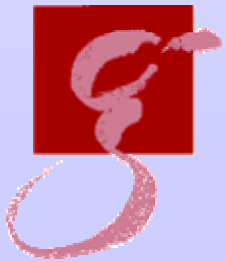
Diagnostic Breadboard and Laser Characterization

Laser Session, 21 March 2006

LIGO-G060042-00-Z



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(Albert-Einstein-Institute Hannover)

Laser Beam Characterization

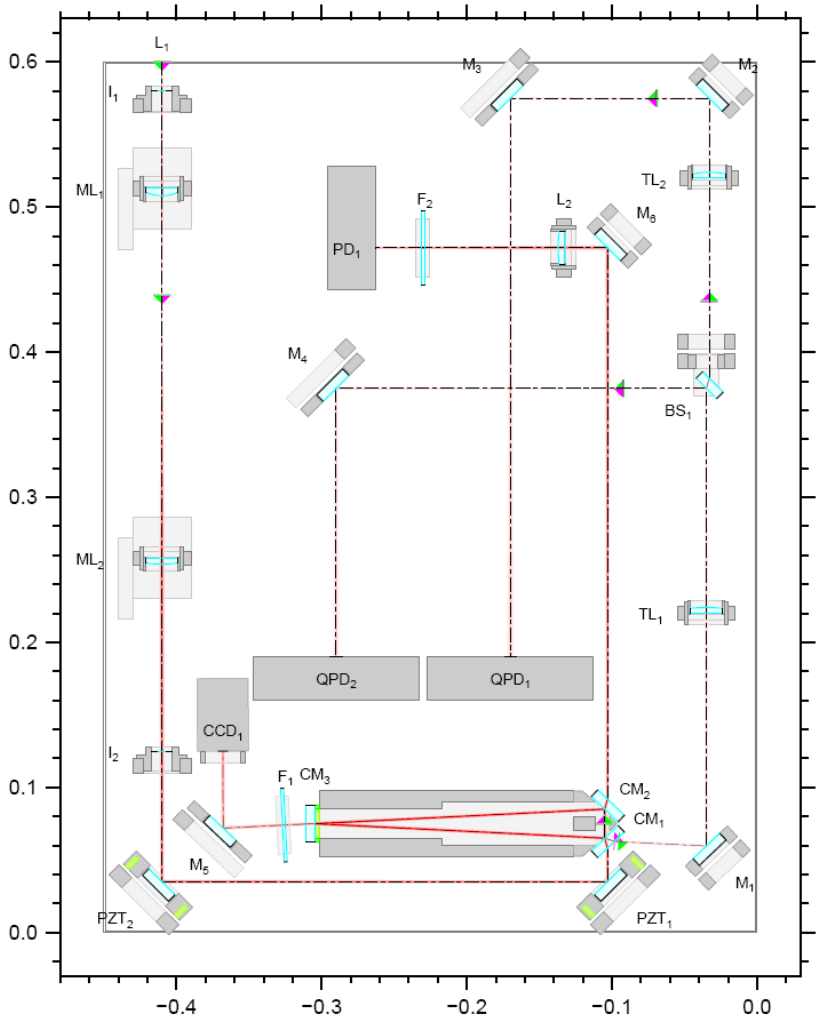
Output Power & RIN

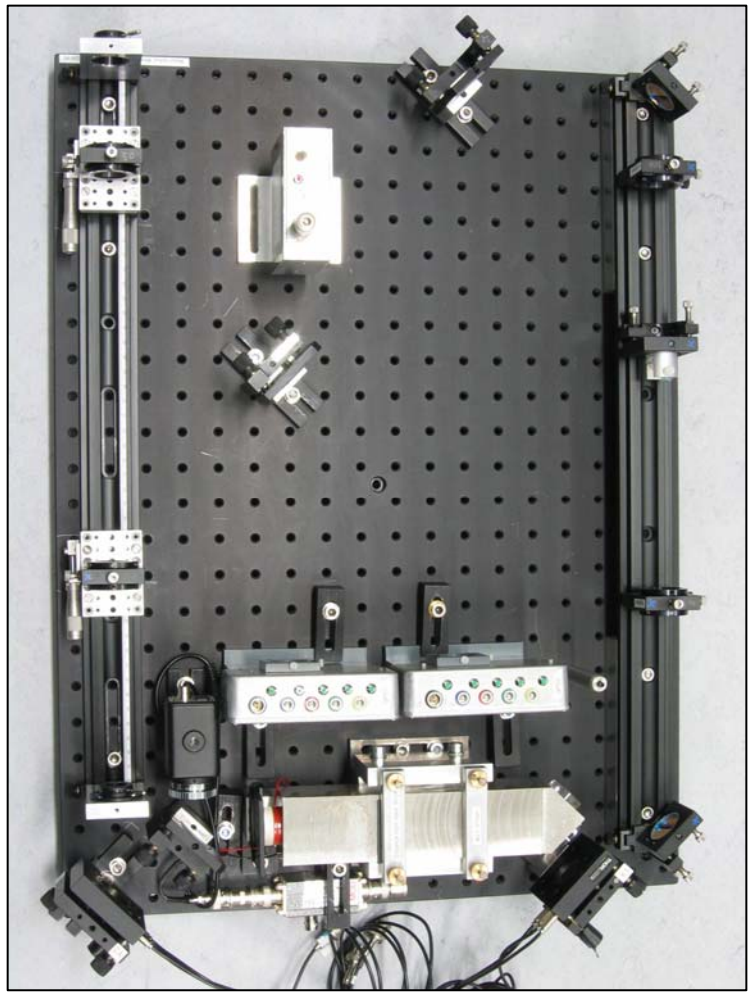
