Jan Stern - a few memories

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My first encounter with Jan

- Spring 1997 : looking for a PhD advisor and subject
- "Masses and properties of light quarks in QCD" ?
- Came to IPN Orsay (getting lost on the way)
- One-hour discussion
- . . . and I began my PhD in summer

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It took me some time to get the full measure of the character
(much longer than my PhD, for sure)

Thanks to Marc Knecht, Bachir Moussallam, Heiri Leutwyler, Jiri Jersak, and in particular to Hagop Sazdjian

From Prague to Orsay

- Born in 1942 in Prague
  (difficult times for his family)
- Studies at Technical University of Prague
  - 1964 : Engineer in Nuclear Physics
  - 1965 : PhD in Theoretical Physics
- 1967 : Stays in Dubna
- 1968 : Leaves for CERN and Bern, meets Leutwyler
- 1969 : Invited in Orsay, then recruited by CNRS
- A few visits to Bern, Ann Arbor...

$\Longrightarrow$A very strong formation in group theory and a specific sensitivity to symmetries, a salient feature of Jan's work

Jan in Prague and Dubna (1) : Light-cone dynamics

At that time, many data on hadrons and competing ideas
dispersion relations, S-matrix, Regge theory, symmetries, quark model...

Internal symmetries like isospin, $SU(3)$ successful in quantum mechanics.
Could it be extended to relativistic systems ?

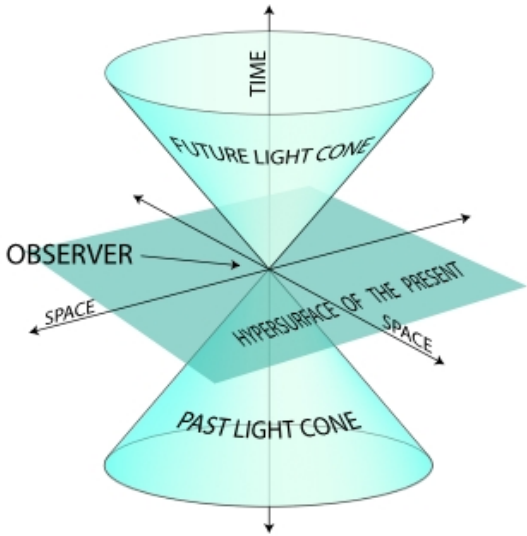
$$Q^a(q) \sim \int d^3x e^{i\vec{q}\cdot\vec{x}} j_0^a(x) \qquad x^0 = 0$$

- Symmetries embedded in current algebra $[j^a, j^b]$ defines $[Q^a, Q^b]$
- Coleman : $\langle 1 \text{ part}|Q^a(q)|\text{more part}\rangle \neq 0$
- Equal-time charge can create particules from $|0\rangle$
- Applications of current algebra often relied on secondary assumptions to get rid of multi-hadron states ($p \to \infty$)

Jan in Prague and Dubna (2) : Light-cone dynamics

In 1967, Jan highlights role of light-like charges

$$\tilde{Q}^a(q) \sim \int d^4x\ \delta(nx) e^{iqx} n^\mu j^a_\mu(x) \qquad n \cdot x = 0$$



where $n^2 = 0$ (e.g. $n = (1, 0, 0, 1)$)
so that $n \cdot x = 0$ is a plane tangent to light-cone

- $\tilde{Q}^a(q)|1\ \text{part} >= |1\ \text{part} >$
- Postulating light-like current algebra

