Beam Tests of a Thin Dual Readout Calorimeter for an Experiment Outside the Earth's Atmosphere

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Advanced Cosmic ray Composition Experiment on the Space Station

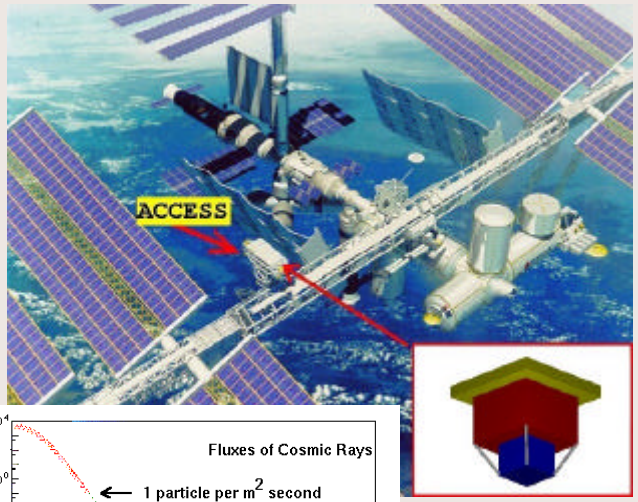
Objective: to measure the energy spectra of individual elements up to 10^{15} eV

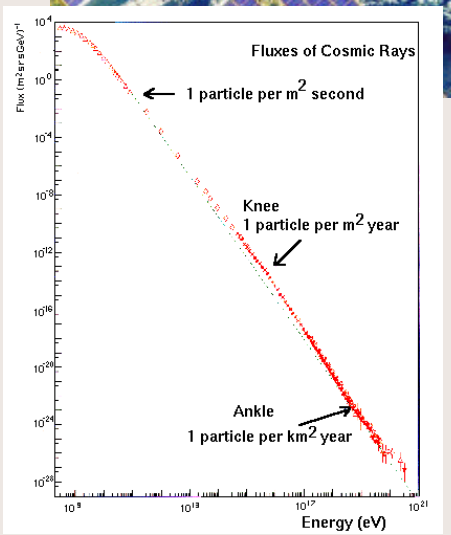
Probe the limits of SN SW models

Cosmic ray propagation

Regions where very few secondaries

Structures produced by different sources in electron spectra





Dual readout

Fluctuations in a thin calorimeter - *em vs leakage*

Scintillator sampling

Quartz sampling

Combination Q+S:

complimentary information:
gives a handle to estimate leakage
event-by-event

The prototype

39 lead plates (1/4" thick, 11" wide)

Scintillator:

fibers d=0.5mm, (SCSN-81M)

layers 1:3, 6 S_x + 6 S_y

Quartz:

fibers d=0.27mm (0.21 mm core)

