Non-introduction

Thankfully, no-one is expecting a “summary”
I am grateful to the plenary speakers
and session conveners
Copyright to Any–and–All mistakes in this talk:
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HEP Panorama

■ The Highest Energies
  ◆ Our pride, source of great hope(s); SM, Higgs, BSM, Flavor, matter at its extremes

■ The neutrino sector
  ◆ Cause ν’s are so very different; PMNS, fermion nature, BSM, sterility

■ The dark sector
  ◆ The experimental evidence for physics outside the SM

■ The cosmos
  ◆ Not strictly always “particle” physics; equally fundamental

■ Dedicated-measurement experiments
  ◆ Complementary to high E; fundamental symmetries

■ Theory: because we need to understand what we’re doing
The Standard Model

It’s about time we change its name to Standard Theory
High machine availability ≈ 50% (many HW issues fixed)
High luminosity lifetime (improved knowledge of machine parameters for operation)
High peak luminosity (small beam size from injectors and stronger focusing)
Still room for improvement in 2017 & 18
More bunches, higher bunch intensity, stronger focusing
SM Highest E; EWSB (“Higgs” sector) (I)

Beyond All Doubt:

it is a Higgs

\[ J^P = 0^+ \]

Ultimate non-universal coupling:
to mass (!)

t, b, \mu points: slight overstatement

Still in Doubt:

is it the Higgs?

\[ \rightarrow \text{establish production and decay (AMAP)} \]
SM EWSB/H sector (II): noteworthy

H-\tau coupling @ CMS: Single-expt observ. of $H\rightarrow\tau\tau$: $5.9\sigma$ (Run1+Run2)

H-b coupling @ ATLAS: Single-expt evidence for $H\rightarrow bb$: $3.6\sigma$ (3.5 from Run2)
SM EWSB/H sector (III): noteworthy

- Coupling to the top quark (special: $y_t \approx 1$)

**H-t coupling:**

ttH production elusive (~1/100 of ggH)

Up to last week: ~hints

**CMS:** 3.3 $\sigma$ (2.5 exp)

**Note:** $H \rightarrow WW$; so no need to assume SM $H \rightarrow bb$
SM EWSB/H sector (IV): for the future

Increased statistics

HH : within factor 20 of SM→HL-LHC

H→μμ: same

Rare decays...

P. Sphicas
Highlights from EPS 2017

eps hep 2017, venice
july 12, 2017

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SM, Highest E; SM minus Higgs

The real thing!

W±W±! 5.3σ!

aTGC – limits

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July 12, 2017
SM, Highest E; EWK precision tests

**m_W**

ATLAS and CMS in good agreement:
- \( m_t^{\text{ATLAS}} = 172.84 \pm 0.70 \text{ GeV} \)
- \( m_t^{\text{CMS}} = 172.44 \pm 0.48 \text{ GeV} \)

Some tension with Tevatron average:
\( m_t^{\text{Tev}} = 174.30 \pm 0.65 \text{ GeV} \)

**m_t**

But beware:
- **m^{\text{pole}} vs m^{MC} & O(\Lambda_{QCD}) effects**

So what next?

**Theory errors:**
- \( M_W = 80.358 \pm 0.008 \text{ GeV} \)
- \( M_t = 177.0 \pm 2.3\text{–}2.4 \text{ GeV} \)

\[ \Delta m_t^{\text{exp}} < \Delta m_t^{\text{the}} \]

\( \rightarrow \) Experiment: more work on \( m_W \) needed!

- \( \pm 0.00052 \)
- \( \sin^2 \theta_W \)

No match, but surprisingly good (and no discrep…)

- \( \pm 0.00016 \)
CERN scientists one step closer to unlocking key to Universe after LHC breakthrough

SCIENTISTS investigating the origins of the Universe through the Large Hadron Collider (LHC) are celebrating a major breakthrough.

