LHC now and in the future

51st International School of Subnuclear Physics

Erice, July 1, 2013
Sergio Bertolucci
CERN
Where we stand

- There is a new boson of mass \(~125\) GeV, with properties consistent with the SM Higgs, **within the current uncertainties**. More data needed to ascertain the nature of this object.
A new particle: no doubt that it is there…

By now we can establish it with a single decay channel!
e.g. $H \rightarrow ZZ \rightarrow 4l$
…it prefers $0^+$ quantum numbers
...its mass is measured to .5%

125.8 ± 0.5(stat.) ± 0.2(syst.)

m_H = 125.5 ± 0.2 ± 0.5
0.6 GeV
...and the signal strength is compatible with a SM Higgs
Where we stand

- There is a new boson of mass \( \sim 125 \text{ GeV} \), with properties consistent with the SM Higgs, within the current uncertainties. More data needed to ascertain the nature of this object.

- So far, no indications of BSM physics from direct searches at the High E Frontier:
  - colored SUSY particles (first generations) ruled out up to O(1 TeV), for a light LSP;
  - “natural” SUSY probed at level of a few hundred GeV of 3rd generation spartners;
  - exotica: heavy objects probed up to masses of 2-3 TeV;
  - a lot of room still to be explored, 14 TeV will be essential!
BSM: we have searched....

e.g. exclusions plots shown at Moriond QCD 2012....
The big picture

inclusive searches

Natural SUSY

long-lived particles, eg. split SUSY

RPV

https://twiki.cern.ch/twiki/bin/view/AtlasPublic/CombinedSummaryPlots

*Only a selection of the available mass limits on new states or phenomena shown. All limits quoted are observed minus 1σ theoretical signal cross section uncertainty.*
SUSY health

- The experiments have already explored a very vast range of masses and parameters.

- Though, too early to declare SUSY’s death, since there remain important parameter regions to be explored, and because:
  - Difficult or impossible to give “absolute” limits, since basically always assumptions involved.
  - Limits quickly degrade or disappear when raising $m($LSP$)$ beyond several hundreds of GeV.
  - Inclusive searches often assume degenerate 1st and 2nd generation squarks. Limits decrease (by several hundreds of GeV) if this is given up.
  - Simplified models make strong assumptions on branching ratios, masses of intermediate states.
  - Theory uncertainties (cross sections/scales/pdfs, initial state radiation).
Where we stand

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- Very rich harvest coming from LHC PbPb and pPb runs
**ALICE: Correlations**

- Correlations for pairs of trigger and associated particles, $p_{T,\text{trig}} > p_{T,\text{assoc}}$, as $f(\Delta \phi, \Delta \eta)$, defined as associated yield per trigger particle.

Excess on both near-side (NS) and away-side (AS) going from p-p/low multiplicity -> high multiplicity events.

Qualitatively similar to CMS ridge.

Projection on $\Delta \phi$ – pPb and pp data.

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- Very few anomalies in the world-wide HEF data, no strongly smoking gun
LHCb rare decay $B_s \to \mu\mu$

The search for $B_s (d) \to \mu\mu$

Branching fractions extracted from unbinned maximum likelihood fit to the mass spectra in 8 (7 TeV) and 7 (8 TeV) bins in BDT

$$\mathcal{B}(B_s^0 \to \mu^+\mu^-) = (3.2^{+1.5}_{-1.2}) \times 10^{-9}$$

SM: $\text{BR}(B_s \to \mu\mu) = 3.5 \pm 0.2 \times 10^{-9}$

HCP 2012
arXiv 1211.2674
LHCb: $\Delta m_S$ in $B_S$ oscillations

Perfect tagging, infinite time resolution

 significance: $\sigma(\Delta m_S) \propto \sqrt{\varepsilon D^2} e^{-\frac{(\Delta m_S \sigma_p)^2}{2}}$

- Tagging: $\varepsilon D^2 \sim 3.5\%$
- Time resolution: $\sigma_t \sim 44$ fs
- Main systematics: decay length scale and momentum scale

$\Delta m_S = 17.768 \pm 0.023$ (stat) $\pm 0.006$ (syst) ps$^{-1}$

(previous result with 0.36/fb = 17.725 $\pm 0.041 \pm 0.026$ ps$^{-1}$)
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- The SM (in terms of its QCD and EWK parts) works perfectly well, up to the % level, at the highest energies probed so far (7 and 8 TeV).