layers 2:3, 13 Q_x + 13 Q_y

Fibers -> **ribbons** *(40mm)* -> **towers**

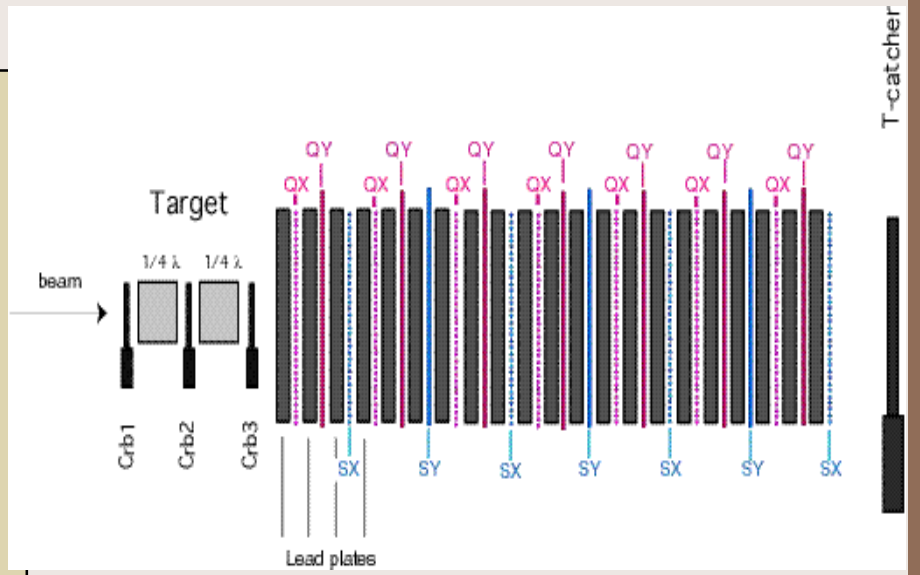
5 ribbons in each layer

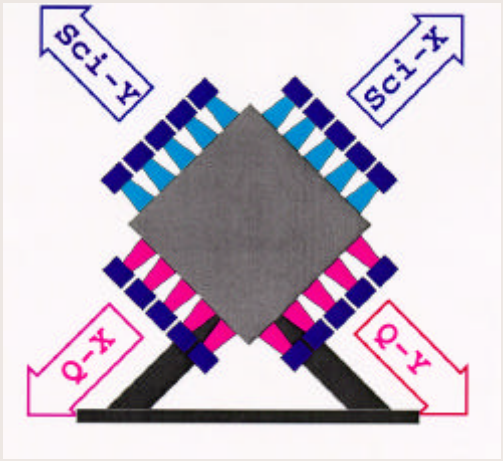
5+5+5+5 **towers -> R5900 PMTs**

Total thickness 1.4 λ_{int}, 45 X_0

S-sampling every 3.4 X_0

Total ~15 km of fibers





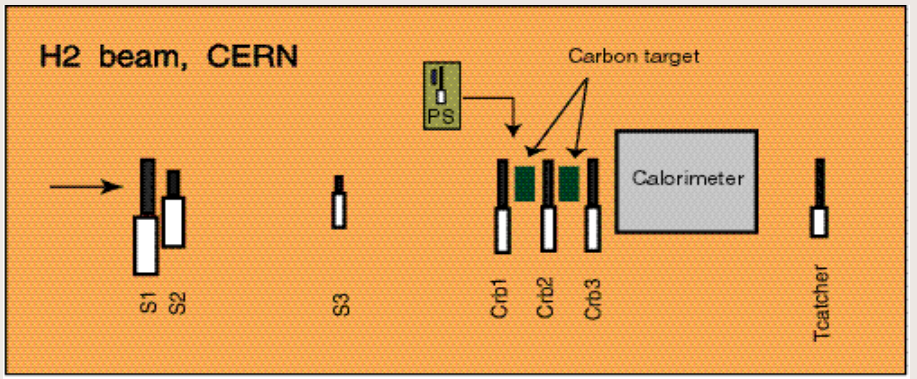
Beam tests at CERN

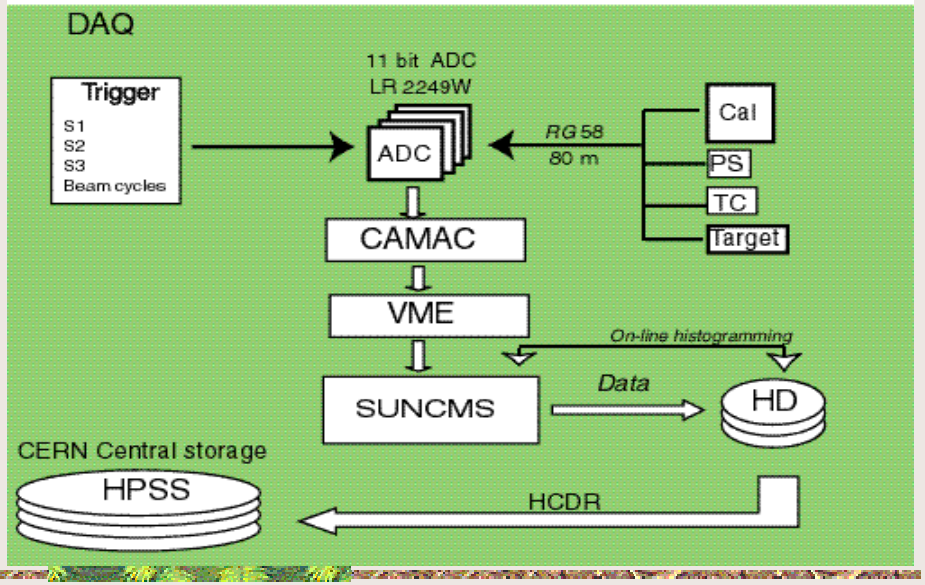
Setup:

- ***Calorimeter***
- ***Target***
- ***Preshower***
- ***Tail Catcher***
- ***Trigger***

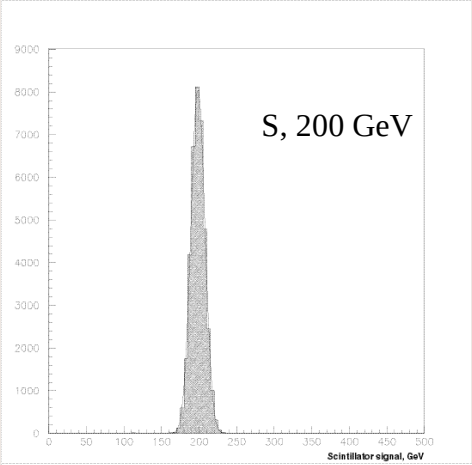
Beams: (***SPS, NA-H2)***

375 GeV p^+ max
50-300 GeV e^- calibration
150-350 GeV π^- E-scan

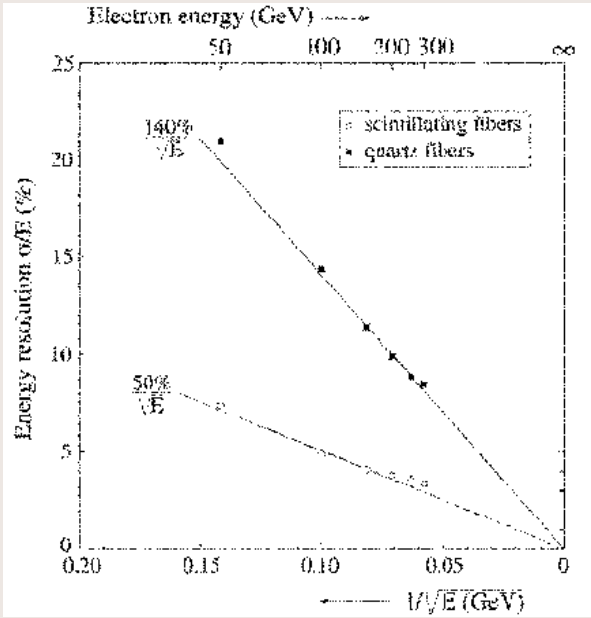




Electrons



Calibration runs with 150 GeV electrons, 3 times during the test
Energy scan 50-300 GeV



Projected to very high energies, sampling fluctuations are small compared to the dominant one

