Interface Control Document

TPC

Prepared by	*Signature*
A. Bellerive, **P. Colas,** **R. Diener,** **K. Fujii,** **L. Jönsen,** **J. Kaminski,** **P. Kluit,** **V. Prahl,** **H. Qi,** **R. Settles,** **A. Sugiyama,** **D. Tsionou,….**	

Accepted by	*Signature*
Xx TPC integration officer	

Approved by	*Function*	*Date*	*Signature*
Paul Colas, **Akira Sugiyama**	ILD TPC conveners	Xx/xx/xx	

Summary	The TPC interfaces to SiECAL, SET, SIT and VDET are described. After a light description of the TPC, this document provides detailed information on the matters which concerns interactions or possible conflicts with other subdetectors: space occupation, power flow, matter budget, vibrations, support. Many of the issues are not decided yet. This document also lists several solutions and options to be studied.
Annexes	

Document Change Record				
Edition	**Revision**	**Date**	**Modified pages**	**Observations**
0	**0**	**2017/09/12**		

1	**0**	**2017/10/04**		
2	**0**	**2017/10/11**		

Distribution	***See Distribution list at the end of this document***

Template V1.0

- Table of Contents -

1. INTRODUCTION

1.1. Scope of the document

The purpose of this version of the document is first to assemble all elements that may be relevant for the TPC. The document doesn't claim however neither exactness nor completeness at this stage. Unless explicitly mentioned, this document does not address software interfaces.

Very preliminary

1.2. Applicable Documents (AD)

Applicable Documents (AD)			
AD	**Title**	**Reference**	**Version**
DBD	ILD DBD	arxiv: 1306.6329	v1
XML 2017	Change in size and small option		
ICD	ILD Conventions and Rules		

1.3. Reference Documents (RD)

Reference Documents (RD)			
RD	**Title**	**Reference**	**Version**
TDD	TPC Technical Document (to be written)		

1.4. Details of change to the previous design

Indicate (if necessary) the changes compared with the previous version of design. This section may become obsolete but since the reference of the document is the DBD and there are unavoidable changes since then we would like to record them here

- In order to study performance vs cost effects, a small ILD model has been established. One of the changes on this model is the change of the TPC outer radius from 1808 mm to 1460 mm.

- Due to the increase of the SiEcal thickness from 185 mm to 223 mm, the TPC barrel (ie outer radius) was decreased to 1426.8 mm in order to compensate for that effect.

- One additional change concerns the material budget of the wall. Even though in the DBD it is mentioned that the field cage material for the inner and outer wall are respectively 1% and 3%, in the DD4HEP model it was initially 0.9% for both walls. This has now been altered and the material budget for the inner and outer field cage walls are 0.9% and 2.7% respectively.

1.5. List of abbreviations

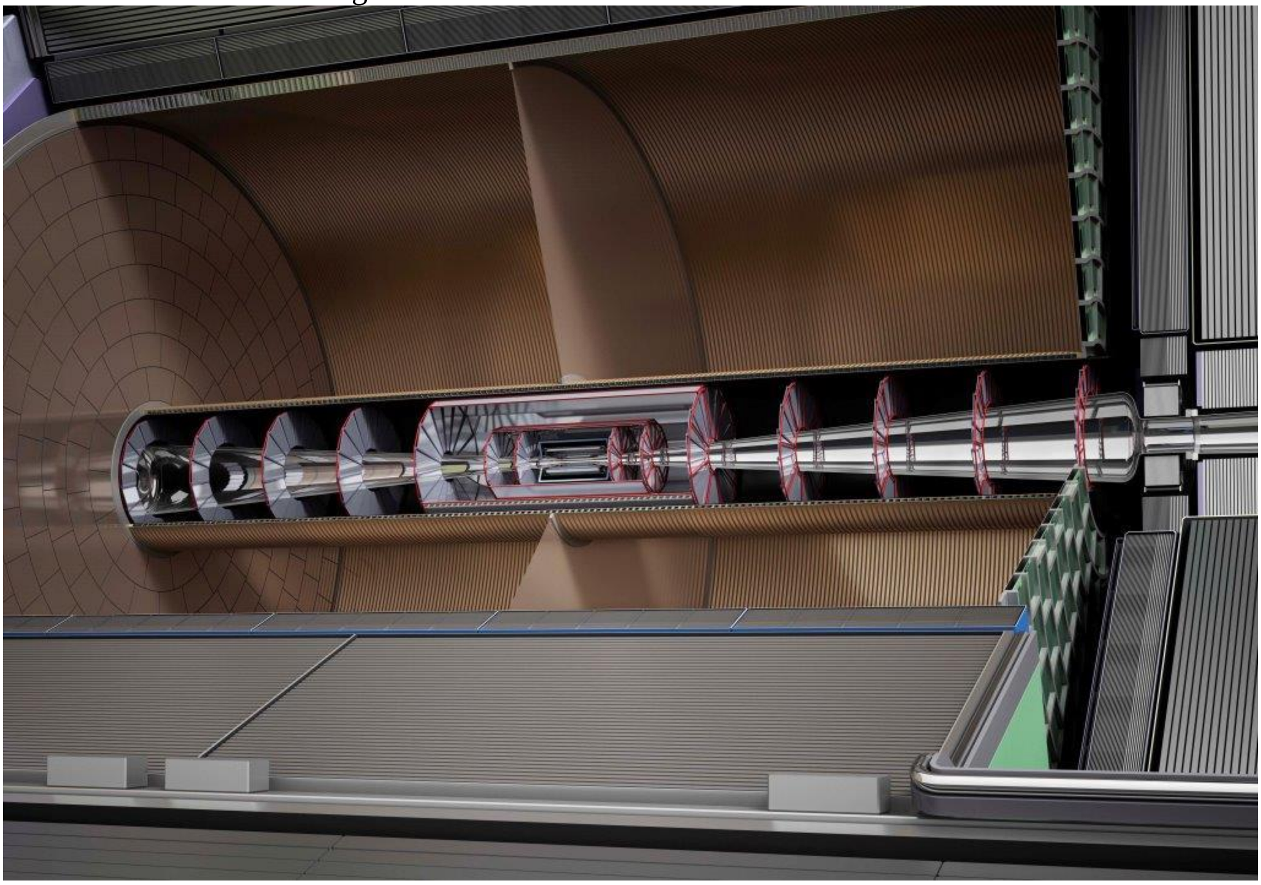
List of Abbreviations			
ISS	Internal Support Structure	**VHV**	Very High Voltage (Cathode polarization)
FC	Field Cage		
LV	Low voltage		
HV	High voltage for detectors		

