Predicting SuSy
&
B-tagging in 2012 with ATLAS

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1 Predicting SuSy

SuSy basics

SuperSymmetry $\equiv$ Spacetime symmetry

Fermionic generator such that:

$$Q|\text{fermion}\rangle = |\text{boson}\rangle \qquad Q|\text{boson}\rangle = |\text{fermion}\rangle$$

Selected piece of superalgebra:

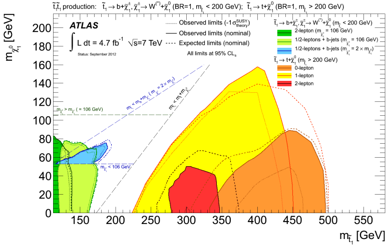
$$[Q_{\alpha i}, P_\mu] = 0$$

SuSy does not change mass!

But obviously no scalar electrons...
Or fermionic photons...

SuSy must be broken ☺

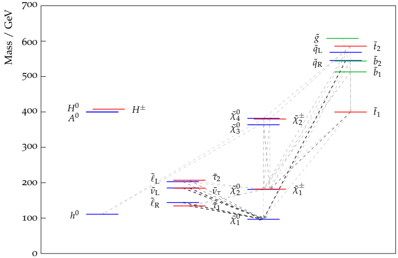
Searching for supersymmetry



SuSy spectrum calculators

- ISASUGRA
- SOFTSUSY
- SPheno
- **SuSpect2**

SuSy searches relies on a basic component, the mass spectrum of the theory



SPS1A spectrum and BR

SuSpect

SuSpect2 is a **Su**persymetric **Spect**rum calculator by A.Djouadi, G.Moultaka and J-L.Kneur:

- well-known code, robust, widely tested
- getting harder and harder to add new features
- published in 2005, since then SuSy landscape changed a lot

We need to broaden the possibilities of SuSpect, this is the goal of **SuSpect3**:

- We don't know what's around the corner so a more flexible code is essential
- Lots of new features are requested by users

I'm working on this with D.Zerwas and the former authors

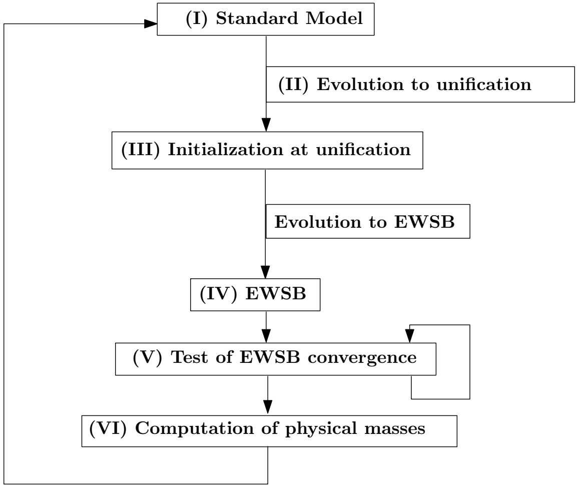
Spectrum recipe

You need:

- field content of your theory: will give you masse matrices and mixings
- Renormalization Group Equations: how your Lagrangian parameters evolve with Q
- some “basic” knowledge of the Standard Model: M_Z boundary conditions
- some high energy boundary(ies): eg, what happens at GUT? (usually your SuSy breaking terms)
- an EWSB mechanism (effective scalar potential and a way to compute its parameters)

Put everything in an iterative process, if you’re lucky enough, you’ll get results.

Overview of the algo.



SuSpect3 status:

- Code is working and useable (for mSUGRA, GMSB, AMSB, Compressed SuSy, low-scale SuSy)
- RGE, EWSB criterion, GUT definition, mass matrices can be modified easily by users
- automated generation of all those sub-bricks with Mathematica code have been started (FeynRules, SARAH)
- lot of “modern novelties”: ROOT output, multithreading
- commissioning started
- alpha release for early 2013

