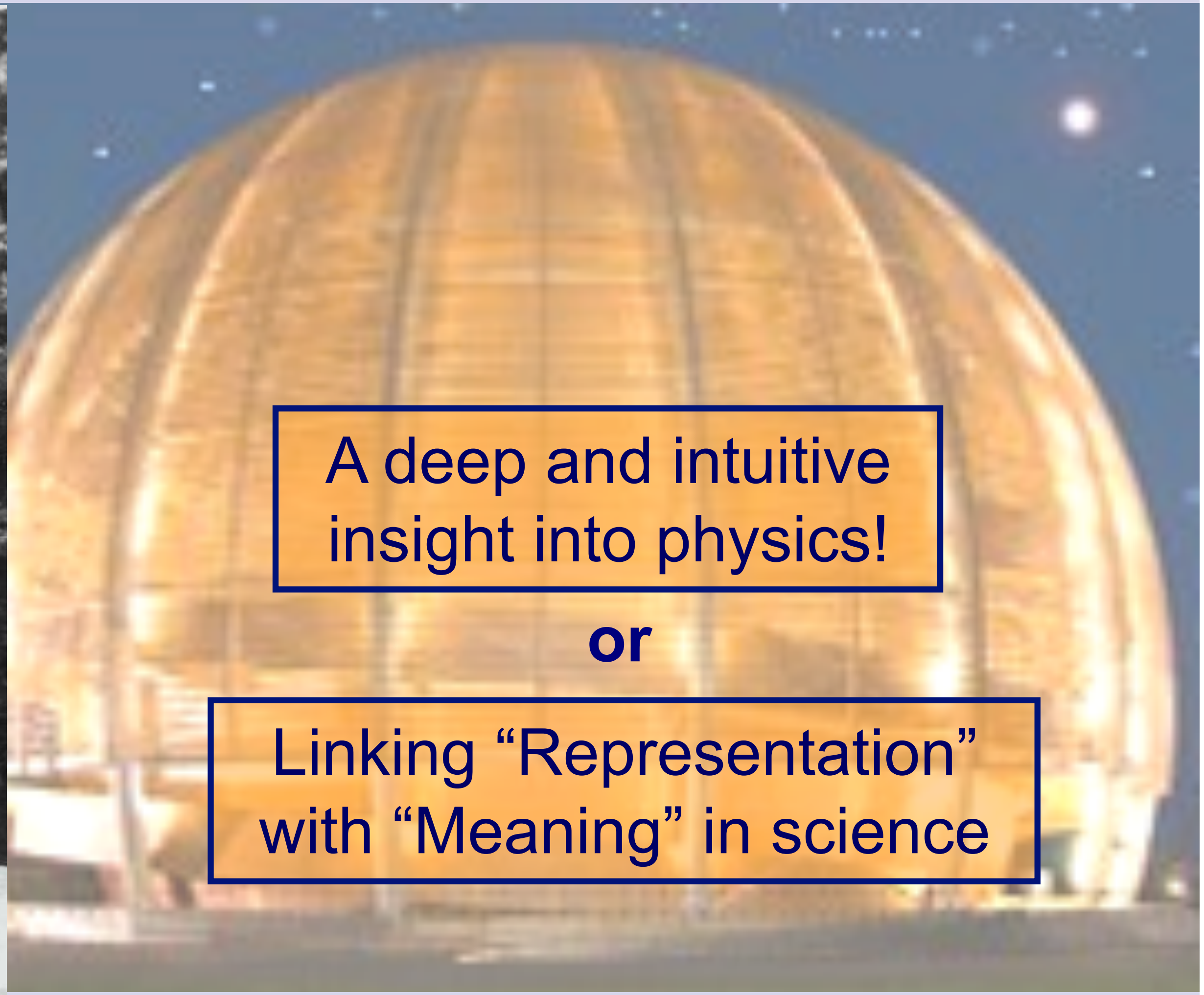
Ericson-Ericson

Contribution to Electro-Weak Interactions

Torleif and Magda, 1956



A deep and intuitive insight into physics!

or

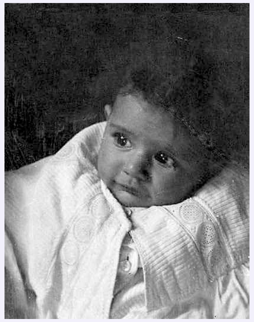
Linking “Representation” with “Meaning” in science

José Bernabéu, CERN, September 2010

1930-1935

Already in these years, the scientific wisdom of Magda and Torleif was apparent.

