Update from Accelerator Division

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Summary

- Maintenance and shifts schedule 2022-2023
- Tandem-CN-AN2000
- PIAVE-ALPI
- Conclusions

Accelerator schedule 2022-2023

Nome attività	Inizio	Fine
TANDEM operation	01/04/2022	14/04/2022
Spring maintenance	15/04/2022	22/04/2022
TANDEM operation	25/04/2022	28/07/2022
PIAVE-ALPI-SPES extraordinary maintenance	10/01/2022	30/09/2022
TANDEM-PIAVE-ALPI operation	03/10/2022	21/12/2022
Winter maintenance	22/12/2022	30/01/2023
TANDEM-PIAVE-ALPI operation	31/01/2023	30/03/2023
Spring maintenace	31/03/2023	28/04/2023
TANDEM-PIAVE-ALPI operation	01/05/2023	27/07/2023
Summer maintenance	28/07/2023	02/11/2023
TANDEM operation	03/11/2023	11/01/2024
CN maintenance	10/01/2022	14/01/2022
CN conditioning	17/01/2022	21/01/2022
CN Winter-Spring operation	24/01/2022	08/04/2022
CN spring maintenance and conditioning	11/04/2022	22/04/2022
CN Spring-Summer operation	25/04/2022	22/07/2022
CN summer maintenance and conditioning	25/07/2022	16/09/2022
CN Autumn operation	19/09/2022	16/12/2022
AN2000 Winter maintenance (ord., str. and cond.)	10/01/2022	27/01/2022
AN2000 Winter-Spring operation	28/01/2022	08/04/2022
AN2000 spring maintenance and conditioning	11/04/2022	15/04/2022
AN2000 Spring-Summer operation	18/04/2022	24/06/2022
AN2000 1st summer maintenance and conditioning	27/06/2022	01/07/2022
AN2000 Summer operation	04/07/2022	05/08/2022
AN2000 2nd summer maintenance and conditioning	29/08/2022	02/09/2022
AN2000 Summer-Autumn operation	05/09/2022	28/10/2022
AN2000 autumn maintenance and conditioning	31/10/2022	04/11/2022
AN2000 Autumn operation	07/11/2022	16/12/2022

2023 small accelerator schedule to be defined

PTA maintenance goals (03/2022)

• Tandem injector upgrade to improve reliability, availability and maintenability		---------->	95%
• **Tandem availability increase**		---------->	**100%**
• **CR07 reliability upgrade and CR01-CR03 availability upgrade**		---------->	**100%**
• **CR14/CR15 valve box upgrade**		---------->	**100%**
• Important improve in the reliability and availability of ALPI vacuum system		---------->	85%
• **ALPI magnets power supplies maintenance**		---------->	**100%**
• **ALPI beam diagnostics maintenance**		---------->	**100%**
• ECR maintenance and Tantalum production tests (needed for U production)		---------->	85%
• PIAVE Cryogenic plant control system upgrade		---------->	90%
• SRFQ special maintenance to reach high accelerating fields (needed for U acceleration)		---------->	45%
• **CRB4 vacuum issue solution and upgrade**	**(acceptable risk – solution postponed)**		
• CR07/CR08 – CR09/CR10 valve box upgrade	(postponed: lack of funds)	---------->	0%
• Medium beta LLRF upgrade	(postponed: lack of manpower)	---------->	0%
• Diagnostic grids amplifier upgrade	(postponed: lack of manpower)	---------->	0%

No impact on AGATA

- 20 deg beam line improval (AGATA beam line):
  - Vacuum system upgrade ----------> 95%
  - Beam diagnostics upgrade (ALPI beam diagnostics moved to AGATA line due to external company delays) ----------> 75%
  - **Alignement correction** ----------> **100%**

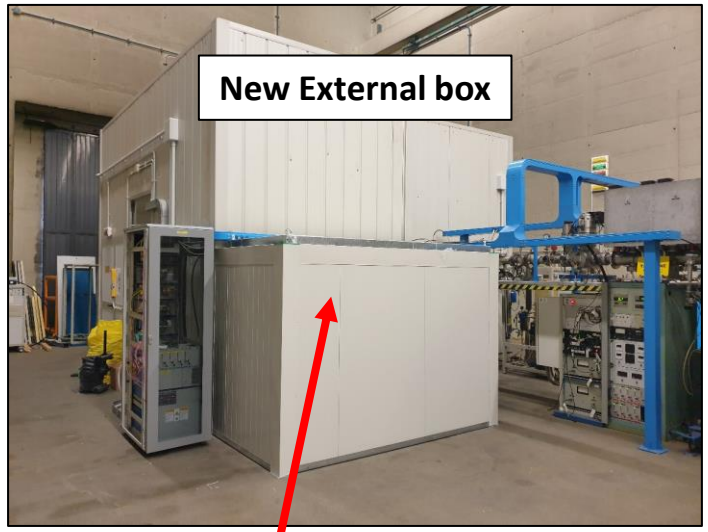
Tandem: injector upgrade

- New power system with insulating transformer
- Safety cage with safe-lock* system to prevent electric shock
- Transformer-platform connection thorugh insulated duct

New electric board

*Lock key

New safety cage



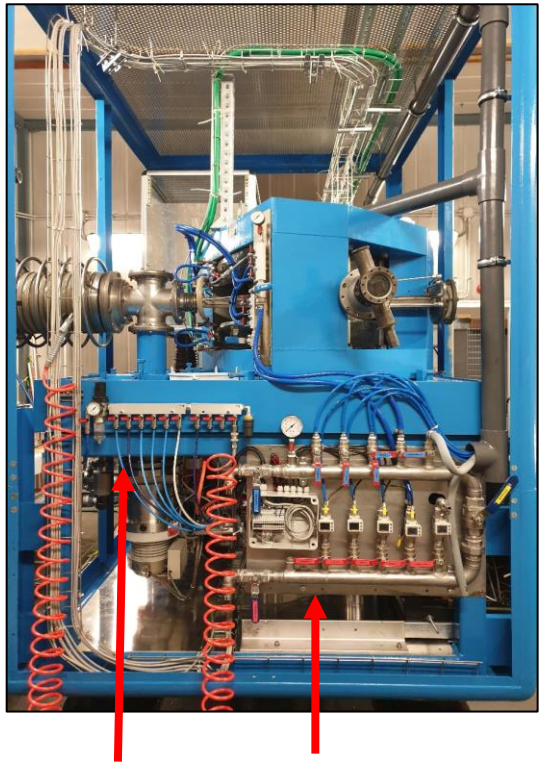
New External box

New transformer with safety switch

Tandem: injector upgrade

- New HV platform electrical distribution
- New control system

New injector rack



New water and compressed air distribution

To do list:

