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Status of Uppsala target activities

- **Pellet track processing and optimization of pellet detection ...** *PhD thesis, A. Pyszniak, Jan/Mar15. (New_PANDA_Website Documents)*
- **High efficiency pellet detection** *Test bench and pellet studies*
- **Pictures from target show at TSL during PANDA CM in June.**
- **Multi-camera readout system.** *UPTS tests*

UPPSALA team (spring 2015)

Senior researchers:	Hans Calén, Kjell Fransson, Pawel Marciniewski
PhD (student):	Andrzej Pyszniak (quitted in June)
Project workers:	Sanne Torgersen, Adéle Wallin
Engineers:	Carl-Johan Fridén, Elin Hellbeck, Dan Wessman

Time resolution, efficiency & measurement dead time

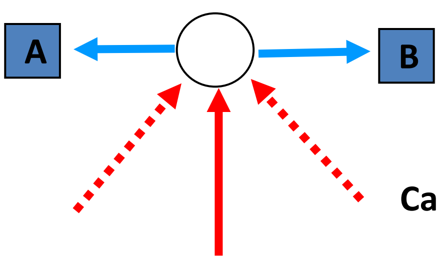
Two cameras (SM2, 2 tap) with 12 μs period time, synchronized with cycles shifted half a period time, measuring the same coordinate at the same (vertical) level gives a time bin of ≈ 3 μs (σ ≈ 0.9 μs).

In this case, the upper tracking section at the generator alone, gives an interaction position vertical (y) coordinate σ ≈ 0.8 mm ….

… and by including the measurement information from the lower tracking section at the dump, a vertical (y) coordinate σ ≤ 0.2 mm is obtained.

With this two-camera arrangement one gets also rid of inefficiencies due to the camera cycle dead times.

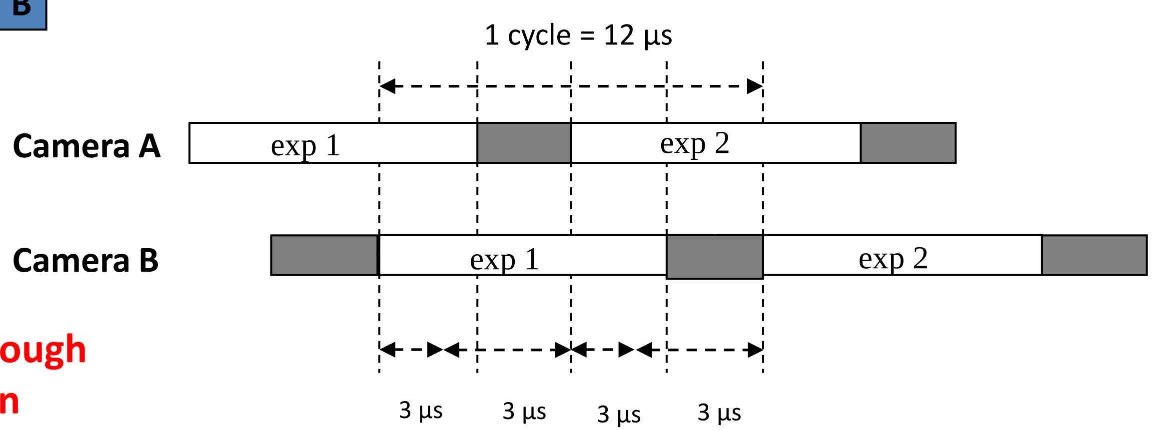
Cameras



Laser(s)

… strong / many enough to give full detection possibility.

Camera exposure cycles



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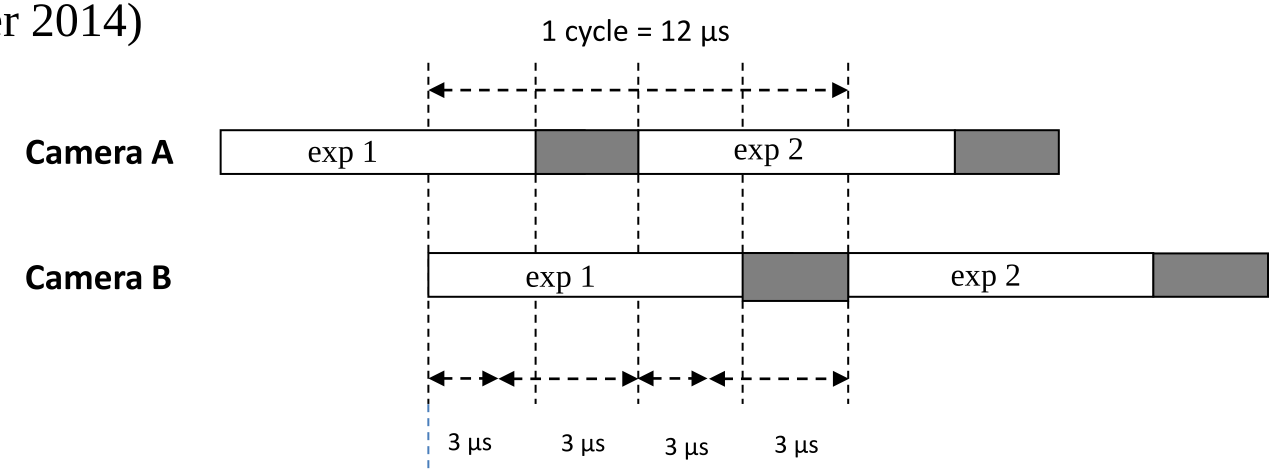
High efficiency pellet detection

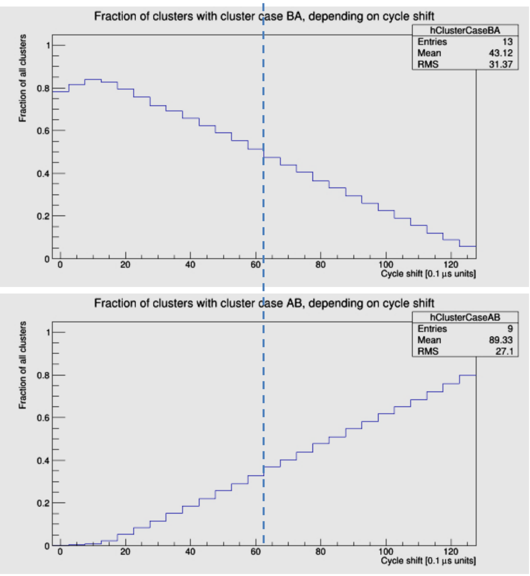
Example studies of shifted cycle with the CamControl r/o system at UPTS with pellets (December 2014)



