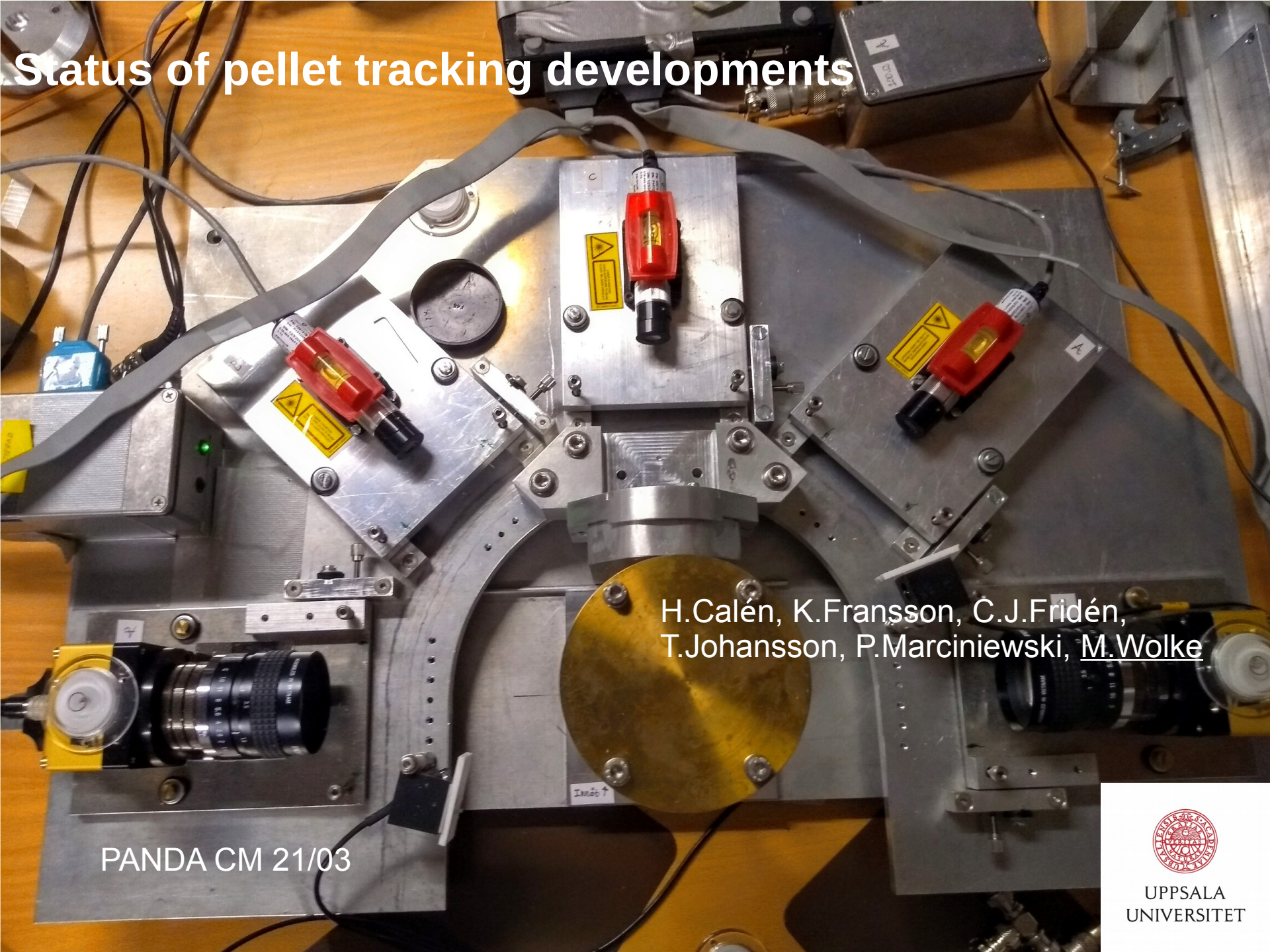
Status of pellet tracking developments



H.Calén, K.Fransson, C.J.Fridén,
T.Johansson, P.Marciniewski, M.Wolke

PANDA CM 21/03

UPPSALA
UNIVERSITET

Pellet tracking

The pellet tracking system for PANDA is based on line-scan CCD cameras and diode lasers configured in several measurement positions.

It is designed to provide:

- individual pellet positions ($\sigma \approx 0.1$ mm) at a hadronic event
- useful information for ≈ 90 % of the hadronic events

The tracking system is separated (geometrically, mechanically, electronically etc.) from target generator and target dump.

The tracking system can also be used as a monitoring system together with any target generator, but only with pellet target in "Pellet Tracking mode" operation it can provide useful tracking info.

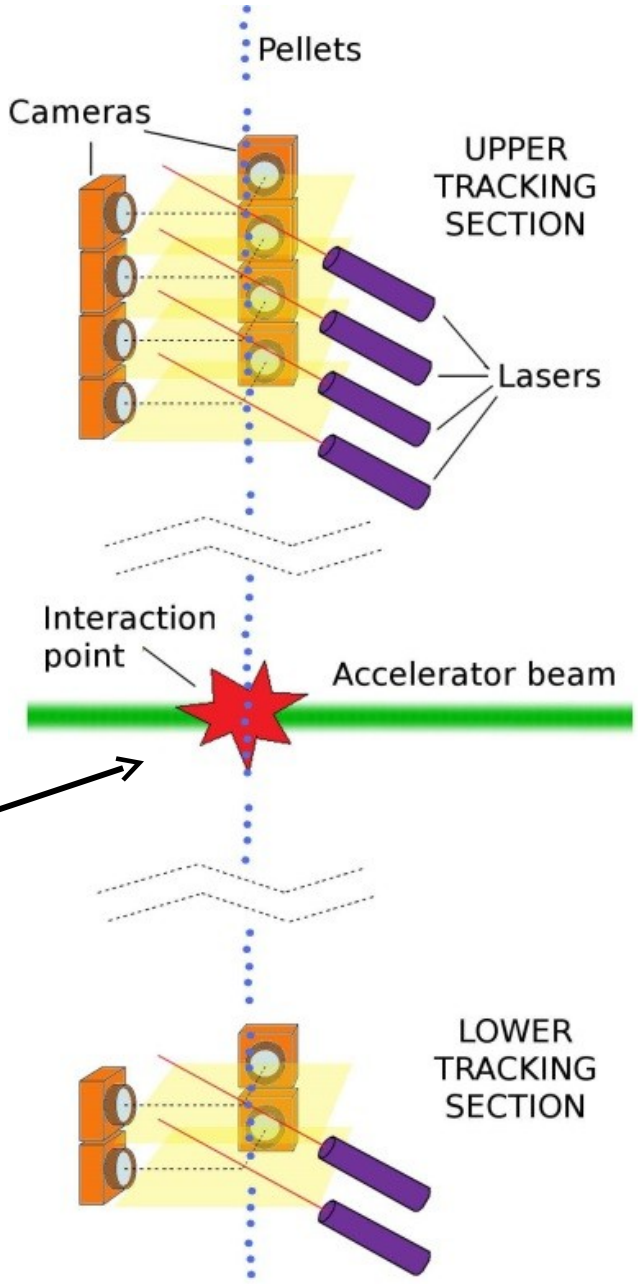
For pellet "Pellet High Luminosity mode" and for Cluster-Jet, it mainly could provide stream (jet) position, shape and time structure info.

