Simulation and Reconstruction Software
-Summary-

Frank Gaede
DESY
LCWS 2007
DESY, June 3 2007

Simulation & Reconstruction I

Status of ILC-LDC Core Software	GAEDE, Frank
ALCPG Software Summary	GRAF, Norman
The ILC and the GRID	GELLRICH, Andreas

core tools- infrastructure

Full simulation study of WW Scattering in the LDC00Sc Detector Model	YAN, Wenbiao
Studies of the ZH Channel using different PFA Algorithms	WICHMANN, Katarzyna
Update of ZHH Studies	MICHELE, Faucci Giannelli

physics w./ full sim/reco

The status of and plans for MarlinTPC	KILLENBERG, Martin
TPC FADC Simulation/Reconstruction in Marlin and LCIO	HUNT, James
Simulation of an All-Silicon Tracker	SCHUMM, Bruce
LDC Tracking Software	RASPEREZA, Alexei
Tracking studies	ONOPRIENKO, Dmitry
Tracking Studies in the 4th Concept	GATTO, Corrado

tracking full detector and tbeam

Simulation & Reconstruction II

PFA Development in the US	
GLD PFA Studies	YOSHIOKA, Tamaki
Track-based Particle Flow Concept	WENDT, Oliver
Status of Particle Flow Reconstruction with PandoraPFA	THOMSON, Mark

Particle Flow

Calorimetry Studies in the 4th Concept	GATTO, Corrado
Mokka Simulation of the CALICE Test Beam	SALVATORE, Fabrizio
Simulation of the Beam Calorimeter	NAUENBERG, Uriel
Photon reconstruction	KRSTONOSIC, Predrag
Pi0 Reconstruction within the Full Simulation Framework	GRIS, Phillipe
Pi0 reconstruction and strip calorimeter clustering with the GLD Calorimeter	JEANS, Daniel
Impact of pi0 Reconstruction and Neutral Hadron Timing on PFA	WILSON, Graham

calorimeter sim & reco

The LCFI Vertex Package	HILLERT, Sonja
Simulation study of a FPCCD based vertex detector at the ILC	NAGAMINE, Tadashi
Rave - first vertexing and b-tagging results with LCIO data	WALTENBERGER, Wolfgang
Vertex Tracker Simulation and Reconstruction Software in Marlin	BATTAGLIA, Marco
Simulation study for EUDET Pixel Beam Telescope using ILC Software	KLIMKOVICH, Tatsiana

vertex sim & reco

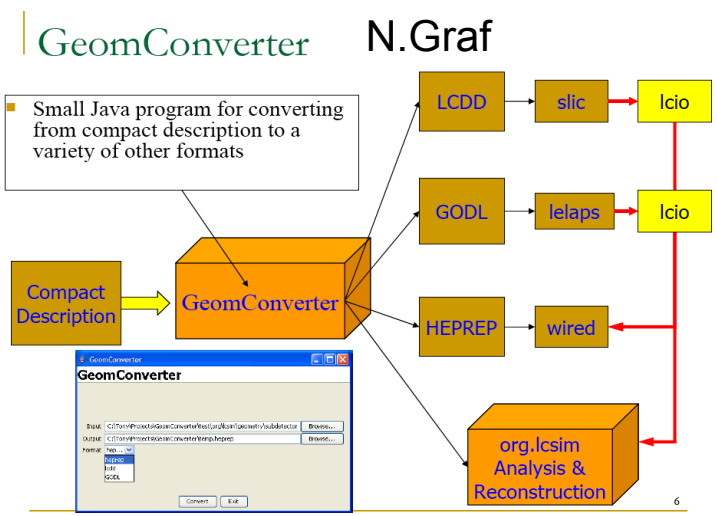
Status and Plans for BDSIM	MALTON, Steve
ILC Jet Energy Working Group - Introduction and Discussion	GRAF, Norman

Software tools/frameworks

	Description	Detector	Language	IO-Format	users
Simdet	fast Monte Carlo	TeslaTDR	Fortran	LCIO	LDC,SID
SGV	fast Monte Carlo	simple Geometry, flexible	Fortran	None/LCIO	LDC,SiLC
LiCToy	fast Monte Carlo	simple trk. Geometry	C++	LCIO	LDC,SiLC
Lelaps	fast Monte Carlo	SiD, flexible	C++	SIO, LCIO	SID
Mokka	full simulation – Geant4	LDC, flexible	C++	ASCI, LCIO	LDC
SLIC	full simulation – Geant4	SiD, flexible	C++	LCIO	SID
Jupiter	full simulation – Geant4	GLD	C++	Root/LCIO	GLD
ILCroot	full sim. – Geant4/Flukka/g3	4th	C++	Root	4th
Marlin	reconstruction and analysis application framework	Flexible	C++	LCIO	LDC
org.lcsim	reconstruction framework	SiD (flexible)	Java	LCIO	SID
Jupiter-Satelites	reconstruction and analysis	GLD	C++	Root	GLD
ILCroot	reconstruction and analysis	4th	C++	Root	4th
LCCD	Conditions Data Tookit	All	C++	LCIO	LDC,Calice,...
GEAR	Geometry description	Flexible	C++	XML	LDC,Calice,...
LCIO	Persistency and datamodel	All	Java, C++, Fortran	-	LDC,SID, GLD,Calice,...
JAS3/WIRED	Analysis Tool/ Event Display	All	Java	xml,stdhep, eprep,LCIO,.	SID
root	Analysis Tool/ Event Display	All	C++	Root	LDC,GLD,4th

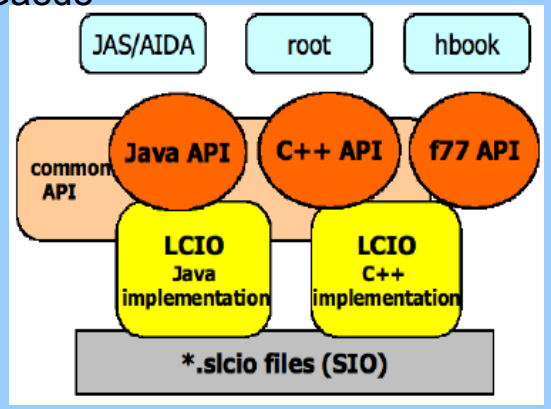
LCIO: basis for 'horizontal' collaboration

Software tools/frameworks



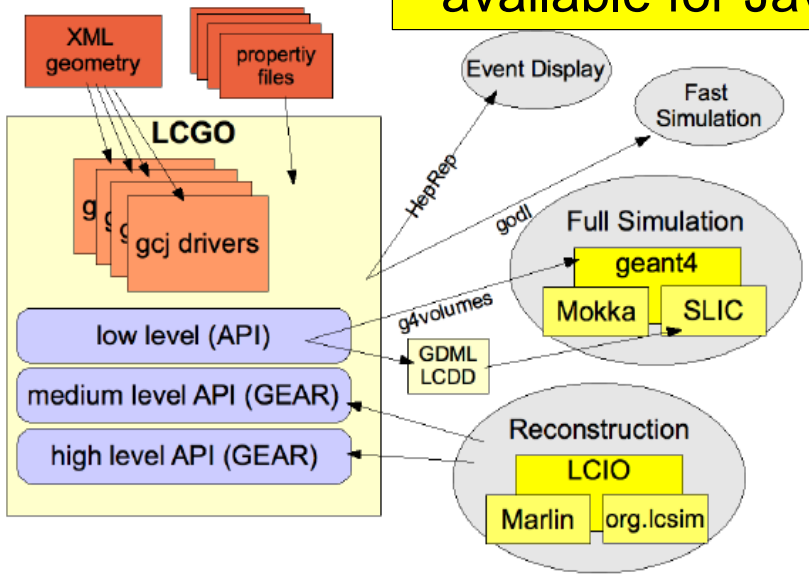
LCIO:
- **runtime extensions**
- **and relations (1-1,1-n,m-n)**
- plans:
  - rewrite I/O
  - faster and direct access
  - split events across files
  - store custom objects

F.Gaede

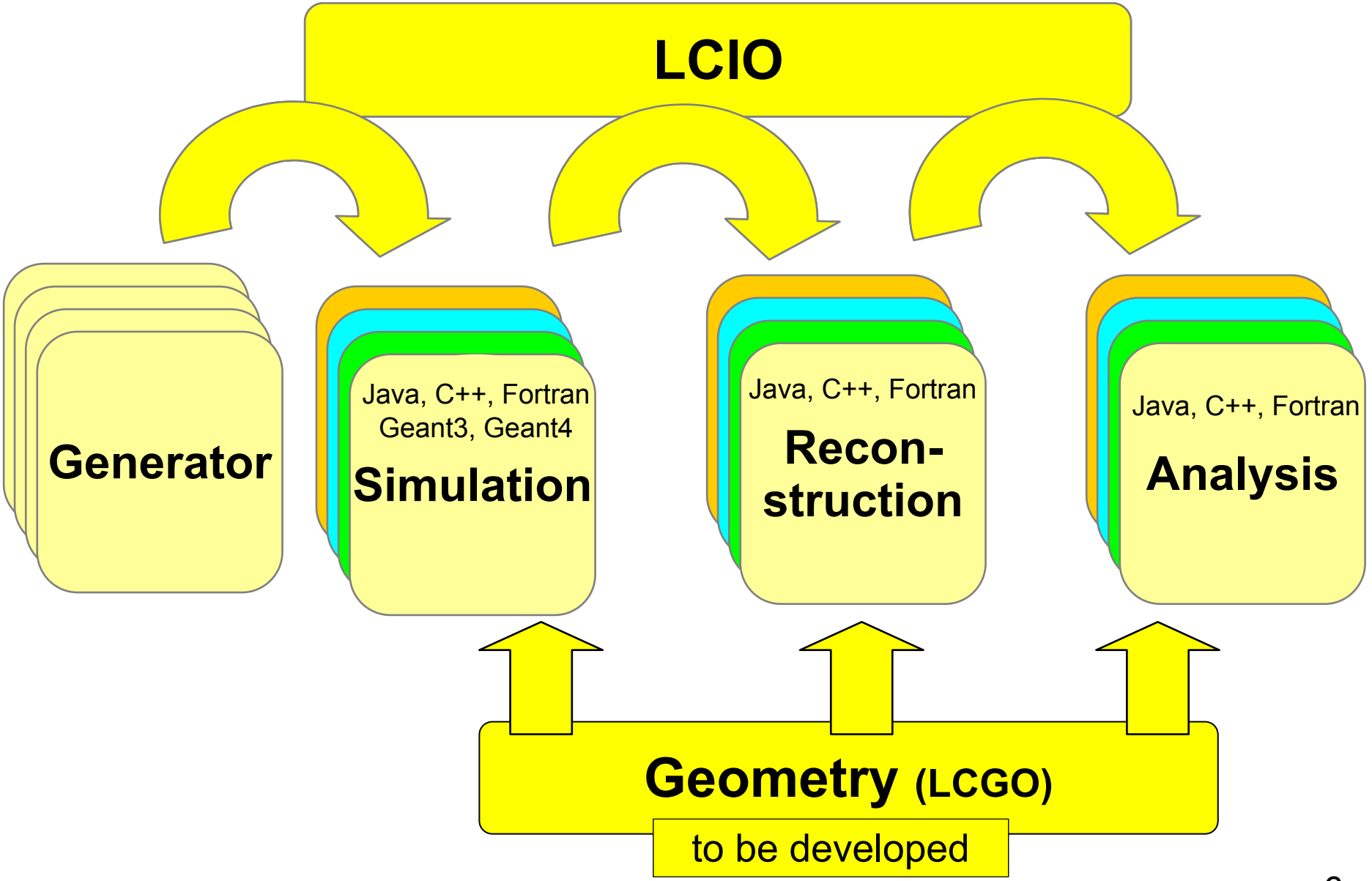


- hierarchical detector model & geometry model
- parameters & identifiers
- solids & materials
- navigation, point location
- logical and physical volumes
- readout
- coordinate transformation
  - local to global
  - global to local
  - parent to local

