Combined test for Linear Colliders

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Goals of a combined test

- PFA is an attractive concept which is the corner stone of two principal ILC concepts (ILD,SID) but until now it is not really tested in real life.
- Few PF Algorithms exist. They were fine tuned for specific sub-detectors. We need to check them and develop new generation which is more flexible. Real data will allow such development
- We need to compare different options for the future LC experiments. Only combined tests can allow a true comparison when it concerns the PFA-related performance.
- Previous experience (DHCAL+Eudet Telescope) showed a real need for a common acquisition system. Combined test will be the place to realize it.

What we can do with a combined test?

Configurations of PFA that we can try to test:

- Charged particles with the same energy
  →need rather high intensity beam.
- Charged and neutral particles together
  →need target and appropriate magnetic field

The second option leads closer to jet configurations

Charged particles with the same energy

Simple configurations : Tracker+ECAL+HCAL

Beam intensities available at the SPS

Up to 10^7 particles/spill of 10 seconds

Calorimeters clock = 5 MHz→ 200 ns window

Probability to have more than 2 tracks in one calo event

(taking a Poisson distribution with $\lambda = 0.2$)

≈0.05

Beam dimensions ≈ 2x2 cm^2

To determine precisely the distance between the tracks we need a tracker in front of the calorimeters

Charged particles with the same energy

Available trackers

1- CMS Telescope:

→ 6 double-layer of silicon strips of 10x10 cm^2 each.

→ Resolution of 30 microns for each layer

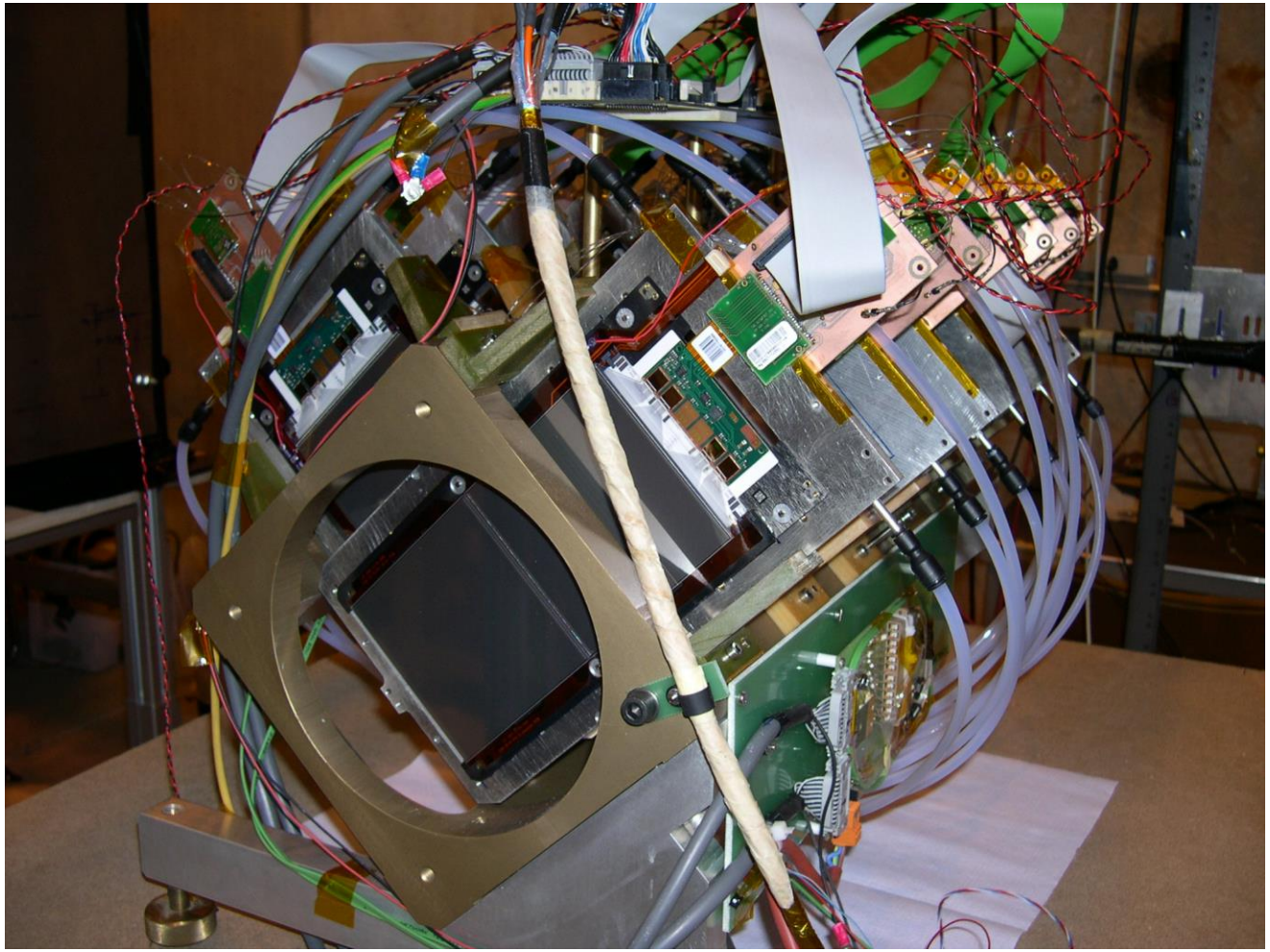
→ 40 MHz clock and integration time <100 ns

