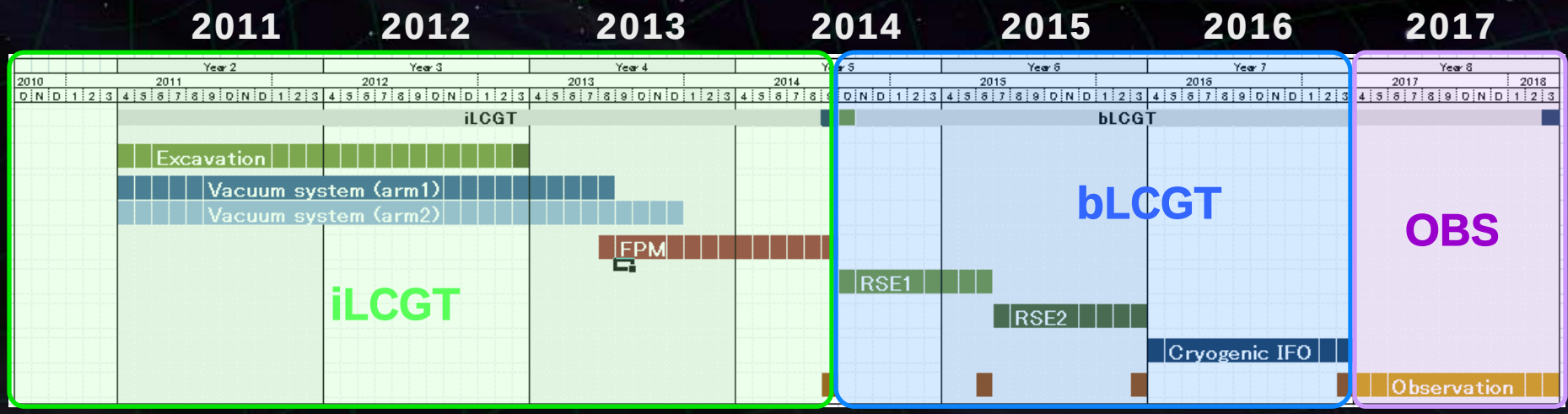
- LCGT is a big project with responsibility. So best effort should
  be made to maximize scientific outcomes and to keep schedule.

- First km-scale interferometer leaded by the Japanese group.
  → Step-by-step construction and commissioning.

Master Schedule

Master Schedule

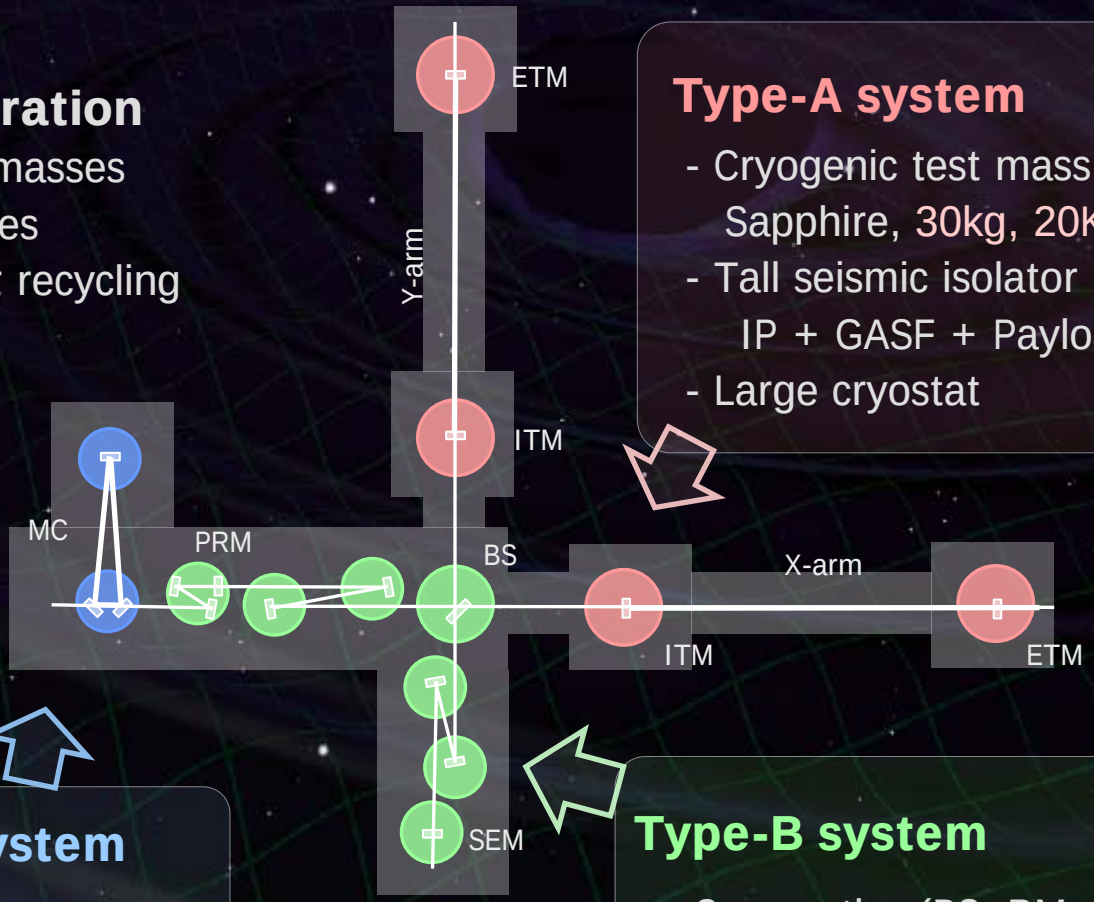
- **iLCGT** : Stable operation with a large-scale IFO (2010.10 - 2014.9)
  - → 3km FPM interferometer at room temperature, with simplified vibration isolation system
  - ~1 month (TBD) observation run
- **bLCGT** : Operation with the final configuration (2014.10 – 2017.3)
  - → RSE, upgraded VIS, cryogenic operation
- OBS : Long-term observation and detector tuning (2017.4 -)



