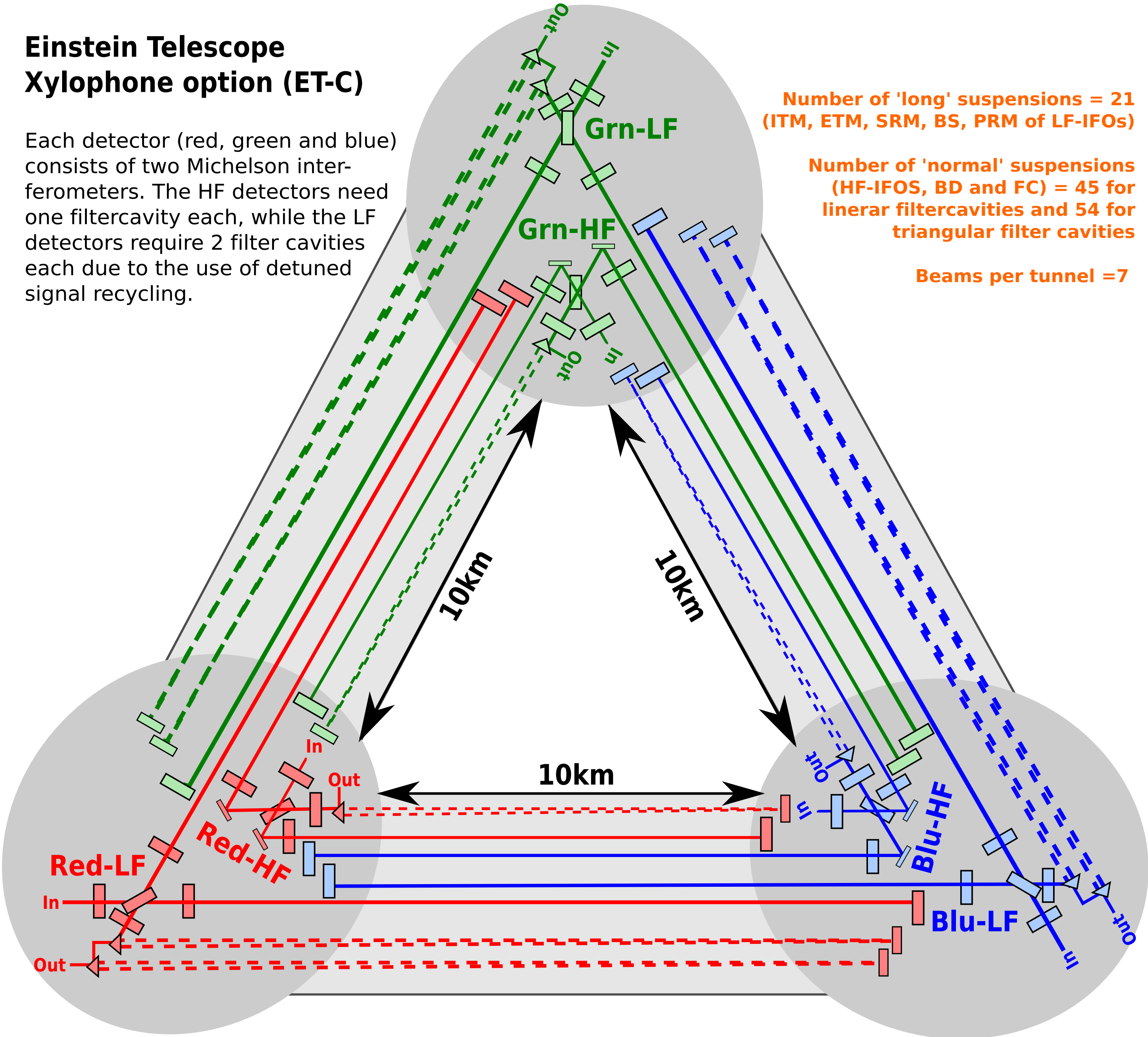
Einstein Telescope
Xylophone option (ET-C)

Each detector (red, green and blue) consists of two Michelson interferometers. The HF detectors need one filtercavity each, while the LF detectors require 2 filter cavities each due to the use of detuned signal recycling.

