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Proposal to be consider at the Collaboration Meeting, Pierre Auger Observatory, Malargüe, June/3-7/2013

Title: Permanent seismic network at the Pierre Auger Observatory

Participant Institutions: Instituto Geofísico-Simológico Volponi (IGSV, belonging to Universidad Nacional de San Juan), Instituto Nacional de Prevención Sísmica (INPRES, from Argentinian Government), Pierre Auger Observatory.

Main goal: To convert from temporary to permanent the five seismic stations installed on year 2010 at the Pierre Auger Observatory building facilities, in advance and as a part of the project “*Sismicidad frecuente y episódica de la región con mayores sismos destructivos del país, implicancias tectónicas y peligrosidad asociada*”, Agencia Nacional de Promoción de Ciencia y Técnica. ANPCyT N° 299/209. PICTO Riesgo Sísmico N° 254. Period: March/2011-March/2014. This research project is referred in the text as PICTO-RS254.

Introduction

Known seismicity in the region (Figure 1) shows a strong earthquake with magnitude $M \sim 6.0$, May/30/1929, that completely destroyed the Villa Atuel town and the Malvinas locality. Felt earthquakes with lesser magnitudes are common. Nevertheless, the geologic structures that might be related to the seismicity are not very well known yet. A seismic network of twelve stations (Tabla 1, Figure 2) was established in order to improve that knowledge. Five of those stations are installed at the Pierre Auger Observatory building facilities; a digital recorded system inside of each LIDAR and corresponding seismic sensors in a vault outside of it (e.g., sensor vault at Los Leones, Figure 3), and also the same instrument disposition is placed at the Balloon Launch Station (BLS). These stations supply energy to the recorders except in Las Amarillas (Figure 4), and the five provides Internet connection for real time data transmission to San Juan Province, Argentina. Las Amarillas station (Figure 3) and the other seven stations are autonomous with energy supplied by battery and solar panels. It would be very useful to keep running as permanent the twelve stations, but this is difficult because most of the equipment may be needed for other experiments and autonomous stations need

financial support for periodic visits, to perform data extraction and maintenance, except at Las Amarillas. That is why we propose to convert to permanent only the stations at the Pierre Auger Observatory. It is interesting to note that their locations fill a gap in the Argentinian national network that it is maintained by INPRES.

Equipment for the Pierre Auger permanent seismic network

Except for COIH the equipment used at present at the Pierre Auger stations (Tabla 1) have short period vertical components. The recorder systems have been assembled within the present project (PICTO-RS254). Cards, which convert analogous to digital signal, were connected to computers. These systems had several computer failures. Thus, it will be convenient to improve them. LAMA has a very good recording system (Refttek 130B, Figure 5) attached to a battery and a solar panel, but the soil conditions are very bad producing high noise. It may be convenient to construct a deeper vault to attenuate the noise.

Once the present project PICTO-RS254 became finalized, then IGSV and INPRES will accord about the sensors and recorders that will be installed in the permanent network since at present all the seismic equipment at Auger belongs to IGSV except for the sensor at COIS (Table 1).

Necessary Improvements at the Pierre Auger Observatory stations

To run as permanent the Pierre Auger seismic network it is necessary the following:

1. Modify a little bit some of the sensor vaults.
2. Implement sensor thermal isolation at the vaults.
3. Safer electrical connection to the recorder system on each LIDAR and BLS.
4. To improve the present digital recording system.
5. Keep running the real time data transmission by Internet.
6. Automatically transmission data in daily periods (not in real time) to servers at IGSV and INPRES.
7. At some point try to find the way to obtain grants for renovating the digital recorder systems and if it were possible to place three component broadband sensors instead of the short period ones. Also some budget for equipment maintenance will be needed.

About the support that it might be expected from the Auger Observatory to fulfill these needs are:

- a) Ricardo Perez Gaita and his team already have collaborated a lot with the vault constructions and could help with items 1, 2, and 3.
- b) Rubén Squartini has been already an enormous aid in electronic and computer jobs and will be very helpful for items 4, 5 and 6. In fact, Rubén Squartini had become directly involved with the seismic network operations

of the project PICTO-RS254. It would be very important that he continue working in the same way for the permanent network.

- c) Ing. Gualberto Ávila have been always paying attention to the needs of the Pierre Auger temporary seismic stations and favored any decision that was needed to keep them running. This attitude would be very helpful for the future permanent seismic network.

Data availability

A complete set of data records will be kept by each of the three participant institutions, and a policy must be worked out to provide data freely upon request for research.

Responsible group for the permanent network operation

Each of the three participants institutions (IGSV, INPRES and Pierre Auger Observatory) will designate a person that will form part of three members Responsible Group for the care and network's decisions. These institutions must agree for the appropriate regulations and formal obligations that concern to the network Responsible Group.

