"POLITEHNICA" UNIVERSITY OF BUCHAREST
FACULTY OF APPLIED SCIENCES
MASTER'S PROGRAM: Laser and Accelerator Engineering and Applications

DISERTATION RESEARCH STATUS

DEVELOPING AN AUTOMATED BEAM ALIGNMENT SOLUTION FOR CETAL BTL

Grad Student:
Ing. Mihail-Gabriel Bărbuță

Coordinator:
Prof. Emil-Ioan Slușanschi

Bucharest
The 21st of January 2016

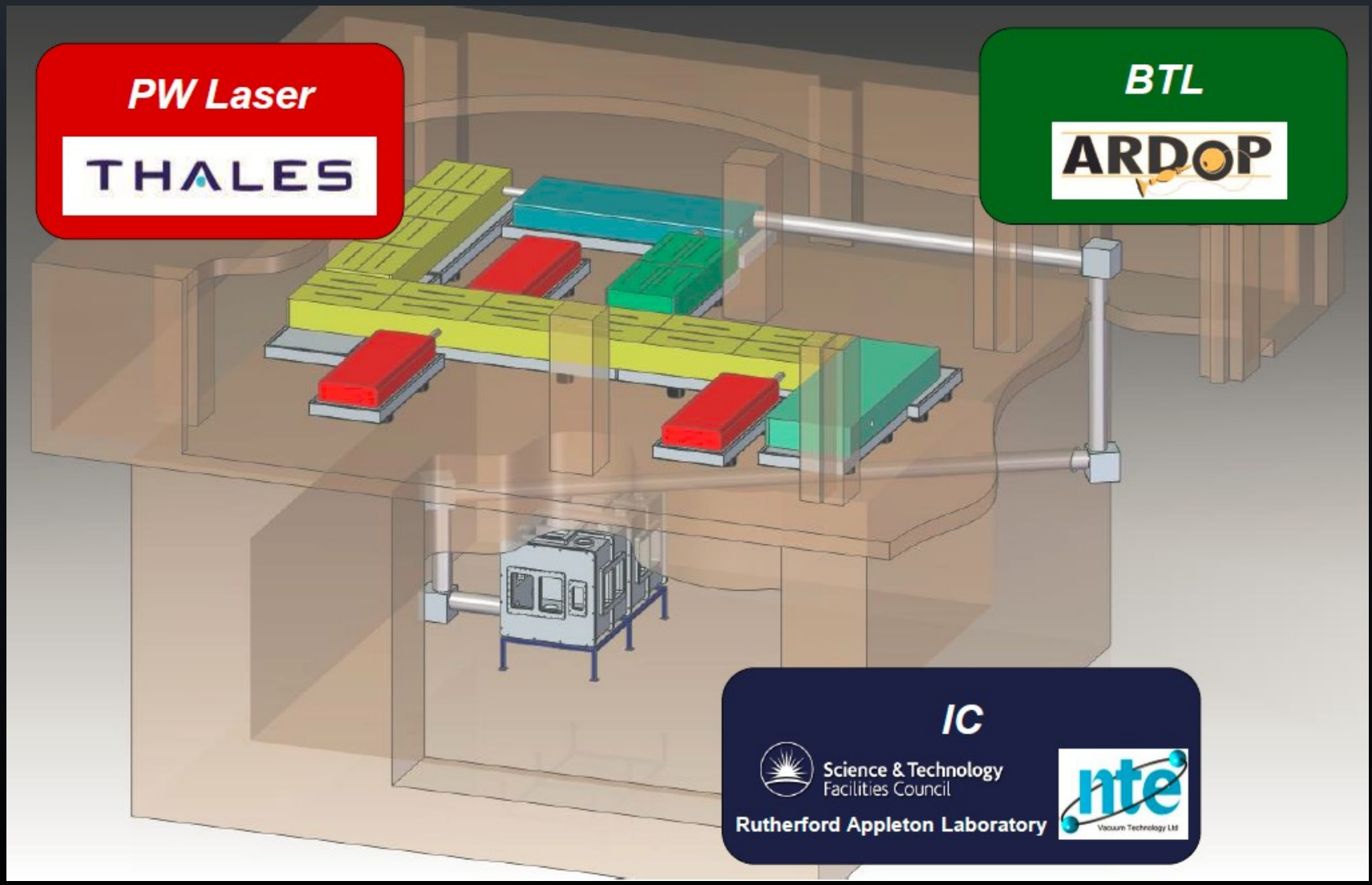
Outline

1. CETAL BTL overview
2. Problem definition
3. Implementation
    - 3.1. Mirror positioning
    - 3.2. Image processing
    - 3.3. Automation concept
4. Conclusions and outlook

