Experimental Summary Talk

Electroweak Interactions & Unified Theories
50th Rencontres de Moriond

La Thuile, 21st March 2015

Terry Wyatt
University of Manchester.
Overview

• $\nu$
• Dark matter searches
• Higgs
• Electroweak
• Top
• Exotica
• Heavy Flavour

• With emphasis on recent, interesting results
• Unfortunately, I have very little time to cover
  – Specifics of individual detectors
  – Future prospects

  – There were some great talks at this meeting – especial credit to the speakers at the YSFs.
**Introduction**

PMNS matrix

\[
U_{\alpha i} = \begin{bmatrix}
1 & 0 & 0 \\
0 & c_{23} & s_{23} \\
0 & -s_{23} & c_{23}
\end{bmatrix} \begin{bmatrix}
c_{13} & 0 & s_{13}e^{-i\delta} \\
0 & 1 & 0 \\
-s_{13}e^{i\delta} & 0 & c_{13}
\end{bmatrix} \begin{bmatrix}
c_{12} & s_{12} & 0 \\
-s_{12} & c_{12} & 0 \\
0 & 0 & 1
\end{bmatrix} \begin{bmatrix}
1 & 0 & 0 \\
0 & e^{i\alpha/2} & 0 \\
0 & 0 & e^{i\beta/2}
\end{bmatrix}
\]

**Terra Cognita:**

\[\begin{align*}
\delta m^2 & \sim 8 \times 10^{-5} \text{ eV}^2 \\
\Delta m^2 & \sim 2 \times 10^{-3} \text{ eV}^2 \\
\sin^2 \theta_{12} & \sim 0.3 \\
\sin^2 \theta_{23} & \sim 0.5 \\
\sin^2 \theta_{13} & \sim 0.02
\end{align*}\]

**Terra Incognita:**

- \(\delta (CP)\)
- sign(\(\Delta m^2\))
- octant(\(\theta_{23}\))
- absolute mass scale
- Dirac/Majorana nature
v Introduction

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\[ \delta (CP) \]
\[ \text{sign}(\Delta m^2) \]
\[ \text{octant}(\theta_{23}) \]

Is there Terra Incognita Incognita?
Common Features of Detectors for Low Energy Neutrinos and Dark Matter

- Deep underground
- Active/passive shielding around active volume
- Fiducial volume to select fully contained events
- Extremely high radiopurity
- Systematic response calibration and monitoring
- Require coincidence between more than one detection technique for signal:
  - E.g., ionization, scintillation light, Cerenkov light, phonons ➔ temperature rise, prompt + delayed signal, etc.
Solar Neutrinos (Borexino)

- 300 tons of liquid scintillator
  - No directional information
- Extreme radiopurity required
- \( pp \nu: \text{counts per day per 100 Tons} = 144 \pm 13 \text{ (stat.)} \pm 10 \text{ (syst.)} \)
- Consistent with expectations from photon luminosity
Comparison of Reactor $\nu$ Experiments

Inverse beta decay

$\bar{\nu}_e + p \rightarrow e^+ + n$

$+H \rightarrow D + \gamma$

$+Gd \rightarrow Gd^* \rightarrow Gd + \gamma's$
Daya Bay

- Factor 4 increase in Gd data set
- $>10^6$ signal events
- Most precise determination of $\sin^2 2\theta_{13}$
  - Already factor $\sim 2$ more precise than achievable with Double Chooz in 5 years’ time!

\begin{align*}
\sin^2 2\theta_{13} & = 0.084^{+0.005}_{-0.005} \\
|\Delta m_{ee}^2| & = 2.44^{+0.10}_{-0.11} \times 10^{-3} (eV^2) \\
\chi^2 / NDF & = 134.7 / 146
\end{align*}
The Reactor Antineutrino Anomaly

- Observed/expected=0.94 (~3σ) deficit in the detected antineutrinos from short baseline reactor experiments

- Possible interpretation as evidence for sterile ν
Disagreement Between Predicted and Observed Absolute Flux at Reactor Near Detectors

Daya Bay

RENO

\[ \sin^2 2\theta_{13} = 0.103 \]

\[ |\Delta m^2_{31}| = 2.32 \times 10^{-3} \text{ eV}^2 \]
Uncertainties in Calculation of Reactor Flux

- These are immensely complicated calculations
- Extremely hard to decide on theoretical grounds which calculation is correct
Clearly a Need for New Experiments
Clearly a Need for New Experiments

- We should support Experiments such as PROSPECT, SOLID, NUCIFER, STEREO
- Until these experiments have been done:
  - Ignore claims about sterile neutrinos based on absolute rates at reactors
  - The quoted systematic uncertainties are underestimated by factor ~2?

