WASA and PANDA vacuum system calculations, target thickness studies at COSY and implications for background in the physics experiments.

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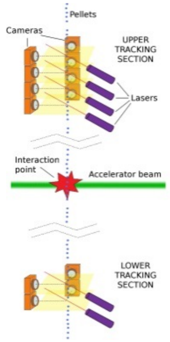
Work done during 2013 and Spring 2014:

- **Vacuum studies at WASA (COSY) and estimates for PANDA.**
  (Johan Löfgren: Vacuum Calculations For Hydrogen Pellet Targets at WASA and PANDA, Johan Löfgren, April 2014, Project report, http://urn.kb.se/resolve?urn=urn:nbn:se:uu:diva-222973)

- **Implementation of pellet tracking in physics experiments – initial studies at WASA**
  (Andrzej Pyszniak: Data analysis. Part of PhD thesis Jan 2015)

- **Vacuum and target thickness studies at COSY and implications for PANDA.**
  (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, Dan Wessman
Project worker:	Johan Löfgren

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

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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

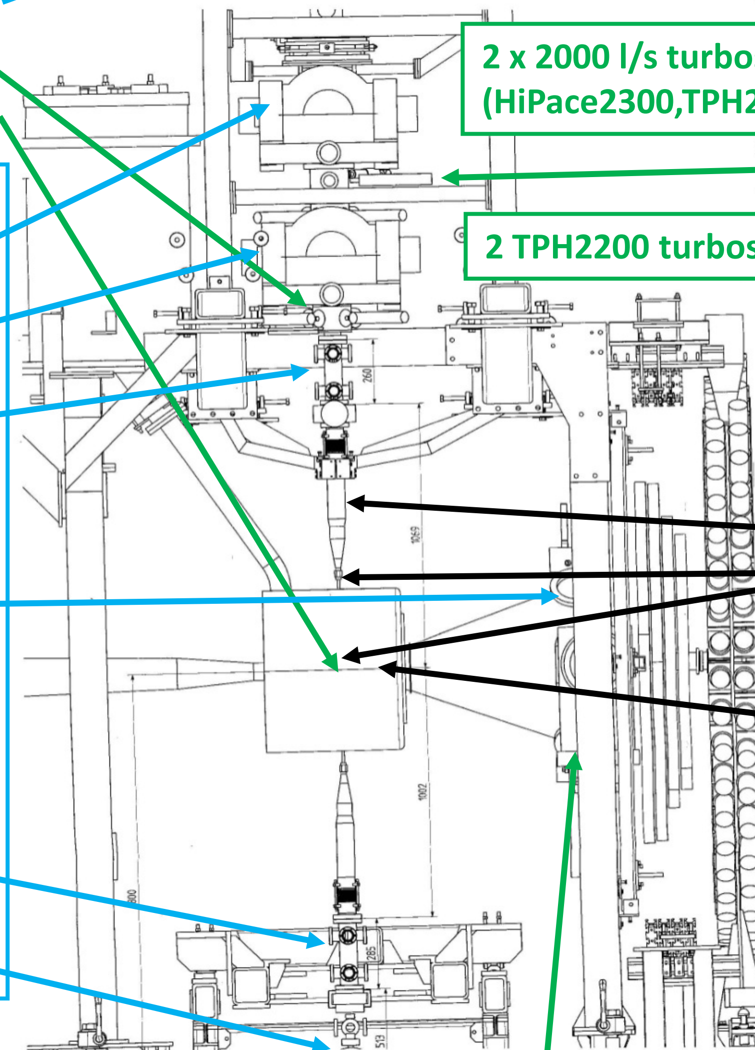
VIC exit

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

2 TPH2200 turbos

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 l/s cryo



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

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

Forw. cone 2 Leybold 1500 l/s cryos

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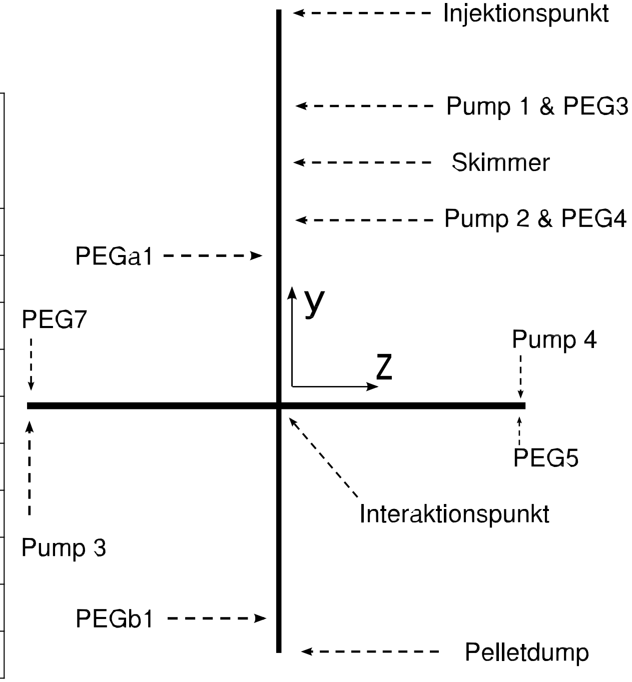
Calculated pressures w/o and with pellets at WASA