Torleif and mother, 1931



Magda, 1930

Madou, Ninouche
Alger, 1933

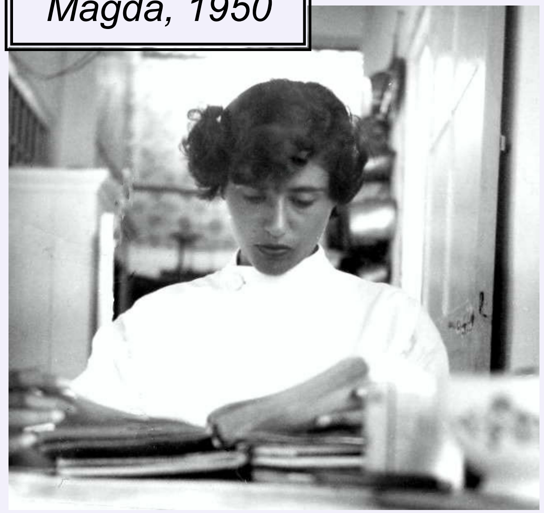
Magda
with family,
1935

Madou,
Yolande,
Ninouche,
Alger,
1935

1950-1958 ⟶ Magda's studies

Magda, 1950

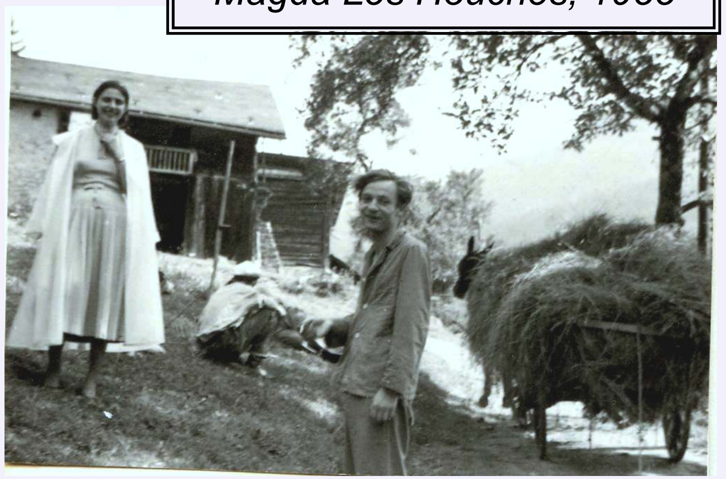
Magda, 1950



Magda, 1952

Magda, 1954

Magda Les Houches, 1955



Magda, from the preparatory classes in Alger for the competition to enter Ecole Normale in Paris,

her adventure trip to Paris to join the Ecole for Girls,

her summer school at Les Houches (Torleif !),

to the success (recognized a posteriori) of her Ph.D. Thesis (1958) in the solid state group at Saclay.

1959 ⟶ Torleif's Thesis

Torleif Thesis, Lund, 1959 Correction

Magda at Torleif's Thesis, Lund,1959. Note Shelly Glashow behind her, together with Danny Kleitman

Torleif's thesis Opponent 2 Daniel Bes, Faculty Opponent Ben Mottelson,

Lund 1959

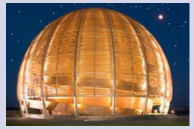
The Thesis, on Deformed Nuclei, had Gustavson, Edlén and Nilsson in the Jury.

1958-1961

- Magda's Thesis (1958), presented at La Sorbonne, on experimental inelastic neutron scattering by a ferromagnet in the vicinity of the Curie temperature.
- A parallel Thesis on the theory of critical phenomena occurring around the Curie point, using the theory of Leon Van Hove, was presented by Pierre-de-Gennes.
- Magda moves to Plasma Physics: the reason was not the abundance of female physicists in this field (!).

Magda at Plasma Conference 1961

1962-1963



In 1962 Viki Weisskopf and Amos de Shalit had launched invitations for this Conference at CERN, the very first (!) in the present PANIC series:

CERN-63-28 ; CERN-TH-331	
Conference title:	International Conference on High-Energy Physics and Nuclear Structure
Date(s), location:	25 Feb -1 Mar 1963, Geneva, Switzerland
Editor(s):	Ericson, Torleif Eric Oskar (ed.)
Imprint Geneva:	CERN, 1963 – 188p.
Subject category	Particle Physics

There was an enthusiastic response,

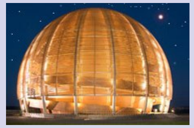
but VW & AdS had done nothing about any details.

