Status of Pellet Tracking and some Vacuum system considerations

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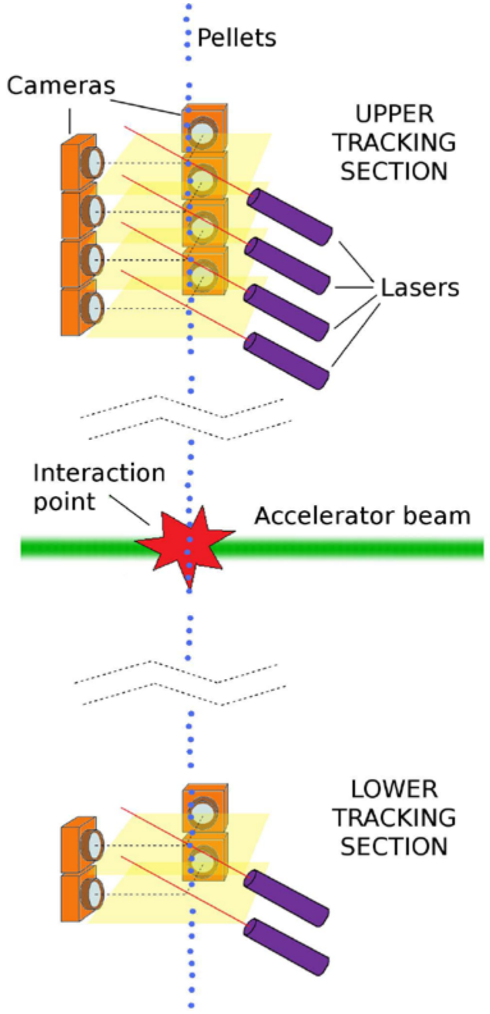
Work during the Spring:

- **Tracking system design. Continued work on lower section and algorithms**
  (Andrzej Pyszniak)

- **Multi-camera readout system.**

- **Vacuum and target thickness studies at COSY and implications for PANDA.**
  (Johan Löfgren: Project work on vacuum calculations)
  (COSY accelerator team: Target thickness measurements)
  (ANKE colleagues: Experience from studies at cluster-jet)



UPPSALA team

Senior researchers:	Hans Calén, Kjell Fransson, Pawel Marciniewski
PhD student:	Andrzej Pyszniak
Engineers:	Carl-Johan Fridén, Elin Hellbeck
Project worker:	Johan Löfgren

Project supported by EC FP7, FNP(eu-MPD) and SRC

Tracking system design status (June 2014)

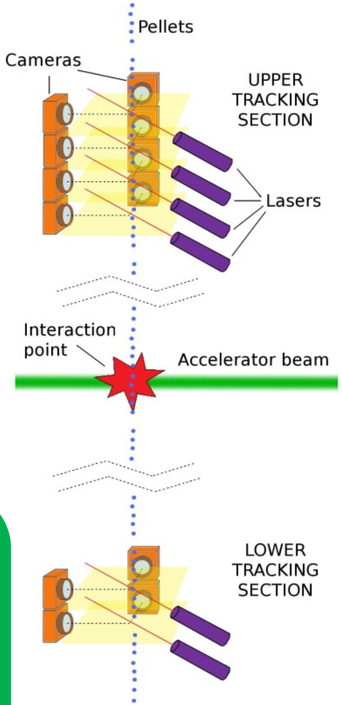
A detailed system design study for PANDA, based on the **upper tracking section** (generator), **was presented January 2013:**

- **Various aspects** of pellet behavior and detection were **simulated** using **realistic parameter** distributions from **UPTS tests.**
- The **resolution and efficiency** were determined by using a first version of **pellet tracking algorithm**.

→ **Transverse** position **resolution is σ ≈ 100 μm**

→ **Vertical resolution is σ ≈ 800 μm** (with 10 μs cycle cameras)

→ **Efficiencies >70 %** as specified **in Target TDR can be achieved**; i.e. useful info for a proper combination of pellet rate (around 10 k/s) and acc.beam size (5-10 mm)



A detailed design study for the lower section (dump) has now been done.
This section is necessary for tuning and checks, but gives also an improvement of vertical position resolution...

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A lower tracking section with 3 levels…

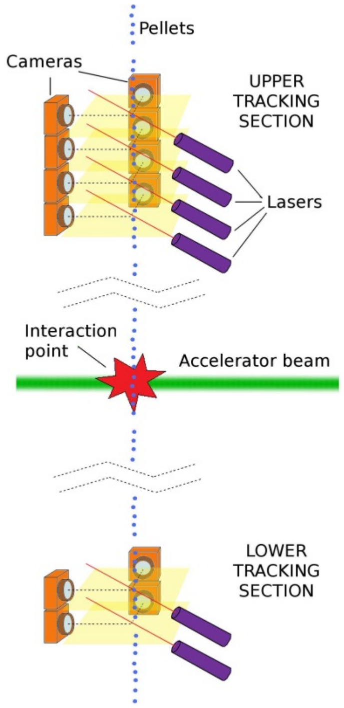
Cameras with f = 25 mm optics
and 10 μs exposure cycle

IMPROVES vertical position resolution
from σ ≈ 800 μm **to σ ≈ 100 μm**

with an efficiency ≈ 80% for a PR=5k/s

…. but the efficiency drops to ≈ 55 % at PR=15k/s
…. when using the first (fast) version of pellet tracking algorithm.

The **pellet tracking algorithm** has now been developed and gives increased efficiency numbers.........



3 measurement levels
at the pellet dump

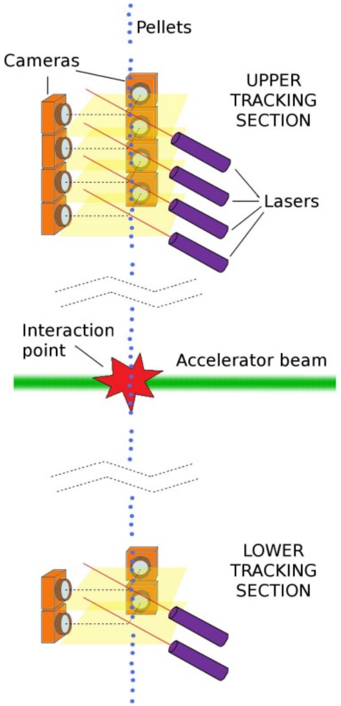
Pellet tracking algorithm efficiency improved.

Tracking system design

PELLET rate 5 k/s				
Camera cycle/exp	Algorithm # levels	Tracking efficiency	Algorithm efficiency	Correct-ness
6.5/5μs	Old 4	54.3%	60.6%	94.7%
	New 4	70.9%	77.6%	98.5%
	New 7	91.6%	97.1%	99.1%
4/4 μs	Old 4	**70.7%**	74.8%	95.0%
	New 4	**83.1%**	86.7%	98.4%
	New 7	**92.7%**	95.3%	99.2%

PELLET rate 14 k/s				
Camera cycle/exp	Algorithm # levels	Tracking efficiency	Algorithm efficiency	Correct-ness
6.5/5 μs	Old 4	47.4%	53.2%	83.5%
	New 4	69.4%	76.0%	96.6%
	New 7	85.6%	90.7%	97.2%
4/4 μs	Old 4	**62.0%**	65.3%	87.8%
	New 4	**80.0%**	83.5%	97.4%
	New 7	**88.9%**	91.4%	97.6%

4 measurement levels at the pellet generator



3 measurement levels at the pellet dump

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Optimization of pellet detection points

Old (simple and fast) tracking algorithm.

Example of some pellet tracking performance numbers.
Occupancy of acc. beam region (ϕ=5 mm).
Compare tracking prediction (trk) with mc reality (plt).

Results April 2013

Note: In this example a "trk" is based on full and correct information from all detection levels, a condition which is very strong….. There is also room for improvement of the tracking procedure …..

Cam cycle (μs)	Plt rate (k/s)	Prb for no plt when no trk	Prb for 1 plt when 1 trk	Correct match when 1 plt & 1 trk
t4/e4	5	0.87	0.76	0.98
t2/e2	5	0.88	0.82	0.99
t4/e4	14	0.61	0.57	0.92
t2/e2	14	0.63	0.62	0.96

Low pellet rate and high time resolution improves tracking performance (as expected).

Effect of detection inefficiency.

Camera deadtime fraction of 20% in this example gives about 20% reduced tracking performance.

