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Development of Pellet Target Tracking Systems in Uppsala

Main activities autumn 2010:

- Time and position correlation studies. Velocity measurements.

- Tracking section with two measurement levels for a prototype system at UPTS.

- Simulation studies.

- Design ideas for PANDA.

Goals for 2011 - 2014:

- Close to 100% efficiency pellet detection.

- Pellet track processing and optimization of pellet detection points.

- Multi-camera readout system.

- A tracking section for PANDA (tested at UPTS).

- Feasibility of laser-induced droplet production.

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Elin Hellbeck, Marek Jacewicz, Pawel Marciniewski
IFA & TSL, Uppsala University

Project supported by JCHP-FFE, EC FP7 and SRC

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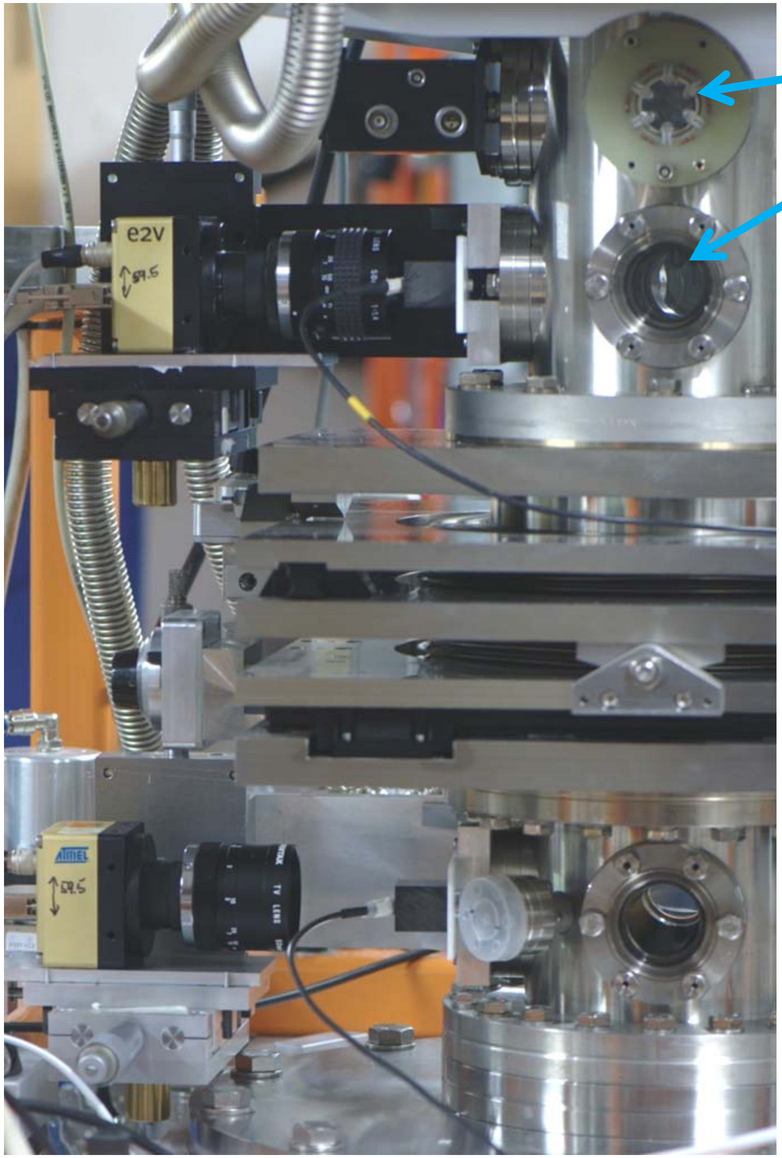
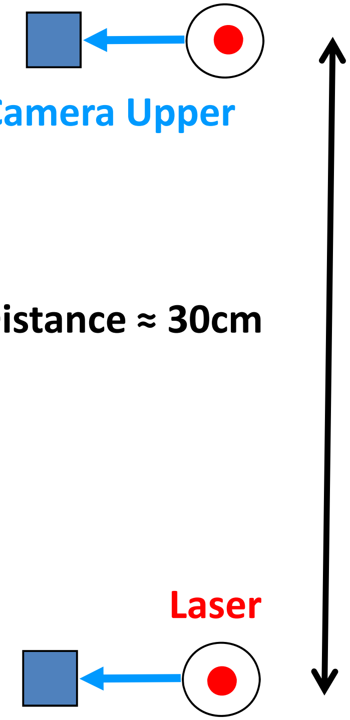
UPTS April/May 2010

Synchronized LS cameras at two levels





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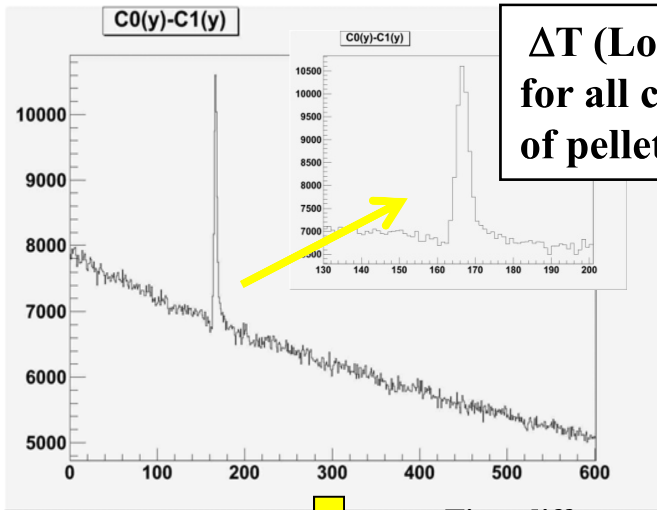
Pellet velocity estimate at UPTS May 2010