Number of 'long' suspensions = 21 (ITM, ETM, SRM, BS, PRM of LF-IFOs)

Number of 'normal' suspensions (HF-IFOS, BD and FC) = 45 for linerar filtercavities and 54 for triangular filter cavities

Beams per tunnel =7



Helge

Low-frequency gravitational-wave detectors comparison

Dual-recycled Fabry-Perot-Michelson interferometer with two long filter cavities

1) Basics:

- L-shaped topology
- 4 heavy arm-cavity mirrors
- 1 beam-splitter mirror
- 1 power-recycling mirror
- 1 signal-recycling mirror
- at least 4 mirrors building up two filter cavities

2) Advantages:

- high experimental experiences with Michelson interferometer topology, linear arm cavities and dual-recycling
- very high sensitivity around the optomechanical and optical resonance frequencies

3) Disadvantages:

- radiation-pressure noise is present, probably limiting the sensitivity at very low frequencies (depending on the level of seismic and gravity gradient noise)
- need heavy test-mass mirrors
- efficient implementation of input-squeezing needs two filter cavities (with low net fractional loss at a specific bandwidth → therefore as long as possible)
- low experimental experiences filter cavities

Helge

Alternative option: LF Sagnac/Speedmeter

Power-recycled zero-area Sagnac interferometer

1) Basics:

- L-shaped topology
- at least 6 arm-cavity mirrors
- 1 beam-splitter mirror
- 1 power-recycling mirror
- 1 folding mirror
- balanced homodyne detection in order to realize radiation-pressure noise cancellation

2) Advantages:

- radiation-pressure noise can be cancelled
- no need for heavy test-masses
- efficient implementation of input-squeezing does not require long filter cavities

3) Disadvantages:

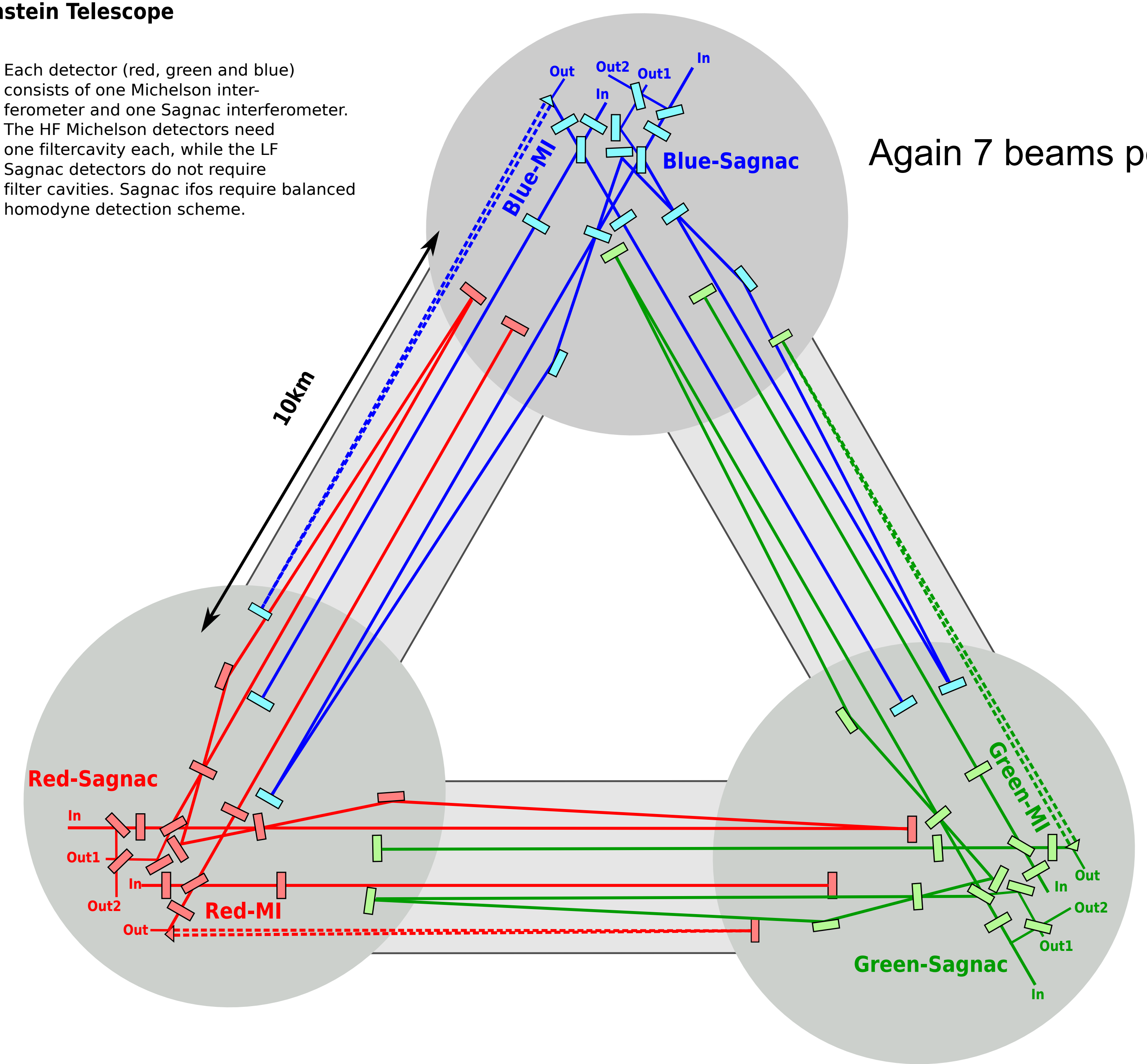
- low experimental experiences with large-scale Sagnac interferometers and with ring cavities
- signal transfer is not flat but decreases linearly with frequency
- need more than one vacuum tube for the arm cavities