Cam cycle (μs)	Plt rate (k/s)	Prb for no plt when no trk	Prb for 1 plt when 1 trk	Correct match when 1 plt & 1 trk
t4/e4	5	0.87	0.76	0.98
t6.25/e5	5	0.82	0.68	0.95
t4/e4	14	0.61	0.57	0.92
t6.25/e5	14	0.52	0.48	0.83

Occupancy of acc. beam region (ϕ=5 mm). Compare tracking prediction (recons.) with mc reality (true) pellet.

Case 0) **NO PELLET IN THE ACC. BEAM**

The 4-level variant corresponds to usage of the upper tracking section only and the 7-level variant to usage of also the dump section.

Camera cycle, pellet rate	Algorithm S(imple), A(dvanced) and number of levels	Probability of no recons. |	Probability of no true pellet in the beam region (time fraction)	Probability of no true |	Probability of no recons. pellet in the beam region when no recons. | true pellet is in the beam region
4/4 μs, 5 k/s	S 4-lev A 4-lev A 7-lev	0.78 0.74 0.72	0.70 0.70 0.70	0.87 0.89 0.98	0.96 0.95 0.998
4/4 μs, 14 k/s	S 4-lev A 4-lev A 7-lev	0.54 0.45 0.39	0.36 0.36 0.36	0.61 0.71 0.94	0.91 0.86 0.99

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Occupancy of acc. beam region (ϕ=5 mm). Compare tracking prediction (recons.) with mc reality (true) pellet.

Case 1) ONE PELLET IN THE ACC. BEAM

The 4-level variant corresponds to usage of the upper tracking section only and the 7-level variant to usage of also the dump section.

Camera cycle, pellet rate	Algorithm S(imple), A(dvanced) number of levels	Probability of exactly one recons | true pellet in the beam region (time fraction)		Probability of one-matching true | recons. pellet in the beam region when exactly one recons. | true pellet is in the beam region	
4/4 μs, 5 k/s	S 4-lev	0.20	0.25	0.75	0.58
	A 4-lev	0.22	0.25	0.73	0.64
	A 7-lev	0.24	0.25	0.96	0.93
4/4 μs, 14 k/s	S 4-lev	0.33	0.37	0.52	0.46
	A 4-lev	0.36	0.37	0.57	0.56
	A 7-lev	0.37	0.37	0.89	0.89

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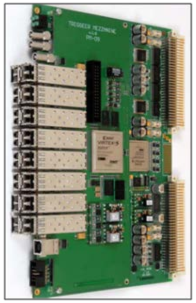
Multi camera readout development: status

Multi-camera system

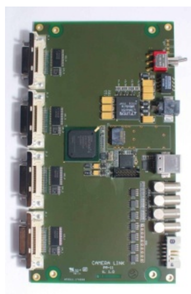
Software: Project works by Malte Albrecht, Madhu Thelajala and Geng Xiaoxiu



CAMCTRL FPGA board (ATLB developed for WASA trigger) is used for readout of up to 8 CAMLINK FPGA boards.

FPGA Software:

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



CAMLINK FPGA card is used for readout of 2-4 cameras:
1'st prototype board debugged and software developed
2 boards of a modified version were produced and tested

FPGA Software:

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

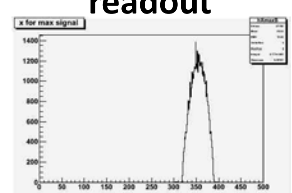
Remaining tasks

- More work on synchronization of boards and cameras
- Implementation in the PTR readout system
- (Camera link readout for 200 kHz cameras)

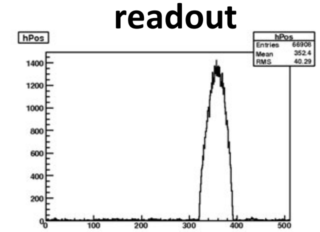
Tests with pellets on development board

Pellet position in the PTR chamber

Frame grabber readout



FPGA readout



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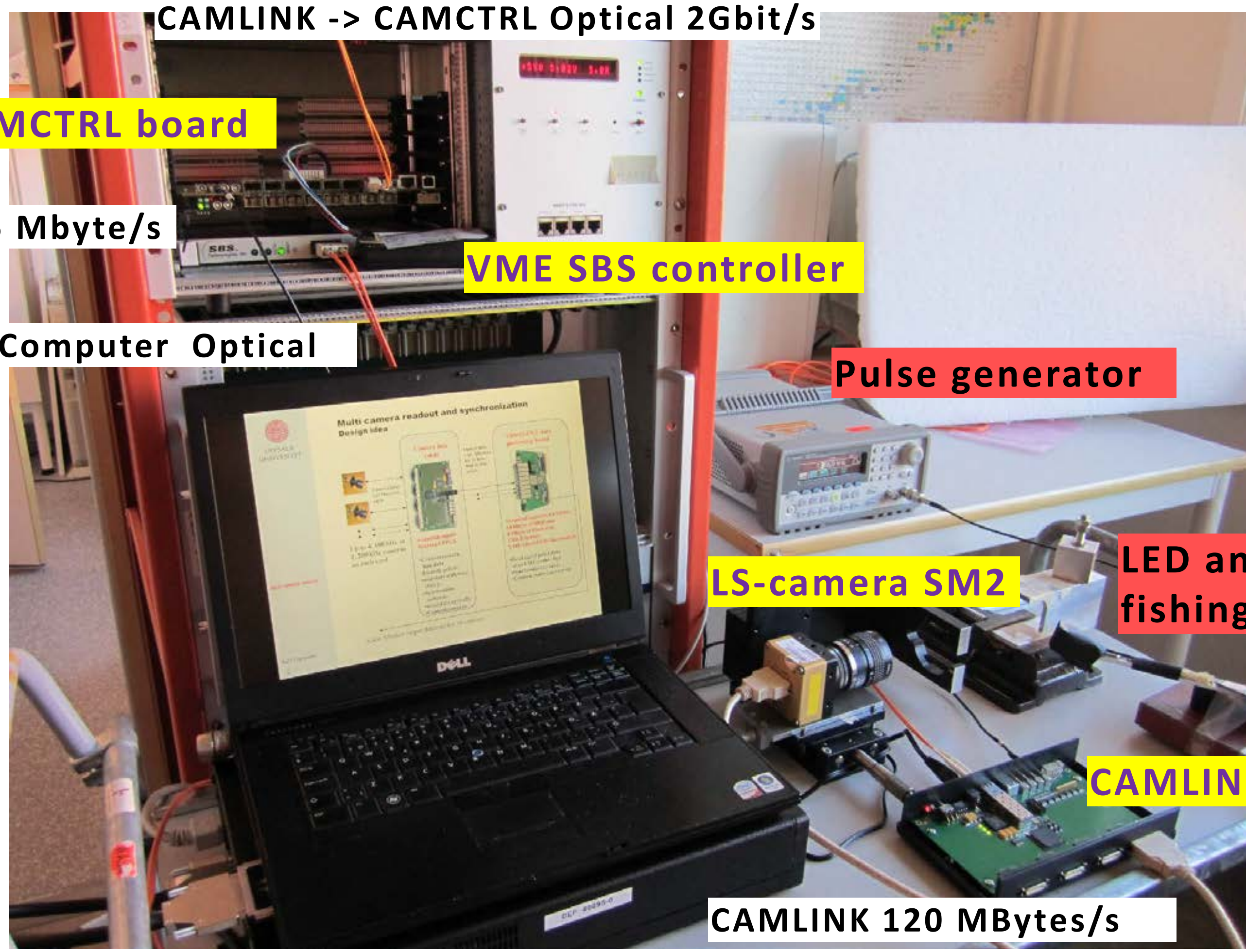
Development setup since last summer:

Communication with camera via VME board



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Pressures with (w/o) pellets at WASA 30/7 2013

P(H2) = 630 mbar
Generation f = 64 kHz
P(DC) = 21 mbar
Pellet counter = 4900/s
Target thickn ≈ 3 e15 at/cm²

VIC length=70mm
Φ=1. -> 0.7mm

VIC exit

Pressures [mbar]
PEG3=1.8e-4 (2.e-4)
PEG4=1.35e-5 (1.2e-5)
PEGa1=1.5e-5(1.e-5)
PEG5=6.e-7(5.e-8)
PEGb1=1.2e-4(1.5e-6)
PEG6=1.3e-4(1.e-6)

