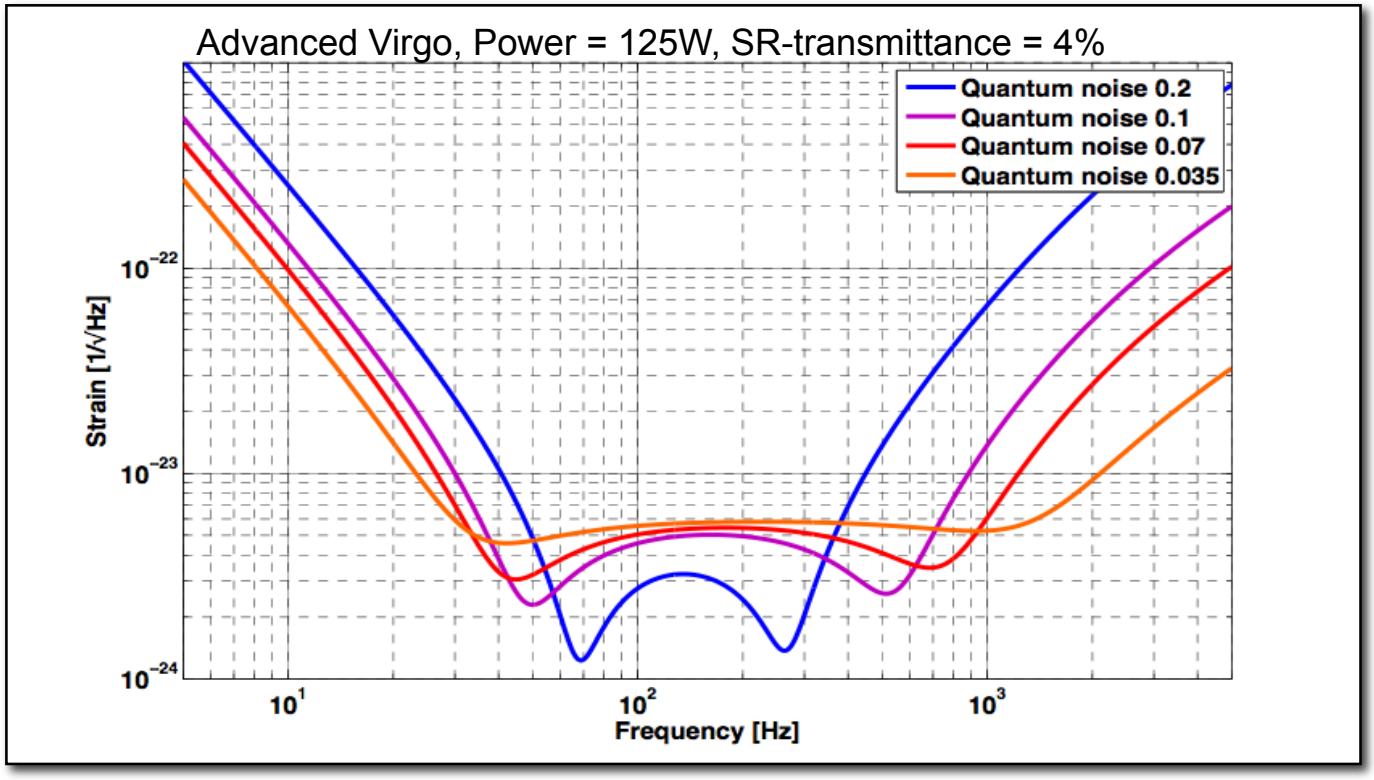
University of Glasgow

- **What is high frequency?**
  - Let's assume 500Hz-5kHz
- **What is important noise at high frequency?**
  - Only shot noise!
- **How can we improve?**
  - **Squeezing? YES! (see slides by Lisa)**
  - **High power? YES!**
  - **Arm length? YES!**
  - Optical configuration? - depends on how much low-frequency sensitivity we are perpared to sacrify..

