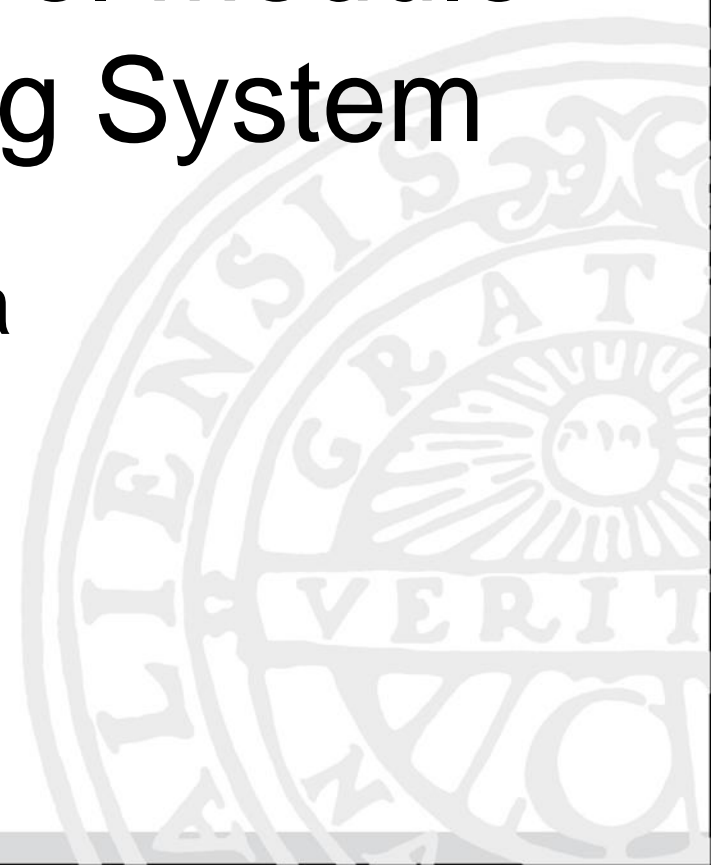




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# A Measurement Level Module for a Pellet Tracking System

Jenny Regina





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# Outline

- Pellets
- The Pellet Tracking System
- The UPTS (Uppsala Pellet Test Station)
- The DM (Detection Module)
- Results
- Outlook
- Summary

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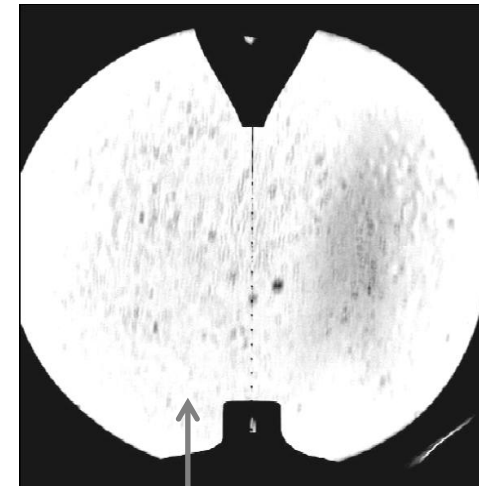
# Pellets

- Spheres of frozen hydrogen
- $\Phi \sim 25 \mu\text{m}$
- Density well above  $10^{15}$  atoms/cm<sup>2</sup> ( $2 \cdot 10^{15}$ - $6 \cdot 10^{15}$  atoms/cm<sup>2</sup> at WASA)
- Internal targets in hadron physics experiments
- Created some distance away from the accelerator
- Travel to the interaction region
- Planned to be used at PANDA experiment at HESR
- Have been used at WASA experiment at the CELSIUS accelerator at TSL and at COSY at FZJ

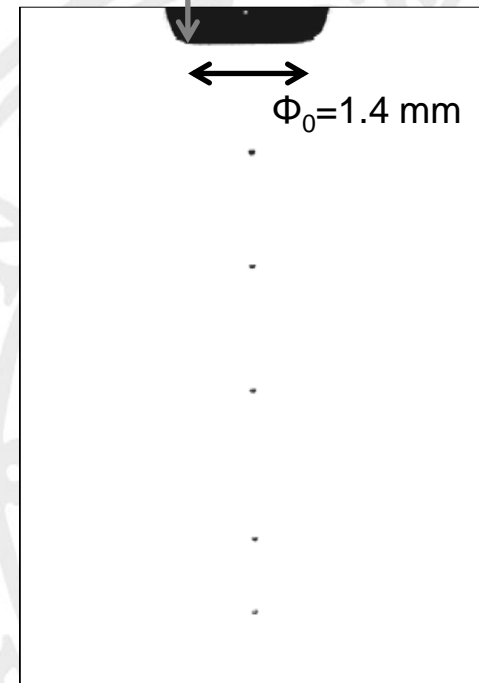
# Pellets

1. Hydrogen gas cooled to 14.1 K
  2. Gas liquefies
  3. A vibrating nozzle ( $\Phi = 11 \mu\text{m}$ ) breaks up the liquid into droplets
  4. Droplets enter a droplet chamber
  5. Droplets reach a VIC (Vacuum Injection Capillary)
  6. Droplets freeze due to high pressure gradient
- pressure before VIC  $\sim 20 \text{ mb}$
  - pressure after VIC  $\sim 10^{-4} \text{ mb}$

