Inclusive measurement of hadronic showers with ECAL

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Outline

- **General**
- **Current status**
- **Proposal – Results**
- **Summary**

General

- CALICE ECAL and HCAL prototypes are under construction for first technology/concept debugging studies on testbeam

- simulation studies reveal significant discrepancies among shower packages, thus preventing model independent predictions on calorimeter performance and reliable detector design optimization

- testbeam program with CALICE ECAL+HCAL prototypes to resolve the situation and reduce the current large uncertainty factors

ECAL+HCAL scint "response" vs model, π^- 10 GeV

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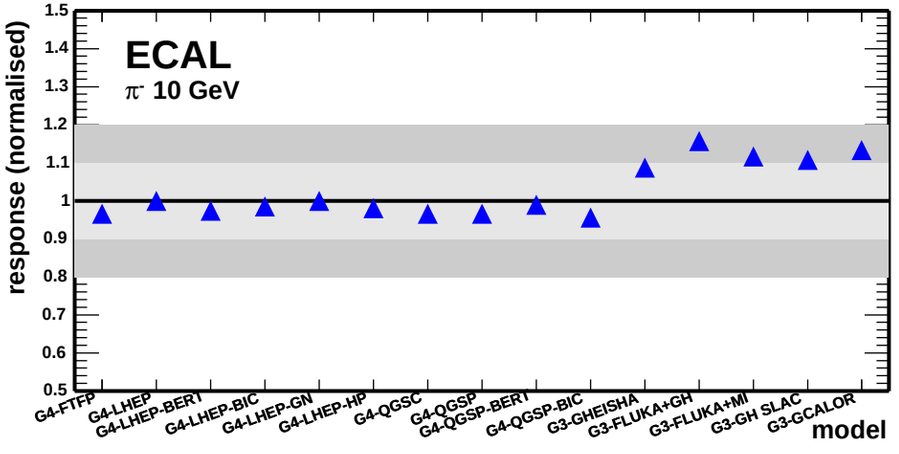

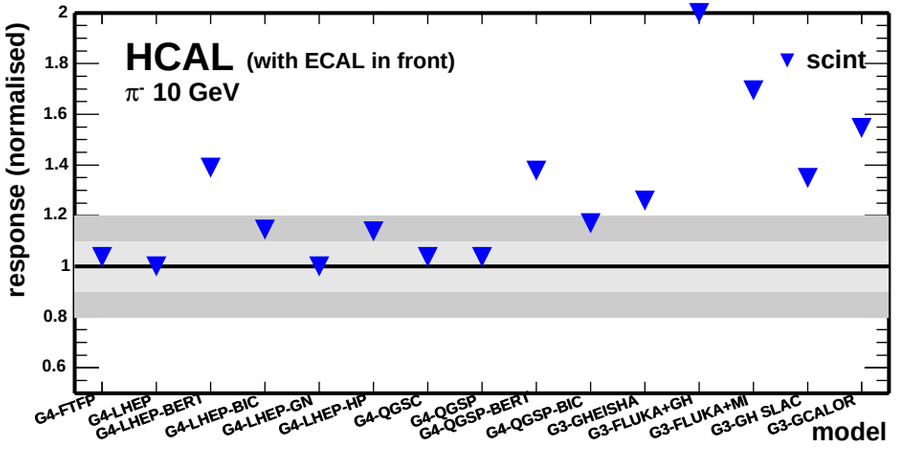

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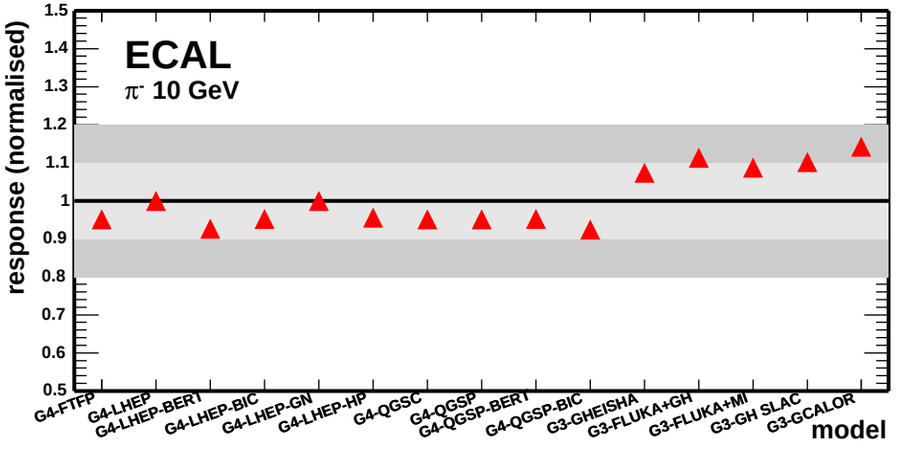
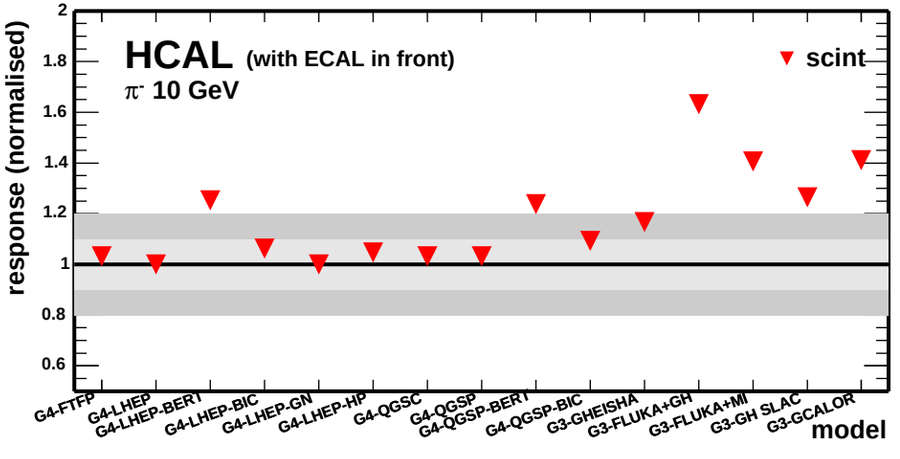
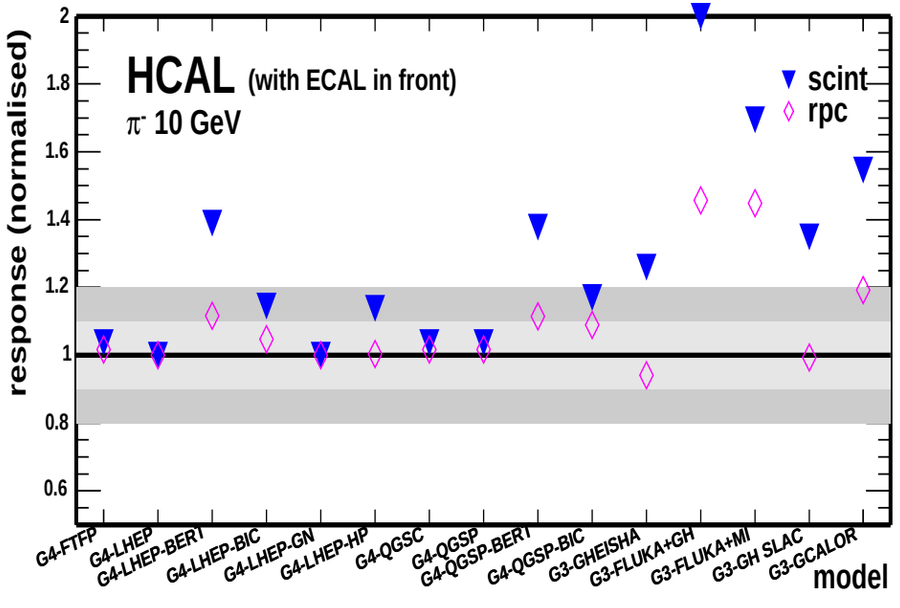




