EARLY DAYS DISCOVERIES AND MOROND

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Moriond QCD and High Energy Interactions
La Thuile, March 21-28, 2015

50th Moriond session, *chairperson Jean Trân Thanh Vân*

Rencontres de Moriond

it's about **Tran & Kim**

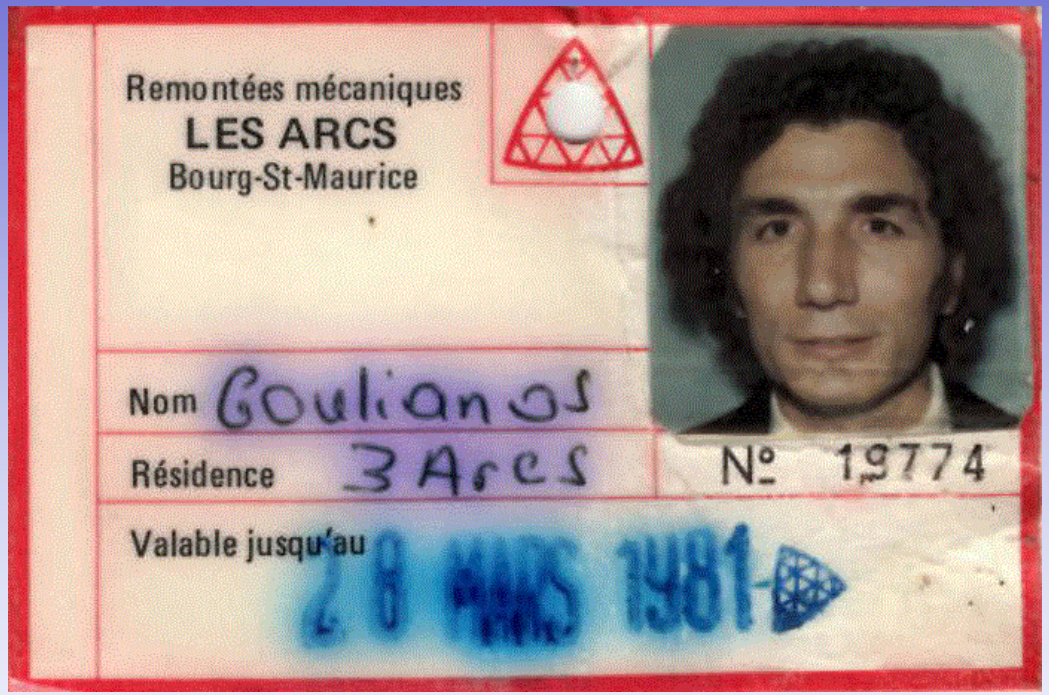
photo credit: Emmanuelle Tran

Mostly personal memories from…

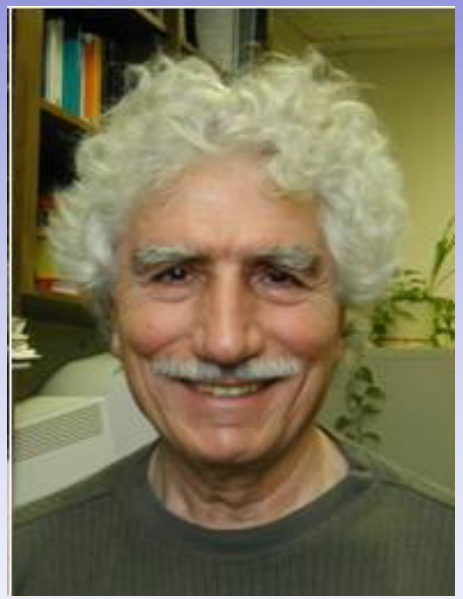
- MORIOND - 22 attended (why Moriond?)
  - Flaine, France 1976-77
  - Les Arcs 78-79-80-81-83-85-90-91-97-99
    - La Plagne 1983-84
  - LaThuile 2000-1-2-3-6-8-9-11-15
- BLOIS / EDS – 11 attended (why Blois?)
  - Chateau de Blois, France 1985
  - Rockefeller U, New York, USA 1987
  - Elba, Italy 1991
  - Brown U, Providence, USA 1993
  - Chateau de Blois, France 1995
  - Pruhonice (Prague), Czech Rep. 2001
  - Helsinki, Finland 2003
  - Blois, France 2005
  - Desy, Hamburg, Germany 2007
  - Quy Nhon, Vietnam 2011
  - Saariselka, Finland 2013

Then and now!