1.6. Nomenclature

Nomenclature			
Module	Module with its electronics	**Field Cage**	Gas-tight double cylinder equipped with a voltage degrader to insure a uniform electric field (figure)
Web	The support of the endcap detector modules	**Patch panel**	Panel to receive cables/fibres from the detectors and to the concentrators, and from the HV and LV supplies to the detectors
Membrane	Thin metallized film stretched in the middle of the field cage to serve as a cathode for the drift electric field	**Endplate**	Readout device closing the gaseous chamber at both ends, composed of modules supported by a web
Ribbon	Carbon Fibre (or metal) part mechanically connecting the TPC to its support (coil or HCAL)		

2. GENERAL DESCRIPTION OF SUBSYSTEM

The TPC is a gas-tight vessel at atmospheric pressure closed by 2 endplates carrying the detector modules. A Technical Design Document will describe it in more detail.



Several options are retained during the R&D and costing periods. The baseline radius, and a reduced radius (so-called 'small' option). The segmentation of the baseline option can be in 4 or 8 "wheels" depending on how large can be the modules, and 3 to 6 wheels for the small option. For the time being, the baseline is with 8 wheels, as this corresponds to module sizes comparable to those tested so far during the R&D phase. Several technologies are under study : Micromegas with a resistive anode, GEM and digital pixels.

3. GENERAL INTERFACE DESCRIPTION

The following items are considered:
Dimensions
Mechanical interface: support of the TPC and support of the ISS by the TPC.
Matter obstruction for the calorimeter (thickness of the FC)
Services (cooling, LV and HV supplies, signal)
Very High Voltage for the field cage.
Gas for the TPC.

