Higgs Pseudo-Observables & Second Riemann Sheet

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SM and BSM physics at the LHC

Based on work done in collaboration with
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Outlines

(1, 2,)

1. *From the analytical structure of NLO - NNLO*
2. *to Higgs pseudo - observables,*

what else, but the inevitable!

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Motivations

experiments

extract so-called **realistic observables** from raw data, e.g. $\sigma(pp \to \gamma\gamma + X)$ and need to present results in a form that can be useful for comparing with theoretical predictions, i.e. the results should be transformed into **pseudo-observables**;

theorists

compute pseudo-observables using the best available technology and satisfying a list of demands from the **self-consistency** of the underlying theory.

Setup

The Higgs boson

as well as the W or Z bosons, are unstable particles; as such they should be removed from in/out bases in the Hilbert space

$$S_{fi} \quad = \quad V_i(s)\,\Delta_H(s)\,V_f(s) + B_{if}(s),$$

where V_i is the **production vertex** $i \to H$ (e.g. $gg \to H$), V_f is the **decay vertex** $H \to f$ (e.g. $H \to \gamma\gamma$), Δ_H is the **Dyson re-summed Higgs propagator** and B_{if} is the **non - resonant background** (e.g. $gg \to \gamma\gamma$ boxes).

Complex pole

Example

$$S_{fi} \;=\; \left[Z_H^{-1/2}(s)\,V_i(s)\right]\frac{1}{s - s_H}\left[Z_H^{-1/2}(s)\,V_f(s)\right] + B_{if}(s).$$

$S \to$ PO

From the S-matrix element for a physical process $i \to f$ we extract the relevant pseudo - observable,

$$S\,(H_c \to f) \;=\; Z_H^{-1/2}(s_H)\,V_f(s_H),$$

PO

which is gauge parameter independent – by construction – and satisfies the relation

$$S_{fi} = \frac{S(i \to H_c)\, S(H_c \to f)}{s - s_H} + \text{non resonant terms.}$$

The **partial decay width** is further defined as

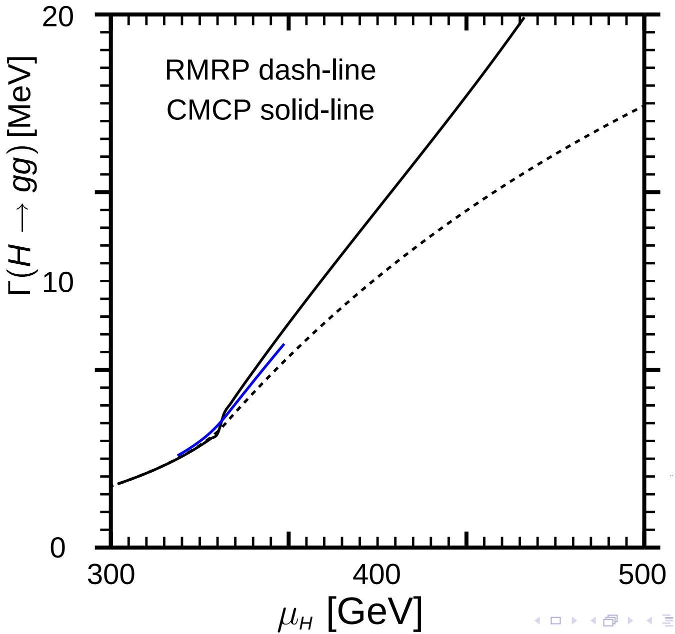
$$\Gamma(H_c \to f) = \int d\Phi_f \sum_{\text{spins}} \left| S(H_c \to f) \right|^2 ,$$