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}	-

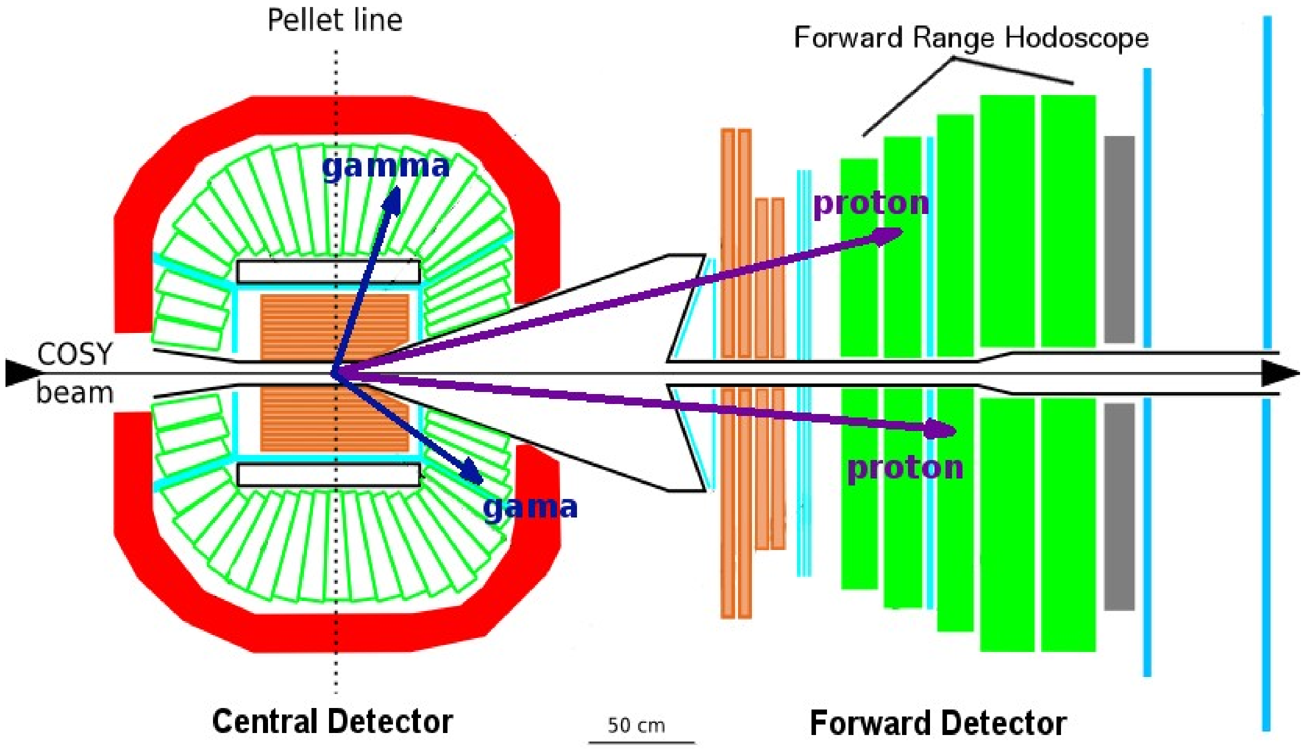
Open shutter (P_o = *measured*)

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}	-

Check of rest-gas event suppression

Test reaction: $pp \rightarrow pp\pi^0 \rightarrow pp\gamma\gamma$

Pbeam = 1.023 GeV/c $\Leftrightarrow$ E_{kin} = 0.45 GeV



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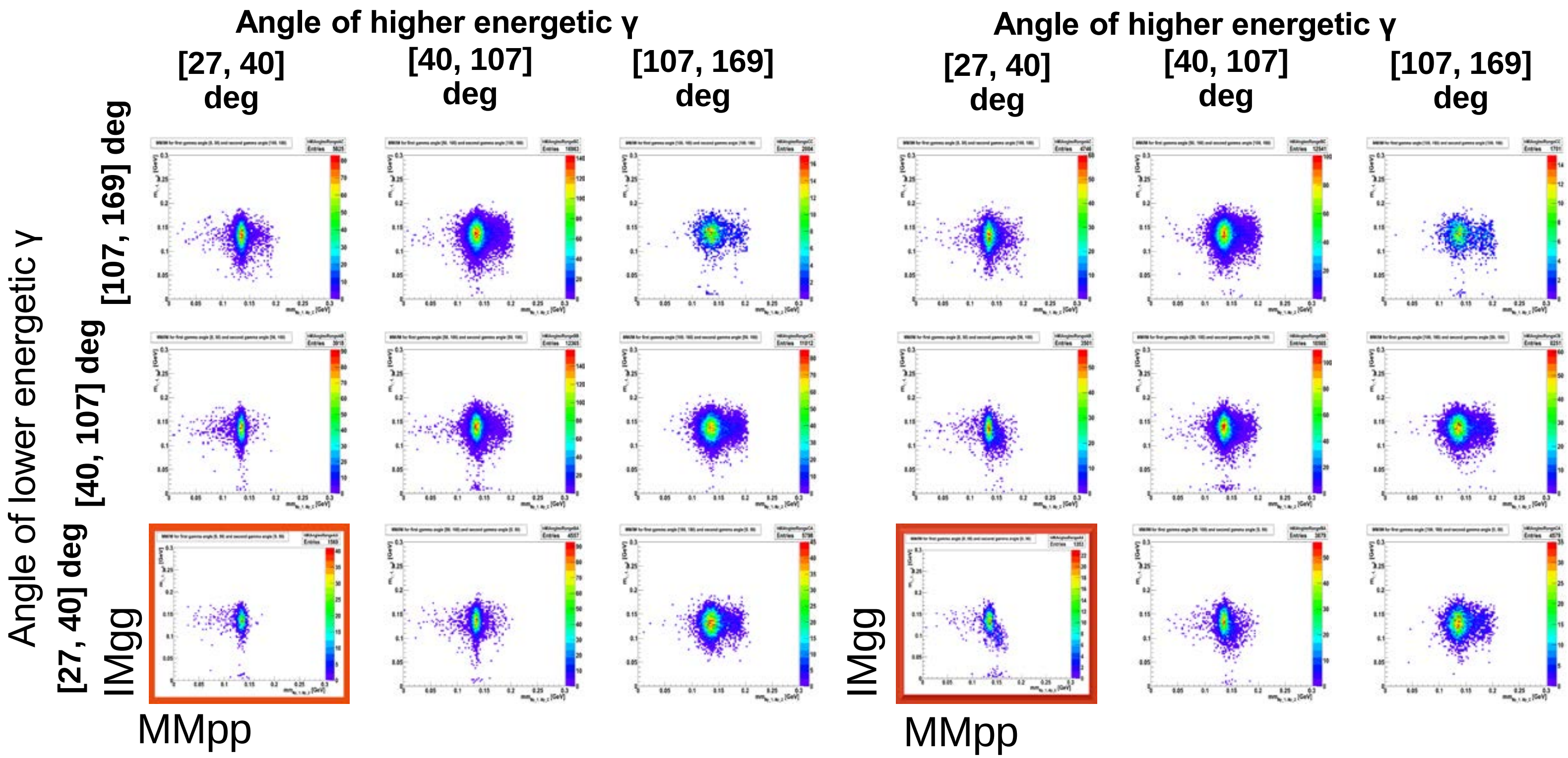
Missing and invariant mass for different gamma angles

