La Thuile, Aosta Valley, Italy
February 26 - March 3, 2012

Julie Kirk

http://agenda.infn.it/conferenceOtherViews.py?view=standard&confId=4116

07/03/2012
About 120 participants
2 sessions a day (8.30-11.30 and 4.30-7.30) covering:

- Cosmology and Astrophysics
- Neutrino Physics and Lepton Flavour Violation
- QCD Physics/Hadronic Interactions
- Flavour Physics/CP Violation and Rare Decays
- Electroweak and Top Physics
- Higgs Searches
- Searching for New Physics
- Perspectives

- Physics and Society
- Young Scientist Forum

Each session about 7-8 20 minute talks with questions
→ selected highlights here

Thorium reactors
Physics in Latin America

New this year:
Experiments asked to nominate good, young scientists to talk about their research.

07/03/2012
To Wi-Fi or NOT to Wi-Fi ??

No Wi-fi in conference room (7th floor). Good as people pay attention to the talks....

..BUT attendance not great at some sessions. Not everyone was out skiing
Summary (sadly)
“Come back next week”
i.e. for Moriond!
Planck – Cosmic Microwave Background

3rd generation of CMB experiment:
- Better angular resolution
- Larger frequency range
Current Status

- 1019 days since launch.
- Satellite and instruments have been working nominally and continuously since start of sky surveys (mid August 2009)
  - HFI ran out of He on 14 Jan 2012 and stopped taking scientifically useful data
  - LFI still data gathering (several months)
- All the sky has been surveyed about five times with both instruments. LFI is already into its sixth sky survey.

Planck is a survey mission

Current results of interest to astrophysics Expect results from cosmological programme in 2013

About 6 months are needed to cover ~95% of the sky.
First full sky CO Map

Shows star forming regions
Cosmic Haze:
Synchrotron emission from centre of galaxy – not consistent with expectations.

SN/ new CR component/ DM??

Also seen by Fermi

3 years smoothed count map above 10 GeV
Positron fraction rises with energy. Confirms PAMELA result
Low energy dark forces

Several unexpected astrophysical observations (PAMELA, ATIC, INTEGRAL, DAMA/LIBRA, CoGent…) could be explained with the existence of a hidden gauge sector weakly coupled with SM through a mixing mechanism of a new gauge boson \( U, A', V \ldots \) with the photon:

\[ e^- \rightarrow e^- \gamma^* \rightarrow e^- U \]

- \( U \) mass range: \( 1 \text{ MeV} \) – few \( \text{GeV} \)
- Coupling constant of electric charge to \( U \): \( \varepsilon \leq 10^{-3} \)
- \( U \) production/decay through photon mixing

\[ \alpha'/\alpha \leq 2 \times 10^{-5} \text{ at } 90\% \text{ C.L. for } 50 < M_U < 420 \text{ MeV} \]
A dark photon can be readily produced in
\[ e^+e^- \rightarrow \gamma A', A' \rightarrow f\bar{f} \]
The limits on \( e^+e^- \rightarrow Y(2S,3S) \rightarrow \gamma\mu^+\mu^- \) can be reinterpreted as limits on dark photon production.

Limit on \( \varepsilon^2 = \alpha'/\alpha \) for various Higgs mass (assuming \( \alpha_0 = \alpha_{em} \))

Substantial improvement over existing limits for
\( m_{h'} < 5 - 7 \text{ GeV} \) if light dark Higgs boson exists

The Higgs'-strahlung process
\[ e^+e^- \rightarrow A^* \rightarrow h' A', h' \rightarrow A' A' \]
is very interesting, as it is only suppressed by \( \varepsilon^2 \) and is expected to have a very small background.
Neutrino Physics

Search for delayed coincidences in the Borexino detector
Main background sources:
• Li-9, He-8, untagged muons, accidentals

3.9 \pm 1.0 (^{+5.8}_{-1.3}) eV/(100 tons \cdot yr)

68.3 \%CL

99.73 \%CL

Geo-neutrinos

AntiNeutrinos emitted in beta decays of naturally occurring radioactive isotopes in the Earth’s crust and mantle

C-11 reduction strategy:
• Threefold coincidence (muon, neutron, C11)
• Pulse shape discrimination electron/gamma/positron (Ps formation)

First pep measurement and the best CNO limit
\[ \Phi_{\text{pep}} (MSW-LMA) = (1.6 \pm 0.3) \times 10^8 \text{ cm}^{-2} \text{s}^{-1} \]
\[ \Phi_{\text{CNO}} (MSW-LMA) < 7.7 \times 10^8 \text{ cm}^{-2} \text{s}^{-1} \] (95\% CL)
Open questions:
- Is $\theta_{23}$ exactly 45 degrees, or not?
- Is $\theta_{13}$ zero, or just small?
- Is there CP violation in the neutrino sector?

