HA Reconstruction at LCC4 with Full Simulation

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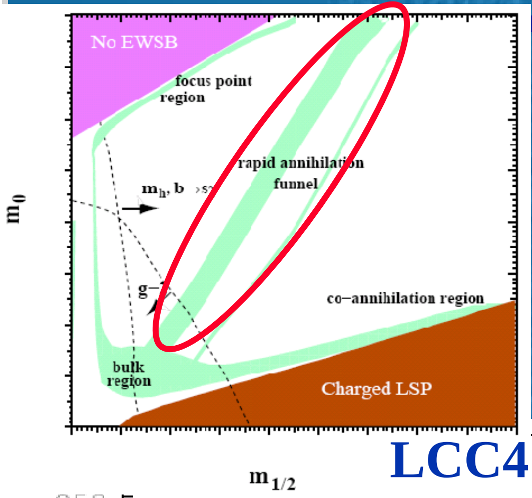
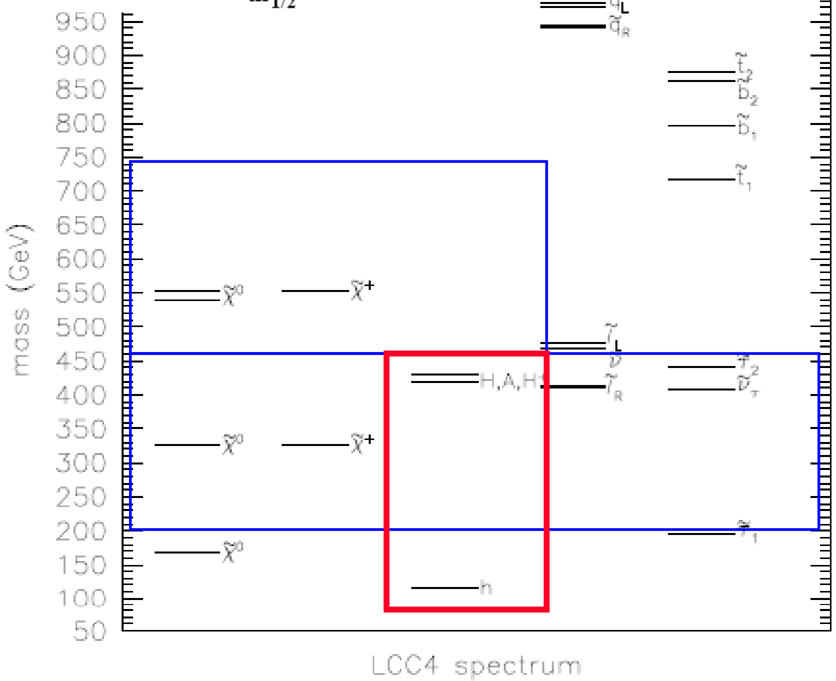
The Higgs Sector of the LCC4 Point

