Outlook
of
R&D for the ILD TPC

LCTPC Review
by
the ECFA Detector R&D Panel
on 4 November 2013

Takeshi Matsuda and Ron Settles
on behalf of LCTPC collaboration

R&D for MPGD TPC
Before ILD DBD for ILC

We have demonstrated through the LP TPC beam tests at DESY:

(1) The basic performance of the MPGD TPCs, in particular, the pad readout options, satisfy the basic requirements for ILD TPC at ILC:

- **MWPC option ruled out,**
- **Micromegas option w/o resistive anode ruled out,**
- **The best possible spatial resolution understood by the analytic formula,**
- **Spatial resolutions by GEM-TPC and Micromegas TPC w/ resistive anode measured at 1T and extrapolated to 3.5T,**
- **Single-electron spatial resolution of the digital TPC measured, and,**
- **Extrapolation confirmed (< 60cm drift) at 4T in the DESY 5T magnet.**

(2) How to build important components of ILD TPC:

- **Thin field cage**
- **Light endplate (Al)**
- **MPGD TPC modules**
- **Experience of the operation of LP TPC**

R&D for MPGD TPC
After ILD DBD for ILC

There are, however, a few important basic issues still remain to be addressed before the detector proposal for ILC

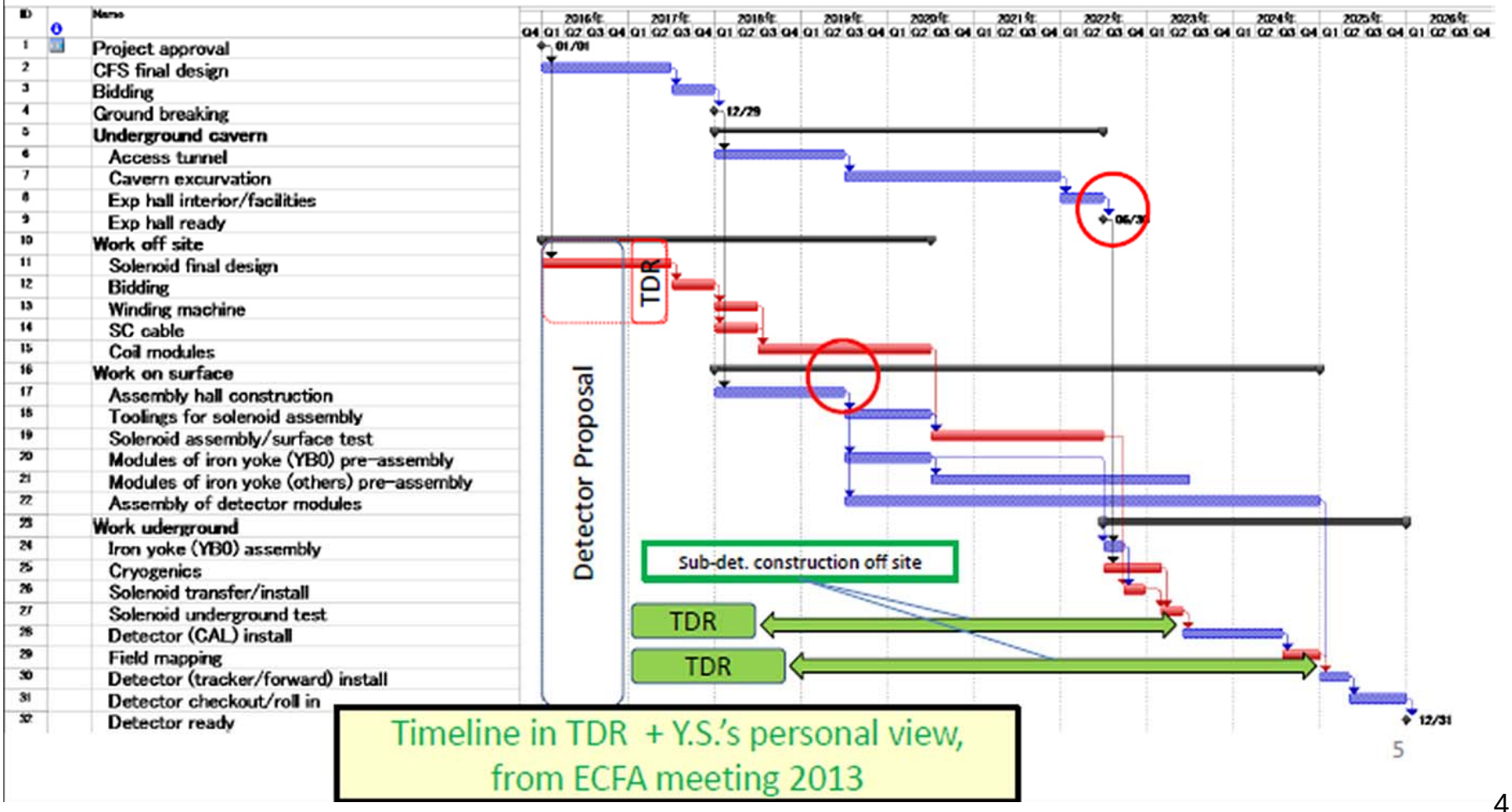
Otherwise, we are entering the phase toward the final design of the ILD TPC.