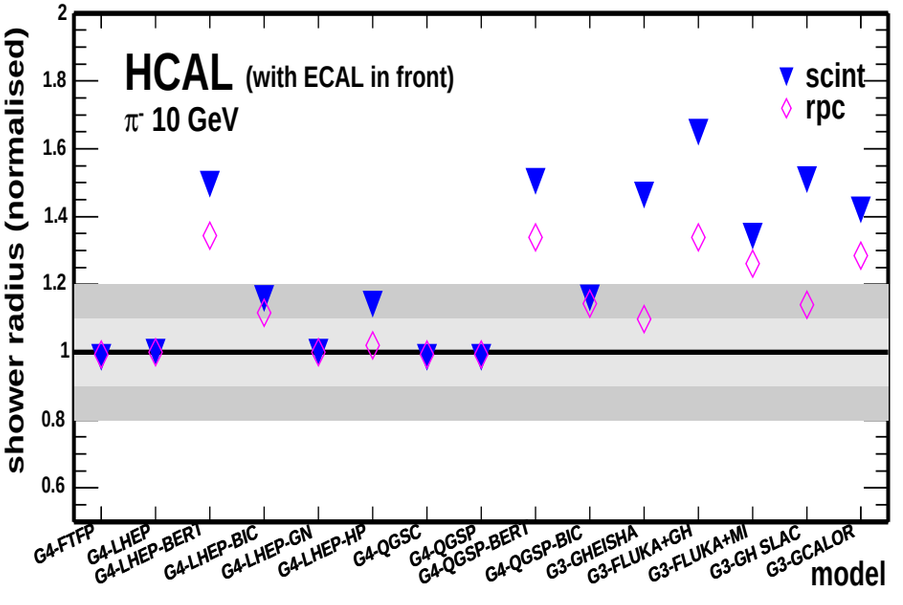
- ▷ **different models predict different calorimeter response**
- ▷ **HCAL more sensitive than ECAL**
- ▷ **EM discrepancies between frameworks seen by ECAL**

