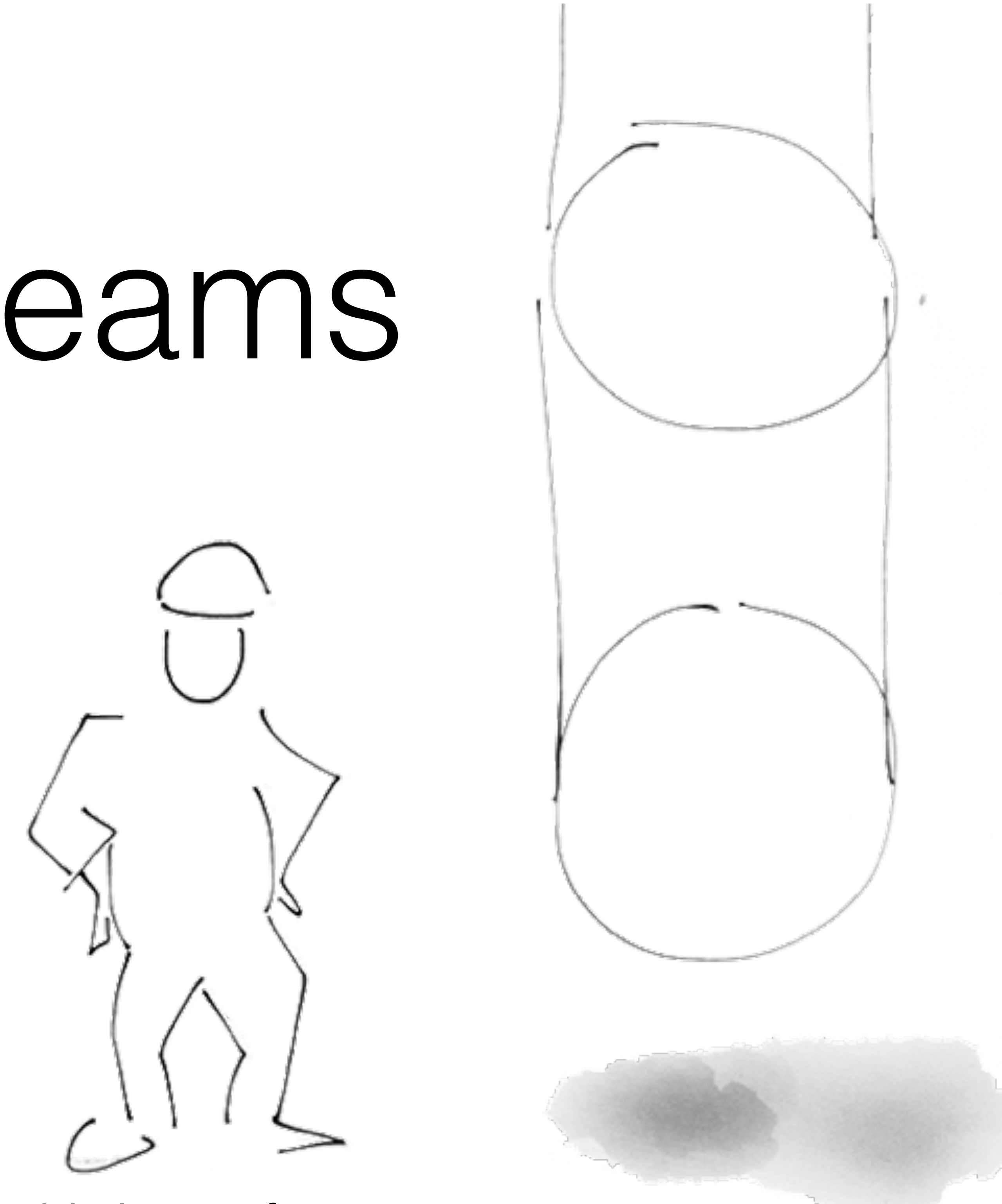
Wide Beams



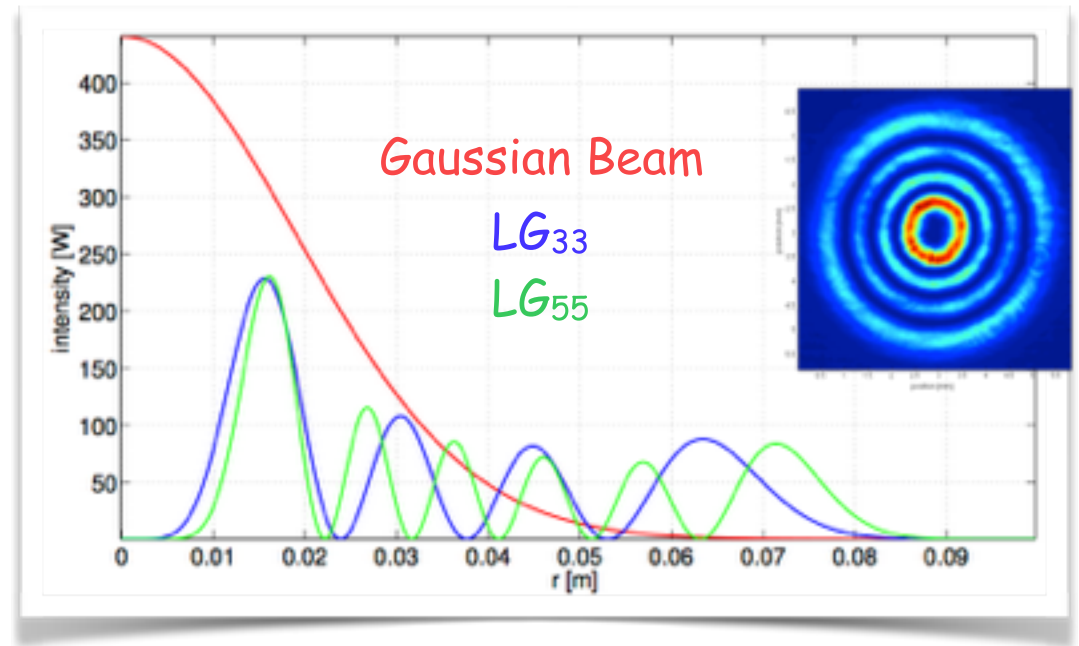
LIGO-G1601204, with input from
Giles Hammond, Norna Robertson, Daniel Sigg, Matteo Tacca,
Geppo Cagnoli, Christophe Michel, Stefan Ballmer and others

Andreas Freise

GWADW, Elba 2016

Laguerre-Gauss modes

- **TN reduction factor (LG_{33}) ~ 1.7**
- Compatible with current spherical mirrors

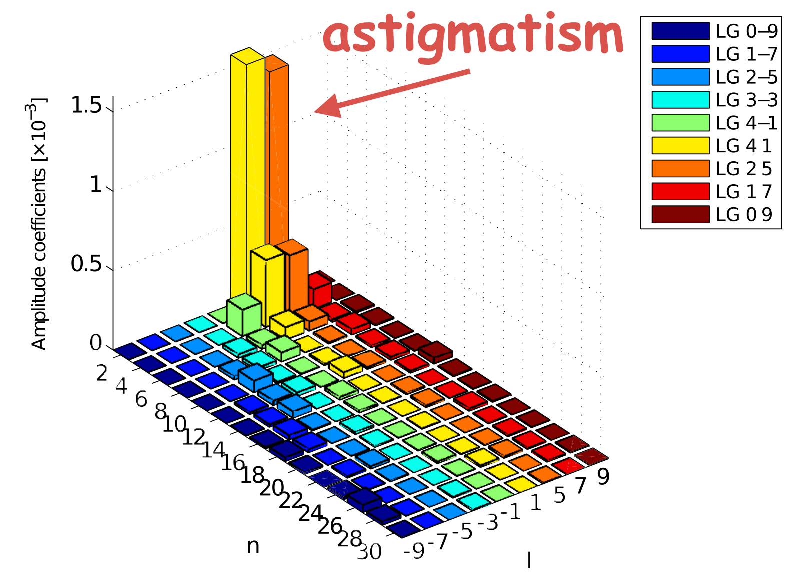


- High purity (> 97 %) LG_{33} mode generated also at high power
- Table-top Fabry-Perot Michelson interferometer realized

Main problem: contrast defect degradation due to the degeneracy, **naively requires better mirror surface by factor of ten.** However, the main effect is due to astigmatism, not small structures.

