Radio-detection of UHECR by the CODALEMA experiment

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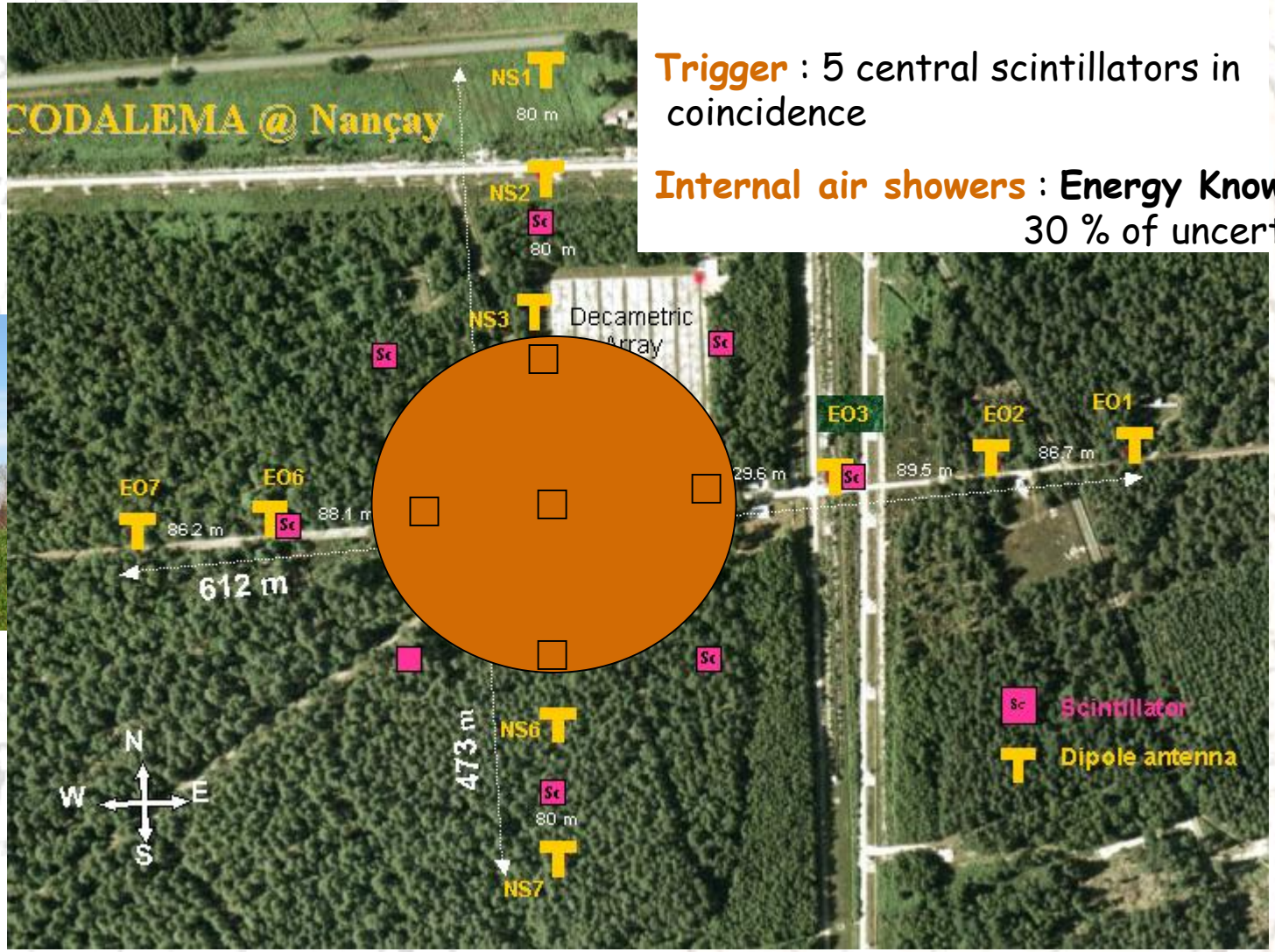
and the CODALEMA collaboration

CODALEMA setup

Scintillator array (trigger)

