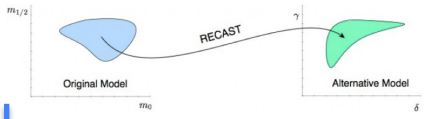


RECAST

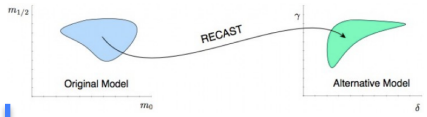
Extending the Impact of Existing Analyses

Itay Yavin

McMaster University & Perimeter Institute

Together with Kyle Cranmer from NYU

MC4BSM, Cornell, May 24, 2012

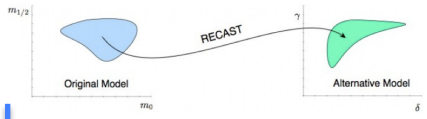


Hypothesis Testing

An important part of scientific progress is hypothesis testing. We construct models of the world and use them to make predictions about processes in nature. We then compare with experiment. We have one extremely important model,

The Standard Model

To go beyond it, we will have to test different hypotheses.



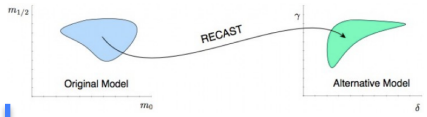
Hypothesis Testing in HEP

Most experiments in high energy physics are ultimately counting experiments,

1) Decay Rates

2) Cross Sections

What is the process of hypothesis testing in high energy physics?

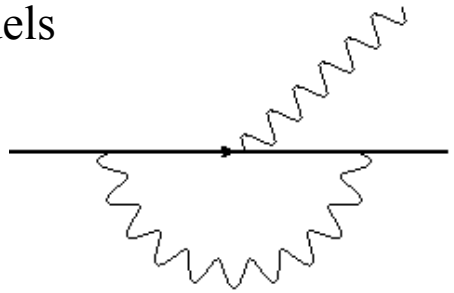


Lepton Flavor Violation

Muons in the Standard Model will never decay into an electron and a photon. That's worth searching for then (MEGA experiment) . . .

$$\mathrm{BR}(\mu^+ \to e^+\gamma) \leq 1.2 \times 10^{-11}$$

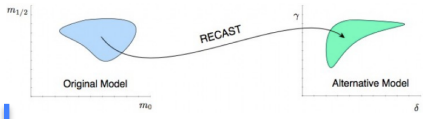
Theorists can calculate in different models



SUGRA,GMSB,AMSB, RS,UED, Little Higgs

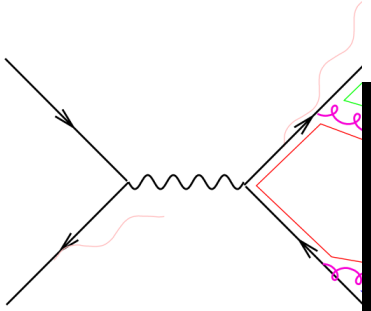
Experimentalists measure independently of models

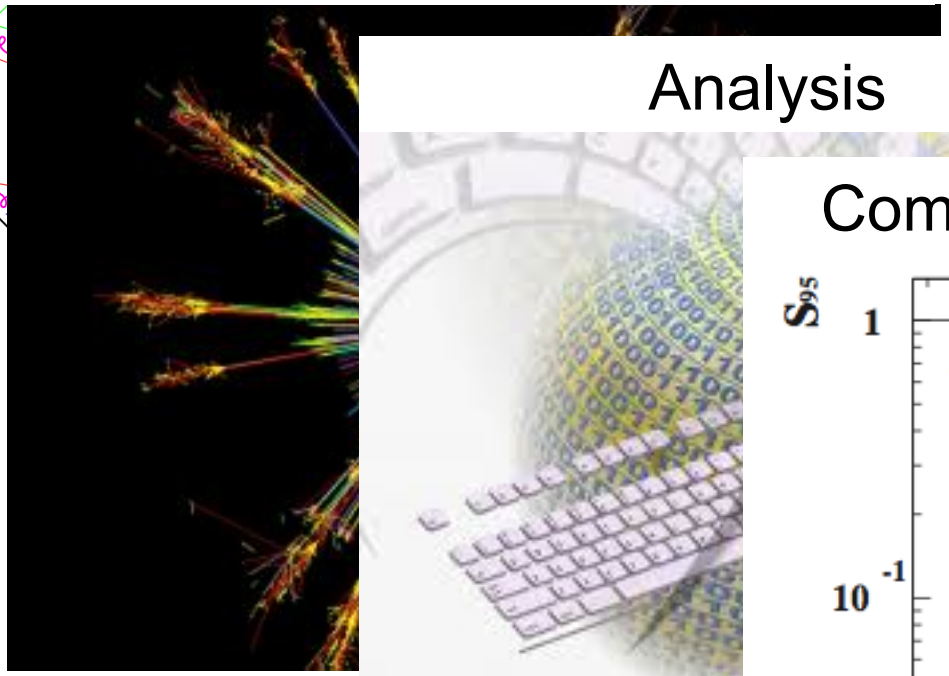
Hypothesis Testing is straightforward, even long after the original analysis



From Theory to Experiment (and back)

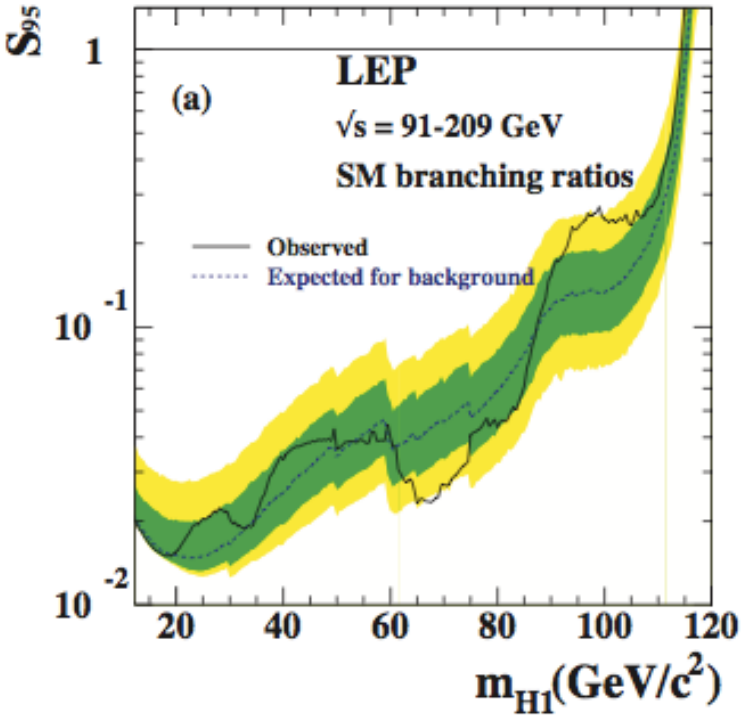
Detector Simulation





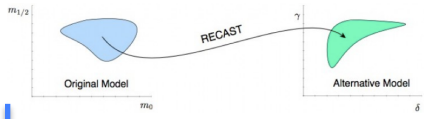
Analysis

Comparison with Data



From D. Zeppenfeld's

Hypothesis testing is not so straightforward.



