Technologiedomein OPTICA

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Einstein Telescope

Inhoud

- Interferometrie
- Onderdelen
- Key challenges

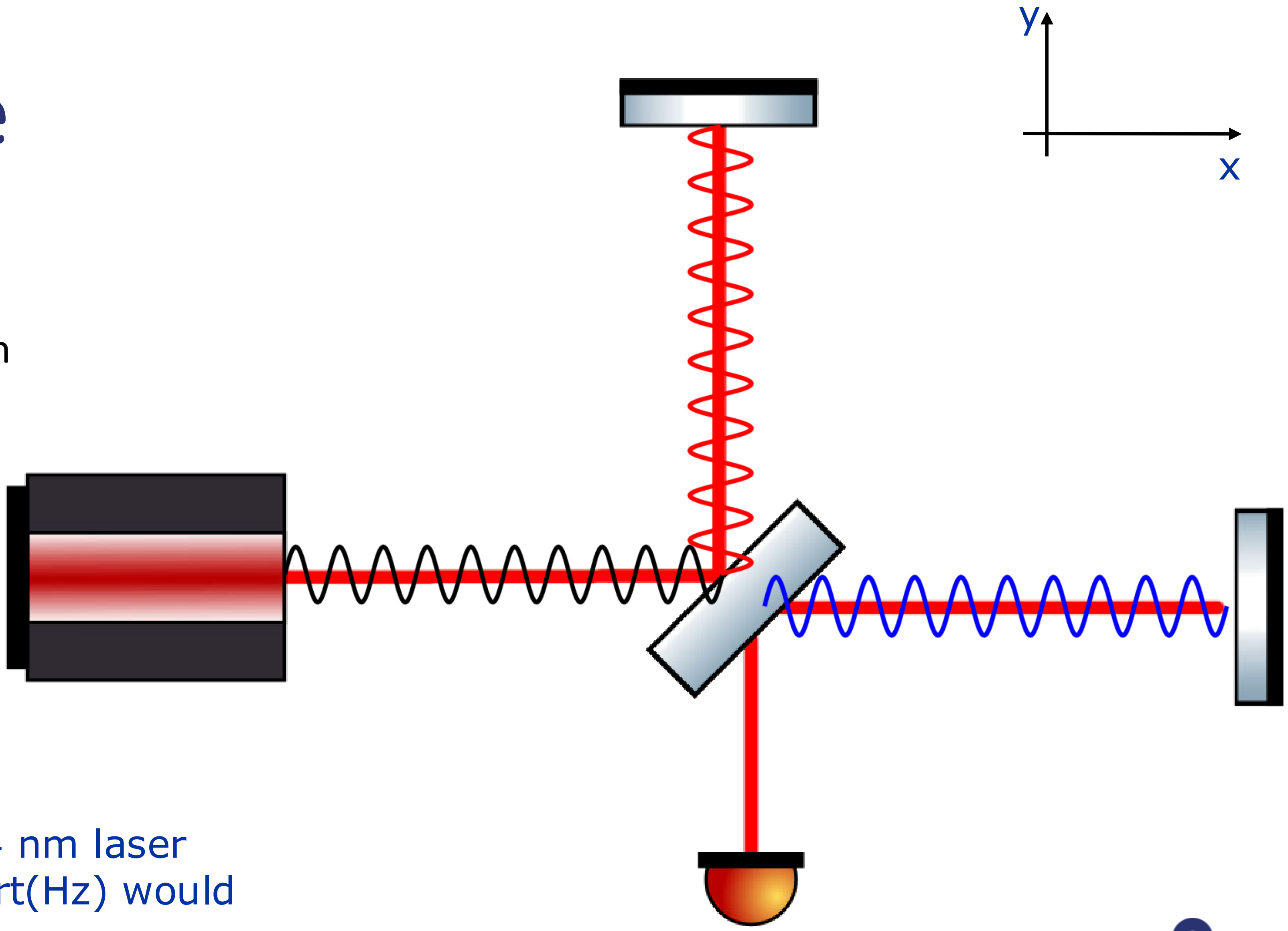
Interferometrie

- Michelson interferometer
- Sensitivity – amplitude strain

=> High powers (P0)

