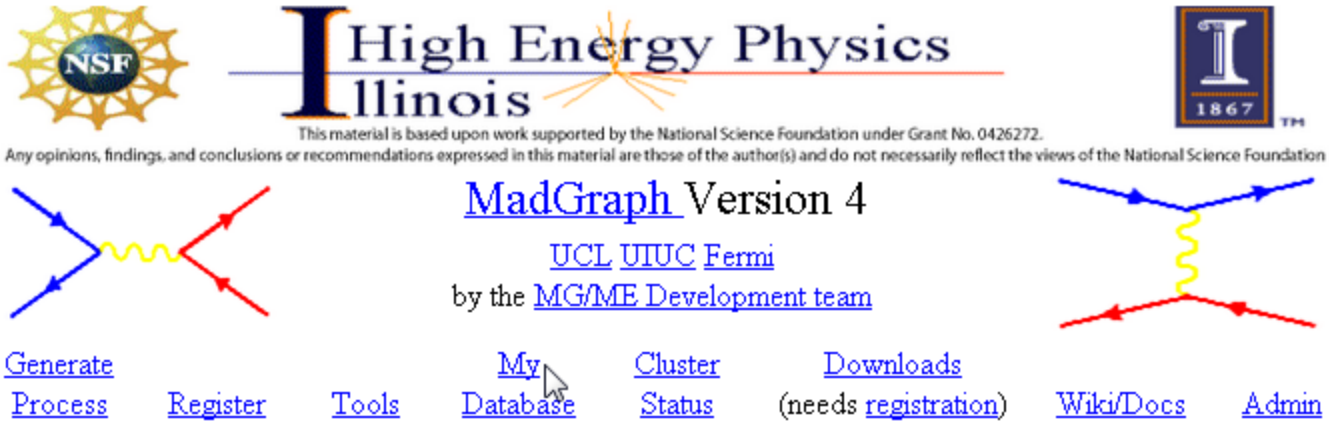
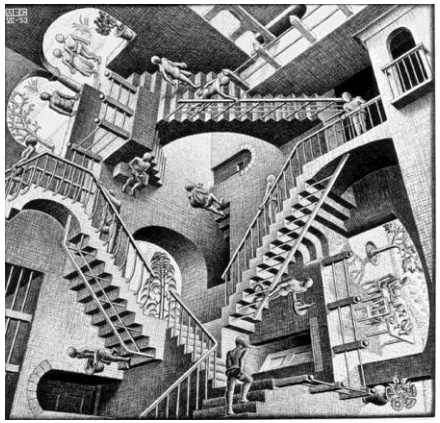
MadGraph/MadEvent

