Advanced VIRGO Input optics

LIGO-G070361-00-Z

The Advanced Virgo injection system

- Advanced VIRGO: in 2011 VIRGO should be ready to be upgraded to a detector with about 200 W input power

- 200 W Laser source: two options are open (see Nary's talk):
  - Solid State Laser source (SSL)
  - Fibre Laser (FL) source

- The layout of the optics downstream of the laser has not been decided. Open options are:
  - In-air elements (Faraday, EOM, mirrors, waveplates, polarizers, …)
  - Suspended resonant input mode cleaner
  - In vacuum suspended optics (Faraday, polarizers)
  - Matching telescope
  - Photonic fibre input mode cleaner
  - Integrated fibre elements

In any case: components withstanding 200 W

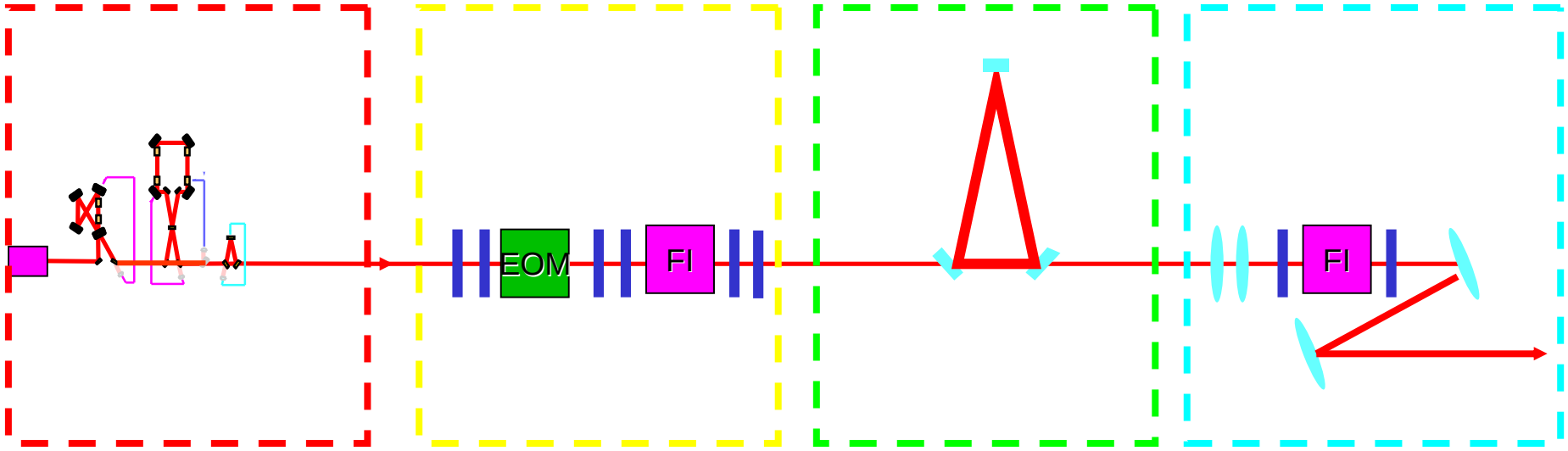
Standard solution (LIGO)