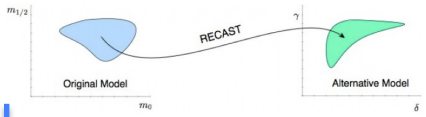
Modern Hypothesis Testing

Many new models going beyond the Standard Model have been suggested:

- SUSY – SUGRA,GMSB,AMSB,…
- RS
- UED
- Little Higgs
- The model not thought of . . .

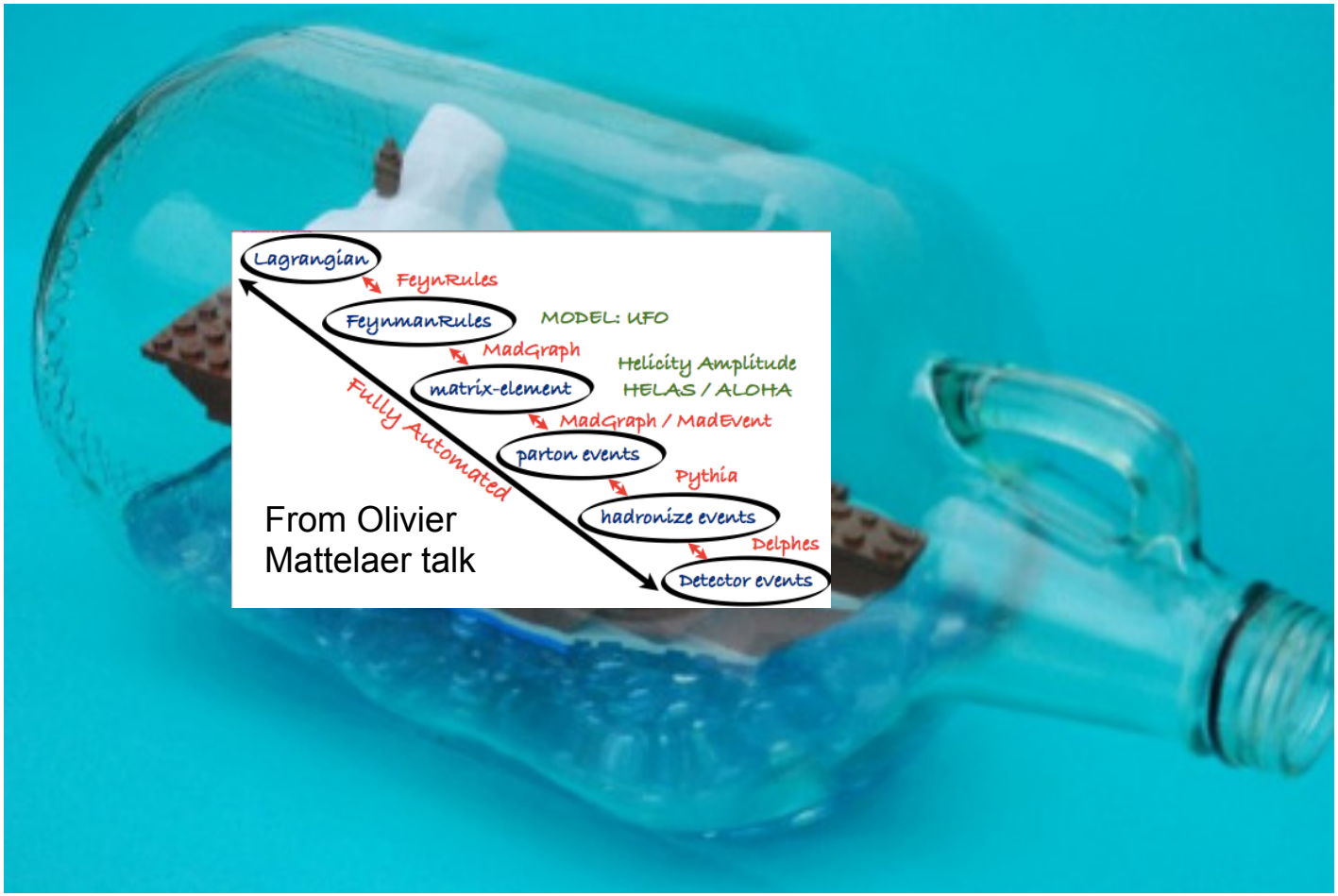
Many powerful tools were created to allow fast incorporation ***and*** simulation of new particle physics,

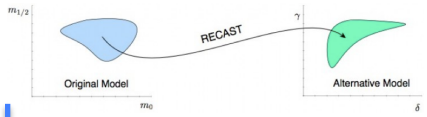
- Madgraph,Calchep
- ALPGEN
- PYTHIA,HERWIG,SHERPA
- FeynRules
- LHE format



Modern Hypothesis Testing

The MC community has made a huge effort to develop all the wonderful MC4BSM tools, how do we take full advantage of that?





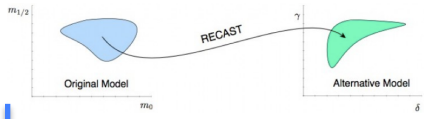
Modern Hypothesis Testing

Considering how many models there are, and the fact that in the future there may be more, how do we test for a new hypothesis?

1) Construct a new analysis.

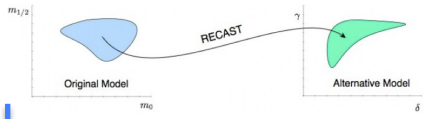
2) Reuse existing analyses.

There are many more models than is possible to address with dedicated analyses. Moreover, most analyses are sensitive to more new physics than what is being tested. This calls for re-usage!



Question

What do you need to know about an existing analysis to reuse it for testing an alternative model?

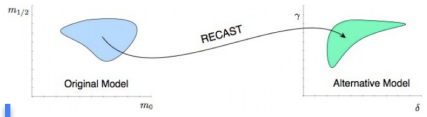


Answer

You only need to know the efficiency of the analysis to an alternative signal.

- No need for data access.
- No need for code access.

Just the ability to recalculate the efficiency of an alternative hypothesis.



How Does It Work?

