GERDA cryostat safety training

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Outline

1) Motivation
2) Tasks of shifter
3) Piping and Instrumentation Diagram P&ID
3) Location of hardware
4) WEB interface and PLC
5) Information available to the LNGS safety people
6) Details about the cryostat
   - insulation vacuum
   - pressure regulation
   - fill level
   - active cooling
   - water tank drainage and heat exchanger
   - N gas for pneumatic valves
7) Alarm actions

Why do we need a shift person?

0) operating a 65 m^3 cryostat in a 600 m^3 water tank is potenially a risky business

1) “everything” is automatized, but there might be situations when a person has to diagnose a problem from above/under-ground and/or to fix s.th.

2) agreement with LNGS: every day shift for cryostat, a GERDA person is underground within 30 min after she/he is called (or a problem reported by GERDA itself), shift list is provided to LNGS

   Note: after 4 months of operation, no call so far and no problem occurred which required a person to come immediately

3) 365 day of operation has to be shared by more than a few people (especially on weekends) even if the chance to have a problem is low

Task of the shifter

0) get acquainted with the system (these slides are on the WEB, HELP on WEB page)
and the current status (ELOG)

1) be reachable by phone during the shift (shifter mobile telephone available soon),
notification by a) GERDA alarm control via SMS b) LNGS guards
Note: GERDA alarm should come first

2) be close to a computer with a WEB browser during your shift

3) need a car to go underground (check access authorization!)

4) try to diagnose a problem
- from outside with the WEB interface (e.g. from your office or home/hotel)
- call an expert in case of questions (phone numbers are stored in the shifter mobile or on WEB),
these are currently
Marco Balata, Stefano Gazzana, Luca Ioannucci,
Matthias Junker, Karl Tasso Knöpfle, Bernhard Schwingenheuer
- find out whether it is safe to enter underground
- go underground for further diagnostics and actions (if useful and safe)

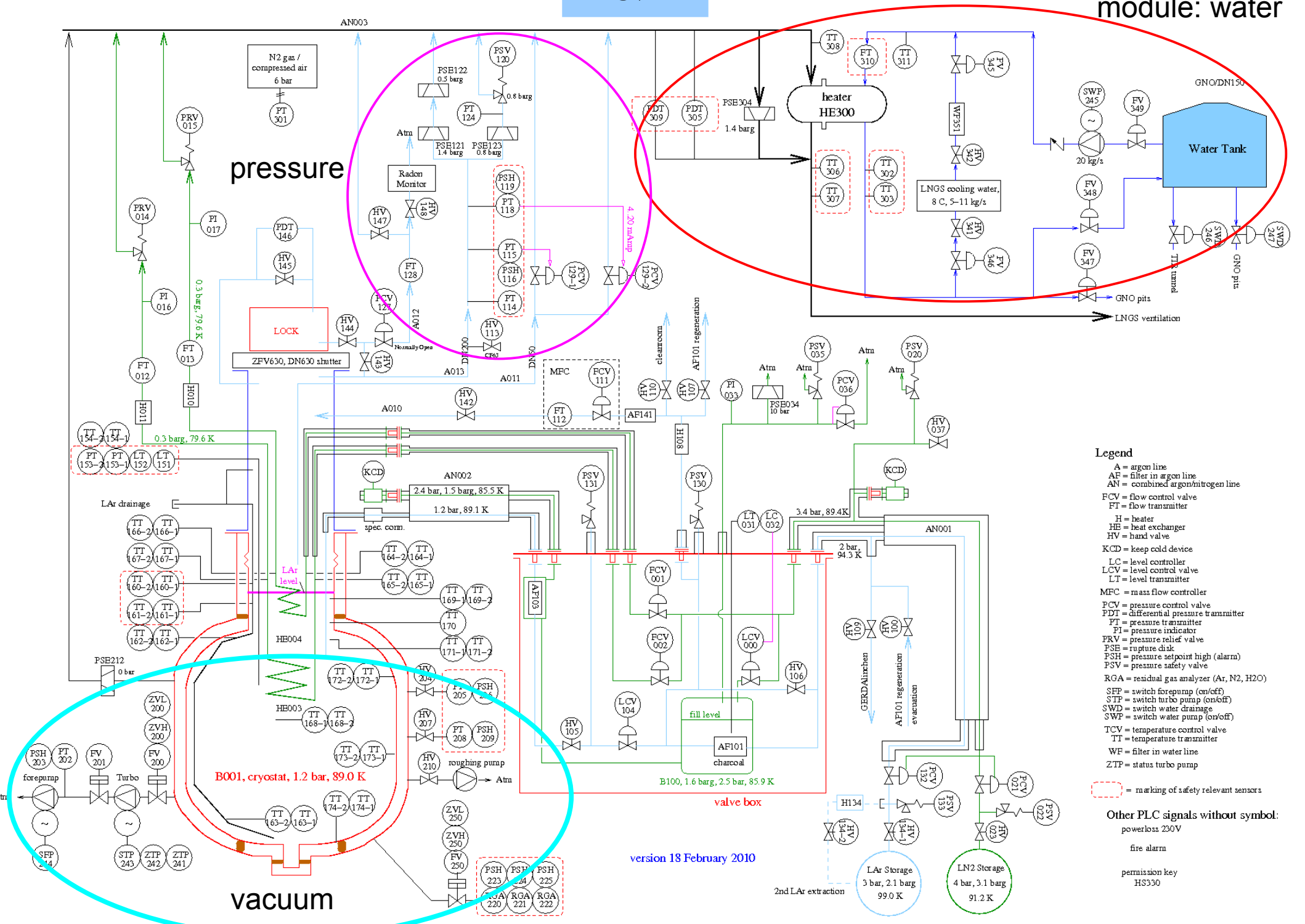
4) some actions can be done with the WEB interface (e.g. setpoint adjustment for valves),
others require to be present underground (e.g. manual operation of valves, after power cut)

5) record any action in the electronic logbook ELOG

6) make an entry into the ELOG server for shifts when you want to take over a shift:
http://teran.lngs.infn.it:20000/GERDA_Safety/
Userid and password are the same as for the internal GERDA web pages,
Note: since the chance that you are called is low, combine this shift with a job when you are at LNGS in any case

P&ID

module: water



Legend

A = argon line
AF = filter in argon line
AN = combined argon/nitrogen line

FCV = flow control valve
FT = flow transmitter

H = heater
HE = heat exchanger
HV = hand valve

KCD = keep cold device

LC = level controller
LCV = level control valve
LT = level transmitter

MFC = mass flow controller

PCV = pressure control valve
PDT = differential pressure transmitter
PT = pressure transmitter
PI = pressure indicator
PRV = pressure relief valve
PSE = rupture disk
PSH = pressure setpoint high (alarm)
PSV = pressure safety valve

RGA = residual gas analyzer (Ar, N2, H2O)

SFP = switch forepump (on/off)
STP = switch turbo pump (on/off)
SWD = switch water drainage
SWP = switch water pump (on/off)

