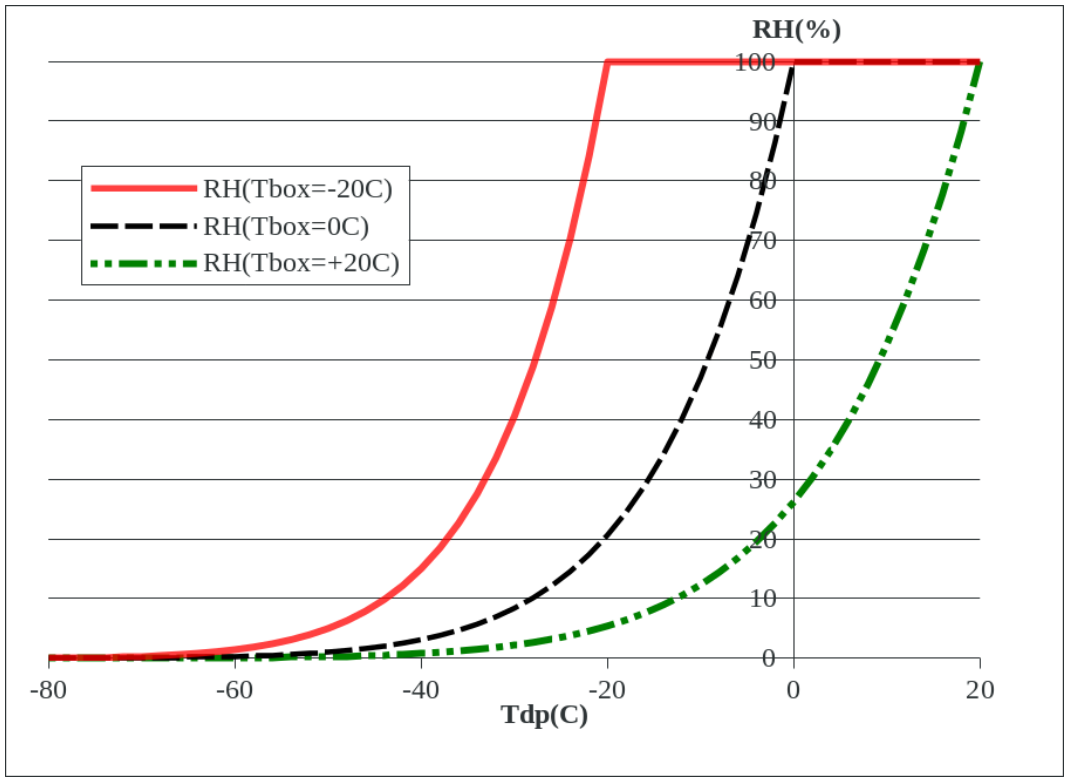
Humidity measurements

Sergey Legotin, Ivan Schemerov (NUST «MISiS»)

CERN, 16.03.2020

Requirements to humidity measurement sistem



Humidity vs DewPoint

Magnus equation

$$RH = 100\exp(\sigma - \gamma)$$

$$\sigma = \frac{b \cdot T_{DP}}{c + T_{DP}} \qquad \gamma = \frac{b \cdot T_{BOX}}{c + T_{BOX}}$$

Important points:

1. Temperature in box T_{BOX} -20 C
2. Need to real time temperature control in the box and near the sensor (using PT100)
3. Case for humidity measurements must be far from radiation area.
4. Humidity in the box must be less than 25%
5. Accuracy of Dew Point measurements is near 3%.
6. System should be scalable

Humidity measurements

DMT143 Dew point sensor

Voltage output from 1 to 5V (step 0.3 mV)

0V for error state

3% accuracy

DMT143 Public Order Form

DMT143 order form(1).pdf

VAISALA

Order form Orderer ____________

Valid from July 2017 Order no. ____________

DMT143 Dewpoint Transmitter

No.	Item	Selection	Details	Code
	Vaisala DRYCAP® Dewpoint Transmitter			**DMT143** | 1 | | | 1 | | | A | S | — PRICE
1	Mechanical connection	**ISO G1/2" thread**		G
		NPT 1/2" thread		N
2	Digital interface	**RS485**		1
3	Analog signal output	**None**	(digital output only)	0
		0...1 V	(1.1 V error state)	A
		0...5 V	(5.5V error state)	B
		4...20mA	(3.6mA error state)	C
		1...5V	(5.5V error state)	D
		0...1 V	(0V error state)	E
		0...5 V	(0V error state)	F
		4...20mA	(0 mA error state)	G
		1...5V	(0V error state)	H
4	Analog output scaling	**None, metric units** (analog signal output selection must be none)		0
		-80…+20 °C Td		1
		-80…+20 °C Tda, dewpoint at ambient pressure		2
	NOTE: Please select U if non-metric units (°F) are needed for analog and/or digital output	**0...1000 ppmv**		3
		0...5000 ppmv		4
		free scaling ppm	Define scale: ____	P
		free scaling Td °F	Define scale: ____	U
		free scaling Td °C	Define scale: ____	X
		free scaling %RH	Define scale: ____	N
5	Alarm LED setpoint	**Off**	**Only fault indication**	A
		-40 °C Td	**Class 2**	B
		-20 °C Td	**Class 3**	C
		-10 °C Td		D
		+3 °C Td	**Class 4**	E
		Other value	**define value: °C Td**	X
		Deactivated	**LED always off**	Z
6	Process gas	**Air**		1
7	Pressure setting for optimized accuracy	**1 bar (abs)**		A
		3 bar (abs)		B
		5 bar (abs)		C
		7 bar (abs)		D
		special (max 50 bar abs)*	Define value: bar	X
8	Cable	**No cable**		0
		0.3 m (1.0 ft)	*HMP50Z032*	*2*
		3 m (9.8 ft)	*HMP50Z30A*	*3*
		5 m (16.4 ft)	*HMP50Z500*	*4*
		10 m (32.8 ft)	*HMP50Z1000*	*5*
		1.5 m (4.9 ft) heavy duty cable	*225777*	*6*
		3 m (9.8 ft) heavy duty cable	*225229*	*7*
9	Sensor protection	**Standard sintered filter**	*spare: DRW010335SP*	A
		Stainless steel filter for vacuum applications	*spare: HM47453SP*	*S*
10	Accessories ONLY for ISO1/2" thread	**no accessories**		0
		basic sampling cell DMT242SC		*1*
		sampling cell with swagelok 1/4" male connectors DMT242SC2		*2*
		sampling cell with quick connector and leak screw, DSC74		*3*
		two pressure sampling cell, DSC74B		*4*
		two pressure sampling cell with cooling/venting coil, DSC74C		*5*
		duct installation flange DM240FA		*6*
		mounting nut		*7*
11	Package	**Standard**		A
12	Identity	**Vaisala**		S
13	User guide language	**no user guide**		A
		multilingual guide		X
			TOTAL	
			QTY	
			TOTAL VALUE	