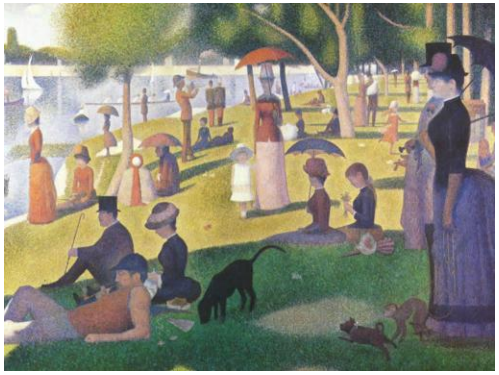


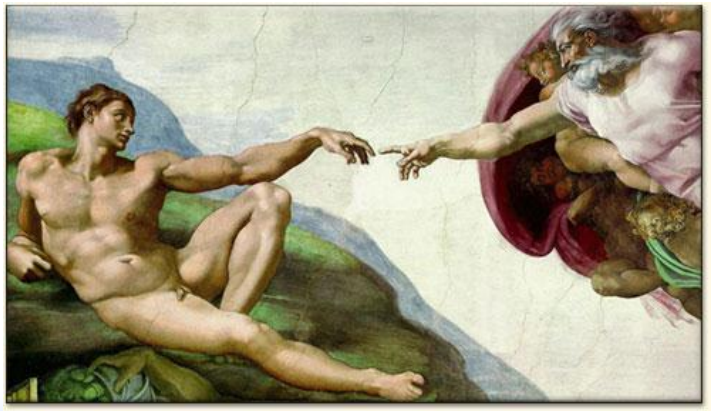
Workshop 1

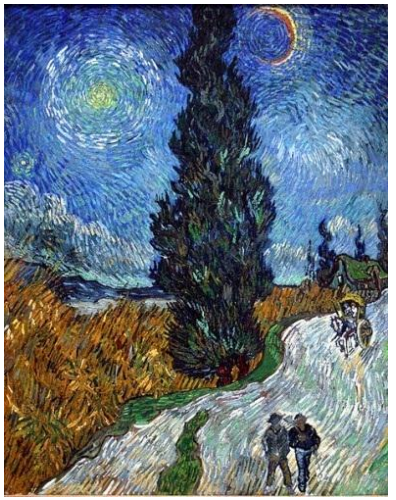
Renormalization / Callibration

Goals





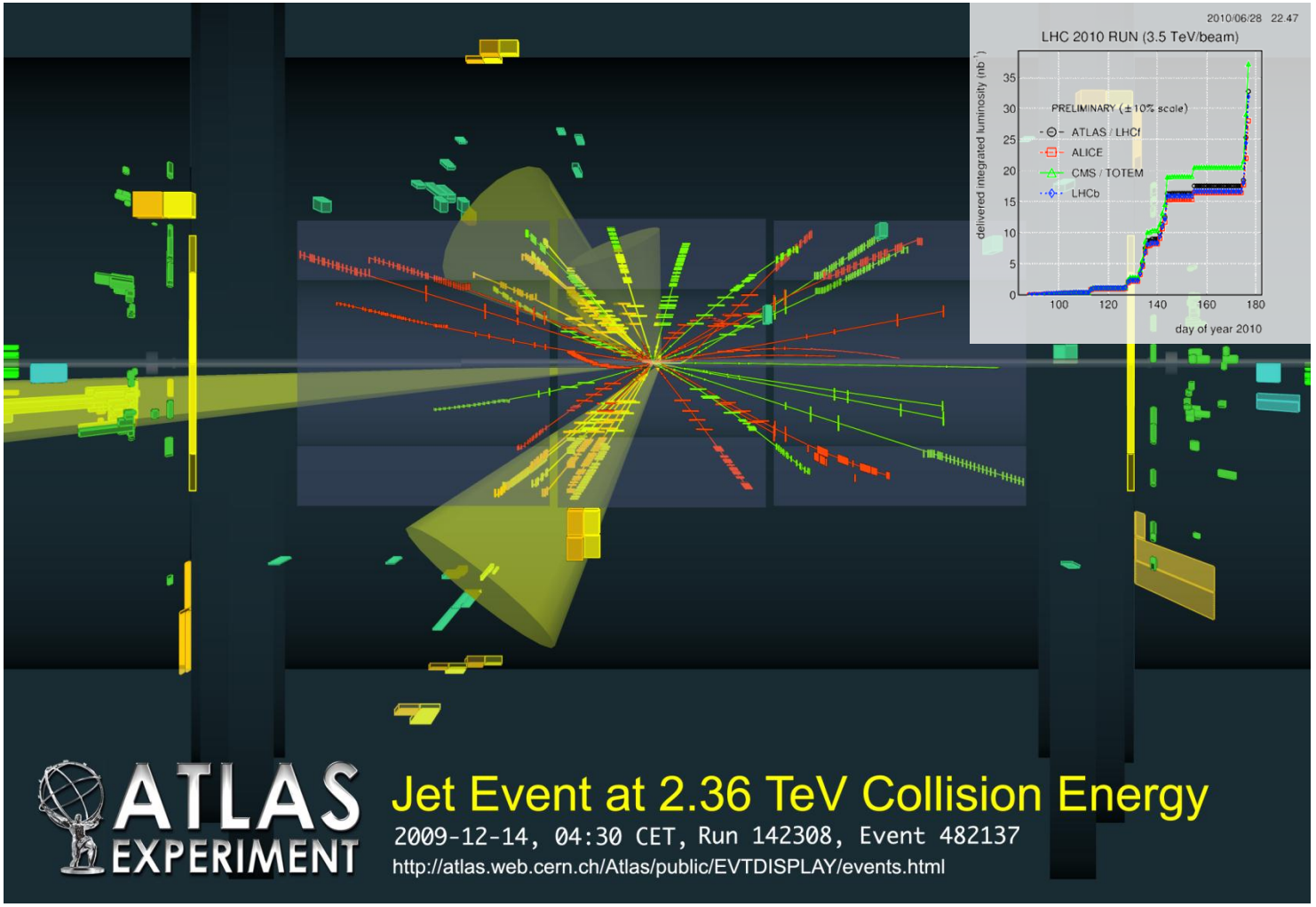




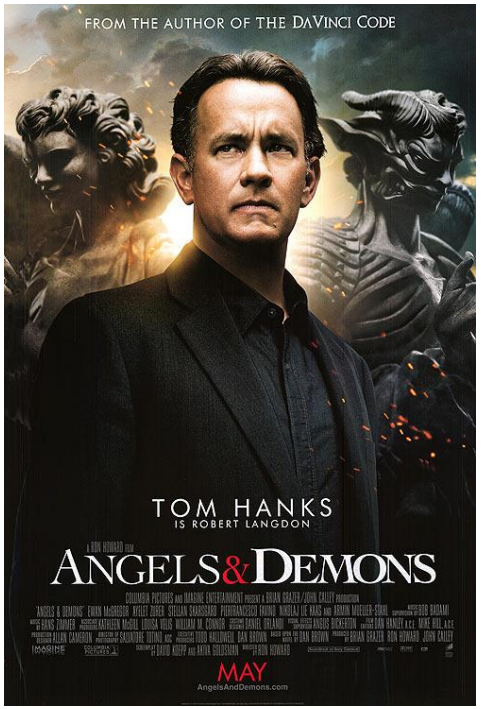
RoadMap

- Motivation, Introduction
- Hadronic Event Generation
- Analysis and Outlook

A Great Time In Physics



A Great Time In Physics



The New York Times

Science

Valerio Mezzanotti for The New York Times

Part of a detector to study results of proton collisions by a particle accelerator that a federal lawsuit filed in Hawaii seeks to stop.

By DENNIS OVERBYE
Published: March 29, 2008

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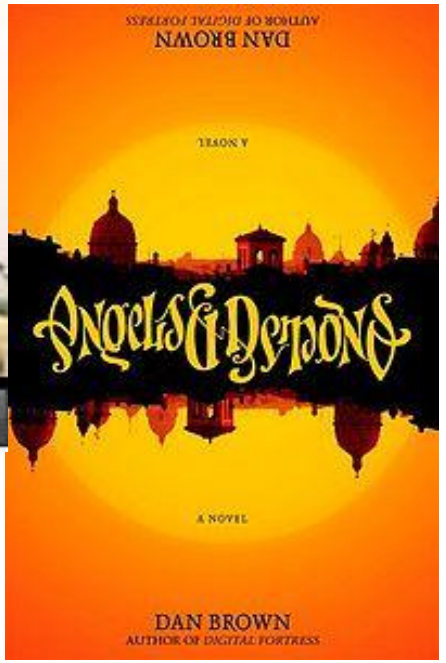
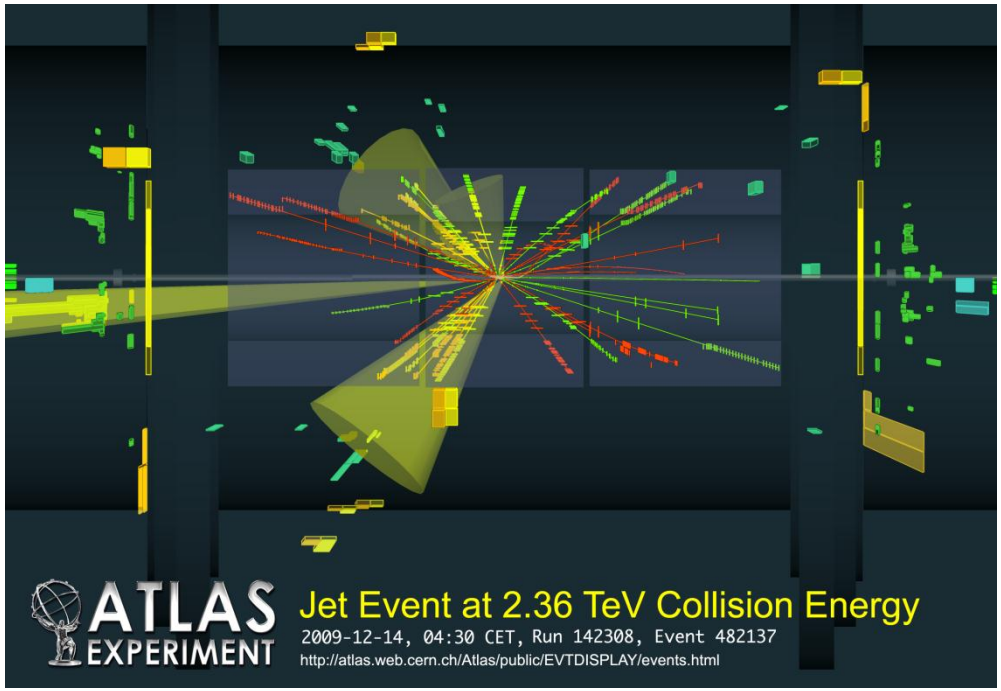
BBC