HCAL rpc – HCAL scint

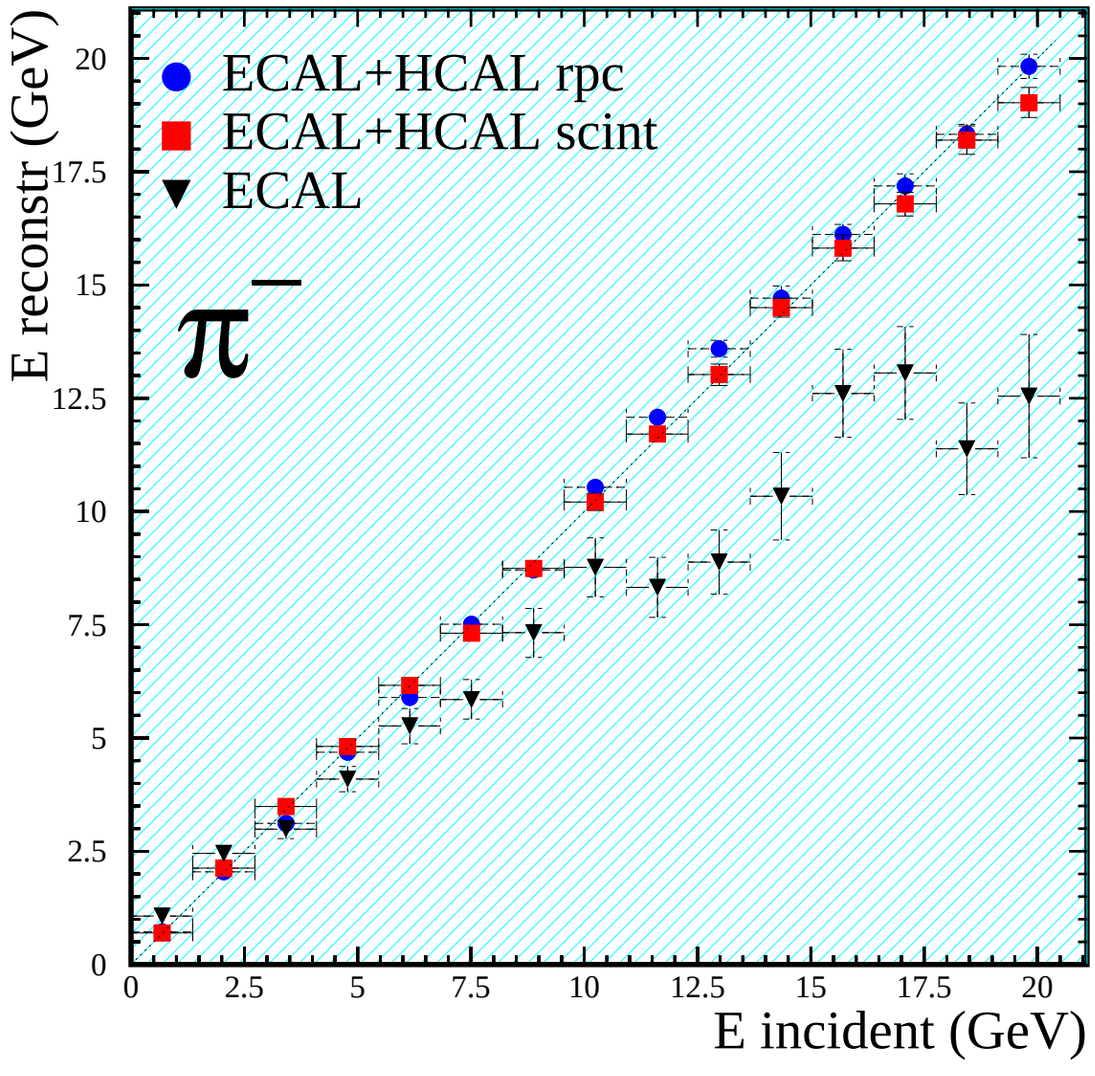
N cells hit



shower width



▷ **HCAL rpc less sensitive to low energy neutrons than HCAL scint**



▷ **combine ECAL+HCAL to study hadronic shower development**

▷ **is it worth exposing ECAL alone to lower energy hadrons?**

In brief

► .

to test and validate the simuation code we need

: projectile, energy, position, angle scans etc.

: (provided available manpower, beam time, beam quality etc.)

► .

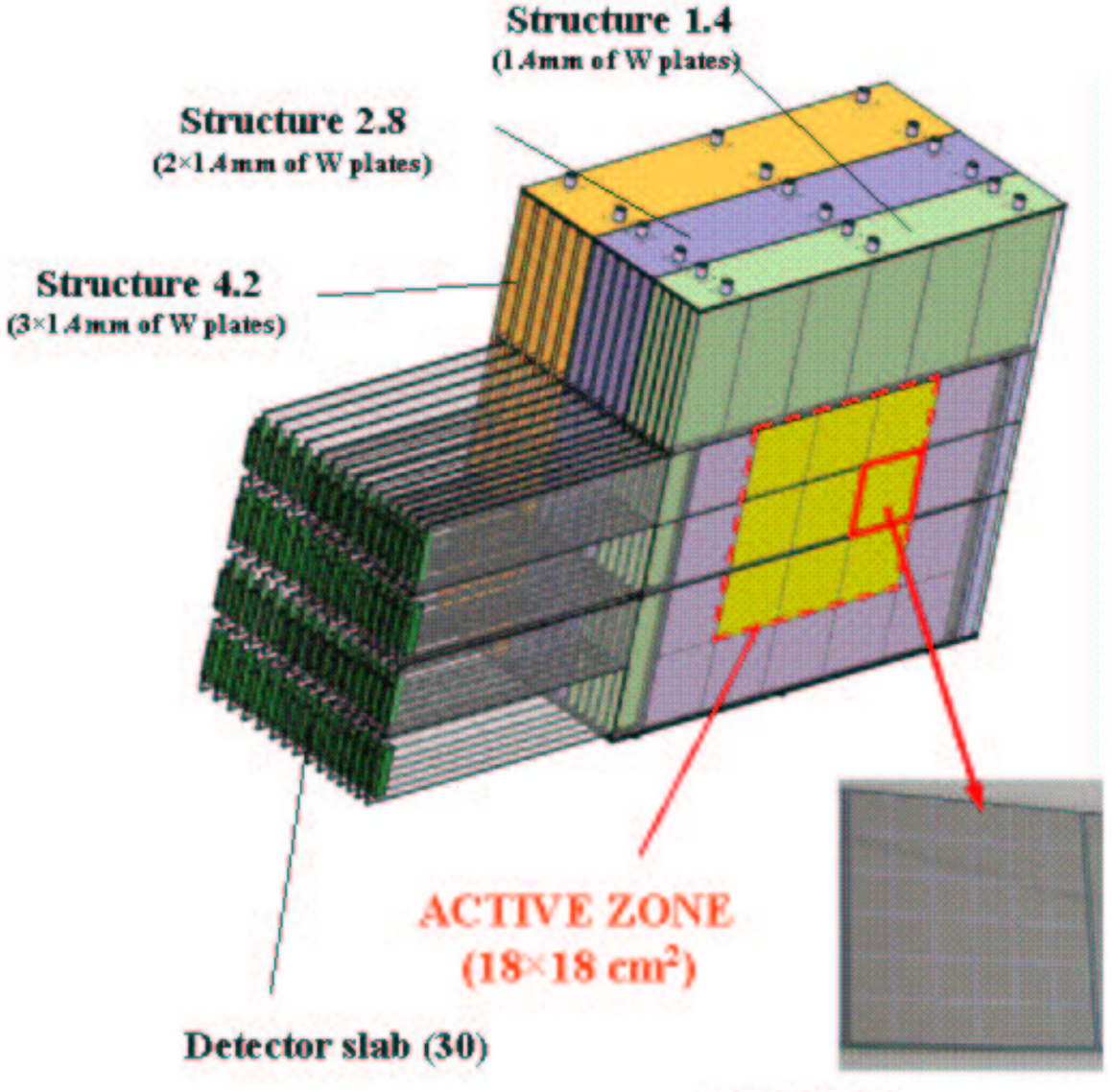
data are always useful and valuable

(especially if taken at the right place and at the right time by the right detector)

: is it worth exposing the ECAL alone to hadronic beam?