=> Long cavities (L)

$$\sqrt{\frac{2\hbar}{P_0\omega_0}\frac{c}{L}}$$

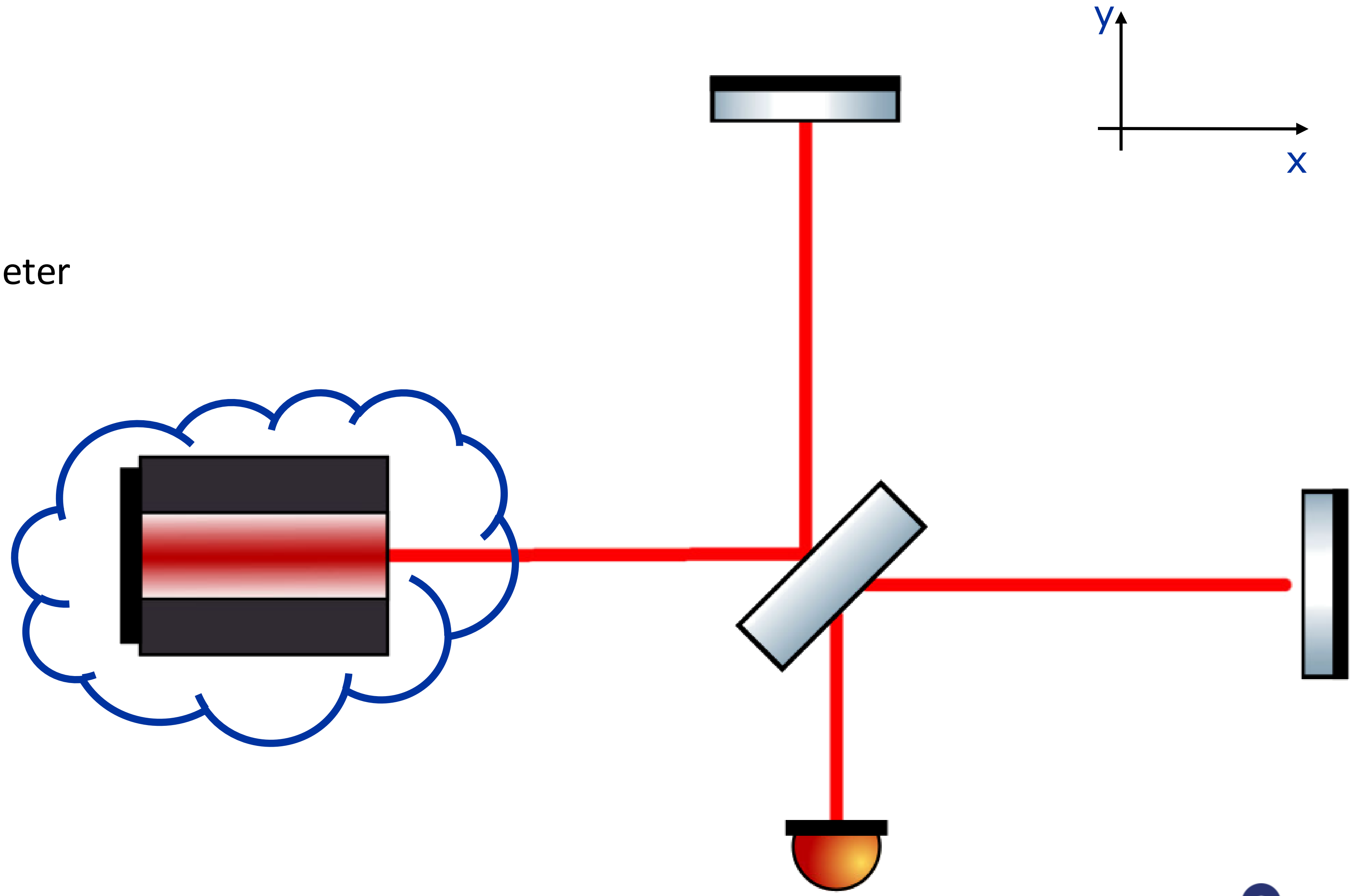


e.g. LIGO : 3km arm length , 1064 nm laser wavelength => reaching 10^{-22} 1/sqrt(Hz) would require **P_0~70kW** !