LCC4 point in A^0 Funnel region

Benchmark point defined in cMSSM

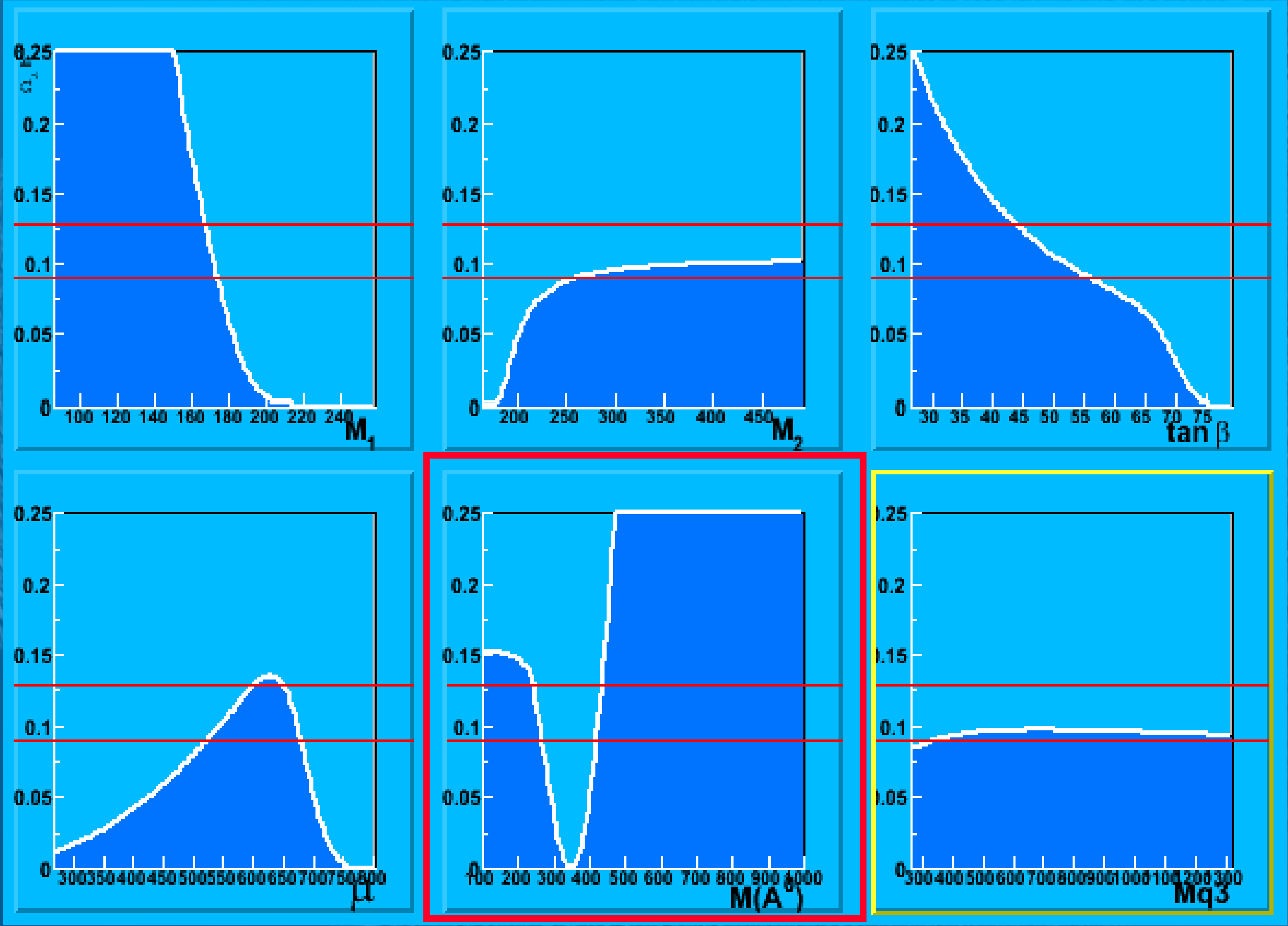


LCC4 Benchmark



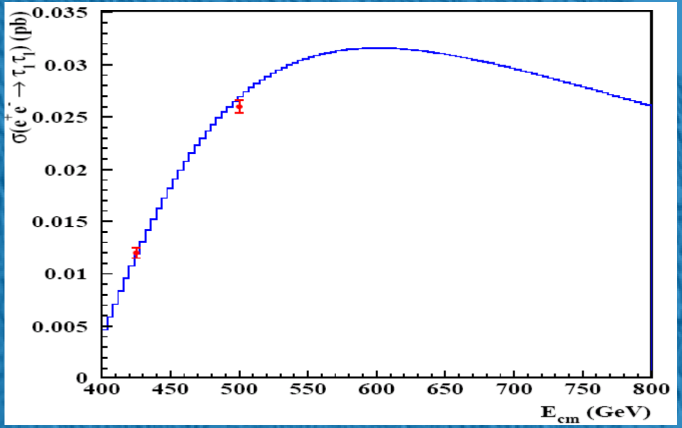
mass/mass splitting	LCC4 value		LHC	ILC 500	ILC 1000
$m(\tilde{\chi}^0_1)$	169.1	±	17.0	-	1.4
$m(\tilde{\chi}^0_2)$	327.1	±	49.		
$m(\tilde{\chi}^0_2) - m(\tilde{\chi}^0_1)$	158.0	±	-	-	1.8
$m(\tilde{\chi}^0_3) - m(\tilde{\chi}^0_1)$	370.6	±	-	-	2.0
$m(\tilde{\chi}^+_1)$	327.5	±	-	-	0.6
$m(\tilde{\chi}^+_1) - m(\tilde{\chi}^0_1)$	158.4	±	-	-	2.0
$m(\tilde{\chi}^+_2) - m(\tilde{\chi}^+_1)$	225.8	±	-	-	2.0
$m(\tilde{e}_R) - m(\tilde{\chi}^0_1)$	243.2	±	-	-	0.5
$m(\tilde{\mu}_R) - m(\tilde{\chi}^0_1)$	243.0	±	-	-	0.5
$m(\tilde{\tau}_1)$	194.8	±	-	0.9	
$m(\tilde{\tau}_1) - m(\tilde{\chi}^0_1)$	25.7	±	-	1.0	
$m(h)$	117.31	±	0.25	0.05	
$m(A)$	419.3	±	1.5 *	-	0.8
$\Gamma(A)$	14.8	±	-	-	1.2
$m(\tilde{u}_R)$, $m(\tilde{d}_R)$	944.,941.	±	94.		
$m(\tilde{s}_R)$, $m(\tilde{c}_R)$	941., 944.	±	97.		
$m(\tilde{u}_L)$, $m(\tilde{d}_L)$	971., 975.	±	141.		
$m(\tilde{s}_L)$, $m(\tilde{c}_L)$	975., 971.	±	146.		
$m(\tilde{b}_1)$	795.	±	40.		
$m(\tilde{b}_2)$	862.	±	86.		
$m(\tilde{t}_1)$	716.	±	(> 345)		
$m(\tilde{g})$	993.	±	199.		

$\Omega_\chi h^2$ and SUSY Parameters at LCC4



LCC4 at ILC at 0.5 and 1 TeV

LCC4 studied in details using `SIMDET` parametric simulation;
Results presented at LCWS04, ALCPG Victoria and ILC-Cosmo study
hep-ph/0410123



Determine $M(\tau_1)$ and $M(\tau_1)$ - $M(\chi_1{}^0)$ from stau threshold scan and decays at 0.5 TeV;

Estimate $\Gamma(A^0)$ from precise $BR(h^0 \to bb)$ at 0.35/0.5 TeV;

$$\Gamma(A^0) = \frac{\mathrm{BR}(h^0 \to b\bar{b})}{\mathrm{BR}(A^0 \to b\bar{b})} \times \Gamma(h^0) \times \tan^2\beta$$

Precisely determine $M(A^0)$, $\Gamma(A^0)$ in HA production at 1 TeV.

Determine μ from $M(\chi_{2,3})$-$M(\chi_1)$ at 1 TeV

H^0A^0 Analysis with Full G4 + Marlin Reconstruction

Results of SIMDET study at the basis of comprehensive study of ILC reach in predicting DM density (**Phys.Rev.D74:103521,2006)**.
Now repeat analysis with full simulation and attempt to improve result with new observables available at ILC

- Generate events with PYTHIA 6.58 + ISASUGRA 7.69
- Full G4 Simulation with Mokka 6.01 for LDC01Sc
- Reconstruction using Marlin + MarlinReco 00.09.06

- 1050 HA signal events simulated and analysed;
- Currently processing ZZ + WW + tt (PYTHIA generation) and bbbb (EW + QCD) (COMPHEP+PYTHIA);

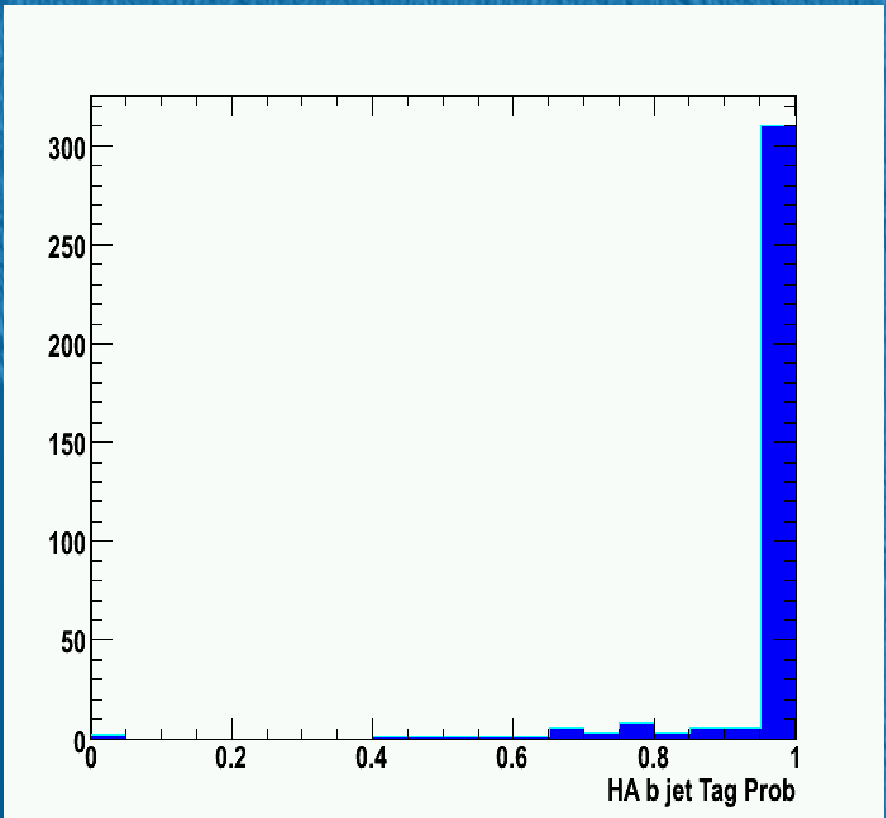
Plan to study result vs. Vertex Tracker geometry and performance.

