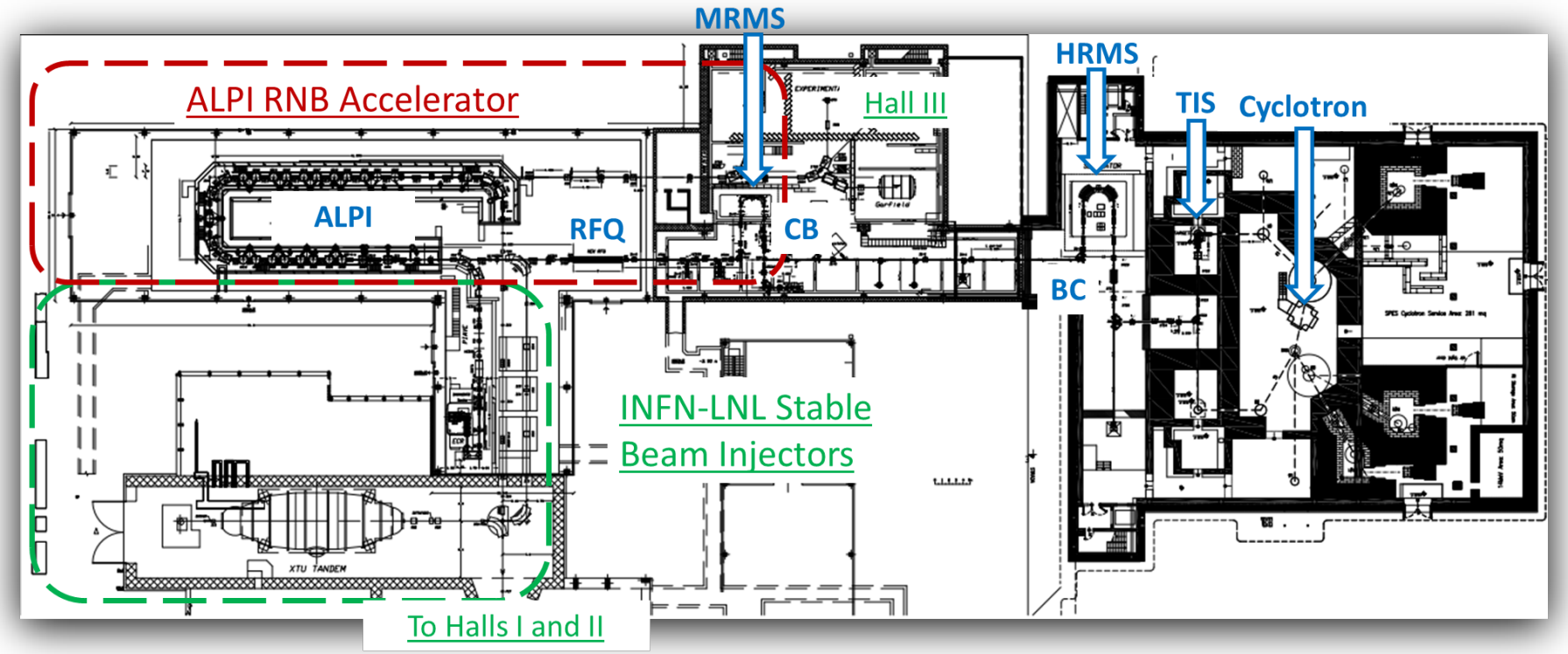
Istituto Nazionale di Fisica Nucleare

Status of Tandem-ALPI-PIAVE and SPES Installations

G. Bisoffi

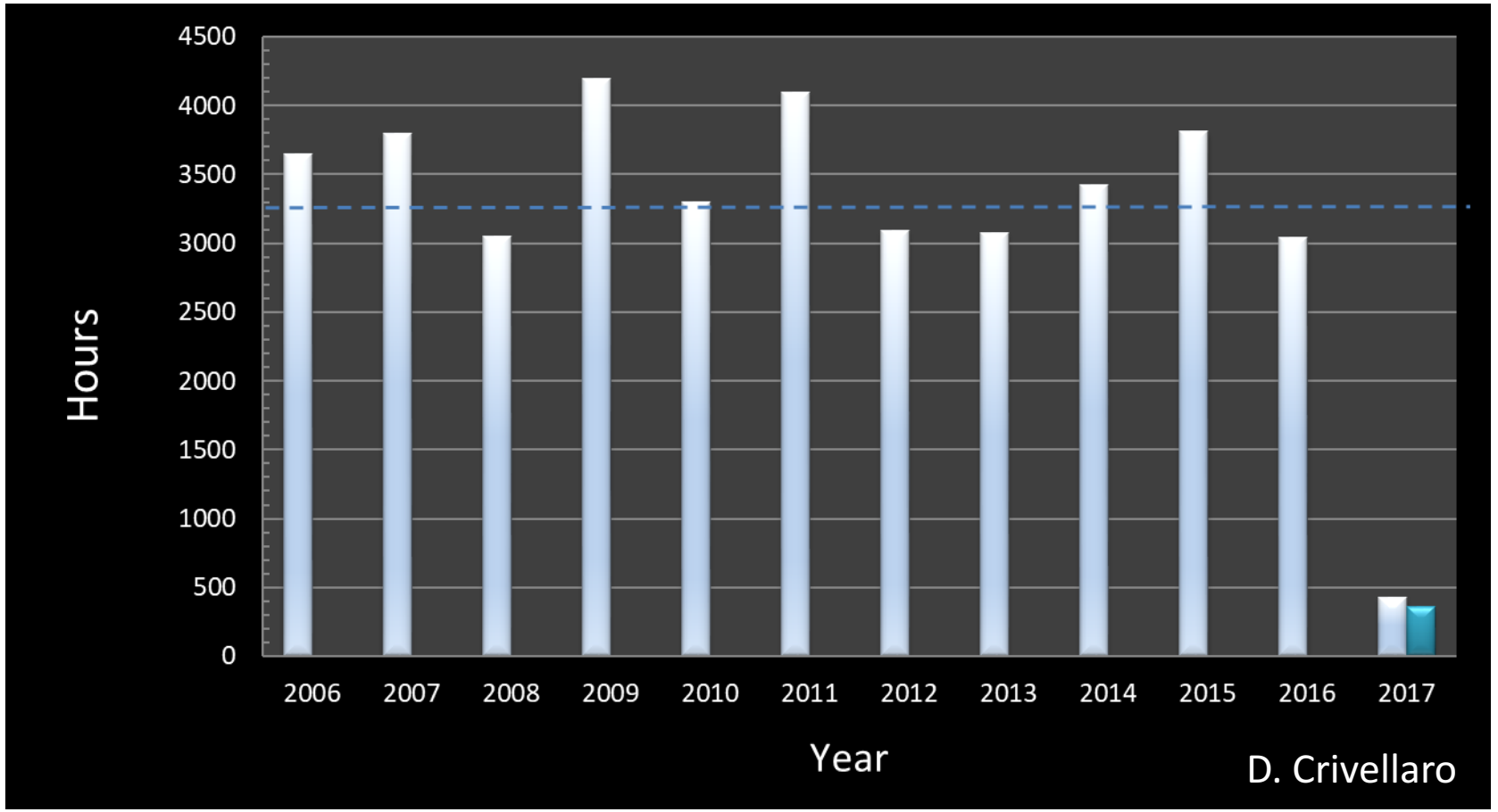
2017 LNL USERS' COMMITTEE ANNUAL MEETING

Presentation Scheme



1. Recovery work of **Tandem** from breakdown
2. Completion of **ALPI** Sp. Maint. on the Cryogenic CS (SPES)
3. Completion of **PIAVE** Sp. Maint. and results
4. Status of **ADIGE** Injector Installations
5. Status of **cyclotron-TIS-LE beam lines** Installations
6. Time frame **2017-2021: operation and installations**

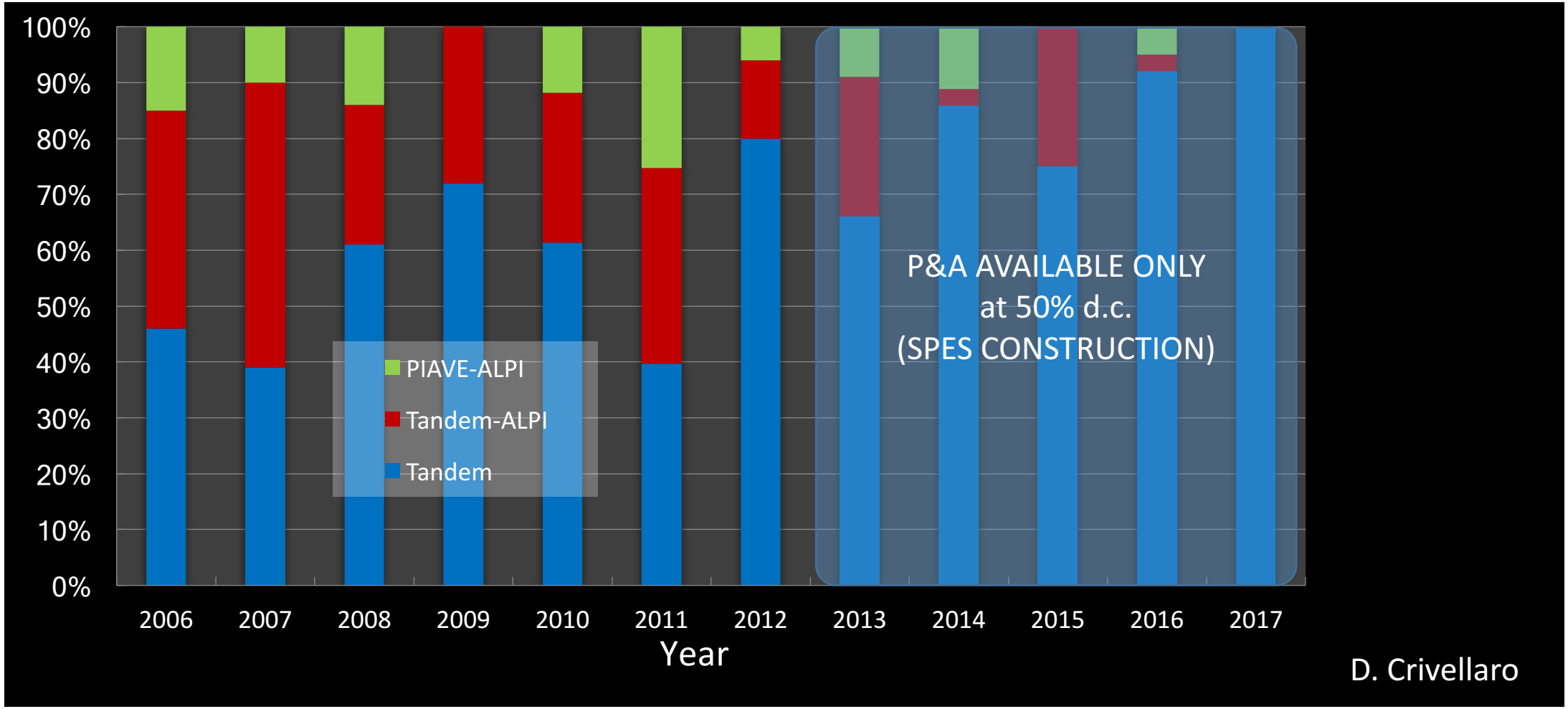
Hours of beam on target (+ accelerator tests)



