Development of a pellet tracking system for PANDA and WASA

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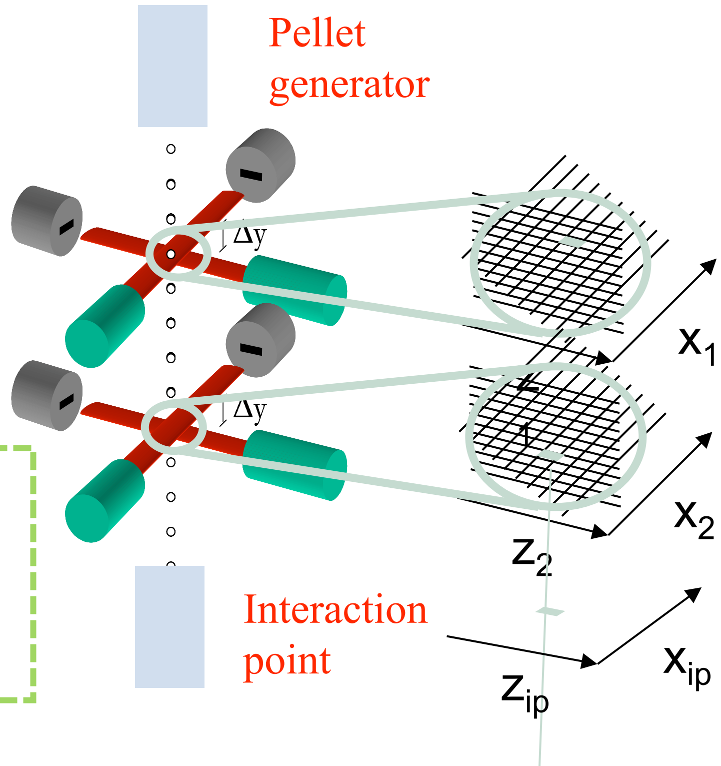
Goal: To know interaction point with a few 100 μm accuracy in 3d(xyz)
Method: **Track pellets !** (and synchronize with time of interaction)
Basis: Pellets Φ= 20-30 μm, v ≈ 70m /s, Δv/v = few %
Pellet stream Φ< 10 mm, intensity 10-20k plts/s
Possible pellet tracking detector positions 1.5-2 m from int. point
⇒ **Need:** Pellet detection accuracy ≤ 50 μm (xyz) and ~2 μs in time
at pellet generator (and maybe detectors also at pellet dump)

Idea:
- use **laser** and **line-scan** (linear CCD) **camera** for pellet detection.



Present main activities:

- Understand camera performance
- Get enough light yield from pellets
- Develop synchr. r/o for 2 cameras
- Design initial few-cameras system

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Nov 2009

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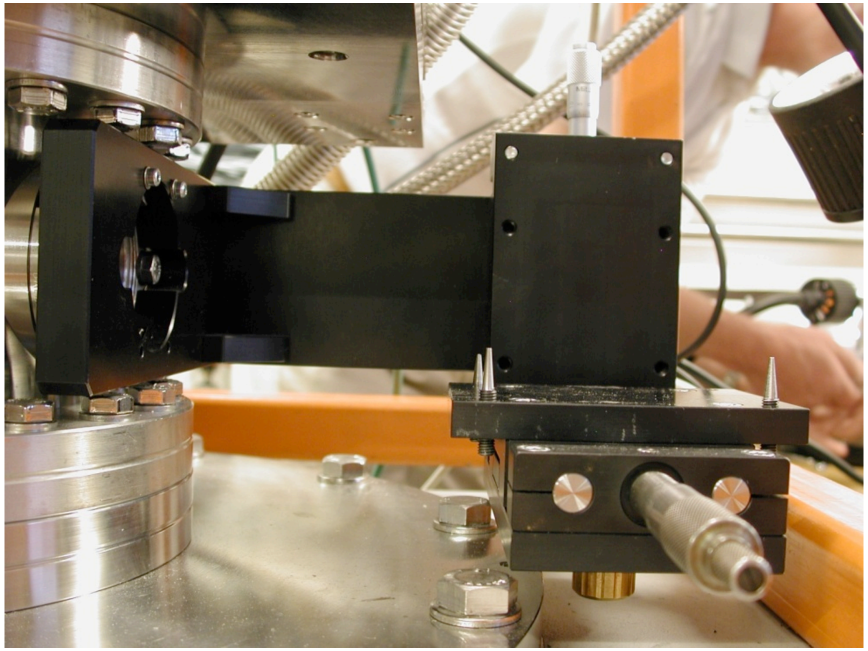
Camera Aviiva M2 CL
linear CCD
- 512 pixels 14 x 14 μm
- max line rate ~ 90 kHz ?
- lenses: f = 50 mm & 25 mm

Camera holder allowing for accurate alignment

Work distance = 240 mm
f = 50 mm lens ⇒
pxl ⇔ 40x40 μm
(total coverage +/- 8 mm)
DOF of a few mm



f=25 mm lens ⇒
pxl ⇔ 100x100 μm
(total coverage +/- 20 mm)

