

Accelerator Status

E. Fagotti on behalf of Accelerator Division

Outline



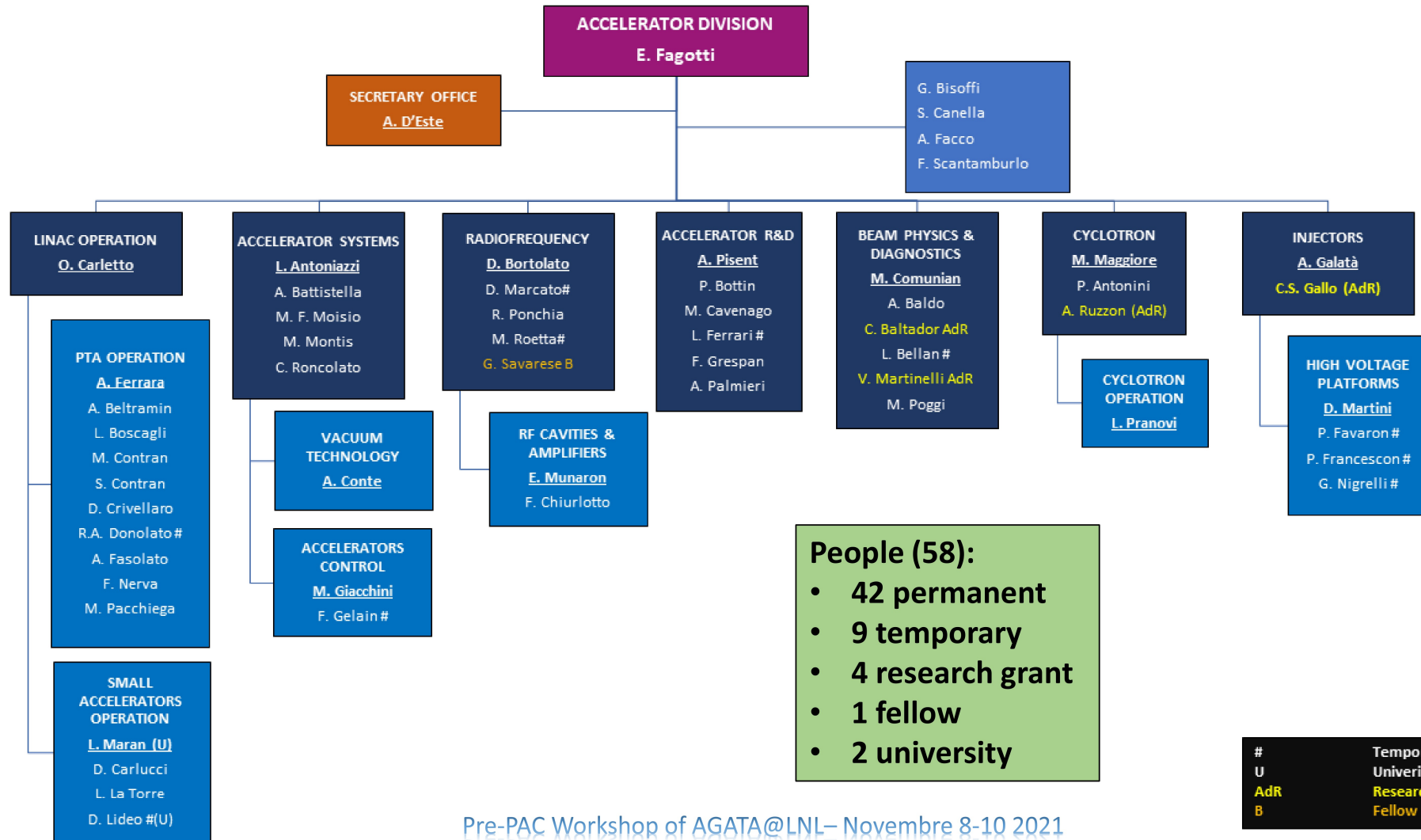
- Accelerator Division organization highlight
- PTA accelerators status and upgrades
 - Tandem injector
 - Tandem accelerator
 - ALPI Beam Optics and Diagnostics
 - ALPI Magnets Power Supplies
 - ALPI Cavities & Cryostats
 - ALPI LLRF and Control System
 - ALPI & AGATA Vacuum System
 - PIAVE Cryogenic System
 - PIAVE Ion Source
 - PIAVE SRFQ
- Pre-PAC: Useful information and preliminary technical evaluation

Accelerator Division organization highlight



- New organization approved in September 2021
- Interdisciplinary Physics Accelerator Service becomes a new Department, called Small Accelerator, together with PTA Operation Department into the new LINAC Operation Service
- Cryogenic Service move into Technical Division
- Radiofrequency and Controls Service becomes the new Radiofrequency Service with the new RF Cavities & Amplifiers Department
- The new Accelerator Systems Service merges the old Vacuum Service and the Control Department for Special Projects. They became the new Vacuum Technology and Accelerator Control Departments
- Source and Injector Service becomes Injector Service with the new High Voltage Platforms Department
- Beam Physics Service becomes Accelerator R&D Service
- Diagnostics Department becomes the new Beam Physics & Diagnostics Service

Accelerator Division new organization chart



PTA and AGATA line maintenance goals (03/2022)