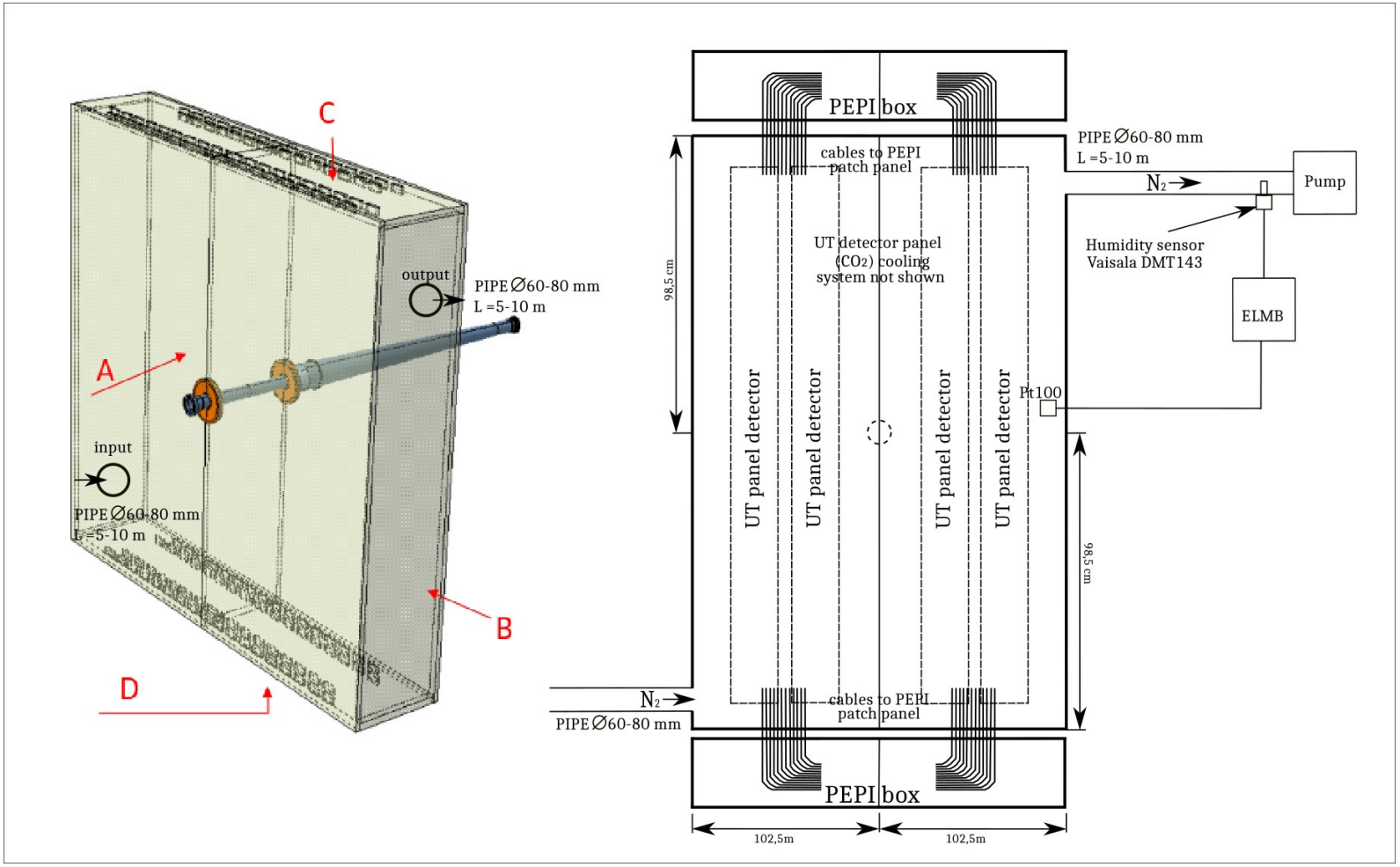
* if measuring in pressures above 20 bara (290 psia) or temperatures below 0 °C, the supply voltage must be 24-28 VDC

Selections in bold are included in the prices of the basic versions.
Selections in italic are available at an extra price.

Example of order code with typical settings:

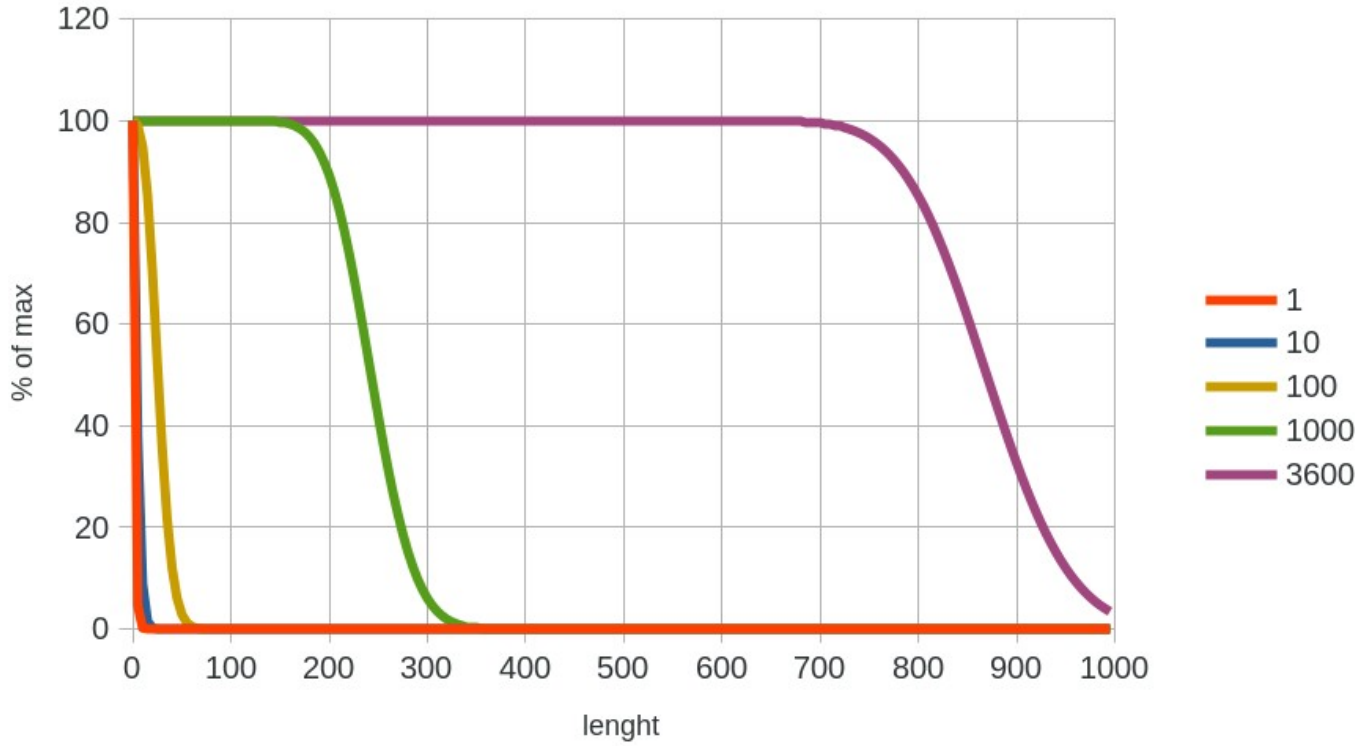
DMT143	G	1	C	1	B	1	A	3	A	0	A	S	X

Scheme 1 (the simplest)



N2 flows through the pipe and blows around the sensor
+ Easy to construct

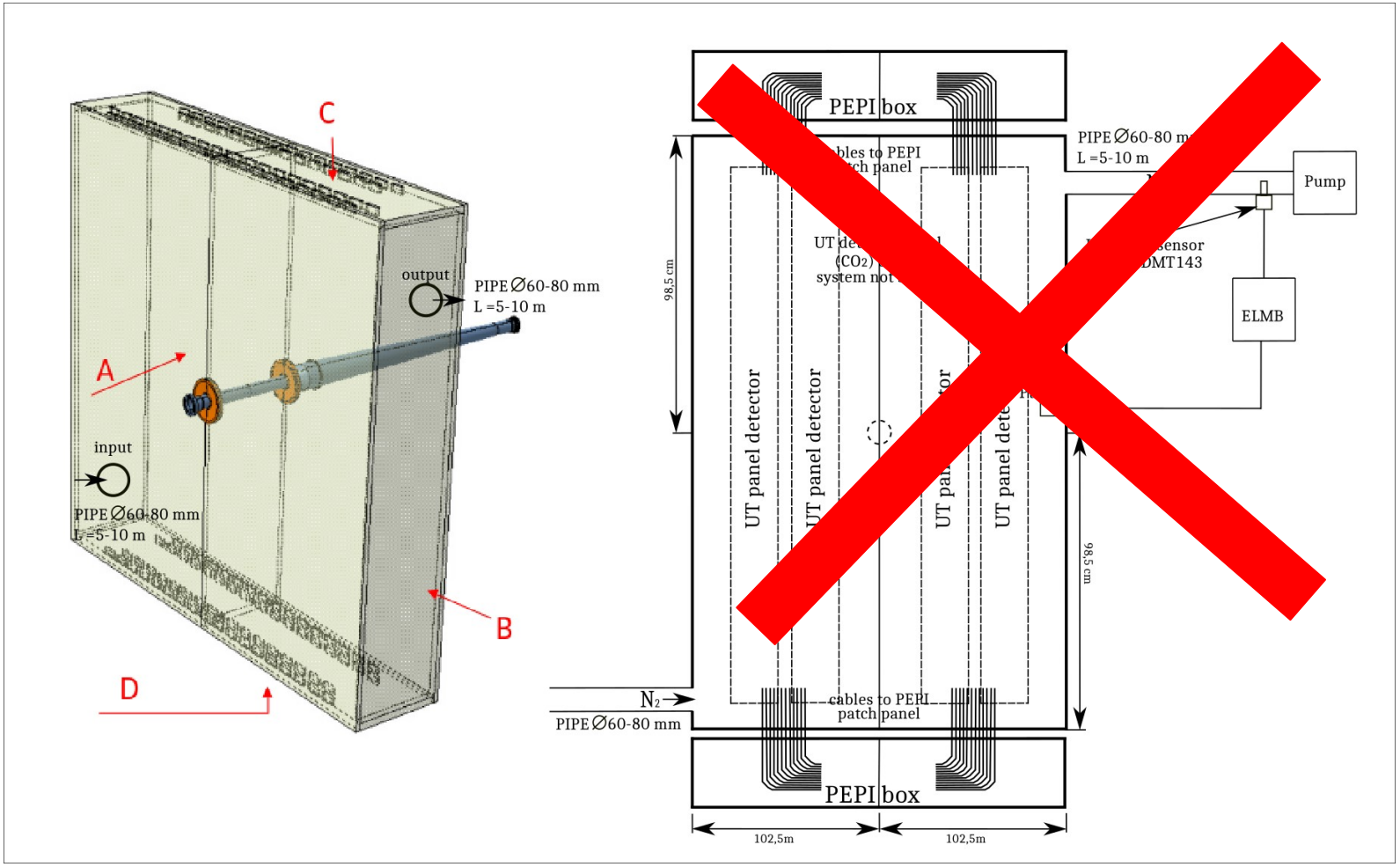
Scheme 1 (the simplest)



Unfortunately, we can't wait while humidity reach the sensor on its own through pipes. For 10 meter pipes, humidity rise time for 0 to actual level with 1bar pressure is ~3 hours.