Outline

1. CETAL BTL overview
2. Problem definition
3. Implementation
4. Conclusions and outlook

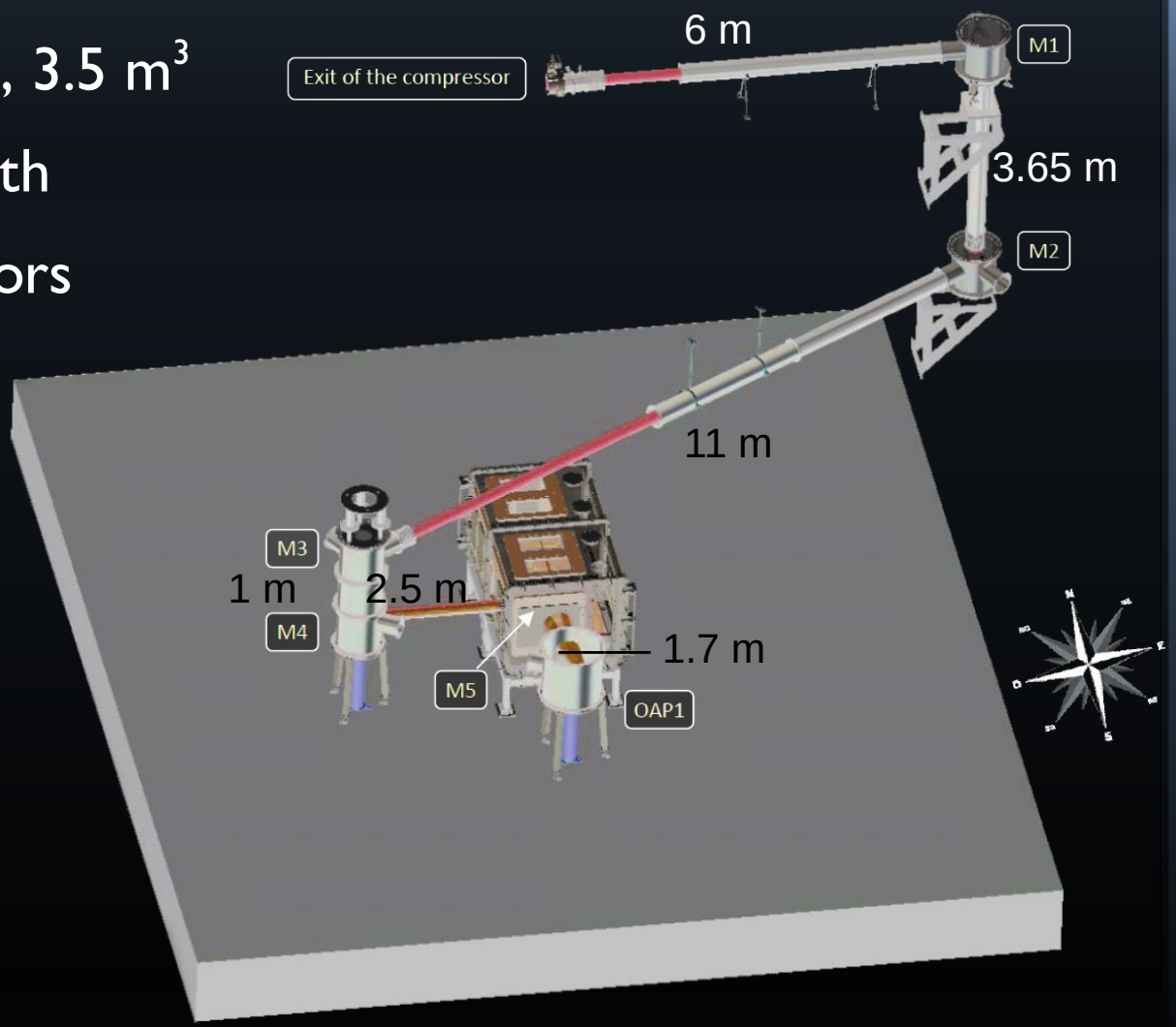
CETAL Overview



CETAL BTL Overview

Beam Transport Line (BTL):

- 10^{-5} mbar vacuum, 3.5 m^3
- 26 m in total length
- 6 motorized mirrors
- 160 mm FWHM beam diameter



Outline

1. CETAL BTL overview
2. Problem definition
3. Implementation
4. Conclusions and outlook

Problem definition

Current situation:

- Manual alignment takes time, requires two operators
- Beam drift due to pressure differential

Requirements:

- Accurately determine the beam deviation
- Command the mirror motor driver to correct the deviation
- Ability to manually control mirror orientations