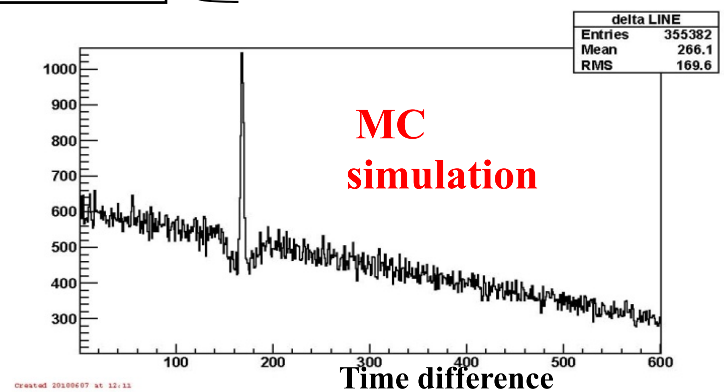
Studies of pellet signal correlations were used to get a hook on pellet velocity distributions …

ΔT (Lower-Upper) for all combinations of pellet time signals

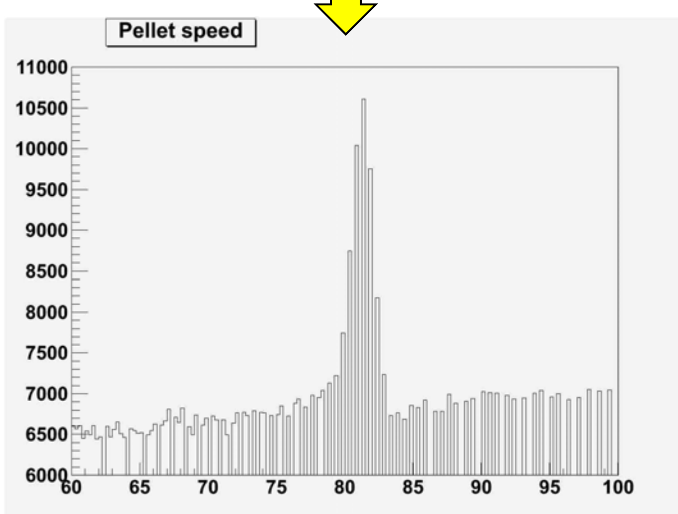
Pellet generation conditions
$f_{droplet} \approx$ 50kHz
$p(H_2) \approx$ 400mbar, p(droplet.ch.) $\approx$ 25mbar
droplet velocity 25 m/s
pellet diameter 20-30 micron (guess)



Time difference



Time difference



60m/s Velocity 100m/s

The good agreement with MC indicates that a "big" fraction of the pellets have a velocity v $\approx$ 80 m/s ……

with a small spread σ_v /v $\approx$ 1%.

Time and position correlation studies

Measurements at UPTS September 2010

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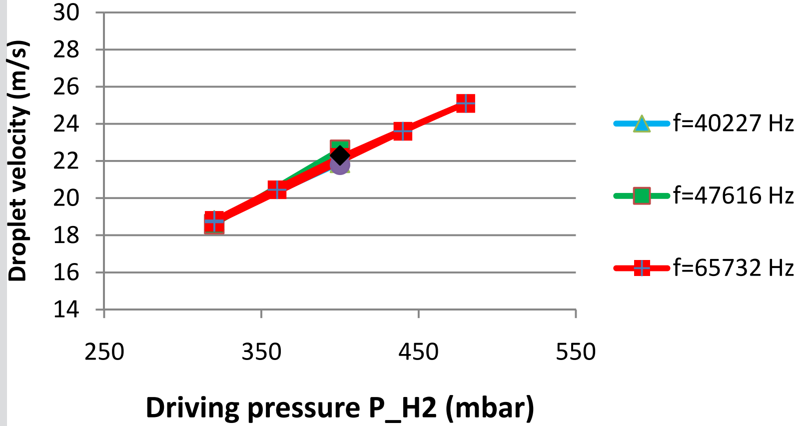
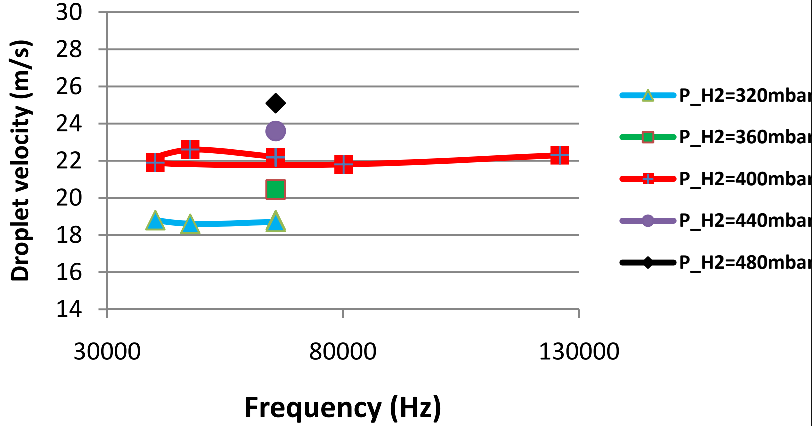
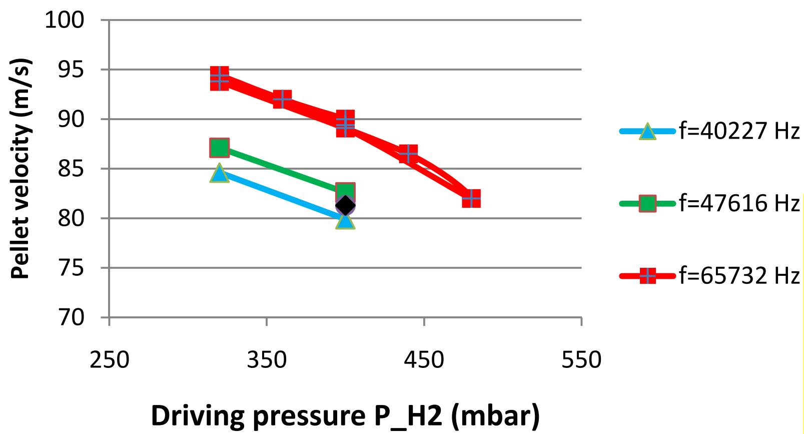
Droplet velocity vs driving pressure and generation frequency