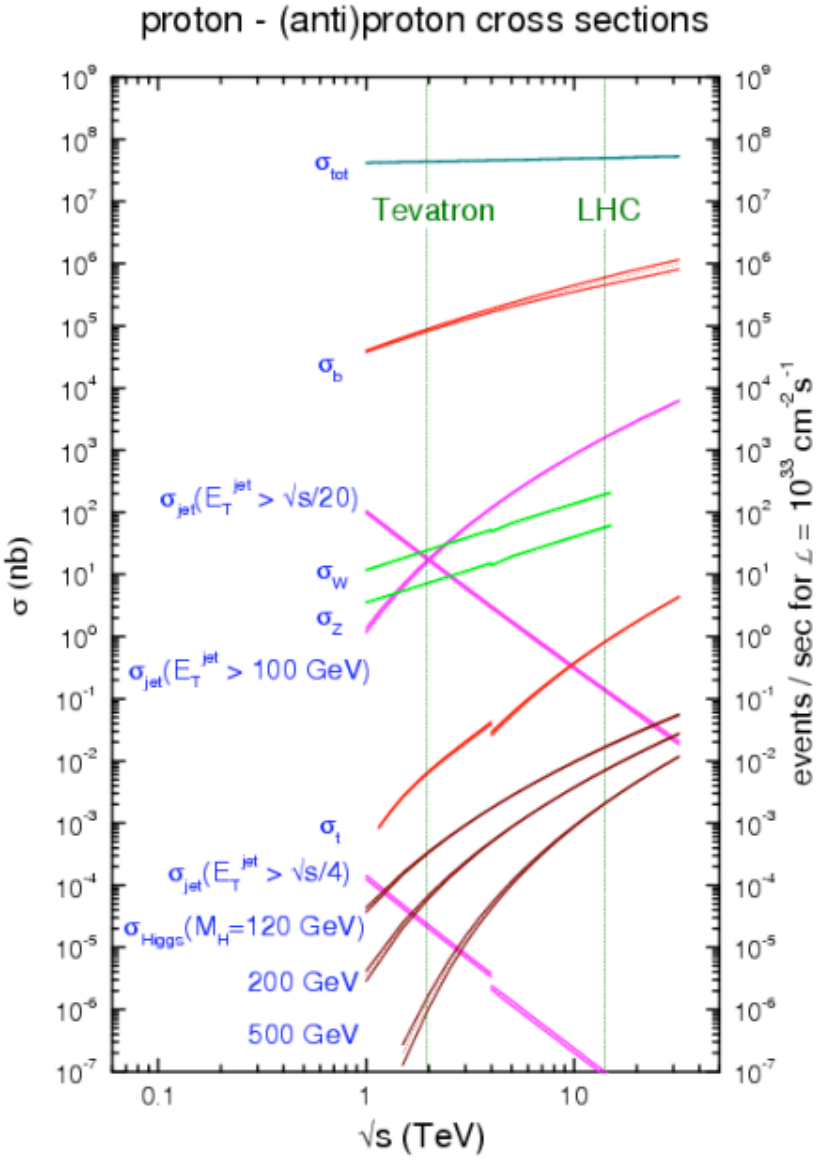


npr

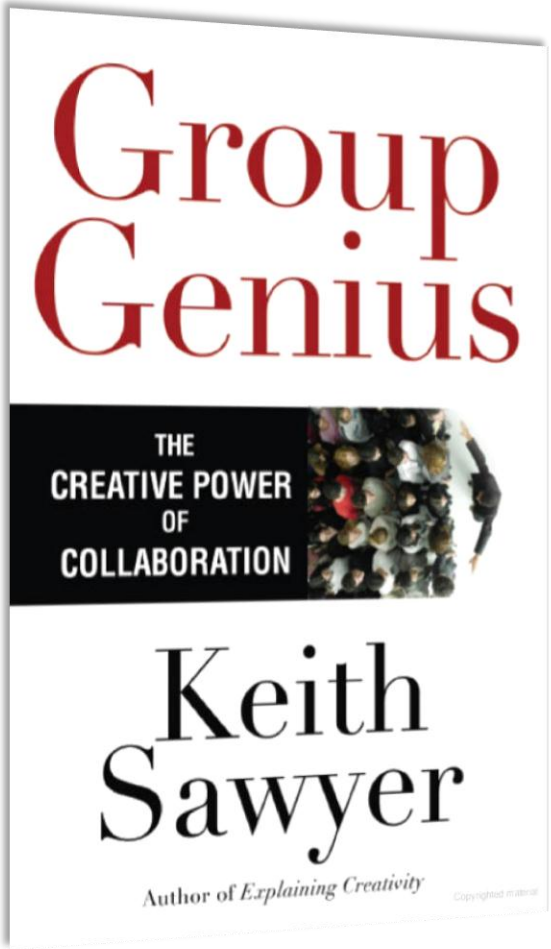
The Challenge

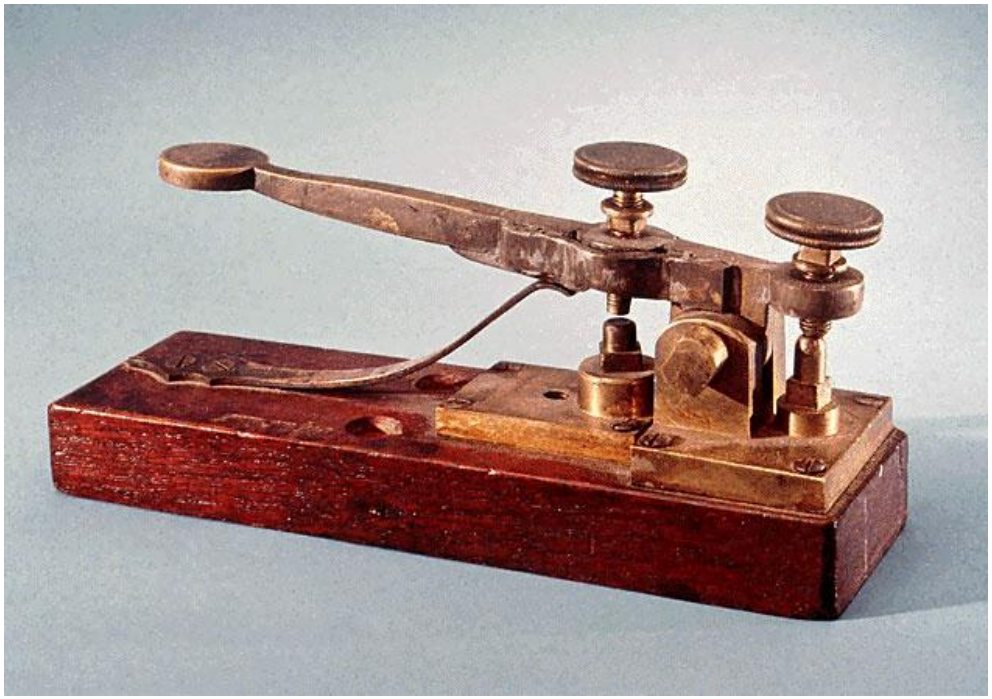
1 / 1,000,000,000





KEY


Group Genius
THE CREATIVE POWER OF COLLABORATION
Keith Sawyer
Author of Explaining Creativity



Form teams of 3

