Software and jet energy measurement

On the importance to understand the simulation

1 - **To test the performance**

2 - **To optimise the detector**

3 – **To use the relevant variable**

Define the task job

> What we want to measure with the detector

JETS , but which energy ?

(Please don't forget the Tau decays for CP violation in Higgs decays)

Define the flexibility of the constraints

> Which values are better to reach in order to cover correctly the physics program

Granularity ?

(Please don't say that detector optimised for PFA can't have compensation)

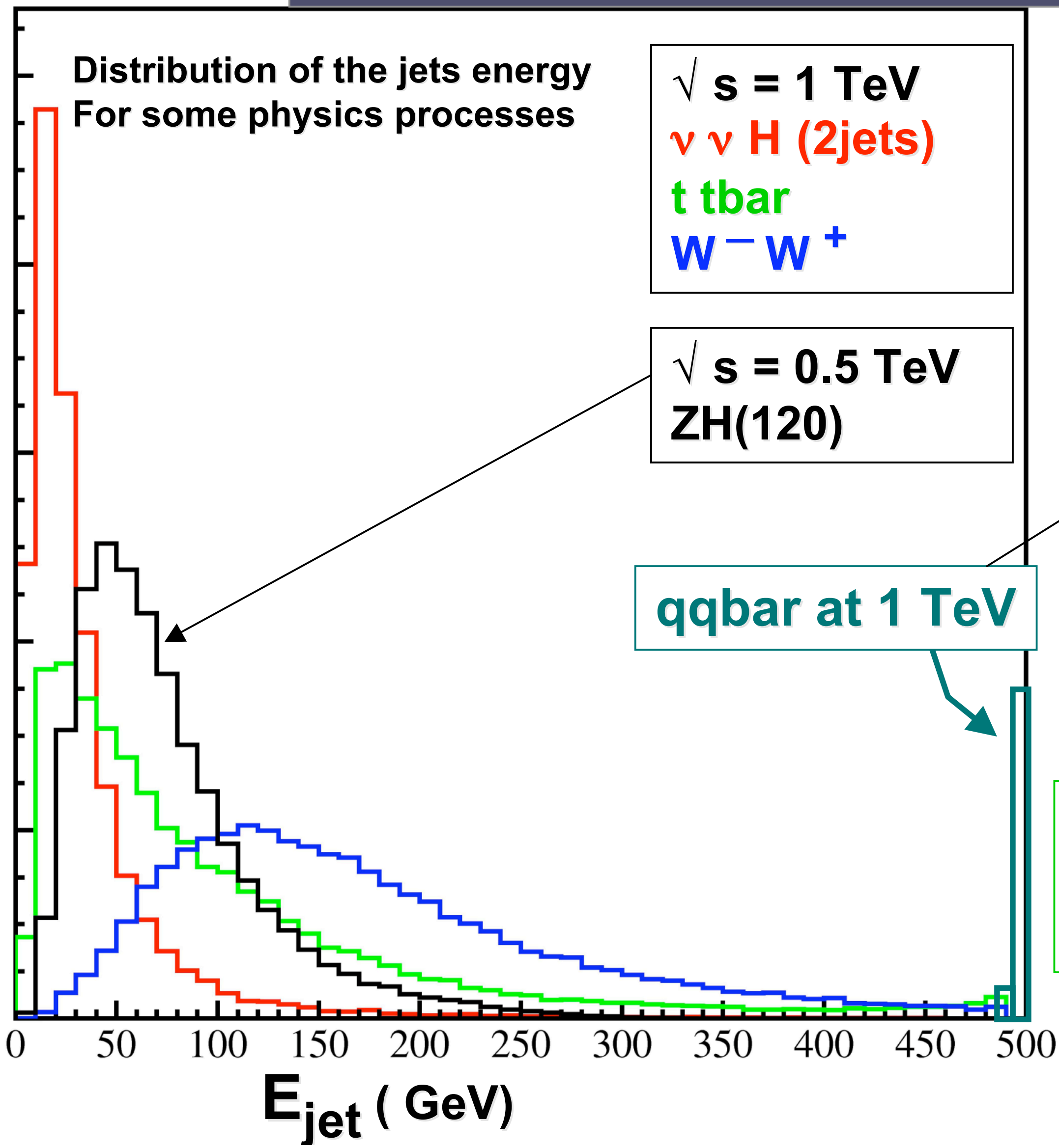
Define the way to choose

> SIMULATION and Test beam

What is in and what is not in simulation

WHICH JETS ?

Jet energy range of interest for a good Jet energy resolution



But which physics need a good Jet energy resolution for this process ?

