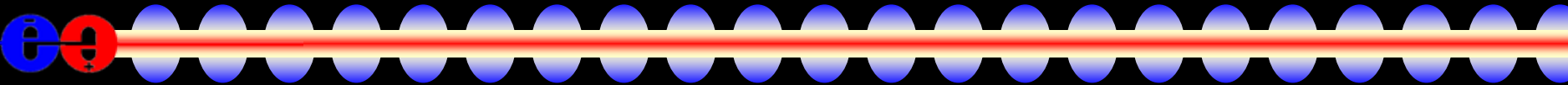


*Detector  
Intelligent ^ Design*

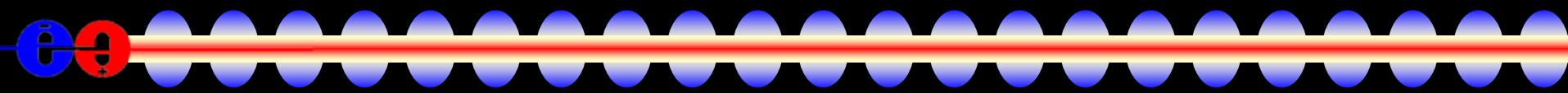
Norman Graf  
SLAC

**BNL Particle Physics Seminar**  
March, 16, 2006

# *Outstanding Issues in HEP*

- 
- Despite the spectacular success of the Standard Model, many questions remain, such as:
    - Pattern of particle masses; why is top so heavy?
      - Evidence for light Higgs...
    - Pattern of quark mixing? Lepton mixing?
    - Origin of CP violation? Baryogenesis?
    - Why 3 generations?
    - Unification?
    - Hierarchy
      - Why is the electroweak scale  $\ll$  Planck scale?
    - Dark Matter?
    - Dark Energy?
    - Quantum Gravity?

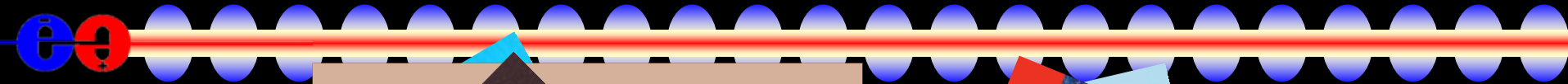
# *The Next Big Machine*



- For precision measurements, want an  $e^+e^-$  collider to complement existing and planned hadron machines.
- There are strong theoretical reasons for wanting to achieve  $\sim 1$  TeV in energy.
- Nature abhors acceleration, so we cannot build such a machine as a circular accelerator.

## International Linear Collider

# Why Another Machine?

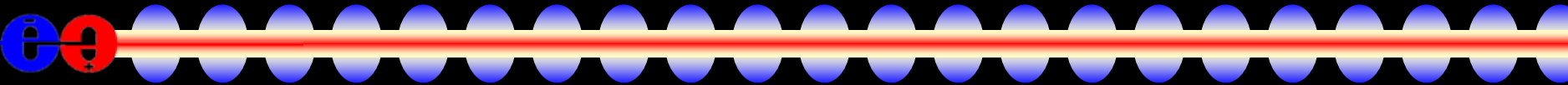


Working Group

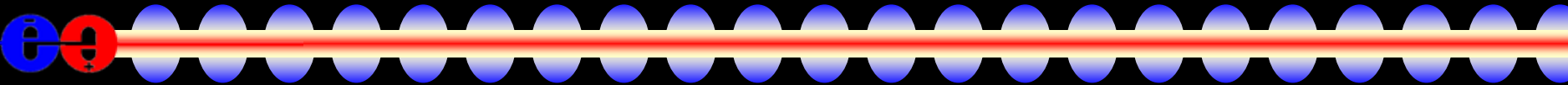
# *Physics & Detector Workshops (LCWS)*

- 
- Saariselka, Finland - September 9 - 14, 1991
  - Hawaii, USA - April 26 - 30, 1993
  - Morioka, Japan - September 8 - 12, 1995
  - Sitges, Spain - April 28 - May 5, 1999
  - Fermilab, USA - October 24-28, 2000
  - Jeju Island, Korea - August 26-30, 2002
  - Paris, France - April 19-23, 2004
  - Stanford, USA - March 18-21, 2005
  - Bangalore India – March 9-13, 2006

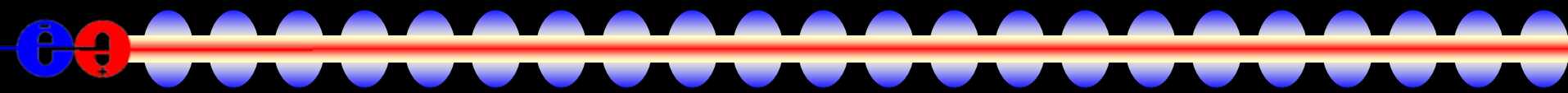
# *Linear Collider Detector Environment*

- 
- Detectors designed to exploit the physics discovery potential of  $e^+e^-$  collisions at  $\sqrt{s} \sim 1\text{TeV}$ .
  - Perform precision measurements of complex final states with well-defined initial state:
    - Tunable energy
    - Known quantum numbers &  $e^-$ ,  $e^+$ ,  $\gamma$  polarization
    - Possibilities for  $\gamma\gamma$ ,  $\gamma e^-$ ,  $e^-e^-$
    - Very small interaction region
    - Momentum constraints (modulo beam & bremsstrahlung)

# *Detector Requirements*

- 
- Desire to fully reconstruct hadronic final states
  - Ability to tag heavy (light) quarks
  - Excellent missing energy/mass sensitivity
  - Require:
    - Exceptional momentum resolution
      - Large volume TPC or low-mass Si  $\mu$ -strip tracker
    - Excellent vertexing capabilities
      - 5-Layer pixel Vertex Detector (  $\sim$ GigaPixel )
    - “Particle Flow” calorimetry
      - Imaging, (non-compensating) sampling calorimeter
    - Hermeticity
      - Minimal supports, on-detector readout.

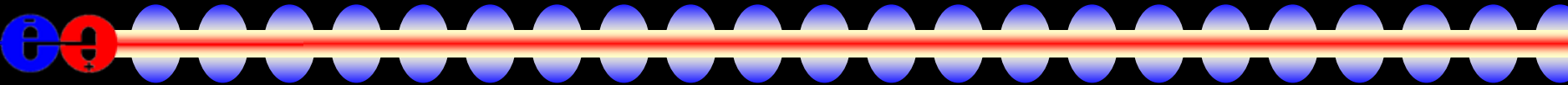
# *Detector Design*



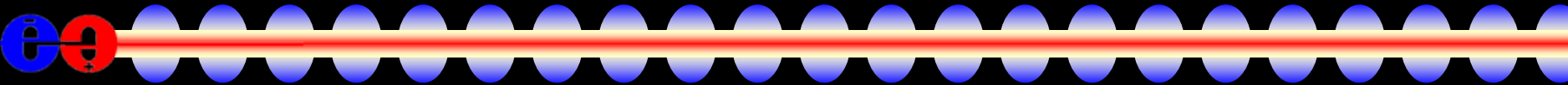
- Perception that LC detectors are trivial to build.
- Much R&D has been done for SSC/LHC, but optimizations are different.
- Hadron colliders have large cross sections and enormous backgrounds
- LC much smaller event rates and data sizes and small backgrounds.
- Robustness vs precision.



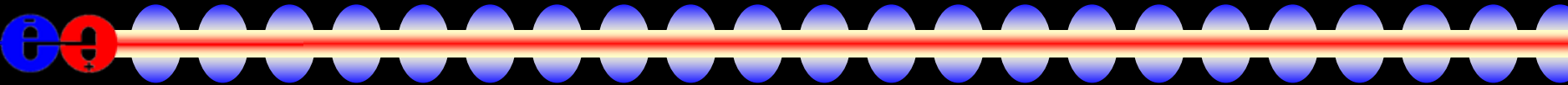
# *LCD Simulation Mission Statement*

- 
- Provide full simulation capabilities for Linear Collider physics program:
    - Physics simulations
    - Detector designs
    - Reconstruction and analysis
  - Need flexibility for:
    - New detector geometries/technologies
    - Different reconstruction algorithms
  - Limited resources demand efficient solutions, focused effort.

# Overview: Goals

- 
- Facilitate contribution from physicists in different locations with various amounts of time available
  - Use standard data formats, when possible.
  - Provide a general-purpose framework for physics software development.
  - Develop a suite of reconstruction and analysis algorithms and sample codes.
  - Simulate benchmark physics processes on different full detector designs.

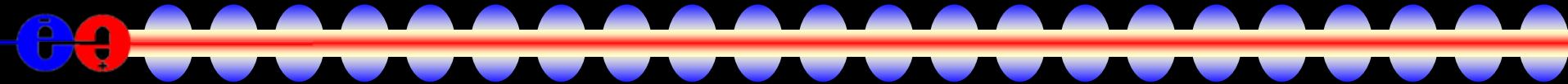
# *Fast Detector Response Simulation*

- 
- Covariantly smear tracks with matrices derived from geometry, materials and point resolution using Billoir's formulation.

<http://www.slac.stanford.edu/~schumm/lcdtrk>

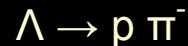
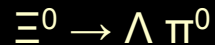
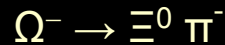
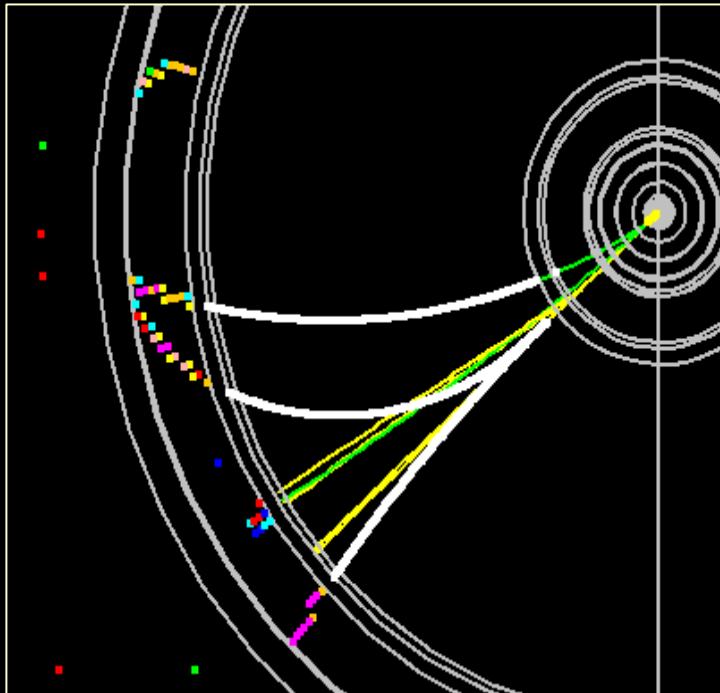
- Smear neutrals according to expected calorimeter resolution (EM for  $\gamma$ , HAD for neutral hadrons)
- Create reconstructed particles from tracks and clusters ( $\gamma$ ,  $e$ ,  $\mu$  from MC,  $\pi^{+/-}$ ,  $K^0_L$  for others)
- Can also dial in arbitrary effective jet energy resolution.

# *lelaps*

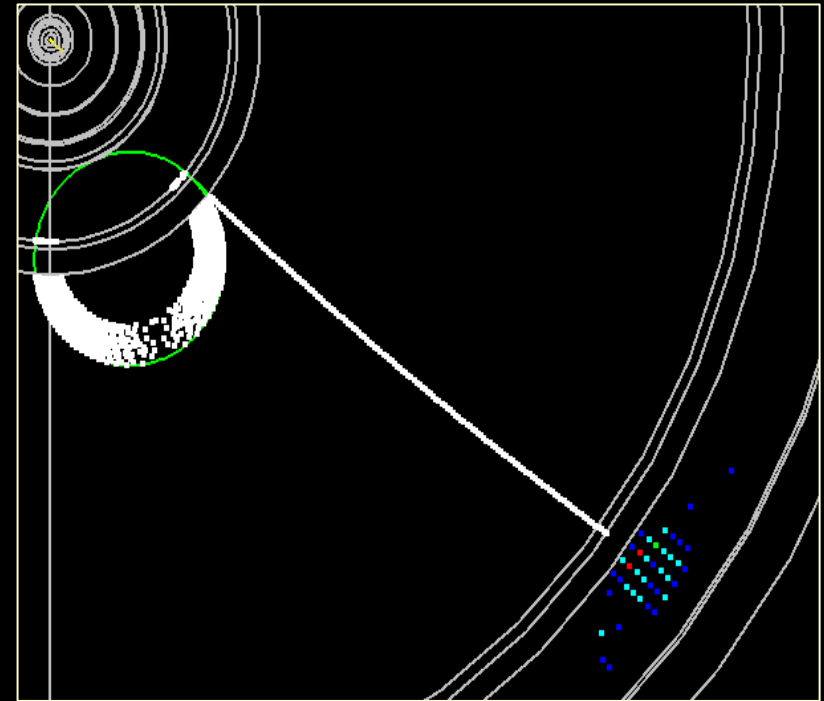
- 
- Fast detector response package.
  - Handles decays in flight, multiple scattering and energy loss in trackers.
  - Parameterizes particle showers in calorimeters.
  - Produces lcio data at the hit level.
  - Uses runtime geometry (compact.xml → god1).
  - An excellent tool for designing tracking detectors!

<http://lelaps.freehep.org/index.html>

# Lelaps: Decays, $dE/dx$ , MCS



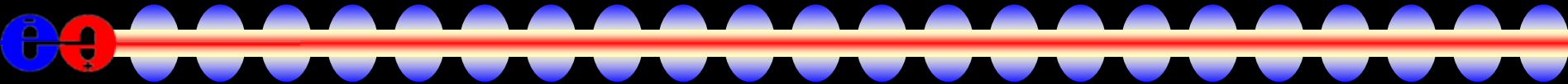
$\pi^0 \rightarrow \gamma \gamma$  as  
simulated by Lelaps for the  
LDC model.



gamma conversion as  
simulated by Lelaps for the  
LDC model.

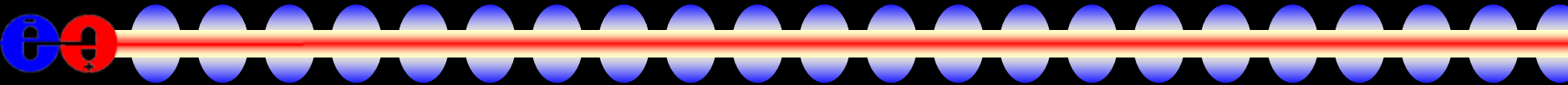
Note energy loss of electron.

