Addendum 2011-12 to the LCTPC MOA: R&D organization and DBD planning

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 2011-12 Activities

1.1 The ILD LOI and DBD

The validation of the ILD Letter of Intent (LOI) in 2009 by the International Detector Advisory Group (IDAG) and GDE Research Director (RD) was accompanied by the charge that ILD should "demonstrate a feasible solution at the end of the TDR phase of the accelerator". The TDR report of the accelerator and the Detailed Baseline Design (DBD) document of the detector are to be submitted at the end of 2012. LCTPC preparations for the DBD will be outlined in Section 3.3.

1.2 ILC-CLIC Collaboration and the LC

Since the start of the offical collaboration between the ILC (low-energy LC option) and CLIC (the high-energy option), 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; of course, the parameters of a TPC for ILC may be different from those for CLIC.

At the meeting https://indico.cern.ch/conferenceDisplay.py?confId=164890 and more recently at http://indico.in2p3.fr/conferenceDisplay.py?confId=6001, it became clear that a low-energy linear collider will be pursued, and the efforts for the machine (the site in Japan) are going forward as reported at http://newsline.linearcollider.org/2011/12/19/.

1.3 New groups

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

2 Responsibilites 2011-12

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**
Louisiana Tech?:	**Lee Sawyer**
–Asia———-	
Tsinghua:	**Yuanning Gao**
Saha Kolkata:	**Supratik Mukhopadhyay**
Hiroshima?	**Tohru Takahashi**
KEK	**Keisuke Fujii**
Kinki	**Yukihiro Kato**
Saga	**Akira Sugiyama**
Kogakuin	**Takashi Watanabe**
JAX Kanagawa?	**Hirokazu Ikeda**
Nagasaki Inst AS	**Takahiro Fusayasu**
Tokyo U A & T?	**Osamu Nitoh**
U Tokyo?	**Sachio Komamiya**
Mindanao?	**Angelina Bacala**
–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**
Karlsruhe?:	**Thomas Müller**
MPI-Munich:	**Ron Settles**
Rostock:	**Oliver Schaefer**
Siegen?:	**Ivor Fleck**
Nikhef:	**Jan Timmermans**
Novosibirsk:	**Alexei Buzulutskov**
St.Petersburg?:	**Anatoliy Krivchitch**
Lund:	**Leif Jönsson**
CERN:	**Michael Hauschild/Lucie Linsen**

Present groups & **CB members** are listed above; missing MOA signatures marked by “?”.

2.1.1 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.

2.1.2 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.

2.1.3 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 will chair the meetings in 2012.

2.1.4 Observers

Groups or persons that could not sign the MOA but want to be observers and informed as to the progress, thus are included the lctpc mailing list, are:
Iowa State, MIT, Purdue, Yale, LAL Orsay/IPN Orsay, TU Munich, UMM Krakow, Bucharest.

2.2 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 2011-12.
–Asia: **Takeshi Matsuda** in 2007-09 and
Akira Sugiyama in 2010-12
–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 voted by the RCs as the Spokesperson for 2012-13.

2.3 Technical Board (TB)

The four workpackages WP(1)-WP(4) used in 2006 – 2009 were supplemented by a fifth workpackage WP(5) in 2010 to prepare for the DBD; the **TB members** are the conveners of 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, **Christoph Rosemann**
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 **Takeshi Matsuda**
c) Distortion correction	Cern,Desy/HH,MPI,JapenseGroups,Victoria **Dean Karlen**
d) Gas/HV/Infrastructure for the LP	Aachen,Desy/HH,Saclay 2010 **Klaus Dehmelt**/2011 **Ralf Diener**

New WP(5) LCTPC preparations for DBD	
a) Advanced endcap mechanics/alignment	Cornell,JapaneseGroups,MPI,Saclay **Dan Peterson**
b) Advanced endcap/SAltro/cooling/PowerPulse	Cern,JapeneseGroups,Lund,Nikhef,Saclay **Anders Oskarsson**/ **Takahiro Fusayasu** 2010 **Luciano Musa**/2011 **Eric Delagnes**
c) Gating device	Cornell,JapeneseGroups,MPI **Akira Sugiyama**/ **Ron Settles**
d) Fieldcage	Desy/HH **Ties Behnke**
e) ILD TPC Integration/Machine-Detector Interface	Cornell,Desy/HH,MPI,Saclay **Volker Prahl**/ **Ron Settles**
f) LCTPC Software Model	Bonn,Carleton,Cern,Desy/HH,JapaneseGroups **Christoph Rosemann**/ **Keisuke Fujii**
g) Testbeams	Desy/HH,JapaneseGroups **Takeshi Matsuda**

The WP(5) issues overlap significantly with the previous structure, since they are closely related. The WP(5) workpackages are meant to specifically guide the DBD preparations; more explanation is presented in Section 3.3.

3 Future R&D, the LP and SPs

3.1 What has been learned

As described in the MOA, 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), items summarizing the learning are:
–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.

The Phase(2) LP and SP tests are expected to take about three 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.

