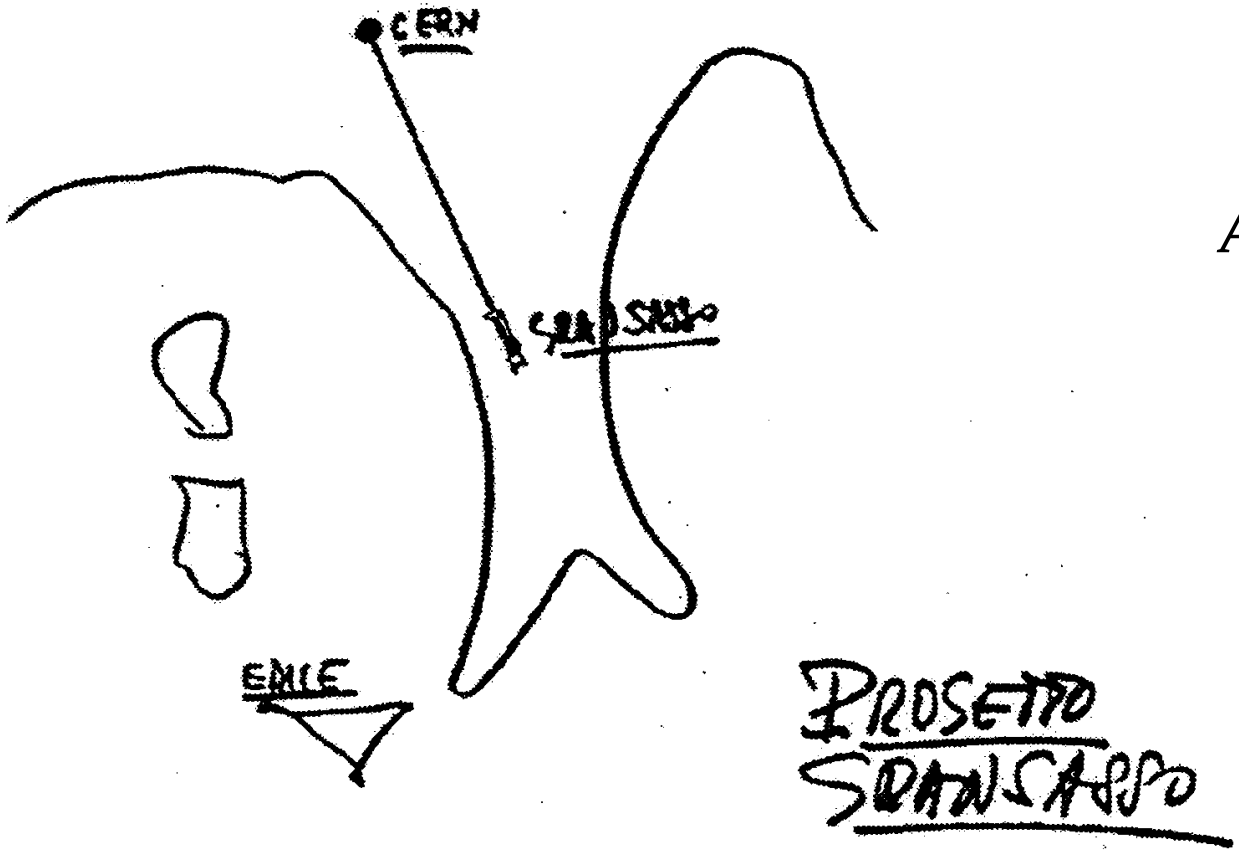
LVD: monitor del fascio CNGS al Gran Sasso

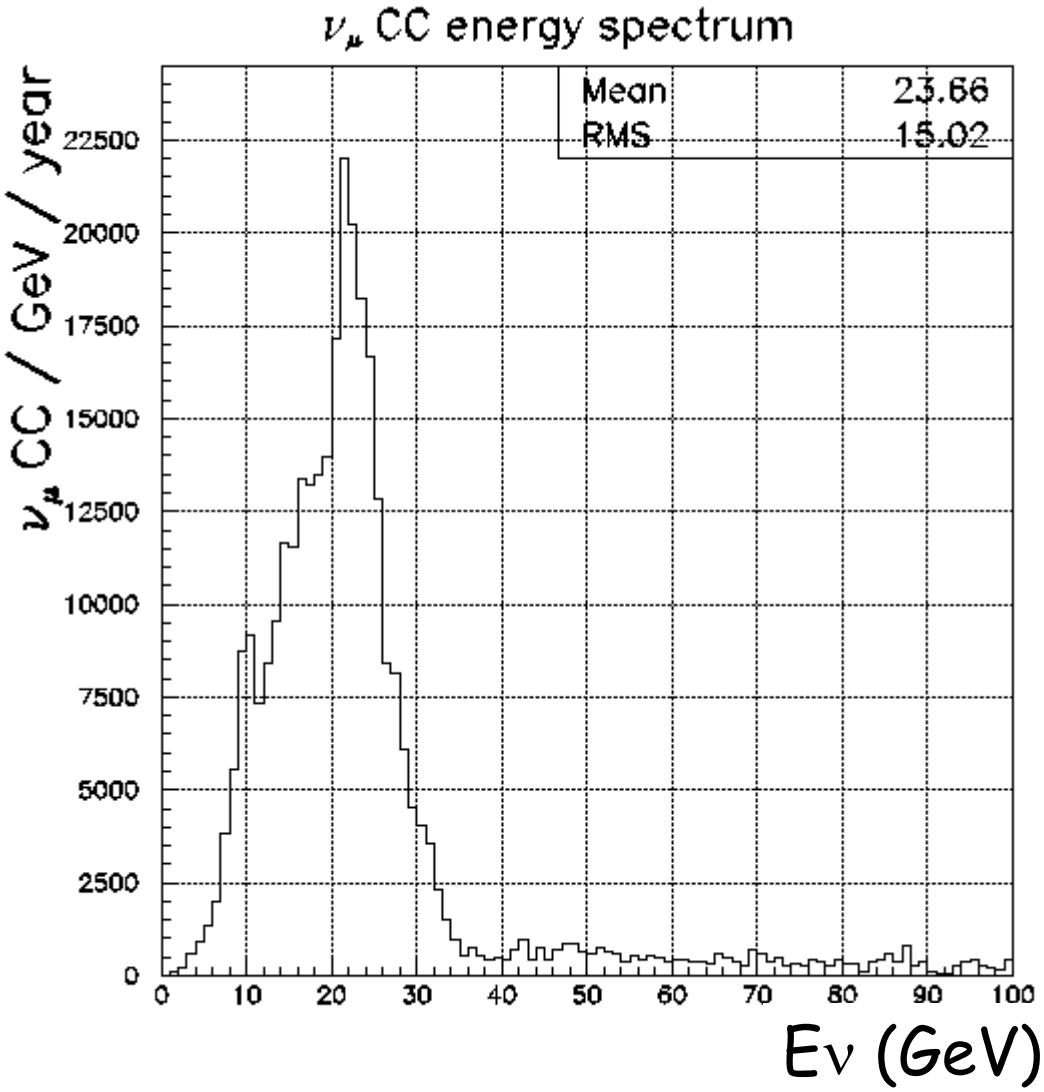
C.F. Vigorito per la Collaborazione LVD
Università e INFN - Torino

COMMISSIONE LAVORI PUBBLICI AL SENATO



A. Zichichi, 1979

The CNGS Beam



ν_μ , <E> ~ 23 GeV

At GS Labs:

~ 2600 CC/kt/y

~ 800 NC/kt/y

~ 17(CC+NC)/kt/day

Adequate monitoring: stat. errors 3% in few days are requested

CERN-SL-2000-063EA
CERN-SL-2001-016EA

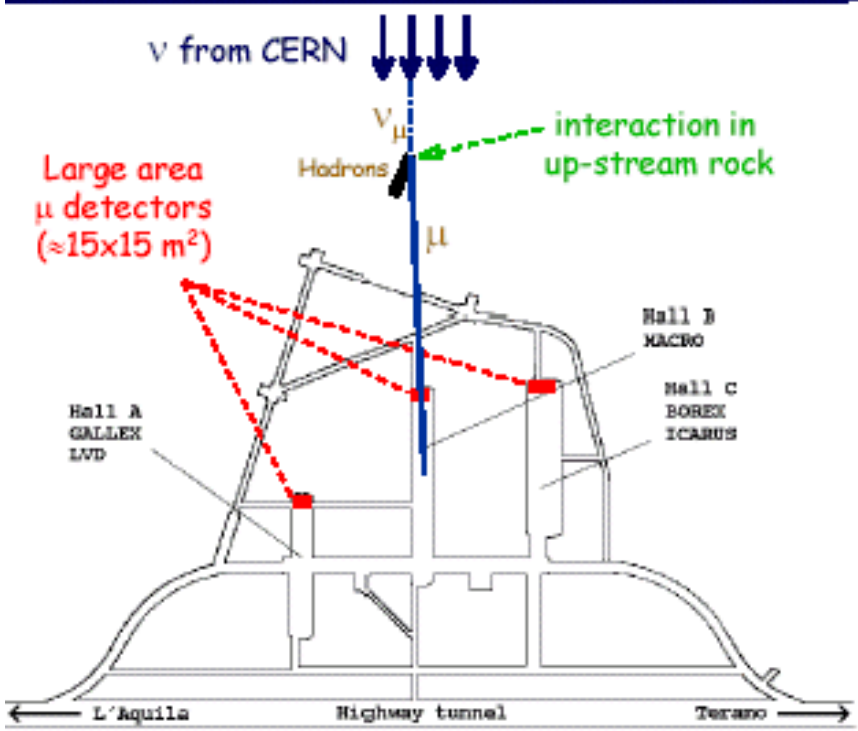
Muons from νμ CC interactions in the rock.

