Software/Simulation Summary

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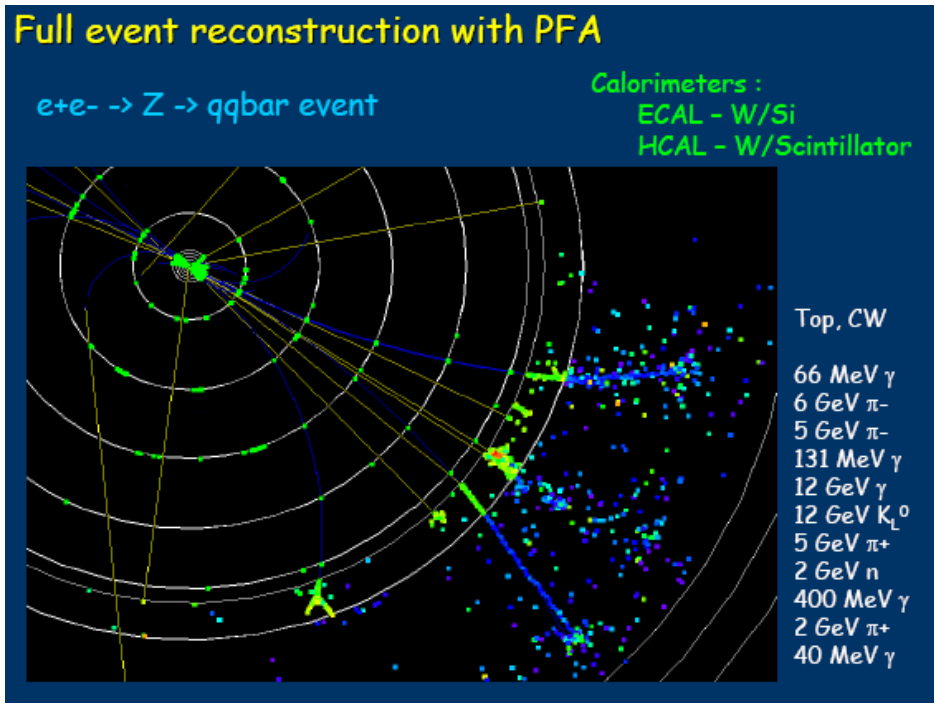


This Talk:

- ★ Why, oh why ?
- ★ Frameworks/Tools
- ★ PFA where art thou ?
- ★ Outlook

❶ Why oh why ?

- ★ Working towards detector DCR by the end of 2006
- ★ Desire full simulation/full reconstruction detector performance studies

Perhaps more importantly:

- ★ 3 out of 4 detector concepts choose high granularity calorimetry (i.e. high cost) for particle flow
- ★ NEED to be convinced that Particle Flow paradigm is correct
- ★ For **Detector DCR** must try to demonstrate the PFA can be made to work for current concepts
- ★ Only(?) evidence that it can be made to work are "old" TESLA studies **(LC-PHSM-2003-001)**
- ★ For **DCR** repeating/validating these studies with current detectors must be a very high priority

So PFA Matters – what matters for PFA ?

Everything !

e.g. Perfect Particle Flow (see P. Krstonosic Vienna ECFA meeting)
e.g. $e^+e^- \rightarrow Z \rightarrow qq$ at 91.2 GeV

Effect	σ[GeV] separate	σ[GeV] not joined	σ[GeV] total ($\%/\sqrt{E}$)	σ % to total
$E_v > 0$	0.84	0.84	0.84 (8.80%)	12.28
$Cone < 5^o$	0.73	← FORWARD REGION		9.28
$P_t < 0.36$	1.36	← TRACKING		32.20
σ_{HCAL}	1.40	← HCAL RESOLUTION		34.12
σ_{ECAL}	0.57	1.51	2.32(24.27%)	5.66
M_{neutral}	0.53	1.60	2.38(24.90%)	4.89
M_{charged}	0.30	1.63	2.40(25.10%)	1.57

To be reviewed

(assumed sub-detector resolutions: ECAL 11%/√E, HCAL 50%/√E +4%)

+ all mistakes made in PFA algorithm

★PFA is delicate - it needs realistic studies: simulation + tracking + clustering

❷ Software FrameworkS/Tools

So where are we as of LCWS06 ?