Summary of uncertainties

<table>
<thead>
<tr>
<th>$\nu_\mu$ signal</th>
<th>$\Delta m^2_{23} = 2.4 \times 10^{-3}$ eV$^2$</th>
<th>$\sin^2 2\theta_{23} = 1.0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\nu$ flux</td>
<td>$\pm 4.8%$</td>
<td></td>
</tr>
<tr>
<td>$\nu$ interactions</td>
<td>$+8.3% - 8.1%$</td>
<td></td>
</tr>
<tr>
<td>Near detector</td>
<td>$+6.2% - 5.9%$</td>
<td></td>
</tr>
<tr>
<td>Far detector</td>
<td>$\pm 10.3%$</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>$+15.4% - 15.1%$</td>
<td></td>
</tr>
</tbody>
</table>

- 31 events pass $\nu_\mu$ selection criterion
- $103.6_{+13.8}^{-13.4}$ expected for no osc, excluded at 4.5$\sigma$
- Fit $E_\nu$ distribution for 2 flavor osc. parameters (binned $\chi^2$ fit)

Best fit: $|\Delta m^2_{32}| = 2.65 \times 10^{-3}$ eV$^2$

$\sin^2 2\theta_{23} = 0.98$
**$\nu_e$ appearance results**

- 6 candidate events observed for background of $1.49 \pm 0.34$
- Probability to see 6 events or more for $\sin^22\theta_{13}=0$ is 0.007 (2.5σ equivalent)
- For $|\Delta m^2_{32}|=2.4 \times 10^{-3}$ eV$^2$; $\sin^22\theta_{23} = 1$
  - Best fit: $\sin^22\theta_{13} = 0.11$
  - $0.03 < \sin^22\theta_{13} < 0.28$ at 90% C.L.
- Recent results are consistent with T2K:
  - MINOS: $\sin^22\theta_{13} < 0.12$ at 90% C.L.
  - Double Chooz: $0.017 < \sin^22\theta_{13} < 0.16$
  - **Combined fit to all three experiments:** $\sin^22\theta_{13} > 0$ at $\sim 3\sigma$

**References:**
- Double Chooz: hep-ex/1112.6353
- Global fit: hep-ph/1111.3330
First neutrinos post-earthquake!

Enormous amount of work by collaborators, labs (KEK, J-PARC) and funding agencies) to make this happen, to which we are very grateful
Recent Experimental Results (2011): $\theta_{13}$ may be large

Accelerator based appearance expts

**T2K**

$\Delta m^2 > 0$

$\Delta m^2 < 0$

$1.43 \times 10^{-3}$ p.c.t.

$\sin^2 2\theta_{13}$

PRL 107, 041801 (2011)

$0.03(0.04) < \sin^2 2\theta_{13} < 0.28(0.34)$ at 90% CL

**MINOS**

$\Delta m^2 > 0$

$\Delta m^2 < 0$

$8.2 \times 10^{-5}$ POT

MINOS PRELIMINARY

PRL 107, 181802 (2011)

Reactor based disappearance expt

**Double Chooz**

arXiv:1112.6353v2

$\sin^2 2\theta_{13} = 0.086 \pm 0.041$ (stat) $\pm 0.030$ (sys)

$0.015 < \sin^2 2\theta_{13} < 0.16$ at 90% CL
Daya Bay Design Principle

- **Identical near and far detectors** cancel many systematic errors
- **Multiple modules** boost statistics while reducing systematic errors with multiple independent measurements
- **Three zone detector design** eliminates the need for spatial cuts which can introduce systematic uncertainties
- **Shielding** from cosmic rays and natural radioactivity reduces background rates
- **Movable detectors** allow possible cross calibration between near and far detectors to further reduce systematic errors.