Fraction of pellet measurements (0-100%)

vs

CamB delay



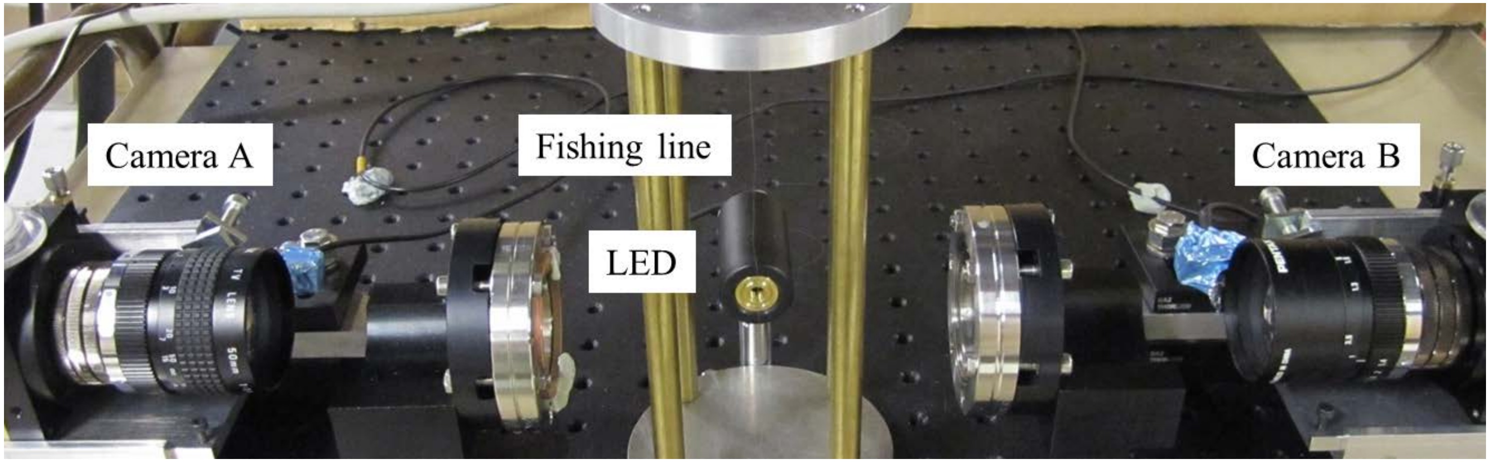
CamA_exp1 + CamB_exp1

CamA_exp2 + CamB_exp1

CamB delay (0-12 μs)

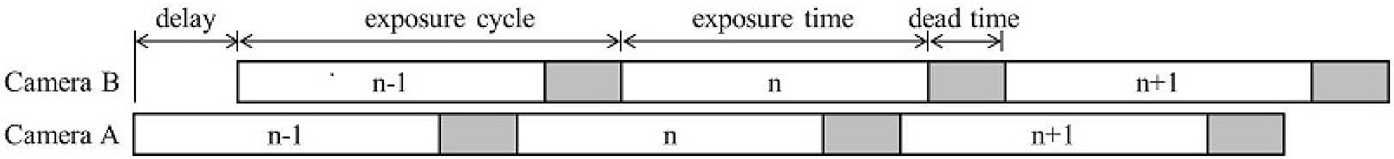
Time resolution & measurement dead time

Test bench setup including camera holders with reference LEDs and vacuum windows .
Two cameras look on a fishing-line illuminated by an LED or a pulsed STR laser.



(Erasmus work M. Kümmel 2013)

Visualization of two synchronized cameras with a time shift.



High efficiency pellet detection

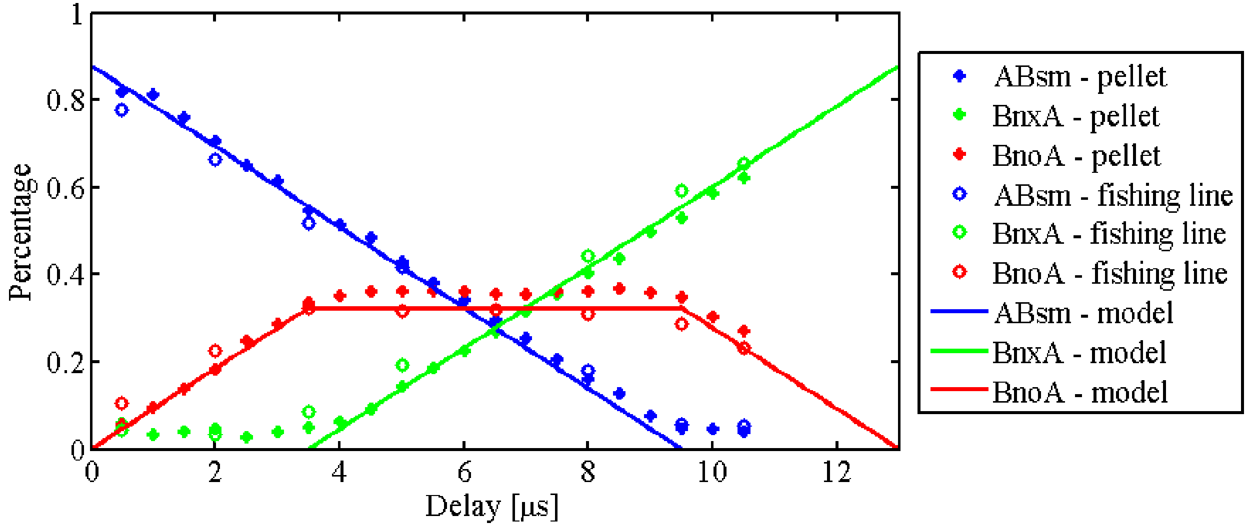
Project work Spring 2015

An Investigation of Improvement of Pellet Tracking System

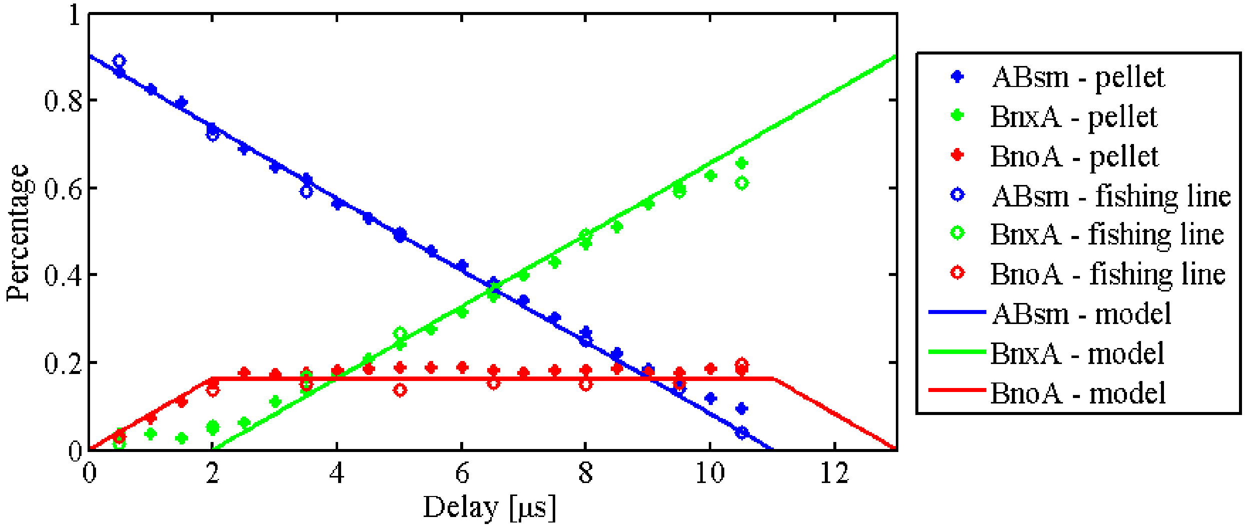
Adéle Wallin and Sanne Torgersen

Test bench "simulations" involving eg exposure cycle, pulse length, focusing, laser power ..

