BSM Tools - Summary

Les Houches ('05): discussions, projects, and results

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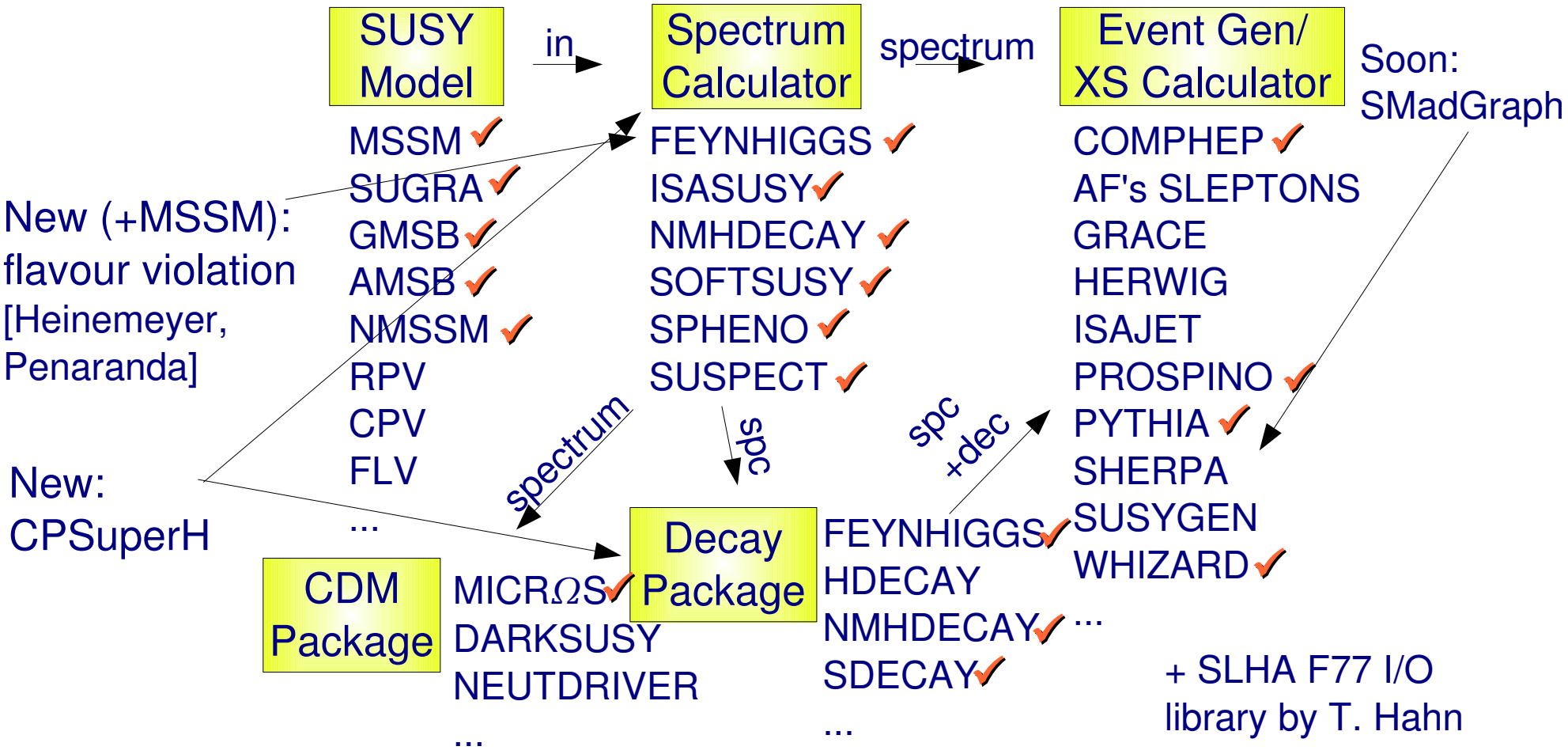
SUSY Les Houches Accord

