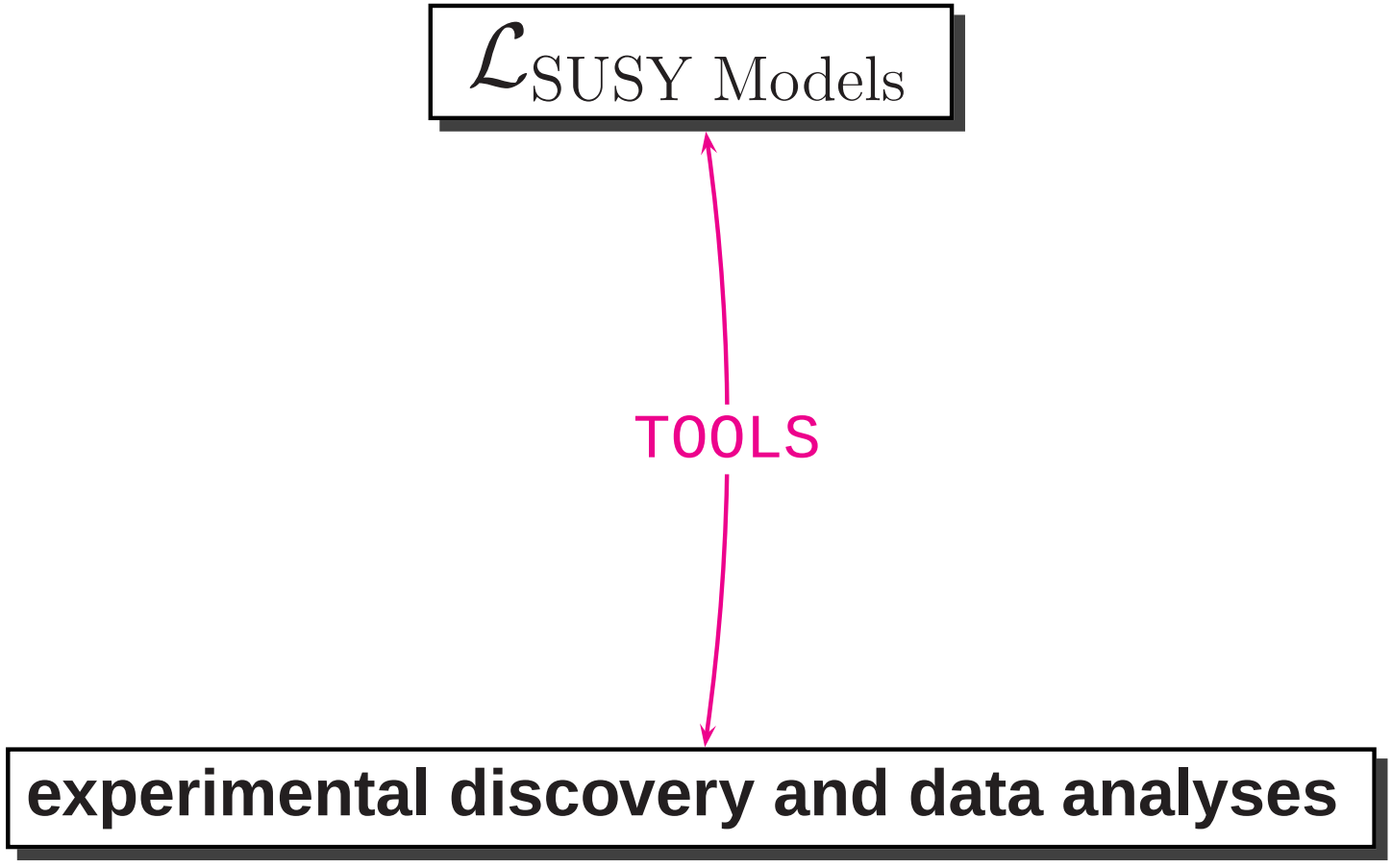
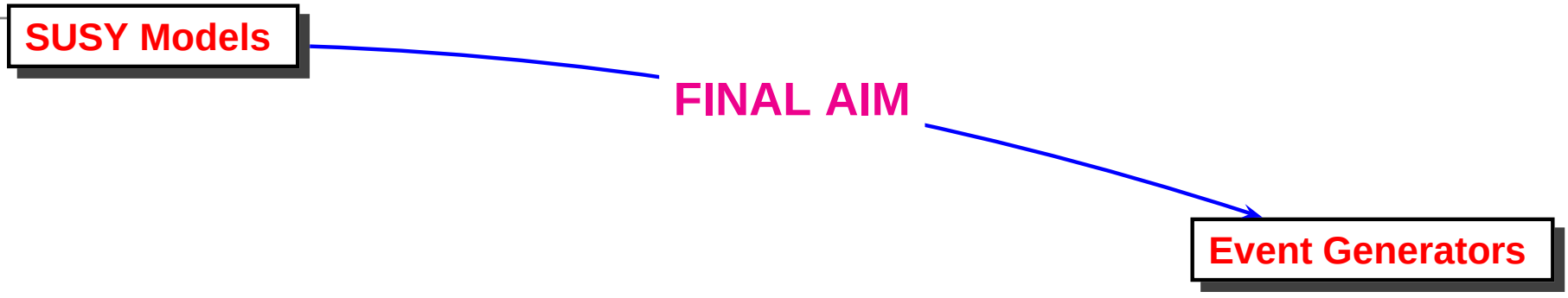
Tools for SUSY
Summary and Outlook