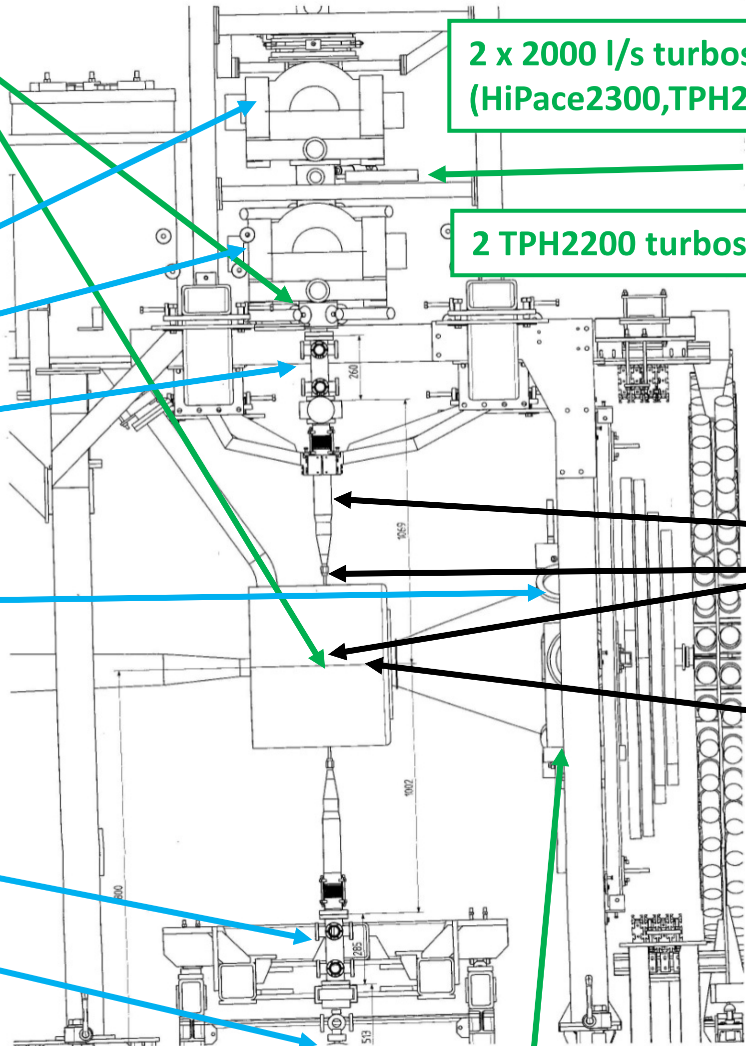
Backw. cone
1 Leybold 1500 cryo

2 x 2000 l/s turbos
(HiPace2300,TPH2200)

2 TPH2200 turbos

Dump 2 x 500 l/s turbos
(TPH510, TMH521)

Forw. cone 2 Leybold 1500 cryos



Distance [mm]	
0	VIC exit
700	Skimmer (Φ 1mm)
1345	Upper PTR section
	Pellet pipe (Φ 90mm) (Φ 10-5mm)
2690	Cosy beam Be pipe (Φ 60mm)
3692	Lower PTR section

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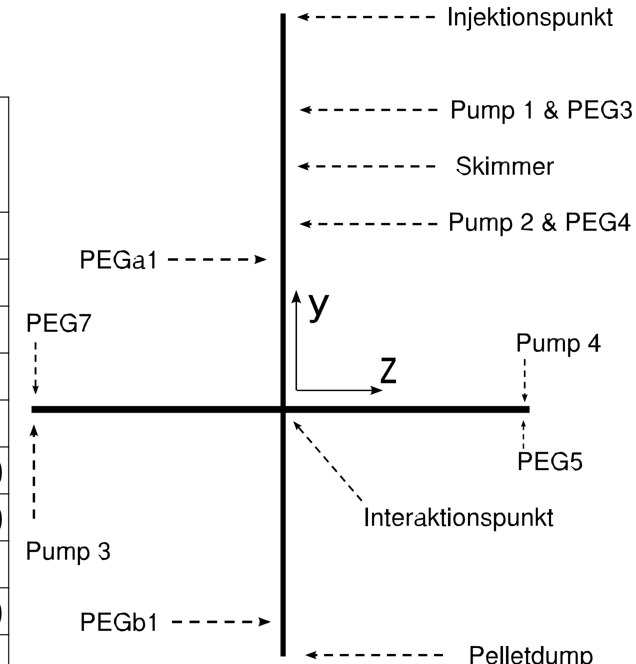
Calculated pressures w/o and with) pellets at WASA

WaC Pellet vacuum

Parameters for gas load and pumping

Parameter	*Outgasing [mbarl/s]*	*Pump speed [l/s]*
Collisions	**0.52 × 10^{-3}**	**-**
Vacuum injection	**483 × 10^{-3}**	**-**
Skimmer	**32.8 × 10^{-3}**	**-**
Interaction point	**0.35 × 10^{-3}**	**-**
Pellet dump	**60.0 × 10^{-3}**	**-**
Pump 1	**-**	**2640 (66%)**
Pump 2	**-**	**2640 (66%)**
Pellet dump	**-**	**500 (50%)**
Pump 3	**-**	**1000 (66%)**
Pump 4	**-**	**500 (16%)**



Closed shutter (P_s = *measured*)

Meas.pt.	***P [mbar]***	***P_s/P***
PEG3	**200 × 10^{-6}**	**1.00**
PEG4	**11 × 10^{-6}**	**0.92**
PEGa1	**11 × 10^{-6}**	**1.10**
PEG5	**0.043 × 10^{-6}**	**0.86**
PEGb1	**1.5 × 10^{-6}**	**1.00**
PEG7	**0.015 × 10^{-6}**	**-**
Int. pt.	**0.046 × 10^{-6}**	**-**

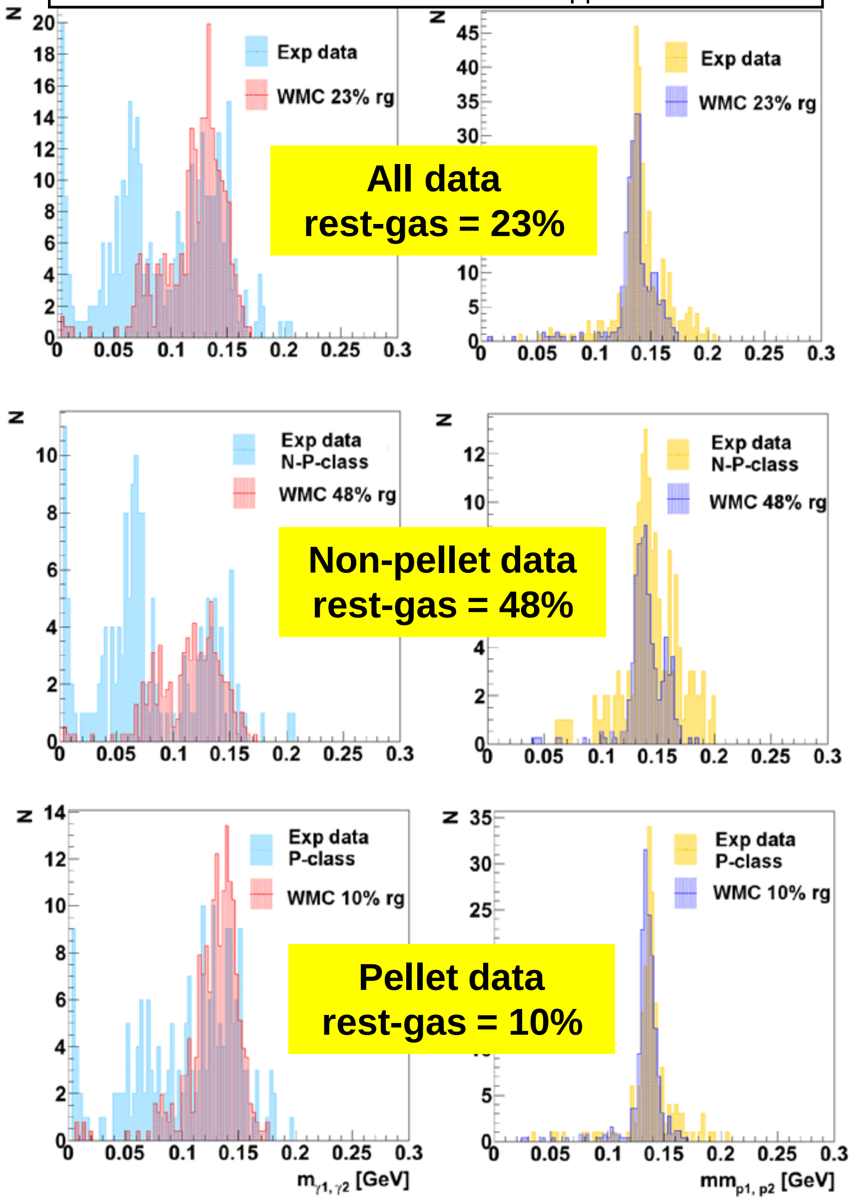
Open shutter (P_o = *measured*)