2- Eudet Telescope

→ 6 layers of silicon pixels 0.7x0.7 cm^2 each

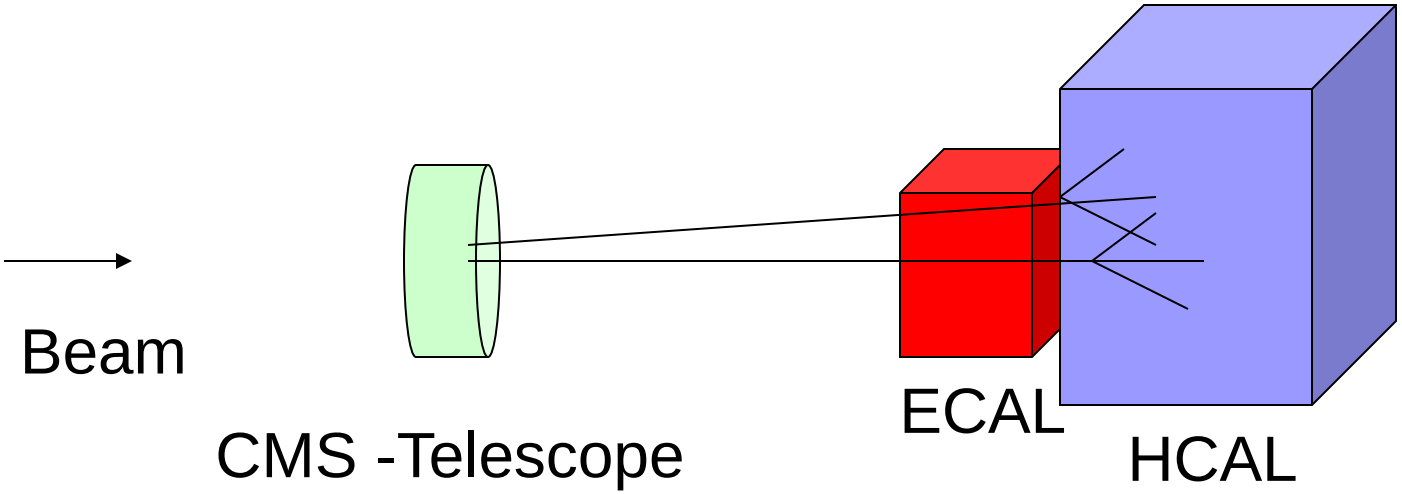
→ Resolution of few microns for each layer

→ Integration time # 200 μs



CMS telescope

Charged particles with the same energy



→Variable distance to accommodate divergent beams
→Acquisition based on Xdaq system
→ Mechanical structure to be developed

Charged and neutral particles

Complicated configurations :