4. MECHANICAL INTERFACE

4.1 Coordinate system

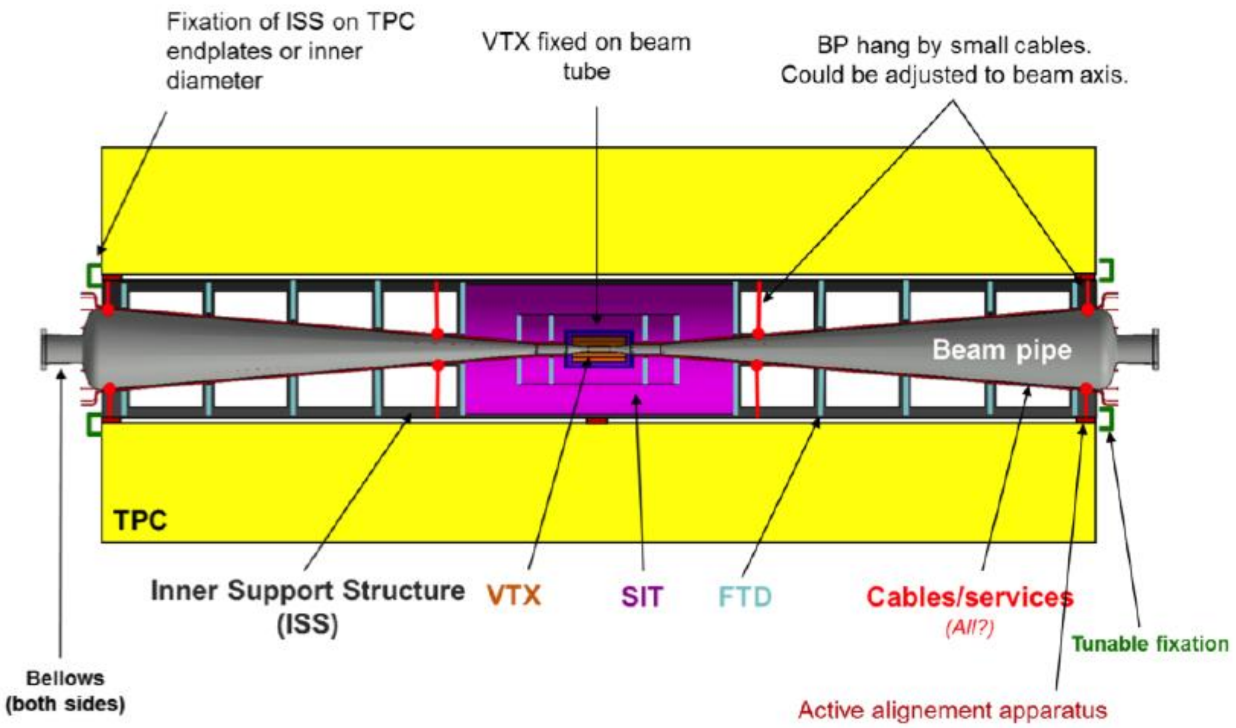
The coordinate system is defined on the 'confluence' site. Two systems of local coordinates are used to positions items in a module:

- a simple Cartesian system (*x*,*y*) with the origin in the center of the module: the *y* axis divides the module symmetrically in two and the *x* axis is the tangent to the circle centered on the beam and passing by the middle of the *y* segment extending from the inner to the outer boarder of the module.
- a polar system (r,ϕ) with r the distance from the beam axis and ϕ the angle with the *y* axis.

4.2 Mechanical concept

The TPC is made of two self-supporting cylinders (the inner and outer field cages) and two endplates bearing the detector modules. The matter used for the field cages is light and very robust.

The TPC is fastened to the HCAL structure or to the coil cryostat. Itself supports Inner Silicon Subdetectors and the vertex detector. (Fig. III-5.8 of DBD – Vol.4 of the ILC TDR 2013).



In both cases (HCAL or coil supporting) there can be 2 to 4 supports, which can be ribbons or bars, or thick plates. The mechanical structure of the ECAL is thought to be too light to bear the weight of the TPC and ISS (roughly 2 tons).

4.3 Critical dimensions.

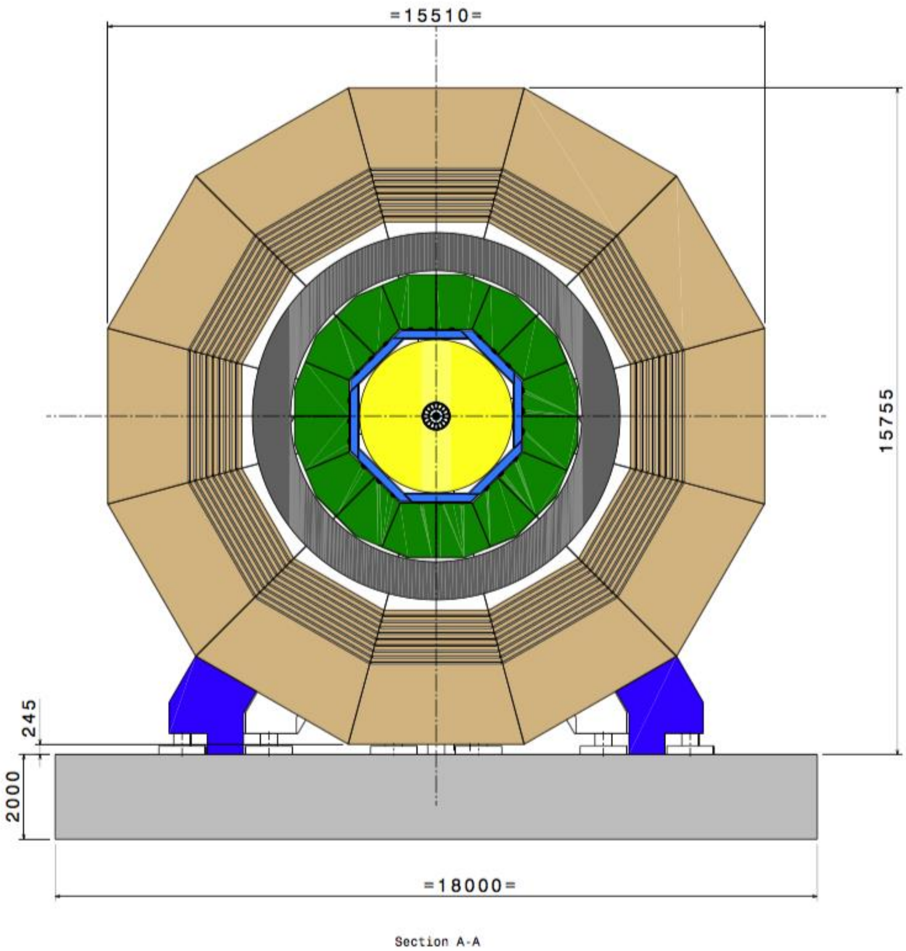
The bulk of the TPC is contained in a cylindrical bounding box of 53xx mm length and 17xx radius, with a bore of 3xx mm radius for the ISS and the vertex detector.