Meas.pt.	***P [mbar]***	***P_o/P***
PEG3	**180 × 10^{-6}**	**0.99**
PEG4	**13 × 10^{-6}**	**0.99**
PEGa1	**16 × 10^{-6}**	**1.00**
PEG5	**0.74 × 10^{-6}**	**0.81**
PEGb1	**125 × 10^{-6}**	**0.957**
PEG7	**0.23 × 10^{-6}**	**-**
Int. pt.	**1.21 × 10^{-6}**	**-**

WaC Pellet vacuum

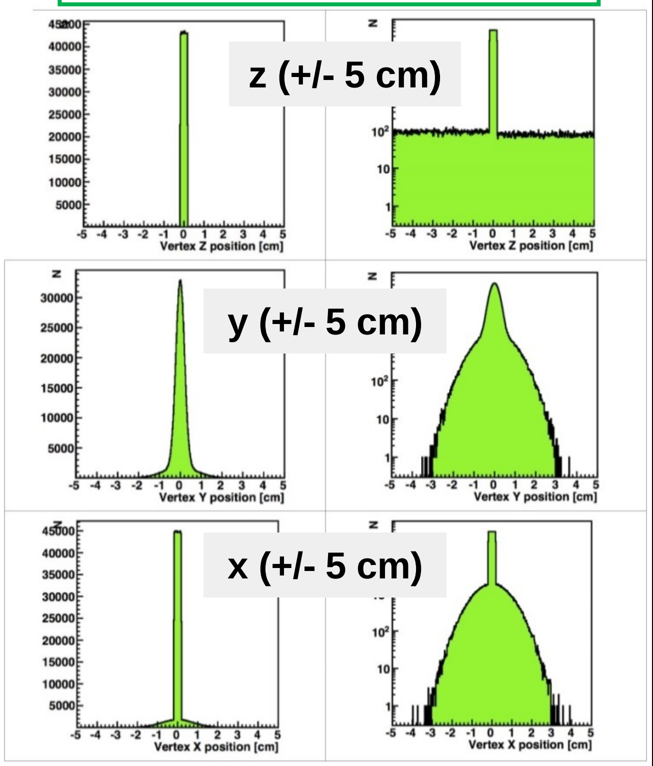
Background study at WASA pp-> pp π^0 run (π^0-> $\gamma\gamma$)

Mγγ (GeV/c²) MM$_{pp}$ (GeV/c²)



Interaction-point distribution at WASA (25% occur in rest-gas)

Lin scale Log scale



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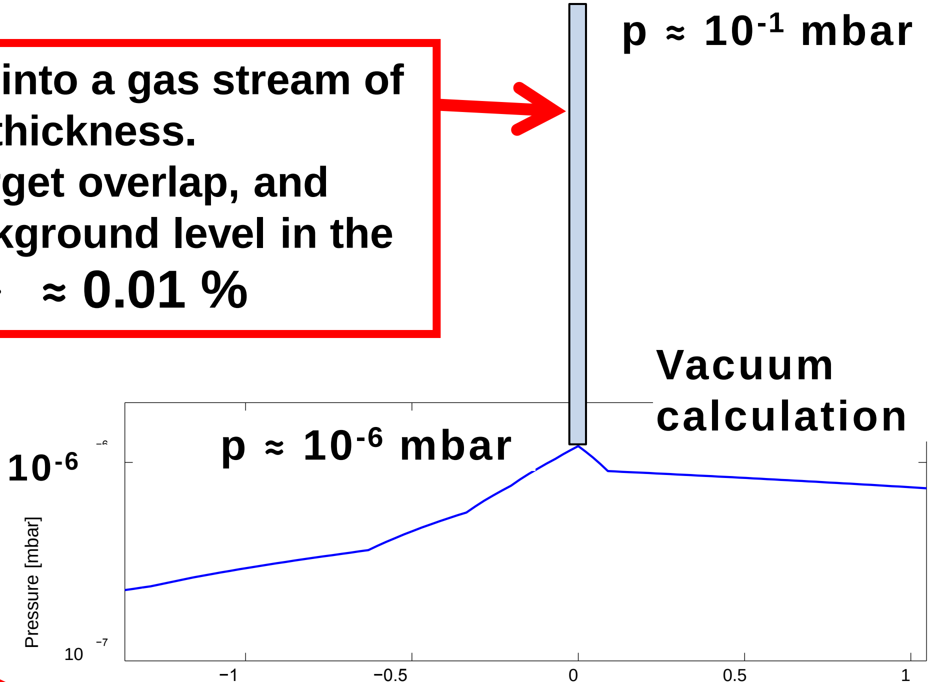
GSI, June 2014
Hans Calén

Background due to “rest-gas” at WASA

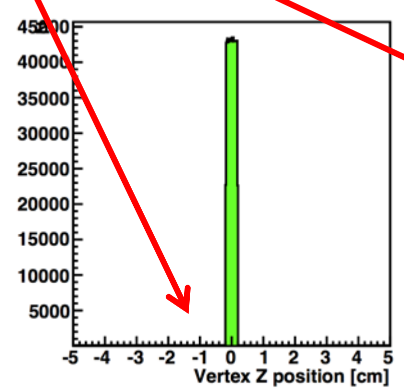
WaC Pellet vacuum

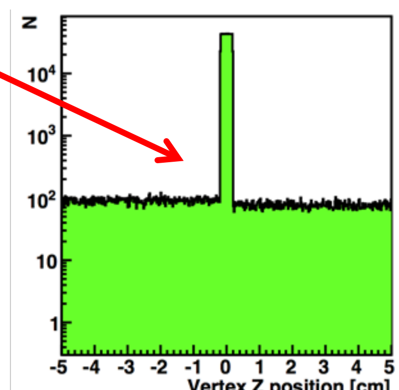
Translate the pellet stream into a gas stream of the same width and target thickness.
Take into account beam-target overlap, and calculate the expected background level in the vertex z-distribution: → ≈ 0.01 %



< z (+/- 50 cm) >

At WASA, the interactions that occur outside of the pellet-stream gives a **background level of typically 0.2 %** in the vertex z-distribution (25% so called rest-gas contribution in MC)





< z (+/- 5 cm) >

Such mismatch might be understood e.g. if 10% of a pellet was always present in the narrow 200 mm long Beryllium beam pipe inside of WASA.

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PHYSICAL REVIEW SPECIAL TOPICS - ACCELERATORS AND BEAMS 11, 052801 (2008)

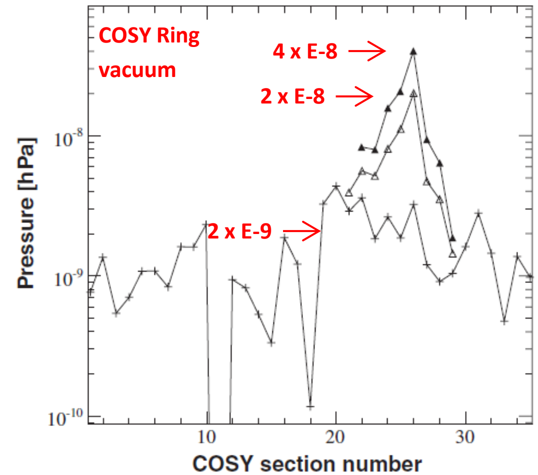
Determination of target thickness and luminosity from beam energy losses

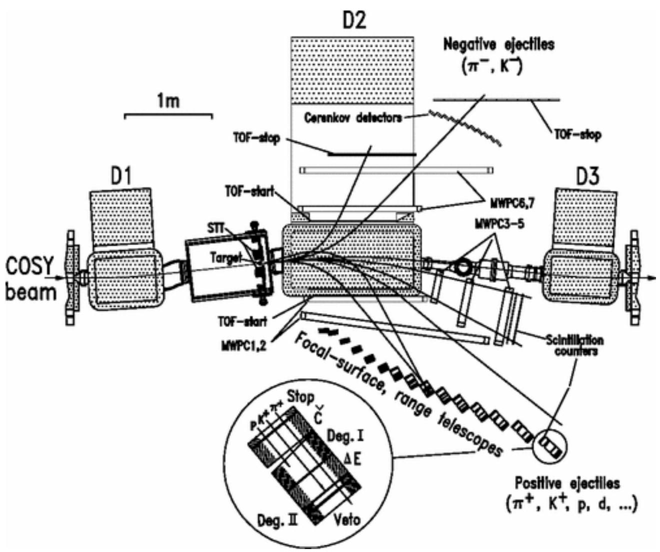
H. J. Stein,[1] M. Hartmann,[1,*] I. Keshelashvili,[1,2] Y. Maeda,[3] C. Wilkin,[4] S. Dymov,[5] A. Kacharava,[1,2] A Khoukaz,[6] B. Lorentz,[1] R. Maier,[1] T. Mersmann,[6] S. Mikirtychiants,[1,7] D. Prasuhn,[1] R. Stassen,[1] H. Stockhorst,[1] H. Ströher,[1] Yu. Valdau,[1,7] and P. Wüstner[8]

