DCC: LIGO-G1601659-v1

ITM Camera Focuser Control Interface and Calibration

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Overview

1. Calibrate PCal ETM cameras to quantify scattering
   - Camera sensor
   - Lens

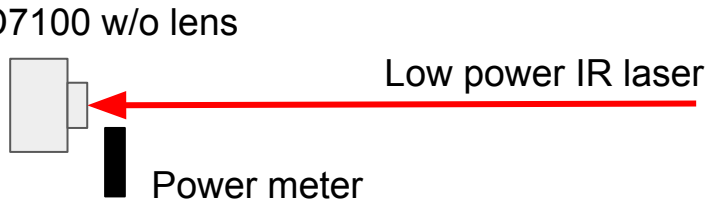
2. Set up similar DSLR cameras for viewing ITMs:
   - Hardware
   - User interface

LHO X-end photo from PCal camera (22/11/2015)

Sample images (ETM)

LHOY ETM, IR
1/100s exposure, ISO 200

LHOY ETM, IR
1/200s exposure, ISO 200



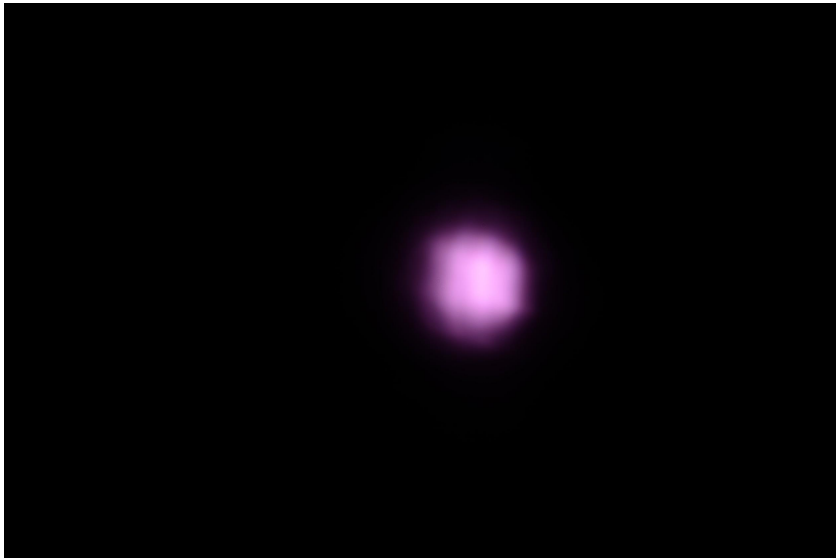
Camera calibration

- Determine relationship between pixel values and power incident on camera sensor

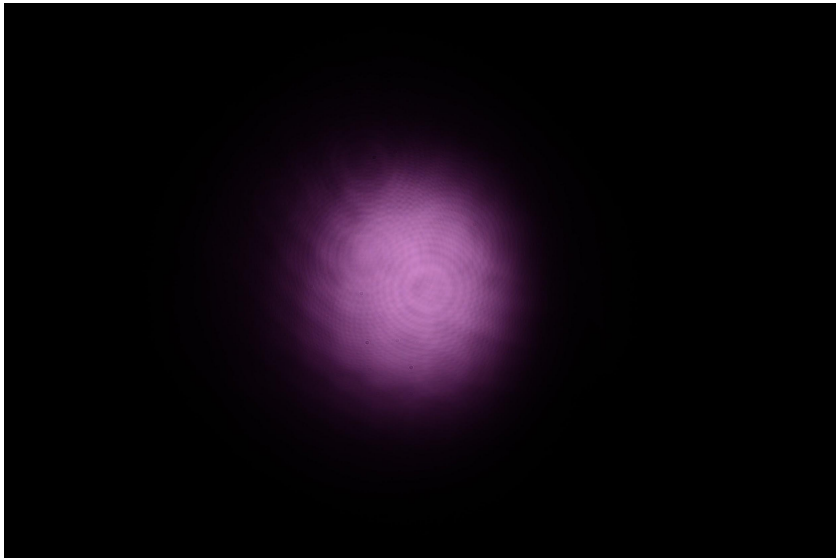
- Two rounds:
  - 1: Narrow beam, 1/2500s exposure, many ISOs
  - 2: Wide beam (BiCC lens), 1/2000s exposure, ISO 100