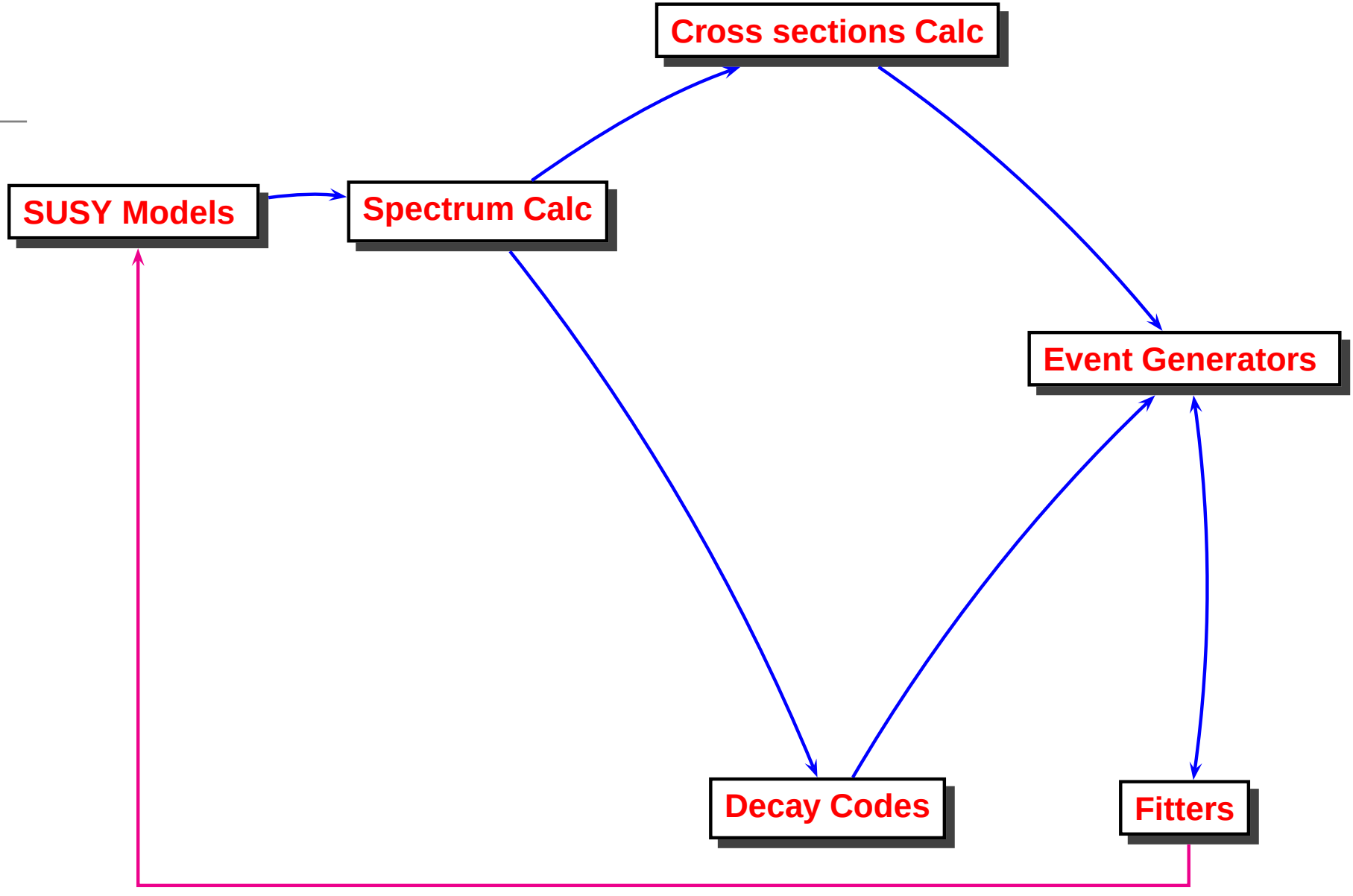
Fawzi BOUDJEMA LAPTH-Annecy, France

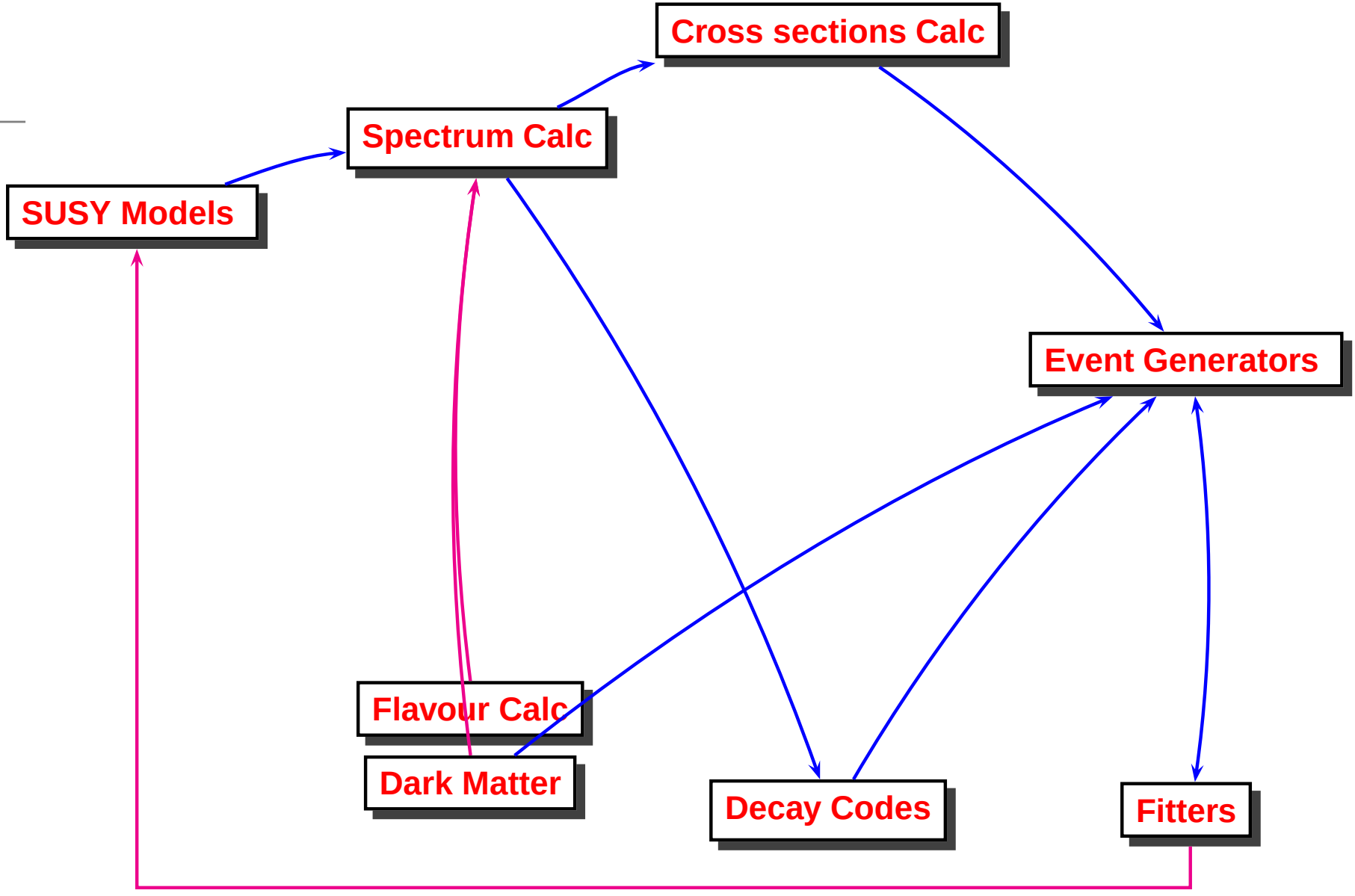
OUTLINE

- What's a tool and what it takes to make one
- How tools should talk to each other
- Talks and Issues discussed in Barcelona
- Organising our work for the future
- Sorry no extra-dim or other non SUSY tools...this time


$\mathcal{L}_{\text{SUSY Models}}$
TOOLS
experimental discovery and data analyses


SUSY Models
FINAL AIM
Event Generators


Cross sections Calc
SUSY Models
Spectrum Calc
Event Generators
Decay Codes
Fitters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Flavour Calc
Dark Matter
Decay Codes
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Cross sections Calc

Spectrum Calc

SUSY Models

- MSSM
  - mSUGRA
  - GMSB
  - AMSB
- NMSSM
- RPV
- CPV
- . . .

Event Generators

Flavour Calc

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Cross sections Calc

Spectrum Calc

- FeynHiggs
- NMHDECAY⋆
- CPSuperH
- RGE Codes
  - Isasusy
  - SoftSusy
  - Spheno
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Event Generators

Flavour Calc

- $(g-2)_\mu$
- $b \longrightarrow s\gamma$
- $B_s \longrightarrow \mu^+\mu^-$

Decay Codes

Fitters

Dark Matter

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- (Neutdriver)

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Feynman rules

(Eff. Pot.)

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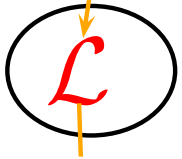

manual

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(Eff. Pot.)

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LANHEP

Feynman rules

(Eff. Pot.)