Some results obtained by the temporary seismic network

Seismicity in the region have been greatly influenced by the great $M_w=8.8$ Maule Earthquake, Chile, 2/27/2010. We could determine: a) the activation of an Andean trough between 35°S and 36°S , b) the aftershock sequence of the earthquake on 6/7/2012, $M_w=6.0$, Chile, near the Argentinian border (36.184°S , 70.943°W , depth=16.7km) that permitted individualize its fault plane from the focal mechanism nodal planes. Tensional effects of the Maule earthquake might be associated to paucity in seismicity of the Malargüe faults and thrust belt northern part, which is commonly seen as a consequence of compressional stress. Other seismicity seen in the region is located in areas nearby the Atuel River. These results are part of those which have been shown in the doctoral thesis "***Sismicidad entre $34.5-36.5^\circ\text{S}$ y $67^\circ-71^\circ\text{O}$ posterior al sismo de Maule, $M_w=8.8$, 27/02/2010 y distribuciones de deslizamientos en placa de Nazca para sismos de profundidades mayores a 100km en secciones plana y normal entre $31-34^\circ\text{S}$*** " by Silvana Spagnotto, Universidad Nacional de San Juan, 3/25/2013.

Conclusions

The five seismic stations installed at the Pierre Auger Observatory by the PICTO-RS254 project, for more than three years, have shown the importance to keep them running as permanent stations once the project became finalized on March/2014. This it is possible in principle at very low cost by using IGSV and INPRES equipment, and the Pierre Auger building facilities, electrical power and Internet connection. Researchers, and technicians from IGSV and INPRES will be

involved in the network operation, but it is desirable and convenient that the Pierre Auger personal become also involved.

The three institutions, Instituto Geofísico-Simológico Volponi (IGSV, Universidad Nacional de San Juan), Instituto Nacional de Prevención Sísmica (INPRES, from Argentinian Government), and Pierre Auger Observatory will designate a Responsible Group for the needs and contingency decisions of the permanent network.

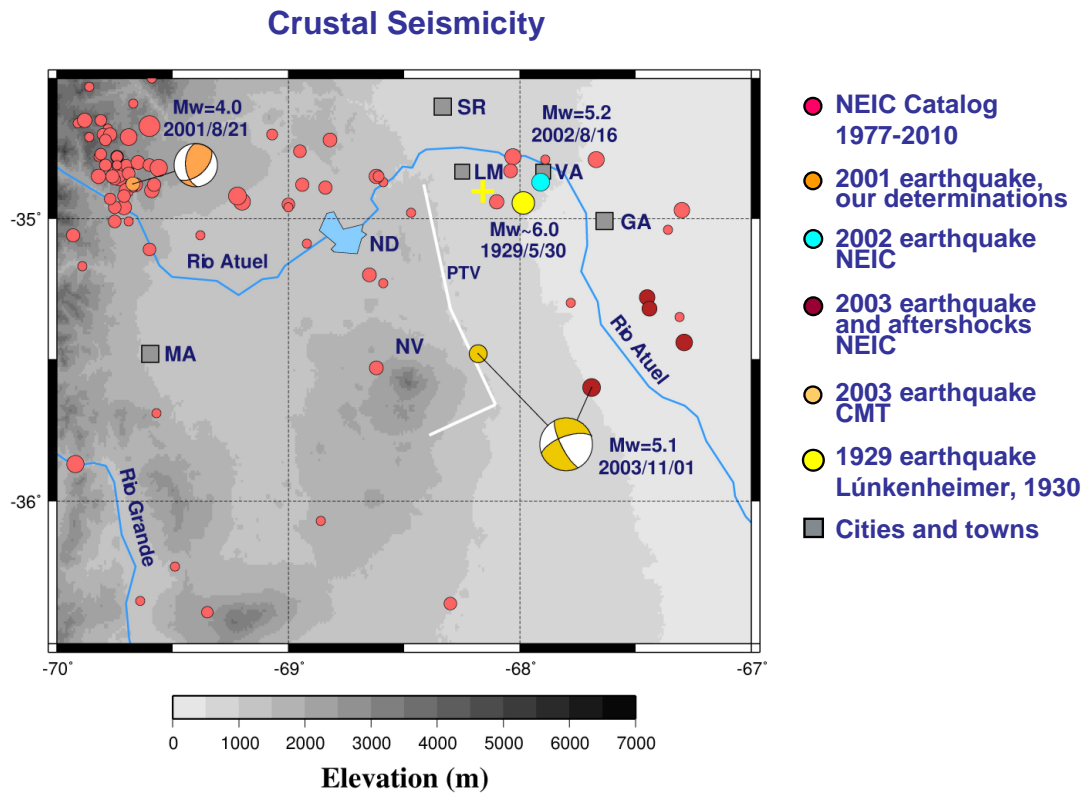


Figure 1. Regional seismicity. Yellow circle and cross show possible locations of the destructive earthquake on 1929. SR, GA, MA: San Rafael, General Alvear, and Malargüe cities. VA: Villa Atuel town. LM: Las Malvinas locality. ND: Nihuil dam. NV: Nevado volcano. White line: Las Malvinas and Nevado faults.