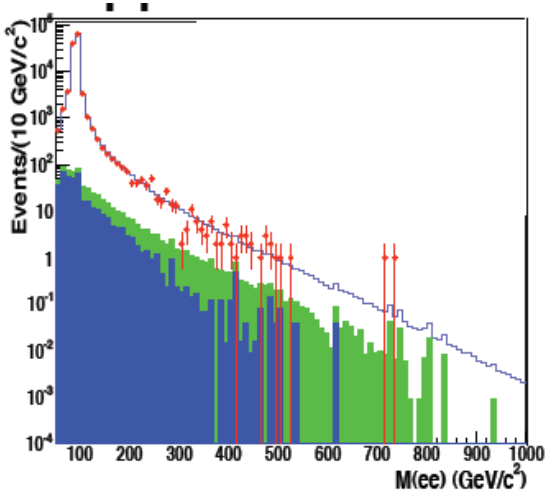
At least 1 computer

At most 2 computers

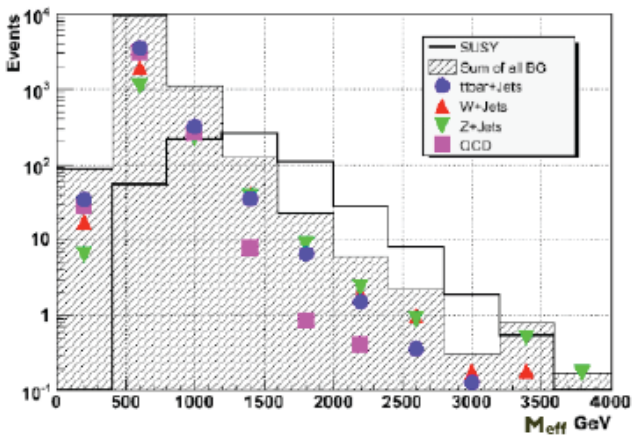
Discoveries at hadron colliders

(adapted from MLM)

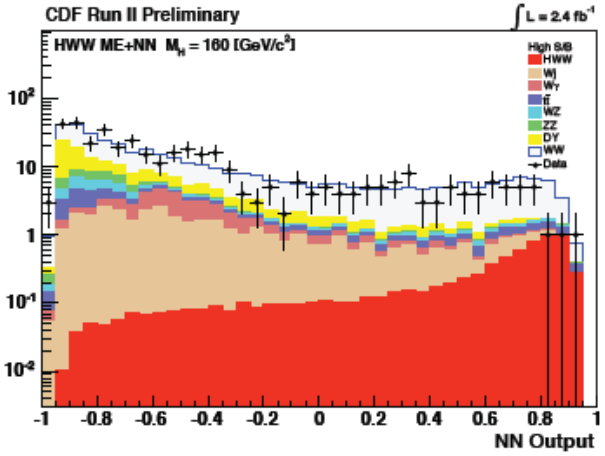
Peak (easy)



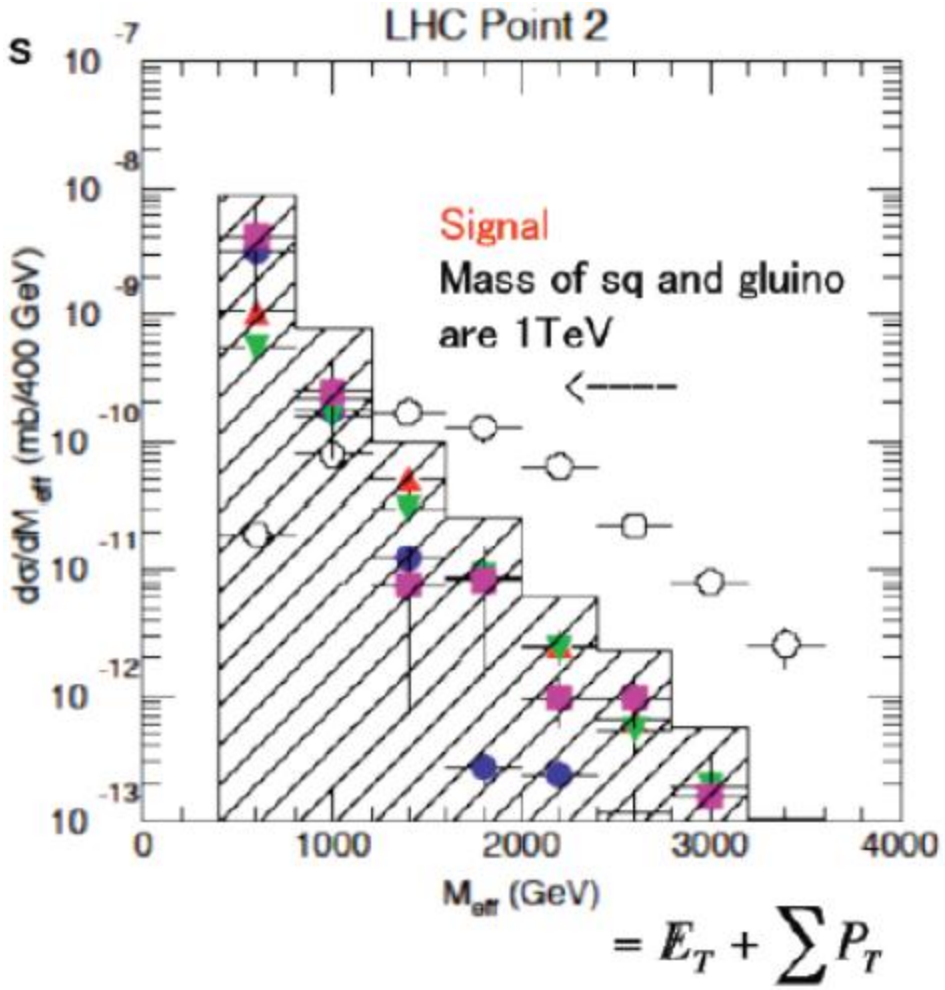
Shape (medium)