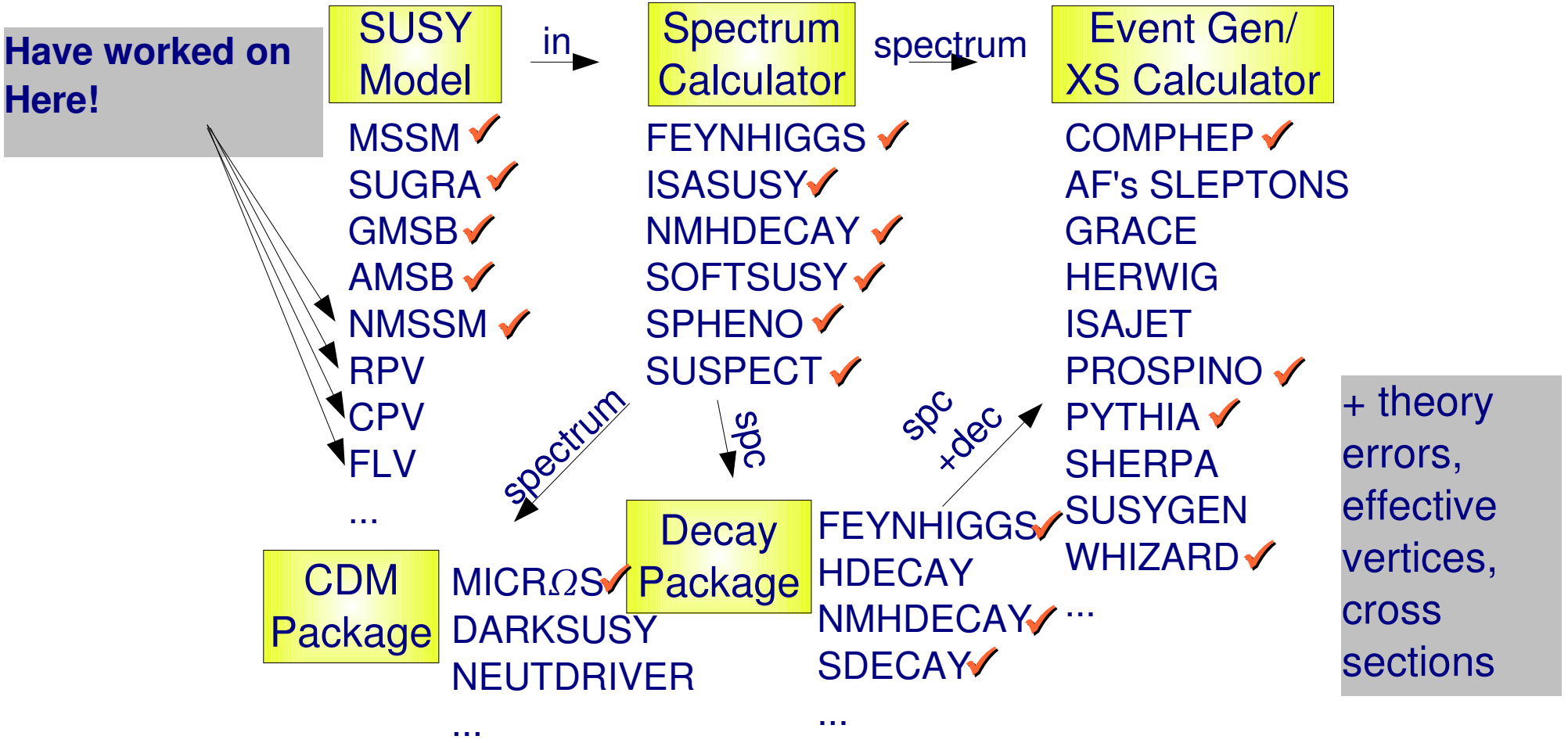
- LH '03: *many* tools -> need to unify -> Accord.

-> JHEP 07(2004)036 [hep-ph/0311123]



SUSY Les Houches Accord

- LH '03: *many* tools -> need to unify -> Accord.
- LH '05: CPV, RPV, FLV, NMSSM, towards th errors, σ, ...