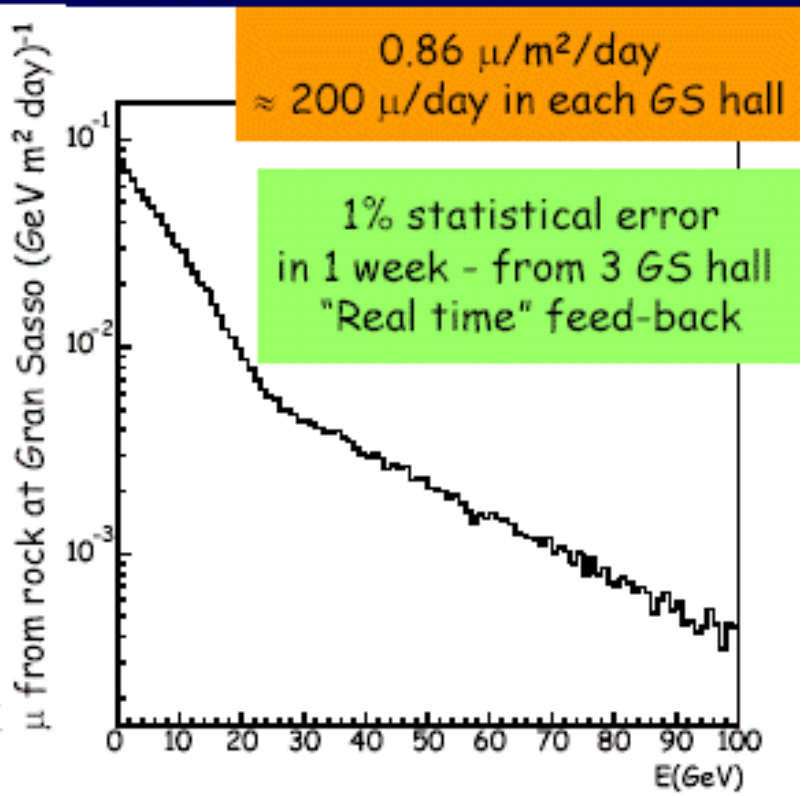
CF..Vigorito, Università & INFN Torino

"to get some feed-back":

Neutrino flux monitors at Gran Sasso

monitor intensity and time-stability of beam





CF..Vigorito, Università & INFN Torino

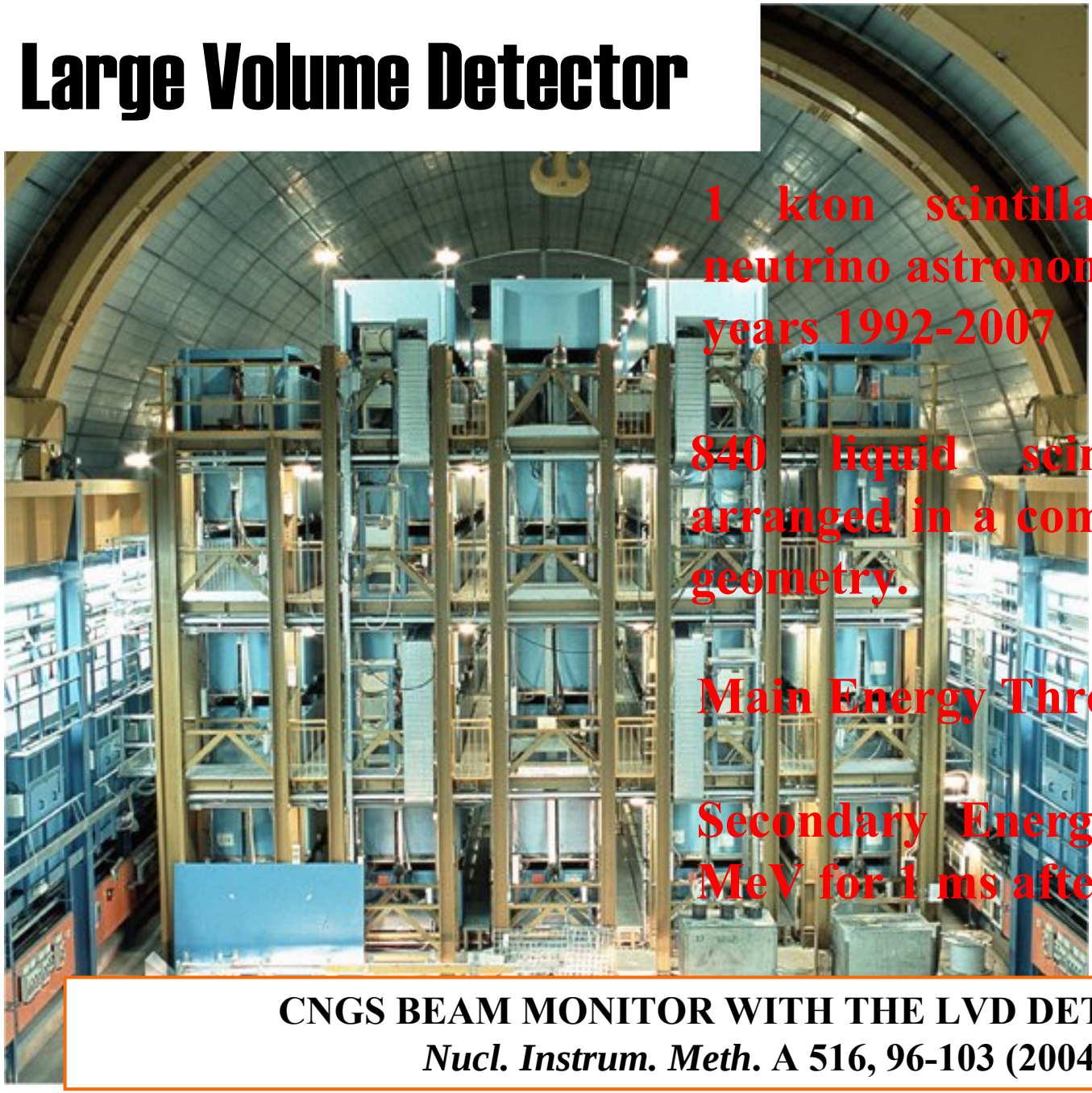
Beam Parameters

Beam parameters	Nominal CNGS beam
Nominal energy [GeV]	400
Normalized emittance [π mm mrad]	H=12 V=8
Emittance [μm]	H=0.028 V= 0.016
Beam size at focal point [mm]	$\sigma_x, \sigma_y = 0.53$
Beam divergence at FP [mrad]	$\sigma_x' = 0.053$ / $\sigma_y' = 0.03$
# extractions per cycle (16.8 s)	2 separated by 50 ms
Batch length [μs]	10.5
# of bunches per pulse	2100
Intensity per extraction [10^{13} p]	2,2
Bunch length [ns] (4s)	2
Bunch spacing [ns]	5
Protons on target per year	4.5 10^{19}

Upgrade phase: $3.5 \cdot 10^{13}$ p

Effective Beam Uptime 0.11 s /day, 2.2 10^{13} p.o.t./spill

Large Volume Detector



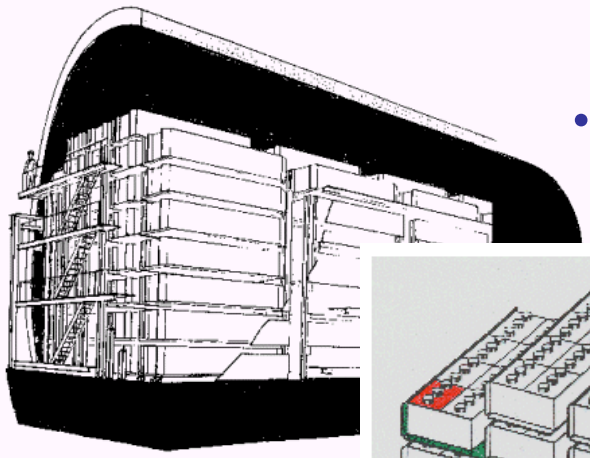
1 kton scintillator detector for neutrino astronomy @ LNGS, 15 years 1992-2007

840 liquid scintillator counters arranged in a compact and modular geometry.

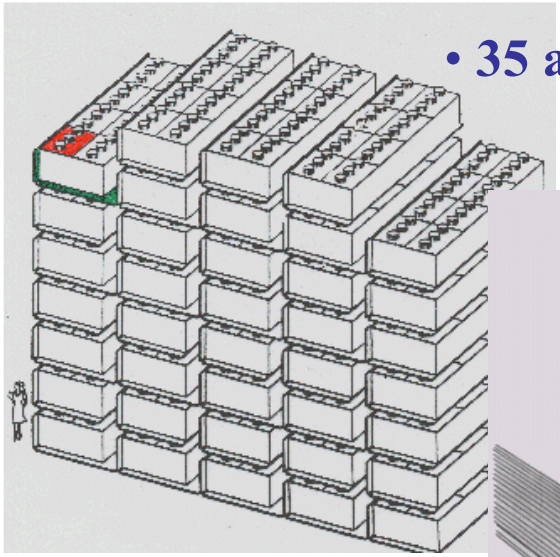
Main Energy Threshold: ~5 MeV

Secondary Energy Threshold: ~ 1 MeV for 1 ms after the trigger

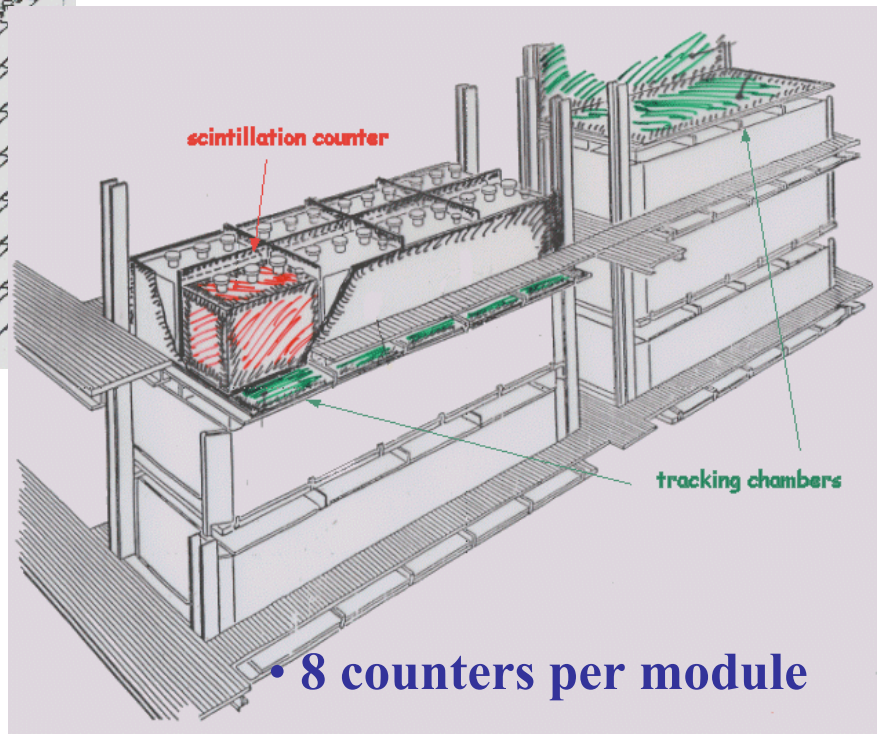
CNGS BEAM MONITOR WITH THE LVD DETECTOR.
***Nucl. Instrum. Meth.* A 516, 96-103 (2004)**



