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News from the UPTS

- **Multi-camera system developments.**
  Readout electronics.
  Mechanics (at UPTS) for additionally 2-4 cameras with lasers being prepared.

- **Studies with pellets at UPTS**
  Beam conditions as for PTR mode of pellet operation at PANDA
  Position resolution, accuracy of extrapolated pellet position.
  DOF … effect of bad focus , pixel clustering.
  Efficiency of pellet detection.
  Rates etc… with different laser configurations.

- **Detailed system design for PANDA with optimized pellet detection levels.**
  Position resolution and efficiency studies.
  Comparison of detection level configurations xzxz and zxxz.

- **Installation of the PTR system in the yoke recesses.**
  Model studies.

- **Vacuum studies at WASA (COSY).**
  Added PEG vacuum gauges in February ….

UPPSALA team

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

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

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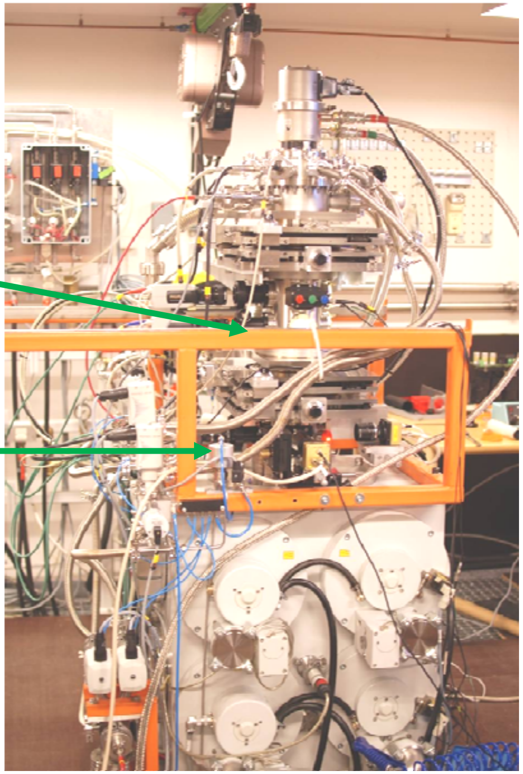
PTR at UPTS

Measurement levels

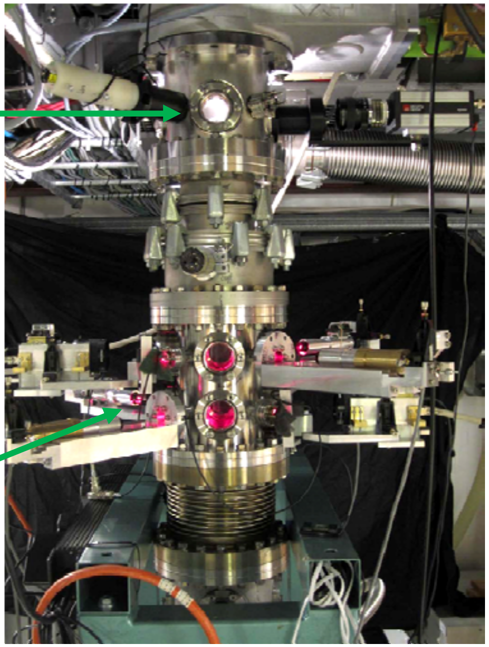
Below VIC one level for a cam and a laser at 90°

Generator floor with one level for two cams (x,z) and one laser at 135°



Dump floor at top of skimmer with one level for 2-4 cams (x,z) with lasers at 135°

Dump floor with two levels for 2-4 cams (x,z) with lasers at 135°



Windows center position vertical distance (mm)

-76.5	DC	
0	VIC exit	
271.5	PTR gen	
1513.0	Skimmer	0
1860.2	PTR upper	347.2
1939.7	PTR lower	426.7
(2690	Cosy beam	1166.5)
(3500?	HESR beam)	

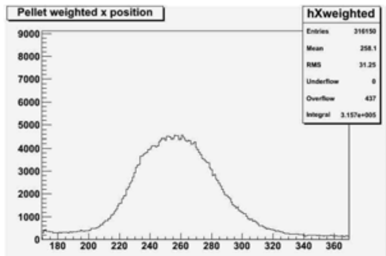
Pellet tracking
Panda CM
CNRS Paris
2012-09-10

UPTS performance August 2012

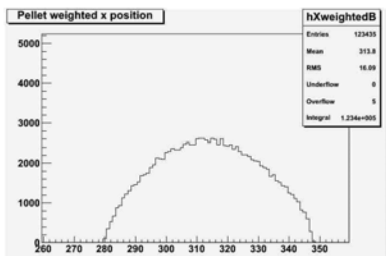
Pellet generation conditions:
Nozzle 270 (Φ=12.9 μm), T_N=14.1 K
$f_{droplet} \approx$ 63kHz, $p_{H2} \approx$ 400 mbar
$p_{droplet\_chamber} \approx$ 21mbar
$v_{droplet}$ =22 m/s, $d_{droplet}$ = 0.34 mm

pellet Φ=25-30 micron (guess)
v_{pellet} =77.9 m/s, σ_v/v_{pellet} = 0.42%

$P_{pump\_block} \approx$ 1.2 e-3 mbar

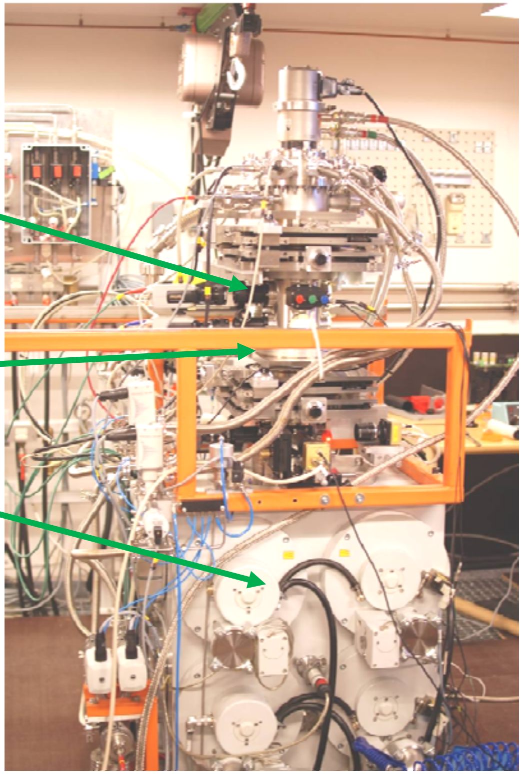


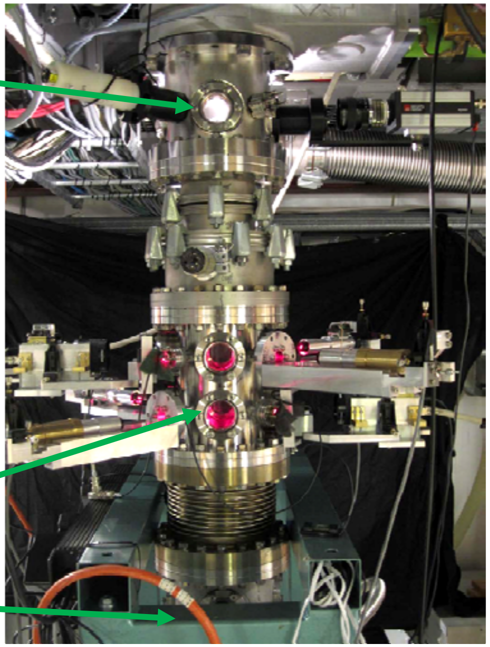
Above skimmer: PR ≈ 57 kHz
FWHM=2.1mm FW ≈ 3.7 mm



