Dr. MICHAEL L. MALLARY, Ph.D., IEEE Fellow

Position Sought Consulting on magnetic recording, magnetic systems, optics, and physics

Degrees Ph.D. California Institute of Technology, 1972, High Energy Physics
S.B. Massachusetts Institute of Technology, 1966, Physics

Major Career Accomplishments

Awarded 158 issued patents
Published 55 technical publications
Awarded the 2013 IEEE Magnetics Society Achievement Award
Invented the Shielded Pole perpendicular write head which is in all disk drives (USPat. #4,656,546)
Conceived of Lower Bit Aspect Ratios for higher capacity disk drives (see publications [15] & [22])
Invented the Diamond inductive head (more than 40,000,000 shipped, USPat. #5,184,267)
Invented spherical aberation correction for 2 Photon Recording on thick media (USPat. #7,593,305)

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EXPERIENCE

Senior Technologist, Western Digital Corporation, San Jose, Ca., 2009 to 9/27/13
- Led the Microwave Assisted Magn. Rec. project which produced Spin Torque Oscillators and did micromagnetic simulations that predicted 3Tb/in^2 (patents pending, USPat. #8,456,967 & [2])
- Worked with the HAMR team to improve performance and reliability (patents pending)
- Developed and used code for Two Dimensional Magnetic Recording (patents pending)
- Used SPICE model to analyze reader electronic signal/noise to extend TuMR (patent pending)

Principal Technologist, Seagate Technology, Pittsburgh, Pa., 2006 to 2009
- Performed HAMR FDTD optical simulations of NFTs and did FEM simulations of write poles
- Initiated the investigation of gold alloys for NFT reliability
- Studied recessed poles for reduced negative field gradient in HAMR [4]
- Initiated analytic studies of NFT temperature rise resulting in an effective heat sinking design
- Participated in HAMR head reliability studies and testing in dry N_2 (USPat. #6,765,379)
- Performed micromagnetic and FEM simulations of Shingled Magnetic Recording
- Led the 2 Photon Volumetric Optical Recording project using pulsed Blue Ray lasers
- Invented spherical aberration compensator for thick 2 photon media (USPat. #7,593,305)

Senior Member of Technical Staff, Maxtor Corporation, Shrewsbury, Ma., 2001 to 2006
- Led the theory group on the development and productization of Perpendicular Recording
- Coached vendors on manufacturing the Shielded Pole head (USPat. # 4,656,546 & see below)
- Did experiments on the performance and reliability of drives including thermal fly height adjustment ([13], USPats.#7,310,194, #7,362,534, #7,403,356, #7,477,470)
- Submitted many Shielded Pole patents to protect expiring IP (USPats. #6,813,106, #6,842,313, #7,075,756, #7,511,921, #7,573,683, #7,620,722, #7,732,069, #7,729,092, and #8,365,393)
- Explained observed high speed writer switching with spin wave damping [5], [6], [8], & [16]

Quantum Fellow, Quantum Corporation & MKQC, Shrewsbury, Ma., 1994 to 2001
- Led theory group in predicting the 1Tb/in^2 Perpendicular Magnetic Recording density limit [14]
- Conducted experiments and theoretical studies of thermal stability
- Initiated the National Storage Industry Consortium advocacy of low bit aspect ratios for higher data density with a presentation at an Extraordinarily High Density Recording meeting[15] & [22]
- Experiemtally and theoretically verified Sharrock's law from 270 hours down to 0.4 ns [7] & [20]
- Program Committee & Session Chair for 1997 Intermag &1999, 2000, 2001, 2002 MMM Conf.
- Wrote the heads chapter in "The Physics of Ultra High Density Magnetic Recording" [15]

- Performed FEM of write poles and micromagnetic analysis of the write and read processes
- Invented an on disk log file architecture for high performance Shingled Magnetic Recording
- Invented asperity avoiding system features for improved head reliability (USPat. #6,567,229)
- Consulted on Terastor HAMR design (USPats. #6,236,513, #6,351,436, and #6,430,123)

Senior Consultant Engineer, Digital Equipment Corporation, Shrewsbury, Ma., 1980 to 1994

