Confusion Term of PFA and Detector Optimization

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The copy of this talk one can find at the http://www.desy.de/˜morgunov

Introduction

Perfect PFA:

Depends on the event structure, but it does not depend on the detector optimization parameters till we do not introduce a calorimeter resolution/granularity as parameters for optimization.

Phenomenological path to the Optimization:

$$\mathcal{E}_{evt} = \mathcal{E}_e + \mathcal{E}_\mu + \mathcal{E}_{charg.had.} + \mathcal{E}_\gamma + \mathcal{E}_{neut.had.} \quad \Rightarrow \quad \sigma_{PFA} = \sigma_{ch.hadr} \oplus \sigma_\gamma \oplus \sigma_{neut.hadr} \oplus \sigma_{conf}$$

PFA confusion term as a value for Detector Optimization studies:

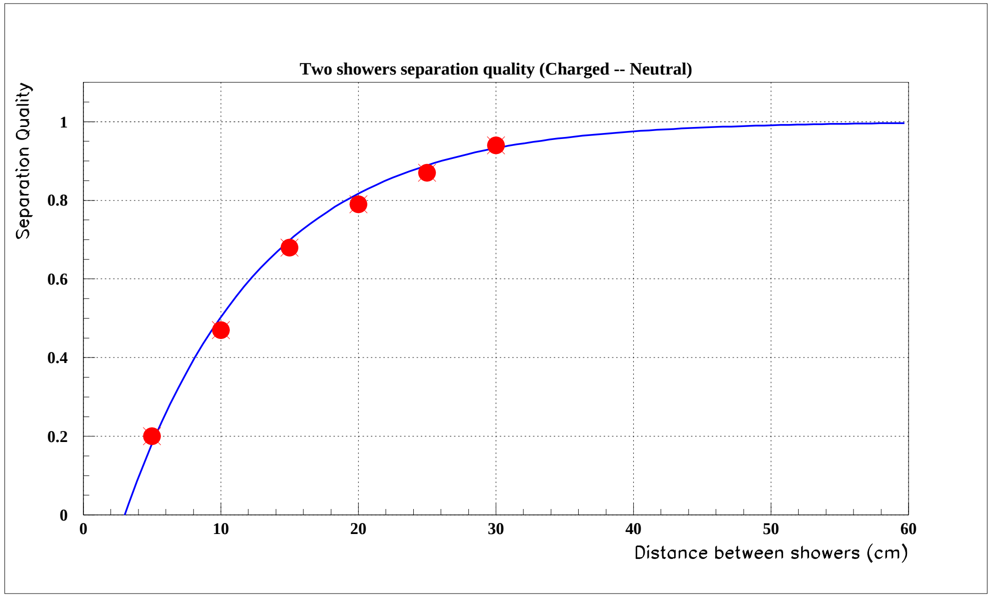
Should be most sensitive due to its nature – it is just an error of energy resolution.

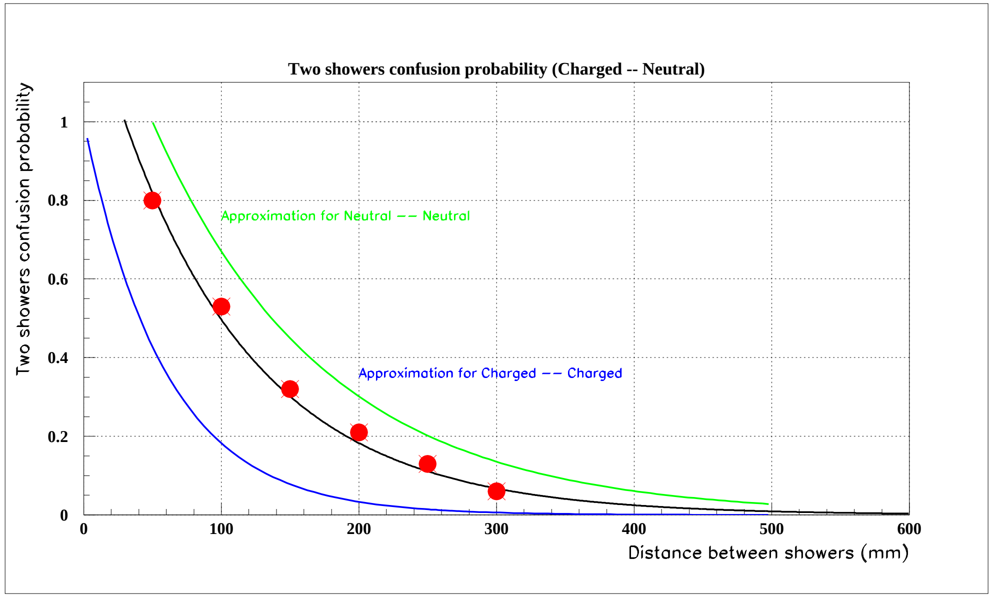
Tracking:

Was done by simple fast simulation inside PYTHIA, and it was checked by full simulation in Mokka

Detectors: SiD, LDC, GLD and its primes (ILD)

Probability to be captured for neutral hadron





Separation quality is a function of distance between two particles (charged + neutral). It was defined as a ratio of number of neutral particles that had got a reconstructed energy after separation in the range of $\pm 3 \ \sigma(E_{true})$ to the whole number of simulated pairs:

Probability to be in energy range.

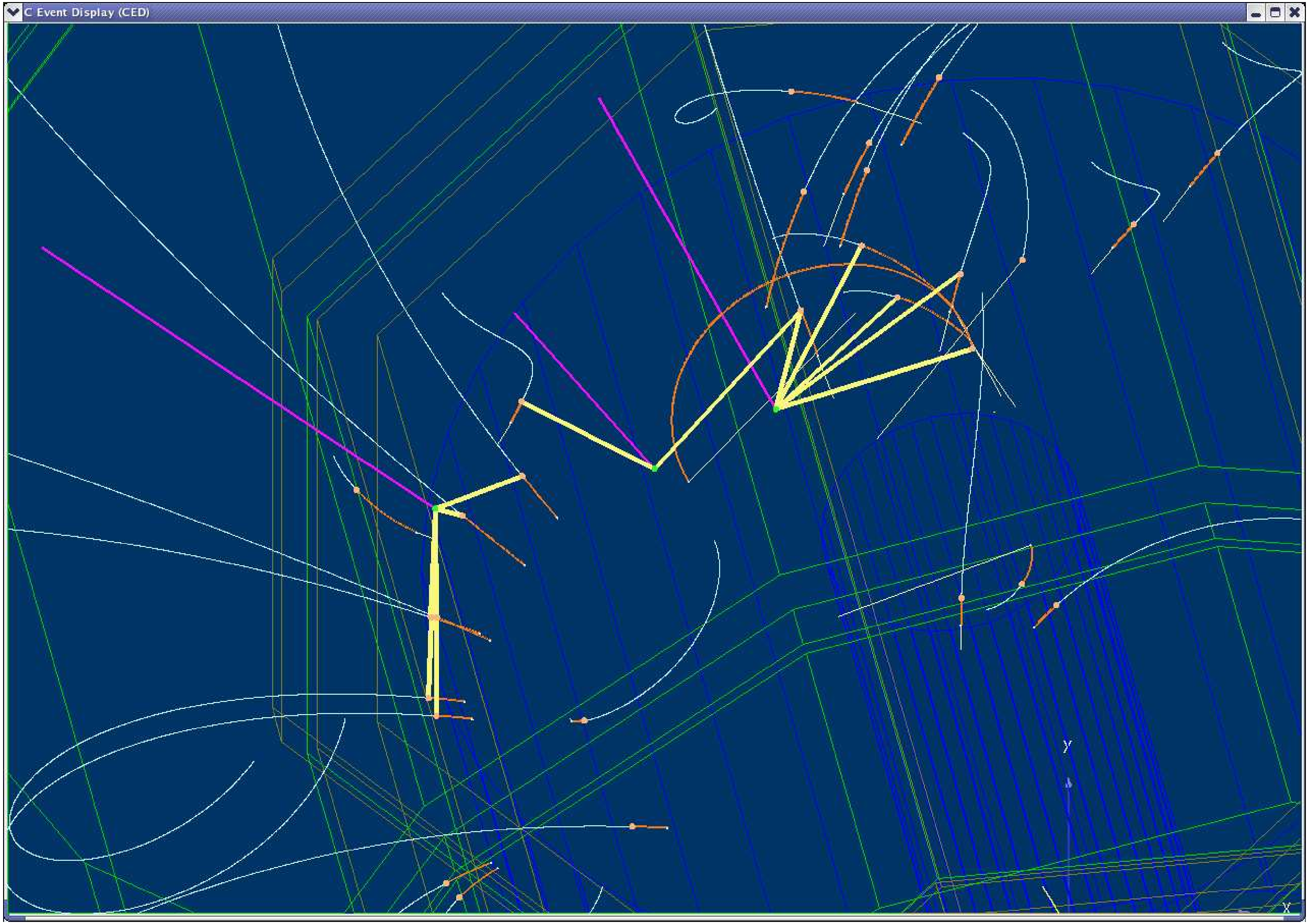
This function is highly dependent on the quality of reconstruction program.