	Description	Detector	Language	IO-Format	Region
Simdet	fast Monte Carlo	TeslaTDR	Fortran	StdHep/LCIO	EU
SGV	fast Monte Carlo	simple Geometry, flexible	Fortran	None (LCIO)	EU
Lelaps	fast Monte Carlo	SiD, flexible	C++	SIO, LCIO	US
Mokka	full simulation – Geant4	TeslaTDR, LDC, flexible	C++	ASCI, LCIO	EU
Brahms-Sim	Geant3 – full simulation	TeslaTDR	Fortran	LCIO	EU
SLIC	full simulation – Geant4	SiD, flexible	C++	LCIO	US
LCDG4	full simulation – Geant4	SiD, flexible	C++	SIO, LCIO	US
Jupiter	full simulation – Geant4	JLD (GDL)	C++	Root (LCIO)	AS
Brahms-Reco	reconstruction framework (most complete)	TeslaTDR	Fortran	LCIO	EU
Marlin	reconstruction and analysis application framework	Flexible	C++	LCIO	EU
hep.lcd	reconstruction framework	SiD (flexible)	Java	SIO	US
org.lcsim	reconstruction framework (under development)	SiD (flexible)	Java	LCIO	US
Jupiter-Satelite	reconstruction and analysis	JLD (GDL)	C++	Root	AS
LCCD	Conditions Data Toolkit	All	C++	MySQL, LCIO	EU
GEAR	Geometry description	Flexible	C++ (Java?)	XML	EU
LCIO	Persistency and datamodel	All	Java, C++, Fortran	-	AS,EU,US
JAS3/WIRED	Analysis Tool / Event Display	All	Java	xml,stdhep, heprep,LCIO,	US,EU

See talk of T.Behnke

Fast Simulation

Full GEANT Simulation

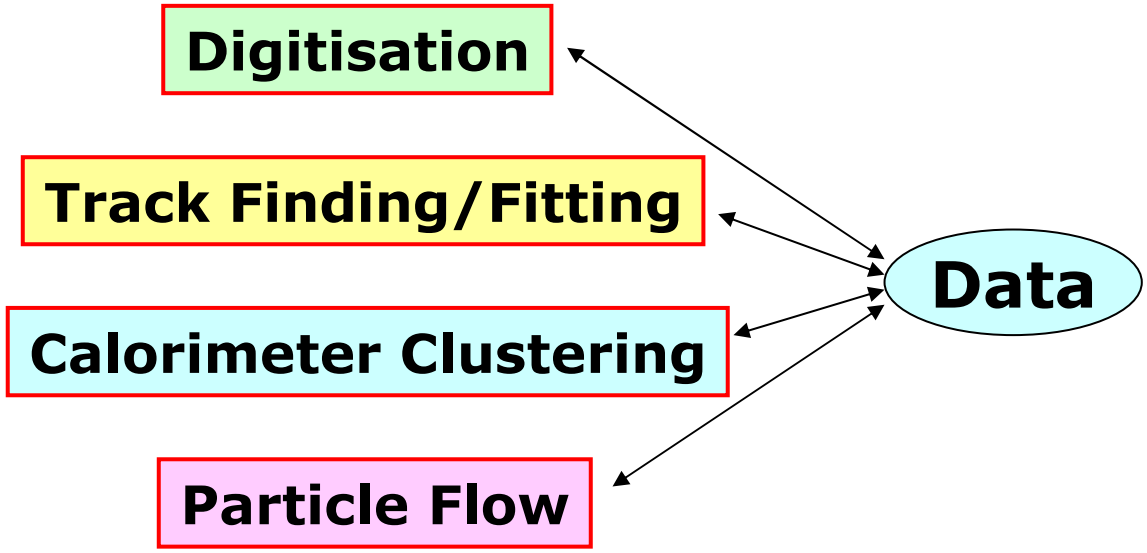
Reconstruction Framework

Geometry/Data Format+..

+reconstruction…

- **Much duplication of work**
- **Currently Software highly tied to concepts/region**
- **Given the lack of resources, this is an unfortunate position**
- **Difficult to see change in short-term, but we should try….**

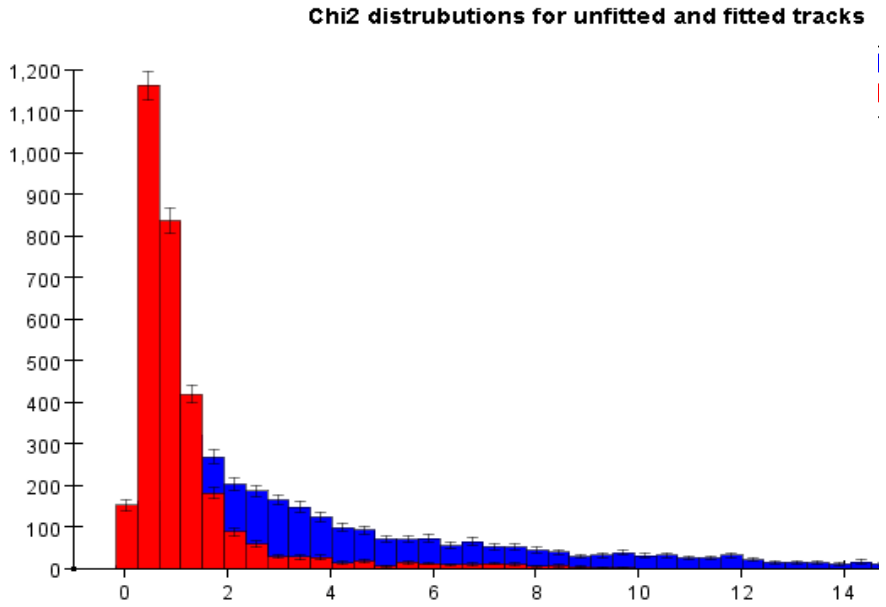
Reconstruction Software



★A lot already exists
★These are serious reco. algorithms

e.g. N.Sinev's talk:

- ★Ported SLD weight matrix fitter to JAS ILC framework
- ★Although not quite finished it is a nice piece of work
- ★**BUT tied to US JAVA-based framework**

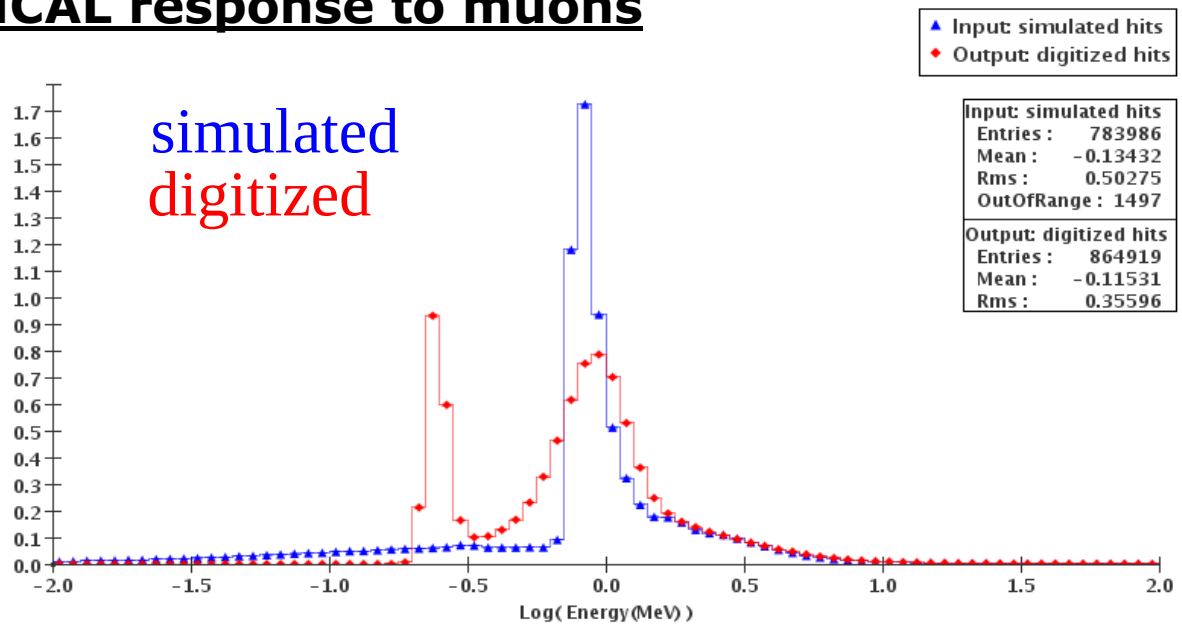


Another new example :DigiSim

See V.Zutshi's talk

- ★**Detailed and very general programme to turn raw MC hits into digitised hits including cross-talk/noise etc.**
- ★**Both a JAVA (JAS) and C++ (MARLIN) version exist**
- ★**BUT writing for 2 frameworks = extra work**

e.g. HCAL response to muons



Overall : Real progress from Snowmass to LCWS06 !

