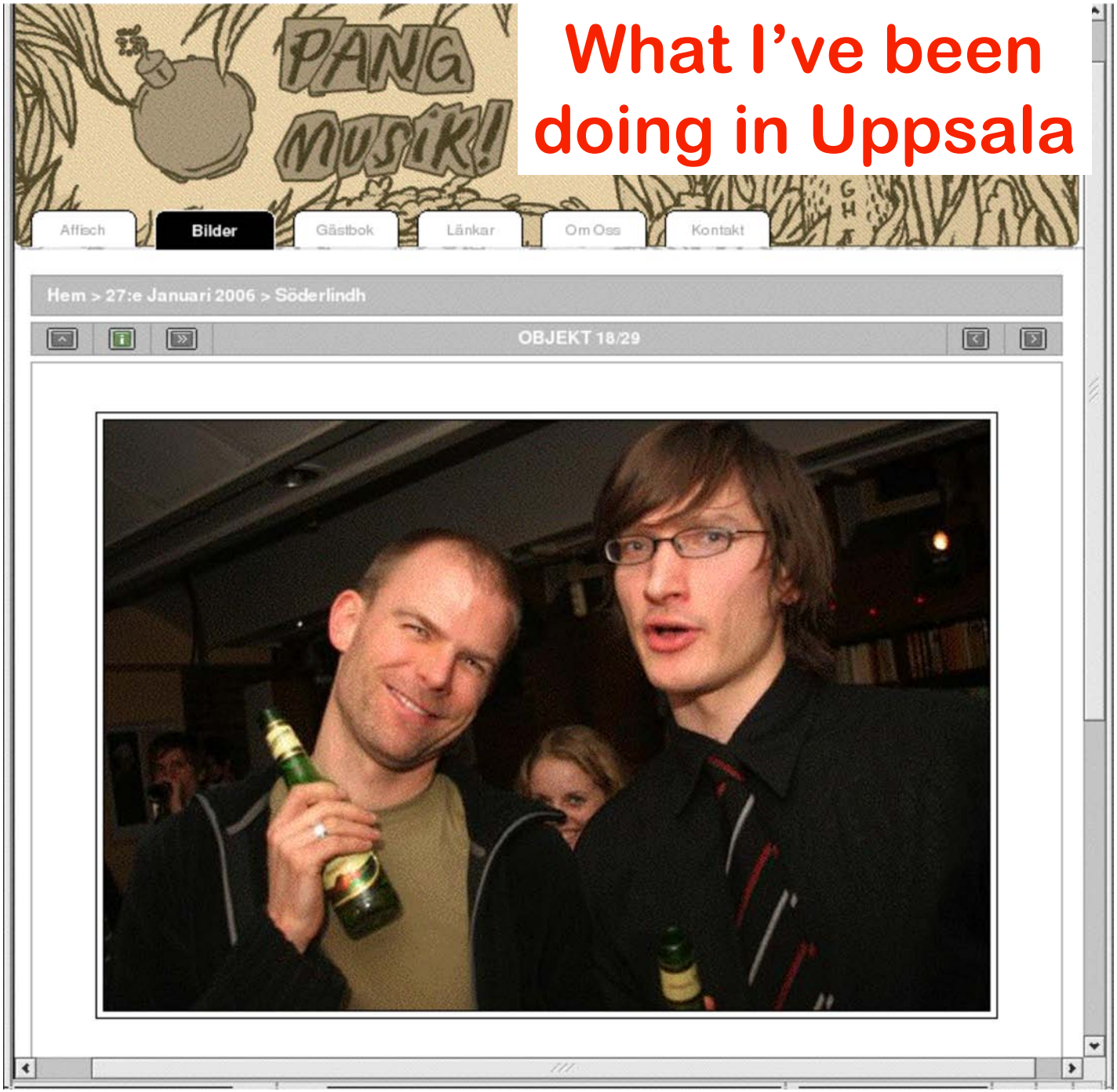
Developments on a Pellet Target
or
"What I've been doing in Uppsala"

Inti Lehmann

Uppsala University

Uppsala, Feb. 10th, 2006

What I've been doing in Uppsala



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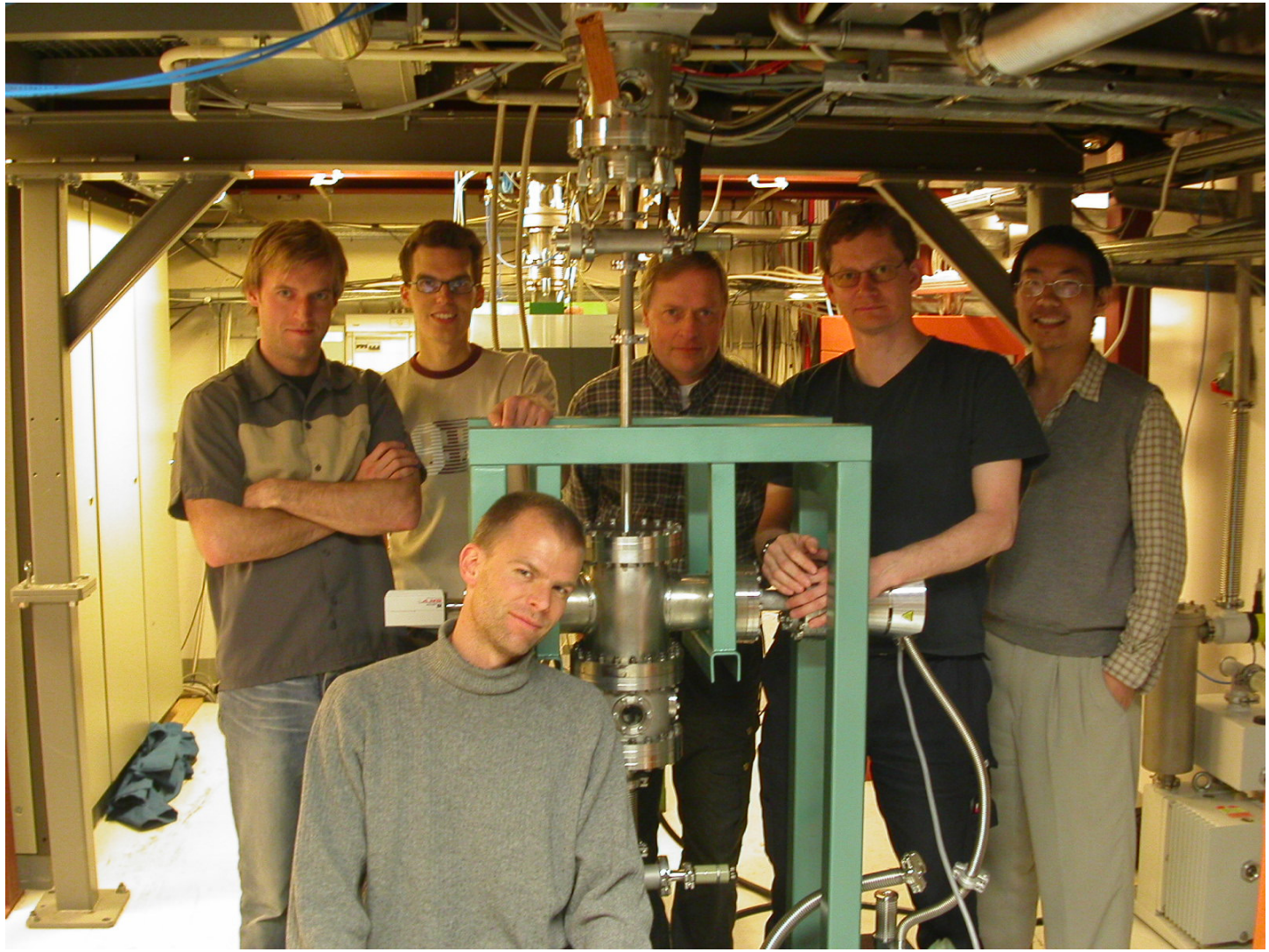
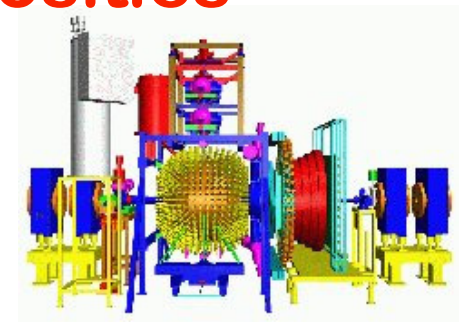


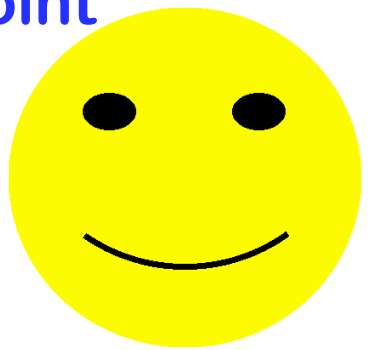
Why a Pellet Target?

- complicated system
- operation is time consuming

Essential for internal experiments with 4π acceptance, and high luminosities

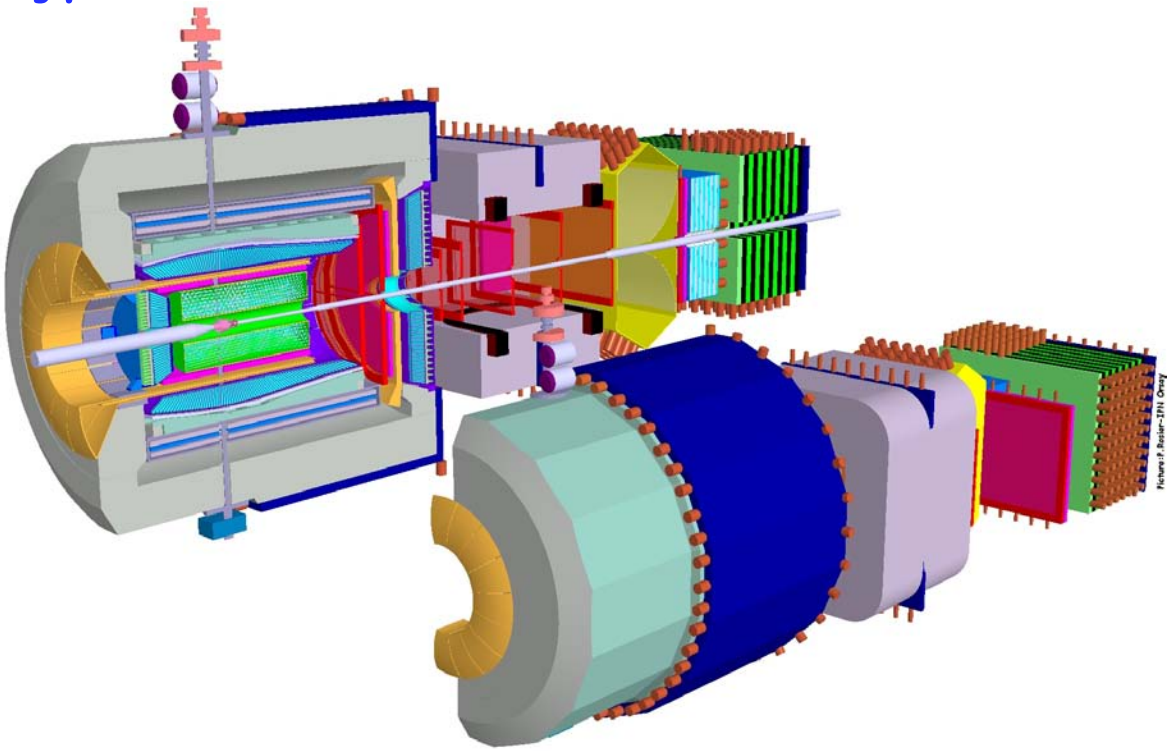


- densities of several 10^{15} protons/cm^2
- small interaction area (few mm)
- no space consumption at the interaction point
- relatively low out-gassing
- defined interaction vertex (30μm)