Title of the novel
"of the interest to be good below 200 - 250GeV "

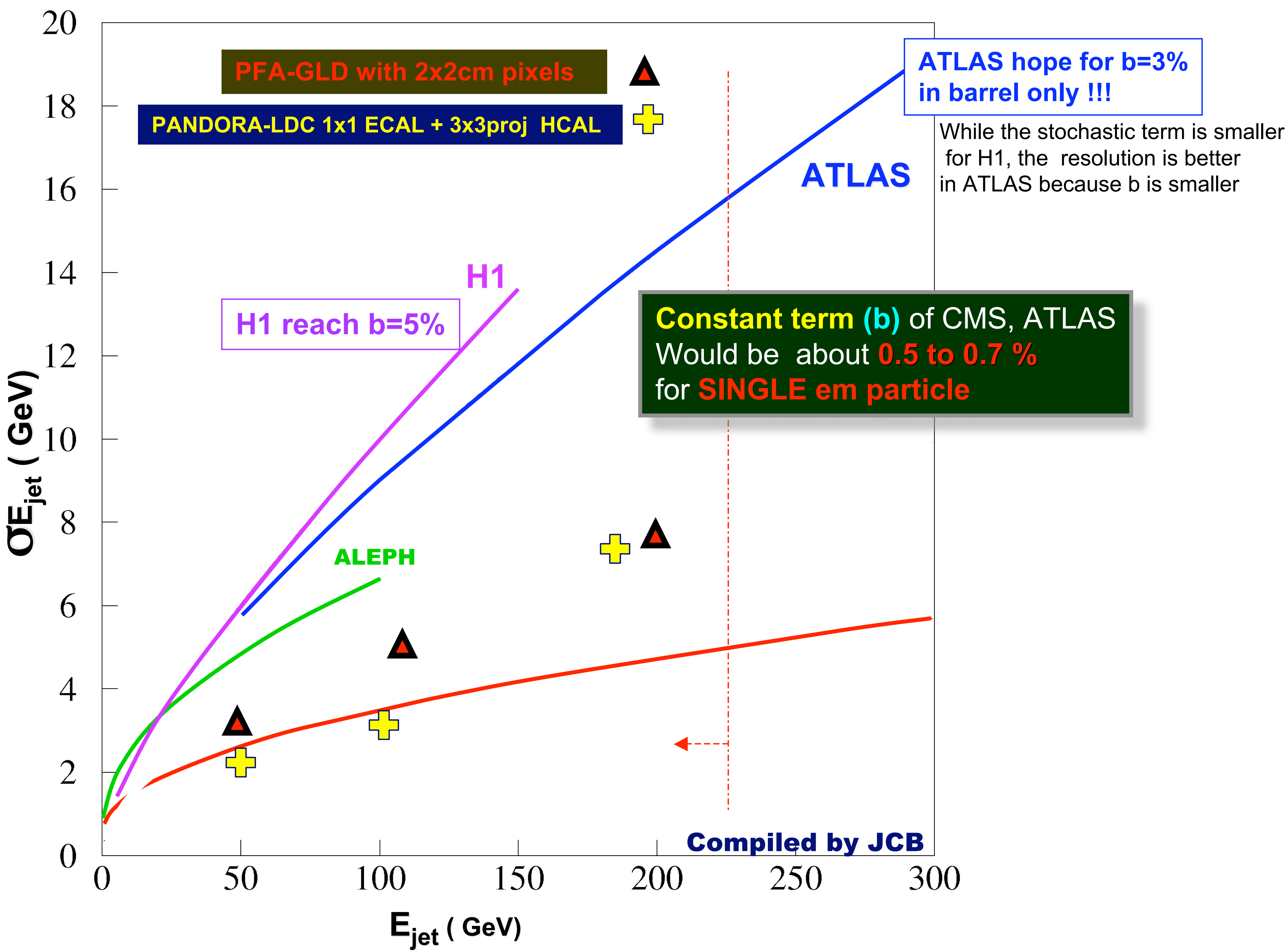
The energy resolution

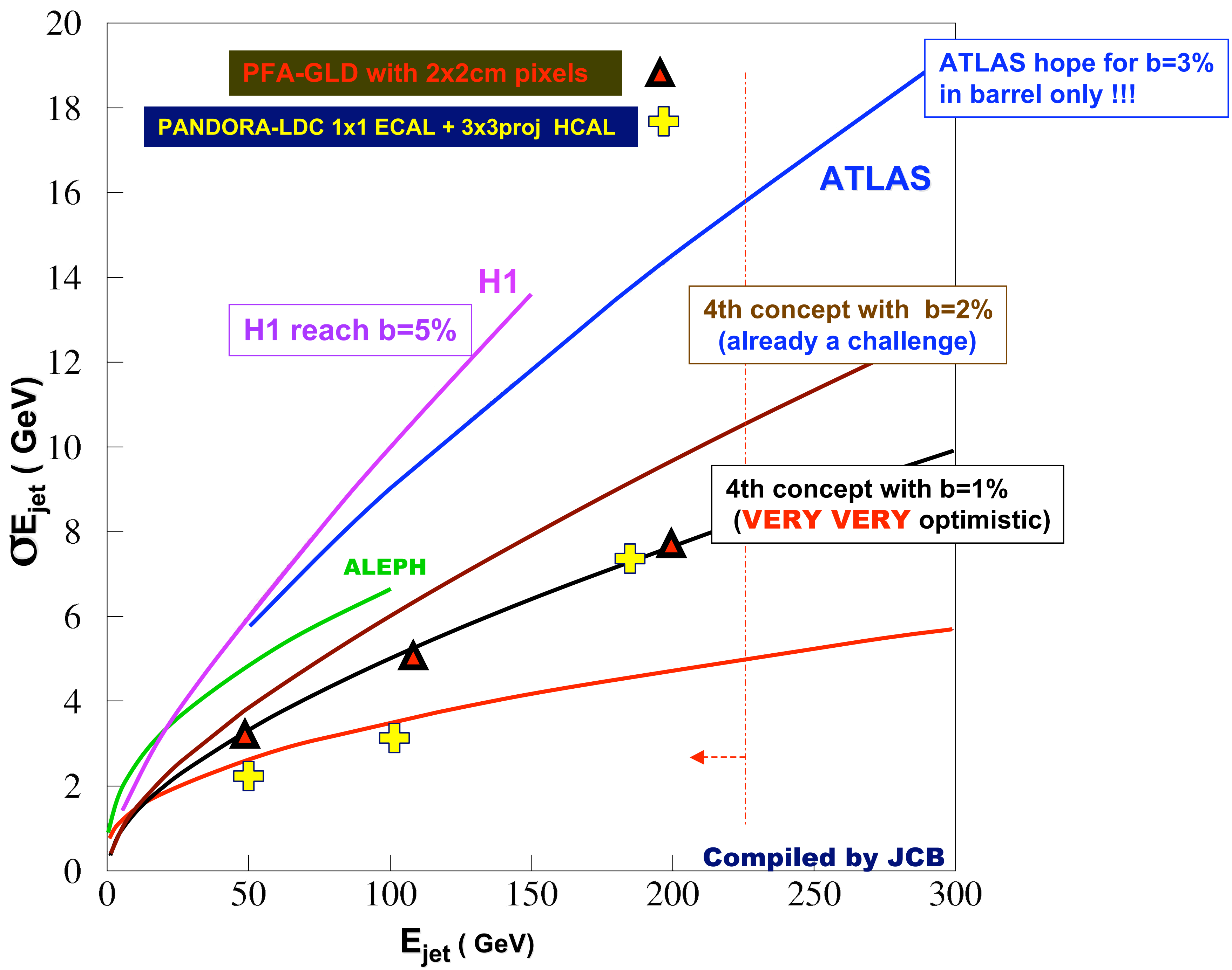
The jet energy resolution could be written as :

$$\Delta E_J = a \times \sqrt{E_J} \oplus b \times E_J + c$$

	a	b	c (GeV)
ALEPH method Quasi PFA	0.59	0	0.6
ATLAS at best !!	0.6	0.03	0
H1	0.5	0.05	0
PFLOW-ILC	0.3	0	0.5

NIM A360 (1995),480


PFA-GLD with 2x2cm pixels
PANDORA-LDC 1x1 ECAL + 3x3proj HCAL
ATLAS hope for b=3%
in barrel only !!!
While the stochastic term is smaller
for H1, the resolution is better
in ATLAS because b is smaller
ATLAS
H1
H1 reach b=5%
Constant term (b) of CMS, ATLAS
Would be about 0.5 to 0.7 %
for SINGLE em particle
ALEPH
Compiled by JCB
σE_jet (GeV)
E_jet (GeV)
0
2
4
6
8
10
12
14
16
18
20
0
50
100
150
200
250
300