- Platform high voltage test (insulated transformer already tested during FAT up to 150 kV) – this week
- GUI to be tested – next week
- **Injector switch-on – 28/03/2022**

April operation:

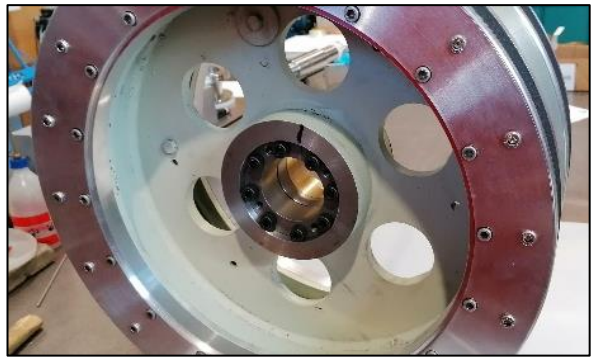
- Two days of lab general power switch off: April 8th and 22nd.
- After full power shut down, Tandem injector need source replacement.
- After source replacement at least two days are needed to stabilize source temperature followed by time needed for beam extraction and for beam acceleration.

Beam available in the first and last week of April

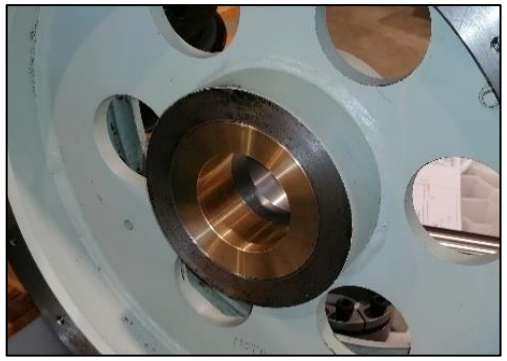
Tandem accelerator

- Base and terminal wheels design and assembly was identified as the major cause of all issues experienced during 2020-2021. 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 assembled and tested with laser tracker

New self centering keyless locking device



New plane bearing



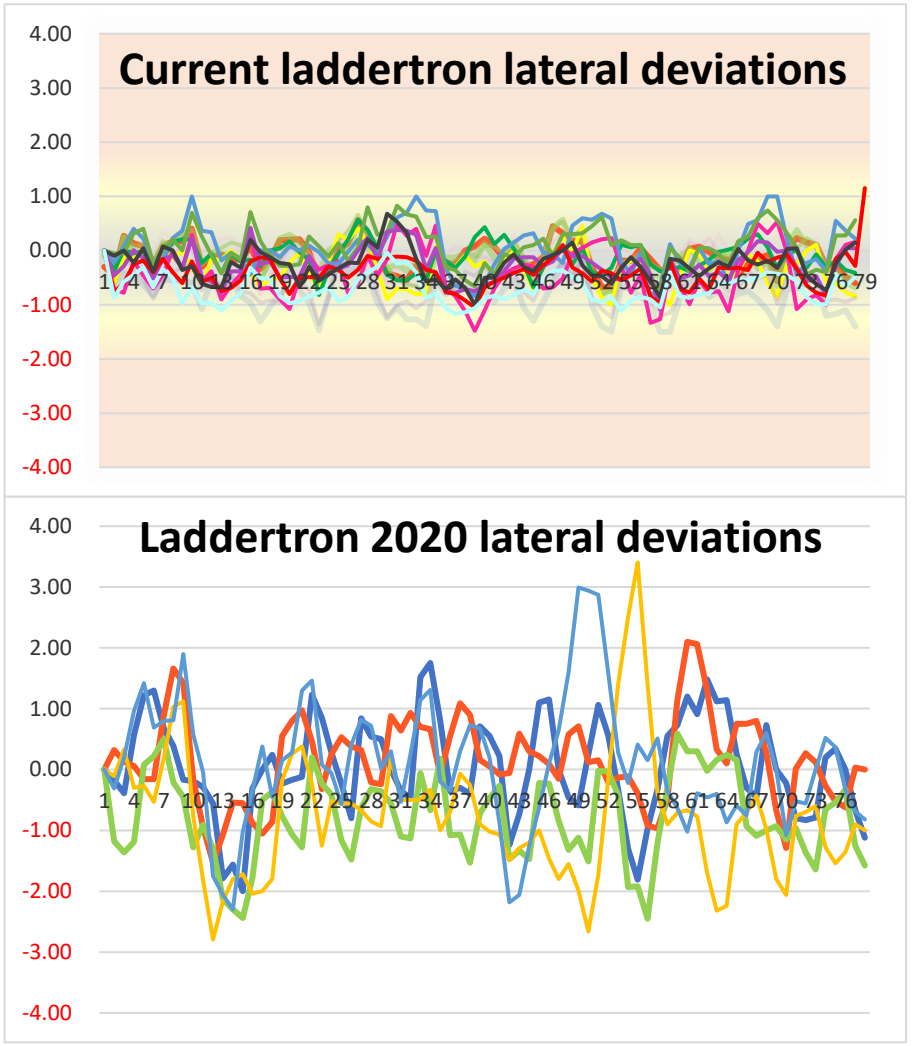
New shaft and bearing assembly

Installation inside tank

Tandem: running in and conditioning

- Laddertron was firstly runned for 253 hours with dimensional checks two times per day. A strong reduction in lateral deviation respect to previous laddertron was measured: **±0.5 mm vs ±3.0 mm**
- Chain elongation converged towards a tension loss of about **100 gr/hr** vs a **500 gr/hr** previous value
- Bars inclination stabilized at **1.8 mm**. Previous value was **above 4.0 mm**.

- After last tests:
  - Pumping down
  - Fill with SF6
  - Conditioning start
- Voltage level reached today: **12.65 MV**

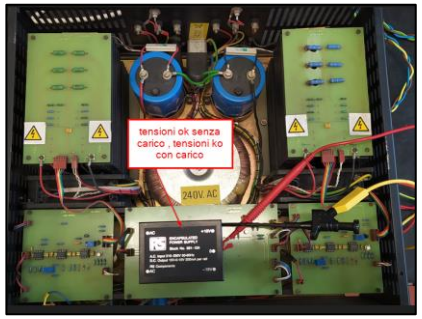


AN2000

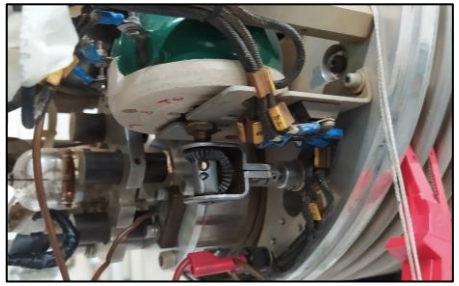
- **Regular shifts** up to mid December
- **Microbeam raster system malfunction** experienced at the end of the autumn shifts was **solved** during winter maintenance
- Special maintenance on the main electric switchboard to mitigate black-out phenomena experience during summer.
- During January start-up, spark issue detected on accelerator focus lens. Tank was opened and issue was fixed in three working days (some resistors and F1 variac were replaced).
- Microbeam **ruster system** working test **completed succesfully**
- **Regular shifs** since January 27th

- Since last November, only one operator can operate machine.

