Introduction for Science Board session

Takuya Hasegawa (KEK)

Goal of WA105 / Dual-Phase ProtoDUNE

Concrete prototyping effort of GLACIER Dual-Phase Liquid Argon TPC towards the envisioned large-scale detectors world wide, and an accompanying campaign of measurements aimed at assessing the systematic errors that will be affecting their intended physics programs based on various detector technologies.

Objectives of WA105 / Dual-Phase ProtoDUNE

Final engineering prototyping toward >10kt Liquid Argon TPC

- <u>Realization of world largest (298t active volume) single cryostat Liquid Argon TPC with GLACIER Dual-Phase Liquid Argon TPC concept</u>
- <u>Demonstration of large scale detector operation with charge signal multiplication, HV, long drift, electronics, non-zero skipping DAQ, on-line processing, etc.</u>
- <u>Demonstration of the measurement performance with accompanying beam test with well defined charged particles</u>
- <u>Assessing the systematic errors that will be affecting their intended physics program with huge detector deep underground operation</u>

Necessary efforts to accomplish the mission

- Prepare for WA105 / Dual-Phase ProtoDUNE measurement
  - Preparation for necessary tools for various study
  - Make appropriate feed back to finalize detector design, and make sure, in time, there is no big issue which potentially impact detector design
- Demonstrate the advantage of GLACIER Dual-Phase Liquid Ar TPC technology

Necessary efforts
to accomplish the mission

- Prepare for WA105 / Dual-Phase ProtoDUNE measurement
  - Preparation for necessary tools for various study

Huge amount of dedicated efforts on light signal simulation have been conducted
• Cathode configuration
• PMT configuration
• etc.

- Demonstrate the advantage of GLACIER Dual-Phase Liquid Ar TPC technology

Necessary efforts
to accomplish the mission

- Prepare for WA105 / Dual-Phase ProtoDUNE measurement
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- etc.

- Demonstrate the advantage of GLACIER Dual-Phase Liquid Ar TPC technology

3m x 1m x 1m measurements
6m x 6m x 6m measurements

- Utilize experimentally validated information by WA105 / Dual-Phase ProtoDUNE as inputs for various subjects

Preparation for WA105 / Dual-Phase ProtoDUNE measurement

Software coordination

- All the necessary codes for 3x1x1 operation including online monitoring processes are functioning well, associated with written description
- All the efforts on 3x1x1, including mock data challenge, are conducted with looking ahead 6x6x6 application
- Code management centralized at CCIN2P3 in Lyon and the production version of codes are maintained at CERN as well
- Massive MC production expected at CCIN2P3 and possible other centers (CCIN2P3 has been utilized for light map production which needs huge amount of CPU)

Effort lead by
Elisabetta Pennacchio (IPNL Lyon)

Software coordination

- All the necessary codes for 3x1x1 operation including online monitoring processes are ... ption
- ... 6x6 application

"Developments and implementation
of the WA105 6x6x6 online storage/processing on the 3x1x1 online storage
and processing small scale test farm"
by Elisabetta Pennacchio (IPNL Lyon)

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Effort lead by
Elisabetta Pennacchio (IPNL Lyon)

General preparation toward 3x1x1 operation

Slow control information interface for WA105Soft
by
Yuriy Onishchuk (Kyiv N. U.)

Explanation of Cosmic Ray Tagger
by
Igor Kreslo (U. Bern)

Charge signal simulation and reconstruction

- Simulation
  - Ready for use for both 6x6x6 and 3x1x1 detectors
  - Refinement such as introducing LEM boundary effects are on going
  - Cosmic/Beam Halo background simulation are prepared
- Reconstruction and related benchmarking tools necessary for 6x6x6 online monitoring processes are being finalized
  - Hit finding
  - Tracking
  - Good cosmic selection

  (For instance for purity/signal_uniformity monitoring)

  *tools for 3x1x1 is ready

Effort lead by

Philippe Cotte (CEA/Saclay)
Elisabetta Pennacchio (IPNL Lyon)
Vyacheslav (Slavic) Galymov (IPNL Lyon)
Laura Zambelli (LAPP Annecy)

Charge signal simulation and reconstruction

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  - Ready for use for both 6x6x6 and 3x1x1 detectors
  - ...ts are

"Charge signal simulation and reconstruction for 3x1x1 and 6x6x6"
by Vyacheslav (Slavic) Galymov (IPNL Lyon)

  - Cosmic/Beam Halo background simulation are prepared

"Simulation of the effect of LEM borders, screw holes, and HV connectors on charge collection efficiency"
by Philippe Cotte (CEA/Saclay)

- F... y
  f... d
  - Hit finding
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Light signal simulation and reconstruction

- Simulation
  - Restructuring and improvement of light map production code has been conducted and revised light map is ready
    (Need S1/S2 calibration with experimental measurement by 3x1x1 detector)
  - Analytical approach on photon propagation is examined toward DUNE far detector
- Reconstruction
  - Work for cosmic ray tagging is on going

Effort lead by

Isabelle De Bonis (LAPP Annecy)
Anne Chappuis (LAPP Annecy)
Jaime Dawson (APC Paris)
Dominique Duchesneau (LAPP Annecy)
Vyacheslav (Slavic) Galymov (IPNL Lyon)
Thomas Patzak (APC Paris)
Alessandra Tonazzo (APC Paris)
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"Light signal simulation for 6x6x6"
by Anne Chappuis (LAPP Annecy)