PTR chamber: PR ≈ 22.5 kHz
FW=2.5 mm

$p_{dump} \approx$ 2.e-2 mbar





Windows center vert. dist. (mm)

-76.5 DC
0 VIC exit

271.5 PTR gen

1513.0 Skimmer
Φ=2 mm

1860.2 PTR up

1939.7 PTR low

(2690 Cosy beam)
(3500? HESR beam)

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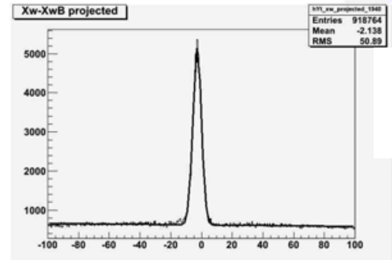
Pellet tracking
Panda CM
CNRS Paris
2012-09-10

Pellet track reconstruction and extrapolation.

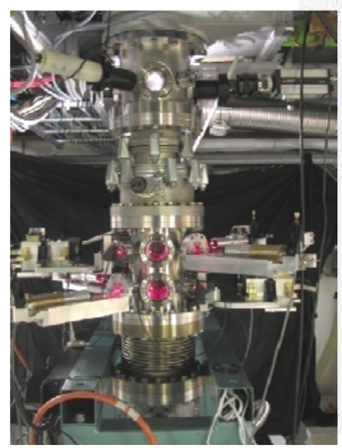
Measure pellet positions at the dump floor.
Select hits from pellets with "right" velocity and reconstruct tracks.
Extrapolate the tracks to the VIC exit where the pellet beam is known (seen on monitor) to have a diameter of 50-100 μm.



Extrapolated track positions at VIC : σ≈ 100 μm

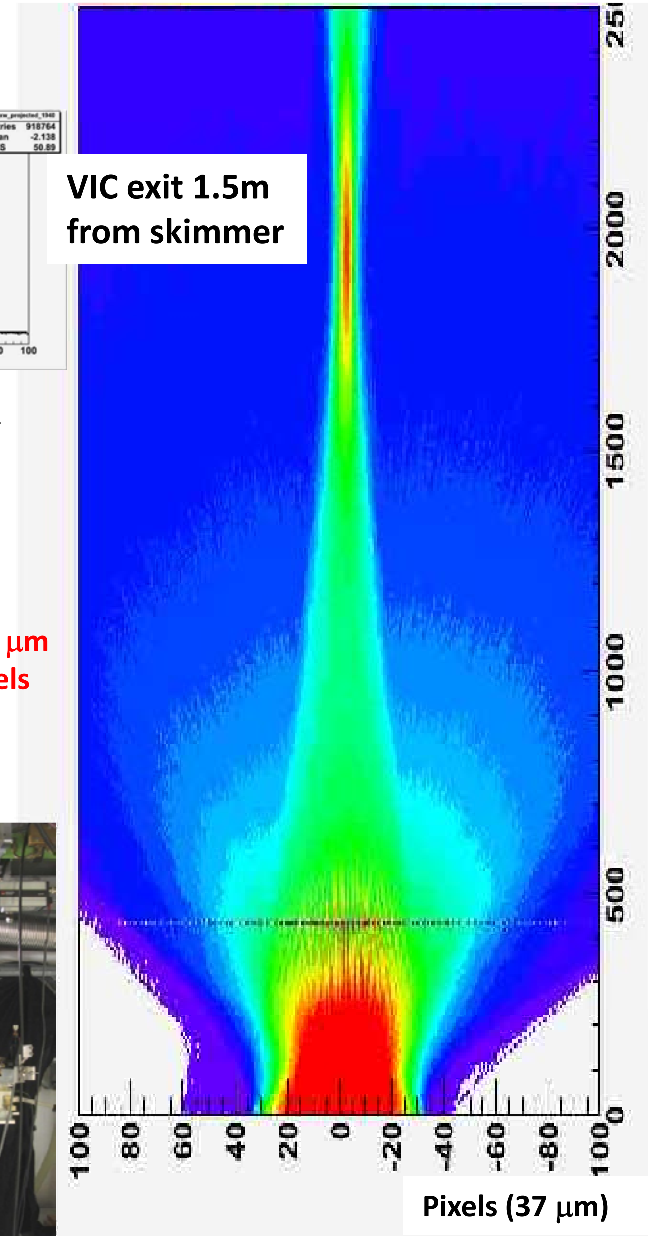
This corresponds to a position accuracy σ ≈ 20 μm at the measurement levels (pixel size ↔ 37 μm).

Positions measured just above skimmer and in PTR chamber.
Lever arm = 427 mm.
Pellet beam size ≈2 mm.



Accuracy of extrapolated pellet position

Pellet track x-distribution versus vertical position



Pellet tracking
Panda CM
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2012-09-10

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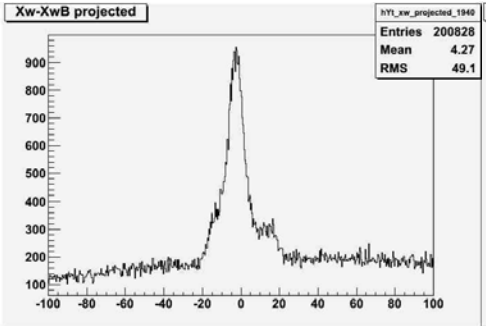
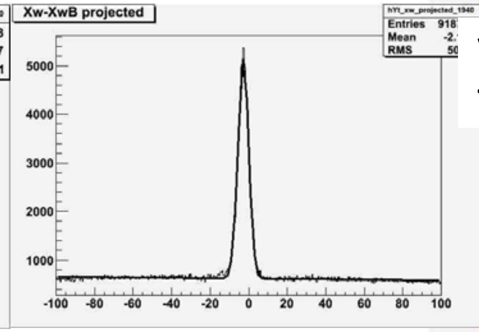
Pellet track reconstruction and extrapolation.

Pellet beam a few mm out of camera focus ….