3.2 Timeline

The following overview is a timeline for completing the studies and the construction of the LCTPC. These timelines over the years have had the tendency to be extended, simply because “things take longer than expected”. This version of the timeline is simplified compared to previous addenda, in that II and III, which had became similar, have been merged.

(I) 2009-13: Continue R&D on technologies at LP, SP, pursue simulations, verify corrections procedures and performance goals.
(II-III) 2011-13: Plan and do R&D on advanced endcap; power-pulsing, electronics and mechanics are critical issues. Write the DBD by the end of 2012.
(IV) 2014-19: Design and build the LCTPC.

3.3 Preparation for the DBD

3.3.1 (I) 2009 - 2013

Present ideas about possible scenarios are summarized in the Table 3. The stages are symbolized by LP1, LP1.5/2 [1] and LP3. Supplemental testing with the SPs, which have been used extensively to date as witnessed by Section 3.1, will continue, since there are still several issues which can be explored more efficiently using small, specialized set-ups. In Table 3, The star * denotes that a decision must be made as to where, CERN, Desy or other, this stage should take place.

Table 3 Scenarios, updated March 2012

Large Prototype R&D		
Device	Lab(years)	Configuration
LP1	Desy(2007-2013)	Fieldcage⊕2 endplates: GEM+pixel, Micromegas+pixel
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.		
LP1.5/2	Desy(2012-13)	Fieldcage⊕thinned endplate: GEM+pixel, Micromegas+pixel
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, test a jet-like environment.		
LP3	C*D*O/ (after 2013)	Fieldcage⊕advanced-endcap prototype: GEM, Micromegas, or pixel
Purpose: Prototype for LCTPC endcap module design: mechanics, electronics, cooling, power pulsing, gating. Demonstrate measurement of high momentum.		

Small Prototype R&D Possibilities		
Device	Lab(years)	Test
SP1	KEK(2007-2013)	Gas tests, gating configurations, Altro
SP2,SP3	C*D*O(2012-2013)	Performance in jet environment
SPn	LCTPC groups(2007-2013)	Performance, gas tests, dE/dx measurements, continuation of measurements in progress by groups with small prototypes

[1] Some had referred to this stage as LP1.5, others as LP2, thus to avoid confusion, this stage is renamed to LP1.5/2

3.3.2 (II-III) 2011 - 2013

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

Table 4

- Software development for simulation and reconstruction
- Electronics development
- Continue tests in electron beam to perfect correction procedures
- Advanced endplate studies with a maximum of 25% X0 including electronics/cooling
- Powerpulsing/cooling tests using both LP and SP
- Design/test gating device
- Future tests in hadron beam for momentum resolution
and for performance in a jet environment

The collaboration meeting 26-27 March 2012 decided that it was not yet necessary to chose between options as described in Section 3.3.4 of Addendum 2010-11, because the performance of the LCTPC for the DBD is guaranteed by Table 5 in Sec. 3.4. However these technical choices will have to be made around the year 2014 in order to design the LCTPC, as described in Sec. 3.3.3 below.

In addition, during the period 2011-2013, 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 2.3.

3.3.3 (IV) 2014 - 2019

At the beginning of the period 2014 - 2019, 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 other options.

3.4 Performance Goals

Performance goals 2012

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

Performance/Design	
Size	$\phi = 3.6$m, L = 4.3m outside dimensions
Momentum resolution (3.5T)	$\delta(1/p_t) \sim 10^{-4}$/GeV/c TPC only ($\times$ 0.4 if IP incl.)
Momentum resolution (3.5T)	$\delta(1/p_t) \sim 2 - 3 \times 10^{-5}$/GeV/c (SET+TPC+SIT+VTX)
Solid angle coverage	Up to $\cos\theta \simeq 0.98$ (10 pad rows)
TPC material budget	$\sim 0.05X_0$ including the outer fieldcage in r
	$< 0.25X_0$ for readout endcaps in z
Number of pads/timebuckets	$\sim$ 1 - 2$\times 10^6$/1000 per endcap
Pad pitch/no.padrows	$\sim$ 1mm$\times$5–10mm/$\sim$150–250 (standard readout)
$\sigma_{\rm point}$ in $r\phi$	$< 100\mu$m (average over $L_{sensitive}$ for straight radial tracks)
$\sigma_{\rm point}$ in rz	$\sim 0.4 - 1.4$ mm (for zero–full drift)
2-hit resolution in $r\phi$	$\sim$ 2 mm (for straight radial tracks)
2-hit resolution in rz	$\sim$ 6 mm (for straight radial tracks)
dE/dx resolution	$\sim$ 5 %
Performance	$> 97\%$ efficiency for TPC only ($p_t > 1$GeV/c), and
	$> 99\%$ all tracking ($p_t > 1$GeV/c)
Background robustness	Full efficiency with 1% occupancy,
Background safety factor	Chamber will be prepared for 10 $\times$ worse backgrounds
	at the linear collider start-up

The Pixel TPC

The pixel TPC R&D is progressing and will provide corresponding table of performance parameters as soon as feasible.