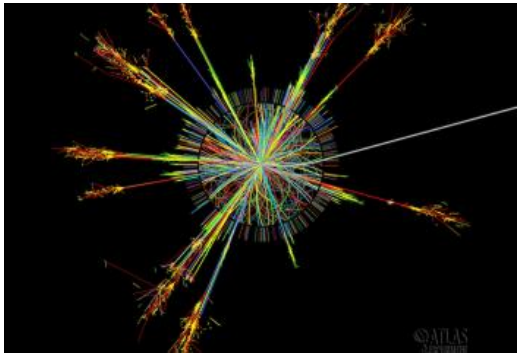
LHE

New signal

Pythia

(Showering & Hadronization)

Detector Simulation

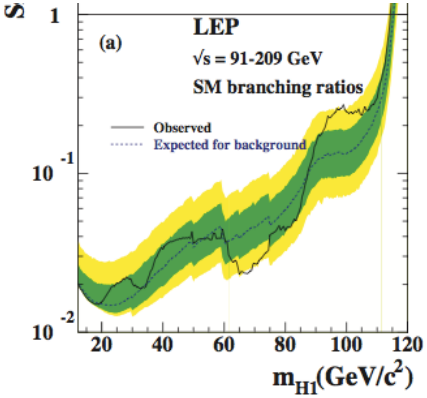


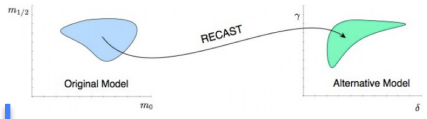
Analysis

Efficiency

for new signal

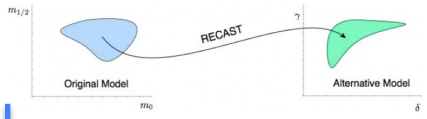
Comparison with data was already done.



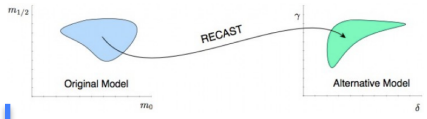


Question

How do we design the framework so as to maintain the collaborations control over their analyses while allowing communication with the community for RECAST requests?



The RECAST Framework



RECAST

Analysis code including all the cuts, detector effects and etc.

Back-End
controlled by collaboration's protocol

API

API

Front-End
Communication Broker

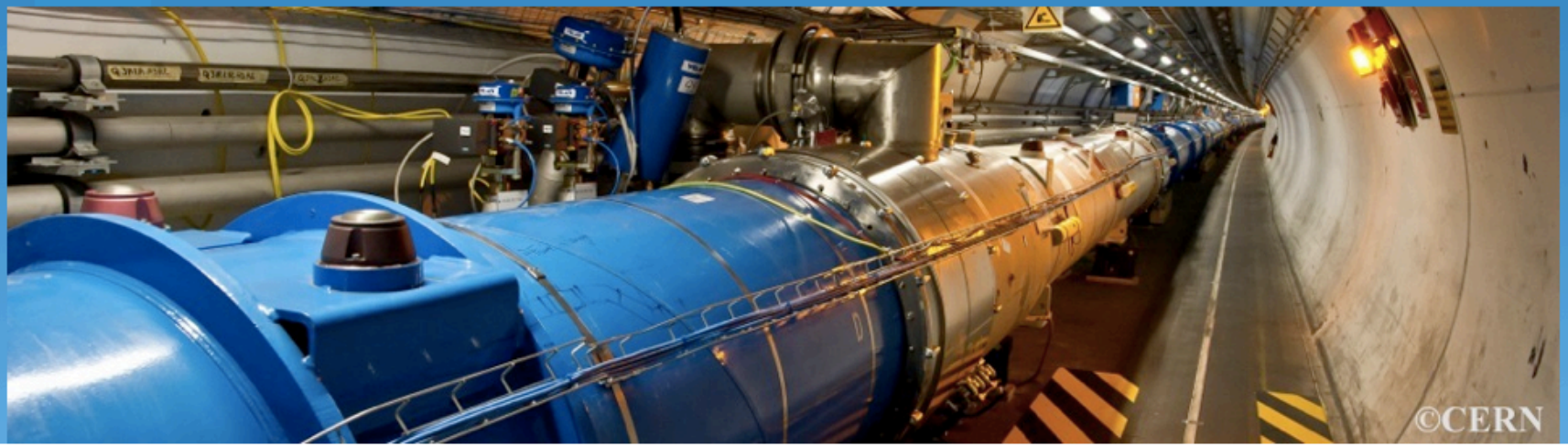
After collaboration's approval

ENERGY STAR HOMES

Request:
New signal, LHE file or model directory

Response:
Selection efficiency, Signal Histogram, cross-section limit

RECAST [beta]



Search

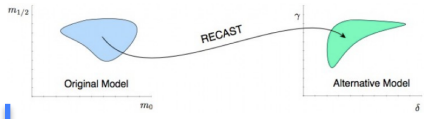
About this site

RECAST is a framework for extending the impact of existing analyses performed by high-energy physics experiments.

1. Anyone can add *analyses* to the Analysis Catalog
2. Anyone can upload alternative signals in the LHE format and *request* that any given analysis is "recast" for their alternative model

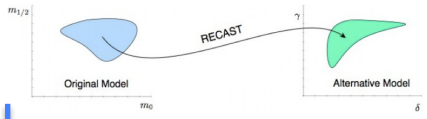
Latest Requests

Request	Analysis	Model	Status
1203.0030	Search for supersymmetry in all-hadronic events with αT	Cascade Decaying Squark Simplified Model	Active
1203.0029	Search for squarks and gluinos using final states with jets and missing transverse momentum with the ATLAS detector in sqrt(s) = 7 TeV proton-proton collisions	Gluino -> Higgsino	Incomplete

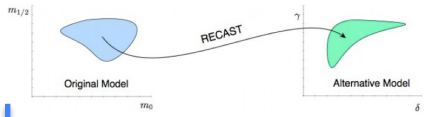


Question

But can existing analyses have anything to say about an alternative signal?