Cycle: 13 µs Exposure: 7 µs Pulse laser: 2.5 µs Pulse calc: 3 µs Min.signal: 0.25 µs

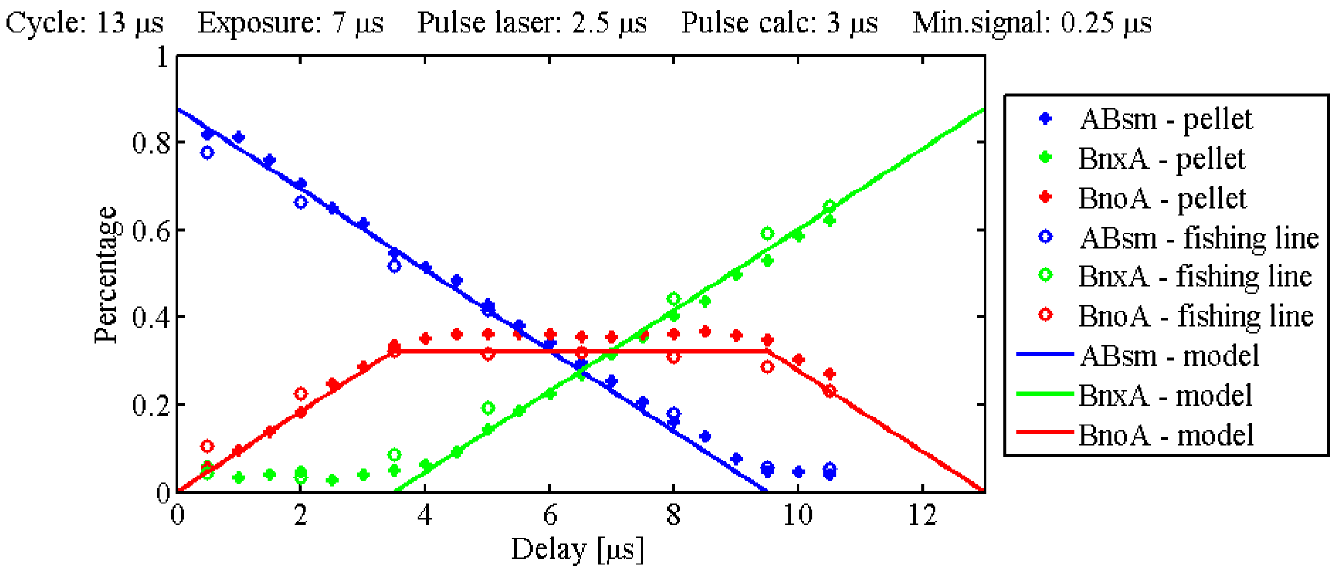


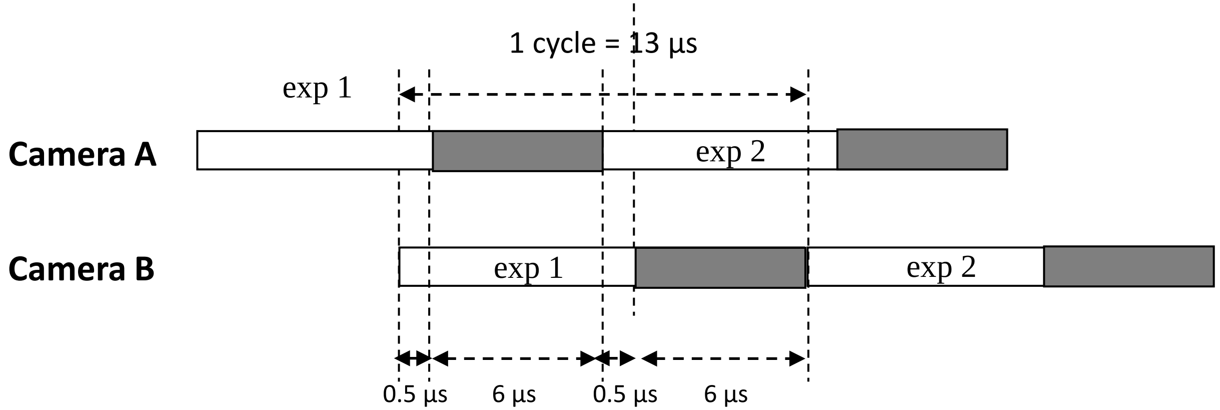
Cycle: 13 µs Exposure: 8.5 µs Pulse laser: 2.5 µs Pulse calc: 3 µs Min.signal: 0.25 µs



From a pellet crossing the line of sight of an LS-camera we expect a 1-2 µs long light signal in the camera..... but to reproduce the pellet detection data a 2.5 µs laser pulse in the test bench or a 3 pulse in the MC-model is needed.

→ For 13 µs cycle, a deadtime ≈ 5 µs gives the best time resolution .....!





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Target show at TSL during PANDA CM in June.

- UPTS in operation. Visual inspection of pellets and pellet stream ....
- UPTS pellet tracking development setup
- Multi-camera readout prototype system
  (first tests of a setup with 4-6 cameras in a real pellet run).
- UPTS pellet generator
- PANDA yoke pit model.
- Prototype of integrated PTR measurement module

Guides: Hans Calén, Kjell Fransson (PTR), Pawel Marciniewski (PTR), Andrzej Pyszniak (PTR), Elin Hellbeck (Pellet generator)

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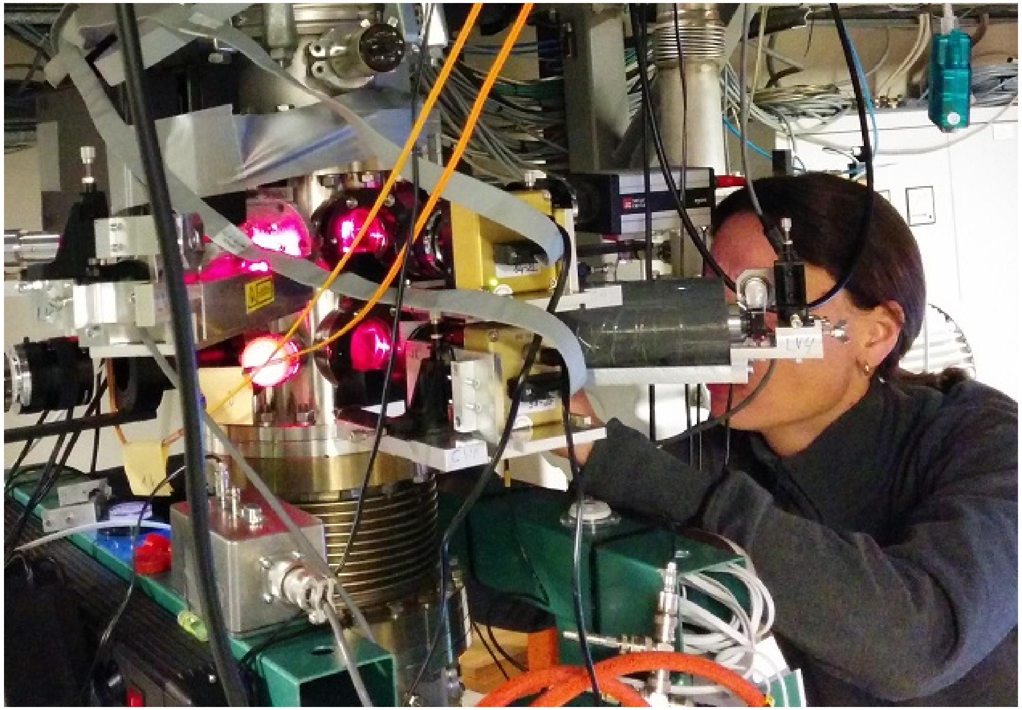
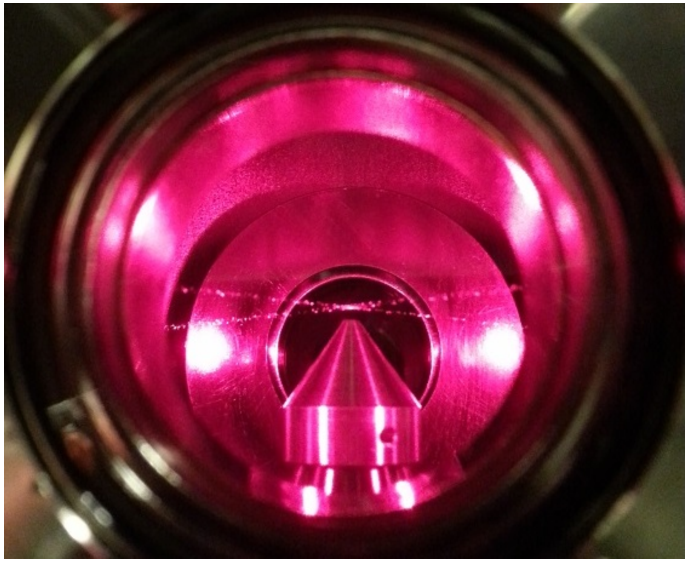
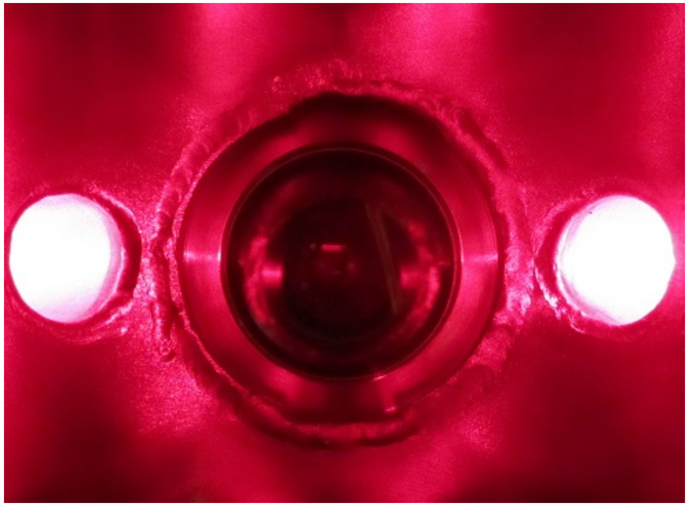
UPTS in operation. Visual inspection of pellets and pellet stream ....







