ProtoDUNE-SP cryogenics coordination meeting
23/11/2016

ProtoDUNE-SP
slow controls overview

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for Slow Controls group

IFIC - (CSIC & Univ. Valencia)

Overview

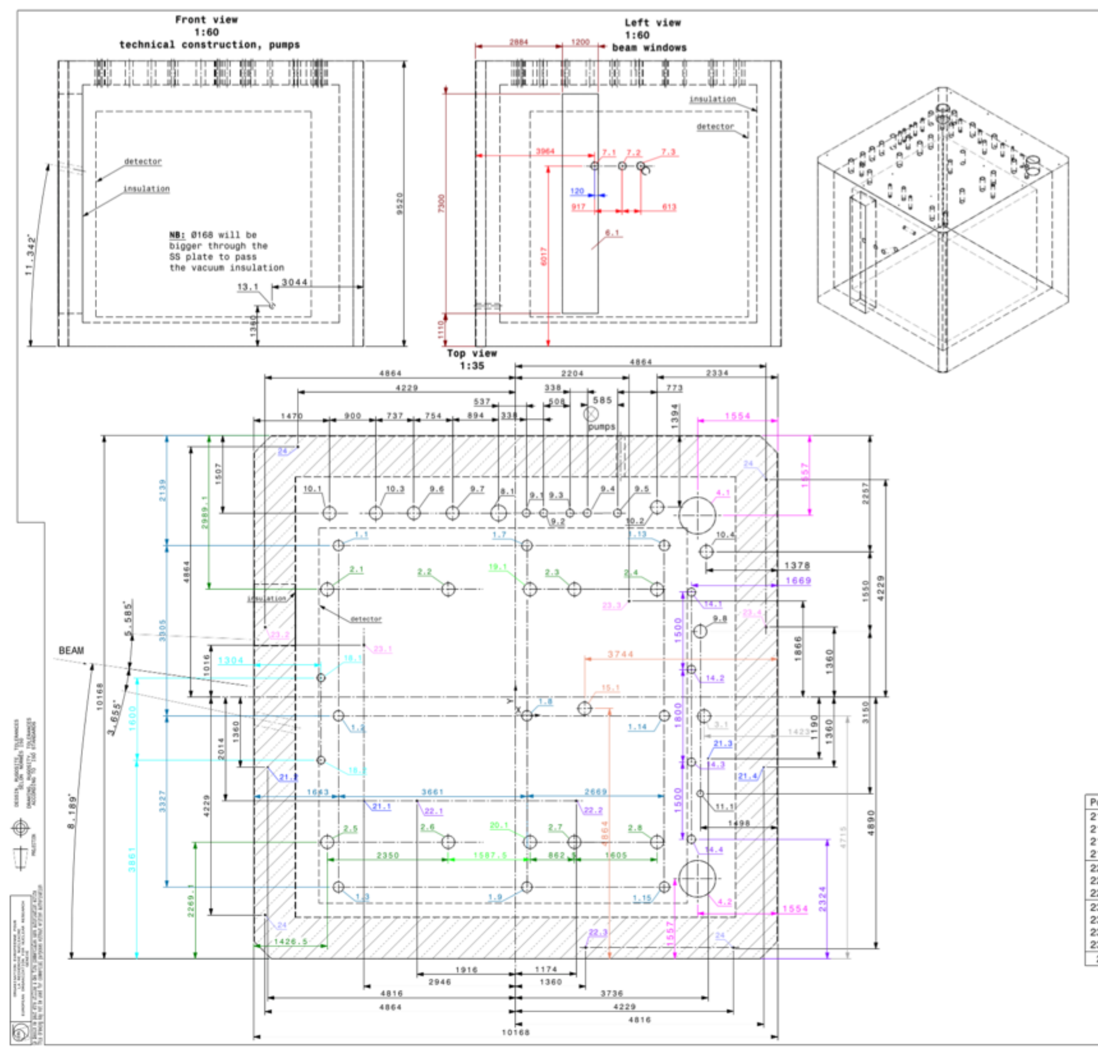
- The slow controls group was formed at the las CM
- Elements considered:
  - Voltage (HV/LV) and current monitoring/control for APA, CPA, PD, Purity Monitors, Outer Veto, Beam plug and corona monitors
  - Impedance monitor for ground planes
  - Instrumentation inside cryostat:
    - Temperatures (T-Gradient in Jelena's talk)
    - Pressure
    - Level meters
    - Cameras & lighting (Mike's talk)
    - Purity monitors (Jianming's talk)
  - Gas trace analysers (???) **Question**: Who is responsible for this ?
  - Slow controls feedthroughs

Items in this talk underlined

Available cryostat ports

- List of available ports from Jack Fowler. Also discussing with David Montanari the ones assigned to cryogenics that we could use

https://edms.cern.ch/ui/file/1543241/3/NP04_penetrations_drawing.pdf



Detector penetrations

Pos.	Diameter [mm]	Description
1.1	Ø200	West transfer rail N support
1.2		West transfer rail Center support
1.3		West transfer rail S support
1.7		Center transfer rail N support
1.8		Center transfer rail Center support
1.9		Center transfer rail S support
1.13		East transfer rail N support
1.14		East transfer rail Center support
1.15		East transfer rail S support
2.1	Ø250	N Signal cable feed thru 1
2.2		N Signal cable feed thru 2
2.3		N Signal cable feed thru 3
2.4		N Signal cable feed thru 4
2.5		S Signal cable feed thru 1
2.6		S Signal cable feed thru 2
2.7		S Signal cable feed thru 3
2.8		S Signal cable feed thru 4
3.1	Ø250	High Voltage Feedthrough
4.1	Ø710	Manhole NE
4.2		Manhole SE
6.1	1200x7300mm	Temporary Construction Opening
7.1	Ø250	Beam Window
7.2		Beam Window
7.3		Beam Window
14.1	Ø160	Laser Port 1
14.2		Laser Port 2
14.3		Laser Port 3
14.4		Laser Port 4
15.1	Ø250	Calibration fibers
18.1	Ø150	Spare near CPA line West side
18.2		Spare near CPA line West side
19.1	Ø250	Spare on North APA signal cable port line
20.1	Ø250	Spare on South APA signal cable port line

