Standard Model measurements

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Introduction

- We had a very interesting parallel session on Thursday, with quite some lively discussions
- Detailed review of the Higgs boson physics, W & Z physics, top quark physics, QCD & PDFs and LHC and beyond
- Analysed in detail the SM physics potential of the various projects on the market
- Nice summary of the main items discusses in that session have been given yesterday

Agenda Sessione Standard Model

Thursday, 22 May 2014

15:00 - 15:15	Introduzione *15'*	Speakers: Stefano Forte (MI), Aleandro Nisati (ROMA1), Giampiero Passarino (Universita' di Torino), Roberto Tenchini (PI)
15:15 - 15:45	Fisica Higgs a LHC *30'*	Speakers: Paolo Giacomelli (BO), Dr. Biagio Di Micco (ROMA3), Stefano Rosati (ROMA1)
15:45 - 16:15	VV scattering e VBF *30'*	Speakers: Pietro Govoni (MIB), Chiara Mariotti (TO), Chiara Maria Roda (PI)
16:15 - 16:45	Prospettive fisica W, Z, QCD *30'*	Speakers: Alberto Mengarelli (BO), Fabio Cossutti (TS), Giancarlo Panizzo (UD)
16:45 - 17:15	Prospettive fisica del top *30'*	Speakers: Patrizia Azzi (PD), Marina Cobal (UD)
17:15 - 17:35	coffee break	
17:35 - 17:55	Fisica a ILC/CLIC *20'*	Speaker: Barbara Mele (ROMA1)
17:55 - 18:15	Fisica a FCC (ee+pp) *20'*	Speaker: Roberto Tenchini (PI)
18:15 - 18:30	Fisica a gamma-gamma colliders: Sapphire *15'*	Speaker: Marco Zanetti (CERN)
18:30 - 18:45	Fisica a LHeC (ep colliders) *15'*	Speaker: Monica D'Onofrio
18:45 - 19:00	Fisica a e+e- bassa energia *15'*	Speaker: Graziano Venanzoni (LNF)
19:00 - 19:30	Discussione fisica a progetti futuri *30'*	

Top priority items that should be investigated

- The recently discovered 125 GeV Higgs boson drives to a number of fundamental open points that are top priority for the physics programme for the LHC and future energy frontier accelerators:

1. **Precision measurements of the 125 GeV Higgs boson properties**
   - **Mass and of the natural width**
   - **Measurement of couplings to elementary fermions and bosons**
   - **Determination of the quantum numbers spin and parity, J^P, and CP properties**
   - **Measurement of the Higgs boson pair production (self-coupling strength)**
   - **Comparison of these physics properties with those predicted by Standard Model**
   - **Is this particle a fundamental object, or it is composite?**

2. **Analyse the Vector Boson scattering cross section (further study of the cross-section regularization);**

3. **Electroweak Precision measurement: W/Z mass, $\sin^2\theta_W$, α_{QED}, top propertites (mass, width, couplings, production, etc)**

4. Search for possible partners (neutral/charged) of the 125 GeV Higgs boson

the “big tools”: colliders

It is useful to discuss scenarios at different timescales:

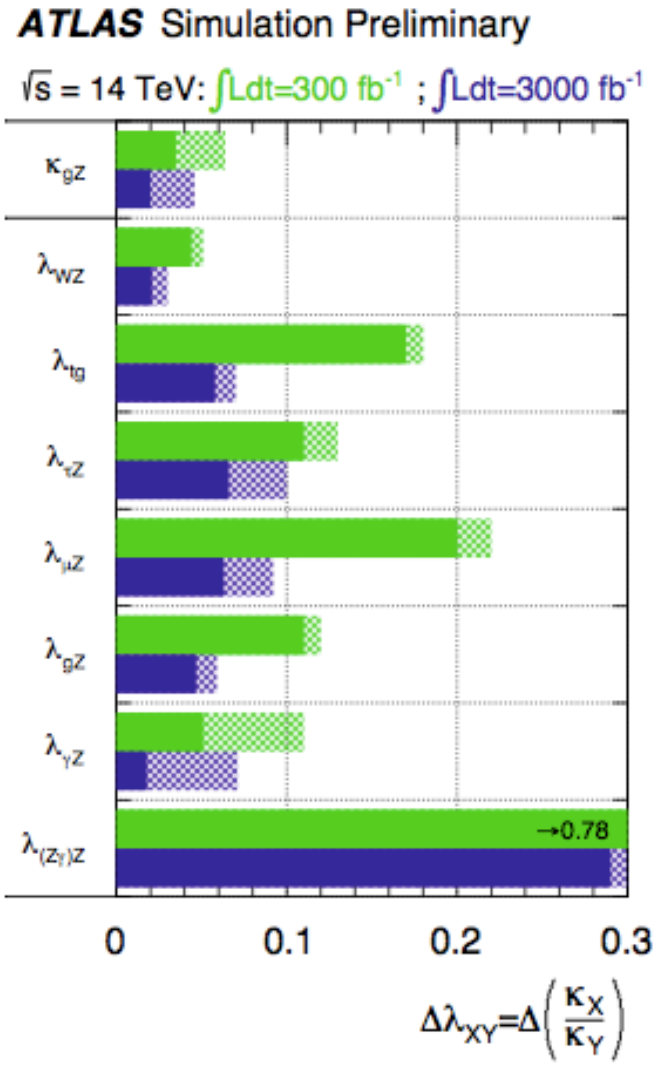
- **The LHC era**, including the High Luminosity extension (HL-LHC), as suggested by the ECFA
  - **We should consider also the physics potential of an energy upgrade of LHC (HE-LHC)**
- **Future colliders**
  - A linear e^+e^- collider at centre-of-mass energy up to 500 GeV (ILC)
    - The physics potential of an increase to 1 TeV (ILC) and 3 TeV (CLIC) should also be considered
  - A circular e^+e^- collider at centre-of-mass energy up to 350 GeV (FCC-ee)
  - A circular pp collider at centre-of-mass energy of 100 TeV (FCC-pp)
  - additional projects such as a p-electron collider using LHC (LHeC), Sapphire, e+e- @ low energy, etc

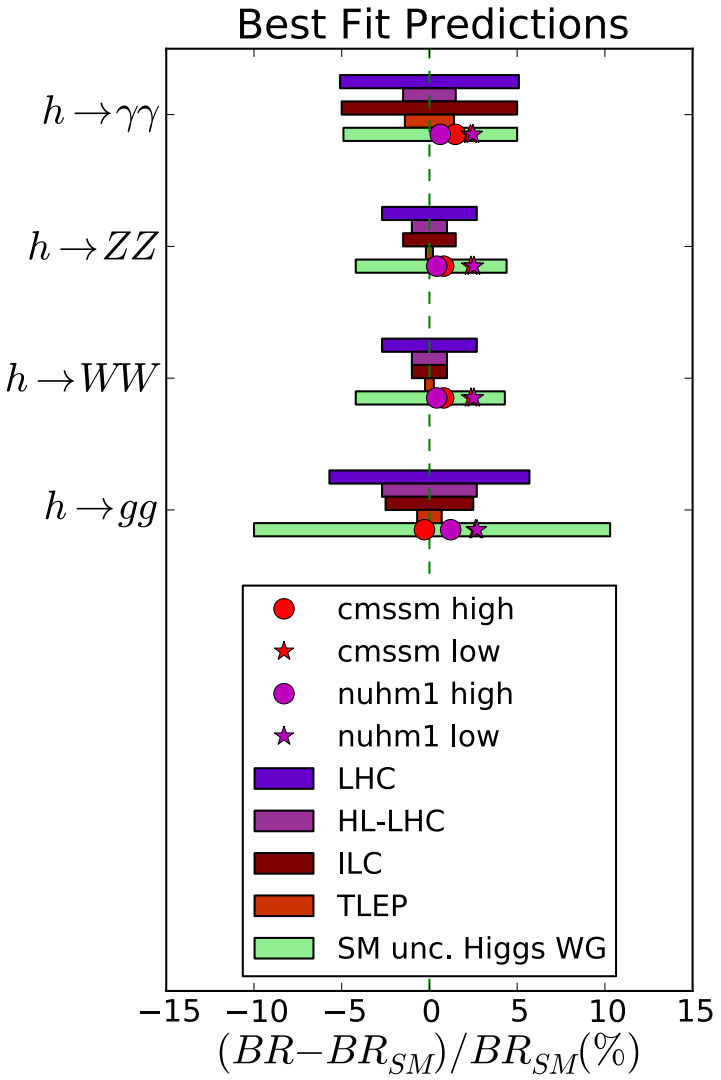
La fisica del bosone … selvaggio!