bLCGT configuration

bLCGT configuration

- Cryogenic test masses
- 3 km arm cavities
- RSE with power recycling



Type-A system

- Cryogenic test mass
  Sapphire, 30kg, 20K
- Tall seismic isolator
  IP + GASF + Payload
- Large cryostat

Type-C system

- Mode cleaner
  Silica, 1kg, 290K
- Stack + Payload

Type-B system

- Core optics (BS, RM ,...)
  Silica, 10kg, 290K
- IP + GASF + Payload
- Stack for aux. optics

Commissioning Plan

- **LCGT schedule is extremely tight.**
  - → We should reduce the amount of the on-site commissioning tasks.
    - Intensive tests are required for each sub-system before installation.
    - Avoid additional tasks only for intermediate steps.
    - Basic policy 'Do not use LCGT as an R&D facility'.

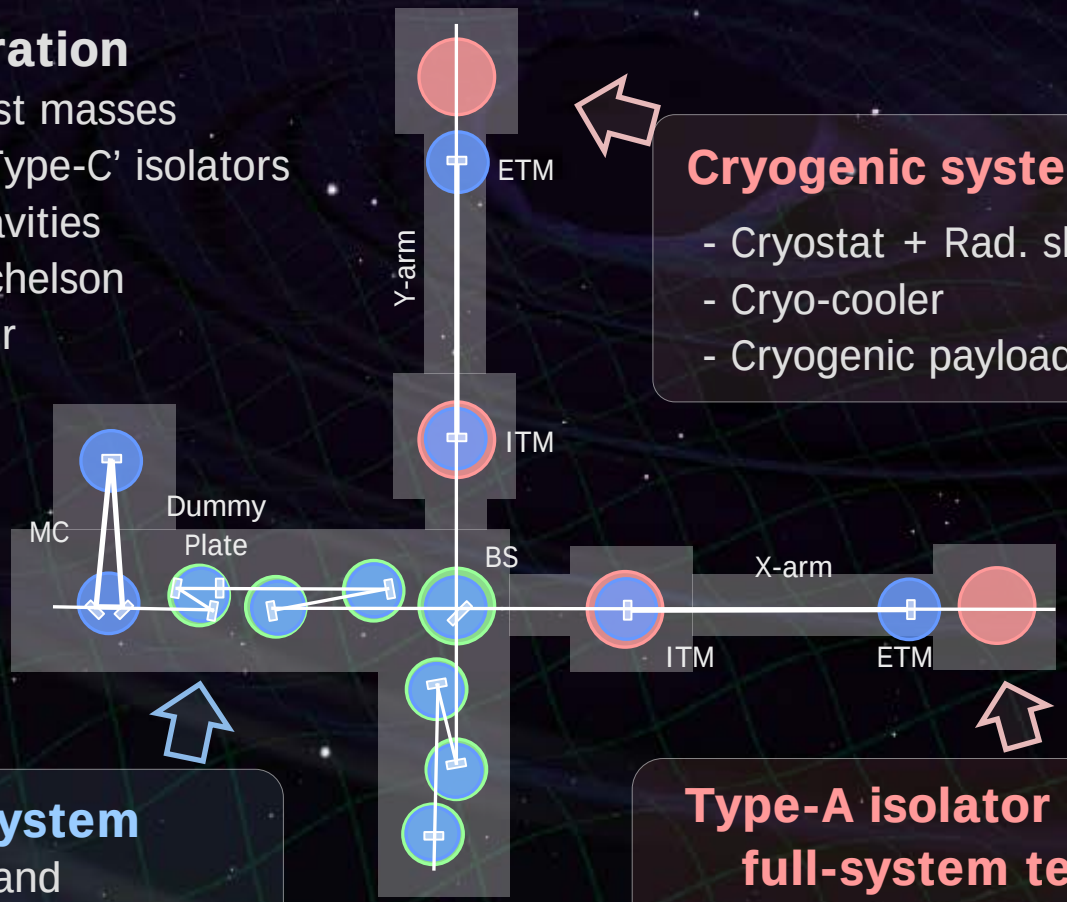
- **It is hard to test the full cryogenic test-mass system.**
  - Type-A isolator test requires a large facility and a quite site.
  - Cryogenic system requires long test time for a cool-down and warm-up cycle.
  - → Hard to avoid technical and schedule risks.