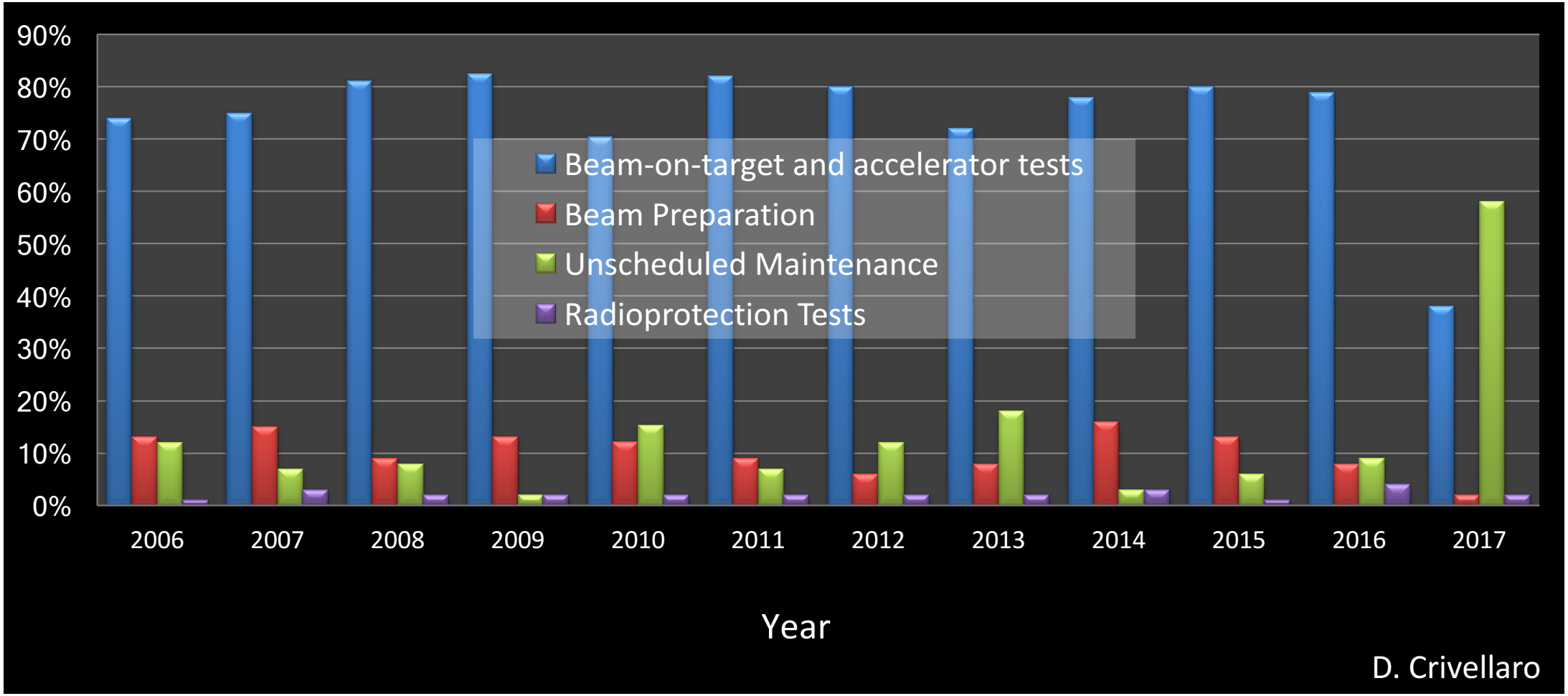
@ July 2017:
429 + 360

2016: lower number due to special T maintenance; 2017: Tandem damages from March 21; PIAVE special Maintenance till July (tests); ALPI special maintenance till October

Sharing among the three configurations



Beam on target and accel. tests vs. BP, UM and RPT



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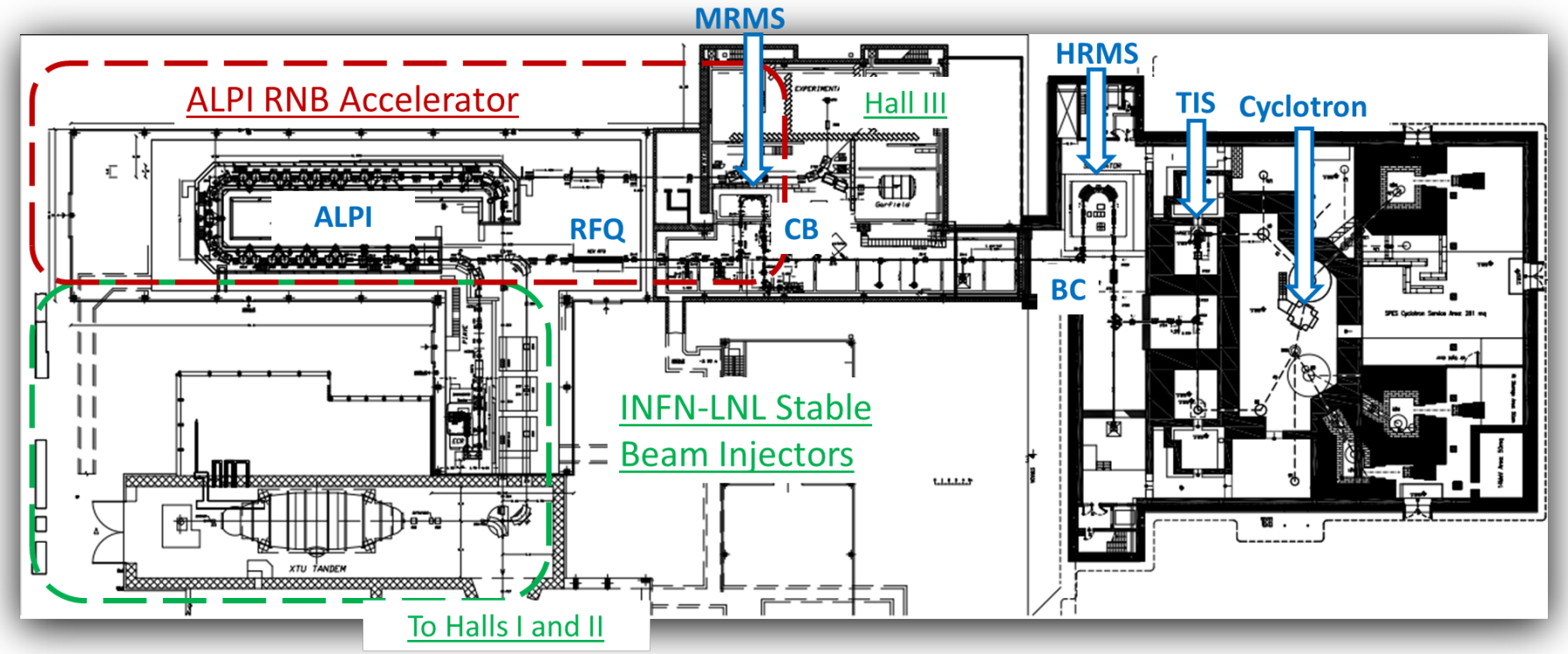

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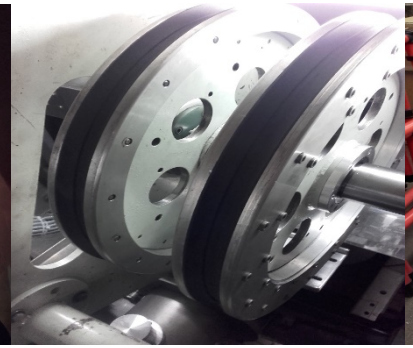
Manutenzioni straordinarie - guasti


Manutenzioni principali autunno 2016: **sostituzione ordinaria Laddertron**, manutenzione straordinaria ruote conduttive e di trascinamento; (…)
Fascio dal 14/11 al 23/12/2016


Manutenzione ordinaria 9-29/01/2017
30/01-14/02: condizionamento con instabilità nella $I_{col,HE}$, identificate a livello sezioni 7 e 8, anomalie di andamento V_T oltre 13 MV, ma …


14/02: rottura link e rilievo rottura cuscinetti ruota ladd. sul terminale
19-28/02: condizionamento (→13 MV), Fascio: 01-21/03
21/03: rottura link – segni di surriscaldamento lato alto campo elettrico di numerosi link → **cambio laddetron** (dopo 2000 h), Allestimento «rapido» e 2 sett. di degassaggio;
16/05-02/06: condizionamento, fino a 14 MV (3x no. scariche !)
02-05/06: guasto link e ripartenza condizionamento
12/06: guasto completo laddertron

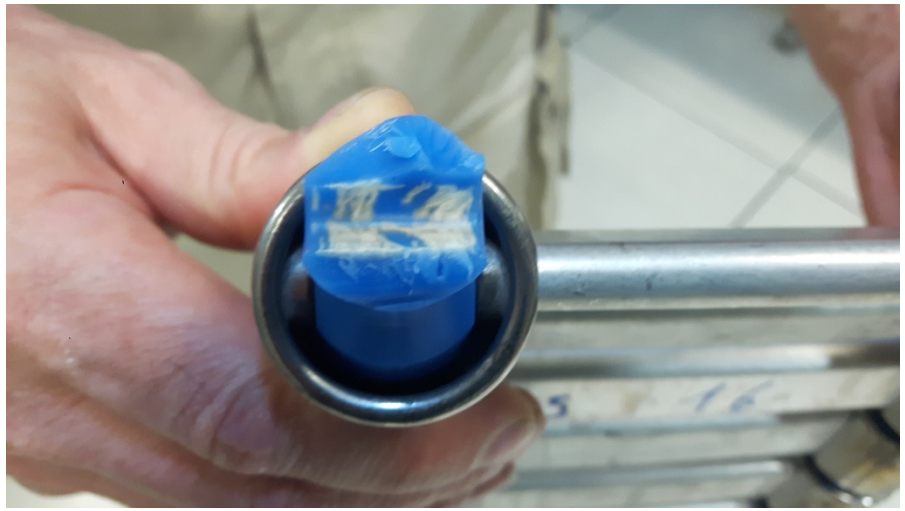
Tandem: various interventions

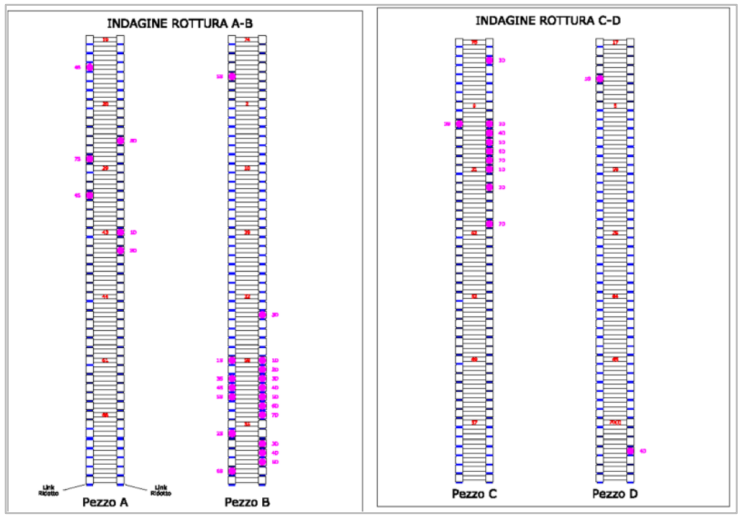
- **Laddetron**:
- Analysis of materials, geometries and mechanical tolerances, surface status, humidity content
- EM studies
- Repair of components damaged in the crash
- Order of new material
- **Sistema del gas di isolamento SF6**:
- Replacement of the filtering material;
- Replacement of humidity sensors, in better functional positions
- Measurement of air content, studies of air pollution outlet
- Various SF6 plant upgrades