: can we extract any useful information?
(complementary to studies performed by ECAL+HCAL)

CALICE ECAL prototype

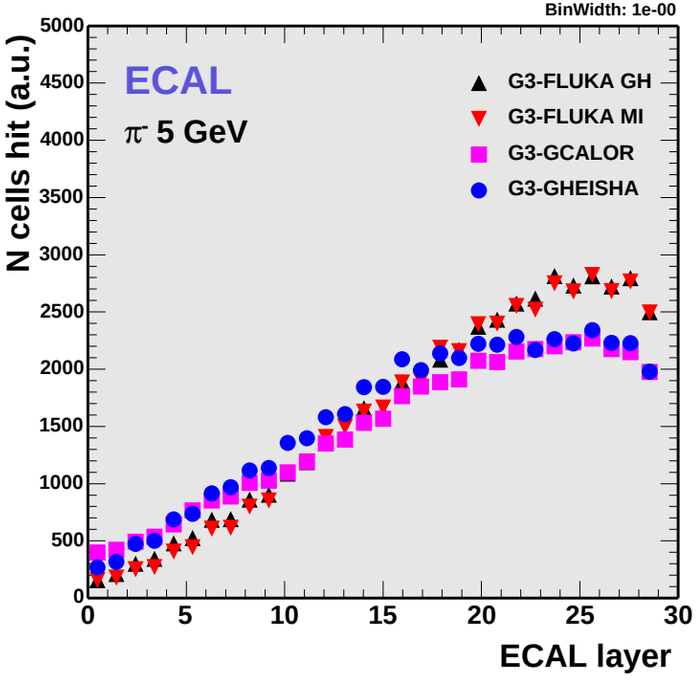


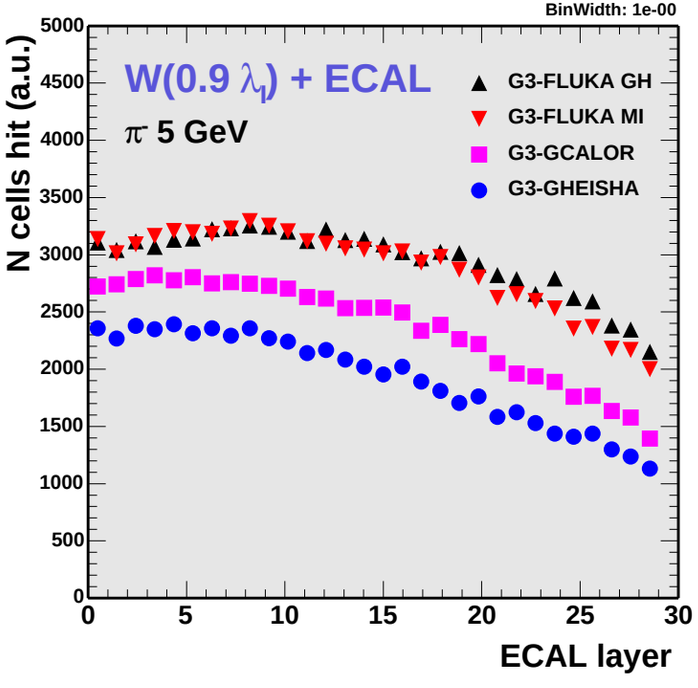
(slide by M.Anduze)

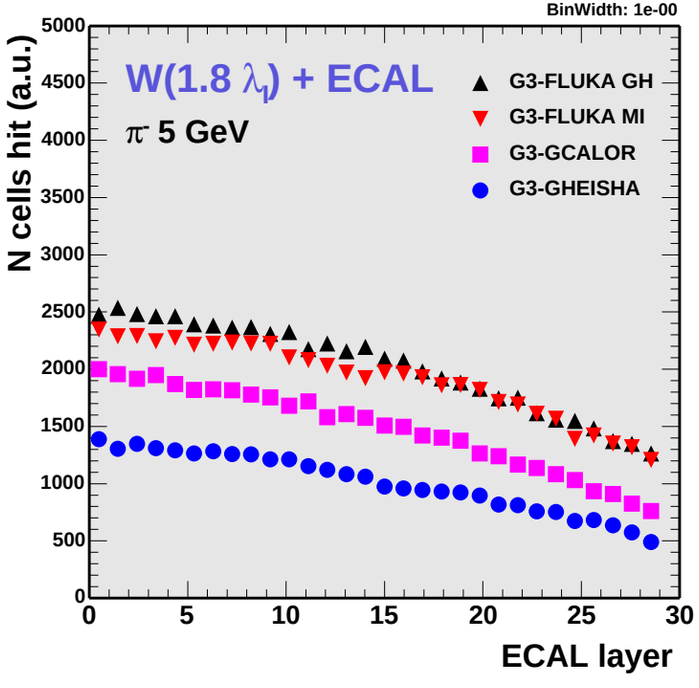
Si Wafer :
6×6 pads of detection
(10×10 mm²)

shower longitudinal profile by W block + ECAL

W block $18 \times 18 \times 8.4\ cm^3$ **W block** $18 \times 18 \times 16.8\ cm^3$



