The SGV fast detector simulation program

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International workshop on future linear colliders, Online, 15-18 March, 2021

Outline


NEED FOR SPEED™
SPEEDHUNTERS
6666
Rocket Bunny
Rocket Bunny

Full SM simulation

Total cross-section @500 GeV for $e^+e^- \to$ 2f and 4f: 350 pb (Whizard),*not* including bhabha, nor $\gamma\gamma$ events !

- $\int \mathcal{L}dt$ = 10 ab^{-1} $\to$ 3.5 $\star 10^9$ events are expected.
- $\sim$ 1-20 ms to generate one event.
- $\sim$ 2 ms to fastsim (SGV) one event.

$\sim 3 \times 10^7$ s of CPU time is needed, ie around 1 year. But:This goes to 2000 years with full simulation.

Then add bhabha's and $\gamma\gamma$ to that $\sim$ an order of magnitude more $\Rightarrow$ without FastSim, many of our results will be systematics dominated by lack of MC statistics!

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SUSY parameter scans

Simple example:

- MSUGRA: 4 parameters + sign of μ
- Scan each in eg. 20 steps
- Eg. 5000 events per point (modest requirement: in sps1a' almost 1 million SUSY events are expected for 500 fb^{-1} !)
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Fast simulation types, and the choice for ILC

Different types, with increasing level of sophistication:

- 4-vector smearing.
- Parametric, needing input from FullSim: Delphes
  - Ignores correlations, eg. between p measurement and ip:s.
  - Hard to handle confusion in high granularity calorimeters.
  - No dE/dx, secondary vertices, effect of hit level inefficiencies ....
  - But very fast, and very condensed output.
  - By theoreticians, for theoreticians.
- Covariance matrix machines, not needing input from FullSim:SGV
  - Full covariance matrix available for each track-helix.
  - Individual shower shape and position generated $\Rightarrow$ can approximate confusion.
  - Hit patterns known $\Rightarrow$ dE/dX and hit-level efficiencies doable.
  - Covariance matrices available $\Rightarrow$ vertex fitting.
  - Anything up to DST-level detail can be output.
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For ILC:

Only Covariance matrix machines have sufficient detail. Here, I'll cover "la Simulation à Grande Vitesse", SGV.

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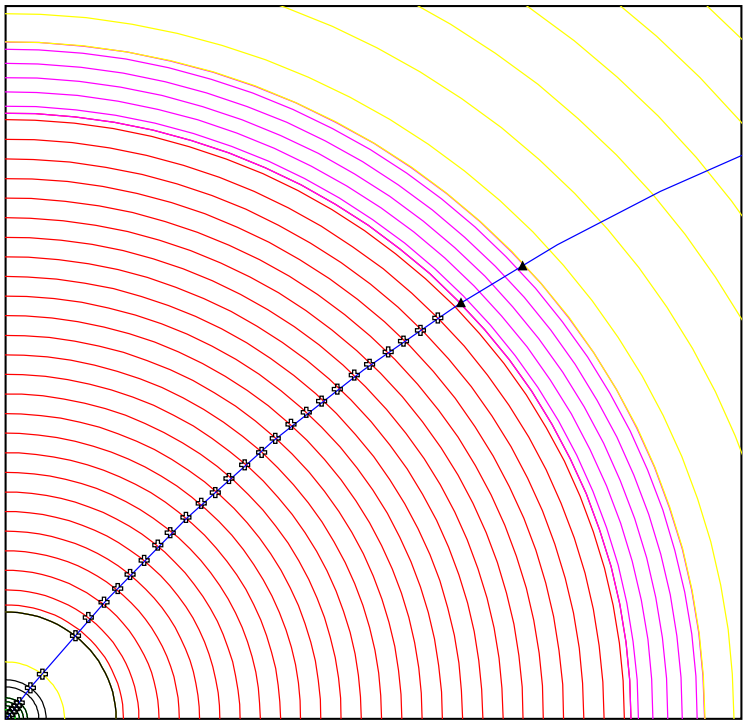
SGV: How tracking works

SGV is a machine to calculate covariance matrices

Tracking: Follow track-helix through the detector.



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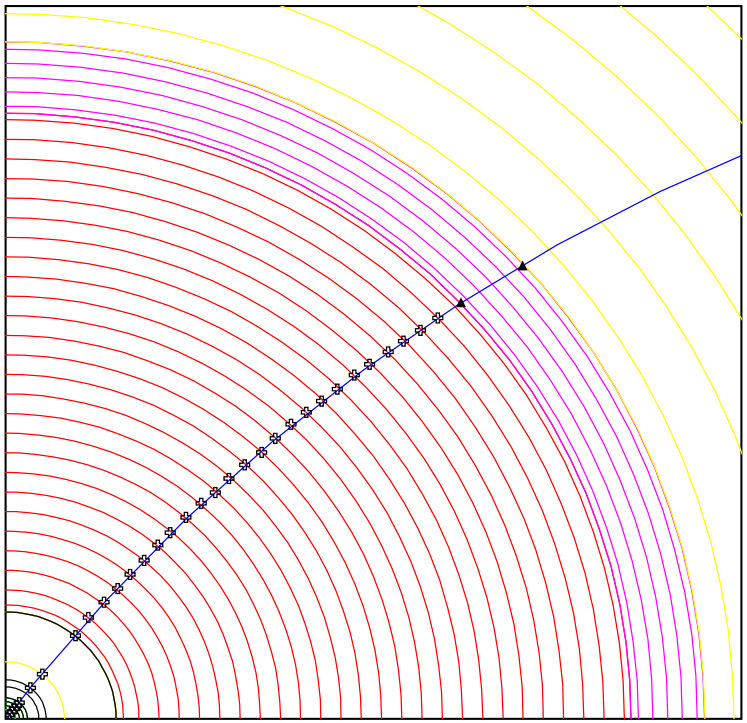

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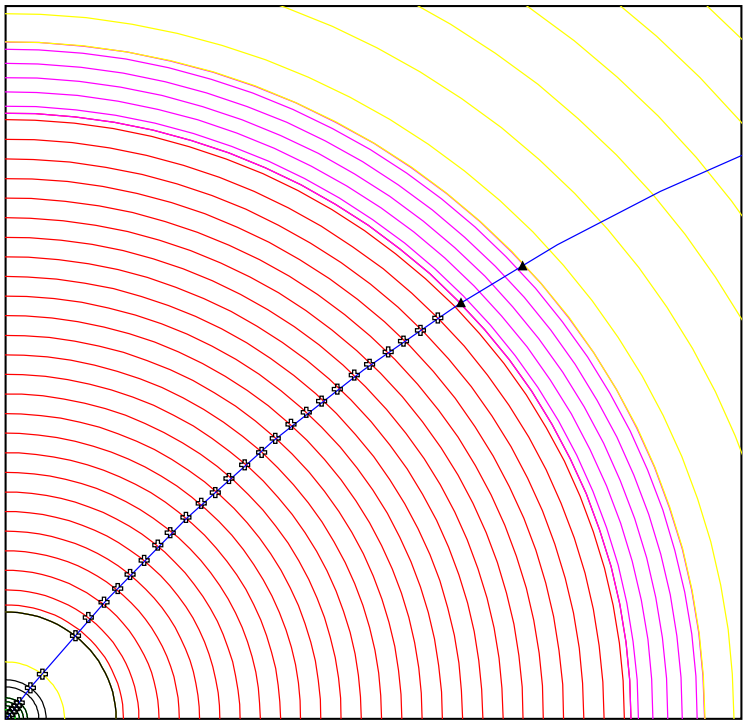