Pellet beam in camera focus

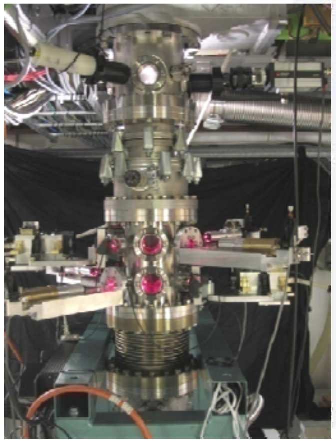




Must avoid/control out of focus effects …

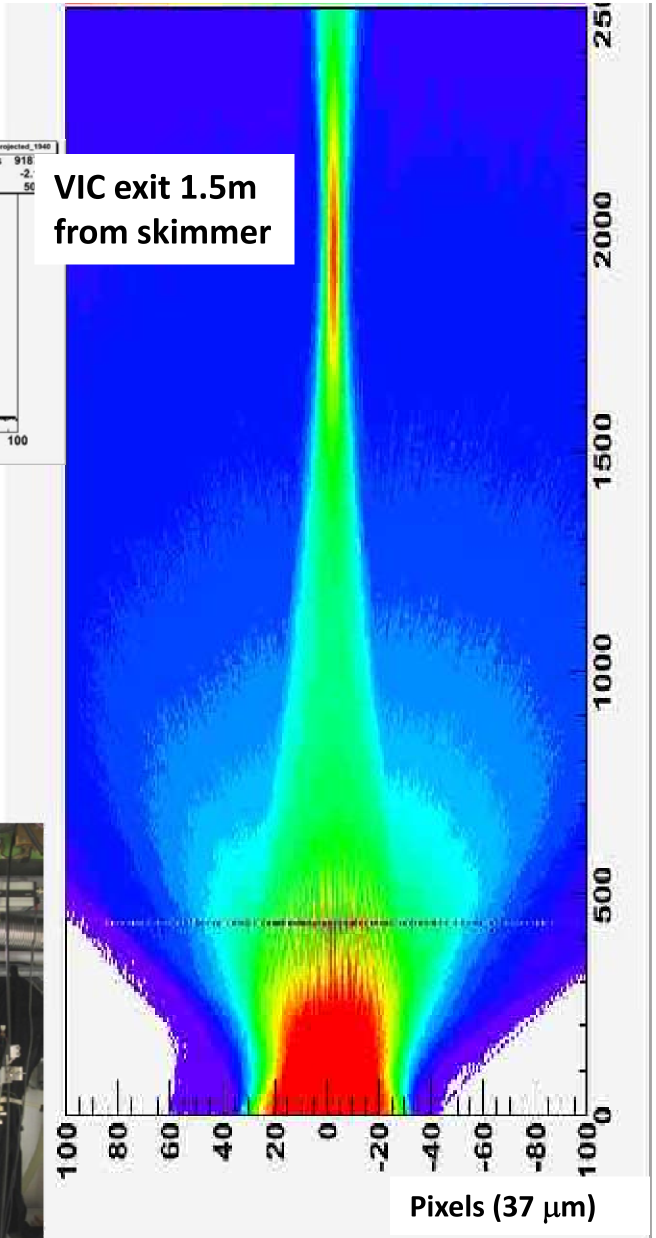
Extrapolated track positions at VIC : σ≈ 100 μm

Positions measured just above skimmer and in PTR chamber.
Lever arm = 427 mm.
Pellet beam size ≈2 mm.



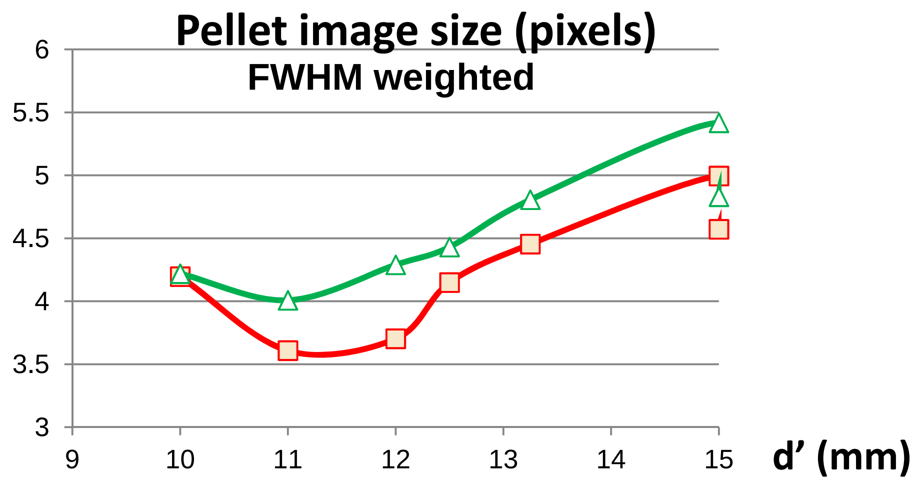
Camera optics studies

Pellet track x-distribution versus vertical position



Blurring due to limited DOF

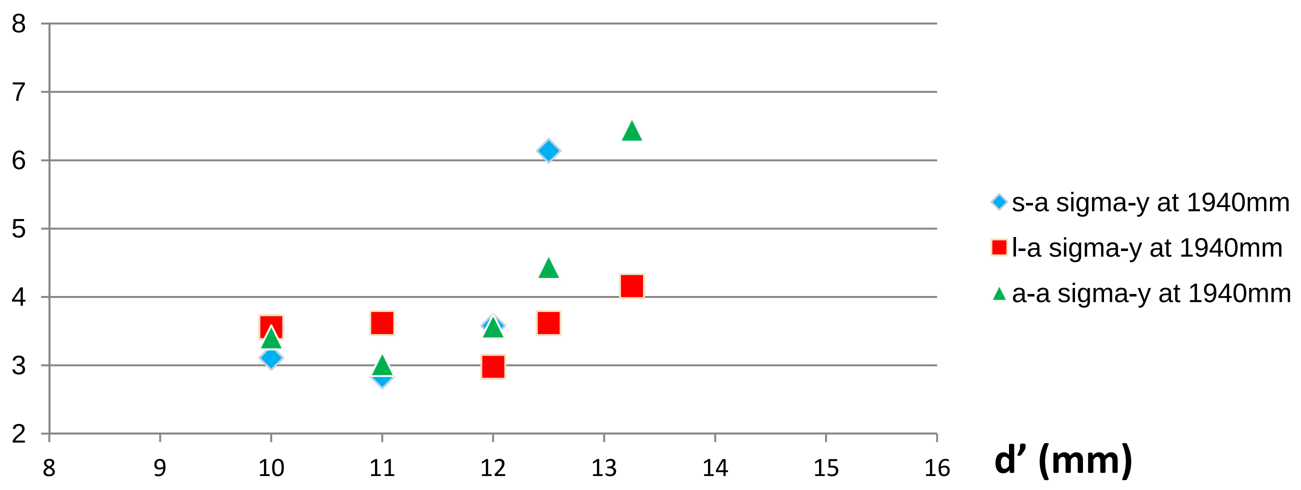
DOF study with cam optics f=50mm, bl.=1.4, d(pelletstream – focalplane) ≈250mm.



Expect (geometrically) image size of 1-2 pixels

Out of field effects are severe outside +/- 2 mm of focus

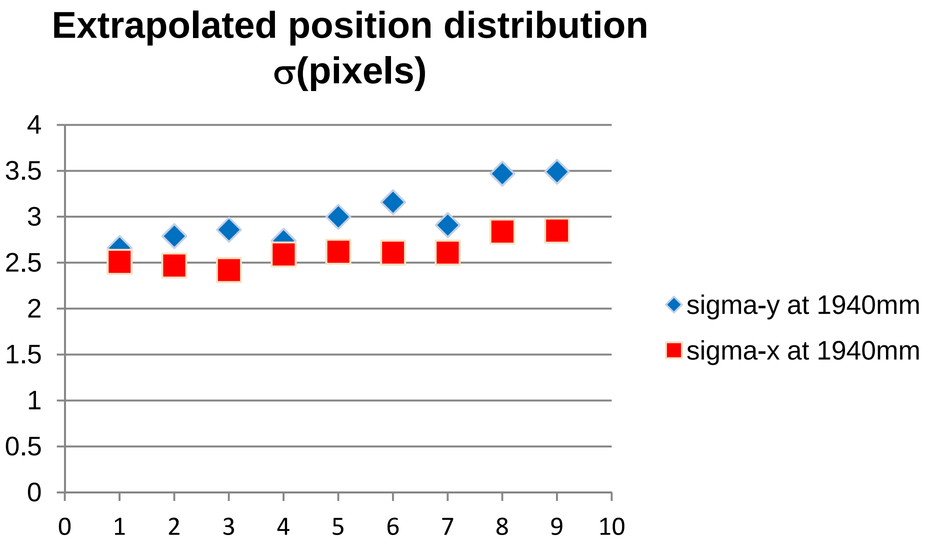
Extrapolated position distribution σ(pixels) at 1940 mm