SLHA: Topics discussed at Les Houches '05

- CPV:
  - Im{} of AU, AD, AE, M1, M2, M3, mu (not Yukawas)
  - PDG #'s for Imaginary snu's: 1000017, 1000018, 1000019 ??
- RPV:
  - Superpotential terms: WLLE, WLQD, WUDD, WLH
  - Soft terms: ALLE, ALQD, AUDD, BLH
- FLV:
  - Diagonal soft entries in EXTPAR -> Matrices: MQ2, MU2, MD2, ML2, ME2 (complex)
- + General: enlarged mixing: mass <-> flavour bases...

SLHA: Mass and Flavour bases

(example)

- Charged colour-singlet fermions

mixing matrix:
m_i = U_ij f_j

Flavour basis

e+	= e+ flavour eigenstate
mu+	= mu+ -"-
tau+	= tau+ -"-
-i ~w+	= charged wino
~h2+	= charged higgsino (up-type)

Mass basis (PDG codes), ordered to reduce to "normal" case:

-11 (e+)	= state that has biggest component of e+
-13 (mu+)	= -"- mu+
-15 (tau+)	= -"- tau+
1000027 (chi1+)	= lightest chargino-like state
1000037 (chi2+)	= heaviest chargino-like state

NB: Mass basis ordered by **flavour content**, not by increasing mass!

SLHA: Mass and Flavour bases

(example)

- Squarks:
  - 1st session: Preliminarily agreed on similar structure as for uncoloured sectors. (CKM-like matrices can always be derived from more elementary mass <-> flavour maps.)
  - 2nd session: Input from flavour BSM meeting -> large interest in using super-CKM definitions.
  - Pilot group [Davidson, Hurth, Porod, Skands] to work out proposal, will take super-CKM as starting point.

SLHA: Mass and Flavour bases

(example)

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SLHA: Theory Errors

- Addressing 2 problems:
  - RGE codes: spectrum uncertainties
    - variation of matching scales, assumptions... -> theoretical uncertainties in spectrum predictions (largely correlated).
    - Introduce (unphysical) input variables corresponding to variations within theoretical uncertainty -> range of spectra. (Similar in spririt to error PDF's)
  - Calculation of observables from spectrum
    - Correlations less clear -> errors uncorrelated to first approximation.
    - -> +/- errors on computed variables (but still *theoretical* errors ...)

SLHA: Cross Sections

- Fit programs use total inclusive cross sections (assumed measurable) to fit model parameters.
  - Convenient with I/O standardization. (NB: Goal *at this point* is *not* to fully parametrize differential cross sections)
  - Introduce blocks (already templated in SPheno) for total inclusive cross sections, eg:

Example

```
BLOCK XSINCL    2212     2212    1.400000E+04   # (+ polarization)
#       XS[pb]      NDA        ID1          ID2        ...       # Final State
 1.0100E-01           2   1000021    1000021                  # ~g ~g
```

SLHA: Effective Couplings / K-factors

- HO codes -> absorb leading effects into effective couplings (where possible)
- -> K-factors (dependent on SUSY pars) which can be passed on to LO codes (on process-by-process basis!)
- NB: Have to be careful to maintain consistency (gauge symmetry, unitarity, ...)
- Georg thinks it's more or less okay...

Tools for Extra Dimensions

- Introduce, review, and collect a repository of available tools.
  (Top of wishlist presented by de Roeck)
- Randall-Sundrum graviton excitations:
  - HERWIG
  - PYTHIA (incl RS+jet)
  - MicrOMEGAs (Servant, Belanger, Pukhov)
  - CompHEP/MadGraph (Frisch, Karagoz)
- ADD graviton excitations:
  - SHERPA... (Gleisberg, Krauss, Matchev)
  - PYTHIA? (Lykken+Matchev, Besancon)
  - CompHEP? (Balazs, ...?)
- Black Holes:
  - CHARYBDIS (Richardson et al)
  - TRUENOIR (Lansberg)
  - "BlackHole" (Tanaka et al)
- Universal Extra Dimensions:
  - CompHEP (Przysiezniak-Frey+Goujdami, Servant+Matchev+student: implementation ready in autumn?)
  - Decays (CMS: Pape, Alemany)
    http://cmslip-ued.web.cern.ch/cmslip-ued/
  - SDecay... (Matchev, Muhlleitner)

