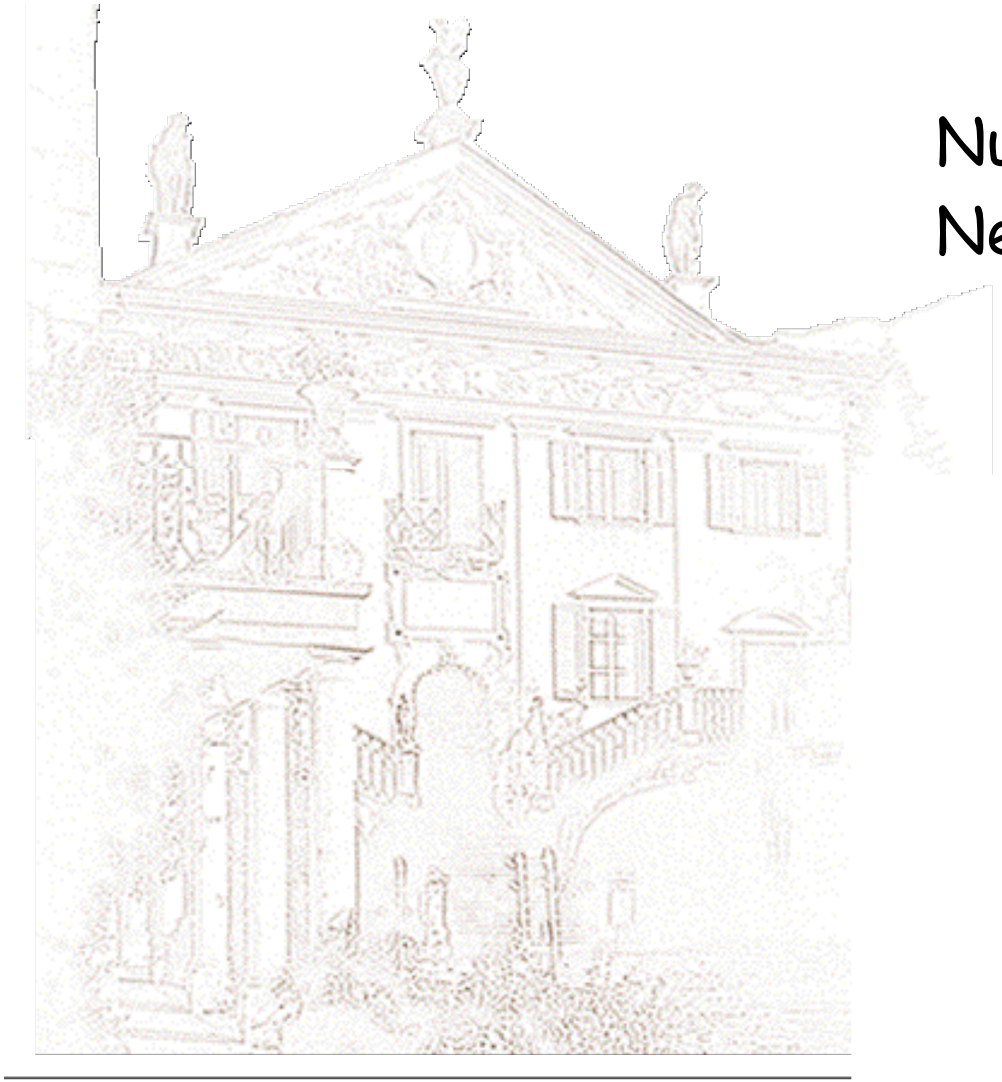
ECT* European Centre for Theoretical Studies in Nuclear Physiscs and Related Areas



Nuclear Forces & QCD: Never the Twain Shall Meet*?

Judith McGovern
Ben Gibson
Bira van Kolck
Rob Timmermans

* Rudyard Kipling: THE BALLAD OF EAST AND WEST (1892)

History of the meeting

- ECT*, Trento, June-July 1999:
  "Nuclear Forces: Modern Developments"
  (with Alfred Stadler)

- INT, Seattle, June 2001:
  "Theories of Nuclear Forces and Few-Nucleon Systems"

- INT, Seattle, Fall Program 2003:
  "Theories of Nuclear Forces and Nuclear Systems"
  (with Dick Furnstahl)

ECT*, Trento, July 1999

OUTLOOK

- ENOUGH with quantitative work!
- LET'S THINK AGAIN!

