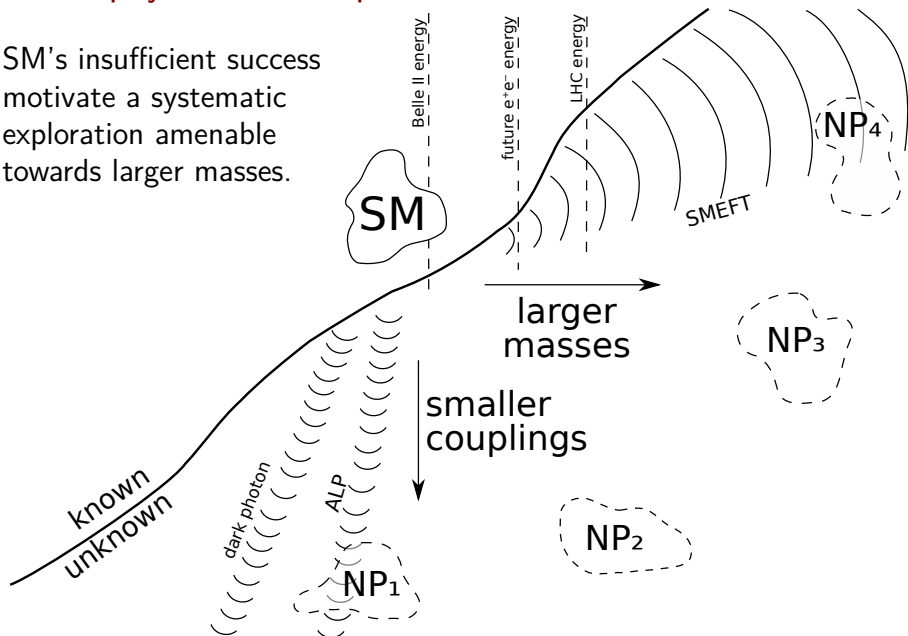# SMEFT status

Gauthier Durieux
(CERN)

few references given as entry points to the literature
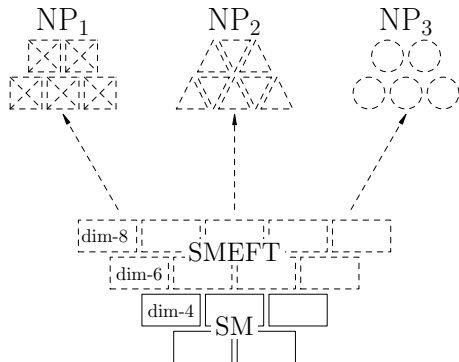
Particle physics' landscape

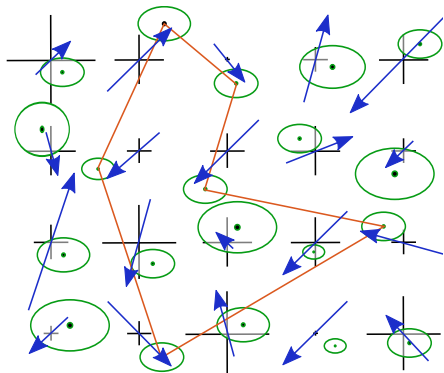SM's insufficient success motivate a systematic exploration amenable towards larger masses.

Taking the SM to higher dimensions

- · using established bricks (fields and symmetries)

- · extension organised by relevance (dimension)

- · including all deformations (theory space coverage)

Isolating patterns of new physics

array of sensitive observables

· precise SM-EFT predictions

· precise measurements

→ correlate deviations

SMEFT status

1. Improved sensitivity   (powerful observables, multidimensionally)

2. Global picture   (parameterisation, sector combinations, fits)

3. Precise interpretation   (higher-order SM/EFT corrections)

4. Models' connection   (charting, matching, positiving, bootstraping)

5. New techniques & understanding   (amplitudes, geometry)

1. Improved sensitivity

· matrix element method defines the theoretical optimal

· ML for invisible PS integration, shower, hadronisation, detector

· multidimensionality curse   [Atwood, Soni '92]   [Diehl, Nachtmann '94]
                                 [Gomez Ambrosio, ter Hoeve, Madigan, Rojo, Sanz '22]

· importance of reweighting   [EFT WG studies: 28 June, 24 May, 6 April]
    negative NLO weights   [Kraus, Martini, Uwer '19]

· ease, understanding, and control

· first non-trivial experimental use of ML for SMEFT   [CMS '21]

2. Global picture

Fitmaker EWPO+diboson+Higgs+top, linear

[Ellis, Madigan, Mimasu, Sanz, You '20]