fwo VLAIO

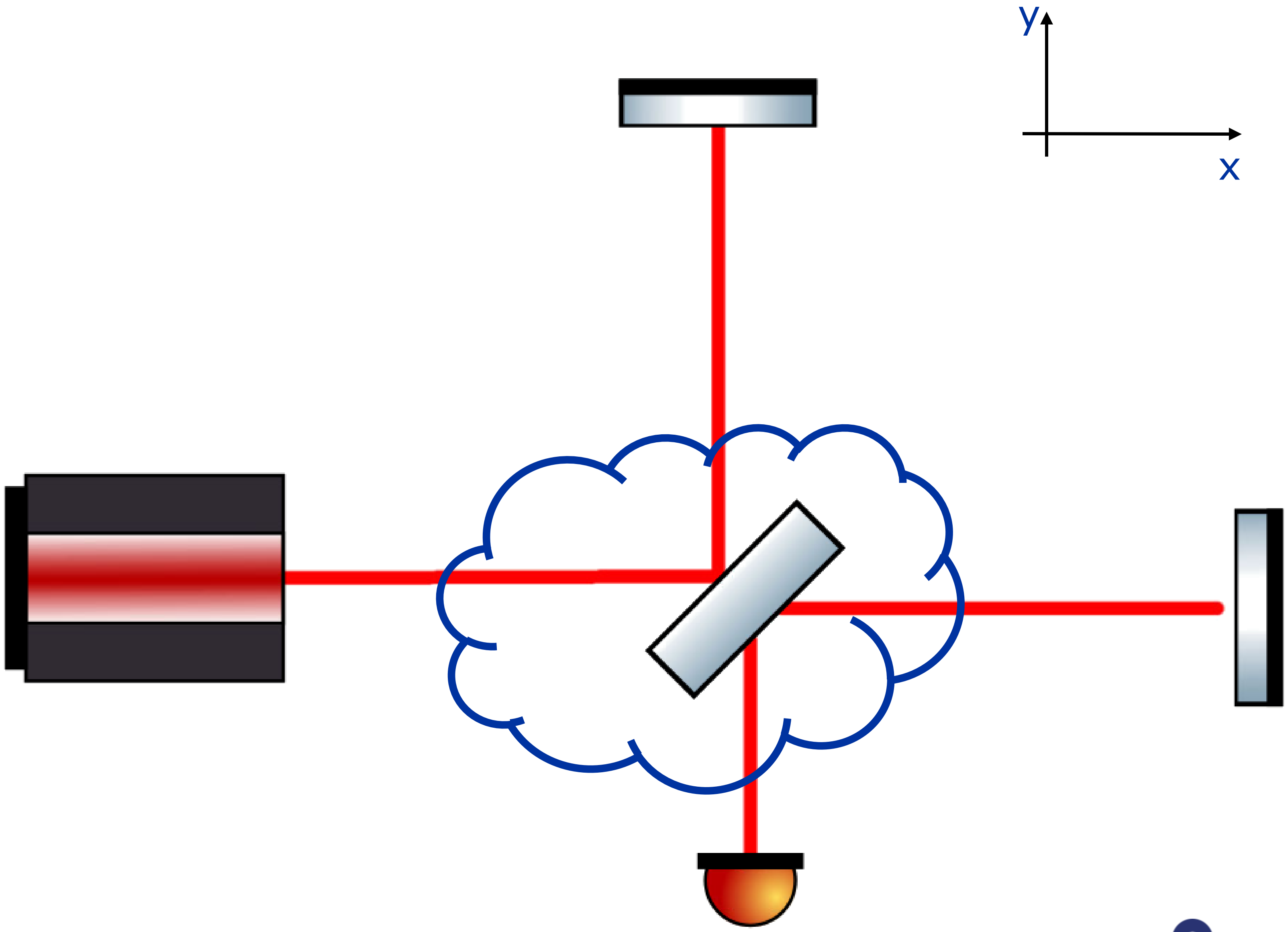
Onderdelen

- Michelson interferometer
- Light source: a laser
  - Coherent
  - Monochromatic
  - Intense