Experimental Layout

<table>
<thead>
<tr>
<th>Overburden</th>
<th>D. B.</th>
<th>L. A.</th>
<th>L. A. II</th>
</tr>
</thead>
<tbody>
<tr>
<td>EH1</td>
<td>280</td>
<td>360</td>
<td>860</td>
</tr>
<tr>
<td>EH2</td>
<td>300</td>
<td>1350</td>
<td>480</td>
</tr>
<tr>
<td>EH3</td>
<td>880</td>
<td>1910</td>
<td>1540</td>
</tr>
</tbody>
</table>

mwe m m m m

*Virginia Tech*  
*Invent the Future*
IBD Candidate Rate

Daya Bay Preliminary

IBD candidates rate (Events/day)

- AD1
- AD2

Run time

Aug 24  Sep 23  Oct 23  Nov 22  Dec 22

L3 core Off  D2 core Off  L3 core On  D2 core On  L2 core Off

Dashed lines indicate reactor shut down or turn on.

Expected events (/day/detector)

<table>
<thead>
<tr>
<th></th>
<th>DYB Site</th>
<th>LA Site</th>
<th>Far Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBD Evts</td>
<td>840</td>
<td>760</td>
<td>90</td>
</tr>
<tr>
<td>BKG Evts</td>
<td>&lt;0.6%</td>
<td>&lt;0.5%</td>
<td>&lt;0.4%</td>
</tr>
</tbody>
</table>

Expected events with all cores ON
“2 months of running to measure theta_13 as non-zero”

Summary

- We have demonstrated the identicalness of the first two detectors at Daya Bay near site
- With all 8 detectors running by summer 2012, Daya Bay is going to provide the most precise measurement of $\theta_{13}$. 
Heavy Ions

(about 30 people in audience and no chairperson!)

J/ψ suppression in Pb-Pb

- ALICE: less suppression than RHIC at forward rapidity
- Similar suppression (not for central collisions) as RHIC at midrapidity

- First measurement in heavy-ion collisions
- J/ψ coming from B decay are strongly suppressed
Production ratio: $\bar{\Lambda}/\Lambda, \bar{\Lambda}/K_S^0$

\[ \bar{\Lambda}/\Lambda = \frac{\sigma(pp \rightarrow \Lambda X)}{\sigma(pp \rightarrow K^0_S X)} \] probes the baryon number transport.

\[ \bar{\Lambda}/K_S^0 = \frac{\sigma(pp \rightarrow \Lambda X)}{\sigma(pp \rightarrow K^0_S X)} \] probes the strange baryon suppression.

Consistency between the two measurements ($\sqrt{s} = 900$ GeV and 7 TeV) and the previous results.

$\bar{\Lambda}/\Lambda$: good agreement with Perugia0 at low rapidity while at high rapidity Perugia NOCR looks to be favoured.

$\bar{\Lambda}/K_S^0$ measured ratio is significantly larger than predicted by the generators, i.e. more baryons are produced in strange hadronization than expected.
High precision — NNLO — is crucial for key processes, but not yet always available:

✓ W, Z, Higgs, γγ, VBF, VH
✗ VV, t̅t̅, inclusive jets, etc.

New in 2011: **NNLO WH** (differential)

![Graph showing NNLO WH](image)

Not always reassuring

**Important also to develop methods so that we’re less sensitive to limits on our precision.**

Generally by finding ways to distinguish signals from the background more efficiently, i.e. increasing S/B.
New twist in antimatter mystery

By Paul Rincon
Science editor, BBC News website

Physicists have taken a step forward in their efforts to understand why the Universe is dominated by matter, and not its shadowy opposite antimatter.

A US experiment has confirmed previous findings that hinted at phenomena outside our understanding of physics.

The results show that certain matter particles decay differently from their antimatter counterparts.

Such differences could potentially help explain why there is so much more matter in the cosmos than antimatter.

The findings from scientists working on the CDF experiment have been presented at a particle physics meeting in La Thuile, Italy.

CDF was one of two multi-purpose experiments at the now-defunct Tevatron particle smashers in Illinois.