4.4 Weights

The total weight of the TPC with the ISS and its content is less than 2 tons. The FC weight is estimated to be 265 kg according to the Large Prototype design. The two webs are 350 kg each (this is for a 4-wheel design in Aluminum), and they carry each 45 kg of PCB. These add up to 1055 kg. Such a structure has been show to deform by less than 200 µm under its weight and an internal overpressure of 100 mbar.

4.5 Positioning and alignment constraints

The alignment of the TPC with respect to the internal trackers have been estimated in an ILD technical note 2016-001 : it has to be well below 10 µm. Such an accuracy can only be obtained by software. The initial mechanical alignment should be within 100 µm- 200µm, which is also the order of magnitude of the deformations under the weight and the inner overpressure of a few mbar.



So far there is no official design of the SET. It could be fasten to the TPC or to the ECAL.

5. ELECTRICAL INTERFACE

The guiding line for the TPC is to have as few connections to the outside world as possible. There will be one or a few HV and LV cables per module, and optical fibres for the signal and the electronics settings. To ease the separation of the detector from the supplies and concentrators, there will be patch panels on each side (A and B). Available space for such patch panels is represented in Fig.4 by grey 10x30 cm² rectangles.

5.1 Block diagram

Figure 1 shows a primitive block diagram for one column of SiEcal slabs (to be adapted to TPC)

