TimeProjectionChamber/SiEnv. R&D for an LC Detector

(see Marcel Stanitzki’s Monday talk, testbeam and tracking sessions for other subdetectors)
TPC R&D Planning

1) Demonstration phase
   - Continue work with small prototypes on mapping out parameter space, understanding resolution, etc, to improve the design of an MPGD TPC.

2) Consolidation phase
   - Build and operate the Large Prototype (LP), Ø ~ 90cm, drift ~ 60cm together with SIT prototype, with EUDET infrastructure as basis, to test manufacturing techniques for MPGD endplates, fieldcage, electronics. The LP has been built now and testing of the options is underway.

3) Design phase
   - During phase 2, the decision as to which endplate technology to use for the LC TPC will be taken and final design started.
TPC R&D summary to date

• Now several years MPGD experience gathered
• Gas properties rather well understood
• Limit of resolution understood
• Resistive foil charge-spreading demonstrated
• CMOS RO demonstrated
• Work in progress with the Large Prototype (LP)
### Table 1: LCTPC R&D Scenarios for Large Prototype and Small Prototypes.

<table>
<thead>
<tr>
<th>Lab</th>
<th>Beams</th>
<th>Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>CERN SPS</td>
<td>10-400GeV $e, h, \mu$</td>
<td>LHC absolute priority</td>
</tr>
<tr>
<td>DESY</td>
<td>1-6.5GeV $e$</td>
<td>&gt; 3 months per year</td>
</tr>
<tr>
<td>Fermilab</td>
<td>1-120GeV $e, h, \mu$</td>
<td>Continuous (5%), except shutdown</td>
</tr>
<tr>
<td>IHEP Protvino</td>
<td>1-45GeV $e, h, \mu$</td>
<td>One month, twice per year</td>
</tr>
<tr>
<td>KEK Fuji</td>
<td>0.5-3.4GeV $e$</td>
<td>From fall 2007, 240 days per year</td>
</tr>
<tr>
<td>SLAC</td>
<td>28.5GeV $e$ (primary)</td>
<td>Parasitic to PepII, non-concurrent with LCLS</td>
</tr>
<tr>
<td></td>
<td>1-20GeV $e, h$ (secondary)</td>
<td></td>
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This list is a couple of years old, being updated at this workshop (see next slide)…
...have to study the options carefully...
Large Prototype TPC
Main objective: Large Prototype (LP) of a TPC.

**Consisting of**
- Field cage
- Readout electronics
- DAQ and Monitoring
- Gas-/HV-system
- Common Software
- SiLC envelope
- End plate
- MPG@ detector modules
- Cosmic/beam trigger

Magnet (PCMAG) + infrastructure
T24 Test beam

**Key:**
- present
- partially missing
- missing
LP Subsystem meeting in Feb-2008
Requirements

• LP needs
  – The detector itself
    • FC 😊
    • Cathode 😊
    • Endplate 😊
    • Amplification panels 😊

Hardware: build together and have a TPC 😊

For details, see talks in alcpg09-tracking session
Wednesday afternoon and Friday morning: Klaus, Hirotoshi, Jan, Aurore, Winfried, Alberto, Steve, Takeshi.
Double GEM

About 3200 channels readout electronics (Altro/Alice)
CERN & Lund

(10000 channels later in 2009)
the idea is known:

Improve the resolution of the Large Prototype TPC by adding a precise measured point of the track (order of 10\u00b5m), inside the gap, between magnet and TPC, on both sides of the TPC.
Next steps, from the LOI:

- 2009-12 Continue R&D on technologies at LP, SP, pursue simulations, verify performance goals.
- 2009-11 Plan and do R&D on advanced endcap; power-pulsing, electronics and mechanics are critical issues.
- 2011-12 Test advanced-endcap prototype at high energy and power-pulsing in high B-field.
- 2013-18 Design and build the LCTPC.

At the beginning of the period 2012-18, the selection must be made from the different technological options – GEM, MicroMegas, resistive anode, pixel, electronics, endcap structure – to establish a working model for the design of the LCTPC. This design will be used for the ILD proposal in 2012 and include pad segmentation, electronics, mechanics, cooling and integration, so that performance, timeline and cost can be estimated reliably. For the technology selection, a scenario could be that questions must be answered as to which options give the best performance based on R&D results from LP, SP, electronics and endcap studies. Main performance criteria could be endcap thickness and $\sigma_{\text{point}}$, double-hit and momentum resolution for single tracks and for tracks in a jet environment. Choice of criteria to use will be decided over the next two years.
FIGURE 4.3-5. (left): Example of resolution results from a small prototype [92] measurements with TDR gas, ArCH$_4$CO$_2$ (96-3-2); other candidate gases are e.g. P$_5$ and ArCF$_4$Isobutane. (Right): Theoretical resolution for ArCF$_4$Isobutane (96-3-1) gas (right), based on an algorithm [79] verified during SP studies.