- Each colour channel R, G, B treated separately

Sample images



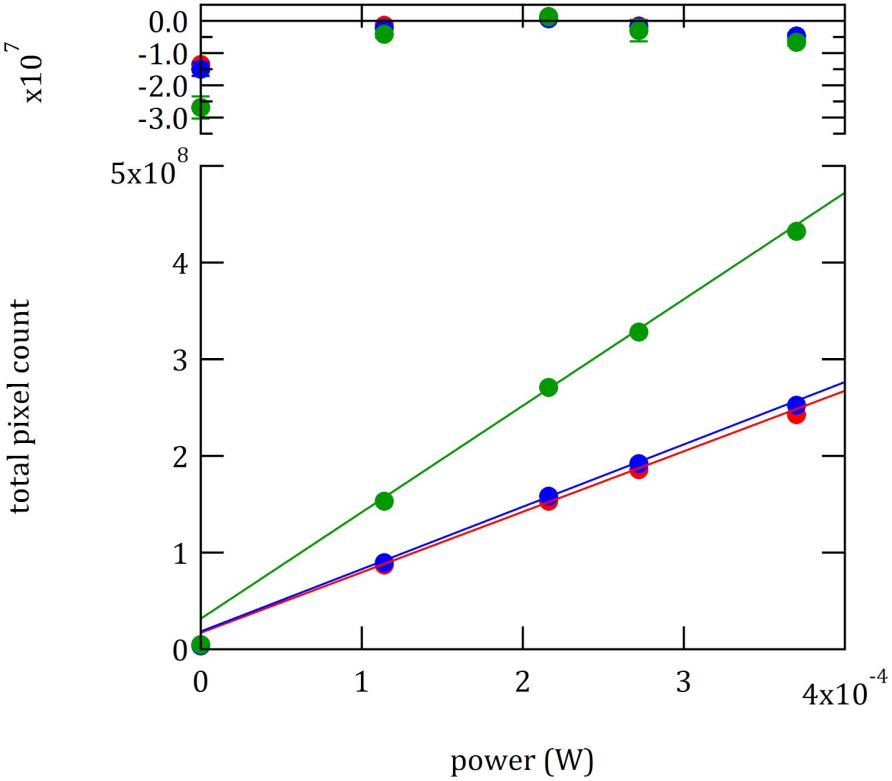
Round 1: 370 microW narrow beam
1/2500 s exposure, ISO 100



Round 2: 441 microW wide beam
1/2000s exposure, ISO 100

Calibration Round 1

ISO 100
Exposure time = 1/2500s
Narrow beam



Red
Function: a + b*x
Coefficient values ± one standard deviation
a = 1.71e+07 ± 8.e+05 (4.7%)
b = 6.25e+11 ± 4.e+09 (0.6%)