The PANDA Experiment

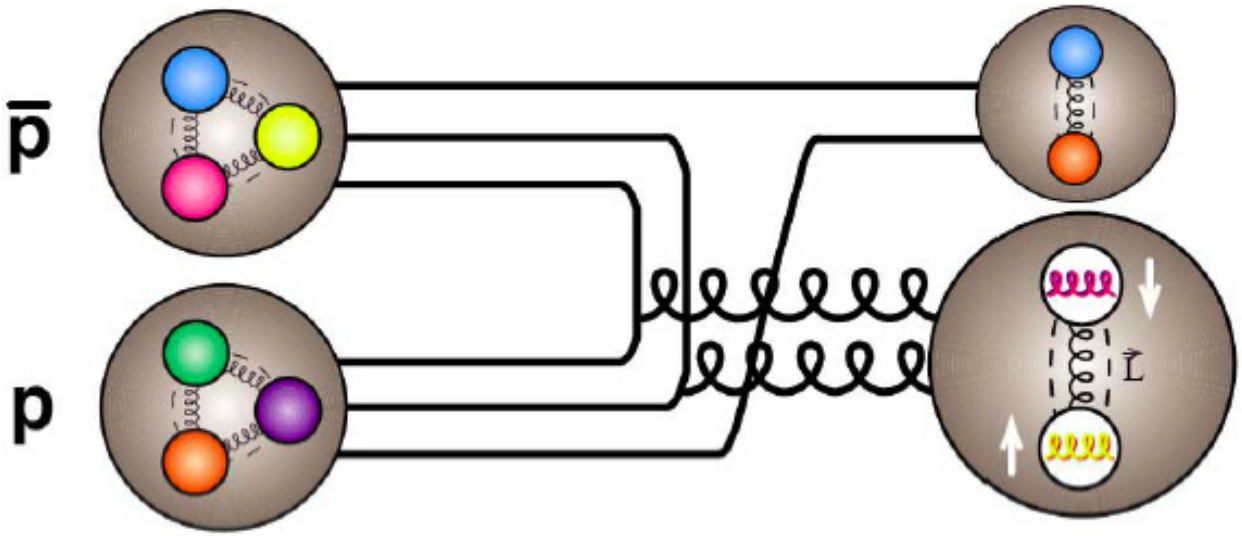
- charmonium spectroscopy
- gluonic excitations (hybrids, glueballs)
- open and hidden charm in nuclei
- γ-ray spectroscopy of hypernuclei
- J/ψ-N scattering
- inverted DVCS
- ...



What is Experimentally Needed?

- **gluon-rich environment**

  ⇒ **proton-antiproton anihilations**



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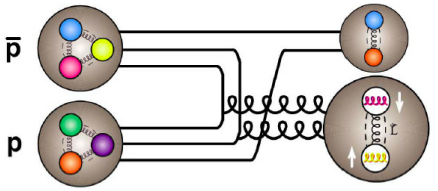
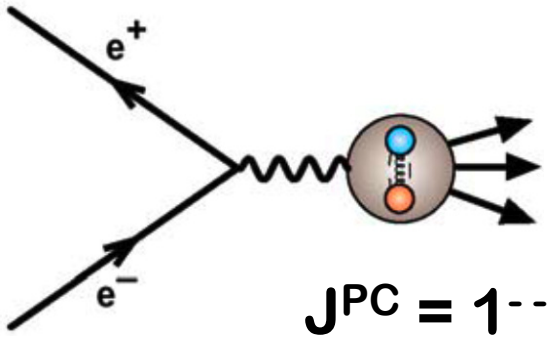
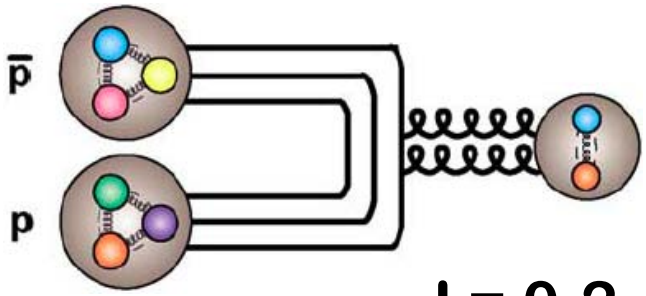


- **all quantum numbers**

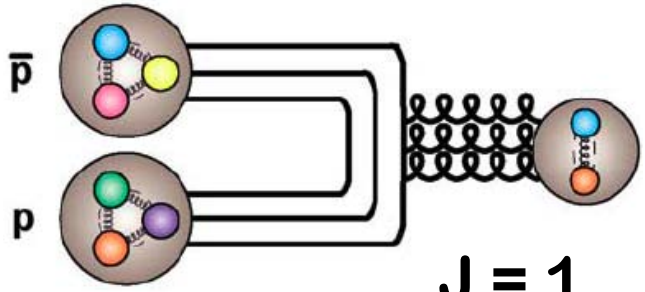
  ⇒ formation exp. i.e. large acc. detector, fixed target



$J^{PC} = 1^{--}$

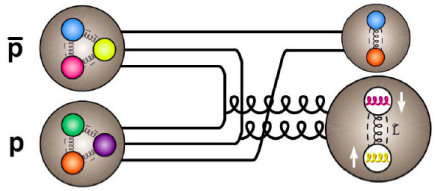


J = 0,2,.. C = +

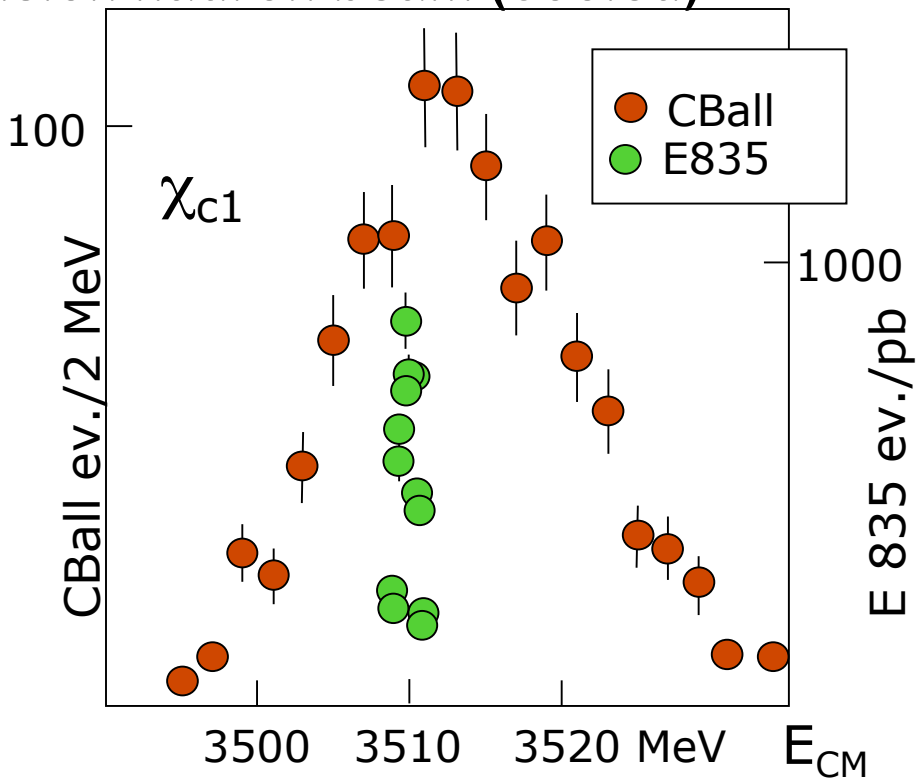


J = 1,.. C = -

What is Experimentally Needed?



- **gluon-rich environment**
  - ⇒ proton-antiproton anihilations
- **all quantum numbers**
  - ⇒ formation exp. i.e. large acc. detector, fixed target
- **precise resonance scan**
  - ⇒ high precision hadron beam (cooled)



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- **all quantum numbers**
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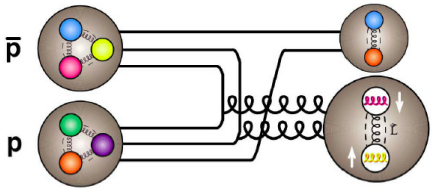
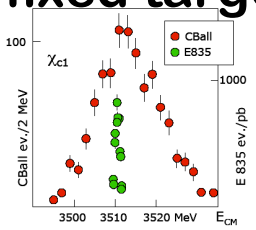
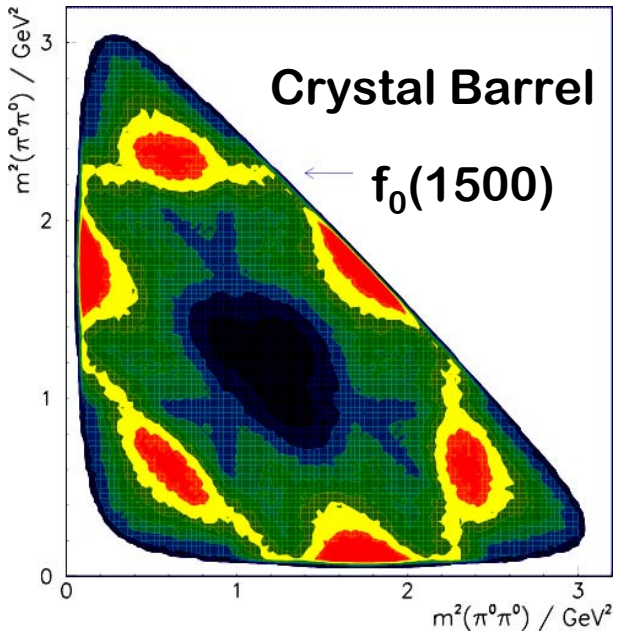
- **precise resonance scan**
  ⇒ high precision hadron beam (cooled)
- **high statistics samples**
  ⇒ high luminosity and prod. cross section

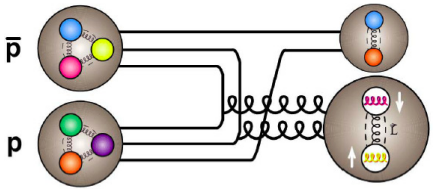


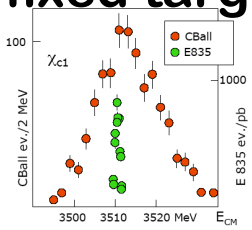


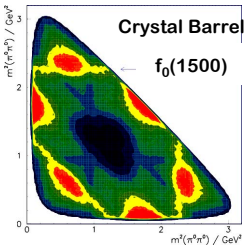


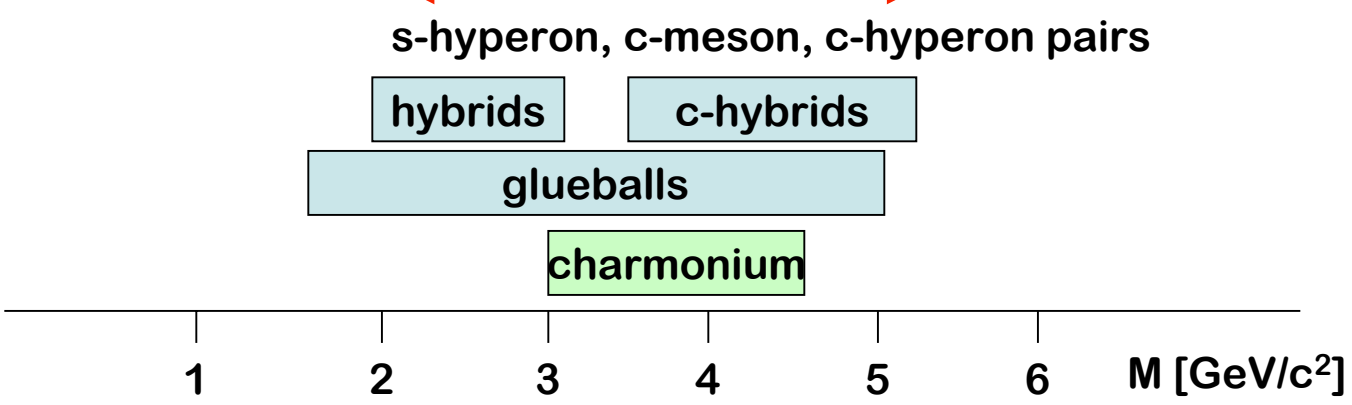
What is Experimentally Needed?