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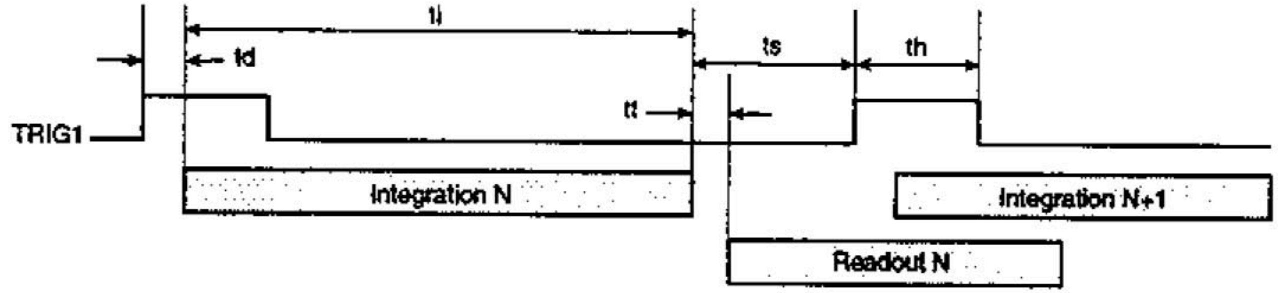
CCD camera shot cycle

- integration time >9 μs
- r/o time ~ 9 μs
- dead time between integration and r/o ~ 1 μs
- dead time between integrations $\sim$ 4 μs

⇒ **microscale inefficiencies**

Figure 3. Timing Diagram



AViiVA M2 CL

2160B–IMAGE–04/03

- Improper operation for shot cycles shorter than $\sim$14 μs (>72 kHz)
- Interference effects if integration and r/o overlaps

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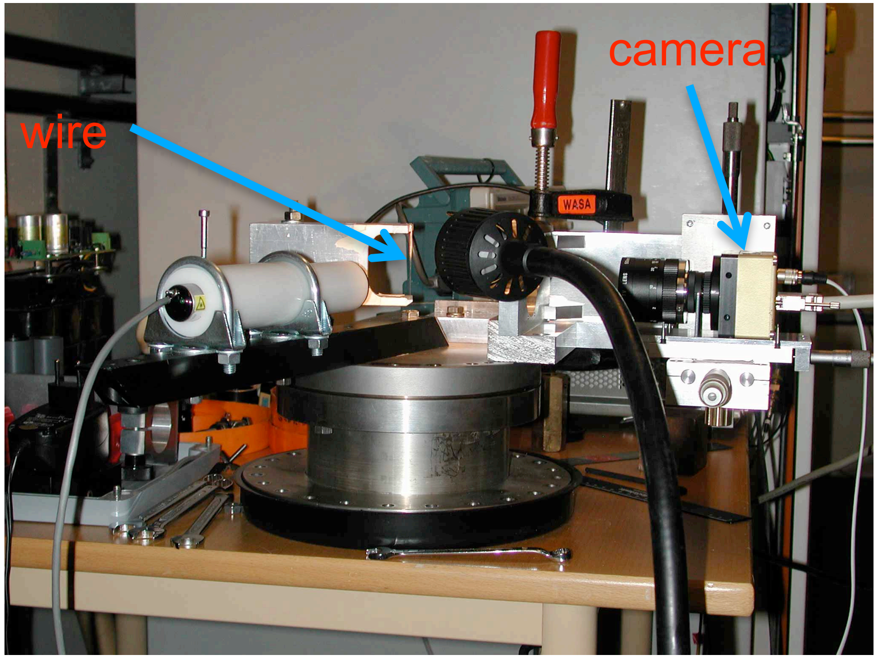
Camera tests with thin wire(s) illuminated by **LED** powered by pulse generator

Used for check of camera performance for different cycle and integration times and different LED pulse lengths, amplitudes and frequencies.



- Pxl pedestal widths and signal resolution (~10 for 12 bit r/o)
- Signal stability
- Linearity vs LED pulse length (ok) and amplitude (?)
- Splitting of signals between lines
- and between pxls (x-talk)
- Interference effects in camera cycle

The same setup but with an evenly illuminated white screen is used to make (check) calibration for the individual pixels.