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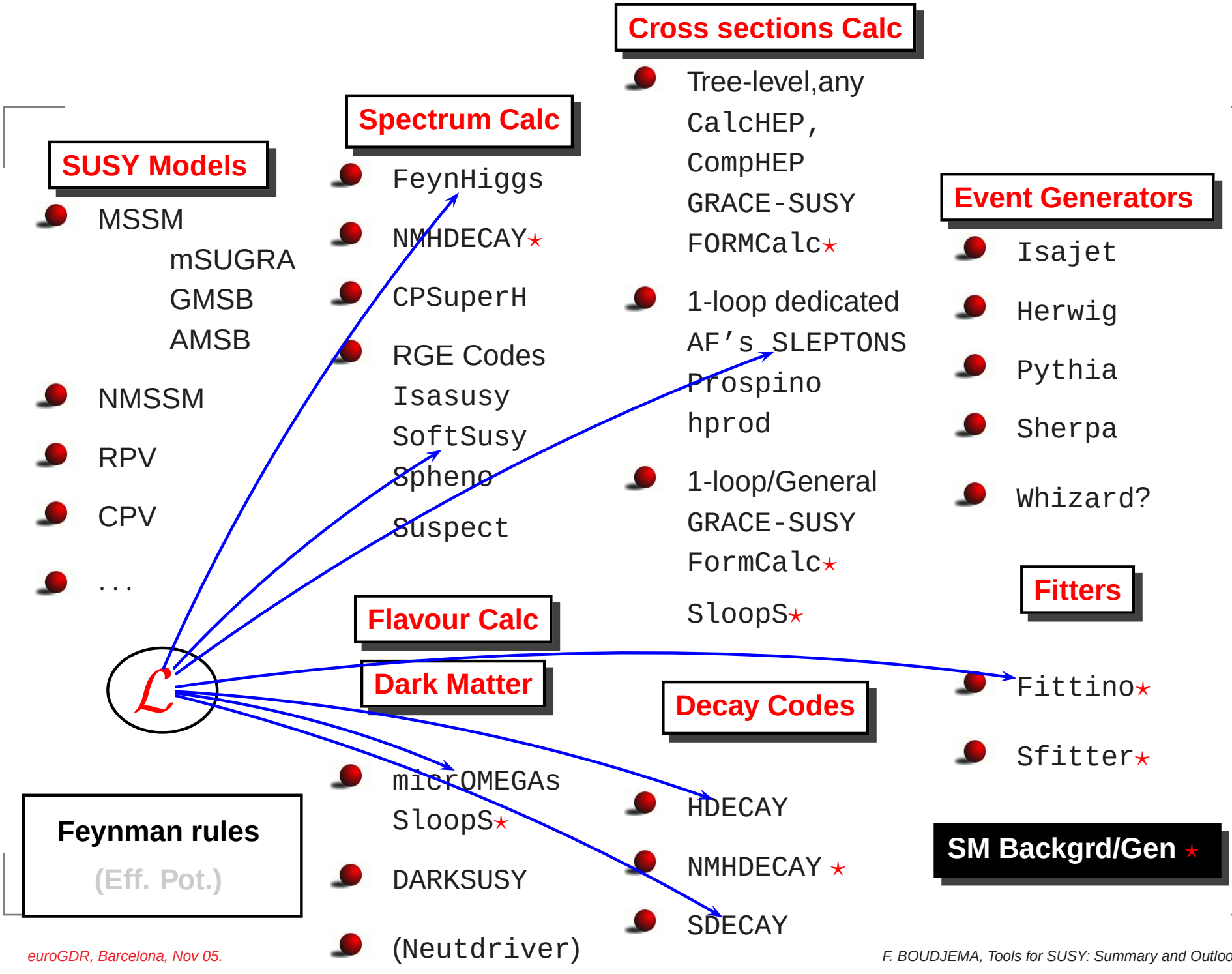
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