[1]*Institut für Kernphysik, Forschungszentrum Jülich, D-52425 Jülich, Germany*
[2]*High Energy Physics Institute, Tbilisi State University, 0186 Tbilisi, Georgia*
[3]*Research Center for Nuclear Physics, Osaka University, Ibaraki, Osaka 567-0047, Japan*
[4]*Physics and Astronomy Department, UCL, London, WC1E 6BT, United Kingdom*
[5]*Laboratory of Nuclear Problems, Joint Institute for Nuclear Research, RU-141980 Dubna, Russia*
[6]*Institut für Kernphysik, Universität Münster, D-48149 Münster, Germany*
[7]*High Energy Physics Department, St. Petersburg Nuclear Physics Institute, RU-188350 Gatchina, Russia*
[8]*Zentralinstitut für Elektronik, Forschungszentrum Jülich, D-52425 Jülich, Germany*
(Received 23 January 2008; published 22 May 2008)

The repeated passage of a coasting ion beam of a storage ring through a thin target induces a shift in the revolution frequency due to the energy loss in the target. Since the frequency shift is proportional to the beam-target overlap, its measurement offers the possibility of determining the target thickness and hence the corresponding luminosity in an experiment. This effect has been investigated with an internal proton beam of energy 2.65 GeV at the COSY-Jülich accelerator using the ANKE spectrometer and a hydrogen cluster-jet target. Possible sources of error, especially those arising from the influence of residual gas in the ring, were carefully studied, resulting in an accuracy of better than 5%. The luminosity determined in this way was used, in conjunction with measurements in the ANKE forward detector, to determine the cross section for elastic proton-proton scattering. The result is compared to published data as well as to the predictions of a phase shift solution. The practicability and the limitations of the energy-loss method are discussed.

Target thickness measurements (2004) with ANKE Cluster-Jet





A) Cosy Beam (CB) energy loss measurements

(CJ=Cluster-Jet)	Target thickness [10^{14} at./cm^2]	
Total (CB on CJ)	**T** = 2.8	
Ring (no CJ)	**R** = 0.14	5%
Rest gas (CB off CJ)	Rg = 0.034	1.2%
(Rest Gas (CB on CJ)	**RG = 0.069**	**2.5% estim.)**

Cluster Jet CJ = T-R-RG = 2.6

B) Vacuum (gauge) measurements

average in Cosy Ring (183m) and at Anke (+/-5m)

	Vacuum [mbar]	→Target thickn. [10^{14} at./cm^2]
Total (CB on CJ)		T =
Ring (no CJ)	2E-9	R = 0.018-0.043 (air–H_2)
Anke (CB off CJ)	2E-8	Rg = 0.024
Anke (CB on CJ)	**4E-8**	**RG = 0.047**

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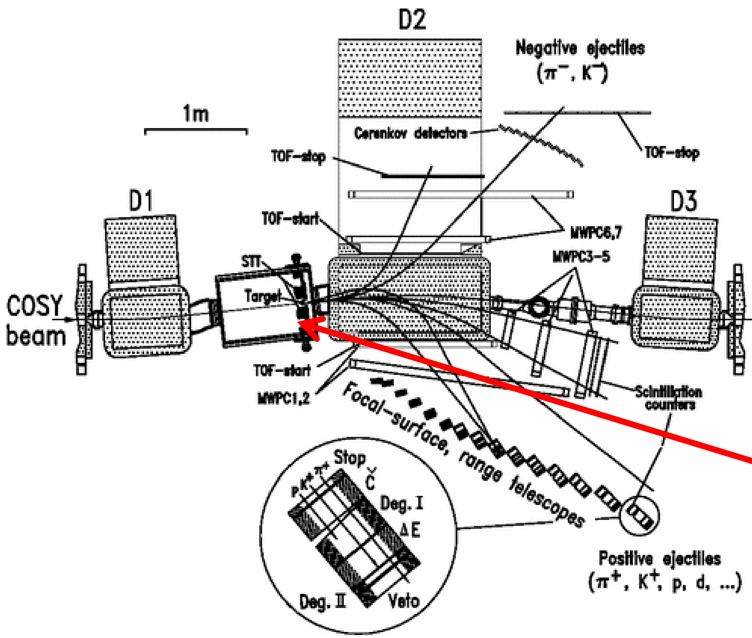
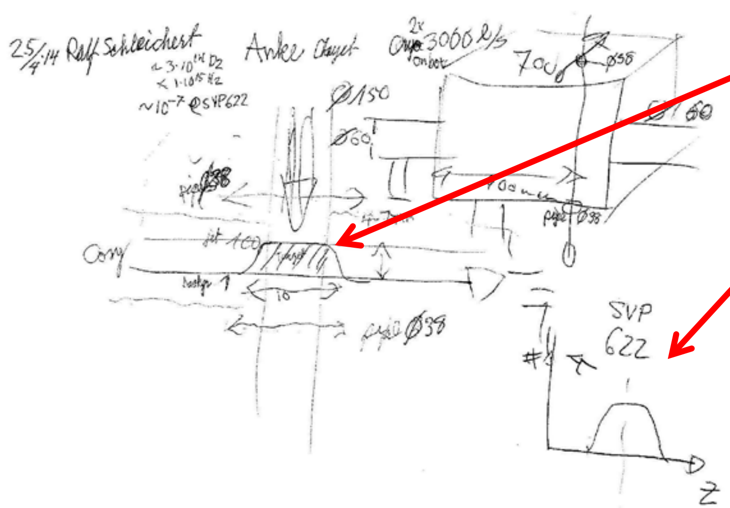
Target conditions at ANKE Cluster-Jet





What info exist about background conditions at ANKE ?

Here are some notes from discussions with Ralf Schleichert, Michael Hartmann and other ANKE colleagues during last months ....

- **Spacious scattering chamber (90x70x20 cm^3) with Ø =38mm entrance and exit pipes for jet and Ø =60mm pipes for Cosy beam.**
- **Vacuum p ≈ 10^{-7} mbar. Two 3000 l/s cryos pump on the scattering chamber.**
- **Sharp and uniform jet profile Ø ≈ 10 mm (FW)**
- **Target thickness up to 1·10^{15} at./cm2 for H2 and 3·10^{14} at./cm^2 for D_2.**
- **Background due to rest gas has been estimated from vertex z-position distribution of reconstructed charged particle events (elastic scattering?).**

The level interactions outside of the jet is typically around 1% of the value inside the jet region .

Background due to "rest-gas" at ANKE

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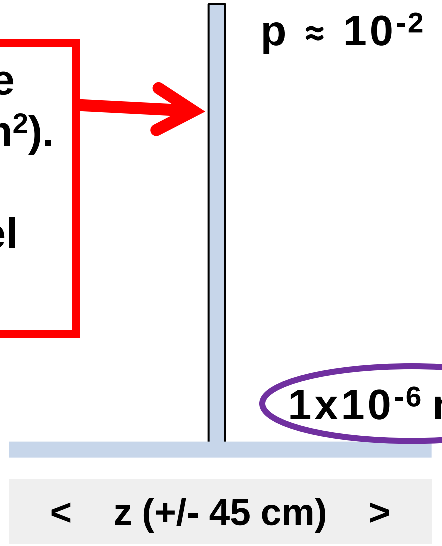
ANKE at COSY vacuum

Translate the cluster jet into a gas stream of the same width and target thickness (7×10^{14} at./cm^2). Take into account beam-target overlap, and estimate (guess) the expected background level in the vertex z-distribution: → ≈ **0.05 %**

$p \approx 10^{-2}$ mbar



1×10^{-6} mbar

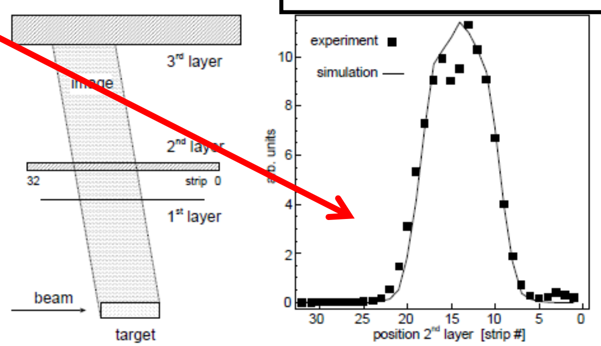
At ANKE, the interactions that occur outside of the cluster-jet gives a **background level of about 1 %** in the reconstructed vertex z-distribution of charged particle event.