Dipole array



Trigger : 5 central scintillators in coincidence

Internal air showers : **Energy Known**
30 % of uncertainty

EW polarization of the Electric field

Statistics

since December 2006, new setup

Effective time : 170 days

Multiplicity >= 3 (3 antennas tagged at least) : 613 events

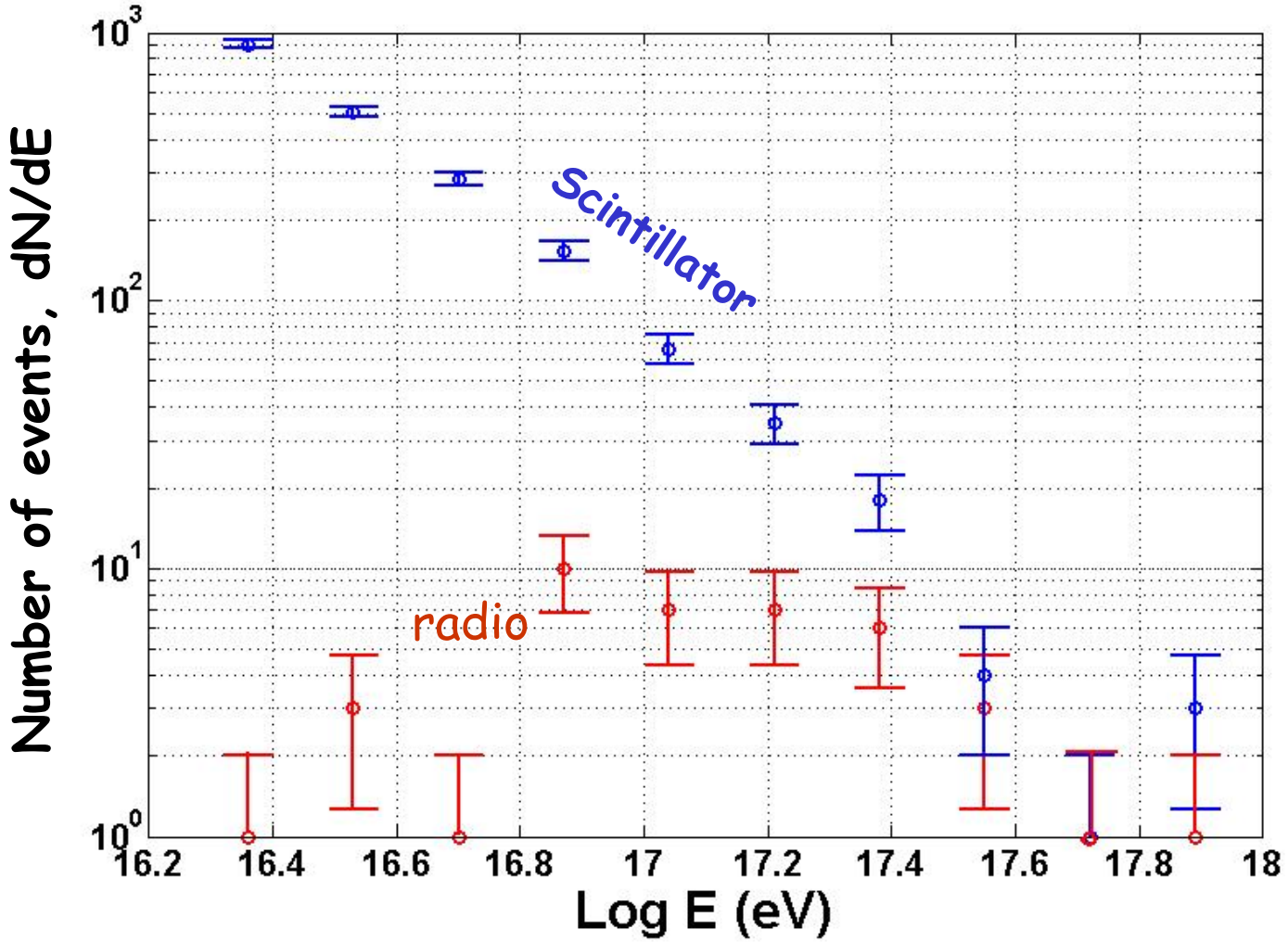
Multiplicity >= 3 + time and angular coincidence between both arrays

141 cosmic ray showers radio-detected

Counting rate : **0.8 events/day**

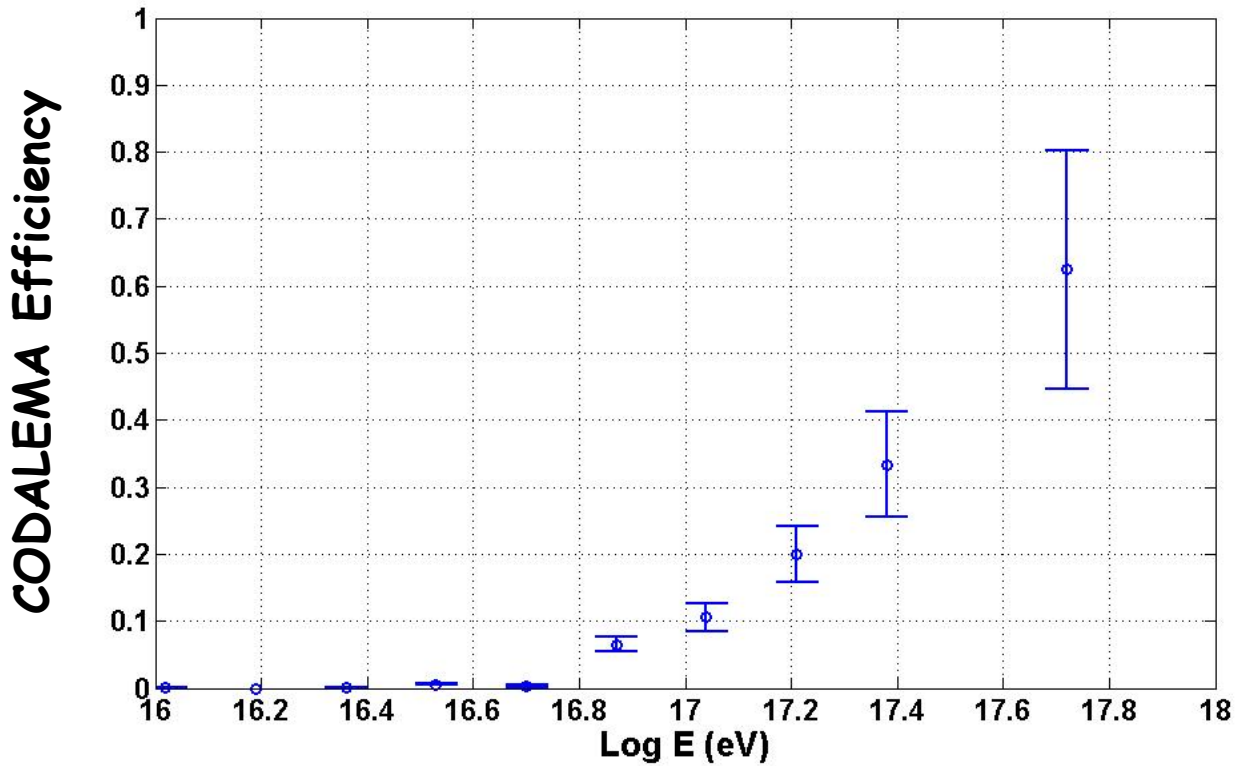
43 showers with energy known (Internal)