Einstein Telescope

Keiko

Each detector (red, green and blue) consists of one Michelson interferometer and one Sagnac interferometer. The HF Michelson detectors need one filtercavity each, while the LF Sagnac detectors do not require filter cavities. Sagnac ifos require balanced homodyne detection scheme.

Again 7 beams per Tunnel.



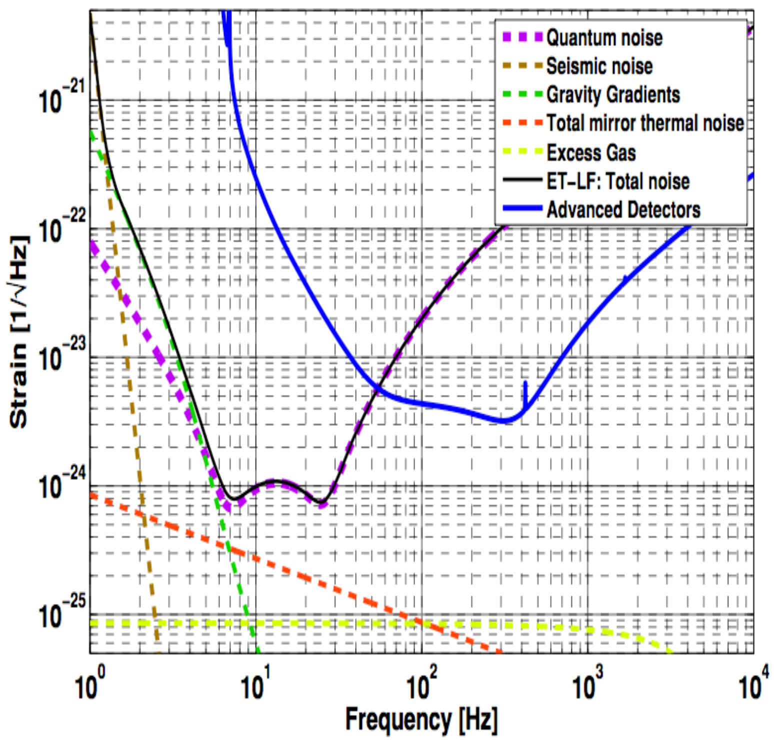
Counting suspensions…

Configuration	asumptions	Cryogenic + Long	Room-T and normal length
ET-C	Filtercavities = 2mirrors	21	45
ET-C	Filtercavities = 3mirrors	21	54
LF=Sagnac, HF =MI	FC = 2mirrors, AC = 3mirrors	27	42
LF=Sagnac, HF =MI	FC = 3mirrors, AC = 3mirrors	27	45
LF=Sagnac, HF =MI	FC = 2mirrors, AC = 4mirrors	39	42
LF=Sagnac, HF =MI	FC = 3mirrors, AC = 4mirrors	39	45

ET-C = 3 Filter cavities,
LF-Sagnac + HF-Michelson = only 1 filtercavity, LF has no SR, the 3 mirrors/bs involved in the balanced Homodyne detection are considered as suspended from normal suspensions.

What beam-sizes /mirror diameter?