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ATLAS hope for b=3% in barrel only !!!
ATLAS
H1
H1 reach b=5%
4th concept with b=2% (already a challenge)
4th concept with b=1% (VERY VERY optimistic)
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σEjet (GeV)
Ejet (GeV)
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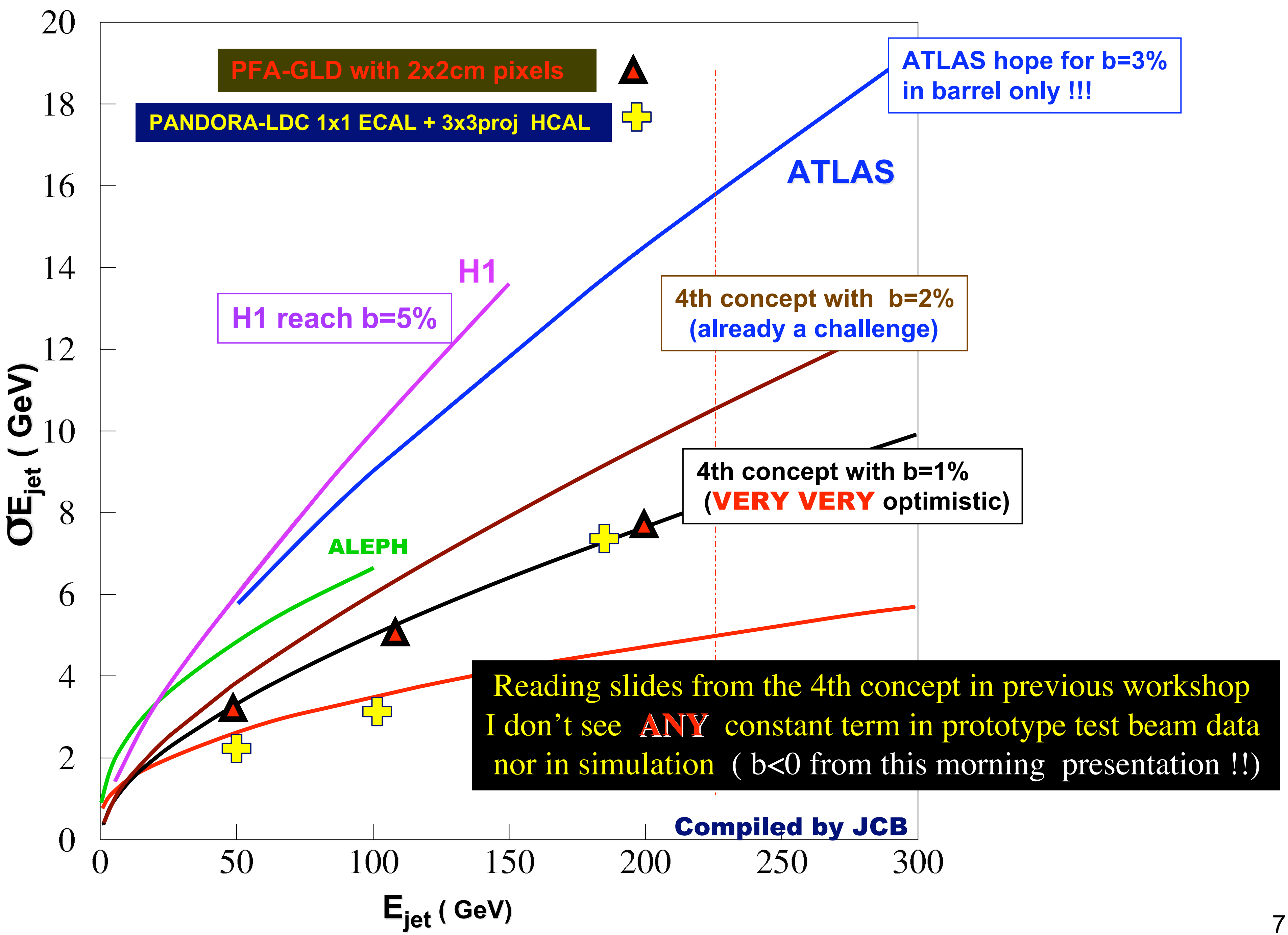
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ATLAS
H1
H1 reach b=5%
4th concept with b=2%
(already a challenge)
4th concept with b=1%
(VERY VERY optimistic)
ALEPH
Reading slides from the 4th concept in previous workshop
I don't see ANY constant term in prototype test beam data
nor in simulation (b<0 from this morning presentation !!)
Compiled by JCB
σE_{jet} (GeV)
E_{jet} (GeV)
0
2
4
6
8
10
12
14
16
18
20
0
50
100
150
200
250
300

Constant term

- Inter-calibration
- Dead zone (between module, between fibbers, between end-cap/barrel)
- Readout response
  - electronic noise (could depend of E and t)
  - light collection
  - effect of irradiation (for example on photocounter , could depend of t)
- Non-linearity
  - linearity of the electronics readout system
  - linearity of the deposited energy in the calorimeter vs particle energy
- Shower Leakage
- QCD effect from Rcone definition of the jets

Constant term

- **Inter-calibration**
- **Dead zone (between module, between fibbers, between end-cap/barrel)**
  (so far, I don't see many space for cables on the nice picture of the 4th concept)
- **Readout response**
  - **electronic noise (could depend of E and t)**
  - **light collection**
  - **effect of irradiation (for example on photocounter , could depend of t)**
- **Non-linearity**
  - **linearity of the electronics readout system**
  - **linearity of the deposited energy in the calorimeter vs particle energy**
- **Shower Leakage**
- **QCD effect from Rcone definition of the jets**

Usually not in simulation or test beam prototype data

- depends on test beam (beam energy, prototype size, study of dead zone, ??etc…)
- depends on the realism of the geometry in the simulation

Optimising a detector

- FIRST of all , **CLUSTERIZE** !!
  (with dedicated algorithm for each shower type : em and hadronic)