TCV = temperature control valve
TT = temperature transmitter

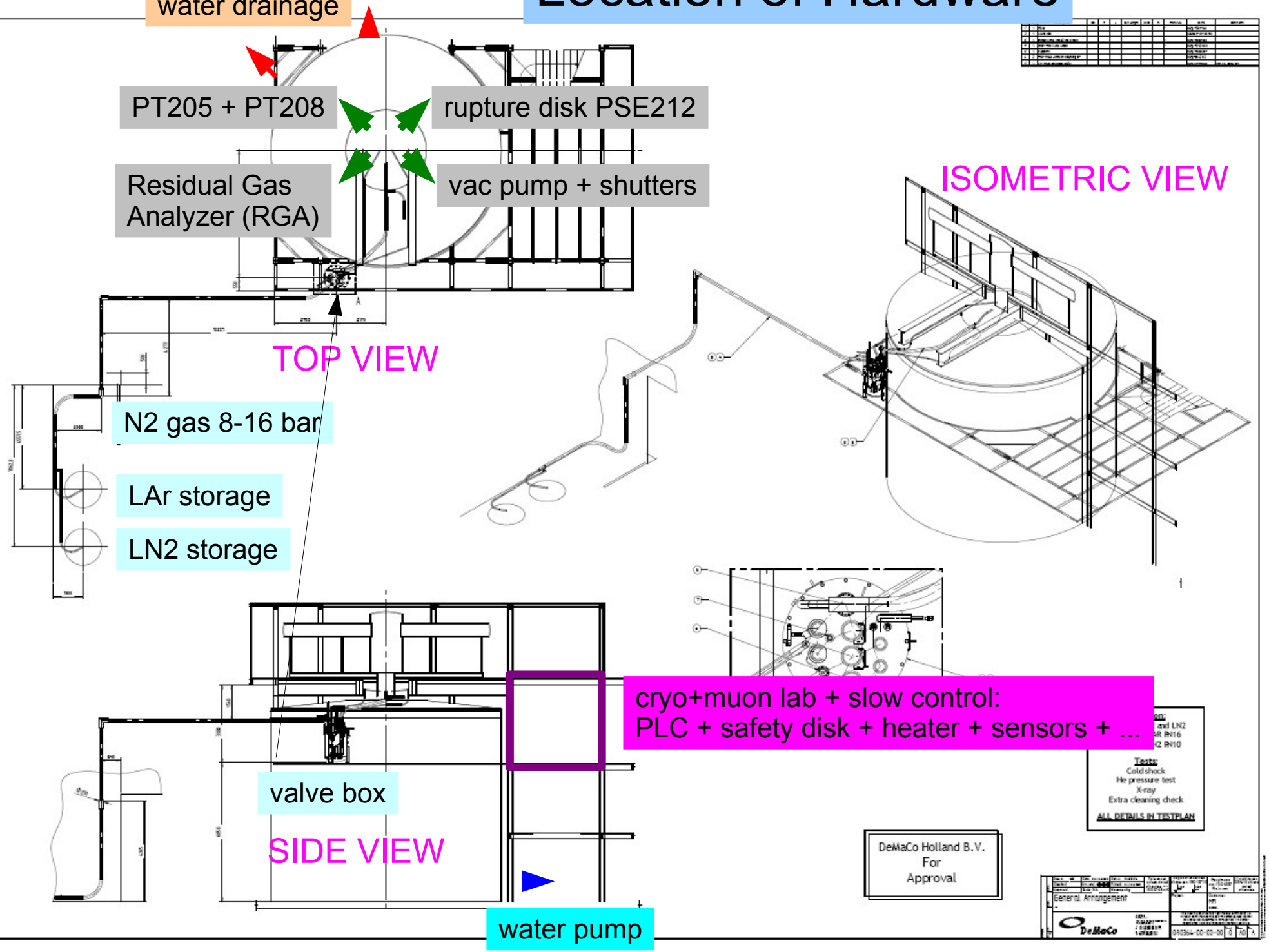
WF = filter in water line

ZTP = status turbo pump

= marking of safety relevant sensors

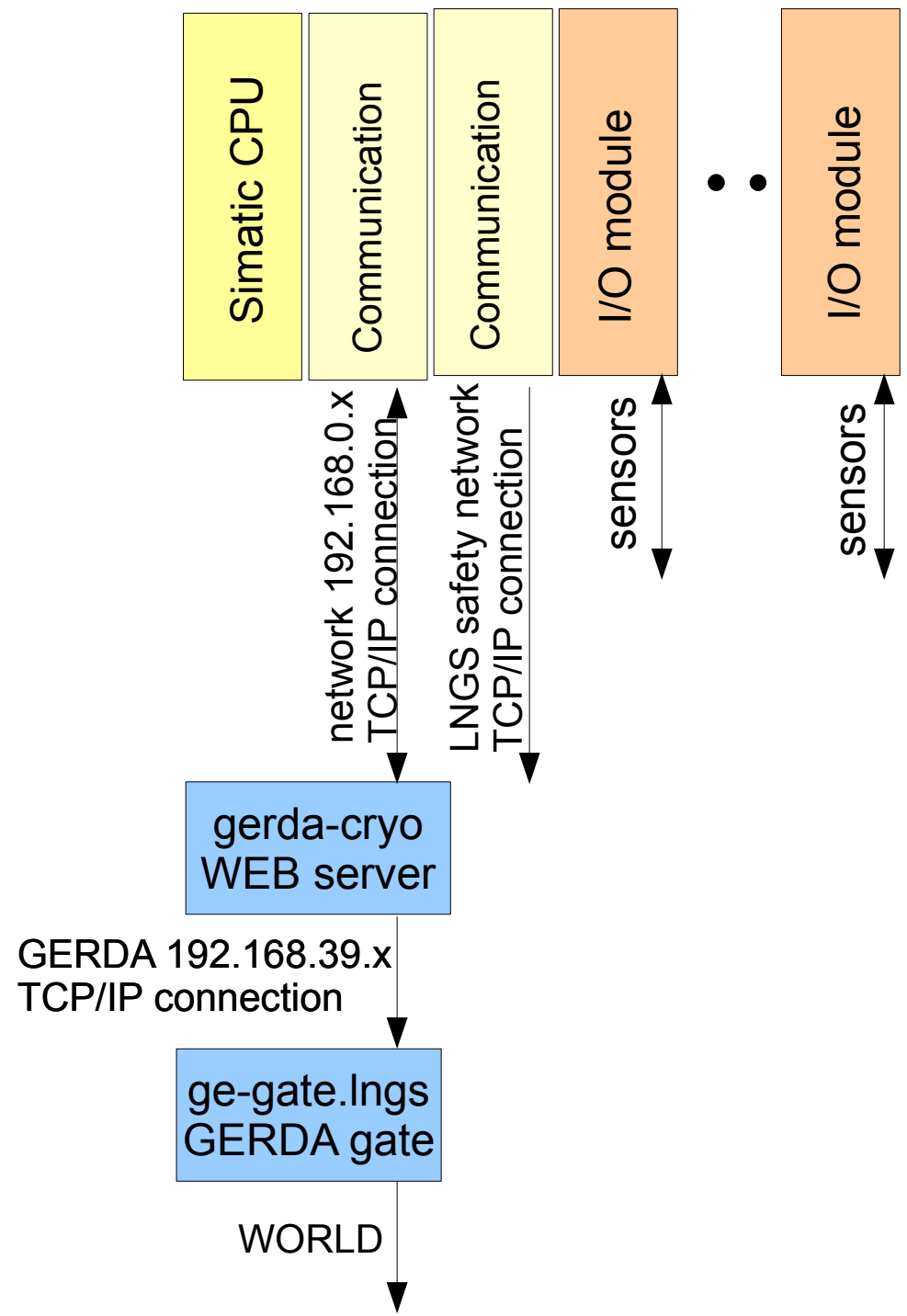
Other PLC signals without symbol:
powerloss 230V
fire alarm
permission key HS330