• 3 Towers

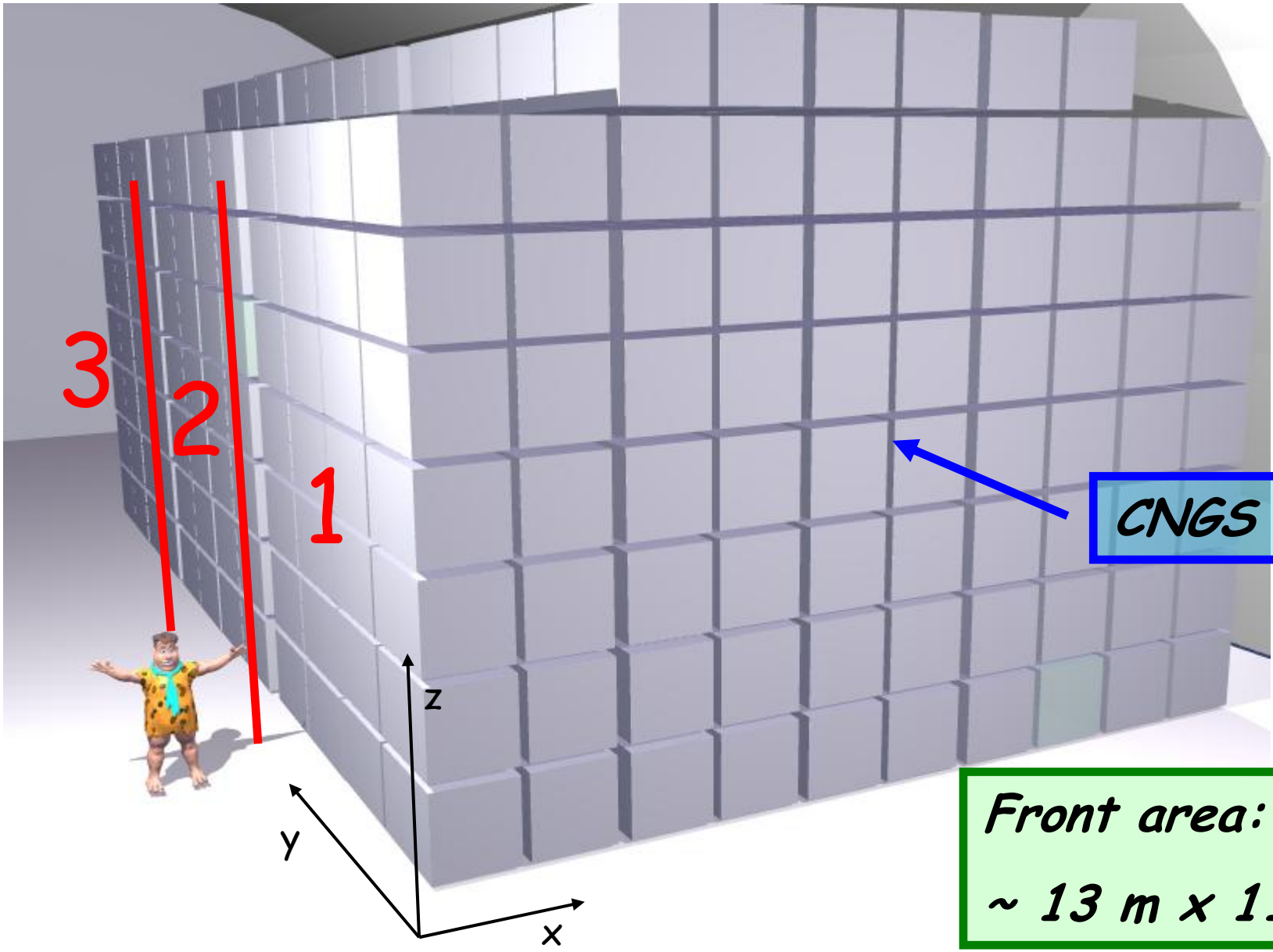


• 35 active modules per tower



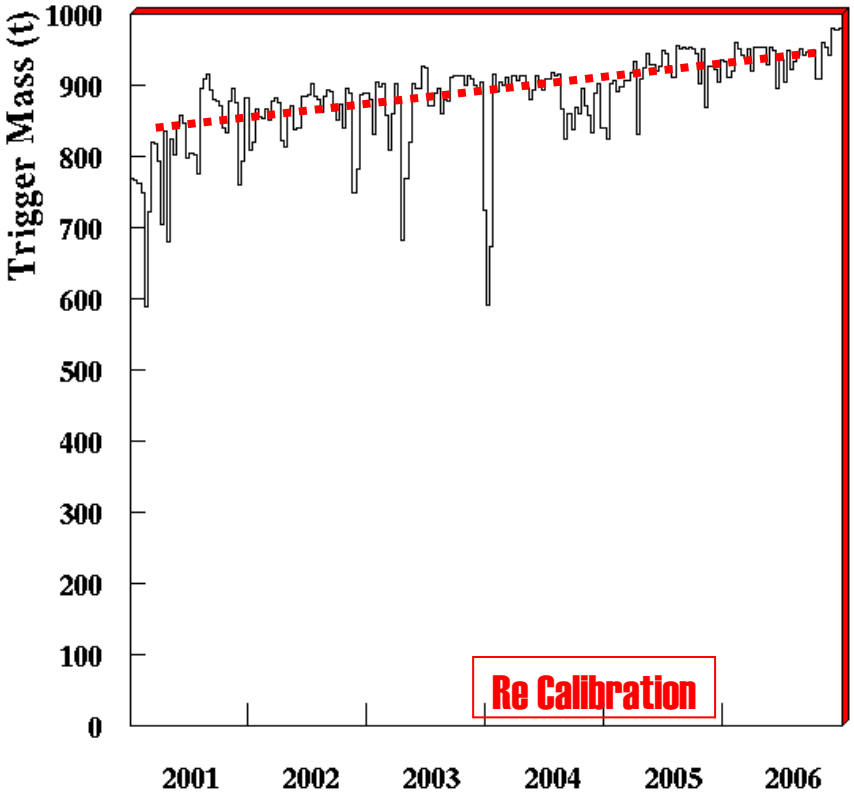
• 8 counters per module

Mass Scintillator 1044 t
Mass Stainless Steel 770 t
Total 1810 t



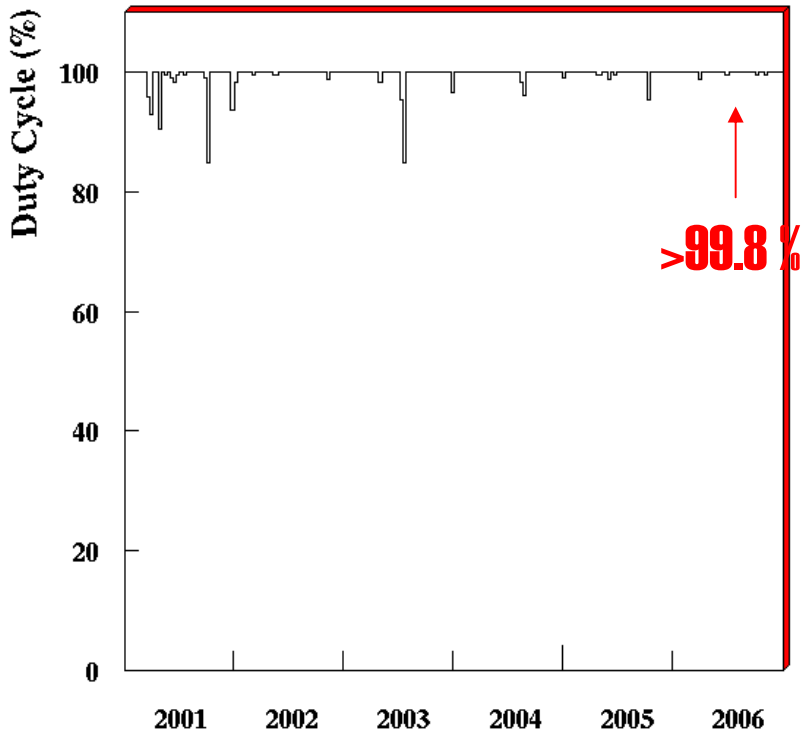
Front area:

~ 13 m x 11 m



980 t., 97% LVD

Duty Cycle



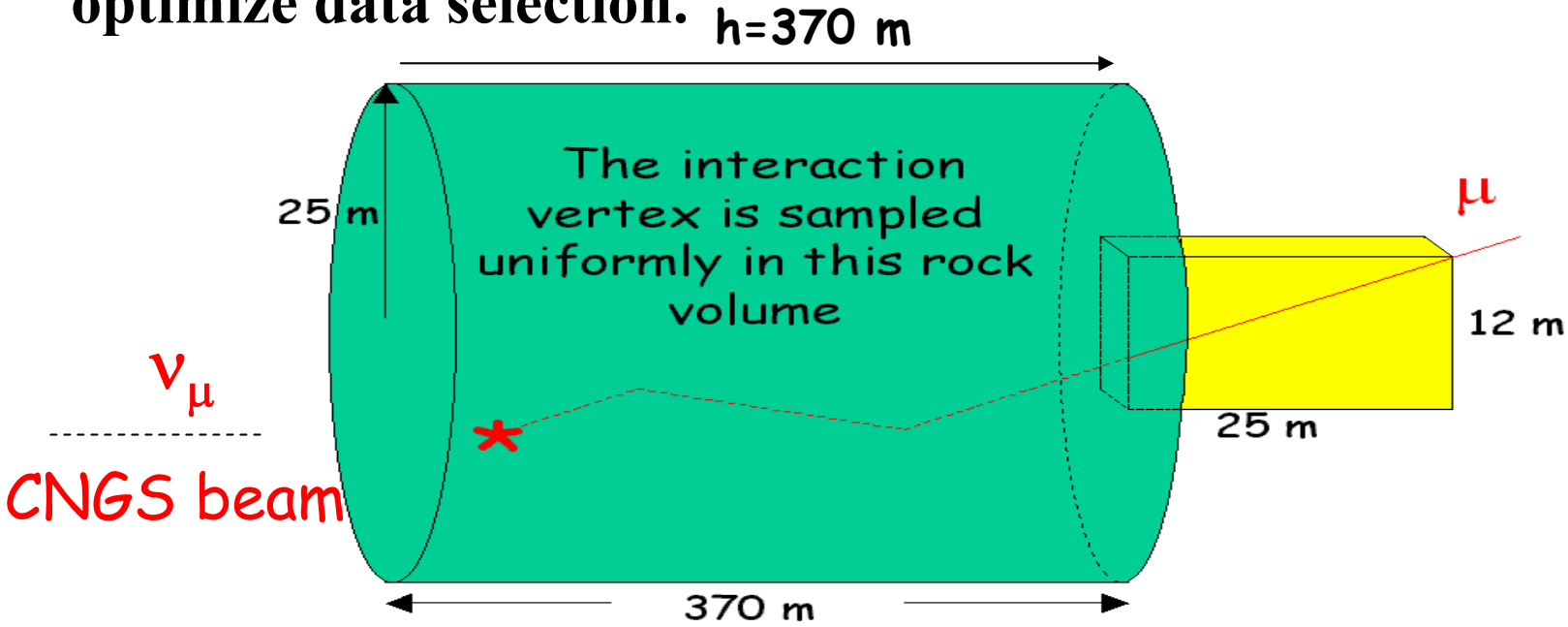
Trigger Mass

New ACQ

LVD monitoring of the CNGS beam

Neutrinos from CNGS are observed through:

- **the detection of muons produced in neutrino CC interactions in the surrounding rock**
- **the detection of the products of the neutrino NC and CC interactions in the detector volume (scintillator and structure).**
- **MC simulation to characterize detector response and optimize data selection.**



Main cuts of the LVD data selection:

• Events with at least one scintillator counter with an energy release greater than 100 MeV.