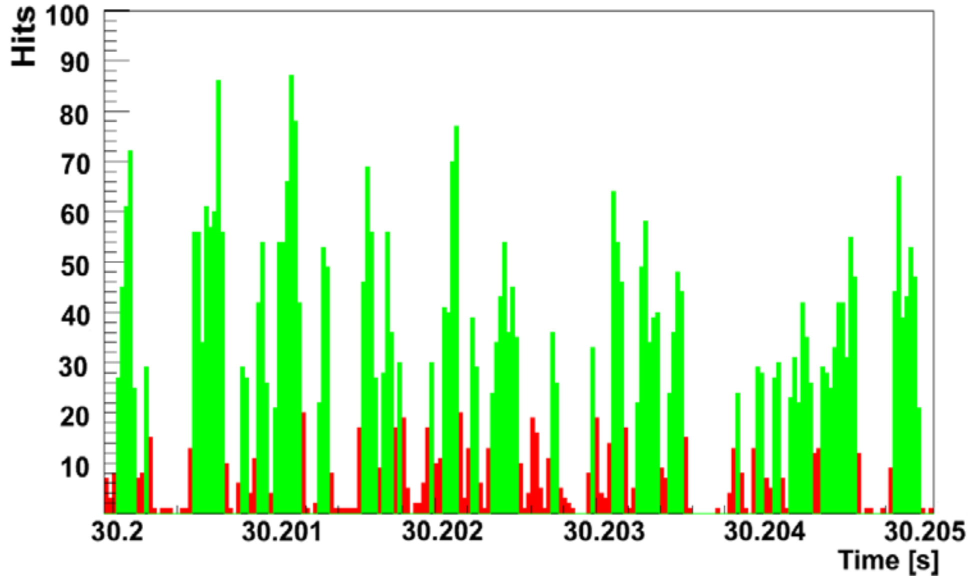
Wasa MC without rest-gas **Wasa MC with 23% rest-gas**



Influenced by the rest-gas contribution:

- Shape of the 2-dim IMγγ-MMpp distribution
- Width and position of the π^0 peak
- Distribution of events between the 9 angle combinations

Events classification from Long-Range TDC
pp elastic scattering event rates)



5 ms

Non-Pellet class

Small instantaneous event rate ⇔ Small probability of pellets in the beam region

0 – 20 events in a 25 µs bin

Pellet class

High instantaneous event rate ⇔ High probability of pellets in the beam region

21+ events in a 25 µs bin

Ranges adjusted to correct for accelerator beam decaying during the cycle
(At the end, the beam intensity ≈ 50 % of initial intensity)

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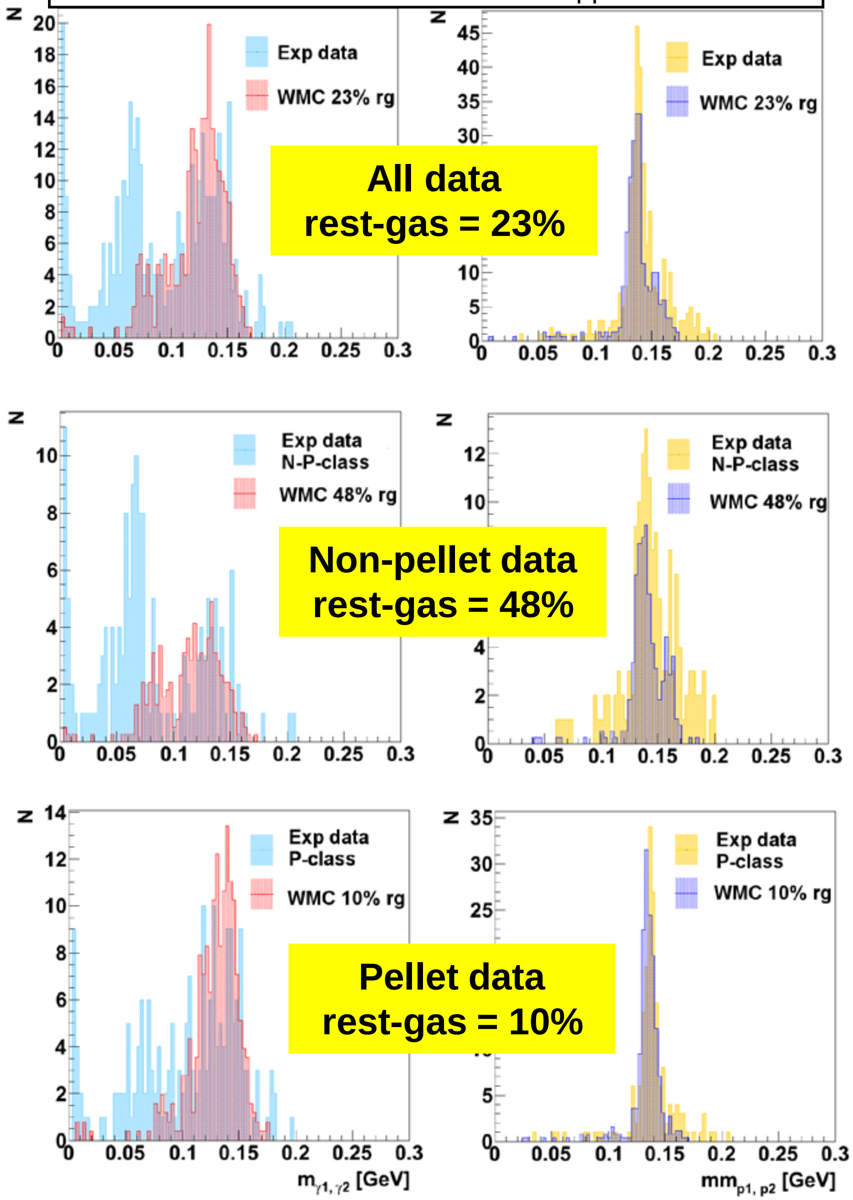
Background study at WASA pp-> pp π^0 run (π^0-> $\gamma\gamma$)