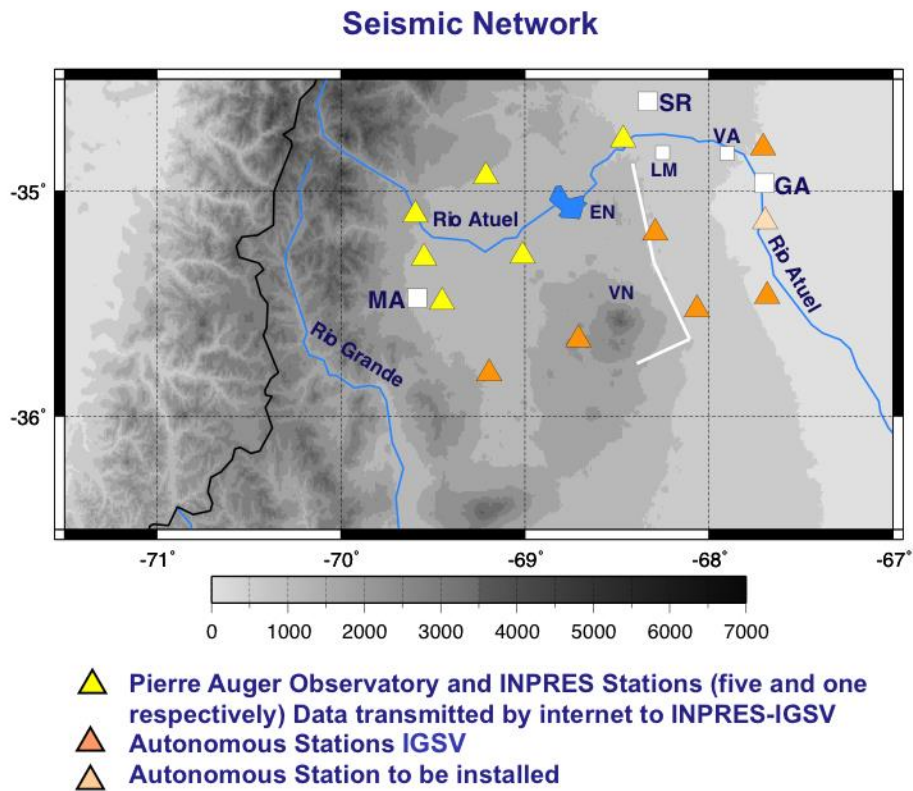


Figure 2. PICTO-RS254 seismic network. Cities, town, localities, volcano and faults are the same as in Figure 1.



Figure 3. Sensors and vault at Los Leones station (PUMA).

STATIONS	LATITUDE	LONGITUDE	SENSOR	RECORDER
LAMA (Las Amarillas) PAO, <i>AUT</i> , <i>RTD</i>	-34.9353	-69.2121	S-13, SP, Z	RefTek 130B 24 Bits
COIH (Coihueco) PAO	-35.1080	-69.5938	Guralp ESP- EDU, IB, Z, N, E	Guralp ESP-EDU 24 Bits
COIS (Coihueco) PAO, <i>RTD</i>	-35.1080	-69.5938	S-13, SP, Z	SARA 24 Bits
BLS1 (Balloon Launch Station), <i>RTD</i>	-35.3002	-69.5467	S-13, SP, Z	SARA 24 Bits
PUMA (Los Leones) PAO, <i>RTD</i>	-35.4958	-69.4497	S-13, SP, Z, N, E	PCN 16 Bits
MORA (Los Morados) PAO, <i>RTD</i>	-35.2915	-69.0118	S-13, SP, Z	PCN 16 Bits
CARA (Carapacho) <i>AUT</i>	-35.8131	-69.1930	S-13, SP, Z	RefTek 130B 24 Bits
SANP (San Pablo) <i>AUT</i>	-35.6619	-68.7087	Guralp 40T, IB, Z, N, E	RefTek 130B 24 Bits
BOBO (Pájaro Bobo) <i>AUT</i>	-35.1879	-68.2913	S-13, SP, Z	RefTek 130B 24 Bits
AGUA (Punta del Agua) <i>AUT</i>	-35.5282	-68.0651	Guralp 40T, IB, Z, N, E	RefTek 130B 24 Bits
TATU (Tatú) <i>AUT</i>	-35.4691	-67.6835	S-13, SP, Z	RefTek 130B 24 Bits
REAL (Real del Padre)	-34.8067	-67.7052	S-13, SP, Z	PCN 16 Bits
SRA (San Rafael) INPRES <i>RTD</i>	-34.7708	-68.4660	Guralp 40T, IB, Z, N, E	RefTek 130 24 Bits
CARM (Carmensa) To be installed in a near future	-35.1370	-67.6940	S-13, SP Z 24 Bits	RefTek 130S 24 Bits
PAO: Pierre Auger Observatory (Malargüe); <i>RTD</i> : Real Time Data transmission by Internet; <i>AUT</i> : Autonomous; IB: Intermediate broadband (up to 30 sec); SP: Short Period; Z vertical component; N, E (North and East horizontal components). NOTE: COIH and COIS have the same location, but different names reflect different equipment types. SRA is an INPRES station that form part of the Argentinian Seismic National Network. Equipment for all other stations belongs to IGSV, except the sensors at COIS and SANP that are INPRES property.				

