LHC
gas system

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Frédéric Merlet

18 Nov 2008

Overview

- Part 1: (Stefan)
  - The gas project in numbers
  - Which gases do LHC detectors need + Why?
- Part 2: (Fred + Patrick)
  - Type of gas systems
  - electrical approach
  - Gas modules explained
  - Control interface

Part 1: LHC Gas Systems

- The LHC gas system project team:
  - 8-9 CERN stuff + 1 fellow
  - ~3 FSU

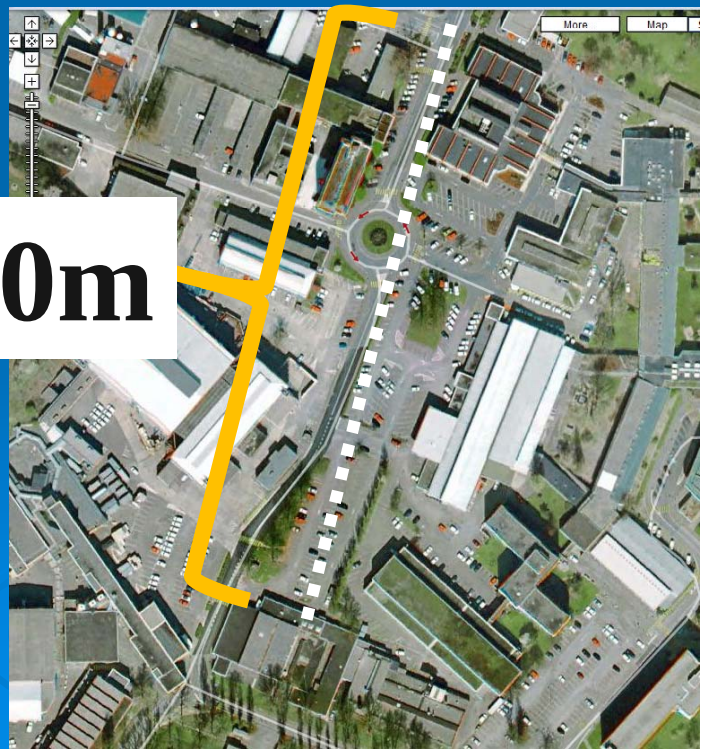
Some numbers

- Constructed ~ 230 gas racks
- + ~ 44 electrical control racks
- operate 24 gas systems

  in 5 LHC experiments

  (+1 inherited gas system,
  TRT forward cooling)

had we to take 1m per rack,
we would get to the
entrance of CERN

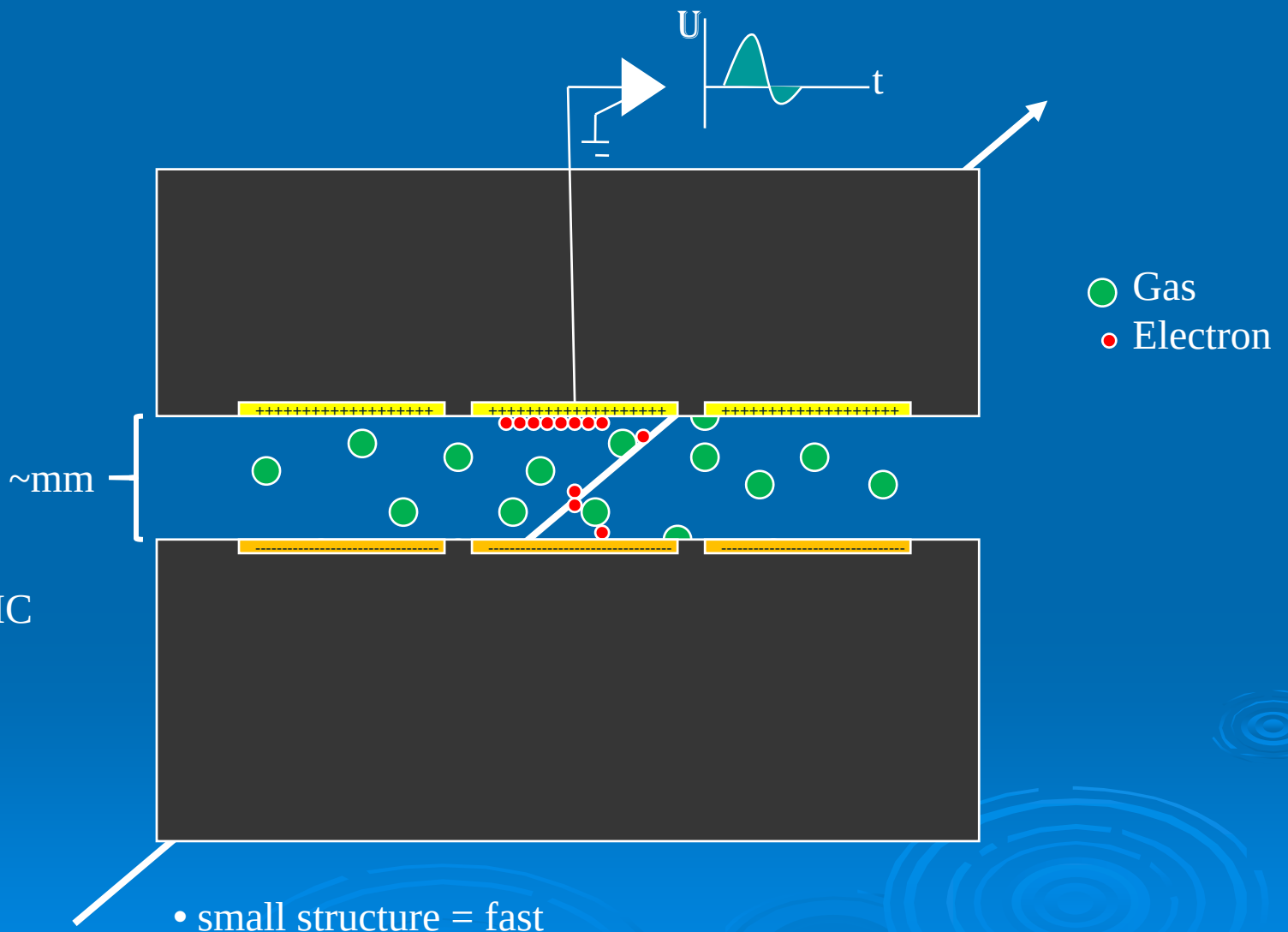


Chamber types

chamber type		ALICE	ATLAS LUCID	CMS TOTEM	LHCb
Trigger		TOF, MTR	TGC, RPC	RPC	
Tracking		TPC, MCH, PMD, TRD(1/2)	MDT, CSC, TRT(1/2)	DT, CSC, T1, T2	Muon, OT
Light	**detection**	HMPID*, TRD(1/2)	TRT(1/2)		
	production		LUCID		RICH1, RICH2
Cooling			TRT CO2 forward		
Inertion			N2 + CO2 purge	N2 Flushing	

* light is converted to electrons via light sensitive cathode

Trigger chambers



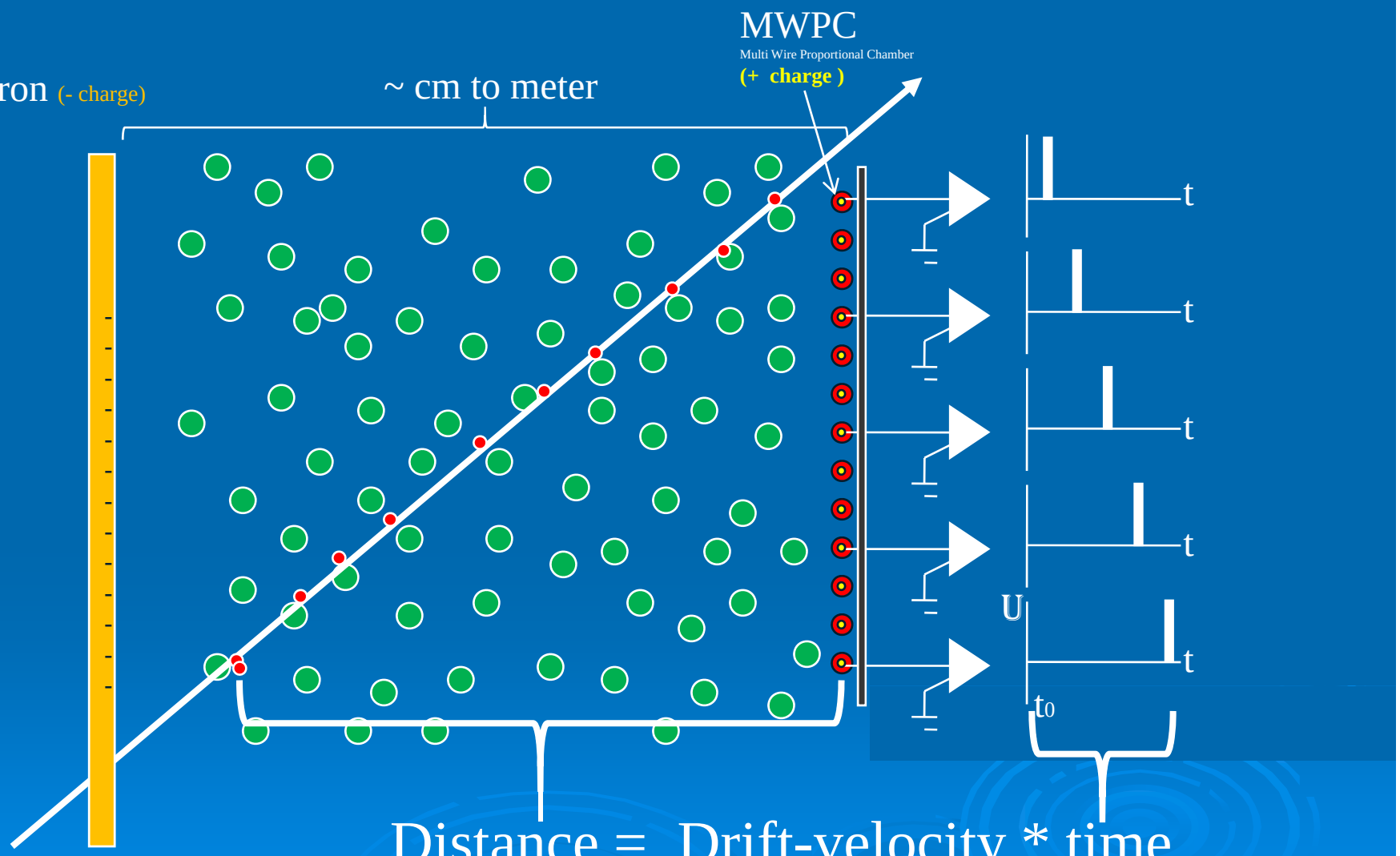
Gas used in LHC detectors:

- C2H2F4
- SF6
- i-C4H10
- CH4
- C2H6

- small structure = fast
- highly quenching gas = quickly ready for new particles

Tracking (drift) chambers

- Gas
- Electron (- charge)

