



# Time Projection Chamber

**Andrew Thompson Werner**



## **Time Projection Chamber:**

*Large Time Projection Chambers for Rare Event Detection*, 2009 The Time Projection Chamber TPC concept add ref to TPC section has been applied to many projects outside of particle physics and the accelerator based experiments where it was initially developed TPCs in non accelerator particle physics experiments are principally focused on rare event detection e.g neutrino and darkmatter experiments and the physics of these experiments can place dramatically different constraints on the TPC design only extensions to the traditional TPCs are discussed here The drift gas or liquid is usually the target or matter under observation and due to very low signal rates a TPC with the largest active mass is desired The large mass complicates particle tracking of short and sometimes very low energy particles Other special design issues include efficient light collection background rejection internal triggering and optimal energy resolution Backgrounds from gamma rays and neutrons are significant design issues in the construction of these TPCs They are generally placed deep underground to shield from cosmogenic particles and surrounded with shielding to reduce radiation from the local surroundings The construction materials have to be carefully screened for radiopurity as they are in close contact with the active mass and can be a significant source of background events The TPC excels in reducing this internal background because the mass inside the field cage forms one monolithic volume from which fiducial cuts can be made ex post facto to isolate quiet drift mass and can be circulated and purified to a very high level Self shielding in these large mass systems can be significant and the effect improves with density The liquid phase TPC can obtain a high density at low pressure which results in very good self shielding and compact installation with a lightweight containment The down sides are the need for cryogenics slower charge drift tracks shorter than the typical electron diffusion lower energy resolution e.g xenon and limited charge readout options Slower charge drift requires long electron lifetimes placing strict limits on the oxygen and other impurities with high electron affinity A significant variation of the liquid phase TPC that improves the charge readout is the dual phase TPC where a gas phase layer is formed above the liquid into which the drifting electrons are extracted and amplified typically with electroluminescence The successful transfer of electrons through the phase boundary requires careful control of its position and setting up an appropriate electric field A high pressure gas phase TPC has no cryogenics and density is easily optimized for the signal but a large heavy pressure vessel is required Although shelf shielding is reduced it can in some cases approach that of the liquid phase in xenon at 50atm the density is about half that of water or about 1/6 of liquid xenon A significant feature of high pressure xenon gas is the energy resolution Below a density of about 0.5g/cc the intrinsic resolution is only a few times that of high purity germanium A neutrino less double beta decay  $0\nu 2\beta$  TPC operated below this density limit could enjoy excellent energy resolution and maintain particle tracking for background rejection An observable interaction with the TPC results in a charged particle that travels in the drift matter exciting and ionizing the atoms until the initial energy is converted into ionization scintillation or heat with relatively large fluctuations around a mean distribution Rare

event TPCs can be designed to detect scintillation light as well as charge to exploit the anti correlation to improve energy resolution and or signal to noise An electric drift field separates the electrons and positive ions from the ionization although the separation is not complete and some electrons are captured exciting atoms and releasing more light than the primary excitation alone The average partition between the scintillation and ionization can be manipulated to increase the ionization at a loss of scintillation by a number of methods such as increasing the strength of the electric field up to a saturation of the ionization yield increasing the temperature to enhance the diffusion of the ionized electrons and adding dopants such as triethylamine that can be photoionized by the scintillation photons releasing more ionization Scintillation light is typically collected with photomultiplier tubes PMTs and avalanche photo diodes APDs although any fast compared to the ionization drift speed light collector capable of detecting the typically UV photons maintaining high radiopurity and perhaps withstanding pressure would work CCDs are slow and therefore only record 2 dimensions integrating over the time direction some of which can be recovered with a few PMTs

**Instrumentation in High Energy Physics** Fabio Sauli, 1992 This volume contains topical papers covering the various aspects of instrumentation in high energy physics The subjects of the contributions all previously unpublished have been chosen to provide an overview of the fundamental processes and of the technological problems encountered in detecting tracking and identifying charged and neutral particles in modern particle physics experiments Each contribution offers a concise but complete description of the state of the art regarding the subject and is addressed to post doctoral and research staff readers it will also be found useful as a teaching aid for students and participants in specialized schools and workshops on intermediate and high energy experimental physics