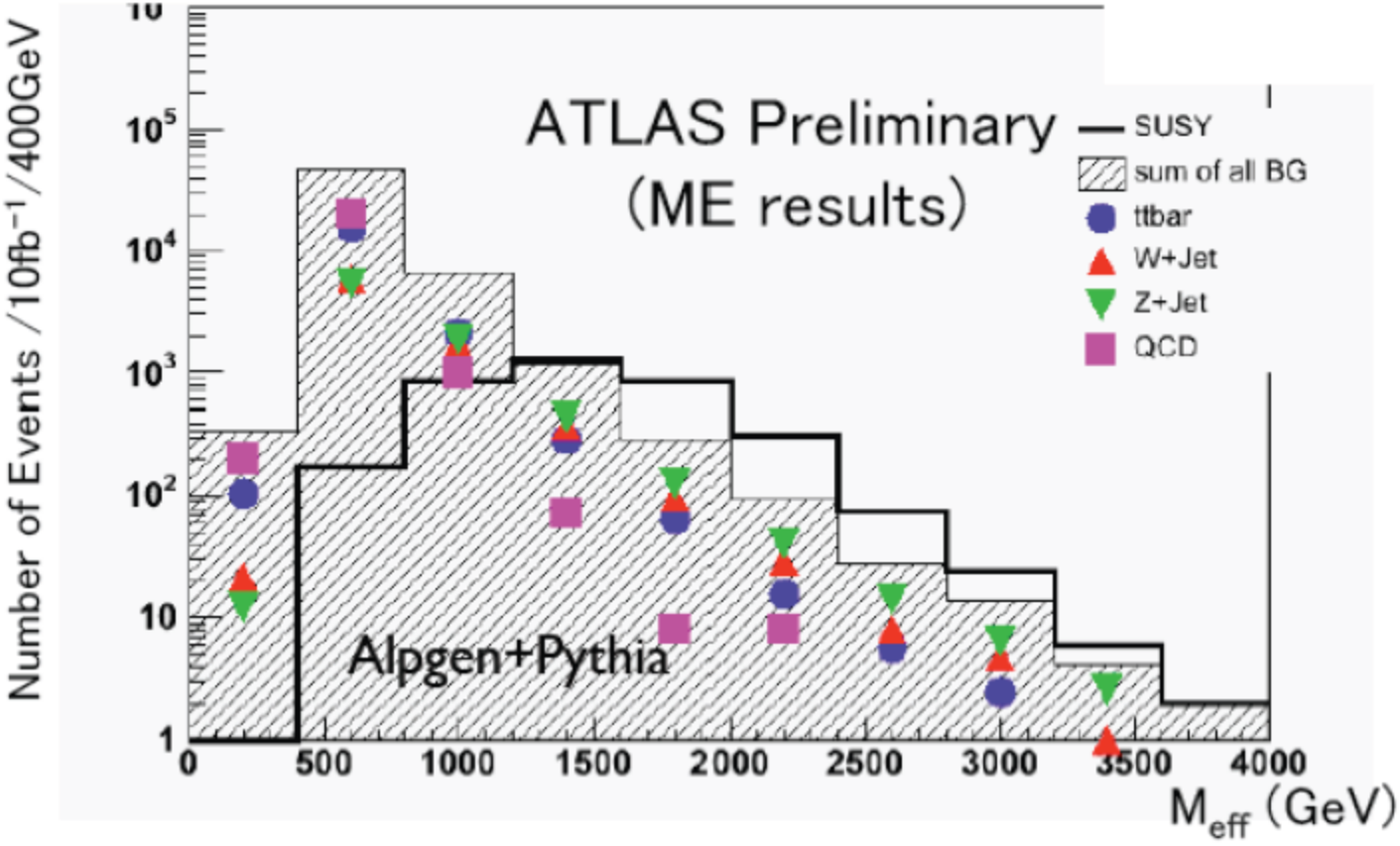
Rate (hard)



