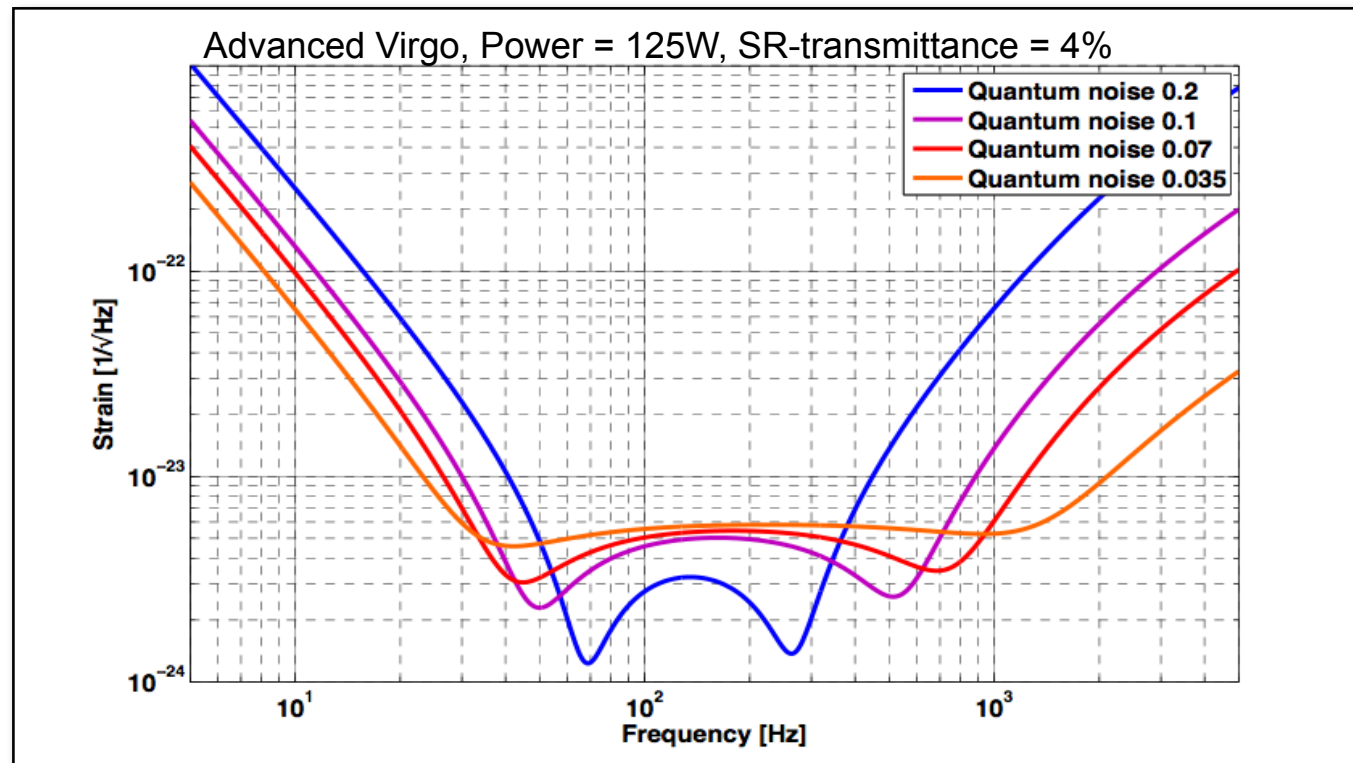




Challenges in the High Frequency Region

- Round table @ GWADW 2012

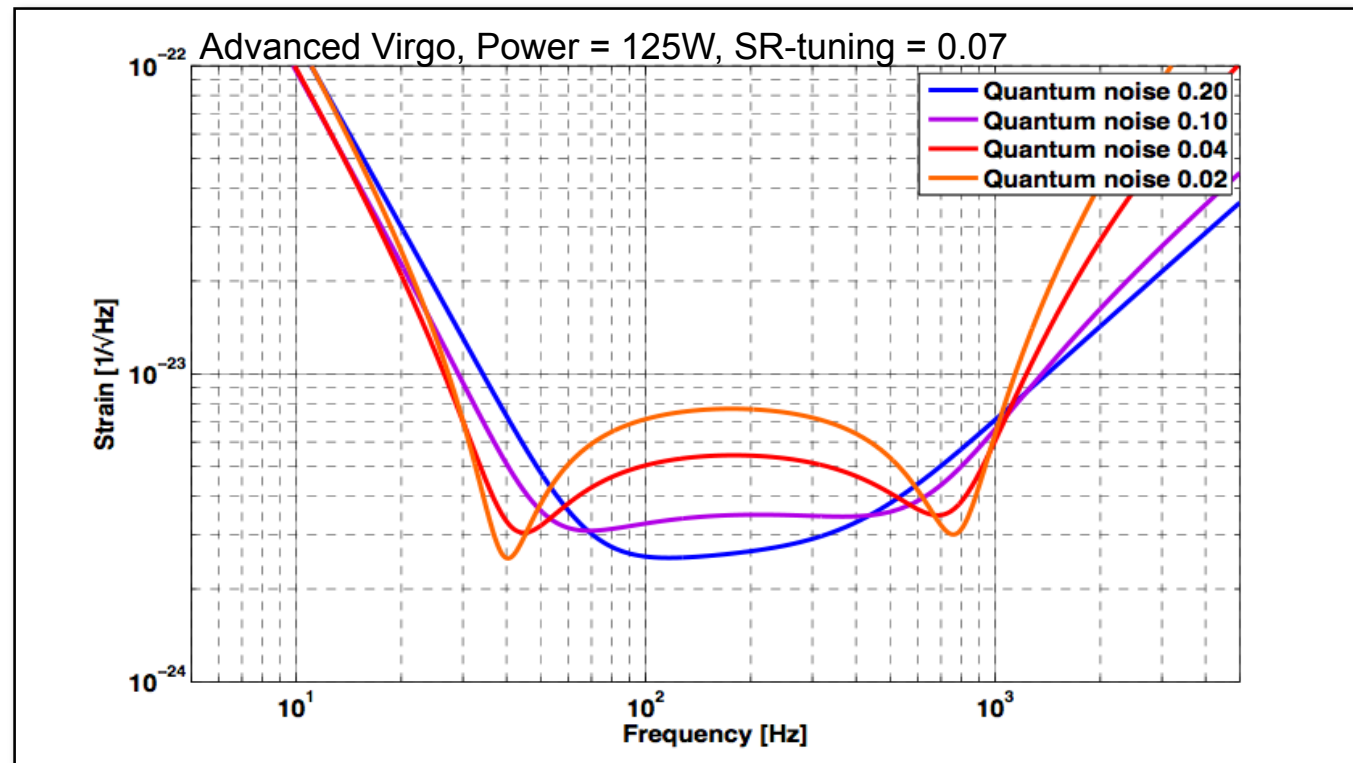
- **What is high frequency?**
 - Let's assume 500Hz-5kHz
- **What is important noise at high frequency?**
 - Only shot noise!
- **How can we improve?**
 - **Squeezing? YES! (see slides by Lisa)**
 - **High power? YES!**
 - **Arm length? YES!**
 - **Optical configuration? - depends on how much low-frequency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