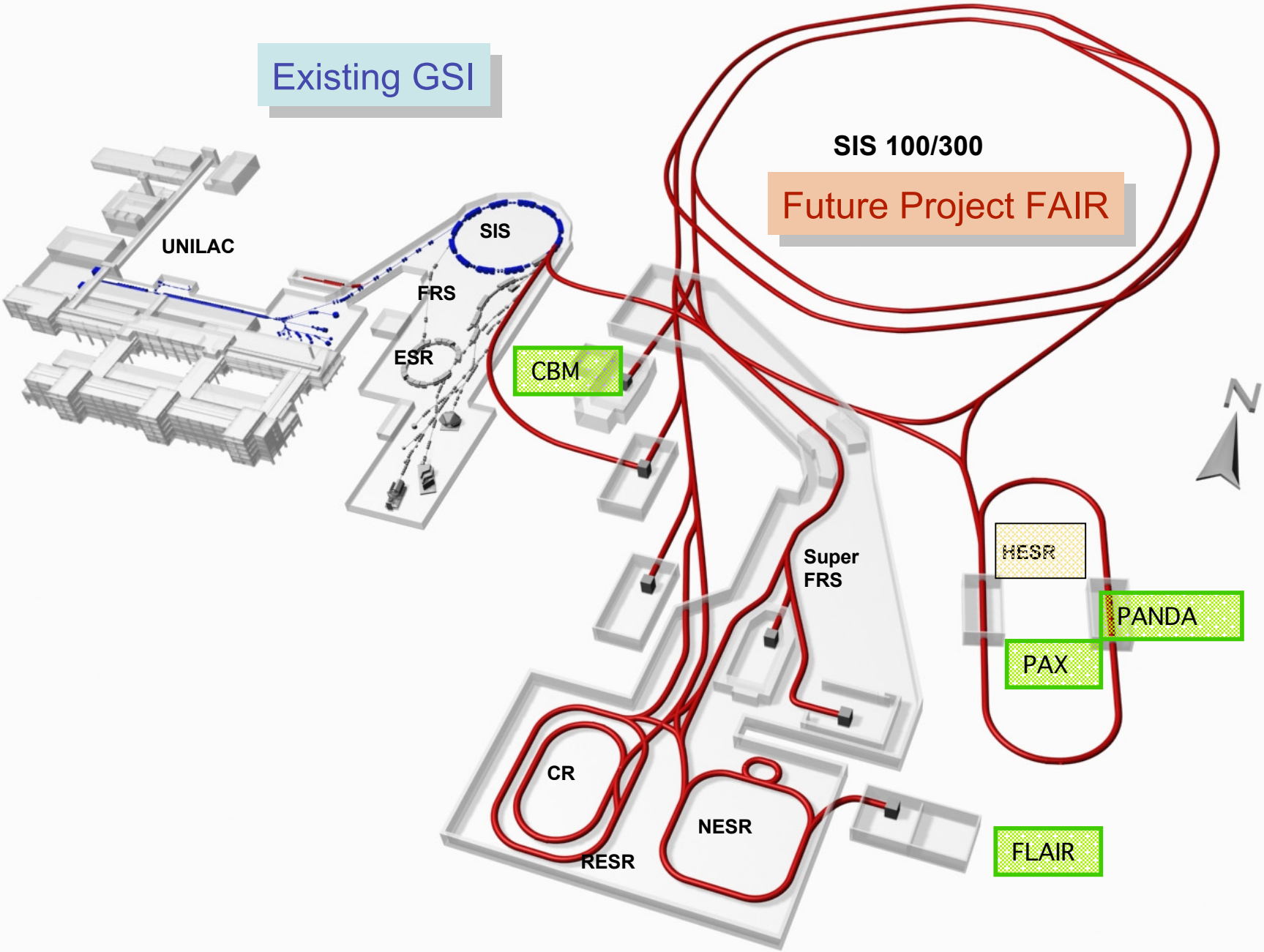
- **gluon-rich environment**
  ⇒ proton-antiproton anihilations
- **all quantum numbers**
  ⇒ formation exp. i.e. large acc. detector, fixed target
- **precise resonance scan**
  ⇒ high precision hadron beam (cooled)
- **high statistics samples**
  ⇒ high luminosity and prod. cross section
- **physics topics**
  ⇒ energy range $p_{\bar{p}}$ = 1.5 - 15 GeV/c

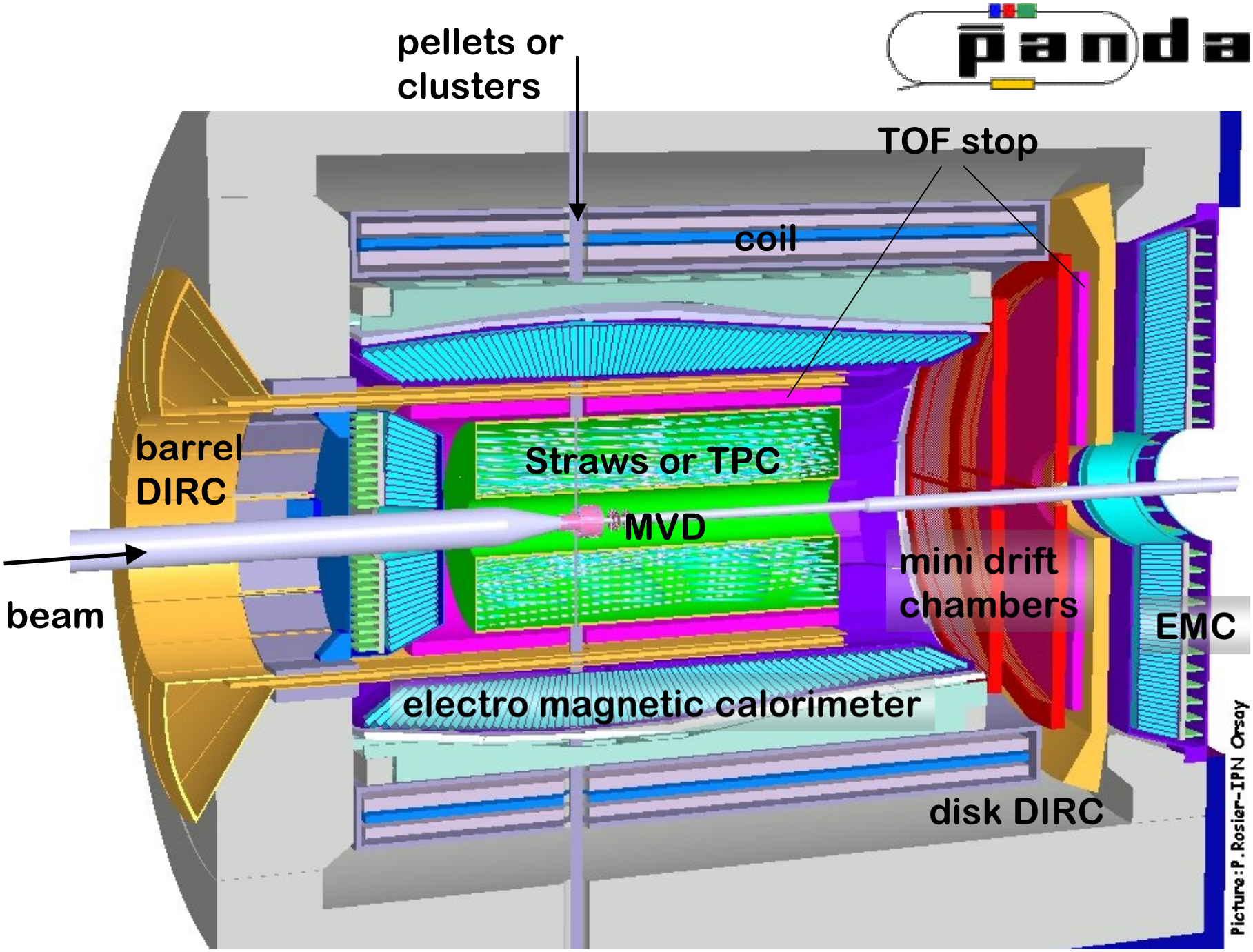








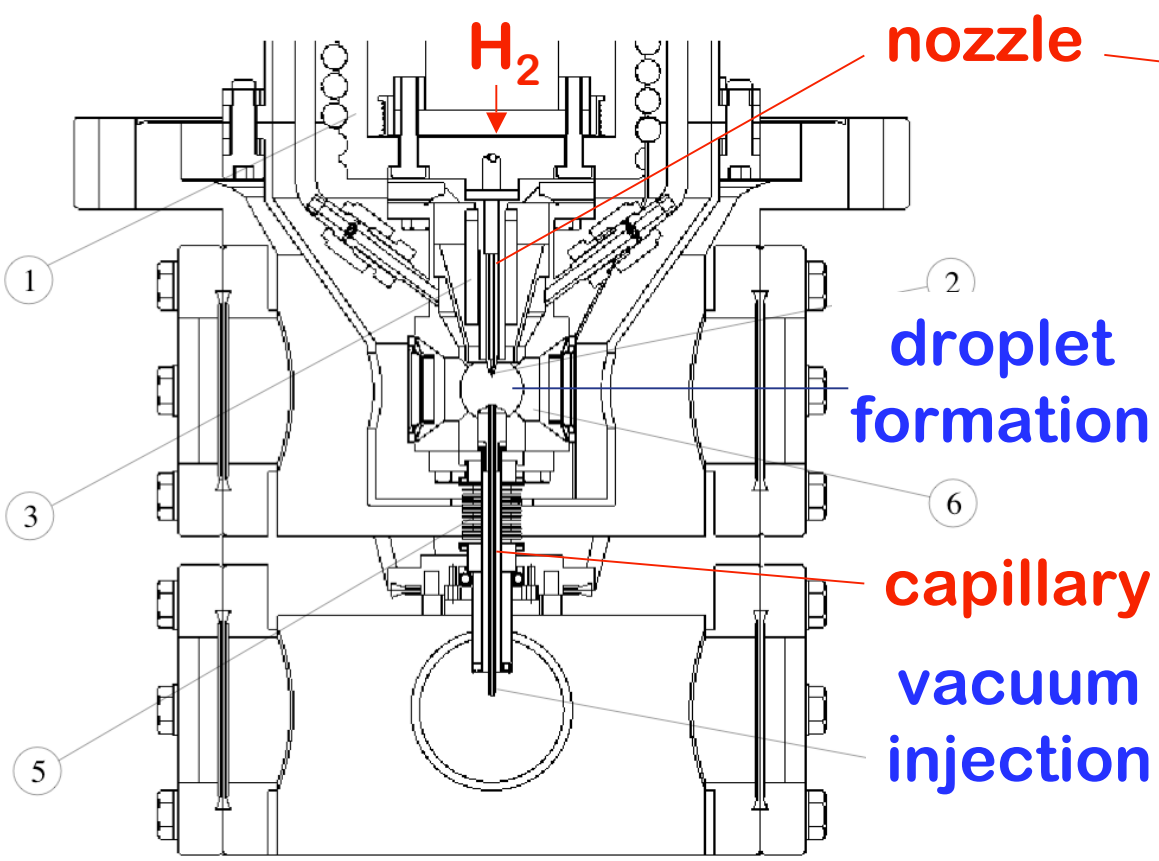

Existing GSI
SIS 100/300
Future Project FAIR
UNILAC
SIS
FRS
ESR
CBM
Super
FRS
HESR
PANDA
PAX
CR
NESR
RESR
FLAIR
N


pellets or clusters
TOF stop
coil
barrel DIRC
Straws or TPC
MVD
beam
mini drift chambers
EMC
electro magnetic calorimeter
disk DIRC
Picture: P. Rosier-IPN Orsay

Requirements on the Target System

- design luminosity: 2×10^{32} /cm^{2}s
  - average density: 3.8×10^{15} atoms/cm^2
  - currently: 1.7×10^{15} atoms/cm^2 .
- reconstruction of short lived reaction products
  - define primary vertex
  - tracking of 25μm pellets under investigation !
- leave space for detectors
  - few mm pipe for 3.7 m length
  - currently: 3.2 m √
- good vacuum in the ring
  - low out-gassing (pumping is restricted)
  - currently under study at Uppsala !
- small beam size (few mm)
  - special requirements on inhomogeneous targets
  - currently: $\sigma_h \times \sigma_v = 1 \times 3$ mm^2 !

