SiD Benchmarking Status

Tim Barklow

Jan 29, 2008

Outline

- Compulsory Physics Benchmarks for LOI
- Additional SiD Benchmarks for LOI
- Manpower
- Tools
- SiD Benchmarking Timeline
- Data Set News
- Examples of recent analysis work

Compulsory LOI Benchmarking List

At a Dec 7 meeting between Sakue Yamada and representatives of SiD, ILD, 4th Concept, and the WWS, it was agreed that the following reactions will be used for LOI Physics Benchmarking:

1. $e^+e^- \to Zh, \to \ell^+\ell^-X,\ l = e, \mu;\ \ m_h = 120$ GeV at $\sqrt{s}$=0.25 TeV

2. $e^+e^- \to Zh,\ Z \to q\bar{q}, \nu\bar{\nu};\ \ h \to c\bar{c},\ \mu^+\mu^-;\quad m_h = 120$ GeV at $\sqrt{s}$=0.25 TeV

3. $e^+e^- \to \tau^+\tau^-$, at $\sqrt{s}$=0.5 TeV

4. $e^+e^- \to t\bar{t}$ at $\sqrt{s}$=0.5 TeV

5. $e^+e^- \to \tilde{\chi}_1^+\tilde{\chi}_1^- / \tilde{\chi}_2^0\tilde{\chi}_2^0 \to W^+W^-\ \tilde{\chi}_1^0\tilde{\chi}_1^0\ /\ ZZ\tilde{\chi}_1^0\tilde{\chi}_1^0$ at $\sqrt{s}$=0.5 TeV

N.B.: The physics observables that are to be measured have not yet been determined.

Compulsory LOI Benchmark Observables - SiD Proposal

1. $e^+e^- \to Zh, \to \ell^+\ell^- X,\ l = e, \mu;\ \ m_h = 120$ GeV at $\sqrt{s}$=0.25 TeV

   M_h & $\sigma(e^+e^- \to Zh)$

2. $e^+e^- \to Zh,\ Z \to q\bar{q}, \nu\bar{\nu};\ \ h \to c\bar{c},\ \mu^+\mu^-;\ \ \ m_h = 120$ GeV at $\sqrt{s}$=0.25 TeV

   BR($h \to c\bar{c}$) & BR($h \to \mu^+\mu^-$)

3. $e^+e^- \to \tau^+\tau^-$, at $\sqrt{s}$=0.5 TeV

   Identification efficiency and purity for $\tau^- \to \pi^-\nu_\tau\ ,\ \rho^-\nu_\tau$

4. $e^+e^- \to t\bar{t}$ at $\sqrt{s}$=0.5 TeV

   $\sigma(e^+e^- \to t\bar{t})$ & M_t (as defined in tree-level event generator such as WHIZARD)

5. $e^+e^- \to \tilde{\chi}_1^+\tilde{\chi}_1^- / \tilde{\chi}_2^0\tilde{\chi}_2^0 \to W^+W^-\tilde{\chi}_1^0\tilde{\chi}_1^0\ /\ ZZ\tilde{\chi}_1^0\tilde{\chi}_1^0$ at $\sqrt{s}$=0.5 TeV

   $M_{\tilde{\chi}_1^+},\ M_{\tilde{\chi}_2^0},\ \ \sigma(e^+e^- \to \tilde{\chi}_1^+\tilde{\chi}_1^-),\ \ \sigma(e^+e^- \to \tilde{\chi}_2^0\tilde{\chi}_2^0)$

Additional SiD Benchmarking Studies for LOI

6. $e^+e^- \to c\bar{c}, b\bar{b}$, at $\sqrt{s}$=0.5 TeV;

   $A_{FB}^{LR}(c)$ & $A_{FB}^{LR}(b)$

7. $e^+e^- \to Zhh$, $m_h = 120$ GeV at $\sqrt{s}$=0.5 TeV;

   g_{hhh}

8. $e^+e^- \to \tilde{\tau}_1\tilde{\tau}_1$, at Point 3 at $\sqrt{s}$=0.5 TeV;

   $M_{\tilde{\tau}_1}$ $\sigma(e^+e^- \to \tilde{\tau}_1\tilde{\tau}_1)$

9. $e^+e^- \to \tilde{t}_1\tilde{t}_1^* \to c\bar{c}\tilde{\chi}_1^0\tilde{\chi}_1^0$, $m_{\tilde{t}_1} = 120$ GeV, $m_{\tilde{\chi}_1^0} = 100$ GeV, at $\sqrt{s}$=0.5 TeV

   $M_{\tilde{t}_1}$, $\sigma(e^+e^- \to \tilde{t}_1\tilde{t}_1^*)$, $\cos\theta_{\tilde{t}}$

10. $e^+e^- \to \tilde{b}_1\tilde{b}_1^* \to b\bar{b}\tilde{\chi}_1^0\tilde{\chi}_1^0$, at $\sqrt{s}$=0.5 TeV