"Cosmic ray tagging with light signal and measurements of scintillation pulse shape at 6x6x6"
by Thomas Patzak (APC Paris)

Effort lead by

Isabelle De Bonis (LAPP Annecy)
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Space charge effect

- Field calculation with COMSOL is set up
- Field map for 6x6x6/3x1x1detectors are available and implemented in WA105Soft
- In case of utilizing field map, diffusion/attenuation are dealt with coherently
- Attempt to evaluate space charge effect has started

Effort lead by

Hiroki Konari (Iwate U.)
Alessandra Tonazzo (APC Paris)
Laura Zambelli (LAPP Annecy)

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“Status of space charge simulation/evaluation method”
Laura Zambelli (LAPP Annecy)

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Hiroki Konari (Iwate U.)
Alessandra Tonazzo (APC Paris)
Laura Zambelli (LAPP Annecy)

Demonstration of the advantage of GLACIER Dual-Phase Liquid Ar TPC

Significant features of GLACIER Dual-Phase Liquid Ar TPC

- High signal to noise ratio, low energy threshold

  (Robust to purity, diffusion and noise conditions)

  - Provided by signal multiplication (adjustable gain) by LEM
  - Provided by proper handling of detector capacitance (anode and short cable)
- High and equal quality 3.125 mm pitch two views readout anode

  (Gives less ambiguous information toward event reconstruction)

  - Provided by avoiding induction plane
- Free from micro-phonic noise (induced by anode wire movement)
  - Provided by rigid structure of read out anode plane
- Good containment of events within uniform media without any dead material
  - Provided by long drift distance (thanks to good S/N)
  - Provided by mostly seamless readout anode plane
- Steady maintainability of the readout eletronics system

  (Accessible and replaceable electronics system located outside of cryostat)

  - Provided by upward direction of the drift charge
- High fiducial_volume/cavern_volume ratio, Reduced no. of readout channel
  - Provided by detector configuration and installation sequence

Significant features of GLACIER Dual-Phase Liquid Ar TPC

- High signal to noise ratio, low energy threshold

  (Robust to purity

  Obvious advantage for low energy measurement
  e.g. Second oscillation max/min, Supernovae neutrino

  - Provided by s
  - Provided by proper handling of detector capacitance (anode and short cable)

- High

  Surely beneficial to all the interested physics cases,
  Accelerator based long baseline neutrino experiments
  Proton decay search / Atmospheric neutrino measurements
  Supernovae neutrino detection & solar neutrino measurements

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  - Pr
- Free f
  - Provided by rigid structure of read out anode plane
- Good containment of events within uniform media without any dead material

  Data quality limitation enforced by hardware
  will never be recoverable by analysis software

  - Provided b
  - Provided b
- Steady maintainability of the readout eletronics system

  (Accessible and replaceable electronics system located outside of cryostat)

  Potentially big impact on overall project cost and sustainability

  - Pro
- High fiducial_volume/cavern_volume ratio, Reduced no. of readout channel
  - Provided by detector configuration and installation sequence

Demonstration with WA105Soft

Students from Iwate University have started performance evaluation

- Calorimetric response for single particle ($e/\gamma/\mu/\pi^{\pm}/\pi^{0}/p/K/$ from a few MeV to a few GeV)
- Signature of particle decay
  - $\pi^0 \rightarrow \gamma\gamma$
  - $\mu \rightarrow e\nu\nu$
  - $\pi \rightarrow \mu\nu$
  - $K \rightarrow \mu\nu$,etc.
  - $p \rightarrow k\ \nu$
  - $p \rightarrow e^{+}\pi^{0}$
- Signature of neutrino interaction

DUNE Dual-Phase detector simulation in LArSoft

“Implementation of dual-phase technology to LArSoft, and reconstruction efficiency in Far Detecctor”
Christoph Alt (ETHZ)

“Calorimetric reconstruction in Far Detector”
Andrea Scarpelli (APC Paris)

Effort lead by

Christoph Alt (ETHZ)
Vyacheslav (Slavic) Galymov (IPNL Lyon)
Elisabetta Pennacchio (IPNL Lyon)
Andrea Scarpelli (APC Paris)
Dorota Stefan (CREN/NCBJ)
Robert Sulej (FNAL/NCBJ)

Tasks of Science Board in coming months

Top priority in coming months

- Conduct analysis of 3x1x1 data
- Write papers accordingly

- The paper can be structured into 2 main parts (see also file in attachment):

Performance of the WA105 LAr-proto ($3x1x1\ m^3$) dual-phase liquid argon Time Projection Chamber

Skelton of first analysis paper prepared by leaders of editorial team
Elisabetta Pennacchio (IPNL Lyon)
Mario Campanelli (UCL)
https://indico.fnal.gov/getFile.py/access?contribId=4&resId=0&materialId=slides&confId=13081
https://indico.fnal.gov/getFile.py/access?contribId=4&resId=1&materialId=slides&confId=13081

Contents

1 Description of the detector operative conditions and of its characterization

2 Analysis of muon cosmic data

In parallel, continue to

- Prepare for 6x6x6
- Demonstrate the advantage of GLACIER Dual-Phase Liquid Ar TPC technology