Summary of the summaries

or

Anything relevant for Session 2 from Session 1?

Günther Dissertori
ETH Zürich

Often heard during last days

ETH Institute for Particle Physics

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ETH Institute for Particle Physics

- **SM rules!**
  - “so what are you going to do during session 2 ? “

Often heard during last days

ETH Institute for Particle Physics

- **SM rules!**
  - “so what are you going to do during session 2 ? “

- My answer:
  - well, we will do a lot of hiking, hunting and gathering (mushrooms, strawberries, ideas)

In general

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- I guess you/we should worry about issues such as
  - impact/importance of PDF uncertainties (eg. at high x)
  - impact of EWK corrections, eg. at high p_T, or in specific final states such as DY, di\tri-bosons, photon-induced processes, eg. \gam\gam\to WW
  - the avalanche of new developments in the ME+PS (especially NLO+PS) MC sector
  - control/description of particularly challenging final states as backgrounds, eg. ttbb, tt+light jets

PDFs

PDFs

ETH Institute for Particle Physics

- See J. Huston's summary talk. Extracts:
  - PDF uncertainties for gluon-gluon fusion
    - trace differences between CTEQ, MSTW and NNPDF to see if uncertainty can be reduced
  - impact of LHC data, current and future

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Studies started:

examine correlations in NNPDF (to be expanded to MSTW,…);
try to understand any differences in the impacts of various experiments;
effects of different heavy quark schemes;
influence of LHC data

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Discussion yesterday:

might be several years away from a significant reduction of gluon pdf uncertainty (?)
***in any case**: new NNLO calculations, ready or to still to come (tT, inc. jets, Z+jets), plus high-precision LHC data in these final states will be crucial!*

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- combination of PDF sets: **META PDFs ?**

META PDFs

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J. Huston's talk

Fits of the fits: META PDFs

PDFs from different groups have different physics inputs. But if we only focus on the phenomenological studies at the LHC with the limited x and Q ranges, the idea of META PDF is reasonable and also feasible.

Procedure (for LHC):
1, selecting a specific x-Q range, and a parameterization form to describe all the PDFs at an initial scale above the bottom quark mass;
2, check that the fitted PDFs can well represent the original PDFs at the x-Q range studied;
3, choosing a scheme to combine the PDF measurements of different groups in the new PDF parameter space;

Benefits:
1, A natural way to compare and combine the LHC predictions from different PDF groups independent of the process, works similarly as the PDF4LHC prescriptions but directly in the PDF parameter space;
2, Especially desirable for including results from large number of PDF groups, in this case also minimizing numerical computation efforts for massive NNLO calculations;

2013/6/5 Les Houches 2013

Talk by Jun Gao

EWK corrections

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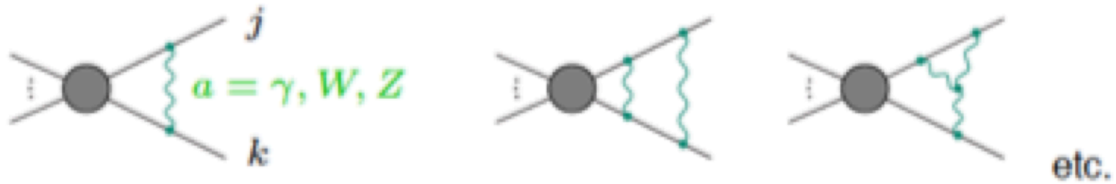
Electroweak Corrections

Electroweak radiative corrections at high energies

Sudakov logarithms induced by soft gauge-boson exchange



etc.

+ sub-leading logarithms from collinear singularities

Typical impact on $2 \to 2$ reactions at $\sqrt{s} \sim 1\,\text{TeV}$:

$$\delta_{\text{LL}}^{1-\text{loop}} \sim -\frac{\alpha}{\pi s_{\text{W}}^2} \ln^2\left(\frac{s}{M_{\text{W}}^2}\right) \simeq -26\%, \qquad \delta_{\text{NLL}}^{1-\text{loop}} \sim +\frac{3\alpha}{\pi s_{\text{W}}^2} \ln\left(\frac{s}{M_{\text{W}}^2}\right) \simeq 16\%$$

$$\delta_{\text{LL}}^{2-\text{loop}} \sim +\frac{\alpha^2}{2\pi^2 s_{\text{W}}^4} \ln^4\left(\frac{s}{M_{\text{W}}^2}\right) \simeq 3.5\%, \qquad \delta_{\text{NLL}}^{2-\text{loop}} \sim -\frac{3\alpha^2}{\pi^2 s_{\text{W}}^4} \ln^3\left(\frac{s}{M_{\text{W}}^2}\right) \simeq -4.2\%$$

⇒ Corrections still relevant at 2-loop level

Note: differences to QED / QCD where Sudakov log's cancel

- massive gauge bosons W, Z can be reconstructed
  ↪ no need to add "real W, Z radiation"
- non-Abelian charges of W, Z are "open" → Bloch–Nordsieck theorem not applicable

Extensive theoretical studies at fixed perturbative (1-/2-loop) order and suggested resummations via evolution equations

Beccaria et al.; Beenakker, Werthenbach; Ciafaloni, Comelli; Denner, Pozzorini; Fadin et Hori et al.; Melles; Kühn et al., Denner et al. '0