1981



2009



➢ hair bleached from the mountain sun!

FLAINE 1976
My first Moriond

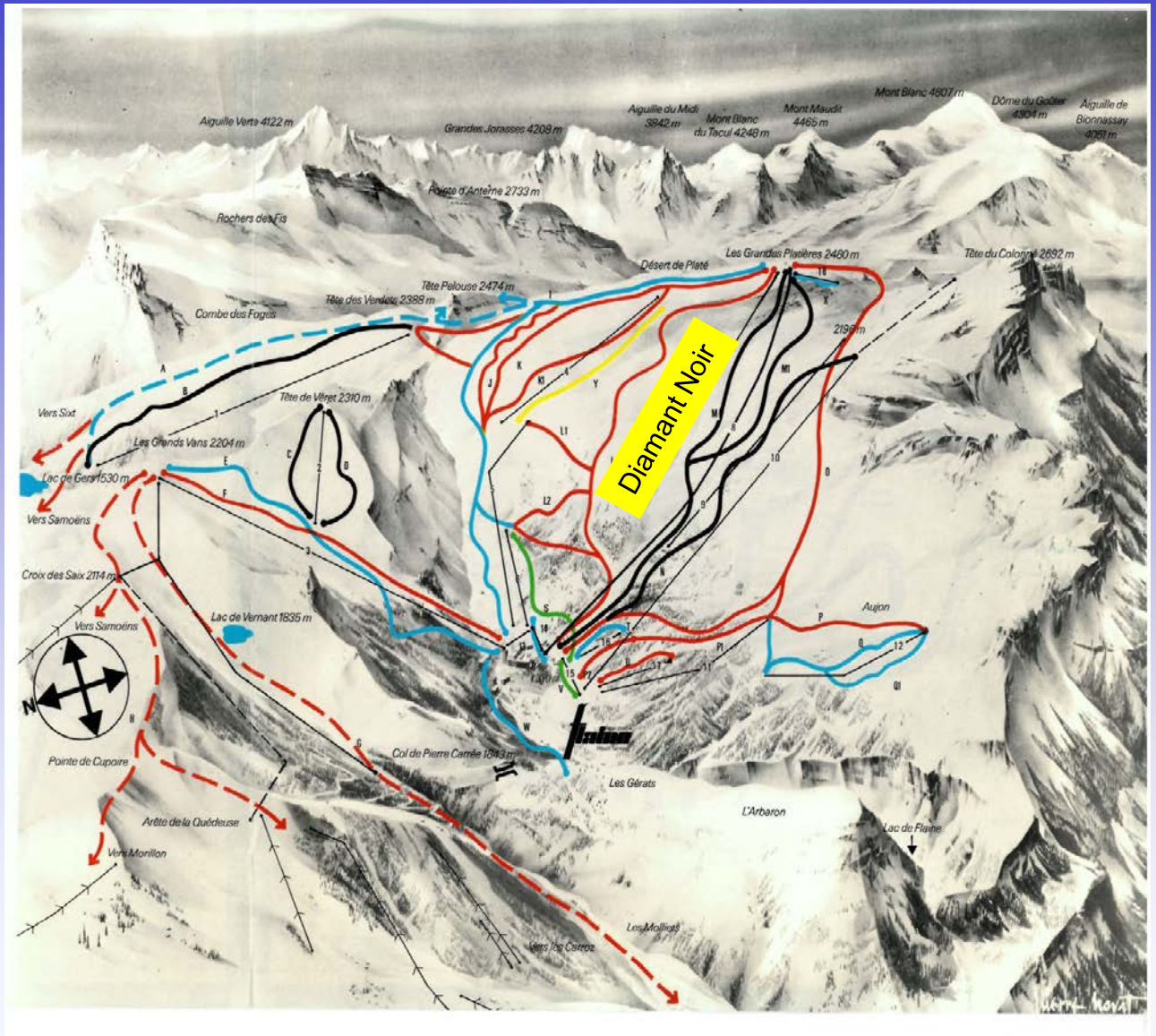
- My talk: “Exclusive Neutral Currents and μe pairs at BNL”
  - **Extra**: the 2-neutrino experiment (talk prepared in 1963)

