



Status of Uppsala target activities

Some recent pellet tracking achievements ...

- Pellet track processing and optimization of pellet detection ... *PhD thesis (AP Jan/Mar15)*
Submitted to New_PANDA_Website 11/2, still unpublished ...
- High efficiency pellet detection *Laser studies*
- Multi-camera readout system. *UPTS tests*

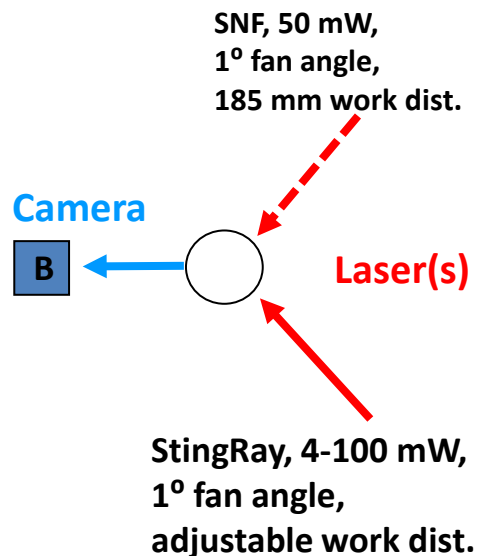
... and some vacuum considerations ...

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



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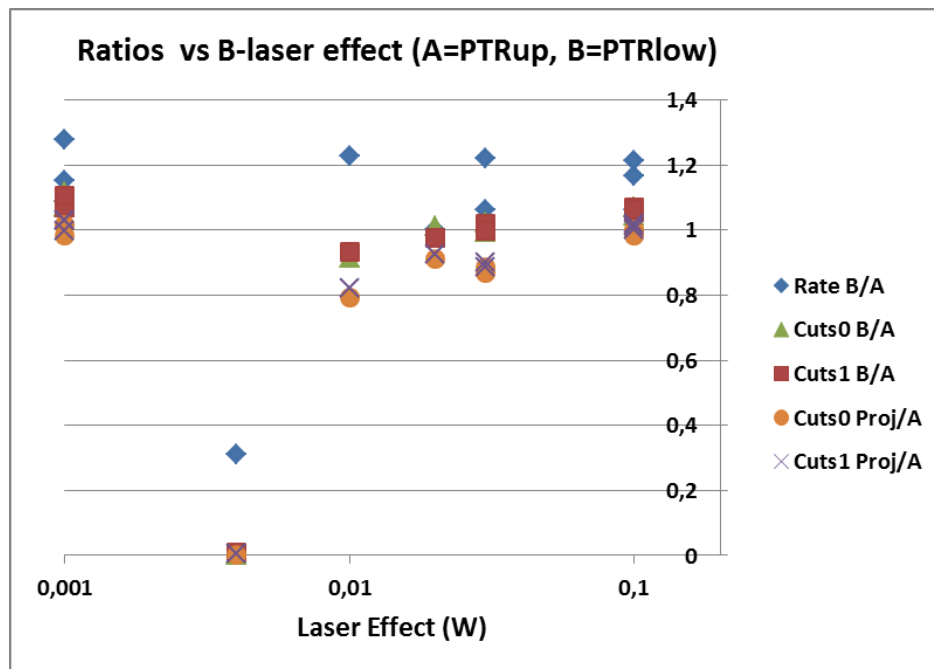
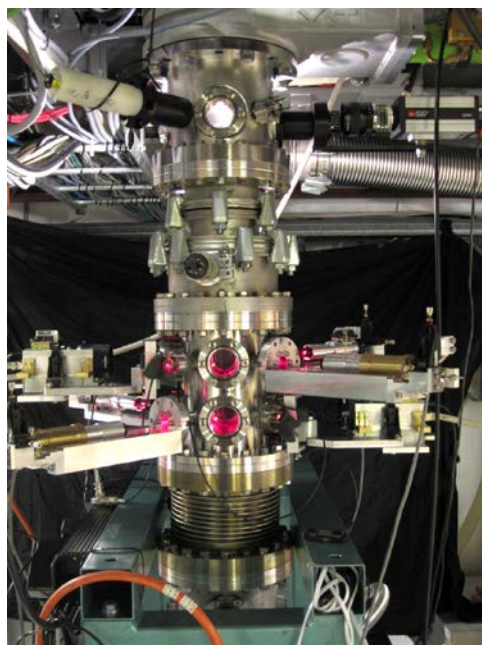
Illumination conditions.



