Short baseline neutrino program in Argentina

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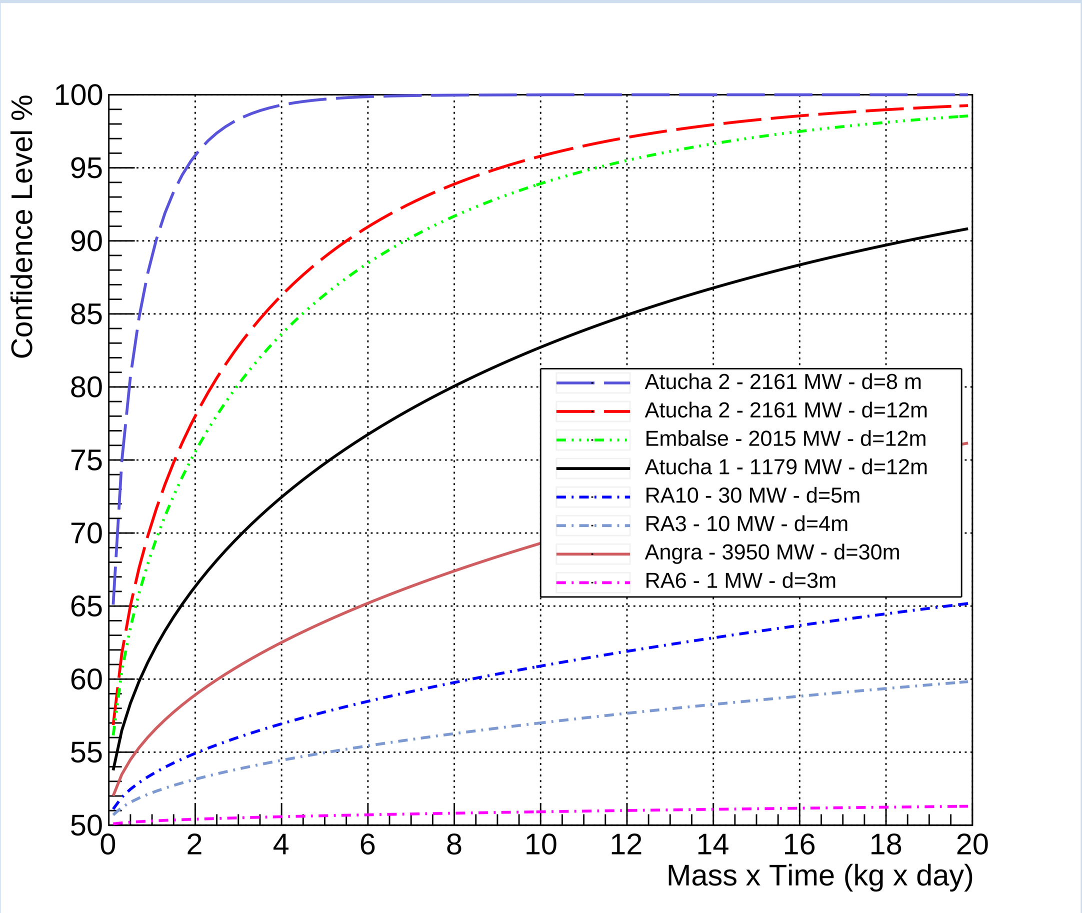
Abstract

We introduce the scientific opportunity that research reactors and nuclear power plants in Argentina represent for short baseline reactor neutrino experiments. Argentina has different kinds of nuclear reactors that can be accessible to perform a variety of experiments in diverse fields. There are research reactors aimed to function as radioisotopes generators, training facilities, R&D in neutron techniques, etc., and three Nuclear Power Plants (NPP) producing 8% of the total power in Argentina. In this work we will be focusing on the characteristics of RA-3 (10 MWth, operational) and RA-10 (30 MWth, under construction), and CNAII (2175 MWth, NPP operational). We have looked through different locations within these facilities, that could allow us to install a neutrino experiment very close to the reactor core (from 5 m to 12 m).