Wow!

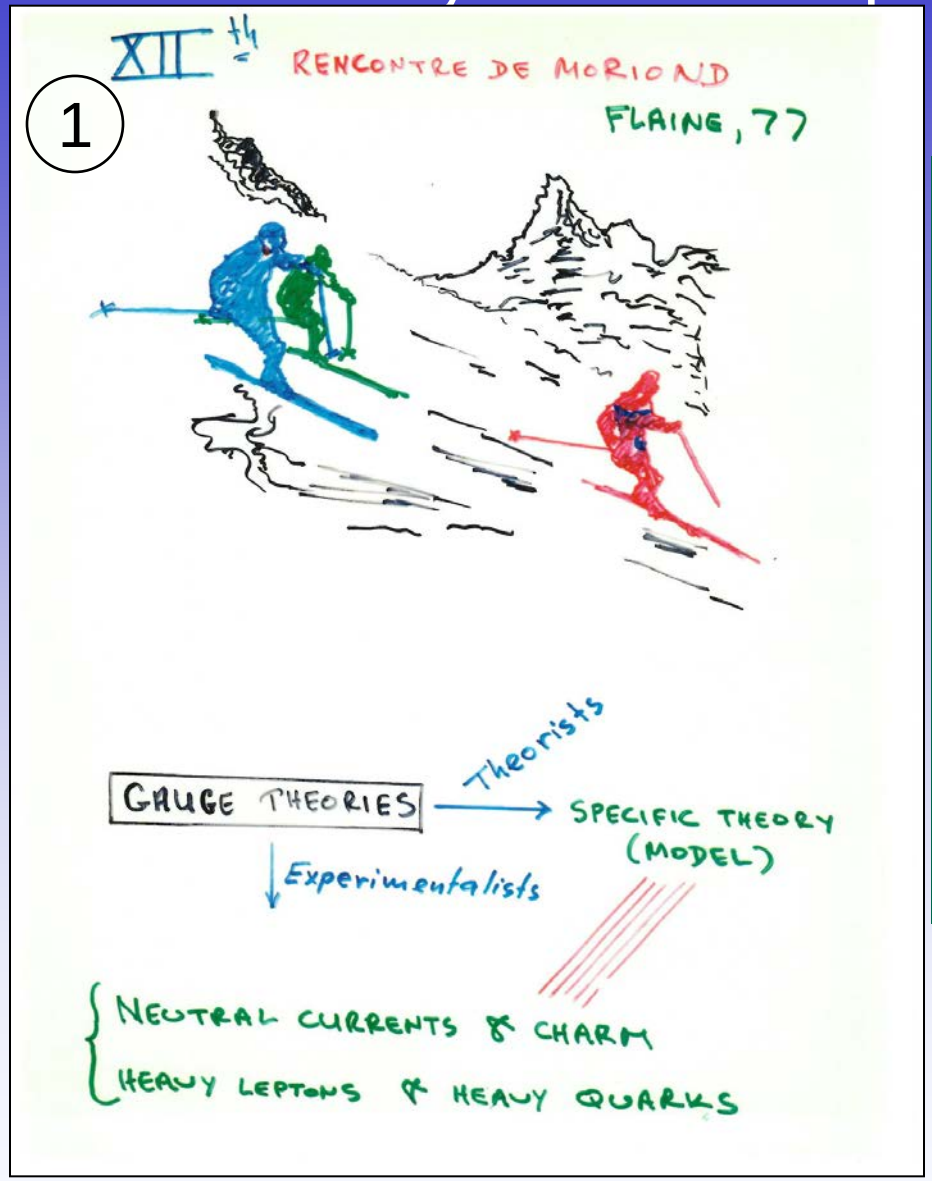
THE MORIOND FORMAT

- New/preliminary results
  - Rubbia (W), Pearl (τ), …
- plenty of discussions
- from ice skating to skiing!
  - My first downhill run
    - ✓ Ice-skating and short skis for braking

Flaine 1976 – 1977 Ski Runs



FLAINE 1977
Summary of EM & Leptonic Interactions Session



- Neutral currents
  - ν_μ+p → ν_μ+p observed Columbia, Illinois, Rockefeller
- Charm
  - SPEAR (LBL-SLAC) → DD*
  - e^+e^- → KX vs $\sqrt{s}$ (SPRAR / DORIS)
- Dileptons
  - Dimuons, eμ, ...
- Heavy leptons
  - τ → τριτον (Martin Perl)

FLAINE 1977
Summary of EM & Leptonic Interactions Session

2 NEUTRAL CURRENTS

→ ∴ 1964 COLUMBIA NEUTRINO EXP.

→ ∴ 1976 (FLAINE) —

Existence firmly established

All properties compatible with W-S

$\nu_\mu p \to \nu_\mu p$ observed (COLUMBIA ILLINOIS ROCKEFELLER

→ ∴ 1977 (FLAINE) —

$\nu_\mu(\bar{\nu}_\mu) p \to \nu_\mu(\bar{\nu}_\mu) p$ Properties studied (Entenberg) (HPW)

→ W-S MODEL OK

[Oxford-Wash. atomic physics exp.
LASER + Bi → ROTATION < 4×10^{-8}
EXCLUDES W-S WITH 90% CONF.]

3 CHARM

→ 1976 Hints : ψ & ψ'