- **Roadmap to solve these concerns.**
  - Install ETMs in front of the original positions (by ~30 m) for the room-temp. interferometer commissioning.
  - Full test of the real VIS and cryogenic system at the end rooms.
  - Half-cryogenic configuration step before the final bLCGT configuration.

iLCGT commissioning

iLCGT configuration

- Room-temp. test masses suspended by Type-C' isolators
- 2.97 km arm cavities
- Fabry-Perot Michelson
- Low laser power



Cryogenic system test

- Cryostat + Rad. shield duct
- Cryo-cooler
- Cryogenic payload

Type-C' system

- Test mass and Core optics (BS, FM,..)
  Silica, 10kg, 290K
- Seismic isolator
  Stack + Type-B Payload

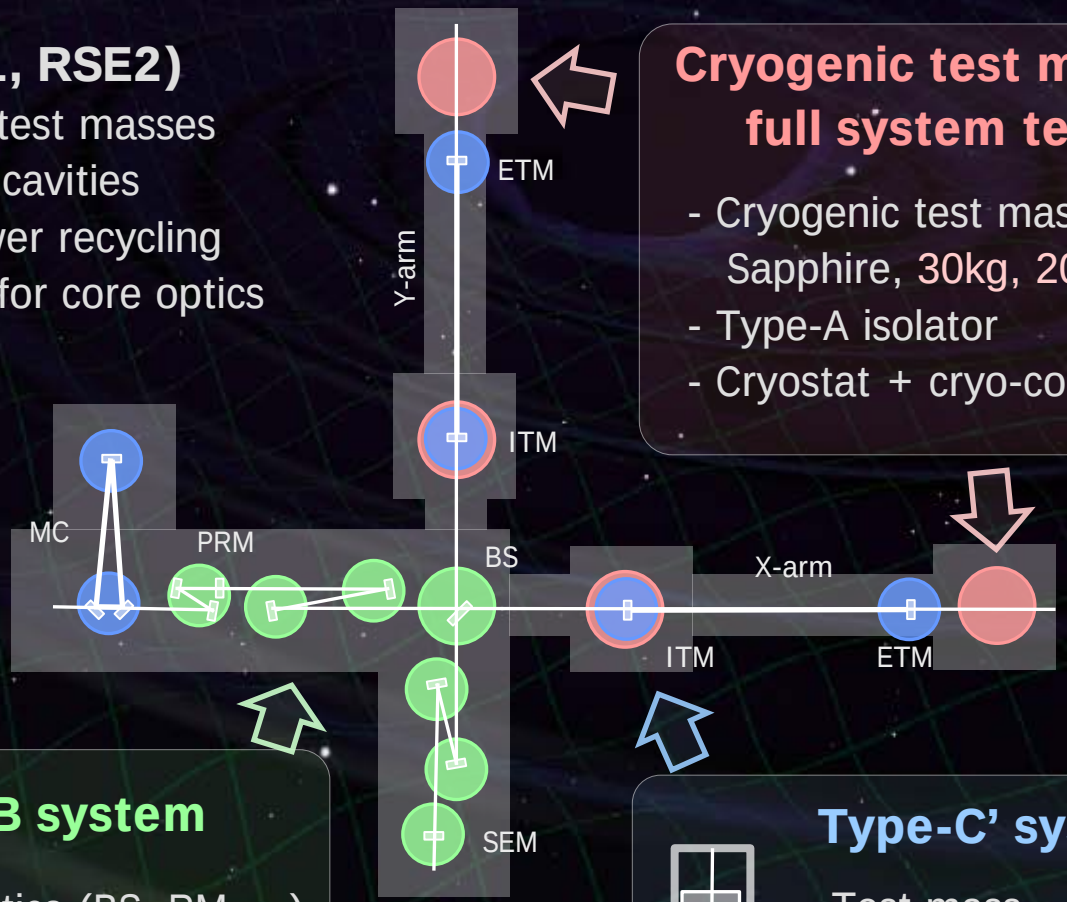
Type-A isolator full-system test

- Room-temp. test
  Sapphire (?), 30kg, 290K
- Tall seismic isolator
  IP + GASF + Payload

bLCGT commissioning (1)

bLCGT (RSE1, RSE2)

- Room-temp. test masses
- 2.97 km arm cavities
- RSE with power recycling
- VIS upgrade for core optics



Cryogenic test mass full system test

- Cryogenic test mass
  Sapphire, 30kg, 20K
- Type-A isolator
- Cryostat + cryo-cooler

Type-B system

- Core optics (BS, RM ,...)
  Silica, 10kg, 290K
- IP + GASF + Payload
- Stack for aux. optics