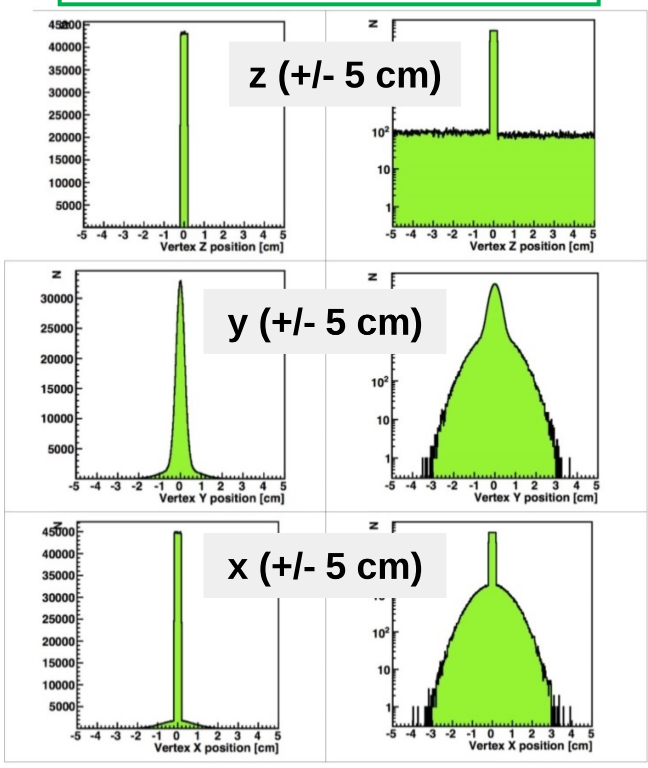
WaC Pellet vacuum

IM$\gamma\gamma$ (GeV/c^2) MM$_{pp}$ (GeV/c^2)



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

Lin scale Log scale



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Background due to “rest-gas” at WASA

WaC Pellet vacuum

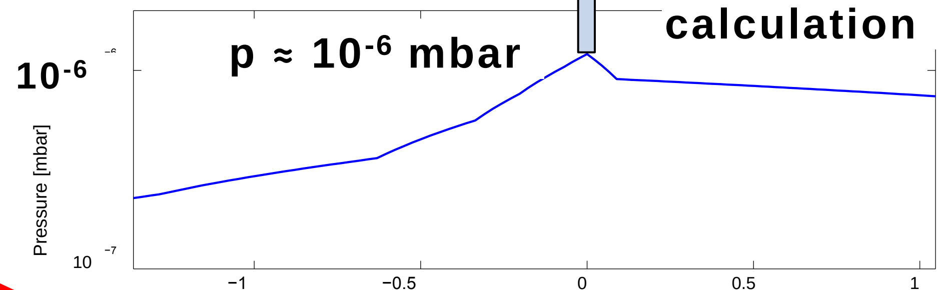
p ≈ 10^{-1} mbar

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 %

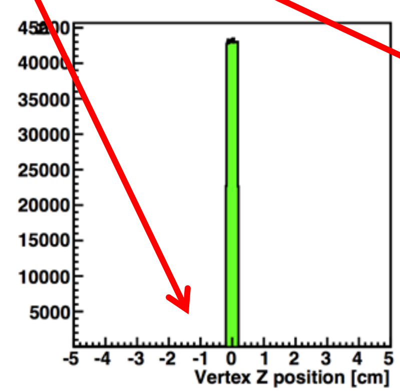
At WASA, the interactions that occur outside of the pellet-stream gives a **background level of typically 0.2 %** in the vertex z-distribution (25% so called rest-gas contribution in MC)

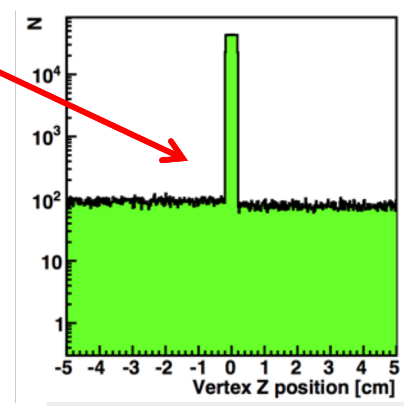
Vacuum calculation

p ≈ 10^{-6} mbar



< z (+/- 50 cm) >





< 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

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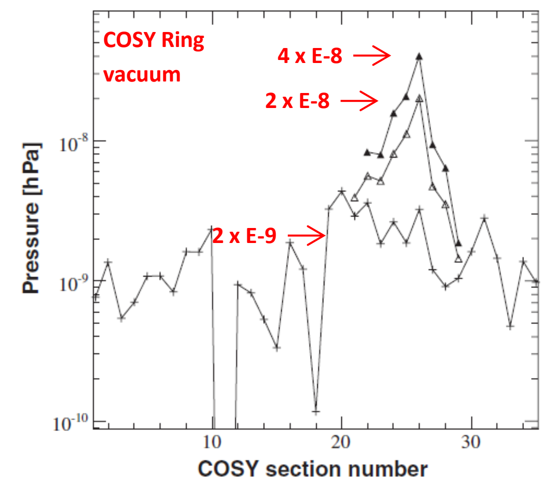
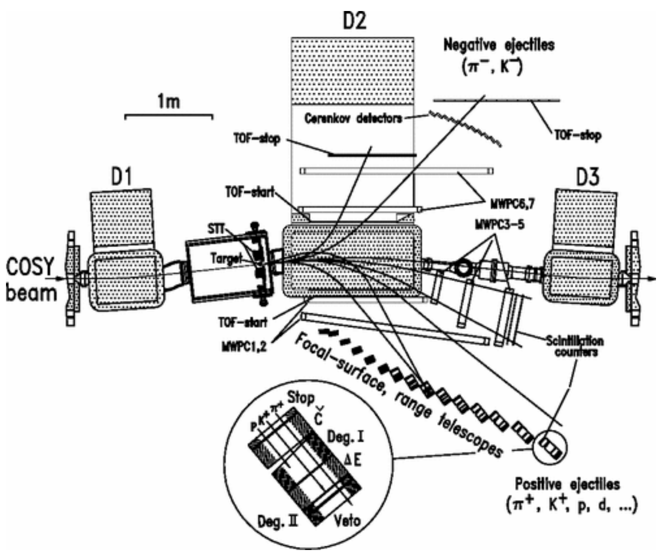
(Received 23 January 2008; published 22 May 2008)