Cryogenic penetrations

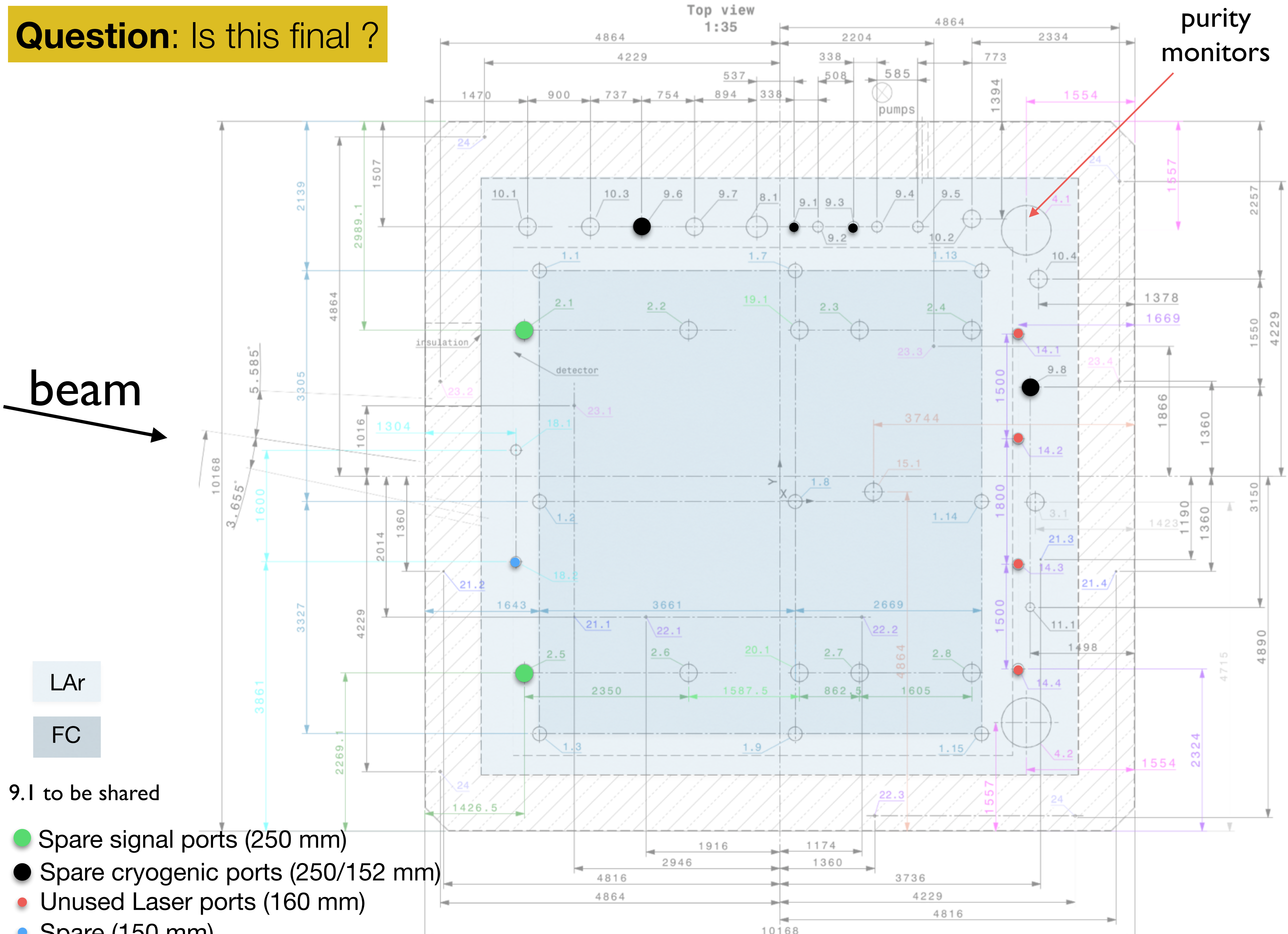
Pos.	Diameter [mm]	Description
8.1	Ø304	GAr Combo
9.1	Ø152	LAr Cooldown
9.2		LAr Distribution
9.3		Lar to Cold Roof
9.4		LAr Cooldown to Condenser
9.5		Gar Boil Off
9.6	Ø250	Spare
9.7		Spare
9.8		Spare
10.1	Ø250	Cryostat Pressure Relief 1
10.2		Cryostat Pressure Relief 2
10.3		Cryostat vacuum Relief 1
10.4		Cryostat vacuum Relief 2
11.1	Ø125	Instrumentation
13.1	Ø168 (See NB in Front view)	LAr Pump 1

GTT

Pos.	Diameter [mm]	Qty.	Description
21.1	Ø25	4	Primary insulation space supply
21.2			Secondary insulation space supply
21.3			Primary insulation space exhaust
21.4			Secondary insulation space exhaust
22.1	Ø40	3	Primary insulation space PT002
22.2			Primary insulation space PT003
22.3			Secondary insulation space PT001
23.1	Ø40	4	Primary insulation space PRV CF003
23.2			Secondary insulation space PRV CF001
23.3			Primary insulation space PRV CF004
23.4			Secondary insulation space PRV CF002
24	Ø40	4	Temperature sensors

DUNE Cryostat
PROTODUNE PENETRATIONS
SCALE 1:1
B. LACARELLE 2016-04-07
NON VALABLE POUR EXECUTION
NOT VALID FOR EXECUTION
CENDUNCR0078
1

Question: Is this final ?