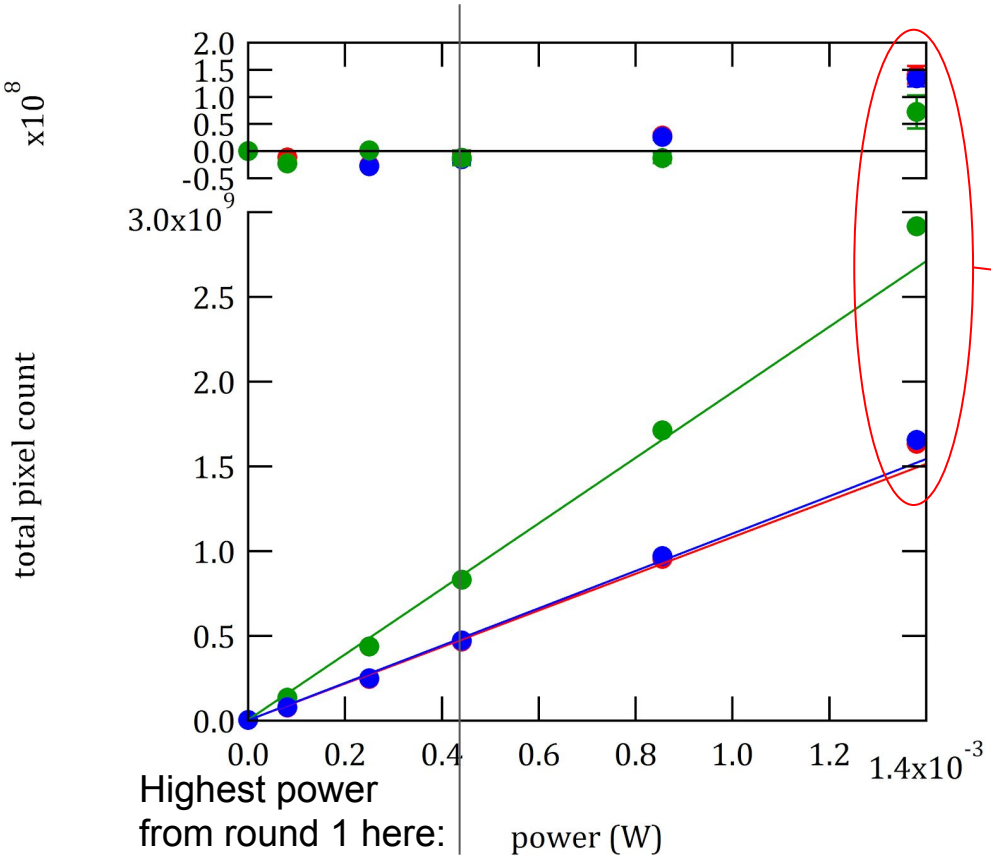
Green
Function: line
Coefficient values ± one standard deviation
a =3.171e+007 ± 1.2e+006
b =1.1009e+012 ± 5.32e+009

Blue
Function: line
Coefficient values ± one standard deviation
a =1.8484e+007 ± 7.63e+005
b =6.4471e+011 ± 3.46e+009

Calibration Round 2

ISO 100
Exposure time = 1/2000s
Wide beam

Note: 1.25x longer exposure time, so we expect slope *b* to be 1.25x the ones at 1/2500s (same ISO) if the shutter speeds can be trusted (assuming beam area doesn't matter).



Highest power from round 1 here:

Red
Function: line
Coefficient values ± one standard deviation
a =3.0673e+006 ± 1.43e+005
b =1.0793e+012 ± 4.48e+009

Green
Function: line
Coefficient values ± one standard deviation
a =3.8364e+006 ± 2.09e+005
b =1.9339e+012 ± 7.79e+009

Blue
Function: line
Coefficient values ± one standard deviation
a =3.0488e+006 ± 1.42e+005
b =1.1007e+012 ± 4.47e+009

High power non-linearity?

Round 1 vs Round 2

Colour	Round 1 slope (counts per watt)	Round 2 slope (counts per watt)	Ratio
Red	1.08e12	6.25e11	1.73
Green	1.92e12	1.10e12	1.75
Blue	1.10e12	6.45e11	1.71

Ratio higher than expected 1.25x;
Could be:

1. Unreliable shutter speed
2. Size/shape of beam matters
3. ???

Further analysis

- Investigate non-linearity at higher power
  - Determine whether due to beam shape or actual non-linearity
  - Beam shape: mask out part of beam and analyse only in that region