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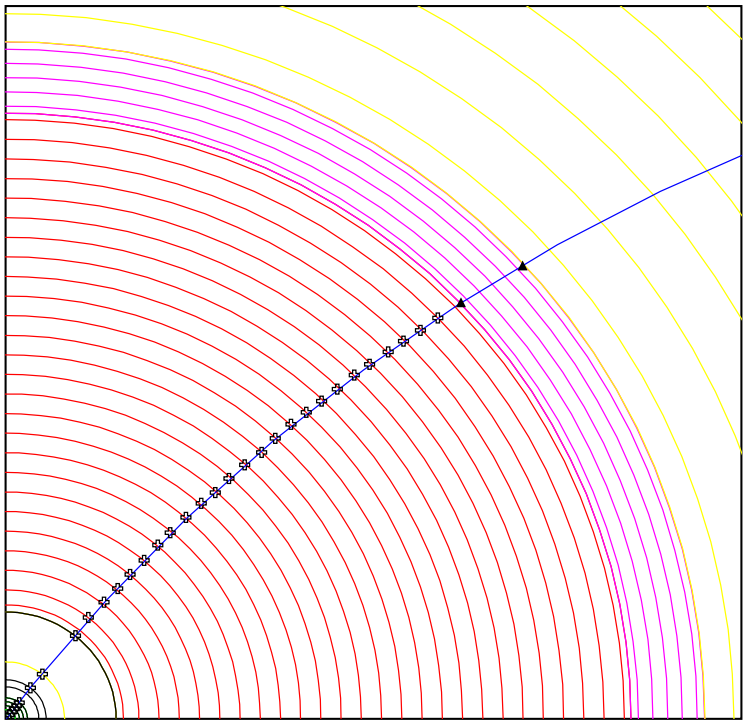

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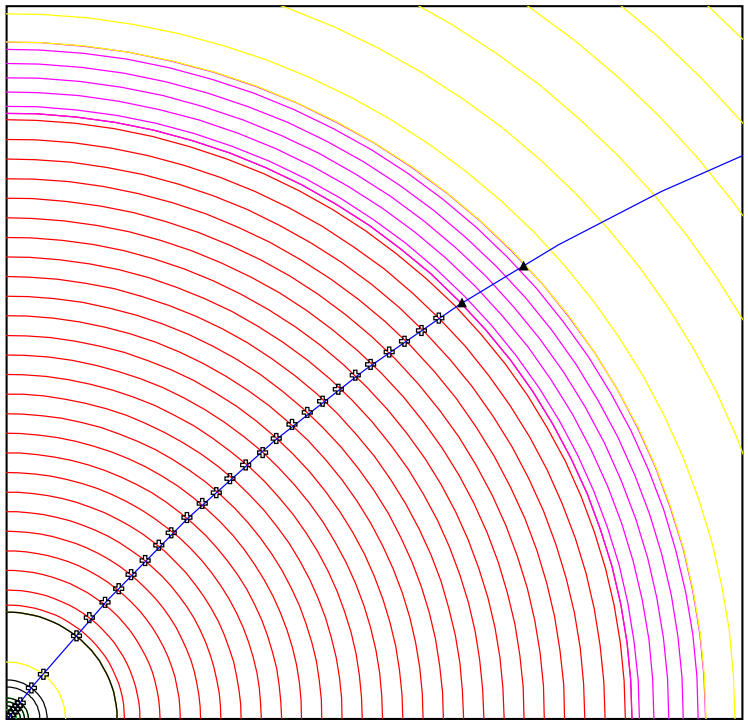

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- Simulate single particle response from parameters.
- Easy to plug in more sophisticated shower-simulation.

Other stuff:

- EM-interactions in detector material simulated
- Plug-ins for particle identification, track-finding efficiencies,...
- Information on hit-patterns accessible to analysis.

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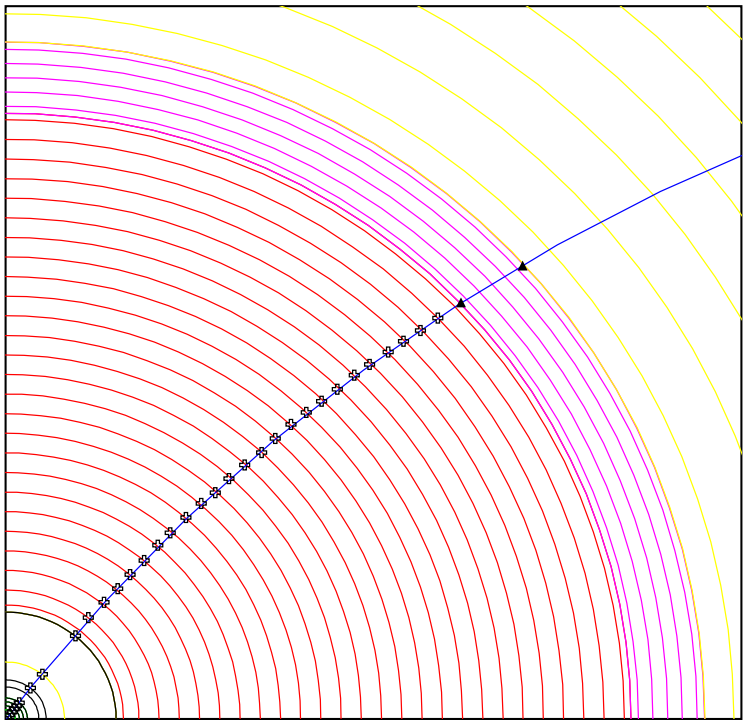

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- User data, delivered in Module-global arrays:
  - Extended 4-vectors .
  - Track helix parameters with correlations.
  - Calorimetric clusters.
  - When relevant: true values.
  - Auxiliary information on particle history, detector-elements used etc.
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- User Analysis tasks :
  - Jet-finding.
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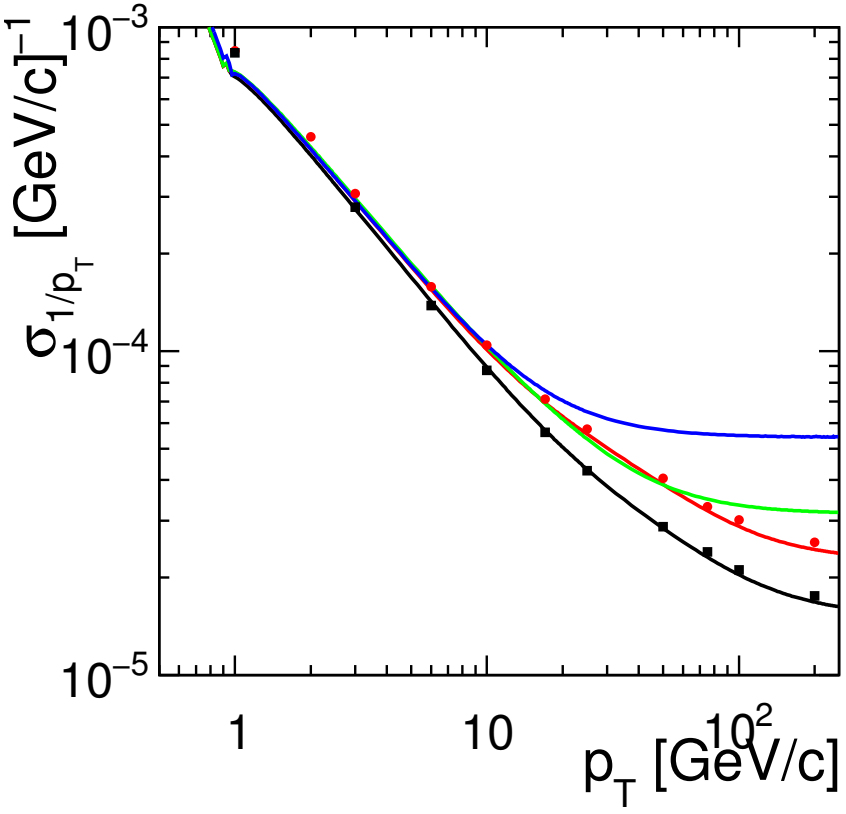