Physicists think the intense heat of the Big Bang should have forged equal amounts of matter and its "mirror image" antimatter. Yet today we live in a Universe composed overwhelmingly of matter.
CP violation

CDF updated

\( \Delta A_{\text{CP}} \) using full run II dataset

(LHCb result shown in PPD seminar last week)

- New CDF result confirms LHCb result: same resolution, <1\( \sigma \) difference in central value
  \[ \Delta A_{\text{CP}}(\text{LHCb}) = [-0.62 \pm 0.21 \pm 0.10] \%
  \]

- When combining à la HFAG with other available measurements, no CPV point is at \(-3.8\sigma\) and
  \[ \Delta A_{\text{CP}}^{\text{dir}} = (-0.67 \pm 0.16)\% 
  \]  
  \[ A_{\text{CP}}^{\text{ind}} = (-0.02 \pm 0.22)\% 
  \]

- CDF will also produce separate measurements of \( A_{\text{CP}}(K^+K^-) \) and \( A_{\text{CP}}(\pi^+\pi^-) \)

Results

\( B_s^0 \to J/\psi \phi \)

Most precise measurements:

\( \Gamma_s = 0.656 \pm 0.009 \) (stat)\( \pm 0.008 \) (syst) ps\(^{-1}\)

\( \phi_s = 0.15 \pm 0.18 \) (stat)\( \pm 0.07 \) (syst) rad

\( \Delta \Gamma_s = 0.123 \pm 0.029 \) (stat)\( \pm 0.011 \) (syst) ps\(^{-1}\)

First direct evidence of non-zero \( \Delta \Gamma_s \)

2 solutions, 1 in agreement with SM prediction

\( \rightarrow \) Current uncertainties still leave room for New Physics

**COMBINATION OF** \( B_s^0 \to J/\psi \phi \) **AND** \( B_s^0 \to J/\psi f_0 \)

\( \phi_s = 0.03 \pm 0.16 \) (stat)\( \pm 0.07 \) (syst) rad
Rare Decays

- **Z-penguin suppressed diagram**
  - doubly suppressed: FCNC & helicity

- **SM-expected Branching Ratio**:
  \[
  B_{SM}(B_s \rightarrow \mu^+\mu^-) = (3.64^{+0.17}_{-0.31}) \times 10^{-9}
  \]

  \[
  B_{SM}(B_d \rightarrow \mu^+\mu^-) = (1.13^{+0.06}_{-0.11}) \times 10^{-10}
  \]

- [The CKM Fitter group - hep-ph 1106.4041]

**Experimental status**

- **CDF**  \( Br(B_s \rightarrow \mu\mu) = 1.8^{+2.1}_{-0.9} \times 10^{-8} \)
  - PRL107, 191801 (2011)

- **DØ**  \( Br(B_s \rightarrow \mu\mu) < 5.1 \times 10^{-8} @ 95% C.L. \)
  - PLB693, 539 (2010)

- **LHCb**  \( Br(B_s \rightarrow \mu\mu) < 1.4 \times 10^{-8} @ 95% C.L. \)
  - PLB 708, 55 (2012)

- **CMS**  \( Br(B_s \rightarrow \mu\mu) < 1.9 \times 10^{-8} @ 95% C.L. \)
  - PRL107, 191802 (2011)

- **ATLAS**:  \( Br(B_s \rightarrow \mu\mu) < 2.2 \times 10^{-8} @ 95% C.L. \)
  - 2.4 fb^{-1}

**NEW at La Thuile**

0.8 \times 10^{-9} < BR(B_s \rightarrow \mu^+\mu^-) < 3.4 \times 10^{-8} 95\% C.L.

**MORIOND 13th March**

0.37 \rightarrow 1 fb^{-1}

BR(B_s \rightarrow \mu\mu) < 4.5 \times 10^{-9} @ 95\% C.L.

**CERN seminar 6th March**

1.14 \rightarrow 4.9 fb^{-1}

BR(B_s \rightarrow \mu\mu) < 7.7 \times 10^{-9} @ 95\% C.L.