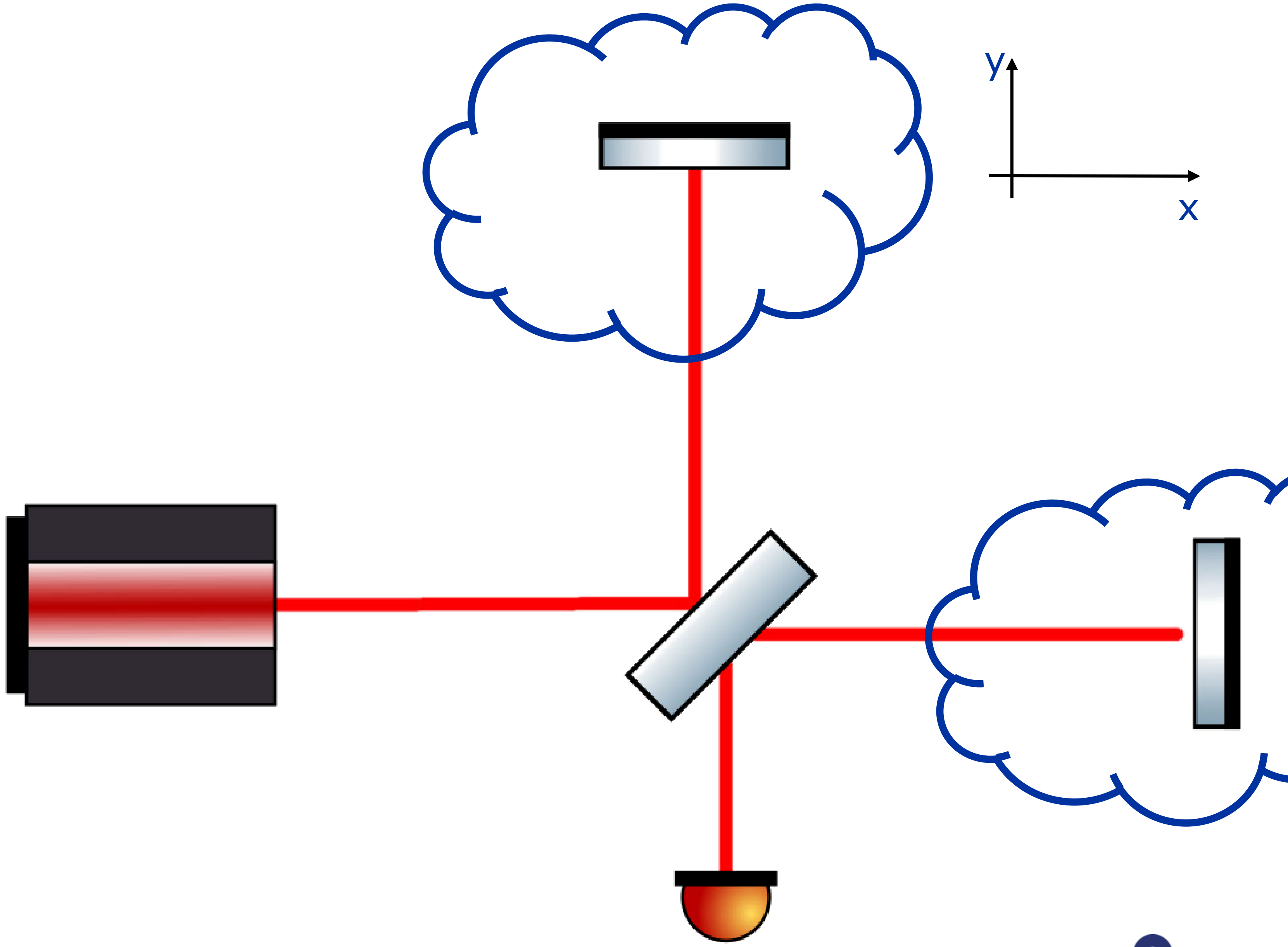
Onderdelen

- Michelson interferometer
- Light source: a laser
  - Coherent
  - Monochromatic
  - Intense
- Beamsplitter
  - 50% towards X
  - 50% towards Y



Onderdelen

- Michelson interferometer
- Light source: a laser
  - Coherent
  - Monochromatic
  - Intense
- Beamsplitter
  - 50% towards X
  - 50% towards Y
- End mirrors
  - Highly reflective
  - Extreme quality
  - Return the lightbeams