UPPSALA UNIVERSITET

Detection configuration, multi-camera operation, readout and fast track finding algorithms are being developed at UU.

Pellet tracking

- **laser beams with a horizontal beam line profile of 3 mm width and 50 μm height.**
- **line-Scan CCD cameras taking one line of 512 pixels, size 35x35 μm², at 100 kHz frequency.**
- **The camera line of sight and the beam line profile of the laser must coincide within 10 μm.**
- **A pellet measurement accuracy of 20 μm.**

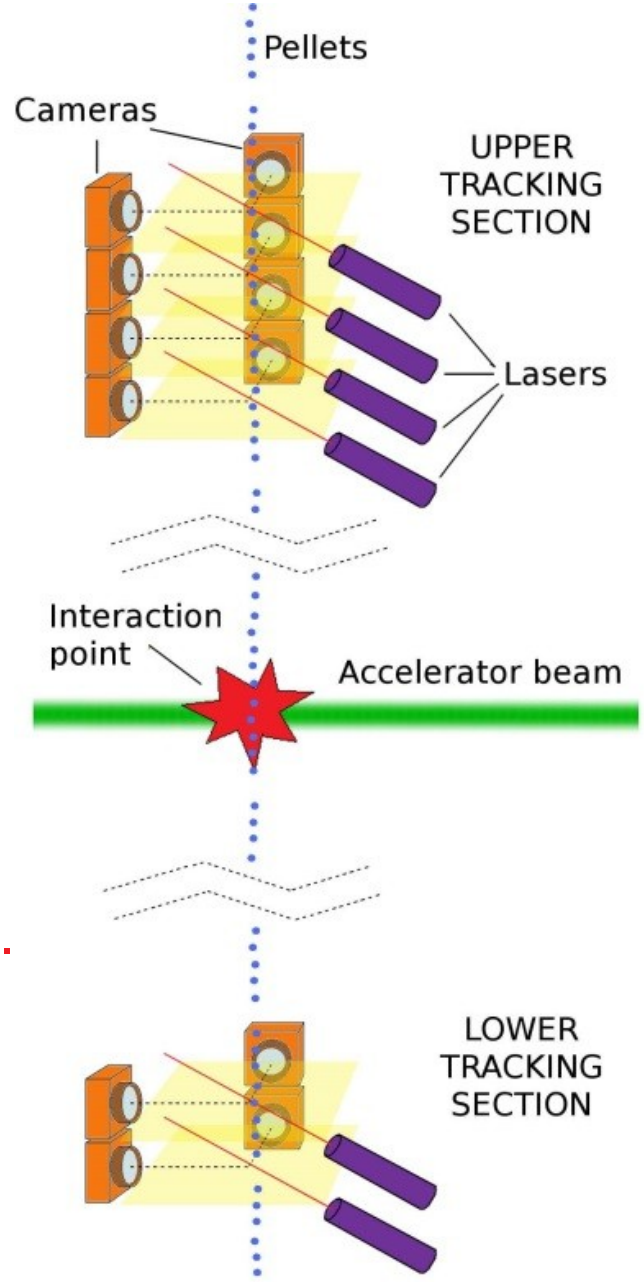


Position of a pellet in the interaction region can be reconstructed with a precision of 0.1 mm

Pellet tracking

- **laser beams with a horizontal beam line profile of 3 mm width and 50 μm height.**
- **line-Scan CCD cameras taking one line of 512 pixels, size 35x35 μm², at 100 kHz frequency.**
- **The camera line of sight and the beam line profile of the laser must coincide within 10 μm.**
- **A pellet measurement accuracy of 20 μm.**

Alignment crucial! Has to be stable against
- mounting at the target chamber
- mechanical vibrations, temperature effects etc.



UPPSALA UNIVERSITET

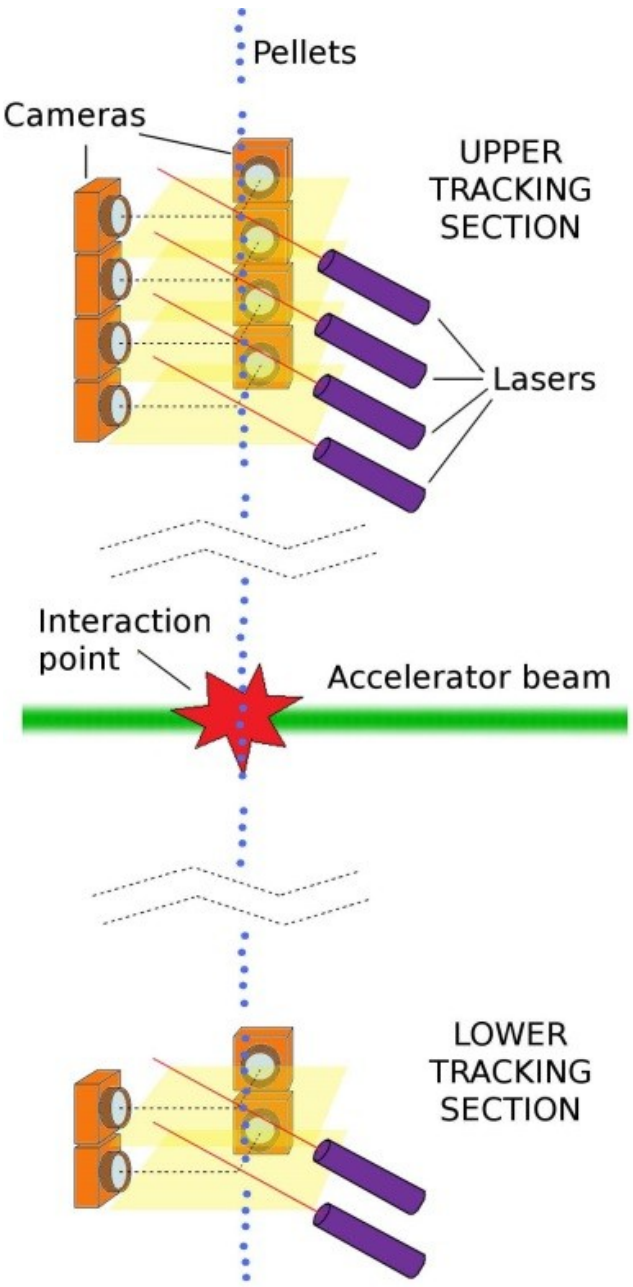
Pellet tracking

Equipment and procedures have been developed* so that the complete measurement level system can be (fine) tuned offline and then be securely installed at the tracking section of the target pipe.

It then maintains its performance during the experimental conditions without need for further manipulation (continuous easy access).