Survey on the laddertron broken links

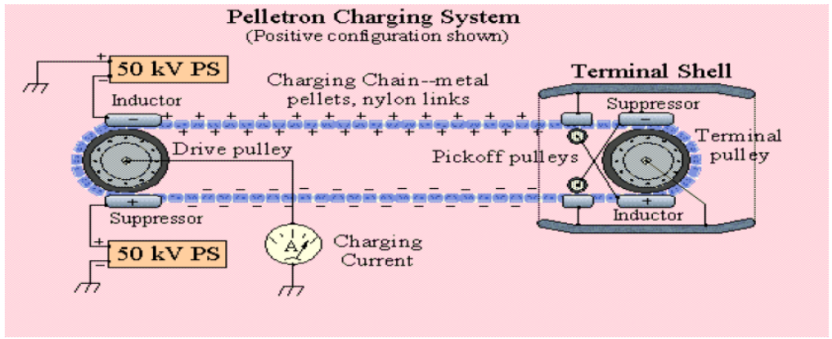


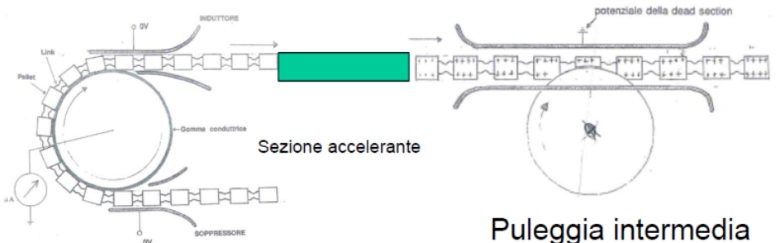
- 56 links with signs of predischarge
- 3 links were found broken with marked discharge signs
- 7 links were found broken without sign of discharge (mechanical impact)



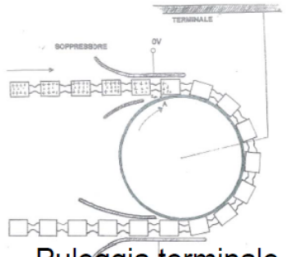
EM analysis on the Laddertron components





Puleggia di base (conduttiva)

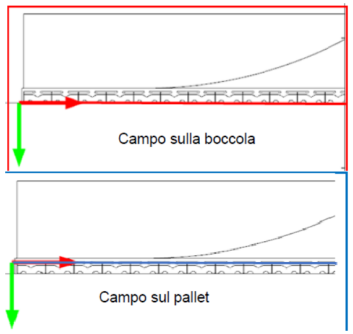
Puleggia intermedia (isolante, dead section)

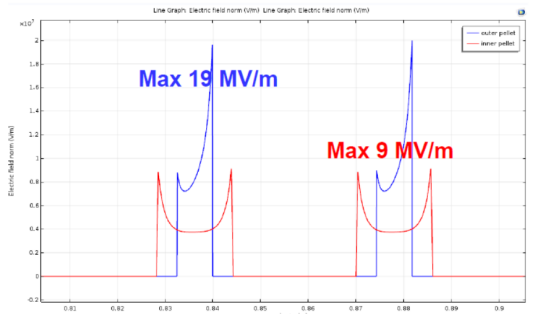


Puleggia terminale (conduttiva)

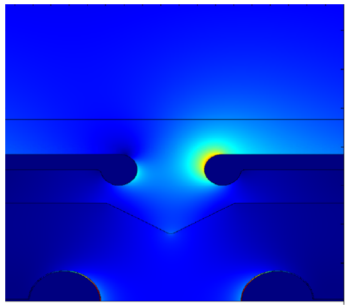
EM analysis of the electric field at the link bushings was carried out: fields increase by ~ 2

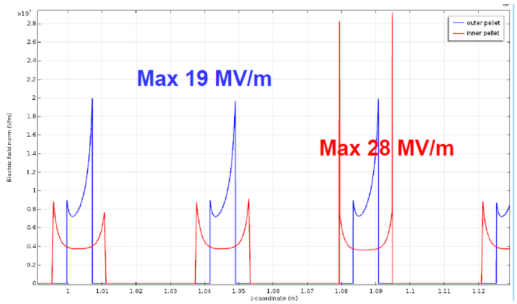
- with a 0,1 SF6 gap between bushing and link
- with wet nylatron.





Material	Break down electric voltage
Nylatron MC 901	25 MV/m (dry) 17 MV/m (wet)
SF6	35 MV/m (at 6 bar) 41 MV/m (at 7 bar)

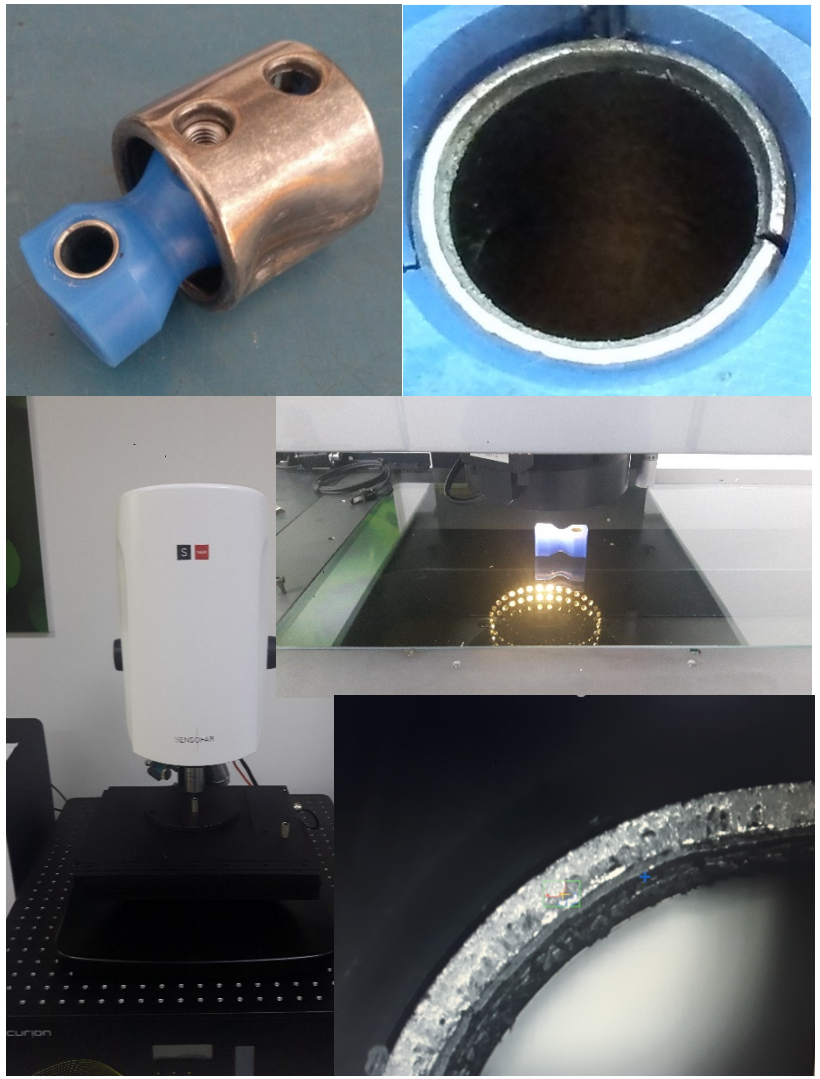




A. Pisent, L. Bellan

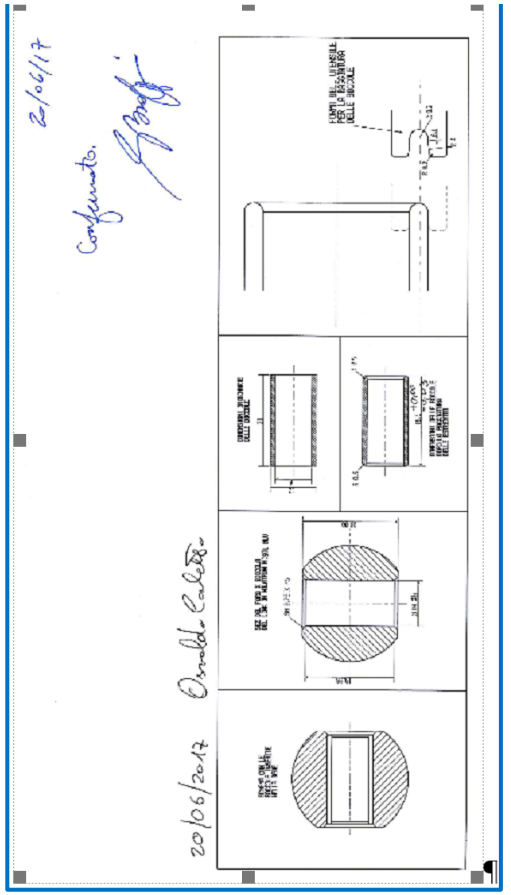
Analysis of Laddertron components

- SEM analysis og all materials show no differences between old and new perishable components (links and bushings) – material looks OK
- Humidity of the nylatron links was checked to be OK (**S. Carturan**). Δm=0,12% in mass between old and new links. Outgassing at 45°C gives insignificant mass reduction.
- Precision of bushings and holes in nylatron was found comparable.
- Surface of 50% of bushings looked VERY different (see aside, **Dept. Of Mechanics, Padova Univ, Macrographies**) → rounded off bushing endings
- Calibration of humidity detectors (SF6 dew point) gone (wet gas?): larger times for humidity reduction
- Air in increased quantity in the SF6 gas?