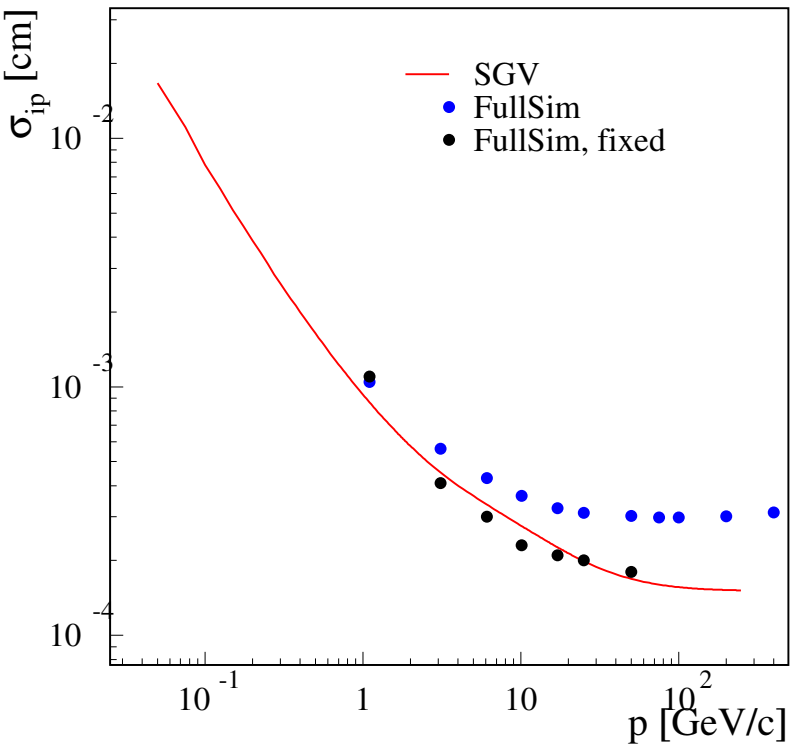

Lines: SGV, dots: Mokka+Marlin

SGV and FullSim ILD: Jets and events

Feed exactly the same physics events through FullSim or SGV.

- Overall:
  - Total seen energy
- $e^+e^- \rightarrow ZZ \rightarrow$ four jets:
  - Reconstructed M_Z at different stages in FullSim.
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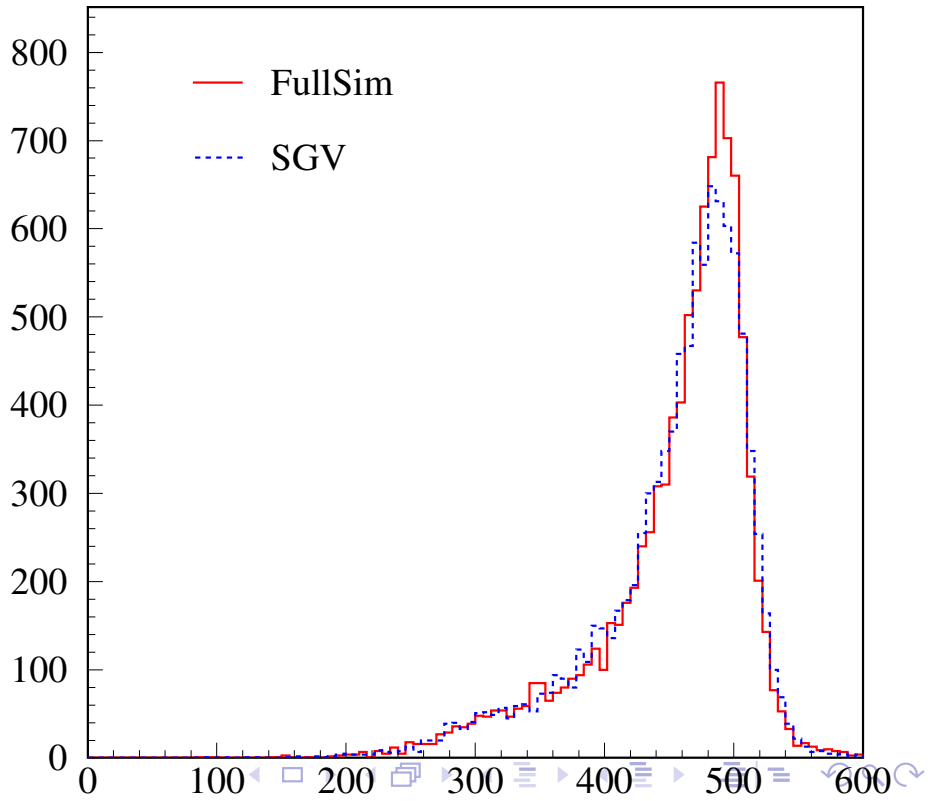

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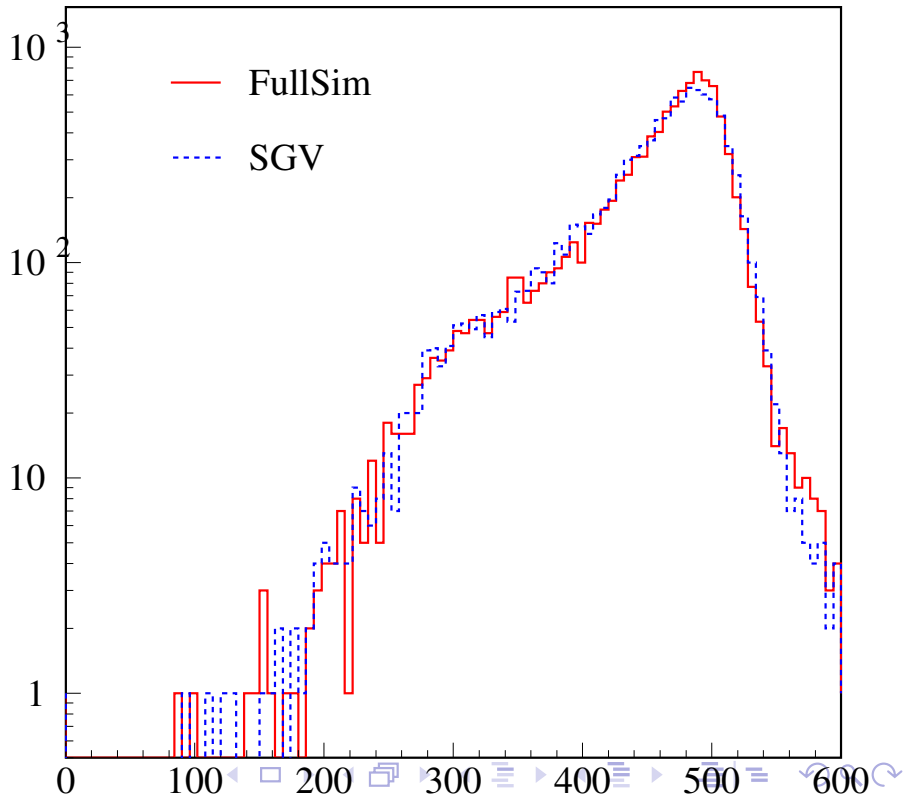