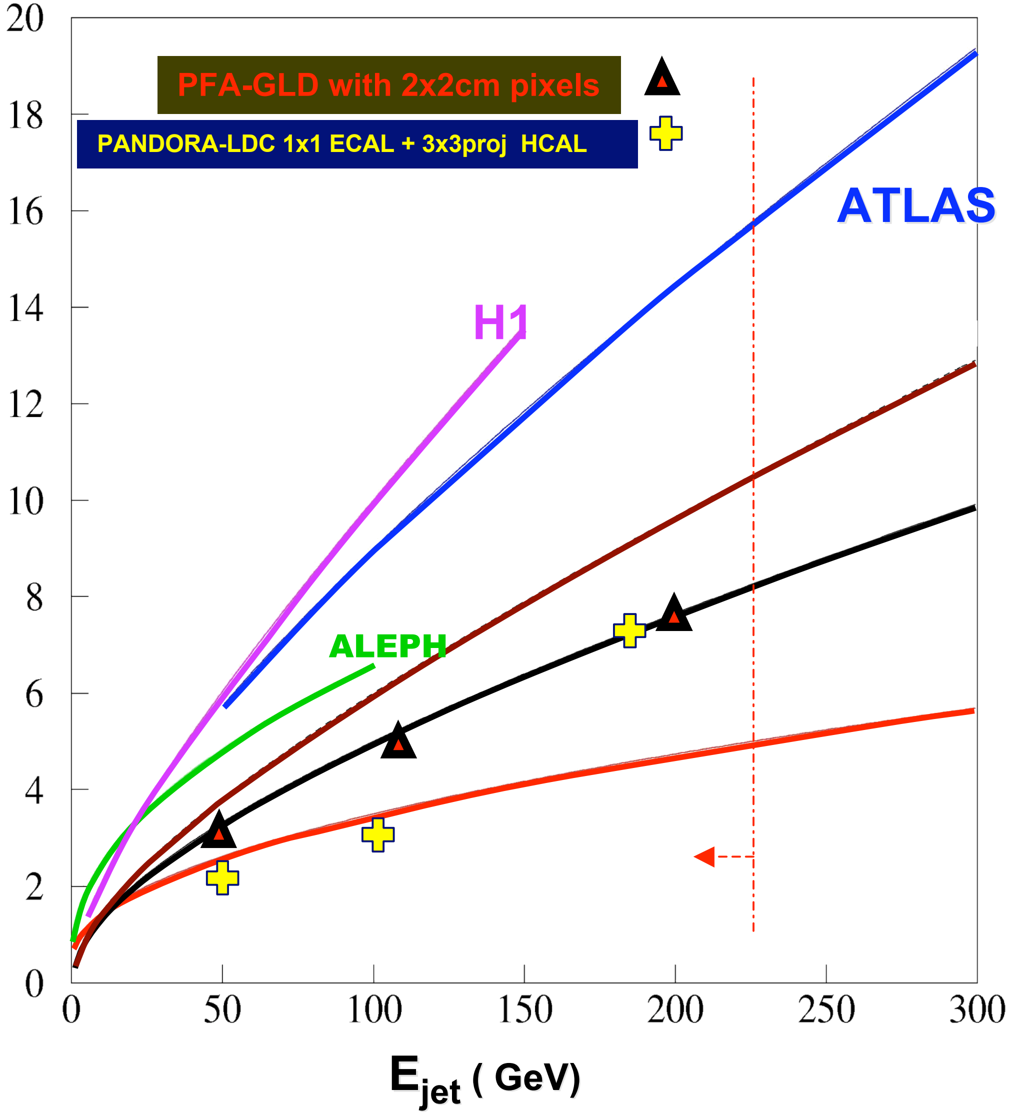
- WARNING, optimised clustering **DEPENDS** on geometry, device and shower type

- Compare Energy, position, direction, resolutions **AFTER clustering**

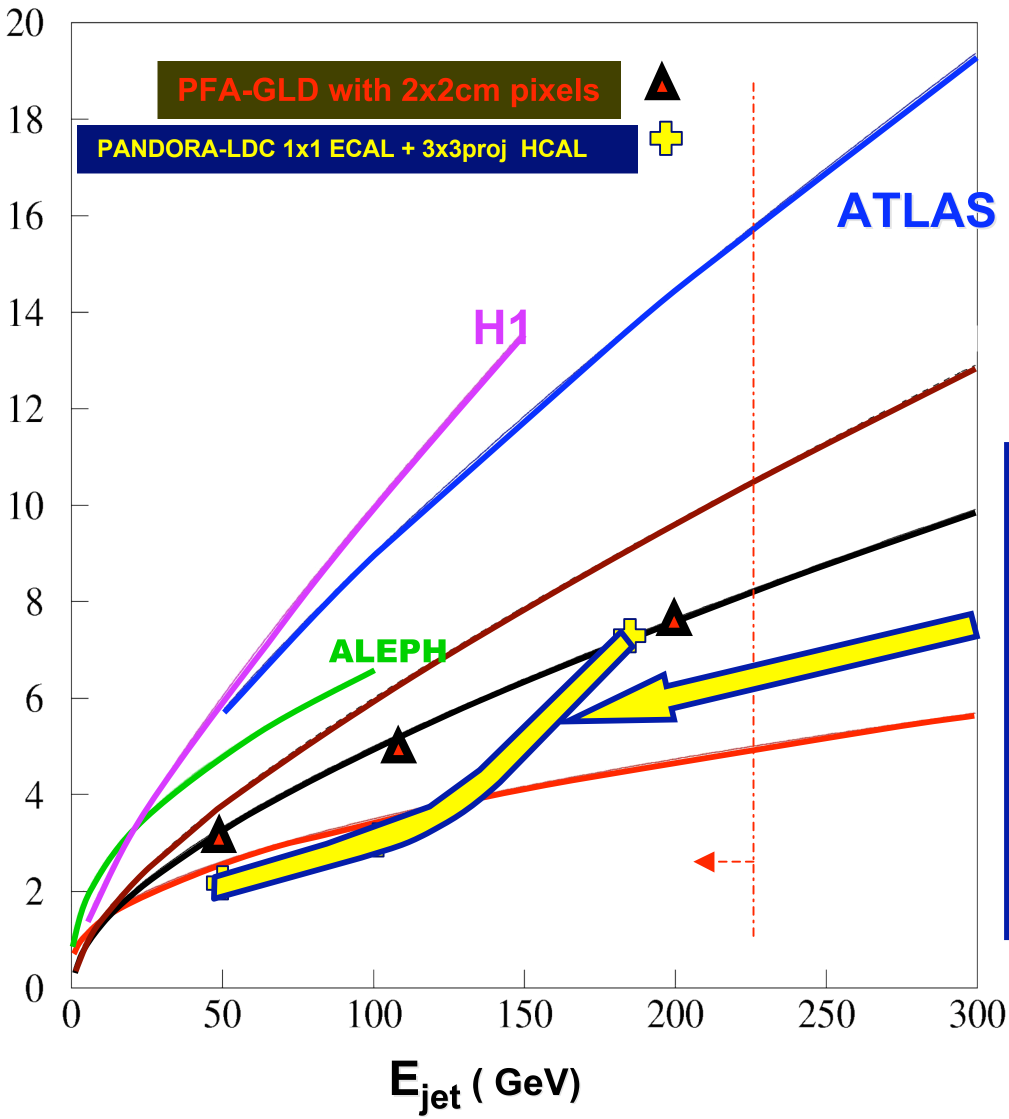
- Ultimate performance estimation MUST include a precise **work on calibration**
  (i.e. on leakage estimation, software compensation , etc..)
  if not done, there is good chance to have bad performance for high energy jet