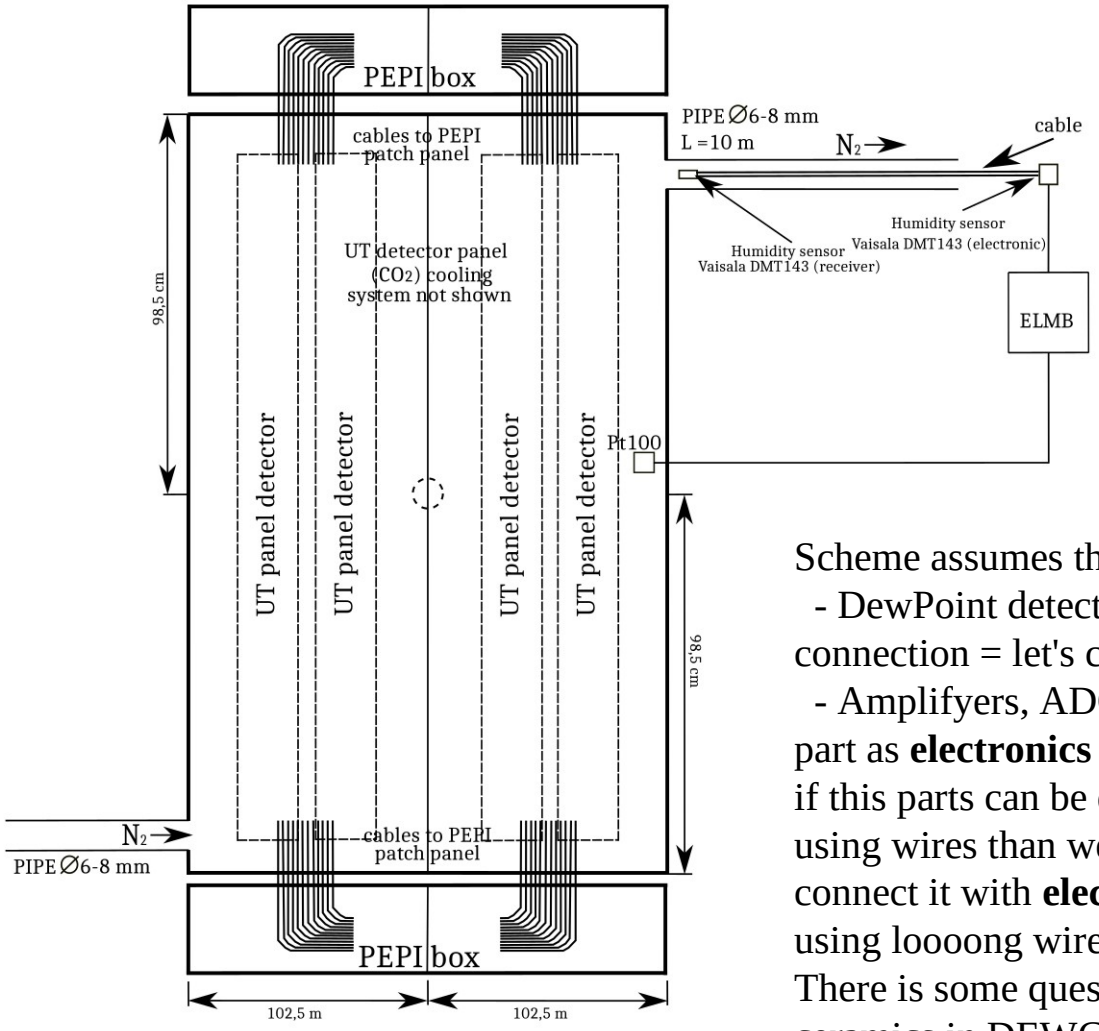
For 5% delta this time is... May be near 3 days? And this is not considering gas friction!

Scheme 1 (the simplest)



- No standard tubes (60-80 mm diameter) – or there is no enough space to detector
- Too high flow speed (1 L/s) – or air from cavern will flow inside the box

Scheme 2 (remote access)