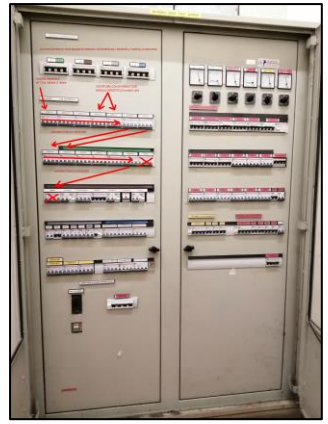
Raster transformer replaced



F1 variac replaced



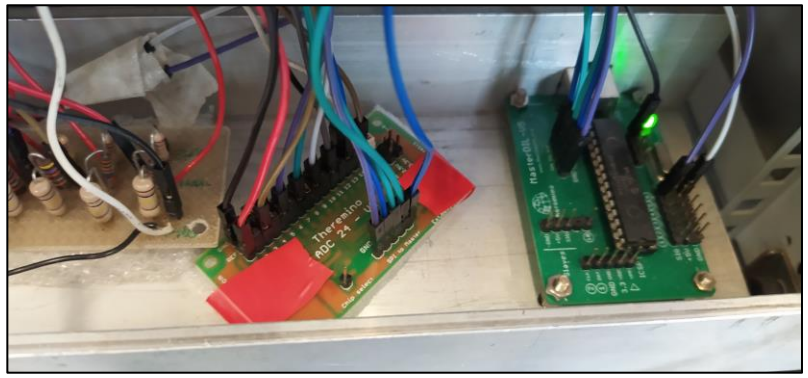
Main AN electric swithboard



CN

- **Regular shifts** up to end of last year
- On January ordinary maintenance with three special interventions:
  - **Source** replacement
  - Accelerator voltage **data-logging** replacement
  - Deep verifications on the step motors zeroing procedure
- New electronic control board for chopper input signal successfully tested.
- **Regular shifs** since January 27th.
- Two weeks ago a special test on 0 deg beamline to check deuteron beam current limit for long runs. **500 nA deuteron beam at 2.7 MeV** can run continuously for more than **20 days on 0 deg beamline**.
- This week first tests to increase maximum proton current.
- External chiller special maintenance next Wednesday

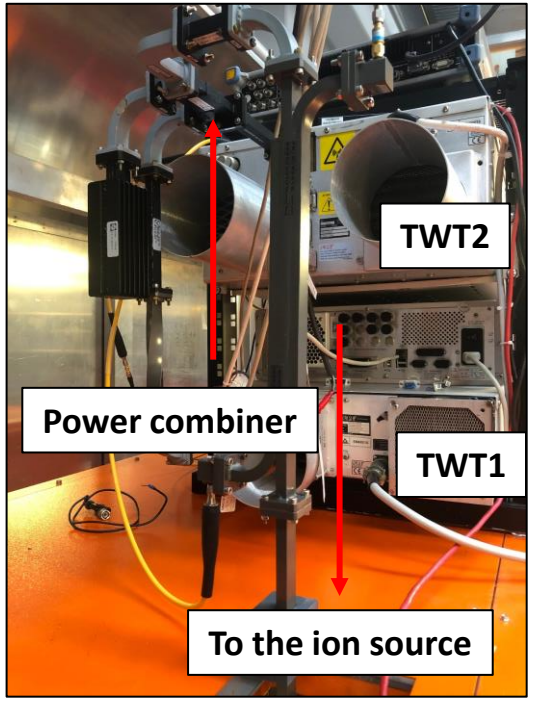
Data-logging circuit



HV terminal gas bottles refill

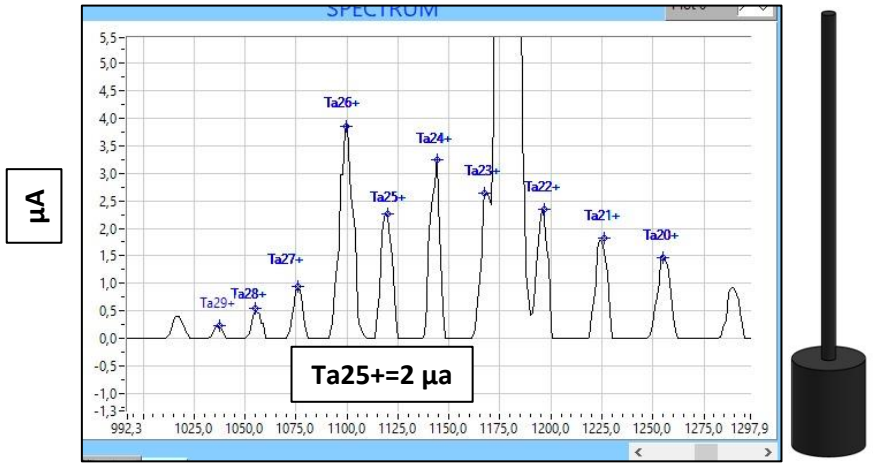
PIAVE: R&D on ECR source

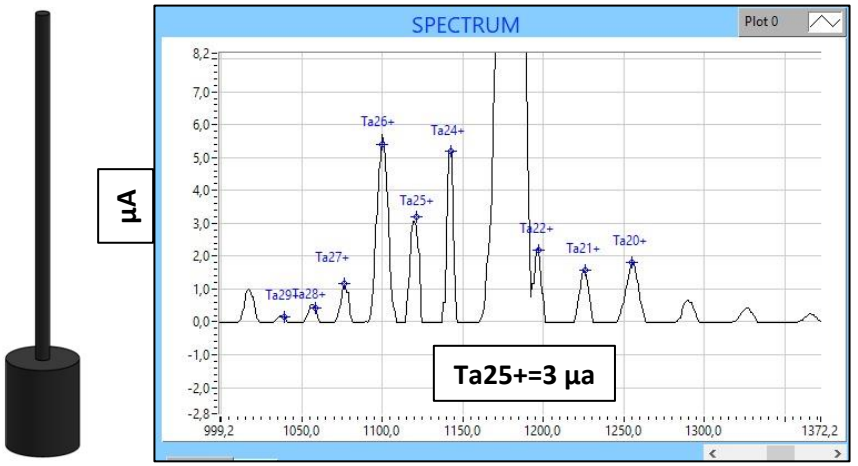
Double frequency test



Toward Uranium production: Sputtering test with Tantalum

The best spectra obtained up to now (preliminary)





