Decades of science

(A personal selection)

Jean-Michel POUTISSOU
past science division head | TRIUMF

TUG AGM 14th December 2009
200th anniversary of Darwin’s birthday
Two passions: Hurdling and Teaching
1975 annual report
The year was 1976

• 1976 is the year of the discovery of the C quark!
• The Glashow, Weinberg Salam model looks more and more promising
• U de Montreal has just received the second large NaI detector (MINA) to complement the TRIUMF one (TINA) and start a rare pion decay program.
• At the SIN(now PSI) PAC meeting in June, Steve Weinberg learned that the SIN rare decay experiment has 6 events that looks like \( \mu \rightarrow e \gamma \) events.
• Via slow mail (remember 1st E-mail was send in 1976!) the world gets in a frenzy and 50 theoretical papers are published within 3 months on what it could mean.
• We quickly convinced Jack Sample to change all our plans and mount a \( \mu \rightarrow e\gamma \) search using the set up for exp 23, building a cave with all the iron shielding piled up at the end of the meson hall for the TNF and all the concrete blocks we could find.
• We got “charter sheet”, gate 1,2,3, reviews, engineering and safety reviews, EEC approval, schedule shuffled in M9 within a month and got to work.
• We sent an abstract to the “PANIC” meeting to be held in Zurich in Aug 1977 without committing to a number for the branching ratio.
When I arrived in Zurich, I am cornered by our friends from SIN. They want to know what our limit is (They know we have not confirmed their 6 "events").

They confirm that they will present an upper limit.

Our final numbers are not revealed until the session on weak interaction.

Steve Weinberg gives the plenary talk. Lincoln Wolfenstein chairs the parallel session on weak interaction.
The Zurich meeting

Steven Weinberg
Harvard University, Cambridge, Massachusetts

Abstract

A review is presented of the general principles and recent developments in unified gauge theories of the weak, electromagnetic, and strong interactions.

Muon nonconservation is also possible in the standard model, if there is more than one scalar doublet. The coupling of Higgs bosons to any particle are generally proportional to the mass of that particle, so one-loop diagrams in which Higgs bosons are emitted and reabsorbed from lepton lines give very small contributions. The dominant effect comes from two-loop diagrams, in which a Higgs boson is emitted from a lepton and absorbed by a virtual W or Z. The branching ratio here depends on many unknown parameters, but under the most favorable circumstances it could take values\(^4\) as large as \((a/\pi)^2 \sim 10^{-8}\).

Very recently, a new upper limit\(^5\) of \(3.6 \times 10^{-9}\) has been set on the \(\mu \rightarrow e\gamma\) branching ratio. From the perspective of SU(2) \(\times\) U(1) gauge theories, this is almost but not quite stringent enough to shed light on the question of whether muon conservation is really a fundamental symmetry principle. An improvement of one more order of magnitude in the sensitivity of this experiment (and experiments on \(\mu \rightarrow e\pi^0\)) would be very illuminating.

42) P. Depommier et al., (Montréal-UBC-Triumph collaboration) to be published. Also see the report of H. P. Povel (ETH-Zürich-SIN-Munich collaboration) at this conference. [See also the edit. postscript after L. Wolfenstein's report.]
WEAK INTERACTIONS - Workshop P

L. Wolfenstein
Carnegie-Mellon University, Pittsburgh, Pennsylvania 15213, USA

Abstract

The study of the weak interactions involving pions, muons, and nuclei can clarify the laws of weak interactions. The present theoretical interest in muon-electron universality, nonconservation of muon number, and second-class currents is discussed.

This session is devoted to weak interaction processes involving pions, muons, and nuclei. The emphasis will be on the role of these processes in clarifying the form of the weak interaction Hamiltonian. The theory of weak interactions has had exciting developments in the last few years. A particular form of unified gauge theory of weak and electromagnetic interactions, which we will refer to as the standard model, has had two striking successes: (1) neutral weak currents have been discovered in high-energy neutrino interactions with protons and neutrons and these currents appear to have a strength and form consistent with the predictions of the model. (2) Charmed particles, needed in the model to explain the absence of strangeness-changing neutral currents, have been discovered with the expected decay modes. Nevertheless, there are indications that this model may not be the total story.