## Pellets have been formed



70 mm

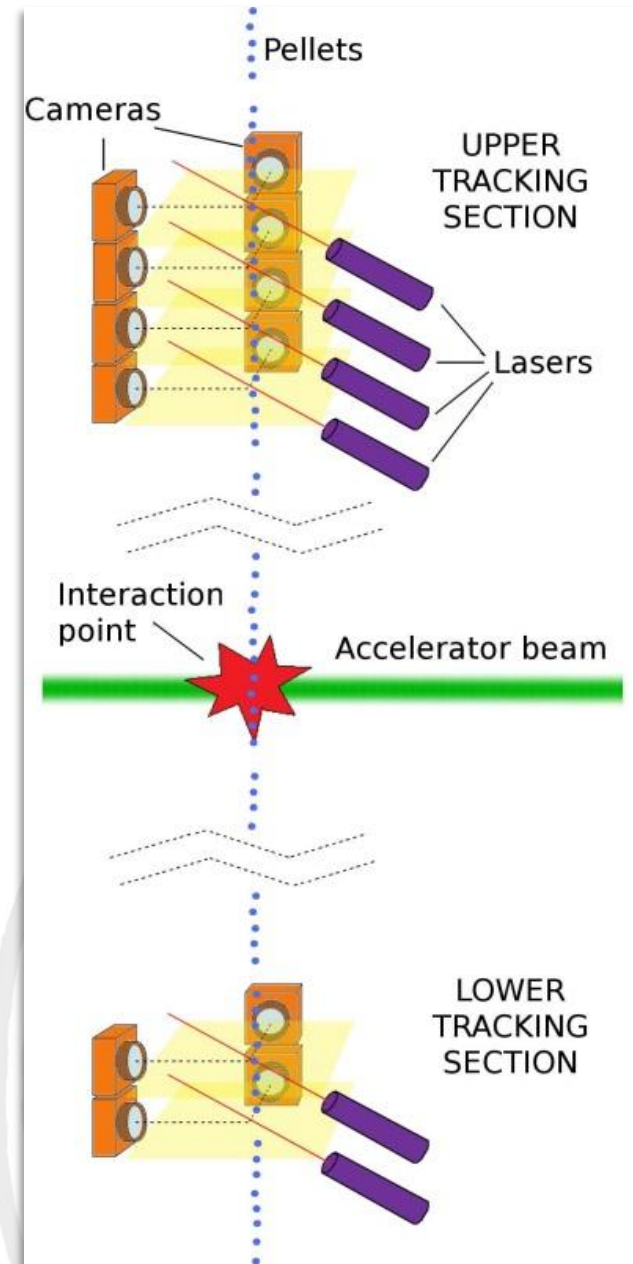


$\Phi_0 = 1.4 \text{ mm}$

# Tracking Pellets

- STR (Structured-light-pattern diode) lasers
- LS (Line-Scan) cameras
- The camera line of sight and the line profile of the laser must coincide in a plane within  $10\ \mu\text{m}$
- A measurement accuracy of  $20\ \mu\text{m}$  at the detection levels is required

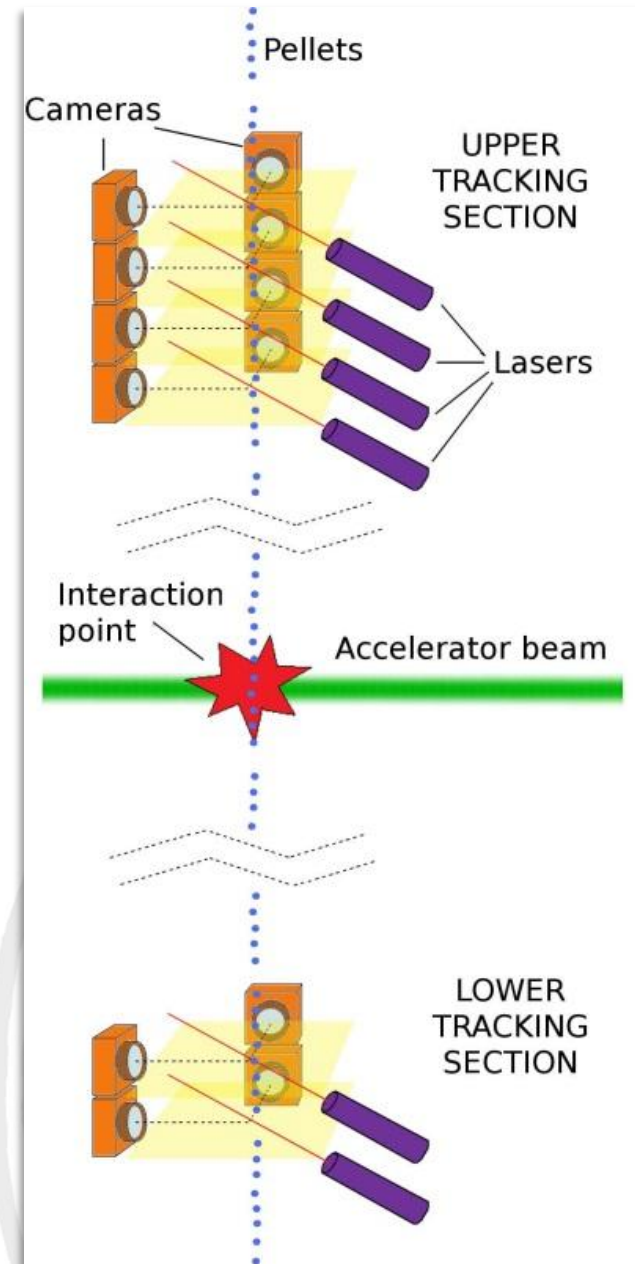
**Position of a pellet in the interaction region can be reconstructed with a precision of 0.1 mm**





# Tracking Pellets

- Alignment of the lasers and cameras in one level is done mechanically
- Alignment of different levels with each other is done in the track reconstruction procedure
- Alignment relative to the accelerator beam is done by including the frequency of reactions as a function of the pellet position