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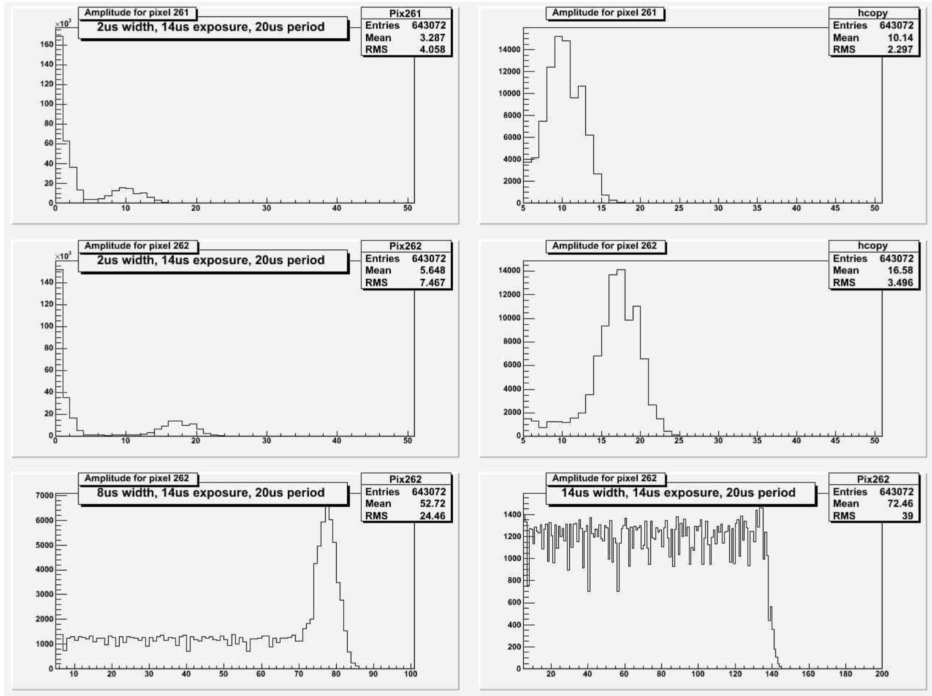
Camera tests with LED

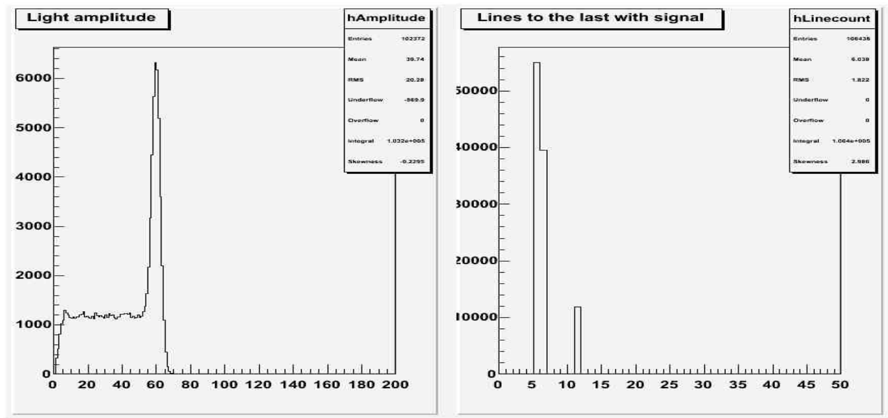
Some pxl signal amplitudes for different cases

Max signal peak seen if LED pulse length different from integration time.
No peak if they are equal (lower right plot).



Expectation from simulation:

- Signal amplitude
- Number of lines since last signal



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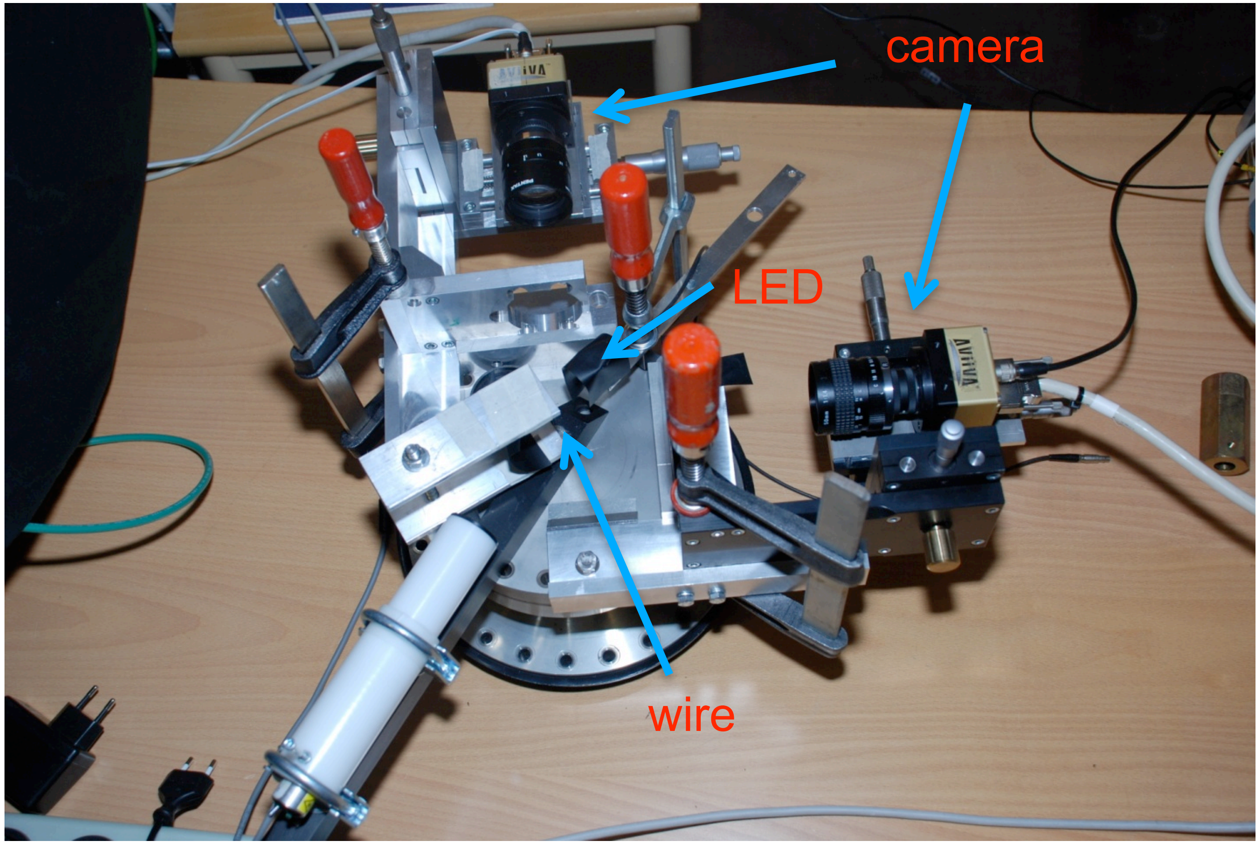
Camera synchronization tests with thin wire illuminated by **LED** powered by pulse generator