  SEE next slide

Serialising the problems

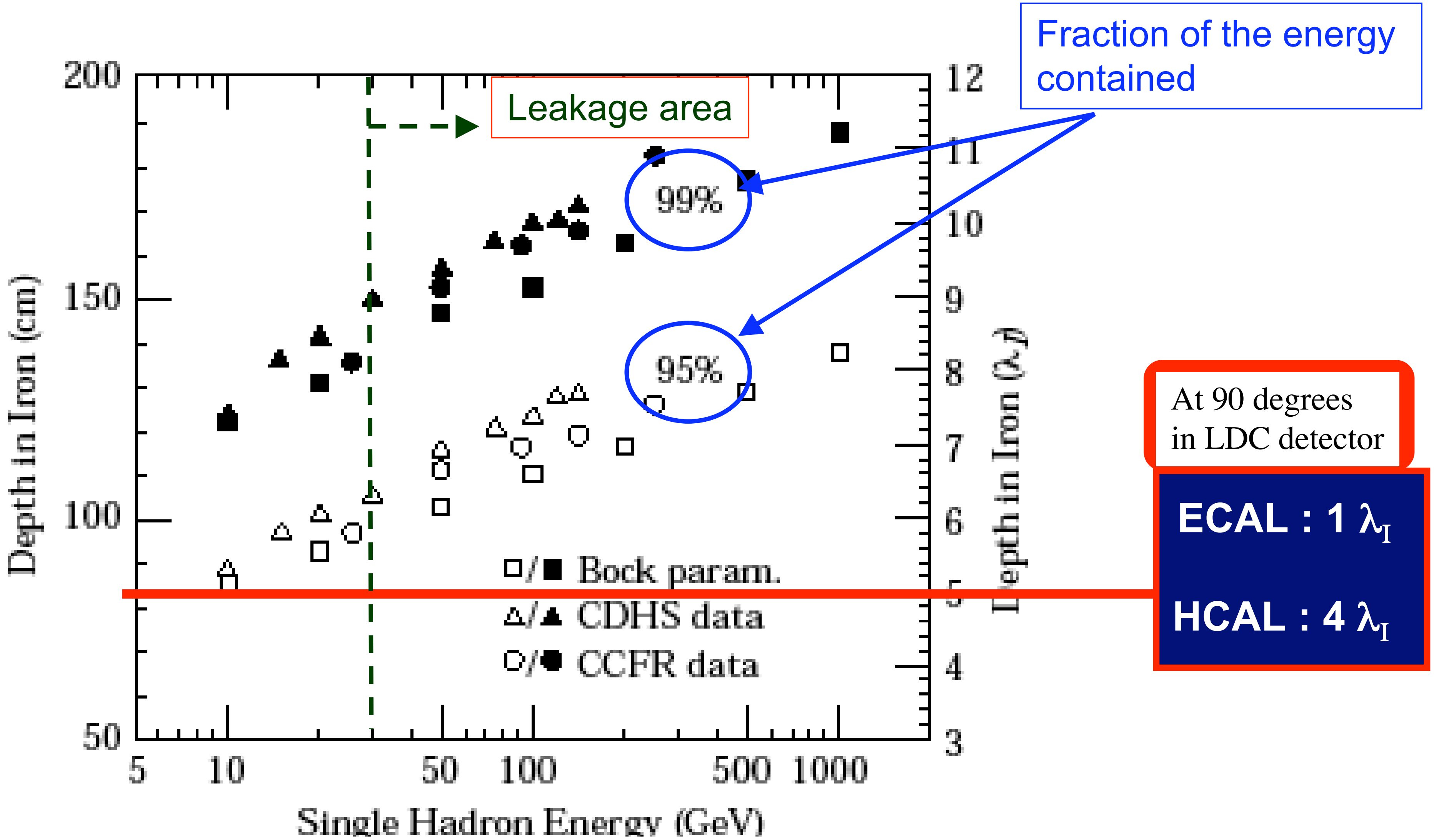


Serialising the problems

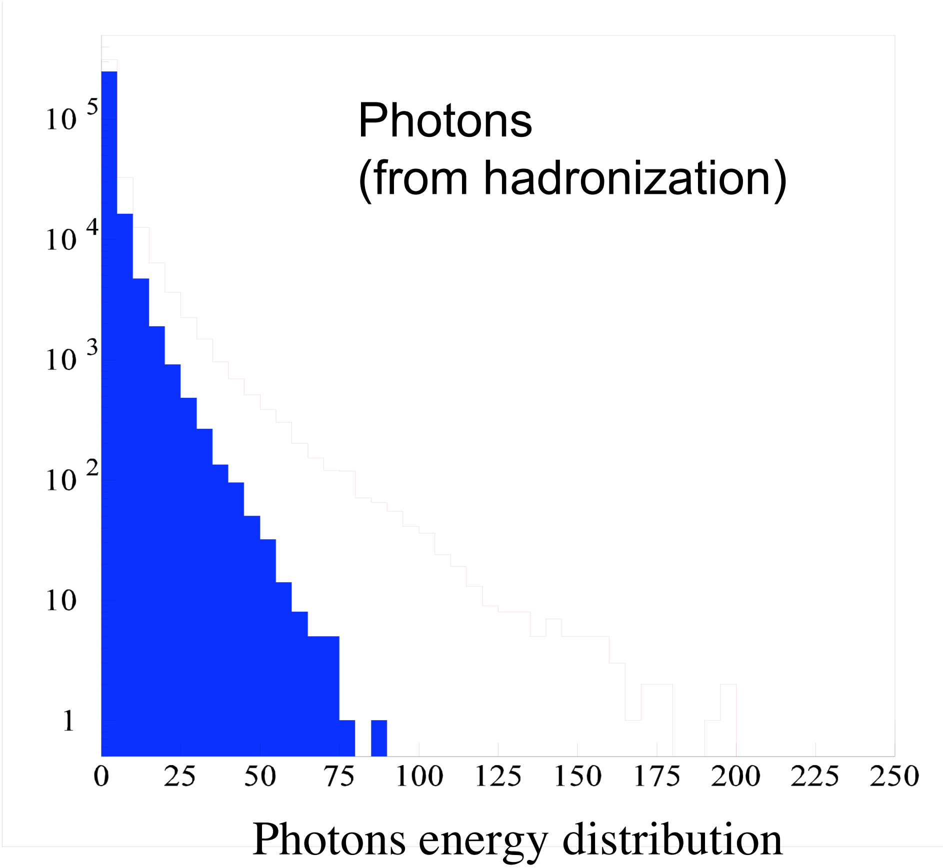