- Similarly important are experiments like
  - SHINE: to measure hadron production for accelerator based ν experiments
  - MINERνA: to measure ν cross sections
T2K: $\nu_e$ Appearance and $\theta_{13}$

- Observation of $\nu_\mu \rightarrow \nu_e$ with 7.3$\sigma$ significance
- No statistically significant measurement of $\delta_{CP}$
Measurements of $\nu_\mu$ Disappearance

- Summary of accelerator and atmospheric $\nu_\mu$

- Interesting that IceCube uncertainties fit on this plot!
Very High Energy Neutrinos with IceCube

- Cerenkov light in ice
- 1 km$^3$ active volume
- 1.5–2.5 km under surface
- $\nu$ detection threshold $\sim$200 GeV
Very High Energy Neutrinos with IceCube

- Energy spectrum of observed events
  - Downward going
  - Upward going

- Low energy shows good understanding of atmospheric and cosmic muon backgrounds
- High energy (37 candidates) shows clear signal for Astrophysical $\nu$
  - $5.7 \sigma$ above backgrounds
Very High Energy Neutrinos with IceCube

- Event topology gives information on ν flavour

Muon track  Shower (cascade)

\[ \nu_\mu + N \rightarrow \mu^- + X \quad \nu_\mu \text{ (NC), } \nu_e, \nu_\tau \]

- Number of observed tracks ≈ expected background
- However, within uncertainties, data perfectly consistent with naïve expectation \( \nu_e, \nu_\mu, \nu_\tau \approx 1:1:1 \)
- Need more data!
Very High Energy Neutrinos with IceCube

- No evidence for clustering of events in direction
Neutrinoless Double Beta Decay

- EXO-200
- 200 kg (76.3 fiducial) of enriched liquid xenon
  - 80% $^{136}\text{Xe}$
- $^{136}\text{Xe}$: 100 kg.years exposure
- $\tau_{1/2}^{0\nu\beta\beta} > 1.1 \times 10^{25}$ years
Super K: Proton Decay Searches

- No data candidate observed (0.7 expected)
- \( \tau/\text{Br}(p\rightarrow e\pi^0) > 1.4 \times 10^{34} \) years (90% CL)

Also:
- \( \tau/\text{Br}(p\rightarrow vK^+) > 5.9 \times 10^{33} \) years (90% CL)
- \( \tau/\text{Br}(p\rightarrow evv) > 1.7 \times 10^{32} \) years (90% CL)
- \( \tau/\text{Br}(p\rightarrow \mu vv) > 2.2 \times 10^{32} \) years (90% CL)

(world’s best limits in each case)
Searches for Dark Matter

- Weak interactions with SM particles
- Stable (or almost so)
- Masses \( \sim \text{GeV} \rightarrow \sim \text{TeV} \)

- Complementary search strategies

- Only negative searches to report 😞

At colliders DM particles may also be produced in decay of other BSM particles
Searches for Dark Matter: Direct Detection

- XENON100 (62 kg target – scintillation light+ionization): Axion search

  ![Expected signal if ALP constitute all of galactic DM gAe = 4x10^{-12}](image1)

- CREST-II (phonons + scintillation) 600 eV threshold

  ![Light Yield vs. Energy with signal region](image2)
Searches for Dark Matter: Indirect Detection

- HESS
  - four 12 m, one 28 m telescopes
  - energy threshold $\mathcal{O}(30 \text{ GeV})$

- Look for DM annihilation to SM particles
- Search in regions where large DM accumulations might be expected:
  - Dwarf galaxies
  - Inner galactic halo
Searches for Dark Matter: Colliders

- DM particles undetected → missing transverse momentum

- Negative searches also in many other channels
  — See later

Treatment of search limits within EFT/Simplified models will be covered in the talk by Alessandro Strumia
Planck