S. Dittmaier

EWK corrections

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Electroweak Corrections

Electroweak radiative corrections at high energies (continued)

Example: Drell–Yan production

Neutral current: $pp \to l^+l^-$ at $\sqrt{s} = 14\,\mathrm{TeV}$ (based on S.D./Huber arXiv:0911.2329)

M_{ll}/GeV	50−∞	100−∞	200−∞	500−∞	1000−∞	2000−∞
σ_0/pb	738.733(6)	32.7236(3)	1.48479(1)	0.0809420(6)	0.00679953(3)	0.000303744(1)
$\delta^{rec}_{q\bar{q},phot}$/%	−1.81	−4.71	−2.92	−3.36	−4.24	−5.66
$\delta_{q\bar{q},weak}$/%	−0.71	−1.02	−0.14	−2.38	−5.87	−11.12
$\delta^{(1)}_{Sudakov}$/%	0.27	0.54	−1.43	−7.93	−15.52	−25.50
$\delta^{(2)}_{Sudakov}$/%	−0.00046	−0.0067	−0.035	0.23	1.14	3.38

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By the way:

do we all speak a common language when we talk about born, dressed, bare (naked, half-naked, FKK, ...) leptons? **---->**

Dressing

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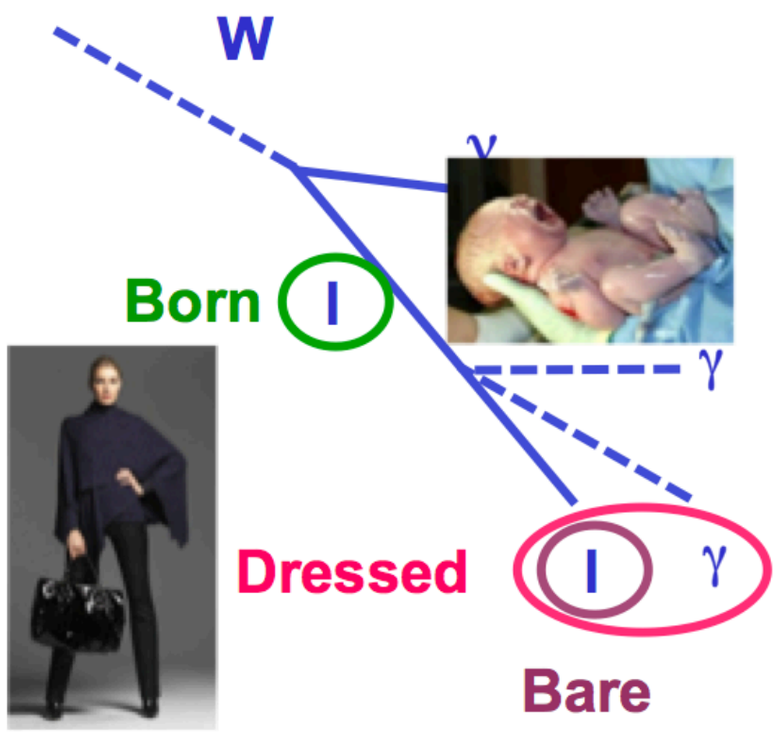
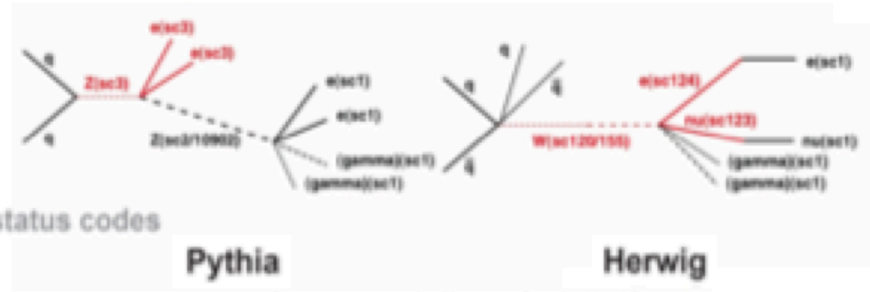
Lepton Definitions – as agreed on in W,Z LPCC EW WG (CMS, ATLAS, Lhcb) in May 2012



Dressing Demystified

- Keep the bare lepton (after FSR) fixed as reference
- Create a new 4-vector as sum of the bare lepton and all photons with $\Delta R<0.1$
  - This 4-vector is the dressed lepton
- Perform all cuts ($p_T(\ell)$, $m(\ell\ell)$, ...) using the dressed leptons and their combinations
  - Do NOT use the boson from the event record! Ever!



ATLAS status codes

Pythia Herwig

4/27/2012 Uta & Alberto - W/Z LHC EW WG 3

During series of meetings, Lhcb and CMS experiments agreed on following up ATLAS proposal of lepton definitions, in particular to add 'dressed' leptons

➔ presented at 22.5.2012 in the LPCC session https://indico.cern.ch/conferenceOtherViews.py?view=standard&confId=178469

Uta Klein

From slides by Atlas W,Z contacts Alberto Belloni & Uta Klein @ W,Z LPCC subgroup meeting 27.4.2012