Background rejection:

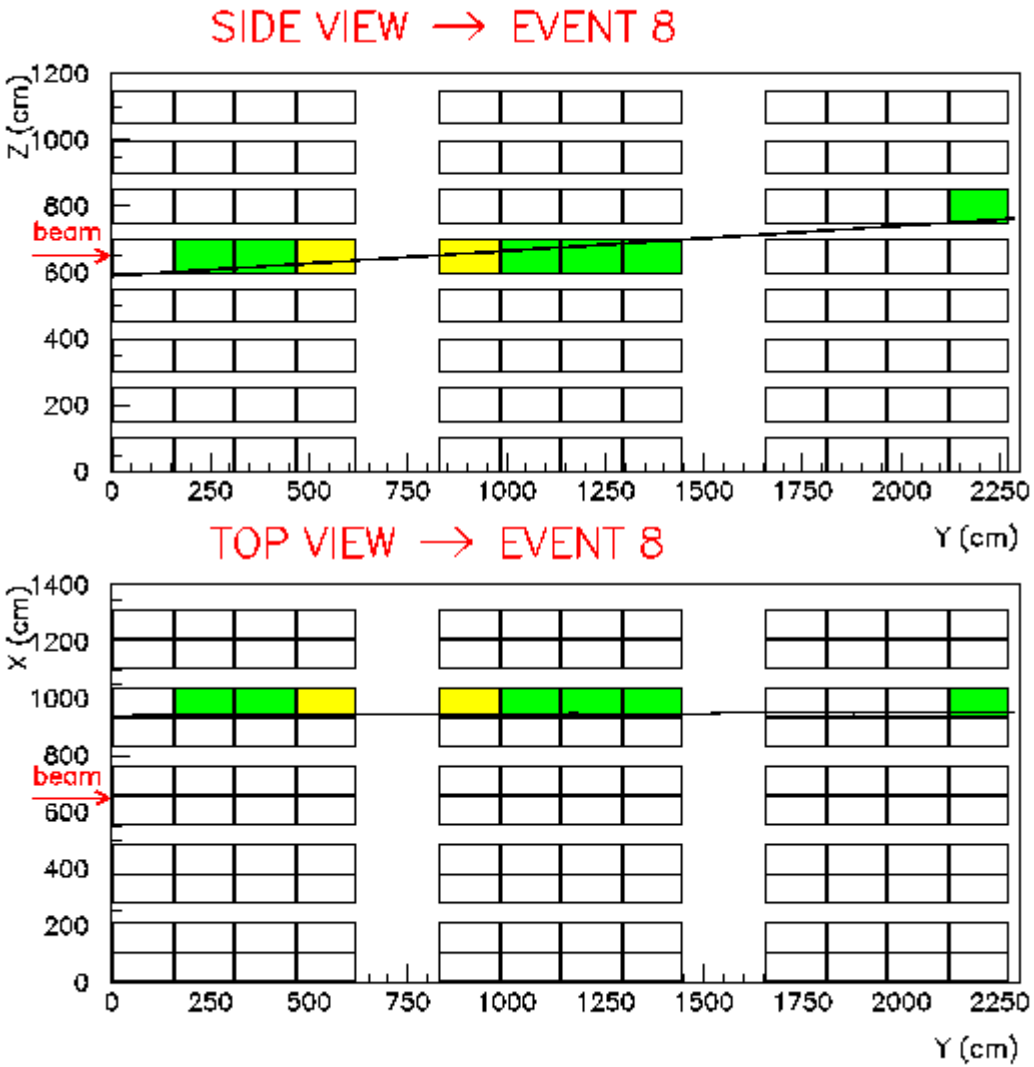
• time coincidence of the event with the CNGS time spill (spill 10.5 μs and 50 ms gap): residual background 0.1 event/day

From the Montecarlo simulation we expect

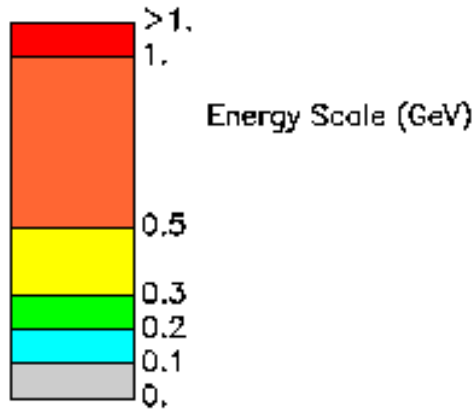
$7.147\ 10^{-16}$ events/proton on target (p.o.t.)

160 events/day (at nominal intensity)

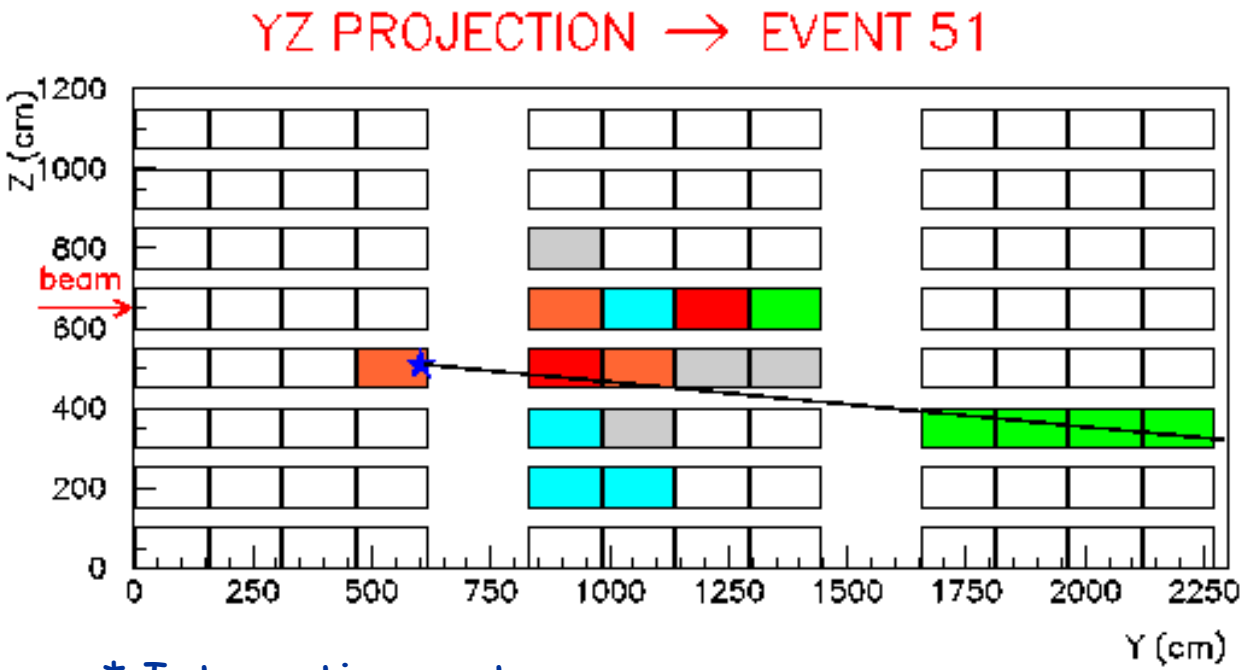
Event Display: μ from rock



Simulation !

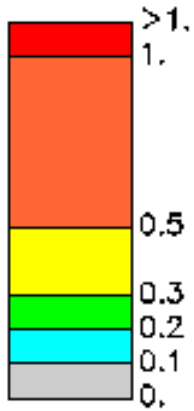


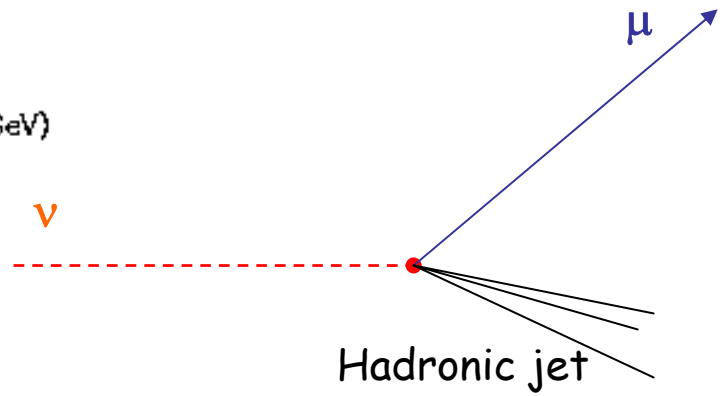
Event Display: internal ν CC



Simulation !