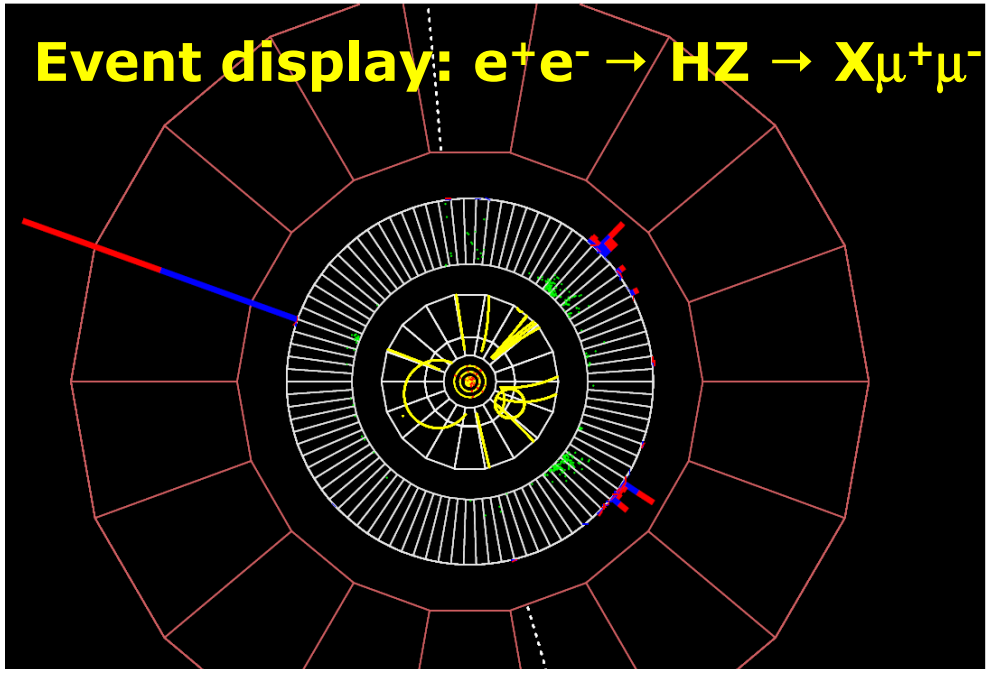
IVth Concept Reconstruction C.Gatto

★ IVth concept often criticised for lack of full simulation demonstration of concept

LCWS06:

★Huge amount of progress on IVth detector concept reconstruction and simulation

★Based on existing, well supported tools : e.g. ROOT



★Impressive progress : expect first performance results soon

❸ PFA where art thou ?

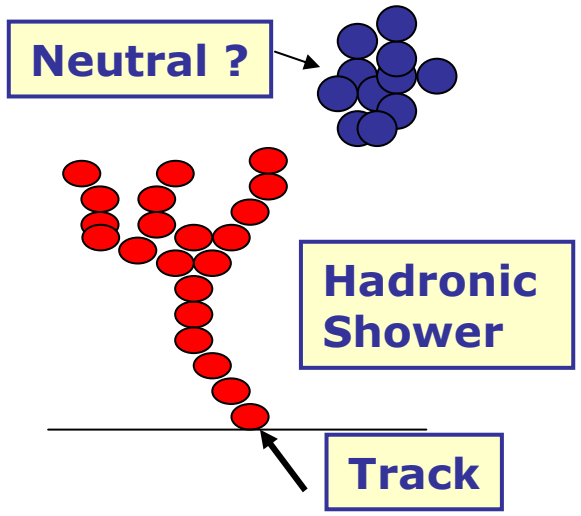
★**PFA paradigm central to GLD, LDC, SiD, concepts**

- **NOT THERE YET !**
- **BUT: Real progress being made with PFA :**
  63.63 % of talks in LCWS06 software session related to PFA
- **Progress, but some way to go…. 6 months ? 1 year ? Longer ?**

PFA challenges: **(Para)**

★ **Many challenges (Adam Para gave an interesting summary)**

★ **HARDEST (?) : separation of neutral and charged hadrons**



- **Irreducible problem ?**
- **Gets worse with higher particle density**
  i.e. higher jet energy/boost
- **So far PFA mainly tested on Z**
- **NOT A GOOD TEST**

Para Challenge: Case of bottles of (moderately good) wine for a demonstration of $0.3/\sqrt{E}$ resolution for ZH events at $\sqrt{s}$=500 GeV

Break even point

★PFA is extremely complex

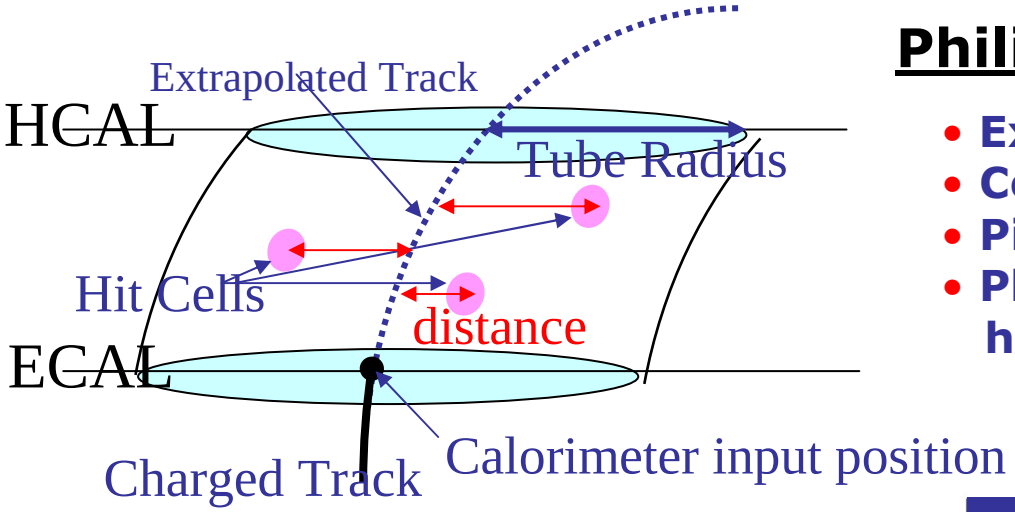
★Can "achieve" worse performance c.f. pure calorimetric measurement