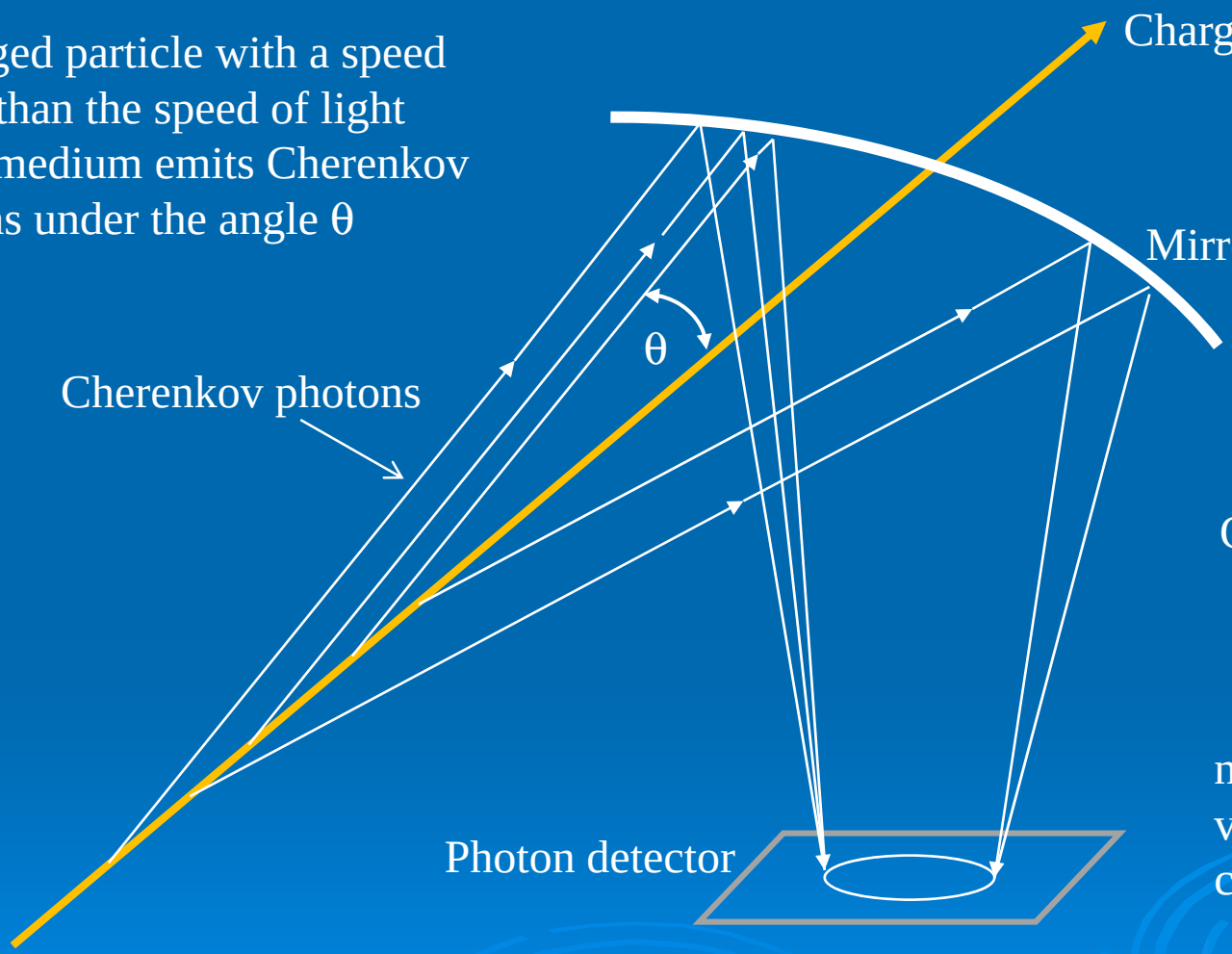


Distance = Drift-velocity * time

- large structure = slow
- precise drift properties = very accurate track reconstruction

Light production: Cherenkov effect

a charged particle with a speed larger than the speed of light in the medium emits Cherenkov photons under the angle θ

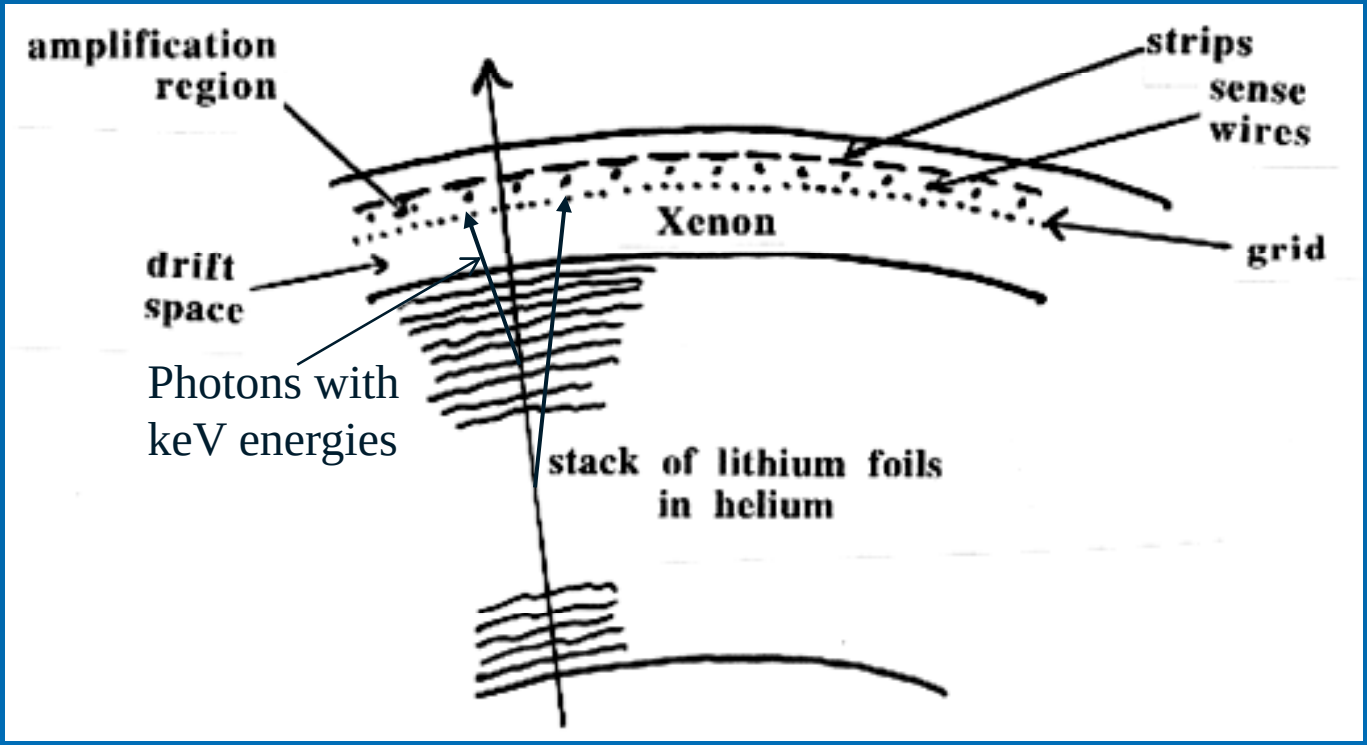


Cherenkov angle:

$$\cos\theta = \frac{c}{n \cdot v}$$

n... refractive index
v... velocity of particle
c... speed of light

Transition radiation



- High Z material needed to detect photons: Xenon, Krypton
- only particle with highly relativistic speeds emit transition radiation → Electron identifier! because electrons are always relativistic due to their small mass.

Chamber Gasses for LHC gas detectors

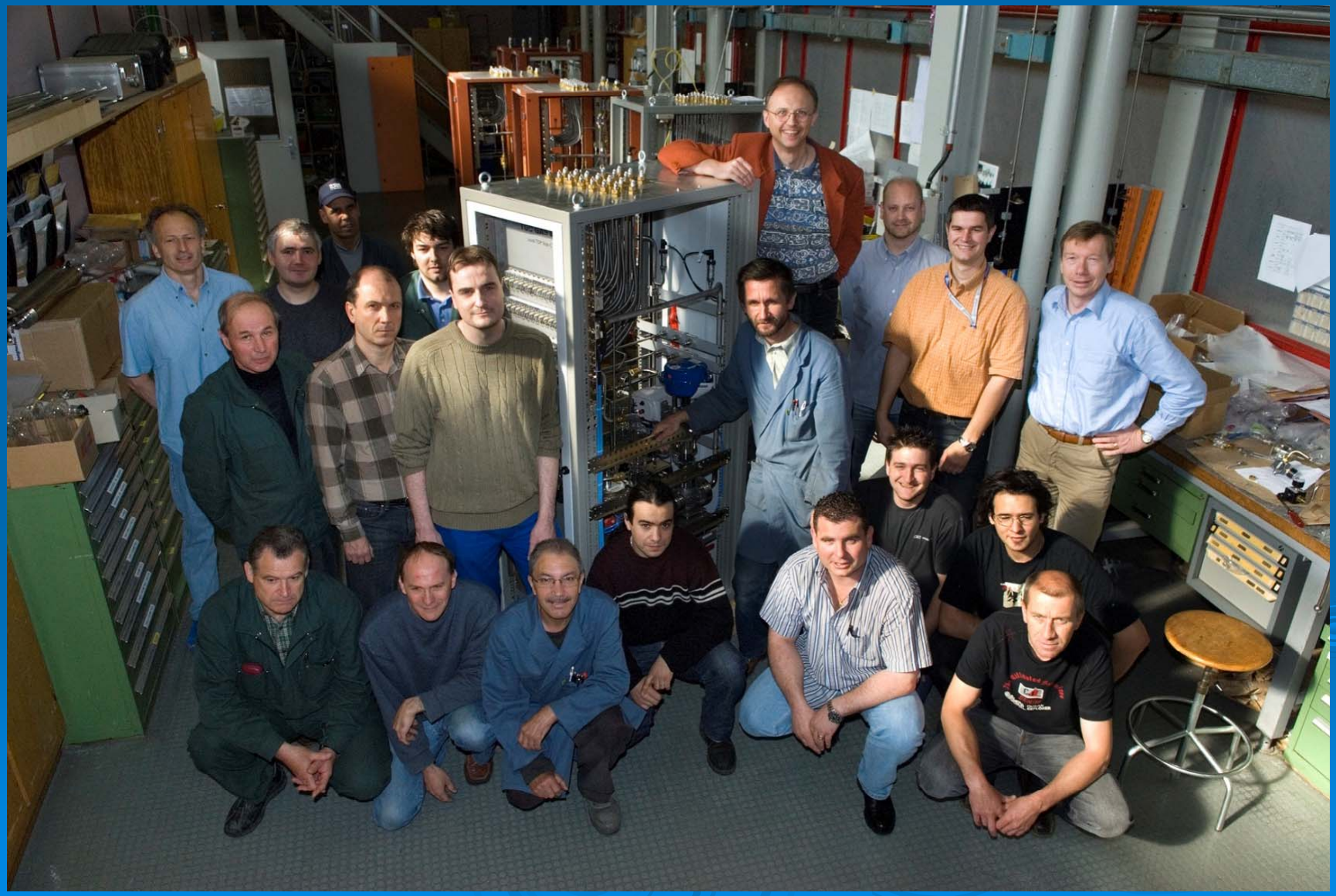
chamber type		
Trigger		C2H2F4, i-C4H10, n-C5H12, SF6, CO2
Tracking		Ar, Ne, Xe, CO2, N2, O2, CF4, CH4
Light	**detection**	**Xenon**
	production	C4F10, CF4, CO2
Cooling		CO2
Inertion		N2, CO2

- flammable gasses
- noble gasses
- expensive gasses
- **outrageously expensive gas**

- end of Part 1.....

  Questions ?