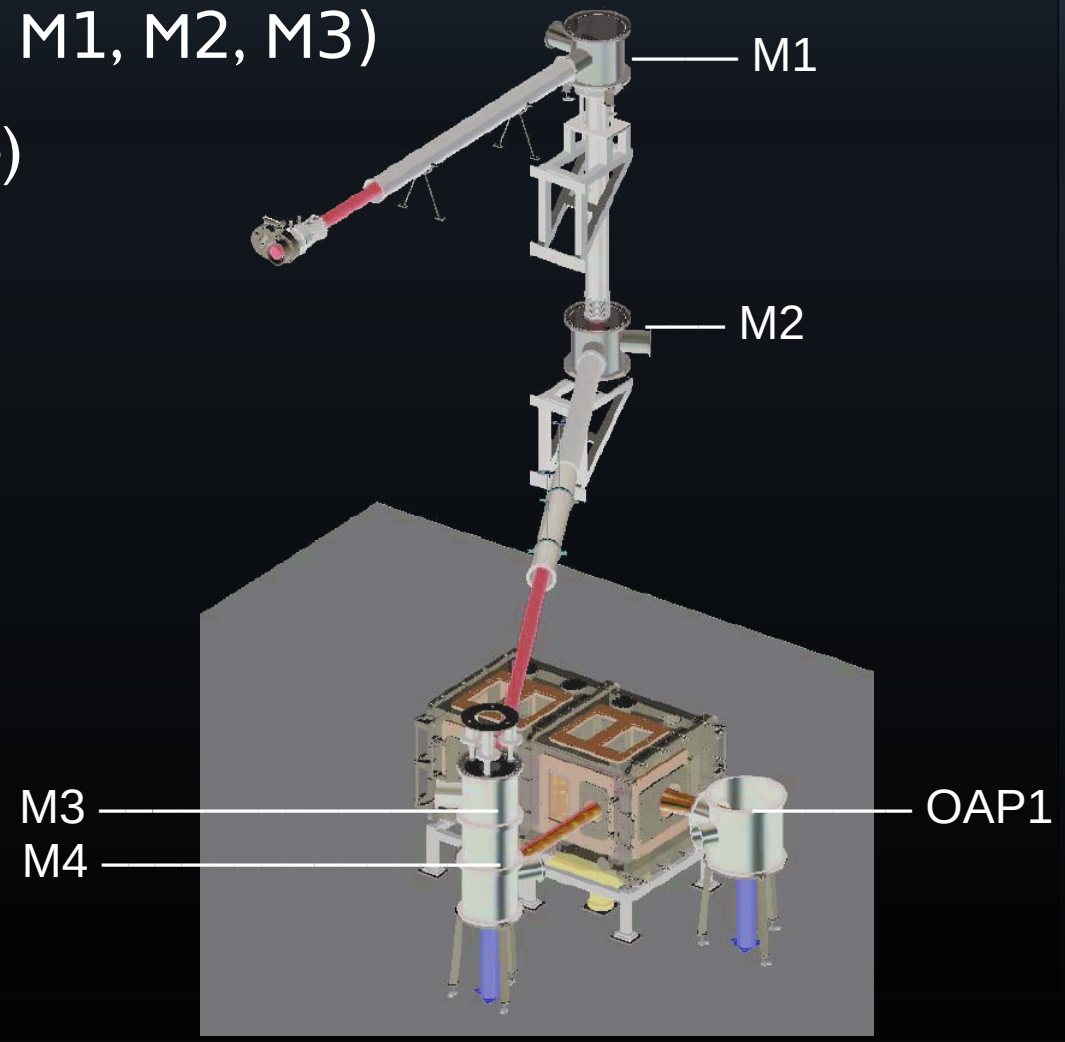
Outline

1. CETAL BTL overview
2. Problem definition
3. Implementation
    - 3.1. Mirror positioning
    - 3.2. Image processing
    - 3.3. Automation concept
4. Conclusions and outlook

Mirror Positioning

Motion constraints:

- M1-M5 – two-axis (in scope: M1, M2, M3)
- OAP1 – 5-axis (out of scope)



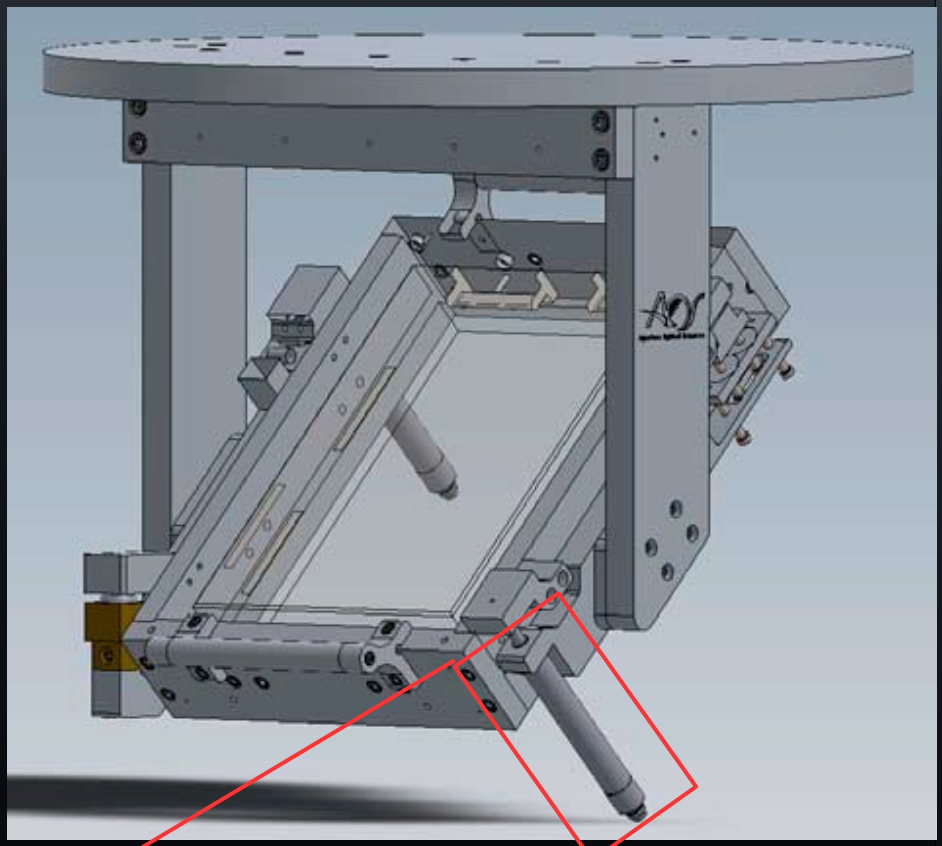
Mirror design

Design:

- Mirror (310 x 230 x 65 mm)
- Kinematic Mounting Frame
- Mount
- Turning box

Actuators: PI-Micos MP-20

- Travel range: 13 mm
- Max. speed: 0.1 mm/s
- Resolution: 0.1 μm
- Backlash: ±1 μm



