Addendum 2017 to the MoA

Preparing for the LC

Reminder: at the moment the collaboration is searching for a speakers bureau chair, a software contact and a pixel coordinator

This information is contained in a draft which has to be corrected and approved by the Collaboration Board

Addendum 2017 to the MoA

A detailed overview of machine and detector was publised in 2013:
https://www.linearcollider.org/ILC/Publications/Technical-Design-Report.

The lastest initiative is to build the ILC in stages starting at 250 GeV, as is well known, as is the fact that he LCC and LCB mandate has been extended by ICFA

Addendum 2017 to the MoA

Collaboration Board

Americas
Carleton/Triumf: Madhu Dixit
Carleton U: Alain Bellerive
Victoria: Dean Karlen
BNL: Alexei Lebedev
Asia
Tsinghua: Yuanning Gao
Hubei: Fan Zhang
IHEP: Huirong Qi
Saha Kolkata: Supratik Mukhopadhyay
Hiroshima: Tohru Takahashi
Iwate: Shinya Narita
KEK: Keisuke Fujii
Kindai: Yukihiro Kato
Saga: Akira Sugiyama
Kogakuin: Takashi Watanabe
Nagasaki Inst AS: Ken Oyama
Europe
Inter U Inst for HEP(ULB-VUB): Gilles De Lentdecker
CEA Saclay: Paul Colas
Bonn: Jochen Kaminski/Klaus Desch
DESY/HH: Ties Behnke
Kiev: Oleg Bezshyyko
MPI-Munich: Ron Settles
Siegen: Ivor Fleck
Nikhef: Jan Timmermans
Lund: Leif Jönsson
CERN: Michael Hauschild/Lucie Linsen

Addendum 2017 to the MoA

Collaboration Board

These groups have switched their status to Observer

Cornell (Dan Peterson),

Indiana(Rick Van Kooten),

Rostock (Roland Waldi),

Aachen (Stefan Roth).

Regional Coordinators

Americas: Dean Karlen in 2007-10,

Alain Bellerive in 2011-17.

Asia: Takeshi Matsuda in 2007-09,

Akira Sugiyama in 2010-17.

Europe: Ron Settles in 2007,

Jan Timmermans in 2008-17.

Addendum 2017 to the MoA

Regional Coordinators
Americas: Dean Karlen in 2007-10,
Alain Bellerive in 2011-17.
Asia: Takeshi Matsuda in 2007-09,
Akira Sugiyama in 2010-17.
Europe: Ron Settles in 2007,
Jan Timmermans in 2008-11,
Jochen Kaminski in 2012-17.

Spokes persons
Ron Settles 2007
Jan Timmermanns 2008 -2011
Jochen Kaminski 2012-2017

Addendum 2017 to the MoA

CB Chair
Leif Jönsson 2012-2017

Editorial Board
Alain Bellerive, Ties Behnke, Madhu Dixit, Takahiro Fusayasu, Keisuke Fujii, Leif Jönsson, Jochen Kaminski, Takeshi Matsuda, Ron Settles, Akira Sugyama and JanTimmermans.
Takahiro Fusayasu agreed to chair the EB in 2016-17

Speakers Bureau
Regional coordinators, Jochen Kaminski, Akira Sugiyama and Alain Bellerive. and one additional person per region { Jan Timmermans, Yulan Li and Dan Peterson (in 2011-13; then David Attie replaced Jan Timmermans in mid-2014. Dan Peterson chaired in 2012, and Allain Bellerive for one year starting mid-2013. David Attie had this task since mid-2014.
XXXXsb2018 will take over the duty next.

Addendum 2017 to the MoA

Technical Board Contacts

- Workpackage(1) Mechanics
- a) LP endplate design
- up to 2016 Dan Peterson daniel.peterson@cornell.edu
- Fieldcage development
- Ties Behnke ties.behnke@desy.de
- b) GEM panels for endplate
- Akira Sugiyama sugiyama@cc.saga-u.ac.jp
- c) MicroMegas panels for endplate
- Paul Colas paul.colas@cea.fr
- d) Pixel panels for endplate
- Jan Timmermans jan.timmermans@nikhef.nl
- e) Resistive anode for endplate
- Madhu Dixit msd@physics.carleton.ca

Addendum 2017 to the MoA

Technical Board Contacts

Workpackage(2) Electronics

a) Standard RO for the LP

Leif Jönsson leif.jonsson@hep.lu.se

b) CMOS RO electronics

Harry van der Graaf vdgraaf@nikhef.nl

c) Standard electronics for LCTPC

up to 2010 Luciano Musa luciano.musa@cern.ch

Workpackage(3) Software
a) LP software/simulation/reconstruction
up to 2014 Astrid Muennich astrid.muennich@desy.de
b) LP DAQ
Gilles De Lentdecker gilles.de.lentdecker@ulb.ac.be
c) LCTPC performance/backgrounds
Keisuke Fujii keisuke.fujii@kek.jp