Energy distribution



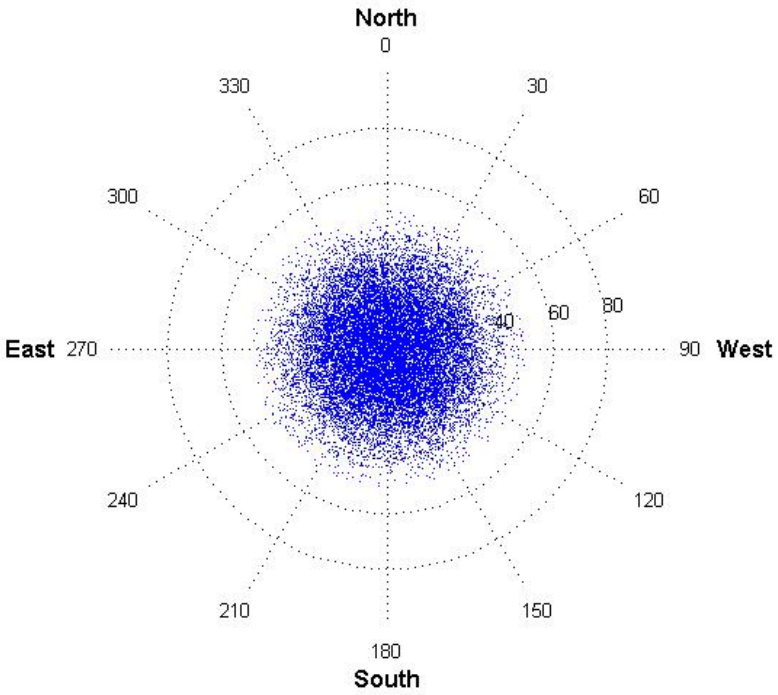
CODALEMA radio-detection efficiency

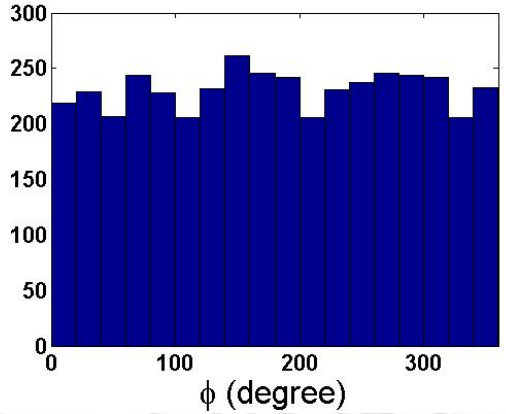
(with one Electric field polarization measured)



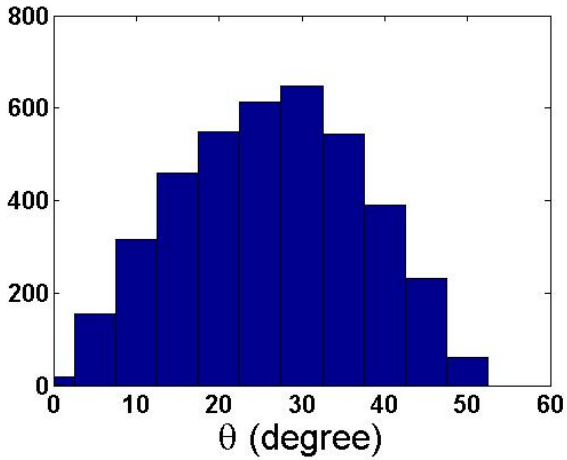
Scintillator distributions (internal showers)