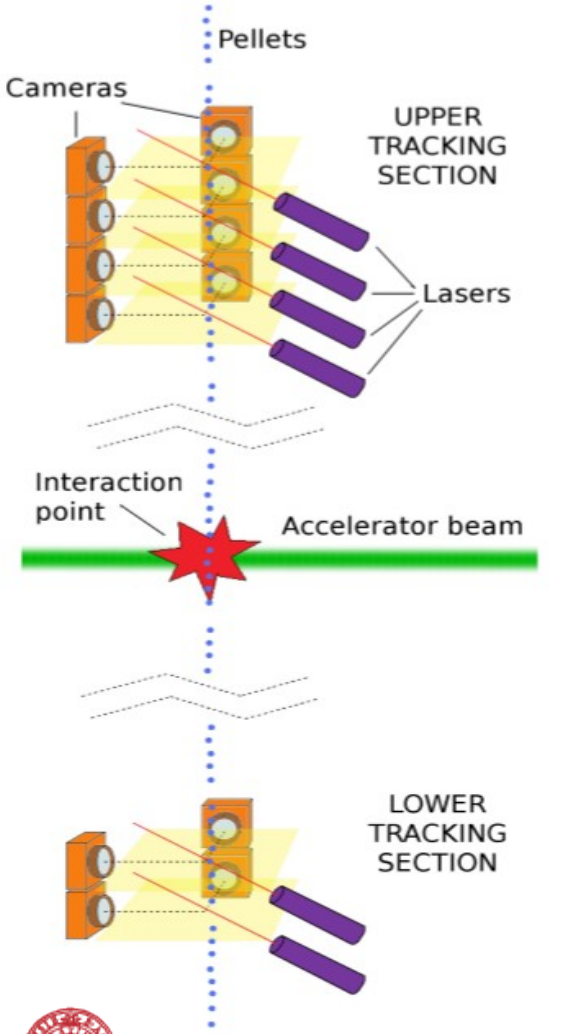
*) **Master** thesis **Jenny Regina**:
A measurement level module for a pellet tracking system (Feb 2017)

*) **Project** report **Dagmar Engelke**:
A hydrogen pellet tracking system (Jan 2020)

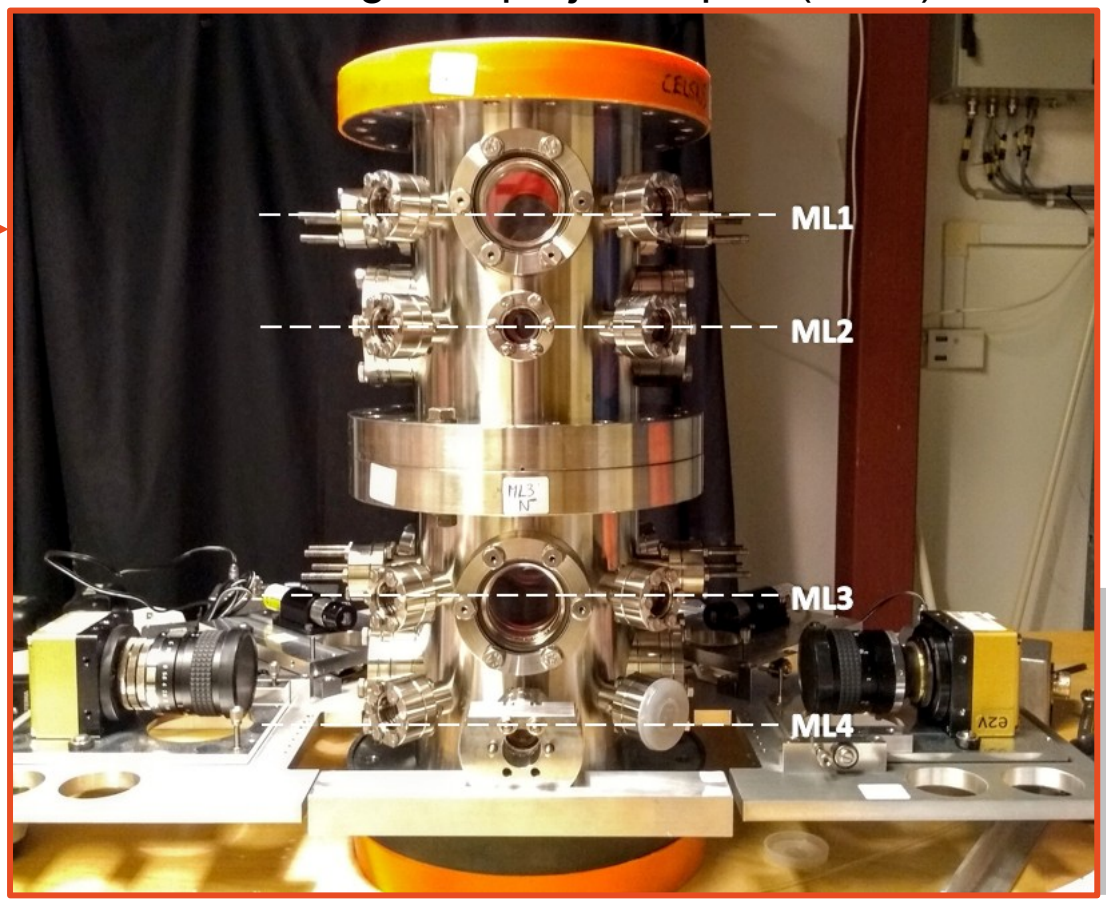


UPPSALA UNIVERSITET

The pellet tracking section



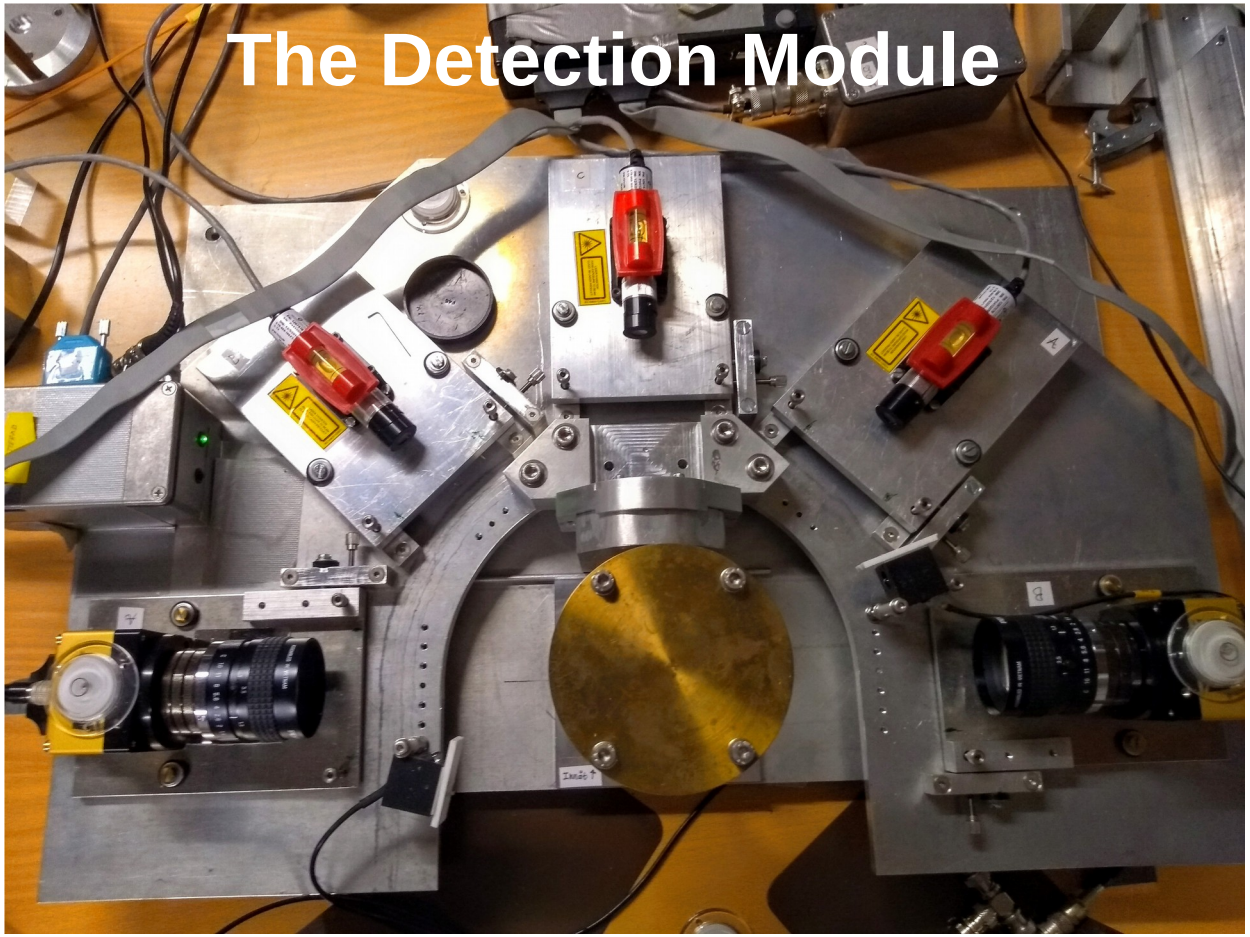
from: D.Engelke, project report (2020)