Sensitivity studies

The sensitivities to observe CEνNS as a function of the parameter mass by time for each distance under consideration -between a detector and the center of the reactor core- was calculated for a Skipper-CCD experiment (see poster #521) These calculation were performed under the point-like reactor approximation.



This figure presents the sensitivity curves for the main Research reactors and Nuclear Power plants in Argentina. According to this plot, νIOLETA will be able to observe CEνNs with a CL above 90% in less than one week.

Physics goals

The accessibility to these reactors opens many opportunities for new science: high precision measurements of the standard model due to the large statistics and less nuclear uncertainties by small momentum transfer; a broad spectrum of non standard interactions including stronger limits on interesting properties like neutrino magnetic moment, dark sector exploration by dark photon mediated interactions search and dark matter production in reactors, setting bounds on solar neutrino floor interaction background for new low threshold electron and nuclear recoil galactic dark matter searches.

Reactor Main Characteristics

	Research reactor		
Name	RA-6	RA-3	RA-10
Power (MWth)	1	10	30
Type	Pool	Pool	Pool
Fuel	U_3Si_2 (20%)	U_3O_8 (20%)	U_3Si_2 (20%)
Reactor ON/Reactor OFF	1	1	4
Location	Bariloche	Ezeiza	Ezeiza
Status	Operational	Operational	Under Construction
Operator	CNEA	CNEA	CNEA

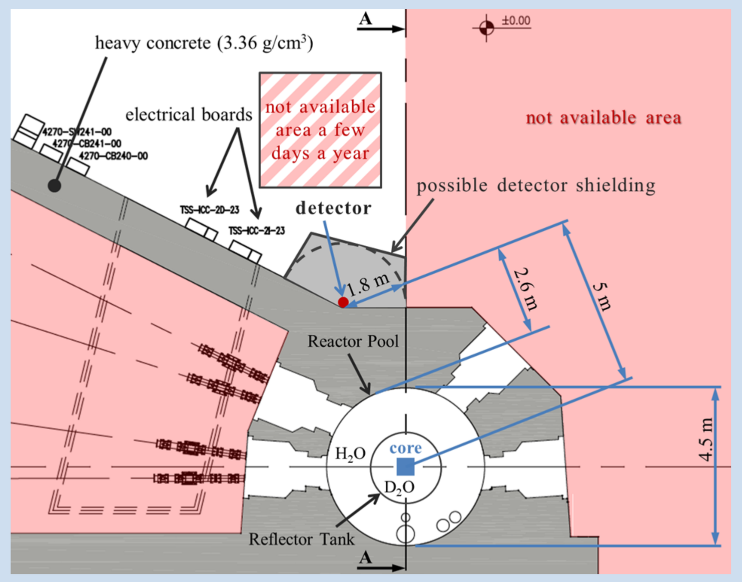
Main features of the reactor facilities in Argentina. Left: RR operated by CNEA, results important to notice that both RA-3 and RA-10 are at CAE, a few kms away from Buenos Aires, close to the international airport. Right: NPP facilities in Argentina are operated by Nucleoeléctrica Argentina SA (NA-SA). CNA I & II facilities are located near the city of Lima, at ~100 km from Buenos Aires.

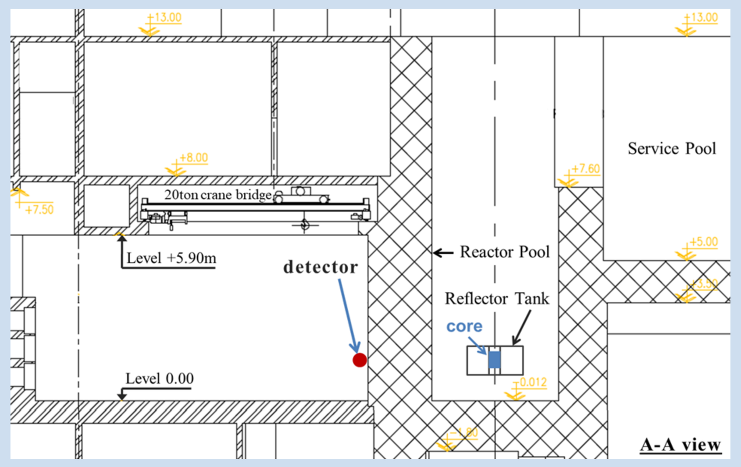
	Power reactor		
Name	Atucha I	Atucha II	Embalse
Power (MWth)	1179	2161	2064
Type	PHWR	PHWR	CANDU
Fuel	ULE (0.85%)	Natural UO_2	Natural UO_2
Reactor ON/Reactor OFF	12	12	13
Location	Lima	Lima	Embalse Rio Tercero
Status	Operational	Operational	Operational
Operator	NA-SA	NA-SA	NA-SA