The earliest schedule (next slide) of the construction of ILD detector shown in the ILD meeting at Cracow (Sept 2013) looks very tight though it may deeply depend on the political situation.

A Possible Schedule of ILC in Japan

As presented in the 2013 ILD meeting in Cracow

- We cannot predict the project approval date, but we should draw a clear timeline after the project approval



Remaining R&D Issues

Before entering the engineering design of ILD TPC, we still need to study the following issues:

A) Ion gate: the most urgent issue,

B) Some issues with MPGD technologies and MPGD modules,

C) Local distortions of MPGD modules,

D) Demonstration of power pulsing (with the SALTRO16 electronics)

E) Cooling of readout electronics and temperature control of TPC

F) Measurement of basic parameters and demonstration of the performance of MPGD TPC in 3.5T magnetic field. Also some engineering issues to be confirmed in the high magnetic field.

Remaining Issues

Ion Gate: The most urgent issue

We need a ion gate: **To prevent the backflow of positive ions from the gas amplification region of the MPGD modules to the drift space of TPC. Distortions by the primary ions at ILC are still negligible.**

Options of ion gate:

GEM gate:	**Tested with the electron transmission of 50%.** **Electron transmission: Can be higher toward at least >70%?** **Mechanically most friendly to the current MPGD modules.**
Traditional wire gate:	**Known to work with high electron transmission (LEP etc.),** **Distortion due to the radial wires?** **Mechanical issue to mount on the MPGD module.**
Wire mesh or grid:	**A solution never be tested.** **One with high ion suppression?** **Mechanical issue to mount on the MPGD module.**

It is urgent **Need to select one option (by early 2015) to beam test new modules with the gate before TDR (2017-2018).**

R&D for GEM gate with electron transmission >70% underway.
Measurement of the distortion due to the radial wires (by a laser beam) planned.
Design of module structure with a gate (in particular, the wire gates) needed.

Remaining Issues

MPGD technologies and MPGD modules

Micromegas module w/ resistive anode: Possible signal pileup in the resistive anode at the ILC environment ?

We need a confirmation by simulation that the performance of the Micrormegas with the resistive anode would not be deteriorated by the signal pile up in the resistive anode in the ILC environment. The real charges of Micromegas spread in the resistive anode toward the sides of the resistive anode with some time delays. When many hits, the pads see induced charge of the sum of the current. The pile up depends how the induced signals of different origins might overlap each other in "one event frame" of TPC (typically in the order of 1 μs).

GEM modules: Are the current modules reliable enough for the ILD TPC?

HV connections to GEMs, GEM stretching, Micro discharge of GEM,,,

InGrid module: An early transition to Timepix 3 necessary.

Need a module design for ILD TPC with all through-silicon holes to remove all the wire bonding around the InGrid chips, the origin of dead space and distortion.

For all modules: A design with the gate!

Remaining Issues
Local Distortion

All current LP modules see large distortions; The old TPC problem in the new regime.

We need to minimize the distortions in the hardware level, and, then correct remaining distortions by software.

(1) Distortions due to specific module structures

Micromegas module:	**Grounded guard structure around the module** **To be modified only in next module.**
Asia GEM module:	**Large gaps of the segmented electrodes on the top surface of GEM (a simple mistake with a fear for GEM breakdown)**

(2) Distortions at the module boundary and the 1mm gap:

E-field calculation and simulation can suggest solutions to reduce the distortion.
Confirm the solutions by beam tests or laser- beam tests.

(3) Develop software to correct remaining distortion after (1) and (2)

Some deterioration of the spatial resolution will remain after the correction.

Remaining Issues

Cooling and Temperature Control of TPC endplate

Two phase CO2 (2PCO2) cooling for ILD TPC endplates:

Installing readout electronics directly on the MPGD module while we keep the pad plane of the module at a given TPC temperature. The temperature control of the pad plane of the module and a proper cooling of electronics become important. 2PCO2 cooling has advantages of constant temperature and high pressure and compact cooling circuit.

(1) Set up two small 2PCO2 cooling units for test at KEK and DESY (currently at NIKHEF) in the beginning of 2014.

(2) The first cooling test of the T2K electronics on the Micromegas module soon. Mock up tests for the S-ALTRO16 electronics in early 2014.

Thermal design of the whole ILD TPC :

ILD TPC design has no thermal jackets on the field cages to minimize the material budget. Addressed in the final design of ILD TPC.

Remaining Issues

Power pulsing and power delivery

Need power pulsing even for low readout electronics at ILD TPC:

(1) Power pulsing of SALTRO16 chip has been demonstrated in the chip test. The reduction factor expected for the ILC bunch structure was around 30.
(2) Power pulsing in LP TPC beam test by SALTRO16 electronics is foreseen.

The power delivery issue has not been addressed so far:

Should be studied together in the design of the final readout electronics for the ILD TPC.

Remaining Issues

Demonstrations in the 3.5T magnetic field

Tests in the 3.5T magnetic field:

(1) Confirmation of performance of MPGD TPC and ion gates,
(2) Measurements of basic parameters of TPC gas, and ,
(3) Engineering issues such as possible mechanical vibration due to the power pulsing .