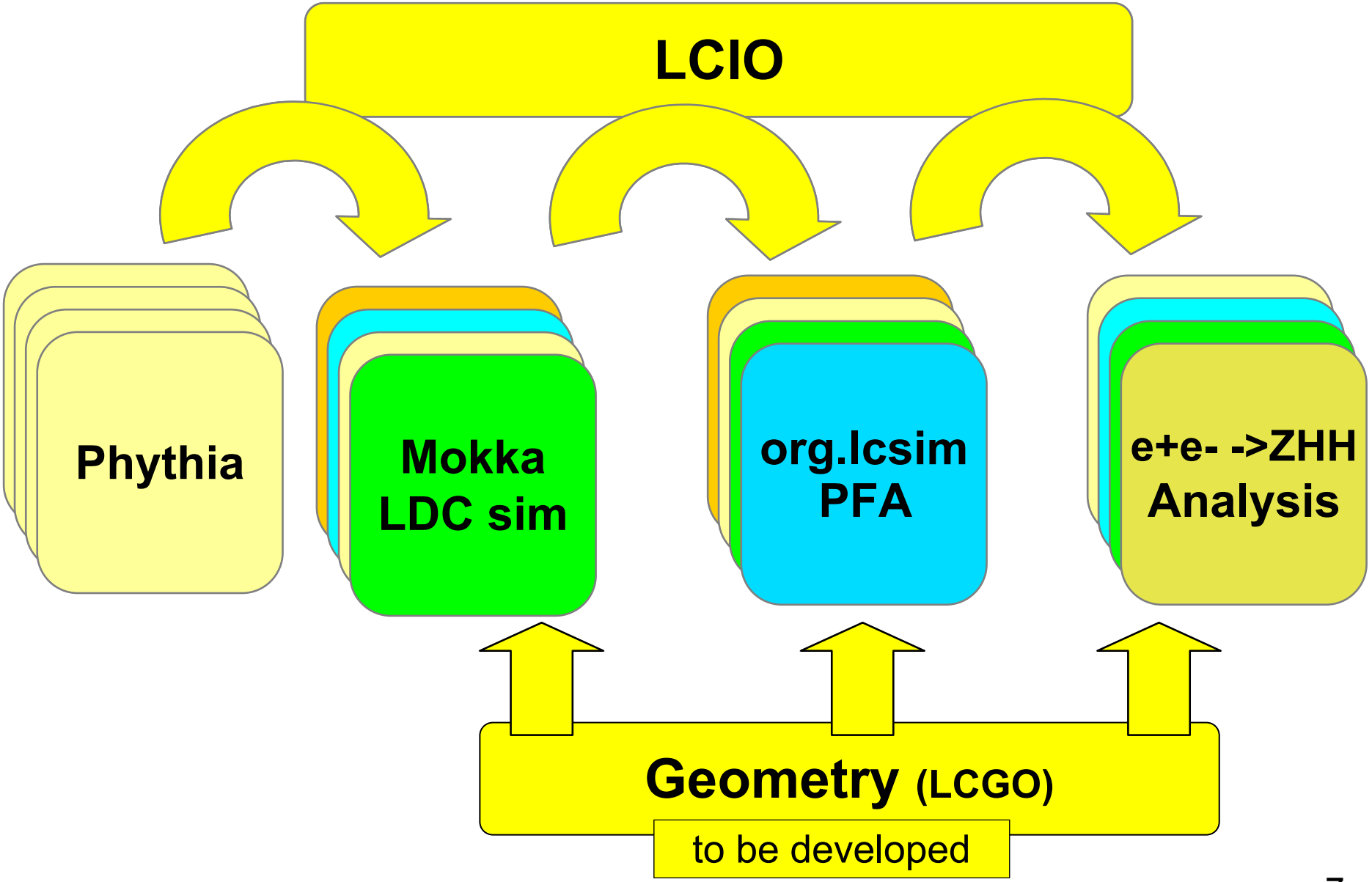
plan: **develop common geometry package LCGO**
- abstract interfaces
- based on functionality in org.lcsim
- available for Java and C++



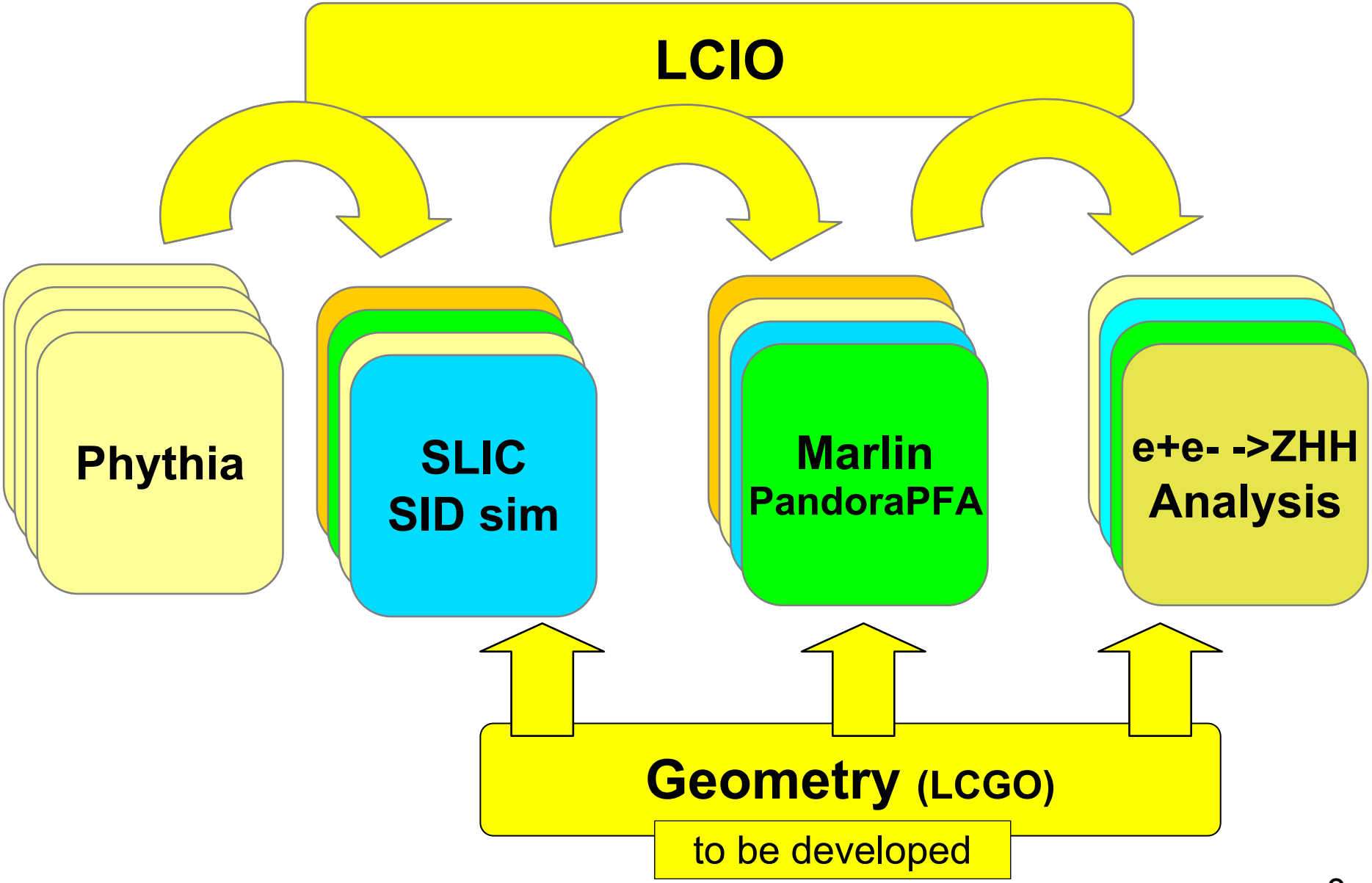
ILC interoperable software chain



ILC interoperable software chain



ILC interoperable software chain



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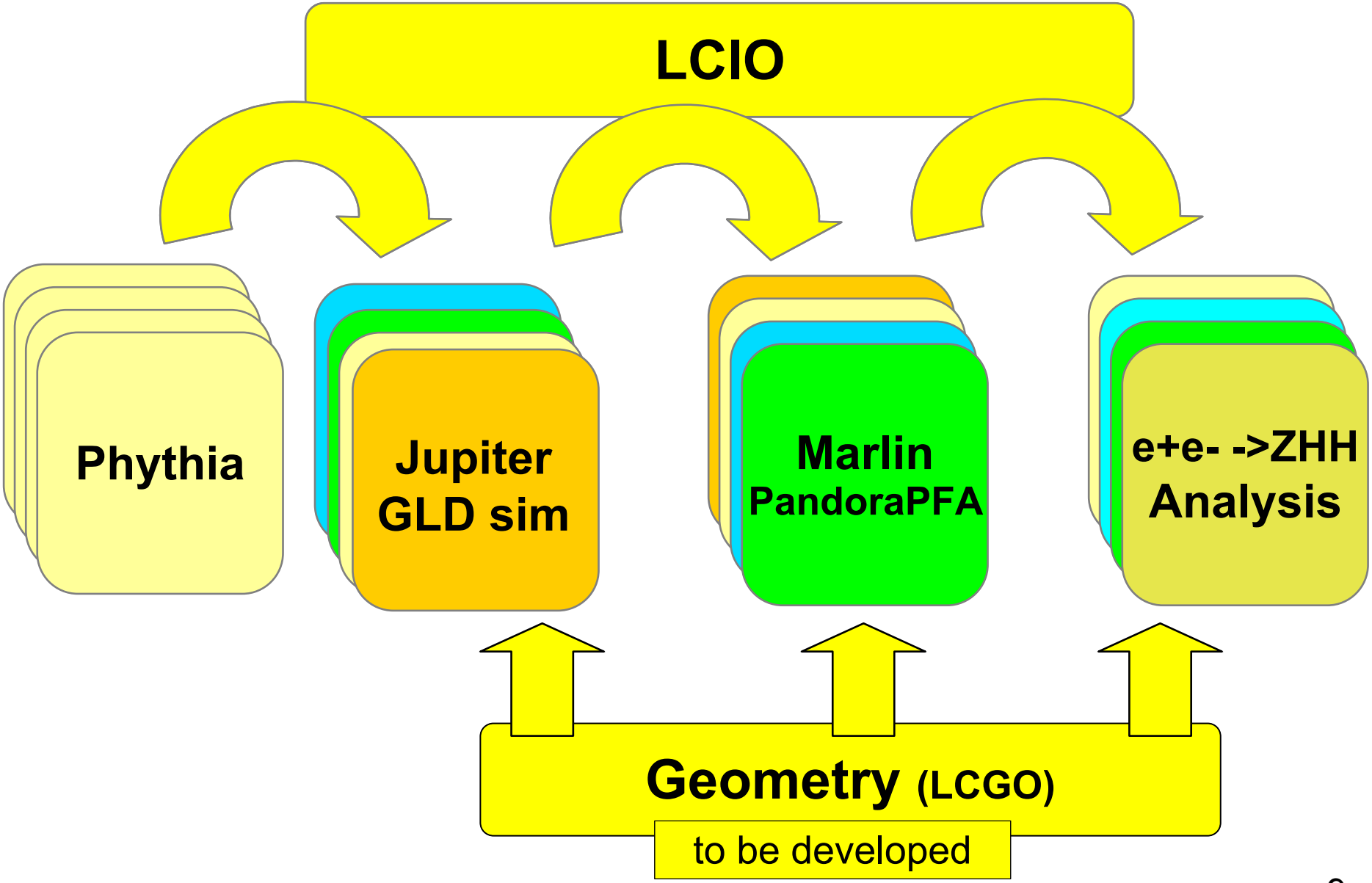
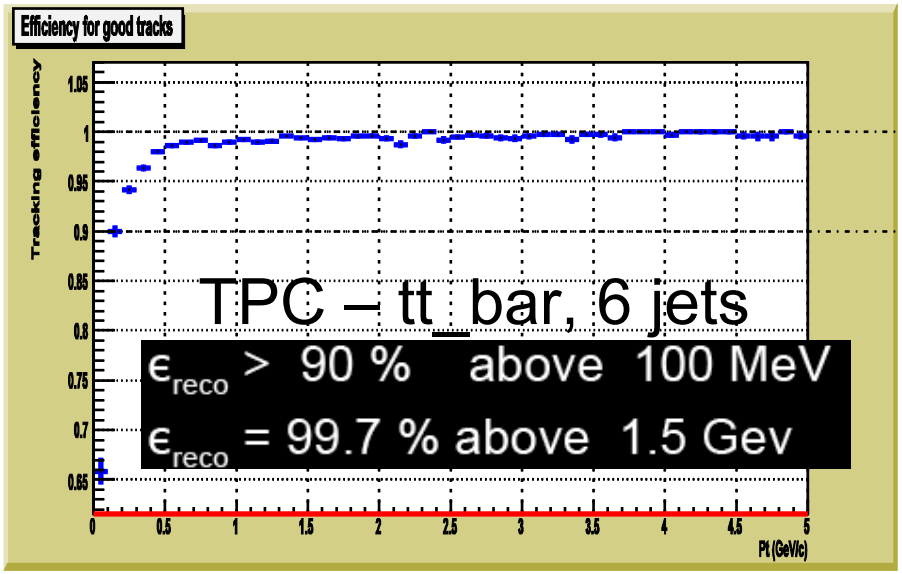