Pellet Generation Principle

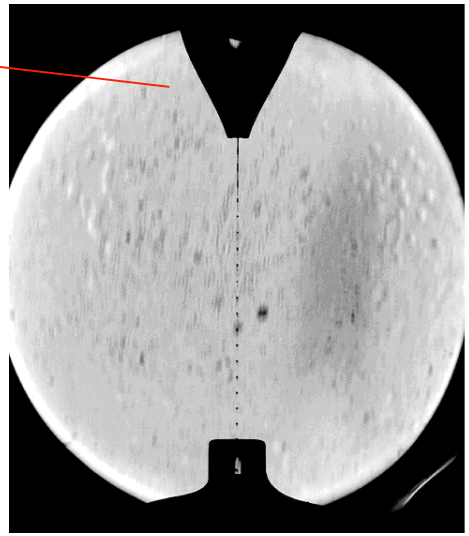


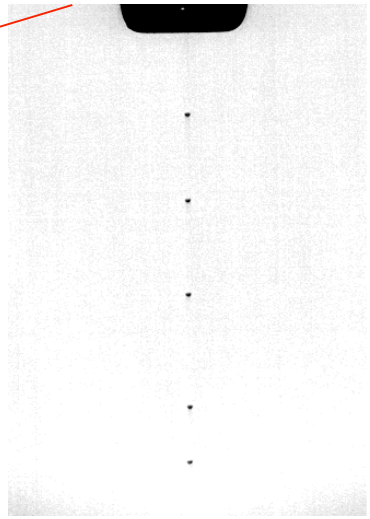
nozzle

droplet formation

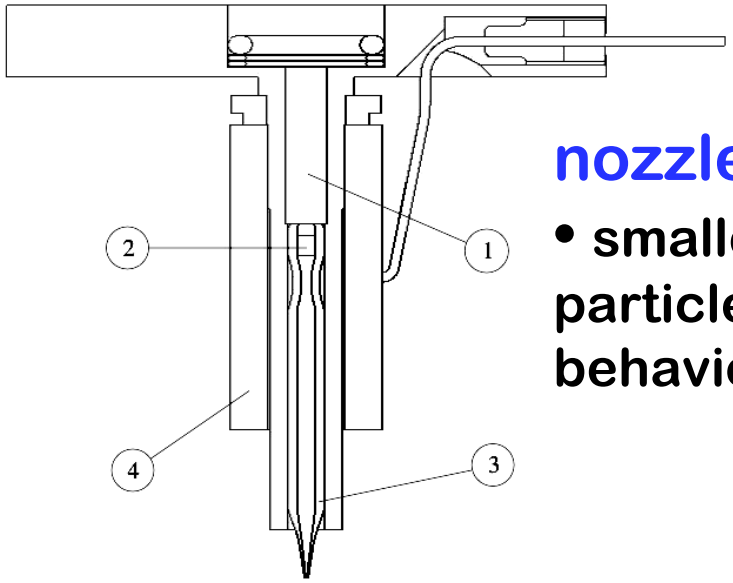
capillary

vacuum injection



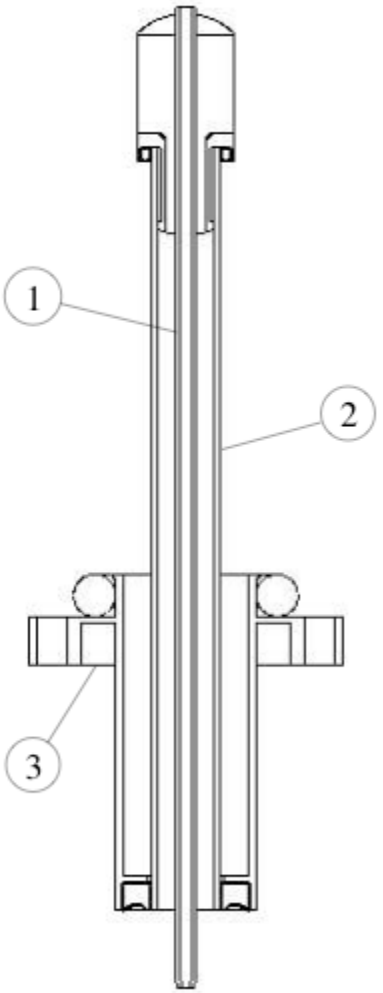


Critical Points



nozzle

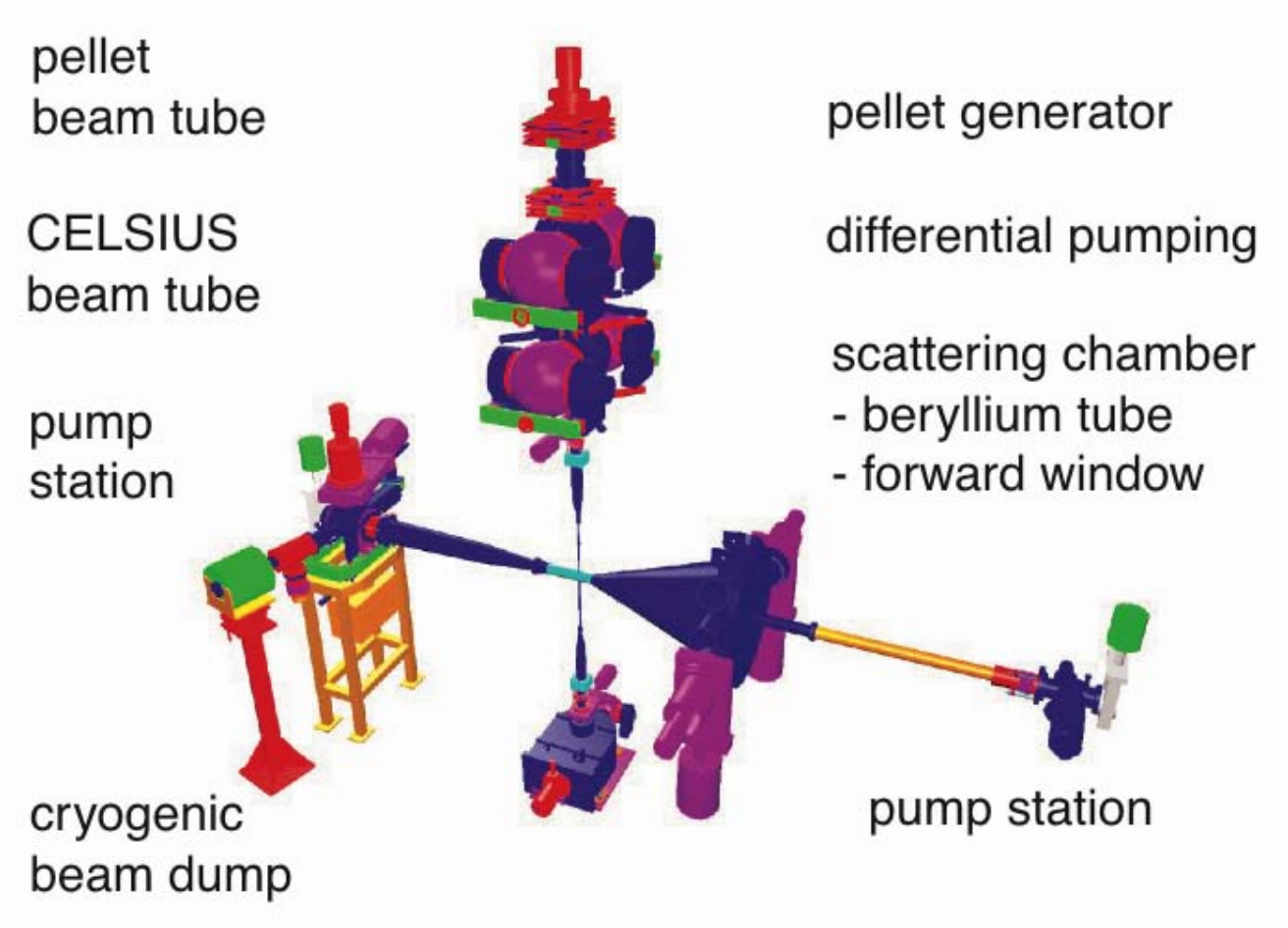
- smallest irregularities or particles cause erratic behaviour



capillary

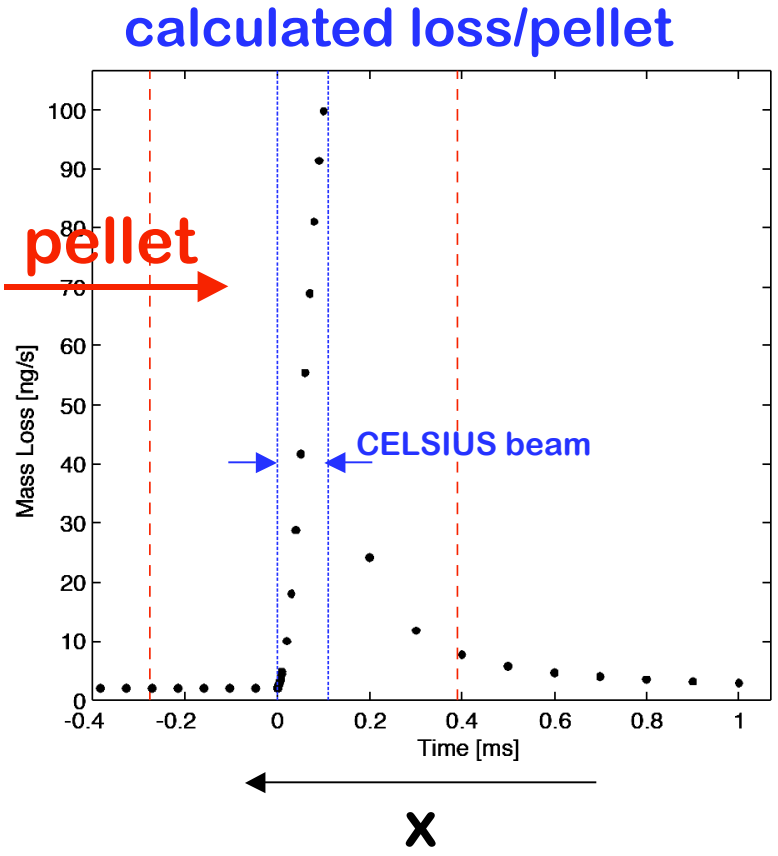
- shape determines gas flow and pellet train properties