RA-10 (Reactor Argentino 10)

The construction of RA-10 Multipurpose Nuclear Reactor is located on an implantation area of 3.85 hectares, with four buildings. The beginning of the commissioning stage (hot test) is expected by the end of 2022.
Its core has a compact geometry (61.5 cm × 46 cm × 41 cm), cooled and moderated by H_2O, reflected by heavy water. Neutrons from the reactor will be used for radioisotope production, in-core irradiation positions, nuclear fuel testing loop, NAA, silicon doping, cold neutron source, etc. Eight neutron beams will be extracted from the core to the "reactor face" and the Guide Building, to be used by the Argentine Neutron Beam Laboratory (LAHN).

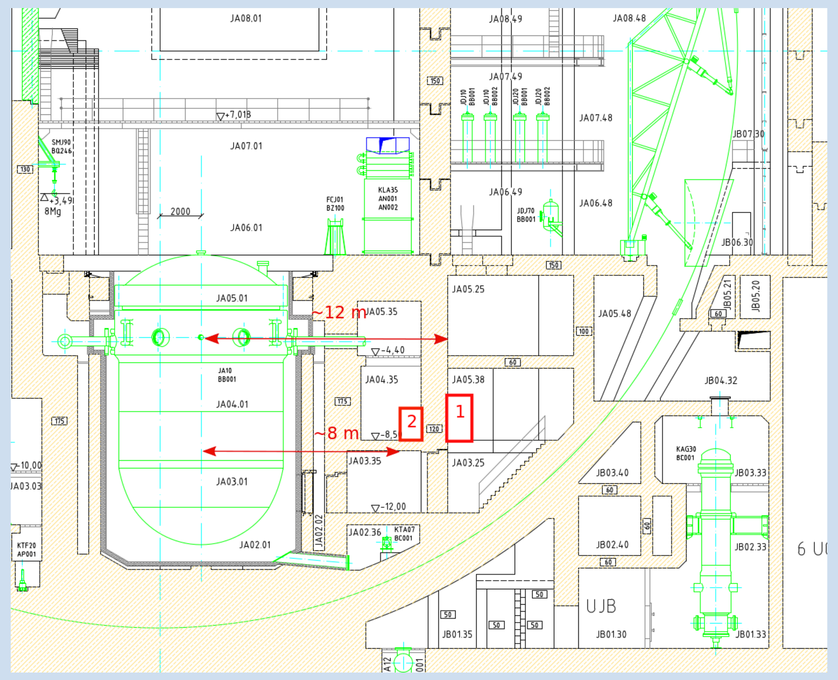
A goal of the RA-10 Project is to encourage new capabilities and contribute to science and development, with a strategic impact on health, technology, services and research. For a neutrino detector, a possible location on the reactor face (in the Reactor Building) can be seen in the figure (plant and vertical view), together with the available space and the shielding provided by the heavy/reinforced concrete of the reactor block and some upper slabs. The detector is 5 m from the center of the core and 1.5 m above the ground.