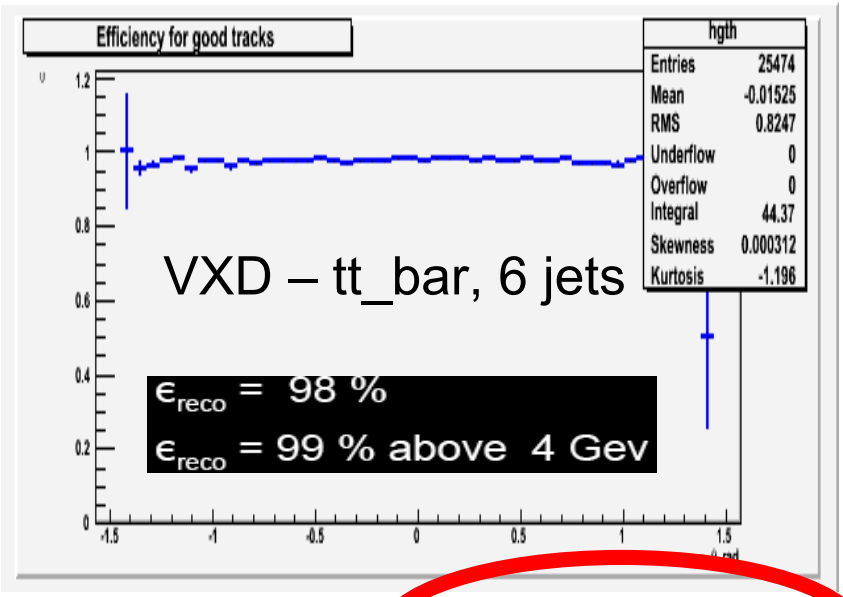
ILC and the grid A.Gellrich

- Grid computing is the strategic technology for future HEP computing
- significant computing resources will be available in the grid only
- virtual organizations 'ilc' and 'calice' are in place and supported by a growing number of grid sites
  - calice is using the grid for massive data processing and storage
  - for the rest of ilc only a few power users
  - -> need a coherent approach to run ilc software on the grid
    - job submission scripts
    - data catalogs
    - software installations (libraries,....)
  - to make it a useful tool for everyone in the comunity

4th concept tracking

C.Gatto





- full Kalman Filter based tracking for TPC, VXD, FTD
- based on ALICE tracking in ILCroot
- huge progress since Bangalore

- We decided to compare TPC vs DCH vs Si Tracker central trackers within the same framework and with comparable cheat
- Goal is to find the detector that best matches the Dual Readout Calorimeters and the Muon Spectrometer

Drift Chamber

- Gas [He-C4H10/90-10]: 0.15%
- Wires: 0.4%
- Vessel:
  - Inner wall: 0.1% X/X_0
  - Outer wall: 2% X/X_0
  - Endcaps (wires, pads,electronics & services included): 8% X/X_0

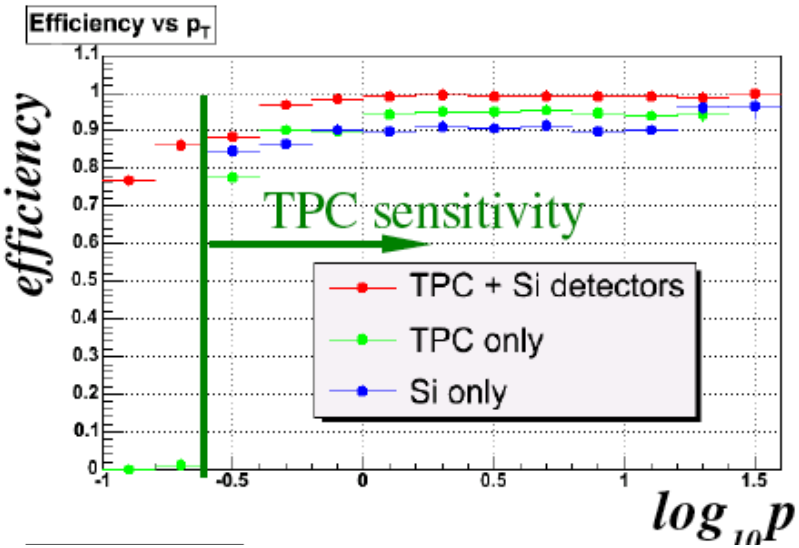
TPC

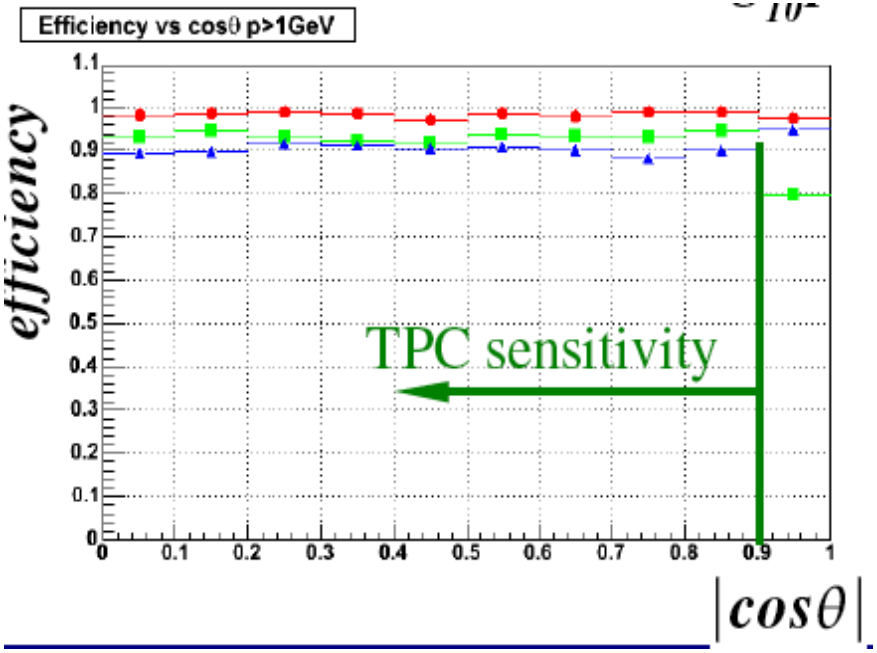
- Gas[Ar-CF4/97-3]: 1.3%
- Vessel:
  - Inner wall + cage: 0.29% X/X_0
  - Outer wall: 1.2% X/X_0
  - Endcaps (wires, pads,electronics & services included): 35-54% X/X_0

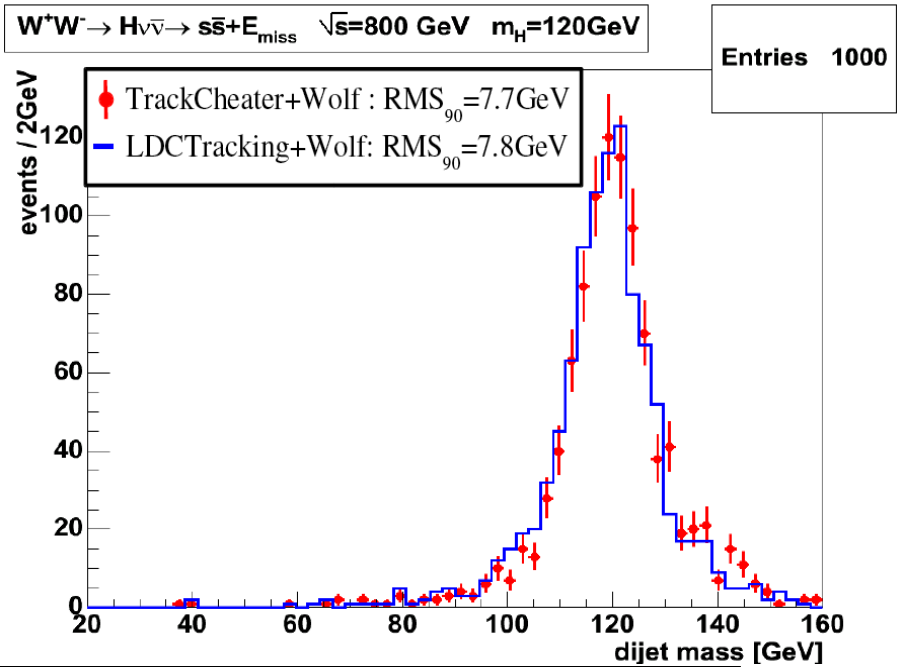
LDC Tracking

A.Raspereza (MPI)

Full LDC Tracking
- TPC: LEPTracking (wrapped f77)
- **VXD, FTD, SIT:**
  - **silicon digitization & tracking**
- LDCTracking:
  - combine tracks
  - find loopers
  - refit