Reconstruction

Di-jet b-tagging for CMOS VTX02

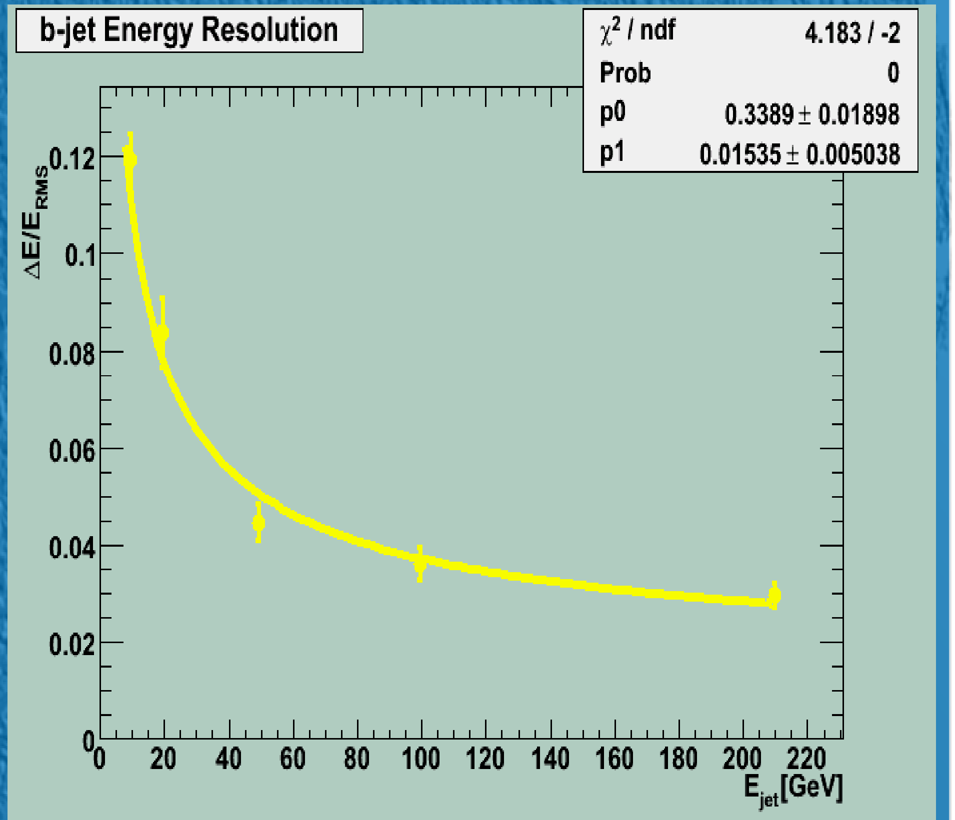
$\varepsilon_b = 0.85$

$\varepsilon_{udsc} = 0.02$



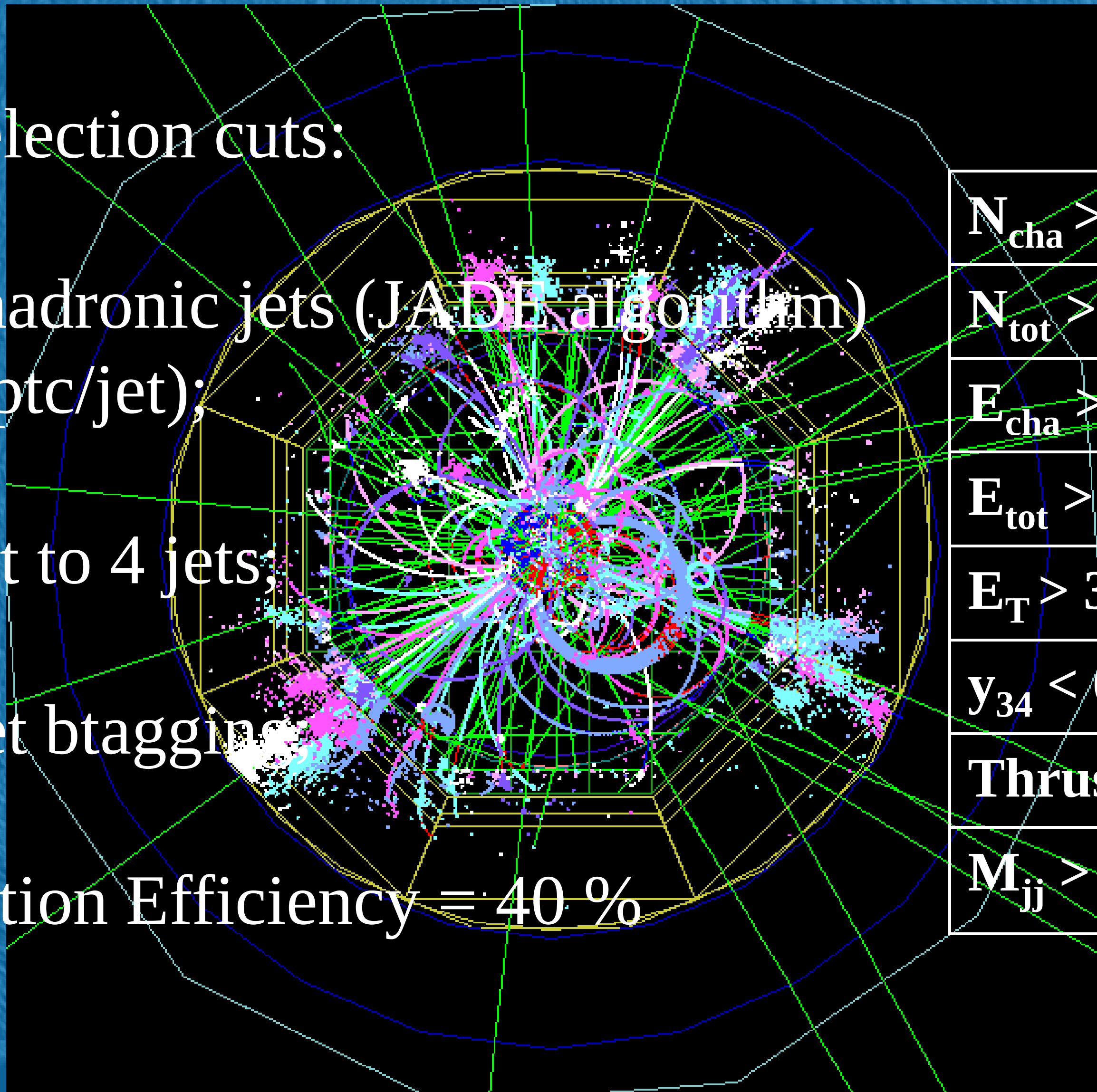
Particle Flow for LDC01Sc Model

[Cluster cheater to achieve $\frac{0.30}{\sqrt{E}}$]