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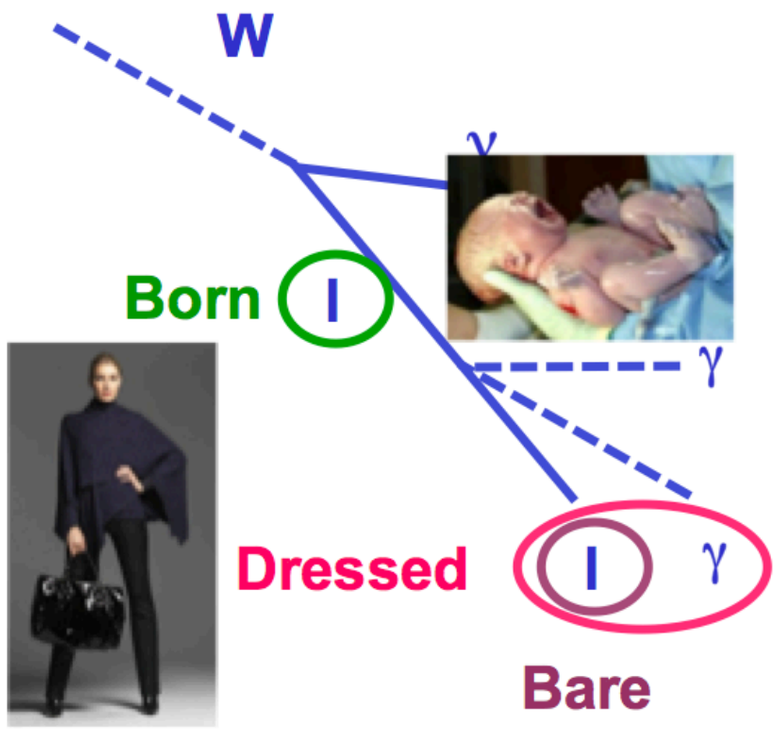

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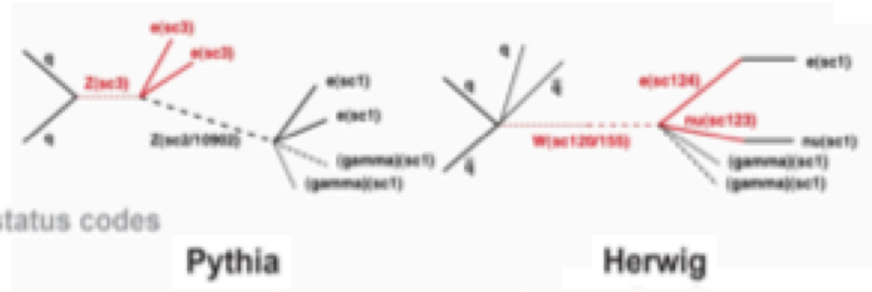

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From slides by Atlas W,Z contacts Alberto Belloni & Uta Klein @ W,Z LPCC subgroup meeting 27.4.2012

Do we know/agree how to deal with DY background, EWK corrections, and their uncertainties, in Z' searches?

A wish list

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NC & CC DY : A wish list for discussion & studies

.. some tasks are already under study also in LPCC and EW experimental and theory WG's

➔ "optimal" choice and documentation of EW parameters and SM inputs for *matched* QCD and EW calculations to be used by theorists and experimentalists → task for Les Houches ? or LPCC? or both?

➔ improved communication between Les Houches and LPCC activities!

❖ Precision evaluation of missing HO EW (ISR, interferences, weak) corrections and QED FSR modelling; application of missing HO EW corrections and remaining systematics

❖ Improved modelling of p_T(W,Z) : implementation of resummation into NLO MC models (but e.g also control of resummation scale)

➔ missing HO EW corrections (+systematic uncertainties) for more complex kinematic variables like phi*(Z), M_T(W), W polarisation ➔ crucial W mass measurement precision!

❖ Improved modelling and uncertainties and measurement proposals for non-resonant photon-induced dilepton productions, but also for the NLO gamma-p induced dilepton and W productions

❖ Improved modelling of real W and Z radiation beyond LO approach outlined by U.Baur, arXiv:hep-ph/0611241

Uta Klein

Why worry about NLO EWK

ETH Institute for Particle Physics

- well, the (N)NLO QCD guys are marching, fast

Why worry about NLO EWK

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NNLO QCD+NLO EW wishlist

Process	known	desired	details
H	$d\sigma$ @ NNLO QCD $d\sigma$ @ NLO EW finite quark mass effects @ NLO	$d\sigma$ @ NNNLO QCD + NLO EW MC@NNLO finite quark mass effects @ NNLO	H branching ratios and couplings
H + j	$d\sigma$ @ NNLO QCD (g only) $d\sigma$ @ NLO EW finite quark mass effects @ LO	$d\sigma$ @ NNLO QCD + NLO EW finite quark mass effects @ NLO	H p_T
H + 2j	σ_{tot}(VBF) @ NNLO(DIS) QCD $d\sigma$(gg) @ NLO QCD $d\sigma$(VBF) @ NLO EW	$d\sigma$ @ NNLO QCD + NLO EW	H couplings
H + V	$d\sigma$ @ NNLO QCD $d\sigma$ @ NLO EW	with $H \to b\bar{b}$ @ same accuracy	H couplings
$t\bar{t}H$	$d\sigma$(stable tops) @ NLO QCD	$d\sigma$(top decays) @ NLO QCD + NLO EW	top Yukawa coupling
HH	$d\sigma$ @ LO QCD (full m_t dependence) $d\sigma$ @ NLO QCD (infinite m_t limit)	$d\sigma$ @ NLO QCD (full m_t dependence) $d\sigma$ @ NNLO QCD (infinite m_t limit)	Higgs self coupling