- Invented, proved (with analytic calculations and customized FEM code), fabricated, and patented (#4,656,546) the Shielded Pole write head which is used in every disk drive today
- Invented the Diamond head which doubles the number of effective turns with 2 yoke turns through the coil,(>40,000,000 shipped, USPats. #5,184,267, #5,195,005, and #5,267,112)
- Invented variable track and bit density in drives (USPats. #6.957,379 and #6,966,225)
- Invented the standard P2 masking of P1 for the track trimming process (USPat. #5,267,112)
- Chaired the $12,000,000 NSIC ATP10Gb/in^2 Heads Project during the proposal phase
- Conceived of rotational flux conduction without wall motion (TFHs work at high frequency [34])
- Conceived of and proved the flux beaming phenomena in uniaxial magnetic materials [33]
- Led the Thin Film Head theory group
- Was Program Committee member & Session Chair for the 1986 & 1988 Intermag Conferences
- Led the effort to identify the source and eliminate magnetic erasure in the R82 disk drive

Senior Research Engineer, Magnetic Corporation of America, Waltham, Ma., 1978 to 1980

- Designed superconductive and conventional magnets for: Magneto Hydro Dynamic power generation; Magnetic Resonance Imaging; Magnetic Separation; Energy Storage; and Free Electron Lasers
- Wrote an accepted DOE proposal for a 5 ton/hr Magnetic Separator to reduce sulfur in coal
- Conducted experiments in magnetic separation of coal, copper, gold, and kaolin clay
- Invented an inexpensive magnetite based ferrofluid activated by AC magnetic fields
- Invented an inductive particle separator for recycling nonmagnetic metals
- Invented a high discharge rate superconducting magnetic energy storage system

Assistant Professor, Northeastern University Physics Department, Boston, Ma., 1974 to 1978

- Wrote and used code for Montecarlo simulations supporting the Fermi Lab proposal for experiments 439 which found early evidence for the 5th quark and analyzed the data
- Built a 300 ton solid iron magnets for experiments 365 and 439
- Taught courses in electronics and wave/resonance phenomena

Research Associate, Rutherford High Energy Research Laboratory, Oxfordshire, U.K., 1972 to 1974

- Designed shielding for a large magnetic spectrometer.
- Designed the optical systems for the spark chambers of a CERN experiment
- Wrote pattern recognition software in 3D for analyzing digitization of spark chamber images.

LIST OF PATENTS (**110** issued U.S. patents, **2** Reissues, and >**48** issued foreign patents which are not listed)

9,042,058 – Shield Design for Middle Shields in a Multisensor Array, 5/26/15
9,034,492 – Sys. & Method for Controlling Damping of Magn. Media for Heat Assisted Magn. Rec., 5/19/15
8,995,086 - Write Head with Floating Side Shields and Enhanced Magnetic Potential, 3/31/15
8,929,180 - EAMR device having laser driving signal & magnetic write signal sharing same ele.cond. 1/6/15
8,923,102 - Optical grading coupling for interferometric wave guide in Heat Assisted Magn. Rec. 12/30/14
8,917,581 - Self-anneal process for a near field transducer and chimney in a HDD assembly, 12/23/14
8,908,330 - Spin torque oscillator for MAMR with optimal geometries,12/9/14.
8,891,207 - Connection scheme for a multiple sensor array usable in 2DMR, 11/18/2014.
8,675,455 - Systems and methods for controlling light phase difference in …, 3/18/14
8,658,292 - System & method for controlling damping of magnetic media for assisted magn. rec.., 2/25/14.
8.649,249 - Printing magnetic pattern onto disk, 2/11/14
8,605,382 - Disk Drive to Load a Head to a load/unload (LUL) zone of .. 12/10/13
8,599,653 - System and methods for reducing condensation along a slider, 12/3/13
8,462,463 - Write fringing reduction for recording media, 6/11/13.