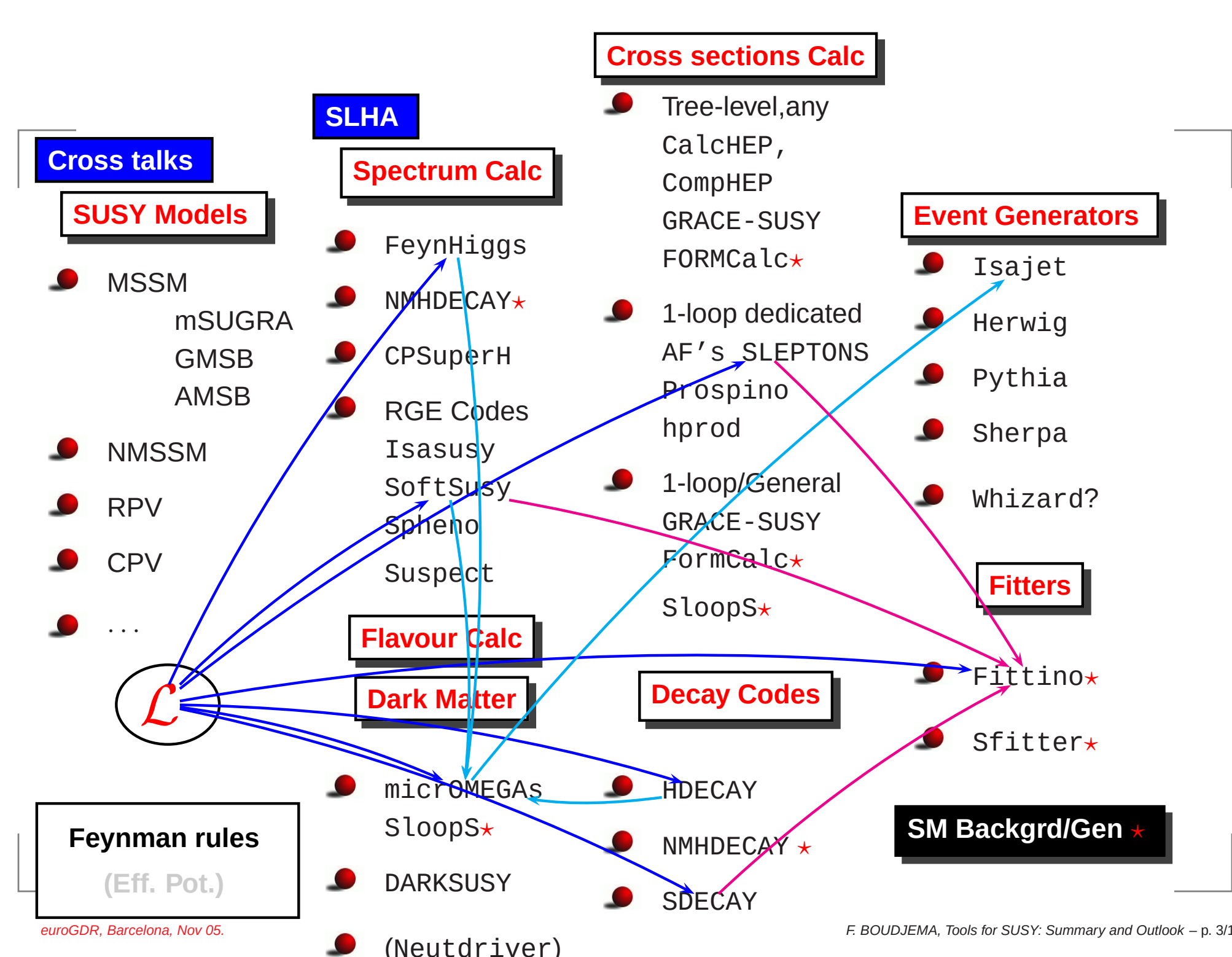
Cross talks
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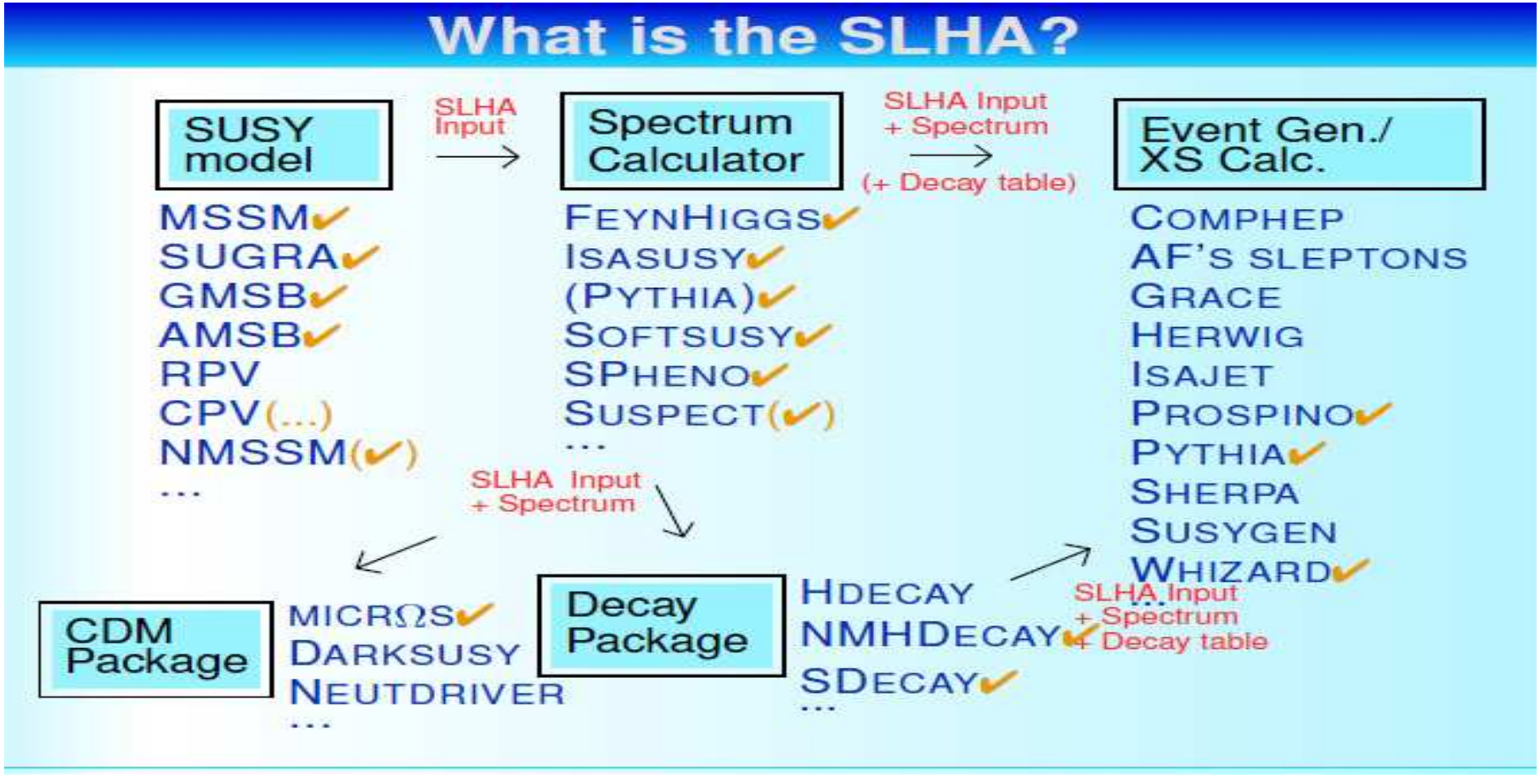
SLHA News 1., Peter Skands