GOAL: at least 4 µA Ta25+

- **Working technique and reproducibility to be improved**
- **New target geometry to be tested**

Paper work to obtain Uranium authorization is underway

PIAVE: SRFQ maintenance

- SRFQ1 and SRFQ2 exposed to air since beginning of 2020. High pressure cleaning is mandatory.
- Agreement with Zanon company for a complete cleaning process in ISO-5 cleanroom.
- SRFQ is under packaging this morning and it will be shipped to Zanon this afternoon.
- Cleaning procedure will be completed mid April.
- After cleaning ordinary maintenance at INFN-LNL.
- In parallel, work on the old slow tuner model upgraded to replace current tuners.
- Cryostat installation and tuner assembly into ex Auriga building (surface pollution minimization)

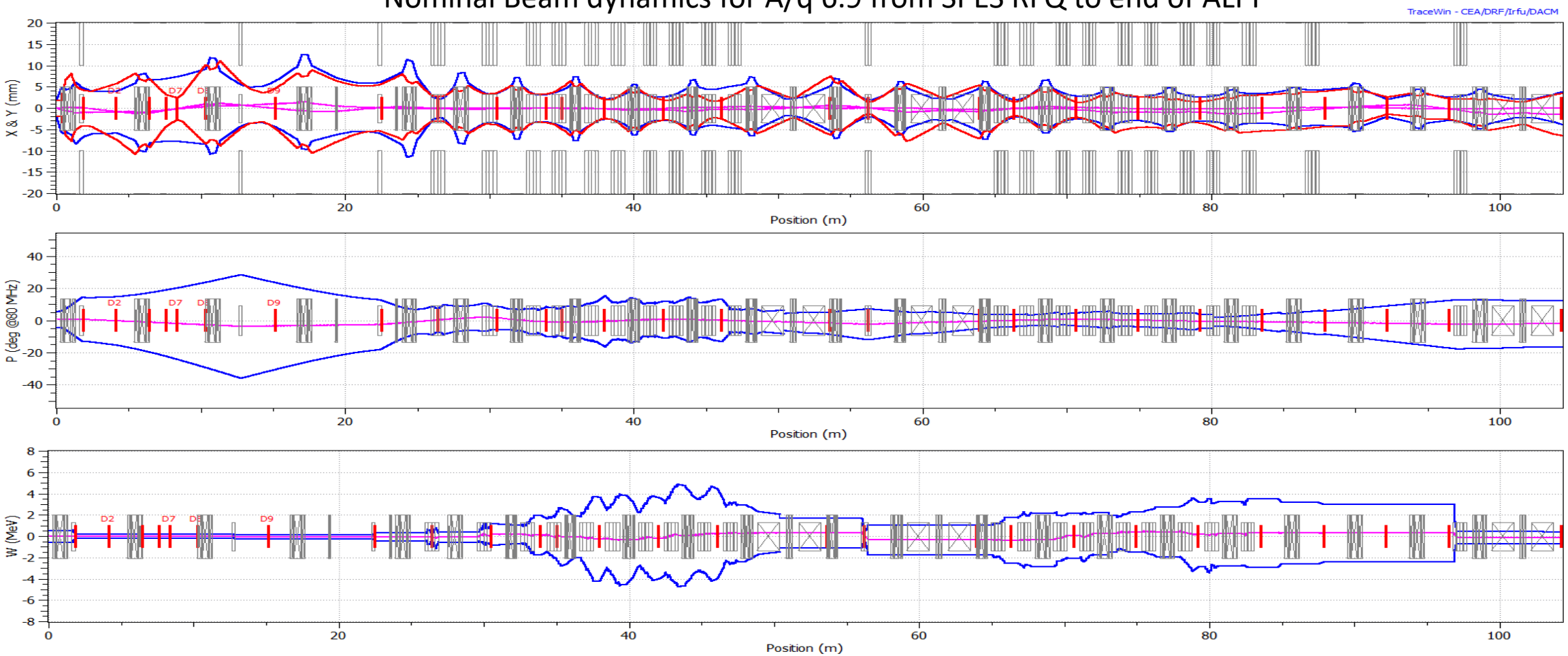
SRFQ ready for packaging

New spare parts warehouse for RF components and controls (amplifiers, LLRF, etc.)

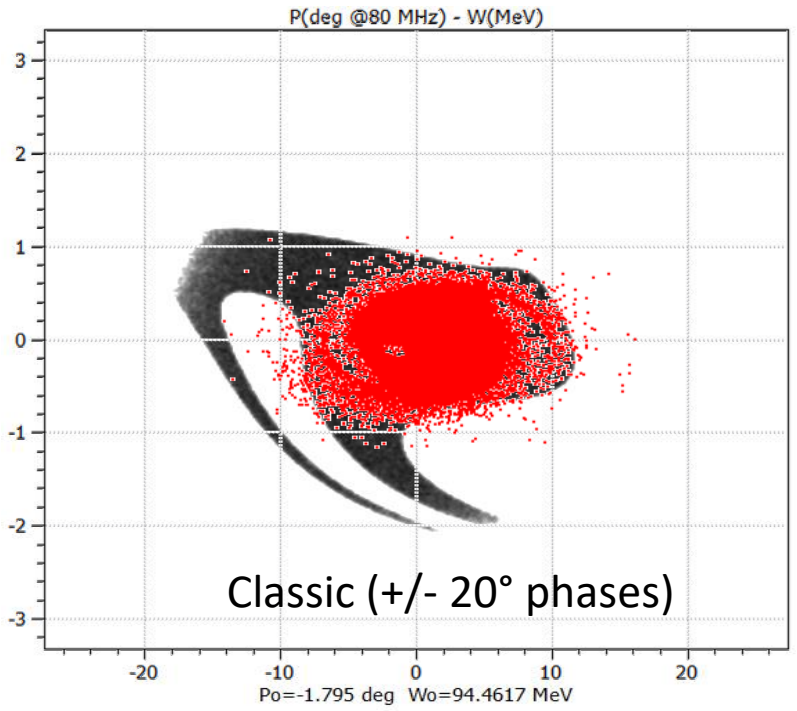
ALPI: longitudinal acceptance optimization

The Beam quality of the line from SPES RFQ through ALPI to exp. Halls needs to be improved (i.e. increase the transmission)