Shower arrival directions calculated with the **scintillator data**





Azimutal distribution

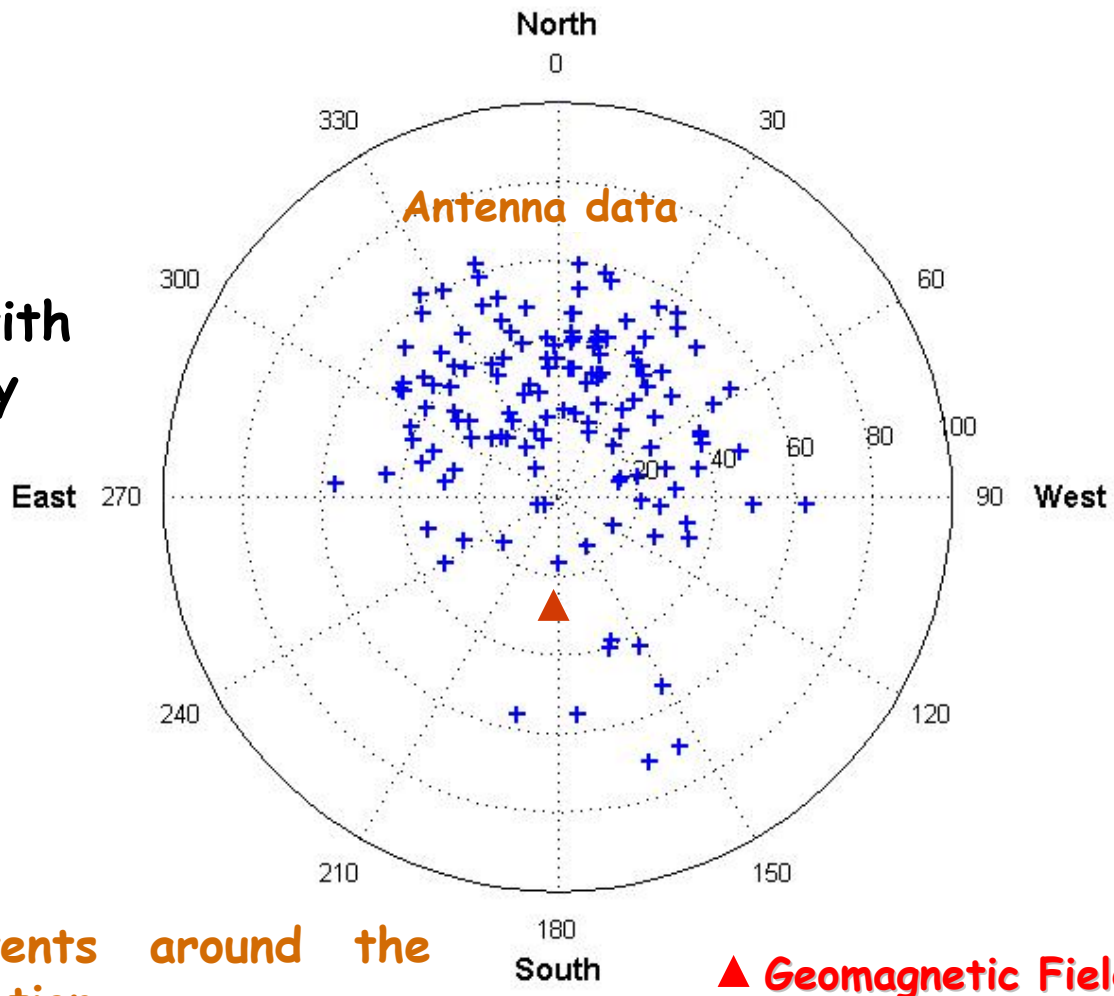


Zenithal distribution
Limited at $\theta < 50°$

Energy threshold for scintillator array ~ 10^{15} eV

Shower arrival directions

141 radio-detected showers in coincidence with particle detector array

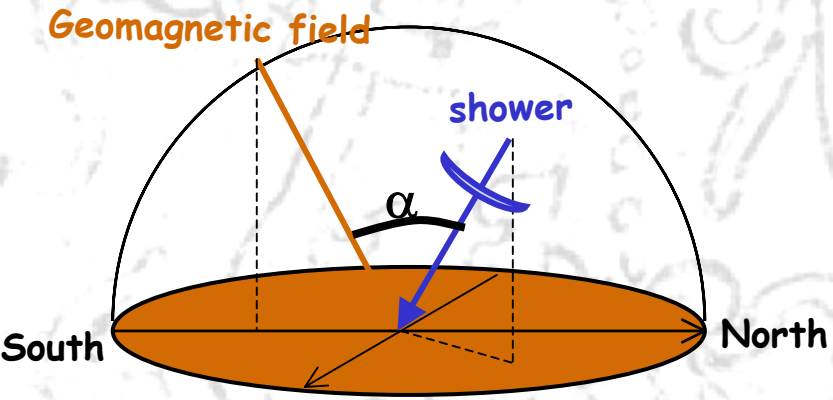