Higgs boson physics

- **Mass and width**
  - HL-LHC: *good indirect determination possible*
  - e+e- colliders: *precision measurement O(few %)*
- **Couplings**
  - HL-LHC: *a few % accuracy*
  - ILC/CLIC: *O(1%) or better*
  - FCC-e+e-: *definitively better than 1%*
- **HH production**
  - Key process for understanding the SM stability, important connections with New Physics
  - HL-LHC: *should be possible (study in progress)*
  - ILC/CLIC: *requires O(1 TeV) collisions for precision study*
  - FCC-e+e-: *some prelinary studies being performed assuming 500 GeV center-of-mass energy*
- **VBS**
  - HL-LHC: *feasibility of VBS studies also at high-pileup level*

Higgs couplings

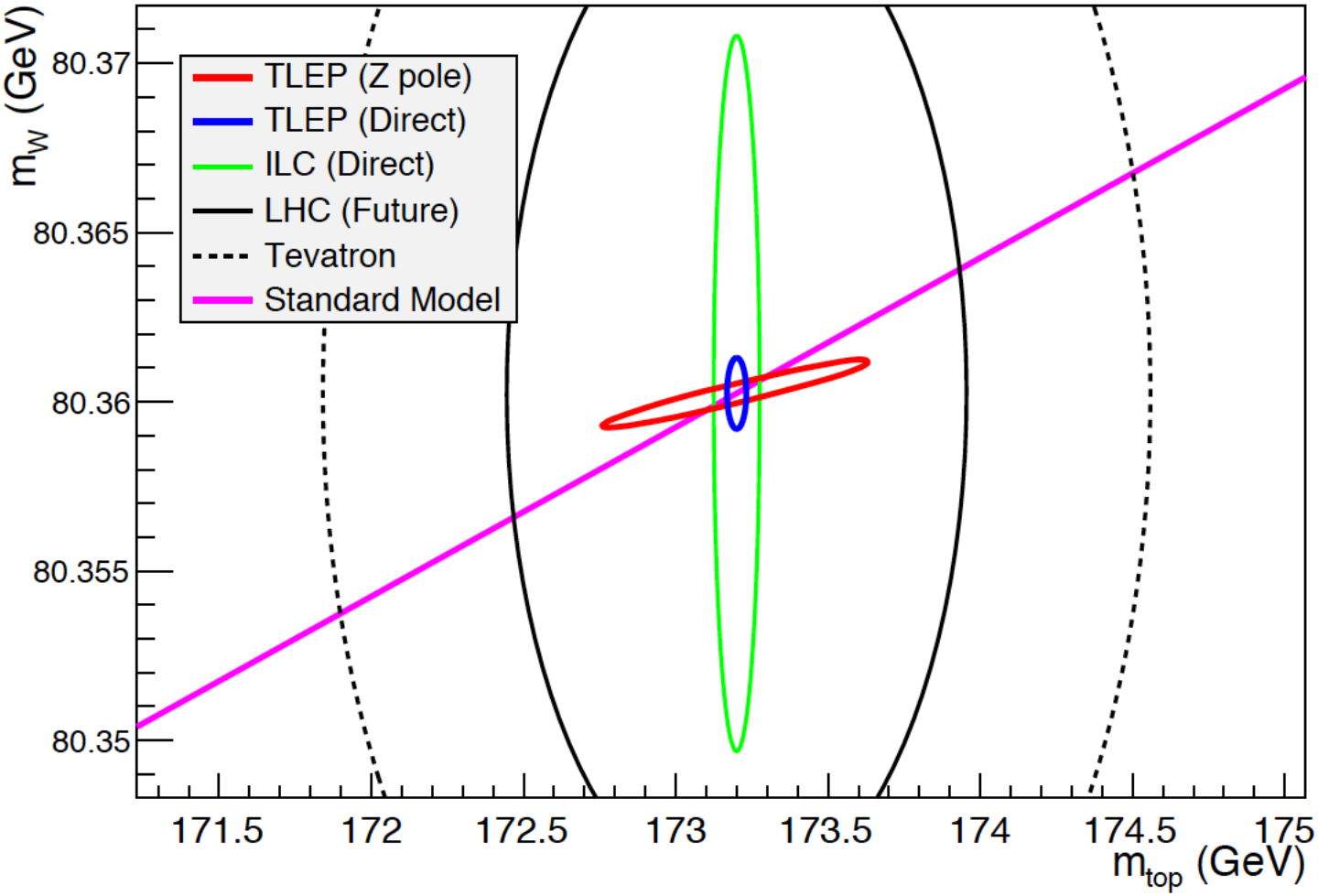




Electroweak physics

- **W mass**
  - (HL-)LHC: *could eventually reach 5 MeV accuracy*
  - e+e- colliders: *about10 MeV for ILC, better than 1 MeV for FCCe+e-*
- **Z mass**
  - FCCe+e-: *about 0.1 MeV (resonant depolarisation)*
- **$\sin^2\theta_W$**
  - (HL-)LHC: *hope to reach LEP precision (10^{-4})*
  - e+e- colliders: *10^{-6} if both beams polarized*
- **α_{QED}**
  - low-energy machine: *needed to match the accuracy on other observables at high energy e+e- colliders*