V.Morgunov

LDC00	Whole calorimeter sum		Check plots	
e+ e- into , at energy	Mean [GeV]	Sigma [GeV]	Mean [GeV]	Estimated energy resolution [GeV]
t tbar, 1000 GeV	982.3	24.6	0.19	18.7
W+ W-, 1000 GeV	992.6	25.5	2.7	17.4
t tbar, 500 GeV	488.8	16.9	1.8	12.6
W+ W-, 500 GeV	496.6	14.5	1.6	10.9
heavy quarks, 500 GeV	495.0	14.8	-0.5	12.8
light quarks, 500 GeV	497.9	14.9	-1.1	14.3
t tbar, 360 GeV	356.4	14.0	5.5	10.0
Z pole, 91.2 GeV	90.4	4.67	-0.06	4.25

- IF PFA performance worse than these values – it is making things worse
- VERY useful sanity check

PFA in GLD T.Yoshioka



Philisophy:

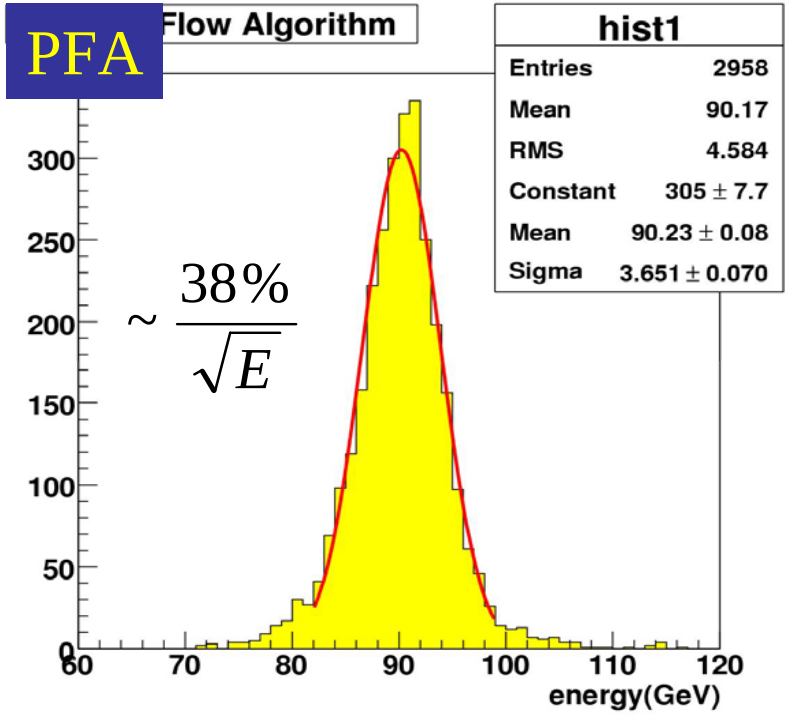
- Extrapolate track into CALO
- Construct tube
- Pick up hits
- Photon ID : classify remaining hits as from hadrons/photons

Performance:

- Z → uds (91.2 GeV)
- "Barrel region"
- add in missing energy from ν
  - centres peak at 91.2 GeV
- Decent performance:

38%/√E(GeV)

BUT doesn't yet work well for higher energies



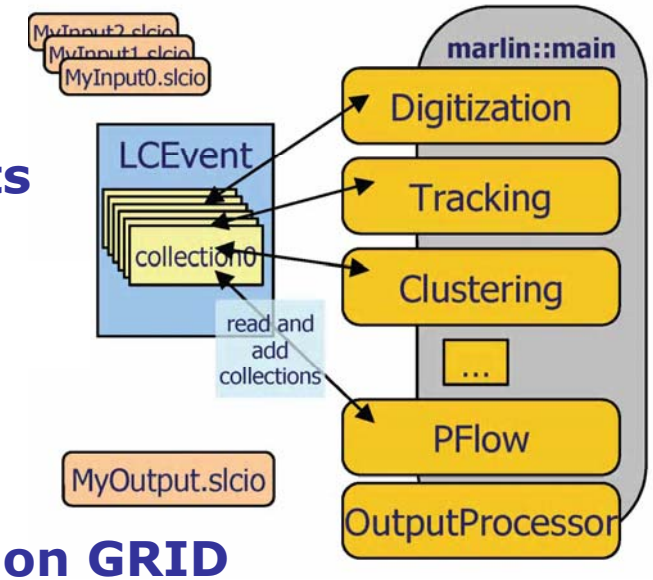
PFA in LDC

Two reasonably well developed algorithms:

- ★ **WOLFPFA [default]** **(Raspareza et al)**
- ★ **PandroraPFA** **(Thomson)**

Both Using MARLIN C++ framework **O.Wendt**

- **Flexible framework**
- **Plug in reconstruction modules**
- **Almost complete reco chain exists**
- **Steering files drive analysis:**
  i.e. swap different modules
  + change algorithm parameters