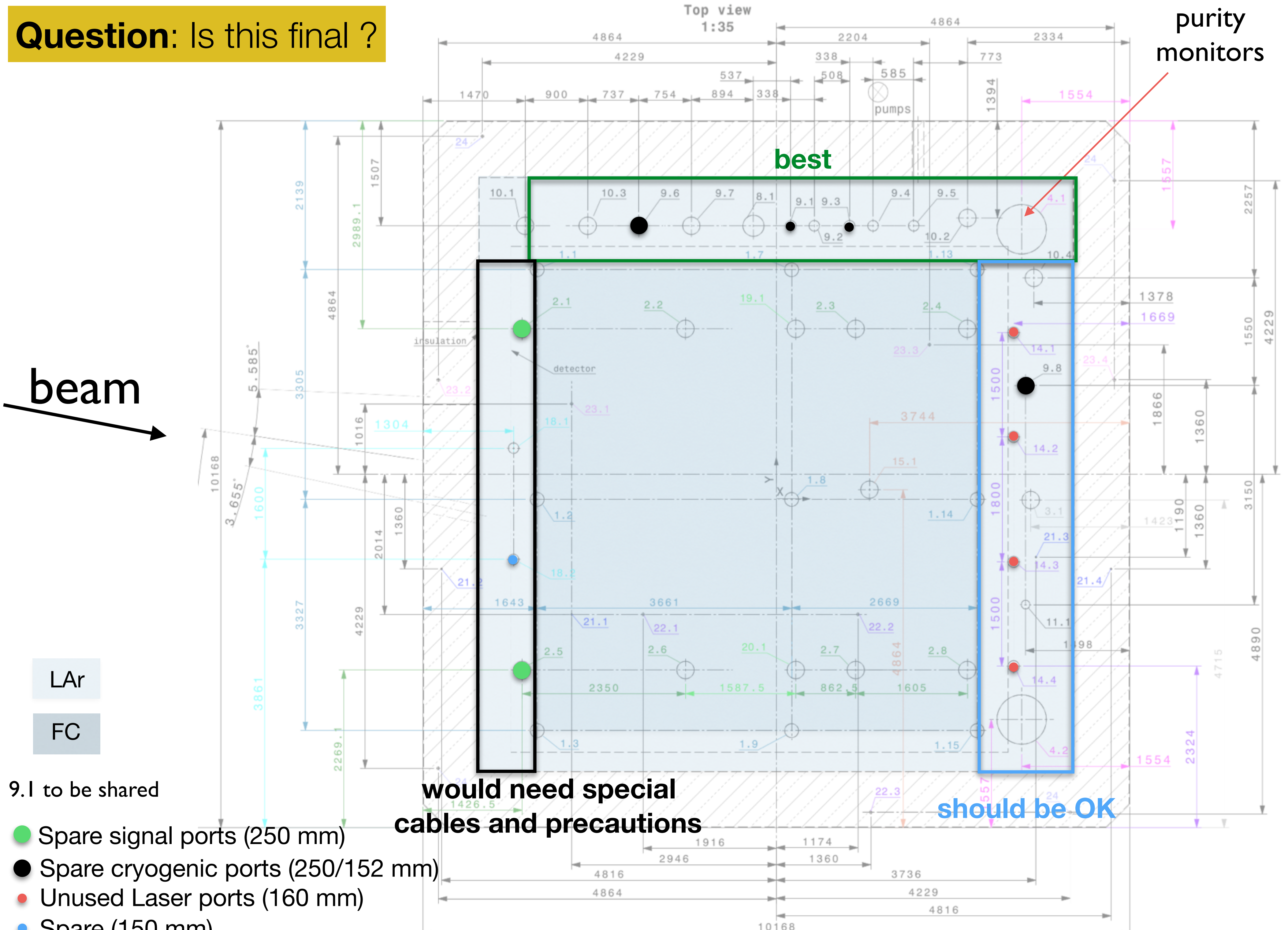
LAr

FC

9.1 to be shared

- Spare signal ports (250 mm)
- Spare cryogenic ports (250/152 mm)
- Unused Laser ports (160 mm)
- Spare (150 mm)

Question: Is this final ?



9.1 to be shared

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- Spare cryogenic ports (250/152 mm)
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- Spare (150 mm)

LAr flow simulations

Fermilab

Managed by Fermi Research Alliance, LLC for the U.S. Department of Energy Office of Science

ProtoDUNE Liquid Argon Flow Simulations

Erik Voirin
Fermilab – Fluid and Thermal Engineering
January 12, 2015

date is wrong (it is January 12, 2016)