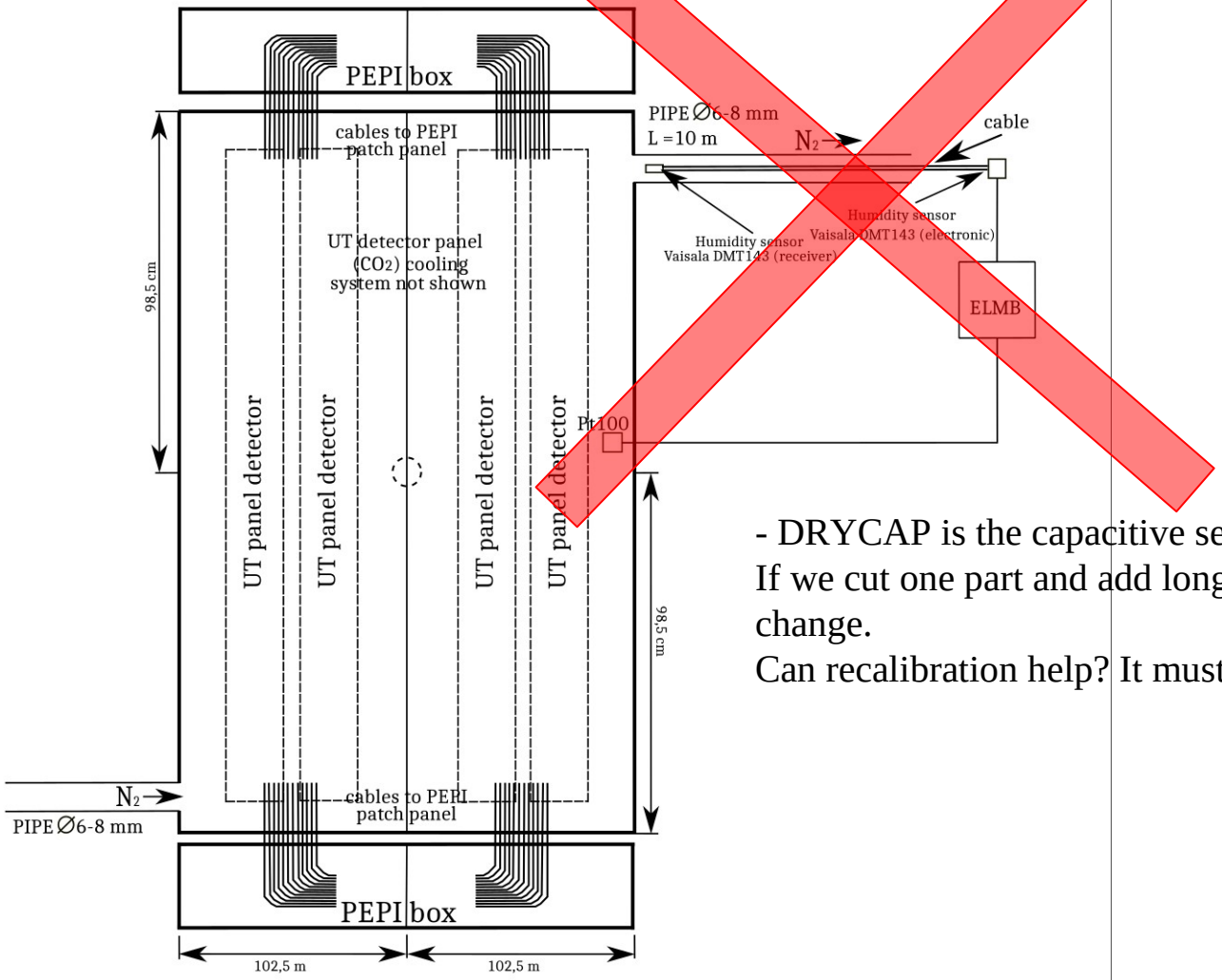


Scheme assumes that we can cut DMT143 in two parts:
- DewPoint detector + porous metal + threaded connection = let's call this part as **reciever**
- Amplifyers, ADC, rectifyers, some stuff = let's call this part as **electronics**

if this parts can be divided and spaced a long distance using wires than we can put a few **recievers** in the box and connect it with **electronics** (it will be in safety place) using loooong wires.

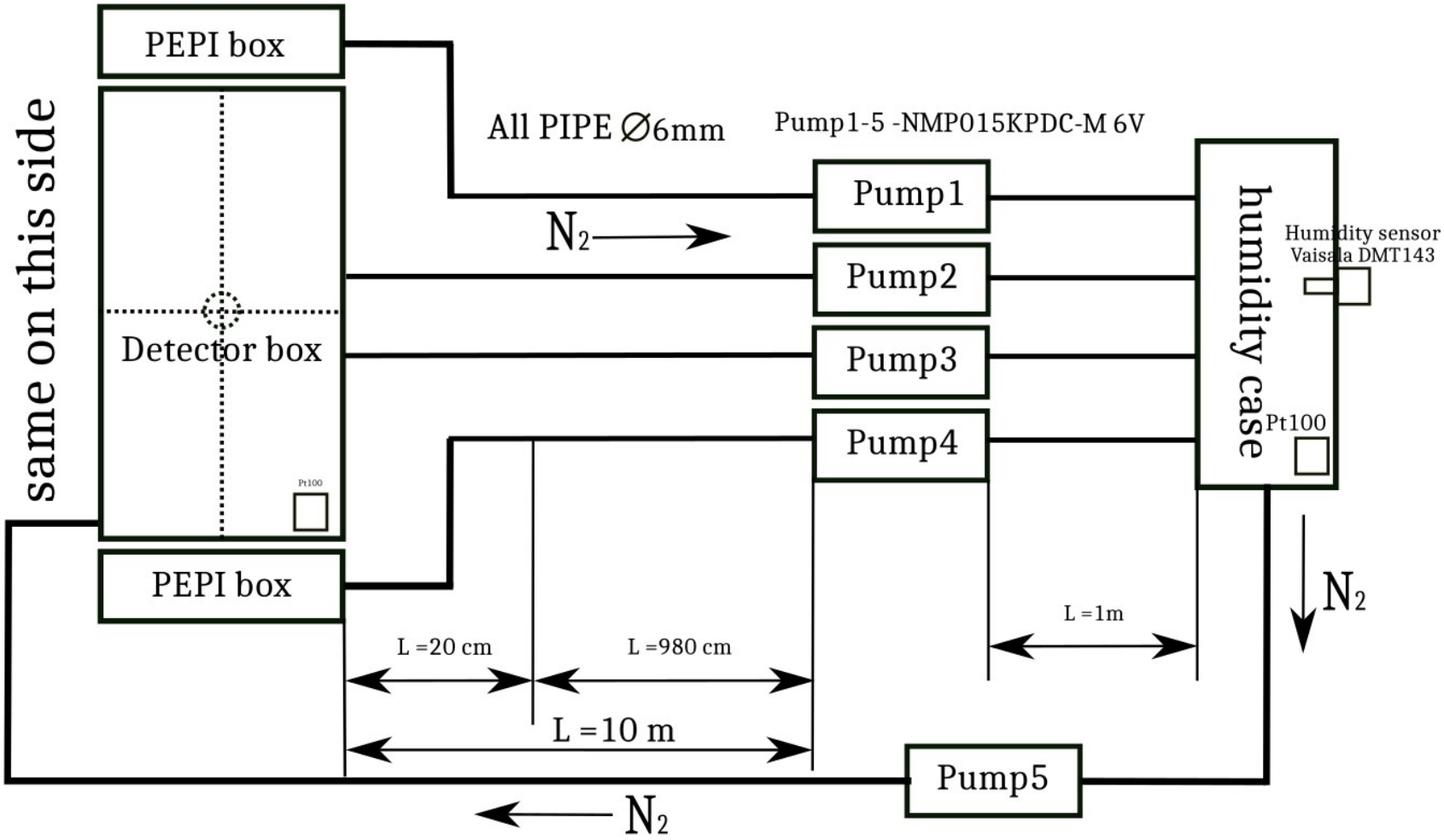
There is some questions about radiation-hardness of ceramics in DEWCAP detector, but it looks decideable.