GAS GROUP



Gas system

Patrick Carrié
Frédéric Merlet

18 november 2008

PH - DT - DI

Conception and fabrication

Of

24 gas systems

for the

5 experiments

of the

LHC

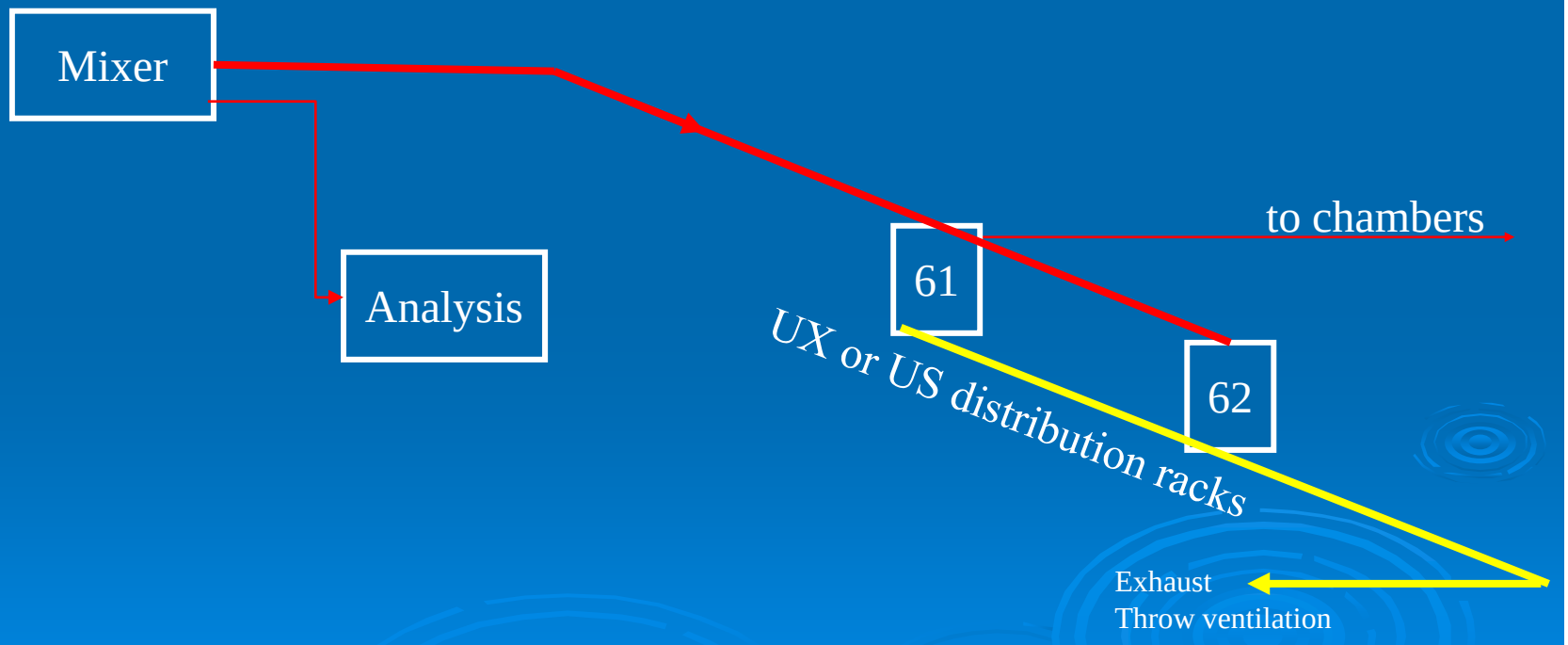
Atlas, Alice, CMS, TOTEM, LHCb

3 types of gas system

- Single pass
- Close loop system
- A mixture of the two types

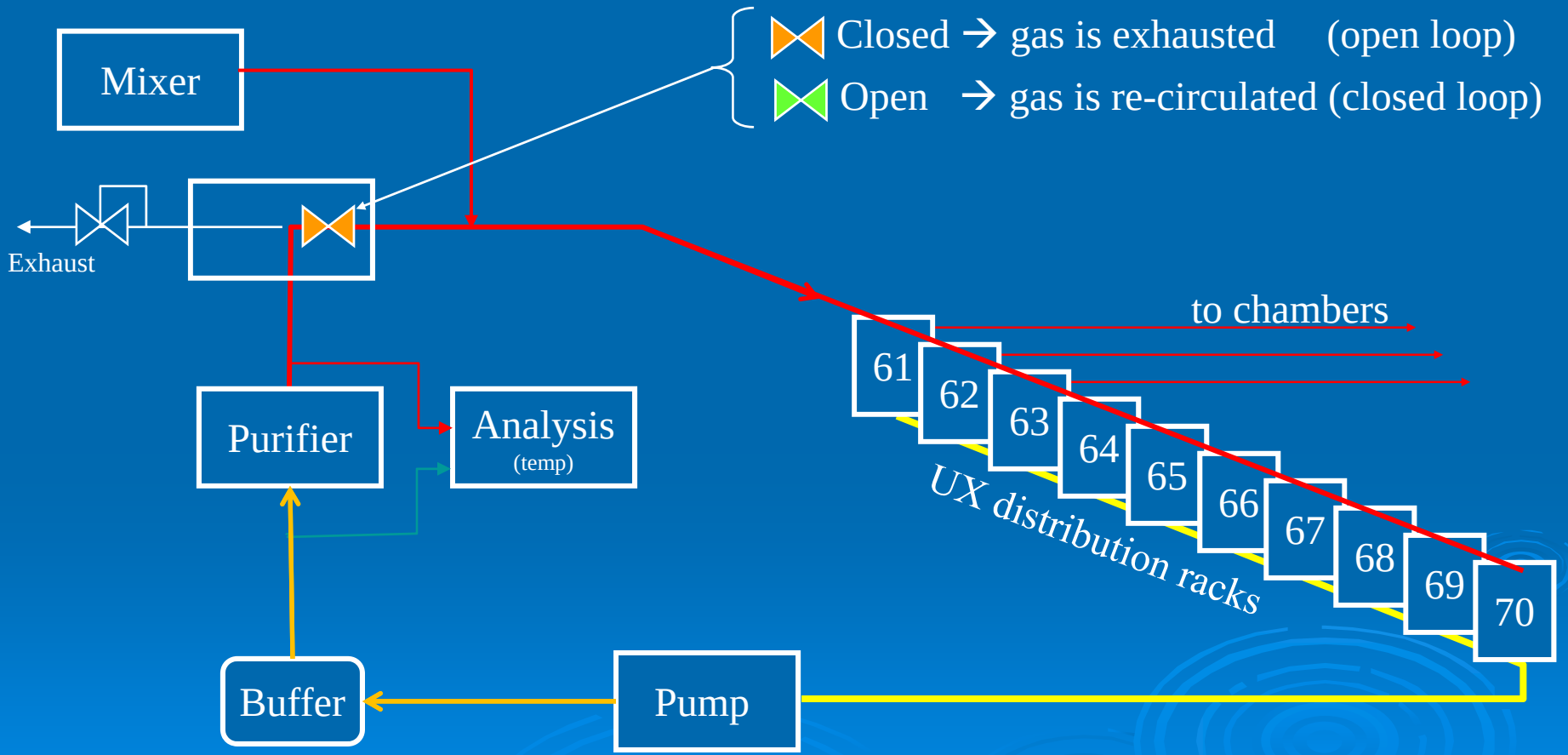
SINGLE PASS SYSTEM

Gas system schematics



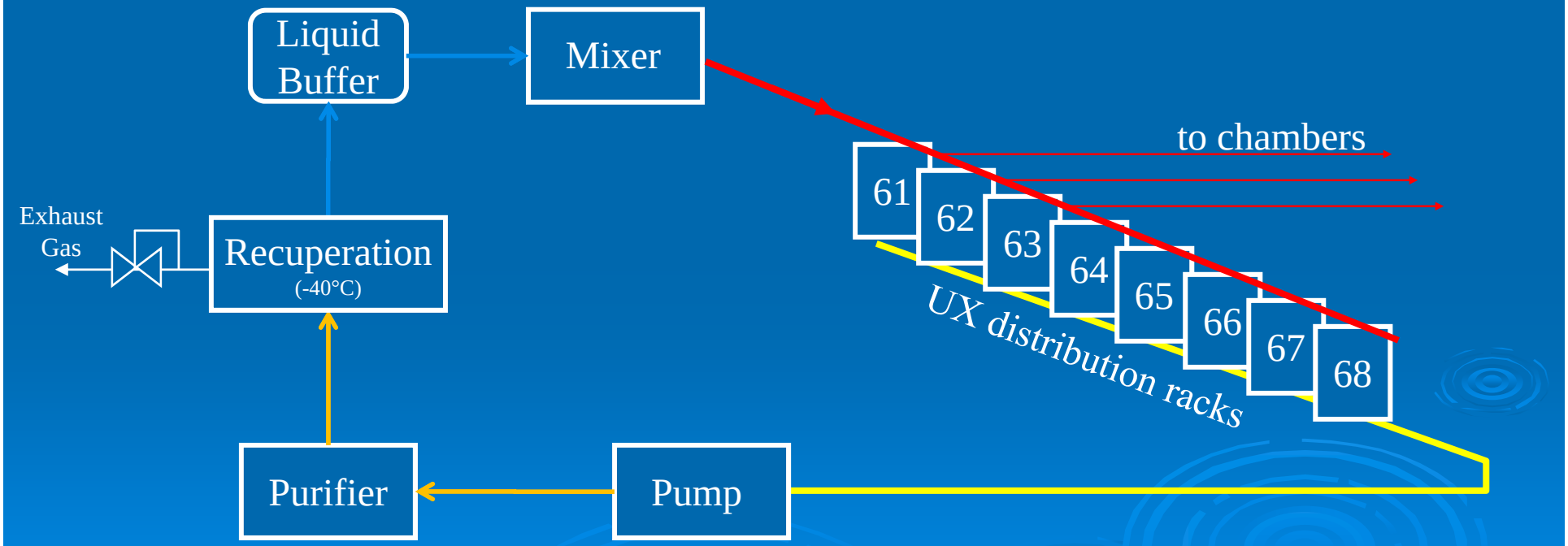
CLOSE LOOP SYSTEM

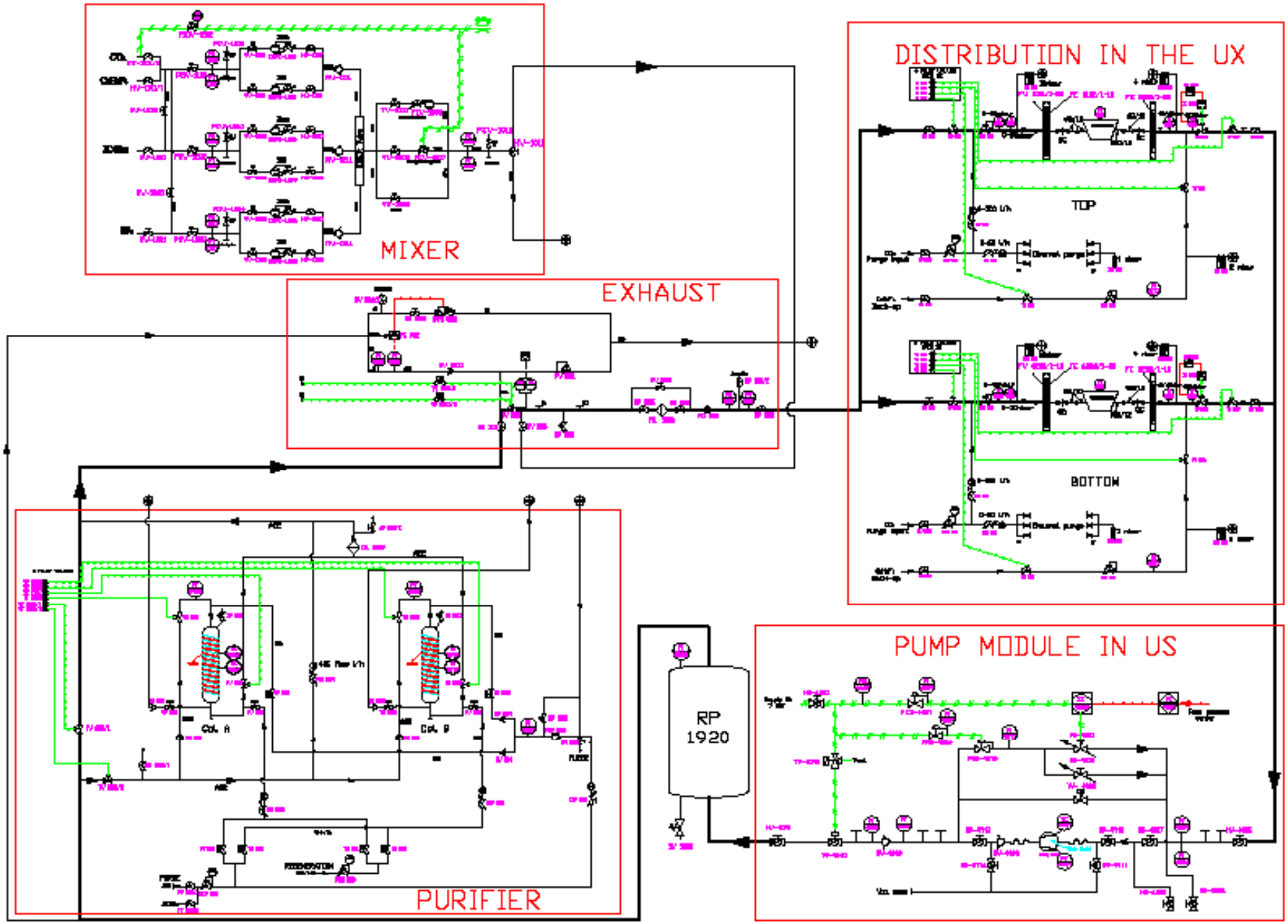
Gas system schematics