4 measurement levels M1..4
each equipped with one
Detection Module

UPPSALA
UNIVERSITET

The Detection Module



D.Engelke, project report (2020)

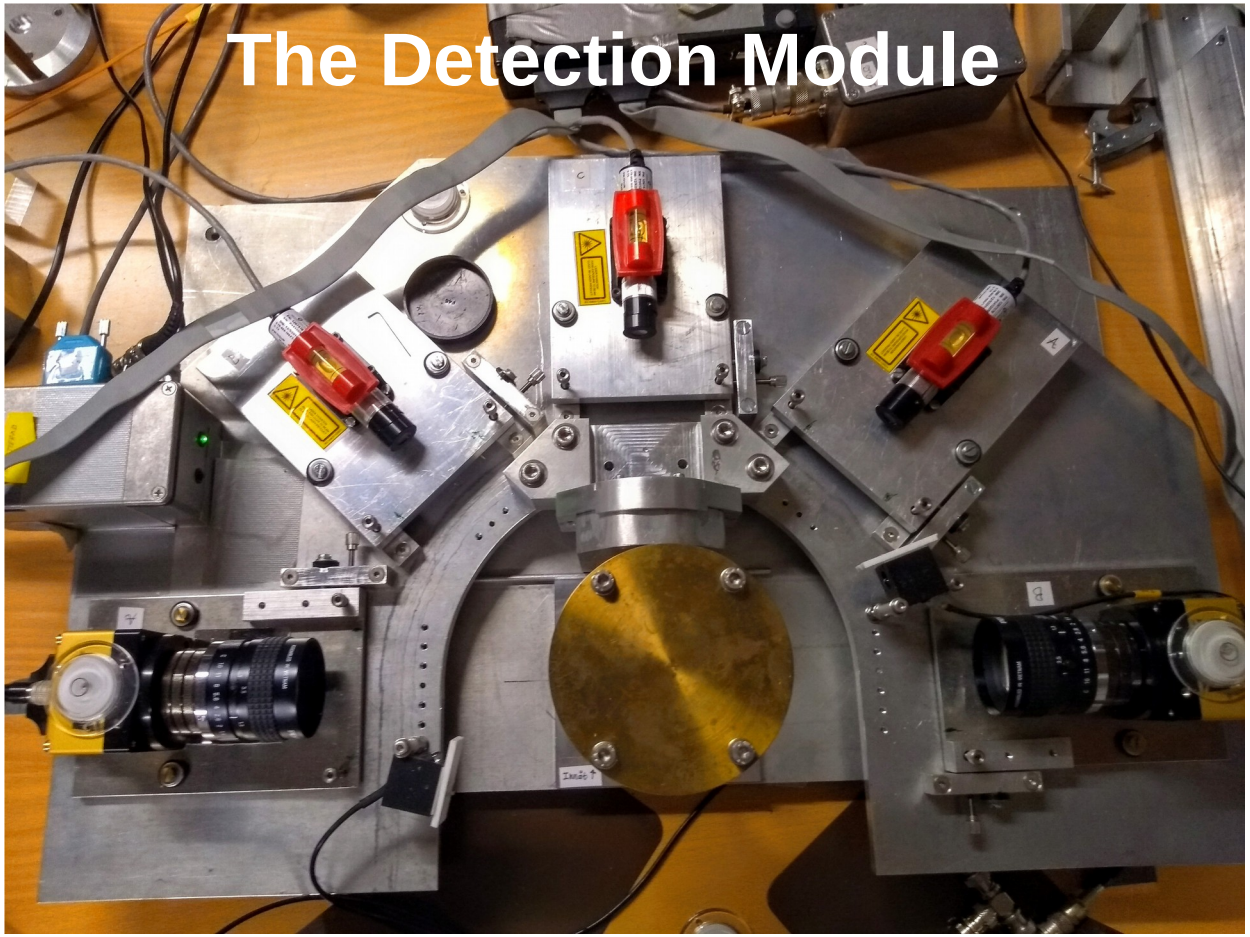
each detection module
equipped with
3 lasers, 2 CCD cameras

Note: a prototype measurement level DM was tested successfully earlier (2016) under real conditions with pellets.

UPPSALA UNIVERSITET

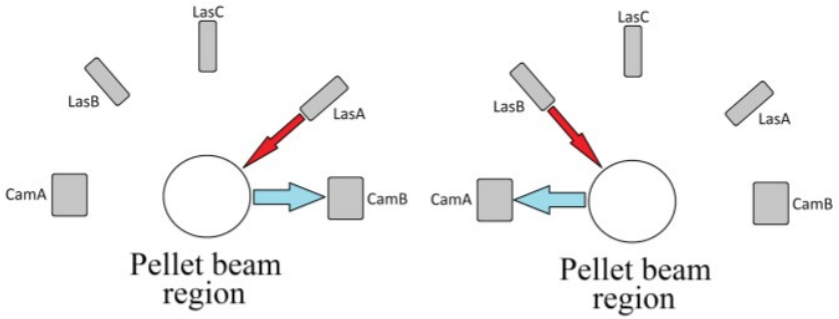
UPPSALA UNIVERSITET

The Detection Module

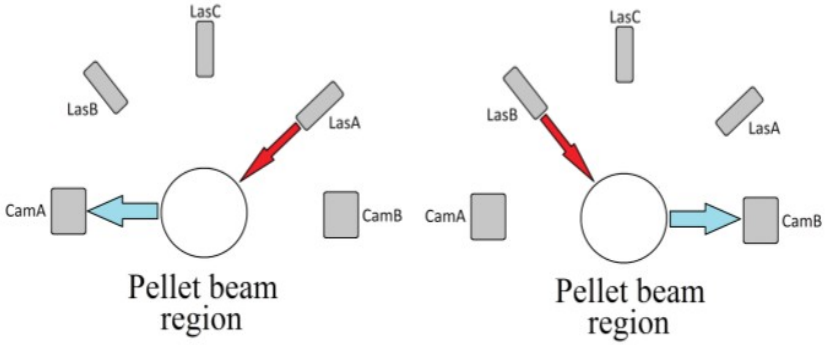


D.Engelke, project report (2020)