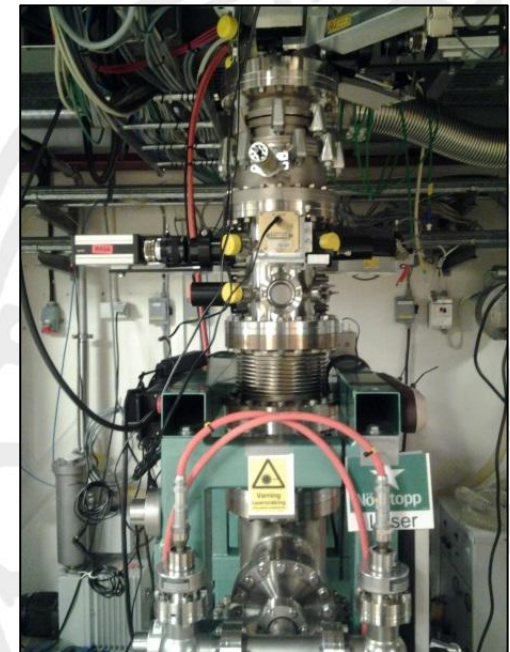
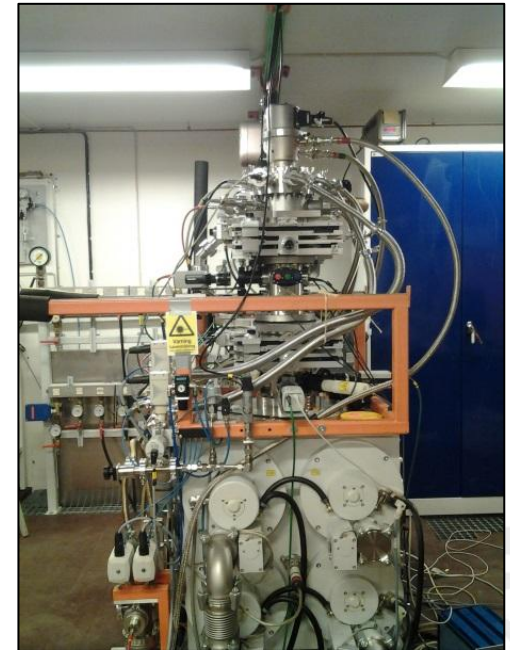
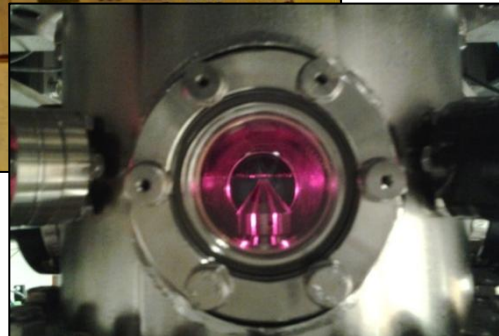






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# UPTS

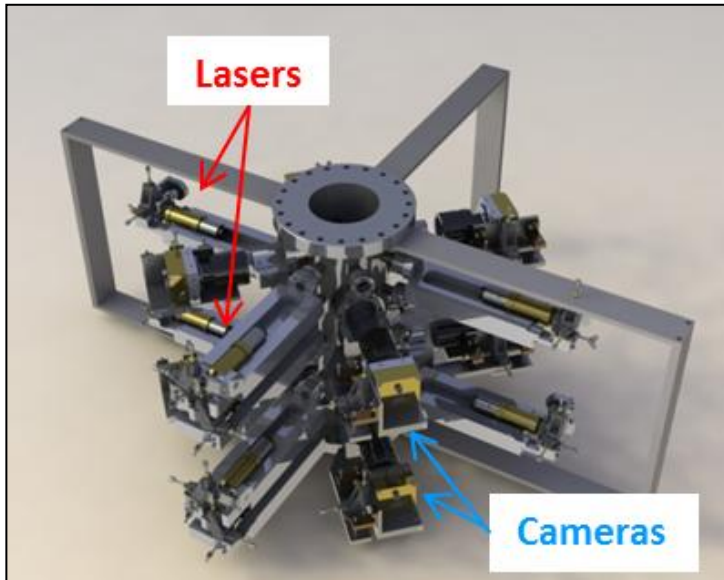


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# Why Do We Need the DM?



## Old conceptual design for a tracking section

- Separate laser and camera holders
- 60 mm spacing between the two levels
- Difficult to align lasers and cameras!

## The DM

1. Provides a possibility to align cameras and lasers away from the pellet beam pipe (at the PTS and at PANDA)
2. The cameras and lasers can be aligned with a simpler and more stable target than a pellet stream
3. Can be used to examine and optimize camera effects