PANDA CM
GSI, September 2015
Hans Calén

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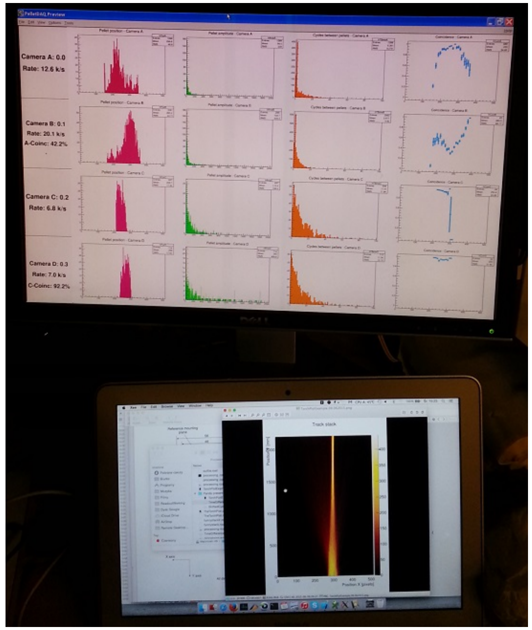
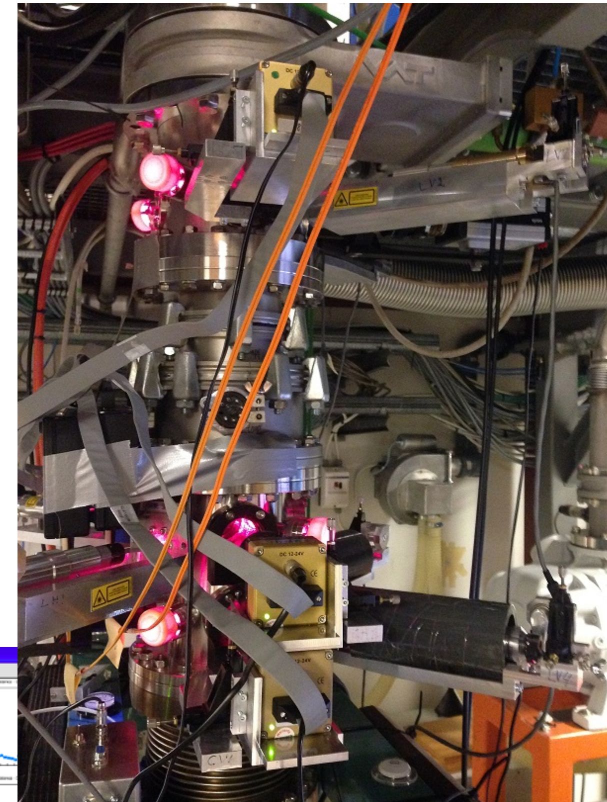
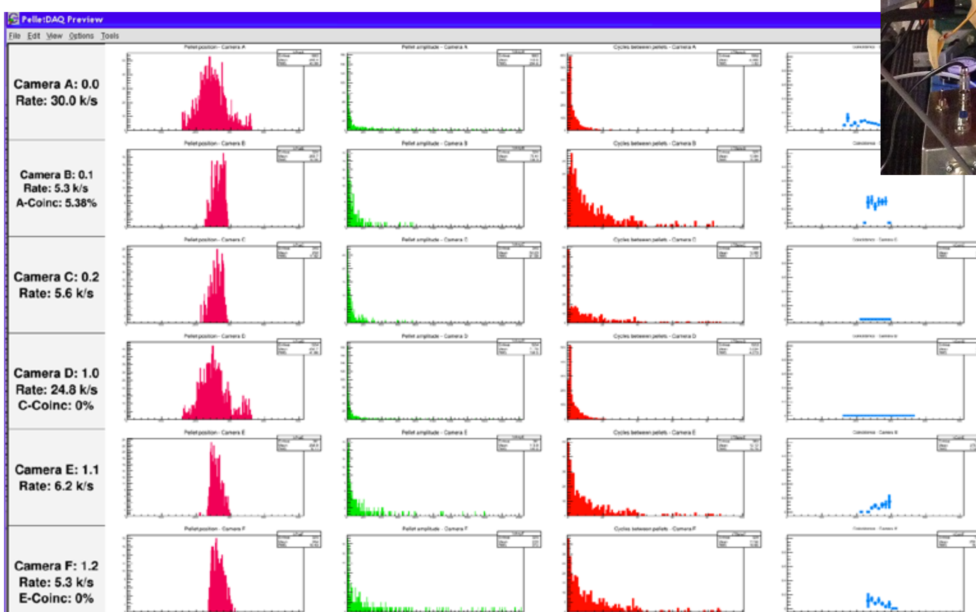
UPTS pellet tracking development setup. Multi-camera readout prototype system







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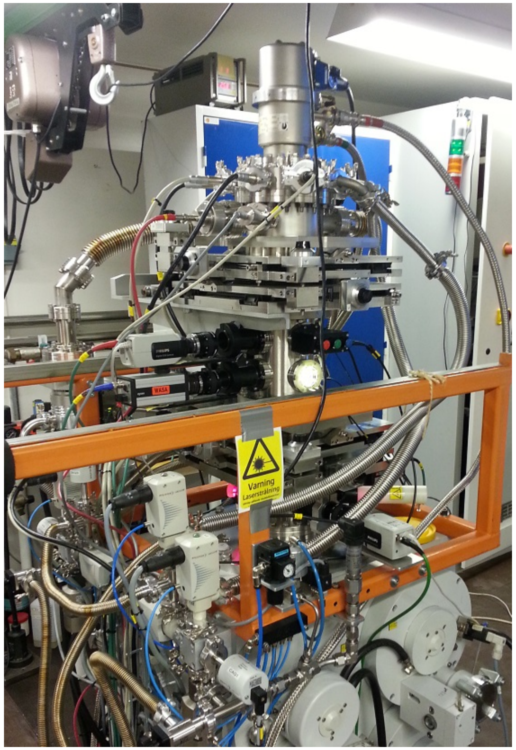
UPTS pellet generator