[Ferrag, Muanza, Kraml, de Roeck, Przysiezniak-Frey, Azuelos, Skands, Grojean, Miakov?, Benakli, Belanger, Pukhov, Semenov, Servant, Giacomo, Pape, Balazs, Dominici, Kazana, Lykken, Matchev?, Alemany, Besancon, Dobrescu, Gustavo, Eduardo,]

Tools for Extra Dimensions

- Validating tools, esp private and semi-public...
  (Effort to be continued when repository more “complete”) [Azuelos, Przysiezniak-Frey + Gojdami, Ferrag + “his” WG, Grojean, Miakov?)]

- Feynman Rules (for general applications) [Csaba (ADD) & Sasha, Bogdan & Gustavo & Eduardo (2 UE), Geraldine (RS), Semenov, Dominici (ADD), Kazana (UED)]

[Ferrag, Muanza, Kraml, de Roeck, Przysiezniak-Frey, Azuelos, Skands, Grojean, Miakov?, Karim, Belanger, Pukhov, Semenov, Servant, Giacomo, Pape, Balazs,Dominici, Kazana, Lykken, Matchev?, Alemany, Besancon, Dobrescu, Gustavo, Eduardo,]

Tools for NMSSM

- NMSSM in NMHDecay, CalcHEP, MicrOMEGAs
- + Being implemented in Spheno
- Still no working event generator
  - Aim here to establish chain: [Pukhov, Skands]
    - Scattering by CalcHEP -> Les Houches event files
    - Decay tables by CalcHEP, NMHDecay, Spheno, ...?
    - Event file + decay tables read by PYTHIA -> events
    - (+ validate against existing HERWIG and PYTHIA hacks)
  - Work in progress...

Hugonie, Pukhov, Skands, Moretti, Kraml, Zerwas, Heinemeyer, Pukhov, Belanger, Porod

micrOMEGAs and relic density

Bélanger, Boudjema, Pukhov, Semenov

- Code to calculate relic density in MSSM and …
- LanHEP: from the Lagrangian writes all masses and couplings in CompHEP/CalcHEP notation
- Input: SLHA
- CalcHEP calculates automatically all necessary cross-sections for annihilation/co-annihilation, colliders…. and 1->2 decays
- Some additional routines implemented for MSSM:

  b->s gamma, B_s ->μμ, g-2..

- micrOMEGAs_2.0 : possibility for implementing new models

- A working example: micromegas_nmssm
  - C. Hugonie + micrOMEGAs: hep-ph/0505142
  - Higgs sector from NMHDECAY

- More examples: (for Les Houches 2005)
  - MSSM with CP-violation (S.Kraml+ micrOMEGAs)
  - Xtra-Dim model, SO(10) with LZP (G. Servant+micrOMEGAs)

Tools For CP Violation

- Event Generator(s) for **CPV**
  - Complex neutralino + chargino mixing in PYTHIA, but rarely used -> validate? (still, spin correllations missing)
  - Spheno, SHERPA, CompHEP intrinsically complex, but CPV never tested yet. How many bugs?
  - FeynHiggs & CPSuperH do CPV.
  - Status of Susygen not clear.
  - CPnSH project (cf Kraml) -> tools needed, but so far no major initiatives at Les Houches.

Kraml, Heinemeyer, Weiglein, Mrenna, Schumacher,Richardson, Schumann, Pukhov, Porod

- Les Houches BSM Tools '05: Conclusions

We'll be ready for Extra Dimensions, FLV, CPV, RPV, NMSSM, ...
Now all we need is a signal.