$p \approx 10^{-7}$ mbar at SVP622, a gauge upstream target (?)

Pressure in scattering chamber? Guess (no vacuum calculations available)

6.4.1 Target Geometry

Example from I.Lehmann, PhD thesis 2003.



(a) Sketch of the principle (b) Target image in the 2nd layer

Figure 6.2: The target is projected onto a plane in the telescope by the selection of a fixed angle. The image (squares) is compared with the distribution from Monte Carlo simulations (line) [62] assuming a rectangular shaped target with a length of 9.5 mm.

It seems possible that a similar discrepancy between the real background level and the level expected from vacuum measurements as at WASA were present also at the ANKE cluster-jet target.

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WaC Pellet vacuum

WASA target thickness estimate from COSY-beam energy loss measurement in a pd run @1GeV in May

A) Cosy Beam (CB) energy loss measurements

(PS=Pellet-Stream)	Target thickn. [10^{14} at./cm^2]
Total (CB on PS)	**T** = 58.2
Ring (no PS)	**R** = 0.12 2%
Rest gas (CB off PS)	Rg < 0.1 << **R**
(Rest Gas (CB on PS)	**RG < 0.13 <2.2% estim.)**

Pellet-Stream PS = T-R-RG = 58

B) Vacuum (gauge) measurements
average in Cosy Ring (183m) and at Wasa (+/-1m)

	Vacuum [mbar]	→Target thickn. [10^{14} at./cm^2]
Total (CB on PS)		T =
Ring (no PS)	1E-8	R = 0.09-0.22 (air – H_2)
Wasa (CB off PS)	7E-7	Rg = 0.17
Wasa (CB on PS)	**9E-7**	**RG = 0.22**

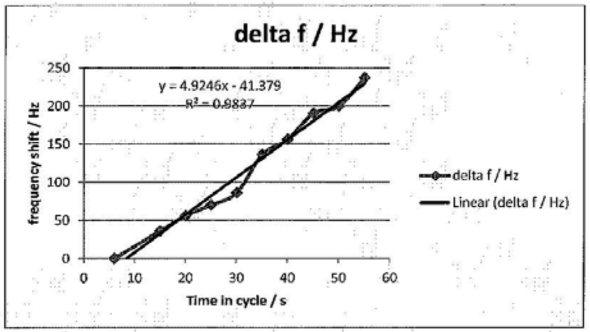
From the actual pellet rate, 12k/s, the obtained target thickn. of $6 \cdot 10^{15}$ at./cm^2 seems high … but it would be possible if pellet size is Ø=40µm ("Std"=30µm).

A estimate based on the pellet generation data:
Φ_{nozzle}=12 µm, $f_{droplet}$ = 55 kHz, p_{H2}= 690 mbar and $v_{droplet}$=20 m/s → $\Phi_{pellet} \approx$ 40 µm.

….. due to the relatively high driving pressure and the low nozzle frequency, big pellets should be expected.

Dieter Prasuhn Target thickness measurement for WASA 20-05-2014

Measured frequency shift vs time for the target thickness measurement:



Measured etha is 0.0485

The frequency shift due to target interaction is:

charge target	mass target	charge proj.	Mass proj.	momentum / MeV/c	kin. Energy MeV	max. Energy loss / MeV	spec energy loss / MeV/g/cm^2	spec enegy loss eV/atoms/cm^2
1	2	1	1	1700.000	1003.468	0.830	3.588	1.185E-17

momentum loss calculated by measured frequency shift:

delta f / Hz =	230.000	δp/p =	3.3150 *1e-03
f_0 / Hz =	1.430560E+06	δT/T=	4.91681 *1e-03
etha =	0.0485	ΔT=	4.93388 MeV
measurement time / seconds =			50.000
no. of turns for the measurement time			7.1510E+07

f0 / Hz= 1.430196E+06

mean energy loss per turn

calculated target-thickness = 5.822E+15 atoms/cm^2 6.899564E-02 eV

vacuum related target thickness = 1.183E+13 atoms/cm^2 at an average pressure 1.00E-08 mbar

This results in an assumed target thickness of $5.8 \cdot 10^{15}$ atoms/cm^2.

DP result: rgas ~ $1 \cdot 10^{13}$ at least << $1 \cdot 10^{14}$
(didn't see any difference to target off)

i) → $1.2 \cdot 10^{13}$
ii) → $5.8 \cdot 10^{15}$
iii) → same as i)

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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	Φ = 3.8 mm	Φ = 10 mm
Target thickness	Few times 10^{15} at./cm^2	Up to 10^{15} at./cm^2 (H_2)
Pressure in scatt.-chamber	≈ 10^{-6} mbar	≈ 10^{-6} mbar (guess)
Background level expected from vacuum situation	≈ 0.01 %	≈ 0.05 %
Background level from event reconstruction	≈ 0.2 %	≈ 1 %
<u>Results from COSY beam energy loss measurements:</u>	May 2014, pd @1GeV	2004, pp @2.65 GeV (published 2008)
Target thickness	$58.0 \cdot 10^{14}$ at./cm^2	$2.60 \cdot 10^{14}$ at./cm^2
Thickness no target	$0.12 \cdot 10^{14}$ at./cm^2	$0.14 \cdot 10^{14}$ at./cm^2
Thickness rest gas	< ”no target” value	$0.07 \cdot 10^{14}$ at./cm^2

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

Fig. 9.2 from Targets TDR (february 2012)

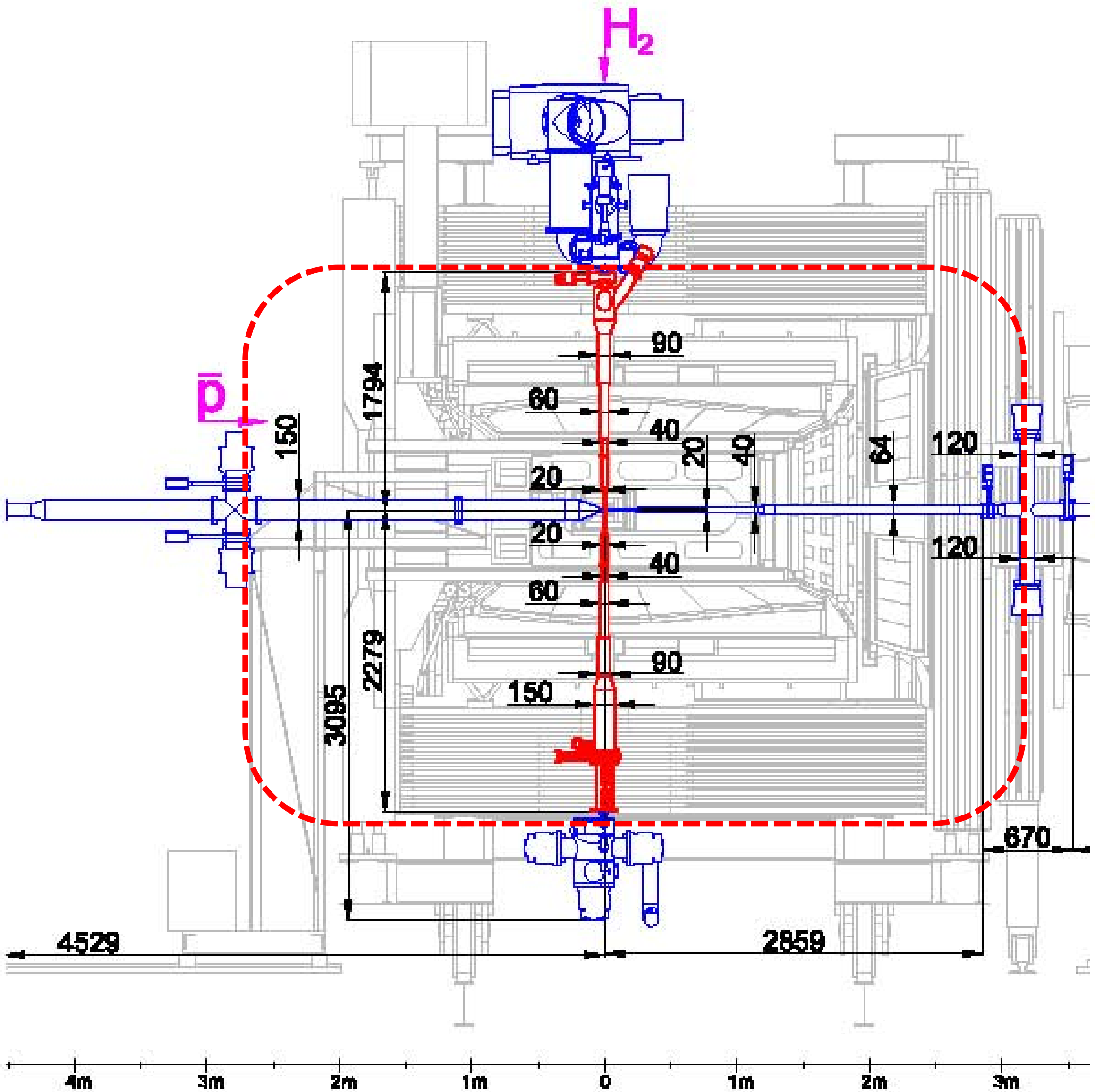

Figure 9.2: Cross section of the Target Spectrometer with detector components in light gray. The target and dump lines are marked in red. The antiproton beam line, as well as the cluster-jet target and the target beam dump, is marked in blue. The dimensions are given in mm. The diameters refer to inner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

