20130607

Addendum 2013 to the LCTPC MOA: R&D following the DBD, preparing for the LC

Overview

The LCTPC Memorandum of Agreement (MOA), the groups which have signed it and the yearly Addenda are available at http://www.lctpc.org/e9/e56939/. Evolution of the collaboration, of the work-package structure and of responsible persons are updated in the yearly Addenda.

1 2013 Activities

As described in the MOA, the R&D preparation of the LCTPC is proceeding in three phases: **1**-Small Prototypes, **2**-Large Prototypes and **3**-Design. Presently the work is mainly in phase **2**, and may pass soon to phase **3** (Section 1.2).

1.1 The ILD LOI and the DBD

The validation of the ILD Letter of Intent (LOI) in 2009 by the International Detector Advisory Group and GDE Research Director was accompanied by the charge that ILD should "demonstrate a feasible solution at the end of the Technical Design Report (TDR) phase of the accelerator". The TDR of the accelerator and the Detailed Baseline Design (DBD) document of the detector have been submitted (in early 2013). The DBD is included in the 'ILC Technical Design Report', encompassing both machine and detectors; the ILD part (new format and missing 'common section') may be downloaded from
https://svnsrv.desy.de/baswebsvn/wsvn/General.ilddbd/trunk/ilddbd/ILD-master.pdf,
user = ILDReader@desy.de, password = ilddbd!

1.2 The LC

Since the start of the offical collaboration between the ILC (0.2 - 1.0 TeV with superconducting cavities) and CLIC (1.4 - 3.0 TeV with two-beam technology), the LCTPC Collaboration has been preparing a TPC for the generic e^+e^- linear collider (LC). The LCTPC concept already allows for higher energies so that no change is needed in the organizational structure; the parameters of a TPC for ILC are somewhat different from those for CLIC.

Recent efforts are underway to have the superconducting linear collider ILC built in Japan. It is envisaged to be realized in two or more stages: first stage, the 250 GeV machine (Higgs' precision measurements), followed by an extension to 500 GeV (top, Higgs' and other precision studies), and finally by an upgrade to ca. 1000 GeV. (Progress is regularly reported in the 'LC Newsline' http://newsline.linearcollider.org.)

In addition, a new leadership arrangement and collaboration, the oversight committee 'Linear Collider Board' and the international 'Linear Collider Collaboration' (LCB and LCC, see the LC Newsline), will replace the structure set up by International Linear Collider Steering Committee several years ago and guide the construction of the ILC.

Thus, with the DBD finished, the ILC happenings in Japan and the LCB/LCC appointments, a turning point in the LCTPC planning is starting.

2 Responsibilites 2013

Present groups and **CB members** are listed next.

2.1 Collaboration Board (CB) – Table 1

–Americas–	
Carleton/Triumf:	**Madhu Dixit**
Carleton U:	**Alain Bellerive**
Montreal?:	**Jean-Pierre Martin?**
Victoria:	**Dean Karlen**
BNL:	**Alexei Lebedev**
Cornell:	**Dan Peterson**
Indiana:	**Rick Van Kooten**
LBNL?:	**Dave Nygren?**
–Asia———-	
Tsinghua:	**Yuanning Gao**
Saha Kolkata:	**Supratik Mukhopadhyay**
Hiroshima?	**Tohru Takahashi?**
KEK	**Keisuke Fujii**
Kinki	**Yukihiro Kato**
Saga	**Akira Sugiyama**
Kogakuin	**Takashi Watanabe**
Nagasaki Inst AS	**Takahiro Fusayasu**
Tokyo U A & T	**Osamu Nitoh**
U Tokyo?	**Sachio Komamiya?**
–Europe———-	
Inter U Inst for HEP(ULB-VUB):	**Gilles De Lentdecker**
CEA Saclay:	**Paul Colas**
Aachen:	**Stefan Roth**
Bonn:	**Jochen Kaminski/Klaus Desch**
DESY/HH:	**Ties Behnke**
Freiburg?:	**Andreas Bamberger/Markus Schumacher?**
Kiev:	**Oleg Bezshyyko**
MPI-Munich:	**Ron Settles**
Rostock:	**Oliver Schaefer**
Siegen:	**Ivor Fleck**
Nikhef:	**Jan Timmermans**
Novosibirsk:	**Alexei Buzulutskov**
Lund:	**Leif Jönsson**
CERN:	**Michael Hauschild/Lucie Linsen**

Note that missing MOA signatures are marked by "**?**" above. These groups can be moved to 'observers' (next section) if they do not wish to sign. It would be helpful if they could decide by the end of 2013, since a turning point in the LCTPC planning will accompany the developments in Japan (Section 1.2).