REPLACE: $\chi^2 \mapsto \chi\text{-sym}$

- BUT: Do not expect any magic.

... be far-sighted:

- IN THE YEAR 2025 — what will be left from χ-sym ☺

Within 1-2 years we will all be using χPT-designed products (3rd generation forces, "standard" 3NF)

The Standard

blah

# of Nuclear Physics

- EFT IS LIKE ANTARCTIC!

  (COLD AND BARREN?)

  FREEZE OUT EVERYTHING,

  ONLY N's AND π's.

  NO ρ, ω, ϕ ; η, η'; $\sigma = \epsilon = f_0(980), f_2, \ldots$

  NO POMERON

  NO EXTENDED NUCLEONS

I. NUCLEAR STANDARD MODEL : DEFINITION

Old Assumptions In Nuclear Physics :

I. There exists a nuclear Hamiltonian of the form :

$$H = -\frac{\hbar^2}{2m}\sum_i \nabla_i^2 + \sum_{i<j} v_{ij} + \sum_{i<j<k} V_{ijk} + \ldots$$

with rapid convergence

such that the Schröedinger Equation:

$$i\,\hbar\,\frac{\partial\Psi(x_1,\ldots x_A)}{\partial t} = H\ \Psi(x_1,\ldots x_A)$$

$$x_i = \mathbf{r}_i,\ \sigma_i,\ \tau_i$$

describes the dynamics of A-nucleons below pion production threshold

AND

II. There exists an electro-weak current operator:

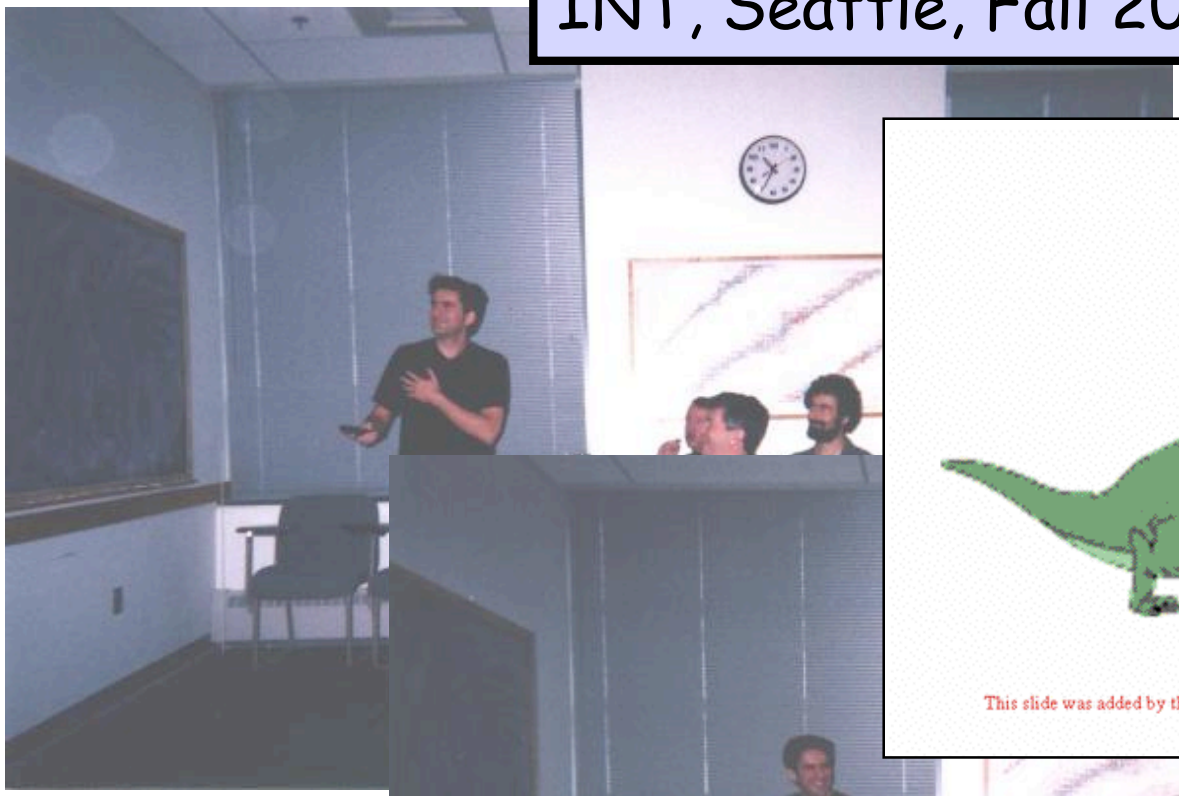
$$\mathbf{J}^\mu = \sum_i \mathbf{j}_1^\mu(i) + \sum_{i<j}\mathbf{j}_2^\mu(i,j) + \sum_{i<j<k}\mathbf{j}_3^\mu(i,j,k) + \ldots$$