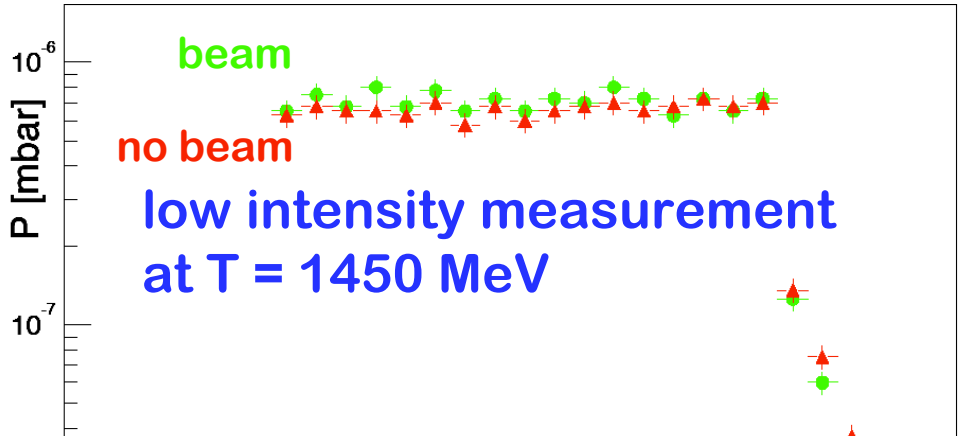
WASA Pellet Target

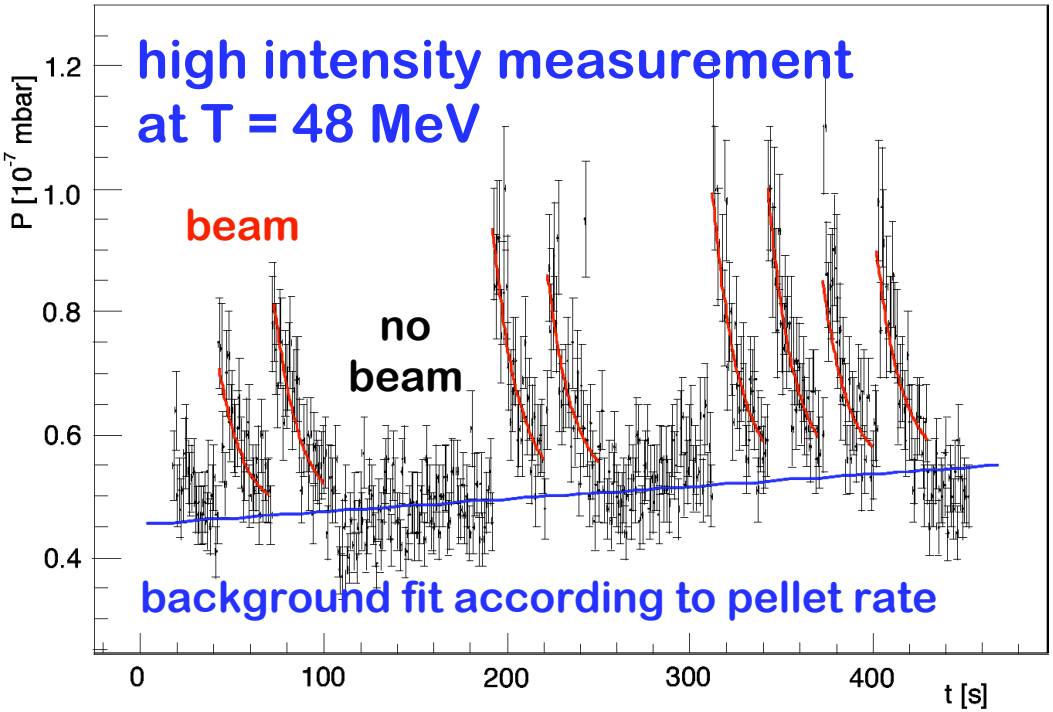


- **access and availability restricted**
- **development of the PTS !**

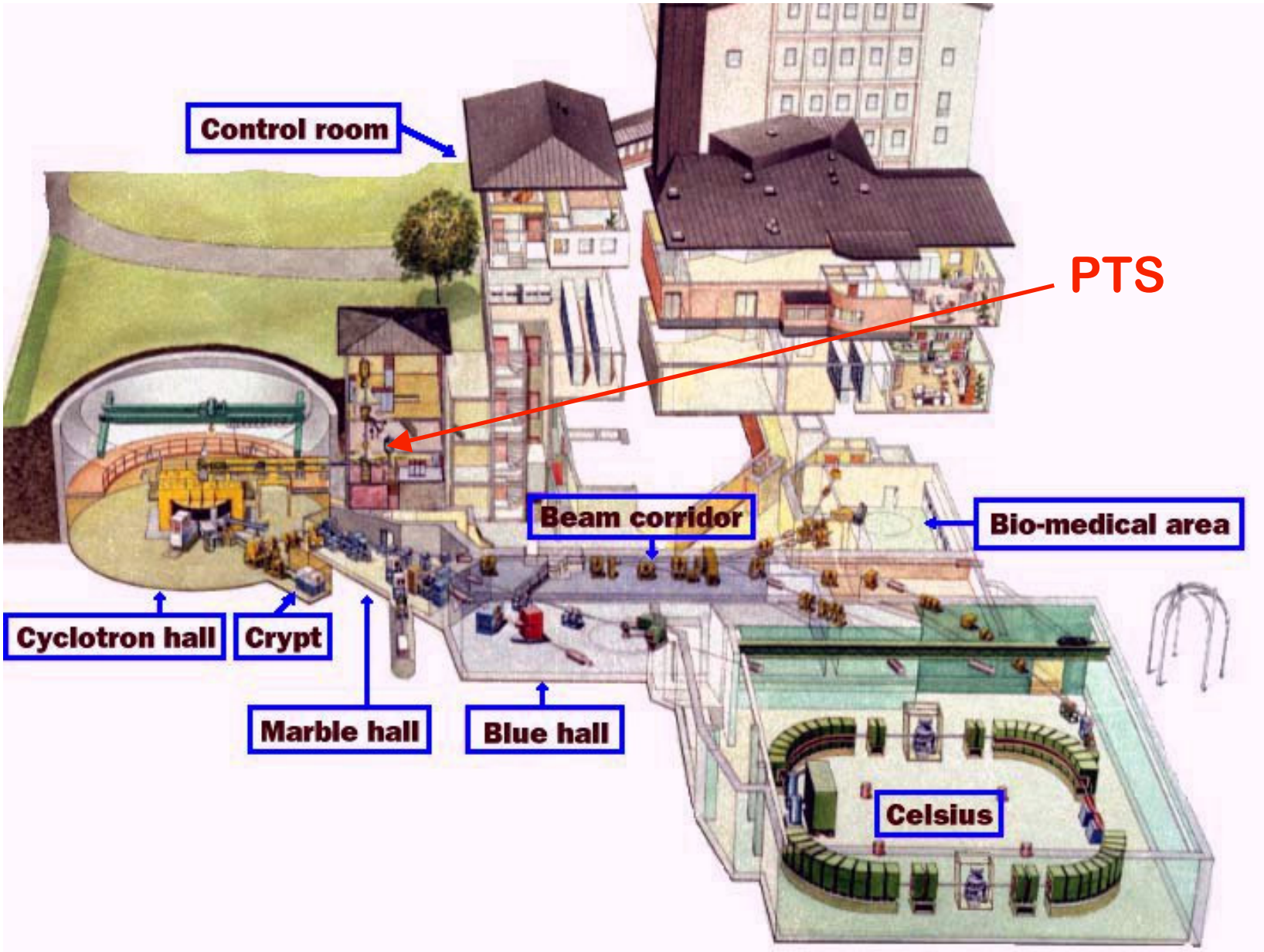
Pellet Heating at WASA



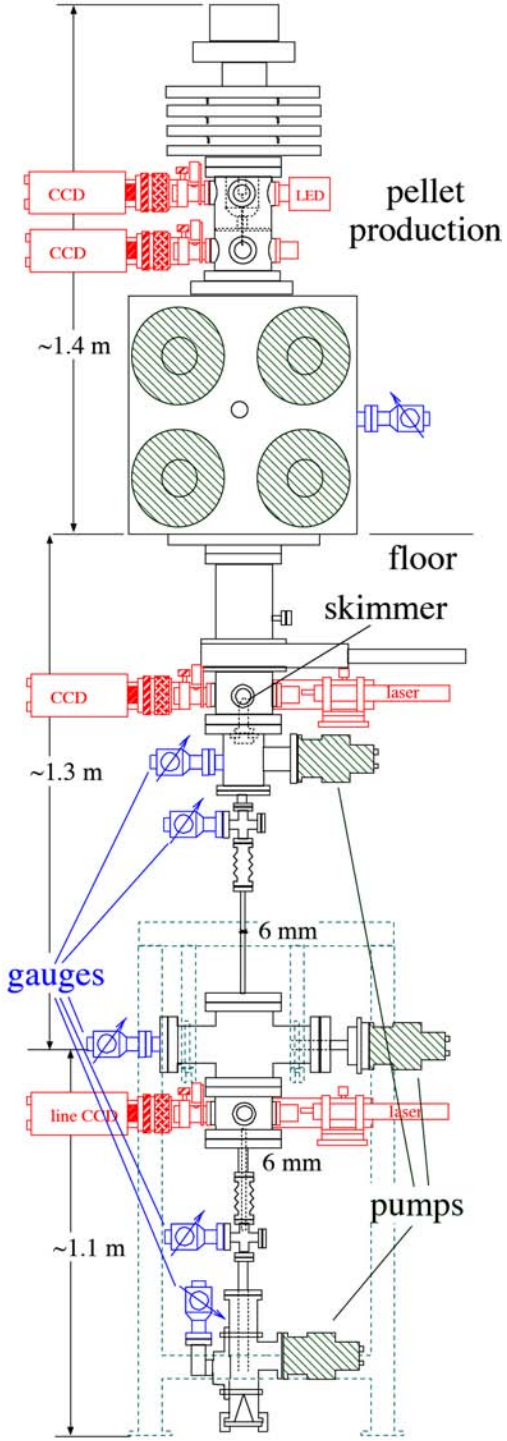


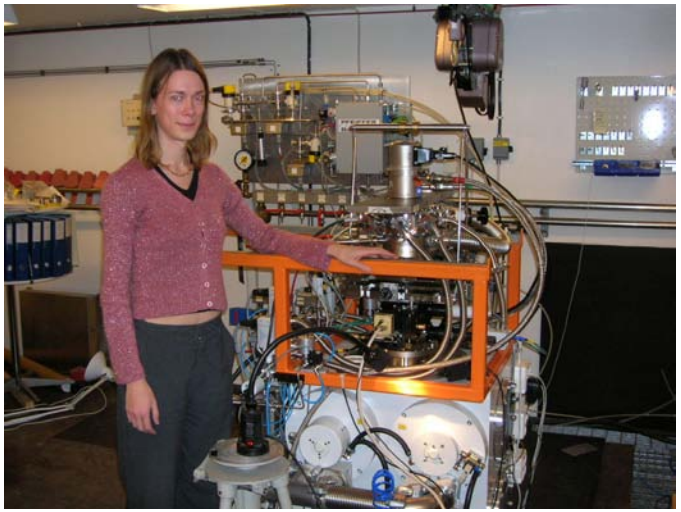


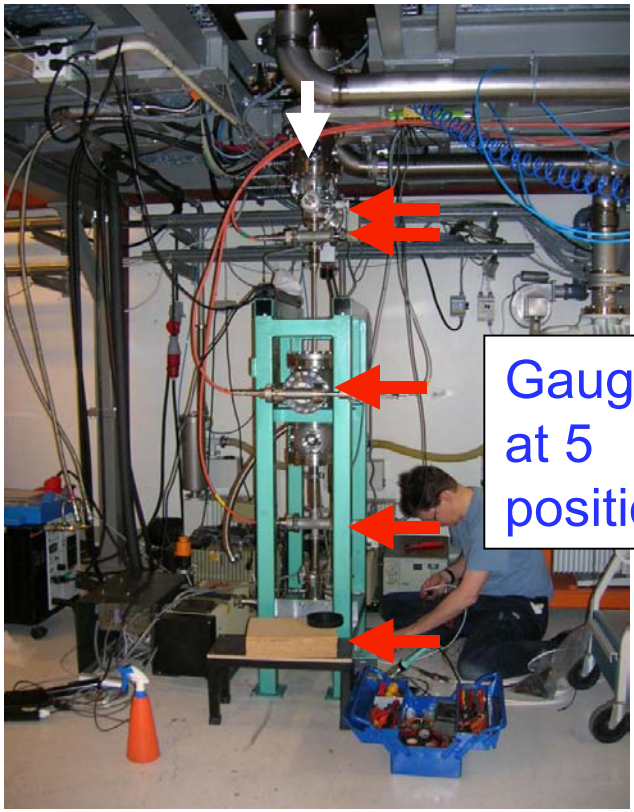
The Pellet Test Station (PTS)