http://docs.dunescience.org:8080/cgi-bin/ShowDocument?docid=928

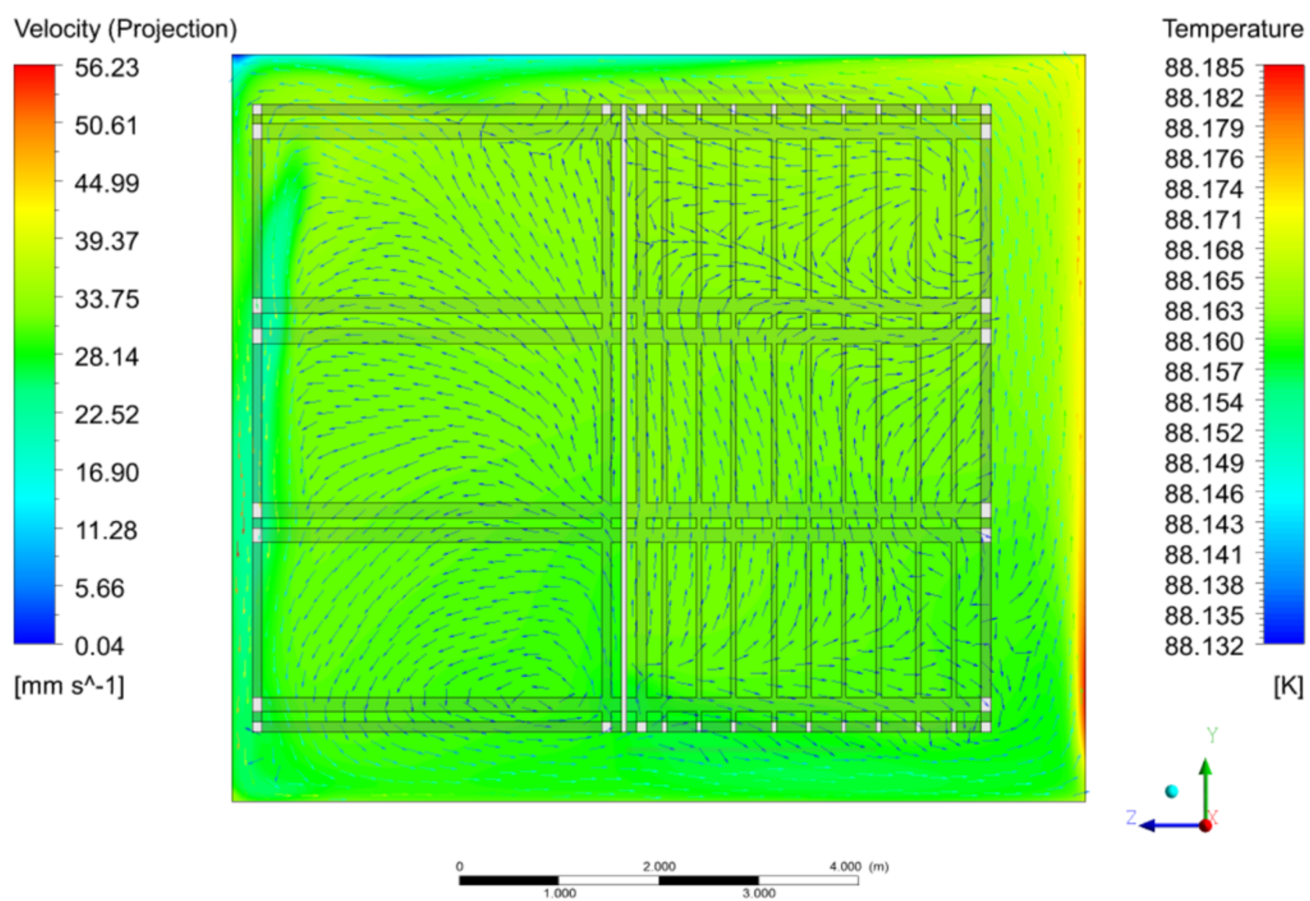
Question: Can we base the requirements on those maps ? Are there newer maps ?

(v1) Pump Discharge at large FC gap end (-Z end), Pump Suction opposite end (+Z end)						
Variable inside Field Cage Volume	**Minimum**	**Average**	**Maximum**	**Range**	**Std Dev**	**(units)**
Temperature Inside Field Cage	88.1416	88.1617	88.1671	0.0255	0.0017243	(K)
Velocity Inside Field Cage	0.0243783	6.589	55.5525	55.528122	6.96325	(mm/sec)
Turbulent Diffusion Coefficient		3.202				(cm^2/sec)
Ratio Turbulent Diffusion to Molecular		3918.8809				
Normalized Surface Impurities	0.993182	0.999627	1.01649	0.023308	0.0020798	
Turbulence Kinetic Energy		0.18301				cm^2/s^2
Turbulence Eddy Frequency		0.0741253				s^-1