- Also should shed some light on differences in slope

ITM cameras

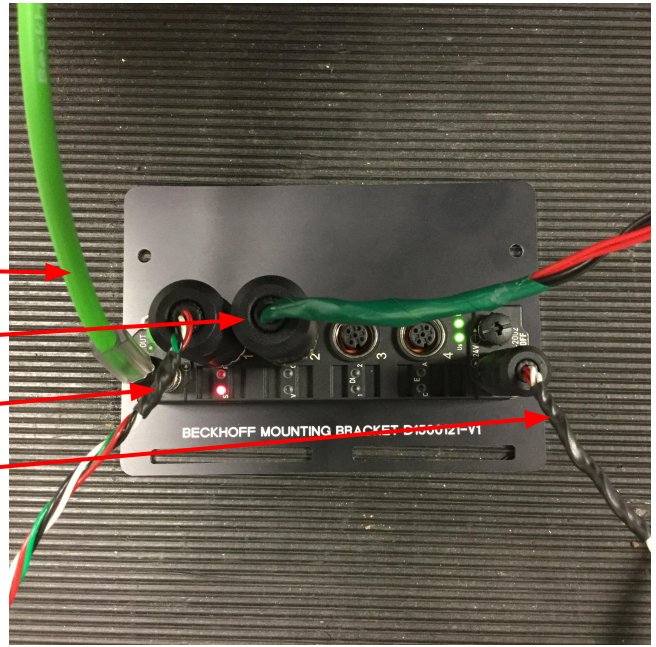
- Different viewport:
  - Viewing angle = 1°
  - Distance = 32.756 m

Source: LIGO Document T14005510-v5

- Celestron 8’’ SCT instead of telephoto lens
- Focus adjustment using stepper motor controlled by Beckhoff module
- Possible position preset support?

Beckhoff module

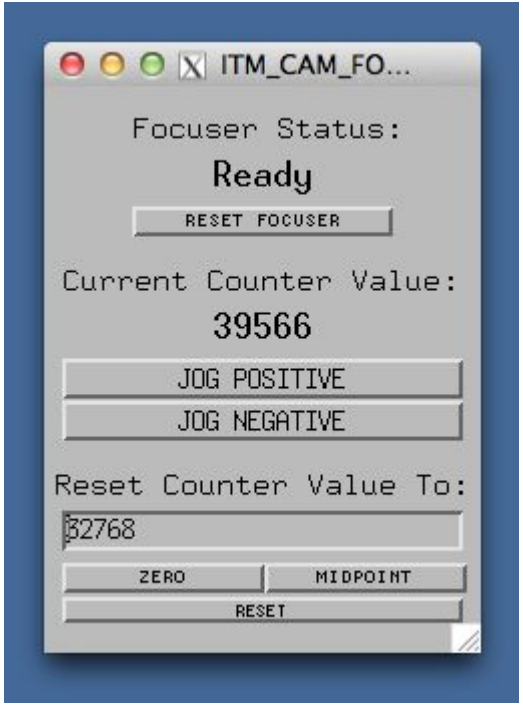
- EP7041-2002
- Connectors / Cables
  - 24 V input (Beckhoff)
  - 12 V input (Motor)
  - Stepper motor
  - Ethernet
- Control through TwinCAT
  - PLC program



Control program + User interface

- Control program
  - Works by controlling velocity
  - Position control not yet supported

- User interface
  - Motor status display
  - Jog buttons
  - Reset counter value

