SEARCHING FOR EXOTICS AT THE LHC

"QCD at Cosmic Energies" workshop

Erice 29/8 - 5/9/2004

Apostolos D. Panagiotou
University of Athens
apanagio@phys.uoa.gr

CENTAURO EVENT

EXPERIMENTAL CHARACTERISTICS

1. No Electromagnetic component $\Rightarrow$ *"No"* π^0

   $\Rightarrow$ *"No"* pions if isospin conserved

2. Very small hadronic multiplicity $\Rightarrow$ *baryons*

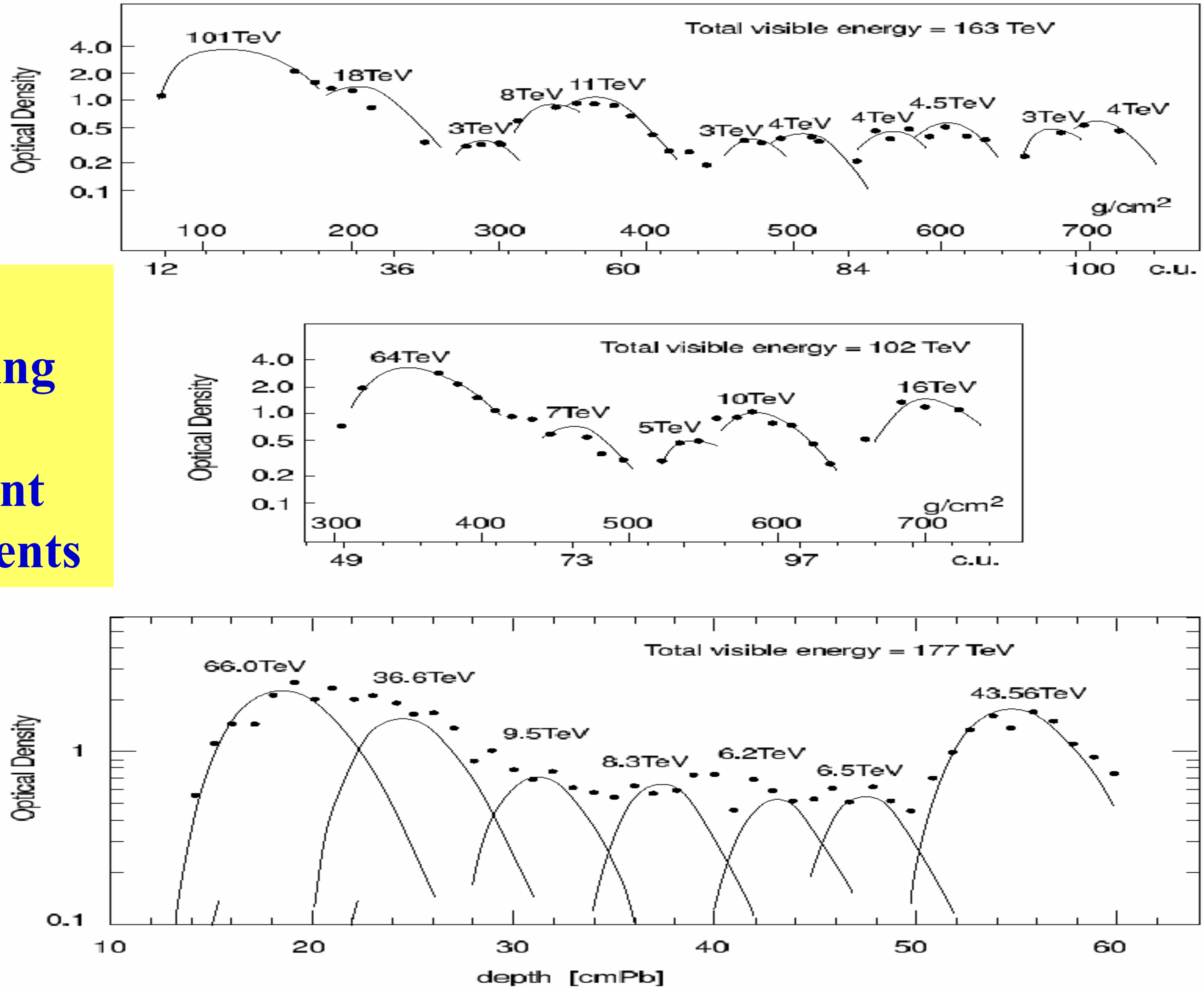
3. Very high: $p_T > 1.5$ GeV/c

4. Event at fragmentation rapidity

Long penetrating (hadronic) component

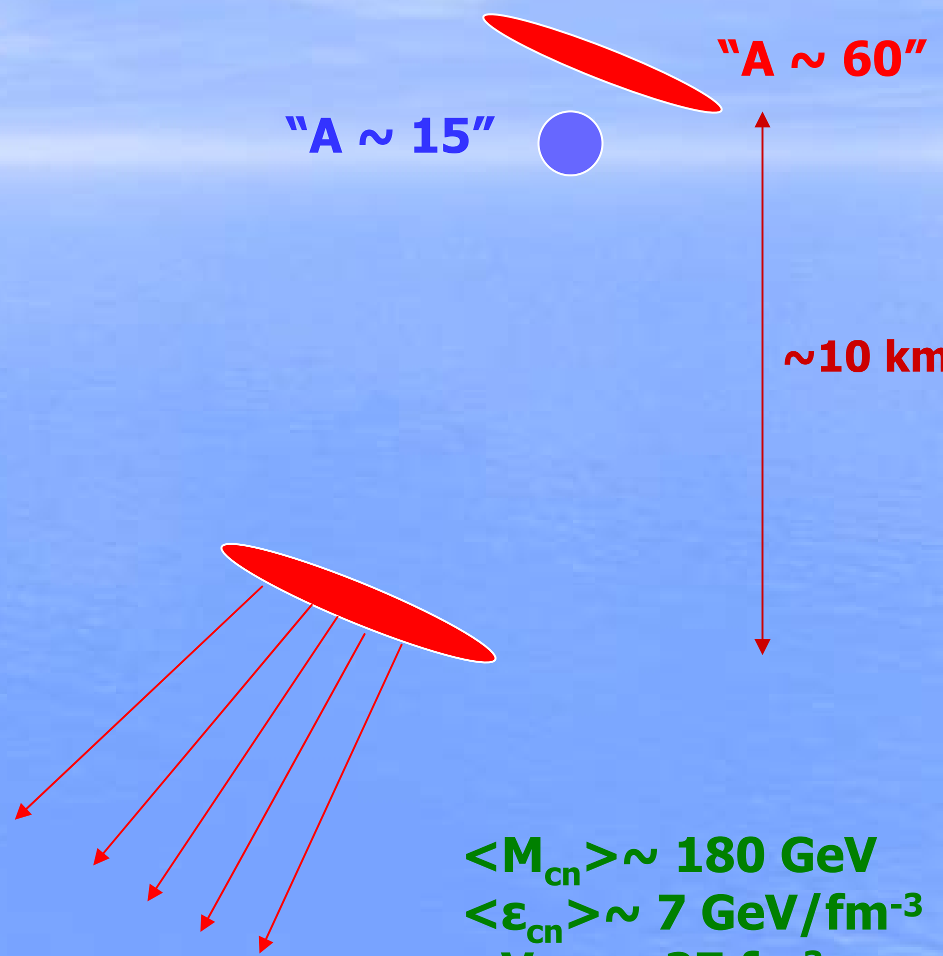
Long Flying Component

(Strangelet ??)