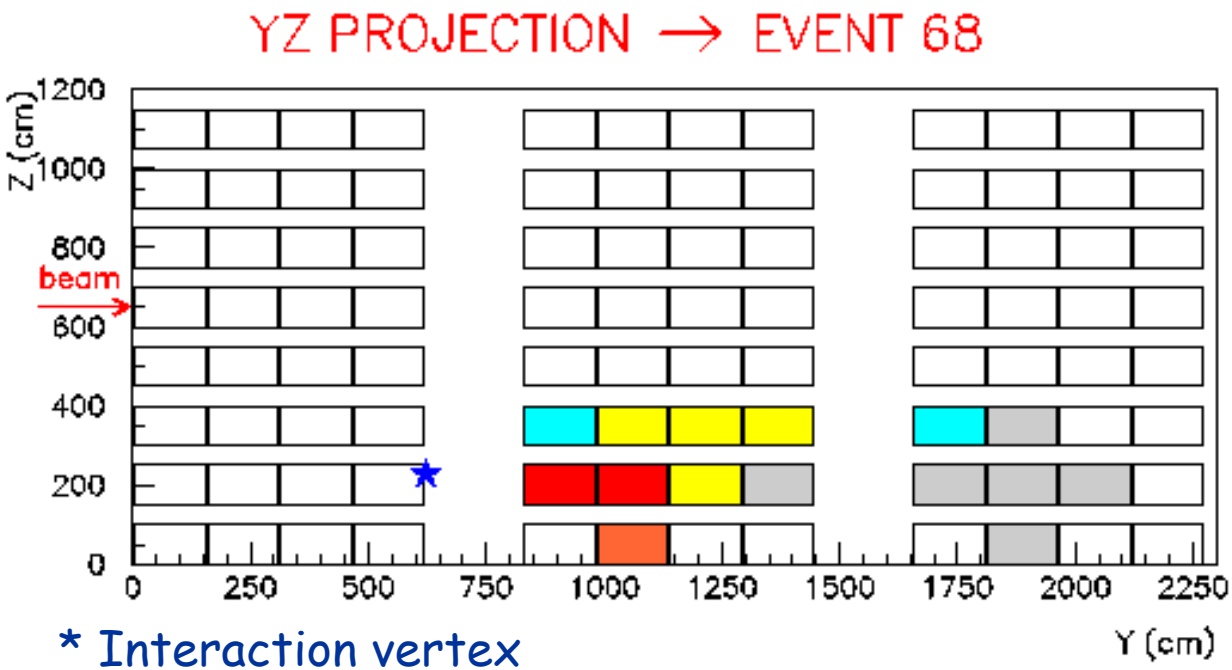
* Interaction vertex
Eν = 26.1 GeV
Eμ = 5.6 GeV
E released = 8.7 GeV
Missing E_h = 6.8 GeV
Missing Eμ = 3.6 GeV
Missing E_{IRON} = 7.0 GeV





CF..Vigorito, Università & INFN Torino

Event Display: internal ν NC



Simulation !

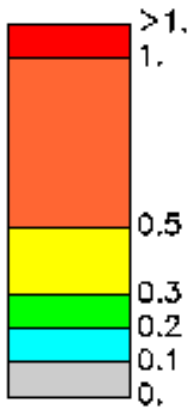
* Interaction vertex

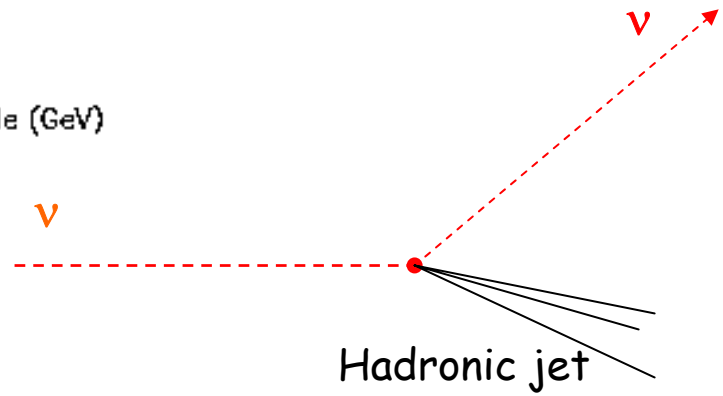
$E\nu$ = 19.5 GeV

E released = 9.8 GeV

Missing E_h = 1.6 GeV

Missing E_{IRON} = 8.1 GeV





CF..Vigorito, Università & INFN Torino

MC Simulation Expectations

	Volume (m3)	Mass (t)
Scintillator	1340	1044
Structure	98.5	770
νμ interaction in LVD	CC 4770/year	NC 1460/year
	~30 (CC+NC)/day	
Crossing muons	33600/year	92% Cuts Efficiency and 79% Geometrical Efficiency
	~120/day	

Results: Beam Commissioning

- **Commissioning week 14th – 18th August 2006**

- **On the 16th the first beam spills @ high intensity: about 1.3 10^{13} p.o.t./spill**

The integrated beam intensity during this period was 2.75 10^{15} p.o.t. and we expected 1.9 events.

- **We observed 2 events; cosmic background 0.07.**

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

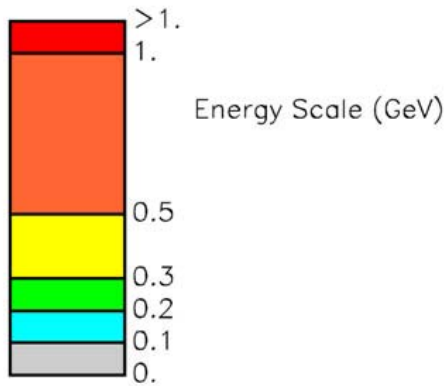
The *Ove* Event

Run 28543 Event 138950

16/8/6 21.8.3

Total energy= 2.18491 GeV

released in 7 counters



CF..Vigorito, Università & INFN Torino

Results: first CNGS Run

Aug 18th, 11:30 UTC -Aug 30th, 3:00 UTC

Intensity @ start time:

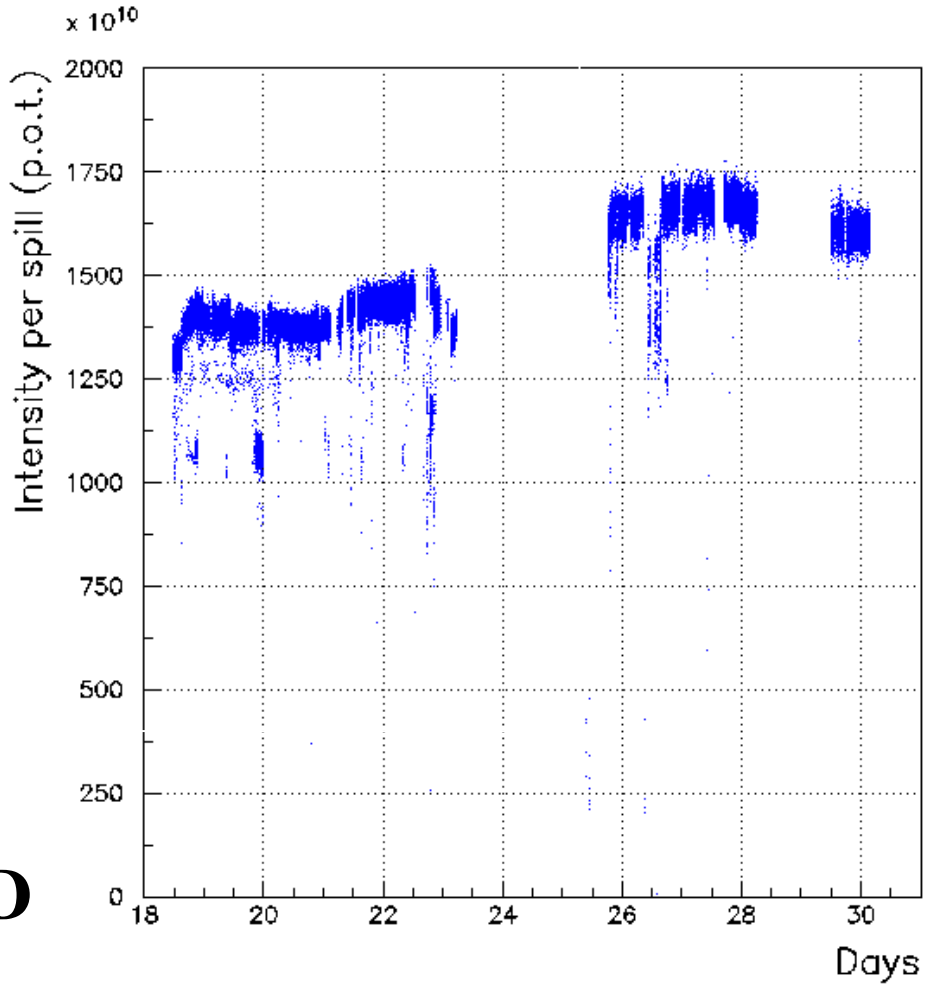
1.4 x 10^{13} p.o.t./spill

Integrated intensity:

8.0 10^{17} p.o.t.

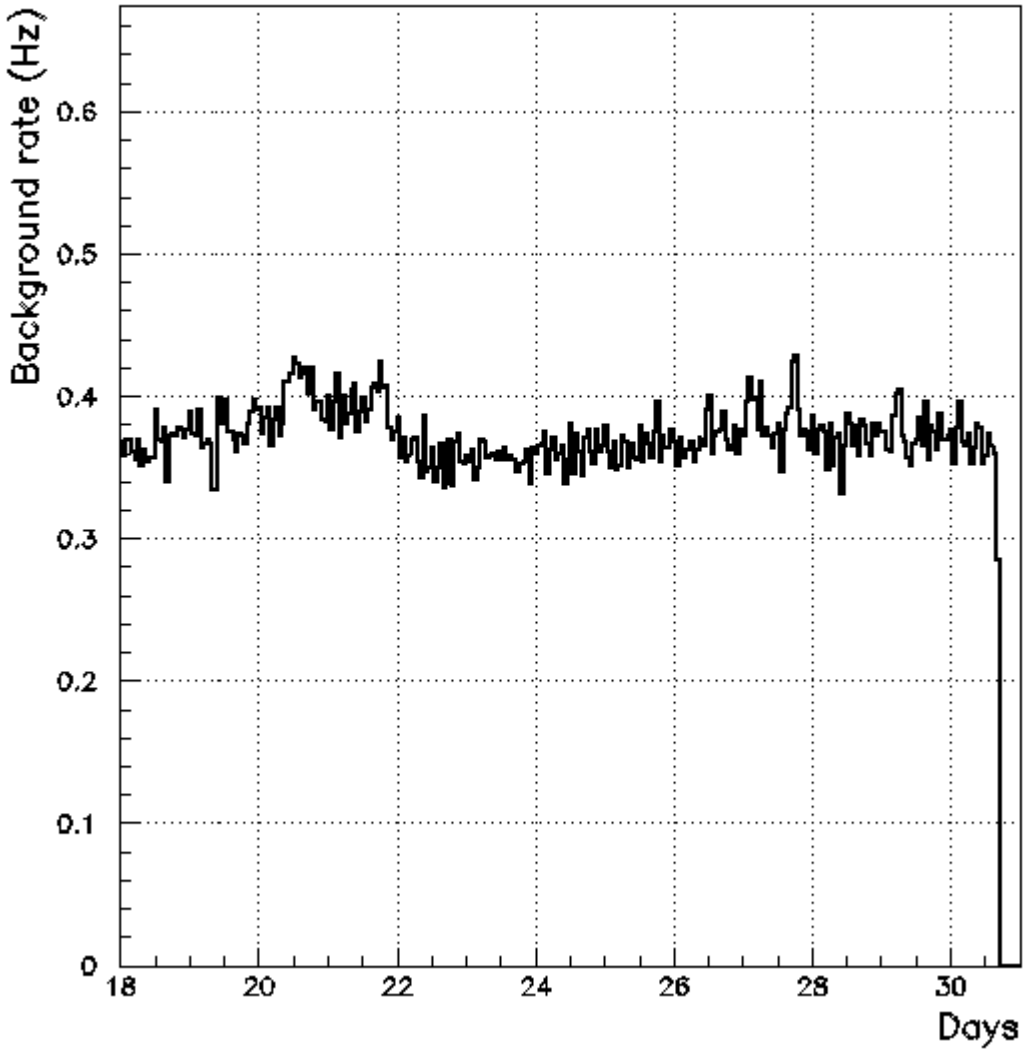
578 events expected in LVD

582 observed



Background Rate in LVD

Background Events: all events with 1 or more counters with at least 100 Mev release, 0.4 Hz.