R-value
DIMUONS & μe
(and the 14π of Nick SAMIOS)

To be convinced that charm really existed we needed more direct evidence.

FLAINE 1977
Summary of EM & Leptonic Interactions Session

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EVIDENCE FOR CHARM

1. OBSERVATION OF CHARMED STATES

➡ SPEAR (LBL-SLAC) Khanh

D, D^* —— $\begin{cases} M_{D^0} = 1868 \pm 3 \\ M_{D^{*0}} = 2006 \pm 1.5 \end{cases}$

DECAY MODES
PARITY VIOLATION

2. $e^+e^- \to KX$ as a function of $\sqrt{s}$.

➡ SPEAR (SLAC-LBL) Lüth

$R_{HAD} - 2.5 \simeq R_K$

DORIS { (PLUTO) Blobel
(DASP) Wallraff

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3. DILEPTONS IN ν-INDUCED REACTIONS

1976 — Dileptons established
"Strange particle crisis"
(Wisc., Harvard, LBL, CERN)

DIMUON EVENTS

➡ MINE (Caltech - Fermilab - Rockefeller)
(presented also some HPWFR results)

➡ MURPHY (Fermilab - Hawaii BC exp.)

➡ BALTAY (Columbia - BNL BC exp.)

$e\mu$ - EVENTS

BALTAY : 71 $\mu^- e^+$ events
$\langle p_e \rangle / \langle p_\mu \rangle = 8\frac{1}{2}$
Evisible ~ flat
Rate = (0.5 ± 0.2) %
~1 strange particle per event.