200 W SSL LASER

IN AIR HP INPUT OPTICS

RESONANT SUSPENDED INPUT MODE CLEANER

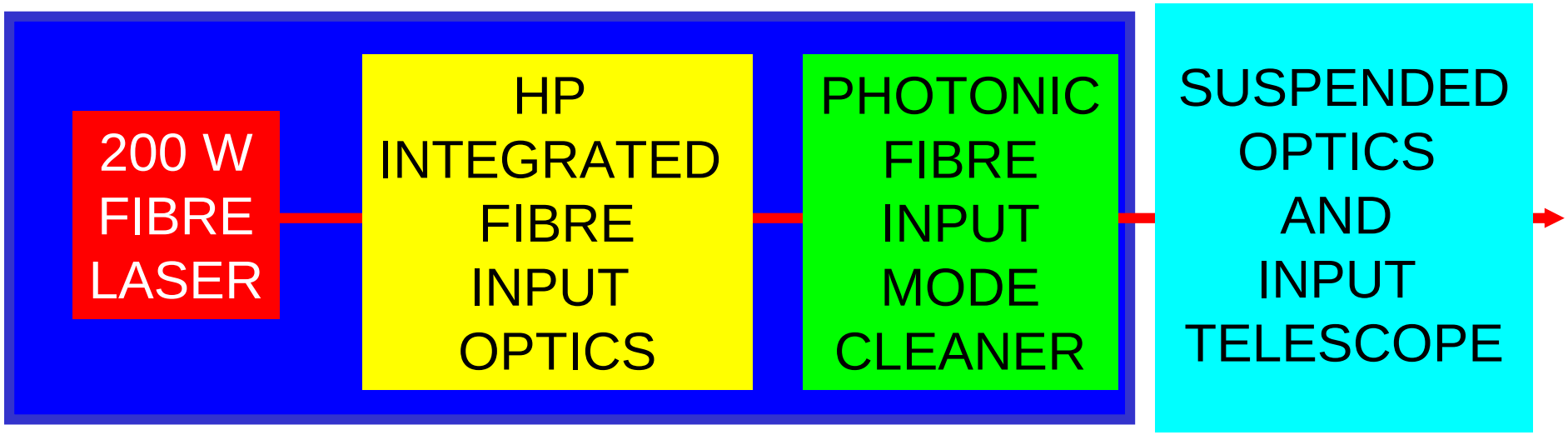
SUSPENDED OPTICS (FI) AND INPUT TELESCOPE

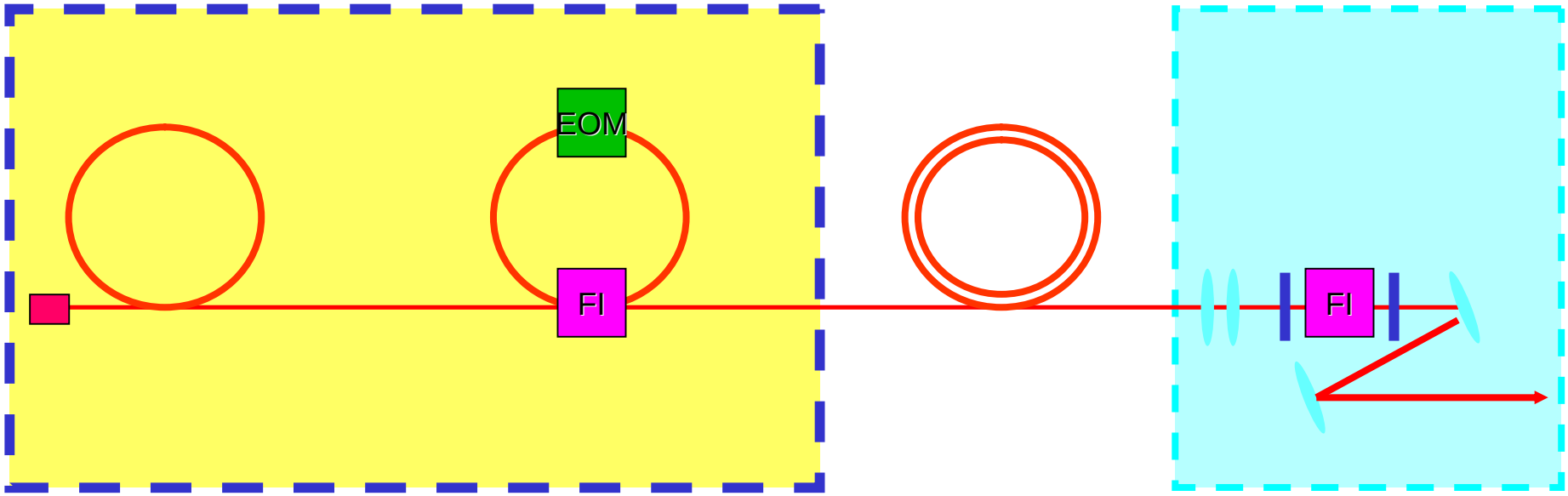


Possible fibre solution:

- Fibre integrated components (EOM, FI, …)
- Fibre IMC
- In vacuum Faraday isolator
- Matching telescope

All fibre solution





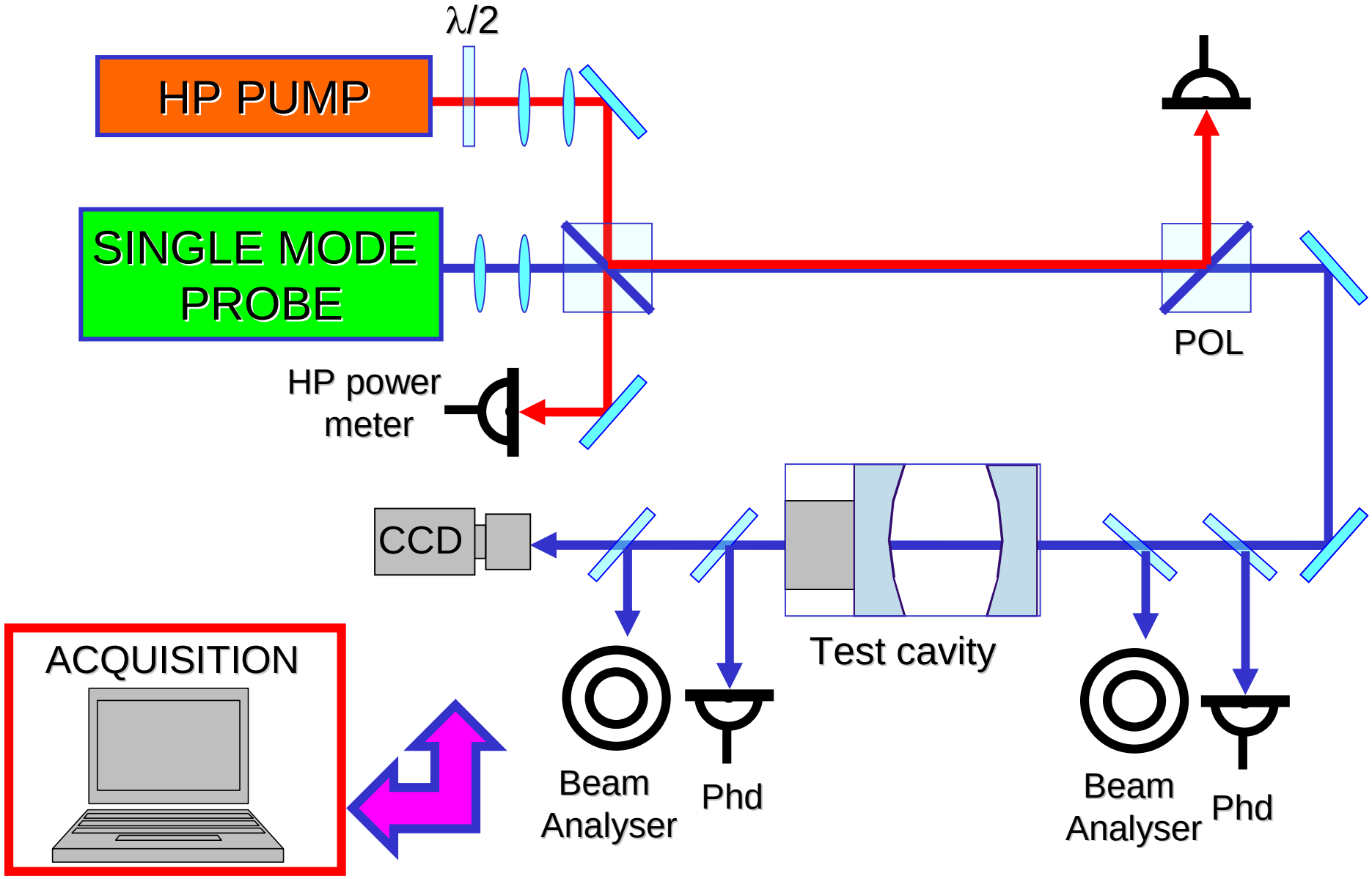
Present advanced VIRGO reference solution