- We have very advanced theory tools at hand, but we will need even better ones!
A summary of Standard Model measurements

The excellent performance in measuring Standard Model physics gives confidence for the readiness of the two experiments to search for New Physics.

Similar beautiful results from ATLAS.

The excellent performance in measuring Standard Model physics gives confidence for the readiness of the two experiments to search for New Physics.
**W/Z (+Jet) Production**

### Inclusive

- **excl. cross sections:**
- **experimental precision at the 1% level, especially for ratio-observables**
- **excellent agreement with NNLO QCD, both at 7 and 8 TeV**
- **many diff. distributions measured**

### +jets

- **V+jets:**
  - “triumph” for MCs with matched matrix elements and parton showers
  - also multi-leg NLO calculations available by now
  - **confidence in background predictions for many searches**
But, despite its success...

.... we know that the Standard Model is not complete because:

- It doesn’t solve the hierarchy problem
- It has no explanation for dark matter/dark energy
- Its mechanisms of CPV are too small to explain matter/antimatter imbalance
- It cannot provide a QFT of gravitation
- ....etc
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- Most important: at the LHC, we are JUST AT THE BEGINNING of the HEF exploration!
Parton luminosities

for a fixed mass scale

2 TeV

rise because of steep fall-off of the lower-energy PDF, at large $x$

from [http://www.hep.phy.cam.ac.uk/~wjs/plots/plots.html](http://www.hep.phy.cam.ac.uk/~wjs/plots/plots.html)

G. Rolandi, private comm.
LHC, the next 20 years

- LHC startup, $\sqrt{s} = 900$ GeV
  - $\sqrt{s}=7\sim 8$ TeV, $L=6\times10^{33}$ cm$^{-2}$ s$^{-1}$, bunch spacing 50 ns

- Go to design energy, nominal luminosity
  - $\sqrt{s}=13\sim 14$ TeV, $L\sim1\times10^{34}$ cm$^{-2}$ s$^{-1}$, bunch spacing 25 ns

- Injector and LHC Phase-1 upgrade to ultimate design luminosity
  - $\sqrt{s}=14$ TeV, $L\sim2\times10^{34}$ cm$^{-2}$ s$^{-1}$, bunch spacing 25 ns

- HL-LHC Phase-2 upgrade, IR, crab cavities?
  - $\sqrt{s}=14$ TeV, $L=5\times10^{34}$ cm$^{-2}$ s$^{-1}$, luminosity levelling

- Quadrant 1
  - $\sim 20-25$ fb$^{-1}$

- Quadrant 2
  - $\sim 75-100$ fb$^{-1}$

- Quadrant 3
  - $\sim 350$ fb$^{-1}$

- Quadrant 4
  - $\sim 3000$ fb$^{-1}$
The machine – LS1

- Repair defective interconnects
- Consolidate all interconnects with new design
- Finish off pressure release valves (DN200)
- Bring all necessary equipment up to the level needed for 7TeV/beam
Dashboards

- General and detailed progress
  
  http://lhcdashboard.web.cern.ch/lhcdashboard/ls1/
Then...

- $E=6.5\text{TeV}$
- $\beta^*=0.5\text{m}$ (maybe 0.4)
- All other conditions as in 2012 i.e. LHC availability same, etc..
## Potential performance

<table>
<thead>
<tr>
<th></th>
<th>Number of bunches</th>
<th>Ib LHC FT[1e11]</th>
<th>Collimator scenario</th>
<th>Emit LHC (SPS) [um]</th>
<th>Peak Lumi [cm⁻²s⁻¹]</th>
<th>~Pile-up</th>
<th>Int. Lumi [fb⁻¹]</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 ns</td>
<td>2760</td>
<td>1.15</td>
<td>S1</td>
<td>3.5 (2.8)</td>
<td>9.2e33</td>
<td>21</td>
<td>24</td>
</tr>
<tr>
<td>25 ns low emit</td>
<td>2320</td>
<td>1.15</td>
<td>S4</td>
<td>1.9 (1.4)</td>
<td>1.6e34</td>
<td>43</td>
<td>42</td>
</tr>
<tr>
<td>50 ns</td>
<td>1380</td>
<td>1.6</td>
<td>S1</td>
<td>2.3 (1.7)</td>
<td>1.7e34 (0.9e34) level</td>
<td>76</td>
<td>40</td>
</tr>
<tr>
<td>50 ns low emit</td>
<td>1260</td>
<td>1.6</td>
<td>S4</td>
<td>1.6 (1.2)</td>
<td>2.2e34</td>
<td>108</td>
<td>...</td>
</tr>
</tbody>
</table>