(Tracker)+TPC+ECAL+HCAL and still modular

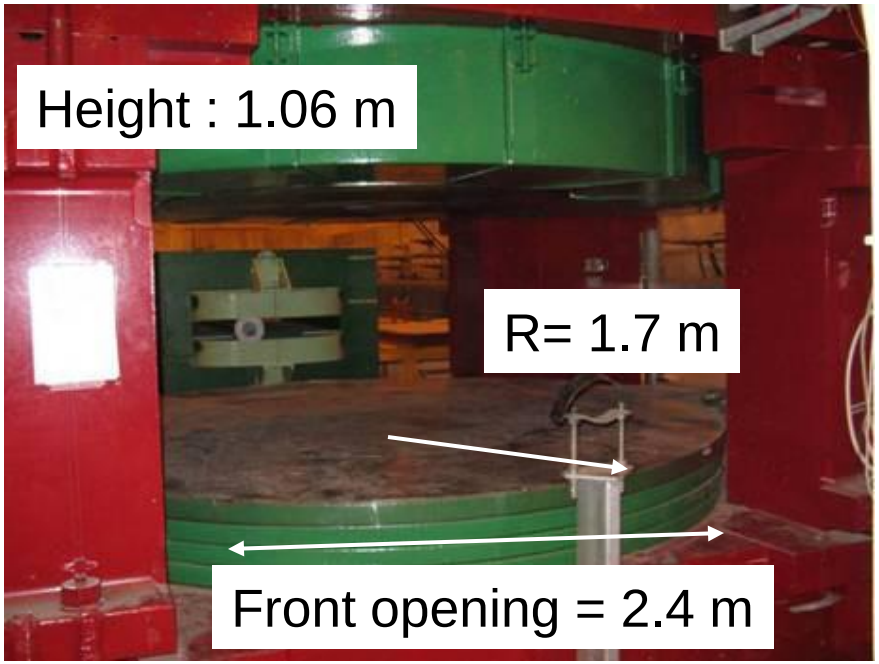
→ We need a target to obtain interactions;

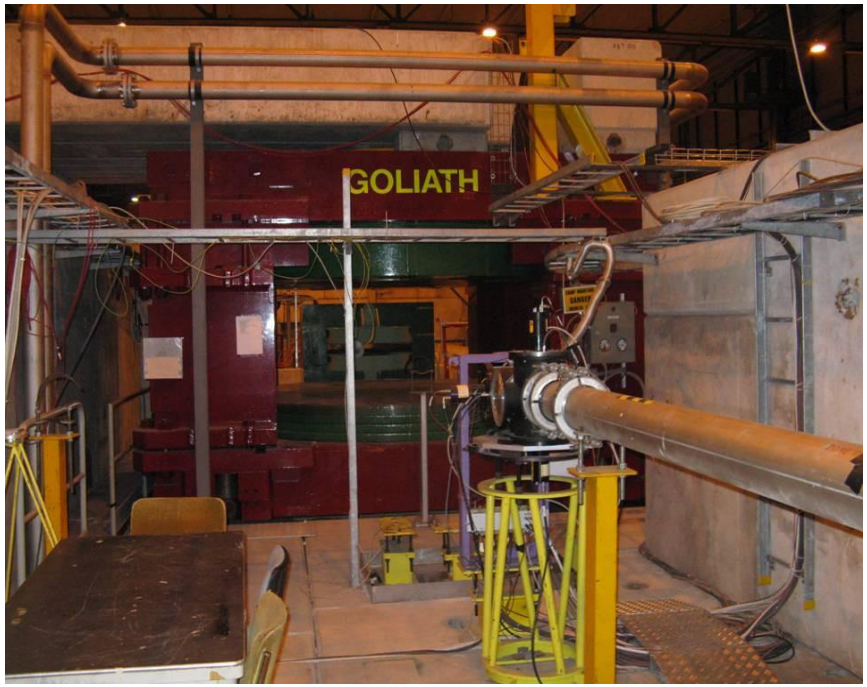
→ We need a magnet to measure momentum of at least part of the particles (need to be carefully evaluated);