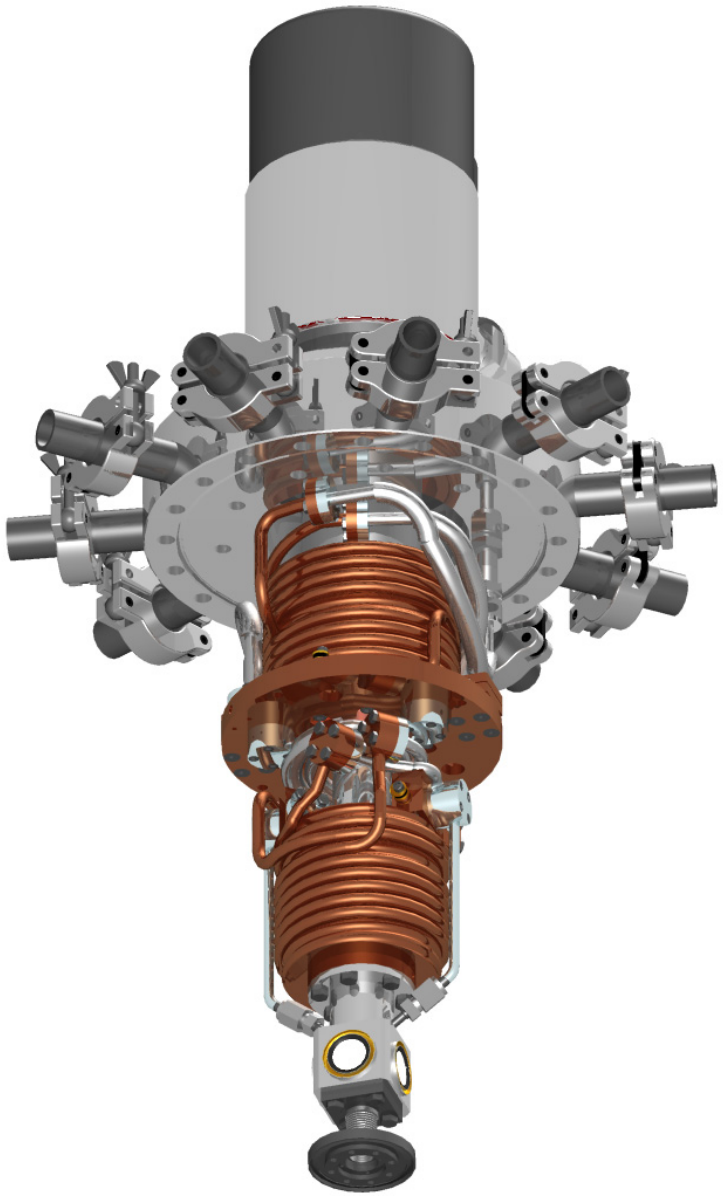
Status 2006







Gauges at 5 positions

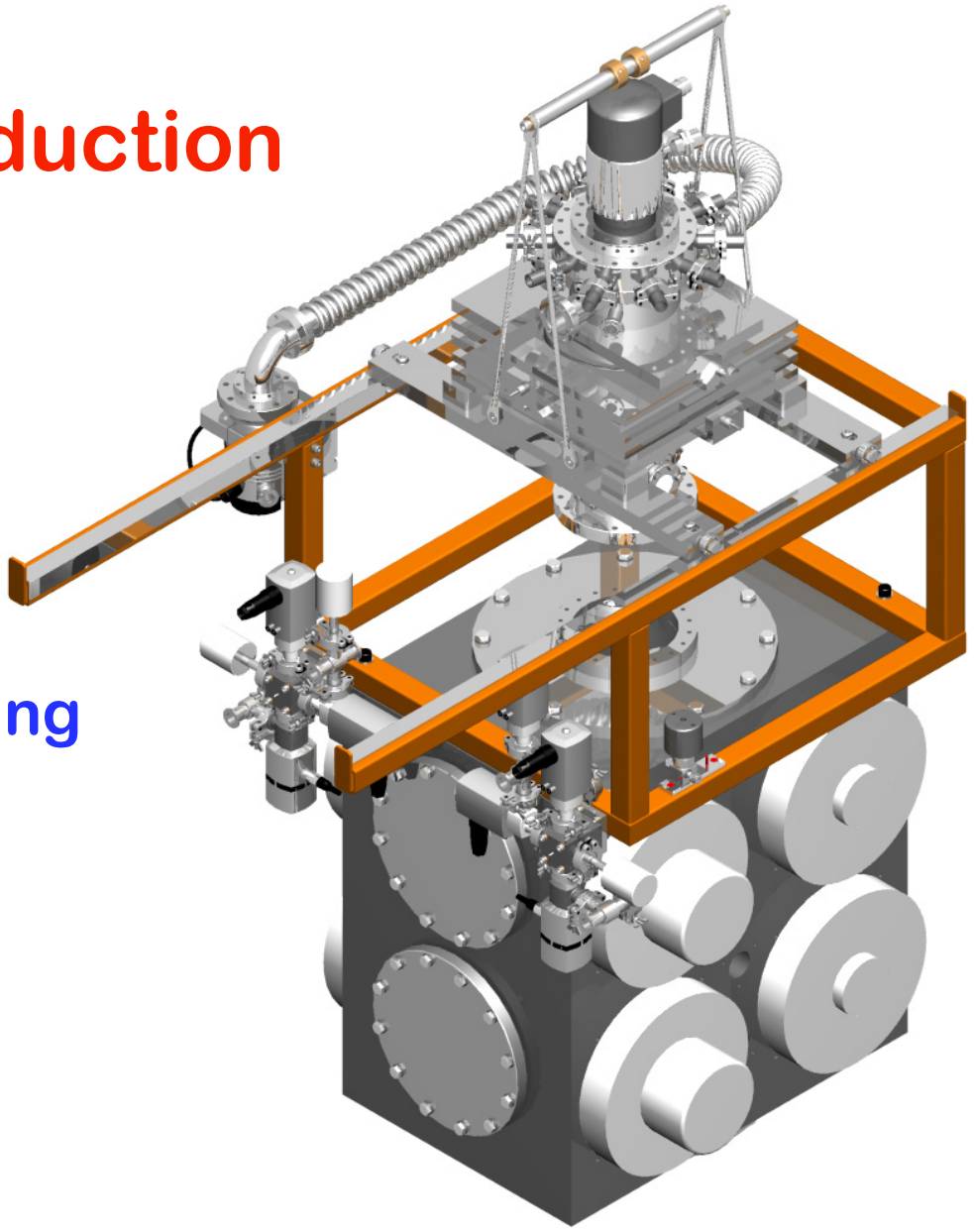


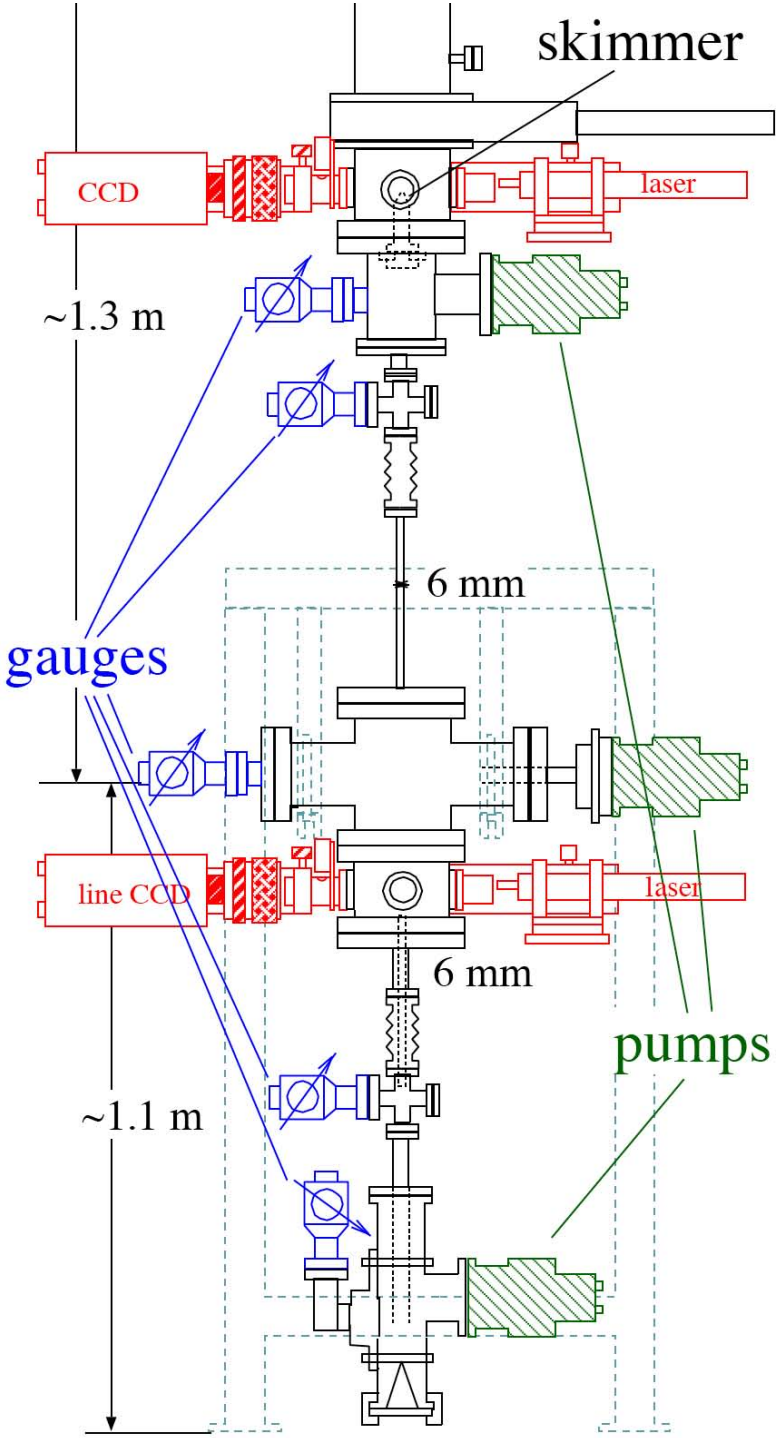
Improved Cold-Head

- lower vibrations
- faster pumping
- vacuum monitoring in all stages
- individual heating
- temperature measurements

Pellet Production

- nozzle + capillary interchangeable with WASA
- good access for mounting
- fast exchange of parts