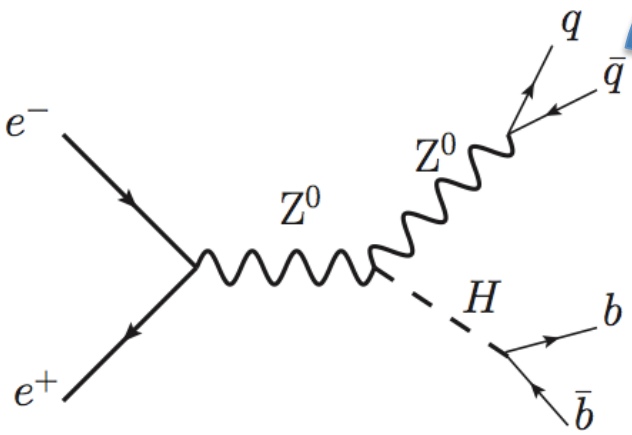
Examples



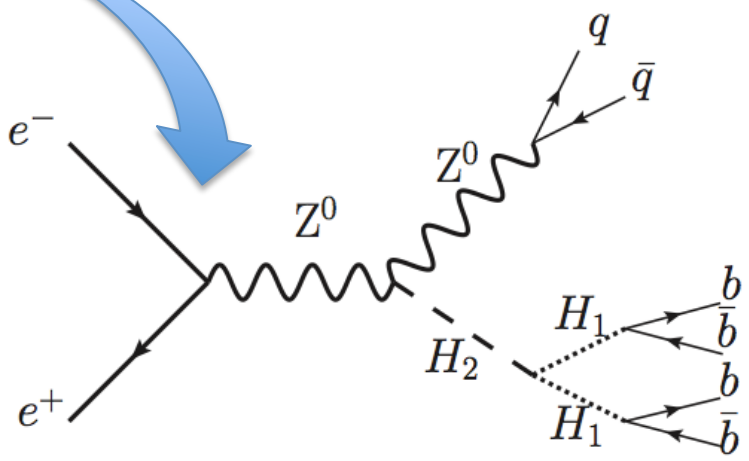
OPAL Higgs Searches

In hep-ex/0406057 OPAL recasted a previous search for Standard Model Higgs to place constraints on MSSM Higgs scenarios

hep-ex/0209078



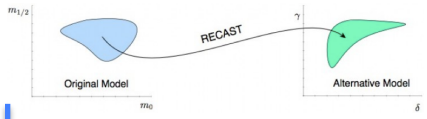
hep-ex/0406057



Importantly, the recasted signal is not even the same topology!

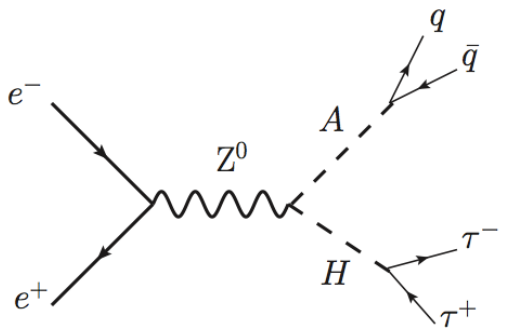
Efficient recasting

$m_{\mathcal{H}_2}$ (GeV)	$m_{\mathcal{H}_1}$ (GeV)	Efficiency for the process $\mathcal{H}_2 Z \to b\bar{b}b\bar{b}q\bar{q}$ at $\sqrt{s}$				
		192 GeV	196 GeV	200 GeV	202 GeV	206 GeV
100.	12.	0.689	0.684	0.717	0.733	0.693
100.	20.	0.651	0.639	0.653	0.659	0.586
100.	30.	0.460	0.461	0.461	0.470	0.480
100.	40.	0.270	0.260	0.283	0.315	0.323
100.	48.	0.328	0.325	0.361	0.392	0.400

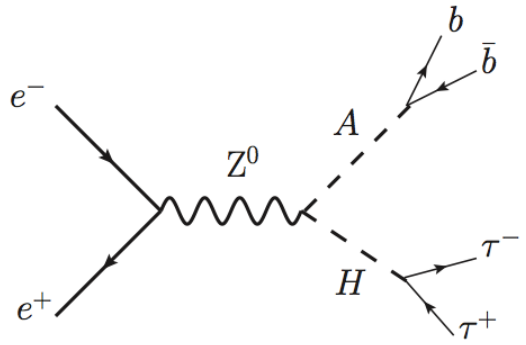


DELPHI Higgs Searches

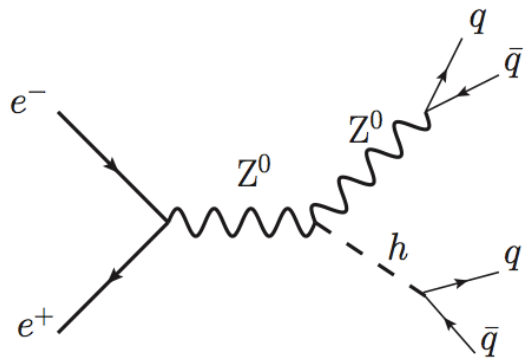
Similar recasting of previous SM Higgs searches was done at DELPHI



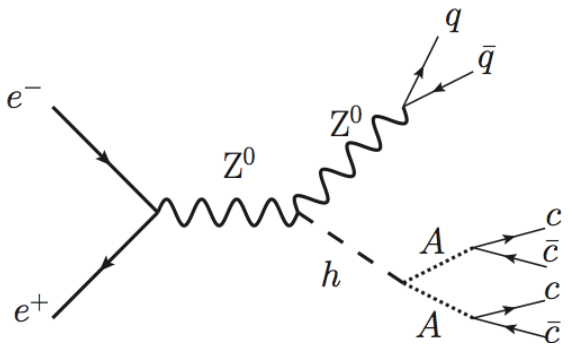
DELPHI Col., Eur. Phys. J. C38 (2004)



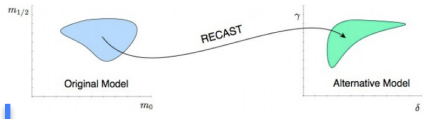
DELPHI Col., Eur.Phys.J. C54 (2008)



DELPHI Col., Eur. Phys. J. C23 (2002)