- 6.5 TeV
- 1.1 ns bunch length
- 150 days proton physics, HF = 0.2
- 70 mb visible cross-section
- * different operational model – **caveat - unproven**

All numbers approximate
In words

- **Nominal 25 ns**
  - gives more-or-less nominal luminosity

- **BCMS 25 ns**
  - gives a healthy $1.6\times10^{34}$
  - peak $\langle \mu \rangle$ around 40
  - 83% nominal intensity

- **Nominal 50 ns**
  - gives a virtual luminosity of $1.7\times10^{34}$ with a pile-up of over 70
  - levelling mandatory

- **BCM 50 ns**
  - gives a virtual luminosity of $2.2\times10^{34}$ with a pile-up of over 100
  - levelling even more mandatory
The experiments

A new mode of operations!

- All busy in repairs, consolidations, first upgrades
- Massive amount of work, with a very tight schedule…
- …while keeping looking at the data, prepare for the next energy
- …and proceed to a very substantial progress in their computing models.

It will need a massive recommissioning, if they want to be at the same readiness level as in 2010
The experiments, upgrades

- Fully engaged in the LS2 upgrades, which is particularly demanding for LHCb and ALICE
- Active R&D programs on the BIG upgrades in 2022
- Need to use the coming run to better focus the program
Extending the reach…

- Weak boson scattering
- Higgs properties
- Supersymmetry searches and measurements
- Exotics
- t properties
- Rare decays
- CPV
- ..etc

Experiments are planning a workshop in October 2013 to assess their physics reach and the implications on the detector upgrades and associated R&D
### CMS Projection

**Assumption** NO invisible/undetectable contribution to $\Gamma_H$:

- **Scenario 1**: system./Theory err. unchanged w.r.t. current analysis
- **Scenario 2**: systematics scaled by $1/\sqrt{L}$, theory errors scaled by $\frac{1}{2}$
  - $\gamma\gamma$ loop at 2-5% level
  - down-type fermion couplings at 2-10% level
  - direct top coupling at 4-8% level
  - gg loop at 3-8% level

### Couplings fit at LHC

<table>
<thead>
<tr>
<th>Coupling</th>
<th>Uncertainty (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>300 fb$^{-1}$</td>
</tr>
<tr>
<td></td>
<td>Scenario 1</td>
</tr>
<tr>
<td>$\kappa_\gamma$</td>
<td>6.5</td>
</tr>
<tr>
<td>$\kappa_V$</td>
<td>5.7</td>
</tr>
<tr>
<td>$\kappa_g$</td>
<td>11</td>
</tr>
<tr>
<td>$\kappa_b$</td>
<td>15</td>
</tr>
<tr>
<td>$\kappa_t$</td>
<td>14</td>
</tr>
<tr>
<td>$\kappa_T$</td>
<td>8.5</td>
</tr>
</tbody>
</table>
Coupling Ratios Fit at LHC

- **Fit to coupling ratios:**
  - No assumption BSM contributions to $\Gamma_H$
  - Some theory systematics cancels in the ratios
- **Loop-induced Couplings $\gamma\gamma$ and gg treated as independent parameter**
  - $\kappa_{\gamma}/\kappa_Z$ tested at 2%
  - gg loop (BSM) $\kappa_t/\kappa_g$ at 7-12%
  - 2nd generation ferm. $\kappa_{\mu}/\kappa_Z$ at 8%
Shut down to fix interconnects and overcome energy limitation (LHC incident of Sept 2008)

Shut down to overcome beam intensity limitation (collimation, New Cryo P4,...) Inj. upgrade
Around 2022 the Present Triplet magnets reach the end of their useful life (due to radiation damage) …and will anyway need replacing.