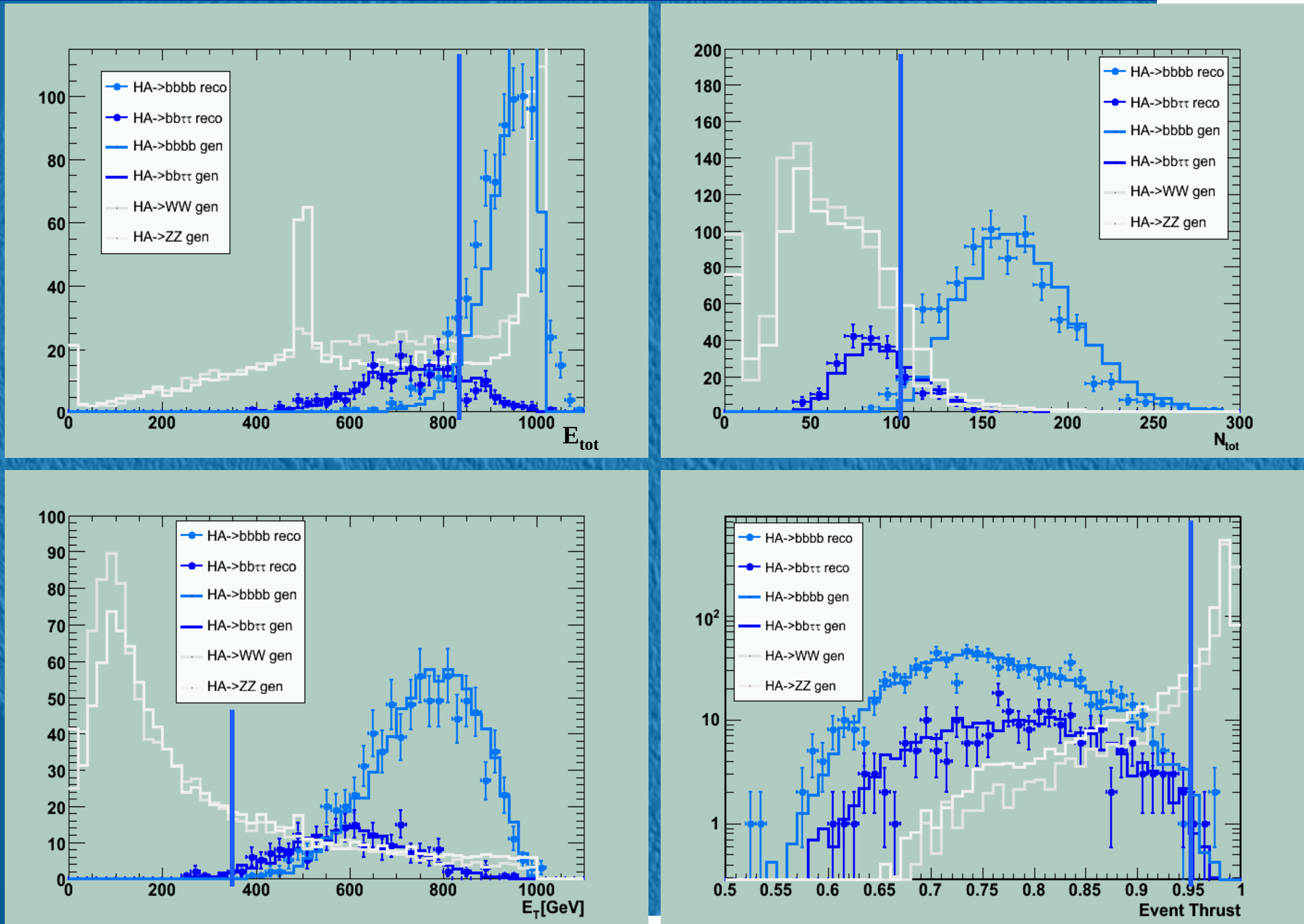
$e^+e^- \to H^0A^0$ Selection Criteria

- General selection cuts:
- at least 4 hadronic jets (JADE algorithm) (at least 5 ptc/jet);
- force event to 4 jets;
- apply di-jet btagging;
- reconstruction Efficiency = 40 %



$N_{cha} > 20$	
$N_{tot} > 100$	
$E_{cha} > 250$ GeV	
$E_{tot} > 850$ GeV	
$E_T > 350$ GeV	
$y_{34} < 0.0025$	
Thrust < 0.96	
$M_{jj} > 150$ GeV	

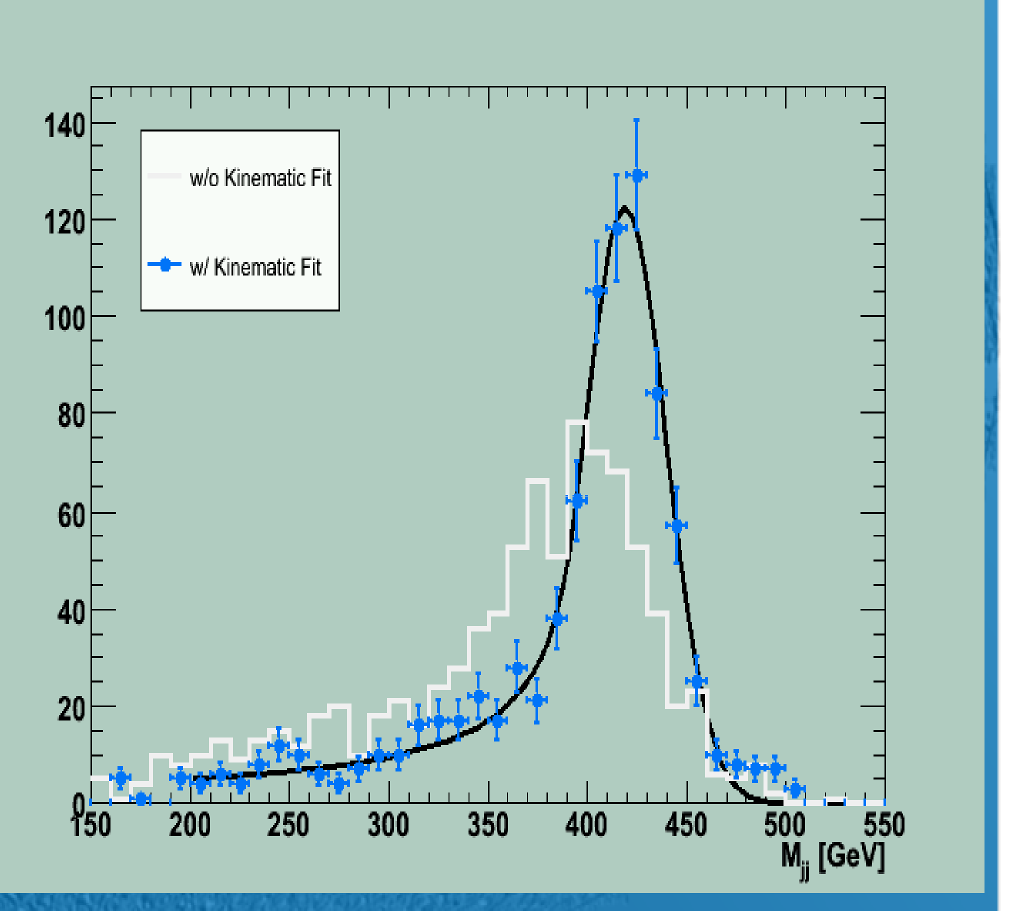
$e^+e^- \to H^0A^0$ Selection Criteria



$e^+e^- \rightarrow H^0A^0$ 4-jet Kinematic Fit

Perform constrained kinematic fit to 4-jet system, which uses Lagrange multipliers and minimises a χ^2 constructed from the measured energies and directions of the jets;

Impose centre-of-mass energy and momentum conservation;
Consider jj jj pairing giving smallest mass difference and plot di-jet masses M_{jj} (2 entries / evt);



Port of `PUFITC+` developed for DELPHI at LEP2 (N Kjaer, M Mulders) to `MarlinReco` framework