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Summary of EM & Leptonic Interactions Session

RADIATIVE DECAYS OF THE $\psi'(3684)$

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DORIS (PLUTO) Blobel

$e^+e^- \to \mu^+\mu^- \gamma\gamma$
ψ' ψ E_γ

χ - (3.418)
(3.454)
(3.508)
(3.552)

NEUTRAL DECAYS OF THE ψ

DORIS (DESY-Heidelberg) Bartel

$\psi\left(\frac{\text{neutrals}}{\text{all}}\right) = (0.7 \pm 0.2)\,\%$

$\begin{cases} (\eta\gamma/\text{all}) = (1.3 \pm 0.4) \times 10^{-3} \\ (\eta'\gamma/\text{all}) = (2.4 \pm 0.7) \times 10^{-3} \\ (\eta'\gamma/\eta\gamma) = 1.8 \pm 0.8 \end{cases}$

$(\rho\pi/\text{all}) = (1 \pm 0.2)\,\%$

Results from "PLUTO"

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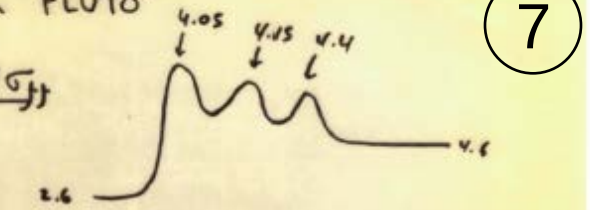
1. $R = \sigma_{tot}/\sigma_{\mu\mu}$



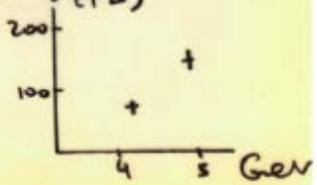
Details of peaks do not agree with SLAC.
e.g. SLAC 4.4 peak is higher by 1 unit of R

2. $e^+e^- \to K_S$ + charged particles.
4.03 vs 3.6 GeV data
Increase comes at $x \lesssim 0.5$

3. No. of K's per event.
Below charmed threshold ~ 0.1 K^0_S/event
Above, ~ 2 K's/event.

4. Inclusive production of J/ψ
$e^+e^- \to$ J/ψ + charged particles
$\sigma \simeq 35$ pb for $4 < \sqrt{s} < 5$ GeV

5. Inclusive $\mu^\pm$ production
$e^+e^- \to \mu^\pm$ + anything



6. χ-states.

FLAINE 1977
Summary of EM & Leptonic Interactions Session

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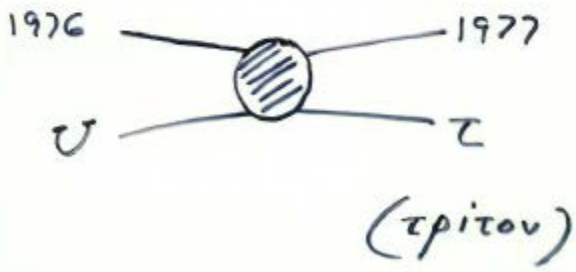

(τρίτον)

— PERLON —

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THE τ - LEPTON

→ SPEAR (SLAC-LBL) M. Perl

$e^+e^- \to \tau^+\tau^-$

$\tau \to \nu_\tau \mu^- \bar{\nu}_\mu$

$\tau \to \bar{\nu}_\tau e^+ \nu_e$

171 events

$M_\tau = 1.9 \pm 0.1$ GeV

$\tau^\pm$, $\nu_\tau(\bar{\nu}_\tau)$ — Sequential lepton.

LEAD-GLASS WALL EXP (SLAC-LBL)

→ DORIS (PLUTO) Blobel

$e^+e^- \to e\mu\phi$

12 events consistent with τ

Also, $e^+e^- \to \mu X$

→ DORIS (DASP) Wallraff

$e^+e^- \to eX$

↳ electron spectrum

FLAINE 1977
Summary of EM & Leptonic Interactions Session

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THE ψ^* LEPTON

➡ SLAC (Santa Cruz, SLAC) C. Heush

$\psi p \rightarrow \psi^* p$

$\hookrightarrow \psi \rho^0$ $\hookrightarrow \pi^+\pi^-$

Peak at $M_{\psi^*} \simeq 1840$ (25 MeV bin res.)

10^{-5} prob. for stat. fluke.