• Improvements for 2015:
  – data calibration
  – better control of systematics
  – full mission data: increase of statistics
  – polarization

\[ \sum (m_\nu) < 0.23\text{eV} \quad (95\% \text{CL limit}) \]

• Neff = effective number of relativistic degrees of freedom
• If ONLY photons and standard light neutrinos contribute to the radiation, expect:
  – \( \text{Neff} = 3.046 \)

• Results:
  \[
  \begin{align*}
  \text{N}_{\text{eff}} &= 2.99 \pm 0.20 \quad \text{Planck TT, TE, EE+lowP} ; \\
  \text{N}_{\text{eff}} &= 3.04 \pm 0.18 \quad \text{Planck TT, TE, EE+lowP+BAO} .
  \end{align*}
  \]

• Constrain contribution from sterile neutrinos, axions, lepton number violation, primordial gravitational waves, etc.
Higgs Boson Mass @ LHC

Precise mass determinations in two channels:

\[ H \rightarrow ZZ \rightarrow l^+l^-l^+l^- \]

\[ (l = e \text{ or } \mu) \]

\[ H \rightarrow \gamma\gamma \]

All other channels have \( \nu \) and/or hadrons in final state
Higgs Boson Mass @ LHC

\[ m_H = 125.09 \pm 0.21 \, \text{(stat.)} \pm 0.11 \, \text{(syst.)} \, \text{GeV} \]

dominated by energy/momentum scale calibration (which is also dominated by available statistics)

Overall 0.19% precision already achieved!
Higgs Boson @ LHC: Signal Strength for Decay Modes

Signal strength: $\mu = \frac{\sigma_{\text{observed}}}{\sigma_{\text{SM}}}$

<table>
<thead>
<tr>
<th>Decay Mode</th>
<th>$\mu$ (ATLAS Preliminary)</th>
<th>$\sigma_{\text{stat.}}$</th>
<th>$\sigma_{\text{sys. inc.}}$</th>
<th>$\sigma_{\text{theory}}$</th>
<th>Total Uncertainty</th>
<th>$\pm 1\sigma$ on $\mu$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H \rightarrow \gamma\gamma$</td>
<td>$1.17^{+0.28}_{-0.26}$</td>
<td>$0.23$</td>
<td>$0.16$</td>
<td>$0.11$</td>
<td>$0.12$</td>
<td>$0.08$</td>
</tr>
<tr>
<td>$H \rightarrow ZZ^*$</td>
<td>$1.46^{+0.40}_{-0.34}$</td>
<td>$0.31$</td>
<td>$0.19$</td>
<td>$0.13$</td>
<td>$0.18$</td>
<td>$0.11$</td>
</tr>
<tr>
<td>$H \rightarrow WW^*$</td>
<td>$1.18^{+0.24}_{-0.21}$</td>
<td>$0.18$</td>
<td>$0.17$</td>
<td>$0.14$</td>
<td>$0.13$</td>
<td>$0.09$</td>
</tr>
<tr>
<td>$H \rightarrow bb$</td>
<td>$0.63^{+0.38}_{-0.37}$</td>
<td>$0.31$</td>
<td>$0.24$</td>
<td>$0.23$</td>
<td>$0.09$</td>
<td>$0.07$</td>
</tr>
<tr>
<td>$H \rightarrow \tau\tau$</td>
<td>$1.44^{+0.42}_{-0.37}$</td>
<td>$0.30$</td>
<td>$0.29$</td>
<td>$0.23$</td>
<td>$0.16$</td>
<td>$0.10$</td>
</tr>
<tr>
<td><strong>Combined</strong></td>
<td><strong>$1.18^{+0.15}_{-0.14}$</strong></td>
<td><strong>$0.10$</strong></td>
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</tbody>
</table>

- Results consistent with SM
Higgs Boson @ LHC: Signal Strength for Production Mechanism

- Again consistent with SM!
  - Of course, with this number of measurements one expects 2 sigma fluctuations!
- Many ways of re-expressing signal strength measurements to focus on particular combinations or ratios ..... 
  - e.g., both experiments have 3–4σ evidence for VBF production mode
- ...... but the essential message remains the same: 
  - Data are consistent with expectations from SM Higgs
Higgs Boson @ LHC

Production kinematics

- Spin 1 and 2 variants ruled out at better than 95% CL
- Limits on possible admixtures of 0⁻ or BSM

