CERN-SPSC-2007-006 , SPSC-SR-016

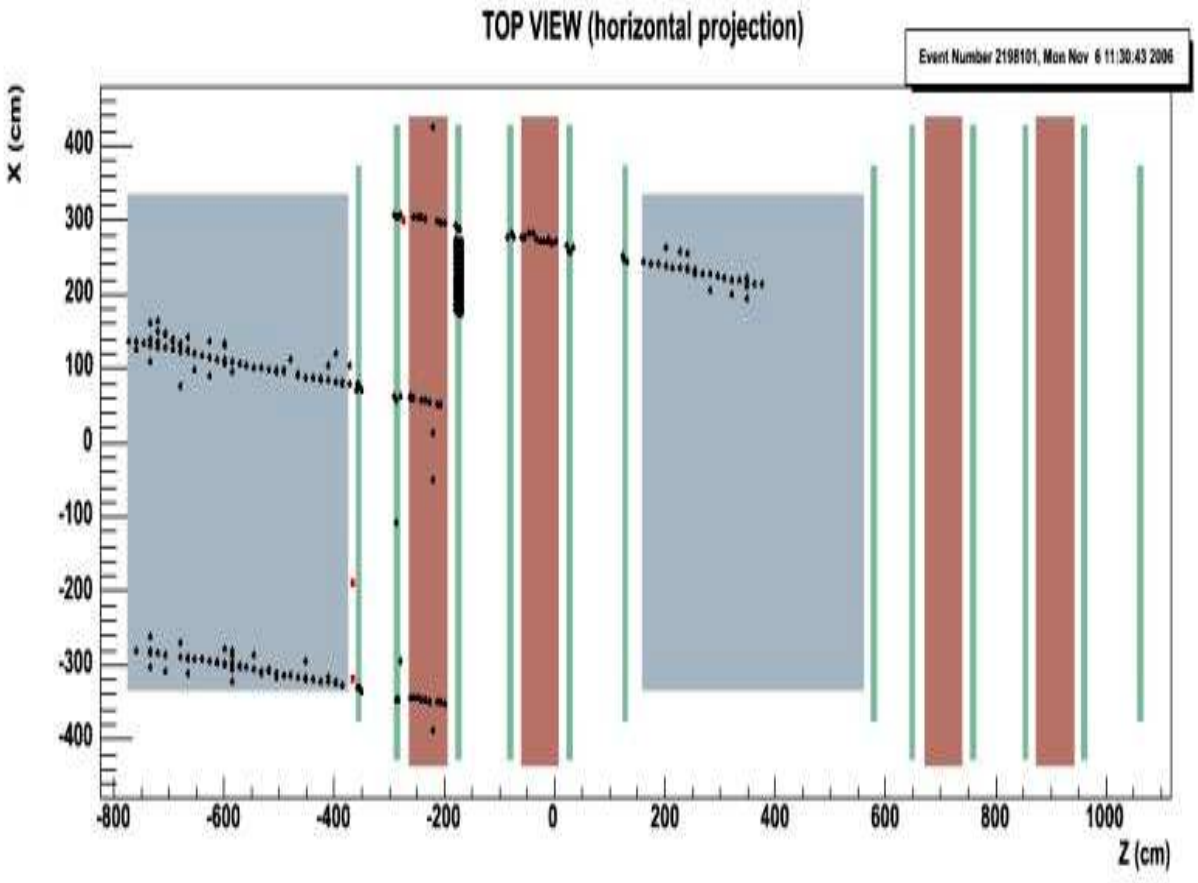
OPERA beam request for a run in 2007

1) Status of the OPERA detector

a. Electronic detectors

The target trackers and the RPC of the spectrometer for the 2 Super-Modules are installed and fully operational. They have been used successfully during the 2 CNGS runs in 2006. The HPT of the spectrometer of the first Super-Module are installed and have been included in the main DAQ during the second CNGS run in 2006. The HPT of the second Super-Module are being installed and the commissioning with cosmic muons is planned to be completed in May 2007. The Veto counter in front of the detector is installed and will be commissioned with cosmic muons in March 2007.