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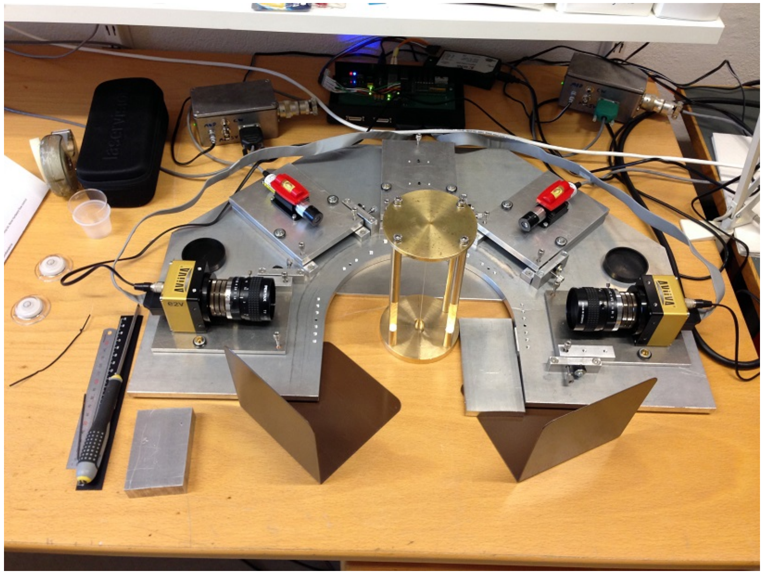
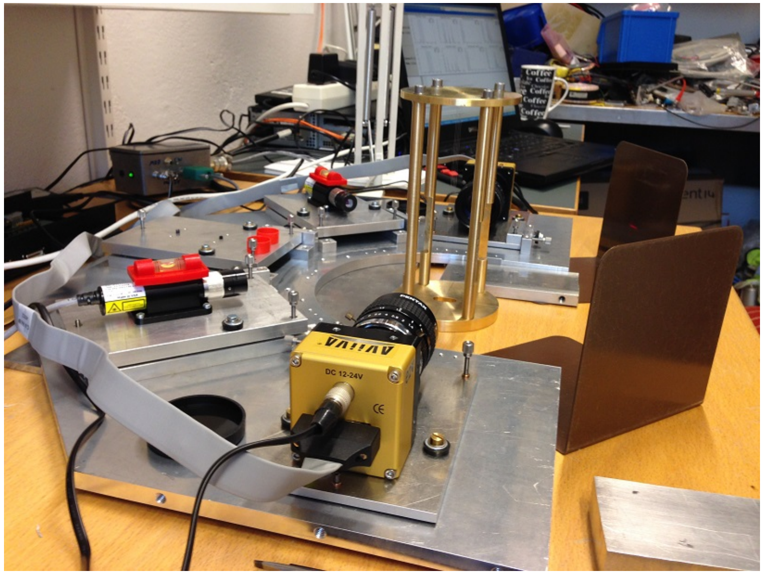
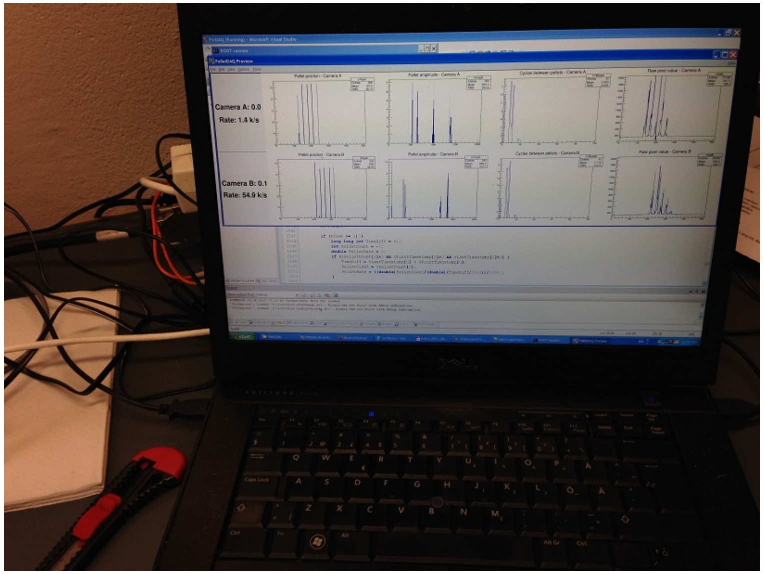
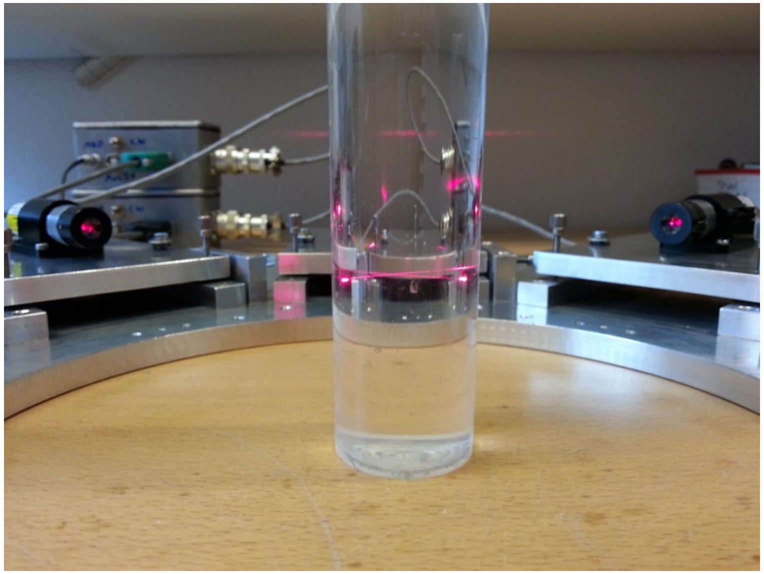
Prototype of integrated PTR measurement module