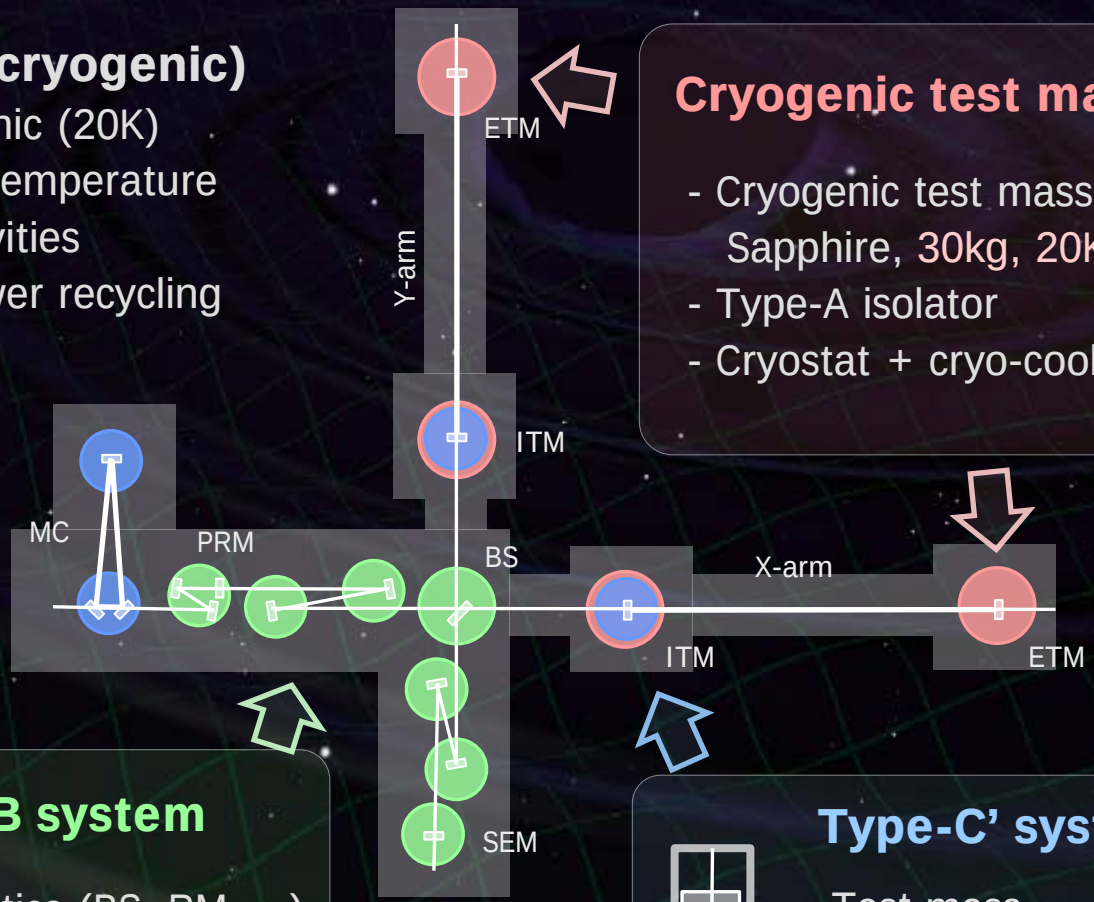
Type-C' system

- Test mass
  Silica, 10kg, 290K
- Seismic isolator
  Stack + Type-B Payload

bLCGT commissioning (2)

bLCGT (Half cryogenic)

- ETM: Cryogenic (20K)
- ITM: Room temperature
- 3 km arm cavities
- RSE with power recycling



Cryogenic test mass

- Cryogenic test mass
  Sapphire, 30kg, 20K
- Type-A isolator
- Cryostat + cryo-cooler

Type-B system

- Core optics (BS, RM ,...)
  Silica, 10kg, 290K
- IP + GASF + Payload
- Stack for aux. optics