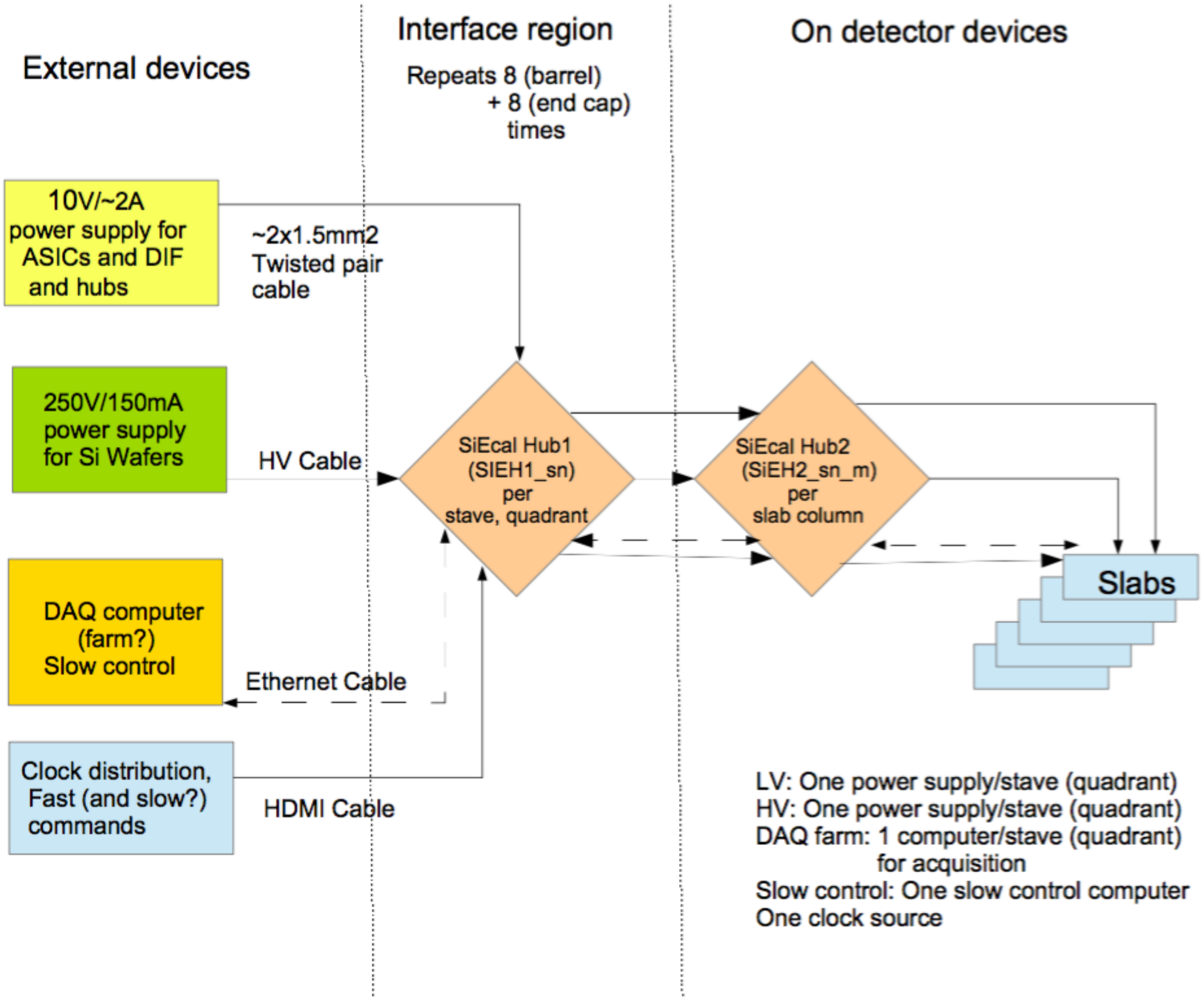


Figure 1 : Schematic view of power distribution and distribution and concentration of other relevant signals and data for one column of slabs.

The cables that arrive or leave from the patch panels have the following purpose:

- Low voltage power supply for the readout electronics and the powering of the active hubs
  - In going cables and their feedback sense
  - 5 V/few A power supply
  - Optical fiber for the signal
- High voltage power supply for the gating device
- High voltage power supply for the gaseous amplification
  - Standard “red” HV cables (fw 100 V, few nA, in going), or a thinner version.
- Optical fibers for data transmission and detector control
  - Out-going and in-going
- Clock distribution

In the following the interfaces are described:

- Power (the type of power [regulated, unregulated, heating-, number of lines for each type):
  At the patch panel the power arrives directly from supplies sitting in the electronics trailer, Low voltage (~5V, few A) for the operation of the readout system. The power should be adequately tuned to avoid useless dissipation in the regulators.
  High voltage (few 100V, few nA) for the gaseous amplification device (technology dependent)
- Remote control: control type (relays, digital ...), the number of each type of control:
  Layers will be switched off by remote control, in principle the layers should be part of a GPIB bus system of which the master card is integrated. Each master card receives commands via Ethernet. (to be corrected by a specialist)
- Insulation:
  Standard HV cables.
- Photoelectric laser source:
  Enlights the cathode with UVs to produce photoelectrons to study and monitor distortions
- Calibration laser:
  Provides a UV beam for alignment purposes
  Gas analysis
  P and T monitoring

For convenience the original instructions are listed below:
It should indicate all electrical interfaces, including redundancies:

- power: the type of power (regulated, unregulated, heating), number of lines for each type;
- remote control: control type (relays, digital ...), the number of each type of control
- insulation;

Other interfaces: clock, other instruments, ...

5.2 Connection diagram

For convenience the original instructions are listed below:
This is a general wiring diagram showing the names of cables, connectors, equipment, ...

5.3 List of Connectors

- USB type Connector
- Standard HV Connector
- Standard Ethernet Connector
- Standard HDMI Connector

For convenience the original instructions are listed below:
This is a general wiring diagram showing the names of cables, connectors, equipment, ...

For each connector on should indicate:

- The location (eg equipment A);
- the name of the connector;
- type (manufacturer's name + complete reference);
- the general function (eg power ...)
- coded pins, keying;
- the precise limits of the respective supplies;
- the principle of shield connections and grounding policy.

5.4 Cabling and connecting sheets

For every connector and every pin it will be specified:

- the signal type (analog, digital, power, RF, ...),
- the waveform (period, duty cycle, maximum value, minimum value)
- a graphical representation for complex signals (ramp, modulation ...),
- the category (transmitter or receiver)
- the reference of the pining of the connector,
- the electrical diagram of the interfaced circuit.

5.5 Electrical grounding scheme

A diagram will indicate how are connected or isolated mechanical grounds, shieldings ...
The maximum contact resistance will be defined.

5.6 Power Consumption

The principle of power pulsing implies that the currents at the ASICs and module cards are enabled with a duty cycle of 1%.

The total power consumption with the present electronic designs (assuming 1.5 10^6 channels per endplate) is 6 kW per endplate (about 4 mW per channel). This can be reduced by a factor of 50 to 100 if the duty cycle of 0.5% can allow switching off the electronics between bunch crossings. The decision to do so also involves assessment of the need to be able to take cosmic data, for alignments purposes, and consideration of possible mechanical effects of power switching within an intense magnetic field. The power dissipated by the electronics could be reduced by a factor of two by limiting the voltage supply. The gas amplification system consumption is negligible.