    $M_{\tilde{b}_1}$, $\sigma(e^+e^- \to \tilde{b}_1\tilde{b}_1^*)$

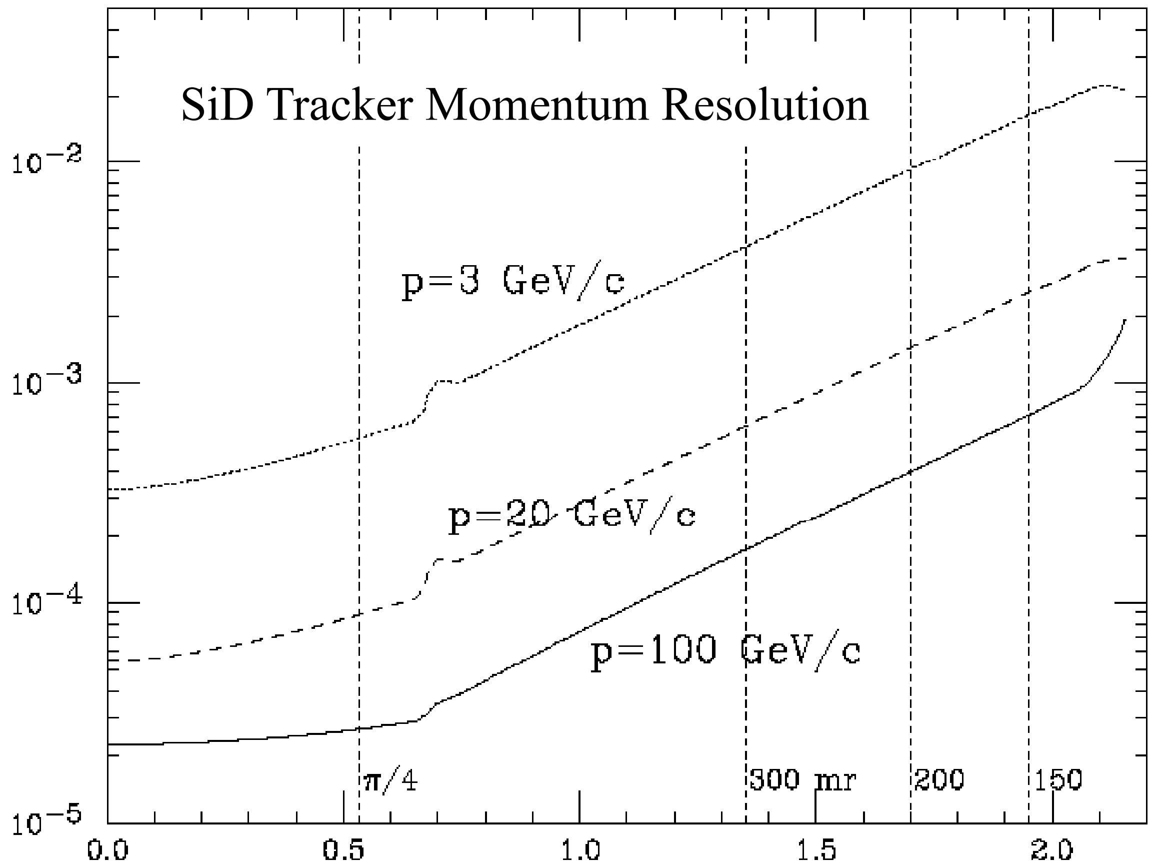
11. $e^+e^- \to \mu^+\mu^-$, at $\sqrt{s}$=0.5 TeV

    Luminosity Weighted $\sqrt{s}$

Manpower

1. $e^+e^- \rightarrow Zh, \rightarrow \ell^+\ell^- X,\ l - e, \mu;\ m_h - 120$ GeV at $\sqrt{s}$–0.25 TeV — SLAC
2. $e^+e^- \rightarrow Zh,\ Z \rightarrow q\bar{q}, \nu\bar{\nu};\ h \rightarrow c\bar{c},\ \mu^+\mu^-;\ m_h = 120$ GeV at $\sqrt{s}$=0.25 TeV — Michigan/RAL/Bristol ?
3. $e^+e^- \rightarrow \tau^+\tau^-$, at $\sqrt{s}$=0.5 TeV — Texas A&M (Alexei Safonov)?
4. $e^+e^- \rightarrow t\bar{t}$ at $\sqrt{s}$=0.5 TeV — Oxford (Eric Devetak)
5. $e^+e^- \rightarrow \tilde{\chi}_1^+\tilde{\chi}_1^- / \tilde{\chi}_2^0\tilde{\chi}_2^0 \rightarrow W^+W^-\tilde{\chi}_1^0\tilde{\chi}_1^0\ /\ ZZ\tilde{\chi}_1^0\tilde{\chi}_1^0$ at $\sqrt{s}$=0.5 TeV — SLAC
6. $e^+e^- \rightarrow c\bar{c}, b\bar{b}$, at $\sqrt{s}$=0.5 TeV; — Oxford (Ben Jeffery)
7. $e^+e^- \rightarrow Zhh,\ m_h = 120$ GeV at $\sqrt{s}$=0.5 TeV; — Oxford (Tomas Lastovicka/Yiming Li)
8. $e^+e^- \rightarrow \tilde{\tau}_1\tilde{\tau}_1$, at Point 3 at $\sqrt{s}$=0.5 TeV; — Texas A&M/Colorado ?
9. $e^+e^- \rightarrow \tilde{t}_1\tilde{t}_1^* \rightarrow c\bar{c}\tilde{\chi}_1^0\tilde{\chi}_1^0,\ m_{\tilde{t}_1} = 120$ GeV, $m_{\tilde{\chi}_1^0} = 100$ GeV, at $\sqrt{s}$=0.5 TeV — Lancaster
10. $e^+e^- \rightarrow \tilde{b}_1\tilde{b}_1^* \rightarrow b\bar{b}\tilde{\chi}_1^0\tilde{\chi}_1^0$, at $\sqrt{s}$=0.5 TeV — Oxford/Montenegro (Gordana Medin)
11. $e^+e^- \rightarrow \mu^+\mu^-$, at $\sqrt{s}$=0.5 TeV — SLAC

org.lcsim FastMC
Tracker momentum error parameterized in terms of momentum and polar angle (B. Schumm)



org.lcsim FastMC
Covariance matrix for 5 tracker variables parameterized in terms of momentum and polar angle (B. Schumm)

$(\Delta r)^2 \ (cm^2)$

Cov matrix entry 1 , 1

41	
13	
0.0000	
1.000	0.1036E-05
1.800	0.5482E-06
3.200	0.3398E-06
5.600	0.2193E-06
10.000	0.1415E-06
18.000	0.1000E-06
32.000	0.7850E-07
56.000	0.6761E-07
100.000	0.6270E-07
180.000	0.6092E-07
320.000	0.6035E-07
560.000	0.6017E-07
1000.000	0.6011E-07
0.1090	
1.000	0.1048E-05
1.800	0.5530E-06
3.200	0.3423E-06
5.600	0.2209E-06
10.000	0.1425E-06
18.000	0.1005E-06
32.000	0.7875E-07
56.000	0.6773E-07
100.000	0.6275E-07
180.000	0.6093E-07
320.000	0.6035E-07
560.000	0.6017E-07
1000.000	0.6011E-07

$(\Delta \varphi)^2$

Cov matrix entry 2 , 2

41	
13	
0.0000	
1.000	0.3674E-06
1.800	0.1325E-06
3.200	0.5287E-07
5.600	0.2259E-07
10.000	0.9152E-08
18.000	0.3661E-08
32.000	0.1535E-08
56.000	0.7042E-09
100.000	0.3814E-09
180.000	0.2715E-09
320.000	0.2370E-09
560.000	0.2262E-09
1000.000	0.2226E-09
0.1090	
1.000	0.3735E-06
1.800	0.1346E-06
3.200	0.5363E-07
5.600	0.2291E-07
10.000	0.9286E-08
18.000	0.3713E-08
32.000	0.1556E-08
56.000	0.7126E-09
100.000	0.3843E-09
180.000	0.2724E-09
320.000	0.2373E-09
560.000	0.2263E-09
1000.000	0.2226E-09