One of the maps for x=2m

- Except near borders ΔT<0.02 K, including borders ΔT<0.05 K

Temperature and Velocity @ X = 2m

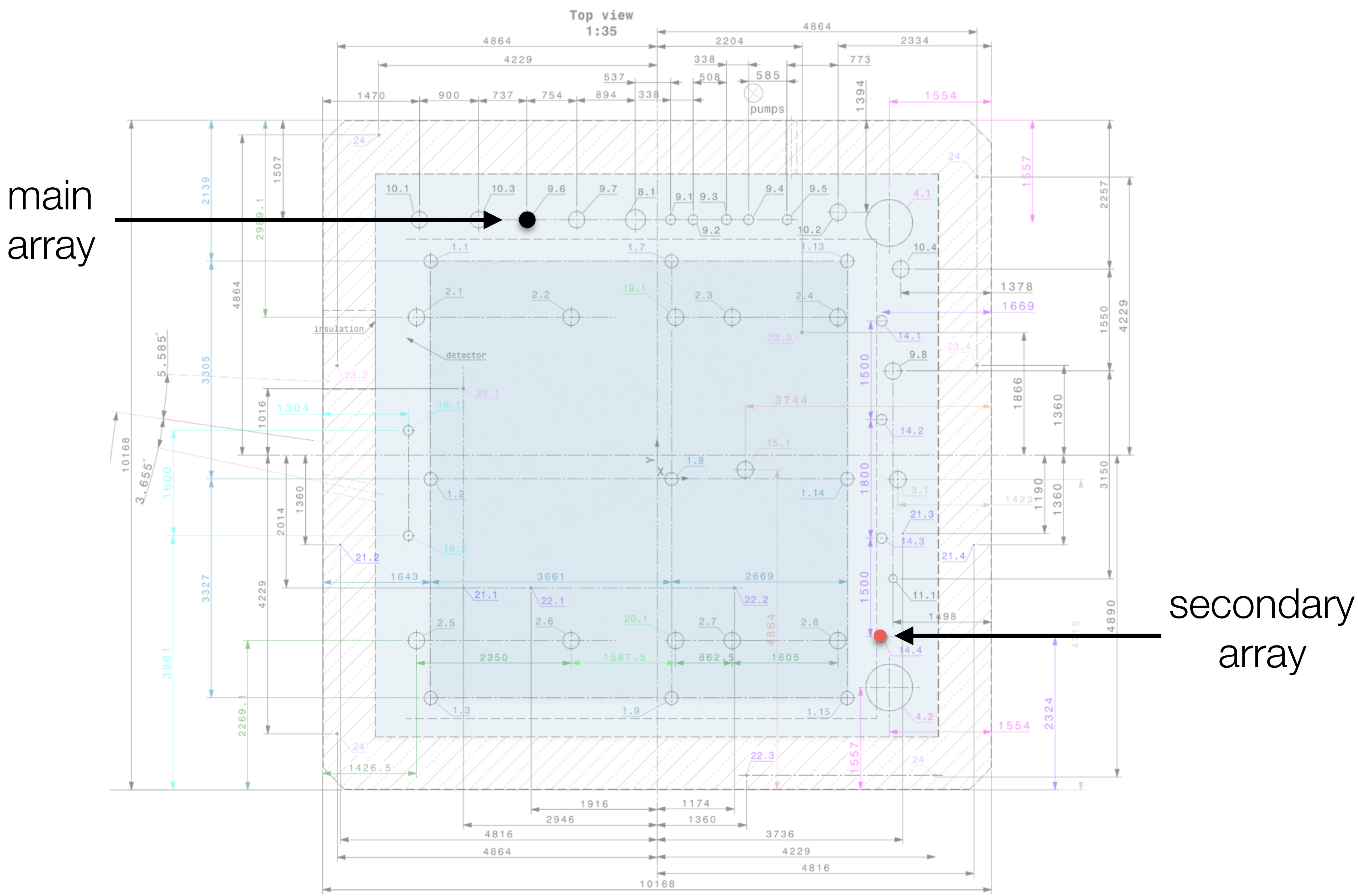


T-gradient monitors

- Much more in Jelena's talk
- We believe a **secondary array** would be desirable in order to properly understand/constraint the temperature maps
  - We don't know how many arrays will be needed in the 10 kton detector
  - For ProtoDUNE some redundancy will be useful
  - ProtoDUNE is the ideal framework to explore new things
    - Non metallic rod to be placed "not behind the APA"
    - Sensors calibrated by us, variable spacing, etc
- As will be shown in Jelena's talk calibrated (10 mK) sensors are 5 times more expensive that uncalibrated ones (500$ vs 100$)
  - Probably affordable for ProtoDUNE, but not for 10 kton. We probably want to build a small setup for calibrating the sensors already for ProtoDUNE
    - Exploring this option in Valencia

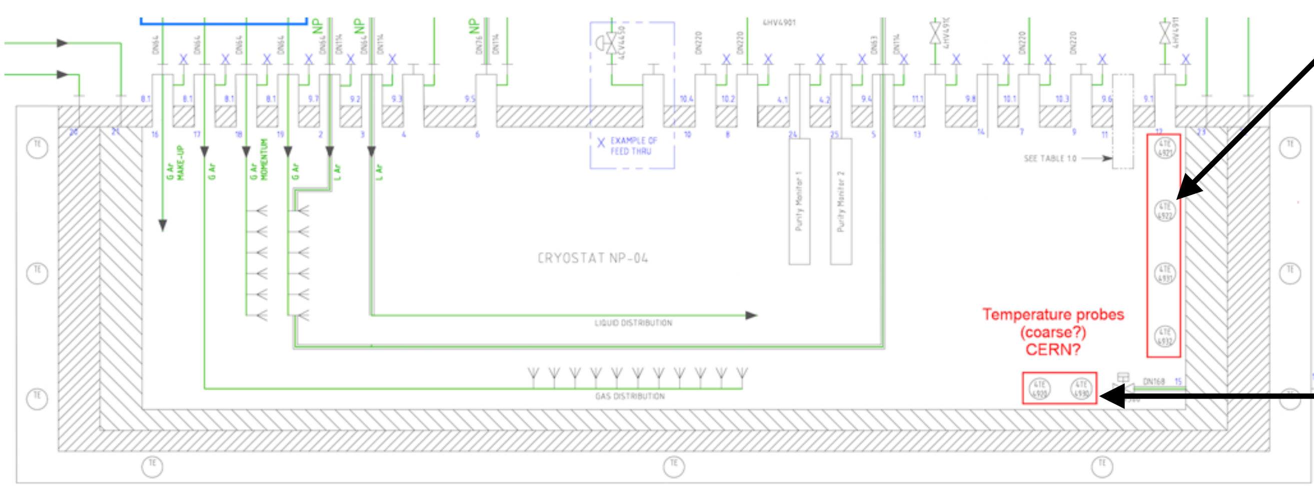
Question: opinions about 2nd array and about calibration

T-gradient monitors



Other T sensors

- The T-gradient monitor(s) covers the entire depth of the cryostat but at fixed x-y, in only one (or two) points
  - Other sensors with similar precision are needed to understand/constraint the simulations
- The **cryogenic system** includes several sensors (~1K precision) attached to the inner membrane (**I think**)
  - Probably not a good location for our purpose since they will be affected by border effects



Question: are these sensors attached to the inner membrane? Are all of them in liquid ?

Question: Where are these sensors?

Other T sensors

- Ideally a grid of sensors surrounding the field cage (all six sides)
- Currently trying to identify mechanical elements where sensors could be attached to
  - Detector support structure (TOP)
  - Purity monitors (NE corner)
  - ….