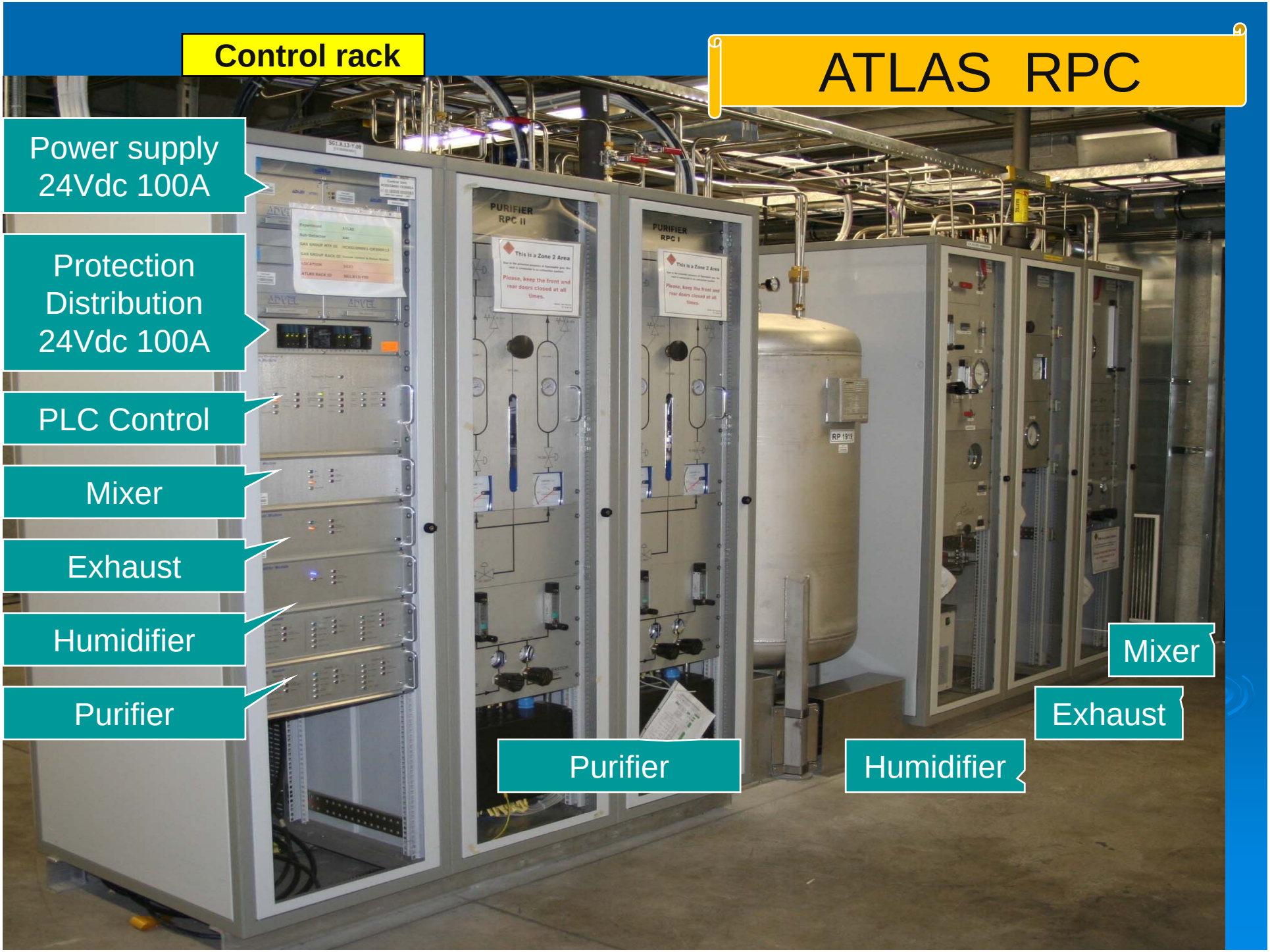
MIXTURE OF THE TWO TYPES

Gas system schematics




MIXER
EXHAUST
DISTRIBUTION IN THE UX
TOP
BOTTON
PURIFIER
RP
1920
PUMP MODULE IN US

ATLAS RPC


Control rack
Power supply 24Vdc 100A
Protection Distribution 24Vdc 100A
PLC Control
Mixer
Exhaust
Humidifier
Purifier
PURIFIER RPC II
PURIFIER RPC I
Purifier
Humidifier
Exhaust
Mixer

44 Control racks

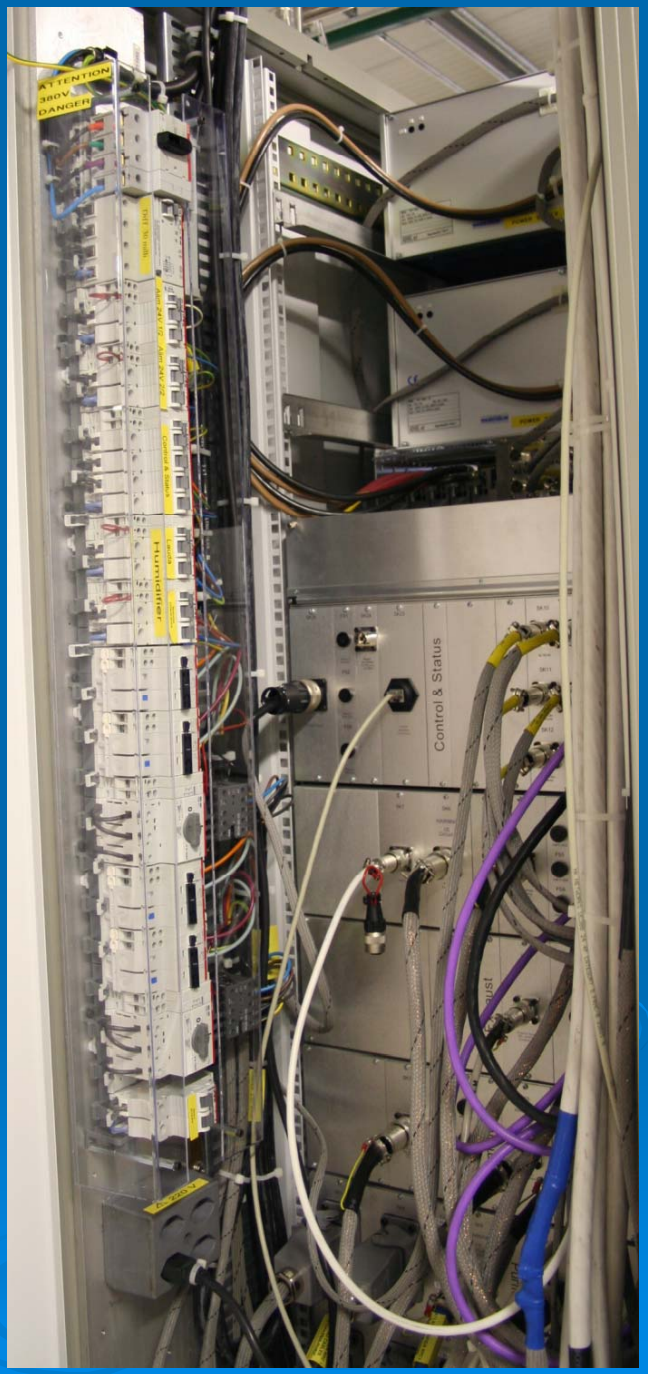
240 / 400 Vac
Distribution and
current protection

Switch

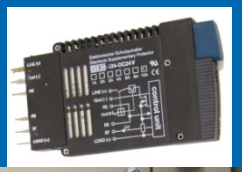
30 mA Protection of
persons and property