• Tandem injector upgrade to improve reliability, availability and maintainability		----->	80%	
• Tandem availability increase		----->	80%	
• CR07 reliability upgrade and CR01-CR03 availability upgrade		----->	85%	
• CR14/CR15 valve box upgrade		----->	100%	
• Important improve in the reliability and availability of ALPI vacuum system		----->	55%	
• ALPI magnets power supplies maintenance		----->	100%	
• ALPI beam diagnostics maintenance		----->	100%	
• ECR maintenance and Tantalum production tests (needed for U production)		----->	60%	
• PIAVE Cryogenic plant control system upgrade		----->	90%	
• SRFQ special maintenance to reach high accelerating fields (needed for U acceleration)		----->	20%	
• CRB4 vacuum issue solution and upgrade		----->	30%	
• CR07/CR08 – CR09/CR10 valve box upgrade	(postponed: lack of funds)	----->	0%	No impact on AGATA
• Medium beta LLRF upgrade	(postponed: lack of manpower)	----->	0%	
• Diagnostic grids amplifier upgrade	(postponed: lack of manpower)	----->	0%	
• 20 deg beam line improval (AGATA beam line):				
• Vacuum system upgrade		----->	60%	
• Beam diagnostics upgrade		----->	30%	
• Alignment correction		----->	50%	

PTA goals (opt.1 - 03/2023 opt.2 - 09/2022)

- CR02 and CR06 availability upgrade
- CR20 maintenance and safety upgrade
- CR07/CR08, CR09/CR10, CR12/CR13 and CR16/CR17 valve box upgrade
- Diagnostic grids amplifiers upgrade (partial)
- Medium beta LLRF software upgrade (partial)
- Medium beta LLRF hardware upgrade (partial)
- Vacuum system infrastructure partial replacement
- RF amplifier partial replacement
- Beam diagnostics partial replacement
- ECR source safety system upgrade

Option 1: Tandem ALPI beams available since 04/2022 - PIAVE injector since 07/22. Available beam energies as reported on lab site in 2022.

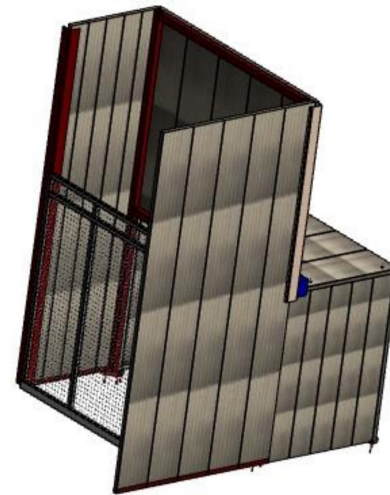
Option 2: Tandem beams available since 04/2022 – ALPI reacceleration and PIAVE injector not available till 09/2022. Available beam energies as reported on lab site in 2023 can be anticipated to October 2022.

Tandem injector

UPGRADE OF THE TANDEM INJECTOR ALMOST COMPLETED



New electrical and water distribution

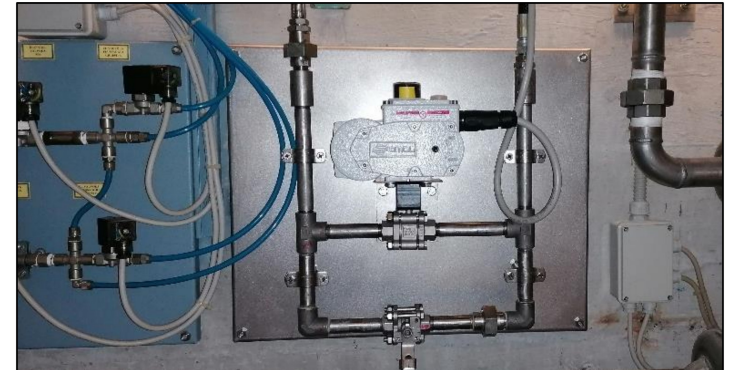


Extension of the Injector's vane and installation of the new transformer: inspection of the companies on week 44

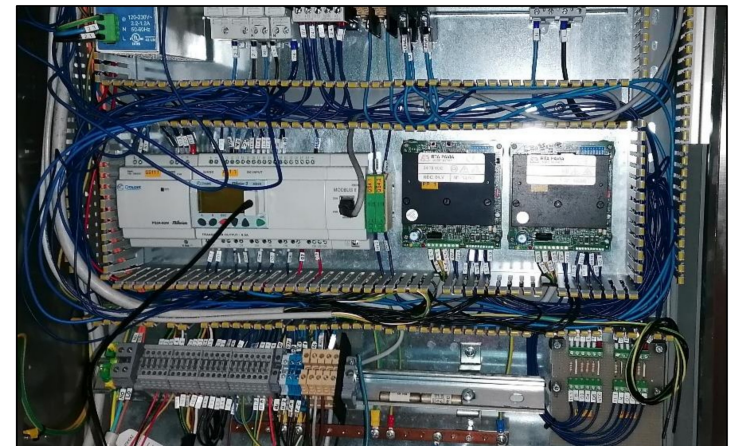
Tandem accelerator

- New laddertron **assembly complete**. Currently under vacuum waiting for installation
- Laddertron chain **pulling system maintenance complete**
- Tandem **vacuum systems** (HE & LE cryo, HE, LE, FC07 and Switching magnet turbo) **maintenance complete**
- SF6 plant maintenance & upgrade:
 - **Leak check** on the whole system with repair in case of losses **complete**
 - **Gas purity check complete**
 - **Automatic** system for source tank internal **pressure regulation almost complete**