If there is a conclusion to this talk, it is that the fundamental laws of weak interactions must be explored in many different ways: beta-decay, weak processes of pions and muons, atomic physics, colliding $e^+e^-$ beams, and high-energy neutrino beams at the largest accelerators all have a role to play.

Editorial postscript:

As this contribution was prepared before the conference it does not contain the latest experimental results on muon number violating processes. With the permission of the authors we are quoting the following preliminary results which have been presented in the workshop P on weak interactions.

The ratio of $\mu^+\mu^-$ relative to the dominant decay mode is

\[ R_{\mu\mu} < 3.6 \times 10^{-9} \]

reported by J.M. Poutissou from the TRIUMF group (abstract P4) and

\[ R_{\mu\mu} < 1.6 \times 10^{-9} \] (90% C.L.)

reported by H.P. Poval from the SIN group (abstract P18).

B. Hahn from the Bern group working at SIN reported the following preliminary limits on $\mu e$ conversion on $^{32}$S:

\[ R_{\mu^-e^-} < 4 \times 10^{-10} \]

and

\[ R_{\mu^-e^+} < 1 \times 10^{-9} \]
Rare decay program
Detector group/Electronics/DAQ

- First TPC use in an experiment.
- Hermes TRD’s chambers
- RMC drift chamber
- E787 drift chamber
- Babar drift chamber
- T2K TPC’s
Rare decay tracking chambers → LADD
T2K cosmic ray event
R. Feynman visited TRIUMF in the winter of 1974.

I showed him the beginning of Bl1A, I was building with John Vincent.

He asked me what I was going to do with it and I answered studying the weak interaction.

He shuddered and said: At that low an energy? I don’t remember if I answered “you surely must be joking Dr. Feynman” but…. I should have.

Anyway we did start a program in muon and pion decay parameters measurement, life time, and rare decays etc.
Search for right-handed currents in muon decay


Lawrence Berkeley Laboratory and Department of Physics, University of California, Berkeley, California 94720

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Department of Physics, Northwestern University, Evanston, Illinois 60201

C. J. Oram
TRIUMF, Vancouver, British Columbia V6T 2A3, Canada
(Received 27 May 1986)

FIG. 1. Experimental 90% confidence limits on the mass squared ratio $\epsilon$ and mixing angle $\zeta$ for the gauge bosons $W_1$ and $W_2$. The allowed regions are those which include $\epsilon=\zeta=0$. The bold ellipse is the combined result from the analysis presented in this paper and from our $\mu$SR analysis (Refs. 11 and 12). The sources of the other limits are described in the text.
Muon decay parameters

FIG. 1. Experimental 90% confidence limits on the mass squared ratio $\epsilon$ and mixing angle $\zeta$ for the gauge bosons $W_1$ and $W_2$. The allowed regions are those which include $\epsilon = \zeta = 0$. The bold ellipse is the combined result from the analysis presented in this paper and from our $\mu$SR analysis (Refs. 11 and 12). The sources of the other limits are described in the text.
Twenty years later

**TWIST** impact on Left-Right model

New limits on non-manifest (generalised) left-right symmetric models.

- **This measurement** (for $P_{\mu,\xi} = 1$)
- Recent TWIST $\rho, \delta$
- Previous TWIST $P_{\mu,\xi}$
- Pre-TWIST
In manifest left-right models, parity is partially restored with a Heavy mass Right handed W with equal coupling strength.

TRINAT goals of 0.1% in $B_\nu$ and $R_{\text{slow}}$

Present TRINAT 3% $B_\nu$, 37K result.
Radiative muon capture on hydrogen

W. Bertl\textsuperscript{3}, S. Ahmad\textsuperscript{1}, D.S. Armstrong\textsuperscript{4}, G. Azuelos\textsuperscript{2,5}, M. Blecher\textsuperscript{4}, C.Q. Chen\textsuperscript{1}, P. Depommier\textsuperscript{5}, P. Gumpflinger\textsuperscript{1}, T.P. Gorringe\textsuperscript{7}, M.D. Hasinoff\textsuperscript{1}, R. Henderson\textsuperscript{3,6}, G. Jonkmans\textsuperscript{5}, A.J. Larabee\textsuperscript{1}, J.A. Macdonald\textsuperscript{2}, S.C. McDonald\textsuperscript{6}, J.-M. Poutissou\textsuperscript{3}, R. Poutissou\textsuperscript{3}, B.C. Robertson\textsuperscript{8}, D.G. Sample\textsuperscript{2}, W. Schott\textsuperscript{1}, G.N. Taylor\textsuperscript{6}, T. von Egidy\textsuperscript{2}, D.H. Wright\textsuperscript{1}, N.S. Zhang\textsuperscript{2}