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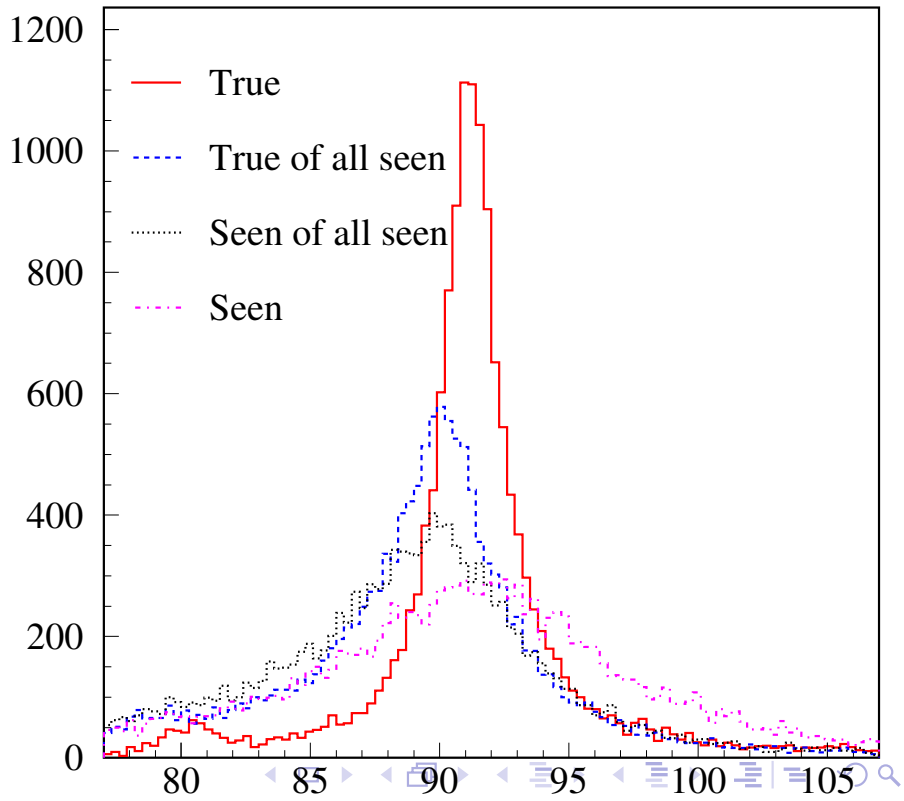

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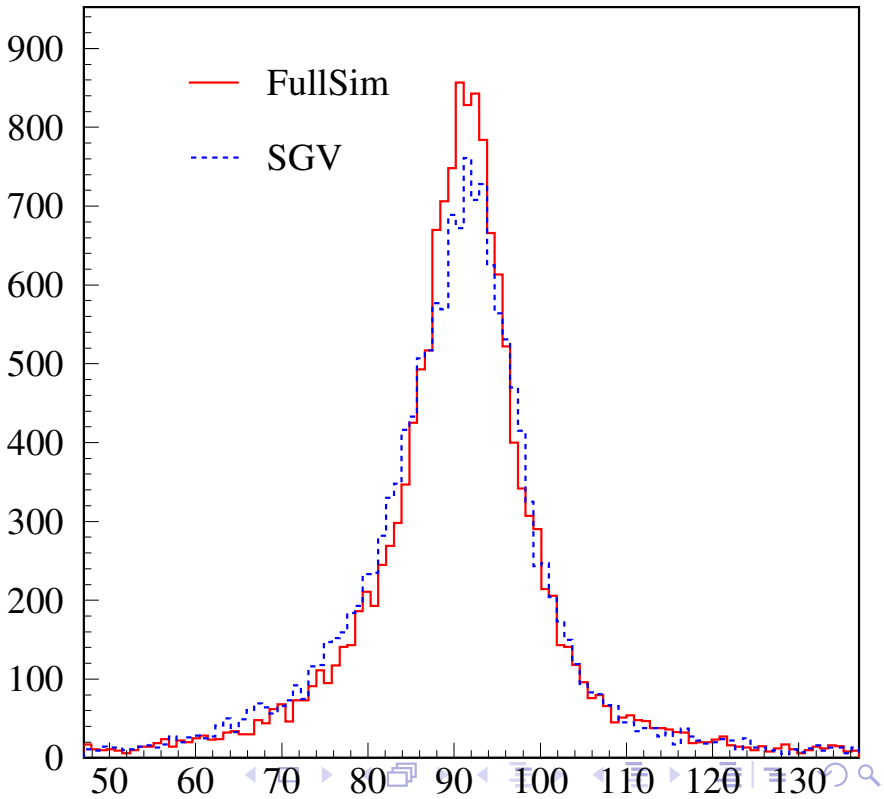

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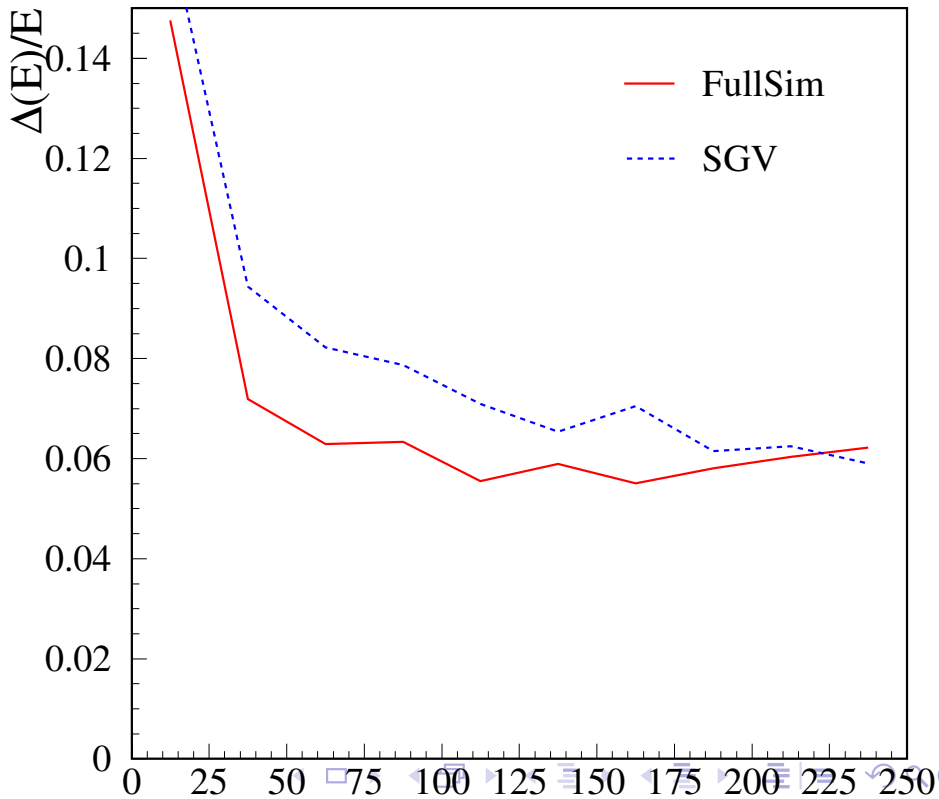

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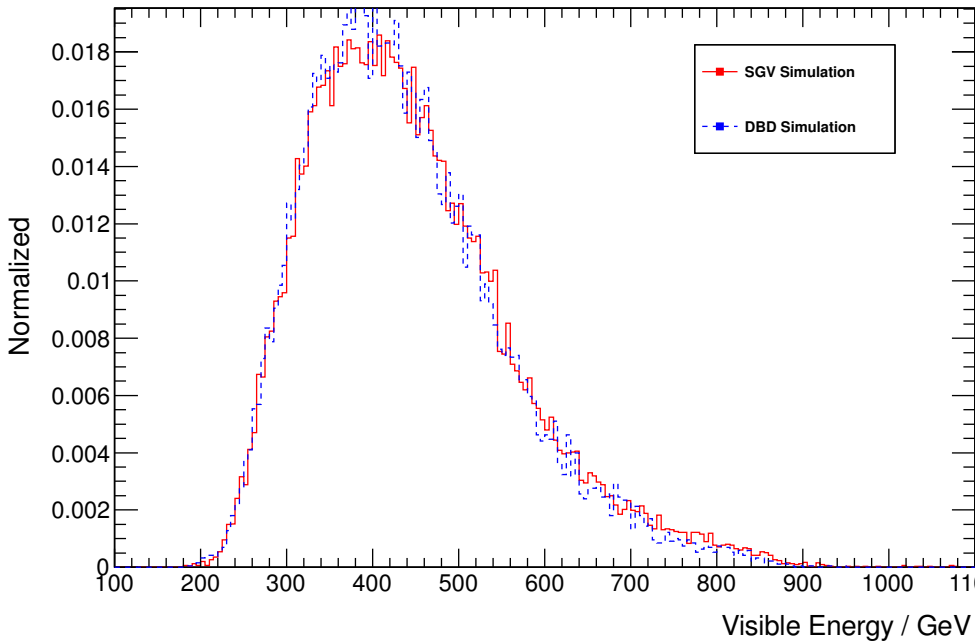