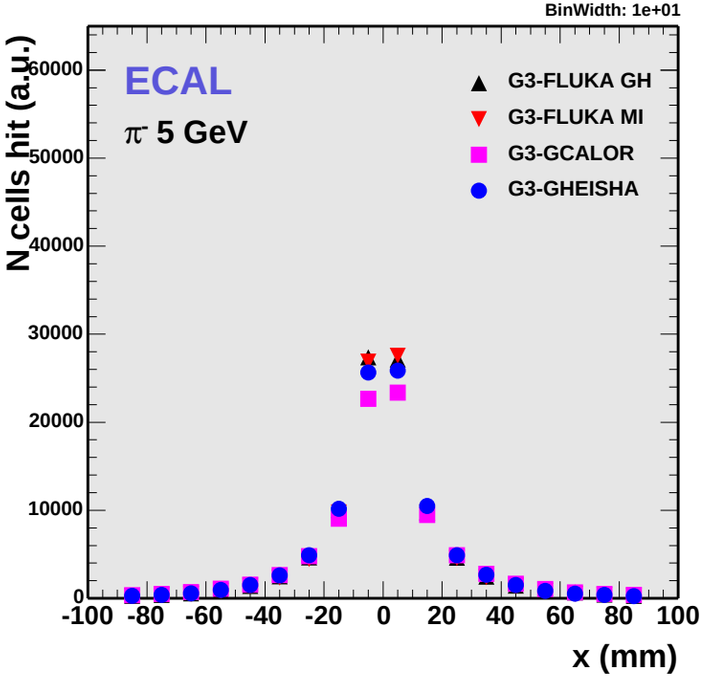


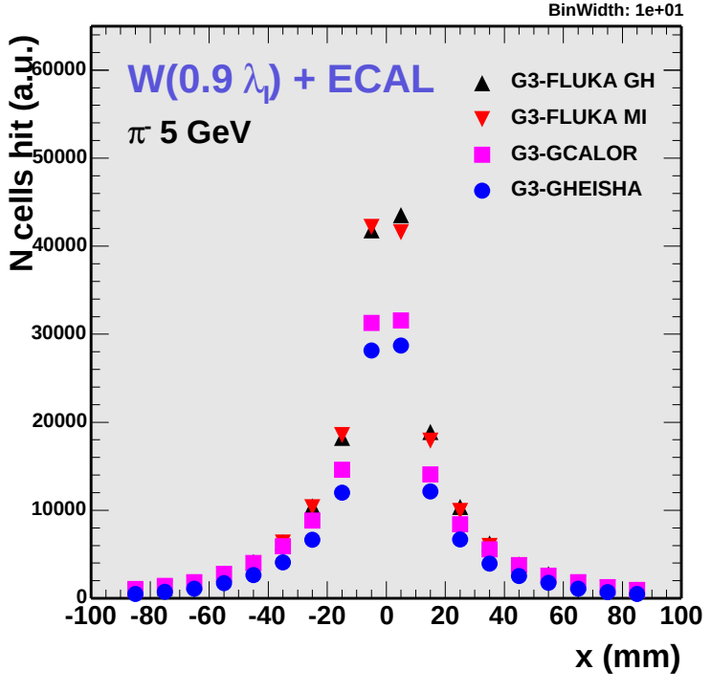


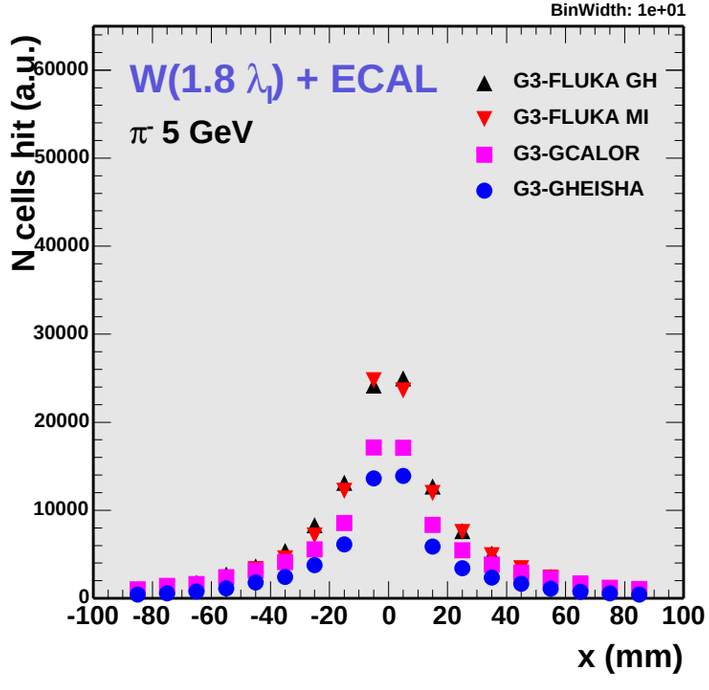
- ▷ differences among models start to show up at the end of ECAL
- ▷ use W block to have similar shower development as in ECAL
- ▷ models clearly distinguishable with block of W in front of ECAL
- ▷ combine "photos" to reveal inclusive longitudinal profile

shower transverse profile by W block + ECAL

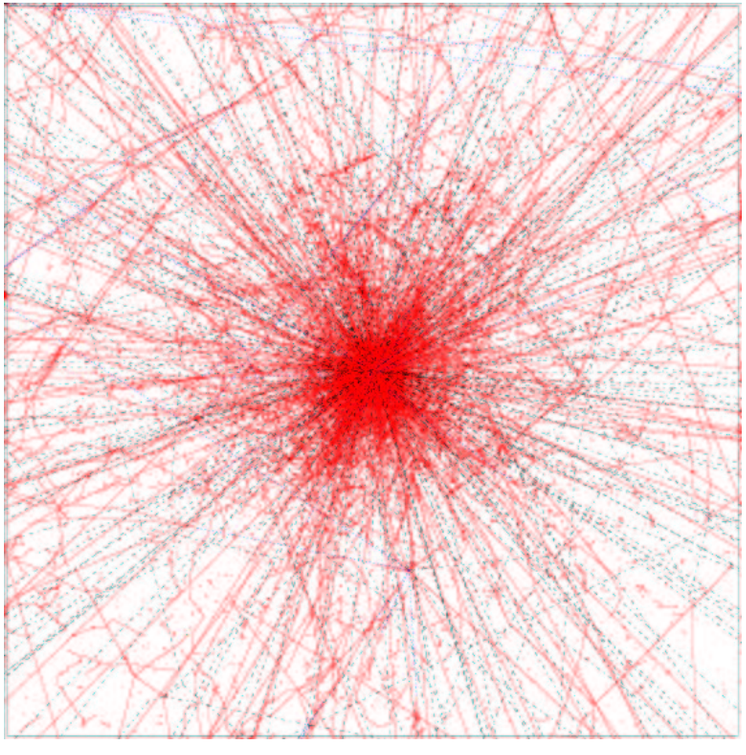
W block $18 \times 18 \times 8.4\ cm^3$ **W block** $18 \times 18 \times 16.8\ cm^3$





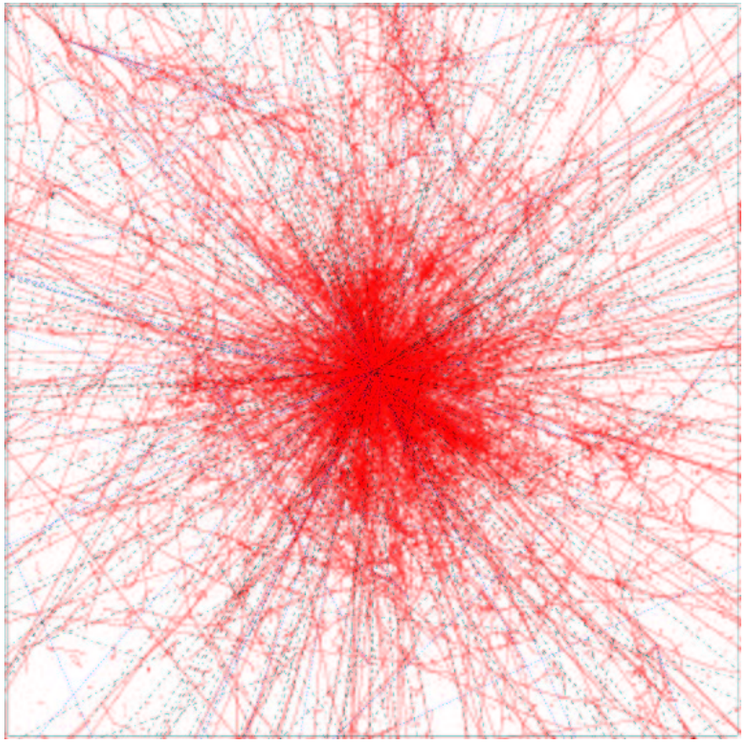


- **front face** $18 \times 18\ cm^2$ **segmented into** $1 \times 1\ cm^2$ **cells, sufficient to record shower's core**
- **differences more pronounced with a block of matter in front of ECAL**