Outline

1. CETAL BTL overview
2. Problem definition
3. Implementation
    - 3.1. Mirror positioning
    - 3.2. Image processing
    - 3.3. Automation concept
4. Conclusions and outlook

Image processing: aquisition

Topology:

- M1 is aligned using image on M2 (near-field)
- M2, M3 are aligned using image on M4 (far-field)

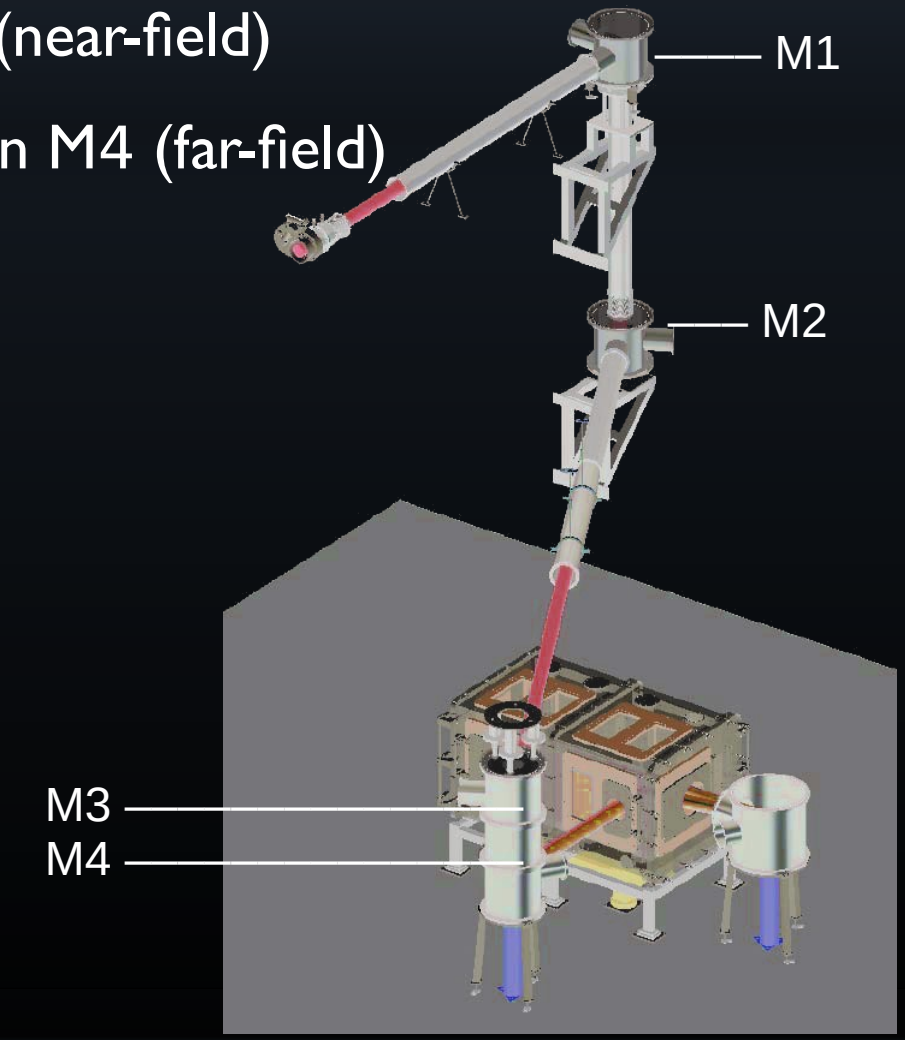
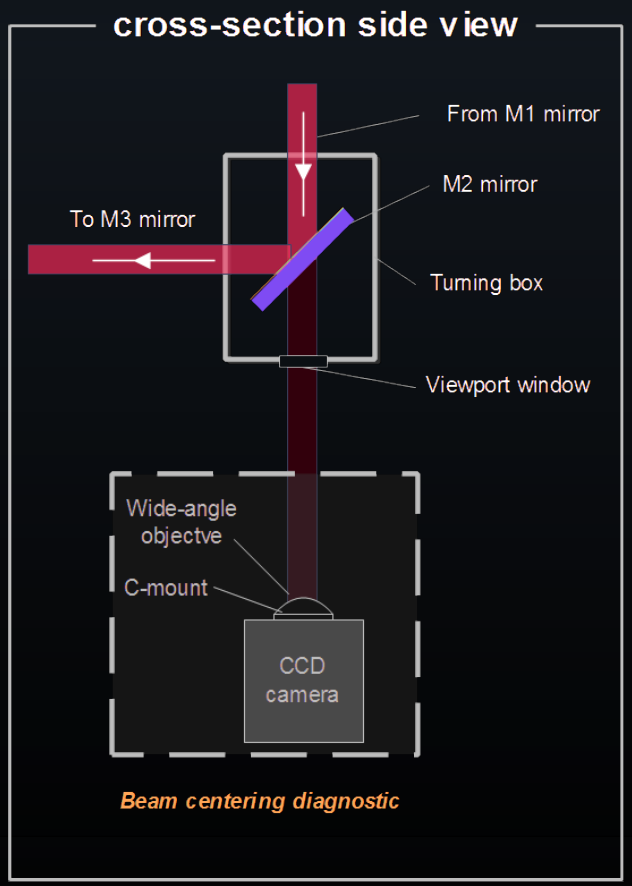


Image processing: diagnostics

Cameras:

- Near-field camera on M2: Webcam, 640 x 480 pixels
- Far-field camera on M4: Basler 782 x 582 pixels



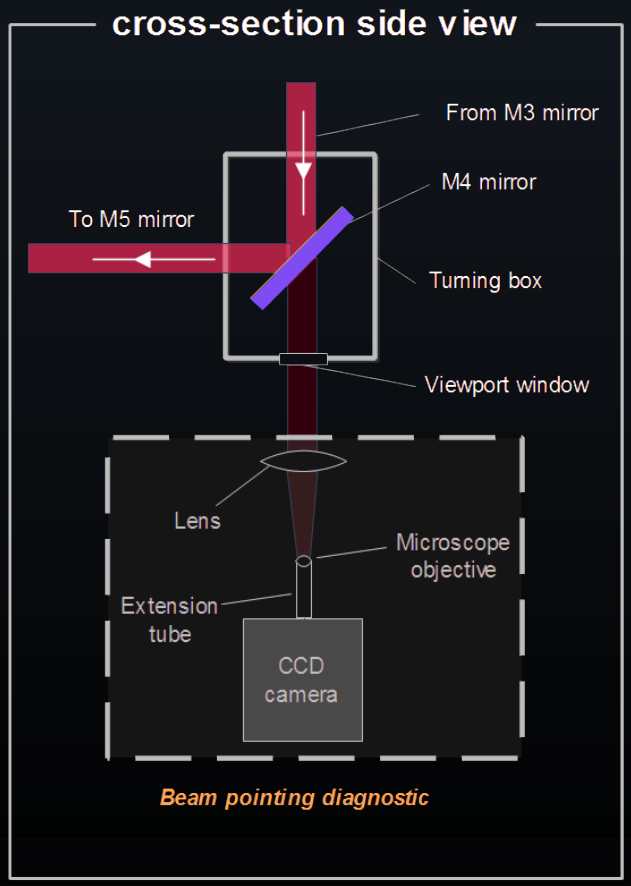
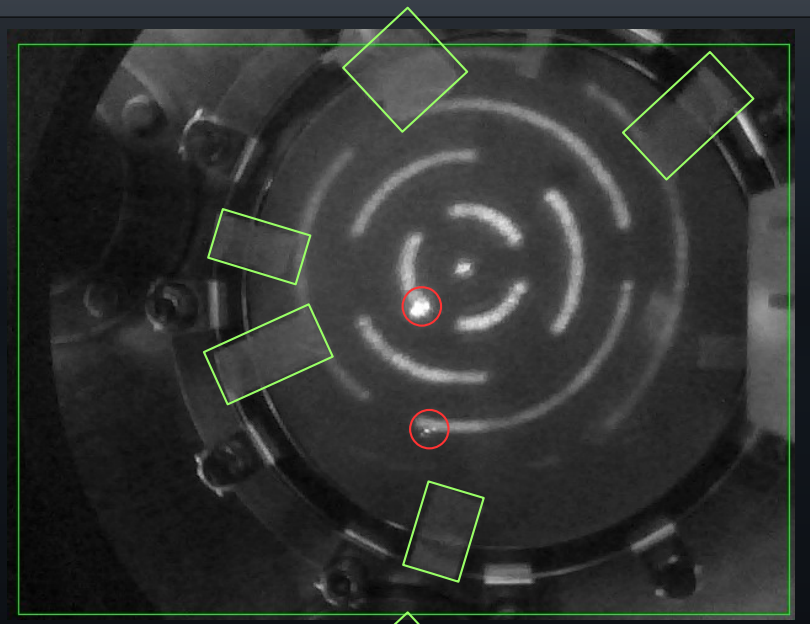


Image processing: near-field processing

Near-field images:

- With alignment mask
- Without alignment mask



Identified issues:

- Mirror defects (red)
- “High-tech” diffuser mounts (green)
- Noise
- …

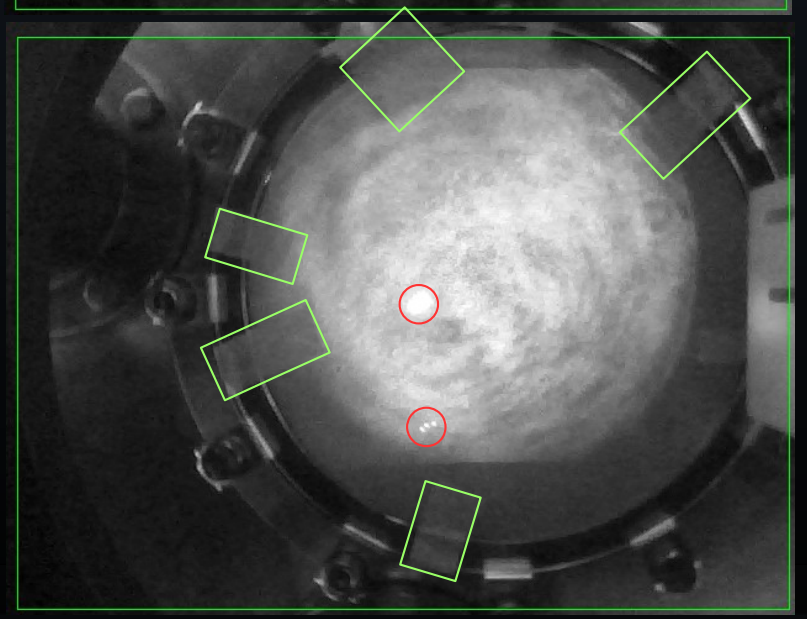


Image processing: near-field processing

Identified issues (cont'd):

