

MEM 2nd workshop discussion

Fabio, Florencia, Kyle, Tilman+all participants

Discussion

1. Is the NLO problem solved?
2. What is the best code to do loops?
3. What is the best code to do NLO computations?

More seriously

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- The impressive progress in our MC/TH tools calls for a change in perspective in the interactions TH/EXP.

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- The impressive progress in our MC/TH tools calls for a change in perspective in the interactions TH/EXP.
 1. Theorists can have a more direct impact on experimental analyses.
 2. Experimentalists can become directly involved in pheno studies.

An energetic MEM workshop

SL events: one quark missed

Observations:
 - one isolated lepton
 - 4 tags + 1 tag'd
 Interpretation:
 - $pp \rightarrow t(\bar{t}) + b(\bar{b}) + \mu + \nu$
 - one quark from W out-of-acceptance

✓ true in ~40% of $t\bar{t}$ events
 ✓ S/B ~ 2.5%

Lorenzo

signal

background

Pierre

- pure left-handed stop,
- stop decays into neutralino + top quark with 100% proba
- $m_{\tilde{t}} = 200$ GeV, $m_{\tilde{\chi}} = 27.5$ GeV
- $\Gamma_{\tilde{t}} = 0.25$ MeV

MEM bounds

MEM Speed-Up
 Profiling (Valgrind)

Patrick

regions of significance

phase space parametrization

no interference/factorize

$$q(x) = -s + \sum_{j=1}^n \log \left(1 + \frac{f_j(x_j)}{f_j(x_j)} \right)$$

MadEvent

$$q(\vec{r}) = -\sigma_{\text{tot},s} \mathcal{L} + \log \left(1 + \frac{d\sigma_s(\vec{r})}{d\sigma_b(\vec{r})} \right)$$

single-event probability

$$\frac{d\sigma_s}{dq} \& \frac{d\sigma_b}{dq}$$

LEPStat4LHC [Kyle Cranmer]

full probability distribution \rightarrow maximum significance

Monte Carlo events:
 - kinematic cuts
 - binned plots for any LO observable
 - include point-wise corrections

Peter

tuning ~ 1:10

LHC8: $m_{\tilde{t}} \sim 700$ GeV

natural SUSY
 $m_{\tilde{t}} \sim 400$ GeV

tuning ~ 1:10²

LHC14: $m_{\tilde{t}} \sim 2$ TeV

Gilad

Evaluation of ME Weights: FSR treatment improvement

Final State Radiation: Zh_{FSR}

- For the future: Evaluation of ME Weights with 1 extra FSR jet
- As expected: **Similar performance that introducing extra variables** \rightarrow Brieuc Francois Master Thesis
- Advantages:
 - More consistent approach
 - It can result in a reduction of number of input variables
- Disadvantage: longer CPU time to compute MF weights \rightarrow Around factor 6

Jesus

$\Delta \epsilon_{\text{exp}} \sim 400$

$\sqrt{s} = 8$ TeV

Ciaran

We present the expected limit, (shading represents theory uncertainty) where the expected no. of events is around the CMS observation (8 TeV data).

The most stringent limits occur around $D > 1$, (run out of statistics beyond that).

$\Gamma_H < (15.7_{-2.9}^{+3.9}) \Gamma_H^{SM}$ at 95% c.l. ($D_S > 1$)

Conclusions

alphes 3 has been out for one year now, with major improvements:

- modularity
- pile-up implementation
- revamped particle flow algorithm
- new visualization tool based on ROOT EVE
- default cards giving results on par with published performance from LHC experiment
- now fully integrated with MadGraph 5

alphes is a great tool for preliminary MEM studies

alphes 2 is no longer supported!!

test it, and give us feedback!

Michael Michele

Is it possible to perform such hypothesis test given complexity of LHC events?

UE, ISR, FSR

Michael

ME vs. Machine learning

- Both used to combine several variables into more sensitive one
- Sensitivity: All physics information at given order is in ME by construction
 - Lacks higher-order radiative corrections and correlations
 - Machine learning may better correlations using full simulation, compared to analytical transfer functions
- Robustness: Since all physics information already encoded in matrix element:
 - No need to re-learn using BDT, NN, etc -- possibly learn suboptimal/wrong dependence
 - MC modeling of data points possible
- Transparency: Conceptual methods -- to spot potential problems, e.g. with transfer function mismodeling
 - Machine learning algorithms are black box
- Power: Fit fundamental parameters of model in large, continuous phase space
 - Compare to pair-wise testing of finite discrete SM-like hypotheses
 - Difficult to generalize machine-learning algorithms to large phase space of continuous parameters being computationally intensive
- Often (not always) gain best of both worlds with ME as input to BDT / NN

Eric

Likelihoods and Kinematic fitter

Kinematic fitter kinematics with quality cuts

No Kinematic fitter
 All permutations in MadWeight

Efe

Likelihoods from SM & spin-uncorr evts and bkg sample under the spin corr hypothesis (H=C)

Using the kinematics determined by kinematic fitter (or adding extra quality criteria) forces the background to be $t\bar{t}$ -like.