[1] B. Mours et al. CQG 23, 5777 (2006) - [2] M. Granata et al., PRL 105 231102 (2010) - [3] P. Fulda et al., PRD 82, 01002 (2010) [4] L. Carbone et al., PRL 110 251101 (2013) - [5] A. Gatto et al., PRD 90, 122011 (2014)

LG modes, possible solutions



- **In-situ thermal correction** of mirrors defects
- **Increasing the surface quality** of the coatings
- Application of a **corrective coating** to correct the mirror defects
- Search for **alternative higher order modes** to relax the specifications on the mirrors

[6] T. Hong et al., PRD 84, 102001 (2011) - [7] C. Bond et al., PRD 84, 102002 (2011) -
[8] R. Day et al., PRD 87, 082003 (2013) [9] A. Allocca et al., PRD 92, 102002 (2015)

Larger beam size (00 mode)

- Thermal noise scales as 1/w
- Free aperture in beam tube ~1m
- Maximum mirror size and weight?
- Maximum coating size?
- Behaviour of arm cavity with large beams?

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Quad Suspension

LIGO

University of Glasgow

General Assumptions for New Quad Design

- Assume test mass is silica: (therefore not cryogenic)
  - *Producing a 400 kg silica mass is "just engineering".*
  - *Technology to grow crystalline masses (Si, sapphire) with the desired bulk properties to such sizes does not exist at present*
- Assume aspect ratio of mass is same as current design
- Assume overall length not limited to the maximum available in the current facilities
- Assume overall mass of the suspension is not limited by the current ISI (internal seismic isolation) design