- Sync issue (purple)
- Clipping (orange)
- Internal reflections (cyan)

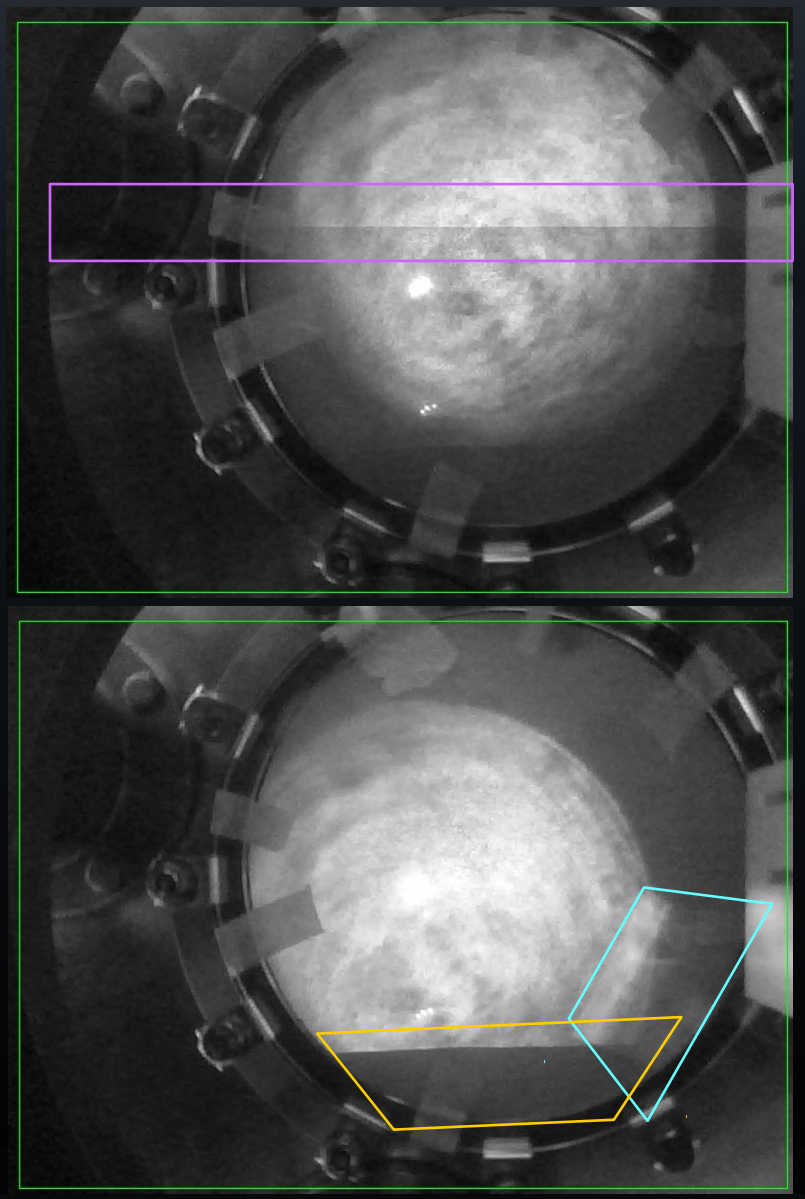
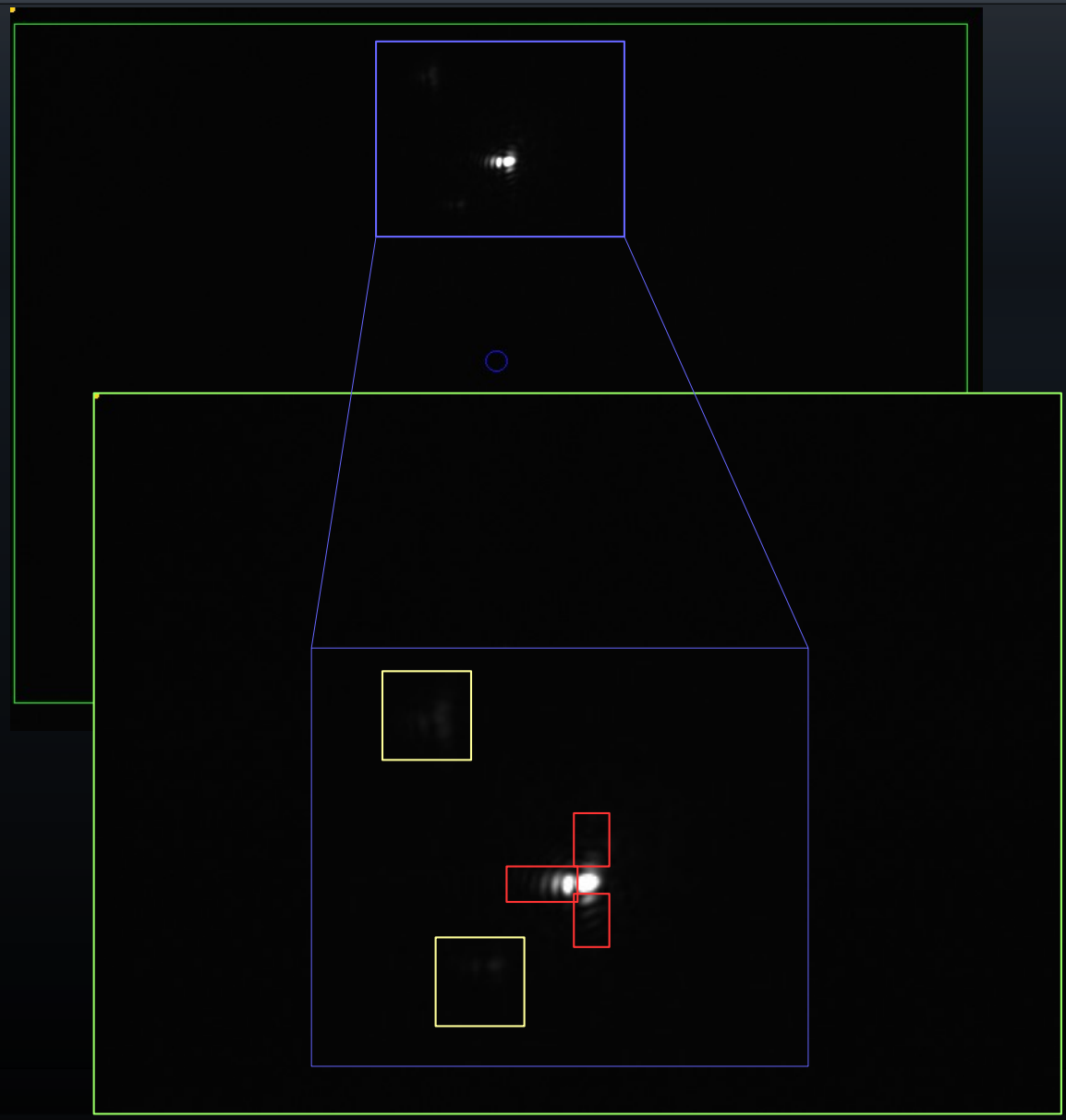