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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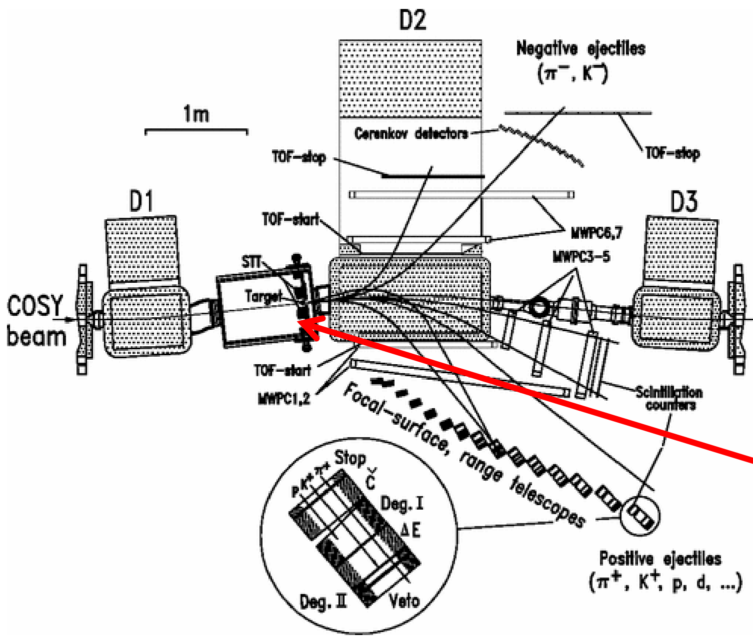
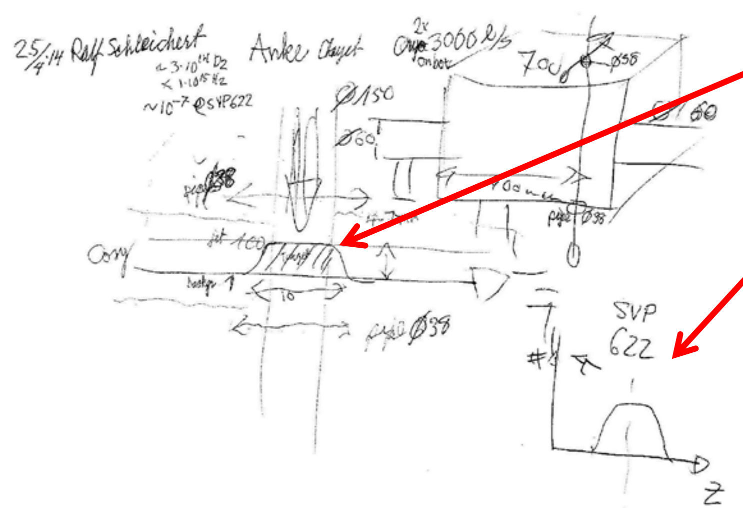




Target conditions at ANKE Cluster-Jet

What info exist about background conditions at ANKE ?

Here are some notes from discussions with Ralf Schleichert, Michael Hartmann and other ANKE colleagues during Spring 2014 ....

- **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 $1 \cdot 10^{15}$ at./cm2 for H2 and $3 \cdot 10^{14}$ 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 of interactions outside of the jet is typically around 1% of the value inside the jet region .

Background due to "rest-gas" at ANKE

ANKE at COSY vacuum

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

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 %

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 (?)

1×10^{-6} mbar

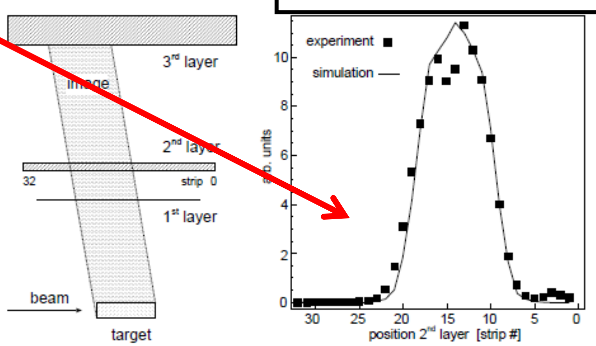
< z (+/- 45 cm) >

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

It seems 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.

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.

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

WaC Pellet vacuum

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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 0.2%
Rest gas (CB off PS)	Rg < 0.06 << **R**
(Rest Gas (CB on PS)	**RG < 0.07 <0.12% 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**

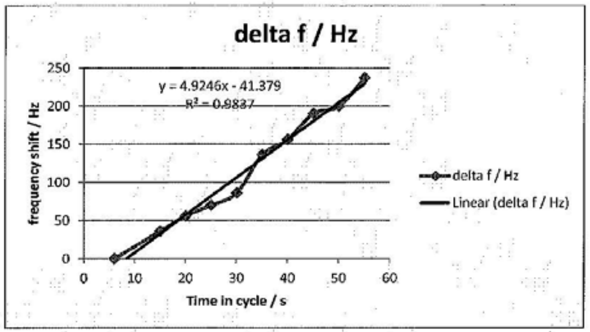
From the actual pellet rate, 12k/s, the obtained target thickn. of $6\cdot10^{15}$ at./cm^2 seems high … but it would be possible if pellet size is Ø=40µm ("Std"=30µm).

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:



$N_c \sim 5\cdot10^9$
$f = 1.43$

Measured etha is 0.0485

PR ~ 12 k/s, v = 70 m/s } d_p ~ 6 mm

The frequency shift due to target interaction is: Φ ~ 25µ → $4\cdot10^{14}$ at → $1.5\cdot10^{13}$ at/cm² in Ø6 beam

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 = 1.430195E+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 $5.8*10^{15}$ atoms/cm^2.