Pellet generation conditions
p(droplet.ch.) ≈ 25mbar
pellet diameter 25-35 micron (guess)





Pellet velocity from LS-camera measurement



Higher driving pressure
⇒ faster (and bigger droplets)
⇒ slower pellets

$$\Delta\phi/\phi \approx 1\% \Leftrightarrow \sigma_v/v \approx 1.5\%$$

(at these conditions)

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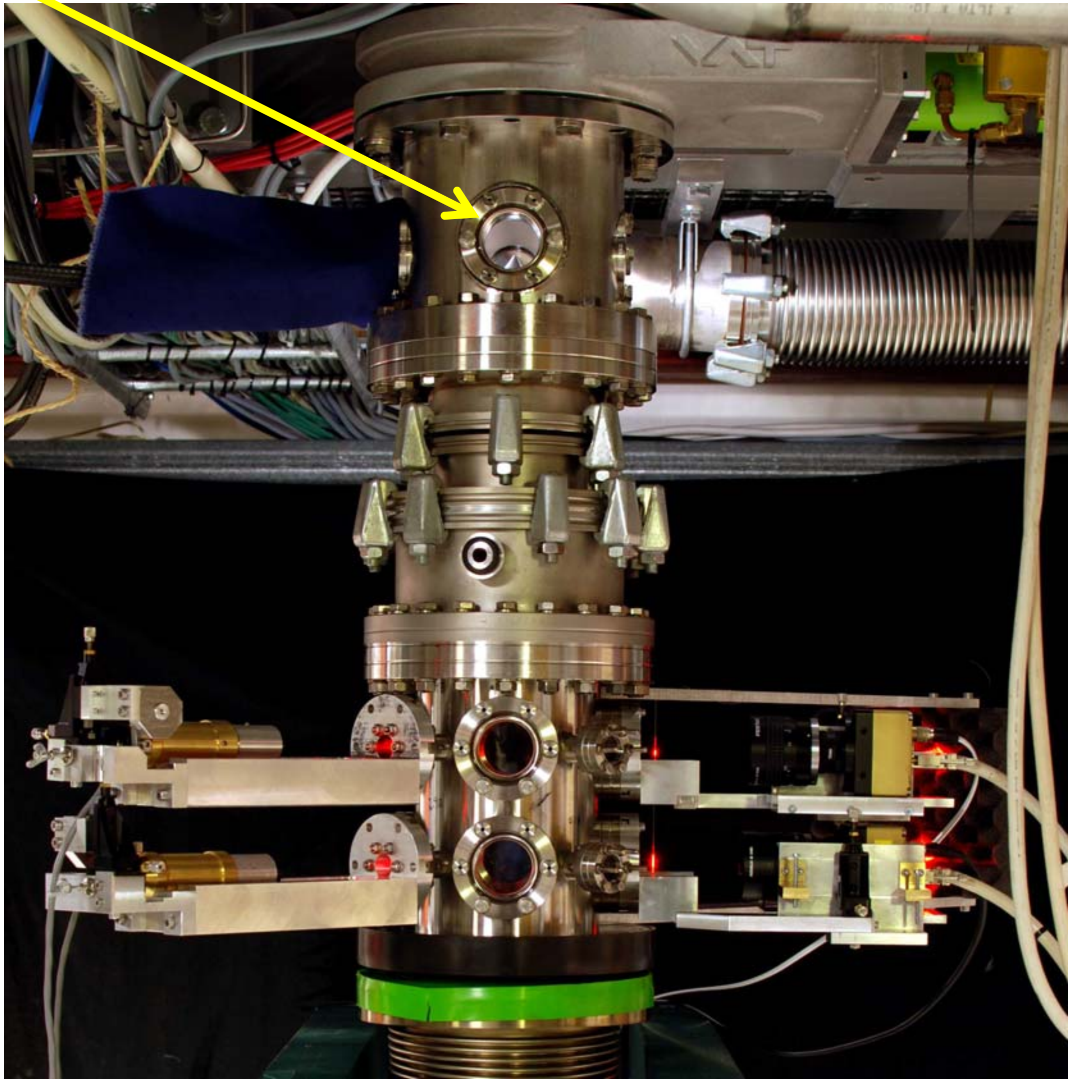
UPTS tracking section

Placed below a skimmer for possibility to reduce pellet rates to below 20 k/s, which allows tracking of individual pellets.

Tracking (i.e. measured pellet velocity and direction) can be checked by measurements one meter away at the existing levels at the pellet generator …
and by the well defined beam position at the VIC exit (2 m above).

UPTS bottom floor



The chamber is designed for measurements with 2-4 cameras at two levels separated by 80 mm.

