Calorimeter for the TESLA-TDR

J-C BRIENT
LPNHE- Ecole Polytechnique

OUTLINE

- Calorimeter concept
- ECAL-HCAL design
- Performances
- Conclusion

PHYSICS INPUT

- Physics with multijets final state

JETS RECONSTRUCTION

- The resolution on the missing energy is of importance

HERMITICY

- electron and muon Id. (Z decay, In B jet, ...)

LEPTON ID.

MACHINE INPUT

- Machine background lead to a 3-4 Tesla field $\longrightarrow$ the coil thickness is about 2 λ_I

Compact ECAL and HCAL inside coil

Muon Id. in calorimeter (P<5-8 GeV)

NUMBERS FROM PAST EXPERIMENTS

Take numbers from ALEPH

▷ At $\sqrt{s} = 91$ GeV, the resolution on the visible mass is $\Delta M_{vis} = 6.5$ GeV

BUT

Source	ΔM_{vis} (GeV)
Calorimeter energy resolution	~ 3.0
Imperfect particle reconstruction	~ 5.5
TOTAL	6.5

CALORIMETER
optimized for the reconstruction
not for the resolution

△ **WARNING** △

Doesn't mean the energy resolution couldn't be reasonnably good

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▷ Due to increase of dead zone of ECAL, the resolution increase with polar angle as $\Delta M_{vis} \times (1+\cos^2\theta)$

CALORIMETER
design geometry without crack
barrel AND end-cap

PARTICLES RECONSTRUCTION

$$\text{Ejet} = \Sigma\, E_{ch} + \Sigma\, E_{\gamma} + \Sigma\, E_{nh}$$

Identification and reconstruction of all eflow objects

▷ **charged tracks** from the tracker devices

▷ **photons** from the ECAL,
with rejection of debris from the charged hadron interaction

▷ **neutral hadrons** (K_L,neutron) from the ECAL and HCAL,
with rejection of debris from the charged hadron interaction

relevant parameters

- **photon** reconstruction **efficiency** (E_γ ,$dist_{\gamma/track}$)
- **rate** of fake photons from charged hadron interaction
- **neutral hadron** reconstruction **efficiency** (E_{h^0},$dist_{h^0/track}$)
- **rate** of fake neutrals from charged hadron interaction

Summary of the concept

- Use a large detector

  ECAL,HCAL with large area

- ECAL-HCAL inside coil. The space needed for HCAL (number of λ_I) **AND** a small Molière radius (for photon rec.) leads to

  ECAL compactness

- **Calorimeter optimize for neutral particles reconstruction rather than the energy resolution.**

  Small pad size, large channel multiplicity

- Identification e/μ/Ch. hadron-baryon

  S/B at the MIP level

- No hole, no dead zone, special attention to low angle region

  dedicated geometry, Intrumented MASK

ECAL design

▷ A Silicon - Tungsten sampling calorimeter

comments:

- Known calorimeter principle
- Seems the best solution for the EFLOW
- fullfiled all requests

▷ A Shashlik calorimeter

comments:

- Well established detector performances by test beam data
- improvment for EFLOW under continuous study
- Clearly cheaper than the previous solution