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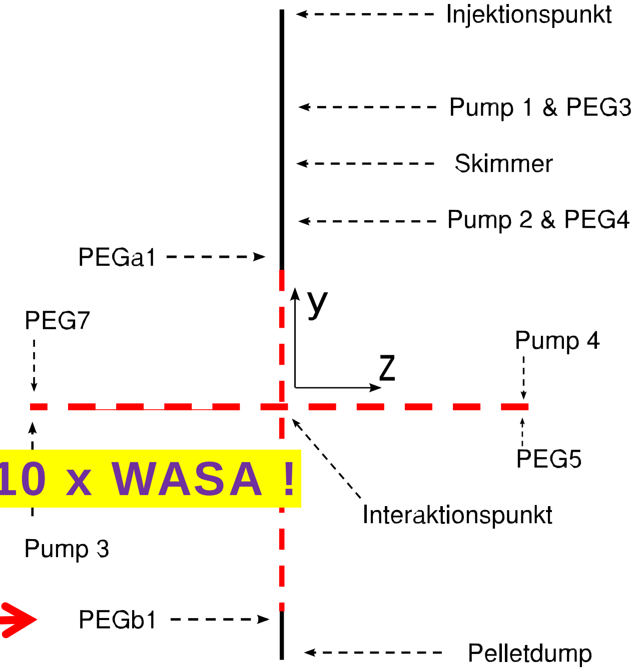
Calculated pressures with pellet target at PANDA

WaC pump configuration and nominal capacity

Measurem. point.	*Plts ON P [mbar]*	*Plts OFF P [mbar]*
PEG3	120×10^{-6}	130×10^{-6}
PEG4	9.5×10^{-6}	7.4×10^{-6}
PEGa1	10×10^{-6}	7.1×10^{-6}
PEG5	0.024×10^{-6}	0.004×10^{-6}
PEGb1	120×10^{-6}	1.5×10^{-6}
PEG7	1.8×10^{-6}	0.092×10^{-6}
Int.pt.	15×10^{-6}	0.67×10^{-6}

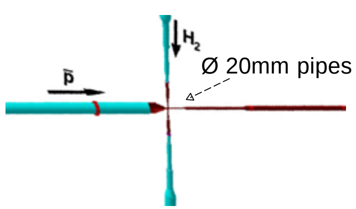
≈10 x WASA !



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	0.47	0.97
PEGb1	0.041	0.24
PEG7	0.42	0.89
Int.pt.	0.41	0.87

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



Comparison with TDR calculations by A. Gruber (~ 2010)
(also using VAKLOOP and target thickness ~ 4 × 10^{15} at /cm^2)

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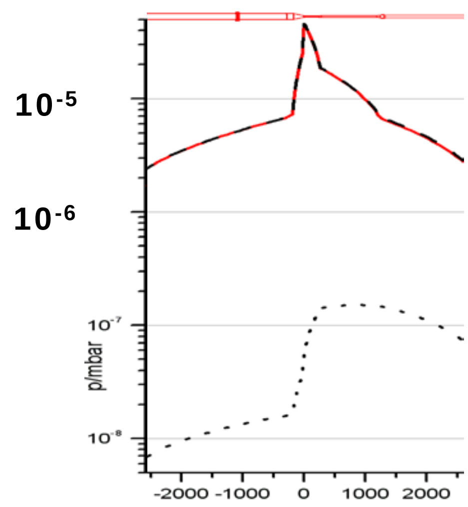
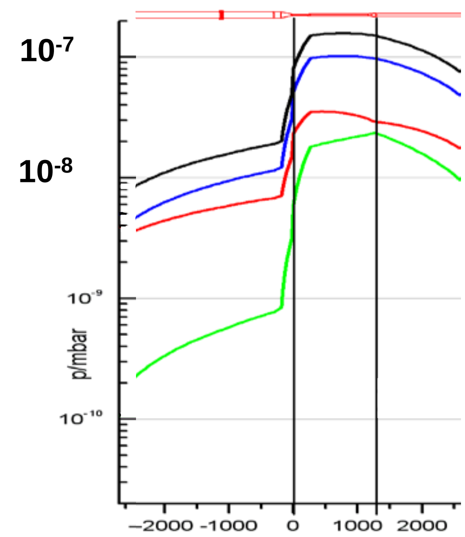
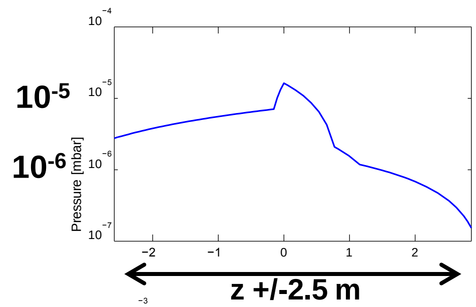
Pellets ON | Pellets OFF

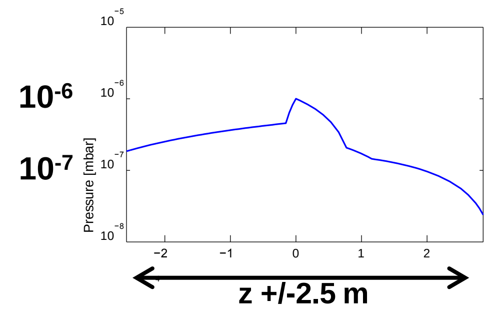
Results from TDR





Results using WASA model.





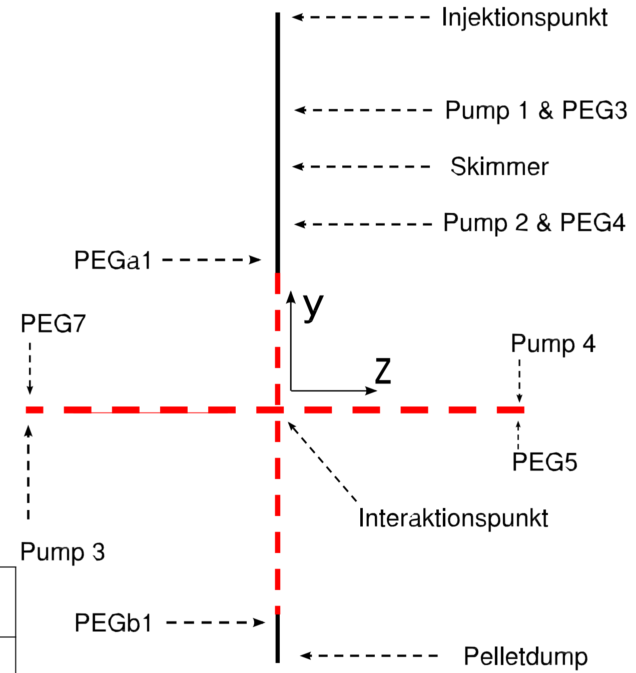
Pressures in mbar
along the accelerator beam line

Calculated pressures for pellet target at PANDA

PANDA Pellet vacuum

PANDA pump configuration

Pumps	*TDR (AG)*	*Wasa (JL)*
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	20.e-6
Dump	200.e-6	60.e-6
Int.point	40.e-6	10.e-6
Upstream	2.e-6	1.5e-6
Downstream	4.e-6	0.8 e-6

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

Pellets OFF

Int.point	2.e-7	10.e-7
Upstream	0.1 e-7	2.e-7
Downstream	1.e-7	1.e-7

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Summary (June 2014)

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Status of tasks connected to FP7 HP3 FutureJet:

3.6 Pellet track processing and optimization of pellet detection points

Detailed design simulations, based on the tracking section at the generator, for PANDA was done *(Milestone 13 report … January 2013)* .