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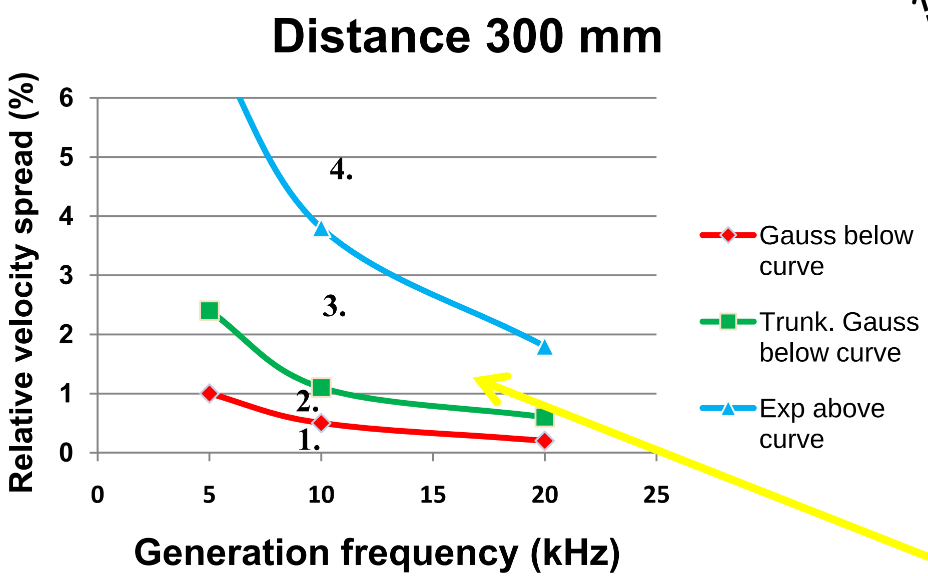
Time between pellets

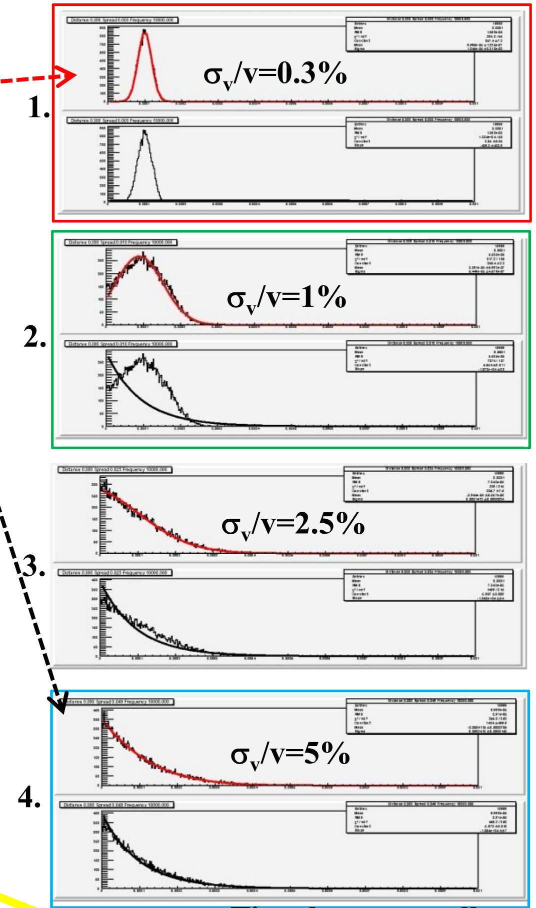
Simulation Studies for the Pellet Tracking System
Pascal Scheffels (Erasmus project report)

Case:

1) Short distance / low vel. spread **Gaussian !**
2) Longer dist. / higher vel. spread **Gauss (trunkated)**
3) Longer dist. / higher vel. spread **Gauss (tail) / Exp ?**
4) Long dist. / high vel. spread **Gauss (tail) / Exp !**



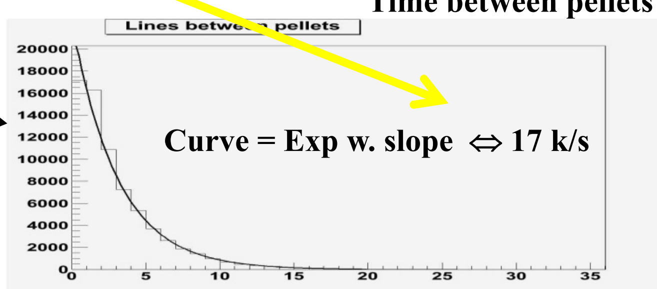
Gauss upper and Exp lower curve



Time between pellets

UPTS measurement

300 mm below VIC exit.
f≈40kHz, $p(H_2)$ ≈ 400mbar, p(DC) ≈ 25mbar



Time between pellets

(total loss = camera deadtime + illumination ineff. + lost pellets)