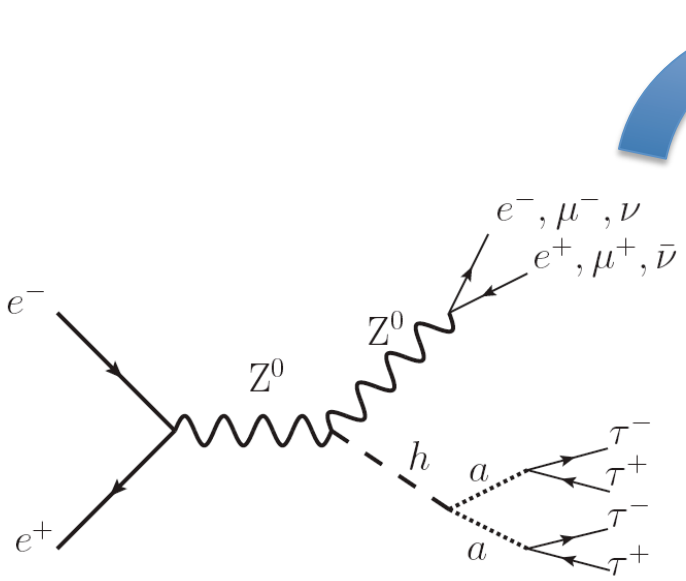


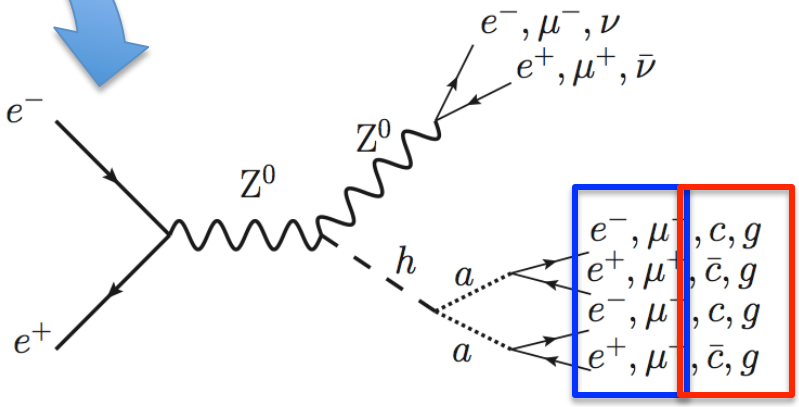
DELPHI Col., Eur.Phys.J. C54 (2008)



Exotic Higgs Searches

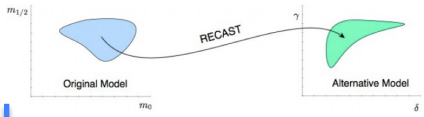
In the original RECAST paper we provided an example, recasting our recent search for Higgs decay to 4 tau-leptons into a limit on other exotic Higgs decays.





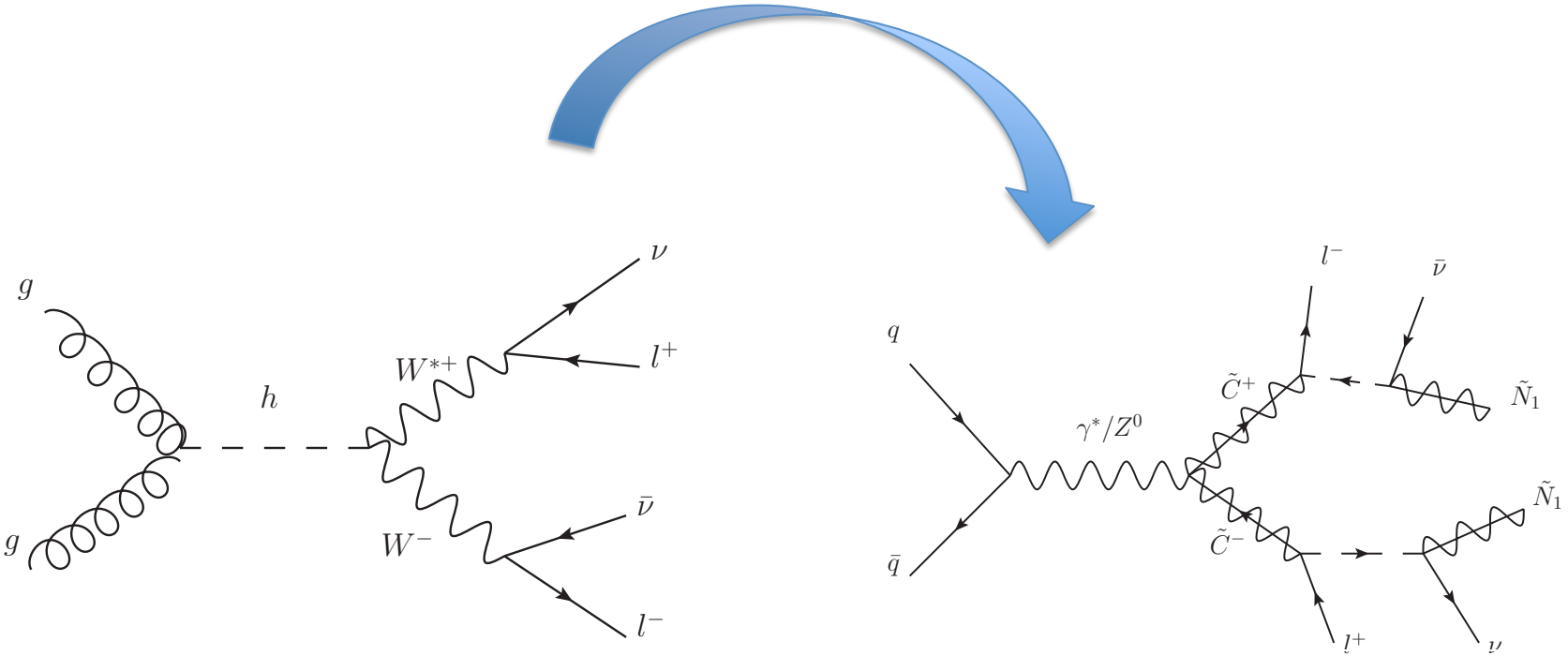
Beacham, Cranmer, and Yavin for the ALEPH collaboration, arXiv:1003.0705, JHEP 1005 (2010) 049

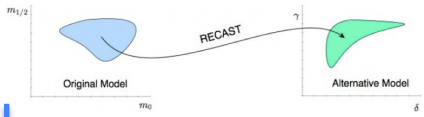
Cranmer and Yavin, arXiv:1010.2506, JHEP 1104 (2011) 038