230 MCBS Smissline

BUS BARS ABB Smissline
4 bars of potency
3 Ph + N
And
2 Bars aux

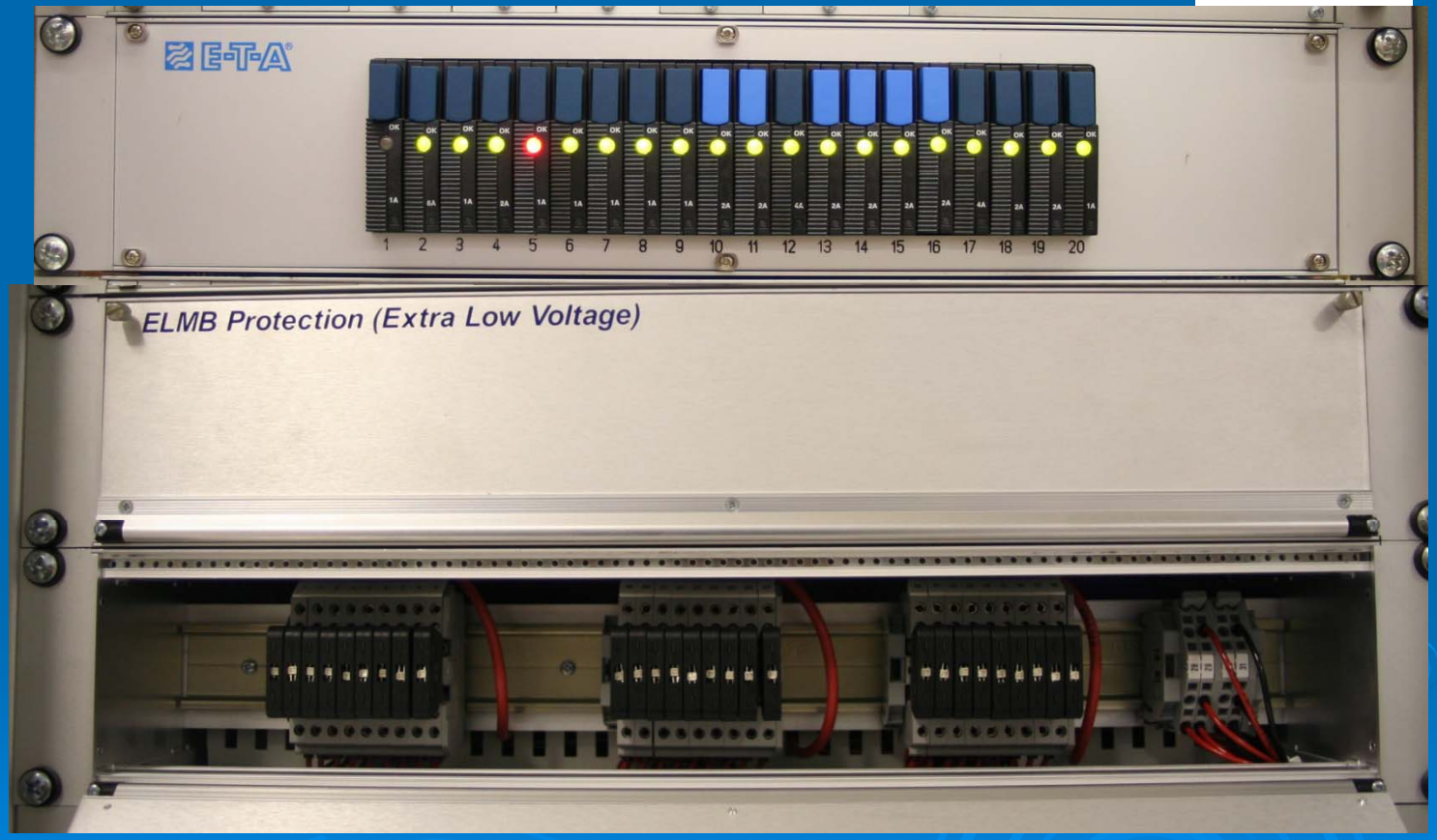


Safety Very low tension



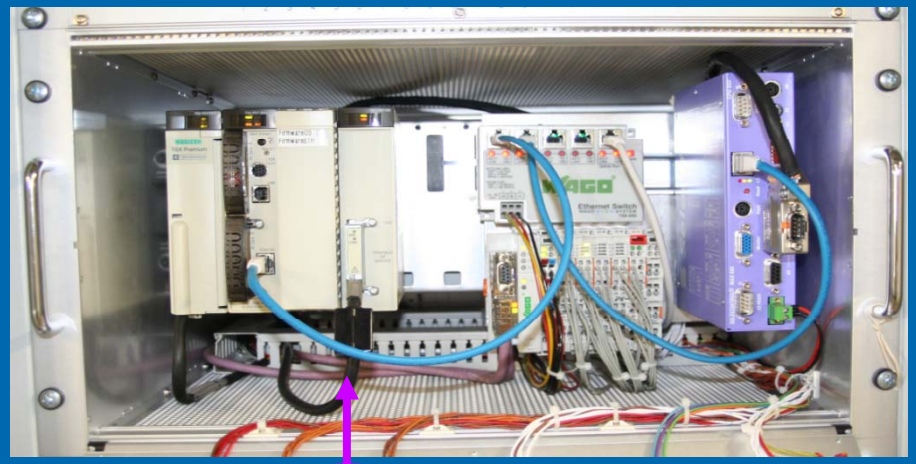
280 MCBS
24 Vdc 150A
ESS20
Version CERN

400 Fuses
18 Vdc
ELMB



2U 88mm
27 circuits

Control Chassis



Ethernet TCP/IP

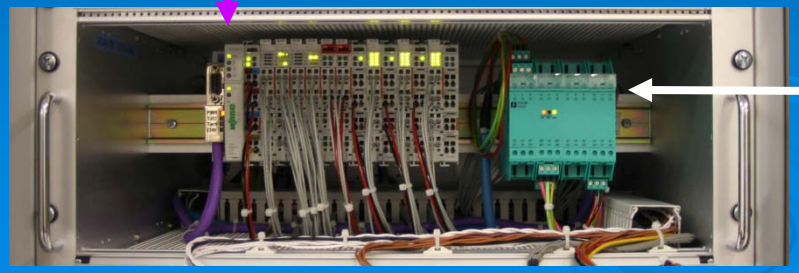
24 Web-Mas

Canbus

28 PLC

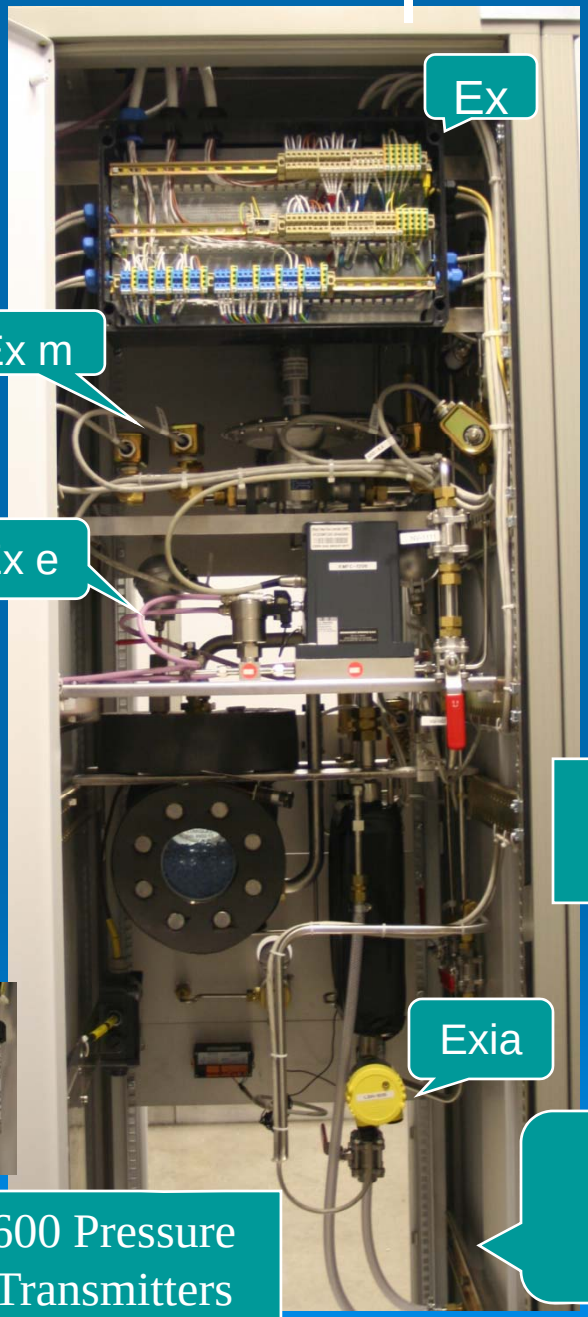
Profibus DP

Profibus DP / PA



200 racks and 200 Chassis

200 racks gas



Ex

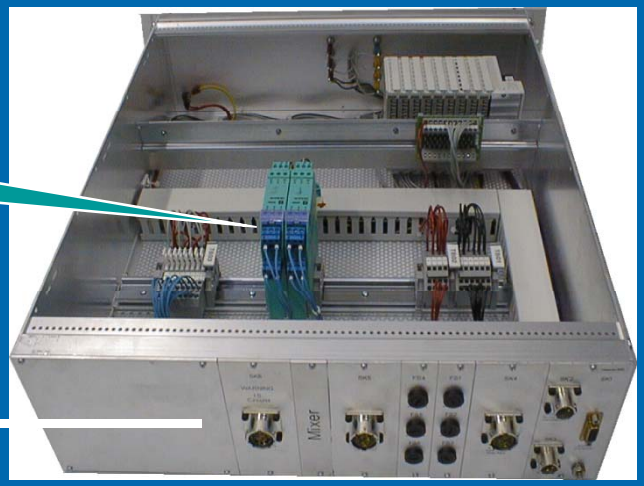
Ex m

Ex e

Exia

600 Pressure Transmitters

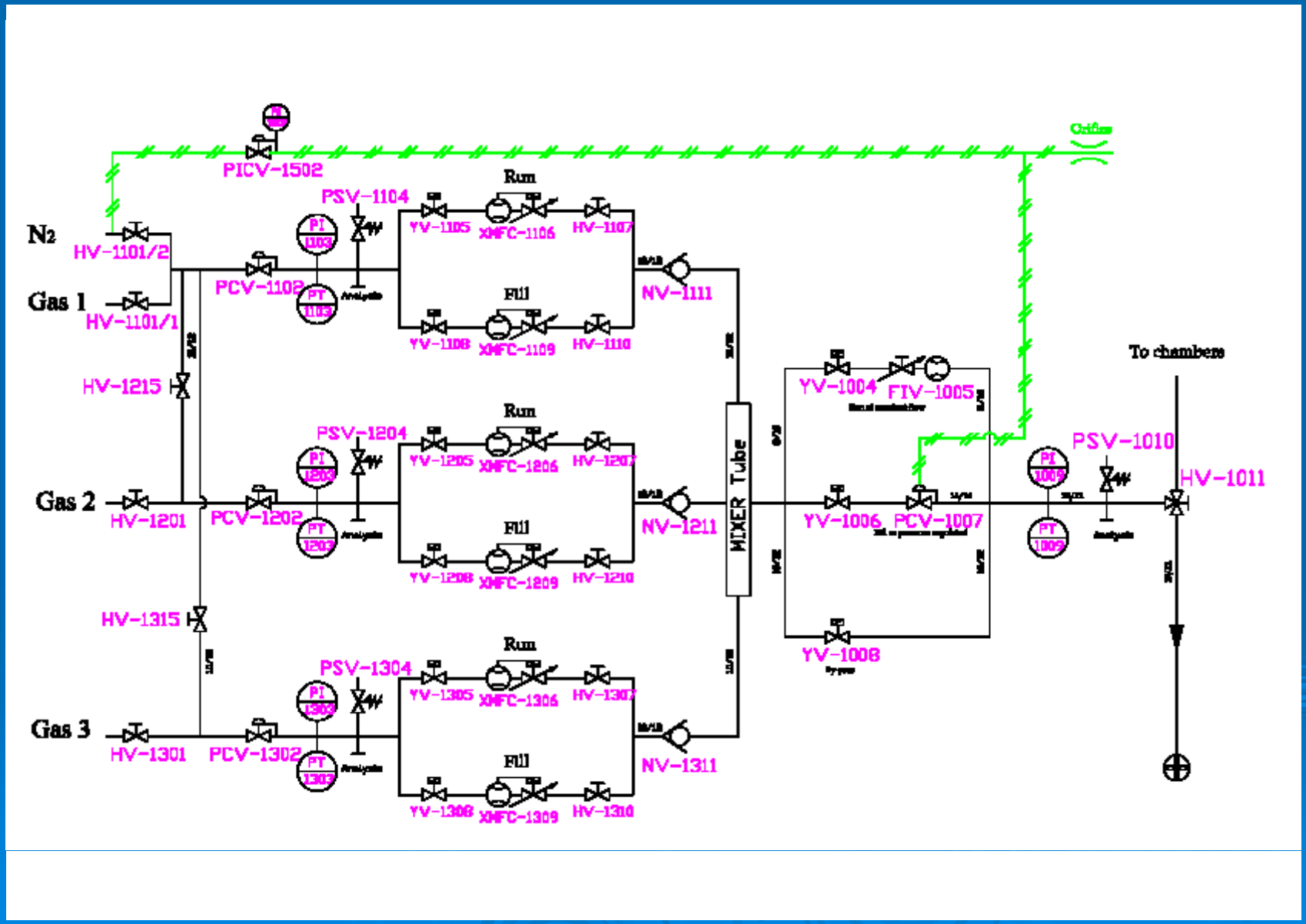
Zone 2
ATEX
Ex



Exia

100 DMFC
Digital Mass Flow Control

Mixer


PICV-1502
Orifice
N2
HV-1101/2
Gas 1
HV-1101/1
HV-1215
PSV-1104
Run
Fill
YV-1105
XMFC-1106
HV-1107
YV-1108
XMFC-1109
HV-1110
PCV-1102
NV-1111
Gas 2
HV-1201
PSV-1204
YV-1205
XMFC-1206
HV-1207
YV-1208
XMFC-1209
HV-1210
PCV-1202
NV-1211
HV-1315
Gas 3
HV-1301
PSV-1304
YV-1305
XMFC-1306
HV-1307
YV-1308
XMFC-1309
HV-1310
PCV-1302
NV-1311
MIXER Tube
YV-1004
FIV-1005
YV-1006
PCV-1007
YV-1008
PSV-1010
HV-1011
To chambers