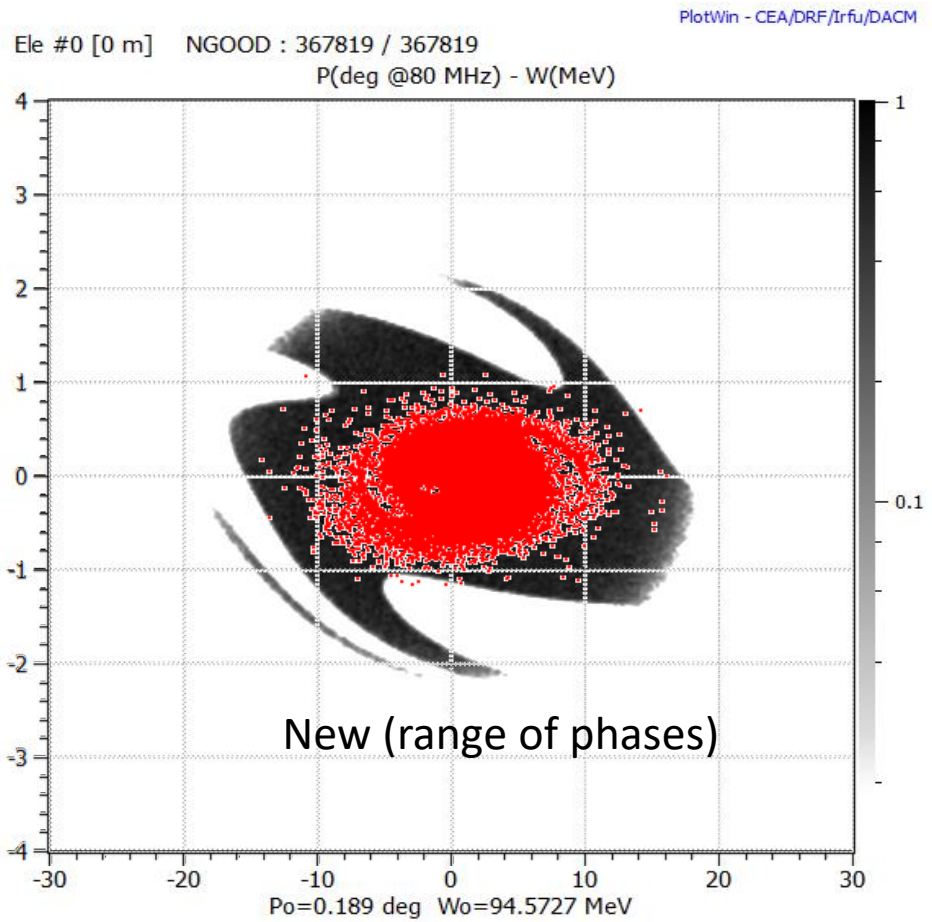
Nominal Beam dynamics for A/q 6.9 from SPES RFQ to end of ALPI



ALPI: Accommodation of SPES beam inside longitudinal acceptance



Classic (+/- 20° phases)



New (range of phases)

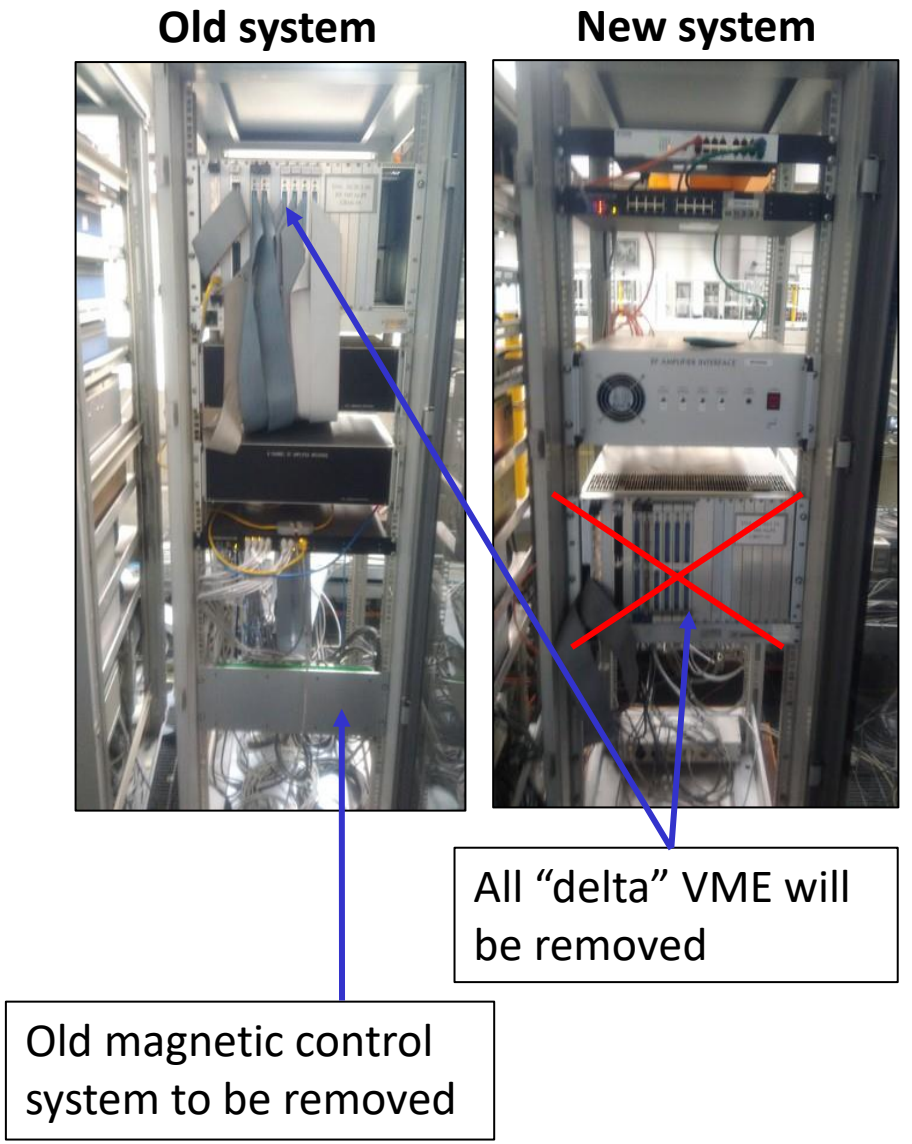
The new solution increases the longitudinal capture in the whole linac and the longitudinal acceptance is increased by a factor 2, as required by the last SPES TAC.

ALPI: Status on Beam Dynamics improvements

- At the state of the art the new set improved:
  - Large increase of longitudinal acceptance (200%) with a small improve of transverse acceptance (about 11%) w.r. classic solution
  - Half the losses
  - Strong robustness with respect to the A/q difference (pilot beam operation in SPES commissioning framework, from 1/800 to 1/300)
- Drawbacks:
  - 4.4% energy loss **at the end** of the acceleration chain
  - Higher longitudinal emittance -> **13% increase** in longitudinal emittance
- Next steps:
  - Error study -> Test of the overall robustness of the new configuration
  - Commissioning test with PIAVE
  - Introduce the new configuration as routine operation

ALPI: RF control system improvement

- Ordinary LLRF controller maintenance
- Maintenance and test of six 160 MHz amplifiers. Waiting for four 80 MHz amplifiers maintenance completion
- Upgraded RF control system for ALPI medium-ß (CR7-CR10) fully assembled
- Upgrade doesn’t include digital LLRF controllers. One of them will be installed before ALPI restart.
- RF control system upgrade for the whole linac before ALPI restart is under evaluation: it will completely replace the old system.