Search for light electroweakinos from Higgs Searches

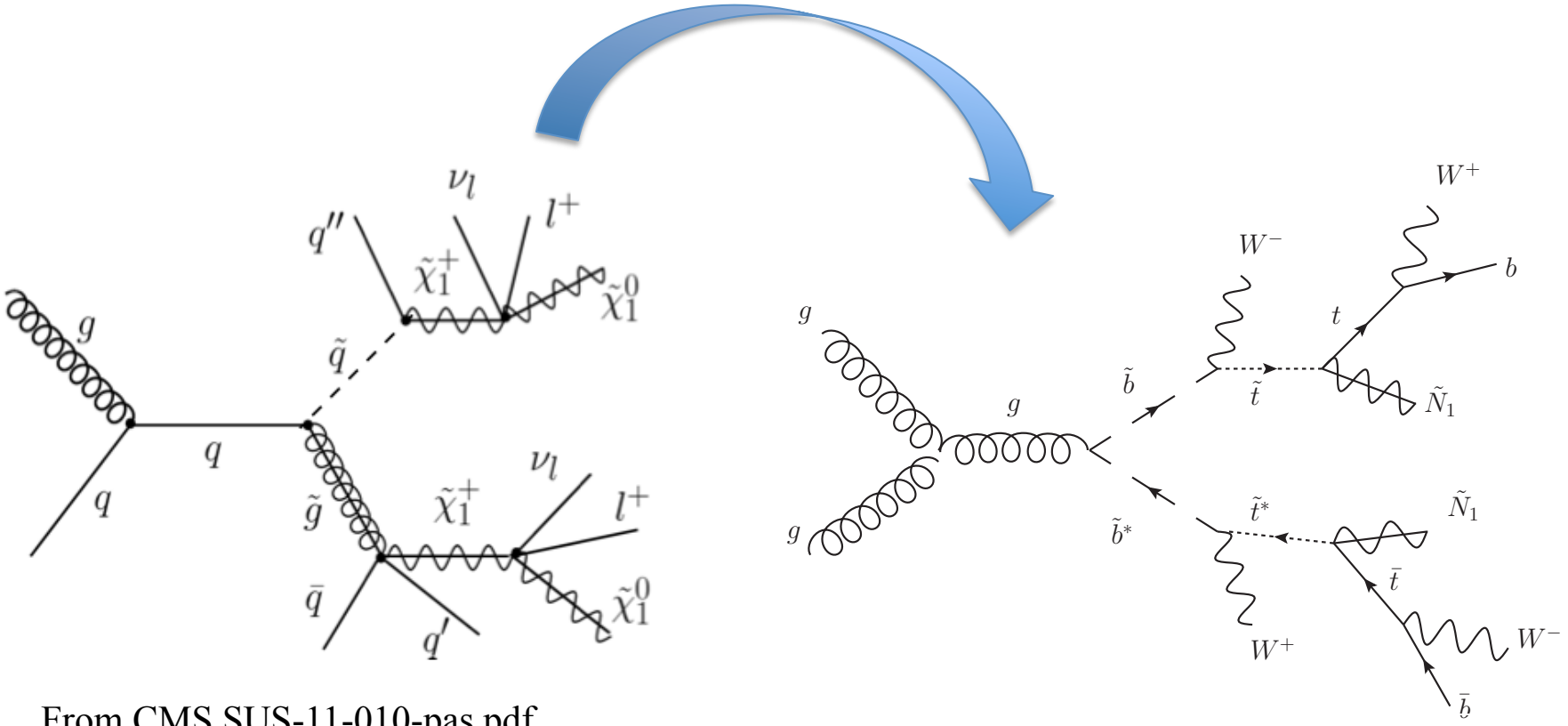
As suggested by M. Lisanti and N. Weiner in arXiv:1112.4834 and RECAST/ 1202.0004, current Higgs searches can be used to place bounds on electroweakino production and decay.



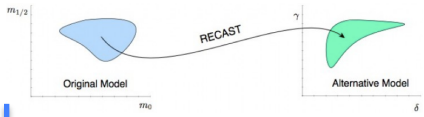


Search for sbottoms from same-sign leptons

As suggested by M. Reece in RECAST/1203.0025 and RECAST/1203.0026, current searches for same-same leptons can also place bounds on sbottom pair production.



From CMS SUS-11-010-pas.pdf



Higgsless search from the search for heavy quarks

As suggested by V. Sanz in RECAST/1203.0024, ATLAS's search for a heavy quark can be recast to a search for the production of heavy quarks in Higgsless models.