Flux regulation valve for SF6 circuit on the source tank



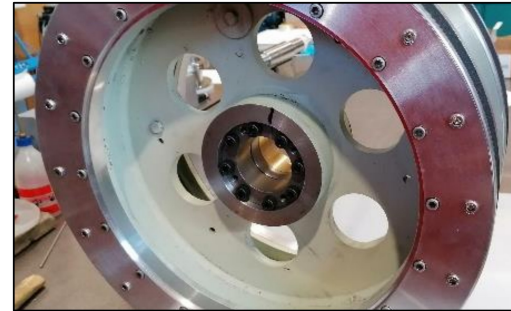
PLC and source tank system regulation



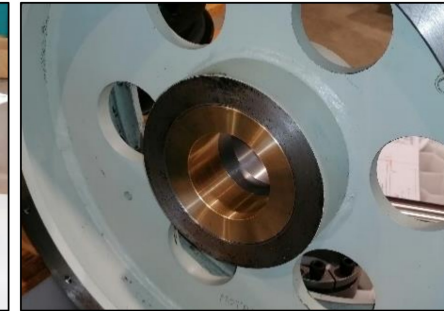
Tandem accelerator

- Base and terminal wheels design and assembly was identified as the major cause of all issues experienced last year and beginning of this year. Many actions were implemented to solve it:
 - A **new shaft** was machined and assembled with **new bearing** with the right tolerances
 - **New self-centering keyless locking** device was implemented on the driving wheels
 - **New aluminum rings** realized according to original drawings: gaps between conductive wheels and aluminum rings were removed
 - **Conductive inserts** for the base wheels replaced with new ones harder than the previous ones and more **similar to the original ones**
 - All dimensions were rectified after assembly
 - Finally wheels experienced **dynamic balancing**
- **Wheels** were **reassembled**
- Laddertron **drive system** is currently **under assembly**
- Final step will be laser tracker verification

New self centering keyless locking device



New plane bearing



New shaft and bearing assembly

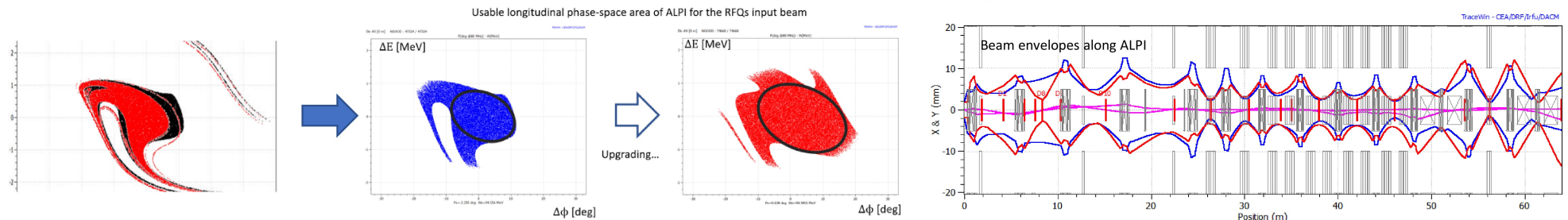


Installation inside tank



ALPI Beam Optics

- In 2019 two main issues were discovered: 1) a bad cavity field calibration for the whole ALPI linac and 2) a phase-field coupling in PIAVE SRFQ2 controller. Solution of these issues greatly improved agreement between simulations and real transport. Difference between experimental setup vs simulated cavities reduced from 7 cavities to 1
- A deep work on beam dynamics was started to increase as much as possible ALPI acceptance optimizing magnets currents and cavity phases. A new optimization process based on genetic algorithms is currently working to increase the robustness of the accelerator dynamics. Acceptance is just more than doubled



- Beam dynamic studies, combined with fast cavity tuning procedure and automatic steering algorithms should simplify beam transport into ALPI accelerator.