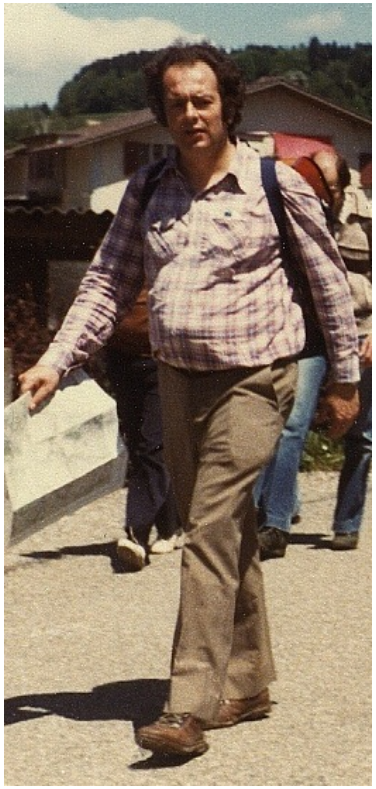
$$[\tilde{Q}^a(q_1), \tilde{Q}^b(q_2)] = i f^{abc} \tilde{Q}^c(q_1 + q_2)$$

  allows one to rederive results of current algebra without fuzzy assumptions (e.g., sum rules)

- Strong constraints on the high-energy behaviour of correlators

$\Longrightarrow$Light-cone interesting to combine internal and Poincaré symmetries and to understand general features of quantum field theories

Jan in Bern : from the light cone to light quarks



With H. Leutwyler (a great friend and opponent, with whom he discussed. . . in French)

- In 1970, QFT and current algebra on the light cone, applied to recent data on DIS (and by others to light-cone sum rules, distribution amplitudes, mended symmetries. . .)
- Try to constrain the 3 dynamical operators embedding strong interactions in the light-cone formulation

Meeting with Gell-Mann (highly esteemed by Jan)

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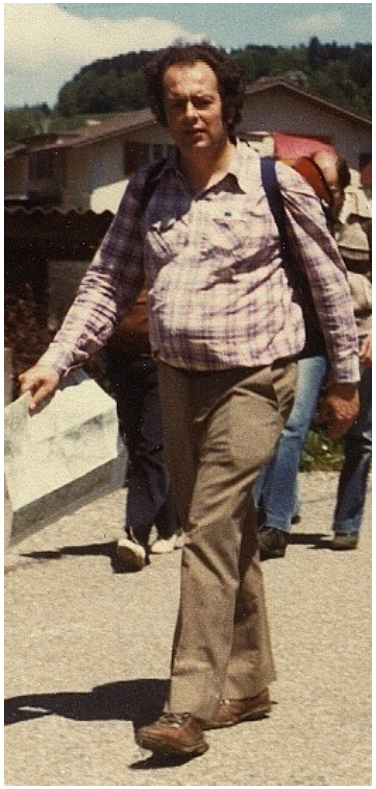

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Some time to get convinced that QCD right theory of strong interactions (too many arguments from perturbation theory, not enough general QFT)

Bern : Times of excitement and fun (great memories for Jan)

Jan in Orsay (1) : different directions

With the advent of QCD, and his own installation in Orsay
Jan explored several directions

- Structure of gauge theories and gauge fields [Craigie, Floratos]
- Chiral symmetry breaking in supersymmetric theories [Knecht]
- Gauge fields with arbitrary spins in connection with string theory [Ouvry]
- . . . and getting into Chiral Perturbation Theory [Sazdjian, Moussallam, Fuchs, Knecht, Girlanda]

Jan in Orsay (2) : $\pi\pi$ scattering

- Reluctant wrt to ChPT because of its perturbative nature
- Growing interest in ChPT once formulated as an effective theory through symmetries
- Basic ideas OK, but shouldn't we test its phenomological relevance ? Possibility of a small quark condensate and Generalized ChPT
- $\pi\pi$ scattering as a relevant probe of chiral symmetry breaking, and in particular of quark condensate for $m_{u,d} \to 0$
- Discussed at length with Bern, in and off Eurodaphne and Euridice meetings

$\Longrightarrow$Structure of $\pi\pi$ amplitude, $K_{\ell 4}$ and $\tau \to 3\pi$ decays, lattice...