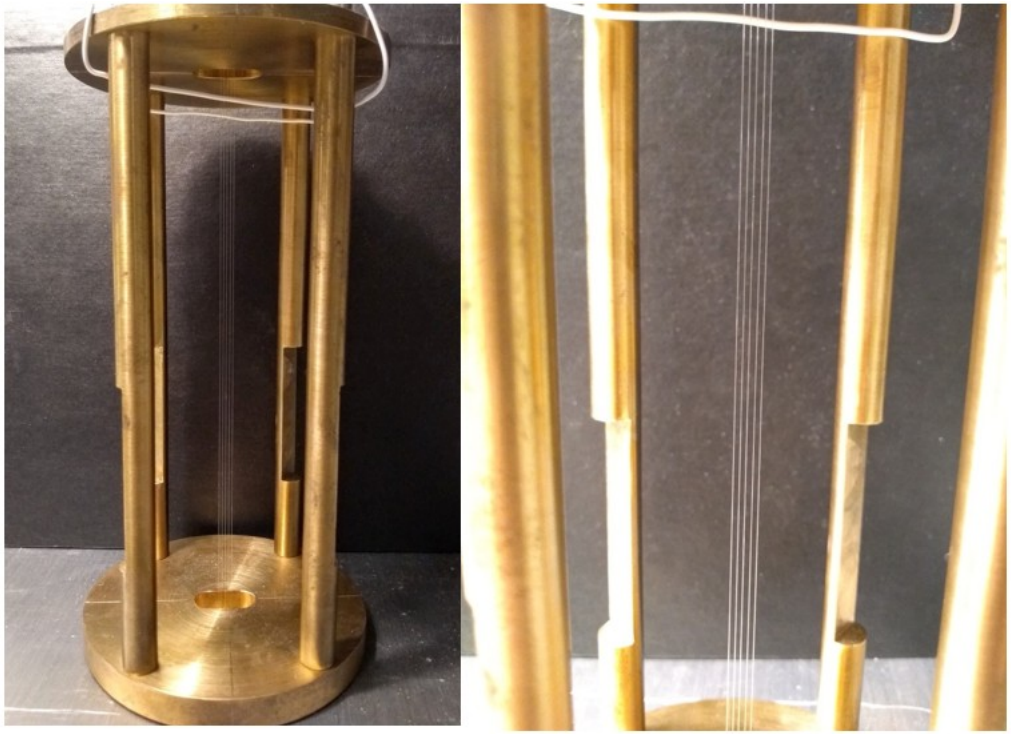
Reflected Light



Refracted Light



Zoom into the pellet beam region...