ALPI Beam Diagnostics

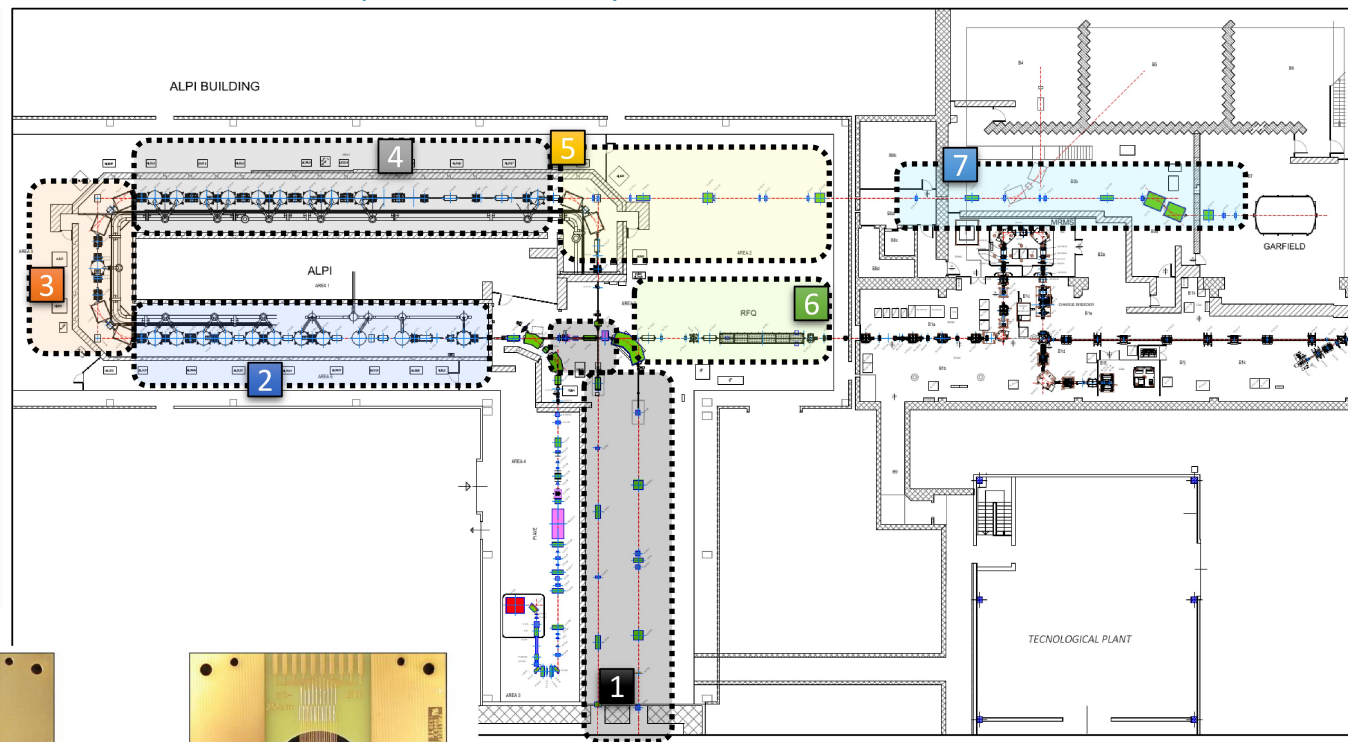
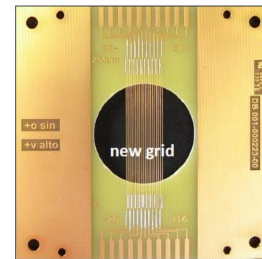
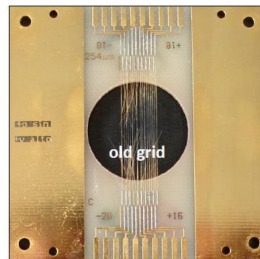
- In parallel **standard diagnostics** experience **deep maintenance** to replace old broken harps with new ones. 14 diagnostics boxes already improved.
- **New grids pre-amplifiers** developed in the SPES framework will start **to be implemented next year**.

- Control logic replacement:

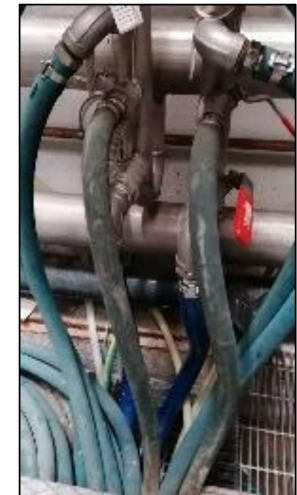
- Hardware
- Software

- New configuration and upgrade sequence:

- Rack4 (D05, D06, D07, D08, D09, D10, D11, D12)
- Rack5 (DE1, DE2, DT1, DT2)
- Rack2 (DI8, DI8B, DI9, D01, D02, D03, D04)
- Rack3 (AL.BI.08, DU2, DU3, AL.BI.11)
- Rack1 (DI3, DI4, DI5, DI6, DI7, DE3, DE4, DE5)
- Rack7 (DT3, DT4, DT5, DT6)
- Rack6 (AD.BI.10, AD.BI.11, AD.BI.12)



ALPI Magnet Power Supplies



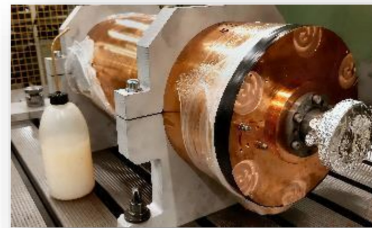
- All magnets power supplies on the Tandem-ALPI-PIAVE complex and on experimental halls completed maintenance.
- Cooling hoses for the PIAVE magnets and power supplies cooling system were replaced with new ones.

Cavities & Cryostats: CR07

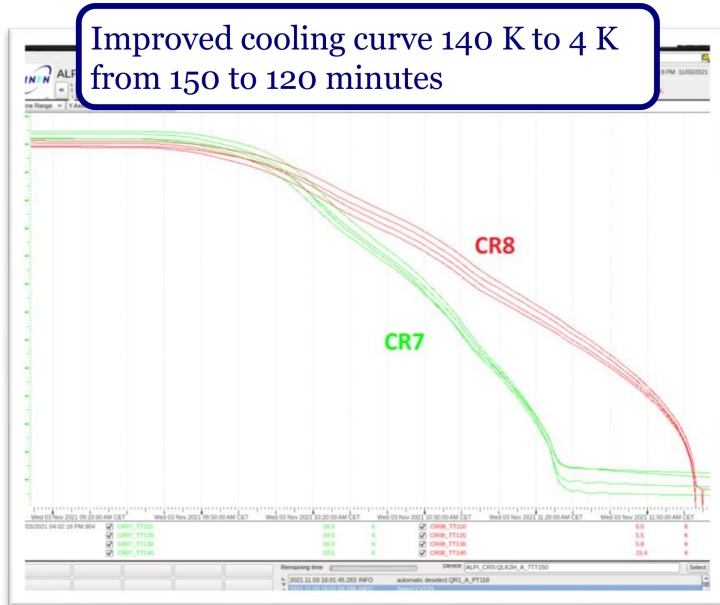
- During 2021 CR07 used as prototype for future developments to be implemented on other cryostats. Main improvements on:
 - **Alignment**
 - **Piping and safety**
 - **Thermal shielding**
 - **Closure plates and tuners connections**
 - **Thermal joints**
 - **New thermal sensors**