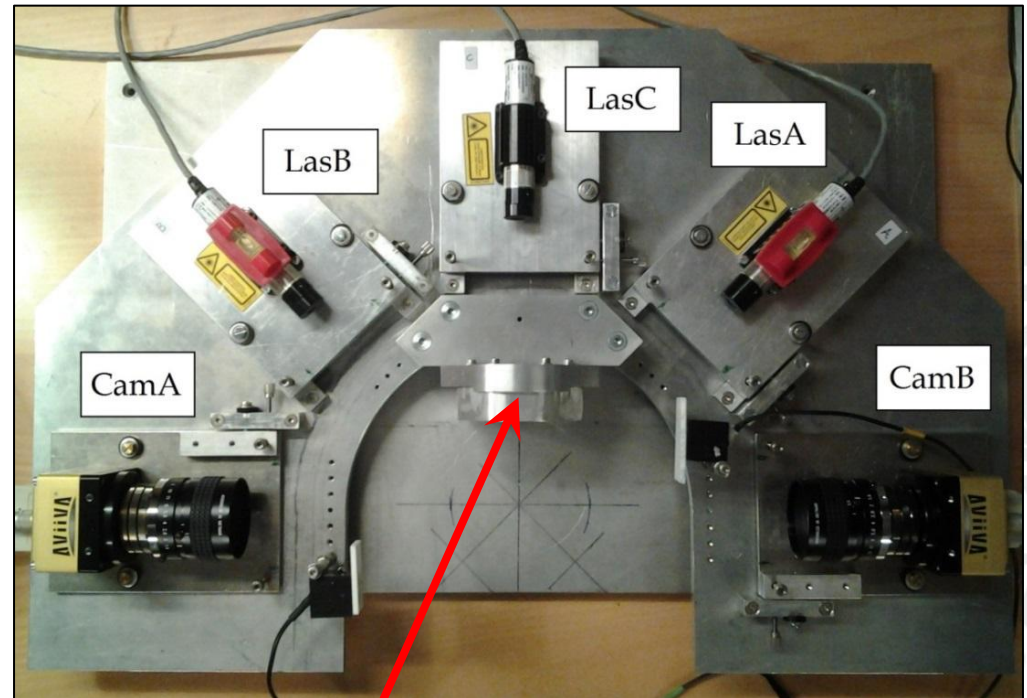


# DM

-At the Alignment Bench

## Lasers

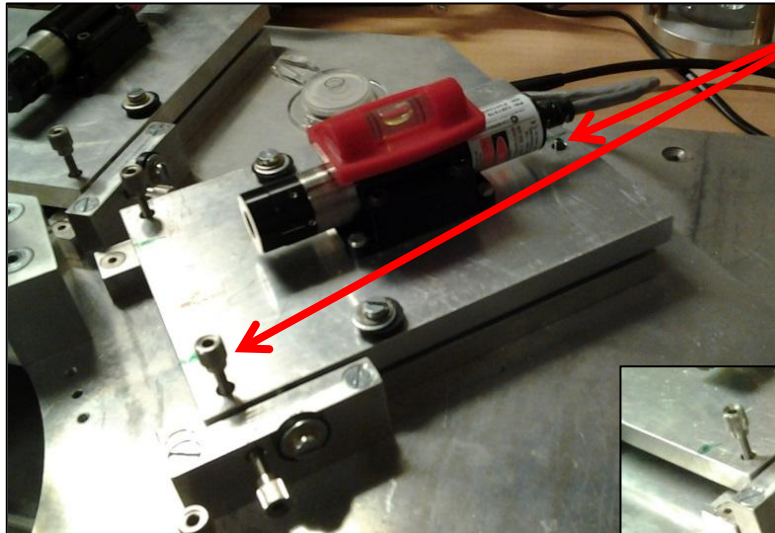
- LasA and LasB are used for pellet measurements
- LasC is used for alignment



The DM plate is fastened to a base plate via a dummy Window-flange

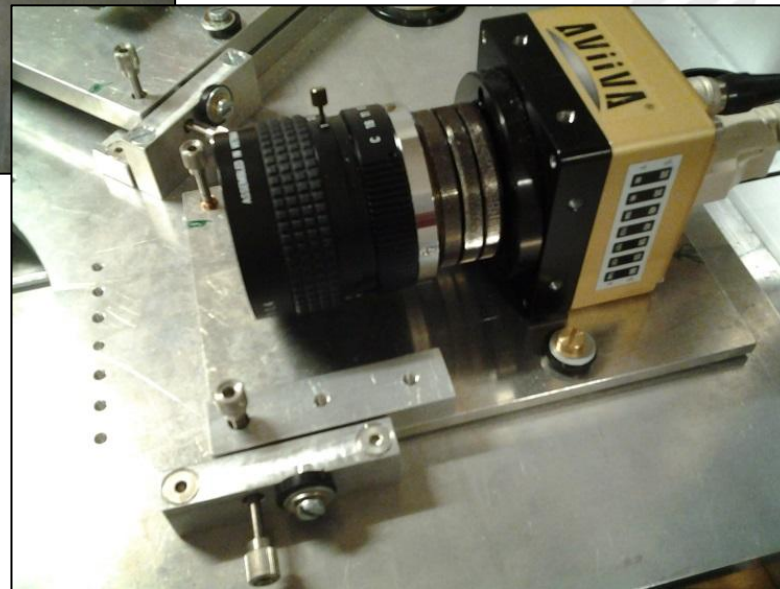


# Cameras and Lasers



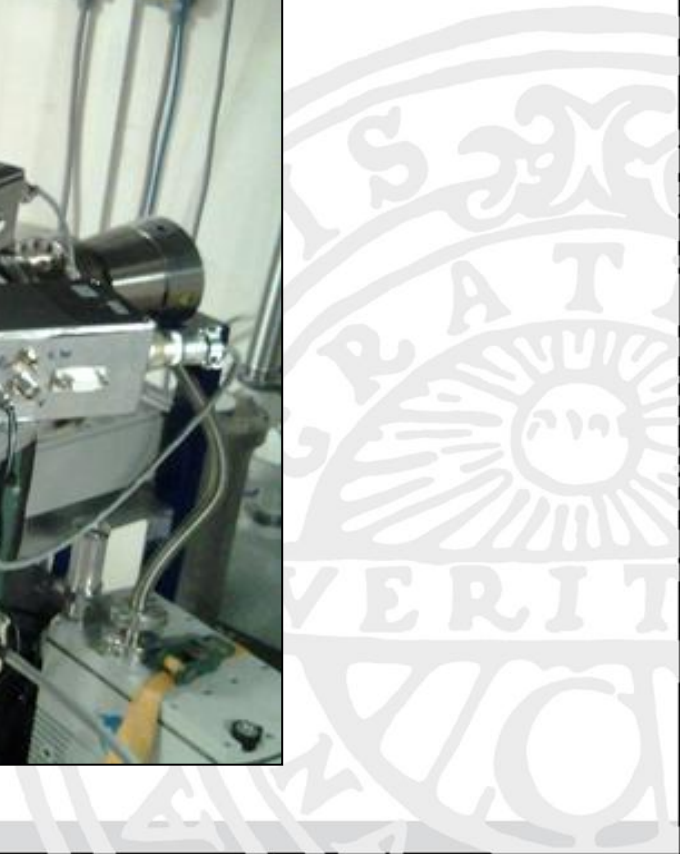
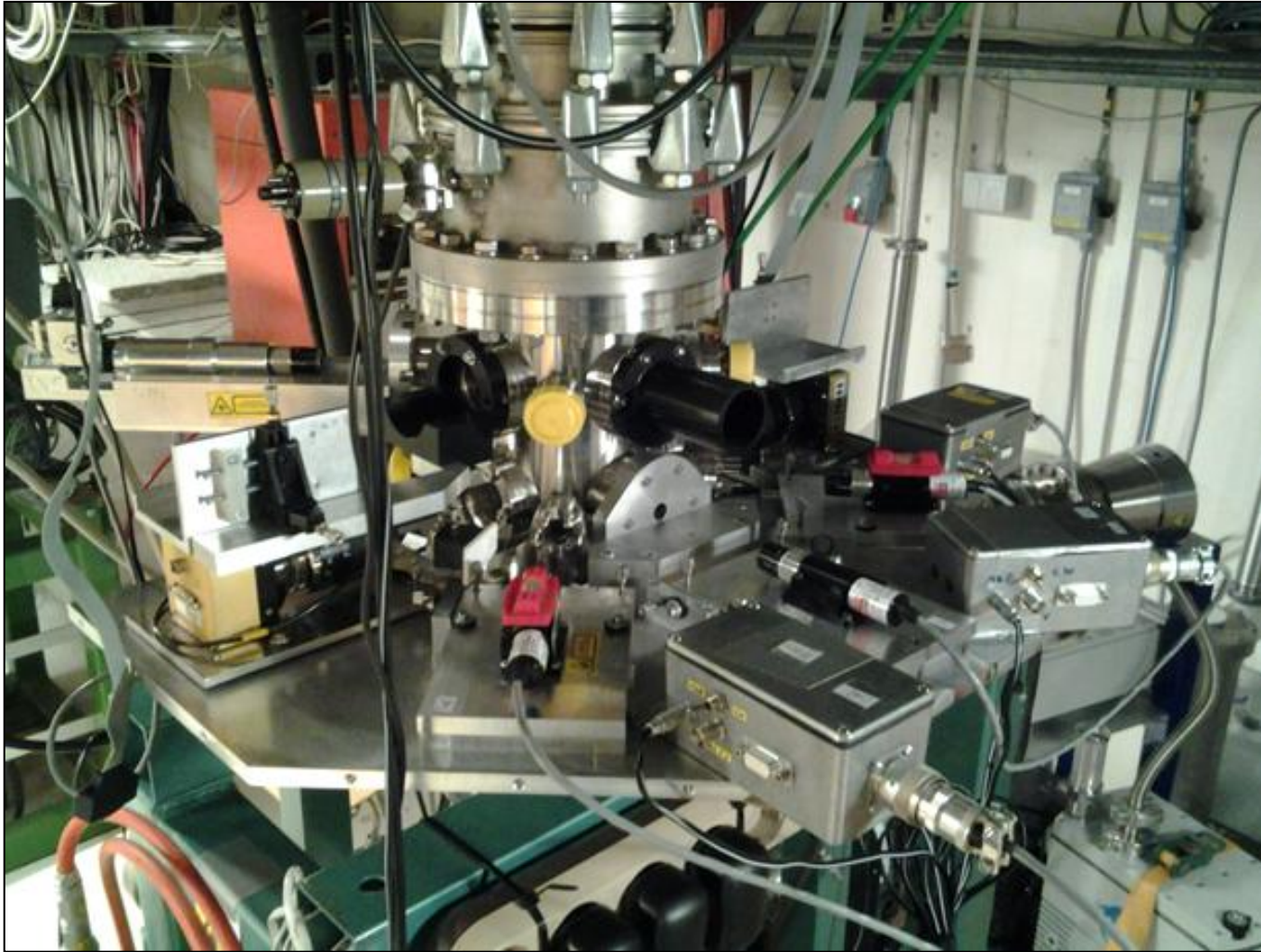
$\mu\text{m}$  screws

