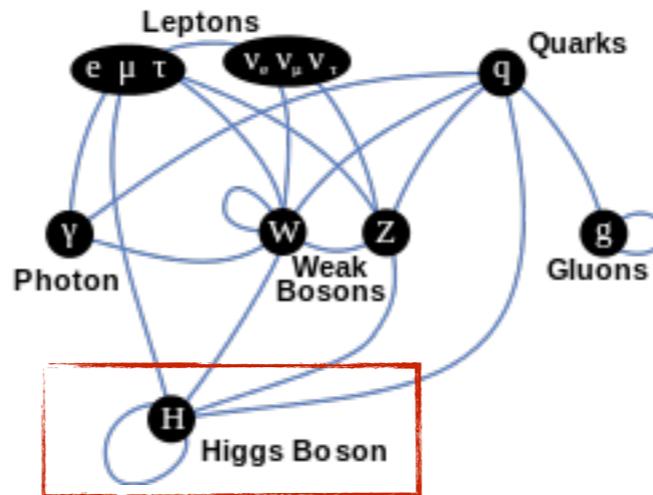


LHC Higgs X-section working Group 2 (Higgs properties)

CERN 14.7.2017



Mingshui Chen, Chris Hays, David Marzocca, Francesco Riva

Organization of the WG2

<https://twiki.cern.ch/twiki/bin/view/LHCPhysics/LHCHXSWG2>

Conveners: Mingshui Chen (CMS), Chris Hays (ATLAS)
David Marzocca (th), Francesco Riva (th)

Fid.XS/STXS subgroup. Conveners: Nicolas Berger (ATLAS),
Pedrag Milanovic (CMS)
Frank Tackman (th),

Activities

- Fid.XS, diff.XS
- STXS
- PO
- EFT
- Top physics

Goals

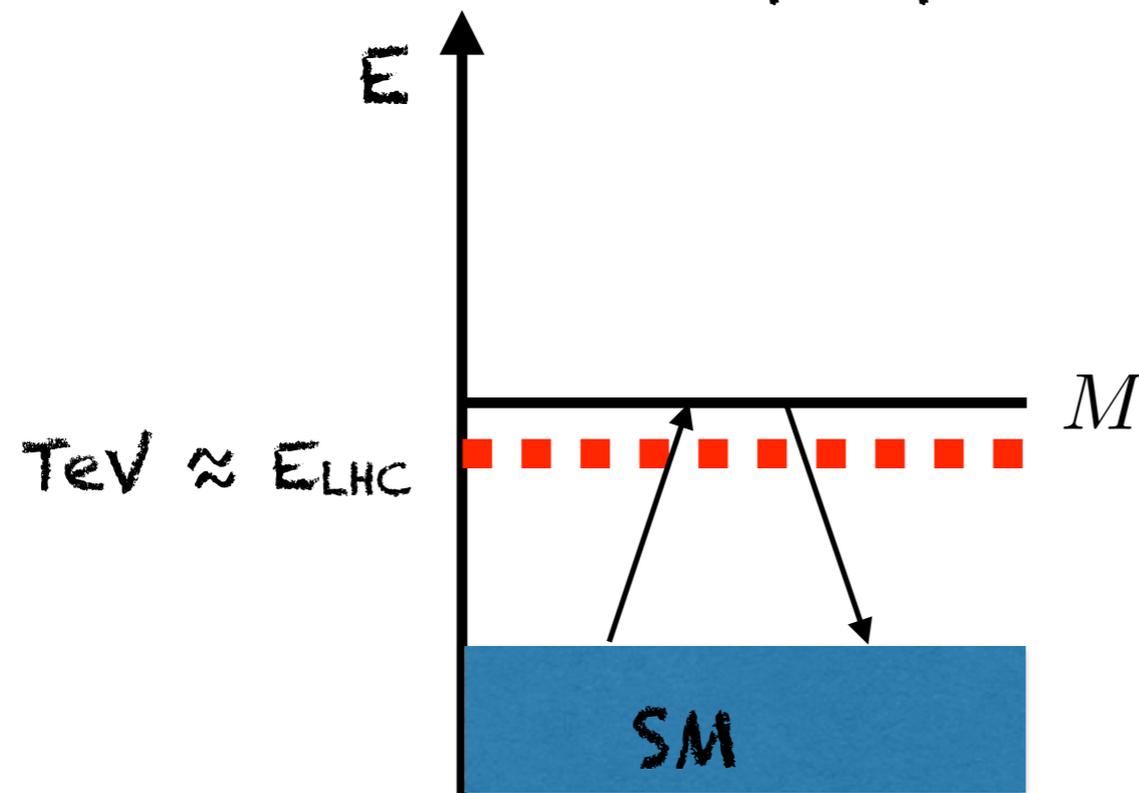
- Foster theory-experiment discussions/ collaborations (bring experts closer)
- Development of explicit tools and strategies for Higgs analyses (e.g. STXS, EFT validity, POs...)
- Work towards a Global Fit for Higgs and Electroweak physics
- Design of benchmark scenarios interesting for interpretation

Higgs Properties

Measurements of Higgs properties priority of LHC

Higgs Properties

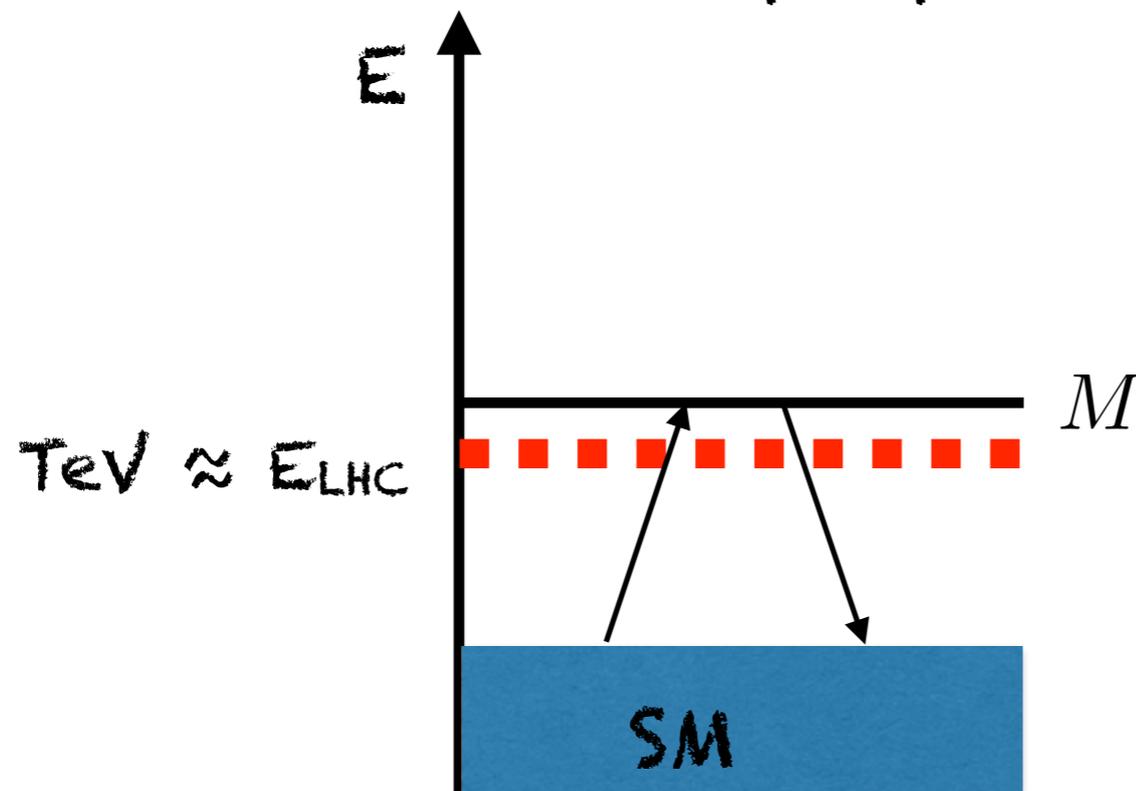
Measurements of Higgs properties priority of LHC