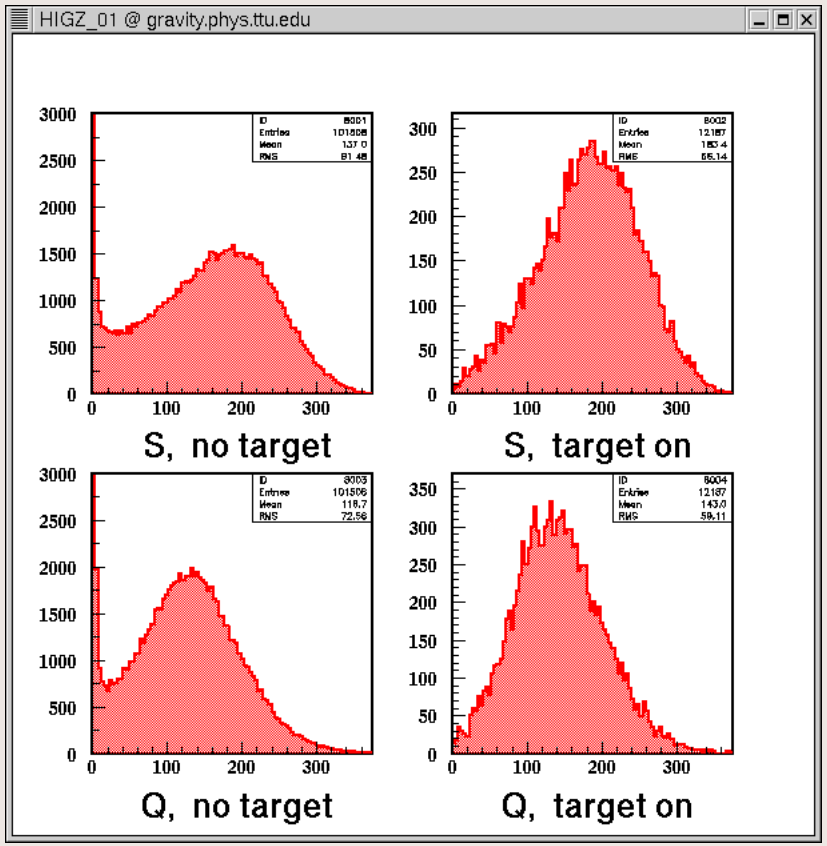
Hadrons

S and Q spectra

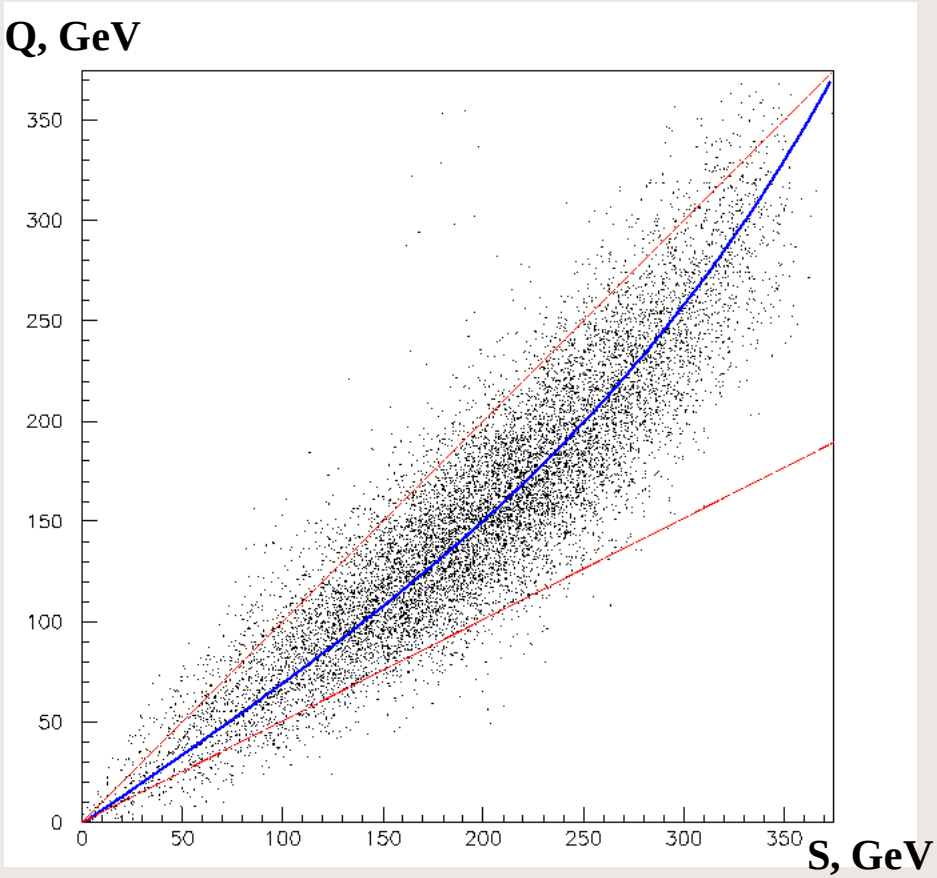
375 GeV protons

no target: low signal in all target counters

target on: shower signal in the last section of the target (1/4 λ)