2 B-Tagging with ATLAS

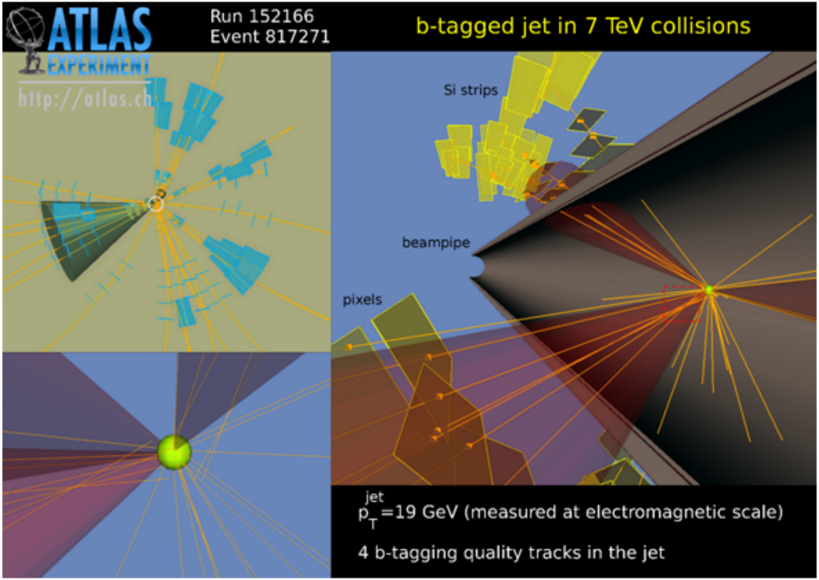
About b-tagging

B-tagging aims to identify jet coming from b-quarks fragmentation, used in:

- Top physics
- Higgs physics
- BSM searches
- ...

B-tagging takes advantage of hard b-quarks fragmentation and of the relative long-lifetime of B-hadrons to identify jets coming from a b-quark

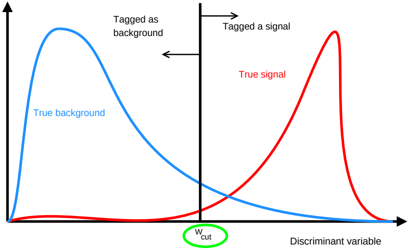
- B-hadrons: $c\tau \simeq 450\ \mu$m (contains a b-quark)
- D-hadrons: $c\tau \simeq 330\ \mu$m (contains a c-quark)


ATLAS EXPERIMENT
http://atlas.ch
Run 152166
Event 817271
b-tagged jet in 7 TeV collisions
Si strips
beampipe
pixels
p_T^{jet}=19 GeV (measured at electromagnetic scale)
4 b-tagging quality tracks in the jet

The cut paradigm

Goal is to build a discriminant between background(light jets, c-jets) and our signal, the b-jets, for that we can use:

- track properties
- secondary vertex properties

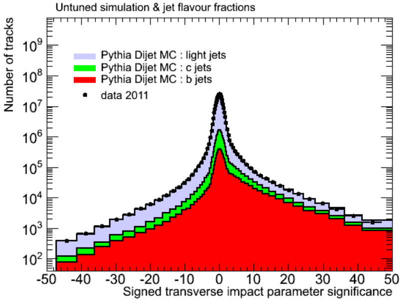


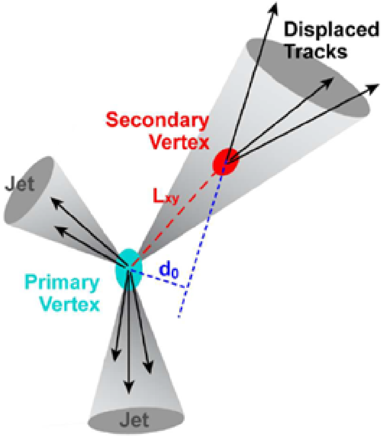
Two important quantities here:

- ϵ_b, b-tagging efficiency: fraction of true b-jets labelled as b-jets
- ϵ_u, light jet mistag rate: fraction of true light jets labelled as b-jets

Impact parameter based tagger

- tracks associated to a b-jet are expected to have a positive impact parameter





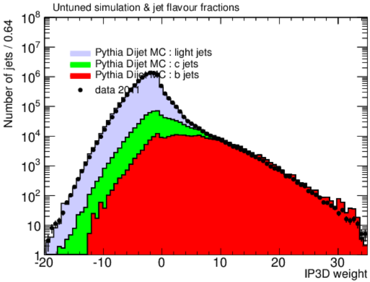
Log-Likelihood Ratio in action

For each track we compute the likelihood of being associated to a b, c or light jets, then we use it to compute a b-tag weight for a jet:

$$\text{b-tag weight} = \sum_{\text{tracks}} \ln\left(\frac{b_i}{u_i}\right)$$

in ATLAS this the so-called **IP3D** tagger
At $\epsilon_b = 70\%$:

ATLAS **IP3D**: $\epsilon_u \sim 3.5\%$



Secondary Vertex

the same principle as **IP3D**, but uses other information to build the LLR

- run the SV finding algo. in the jet
- if one is found (70% of time), use mass, energy fraction.. to compute the LLR

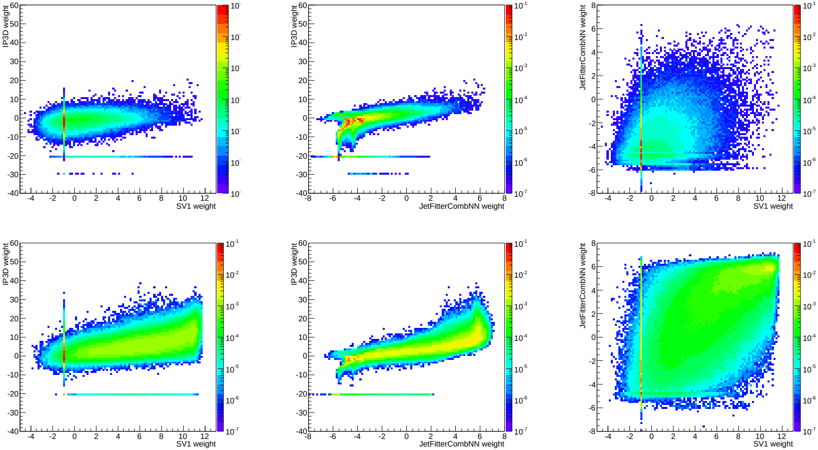
Another class of properties are the decay chain informations, this is the **JetFitter** algorithm
At $\epsilon_b = 70\%$:

ATLAS **SV1**: $\epsilon_u \sim 4.5\%$
ATLAS **JetFitter**: $\epsilon_u \sim 2\%$

Correlation between taggers

light jets

b-jets

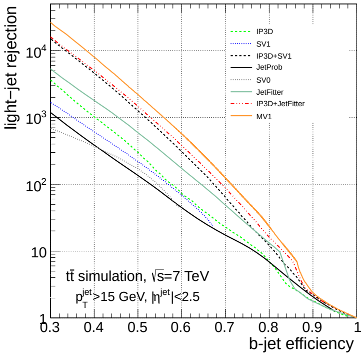


IP3D VS SV1 **IP3D VS JetFitterCombNN** **JetFitterCombNN VS SV1**

MV1

MV1 was the 2012 baseline tagger

- Artificial Neural Network combining:
  - **IP3D** weight: impact parameters information
  - **SV1** weight: secondary vertex information
  - **JetFitterCombNN**: decay chain informations
- trained to discriminate light and b-jets



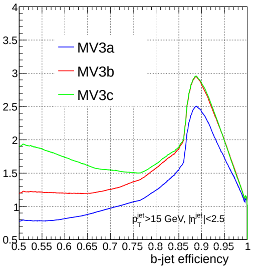
At $\epsilon_b = 70\%$:

ATLAS **MV1**: $\epsilon_u \sim 0.7\%$, $\epsilon_c \sim 20\%$
CMS **CSV**: $\epsilon_u \sim 2\%$, $\epsilon_c \sim 20\%$

B-tagging in 2013

In 2013 a new generation of taggers will be proposed:

- c-taggers:
  - growing activity for flavour-tagging
  - **JetFitterCharm**, a large ANN dedicated to c identification, will be used in 2013
- **MV3**:
  - large BDT using low-level b-tagging variables
  - $\mathcal{O}(10\%)$ light jet rejection improvement with respect to MV1
  - trained in 3 flavors (bVSu, bVSc, cVSu)
  - under integration in ATLAS framework, will most likely be used this summer



SuSy searches

Theoretical code, SuSpect3:

- upcoming release
- wider model range than SuSpect2

ATLAS b-tagging:

- new taggers with $\mathcal{O}(10\%)$ improvements

I'm now switching to searches for EW production of SuSy:

$$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0 \to (Z/h)W^{\pm} + 2\tilde{\chi}_1^0 \to l^{\pm} + b\bar{b} + \not{E}_T$$

Merci de votre attention