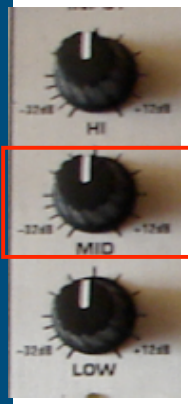
Signal-Recycling (de)tuning

knob 1

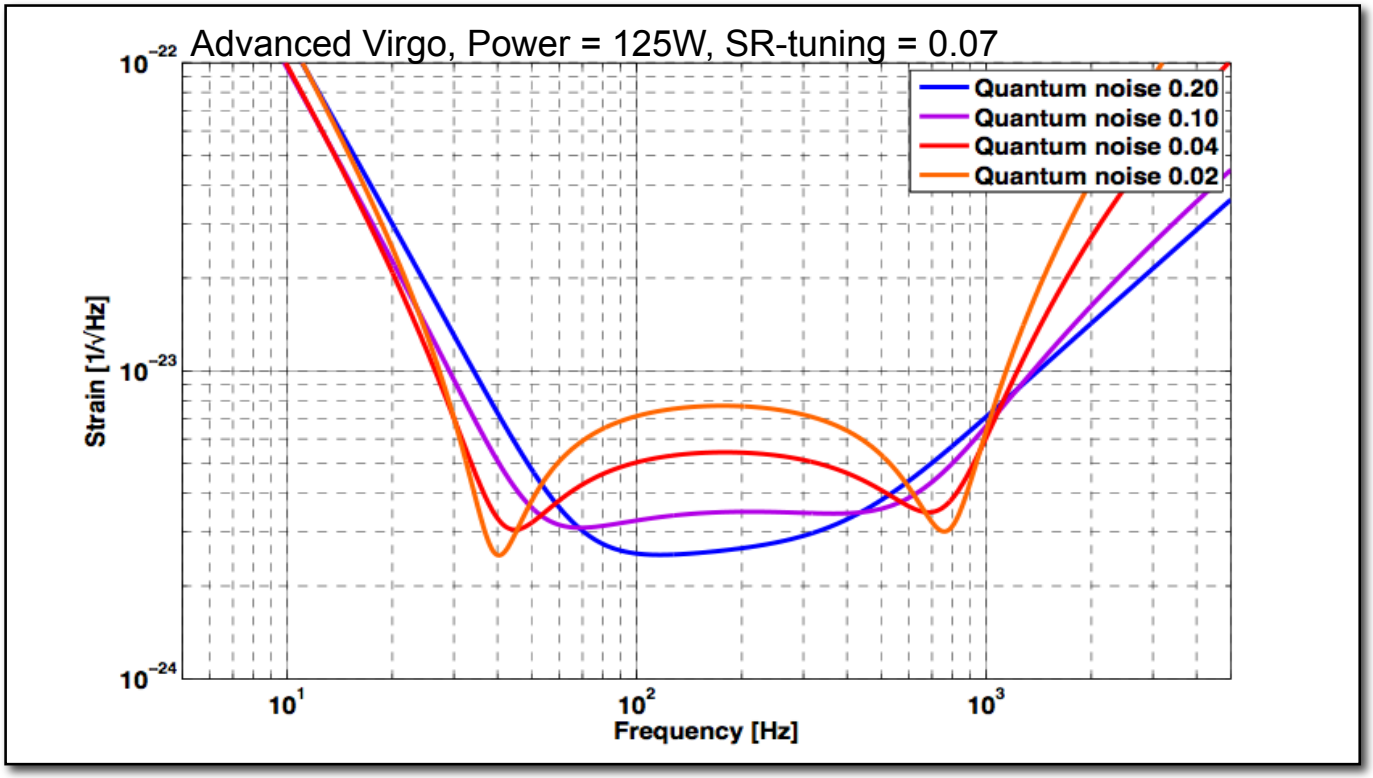


- **Frequency of pure optical resonance goes down with SR-tuning.**
- **Frequency of opto-mechanical resonance goes up with SR-tuning**