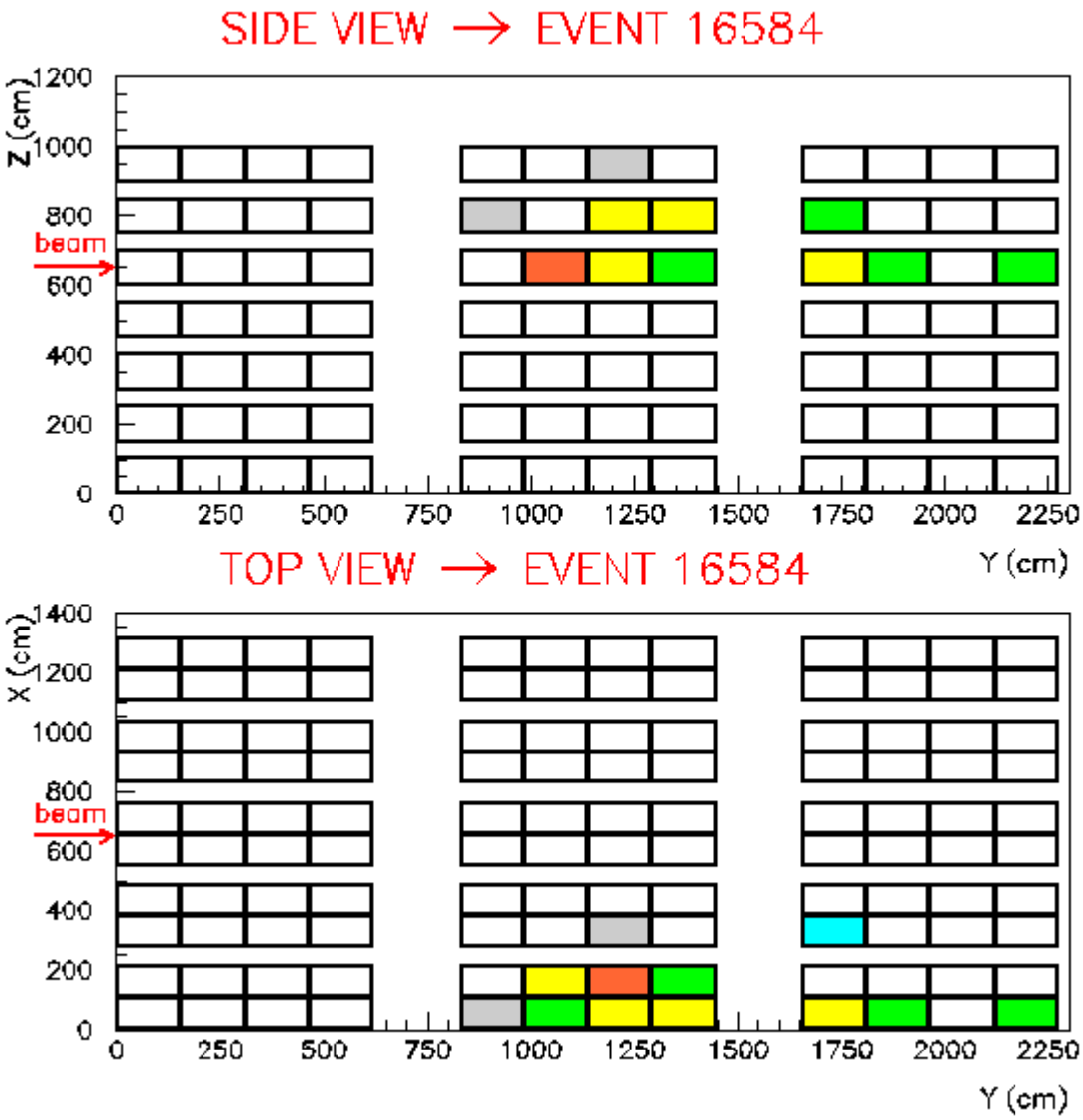


1. **CNGS events searched in a ± 15 μs windows around the spill time.**

2. **56976 spills found in the CERN-CNGS database. 56976 x 30 μs x 0.4 Hz = 0.7 events.**

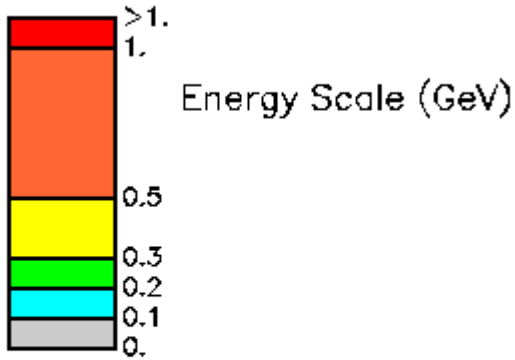
3. **Among the 582 detected events, less than 1 is due to the background.**

ν interacions in LVD



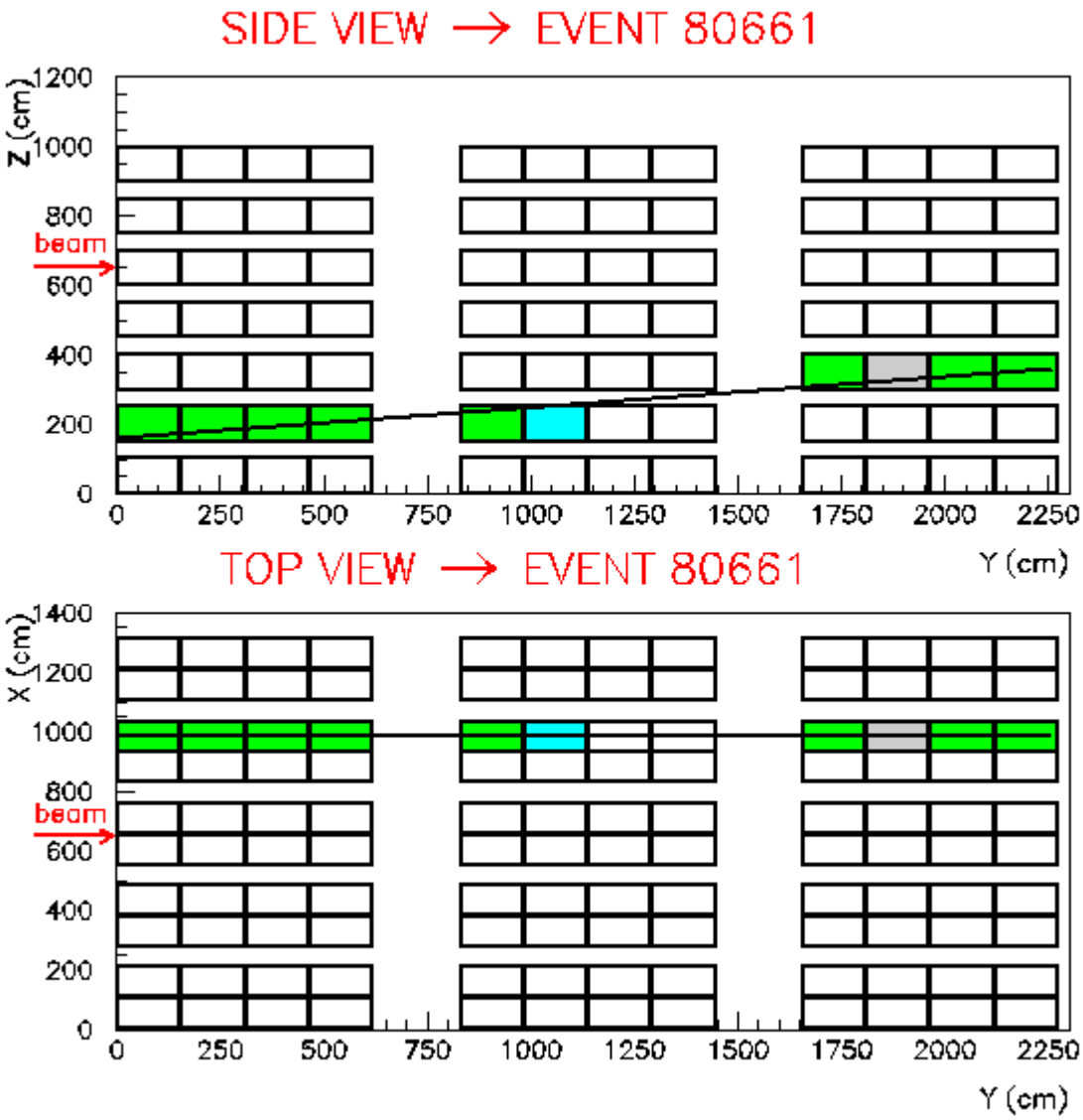
Run 28598 Event 16584
22/8/2006 13.15.27
Total energy= 3.37078 GeV
released in 17 counters