$(\Delta \Omega)^2 \ (cm^{-2})$

Cov matrix entry 3 , 3

41	
13	
0.0000	
1.000	0.4526E-09
1.800	0.1402E-09
3.200	0.4470E-10
5.600	0.1479E-10
10.000	0.4752E-11
18.000	0.1541E-11
32.000	0.5423E-12
56.000	0.2239E-12
100.000	0.1164E-12
180.000	0.8219E-13
320.000	0.7174E-13
560.000	0.6848E-13
1000.000	0.6740E-13
0.1090	
1.000	0.4610E-09
1.800	0.1428E-09
3.200	0.4553E-10
5.600	0.1506E-10
10.000	0.4838E-11
18.000	0.1568E-11
32.000	0.5510E-12
56.000	0.2268E-12
100.000	0.1173E-12
180.000	0.8248E-13
320.000	0.7183E-13
560.000	0.6851E-13
1000.000	0.6741E-13

$(\Delta z)^2 \ (cm^2)$

Cov matrix entry 4 , 4

41	
13	
0.0000	
1.000	0.1043E-05
1.800	0.5589E-06
3.200	0.3888E-06
5.600	0.3325E-06
10.000	0.3133E-06
18.000	0.3072E-06
32.000	0.3053E-06
56.000	0.3048E-06
100.000	0.3046E-06
180.000	0.3045E-06
320.000	0.3045E-06
560.000	0.3045E-06
1000.000	0.3045E-06
0.1090	
1.000	0.1063E-05
1.800	0.5663E-06
3.200	0.3914E 06
5.600	0.3333E-06
10.000	0.3136E-06
18.000	0.3073E-06
32.000	0.3054E-06
56.000	0.3048E-06
100.000	0.3046E-06
180.000	0.3045E-06
320.000	0.3045E-06
560.000	0.3045E-06
1000.000	0.3045E-06

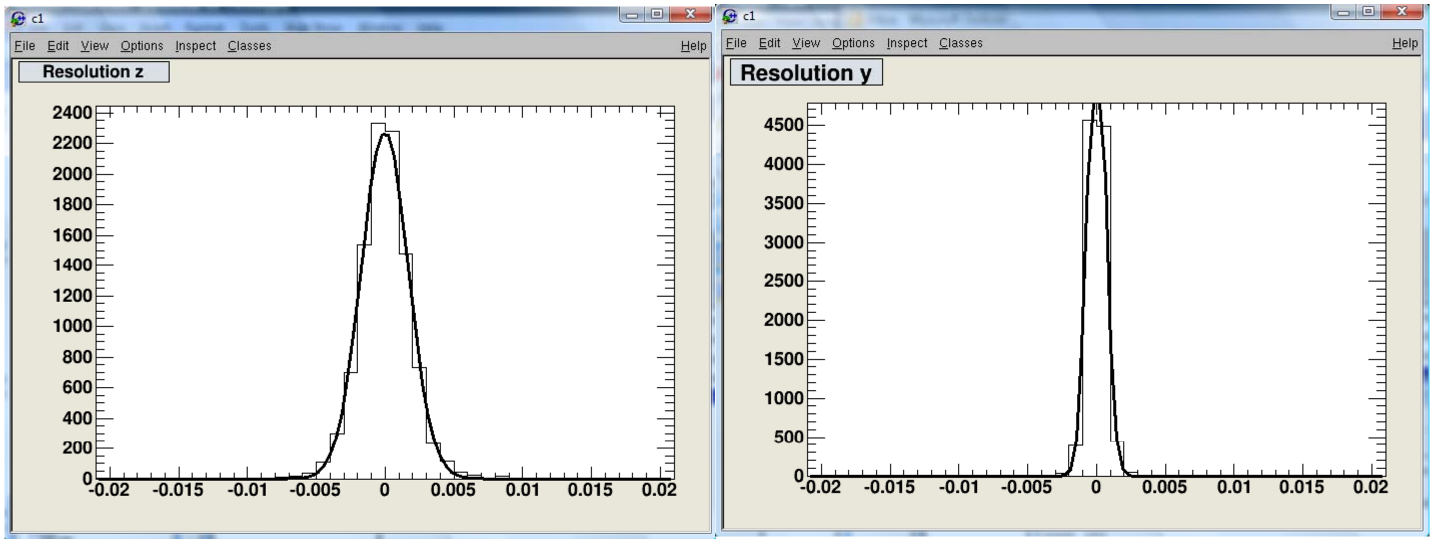
$(\Delta \lambda)^2$

Cov matrix entry 5 , 5

41	
13	
0 0000	
1.000	0.3656E-06
1.800	0.1316E-06
3.200	0.5537E-07
5.600	0.3090E-07
10.000	0.2267E-07
18.000	0.2006E-07
32.000	0.1926E-07
56.000	0.1901E-07
100.000	0.1893E-07
180.000	0.1890E-07
320.000	0.1890E-07
560.000	0.1889E-07
1000.000	0.1889E-07
0.1090	
1.000	0.3757E-06
1.800	0.1349E-06
3.200	0.5648E-07
5.600	0.3127E-07
10.000	0.2279E-07
18.000	0.2010E-07
32.000	0.1927E-07
56.000	0.1902E-07
100.000	0.1893E-07
180.000	0.1891E-07
320.000	0.1890E-07
560.000	0.1889E-07
1000.000	0.1889E-07

Primary Vertex Reconstruction with org.lcsim FastMC

- 2 μm in z-direction
- <0.8 μm in x-y plane (beamspot constr.) 2 μm (no beamspot constr.)
- Vertex resolution pulls are nice Gaussians with σ ~ 1.1 for all x,y and z