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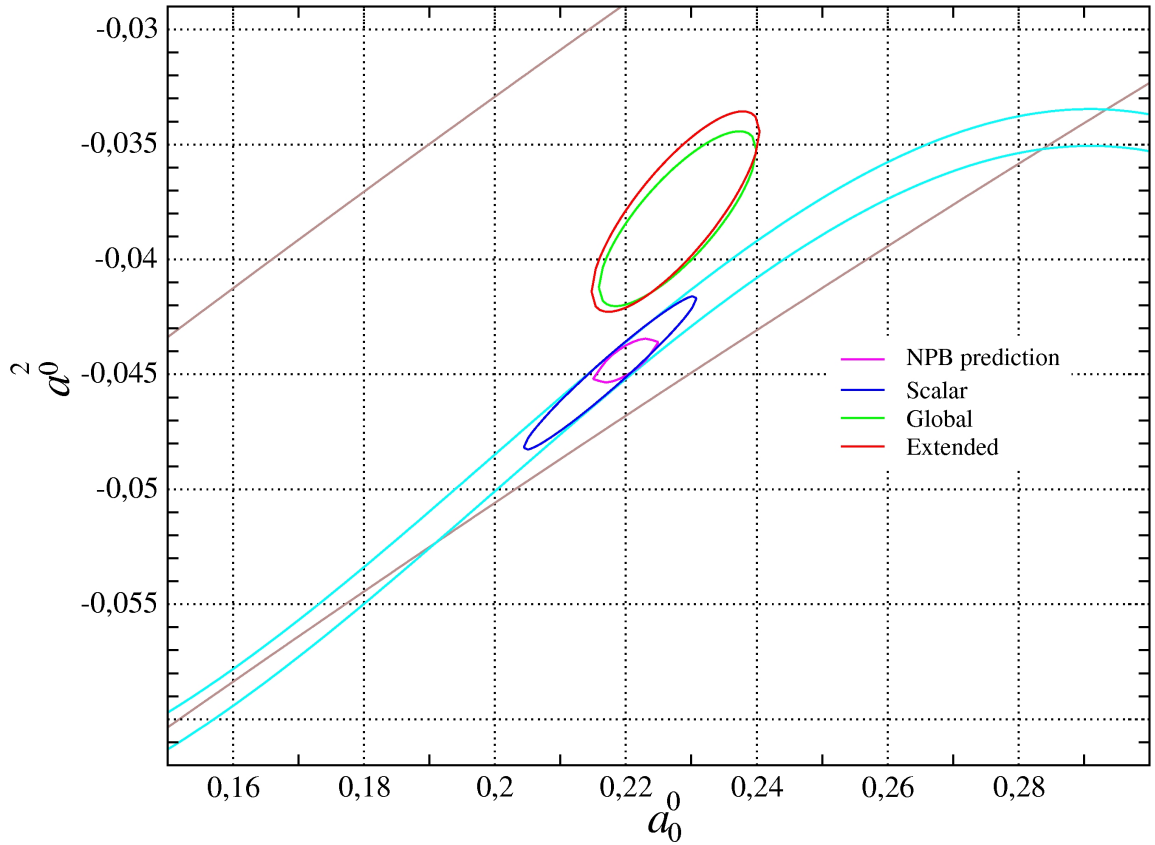
$\Longrightarrow$Structure of $\pi\pi$ amplitude, $K_{\ell 4}$ and $\tau \to 3\pi$ decays, lattice...