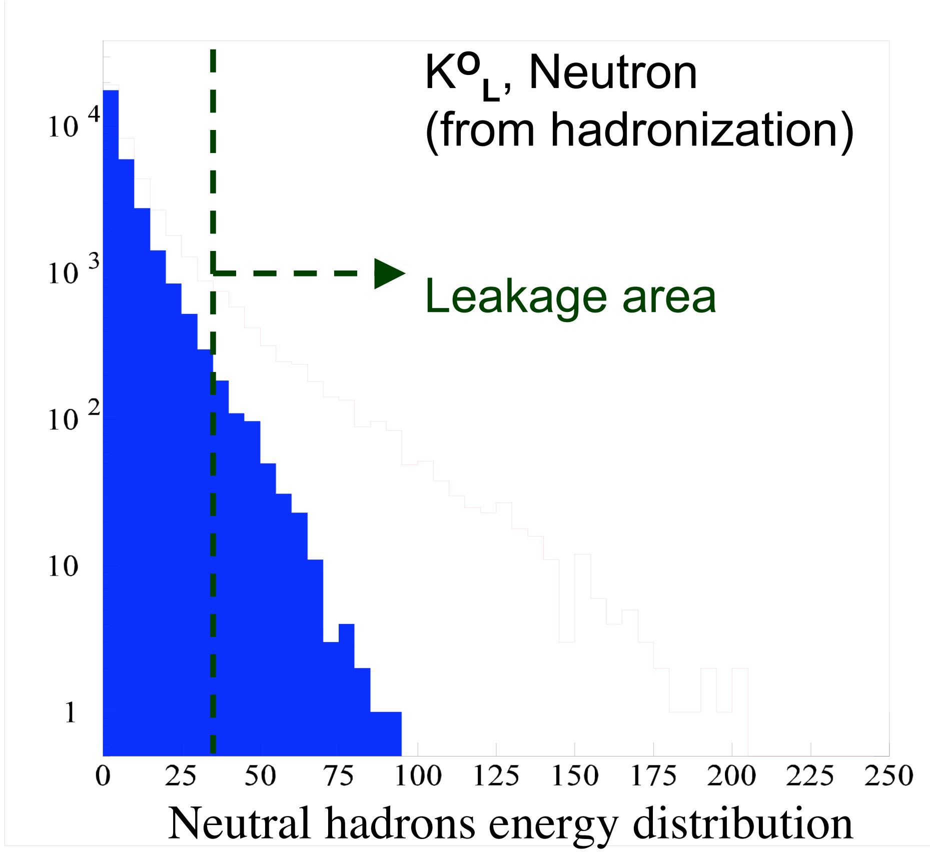
The rising is not observed with GLD PFA
So why is it like that with PANDORA