SuperSymmetry at LHC

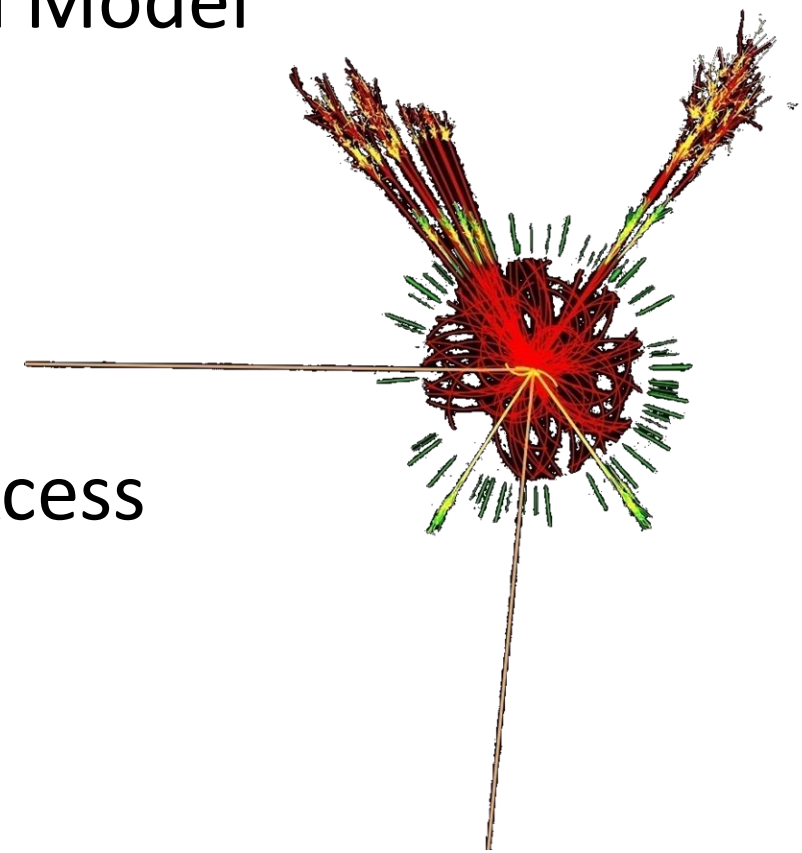


New MC shows much harder!



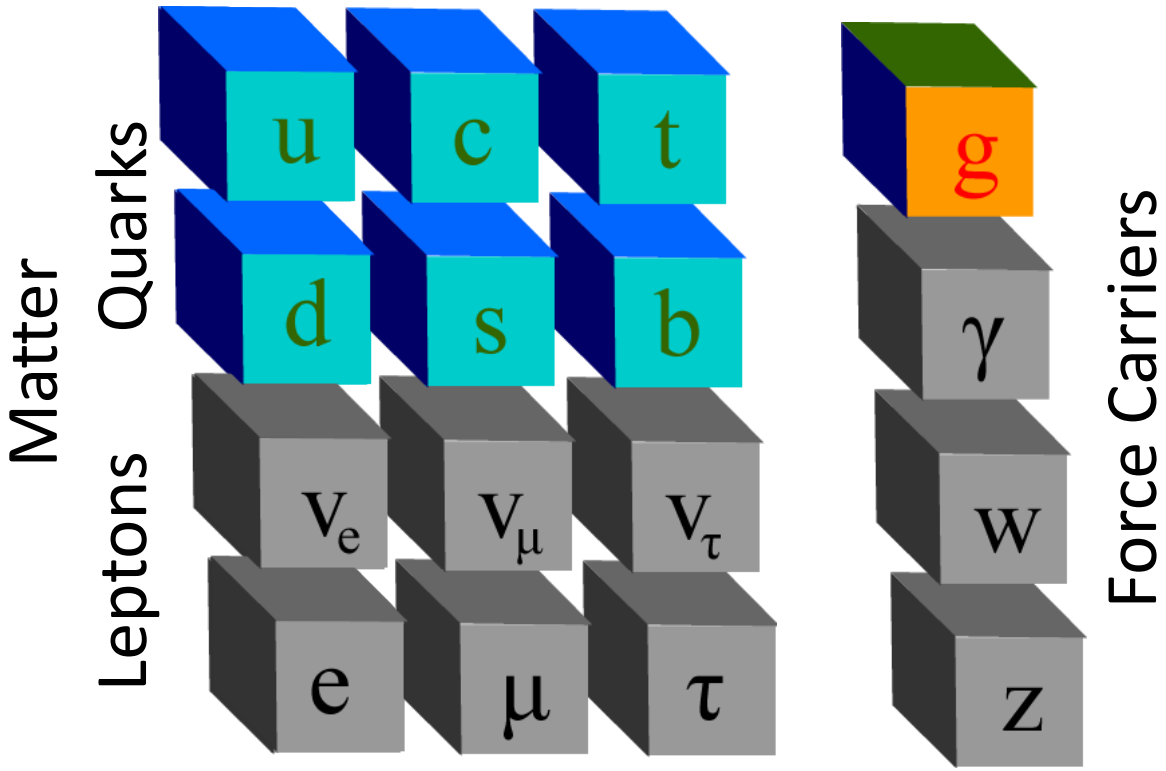
Discovery Path @ LHC

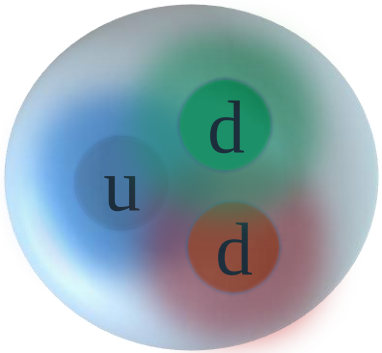
- Rediscover Standard Model
- Identify excess
- Identify nature of excess
- Repeat

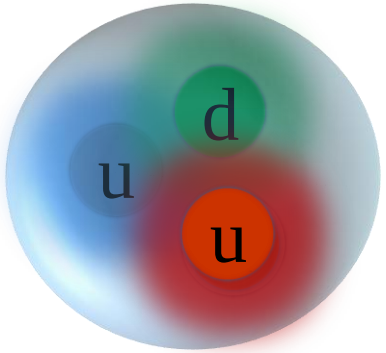


Standard Model

$$E = mc^2$$







Details

$$\mathcal{L}_{QCD} = -\frac{1}{2}\mathrm{Tr}\left(\mathbf{G}^{\mu\nu}\mathbf{G}_{\mu\nu}\right) + \bar{\mathbf{q}}\left[i\gamma^{\mu}\mathbf{D}_{\mu} - m_q\right]\mathbf{q}$$

$$= -\frac{1}{4}\left(\partial^{\mu}G_a^{\nu} - \partial^{\nu}G_a^{\mu}\right)\left(\partial_{\mu}G_{\nu}^{a} - \partial_{\nu}G_{\mu}^{a}\right) + \sum_q \bar{\psi}\left[i\gamma^{\mu}\partial_{\mu} - m_q\right]\psi$$

$$+ \frac{1}{2}\sum_q g_s\left[\bar{q}_{\alpha}\left(\lambda^{a}\right)_{\alpha\beta}\right]$$

$$- \frac{1}{2}g_s f_{abc}\left(\partial_{\mu}G_{\nu}^{a} -$$

$$\mathbf{W}_{\mu\nu} \equiv \frac{i}{g}\left[\mathbf{D}_{\mu}, \mathbf{D}_{\nu}\right] \equiv \frac{\vec{\sigma}}{2}\cdot\vec{W}_{\mu\nu} \rightarrow \mathbf{U}_{\mathrm{L}}\,\mathbf{W}_{\mu\nu}\,\mathbf{U}_{\mathrm{L}}^{\dagger} \quad ; \quad B_{\mu\nu} \equiv \partial_{\mu}B_{\nu} - \partial_{\nu}B_{\mu} \rightarrow B_{\mu\nu}$$