Now the lower section at the dump is also included in the design …

3.7 Multi-camera readout system

h-w: 2nd version of CAMLINK FPGA board tested and works...
s-w: Complete readout chain (camera-to-computer) works.
Preparing for operation with 4 cameras under real conditions.

Status of other tasks:

- **Results of vacuum measurements at WASA (COSY) has been analyzed .... and compared with background in hadronic event distributions.**
  The results are used in evaluation of the vacuum situation at PANDA, e.g. for the need of "extra" pumps .... etc

- **A comparison between target related background conditions at WASA and at ANKE (COSY) was done.**
  The real physics background level seems to be much higher than what is expected from vacuum conditions for both pellet and cluster-jet target.

With the present vacuum system design, much worse conditions than those we have at WASA are anticipated !
Events from "rest-gas" must be included in simulations .....
so we can be able to judge if this is a serious problem ....

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Comments regarding new vacuum estimates for PANDA (Presented in the target group meeting, CM at GSI March 2014)

Results of vacuum measurements at WASA (COSY) have been analyzed .... and were compared with "rest-gas" background in hadronic event distributions.
Vacuum calculations, modelling WASA, reproduce well all the gauge readings both with pellets ON and OFF. From the results we expect that 0.5% of the total target thickness is due to residual gas in the narrow Be-pipe (l=200 mm, diam.=60 mm). From the event analysis we expect around 10%. The difference may be due to non optimal pellet stream conditions (that should be easy to improve in a new target design).

For making estimates for PANDA, the target cross was exchanged with the one for PANDA while the WASA pumping sections were kept in the model (the pumping capacity is similar). The calculations now gives 10 times higher pressure than in WASA at the interaction point for both pellets ON and OFF. From this we expect that 5% of the total target thickness will be due to residual gas in the narrow part of the PANDA beam-pipe (l=700 mm, diam.=20 mm). This should be considered as a lower limit. What the rest-gas background level in the event analysis will be, depends on the real quality of the target and accelerator beams.
Compared with the results presented in the Target TDR, the new calculations give 4 times lower pressure for pellets ON and 5 times higher pressure for pellets OFF at the interaction point. The TDR calculations actually gives a pressure with cluster-beam ON which is 60% lower than the pressure from the new calculations with pellets OFF.

With the present PANDA vacuum system design, much worse conditions than those we have at WASA must be anticipated !

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PANDA pellet tracking system

Project planning (June 2014)

Design: Conceptual and system design ready (TDR +++).
Detailed mechanical design remains.
Detailed camera r/o and control system in progress.

Preparation of a tracking section for PANDA:
Not funded.

Risks: Evaluation done (most recent one in autumn 2013).

Financing, applications: (Approval of TDR may help ...)
Running: SRC application 2015-18 submitted.
HPH application 2015-17 to be submitted.
Equipment: KAW application was (strongly) rejected.
CTS application(30k€) 2015-16 submitted.
No other possibility in SE at present.

Time line: If applications for running are successful some design and development work can continue. If the CTS application is approved one (of seven) detection module can be prepared.
Preparation of main equipment must still wait.

PTR items for FAIR Risk Management

PTR-001

Multi-Camera readout. Delay … Many other tasks relies on tests with multi-camera setup … (mainly resource issue)

PTR-002

Operation in magnetic field. Tests done, (if problems later … design shielding)

PTR-003

Overheating of cameras. Studies done, (if problems later … provide cooling)

PTR-004

Too poor conditions for pellet detection at the dump. Tests done at UPTS … (adapted design)

PTR-005

Instability of mechanical alignment. Design … (minimize risk, allow fine-tuning)

PTR-006

Too poor access for mechanical tuning and replacement of malfunctioning parts.
Design … (allow fine-tuning, special tools)

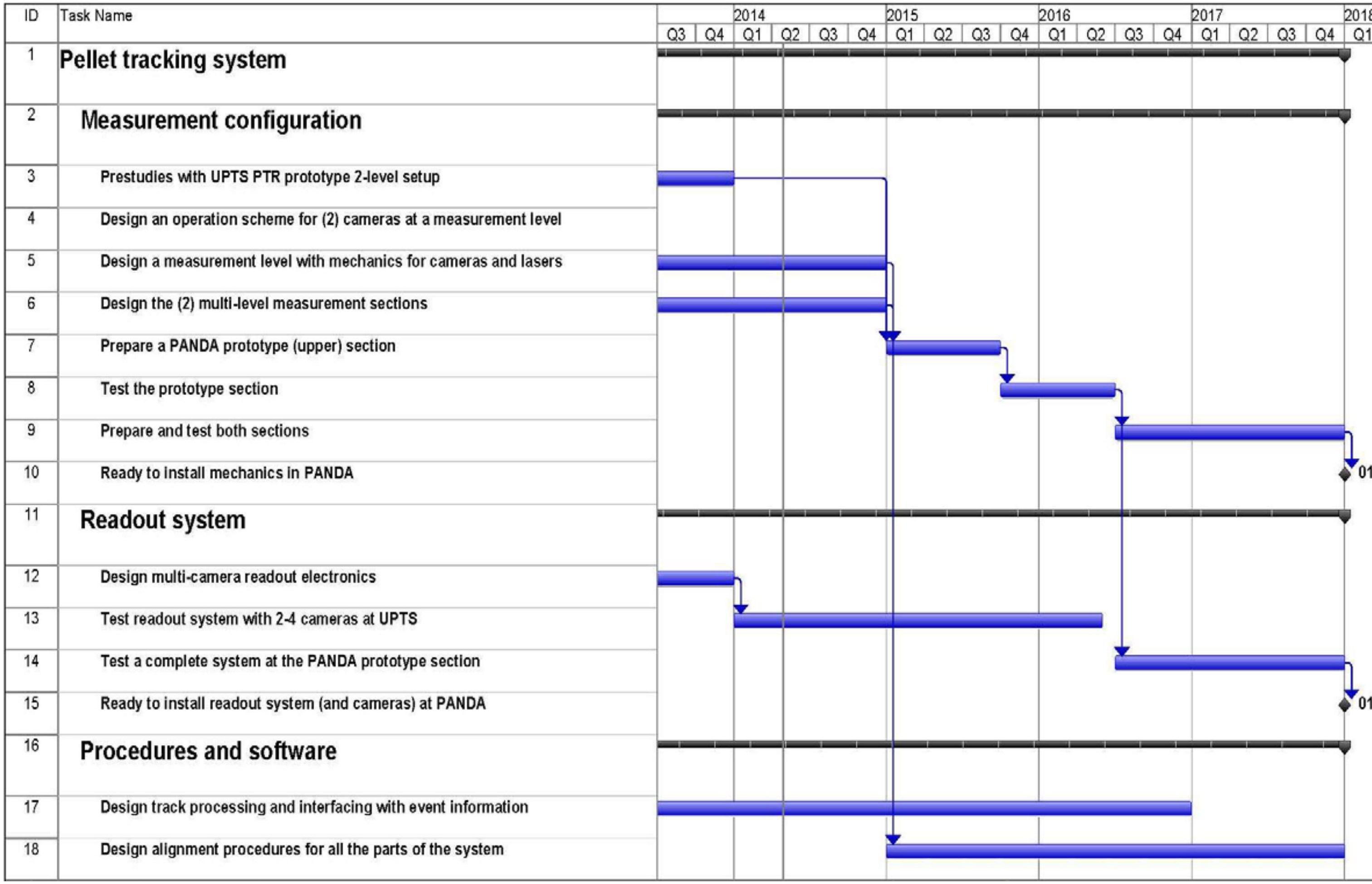
PTR-007

Insufficient resources for development and preparation of a full prototype section.
Mainly personnel. No financing …

PTR-008

Insufficient resources for preparation of full system to be installed at PANDA.
Equipment and personnel. No financing ...

Project plan for the pellet tracking system developments 2014-2017



UPTS at TSL

Need for new funding (pers+eqpt)

EC HP3+HPH: 30% eng (+cons)

SRC: 20% eng (+cons+eqpt)

PhD student: (JU/UU)

JCHP-FFE: (pers 2009-2014)

UU pers (55% res, 20% eng)

(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/H=Hadron Physics 3/Horizon, SRC=Swedish Research Council, JCHP-FFE=Jülich Center for Hadron Physics – Fremde Forschung und Entwicklung)

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