Frequency noise

Beam Pointing

Beam Quality

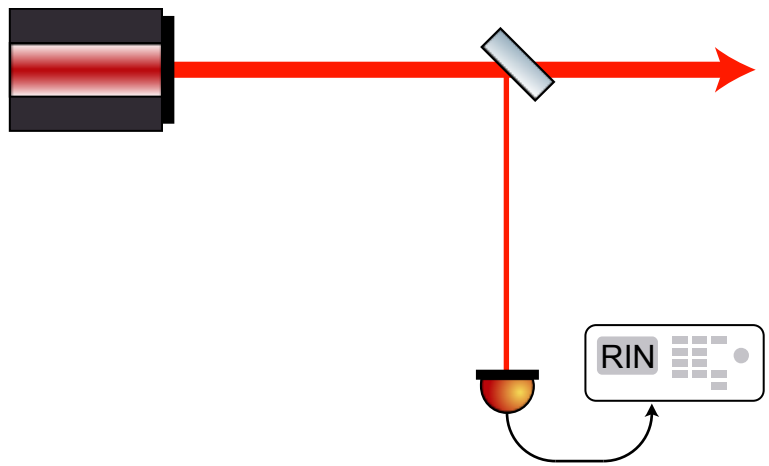
Auto-Alignment





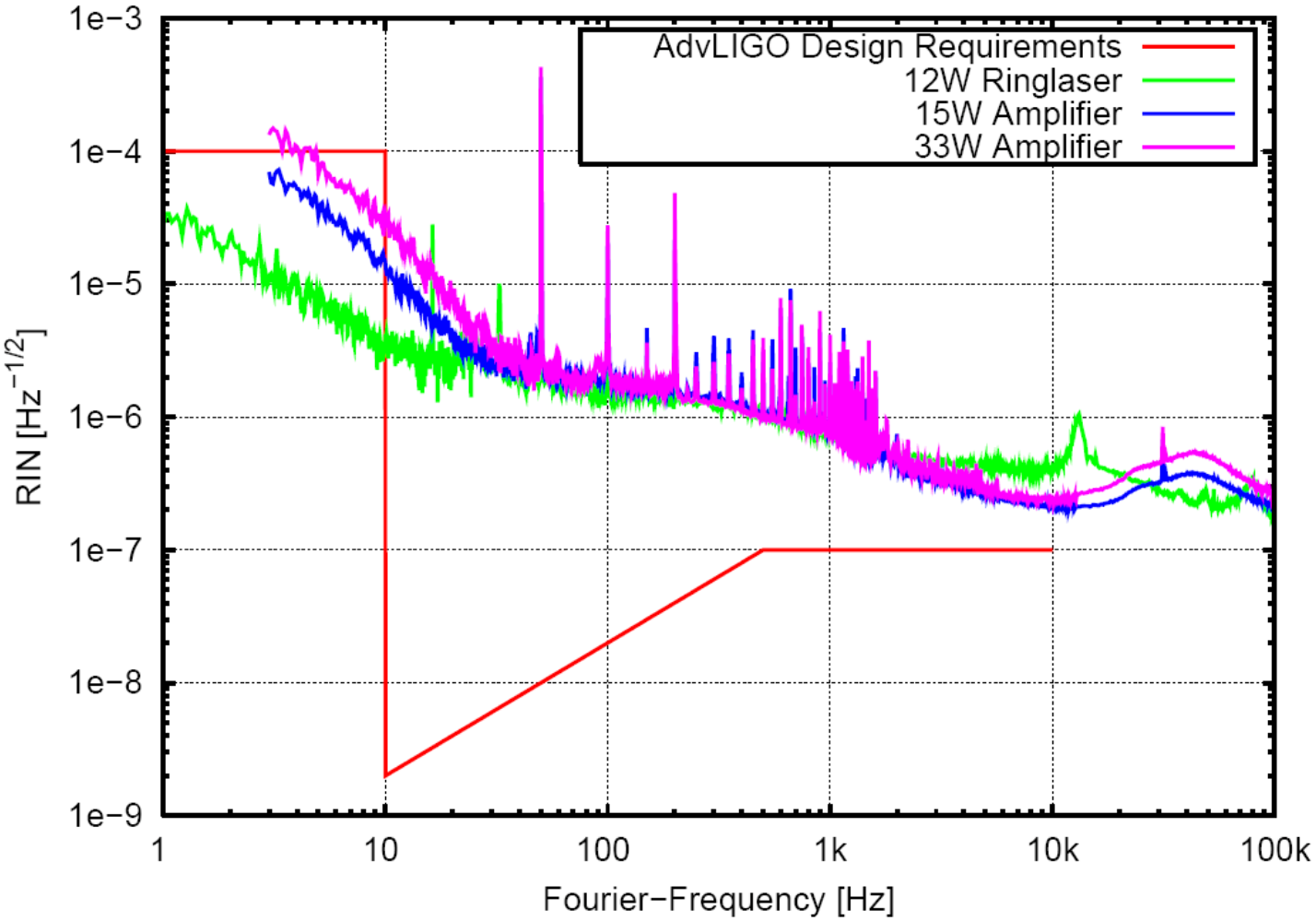
Output Power & RIN
Measurement Method

- 1 mm, 2 mm InGaAs PD with transimpedance amplifier
- RIN spectrum measured with SRT785 analyzer
- Long term output power measured with A/D board