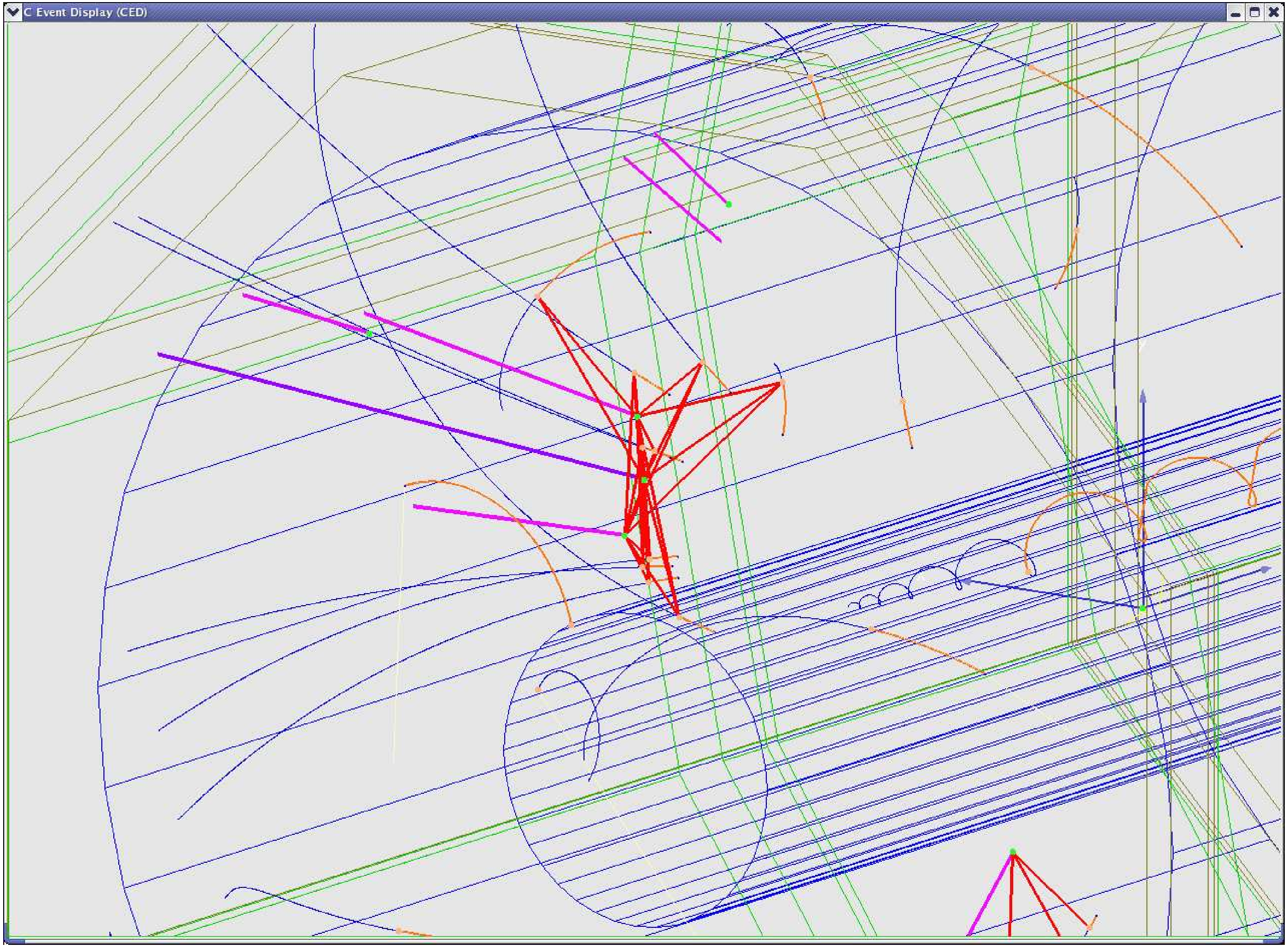
If one will subtract the separation quality from unity, one should get a **probability of neutral hadron to be captured by charged one**.

It does not depend on the detector parameters (B, L, R) except of HCAL resolution and granularity.

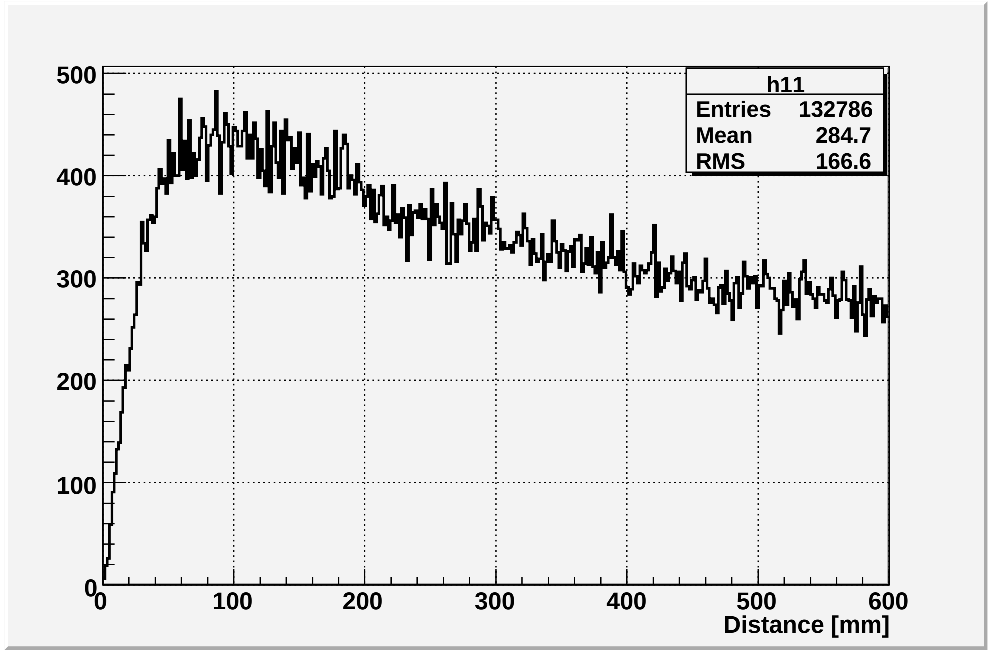
see Appendix for details.