8,456,967 - System & Method for Providing a Pole Pedestal for Microwave Assisted Magn. Rec., 6/4/13.
8,365,393 - Manufacturing Method for Write Heads with Floating Side Shields, 2/5/13
8,243,389 - Write Fringing Reduction for Recording Media, 8/14/12.
8,077,417 - Skip Block Writing for Bit Patterned Media, 12/13/11.
7,880,999 - Magnetic Storage System with Read During Write,2/1/11
7,876,529 - Rec. Disk with AF Coupled multi-Layer FM Isl. Disposed in Trench Bet. Discrete Tracks,1/25/11
7,835,099 - Method and System for Error Checking in Bit Patterned Media , 11/16/10
7,796,358 - Method and Apparatus for Eliminating Spike Noise in a Soft Magnetic Under-layer, 9/14/10.
7,782,574 - Magn. Heads Disk Dr. & Method with Thicker Read Shields for Red. Stray Field Sens., 8/24/10.
7,732,069 - Thin SUL Media with Shielded Pole Head, 6/8/10.
7,729,092 - Shielded Pole Writer Under Reader, 6/1/10
7,706,109 - Low Coefficient of Resistivity on Slider Tunneling …4/27/10.
7,688,544 - Magnetic Heads, Disk Drive, and Method with Floating Pole Tip … 3/30/10.
7,663,840 - Storage Apparatus having a Recording Medium with a Thermal Insulation Barrier, 2/16/10.
7,656,619 - Magn. Head Slider for Disk Drives having Heating Ele. and Ped. in Thk Undercoat Layer ,2/2/10
7,620,772 - Method & Structure for Dyn. Data Den. in a Dyn. Mapped Mass Storage Device, 11/17/09.
7,618,721 - Master for Printing Servo Patterns, 11/17/09.
7,593,305 - Remove Spherical Aberrations for 2 Photon Recording, 9/22/09.
7,589,936 - Center Tapped Write Coil .. 9/15/09.
7,573,683 - Write Head with Floating Side Shields… 8/11/09.
7,573,674 - Storage Disk having increased Damping Characteristics and Manufacturing Methods 8/11/09.
7,515,371 - Channel Postamble Extension to De-gauss Pole Tips , 4/7/09
7,511,921 - B2 – Read&Write Head with a Portion of the Write Coil Distributed about the Write Pole,3/31/09.
7,509,728 - Method for Adjusting Head-to-Disk Spacing in a Disk ,3/31/09.
7,477,470 - Controlling Head Fly Height Based on Head Heater Resistance, 1/13/09
7,430,095 - Tapered Write Pole for Reduced Skew Effect, 9/30/08.
7,403,356 - Disk Drive Having Slider Mover with Low Thermal Coefficient of Resistivity, 7/22/08.
7,375,915 - Disk Drive that Varies Power to a Transverse Mover During Disk Drive Operation, 5/20/08
7,372,664 - Tech. to Red. Adj.Trk Eras. Incl. a Write Pole with a Tip Having Faces at Angeles,5/13/08.
7,362,534 - System for Detecting a Change in Head to Disk Contact Status in a Disk Drive, 4/22/08.
7,324,304 - Tapered Write Pole for Reduced Skew Effect, 1/29/08.
7,310,194 - System for Monitoring& Dynamically Head to Disk Spacing in a Disk Drive,12/18/07.
7,292,414 - External Coil Bias for Giant Magneto-Resistive Sensor, 11/6/07.
7,289,302 - On Slider Inductors and Capacitors to Reduce Electrostatic Discharge Damage, 10/30/07.
7,234,227 - Method for Centering Disks in a Magn, Disk Assembly, 6/6/07.
7,230,790 - Magn. Disk Drive with Servo Bursts and Alternating Magn. Pol. Regions there between, 6/12/07
7,184,241 - Disk Drive that Performs Cold Writes to Erase Buffer, 2/27/07
7,182,844 - Lactose Test Apparatus, 2/27/07
7,161,755 - Increasing Areal Density in Magnetic Recording, 1/27/07
7,149,045 - Longitudinal Media with Soft Underlayer, 12/12/06
7,075,756 - Shielded Pole Writer, 7/11/06
6,966,225 - Capacitive Accelerometer with Liquid Dielectric, 11/22/05.
6,957,379 - Method and Apparatus for Selecting Storage Capacity of Data Storage Media, 10/18/05
6,950,277 - Concave Trailing Edge Write Pole for Perpendicular Recording, 9/27/05
6,842,313 - Floating Down Stream Perpendicular Write Head Shield, 1/11/05
6,813,106 - Premagnetization Process for Printed Longitudinal Media, 11/2/04.
6,765,379 - Method and Device for Testing Disk Drive Head while Directing Gas Across the Head – 7/20/04.
6,567,229 - Avoiding Asperities on a Storage Media – 5/20/03
6,430,123 - Scanning Micropatterns on an Optical Media - 8/6/02.
6,359,757 - Electrostatic Actuator 3/19/02.
6,359,744 - Reduced Thermal Decay of Data Signals Recorded on Magnetic Media 3/19/02.
6,351,436 - Field Enhancing Magnetic Pole for Magneto-Optic Recording and Reproduce Devise, 2/26/02.
6,307,719 - Suspension Assembly with Adjustable Gram Load, 10/23/01
6,236,513 - Integrated Objective Solid/Immersion Lens for Near Field Recording,5/22/01.
5,959,814 - Magnetic Disk Having Separate Park and Take-Off Zones,9/28/99.
5,940,253 - Laminated Plated Pole Pieces for Thin Film Magnetic Transducers, 8/17/99.