HCAL design

▷ A Tile sampling calorimeter

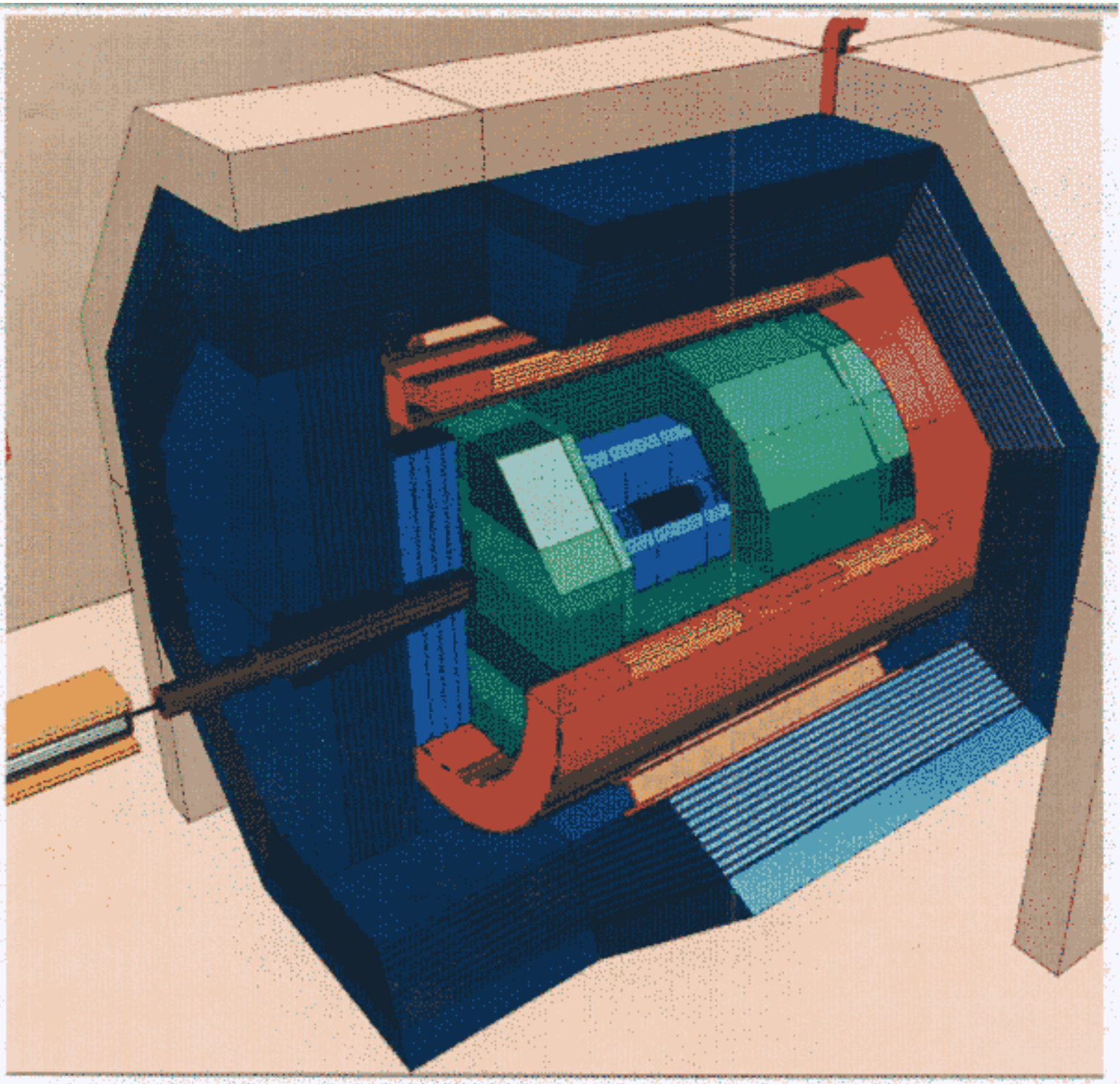
comments:

- Well known techniques
- could give a good hadronic resolution
- pad size is clearly the key point for the EFLOW

▷ A Digital calorimeter

comments:

- Sampling calorimeter with digital pad read-out
(limited Geiger or RPC's)
- The energy is reconstructed from the pad multiplicity.
- the principle has been tested using ALEPH data
- A priori, it could be relatively cheap



The missing link

Because the usual test of calorimeter performances is done with single particle (electron,pion, photon), there is a missing link to follow the general philosophy of the design:

The reconstruction algorithm

For photon as well as neutral hadron, PID,...

This link is essential to test correctly the designed calorimeter for the point of view of eflow/jets

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NEW !! NEW !! NEW !! NEW !! NEW !! NEW !! NEW !!

We have to consider this link as a part of the whole detector design project

The design of the calorimeters is given by the " directoire "
(french historical word for triumviratus , troika,....)

Hardware , software and physics impact

Quantify the tests on

Photon reconstruction

- classical algorithm is ready
- new method,appraoch is under development
  (see LC-note and LCW2000)

Lepton identification

- classical technique based on a likelihood estimator

Neutral hadron reconstruction

- to be done for the case of the TILE calorimeter
- Software of image processing for digital calorimeter