Image processing: far-field processing

Far-field images:

- Misaligned
- Aligned



Identified issues:

- Internal reflections

Outline

1. CETAL BTL overview
2. Problem definition
3. Implementation
    - 3.1. Mirror positioning
    - 3.2. Image processing
    - 3.3. Automation concept
4. Conclusions and outlook

Automation: Milestones

Milestones:

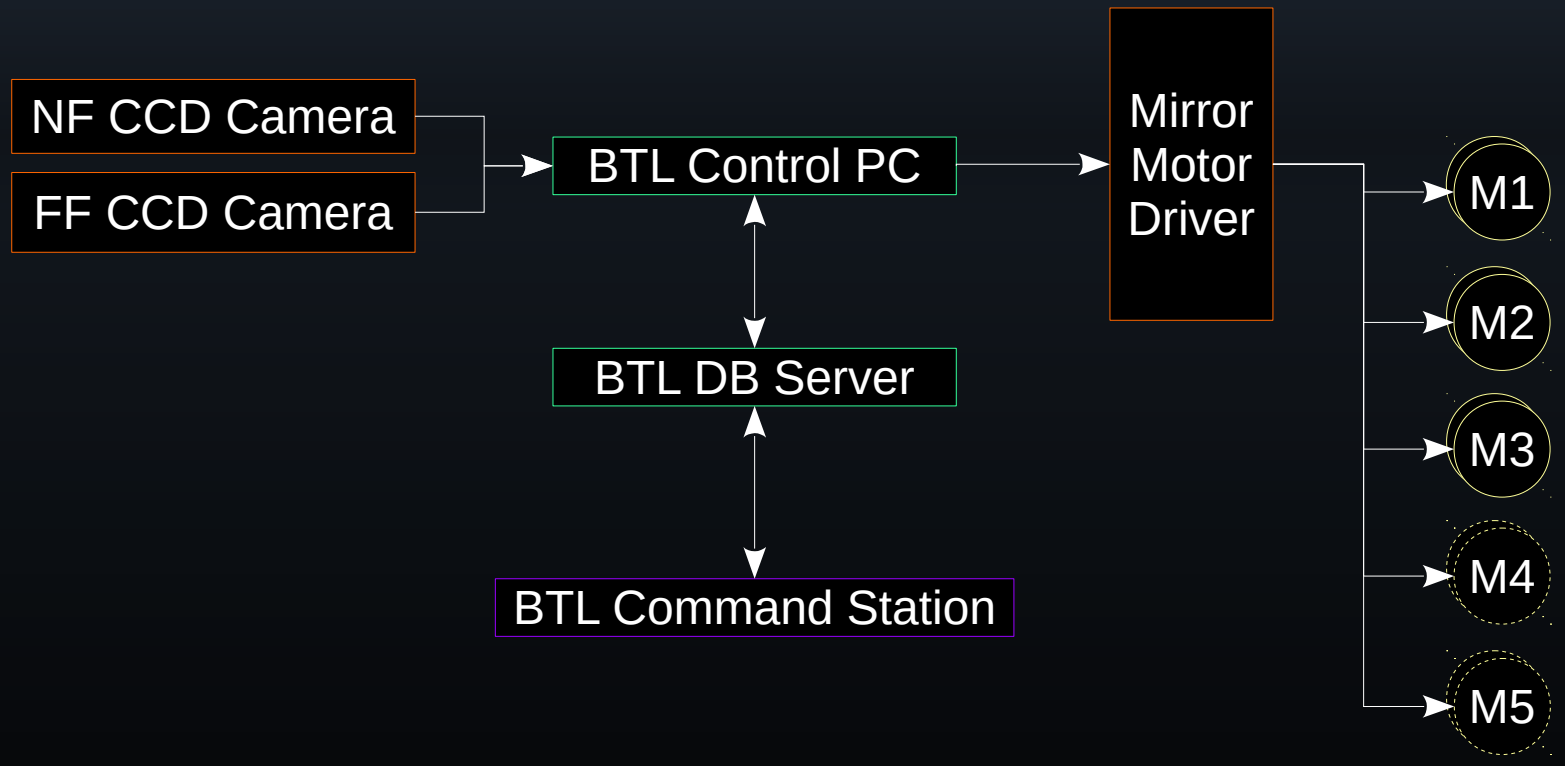
1) Accurately determine beam deviation
2) Manual motor control with GUI
3) Loop integration