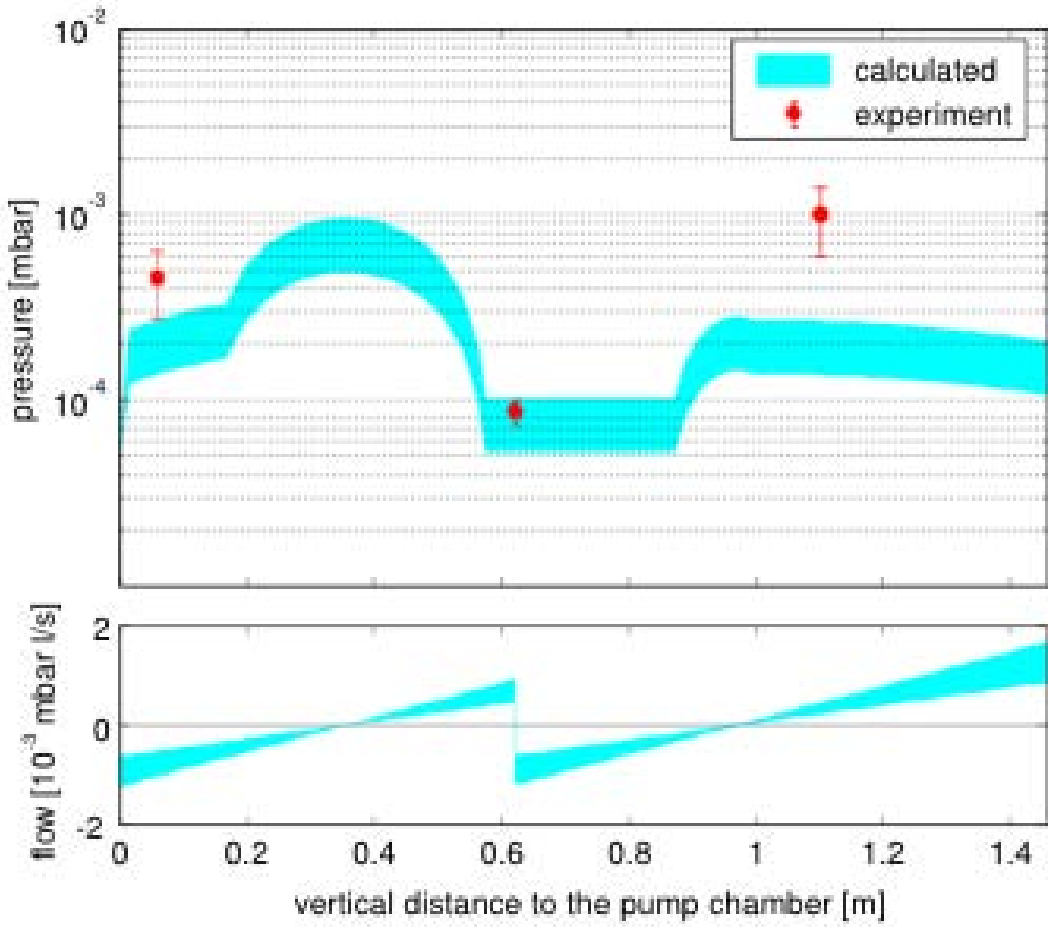




Lower Vacuum System

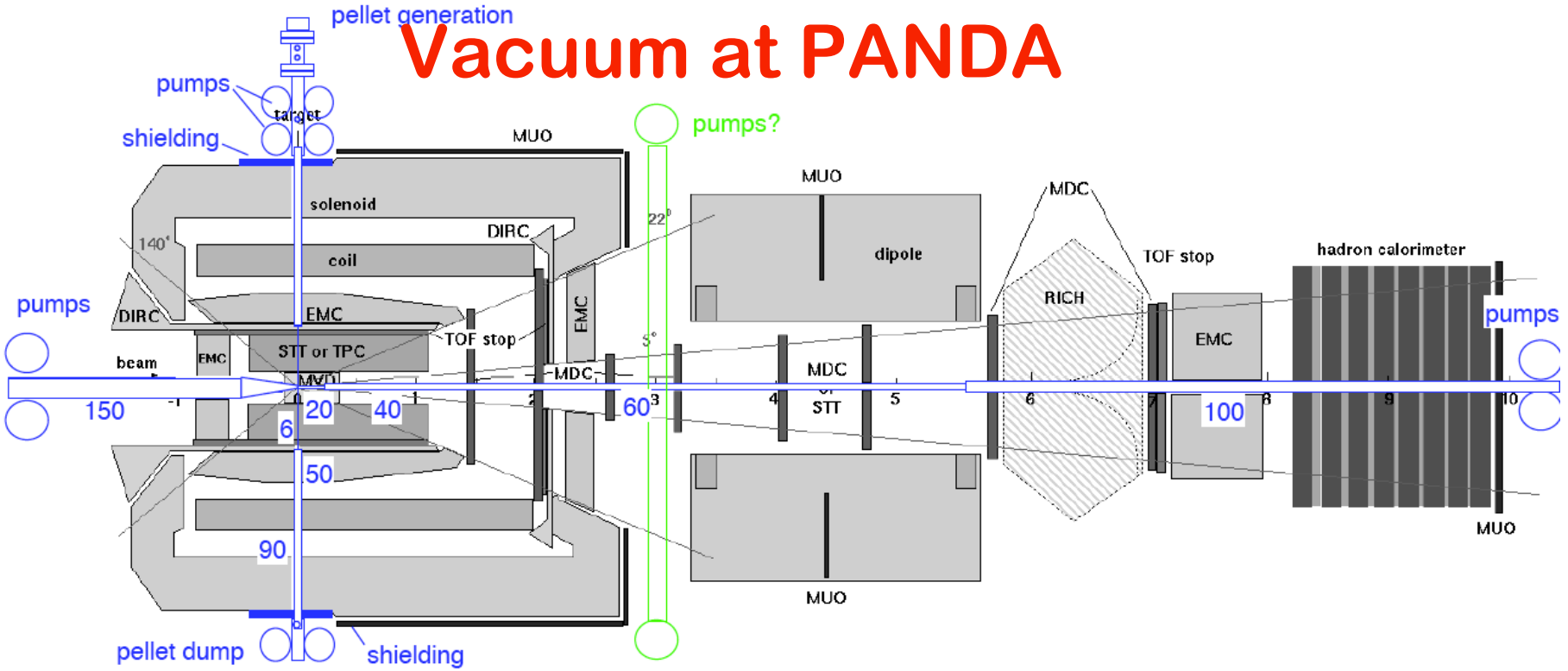
- simulating PANDA vacuum-wise
- vacuum monitoring at five points
- observation of the pellets CCD and line-scan cameras
- pellet counter
- flexible design

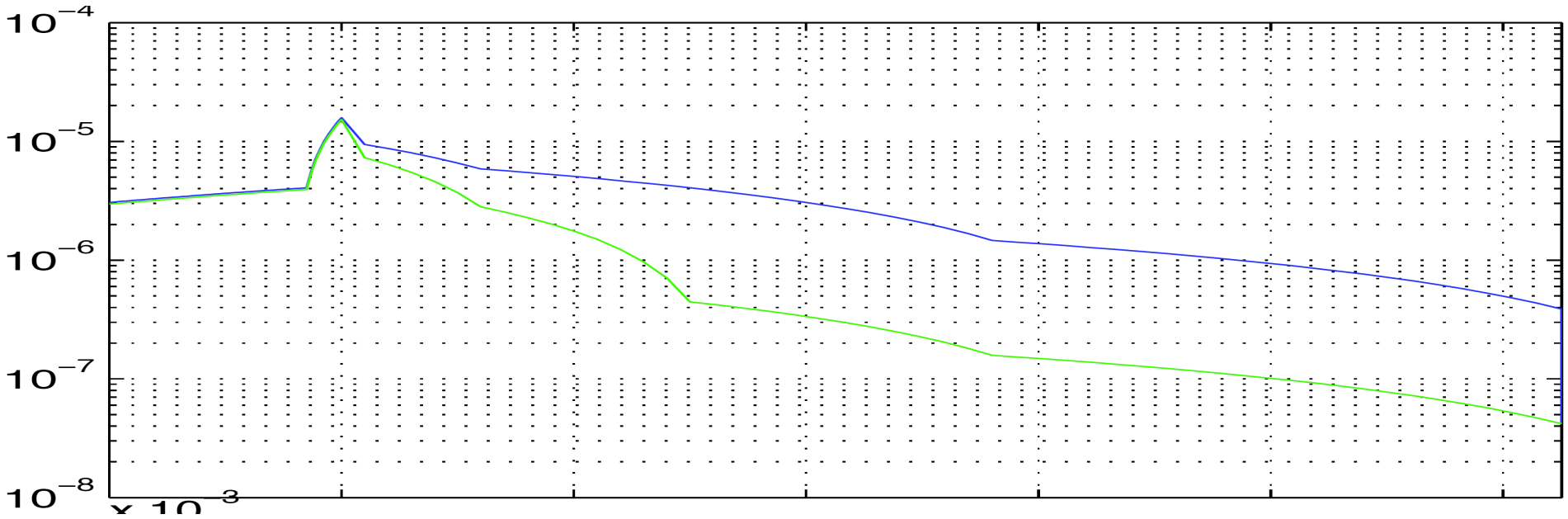
First Results on the Vacuum

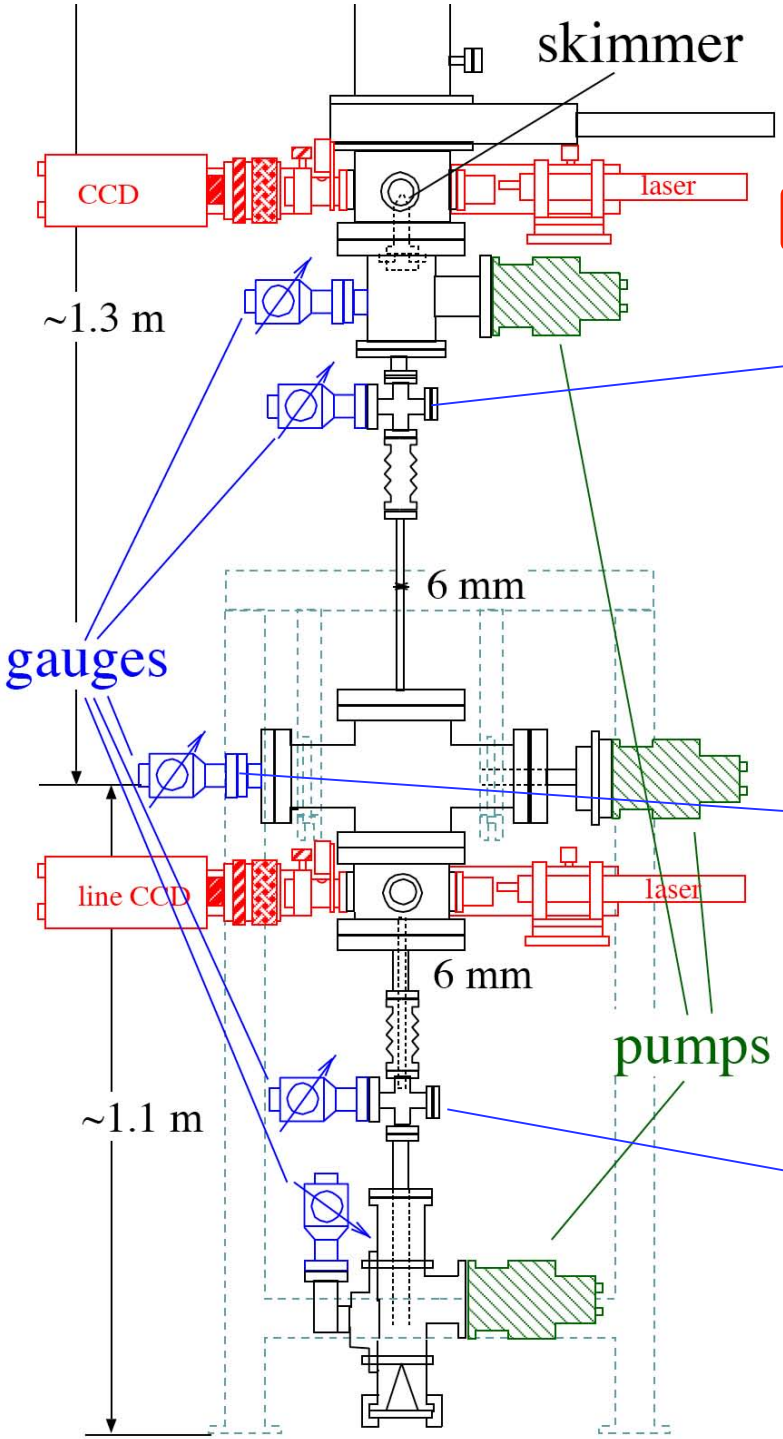


- measurements with a stable pellet train
- calculations using VACLOOP
- agreement of experiment and calculations

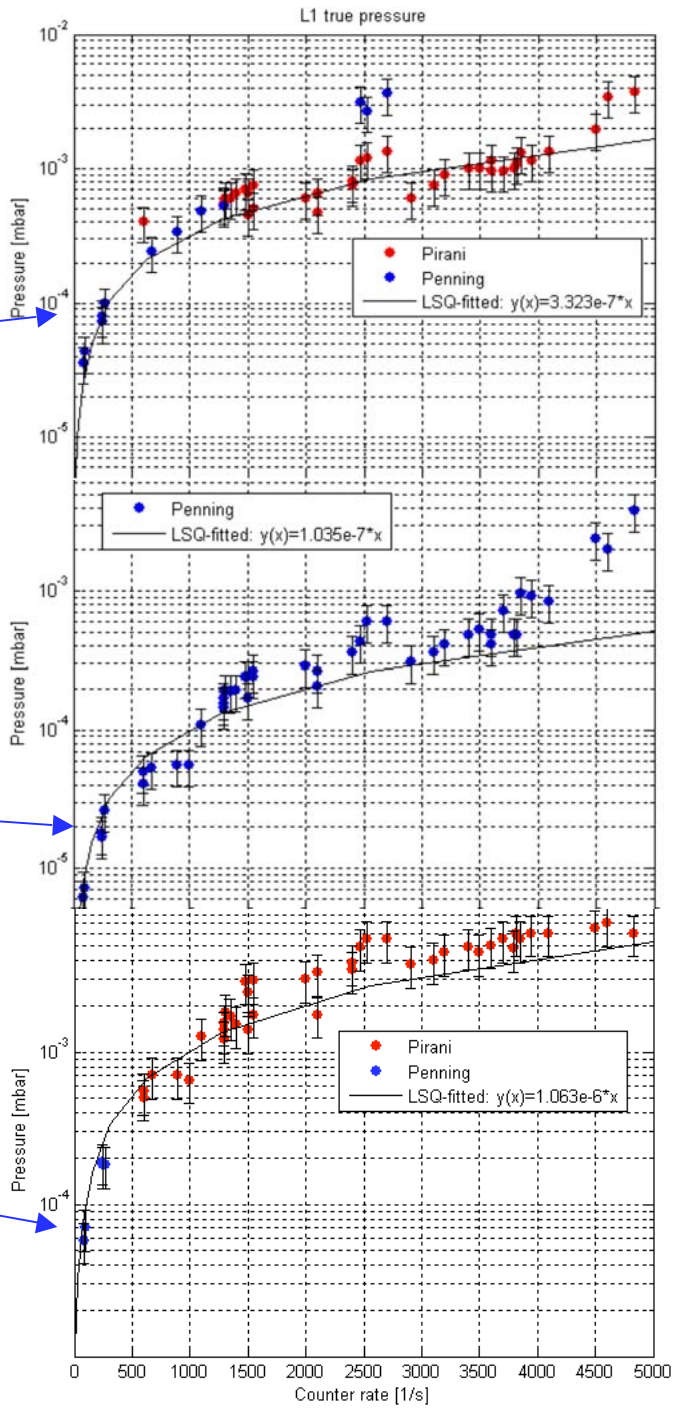
Vacuum at PANDA



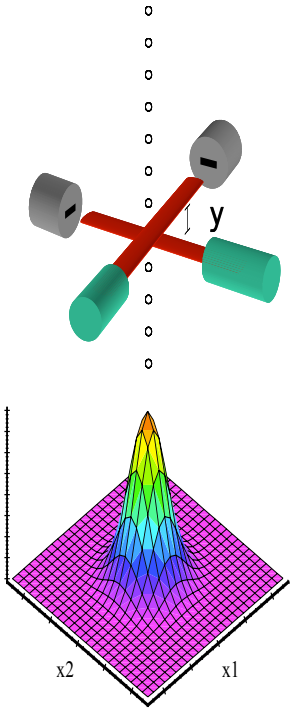



skimmer
CCD
laser
~1.3 m
6 mm
gauges
line CCD
laser
6 mm
pumps
~1.1 m

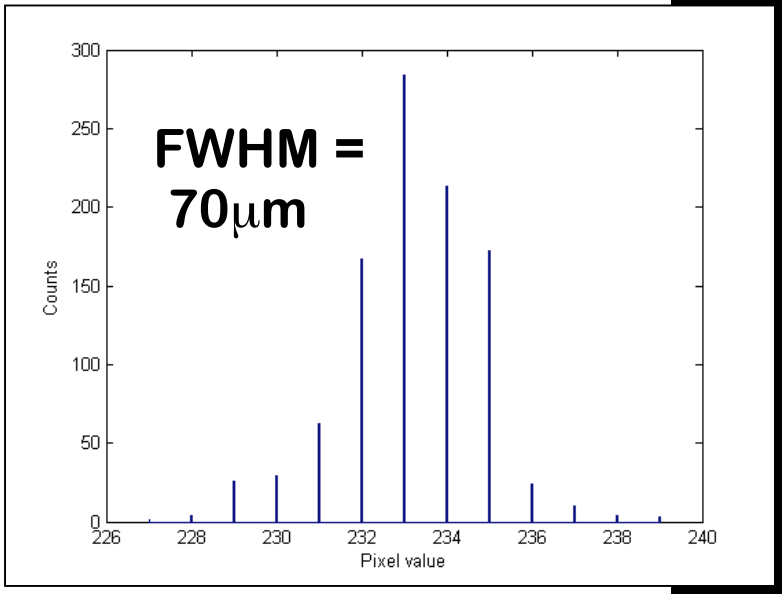
New Results


L1 true pressure
Pressure [mbar]
Pirani
Penning
LSQ-fitted: y(x)=3.323e-7*x
Penning
LSQ-fitted: y(x)=1.035e-7*x
Pirani
Penning
LSQ-fitted: y(x)=1.063e-6*x
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Counter rate [1/s]