5,830,587 - Magnetic Devices with Enhanced Poles, 11/3/98
5,805,392 - Laminated Plated Pole Pieces for Thin Film Magnetic Transducers, 9/8/98
5,801,910 - Long Saturation Zone Magnetic Write Head, 9/1/98.
5,724,212 - Method and Apparatus for Increasing Data Den. in Magn. Data Storage Disk Drives 3/3/98.
5,654,854 - Long. Biased MR Sensor Having a Concave Shape ..., 8/5/97.
5,571,573 - Magnetic Device with Enhanced Poles, 11/5/96
5,431,969 - Method of Making Magnetic Media for Longitudinal Rec.,7/11/95.
5,428,893 - Transducer with Improved Inductive Coupling, 7/4/95.
5,428,887 - Method of Making a Trans. with Improved Ind. Coupling, 7/4/95.
5,384,680 - Perpendicular Anisotropy in Thin Film Devises, 1/24/95.
5,333,086 - Thin Film 2 Pole Ind. Head with Min. Secondary Pulses,7/26/94.
5,314,596 - Process for Fab. Mag. Film Rec. Heads for Use with...,5/24/94.
5,311,387 - Three Pole Magnetic Recording Head, 5/10/94.
5,311,386 - Transducer with Improved Inductive Coupling, 5/10/94.
5,267,112 - Thin Film Read/Write Head for Min. Erase Fringing and Method for Making the Same, 11/30/93.
5,240,740 - Thin Film Head with Minimized Secondary Pulses, 8/31/93.
5,229,901 - Side by Side Read/Write Heads with Rotary Positioner, 7/20/93.
5,226,966 - Apparatus for Prov. Uniaxial Ani. in Mag. Rec. Disk, 7/13/93.
5,195,005 - Transducer with Improved Inductive Coupling,(2XDiamond)3/16/93
5,193,039 - Permanent Magnet Easy-Axis Biased MagnetoResistive Head,3/9/93
5,184,267 - Transducer with Improved Inductive Coupling, ("Diamond") 2/2/93.
5,176,965 - Magnetic Medium for Longitudinal Recording,1/5/93.
5,157,570 - Mag. Pole Config. for High Den. Thin Film Rec. Head, 10/20/92.
5,147,679 - Method for Prov. Uniaxial Ani. in Mag. Rec. Disk, 9/15/92.
5,134,535 - Architecture for a Thin Film Magnetic Recording Head, 7/28/92.
5,111,352 - Three-Pole Magnetic Head with Reduced Flux Leakage, 5/5/92.
5,108,837 - Laminated Poles for Recording Heads, 4/28/92.
5,103,553 - Method of Making a Magnetic Recording Head, 4/14/92.
5,095,613 - Thin Film Head Slider Fab. Process, 3/17/92(Re 35,477-3/18/97).
5,089,334 - Flux Spreading Thin Film Magnetic Devices, 2/18/92.
5,085,935 - Flux Spreading Thin Film Magnetic Devices, 2/18/92.
4,935,832 - Recording Heads with Side Shields, 6/19/90.
4,931,886 - Apparatus and Method to Suppress Perpendicular Fields in Longitudinal Recording, 6/5/90.
4,912,584 - Method for Fabricating Magnetic Recording Poles, 3/27/90.
4,907,113 - Three-Pole Magnetic Recording Head, 3/6/90.
4,828,966 - Method for Producing a Hall Effect Sensor for Magnetic Recording Heads, 5/9/89.
4,695,351 - Method for Producing Magnetic Heads, 9/22/87.
4,656,546 - Vertical Magnetic Recording Arrangement, 4/7/87. Re 33,949 6/2/92. (**Shielded Pole head**)

PUBLICATIONS LIST (authored and co-authored a total of **55** technical publications)

Data Storage Publications (34)

[0] Damping in composite perpendicular recording media", *Appl. Phys. Lett.* (Under review).

[1] Atomistic Simulation for Thermal Switching Distribution of FePt Grains, accepted for publication in APL .