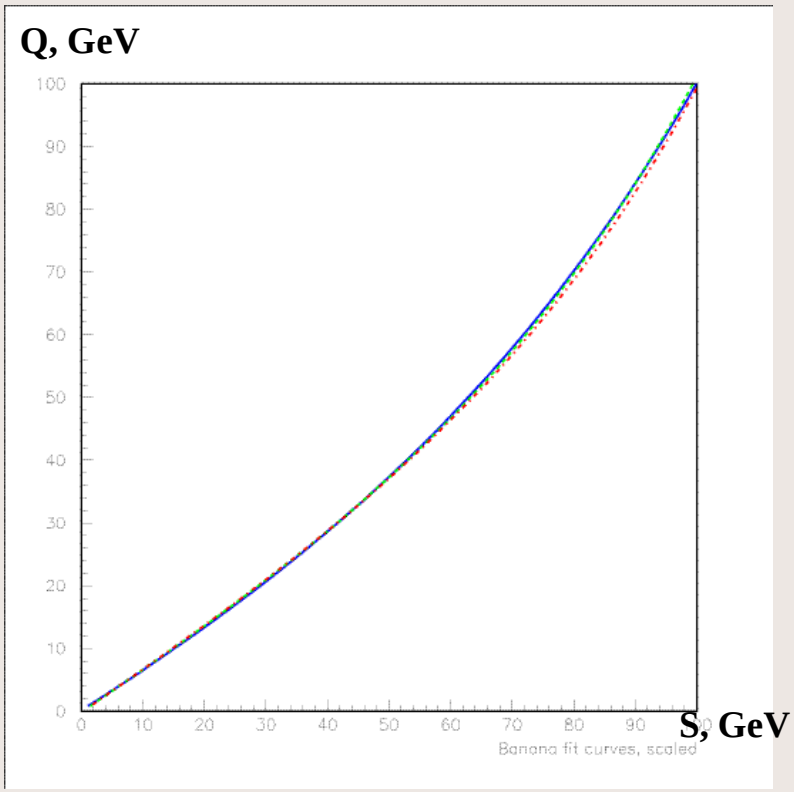


S-Q correlation plot (banana)



Scaled correlation curves , correction

Scaled underline banana curves for 150, 250 and 375 GeV pion runs

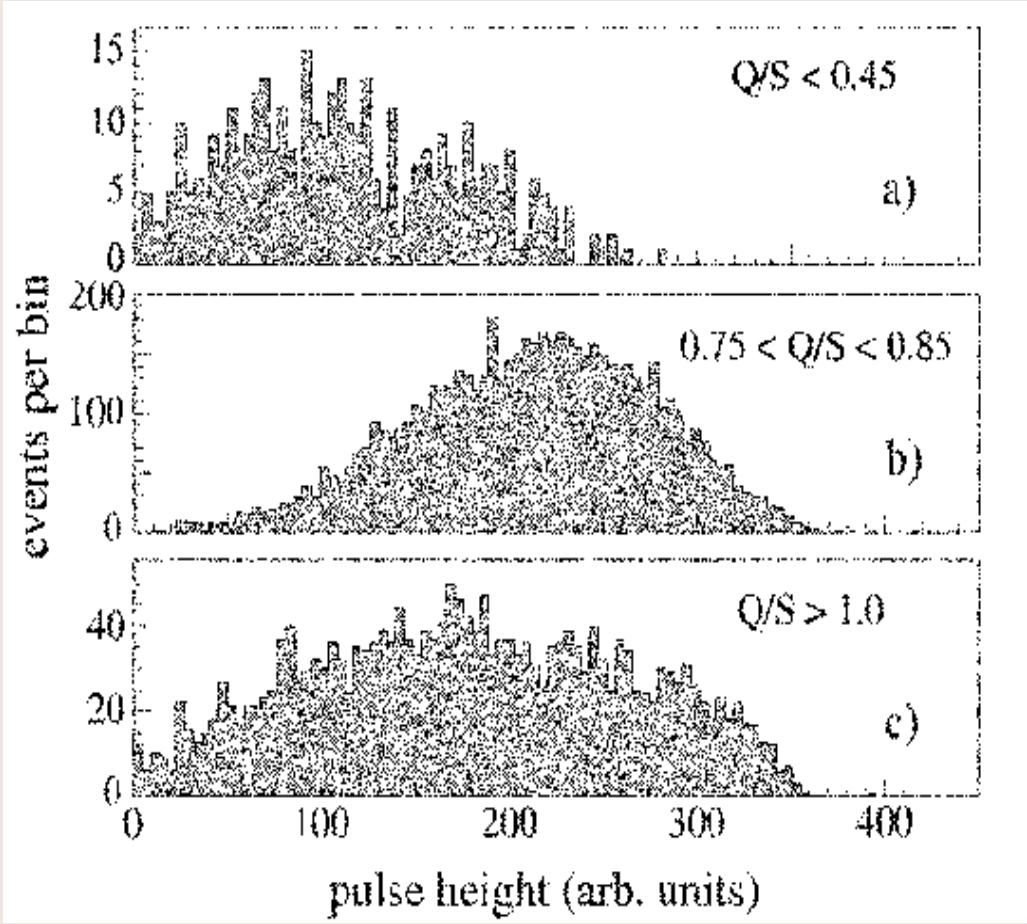


Correction procedure:

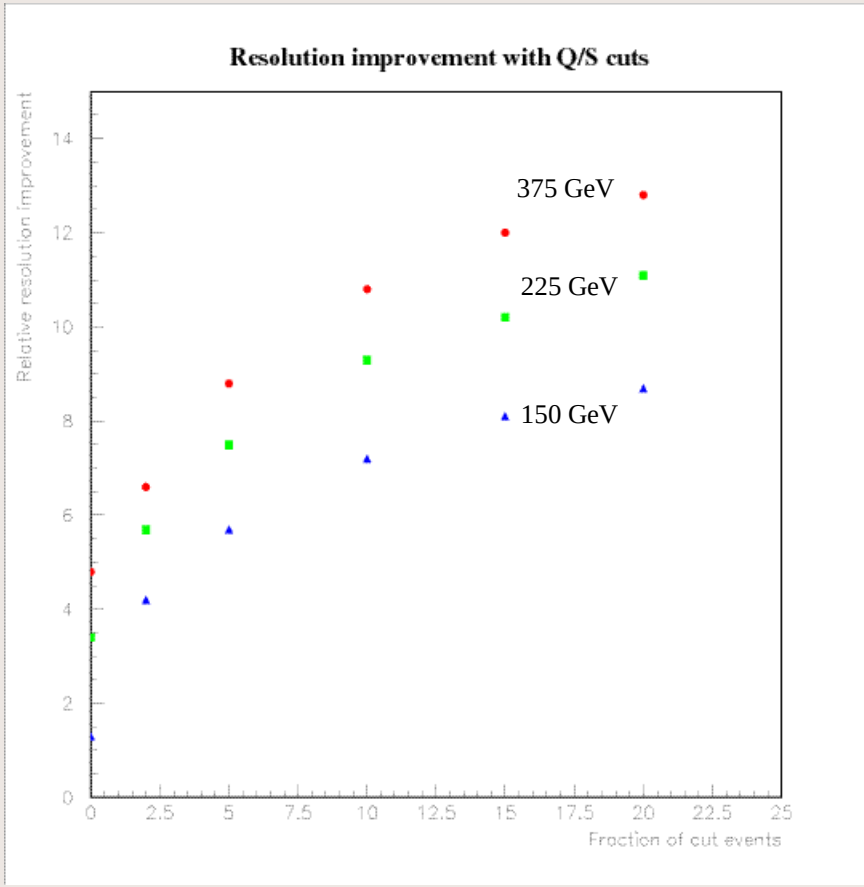
1) narrow bins in Q/S
2) for each k-th bin - define
$<S_k>/<S>$
3) fit $<S(Q/S)>/<S>$ with smooth curve P4(Q/S)
4) apply correction for each event
$S_i \rightarrow S_i/P4(Q/S)$

Tails of Q/S

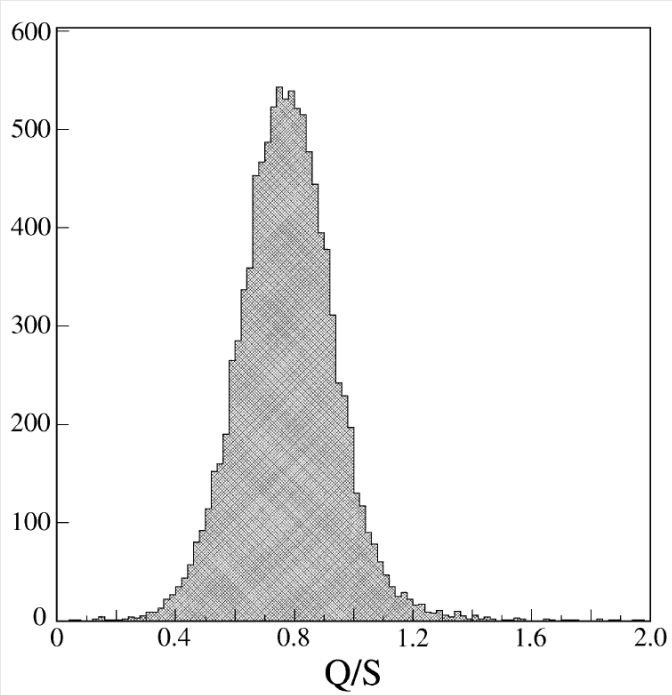
Tails of Q/S emphasize tails of the S-spectrum