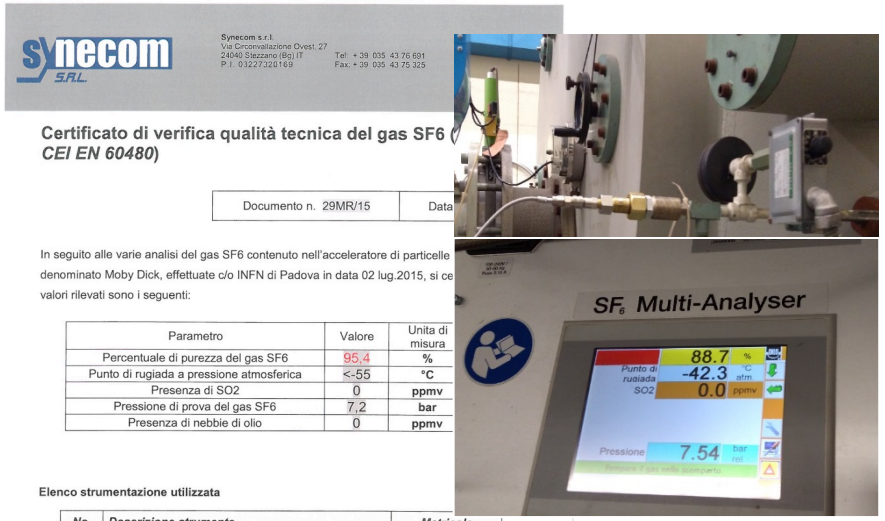
TE.SI. LABORATORY FOR PRECISION AND MICRO MANUFACTURING PARTNER STRATEGICO DI: **REGIONE VENETO**

TE.SI. è un laboratorio dell'Università di Padova, Dipartimento di Ingegneria Industriale, che opera nell'ambito della produzione manifatturiera di prodotti ad elevata precisione e valore aggiunto e si pone l'obiettivo di sviluppare percorsi di innovazione che sostengono il miglioramento e l'innovazione di processo, prodotto e sistema produttivo.



Special Maint. of the SF6 gas plant

1. SF6 filtering material relpacement (it will be done regularly)
2. Purchase of 3 new dew point gauges (prepared for easy replacement for calibration)
3. Spectrometry of gas composition (air content) in the SF6 tank: e.g. a leak was found which could explain the air inlet; preparation for air purge (in coll. with CNRS-Orsay)
4. Various upgrades of the SF6 plant (permanent SF6 recirculation system implemented)

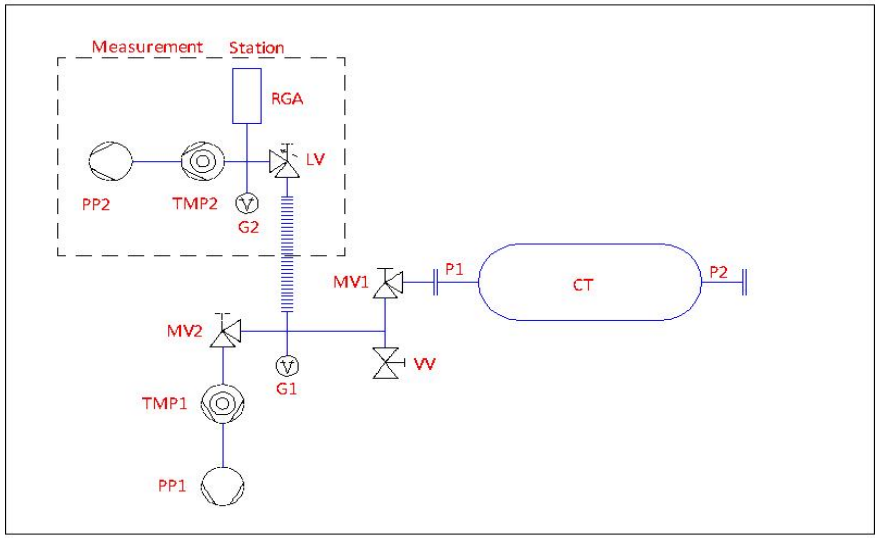


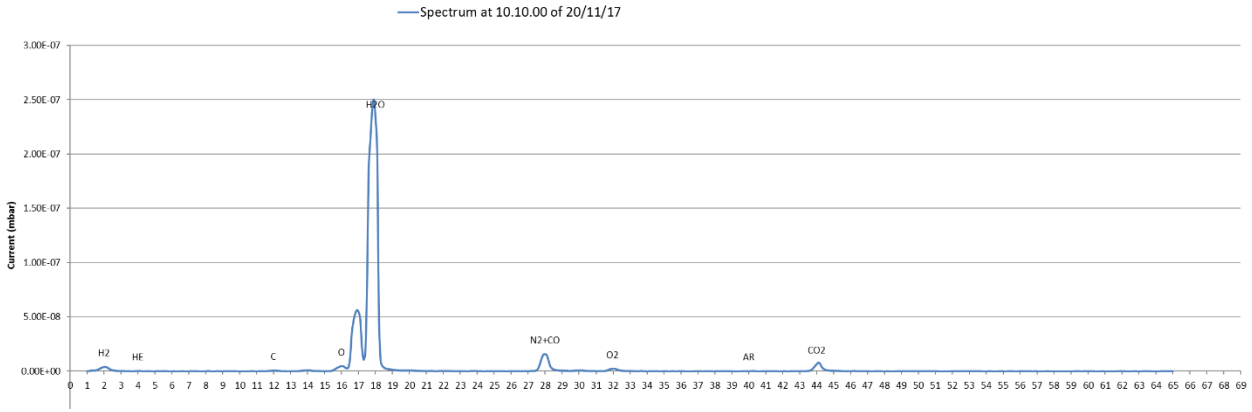
G. Daniele, M. Pacchiega

Tandem – Latest steps, restart plan

- **End July 2017**: laddetron components ordered
- **20-29 September**: components received and assembly starts
- **20 October**: completion of Laddertron assembly
- **23 October**: start of Laddertron outgassing (typical 6 weeks; this time with vacuum and spectrometry to monitor the process);
- **04/09-13/11**: repair of broken Laddertron components; upgrades on the SF6 plant;
- **14/11/2017**: start of PIAVE-ALPI conditioning in 7x24H shifts, work on Tandem suspended
- Installation of new humidity gauges and their control (during PA shifts in Nov-Dec 2017)
- **10 January 2017**: Tandem work will be resumed, laddetron assembly, checks and running in (4 weeks)
- **05-25/02/2017** (tentative): Tandem conditioning up to a cautious value of 13 MV (meanwhile, PIAVE-ALPI shifts for physics)
- Operational for physics **from** around **26 February 2018**

Monitoring of laddertron outgassing





- Laddertron outgassing tank equipped with TMP in addition to the scroll pump
- Vacuum level and RGA outcome monitored periodically to follow the decrease of water content
- The process will continue beyond the typical-minimum 4 weeks period, due to the maintenance interruption pro PA operation

C. Roncolato

SSI: Tandem Source and Platform

- Installed **new alternator**.
- Balance of loads on the various phases: checked
- Designed new **SIL III access to the injector** (components purchased).
- Designed **new vacuum control system** (components purchased).
- Draft of the manual prepared.
- **New HV power supply** (to be connected).
- Verified vacuum system functionality.
- Purchased new wall (awaiting installation by the MW).

After such installation:

- Switching on the **conditioning** of the compartment.
- **High voltage test** of platform and source
- Various functional verifications.
- Ready to start shifts.

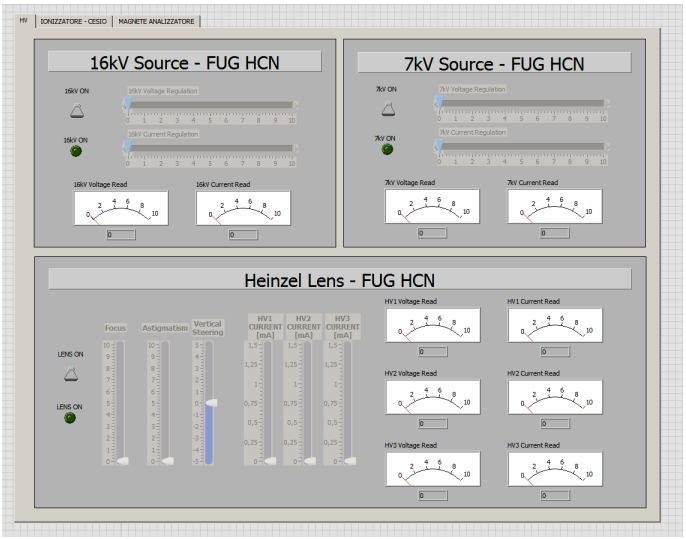
A. Galatà

Double Alternator

SSI: source test bench

- Rack designed by SSI was delivered
- False floor strengthened.
- Some components (relè HV) were delivered with delay (Nov 19!)
- Vacuum system tests on-going
- Labview control system designed and realized
- Cabling and safety system will be concluded within November
- Functionality tests (after 8 years idleness) will follow
- SPES diagnostics box installations being defined.