Addendum 2017 to the MoA

Workpackage(4) Calibration
a) Field map for the LP
Lucie Linsen lucie.linssen@cern.ch
b) Alignment
Takeshi Matsuda takeshi.matsuda@kek.jp
c) Distortion correction
Dean Karlen karlen@uvic.ca
d) Gas/HV/Infrastructure for the LP
Ralf Diener ralf.diener@desy.de

Addendum 2017 to the MoA

WP(5) Coordination of LCTPC R&D
a) Advanced endcap and fieldcage
Ties Behnke ties.behnke@desy.de
b) Advanced endcap/Electronics development
Anders Oskarsson anders.oskarsson@hep.lu.se
Leif Jönsson leif.jonsson@hep.lu.se
up to 2010 Luciano Musa luciano.musa@cern.ch
2011 Eric Delagnes eric.delagnes@cea.fr
Advanced endcap/power pulsing/cooling
Takahiro Fusayasu fusayasu takahiro@nias.ac.jp
c) Gating device !
Akira Sugiyama sugiyama@hep.phys.saga-u.ac.jp
d) ILD TPC Integration/Mach-Det Interface !
Volker Prahl volker.prahl@desy.de
Ron Settles settles@mppmu.mpg.de
Proposal: ILD contacts:
Akira Sugiyama sugiyama@hep.phys.saga-u.ac.jp
Paul Colas paul.colas@cea.fr
e) LCTPC Software/Correction methods
up to 2014Astrid Muennich astrid.muennich@desy.de
2018XXXXsw xxxx@xxxx.xx
f) Pixel-Module Development
up to 2015 Michael Lupberger michael.lupberger@cern.ch
Jochen Kaminski kaminski@physik.uni-bonn.de
2018XXXXpixel xxxx@xxxx.xx

Addendum 2017 to the MoA

<u>Future R&D</u>

A summary of what has been learned up to now:

--the MWPC option has been ruled out,

--the MicroMegas option without resistive anode has been ruled out,

--gas properties have been well measured,

--many years of MPGD experience have been gathered,

--the best possible point resolution is understood,

--the resistive-anode charge-dispersion technique has been demonstrated,

--reliable assemblies of GEM-modules and MicroMegas-modules have been developed,

--CMOS pixel RO technology has been demonstrated,

--the dE/dx resolution has been conrmed,

..design of the gating device has been successful.

Addendum 2017 to the MoA

2014-2017 Scenarios

Table 3 Scenarios, updated November 2017

Large Prototype R&D		
Device	Lab(years)	Configuration
Preliminary	Desy(2013-15)	Fieldcage⊕first endplates: GEM, MicroMegas, or pixel
Purpose: Test construction techniques using ∼10000 pad read-out channels to demonstrate measurement of the Desy test-beam or cosmics over 70cm tracklength, including development of correction procedures.		
Improved	Desy(2016-17)	Fieldcage⊕thinned endplate: GEM, MicroMegas, or pixel
Purpose: Continue tests using 10000 pad read-out channels to demonstrate measurement of the Desy test-beam or cosmics 70cm tracklength using LP1 thinned endplate and external detector. If possible, simulate a jet-like environment. Pixels will continue testing a'100-chip' LP-module.		
Final	Desy(2018-19)	Fieldcage⊕advanced-endcap prototype: GEM, MicroMegas, or pixel
Purpose: Prototype for LCTPC module design with items that are ready: mechanics, electronics, cooling, power pulsing, gating; new fieldcage and SAltro/GdSP channels		

Addendum 2017 to the MoA

<u>2017 Present thinking</u>

- Continue tests in the Desy test-beam or cosmics to perfect correction procedures and to verify point, two-point, dE/dx resolutions
- Continue to design/test gating device
- Endplate/module/eldcage studies
with a maximum of 25% X0 in the endplate including electronics/cooling
- Software development for simulation and reconstruction
- Common DAQ for running the TPC and silicon trackers together
- Electronics development: the design of a new readout chip is a most urgent problem to be solved by the collaboration.
- Powerpulsing/cooling tests using both LP and SP
- Test all components of LCTPC for electron-attachment emissions into the TPC gas
- A move to a hadron beam is possible, but may not happen, so ways should be found to do the tests at Desy

More discussions on the tasks ahead were held at workpackage meetings
176/185/222/258
where more details can be found. The indico links for these meetings are
176{http://agenda.linearcollider.org/event/6097/
185{http://agenda.linearcollider.org/event/6251/
222{http://agenda.linearcollider.org/event/6786/
258{http://agenda.linearcollider.org/event/7510/

Addendum 2017 to the MoA

After 2018 - 2019

Shortly after a positive decision in Japan, a selection must be made from the dierent 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 continuing on other options.