- Heavy **BSM physics** can modify **SM processes** properties
- **TeV** new physics in Higgs sector particularly motivated

Higgs Properties

Measurements of Higgs properties priority of LHC



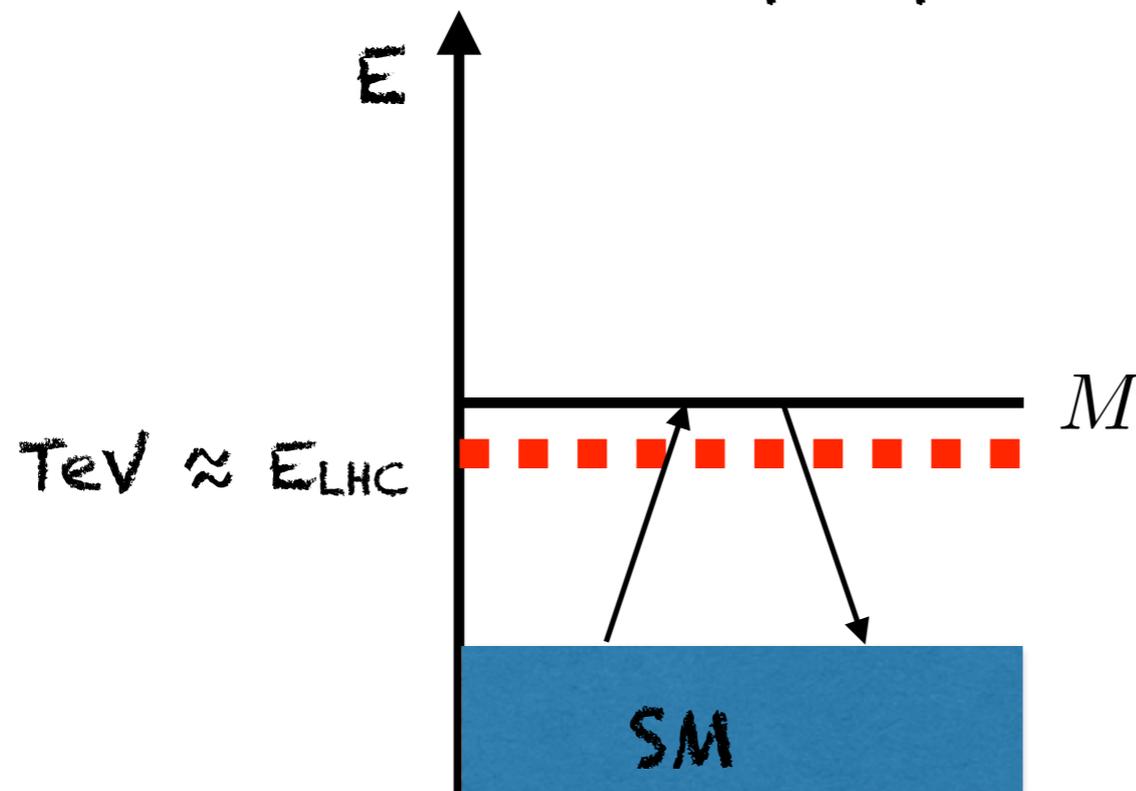
Effective Theories

- Heavy **BSM physics** can modify **SM processes** properties
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- # Relevant effects at $E \ll M \ll \#$ BSM models

Measurements of Higgs properties allow for
model-independent BSM searches

Higgs Properties

Measurements of Higgs properties priority of LHC



Effective Theories

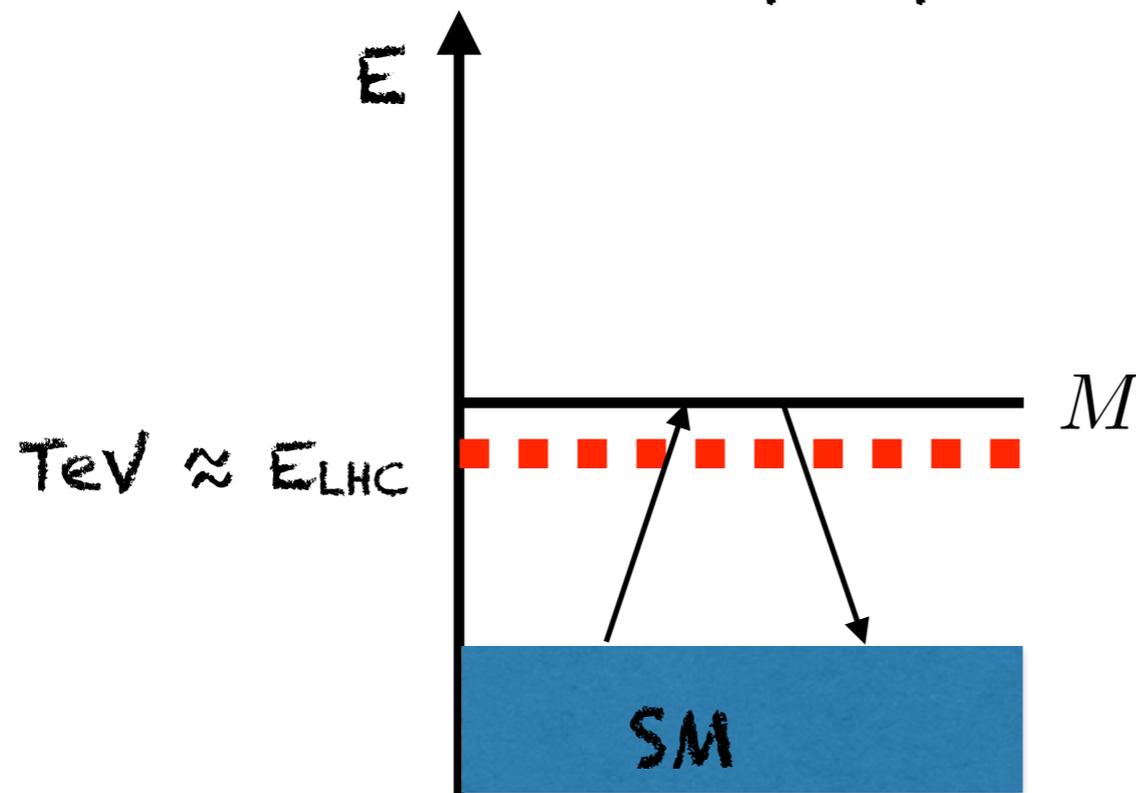
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... maybe