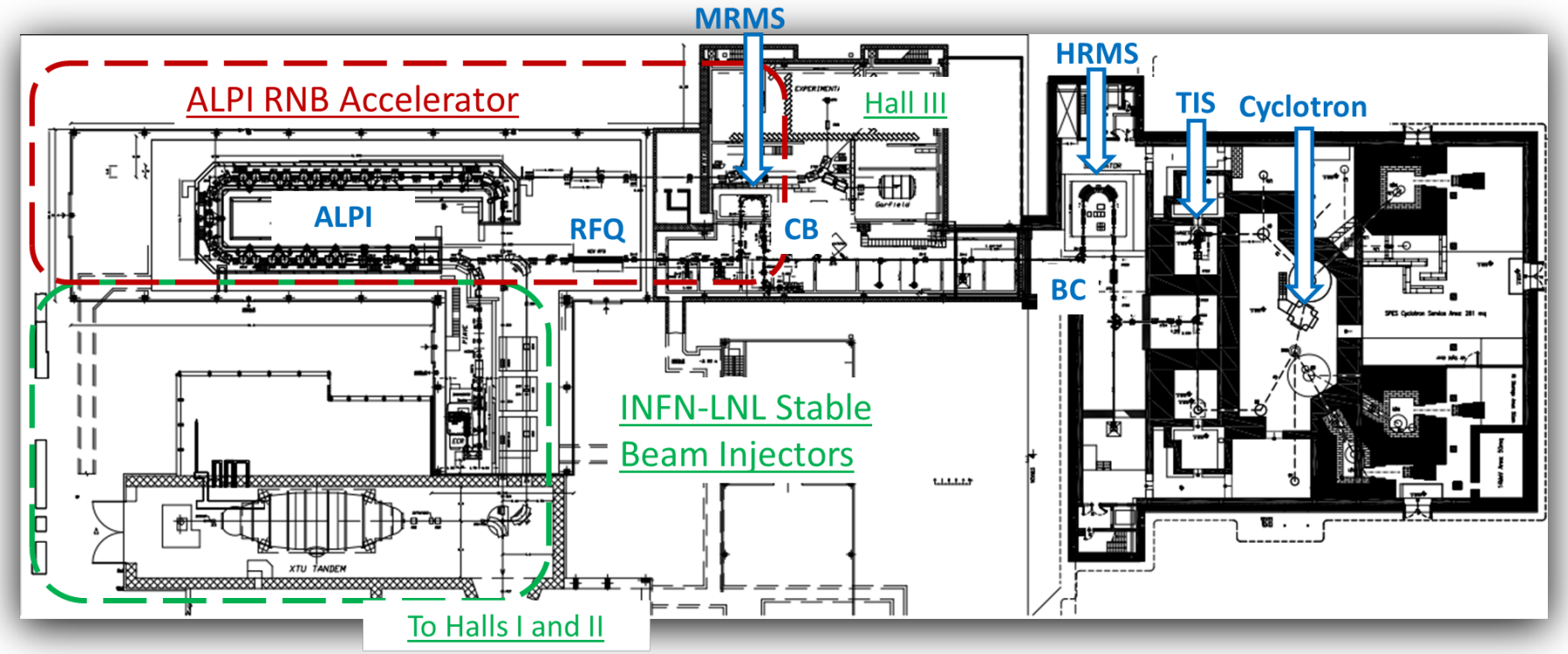
New Bench Rack



LV CONTROL SYSTEM

A. Galatà

Presentation Scheme



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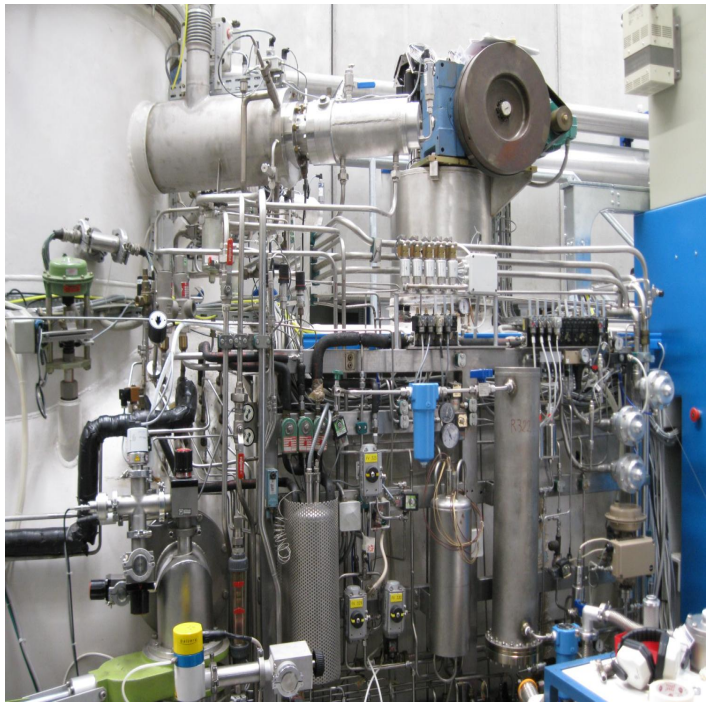
Refurbishment of ALPI Cold-Box Control

Reported at PAC meeting, July 2016

Being performed at low investment cost on CERN-UNICOS standard (4 LNL t-FTE, 9 months). ***Know-how will be in-house!***

1. *Prototype work on LNL liquifier TCF20: successfully completed in 2012 (by CERN experts)*
2. *Training of LNL cryogenic expert at CERN in 2014-2015 (HIE-Isolde group)*
3. *Migration from old-fashioned to CERN-UNICOS control system on going (April –December 2016)*

Check point in Nov 2016: to start with still old or new system in January 2017 for ALPI operation with stable beam.

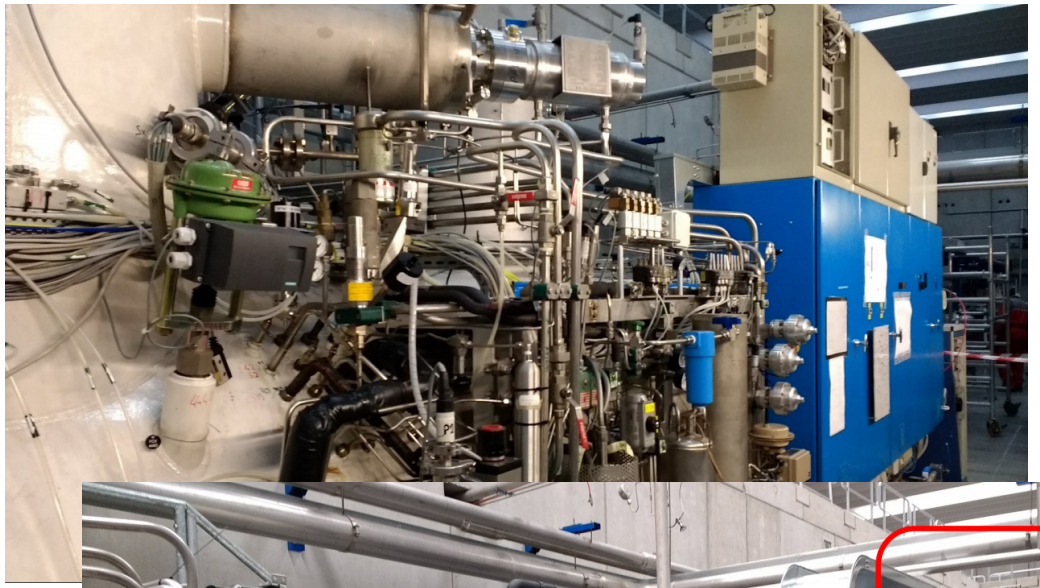


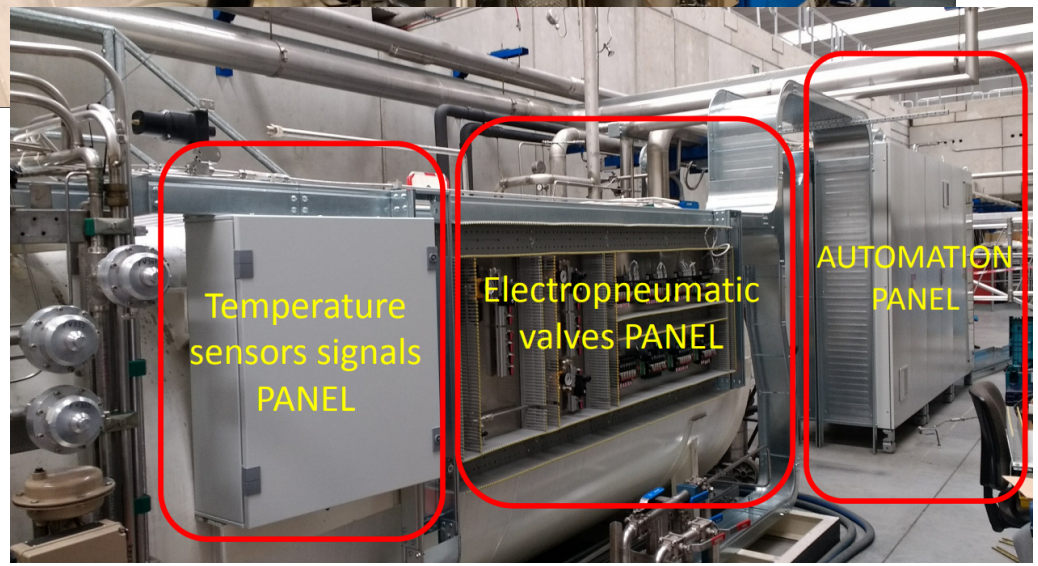
TODAY:

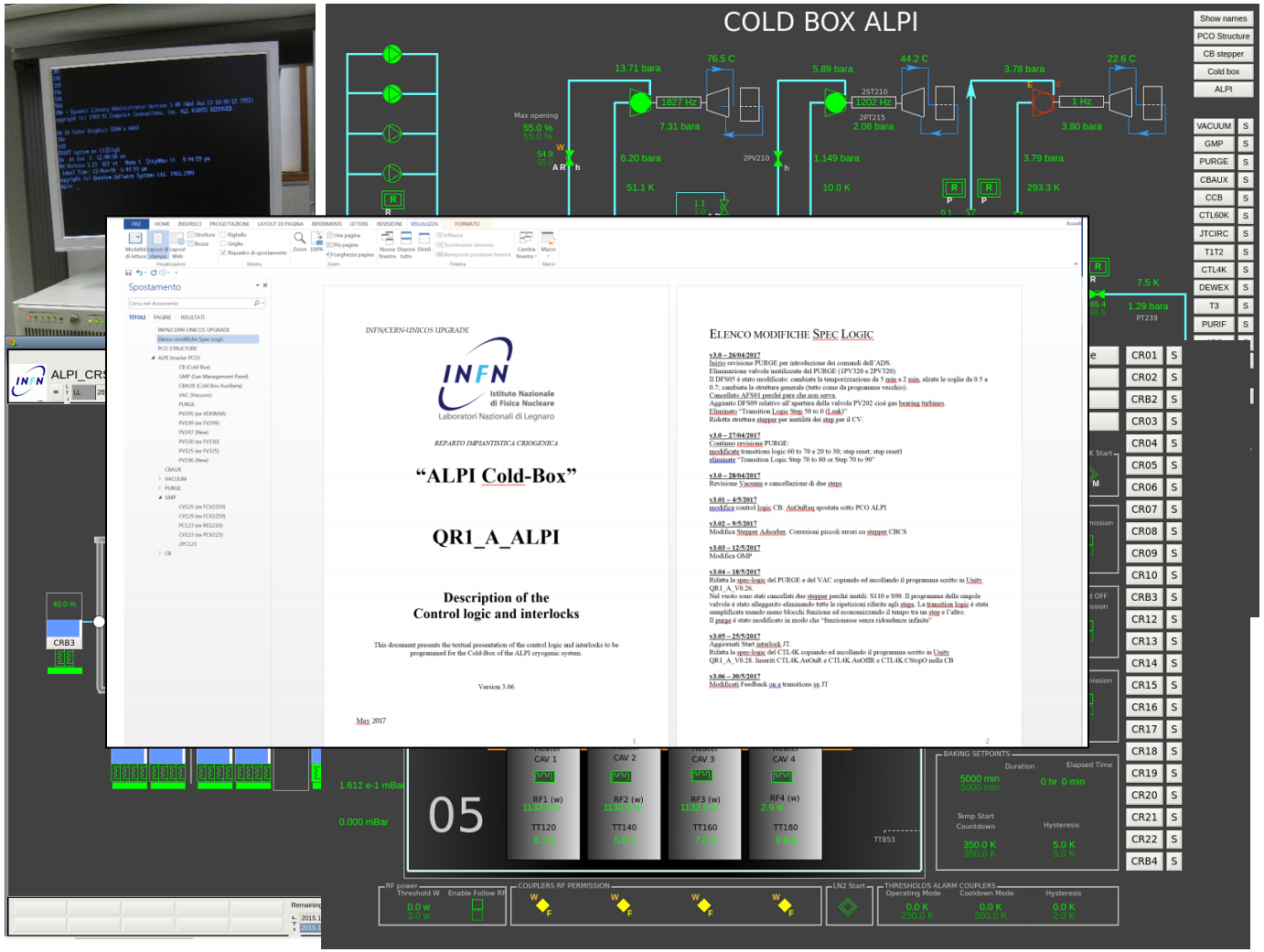
- Maintenance took longer than expected
- Dec 2016: decision to proceed with the old CS (period May-July 2017)
- Feb 2017: after PAC meeting, decided to go on with Tandem only (which then broke); CS upgrade resumed, **completed in September 2017**