Mixer

Mixture

1 gas	Ar	CH_4
2 gas	N_2	IC_4H_{10}
3 gas	CF_4	SF_6
4 gas	CO_2	Xe
	$C_2H_2F_4$	Ne

Evaporation

1 liquid

C_5H_{12}

C_4F_{10}

H_2O eau ! Oups 40g/h

Flow

100 l/h

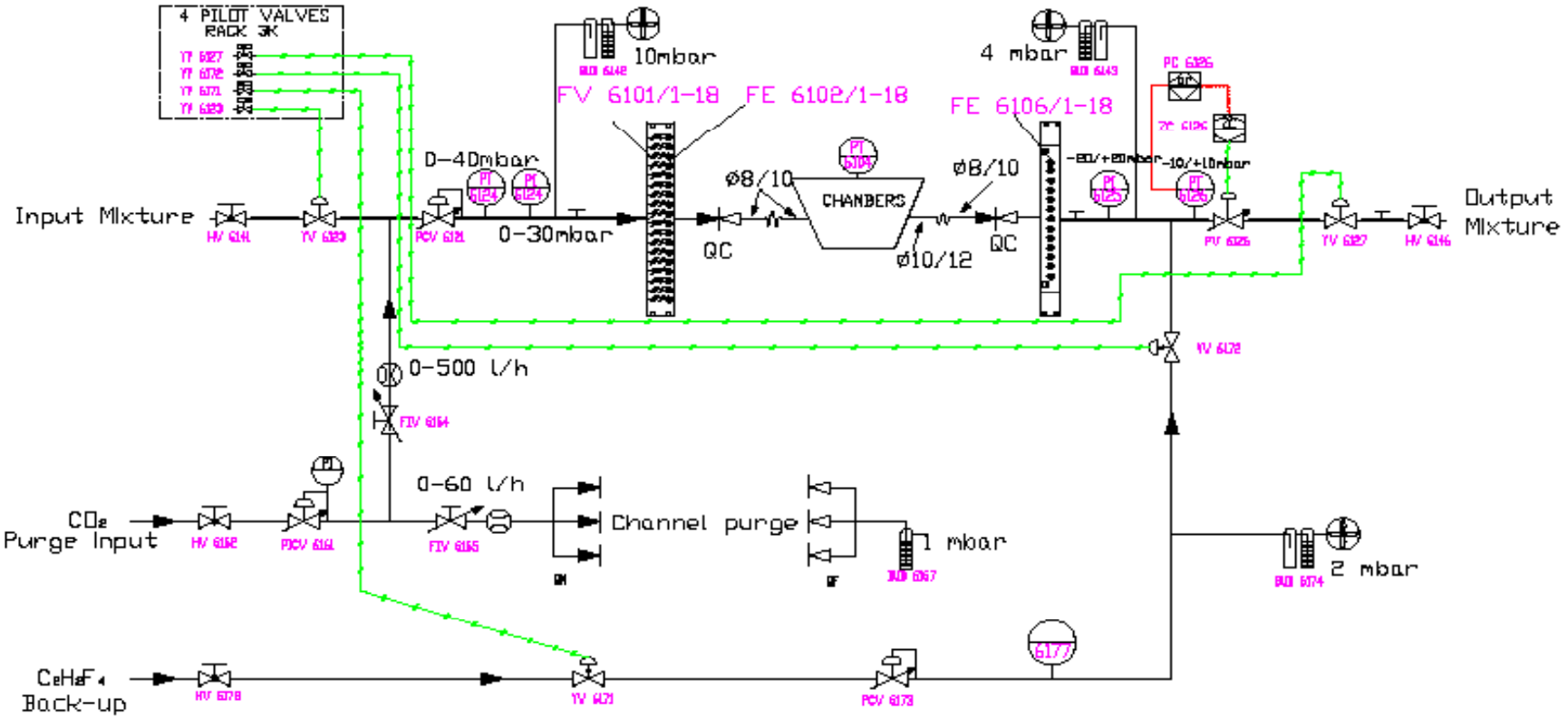
17 m^3/h

Pressure

50 mbar

2.1 bar

Distribution



73 distributions racks in LHC

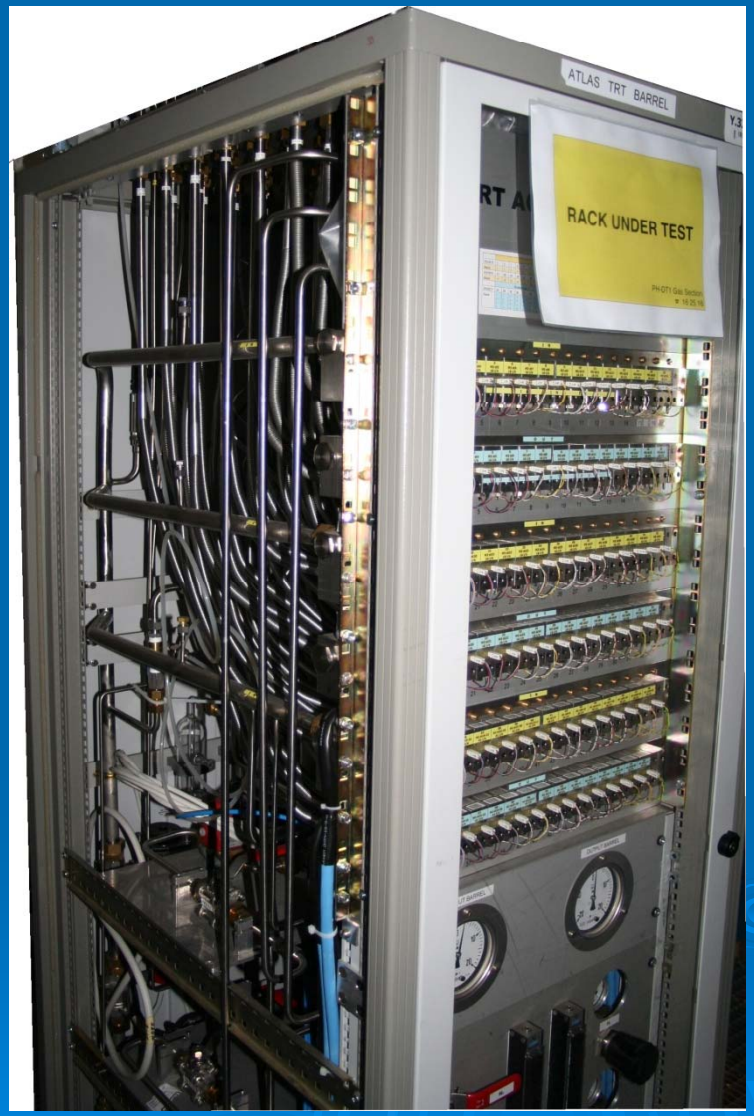
- 1 rack 1 channel TPC - RICHS

  Pressure 1mbar Flow 11m^3/h

- 1 rack 108 channels

  Pressure 1mbar Flow 16m^3/h

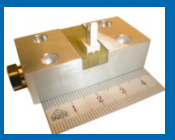
  Flow cells Flows 1.5l/h 600l/h

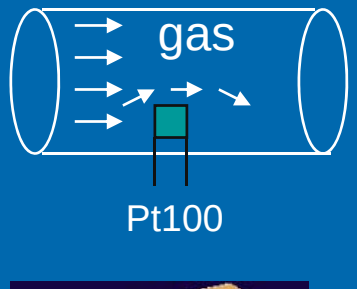


988 Cells max per system

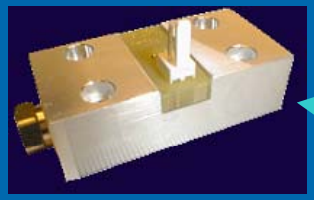
WebMas - ELMB Flow

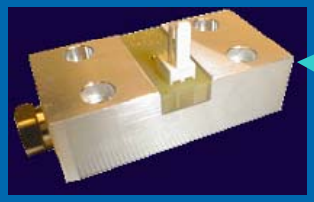
Measurement System

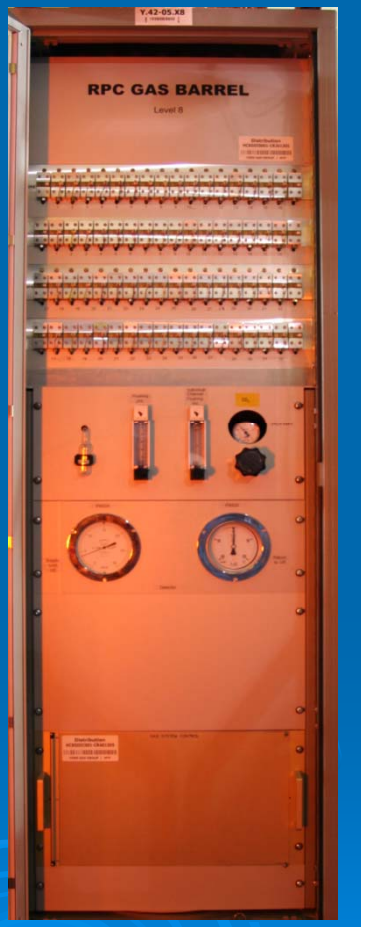




CAN Bus (CANOpen)







Ethernet (TCP/IP Modbus)

WebMas (Selectron CPU 852)

ATLAS 1190 cel
ALICE 310 cel.
CMS 1744 cel.
TOTEM 80 cel
LHCb 456 cel

3780 flow cells

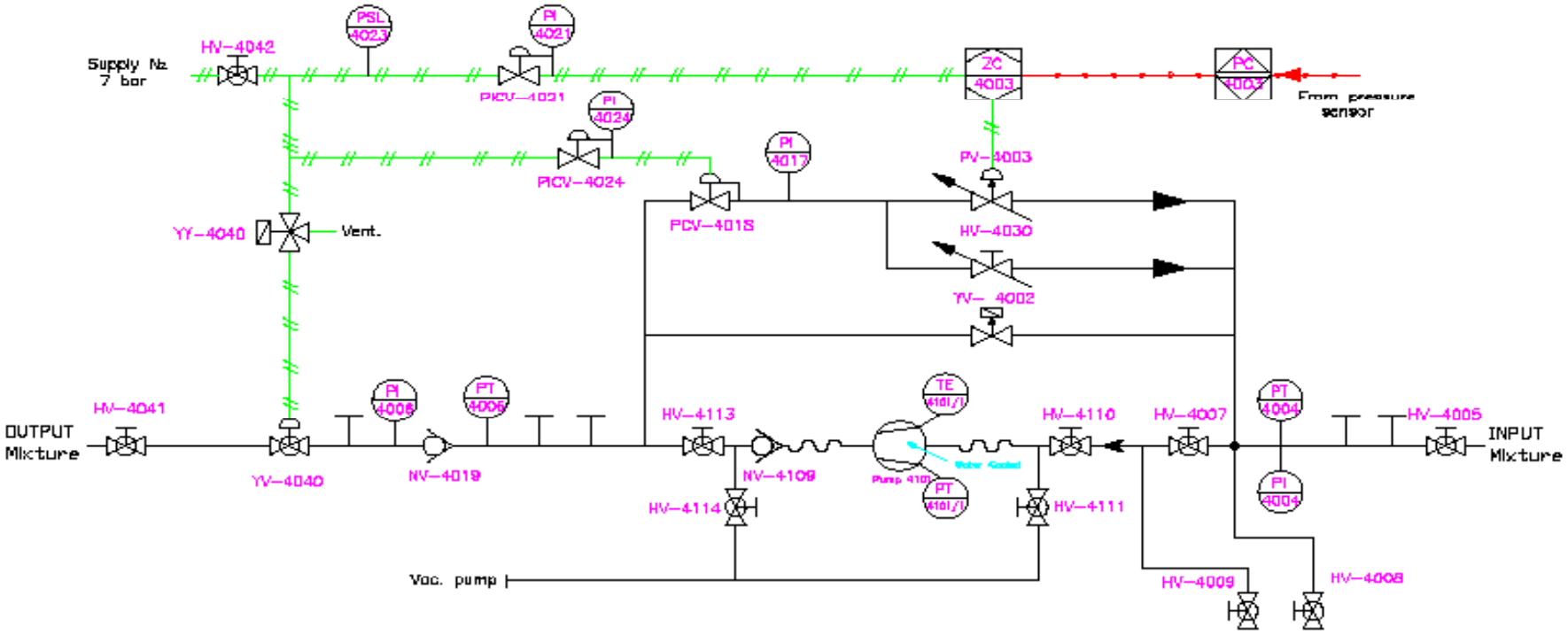
188 ELMB cards

120 supplies cards

20 WebMas

73 racks

Pump


Supply N2
7 bar
HV-4042
PSL 4023
PI 4021
PICV-4021
ZC 4003
PC 4003
From pressure sensor
PI 4024
PICV-4024
PI 4017
PCV-4018
PV-4003
HV-4030
YV- 4002
YY-4040
Vent.
HV-4041
OUTPUT Mixture
PI 4006
FT 4006
YY-4040
NV-4019
HV-4113
NV-4109
HV-4114
TE 4101/1
Pump 4101
Water Cooled
PT 4101/1
HV-4110
HV-4111
HV-4007
PT 4004
PI 4004
HV-4005
INPUT Mixture
Vac. pump
HV-4009
HV-4008