Simulated Events

- **Large events samples generated on GRID**
- **0.5 M events**
  - **different processes**
  - **different detectors**
- **Basis to test LDC PFA performance**

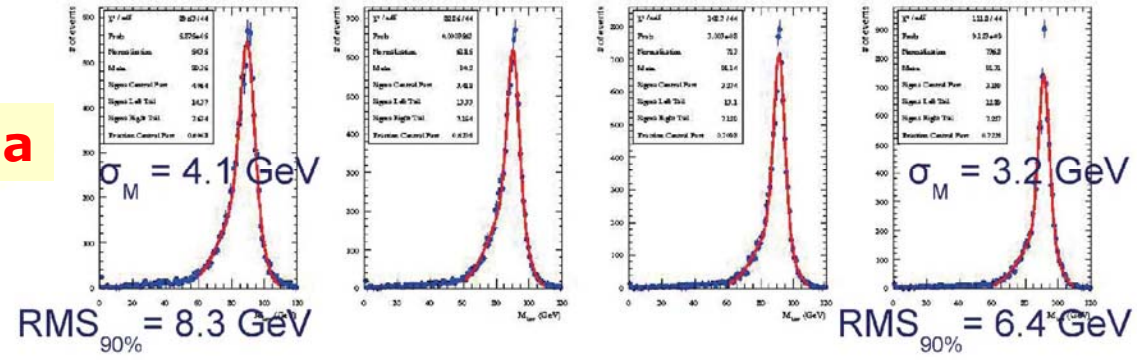
Wolf Results O.Wendt

NOTE: Z→qq and Z→l⁺l⁻

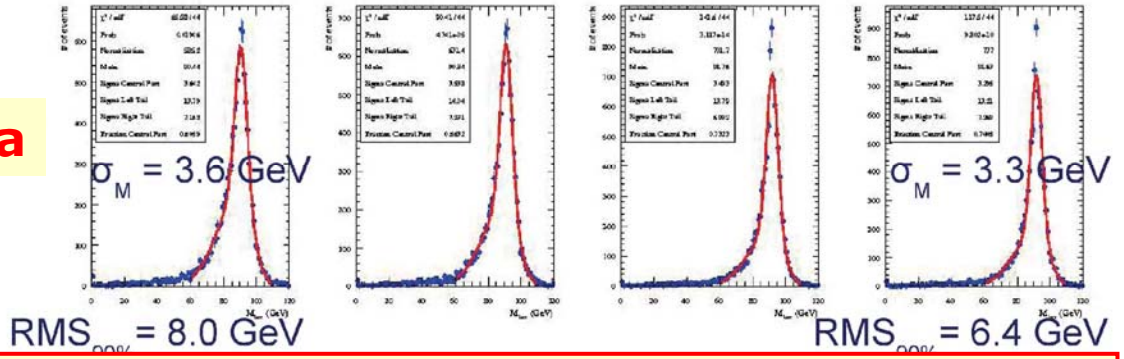
LDC **Tesla**

R=1380 **R=1580** **R=1690** **R=1890**

B=3 Tesla



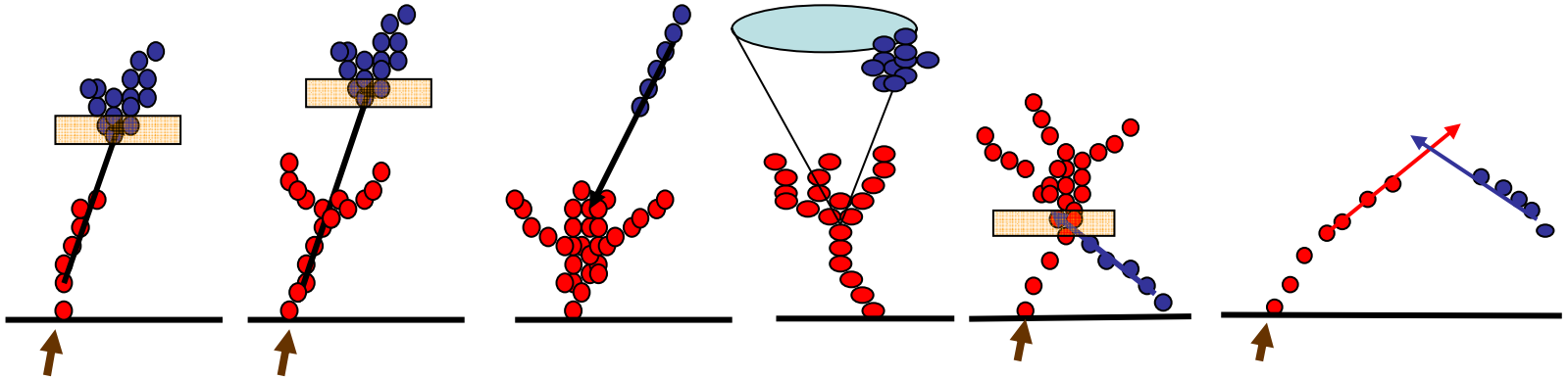
B=3 Tesla



★**First attempt at performance vs detector size**
★**No significant dependence of jet energy resolution**
★**BUT, DON'T YET TAKE TOO SERIOUSLY: Zs + could be just the algorithm**