New stronger lasers with variable power allows for measurements of efficiency curves (Nov 14).

By comparing pellet rates at the two levels and the number of reconstructed tracks for different power settings one can get an estimate of the illumination efficiency.

At a laser power of 30 mW the efficiency curve reaches a plateau (at $\approx 95\%$)

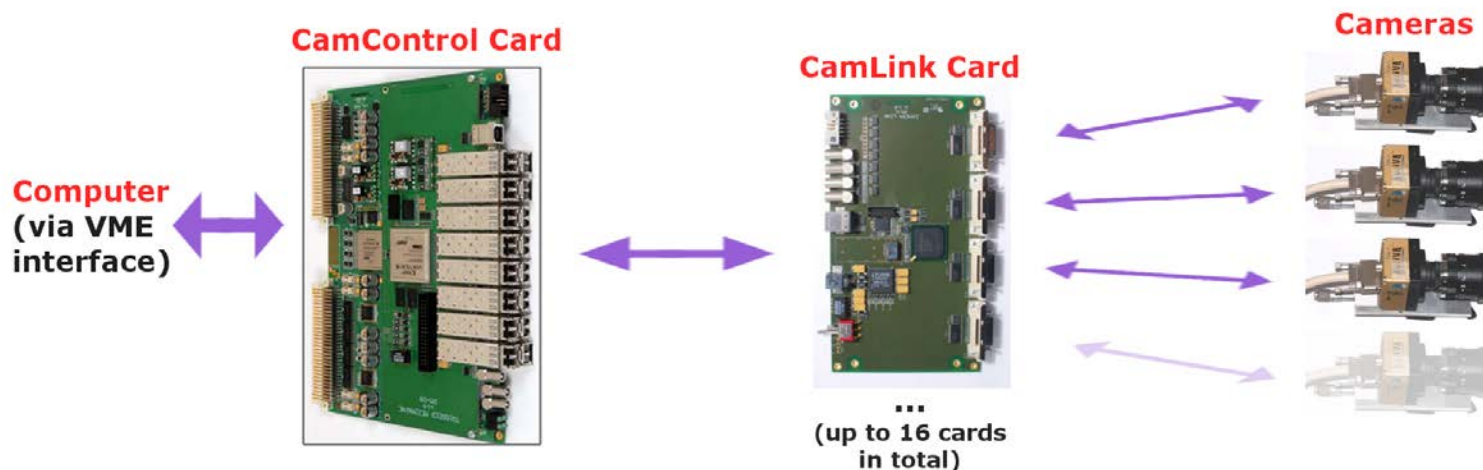


High efficiency pellet detection



Multi camera readout development

Project reports by Malte Albrecht, Madhu Thelajala and Geng Xiaoxiu (www.physics.uu.se/np/panda/pub)



CAMCTRL FPGA card (ATLB originally for WASA trigger) is used for readout. It has capacity of up to 8 CAMLINK FPGA cards.

FPGA Software:

- Control and readout of camera link card ready
- VME readout ready

CAMLINK FPGA card is used for readout of 3-4 cameras:

The 2nd vsn of cards were produced and tested successfully.

FPGA Software:

- Camera readout and pellet recognition implemented
- Communication with camera and CAMCTRL card works

Remaining tasks

- 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 ...

... operation with 3 cameras at UPTS started in December.