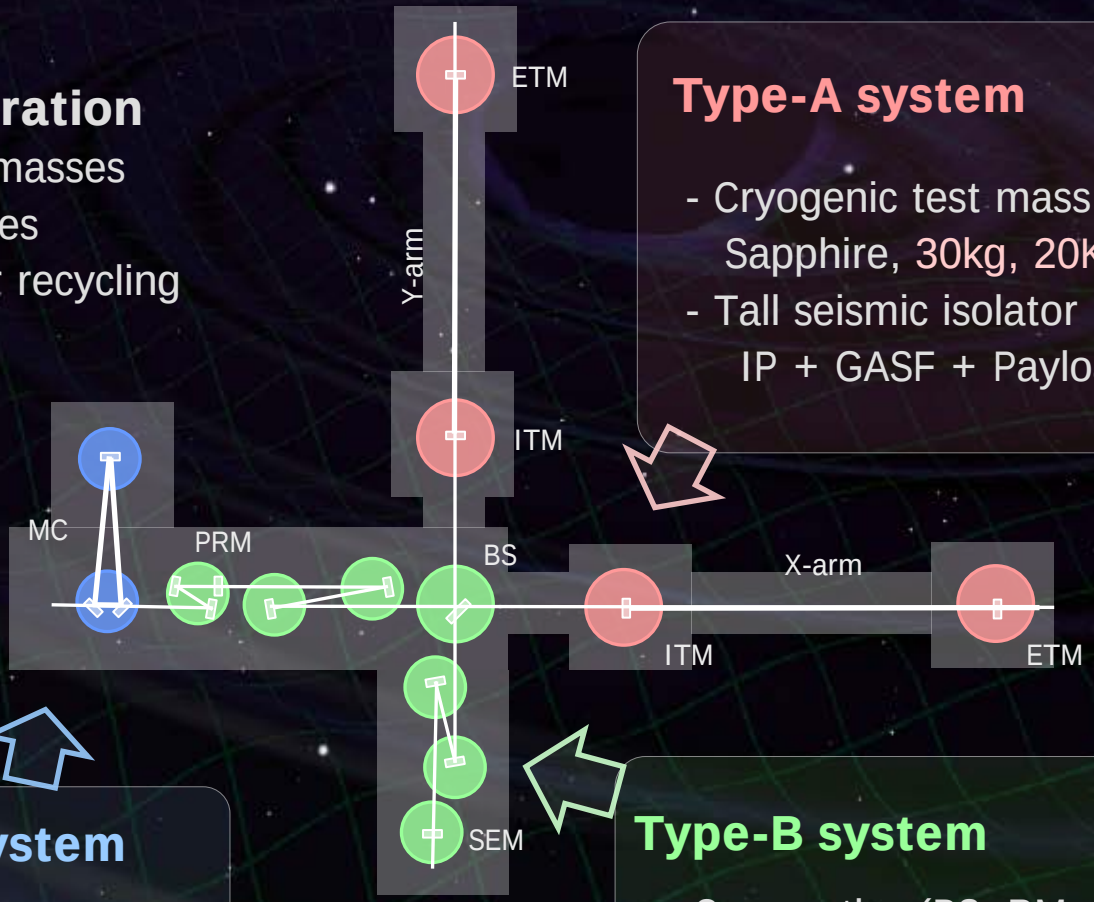
Type-C' system

- Test mass
  Silica, 10kg, 290K
- Seismic isolator
  Stack + Type-B Payload

bLCGT configuration

bLCGT configuration

- Cryogenic test masses
- 3 km arm cavities
- RSE with power recycling



Type-A system

- Cryogenic test mass
  Sapphire, 30kg, 20K
- Tall seismic isolator
  IP + GASF + Payload

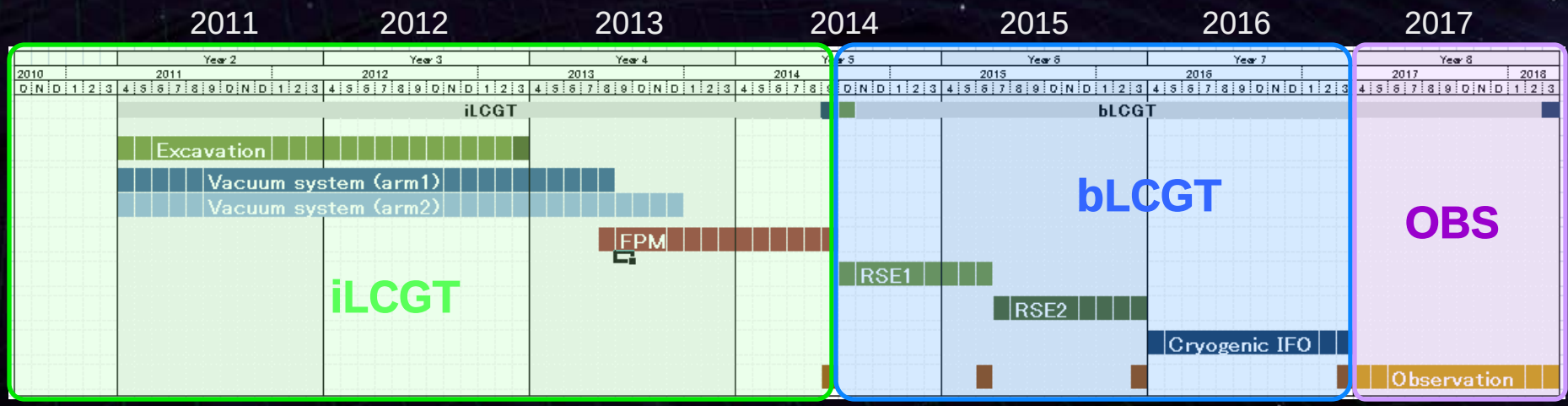
Type-C system

- Mode cleaner
  Silica, 1kg, 290K
- Stack + Payload

Type-B system

- Core optics (BS, RM ,...)
  Silica, 10kg, 290K
- IP + GASF + Payload
- Stack for aux. optics

Draft Schedule



Type-A,B,C system development →

System construction and test →

Type-A, B installation and shakedown →

Type-C' installation and shakedown →

Room-temperature IFO commissioning →

Half-cryogenic operation →

Full-cryogenic operation →

Observation and tuning →

Type-A,B construction and test →

Cryostat + Cryo-payload Prototype test →

Cryogenic full system installation and shakedown

Observation runs

- **Step-by-step commissioning plan**
  - → Observation or engineering run is planed at each step.
    - Test of full detector system including a data-processing.
    - Detector characterization on long-term stability.
    - Development of data-analysis pipelines.