Onderdelen

- Michelson interferometer
- Light source: a laser
  - Coherent
  - Monochromatic
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  - 50% towards X
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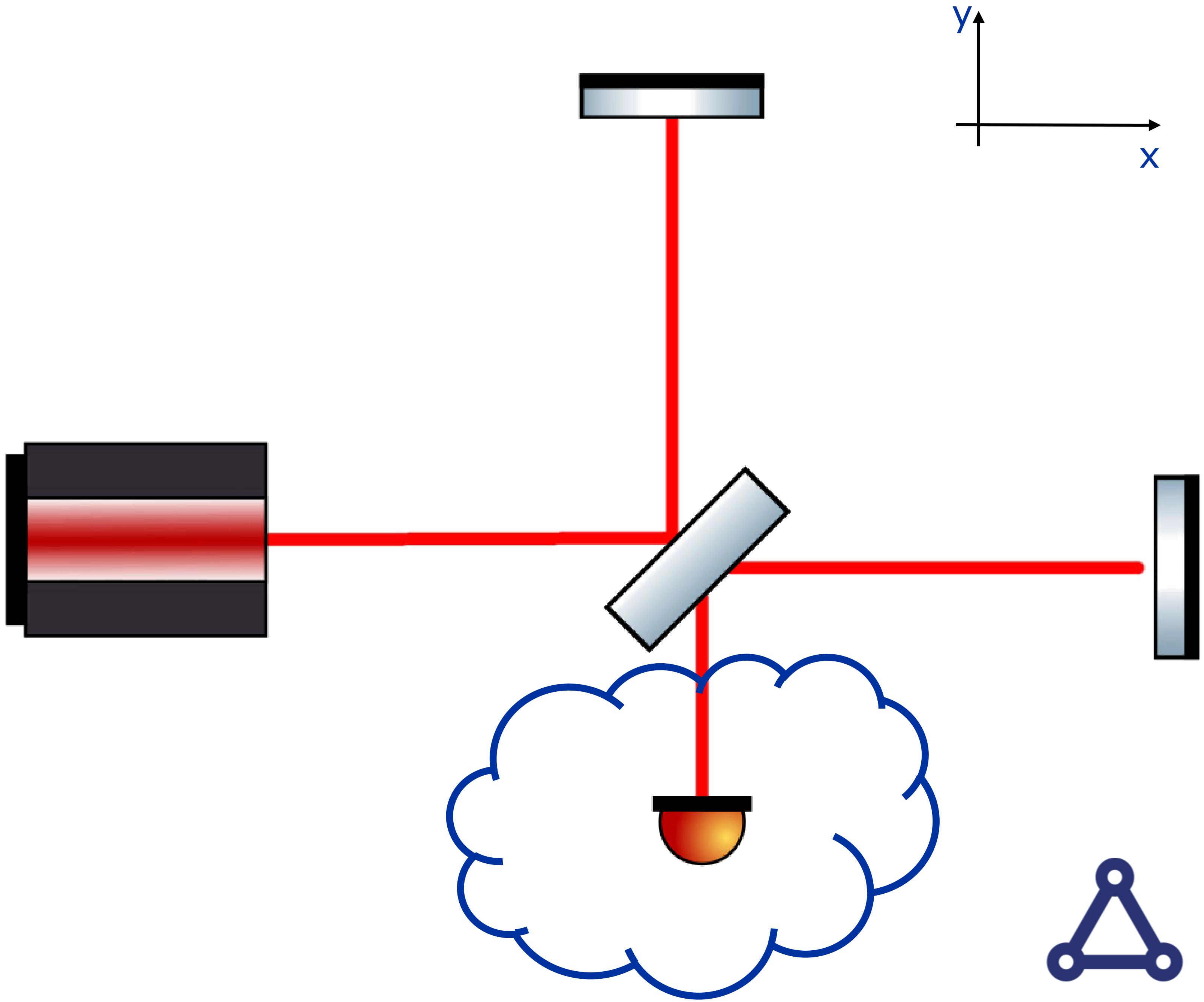
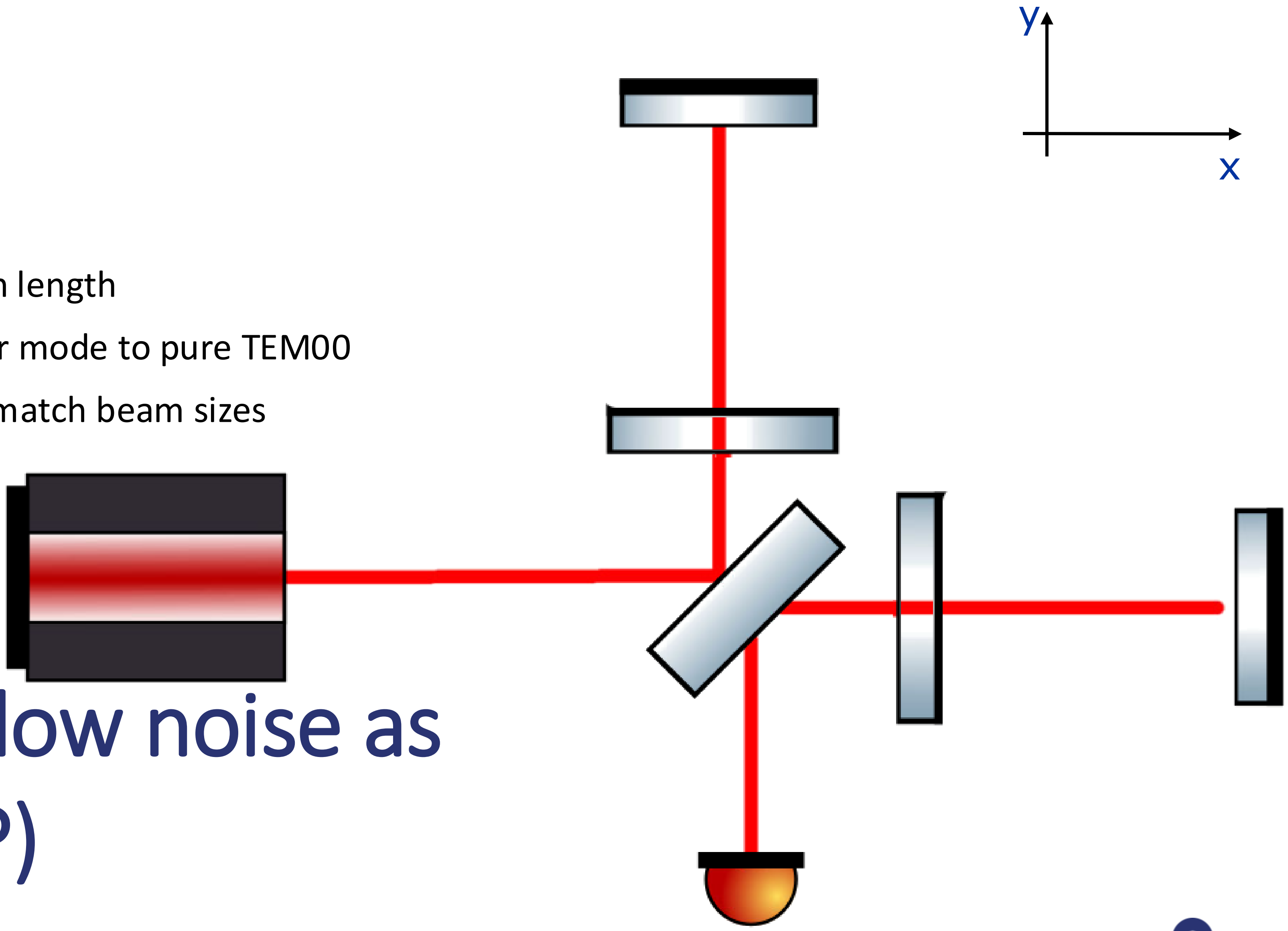
- End mirrors
  - Highly reflective
  - Extreme quality
  - Return the lightbeams
- Photodiode
  - Low noise
  - Looks at darkness