# *Detector Design (GEANT 4)*

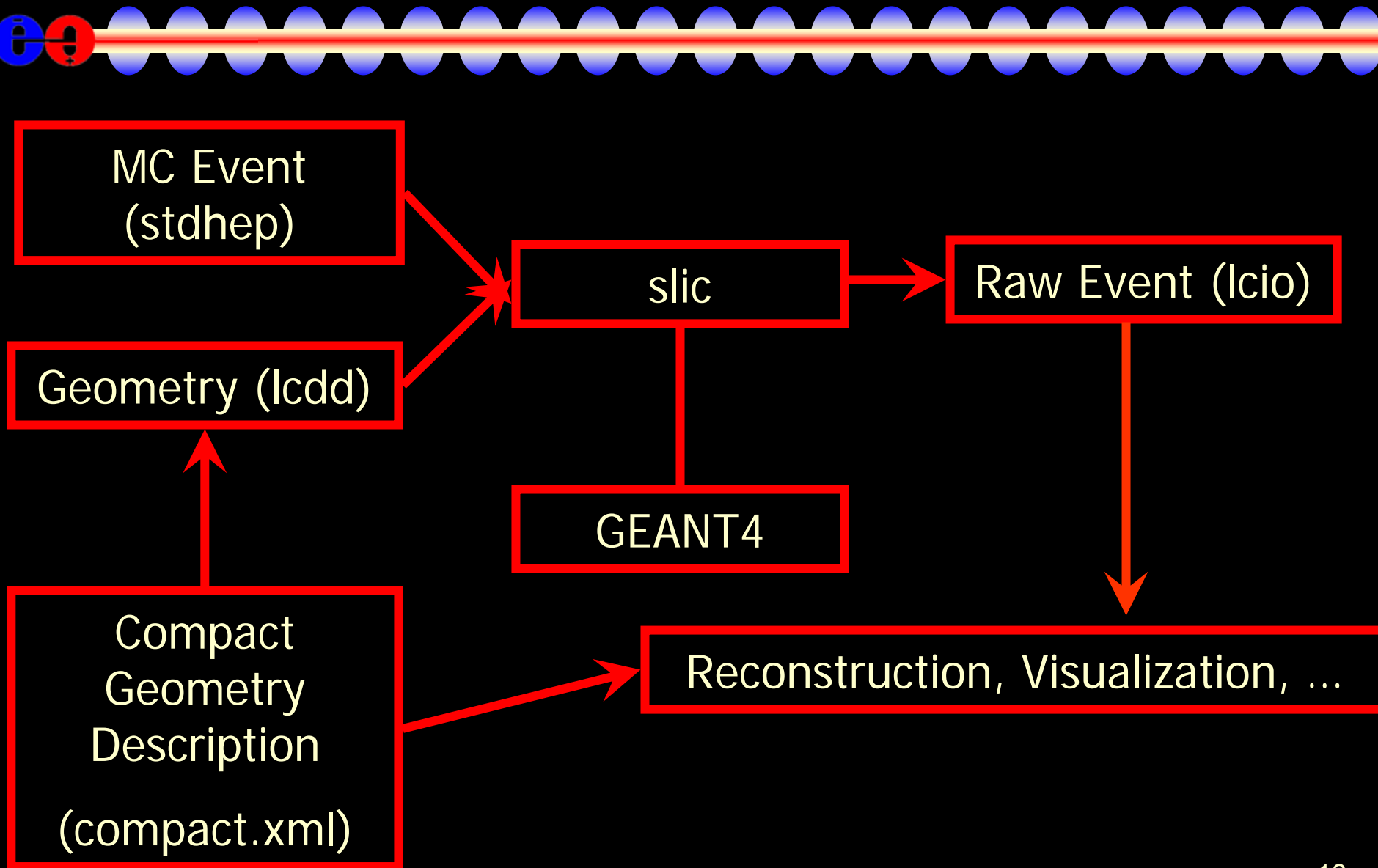


- Need to be able to flexibly, but believably simulate the detector response for various designs.
- GEANT is the de facto standard for HEP physics simulations.
- Use runtime configurable detector geometries
- Write out “generic” hits to digitize later.

# *Full Detector Response Simulation*

- 
- Use Geant4 toolkit to describe interaction of particles with matter.
  - Thin layer of LC-specific C++ provides access to:
    - Event Generator input ( binary stdhep format )
    - Detector Geometry description ( XML )
    - Detector Hits ( LCIO )
  - Geometries fully described at run-time!
    - In principle, as fully detailed as desired.
    - In practice, will explore detector variations with simplified approximations.

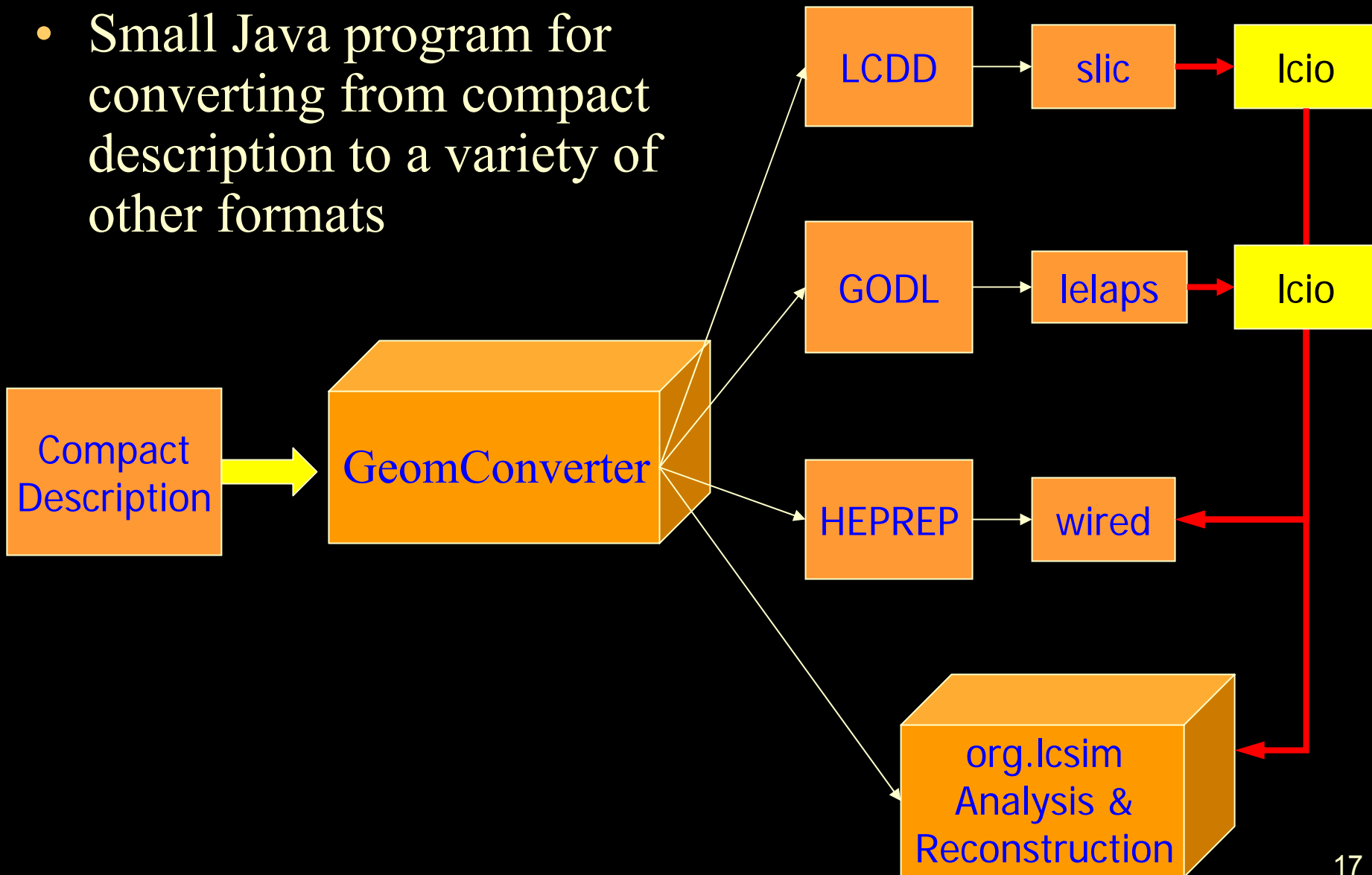
# *LC Detector Full Simulation*



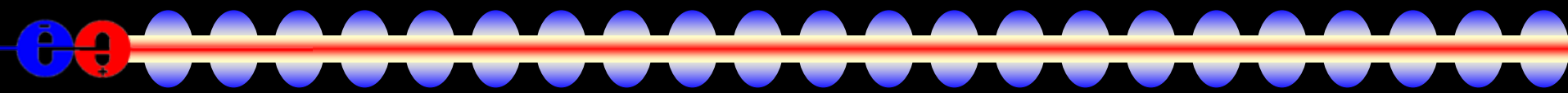


# GeomConverter

- Small Java program for converting from compact description to a variety of other formats

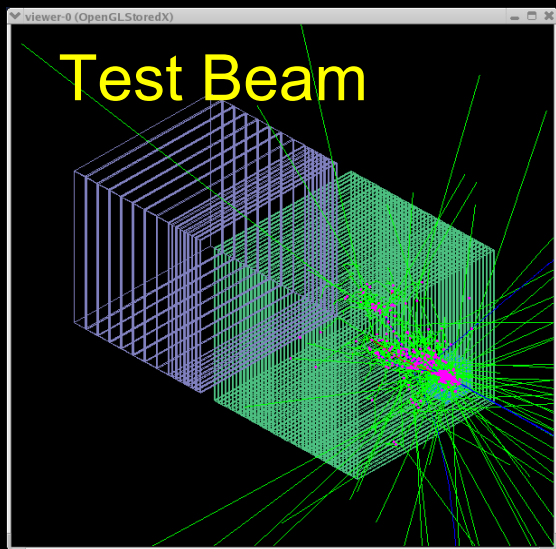
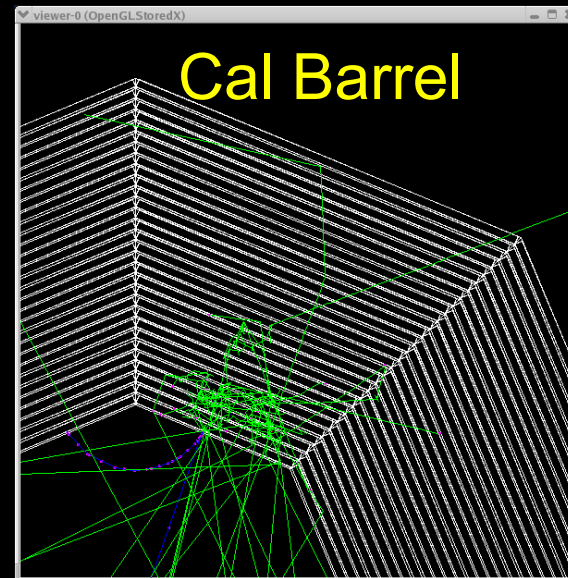
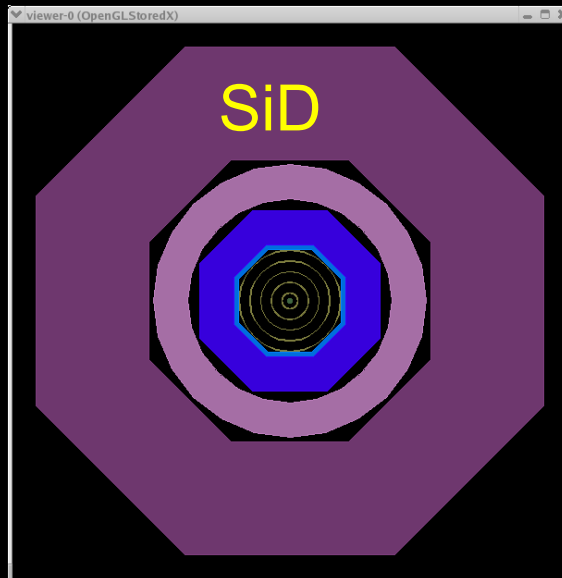
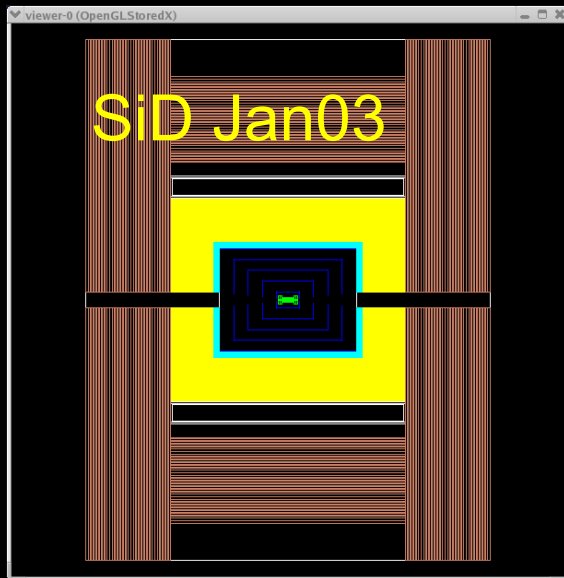


# Detector Variants

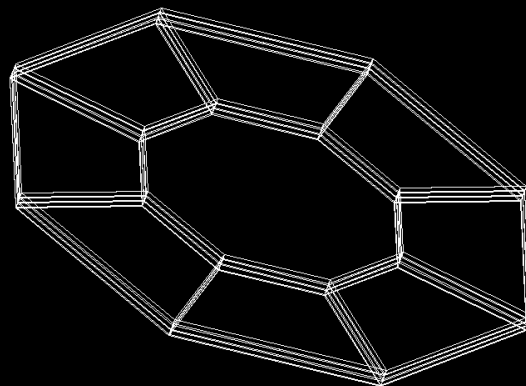


- Runtime XML format allows variations in detector geometries to be easily set up and studied:
  - Stainless Steel vs. Tungsten HCal sampling material
  - RPC vs. GEM vs. Scintillator readout
  - Layering (radii, number, composition)
  - Readout segmentation (size, projective vs. nonprojective)
  - Tracking detector technologies & topologies
    - TPC, Silicon microstrip, SIT, SET
    - “Wedding Cake” Nested Tracker vs. Barrel + Cap
  - Field strength
  - Far forward MDI variants (0, 2, 14, 20 mr )