Long penetrating hadronic component in CR events

Nucleus – Nucleus Collision



Zeit. Phys. A333 (1989) 355
Phys. Rev. D45 (1992) 3134
Astrop. Phys. 2 (1994) 167
J. Phys. G: Nucl. Part. Phys. 23(1997)2069
EPJ direct C9(2000)1
Astrop. Phys. 13 (2000) 173
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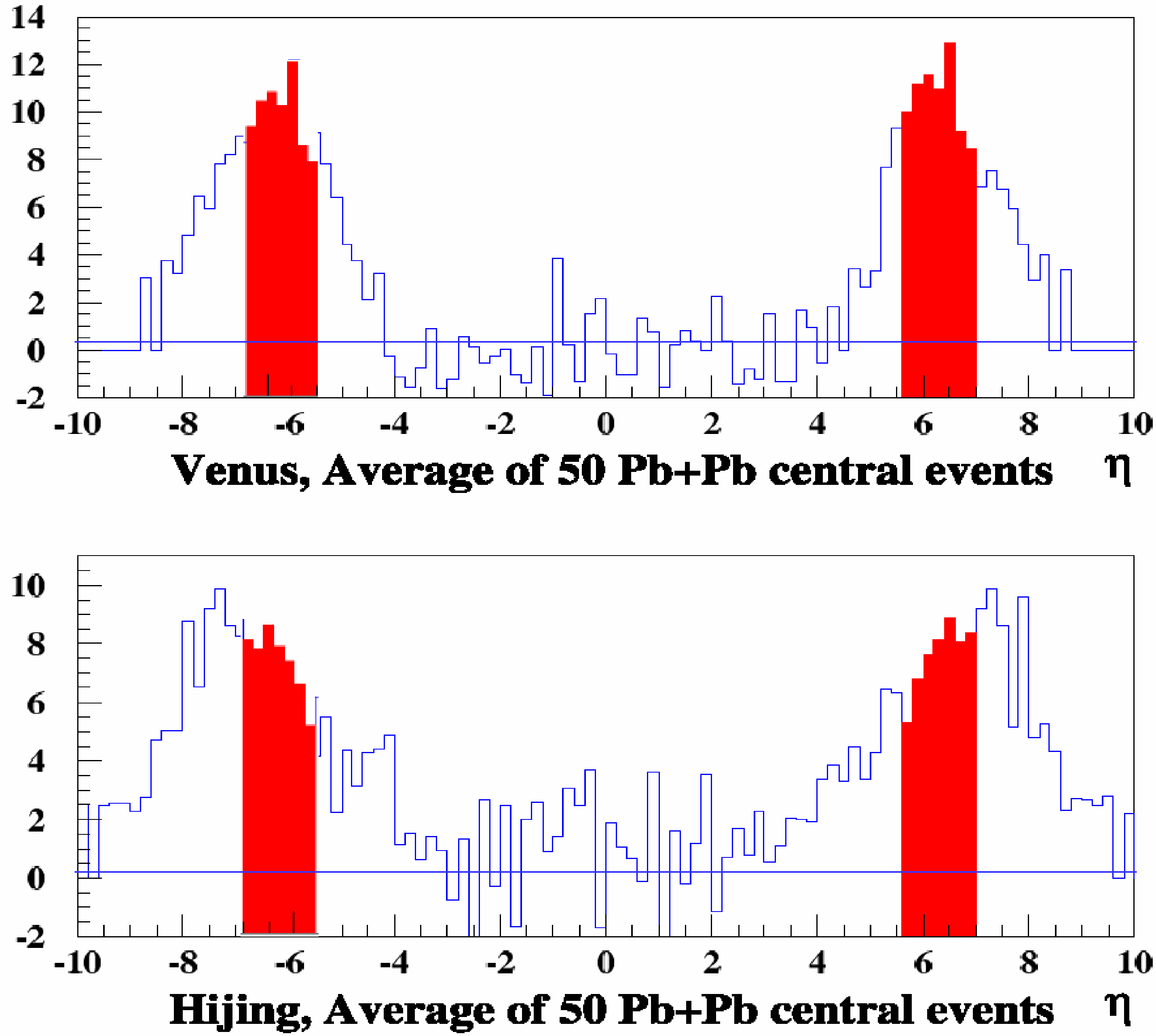
$\langle M_{cn} \rangle \sim 180$ GeV
$\langle \varepsilon_{cn} \rangle \sim 7$ GeV/fm^{-3}
$\langle V_{cn} \rangle \sim 27$ fm^3
$\langle \mu_q \rangle \sim 600$ MeV
$\langle T_{cn} \rangle \sim 130$ MeV

Net Baryon Number at the LHC
In Red the CASTOR Acceptance

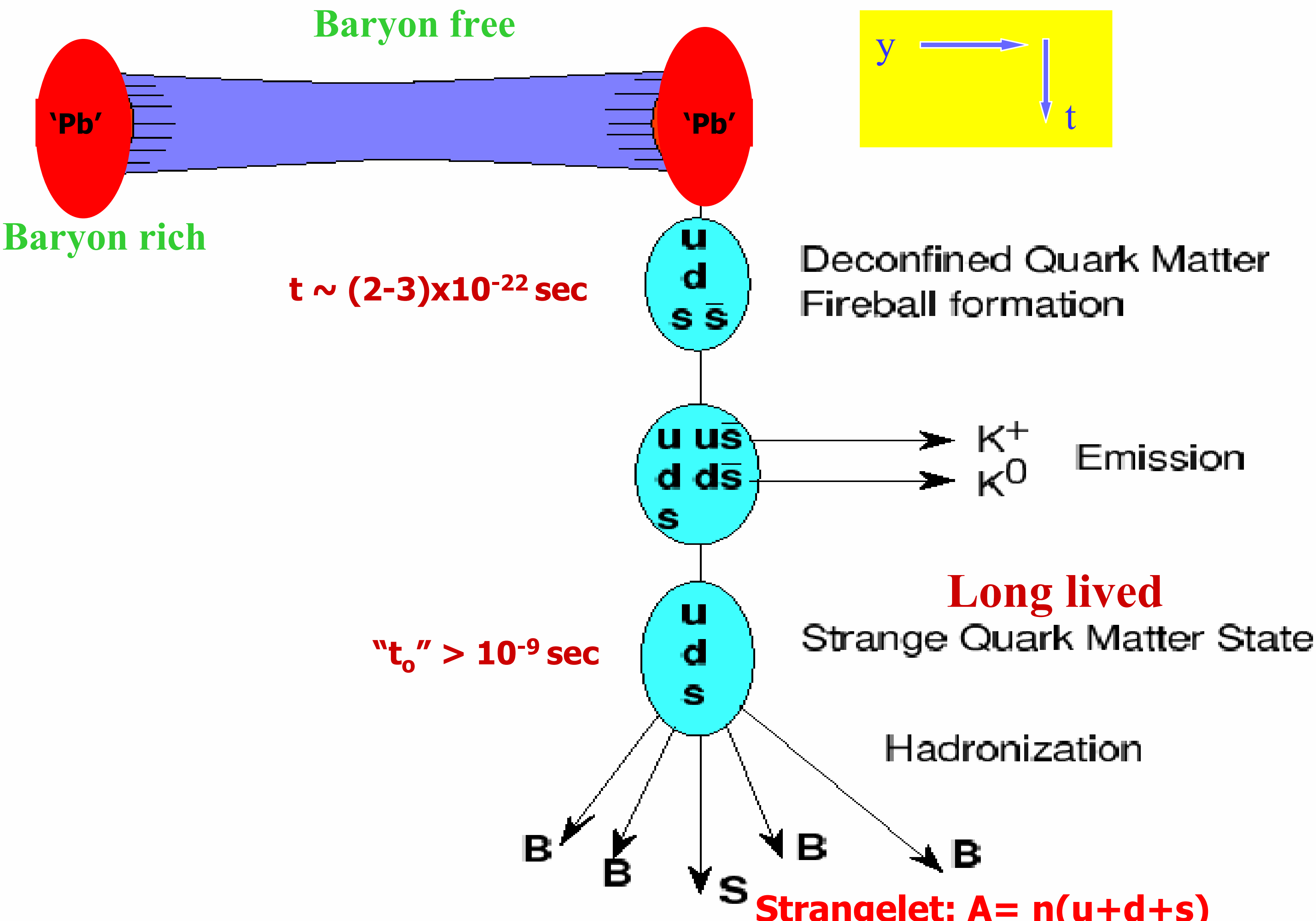


Peak of baryon distribution (BRAHMS)

$\eta \sim \eta_{beam}$ - 2.4

$\sim$ 6.3

Schematic Representation of the Centauro Model



Average characteristic quantities of modeled Centauro events and Strangelets produced in Cosmic Rays and expected at the LHC.