Need to be careful with:

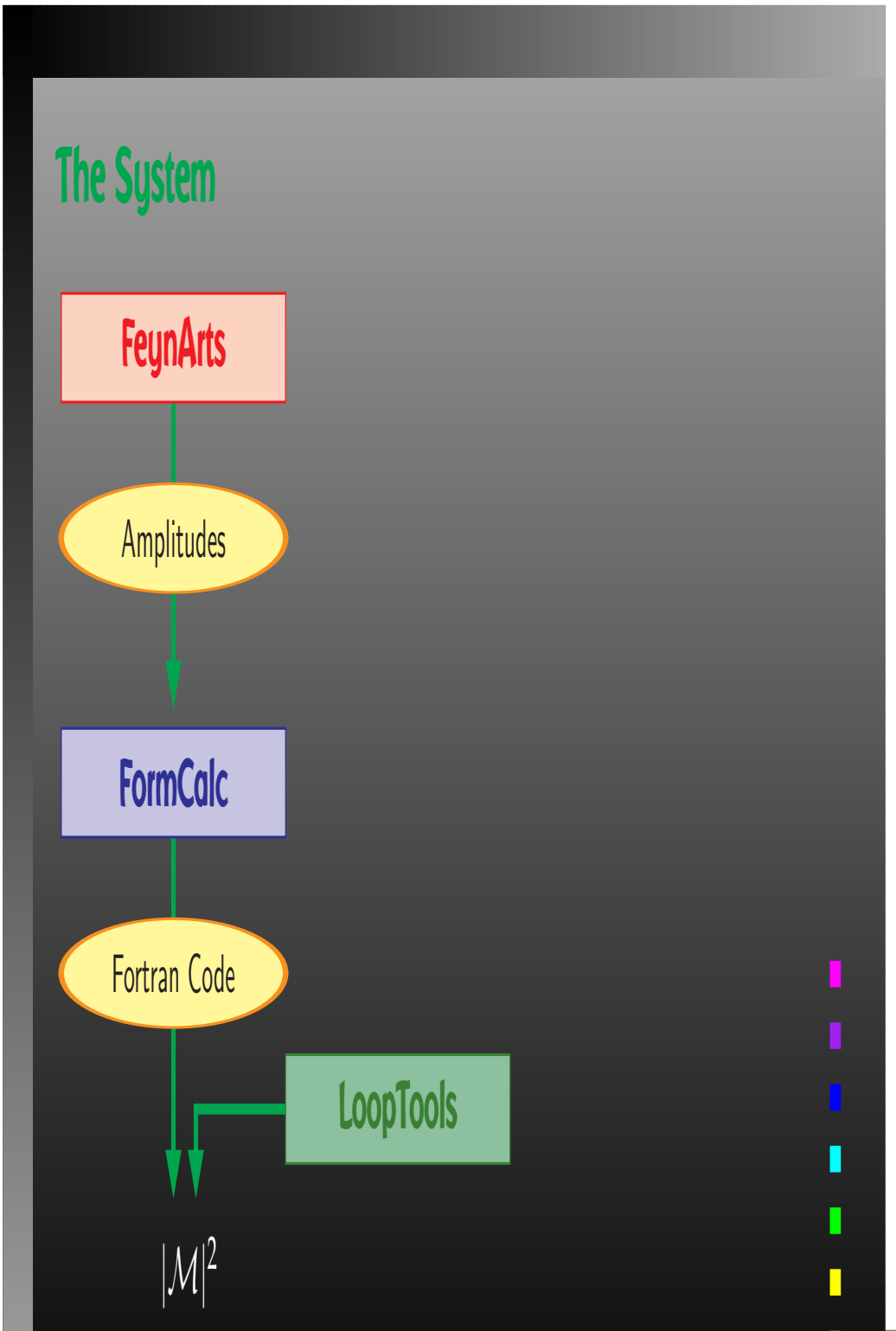
- Signs, factors $\sqrt{2}$, etc.
- Mixing angles: clockwise or counter? Reflections?
- (Eigen)state decompositions.
- Renormalization schemes/scales.
- Effective field content (sparticles integrated out or not)
- Your favourite headache.

What you get from SLHA is unique and well-defined!