Signal-Recycling mirror transmittance

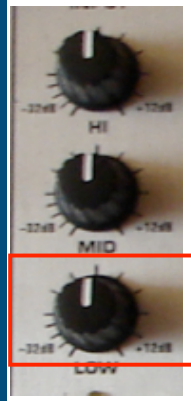


knob 2

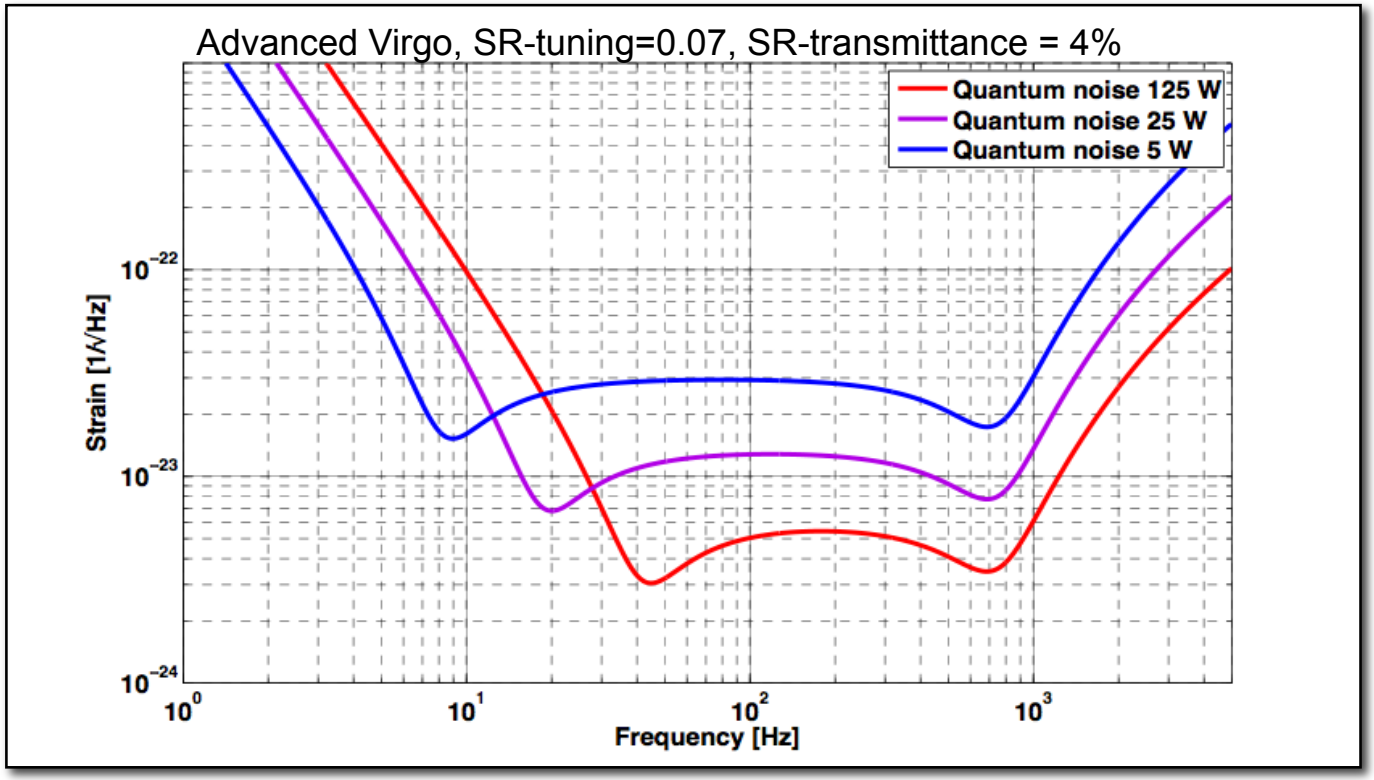


- **Resonances are less developed for larger SR transmittance.**

Knob 3: Optical Power