P. Modanese

ALPI Cryogenic CS Upgrade

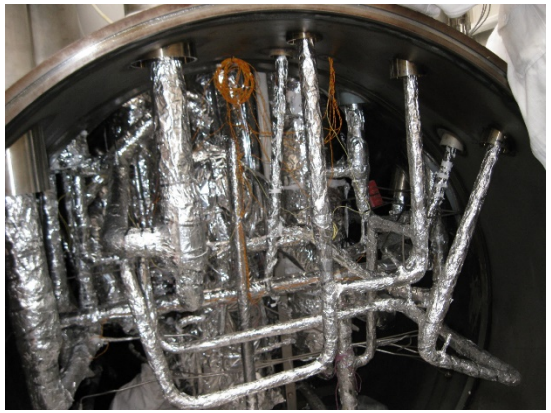


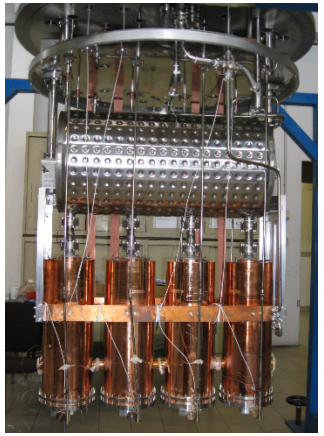


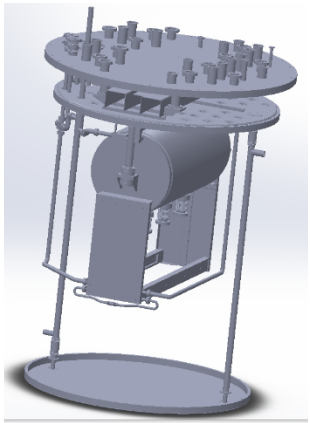


Cryogenics and cryostats: to be done

- Solve remaining bugs still (within 2018)
- Integrate resonator RF power signals to balance cryogenic power (within 2017)
- Fix cold leak on CB (2018)
- Integrate vacuum system signals – safety (in itinere - 2018)
- Update old cryomodules to new CS standards
- Update manual of CB and cryomodules CS
- CR01 and CR02 from PIAVE to ALPI (with liqN-cold couplers)
- Two new equipped cryostats CR21 and CR22 (higher beam energy)
- New recovery+purification and their CS; new compressor CS
- New valves in Valve Boxes







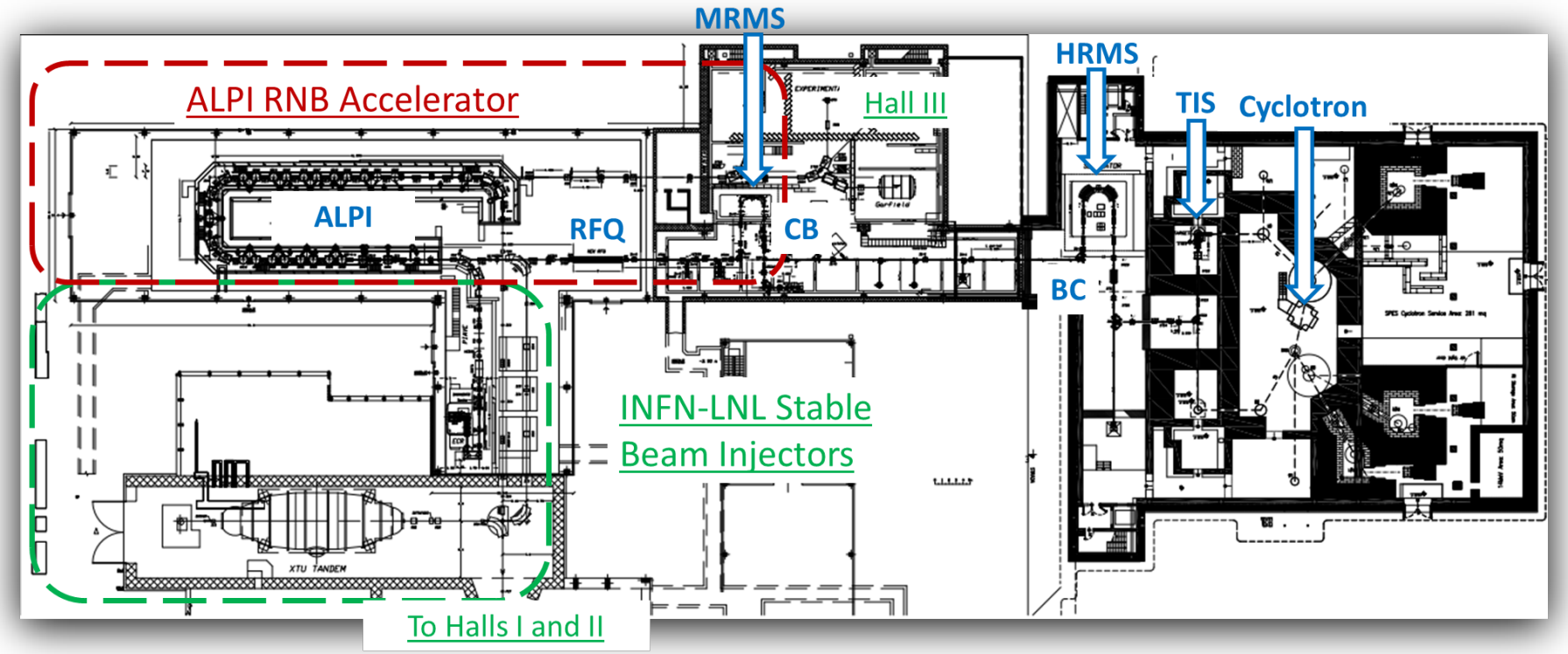
P. Modanese

ALPI Present Status

- **Oct 17: cryogenic plant with UNICOS CS started successfully!**
- Still issue with a vacuum leak at the Cold Box (under control so far) and on CR03 (to be tested in the current week at 4K)
- Cavity preparation on-going: bakeout and multipacting conditioning done; cooldown done; conditioning at 4K from Nov 20 to Dec 1
- **Operational from Dec 4.**

delay of 2 weeks vs. the original plan (20 Sep →), due to LNL electric infrastructure faults in September and October

Presentation Scheme



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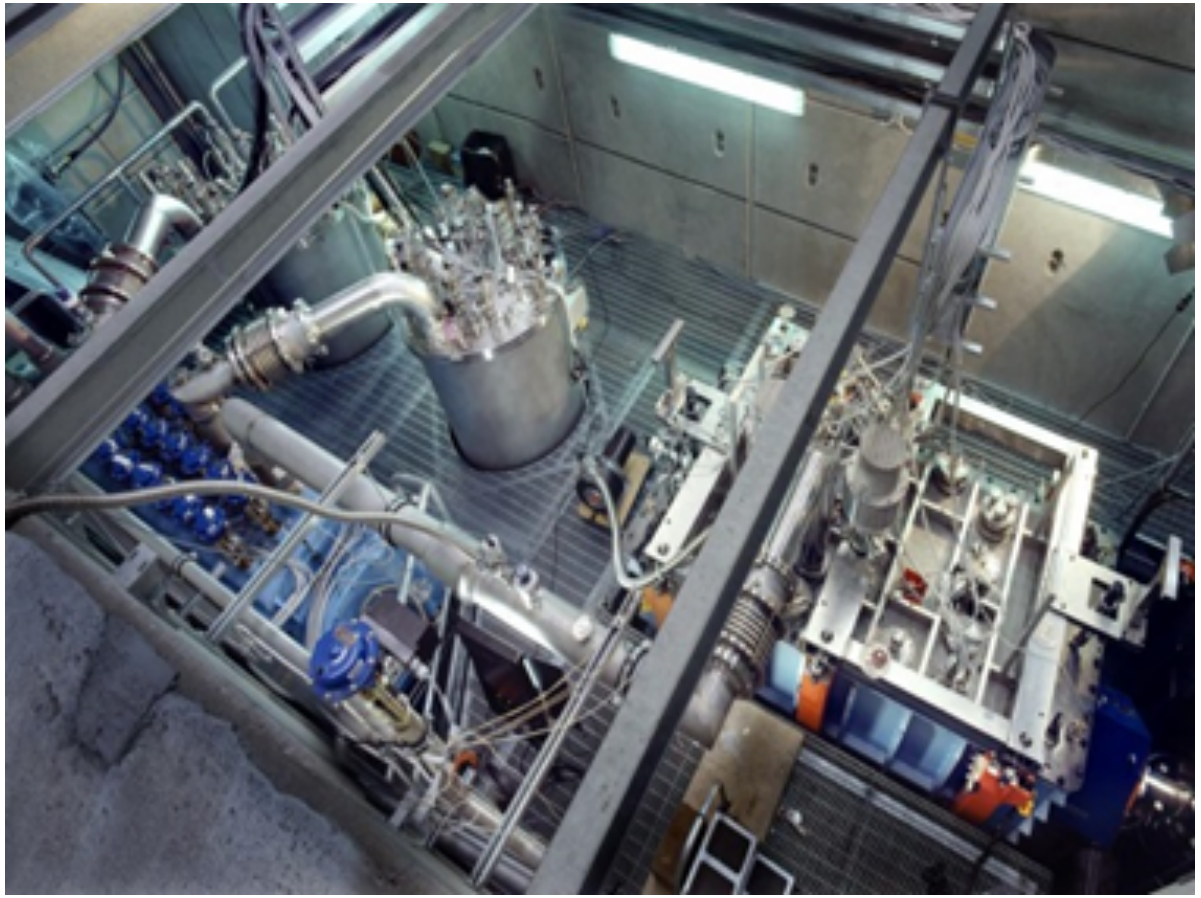
SRFQ Cryomodule Sp. Maintenance