→ A first step is to place the TPC in the magnet

Charged and neutral particles

Any available magnet? Yes Goliath





SPS/H4 line

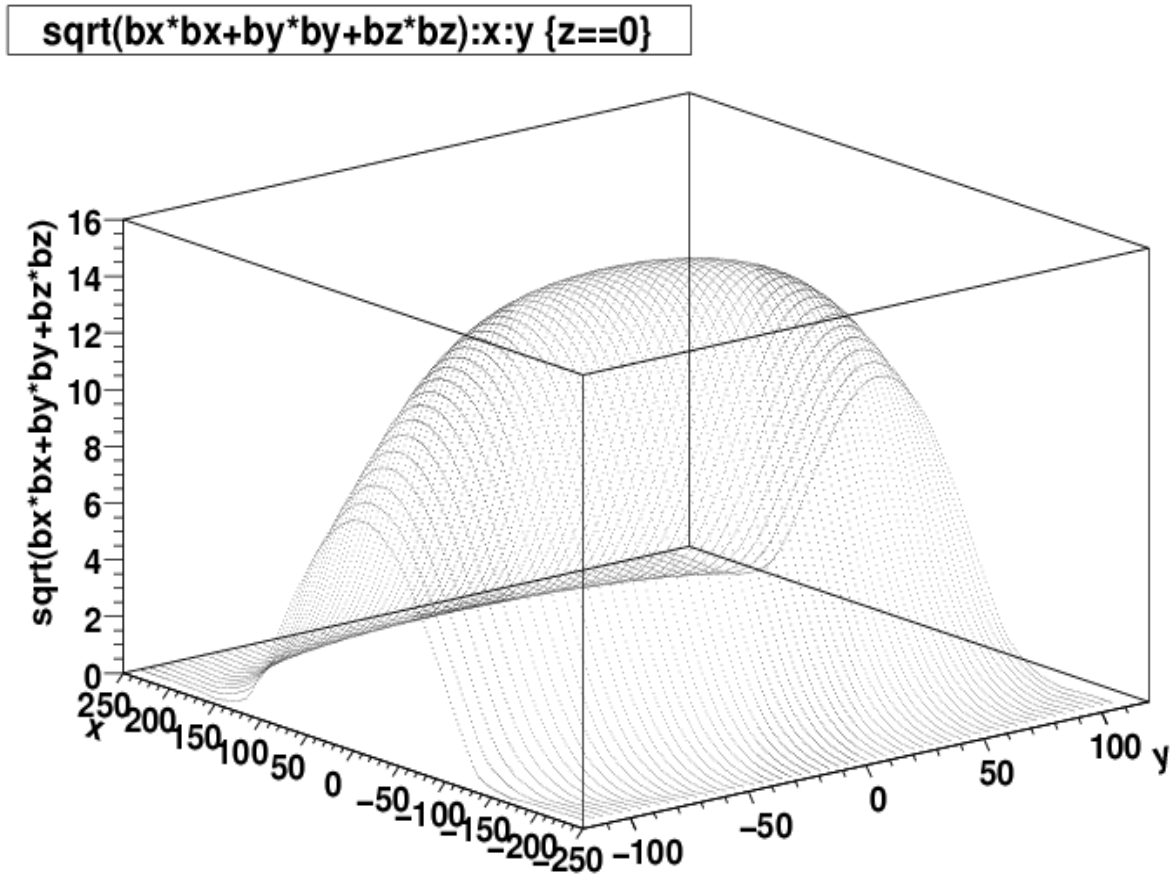
Courtesy M. Alfonsi

Charged and neutral particles

→ 1.4 T is it enough?