**CERN seminar 13th March**

7 \rightarrow 10 fb^{-1}

BR(B_s \rightarrow \mu^+\mu^-) = (1.3^{+0.9}_{-0.7}) \times 10^{-8}
Lots of other B physics

$M_{X(3872)} = 3871.95 \pm 0.48 \text{ (stat)} \pm 0.12 \text{ (syst) MeV}$

$M(B_c^+) = 6268.0 \pm 4.0 \text{(stat)} \pm 0.6 \text{(syst) MeV}$

$\text{Mass } (\chi_b(3P)) = 10.530 \pm 0.005 \text{ (stat.)} \pm 0.009 \text{ (syst) GeV}$

Observation of $Y(5S) \rightarrow Y(1D)\pi^+\pi^-$

Discovery of $Z_b$

Electroweak systematics limited

τ channels still statistics limited

W/Z @ LHC
**W charge asymmetry**

- Good agreement with HERAPDF
- More flat than MSTW ($\chi^2=5.3$), CT10 ($\chi^2=2.1$), NNPDF ($\chi^2=4.1$)
- Provides significant constraints to the PDF global fits

$W$ polarisation measurements

$f_L + f_R + f_0 = 1$.
Di-bosons @ Tevatron

Heavy Diboson Production

\[ \sigma(WZ) = 3.9^{+0.6}_{-0.5}( \text{stat.})^{+0.6}_{-0.4}( \text{syst}) \text{ pb} \ (SM = 3.46 \pm 0.21 \text{ pb}) \]

\[ \sigma(ZZ) = 1.64 \pm 0.44( \text{stat.})^{+0.13}_{-0.15}( \text{syst}) \text{ pb} \ (SM = 1.30 \pm 0.10 \text{ pb}) \]

\[ \sigma(WZ) = 4.50 \pm 0.61( \text{stat.})^{+0.16}_{-0.25}( \text{syst.}) \text{ pb} \]
Di-bosons @ Tevatron

$\sigma(ZZ) = 1.64 \pm 0.44^{+0.13}_{-0.15} \text{ pb} (S/M = 1.30 \pm 0.10 \text{ pb})$

CDF Run II, $p\bar{p}$ at $\sqrt{s} = 1.96$ TeV

Production Cross Section [pb]
Wjj anomalous production

- DØ repeated CDF analysis → with some minor differences
- No significant discrepancy w.r.t. background model
- Results are 2.5 σ apart

- 4.1σ excess seen in dijet mass spectrum of W+2jet sample
  - Binned χ² fit to Mjj distribution consistent with σ = 3.0pb ± 0.7
  - Many cross checks performed: various bkg control regions, W+jets modelling etc
  - PHYS. REV. LETT. 106, 171801 (2011), and Public Webpage

- S/B 10x worse at LHC
- Hard to understand W+ jets at that level
New W mass from CDF

Previously

**SM Fit** $M_H = 92^{+34}_{-26}$ GeV

$M_H < 161$ GeV @95% CL

$M_W = 80387 \pm 12_{\text{stat}} \pm 15_{\text{syst}}$ MeV/c²

$M_H = 90^{+29}_{-23}$ GeV

$M_H < 145$ GeV @95% CL
Top physics

- **D0 l+jets 5.3 fb\(^{-1}\):**
  \[ \sigma_{t\bar{t}} = 7.78 \pm 0.77^{+0.64}_{-0.64} \text{ (stat+sys) pb} \]

- **CDF l+jets 4.6 fb\(^{-1}\):**
  \[ \sigma_{t\bar{t}} = 7.82 \pm 0.55 \text{ (stat+sys) pb} \]

with a theoretical NNLO\(^{\text{approx}}\) cross section of

- \( \sigma_{t\bar{t}} = 7.46 \text{ pb} @ m_{t\bar{t}} = 172.5 \text{ GeV} \) (PRD 78, 034003 (2008))

### D0 Run II

**July 2011**

<table>
<thead>
<tr>
<th>( \ell \ell + \text{jets} ) (##j)</th>
<th>( \ell \ell + \text{jets} ) (##j, ##b)</th>
<th>( \ell \ell + \text{jets} ) (##j, ##b, ###j)</th>
<th>( \ell \ell + \text{jets} ) (##j, ##b, ###j, ###b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.43 \pm 0.10^{+0.92}_{-0.80} \text{ pb}</td>
<td>7.65 \pm 0.26^{+0.70}_{-0.69} \text{ pb}</td>
<td>7.27 \pm 0.45^{+0.79}_{-0.70} \text{ pb}</td>
<td>7.10^{+0.80}_{-0.70} \text{ pb}</td>
</tr>
</tbody>
</table>

