Update on Higgs mass

Jan Eysermans (MIT)

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Recap Higgs Mass

Higgs mass extracted from fitting recoil distribution

$$M^2_{recoil} = (\sqrt{s} - E_{l\bar{l}})^2 - p^2_{l\bar{l}} = s - 2E_{l\bar{l}}\sqrt{s} + m^2_{l\bar{l}}$$

- Muon and electron final states
- Tight event selection (follow closely the ZH cross-section selection)
- Categorize in central and forward regions to probe different material budget
    - In total 3 categories: central, forward, central+forward
- Done at center-of-mass 240 and 365 GeV
    - Limited sensitivity at 365 due to small statistics, higher BES and ISR

Simultaneous fit over all the 12 categories (2 flavor, 3 angular categories, 2 ECM)

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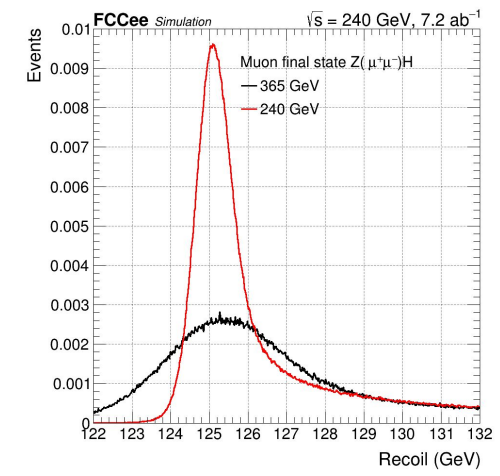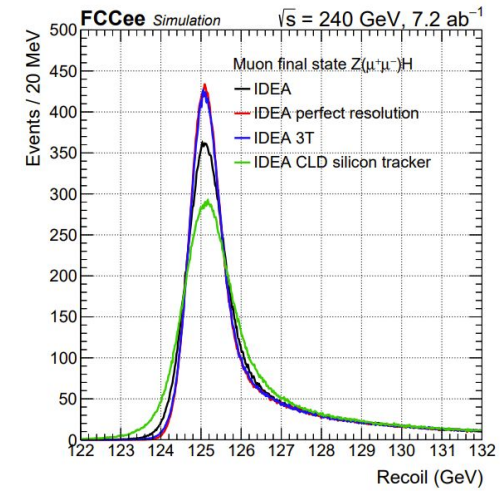
Bug found in previous mass fits

Previous mass fits are affected by a bug in the datacards used for Combine to run the fit

- Basically the background shapes were wrongly assigned when combining different results
- This lead to an underestimation of the Higgs mass uncertainty

It affected combinations only

- Categorized combinations (angular categories)
- Flavor combinations (electron+muon)
- Center-of-mass combinations

New results after fixing the bug

Comparing before and after bugfix with same integrated luminosity (7.2 ab-1) at 240 GeV

- E.g. stat. only muon channel 4.08 → 4.79 MeV (17% increase)

- Difference between nominal (categorized) and inclusive is negligible → no benefit from categorization anymore

- Potential optimization of categorization or drop it (reduce fit complexity)

Before

Final state	Muon	Electron	Combination
Nominal	4.08 (4.86)	5.15 (5.81)	3.13 (3.99)
Inclusive	4.83 (5.51)	6.15 (6.70)	3.74 (4.48)

After

Final state	Muon	Electron	Combination
Nominal	4.79(5.50)	6.06(6.68)	3.76(4.53)
Inclusive	4.83(5.51)	6.15(6.70)	3.80(4.54)

Results with updated luminosity

Using 10.8 ab-1 (240 GeV) and 3 ab-1 (365 GeV)