- Mirror size driven by coating noise.
- MI-HF detector = 60cm mirror
  - Silica available in that size
- MI-LF detector
  - Maximal silicon size = 50cm
  - ET-C assumed = 60cm
  - 50cm => 20% mirror TN
  - No significant change in h(t)
  - Can we go even smaller??



Andreas

Minimal mirror sizes

- Please see ET not from Andreas.
- This is a short summary:

setup	mirror diameter [cm]
LG00, 1064nm	35
LG33, 1064nm	57
LG00, 1550nm	42
LG33, 1550nm	68

- So in principle, we could go a little bit smaller for the MI-LF detector … *do we want that?*

Mirror sizes of filter-cavity

- Relaxed thermal noise requirements.
- So we can go for the smallest beams that are resonable in terms of resonator stability

- HF-filtercavities are 1064nm, LG33 = 57cm
- LF-filtercavities are 1550nm, LG00 = 42cm

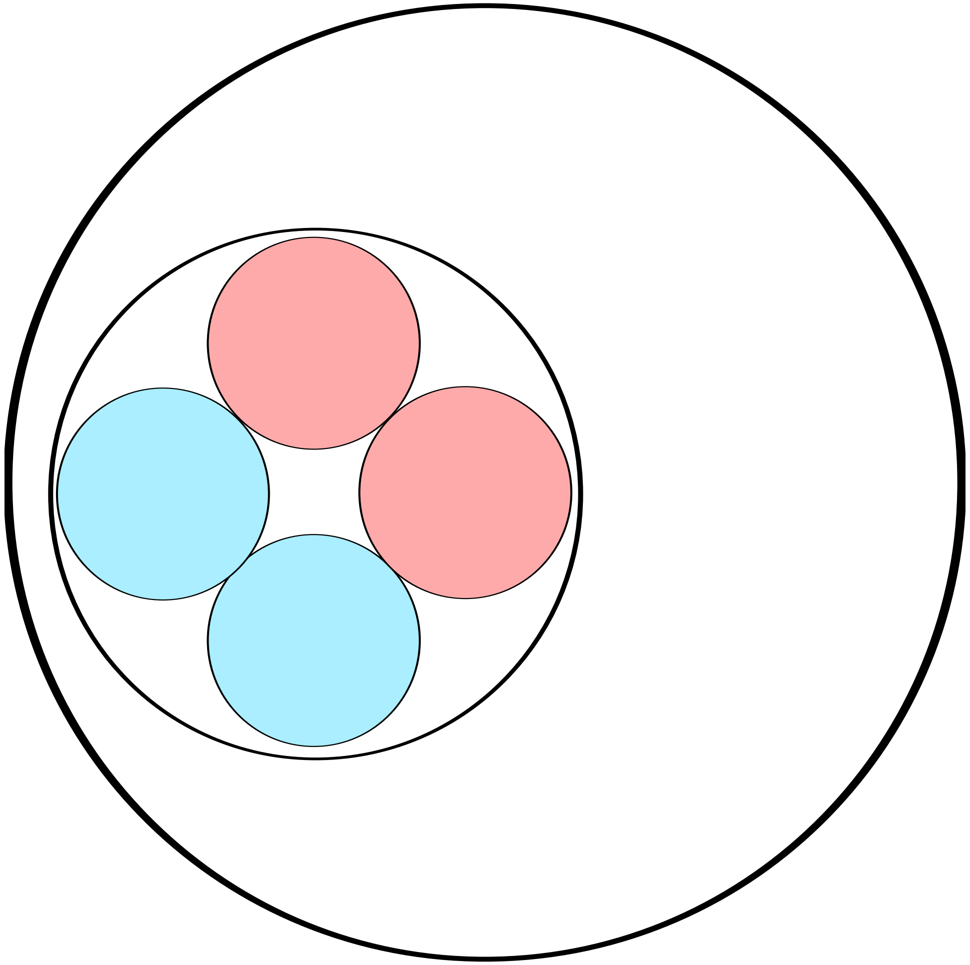
Summary of mirror sizes

- ET-C configuration
  - HF detector (silica): 60cm + 1x 57cm (Filtercavity)
  - LF detector (silicon): 50cm + 2x 42cm (Filtercavities)

- For LF = Speedmeter
  - HF detector (silica): 60cm + 1x 57cm (Filtercavity)
  - LF detector (silicon): ??? Depends on arm cavity design (3 or 4mirrors, mirrors under angle?)