- Leakage on EM shower ?
- Leakage on hadronic shower ?
- energy resolution on Hadronic shower ?
- related to the PFA algorithm ?
- Related to the detector itself ?
- SEGMENTATION
- etc…


Leakage area
Fraction of the energy contained
99%
95%
Depth in Iron (cm)
Depth in Iron (λ_I)
Single Hadron Energy (GeV)
□/■ Bock param.
△/▲ CDHS data
○/● CCFR data
At 90 degrees in LDC detector
ECAL : 1 λ_I
HCAL : 4 λ_I

Jet 100 GeV vs Jet 250 GeV





PFA will not perform correctly for high energy jet without a dedicated leakage correction for neutral hadronic shower (or a very large number of interaction length)

Use the relevant variables

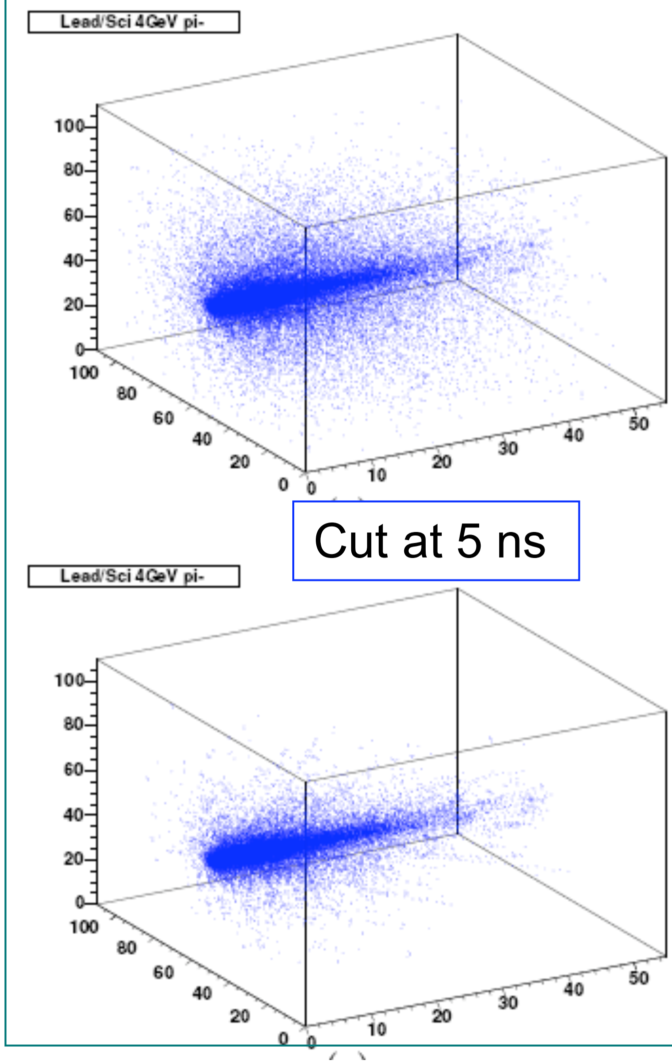
time of arrival after the BX

(A large fraction of neutron signal is beyond 150 ns)

- Could be used to separate the neutron component of the shower
- could create pile up from one BX to the next ones
- could be a nice tool for the PFA
- Could be taken into account in the 4th concept ??
- Could improve the PFA for Scintillator calorimeter

The time must be integrated in the PFA (reconstruction)

4GeV pion in Lead/scint



Conclusion

Optimising the detector, it is better to

1 – Understand what is in the simulation and what is not !!
Depending on what is in the simulation, wrong conclusion could be obtained
example : constant term in calorimetric approach

2 – To remember that limitation can also come from the proposed detector
When testing performance at high energy , check also the limitation
of the simulated detector (example with the energy leakage).
Risk of mixing different sources leading to bad PFA performance

3 – To take the relevant variable
In case of scintillator, silicon, the introduction of the timing (or cut on timing)
Could change the picture for the neutral hadron. Time is one of the relevant variable
It has to be included in the game (PFA or not)

The angular dependence !!

➢PFA method could be affected by a degradation with polar angle (reduce bending separation in endcap).