Accuracy of extrapolated position for some different pixel-cluster sizes

120531		10.07 y	13.42 x
Cluster sizes s=small a=all l=large			
Class u-l	Code	sigma at 1940 mm	
		y	x
ss	1	2.66	2.51
sa	2	2.79	2.47
sl	3	2.86	2.42
as	4	2.74	2.59
aa	5	3	2.62
al	6	3.16	2.61
ls	7	2.91	2.61
la	8	3.47	2.84
ll	9	3.49	2.85

Cameras u=up (skimmer) d=down (ptr-lo dump)



Position resolution not too much influenced by pellet image size !

Increased image size may be due to:
- electronics crosstalk
- optics
- off focus pellets
- bigger pellets / pellet clusters
- .....

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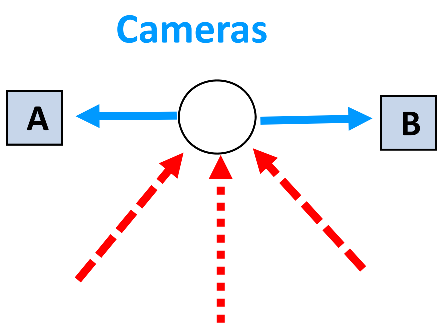
Illumination conditions.



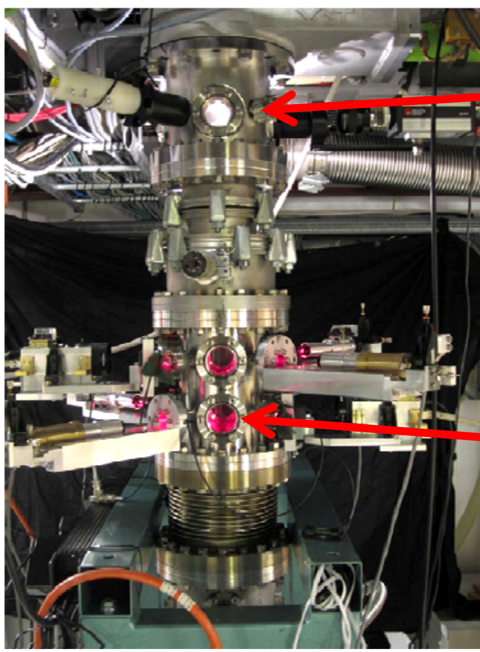
Laser(s)

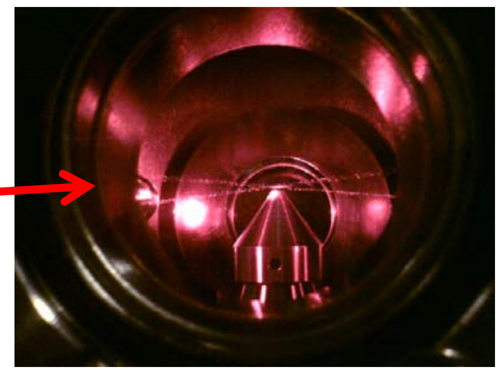
… strong / many enough to give full detection possibility.

Different configurations with two laser beams give possibility to estimate the inefficiency due to limited illumination….

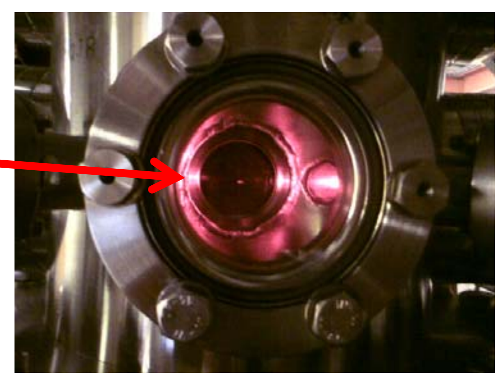
E.g. with one laser in 135^{o} configuration it seems that one have an illumination inefficiency of 5-20%.

First detailed measurements to study this have been done ….





Two laser beams seen (thanks to bouncing pellets) above the skimmer.



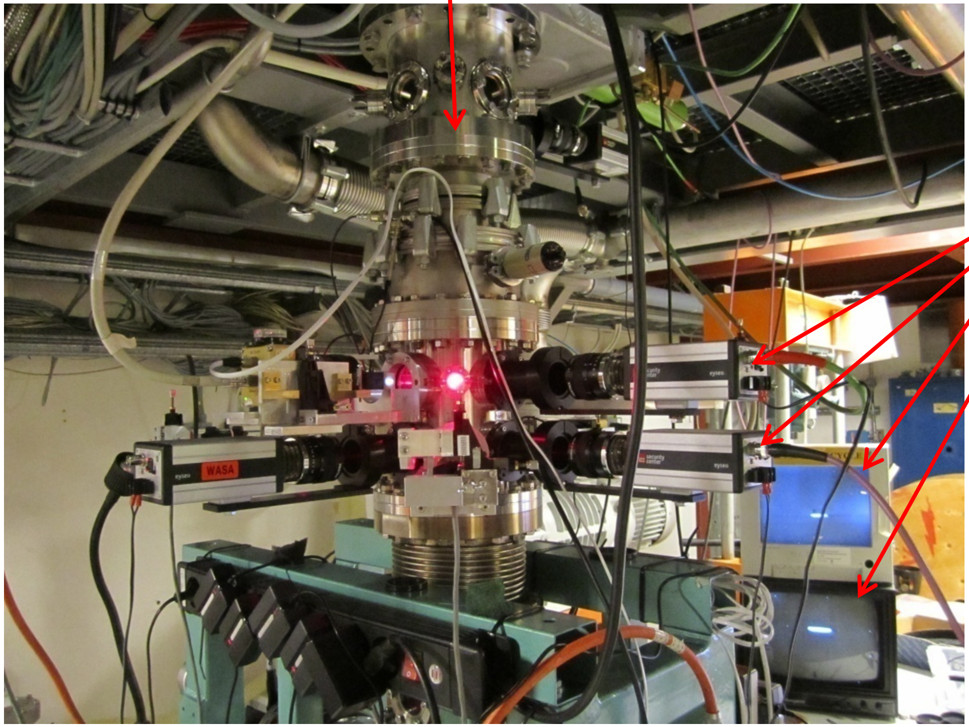
Pellet beam crossing laser beams in the center of the tracking chamber.

PTR chamber at UPTS

DN150CF FLANGE

Std CCD camera system

Height 220 mm



Diameter 1000 mm

CCD cameras are used for alignment of laser beams and for general monitoring in the PTR prototype section.

