COLD: COOL COPPER OPERATION LINAC DEMONSTRATOR PROJECT

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On behalf of the Accelerator & Source Division and international collaboration: SLAC, INFN, CERN, PSI, CORNELL

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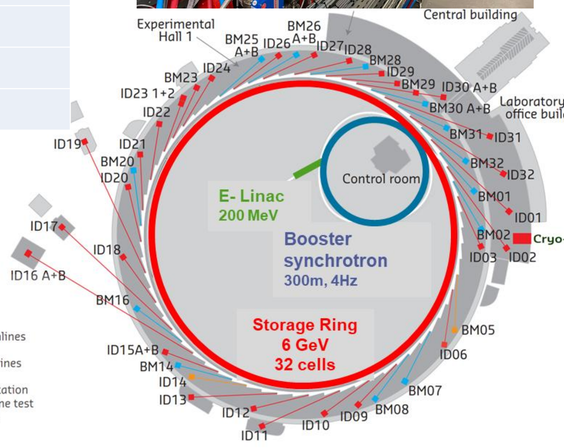
The European Synchrotron Radiation Facility – Extremely Brilliant Source (ESRF-EBS) upgrade has enabled users, since August 25, 2020, to benefit from the first high-energy fourth-generation storage ring light source. For cost and scheduling considerations, the booster injector was refurbished rather than upgraded. However, the long-term ESRF strategy envisions an upgrade of the injector complex to a full-energy 6 GeV linear accelerator (linac). Such a linac must be accommodated within the ESRF site, imposing a maximum footprint of approximately 145 m. To meet this constraint, high-gradient accelerating structure technology developed at SLAC has been selected as a key enabling solution to achieve a compact design. The implementation of a photoelectron gun is expected to deliver a beam with a reduced six-dimensional phase space at extraction, while the adoption of a pulse compression scheme to power the SLAC-type structures offers a significant cost reduction. This poster presents the Cool Copper Operation Linac Demonstrator (COLD) project, recently initiated at ESRF. The project aims to develop a pre-injector linac and to validate the critical technologies required for a high-gradient, cost-effective 6 GeV linac.

	Units	ESRF	ESRF-EBS
Energy	GeV	6	6
Circumference	m	844.4	844
Lattice		DBA	HMBA
Current	mA	200	200
Lifetime	h	50	23
Emittance H	pm rad	4000	133
Emittance V	pm rad	4	10*

The ESRF

19 partner nations
Annual budget: 100 million euros
Staff: 700 people, 40 nationalities
Legal status: Private civil company



Injector Upgrade

Long-term

Injector upgrade

COLD — Started ✓

NEW Linac

Replace existing injectors with a full energy injector linac

- Higher injection efficiency, lower injection perturbation, enable/facilitate future SR upgrades
  - ✓ 6GeV + margin
  - ✓ > 600 pC (single bunch)
  - ✓ < 1 nm.rad at SR injection
  - ✓ < 0.1 % energy spread
  - ✓ < 1 mm bunch length
  - ✓ > 4 Hz repetition rate
  - ✓ Bunch spacing 2.8 ns (in the SR)
  - ✓ Fits on site (maximum 180 m)
  - ✓ As low energy consumption as possible

User facility:
- Reliability
- Maintainability
- Stability
- Reproducibility
- Sustainability
- NO FEL

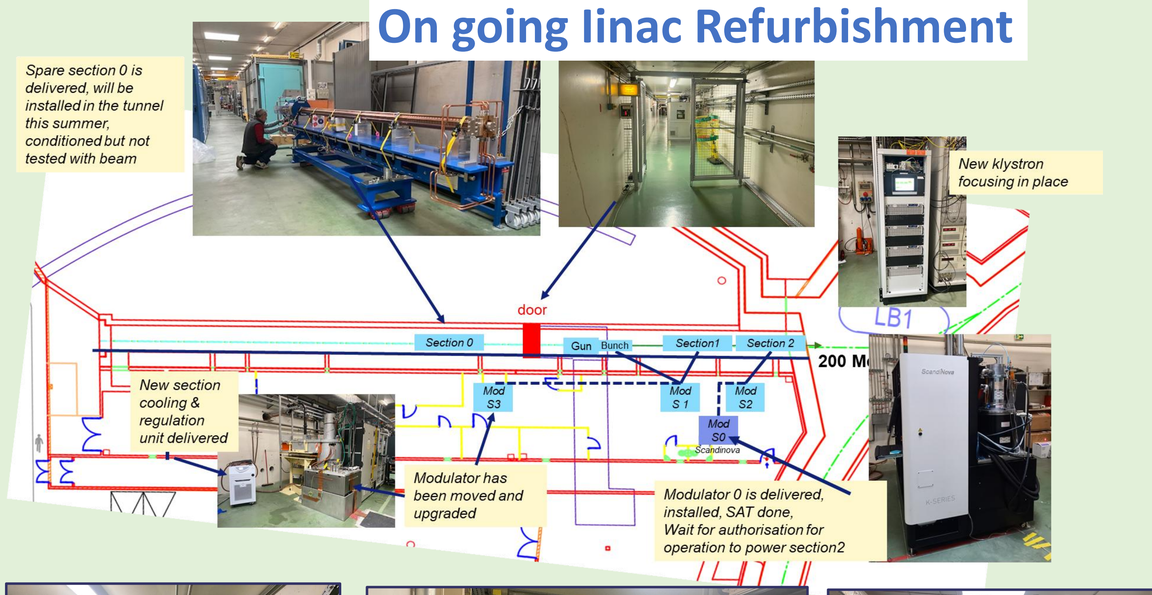
SR Injection section improvement — Advanced ✓
Non-linear injector kicker
Transparent injections
Maintain injection efficiency