Scheme 2 (remote access)



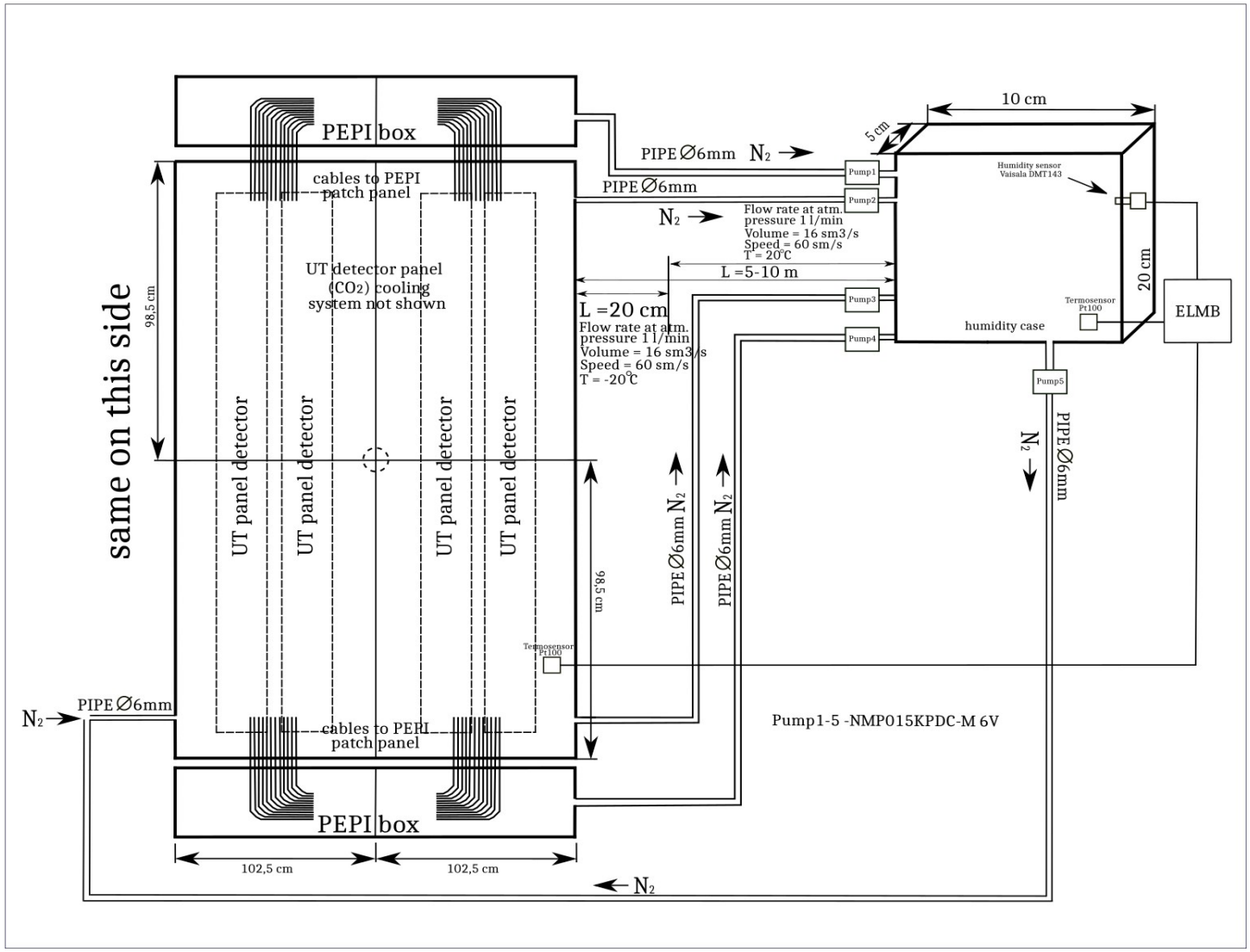
- DRYCAP is the capacitive sensor.
If we cut one part and add long wires, capacity will change.
Can recalibration help? It must be checked.

Scheme 3 (more pipes)



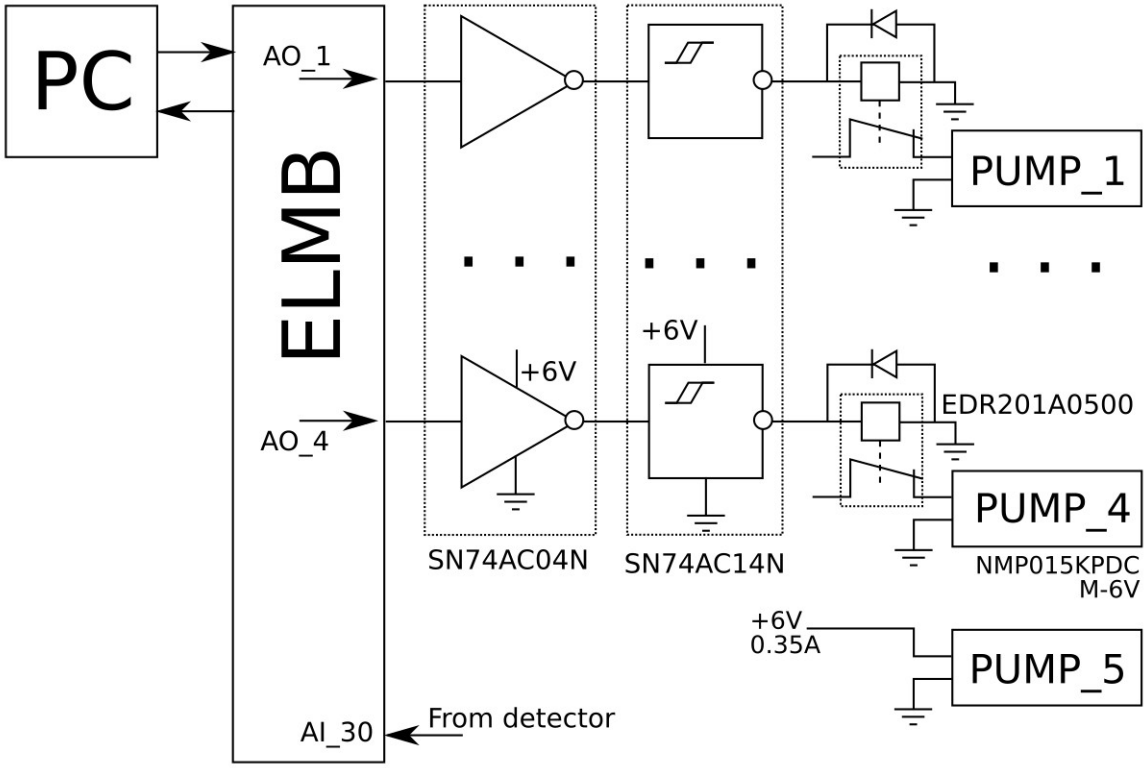
Little case with DMT143 sensor is in the safety place.
If we need humidity measurements in one more point – we can add one more pipe.
Use the PUMP to deliver gas to sensor. And pump to get it out of here.
We can use ELMB system to choose the measured point.