Preliminary DiJet Mass Fit

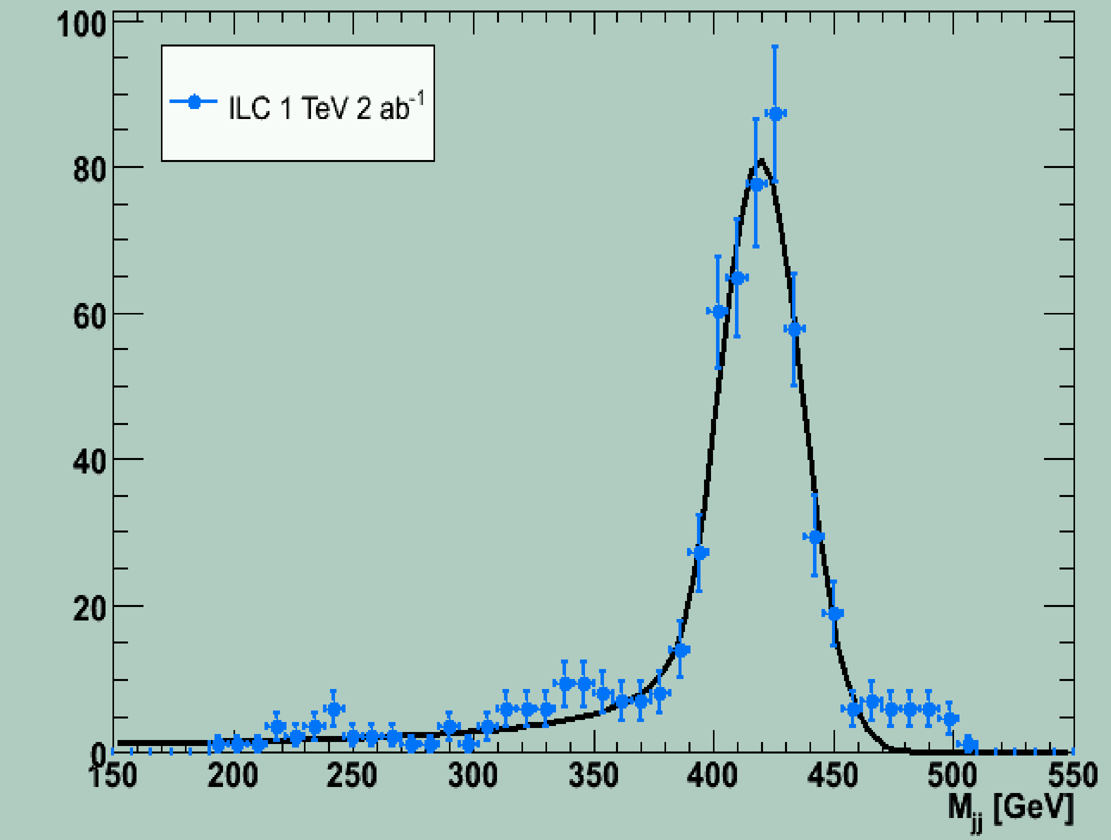
Optimise resolution with
$|M_{jj1} - M_{jj2}| < 25$ GeV

Total Efficiency 23%

Fit with Crystal Ball Function and extract Mass and Width:

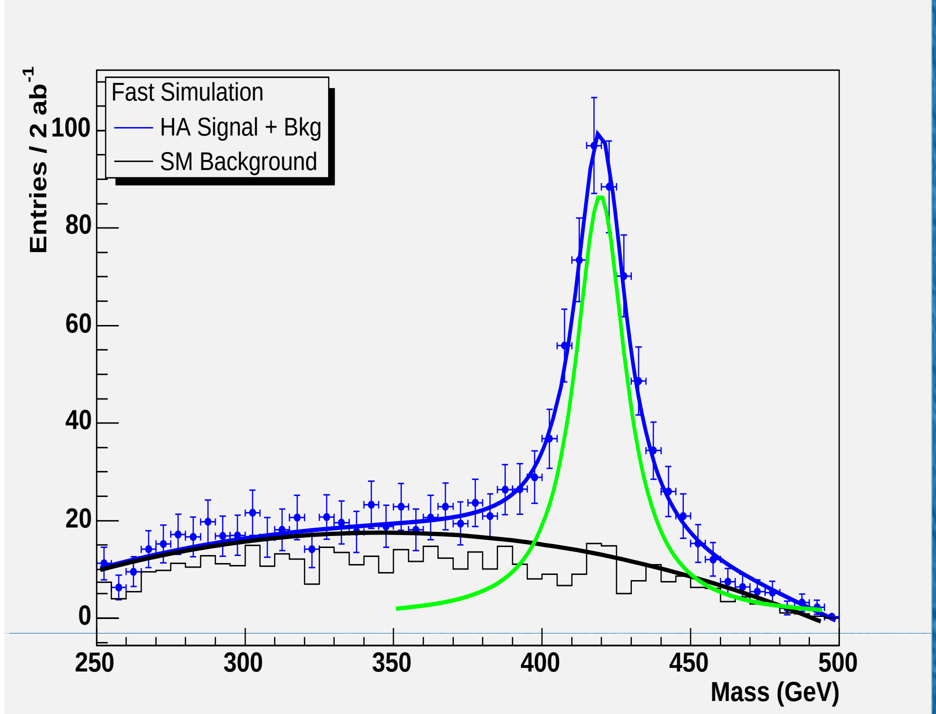
$$M = (419 \pm 0.9)\text{GeV}$$
$$\Gamma = (17 \pm 0.9)\text{GeV}$$

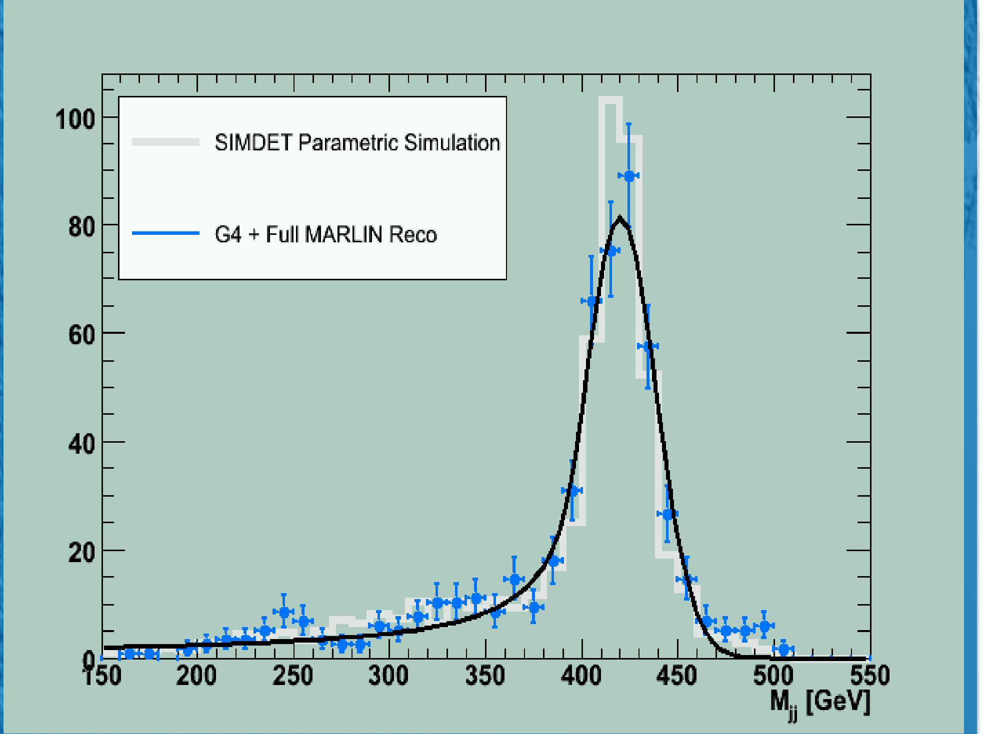
(Preliminary)