PUMP Rack

3 Types

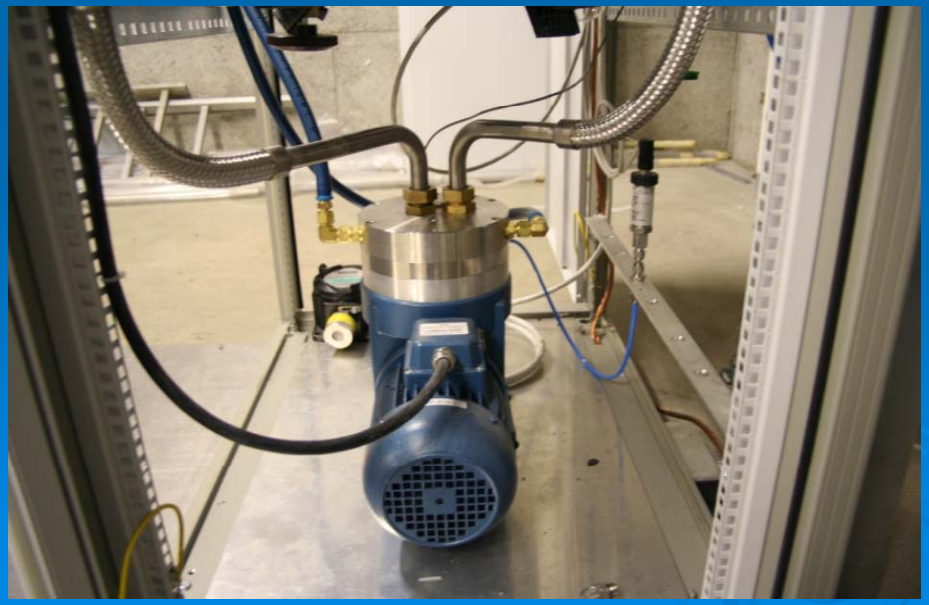
- Membranes pump
- Pistons pump (without grease)
- Turbo pump

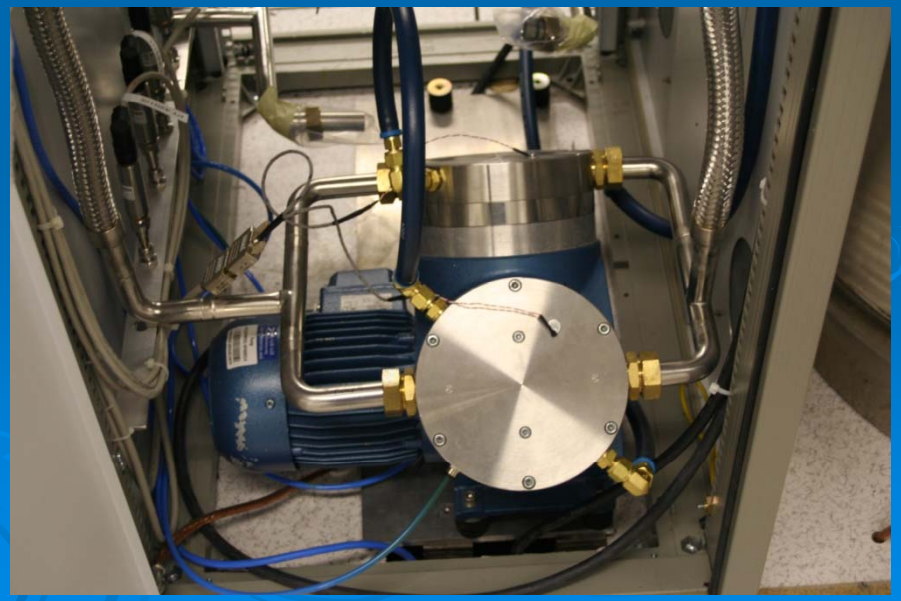
MEMBRANE PUMP

80% Membranes pump

Pressure -100 mbar / +2 Bar

Flow 9m^3/h - 16 m^3/h





TURBO PUMP

Pressure 1.9 bar / +2.15 Bar

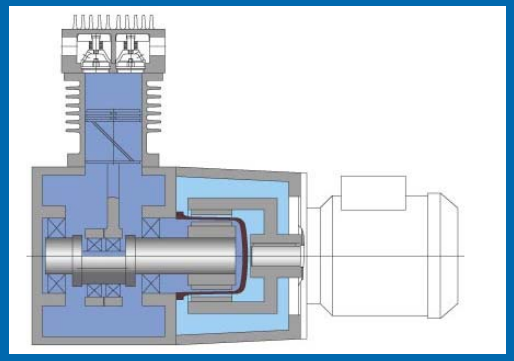
Flow 230 m^3/h

Rotation Speed 50000 tr/min

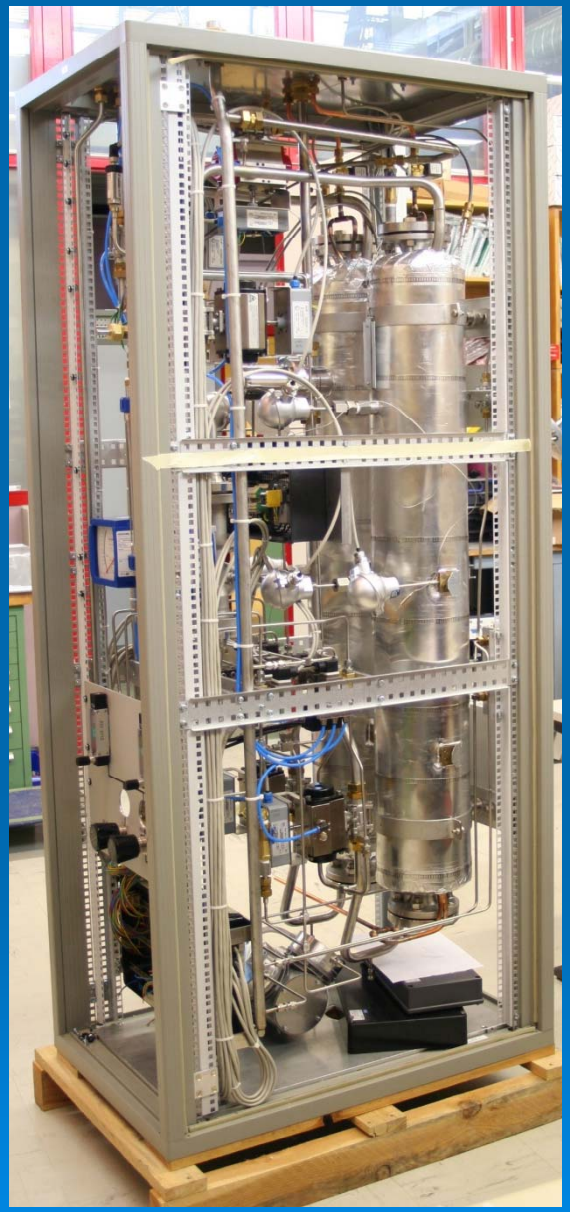
PISTONS PUMP

Pressure 0 bar / +7 bar

Flow 16 m^3/h



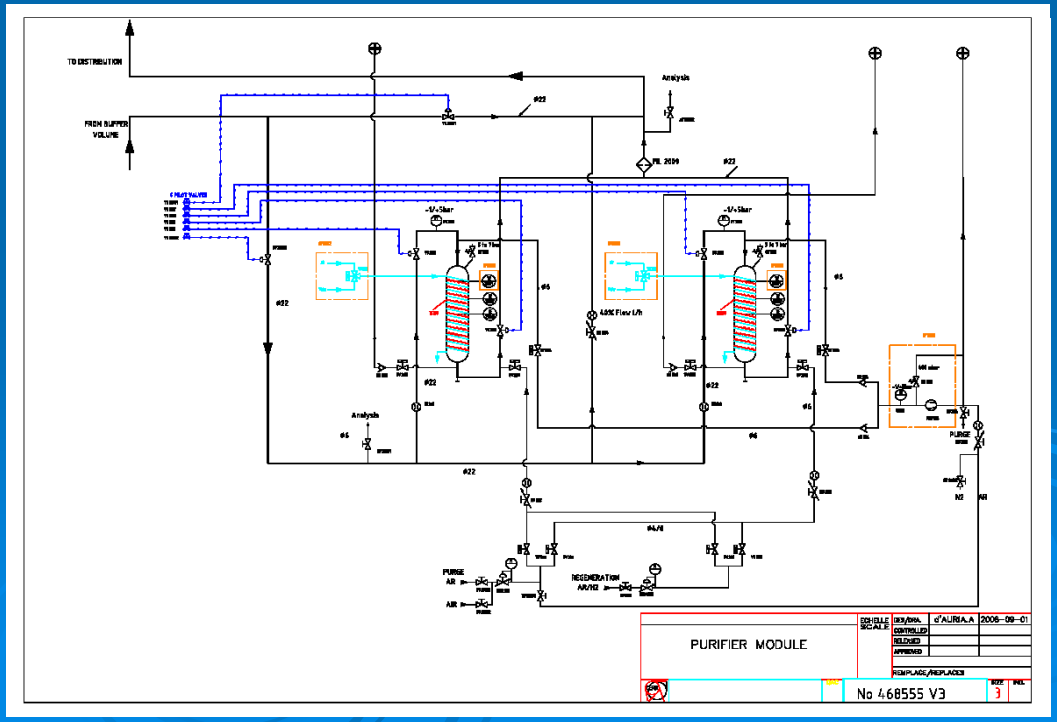
PURIFIER



Traps H_2O + O_2

Molecular sieve (5Å) adsorbing water vapor
Cupper adsorbing oxygen
Ni adsorbing oxygen (water vapor)