After 2018 - 2019, the design of the ILD TPC could follow in preparation for the TDR of the ILD tracking system.

Performance Goals

Understanding the properties and achieving the best possible point resolution have been the object of R&D studies of Micro-Pattern Gas Detectors, GEM, MicroMegas, and pixel, and results from this work used to dene the parameters in Tables 5 and 6. These studies will continue for the next few years in order to improve on the performance. Upgrades to the preliminary design will be implemented where improvements have been established by R&D results and are compatible with the LC timeline. The options are MicroMegas with resistive anode with standard electronics, or GEM with standard electronics, or the pixel TPC with CMOS electronics which is being tested with 'Ingrid': MicroMegas integrated on a pixel chip.

Also noted is the study by the ILD collaboration of a 'large' version with 1808 mm TPC outer radius and 3.5T B-eld (the standard used up to now) and a new 'small' version with 1460 mm TPC outer radius and 4T B-eld. The Table 5 below is for the large version, Table 6 for the small version. The values in the two tables are approximations only and arepresented for the purpose of comparison.

Addendum 2017 to the MoA

Footnote to the tables

---

[1]The point resolution, 0.1 mm, for this year's tables was asumed to be the same for GEM and MicroMegas. The value for the pixel option was assumed to be $0.055mm/\sqrt{12}$ for zero drift and 0.4mm for maximum drift (see the talk on pixel simulation at the 264th WP meeting on 11 May 2017, https://agenda.linearcollider.org/event/7634/). Resolutions for both pad and pixel versions are presented there.

[2]For the effective track length in both cases, small and large, 100mm has been added to the inner radius and 100mm subtracted from the outer radius, in order to account for fieldcages, mechanics and services.

[3]The overall tracking resolution (including silicon tracking) would be roughly $\simeq 2 \times 10^{-5}$ for the large version and $\simeq 3 \times 10^{-5}$ for the small version.

[4]For this simple calculation, the assumption for the pixel TPC is that a track travels from the inner radius at the middle of the TPC $(r, \phi, z \simeq 429mm, \phi = K(constant), 0mm)$ to the outer radius near the endcap $(r, \phi, z \simeq 1700mm(large), \phi = K, 2200mm)$, $(r, \phi, z \simeq 1300mm(small), \phi = K, 2200mm)$, that three-fourths to one-half of the track length ($ld \equiv$ long drift) uses the standard dE/dx (truncated mean) estimation with a resolution of $\sigma_{ld} \simeq 5\ \%$ and that one-fourth to one-half ($sd \equiv$ short drift) uses cluster counting with a resolution of $\sigma_{sd} \simeq 3\ \%$. The weighted mean is calculated with weights $\frac{1}{\sigma_{ld}{}^2}$ and $\frac{1}{\sigma_{ld}{}^2}$ for the ld and sd, respectively. The two errors are combined in the standard way: $\frac{1}{\sigma_{hypotheticaltrack}{}^2} = \frac{1}{\sigma_{ld}{}^2} + \frac{1}{\sigma_{sd}{}^2}$.

Addendum 2017 to the MoA

Table 5, large TPC, for pad/*pixel* electronics	
Parameter	
Geometrical parameters	r_{in} 329 mm, r_{out} 1808 mm, z $\pm$ 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	$\simeq 10^6/1000$ per endcap
Number of pixels/timebuckets	$\simeq$ *$10^9/1000$ per endcap*
Pad pitch/ no.padrows	$\simeq 1\times 6\ mm^2$ / 213
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	$\simeq 5$ %
dE/dx resolution	$\simeq$ *4 %*
Momentum resolution at B=3.5 T	$\delta(1/p_t) \simeq 10^{-4}$/GeV/c (TPC only)
Momentum resolution at B=3.5 T	$\delta(1/p_t) \simeq$ *0.3$\times$ 10^{-4}/GeV/c (TPC only)*

Addendum 2017 to the MoA

Table 6, small TPC, for pad/*pixel* electronics

Parameter	
Geometrical parameters	r_{in} 329 mm, r_{out} 1460 mm, z $\pm$ 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	$\simeq 5\times 10^5/1000$ per endcap
Number of pixels/timebuckets	*$\simeq 5\times 10^8/1000$ per endcap*
Pad pitch/ no.padrows	$\simeq 1\times 6\ mm^2$ / 155
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	$\simeq 6$ %
dE/dx resolution	*$\simeq 5$ %*
Momentum resolution at B=4 T	$\delta(1/p_t) \simeq 2\times 10^{-4}$/GeV/c (TPC only)
Momentum resolution at B=4 T	*$\delta(1/p_t) \simeq 0.6\times 10^{-4}$/GeV/c (TPC only)*