New cooling system



Alignment

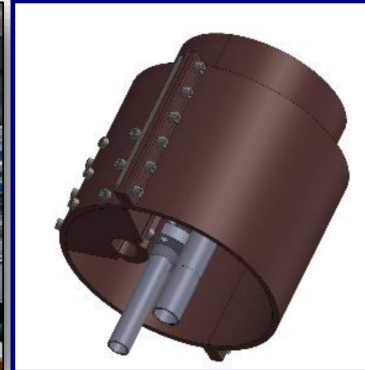


Cavities & Cryostats: CR07

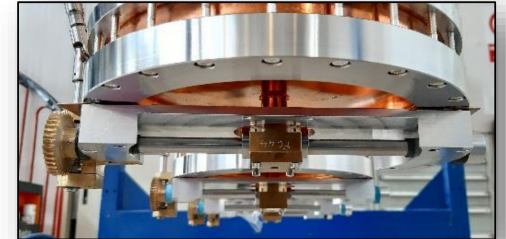
Piping and Safety



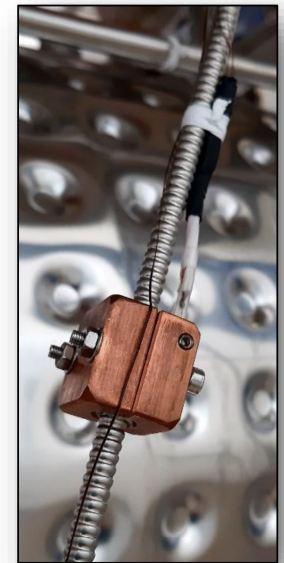
Thermal shielding



Closure plates and tuner connections



New thermal sensors



New thermal joints



Cavities & Cryostats: CR01

- During 2021 CR01 used as prototype for future developments to be implemented on other low beta cryostats. Main improvements on:

- Tuner revision
- Plate characterization
- New reference for alignment
- New shielding
- LN2 circuit replacement
- Safety

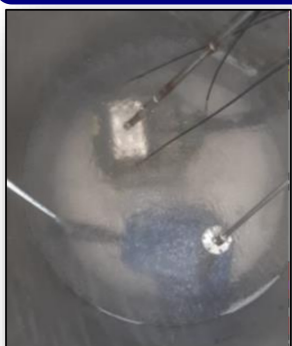
Tuner mechanical revision



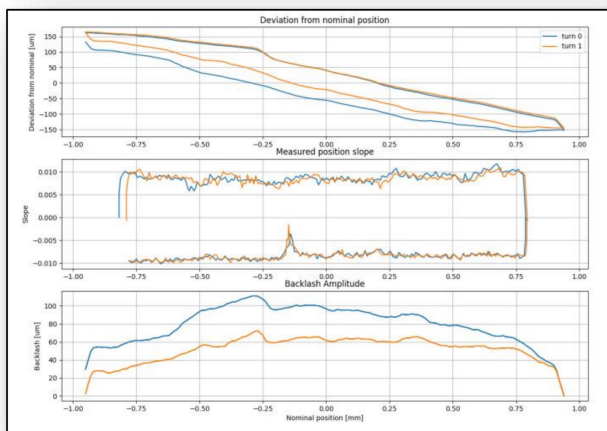
New reference for alignment



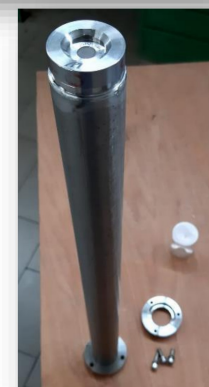
Mechanical test in LN₂



Tuner RF characterization



Cavity move check during vacuum pumping and cooldown



Cavities & Cryostats: CR03

- Currently under maintenance.
 - Tuner disassembled and tested in LN2
 - Closure plate issue on QWR3
 - Modifications implementations underway

Mechanical test in
LN₂



Nb plates in CR3 differ respect to
other low beta plates



ALPI Status (April 2021): low beta cryostats



CR01	Nominal field (MV/m)	Current field (MV/m)	CR02	Nominal field (MV/m)	Current field (MV/m)	CR03	Nominal field (MV/m)	Current field (MV/m)
QWR1	5	2.1	QWR1	5	2.1	QWR1	5	5.0
QWR2	5	2.1	QWR2	5	3.5	QWR2	5	4.98
QWR3	5	2.1	QWR3	5	3.5	QWR3	5	Tuner out
QWR4	5	2.1	QWR4	5	3.58	QWR4	5	Tuner out

CR04	Nominal field (MV/m)	Current field (MV/m)	CR05	Nominal field (MV/m)	Current field (MV/m)	CR06	Nominal field (MV/m)	Current field (MV/m)
QWR1	5	4,85	QWR1	5	4.5	QWR1	5	4.37
QWR2	5	5,06	QWR2	5	4.5	QWR2	5	Not usable
QWR3	5	4,84	QWR3	5	3	QWR3	5	4.99
QWR4	5	4,94	QWR4	5	4.99	QWR4	5	2.09

- 10 / 24 can guarantee near nominal performances
- 5 / 24 could be recovered with conditioning
- 9 / 24 need maintenance