20/5-14 1730

DP result: rgas ~ $1\cdot10^{13}$ at least << $1\cdot10^{14}$ (didn't see any difference to target off)

i) ⟶ $1.2\cdot10^{13}$
ii) ⟶ $5.8\cdot10^{15}$
iii) ⟶ same as i)

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)
Background level expected from vacuum situation	≈ 0.01 % (H_2)	≈ 0.05 %
Background level from event reconstruction	≈ 0.2 % (eg pp@0.5 GeV)	≈ 1 %
<u>Results from COSY beam energy loss measurements:</u>	May 2014, pd @1GeV	2004, pp @2.65 GeV (published 2008)
Target thickness	58.0·10^{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
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

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	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 ....

Fig. 9.2 from Targets TDR (february 2012)

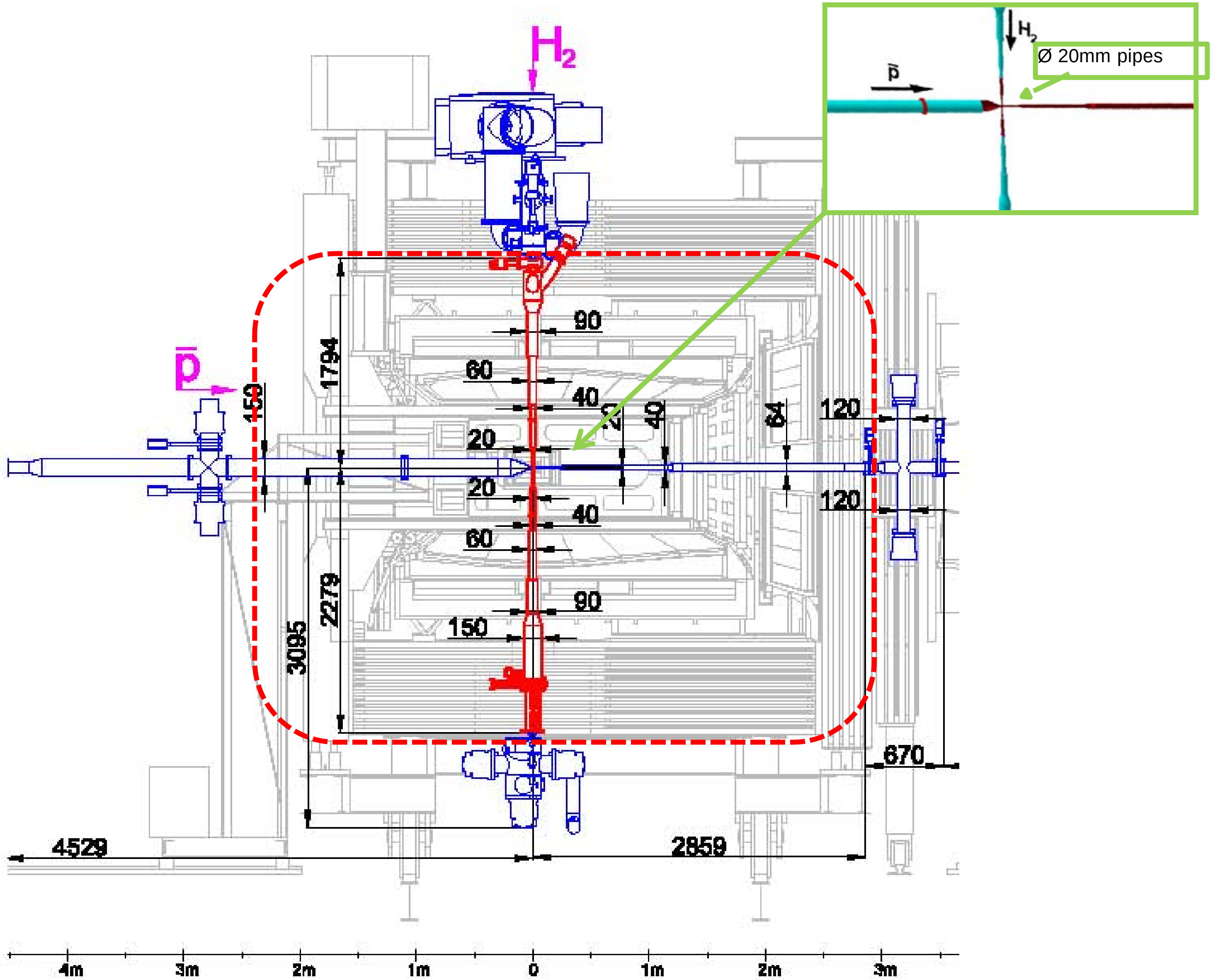

Figure 9.2: Cross section of the Target Spectrometer with detector components in light gray. The target and dump lines are marked in red. The antiproton beam line, as well as the cluster-jet target and the target beam dump, is marked in blue. The dimensions are given in mm. The diameters refer to inner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

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Calculated pressures with pellet target at PANDA

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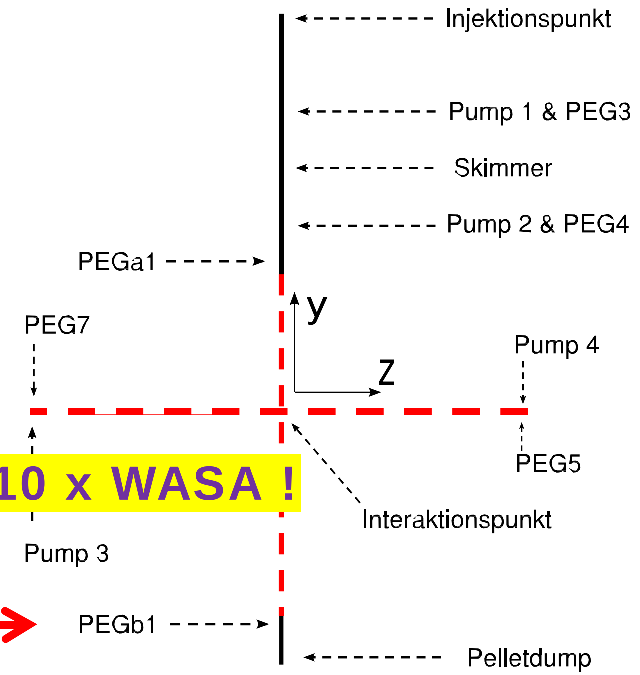
WaC pump configuration and nominal capacity

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}

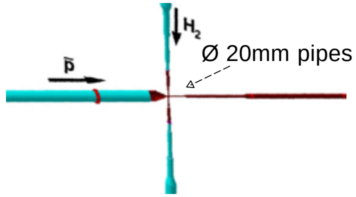
≈10 x WASA !