→TPC could be included easily? Yes

→ Calorimeters inside Goliath? Difficult



Map realized by NA57 experiment

Charged and neutral particles

Another Magnet : H2 beamline CMS magnet

→3T
Space : about $1m^3$

→TPC could be
included easily? yes

→ Calorimeters :
Ecal prototype Yes but not $1m^3$ HCAL
Could be placed outside the magnet

SDHCAL on the H2 line in front of the H2 magnet

Proposal

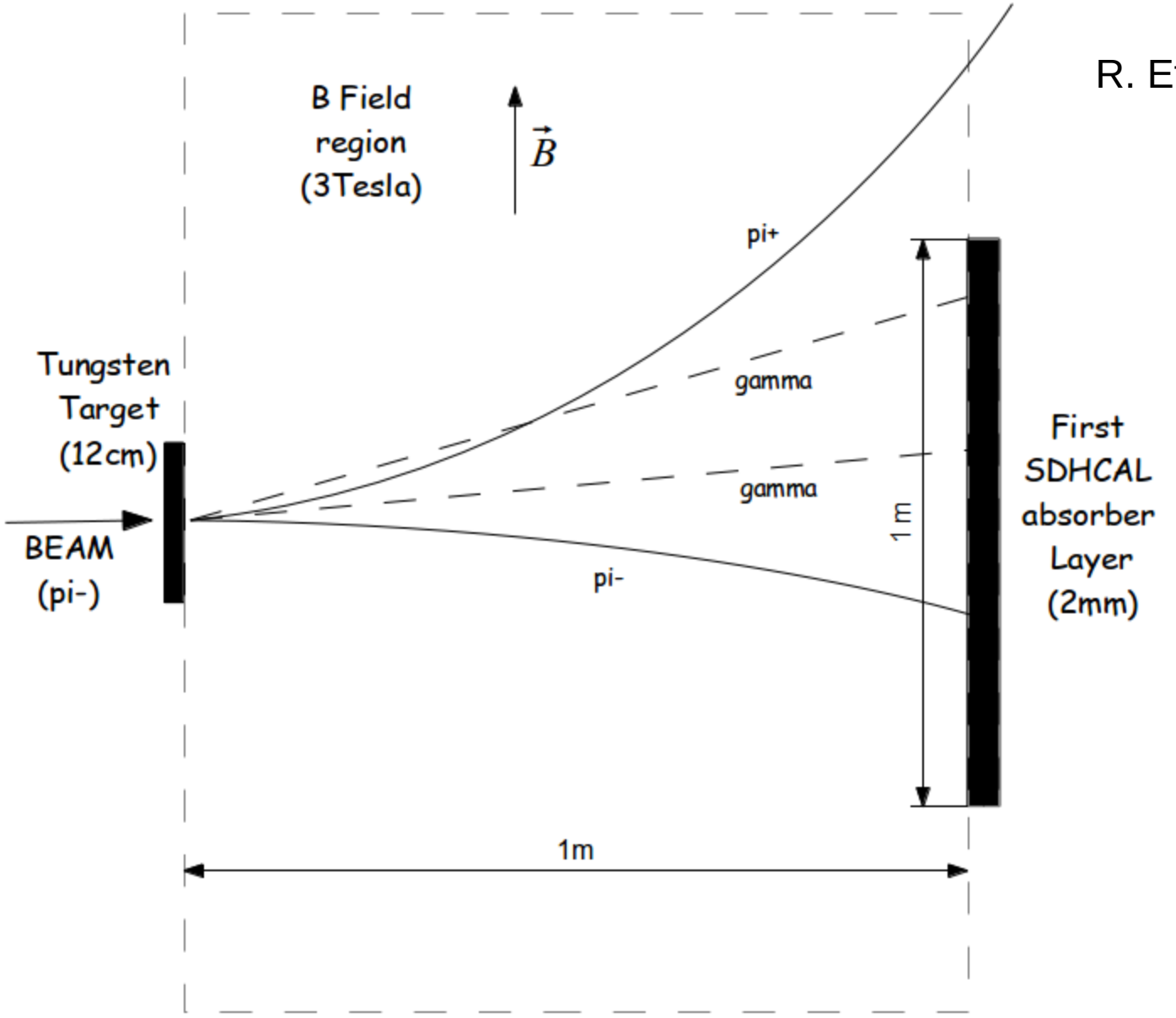
To have a combined test with TPC and SDHCAL as a first step in a series of common tests including Pixel detectors, Ecal and HCAL of different technologies could follow.