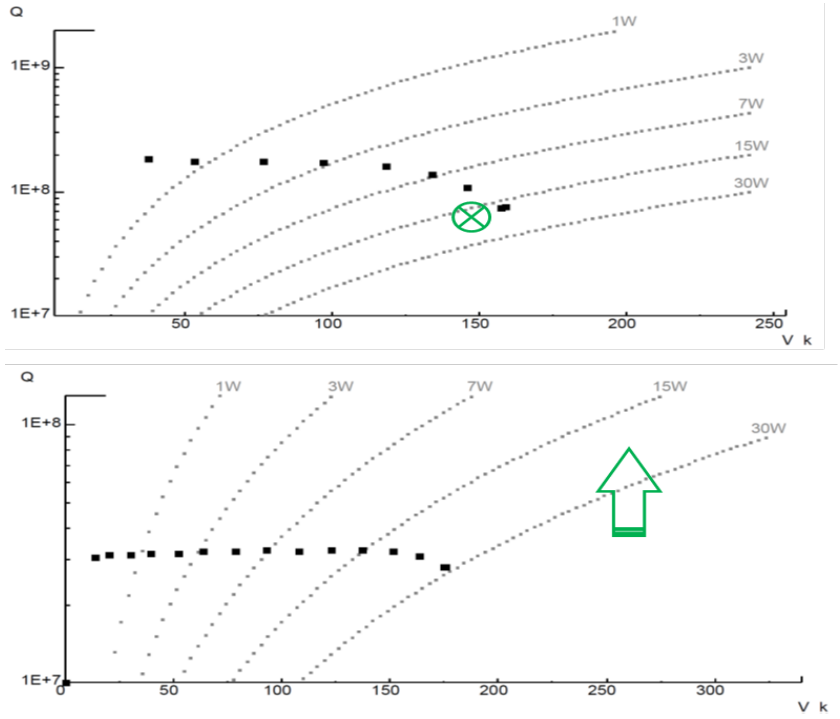
1. $E_{acc,max}$ by around 20% larger (larger A/q values accel.ted);
2. Reparation of heating resistors, T sensors, level meters (He and N);
3. New slow+fast frequency tuning system (more efficient and reliable);
4. Increase of He gas draining capability of the resonators (→ more efficient RF conditioning);
5. Laser alignment onto the beam line (better transmission).



Started in 2015

First Session: completed in Spring 2016

- *Maintenance was not fully successful: slow tuner issues (large mechanical backlash, insufficient f-range) ; on SRFQ2 – Q curve is anomalous (evidence of RF load outside the 4K environment, **FT** too strongly coupled to the cavity)*
- *PIAVE could operate only with SRFQs (globally) at 50% of their design field, and was used with a 20^Ne experiment*
- *New shorter maintenance planned (Fall-WINTER 2016-2017)*



SRFQ1 Q-curve: the desired performance was achieved, after a few days of RF conditioning (also with He in the $1x10^{-5}$ mbar range) – sign that sputtering on end-plates was fine and Chemical Etching fruitful

Fast Tuners

- **Fast tuners**: behaviour at 300K was carefully checked, and found consistent with correct behaviour at 4K
  - ✓All electronic components taken apart and measured
  - ✓New components (fuses, capacitors) graciously sent from anl-USA (r. Pardo)
  - ✓A couple of loose bolts identified
- Penetration of the FT antenna (SRFQ2) had to be decreased, to lower its Q-loading (at the expense of the f-control window; which is, however, sufficient)

D. Bortolato

Slow Tuners – Mechanical upgrade

Rifatto l'albero di trasmissione con giunti esagonali e spine.

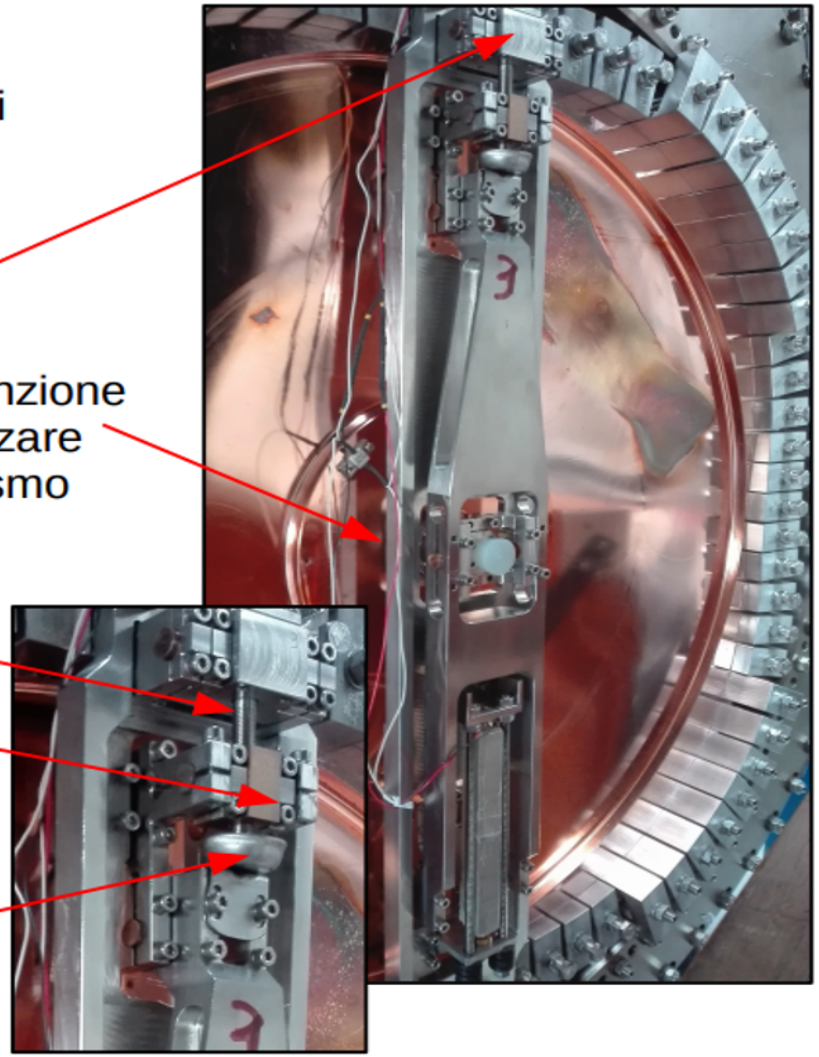
Sostituiti cuscinetti RS (di qualità superiore)

Ricalibrati gli spessori di giunzione col piatto in modo da ottimizzare punto di lavoro del cinematismo

Rifatto albero filettato INOX

Sostituito blocchetto rame-berillio con un tipo più duro

Protezione per eventuale polvere da usura (problema non completamente risolto).