Comparison with SIMDET

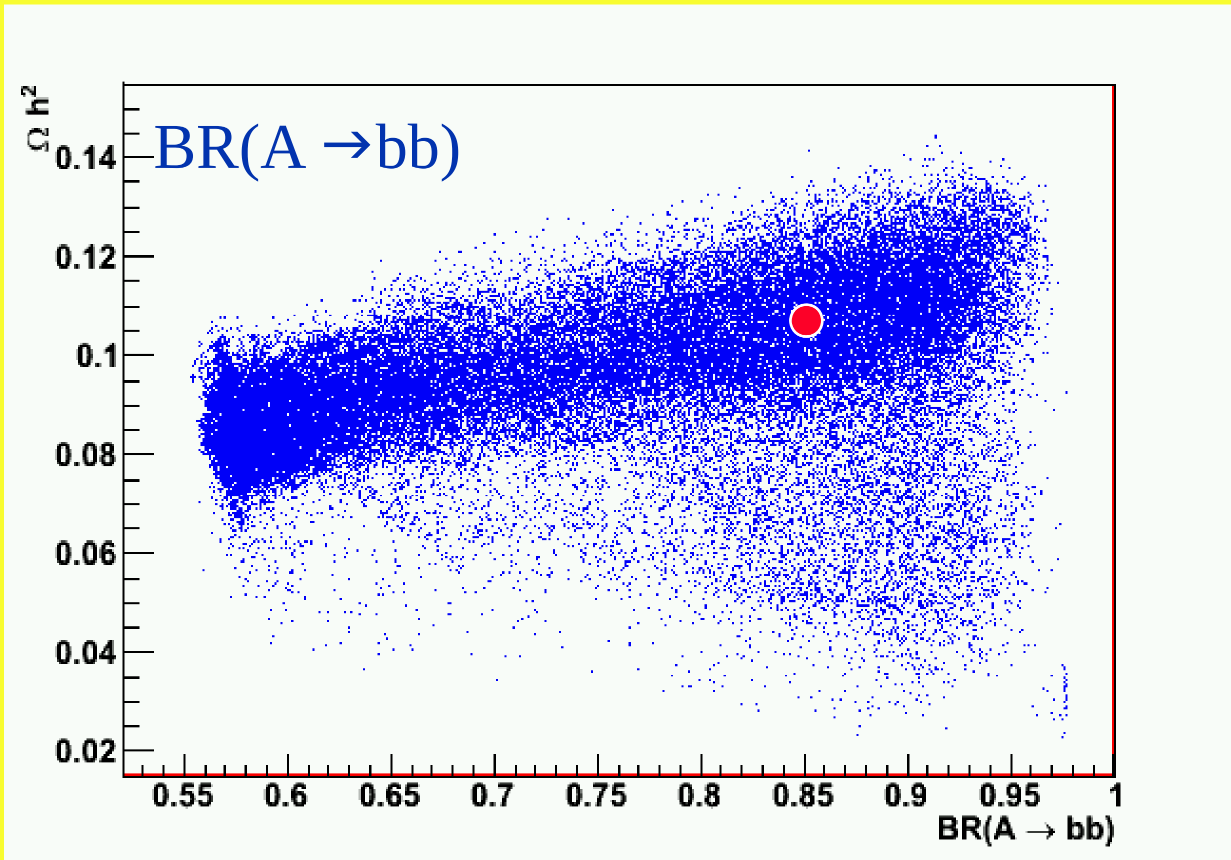
SIMDET	5-par Fit
$M(A)$ (GeV)	418.9±0.8
$\Gamma(A)$ (GeV)	16.1±2.7
$M(H) - M(A)$ (GeV)	1.4 (Fixed)



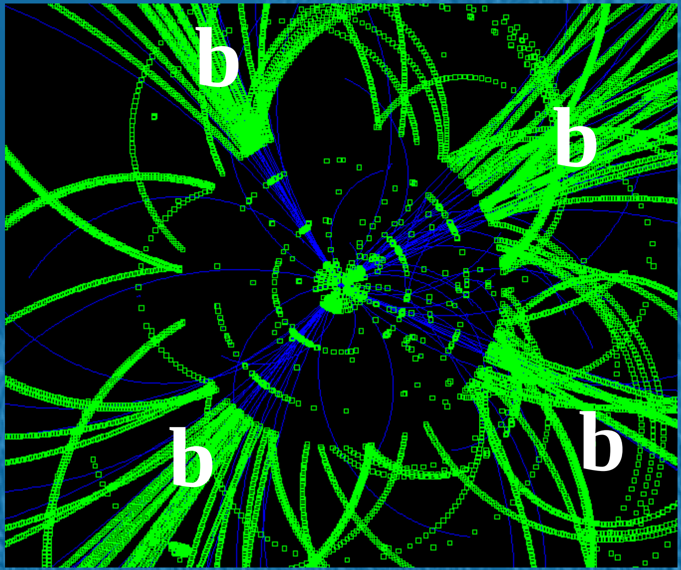


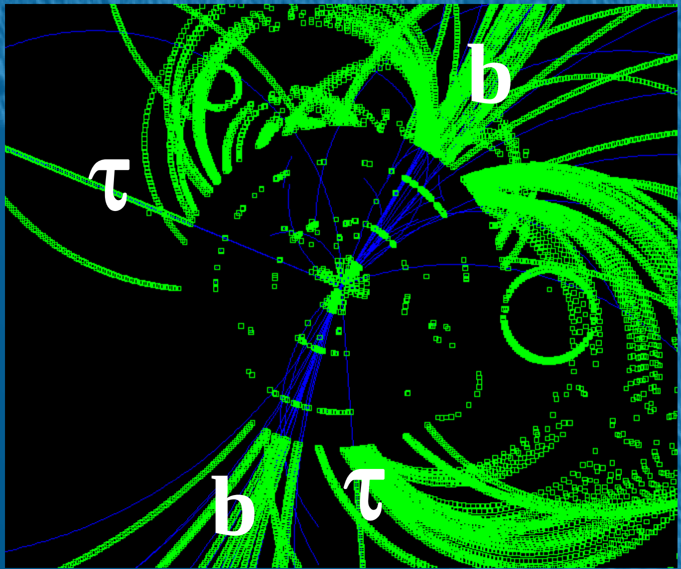
Further DM Constraints from HA

Analysis of Markov Chain MSSM scans to identify further observables to possibly improve DM density determination at the ILC



A^0 Branching Fraction Determination





Contrast bbττ to bbbb based on missing energy, nb. of hadronic jets and jj+recoil masses;

bbττ Reconstruction Efficiency 35%

Determine BR(A→ττ) from rate of bbττ to bbbb tags, WW + ZZ background appears small;

Expect $\frac{\delta \mathrm{BR}(\mathrm{A} \rightarrow \tau\tau)}{\mathrm{BR}(\mathrm{A} \rightarrow \tau\tau)} \sim 0.15$

$$\frac{\delta \mathrm{BR}(\mathrm{A} \rightarrow bb)}{\mathrm{BR}(\mathrm{A} \rightarrow bb)} \sim 0.07$$