$$W_{\mu\nu}^{i} = \partial_{\mu}W_{\nu}^{i} - \partial_{\nu}W_{\mu}^{i} + g\,\varepsilon^{ijk}\,W_{\mu}^{j}W_{\nu}^{k}$$

$$\mathcal{L}_{\mathrm{K}} = -\frac{1}{4}B_{\mu\nu}B^{\mu\nu} - \frac{1}{2}\mathrm{Tr}\left(\mathbf{W}_{\mu\nu}\mathbf{W}^{\mu\nu}\right) = -\frac{1}{4}B_{\mu\nu}B^{\mu\nu} - \frac{1}{4}\vec{W}_{\mu\nu}\vec{W}_{\mu\nu} = \mathcal{L}_{\mathrm{kin}} + \mathcal{L}_3 + \mathcal{L}_4$$

$$\mathcal{L}_3 = -ie\cot\theta_W\left\{\left(\partial^{\mu}W^{\nu} - \partial^{\nu}W^{\mu}\right)W_{\mu}^{\dagger}Z_{\nu} - \left(\partial^{\mu}W^{\nu\dagger} - \partial^{\nu}W^{\mu\dagger}\right)W_{\mu}Z_{\nu} + W_{\mu}W_{\nu}^{\dagger}\left(\partial^{\mu}Z^{\nu} - \partial^{\nu}Z^{\mu}\right)\right\}$$

$$-ie\left\{\left(\partial^{\mu}W^{\nu} - \partial^{\nu}W^{\mu}\right)W_{\mu}^{\dagger}A_{\nu} - \left(\partial^{\mu}W^{\nu\dagger} - \partial^{\nu}W^{\mu\dagger}\right)W_{\mu}A_{\nu} + W_{\mu}W_{\nu}^{\dagger}\left(\partial^{\mu}A^{\nu} - \partial^{\nu}A^{\mu}\right)\right\}$$

$$\mathcal{L}_4 = -\frac{e^2}{2\sin^2\theta_W}\left\{\left(W_{\mu}^{\dagger}W^{\mu}\right)^2 - W_{\mu}^{\dagger}W^{\mu\dagger}W_{\nu}W^{\nu}\right\} - e^2\cot^2\theta_W\left\{W_{\mu}^{\dagger}W^{\mu}Z_{\nu}Z^{\nu} - W_{\mu}^{\dagger}Z^{\mu}W_{\nu}Z^{\nu}\right\}$$

$$-e^2\cot\theta_W\left\{2W_{\mu}^{\dagger}W^{\mu}Z_{\nu}A^{\nu} - W_{\mu}^{\dagger}Z^{\mu}W_{\nu}A^{\nu} - W_{\mu}^{\dagger}A^{\mu}W_{\nu}Z^{\nu}\right\} - e^2\left\{W_{\mu}^{\dagger}W^{\mu}A_{\nu}A^{\nu} - W_{\mu}^{\dagger}A^{\mu}W_{\nu}A^{\nu}\right\}$$

Perturbation Theory

$$\sigma = \frac{1}{2s}\int |M|^2 \, d\Phi$$

$$M = \left\langle \mu^+\mu^- \left| T\left(e^{-i\int H_I dt}\right) \right| e^+e^- \right\rangle \qquad H_I \approx 0$$

$$M \approx \left\langle \mu^+\mu^- \left| H_{\text{int}} \right| e^+e^- \right\rangle$$

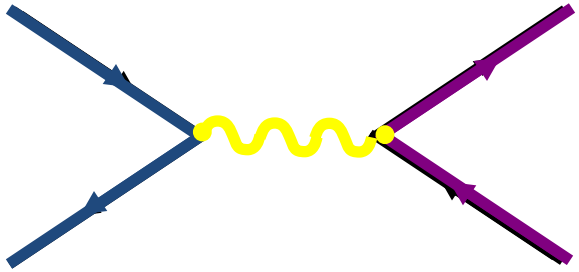
Example: $e^+e^- \rightarrow \mu^+\mu^-$

- Scattering cross section

$$\sigma = \frac{1}{2s}\int |M|^2 \, d\Phi$$

$$M \approx \langle \mu^+\mu^- | H_{\text{int}} | e^+e^- \rangle + \ldots$$

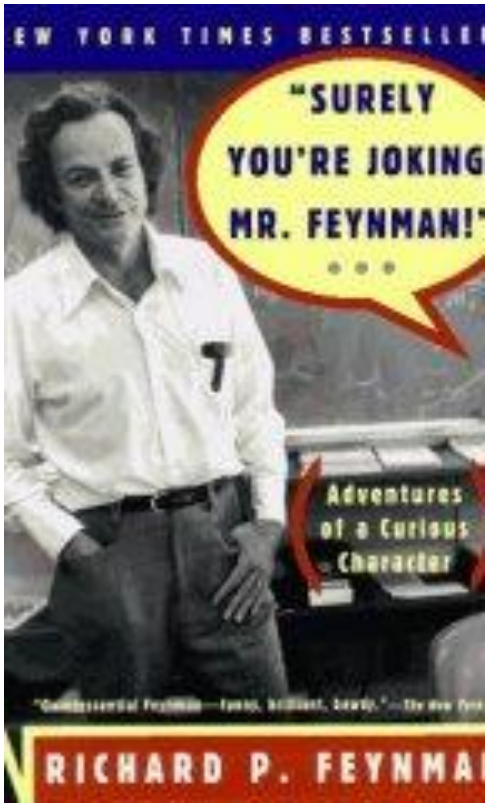
- Feynman Diagrams



$$M \approx \bar{v}(e^+)\,(-iq\gamma^\mu)\,v(e^-)\,\frac{-ig_{\mu\nu}}{p^2}\,\bar{u}(\mu^+)(-iq\gamma^\nu)u(\mu^-)$$

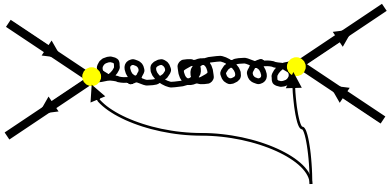
Feynman Rules!