Onderdelen

- Michelson interferometer
- Fabry-Perot cavity: increase arm length
- Optical filters: cleaning the laser mode to pure TEM00
- Mode matching: telescopes to match beam sizes



Ultiem doel: as low noise as possible (ALNAP)

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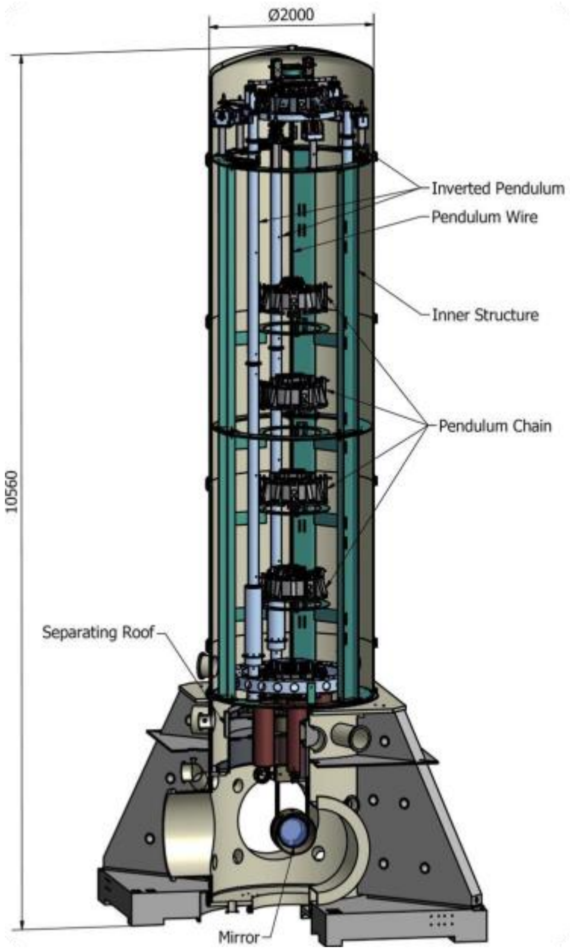
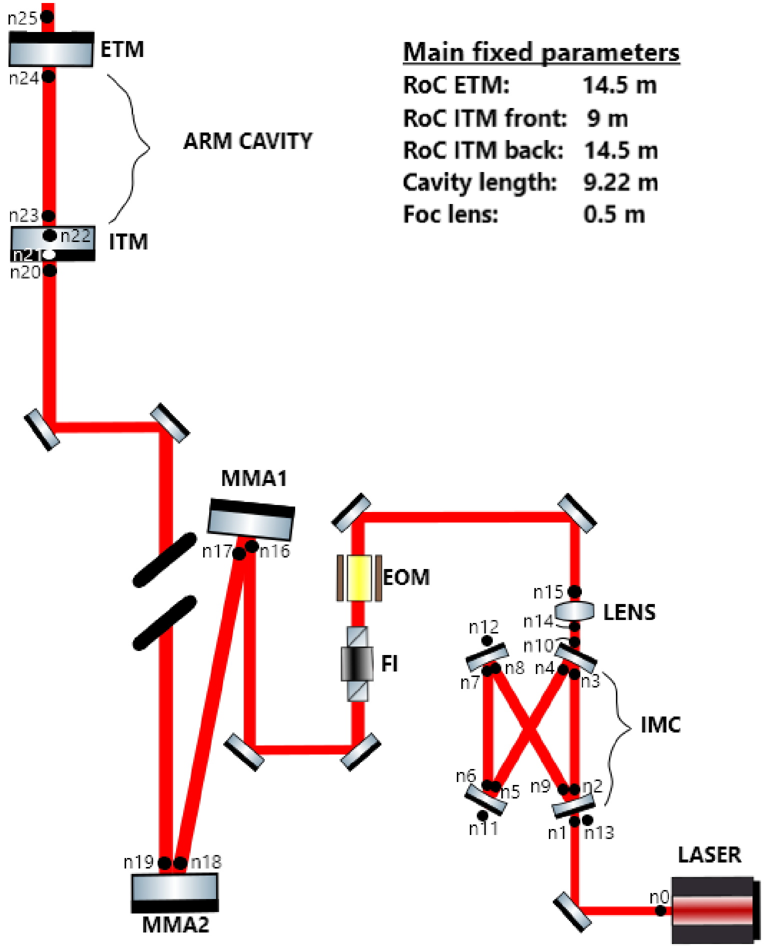
Onderdelen