Centauro	Cosmic Rays	LHC
Interaction	"$Fe + N$"	$Pb + Pb$
$\sqrt{s}$	$\gtrsim$ 6.76 TeV	1148 TeV
Fireball mass	$\gtrsim$ 180 GeV	$\sim$ 500 GeV
y_{proj}	≥ 11	8.67
γ	$\geq 10^4$	$\simeq 300$
η_{cent}	9.9	$\simeq 5.6$
$\Delta\eta_{cent}$	1	$\simeq 0.8$
$< p_T >$	1.75 GeV	1.75 GeV (*)
Life-time	10^{-9} s	10^{-9} s (*)
Decay probability	(x $\geq$ 10 km) 10 %	(x $\leq$ 1 m) 1 %
Strangeness	14	60 - 80
f_s (S/A)	$\simeq 0.2$	$\sim$ 0.1 - 0.4
Z/A	$\simeq 0.4$	$\sim$ 0.3 - 0.4
Event rate	$\simeq$ 1 %	$\simeq$ 0.1 %
"Strangelet"	Cosmic Rays	LHC
Mass	$\simeq$ 7 - 15 GeV	10 - 80 GeV
f_s	$\simeq 1$	$\simeq 1$
η_{str}	$\eta_{Cent} + 1.2$	$\eta_{Cent} + 1.2$

(*) assumed

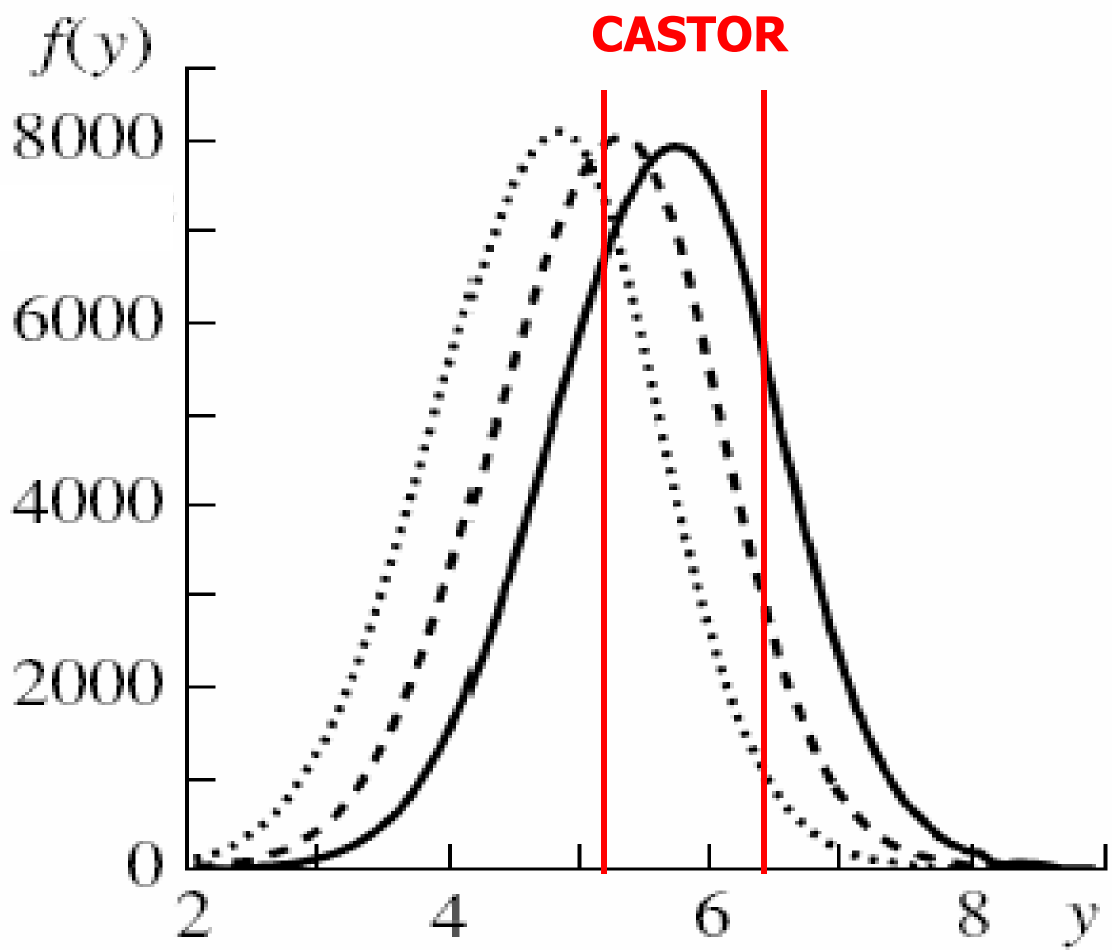


Fig. 7. Rapidity distribution of hadrons in Centauro events induced by Pb + Pb collisions at an energy of $\sqrt{s} = 5.5$ TeV per nucleon for three values of the fireball rapidity shift: $\Delta y_{\mathrm{fb}} =$ (solid curve) 2.0, (dashed curve) 2.5, and (dotted curve) 3.0.

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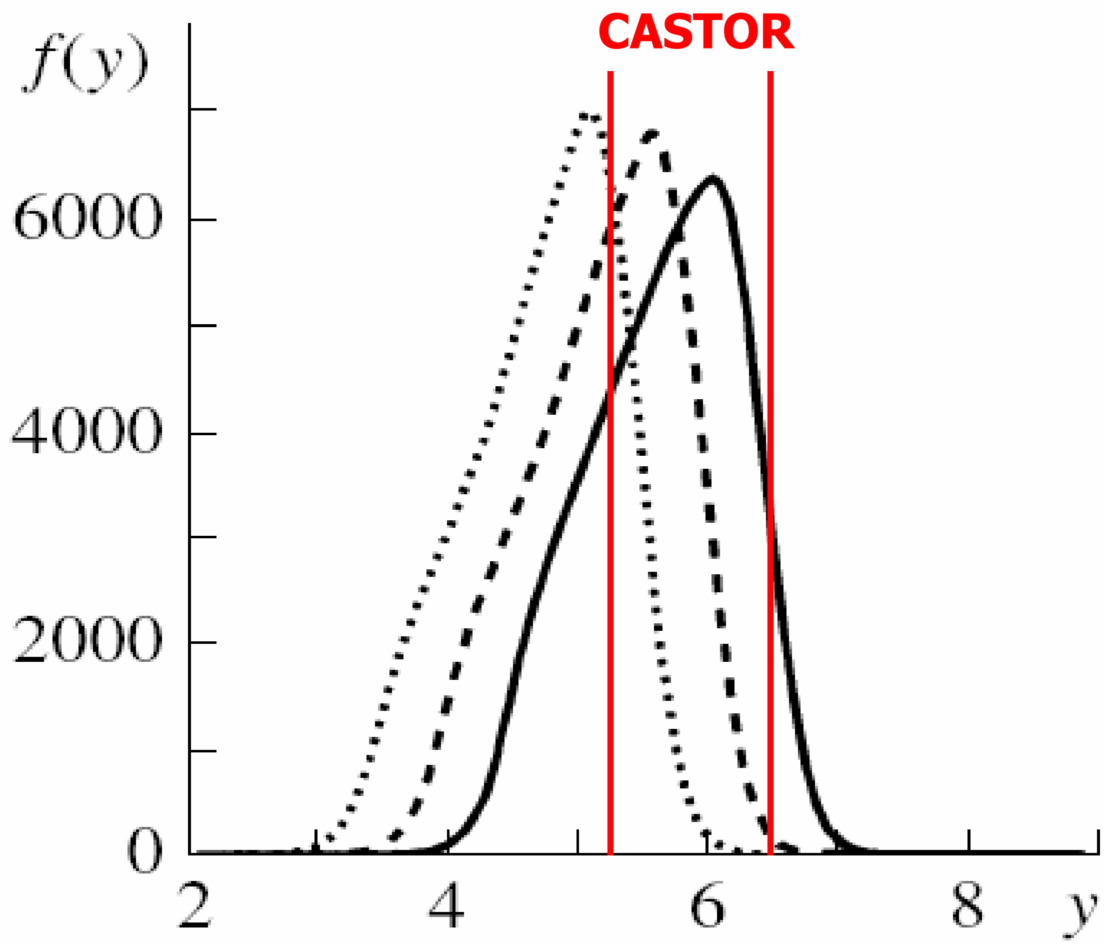