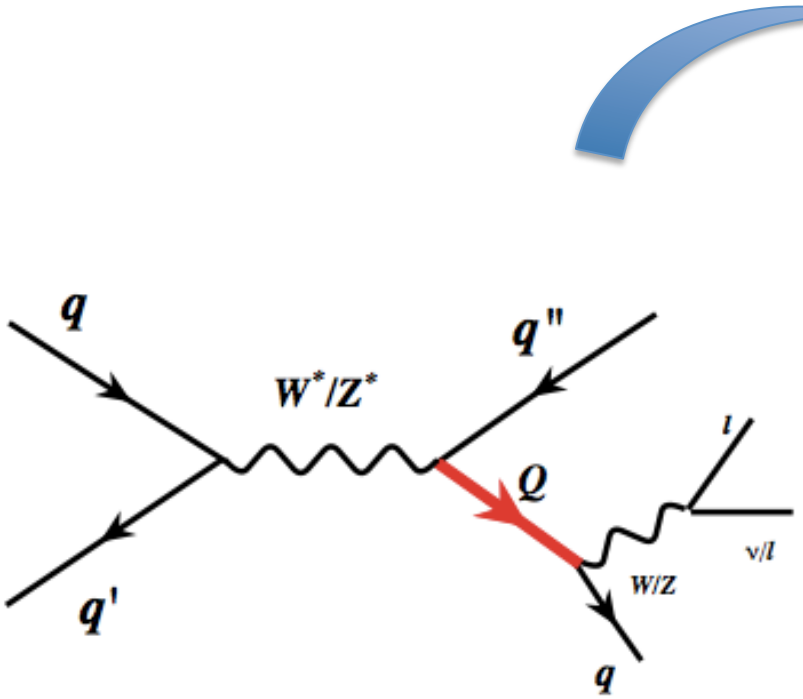


Fig. from ATLAS - 1112.5755

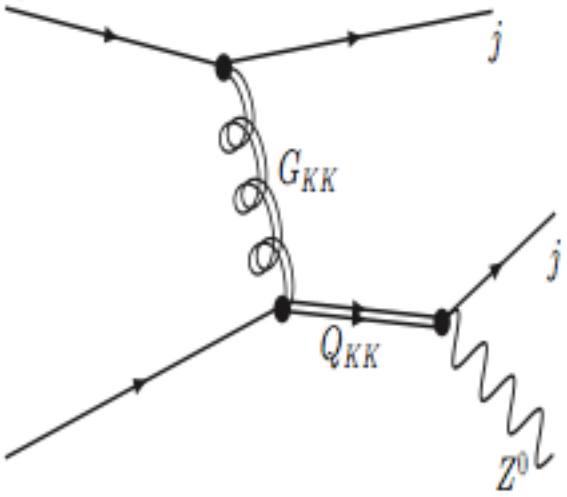
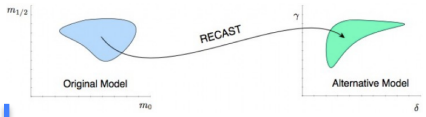
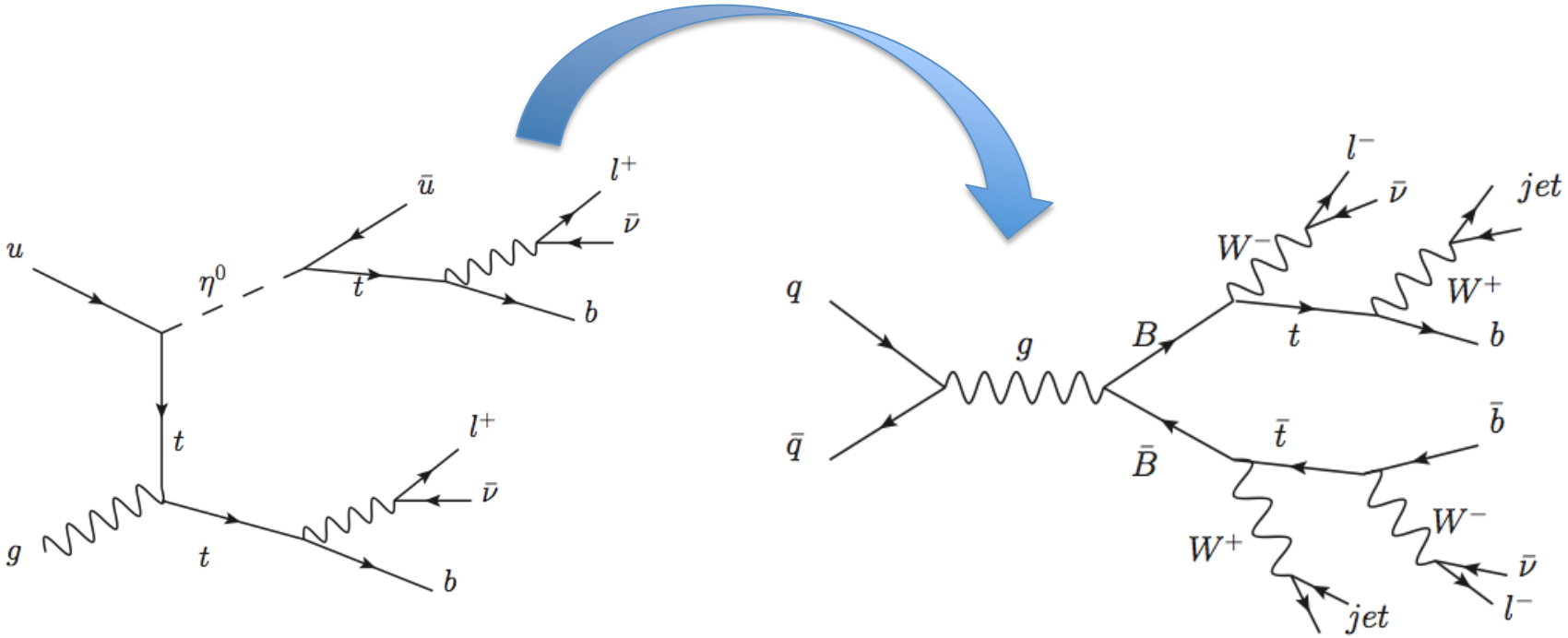


Fig. from Martin & Sanz 1112.5755



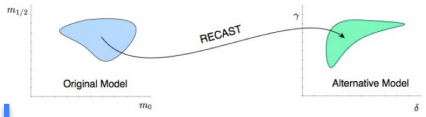
CDF 4th Generation Search

D. Whiteson for CDF recasted a previous search for maximal flavor violating scalars into a search for 4th generation b-quarks. Both scenarios lead to $\ell^{\pm}\ell^{\pm}bj\not{E}_T$



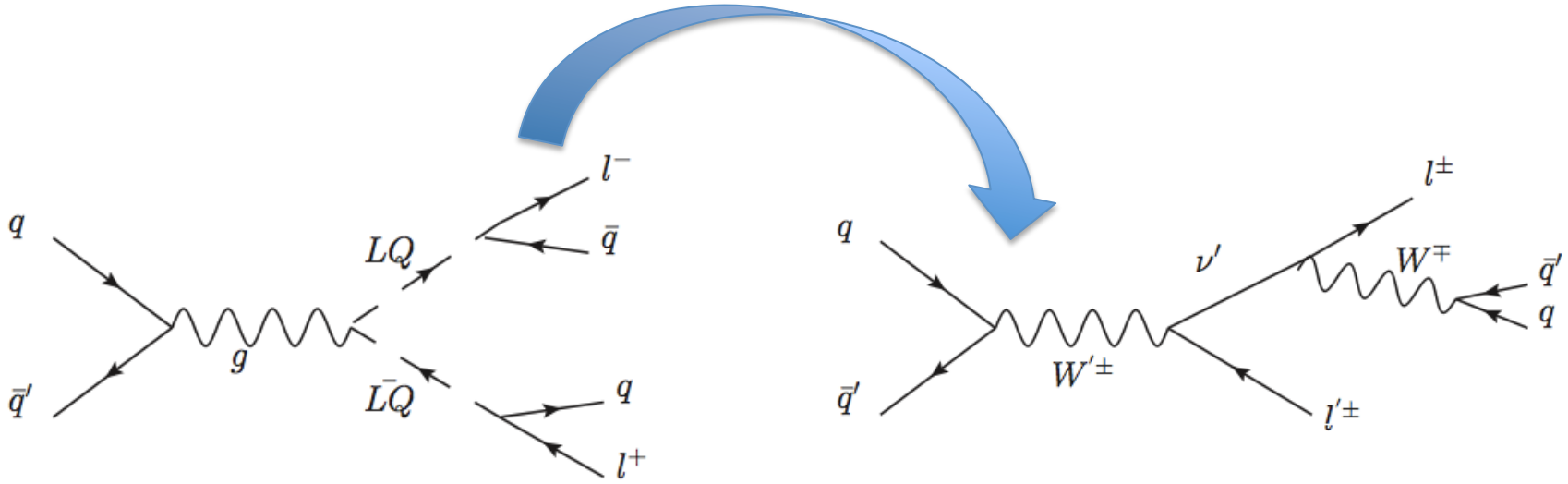
0809.4903

PRL 0912.1057



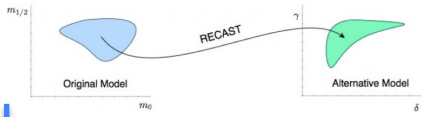
W’ hunt from Leptoquark search

M. Schmaltz and C. Spethmann suggested a recast of a leptoquark search that was done by D0 to place bounds on W’ particles expected in Little Higgs theories,



0710.0255

????.????



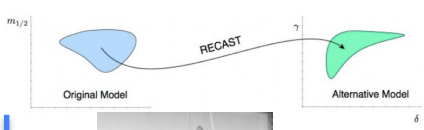
Demonstration

In 1103.3014, *"T-Quarks at the LHC: 2010-12"*, M. Perelstein & J. Shao, recasted a search for SUSY in CMS into a search for T-quarks, which can be thought of as a simplified model for UED and/or Little Higgs models.

They have reproduced a CMS analysis searching for SUSY in jets + missing energy (1101.1628). Maxim and Jing have kindly agreed to use the mock back-end of the analysis they recreated for a demonstration of the RECAST front-end.