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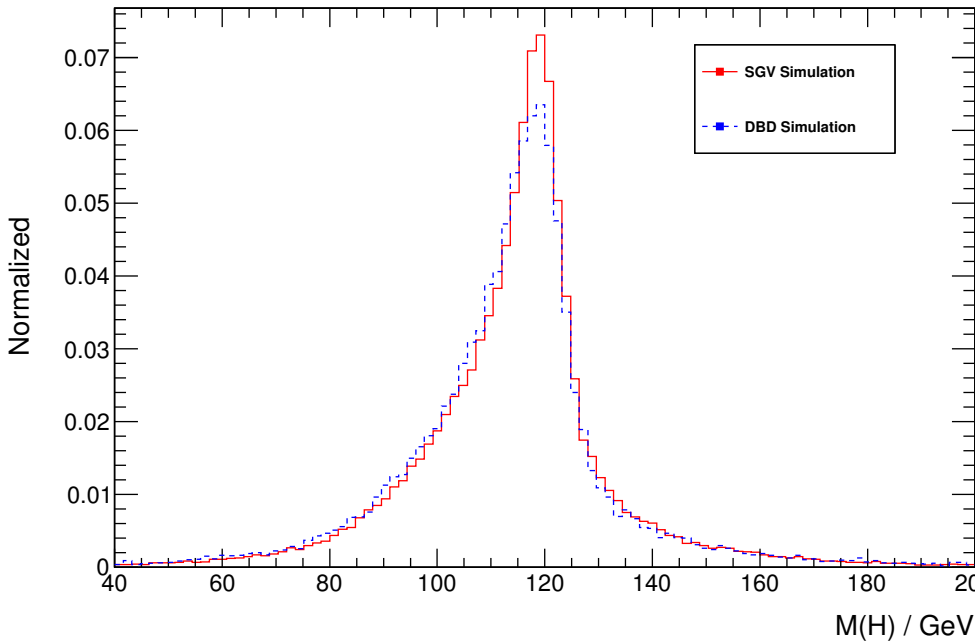

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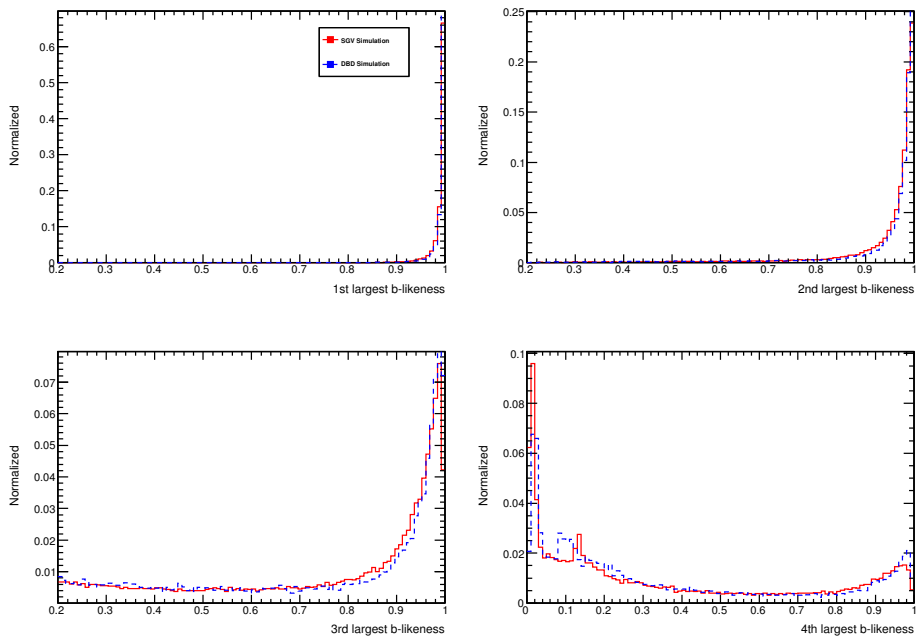

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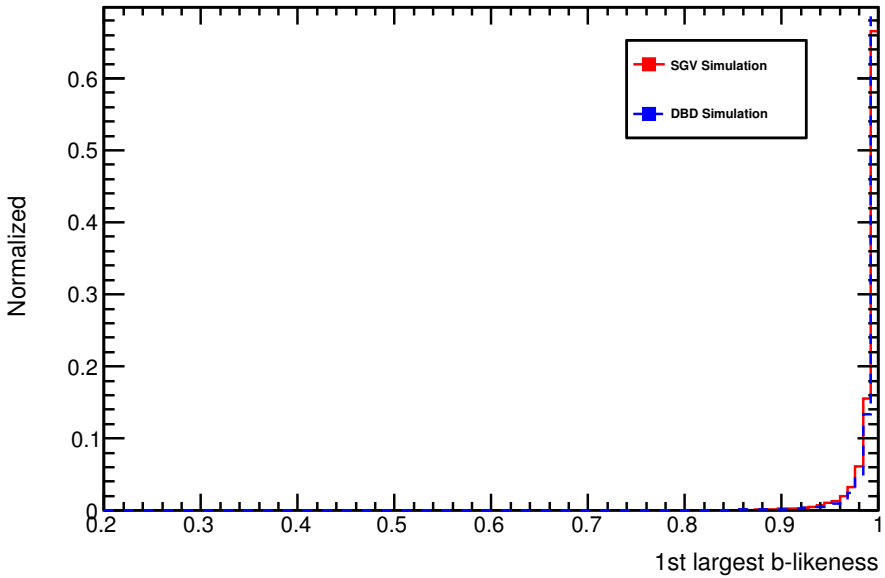