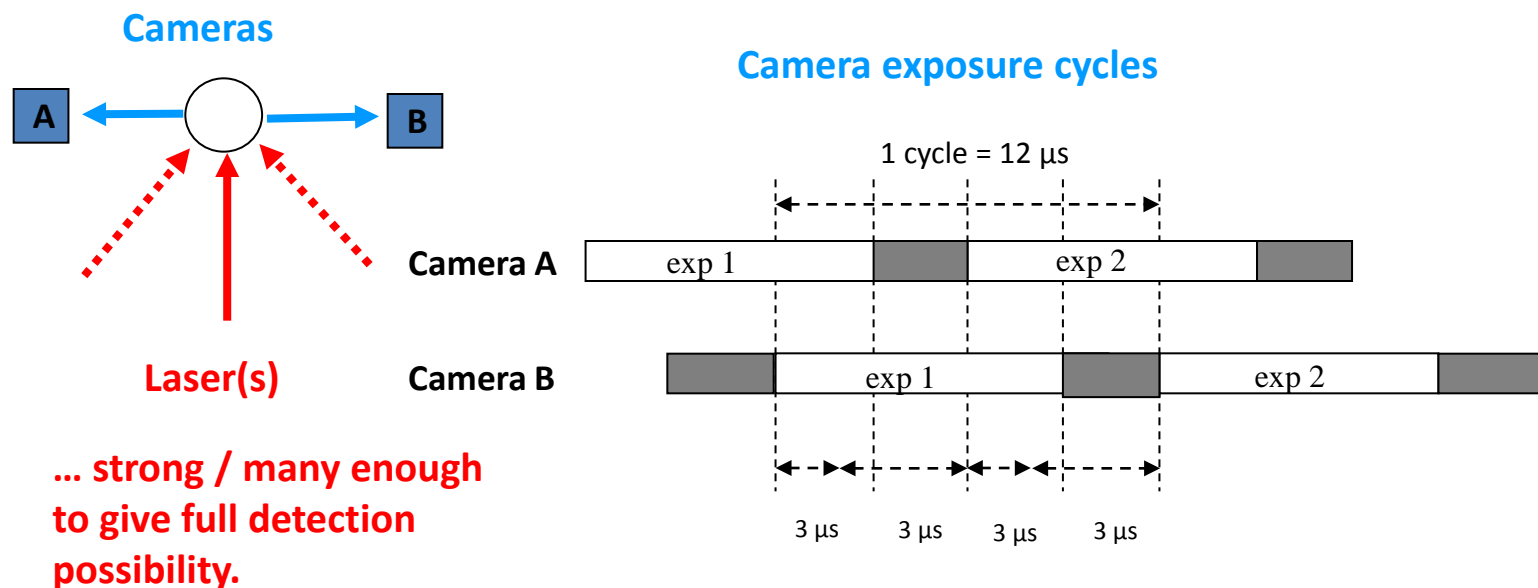
Time resolution, efficiency & measurement dead time

Two cameras (SM2, 2 tap) with $12\ \mu\text{s}$ period time, synchronized with cycles shifted half a period time, measuring the same coordinate at the same (vertical) level gives a time bin of $\approx 3\ \mu\text{s}$ ($\sigma \approx 0.9\ \mu\text{s}$).

In this case, the upper tracking section at the generator alone, gives an interaction position vertical (y) coordinate $\sigma \approx 0.8\ \text{mm}$

... and by including the measurement information from the lower tracking section at the dump, a **vertical (y) coordinate $\sigma \leq 0.2\ \text{mm}$** is obtained.