2.2 Observers

'Oberservers' are groups or persons that could not sign the MOA but want to be informed as to the progress, thus are included in the lctpc mailing list:
Iowa State, MIT, Purdue, Yale, Louisiana Tech, JAX Kanagawa, Mindanao, LAL Orsay/IPN Orsay, TU Munich, Karlsruhe, UMM Krakow, Bucharest, St.Petersburg.

2.3 New groups

The LCTPC collaboration (http://www.lctpc.org) is open to all, and a group (including Observers) wishing to join should contact us.

3 Further LCTPC Collaboration Information

3.1 Regional Coordinators (RC)

The RCs for 2007-2011, after selection of candidates by search committees in each region, were elected by the CB members of the respective region for a two-year period. They are
–Americas: **Dean Karlen** in 2007-10 and
Alain Bellerive in 2011-13.
–Asia: **Takeshi Matsuda** in 2007-09 and
Akira Sugiyama in 2010-13.
–Europe: **Ron Settles** (who requested to continue for only one year) in 2007,
Jan Timmermans in 2008-11 and
Jochen Kaminski in 2012-13.

RCs and emeritus RCs will be exofficio members of RC and CB meetings.

Spokesperson selection: The RCs decided not to have a predetermined rotation of RCs as their chairperson and spokesperson for the collaboration; he/she will be chosen by the RCs once per year. Ron Settles had this function in 2007, and Jan Timmermans was voted as Chairperson/Spokesperson for 2008-11. Jochen Kaminski was chosen by the RCs as the Spokesperson for 2012-13.

3.1.1 CB Chair

In 2009, the Collaboration Board decided that each year it will appoint one member to chair its meetings. Leif Jönsson agreed to chair the CB meetings in 2012-13.

3.1.2 Editorial Board

The editorial board set up in 2011 is made up of: Alain Bellerive, Ties Behnke, Keisuke Fujii, Leif Jönsson, Dean Karlen, Takeshi Matsuda, Dan Peterson, Ron Settles, Akira Sugyama and Jan Timmermans.

3.1.3 Speakers Bureau

The speakers bureau formed in 2008 to monitor the Large Prototype talks at major conferences is made up of: the three regional coordinators – Jochen Kaminski, Akira Sugiyama and Alain Bellerive – and one additional person per region – Jan Timmermans, Yulan Li and Dan Peterson – in 2011-12. Dan Peterson chaired the meetings in 2012. Allain Bellerive has agreed to chair the meetings for one year starting mid-2013.

3.2 Technical Board (TB)

There are four original workpackages in the MOA (WP(1)-WP(4)) which were supplemented by a fifth workpackage WP(5) in 2010 to prepare for the DBD; with the DBD finished, WP(5) will now oversee the R&D and is being reorganized this year. The workpackages have bi-weekly meetings convened by the collaboration spokesperson Jochen Kaminski. In addition, there is a monthly 'analysis meeting' chaired by Paul Colas.

The **TB members** are the conveners for the workpackages.

Table 2

Workpackage	Groups involved **Convener**
Workpackage(0) TPC R&D Program	LCTPC collaboration
Workpackage(1) Mechanics	
a) LP endplate structure, design	Bonn,Cornell,Desy/HH,JapaneseGroups,MPI,Saclay **Dan Peterson**
b) Fieldcage, laser, gas	BNL,Desy/HH **Ties Behnke**
c) GEM panels for endplate	Bonn,Cornell,Desy/HH,JapaneseGroups,Tsinghua **Akira Sugiyama**
d) Micromegas panels for endplate	Carleton,Cornell,SahaKolkata,Saclay **Paul Colas**
e) Pixel panels for endplate	Bonn,Freiburg,Nikhef,Saclay **Jan Timmermans**
f) Resistive anode for endplate	Carleton,SahaKolkata,Saclay **Madhu Dixit**
Workpackage(2) Electronics	
a) Standard RO for the LP	Brussels,Cern,Desy/HH,Lund **Leif Jönsson**
b) CMOS RO electronics	Bonn,Nikhef,Saclay **Harry van der Graaf**
c) Standard electronics for LCTPC	Brussels,Cern,Desy/HH,Lund, JapaneseGroups,Tsinghua 2010 **Luciano Musa**