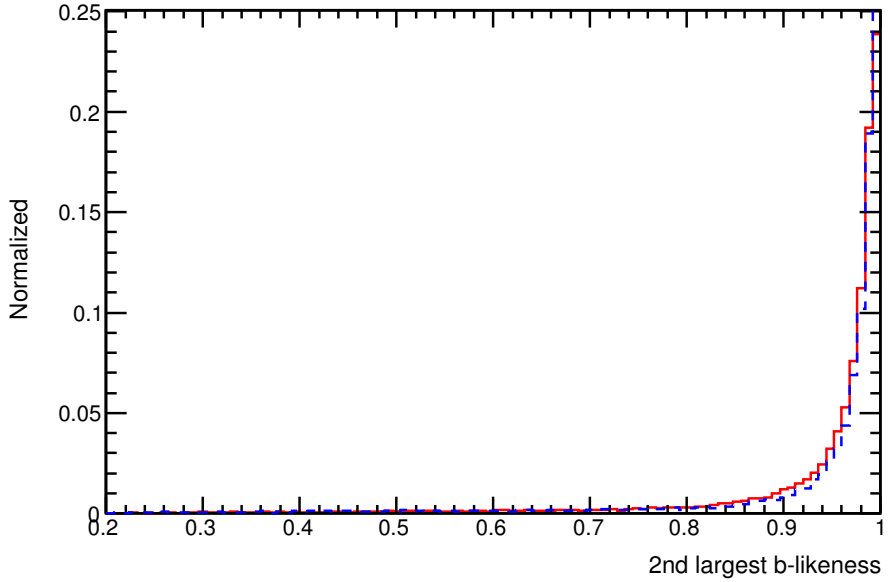

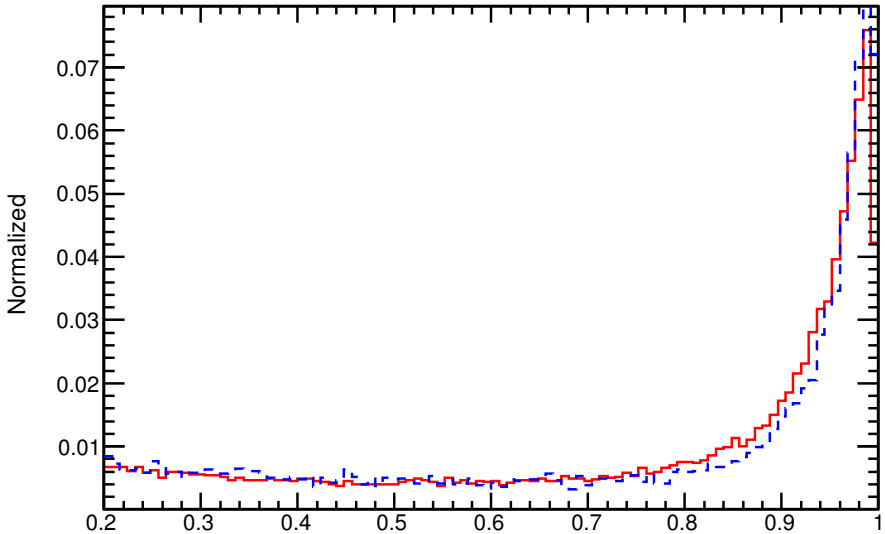

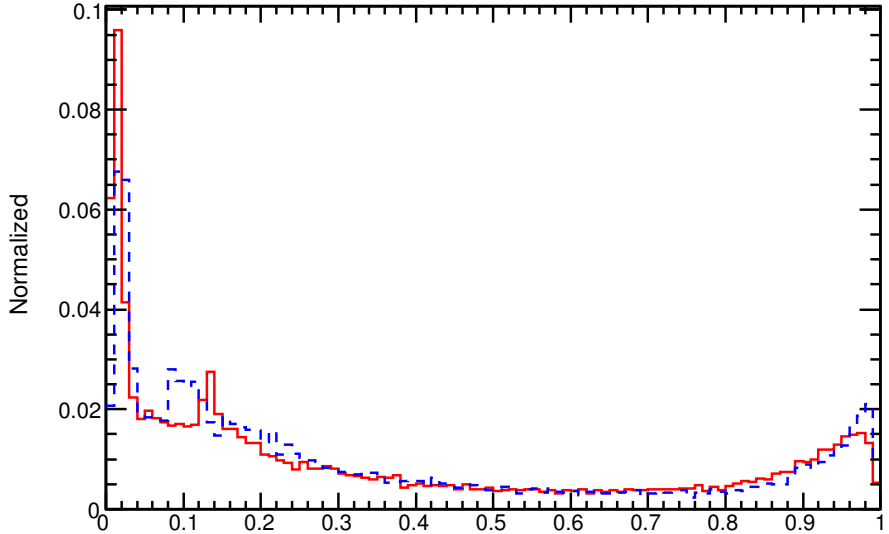

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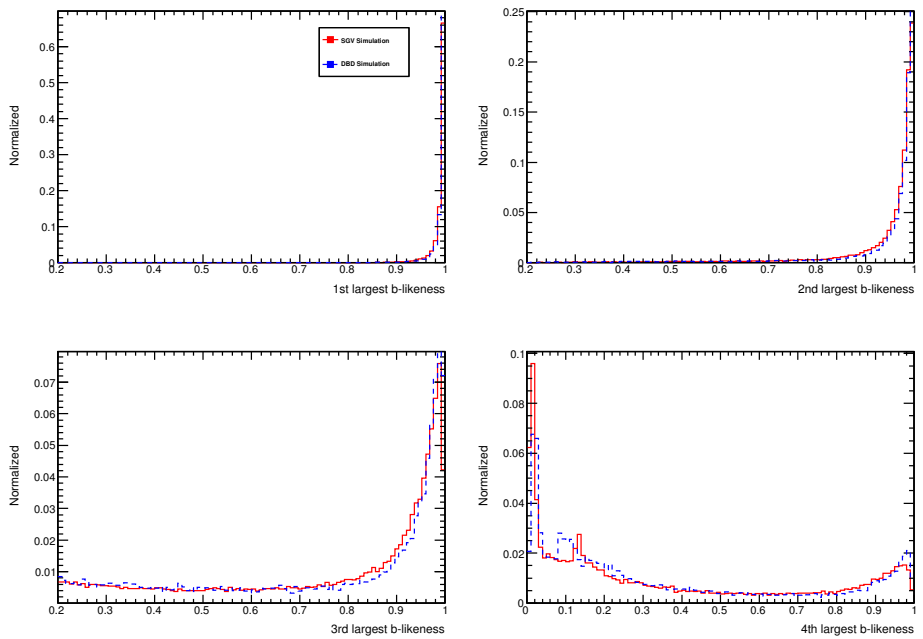

SGV at work: mass-production

SGV has been used to produce ILD LCIO DST:s for the full DBD benchmarks- several times.

- 43 Mevents.
- $\sim$ 1 hour of wall-clock time (first submit to last completed) on the German NAF.
- SUSY slepton scan: Generate 1000 events at all possible slepton and LSP masses on a 1 GeV $\times$ 1 GeV grid @ E_{CMS} 500 GeV (=31 000 points) $\Rightarrow$ 31 Mevents.
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Technicalities

- Written in Fortran 08, a re-write of the Fortran77-based SGV2 series.Managed in SVN.Install script included.
- Requires:
  - Fortran compiler, e.g. gfortran - any version between 4.7 and 10 ($\Rightarrow$ future-proof!).
  - Standard Linux math: `blas` and `lapack`.
  - PYTHIA vers 6 (even if not needed for event-generation: SGV uses many PYTHIA6 extras).
  - To produce the doc's during installation: `TexLive` and `pandoc`
- Features:
  - On-demand memory allocation.
  - Callable PYTHIA, Whizard 1.x, ...
  - Input from Hepevt/PYJETS, stdhep, slcio, GuineaPig.
  - Output of generated event to PYJETS, stdhep or slcio.
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Steering SGV

Two steering files...

- Program steering:
  - Single file, with sections for general, generator, detector and analysis steering.
  - Many examples included.
  - Extensive comments in these.
- Geometry description:
  - Described by cylinders and planes.
  - Attach material properties (rad. length, material, int. length, ...)
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  - Comparisons to FullSim was shown to be quite good, also for complicated features like h.f. tagging.
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  - Still: SGV is as fast as eg. `Delphes`.
- Many input-methods (internal and external). No output format imposed on the user, plugins for LCIO and Root output available.
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Thank You !

Backup

BACKUP SLIDES

... a tool for rapid LC studies?

Peer-reviewed papers using SGV

- Phys. Rev D101 (2020) 7, 075053
- ILD-PHYS-2019-001 (Accepted by Phys. ReV. D)
- Eur.Phys.J.C 76 (2016) 4,183
- Eur.Phys.J.C 75 (2015) 12, 617
- Phys. Rev D 91 (2015) 113007
- Phys. Rev D 90 (2014) 114029
- Phys. Rev D 89 (2014) 11, 113006
- Eur.Phys.J.C 73 (2013) 12,2660
- Eur.Phys.J.C 72 (2012) 2213
- Phys. Rev. D 82 (2010) 055016
- NIM A 579 (2007) 750
- Eur. Phys. J. C 31 (2003) 421
- Eur. Phys, J. direct (2000) 1

+ innumerable theses, reports, arXiv submissions and conference proceedings. Including the Tesla TDR, LoI, TDR, the IDR and ILC/ILD inputs to EPPSU and Snowmass 2013.

... a tool for rapid LC studies ?