Panda CM
GSI 2010-11-29
Hans Calén

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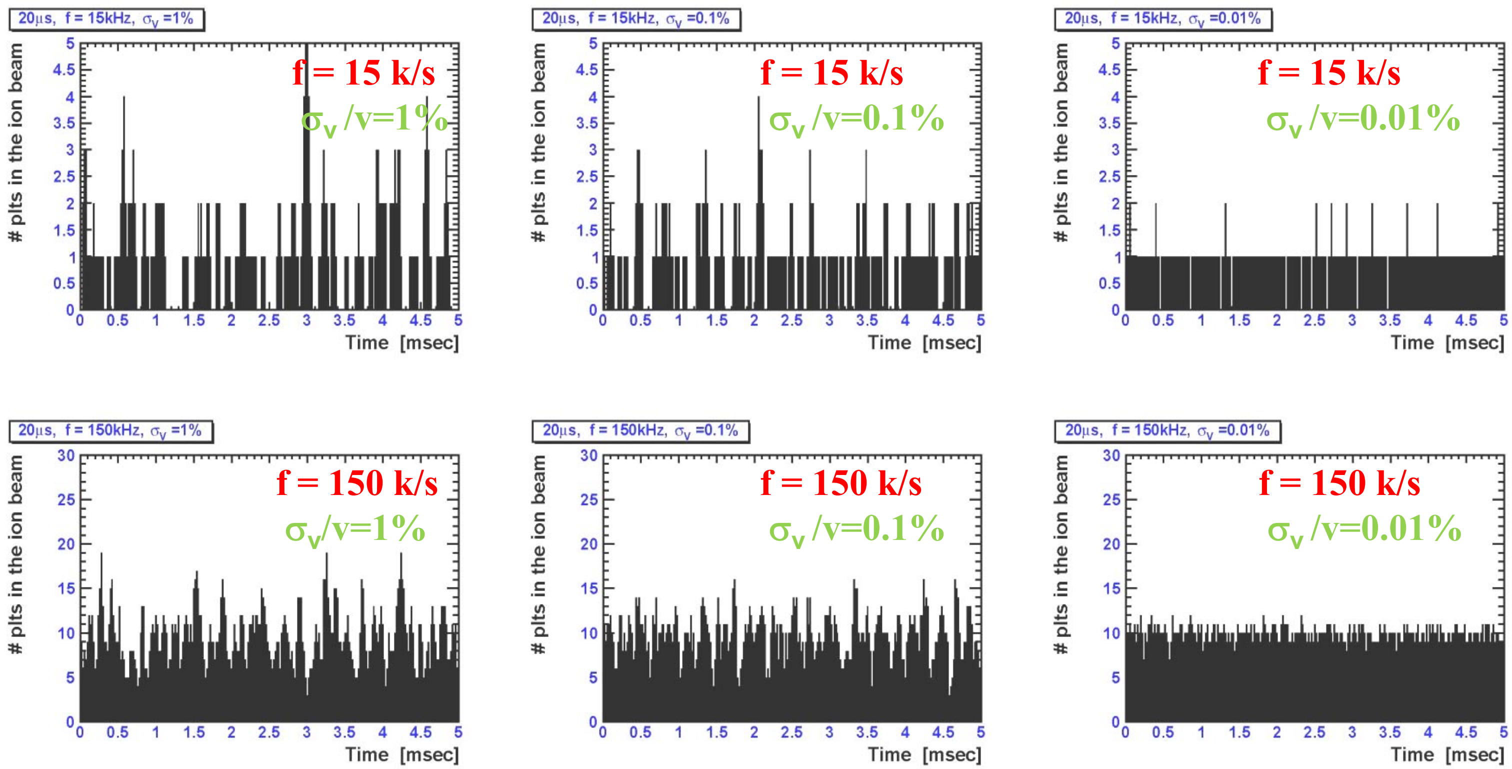
Target thickness fluctuations

Number of pellets in accelerator beam vs time (during 5 ms) for pellet occurence frequencies, 15 & 150 k/s, and different pellet velocity spreads:

MC results for pellet v=60 m/s and accelerator beam Φ=4 mm. (Pellet crossing duration ≈70 μs) .



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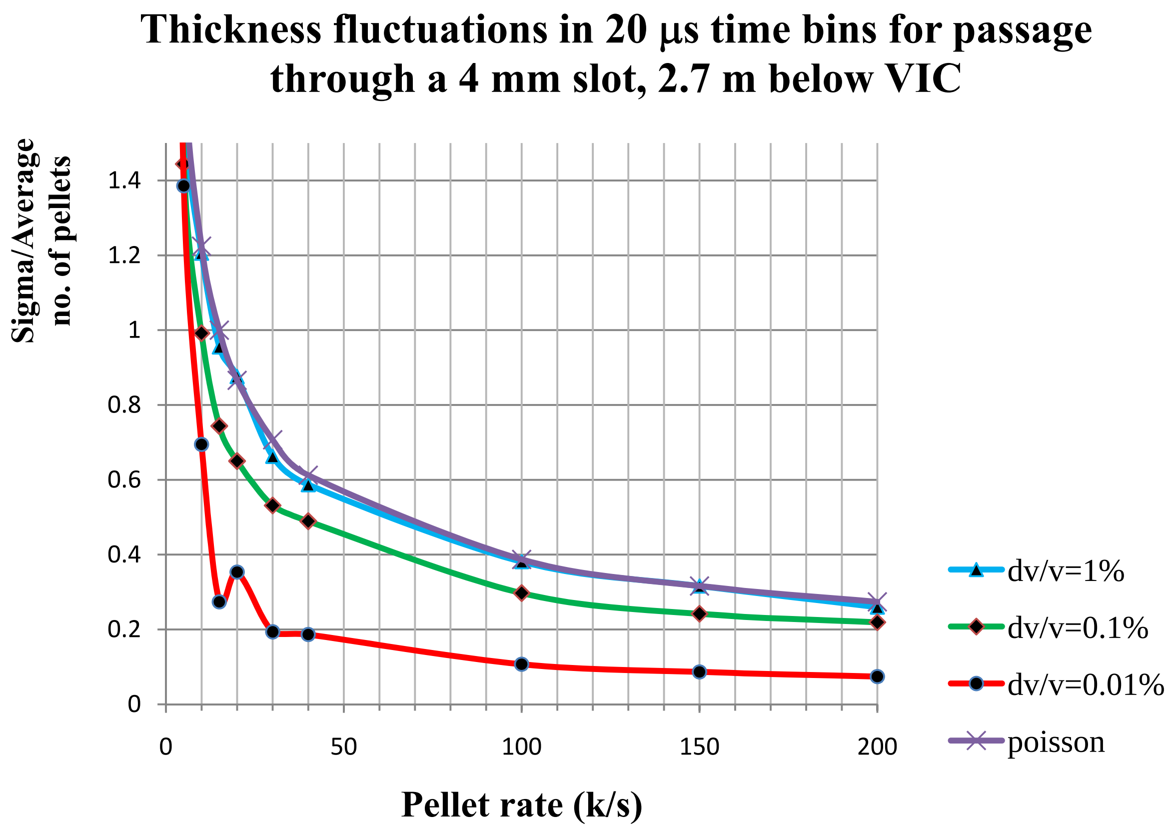
Target thickness fluctuations

Number of pellets in ion beam vs pellet generation frequency

MC results for pellet v=60 m/s and ion beam Φ=4 mm.