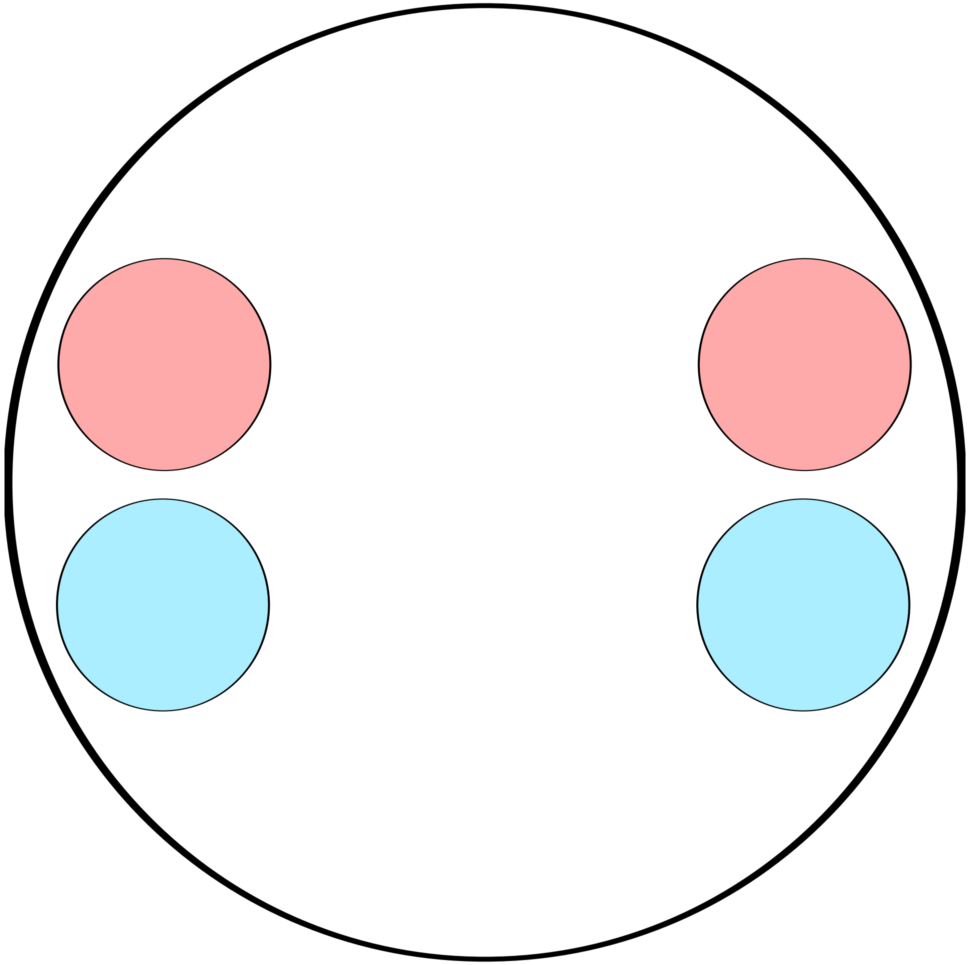
How to go from mirror size to required 'space'

- Mirror size + some distance between beam and the baffles + some space for baffles.
- Dummy example: ET-C HF Michelson detector
  - 60cm mirror diameter
  - 10cm (?) distance between mirror and baffles
  - 10cm radius of baffles
  - TOTAL = 1m diameter tube
- Key question: What distance between beam and baffles?
  - Current detectors use very large distance
  - We want to go as small as possible
  - Diffraction, scattering, vacuum (tube conductivity)



- Each tunnel will contain 2 warm HF detector arms and 2 cold LF detector arms.
- Assuming each is 1m in diameter.
- Putting all of them into a single tube would require 2.5m diameter.
- Tunnel of 4.5m diameter
- Might be quite difficult to somehow separate the individual beams?
- What is about redundancy? If one detectors is upgraded the full arm is not available.

