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SuperChooz Exploration: Reactor & Solar Neutrino Physics

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A new Europe-based flagship neutrino experiment potential opens by exploiting a unique opportunity effectively hidden in the Chooz nuclear reactor site (France). The **SuperChooz** project's birth is tied to the dismantling of the EDF Chooz-A nuclear reactor complex. Built around the 60s and unknown to most scientists, the Chooz-A site offers an underground volume of up to 50,000m³ available for fundamental neutrino science using the EDF Chooz-B, two most powerful N4-PWR nuclear reactors located at ~1km away. The combination embodies the third generation of possible fundamental science at Chooz —Europe's most renowned site for reactor neutrino research —while this time, detectors may reach a scale comparable to the world's largest neutrino detector, such as the SuperKamiokande (Japan). The main experimental challenge is the site's shallow overburden (~100m) demanding the use of the novel **LiquidO** technology, originally pioneered around 2012 by the CNRS (France) and now led by the homonymous international consortium. The new detection methodology heralds the unprecedented active background rejection needed for detection beyond reactor neutrinos only, thus enabling unique solar neutrino detection. The SuperChooz physics programme is designed to address some of the world's most precise measurements, additionally probing a few of the most insightful building-block symmetries of the Standard Model, enabling possible discovery potential. SuperChooz programme also offers synergy potential allowing to boost the sensitivities of other world neutrinos flagship experiments, such as DUNE (US), JUNO (China) and HyperKamiokande (Japan).

The exploitation of the Chooz-A site for fundamental science has been in active discussion between CNRS and EDF since 2018, upon the completion of the Double Chooz experiment, whose results grant vast data-based knowledge for the accurate design of SuperChooz. The first neutrino reactor-based physics studies were released at the EPS-HEP-2019 conference (Ghent, Belgium). Since September 2022, CNRS and EDF have signed the cooperation agreement, officially starting the so-called **SuperChooz Pathfinder** era to address the project's technical feasibility. The approved **AntiMatter-OTech** project, funded by the EU-EIC (France, Germany, Spain) and UKRI (UK), will address the specific LiquidO's performance demonstration within the same time scale while establishing a new experiment in fundamental physics called **vCLOUD** at Chooz, including the direct participation of EDF in neutrino-based innovation for the first time.

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