Table 1. Locations and equipment for the PICTO-RS254 network stations.



Figure 4. Las Amarillas station (LAMA). Arrows show GPS, solar panel and sensor vault.

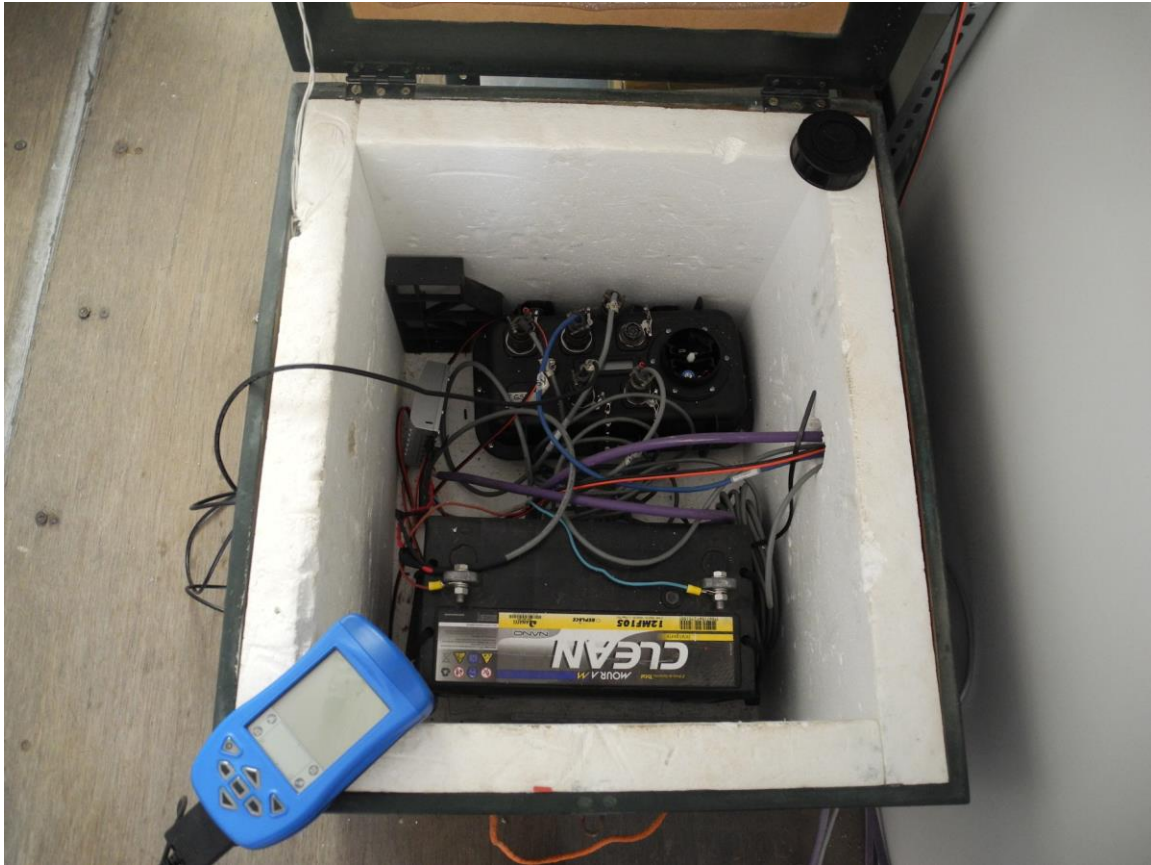


Figure 5. Las Amarillas station (LAMA). RefTek 130B recorder system, Refraction Technology Inc., USA. It is the same as in stations CARA, SANP, BOBO, AGUA, and TATU (Table 1).

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