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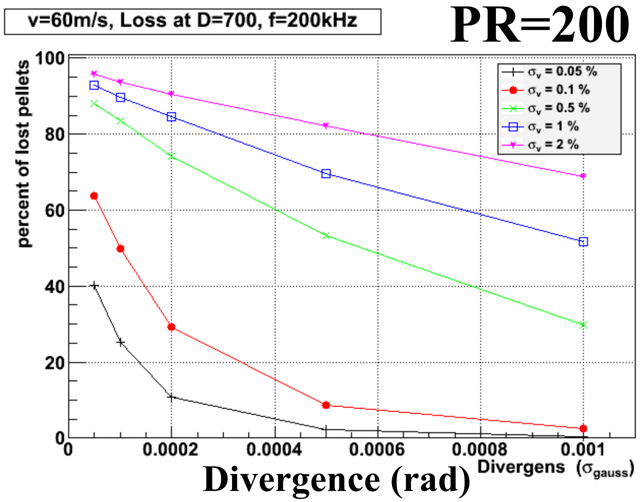
Intra-beam pellet-pellet collisions

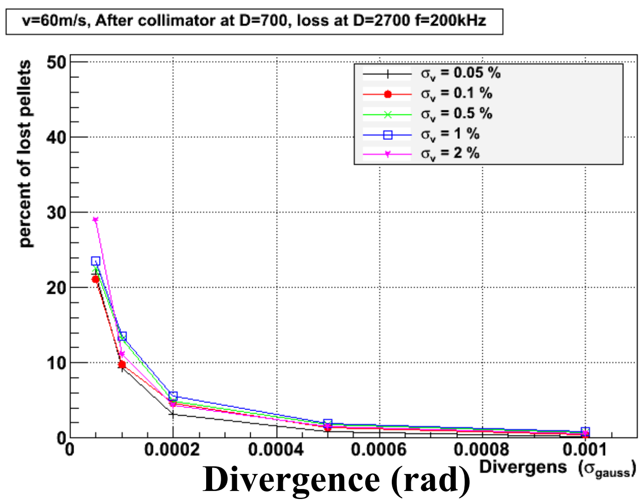
Simulation studies

Fraction of "primary" pellets that collides vs beam divergence for different velocity spreads σ_v /v = 0.05, 0.1, 0.5, 1, 2 %.