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

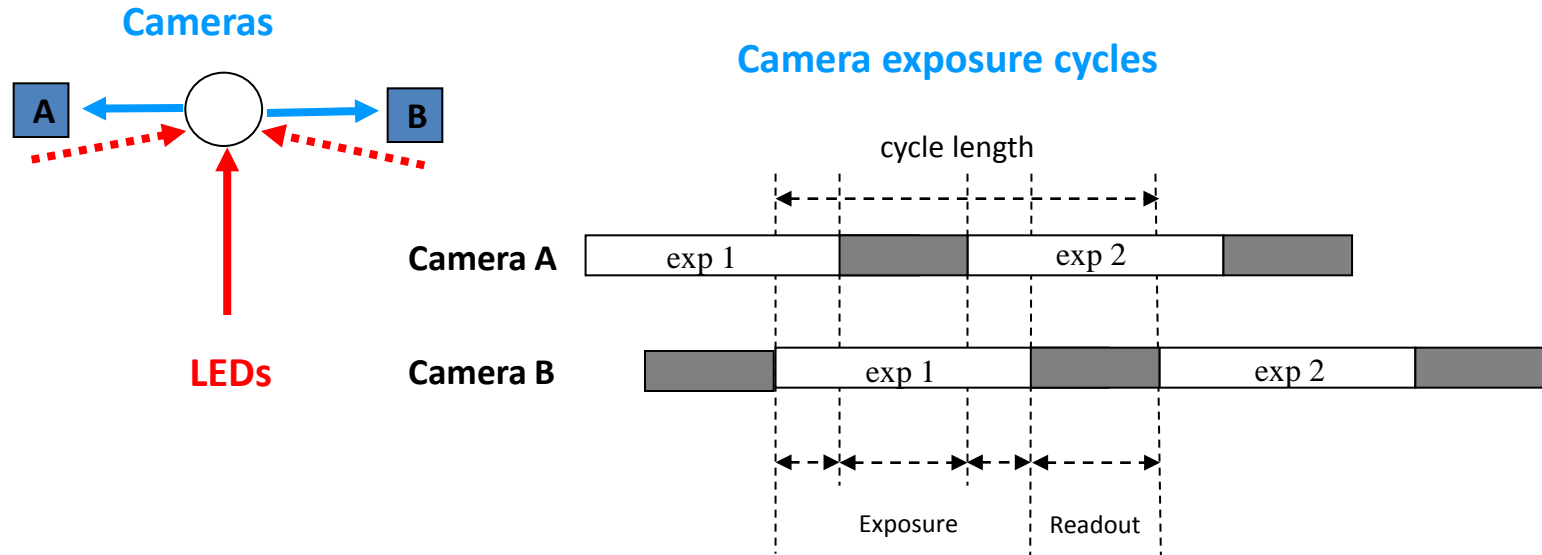




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Time resolution & measurement dead time

High efficiency pellet detection



Test bench setup including camera holders with reference LEDs and vacuum windows .

Two cameras look on a fishing-line illuminated by an LED.

(Erasmus work M. Kümmel 2013)

PANDA CM

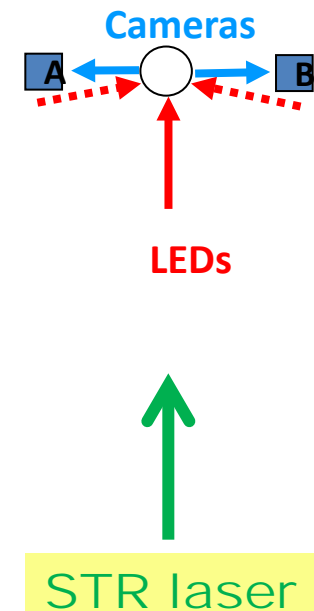
Giessen, March 2014

Hans Calén



Some studies in the test bench 2013:

- + **Effects of misalignments of the cameras** (the idea is to develop an algorithm for aligning the cameras, with automation in mind).
- + How to optimize the placement and mounting of the synchronization-monitoring diodes.
- + Interference of objects in the window with the pellet detection (masks of paper with a circular hole was used) and how to get a good monitoring signal without disturbing the pellet detection.
- + How noise ("pellets" at wrong positions) could be suppressed by choosing proper camera parameters e.g. for the offset balance between even and odd pixels for each camera.
- + **Delayed cycle operation with simulated pellets from a diode, to investigate the possible time resolution and e.g. tune the length of time bins.**



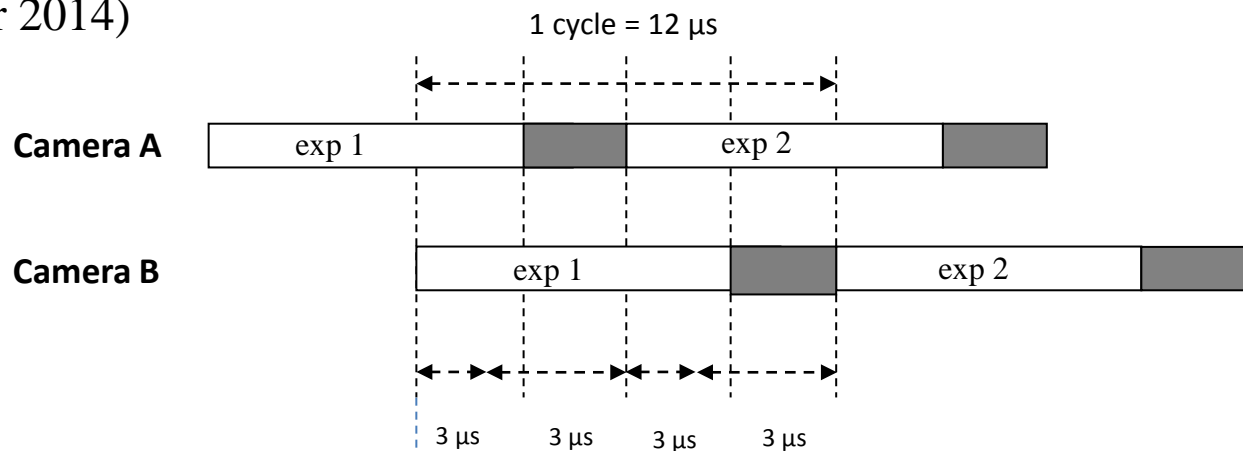
Our new StingRay lasers have variable power and are pulsable which should make possible more realistic tests