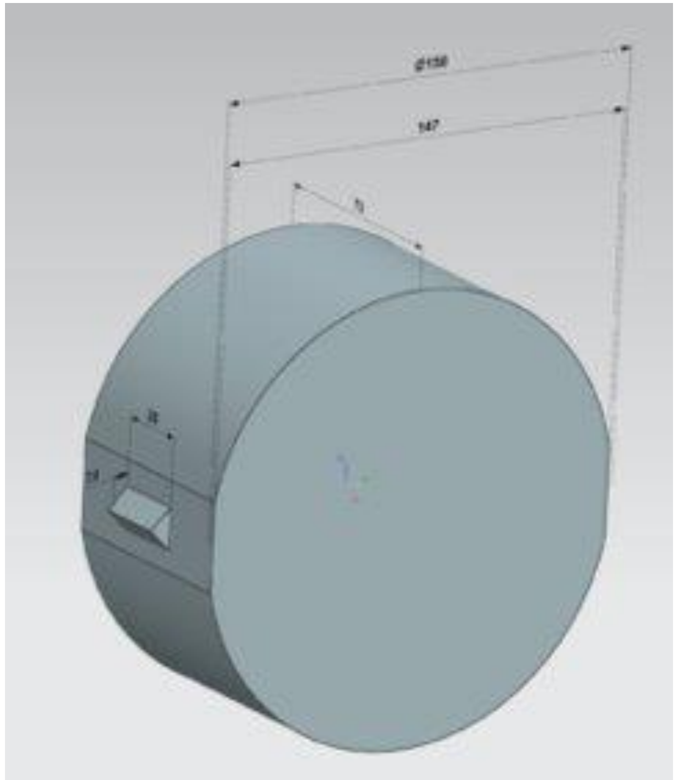
- EO modulatoren
- Fiber-optics
- Optomechanica
- Piezo-gestuurde elementen
- UHV compatibility
- Absorberende lagen
- Cryogene omstandigheden
- Laser amplifiers
- …