In the pixellised option, the consumption is as much as 50 kW per endplate. Then, a reduction by a factor of 50 should be possible, thanks to power pulsing, and the cooling system and the diphasic CO_2 cooling system should be able to extract the remaining kW.

Power will also be dissipated in the cables bringing the low voltage (25 A or 32 A copper cables, with 4 mm and 6 mm^2 section respectively). If it turns out to be the case, a solution might be studied by bringing the current at higher voltage and making use of DC-DC converters to obtain the operational voltage.

5.7 Other electrical interfaces

For the moment we use this section to describe what is inside the electronic trailer.

- HV power supplies
- 16 LV power supplies (type Lambda devices)

- Computer Farm (typically 16 DELL Poweredge),
- Connected to central storage of Central DAQ system for event building?
- Alternative direct SiECal data immediately to central DAQ system

For convenience the original instructions are listed below:
This section defines all other electrical interfaces (clock s, other instruments ...).

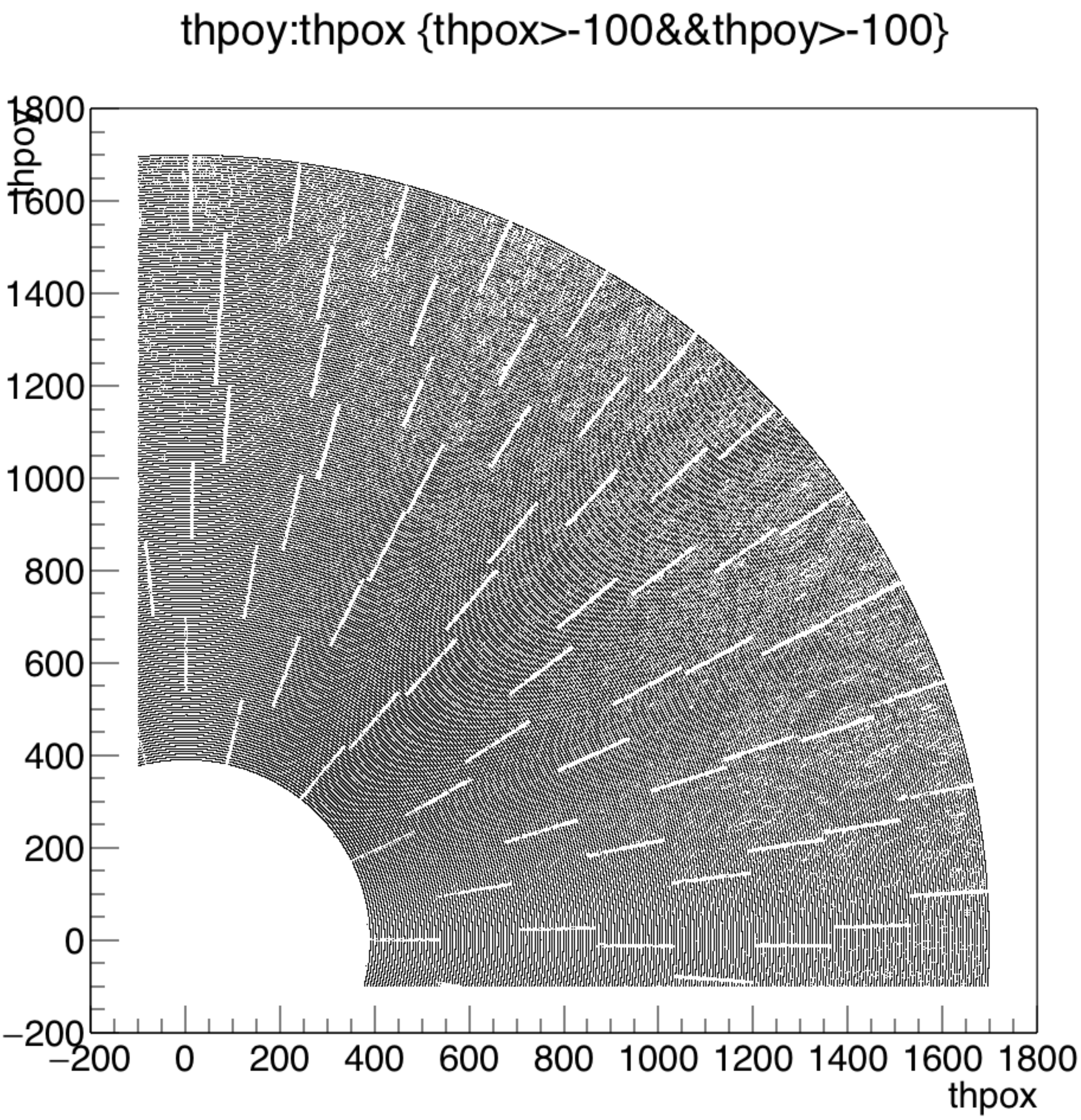


Figure 2. . Sketch of a TPC end plate	Figure 3. Sketch of the TPC sectors divided in 6 groups