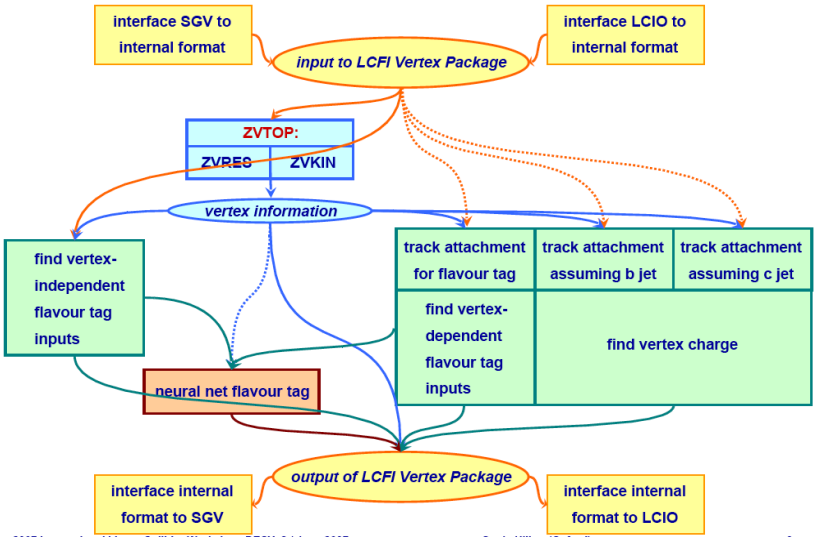


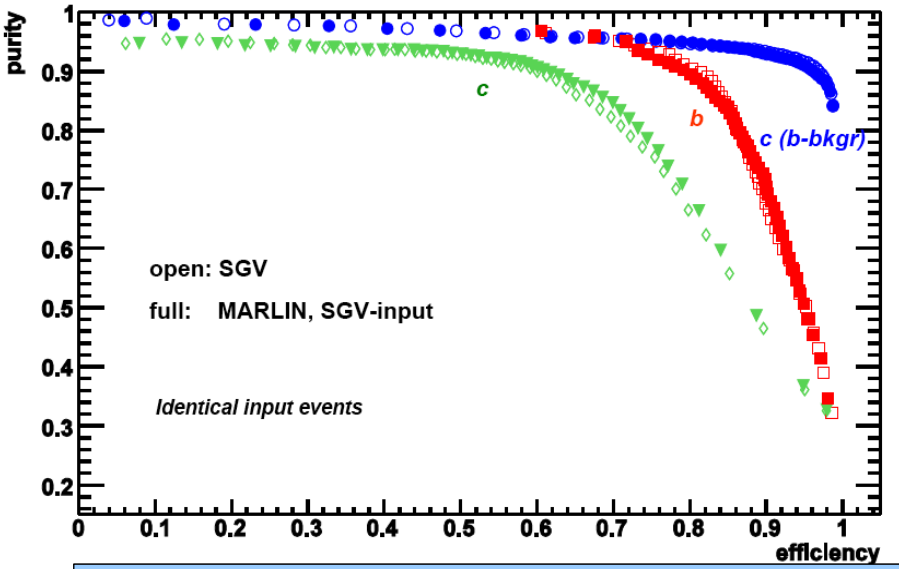


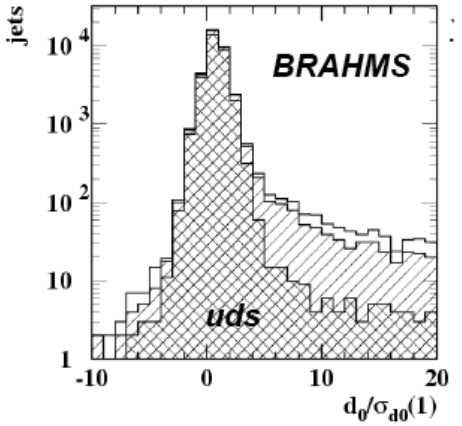
- can now use real tracking code and PFA for detector optimization

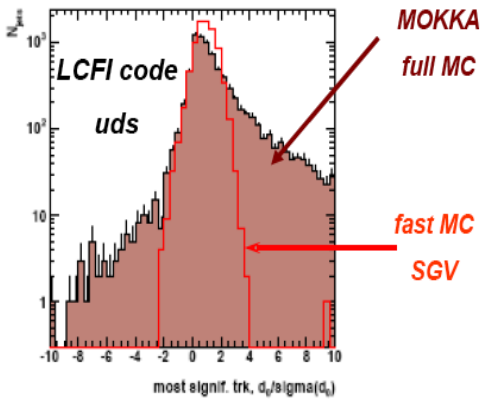
LCFIVertex

S.Hillert, LCFI









new C++ implementation of ZVTOP vertex finder/fitter (ZVRES/ZVKIN)

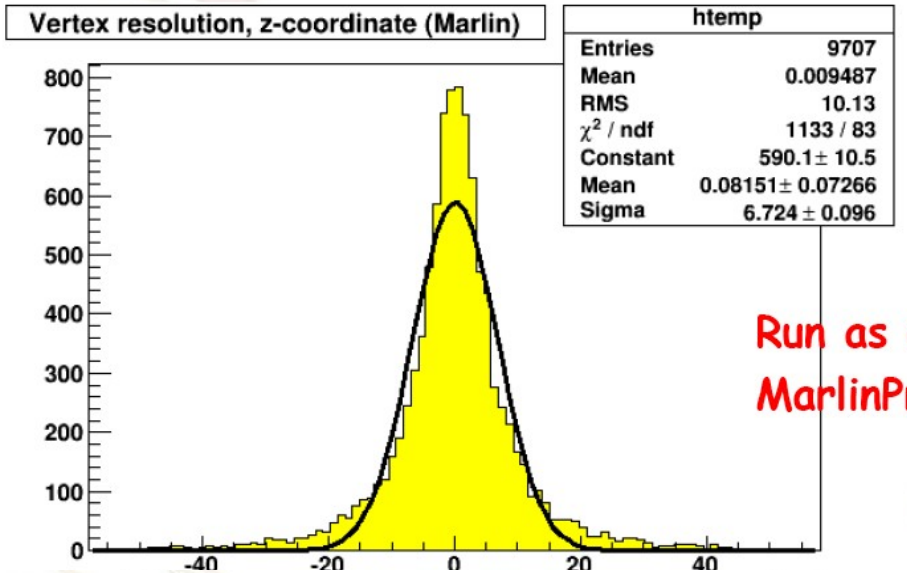
- Neural Net flavor tagging
- vertex charge for b and c jets

- results agree nicely with previous f77 version (based on SGV)
- currently investigating issues with NN input quantities from full sim/tracking
- close collaboration with LDCTracking group

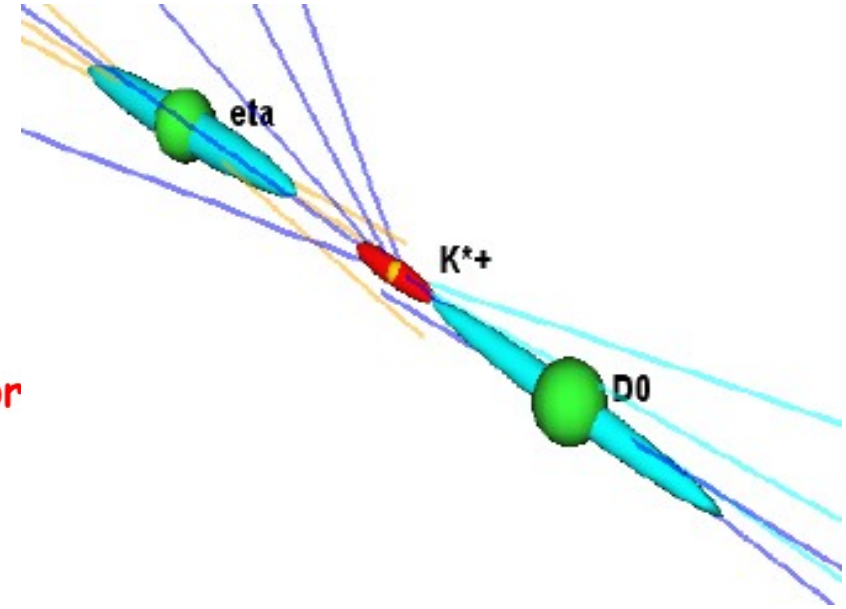
soon vertexing and flavor tagging based on full simulation and real tracking available for physics studies

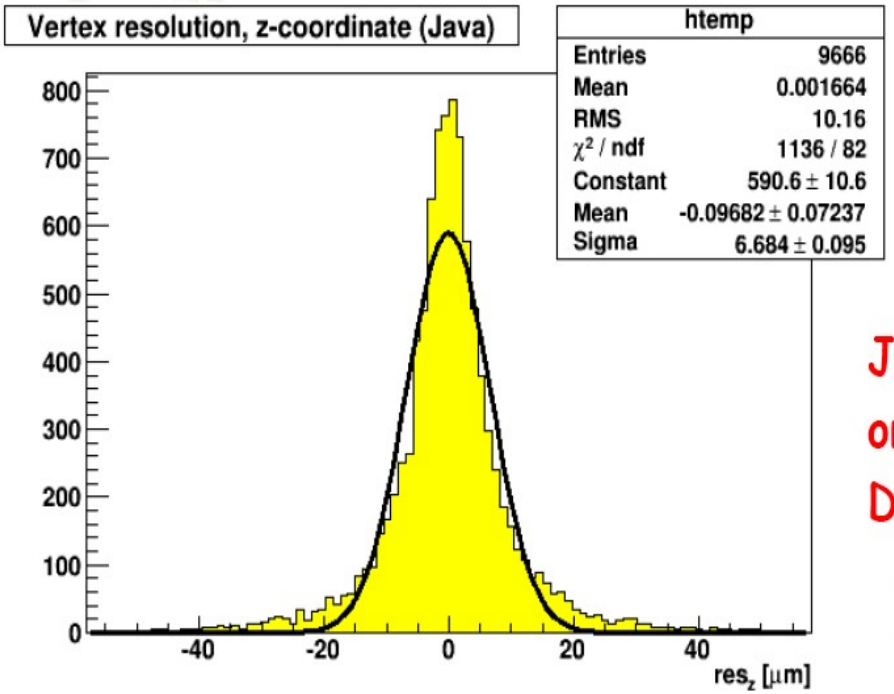
Rave vertexing

W.Waltenberger



Run as a MarlinProcessor





JavaRave!
org.lcsim-Driver!

