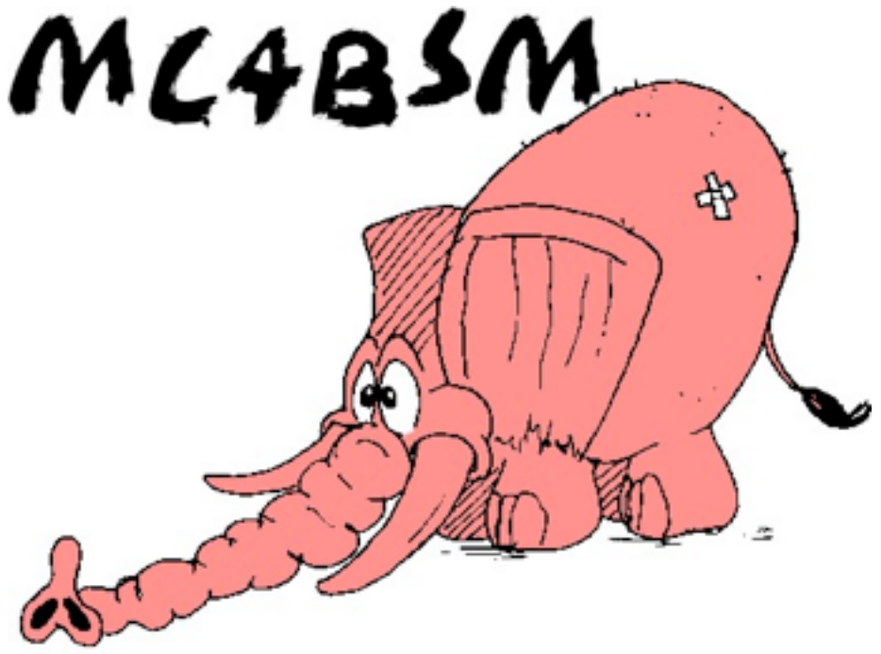


Monte Carlo Tools for Beyond the Standard Model Physics

P. Skands (CERN PH/TH)

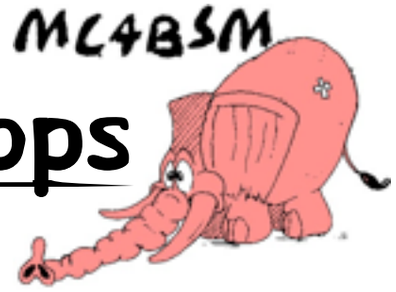
Next Workshop: Copenhagen, Apr 14-16, 2010

http://mc4bsm.nbi.dk/

- The mechanism which breaks electroweak symmetry remains a fundamental, unsolved mystery
- It must involve new physics at the TeV scale
- Several theoretical ideas for what new physics might be have been proposed: supersymmetry, dynamical symmetry breaking, extra dimensions, little higgs, ...
- True model is unknown: only indirect constraints and theoretical prejudice to guide us at this point...
- All models predict discoveries at the LHC - theory will be confronted with data soon!
- Detailed predictions will be needed for theoretical interpretation of the data

Perelstein, MC4BSM 2008

Motivation for the MC4BSM Workshops



- Generic problems
  - Experimentalists' complaints
    - "This model is very nice, but do you have an event generator for it? Is this model in PYTHIA? ..."
  - Lack of manpower among MC writers
  - Too many/too active model builders