SLHA News 2. Peter Skands



FormCalc., Thomas Hahn



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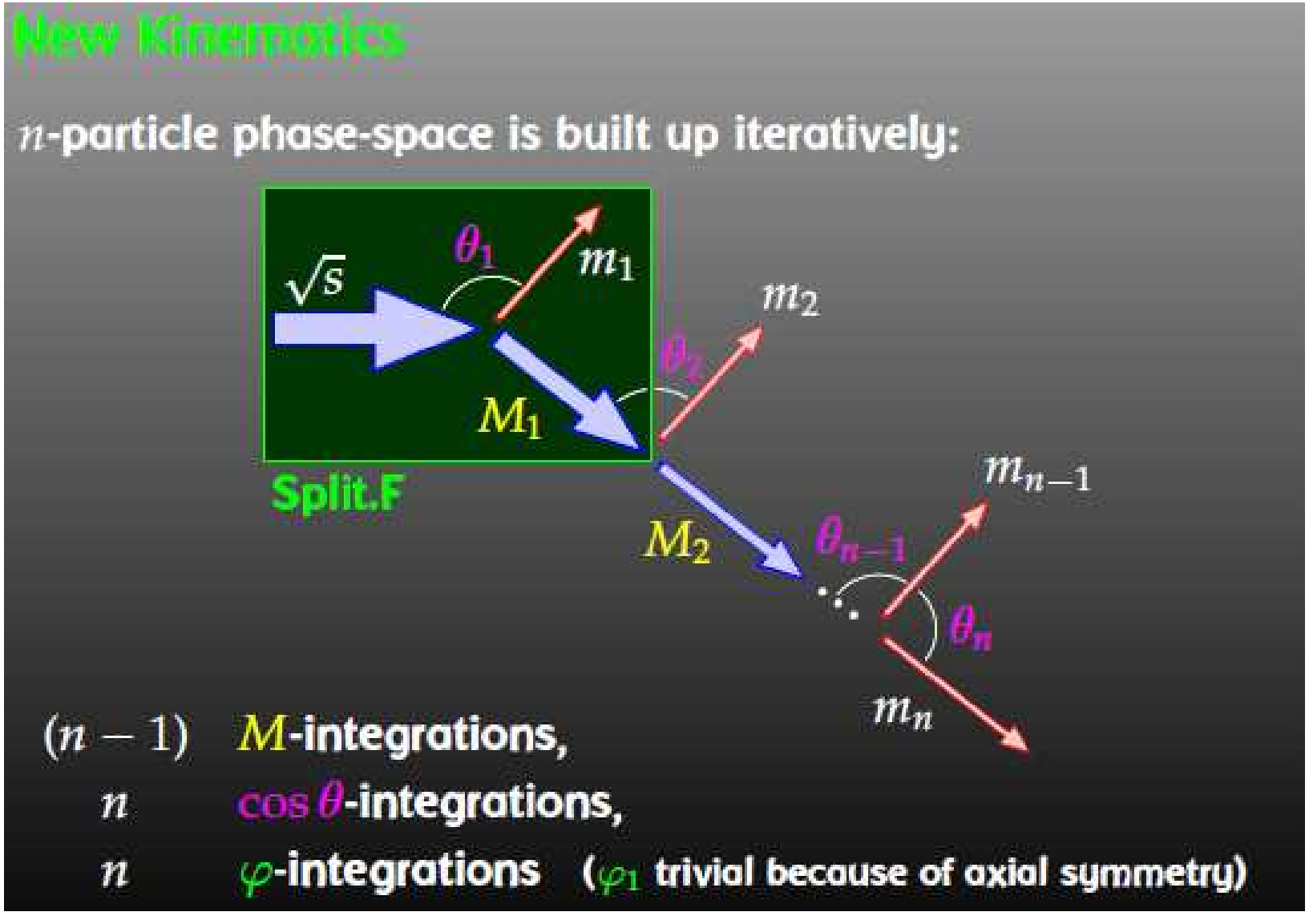


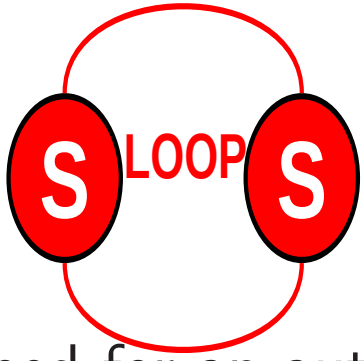
FormCalc., Thomas Hahn

The FeynArts-FormCalc-LoopTools system can now do

- full $2 \to 3$ calculations
  (not just $2 \to 2$ with hard bremsstrahlung),
- in the SM, MSSM, or THDM
  (or user-defined models),
- for partonic, hadronic, or photonic initial states,
- at tree or one-loop level.

Many of the improvements mentioned before do not show up on this list but make life easier for the user.

David Temes, SloopS



FB, A. Semenov, D. Temes

- Need for an automatic tool for susy calculations applicable for collider physics, astrophysics (indirect detection rates) and cosmology (relic density)
- handles large numbers of diagrams both for tree-level
- and loop level
- able to compute loop diagrams at $v = 0$: dark matter, LSP, move at galactic velocities, $v = 10^{-3}$
- ability to check results: UV and IR finiteness but also gauge parameter independence for example (here general non-linear gauges)
- ability to include different models easily and switch between different renormalisation schemes

Strategy: Exploiting and interfacing modules from different codes

Lagrangian of the model defined in LanHEP

- particle content
- interaction terms
- shifts in fields and parameters
- ghost terms constructed by BRST

↓ ↓

Generic Model
-kinematical structures

Classes Model
-Feynman rules, including CT

⇓

Evaluation via FeynArts-FormCalc

LoopTools modified!!
tensor reduction inappropriate for small relative velocities
(Zero Gram determinants)