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28 October 1991
From RMC to J-PARC

- Recent results
Parity Violation in Proton-Proton Scattering at 221 MeV

Weak Nucleon-nucleon couplings

Cs anapole moment further confuses an already uncertain plot

Need independent evidence of the $^{18}\text{F}$ conclusion that $\Delta l=1$ PNC is weak*

Need a set of np experiments to supplement these data

*See talk by Valery Nesvizhevsky
collinear optical pumping for fast atomic beam (alkaline)

Major involvements in G0, Qweak, Moller exp. at J-LAB, Polarized proton Ion source for RHIC by A.Zelensky. In the future UCN at TRIUMF
PION physics
Pion Nucleon

- Experiments to test the predictions of ChPT and determine the LECs of ChPT
- E560: Analyzing Powers for $\pi p$ elastic 57 to 267 MeV
- E624: Differential Cross sections for ($\pi,\pi\pi$)
- E778: $\pi p$ elastic in region of Coulomb Nuclear Interference
- E862: Analyzing Powers for ($\pi,\pi\pi$)

G. Hoehler: "These measurements will lead to a more accurate value of the $\Sigma$ term, and will be helpful in the search for violations of charge independence near threshold"
Dibaryon Investigations

• There was considerable excitement with reports of a $\pi^-pp$ resonance (the d’) which we addressed with three experiments

  • **E725**: $^4\text{He}(\pi^+, \pi^-)pppp$ using Regina cryogenic target
  
  • **E719**: $^4\text{He}(\pi^+, \pi^-pp)pp$ using a Helium gas target to determine invariant mass spectra.
  
  • **E785**: $^3\text{He}(\pi^-, \pi^+n)nn$ using Regina cryogenic target

• **No significant dibaryon signal was observed**
Pion Nuclear Experiments

• CHAOS provides good kinematical information for multiparticle final states with relatively large solid angle.

• **E721**: pion deuteron breakup investigating Delta N FSI

• **E722**: Pion Absorption mechanisms

• **E723**: Pion Nuclear Reactions

• **E653, E781**: Pion induced pion production – FSI dependence upon nucleus for isospin 0 vs 2 which many interpret in context of medium modification of interaction.
Where are all these data used today:

• Just one example close to my interest is in the new generation of neutrino interaction Monte Carlo codes. (Genie, Neut)

• In the T2K experiment we have to understand in detail the response difference of SK water cerenkov detector (High pion momentum threshold) from the ND280 detector (low pion threshold, better Neutrino energy reconstruction)
Moe Kermani
Director, President and CEO
Moe Kermani brings to Bycast extensive experience with entrepreneurial technology driven companies. Before joining Bycast, Moe was the Chief Scientist and Director of Research and Development for Sonigistix Corporation, a world leader in the field of high performance audio systems. Previously, Moe was involved in physics research at the TRIUMF Particle Physics Research Laboratory. Moe holds a M.Sc. and Ph.D. in physics from the University of British Columbia, and he has been awarded several US patents for his work at Sonigistix.

40 under 40 award in 2001
Chargex facility for $(n,p)$ and $(p,n)$ reactions

Fig. 28. Schematic drawing of CHARGEX neutron-beam facility, LH$_2$ target, and front end detectors for $np \rightarrow nnp$ measurement.
Chargex facility

Fig. 28. Schematic drawing of CHARGEX neutron-beam facility, LH$_2$ target, and front end detectors for $np \rightarrow d\pi$ measurement.
Chargex impact

• From Karl Heinz Langanke:
  “(n,p) data from TRIUMF are the best source of information on electron capture rates for Supernovae modeling in the f/p shell region “

• (n,p) at zero degree and intermediate energies is dominated by the $\sigma \tau$ operator.