Topological approach to PFA M.Thomson

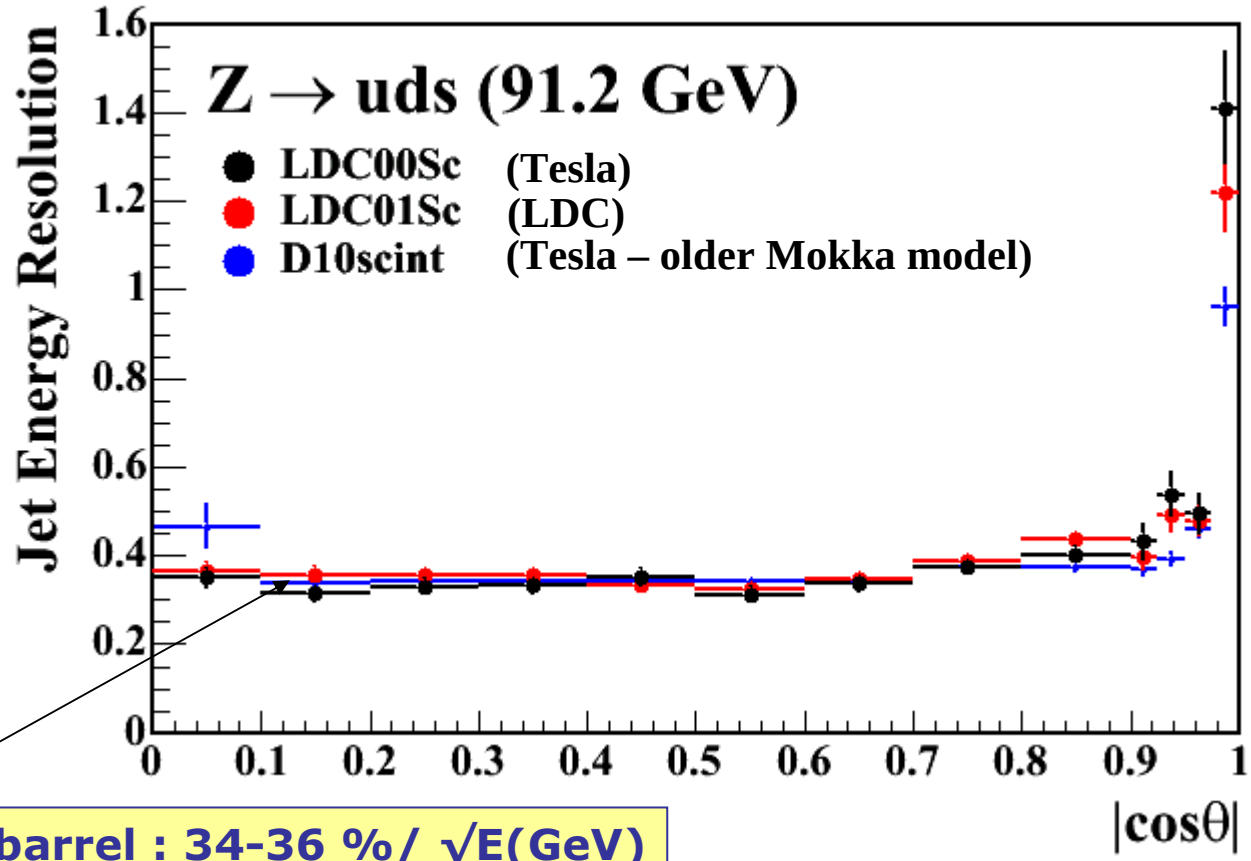
- ★ Work from the premise that PFA is not a pure ECAL/HCAL clustering problem
- ★ PFA and calorimeter clustering performed together
- ★ Start by applying loose clustering
- ★ Then join clusters using topology



- ★ Algorithm defined by loose cluster finding + topological rules to join clusters

Results : Z uds events
Angular dependence

- Plot resolution vs generated polar angle of qq system



- In barrel : 34-36 %/ √E(GeV)

BUT doesn't yet work well for higher energies

SiD : PFA studies in US

U.Mallik + V.Zutshi

A lot of activity in US
Work on 4+ distinct algorithms
Still work in progress....