Maxim Perelstein
Requester

Jing Shao
Provider



RECAST - Sequence

Initiator : User

RECAST front-end

RECAST API

RECAST back-end

Experimentalist : Subscriber

Analysis Framework

Collaboration Approval Board

Add Request

Notify Subscriber

Accept Request

Send Request (LHE,...)

Document

LHE
T-quarks

Submit Jobs

New Result

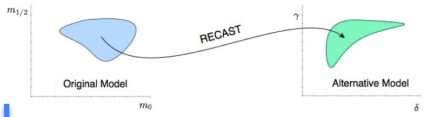
Request Approval

Grant Approval

Send Result

Notify

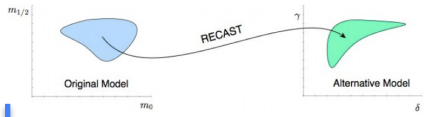
Time



Recasting

- Does not require access to or reprocessing of the data
- Does not involve design of new event selection criteria
- Does not require additional estimates of background rates or systematic uncertainties

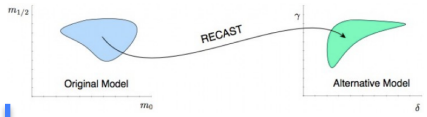
- Extends the impact of existing experimental searches
- Targets physics scenarios of interest to the community
- Provides accurate interpretation of model-independent and signature-based searches in the context of a specific model
- Facilitates the consideration of new models even after the analysis is done
- Allows collaborations to control the approval of new results
- Complements data archival efforts



Future Directions

We will enjoy a wealth of data from the LHC over the next several years.

- We hope that analyses' back-ends will be implemented.
- Many more RECAST results.
- inSpire has expressed interest in RECAST and we hope to integrate it into the new inSpire engine in the future.
- A qualitative change in the way we do hypothesis testing of alternative models.



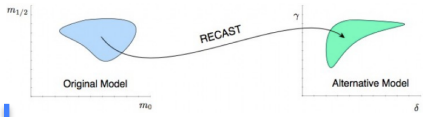
Final Thoughts

• RECAST helps to unleash the full power of all the MC4BSM tools that have been developed.

• RECAST becomes useful when data is no longer exponentiating. Analyses are more precious.

• RECAST is particularly important once an experiment stops running, e.g. Tevatron, LEP2. Also during the LHC shutdown.

• Huge datasets, very large number of models, complex simulation tools – HEP is at the frontier of hypothesis testing. RECAST is the logical next step.

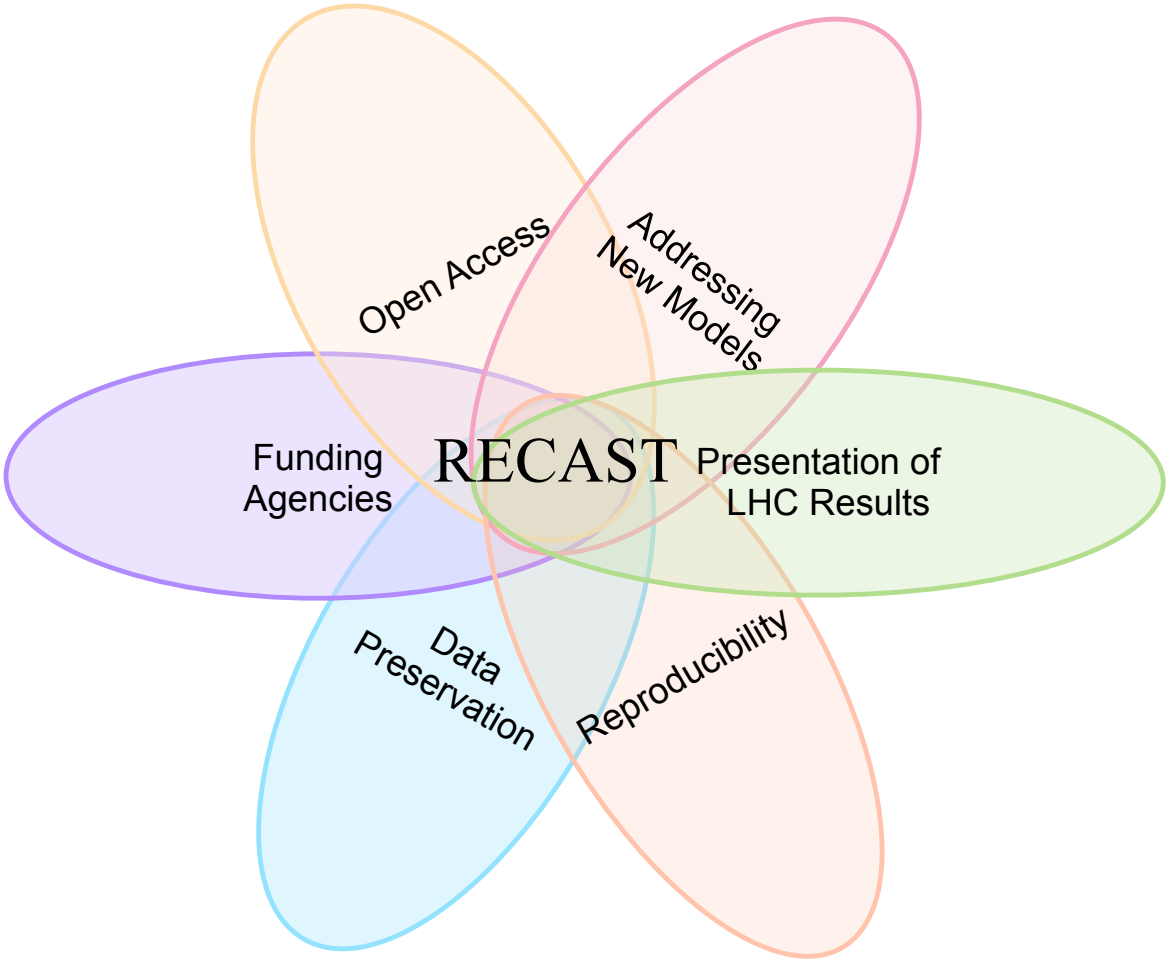


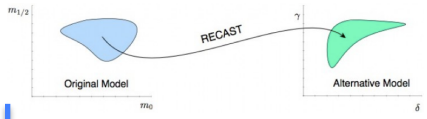
The Big Picture

There are several overlapping discussions where RECAST is relevant:

Physics: Addressing new models, presentation of LHC results.

Policy: data preservation, open access, reproducibility, . . .





The End

Happy Recasting

Visit us and let us know what do you think @

recast.perimeterinstitute.ca

arXiv:1010.2506