SMEFiT diboson+Higgs+top, some NLO QCD,

[Ethier, Magni, Maltoni, Mantani, Nocera, Rojo, Slade, Vryonidou, Zhang '21]

HEPfit EWPO, flavour, future

[de Blas, Pierini, Reina, Silvestrini '22]

EFTfitter top+B+EWPO, 14 op

[Grunwald, Hiller, Kröninger, Nollen '23]

SFitter EWPO+diboson diff.+Higgs, top+B

[Brivio, Bruggisser, Elmer, Geoffray, Luchmann, Plehn '22]

OptEx EWPO+diboson diff.+Higgs+diHiggs, 23 op, no 4f, linear

[Anisha, Das, Banerjee, Biekötter, Chakrabortty, Patra, Spannowsky '21]

Flavio B+Drell-Yan+EWPO

[Greljo, Salko, Smolkovi, Stangl '22]

HighPT B+Dell-Yan

[Allwicher, Faroughy, Jaffredo, Sumensari, Wilsch '22]

[see the more comprehensive table by Anke Biekötter]

2. Global picture

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HEPfit   EWPO, flavour, future

more observables
less restrictive flavour assumptions
better predictions
facilitated interpretations

$\longrightarrow$ build LHC legacy

[de Blas, Pierini, Reina, Silvestrini '22]

EFTfitter   top+B+EWPO, 14 op.

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[see the more comprehensive table by Anke Biekötter]

- shared predictions: validated, consistent, state-of-the-art

  [H+EFT WG studies]

- cross-validation of fitting machineries

- uncertainties on EFT parameterisation   [Altmannshofer, Stangl '21]

- EFT in backgrounds (signal $\to$ signature)   [CMS b+leptons '20, '23]

  [ATLAS four-lepton '21]

- joint EFT+PDF fits   [Gao, Gao, Hobbs, Liu, Shen '22]

  [Kassabov, Madigan, Mantani, Moore, Morales Alvarado, Rojo, Ubiali '23]

3. Precise interpretation

- $pp \to jj$ ($q\bar{q}q\bar{q}$)   [Gao, Li, Wang, Zhu, Yuan '11]
- $pp \to t\bar{t}$ ($q\bar{q}t\bar{t}$)   [Shao, Li, Wang, Gao, Zhang, Zhu '11]
- $pp \to VV$ [Dixon, Kunszt, Signer '99] [Melia, Nason, Röntsch, Zanderighi '11]
  [Baglio, Dawson, Homiller, Lane, Lewis '17, '18, '19, '20] [Chiesa, Denner, Lang '18]

- EWPO (top)   [Zhang, Greiner, Willenbrock '12]
- top decays   [Zhang '14] [Boughezal, Chen, Petriello, Wiegand '19]
- top FCNCs   UFO   [Degrande, Maltoni, Wang, Zhang '14] [GD, Maltoni, Zhang '14]
- $pp \to t\bar{t}$ (chromo-dipole)   [Franzosi '15]
- $h \to \gamma\gamma$, VV, γZ [Hartmann, Trott '15] [Ghezzi, Gomez-Ambrosio, Passarino, Uccirati '15] [Dawson, Giardino '18]
  [Dedes, Paraskevas, Rosiek, Suxho, Trifyllis '18] [Dawson, Giardino '18] [Dedes, Suxho, Trifyllis '19]

- $h \to f\bar{f}$ [Biekötter, Cullen, Gauld, Pecjak, Scott, Smith '15, '16 '19, '20, '23]
- $pp \to tj$ [Zhang '16] [de Beurs, Laenen, Vreeswijk, Vryonidou '18]
- $pp \to t\bar{t}Z$, $gg \to ZH$ [Röntsch, Markus Schulze '14] [Bylund, Maltoni, Vryonidou, Zhang '16]
- $pp \to t\bar{t}H$, $gg \to Hj$, HH [Maltoni, Vryonidou, Zhang '16]
- $pp \to HV$ [Degrande, Fuks, Mawatari, Mimasu, Sanz '16] [Alioli, Dekens, Girard, Mereghetti '18]
- Z, W poles   [Hartmann, Shepherd, Trott '16] [Bellafronte, Dawson, Ismail, Giardino '18, '18, '19, '22, '23]
                                                                          [Biekötter, Pecjak, Scott, Smith '23]