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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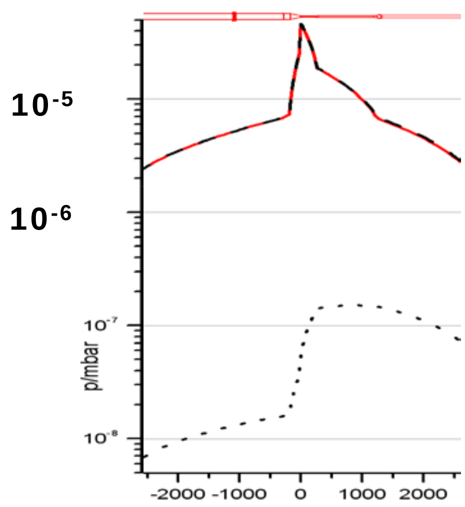
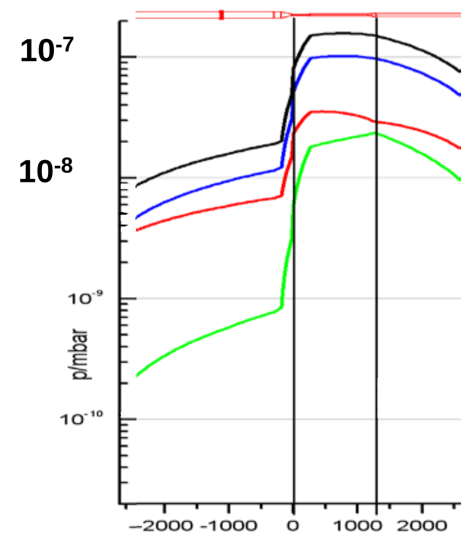
Pellets ON

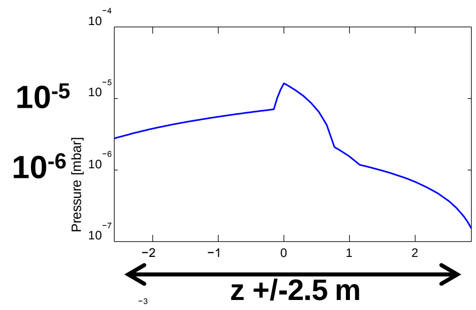
Pellets OFF

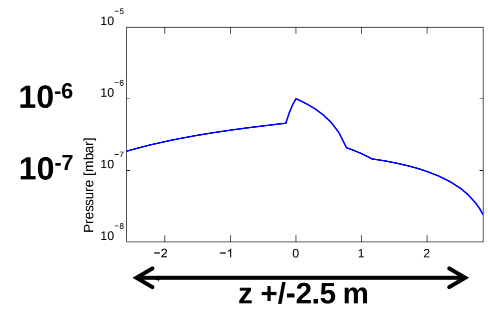
Results from TDR





Results using WASA model.





Pressures in mbar
along the accelerator beam line

Calculated pressures for pellet target at PANDA

PANDA Pellet vacuum

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PANDA pump configuration

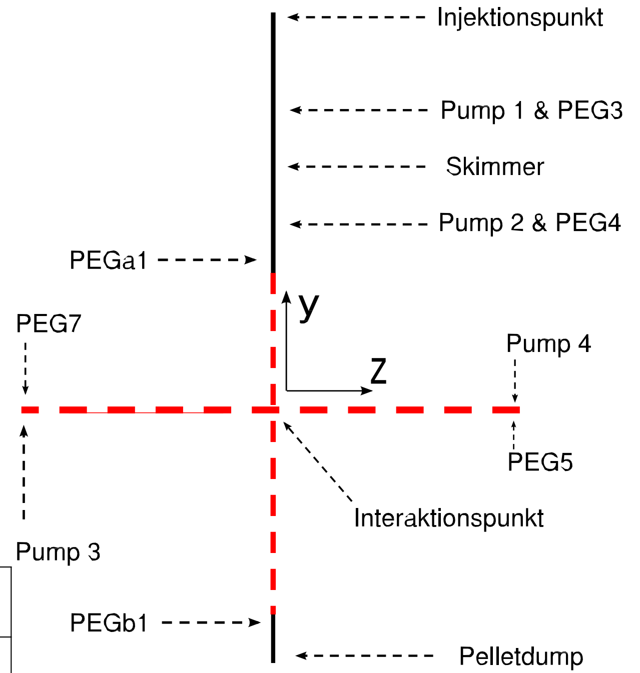
Pumps	*TDR (AG)*	*Wasa (JL)*
Generator	**2x360 l/s**	**4000 l/s**
Dump	**-**	**1000 l/s**
Upstream	**2x1000 l/s**	**1500 l/s**
Downstream	**2x700 l/s**	**3000 l/s**

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**

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**



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

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Target condition studies at COSY

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 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)

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 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 suggestion :

Tests of PANDA clusterjet at COSY

Using parts of WASA for testing of the PANDA clusterjet would give the possibility to make direct comparisons with WASA performance for measurements of physics reactions under real experimental conditions.

Different variants have been discussed. The best would probably be to use both parts of the FD and the CsI calorimeter for measurement of the pp -> ppgg reaction. Then we can really establish the experimental conditions in a setup with similar geometry as PANDA.

A nice thing is that the gammas are not very sensitive to material in the way, ie the detailed design of the scattering chamber. Eg can a st.steel Panda cross be installed and studied with respect to background situation. Another advantage is that there are established simple data analysis software that many people are well experienced with.

The suggestion is to use (keep) the following detector parts:

- **SEC, SEF (iron yoke w/o back endcap halves),**
- **PSC, PSF (or use some other plastic veto counters instead of PSC),**
- **FPC, FRH and FHD (or FWC).**

This means removing the solenoid (no thin holes), removing MDC (new PANDA-like target cross) and some FD scint. planes can be skipped (especially for pi0 case).