Decay kinematics
Higgs Boson @ LHC: Indirect Determination of Higgs Width

- High mass tail in $H \rightarrow ZZ \rightarrow l^+l^-l^+l^-$ sensitive to $\Gamma_H$
  - At 95% CL: $\Gamma_H/\Gamma_{SM} < 4$ (CMS) < 5.5 (ATLAS)
  - Requires some assumptions
Higgs Boson @ LHC

Searches for rare/exotic Higgs decays

- E.g., $H \rightarrow \mu \mu$
- $\text{Br}(95\% \text{ CL limit})/\text{Br}(\text{SM}) \sim 7$ (both experiments)
  - $\text{Br}(\text{SM}) = 2.2 \times 10^{-4}$ \(~1/10 \text{ Br}(H \rightarrow \gamma \gamma)\)
- Important to demonstrate non-universality of lepton couplings!

\[\text{Br}(H \rightarrow \text{invisibles}) < 30\% \at 95\% \text{ CL}\]
- Similar results from both experiments

Searches for additional (higher mass) Higgs

- E.g., Search for $H \rightarrow ZZ \rightarrow l^+l^-bb$ (2 b-tag)

The bottom line:

- All (presented in public) searches give negative results
Higgs Boson @ LHC: Closing Remarks

• So little data, such low energy! (25 fb\(^{-1}\), 7–8 TeV)
  – Even just observing the Higgs was a surprise!
• To be able to make such precise measurements is astounding!
• Each one of these individual measurements required huge effort and ingenuity
  – which flashed by in 20 seconds of even the dedicated talks
• - measurements are in very good agreement with SM predictions

A comment on theoretical uncertainties

• Predictions for signal strength precision with 300 & 3000 fb\(^{-1}\)
• With today’s tiny dataset measurements within factor 2 of theoretical uncertainty
• Huge theoretical effort will be needed to reduce these uncertainties to an adequate level!
Global Electroweak Fit

- Corrections calculated to 2-loop EW precision

- Mixed EW-QCD terms only at order $\alpha \alpha_s$

- Include $\Delta m_t = 0.5$ GeV theoretical uncertainty

- Improving direct $\Delta M_W$ a high priority
  - $\Delta M_W = 15$ MeV (direct), c.f. 8 MeV (fit)

- Consistent fit to all the data
  - $\chi^2 = 17.8$ for 14 d.o.f.
Multi-Boson Measurements

• E.g. $W^+W^-$ cross section

\[
\sigma_{W^+W^-} = 60.1 \pm 0.9 \text{(stat.)} \pm 3.2 \text{(exp.)} \pm 3.1 \text{(th.)} \pm 1.6 \text{(lum.)} \text{pb}
\]
compatible with NNLO theory prediction: $59.8^{+1.3}_{-1.1}$ pb

• A tri-boson final state: $W\gamma\gamma \rightarrow l\nu\gamma\gamma$

• First evidence (3.7 $\sigma$ significance)

• N.B. NLO EWK corrections are NOT available in most cases
  – Largest effect in high $p_T$ regions and this is just where data are sensitive to anomalous coupling effects
EW Measurements from Tevatron: p\bar{p} has a big advantage!

$W^\pm \rightarrow l^\pm \nu$ asymmetry

- Inclusive data well described

$Z \rightarrow e^+e^-$ forward-backward asymmetry

- Sensitive to light (u,d) quark couplings
- DØ $Z \rightarrow e^+e^-$ competitive with LEP combined $A_{FB}^{ll}$

Separate low ($25 < E_T^{e, \nu} < 35$ GeV) and high ($E_T^{e, \nu} > 35$ GeV) regions poorly described
EW Measurements from Tevatron

$\phi^*_\eta$ in $Z/\gamma^* \rightarrow \mu^+\mu^-$ (30 $< M_{\mu\mu} <$ 500 GeV, in bins of $M_{\mu\mu}$ and $Z/\gamma^*$ rapidity)

$$\phi^*_\eta = \tan(\phi_{acop}/2)\sin(\theta^*)$$

Ratio between rapidity bins cancels large theory systematic

W+heavy flavour jets

WW+jets
**EW Measurements from Tevatron**

\[ \phi^*_\eta \text{ in } Z/\gamma^* \rightarrow \mu^+\mu^- \quad (30 < M_{\mu\mu} < 500 \text{ GeV}, \text{ in bins of } M_{\mu\mu} \text{ and } Z/\gamma^* \text{ rapidity}) \]

\[ \phi^*_\eta = \tan(\phi_{acop}/2)\sin(\theta^*) \]

- Ratio between rapidity bins cancels large theory systematic
- Or is this QCD!?
The Top Quark Turns 20!