γ	QED	$q\bar{q}\gamma$ $l^-l^+\gamma$	$W^+W^-\gamma$	
Z	QED	$q\bar{q}Z$ $l\bar{l}Z$	W^+W^-Z	
W^{+-}	QED	$q\bar{q}'W$ $l\nu W$		$WWWW$
g	QCD	$q\bar{q}g$	ggg	$gggg$
h	QED (m)	$q\bar{q}h$ $l\bar{l}h$	W^+W^-h	ZZh



Feynman Rules!

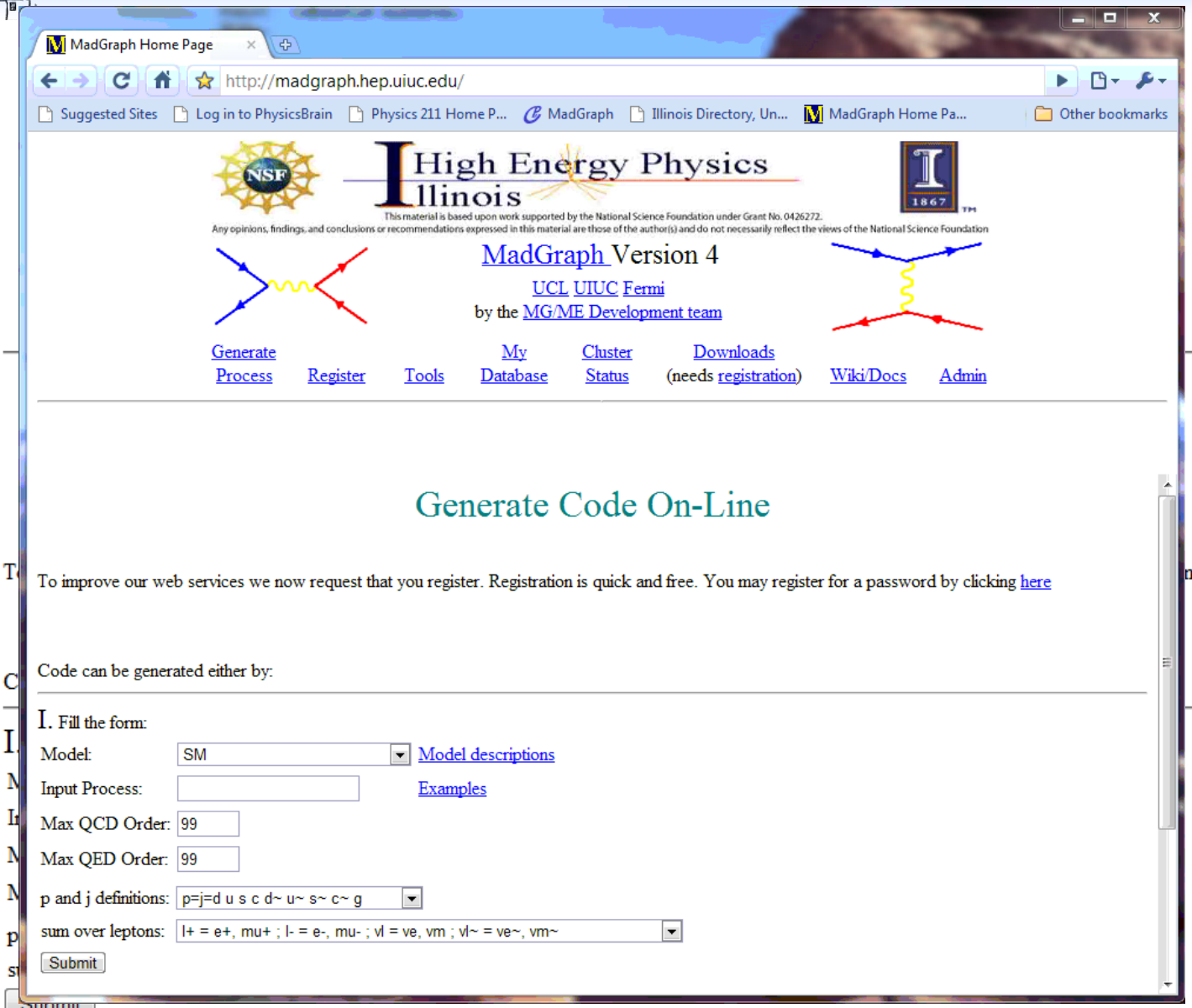
- These are basic building blocks, combine to form “allowed” diagrams
  - e.g. u u~ -> t t~



Order is QCD^2

γ	QED	$q\bar{q}\gamma$ $l^-l^+\gamma$	$W^+W^-\gamma$	
Z	QED	$q\bar{q}Z$ $l\bar{l}Z$	W^+W^-Z	
W	QED	$q\bar{q}'W$ $l\nu W$		$WWWW$
g	QCD	$q\bar{q}g$	ggg	$gggg$
h	QED (m)	$q\bar{q}h$ $l\bar{l}h$	W^+W^-h	ZZh

- Draw Feynman diagrams:
  - gg -> tt~ (gg -> bb~ e+ ve j j)
  - gg -> tt~h
- Determine “order” for each diagram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MadGraph Version 4
UCL UIUC Fermi
by the MG/ME Development team
Generate Process
Register
Tools
My Database
Cluster Status
Downloads (needs registration)
Wiki/Docs
Admin
Generate Code On-Line
To improve our web services we now request that you register. Registration is quick and free. You may register for a password by clicking here
Code can be generated either by:
I. Fill the form:
Model: SM
Model descriptions
Input Process:
Examples
Max QCD Order: 99
Max QED Order: 99
p and j definitions: p=j=d u s c d~ u~ s~ c~ g
sum over leptons: l+ = e+, mu+ ; l- = e-, mu- ; vl = ve, vm ; vl~ = ve~, vm~
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High Energy Physics Illinois

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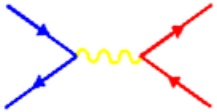
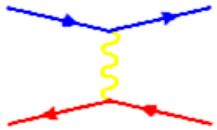


MadGraph Version 4

UCL UIUC Fermi

by the MG/ME Development team



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http://madgraph.hep.uiuc.edu/

MadGraph/MadEvent Registration

Please complete the form below. Your username and password will be sent to the e-mail address you enter.

First Name: Tim

Family Name: Stelzer

Name of your institution: Cargese

Your e-mail address: tstelzer@illinois.edu

The letter sequence you can read on the following image: xspkek

SUBMIT