[2] Head and Media Challenges for 3 Tb/in^2 Microwave Assisted Magnetic Recording, IEEE TransMagn.,Vol 50, No.7,p1-8, July 2014.

[3] Observation of Microwave-Assisted Magnetization Reversal in Perpendicular Recording Media *Appl. Phys. Lett.* **103**, 042413 (2013).

[4] Effect of Gradient Alignment in Heat Assisted Magnetic Recording, JAP105, 07B905 (2009).

[5] Perpendicular Recording Write Process Modeling Issues, JMMM, Vol 321, No. 6, p566-571, March 2009.

[6] Perpendicular Magnetic Recording Write Head Design, Special Issue of International Journal of Product Development on "Advances in Data Storage Systems and Technology", Vol. 5 , No.3/4, Jan-March, 2008.

[7] Measurement of Subnanosecond Longitudinal Media Switching, IEEEE TransMagn, Vol42, No.10, p2402, 10/2006.

[8] Micromagnetic Study of the Effect of Spatial Variations in Damping in Perpendicular Recording, IEEEE TransMagn, Vol42, No.10, p2428, 10/2006.

[9] Write performance of shielded pole heads on media with thin soft underlayers J. Applied Physics,97,10P103,May 2005.

[10] Micromagnetic Modeling of SNR Performance of Longitudinal and Perpendicular Media with various head/SUL combinations, IEEE TransMagn., Vol 40 , No.4 , p2555 July 2004.

[11] Meas. of Trans. Shape, Width, & Total Magn. Spacing. IEEE TransMagn.,Vol 40,No.4, p2567,July 2004.

[12] Experimental Study of Amplitude Asymmetry Effects in Perpendicular Recording, IEEE TransMagn., Vol39 , No.5 , p2222, Sept. 2003.

[13] Adjusting the Fly Height of Heads in Disk Drives, Freepatentsonline.com, 2003.

[14] One Terabit per Square Inch Perpendicular Recording Conceptual Design, IEEE TransMagn., Vol38, No.4, p1719-1724(July-2002).

[15] Recording Head Design - Chapter 11, The Physics of Ultra High Density Magnetic Recording, Springer Verlag,ISSN 0931-5195, ISBN 3-540-42370-2 , p314-348(2001), E. Plumer & D. Weller (editors)

[16] Micromagnetic Study of Switching Speed in Perpendicular Recording Media, IEEE TransMagn., VOL.37, No.4, p 1564(2001).

[17] Measurement of the Thermal Stability Factor Distribution in thin Film Media, IEEE TransMagn.,VOL.37,No.4, p 1528(2001)

[18] The Effect of Intergranular Exchange on Thermal Energy Barrier Distributions in Longitudinal Media, IEEE TransMagn.,VOL.37,No.4, p 1558(2001) ,

[19] Media Thermal Robustness (MTR) Test to Quantify Lifetime for Media Thermal Decay, IEEE TransMagn., VOL.37,No.4, p 1561(2001).

[20] Measurement of the Time Dependence of the Switching Field of Thin Film Media Down to 1.6 ns, IEEE TransMagn.,Vol36,No.5,p2477(2000).

[21] Signal to noise comparison between GMR and spin tunneling sensors -DIG INTERMAG CONF. BP-11.

[22] Magnetic Recording Technology for 10Gb/Sq" and Beyond, Proceedings of the Fifth International Conf. on Magnetic Materials, Processes, and Devices, PV98-20, ISBNI-56677-214-1, p19(1998), invited paper.

[23] Two Dimensional Model of Eddy Currents and Saturation in Thin Film Write Heads - IEEE Trans Magn., Vol34, NO.4, p1465 (1998).

[24] Effective Field Gradient Dependence on Write Field Rise Time - Paper at the 1996 Intermag Conference IEEE Trans Magn., Mag-32, No.5, pp.3527(1996).

[25] Performance Evaluation of Different Pole Geometries in Thin Film Heads- Presented at the 6th Joint

MMM-Intemag Conf. Published in the IEEE Trans Magn., Mag-30, No.6 pp.3876-3879(1994).

[26] Effect of Rise Time and Field Gradient on Non-linear Bit Shift in Thin Film Heads - Presented at the 6th Joint MMM-Intemag Conf.Published in the IEEE Trans Magn., Mag-30, pp.3879-3881(1994).

[27] Advanced Multi-Via Heads - IEEE TransMagn,MAG-30,No.2,287(1994).