G1601071: Talk by Giles and Norna tomorrow at 18:40

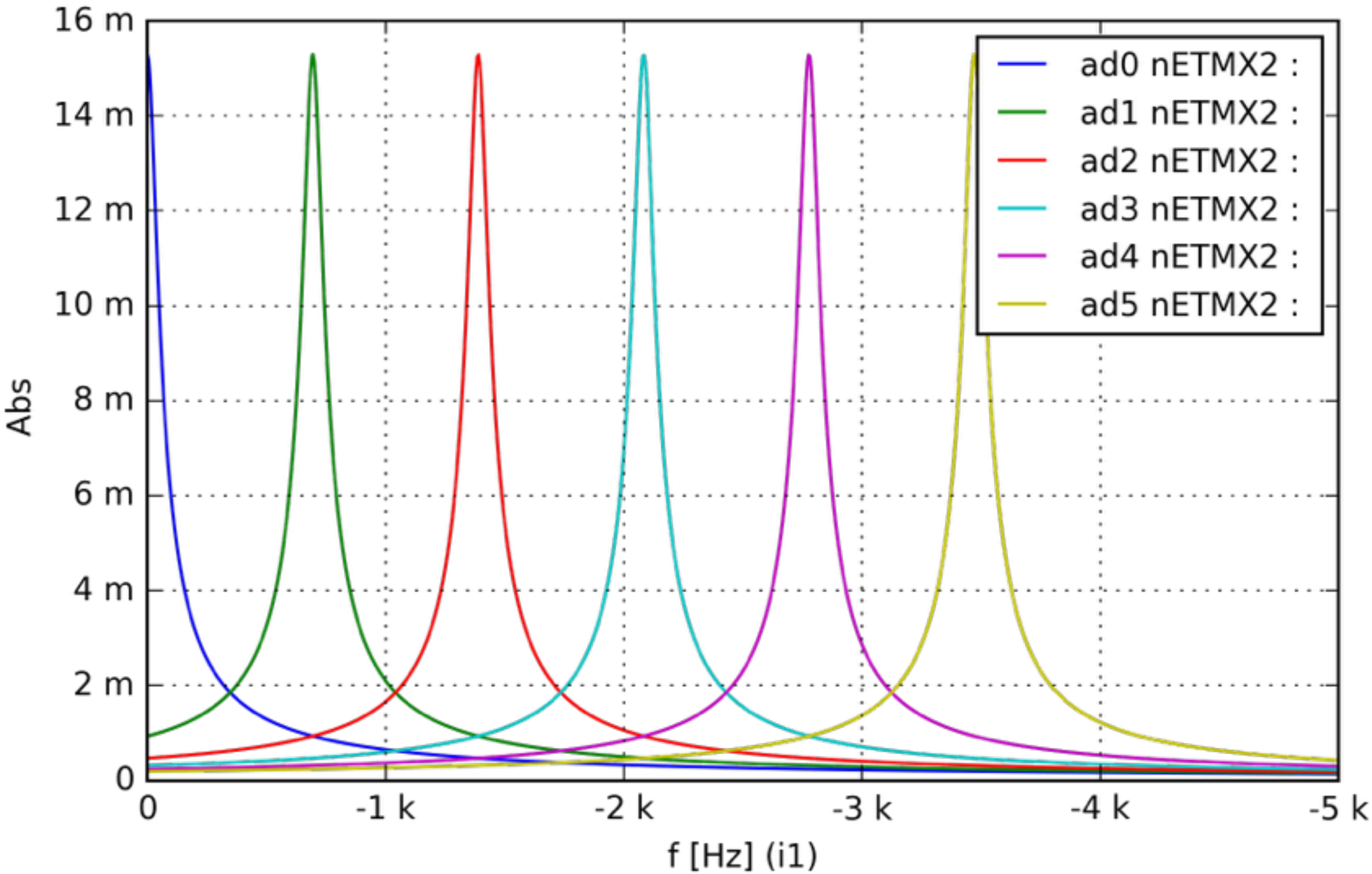
160 kg mirror

- Scaling factor (160/40)^(1/3) ~ 1.6 (1.8)
- Mirror diameter ~ 55 cm
- Beam radius (5ppm clipping) ~ 11 cm
- Cavity: g= 0.989, Gouy= 12deg,
  mode separation 1280 Hz

400 kg mirror