→We need to simulate the setup and optimize it. DD4HEP could be the framework. This will allow to select the target nature and its thickness, the distance between the TPC and the calorimeters…
A collaboration between the experts of the two communities is needed.

→We need to agree on a common DAQ system. We have the expertise of Xdaq of CMS which is easily extensible to other detectors but EUDAQ is also an option. We need to agree on the modes to be used: triggerless? Power-pulsed?.. For SDHCAL the different modes are possible

→We need to submit a formal request to CERN not only to have a TB at H2 but also to do the needed work to ensure a 3-Tesla magnetic field and enough time access in the coming years.

R. Eté


B Field
region
(3Tesla)
$\vec{B}$
pi+
gamma
gamma
pi-
Tungsten
Target
(12cm)
BEAM
(pi-)
1 m
First
SDHCAL
absorber
Layer
(2mm)
1m

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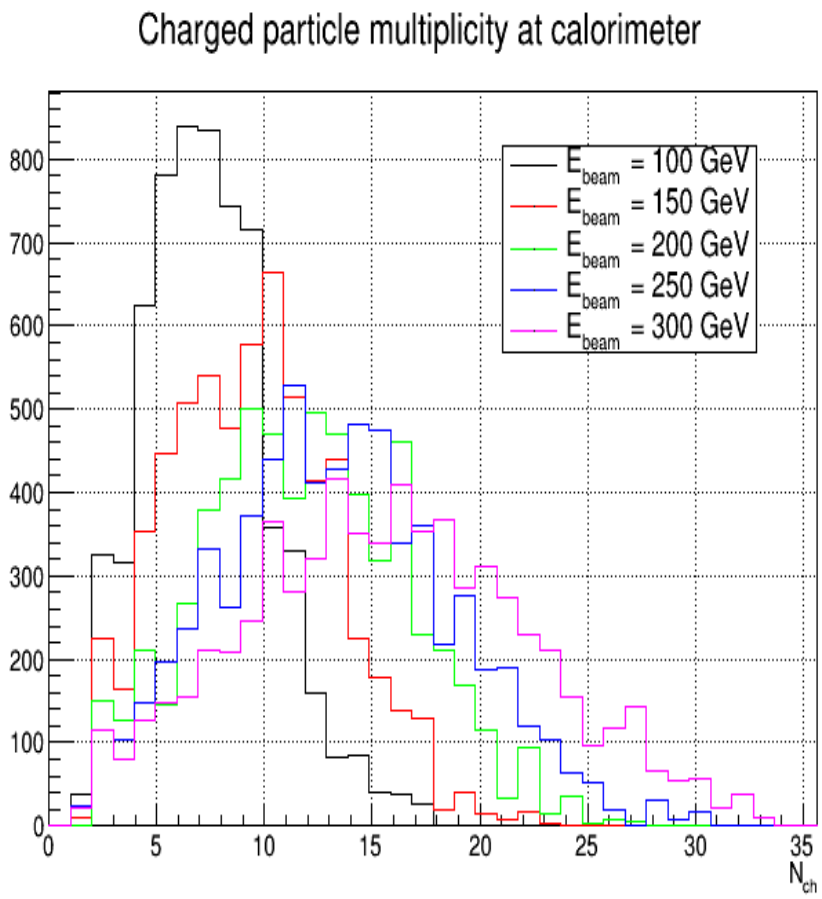
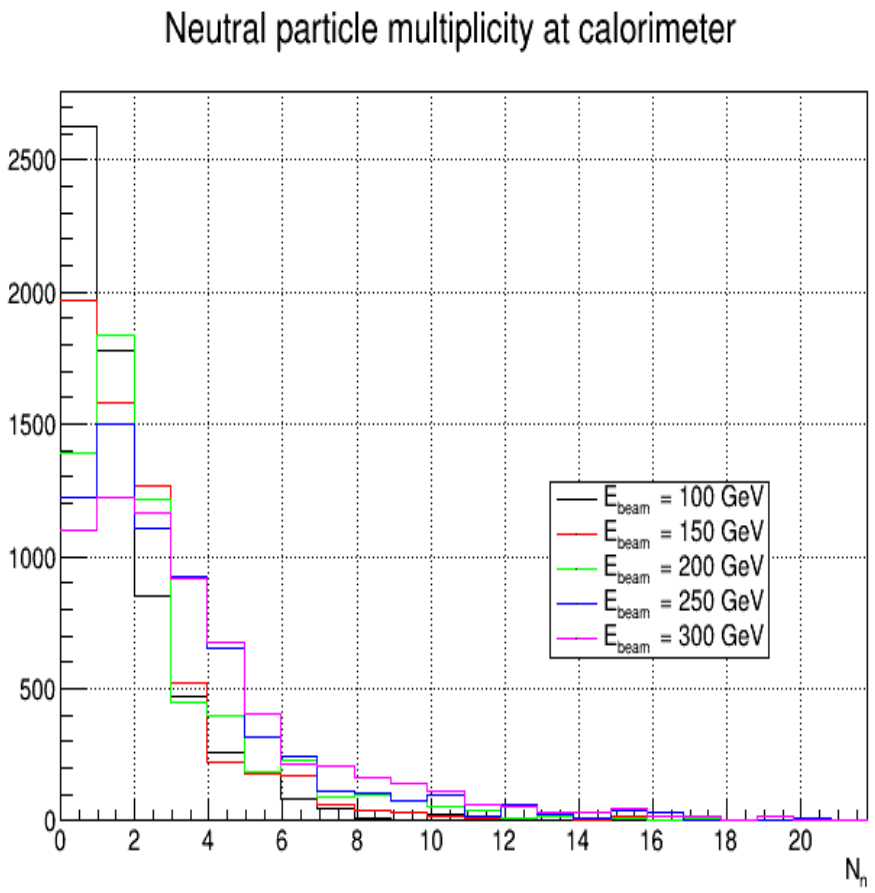