ALPI Status (October 2021): low beta cryostats



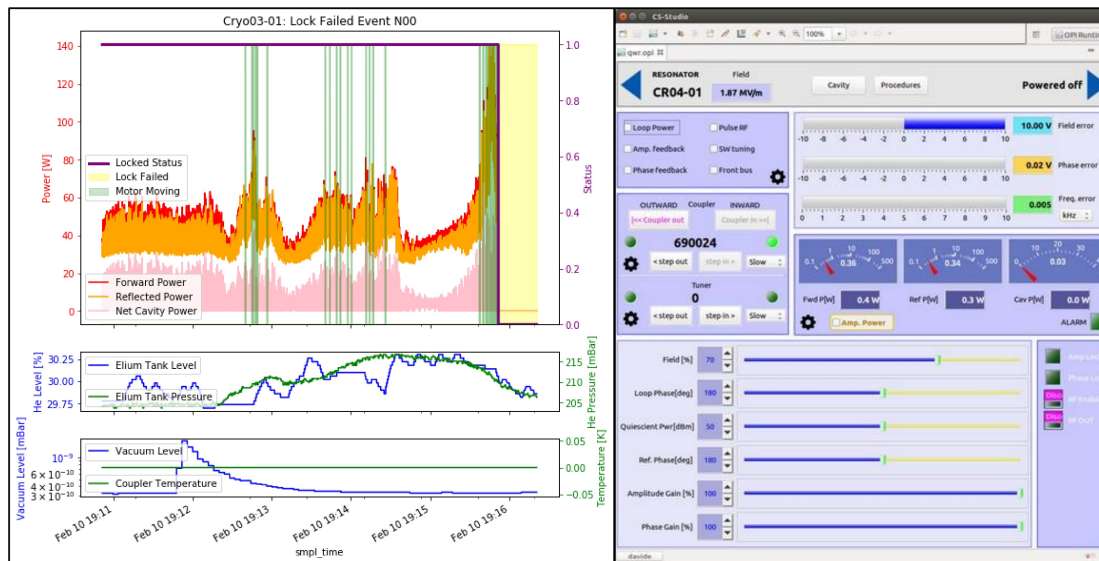
Maintenance complete. Under test			CR02	Nominal field (MV/m)	Current field (MV/m)	Under maintenance		
			QWR1	5	2.1			
			QWR2	5	3.5			
			QWR3	5	3.5			
			QWR4	5	3.58			

CR04	Nominal field (MV/m)	Current field (MV/m)	CR05	Nominal field (MV/m)	Current field (MV/m)	CR06	Nominal field (MV/m)	Current field (MV/m)
QWR1	5	4,85	QWR1	5	4.5	QWR1	5	4.37
QWR2	5	5,06	QWR2	5	4.5	QWR2	5	Not usable
QWR3	5	4,84	QWR3	5	3	QWR3	5	4.99
QWR4	5	4,94	QWR4	5	4.99	QWR4	5	2.09

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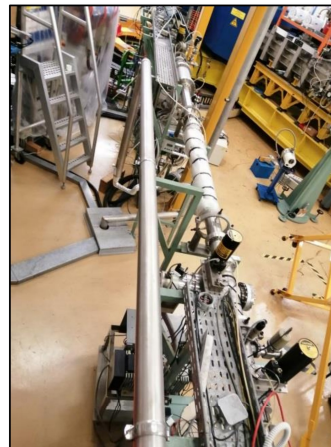
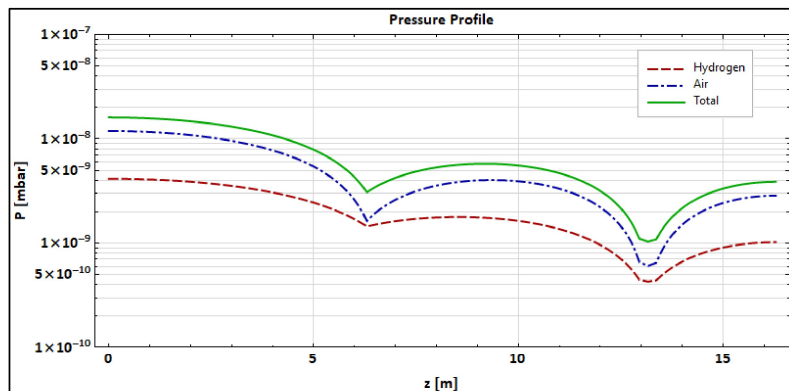
ALPI LLRF and Control System

- SW Control system:
 - Already updated to the new version for low beta cryostats CR01-CR06 & HEB0
 - Update for the medium beta cryostats CR07-CR10 expected April 2022
- Ordinary device maintenance expected within March 2022:
 - Broken Fans, filter cleaning, power supply substitution (from RF Amplifier and LLRF controllers) scheduled from next december
 - HEB1 RF power line to be mounted starting from February 2022



ALPI and AGATA vacuum system

- Current vacuum system maintenance is already completed.
- Unfortunately, ALPI vacuum system is very old. Both vacuum pumps and controllers are no more available on the market and **vacuum control system is developed and managed by a unique company that at the end of this year will definitively close**. We received from INFN on October 20th an extra budget to solve the problem. All the budget was already used to acquire new components. The vacuum system **recovery plan will solve the issue before AGATA campaign** (April 2022).
- In parallel **upgrade of the AGATA vacuum line is ongoing**. General layout are already available and after measurement of the line with laser tracker concluded last week, we can define the final configuration, acquire what is needed, install new system and test it before the end of March 2022.