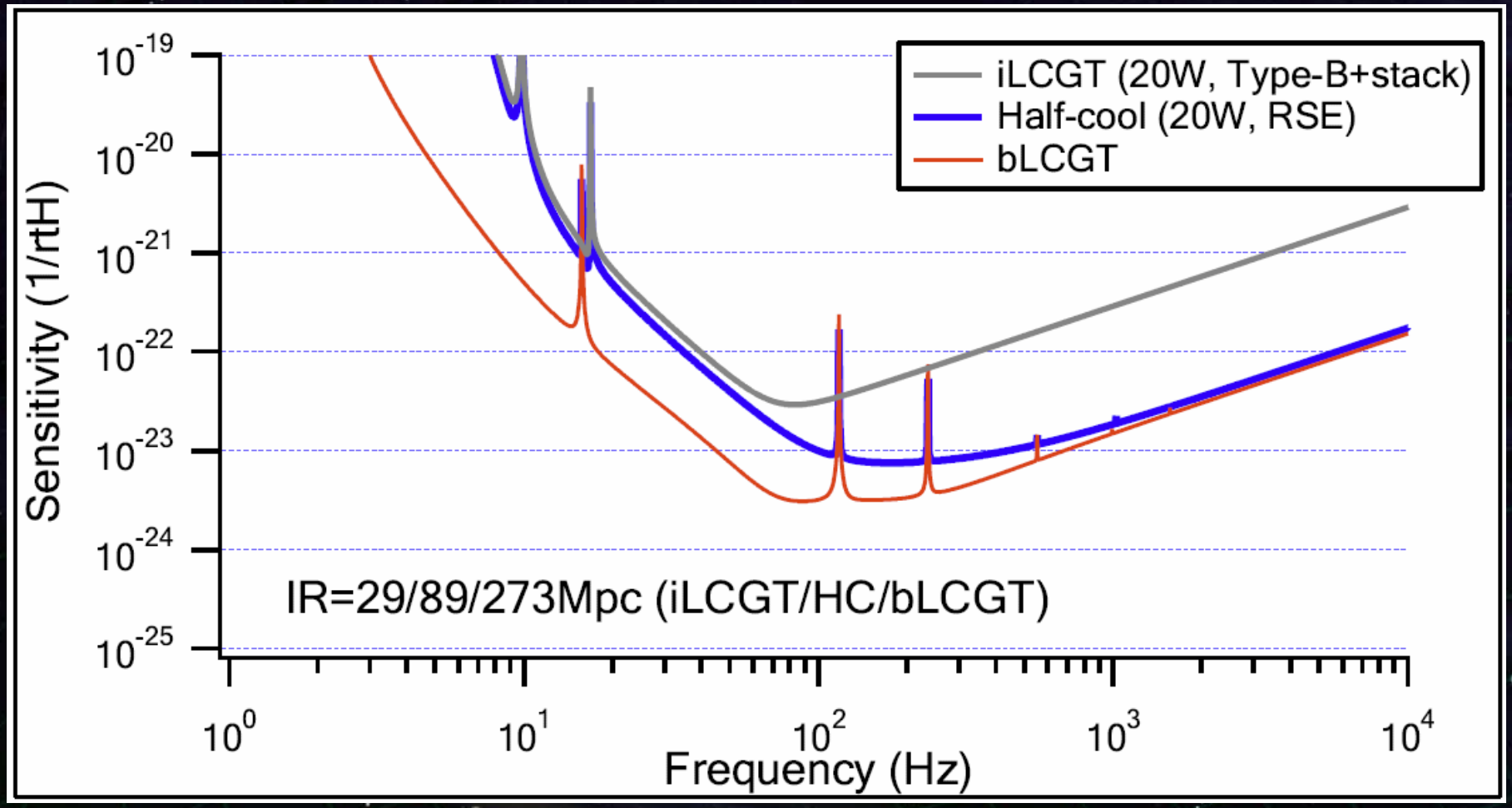
Observable range for NS binary inspiral Fundamental noise limit

iLCGT	29 Mpc	FPM, Low power, 10kg Silica, Temp: 300K
Half cryogenic	89 Mpc	RSE, Low power, 10kg Silica, Temp: 20K + 300K
Final bLCGT	273 Mpc	RSE, High power, 30kg Sapphire, Temp: 20K

(Source at optimal direction, Threshold : SNR 8)

- **Tight schedule**
  - First priority is to operate LCGT with the final configuration.
  - Refrain from spending too much time for the intermediate runs.

Sensitivity



Discussions

Before the External Review

Plan before the external review

- **iLCGT**
  - Installation of Type-A isolators for the test masses for the room-temp. interferometer operation.
  - Crumping of the isolator above the payload.

- **Early phase in bLCGT**
  - Installation of RSE and upgrade of isolators.
  - Operation of the room-temp. interferometer as a full system.

- **Latter phase in bLCGT**
  - Replacement of the test-mass payload and vacuum system to the cryogenic payload and cryostat.
  - Installation of the radiation shield ducts.
  - Operation of the cryogenic interferometer as a full system.

External Review Comments

Recommendations by the external review committee

- **Use Type-B system in the iLCGT room-temp. operation**
  - Reduce technical risks using the experiences by TAMA-SAS.
  - Earlier start of commissioning.
- **Avoid replacement of isolation systems after installation**
  - Reduce the additional tasks.
  - Shorten the total commissioning time to realize the final LCGT.
- **Abandon the two-layer structure**
  - Big hole will be convenient for the possible future upgrades.
  - Risk management for vibration isolation system.
- **Early start of full-system test for the Type-B isolator**
  - Gain technical feasibility.

- **Consider about observation run with the room-temp. IFO.**
- **Consider about a half cryogenic step before the full configuration**.

Current Plan

Advantages in the current plan

- **Earlier start of the interferometer commissioning**
  - Type-C' : a simple isolation system based on the experiences in TAMA.
  - Replacement after installation is minimized.
- **Full-system test of the isolator and cryogenic system**
  - Real-system test at the site in parallel to the IFO commissioning.
  - Reduction of the technical risks and compression of the total schedule.
  - Smooth upgrade to the half-cryogenic configuration.

Options

- **Earlier full system test of the Type-B isolator at the site**
  - Test using some of the core optics.
  - Reduce the technical jump from the Type-C' isolator.
  - Gain experiences for the Type-A isolator.
- **Flexibilities in the commissioning plan**
  - More challenging plans depending on the development status.
  - Any ideas to accelerate the schedule.