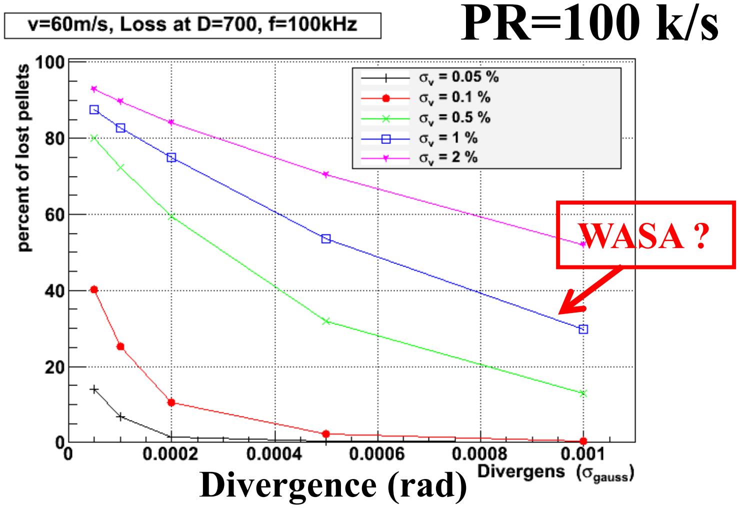
0 - 700mm | **700 – 2700 mm**

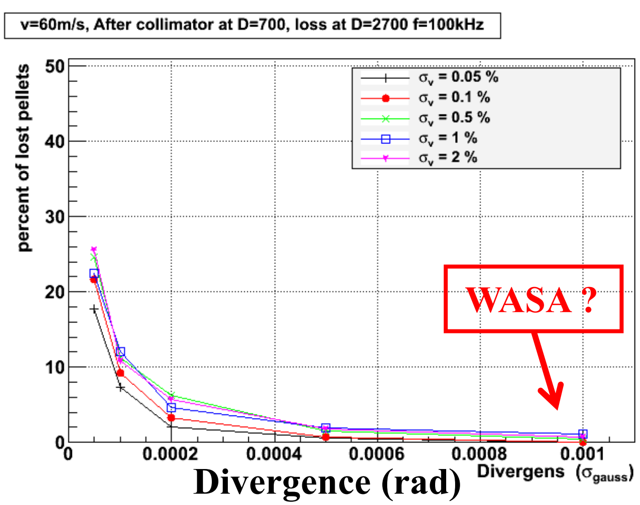
PR=200 k/s





PR=100 k/s



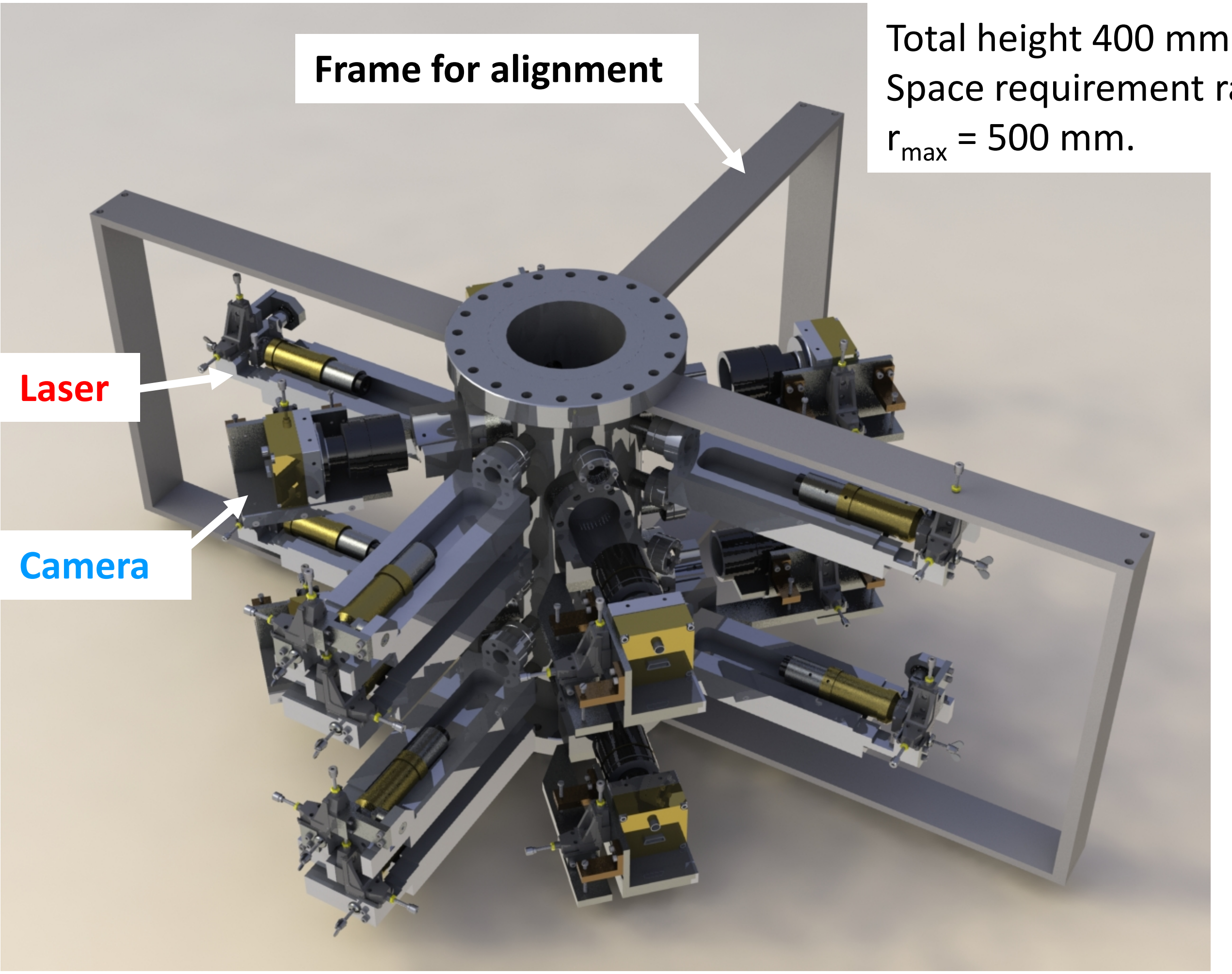


PTR for PANDA

Planned activities: Multi-camera system

Design idea: Multi-camera pellet tracking section for determination of velocity and 3-d direction for individual pellets

Four levels for measurements, each with two lasers and two LS-cameras.
- Distance for velocity determination 60 – 260 mm.
- Distance for direction determination 200 mm (…internally… one can use VIC exit also).



Total height 400 mm.
Space requirement radially:
r_{max} = 500 mm.

Design Masih Noor, CAI (Center for Accelerator and Instrument Development), Uppsala University