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

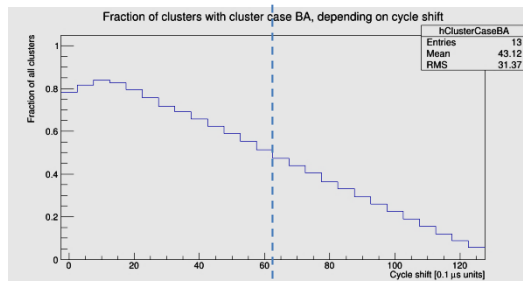
High efficiency pellet detection



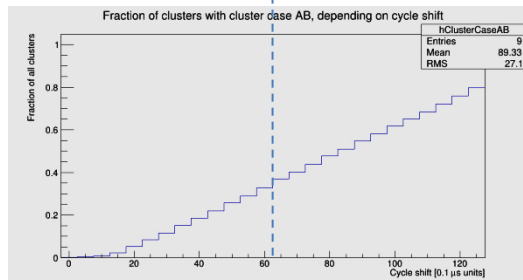
Fraction
of pellet
measurements
(0-100%)

vs

CamB delay



CamA_exp1 + CamB_exp1



CamA_exp2 + CamB_exp1

→
CamB delay (0-12 μ s)

PANDA CM

Giessen, March 2014

Hans Calén



PANDA pellet tracking system

Project planning status (March 2015)

- Design:** Conceptual and system design ready (TDR +++).
PhD thesis (Jan15), A.Pyszniak :
“Development and Applications of Tracking of Pellet Streams”
Mechanical design of measurement level module started.
Detailed design of camera r/o and control in progress.
- 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.**
SRC application 2016-19 will be submitted.
HPH2020 application will be rejected
Equipment: **KAW application was (strongly) rejected Oct13.**
CTS appl. (30k€) approved Nov14 !
We see no other possibility in SE at present.
- Time line:** If new SRC application successful some design and development work can continue.
The CTS grant makes possible the preparation of one (out of seven) detection module 2015-16
(if we can keep personnel).
Preparation of main equipment must still wait.

(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)



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

Target condition
studies at COSY

	WASA pellet	ANKE cluster-jet
Target beam size	$\Phi = 3.8 \text{ mm}$	$\Phi = 10 \text{ mm}$
Target thickness	$2 - 6 \cdot 10^{15} \text{ at./cm}^2 (\text{H}_2, \text{D}_2)$	$0.3 \cdot 10^{15} \text{ at./cm}^2 (\text{H}_2)$
Pressure in scatt.-chamber	$\approx 10^{-6} \text{ mbar (modelled)}$	$\approx 10^{-6} \text{ mbar (guess)}$
1 Background level expected from vacuum situation	$\approx 0.01 \% (\text{H}_2)$	$\approx 0.05 \%$
2 Background level from event reconstruction	$\approx 0.2 \% (\text{eg pp@0.5 GeV})$	$\approx 1 \%$
<u>Results from COSY beam energy loss measurements:</u>	May 2014, pd @1GeV	2004, pp @2.65 GeV (published 2008)
Target thickness	$58.0 \cdot 10^{14} \text{ at./cm}^2$	$2.60 \cdot 10^{14} \text{ at./cm}^2$
Thickness no target	$0.12 \cdot 10^{14} \text{ at./cm}^2$	$0.14 \cdot 10^{14} \text{ at./cm}^2$
3 Thickness rest gas ...expected background level	$< \text{"no target"} \text{ value}$ $< 0.004\%$	$0.07 \cdot 10^{14} \text{ at./cm}^2$ 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	Narrow cross. Accelerator pipe $\Phi=60$ (Pellet pipe $\Phi=5$).	Big box lwh=900x700x200 (Cluster pipe $\Phi=38$).
Pumping of interaction region	Upstr and downstr ≈ 1 m	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	External detection of photons and protons.	Internal detection of single protons/deutrons.
..... and reconstruction	Complete eta/pi0 production events	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