- Scaling factor (400/40)^(1/3) ~ 2.2 (2.5)
- Mirror diameter ~ 75 cm
- Beam radius (5ppm clipping) ~ 15 cm
- Cavity: g= 0.997, Gouy= 7deg,
  mode separation= 700 Hz

Mode separation



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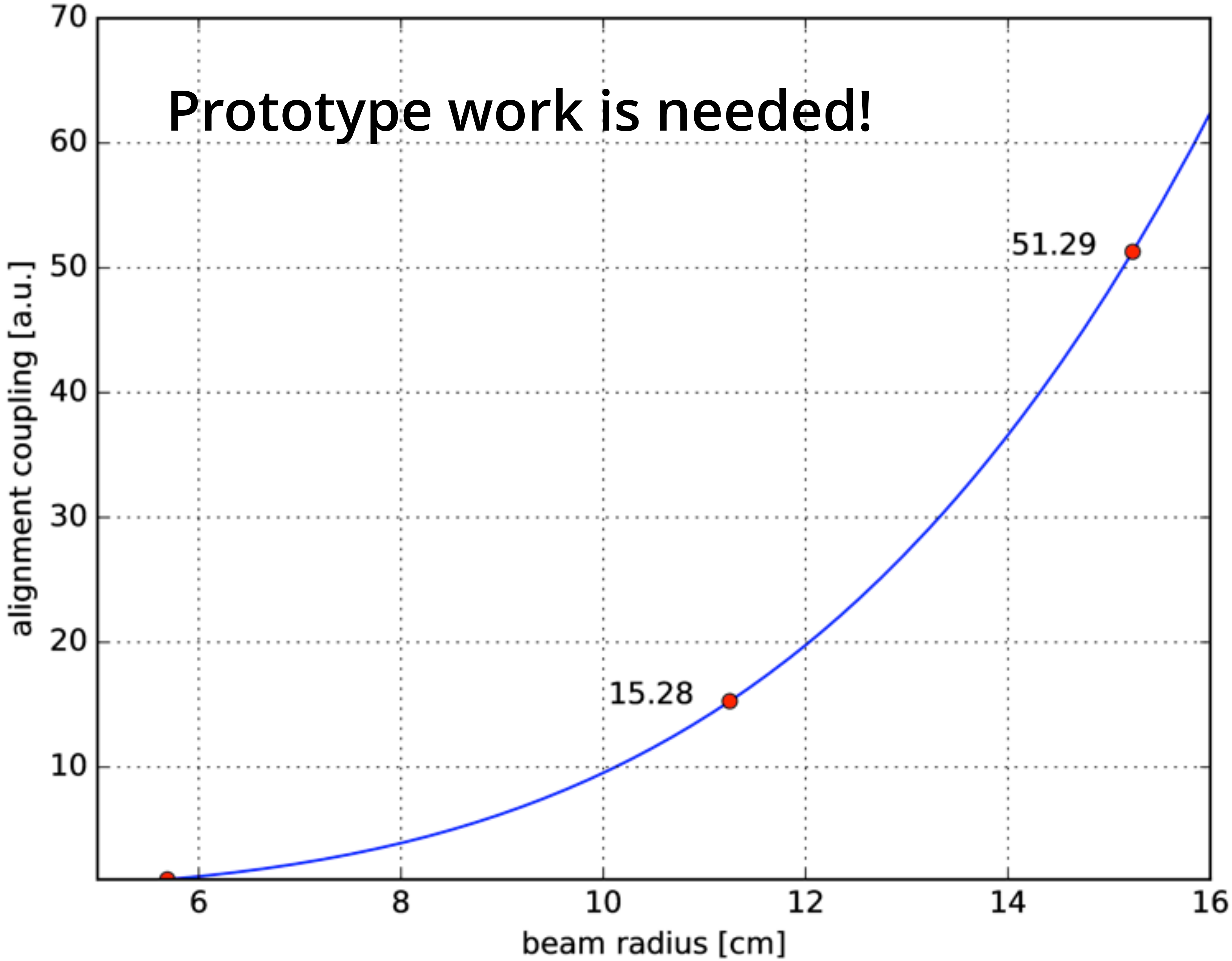
Alignment coupling (w^6)