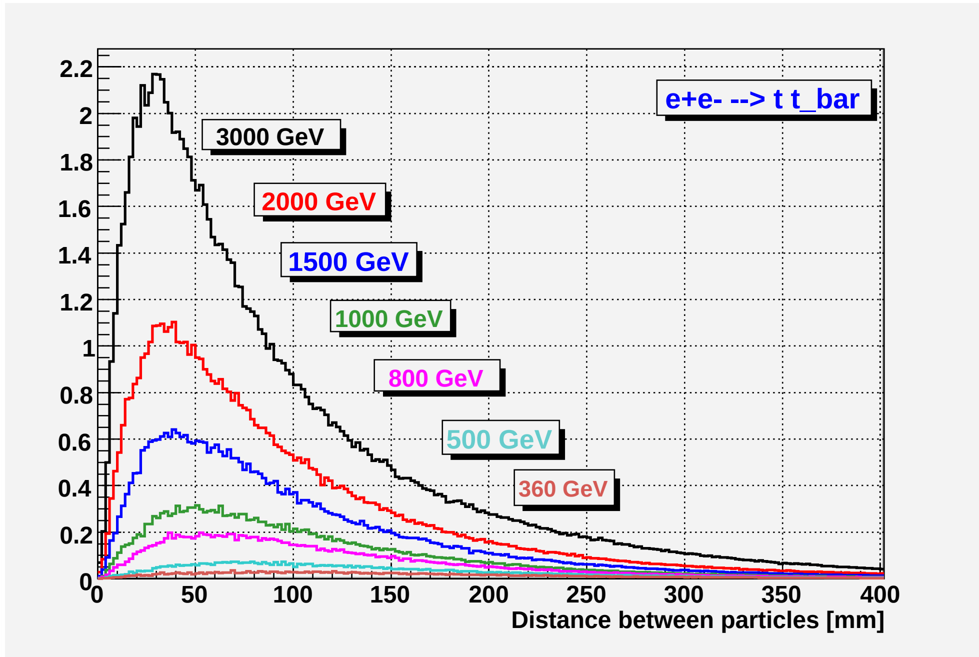
What is about a distribution of distances at the calorimeter face?


C Event Display (CED)
y
x


C Event Display (CED)

Partial confusion term is integral





After tracking in the tracker volume one can get a position of particle impact point at the calorimeter face. Here is a distribution of distances between any neutral hadron and any charged particle impact points at the calorimeter face.

An integral convolution of the distances between showers (charged + neutral) at the calorimeter face with capture probability and with a part of neutral particle energy will give us the energy lost distribution due to the confusion term.

This integral was taken by Monte–Carlo method.

see Appendix for details.

Detector models

Parameters of detectors are close to actual.

Detector	B field [Tesla]	R_{inner} [mm]	R_{outer} [mm]	Dist to EndCap [mm]
GLD	3.0	450.	2100.	2800.
ILD (prime)	3.5	300.	1820.	2550.
LDC	4.0	300.	1600.	2300.
ILD (L+∼20cm)	3.5	300.	1820.	2800.
ILD (R+∼20cm)	3.5	300.	2000.	2550.
SiD	5.0	200.	1270.	1800.

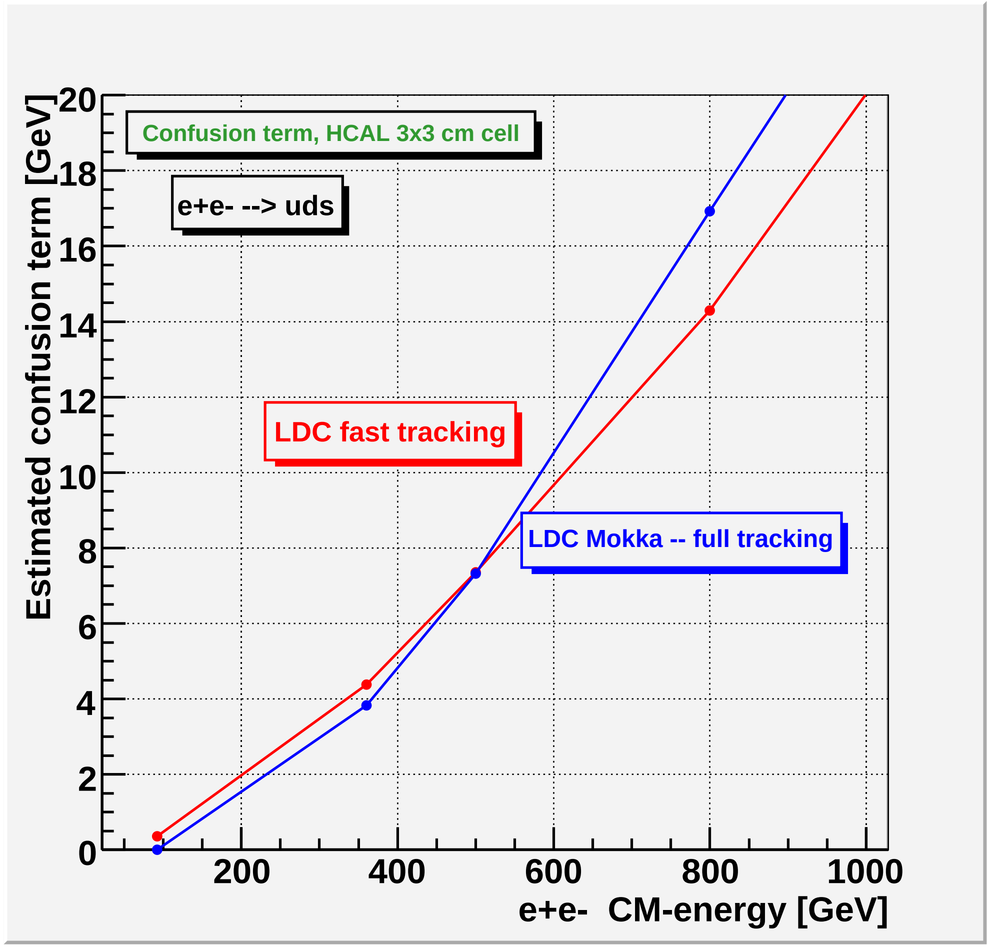
List of center mass energies: 92, 360, 500, 800, 1000, 1500