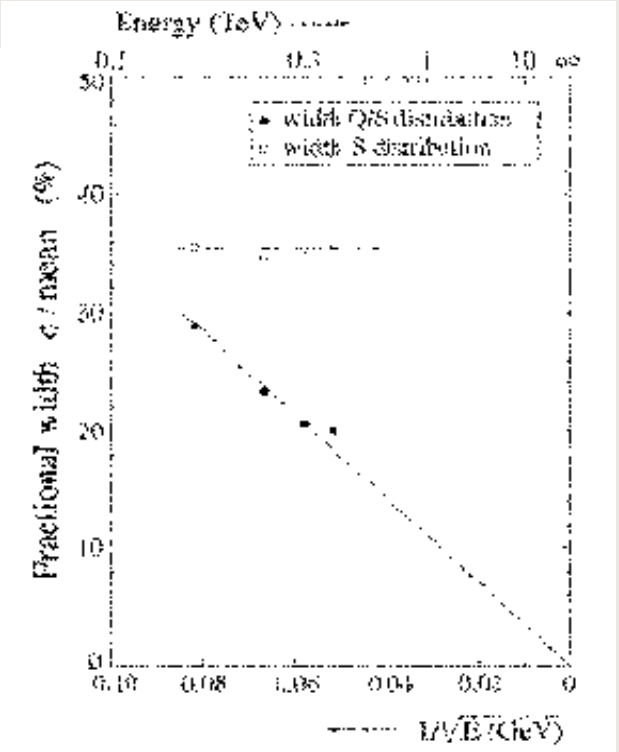


Relative resolution improvement after correction and cuts



Q/S width





The width of Q/S distribution is crucial for the method

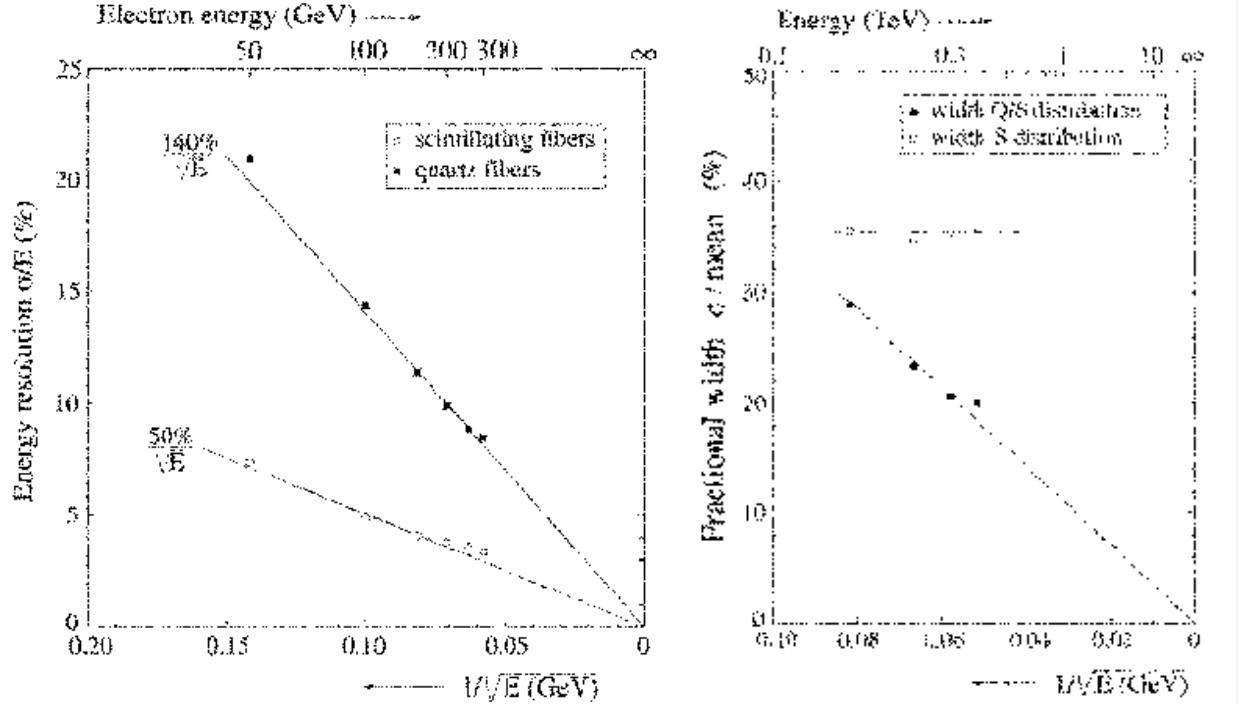
expected to be small at higher energies

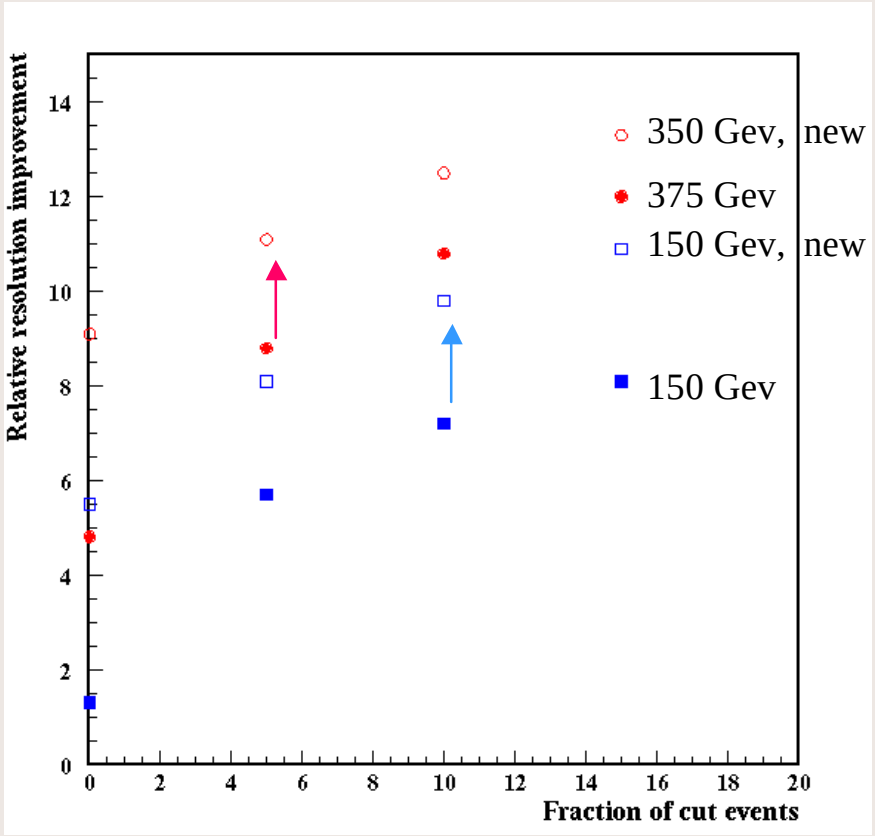
Data added to plots in attachment

New data - light output increased

Beam test in August, 2000: *modified calorimeter*

1) **4 times more quartz in central towers**
2) **Quartz window PMTs (R5900-6) in central towers**




Relative resolution improvement
Fraction of cut events
350 Gev, new
375 Gev
150 Gev, new
150 Gev
0
2
4
6
8
10
12
14
16
18
20

Conclusions

-Two types of readout, Q and S, give complementary information about shower development

-Combining Q and S makes it possible to reduce the main source of fluctuations in this calorimeter

-Correction procedure may be energy independent

-Improvement that can be achieved is limited by the light yield in quartz in the energy range studied

-Subsequent tests confirmed that light output increase results in further improvement of the method

-If the trend continues, considerable improvement in energy resolution may be expected in the energy range of ACCESS interest (>10 TeV)