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Coating Uniformity

- Weight and size can be handled by coaters in time (160kg probably today, 400kg in the future)

- Same coating uniformity at larger sizes needs work

See also previous talks by Stefan Ballmer: G1500292 and G1500701, and Matteo Tacca VIR0244A-15

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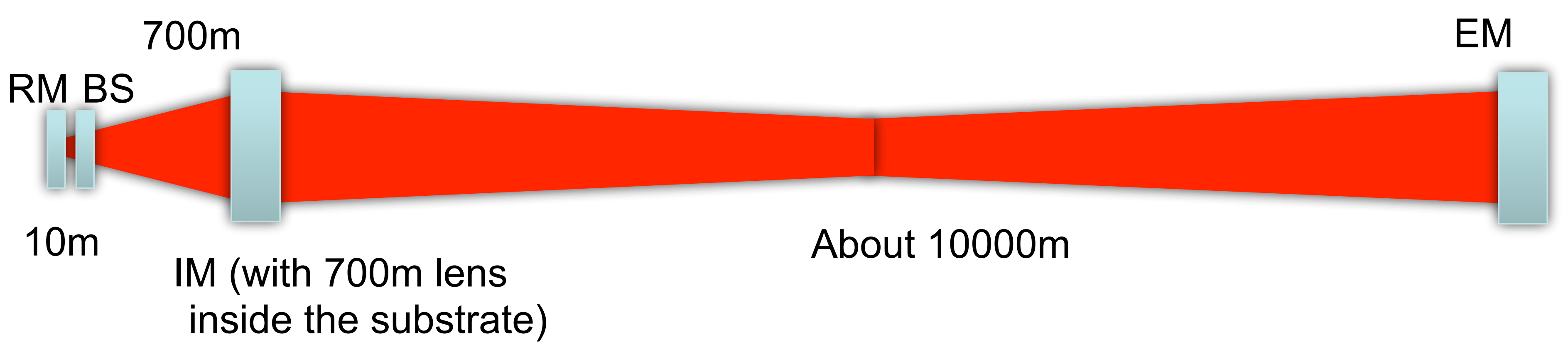
BS size

- BS must be larger than an optic under normal incidence by sqrt(2)
- Maybe keep beam in central interferometer small, from the ET design:



ET design document: http://www.gwoptics.org/research/et/

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- Laguerre-Gauss modes : 1.7 TN reduction, good body of work for preliminary investigations, currently not actively continued

- Large beam and mirror sizes: 1.7 or 2.5, an ‘engineering problem’ for the suspension, challenge for coating uniformity, and need some better approach for alignment control

Not all of this sounds like fun, but is any of this really more difficult than cryogenics (or any other advanced technique)?