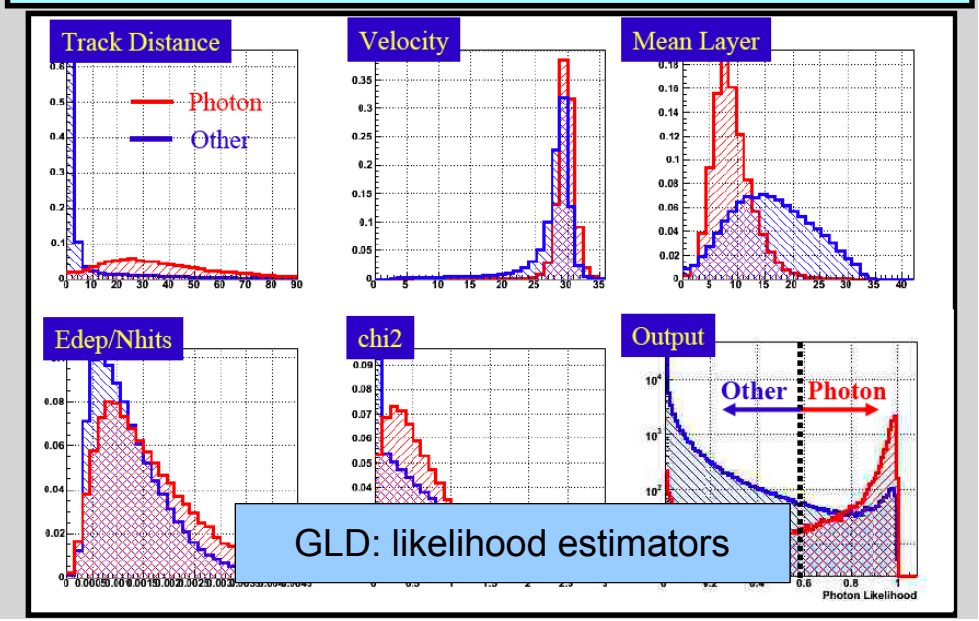
interface to CMS vertex finding and fitting algorithms

- light interface to Marlin/LCIO
- interface (SWIG) to Java org.lcsim

- nice example for:
  - **using existing software**
  - **cross concept collaboration**

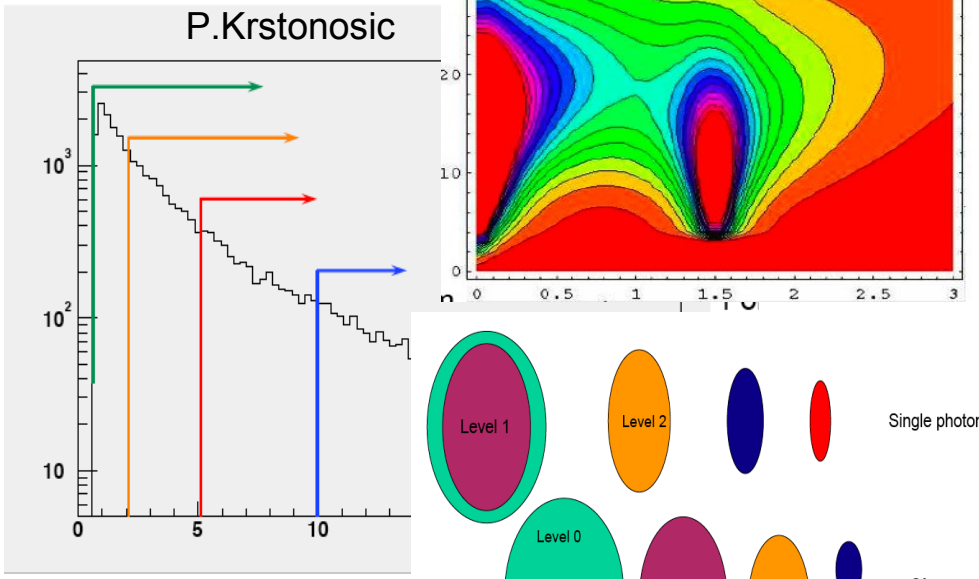
photon/pi0 finding algorithms

- Five variables are selected to form the photon likelihood function.

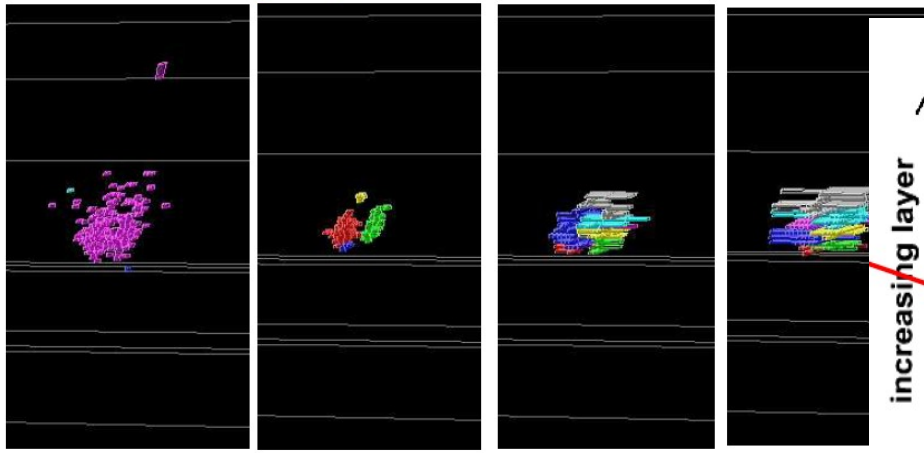


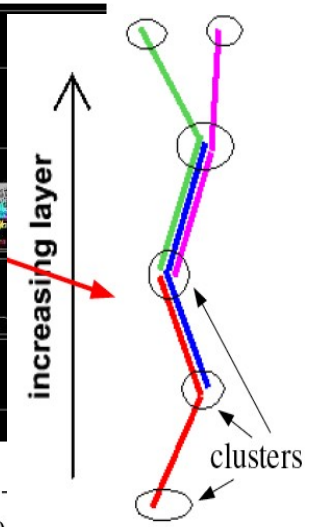
GLD: likelihood estimators

LDC: multiple clustering with E dependend cut



events displays: same 10 GeV π^0 event





present clusterin
1x1cm
1 x 10 cm

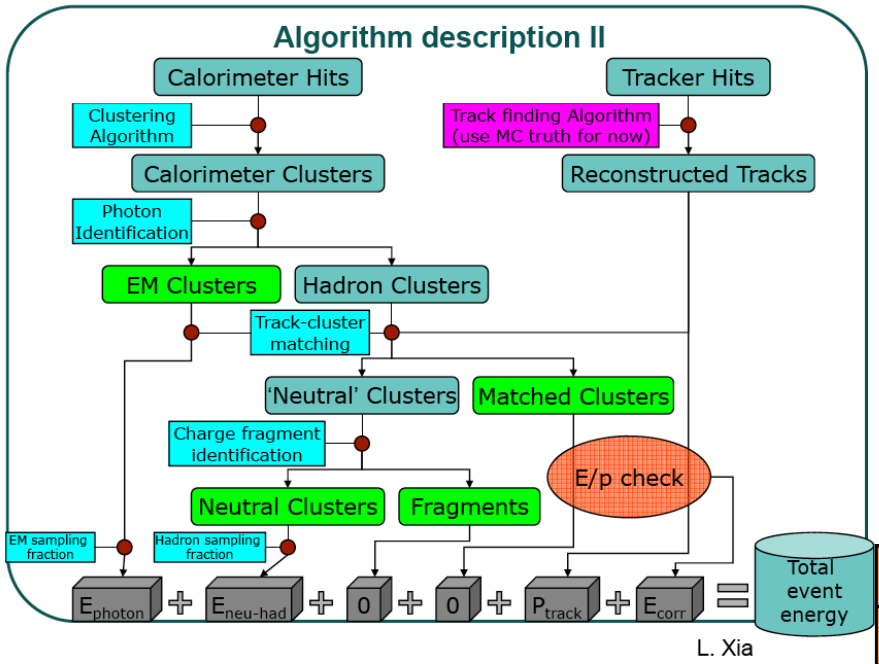
GLD: track like clustering

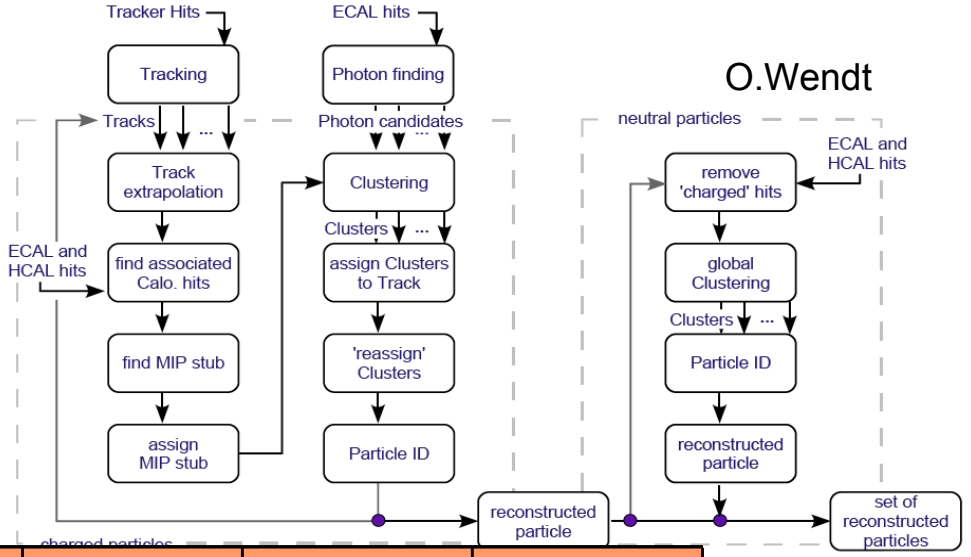
D.Jeans

different algorithms for photon and pi0 finding presented

- however in different frameworks
- interoperability would be preferable...

existing PFA packages





SID	PFA1	org.lcsim	M.Charles
SID	PFA2	org.lcsim	L.Xia
SID	PFA3	org.lcsim	Graf/Magill
LDC	Wolf	Marlin	A.Raspereza
LDC	TrackBased	Marlin	O.Wendt
LDC	PadoraPFA	Marlin	M.Thomson
GLD	GLD-PFA	Uranus	T.Yoshioka

i. Preparation (MIP hit ID, isolation, tracking)
ii. Loose clustering in ECAL and HCAL
iii. Topological linking of clearly associated clusters
iv. Courser grouping of clusters
v. Iterative reclustering
vi. Photon Recovery (NEW)
vii. Fragment Removal (NEW)
viii. Formation of final Particle Flow Objects (reconstructed particles) – not very sophisticated

Order inter-changable

M.Thomson

- a number of different PFAs exist in the different frameworks
- different order of various steps of particle identification and iterations
- different level of sophistication

posibility of crosschecking results

PFA performance

- PandoraPFA

rms90

E_{JET}	$\sigma_E/E = \alpha/\sqrt{(E/GeV)}$ $\lvert\cos\theta\rvert<0.7$	σ_E/E
45 GeV	0.295	4.4 %
100 GeV	0.305	3.0 %
180 GeV	0.418	3.1 %
250 GeV	0.534	

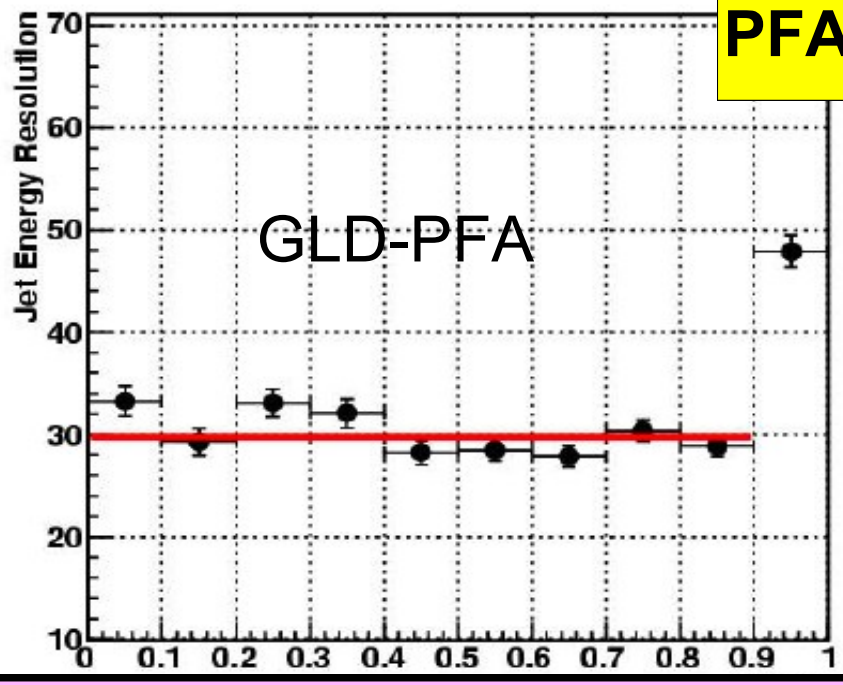
0.35 at LCWS06

For jet energies < 100 GeV
ILC "goal" reached !!!