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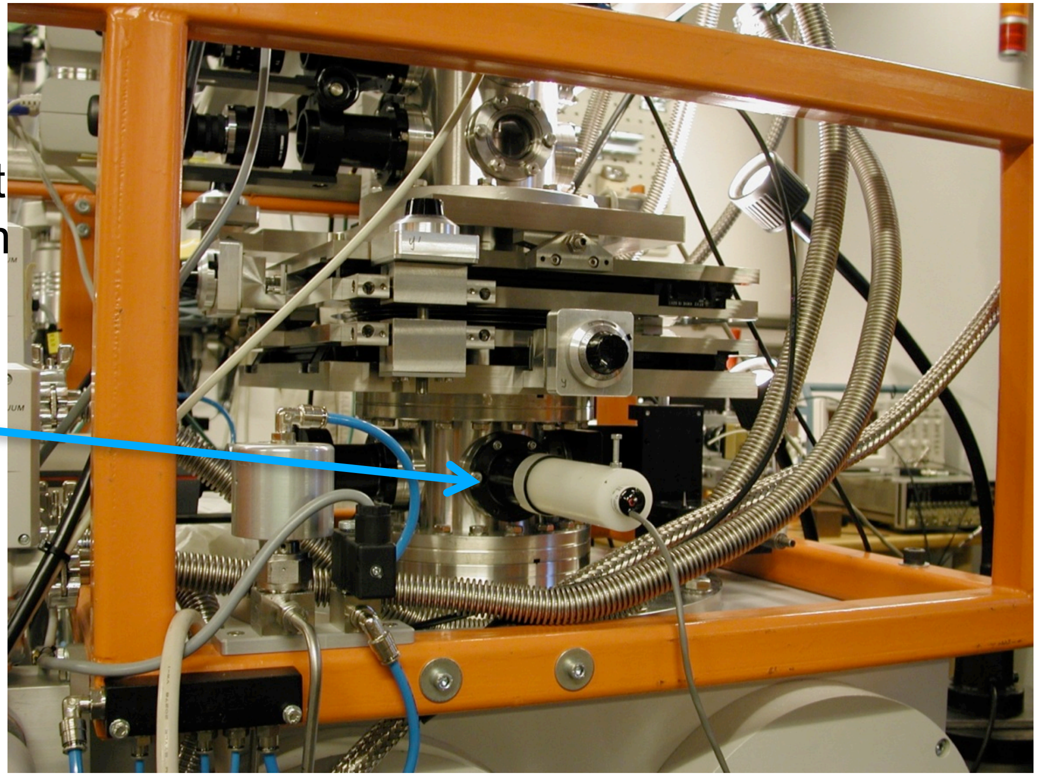
Laser beam
50 µm (y) x 30 mm (x) at
work distance = 185 mm

Laser/holder

Lasiris MFL 35/26 mW
SNF 50/37 mW



Pellets with v ~70 m/s ⇒1 µs light pulse in 50 µm laser beam

…. gave too low signals for fully efficient detection ….

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Efficient tracking requires that the signals from (all) individual pellets should be clearly separable from background !