FIGURE 4.3-6. (Top left): Event display from the LP beam tests. (Top right) View of the Endcap subdivision as used for the Large Prototype. (Bottom left) Conceptual design of enplate for LCTPC. (Bottom right) Possible layout of PCB, electronics and cooling for the LCTPC.
Work plan after validation till 2013

We plan that each validated detector group will produce detailed baseline design by 2012. To this end the following items need to be accomplished.

1. Demonstrate proof of principle on critical components
   When there are options, at least one option should be advanced to a level of maturity which verifies feasibility.

2. Define a feasible baseline design. While a baseline will be specified, options may also be considered.

3. Complete basic mechanical integration of the baseline design accounting for insensitive zones such as the beam holes, support structure, cable, gaps or inner detector material.

4. Develop a realistic simulation model of the baseline design, including identified faults and limitations.

5. Develop a push-pull mechanism, workout the moving procedure, time scale, alignment and calibration scheme in cooperation with the relevant groups.

6. Develop a realistic concept of integration with the accelerator including the IR design.

7. Simulate and analyse updated benchmark reactions with the realistic detector model. Include the impact of detector dead zones and updated background conditions.

8. Simulate and study some reactions at 1 TeV, including realistic higher-energy backgrounds, demonstrating detector performance.

Bottom line:
We LCTPC have to make certain decisions and write them up by the end of 2012…
TPC R&D Priorities

1a) advanced endplate studies (max. 15% X0 including cooling)
1b) continue tests in electron beam for correction procedures
2a) future tests in hadron beam
   a) for momentum resolution
   b) for two-track resolution in a jet environment
2b) powerpulsing/cooling tests, both on LP and SP
3) ion backflow studies:
   a) simulations of ion sheets for Gem, Micromegas
   b) design/test gating device
Design team being set up after discussions at LCTPC collaboration meeting last week

**TPC design/performance discussion at LCTPC collaboration meeting 20090921**

<table>
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<tr>
<th>Overview</th>
<th>Ties Behnke</th>
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**Mechanics design**

---overall mechanics  
  tolerances for alignment  
  field cage  
  advanced endcap  
---overall structure  
  mpdg+gate  
  cooling  

**Electronics**

---sAltro  
  Luciano Musa  
  Magnus Mager  
  Antoine Junike  
  power-pulsing etc  
  Takahiro Fusayasu

**R&D steps(incl. beam)2009-2012**

---LP issues/plans  
  Klaus Dehmelt  
  engineering R&D  
  LOI + more discussion

**How to make technical choices in 2012**

  First ideas in LOI
Table 1: LCTPC R&D Scenarios for Large Prototype and Small Prototypes.

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<th>Device</th>
<th>Lab(years)</th>
<th>Large Prototype R&amp;D</th>
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<tbody>
<tr>
<td>LP1</td>
<td>Dory/Endeavor(2007-2010) Fieldcage+2 endplates: GEM+pixel, Micromegas+pixel</td>
<td>Purpose: Test construction techniques using (~10000) Alto or T2K channels to demonstrate measurement of 6 GeV/c beam momentum over 70cm tracklength, including development of correction procedures.</td>
</tr>
<tr>
<td>LP1</td>
<td>FLorCern/Aida?(fp7)     Fieldcage+2 endplates: GEM+pixel, Micromegas+pixel</td>
<td>Purpose: Continue tests using (10000) Alto or T2K channels to demonstrate measurement of 100GeV beam momentum over 70cm tracklength, in a jet environment and with ILC beam structure using LP1.</td>
</tr>
<tr>
<td>LP2</td>
<td>FLorCern/Aida?(fp7)     Fieldcage+endplate: GEM, Micromegas, or pixel</td>
<td>Purpose: Prototype for LCTPC including gating and other options; demonstrate measurement of 100GeV beam momentum over 70cm tracklength, and in jet environment and ILC beam structure, test prototype LCTPC electronics/PP.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Device</th>
<th>Lab(years)</th>
<th>Small Prototype R&amp;D Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP1</td>
<td>KEK(2007-2009)</td>
<td>Gas tests, gating configurations</td>
</tr>
<tr>
<td>SP2,SP3</td>
<td>FLorCern(2009-2011)</td>
<td>Performance in jet environment</td>
</tr>
<tr>
<td>SPn</td>
<td>LCTPC groups(2007-2012)</td>
<td>Performance, gas tests, dE/dx measurements, continuation of measurements in progress by groups with small prototypes</td>
</tr>
</tbody>
</table>
Possible Magnets

- **PCMAG**
- **Triumf (Twist) Magnet (Madhu Dixit)**
  - 2 T
  - 1m φ, 2.2m length
  - Available?
- **KeK (Amy) Magnet (Takeshi Matsuda)**
  - 3 T
  - 2.4m φ, 1.6m length
  - Available now (in principle)
- **~3 T magnet from CERN?**
Fig. 1. A cross-sectional view of the AMY detector.
Bottom line for testbeam: move LP to hadron beam end of 2010
Conclusions:
None