And has still been a vibrant field of study in recent years
(at both Tevatron and LHC)
Top Quark Production Cross Section@LHC

- Huge theoretical progress!

ATLAS: \( m_t^{\text{pole}} = 172.9 \pm 2.6 \text{ GeV} \)

CMS: \( m_t^{\text{pole}} = 176.7 \pm 3.0 \text{ GeV} \)

EPJC74 (2014) 3109 (Nov ‘14)

PLB 728 (2014) 496 (Nov ‘14)
Top Mass@LHC

- CMS: lepton+jets
- Most precise single measurement at LHC to date
- Requires very careful calibration of jet energy scale
- Cross-check of b-jet energy scale
  - compare $p_T$ balance in $Z + \text{jet}$ and $Z + \text{b-jet}$ events

$\mathbf{m_t = 172.0 \pm 0.2(\text{stat}) \pm 0.8(\text{syst}) \text{ GeV}}$
Top Mass@Tevatron

- Also at Tevatron significant recent progress

- Relationship between $M_t^{MC@NLO}$ and $M_t^{GFitter}$ to be discussed in talk by Alessandro
Single Top Production@LHC
Observation of Single Top production in s-channel@Tevatron

Significance 6.3 $\sigma$

$|V_{tb}| > 0.92$ at 95% C.L.

$|V_{tb}| = 1.02 \pm 0.06$
Top Quark Asymmetries

- Full Tevatron dataset agree with latest predictions
Searches for BSM Physics@LHC

• All the ‘easy’ stuff was done by Moriond 2013!
• Subsequently: great ingenuity in ‘leaving no stone unturned’

E.g., Searches for Long-lived BSM particles

- Search for anomalous displaced vertices
- Search for stable massive particles using $dE/dx$ in pixel tracker
Searches for BSM Physics@LHC

Stop pair with small stop-top mass difference (\(\Delta m\)) `compressed SUSY’

- For large \(\Delta m\) this is `easy’
  - See tt events with anomalously large \(E_{\text{Tmiss}}\)
- For low \(\Delta m\) stop pair events look very much like tt!
- Exploit:
  - Increase in measured cross section
  - Modified `spin correlations’
- Nice example of potential for precise measurements to be sensitive to BSM physics!
Searches for BSM Physics@LHC

`Boosted’ top jets

- At TeV energies even the top quark is `light’
- All decay products end up in one `fat’ jet
- Various techniques to disentangle sub-structure

Use boosted technique to extend measurement of top quark $p_T$

No excess observed  
Set limits on $Z’$ production
LHCb: $B^0 \rightarrow K^{*0} \mu^+ \mu^-$ with 3fb$^{-1}$

Decay fully described by three helicity angles $\tilde{\Omega} = (\theta_\ell, \theta_K, \phi)$ and $q^2 = m_{\mu\mu}^2$

Veto

$\Psi(2s) \rightarrow \mu^+ \mu^-$

$J/\psi \rightarrow \mu^+ \mu^-$
(used as a calibration, cross-check sample)
LHCb: $B^0 \rightarrow K^{*0}\mu^+\mu^-$ with $3\text{fb}^{-1}$

- Total signal yield = $2398 \pm 57$ events
- Significant signal seen in each bin of $q^2$
LHCb: $B^0 \rightarrow K^{*0} \mu^+ \mu^-$ with 3fb$^{-1}$

1D projections of multidimensional likelihood for $1.1 < q^2 < 6$ GeV$^2$

Efficiency-corrected data well described by fitted likelihood distribution
LHCb: $B^0 \rightarrow K^{*0} \mu^+ \mu^-$ with 3 fb$^{-1}$

- $P'_5$ is a combination of the fitted angular coefficients for which hadronic form factor uncertainty should be small.

- Naïve significance of discrepancy in the two $q^2$ bins from 4–8 GeV$^2$ is 3.7 $\sigma$. 