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

Target condition
studies at COSY

	Pellet (PTR mode)	Cluster-jet
Basic parameters: Target beam size Target thickness	$\Phi = 4 \text{ mm}$ $2 \cdot 10^{15} \text{ at./cm}^2 (\text{H}_2)$	$\Phi = 4\text{-}15 \text{ mm (oval)}$ $1 \cdot 10^{15} \text{ at./cm}^2 (\text{H}_2)$
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 $\Phi=20$.	Target pipe wider than at WASA ($\Phi=5$). Good (?)	Target pipe tighter than at ANKE ($\Phi=38$). 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)



Fig. 9.2 from Targets TDR (february 2012)

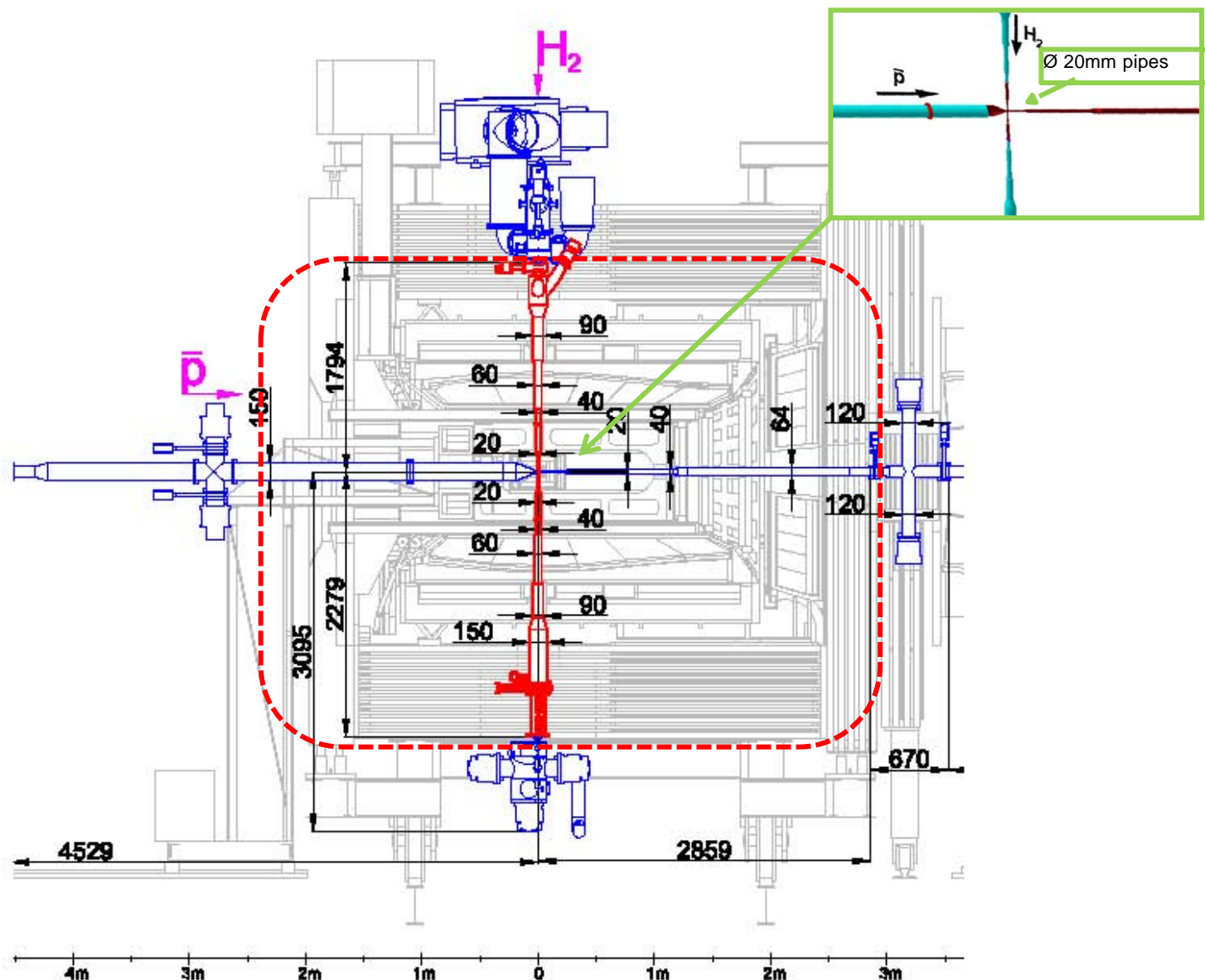


Figure 9.2: Cross section of the Target Spectrometer with detector components in light gray. The target and dump lines are marked in red. The antiproton beam line, as well as the cluster-jet target and the target beam dump, is marked in blue. The dimensions are given in mm. The diameters refer to inner diameters of the tubes.

