LHC Higgs Cross Section WG:

Pseudo Observables

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1. Introduction
2. What has been done (few)
3. What has to be done (a lot)

1. Introduction

"Pseudo observables" vs. "realistic observables":

What is measured in a detector?

→ tracks and hits . . . Ok:

– cross sections

– forward-backward (etc.) asymmetries

– line shape observables

⇒ realistic observables (RO)

What (else) do we want?

– particle masses

– partial widths

– couplings

⇒ pseudo observables (PO)

Extraction of PO from RO:

Depends on:

- experimental cuts
- detector effects
- experimental set-up
- ...

$\Rightarrow$ deconvolution (unfolding) procedure

- unfolding QED corrections
- subtraction of interference terms
- unfolding higher-order QCD corrections

$\Rightarrow$ model dependence enters

(POs are obtained in the SM!?)

Example from LEP:

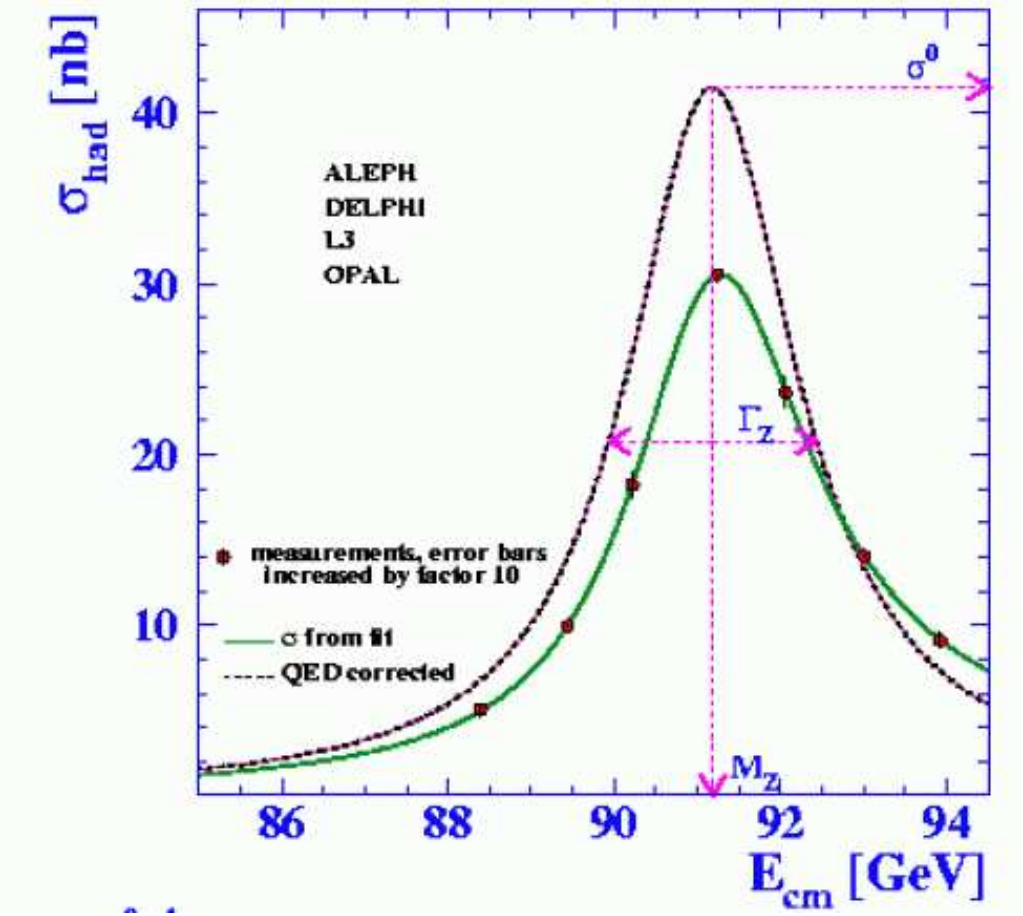
Realistic observables:

- $\sigma(e^+e^- \to Z \to f\bar{f})$
- Z line shape
- A_b^{FB}, A_e^{LR}, ...

Pseudo observables:

- M_Z, Γ_Z, σ^0
- $\sin^2\theta_{\mathrm{eff}}$
- number of families/neutrinos
- ...