Table 1: Wishlist part 1 – Higgs (V = W, Z)

add a column here for current exp precision and that expected at 14 TeV

N. Glover, S. Dittmaier

NNLO QCD + NLO EWK wishlist

Process	known	desired	details
$t\bar{t}$	σ_{tot} @ NNLO QCD $d\sigma$(top decays) @ NLO QCD $d\sigma$(stable tops) @ NLO EW	$d\sigma$(top decays) @ NNLO QCD + NLO EW	precision top/QCD, gluon PDF, effect of extra radiation at high rapidity, top asymmetries
$t\bar{t}$ + j	$d\sigma$(NWA top decays) @ NLO QCD	$d\sigma$(NWA top decays) @ NNLO QCD + NLO EW	precision top/QCD top asymmetries
single-top	$d\sigma$(NWA top decays) @ NLO QCD	$d\sigma$(NWA top decays) @ NNLO QCD (t channel)	precision top/QCD, V_{tb}
dijet	$d\sigma$ @ NNLO QCD (g only) $d\sigma$ @ NLO weak	$d\sigma$ @ NNLO QCD + NLO EW	Obs.: incl. jets, dijet mass → PDF fits (gluon at high x) → α_s CMS http://arxiv.org/abs/1212.6660
3j	$d\sigma$ @ NLO QCD	$d\sigma$ @ NNLO QCD + NLO EW	Obs.: $R3/2$ or similar → α_s at high scales dom. uncertainty: scales CMS http://arxiv.org/abs/1304.7498
γ + j	$d\sigma$ @ NLO QCD $d\sigma$ @ NLO EW	$d\sigma$ @ NNLO QCD +NLO EW	gluon PDF γ + b for bottom PDF

Table 2: Wishlist part 2 – jets and heay quarks

N. Glover, S. Dittmaier

Why worry about NLO EWK

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NNLO QCD+NLO EW wishlist

Process	known	desired	details
H	$d\sigma$ @ NNLO QCD $d\sigma$ @ NLO EW finite quark mass effects @ NLO	$d\sigma$ @ NNNLO QCD + NLO EW MC@NNLO finite quark m	H branching ratios
H + j	$d\sigma$ @ NNLO QCD (g only) $d\sigma$ @ NLO EW finite quark mass effects @ LO	$d\sigma$ @ NNLO finite quark m	
H + 2j	σ_{tot}(VBF) @ NNLO(DIS) QCD $d\sigma$(gg) @ NLO QCD $d\sigma$(VBF) @ NLO EW	$d\sigma$ @ NNLO	
H + V	$d\sigma$ @ NNLO QCD $d\sigma$ @ NLO EW	with $H \to b\bar{b}$	
$t\bar{t}H$	$d\sigma$(stable tops) @ NLO QCD	$d\sigma$(top decays @ NLO QCD	
HH	$d\sigma$ @ LO QCD (full m_t dependence) $d\sigma$ @ NLO QCD (infinite m_t limit)	$d\sigma$ @ NLO QC $d\sigma$ @ NNLO	

Table 1: Wishlist part 1 – Hig

N. Glover, S. Dittmaier

NNLO QCD + NLO EWK wishlist

N. Glover,
S. Dittmaier

Process	known	desired	details
V	$d\sigma$(lept. V decay) @ NNLO QCD $d\sigma$(lept. V decay) @ NLO EW	$d\sigma$(lept. V decay) @ NNNLO QCD + NLO EW MC@NNLO	precision EW, PDFs
V + j	$d\sigma$(lept. V decay) @ NLO QCD $d\sigma$(lept. V decay) @ NLO EW	$d\sigma$(lept. V decay) @ NNLO QCD + NLO EW	Z + j for gluon PDF W + c for strange PDF
V + jj	$d\sigma$(lept. V decay) @ NLO QCD	$d\sigma$(lept. V decay) @ NNLO QCD + NLO EW	study of systematics of H + jj final state
VV′	$d\sigma$(V decays) @ NLO QCD $d\sigma$(stable V) @ NLO EW	$d\sigma$(V decays) @ NNLO QCD + NLO EW	off-shell leptonic decays TGCs
gg → VV	$d\sigma$(V decays) @ LO QCD	$d\sigma$(V decays) @ NLO QCD	bkg. to $H \to VV$ TGCs
Vγ	$d\sigma$(V decay) @ NLO QCD $d\sigma$(PA, V decay) @ NLO EW	$d\sigma$(V decay) @ NNLO QCD + NLO EW	TGCs
$Vb\bar{b}$	$d\sigma$(lept. V decay) @ NLO QCD massive b	$d\sigma$(lept. V decay) @ NNLO QCD massless b	bkg. for $VH \to b\bar{b}$
VV′γ	$d\sigma$(V decays) @ NLO QCD	$d\sigma$(V decays) @ NLO QCD + NLO EW	QGCs
VV′V″	$d\sigma$(V decays) @ NLO QCD	$d\sigma$(V decays) @ NLO QCD + NLO EW	QGCs, EWSB
VV′ + j	$d\sigma$(V decays) @ NLO QCD	$d\sigma$(V decays) @ NLO QCD + NLO EW	bkg. to H, BSM searches
VV′ + jj	$d\sigma$(V decays) @ NLO QCD	$d\sigma$(V decays) @ NLO QCD + NLO EW	QGCs, EWSB
γγ	$d\sigma$ @ NNLO QCD		bkg to $H \to \gamma\gamma$