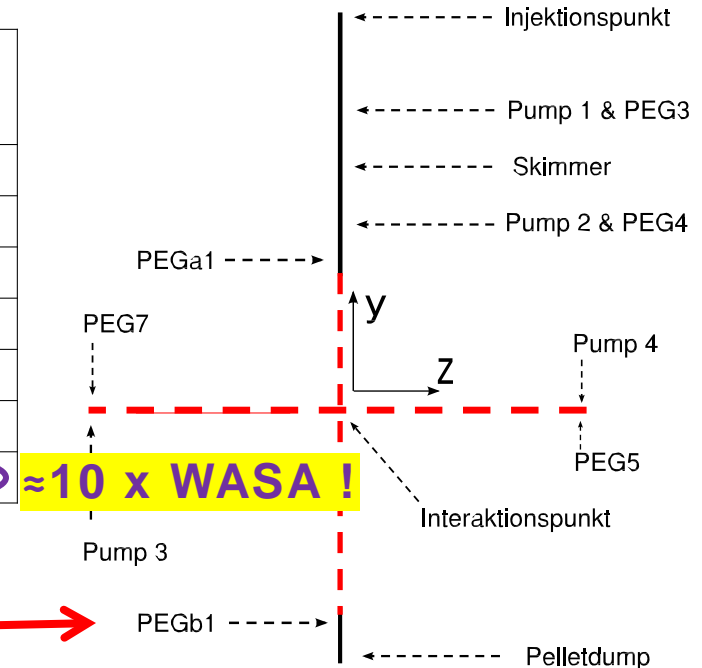


Calculated pressures with pellet target at PANDA

PANDA Pellet vacuum

WaC pump configuration
and nominal capacity

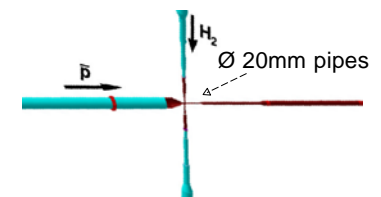
Measurem. point.	Plts ON P [mbar]	Plts OFF P [mbar]
PEG3	120×10^{-6}	130×10^{-6}
PEG4	9.2×10^{-6}	7.3×10^{-6}
PEGa1	9×10^{-6}	7.1×10^{-6}
PEG5	0.048×10^{-6}	0.005×10^{-6}
PEGb1	120×10^{-6}	1.5×10^{-6}
PEG7	1.8×10^{-6}	0.09×10^{-6}
Int.pt.	14×10^{-6}	0.66×10^{-6}



WaC pump configuration with
EXTRA 500 l/s pump at PEGb1

Measurem. point.	Plts ON P_{extra} / P	Plts OFF P_{extra} / P
PEG3	1.0	1.0
PEG4	1.0	1.0
PEGa1	0.88	1.0
PEG5	0.45	0.94
PEGb1	0.04	0.24
PEG7	0.42	0.89
Int.pt.	0.43	0.88

The red cross
= PANDA piping
(The rest are WASA
components)





Calculated pressures for pellet target at PANDA

PANDA pump configuration

<i>Pumps</i>	<i>TDR (AG)</i>	<i>Wasa (JL)</i>
Generator	2x360 l/s	4000 l/s
Dump	-	1000 l/s
Upstream	2x1000 l/s	1500 l/s
Downstream	2x700 l/s	3000 l/s