Booster refurbishment — Procurement ✓
Lower natural emittance
Higher injection efficiency in SR
Higher extraction efficiency

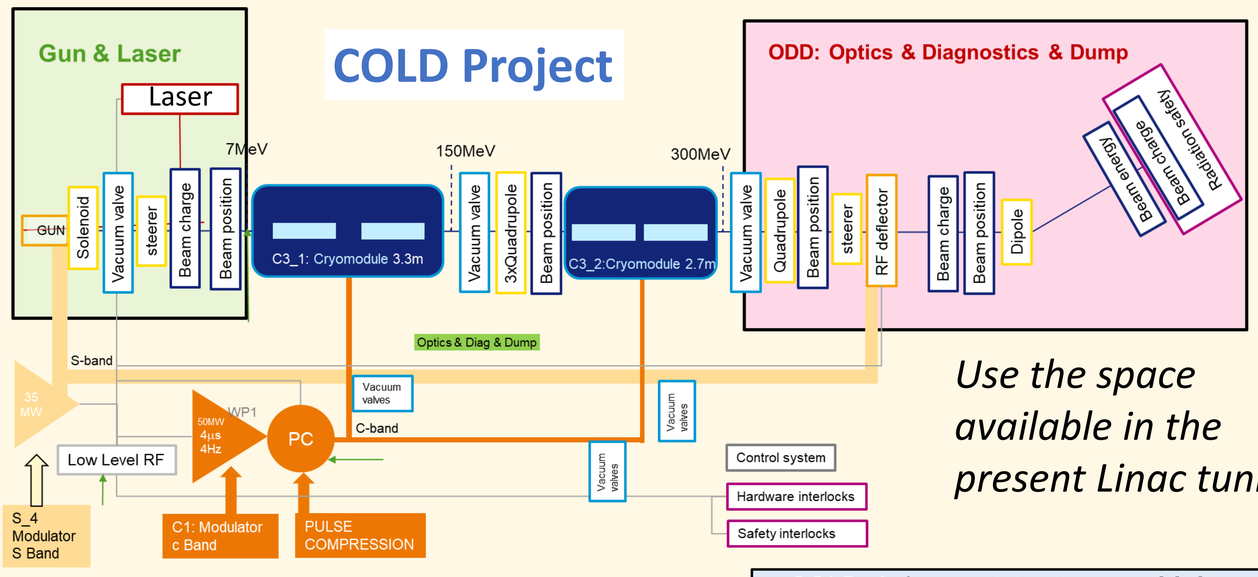
Linac refurbishment — Procurement ✓
More reliability
Modernization