Fig. 9. Rapidity distribution of strangelets produced in the decay of a Centauro fireball in Pb + Pb collisions at an energy of $\sqrt{s} = 5.5$ TeV per nucleon for three values of the fireball rapidity shift: $\Delta y_{\mathrm{fb}} =$ (solid curve) 2.0, (dashed curve) 2.5, and (dotted curve) 3.0.

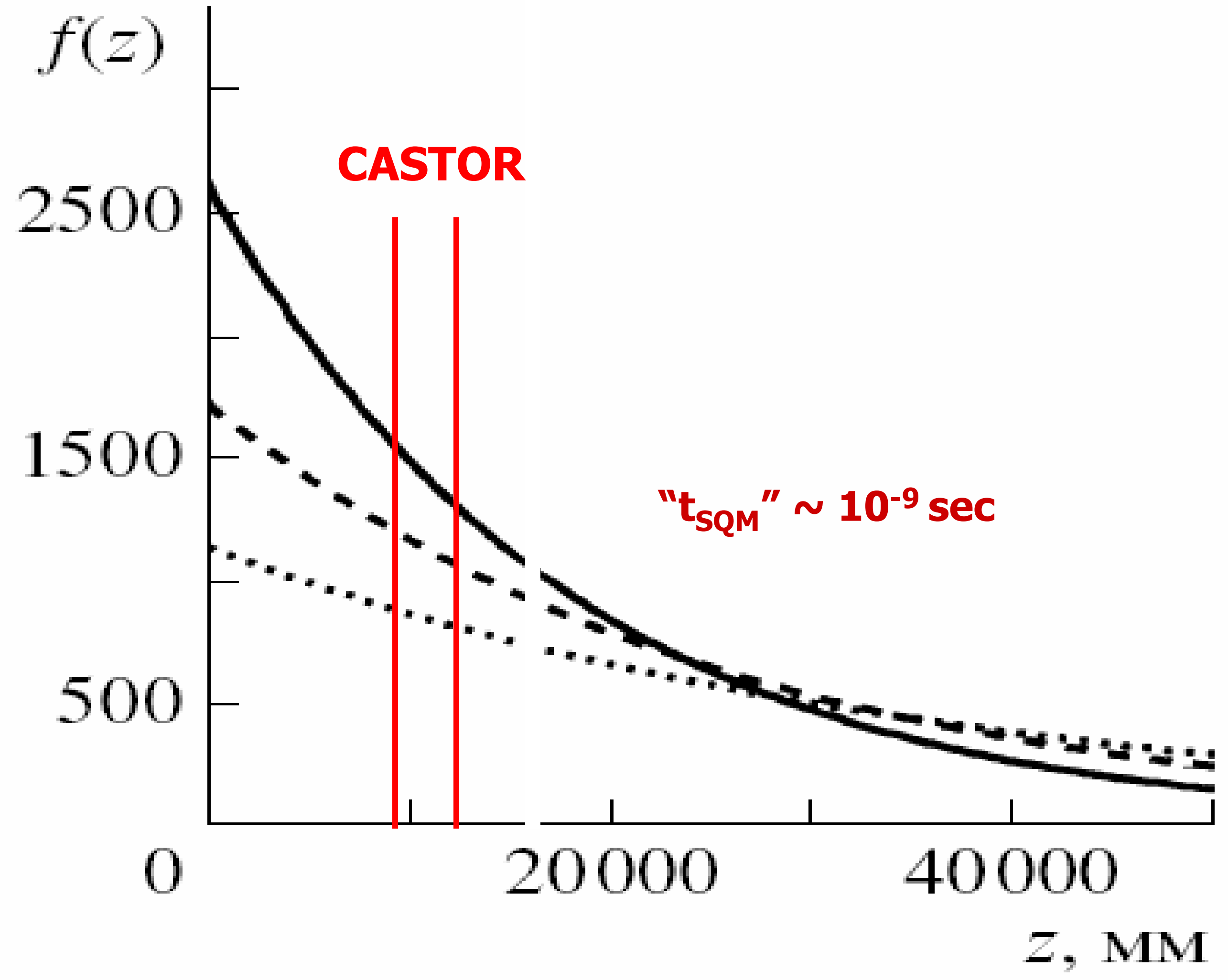

Fig. 10. Decay-length distribution of an SQM fireball at $T = 250$ MeV and $\mu_b = 1.8$ GeV for three values of the fireball rapidity shift: Δy_{fb} = (solid curve) 3.0, (dashed curve) 2.5, and (dotted curve) 2.0.