**Dileptons:**

- \( \ell \ell + \text{jets} \) (\#\#j, \#\#b) | \( \ell \ell + \text{jets} \) (\#\#j, \#\#b, \#\#\#j) | \( \ell \ell + \text{jets} \) (\#\#j, \#\#b, \#\#\#j, \#\#\#b) |
| 7.30 \pm 0.12 \pm 0.01 \pm 0.01 \text{ pb} | 6.30 \pm 0.13^{+0.08}_{-0.06} \pm 0.04 \pm 0.04 \text{ pb} | 6.9 \pm 0.13^{+0.08}_{-0.05} \pm 0.04 \pm 0.04 \text{ pb} |

**Leading + Subleading:**

- \( \ell \ell + \text{jets} \) (\#\#j, \#\#b) | \( \ell \ell + \text{jets} \) (\#\#j, \#\#b, \#\#\#j) | \( \ell \ell + \text{jets} \) (\#\#j, \#\#b, \#\#\#j, \#\#\#b) |
| 7.14 \pm 0.20 \pm 0.01 \pm 0.01 \text{ pb} | 6.20^{+0.09}_{-0.06} \pm 0.04 \pm 0.04 \text{ pb} | 6.9^{+0.09}_{-0.06} \pm 0.04 \pm 0.04 \text{ pb} |

**Top Physics:**

- **ATLAS Preliminary**
  - **L = 700 fb\(^{-1}\)**
  - **e\(\pm\) 5 Jets**

**Dileptons:**

- \( p_T(t/t\bar{t}) \)

\[ \sigma_{t\bar{t}} = 179.0 \pm 9.8 \text{ (stat. + syst.)} \pm 6.6 \text{ (lumi.) pb} \]

**CMS combined 2011:**

\[ \sigma_{t\bar{t}} = 165.8 \pm 2.2 \text{ (stat.)} \pm 10.6 \text{ (syst.)} \pm 7.8 \text{ (lumi.) pb} \]
Single top @ tevatron

Separate t- and s- Channel Production

- 2-dimensional measurement of s- and t-channel
  - t-channel sensitive to anomalous couplings
  - s-channel sensitive to resonances
- strategy: train separately for s- and t-channel
- CDF 3.2 fb$^{-1}$:
  - $\sigma (t) = 0.8 \pm 0.4$ pb (PRD 82, 112005 (2009))
  - $\sigma (s) = 1.8^{+0.7}_{-0.5}$ pb
- D0 5.4 fb$^{-1}$:
  - $\sigma (t) = 2.90 \pm 0.59$ pb (PLB 705, 313 (2011))
  - $\sigma (s) = 0.98 \pm 0.63$ pb
- t-channel observation with 5.5 $\sigma$ at D0
  - main systematics from background

LHC also starting to show results
Spin Correlation

- even tops are not produced in polarized state, the spins are correlated
- the correlation strength $A$

$$A = \frac{N_{\uparrow\uparrow} + N_{\downarrow\downarrow} - N_{\uparrow\downarrow} - N_{\downarrow\uparrow}}{N_{\uparrow\uparrow} + N_{\downarrow\downarrow} + N_{\uparrow\downarrow} + N_{\downarrow\uparrow}}$$

- depends on the production mode → different for Tevatron and LHC
- choice of spin basis (here beam basis)

- due to the short top lifetime the spin does not flip and is reflected in the angular distributions of the decay products

$$\frac{1}{\sigma} \frac{d\sigma}{d \cos \theta_i} = \frac{1}{2} (1 + \alpha_i \cos \theta_i)$$

with $\alpha = 1$ for charged leptons and down-type quarks

- thus spin correlation can be measured by studying e.g.

$$\frac{1}{\sigma} \frac{d^2\sigma}{d \cos \theta_1 d \cos \theta_2} = \frac{1}{4} \left( 1 - C \cos \theta_1 \cos \theta_2 \right)$$

where $C = A \alpha_1 \alpha_2$
Spin Correlation

- Even tops are not produced in polarized state, the spins are correlated.
- The correlation strength $A$

- **D0 5.4 fb$^{-1}$ dilepton**:
  $$C_{\text{beam}} = 0.57 \pm 0.31 \text{ (stat+syst)}$$

- **D0 5.3 fb$^{-1}$ l+jets**:
  $$C_{\text{beam}} = 0.89 \pm 0.33 \text{ (stat+syst)}$$

- 30% increased sensitivity
- Excellent agreement with SM
- Combining statistically independent results:
  $$C_{\text{beam}} = 0.66 \pm 0.23 \text{ (stat+syst)}$$
  - $C < 0.26 @ 95\% \text{ C.L.}$ and $C < 0.04 @ 99.7\% \text{ C.L.}$
  - $C = 0 @ 3.1 \sigma \text{ SD} \text{ (PRL 108, 032004 (2012))}$

  => First evidence for non-vanishing spin correlation!