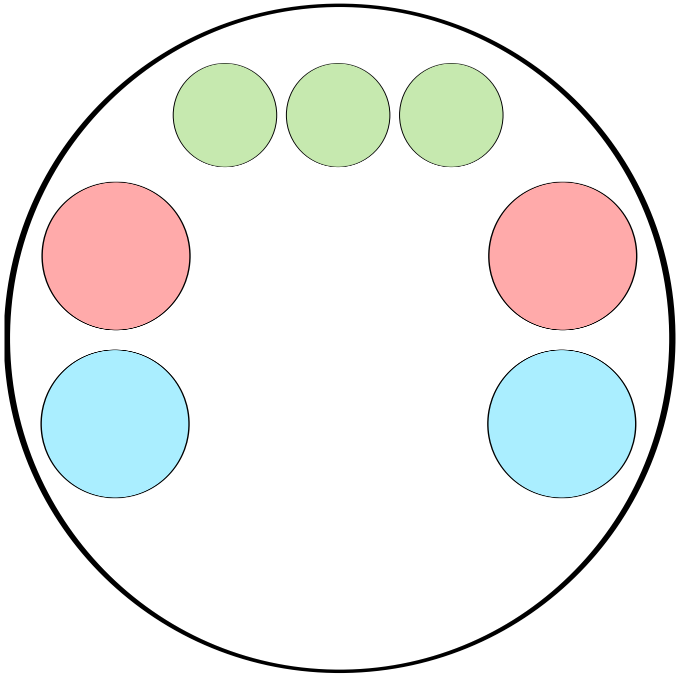
- No Filter cavities considered so far.
- No Sagnac-compatible arm cavities considered. They would need more space

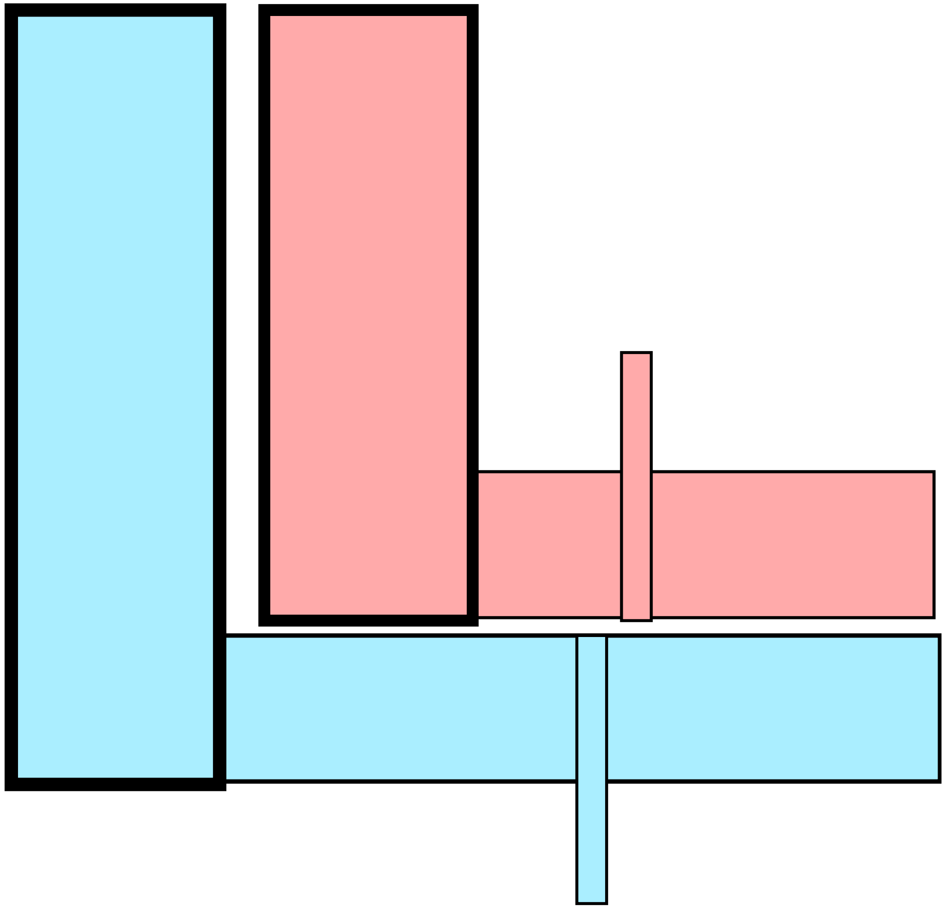


- Each tunnel will contain 2 warm HF detector arms and 2 cold LF detector arms.
- Assuming each is 1m in diameter.
- Tunnel of 4.5m diameter
- Redundancy is given.
- Also beams are easy to separate.
- However, need 4 beam pipes.

- No Filter cavities considered so far.
- No Sagnac-compatible arm cavities considered. They would need more space

Tunnel cross-section including
3 Filter cavities of 70cm diameter





Side view: tubes, valves and ‘towers’…