SGV was used for

- Defining the forward tracking geometry of LDC:
  - Vienna 2005. ▸ LDC and ▸ tracking
- The utility (or not) of the silicon envelope
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- Merge of LDC and GLD into ILD
  - ▸ Cambrige 2008
- Define the options for the IDR
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Calorimeter simulation: SGV strategy

- Concentrate on what really matters:
  - True charged particles splitting off (a part of) their shower: double-counting.
  - True neutral particles merging (a part of) their shower with charged particles: enetgy loss.
- Don't care about neutral-neutral or charged-charged merging.
- Nor about multiple splitting/merging.
- Then: identify the most relevant variables available in fast simulation:
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Observed distributions

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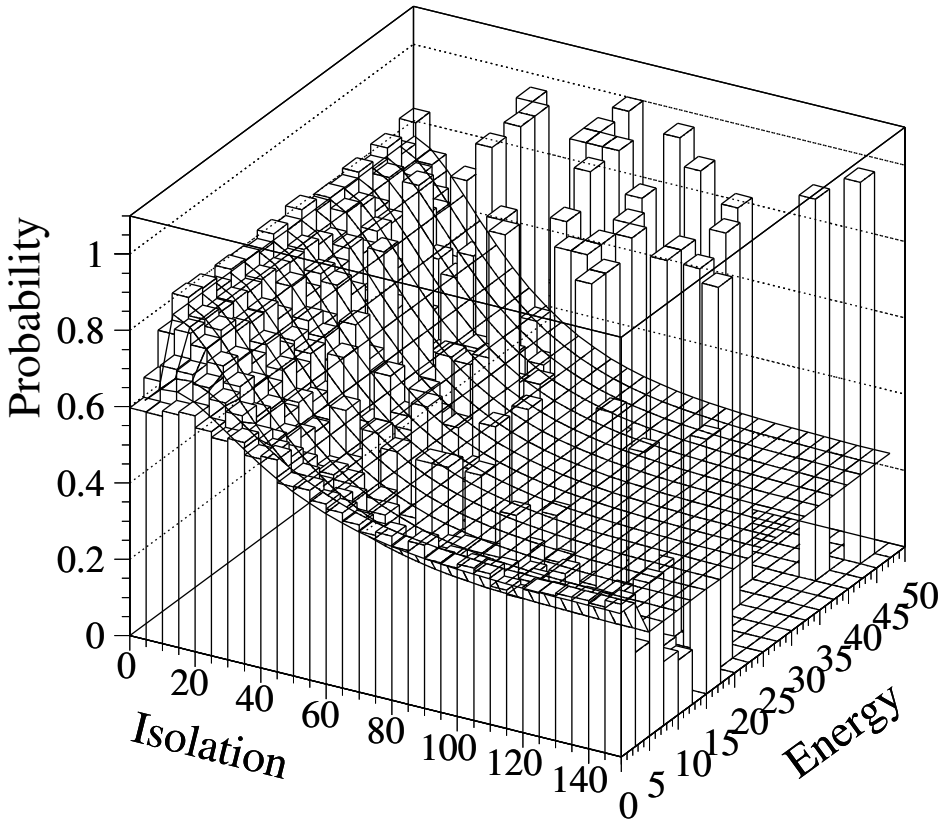
- Fraction the energy vs distance
- ... and vs E
- Fit of the Distribution of the fraction
- Average fraction vs. E and distance.



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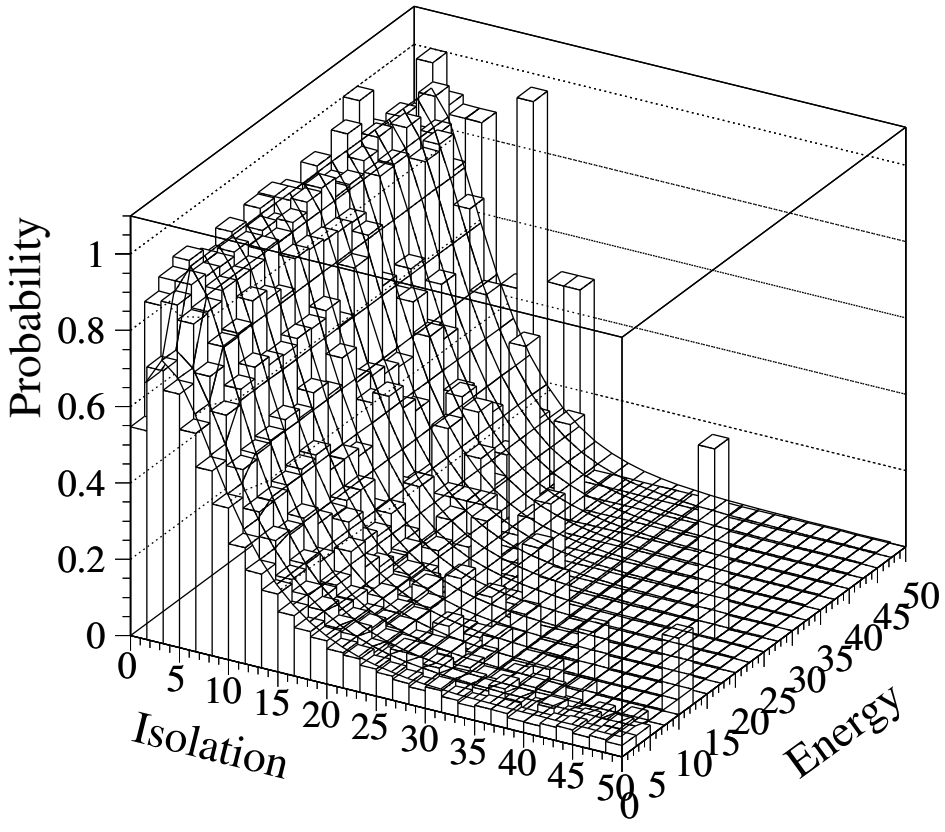

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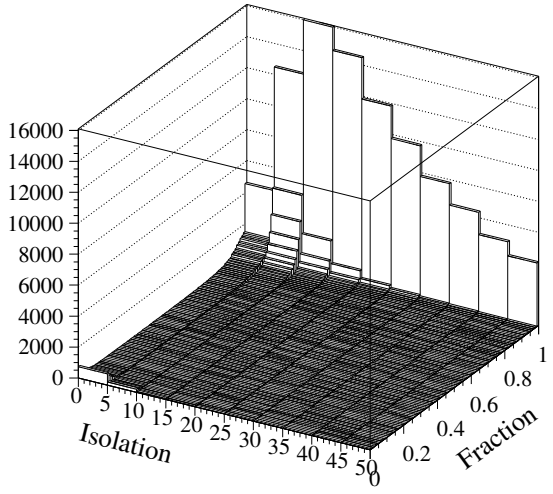