- $pp \to h$ [Grazzini, Ilnicka, Spira, Wiesemann '16] [Deutschmann, Duhr, Maltoni, Vryonidou '17]
- $pp \to tjZ$, tjh [Degrande, Maltoni, Mimasu, Vryonidou, Zhang '18]
- $pp \to$ jets (triple gluon)   UFO   [Hirshi, Maltoni, Tsinikos, Vryonidou '18]
- Higgs self-coupling   [McCullough '13] [Gorbahn, Haisch '16] [Degrassi et al. '16, '17] [Bizon et al. '16] [Kribs et al. '16]
  [Maltoni, Pagani, Shivaji, Zhao '17] [Di Vita, GD, Grojean, Gu, Liu, Panico, Riembau, Vantalon '17]

- EW Higgs & WW (top)   [Vryonidou, Zhang '18] [GD, Gu, Vryonidou, Zhang '18] [Boselli, Hunter, Mitov '18]
- EW $pp \to t\bar{t}$ (ttZ,tth)   [Martini, Schulze '19] [Martini, Pan, Schulze, Xiao '21]
- all QCD and four-quarks   UFO   [Degrande, GD, Maltoni, Mimasu, Vryonidou, Zhang '20]
- EW $pp \to \ell^+\ell^-$ [Dawson, Giardino '21, '22]
- EW $QQQQ$ in $gg \to h$, $h \to bb$, $pp \to tth$ [Alasfar, de Blas, Gröber '22]
- NNLO $pp \to Zh \to \ell^+\ell^- b\bar{b}$ [Haisch, Scott, Wiesemann, Zanderighi, Zanoli '22]
- NNLO VBF   [Asteriadis, Caola, Melnikov, Röntsch '22]

· deploy NLO QCD, systematise NLO EW + their pheno

· gain accuracy+precision, new sensitivities+degeneracies

· account for RG running, go beyond one-loop

[Aoude, Maltoni, Mattelaer, Severi, Vryonidou '22]
[Bern, Parra-Martinez, Sawyer '20]

· explore dim>6, benchmark dim-6 truncation validity

[Ellis, Mimasu, Zampedri '23]
[Degrande, Li '23]
[Heinrich, Lang '22]

4. Models' connexion

- charting

  EFT space populated by models [GD, McCullough, Salvioni '22]

- matching [LHC EFT WG note '22]
  - CoDEx (func) [Bakshi, Chakrabortty, Patra '18]
  - Matchmakereft (diag) [Carmona, Lazopoulos, Olgoso, Santiago '21]
  - Matchete (func) [Fuentes-Martín, König, Pagès, Thomsen, Wilsch '22]
      - evanescent op [Fuentes-Martín, König, Pagès, Thomsen, Wilsch '22]

  - specific models [Dawson, Fontes, Quezada-Calonge, Sanz-Cillero '23]
  [Banta, Cohen, Craig, Lu, Sutherland '23]

- positiving and bootstraping [Riembau '22] [Miro, Guerrieri, Gumus '22]
  - BSM starts at dim-8
  - pheno starts at dim-8 [Bellazzini, Riva '18] [Gu, Wang, Zhang '20]
  - sum rules apply at dim-6 [Remmen, Rodd '22]

5. New techniques & understanding

· on-shell anomalous dimensions and selection rules

[Cheung, Shen '15], [Azatov et al. '16], [Bern et al. '19, '20][Jiang et al. '20], [Elias Miró et al. '20, '21], [Baratella et al. '20, '20, '21][Accettulli Huber, De Angelis '21], [Delle Rose et al. '22], [Baratella '22] [Machado, Renner, Sutherland '22], [Chala '23]

· on-shell operator enumeration

[Shadmi, Weiss '18], [Ma, Shu, Xiao '19], [Falkowski '19], [GD, Machado '19] [Li, Ren, et al. '20, '20], [Harlander, Kempkens, Schaaf '23]

· Hilbert series

[Kondo, Murayama, Okabe '22] [Sun, Wang, Yu '22] [Gráf, Henning, Lu, Melia, Murayama '22]

· on-shell EFT amplitude construction

[Aoude, Machado '19], [GD, Kitahara, Shadmi, Weiss '19], [GD et al. '20] [Balkin et al. '21], [Dong, Ma, Shu, Zheng '21, '22], [De Angelis '22] [Bradshaw, Chang, Chen, Liu, Luty '22, '23], [Liu, Ma, Shadmi, Waterbury '23]

· on-shell matching

[Delle Rose, von Harling, Pomarol '22] [De Angelis, GD 'xx]

· field geometry

[Corbett, Martin '23] [Martin, Trott '23] [Craig, Lee, Lu, Sutherland '23] [Helset, Jenkins, Manohar '22] [Brivio, Davighi, Alminawi 'xx]

· double copy

[Bonnefoy, GD, Grojean, Machado, Roosmale Nepveu '21]

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