But many interesting ideas currently being investigated

- ★ Nearest neighbor clustering
- ★ MST clustering
- ★ Directed tree clustering
- ★ Density Weighted cluster algorithm
- ★ Fixed Cone cluster algorithm

CLUSTERING

- ★ Calorimeter track-segment finder
- ★ Track-MIP match

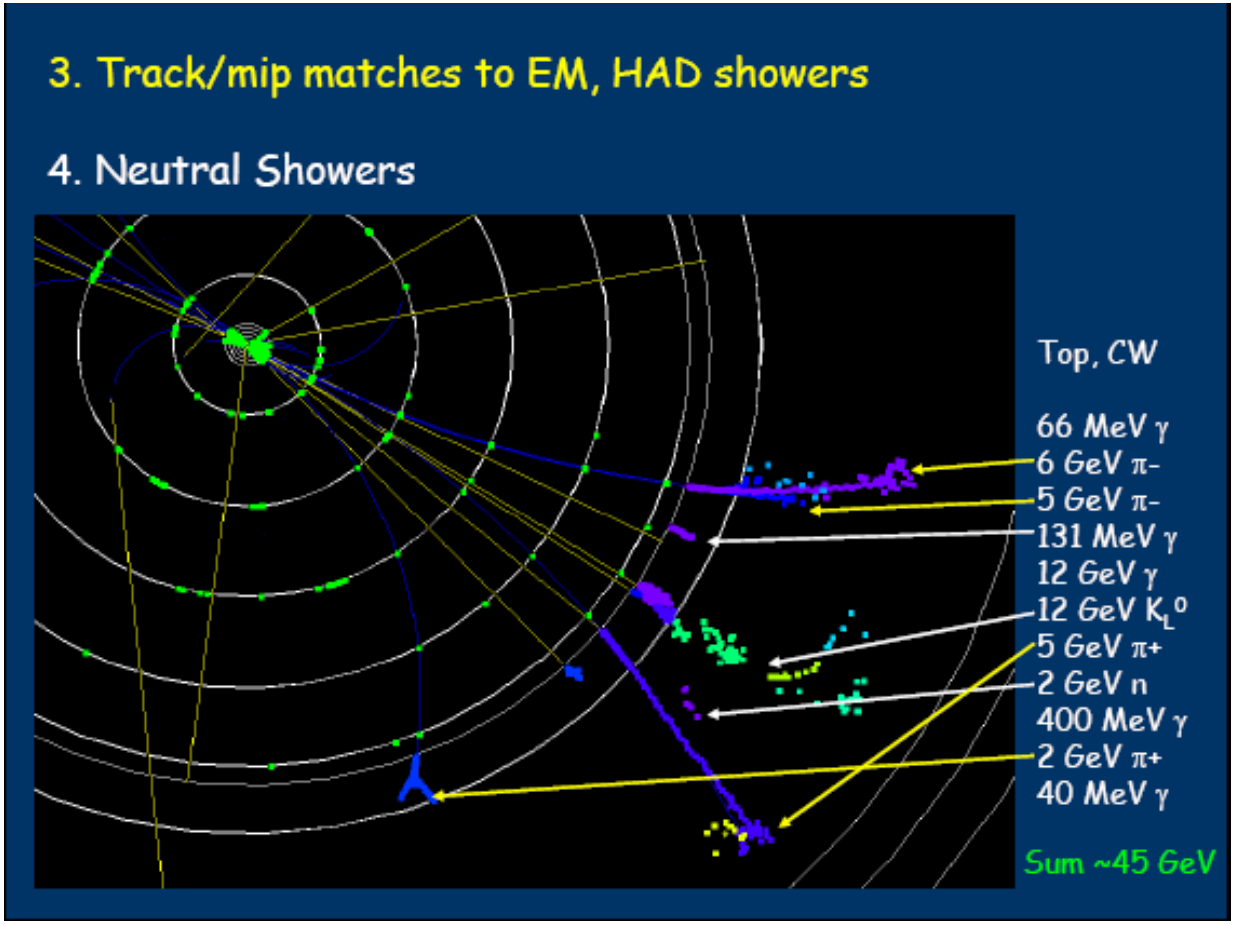
CALO TRACKING

- ★ H-matrix (& others) for photon id
- ★ Neural networks
- ★ Neutral fragment identification and matching

CLUSTER IDENTIFICATION

- ★ and many others.....

e.g. Work at ANL:



Currently achieve: ~40%/√E(GeV)

❹ Conclusions and Outlook

Why ?

★Sophisticated Reconstruction vital to prove ILC detector concept paradigms (PFA or IV)

Software Frameworks/Tools

★ Lots of progress worldwide
★ Both on frameworks and reconstruction tools
★ BUT… lack of shared software/frameworks isn't helping
★ Lots of duplicated work !

PFA where art thou ?

★ Lots of activity worldwide
★ But not there yet (goal 30%/√E) ….

σ_E/E = 34-40 %/√E(GeV)

★ Not bad, but this is only for Z at 91.2 GeV
★ But, don't give up on PFA… good performance was achieved for Tesla TDR

Where next (personal view)?

★ Full detector studies by end 2006 ➡ VERY CHALLENGING !
★ Not impossible… not helped by lack of shared effort
★ Detector concepts need to collaborate more effectively

Event display: $e^+e \rightarrow H^oZ^o \rightarrow X\mu^+\mu^-$