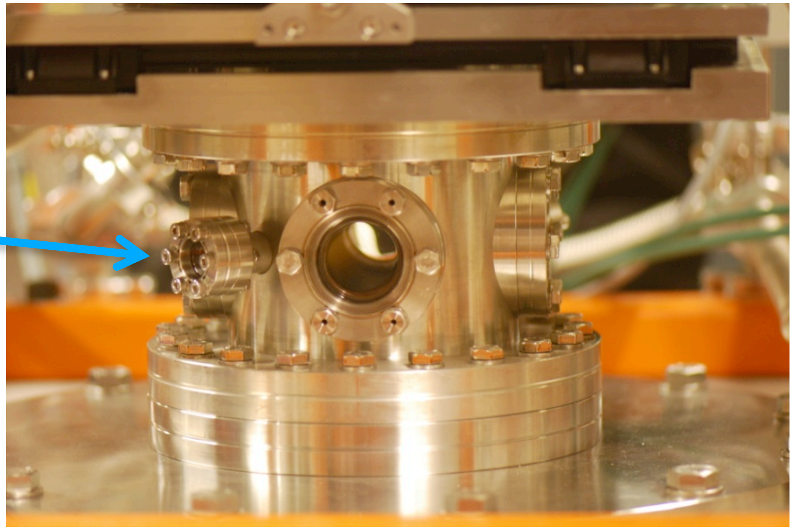
Need for improvements:

- **Longer light pulses.** Decrease camera magnification and increase laser profile. Worsens time resolution …

- **More intense laser.** Didn't find so far …

- **Find better illumination conditions.** A 45 degree geometry seems promising !

New ports for laser



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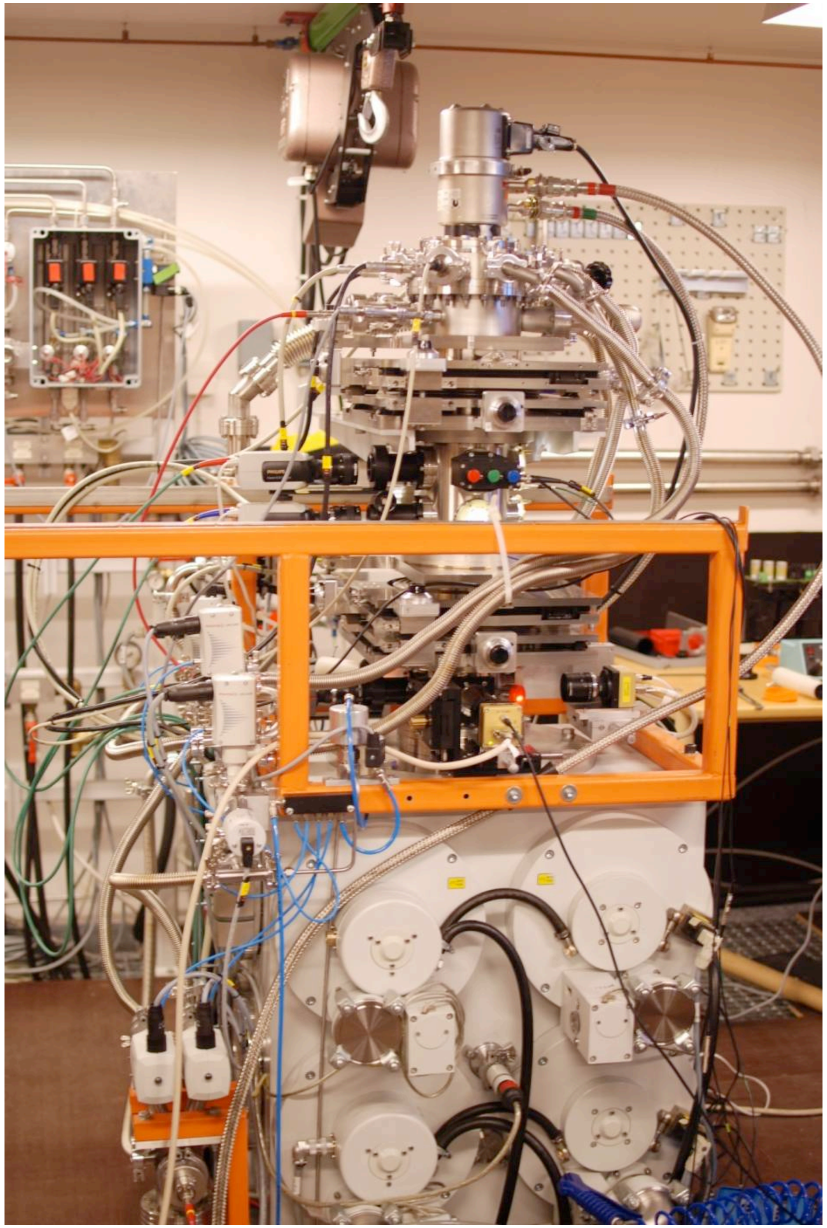
UPTS November 2009