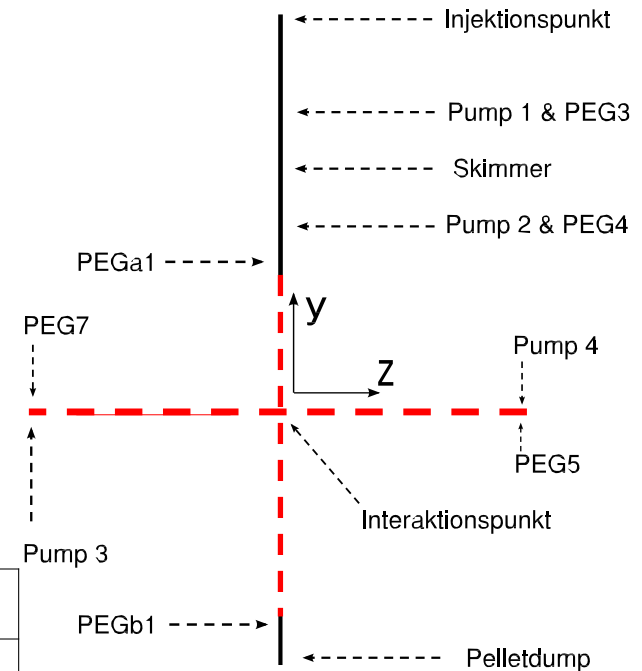
Pellets ON

Pressure (mbar)	TDR (AG)	Wasa (JL)
Generator	20.e-6	9.e-6
Dump	200.e-6	120.e-6
Int.point	40.e-6	14.e-6
Upstream	2.e-6	1.8e-6
Downstream	4.e-6	0.05e-6

Pellets OFF

Int.point	2.e-7	7.e-7
Upstream	0.1 e-7	1.e-7
Downstream	1.e-7	0.05e-7

PANDA Pellet vacuum



The red cross
= **PANDA piping**
(The rest are WASA components)



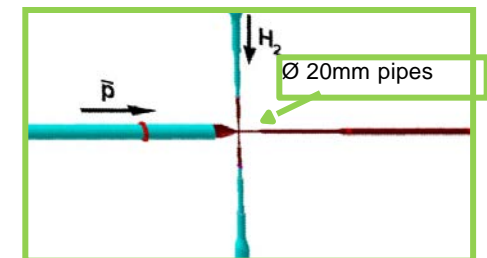
Pumping capacity cases. (The TDR case is given for reference only).

<i>Pumps</i>	<i>TDR</i>	<i>LOW</i>	<i>NOMinal</i>	<i>EXTRA</i>
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.

<i>Cases</i>	<i>Upstr</i>	<i>IP</i>	<i>Downstr</i>
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.





Summary

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.



... and a comment on targets for the high luminosity option.

One should not yet rule out the pellets in favour of the clusterjet for the high luminosity mode (i.e. with target thickness $> 1e15$ at/cm²) of running. From the studies of physics background in WASA and ANKE at COSY, it seems that the cluster-jet could give a higher ($>10x$) background than pellets for the same luminosity. Neither the difference or the absolute level have been understood from the vacuum situation (or vacuum calculations) so far.

A similar conclusion concerning background was obtained at CELSIUS, after careful investigations when some colleagues had the feeling that “it was better with the cluster-jet”. Part of it has to do with which hadronic reactions one measures, if “rest-gas” reactions cause problems or not.

We know from WASA that a pellet beam of 3.8mm diameter works well in a 5mm pipe (and e.g. don't cause more gas load than a 2.7mm pellet beam). At CELSIUS and at COSY the clusterjet beam pipes were much more generously sized, e.g. diam. 38mm for a 10mm jet at ANKE and nevertheless gave more background than the pellet case at WASA.

How will the 15mm (FW) cluster-jet for PANDA manage the 20mm pipes? This must be checked by measurements, that are planned at COSY.

The background level will probably set the real limitation for usable target thickness. It is not only that the accelerator beam can survive long enough.

We must of course also be clear on how sensitive our (“prime”) reactions are to rest-gas, so careful simulations must include rest-gas, event overlaps etc