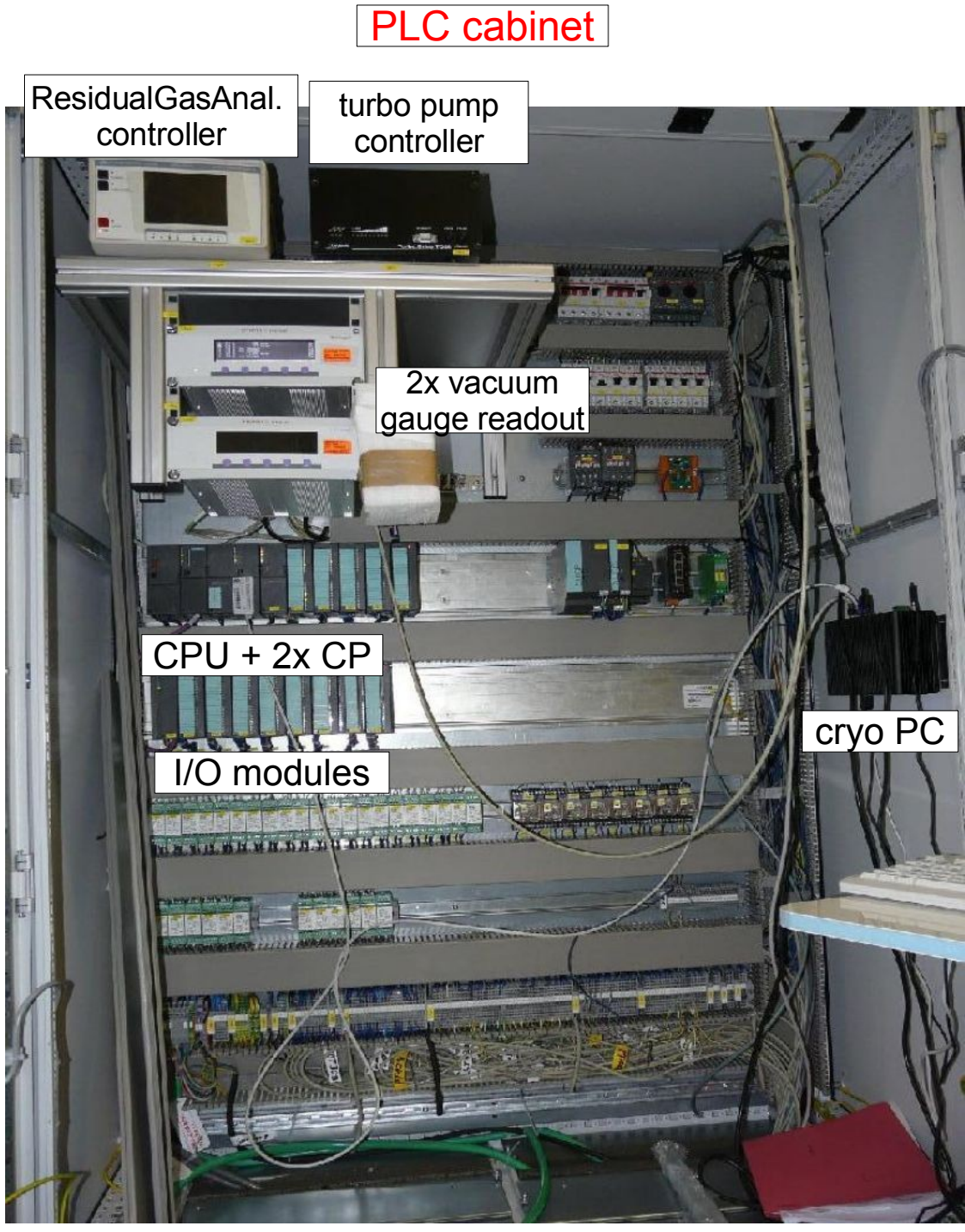
Location of Hardware



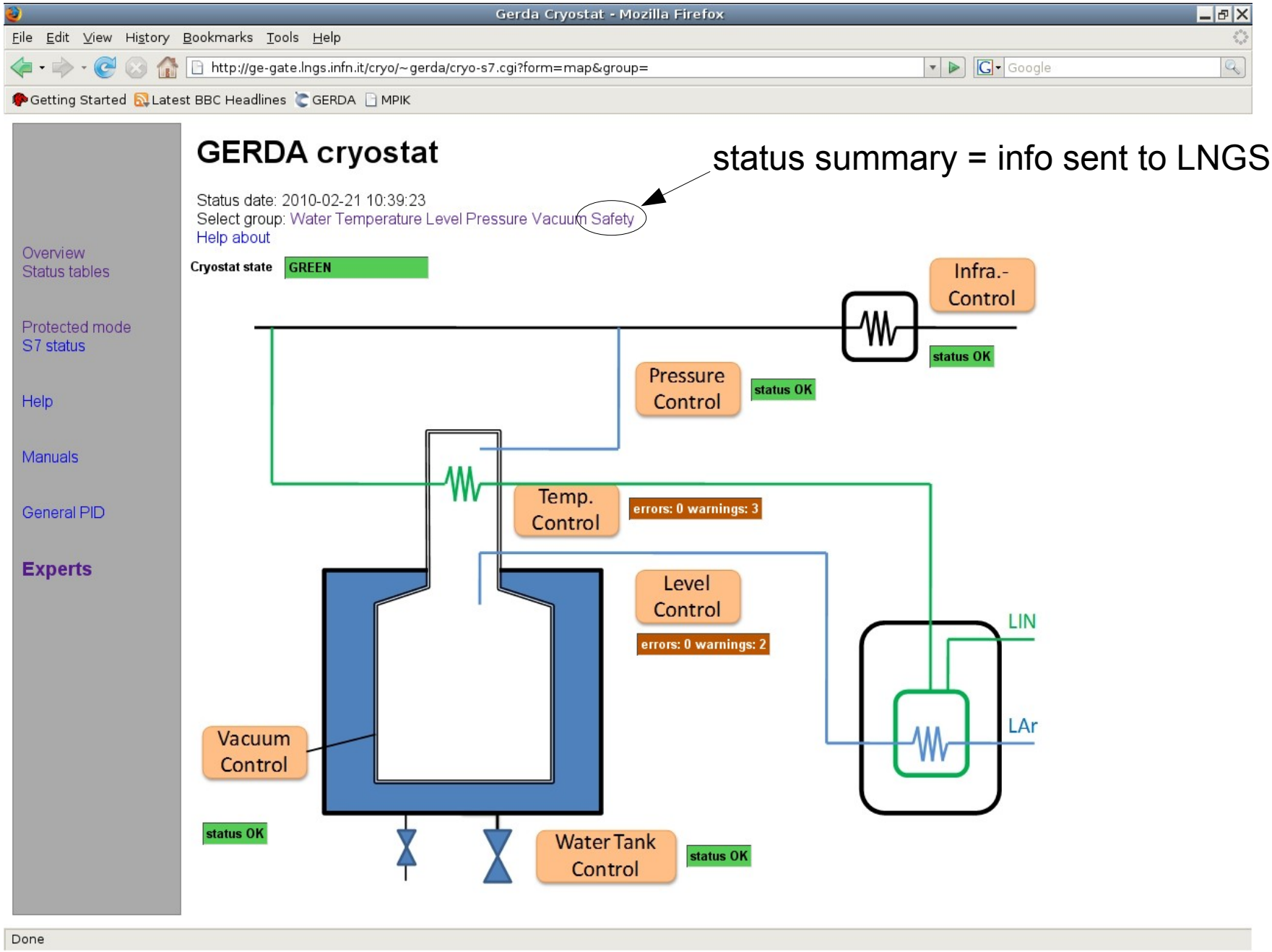
Storage tanks in TIR tunnel

WEB interface and PLC

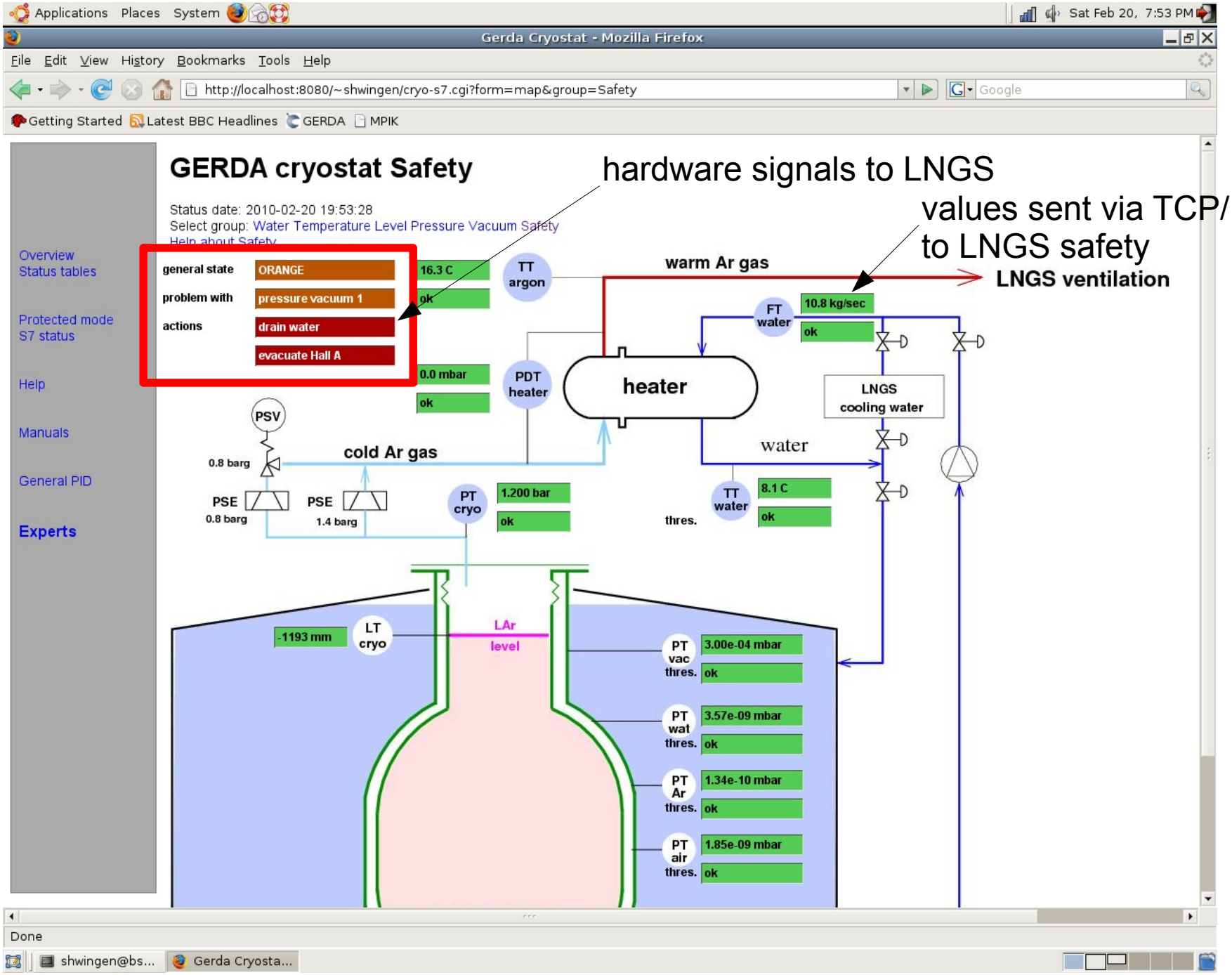




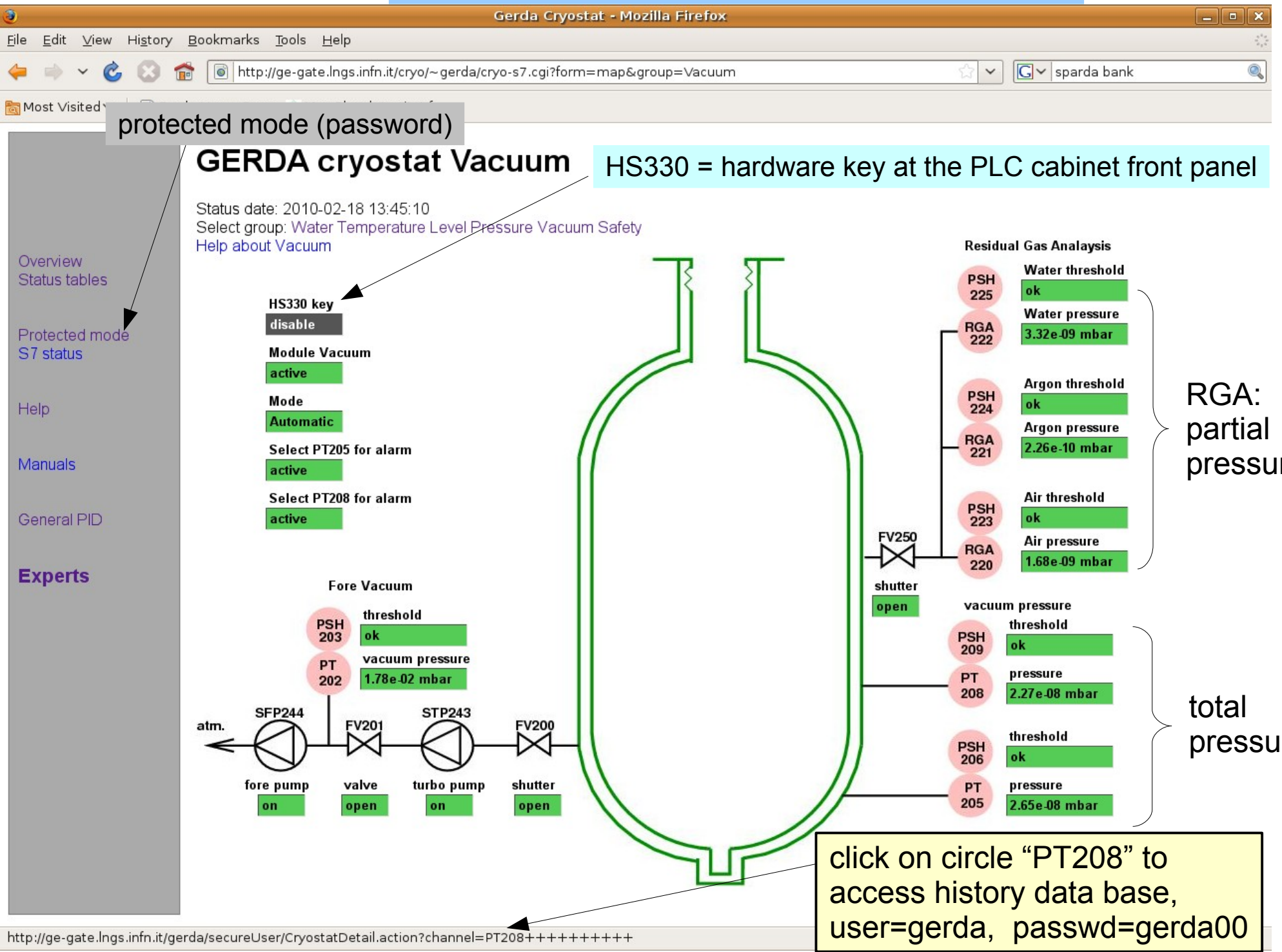
cryostat WEB page



“safety” page

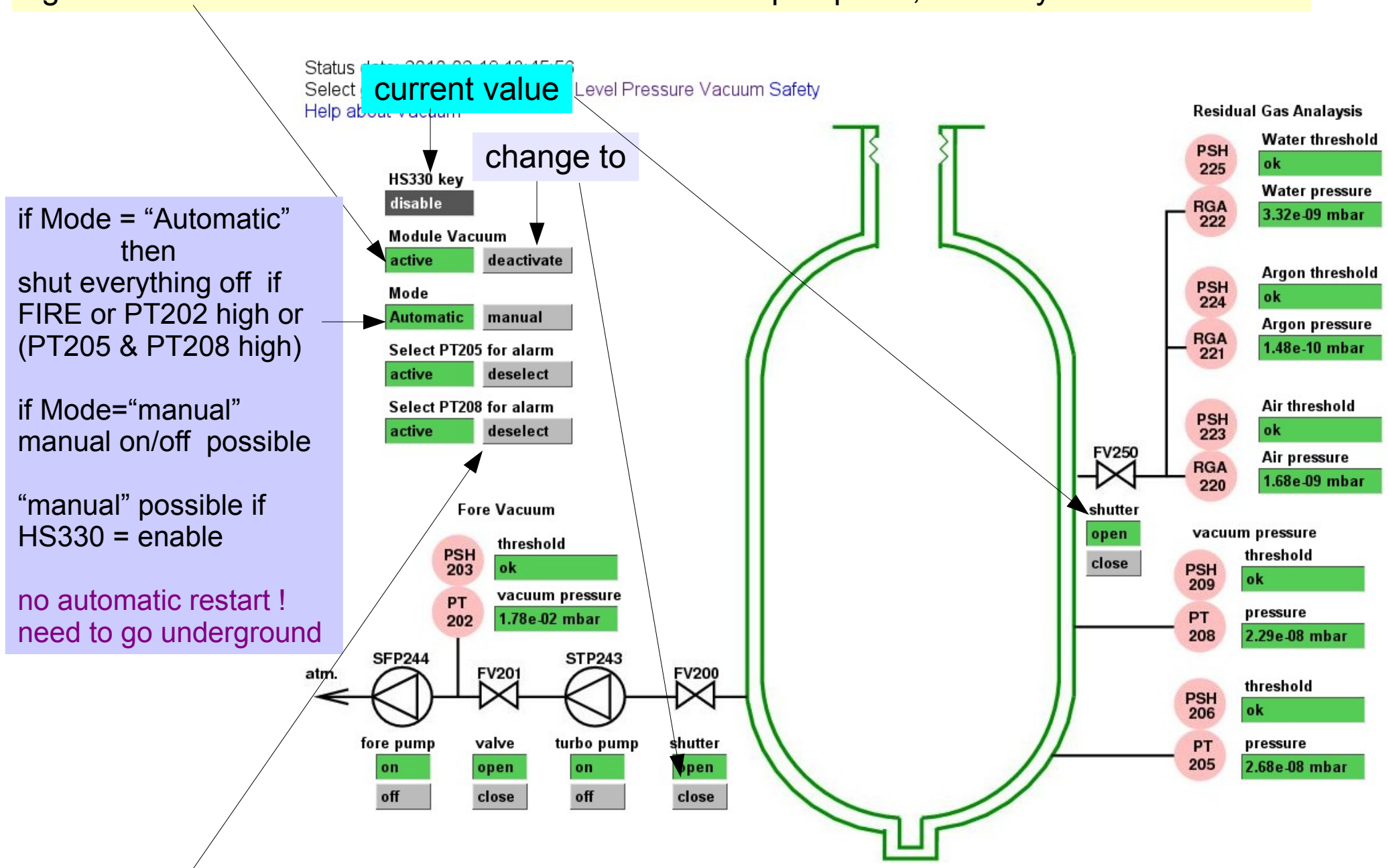

Applications Places System
Sat Feb 20, 7:53 PM
Gerda Cryostat - Mozilla Firefox
File Edit View History Bookmarks Tools Help
http://localhost:8080/~shwingen/cryo-s7.cgi?form=map&group=Safety
Getting Started
Latest BBC Headlines
GERDA
MPIK
GERDA cryostat Safety
Status date: 2010-02-20 19:53:28
Select group: Water Temperature Level Pressure Vacuum Safety
Help about Safety
Overview
Status tables
Protected mode
S7 status
Help
Manuals
General PID
Experts
general state
ORANGE
problem with
pressure vacuum 1
actions
drain water
evacuate Hall A
hardware signals to LNGS
values sent via TCP/IP
to LNGS safety
16.3 C
ok
TT
argon
warm Ar gas
LNGS ventilation
FT
water
10.8 kg/sec
ok
0.0 mbar
ok
PDT
heater
heater
LNGS
cooling water
PSV
0.8 barg
cold Ar gas
water
PSE
0.8 barg
PSE
1.4 barg
PT
cryo
1.200 bar
ok
TT
water
8.1 C
ok
thres.
-1193 mm
LT
cryo
LAr
level
PT
vac
thres.
3.00e-04 mbar
ok
PT
wat
thres.
3.57e-09 mbar
ok
PT
Ar
thres.
1.34e-10 mbar
ok
PT
air
thres.
1.85e-09 mbar
ok
Done
shwingen@bs...
Gerda Cryosta...