org.lcsim FastMC

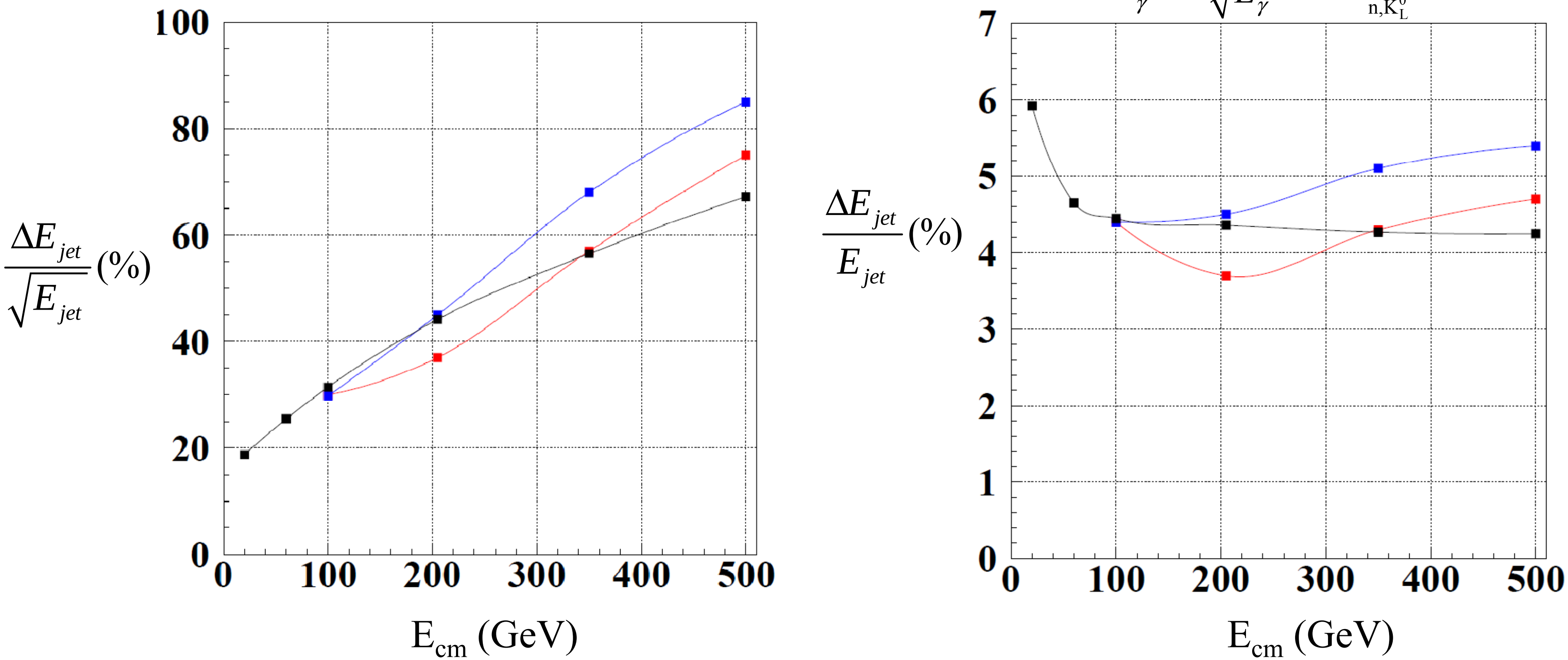
Figure shows smearing with beamspot constraint → (x,y) affected…

org.lcsim FastMC simulation of Calorimeter/PFA output

Use tracker momentum for all charged tracks within acceptance;
account for confusion term by blowing up single particle resolution for neutral hadrons

GLD PFA (blue) — LDC PFA (red) — org.lcsim FASTMC with (black)

$$\frac{\Delta E_\gamma}{E_\gamma} = \frac{0.18}{\sqrt{E_\gamma}} \qquad \frac{\Delta E_{n,K_L^0}}{E_{n,K_L^0}} = 0.28$$



Light quark jets ee→qq

Alternative to org.lcsim FastMC:

Perfect Pattern Recognition Particle Flow Reconstruction or PPR PFA

(Ron Cassell)

What does PPR PFA do?

- Input: Full detector simulations (SLIC)
- Output: Collection of ReconstructedParticles
- Original intent: Examine the potential of a PFA for a detector

How does PPR PFA do it?

- For charged particles that are “trackable”, define Tracks and smear parameters (MCFast).
- Define a set of “reconstructable” particles (avoid double counting)
- For “nontrackable” particles, assign energy deposits in the calorimeters (cheat) and do neutral particle reconstruction using those deposits.

How realistic is PPR PFA?

- Tracking: The tracking is parameterized as in the FastMC. However, full detector effects (interactions and decays) before the calorimeter are taken into account in deciding which particles are actually tracked.
- Neutrals: No parameterization. Perfect pattern recognition (no confusion term), but actual detector responses used for energy and direction. So most of the nasty nonlinear, nongaussian effects are included.

PPR PFA Status

- The perfect pattern recognition PFA appears to be ready for use in benchmarking, with a test sample of Zhh events at 500 GeV processed and ready to look at.
- Benchmarking group will begin looking at the Zhh test sample shortly.

List of LOI tasks and time line for these tasks

Subgroup	LOI-task	Sub-tasks	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep
BENCHMARK	**strategy for LOI**	define benchmark reactions and observables										
BENCHMARK	**MC Physics Event Generation**	Modify 500 GeV SM data										
		Gen 250 GeV SM data										
		Gen 250 GeV beam bgnd										
		Gen non-SM signals										
BENCHMARK	**Physics analysis algorithm development**	identify people										
		algorithm bench 1										
		algorithm bench 2										
		algorithm bench 3										
		algorithm bench 4										
		algorithm bench 5										
		algorithm bench 6,7,10										
		algorithm bench 8										
		algorithm bench 9										
		algorithm bench 11										
BENCHMARK	**Preparation for full sim. & recon.**	Establish ground rules for full sim.& recon										
		Perform dress rehearsal of full sim. & recon. chain										
		Negotiate cpu/disk alloc w/ SLAC &Fermi computing										
BENCHMARK	**Full sim., recon., & analysis for LOI**	Perform full sim. & recon., and produce LCIO files										
		tune/train physics alg using fully sim LCIO as input										
		final physics analysis results ready										
BENCHMARK	**write LOI section**	select editors										
		subsection outline										
		identify authors										
		create it										

LOI tasks and fraction completed

Subgroup	LOI-task	Sub-tasks	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
BENCHMARK	**strategy for LOI**	define benchmark reactions and observables										
BENCHMARK	**MC Physics Event Generation**	Modify 500 GeV SM data										
		Gen 250 GeV SM data										
		Gen 250 GeV beam bgnd										
		Gen non-SM signals										
BENCHMARK	**Physics analysis algorithm development**	identify people										
		algorithm bench 1										
		algorithm bench 2										
		algorithm bench 3										
		algorithm bench 4										
		algorithm bench 5										
		algorithm bench 6,7,10										
		algorithm bench 8										
		algorithm bench 9										
		algorithm bench 11										
BENCHMARK	**Preparation for full sim. & recon.**	Establish ground rules for full sim.& recon										
		Perform dress rehearsal of full sim. & recon. chain										
		Negotiate cpu/disk alloc w/ SLAC &Fermi computing										
BENCHMARK	**Full sim., recon., & analysis for LOI**	Perform full sim. & recon., and produce LCIO files										
		tune/train physics alg using fully sim LCIO as input										
		final physics analysis results ready										
BENCHMARK	**write LOI section**	select editors										
		subsection outline										
		identify authors										
		create it										