[28] A New Thin Film Head which Doubles the Flux through the Coil, Invited Paper at the 1993 Intermag Conference, IEEE Trans. MAG-29, p3832(1993).

[29] Improved Cross-Talk Performance From Multilayer Longitudinal Media With a Hall Head, J. Appl. Phys. 73(10), 15may1993, p6229.

[30] Effects of Substraite Eddy Currents on Magnetic Anisotropy in Permalloy Underlayers for Perp. Media, Japan. J. Appl. Phys. 31(2B),L172(1992).

[31] Frequency Response of Thin Film Heads with Longitudinal and Transverse Anisotropy, IEEE Trans. MAG-26, No.5, p1334(1990).

[32] Three Dimensional Transmission Line Model for Flux Conduction in Thin Film Heads, J. Appl. Phys. 67(9), 4863(1990).

[33] Conduction of Flux at High Frequencies by a Charge Free Magnetization Distribution, IEEE Trans. MAG-24, No.6, 2374(1988).

[34] Conduction of Flux at High Frequencies in Permalloy Strip by Small-Angle Rotations, J. Appl. Phys. 57, 3952 (1985).

FUNDAMENTAL PHYSICS PUBLICATIONS (21)

[35] Our Improbable Universe, Thunder's Mouth Press, ISBN 1-56858-301-X, 2004 (Cosmology & evolution)

[36] Production Dyn. of the Upsilon in Proton-Nucleon Interactions,Phys. Rev. Let. 55, 1962(1985).

[37] Exper. Test of the Drell-Yan Model In P+W = $\mu^+ + \mu^-$ + X, Phys. Rev. Let. 46, 1607(1981).

[38] A high-statistics study of dimuon production by 400 GeV/c protons AIP Conference Proceedings, 1981.

[39] High Stati. Study of Dimuon Production by 400 GeV Protons, Proc. of the 19th Int. Conf. on High Energy Physics, Tokyo, Japan (1978).

[40] Multimuon Prod. by 400 GeV Protons, Proc. of the Vanderbilt Conf., Amer. Institute of Physics (1978).

[41] Search for Forward Production of Massive States Which Decay with Muon Emission, Phys. Rev. Let., 1977,

[42] Dimuon production by protons in Tungsten, AIP Conference Proceedings, 1978

[43] Confirmation of Enhancement in the Dimuon Mass Spectrum at 9.5 GeV, Phys. Rev.D18,194 (1978).

[44] Dimuon Production in Pion-Fe and P-Fe Interactions at 200 GeV and 240 GeV, Invited Paper, Washington Meeting of the Am. Phys. Soc., Bull. Am. Phys. Soc. II, 21, 577(1976).

[45] Dimuon Production by Pions and Protons in Iron and a Search for the Production in Hydrogen of New Particles which Decay into Muons, Invited Paper, Proc. of the Vanderbilt Conf., Am. Inst. of Phys.(1976).

[46] Dimuon Production of Pions and Protons at Fermilab, Invited Paper, Seattle Meet. of the Div. of Particles and Fields, Am. Phys. Soc. Aug(1975).

[47] Dimuon Production of Pions and Protons, Invited Paper, Int. Conf. on Electron and Photon Interaction at High Energy, Stanford Univ.(1975).

[48] Psi(3.1) Production by Pions and Protons at Fermilab, Invited Paper, Proc. of Summer Inst. on Particle Phys.ics, Stanford Lin. Acc. Cent, (1975).

[49] Psi(3.1) Production by Pions and Protons, Phys. Rev. Let. 35,346(1975). Sited by 34

[50] New Data and Partial Wave Analysis for the Reaction Pion+Proton to Lambda+Kaon, Rutherford Lab. Report #RL-75-089.

[51] Mass Spectrum in the Q Region of Strange Mesons Produced in Pion Proton Collisions at 6.15 GeV/c, Lett. Nuovo Cimento 13, 265(1975).

[52] The Reaction π + p $\rightarrow K_o + \Lambda_0$ + up to 1334-MeV/c, Nuclear Physics B .

[53] Three Body Production of Neutral K Mesons, Physical Review D3, 1953-1969(1973).

[54] Thesis, CP and the Three Pion Decay of the Neutral K Meson, California Institute of Technology (1972).

[55] Measurement of the Delta S = - Delta Q Amplitude in Neutral K to Pion-Electron-Neutrino Decay, Phys. Rev. Letters 25, 1214(1970)