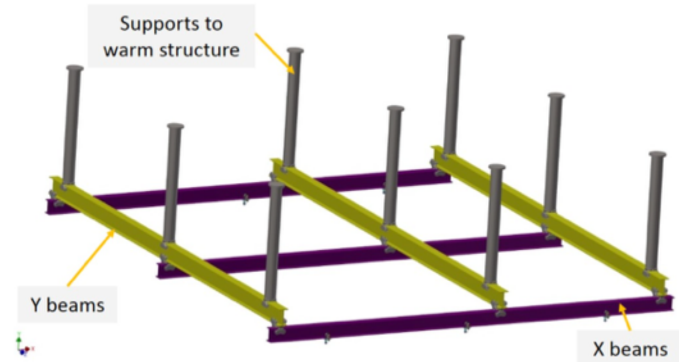


Figure 2.66: Detector support system

- Questions:
  - I guess we need at least a sensor in the gas. Already considered by the cryogenics system? 4TE4921 ?
  - Are we interested about temperatures near the inner membrane ? If so we could consider installing high precision sensors instead of the cryogenics ones, to be shared with cryogenics system
  - Can cryogenics system use some of the slow control sensors ?

Level meters

- Purpose is twofold:
  - Monitor the filling of the tank
  - Keep LAr surface around its nominal level
- Nominal LAr level is 378 mm above the ground planes
- HV Interlock value 100 mm above the ground planes
- The **cryogenics** system has a **differential pressure level meter** (4PDT4912) with 0.1% precision (7.5 mm at the nominal level), which should be enough to guaranty a safe level
- We believe a redundant system should be used for the interlock. The **T-gradient monitor** could be used in or:
  - Interlock if 4PDT4912 or T-gradient reports level below interlock value

Question: anything else needed ?

Pressure

- We haven't discuss much about pressure yet
- DP plans to install sensors in some of the feedthroughs, but we don't have more info yet
- Trying to understand the sensors of the cryogenics system. Is there anything in the gas ullage ?

Question: At this level any input would be welcomed

Cryogenic sensors

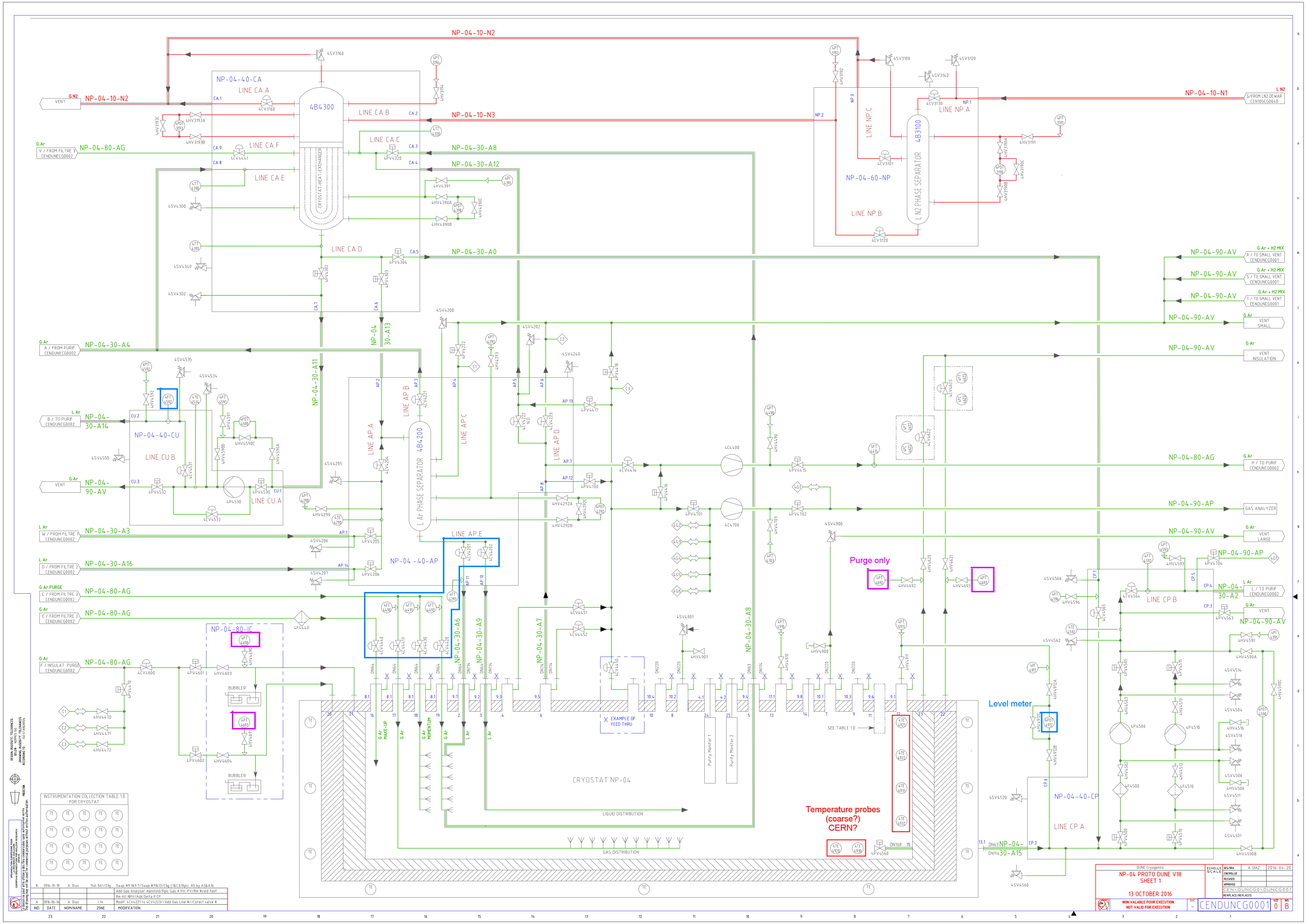
- Flor has extracted the relevant info from NP-04 P&ID provided by David Montanari
- In the next slides:

[blue box] most like interesting for SC

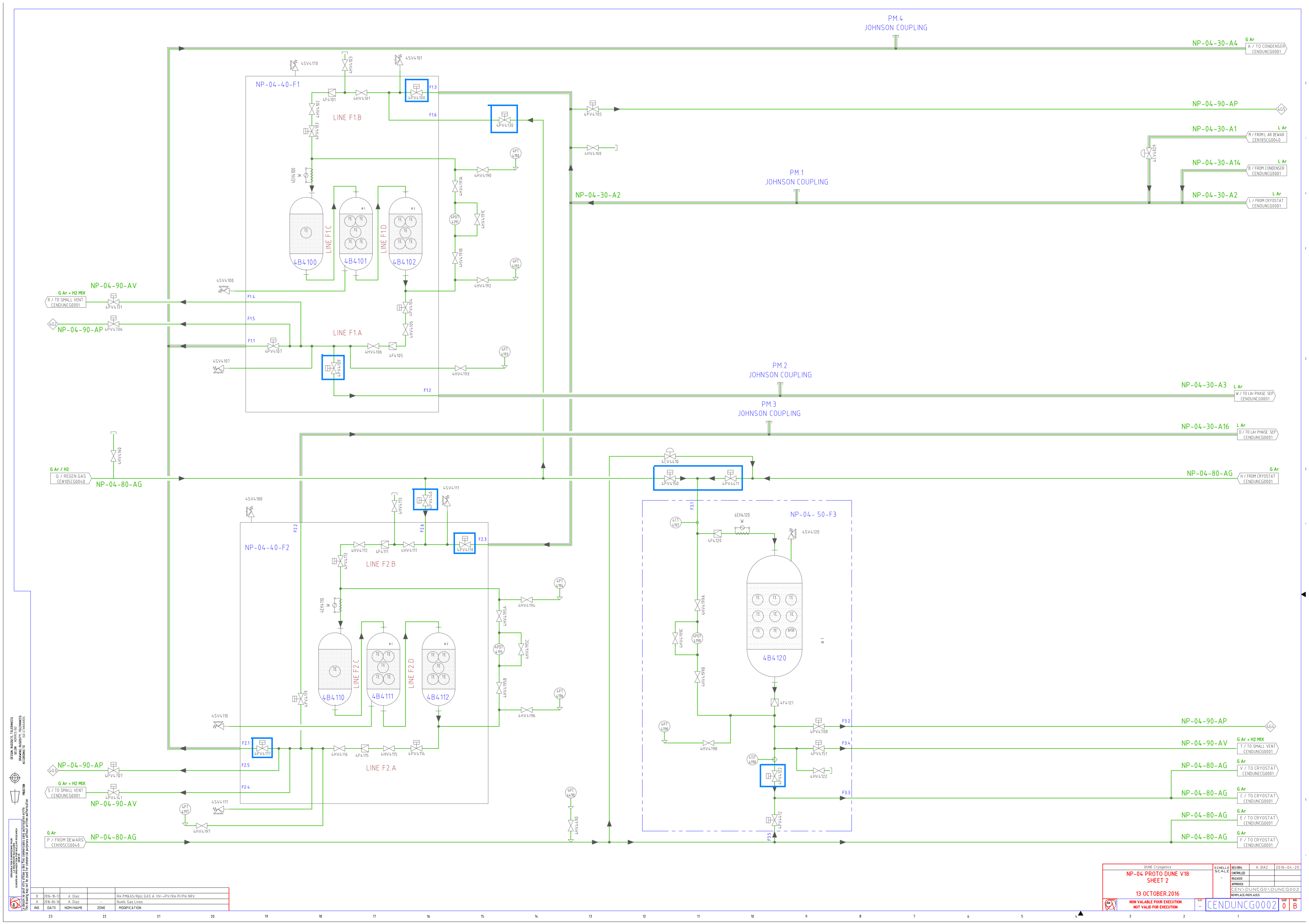
[magenta box] used only during purge

[red box] coarse temperature sensors **Question**: is this CERN's responsibility ?

PT = pressure transmitter
FT = flow transmitters
TE = temperature probe
CV = control valve
PDT = differential pressure transmitter



NP-04-10-N2
NP-04-10-N3
NP-04-10-N1
NP-04-40-CA
LINE CA.A
LINE CA.B
LINE CA.C
LINE CA.D
LINE CA.E
LINE CA.F
4B4300
CRYOSTAT HEAT EXCHANGER
NP-04-60-NP
LINE NP.A
LINE NP.B
LINE NP.C
4B3100
LN2 PHASE SEPARATOR
NP-04-80-AG
NP-04-30-A8
NP-04-30-A12
NP-04-30-A0
NP-04-30-A4
NP-04-30-A14
NP-04-40-CU
LINE CU.A
LINE CU.B
NP-04-90-AV
NP-04-30-A3
NP-04-30-A16
NP-04-30-A11
NP-04-30-A13
NP-04-40-AP
LINE AP.A
LINE AP.B
LINE AP.C
LINE AP.D
LINE AP.E
4B4200
L Ar PHASE SEPARATOR
NP-04-30-A6
NP-04-30-A9
NP-04-30-A7
NP-04-30-A8
NP-04-90-AP
NP-04-80-IC
NP-04-30-A2
NP-04-30-A15
NP-04-40-CP
LINE CP.A
LINE CP.B
GAS ANALYZER
VENT LARGE
VENT SMALL
VENT INSULATION
BUBBLER
INSTRUMENTATION COLLECTION TABLE 1.0 FOR CRYOSTAT
CRYOSTAT NP-04
LIQUID DISTRIBUTION
GAS DISTRIBUTION
EXAMPLE OF FEED THRU
Purity Monitor 1
Purity Monitor 2
Purge only
Level meter
Temperature probes (coarse?) CERN?
DUNE Cryogenics
NP-04 PROTO DUNE V18
SHEET 1
13 OCTOBER 2016
NON VALABLE POUR EXECUTION
NOT VALID FOR EXECUTION
ECHELLE SCALE
DES/DRA. A. DIAZ 2016-04-20
CONTROLLED
RELEASED
APPROVED
CEN\DUNCG0\DUNCG001
REMPLACE/REPLACES
QAC
CENDUNCG0001
SIZE 0
IND. B