Summary

Roadmap special working group

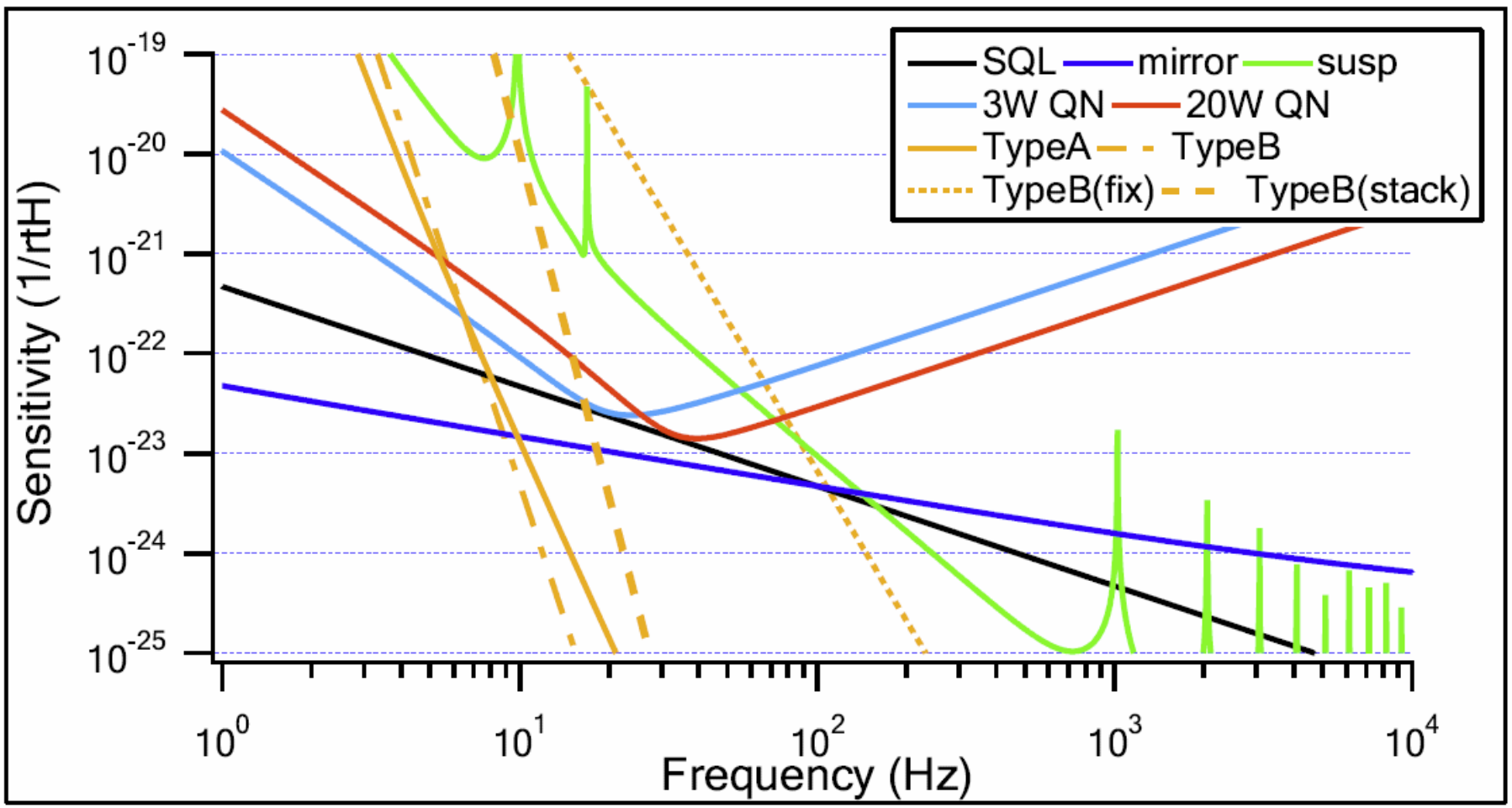
- Summarized information on the project target and constraints.
- Determined the basic policies.
- Made a master schedule for the LCGT commissioning.

Next steps

- Will complete the working group
  after summarizing a recommendation document.
- Detailed discussions on the roadmap will be led by the SEO.

Backups

Sensitivity



IR = 29/17Mpc (TypeA/B/Bstack, 20W/3W), 21/11Mpc (TypeB-fix, 20W/3W)

Detection probability

Detection probability in one-year observation

⇨ **Success probability of the LCGT project**

	IR	DP
BRSE	114 Mpc	99.6 %
VRSE-B	112 Mpc	99.4 %
VRSE-D	123 Mpc	99.9 %
DRSE	132 Mpc	99.9 %