Table 3: Wishlist part 3 – EW gauge bosons (V = W, Z)

Why worry about NLO EWK

ETH Institute for Particle Physics

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NNLO QCD+NLO EW wishlist

Process	known	desired	details
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H + j	$d\sigma$ @ NNLO QCD (g only) $d\sigma$ @ NLO EW finite quark mass effects @ LO	$d\sigma$ @ NNLO finite quark m	
H + 2j	σ_{tot}(VBF) @ NNLO(DIS) QCD $d\sigma$(gg) @ NLO QCD $d\sigma$(VBF) @ NLO EW	$d\sigma$ @ NNLO	
H + V	$d\sigma$ @ NNLO QCD $d\sigma$ @ NLO EW	with $H \to b\bar{b}$	
$t\bar{t}H$	$d\sigma$(stable tops) @ NLO QCD	$d\sigma$(top decays @ NLO QCD	
HH	$d\sigma$ @ LO QCD (full m_t dependence) $d\sigma$ @ NLO QCD (infinite m_t limit)	$d\sigma$ @ NLO QC $d\sigma$ @ NNLO	

Table 1: Wishlist part 1 – Hig

N. Glover, S. Dittmaier

NNLO QCD + NLO EWK wishlist

N. Glover,
S. Dittmaier

NNLO QCD + NLO EWK wishlist

Process	known	desired	details
V	$d\sigma$(lept. V decay) @ NNLO QCD $d\sigma$(lept. V decay) @ NLO EW	$d\sigma$(lept. V decay) @ NNNLO QCD + NLO EW MC@NNLO	precision EW, PDFs
V + j	$d\sigma$(lept. V decay) @ NLO QCD $d\sigma$(lept. V decay) @ NLO EW	$d\sigma$(lept. V decay) @ NNLO QCD + NLO EW	Z + j for gluon PDF W + c for strange PDF
V + jj	$d\sigma$(lept. V decay) @ NLO QCD	$d\sigma$(lept. V decay) @ NNLO QCD + NLO EW	study of systematics of H + jj final state
VV′	$d\sigma$(V decays) @ NLO QCD $d\sigma$(stable V) @ NLO EW	$d\sigma$(V decays) @ NNLO QCD + NLO EW	off-shell leptonic decays TGCs
gg → VV	$d\sigma$(V decays) @ LO QCD	$d\sigma$(V decays) @ NLO QCD	bkg. to $H \to VV$ TGCs
Vγ	$d\sigma$(V decay) @ NLO QCD $d\sigma$(PA, V decay) @ NLO EW	$d\sigma$(V decay) @ NNLO QCD + NLO EW	TGCs
$Vb\bar{b}$	$d\sigma$(lept. V decay) @ NLO QCD	$d\sigma$(lept. V decay) @ NNLO QCD	bkg. for $VH \to b\bar{b}$
		ess b	
		decays) LO QCD + NLO EW	QGCs
		decays) O QCD + NLO EW	QGCs, EWSB
		decays) O QCD + NLO EW	bkg. to H, BSM searches
		decays) O QCD + NLO EW	QGCs, EWSB
			bkg to $H \to \gamma\gamma$

W gauge bosons (V = W, Z)

see WIKI.....

ALSO (see eg. D. de Florian's summary):

- coming: first approximations for N³LO Higgs prod!
Full N³LO in a couple of years?
- seen: possibly big impact of HQ masses, esp. b-mass, on low-pt Higgs spectrum, under study....
- NNLO double Higgs prod. under way

Higgs

ETH Institute for Particle Physics

- See summary talks by M. Kado and D. de Florian

Entering the Precision Era for Higgs

- Precision in signal modeling
  - Precise assessment of TH uncertainties for couplings
  - Total cross sections: acceptance uncertainties
  - Fiducial cross sections: Definition of fiducial regions
  - Important (fiducial) differential cross sections (pT, eta, etc…)
  - Definition of ratio measurements to cancel systematics

- Precision in background modeling
  - H_{125} direct couplings to main fermions (tau and b)
  - H_{125} direct top Yukawa couplings

Higgs

ETH Institute for Particle Physics

- See summary talks by M. Kado and D. de Florian

Entering the Precision Era for Higgs

- Precision in signal mode
  - Precise assessment of TH
  - Total cross sections: acc
  - Fiducial cross sections:
  - Important (fiducial) diff
  - Definition of ratio meas
- Precision in backgroun
  - H_{125} direct couplings to
  - H_{125} direct top Yukawa

TH Uncertainties (Mostly Signal)

- Treatment of TH systematic unc
  - Paradigm for measurements ha ic uncertainties usually treated statistically).
  - What is the best modeling of TH

Not discussed!
Probably next session

- Jet bin uncertainties, VBF phase space in particular:
  - Improvements TH uncertainty treatment?
  - Should we use a "standardized" set of VBF criteria?
  - More direct and explicit use of jet veto?
  - Can the ggF uncertainty be constrained from 2-jet slightly larger phase space?

(see Daniel's talk)

- PS and underlying event:
  - Common definition of tunes to use for UE
  - PS systematic uncertainties common strategy

Discussed mostly for background simulation

- Interference:
  - γγ full NLO interference estim
  - Can interferometry (mass shi width) really work (**arXiv:1305.3854**)?