PIAVE cryogenic: control system upgrade



SRFQ electric board



New PIAVE board

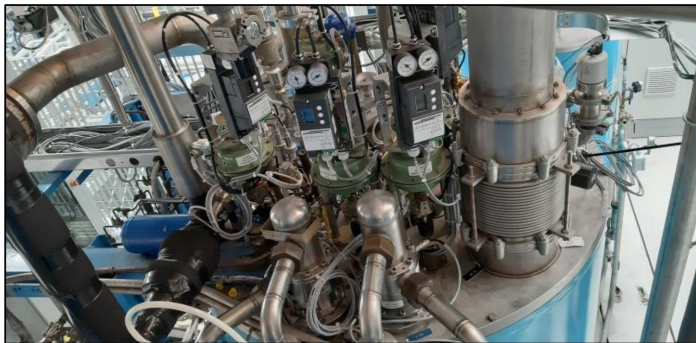
Currently under test



Cold Box Purifier



Gas control panel

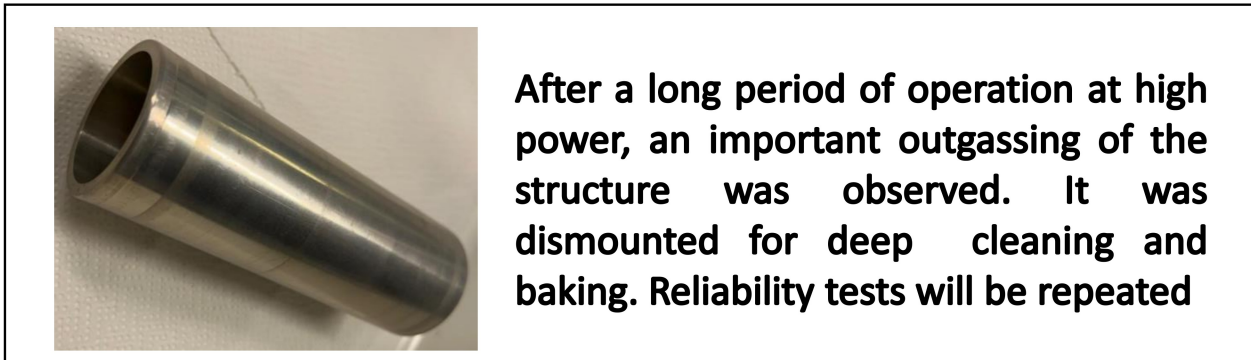
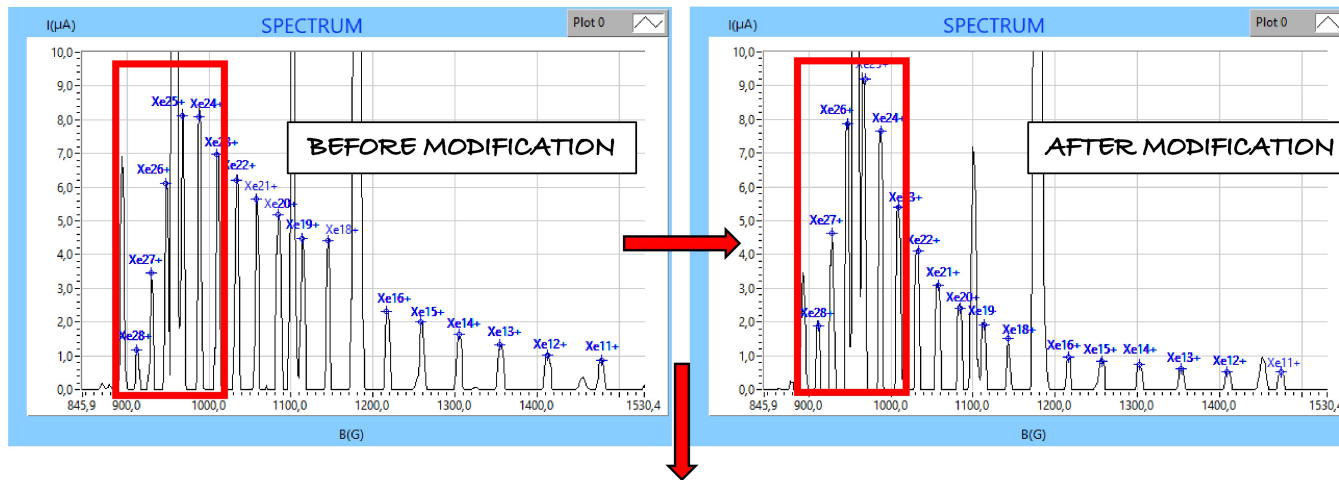