First tests with pellets and two synchronized cameras

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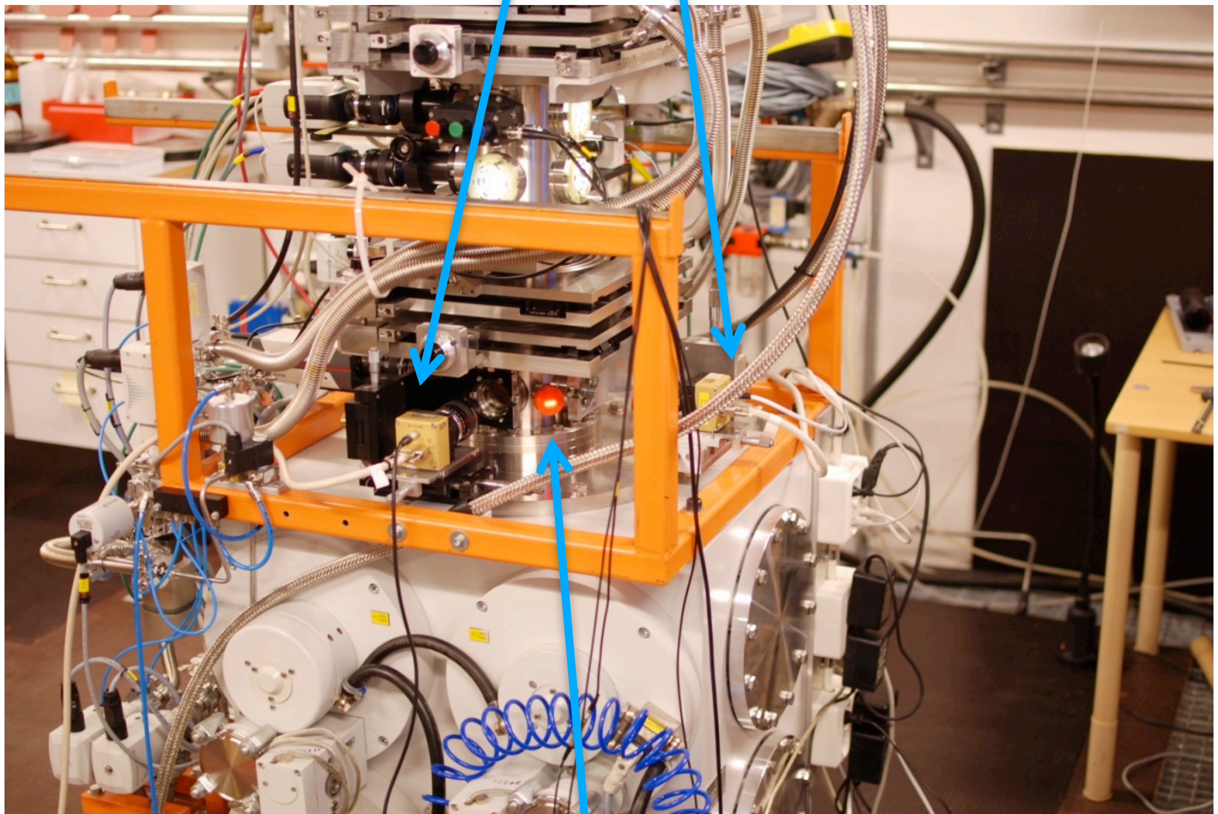
45 degree illumination geometry



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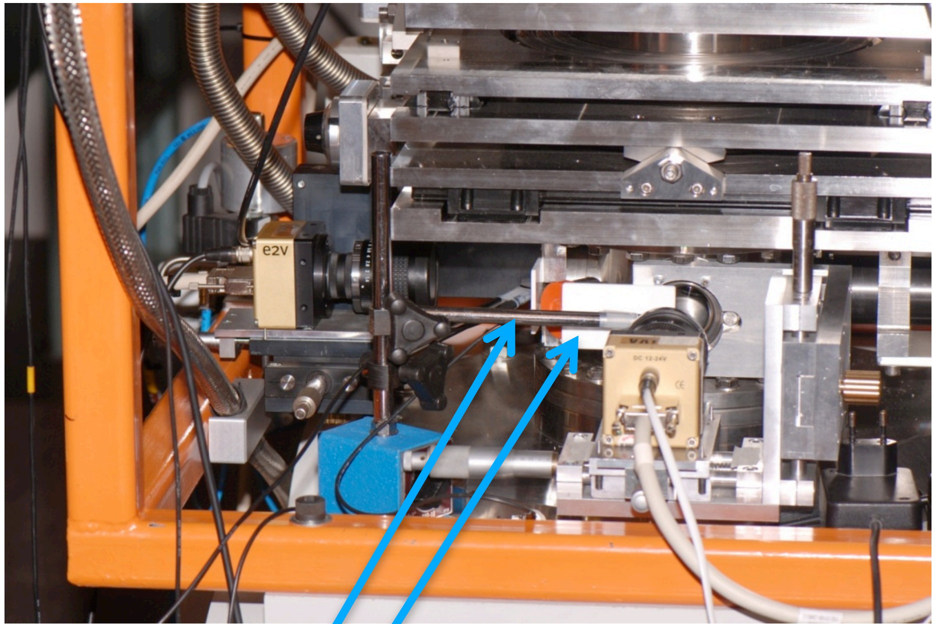
How to control camera synchronization ?