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



knob 2

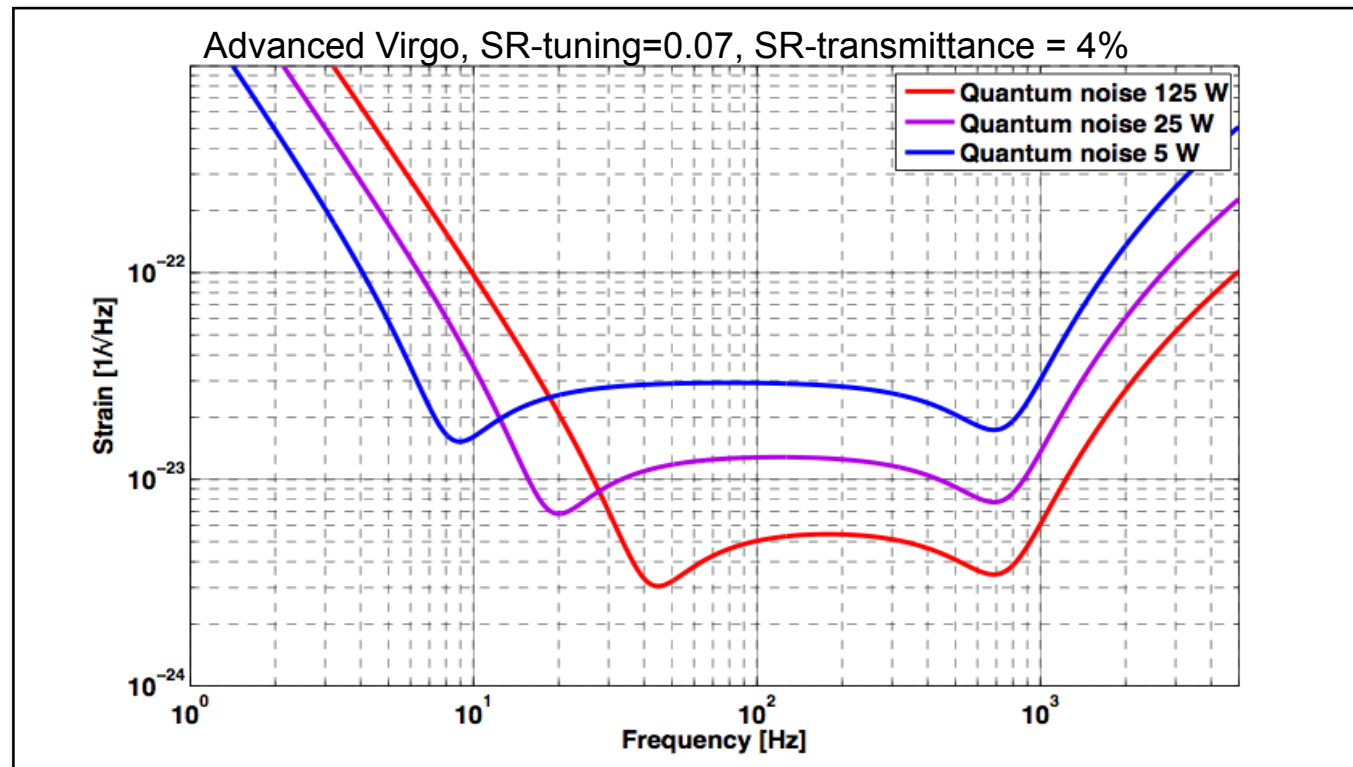


- Resonances are less developed for larger SR transmittance.