$\to$ M_Z depends (slightly) on M_H



RO $\to$ QED deconvolution $\to$ PO: M_Z, Γ_Z, $\sigma^0 = 12\pi \dfrac{\Gamma_e \Gamma_f}{M_Z^2 \Gamma_Z^2}$

A lot of important(?) work has to be done:

1. What are our pseudo observables?
   mass? cross sections? partial widths? couplings? combinations?
   Priorities?

2. How are/can they be extracted?
   Model dependence?

3. Theory status?
   Implications?

4. Status of MC tools?
   – interference? background subtraction?
   – extraction of $\Gamma \times$ BR?

5. Necessary improvements?

6. . . . ???

Problems: part I

The (few) people have quite different ideas what exactly has to be done, what are the priorities

"Theory side":
- "Crystal clear" definitions
- What is the correct definition of mass?
- Raw data? Model dependence?
- Interference with background
- Impact of Higgs widths
- Impact of ISR, FSR, ...?
- ...

"Experimental side":
- How to extract couplings?
- Can couplings be extracted?
- Interplay of XS and BR
- ...

Problems: part II

(Allowed) interaction between theory and experiment,
between ATLAS and CMS
(different "backgrounds" of theory and experiment . . .)

All "public" results need approval from ATLAS and/or CMS . . .

Now: Solution seems to be found:
Theorists (of LHC-Higgs-XS-WG) can work with (published) ATLAS/CMS data and perform "theory analyses". :-)

2. What has been done (few)

First agreement:

> Concerning the Higgs mass:
>
> The object we have to deal with is the complex pole of the propagator.
>
> The mass is the real part of the complex pole.

Implications?

Everything so far really done deals only with M_H ...

First (simplified) overview of work:

1. Prepare an overview of "complexeties" in order to clarify where which problem arises, i.e.
   prepare a list of M_H regions with
   - relevant channels
   - relevant problems
   - irrelevant problems (i.e. possible simplifications)

2. Analyze mass definitions in MC tools:
   - which MCT are used for which M_H region/channel?
   - what is the respective M_H defintion (if any)?

3. Compile a list of "best MCT", i.e. the ones that include a proper M_H definition

4. Effects of MCT mass definitions on extraction of "correct" mass?
   - Comparison?
   - Conversion?

First (simplified) overview of work:

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Related idea: first step(s) in $\gamma\gamma$

– take $\gamma\gamma$ distributions (realistic, but fake) including errors

needed: RO, not "only" raw data

important: how are PO extracted from RO?

– perform "mass extraction" with "box detector"
(neglect for now experimental issues, "don't touch detectors")
$\rightarrow$ M_H, $\sigma(gg \rightarrow H) \times \mathrm{BR}(H \rightarrow \gamma\gamma)$ extracted from complex pole
$\rightarrow$ how/which MC tool?

– compare with real mass (definition)

– analyze effects of mass extraction, MCT, interference, etc.

So far: "TH proposal", under discussion between TH and EXP ...

If this works out, next step could be $H \rightarrow ZZ \rightarrow 4l$

3. What has to be done (a lot)

1. Prepare an overview of "complexeties" in order to clarify where which problem arises, i.e.
   prepare a list of M_H regions with → continue
   - relevant channels
   - relevant problems
   - irrelevant problems (i.e. possible simplifications)

2. Analyze mass definitions in MC tools: → check MCT
   - which MCT are used for which M_H region/channel?
   - what is the respective M_H defintion (if any)?

3. Compile a list of "best MCT", i.e. the ones that include a proper M_H definition

4. Effects of MCT mass definitions on extraction of "correct" mass?
   - Comparison? → perform comparison
   - Conversion? → determine conversion

More things to be done:

- Extend list of POs
  $\rightarrow$ more "crystal clear" definitions

- What can be extracted? How?
  $\rightarrow \Gamma \times$ BR? spin? quantum numbers?

- Prepare for more complicated scenarios?

- ...

Do we need a new MCT for PO extraction?

Problems: part III

Q: What is urgent? How to continue? Focus on 1 fb^{-1}@7 TeV?

PO contacts:
Michael Dührssen, Martin Grünewald, S.H., Giampiero Passarino

+ some more "expressed interest"

⇒ more experimentalists needed!

⇒ more theorists needed!

Q: How to exploit overlap with other groups?