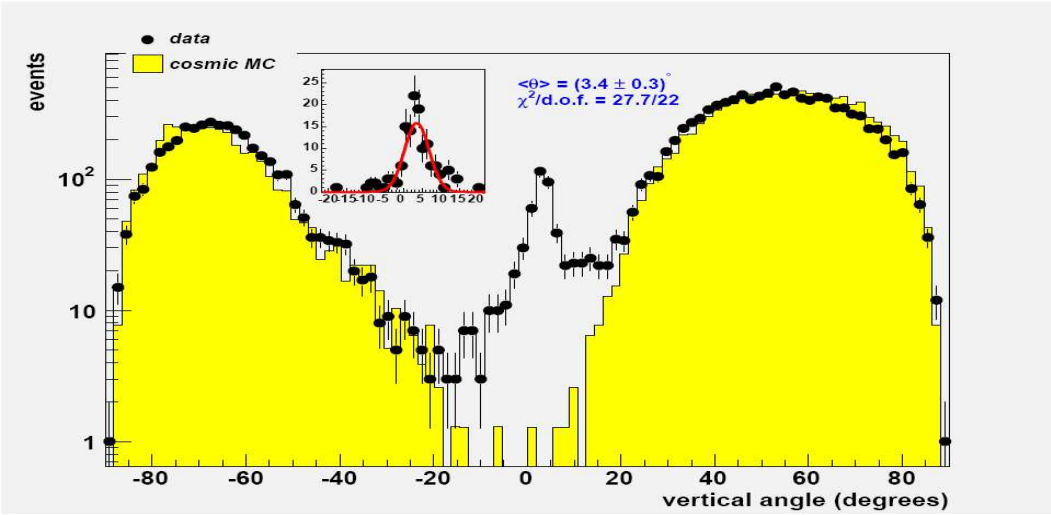
The main DAQ, including the GPS timing system, is operational with all sub-detectors and has been successfully used during the commissioning of the sub-detectors and the 2 CNGS runs in 2006

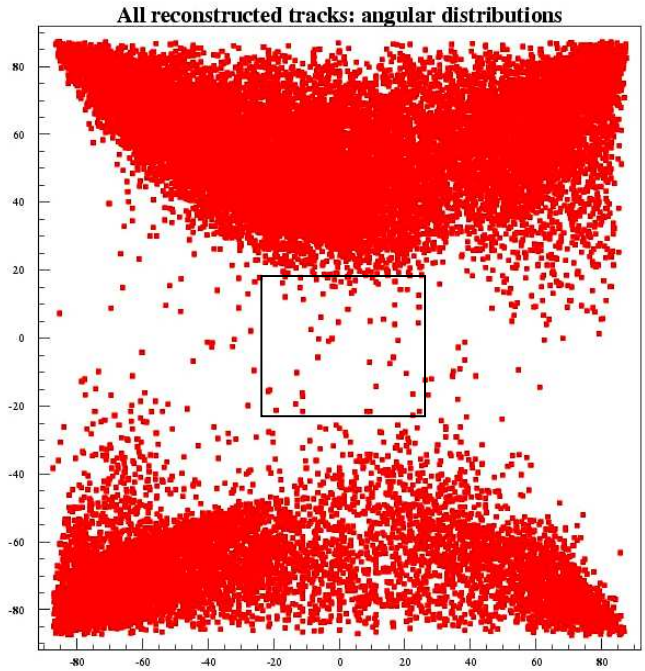


The picture above shows a multi muon event crossing the TT of the 2 Super-modules, the RPC and HPT of the first spectrometer.

b. Data analysis

The data analysis chain for the electronics detectors and for the scanning is operating and being tuned with cosmic rays. As an example, in the next figure, the measured angular distribution of the reconstructed tracks in the RPC corresponding to the data collected during the run in August 2006 muons is compared (absolute comparison) to the expected distribution for the cosmic muons and the beam rock interactions:

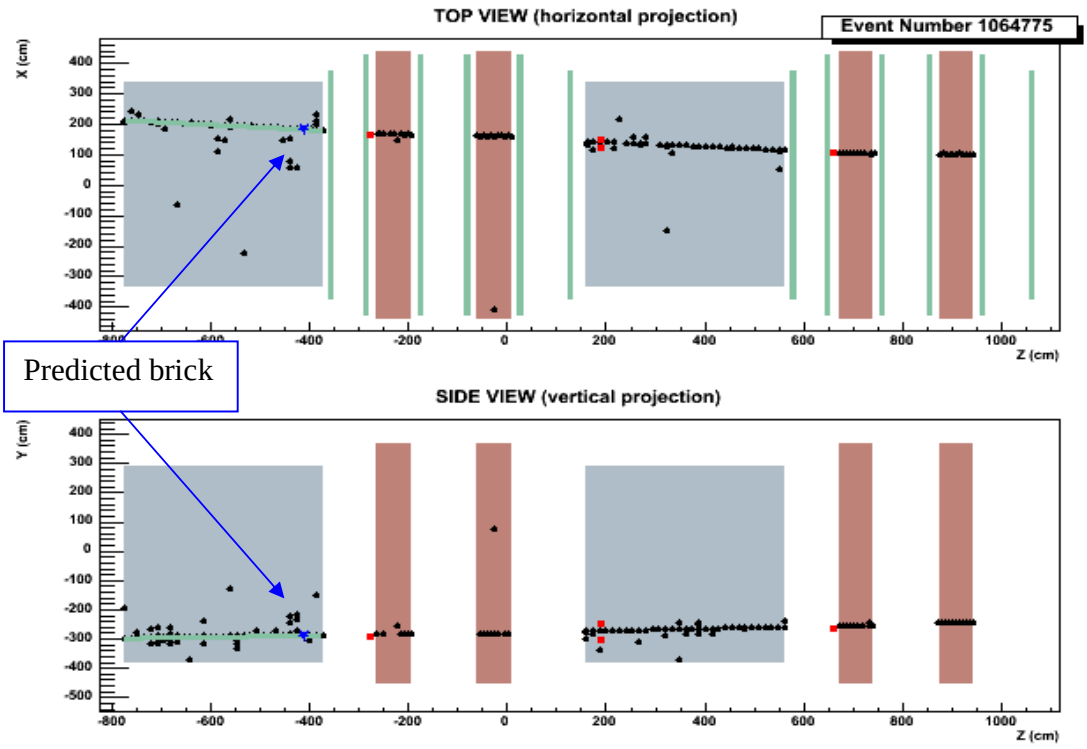


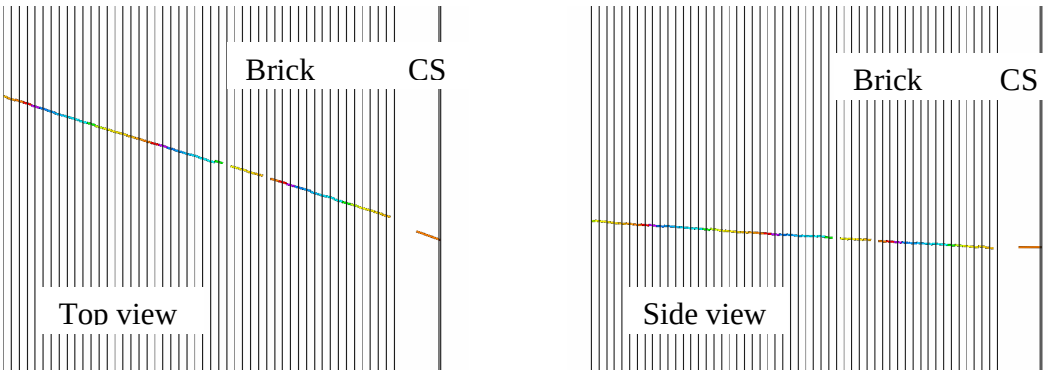


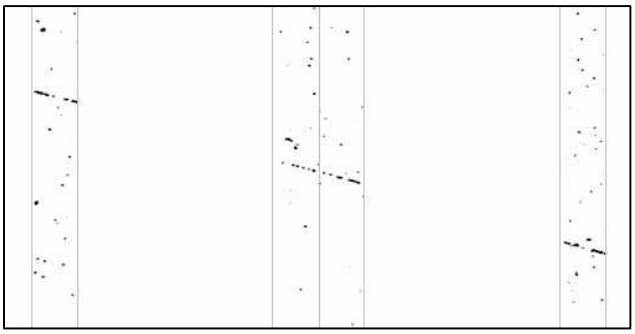
This plot shows the 2D angular distribution of the tracks reconstructed in the TT.
The black box represents the angular acceptance of the scanning system: ± 23°.
The rate of the reconstructed tracks inside the angular acceptance is ~5 /day.

The quality of the prediction from the reconstructed tracks in the electronic detectors into the CS and the brick has been successfully tested during the run in October.

The following pictures show one rock muon associated to the CNGS reconstructed in the electronic detectors and in the brick predicted by the reconstruction software:







Details of the CS scanning showing the reconstructed grains.

c. Brick production and handling

The BAM has been installed in the LNGS underground laboratory from July 2006 until the end of September 2006. We have lost 1 month due to the breakdown of the UPS system of the Laboratory.

All the components of the bricks are available:

- The JL Goslar company has achieved a production rate of 40 000 Pb plates (>700 bricks) per day (2 shifts)
- The CS facility is operational: 20000 have been produced and the production rate is 1700 CS per day

We have used the last 3 months of 2006 for the final commissioning of the brick production (BAM) and handling (BMS).

The main items for tuning the BAM were:

- To take into account the achieved quality of the brick components, mainly the Pb plates (shape and stickiness) and emulsions (shape strongly related to the hygrometric conditions)
- To produce bricks with the needed shape (wrapping over thickness)
- To optimize the material used for the skates of the brick in order to get the proper sliding coefficient for a row of bricks in the brick wall

The main items for the tuning of the BMS were:

- To study the samples of bricks produced by the BAM
- To adapt the reading of the matrix code engraved onto the brick
- To check all the automatic missions and the data base management on real bricks

The commissioning of the BAM and the BMS is completed. 1300 bricks are already inserted inside the detector. The brick production will ramp up from 1 transportation drum per day (234 bricks) during the weeks 5 to 9, to 2 drums per day weeks 10 to 13.

The brick production rate which can match the Pb plate production, the BAM and BMS speed is 702 bricks per day (3 transportation drums) assuming that we will obtain the resources for running with 2 shifts for the BAM and the BMS. We should reach this rate by the end of March and we have made an estimate of the filling of the detector under this assumption.

Taking into account the missing emulsions (20%, due to the lack of funding in Japan) the maximum number of bricks to be produced will be ~170000. We have optimized the filling of the detector in order to reduce the event losses:

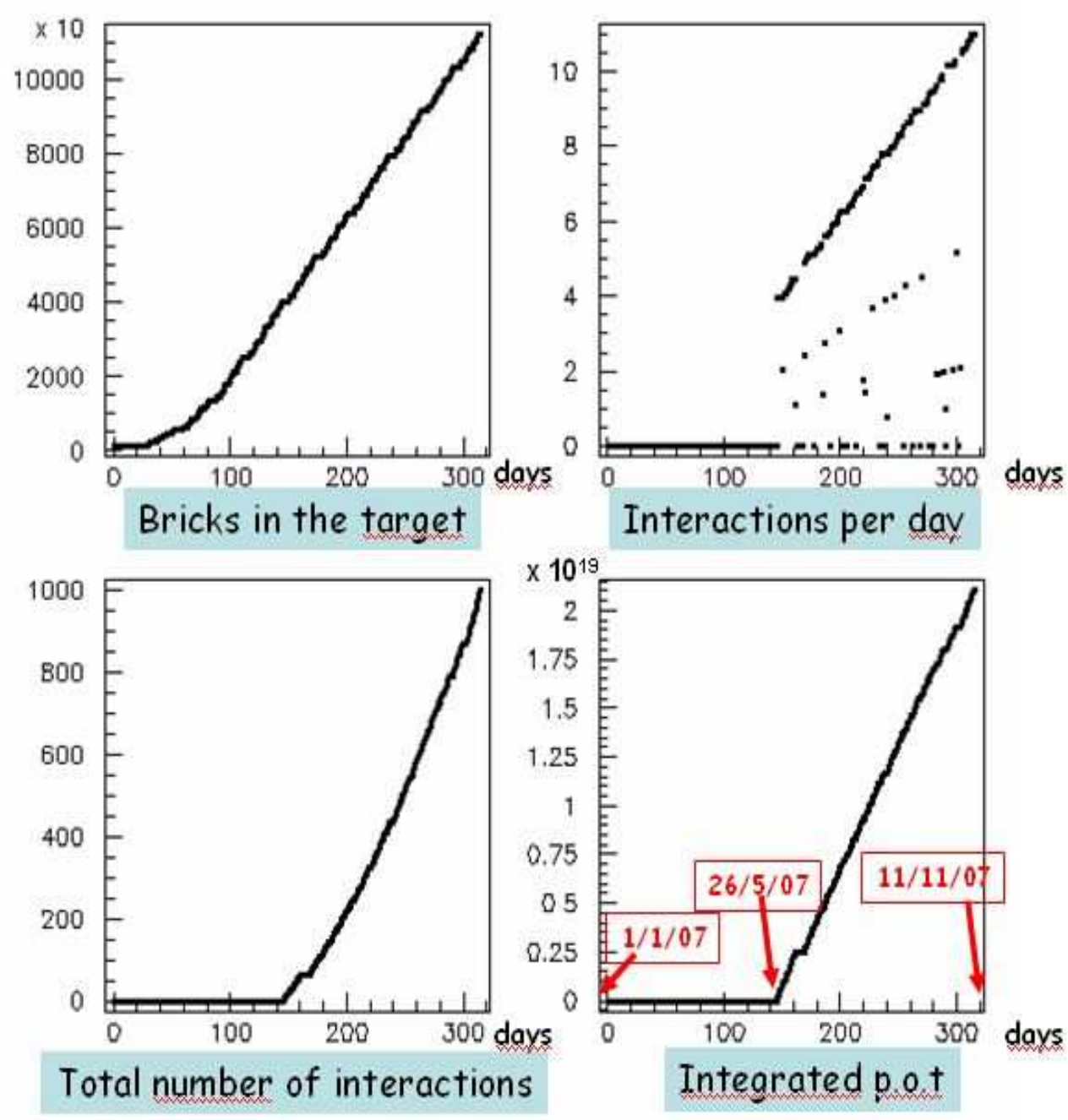
- Leaving 3 rows empty at the bottom and the top of each plane
- Leaving 2 planes empty on both sides of the target

We end up with 81432 bricks per Super-module.

Bricks at the start of the SPS physics program (26/05/07)	Bricks at the end of the SPS physics program (11/11/07)	Completion of the detector filling
40738	111982	End of March 2008

The following figures show the number of bricks in the target as a function of time and for the case of 3 CNGS cycles per SPS super-cycle:

- The interaction rate per day
- The integrated number of events
- The integrated proton number onto the CNGS target



d. Brick processing

The brick processing is made in 5 steps:

- Xray marks for the alignment between the 2 emulsion sheets of the CS and between the CS doublet and the brick: the equipment is ready and have been used during the October run. The final automation system is being implemented
- The CS doublet development: the equipment is installed in the underground lab and used regularly for test purposes
- The CS scanning: the station at LNGS is operational since the beginning of the year 2006. 4 automatic microscopes have been used in 2006 and 6 will be available for the run in 2007, this will allow to scan 7 CS doublet per day in Europe
- Xray mark on the side of the brick and cosmic irradiation for the inter-plates alignment
- Optical printing of grids and labels followed by the plate development performed in the dedicated facility at the surface laboratory.
- The brick scanning: this task is performed by the scanning laboratories in Europe and in Japan

All those equipments are ready and have been used during the run in October.