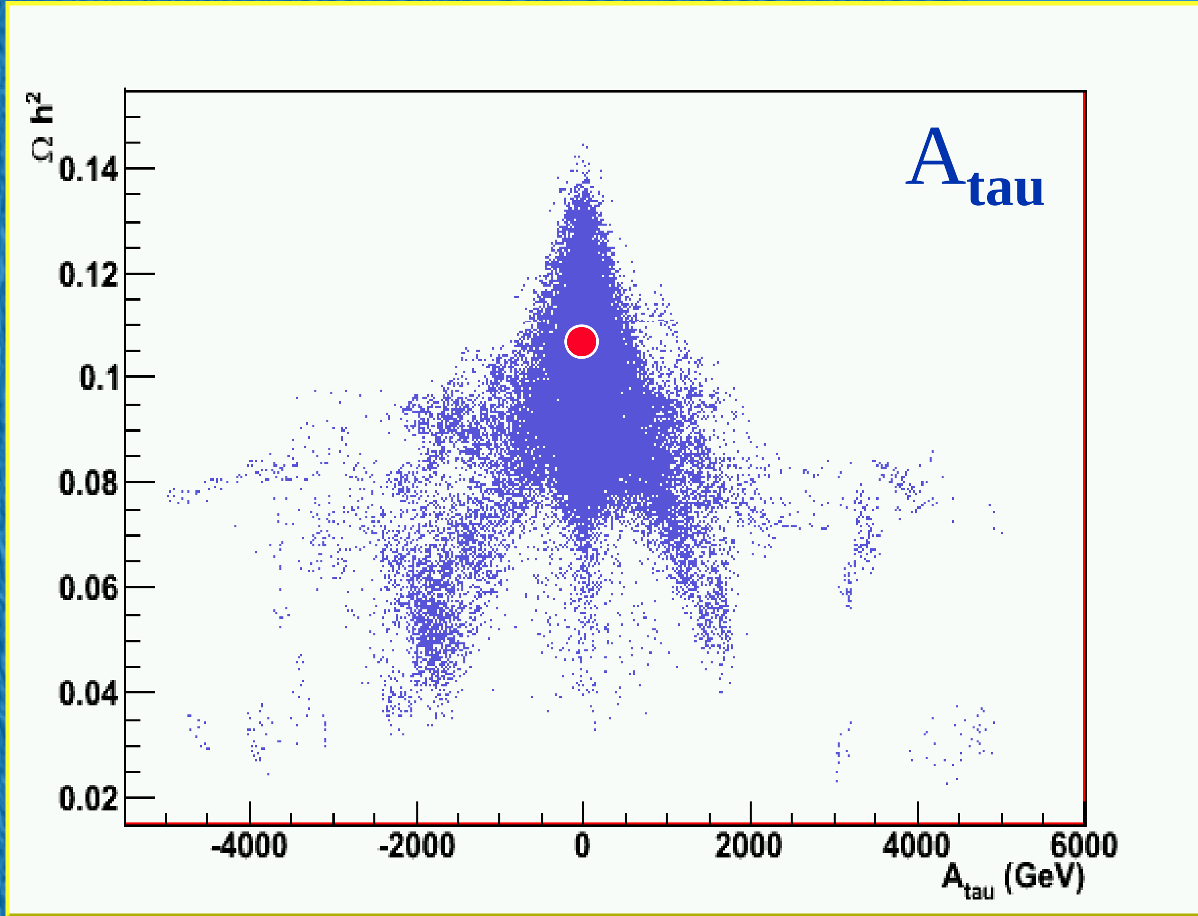
Stau Tri-linear Coupling - A_{tau}

Constrain A_{tau} through $H \rightarrow \tilde{\tau}\tilde{\tau}$ decays:

Stau Couplings to H/A:

A	$A_{tau} \tan\beta + \mu$
H	$A_{tau} \frac{\cos\alpha}{\cos\beta} + \mu \frac{\sin\alpha}{\cos\beta}$

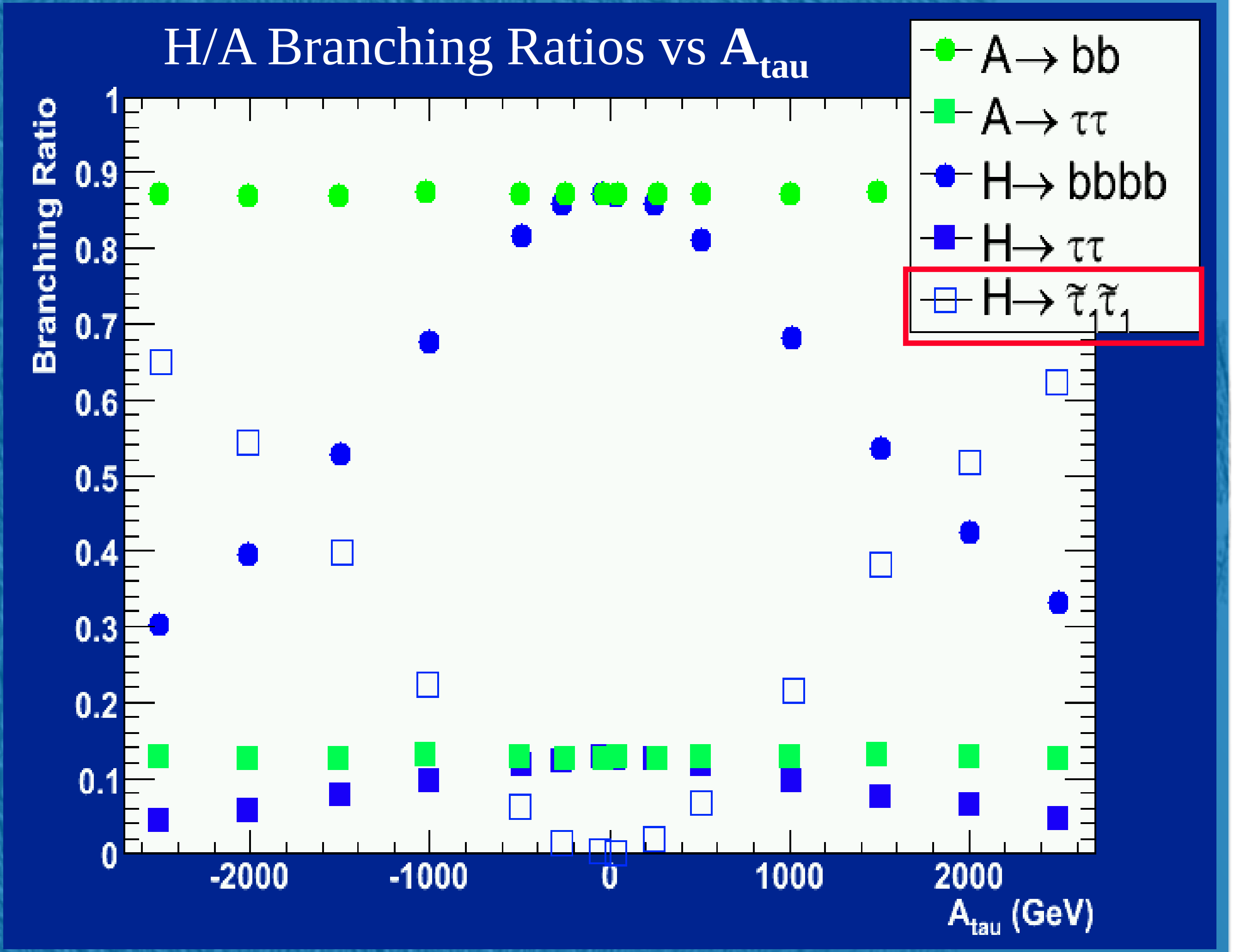
In A funnel, $M_A < M_{\tau 1} + M_{\tau 2}$ and the only such decay allowed by CP for the pseudoscalar $A \rightarrow \tau_1 \tau_2$ is not available;



Heavy H0 $\rightarrow \tau_1 \tau_1$ scales with Atau and can be used to constrain stau trilinear coupling in this regime.