Relative Intensity Noise

Measurements

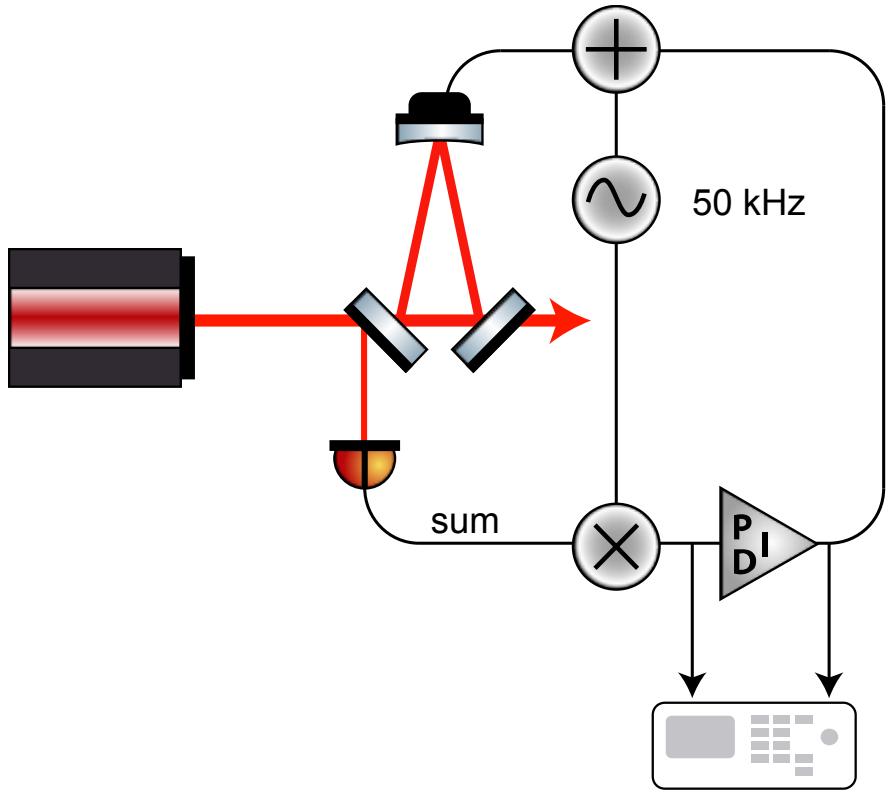


Frequency Noise

Measurement Method

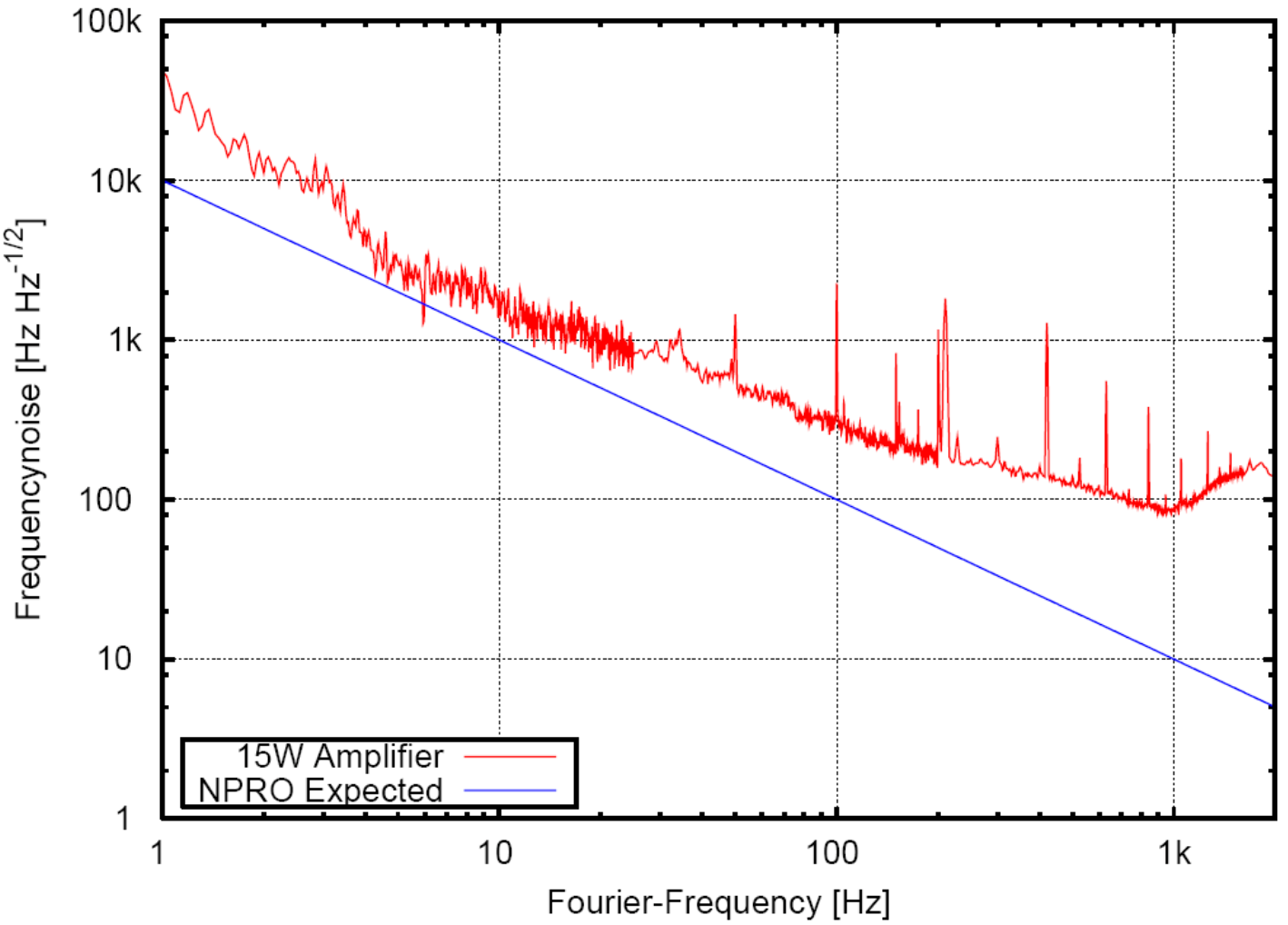
- Dither lock with modulation at 50 kHz
- Sum signal of one QPD for dither lock
- Unshielded PMC at air as frequency reference
- Finesse of PMC: 200
- Unity gain at 1.6 kHz