- Thus, spin correlation can be measured by studying e.g. $b$-jet

\[
\frac{1}{\sigma} \frac{d^2\sigma}{d\cos\theta_1 d\cos\theta_2} = \frac{1}{4} \left(1 - C \cos\theta_1 \cos\theta_2 \right)
\]

where $C = A \alpha_1 \alpha_2$
Top Asymmetry $A_{fb}$

- measurements higher than prediction
- even larger difference for $A_{fb}^{\perp}$
  - D0 1+jets: $A_{fb}^{\perp} = 14.2 \pm 3.8 \%$ where MC@NLO : $A_{fb}^{\perp} = 0.8 \pm 0.6 \%$
  - CDF dilepton: $A_{fb}^{\perp} = 21 \pm 7 \%$

- asymmetry depends on several variables like $m_{Z}$, $|y|$  
  - e.g. new physics could lead to a different mass dependency

07/03/2012
... And at LHC

Result:
\[ A_C = -0.018 \pm 0.028 \text{ (stat.)} \pm 0.023 \text{ (syst.)} \]

- consistent with the SM value of \[ A_C^{PP} = 0.006 \pm 0.002 \]

- limits on allowed \( A_C(\text{LHC}) \) and \( A_{FB}(\text{Tevatron}) \) regions can constrain some models proposed to explain the Tevatron \( A_{FB} \)
Top Mass

ATLAS Preliminary

<table>
<thead>
<tr>
<th>Channel</th>
<th>m_{top} [GeV]</th>
</tr>
</thead>
<tbody>
<tr>
<td>e+jets (1d)</td>
<td>172.9 ± 1.5 ± 2.5</td>
</tr>
<tr>
<td>μ+jets (1d)</td>
<td>175.5 ± 1.1 ± 2.6</td>
</tr>
<tr>
<td>e+jets (2d)</td>
<td>174.3 ± 0.8 ± 2.3</td>
</tr>
<tr>
<td>μ+jets (2d)</td>
<td>175.0 ± 0.7 ± 2.6</td>
</tr>
<tr>
<td>l+jets</td>
<td>174.5 ± 0.6 ± 2.3</td>
</tr>
<tr>
<td>Most precise (CDF l+jets)</td>
<td>173.0 ± 0.7 ± 1.1</td>
</tr>
<tr>
<td>Tevatron September 2011</td>
<td>173.2 ± 0.6 ± 0.8</td>
</tr>
</tbody>
</table>

(Date: February 23, 2012)

- Reduction of the systematics uncertainty needed to reach Tevatron measurement uncertainty.
- Challenging, but there is a lot of space for improvement wrt. currently published measurement, incl. reducing JES, MC modelling uncertainties, reducing MC stats. effects by generating huge samples...
HIGGS - Tevatron

Limits for $H \rightarrow b\bar{b}$

Summer 2011
Tevatron Run II Preliminary $H \rightarrow b\bar{b}$ Combination, $L = 8.6$ fb$^{-1}$

New results coming very soon

Searches with Taus

Limits at $M_H = 115$ GeV:
Exp: $13 \times \sigma_{SM}$
Obs: $12 \times \sigma_{SM}$

15% improvement in limits

Diphoton final states

Limits improved by 15-25%

High mass search updated: 12% better at 165 GeV

CDF Sensitivity close to TeV sensitivity in July 2011.
CDF gave us a taste of what is to come??

**Conclusions**

- The CDF Collaboration has produced Higgs searches with expected sensitivities a factor of 2 better than 2007 beyond luminosity additions!

- CDF is sensitive to $<\sqrt{2}x\text{SM}$ Everywhere
  - 2XCDF would have >25% chance of 3-sigma!

- Tevatron Leads in $H \rightarrow bb$

- The Tevatron full dataset combined Higgs search will be exciting!