% completed as of 27 Jan 2008

500 fb -1 SM Data Sample at Ecm=500 GeV

Data Sample

Stdhep files for an Ecm=500 GeV SM data sample assuming a 120 GeV Higgs mass are available at ftp://ftp-lcd.slac.stanford.edu/ilc/ILC500/StandardModel/ .
There are 487,603,537 events (250 fb -1 luminosity) with -80% electron/ +30% positron polarization, and 474,837,805 events (250 fb -1 luminosity) with +80% electron/ -30% positron polarization.
The WHIZARD Monte Carlo version 1.40 is used for parton generation. The Makefile and build log files for this implementation of WHIZARD can be found in
ftp://ftp-lcd.slac.stanford.edu/ilc/ILC500/StandardModel/whizard-v1r4p0 .

Event Weight

Due to the presence of some high cross section processes the events are not completely unweighted.
The event weight must therefore always be considered when analyzing events.
This weight is stored in the variable EVENTWEIGHTLH in the stdhep common block HEPEV4.

Process Identification

Events corresponding to hundreds of different processes are stored in random order in the stdhep files.
For each event
the variable IDRUPLH from the stdhep common block HEPEV4 is used to identify the process.

Suppose that an event has IDRUPLH=14995 . The information about the generation of this event can be found in the directory
ftp://ftp-lcd.slac.stanford.edu/ilc/ILC500/StandardModel/run_output/w14995/run_01/ .
For example the log file is
ftp://ftp-lcd.slac.stanford.edu/ilc/ILC500/StandardModel/run_output/w14995/run_01/whizard.log ,
the whizard input file is
ftp://ftp-lcd.slac.stanford.edu/ilc/ILC500/StandardModel/run_output/w14995/run_01/whizard.in
and cross section information is in
ftp://ftp-lcd.slac.stanford.edu/ilc/ILC500/StandardModel/run_output/w14995/run_01/whizard.n3n3n3n3ss_o.out

Full 2 ab-1 SM Data Sample is also available via ftp. Here each file corresponds to a particular initial e-/e+ pol. and final state.

FTP directory /ilc/whizdata/ILC500/ at ftp-lcd.slac.stanford.edu

To view this FTP site in Windows Explorer, click **Page**, and then click **Open FTP Site in Windows Explorer**.