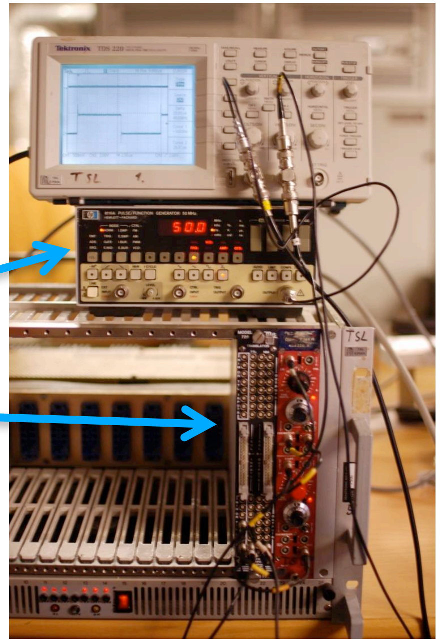
An idea is to use synchronized LEDs providing short light signals with low frequency …
But where to place the LEDs ?

Seems promising to have illuminated white screens placed at the vacuum window and at the edge of the field of sight of the cameras. (Means also very out of focus).

Pulse generators:

for LEDs

for Camera cycle



Status, plans, goals, resourses: November 09

Status

Reasonable understanding of LS-camera operation.
Pxl signal calibration procedure.
Synchronized r/o of 2 LS-cameras.
Improving illumination of the pellets.
Simulation studies of initial few-cameras system.
Continued basic performance studies/optimization.

Plan 2010

Improve LS-camera performance
Design few-cameras tracking system.
Prepare initial tracking system based on 2-4 LS-cameras.

Goal 2011-12

Full performance simulations of possible tracking system configurations and algorithms using realistic pellet stream parameters. Design full scale system.
Mechanics, detectors, lasers, readout, software
Prototype ….

Personnel: Kjell Fransson (researcher)
Carl-Johan Fridén (engineer 10%)
Elin Hellbeck (engineer 30%)
Pascal Scheffels (Erasmus student – June 2010)
Hans Calén (researcher)
+ support from workshops in Uppsala and Jülich

Financing: EU FP7, COSY FFE, SRC

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Project plan: Tasks and schedule

2008-12-11 hc

1. Pellet TRacking (PTR) system

a) **Pellet detection. Optimize laser and optical performance (UPTS)**

b) **Prepare mechanics for initial system of 2 LS-cameras and laser**

c) **Design (and simulation) study of initial tracking system**

d) **Prepare system for triggering, synchronization and readout of the 2 LS-cameras**

e) **Test and tune operation of system of 2 LS-cameras with pellets (UPTS, WASA)**

f) **Measure pellet stream parameters (UPTS)**

g) **Make performance simulations of possible tracking system configurations and algorithms using realistic pellet stream parameters**

h) **Prepare a PTR chamber to be placed below the pellet stream collimator (UPTS)**

i) **Tune operation with realistic pellet stream (UPTS, WASA)**

j) **Design full scale system. Mechanics, detectors, lasers, readout, software**

2. Optimization of pellet stream at UPTS

a) **Droplet generation**

b) **Vacuum injection**

c) **Collimation, dumping**

Nov 09

(high priority)
Ok …
Ok
In progress
In preparation
UPTS
Partly done
Not started

Partly done
Not started
Not started
(lower priority)
In progress
In progress
Not started

Time table	1.a	1.b	1.c	1.d	1.e	1.f	1.g	1.h	1.i	1.j		2.a	2.b	2.c	
Spring 09	X	X	X	X	X	X						X	X		
Fall 09	X		**m**	X	X	X	X	X	X			X	X	X	
Spring 10				X	X	(x)	X	X	X			(x)	(x)	(x)	
Fall 10				**m**	**m**	(x)	X		X			(x)	(x)	(x)	
Spring 11						(x)			X	X		(x)	(x)	(x)	
Fall 11									X	X		(x)	(x)	(x)	
Spring 12									X	X					
Fall 12										X					

m = FP7 target project milestone
(x) = depends on future of TSL (runs on 1-year contracts)