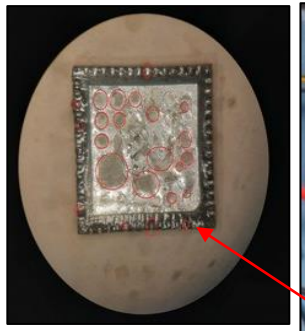


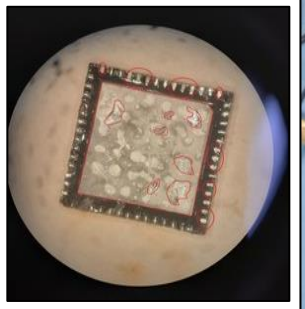
ALPI: LLRF production

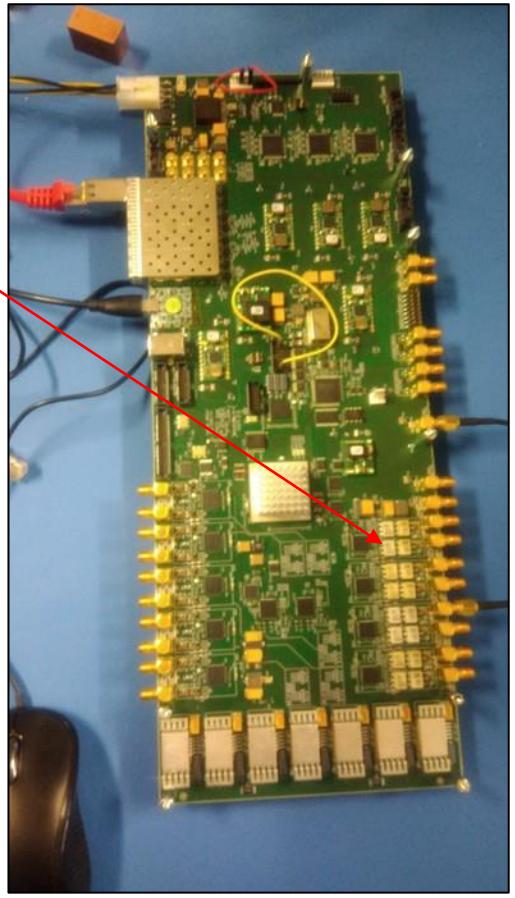
Delays to electronic market general crisis

- Following prototypes validated and series production started end of september 2021:
  - LLRF front/back-end analogic board (25 pc)
  - RF power monitoring board (25 pc)
  - LLRF front panel board (25 pc)
  - Grid preamplifier board for Beam Instrumentation (80pc)
- New LLRF controller prototype board finally validated after production process revision.
- Firmware update ongoing

Digital controller prototype already tested





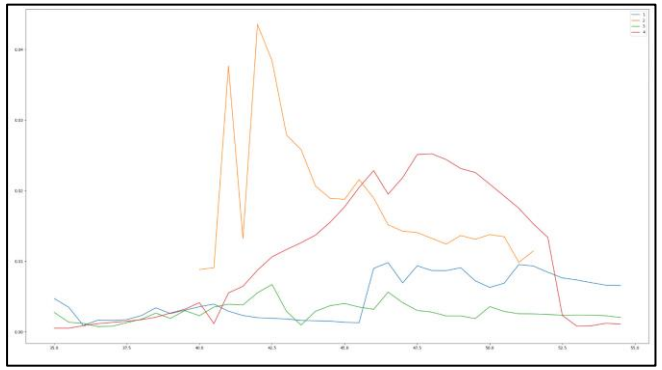


Issue discovered during brazing process

ALPI: cryostats tuners maintenance

Low beta cryostats is onging

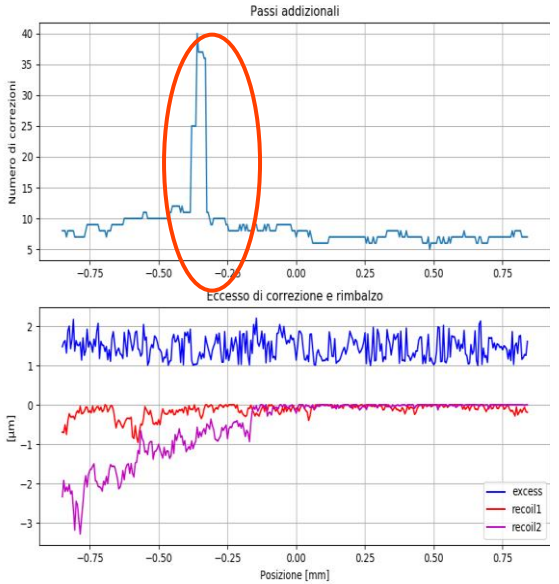
- CR1 maintenance complete. Successfully tested
- CR3 maintenance completed. Installed on line. To be tested.
- CR7 additional maintenance complete. Installed on line. To be tested.
- CR6 under maintenance (check to acoustic vibration response)