- Bandwidth limited by demodulation electronics to 2 kHz



Frequency

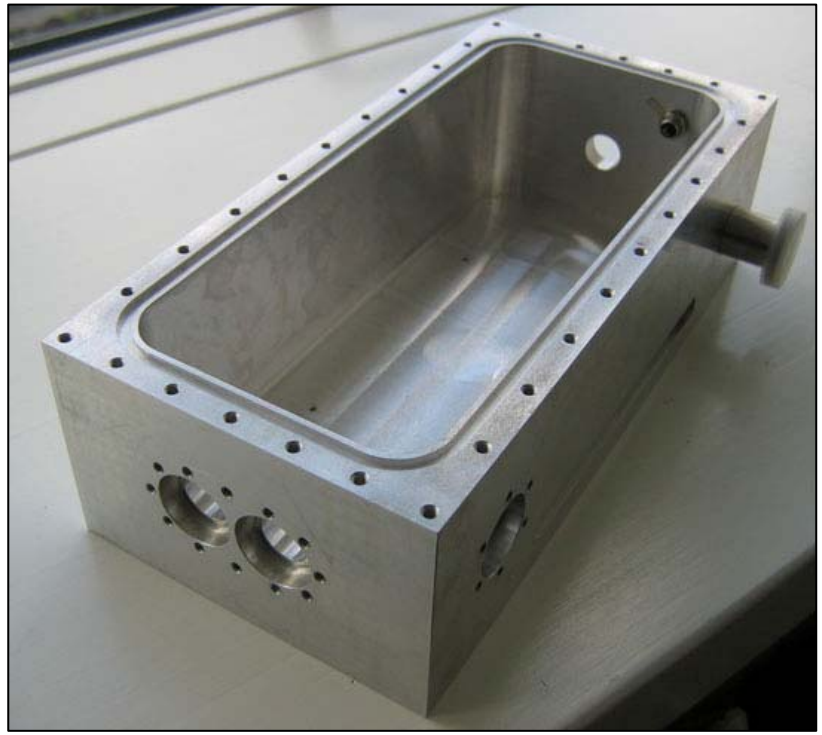
Measurements



Frequency Noise

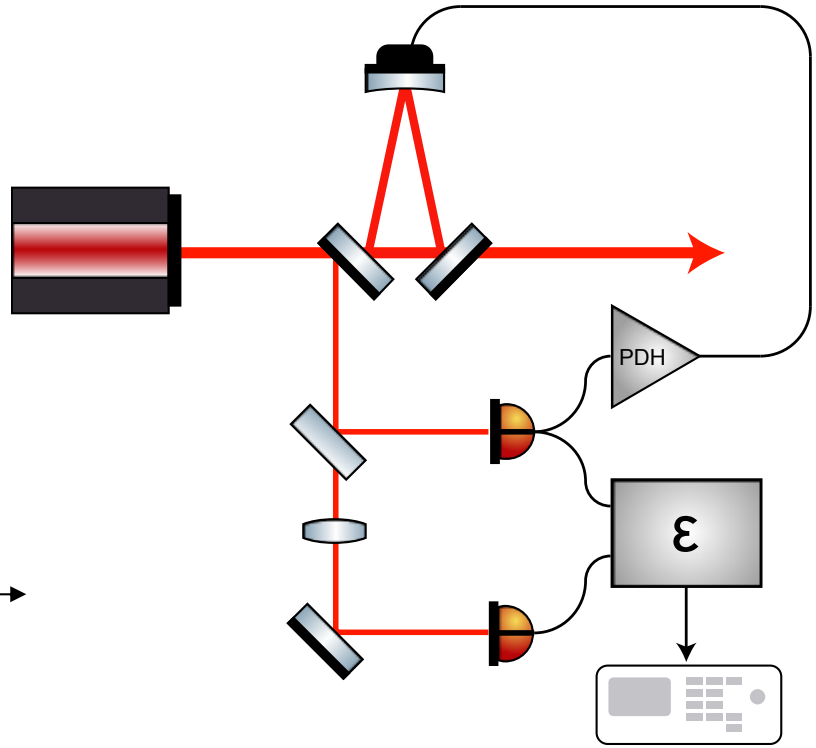
Improvements for Diagnostic Breadboard

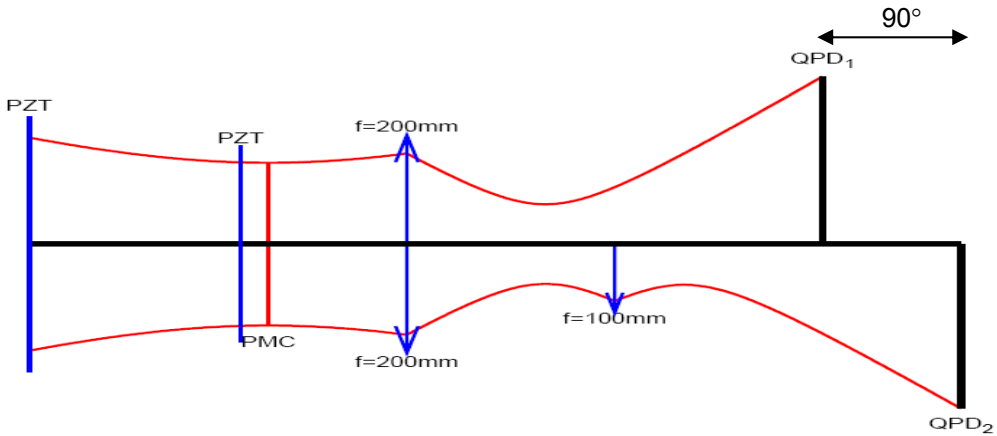
- Vacuum tank for PMC
- Dither lock modulation:
  50 kHz → 1 MHz
- Bandwidth of dither lock error signal:
  2 kHz → 100 kHz



Pointing
Measurement Method

- Differential wavefront sensing
- Time series acquired with A/D board
- ε_1 computed from time series
- No auto-alignment
- Bandwidth limited to 2 kHz
- Sensitivity limited by A/D board