+ A certain contamination of wrong jet-parton permutations will always be present \rightarrow Increases the uncertainty.

\rightarrow Running over all permutations in MadWeight ensures the correct one is always considered and yields smaller uncertainty.

Conclusions

PHENOMENOLOGICALLY RELEVANT CASES (HIGH ENERGY COLLIDERS)

THE SPECTRUM OF ENERGY IN TWO BODY DECAYS ENCODES IN A SIMPLE WAY AN INVARIANT OF THE TWO BODY DECAY KINEMATICS

Roberto

PEAK

KINKS OR PLATEAUS ARE POSSIBLE AS WELL

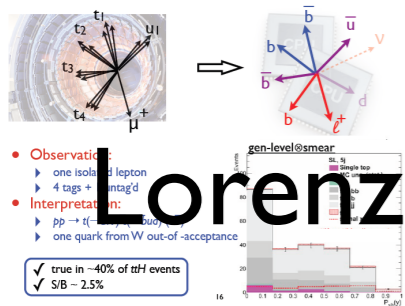
importance of Interference

Jamie

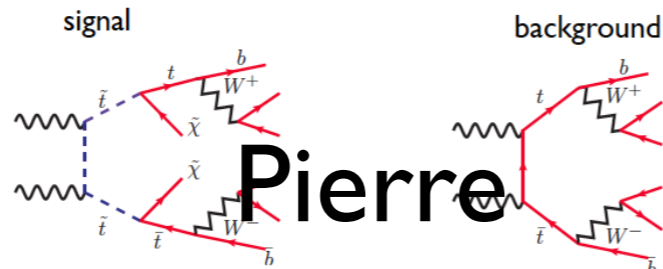
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Lorenzo



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- pure left-handed stop,
 - stop decays into neutralino + top quark with 100% probability
 - $m_{\tilde{t}} = 200 \text{ GeV}$, $m_{\tilde{\chi}^0} = 27.5 \text{ GeV}$
- only bkg = $t\bar{t}$ in the corresponding decay channels
 - MEM bounds

MEM Speed-Up
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regions of significance

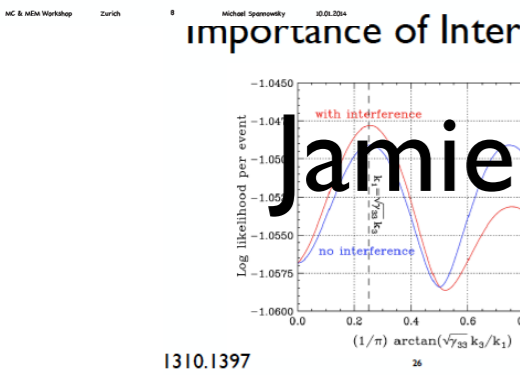
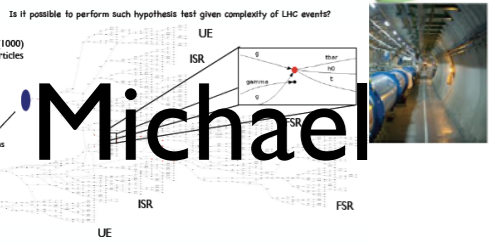
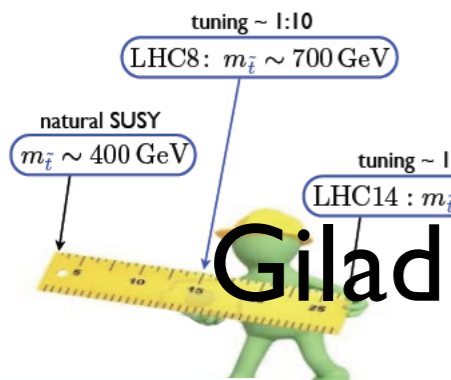
phase space parametrization

MadEvent MadGraph

$$\log \left(1 + \frac{d\sigma_s(\vec{r})}{d\sigma_b(\vec{r})} \right) \xrightarrow{MC} q(\vec{r}) = -\sigma_{\text{tot},s} \mathcal{L} + \log \left(1 + \frac{d\sigma_s(\vec{r})}{d\sigma_b(\vec{r})} \right)$$

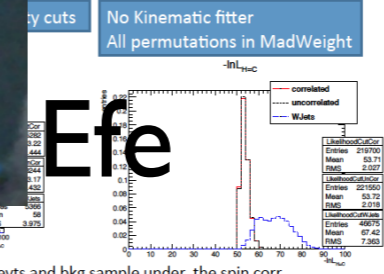
probability
 Monte Carlo events:
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Peter



- Eric**
- discriminants
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 - Machine learning algorithms are black box
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c.l. . . ($D_s > 1$)
 much smarter.
 Kinematic fitter