PANDA CM
GSI, September 2015
Hans Calén

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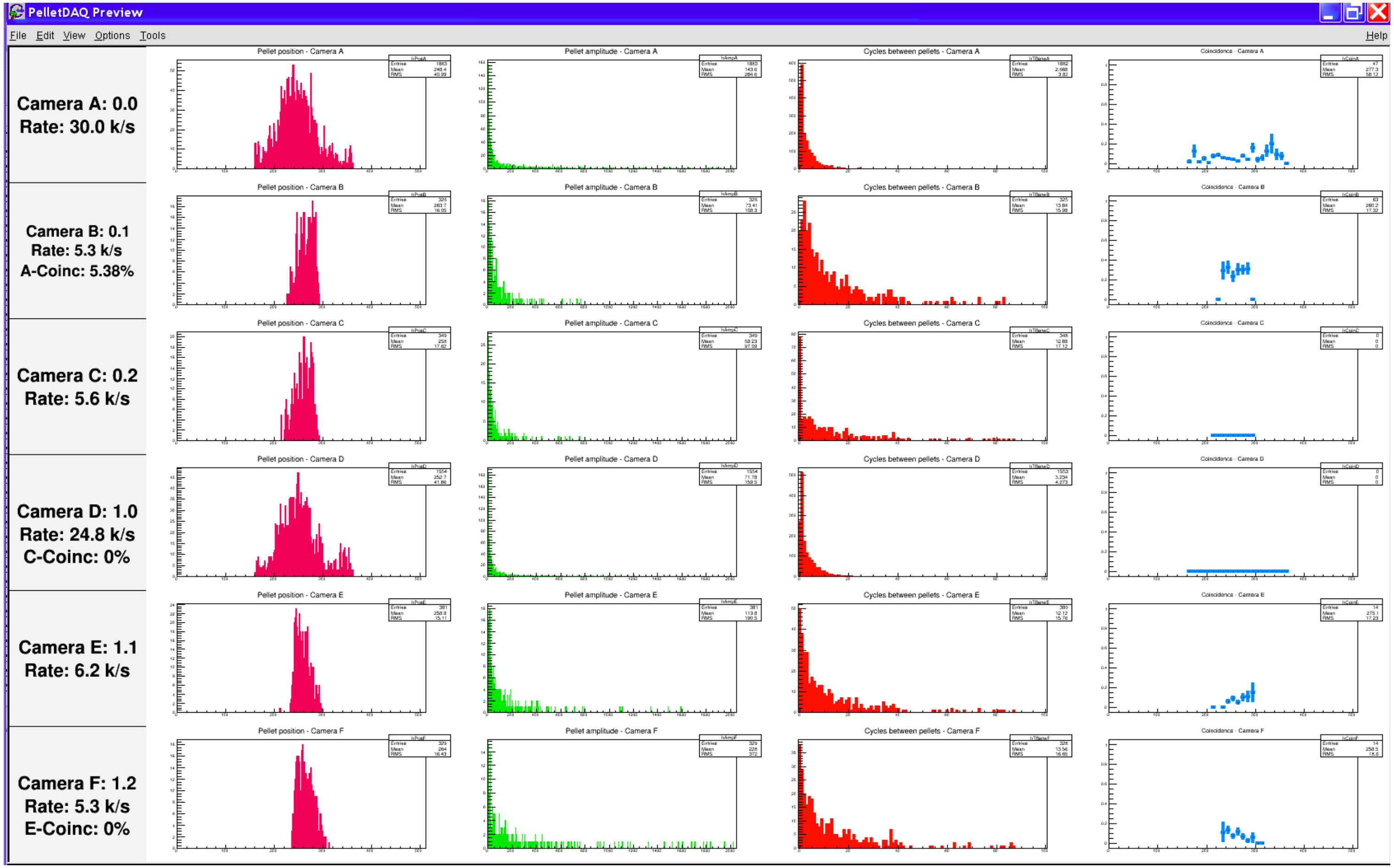
Multi-camera readout system

Multi camera readout development

From project description by Andrzej Pyszniak (June 2015)

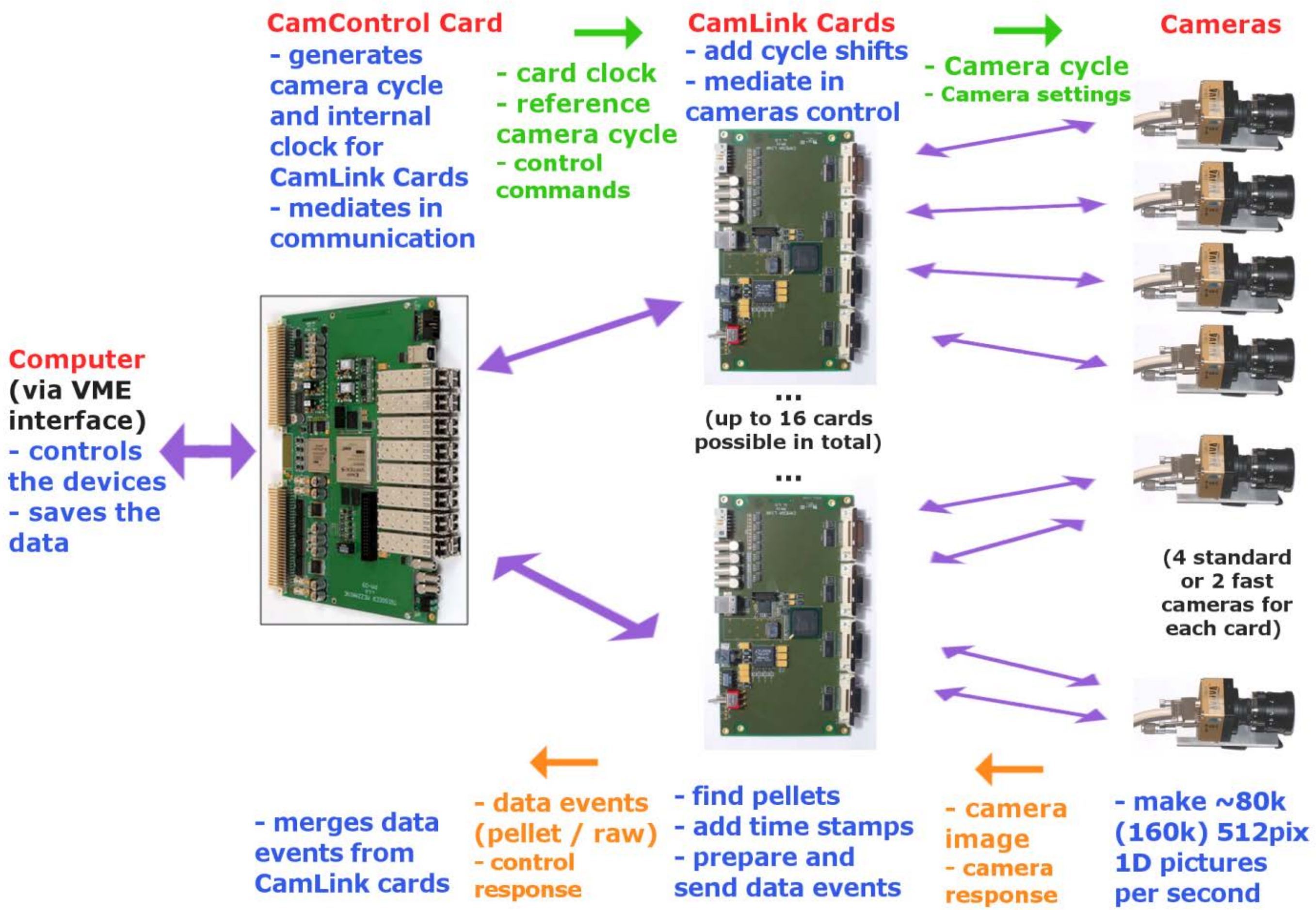
Six synchronized cameras at UPTS in a pellet run (CamControl r/o).

Pellet stream profile **Signal ampl.** **Lines btw plts** **Alignm.ctrl.**



Multi camera readout development

From project description by Andrzej Pyszniak (June 2015)



Remaining work

- **Continue synchronization of cards and cameras ..... in pellet runs.**
- **Implementation in the PTR data handling and analysis software.**
- **Extensive complete tests with different multi-camera setups ...**

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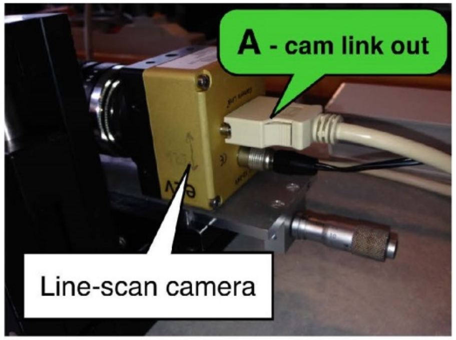
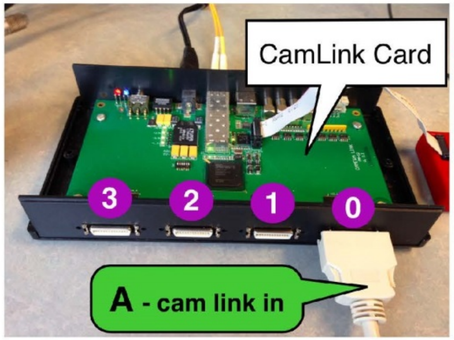
Multi camera readout development