JETS reconstruction

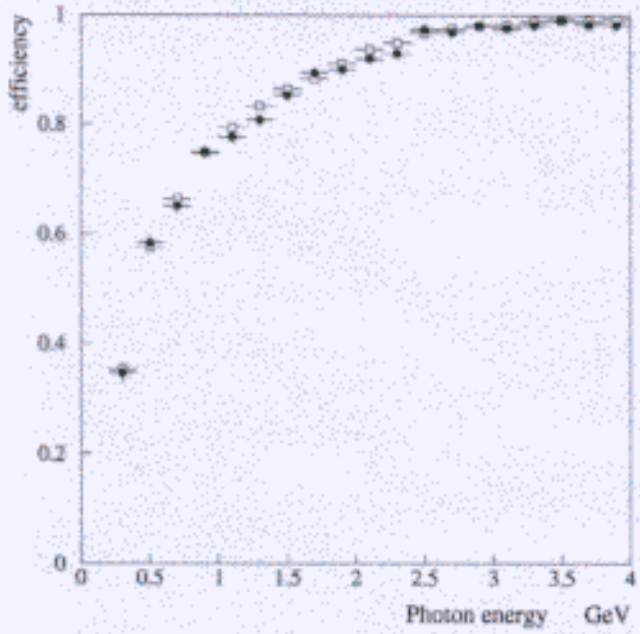
Jet energy resolution
visible mass

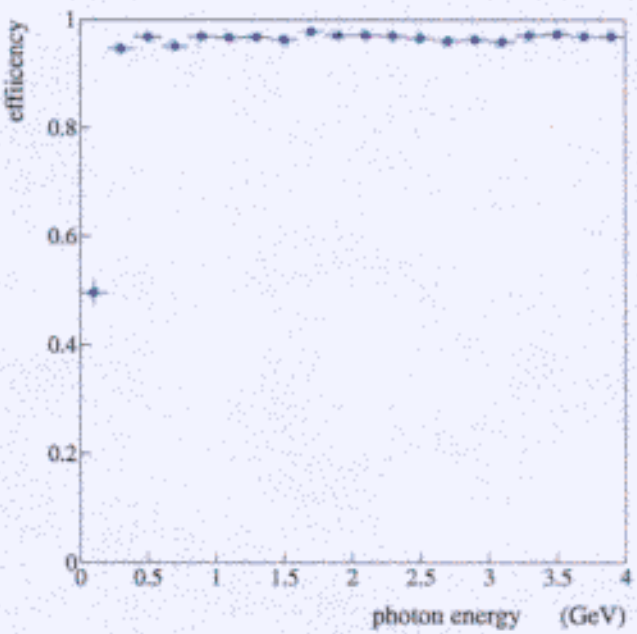
Photon treatement

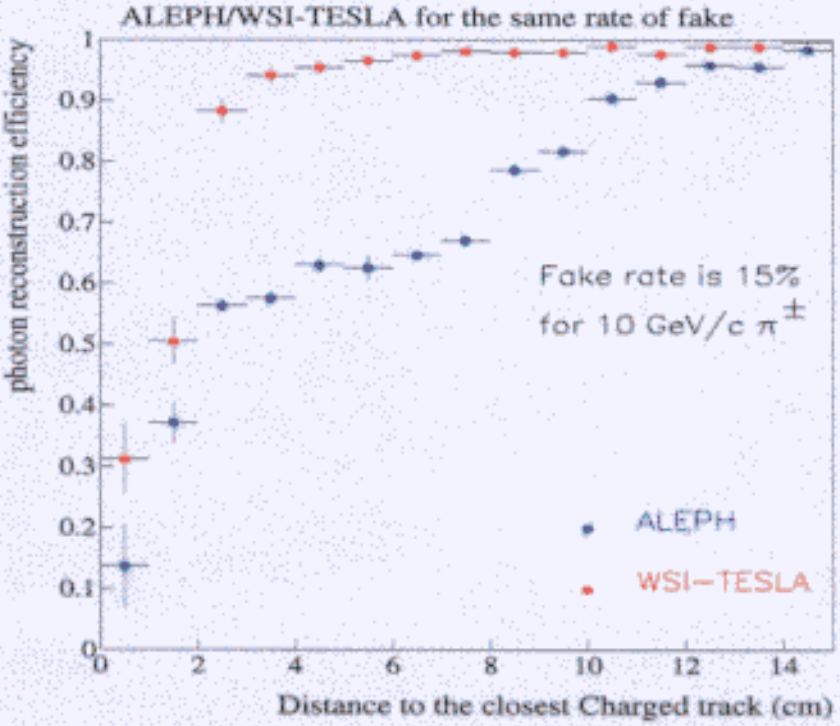
For example here for WSI $\oplus$ PFD02 (see LC note)

Depends on the software reconstruction package

For the same rate of fake photon







Lepton identification

Isolated track

ID. / particle	e	μ	h
e	99.8 %	0.	$\sim 5.\ 10^{-4}$
μ	0.	99.8 %	$\sim 5.\ 10^{-3}$
h	0.2%	0.2%	99.5 %

For the muon, the results has been shown at the ECFA-Obernai.