W block $18 \times 18 \times 8.4\ cm^3$

(100 showers of 5 GeV π^-'s)

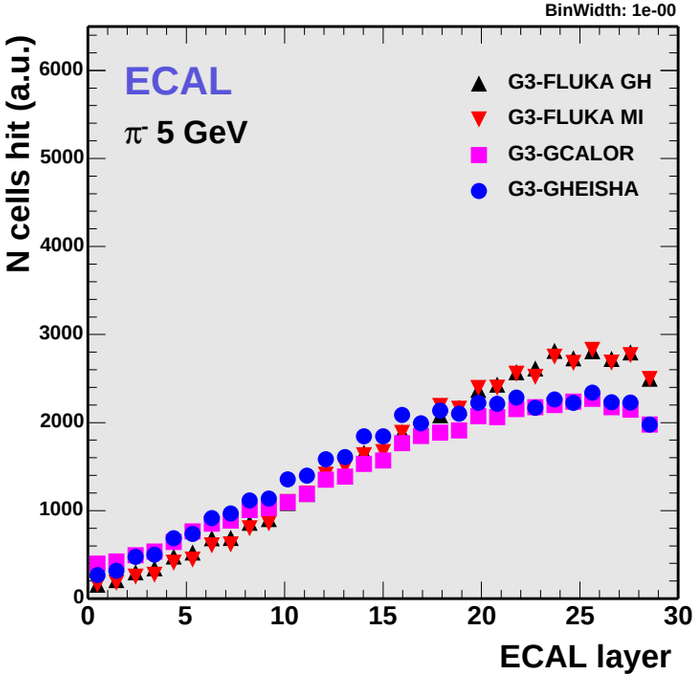


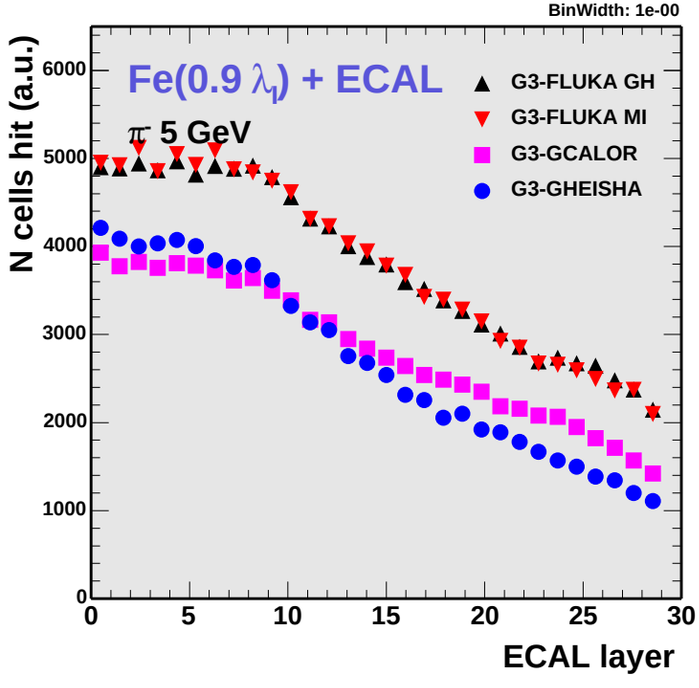
Fe block $18 \times 18 \times 14.7\ cm^3$

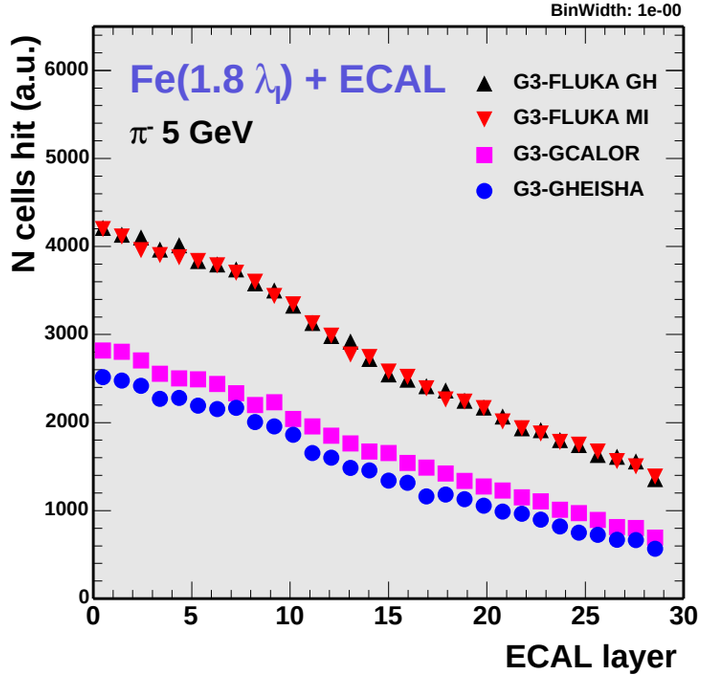
(100 showers of 5 GeV π^-'s)

shower longitudinal profile by Fe block + ECAL

Fe block $18 \times 18 \times 14.7\ cm^3$ **Fe block** $18 \times 18 \times 29.4\ cm^3$