- **Current combined uncertainty: 3.05(3.93) MeV**

- Systematics contribute ~2.5 MeV, ecm uncertainty dominant

- Improvement by adding 365 GeV ~ 1%

Stat. Only

Stat.+Syst.
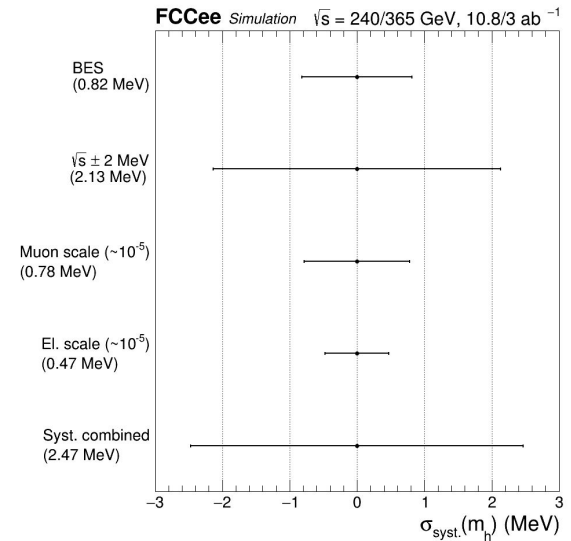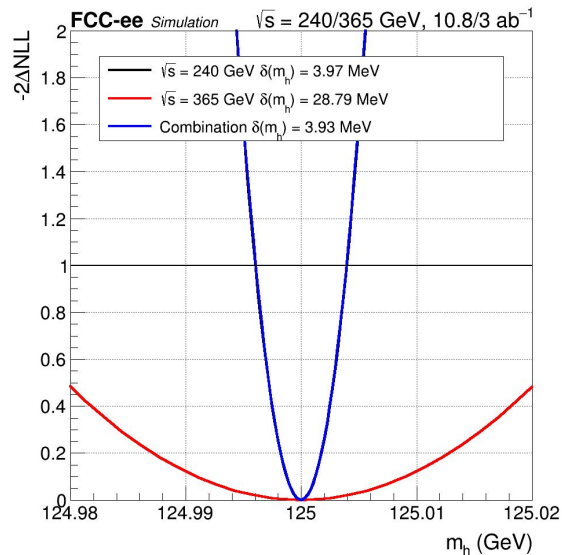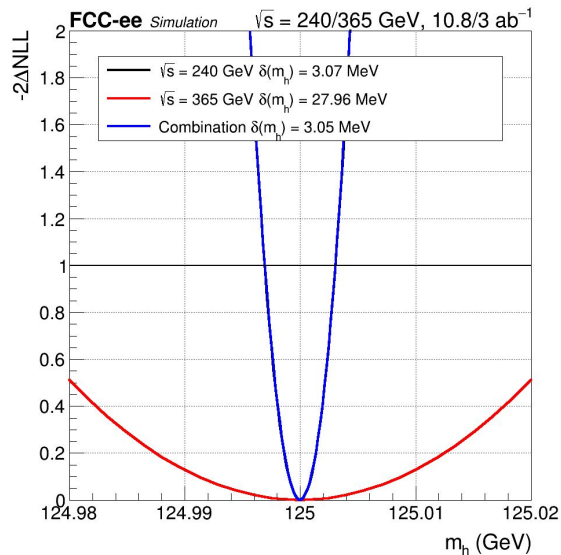
Detector configurations

Only for at 240 GeV, 10.8 ab-1

Numbers could still slightly change due to fit optimizations

Nominal configuration

Crystal ECAL to Dual Readout

Nominal 2 T → field 3 T

IDEA drift chamber → CLD Si tracker

Impact of Beam Energy Spread

Perfect (=gen-level) momentum resolution

Final state	Muon	Electron	Combination
Nominal	3.92(4.74)	4.95(5.68)	3.07(3.97)
Inclusive	3.92(4.74)	4.95(5.68)	3.10(3.97)
Degradation electron resolution	3.92(4.74)	5.79(6.33)	3.24(4.12)
Magnetic field 3T	3.22(4.14)	4.11(4.83)	2.54(3.52)
Silicon tracker	5.11(5.73)	5.89(6.42)	3.86(4.55)
BES 6% uncertainty	3.92(4.79)	4.95(5.92)	3.07(3.98)
Disable BES	2.11(3.31)	2.93(3.88)	1.71(2.92)
Ideal resolution	3.12(3.95)	3.58(4.52)	2.42(3.40)
Freeze backgrounds	3.91(4.74)	4.95(5.67)	3.07(3.96)
Remove backgrounds	3.08(4.13)	3.51(4.58)	2.31(3.45)