CERN scientists one step closer to unlocking key to Universe after LHC breakthrough

SCIENTISTS investigating the origins of the Universe through the Large Hadron Collider (LHC) are celebrating a major breakthrough.

Quantitative testers of QCD rejoice!
First observation of doubly-charmed baryon, the $\Xi_{cc}^{++}$

SCIENTISTS investigating the origins of the Universe through the Large Hadron Collider (LHC) are celebrating a major breakthrough.

http://www.express.co.univ/news/science/825660/
CERN-Large-Hadron-Collider-discovers-baryons
Jet substructure: a major new tool

Cool stuff: W/Z→qq

Opens up possibility of inclusive gg→H→bb (!)

Theory: Incredible strides

gg→H at NNNLO

Sensitive to EWK corrs!
Beyond the SM

Supersymmetry
Others
Supersymmetry: how we got here

**SUSY Summary**

- SUSY discovery (should be) easy and fast
  - Expect very large yield of events in clean signatures (dilepton, diphoton).
  - Establishing mass scale is also easy ($M_{\text{eff}}$)
- Squarks and gluinos can be discovered over very large range in SUGRA space ($M_0, M_{1/2}$)$\sim (2,1)\text{TeV}$
  - Discovery of charginos/neutralinos depends on model
  - Sleptons difficult if mass $> 300$ GeV
  - Evaluation of new benchmarks (given LEP, cosmology etc) in progress
- Measurements: mass differences from edges, squark and gluino masses from combinatorics
  - Can extract SUSY parameters with $\sim (1-10)\%$ accuracy

Then, in 2012, we found a H boson at 125 GeV...

The 2012’s: Full models too ambitious... [SUSY] only needs to be “natural”
Supersymmetry: where we are today

From the CMMSM to the SMS

86% of all hadronic production in CMSSM consists of “simple” decay chains. This makes it particularly amenable to being approximated with a 3-particle OSET.

ATLAS SUSY Searches - 95% CL Lower Limits

Preliminary

CMS Preliminary

Moniord 2017

pp → g→ g → tt \tilde{\chi}_j

35.9 fb \textsuperscript{-1} (13 TeV)

\tilde{\chi}_j \tilde{\chi}_j

Observed

Expected

May 2017

ATLAS Preliminary

fs=8.13 TeV, 20.3-36.1 fb \textsuperscript{-1}

\tilde{\chi}_i \tilde{\chi}_j

\tilde{\chi}_0

Partial decay modes for the SUSY particle decays.
We will always have Higgsinos… μ term must be \( \sim O(M_H) \)

Compressed spectra

Long Lifetimes
- Small couplings: RPV decays, dark sector coupling
- Small Δm: almost degenerate NLSP heavy messenger: Z', split SUSY
- Hidden valleys…

Dedicated (re)tracking

dE/dx

What is really needed:
Systematic study of all SUSY and DM space under long-τ hypothesis

CERN LLP Workshop  

P. Sphicas  
Highlights from EPS 2017  

EPS HEP 2017, Venice  
July 12, 2017
Non-SUSY BSM: vast, simply vast...
Non-SUSY BSM: vast, simply vast...

Exotics models
- Long-lived (SUSY or not)

Looked for a lot of possible new things
Nothing has turned up yet
Still looking intensively

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Physics of Flavor

CP violation, CKM triangle(s)
Rare processes
Windows to new physics? (or lessons in statistics and/or systematics in theory calculations)?
**Flavor Physics: CKM**

\[ \gamma = (76.8^{+5.1}_{-5.7})^\circ \]

\( \gamma \): \( \text{arg}(V_{ub}) \);
aka “the tough one”
aka “the DK angle”
\( \text{(D}_s\text{K, DK, D}^*\text{K…)} \)

Tricks to correct for penguins/FSI…

But… Trouble (?) in semileptonics

\[ R(D^{(*)}) = \frac{B(B \rightarrow D^{(*)} \tau \nu)}{B(B \rightarrow D^{(*)} \ell \nu)} \]

\( 4\sigma \) (!?)