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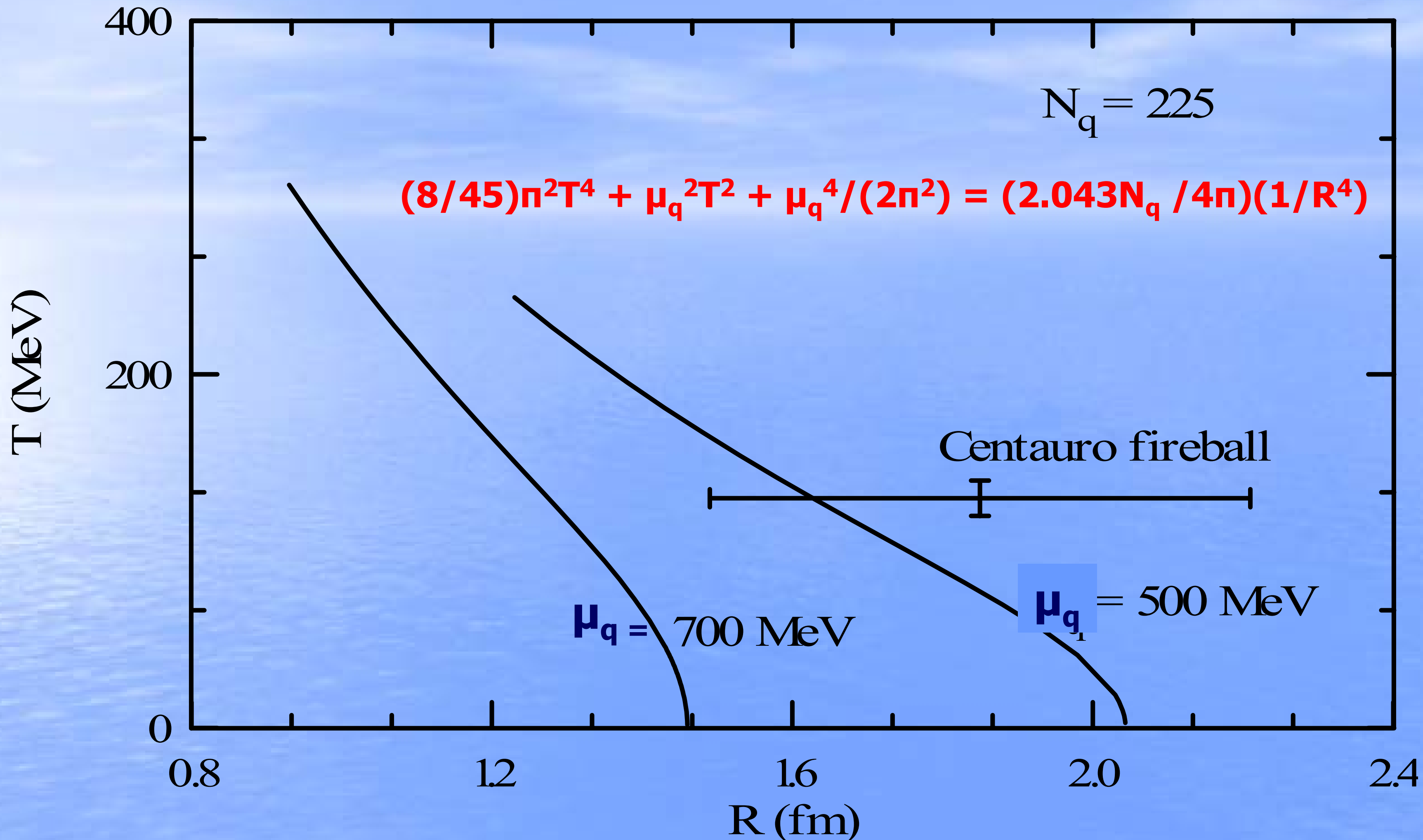
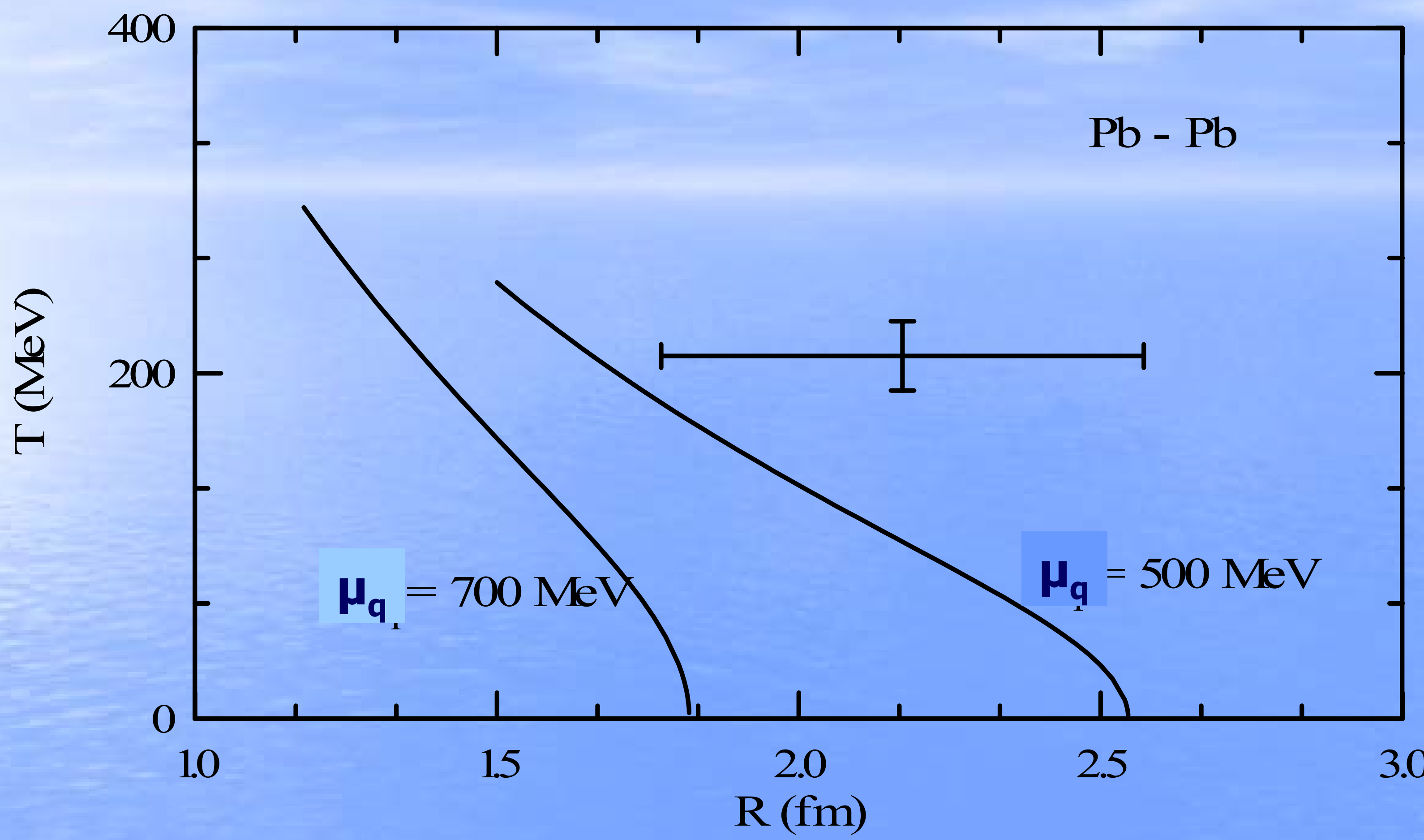


DQM-bag stability curves: *T* as a function of *R* with $\mu_q = 600 + \Delta\mu_q$ and $\mu_q = 600 - \Delta\mu_q$, corresponding to C-R Centauro fireball values.



DQM-bag stability curves: *T* as a function of *R* with μ_q = 600 + Δμq and μ_q = 600 - $\Delta\mu_q$, corresponding to Pb+Pb Centauro fireball values at the LHC.

Strangelet Interaction in the CASTOR Calorimeter

EPJ direct C9(2000)1

A strangelet is considered to be an object with radius

$$R = r_0 \mathrm{A}_{str}^{1/3}$$

where the rescaled radius is taken to be

$$r_0 = \left(\frac{3\pi}{2(1-2\alpha_s/\pi)[\mu^3 + (\mu^2 - m_s^2)^{3/2}]}\right)^{1/3}$$

The mean interaction path of strangelets in the W absorber is

$$\lambda_{str-W} = \frac{\mathrm{A}_W m_n}{\pi(1.12\mathrm{A}_W^{1/3} + r_0 \mathrm{A}_{str}^{1/3})^2}$$

Penetrating through the calorimeter a strangelet undergoes collisions with W nuclei. At each collision it is separated into a surviving spectator part and a wounded part.