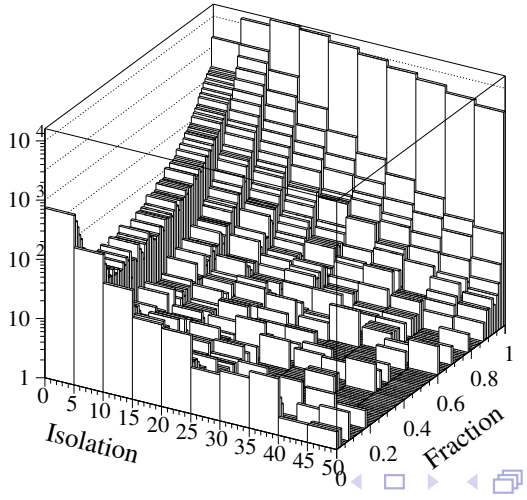

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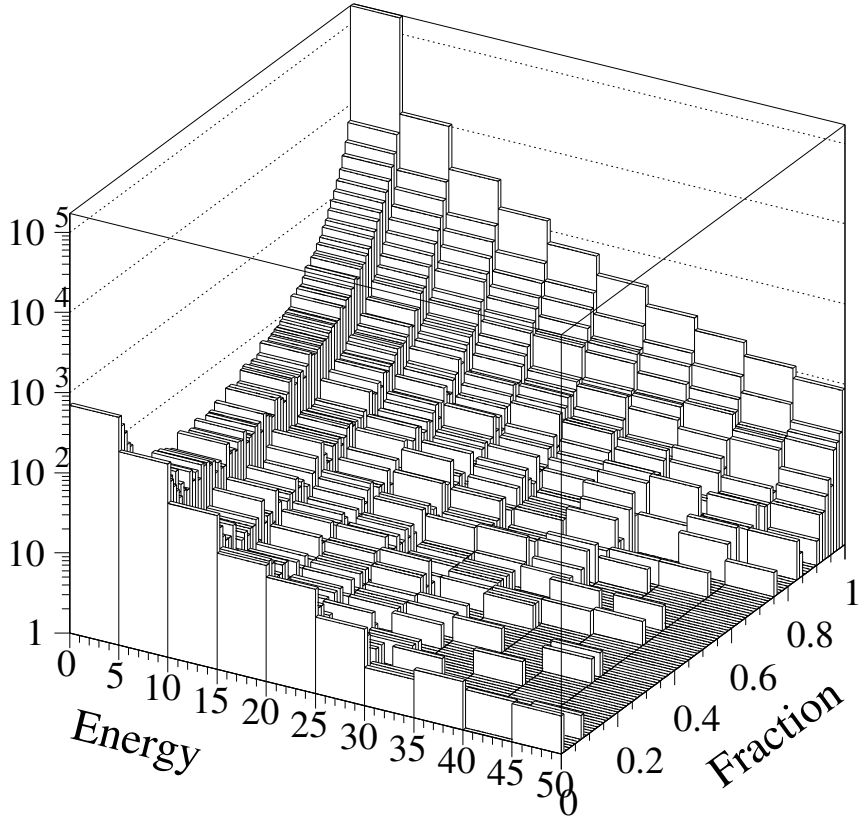

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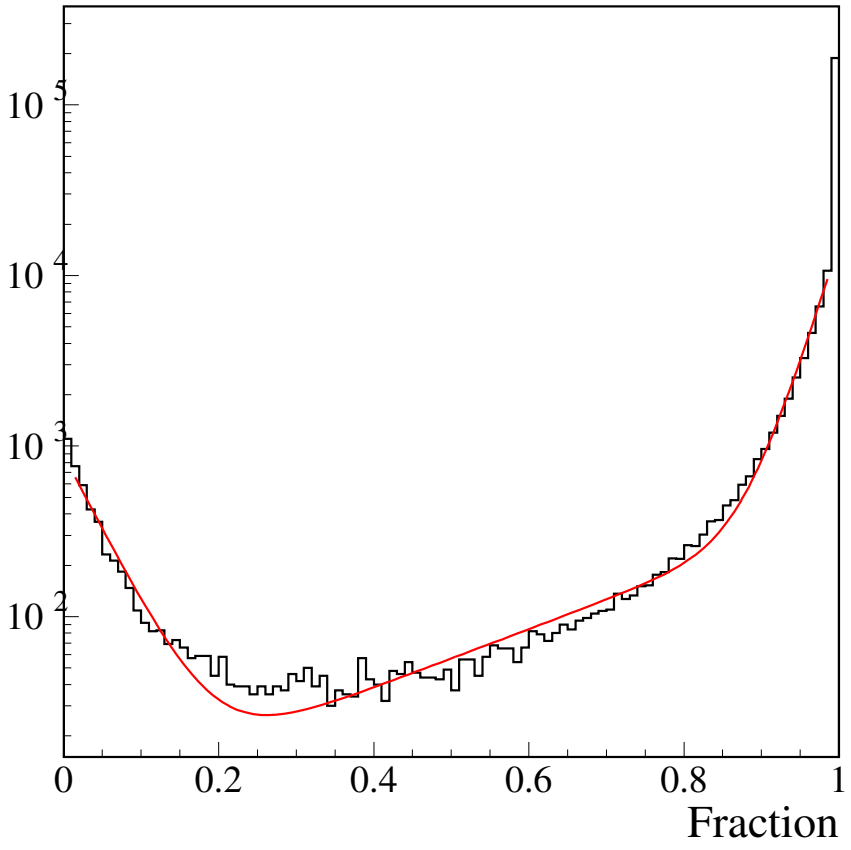

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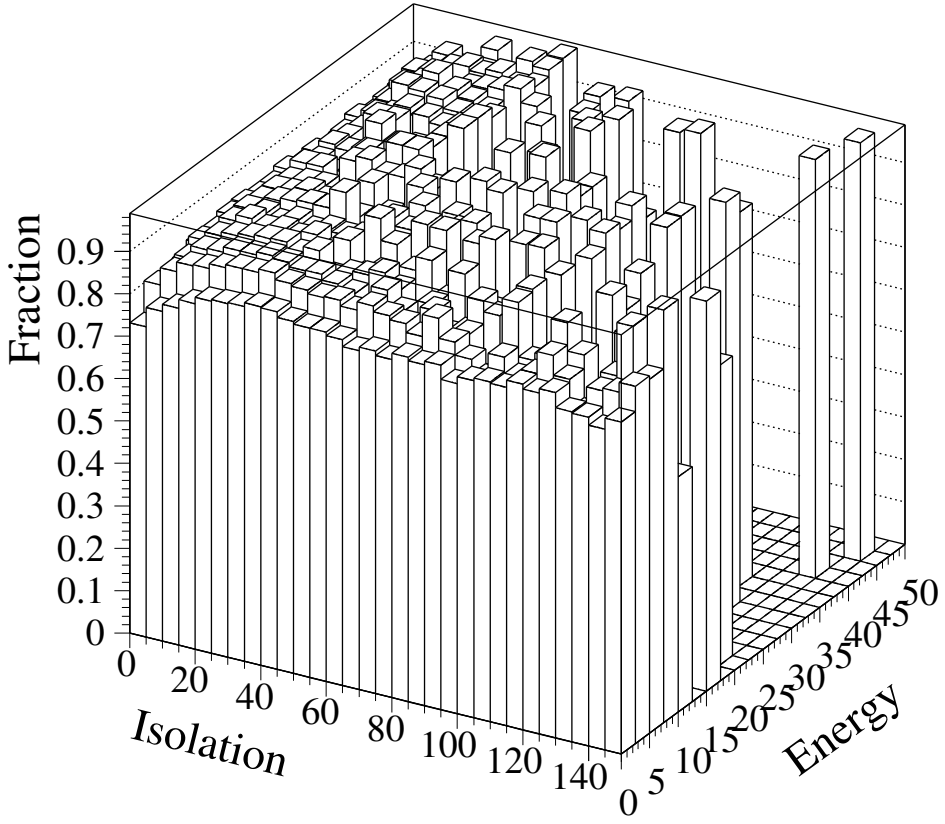

LCIO Collections with DST output

- Added sensible values to all collections that will (probably) be there on the DST from the fullSim production.
  - BuildUpVertex
  - BuildUpVertex_RP
  - MarlinTrkTracks
  - PandoraClusters
  - PandoraPFOs
  - PrimaryVertex
  - RecoMCTruthLink
  - MCParticlesSkimmed
  - V0Vertices
  - V0RecoParticles
  - BCALParticles
  - BCALClusters
  - BCALMCTruthLink
  - PrimaryVertex_RP
- Also added more relation links:
  - MCTruthRecoLink
  - ClusterMCTruthLink
  - MCTruthClusterLink
  - MCTruthTrackLink
  - TrackMCTruthLink
  - MCTruthBcalLink

Comments

Secondary vertices (as before):

- Use true information to find all secondary vertices.
- For all vertices with ≥ 2 seen charged tracks: do vertex fit.
- Concequence:
  - Vertex *finding* is too good.
  - Vertex *quality* should be comparable to FullSim.

In addition: Decide from parent pdg-code if it goes into BuildUpVertex or V0Vertices !

MCParticle :

- There might be some issues with history codes in the earlier part of the event (initial beam-particles, 94-objects, ...)

Comments

Clusters:

- Are done with the Pandora confusion parametrisation on.
- Expect $\sim$ correct dispersion of jet energy, but a few % to high central value.
- See my talk three weeks ago.
- Warning: Clusters are always only in one detector , so don't use E_{had}/E_{EM} for e/π: It will be $\equiv$ 100 % efficient !

Navigators

- All the navigators that the TruthLinker processor makes when all flags are switched on are created:
  - Both Seen to True and True to Seen (weights are different !)
  - Seen is both PFOs, tracks and clusters.
  - The standard RecoMCTruthLink collection is as it would be from FullSim ie. weights between 0 and 1.