$$N_{\text{model builders}} >> N_{\text{MC writers}}$$

  - As a result,

$$N_{\text{existing models}} >> N_{\text{implemented models}}$$

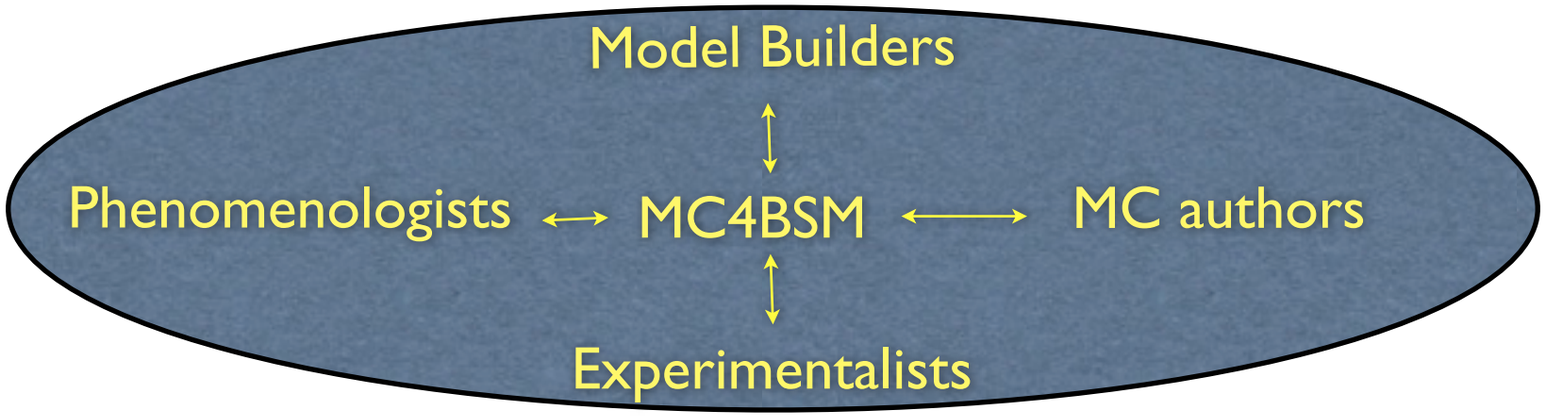
  - Actually it is even worse:

$$\frac{dN_{\text{existing models}}}{dt} >> \frac{dN_{\text{implemented models}}}{dt}$$

Matchev, MC4BSM 2009

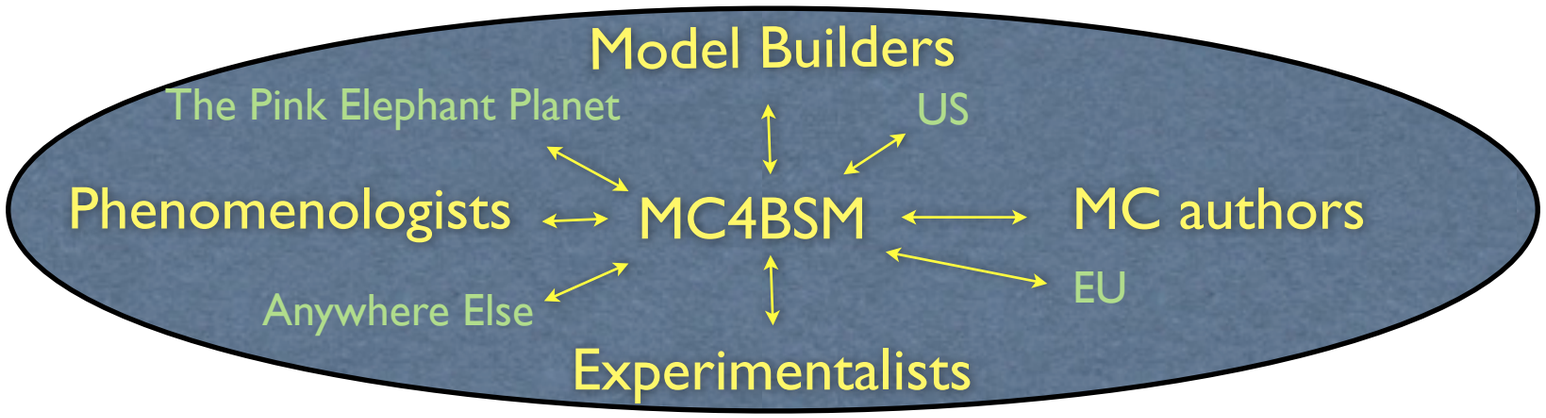
- **Aim:**

To facilitate collider pheno studies of new physics models



- **Content:** 2-3 days with overviews and implementations plus plenty of time for discussions, tutorials, ...
  - **Emphasis on <u>new</u> physics**
    - Little focus on (mainstream) SUSY since already vast array of SUSY tools + workshops

Strong Modeling Community in US
Strong MC Community in Europe



- Fermilab March 2006
- Princeton March 2007
- CERN March 2008
- UC Davis Apr 2009
- Copenhagen Apr 2010

- + Emphasis on travel support for overseas transport
- + Emphasis on travel support for young people

"NEW PHYSICS PIPELINE"