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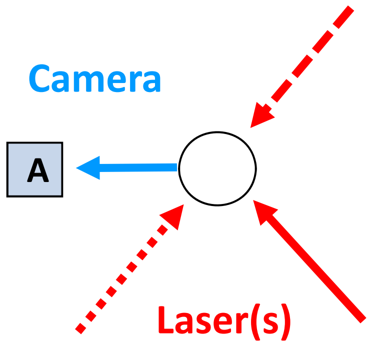
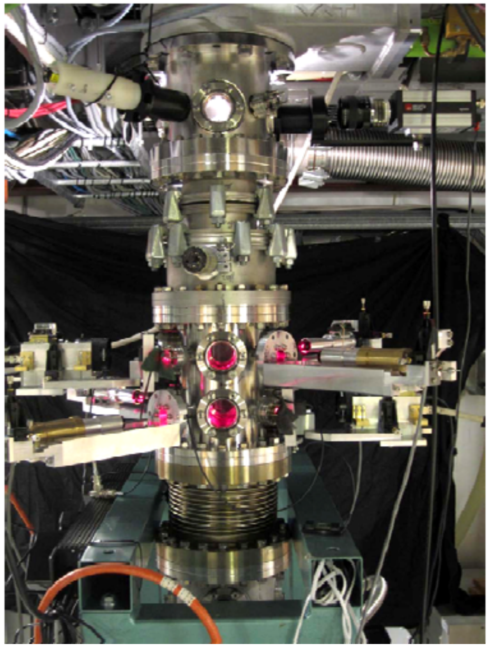
Illumination conditions.



SNF lasers, 50 mW,
1^{o} fan angle,
185 mm work distance



Different configurations with two laser beams give possibility to estimate the inefficiency due to limited illumination….

Measurement were done with two cams, one at each of the two levels of the PTR prototype chamber

- Both lasers ON at both levels give similar PelletRates.
- As reference PRs from one level is used.

- Comparison of rates with different combinations of two laser beams give possibility to estimate the (relative) inefficiency due to limited illumination….
  With the laser beam at 135^{o} (transmission) we got <10 % inefficiency and at 45^{o} (reflexion) we got 5-30%.
  The lasers are individuals ….. and this shows up most in reflexion mode since the pixel signal amplitudes are typically one third compared to transmission.

- By comparing number of reconstructed tracks with the PRs one can get an estimate of the absolute efficiency.
  For each level we got an efficiency of 80-85%.
  (From the camera cycle deadtime alone one expects an inefficiency in the range 5-15%).

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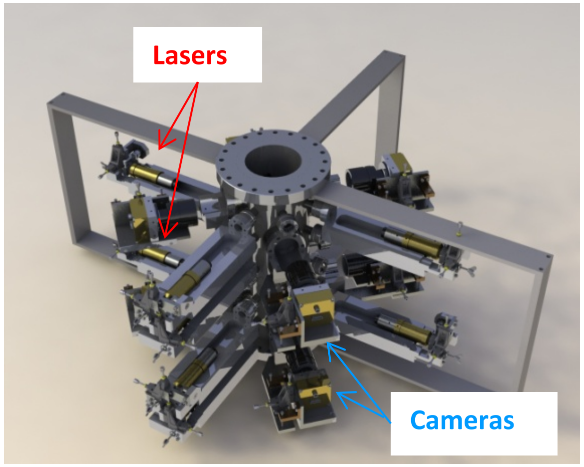
Detailed system design with optimized pellet detection levels



Version 0 tracking section:

4 levels (2x,2z) , each with 2 lasers and 2 LS-cams.

- Total height 400 mm. Radial size r_{max} = 500 mm.

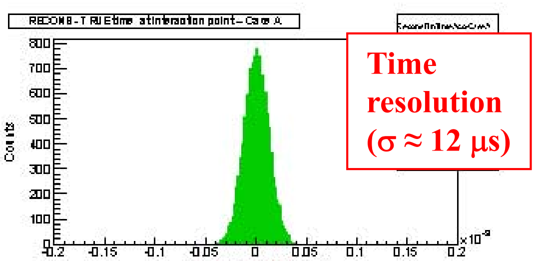
- Distance for velocity determination 60 – 260 mm.

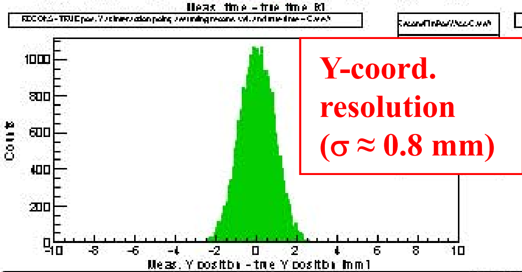
- Distance for direction determination 200 mm (…internally… if one use VIC exit: > 500 mm).

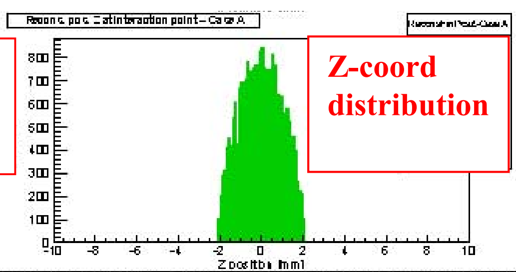
Pellet Tracking Example study for Panda (A. Pyszniak)

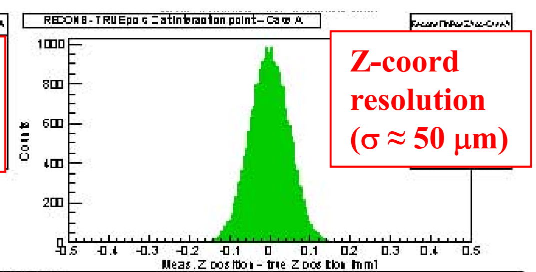
Generation point (VIC) at 3000 mm
VIC position used for XZ tracking
Measurement point 1 at 2300 mm (X)
Measurement point 2 at 2240 mm (Z)
Measurement point 3 at 2100 mm (X)
Measurement point 4 at 2040 mm (Z)
Interaction point at 0 mm
Number of generated pellets: 100k
Generation frequency: 40 kHz
Velocity mean: 70 m/s, sigma: 1%
Stream divergence: 1 mrad
Skimmer: 1mm diam @ 2301 mm
Pellet 25 µm, Pixel: 37 µm, Exp. Thr: 0.05
Camera cycle/exposure: 4/4 µs
Surv. prob. at gen.: 1 => Eff pel. rate at meas. points: » 14 k/s
Half width of the search window: 2 vel. sigma
Half width of the search window at test position: 35µ s

Examples of some pellet tracking distributions at the interaction point.









[Date: 20120530] Camera cycle: 4/4 µs; Eff pel rate at meas. points: ≈14k/s, Gravity NOT used in generation CASE A Page 41

Pellet tracking
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2012-09-10

Detailed system design with optimized pelletdetection levels

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Example of some pellet tracking performance numbers.