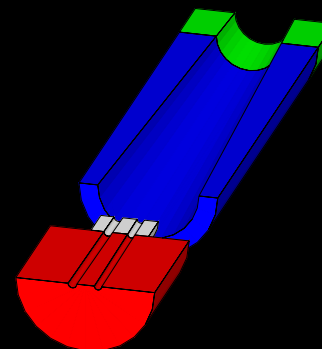
# Example Geometries



Cal Endcap



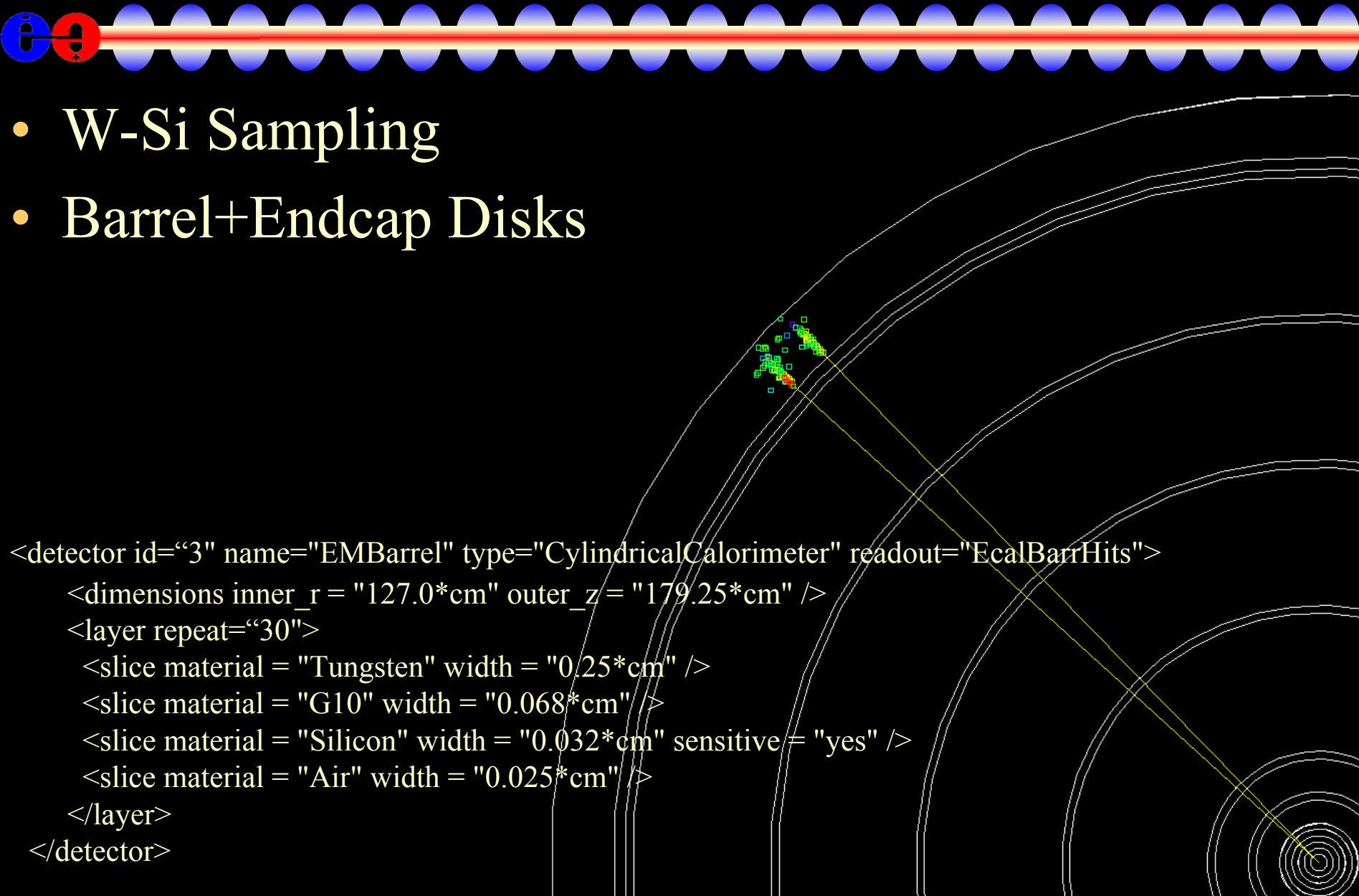
MDI-BDS



# EM Calorimeter

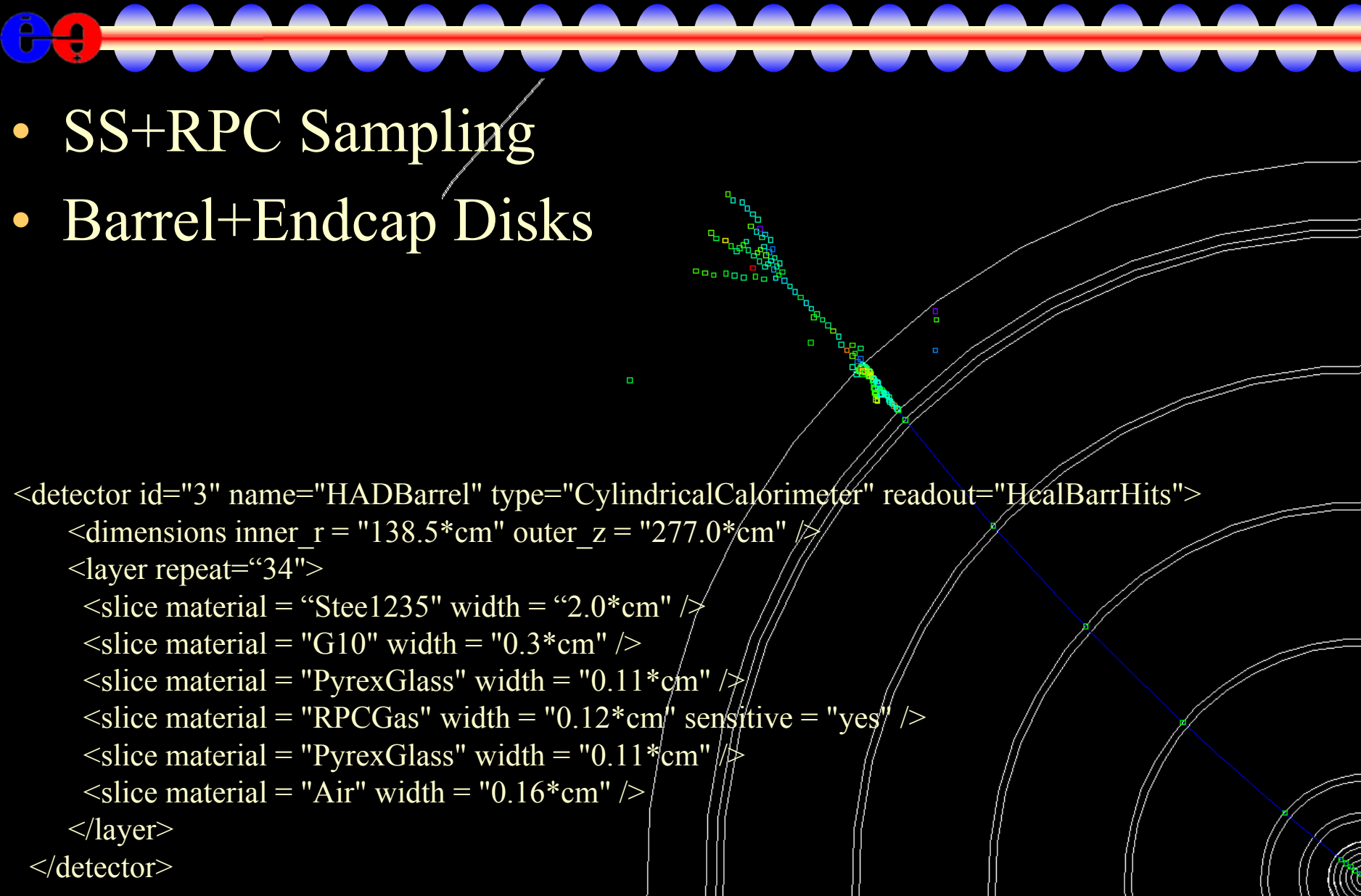
- W-Si Sampling
- Barrel+Endcap Disks

```
<detector id="3" name="EMBarrel" type="CylindricalCalorimeter" readout="EcalBarrHits">  
  <dimensions inner_r = "127.0*cm" outer_z = "179.25*cm" />  
  <layer repeat="30">  
    <slice material = "Tungsten" width = "0.25*cm" />  
    <slice material = "G10" width = "0.068*cm" />  
    <slice material = "Silicon" width = "0.032*cm" sensitive = "yes" />  
    <slice material = "Air" width = "0.025*cm" />  
  </layer>  
</detector>
```

The diagram illustrates the EM Calorimeter's structure. At the top, a horizontal red and orange beam represents an incoming particle. This beam passes through a series of blue circular disks, which are the detector layers. Below the beam, a series of white concentric arcs represent the cylindrical geometry of the calorimeter. A small cluster of colored squares (green, yellow, red) is shown within the detector layers, indicating a particle interaction or energy deposit. A yellow line extends from this cluster towards the bottom right corner of the image.

# Hadronic Calorimeter

- SS+RPC Sampling
- Barrel+Endcap Disks

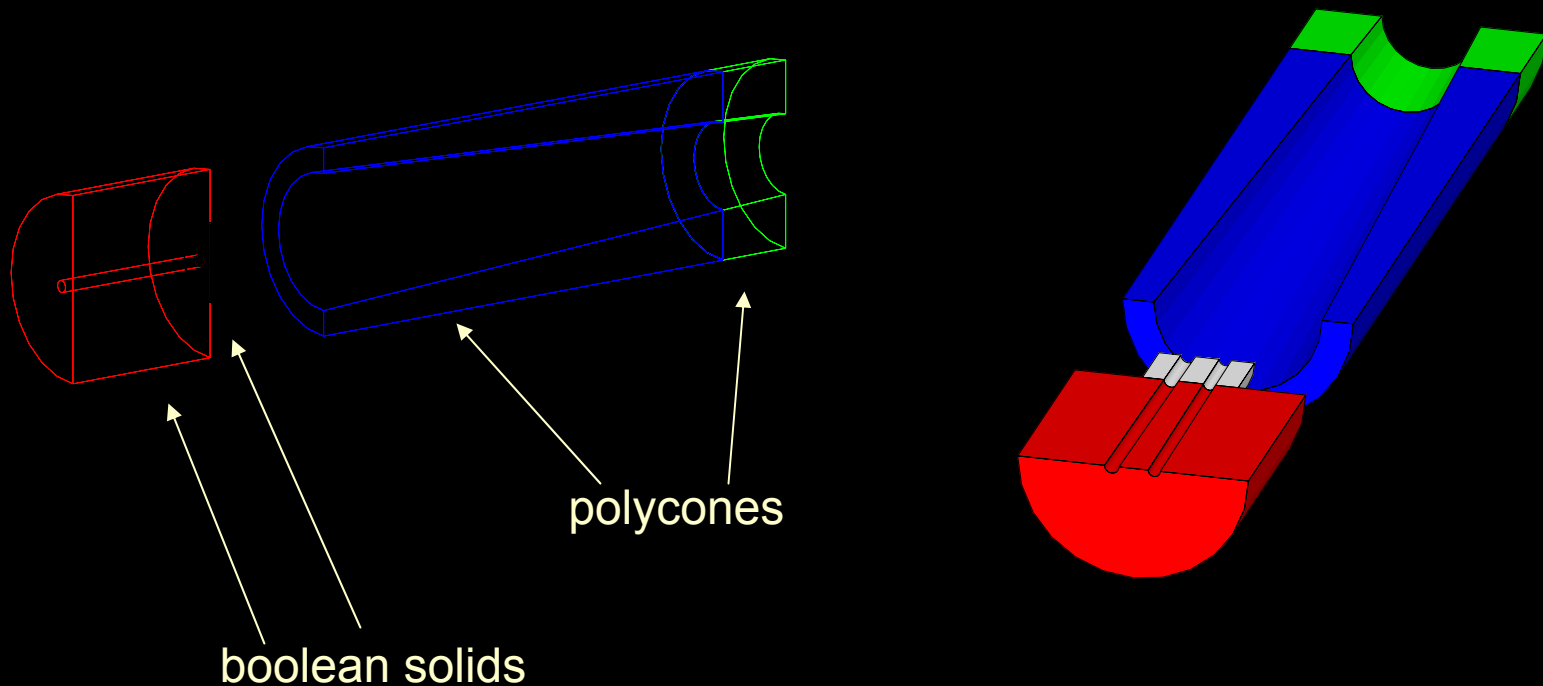


The diagram illustrates a hadronic calorimeter. At the top, a horizontal track of blue spheres represents the detector's sampling structure. A red and orange particle track enters from the left, passing through several layers of concentric white circles representing detector disks. A cluster of multi-colored squares (green, yellow, red, blue) marks the interaction point where the particle track hits the detector. Below the diagram, XML code defines the detector's geometry and material layers.

```
<detector id="3" name="HADBarrel" type="CylindricalCalorimeter" readout="HealBarrHits">  
  <dimensions inner_r = "138.5*cm" outer_z = "277.0*cm" />  
  <layer repeat="34">  
    <slice material = "Steel235" width = "2.0*cm" />  
    <slice material = "G10" width = "0.3*cm" />  
    <slice material = "PyrexGlass" width = "0.11*cm" />  
    <slice material = "RPCGas" width = "0.12*cm" sensitive = "yes" />  
    <slice material = "PyrexGlass" width = "0.11*cm" />  
    <slice material = "Air" width = "0.16*cm" />  
  </layer>  
</detector>
```