Cryostat Insulation Vacuum



WEB page in “protected mode” (example vacuum)

Lgoic: if Module=“inactive” all valves closed and all pumps off, normally Module=“active”



if Mode = “Automatic”
then
shut everything off if
FIRE or PT202 high or
(PT205 & PT208 high)

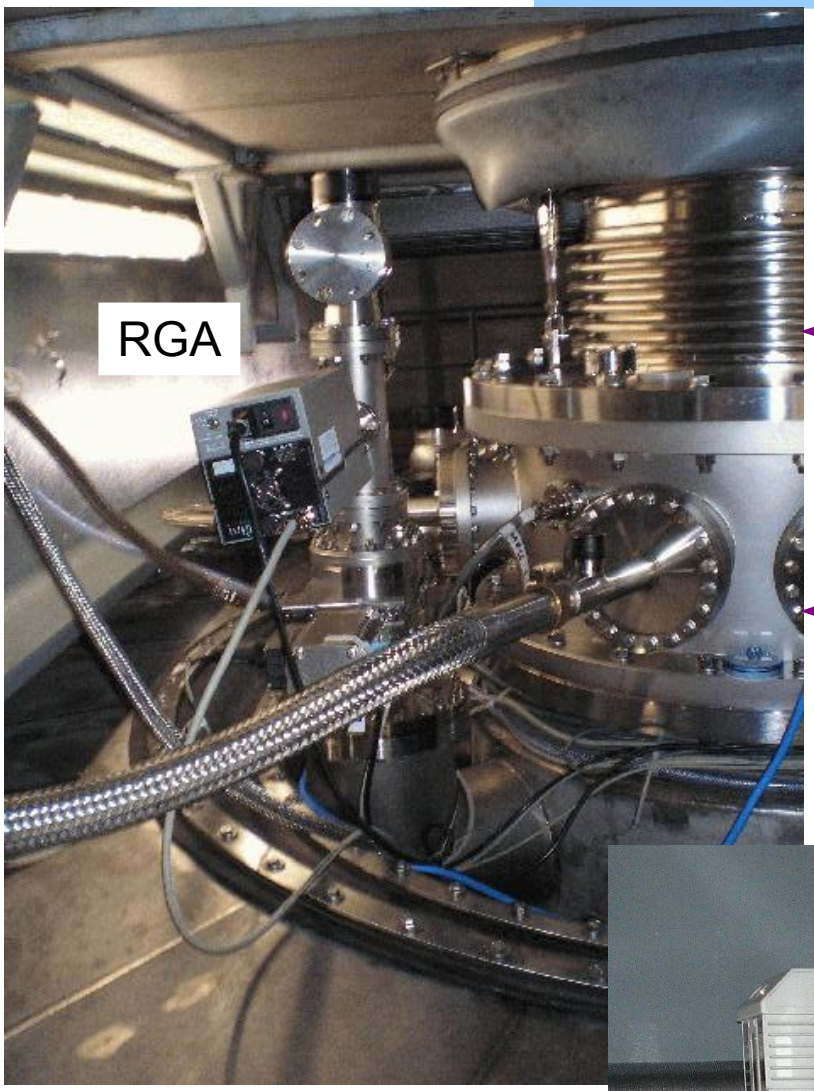
if Mode=“manual”
manual on/off possible

“manual” possible if
HS330 = enable

no automatic restart !
need to go underground

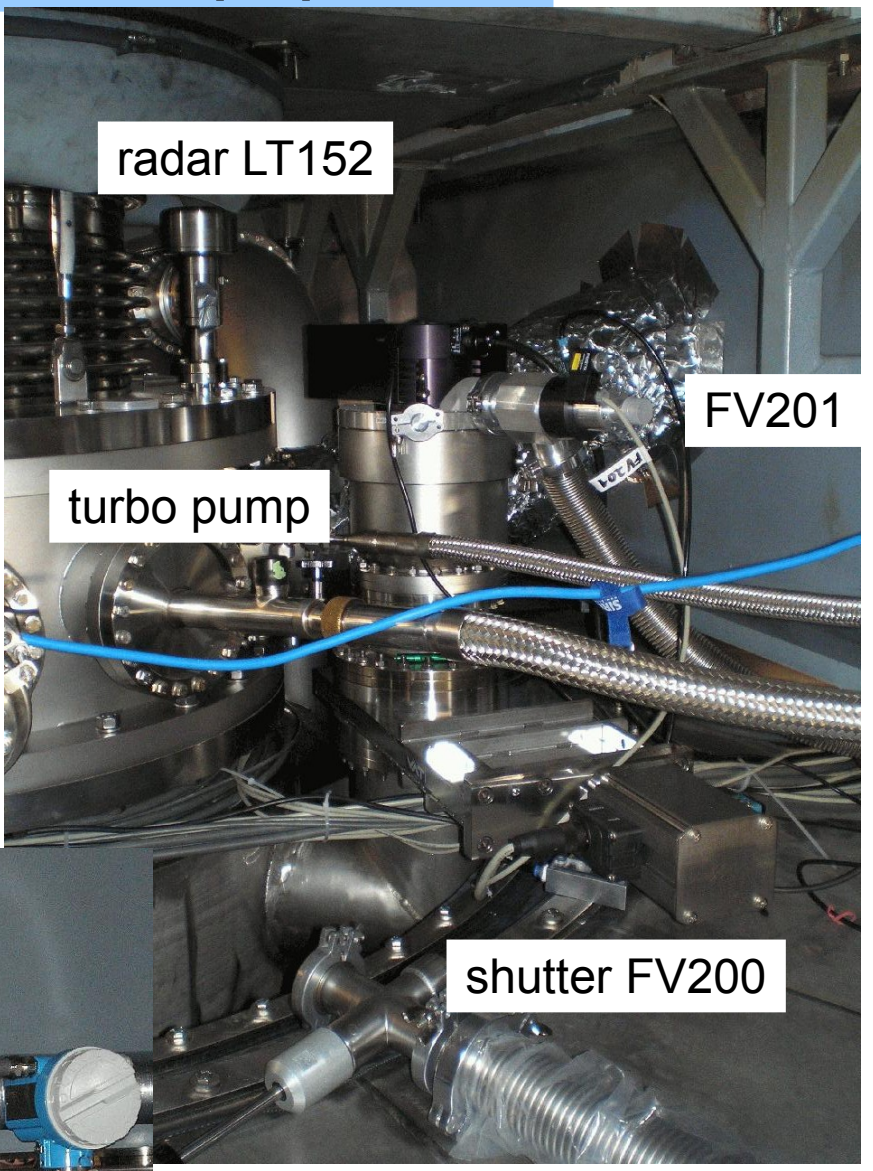
if PT205 or PT208 broken (e.g. cable broken), sensor “deselected” automatically by PLC