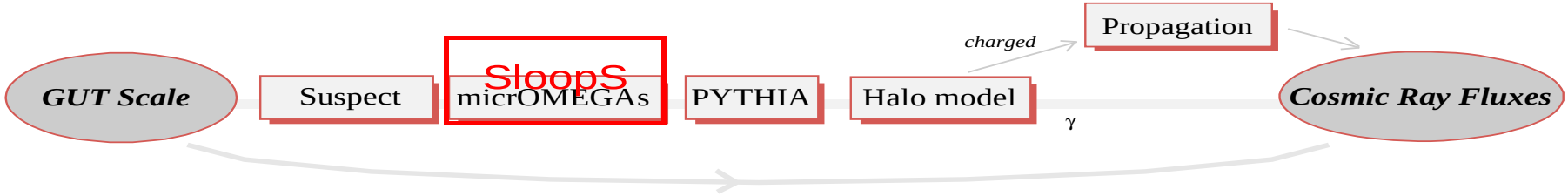
⇑

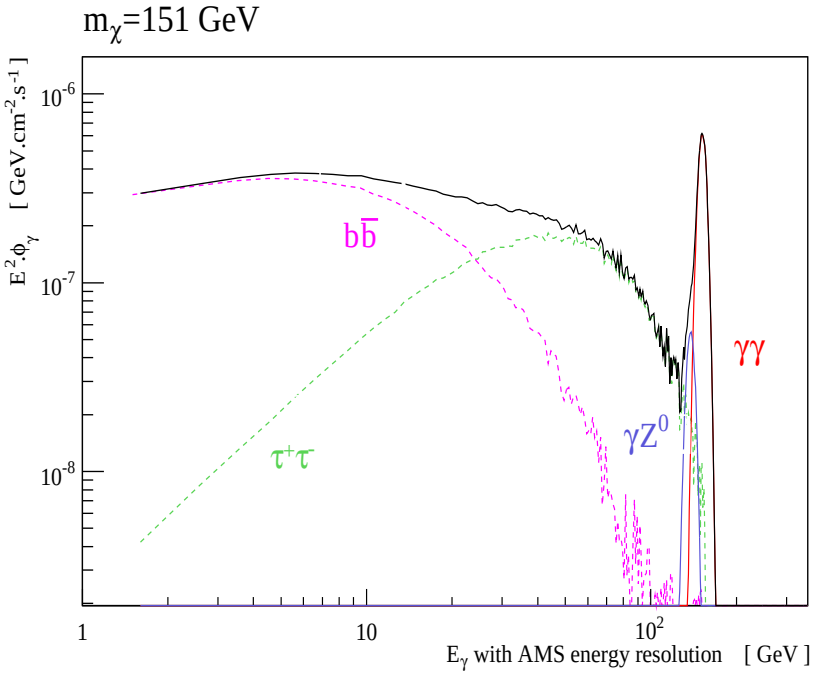
Renormalisation scheme

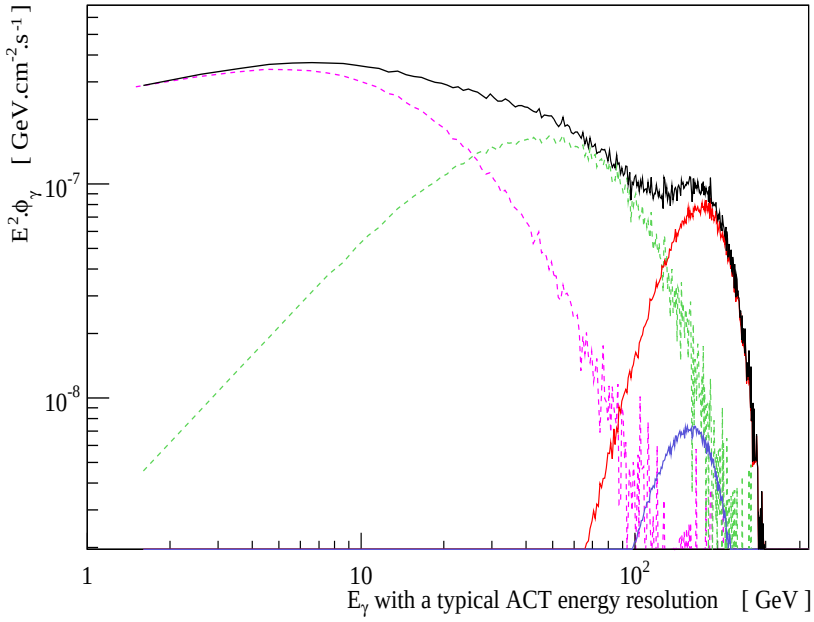
- definition of renorm. const. in the classes model

Non-Linear gauge-fixing constraints, gauge parameter dependence checks

SloopS, micrOMEGAs, AMS/HESS simulation







SIMULATION: Parameterising the halo profile:

$(\alpha, \beta, \gamma) = (1, 3, 1)$, $a = 25$kpc. (core radius), $r_0 = 8kpc$ (distance to galactic centre),

$\rho_0 = 0.3\, GeV/cm^3$ (DM density), opening angle cone 1^o

SUSY parameterisation : $m_0 = 113$GeV, $m_{1/2} = 375$ GeV, $A = 0$, $\tan\beta = 20$, $\mu > 0$

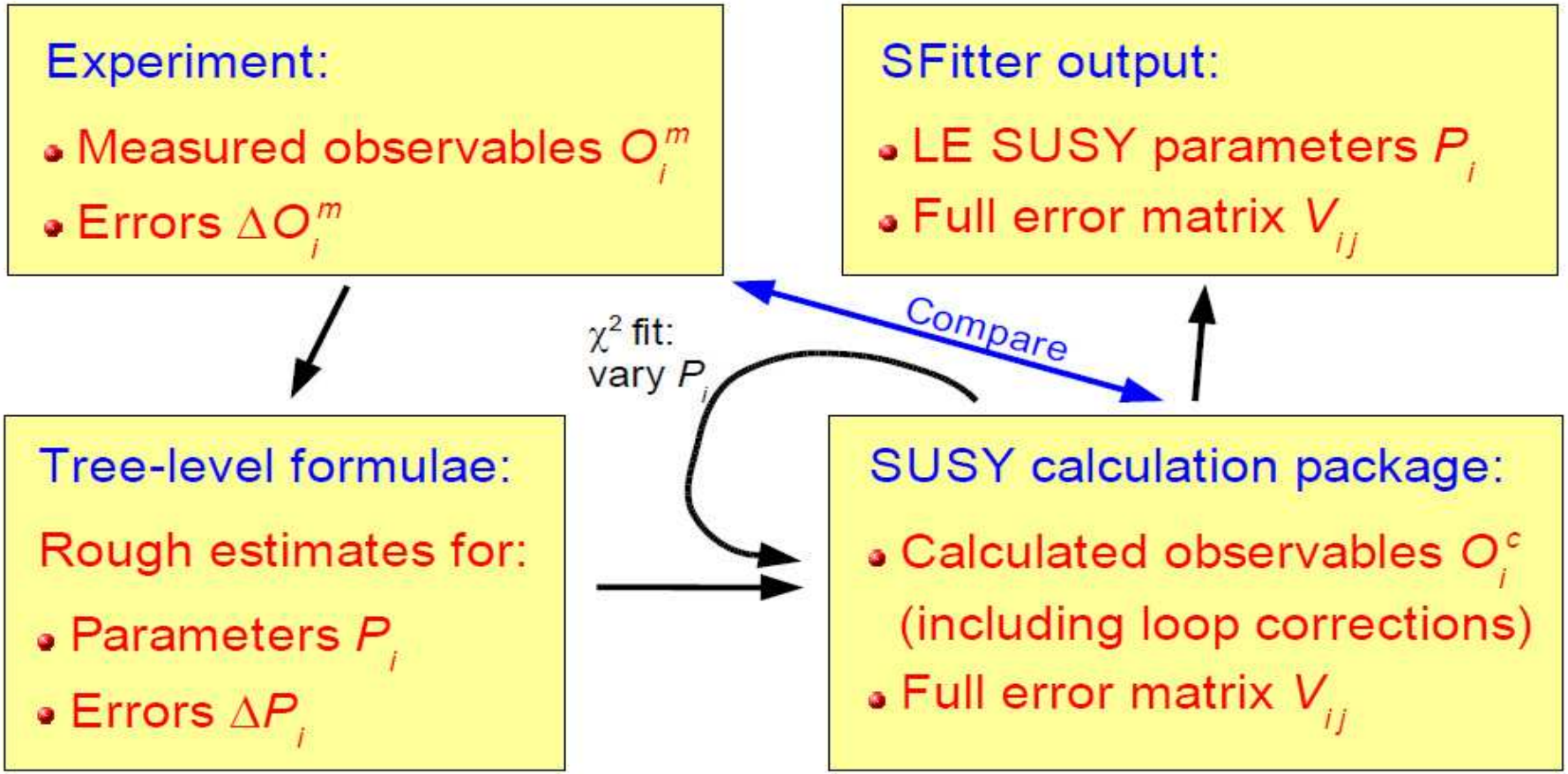
γ lines could be distinguished from diffuse background