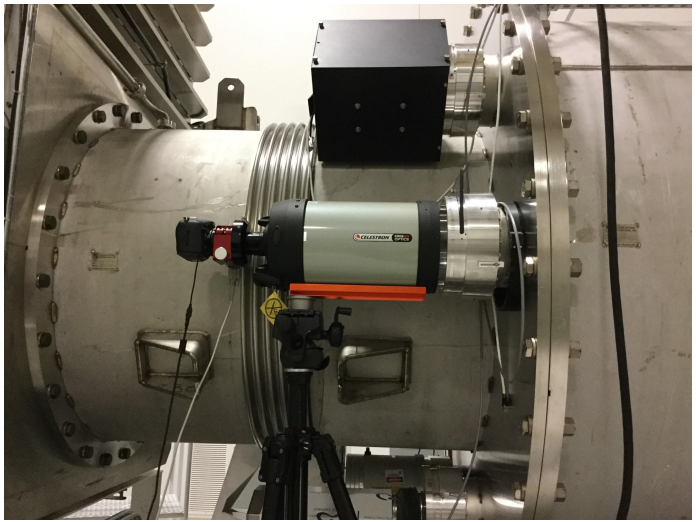


Alpha version of UI with alpha version of control program

Installation

- Not installed
  - Issues with housing dimensions

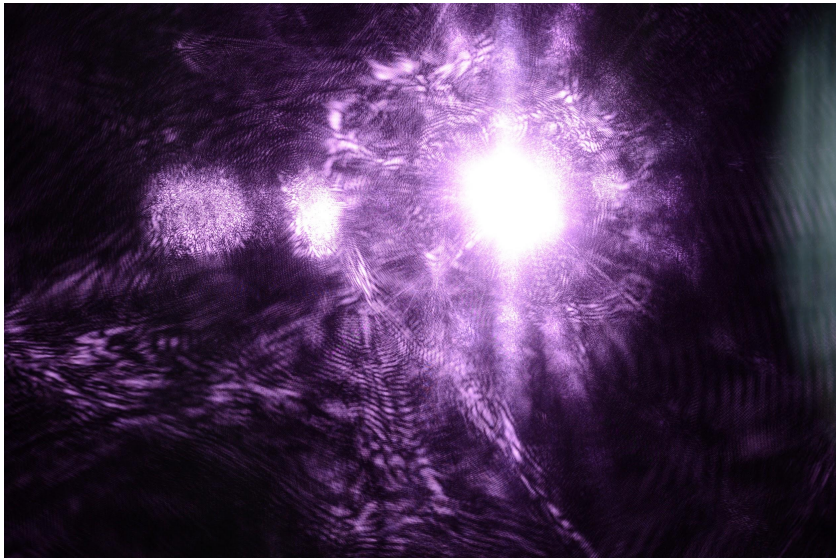
- Preliminary images with tripod
  - Check magnification
  - Check focusing



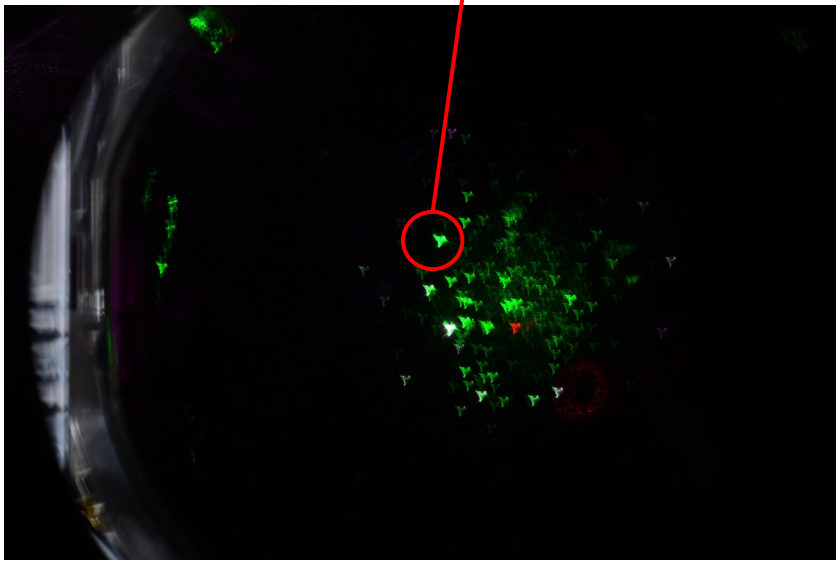
Tripod set-up at viewport of LHOY ITM

ITM images (?)

Triangular features: distortion by viewport and/or alignment issues (?)



LHOY long exposure, IR



LHOY green, focused (?)

Final remarks

- Camera calibration
  - Some mysteries; further analysis needed
- ITM cameras
  - Rough focusing with alpha version of program, still no presets
  - Image quality: consider possible ways to improve
    - Will reducing aperture size help?