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

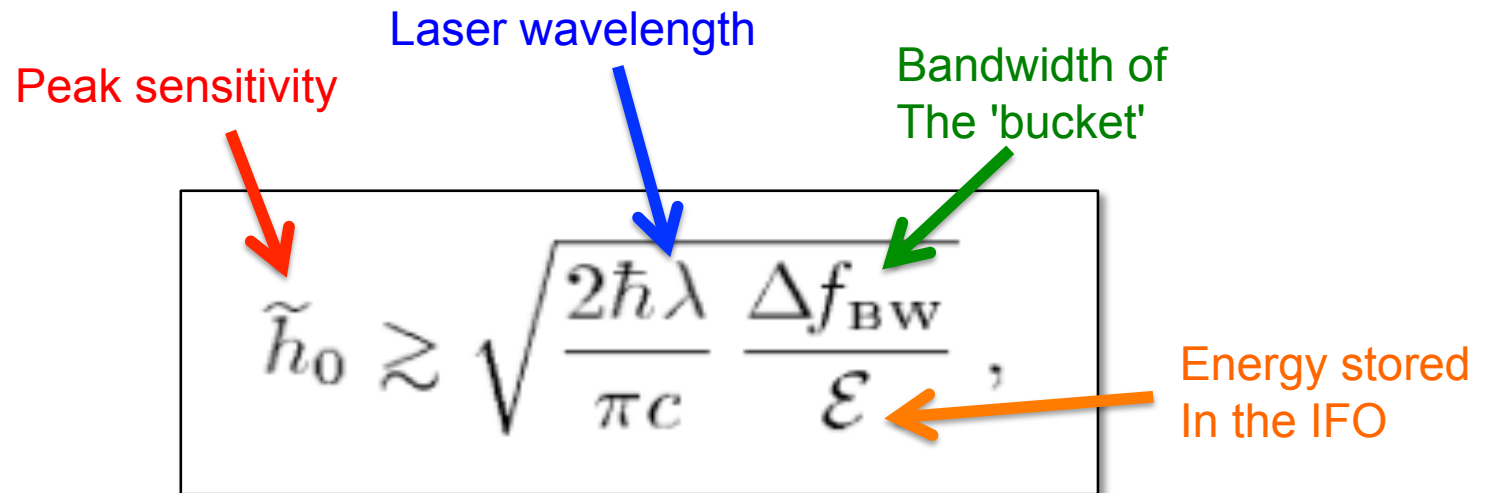
Peak sensitivity

Laser wavelength

Bandwidth of The 'bucket'

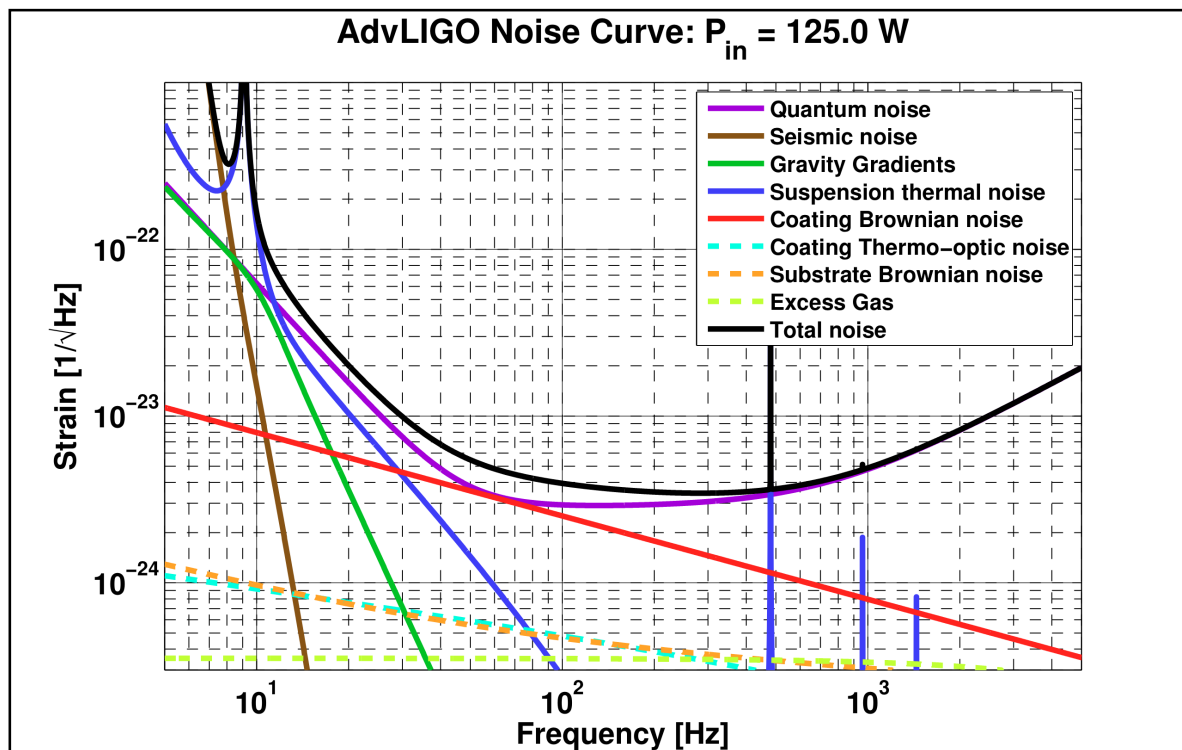
$$\tilde{h}_0 \gtrsim \sqrt{\frac{2\hbar\lambda}{\pi c} \frac{\Delta f_{\text{BW}}}{\mathcal{E}}},$$