\( V_{cb} \) & \( V_{ub} \)
Tension in inclusive vs exclusive determinations: still there;
but hard to get excited given uncertainties, \( \text{D}^{**} \), etc
Flavor Physics: rare processes (I)

**Run I:**

LHCb alone: >7σ

... and did away with many hopes for signs of NewPhys

What’s left:

[Graph showing BR(B_d → μμ) vs BR(B_s → μμ) with various models and exclusion regions.

**Candidates at large BDT response:**

\[
\Gamma + \bar{\Gamma} \sim e^{-t/\tau_{B_s}} \left\{ \cosh \left( \frac{\Delta\Gamma_s}{2}t \right) + A_{\Delta\Gamma} \sinh \left( \frac{\Delta\Gamma_s}{2}t \right) \right\}
\]

\[
\tau_{\mu^+\mu^-} = \frac{\tau_{B_s}^0}{1 - y_s^2} \left[ 1 + 2A_{\Delta\Gamma}^{\mu^+\mu^-} y_s + y_s^2 \right] \frac{1 + A_{\Delta\Gamma}^{\mu^+\mu^-} y_s}{1 + A_{\Delta\Gamma}^{\mu^+\mu^-} y_s}
\]

Not sensitive to A, yet, but getting there...

Future: info on extended scalar sector

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Flavor Physics: rare processes (II)

Is there a connection to the R(D*) issue?
AND to the $\mu\mu K^*$ angular distributions?
Some think so; e.g. see A.Greljo at this conference
(https://indico.cern.ch/event/466934/contributions/2585682/)

Supposedly “clean” observables
But are we ready to give up on universality?

The bad news: ATLAS+CMS cannot help
in $R(K)$, $R(K^*)$ (eeK*) very, very hard...
Flavor: Non-b sector

Hadron Vacuum Polarisation: effect on $a_\mu$

Reminder: $g$-2 effect

CMSSM

NUHM1

Muon LFV searches by dedicated experiments
Final MEG upper limit $B(\mu \rightarrow e\gamma) < 4.2 \times 10^{-13}$ @90% CL

2017: relatively quiet year
Exciting times ahead with MEGII, Mu2e, COMET, Mu3e
Extreme Matter

Evolution: physics studies of matter at its extreme started with Heavy Ions. Then it spilled over to nucleon-nucleon... and then to nucleon-HI... Emerging picture of describing all three
Heavy Ion Physics

- **Soft Probes (strangeness enhancement)**
  - Reason behind building a TPC...
- **Collective phenomena**
- **Suppression phenomena**
  - $J/\psi$ (since ~ever in the field) and Y production
  - Rich physics in Hard Probes (jets vs $\gamma$/$W$/$Z$); a present from RHIC to the LHC
From pp to pPb to PbPb

Strangeness increases with multiplicity also in pPb AND in pp

Will pp ratios converge to Pb-Pb values?
Heavy Ions: collectivity (flows)

Multipole expansion

\[ \frac{d^3N}{dyd^2p_T} = \frac{d^2N}{dydp_T^2} \left[ 1 + 2 \sum_{n=1}^{\infty} v_n(p_T)\cos(\phi - \psi_n) \right] \]

\[ \psi_n = \frac{1}{n} \arctan \left( \frac{\langle p_T \sin n\phi \rangle}{\langle p_T \cos n\phi \rangle} \right) \]

“One fluid to rule them all”

P. Romatschke

Charm flows too

\[ v_2(D): \text{old} \]
Heavy ions: suppression & hard(er) probes

\[ R_{AA} = \frac{AA \text{ rescaled pp}}{\langle N_{\text{coll}} \rangle d^2 N_{pp}/dpTdy} = \frac{d^2 N_{AA}/dpTdy}{d^2 N_{pp}/dpTdy} \]

Jet production; evolution

\[ R_{AA} = \frac{AA \text{ rescaled pp}}{\langle N_{\text{coll}} \rangle d^2 N_{pp}/dpTdy} \]

\[ R_{pp: \text{LHCb}}(J/\psi) \approx \text{Suppr}(D^0) \]

J/ψ via cc coalescence or recombination

dijet imbalance: due to “fragmentation” and not “path length”?