For the electron, see LC-note on Eflow (pre-final draft is ready, final draft within 2-3 weeks)

In jet

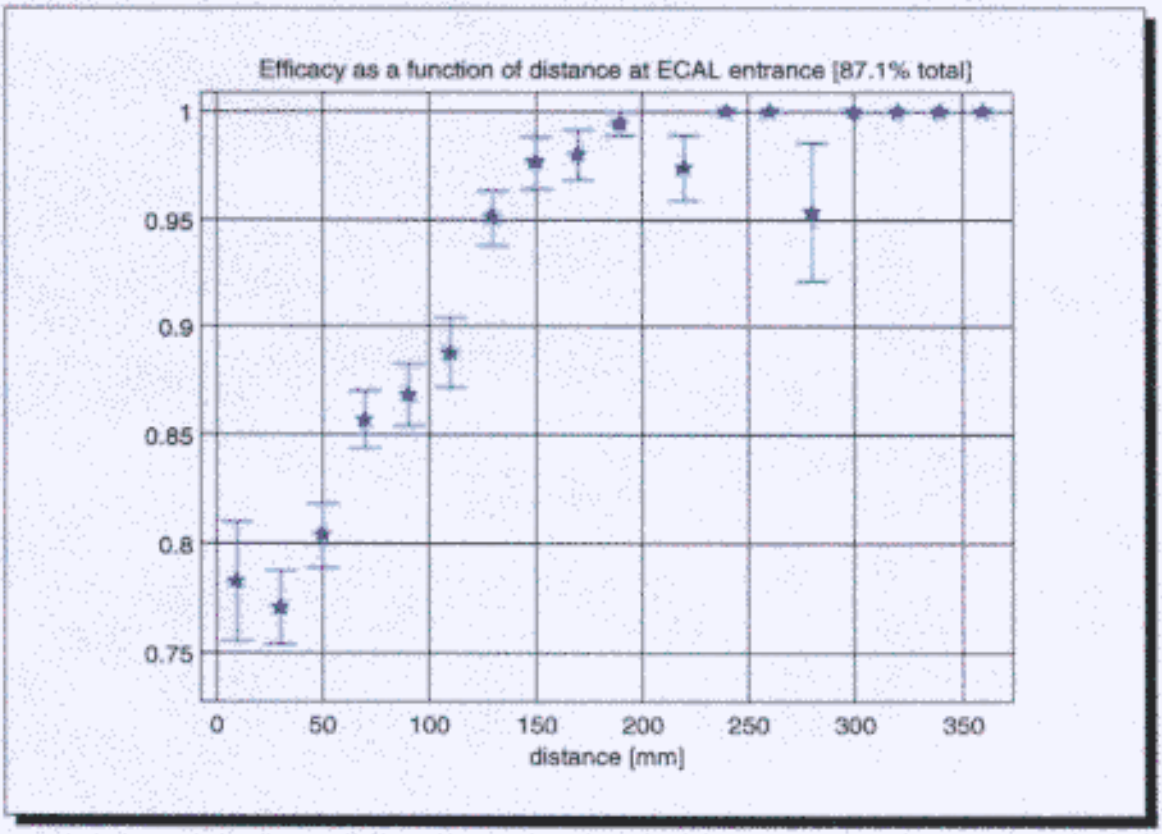
ID. / particle	e	μ	h
e	-	-	$\sim$ -
μ	0.	92. %	$\sim 1.5\ 10^{-2}$
h	-	8.%	-

For momentum as low as 2 GeV !!!
electron not yet.

Neutral hadron treatement

• **IT IS POSSIBLE** to reconstruct a neutral hadron very close to a charged track with reasonable efficiency and resolution (D.Orlando at ECFA-PADOVA).