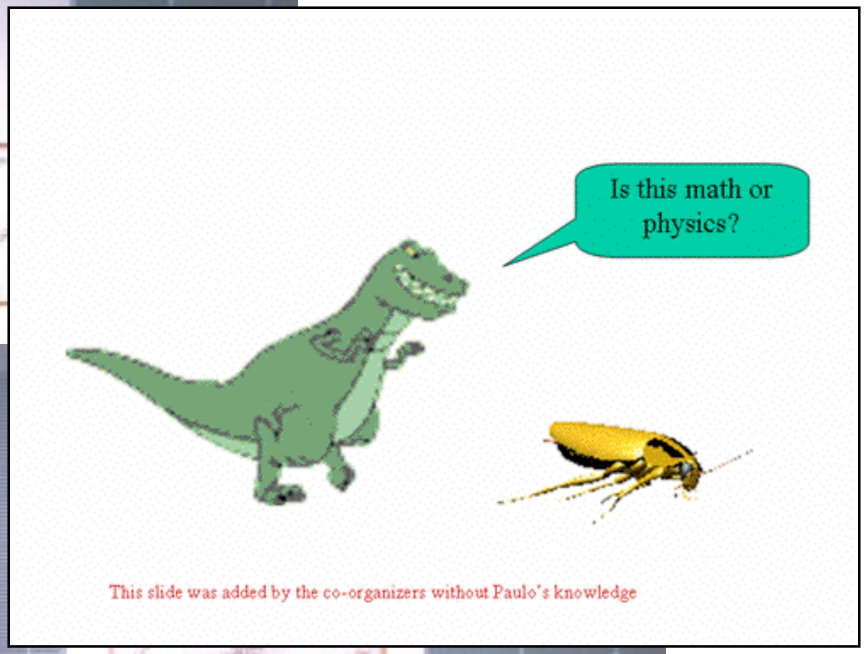
with rapid convergence

which describes the coupling of nuclei to electro-weak fields

INT, Seattle, June 2001

INT, Seattle, Fall 2003





The true landscape

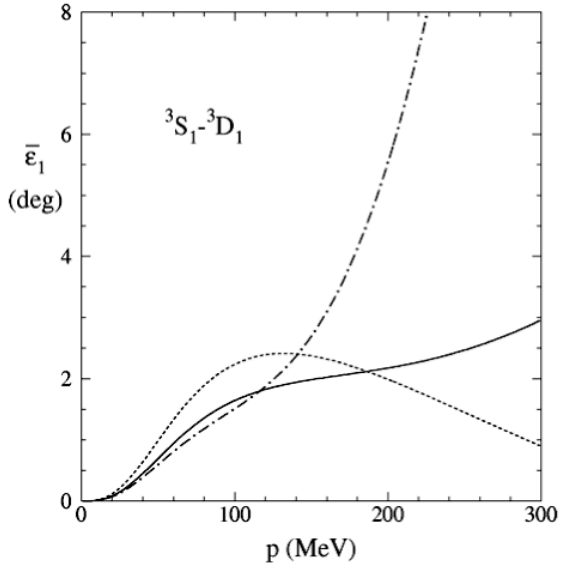
what does the dinosaur see?