Charged particle multiplicity at calorimeter
E_beam = 100 GeV
E_beam = 150 GeV
E_beam = 200 GeV
E_beam = 250 GeV
E_beam = 300 GeV
N_ch


Neutral particle multiplicity at calorimeter
E_beam = 100 GeV
E_beam = 150 GeV
E_beam = 200 GeV
E_beam = 250 GeV
E_beam = 300 GeV
N_n

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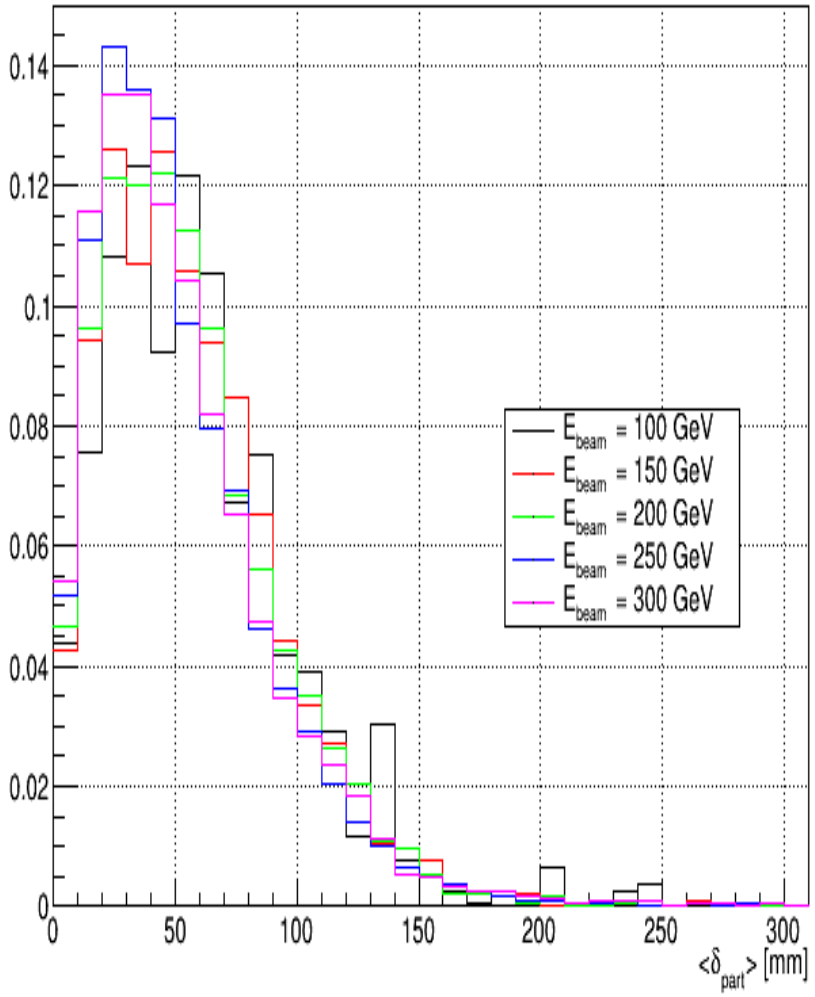
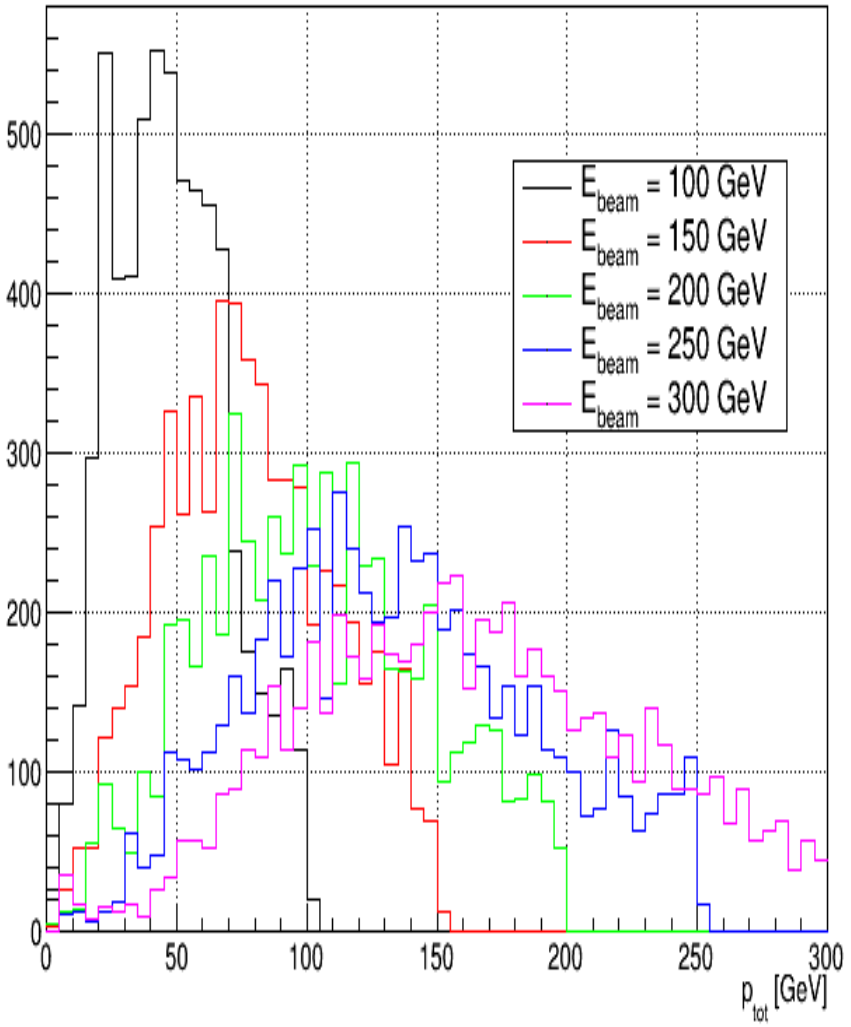
Distance between particles at calorimeter



Total momentum at calorimeter



Conclusion

- Simple case of FPA study can be achieved at low cost by combining existing/future calorimeters prototypes
- More advanced PFA study needs more sophisticated setup including TPC and calorimeters. Some elements exist already and need to be evaluated correctly.
- A combined, modular test is not a new idea but it becomes now necessary to validate concepts and options.