Torleif was given the task of its organization from scratch within 3 months only!!!

Among the speakers, Wilkinson, Kendall, Ericson, Peierls, etc.

This conference marked the creation of “Intermediate Energy Physics” as a distinct field.

Polarizability effects



“Theory of Polarization Shifts in exotic atoms”

T. Ericson, J. Hüfner, Nucl.Phys. B 47, 205 (1972)

<u>Static</u> E1 polarizability in both components, H and N:

For $l \geq 4$ levels, the energy shift is dominated by the NR potential

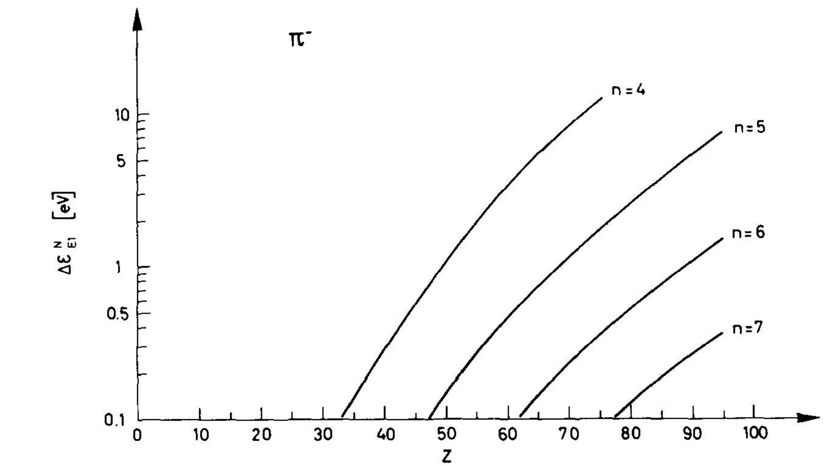
$$\Delta\varepsilon = -\frac{1}{2}e^2\left(\alpha^N + Z^2\alpha^H\right)\left\langle r^{-4}\right\rangle_{n_0 l_0}$$

$$\alpha = \frac{1}{2\pi^2}\sigma_{-2}$$

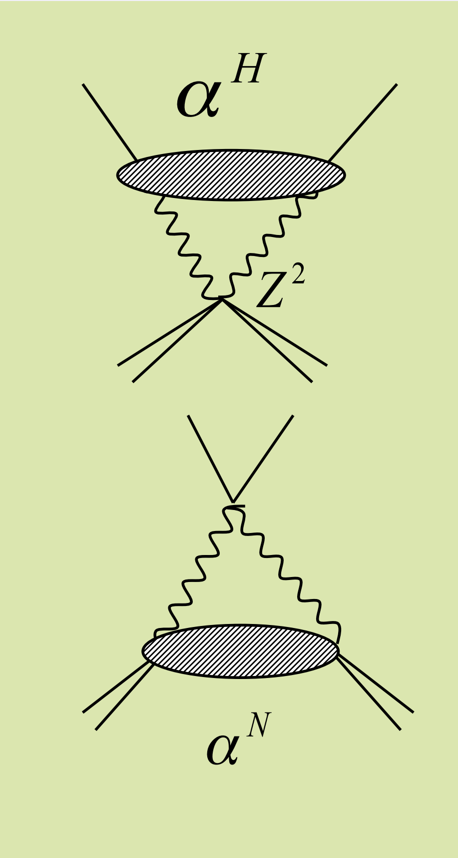
For

$\pi^-, K^-, \bar{\mathrm{p}}$

atoms

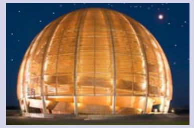


Nuclear polarization shifts in pionic atoms for circular orbits with $n \geqslant 4$ as a function of Z. The curve for the $n = 4$ orbit has been stopped where the E2 polarization shift exceeds the E1 shift.



A significant fraction of the total shift → Information on α^H !