In spill (4545 ns)
p.o.t. 1.43E+13

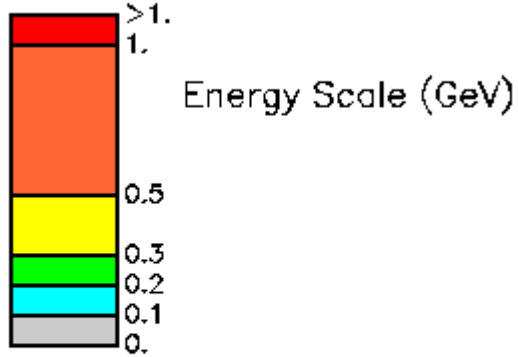


CF..Vigorito, Università & INFN Torino

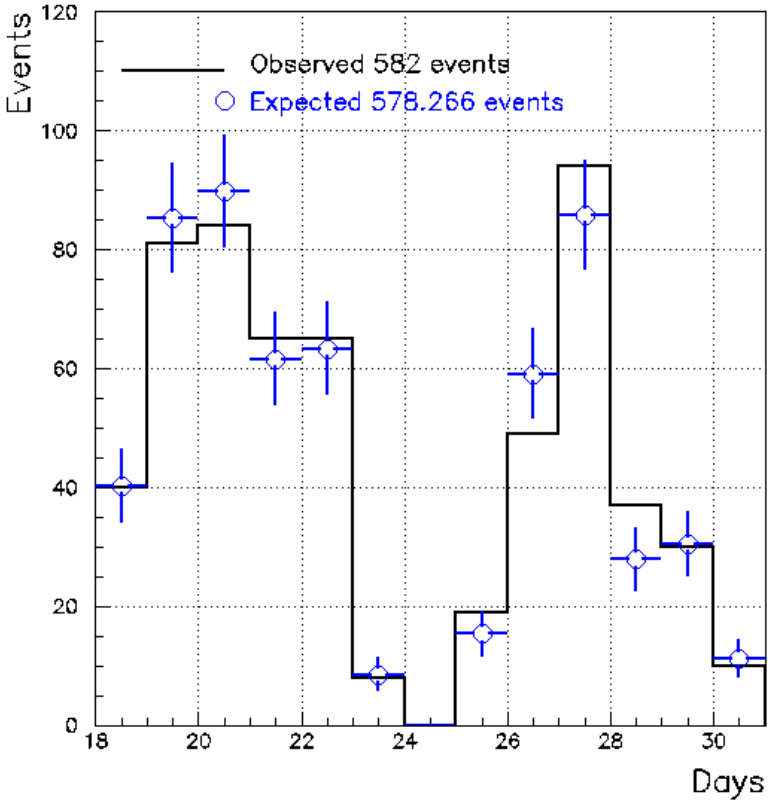
μ crossing in LVD

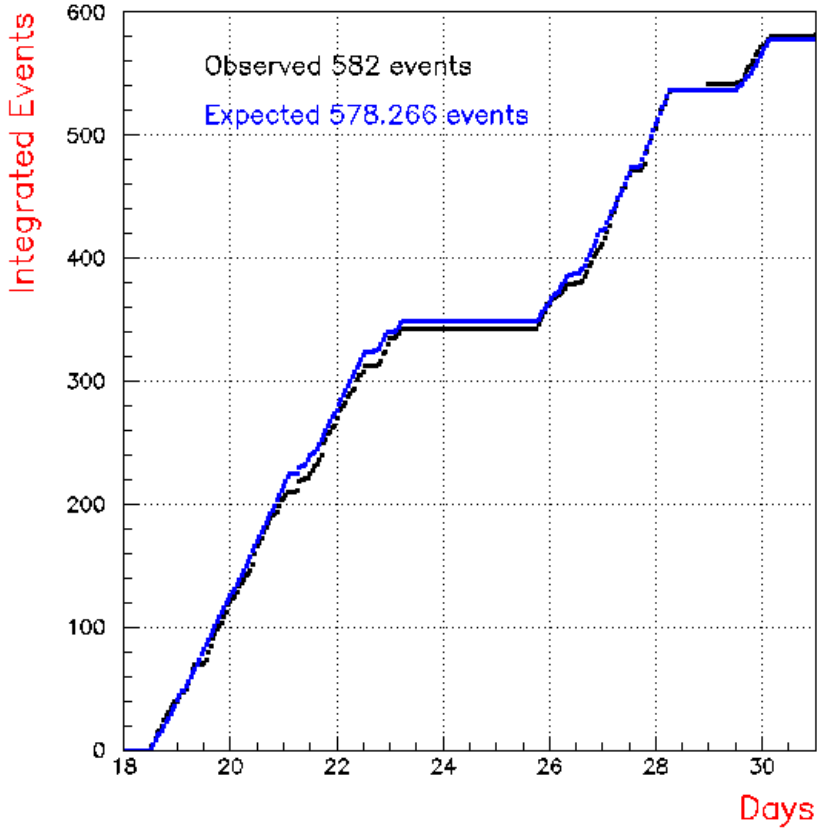


Run 28593 Event 80661
22/8/2006 1.40.12
Total energy= 2.03299 GeV
released in 10 counters
ϑ= 84.9111, φ= 270
In spill (4609 ns)
p.o.t. 1.43E+13



Rate of LVD Events

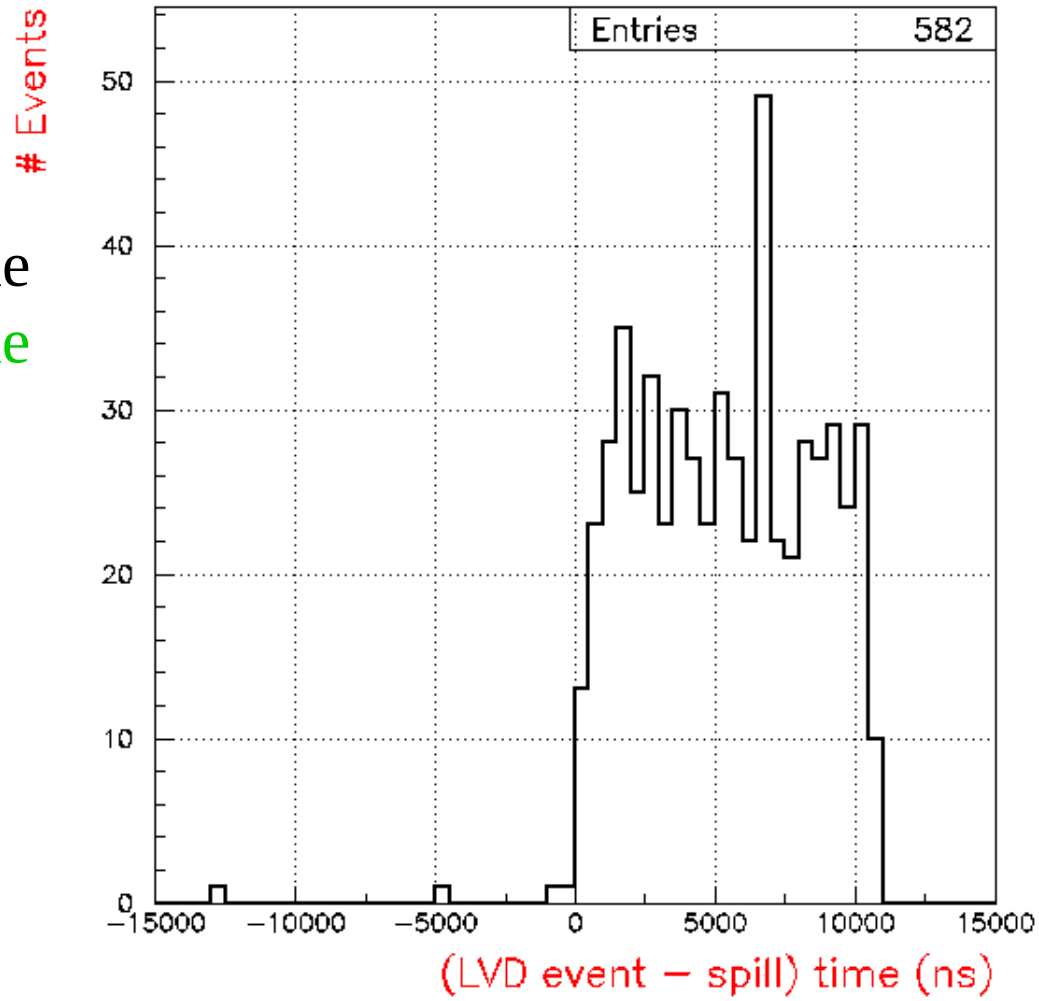




Agreement between the observed events and the expected from the beam intensity!