Workpackage(3) Software	
a) LP software/simulation/reconstruction	Bonn,Cern,Desy/HH,Victoria, **Astrid Muennich**
b) LP DAQ	Brussels,Lund **Gilles De Lentdecker**
c) LCTPC performance/backgrounds	Bonn,Carleton,Cern,Desy/HH,JapaneseGroups **Keisuke Fujii**

Workpackage(4) Calibration	
a) Field map for the LP	Cern,Desy/HH **Lucie Linsen**
b) Alignment	Cornell,Cern,Desy/HH,JapaneseGroups **Takeshi Matsuda**
c) Distortion correction	Cern,Desy/HH,MPI,JapenseGroups,Victoria **Dean Karlen**
d) Gas/HV/Infrastructure for the LP	Aachen,Desy/HH,Saclay **Ralf Diener**

WP(5) Coordination of LCTPC R&D	
a) Advanced endcap mechanics/alignment	Cornell,JapaneseGroups,MPI,Saclay **Dan Peterson**
b) Advanced endcap/Electronics development	Cern,JapeneseGroups,Lund,Nikhef,Saclay **Anders Oskarsson**/ **Leif Jönsson** 2010 **Luciano Musa**/2011 **Eric Delagnes**
Advanced endcap/cooling/	Desy,JapeneseGroups,Lund,Nikhef **Takeshi Matsuda**
Advanced endcap/power pulsing	Cern,Desy,JapeneseGroups,Lund,Nikhef,Saclay **Takahiro Fusayasu**
c) Gating device	Cornell,JapeneseGroups,MPI **Akira Sugiyama**/ **Philippe Gros** **Ron Settles**
d) Fieldcage	Desy/HH **Ties Behnke**
e) ILD TPC Integration/Mach-Det Interface	Cornell,Desy/HH,MPI,Saclay **Volker Prahl**/ **Ron Settles**
f) LCTPC Software/Correction methods	Bonn,Carleton,Cern,Desy/HH,JapaneseGroups **Astrid Muennich**/ **Keisuke Fujii**

The WP(5) workpackages overlap significantly with the previous structure, and will now oversee the LCTPC R&D after the DBD; more explanation is presented in Section 4.3.

4 Future R&D, the LP and SPs

4.1 What has been learned

As written in Section 1, the R&D is proceeding in three phases: (1) Small Prototypes–SP, (2) Large Prototypes–LP and (3) Design.

Up to now during Phase(1), a summary of what has been learned:

- many years of MPGD experience has been gathered,
- gas properties have been well measured,
- the best possible point resolution is understood,
- the resistive-anode charge-dispersion technique has been demonstrated,
- CMOS pixel RO technology has been demonstrated,
- the MWPC option has been ruled out,
- the Micromegas option without resistive anode has been ruled out,
- reliable assemblies of GEM-modules and Micromegas-modules have been developed.

The Phase(2) LP and SP tests are expected to take several years and will be followed by Phase(3), the design of the LCTPC. A scenario for Phase(2) options is presented below in Table 3 which will be readjusted as the timeline evolves.

4.2 Timeline

The following overview is a timeline for completing the studies and the construction of the LCTPC. The dates over the years have had the tendency to slip, simply because "things take longer than expected". The timeline for the the ILC machine in Japan (Section 1.2) is reflected in the following sections.
2009 - 2013: Continue R&D on technologies at LP, SP, pursue simulations, verify corrections procedures and performance goals.
2011 - 2014: Plan and do R&D on advanced endcap; power-pulsing, electronics and mechanics are critical issues.
After 2014-15: Design the LCTPC.

4.3 R&D after the DBD

4.3.1 2009 - 2013

Present ideas about possible scenarios are summarized in the Table 3. The stages are symbolized by LP1, LP2, and LP3. Supplemental testing with the SPs, which have been used extensively to date by the LCTPC collaboration (Section 4.1) will continue, since there are still several issues which can be explored more efficiently using small, specialized set-ups.