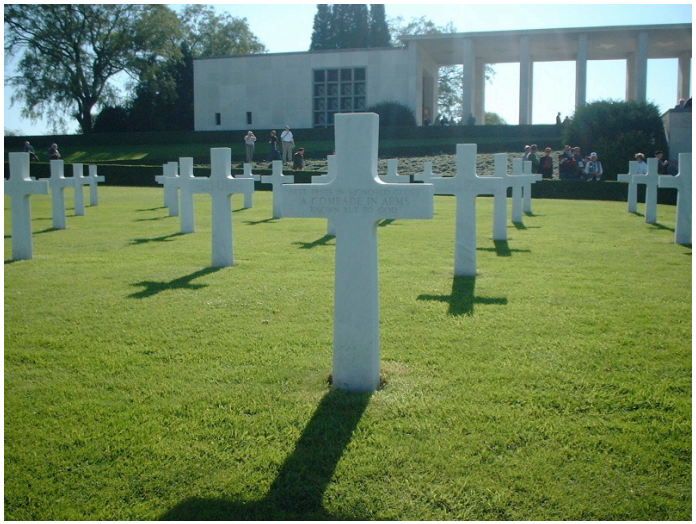
what does the cockroach see?

A Few Issues for this Workshop

Is nuclear EFT dead?

- Perturbative pions, Q-counting, L-counting (futile counting),...
- Pionless EFT > effective-range theory?
- Pionful EFT : cut-off dependence?

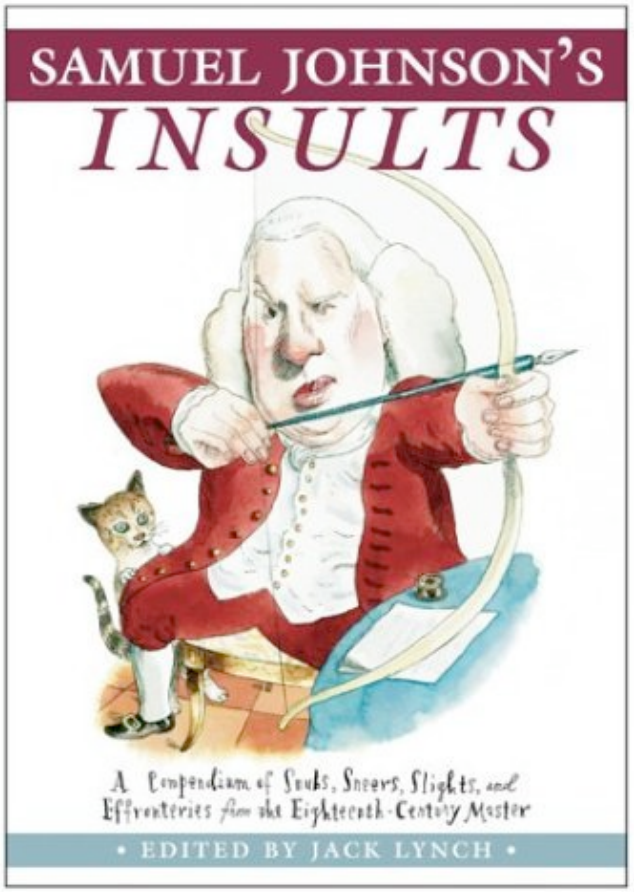




-Successes? A_y-puzzle, Q_d-problem, etc. are all still with us...
- EFT potentials, a.k.a. the "new Bonn potential": How good are they?
- Progress in the 3N system?

- Will there be a renaissance?