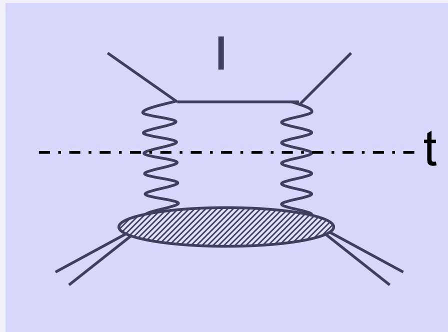
Polarizability effects



"Polarizability Effects in Electronic and Muonic Atoms"

J.B., T. Ericson, Z. Phys. A 309,213 (1983)

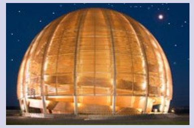
For leptonic atoms, however, no strong absorption effects → l=0:
Divergent in the static limit and wrong!
Non-locality from intermediate lepton propagation removes the divergence; the lepton virtual kinetic energy is either $t/2\mathrm{m}$ or $\sqrt{t} \sim \omega$ (nuclear excitation)



- For muons, non-relativistic for nuclei except hydrogen, but not static $\longrightarrow \dfrac{4m_\mu}{\omega\sqrt{t}}\dfrac{1}{t+2m_\mu\omega}$
- For electrons, highly relativistic $\longrightarrow \dfrac{5m_e}{2\omega^2}\dfrac{1}{t}$
- Physics of virtual photons at short atomic distances $|\psi_{n0}(0)|^2$ instead of " long range r $^{-4}$"

→The relevant Sum-Rule is not σ_{-2}, but $(2m_\mu)^{\frac{1}{2}}\displaystyle\int_{\omega_{th}}^{\infty} d\omega \frac{\sigma_\gamma(\omega)}{\omega^{\frac{3}{2}}}$ for muons

and $(5m_e)\displaystyle\int_{\omega_{th}}^{\omega} \mathrm{d}\omega \frac{\sigma_\gamma(\omega)}{\omega^2}\left[\ln\frac{2\omega}{m_e}+\frac{19}{30}\right]$ for electrons



Nucleon e.m. polarizabilities

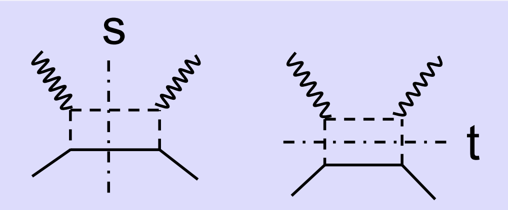
J.B., T. Ericson, C. Ferro-Fontan Phys. Letters 49B, 381(1974)

Extension of low energy theorem of Low, Gell-Mann and Goldberger for Compton scattering (mass, charge and magnetic moment), to quadratic terms in the photon energy: α, β represent the response of the system to the e- and m- fields of the photon.

-Forward sum rule: $$\alpha + \beta = \frac{1}{2\pi^2}\int_{\omega_0}^{\infty}\frac{d\omega}{\omega^2}\sigma_T(\omega) = (14.2 \pm 0.3)\times 10^{-4}\, fm^3$$

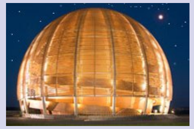
Baldin-Lapidus

-Backward sum rule: (BEF) $$\alpha - \beta = \frac{1}{2\pi^2}\int_{\omega_0}^{\infty}\frac{d\omega}{\omega^2}\left(1 + 2\frac{\omega}{m}\right)^{\frac{1}{2}}\left[\sigma(\Delta P = \mathrm{yes}) - \sigma(\Delta P = no)\right]$$