$K_{\ell 4}$ decays

- For a long time, only "high-statistics" Geneva-Saclay experiment
- 2000 : results from E865 (Brookhaven)
- 2007 : results from NA48/2

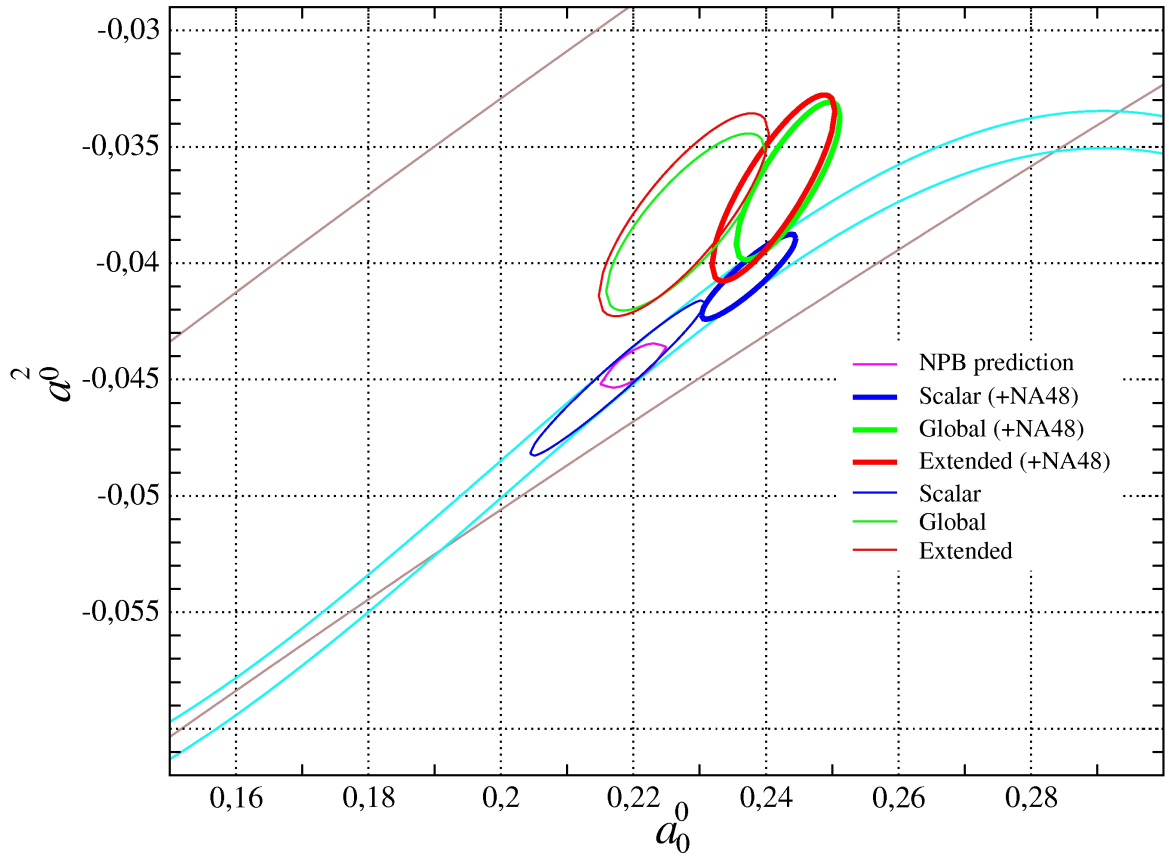
Scattering lengths after E865 data



Two different fits of $K_{\ell 4}$ data supplemented with

- info on pion scalar radius [Colangelo, Gasser, Leutwyler]
- data in $I = 2, \ell = 0$ channel [Fuchs, Girlanda, Stern]

Scattering lengths after NA48 (preliminary) data



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Jan in Orsay (3) : Role of the strange quark