-for precision height  
adjustment and rotation



# DM

-At the Pellet Tracking Chamber





# Alignment Bench Targets

- Fishing Lines



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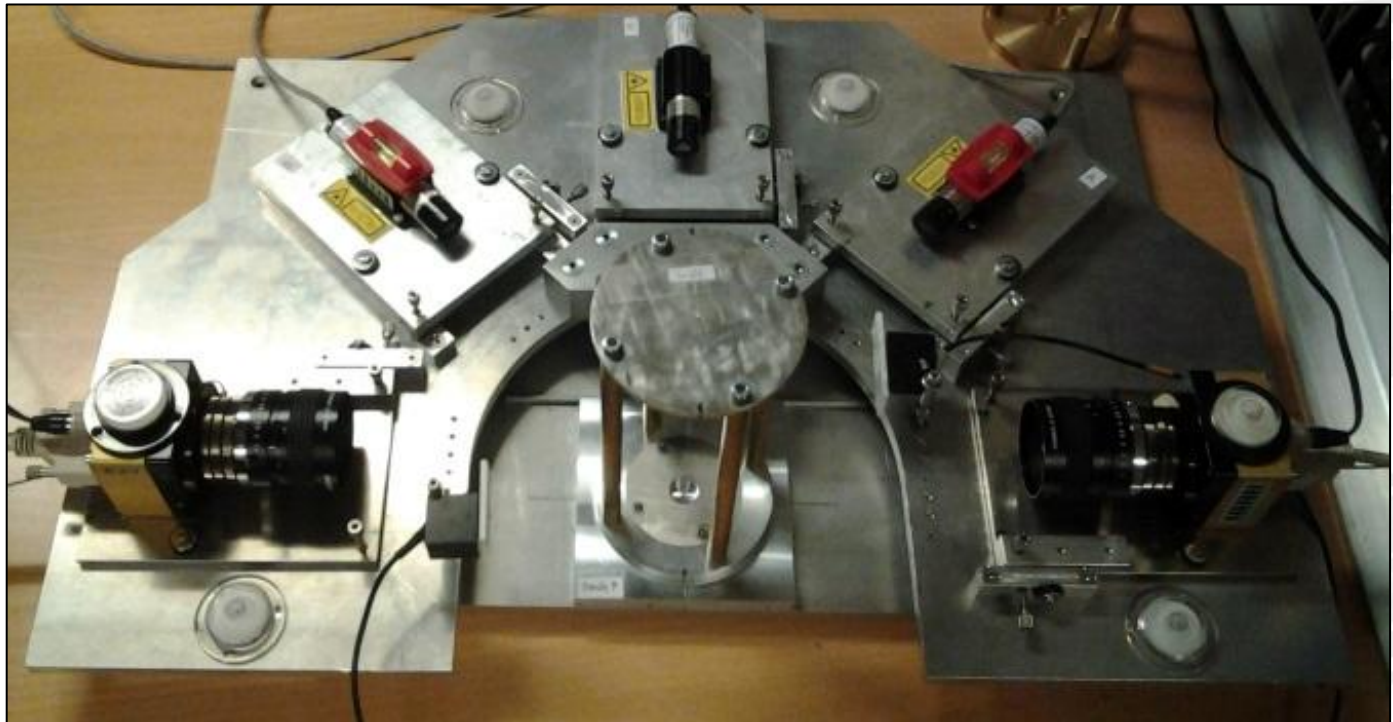




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# Alignment

- CamA and CamB are aligned with respect to LasC
- LasA and LasB are aligned with respect to CamA and CamB
- Fine adjustments can be made