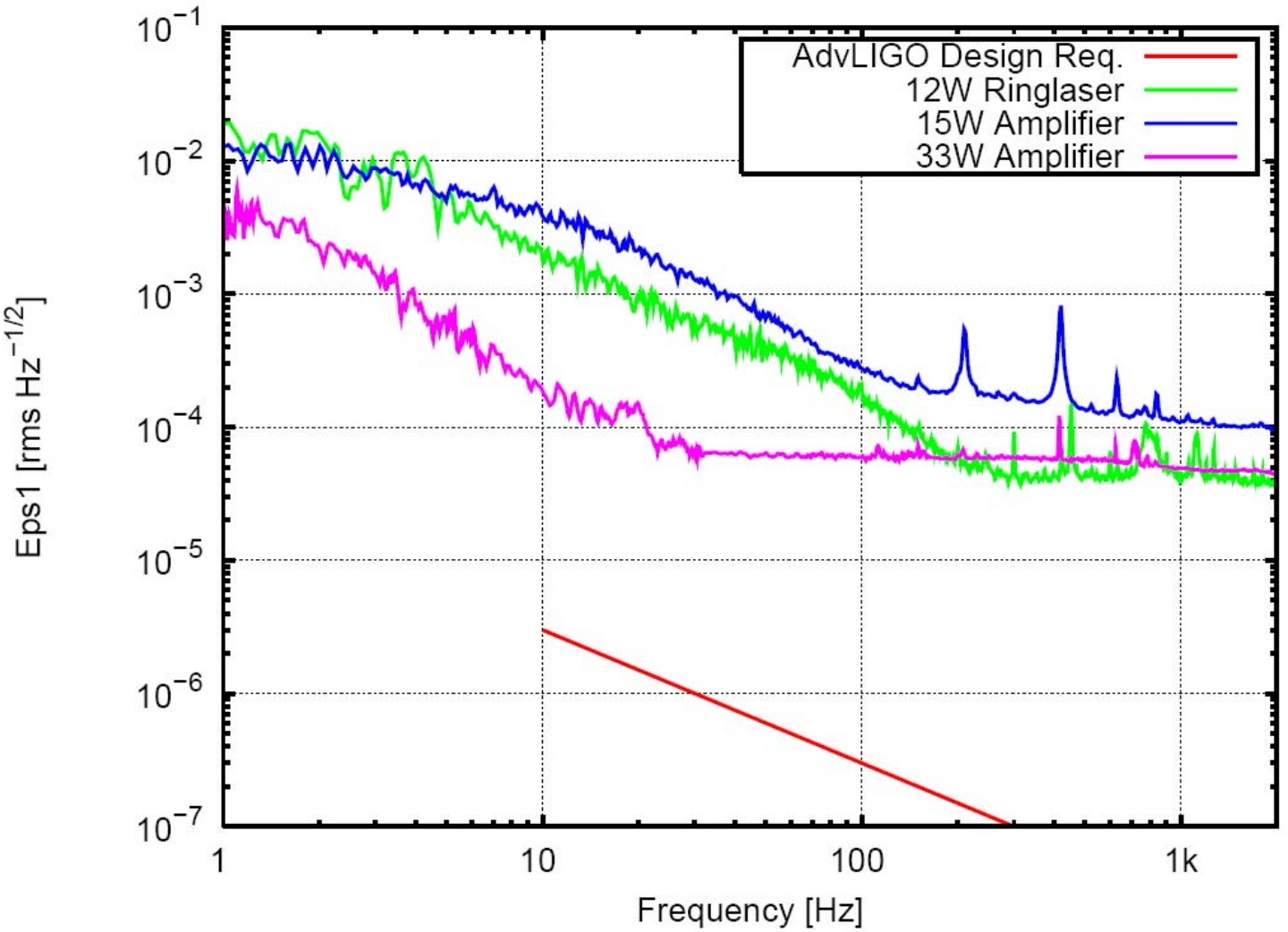




$$\varepsilon_1 = \sqrt{(\delta x / w_0)^2 + (\delta\alpha / \Theta_d)^2}$$

Pointing

Measurements

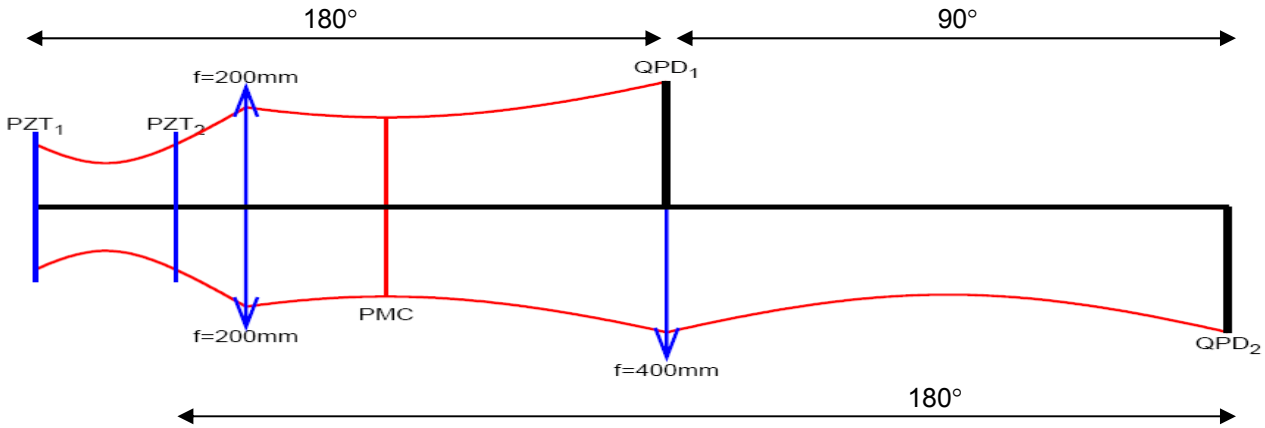


Pointing

Improvements for Diagnostic Breadboard

- Auto-alignment at low frequencies to stay in linear error signal range, PZTs with bigger range
- Real-time calculation of ε_1 including ctrl signals
- No orthogonalization electronics needed

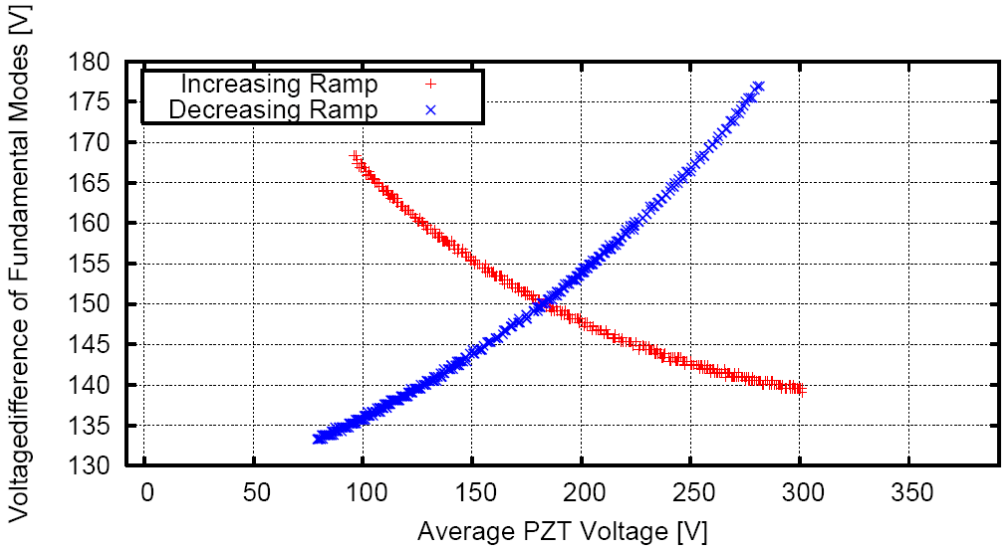
- Bandwidth of DWS signals:
  2 kHz → 100 kHz
- Improved sensitivity:
  Better signal conditioning before A/D conversion