Higgs Properties

Measurements of Higgs properties priority of LHC



Effective Theories

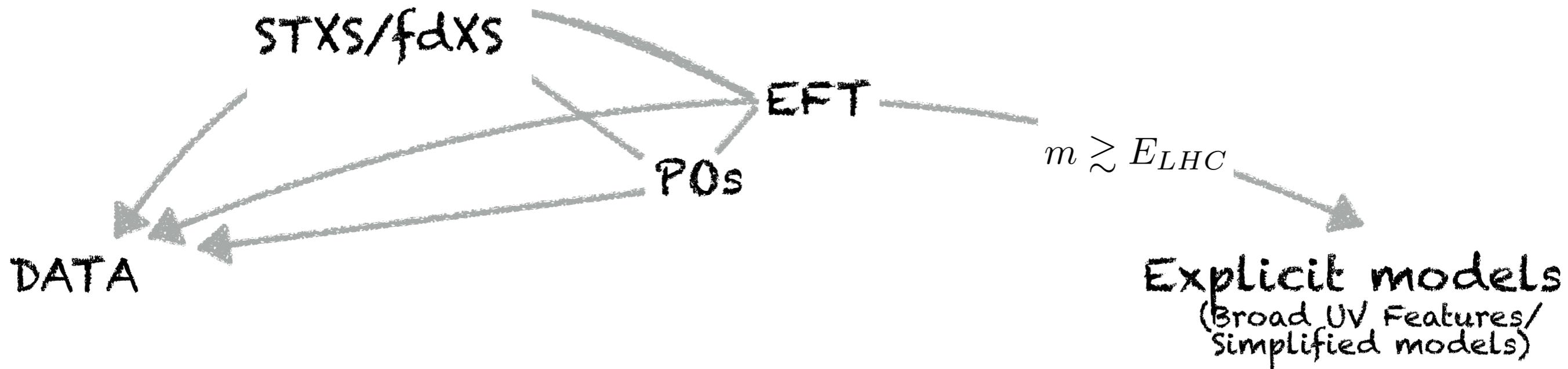
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- # Relevant effects at $E \ll M \ll$ # BSM models

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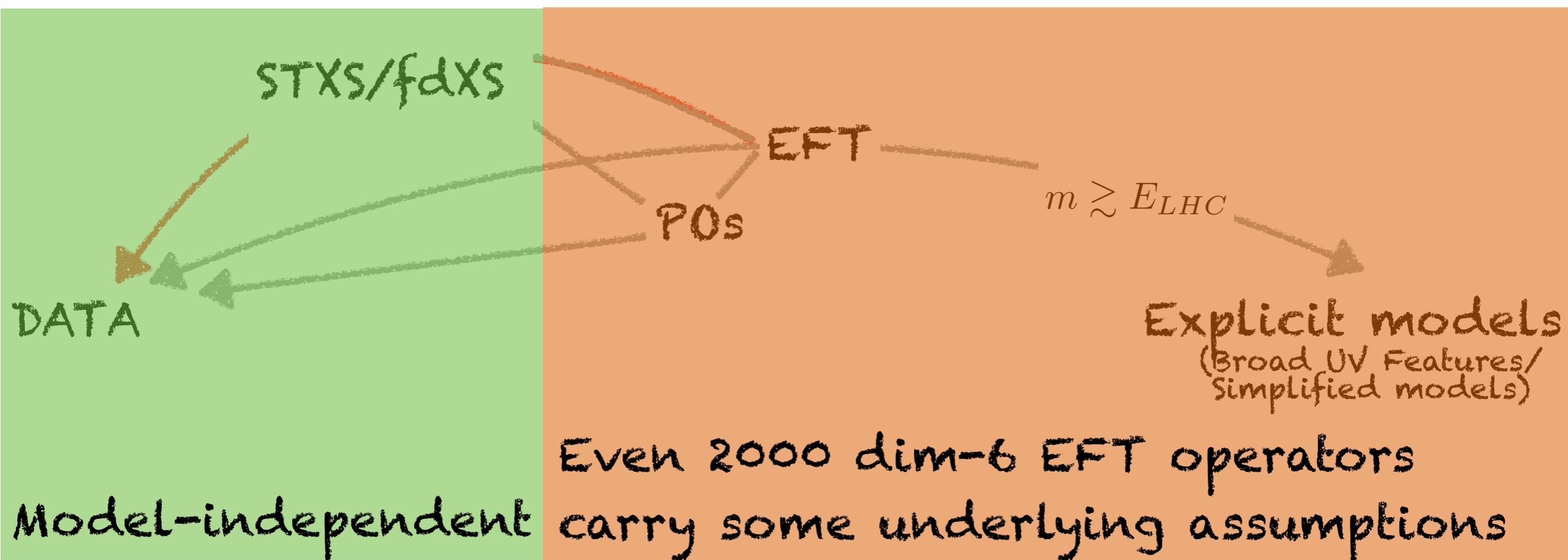
Workflow, from experiment to models

- Target:**
- keep relevant experiment info (for now and future)
 - maximize sensitivity to BSM