Scheme 3 (sizes)



- Construction is not so simple. If we want to add one more point – we need to add one more pipe and one more pump (but there is still one DMT143 sensor).

How we can choose measured point using ELMB



ELMB has several analog outputs. If we connect it to relays, it will be possible to choose one of pump. It is possible to measure all points one by one.
5 minutes is enough to one point.

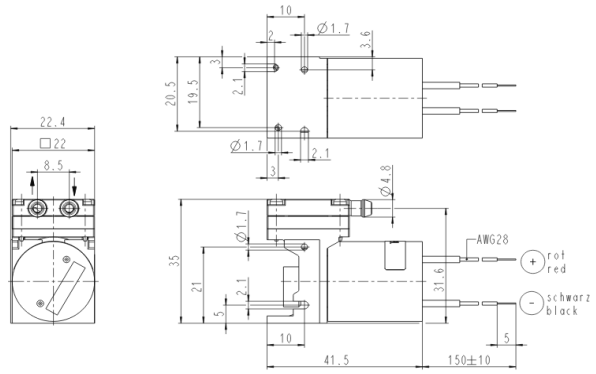
Pump

NMP015KPDC-M

PERFORMANCE DATA

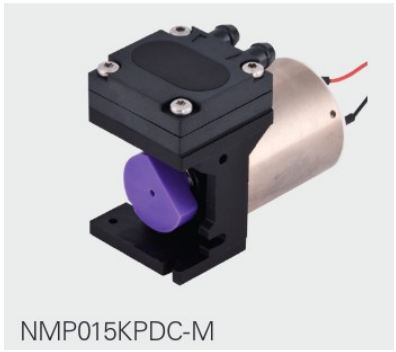
Series model	Flow rate at atm. pressure (l/min)	Max. operating pressure (bar rel)	Ultimate vacuum (mbar abs.)
NMP015KPDC-M 6V	1.5	0.9	400
NMP015KPDC-M 12V	1.6	0.9	400

NMP015KPDC-M



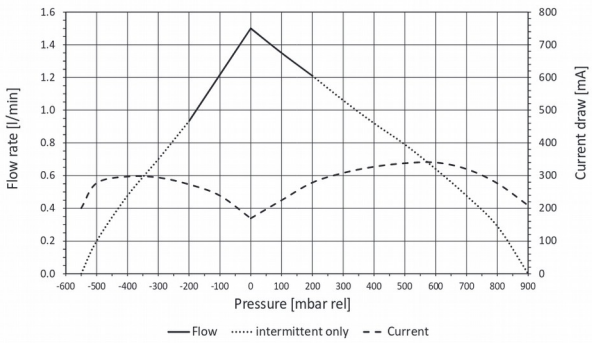
Dimensions in mm

PERFORMANCE DATA								
Series Model	**NMP015**							
Material design	**KPDC-S**		**KPDC-M**		**KPDC-L**		**KPDC-B**	
Pump head	PPS							
Diaphragm	EPDM (PTFE on request)							
Valves	EPDM (FFKM on request)							
Flow rate at atm. pressure (l/min)	1.4	1.3	1.5	1.6	1.3	1.4	1.3	1.3
Ultimate vacuum (mbar abs.)	400	400	400	400	400	400	400	400
Ultimate pressure (bar rel)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Permissible media and ambient temperature (° C/° F)	+5° C to +40° C / 41° F to 104° F (-20° C to +60° C / -4° F to 140° F on request)							
Weight (g/oz)	44/1.55		63/2.22		47/1.66		55/1.94	
ELECTRICAL DATA								
Voltage (V)	3.5	6	6	12	3.5	6	6	12
Motor	DC		DC		DC		Brushless DC	
I_{max} (A)	0.5	0.32	0.38	0.19	0.45	0.26	0.29	0.15