CNA II (Central Nuclear Atucha II) Nuclear Power Plant

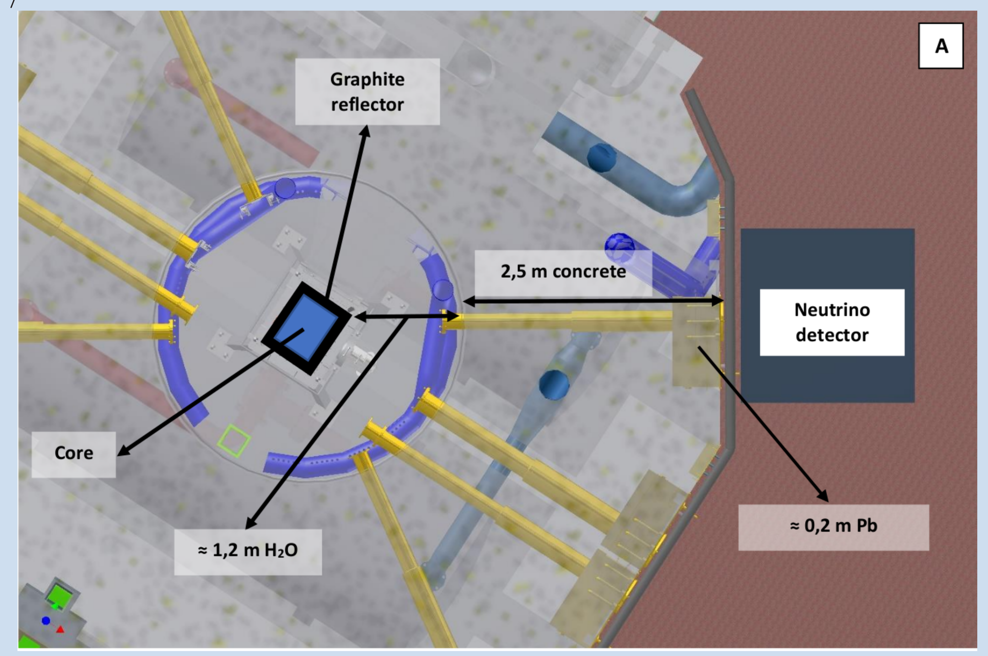
Atucha II is a pressurized heavy water reactor of German design (Siemens) commissioned on 2014. It has 451 fuel elements, each one with an active length equal to 5.3 m and a diameter of nearly 10 cm (with a cylindrical shape). The fuel elements are vertically allocated inside a pressure vessel (14 m high and 8.44 m wide) in a triangular grid, the distance between fuel elements centers is 27.2 cm. On 2019 we started the talks to see the possibility of placing a neutrino experiment in this facility. We discuss the technical requirements and the availability of spaces.



On December 2019 we visit the reactor to inspect the suggested places, these are pointed out in the figure. Position 1, in the JA 05.38 sector is around 12 m away from the reactor core. This position is shielded for most of the background radiation coming from the reactor by a double concrete wall. The dose measured at this position is around 1μSv/h, the same value as outside the reactor at ground level. On the other hand, position 2 is at ~8 m from the core, the background radiation is more intense at this location. A thoughtful evaluation of the shielding must be done.

RA-3 (Reactor Argentino 3)

Commissioned on December 1967, the RA-3 was focused from the beginning on supporting developments in radiopharmacy, NAA and the production of radioisotopes mainly for medical use. The reactor beam hall is at the core level. It´s a radiologically controlled area where gamma dose rate is about 1-2 μSv/h and the neutron dose rate is lower than 1 μSv/h.



The thickness of the concrete shield of the reactor is about 2.5 m, which adds up to approximately 1.2 m of water in the reactor tank up to the core. The optimal location where the experimental setup for the neutrino experiments it is located near the end of one of the beam extraction channel. Since this one is currently unused, it is shielded inside with concrete blocks (2.3 m total), that can be removed, and it has a 0.2 m thick lead shield at the end.

Conclusions

⇒ We have presented the main characteristics of two RR (RA-3 and RA-10) and a NPP (CNA II) that can accommodate a short baseline neutrino experiment.
⇒ The possible distances in which the detector can be placed allow a very good perspective to measure the CEνNS for the different reactors.
⇒ Comparing with CONNIE experiment, where the reactor has twice the power of CNA II but the experiment is 30 m away, the neutrino flux at 12 m in CNA II is a factor three higher, and therefore, the opportunity for observing CEνNS increase significantly. Even more considering Skipper-CCD detectors as was shown.