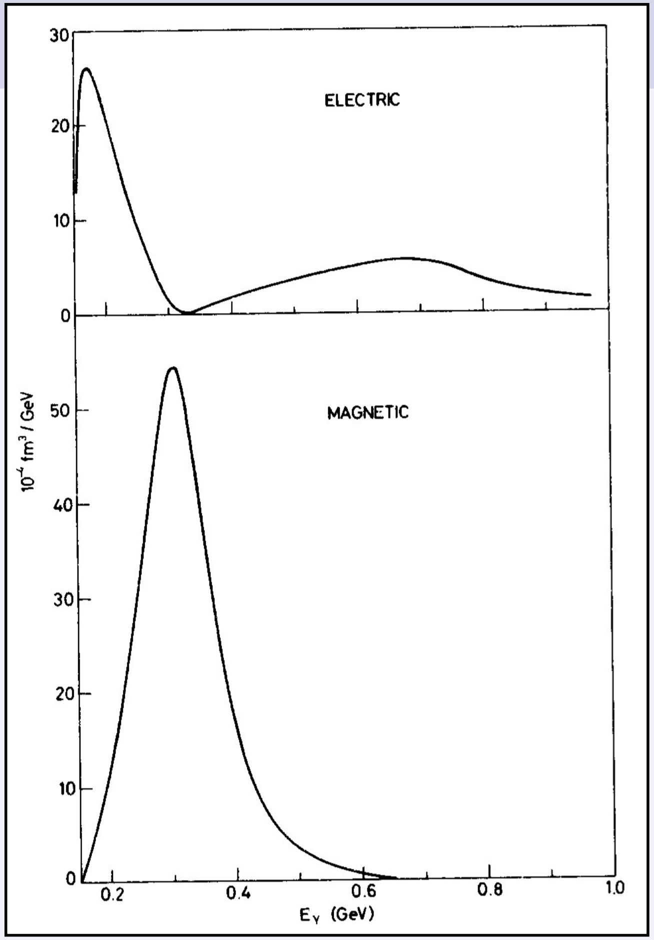


+ (annihilation Channel $\gamma\gamma \rightarrow N\overline{N}$ contribution)

How to explain $\alpha > \beta$ experimentally? The most conspicuous property of nucleon structure is its magnetic excitation Δ by spins, leading to $\beta_s > \alpha_s$



Nucleon e.m. polarizabilities



The input to the polarizability sum rules in the s-channel

-Conclusion from experiment and (BEF) sum rule:

One would need a strong scalar-isoscalar $\pi\pi$ -interaction in the t-channel: the σ !!!:

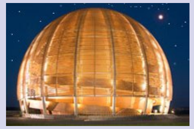
The "composite Higgs" of QCD

-In the last 30 years……Ups & Downs
σ-resonance in the RPP

-The solution came in the last decade establishing the σ (H. Leutwyler et al.) as a low mass pole far from the real axis.

-More recently, J.B. & J. Prades† used the (BEF) sum rule and the experimental α, β to fix the coupling $\sigma \rightarrow \gamma\gamma$

Axial Polarizability and Weak Currents in Nuclei



J. Delorme, Magda Ericson, A. Figureau, C. Thevenet, Annals Phys. 102,273 (1976)

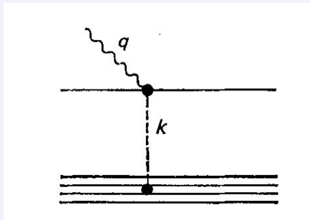
MOST INTERESTING: How much does a nucleon inside a nucleus differ from a free nucleon ?

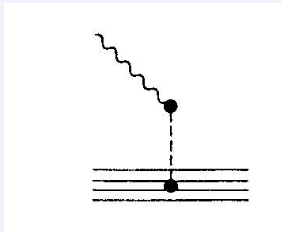
-A basic relation between the Axial Current and the pionic field through PCAC

-Influence of isobar excitation → Axial Polarizability → p-wave π - N scattering volume

→Quenching of the axial coupling in heavy nuclei, by the Ericson-Ericson-Lorentz-Lorenz effect-effect

$$\vec{A}(x) = -g_A \eta(x)\vec{\sigma}(x) + f_\pi[1+\alpha(x)]\vec{\nabla}\varphi(x)$$





$$\text{with } \eta \sim 1 + \frac{\alpha}{3}$$

→A single parameter, the Axial Polarizability, gives the physics: Magda established a correspondence between static dielectric and axial quantities → prediction of critical phenomena in nuclear matter and their precursors, similar to e.m.

Intriguing: Is $\tilde{g}_A \sim 1,\ \tilde{g}_p \sim 0?$ A “bare” nucleon? Chiral restoration?