Build a Model

Identify Collider Signatures

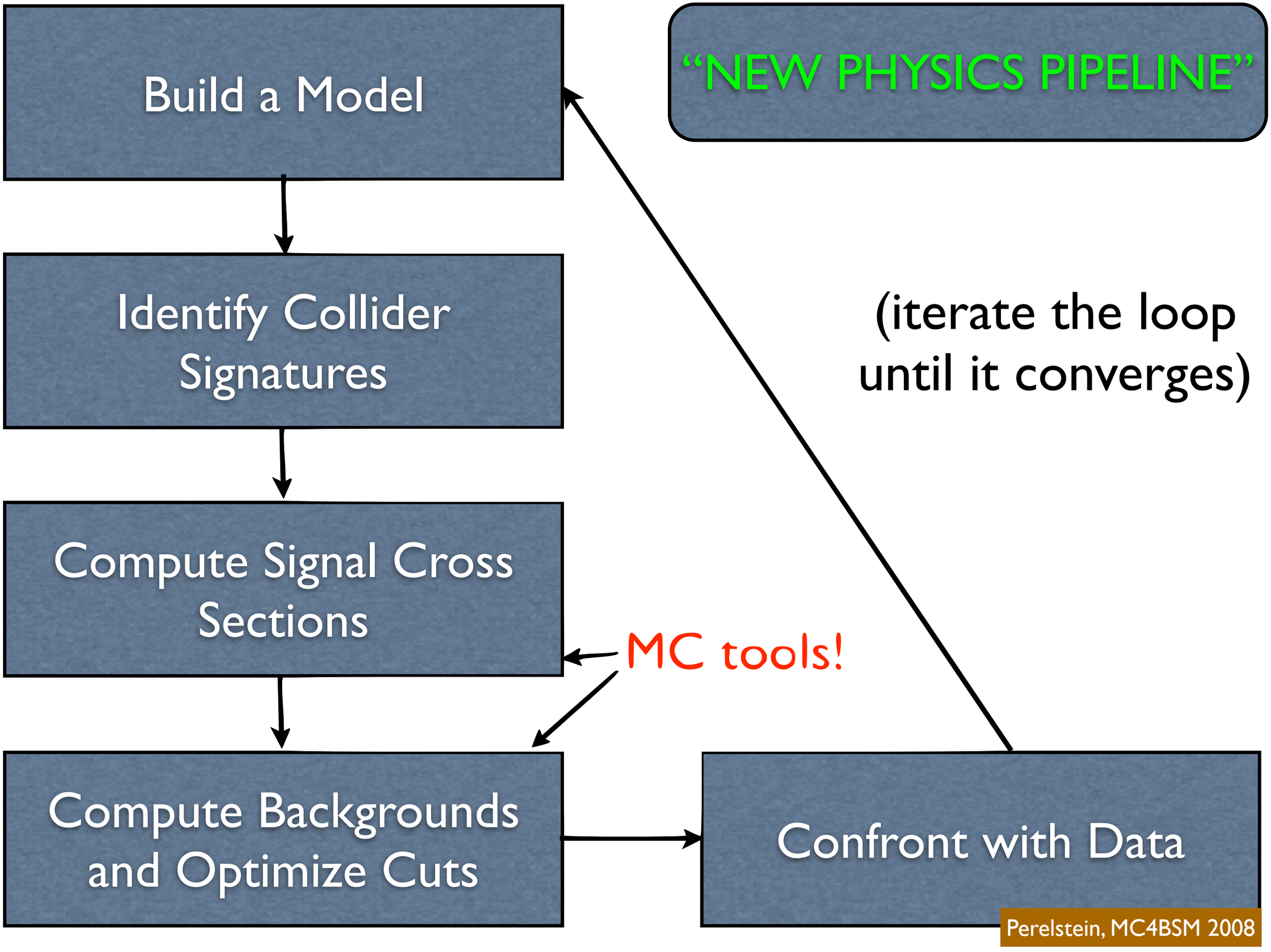
Compute Signal Cross Sections

MC tools!

Compute Backgrounds and Optimize Cuts

Confront with Data

Perelstein, MC4BSM 2008


Build a Model
Identify Collider Signatures
Compute Signal Cross Sections
Compute Backgrounds and Optimize Cuts
Confront with Data
"NEW PHYSICS PIPELINE"
(iterate the loop until it converges)
MC tools!
Perelstein, MC4BSM 2008

- Since models will change "in real time", flexibility is the key desired feature of the BSM MC tools

- In the past, general-purpose MC tools had a small number of models (or processes) hard-wired, with significant effort and expert-level coding required to add a new model/ process

- Now: any new physics model can be realistically simulated within hours by a physicist with rudimentary software skills (e.g. myself) as long as:

  - all new particles are spin <=2
  - couplings of "known" Lorentz structures only
  - no new long-lived colored states or exotic color rep's