★For a Gauge boson mass resolution of order $\Gamma_{W/Z}$

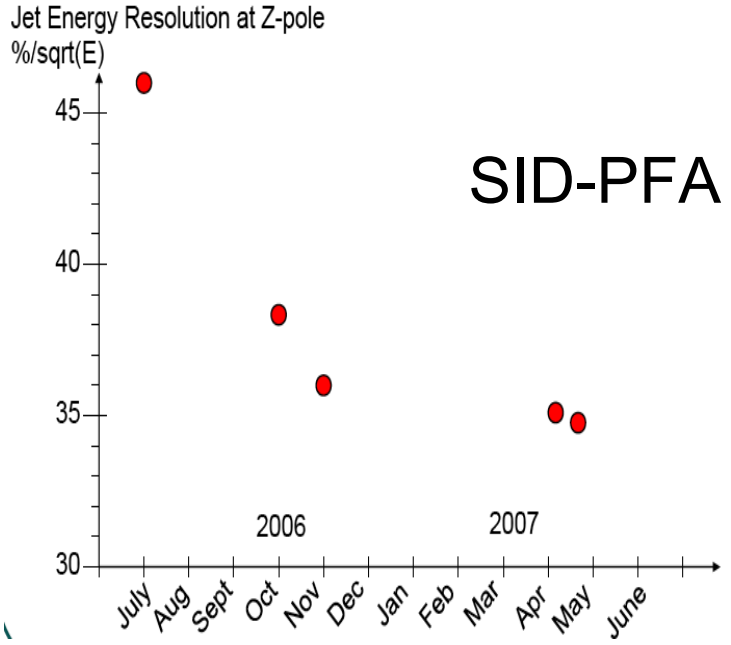
E_{jj}/GeV	$\alpha(E_j)$	σ_{Ej}/E_j
91	< 26 %	3.8 %
200	< 38 %	3.8 %
360	< 51 %	3.8 %
500	< 60 %	3.8 %

PFA works !



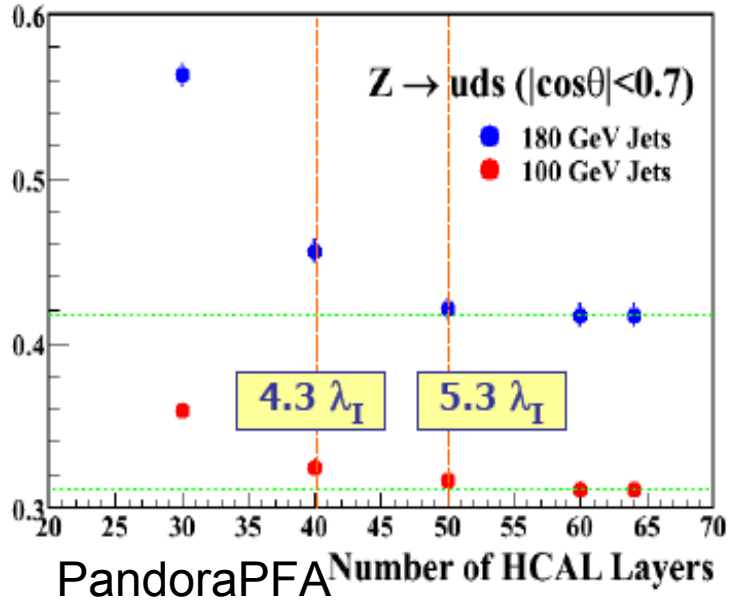
GLD-PFA

- Almost no angular dependence : ~30%/√E for $|\cos\theta|<0.9$.
- cf. 60 %/√E w/o the PFA (sum up the calorimeter energy)

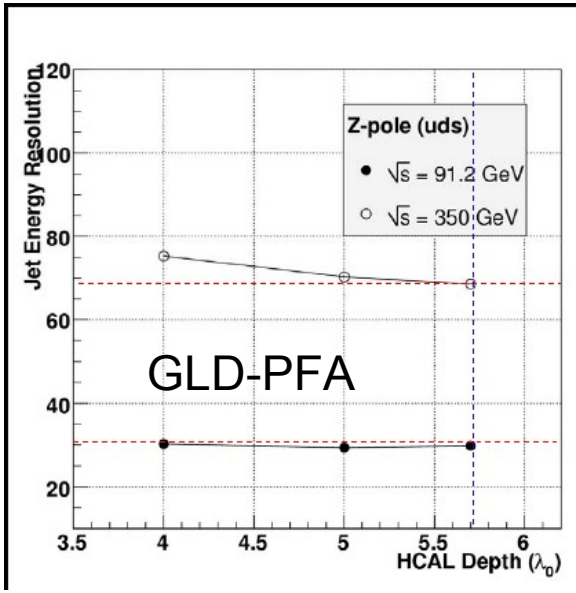


SID-PFA

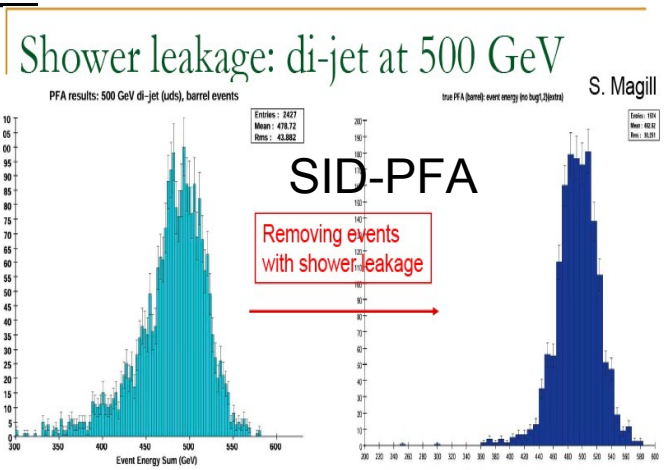
PFA for detector optimization



PandoraPFA

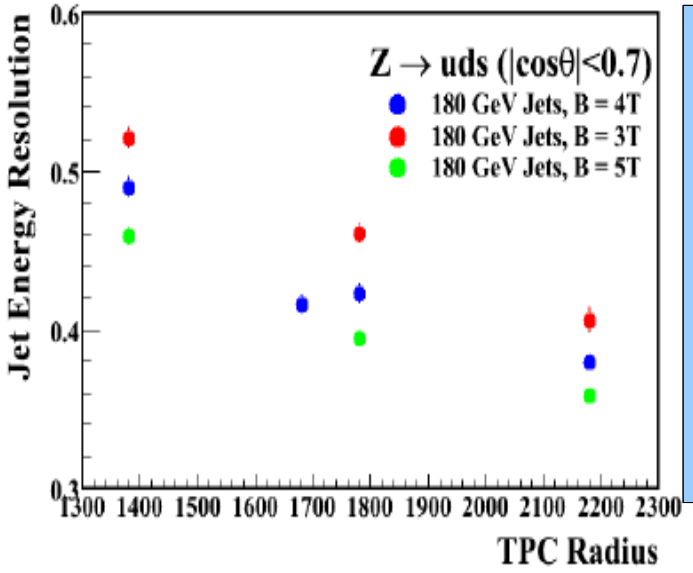


GLD-PFA



RMS = 43.88 GeV
RMS90 = 28.11 GeV
[127.%/sqrt(E)]

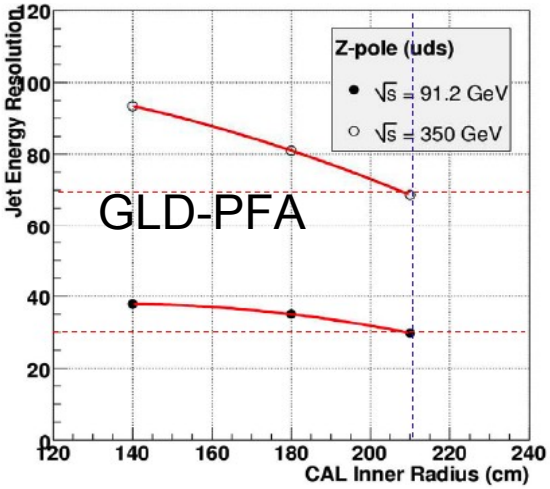
RMS = 30.25 GeV
RMS90 = 21.4 GeV
[~97%/sqrt(E)]



PFA improves with:

- thicker Hcal
- larger Tracking radius
- higher Bfield

- can use PFA for cost conscious optimization

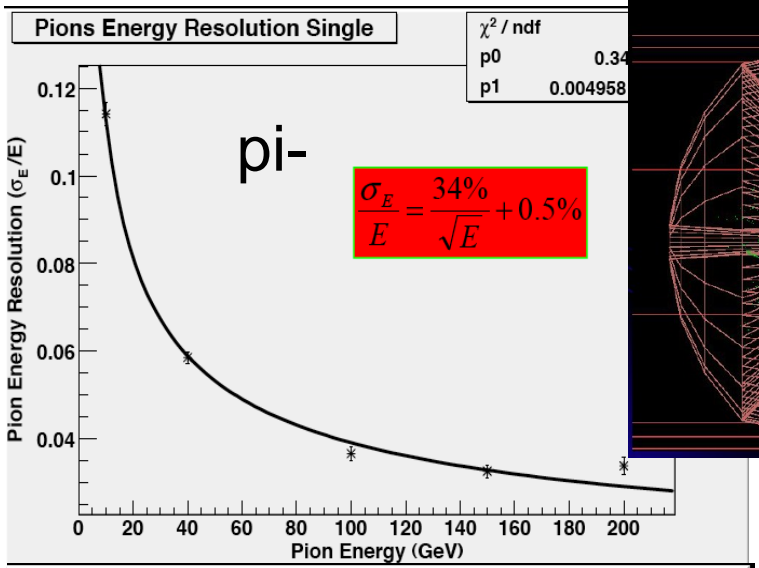


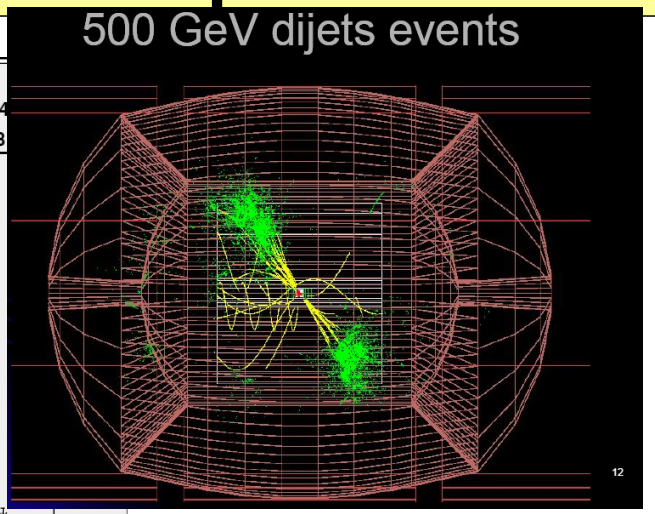
GLD-PFA

Frank Gaede , LCWS2007, DESY,

4th concept calorimetry

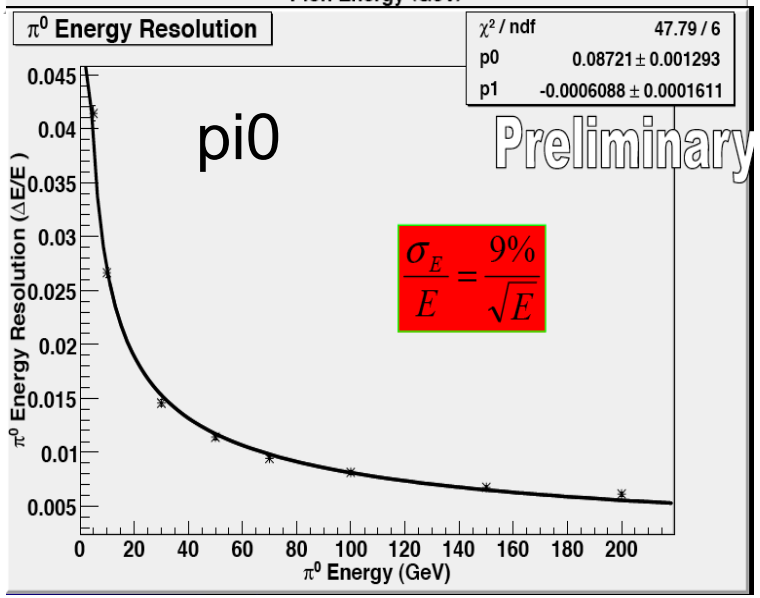
A.Mazzacane
C.Gatto

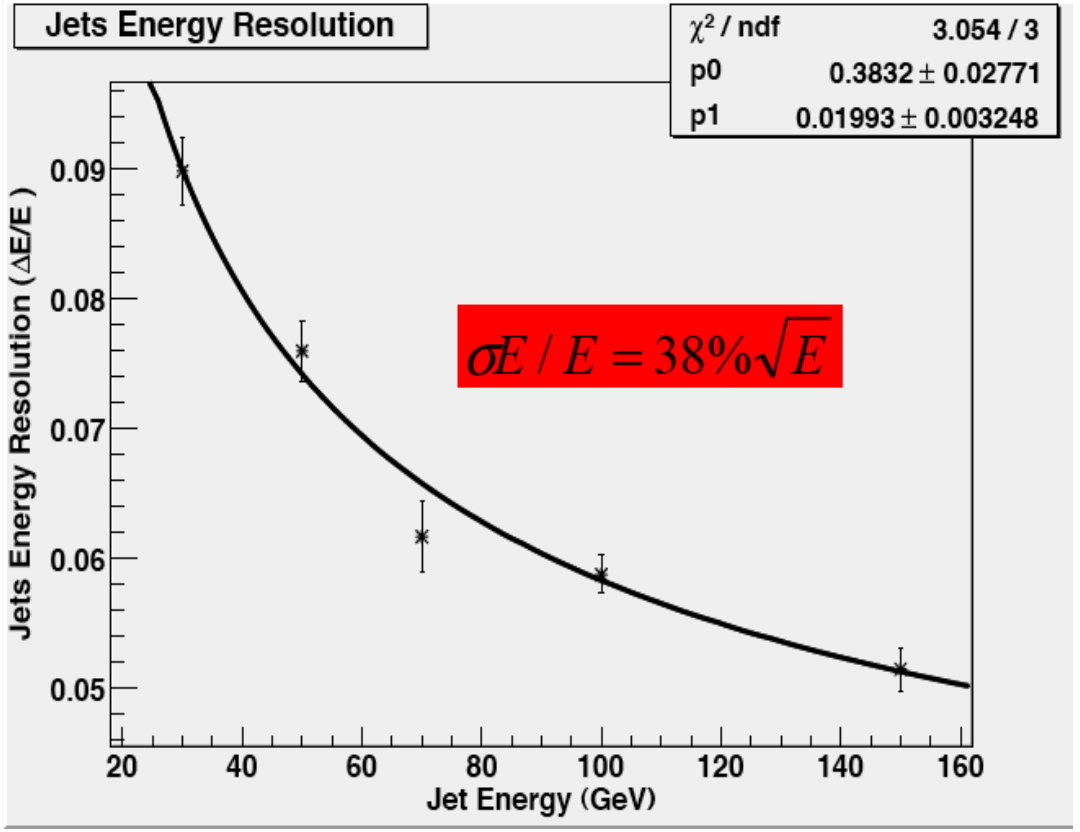




dual readout calorimeter cherenkov&scintilator

- very high resolution for single hadrons and photons/electrons
- jet energies from calorimeters only (no PFA)



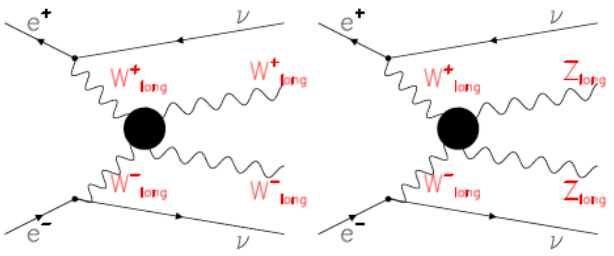


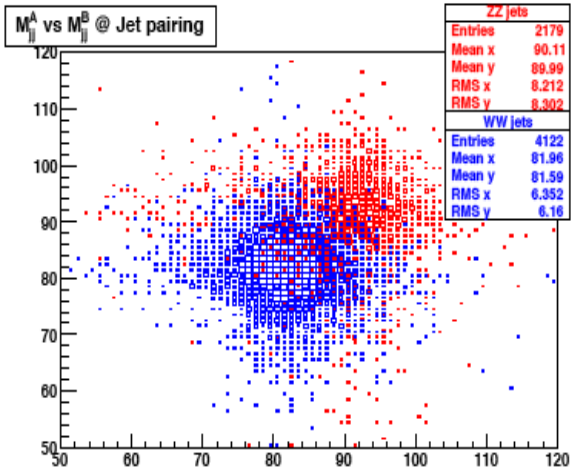
$$\frac{\sigma_E}{E} = \frac{6\%}{\sqrt{E}} [e^- @ 40\text{GeV}]$$

WW scattering with full sim-reco

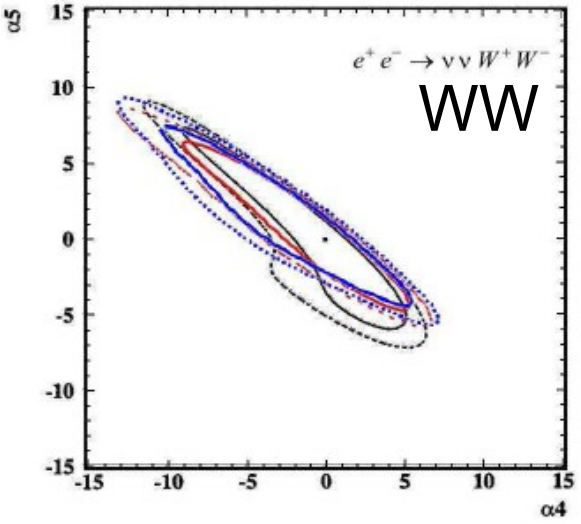
David Ward and Wenbiao Yan

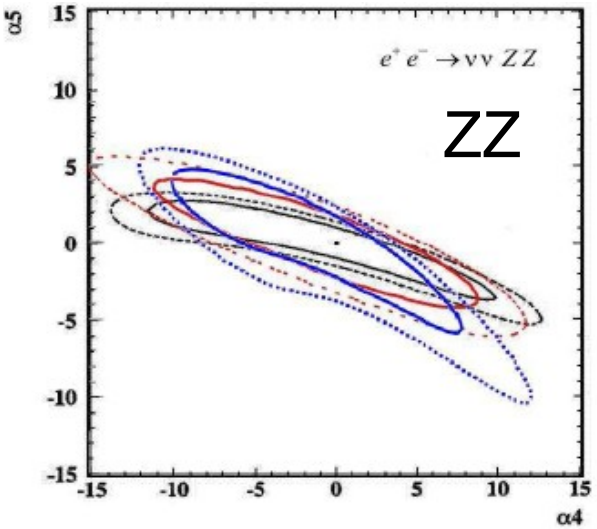
UNIVERSITY OF CAMBRIDGE





SW- tools:
- Mokka LDC00Sc
- MarlinReco/MarlinUtil
- TrackCheater
- PandoraPFA



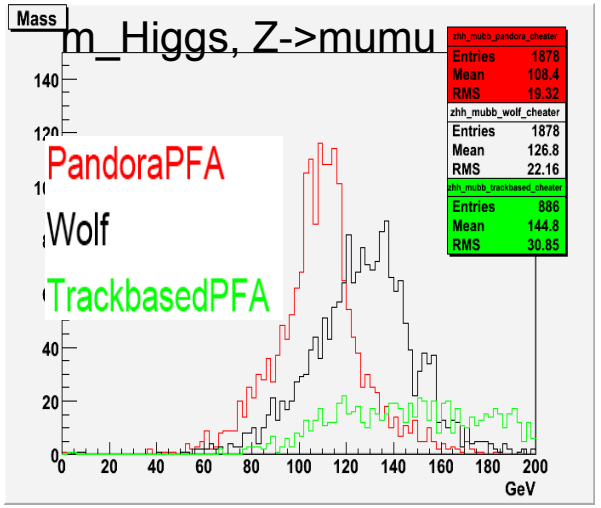


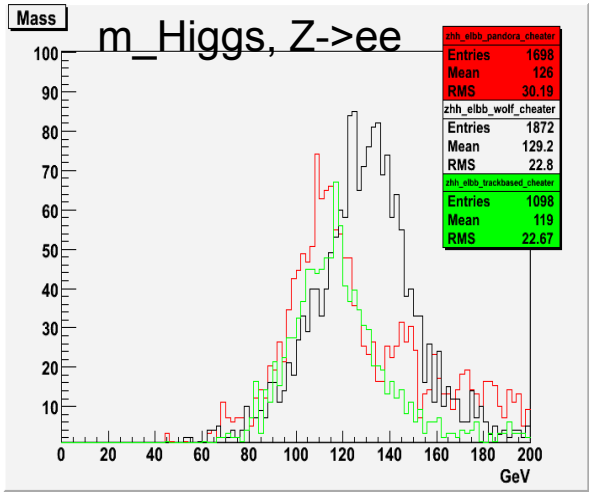
- **Possible improvements**
  - **b-tag $\to t\bar{t}$ events**
  - **lepton identification $\to e\nu WZ$**

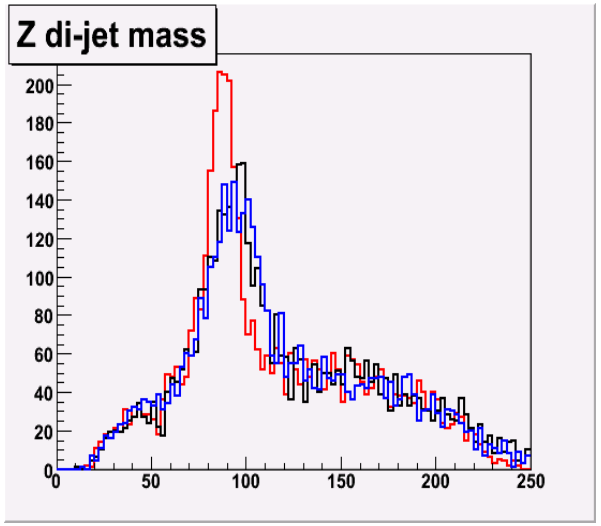
- full sim & reco
- Tesla fast simulation