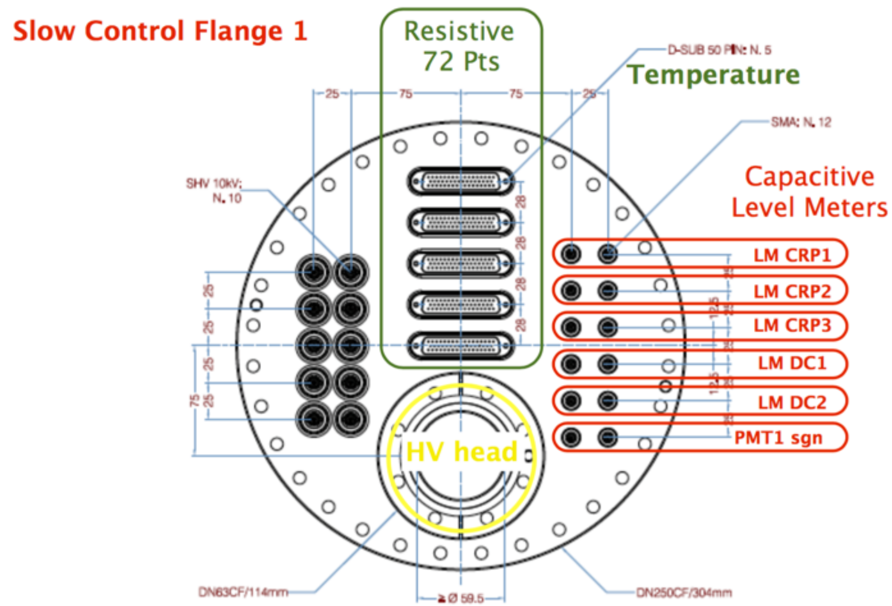


PM.4
JOHNSON COUPLING
NP-04-30-A4
G Ar
A / TO CONDENSER
CENDUNCG0001
NP-04-40-F1
LINE F1.B
LINE F1.C
LINE F1.D
LINE F1.A
4B4100
4B4101
4B4102
NP-04-90-AP
NP-04-30-A1
L Ar
NP-04-30-A14
B / FROM CONDENSER
NP-04-30-A2
L / FROM CRYOSTAT
PM.1
JOHNSON COUPLING
NP-04-90-AV
G Ar + H2 MIX
R / TO SMALL VENT
CENDUNCG0001
PM.2
JOHNSON COUPLING
NP-04-30-A3
PM.3
JOHNSON COUPLING
NP-04-30-A16
G Ar / H2
Q / REGEN GAS
NP-04-80-AG
H / FROM CRYOSTAT
NP-04-40-F2
LINE F2.B
LINE F2.C
LINE F2.D
LINE F2.A
4B4110
4B4111
4B4112
NP-04- 50-F3
4B4120
S / TO SMALL VENT
P / FROM DEWARS
T / TO SMALL VENT
V / TO CRYOSTAT
C / TO CRYOSTAT
E / TO CRYOSTAT
F / TO CRYOSTAT
DUNE Cryogenics
NP-04 PROTO DUNE V18
SHEET 2
13 OCTOBER.2016
ECHELLE SCALE
DES/DRA. A. DIAZ 2016-04-20
CONTROLLED
RELEASED
APPROVED
CEN\DUNCG0\DUNCG002
REMPLACE/REPLACES
NON VALABLE POUR EXECUTION
NOT VALID FOR EXECUTION
QAC -
CENDUNCG0002
SIZE 0
IND. B

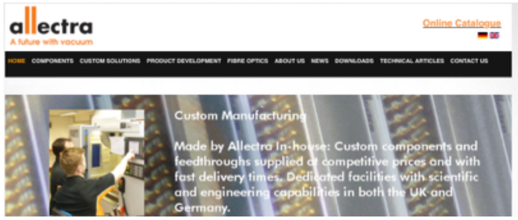
Flanges

- Our flanges are not the same as DP:
  - We don't need: SHV, SMA, USB, HV head
  - We need mainly DSUB-50 (T-sensors and cameras) and something for LED power
- T-gradient monitor(s) will have its own flange (~6 DSUB-50 connectors)
- We should design our own flanges

ProtoDUNE-DP



Question: DP is considering these two companies. Any advice in this respect ?



Next actions

- T-gradient monitors:
  - Number, precision, density of sensors, feedthroughs, calibration, …
- Other T sensors:
  - Number, location, mechanical supports, ….
- Pressure sensors
- Feedthroughs and flanges
  - We know the available ports, converge on the ones we will use
  - Complete as soon as possible the list of connectors we will need in the flanges

backup

Item	Cryostat port		Connector		Comments
	Name	ID	Type	Number	
Cathode HV	HV FT	3.1			
Beam Plug					
Corona Monitors	Outside				
APA, FC, ED bias	Signal FTs	2.2, 2.3, 2.4 2.6, 2.7, 2.8			
APA electronics					
PD sensors	Signal FTs	2.2, 2.3, 2.4 2.6, 2.7, 2.8			
PD electronics					
PD calibration					
Outer Veto HV	outside				
Outer Veto LV					
Purity Monitors	NE Manhole	4.1			
T-gradient monitor	spare cryo	2.6	DSUB-50	6	4 pins/sensor. 70 sensors
Other T sensors	Slow Control	?	DSUB-50		all in the same FT ?
Pressure sensors	Slow Control	?			
Level meters	cryo	?			
Cameras	Slow Control	?	DSUB-50	2-3	
LEDs	Slow Control	?	AMPHEMOL MDC 10 pins		