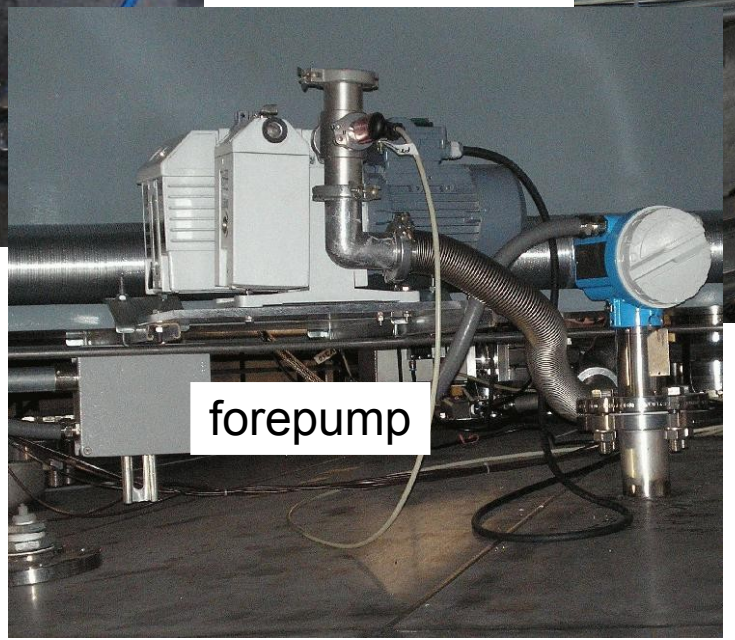
Pictures of vacuum equipment



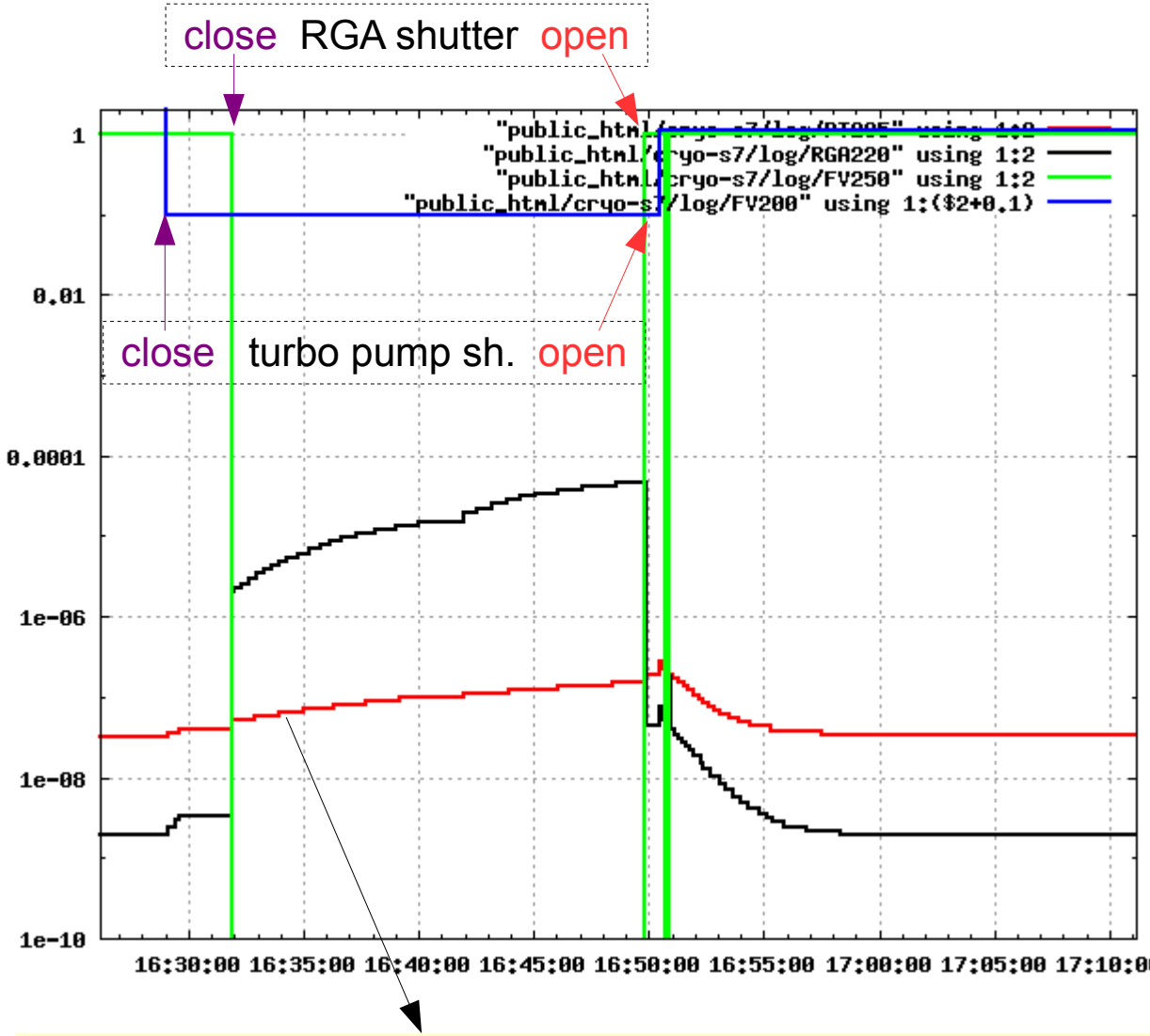
compensator

manifold





Vacuum was 1E-5 mbar before cool down, is now 2E-8 mbar, stable for months



shutter mass spectometer (RGA)
shutter turbo pump

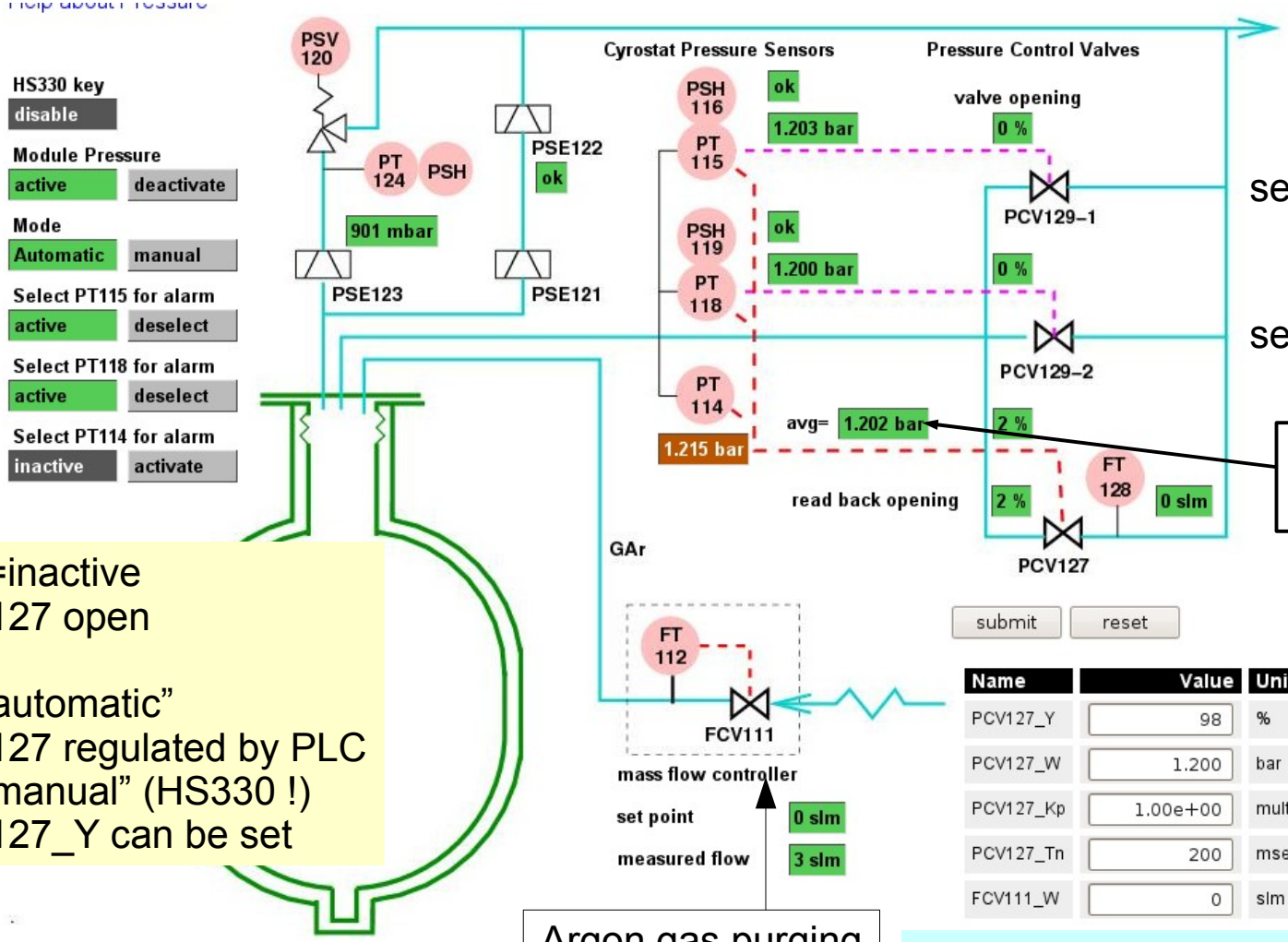
total pressure

N2 partial pressure
(H2O partial pressure also jumps by factor ~8 when shutter closes)

pressure increase ~ 1E-7 mbar in 20 minutes →
leak rate = 1E-7mbar * 6500 l/ 1200 sec ~ 4e-7 mbar *l/sec
→ it takes 1e-4 mbar * 6500 l / 4E-7 (mbar * l/sec) > 2 weeks before P reaches 1E-4 mbar

Pressure regulation

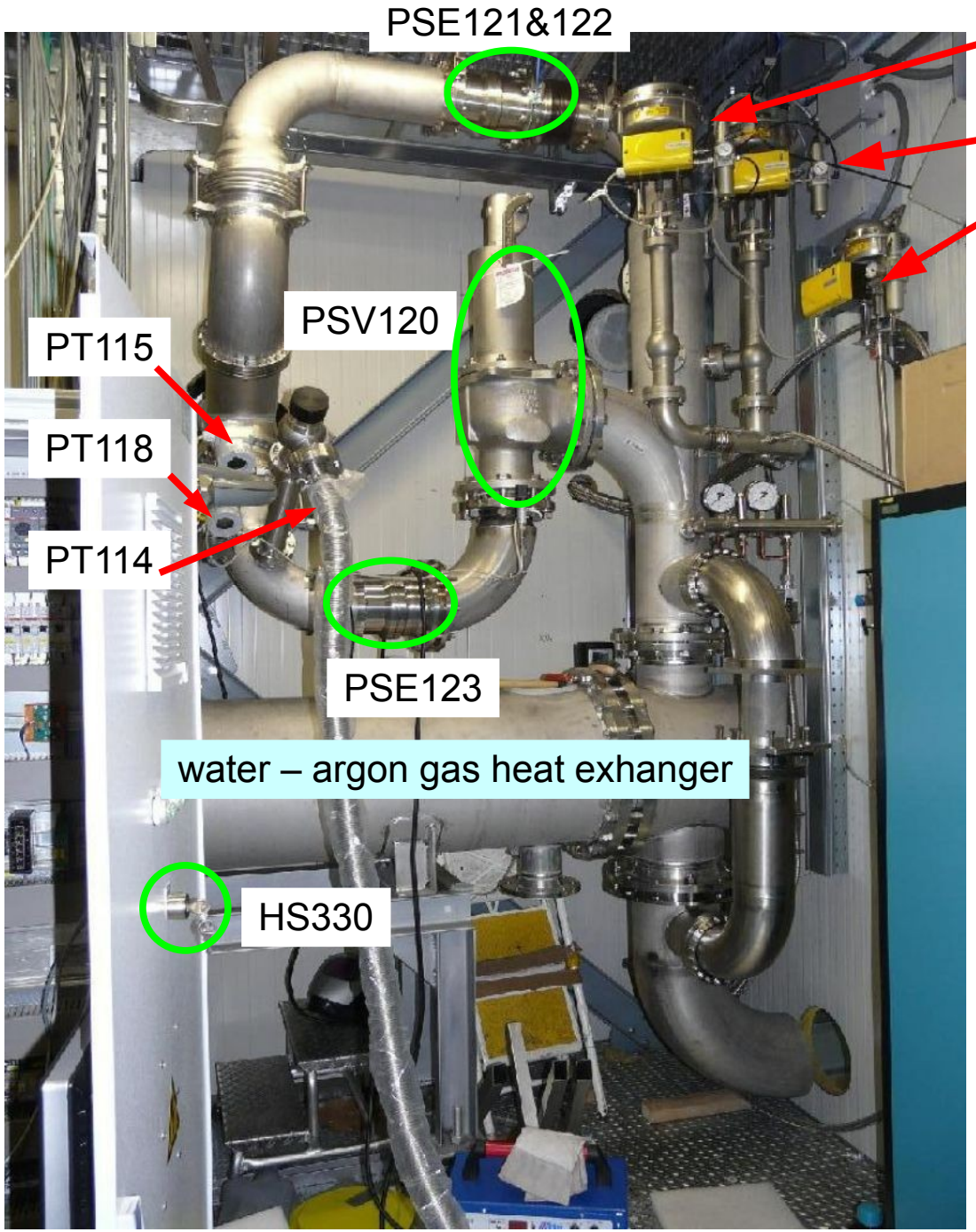
safety features: - safety valve PSV120 (0.8 barg) & PSE121 (1.4 barg) in parallel (10000 Nm^3/h each)
- PT115 regulates PCV129-1, PT118 regulates PCV129-2 (4..20 mA)
  independent of PLC, own power supply
  PLC reads out PT115/118 in “spy”-mode via transformers (digital HART signal)
- PCV127 controlled by PLC, Normally Open (in case no power or no compressed air),
  Proportional-Integral regulator output Y = Kp * {(X-W) + 1/Tn * integral(X-W) dt }