LIGO:

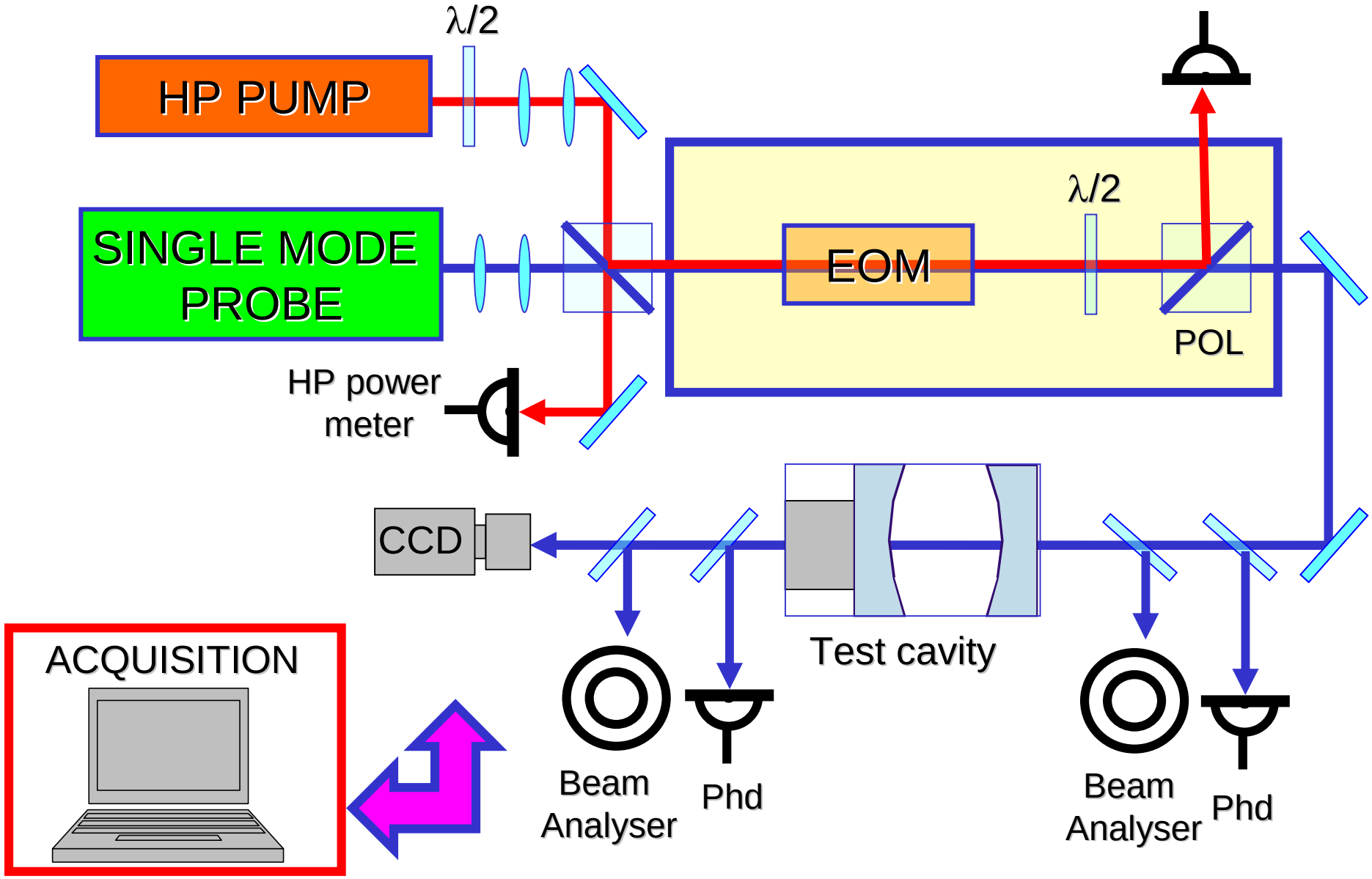
- Solid State Laser source
- In-air components
- Suspended resonant IMC
- In vacuum Faraday isolator and suspended optics
- Matching telescope
- Lots of R&D already done