1 or **5**

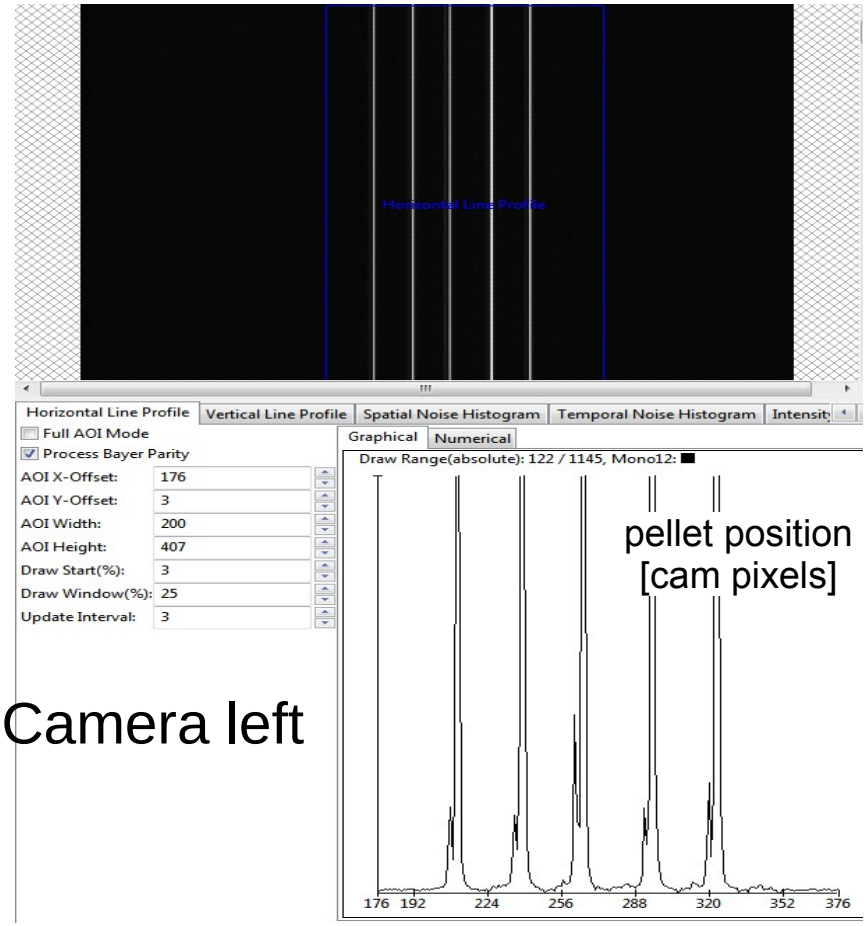
0,08 mm fishing lines

UPPSALA
UNIVERSITET

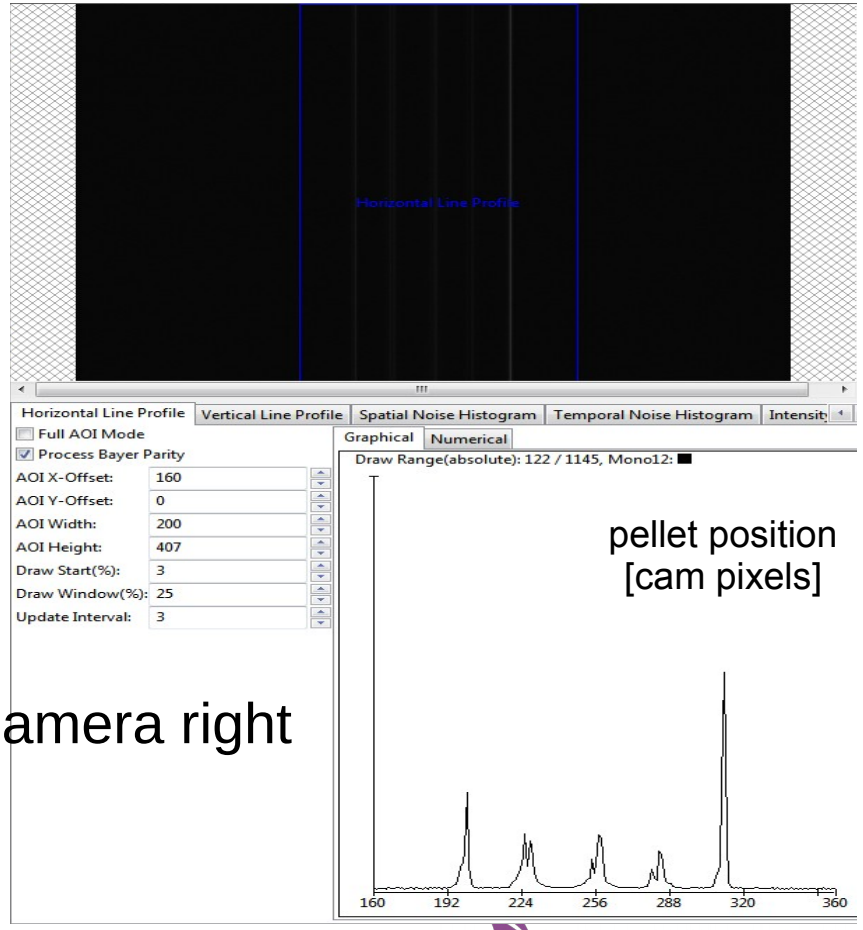
Camera and laser alignment at DM

refractions…

...and reflections



Camera left



Camera right

D.Engelke, Fontys Eindhoven, project report (2020), available at physics.uu.se

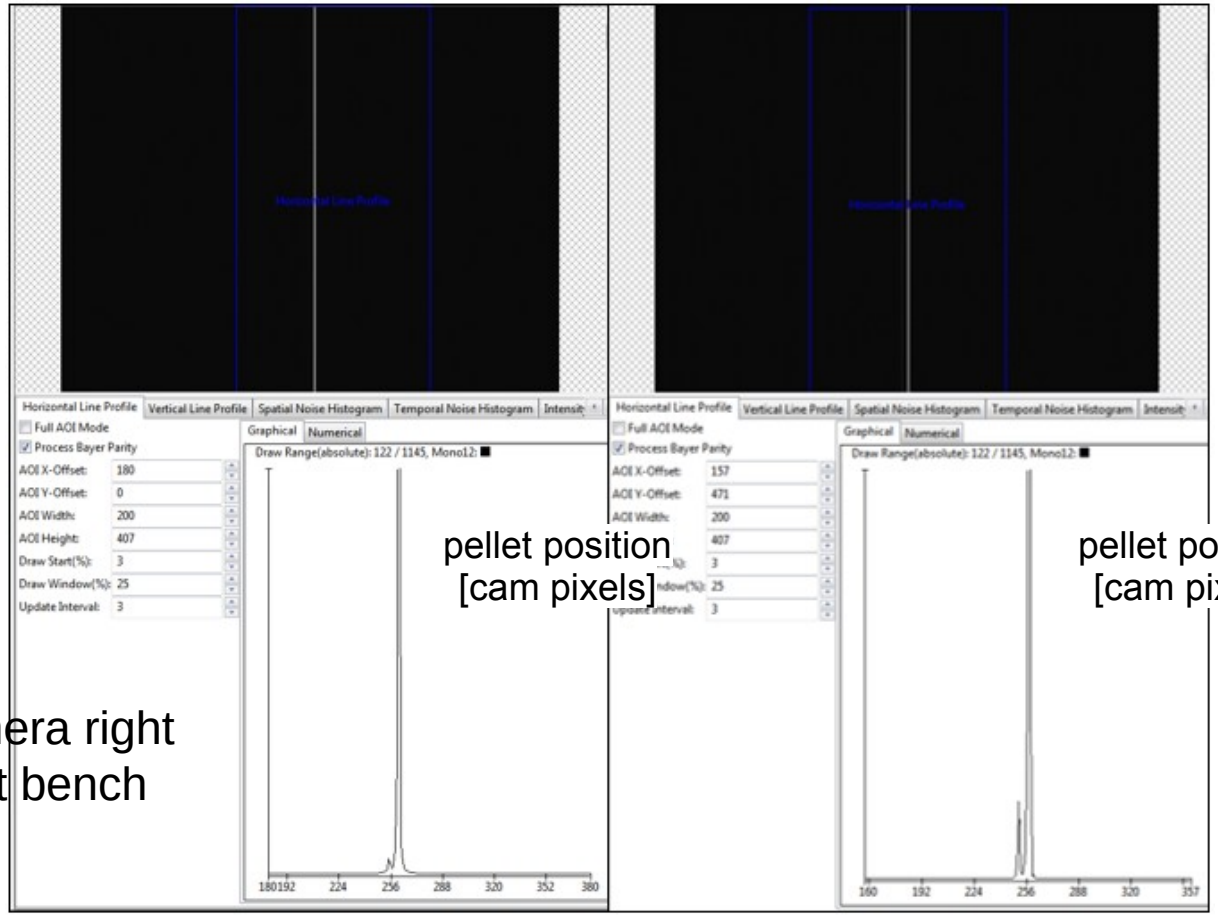
UPPSALA UNIVERSITET

Fontys University of Applied Sciences

Alignment on test bench and tracking chamber

test bench…

...and tracking chamber



pellet position [cam pixels]

pellet position [cam pixels]

Camera right test bench

Camera right tracking chamber

no effect of
- mounting at the tracking chamber
- glass windows

Alignment on the detection module can be kept stable when mounting at the target chamber