*Studies with a Liquid Argon Time Projection Chamber* Michael Schenk, 2015-04-02 Michael Schenk evaluates new technologies and methods such as cryogenic read out electronics and a UV laser system developed to optimise the performance of large liquid argon time projection chambers LArTPC Amongst others the author studies the uniformity of the electric field produced by a Greinacher high voltage generator operating at cryogenic temperatures measures the linear energy transfer LET of muons and the longitudinal diffusion coefficient of electrons in liquid argon The results are obtained by analysing events induced by cosmic ray muons and UV laser beams The studies are carried out with ARGONTUBE a prototype LArTPC in operation at the University of Bern Switzerland designed to investigate the feasibility of drift distances of up to five metres for electrons in liquid argon

*The Origins and Evolution of the Time Projection Chamber (TPC) Idea*, 2012 In February 1974 I conceived an idea for a tracking detector with only one spatial projection thereby eliminating ambiguities that occur in conventional detector systems based on wires I called it the Time Projection Chamber or TPC a name that has stuck even though the concept has evolved considerably over the following decades I will recount the history leading to its conception and development in that now distant epoch and will attempt to show why this is an interesting and instructive story and how the idea may continue to extend scientific reach in the coming era

*Introduction to Liquid Argon Time Projection Chamber*

*Operation and Calibration Methods* Kelley Ruhn, 2022 Neutrinos are an interesting type of particle that could provide insight to unanswered questions such as the imbalance of matter and antimatter in the universe However they re difficult if not impossible to detect directly Modern particle physics experiments build detectors called Liquid Argon Time Projection Chambers LArTPCs that detect the products of neutrino interactions Due to various processes that take place within the detector the data that comes out of these detectors ends up being distorted various calibration techniques are necessary to ensure that the data is accurate and undistorted All of these aspects of LArTPCs are complex on their own let alone when they are all occurring in tandem In this paper I will describe the basic principles behind LArTPC operation and data collection and the calibration techniques that are carried out in the detector I will also provide a brief comparison of various data from several of the more recent LArTPC experiments This description of basic principles may prove useful to people who are familiarizing themselves with LArTPC experiments as part of their research endeavors Particle Detectors Claus Grupen, Boris Shwartz, 2023-07-27 This book is a reference on particle detectors for graduate students and researchers in particle physics **Techniques for Nuclear and Particle Physics Experiments** William R. Leo, 2012-12-06 Not quite six years have passed since the appearance of the first edition of this book This is not a long period Yet the rapid pace of scientific and technological development today is such that any book on experimental technique must be wary of becoming obsolete in some way or another even in such a short span of time Thus when the publisher Springer Verlag informed me of the need for a new printing of this book I decided it was an opportune moment to update some of the chapters as well as to include some new material The result is this second edition The most notable changes have been in Chapters 2 and 3 In the latter which concerns radiation protection most of the sections have been rewritten to take into account the new recommendations from the International Commission on Radiation Protection the most important of which are the new dose limits for exposure to ionizing radiation In addition emphasis has now been put on the use of SI units in dosimetry i e the Gray and Sievert which have now become standard **Triggering the LBL Time Projection Chamber**, 1981 A fast digital trigger was built for the LBL Time Projection Chamber TPC installed in the PEP 4 detector at SLAC The TPC is an innovative High Energy Physics detector which will provide particle identification from dE/dx information within the tracking volume The TPC trigger uses discriminator signals from 2220 dE/dx wire channels to require a track of ionization in the TPC which originates from the colliding beam intersection region The trigger processing is performed as the ionization drifts onto the proportional wires and is completed 17 ns after beam crossing This report describes the basic operation of the TPC detector and its trigger a pretrigger which uses prompt TPC information from the endcap region and the electronic implementation The trigger can be tested with realistic simulated patterns of ionization deposits in the TPC which are stored in local memories Test results from electronic simulations and first results of a test with cosmic rays are shown *Energy Research Abstracts*, 1986 *High Energy Physics Index*, 1990 *A Self-triggered Readout for a Time Projection Chamber*