Key challenges

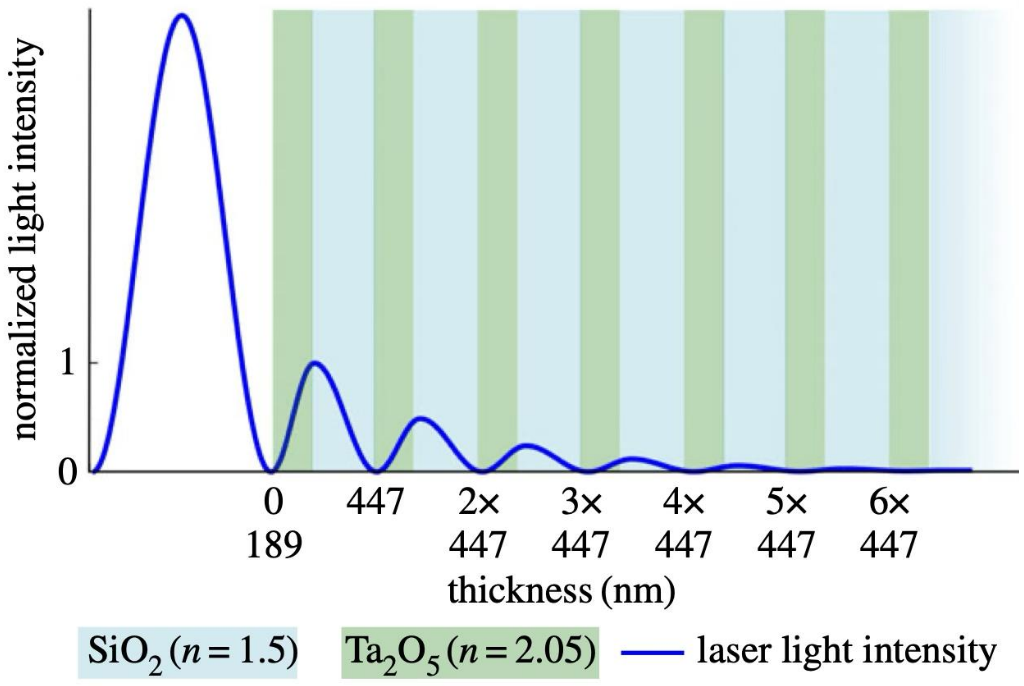
- ETM/ITM spiegels
  - For 1550 nm LF sensitivity
  - <111> high-purity silicon (<5 ppm/cm)
  - D 550 mm, ~140 mm thick, 300kg / mirror
  - Concave radius ~ 5 km
  - <0.3 nm PV high-frequency surface error
  - <2 nm low-frequency surface error
  - <0.1 nm RMS surface roughness
  - Cryogenic (18K) UHV
  - Low loss coatings



fwo VLAIO

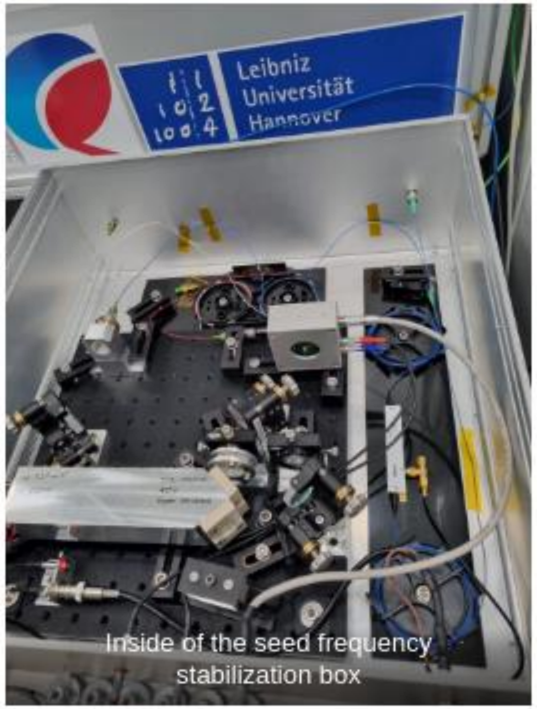
Key challenges

- Coatings
  - Pairs of low / high refractive index materials
  - Total reflection ETM: 99,999%
  - Uniformity: ± 0.03%
  - Optical & scattering losses: < 1 ppm
  - Mechanical losses: < 10^{-4}
  - State of the art amorphous silica / tantala coatings not good enough
  - Search for new materials: crystalline – KU Leuven, amorphous UGent
  - Explore alternative production methods MBE – KU Leuven, ALD - UGent



Key challenges

- Laserbronnen
  - 1064 nm; 700W HG_{00} (ET HF)
  - 1550 nm 5W (ET LF)
  - 2090 nm?
  - Amplificatie tot kW-niveaus
  - Modulatie met RF signalen



Courtesy ETPathfinder UMaastricht

Key challenges

- Absorberende lagen
  - Ultra-absorberend
  - Hoogvermogen
  - UHV compatibel
  - In-situ aanbrengen?

Key challenges

- Instrumentatie
  - Low-noise detectoren
  - Faze-camera's
  - EO controls
  - ...

Uw bijdrage?

- ...

Einstein Telescope