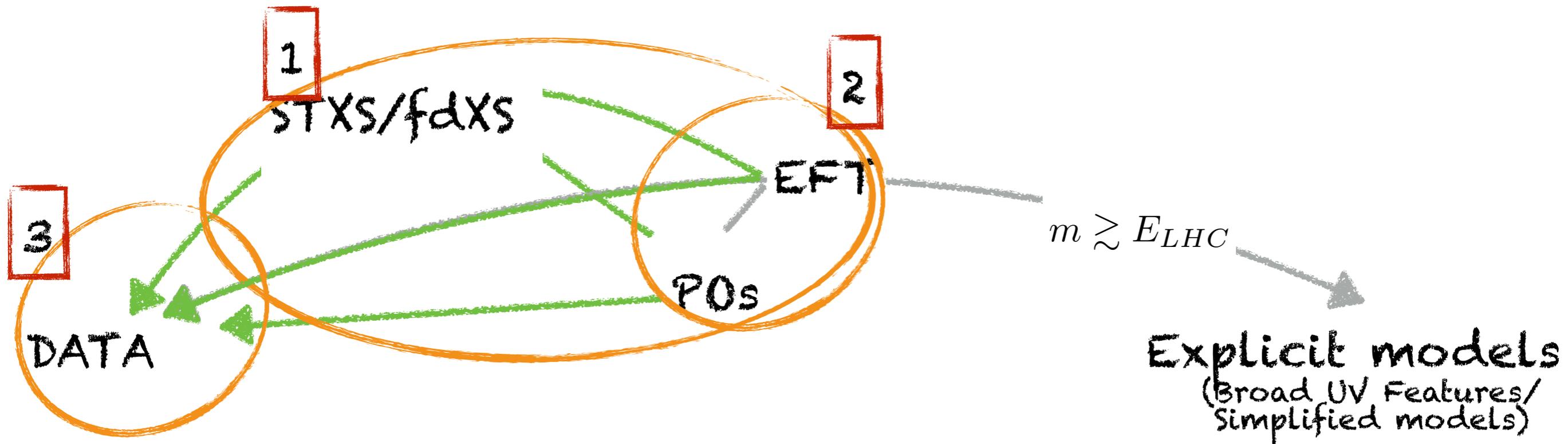


Workflow, from experiment to models

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Objectives



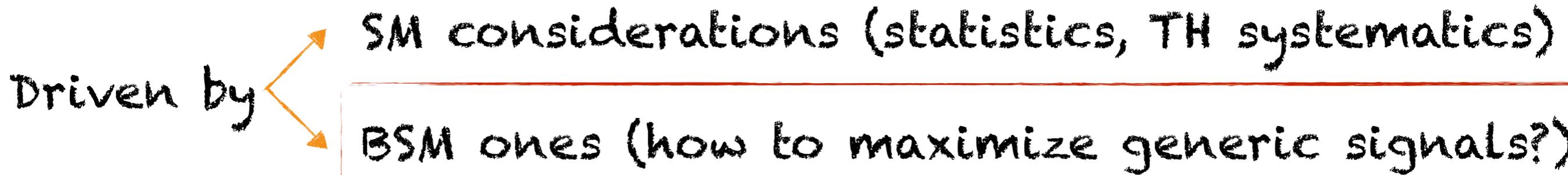
1 EFTs/POs and STXS/fdXS

2 Well-defined interpretation schemes (benchmarks)

3 Extension to Electroweak data

3 documents

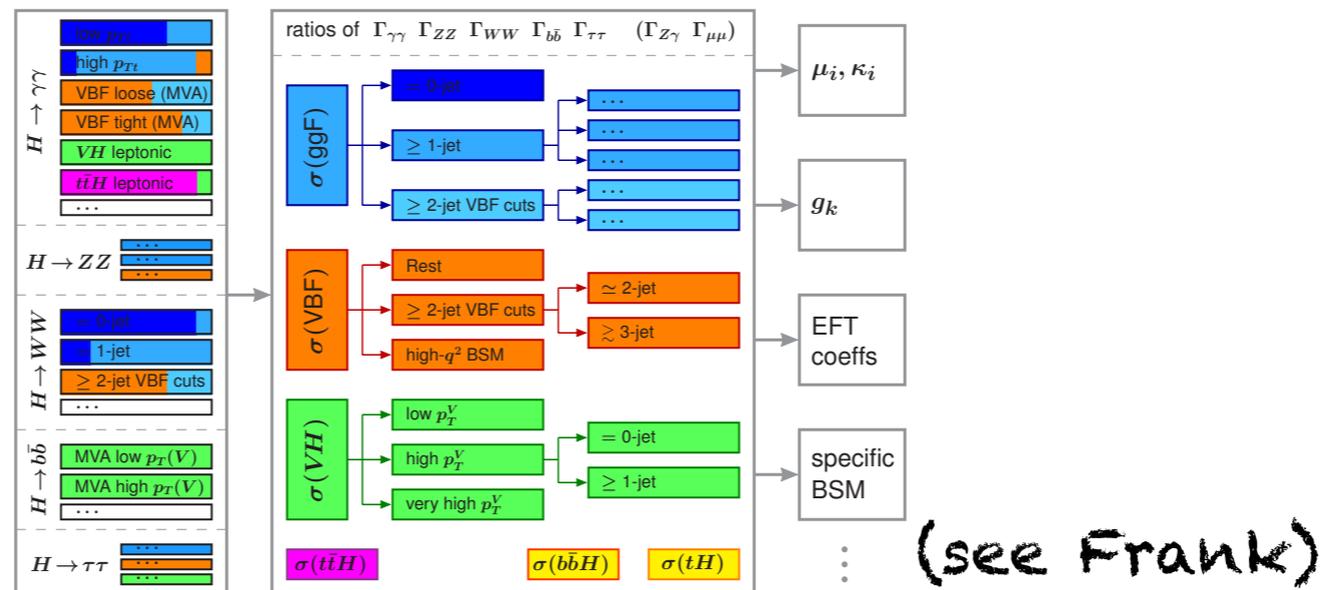
Recommendations on data presentation



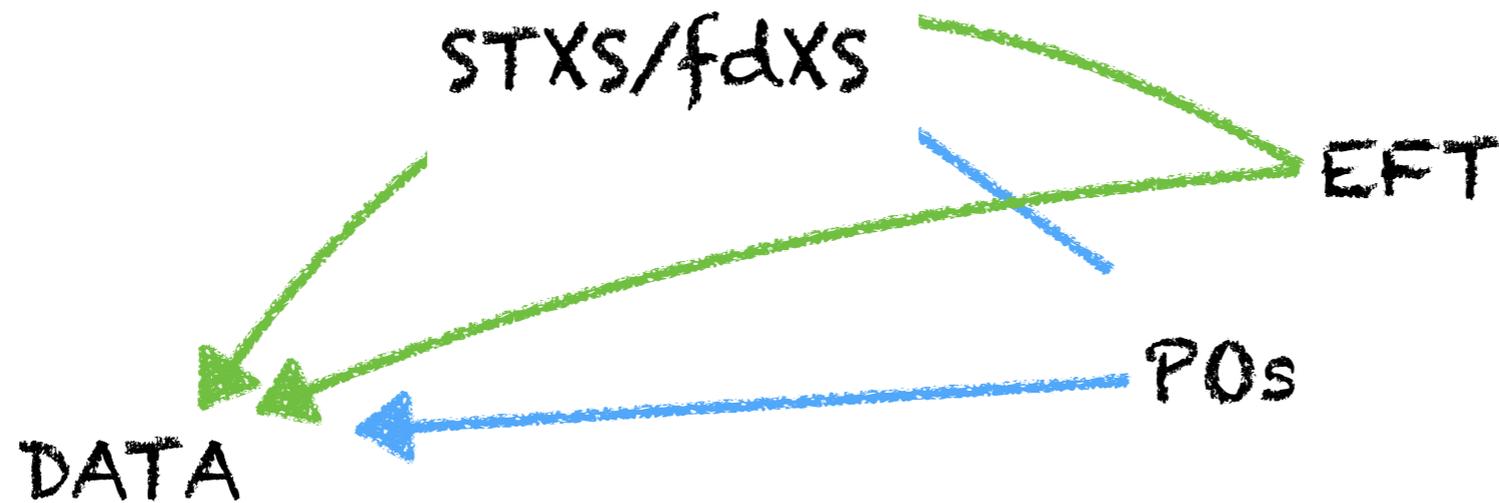
Simple situations: fiducial/differential Xsections (fXS)