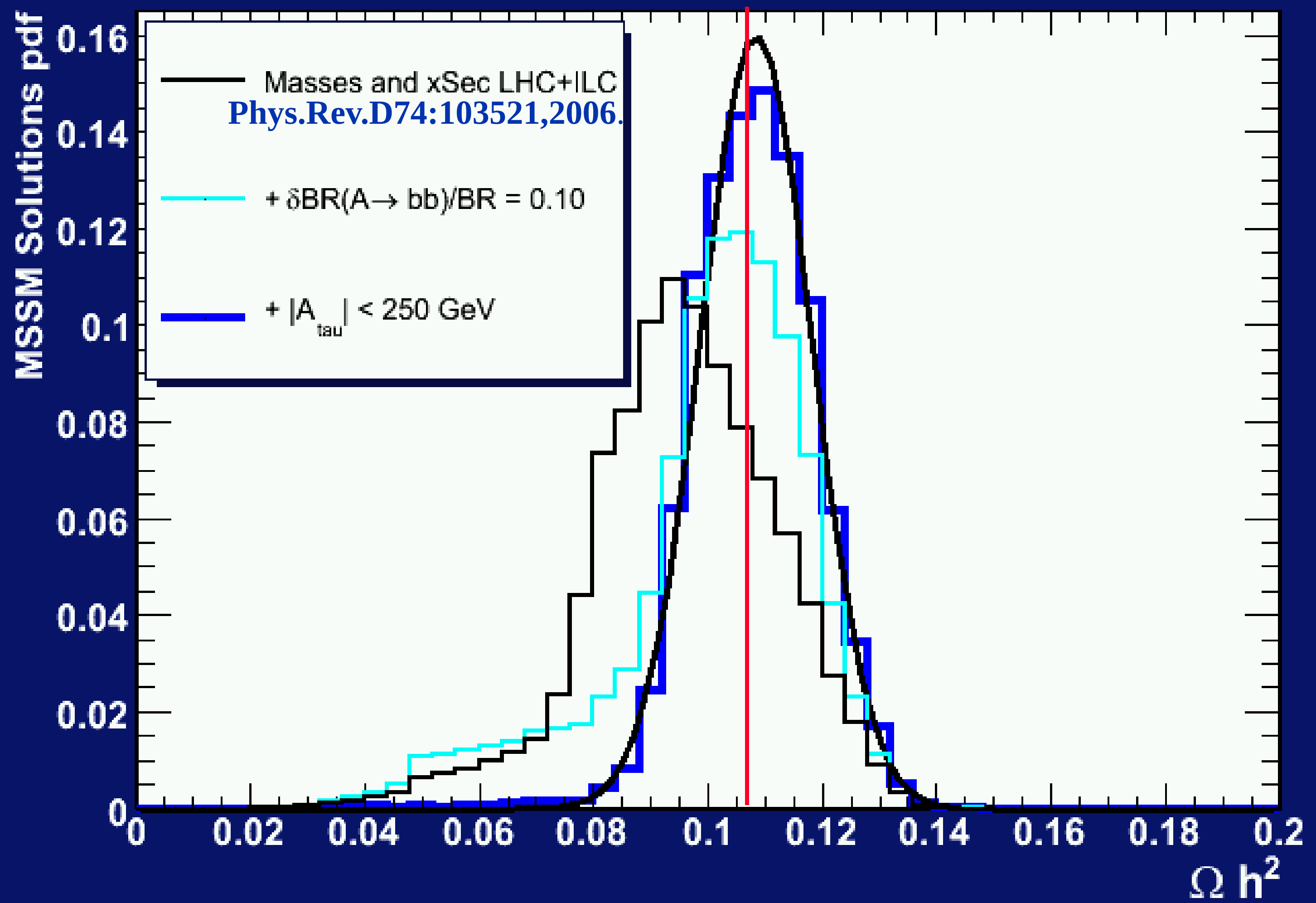
Stau Tri-linear Coupling - A_{tau}

A_{tau} scan for LCC4 MSSM parameters with `HDECAY 2.0`

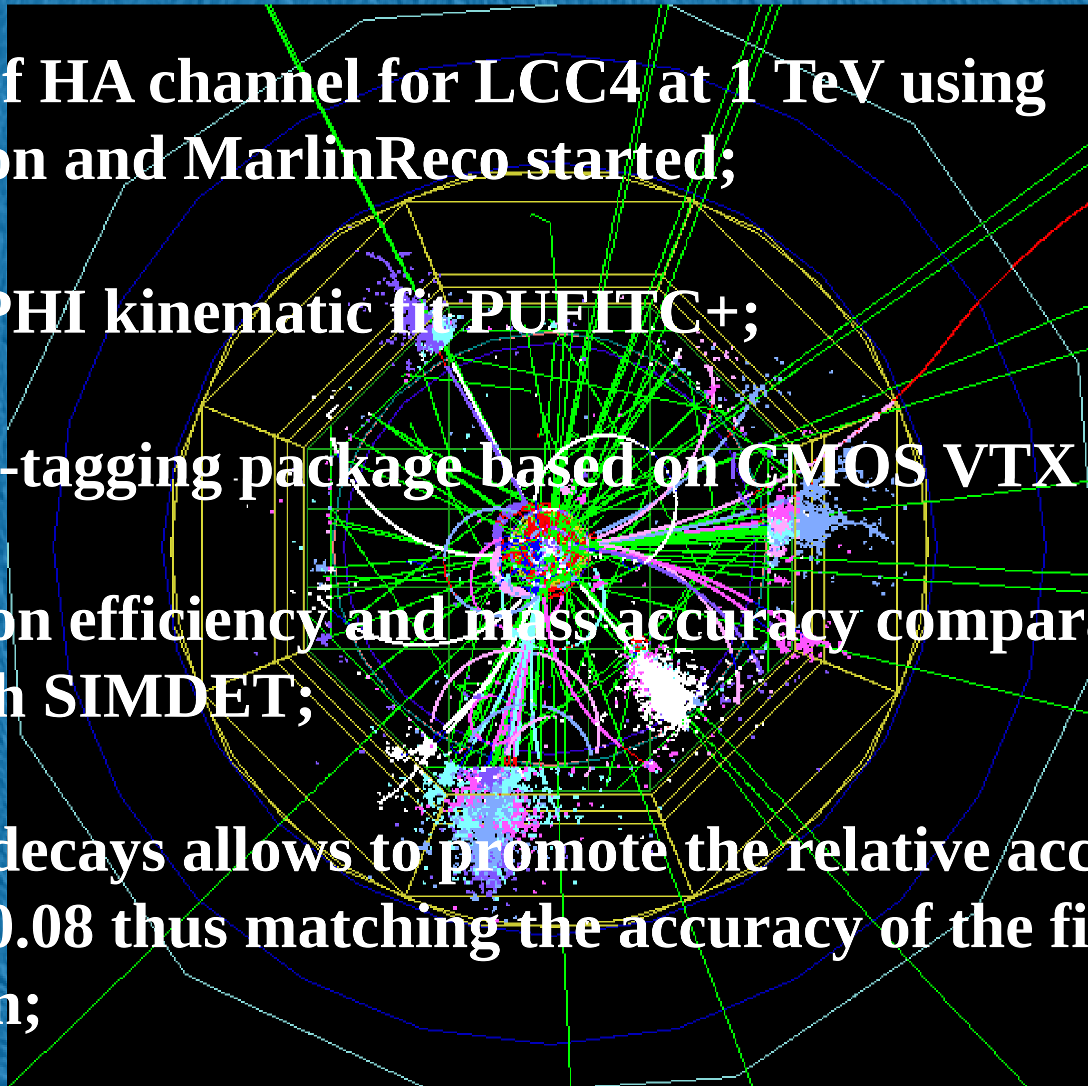


Large $H \rightarrow \tau_1 \tau_1$ can be detected by standard $bb\tau\tau$ + bbbb analysis and used to constrain Stau trilinear coupling

DM density accuracy for LCC4 with HA analysis



Conclusion



- Re-analysis of HA channel for LCC4 at 1 TeV using full simulation and MarlinReco started;
- Ported DELPHI kinematic fit PUFITC+;
- Developing b-tagging package based on CMOS VTX Tracker;
- First results on efficiency and mass accuracy comparable to those obtained with SIMDET;
- study of HA decays allows to promote the relative accuracy on Ωh^2 from 0.16 to 0.08 thus matching the accuracy of the first WMAP determination;