Cold Box

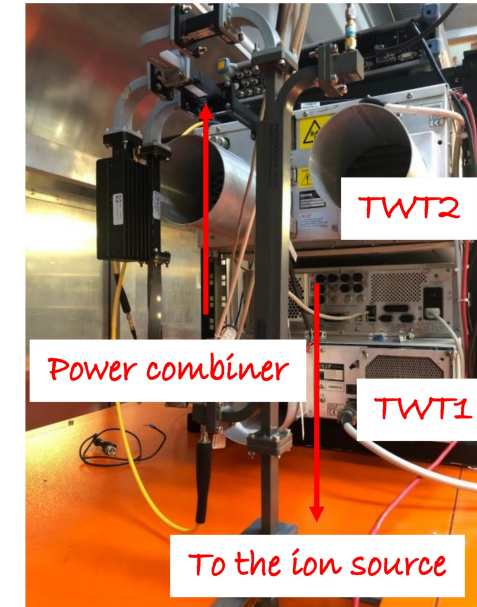
PIAVE ion source

PLASMA CHAMBER MODIFICATION

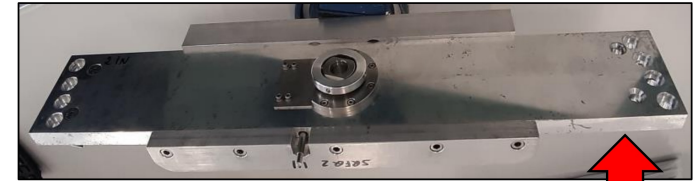
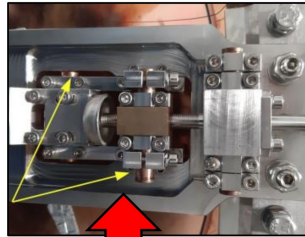
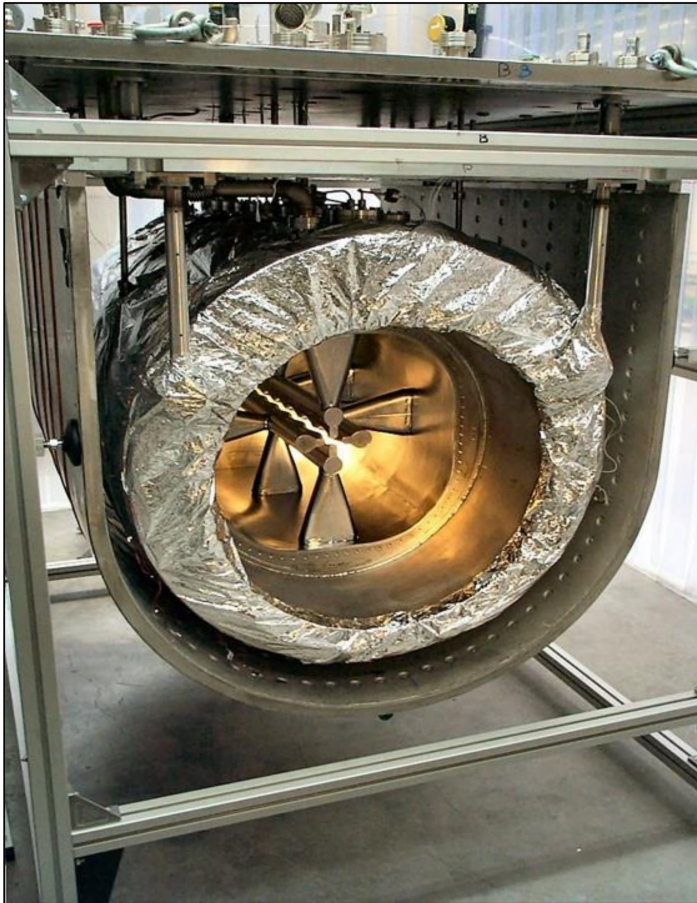
- Reduction of radius to excite $TM_{0,m,0}$ modes
- Improved performances with ^{136}Xe



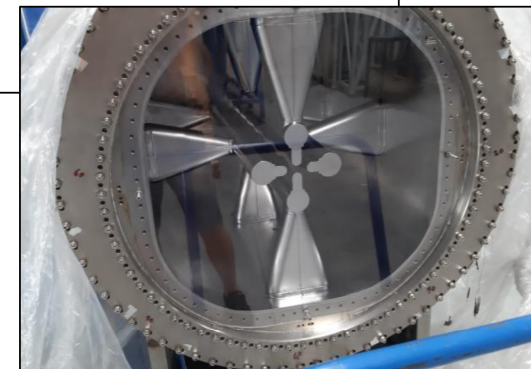
FREQUENCY HEATING TESTS ONGOING



Ta sputtering target available within November.
Test in December (preparatory for U production)



- Issue detected on the PIAVE SRFQ slow tuner current design.
- A previous version of tuner under revision to solve the problem.
- In view of high fields needed for Uranium acceleration, conventional cleaning process will change:
 - Cleaning with acetone
 - Cleaning with ultra-pure water in ISO 10 area
 - Dry process in ISO7 cleanroom for 12 hours (at least)
 - Dry process completed with nitrogen flux in ISO7
 - Cavity closed with final terminal plate in ISO7



Pre-PAC: useful information

- Useful links and contacts:
 - https://www.inl.infn.it/wp-content/uploads/Fasci_TAP.pdf Summary of the available beams and energies of TAP complex. It may not include all possible beams, but it is a good summary. It is under continuous update, feedback after feedback.
 - In case requested beam is not present in the previous link, or higher current and/or energy is required, user is strongly encouraged to contact acceleration division through: PACbeams@Inl.infn.it.
- [PACbeams mailing list](#) is a mailing list that automatically contact all accelerator division expertise (Linac operation, Injector, Beam Physics & Diagnostics Services). If a complete evaluation of the proposal feasibility is required, email must include:
 - **Beam species**
 - **Energy [MeV]**
 - **Current [pA]**
- Other [specific questions](#) that does not include a complete evaluation of the feasibility [are also welcomed](#).
- After PAC outcomes, there will be a [deeper evaluation of the accepted LOI's](#).
 - These evaluations will involve also other services of the acceleration division such as [Systems for the Accelerators Service](#) and [Radio-Frequency Service](#).
 - Essential information's of the post-maintenance machine status will determine the final analysis on the feasibility, especially with respect to energy parameter.