2) Physics reach with the requested run in 2007

a. Interaction rate

As an example we have estimated the number of neutrino interactions which can be registered in the OPERA detector with the following assumptions of the CNGS running (performance achieved during the 2006 runs):

- Official SPS schedule for 2007 : 135 useful days
- 1.7 10^{13} pot/extraction, 70% efficiency for the machines complex
- 2 Super- cycle types:
  - 1 CNGS cycle every16.8 seconds (1.22 10^{17} pot/day)
  - 3 CNGS cycles every 39.6 seconds (1.56 10^{17} pot/day)

	Integrated nb. of pot	Interactions in the bricks *(3 drums/day)*	Rock muons
1 CNGS / Super-Cycle	1.65 10^{19}	787	2640
3 CNGS / Super-Cycle	2.10 10^{19}	1001	3360

The following table gives the classification of the neutrino interactions in the bricks:

υ_μ CC	75.5%
υ_μ NC	22.4%
Anti υ_μ CC	1.5%
All ν_e	.5%

b. Goals of the run in 2007

- **Tuning of the complete data analysis chain**
  - Commissioning of the 2 spectrometers
  - Final alignment of the electronic detectors : a minimum number of 1000 beam tracks are needed for
  - Tuning and efficiency measurement of the brick finding algorithms
  - Validation of the candidate brick extraction procedure
  - Validation of the CS and brick scanning strategy
  - Tuning and efficiency measurement of the vertex finding methods

- **CNGS beam cross check**

The measurement of the neutrino energy spectrum and of the anti-neutrino component is an important cross check of the CNGS. It cannot be done in an accurate way by using rock interactions.

- **Check of the decay search**

Assuming a total number of neutrino CC interactions in the target of about 500, we expect about 20 charmed hadron decays with the primary muon identified (a total charm-production cross-section of 4% has been assumed). Even considering an efficiency of about 50% in going from the brick finding down to the decay search, we expect to detect about 10 charmed hadron decays. Despite the limited statistics these events will allow a thorough check of the event selection by using topological criteria, of the event analysis chain and will provide a first rough experimental measurement of the decay location efficiency.

- **Tuning of the kinematical analysis**

The achievement of a powerful background reduction in the hadronic Tau decay channel strongly relies on the kinematical analysis performed both at the primary and the decay vertices. On the other hand, the rejection power against the background can only be evaluated by using a Monte Carlo simulation. Therefore, it is mandatory to perform a detailed comparison of the Monte Carlo to real data. Indeed, the kinematics at the primary vertex (missing transverse momentum, prong multiplicity, angular distributions)

is affected by processes like the Fermi motion of the nucleons inside the nucleus and the re-interaction of the produced hadrons within the nucleus.

In order to check the reliability of the kinematical analysis, we plan to perform a full kinematical reconstruction of the whole sample, both CC and NC, collected during the 2007 neutrino run.

3) Conclusion

Summarizing the previous discussions, we can conclude:

- The data collection from the electronic detectors and from the scanning systems have been validated during the 2 beam runs in 2006
- The data analysis is being debugged using the recorded data but we need more data in order to complete the full commissioning of the analysis software
- The filling of the detector with bricks is now started and we can accumulate several hundred events in 2007 for starting the OPERA physics program

We have used 8.4 10^{17} pot in 2006 (the *nominal* CNGS year is corresponding to 4.5 10^{19} pot).

We are requesting for 2007:

- **One period of 2 weeks** when the CNGS will be operational at the beginning of the SPS physics program with the maximum proton intensity which can be achieved
- **A second period at the end of the SPS physics program accumulating 10^{19} pot** in order to get **500 interactions** in the bricks which is the bare minimum for the validation of the experiment.