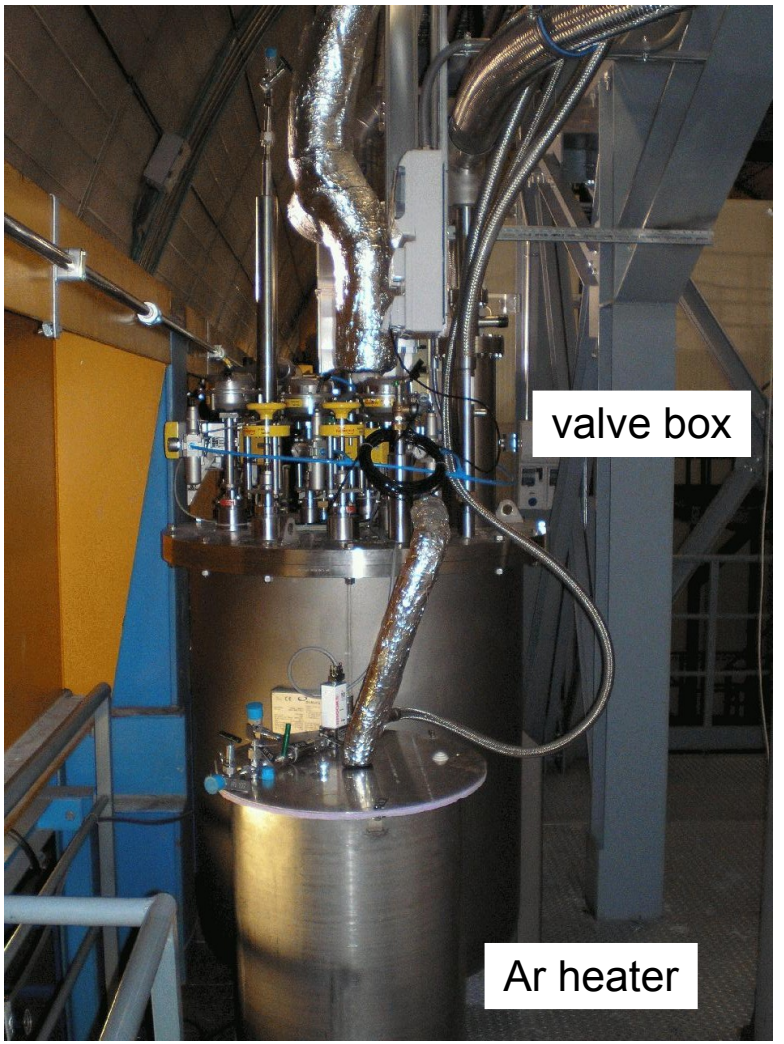


Module=inactive
→ PCV127 open

Mode=”automatic”
→ PCV127 regulated by PLC
Mode=”manual” (HS330 !)
→ PCV127_Y can be set

Pictures of pressure equipment in cryo-mu lab





Level sensors

swimmer

REED contacts
& R chain inside

radar

2.5 m long wire in pipe,
measure time of travel
of GHz pulse

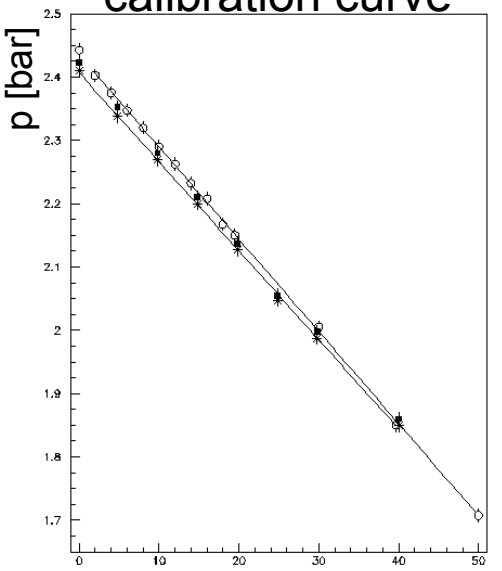
condensation device

thin pipe (ID=2 mm)
connected to 0.5 l
container filled with
argon gas at 2.5 bar

when pipe is in LAr
→ Ar condensates
inside pipe
→ lower pressure

amount of condensation
depends on fill level

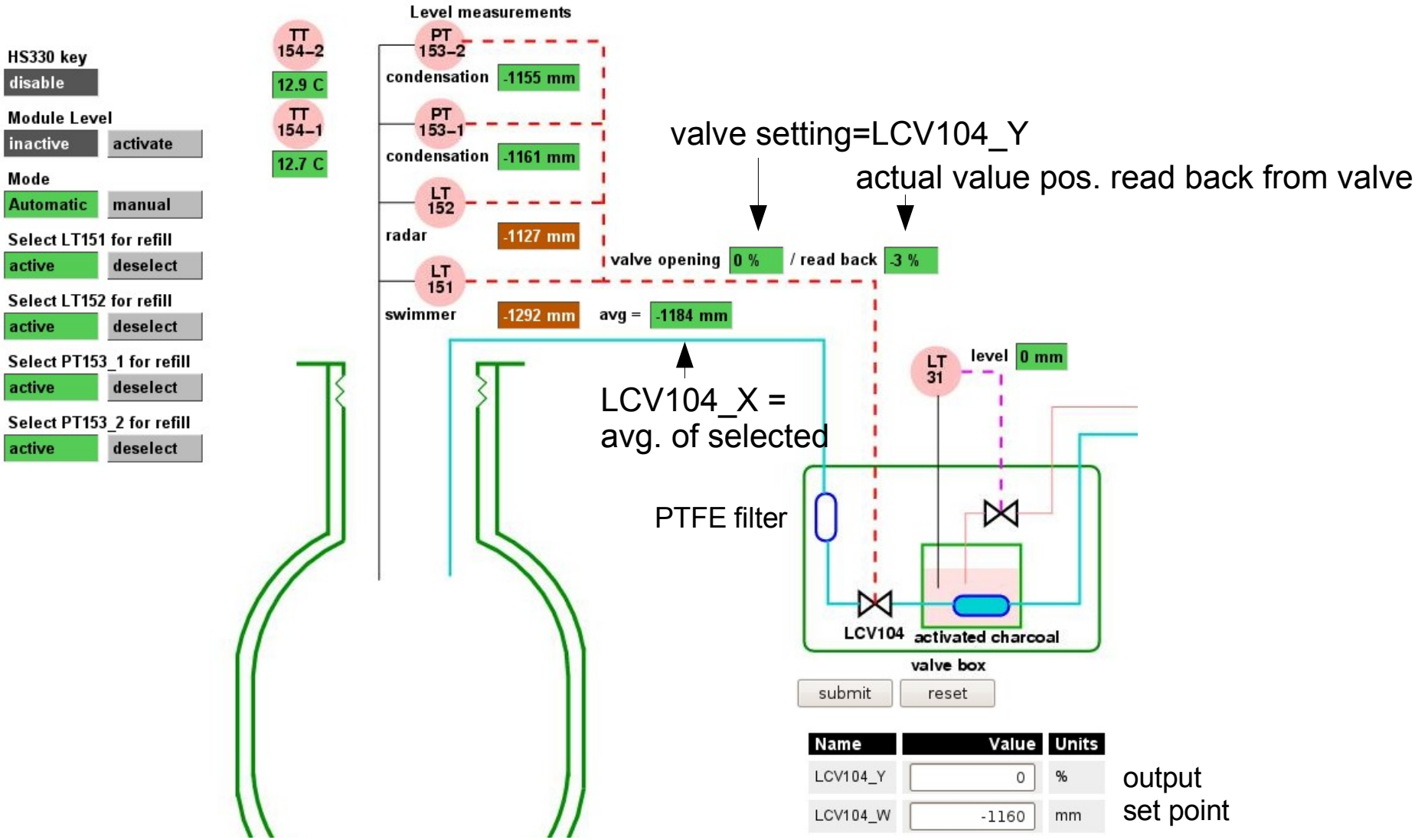
calibration curve



level [cm]

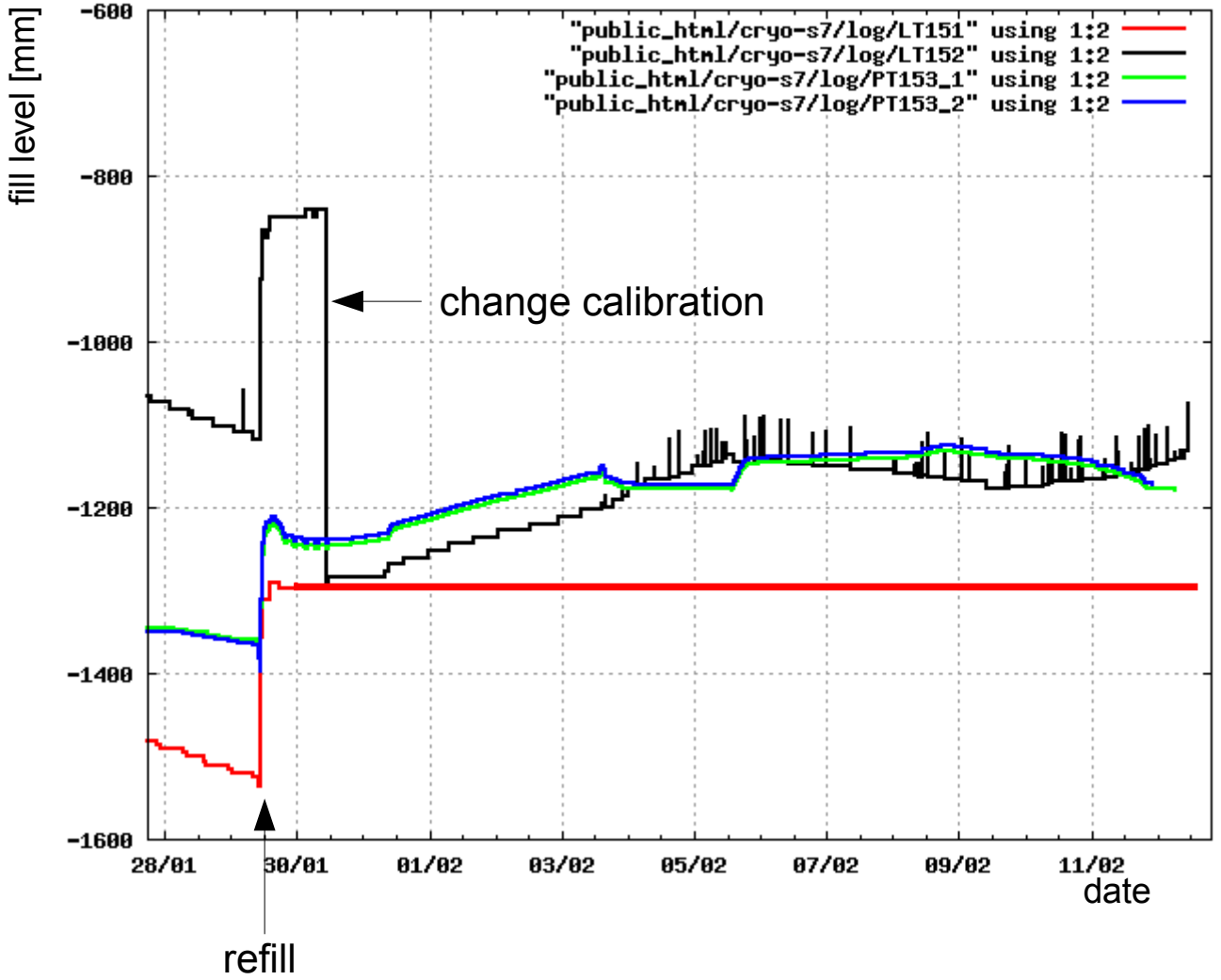
Level control

level 0 mm = upper edge of “manifold”, normal fill level between -1100 and -1200 mm



LCV104 (only open/close positions) can be used for automatic refill
active cooling → no losses → no automatic refill enabled (Module = inactive)
for Manual operation: Module=active, HS330=enable. Mode=manual, change LCV104_Y

Level sensor problems:



radar: check current calibration,
sometimes noisy (if boiling?)