Table 3		Scenarios, updated March 2013
		Large Prototype R&D
Device	Lab(years)	Configuration
LP1	Desy(2007-2013)	Fieldcage⊕first endplates: GEM- or Micromegas-techn. with pads or pixels
Purpose: Test construction techniques using ∼10000 Altro or T2K channels to demonstrate measurement of 6 GeV/c beam momentum over 70cm tracklength, including development of correction procedures.		
LP2	Desy(2013-14)	Fieldcage⊕thinned endplate: GEM- or Micromegas-techn. with pads or pixels
Purpose: Continue tests using 10000 Altro or T2K channels to demonstrate measurement of beam momentum over 70cm tracklength using LP1 thinned endplate and external detector. If possible, simulate a jet-like environment. Pixels plan a full area ('100-chip') LP-module. a		
LP3	Desy(after 2014)	Fieldcage⊕advanced-endcap prototype: GEM- or Micromegas-techn. with pads or pixels
Purpose: Prototype for LCTPC endcap module design: mechanics, electronics, cooling, power pulsing, gating; new fieldcage and SAltro/GdSP channels if ready		
		Small Prototype R&D History/Possibilities
Device	Lab(years)	Test
SP(i)	LCTPC groups(2007-2014)	Performance, gas, gating, dE/dx, power pulsing, continuation of measurements in progress by groups (i) with small prototypes

4.3.2 2011 - 2014

TPC design, performance and engineering issues result in the reassessment of the R&D priorities which is a continuing process. Table 4 reflects the present thinking:

Table 4

- Continue tests in electron beam to perfect correction procedures and to verify point, two-point, dE/dx resolutions
- Design/test gating device
- Endplate/module studies with a maximum of 25% X0 including electronics/cooling
- Software development for simulation and reconstruction
- Electronics development
- Powerpulsing/cooling tests using both LP and SP
- Test radiation hardness of T2K gas
- Test all components of LCTPC for electron-attachment emissions into the TPC gas
- A move to a hadron beam should be considered only after work on the LP at Desy has been completed

The collaboration decided that it was not yet necessary to chose between options, because the performance of the LCTPC for the DBD is guaranteed by Table 5 in Sec. 4.4. However these technical choices will have to be made around the year 2014-15 in order to design the LCTPC, as described in Sec. 4.3.3 below.

In addition, during the period after 2011, mechanical studies of endcap designs that were successful as computer models will follow. In preparation for LP3 in Table 3, several prototypes of the advanced endcap will be manufactured; both scale-models (20-50% full size) and sections of the full size endplate will be used to evaluate the manufacturing integrity.

Prototype electronics, cooling, power pulsing and gating will be included in LP3 where possible, otherwise tested in SPs. The design/manufacture of LP3 will be coordinated by Workpage (5) in Section 3.2.

4.3.3 After 2014-15

During the period 2014-15, shortly after a positive decision in Japan, a selection must be made from the different technological options – GEM, MicroMegas, resistive anode, pixel, electronics, gating device, endcap structure, cooling, mechanics, integration – to establish a working model for the design of the LCTPC. This will not rule out R&D on other options.

4.4 Performance Goals

Performance goals 2013

Performance and design parameters for an LCTPC with standard electronics are recalled here. Understanding the properties and achieving the best possible point resolution have been the object of R&D studies of Micro-Pattern Gas Detectors, MicroMegas and GEM, and results from this work used to define the parameters in Table 5. The parameters in this preliminary design represent the best technical solution at the moment and have been agreed upon by the LCTPC Collaboration.

These studies will continue for the next few years in order to improve on the performance. Upgrades to the preliminary design and Table 5 will be implemented where improvements are warrented by R&D results and are compatible with the LC timeline. The options with standard electronics are MicroMegas with resistive anode or GEM. The pixel TPC with CMOS electronics is compatible with MicroMegas or GEM.

Table 5, as presented in the DBD

Parameter	
Geometrical parameters	r_{in} 329 mm, r_{out} 1808 mm, z ± 2350 mm
Solid angle coverage	Up to $\cos\theta \simeq 0.98$ (10 pad rows)
TPC material budget	$\simeq 0.05\ X_0$ including outer fieldcage in r
	$< 0.25\ X_0$ for readout endcaps in z
Number of pads/timebuckets	$\simeq$ 1-2 $\times 10^6$/1000 per endcap
Pad pitch/ no.padrows	$\simeq 1\times 6$ mm^2 for 220 padrows
σ_{point} in $r\phi$	$\simeq 60\ \mu$m for zero drift, $< 100\ \mu$m overall
σ_{point} in rz	$\simeq 0.4 - 1.4$ mm (for zero – full drift)
2-hit resolution in $r\phi$	$\simeq 2$ mm
2-hit resolution in rz	$\simeq 6$ mm
dE/dx resolution	$\simeq 5$ %
Momentum resolution at B=3.5 T	$\delta(1/p_t) \simeq 10^{-4}$/GeV/c (TPC only)