The problem: A high field solenoid need to be found!

The DESY 5T magnet (KOMAG) has been dismantled from the new He line at DESY for some time. We need either to revive the 5T magnet (by moving it to one of our institutes or by a modification), or to find another high field magnet available for us. With our limited human resource, very preferable to set it up in one of our institutes. A solenoid is preferred.

Remaining Issues

Optimization of ILD TPC

Optimization of the ILD detector in coming few years:

Some specific issues for TPC such as dE/dX performance which we have not addressed very well both in measurement and simulation.

Final specification of ILD TPC before prioritization of different MPGD technologies in TDR:

The final design of the ILD TPC will be given in TDR in 4 - 5 years. We review our specification of the ILD TPC, based on the results and experience from the LP beam tests. It includes pad size, module size, TPC gas, in particular, in the context of the neutron background, Specifications of TPC readout electronics, calibration and operation of ILD TPC, etc. We need to fully utilize our simulation tool for the optimization.

Toward the Final Design of ILD TPC

Readout Electronics

Our history of TPC readout electronics:

ALEPH electronics (for some small prototype tests)
T2K electronics (for LP TPC)
PCA16 + ALTRO electronics (for LP TPC)
SALTRO16 electronics (for LP TPC)
GdSP? (for ILD TPC)

SALTRO16 chip: ***The first analog-digital integrated chip for low noise application satisfies our specification except the packing density and power consumption (ADC).***

Besides, its hard-wired digital processing not optimized for the MPGD TPC, and the SALTRO development team has been resolved.

***GdSP*: New development for a high-density (> 64 ch/chip), lower power chip as the successor of the SALTRO. Situation not very clear now. Need to establish our own group of experts and significant budget urgently.**

Schedule: **With the rapid development of technology and our limited resource, may be realistic to start development after establishment of ILC Lab (in 2017, or, 9 years before the installation of ILD TPC in ILD detector).**

Toward the Final Design of ILD TPC

Field cage, endplates and all

R&Ds in LP TPC so far:

Construction of the light and thin field cages for the LP TPC
Construction of the two types of Al endplates for the LP TPC
Some simulation study for the field cage and the Al endplate for ILD TPC
Some study of the TPC support.
Thin central cathode (in prep.)
Tool for the installation of LP module (in prep.)
Laser beam calibration (in prep.)

Many details of the ILD TPC still to be studied for TDR:

Details of mechanical design of ILD TPC and its support,
Design of a support structure for the outer silicon detector on the outer field cage
Structures inside the field cage:
- **Details of the central cathode electrode and its HV supply, Resistor chains with a cooling and shielding etc.**

Thermal design of ILD TPC
Monitoring system
Measures for earthquakes in Japan

We need to activate and enlarge our mechanical group asap.

Toward the Final Design of ILD TPC

Software

So far:

Software packages for the LP beam test with its core package Marlin TPC for reconstruction of TPC tracks and analysis with tools necessary for the data analysis at LP TPC.

Study of the local distortions has been made using CST™ and Garfield++.

In coming few years: need to perform more simulation

Implementation of the resistive anode,
Tracking code for the digital TPC,
More studies of local distortion and its correction,
Simulation studies for the optimization,
Update of background including the neutrons,
Design and methods of TPC calibrations,
Demonstration of actual track reconstruction of events in one full bunch train
,,,,,,

What is missing here is not ideas, but human resource for simulation!

Toward the Final Design of ILD TPC

The earliest timeline?

2014-15	R&D on ion gates and a decision on the ion gate:
2015-17	Beam tests of new LP modules with the gate
2017	Prioritization of the MPGD technology and module
2017(*)	ILC LAB & ILD detector proposal
2017-19	Final design of the readout electronics for ILD TPC and its verifications
	Design of ILD TPC
2018-19(*)	TDR for the ILD tracking system:
2019-23	Prototyping and production: Electronics (chips→boards)
	Prototyping and production: Modules
	Production: Field cage/endplate and all others
	All others
2024-25	TPC integration and test
2026(*)	TPC Installation into the ILD detector
2027	ILC commissioning

(*) In this slide we delayed by one year the ILD-ILC schedule shown at the ILD meeting at Cracow (Sept 2013) to be a bit more realistic.

Conclusions

Through the LP TPC beam tests at DESY, we have demonstrated that the basic performance of the MPGD TPCs, in particular, the pad readout options, satisfy the basic requirements for ILC (ILD) TPC.

It was there demonstrated how to build some major components of the ILD TPC such as the MPGD modules, the thin field cage and the light Al endplates. We have accumulated experiences of the operation of MPGD TPC.

However, still some issues remain to be addressed in coming few years before the detector proposal for ILC.

The schedule of ILC in Japan and ILD detector (presented in the 2013 ILD group meeting at Cracow) is very tight, while the available resource available for the LC TPC collaboration and the ILD group has been very much limited.

The LC TPC collaboration needs to make its best effort to recruit new members. Even though it would not be easy before ILC in Japan is approved officially.