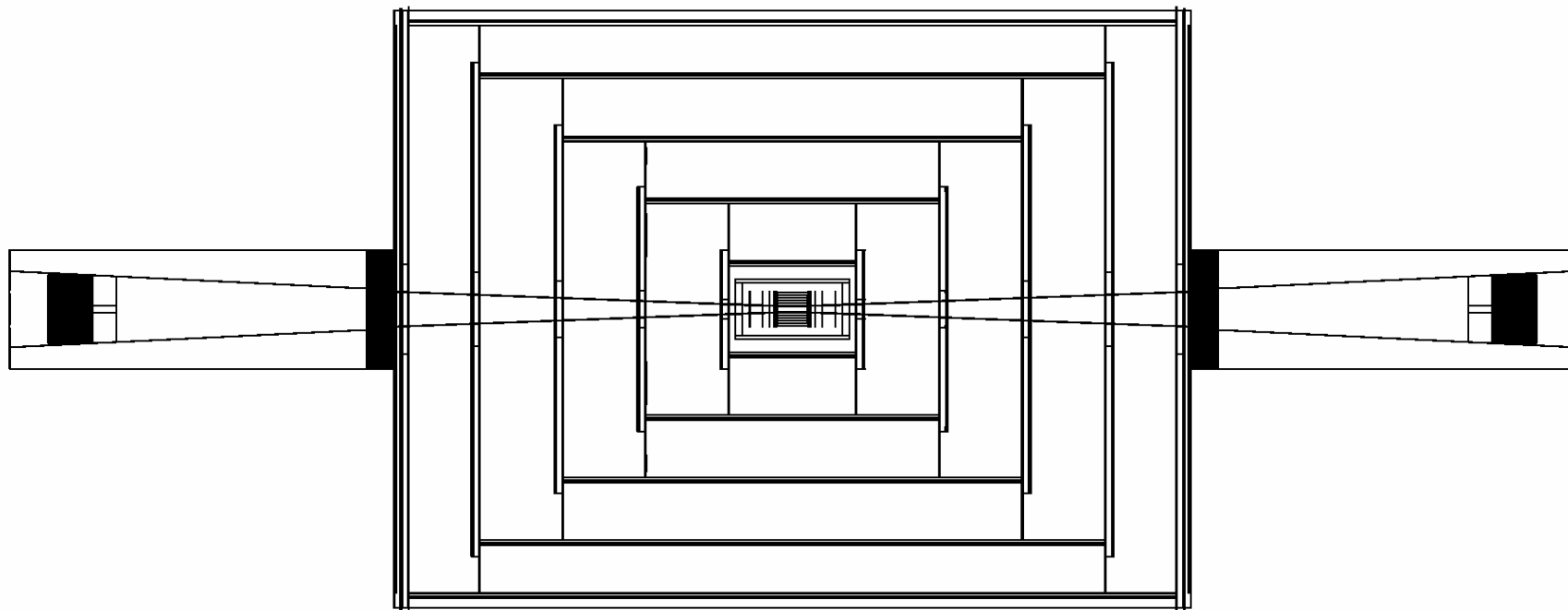
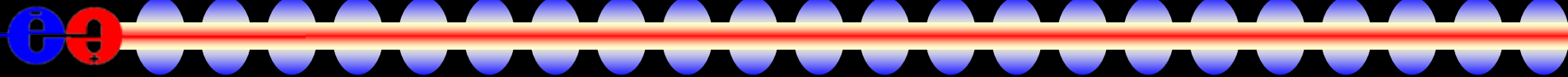
# *Far forward calorimetry*

## Machine Detector Interface and Beam Delivery System

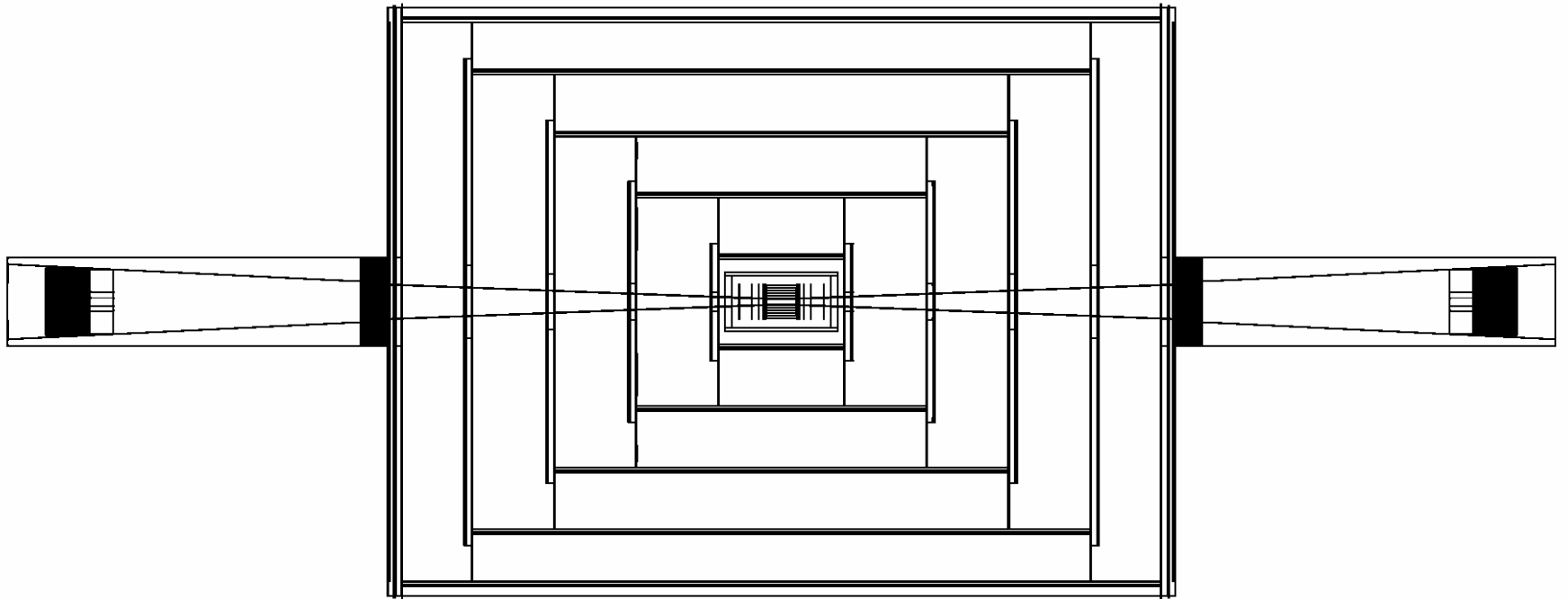
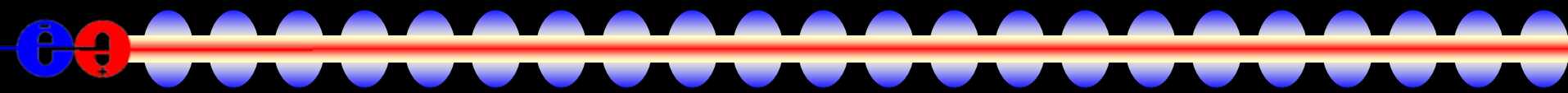


Both 2 and 20 milliradian solutions implemented.

# *2 m<sub>r</sub> crossing angles*

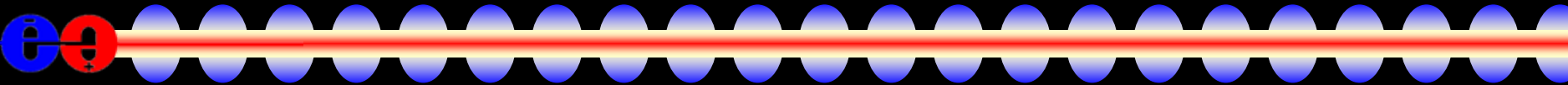


# *20 mr crossing angles*

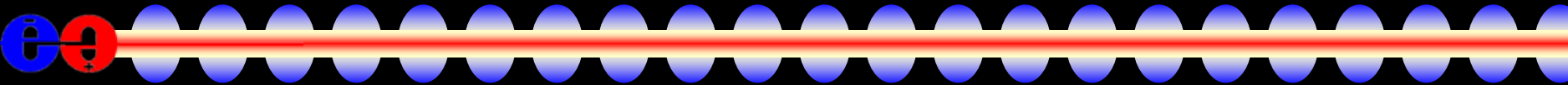




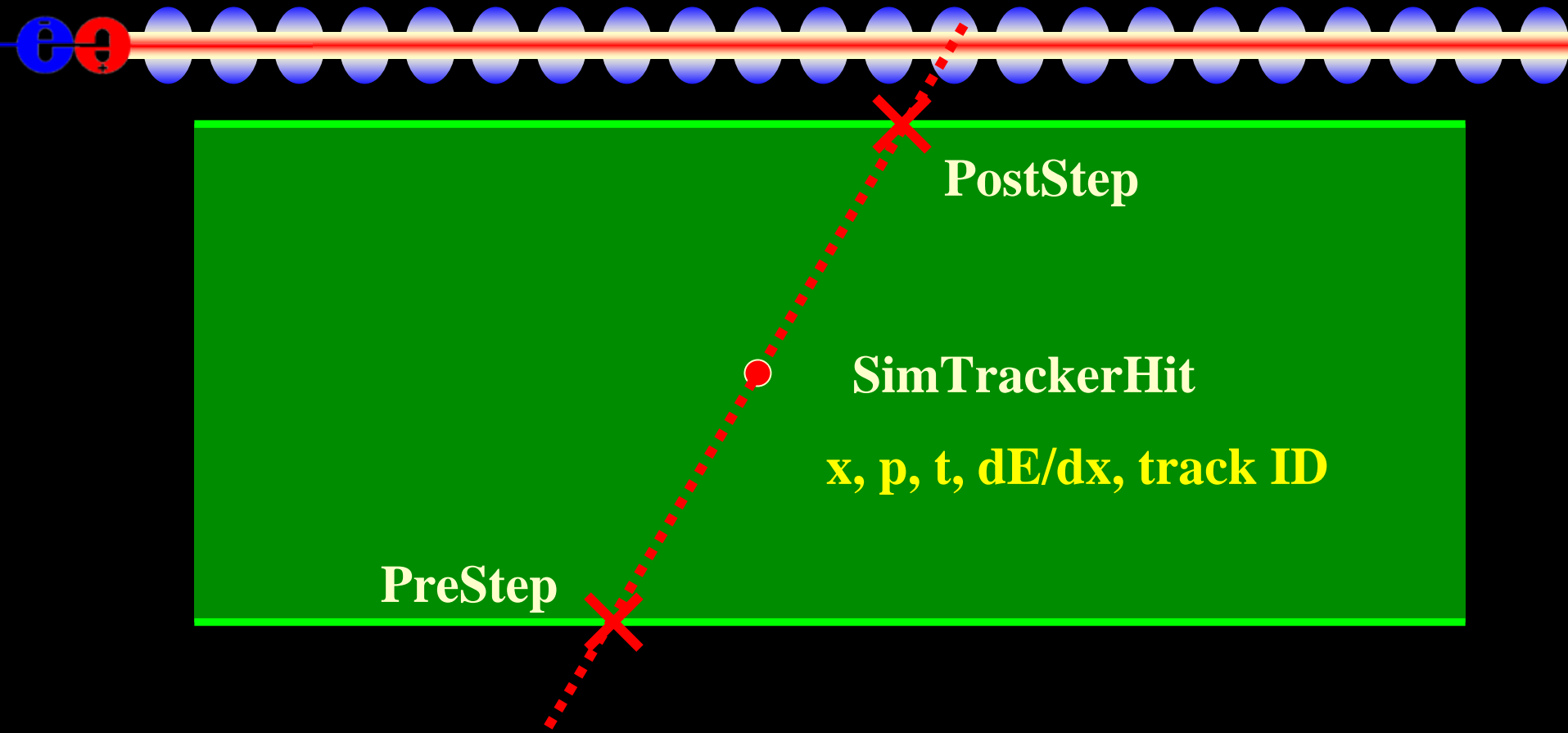
# *Geant4 Calorimeter Studies*

- 
- Still investing a lot of time understanding Geant4!
  - Strong EM calorimeter resolution dependence on range cuts, reported several years ago, appears to be fixed in latest Geant4 release.
  - Energy non-conservation in hadron showers.
    - Bugs found in GEISHA and patches provided for G4 several years ago, not all of which were adopted.
    - $n$  and  $\bar{n}$  treated with different models.
    - New hadronics coordinators appointed at last Geant4 collaboration meeting.

# *Geant4 Tracking Studies*

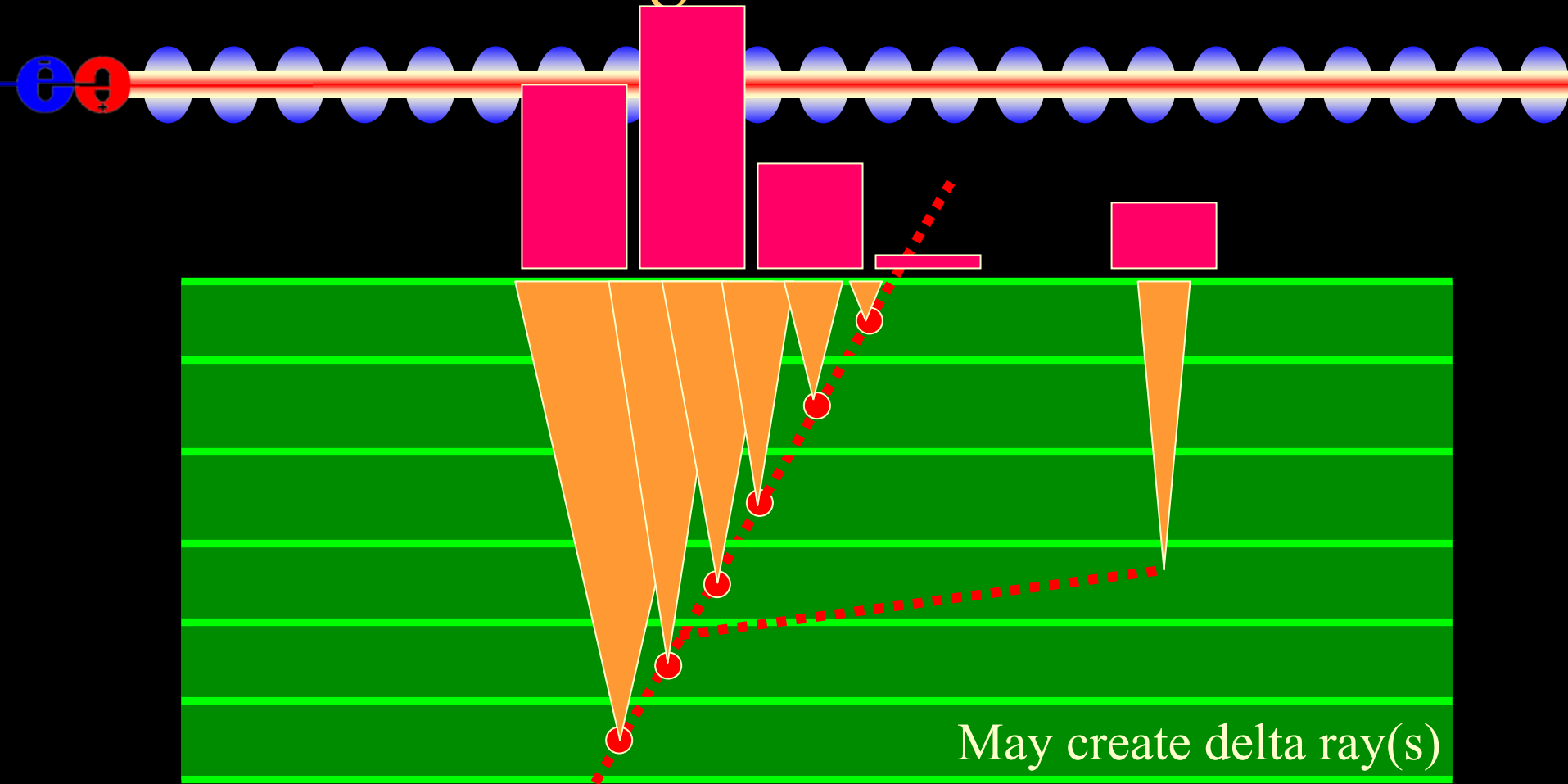
- 
- Currently using large G4 step lengths in silicon
    - normally only one hit per layer per track
    - digitization step then subdivides energy and introduces charge diffusion and Lorentz angle effects.
  - Investigating smaller range and step sizes to improve simulation at the Geant level.
    - Reducing range cuts increases number of secondaries produced and explicitly tracked.
    - MaxStepLength limits step when no other process occurs. Reducing this increases the number of hits.