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The elusive neutrino(s)

The very nature:
Oscillations, more mass generation questions (beyond EWSB?)
Richness of the lepton sector (PMNS, CP violation)
Majorana/Dirac…
Sterile neutrinos?
Neutrinos: oscillations (I)

T2K samples

$\mu^+/-$ rings CC-0
$\pi^0$ e $^+/-$ rings CC-0
$\pi^-$ rings CC-1
$\pi^+$ sample since ICHEP 2016

MC: 68.3  data: 66
MC: 6.3   data: 4
MC: 137.8 data: 135
MC: 3.1   data: 5
MC: 28.6  data: 32

5 samples of charged-current (CC) $\nu$ interactions:

determination of oscillation parameters

$\nu_{\mu}$-mode
$\nu_{e}$-mode

T2K churning away

Results (Bayesian analysis)

T2K data only

T2K data $+$ $\sin^2\theta_{13}$ from reactor (PDG 2016)

Both mass orderings (normal + inverted) included in the posterior probability density.

90% credible interval (CI) have a 90% probability of containing true value
Neutrinos: oscillations (II)

Meanwhile at FNAL

NOVA

some tension

Known parameters

\( \delta m^2 \) 2.3 %
\( \Delta m^2 \) 1.6 %
\( \sin^2 \theta_{12} \) 5.8 %
\( \sin^2 \theta_{13} \) 4.0 %
\( \sin^2 \theta_{23} \) ~ 9 %

all < 10%...

Precision Era!

E.Lisi

Unknown params

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The prized measurement

Principle: $\theta_{13}$

The “reactor anomaly”

Evolution of fission fractions in a nuclear reactor core

- $^{235}\text{U}$, 6.7 MeV / fission (expected)
- $^{239}\text{Pu}$, 4.4 MeV / fission (expected)

<table>
<thead>
<tr>
<th>Fission Fraction (%)</th>
<th>burn-up (MWD/TU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{235}\text{U}$</td>
<td>6.7</td>
</tr>
<tr>
<td>$^{239}\text{Pu}$</td>
<td>4.4</td>
</tr>
</tbody>
</table>

Effect: $E$ dependent

→ Damps enthusiasm

But not for Sterile vs
Neutrinos: Majorana/Dirac (0νββ)

As fundamental as a question can get

\[ m_{\beta\beta} = |c_{13}^2 c_{12}^2 m_1 + c_{13}^2 s_{12}^2 m_2 e^{i\phi_2} + s_{13}^2 m_3 e^{i\phi_3}| \]
\[ \Sigma = m_1 + m_2 + m_3 \]