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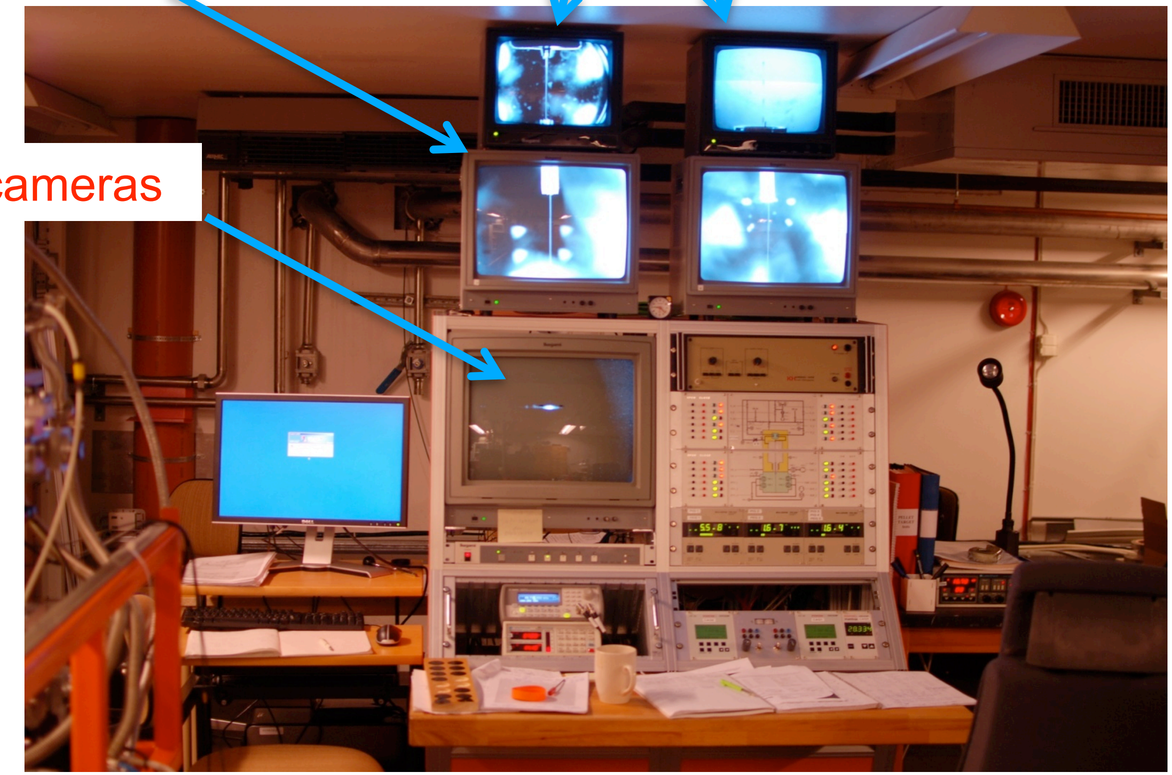
UPTS control

CCD camera monitors

Droplet chamber

Vacuum injection
capillary exit

At LS-cameras



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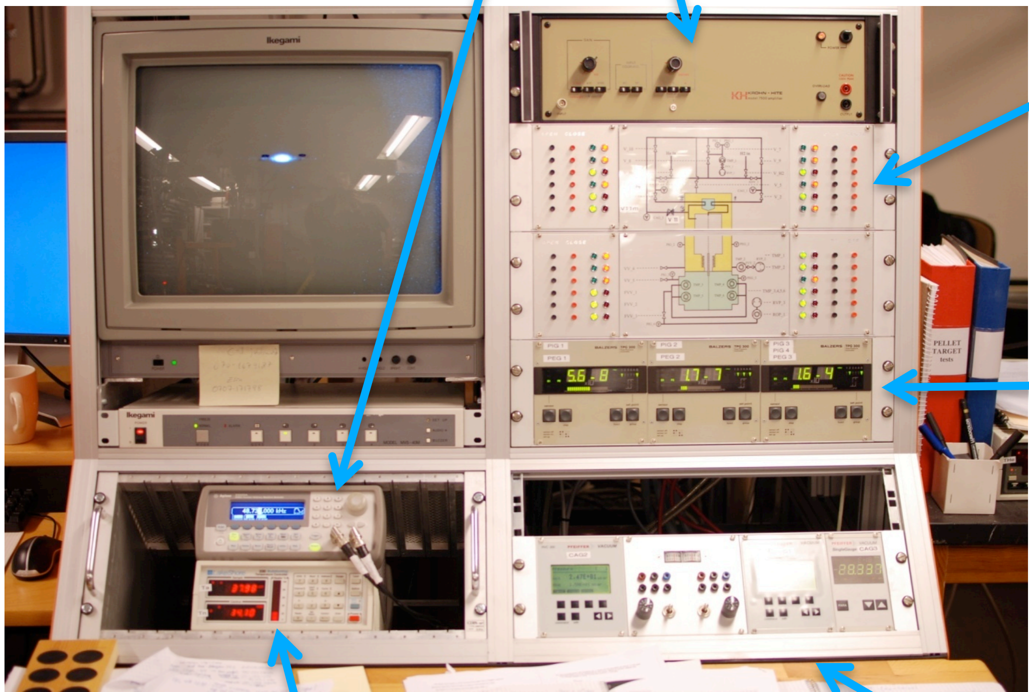
UPTS control

Frequency generator and amplifier for the transducer



Control of valves and pumps

Vacuum display

Temperature control

Control of hydrogen and carrier gas