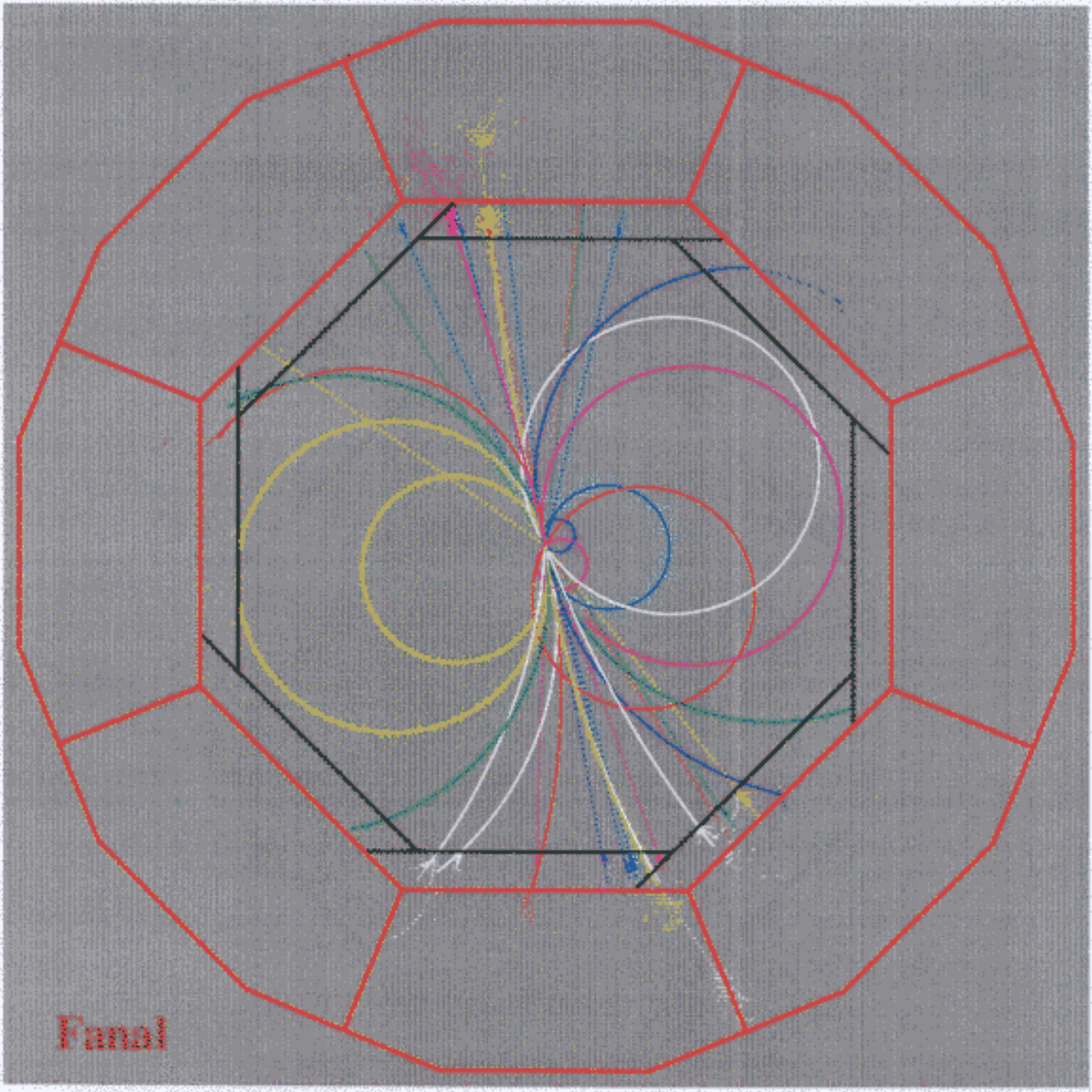
Topological method - Full simulation/reconstruction



Package too slow to be used for jets

Work in progress to adapt it for jets

Use the results from the package (efficiency (E_{h^0}, dist.) , Rate of fake,...) and use it for fast simulation for jets. (NO reason to be far from full simulation/reconstruction)