★ Shower deficit in the South direction

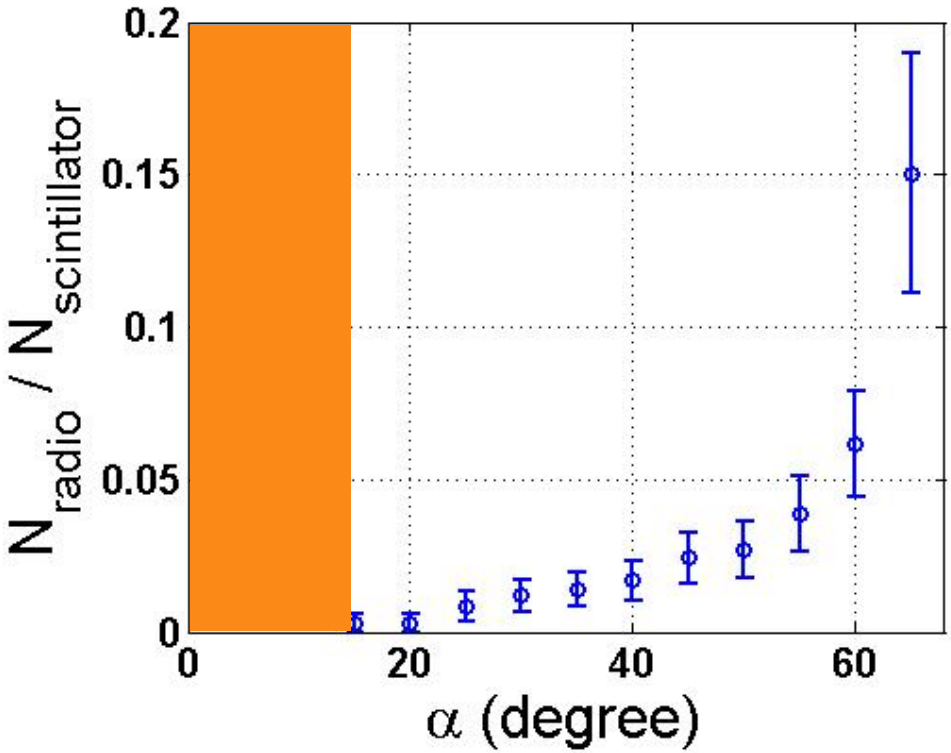
★ Small number of events around the Geomagnetic field direction

▲ Geomagnetic Field @ Nançay
θ = 27 °, ϕ = 180°

Geomagnetic effect



α : angle between Geomagnetic field and cosmic ray arrival direction



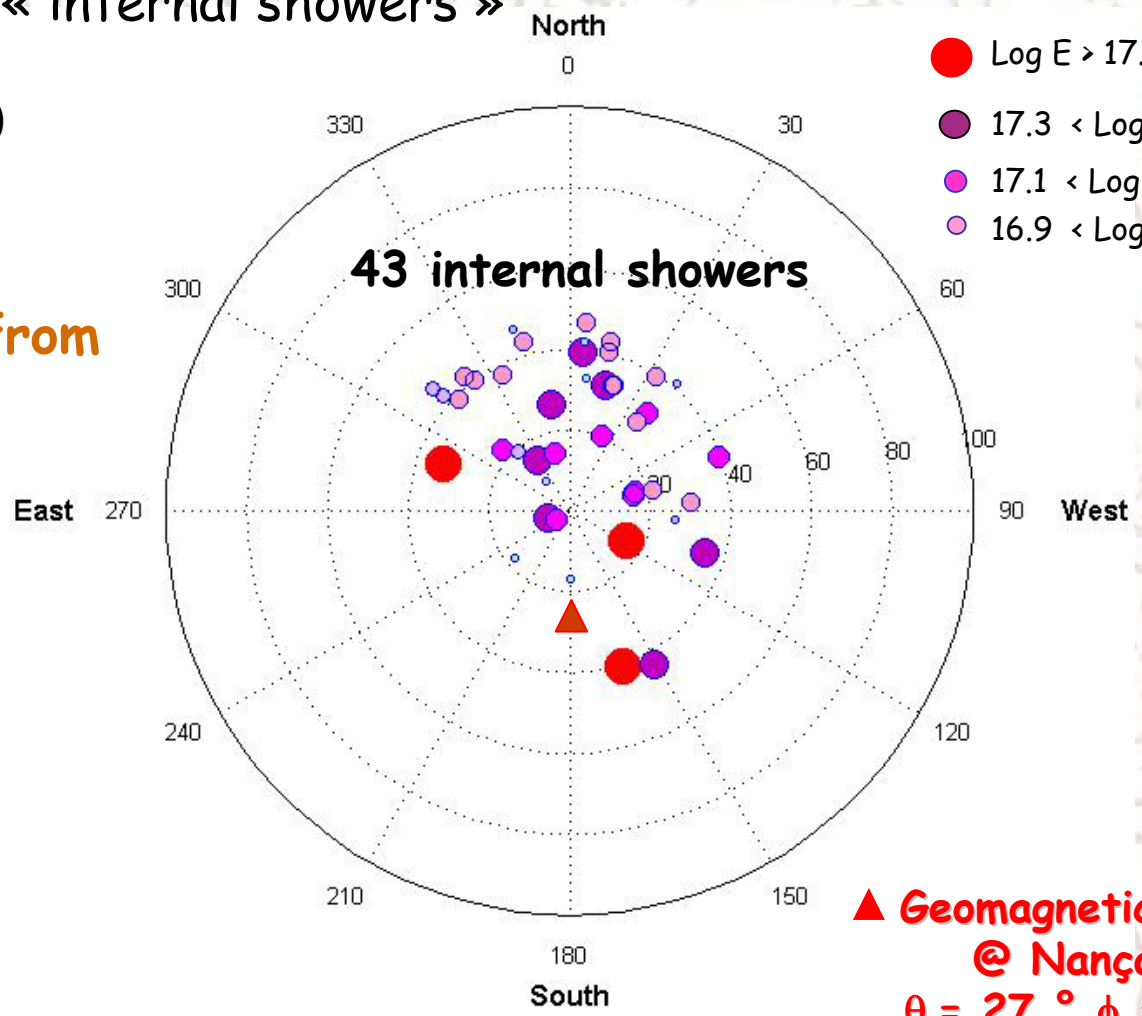
Corrected for the triggered events distribution dN/dα