Up to higher level directory

```
09/16/2007 12:00AM      Directory .
03/14/2007 12:00AM      Directory ..
09/14/2007 09:12PM            144 copy.sh
09/14/2007 09:09PM         60,980 theoryDiskContents.txt
09/14/2007 06:15PM         60,911 tmp.txt
09/14/2007 09:16PM  2,138,688,564 w11715_01.stdhep
09/14/2007 09:19PM  2,138,688,564 w11715_02.stdhep
09/14/2007 09:22PM  2,138,688,564 w11715_03.stdhep
09/14/2007 09:23PM    243,273,156 w11715_04.stdhep
09/14/2007 09:23PM    573,450,716 w11715_05.stdhep
09/14/2007 09:27PM  2,138,688,564 w11716_01.stdhep
09/14/2007 09:30PM  2,138,688,564 w11716_02.stdhep
09/14/2007 09:33PM  2,138,688,564 w11716_03.stdhep
09/14/2007 09:34PM    812,779,312 w11716_04.stdhep
09/14/2007 09:35PM    713,262,648 w11716_05.stdhep
09/14/2007 09:38PM  1,407,942,308 w11719_01.stdhep
09/14/2007 09:40PM  1,408,367,732 w11720_01.stdhep
09/14/2007 09:40PM    145,274,324 w11723_01.stdhep
09/14/2007 09:40PM    145,384,112 w11724_01.stdhep
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09/14/2007 10:19PM  2,138,688,564 w11732_02.stdhep