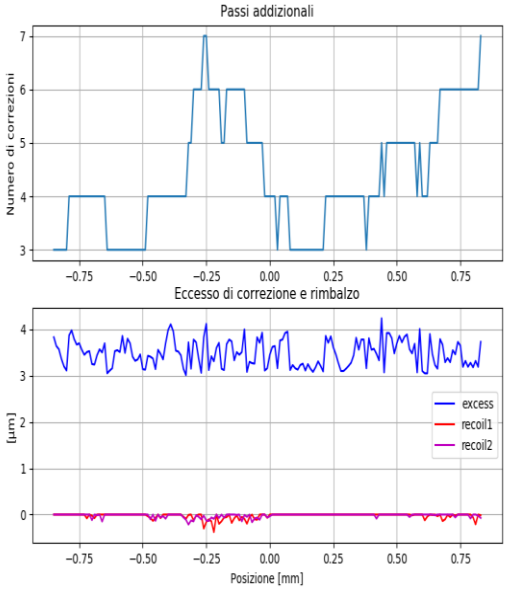
Next steps

- CR2 maintenance feasibility under evaluation

Backlash unrepeatability before maintenance



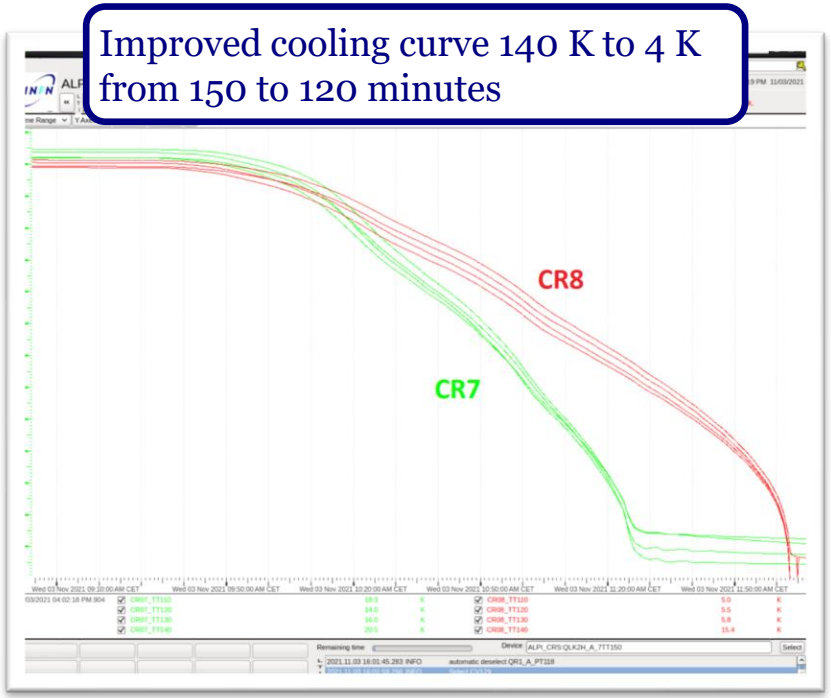
Issue solved after maintenance



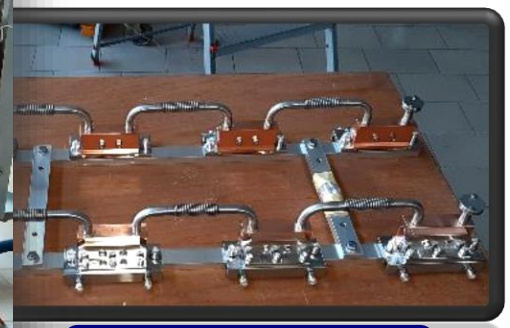
Very preliminary results

Cavities & Cryostats: CR07

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



Improved cooling curve 140 K to 4 K from 150 to 120 minutes



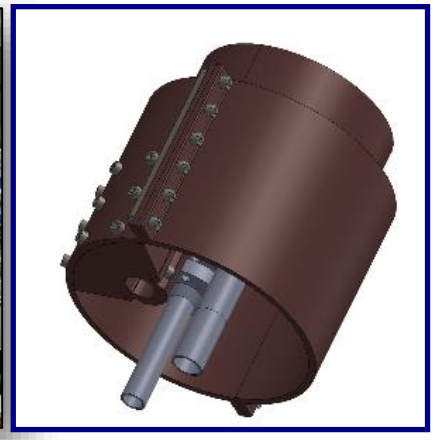
New cooling system

Alignement

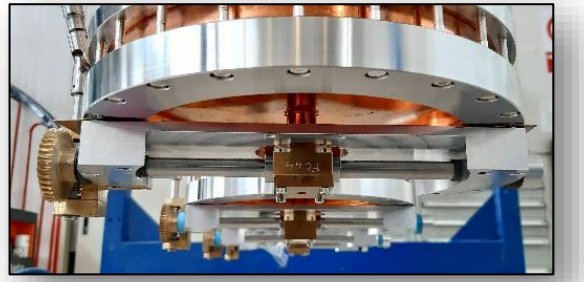
Cavities & Cryostats: CR07

Piping and Safety

Thermal shielding



Closure plates and tuner connections



New thermal sensors

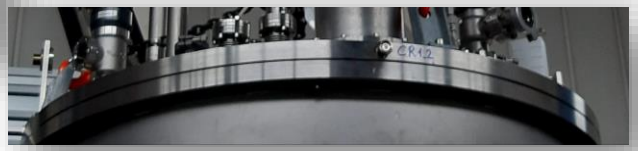
New thermal joints

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 alignement**
  - **New shielding**
  - **LN2 circuit replacement**
  - **Safety**

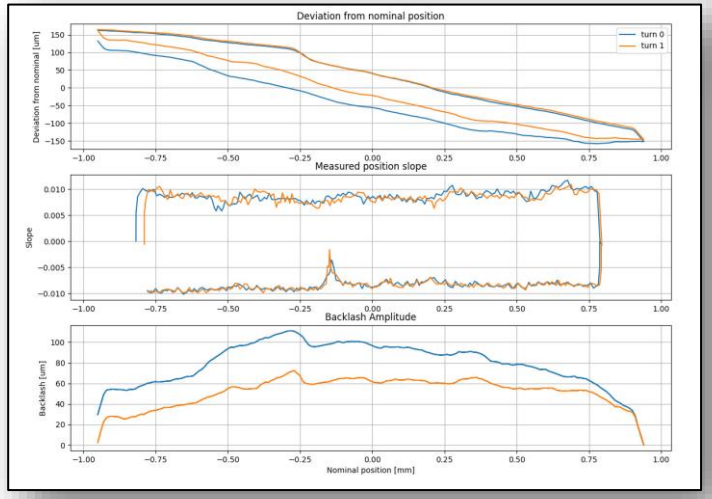
Tuner mechanical revision

New reference for alignement



Mechanical test in LN2

Tuner RF characterization



Cavity move check during vacuum pumping and cooldown

ALPI Status (April 2021): low beta cryostats

CR01	Nominal field (MV/m)	Current field (MV/m)
QWR1	5	2.1
QWR2	5	2.1
QWR3	5	2.1
QWR4	5	2.1

CR02	Nominal field (MV/m)	Current field (MV/m)
QWR1	5	2.1
QWR2	5	3.5
QWR3	5	3.5
QWR4	5	3.58

CR03	Nominal field (MV/m)	Current field (MV/m)
QWR1	5	5.0
QWR2	5	4.98
QWR3	5	Tuner out
QWR4	5	Tuner out

CR04	Nominal field (MV/m)	Current field (MV/m)
QWR1	5	4,85
QWR2	5	5,06
QWR3	5	4,84
QWR4	5	4,94

CR05	Nominal field (MV/m)	Current field (MV/m)
QWR1	5	4.5
QWR2	5	4.5
QWR3	5	3
QWR4	5	4.99

CR06	Nominal field (MV/m)	Current field (MV/m)
QWR1	5	4.37
QWR2	5	Not usable
QWR3	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 (January 2022): low beta cryostats

Maintenance complete.
Performance recovered.

Maintenance feasibility
under evaluation.

Maintenance complete.
Installation complete. To be checked.