Dinner discussions only

ttH

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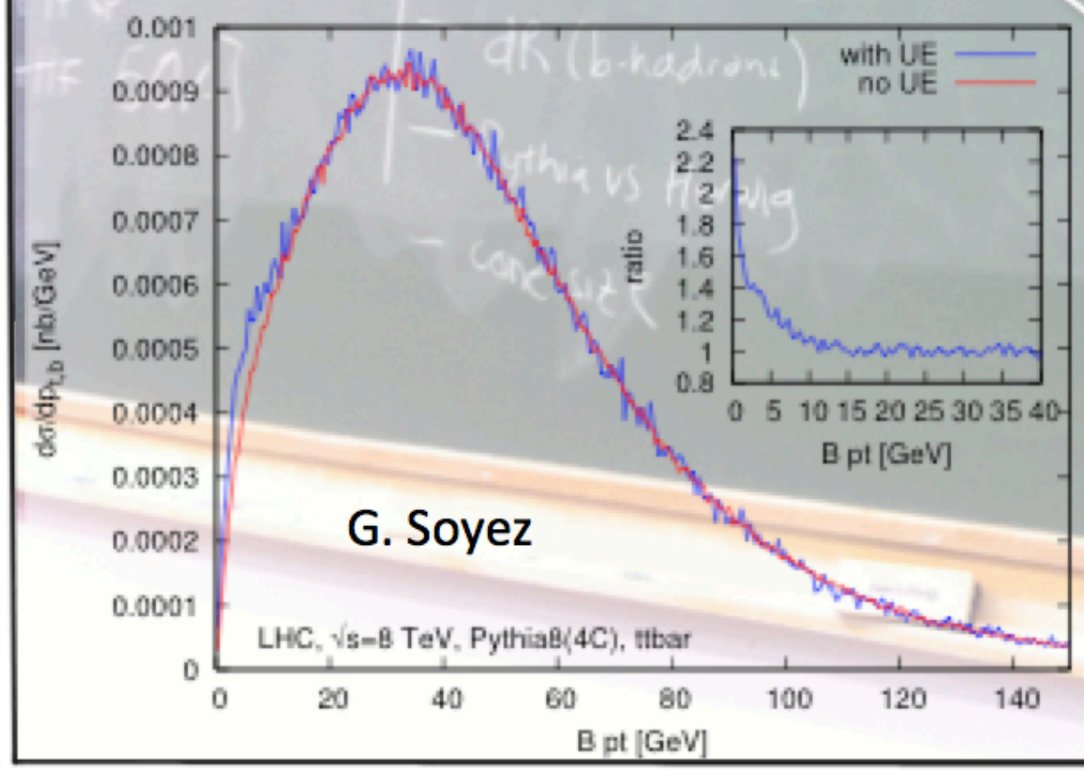
Seemingly wrong choice...
Ouch... !

Shopping List
- comp of tt+L?
- underlying vs PS [Jimmy]
- initial state b's
- dR(b-hadronic)
- dPhi
- hb → hadronic top
- cut on b P_T?

- HFOR → 0.2

$P_T^{b\bar{b}} / P_T^{b\bar{b}} + P_T^0$] all pairs

Contribution of UE b-pairs...