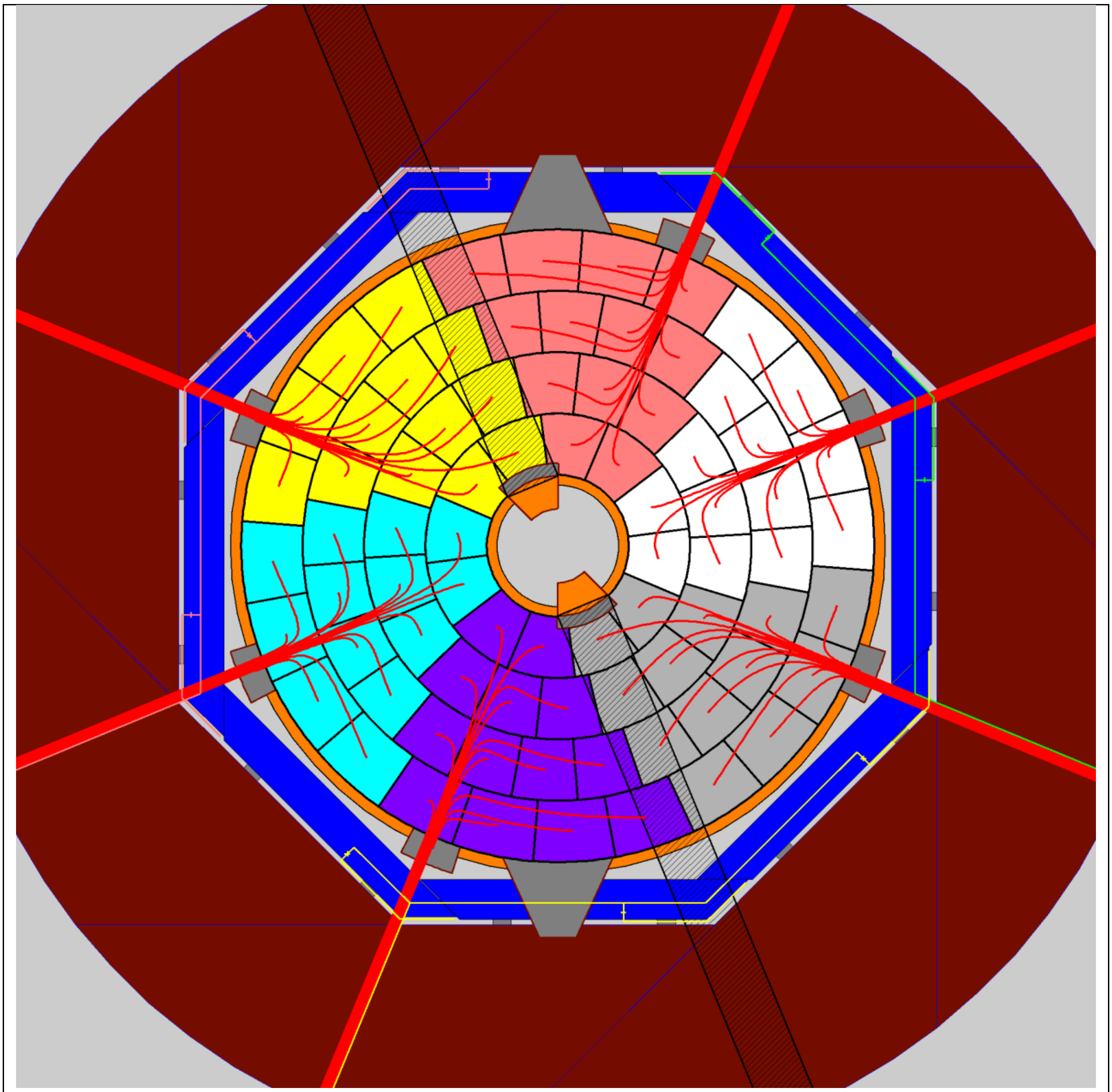


Figure 4. The TPC is shown hanging from the HCal. The ECal barrel is also represented with its rails.

6. FLUID INTERFACE

To avoid inhomogeneity of its properties, the temperature gradient has to be kept at a minimum, which implies taking the heat generated by the readout electronics while keeping the endplate at room temperature. For this, a 2-phase CO_2 cooling solution has been studied. The cooling fluid composed of co-existing gas and liquid CO_2 will be circulated in 2.5 mm diameter pipes in the modules (or the PCB will be equipped with microchannels), under a pressure of 50 to 100 bars. For instance, each endplate can be equipped by 6 loops, each 8 m long, with a 3.0 g/s mass flow of the

2-phase fluid. This allows 170 W to be removed per such loop. The diphasic fluid can be supplied by a 5 mm circular pipe around the endplate. The gaseous CO_2 can be collected from the 6 sextants by an 8-mm diameter circular pipe around the endplate.