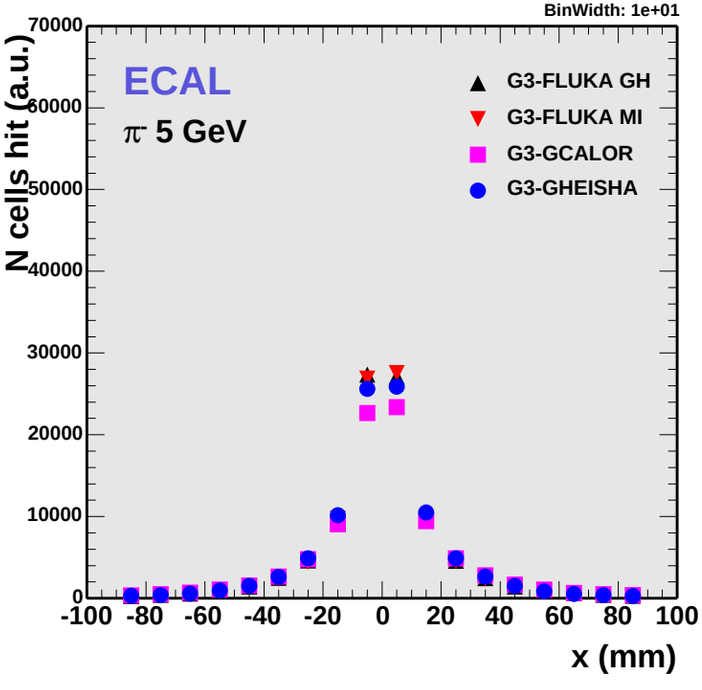


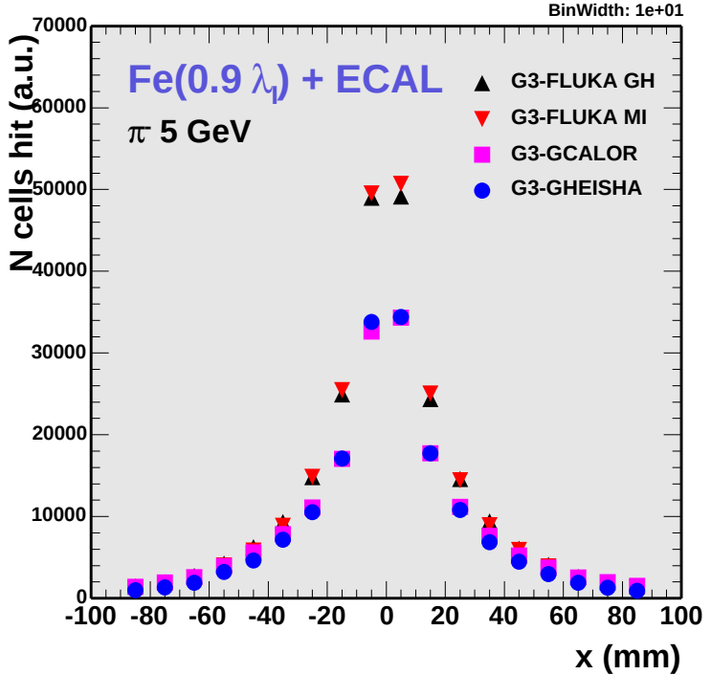


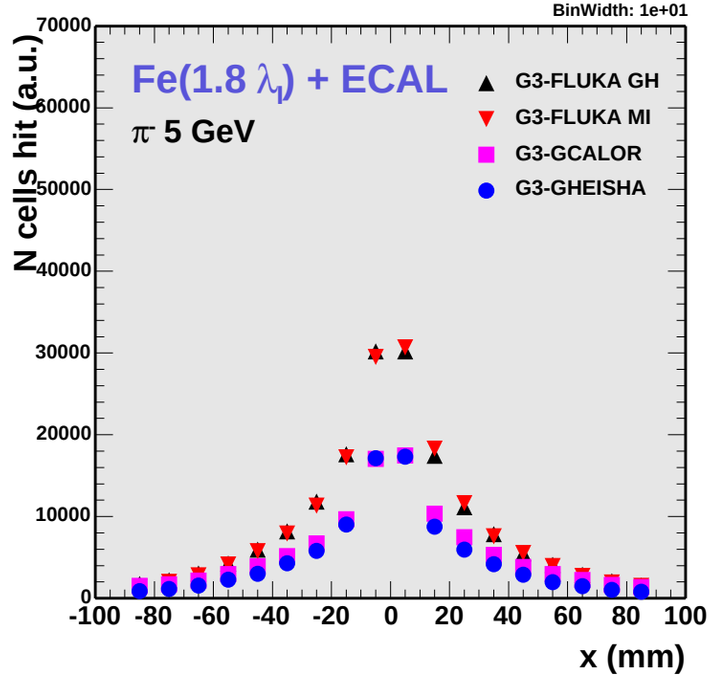
- ▷ **shower develops differently in W and in Fe**
- ▷ **"photos" can not be combined to reveal inclusive profile**
- ▷ **still useful information can be extracted**

shower transverse profile by Fe block + ECAL

Fe block $18 \times 18 \times 14.7\ cm^3$ **Fe block** $18 \times 18 \times 29.4\ cm^3$







Summary

► .

current poor understanding of hadronic shower development

: leads to significant discrepancies among available simulation packages

: does not permit reliable model independent predictions

► .

data needed to test – validate – improve simulation code

: simple low cost method to exploit the high granularity
and the portability of ECAL can provide useful results

: complementary to further detailed studies performed in an
extensive testbeam program with ECAL+HCAL combined

BACK-UP SLIDES

model tag		brief description
G3-GHEISHA	:	GHEISHA
G3-FLUKA+GH	:	FLUKA, for neutrons with $E <$ 20 MeV GHEISHA
G3-FLUKA+MI	:	FLUKA, for neutrons with $E <$ 20 MeV MICAP
G3-GH SLAC	:	GHEISHA with some bug fixes from SLAC
G3-GCALOR	:	$E <$ 3 GeV Bertini cascade, 3 $< E <$ 10 GeV hybrid Bertini/FLUKA, $E >$ 10 GeV FLUKA, for neutrons with $E <$ 20 MeV MICAP
G4-LHEP	:	GHEISHA ported from GEANT3
G4-LHEP-BERT	:	$E <$ 3 GeV Bertini cascade, $E >$ 3 GeV GHEISHA
G4-LHEP-BIC	:	$E <$ 3 GeV Binary cascade, $E >$ 3 GeV GHEISHA
G4-LHEP-GN	:	GHEISHA + gamma nuclear processes
G4-LHEP-HP	:	as G4-LHEP, for neutrons with $E <$ 20 MeV use evaluated cross-section data
G4-QGSP	:	$E <$ 25 GeV GHEISHA, $E >$ 25 GeV quark-gluon string model
G4-QGSP-BERT	:	$E <$ 3 GeV Bertini cascade, 3 $< E <$ 25 GeV GHEISHA, $E >$ 25 GeV quark-gluon string model
G4-QGSP-BIC	:	$E <$ 3 GeV Binary cascade, 3 $< E <$ 25 GeV GHEISHA, $E >$ 25 GeV quark-gluon string model
G4-FTFP	:	$E <$ 25 GeV GHEISHA, $E >$ 25 GeV quark-gluon string model with fragmentation ala FRITJOF
G4-QGSC	:	$E <$ 25 GeV GHEISHA, $E >$ 25 GeV quark-gluon string model