# Current Hit Creation



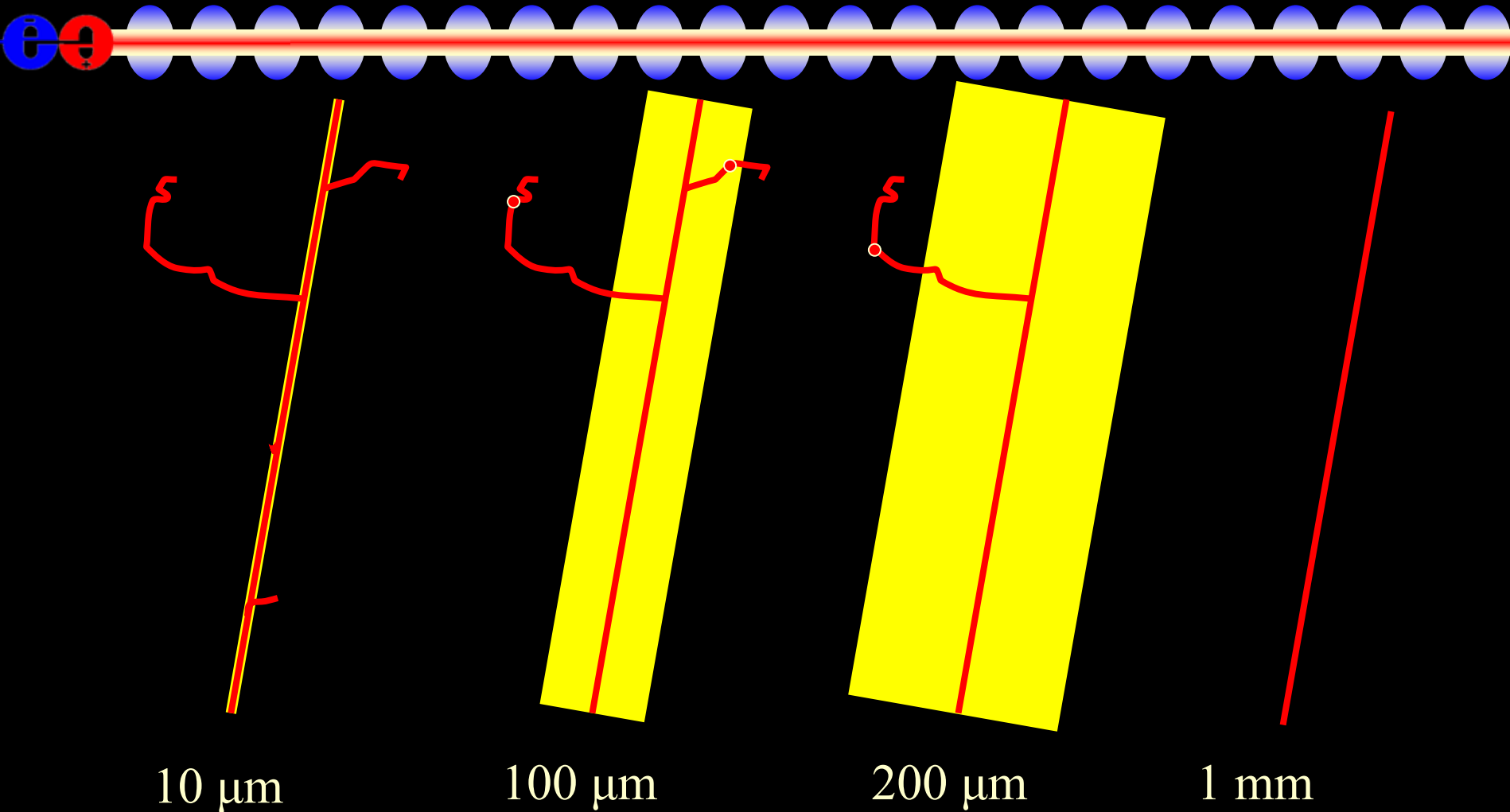
With large current step limits and range cuts in Geant4, usually get a single step in sensitive silicon, with hit placed in center of volume, and only  $dE/dx$  along path.

# Digitization



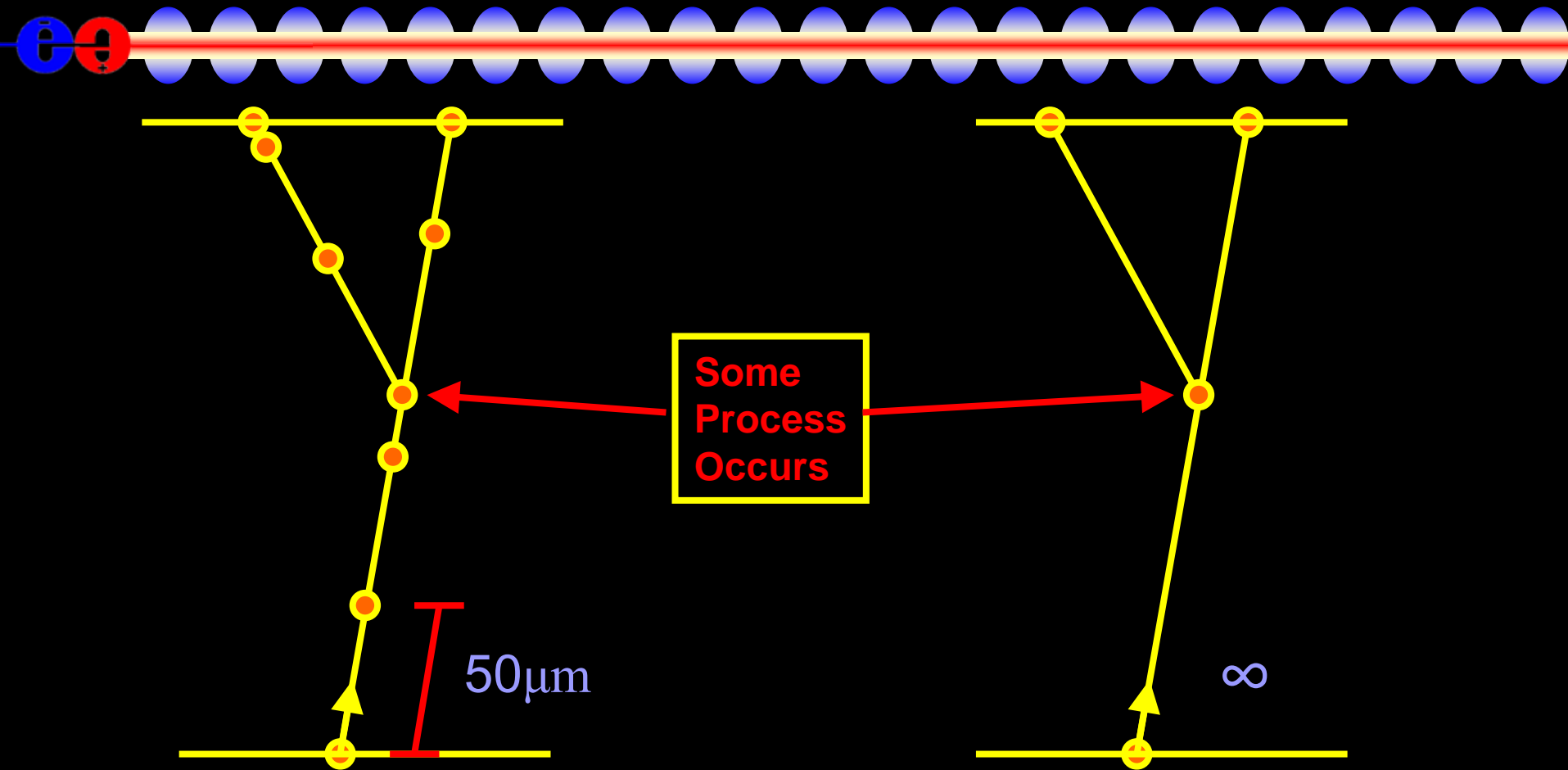
Usual digitization algorithm starts by artificially subdividing the step and distributing the deposited energy in subslices. These depositions are then drifted to the surface, with appropriate diffusion and Lorentz angle effects, to provide hits in strips.

# *G4 Cuts - Range Cuts*



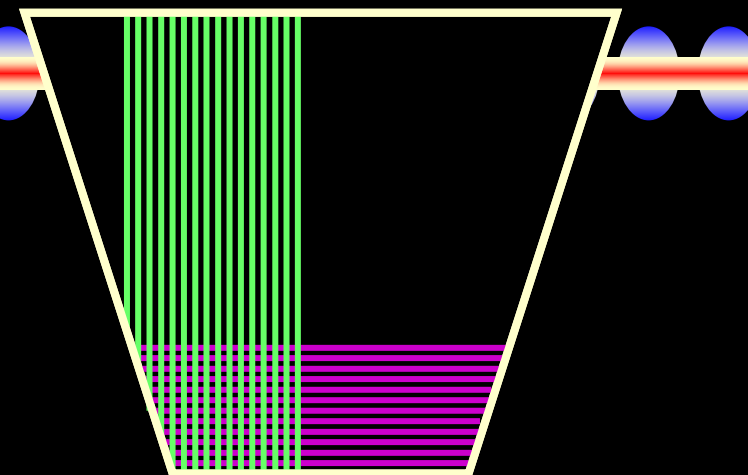
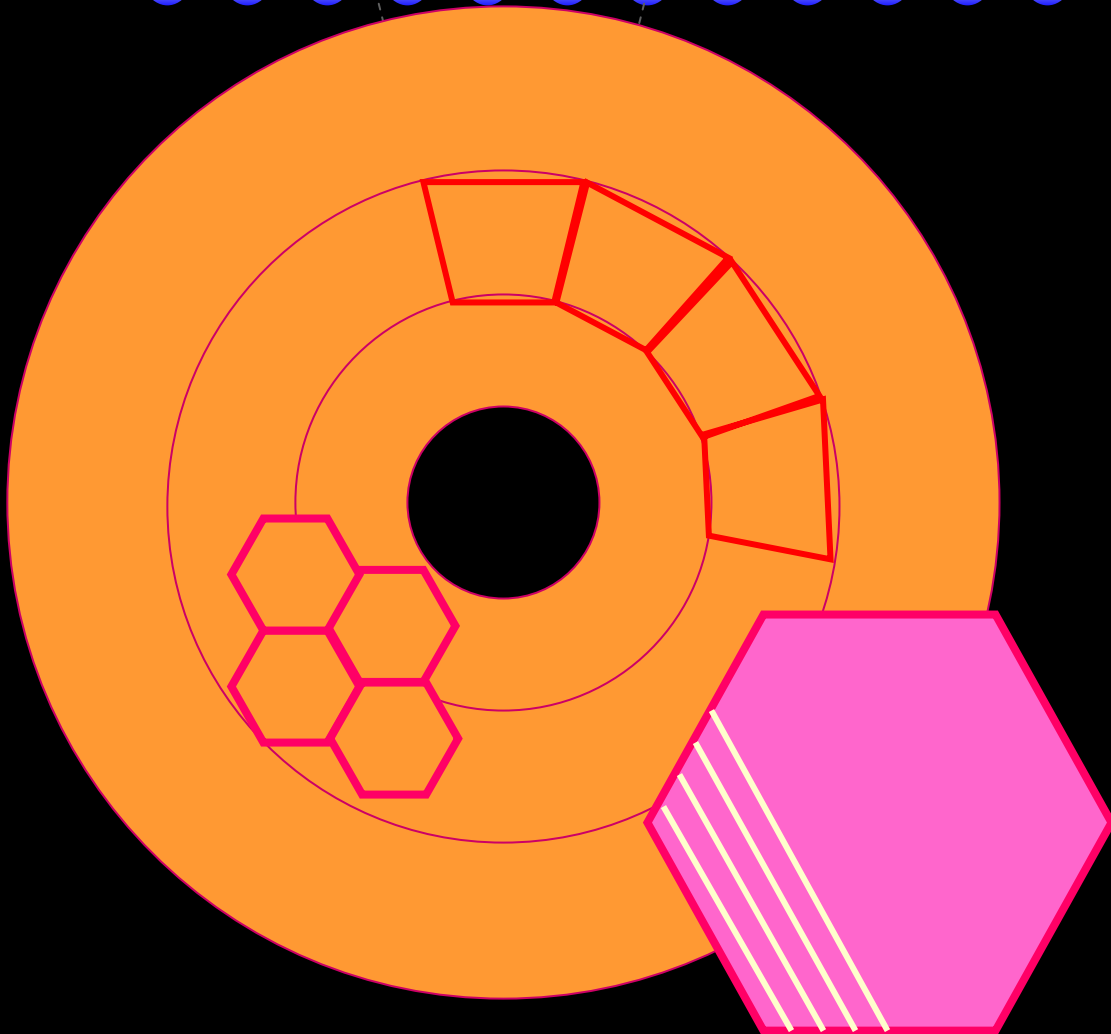
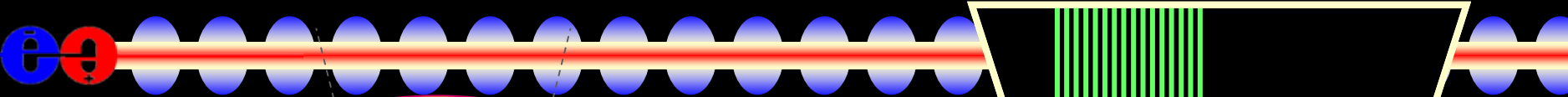
Reducing range cuts increases number of secondaries produced and explicitly tracked