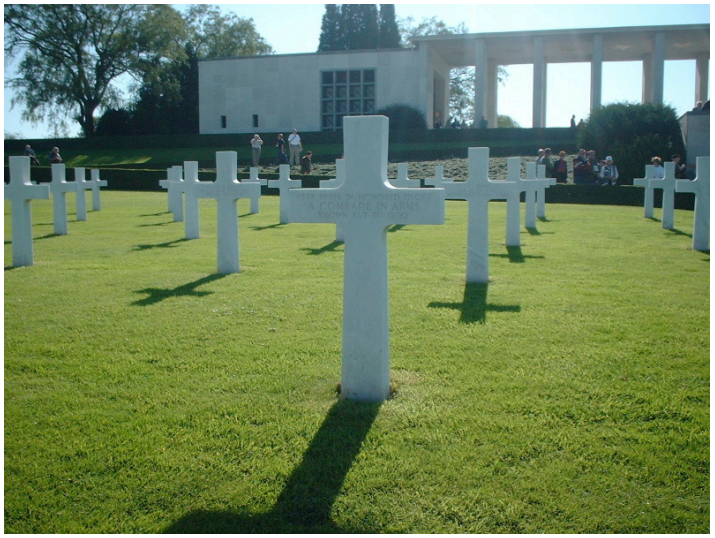
"Sir, [pionless EFT] is like a dog's walking on his hind legs.
It is not done well; but you are surprised to find it done at all."



A Few Issues for this Workshop

Are potential models any less dead than EFT?

- Where is AV22+UX? Nijm-III? Paris-Uppsala potential?
- Where is PWA0x?
- Will there be an end to χ^2-paranoia?
- What about chiral symmetry?
- Whatever happened to QCD?



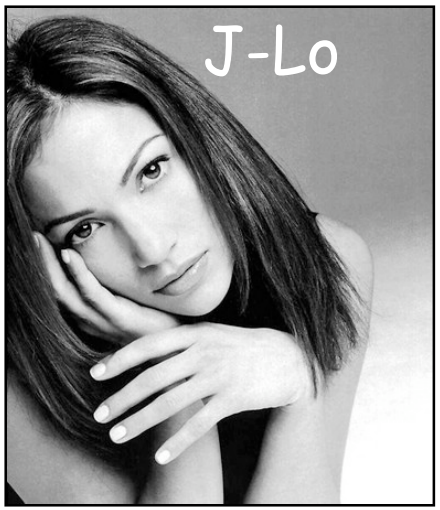
-Successes? A_y-puzzle, Q_d-problem, etc. are all still with us…
- Conventional potentials: How good are they? # parameters < 100?
- Progress in the 3N system?

- How dead do they have to be?!

A Few Issues for this Workshop

$V_{low\text{-}k}$: What is the point?

- What is the predictive power?
- Never better (or worse?) than starting point.
- What, if any, is the relation to chiral EFT?
- What about 3N-forces?
- What about currents: $J_{low\text{-}k}$?



Many-body techniques: the hope & the promise?

- NCSM: Is there convergence for heavier systems than ^{4}He?
- GFMC: Which observables other than energy levels?
- AFDMC, Coupled-clusters, lattice, …
- For all: (i) What is the limit in terms of A?
  (ii) What is the proper input (2NF, 3NF)? EFT? AV18+UIX?

And finally: *What about QCD?*

Dinosaurs vs. Cockroaches

- Cockroaches can't do too much
  - but they feel good about what they *can* do because it is systematically connected to QCD (*well sort of*).

- Dinosaurs can do a lot
  - but as a matter of principal they should feel bad about it because there is only a tenuous connection to QCD.

- In this work I do virtually nothing
  - but I should feel *great* about it since it is directly from QCD

ECT*, Trento, 2005

Week 1	**Monday 20-6**	**Tuesday 21-6**	**Wednesday 22-6**	**Thursday 23-6**	**Friday 24-6**
Morning	Timmermans	Carlson	Coraggio	Kievsky	Quaglioni
	Friar	de Swart	Gross	Machleidt	Ruiz Arriola
Afternoon	Vigdor	Nogga	Pederiva	Gardestig	Thomas
	Navratil	Schwenk	Dean	Horowitz	Zuker
Week 2	**Monday 27-6**	**Tuesday 28-6**	**Wednesday 29-6**	**Thursday 30-6**	**Friday 1-7**
Morning	Lazauskas	Deltuva	Marcucci	Oka	Cohen
	Rentmeester	Epelbaum	Higa	Pavon Valderrama	van Kolck
Afternoon	Griesshammer	Birse	Hemmert	Phillips	
	Truhlik	Kaiser	Stetcu	Weise	