For each pellet passing the interaction region at time window of +/-35 ms is set up. One then checks the result of the pellet tracking…

Cam cycle (μs)	Plt rate (k/s)	Prb any (one) track in 70μs time window	Correct plt ident.	Tracking performance
t4/e4	5	0.930 (0.667)	0.874 (0.961)	0.813 (0.641)
t2/e2	5	0.947 (0.679)	0.922 (0.970)	0.873 (0.659)
t4/e4	14	0.926 (0.382)	0.667 (0.829)	0.618 (0.316)
t2/e2	14	0.947 (0.378)	0.774 (0.861)	0.733 (0.325)

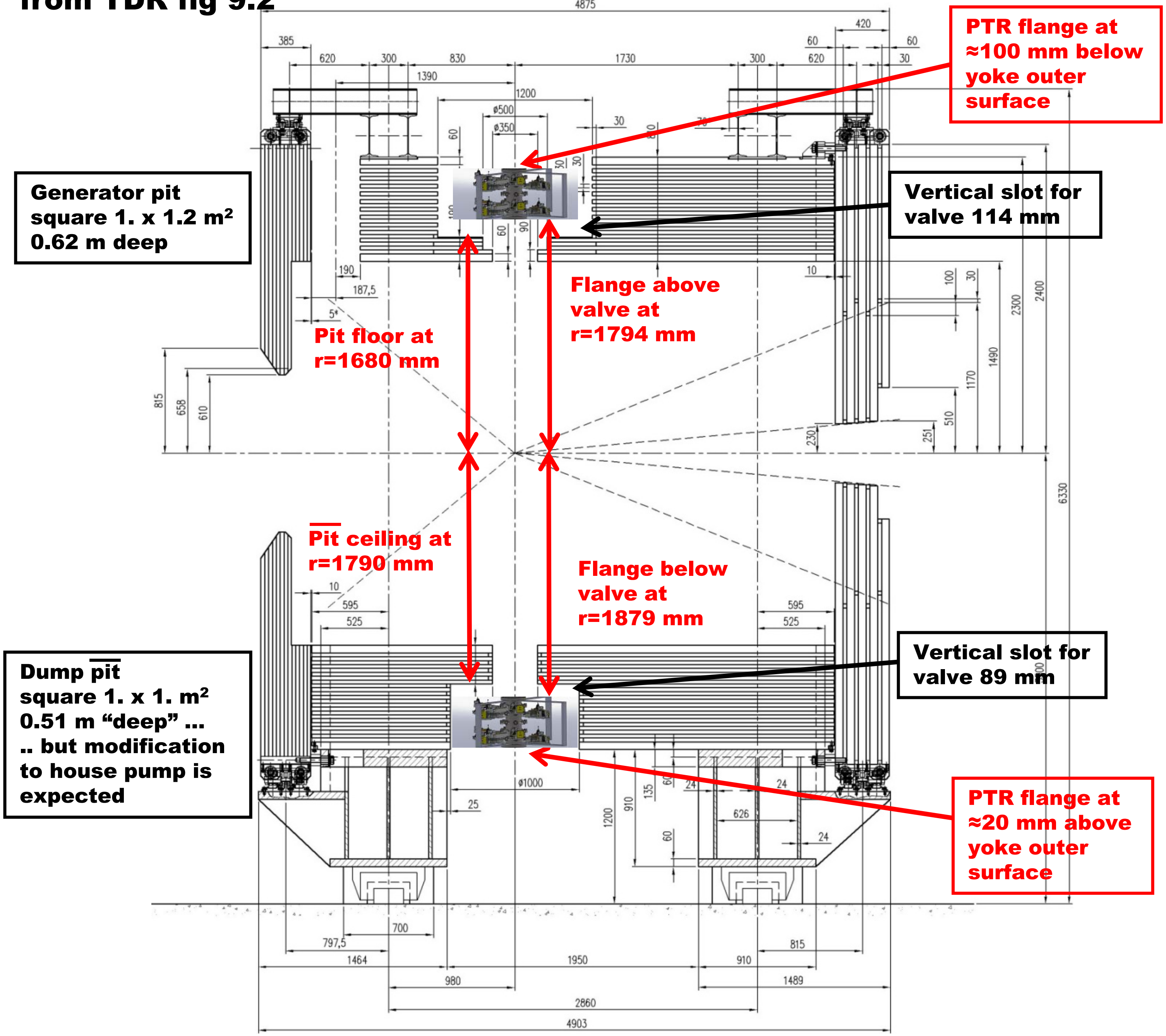
Low pellet rate and high time resolution improves tracking performance (as expected).

Effect of detection inefficiency.

Camera deadtime fraction of 20% in this example gives 30% reduced tracking performance.

Cam cycle (μs)	Plt rate (k/s)	Prb any track in 70μs time window	Correct plt ident.	Tracking performance
t4/e4	5	0.930	0.874	0.813
t6.25/e5	5	0.701	0.802	0.562
t4/e4	14	0.926	0.667	0.618
t6.25/e5	14	0.796	0.534	0.425

Drawing (H. Orth May 2, 2012). Positions for target pipe valve flanges from TDR fig 9.2



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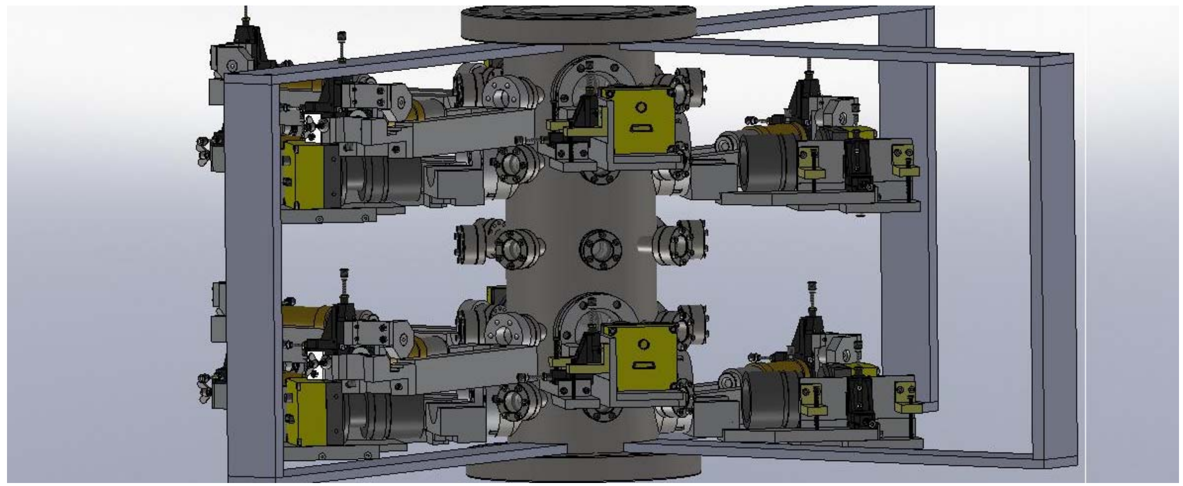
Pellet tracking
Panda CM
CNRS Paris
2012-09-10

PTR section conceptual design (2010)

DN150CF FLANGE

Height 400 mm



Diameter 1000 mm

Development of the procedure of installation in the PANDA iron yoke recesses and method of access to the PTR sections needs model tests.

Fitting of the PTR system in the recesses in the iron yoke.

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General comment:

The space needed for the actual PTR equipment is given in the TDR, i.e. for each section 0.4 meter height and 0.5 meter radially. This equipment fits in both the upper (1x1.2 m^2) and lower (1x1 m^2) rectangular shaped "pits". The PTR section will extend to ≈100mm inside the yoke surface. (Then the pellet generator section can be placed at 2.2 m distance from the accelerator beam (≈ 0.85 m more distant than at WASA)).
In addition, space for installation, adjustment and access for fine-tuning/service during operation is required.

Some comments and conclusions from the model study.

Pumps in the pit.