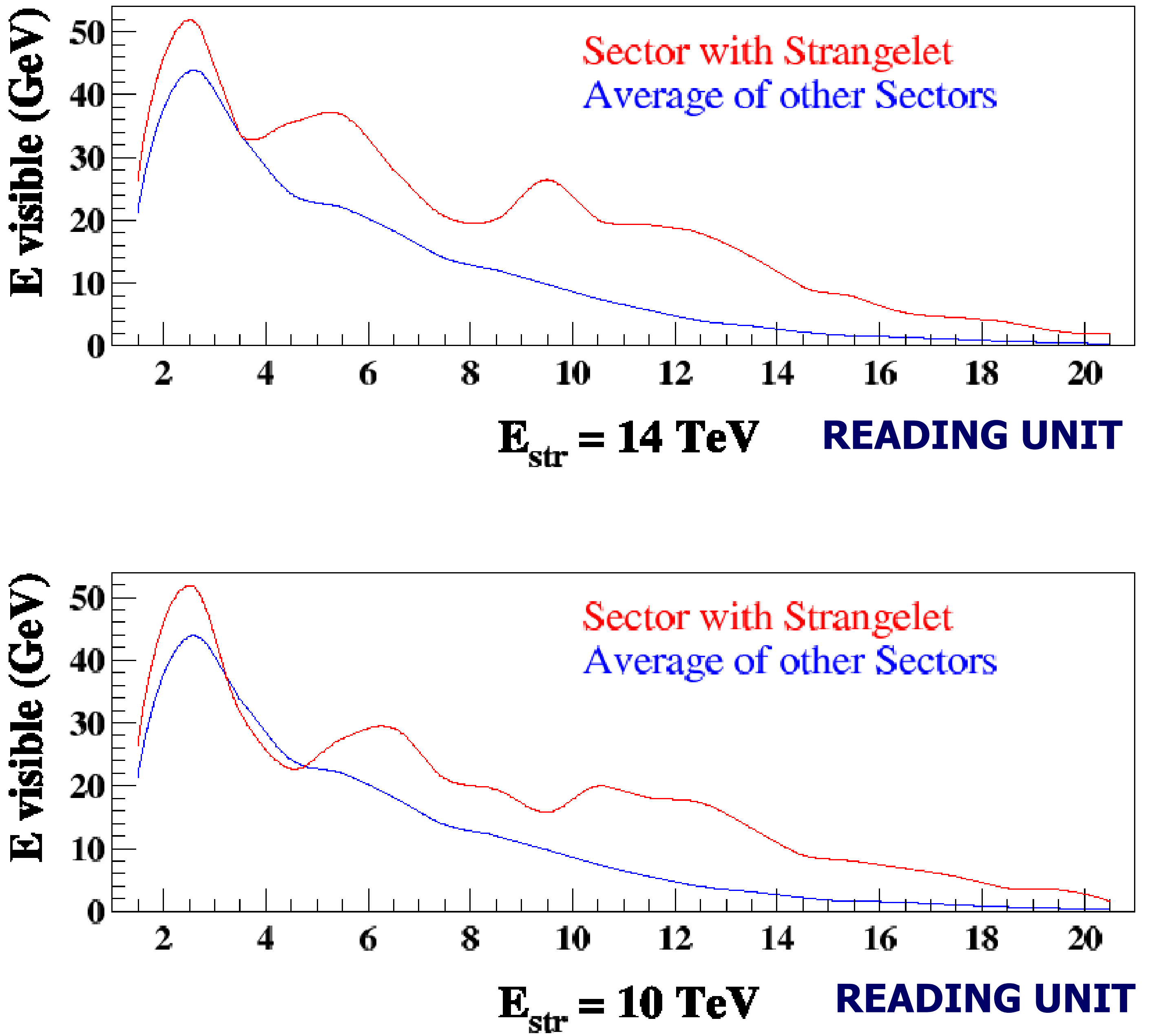
- The spectator part continues its passage.
- The wounded part is destroyed.

The particles which are generated at the consecutive collision points interact with the W nuclei in the normal way, resulting in the electromagnetic/hadronic cascade which develops in the calorimeter.

The process ends when the entire strangelet is consumed.