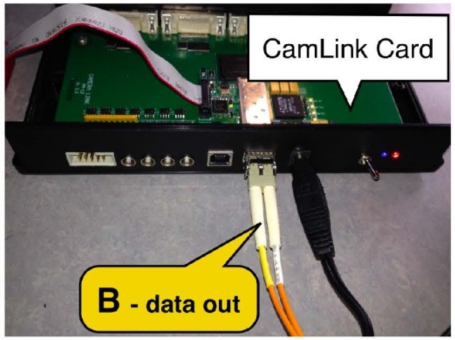
From project description by Andrzej Pyszniak (June 2015)



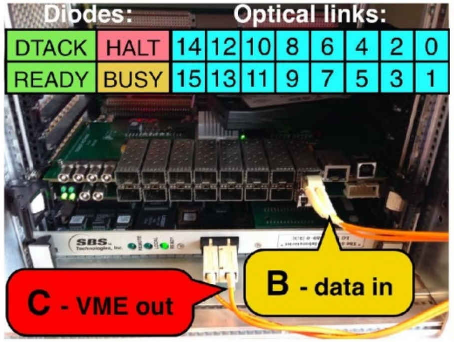
(a) Line-scan camera



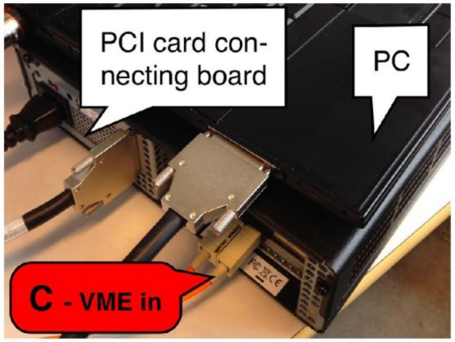
(b) CamLink Card - front view



(c) CamLink Card - rear view



(d) CamControl Card and VME controller



(e) PCI card for reading VME and a PC computer

Fig. 1: Hardware elements of the pellet data acquisition system with indicated connections between them

PANDA pellet tracking system

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Project planning status (September 2015)

Design: Conceptual and system design done (TDR (2012) +++).
PhD thesis (Jan15), A.Pyszniak :
"Development and Applications of Tracking of Pellet Streams"
Measurement level module prototype ready for testing.
Multi-camera r/o and control being tested.

Preparation of tracking section(s) for PANDA: Not funded.

Risks: Evaluation done (autumn 2013 (TDR), feb 2015 (SG)).

Financing, applications:

Running: SRC application 2015-18 rejected Nov14.
No new SRC application submitted....
HPH2020 application rejected ….

Equipment: KAW application was (strongly) rejected Oct13.
CTS appl. (30k€) approved Nov14 !
We see no other possibility in SE at present.

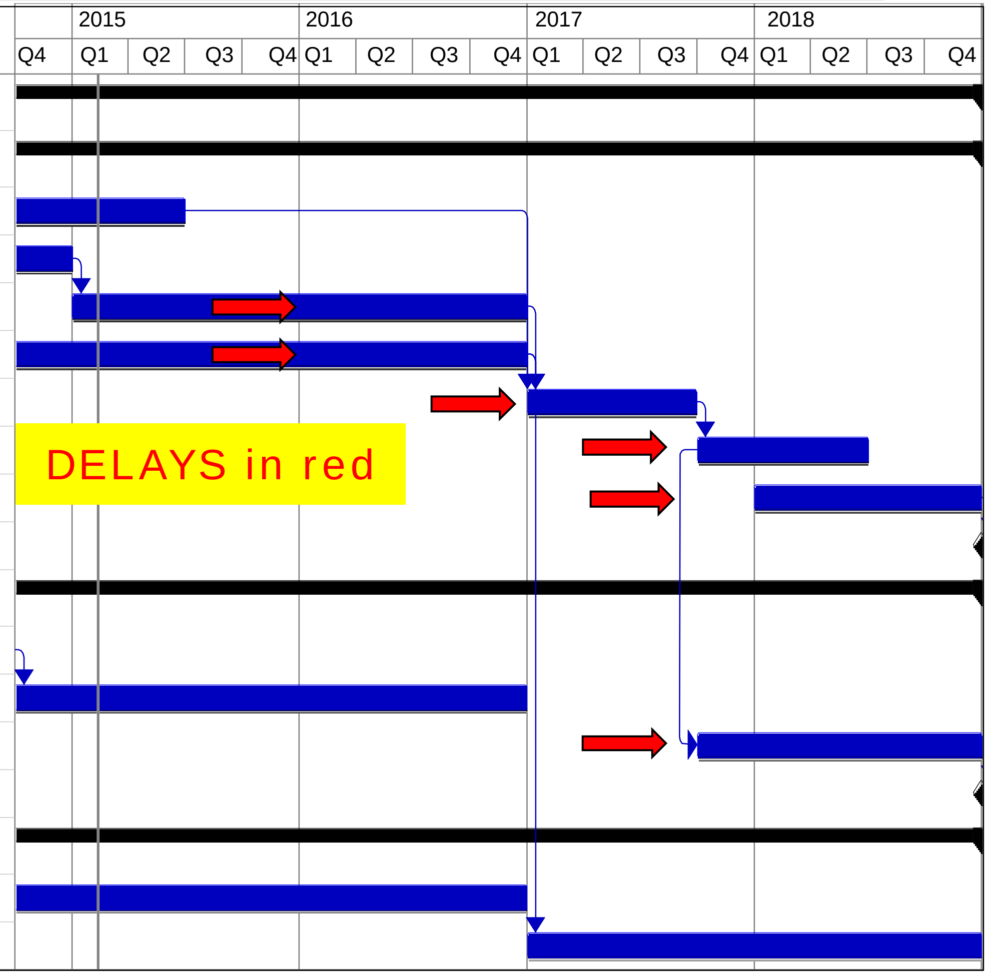
Time line: Need for new funding in order to continue some design and development work.....
The CTS grant makes possible the preparation of one (out of seven) detection module 2015-16 ….

Preparation of main equipment must still wait.

Project plan for the pellet tracking system developments 2015-2018

Jan 2015

ID	Task Name
1	**Pellet tracking system**
2	**Measurement configuration**
3	**Prestudies with UPTS PTR prototype 2-level setup**
4	**Design an operation scheme for (2) cams at a meas. level**
5	**Design a meas. level with mechanics for cams and lasers**
6	**Design the (2) multi-level measurement sections**
7	**Prepare a PANDA prototype (upper) section**
8	**Test the prototype section**
9	**Prepare and test both sections**
10	**Ready to install mechanics in PANDA**
11	**Readout system**
12	**Design multi-camera readout electronics**
13	**Test readout system with 2-4 cameras at UPTS**
14	**Test a complete system at the PANDA prototype section**
15	**Ready to install readout system (and cameras) at PANDA**
16	**Procedures and software**
17	**Design track processing and interfacing with event info**
18	**Design alignm procedures for all the parts of the system**



UPTS at TSL

Need for new funding (pers+eqpt)