• Get Gamow-Teller strength distribution

• Electron capture rates
  
  $^{48}\text{Ti}$, $^{51}\text{V}$, $^{55}\text{Mn}$, $^{54,56}\text{Fe}$, $^{58,60,62,64}\text{Ni}$,
  $^{59}\text{Co}$, $^{70,72}\text{Ge}$, $^{76}\text{Se}$, $^{90}\text{Zr}$, $^{208}\text{Pb}$
Nuclear medicine in the 80’s

References:
Nuclear medicine
Initiation of the MuSR program:

- Hayano First PhD student to graduate at TRIUMF, Nishina Prize winner 2008

- T.Yamazaki, Bunka Karosha prize 2009, Nishina prize 1975

- S.Nagamiya, J-PARC director

- N.Nishida, chair of meson users in Japan.

- Brewer, Brockhouse medal 2008

- Fleming, Seaborg prize 2004
The year was 1987

- Pre 1987: MuSR, $\mu$SR techniques developed but program in search of a focus.
- After 1987: HTSC dominates the $\mu$sr program for a long time and still does to some extent.
- Best YBCO samples coming from Walter Hardy’s lab at UBC.
- Best technique to get coherence length and pairing symmetry.
- Nobel prize to Alex Muller and Georg Bednorz 1987.

**SHORT HISTORY of SUPERCONDUCTORS:**

<table>
<thead>
<tr>
<th>Year</th>
<th>Compound</th>
<th>Temperature</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1911</td>
<td>Hg</td>
<td>4.2 K</td>
<td>K. Onnes</td>
</tr>
<tr>
<td>1933</td>
<td>NbC</td>
<td>~10 K</td>
<td>?</td>
</tr>
<tr>
<td>1948</td>
<td>NbN</td>
<td>16 K</td>
<td>?</td>
</tr>
<tr>
<td>1952</td>
<td>Nb$_3$Sn</td>
<td>18 K</td>
<td>?</td>
</tr>
<tr>
<td>1972</td>
<td>Nb$_3$Ge</td>
<td>23 K</td>
<td>?</td>
</tr>
<tr>
<td>1982</td>
<td>BaPb$_{1-x}$Bi$_x$O$_3$</td>
<td>13 K</td>
<td>Bednorz &amp; Muller</td>
</tr>
<tr>
<td>1986: May</td>
<td>La$_{2-x}$Ba$<em>x$CuO$</em>{4-y}$</td>
<td>33 K</td>
<td></td>
</tr>
<tr>
<td>1986: Dec.</td>
<td>La$_{2-x}$Sr$<em>x$CuO$</em>{4-y}$</td>
<td>38 K</td>
<td>Bell Labs group</td>
</tr>
<tr>
<td>1987: Feb.</td>
<td>Y$_{2-x}$Ba$<em>x$CuO$</em>{4+y}$</td>
<td>94 K</td>
<td>Houston group</td>
</tr>
<tr>
<td>1987: March</td>
<td>Sc$_{2-x}$Ce$<em>x$CuO$</em>{4+y}$</td>
<td></td>
<td>Rumours Berkeley group + others</td>
</tr>
</tbody>
</table>

- Hardy (UCB) produces La$_{2-x}$Sr$_x$CuO$_{4-y}$ and YBa$_{2-x}$Cu$_3$O$_{6+y}$ successfully for CERN Bosons!
- “The Right Stuff” YBa$_{2-x}$Cu$_3$O$_6$!
- Chakradeo (UCB materials) starts production.
- Negotiations with CTF systems + TRL Ltd (?)
- “Emergency” TRIUMF exp. on “Right Stuff”
New MuSR facilities

• Syd and Gerald are building the new MuSR facilities for the future.
RED GIANT at TISOL

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Department of Chemistry, Simon Fraser University, Burnaby, British Columbia, Canada V5A 1S6
Department of Physics, University of Alberta, Edmonton, Alberta, Canada T6G 2J1
Red Giants

- $^{16}\text{N}$ beta delayed alpha emission
- $^{16}\text{N}$ beam (Dombsky/d’Auria)
- 4T solenoid not funded by NSERC
- Negotiated a set of 4T SC coils to be made by INR by the Lobashev group.

New method found to get rid of electrons

1993 Red giant publication in famous astrophysics newspaper:

The Toronto Star
Passing the baton

• A generation of pioneers built and developed TRIUMF

• We had a lot of fun because we were given a lot of opportunities and freedom to explore what we fancied most

• New generation of talented researchers has joined the family and I wish they have the same opportunities.
Merci!

Thank You!