Nice to have:

- NF beam centroid without mask
- Calibrated mirror motion profiles
- Interlock integration
- Scalability

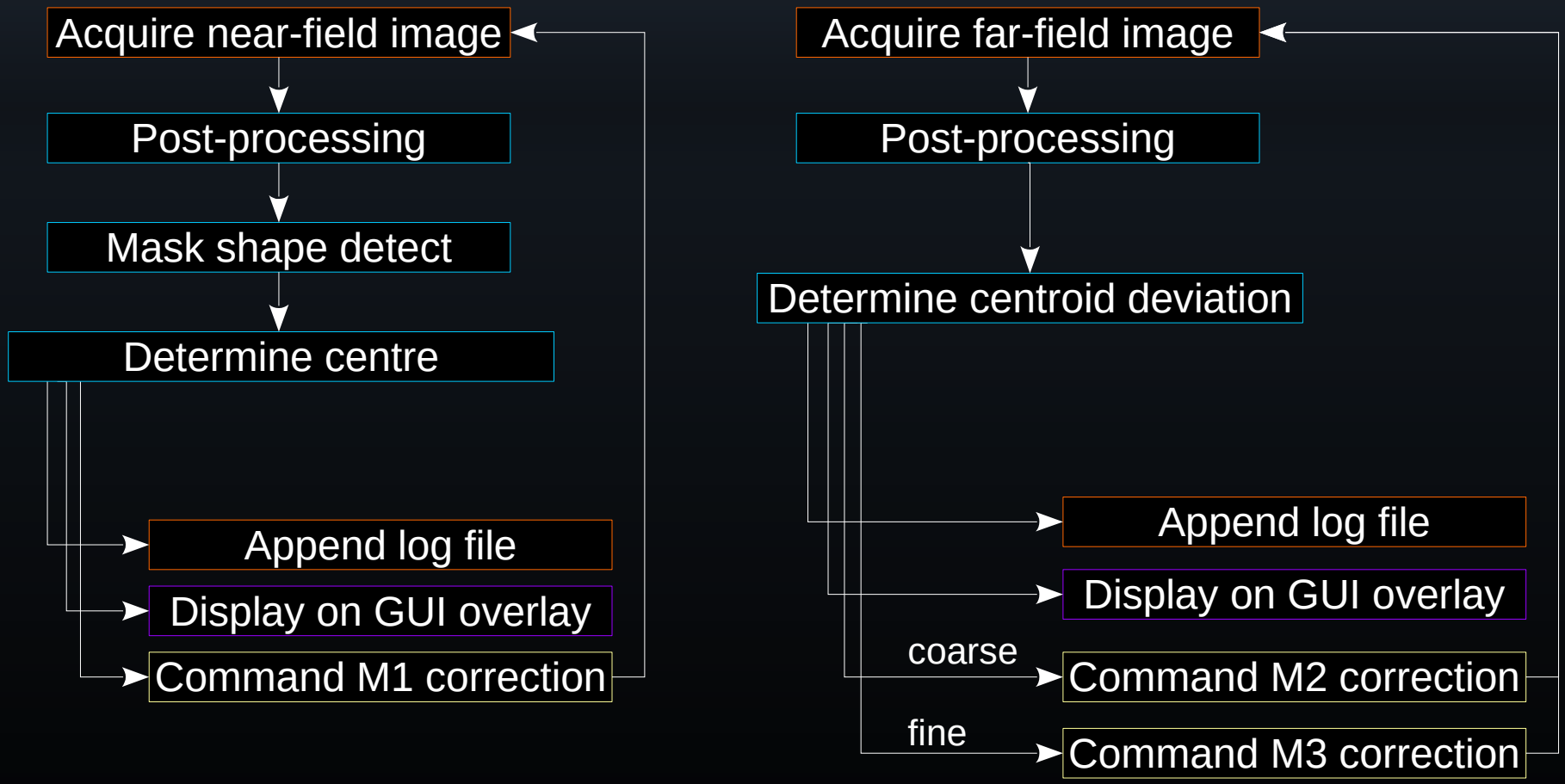
Automation: Architecture

Architecture and integration:



Automation: Application

Program structure:



Automation: Development

Development:

- Python – integration with existing command framework
- Libraries: numpy, scipy, OpenCV, matplotlib
- GUI solution TBD

Outline

1. CETAL BTL overview
2. Problem definition
3. Implementation
4. Conclusions and outlook

Conclusions

- Beam alignment automation is necessary
- Performed requirements and risks analysis
- Designed application architecture and topology
- Proposed solution will use mostly existing infrastructure

Outlook

- Code implementation and integration
- GUI design
- Testing phase and commissioning
- Potential implementation on other mirrors

Thanks for your attention :)