- A program for developing High Power Input Optical components has been funded (February 2007):
- All what is necessary for setting up the HP power source is being purchased:
  - HP Ytterbium laser (IPG 200 W)
  - Optics
  - Beam analyser
  - Detectors
  - Cavities
  - Clean air, beam dumps
  - Vacuum chamber
  - …
- First tests:
  - Tests on DKDP samples could start in Fall
    Simulation and tests of thermal effects in Faraday isolators are being performed
    (see Slim's talk)
  - Even if Advanced VIRGO polarizers reference solution is likely calcite, tests on Brewster polarizers (General Optics substrates and Lyon coatings) for VIRGO+ will start in fall 2007

HP- IO components for Advanced Virgo

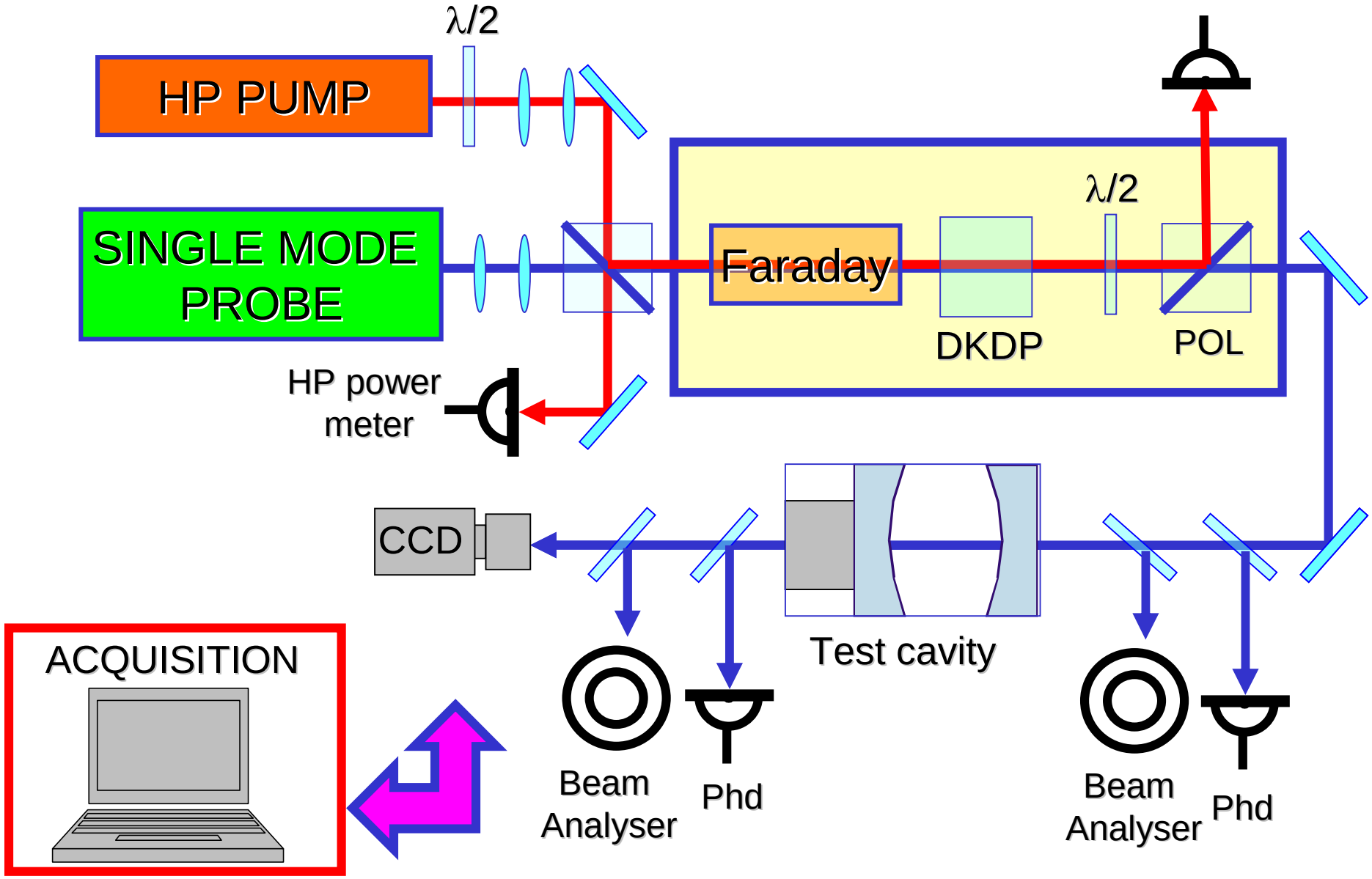


HP- IO components for Advanced Virgo



- In VIRGO+ EOM made of KTP crystal will be used
  - Same as present VIRGO
  - Thermal focal length (about 30 m) corrected by the in air tuning telescope