Complex situations: Simplified Template Xsections (STXS)

Mutually exclusive bins/separate production modes



1 BSM (EFT/PO) Input to STXS for stage 2



Comparison of Data \rightarrow STXS \rightarrow EFT/PO vs Data \rightarrow EFT/PO

Ongoing Les Houches project:
<https://phystev.cnrs.fr/wiki/2017:groups:np:stxsveeft>

- \rightarrow Optimize binning for BSM
- \rightarrow Identify cases that require dedicated studies (see benchmarks later)

1 BSM (EFT/PO) Input to STXS for stage 2

Prepare tools for STXS \rightarrow EFT/PO fit

\rightarrow Equations $N_{STXS} = SM + \#_1 c_{BSM} + \#_2 c_{BSM}^2$

$H \rightarrow 4\ell$	$52c_{2W} + 14c_B + 15c_{HW}$ $-4.4c_{HB} + 10(c_{Hl} + c_{\tilde{H}l})$	$230c_{2W}c_{HW} + 220c_{2W}(c_{Hl} + c_{\tilde{H}l})$ $+210c_{2W}c_B$
-----------------------	-----------------------------------------------------------------------------	---------------------------------------------------------------------------

Ongoing: Hays, Zemaityte, ...

\rightarrow Tools for EFT in NLO MC

Ongoing: Degrande, Maltoni, Mimasu, Zhang, Vryonidou
See Mimasu talk at WG2 kickoff meeting:
<https://indico.cern.ch/event/632454/>

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Prepare tools for STXS → EFT/PO fit

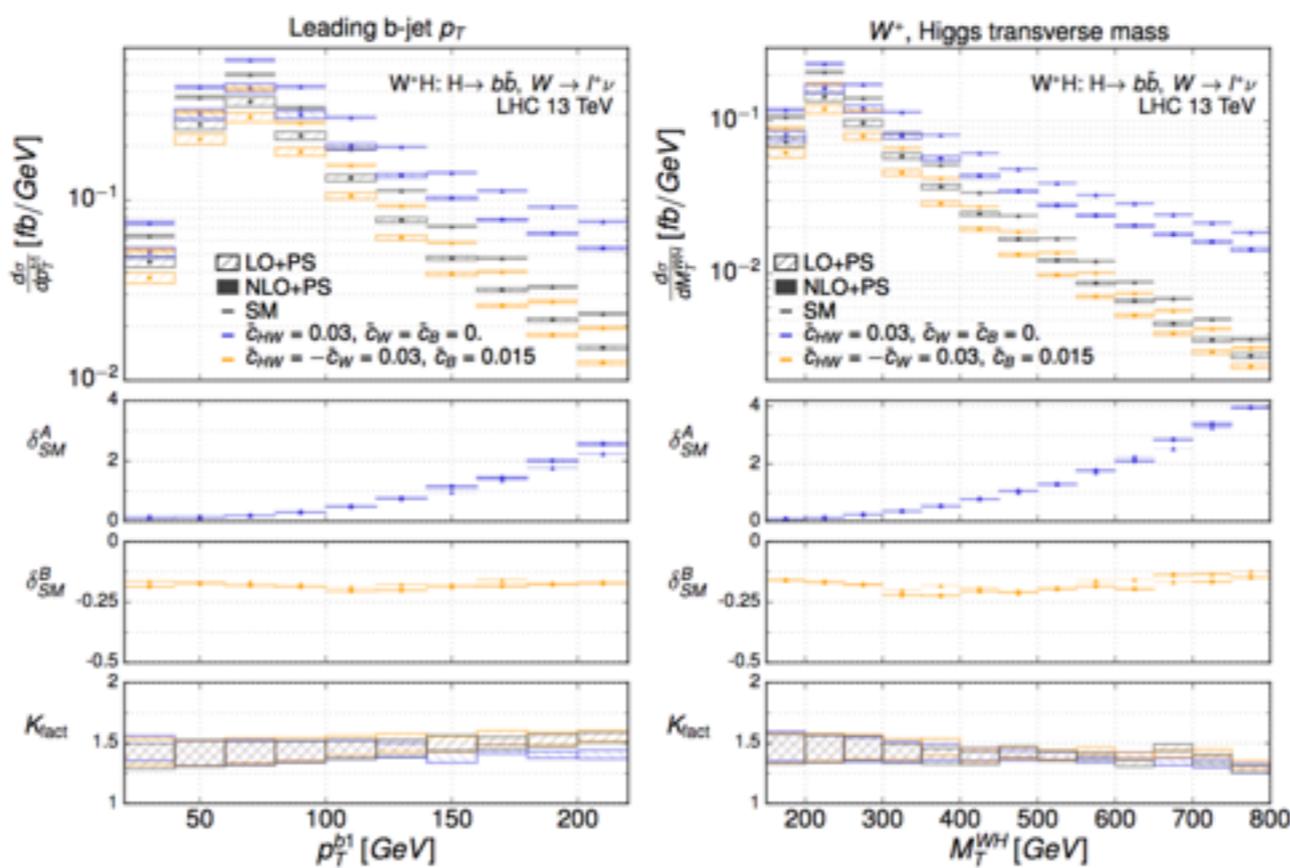
→ Equal

$H \rightarrow$

→ Tools

$$pp \rightarrow W^+ H \rightarrow l^+ \nu bb$$

Large effects: benchmark **B**) does not exhibit strong “EFT” features
 The $g_{h\nu\nu}^{(2)}$ Lorentz structure is responsible for these



Benchmarks saturating current limits from a fit to Run 1 data

$c_{\tilde{H}l}$

ν, Z emaityte,...

hang, Vryonidou
 ckoff meeting:
 event/632454/

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\rightarrow Tools for PO at NLO

Latest PO development: NLO in QCD

HiggsPO code can be found at <http://www.physik.uzh.ch/data/HiggsPO/>

Allows to simulate EW Higgs production (VH, VBF) in the PO formalism @ NLO in QCD.

Higgs PO

DESCRIPTION	DOWNLOAD	CONTACTS
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Example: Zh at NLO