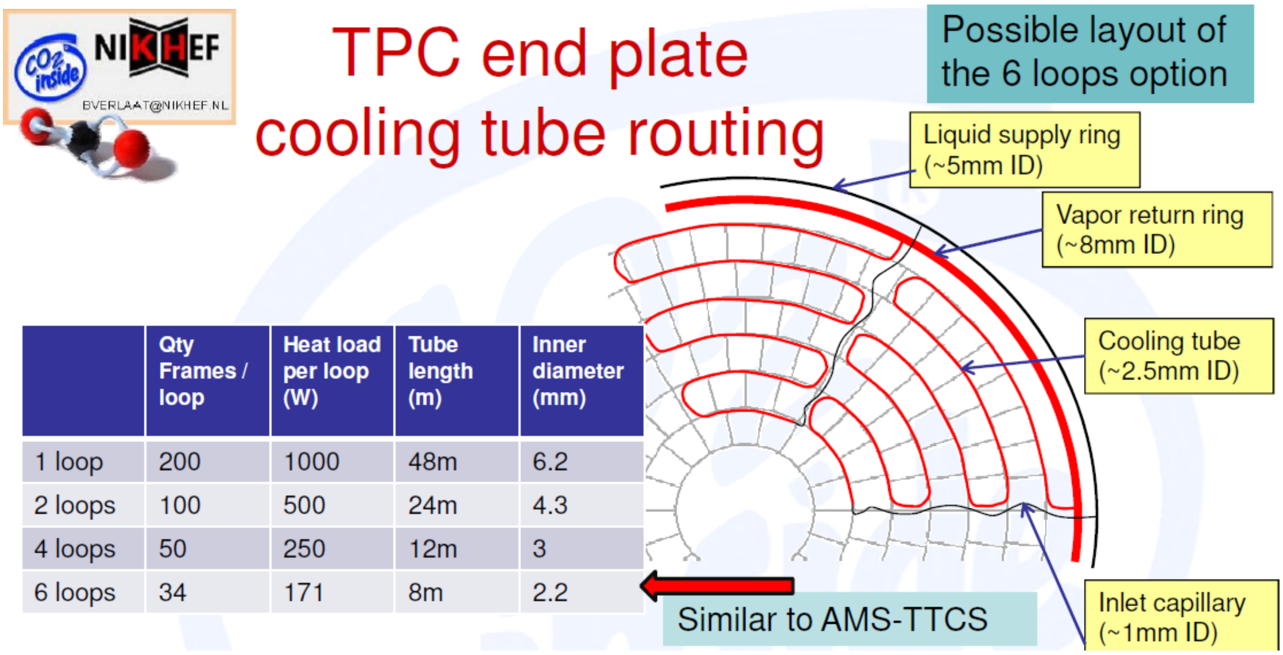
5.8 Gas system Interface

The detector gas mixture will be brought and expelled by 2 cm diameter pipes. The purity has to be kept at the 10^{-5} level to avoid electron capture during the drift. The 50 m3 volume has to be renewed every xxx days.

5.9 Cooling fluid system Interface

The information here and in Sec. 8 is extracted from a detailed study of the cooling system that is available under [xxx].

The TPC will be cooled by a diphasic CO2 system. A compressor is located outside *about 30 m off the beam axis of the ILD Detector* and the cooling fluid will be brought to and away from each endplate. From there it is further distributed to the individual modules by manifolds. Possibly several modules (maybe four?) can be served in series. Fig.xx shows the general concept of the cooling system.



	Qty Frames / loop	Heat load per loop (W)	Tube length (m)	Inner diameter (mm)
1 loop	200	1000	48m	6.2
2 loops	100	500	24m	4.3
4 loops	50	250	12m	3
6 loops	34	171	8m	2.2

7. THERMAL INTERFACE

For the subsystems:

- Thermal dissipation: in and out of operation

The TPC will evacuate all its produced heat by means of the cooling system. The only sources of heat dissipation are the cooling pipes in which CO2 will undergo phase transition from around 21°C to 22 °C.

- Limit temperatures: during standby mode, for switching power, in operation - 60 °C.

8. INTERFACES FOR DETECTOR TESTING

These are the specific interfaces related to the test equipment:

- MSE interfaces: mechanical assembly test ... ;
- ESE interfaces: electrical interfaces with the test and verification systems;
- OSE interfaces: reference cubes, or targets for the surveys ...

Here will be described the laser for calibration and for distortion measurements.

TO DO LIST

Actions	Who ?	When ?
Add photoelectric laser source and calibration laser (Section 8)	Huirong Qi	Week 41
Power dissipation in electronics and module weight; description of cables	Leif Jönsen	

DISTRIBUTION LIST

INTERNAL Distribution	EXTERNAL Distribution	
	Name	Laboratory