- Reference solution: Advanced LIGO EOM:
  - RTP EOM crystal:
    - About 10 times lower absorption (0.005 m^{-1} vs 0.05 m^{-1})
    - Lower dn_z/dT
    - Higher damage threshold
    - wedged (about 3°) EOM crystals
- We will in any case perform tests on KTP EOM (already for VIRGO+)

HP- IO components for Advanced Virgo



Faraday isolator

- An in-vacuum Faraday isolator will be used even with a fibre IMC
- Good experience already acquired in Virgo:
  - Thermal lensing
  - Thermal effects on isolation
- Many things understood ad a lot of simulation performed
- Results can be compared with those of LIGO
- Ready to start soon high power in-vacuum tests (Slim's talk)
- Reference solution for Advanced Virgo: Advanced LIGO Faraday Isolator

Fibre solution

Fibred components: (like integrated fibred EOM, FI)

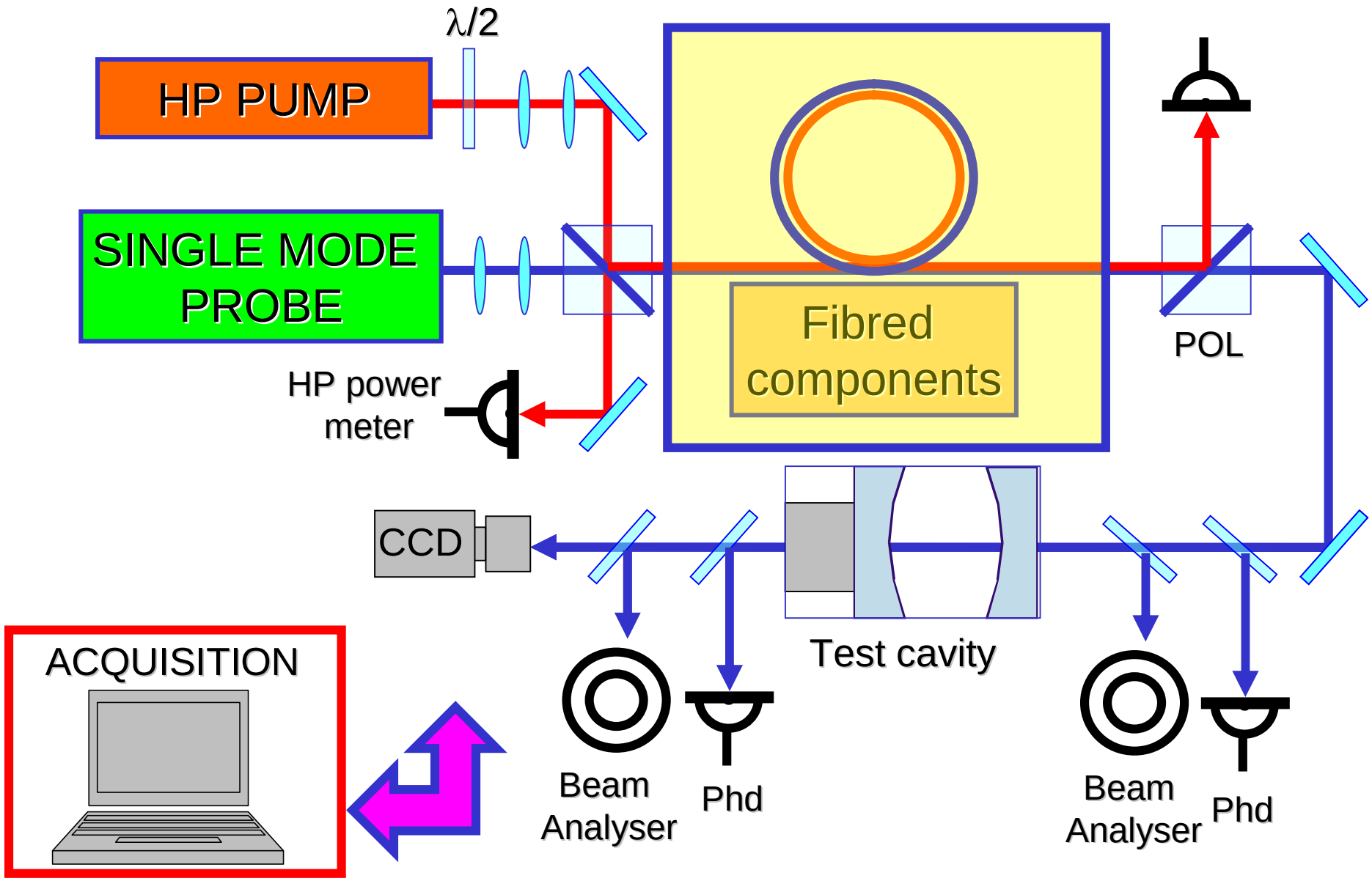
Apparently more advantageous:

- Reliability
- Alignment
- Neither acoustic nor seismic noise
- High power
- Telecom tested solutions
- Easily integrated with a fibred input mode cleaner
- …

But:

- More experience needed soon
- Very short time to make high power tests

Possible adaptation for HP-IO fibred components



At the same time we need:

Start requirements computation (EOM, IMC, telescopes, stabilization, …)

- Start simulation and design of a possible resonant IMC
- Start simulation and design of a possible matching telescope
- Take advantage from LIGO R&D
- Perform our own R&D and develope experience

Input Optics (Faraday, EOM, Polarizers, …)

Requirements:

- Faraday (in air and in vacuum)
  - Level of power impinging on them
  - Level of optical isolation
  - Insertion loss allowed
  - Beam distorsion allowed
  - Compensation (lensing, isolation)
- EOM:
  - Minimum modulation depth
  - Stability of sidebands
  - Level of power impinging on them
- Polarizers, mirrors, splitters (scattering issues)
- How things will change depending on the choices for the ITF (for example if there will be DC detection).

Requirements:

Which are the different options open

- Suspended
- Fibre

In case of suspended IMC:

- Length, Finesse, transmission, use of dihedron
- Frequency pole for HF noise
- Scattered light on the mirrors and on their support,
- Seismic isolation of the mirrors
- Filtering

Requirements:

- Which are the different options:
  - Long, short
  - Standard lenses
  - Parabolic, off-axis
  - Adaptive matching
- Stability, Matching, Insertion loss by aberrations
- Seismic isolation
- Scattering: maximum reflection by AR coatings
- Depending on:
  - Different possible IMC
  - ITF configuation

What is being done

- In-air HP-IO components: Activity started: EGO, Pisa, Naples
- In vacuum suspended optics: Activity started: EGO, Pisa, Naples
- Integrated fibre elements: To be decided: Possible within the EGO, Pisa, Naples R&D (coordinated with NIce activity)
- Suspended resonant IMC: Very little action taken
- Matching telescope No action taken

WG2 involved people

- 21 People included in the WG2 mailing list
- Work effectively performed by only a few of them
- All of them are also involved in the Virgo Commissioning and/or in the Virgo+ ugrades
- More collaboration with WG1 is needed: very important for defining requirements
- Injection system configuration: not yet assessed

- Manpower, at least up to now, is not sufficient

- After the start of the Science Run more time/people will be available