Quasielastic electron scattering

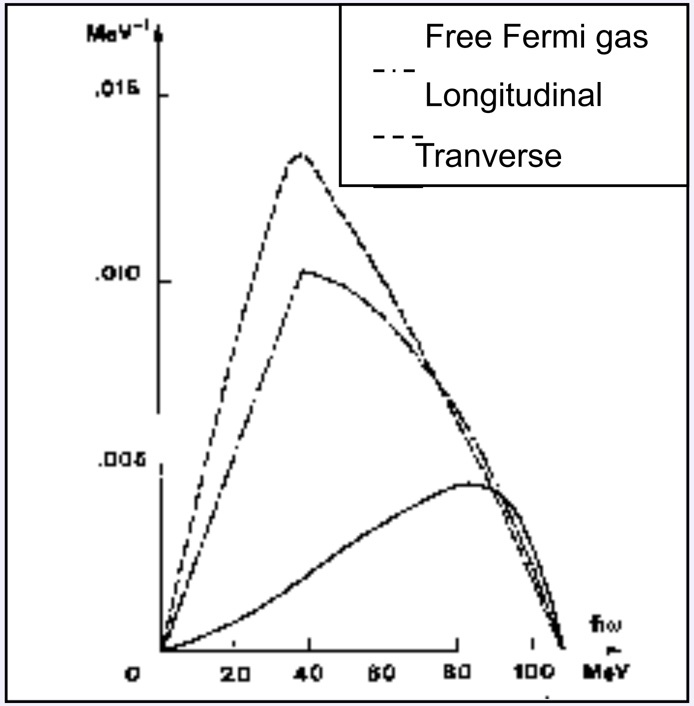
"Quenching and Hardening in the Transverse Quasielastic Peak"

W.M. Alberico, Magda Ericson, A. Molinari, Nucl. Phys. A379, 429 (1982)

- A framework for the response of nuclear matter to spin-isospin probes
  - Longitudinal $\vec{\sigma}.\vec{q}\,(\pi)$
  - Transverse $\vec{\sigma}\, x\, \vec{q}$

Due to collective effects, the two responses have a very different behaviour for moderate momenta $q \gtrsim 1\, fm^{-1}$, with respect to the free Fermi gas:

-The transverse is quenched and hardened
Reason→ no light meson,
the particle-hole force remains repulsive.



- Experimental test → Magnetic inelastic electron scattering on ^{56}Fe

- Good agreement at q~200-300 MeV and low-energy $\omega \lesssim$ 80 MeV

- At higher ω -energies, inclusion of two particle-two hole excitations→ the Δ!

Ann. Physics. 154, 356 (1982)

Neutrino Interactions with Nuclei

"A unified approach for nucleon knock-out, coherent and incoherent pion production"

M. Martini, M. Ericson, G. Chanfray, J. Marteau, Phys.Rev.C80, 065501 (2009)

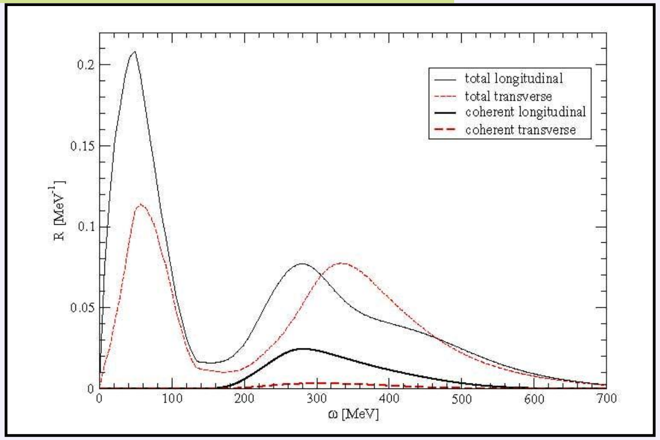
"Quasielastic" Phys.Rev. C81,045502 (2010) !!!!!!!

Spin-isospin longitudinal coupling: A distinct feature of neutrino interaction

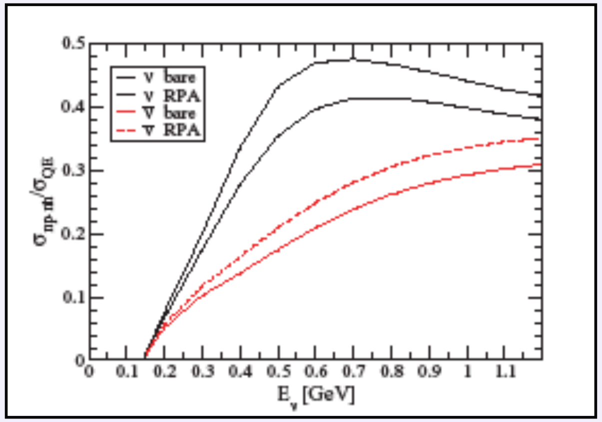
- In coherent pion production, the longitudinal component is much larger

  ⟶ A softening of the response

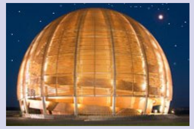
- Prediction of CC and NC ν_μ–induced coherent π -production



- Quasielastic dominated by the transverse response….. BUT the multinucleon excitations produce a sizable increase of the inclusive QE cross section.