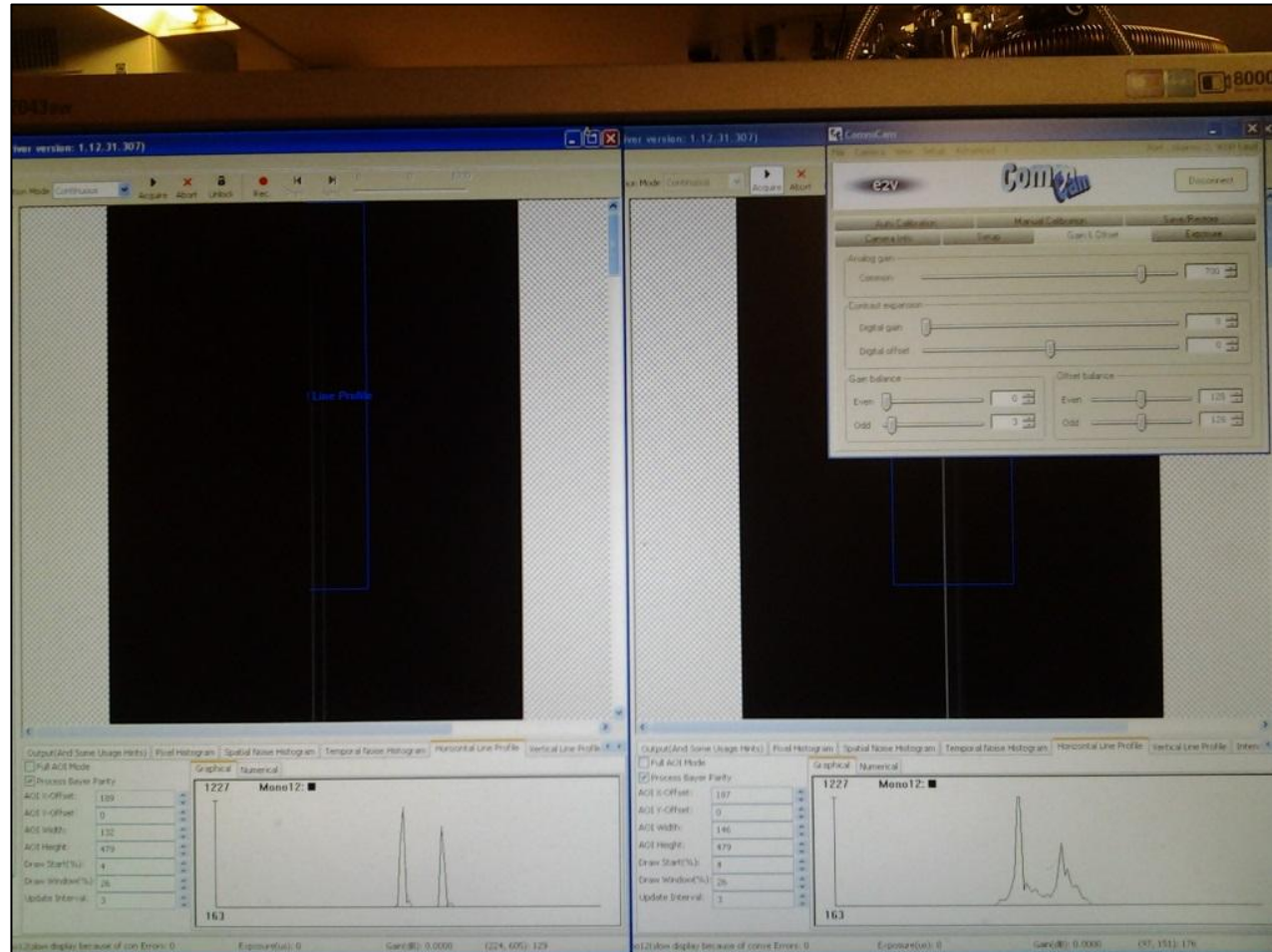
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# Alignment



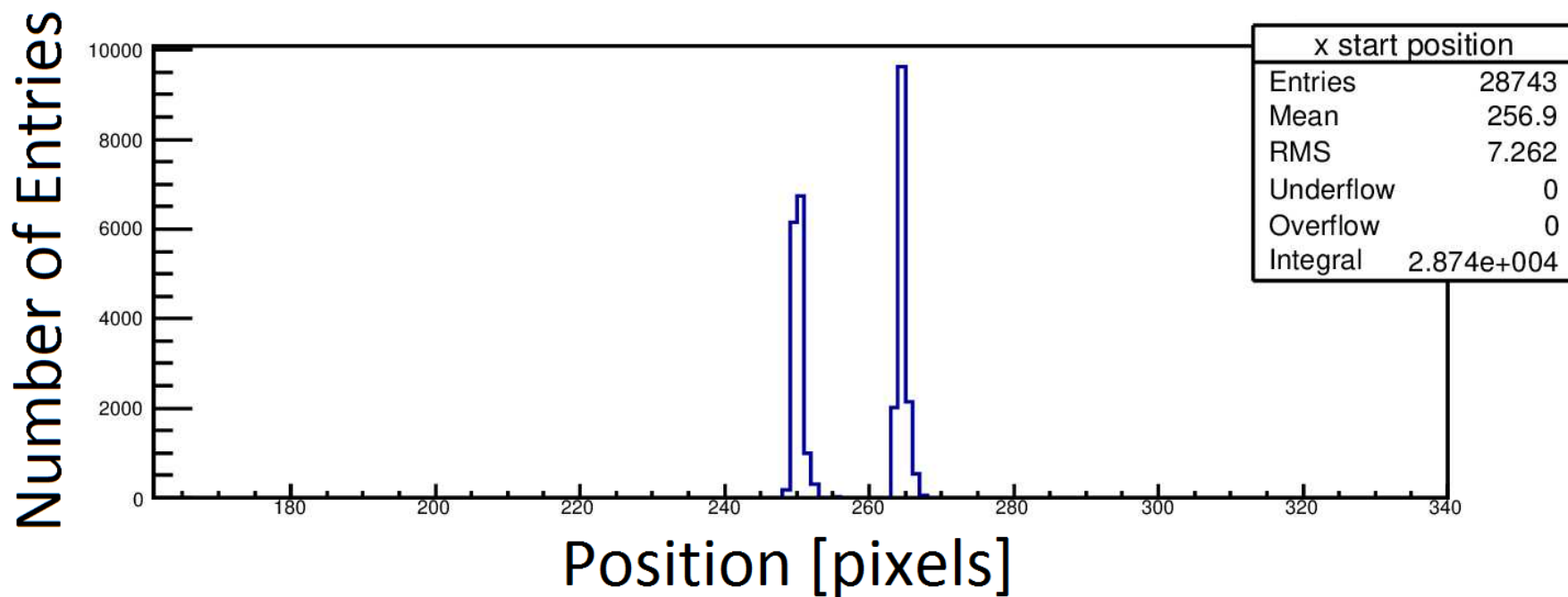
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# Data Analysis