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Next Steps with SM Data Set

- Remove 120 Higgs from n fermion final states at Ecm=500 GeV, and add explicit ffH, ffHH, etc final states
- Produce full SM data set with Ecm=250 GeV

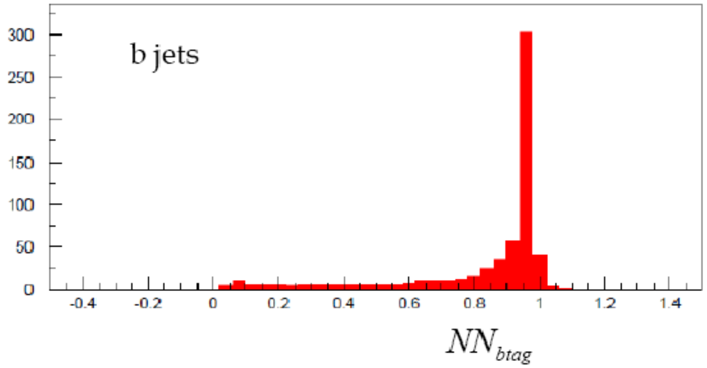
ZHH Channel
First Attempt with the LCFI Package

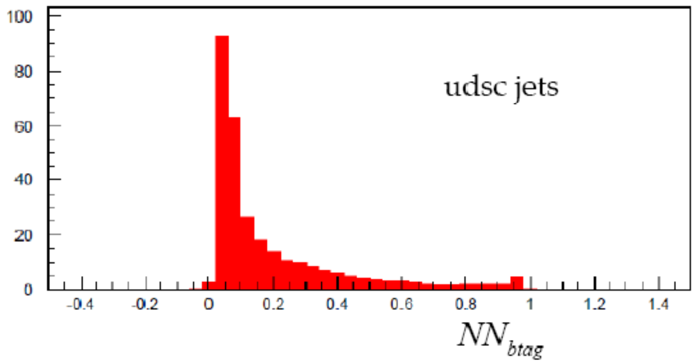
SiD Benchmarking meeting
January 15, 2008

Tomáš Laštovička, Andrei Nomerotski
Yiming Li

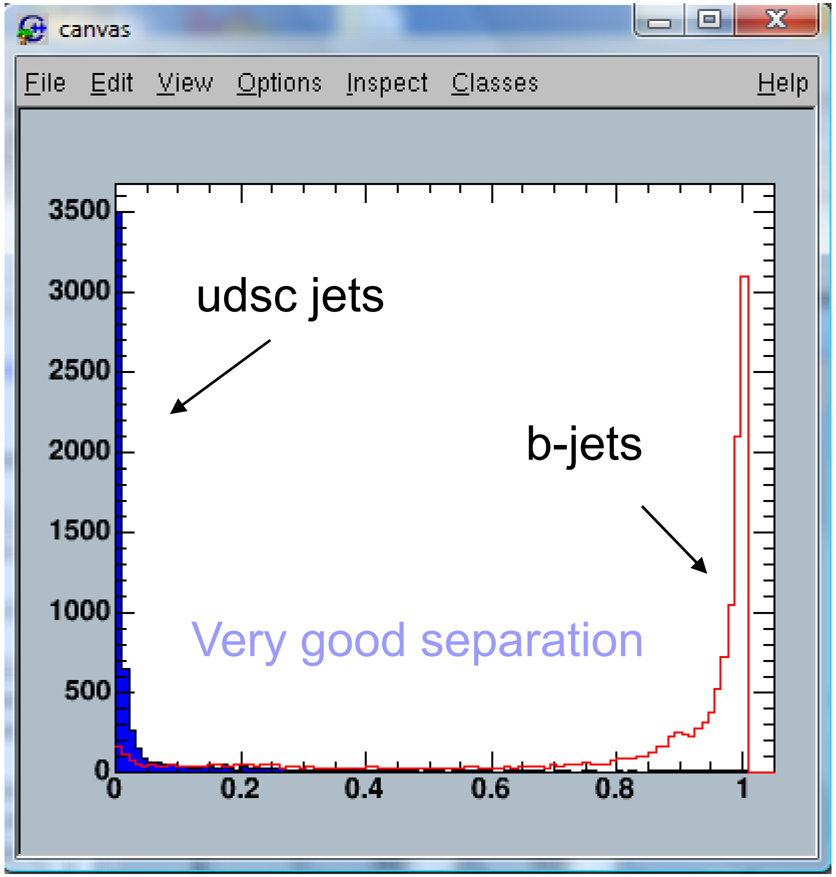
Neural Net Outputs

Tim's net



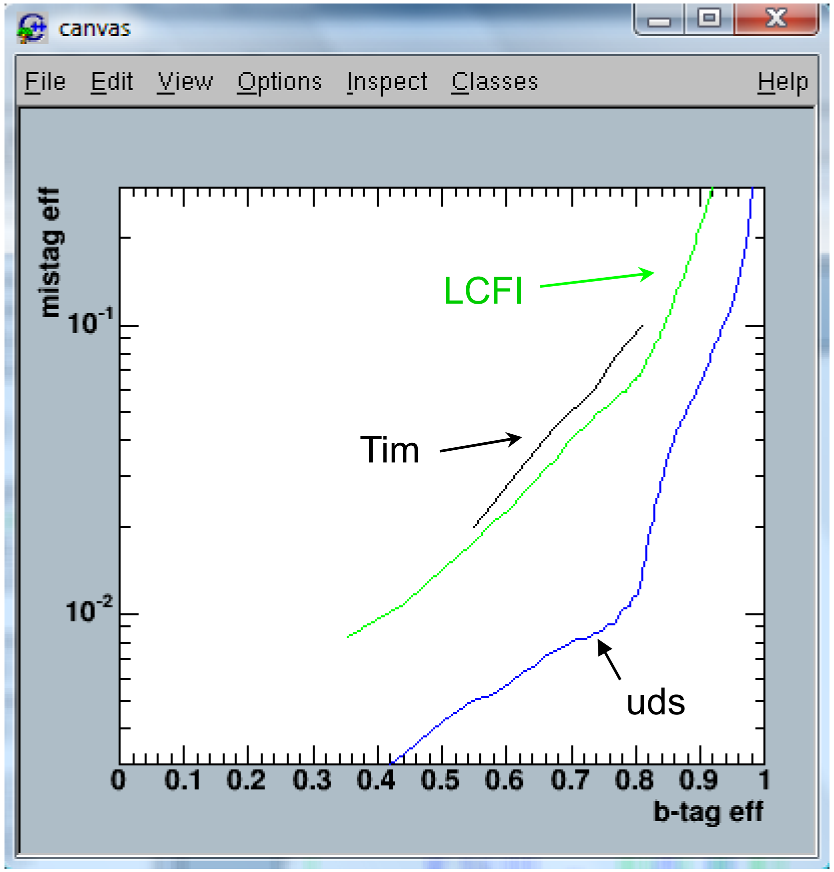


LCFI



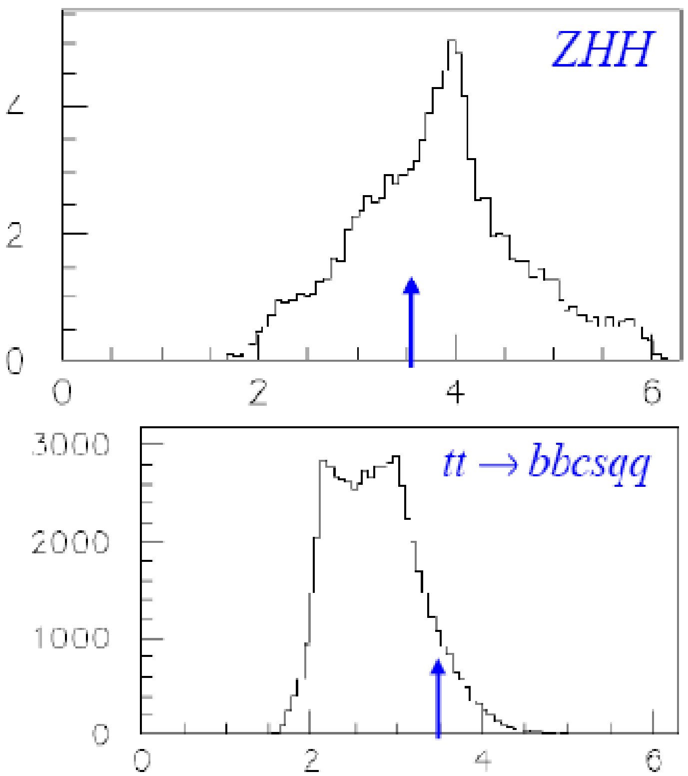
NN performance comparison

- c-mistag efficiency versus b-tagging efficiency
  - LCFI slightly better
  - Note the logarithmic scale
  - Tim's points measured by ruler, based on his efficiency plot shown in Hamburg.
  - ZHH events (signal)

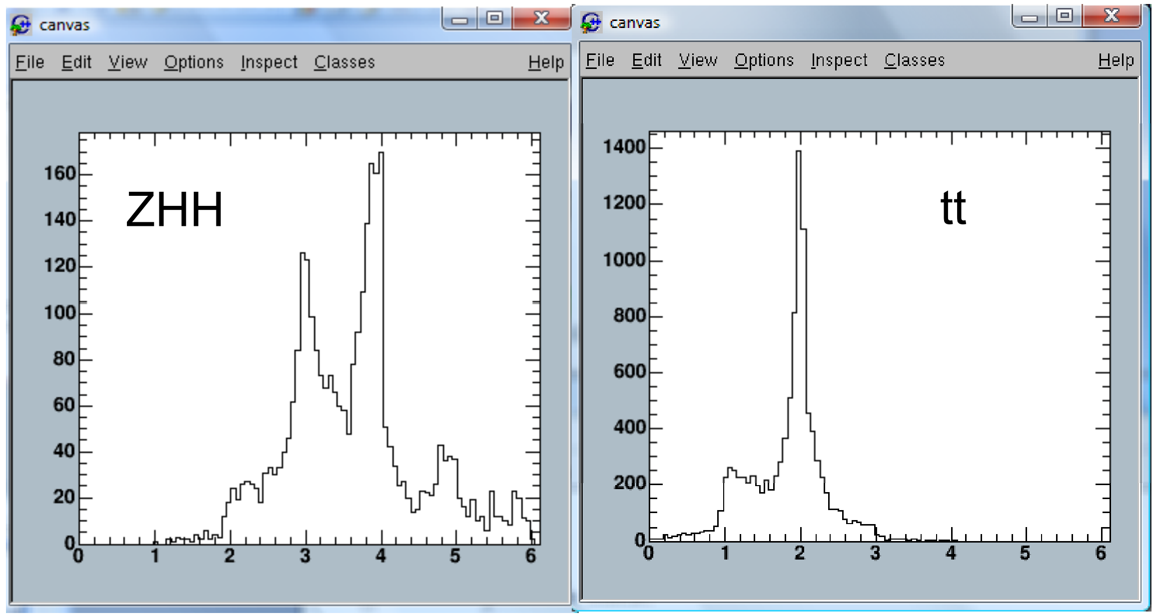


Sum of neural net outputs for all jets

Tim's net



LCFI



Rather different shapes. LCFI has more binary behaviour.

SUSY: sbottom analysis

Gordana Lastovicka-Medin