Geomagnetic effect / Energy

Energy known only for « internal showers »

(CIC method, precision 30 %)

Air showers detected from the South are more energetic



Geomagnetic effect / Energy

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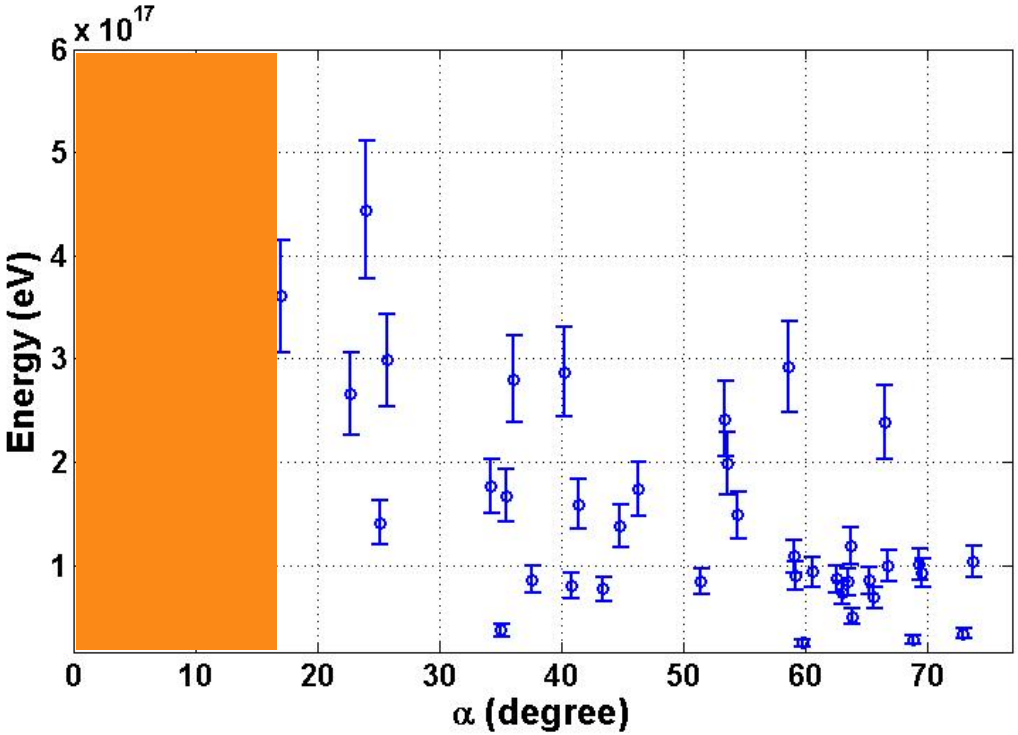


Low counting rate around the Geomagnetic field

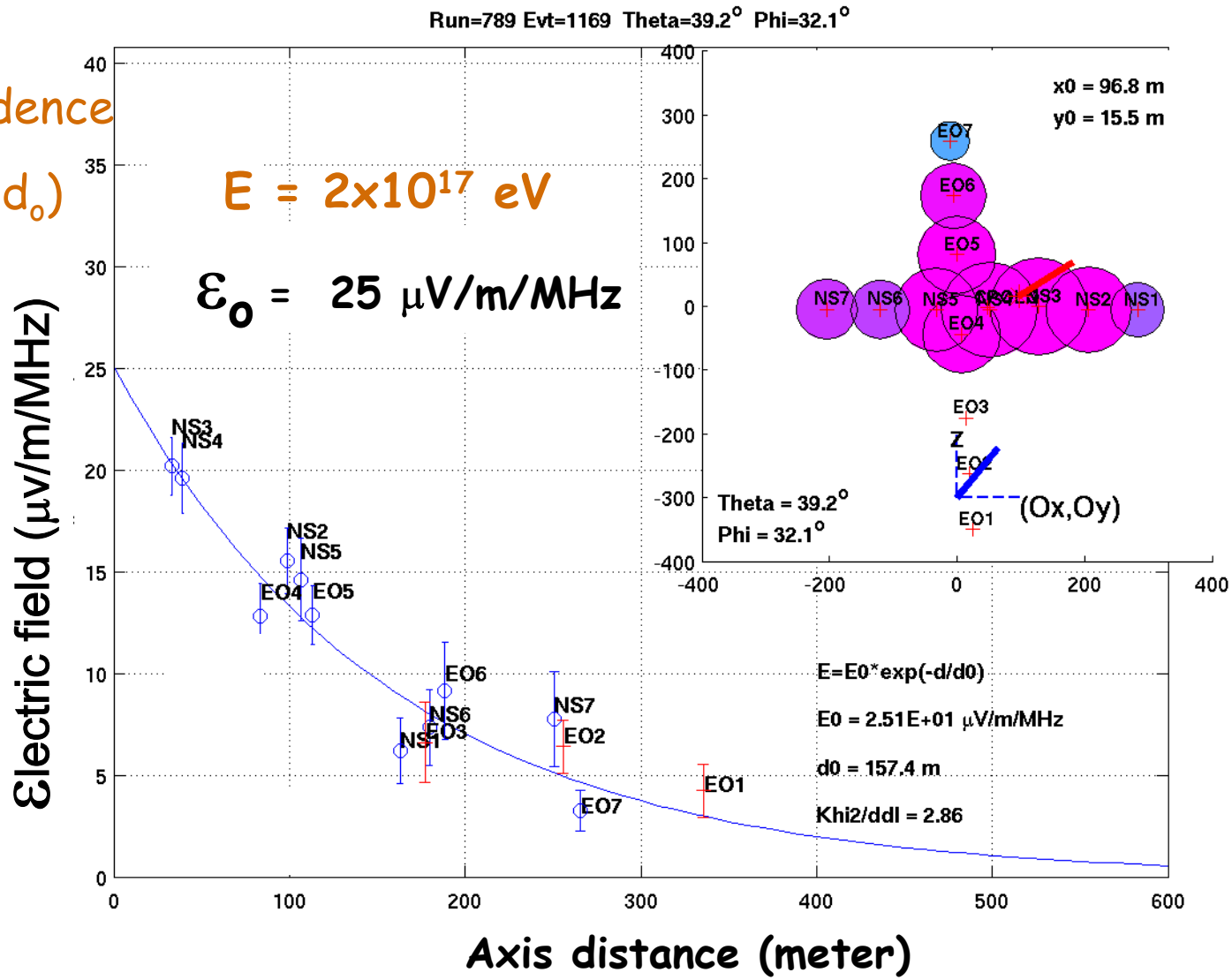
Deficit of low energy events for small α

