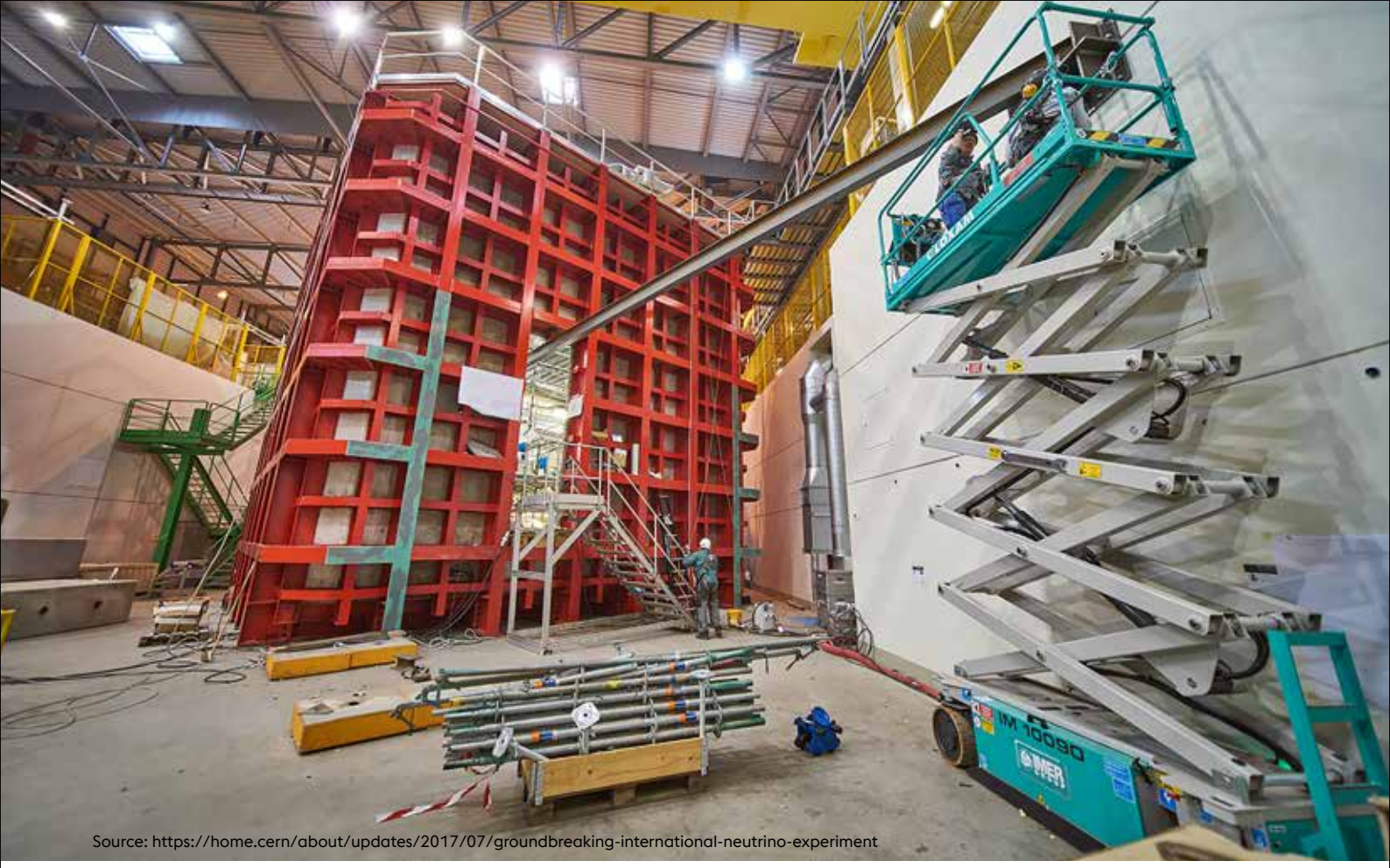


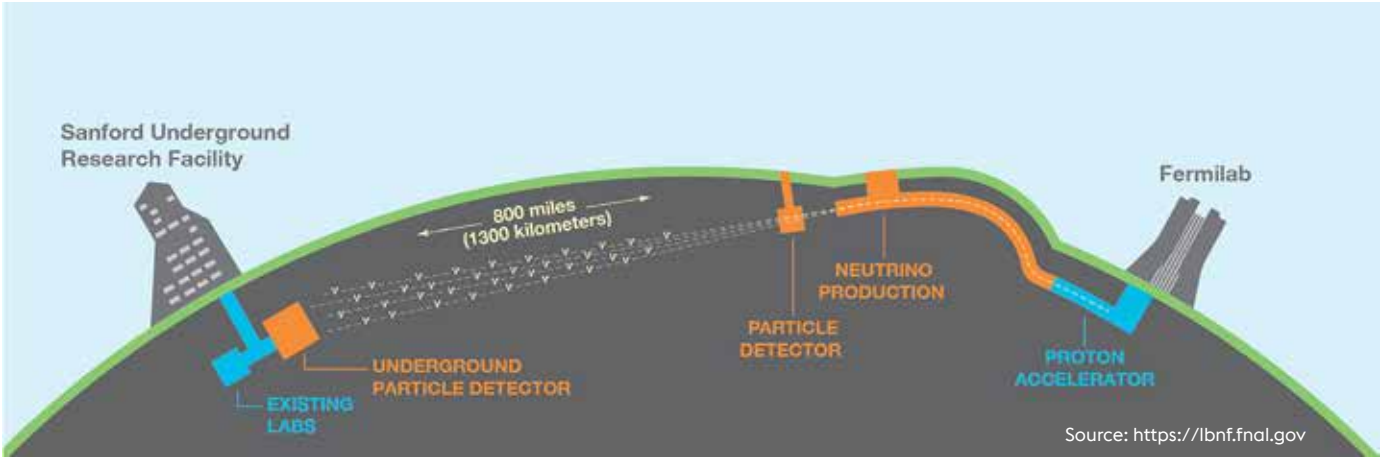
Source: https://home.cern/about/updates/2017/07/groundbreaking-international-neutrino-experiment

Far detector prototype at CERN. The final DUNE detectors will be 20 times larger and will be located at the Long Baseline Neutrino Facility in the United States.

WELDING OF VESSELS FOR THE DEEP UNDERGROUND NEUTRINO EXPERIMENT PROTOTYPE DETECTORS

CERN, Switzerland

Catching neutrinos to understand the universe. Neutrinos are tiny elementary particles which travel at almost the speed of light and penetrate right through atoms without interacting with them. They are a billion times more abundant in the cosmos than the particles that make up stars, planets and people. The Deep Underground Neutrino Experiment (DUNE) is one of the greatest scientific projects of our time aiming to unravel the mystery of how the universe came to exist of matter rather than antimatter. In less than a decade from now, Fermilab in the United States will be sending the world's highest-intensity neutrino beam from their laboratory in Batavia, Illinois through the earth's crust to be intercepted by cryogenic far detectors at the Sanford Underground Research Facility located in a 1,500 m deep mine at a distance of 1,300 km in Lead, South Dakota. Here argon atoms colliding with neutrinos will release a flash of light and a cascade of electrons that can be measured and analyzed



The Long Baseline Neutrino Facility, principle sketch.

European Engineering. Two prototypes of the cryogenic far detectors were built at CERN, the European Organization for Nuclear Research in Geneva, Switzerland, who is a major partner in the international DUNE project and home of the Large Hadron Collider – another ground breaking project to study the fundamental particles. CERN employs 10 times more engineers and technicians than researchers, building and testing the machines and systems that physicists rely on. From the outside, the detectors look like a giant Rubik Cube. Inside the 12 x 12 x 12 m reinforced main frame is an insulated liquid-tight metallic vessel designed to hold about 800 tons of argon cooled to -196 °C. The structural steel frame provides the necessary support for the considerable hydrostatic pressure of the contained liquid.