- Difference between $N_f = 2$ and $N_f = 3$ chiral symmetry breaking ?
- Effect of strange quark loops in the vacuum
- Significant suppression of quark condensate $\Sigma(3)$ $[m_{u,d,s} \to 0]$ with respect to $\Sigma(2)$ $[m_{u,d} \to 0$ and m_s physical$]$
- . . . related to peculiar dynamics of light scalars
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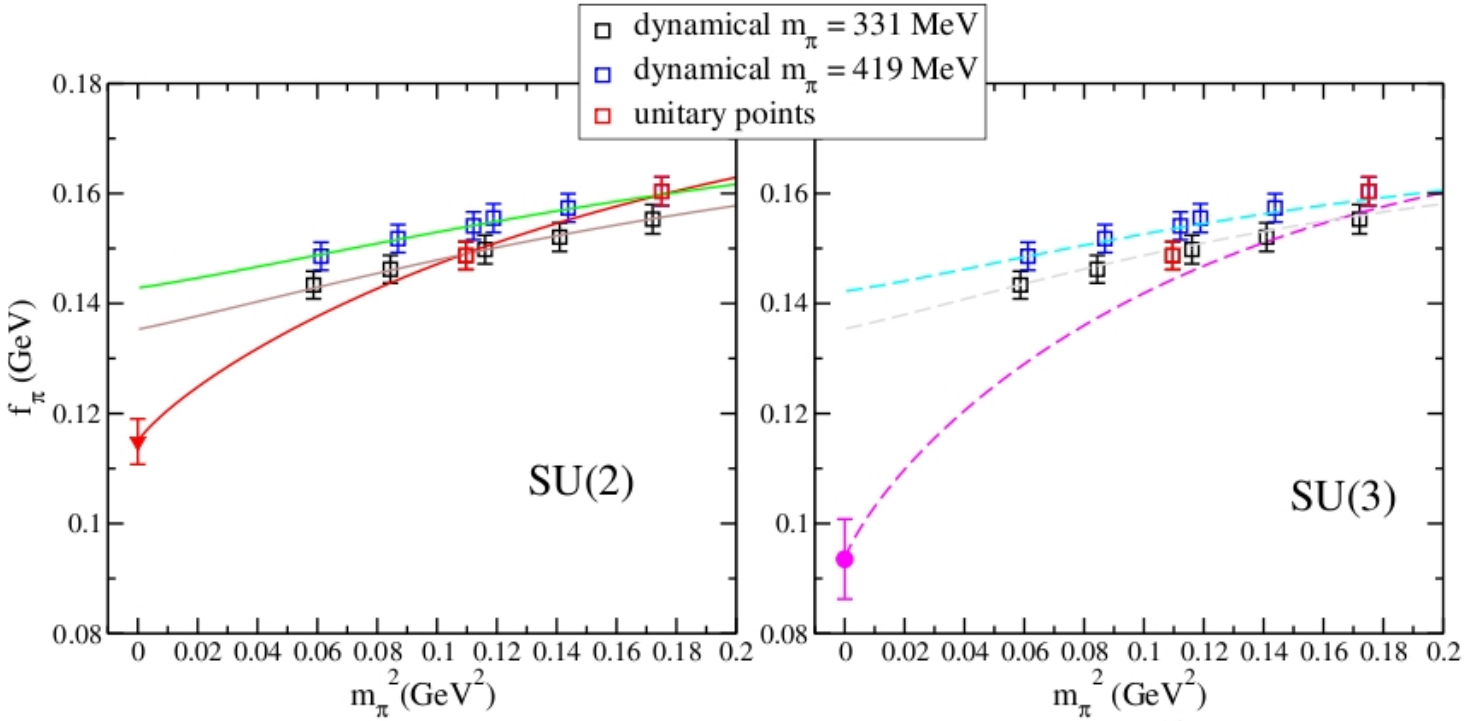
Lattice with 2+1 dynamical flavours hints at such a scenario now

- MILC @ LATTICE 07 : $\Sigma(2)/\Sigma(3) \simeq 1.52(17)(^{+38}_{-15})$
- UKQCD-RBC @ Capri08 : Difficulties to fit 2+1 data with $N_f = 3$ ChPT, use only $N_f = 2$
- PACS-CS @ LATTICE 08 : Large NLO contributions in $N_f = 3$ ChPT due to m_s

Comparison of Results obtained using SU(2) and SU(3) ChPT



$$f_\pi/f \simeq 1.08\,, \quad f/f_0 = 1.23(6)\,, \quad (f/f_{0\,\mathrm{MILC}} = 1.15(5)^{+13}_{-3})\,,$$

$$f_\pi = (124.1 \pm 3.6_{\mathrm{stat}} \pm 6.9_{\mathrm{syst}})\mathrm{MeV} \simeq (124.1 \pm 7.8)\mathrm{MeV}$$

- The large value of f_π/f_0 (and even larger values of f_P/f_0 of 1.6 or so) lead us to present our results based on $SU(2) \times SU(2)$ ChPT.