Extremely active field

<table>
<thead>
<tr>
<th>Source</th>
<th>Mass (kg)</th>
<th>Detector</th>
<th>Sensitivity (\tau_{1/2}) (yr)</th>
<th>Sensitivity (m_{\beta\beta}) (meV)</th>
<th>Background (/kev/kg/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GERDA 76Ge</td>
<td>43.4</td>
<td>HPGe</td>
<td>5.3x10^{25}</td>
<td>150-330</td>
<td>10^{-3}</td>
</tr>
<tr>
<td>CUORE/Cuoricino 130Te</td>
<td>206</td>
<td>Bolometers</td>
<td>9x10^{25}</td>
<td>50-130</td>
<td>0.01</td>
</tr>
<tr>
<td>NEXT 136Xe</td>
<td>100</td>
<td>HP-TPC</td>
<td>6x10^{25}</td>
<td>200</td>
<td>4x10^{-4}</td>
</tr>
<tr>
<td>CUPID 82Se</td>
<td>5.2</td>
<td>Bolometers</td>
<td></td>
<td>~0</td>
<td></td>
</tr>
<tr>
<td>SNO+ 130Te</td>
<td>1300</td>
<td>Lq. Scinti</td>
<td>2x10^{25}</td>
<td>40</td>
<td>5x10^{-5}</td>
</tr>
<tr>
<td>SuperNEMO 82Se</td>
<td>100</td>
<td>Tracker</td>
<td>10^{26}</td>
<td>40-110</td>
<td></td>
</tr>
<tr>
<td>KamLAND-Zen 136Xe</td>
<td>383</td>
<td>Lq. Scinti</td>
<td>1x10^{26}</td>
<td>61-165</td>
<td>1.6x10^{-4}</td>
</tr>
<tr>
<td>AXEL 136Xe</td>
<td>100</td>
<td>HP-TPC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PANDAX-III 136Xe</td>
<td>200</td>
<td>HP-TPC</td>
<td>5x10^{25}</td>
<td>90-230</td>
<td>1x10^{-4}</td>
</tr>
<tr>
<td>EXO 136Xe</td>
<td>76.5</td>
<td>Lq-TPC</td>
<td>1.1x10^{25}</td>
<td>190-450</td>
<td>1.7x10^{-3}</td>
</tr>
</tbody>
</table>

Often said: “ν masses a clear indication of New Physics”; because if Dirac, need \(y_\nu \sim 10^{-12}\); Yet, we do accept: \(y_e \sim 10^{-6}\) (\(y_t \sim 1\))

While the addition of a ν\(_R\) would be a “change to the SM”, it would be a very minor one. The REAL NP would be in the alternate mechanisms...
Anomalies in Short Baseline Oscillations

Highlights from EPS 2017

Taking 5 MeV bump as due to sterile ν

ν_e shortage in reactor expts

ν_e DIS
sin^2 2θ_{ee} \approx 4|U_{ee}|^2

ν_μ DIS
sin^2 2θ_{μμ} \approx 4|U_{μμ}|^2

ν_μ \rightarrow ν_e APP
sin^2 2θ_{νμ} = 4|U_{ee}|^2|U_{μμ}| \approx \frac{3}{7} \sin^2 2θ_{ee} \sin^2 2θ_{μμ}


Very active field

A reminder…

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The Dark Sector
The Dark Sector

- An experimental Fact & still a TOTAL mystery

- Nightmare scenario: totally dark
  - Only Gravity to play with…

- More promising: several (3? 20? more?) shades of grey
DM: direct detection experiments (I)

Two-phase Xe expts continuing to increase their sensitivity

Impressive bkg level: $0.2 \times 10^{-3}$ evt/day/kg/keV

Sensitivity to a 50 GeV WIMP

Expected:
- XENON1T
- XENONnT
- LZ

Neutrino coherent scattering

Cross Section [cm$^2$]

- v floor
- solar $\nu$'s
- atmospheric $\nu$'s

Expected:
- XENON100 combined
- PandaX
- XENON100
- LUX
- XENON100
- LZ

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DM indirect searches: cosmic ray expts

The dream scenario

Positrons: $\chi + \chi \rightarrow e^+ + \ldots$

$m\chi = 800$ GeV

$m\chi = 400$ GeV

Collision of Cosmic Rays

I. Cholis et al., arXiv:0810.5344

Reality: tantalizing fall (?!). But pulsars? Moreover: antiprotons!

Preliminary Data. Please refer to the AMS forthcoming publication in PRL.

The $e^+$ and $e^-$ fluxes with 5 years of AMS:

B. Bertucci - EPS 2017

July 11, 2017

AMS 02

Future

AMS results on the $p/p$ flux ratio

We have to wait….extend measurement @ 1 TeV

Increase statistics & energy range

Better understanding of astrophysical background from other measurements (nuclei)

Study other anti-particle channels

A parting thought: difficult measurements

AMS-02

ATIC

BETS 97&98

PPB-BETS 04

Fermi-LAT (2017)

HEAT

H.E.S.S.