IMPORTANCE for MiniBooNE and other present ν-experiments



Weak Interaction, Symmetries

“Six-Fermion Weak Interaction”

T. Ericson, S.L. Glashow, Phys. Rev. 133B, 130(1964)

In modern language, it would be an Effective dimension-9 Operator for the search of $\nu \; p \rightarrow \nu \; \mu \; \bar{e} \; p$

In the 60’s, this was an alternative to Vector Bosons mediating the weak interactions. With the amplitude

$$\lambda^{-3} 2^{-\frac{1}{2}} G J_{\mu} J_{\mu}^{\dagger} \left(\bar{p}p\right)$$

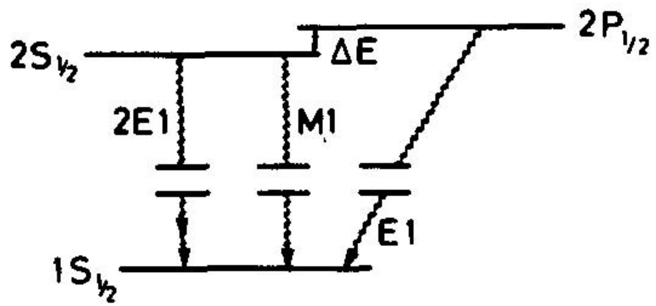
one is able to search for possible effects at high energies, or for the stimulated decay of muons bound in hydrogen

$$\mu \, p \rightarrow e \bar{\nu} \, \nu' \, p$$

Weak Interaction, Symmetries

"Parity Violation by Neutral Currents in Muonic Atoms"

J.B., T.Ericson, C. Jarlskog, Phys. Letters 50 B, 467 (1974)



The one-and two-photon transitions between the levels n=1 and 2

Due to the interference of amplitudes mediated by γ-exchange and Z-exchange between the muon and the nucleus in the atom, the 2S state has Parity Mixing with the 2P state → Radiative Decay to the 1S groundstate has a Total Transition Amplitude

$$A(M1) + \eta \; A(E1)$$

with a spectacular enhancement of the effect induced by level quasi-degeneracy in η

Observables → Circular polarization of the "would-be" M1 photon.

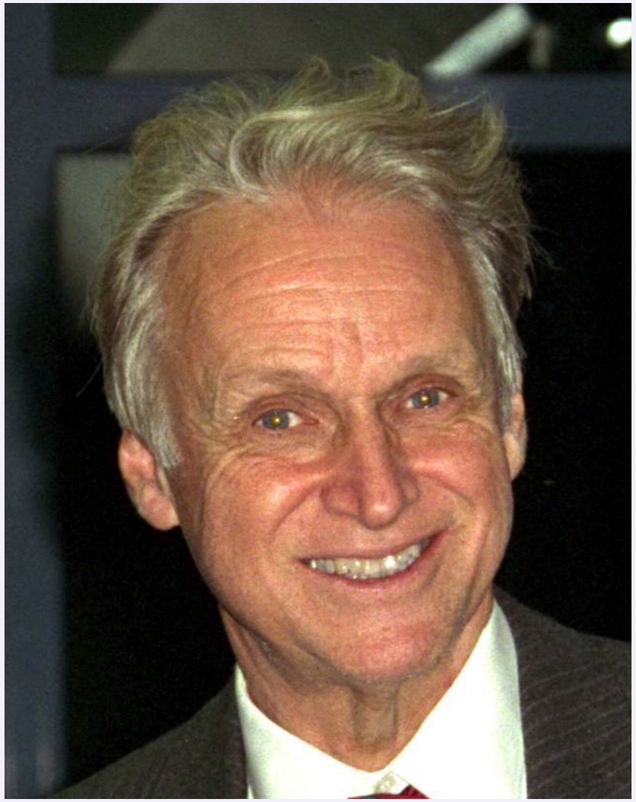
→ Correlation of photon momentum with muon polarization

→ Angular correlation of photon with electron from final $\mu - \mathrm{decay}$

For the $\left(\mu, {}^4He\right)^+ atom$, the PV effect is 3.10^{-2}

This was a highly influential paper for experimental studies and has become the pedagogical presentation in textbooks, but the actual experiment could not be performed for this transition.

In the first flush of youth, your long friendship is permanently a pleasure



Torleif Ericson

Magda Ericson