- Release observed limits next Weds at Moriond!
- Tevatron Combination talk at Moriond EWK by Wade Fisher!
**HIGGS - LHC**

- **Higgs search at LHC/ATLAS is very exciting now!**
  - ATLAS still have several channels (WW/ττ/bb etc) to be updated.
  - Wait for new results until Morinod conf.

- In the low mass region, we have a small un-excluded mass window of 115.5-131GeV.

- Small excess around 126GeV is real? -> **No conclusion at the moment**
  - Still ~2-3 sigma level with the look elsewhere effect.
  - We need more data in this year.

"More data are required to ascertain the origin of the observed excess.”
Beyond Standard Model

Lots of searches
No signals
and now for something
completely different...
Problems for nuclear power:

- Public acceptance
- Real accidents
- Radioactive waste
- Proliferation concerns
- Not competitive in terms of cost
Thorium/Uranium Fuel Cycle

- U-235 is the only naturally occurring fissile material
- U-233 is also fissile but does not exist in nature
- U-233 can be produced from Th-232 via neutron capture
- Reactors that generate fissile U-233 from Th-232 are Breeder Reactors

“Previous work on Thorium reactors dropped because they didn’t produce enough Plutonium!”

Thorium currently costs only US$30/kg, while the price of Uranium has risen above $100/kg, not including costs for enrichment and fuel fabrication.

Minor actinides -> long lived radioactive waste

~4 times more abundant than U-238, 400 times more abundant than U-235
As abundant as lead
Advantages of Thorium: Raw Material and Resource Utilization for 1GW-year

**Light Water Reactor**
- 250 tons of uranium containing 1.75 tons of uranium-235
- 35 tons of enriched uranium (1.15 tons of uranium-235)
- 215 tons of depleted uranium-238 (0.6 tons of uranium-235)
- 35 tons of spent fuel stored containing:
  - 33.4 tons of uranium-238
  - 0.3 tons of uranium-235
  - 1.0 tons of fission products
  - 0.3 tons of plutonium

**Liquid Fluoride Thorium Reactor**
- 1 ton of thorium
- Fluoride reactor converts thorium-232 to uranium-233 and burns it
- 1 ton of fission products
- In 10 years, 83 percent of fission products are stable
- 17 percent of fission products are stored for approximately 300 years
- 0.0001 tons of plutonium
**Waste Storage**

![Graph showing waste storage decay over years](image)

**Deploying Thorium Energy: Three Approaches**

- Thorium fuel in solid form in conventional reactors
- Thorium as fuel in molten-salt reactors
  - Accelerator-driven Subcritical Reactors using Thorium fuel
  - C. Rubbia, Energy Amplifier

- **Europe**: Belgium has committed to build MYRRHA, the first ADS demonstration reactor
- **India**: National nuclear power strategy is based on Thorium; ADS is needed to breed U-233
- **China**: Announced development program to build 1 GW ADS by 2032
Trainees at CERN (Jan. 2006)

HELEN
High Energy Physics LatinAmerican-European Network

Latin America to Europe (Months, total HELEN)

Latin America to Latin America (HELEN total)

Distribution of All CERN Users by Nation of Institute on 9 January 2012

HELEN has operated from July 2005 to April 2009

Users from LA
2001: 65
2012: 170
Brazil becoming Associate State?

CANDIDATE FOR ASSOCIATION

MEMBER STATUS
Argentina 19
Australia 26
Austria 0
Belgium 14
Brazil 2
Canada 187
Chile 15
Cuba 0
Denmark 0
Estonia 0
Finland 0
France 10
Germany 986
Greece 5
Hungary 2
Ireland 0
Italy 55
Japan 0
Korea 0
Mexico 0
India 1
Peru 1
Poland 0
Portugal 4
Russia 0

total: 6600

CANDIDATE FOR ASSOCIATION

Observer: 0

ASSOCIATE MEMBER IN THE CERN FAMILY

ASSOCIATE MEMBER IN THE CERN FAMILY

Israel 62

Others: China 45

500

07/03/2012
- 4 years, budget 3.245 ME, 1803 months;
- started 1feb 2011 (about 2 years gap from HELEN).
Thankyou for listening!

http://agenda.infn.it/conferenceOtherViews.py?view=standard&confId=4116