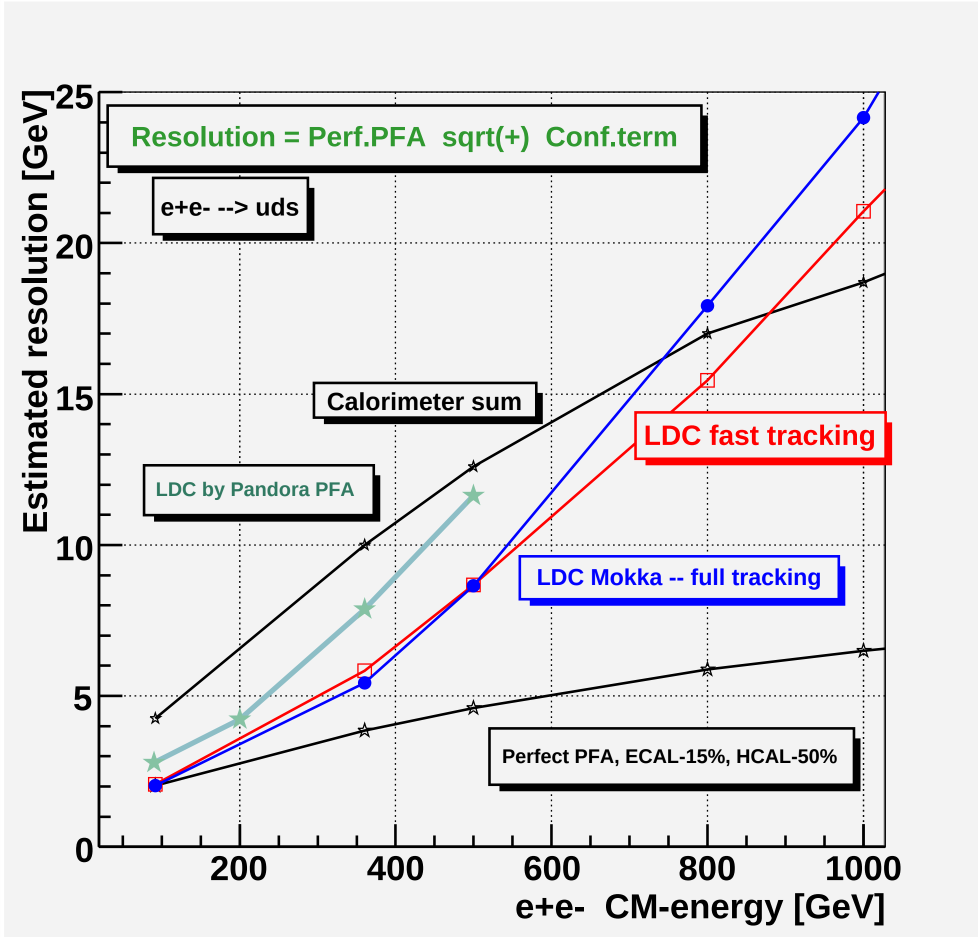
List of reactions:

$e^+e^- \to u, d, c\ quarks$ (two–three jets), $e^+e^- \to c, b\ quarks$ (two–three jets),

$e^+e^- \to W^+W^-$ (four jets selected), $e^+e^- \to t\bar{t}$ (six jets selected).