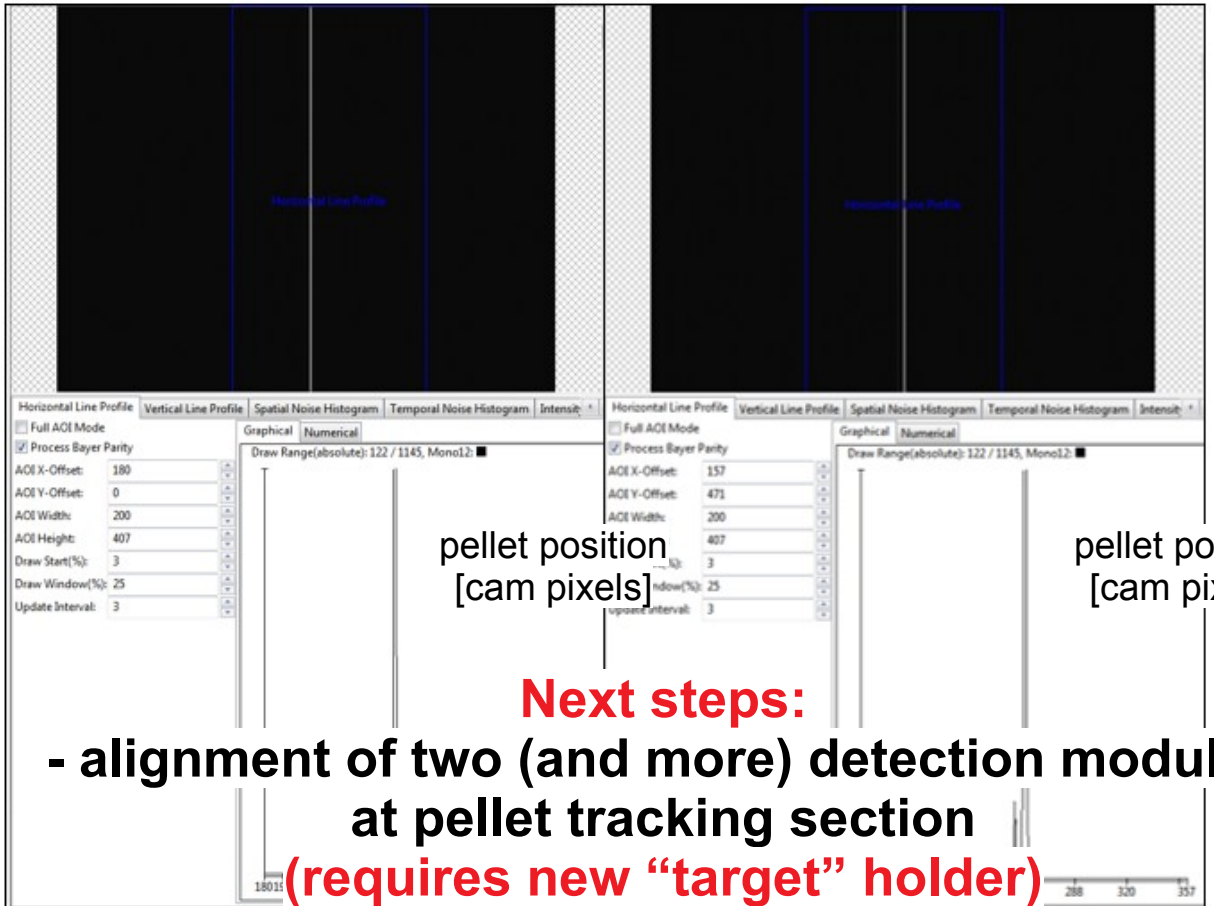
UPPSALA UNIVERSITET

Fontys University of Applied Sciences

Alignment on test bench and tracking chamber

test bench…

...and tracking chamber



pellet position [cam pixels]

pellet position [cam pixels]

no effect of
- mounting at the tracking chamber
- glass windows

Next steps:

- alignment of two (and more) detection modules at pellet tracking section
(requires new "target" holder)

- system test with two (and more) detection modules with pellet operation
(requires sync/readout and pellet operation)

UPPSALA UNIVERSITET

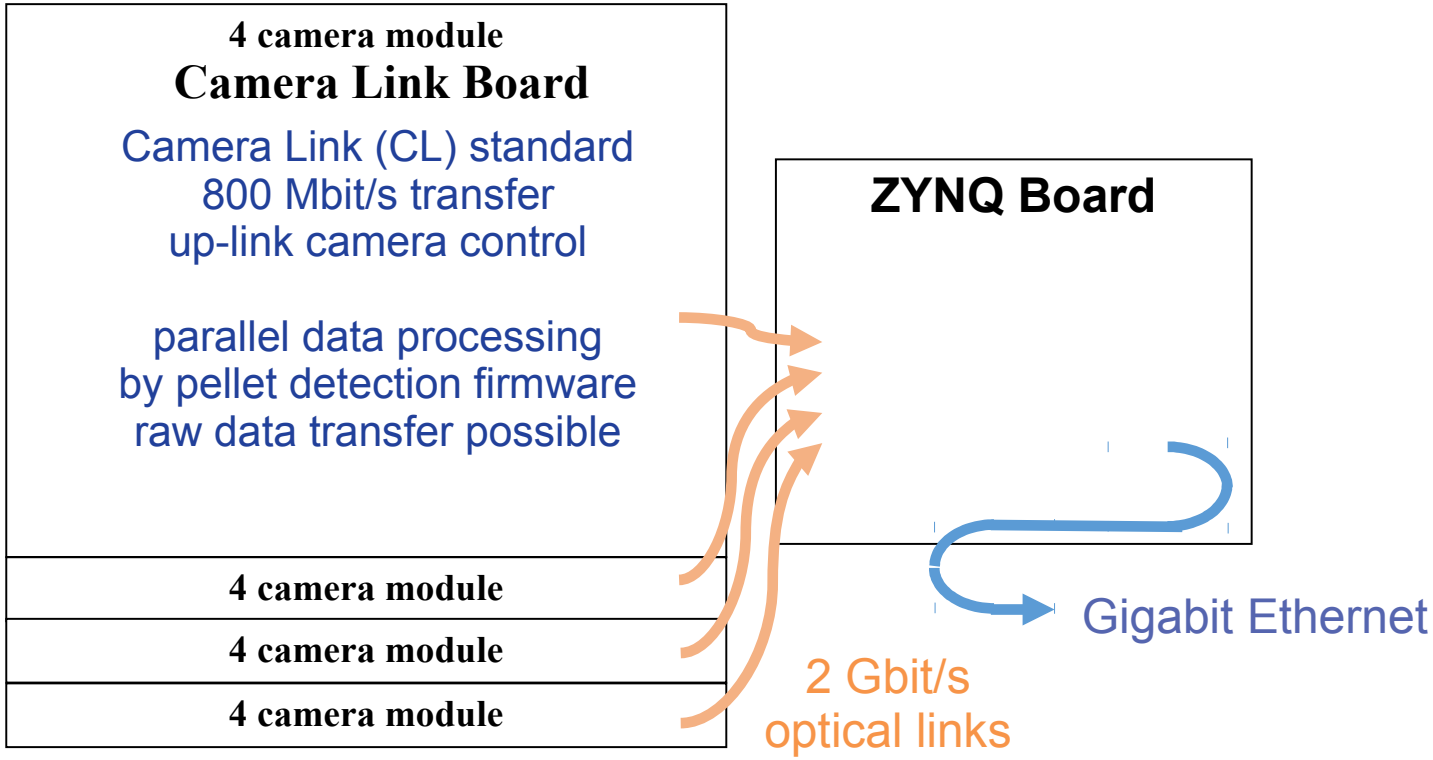
Fontys University of Applied Sciences

Readout and data acquisition

presently: readout, data transfer from CamLink to ATLB and VME

ATLB/Optical Data Collection for VME, Internal report, P. Marciniewski (2013)