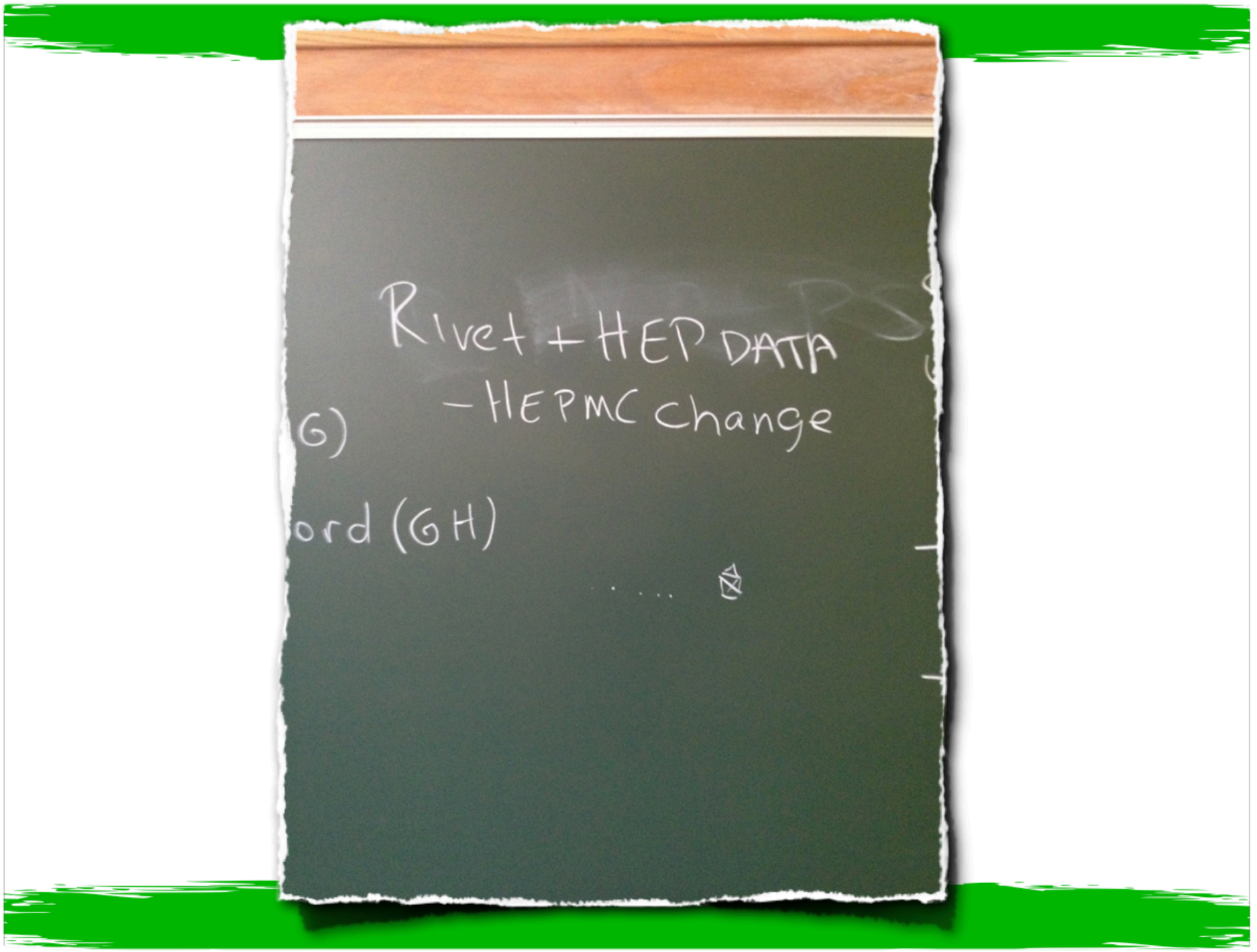


Monte Carlos, Tools

ETH Institute for Particle Physics

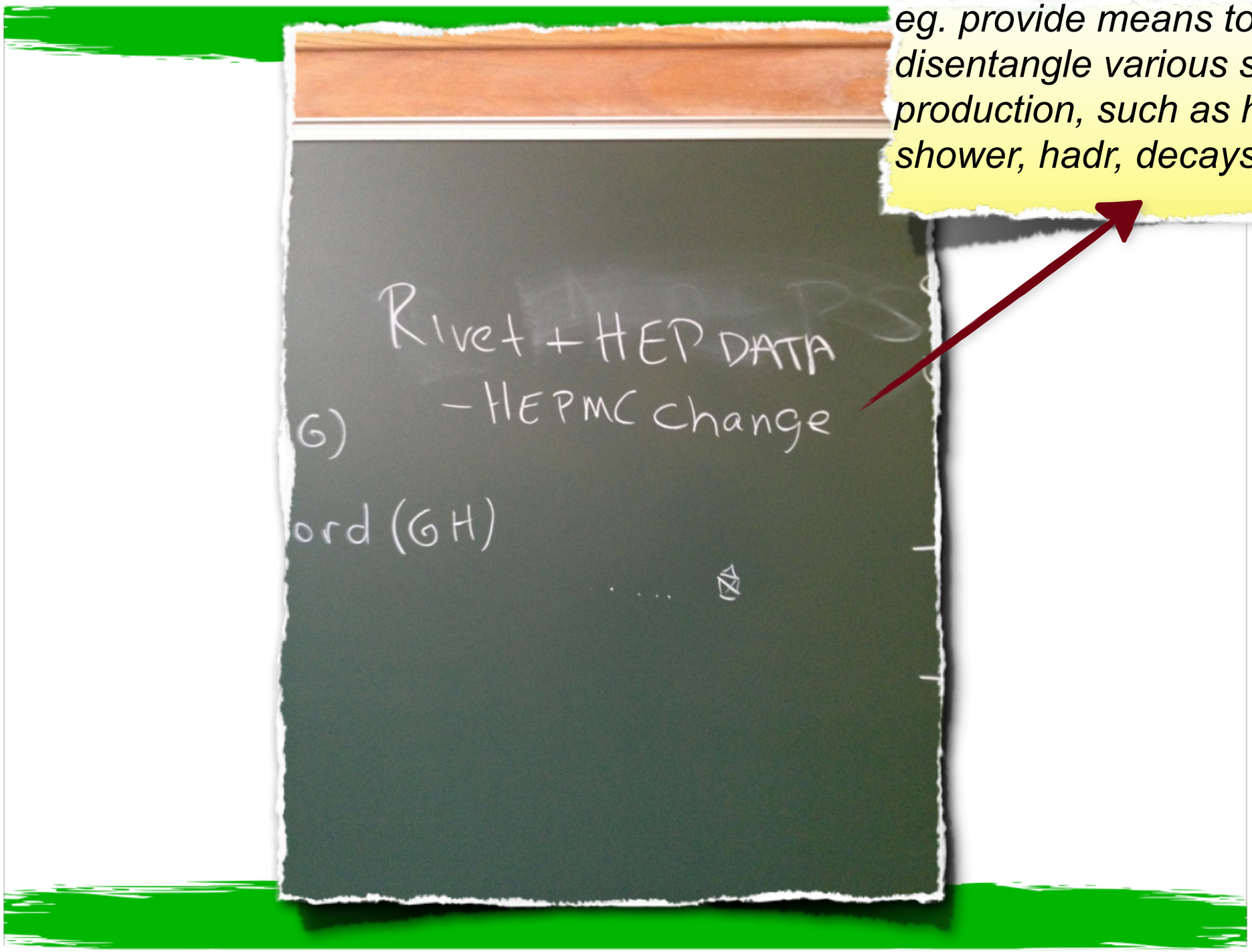
- See summary talk by K. Hamilton and G. Soyez
- Some relevant points:
  - an attempt to **update BLHA** (see Gudrun Heinrich)
  - many discussions on **H+jet(s) modeling** (relevance for VBF)
  - **NLO+PS MCs**: would be nice if new codes were able to spit out also the uncertainties (on their predictions), ... , some thinking started...
  - Program established for **extensive comparisons (of many codes, with data)**, using jet data, V+jet data, gamgam data
  - **Boosted jet substructure in searches with high PU**
    - some studies started. Possible to reduce/eliminate bias and improve JER at the same time?