Time-efficient welding. On time construction of the two far detector prototypes involved a major challenge in the assembly welding of the mainframe out of modules prefabricated by Revas Constructions Métalliques SA in Sion, Switzerland. The thick-walled modules consisted of welded H-profiles in EN 10025: S355NL with mostly multi-layer fillet welds in predominantly the down hand position, but with associated positional welding. Revas applied the manual MCAW process with BÖHLER HL 51 T-MC metal-cored wire. It is optimized for travel speed in the downhand position and requires no de-slagging for multi-layer welds. For the erection of the mainframe at CERN, productive manual welding was a major requirement along with flexible all-positional weldability of the selected filler materials. The modules in S355NL received from Revas first needed to be connected to one another to form wall sections with butt and fillet welds in all welding positions. Subsequently, AISI 304L stainless steel plate was laid out on top of the wall sections and connected to S355N with fillet welds in the overhead position. After erection of the wall sections, the complete wall was formed by connecting the mainframe in S355NL – again a job in all welding positions - followed by the vertical-up welding of AISI 304L to form the isolating outer vessel of the cryogenic detectors.

Three different types of all-positional rutile cored wires were advised by voestalpine Böhler Welding and tested in newly established welding procedure qualifications. All of them offer an outstanding productivity in positional welding. Always operating with a spatter-free spray arc, they are extremely welder-friendly while assuring even penetration and side-wall fusion to prevent lack-of-fusion defects. They are the ideal set of filler materials for this kind of multi-faceted constructions. The selected cored wires were:

» BÖHLER Ti 60 T-FD for S355NL to S355NL
» BÖHLER CN 23/12 PW-FD for S355NL to 304L
» BÖHLER EAS 2 PW-FD for 304L to 304L

The welding procedure qualifications took place under supervision of a voestalpine Böhler Welding cored wire application specialist. Welders from Russia and France were trained in their national languages with help of Böhler Welding sales representatives for their respective countries. The productive welding solution and the rendered support enabled CERN to complete the construction of the two prototype detectors in time for their planned testing in the USA.

The welding procedure qualifications took place under supervision of a voestalpine Böhler Welding cored wire application specialist.

CERN SWITZERLAND – WELDING OF VESSELS FOR THE DEEP UNDERGROUND NEUTRINO EXPERIMENT PROTOTYPE DETECTORS

Project summary with customer benefits

FILLER MATERIALS, BASE MATERIALS AND WELD REQUIREMENTS

BÖHLER Ti 60 T-FD Ø 1.2 mm

EN ISO 17632-A: T50 6 1Ni P M21 1 H5
AWS A5.36 : E81T1-M21A8-Ni1-H4
Shielding gas M21

BÖHLER EAS 2 PW-FD Ø 1.2 mm

EN ISO 17632-A: T 19 9 L P M21/C1 1
AWS A5.22 : E308LT1-4/-1
Shielding gas M21

BÖHLER CN 23/12 PW-FD Ø 1.2 mm

EN ISO 17632-A: T 23 12 L P M21/C1 1
AWS A5.22 : E309LT1-4/-1
Shielding gas M21

Base Materials

EN 10025: S355NL (welded profiles)
AISI 304L (plate)

Weld types

Butt and fillet welds in all positions
S355NL to S355NL
AISI 304L to AISI 304L
S355NL to AISI 304L

Mechanical requirements weld

YS >355 MPa
UTS>500 MPa

Additional weld requirements

Good welding productivity in all positions
Excellent welding characteristics for positional welding

CUSTOMER BENEFITS

- Best possible productivity in manual positional welding
- Excellent (spray arc) welding characteristics. Welder-friendly.
- Very good wetting behavior
- A single parameter setting for all positions per cored wire type possible
- Self-releasing slag
- Excellent bead appearance with finely rippled surface
- Use of a single shielding gas (M21)
- Excellent strength and low-temperature CVN properties
- Use of ceramic backing for economic root deposition possible

JOIN! With over 100 years of experience, **voestalpine Böhler Welding** is the global top address for the daily challenges in the areas of joint welding, repair, hardfacing and cladding as well as brazing. Customer proximity is guaranteed by more than 40 subsidiaries in 25 countries, with the support of 2,200 employees, and through more than 1,000 distribution partners worldwide. With individual consultation by our application technicians and welding engineers, we make sure that our customers master the most demanding welding challenges. voestalpine Böhler Welding offers three specialized and dedicated brands to cater our customers' and partners' requirements.

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