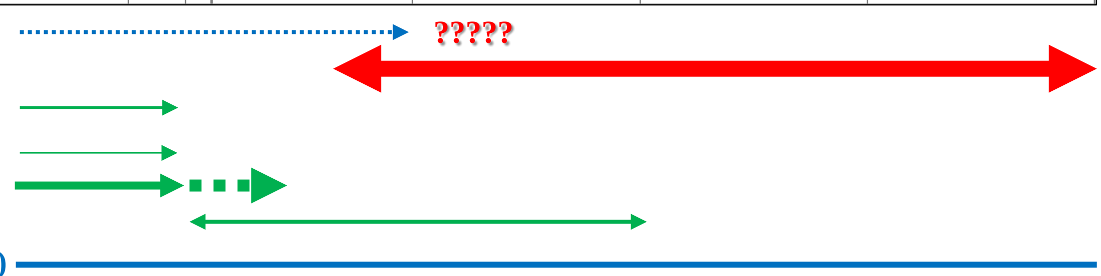
EC HP3: 30% eng (+cons)

SRC: 20% eng (+cons+eqpt)

PhD student: (JU/UU) ID=3,13,17

CTS: 13% eng (+30k€ eqpt) ID=5

UU pers (55% res, 10% eng (ID=12,13))



(pers=personnel, eqpt=equipment, cons=consumables, eng=engineer, res=researcher, UPTS=Uppsala Pellet Test Station, TSL=The Svedberg Laboratory, UU=Uppsala Univ., JU=Jagiellonian Univ., EC=European Commission, HP3=Hadron Physics 3, SRC=Swedish Research Council, CTS=Carl Tryggers Foundation)

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The vacuum situation at PANDA

Studies (2013-2014) based on :

- Experience from COSY (and CELSIUS)
- Calculations for PANDA

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Summary of comparison between target related background conditions at WASA and at ANKE.

		WASA pellet	ANKE cluster-jet
	Target beam size	Φ = 3.8 mm	Φ = 10 mm
	Target thickness	2 - 6 · 10^{15} at./cm^2 (H_2,D_2)	0.3 · 10^{15} at./cm^2 (H_2)
	Pressure in scatt.-chamber	≈ 10^{-6} mbar (modelled)	≈ 10^{-6} mbar (guess)
1	Background level expected from vacuum situation	≈ 0.01 % (H_2)	≈ 0.05 %
2	Background level from event reconstruction	≈ 0.2 % (eg pp@0.5 GeV)	≈ 1 %
	Results from COSY beam energy loss measurements:	May 2014, pd @1GeV	2004, pp @2.65 GeV (published 2008)
	Target thickness	58.0·10^{14} at./cm^2	2.60·10^{14} at./cm^2
	Thickness no target	0.12·10^{14} at./cm^2	0.14·10^{14} at./cm^2
3	Thickness rest gas ...expected background level	< "no target" value < 0.004%	0.07·10^{14} at./cm^2 0.02 %

There are certainly differences between the pellet and the cluster-jet target situation .... but nothing very dramatic (or unexpected*) was found in this study.

All 3 methods, give physics background levels that are ≈ 5 times higher for Anke CJT than for Wasa PT.

*) e.g. from experience at CELSIUS

Some features of the background condition measurements at WASA and at ANKE.

Target condition studies at COSY

	WASA pellet	ANKE cluster-jet
Geometry at interaction region Pumping of interaction region	Narrow cross. Accelerator pipe Φ=60 (Pellet pipe Φ=5). Upstr and downstr ≈ 1 m	Big box lwh=900x700x200 (Cluster pipe Φ=38). Direct (?) on the box
Vacuum measurements	in pellet pipe up/down and acc.beam pipe (scattering chamber) ≈ 1 m from IP	upstream of the scattering chamber
Background measurement i.e. event detection ..... and reconstruction	External detection of photons and protons. Complete eta/pi0 production events	Internal detection of single protons/deutrons. Single tracks
COSY beam energy loss measurement	Worked (despite small space in scatt.chamber)	Worked well

The three type of measurements should be done at the same time or under same conditions. This was unfortunately not the case for the presented studies.

The measurement of background event level is higher than what is expected from both vacuum and acc.beam energy loss measurements. It must be understood why ....

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Comments on expected background conditions at PANDA from the measurements at COSY.

	Pellet (PTR mode)	Cluster-jet
Basic parameters: Target beam size Target thickness	Φ = 4 mm 2 · 10^{15} at./cm^2 (H_2)	Φ = 4-15 mm (oval) 1 · 10^{15} at./cm^2 (H_2)
Background expected at PANDA from just scaling up WASA / ANKE values due to 10x worse vacuum.	Bg event level 2% in vertex-z distr. <10% of target thickn. due to rest-gas	Bg event level 10% in vertex-z distr. ≈25% of target thickn. due to rest-gas
Expectations from differences of PANDA with respect to WASA and ANKE		
Narrow cross. Accelerator and target pipe Φ=20.	Target pipe wider than at WASA (Φ=5). Good (?).	Target pipe tighter than at ANKE (Φ=38). Bad (?).
Better skimming of the target beam at the generator.	Better catching of skimmed-off pellets and a second skimmer at the PTR section. Good !	A narrow oval skimmer should reduce the gas load with 65% compared to a std round one. Good !
Better target dump.	Better pumping and maybe improved dump design (needs testing). Good !	Yes ? (Lack of knowledge about ANKE dump)

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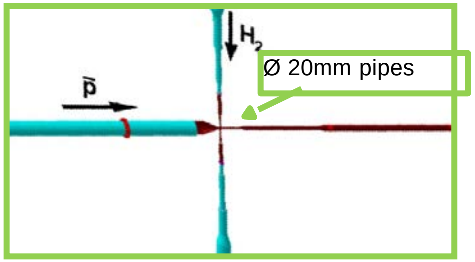
Pumping capacity cases. (The TDR case is given for reference only).

Pumps	*TDR*	*LOW*	*NOMinal*	*EXTRA*
Generator	720 l/s	2650 l/s	4000 l/s	
Dump	-	1000 l/s	1000 l/s	**NOM+500 l/s**
Upstream	**2000 l/s**	**1000 l/s**	**1500 l/s**	
Downstream	**1400 l/s**	**500 l/s**	**3000 l/s**	

Vacuum pressures for different cases compared to the case with nominal (WaC) pumping capacity.

Cases	*Upstr*	*IP*	*Downstr*
NOMinal pumping WaC	**1.8e-6**	**14.e-6**	**0.05e-6**
EXTRA 500 l/s pump at dump	**42%**	**43%**	**45%**
LOWer pumping capacity	**150%**	**112%**	**640%**
Narrow forw pipe L=23->77 cm	**102%**	**106%**	**50%**

- **It seems difficult to influence the pressure at the IP dramatically with the present pump configuration.**
- **The vacuum upstream and downstream is just proportional to the pumping capacity there.**
- **The upstream pressure is higher since there the gas is pumped away.**
- **Good pumping in the target pipe is most important.**



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Summary on vacuum studies .... (March 2015)

Vacuum gauge info at WASA PT is well understood from std calculations.

It is >2x worse than expected from COSY beam energy loss measurements.

More seriously is that the “rest-gas” background in event distributions is about 20x higher than expected.

The same ratios seem to be valid at ANKE CJT.

The relation between background in event distributions and vacuum is obviously not understood. (Is it maybe a scaling factor that should be applied due to the cryogenic nature of the targets ? But beam energy loss then ?)

The 3 methods (vacuum, beam energy loss and event analysis) give physics background levels that are ≈ 5 times higher for ANKE CJT than for WASA PT.

For PANDA PT estimates, the target cross was exchanged in the model while the WASA pumping sections were kept. The calculations gave 10 times higher pressure than at WASA at the interaction point both for pellets ON and OFF.

Compared with the Target TDR, the new calculations give 3-4 times LOWER pressure for pellets ON and 5 times HIGHER pressure for pellets OFF at the IP.

The TDR calculations actually gave a pressure with cluster-beam ON which is 60% lower than the pressure from the new calculations with pellets OFF.