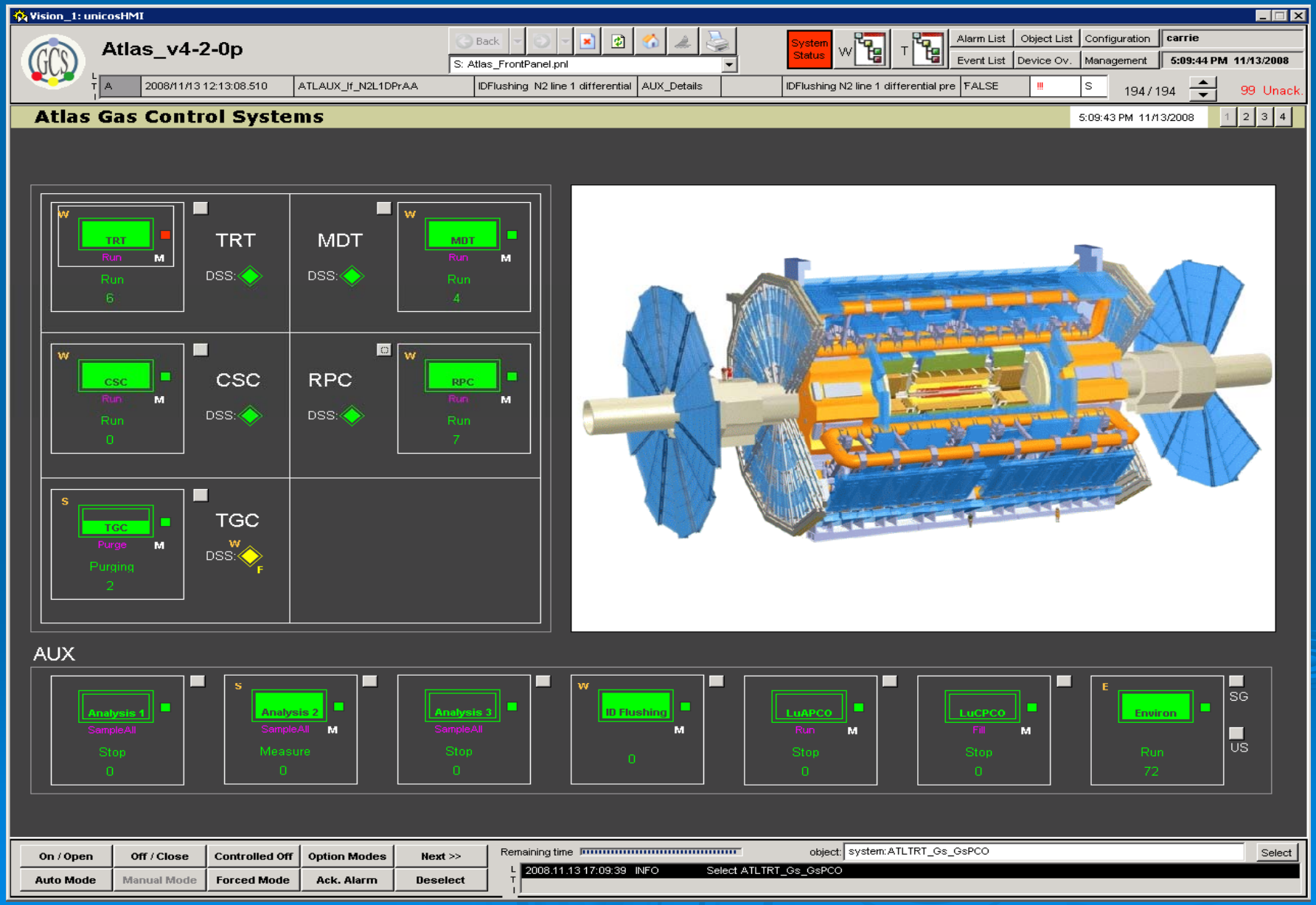
20ºC 300ºC



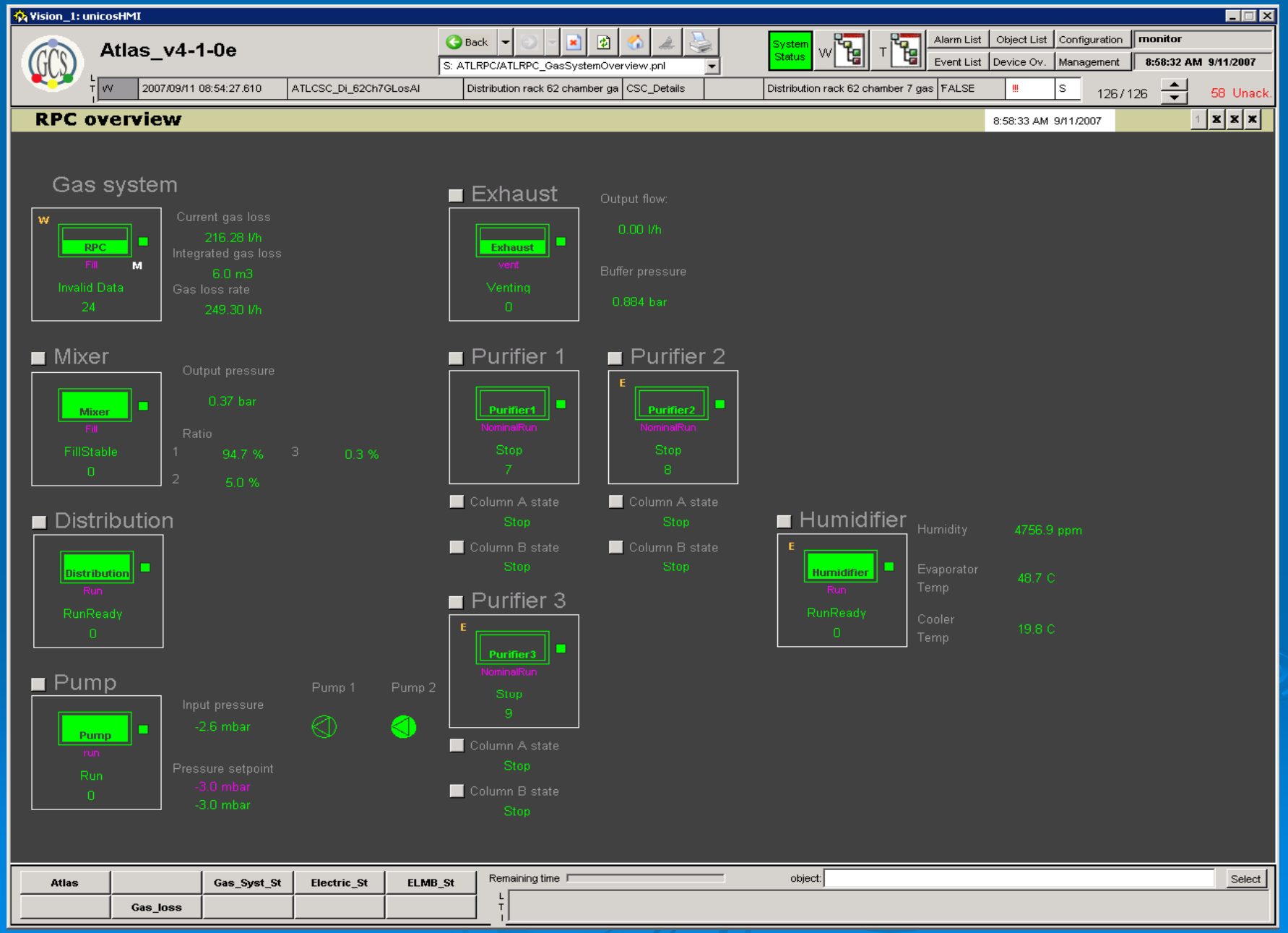
TOOLS via PVSS
Gas system

G.C.S.
Gaz Control System

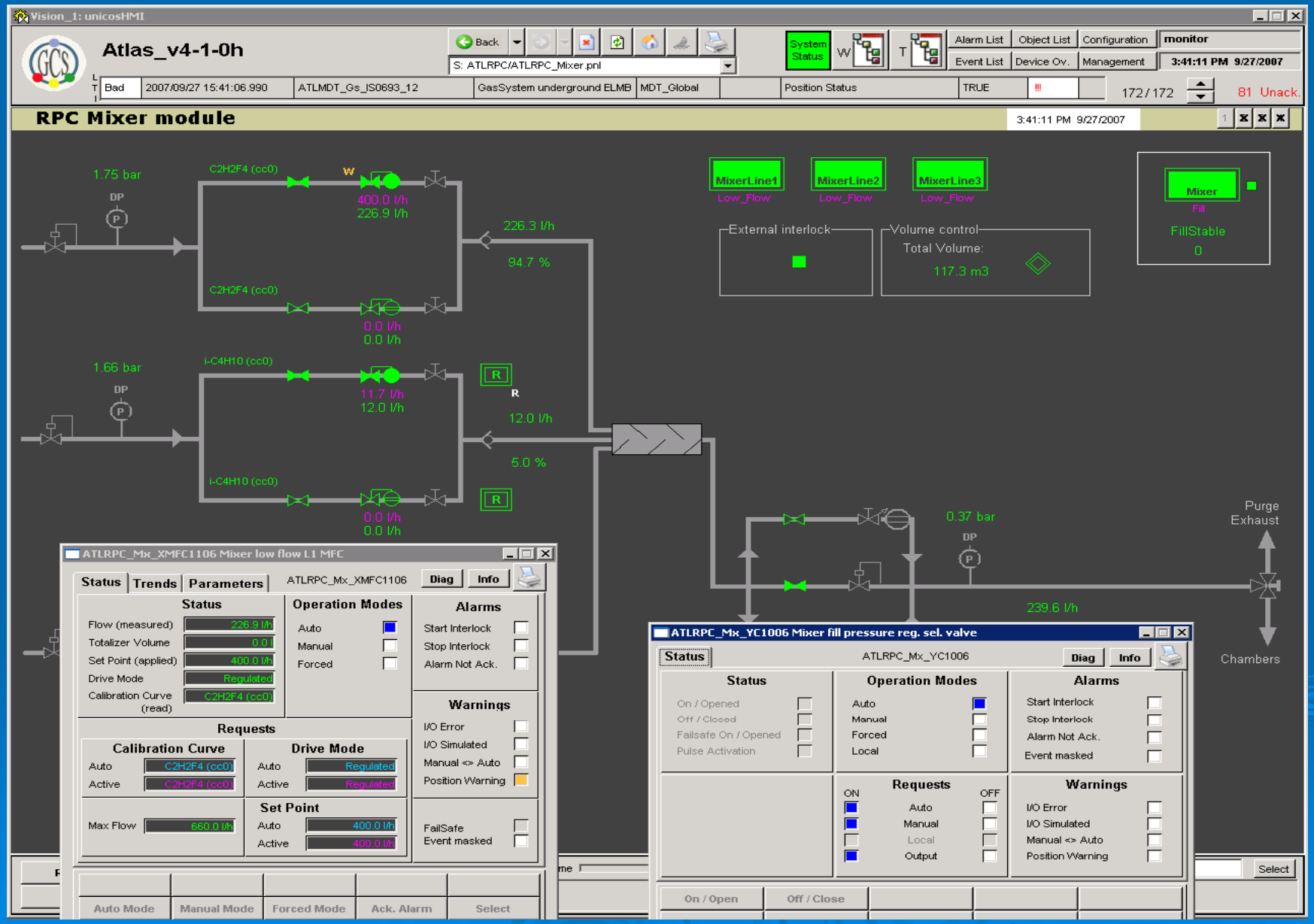
TOOLS for GCS



GCS


Vision_1: unicosHMI
Atlas_v4-1-0e
Back
S: ATLRPC/ATLRPC_GasSystemOverview.pnl
System Status
Alarm List
Object List
Configuration
monitor
Event List
Device Ov.
Management
8:58:32 AM 9/11/2007
2007/09/11 08:54:27.610
ATLCSC_Di_62Ch7GLosAl
Distribution rack 62 chamber ga
CSC_Details
Distribution rack 62 chamber 7 gas
FALSE
126 / 126
58 Unack.
RPC overview
8:58:33 AM 9/11/2007
Gas system
RPC
Fill
Invalid Data
24
Current gas loss
216.28 l/h
Integrated gas loss
6.0 m3
Gas loss rate
249.30 l/h
Exhaust
Exhaust
vent
Venting
0
Output flow:
0.00 l/h
Buffer pressure
0.884 bar
Mixer
Mixer
Fill
FillStable
0
Output pressure
0.37 bar
Ratio
1 94.7 %
2 5.0 %
3 0.3 %
Purifier 1
Purifier1
NominalRun
Stop
7
Column A state
Stop
Column B state
Stop
Purifier 2
Purifier2
NominalRun
Stop
8
Column A state
Stop
Column B state
Stop
Distribution
Distribution
Run
RunReady
0
Purifier 3
Purifier3
NominalRun
Stop
9
Column A state
Stop
Column B state
Stop
Humidifier
Humidifier
Run
RunReady
0
Humidity
4756.9 ppm
Evaporator Temp
48.7 C
Cooler Temp
19.8 C
Pump
Pump
run
Run
0
Input pressure
-2.6 mbar
Pressure setpoint
-3.0 mbar
-3.0 mbar
Pump 1
Pump 2
Atlas
Gas_loss
Gas_Syst_St
Electric_St
ELMB_St
Remaining time
object:
Select

GCS


Vision_1: unicosHMI
Atlas_v4-1-0h
Back
S: ATLRPC/ATLRPC_Mixer.pnl
System Status
Alarm List
Object List
Configuration
monitor
Event List
Device Ov.
Management
3:41:11 PM 9/27/2007
Bad
2007/09/27 15:41:06.990
ATLMDT_Gs_IS0693_12
GasSystem underground ELMB
MDT_Global
Position Status
TRUE
172 / 172
81 Unack.
RPC Mixer module
3:41:11 PM 9/27/2007
1.75 bar
DP
C2H2F4 (cc0)
400.0 l/h
226.9 l/h
226.3 l/h
94.7 %
0.0 l/h
0.0 l/h
1.66 bar
i-C4H10 (cc0)
11.7 l/h
12.0 l/h
12.0 l/h
5.0 %
0.0 l/h
0.0 l/h
MixerLine1
Low_Flow
MixerLine2
Low_Flow
MixerLine3
Low_Flow
External interlock
Volume control
Total Volume:
117.3 m3
Mixer
Fill
FillStable
0
0.37 bar
239.6 l/h
Purge Exhaust
Chambers
ATLRPC_Mx_XMFC1106 Mixer low flow L1 MFC
Status
Trends
Parameters
ATLRPC_Mx_XMFC1106
Diag
Info
Flow (measured)
Totalizer Volume
Set Point (applied)
Drive Mode
Calibration Curve (read)
Operation Modes
Auto
Manual
Forced
Alarms
Start Interlock
Stop Interlock
Alarm Not Ack.
Warnings
I/O Error
I/O Simulated
Manual <> Auto
Position Warning
FailSafe
Event masked
Requests
Calibration Curve
Drive Mode
Set Point
Max Flow
660.0 l/h
Auto Mode
Manual Mode
Forced Mode
Ack. Alarm
Select
ATLRPC_Mx_YC1006 Mixer fill pressure reg. sel. valve
ATLRPC_Mx_YC1006
On / Opened
Off / Closed
Failsafe On / Opened
Pulse Activation
Local
Event masked
ON
OFF
Output
On / Open
Off / Close

CMS

ATLAS
TGC

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TGC

ANALYSIS