Energy stored In the IFO



- 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."**

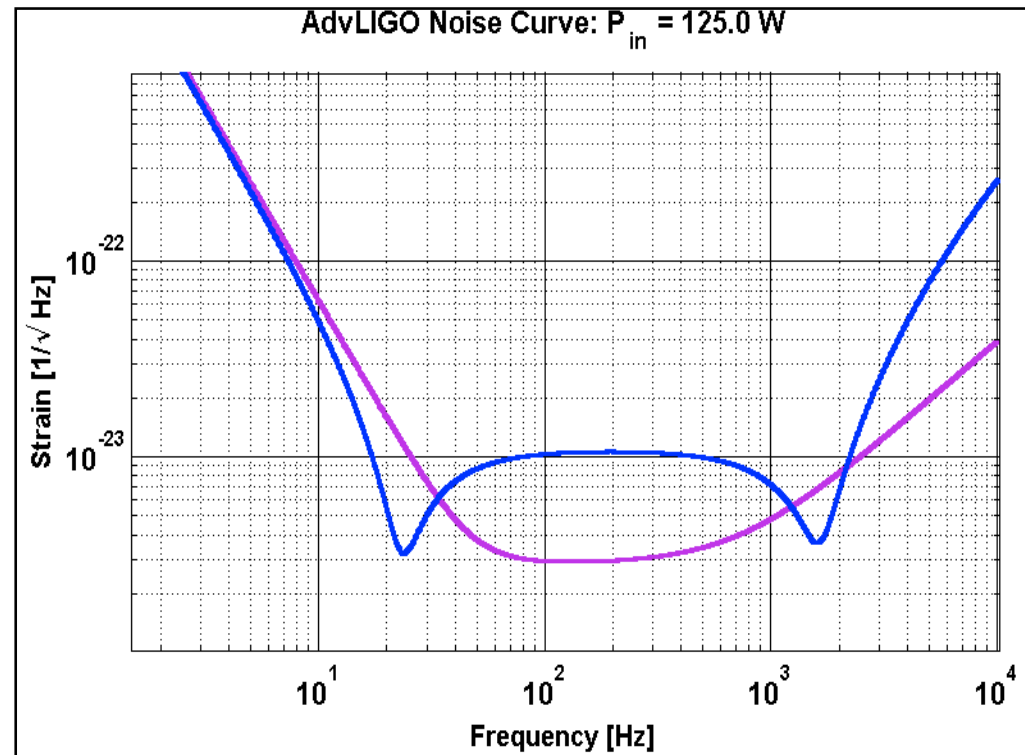
Jun's Theorem: aLIGO as example



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

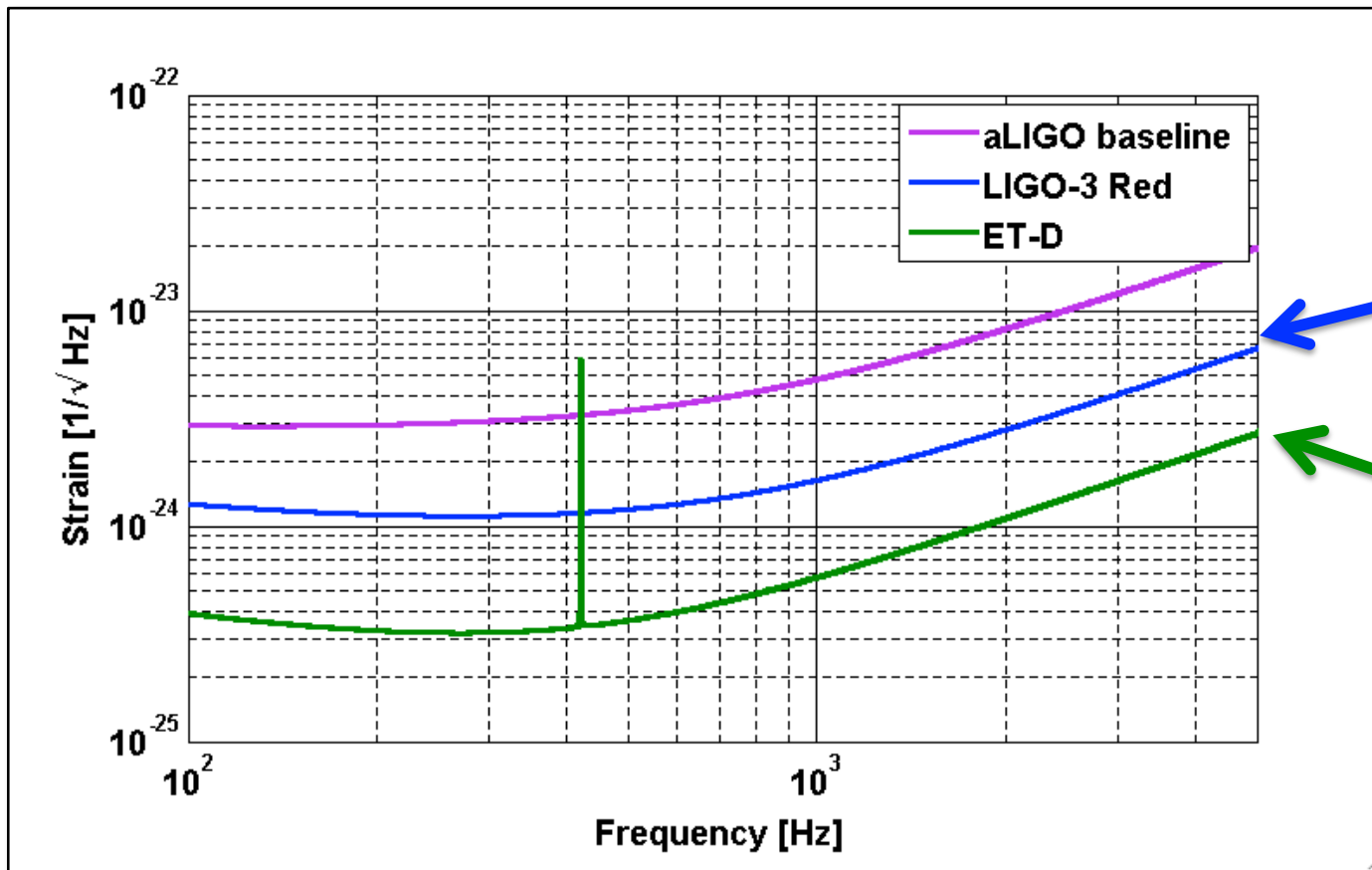
1064nm (points to λ)
10J (points to \mathcal{E})
~500 Hz (points to Δf_{BW})

- **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 expect from the future ?



LIGO3: Lots of squeezing

ET: Squeezing + Longer arms + more power