Medium term

On going linac Refurbishment



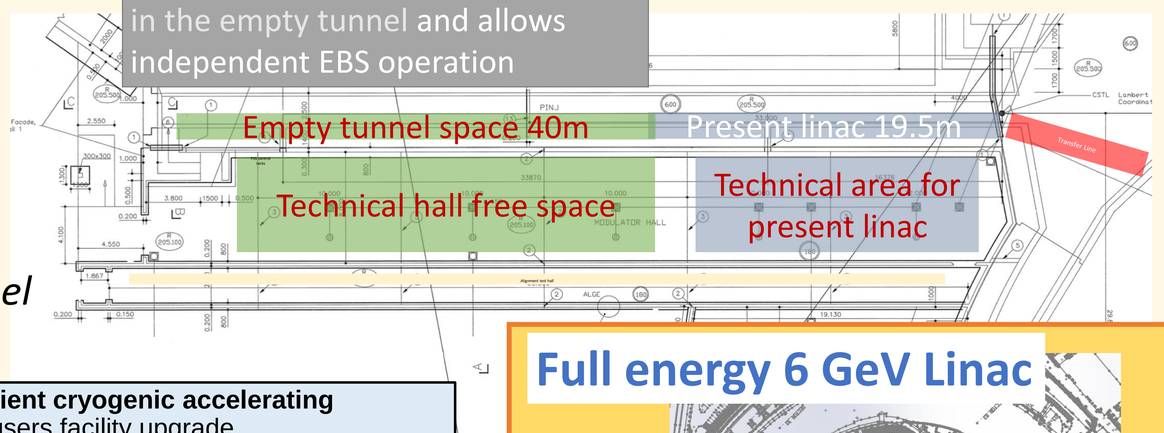
COLD Project



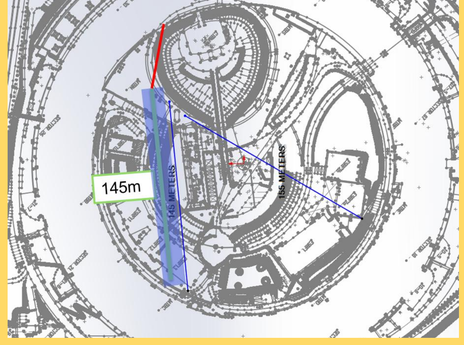
Use the space available in the present Linac tunnel

~0.5GeV C³ demonstrator could fit in the empty tunnel and allows independent EBS operation

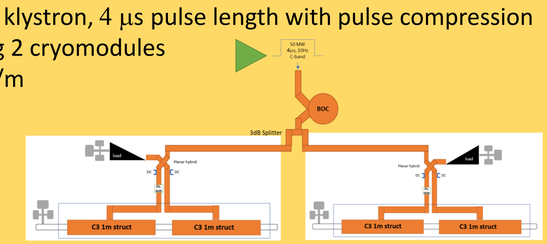
60m long tunnel



Full energy 6 GeV Linac



Phase A (blue): Construction of a new building with a new tunnel and technical area in parallel to the existing Linac
Phase B (Green): Installation and commissioning of the Linac
- 40 cryomodules with 2 accelerating structures
- 50MW klystron, 4 μs pulse length with pulse compression feeding 2 cryomodules
- 75 MV/m



Phase C (Red): Construction of the transfer line and connection to the storage ring

- COLD: A demonstrator to prove **high gradient cryogenic accelerating structures and photogun operation** for users facility upgrade
- *The ongoing Linac refurbishment is essential for medium term reliability of the facility and will benefit the implementation of COLD. Installation of COLD will start after the RF conditioning of the spare cavity for the linac refurbishment .*
- COLD is primarily a demonstrator and is an essential project for medium & long term reliability and performance of the facility
- The infrastructure is being adapted (LN2 and water cooling being the largest adaptation)
- Beam safety authorization request is on going and should be obtained on time
- COLD project is compatible with ESRF user operation
- COLD project is an exciting project for the coming years and for junior generations
- Human resources to carry out and support the project is the critical issue

Date	Instrument added to the installation	Beam achievements	project
2026-Dec SD	**ModS4- RF-unit (SAT)**		*Phase 0*
2027-May SD	**First C-band RF-unit**		*Phase 0*
2027-Aug SD	**First C-band Acc. Struct.**		*Phase 0*
2028-May SD	**Infrastructures installation**		*Phase 1*
2028-May SD	**Diagnostics and beam dump**		*Phase 1*
2029-Jan SD	**S-band photo-gun + laser**	***7MeV photogun beam***	*Phase 1*
2029-May SD	**Beam in Acc. Struct.**	**150MeV beam**	*Phase 1*
2030-May SD	**RF deflector**	***2ps bunch length***	*Phase 1*
2029-Dec SD	**Acc, structure Second C-band**		*Phase 2**
2030-Sep	**Beam in Acc. Struct.**	**300MeV beam**	*Phase 2**
2031-Aug SD	**TL1 Upgrade and inject in booster**	**300MeV beam to booster**	*Phase 3**

** Phase 2 &3 are not financed*

5th Workshop on Particle Accelerator Upgrade - Removal and Installation (PAU R&I), Paul Scherrer Institute, Park hotel Bad Zurzach. Switzerland, 4-7 May, 2026

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