Download the model

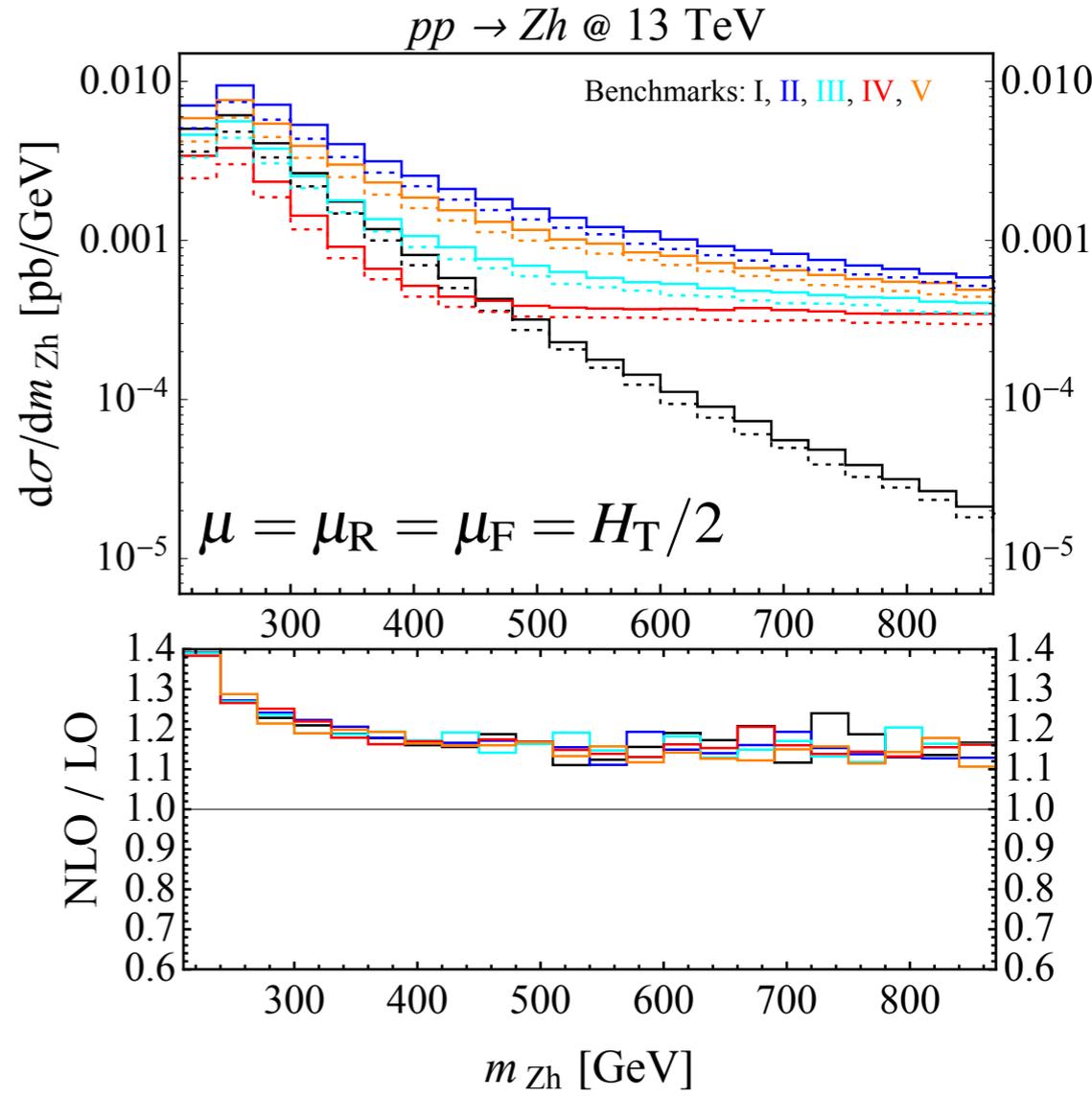
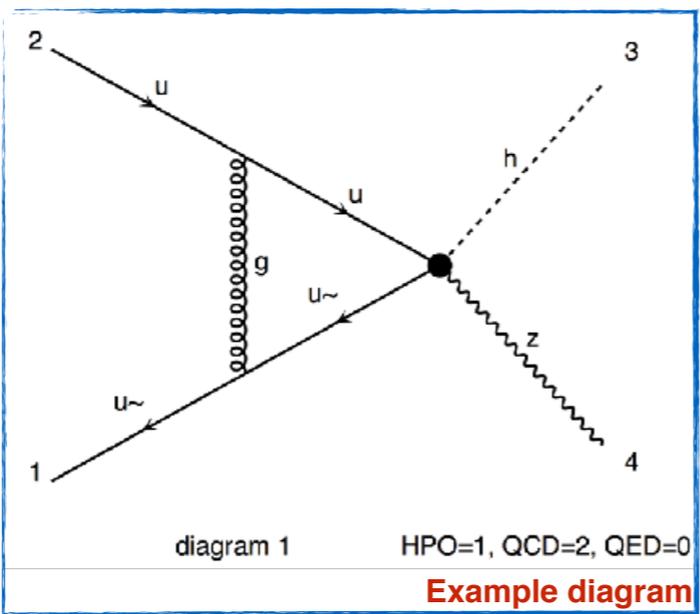
Version 1.2 - NEW

HiggsPO UFO model for electroweak Higgs production at NLO in QCD.

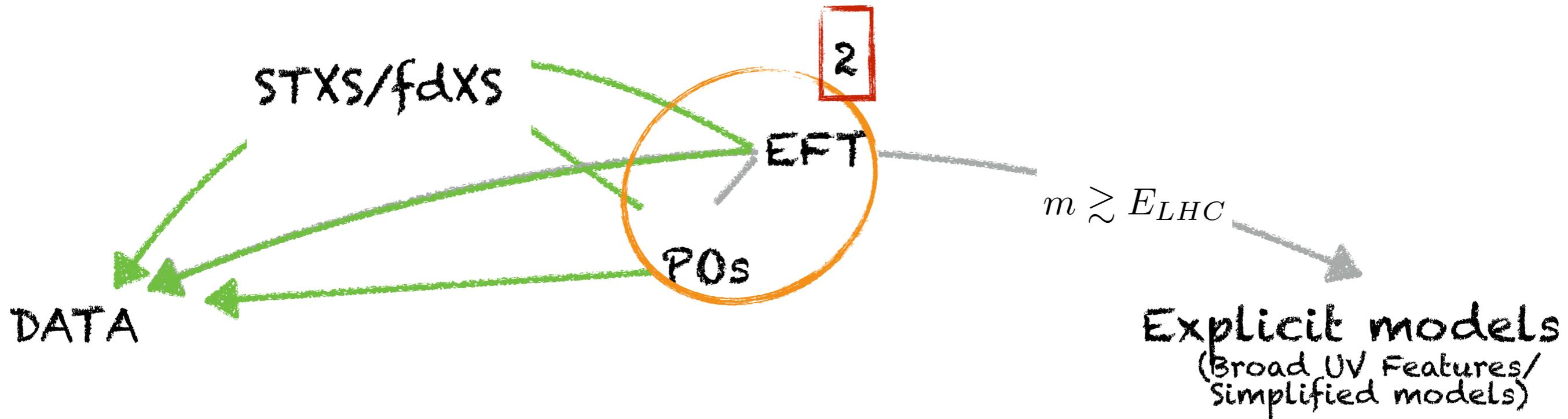
- UFO model: [HPO_ewk_prod_NLO](#) (zip)
- Presentation and examples (slides from the LHC HXSWG meeting of May 8th, 2017): [link](#)

For info and examples see A. Greljo [talk](#) at WG2 kickoff meeting.

Paper coming soon.