# *G4 Cuts - Max Step Length*

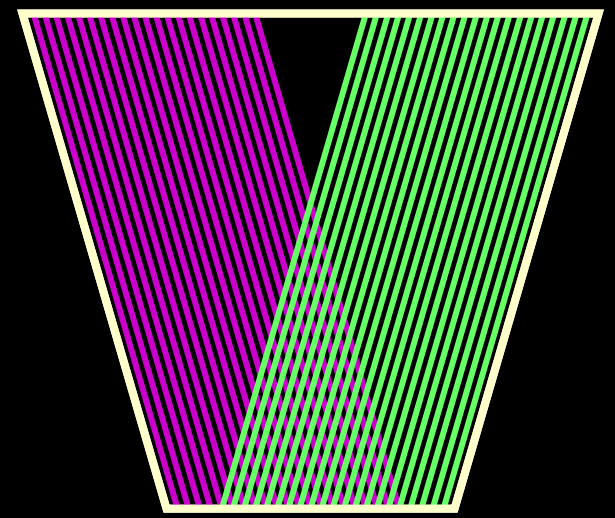


**Limits step when no other process occurs in that distance.  
Reducing size limit increases number of hits produced.**

# *Tiling Forward Disks*



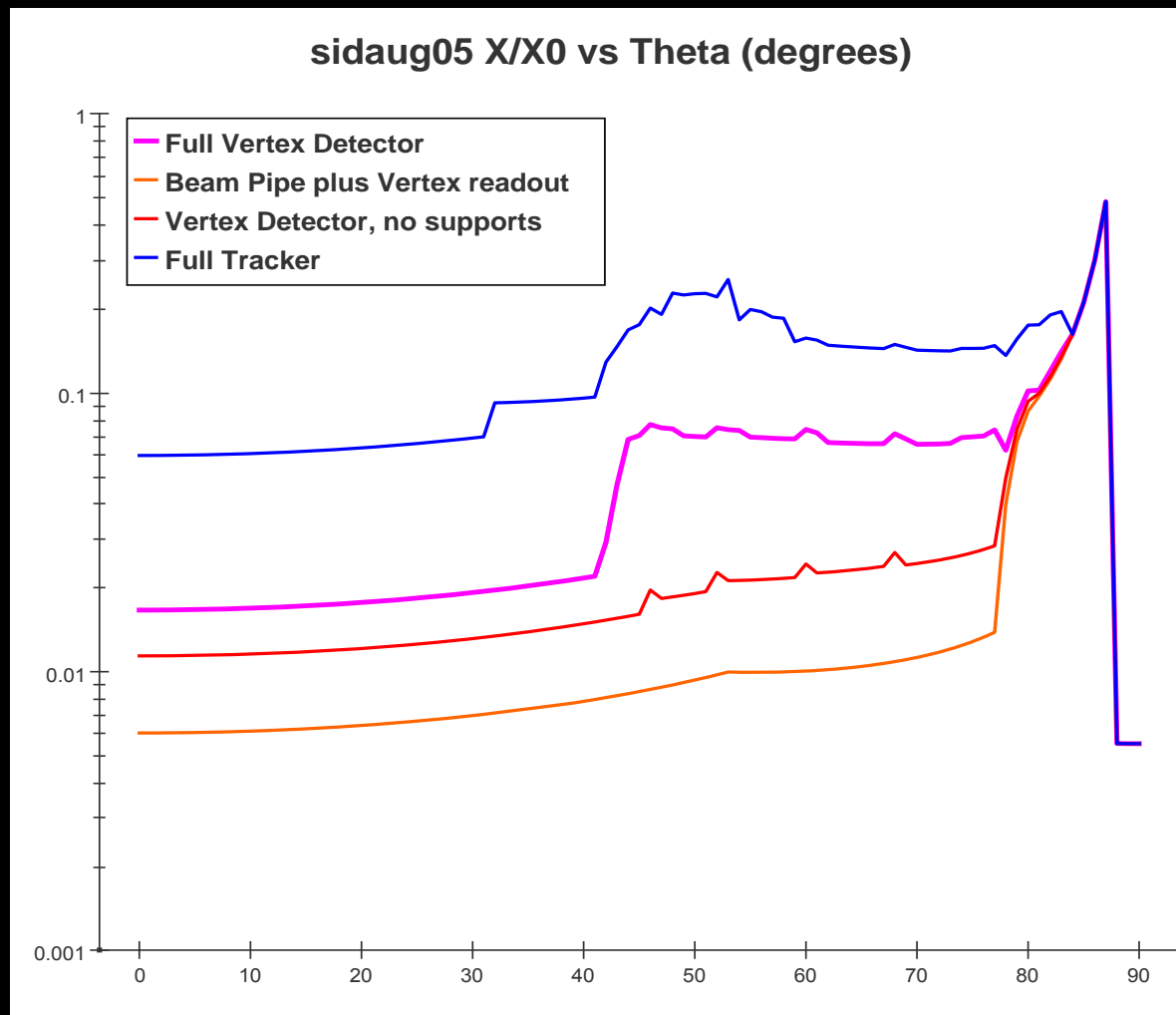
**Large Angle Stereo**



**Shallow Angle Stereo**

# Geant4 Tracking Studies

- New tool allows plots of material budget to be easily created.
- Tracks geantino through detector and sums up radiation and interaction lengths.



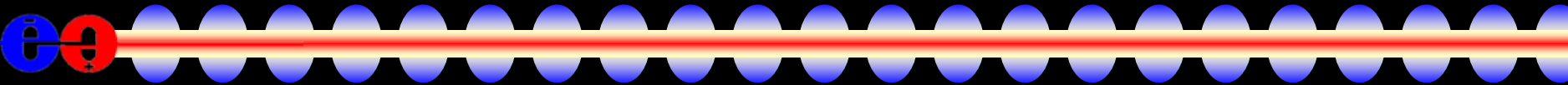


# “Signal” and Diagnostic Samples

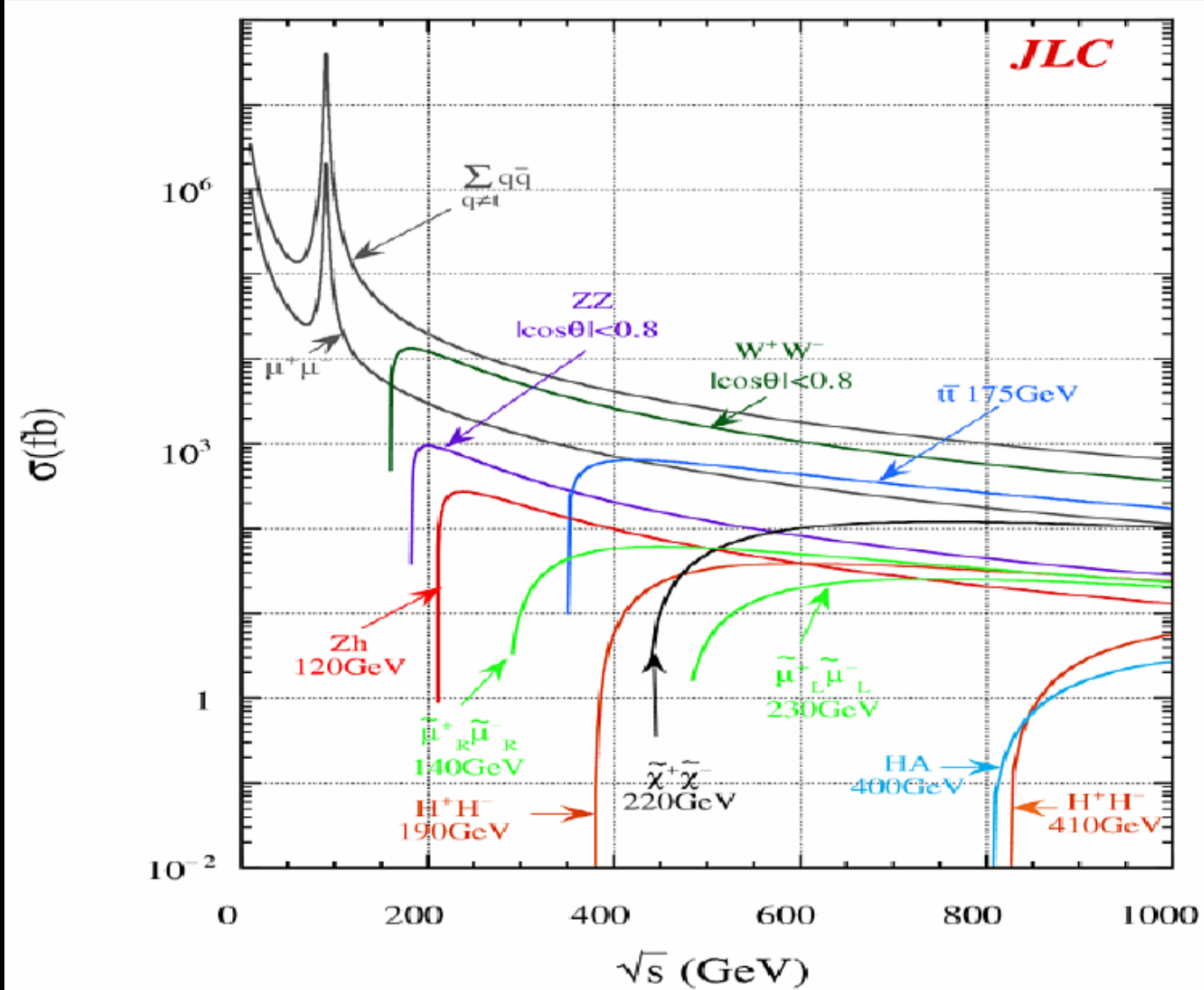
- Have generated canonical data samples and have processed them through full detector simulations.
- simple single particles:  $\gamma$ ,  $\mu$ ,  $e$ ,  $\pi^{+/-}$ ,  $n$ , ...
- composite single particles:  $\pi^0$ ,  $\rho$ ,  $K^0_S$ ,  $\tau$ ,  $\psi$
- Z Pole events: comparison to SLD/LEP
- $WW$ ,  $ZZ$ ,  $t\bar{t}$ ,  $q\bar{q}$ , tau pairs, mu pairs,  $Z\gamma$ ,  $Zh$ :
- Web accessible:

<http://www.lcsim.org/datasets/ftp.html>

# “Standard Model Background”

- 
- Generate an inclusive set of MC events with all SM processes + backgrounds arising from beam- and brems-strahlung photons and machine-related particles.  $500 \text{ fb}^{-1}$  @ 0.5 TeV,  $2 \text{ ab}^{-1}$  @ 1.0 TeV
    - WHIZARD Monte Carlo used to generate all 0,2,4,6-fermion and t quark dominated 8-fermion processes.
  - Used for realistic analyses and represents a “standard” sample.
  - Canonical background for Beyond-SM searches.
  - 100%  $e^-$  and  $e^+$  polarization used in generation. Arbitrary electron, positron polarization simulated by properly combining data sets.
  - Fully fragmented MC data sets are produced. PYTHIA is used for final state QED & QCD parton showering, fragmentation, particle decay.
  - 1 year’s worth of stdhep files fits on one external harddrive.

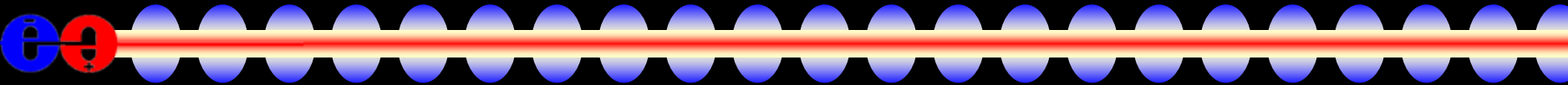
# “Standard Model Background”



# Reconstruction/Analysis Overview

- Java based reconstruction and analysis package
  - Runs standalone or inside Java Analysis Studio (JAS)
  - Fast MC → Smeared tracks and calorimetry clusters
  - Full Event Reconstruction
    - detector readout digitization (CCD pixels & Si  $\mu$ -strips)
    - *ab initio* track finding and fitting for  $\sim$ arbitrary geometries
    - multiple calorimeter clustering algorithms
    - Individual Particle reconstruction (cluster-track association)
  - Analysis Tools (including WIRED event display)
  - Physics Tools (Vertex Finding, Jet Finding, Flavor Tagging)
  - Beam background overlays at detector hit level

# Tracking Detector Readout

- 
- Hits in Trackers record full MC information.
  - Digitization is deferred to analysis stage.
  - Nick Sinev has released a package to convert hits in silicon to CCD pixel hits.

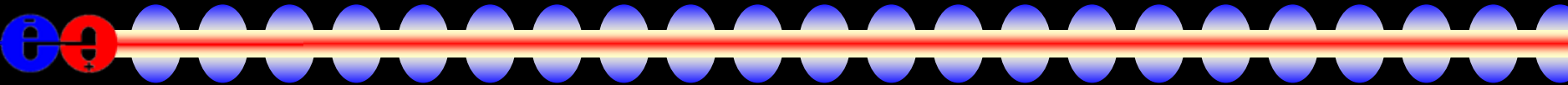
MC Hits → Pixels & PH → Clusters → Hits ( $x \pm \delta x$ )

- UCSC developed long-shaping-time  $\mu$ -strip sim.

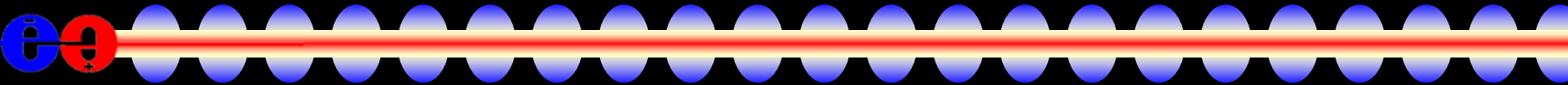
MC Hits → Strips & PH → Clusters → Hits ( $\varphi \pm \delta\varphi$ )

- SLAC developing short-strip simulation.
- Needed to correctly study occupancies, overlaps, ghost hits, etc.