Accuracy



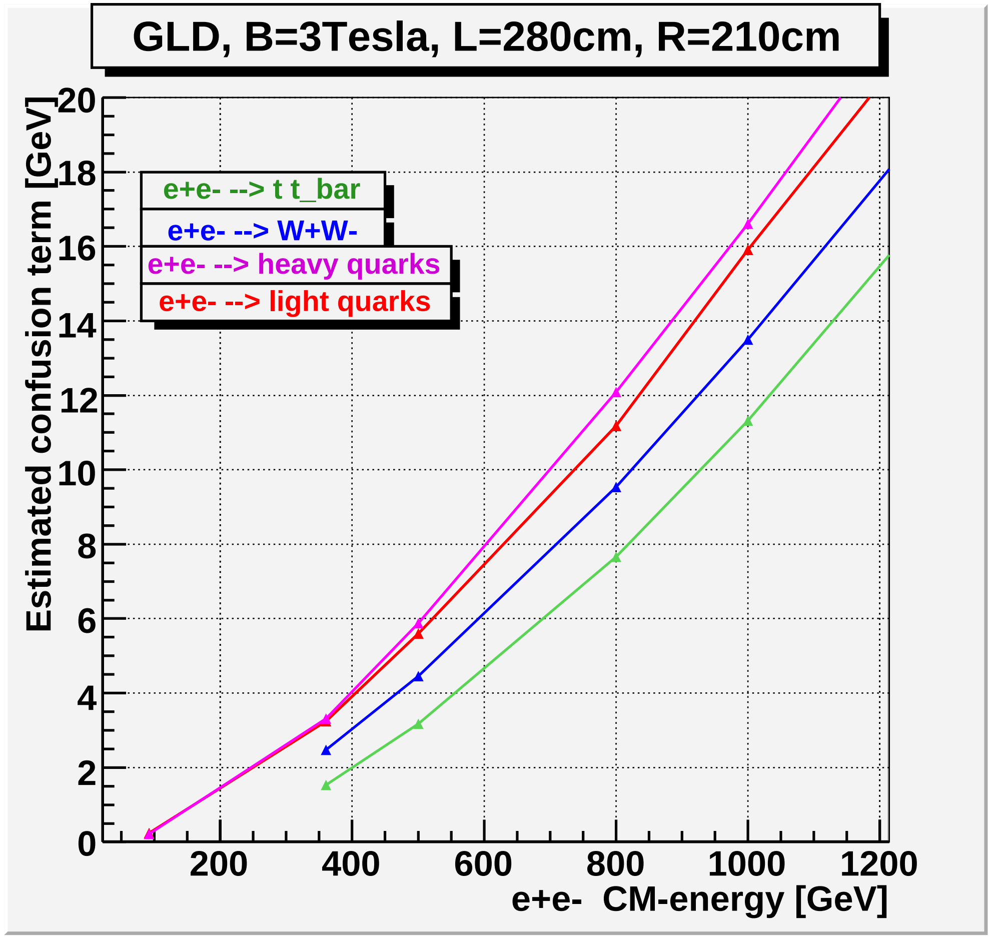


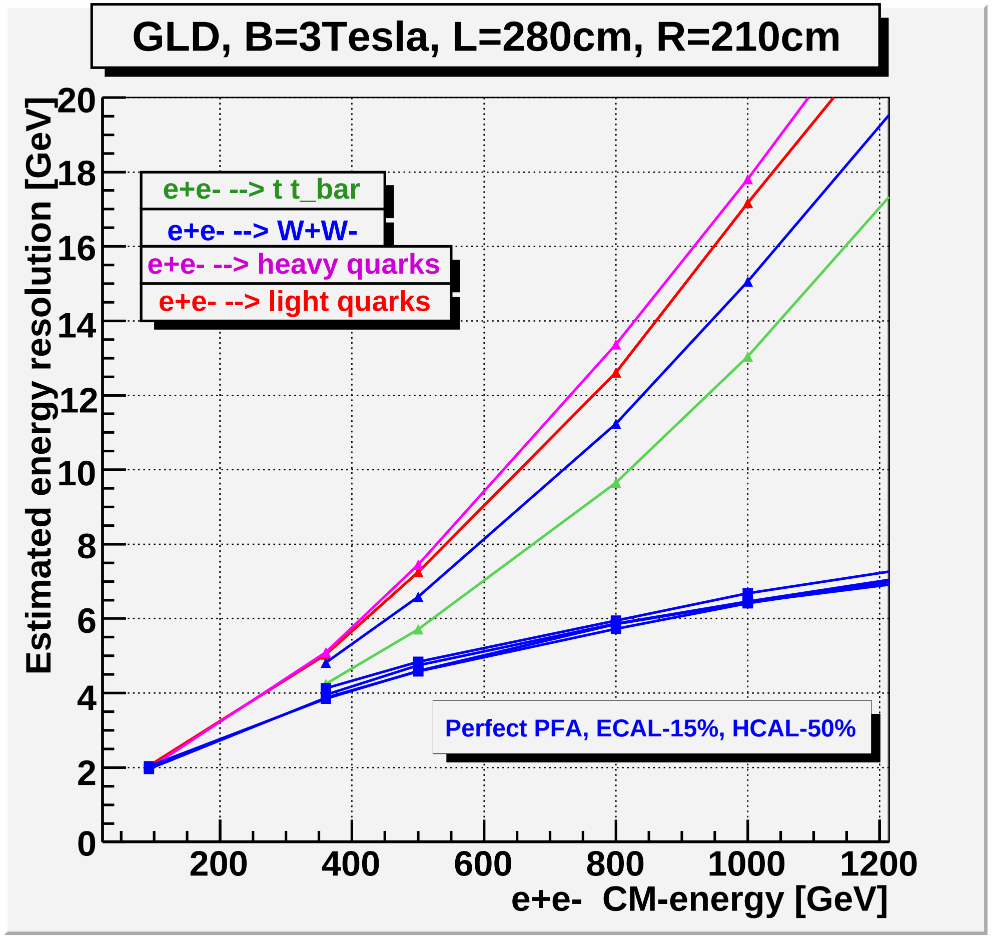
Mokka full tracking takes into account all materials up to the calorimeter face and all particle decays and interactions.

Integration procedure with fast tracking was tuned to reproduce full Mokka tracking.

Estimated resolution is approximately collinear with full reconstruction by Pandora PFA. see ILD Meeting, Zeuthen, 16/01/2008