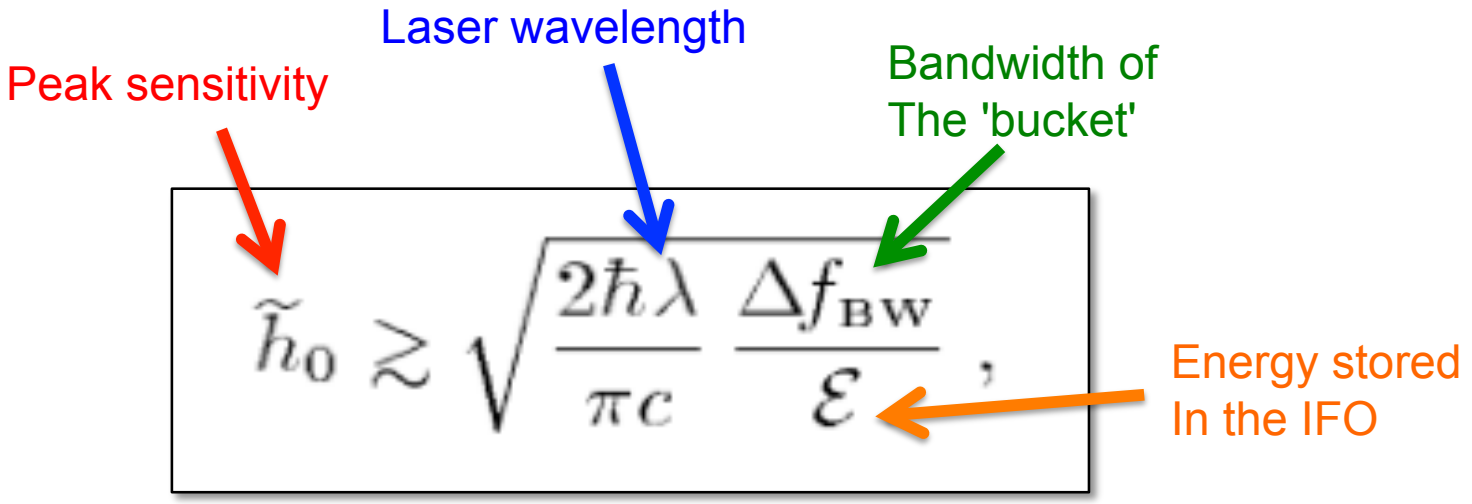


knob 3



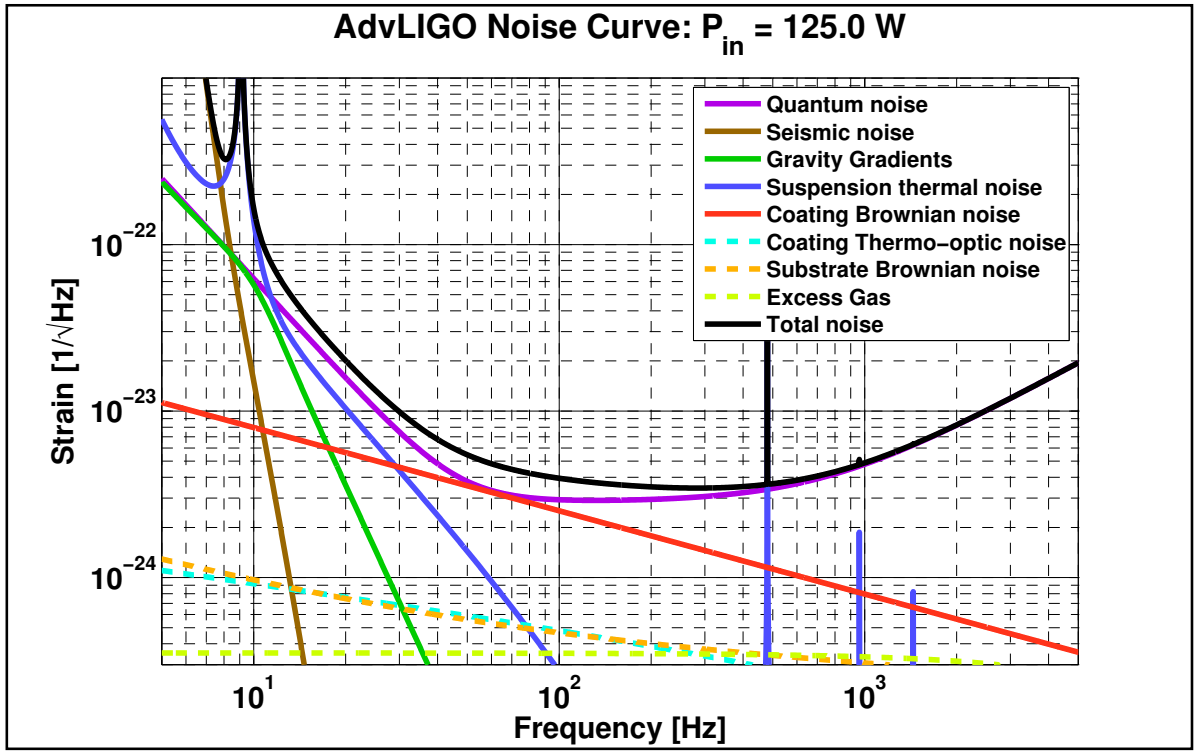
- **High frequency sensitivity improves with higher power (Shotnoise)**
- **Low frequency sensitivity decreases with higher power (Radiation pressure noise)**