ECAL+HCAL scint "response" vs model, π^- 1 GeV

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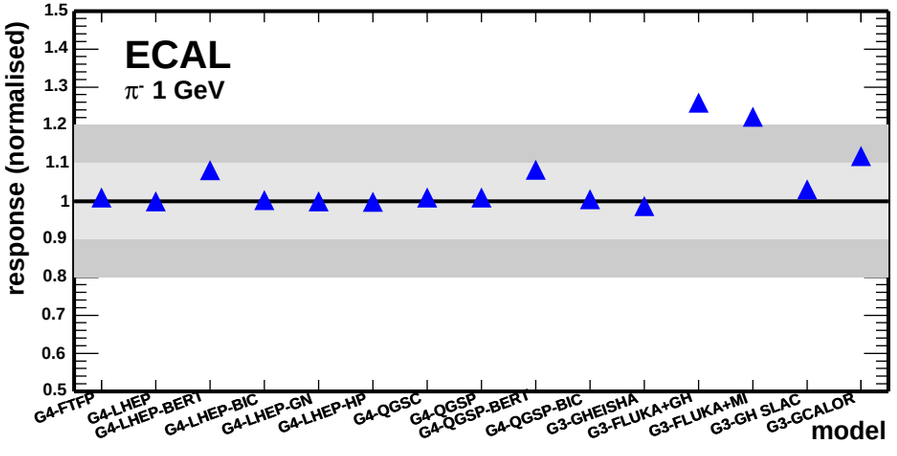

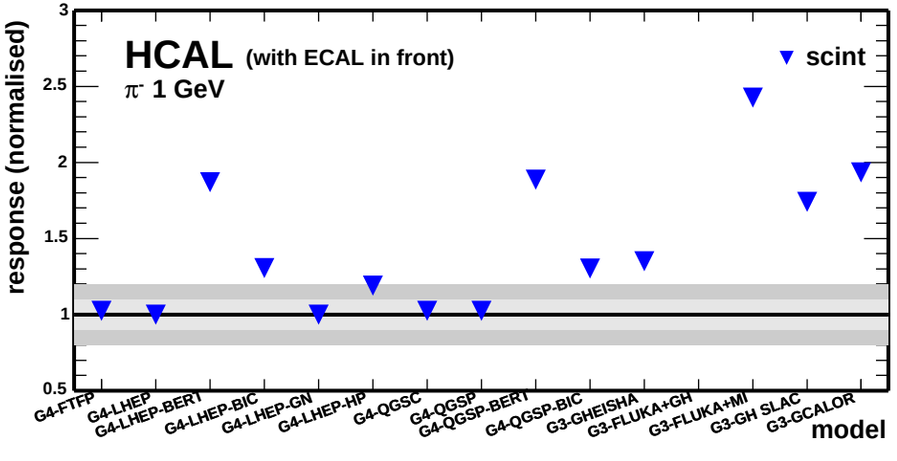

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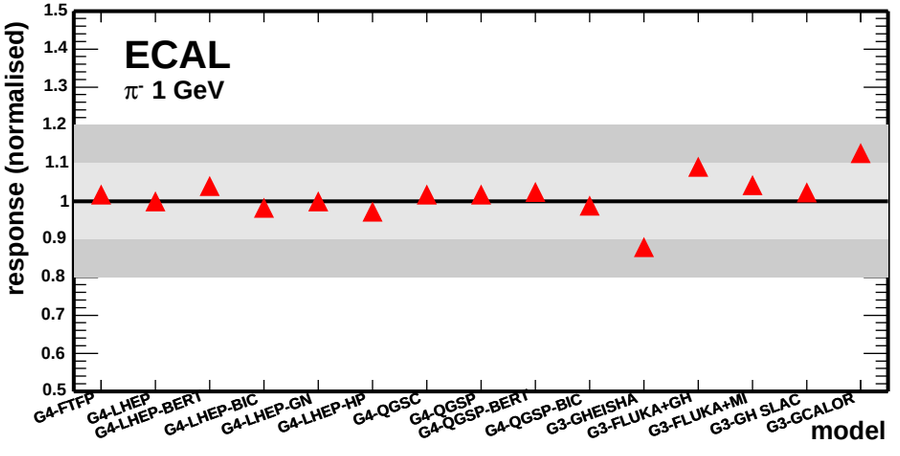

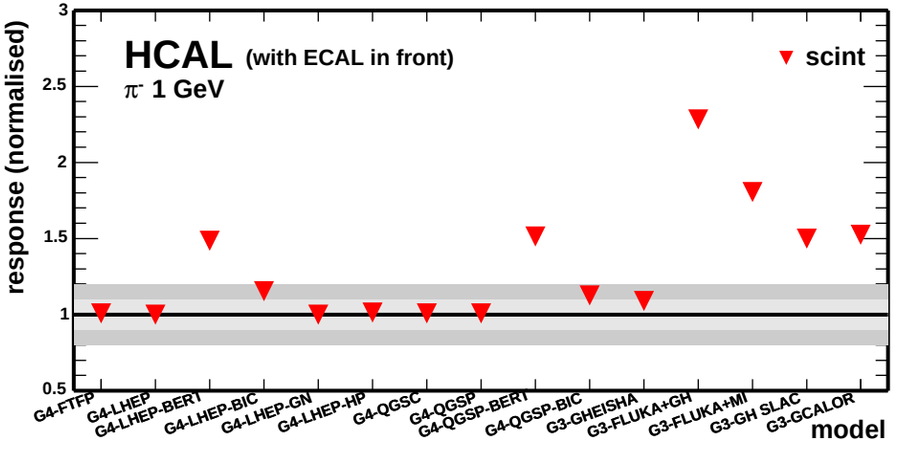

- ▷ **same pattern as at 10 GeV case, even more pronounced**
- ▷ **ECAL standalone may have some discriminating power**