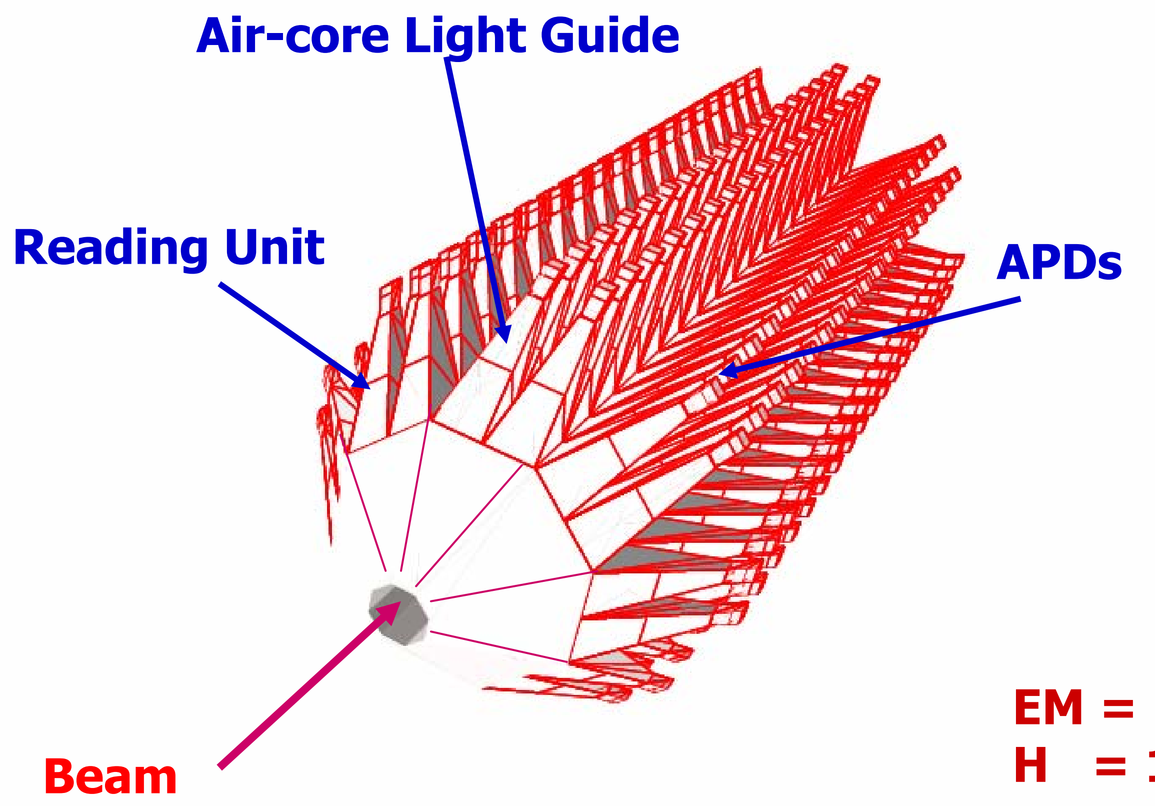
Strangelet A_{str}=20, μ=600 MeV

Simulation of the passage of a Strangelet through CASTOR



CASTOR at CMS

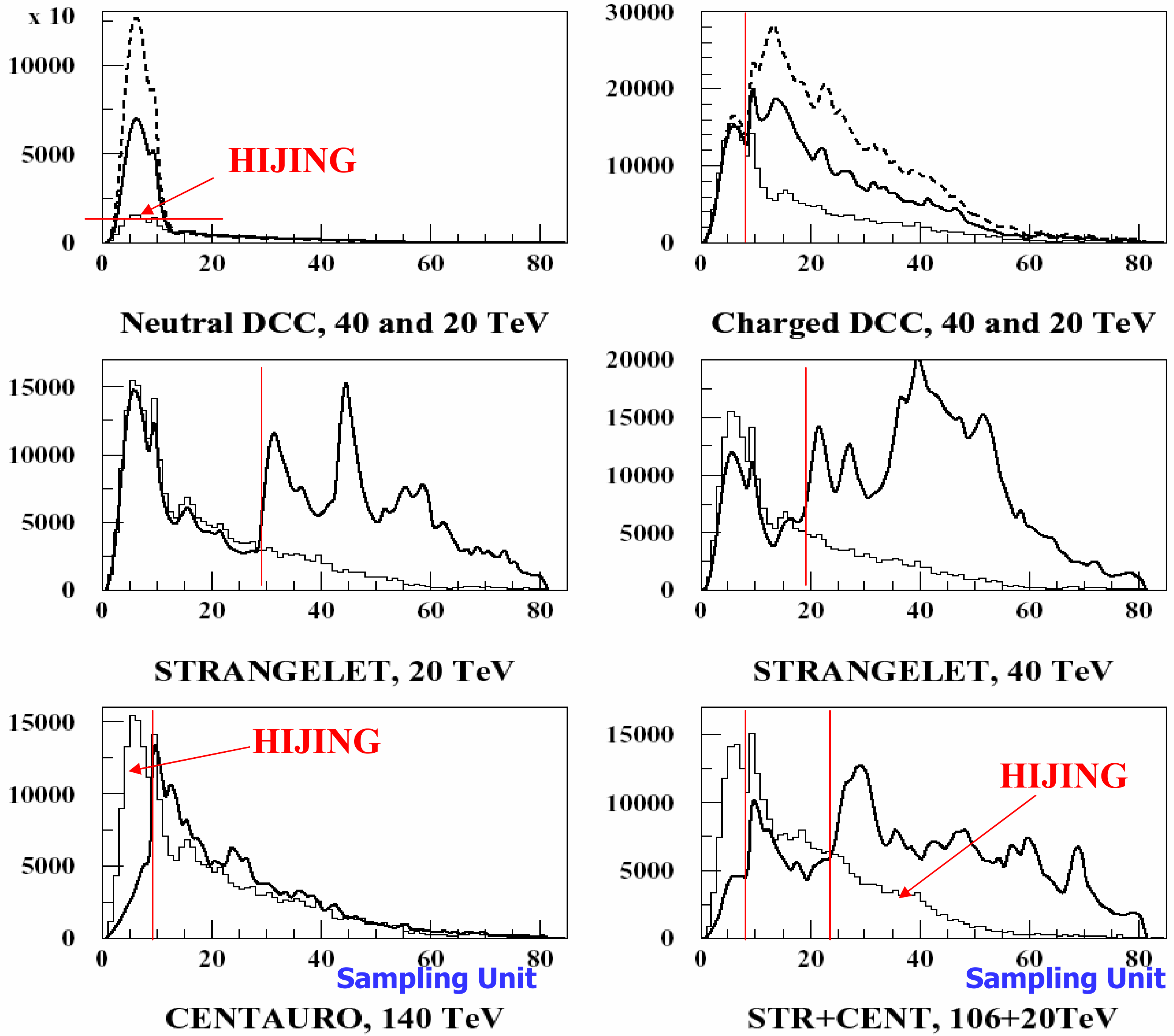
H
CASTOR
A
L



EM = 2 RU
H = 18 RU

EXOTIC EVENTS (signal + background) in comparison with HIJING

DEPOSITED ENERGY GeV



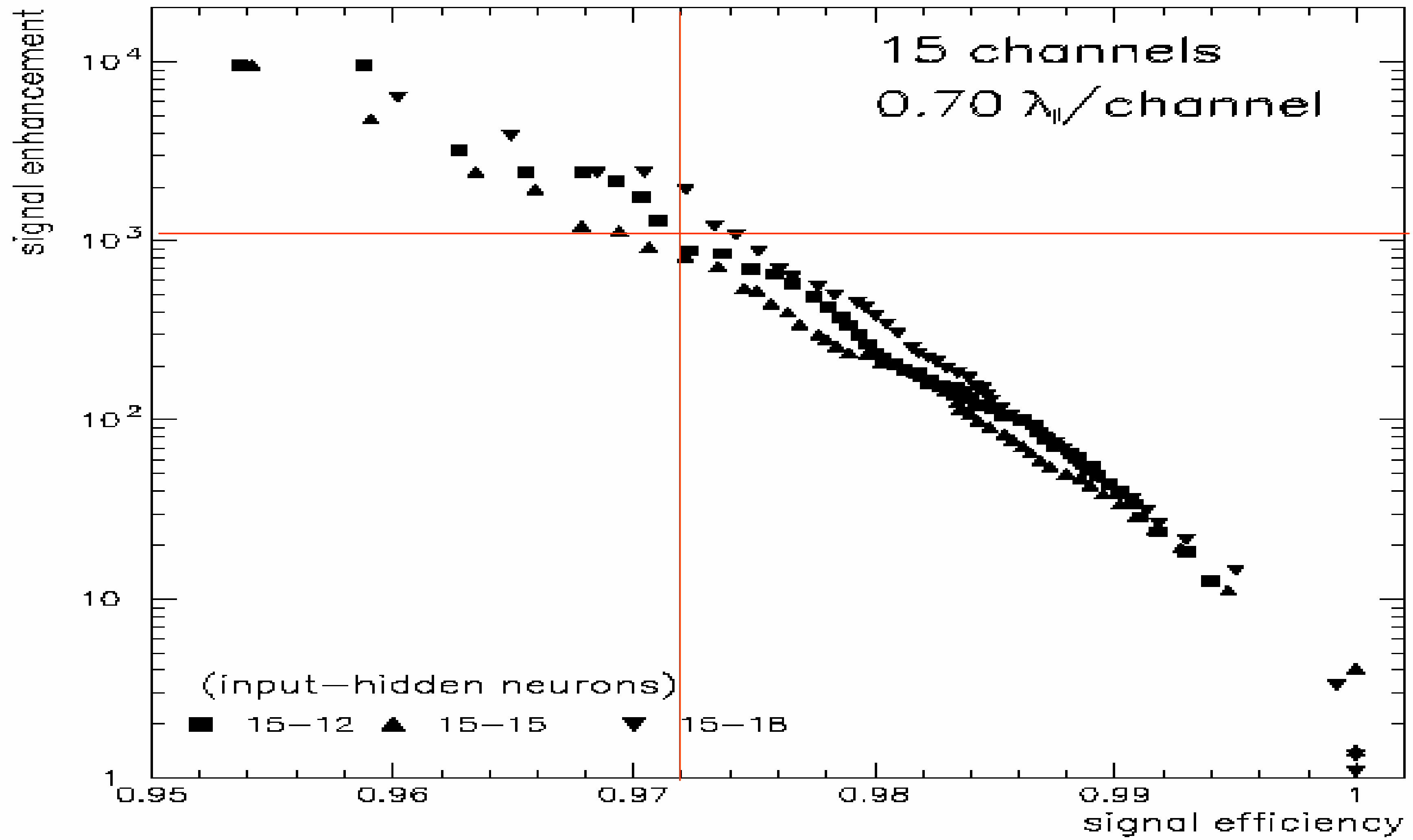


Figure 5. Enhancement of the signal/background ratio for strangelet detection in CASTOR obtained through application of the neural network technique.