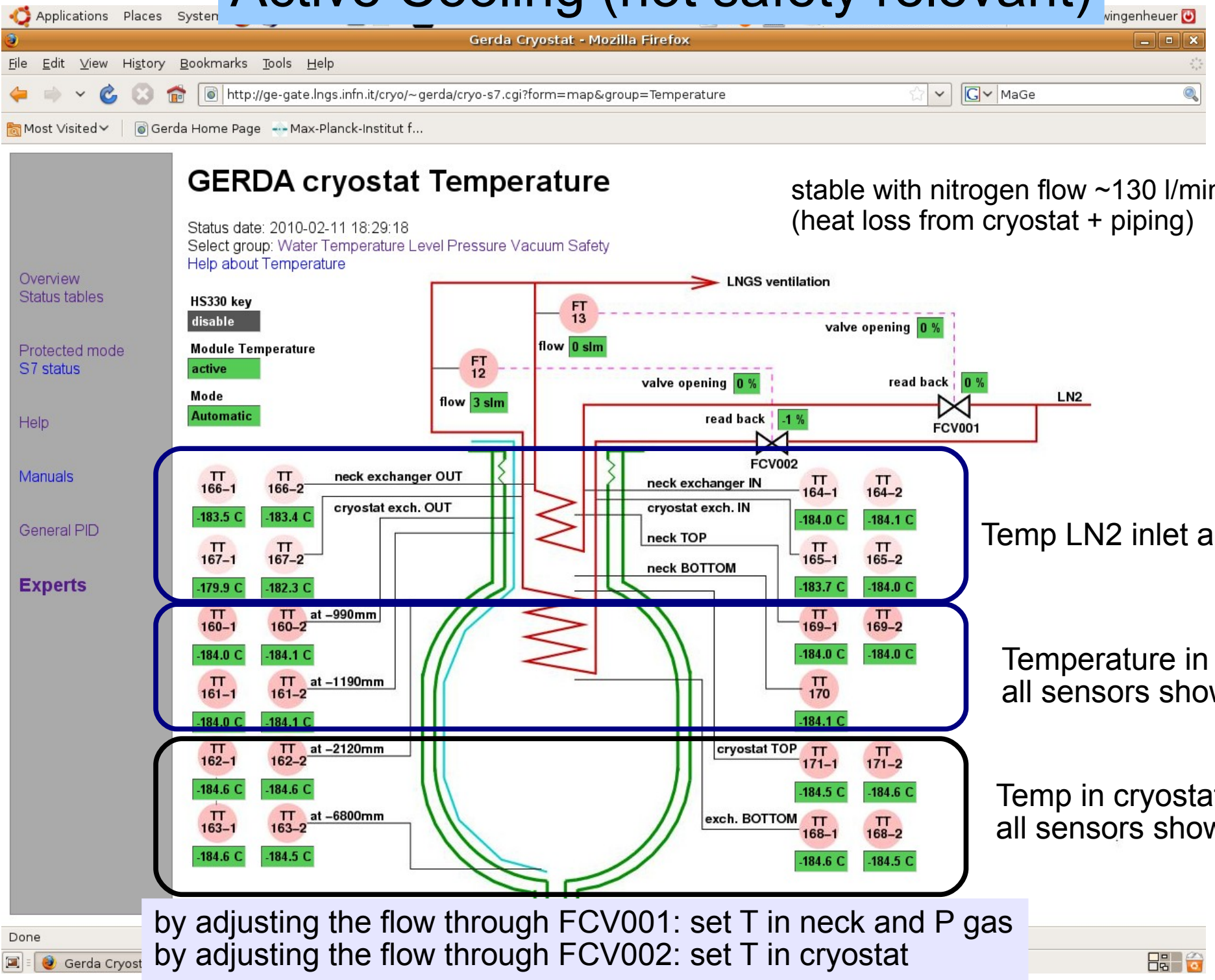
condensation: depends on ambient T

swimmer: mechanically blocked

Radar (LT152) most reliable !

no automatic refilling enabled → not safety relevant,
fill level depends on LAr temperature ($\Delta T = 1$ K → $\Delta V = 280$ l = 56 cm fill level in neck)

Active Cooling (not safety relevant)



stable with nitrogen flow ~130 l/min gas
(heat loss from cryostat + piping)

Temp LN2 inlet and outlet

Temperature in neck
all sensors show same T

Temp in cryostat constant
all sensors show same T

by adjusting the flow through FCV001: set T in neck and P gas
by adjusting the flow through FCV002: set T in cryostat

Argon evaporation

Cryostat channel data - Mozilla Firefox

File Edit View History Bookmarks Tools Help

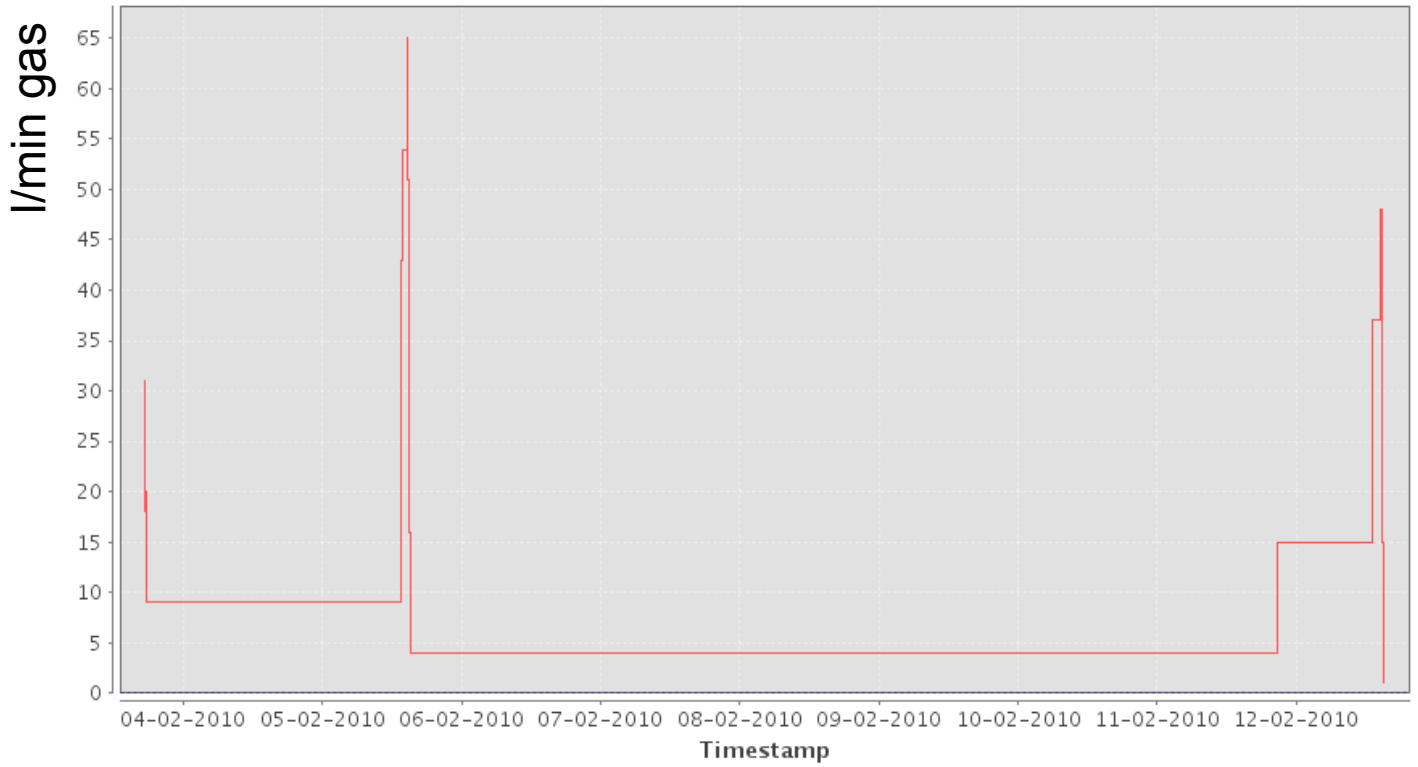
http://ge-gate.lngs.infn.it/gerda/secureUser/CryostatDetail.action

Most Visited | Gerda Home Page | Max-Planck-Institut f...

Cryostat channel "FT128 " detail

| HOME | Back |

Ar evaporation rate



From: 01/02/2010 01:00:00

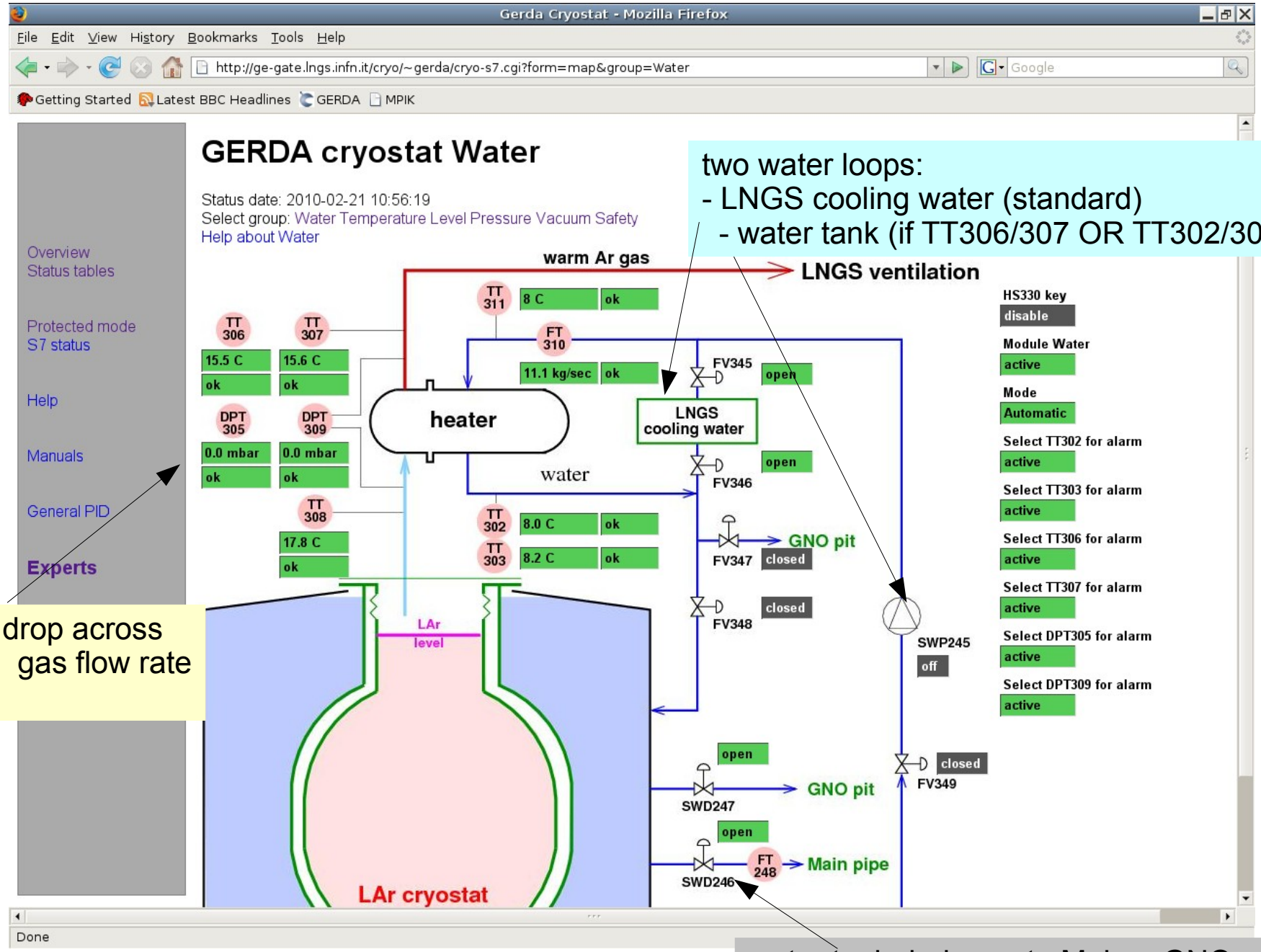
To: 20/02/2010 01:00:00

☐ Use log scale

Submit

database access 19Feb
last value stored=0 on 12Feb
(new entry only if value changes)