In addition the Luminosity of the LHC will saturate by then

Time for an upgrade!
The main objective of HL-LHC is to implement a hardware configuration and a set of beam parameters that will allow the LHC to reach the following targets:

- A luminosity of $5 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$ with leveling
- Implies a “Virtual” peak luminosity of $>10^{35} \text{ cm}^{-2}\text{s}^{-1}$
- An integrated luminosity of $250 \text{ fb}^{-1}$ per year, enabling the goal of $3000 \text{ fb}^{-1}$ twelve years after the upgrade.

Why Level?

- Allow design integrated Luminosity for a lower peak L, and less pile up for the experiments
- Lower peak heat deposition in the magnets
Efficiency is defined as the ratio between the annual luminosity target of 250 fb\(^{-1}\) over the potential luminosity that can be reached with an ideal cycle run time with no stop for 150 days: \(t_{\text{run}} = t_{\text{lev}} + t_{\text{dec}} + t_{\text{turn}}\). The turnaround time after a beam dump is taken as 5 hours, \(t_{\text{decay}}\) is 3 h while \(t_{\text{lev}}\) depends on the total beam current.

### Target parameters for HL-LHC run

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Nom. 25 ns</th>
<th>Target 25 ns</th>
<th>Target 50 ns</th>
<th>LIU 25 ns</th>
<th>LIU 50 ns</th>
</tr>
</thead>
<tbody>
<tr>
<td>(N_b [10^{11}])</td>
<td>1.15</td>
<td>2.0</td>
<td>3.3</td>
<td>1.7</td>
<td>2.5</td>
</tr>
<tr>
<td>(n_b)</td>
<td>2808</td>
<td>2808</td>
<td>1404</td>
<td>2808</td>
<td>1404</td>
</tr>
<tr>
<td>(I [A])</td>
<td>0.56</td>
<td>1.02</td>
<td>0.84</td>
<td>0.86</td>
<td>0.64</td>
</tr>
<tr>
<td>(\theta_c [\mu rad])</td>
<td>300</td>
<td>475</td>
<td>445</td>
<td>480</td>
<td>430</td>
</tr>
<tr>
<td>(\beta^* [m])</td>
<td>0.55</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>(\varepsilon_n [\mu m])</td>
<td>3.75</td>
<td>2.5</td>
<td>2.0</td>
<td>2.5</td>
<td>2.0</td>
</tr>
<tr>
<td>(\varepsilon_s [eV s])</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>IBS h [h ]</td>
<td>111</td>
<td>25</td>
<td>17</td>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>IBS l[h ]</td>
<td>65</td>
<td>21</td>
<td>16</td>
<td>21</td>
<td>13</td>
</tr>
<tr>
<td>Piwinski</td>
<td>0.68</td>
<td>2.5</td>
<td>2.5</td>
<td>2.56</td>
<td>2.56</td>
</tr>
<tr>
<td>F red. fact.</td>
<td>0.81</td>
<td>0.37</td>
<td>0.37</td>
<td>0.37</td>
<td>0.36</td>
</tr>
<tr>
<td>b-b/IP[10^{-3}]</td>
<td>3.1</td>
<td>3.9</td>
<td>5</td>
<td>3</td>
<td>5.6</td>
</tr>
<tr>
<td>(L_{\text{peak}})</td>
<td>1</td>
<td>7.4</td>
<td>8.4</td>
<td>5.3</td>
<td>7.2</td>
</tr>
<tr>
<td>Crabbing</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>(L_{\text{peak}}) virtual</td>
<td>1</td>
<td>20</td>
<td>22.7</td>
<td>14.3</td>
<td>19.5</td>
</tr>
<tr>
<td>Pileup (L_{\text{lev}} = 5L_0)</td>
<td>19</td>
<td>95</td>
<td>190</td>
<td>95</td>
<td>190</td>
</tr>
<tr>
<td>Eff.(\uparrow) 150 days</td>
<td>0.62</td>
<td>0.61</td>
<td></td>
<td>0.66</td>
<td>0.67</td>
</tr>
</tbody>
</table>

*baseline*
Both ATLAS and CMS detectors are planning important upgrades to stand the harsher running conditions at HL-LHC: pile-up, rates, radiation damage.

- Pile-up ~ 4-5 times more pile-up than today.

Plan: keep detector performance for main physics objects at the same level as we have today.

- Improved trigger system
- New tracking systems
- Improved forward detectors
- ...
and elsewhere?
A lepton collider: a decisive asset…

..if

- Can be decided/built soon
- It might start at 250 Gev, but it should be upgradable at 500 GeV, with a possible extension to 1 TeV c.m.