H.E.S.S. (LE)

AMS-02 Electron + Positron flux: Fermi 2017

New measurement from Fermi:

$\Phi$ now agreement with AMS up to $\approx 100$ GeV

Different (smooth) spectrum above

New measurements expected by AMS, DAMPE, CALET….
DM indirect searches: \(\gamma\)-ray expts

Clearly, experiments have evolved significantly; Caveats: not in control of the beam; not in control of the space between the source and the experiment; “limits are easy; signal very hard!”

Excess – significant? DM???

Accounts for much of the effect?

Add pulsars…
DM indirect detection: collider expts

\[ \frac{g_q g_\chi}{M^2 - q^2} = \frac{g_q g_\chi}{M^2} \left( 1 + \frac{q^2}{M^2} + \cdots \right) = \frac{1}{\Lambda^2} \left( 1 + \frac{q^2}{M^2} + \cdots \right) \]

Simplified models

V/A: \( g_\chi = 1, g_q = 0.25 \)
P/S: \( g_\chi = g_q = 1 \)

Can interpret all resonance searches in terms of DM

And many many more…

Spin-Independent

Spin-dependent

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The rest of the Universe

CMB, Dark Energy,
Gravitational physics
The Power of Combining Probes

Best constraints obtained by combining cosmological probes

Combining LSS probes (from same survey) requires more advanced strategies

Clustering, clusters and WL probe same underlying density field, are correlated
correlated systematic effects require joint analysis

Olivier Doré
AAS, WFIRST Science, Kissimmee, January 5th 2016

The Observational Foundations of Dark Energy

• Weak-Lensing not presented is also complementary.

SNe luminosity distance measurement (Nobel 2011)
CMB angular diameter distance measurement

Combination

Matter Density Cosmological Constant, i.e. Dark Energy

DES-Y1 Results
Preliminary
-0.05 0.0 0.05 0.1 0.15
DES-Y1 weak lensing: factor ~2 increase in constraining power consistent cosmology constraints from weak lensing and clustering

DES-Y1 3x2pt: first joint analysis in configuration space

François R. Bouchet, EPS-HEP@Venezia, 12 july 2017

"Cosmic Microwave Background"

The Planck 2015 CMB polarisation sky at 5 arc minute resolution

The gravitational effects of intervening matter bend the path of CMB light on its way from the early universe to the Planck telescope. This "gravitational lensing" distorts our image of the CMB (smoothing on the power spectrum, and correlations between scales)
The Cosmos: GW Wave spectrum

- Relic radiation
- Cosmic Strings
- Extreme Mass Ratio Inspirals
- Supermassive BH Binaries
- BH and NS Binaries
- Supernovae
- Spinning NS
- Supermassive BH Binaries
- Binaries coalescences
- Extreme Mass Ratio Inspirals
- Pulsar timing
- Space detectors
- Ground interferometers

Frequency spectrum:
- $10^{-16}$ Hz
- $10^{-9}$ Hz
- $10^{-4}$ Hz
- $10^0$ Hz
- $10^3$ Hz

EPS-HEP2017
Tests of GR: ok (classical gravity ok)

Limit on $m_g$:

$$E^2 = p^2 c^2 + A \cdot p^\alpha c^\alpha$$

$$v_g/c = 1 + (\alpha - 1) A E^{\alpha-2}/2$$

$\delta \Psi(A, \alpha)$

$$m_g < 7.7 \times 10^{-23} \text{ eV/c}^2$$

GW detectors to trigger EM telescopes (radio, $\gamma$-rays & $\nu$ detectors)

> 80 MOUs signed!

Bright future: LISA, Einstein; even “apps to nuc&part” physics:

Phase transition for collaborations: $\sim 10^3$ scientists (and board, committees, MOUs, L1/L2/L3 mgmt...)