Andrew Thompson Werner,2004 A self triggering readout for a time projection chamber TPC is presented with applications to novel forms of data acquisition for high energy physics application The construction and initial testing of the readout electronics are described as well as the readout implementation in a prototype drift chamber Tracking and range information for 800 alpha particle events is compared with theory as a preliminary confirmation of correct readout operation **A GEM Based Time Projection Chamber with Pixel Readout** Christoph Brezina,2013 *Electroweak Effects at High Energies* Harvey B. Newman,2013-06-29 The first Europhysics Study Conference on Electroweak Effects at High Energies was held at the Ettore Majorana Centre for Scientific Culture in Erice Sicily from February 1 12 1983 The conference was attended by 61 physicists from 11 countries The conference was sponsored by the European Physical Society the Italian Ministry of Public Education the Italian Ministry of Technological Research the Sicilian Regional Government and the California Institute of Technology CONFERENCE FORMAT The Study Conference followed a new intensive format in which the state of our knowledge of the electroweak interaction and the relation of the electroweak sector to Grand Unified and Superunified Theories was reviewed in some depth During the two week conference 54 experimental and theoretical talks were presented and four evening discussion sessions were held The Erice surroundings the wide ranging conference program and the fact that nearly all of the participants were directly involved in recent major experimental or theoretical developments led to animated and very friendly discussions Participants had the rare opportunity to view most of the major trends in high energy physics in a short interval of time and to discuss and contemplate the trends in the uniquely peaceful yet stimulating atmosphere which is an Erice tradition INIS Atomindex ,1987 Nuclear Fission Patrick Talou,Ramona Vogt,2023-01-01 This book provides advanced students and postdocs as well as current practitioners of any field of nuclear physics involving fission an understanding of the nuclear fission process Key topics covered are fission cross sections fission fragment yields neutron and gamma emission from fission and key nuclear technologies and applications where fission plays an important role It addresses both fundamental aspects of the fission process and fission based technologies including combining quantitative and microscopic modeling **Quark Matter** Helmut Satz,Hans J. Specht,Reinhard Stock,2012-12-06 From the Editors Preface Quark Matter 1987 was attended by about 250 scientists representing 75 research institutions around the world the scientific community engaged in experimental and theoretical studies of high energy nuclear collisions The central theme of the meeting was the possibility of achieving extreme energy densities in extended systems of strongly interacting matter with the ultimate aim of creating in the laboratory a deconfined state of matter a state in which quarks and gluons attain the active degrees of freedom High energy accelerator beams and cosmic radiation projectiles provide the experimental tools for this endeavour on the theoretical side it is intimately connected to recent developments in the non perturbative study of quantum chromodynamics Phase transitions between hadronic matter and quark gluon plasma are of basic interest also for our understanding of the dynamics of the early universe A very special feature of this Sixth Quark

Matter Conference was the advent of the first experimental results from dedicated accelerator studies These were conducted during 1986 87 at the AGS of Brookhaven National Laboratory and at the CERN SPS An intense discussion of these data formed the main activity of the meeting **The Time Projection Chamber** J.A. Macdonald,1984 *Some TPC (Time Projection Chamber) Measurements in an Oxygen Beam at the AGS.* ,1988 The principal detector for AGS Experiment 810 is a Time Projection Chamber TPC in which it is intended to measure momenta and angles of a major fraction of the charged particles from each light ion collision This report describes the results of a test of a prototype of the TPC in a beam of  $14.6 \times 16.2336$  GeV c oxygen ions run in June of this year **Application of Accelerators in Research and Industry** Floyd D. McDaniel,Barney L. Doyle,2009-04-03 All papers have been peer reviewed The conference brings together scientists and physicians from universities national laboratories research institutes and industry worldwide who use particle accelerators in their research medical and industrial applications The topics presented at the conference included accelerator technology and applications atomic nuclear physics national and homeland security ion beam analysis modifications medical applications radioisotopes radiation effects teaching with accelerators nano scale fabrication focused ion beams and PIXE

*Liquid-Argon Time Projection Chambers in the U.S.* ,2009 Liquid Argon Time Projection Chamber LAr TPC detectors are ideally suited for studying neutrino interactions and probing the parameters that characterize neutrino oscillations The ability to drift ionization particles over long distances in purified argon and to trigger on abundant scintillation light allows for excellent particle identification and triggering capability Recent U S based work in the development of LAr TPC technology for massive kiloton size detectors will be discussed in this talk including details of the ArgoNeuT Argon Neutrino Test test beam project which is a 175 liter LAr TPC exposed to Fermilab s NuMI neutrino beamline

## **Time Projection Chamber** Book Review: Unveiling the Magic of Language

In an electronic era where connections and knowledge reign supreme, the enchanting power of language has become more apparent than ever. Its ability to stir emotions, provoke thought, and instigate transformation is actually remarkable. This extraordinary book, aptly titled "**Time Projection Chamber**," written by a highly acclaimed author, immerses readers in a captivating exploration of the significance of language and its profound effect on our existence. Throughout this critique, we will delve into the book's central themes, evaluate its unique writing style, and assess its overall influence on its readership.

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