**Best candidate: the International Linear Collider:**

- Mature design
- TDR delivered
- Japanese community has submitted to the government a request to host it.
500 GeV CM with 31 km → upgrade later to ~ 1TeV CM with 50 km
Luminosity $1.8 \times 10^{34} \text{ /cm}^2\text{s (@500 GeV CM)}$
ILC features: cleanliness

- Collision of two elementary particles
  - proton + proton at LHC
    - Proton = 3 quarks + gluons
  - electron + positron at ILC
  → Signal is clearly seen without much noises
  → Trigger-less data taking
  → Theoretically clean
    (less theoretical uncertainties)
ILC features: control

- Initial state of electron-positron interaction:
  - Energy-momentum 4-vector is specified
  - Electron polarization (80%~90%) is specified
    - Positron polarization (60%) is optional (30% comes for free)

Energy-momentum 4-vector
→ e.g. recoil mass analysis: tagged Higgs
Higgs to ALL (including invisible final state)

ILC

LHC

H → γγ

H → ZZ
Electron polarization

Specify the intermediate state
- Right-handed e- turns off $A^0$
  - Information on the gauge structure of the final state

Increase rates
- e.g. $P^-/P^+ = -0.8/0.3$:
  Increases the H production mode
  \[
  \sigma(\nu\nu H) \text{ by } X \times 2.34 \ (=1.8 \times 1.3)
  \]

Background rejection
- Right-handed e- turns off $W$

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  \]

Background rejection
- Right-handed e- turns off $W$

\[
\begin{align*}
\text{e.g. acoplanar muon pair production such as smuon pair production}
\end{align*}
\]
LHC vs LC: „signal strength“

LHC – mostly syst. limited
LC – mostly stat. limited
ILC1000/CLIC1400 further improves precision

KD attempt to compile available experimental studies.
(best estimates)

HANDLE WITH CARE

fineprint:

ATLAS/CMS from Krakow notes (= preliminary!)

LHC = (ATLAS+CMS)/2 (300 fb⁻¹)
HL-LHC = ATLAS (3000 fb⁻¹)
ILC250 = 250 fb⁻¹ at 250 GeV
+ILC500 = 500 fb⁻¹ at 500 GeV +
250 fb⁻¹ at 250 GeV
ILC1000 + CLIC3000
are only examples

1) prec. on $\sigma_{zz}$(total)
2) prec. on $\sigma_{WW}$(total)
ILC: not only a precision machine

- Great impact in exploring the EWK part of Supersymmetry, in a region which might be not accessible at the LHC, because the unfavorable S/B.
- A fundamental contribution in the precision studies of the W and Z bosons and the top quark.

The joint information coming from LHC and ILC will be a “conditio sine qua non” to enable the next particle accelerator at the energy frontier
and beyond LHC?
### Not only luminosity: High Energy LHC

#### Preliminary HE-LHC - parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal LHC</th>
<th>HE-LHC</th>
</tr>
</thead>
<tbody>
<tr>
<td>beam energy [TeV]</td>
<td>13.6</td>
<td>16.5</td>
</tr>
<tr>
<td>dipole field [T]</td>
<td>8</td>
<td>20</td>
</tr>
<tr>
<td>dipole coil aperture [mm]</td>
<td>20</td>
<td>40-45</td>
</tr>
<tr>
<td>#bunches / beam</td>
<td>300</td>
<td>1404</td>
</tr>
<tr>
<td>bunch population [$10^{11}$]</td>
<td>12</td>
<td>1.29</td>
</tr>
<tr>
<td>initial transverse normalized emittance [μm]</td>
<td>7.5</td>
<td>3.75 (x), 1.84 (y)</td>
</tr>
<tr>
<td>number of IPs contributing</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>maximum total beam intensity</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>IP beta function [m]</td>
<td>0.55</td>
<td>1.0 (x), 0.43 (y)</td>
</tr>
<tr>
<td>full crossing angle</td>
<td>285 (9.5 $\sigma_{x,y}$)</td>
<td>175 (12 $\sigma_{x_0}$)</td>
</tr>
<tr>
<td>stored beam</td>
<td>362</td>
<td>479</td>
</tr>
<tr>
<td>SR power</td>
<td>3.6</td>
<td>62.3</td>
</tr>
<tr>
<td>longitudinal cooling / bunching time [h]</td>
<td>12.9</td>
<td>0.98</td>
</tr>
<tr>
<td>events per bunch</td>
<td>19</td>
<td>76</td>
</tr>
<tr>
<td>peak luminosity [cm$^{-2}$s$^{-1}$]</td>
<td>1.0</td>
<td>2.0</td>
</tr>
<tr>
<td>beam lifetime</td>
<td>46</td>
<td>13</td>
</tr>
<tr>
<td>integrated luminosity over 10 h [fb$^{-1}$]</td>
<td>0.3</td>
<td>0.5</td>
</tr>
</tbody>
</table>
HE-LHC – LHC modifications