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The enablers

Machines
Detectors
For sure applications for the next decade will be extremely sensitive to latency. One Approach among many:

Static System with Line-of-Sight (LOS) data transfer Communication

Wireless Data Transmission (?)

Reduced material Latency ($v_{\text{mmw}}$ > $v_{\text{fiber}}$)

Cross obstacles…

Wireless Readout

Soltveit

EPS-HEP 2017

Detector Improvements

Remote readout

Cross obstacles

Latency ($< 3$, p)<

Reduced material

Topographical obstacles, and faster Inst.

~15% merged vertices → ~1.5%

TOF $\sigma \approx 30$ ps, $|\eta| < 3$, $p_T > 0.7$ GeV

factor 4-5 effective pile-up reduction

Towards dream of full readout?

Online reconstruction

LHCb

Run I

Run II

4D reconstruction

VBF $H \rightarrow \tau \tau$ in 200 p-p collisions

Particle Flow

Spread to hadron collisions; now to new detector designs

P. Sphicas

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Towards a new machine

“Technically limited schedule”

As for next step in energy: driven by magnets… begs for more investment on this front
And of course on new acceleration methods.
Some parting thoughts

Instead of a summary of the highlighted highlights...
What if we don’t find new physics in Run II/Run III? Fundamentalitis

- Fundamentalitis is “a serious condition that causes its victims to believe that the only thing worth thinking about is the deep nature of reality as manifested through the fundamental laws of physics.”
  - Two notable examples – from giants of physics: Einstein (well known, on GUT) and Oppenheimer. Take the latter:
    - In 1939 (with Snyder) started BH physics: he showed that an in-falling observer on the surface of an object whose mass exceeded a critical mass would appear to be in a state of perpetual free fall to an outsider.
    - Then Oppenheimer forgot all about it and never said anything about black holes for the rest of his life. (Getting distracted by the bomb helped)
  - For Oppenheimer, BHs were mundane: they were but particular solutions of GR; The big deal was GR itself.

- Freeman Dyson:
  - “Oppenheimer in his later years believed that the only problem worthy of the attention of a serious theoretical physicist was the discovery of the fundamental equations of physics. Einstein …. felt the same way... Once you had discovered the right equations, then the study of particular solutions of the equations would be a routine exercise for second-rate physicists or graduate students.”
  - Similarly, Einstein spent his last few years in a futile search for a Grand Unified Theory (took things to the ultimate, as far as doubting QM)

- Fast-forward in BH physics: Hawking radiation; Bekenstein entropy; nowadays: link between information theory and BH physics; the firewall (?)… or non-locality (e^–S)…

http://blogs.scientificamerican.com/the-curious-wavefunction
The panorama of particle physics, again

- **Energy Frontier, the LHC, is en route to**
  - Probing the Higgs sector; exploring BSM
  - Completing the physics of flavor in the quark sector
  - Providing a new picture of hadronic matter
  - And on the side: providing important information on DM

- **Neutrinos: weakly interacting so least known thus far**
  - Exciting sneak preview of CP violation? En route to PMNS…
  - Mass generation mechanism beyond EWSB and H…
  - Very promising program of work and experiments ahead

- **Dark Matter: if it’s some shade of grey, we’ll see it**
  - Direct experiments are approaching the neutrino wall
  - Tantalizing hint from astrophysics; LHC complementary

- **The Cosmos**
  - Only place where we can play with gravity; and where densities can be very high
  - The scientific program being laid out holds tremendous promise

- **Fundamental measurements**
  - They remain so; a surprise can show up at any time
We are advancing on all fronts – and it’s impressive
We are advancing on all fronts – and it’s impressive

All in all:

- It’s still extremely interesting to be in Particle Physics
We are advancing on all fronts – and it’s impressive.

All in all:

- It’s still extremely interesting to be in Particle Physics.
- And it’s still an honor and a privilege (to be in Particle Physics).
We are advancing on all fronts – and it’s impressive

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Warm thanks to the organizers for a beautiful and stimulating conference!