A 30 degree tilted pump pipe (with valve) can be placed in one quadrant only. In such case the pump will extend outside the "pit".
S-shaped pump pipes can be put in 2 quadrants (3 if PTR section moved out ≈50 mm). The space for each pump can then be 200 x 200 x h300 mm^3 (in quadrant corners). A 250-300 l/s turbo would fit geometrically in this space.

Installation of PTR section.

Mechanics for cameras and lasers should be attached and aligned before installation in the pit. The PTR section should then be attached section to the target pipe. The access to the flange above the valve might be too difficult. In such case the space can be increased by moving out the PTR section a few cm.

Access to PTR components during pellet operation.

Fine-adjustment of cameras and lasers must be done with pellet beam. Then human access to the equipment is needed when the pellet generator and dump are in place (also for possibility to replace malfunctioning cams, lasers, LEDs …).
This mainly concerns design and configuration of equipment placed just outside the pits.

Camera electronics.

Might be disturbed by pumps and magnetic field. The closest distances of camera to yoke iron and of camera to pump are 200-250mm in the model study….
Cameras need air cooling …. Some fans may do the job.

Fig. 9.2 from Targets TDR (february 2012)

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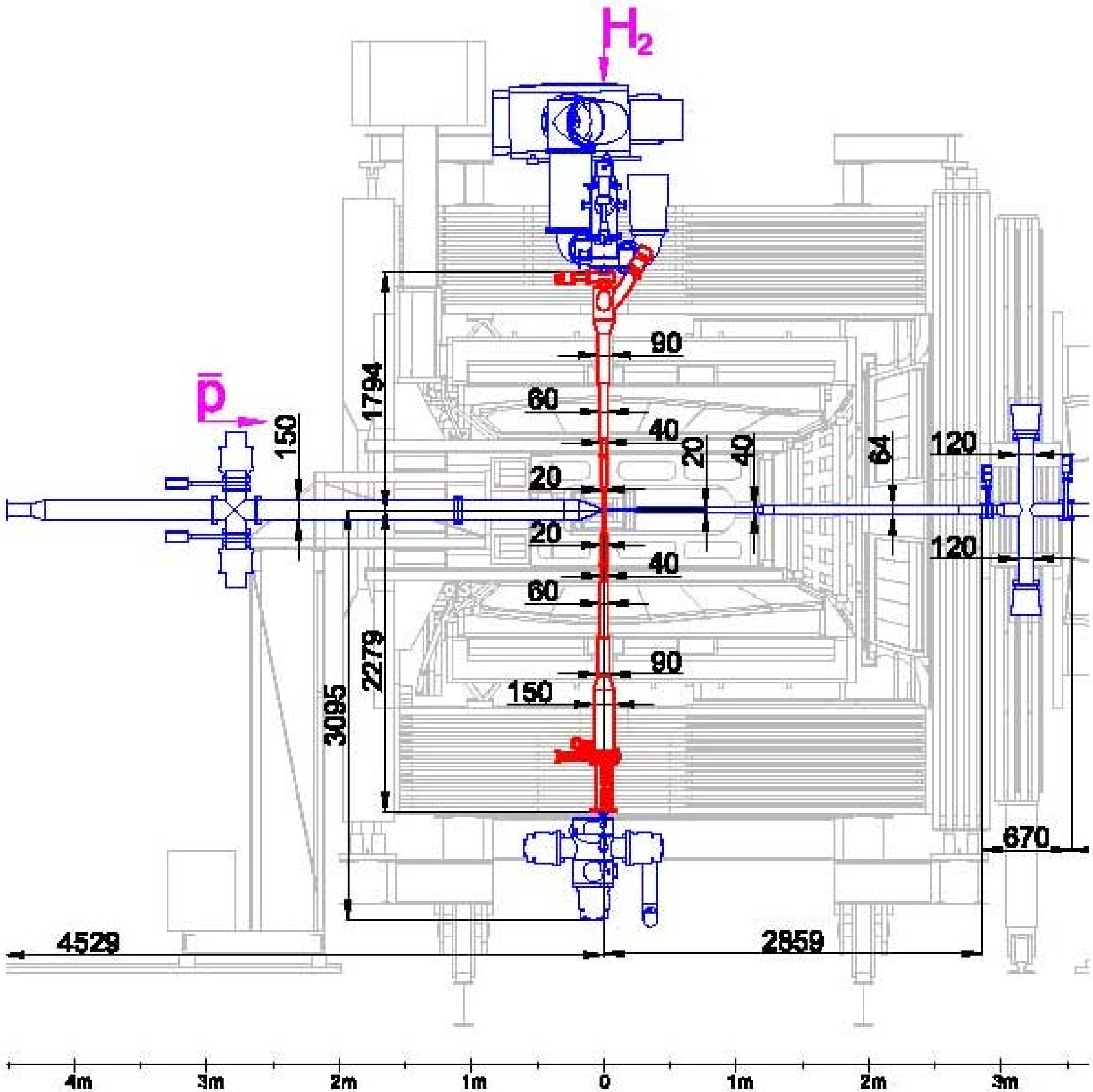

Figure 9.2: Cross section of the Target Spectrometer with detector components in light gray. The target and dump lines are marked in red. The antiproton beam line, as well as the cluster-jet target and the target beam dump, is marked in blue. The dimensions are given in mm. The diameters refer to inner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

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Pressures with pellets at WASA 14/8-12

P(H2)=625mbar
Generation f=85kHz
P(DC)= 18.5mbar
Pellet counter=5000/s
Target thickn=2.5e15 at/cm²

VIC length=70mm
Φ=1. -> 0.7mm

VIC exit

Pressures (mbar)
PEG3=1.9e-4 (2.2e-4)
PEG4=1.5e-4 (1.4e-5)
PEGa1=5.e-5(2.2e-5)
PEG5=1.2e-6(3.e-8)
PEGb1=8.e-4(1.5e-6)
PEG6=2.4e-4(1.e-6)

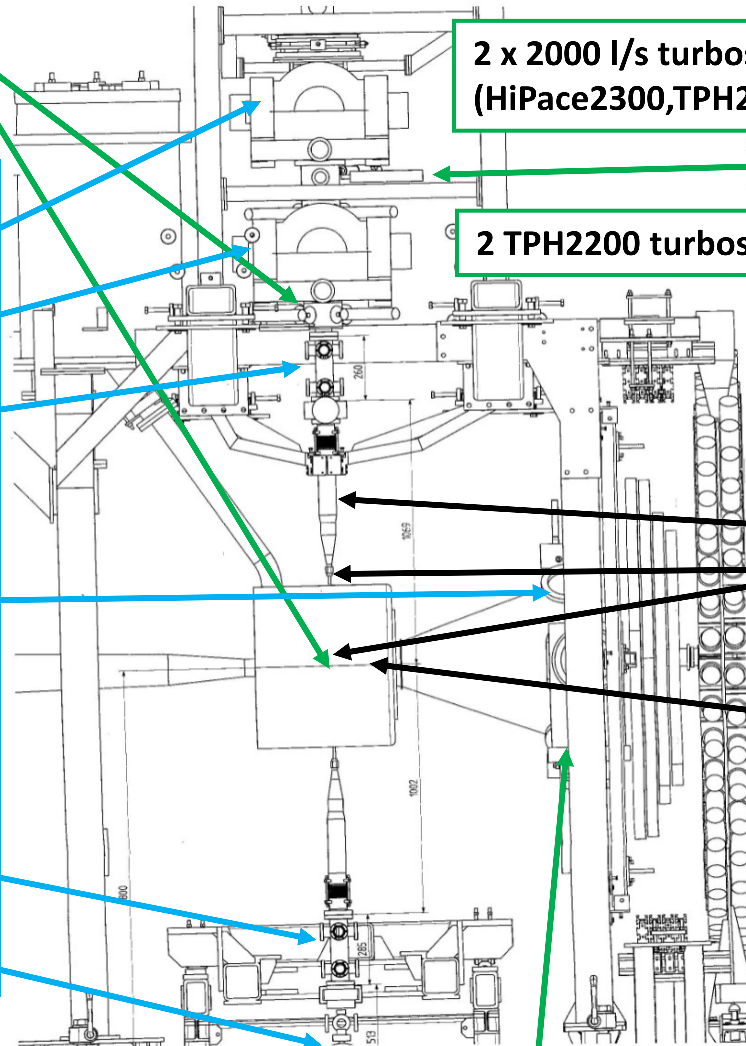
2 x 2000 l/s turbos
(HiPace2300,TPH2200)