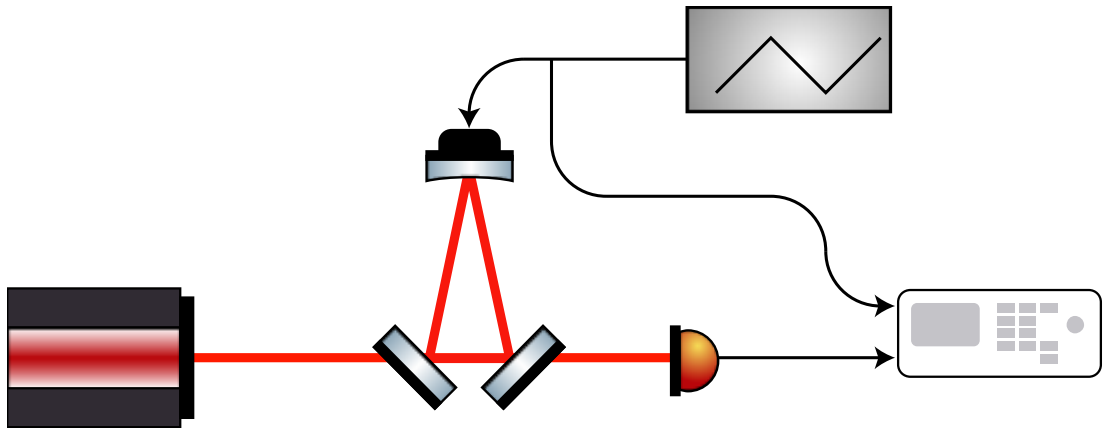


Beam Quality

Measurement Method

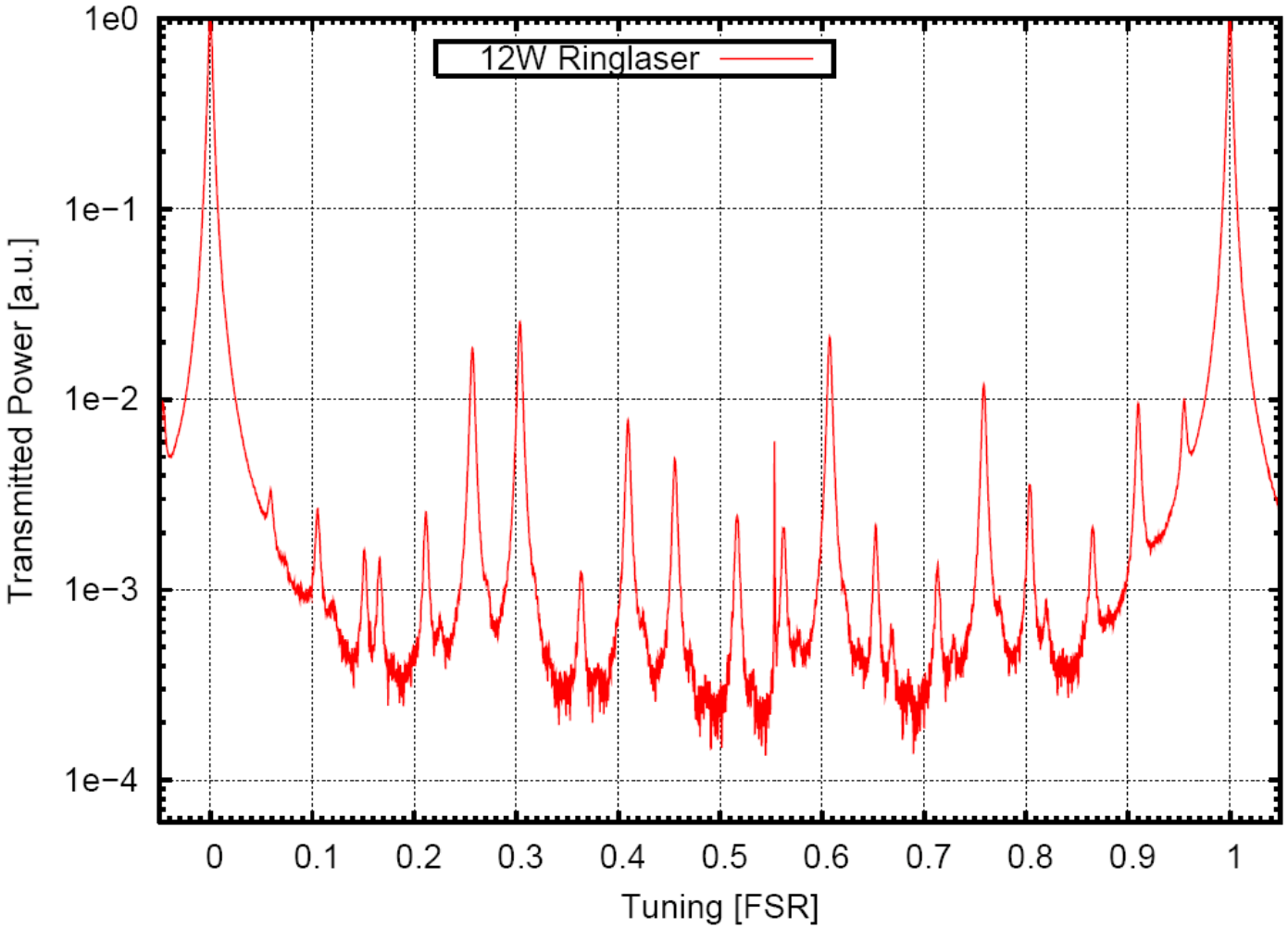
- Modescan: transmission of PMC dependent on tuning
- Scantime: 20 ms / FSR
- PMC PZT calibration, 0..400V, 2.5 FSR
- Program to calculate power in TEM_{00} and M^2
- Precision: 1% for TEM_{00} power