Cannot be $D(1864)$ or heavy muon

$\hookrightarrow K\pi\pi$ (K misidentified as ψ)

➡ THE ? LEPTON

Fermilab (HPWFR) Benvenuti

5 trimuon events

Cannot be from hadronic sources

Speculation: from new leptons

e.g. $\nu N \rightarrow L^- X$

$\hookrightarrow \psi^- \bar{\nu}$ $L^0 \hookrightarrow \psi^+ \psi^- \nu$

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THE END

The τ (τριτον) Lepton

EVIDENCE FOR, AND PROPERTIES OF, THE NEW CHARGED HEAVY LEPTON* †

Martin L. Perl
Stanford Linear Accelerator Center
Stanford, California 94305, USA

*Paper presented at the XII Rencontre de Moriond (Flaine, March 6-18, 1977; to be published in the Proceedings of the XII Recontre de Moriond, edited by Tran Thanh Van, R.M.I.E.M. Orsay.

MORIOND 1977 SUMMARY TALK

THE FINISH *

(SUMMARY AND CONCLUSION)+

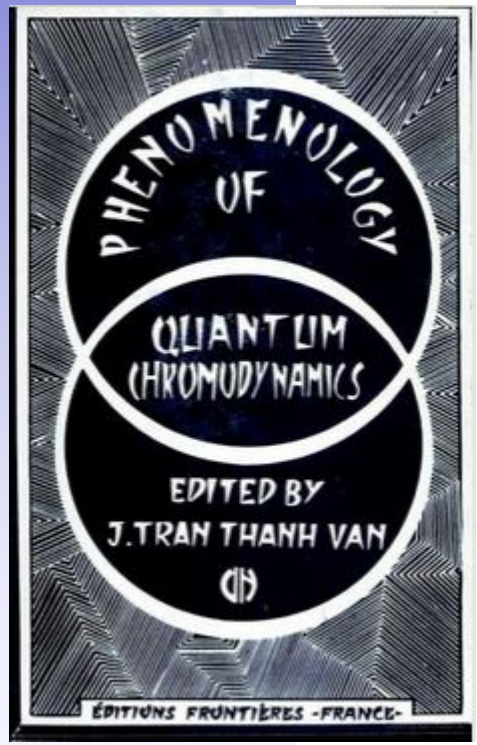
K. GOULIANOS
The Rockefeller University
New York, N. Y. 10021 (USA)

* Concluding remarks at the Leptonic Interactions session of the XIIth Rencontre de Moriond, Flaine, Haute-Savoie, France, March 6-12, 1977.

At the end of an intense, intellectually stimulating and physically exhausting week --- there were six hours of scheduled talks, several hours of informal discussion, and four hours of compulsory (I swear!) skiing every day --- the "Summary and Conclusion" lecture seemed like "THE FINISH" of a long and exciting race.

MORIOND 1978 – LES ARCS

XIII th Rencontre de Moriond - Session I, Les Arcs
(Savoie) France - March 12 - 18, 1978



WHAT IS GLUE GOOD FOR? or GLUONS COME OUT OF THE CLOSET

S. D. Ellis †
Department of Physics
University of Washington
Seattle, Washington, U.S.A. 98195

STUDYING GLUON PROPERTIES EXPERIMENTALLY*, †

G.L. Kane
Physics Department
University of Michigan
Ann Arbor, MI 48109 USA

MORIOND 1978 – LES ARCS
Leon and the Peon

DILEPTONS AT MORIOND

Leon M. Lederman
Columbia University

Leon

DIFFRACTIVE HADRON DISSOCIATION

K. Goulianos
The Rockefeller University
New York, N. Y. 10021

the Peon

MY MORIOND

The conference that shaped my life

- All welcome: Students, Professors, Scientists, Engineers
- Prerequisites: a passion for science – and skiing!
  - ancient Greece: healthy mind in healthy body
- Rewards: meet other scientists, make life-long friends

- Meet Kim and Tran – and your hard work will be fun!

MORIOND still going strong!

Thank you for your attention