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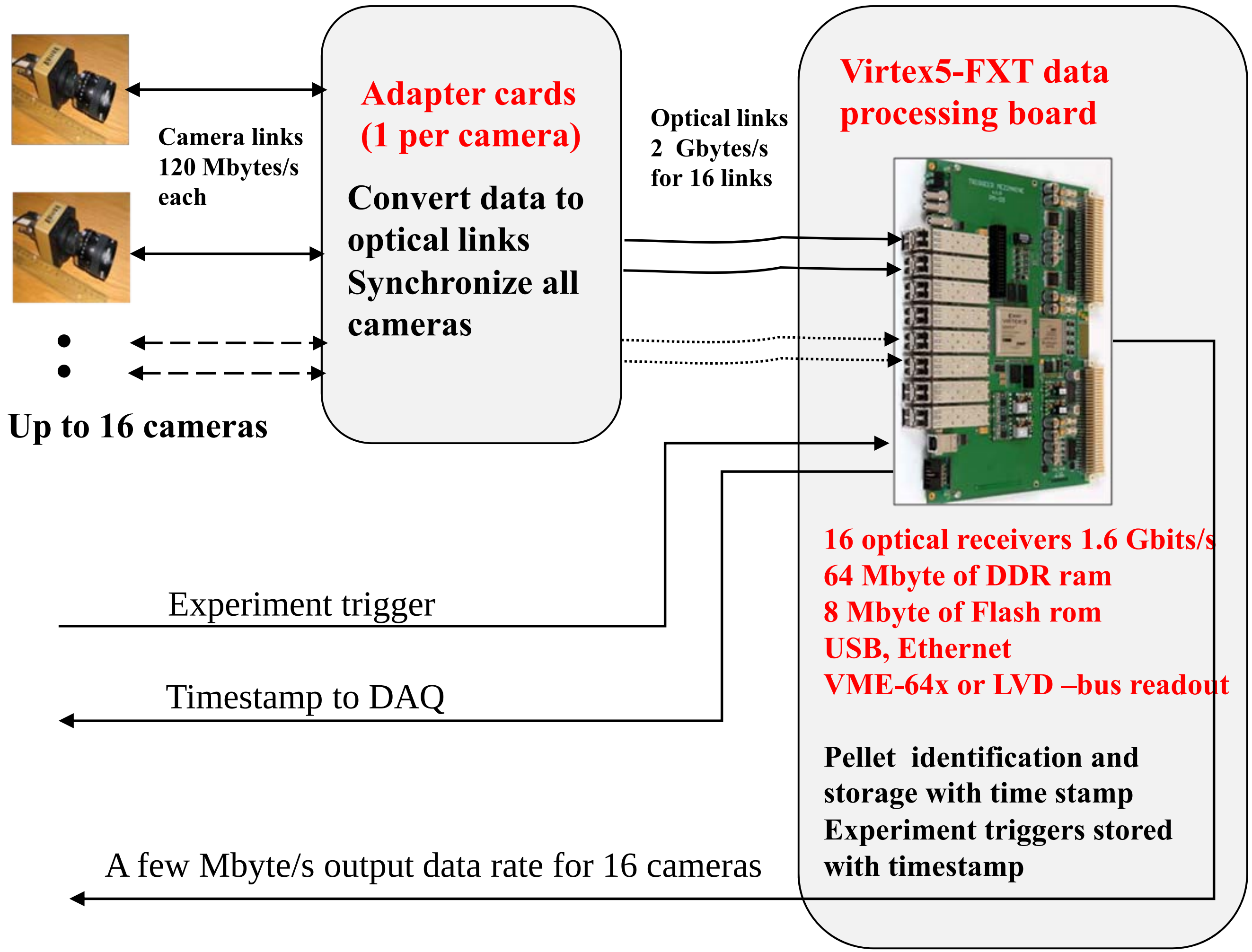
Multi camera readout and synchronization



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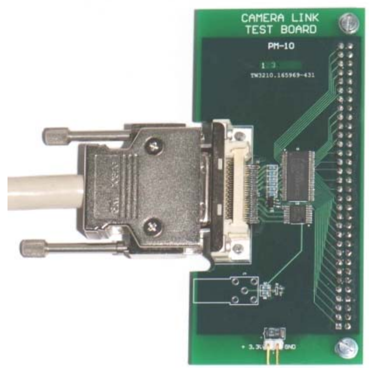
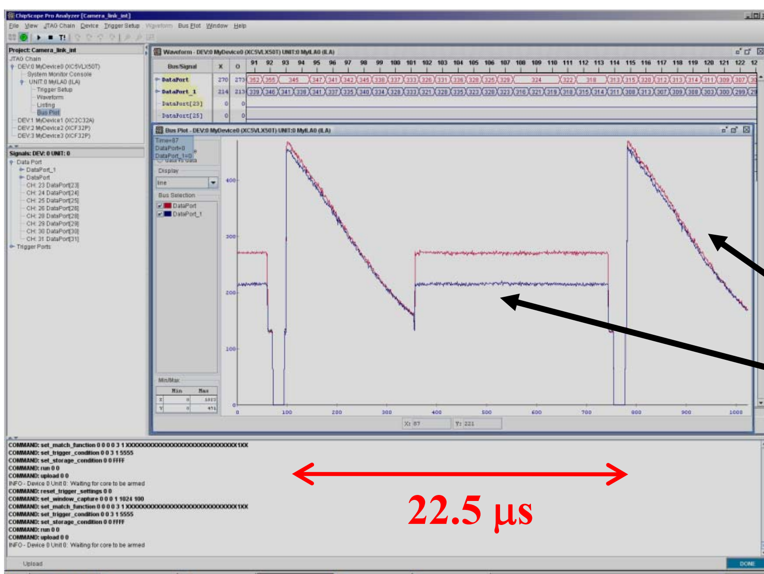
Multi camera readout development prestudies



CameraLink bus
Signal converter card
"Serial" ⇒ parallel bus

Virtex-5 development board
Study of camera signal behavior



22.5 µs

Pixel signal monitoring
for 22.5 µs camera cycle
Signal amplitudes 2 x 256 pixels
Readout idle time (exposure)

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GSI 2010-11-29
Hans Calén

Status and Conclusions November 2010

Synchronized operation with two cameras works !

Illumination/detection conditions good … but should be improved

Desired transverse (x,z) position resolution reachable with present cameras. Solution for good time ($\Rightarrow$ y position) resolution and high camera efficiency exists

Clear indication that pellet velocity spread $\sigma_v / v \leq 1\%$ can be obtained

$\Rightarrow$ Effective pellet tracking possible !!!

Preparation of a first prototype PTR system for UPTS in progress:

- **Tracking chamber with two levels of pellet detection**
- **2-3 LS-cameras with lasers**

Design & preparation of tracking systems with more LS-cameras.
A design idea of a system for PANDA exists $\Rightarrow$ TDR.
Preparing simulations for the design of a full scale system.
New readout system planned (prototype work)