First results of the CNGS beam monitor with LVD

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Figure 1.1.1: Sketch by A. Zichichi, 1979
Why a monitor at LNGS?

"to get some feed-back":

Neutrino flux monitors at Gran Sasso
monitor intensity and time-stability of beam

Large area 
μ detectors
(≈15x15 m²)

from CERN

Hadrons

interaction in up-stream rock

νμ

ν from CERN

νμ

Halls

L’Aquila
Highway tunnel
Terano

0.86 μ/m²/day
≈ 200 μ/day in each GS hall

1% statistical error
in 1 week - from 3 GS hall
"Real time" feedback

18 September 2002
CNGS - a long baseline neutrino beam facility in Europe,
presented by K. Eiseiener (CERN) at Aarhus University

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Large Volume Detector

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Large Volume Detector

- 3 identical towers in the detector
- 35 active modules in a tower
- 8 counters in one module

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Neutrinos from CNGS are observed through:

- the detection of **muons** produced in neutrino **CC** interactions with the surrounding rock or in the detector
- the detection of the **hadron jets** produced in neutrino **NC/CC interactions** in the detector

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LVD monitor of the CNGS beam

The neutrino candidate are defined as at least a signal from a counter of the detector with an energy deposit greater than 100 MeV.

We can discriminate CNGS event from cosmic muons requiring:

- horizontal direction of the reconstructed muon
- time coincidence of the event with the CNGS time spill (cosmic muon background is then about 0.2 events/day)

From the Montecarlo simulation we expect $6.67 \times 10^{-16}$ events/proton on target (p.o.t.)

1 year of data (200 days) $\rightarrow$ $4.5 \times 10^{19}$ p.o.t. $\rightarrow$ 150 events/day

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Event Display: $\mu$ from rock

Simulation!

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Event Display: internal $\nu$ CC

* Interaction vertex
  $E_\nu = 26.1 \text{ GeV}$
  $E_\mu = 5.6 \text{ GeV}$
  $E$ released = 8.7 GeV
  Missing $E_h = 6.8$ GeV
  Missing $E_\mu = 3.6$ GeV
  Missing $E_{\text{IRON}} = 7.0$ GeV

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Event Display: internal $\nu$ NC

YZ PROJECTION $\rightarrow$ EVENT 68

* Interaction vertex

$E_v = 19.5 \text{ GeV}$

$E$ released = 9.8 GeV

$\text{Missing } E_h = 1.6 \text{ GeV}$

$\text{Missing } E_{\text{IRON}} = 8.1 \text{ GeV}$

Simulation!

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Results
CNGS beam: commissioning

During the commissioning week, 14 - 18 August, the CNGS beam started. On the 16th there were the first beam spills with high intensity (about $1.3 \times 10^{13}$ p.o.t./spill); the integrated beam intensity during this period was $2.79 \times 10^{15}$ p.o.t. and we expected 1.9 events.

We observed 2 events (cosmic background of about 0.07).

On August 16th, at 20:08:03 UTC, the LVD detector has seen the first CNGS event: OvE!

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The first CNGS event: OvE

LVD SIDE VIEW

SIDE VIEW → EVENT 138950

TOP VIEW → EVENT 138950

Run 28543  Event 138950
16/8/6 21.8.3
Total energy = 2.18491 GeV
released in 7 counters

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CNGS beam run

From August 18th, at about 11:30 UTC, the CNGS beam started with an intensity of about $1.4 \times 10^{13}$ p.o.t./spill, about 60% of the nominal intensity).

In about 89 hours of data taking LVD has collected 289 CNGS events.

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Event Display: $\mu$ from rock

SIDE VIEW $\rightarrow$ EVENT 39368

TOP VIEW $\rightarrow$ EVENT 39368

Run 28569  Event 39368
19/8/6  13.15.7
Total energy = 1.93895 GeV
released in 9 counters

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Event Display: internal ν CC?

SIDE VIEW → EVENT 102901

DATA!

Run 28577  Event 102901
20/8/6  10.6.27
Total energy= 7.75282 GeV
released in 38 counters

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Event Display: internal $\nu$ NC/CC?

**DATA!**

Run 28560  Event 38069  
18/8/6  14.44.58  
Total energy = 1.26835 GeV  
released in 9 counters

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LVD rate

CNOS run started on 18th August UTC time 11.30
- Observed
- Expected = (6.7 \times 10^{-16} \text{ ev/p.o.t.}) \times \text{beam intensity}

Run time (1 bin = 1 hour)

Integrated beam intensity (p.o.t.)

# Events

0 100 200 300 400 500 600
18.8, 11:30
20.8, 09:12
21.8, 07:30
22.8, 04:17

Expected
Observed

Agreement between the observed events and the expected from the beam intensity!

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Time event distribution

The LVD CNGS events time distribution with respect to the time spill agrees with the duration of the spill!

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Nb fired counters

<table>
<thead>
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<th>Entries</th>
<th>289</th>
</tr>
</thead>
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<tr>
<td>Mean</td>
<td>7.289</td>
</tr>
<tr>
<td>RMS</td>
<td>4.828</td>
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</tbody>
</table>

Measured

Simulated

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Total energy released

<table>
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<tr>
<th>Entries</th>
<th>289</th>
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<td>1243.0</td>
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<tr>
<td>RMS</td>
<td>800.4</td>
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Measured

Simulated

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Beam database

It seems that there are some discrepancies in the CNGS beam database:

- sometimes there is no information about the beam spill intensity (about 5%)

- some good events (about 10% - preliminary) are not in coincidence with the time spill
Conclusion

The analysis of data taking with the LVD detector shows that:

*the CNGS beam is working very well as it was expected*

✓ we continue to collect data and update the results
✓ we want to make a deeper analysis of the data to extract more informations (external/internal, CC/NC)

CONGRATULATIONS TO THE CNGS CERN GROUP AND TO ALL LNGS PEOPLE!

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The End?
No, the Beginning!