Conclusions

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Roberto

KINKS OR PLATEAUS ARE POSSIBLE AS WELL

- Likelihoods from SM & spin-uncorr evts and bkg sample under the spin corr hypothesis (H=C)
- Using the kinematics determined by kinematic fitter (or adding extra quality criteria) forces the background to be $t\bar{t}$ -like.
- A certain contamination of wrong jet-parton permutations will always be present
- Increases the uncertainty.
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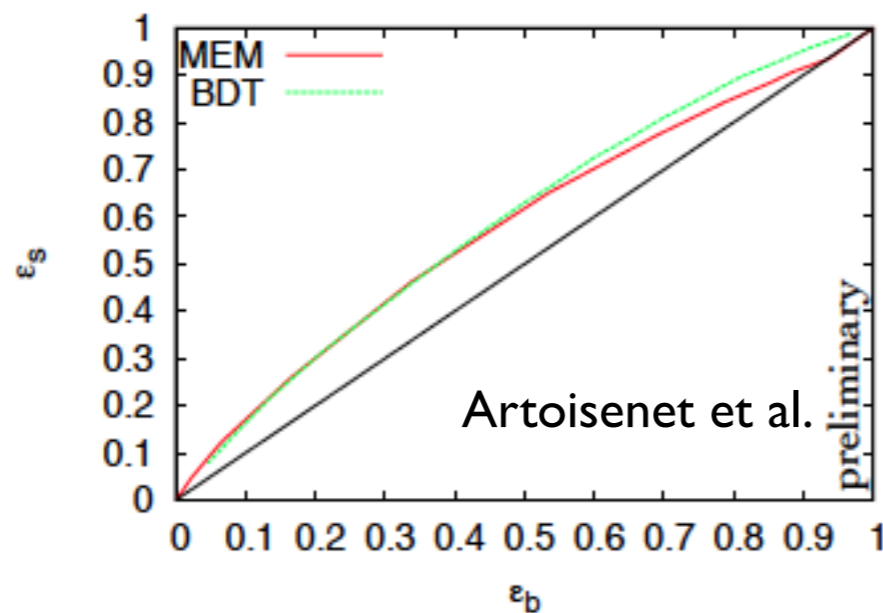
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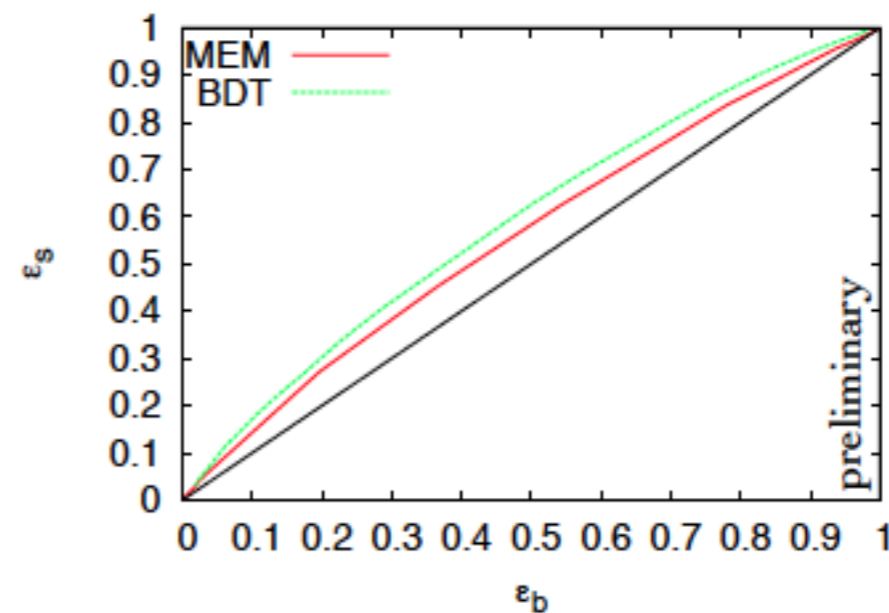
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 - New ideas (Max significance, ...)
 - New tools and updates (Berlin MEM tool, MadMax, DELPHES3, MadWeight(5), MEM@NLO, SMEM..)
 - New studies (tth, stops, single-tops, ttbar spin correlations, $H \rightarrow 4l$, ZH) TH as well as EXP!

Summary

- Discussion/comparison (properties and performance and philosophy) with kinematical variables and MVA (BDT, NN)



dilepton channel



single-lepton channel

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- Can the MEM be put on TH solid ground (ex. fully worked out NLO formulation, PS effects)?
- Are there clear examples of outperformance with respect to machine learning approaches?
- What are the syst. uncertainties that could be clearly parametrized and included?

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- What are the syst. uncertainties that could be clearly parametrized and included?
- What are the general statistical tools/framework needed for any analysis that could be made available?
- Interoperability/Modularity standards (à la LH..)
- Setting up/collecting benchmarks for speed/efficiency/....
- More...

Open detailed studies

Open detailed studies

- ~~Pairing with boosted techniques~~ (see Michael's talk..)
- Extra jet radiation
- Reducible background
- High-statistics strategies
- Combinatorics optimization (e.g. with kinematic fitting)
-more to be added here...

Next actions

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- Next general meeting in the US end of 2014/ beginning of 2015
- Self-organized intermediate topical working sessions on “MEM community” projects
- Web point of reference (page or wiki)
- more...?

Thanks!