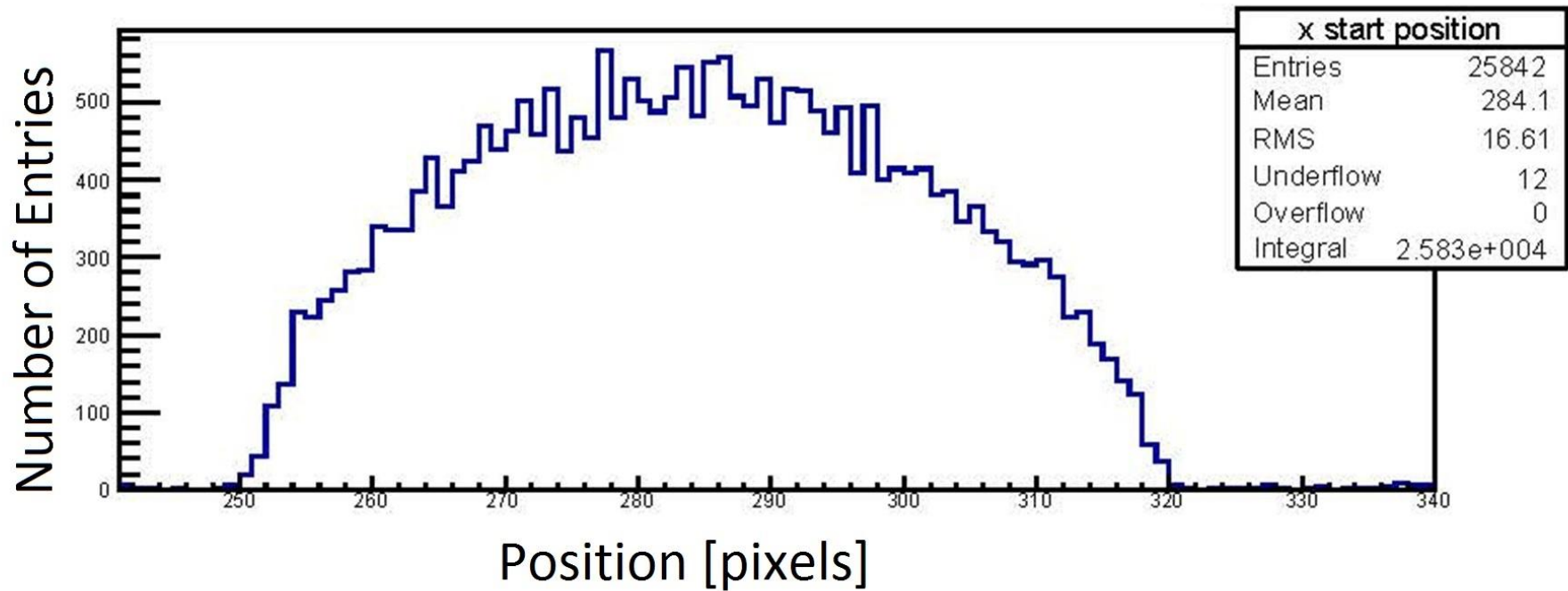
## - Position Distribution of Two Fishing Lines





# Data Analysis

## - The Pellet Stream Spatial Distribution



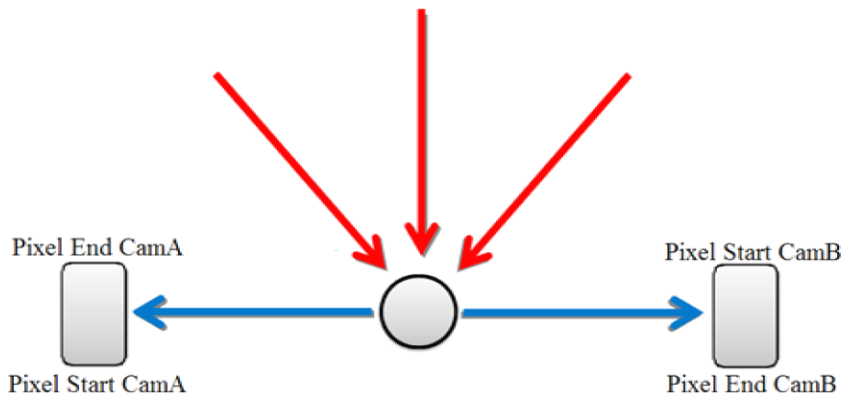


# Data Analysis

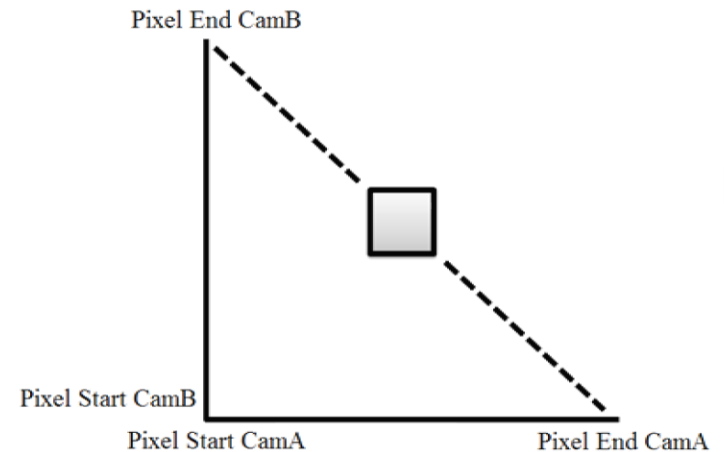
Can detect relative changes in the camera position

