Addendum 2010-11 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. Evolution of the collaboration, of the work-package structure and of responsible persons are updated in the yearly Addenda.

1 2010-11 Activities

1.1 Organizational Issues

The Addendum 2008 described the creation of an editorial board and of a speakers bureau:

> **2.5 Publications** All results obtained from the work within the LCTPC collaboration will be openly available to all members, and data obtained using common prototypes or common equipment will belong to all collaborators. The groups agree that they will not publish or make otherwise public any information belonging to LCTPC without obtaining prior agreement of the collaboration. Results from the collaboration will be published under the name "LCTPC Collaboration". The CB will install a proper editorial process before releasing material to the public. In case of a conflict the collaborators agree to accept the decision of the CB as final.
>
> Similarly the CB has installed a speakers bureau which will review all talks pertaining to the common equipment. The method may include the organizataion of practice talks which can be reviewed and modified by the speakers' bureau.

1.1.1 Editorial Board

An editorial board has now been set up to review publications in 2011: Alain Bellerive, Ties Behnke, Keisuke Fujii, Leif Jönsson, Dean Karlen, Takeshi Matsuda, Dan Peterson, Ron Settles, Akira Sugyama and Jan Timmermans. The following rules have been agreed on:
- An author will submit a draft to the editorial board which reviews the draft and makes suggestions (everything per email).
- After this first pass, the draft is circulated to the lctpc@desy.de which has two weeks to submit comments.
- The LCTPC editorial board has a final meeting with the author(s) (phone meeting or email) to come up with the final version.
- If there are non LCTPC-members, the following quote will be included on the cover page: "This author list consists of members of the LCTPC Collaboration and also of non-members indicated by an asterisk in the NN group."

1.1.2 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 – Jan Timmermans, Akira Sugiyama

and Alain Bellerive – and one additional person per region – Jochen Kaminski, Yulan Li and Dan Peterson – in 2011. Dan Peterson will chair the meetings in 2011.

1.1.3 CB Matters

In 2009, the Collaboration Board decided that each year it will appoint one member to chair its meetings. For 2011, Leif Jönsson agreed to chair the CB meetings. At the CB meeting on 11 July 2011, it was decided that the CB meetings should be held more frequently, two or three times a year.

1.1.4 ILC-CLIC Collaboration

Following the offical collaboration between ILC and CLIC, the LCTPC Collaboration is now 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.

1.2 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. Preparations for the DBD will be outline in Section 3.3.

The RD produced a workplan for the DBD which can be used as a guide for our preparations. Relevant for the LCTPC are the "demonstration of proof of principle on critical components, definition of a feasible baseline with options, completion of mechanical design and development of a realistic simulation." All of these points are covered in the ILD LOI, and further work will involve R&D priorities and design issues for the next two-to-three years.

Responsibilites 2010-11 are reviewed in Section 2, future R&D and planning for the DBD are covered in Section 3.

2 Responsibilites 2010-11

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:	**Ties Behnke**
UHamburg:	**Ties Behnke**
EUDET (up to 2011):	**Joachim Mnich**
Freiburg?:	**Andreas Bamberger/Markus Schumacher**
Karlsruhe?:	**Thomas Müller**
MPI-Munich:	**Ron Settles**
Rostock:	**Henning Schroeder**
Siegen?:	**Ivor Fleck**
Nikhef:	**Jan Timmermans**
Novosibirsk:	**Alexei Buzulutskov**
St.Peterburg?:	**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 New groups

The LCTPC collaboration (http://www.lctpc.org) is open to all, and a group wishing to join should contact us. Recently (in 2010) two new groups have signed the MOA.

2.1.2 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.
–Asia: **Takeshi Matsuda** in 2007-09 and
Akira Sugiyama in 2010-11
–Europe: **Ron Settles** (who requested to continue for only one year) in 2007 and
Jan Timmermans in 2008-11.
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.

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:
–over 6 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.[1]

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 the currently envisioned timeline for completing the studies and the construction of the LCTPC.

(I) 2009-13: Continue R&D on technologies at LP, SP, pursue simulations, verify corrections procedures and performance goals.

[1] See PRC2010 Report http://www.lctpc.org/e10/e96773/

(II) 2009-11: Plan and do R&D on advanced endcap; power-pulsing, electronics and mechanics are critical issues.
(III) 2011-12: Test advanced-endcap prototype and power-pulsing; write the DBD
(IV) 2012-18: 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, LP2. 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, Fermilab, CERN, Desy or elsewhere, this stage should take place.

Table 3 Scenarios, updated April 2010

Large Prototype R&D		
Device	Lab(years)	Configuration
LP1	Desy(2007-2011)	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	Desy(2012)	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.		
LP2	FL*C*D*O/ (after 2012)	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(2007-2011)	Gas tests, gating configurations, Altro
SP2,SP3	FL*C*D*O(2011-2013)	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

3.3.2 (II) 2009 - 2011

TPC design, performance and engineering issues were presented at LCTPC collaboration meetings on 21-22 September 2009
http://ilcagenda.linearcollider.org/conferenceDisplay.py?confId=3742

and 6-7 July 2011
http://ilcagenda.linearcollider.org/conferenceDisplay.py?confId=5231. These meetings included a reassessment of the R&D priorities, a continuing process. Table 4 reflects the present thinking, in approximate order of priority:

Table 4

- Continue tests in electron beam to perfect correction procedures
- Advanced endplate studies with a maximum of 25% X0 including 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
- Ion backflow simulations of ion sheets for Gem, Micromegas

3.3.3 (III) 2011 - 2012

During the period 2011-2012, mechanical studies of endcap designs that were successful as computer models in period II will follow. In preparation for LP2 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 LP2 where possible, otherwise tested in SPs. The design/manufacture of LP2 will be coordinated by Workpage (5) in Section 2.3.

3.3.4 (IV) 2012 - 2018

At the beginning of the period 2012-18, 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 preliminary design will be used for the ILD DBD in 2012 so that performance, timeline and cost can be estimated reliably. This will not rule out other options.

3.4 Performance Goals

Performance table in the ILD LOI
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)	$\delta(1/p_t) \sim 9 \times 10^{-5}$/GeV/c TPC only ($\times$ 0.4 if IP incl.)
Momentum resolution (3.5T)	$\delta(1/p_t) \sim 2 \times 10^{-5}$/GeV/c (SET+TPC+SIT+VTX)
Solid angle coverage	Up to $\cos\theta \simeq 0.98$ (10 pad rows)
TPC material budget	$\sim 0.05\mathrm{X}_0$ including the outer fieldcage in r
	$< 0.25\mathrm{X}_0$ for readout endcaps in z
Number of pads/timebuckets	$\sim$ 1 - $2{\times}10^6$/1000 per endcap
Pad size/no.padrows	$\sim$ 1mm$\times$4–8mm/$\sim$200 (standard readout)
σ_{point} in $r\phi$	$< 100\mu$m (average over $\mathrm{L}_{sensitive}$ for straight radial tracks)
σ_{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 ($\mathrm{p_t} > 1$GeV/c), and
	$>$ 99% all tracking ($\mathrm{p_t} > 1$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.