HE-LHC 2030-33

SPS+, 1.3 TeV, 2030-33

2-GeV Booster

Linac4
High Energy-LHC (HE-LHC)

CERN working group since April 2010

EuCARD AccNet workshop HE-LHC’10, 14-16 October 2010, Proc. CERN-2011-003

key topics

beam energy 16.5 TeV; 20-T magnets
cryogenics: synchrotron-radiation heat radiation damping & emittance control
vacuum system: synchrotron radiation control
new injector: energy > 1 TeV

parameters

<table>
<thead>
<tr>
<th></th>
<th>LHC</th>
<th>HE-LHC</th>
</tr>
</thead>
<tbody>
<tr>
<td>beam energy  [TeV]</td>
<td>7</td>
<td>16.5</td>
</tr>
<tr>
<td>dipole field  [T]</td>
<td>8.33</td>
<td>20</td>
</tr>
<tr>
<td>dipole coil aperture [mm]</td>
<td>56</td>
<td>40</td>
</tr>
<tr>
<td>#bunches</td>
<td>2808</td>
<td>1404</td>
</tr>
<tr>
<td>IP beta function [m]</td>
<td>0.55</td>
<td>1 (x), 0.43 (y)</td>
</tr>
<tr>
<td>number of IPs</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>beam current [A]</td>
<td>0.584</td>
<td>0.328</td>
</tr>
<tr>
<td>SR power per ring [kW]</td>
<td>3.6</td>
<td>65.7</td>
</tr>
<tr>
<td>arc SR heat load dW/ds [W/m/ap]</td>
<td>0.21</td>
<td>2.8</td>
</tr>
<tr>
<td>peak luminosity [10^{34} cm^{-2}s^{-1}]</td>
<td>1.0</td>
<td>2.0</td>
</tr>
<tr>
<td>events per crossing</td>
<td>19</td>
<td>76</td>
</tr>
</tbody>
</table>

Table: Turns %

<table>
<thead>
<tr>
<th>Material</th>
<th>Turns</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nb-Ti</td>
<td>40</td>
<td>28%</td>
</tr>
<tr>
<td>Nb_3Sn</td>
<td>58</td>
<td>41%</td>
</tr>
<tr>
<td>HTS</td>
<td>45</td>
<td>31%</td>
</tr>
</tbody>
</table>

E. Todesco
Thinking BIG

This large tunnel would also allow e+e- and e-p collisions as well as pp collisions.
CERN today....into the future

- CLIC conceptual design report published
- Participation in all LC activities
- LHeC conceptual design report published
- R&D for high-field magnets (towards HE-LHC)
- Accelerator R&D (HP SPL, Plasma Acc)
- Participation in Neutrino-Projects studied
CERN going global….

- Membership for Non-European countries

- New Associate Membership defined

- CERN participation in global projects independent of location
From Choices to Choice

- Roadmap (Japan) just published
- Roadmap discussion (US) in progress, completes next year
- Update of the European Strategy for Particle Physics completed ≡ Strategy of Europe in a global context
  - Several Meetings with international participation
    Open meeting September 2012, Cracow, then drafting session in January 2013 in Erice
    - Official approval in Bruxelles, 29-30 May 2013
- Use as 1st step to harmonize globally Particle Physics Strategy
In summary

- 2010-2012: extraordinary years!
- But we are just at the beginning of a long journey.
- By now, experimental results are dictating the agenda of the field.
- We need to accelerate the reflection on next steps
- No time to idle: a lot of work has to be done
In summary

We will need

- Flexibility
- Preparedness
- Visionary global policies
Thank you!

...and a bit of luck!