CR04	Nominal field (MV/m)	Current field (MV/m)
QWR1	5	4,85
QWR2	5	5,06
QWR3	5	4,84
QWR4	5	4,94

CR05	Nominal field (MV/m)	Current field (MV/m)
QWR1	5	4.5
QWR2	5	4.5
QWR3	5	3
QWR4	5	4.99

Under maintenance.

ALPI: control systems installation and upgrades

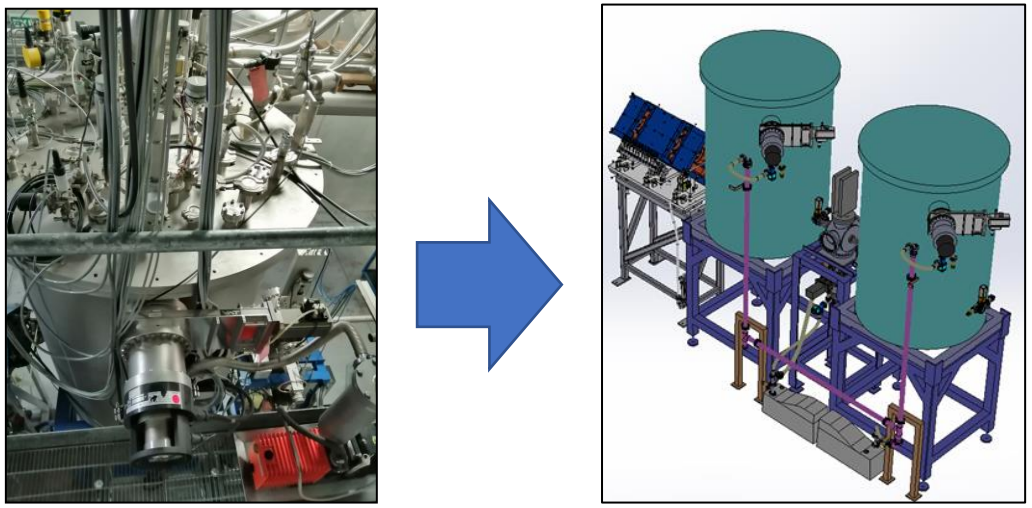
- Network cabling upgrade (complete)
- Tandem injector control system upgrade (ongoing 95%)
- Accelerator supplementary data archiver (under production)
- Diagnostics control software development and controller upgrade (waiting for material)
- Magnet power supplies control under revision: from local PLC to centralized control (hardware maintenance time reduction)

- RFQ SPES ancillaries developments and/or supports to general services
  - Eletric power plants and cooling systems supports
  - Solution of the safety issue related to magnet double powering
  - RF and RFQ skid upgrades

ALPI: vacuum technologies

- Ordinary ALPI primary and TM pumps maintenance: ongoing
- Cryostats vacuum system maintenance: ongoing
- Controller migration: from TELEMA to EPICS: quite complete
- New pre-vacuum controllers replacement: ongoing
- New vacuum system for AGATA beamline: quite complete

AGATA line aligned



Conclusions

- TANDEM special maintenance is on time. Accelerator conditioning reached 13 MV. Conditioning will reach 14.5 MV before end of March. Maximum working voltage will be 14 MV. Plan is to work just with Tandem till the end of July.
- CN is working in regular way. AN2000 experiences some delay due to operators availability. First stop for both machines will be on April.
- PIAVE-ALPI maintenance is ongoing. Both accelerators are scheduled to give beam on target next October.
- PIAVE maintenance goal: increase machine performances in view of Uranium acceleration.
- ALPI current maintenance goals:
  - increase maximum beam energy for Uranium acceleration (maintenance of all LB cryostats but CR4-CR5)
  - decrease A/q sensitivity for RIB acceleration with SPES (strong increase in ALPI longitudinal acceptance)
  - increase beam availability (vacuum and control system optimization to reduce fault risks).
- PIAVE and ALPI will be available since October 2022 and till July 2023.
- Between summer and winter 2023, new ALPI maintenance to increase maximum energy. In the meantime Tandem will work for experiments.

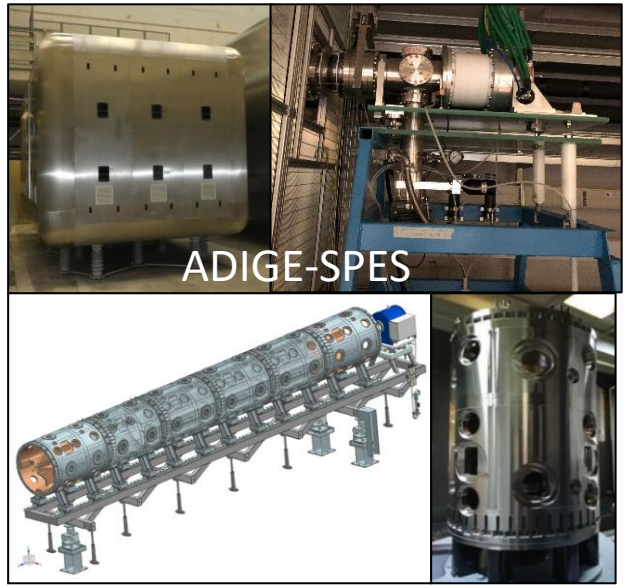
Thank you


CN - AN2000

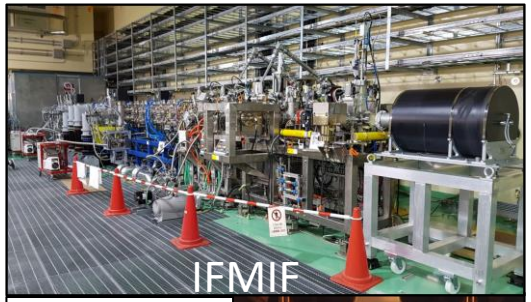

TANDEM


PIAVE-ALPI


SPES Cyclotron


ADIGE-SPES


SPES -Controls
SPES-Transport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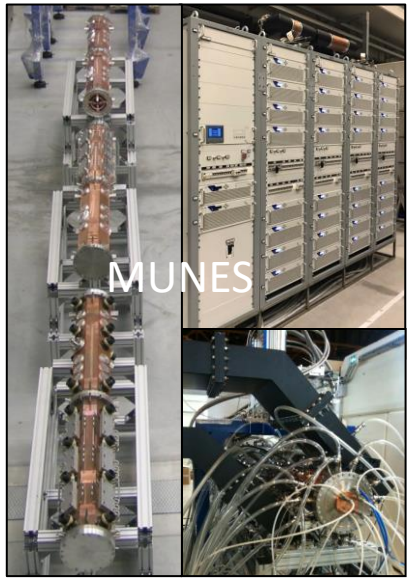
ESS


MUNES