Objectives



2 Well-defined interpretation schemes (benchmarks)

2

Well-defined interpretation schemes (benchmarks)

Provide a limited number of interpretation frameworks to complement STXS/fXS in LHC analyses

Motivated by  BSM
Extracting more info from data than STXS

→ POs: all available info (up to $O(p^2)$) in $h \rightarrow 4f$

Well-defined interpretation schemes

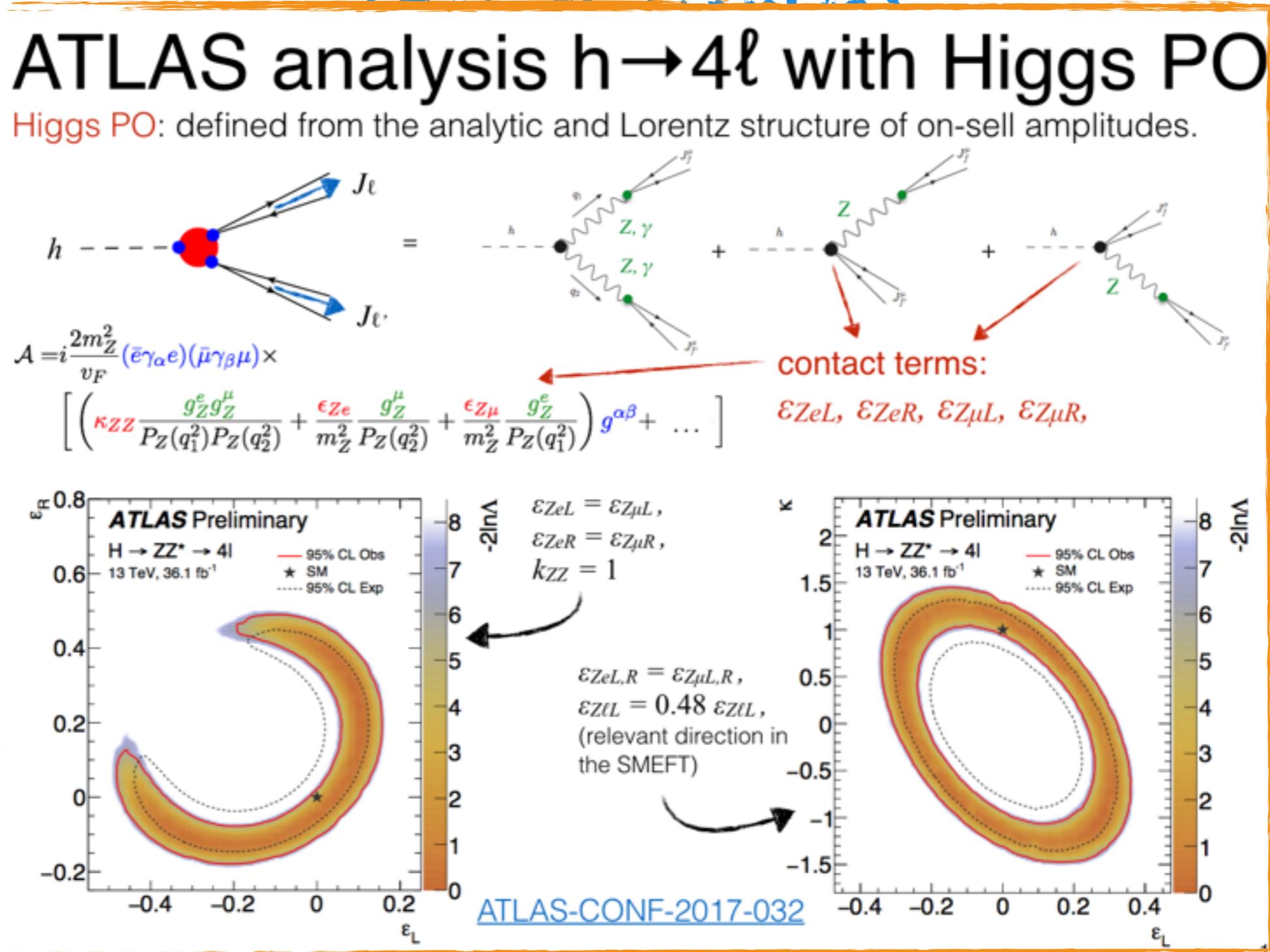
Provide
to com

Motivate

POs: a

eworks

an STXS



2

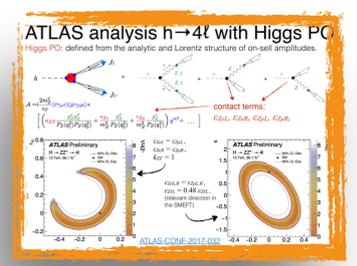
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Motivated by

- BSM
- Extracting more info from data than STXS

→ POs: all available info (up to $O(p^2)$) in $h \rightarrow 4f$



→ Motivated subsets of EFT (e.g. SUSY/Composite Higgs,...)

→ Good against EFTfobia (2499 -> few)

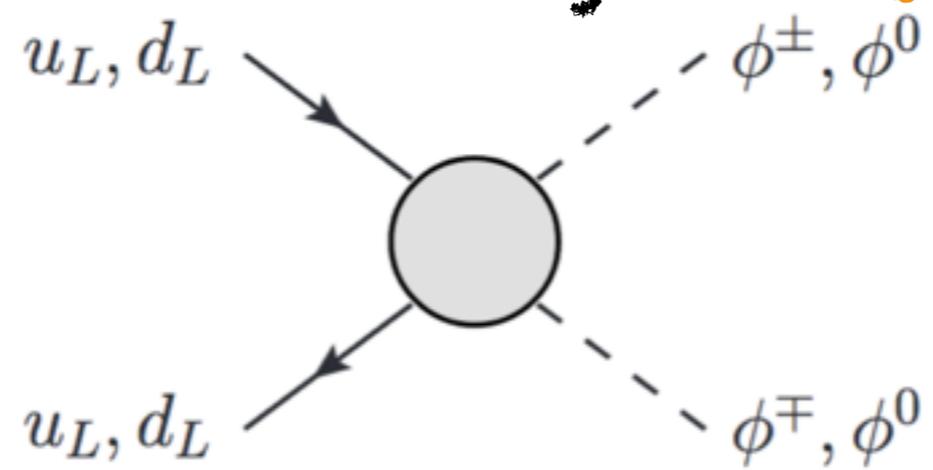
→ Interpretation framework of **broad** BSM
(not model-independent)

2

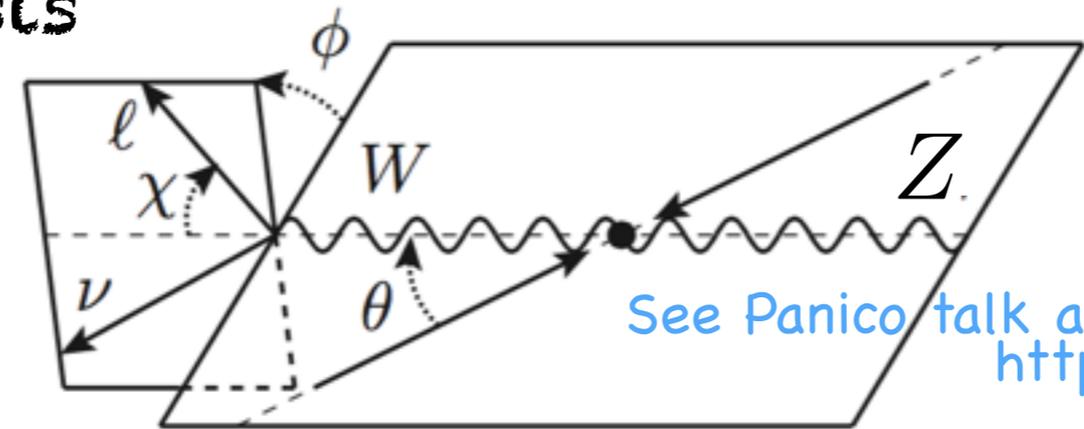
Well-defined interpretation schemes (benchmarks)