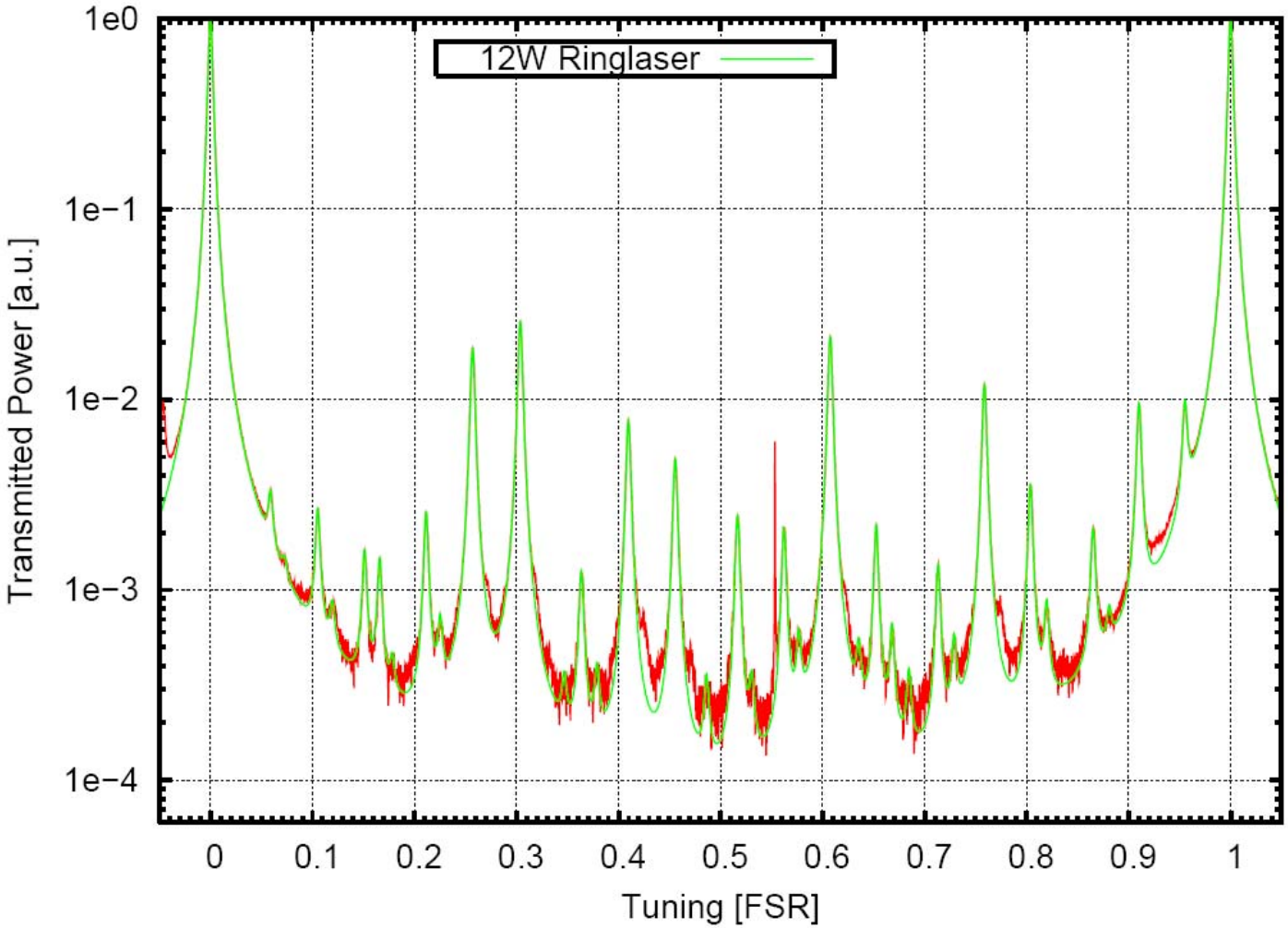
Beam Quality

Measurements



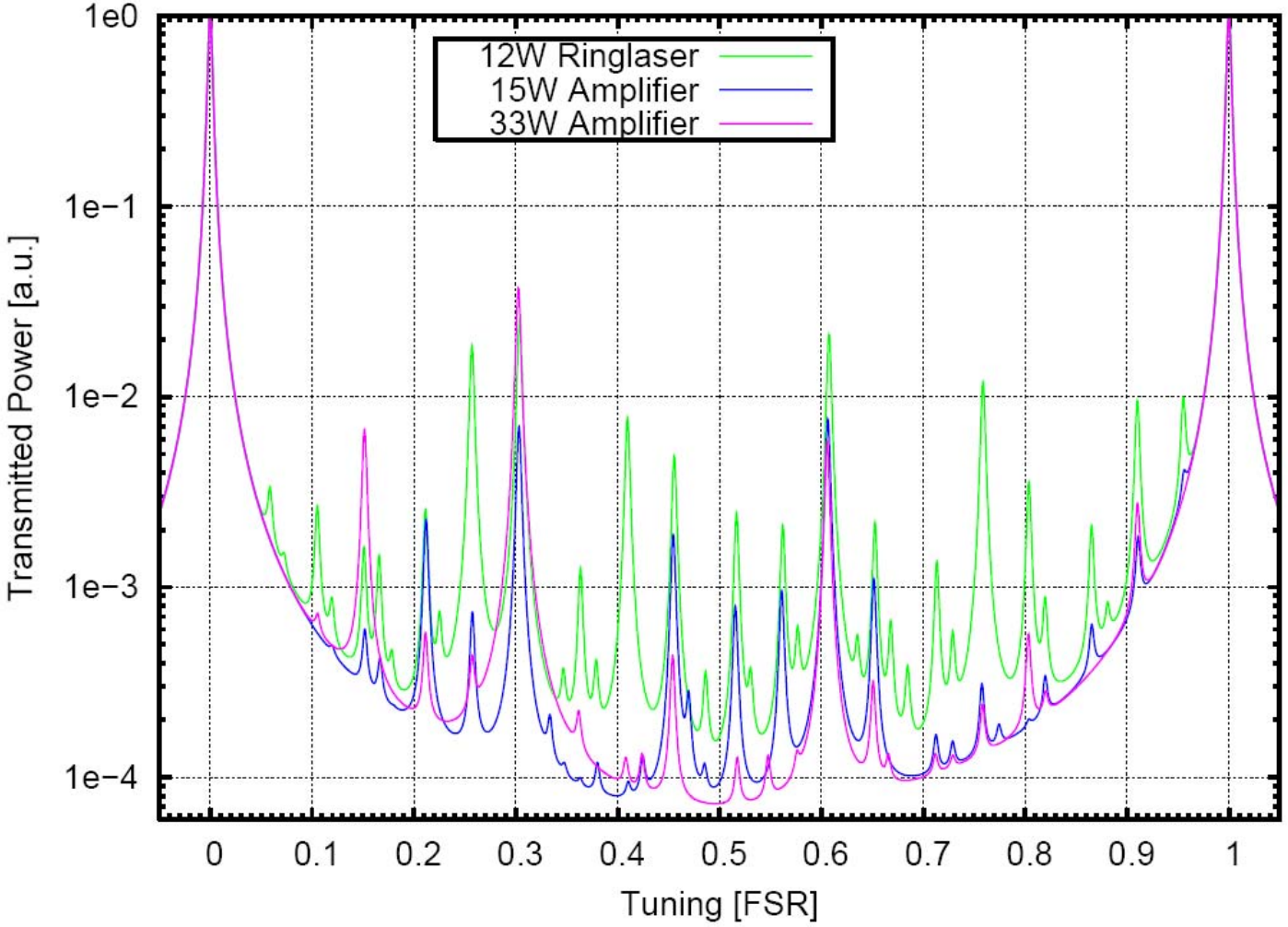
Beam Quality

Measurements



Beam Quality

Measurements



12W Ringlaser
88.4% Gauß
$M^2 = 1.56$

15W Amplifier
97.5% Gauß
$M^2 = 1.10$

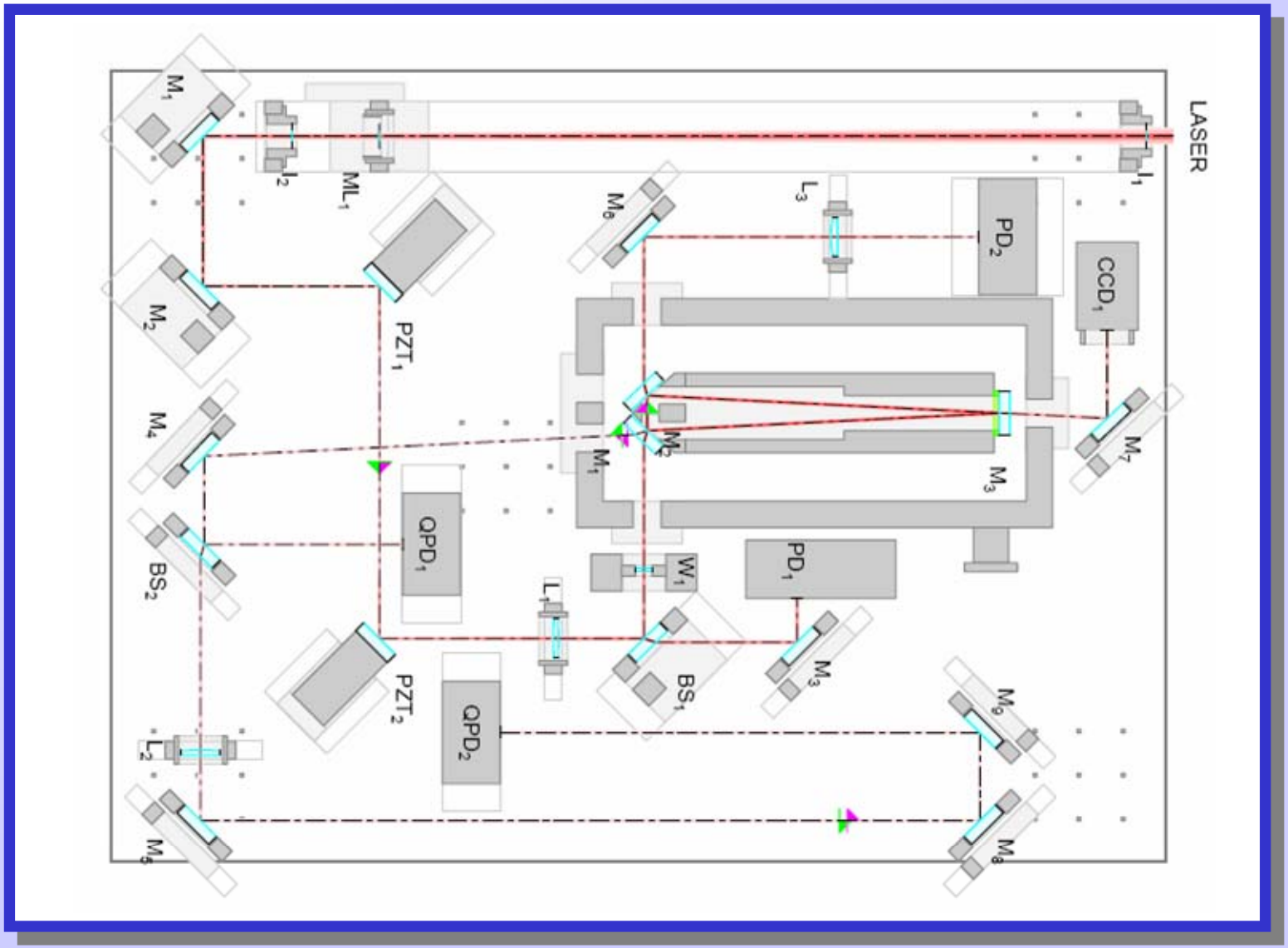
33W Amplifier
95.0% Gauß
$M^2 = 1.12$

Beam Quality

Improvements for Diagnostic Breadboard

- PMC PZT with bigger range:
  0..400V → 0..100V
  2.5 FSR → ≈ 4 FSR
- PD with integrated DC Amplifier and automatic Offset Compensation

Diagnostic Breadboard



Summary

- Auto-alignment
- Design of Diagnostic Breadboard
- Laser Characterization
  - Output Power, RIN
  - Frequency
  - Pointing
  - Beam Quality