RIVET, HEPDATA, HEP MC



RIVET, HEPDATA, HEP MC

ETH Institute for Particle Physics



eg. provide means to easily disentangle various stages of the MC production, such as hard scatter, MPI, shower, hadr, decays

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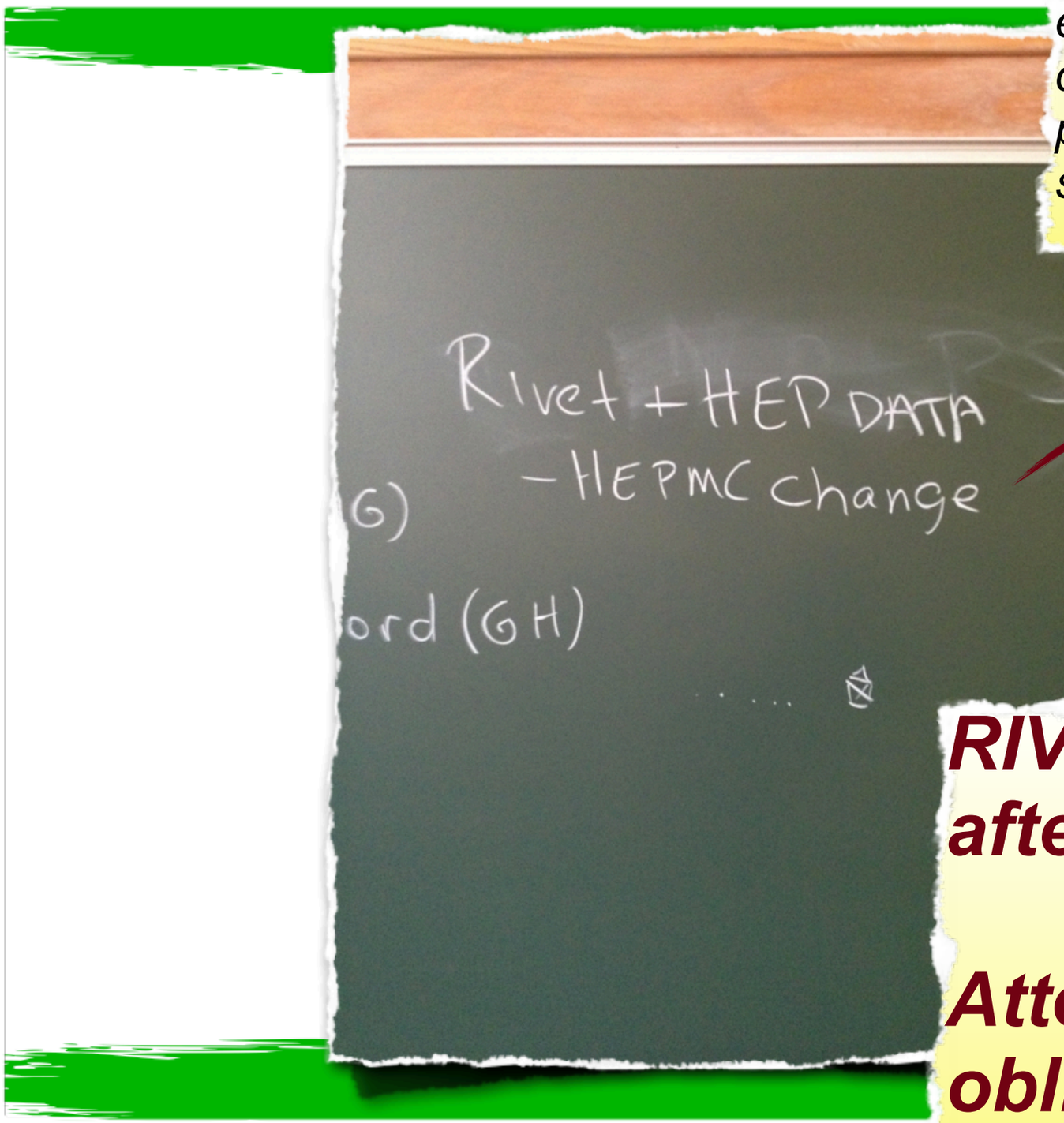

eg. provide means to easily disentangle various stages of the MC production, such as hard scatter, MPI, shower, hadr, decays

RIVET Tutorial this afternoon

Attendance is obligatory

And now:

- march, march, march, ...