evolution of EWK data

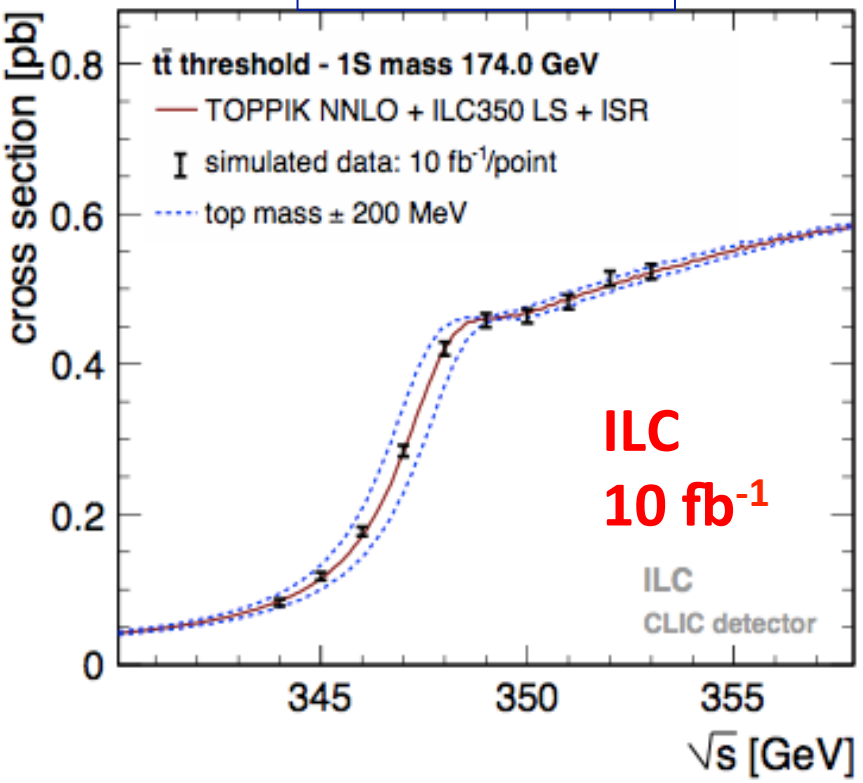


Top physics

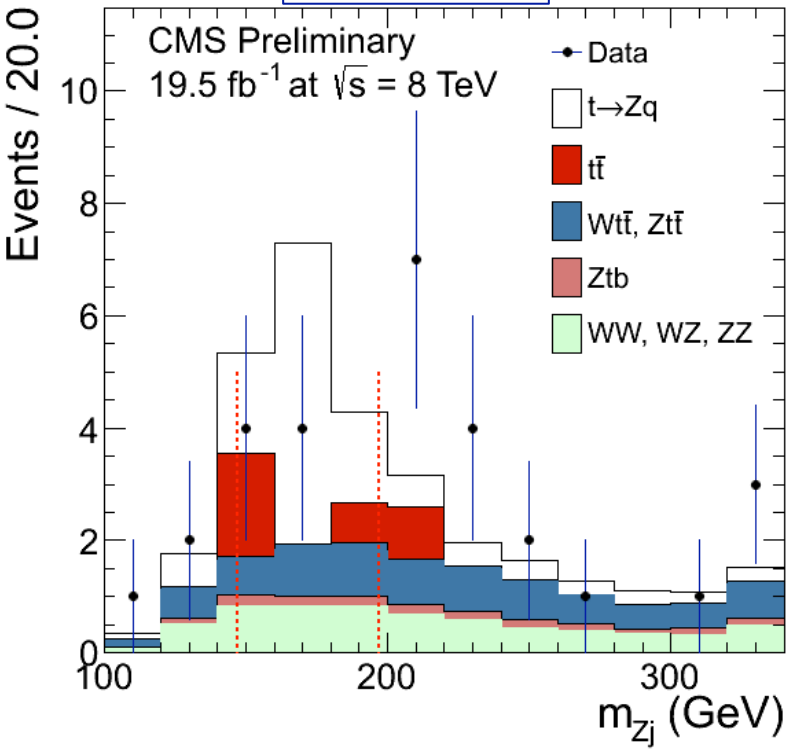
- **top mass**
  - HL-LHC: *can go well below the "theory uncertainty" on the "pole mass" (~0.5 GeV)*
  - e+e- colliders: *well below 100 MeV*
- **Rare decays**
  - HL-LHC: *10^{-6} on the $t \rightarrow Zq$, γq B.R. and 10^{-4} on the $t \rightarrow Hc$ B.R.*
- Furthermore: single top, top charge asymmetry, couplings, etc

Top physics

mass scan



t → Zq



Extrapolation @ HL-LHC: ~ 10^{-6}

“The next 10 years…”

- Top priority for the next years is the study of the 125 GeV Higgs boson discovered at LHC

“The next 10 years…”

- Top priority for the next years is the study of the 125 GeV Higgs boson discovered at LHC
- The only viable and realistic option for this investigation performed by the next ~ ten years is the luminosity upgrade of LHC

What  Next ?

- We are not facing a "standard", but an **"exceptional" model**, it must be challenged with higher precision.
- There are two possible scenarios:
  1. We will see some indication of New Physics at a scale "not far" from the LHC energy scale

     ➔ **STOP – RESET – START** ☺
  2. We do not see any NP signals ➔ **this is the real case to which we need to give an answer**

What  Next ?

- Two-alternative options:
  1. Study the 125 GeV Higgs boson at the ultimate precision that an e+e- collider can give you, together with other electroweak observables → this can pave the way to NEXT high-energy hadron collider. Or:
  2. Go right away to a very high energy machine with strong potential of discovering of new physics (very high energy hadron collider or linear collider)

➔ This is the question we need to address

backup

What "others" say? ➔ P5

- Use the Higgs boson as a new tool for discovery
- Pursue the physics associated with neutrino mass
- Identify the new physics of dark matter
- Understand cosmic acceleration: dark energy and inflation
- Explore the unknown: new particles, interactions, and physical principles.

- The enormous physics potential of the LHC, which will be entering a new era with its planned high-luminosity upgrades, will be fully exploited. The U.S. will host a world-leading neutrino

- The interest expressed in Japan in hosting the International Linear Collider (ILC) is an exciting development. Participation by the U.S. in project construction depends on a number of important factors, some of which are beyond the scope of P5 and some of which depend on budget Scenarios. As the physics case is extremely strong, all Scenarios include ILC support at some level through a decision point within the next 5 years.