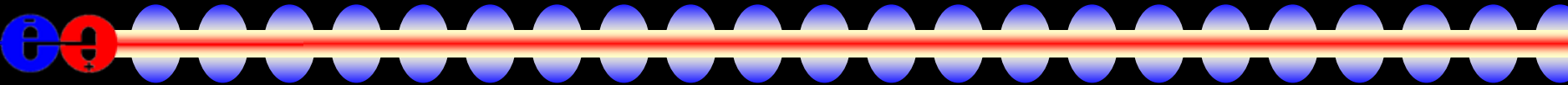
# Track Finding

- 
- Standalone pattern recognition code for the 2D Barrel VXD hits.
    - High efficiency, even in presence of backgrounds.
    - Efficient at low momentum.
    - Propagates tracks into Central Tracker to pick up  $\varphi$  hits
  - Conformal-mapping pattern recognition also available, applicable also to TPC.
  - Work ongoing to find MIP stubs in calorimeter and propagate inwards to tracker.

# Tracking

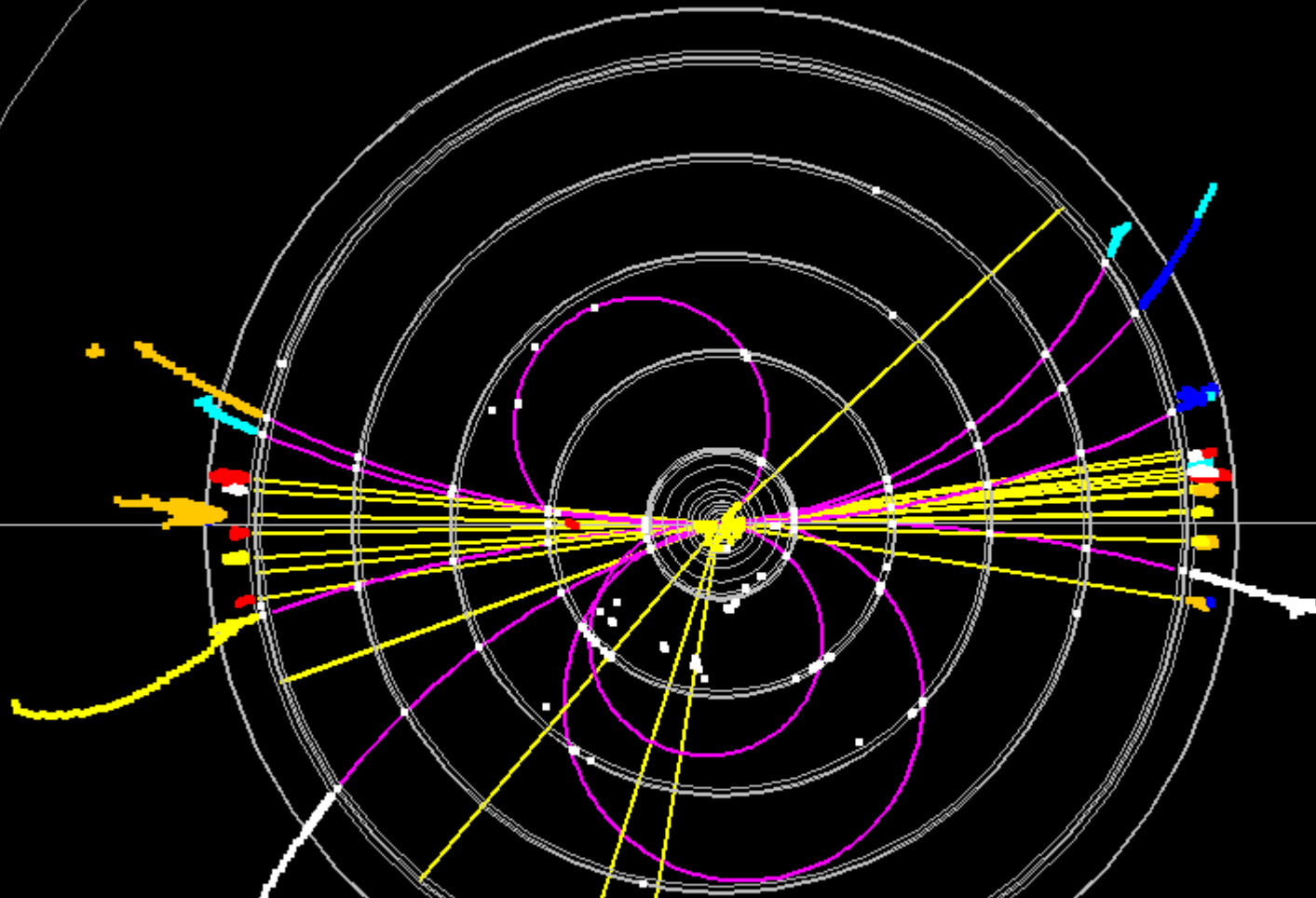
- 
- Analytic covariance matrices available for fast MC smearing for each detector. Uses [lcdtrk](#).
  - Track “cheater” available for studies of full detector simulation events. Assigns hits on basis of MC parentage.
  - Ab initio track finding packages.
  - Fitting code incorporating multiple scattering and energy loss via weight matrix or Kalman Filter available.

# *Particle Reconstruction*

- 
- Several groups are following different approaches towards individual particle reconstruction (“particle flow”).
  - Template allows plug-and-play of different approaches.
  - Have first packages for identifying photons, electrons, charged & neutral hadrons and muons.
  - Being tuned and optimized for different detectors and different final states.
  - Main tool for detector optimization.



# *Individual Particle Reconstruction*



- Tracks and Clusters form ReconstructedParticles.
- Goal is 1:1 ReconstructedParticle  $\Leftrightarrow$  MCParticle

# *Java Analysis Studio (JAS)*

- Integrated Development Environment (editor, compiler)
- Cross-platform physics analysis environment with iterative, event-based analysis model
  - quick development, debugging, ad hoc analysis
  - additional functionality with plugins
- Dynamically load / unload Java analysis drivers
  - Supports distributed computing.
- Plotting and fitting and analysis (cuts, scripting) engine
  - 1D, 2D histograms, clouds, profiles, dynamic scaling, cuts
  - high-quality output to vector or raster formats
- Integrated event browser and event display

JAS

# JAS editor/compiler

The screenshot displays the JAS3 editor/compiler interface. The main window is titled "JAS3" and contains a menu bar (File, Edit, View, Tuple, Loop, LCIO, Window, Help) and a toolbar. The left sidebar shows a file tree with "DataSets" and "Programs" folders, and a sub-folder "CombinedConeClusterAnalysisDriver". The main editor window displays the source code for "CombinedConeClusterAnalysisDriver.java". The code includes a header with creation date and author information, and a class definition for "CombinedConeClusterAnalysisDriver" that extends "Driver". The class contains a constructor and a "process" method that iterates over calorimeter hits and clusters them based on a radius and energy thresholds. The right sidebar shows a visualization window displaying a complex geometric structure, likely a detector layout or a cluster of hits, rendered in white and green on a black background. The bottom status bar shows the time "9:23:33 PM" and the message "----- compile successful". The bottom-most status bar indicates "Analyzed 1 records in 190ms" and "24.6/34.4MB".

```
70 CombinedConeClusterAnalysisDriver.java
71 *
72 * Created on March 3, 2006, 4:21 PM
73 *
74 * To change this template, choose Tools | Template Manager
75 * and open the template in the editor.
76 *
77 *
78 /**
79 *
80 * @author ngraf
81 *
82 */
83 public class CombinedConeClusterAnalysisDriver extends Driver
84 {
85     private FixedConeClusterer _clusterer;
86     /** Creates a new instance of CombinedConeClusterAnalysisDriver */
87     public CombinedConeClusterAnalysisDriver()
88     {
89         double radius = 1.2;
90         double seedEnergy = 0.0;
91         double minEnergy = 0.0;
92         _clusterer = new FixedConeClusterer(radius, seedEnergy, minEnergy);
93     }
94     protected void process(EventHeader event)
95     {
96         // the list of hit cells to cluster
97         List<CalorimeterHit> cellsToCluster = new ArrayList<CalorimeterHit>();
98         // get all the calorimeter hits in this event...
99         List<List<CalorimeterHit>> collections = event.get(CalorimeterHit.class);
100
101         for (List<CalorimeterHit> collection : collections)
102         {
103             LCMetaData meta = event.getMetaData(collection);
104             System.out.println(meta.getName()+" has "+collection.size()+" hits");
105             for (CalorimeterHit hit : collection)
106             {
107                 // should apply cut here...
108                 // punt for now and add ALL hits
109                 cellsToCluster.add(hit);
110             }
111         }
112
113         System.out.println("Event has "+cellsToCluster.size()+" hit cells");
114     }
115 }
```

# JAS event browser

JAS3

File Edit View Tuple Loop LCIO Window Help

pythiaZPolebbar-0-1000\_SLIC\_v1r13p3\_sit00.slcio

DataSets  
Programs  
ClusterFinding  
aida22594aida

LCSim Event  
Run:0 Event: 179

Event

- EcalBarrHits
- EcalBarrHitsNNClusters
- EcalEndcapHits
- EcalEndcapHitsNNCluste
- ForwardEcalEndcapHits
- HcalBarrHits
- HcalBarrHitsNNClusters
- HcalEndcapHits
- HcalEndcapHitsNNCluste
- LuminosityMonitorHits
- MCParticle
- MCParticleEndPointEnerg
- MuonBarrHits
- MuonEndcapHits
- TrkBarrHits

LCIO Event Header

Run	0
Event	179
Time Stamp	Thu Feb 16 10:34:33 PST 2006
Detector Name	sid00

Collections

Name	Type	Size
EcalEndcapHitsNNClusters	org.lcsim.event.Cluster	22
EcalEndcapHitsNNClusters	org.lcsim.event.Cluster	22
EcalBarrHitsNNClusters	org.lcsim.event.Cluster	24
HcalBarrHitsNNClusters	org.lcsim.event.Cluster	7
HcalEndcapHitsNNClusters	org.lcsim.event.Cluster	3
VbEndcapHits	org.lcsim.event.SimTrackerHit	72
EcalBarrHits	org.lcsim.event.SimCalorime...	1036
EcalEndcapHits	org.lcsim.event.SimCalorime...	1084
ForwardEcalEndcapHits	org.lcsim.event.SimCalorime...	33
HcalBarrHits	org.lcsim.event.SimCalorime...	197
HcalEndcapHits	org.lcsim.event.SimCalorime...	129
LuminosityMonitorHits	org.lcsim.event.SimCalorime...	0
MuonBarrHits	org.lcsim.event.SimCalorime...	1

LCSim Event  
Run:0 Event: 179

Event

- EcalBarrHits
- EcalBarrHitsNNClusters
- EcalEndcapHits
- EcalEndcapHitsNNCluste
- ForwardEcalEndcapHits
- HcalBarrHits
- HcalBarrHitsNNClusters
- HcalEndcapHits
- HcalEndcapHitsNNCluste
- LuminosityMonitorHits

Collection: EcalEndcapHits size:1084 flags:e0000000

id:	system	id:	layer	id:	barrel	id:	x	id:	y	raw energy (...)	corrected e...	x (mm)	y (mm)	z (mm)	time (ns)
6		0	2	77		304	1.0683E-4	0084284	271.25	1065.8	-1683.3	6.7236			
6		1	2	77		304	1.1771E-4	.0092868	271.25	1065.8	-1687.1	6.7386			
6		2	2	77		305	1.0897E-4	.0085971	271.25	1069.2	-1690.8	6.7536			
6		3	2	77		306	1.2685E-4	.010008	271.25	1072.8	-1694.6	6.7685			
6		4	2	77		306	4.6335E-5	.0036556	271.25	1072.8	-1698.3	6.7834			
6		4	2	77		307	1.2153E-4	.0095883	271.25	1076.2	-1698.3	6.7840			
6		10	2	83		303	3.6268E-4	.028614	292.25	1062.2	-1720.8	7.2580			
6		26	2	105		200	2.0871E-5	.0016466	369.25	701.75	-1798.3	101.67			
6		21	2	55		297	1.4128E-5	.0011147	194.25	1041.2	-1767.1	12.514			
6		9	2	77		309	8.8875E-4	.070119	271.25	1083.2	-1717.1	6.8521			
6		6	2	73		299	3.4643E-4	.027332	257.25	1048.2	-1705.8	7.4273			
6		7	2	93		313	6.7790E-4	.053483	327.25	1097.2	-1709.6	8.2976			