Heat exchanger and water tank drainage

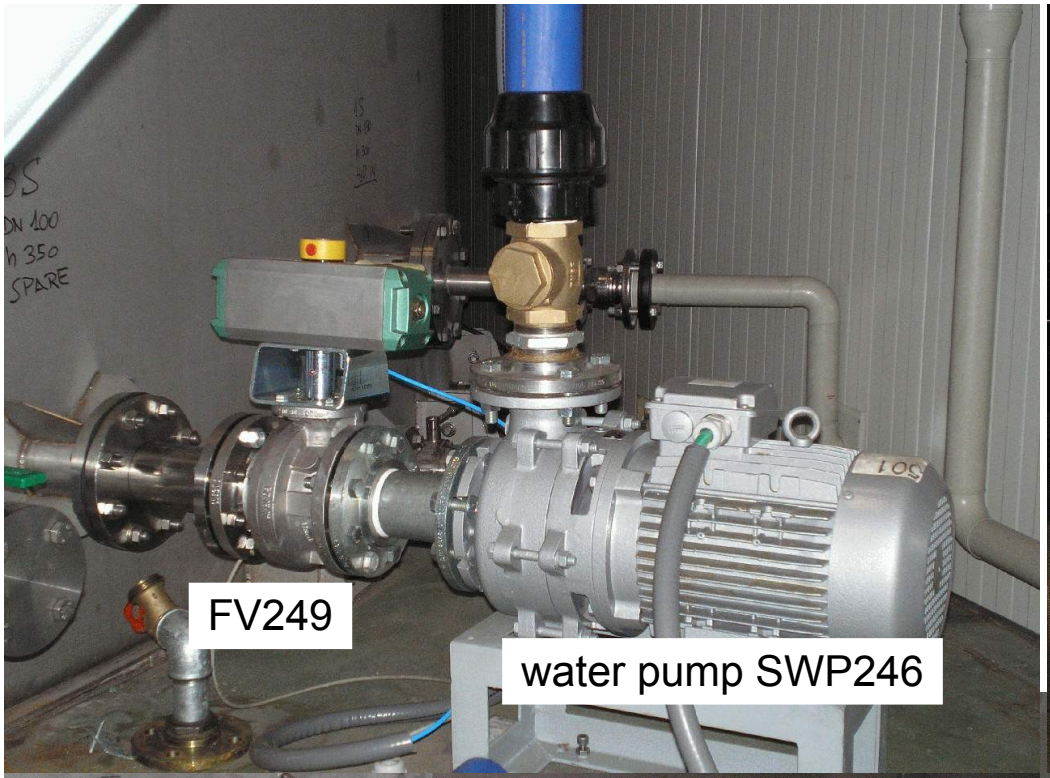


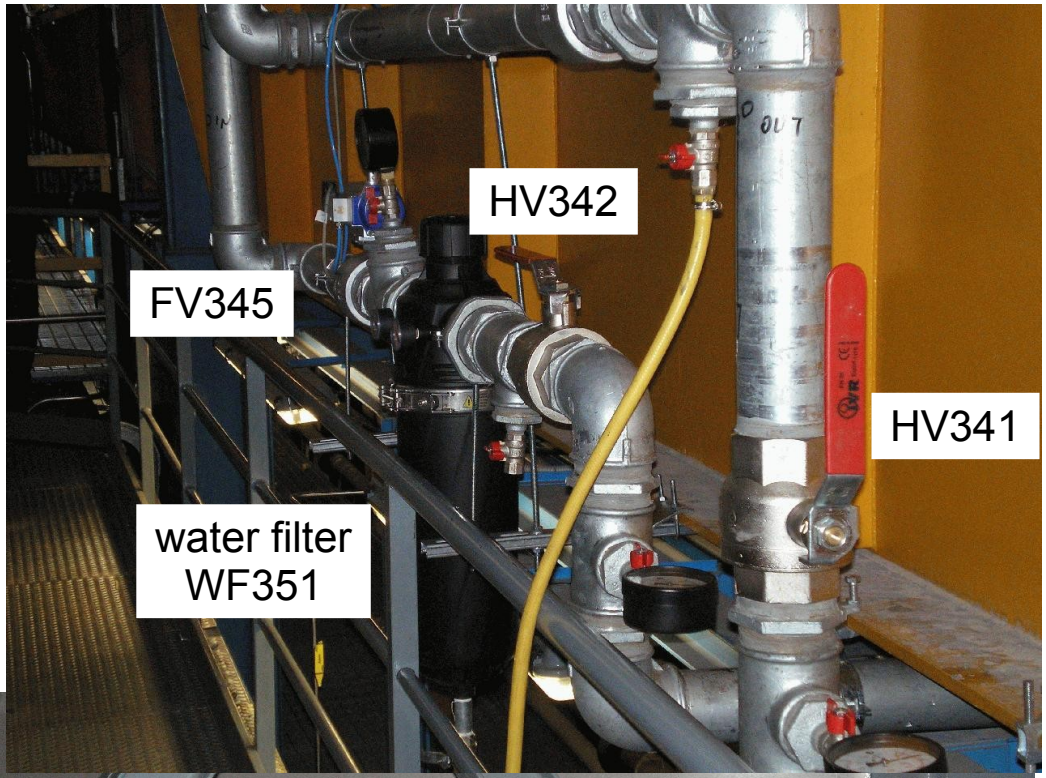
two water loops:
- LNGS cooling water (standard)
  - water tank (if TT306/307 OR TT302/303 < 2C

pressure drop across heater → gas flow rate → alarm

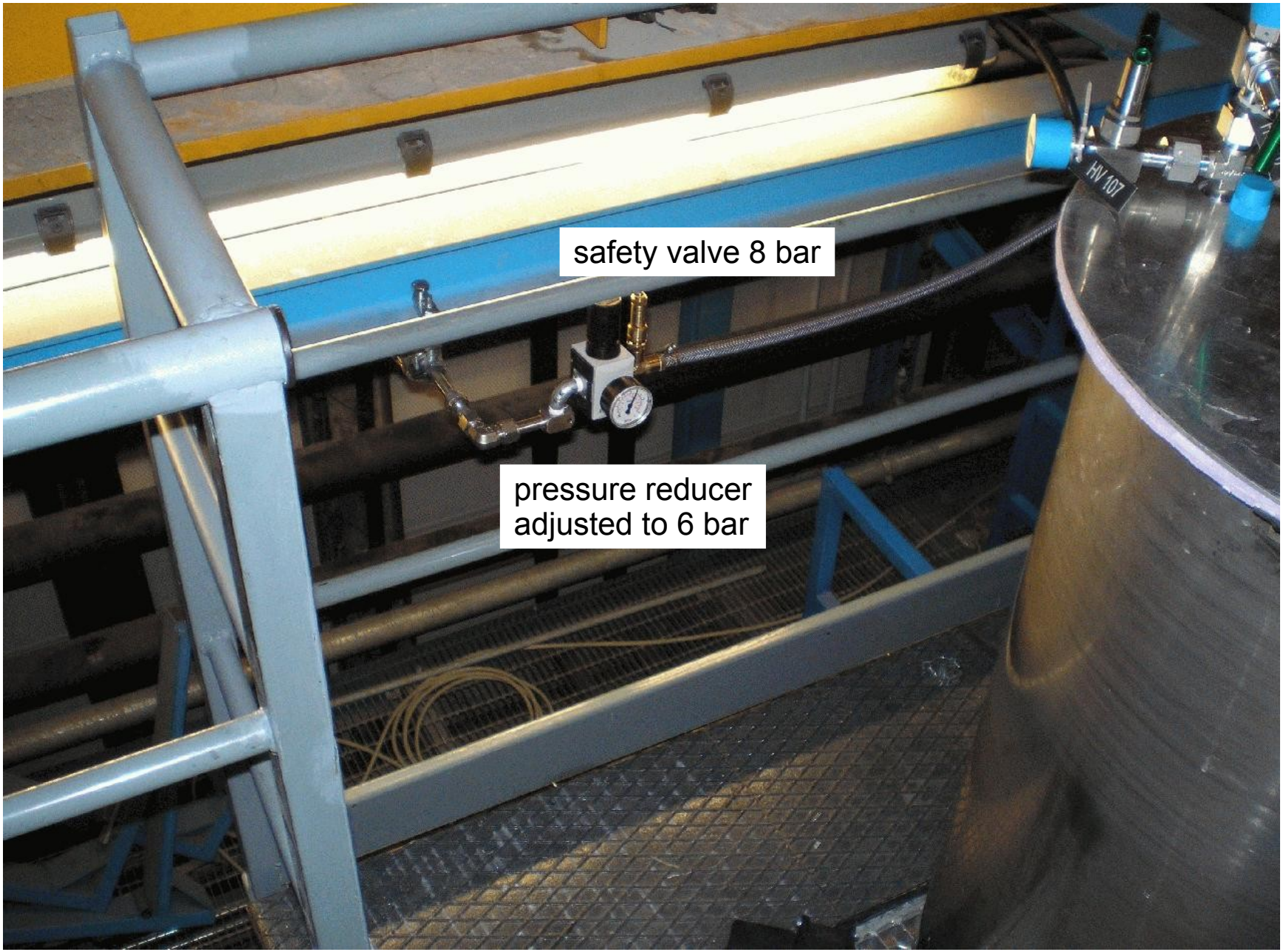
water tank drainage to Main + GNO
automatic drainage in case of problems

Pictures of Hardware ...





N2 gas for pneumatic valves



use N2 gas from 3rd storage tank instead of compressed air

Alarm actions

state	P_cryo bar(abs)	P_vac mbar	level	p_RGA mbar	Δp_h* mbar	T_Ar.gas Celsius	Flow_wat l/sec	T_water Celsius	Incr. Vent.	Drain Water	Evac HallA	close tunnel
green	<1.5	<1E-4	ok	ok	<10	>2	>5	>6				
yellow												
Y1				N2>1E-4								
Y2			high									
Y3							<5					
Y4	>1.5											
Y5								2-6				
orange												
O1				Ar>1E-4						x	x	
O2				water>1E-4						x	x	
O3		1E-4<p<0.1								x	x	
O4					10<p<30				x	x	x	
O5						-5<T<+2			x	x	x	
red												
R1		>0.1							x	x	x	
R2					>30				x	x	x	
R3						<-5			x	x	x	
R4								<2	x	x	x	
R5**					>30	<-5		<2	x	x	x	x

*Δp_h = pressure drop heater, 10 mbar ~ 250 Nm^3/h argon gas, 30 mbar ~ 2500 Nm^3/h

** for R5: any combination of 2 conditions of the 3 has to be true

if more than 1 sensor available: analog = take average (autom. sensor disable in case or failure),
digital = both have to give alarm

Summary

Thanks a lot for your attention

This talk contains more information than you can grasp in one hour,
please go through the slides and read the HELP on the WEB page

Ask the experts if you have questions,
Help to improve the WEB page if you find s.th. which is wrong/confusing

Please help with shifts when you are at LNGS