GLD, $e^+e^- \longrightarrow$ *any partons*



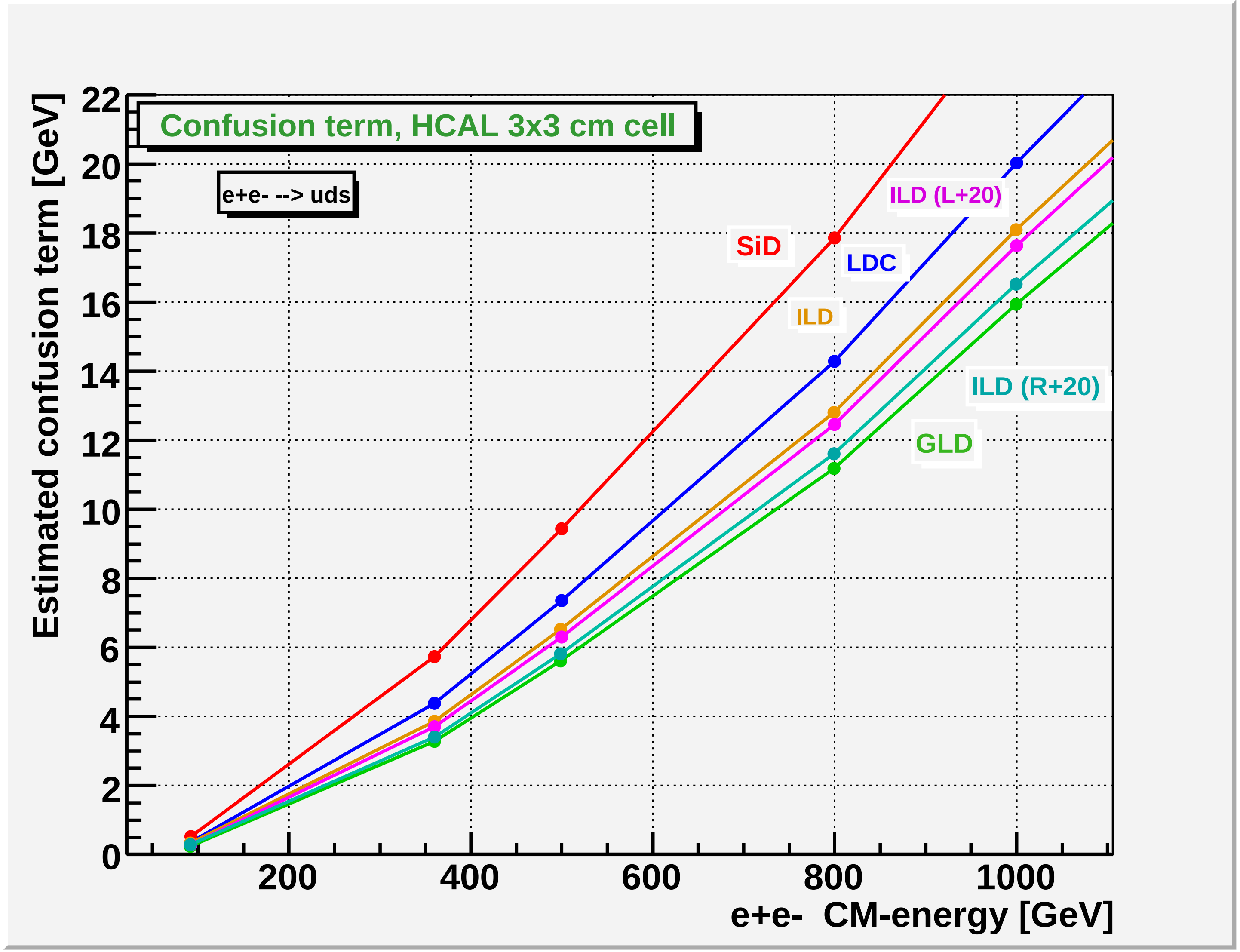


$$\sigma_{\mathcal{E}} = \sigma_{PerfectPFA} \oplus \sigma_{conf}$$

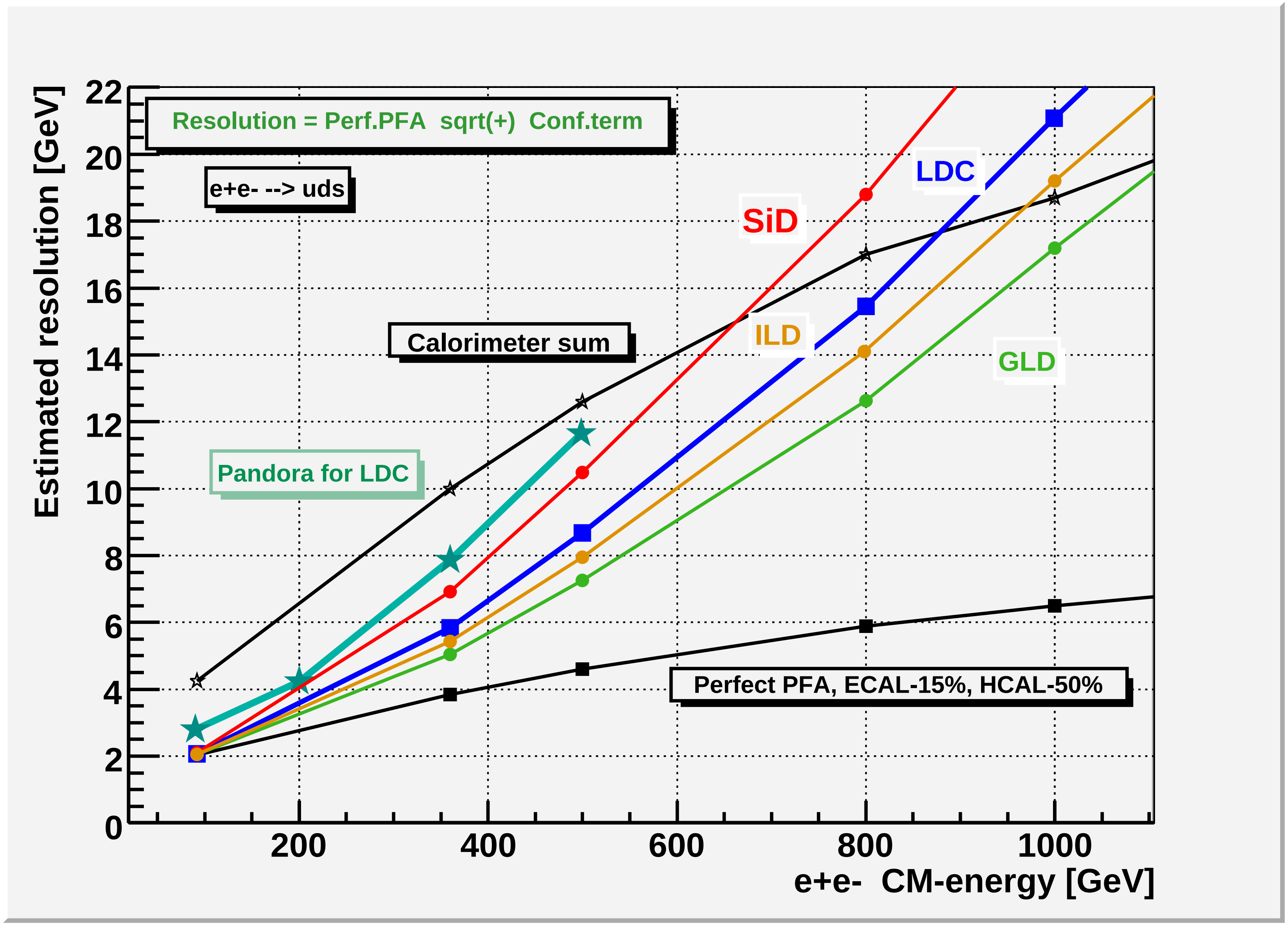
Confusion term is strongly depend on the physical process type. (the density of jets).

However for perfect PFA a physical process type is less significant.

Confusion terms, $e^+e^- \rightarrow u, d, s$, all detectors



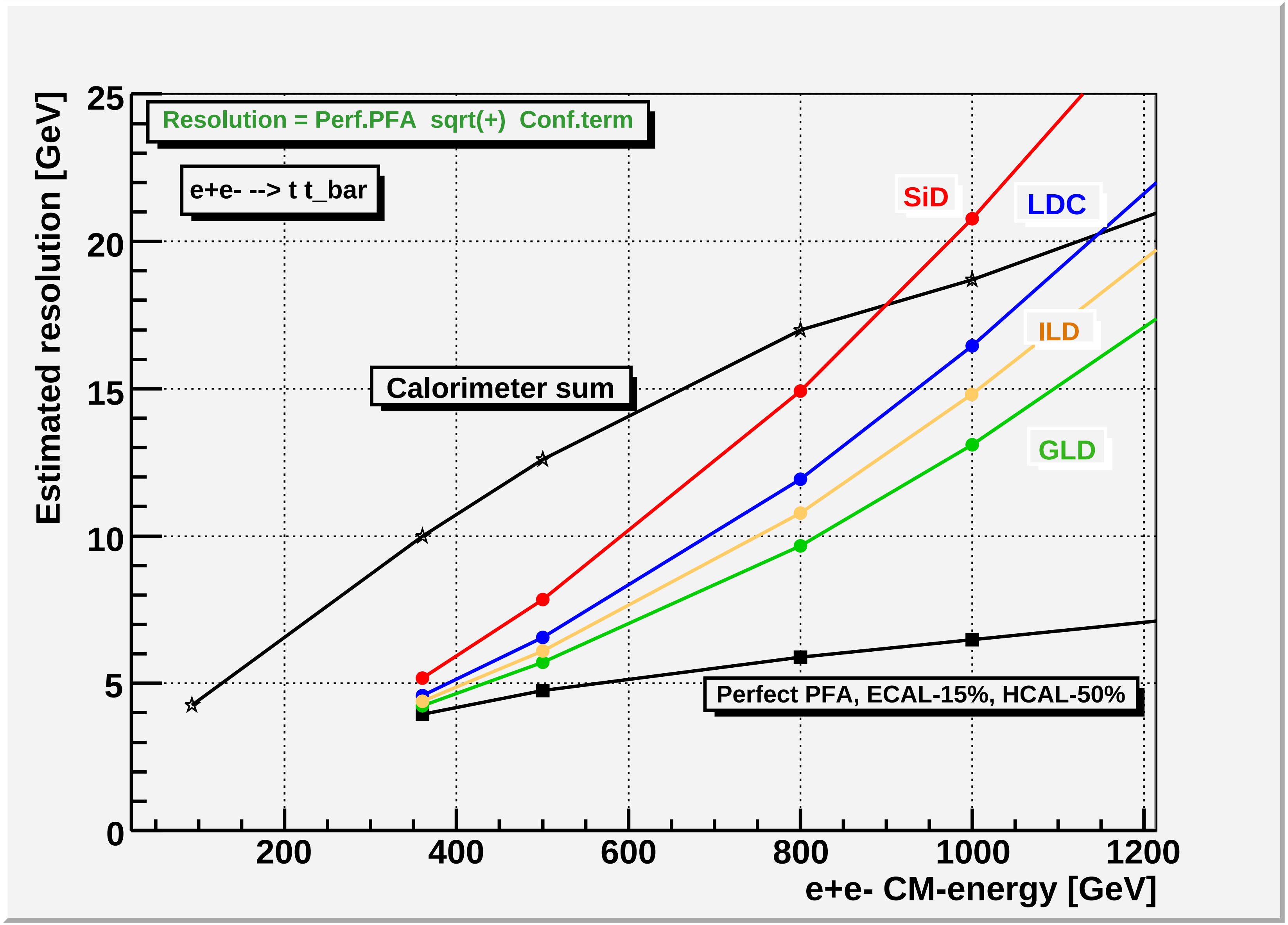
Calorimeter barrel radius is more significant than distance to the calorimeter endcap.



Continue of this prediction over the calorimeter line is meaningless – it needs another reconstruction algorithm.

Calorimeter only resolution is taken from http://www.desy.de/˜morgunov/talks_articles/AbsCalibr.pdf (Bangalor)

Resolution, $e^+e^- \rightarrow t\bar{t}$



Conclusion

1. Method of calculation of partial confusion term of PFA was developed.
2. This fast and sensitive method could be applied as zero approximation of detector optimization.
3. Radius of the calorimeter barrel is more significant parameter to get a better resolution in compare with distance to calorimeter endcap.
4. It was shown that GLD has won this round in term of upgadability, at least.
5. PFA will work up to 800 GeV center of mass energy better then pure calorimeter energy sum.
6. Results of this phenomenological procedure shows that the reconstruction program for higher energies should consists of at least two different algorithms. One is the conventional PFA (first clusterization of around track prediction then subtraction–substitution scheme) and another one is close to the old Energy Flow that was used at LEP or HERA experiments (clusterization without track prediction, then cluster to track matching). For comparison of these two methods see: http://www.desy.de/~morgunov/talks_articles/Krakow.ps.gz
Reconstruction program should be able to make choice between these two algorithms to apply it for different jet energies.