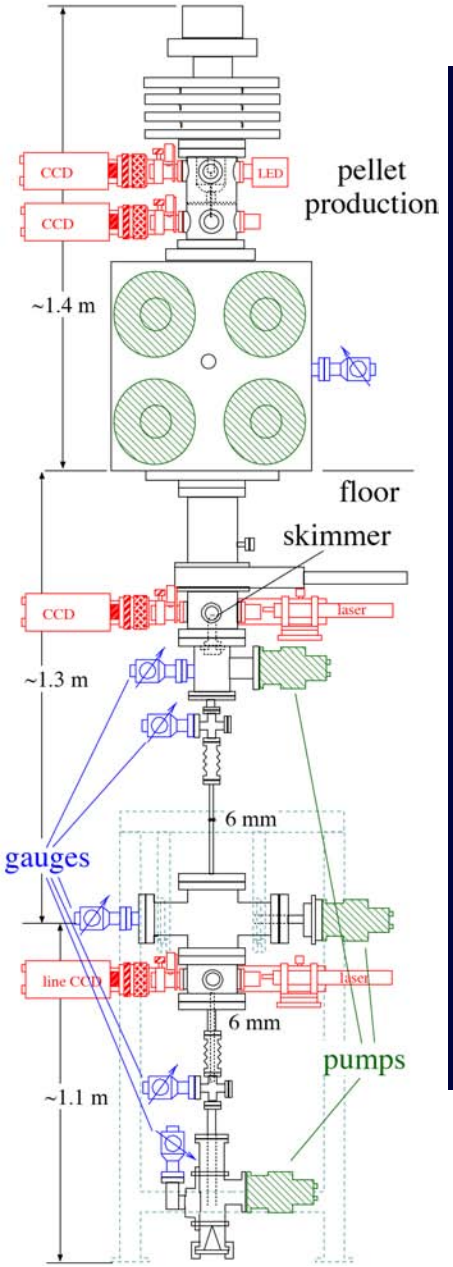
Individual Pellet Tracking System

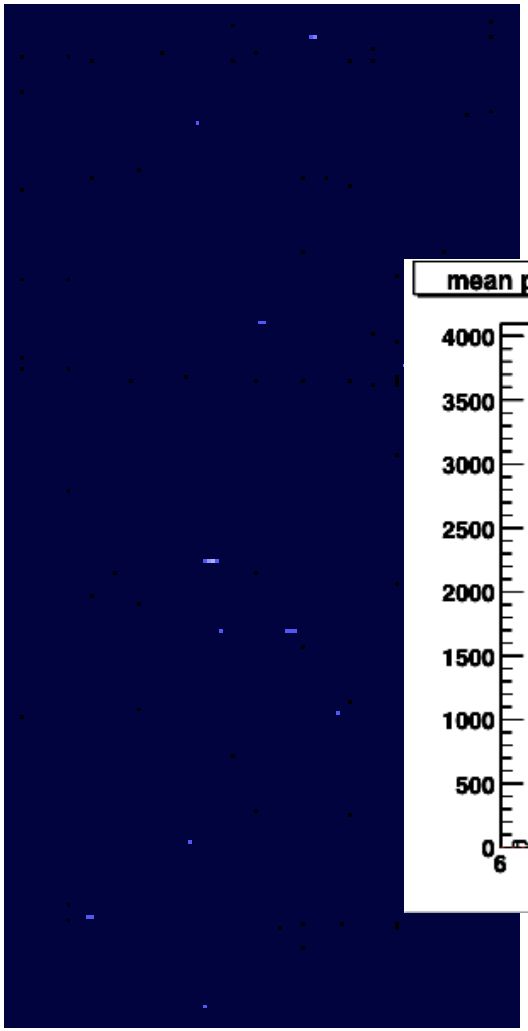


98 kHz, 512 pixel line-scan camera

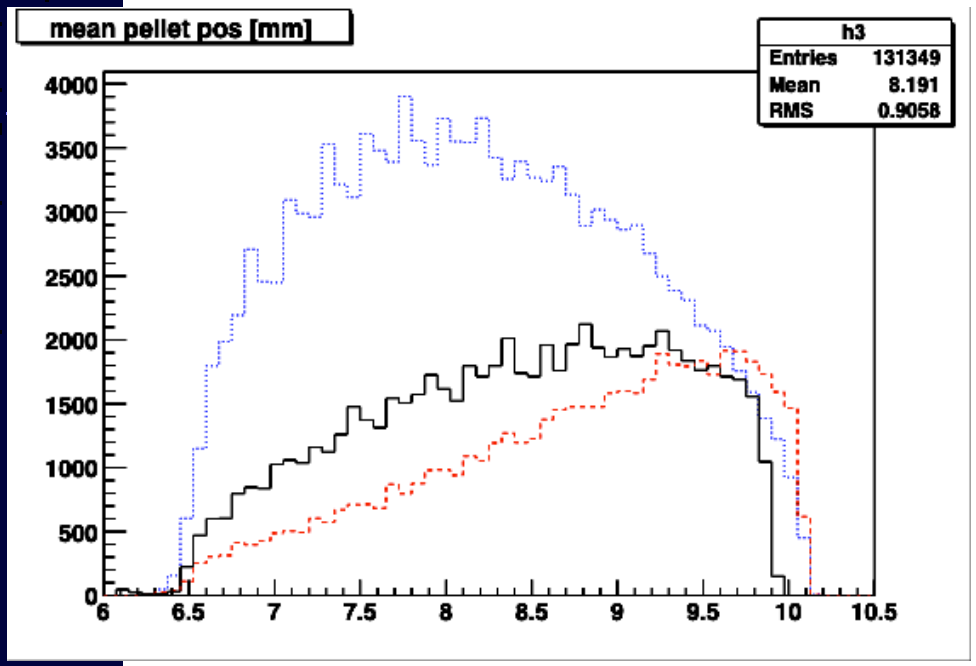


Pellet Train at the Interaction Point



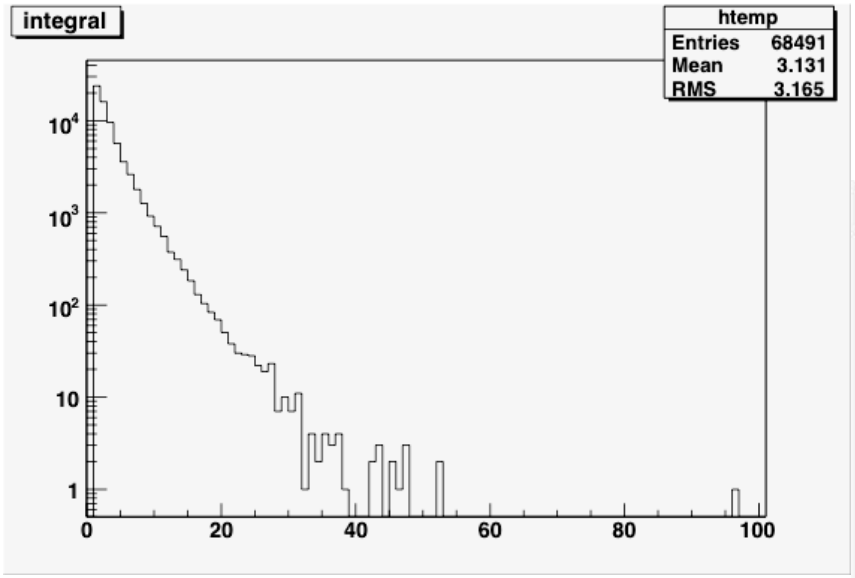


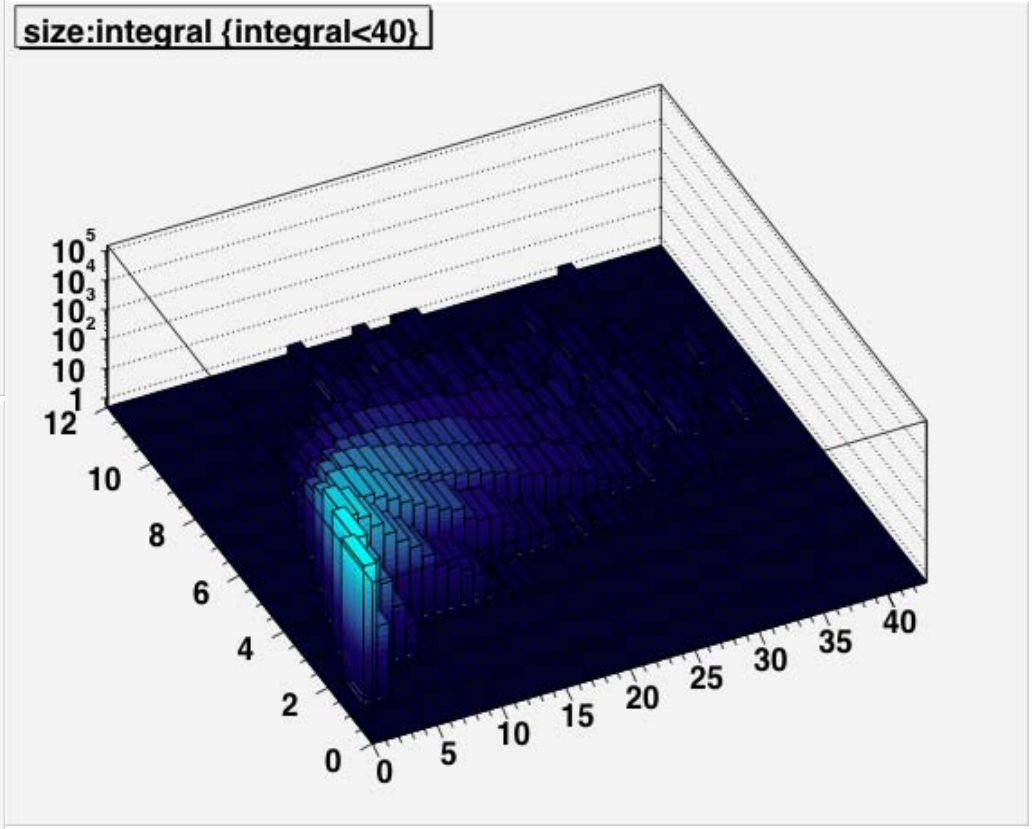
3000 - 4500 pellet/s



train radius 1.75 mm

Pellet Train at the Interaction Point





What is the efficiency?

Conclusions

System extended meanwhile!

- pellet targets - solution for internal targets with
  - space for detectors around the interaction point
  - low out-gassing
  - high luminosities
  - vertex definition
  - but: beam size has to be matched (or larger)
- achievements at Uppsala:
  - dedicated test stand
  - R&D on all components started
  - vacuum compatibility studies for PANDA
  - first pellets tracked with a CCD camera
- use at COSY, CSR, and