Final

Quasi-full reconstruction

definition

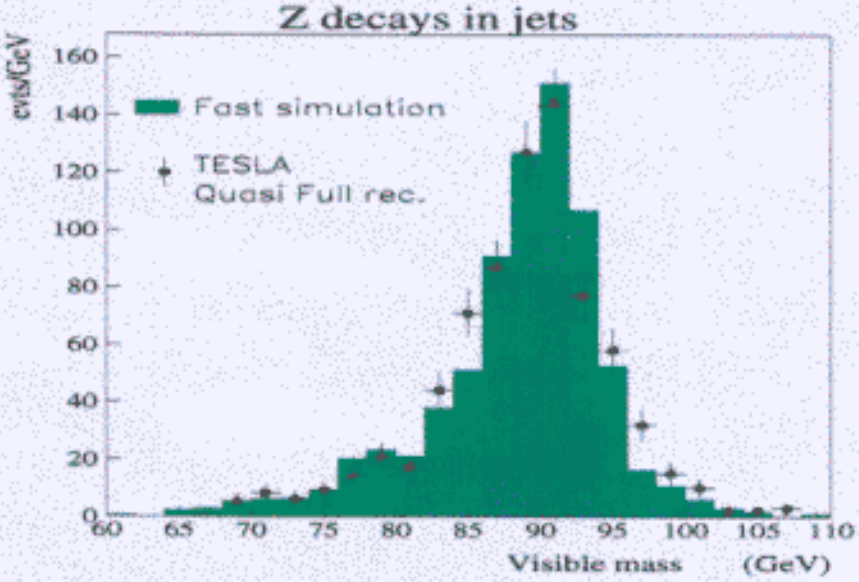
▷ **charged tracks**
- Fast simulation
- Effic(track) = 0.997
- Pmin=0.2 GeV/c

▷ **photons**
- Full reconstruction
- No special care of calibration
- Emin=0.2 GeV

▷ **neutral hadrons** (K_L,neutron)
- Fast simulation
- Fake rate and efficiency(E,Distance) from full rec.
- Emin=0.5 GeV

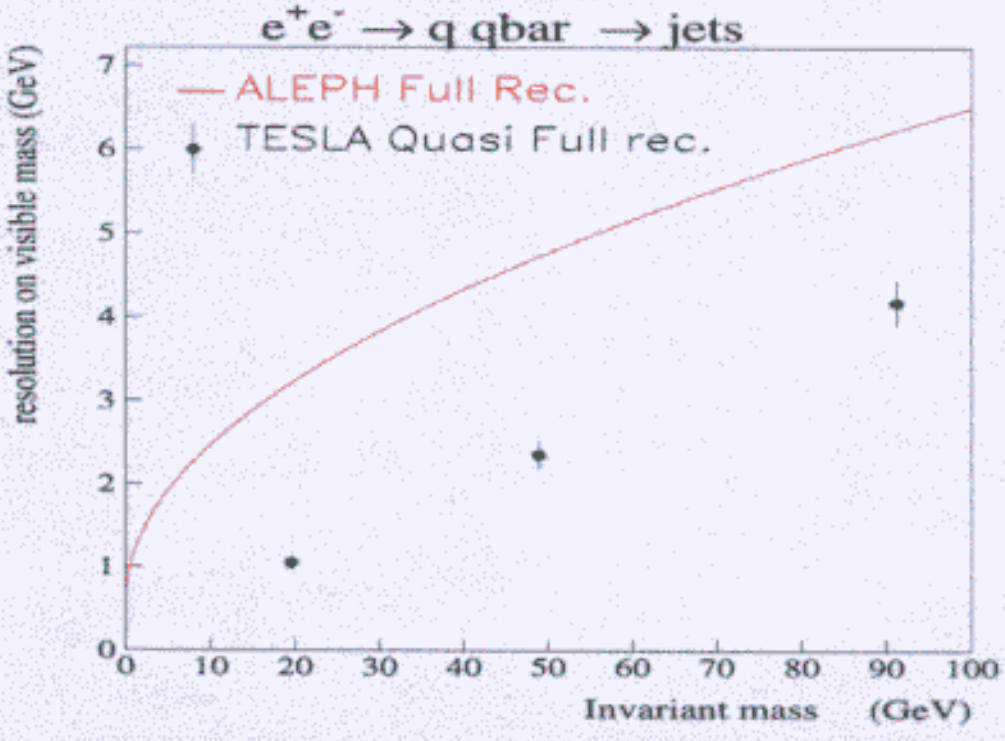
JETS : The graal

▷ Test of the quasi-full versus fast reconstruction(green)



▷ Quantify the gain in resolution for jets final state

For example compare to ALEPH



Conclusion

Particle decaying into boson(s) or multijets are the dominant final state in e^+e^- collision at $\sqrt{s} \leq 500$ GeV

THEREFORE

A rather new philosophy has to be taken for the calorimeter design **the EFLOW in jets is the guide line**

- A large number of peoples have made large efforts to have a coherent design based on this guide line.
- The proposed calorimeters seems to be technically feasable. Work is in progress
- The full reconstruction is in progress

The first results show

a very promising mass/energy resolution in jets final states