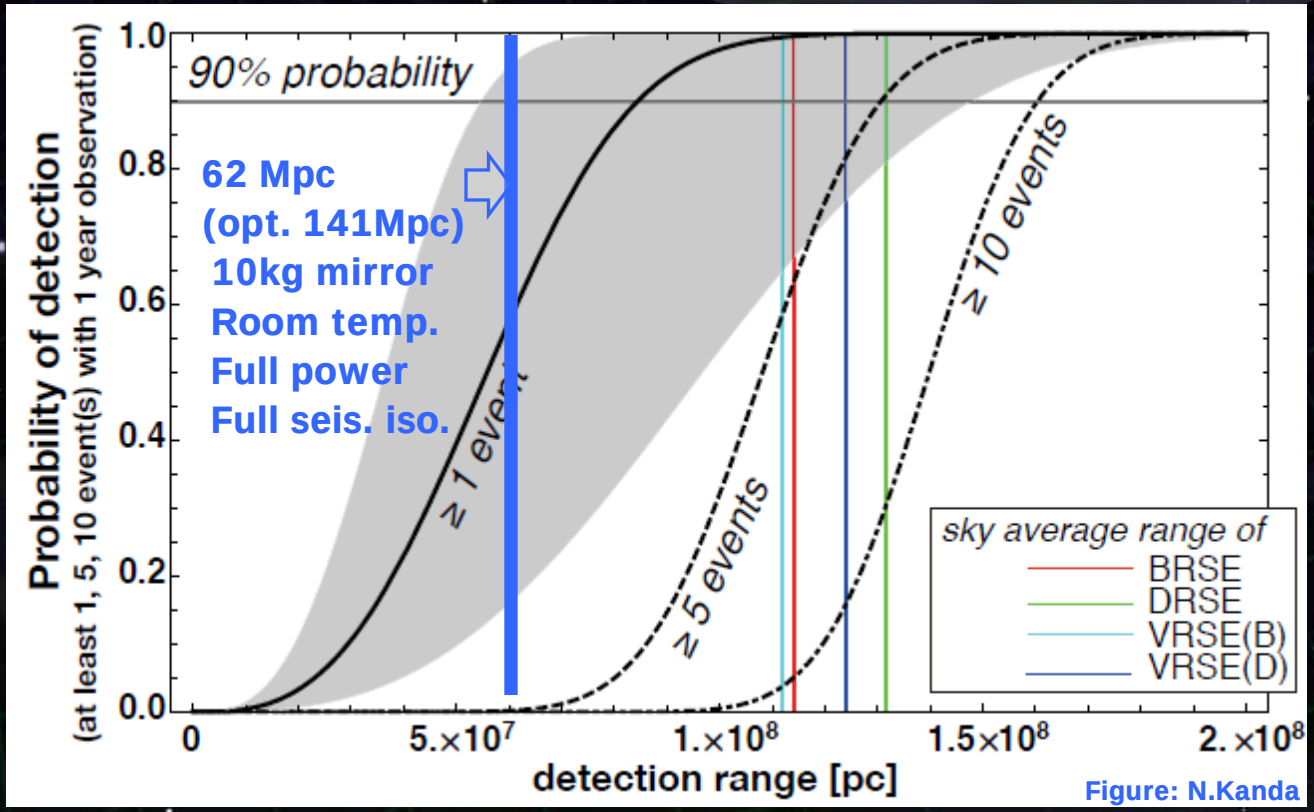
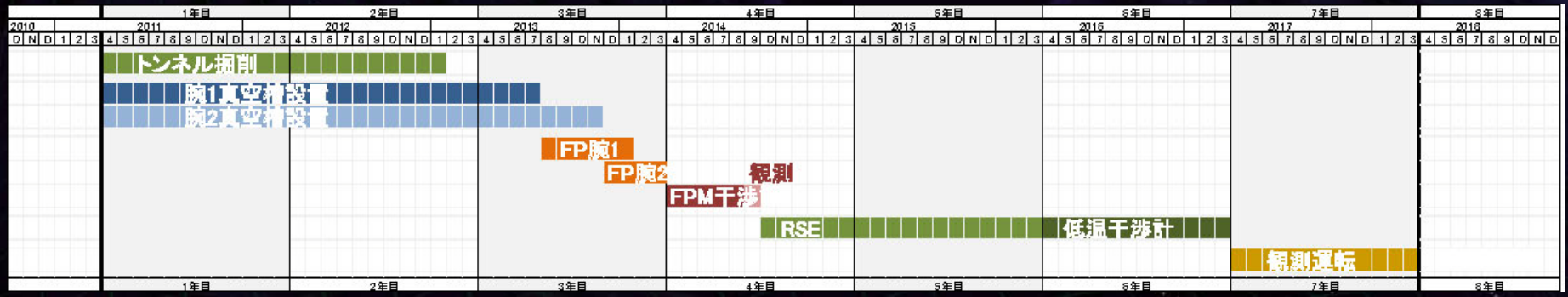


Figure: N.Kanda

Assume
Poisson distribution

Schedule

2011 2012 2013 2014 2015 2016 2017



iLCGT
- Tunnel, Vacuum system,
- Laser, Input optics,
- Suspension,
- Fabry-Perot-Michelson interferometer
- Control and DAQ system

bLCGT
- Power-recycling, RSE
- Cryogenics
- Sensitivity and stability

Observation

Master Schedule

Draft for discussion

- 6 Milestones

Stage	Phase	Name	Period	Scope
iLCGT	0	EAF	2011.4 - 2013.3	Excavation and Facility
iLCGT	1	FPM	2013.4 - 2014.9	Operation of FPM IFO
bLCGT	2	RSE1	2014.10 - 2015.6	RSE operation
bLCGT	3	RSE2	2015.7 - 2016.3	Upgrade of VIS
bLCGT	4	CRSE	2016.4 – 2017.3	Cryogenic system
OBS	5	OBS	2017.4 –	Observation and tuning

2011 2012 2013 2014 2015 2016 2017