To do

1. Take into account of charged showers satellites to get a full confusion term.
2. Look at more detector configurations as zero approximation before full simulation (much less time consuming)
3. Look at other physical channels with different jet density.
4. Look at the tracker quality at high energies and its influence on PFA.

Appendix

Remarks on page 3

Left hand side:

Separation quality was extracted from double particle simulation during CALICE HCAL design studies.

see: http://www.desy.de/~morgunov/talks_articles/morg_rasp_lcws_2004.pdf

A. Raspereza's program has two steps:

1. Hits in volume of overlapped hadron showers were decomposed into number of clusters with different properties by DeepAnalysis algorithm.
2. It make splitting of these set of clusters into two separated hadron showers using cluster properties.

This program work for two showers only. Could be rewritten as a full reconstruction PFA.

Right hand side:

The energy of such a particle will be lost partially and this lost energy could be classified as event energy error and could be added as a confusion term into energy resolution!

Remarks on page 6

The resolution of electromagnetic (gammas) part of event was included into perfect PFA. The efficiency for gammas is of about 99 percent, see Predrag Krstonosis dissertation at DESY. So gammas is not involved into confusion term of PFA.

There is no double counting in this distribution. Each charged hadron has its own possibility to catch a “part” of a neutral particle that is near by during a reconstruction procedure.

The calculation of the correct energy weight for the neutral hadron is based on the subtraction–substitution scheme that was proposed in http://www.desy.de/ ˜ morgunov/talks_articles/Snowmass_rec_morgunov.ps.gz

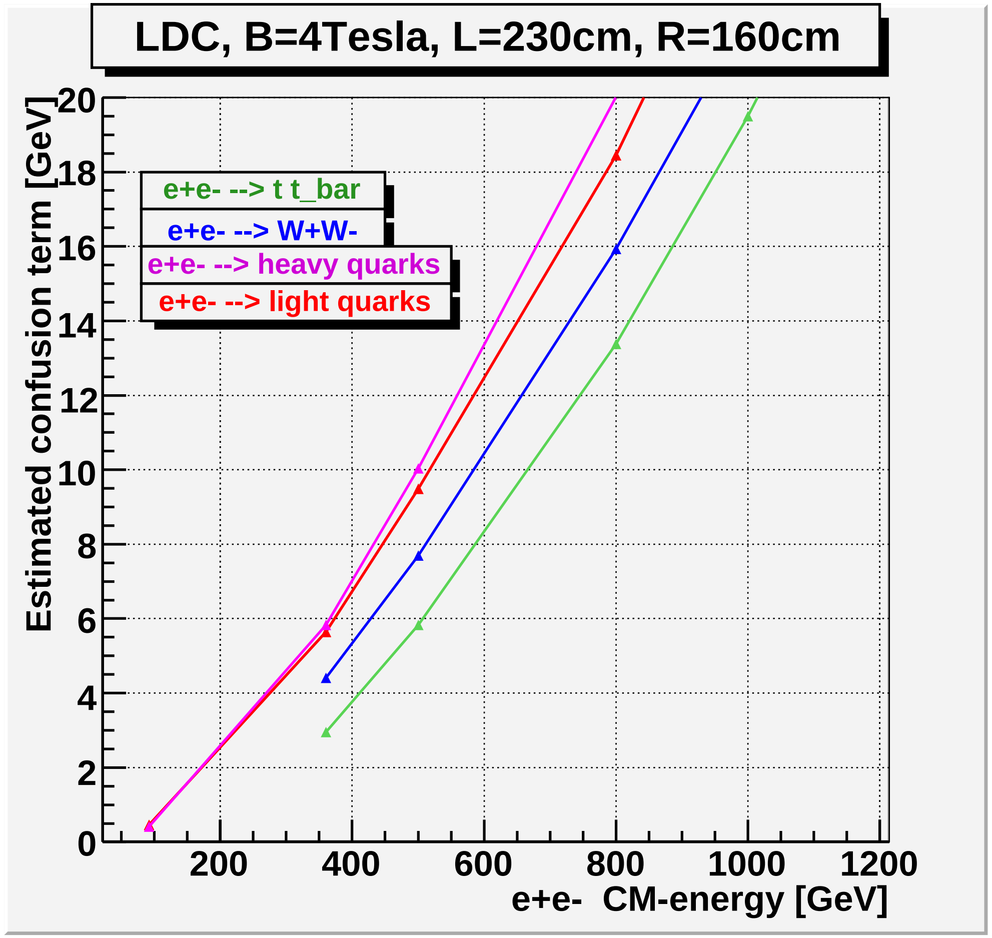
Briefly about Subtraction–Substitution scheme for charged hadrons:

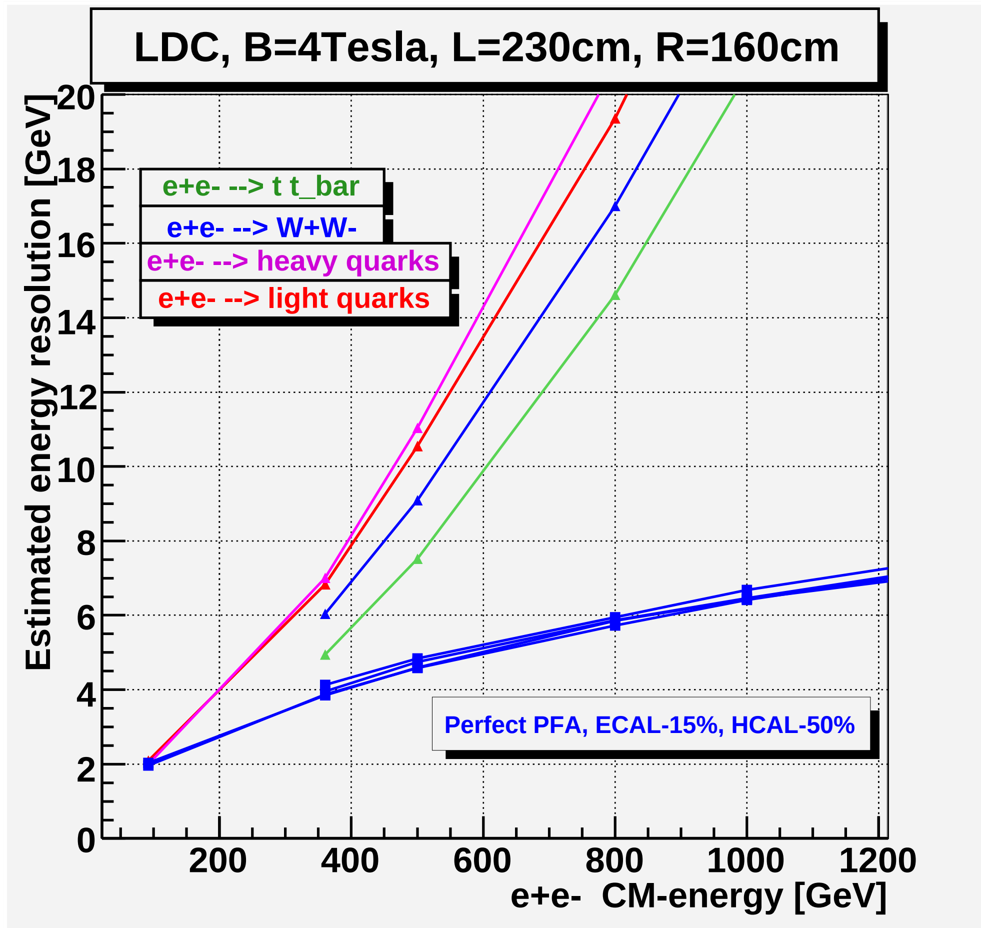
If momentum of charged particle well known than the shower collected around track prediction should not consists of more then $E_{charged} + 2 \times \sigma_E$; where $E_{charged}$ is well defined by it momentum measured by tracker and σ_E is defined by calorimeter resolution.