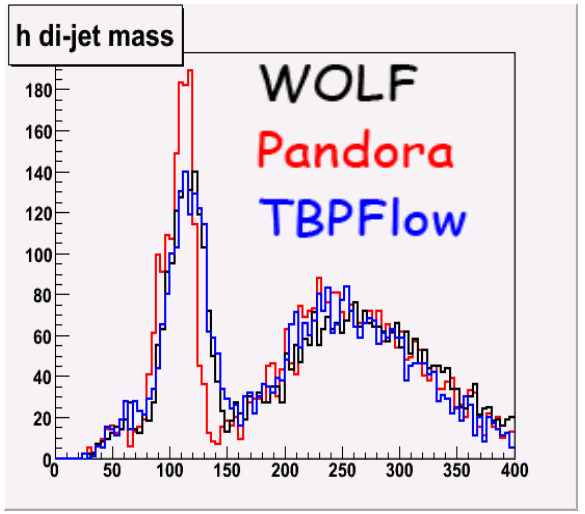
full simualtion and reconstruction tools start to have maturity to be used for validation of results from fast simulation

physics with different PFAs









Michele Faucci Gianelli
ZHH analysis

SW- tools:
- Mokka
- MarlinReco/MarlinUtil
- TrackCheater/LDCTracking
- ***PandoraPFA***
- ***Wolf***
- ***TrackBasedPFA***

Katarzyna Wichmann
Higgstrahlung analysis

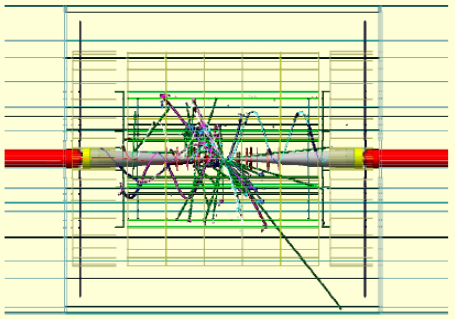
- modular frameworks allow comparison of different (PF)Algorithms
- can use multiple algorithms for cross check of detector optimization
- so far Pandora is best

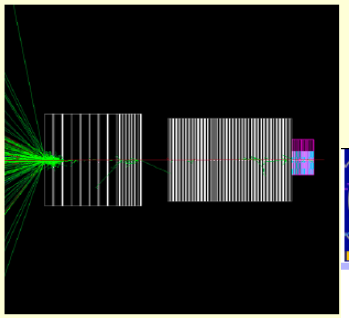
testbeam SimReco software

Same tool for final detector and prototypes

- One Geometry db that stores information about geometries supported in the simulation (e.g. LDC, TB, etc)

F.Salvatore



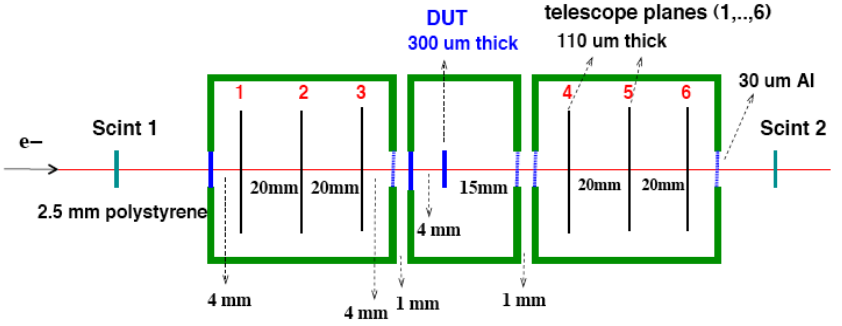


tbeam core software tools [Calice, TPC, PixelTelescope]:

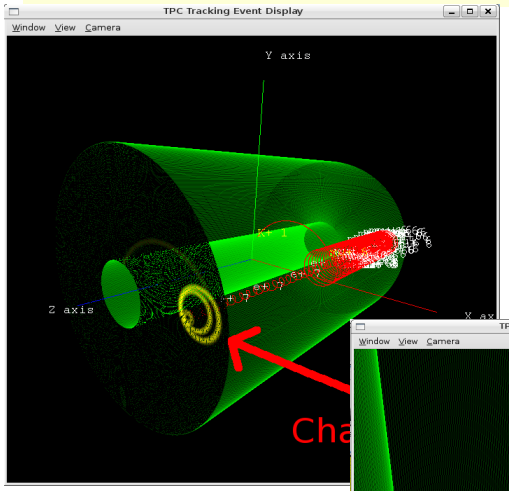
- Mokka
- LCIO
- Marlin, MarlinReco, MarlinUtil
- Gear
- LCCD

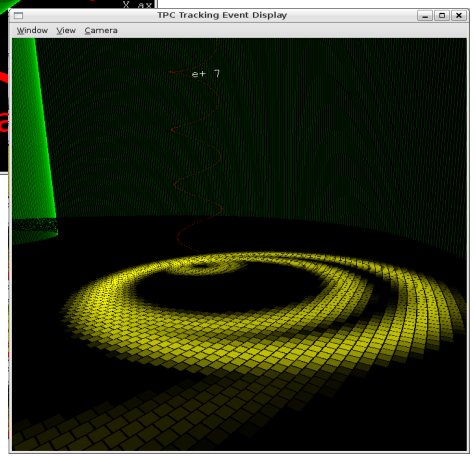
Telescope geometry

T.Klimkovich



- Electrons: 1-6 GeV/c
- Assumed intrinsic resolution of a telescope plane is 3 μm (hit positions are smeared)
- Three separate shielding boxes $\Longrightarrow$ flexible setup





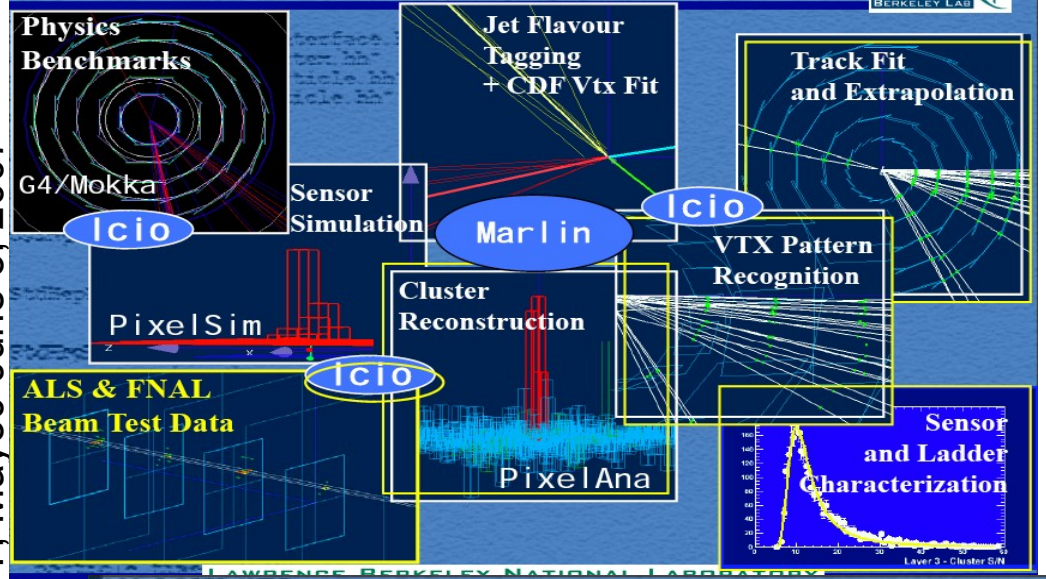
J.Hunt:
new TPC event display (LCIO)

- using the same software tools in both testbeam and full detector studies provides synergy effects for both worlds

LBL vertex software

M.Battaglia

VTX Simulation, Reconstruction, Analysis



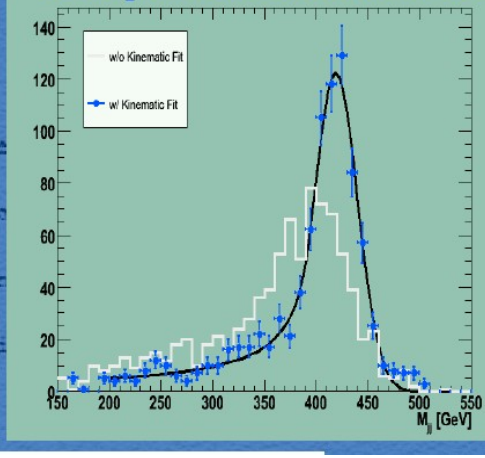
DELPHI Mass Constrained Fit (MassConstrainedJJFit)

Port of PUFITC+ developed for DELPHI at LEP2 (N Kjaer, M Mulders) to MarlinReco framework using a C++ wrapper;

Performs 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;

ows to impose centre-of-mass rgy and momentum conservation, ay mass, equal masses for jj pairs;

Example in HA→bbbb at 1 TeV



CDF and HERAB Vertex Fit (CTVMFTVertexFit & TelescopeVertexFit)

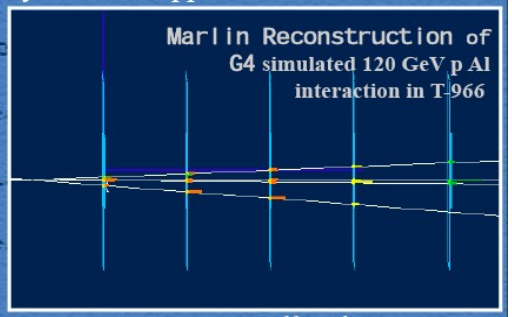
Port of CTVMFT developed for CDF (J Marriner, JP Berge, F Bedeschi), and used by ATLAS, to MarlinReco framework using a C++ wrapper;

Geometrical vertex fit allowing mass, beamspot constraints; currently used to implement recovery of b-jet energy with s.l. decays;

Port of VTlib originally developed for HERAB (T Lohse), and later ported to LHCb, to MarlinReco framework, by a C++ wrapper;

Kalman Filter to perform vertex fit of straight tracks, allows to impose mass constraints;

Useful for beam tests w/o B field, will be used for analysis of T-966 data at FNAL MBTF.



Starts from Tracks collection and generates a Vertex collection

LAWRENCE BERKELEY NATIONAL LABORATORY

- **combined framework for testbeam and full detector optimization**
- **provide wrapped versions of existing tools to the ILC community**

Conclusion & Outlook

- enormous progress since LCWS 2006:
  - **established that PFA provides the required jet energy resolution**
  - Vertexing and flavor tagging tools available
  - high performance full Tracking algorithms available
  - **-> can use full reconstruction for**
    detector optimization
    and physics studies

Outlook

- need to further refine and improve PFA algorithms
  - low level tools for PID, pi0, photons,...
- ***increase horizontal collaboration between sw frameworks***
  - ***e.g. common geometry, improve LCIO,...***
- new international **Jet Energy Working Group**:
  - benchmark physics analysis
  - apply across concepts

USE THE TOOLS – THEY ARE THERE