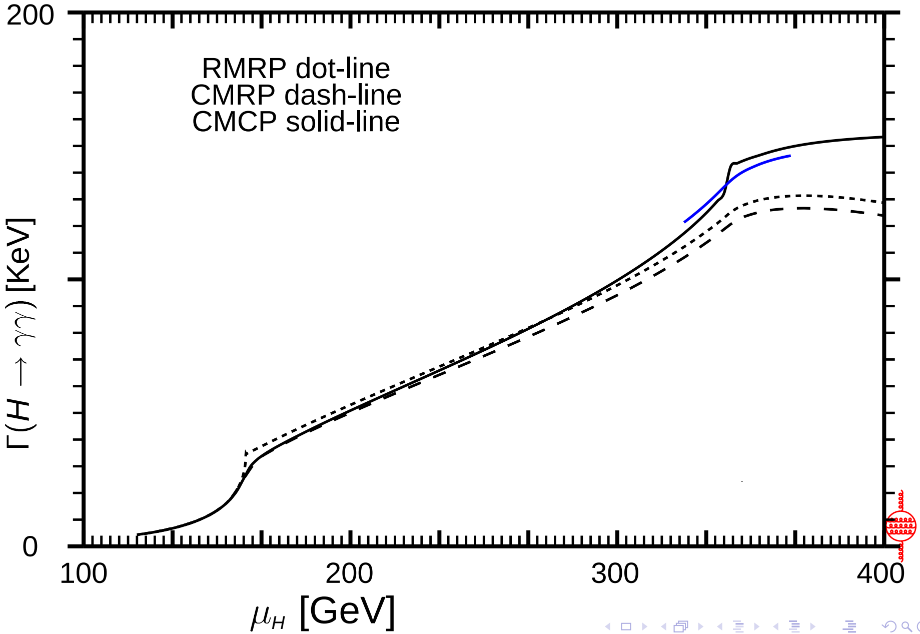
where the integration is over the phase space spanned by $|f>$, with the constraint $P_H = \sum p_f$.

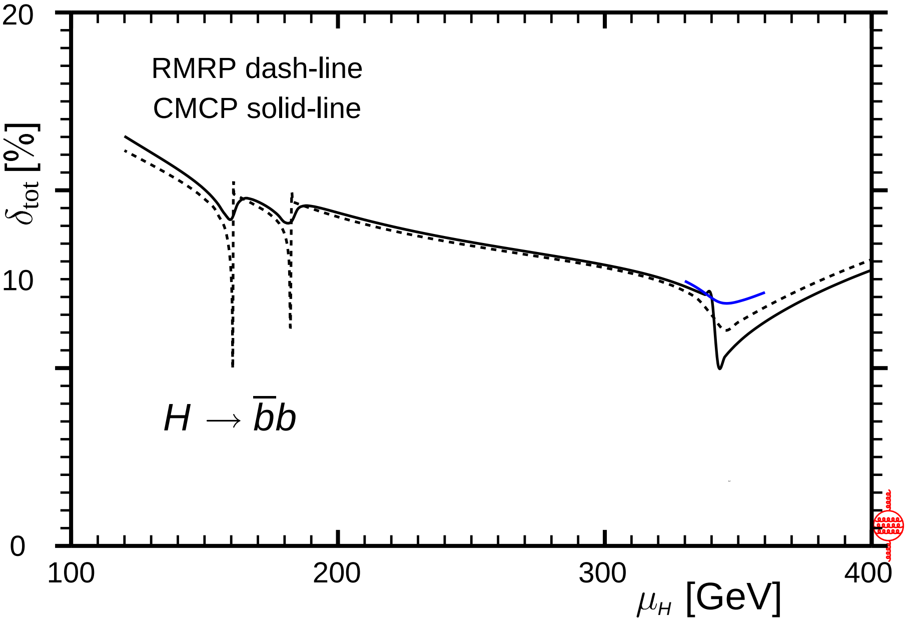
Schemes

Schemes

- **RMRP** scheme, the usual on-shell scheme; all masses and all Mandelstam invariants are real;
- **CMRP** scheme, the complex mass scheme with complex internal W and Z poles but with a real, external, on-shell Higgs with standard LSZ wave-function renormalization;
- **CMCP** scheme, the (complete) complex mass scheme with complex, external, Higgs where the LSZ procedure is carried out at the Higgs complex pole (on the second Riemann sheet).


RMRP dash-line
CMCP solid-line
20
10
0
300
400
500
Γ(H → gg) [MeV]
μ_H [GeV]


200
0
RMRP dot-line
CMRP dash-line
CMCP solid-line
$\Gamma(H \to \gamma\gamma)$ [KeV]
100
200
300
400
μ_H [GeV]


RMRP dash-line
CMCP solid-line
$H \to \overline{b}b$
δ_{tot} [%]
μ_H [GeV]
20
10
0
100
200
300
400