So, the energy lost by neutral particle could not be more than $2 \times \sigma_{E_{charged}}$

Similar scheme was recently introduced into Pandora.

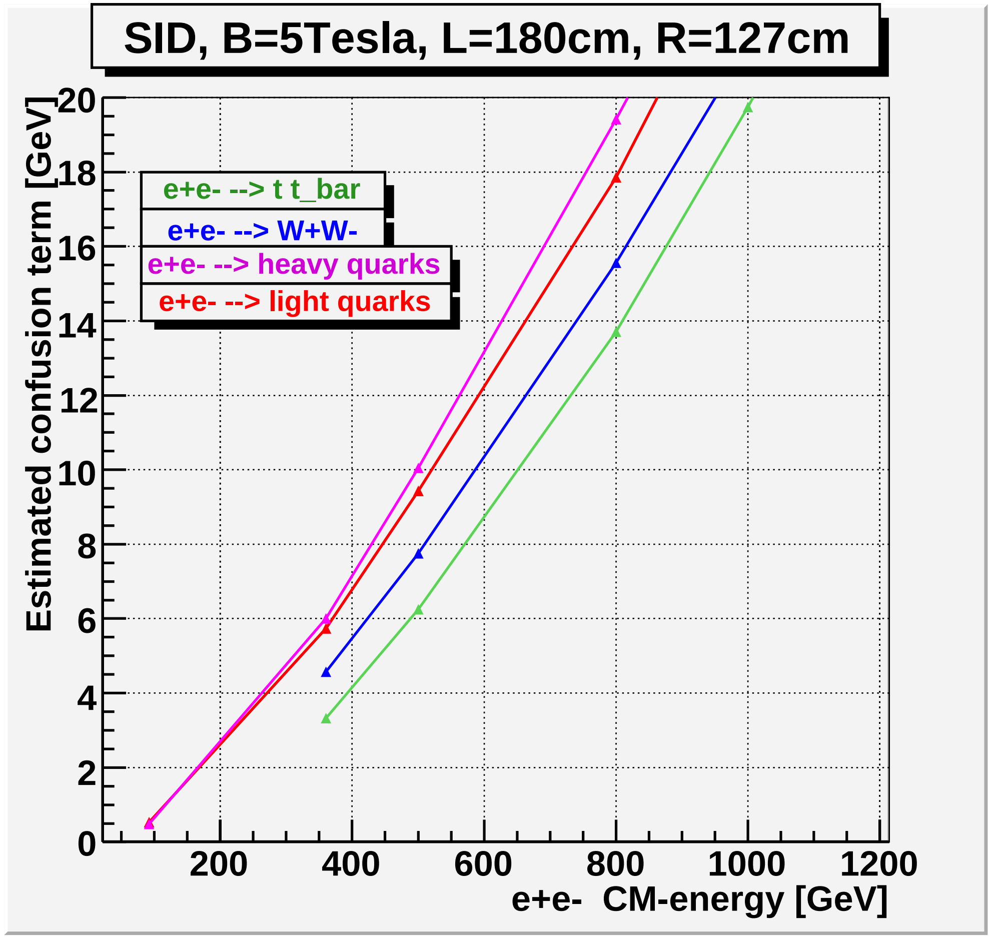
LDC, $e^+e^- \rightarrow$ *any partons*

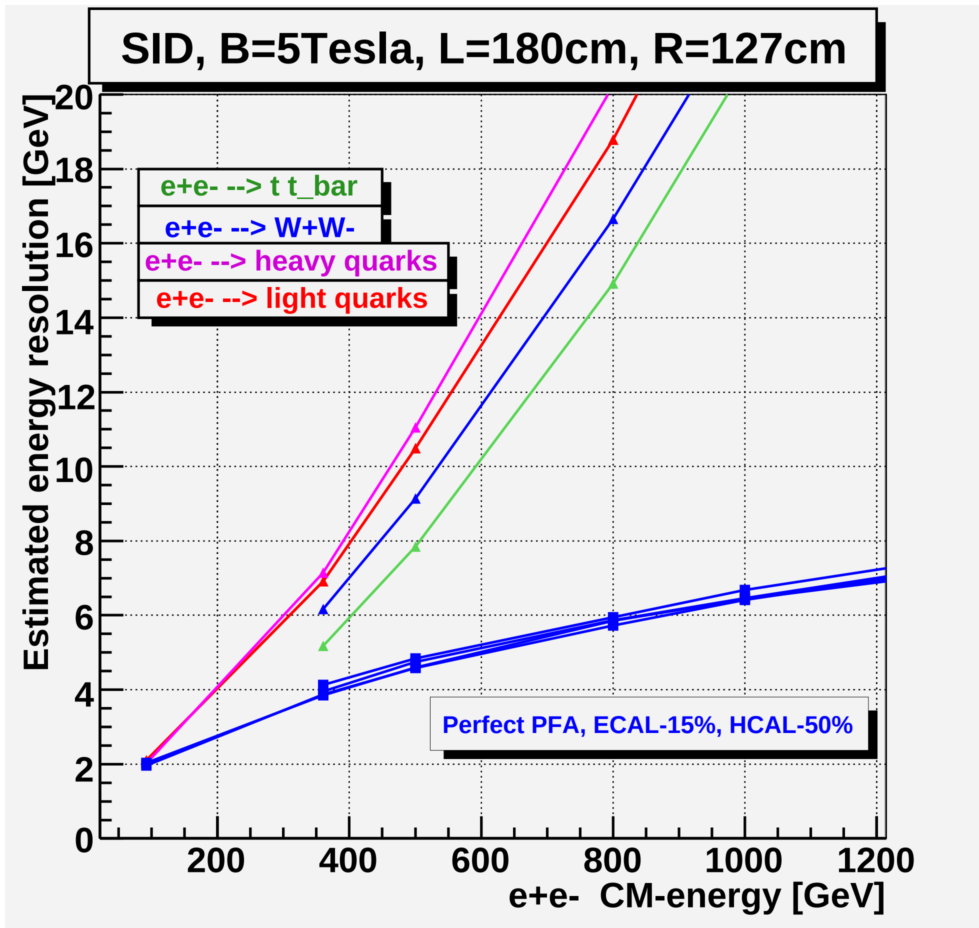




$$\sigma_{\mathcal{E}} = \sigma_{PerfectPFA} \oplus \sigma_{conf}$$

SID, $e^+e^- \longrightarrow any\ partons$





$$\sigma_{\mathcal{E}} = \sigma_{PerfectPFA} \oplus \sigma_{conf}$$