JAS3Tree x WIRED x

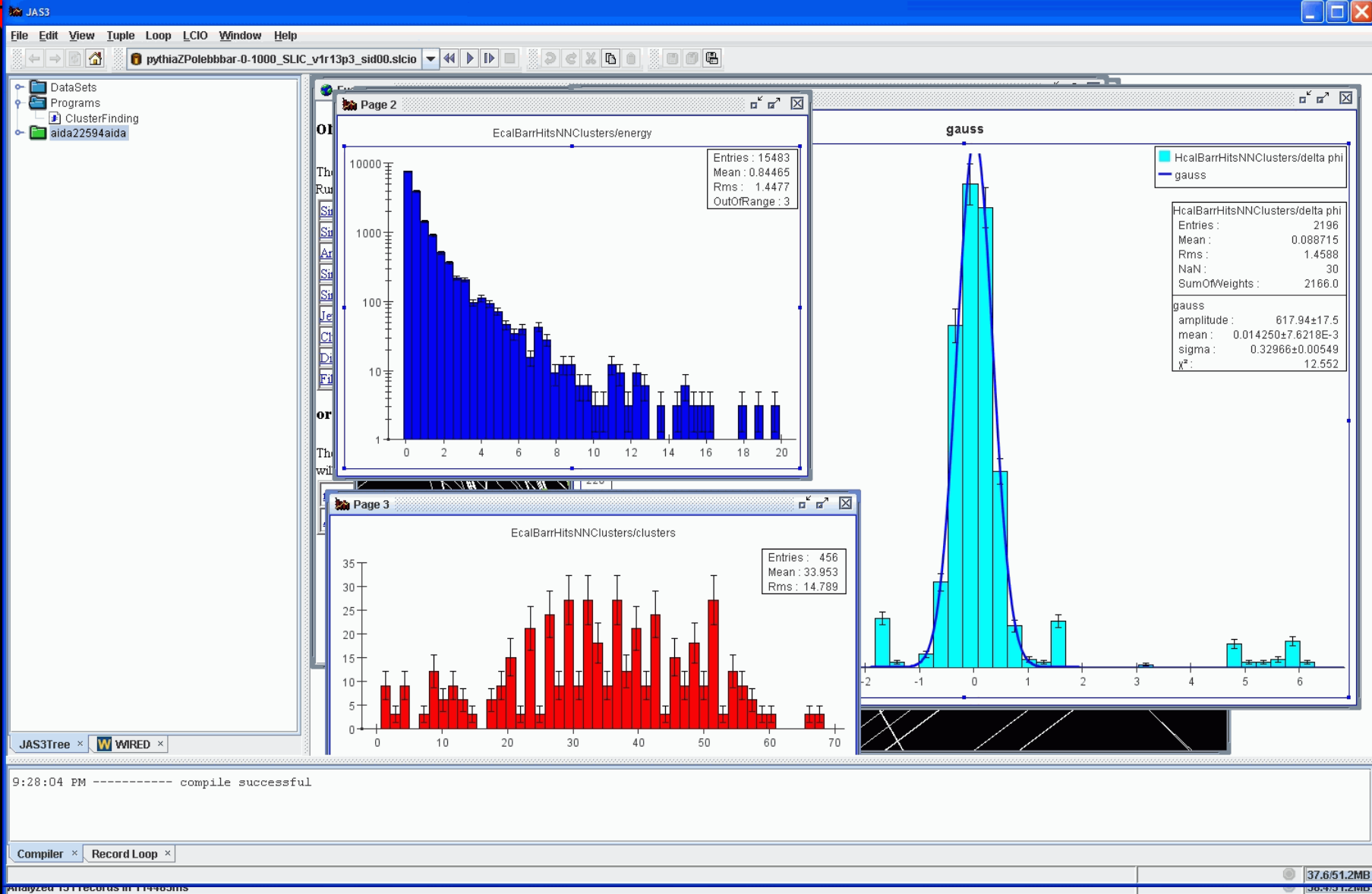
9:28:04 PM ----- compile successful

Compiler x Record Loop x

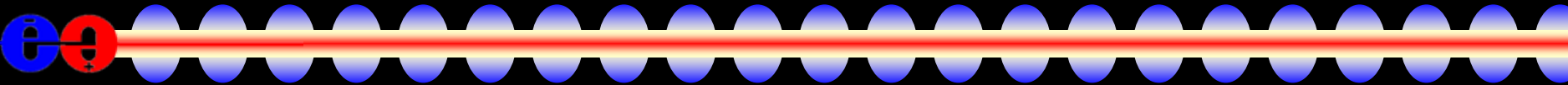
Analyzed 151 records in 114485ms

38.4/51.2MB

# JAS histogramming/fitting



# *JAS LCD Physics Utilities*

- 
- Physics Utilities
    - 4-vector, 3-vector classes
    - Event shape/Thrust finder
    - Jet Finders
      - Many kT algorithms implemented (e.g. Jade and Durham )
      - Extensible to allow implementation of other algorithms
  - Event Displays
    - 2D - Suitable for debugging reconstruction and analysis
    - Wired for full 3D support
  - Particle Hierarchy Displays

# Wired LCD Event Display

The screenshot shows the JAS3 software interface. The main window, titled "View 1", displays a 3D visualization of particle tracks and detector hits. The tracks are represented by white lines, and the hits are shown as small colored squares (green, yellow, blue, red) scattered throughout the detector volume. The detector is overlaid on a grid. The interface includes a menu bar (File, Edit, View, Tuple, Loop, LCIO, Window, Help), a toolbar with various icons, and a left sidebar with an "Interaction" tree. The tree lists various detector components and hit types, such as "EcalEndcapHitsNNClusters", "HcalBarrHits", and "MCParticle". A status bar at the bottom shows the time "9:28:04 PM" and the message "compile successful".

Interaction

- DetectorType
- EventType
- EcalEndcapHitsNNClusters
- VbEndcapHits
- EcalBarrHits
- EcalEndcapHits
- ForwardEcalEndcapHits
- HcalBarrHits
- HcalEndcapHits
- LuminosityMonitorHits
- MuonBarrHits
- MuonEndcapHits
- TkrBarrHits
- TkrEndcapHits
- VbBarrHits
- EcalBarrHitsNNClusters
- HcalEndcapHitsNNClusters
- HcalBarrHitsNNClusters
- MCParticle
  - Neutral
  - Charged

Apply immediately

Hide below level:

JAS3Tree x WIRED x

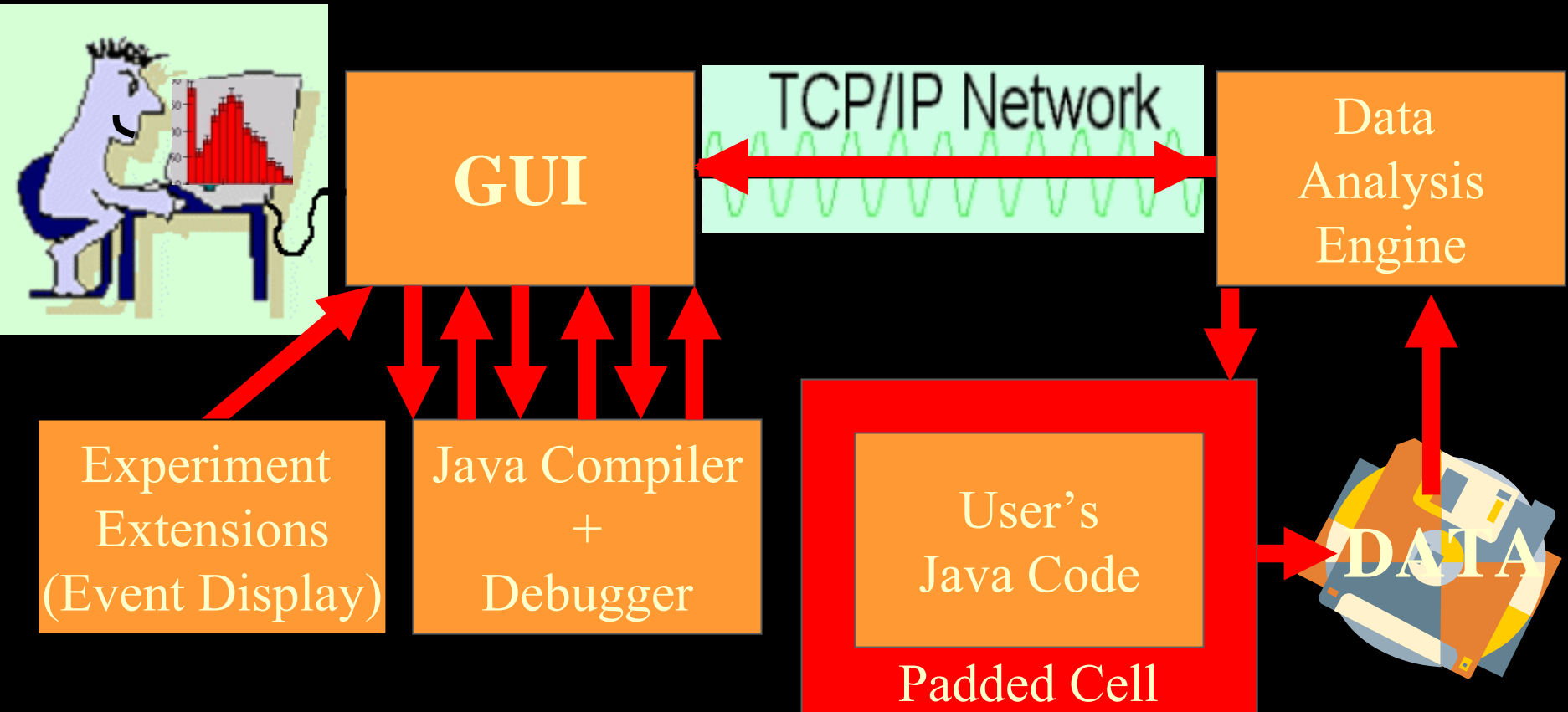
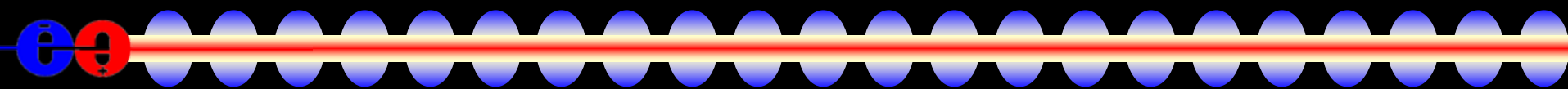
9:28:04 PM ----- compile successful

Compiler x Record Loop x

37.8/51.2MB

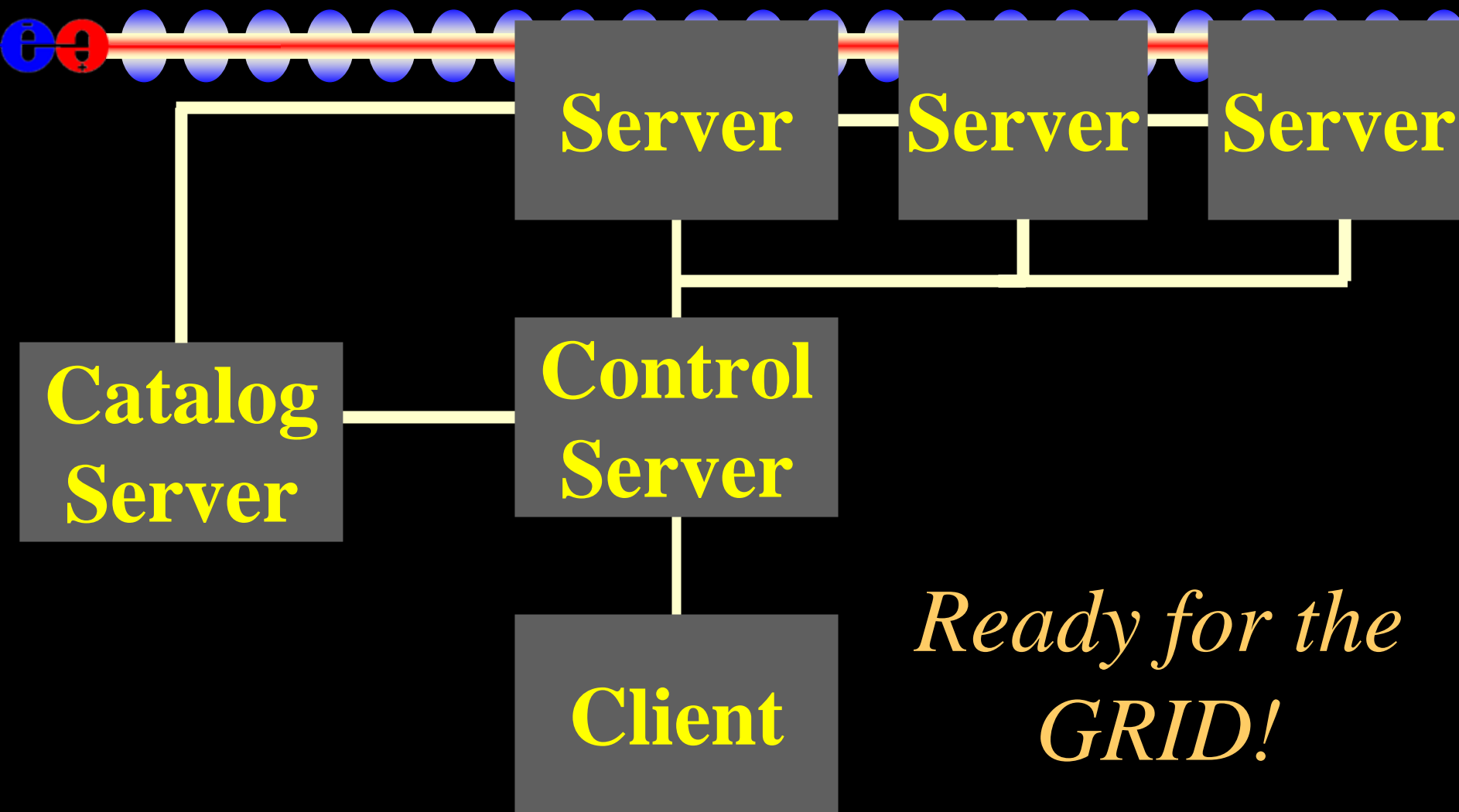
sNNClusters/delta phi	2196
sNNClusters/delta phi	0.088715
	1.4588
ghts :	30
	2166.0
	617.94±17.5
	0.014250±7.6218E-3
	0.32966±0.00549
	12.552

# JAS Remote Data Access





# *Distributed Analysis*



*Ready for the  
GRID!*

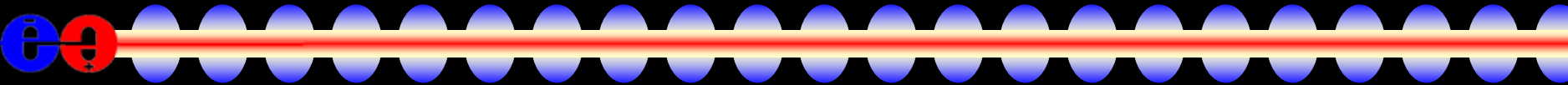
# *Detector Optimization (Costing)*

- Goal is to fully simulate and validate baseline design.
- Then determine the dependence of performance on detector attributes.
- Iterate to achieve balance of cost, risk, & performance

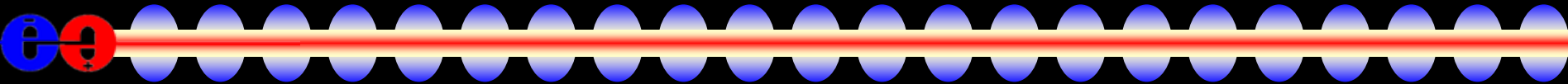
Spreadsheet

- Excel Spreadsheet demo of costing vs parameters.

# *Simulation Summary*

- 
- ALCPG sim/reco supports an ambitious international detector simulation effort. Goal is flexibility and interoperability.
  - Provides full data samples for ILC physics studies.
  - Provides a complete and flexible detector simulation package capable of simulating arbitrarily complex detectors with runtime detector description.
  - Reconstruction & analysis framework exists, various algorithms implemented.
  - Need to iterate and apply to various detector designs.

# *Additional Information*

- 
- Wiki - <http://confluence.slac.stanford.edu/display/ilc/Home>
  - lcsim.org - <http://www.lcsim.org>
  - org.lcsim - <http://www.lcsim.org/software/lcsim>
  - Software Index - <http://www.lcsim.org/software>
  - Detectors - <http://www.lcsim.org/detectors>
  - ILC Forum - <http://forum.linearcollider.org>
  - LCIO - <http://lcio.desy.de>
  - SLIC - <http://www.lcsim.org/software/slic>
  - LCDD - <http://www.lcsim.org/software/lcdd>
  - JAS3 - <http://jas.freehep.org/jas3>
  - AIDA - <http://aida.freehep.org>
  - WIRED - <http://wired.freehep.org>