→ Identify processes where **EFT** particularly **simple** or where **dedicated** analysis particularly advantageous

Ex: **VH** at high-E modified by a **single dim-6** effect

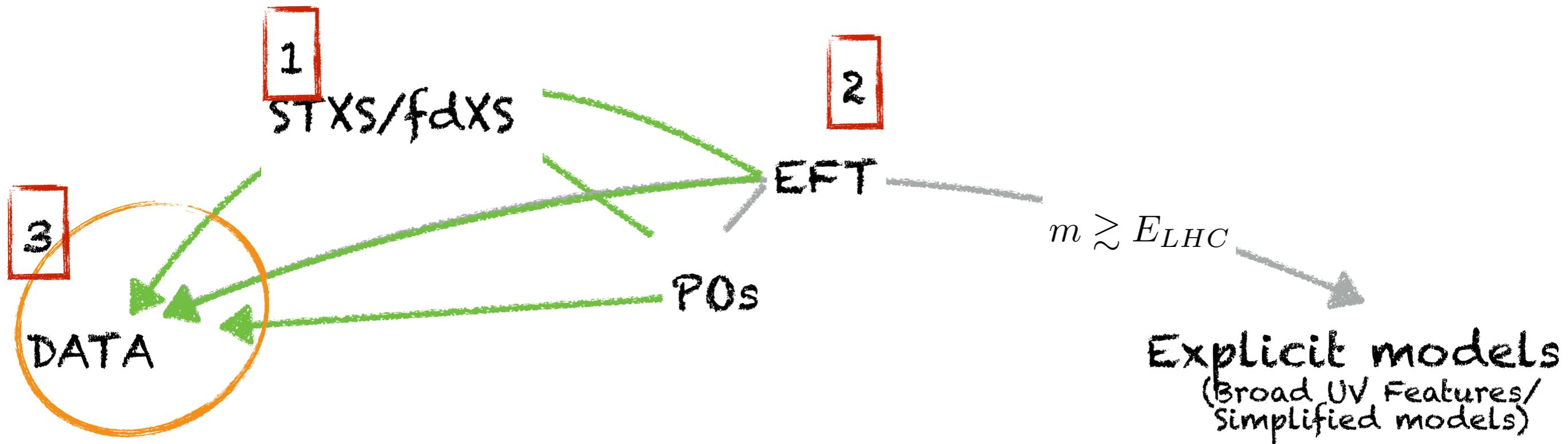


Ex: **WZ** (see motivation later) – angular information improves analysis



See Panico talk at Joint EWK+HXSWG2 meeting <https://indico.cern.ch/event/651519/>

Objectives

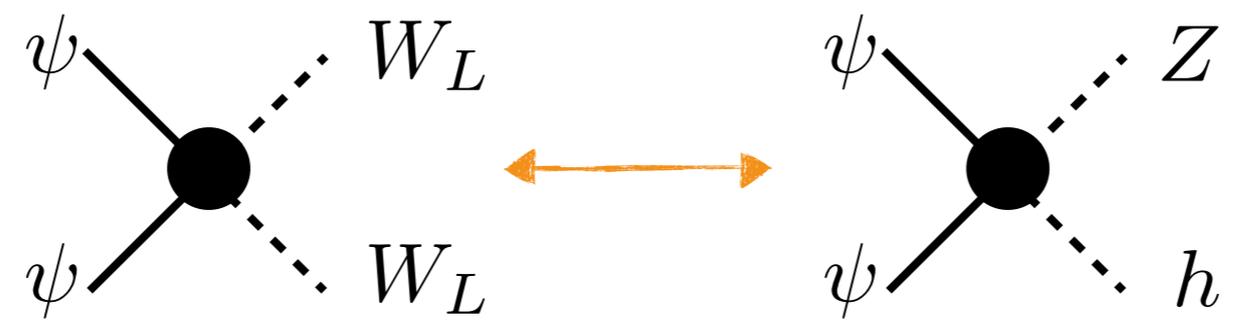


3 Extension to Electroweak data

3 Higgs+Electroweak Combination

In the SM, all scalars belong to the Higgs doublet:

$$\begin{pmatrix} h^+ \\ h + ih^0 \end{pmatrix} \begin{matrix} \leftarrow W_L \\ \leftarrow Z_L \end{matrix}$$



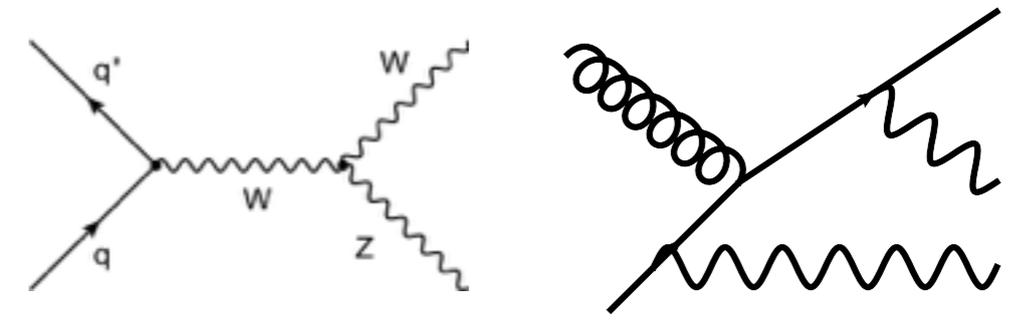
- The same physics can be tested in Higgs or EW sectors
- In particular: dibosons WZ , WW

3 Higgs+Electroweak Combination

→ Definition of common analysis framework (ATLAS/CMS)

STXS? dXS? EFT? PO?

→ STXS: Motivated by sizable NLO



→ EFT/PO: Motivated by unique high-E effect and improved sensitivity from dedicated study

→ Design analyses to allow EFT validity discussion

Conclusions

Higgs properties: very important!

WG2 has 3 ongoing lines of activity (-> documents)

→ BSM (EFT/PO) ↔ STXS stage 2

→ Priority interpretation scenarios

BSM motivated: e.g. SUSY/Compositeness

Experiment motivated: POs, Processes with simple EFT (e.g. Hgh-E)

→ Combination Higgs+EW

Variety of activities (tools, BSM perspective, recommendations, physical analyses, fits, diplomacy,...)

Join in!