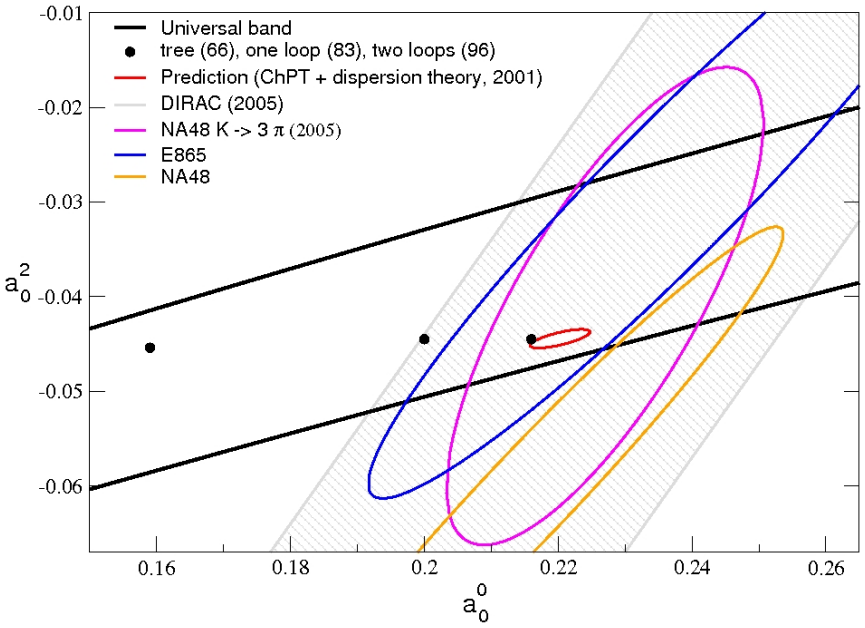
Sachrajda [Capri08]

Impact of isospin-breaking

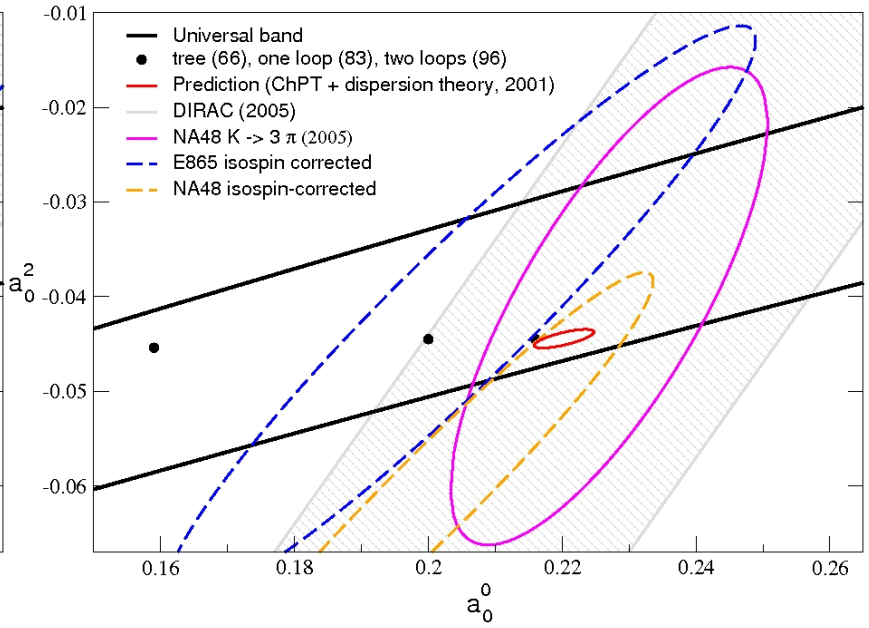
Jan puzzled by $K_{\ell 4}$ data from NA48/2, indicating a low condensate $\Sigma(2)$
by that time, he expected $\Sigma(2)$ large and $\Sigma(3)$ small