2 TPH2200 turbos

Backw. cone
1 Leybold 1500 cryo

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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Status August 2012

- 1st prototype PTR system is in operation since March 2011 at UPTS :
  - Tracking chamber with two levels of pellet detection.
  - Two LS-cameras, now possible with two lasers each.
- Extension of the tracking system at UPTS to 6 LS-cameras:
  - Cameras & lasers purchased. Mechanics being prepared.
  - Development of a new readout system in progress.

- LS camera (100kHz model) performance well understood ...
  … regular operation of 2 synchronized LS-cameras with 12 μs cycle.
- Required transverse position resolution has been demonstrated.
- Detection / illumination conditions … are being optimized.
  The first quantitative results from detailed detection efficiency studies show that it should be possible to reach close to 100%.
- Solution for good time (⇒ y position) resolution and high camera efficiency exists.
- Pellet velocity spread σ_v /v <<1% should be possible to obtain.

- Simulations for the detailed design of a system for PANDA in progress.
- Vacuum measured at WASA, for use in PANDA design studies….
- Model studies for the installation of PTR system in yoke recesses.

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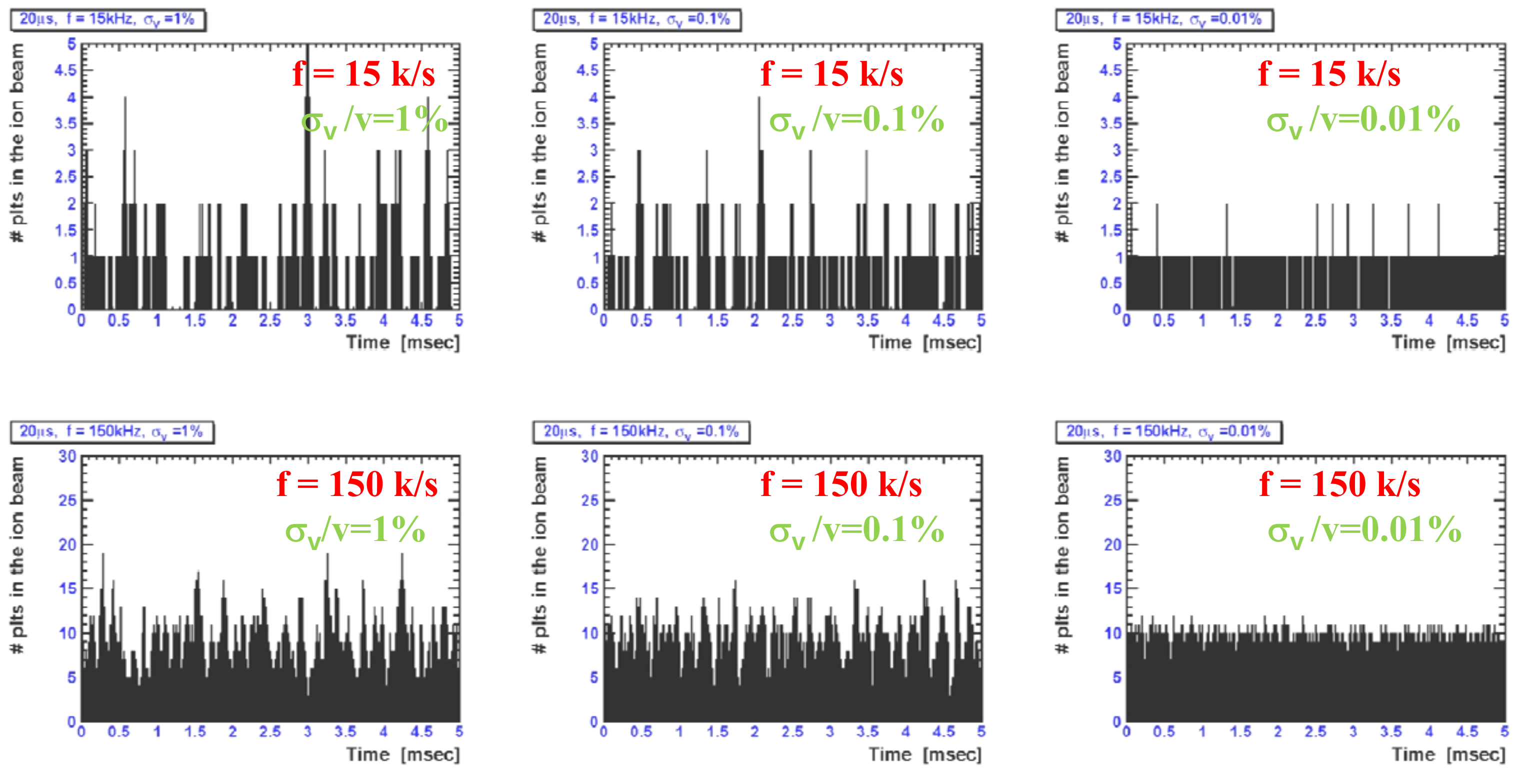
Target thickness fluctuations

Number of pellets in accelerator beam vs time (during 5 ms) for pellet occurence frequencies, 15 & 150 k/s, and different pellet velocity spreads:

MC results for pellet v=60 m/s and accelerator beam Φ=4 mm.
(Pellet crossing duration ≈70 μs) .



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Accuracy of extrapolated position for some different pixel-cluster sizes

120531 10.07 y 13.42 x

Cluster sizes s=small a=all l=large Cameras u=up (skimmer) d=down (ptr-lo dump)

Class u-l	Code	sigma at 1940 mm y	x
ss	1	2.66	2.51
sa	2	2.79	2.47
sl	3	2.86	2.42
as	4	2.74	2.59
aa	5	3	2.62
al	6	3.16	2.61
ls	7	2.91	2.61
la	8	3.47	2.84
ll	9	3.49	2.85

Accuracy of extrapolated position for different focal distances (and pixel-cluster sizes).

120530

Cluster sizes s=small a=all l=large Cameras u=up (skimmer) d=down (ptr-lo dump)

time	focus u pos(mm)	sigma at 1940 mm sa	la	aa	1513 mm aa
1120	10	3.11	3.56	3.41	5.79
1430	11	2.84	3.62	3.02	4.36
1400	12	3.58	2.98	3.57	4.88
1141	12.5	6.14	3.62	4.44	5.84
1343	13.25	12.31	4.16	6.45	8.49
1356	15				
1137	15				