NMHDECAY version 2.0, Ulrich Ellwanger

NMSSM: possible solution to the μ problem: Add a Singlet S with

- $\mu H_u H_d \longrightarrow \lambda S H_u H_d + \frac{\kappa}{3} S^3$ + new soft susy breaking terms
  $\lambda A_\lambda S H_u H_d + \frac{\kappa}{3} A_\kappa S^3 + m_S^2 S^2$
- Parameter space: $M_Z,\ tan\beta,\ \mu_{eff},\ \lambda,\ \kappa,\ A_\lambda,\ A_\kappa$
- Physical Higgs states: "MSSM+" 1 extra CP+ and 1 extra CP−
- RC to Higgs mass spectrum: (* = New in version 2.0)
  $h_{t/b}^4$ (exact), $h_{t/b}^6$ (LLA), $\alpha_s h_{t/b}^4$ (LLA), $g^2 h_{t/b}^2$ (exact)*,
  g^4, $g^2\lambda^{2*}$, $g^2\kappa^{2*}$, λ^{4*}, κ^{4*}, $\lambda^2\kappa^{2*}$ (all LLA)
- * $BR(b \longrightarrow s\gamma)$ to lowest order
- * $H_i \longrightarrow \tilde{f}_i \tilde{f}_j^\star$
- * Link to a NMSSM version of `MicrOMEGAs`
- * Input/output in SLHA format possible

Fittino by Peter Wienemann and SFITTER by Dirk Zerwas.



tree-level vs "1-loop level"

Fittino by Peter Wienemann and SFITTER by Dirk Zerwas.

- `Spheno: theory Code`: so not really cross sections
- Fits to LHC and ILC (18 SUSY parameters, or mSUGRA SPS1a' or slightly beyond....
- edges do better than masses (exploit full correlation matrix)
- precision at percent-level (or better apart from A_b)
- applications:
    1. run up to unification scale
    2. "reconstruct" relic density:

$\Omega_{LSP}h^2 = 0.191 \pm 0.0003$ (LHC+ILC) ± 0.005 (LHC)

SM: Summary of Lyon Meeting on (SM) QCD Tools

SM=Steve Muanza

SM=Standard Model

- MC at NLO
- automatic resummation
- plans for $2 \longrightarrow 3, 4$ and benchmark cross sections

Yuri Dokhsitzer: "virtual SUSY is helping QCD *(twistor techniques!)*, QCD will pay back discovering *"real"* SUSY

Future collaborations 1.

BSM Tools Repository

- http://www.ippp.dur.ac.uk/montecarlo/BSM

  Please submit your code

  make it SLHA compliant, if SLHA exists for the model please give a description of the code: what physics there is inside not just how to run it!!

  at the moment only 6 tools listed so far...

- other of repositories, e.g. http://mcelrath.org/Notes/Software (see also open directory project)

- old tools for susy, GDR Outils

  http://wwwlapp.in2p3.fr/gdr-outils/GDRoutils/outilsp1.html

- For codes that do the same things (or supposed to do the same thing)

  Comparison page like what is done with RGE (see Sabine Kraml's page)

Future collaborations 1.

Organise round-tables involving model builders, calculation theorists, experimentalits

- More work on New Physics which is not SUSY
- for some SUSY models, probably need "background tools": contact with SM/QCD tools
- experimentalits need to speak up and ask what is needed most urgently : priority list (similar to what has been done for SM in Les Houches)
- how should codes be interfaced and written: modules, C++, SLHA

Importance of tools meetings,one-year before LHC start...!

Tools for SUSY and the New Physics

June 26-28, 2006

LAPTH-LAPP, Annecy-le-Vieux, FRANCE

Welcome | Registration | Program | Participants | Accomodation | Committee

TOOLS 2006

Tools for Susy and the New Physics

June 26-28, 2006 LAPTH-LAPP, Annecy-le-Vieux, France

The aim of the Workshop is to review the main calculational tools, including generators and Monte-Carlos, for the beyond standard model particle searches at present and future colliders as well as in non collider physics experiments such as dark matter searches. Apart from the talks, discussion sessions are planned. In these round tables we expect to discuss how the existing programs could be improved, how to incorporate different existing constraints, how to best present future data and how modules from different codes could sewn together and interchanged.

Tools for SUSY : 1998 - 1999 - 2000

Secretariat

TOOLS 2006 (Organisation Email) : tools2006@lapp.in2p3.fr
Secretary : Turc-Poencier Dominique Tel : +33 4 50 09 16 84

TOOLS2006 webpage

Similar 2-day Workshop (Collider only) at Fermilab, 20-21 March 2006 (details Peter Skands)