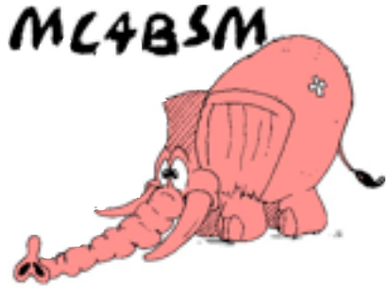
- Full implementation of such models ahead of data seems unnecessary; removing these limitations is more useful

Maxim Perelstein

Perelstein, MC4BSM 2008

Tools

- **2 Philosophies**
  - Modular *(divide et impera)*
    - Minimal capabilities in general-purpose generators
    - Interfaced chain of special-purpose tools => BSM-LHEF
    - *Caesar, Machiavelli, CompHEP/CalcHEP, MadGraph, Bridge, (Herwig), Pythia, Whizard, EvtGen, Photos, Tauola, ...*
  - Monolithic *(superior force)*
    - Everything in one => LHEF is pointless
    - *Genghis Khan, Attila the Hun, Sherpa, (Herwig++)*



Tools

- **2 Philosophies**
  - Modular *(divide et impera)*

    Flexible and can **specialize** on one thing
    User needs to run **more codes**
    Have to maintain/debug the **interfaces**

  - Monolithic *(superior force)*

    User needs to run one code: **cleaner**
    Have to do **everything yourself**

Tools Readiness

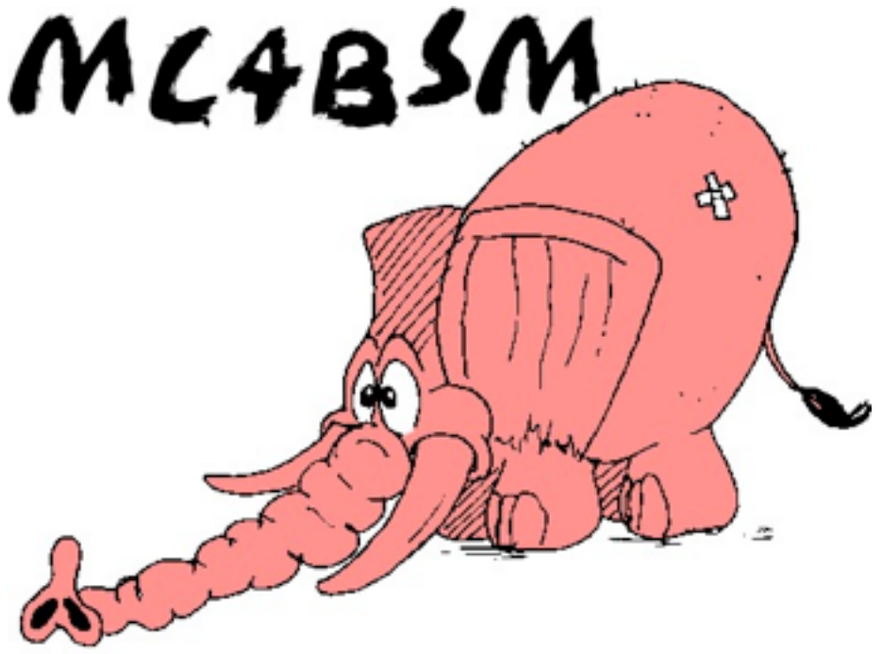
- By now, relatively straightforward to go from:
  - Model to Model File *(coded Lagrangian)*
    - LanHEP, FeynRules (Mathematica package)
  - Model File to Fixed-Order Events
    - CalcHEP, CompHEP, Herwig++, MadGraph, Sherpa, Whizard
  - Fixed-Order to Particle-Level Events
    - Herwig++, Pythia (via BSM-LHEF), Sherpa

Still missing: know-how

Experimentalist: *which models are out there? What are their signatures?* Model Builder: *how do I 'provide' my model?*
Phenomenologist: *how do I get events for this model?* MC author: *how do I minimize the work I have to do?*

Tools Readiness

- **The function of** MC4BSM
  - **To survey** what is available. To provide feedback on user experiences with Monte Carlo tools for BSM
  - **To identify** promising models (or processes) for which the tools have not yet been constructed and start filling up these gaps.
  - **To propose** ways to streamline the process of going from models to events, i.e. to make the process more user-friendly so that more people can get involved and perform serious collider studies outside of the MSSM



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Registration Closes Apr 1 (will probably be extended to Apr 5)