Evidence for a geomagnetic effect in the radio emission process (not only geosynchrotron)

Electric Field Topology

Exponential dependence

$\mathcal{E} = \mathcal{E}_o \exp(-d/d_o)$



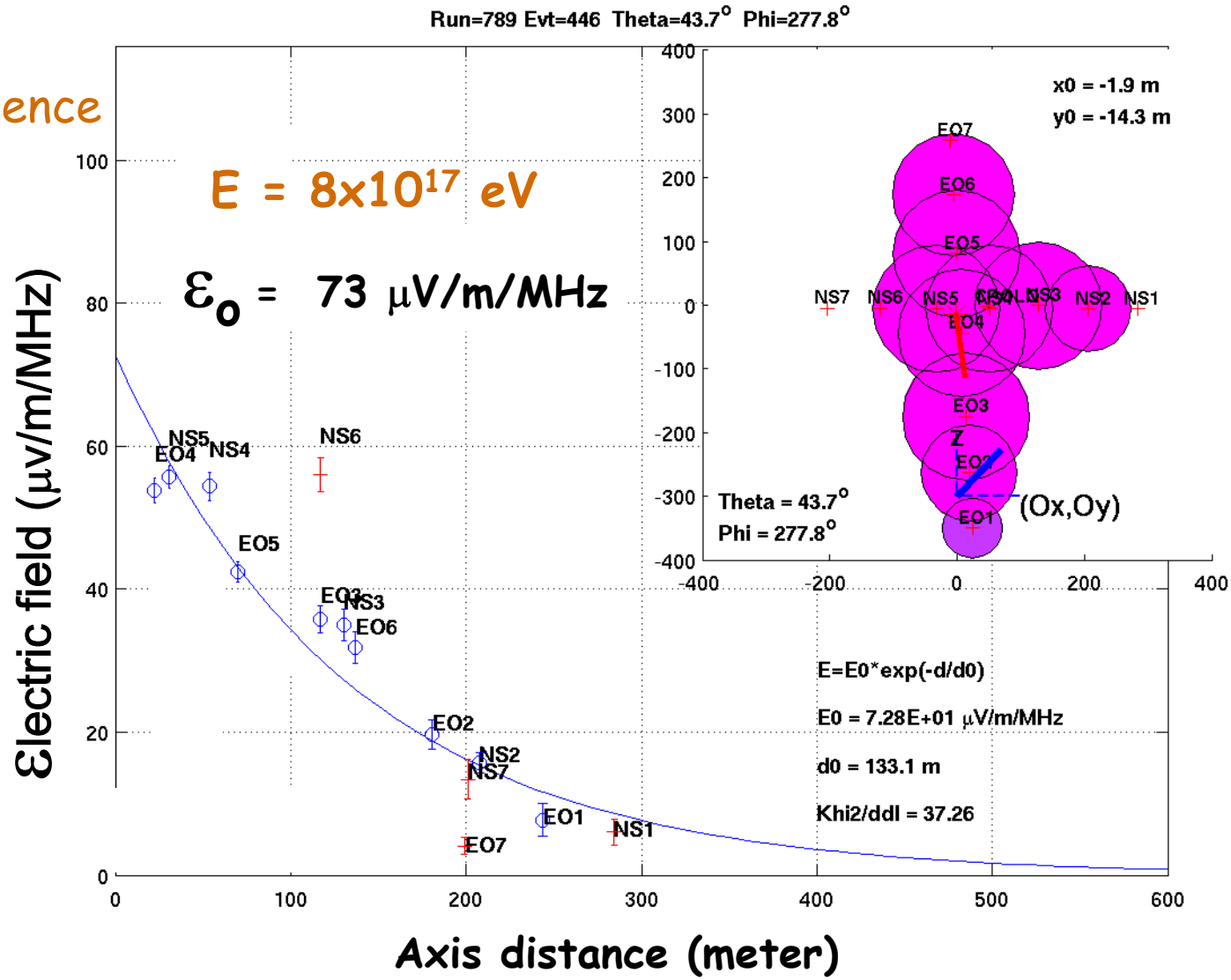
Electric Field Topology

Exponential dependence

$\mathcal{E} = \mathcal{E}_o \exp(-d/d_o)$

More statistic needed to correlate

$\mathcal{E}_o$ and Energy

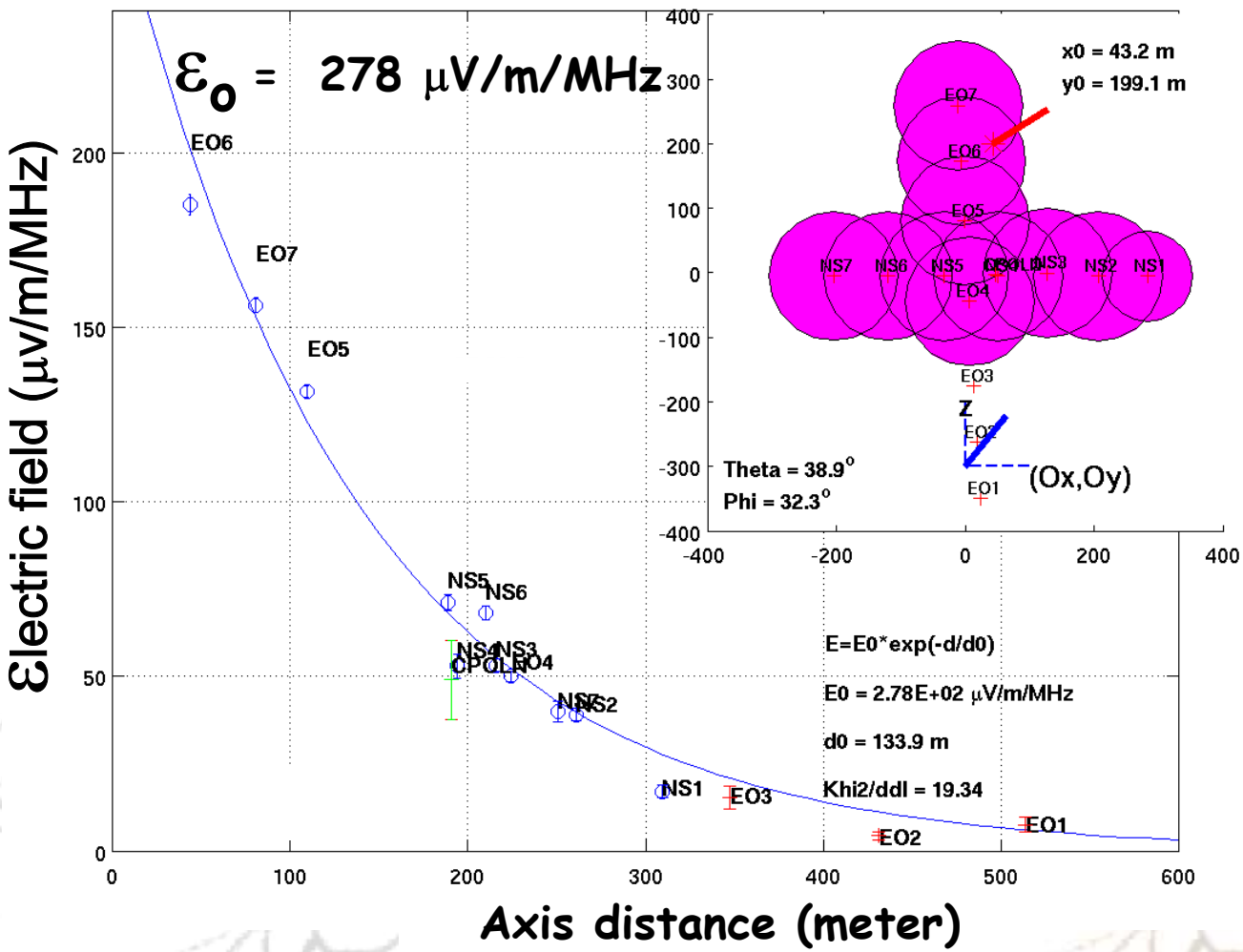


Electric Field Topology

"Giant event" (Energy above 10^{18} eV)

Unfortunately not internal

HUGE electric field !



CONCLUSION

★ CODALEMA radio detection efficiency increases with energy

Evidence for a Geomagnetic effect

radio-detection deficit close to the Geomagnetic field direction

➡ effect on the radio-detection efficiency around 10^{17}eV

➡ constraint on the emission process

Detection of all polarization could help

★ At the present time, we do not see clear correlation between the cosmic ray Energy and the measured electric field

➡ Larger autonomous antennas array (in 2008 @ Nançay)

CODALEMA @ ICRC 2007 see also 3 posters

- **Radiodetection of astronomical phenomena in the cosmic ray dedicated CODALEMA experiment**
  Jacob Lamblin

- **Design and performance of a fully autonomous antenna for radio detection of extensive air showers**
  Benoît Revenu

- **Radio detection of High-Energy cosmic rays at the Pierre Auger Observatory**
  A Van Den Berg