$\Longrightarrow$Role of isospin breaking [Gasser, Colangelo, Rusetsky, Kubis, Knecht]

[Colangelo, Kaon 2007]



Without isospin corrections



With an estimate of isospin corr

Agreement with Jan's idea of different $N_f = 2$ and $N_f = 3$ patterns ?

Jan in Orsay (4) : EFT of electroweak symmetry breaking

Over the last ten years, Jan turned to electroweak symmetry breaking

- Many different attempts to build a consistent EFT of electroweak symmetry breaking without explicit Higgs
- Naturalness : which symmetries can suppress the operators arising in EFT and not observed ?
- Symmetry group S_{nat} consisting of elementary sector (SM fermions and gauge fields) and composite sector (Goldstone bosons for W and Z)
- Broken into $SU_W(2) \otimes U_Y(1)$ by spurions connecting the two sectors
- These spurions provide power counting for size of deviations from SM

$\Longrightarrow$In the expansion of the EFT, first non-SM effects correspond to V+A contributions to W-quark interaction [Hirn]

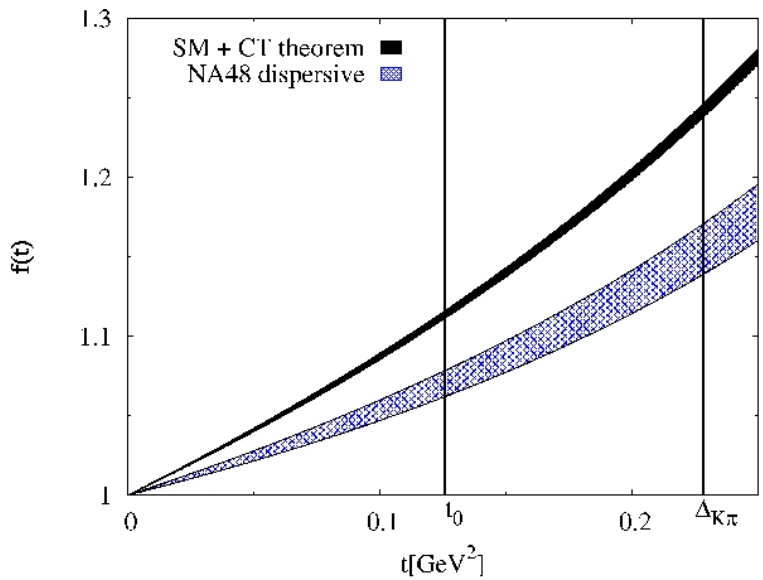
Jan in Orsay (5) : Right-handed currents

Are weak right-handed currents really ruled out experimentally ?

[Passemar, Oertel, Bernard]

Few places where high accuracy can be reached

- $K_{\ell 3}$ decay (πK information and Callan Treiman th) [unconfirmed hopes from NA48]
- Hadronic τ decays
- $\pi^0 \longrightarrow 2\gamma$
- $\pi\pi$ scattering
- Inelastic ν scattering
- W semi-inclusive decays...



What about heavy quarks ? Departures from SM in the same framework ?

Jan Stern

- A deep physicist with a relevant and long-lasting impact
- Somebody to learn many things from
- A challenger of common views with a great intuition
- . . . who invited (and sometimes provoked) others to go further
- A passionate man

Our community owes him a lot.
We miss him.