(University of Montenegro)

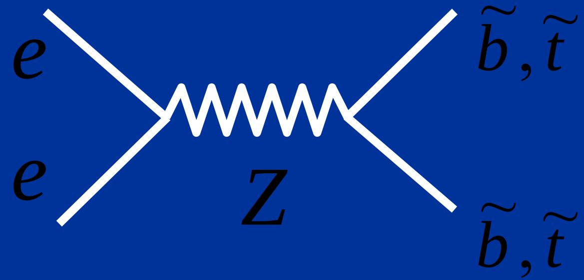
22/1/2008

with Sasha Belyaev, Andrei Nomerotski,

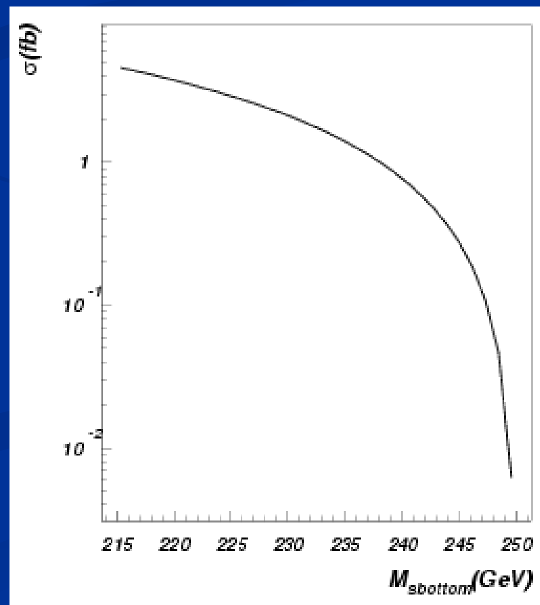
Tomas Lastovicka and Marija Kovacevic

SUSY: sbottom analysis

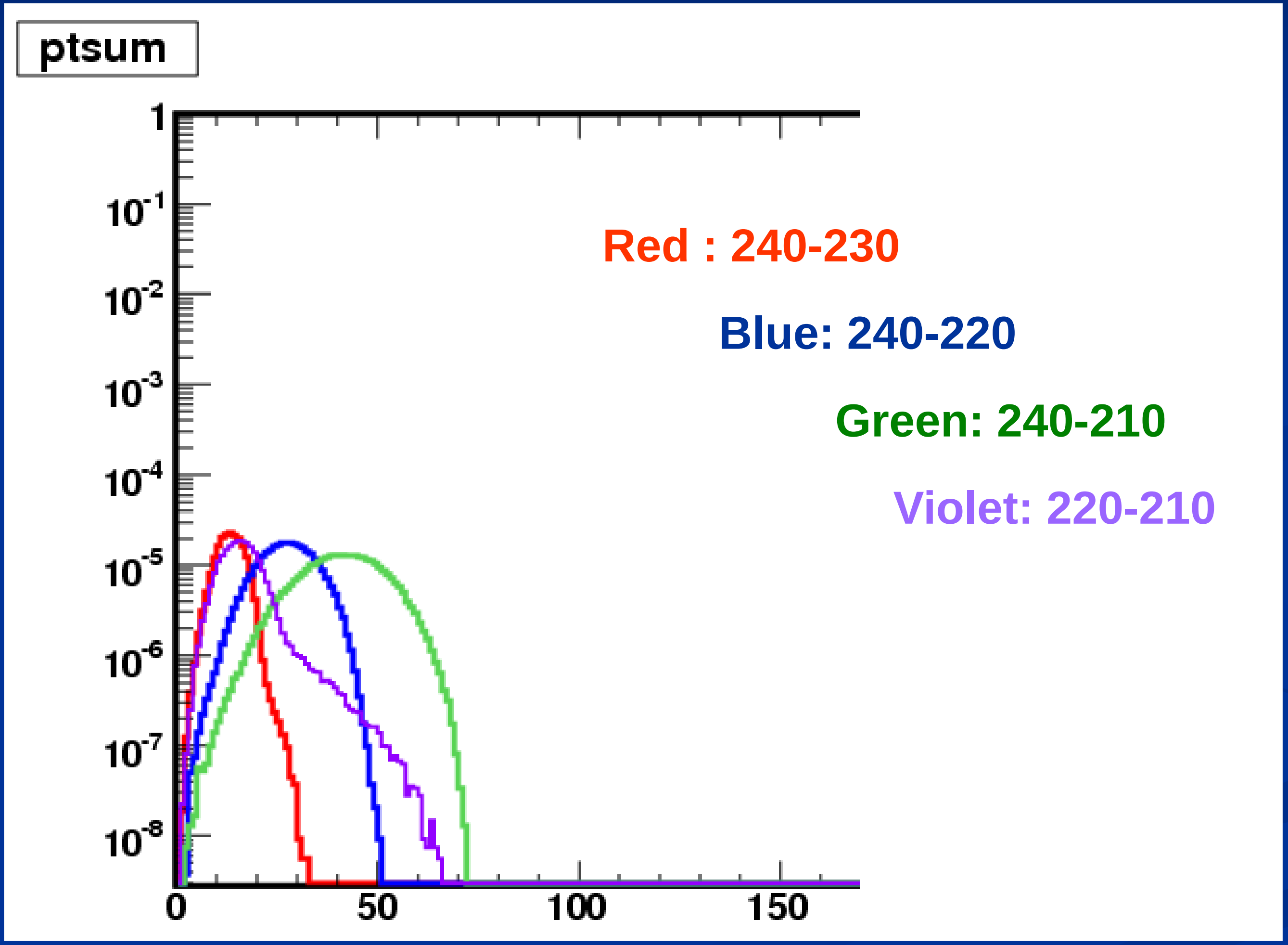
- See talks of Andrei and Tomas on previous WP1 meetings for more details.
- The main idea is that SUSY neutralino is a dark matter candidate. In order not to have too many neutralinos left in our universe they must annihilate effectively – with sbottoms. **SMALL MASS SPLIT**
- Sbottoms can be eventually produced at ILC via



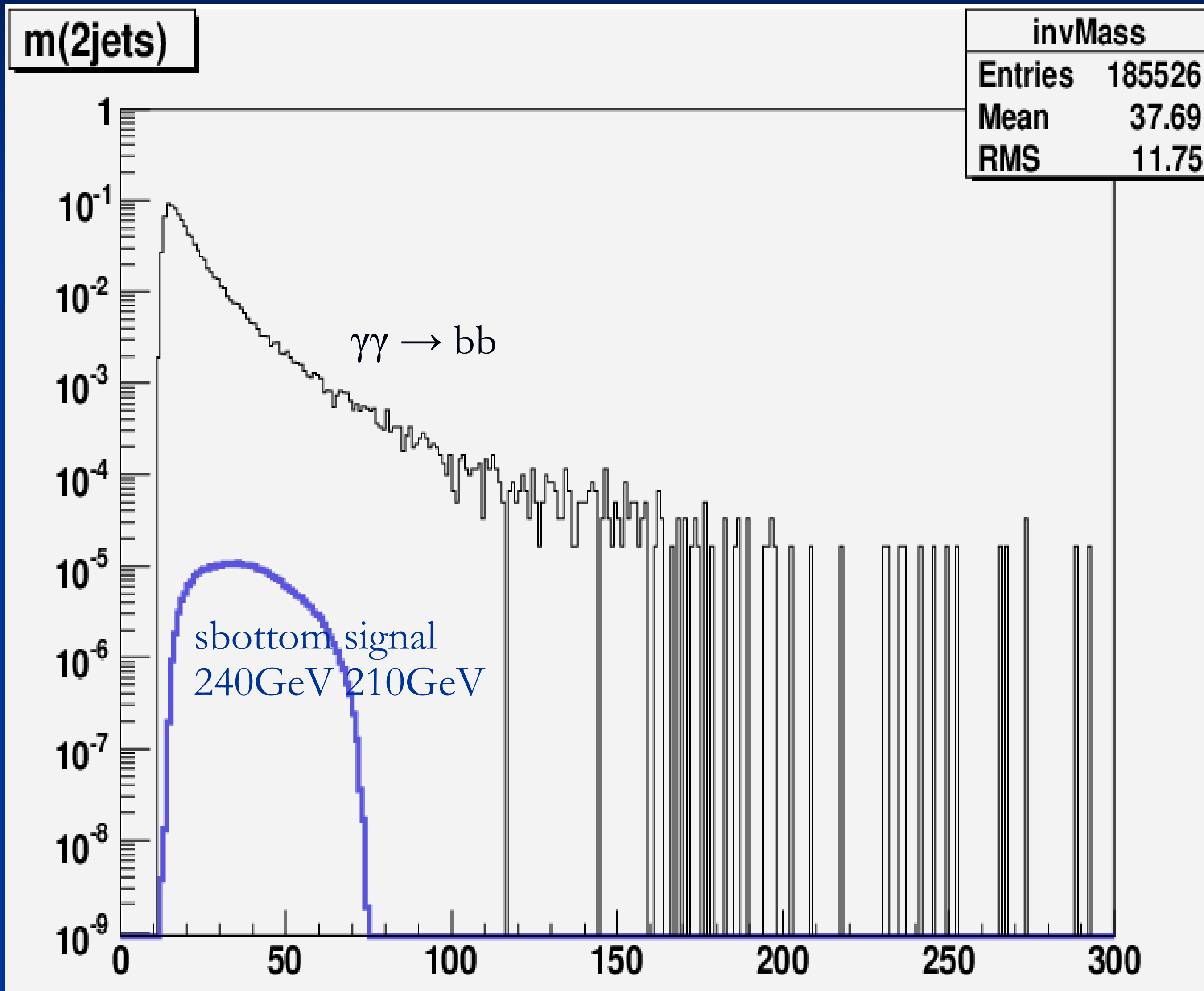
and then decayed to b-quarks and neutralinos.



Signal samples



Invariant mass of jets



Summary

- Compulsory benchmark reactions almost defined
- Additional benchmarks are a good match to our personnel
- SLAC/Oxford core of benchmarking group is still intact and is ready to push forward with the LOI
- Analysis algorithm development continues and is even growing. We should be ready for full PFA when it becomes available.