Time Event Distribution

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

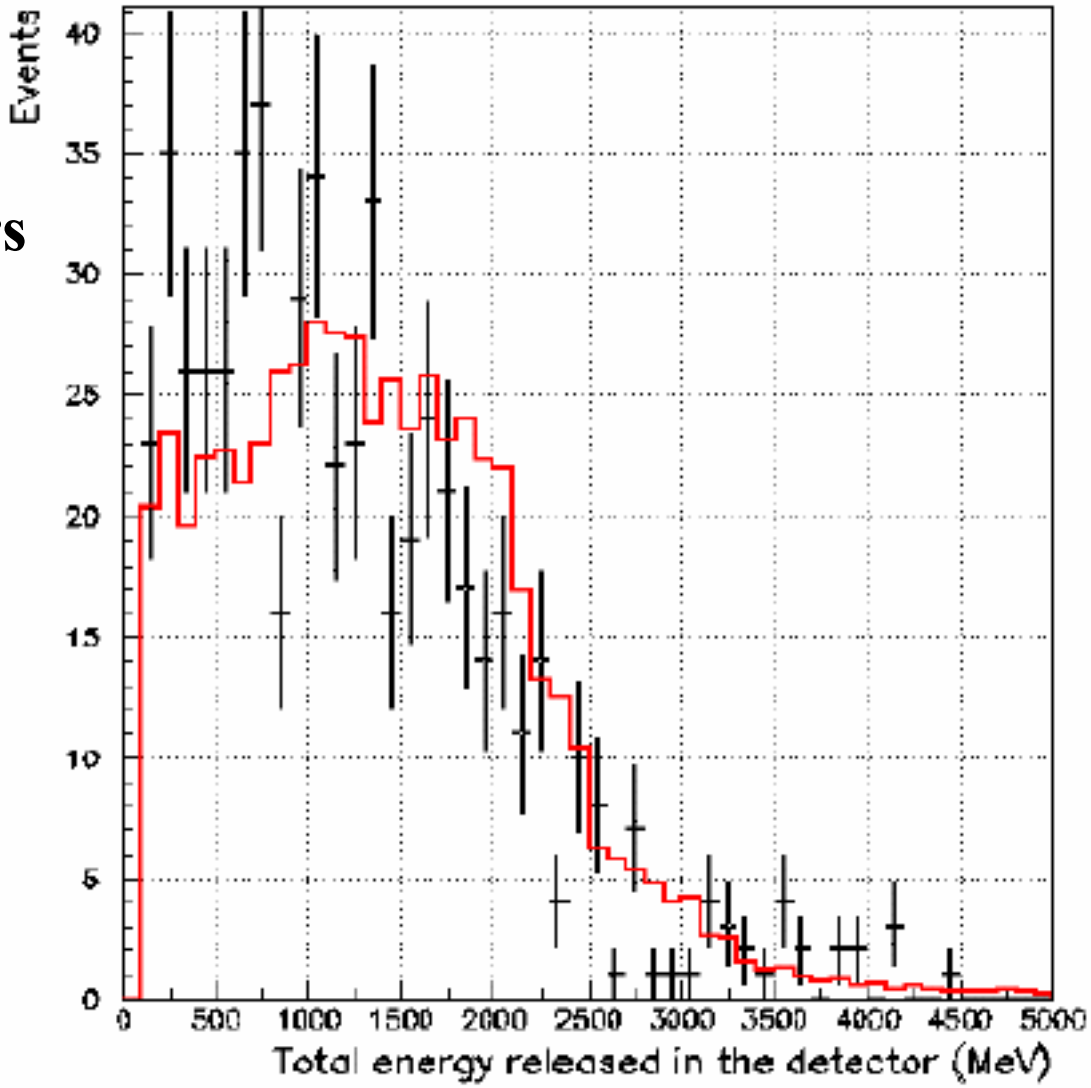


Comparison with MC Simulation

- Number of hit Counters
- Energy Release

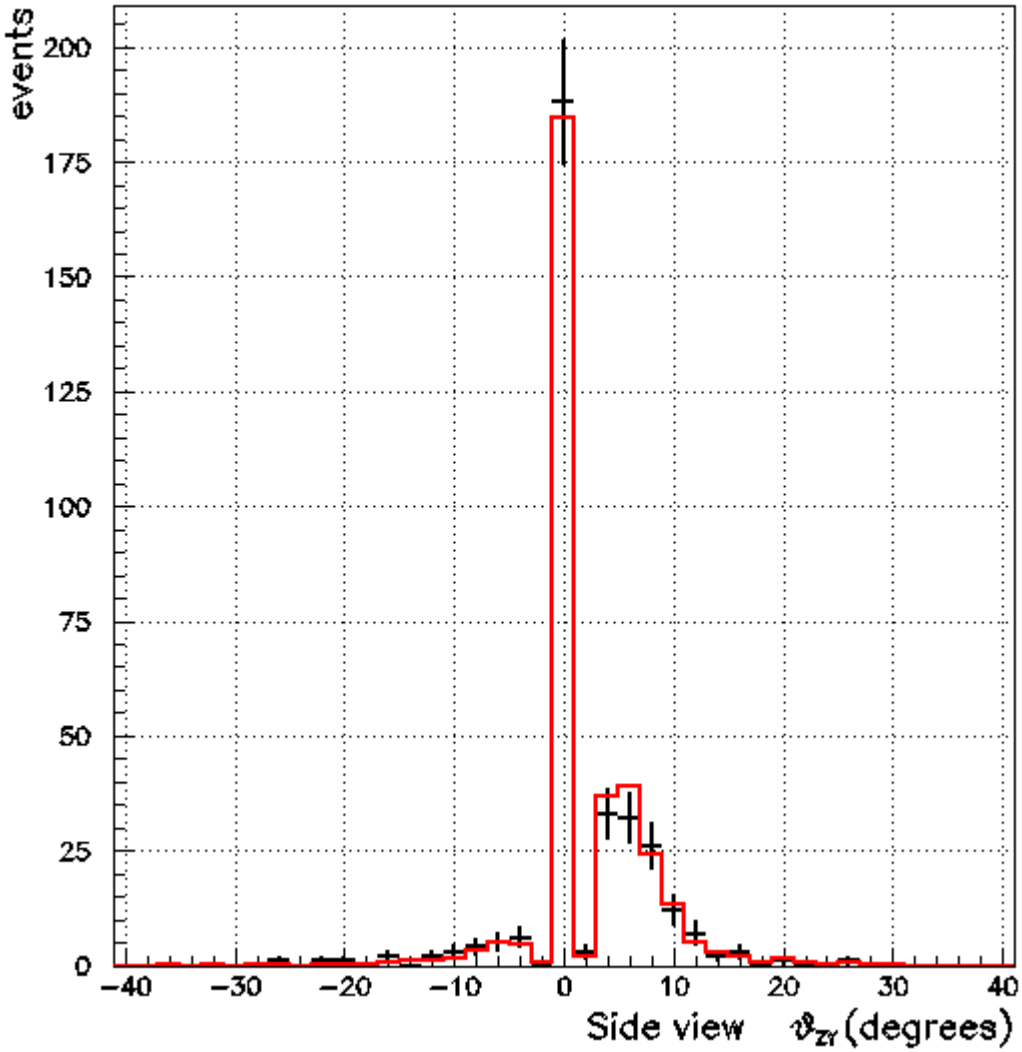
Blank data

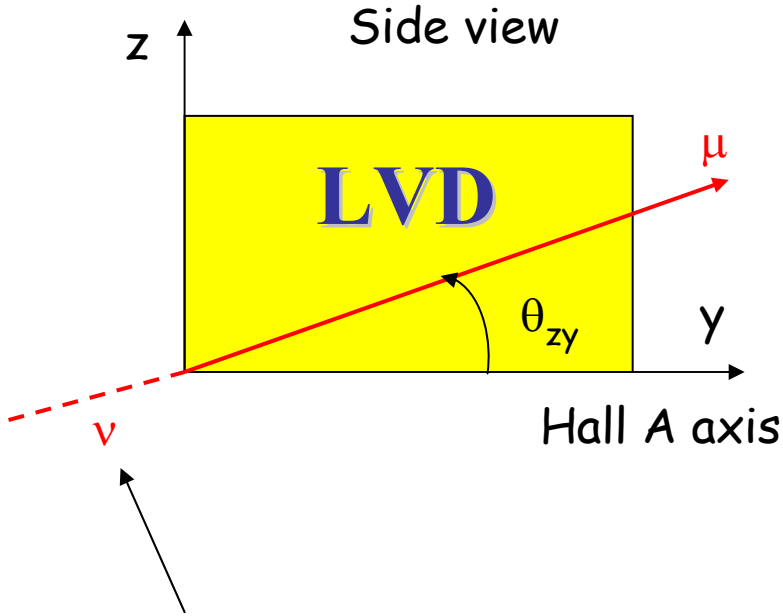
Red Simulation



Muon direction: Side View

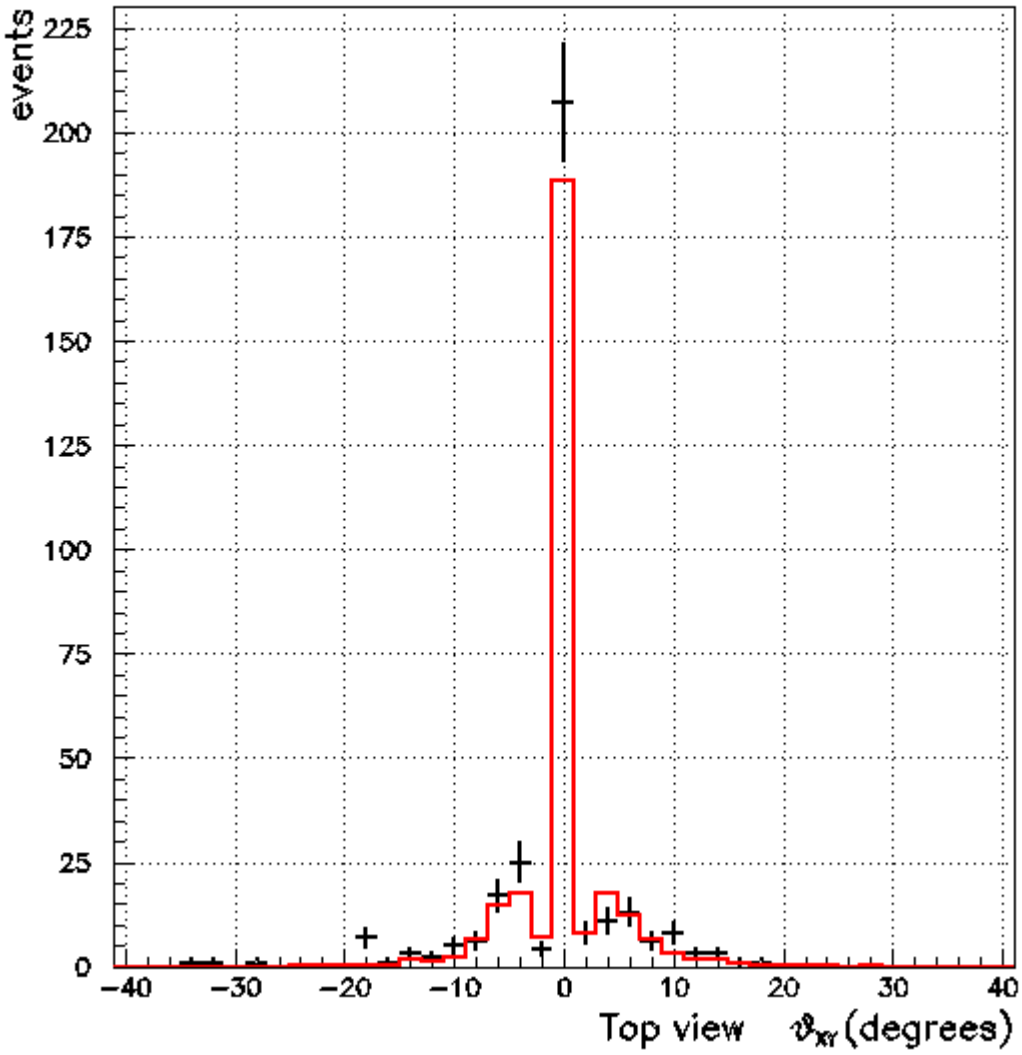
334 events (over 582) are reconstructed with a good χ^2

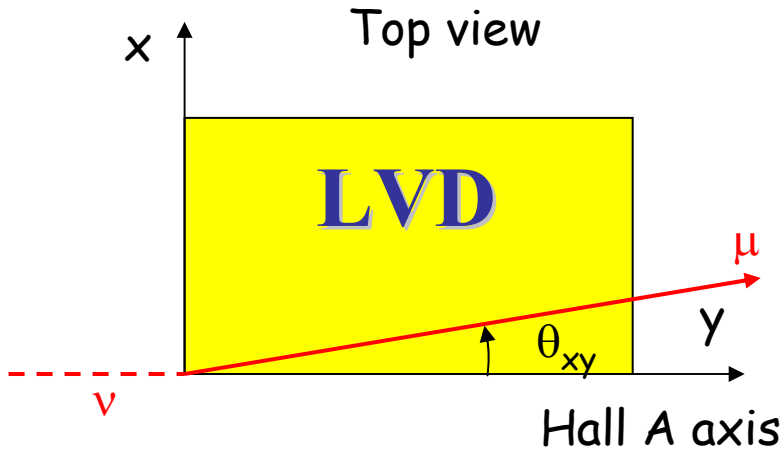




The beam direction is about 3.5° over the horizon

Muon direction: Top View





The beam direction is aligned with the hall A axis

Conclusions

CNGS & LVD	Intensity (p.o.t.)	CNGS events in LVD
Nominal	$4.5\ 10^{19}$ per year	~ 160 / day
Commissioning Aug. 14-18	$2.79\ 10^{15}$	1.9 expected 2 detected
First Run Aug. 18 (11.30) - 30 (03.00)	$8.10\ 10^{17}$	578 expected 582 detected

The analisys of LVD data shows that:

<u>the CNGS beam is working as it was expected</u>

Waiting for next CNGS RUN

CF..Vigorito, Università & INFN Torino