![Graph showing $P'_5$ vs $q^2$](image-url)
LHCb: $B^0 \rightarrow K^*0\mu^+\mu^-$ with $3\,\text{fb}^{-1}$

- $P'_5$ is a combination of the fitted angular coefficients for which hadronic form factor uncertainty should be small

- Naïve significance of discrepancy in the two $q^2$ bins from 4–8 GeV$^2$ is 3.7 $\sigma$
- Results with $3\,\text{fb}^{-1}$ compatible with and more precise than those with $1\,\text{fb}^{-1}$
LHCb: CP Violation in $B_s^0$

Decay angular distributions in $B_s^0 \to J/\psi K^+ K^-$

Measurements dominated by LHCb
($B_s^0 \to J/\psi \pi^+ \pi^-$
and $B_s^0 \to J/\psi K^+ K^-$)
LHCb: Direct Measurement of CKM Angle $\gamma$

\[ \gamma \equiv \arg \left( -\frac{V_{ud}V^*_{ub}}{V_{cd}V^*_{cb}} \right) \]

- **Indirect measurements** (dominated by loops):
  - CKMFitter: \((66.9^{+1.0}_{-3.7})^\circ\) (global fit w/o $\gamma$ meas.)

  ![Graph showing indirect measurements]

- **Direct measurements**
  - BaBar: \((69^{+17}_{-16})^\circ\)
  - Belle: \((68^{+15}_{-14})^\circ\)
  - LHCb: \((73^{+9}_{-10})^\circ\)

  ![Graph showing direct measurements]

- Still a long way to go before direct measurements match indirect precision
LHCb: determination of CKM element $|V_{ub}|$

- First observation of exclusive decay $\Lambda_b \rightarrow p\mu^-\nu$
  - $\text{Br}(\Lambda_b \rightarrow p\mu^-\nu) = (3.92\pm0.83) \times 10^{-4}$

Tension between $|V_{ub}|$ measured in:

- Inclusive decays
- Exclusive decays
LHC Machine

10,170 high current splices, of which 3000 completely reworked
Magnet retraining going slowly in the last sector 45
LHC Machine

10,170 high current splices, of which 3000 completely reworked

Integrated luminosity plan for run 2

<table>
<thead>
<tr>
<th>Year</th>
<th>Peak lumi E34 cm⁻²s⁻¹</th>
<th>Days proton physics</th>
<th>Approx. int lumi [fb⁻¹]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>1.3</td>
<td>100</td>
<td>10</td>
</tr>
<tr>
<td>2016</td>
<td>1.5</td>
<td>160</td>
<td>35</td>
</tr>
<tr>
<td>2017</td>
<td>1.7</td>
<td>160</td>
<td>45</td>
</tr>
<tr>
<td>2018</td>
<td>1.7</td>
<td>40</td>
<td>10</td>
</tr>
</tbody>
</table>
Plus ça change .... ?

Daniel Treille
Plus ça change .... ?
We have re-entered the regime of ............

Daniel Treille
Some Thoughts on the Above

- We have collected only 1% of the foreseen LHC integrated luminosity at ~half the design √s
- However, we may have to face the prospect that BSM particles may not appear in direct searches in Run 2
- We may have to rely on precision measurements to discover new physics

- In the days of LEP there was a fairly natural dividing line between `Electroweak' and `QCD'
  - modulo αs, hadronic event selection efficiencies, etc.
- In hadron collisions `Electroweak' and `QCD' are inextricably linked
  - We use `Electroweak' probes to test QCD/tune MC
  - As we have seen at this meeting QCD uncertainties are already significant or even dominating some measurements

- A comment from an experimentalist on the theory programme
- In the ν, DM and heavy flavour sessions there was a healthy balance between `down to earth' and `speculative' theory talks
- In the `energy frontier' (Higgs, EW, top and exotics) sessions this was not the case
  - 12 talks, of which only one or two were related to issues affecting precision measurements
  - Overwhelming majority devoted to BSM model building or parameterizing BSM effects in EFT, etc.

- After ~40 years of the split between `Moriond EW' and `Moriond QCD', perhaps it’s time to consider if this structure best meets the aims of Moriond
  - To be `useful'
  - To bring experimentalists and theorists together
There is no Summary of the Summary of the Summary of the Summary of the Summary