Jun's Theorem



- Theorem from Jun Mizuno (PhD thesis 1995).
- **"Any configuration storing the same amount of energy will have the same sensitivity when optimised for the same bandwidth."**

Jun's Theorem: aLIGO as example



1064nm

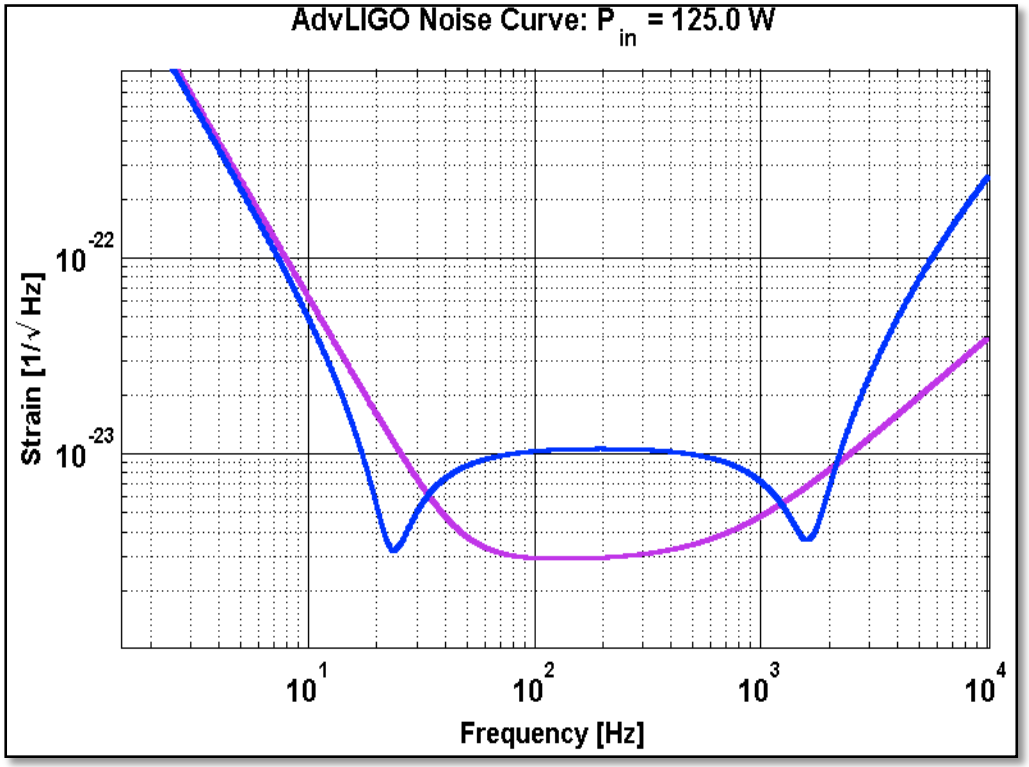
10J

~500 Hz

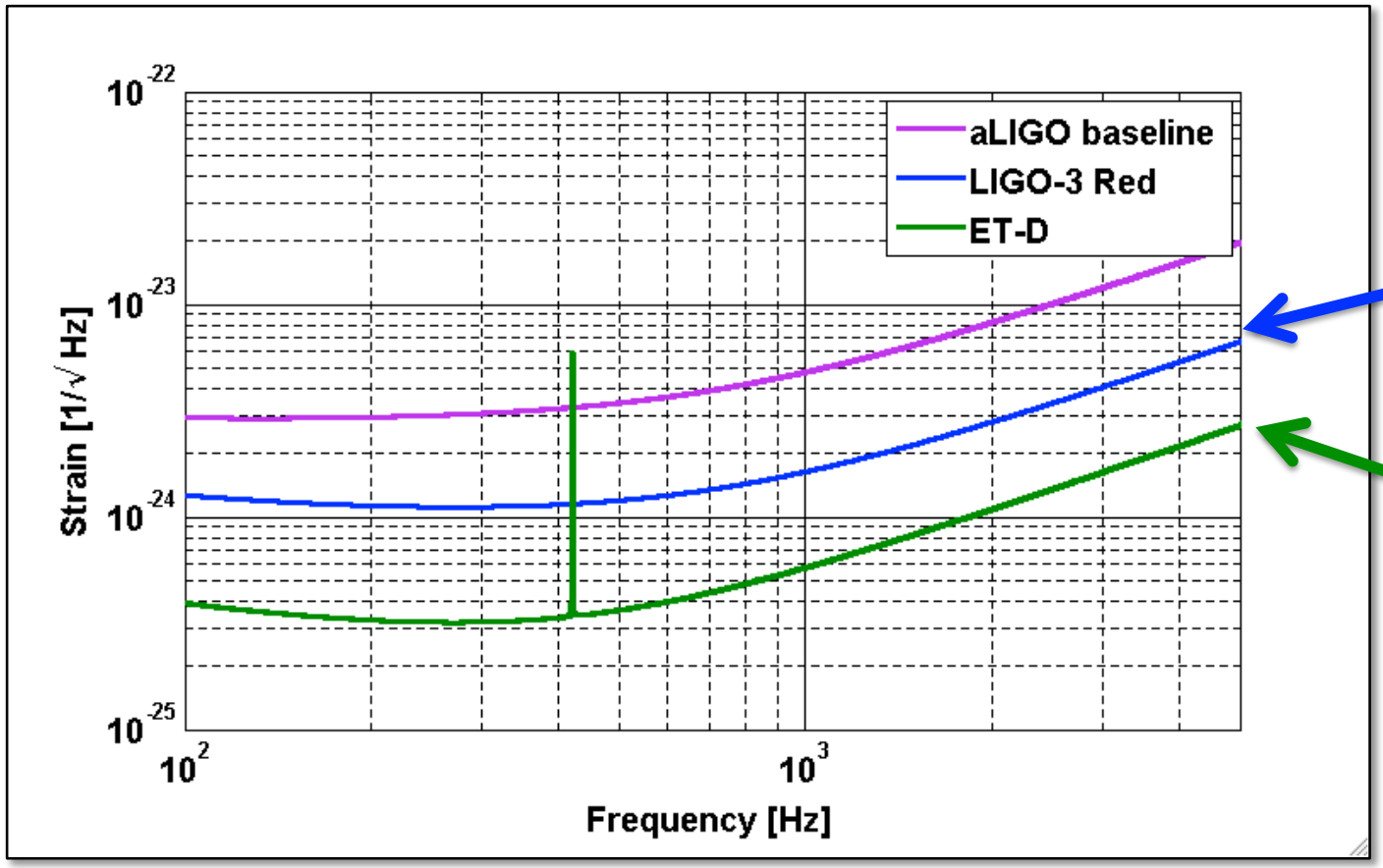
$$\tilde{h}_0 \gtrsim 3.3 \cdot 10^{-24}/\sqrt{\mathrm{Hz}} \times \left[\frac{\lambda}{1\,\mu\mathrm{m}}\right]^{\frac{1}{2}} \left[\frac{\mathcal{E}}{20\,\mathrm{J}}\right]^{-\frac{1}{2}} \left[\frac{\Delta f_{\mathrm{BW}}}{1\,\mathrm{kHz}}\right]^{\frac{1}{2}}.$$

Detuned RSE

- **How about detuned RSE?**
  - Can give improved HF sensitivity, **but on a hugely reduced LF sensitivity.**
  - Also losses will pose a limit on how narrow band you can do the RSE.
  - Perhaps for this better to use delay lines + signal recycling. Something like GEO style interferometer with 10km arm length.



What to expaect from the future ?



LIGO3: Lots of squeezing

ET: Squeezing + Longer arms + more power