NMP015KPDC-M

NMP015KPDC-M 6V FLOW CURVE



1.5 L/min
6 V / 0.38 A
Permissible temperature — from -20 to +60 C

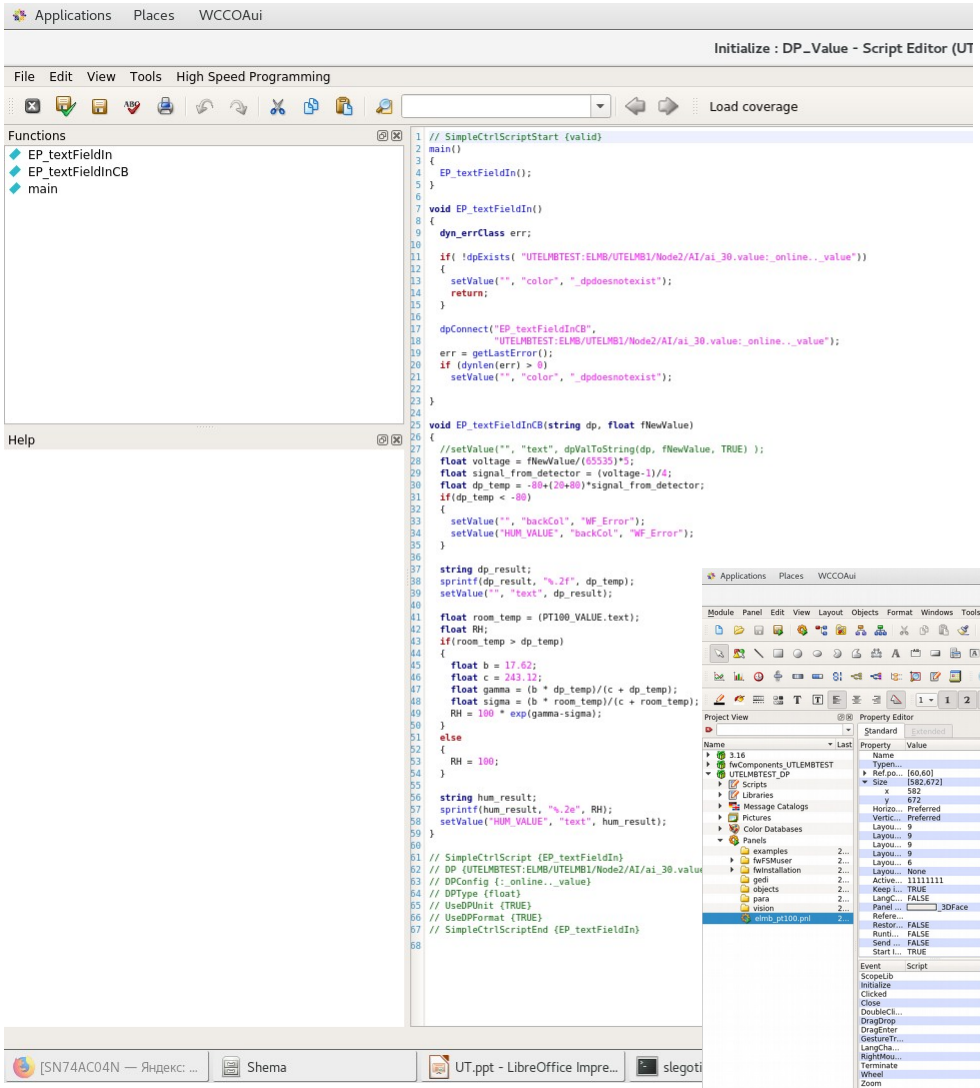
Unit price ~300 CHF

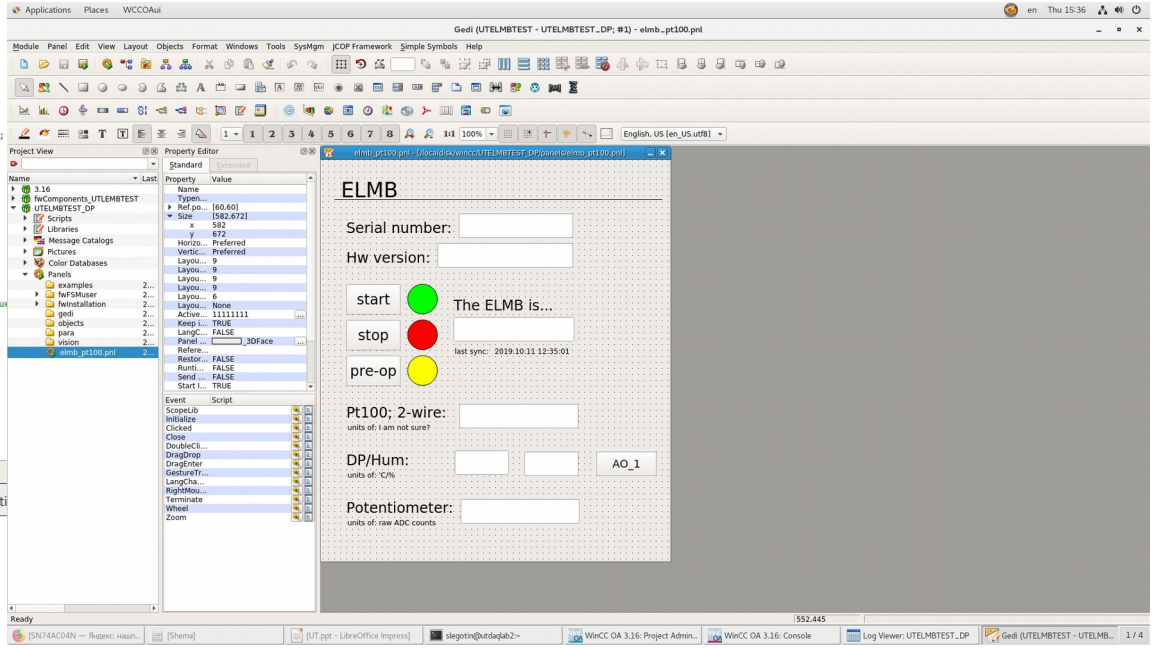
What about price?

One-point measurements:
1) DMT143 DewPoint sensor = 1000 CHF
2) 2 pumps (in+out) NMP015KPDC-M(6V): 2*300 = 600 CHF
3) PCB + triggers etc = 200 CHF
4) Copper pipes (2 x 6 mm x 10 m): 20x6 = 120 CHF
= sum: 1920 CHF

For next point:
2.2) One more pump = 300 CHF
3.2) One more relay + trigger + rectifiers + wires + something else = 20 CHF
4.2) One more pipe (6mm x 10 m): 10x6 = 60 CHF
= sum: 380 CHF for next point

WinCC communication interface





We write some scripts to get information from sensor, to collect and analyse it.
But it is hard to get information without sensor.