foreseen: readout, data transfer from CamLink to ZynqBoard



Readout and data acquisition

4 camera module

Camera Link Board

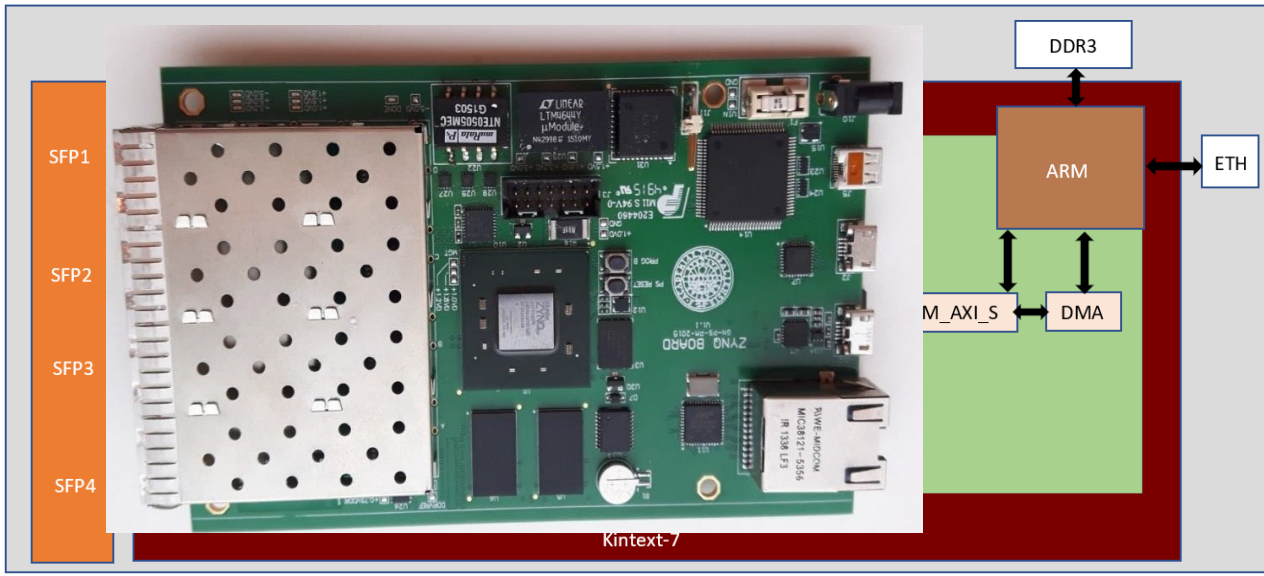
Camera Link (CL) standard
800 Mbit/s transfer
up-link camera control

parallel data processing
by pellet detection firmware
raw data transfer possible

4 camera module

4 camera module

4 camera module



ZYNC Xilinx SOC family (FPGA with PL, PS)

data buffering to collect full frames
optimized transfer to Gigabit Ethernet port

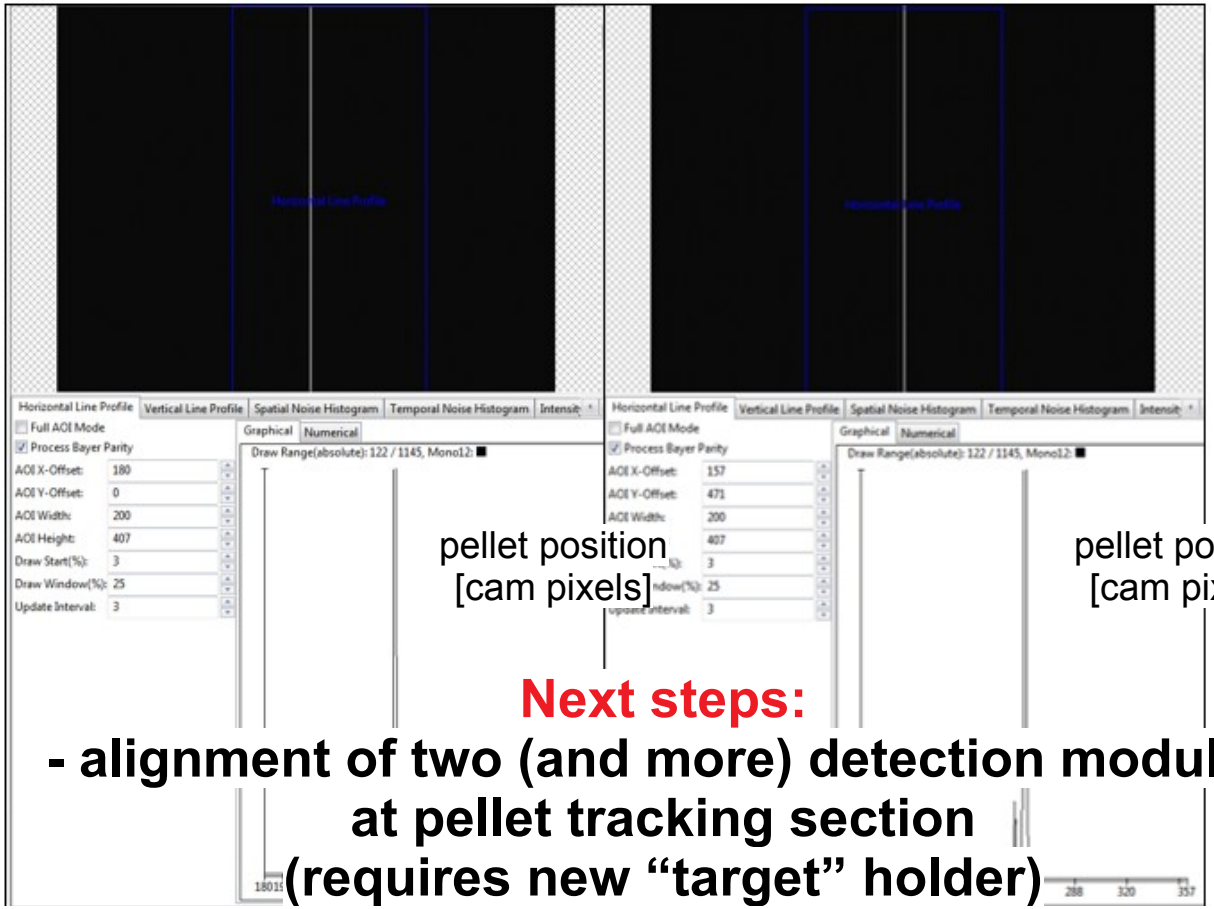
UPPSALA UNIVERSITET

S.Borrami, *Data Acquisition System for the ZynqBoard* (2019)

Alignment on test bench and tracking chamber

test bench…

...and tracking chamber



pellet position [cam pixels]

pellet position [cam pixels]

no effect of
- mounting at the tracking chamber
- glass windows

Next steps:

- alignment of two (and more) detection modules at pellet tracking section (requires new "target" holder)

- system test with two (and more) detection modules with pellet operation (requires sync/readout and pellet operation)

UPPSALA UNIVERSITET

Fontys University of Applied Sciences

Pellet operation at UU/TSL

Slightly disadvantageous situation:

- pellet operation involves running costs (almost no funding for pellet tracking activiities available)

- TSL is being decommissioned → UPTS will lose available infrastructure

The good news:

- successful application to UU Department of Physics and Astronomy Infrastructure Funding (≈15 kEUR/y for 4 years)

- allows to pursue JRA11-Cryojet project, upgrades at UPTS to replace TSL infrastructure, operation with pellets

UPPSALA
UNIVERSITET

Status of pellet tracking developments

Detection module alignment and installation procedure tested, fully documented

to be done: improved target holder for multi-level alignment

to be done: system test w.r.t temperature, mechanical shocks, vibrations

New readout hardware developed (ZynqBoard)

to be done: implement readout with ZynqBoard

UU Infrastructure funding secured for 4 years

prerequisite towards full mechanical/operational system test

Missing:

- full funding for complete system (cameras, lasers, mechanics, approx 20 + 40 kEUR for generator + dump)
- design of dump tracking section

UPPSALA UNIVERSITET