- Compare pixel correlation plots from two different measurements

Experimental Setup



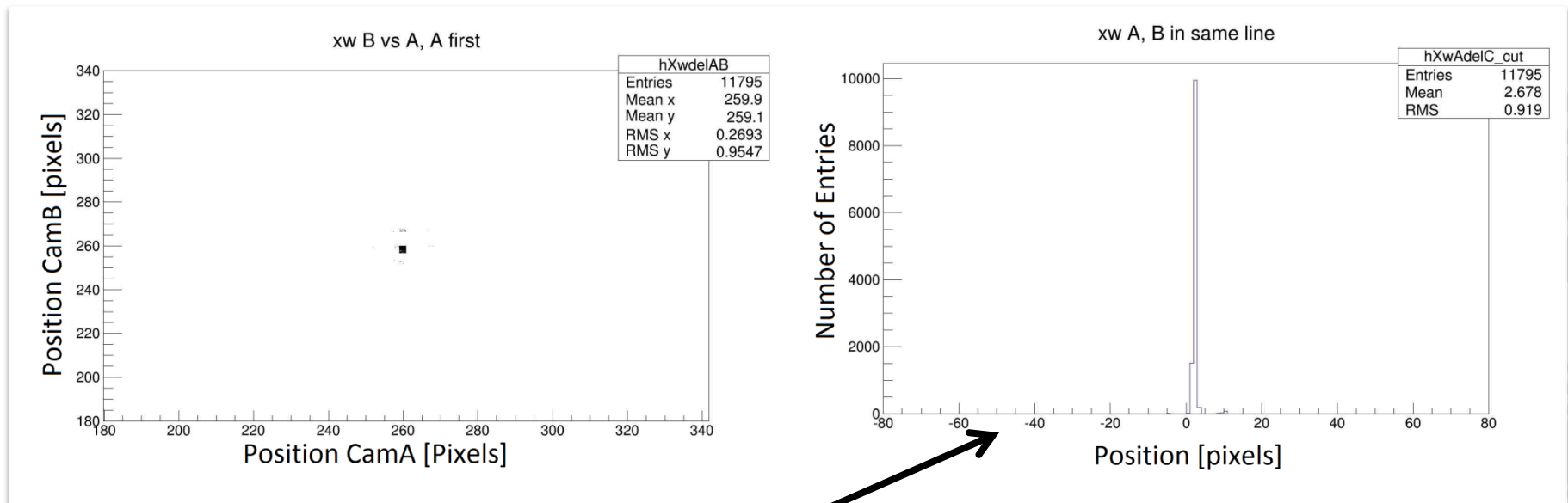
Pixel Correlation Plot





# Data Analysis

Can detect relative changes in the camera position



Deviation from the dotted line



# Stability of the Alignment

- 1. Temperature Changes (~10°C)**
- 2. Transportation (from the desktop setup to the pellet beam pipe)**
- 3. Exposure to Vibrations (due to pumps during pellet runs)**

# Expansion of the Material

Distance between camera and pellet stream: 250 mm

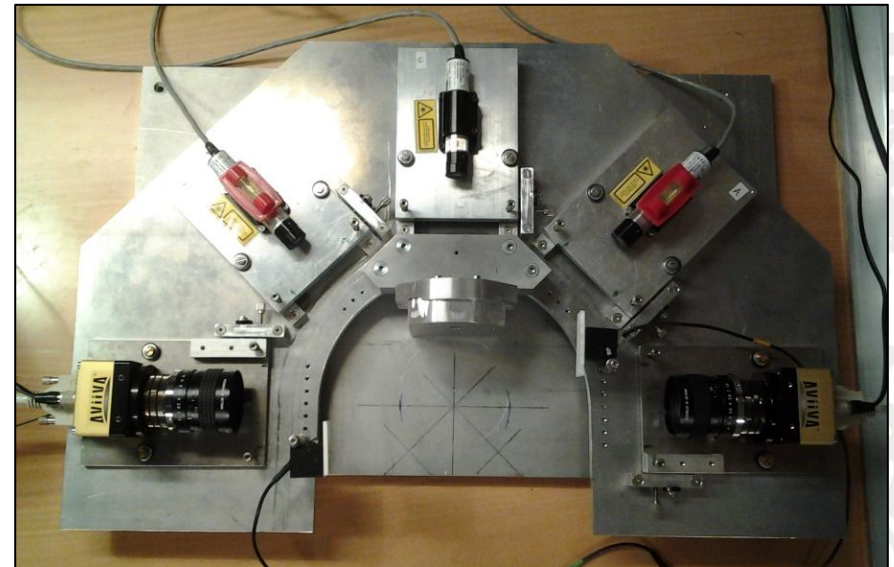
Distance between laser and pellet stream: 185 mm

Expansion of DM over 0.5 meter at a temperature difference of 5°C: 0.07 mm

Expansion/contraction in all directions→  
Only expected noticeable effect is that  
distance between camera and target  
changes

→Maximal change in distance between  
camera and target: 0.035 mm

→ 0.2% change in camera picture size,  
not detectable!





# Results

No change in alignment was observed in any of the stability investigations

Estimated limits on the stability of the alignment taking into account the method of investigation:

## 1. Temperature Changes (of $\sim 5^{\circ}\text{C}$ )

- Vertical alignment of all cameras and lasers differ less than  $40\ \mu\text{m}$
- Relative horizontal position of CamA and CamB differ less than  $37\ \mu\text{m}$  (one pixel)



# Results

## 2. Transportation

- Vertical alignment of CamA, CamB, LasA and LasB differ less than 40  $\mu\text{m}$
- Relative horizontal position of CamA and CamB differ less than 37  $\mu\text{m}$  (one pixel)

## 3. Exposure to Vibrations

- Vertical alignment of all cameras and lasers differ less than  $\sim 60 \mu\text{m}$
- Relative horizontal position of CamA and CamB differ less than  $\sim 37 \mu\text{m}$  (one pixel)



# Summary

## The DM

- consists of a DM plate with cameras and lasers for pellet detection and alignment
- can be aligned in a desktop setup and be transported to the tracking section of a pellet beam pipe
- is needed for testing the setup of cameras and lasers with other targets than a pellet beam
- is needed in order to examine the optics of the lasers and cameras

## Results

The alignment of the cameras and lasers on the DM was found to be stable against transportation, vibrations and temperature variations which are the main sources of distortions anticipated





# Outlook

- More precise measurement of the height of the camera- and laser-plates
- Reduction of the weight of the DM
- Further investigations of the optics of the cameras and lasers
- Optimizing time resolution by tuning the camera exposure cycle
- Another level to the PTS tracking section will be added 60 mm above the existing one
- Work on our new readout systems that will handle all detection levels needed finally



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# Thank You!



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