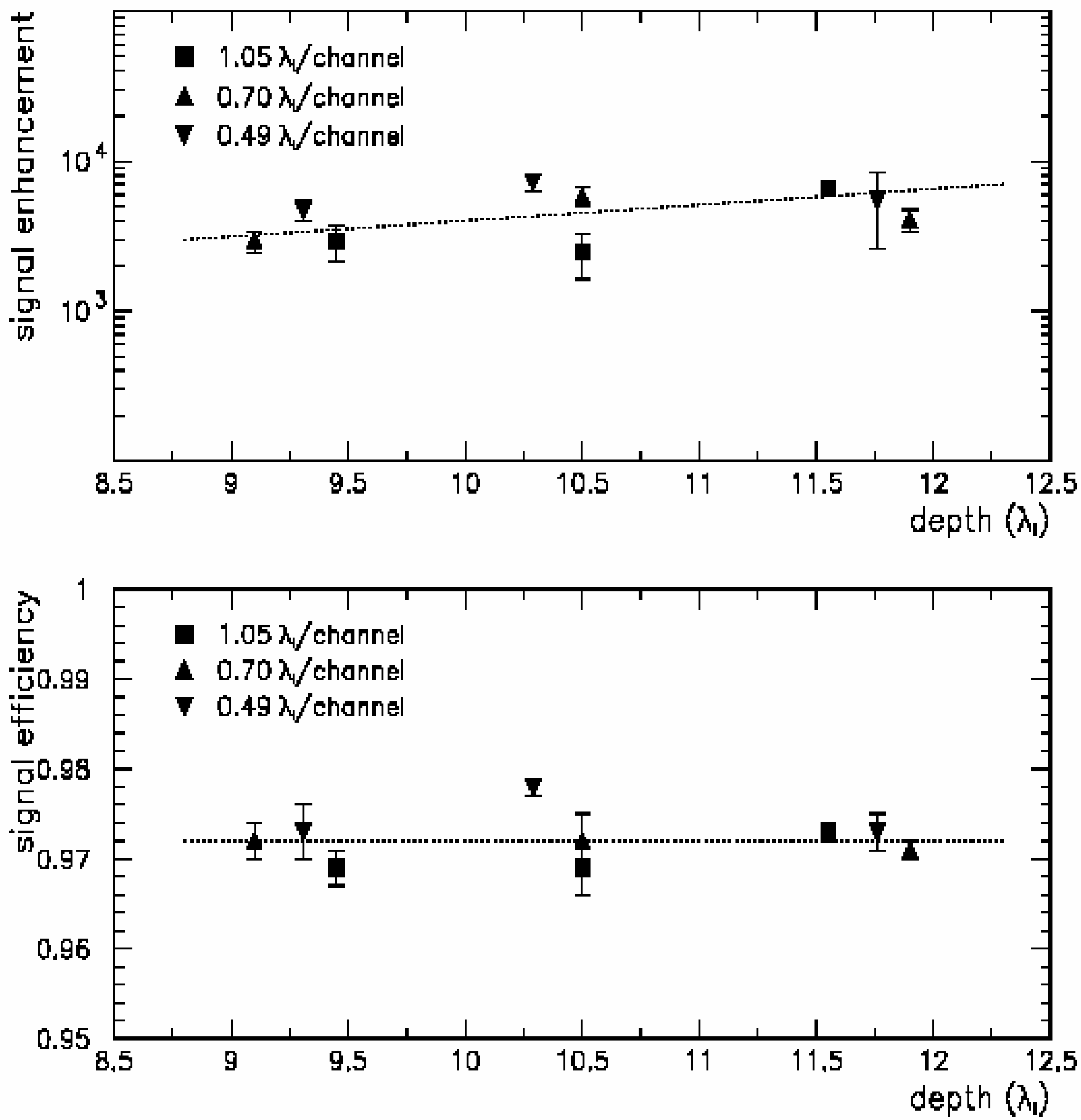
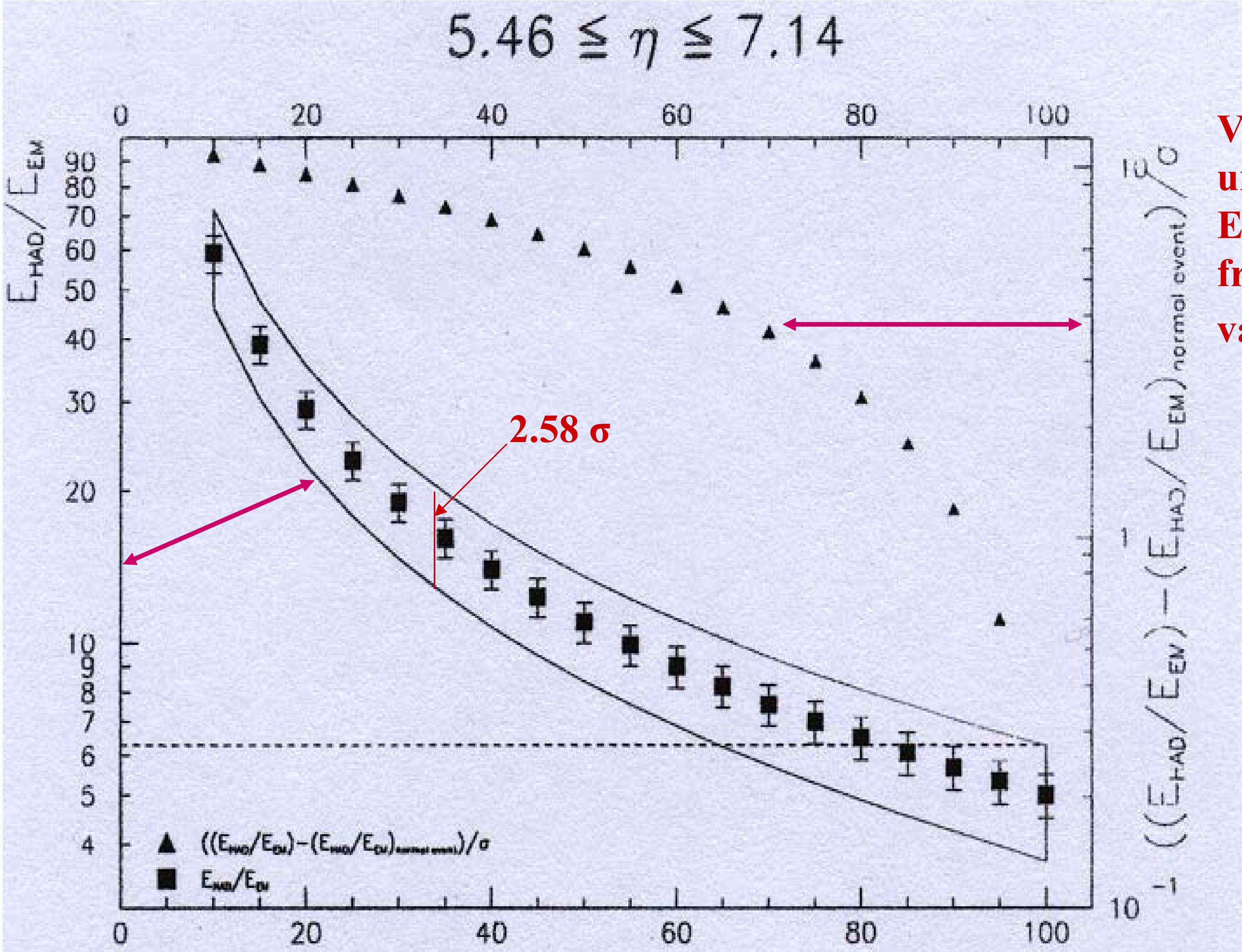


Figure 14: average signal enhancement (at $\epsilon_s = 0.96$) and efficiency (at $\frac{\epsilon_s}{\epsilon_b} = 1000$) as a function of total calorimeter depth for different channel configurations. A trendline is shown to guide the eye.



Variance, in units of σ, of E_{HAD}/E_{EM} from normal value.

% of total energy in Castor acceptance from 'normal' events. The remaining energy is from Centauro event.

SUMMARY

- Exotic C-R events may be observed and studied under controlled experiment at the LHC.
- CASTOR is designed to study such events.
- Soon we will check the correctness of the Centauro model and the existence of the so-called "CR Exotic events.