The PSC must be modified at the target pipe and a new support (cylinder) is needed. The forward cone of the scattering chamber will stay. There is a welding flange that was intended for possibility of replacing the MDC-Be-pipe part. It can be cut (grinded) and a new central part can be welded in place of MDC. There could be inserted a flange allowing for simple changes between different variants of target cross.

If there is lack of space for jet dump one can remove some PMTs (holders) at the target pipe. One could even separate the calorimeter halves a little, but in that case the setup is changed and analysis programs must be modified.

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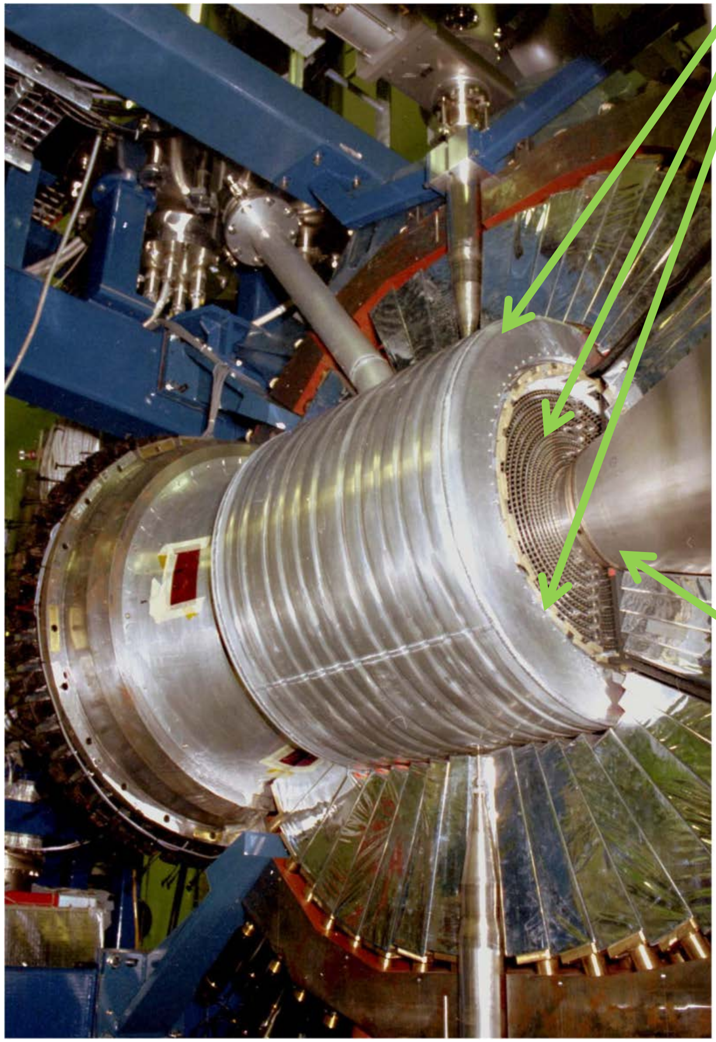
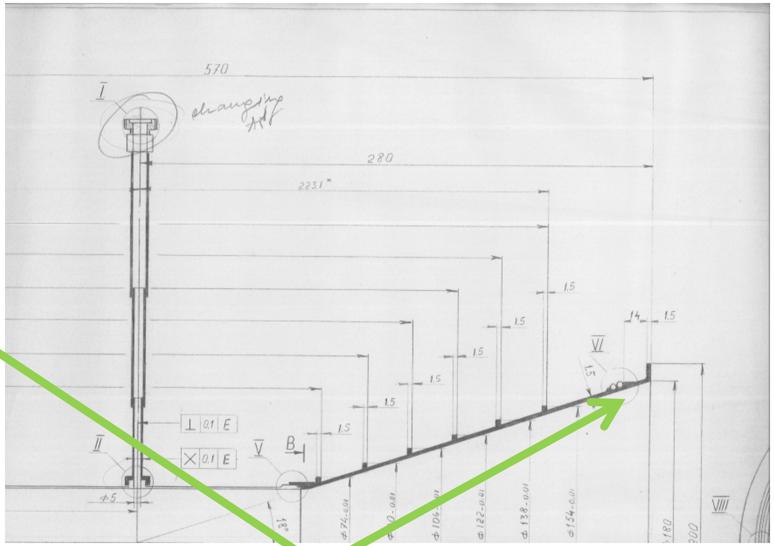
WASA CD

The suggestion is to use (keep) the following detector parts:
- **SEC, SEF (iron yoke w/o back endcap halves),**
- **PSC, PSF (or use some other plastic veto counters instead of PSC),**
- **FPC,FRH and FHD (or FWC).**

This means removing the solenoid (no thin holes) removing MDC (new PANDA-like target cross). The PSC must be modified at the target pipe and a new support (cylinder) is needed. The forward cone of the scattering chamber will stay.





There is a welding flange that was intended for possibility of replacing the MDC-Be-pipe part. That can be cut (grinded) and a new central part can be welded in place of MDC. There could be inserted a flange allowing for simple changes between different variants of target cross.

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PANDA CM
FZJ, Dec 2014
Hans Calén

UPPSALA
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WASA/PROMICE ...... (CHiC) ...
Scattering chamber and windows for sale at TSL (?)

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Comments regarding new vacuum estimates for PANDA (Presented 1st time in the target group meeting, CM at GSI Mar14)

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 one would 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).

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 speed is similar). The calculations now gives 10 times higher pressure than at WASA at the interaction point for both pellets ON and OFF.

From this model, 5% of the total target thickness will be due to residual gas in the narrow part of the PANDA beam-pipe (l=230 mm, diam.=20 mm).

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

In the hadronic event distributions a 20x higher background level than expected from vacuum calculations was observed at WASA.

A comment after TGT group session, CM at GSI June 2014

One should not rule out the pellets in favour of the clusterjet for the high luminosity mode (i.e. with target thickness > 1e15 at/cm2) of running yet. From the studies of physics background in WASA and ANKE at COSY, it seems that the cluster-jet would 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 result 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 "restgas" 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 still 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.
The background level will probably set the real limitation for usable target thickness with cluster-jet. It is not only that the accelerator beam can survive.

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

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