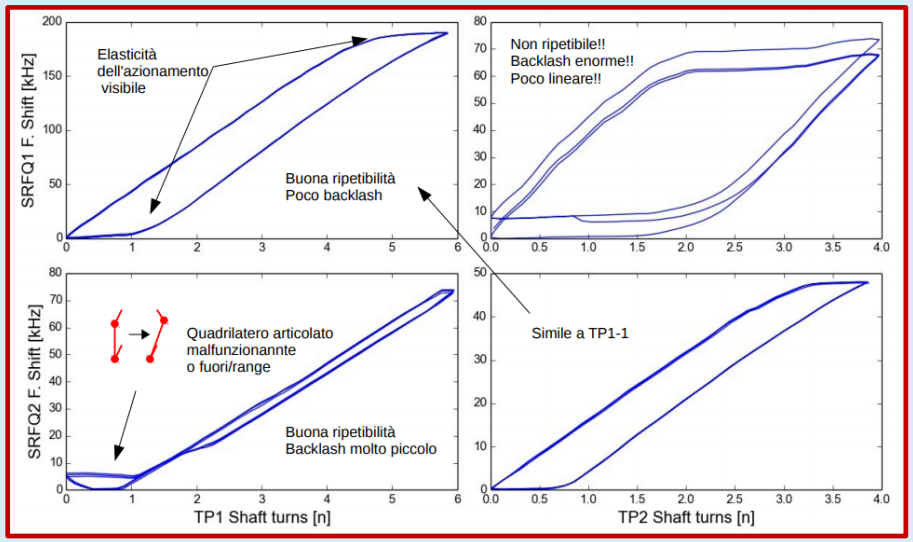


E. Bissiato
A. Minarello

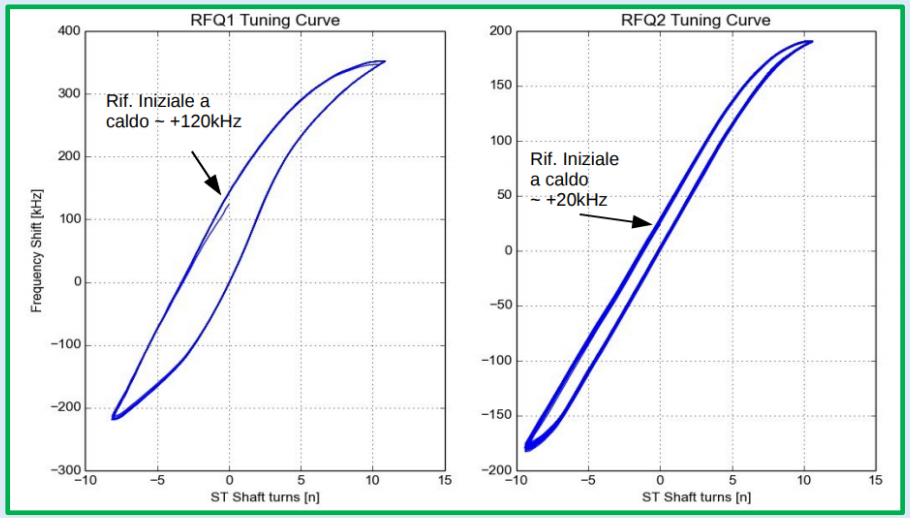
Results

SLOW TUNERS

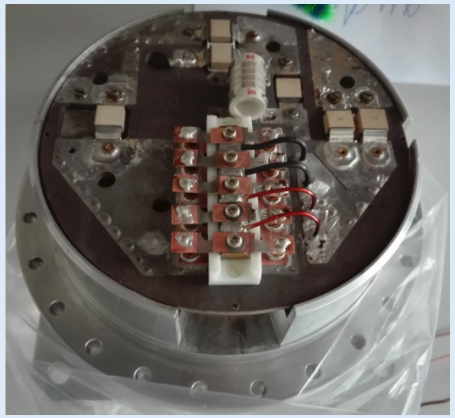
Before



After

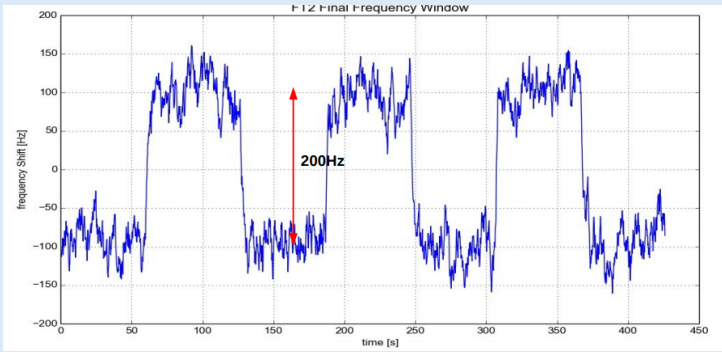


FAST TUNERS



Thorough Check

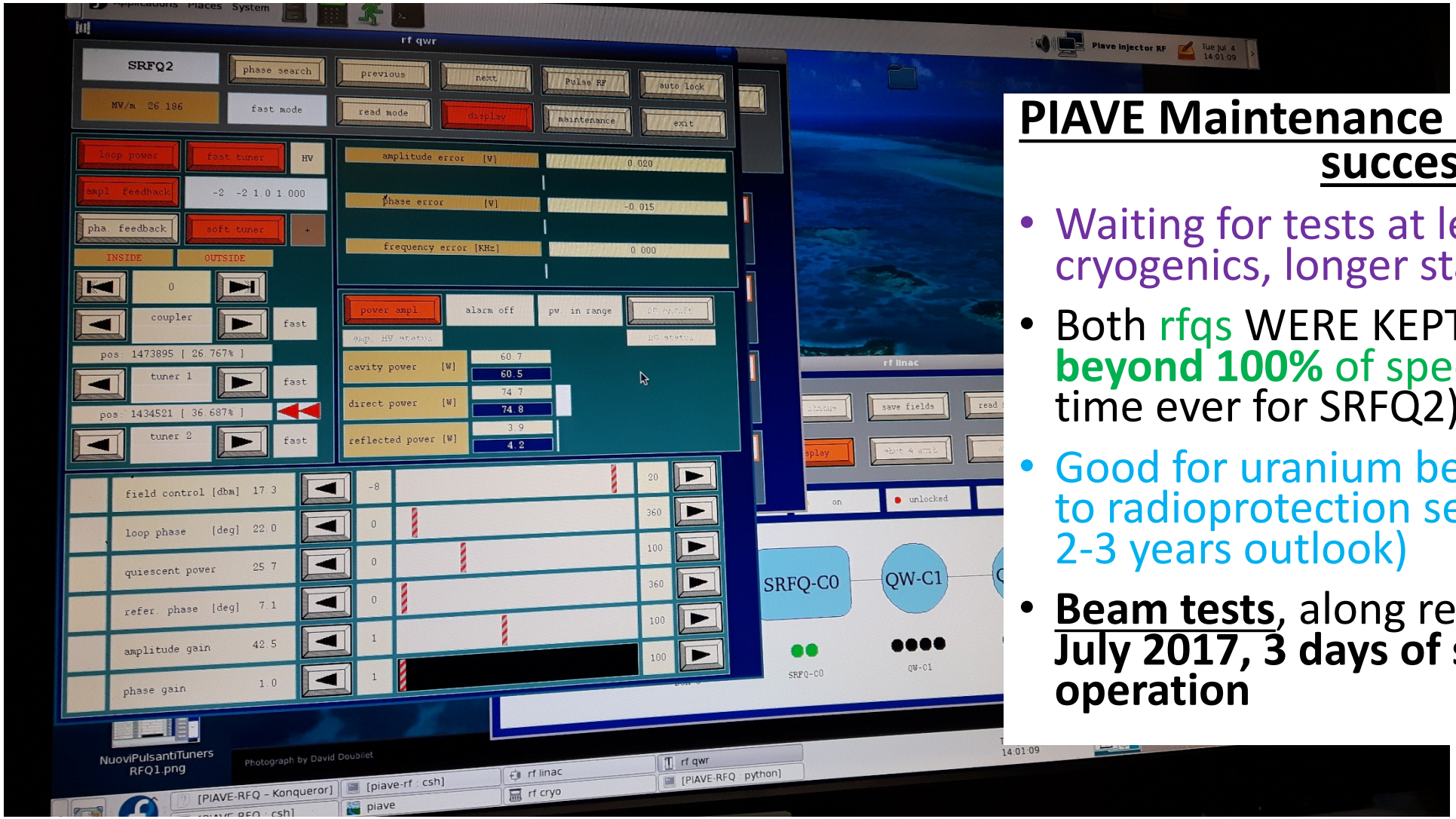
- All capacitors, diodes, fuses, joining cables replaced, plus the 50 Ω broken termination on FT2
- US rinsing.
- All screws tightened.
- Diodes behaviour checked



FT1 windows still ok; FT2 window now correct (at 300 and 4K), after moving FT2 out by 6,5 mm.

D. Bortolato, F. Chiurlotto, E. Munaron

SRFQs over specs, ϕ&A locking and beam through

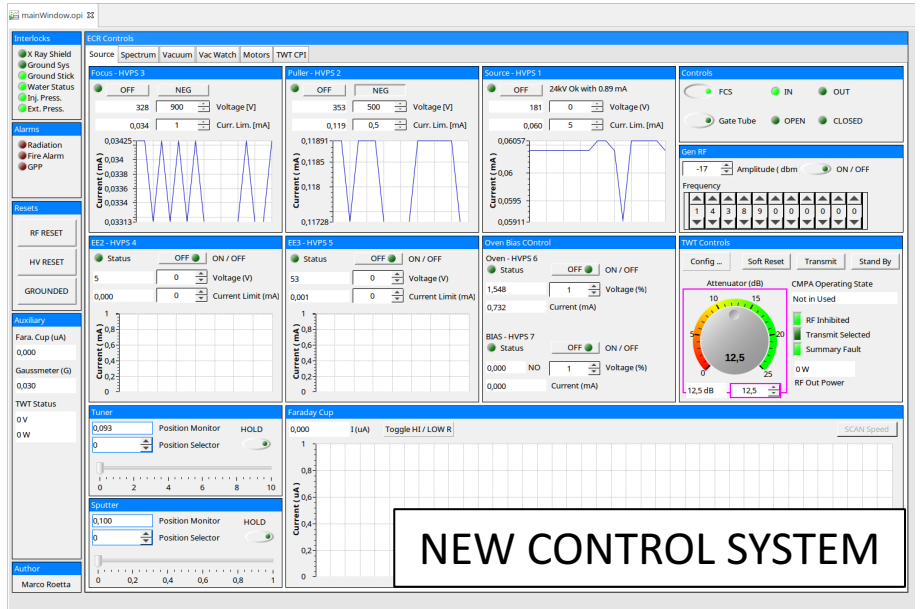


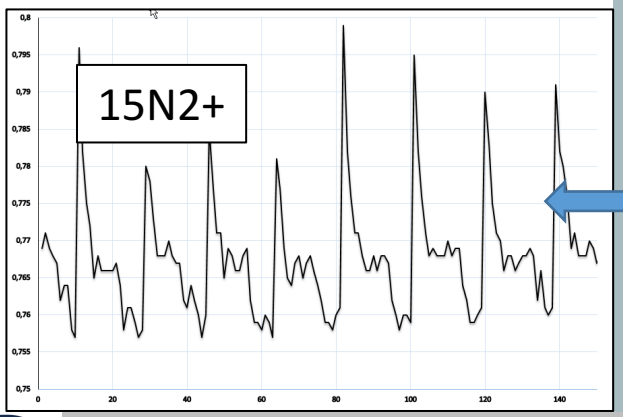
PIAVE Maintenance completed with success.

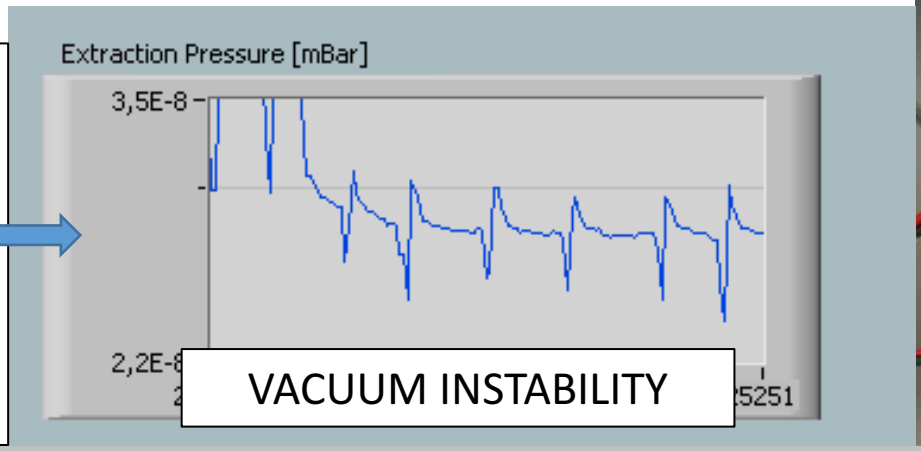
- Waiting for tests at less stable cryogenics, longer stability tests…
- Both rfqs WERE KEPT stably locked **beyond 100%** of specified field (1st time ever for SRFQ2) for DAYS
- Good for uranium beams ! (request to radioprotection service triggered – 2-3 years outlook)
- **Beam tests**, along realigned piave: in **July 2017, 3 days of stable 24h operation**

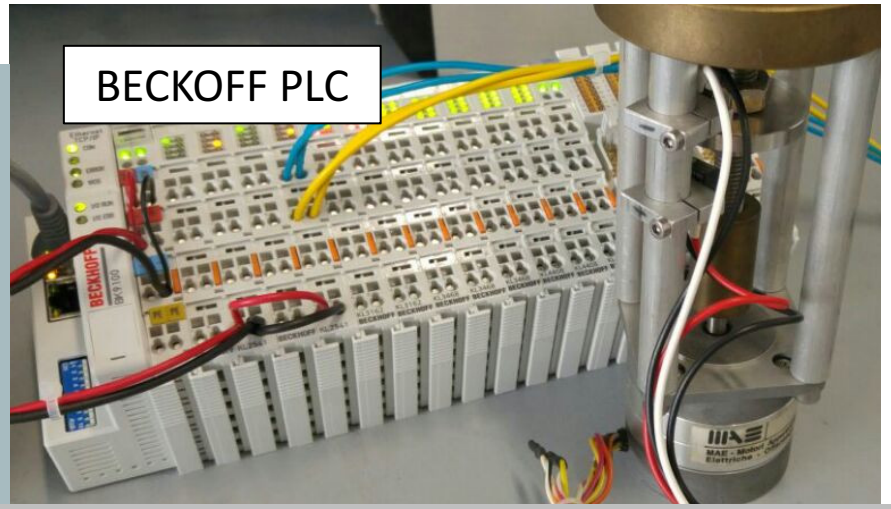
LEGIS ECR Ion Source Status

- Handover from M. Sattin to D. Martini (plants)
- M. Sattin: completing the ECR Manual
- HW for the new CS installed
- New CS developed by SPES Control WP (M. Roetta)
- SW debugged at 90% (beams required for last 10%)
- Nasty periodic vacuum leaks yet not removed (since July).
- WK47: Operation will be resumed
- «Assegno di ricerca» for ECR and Charge Breeder operation started.





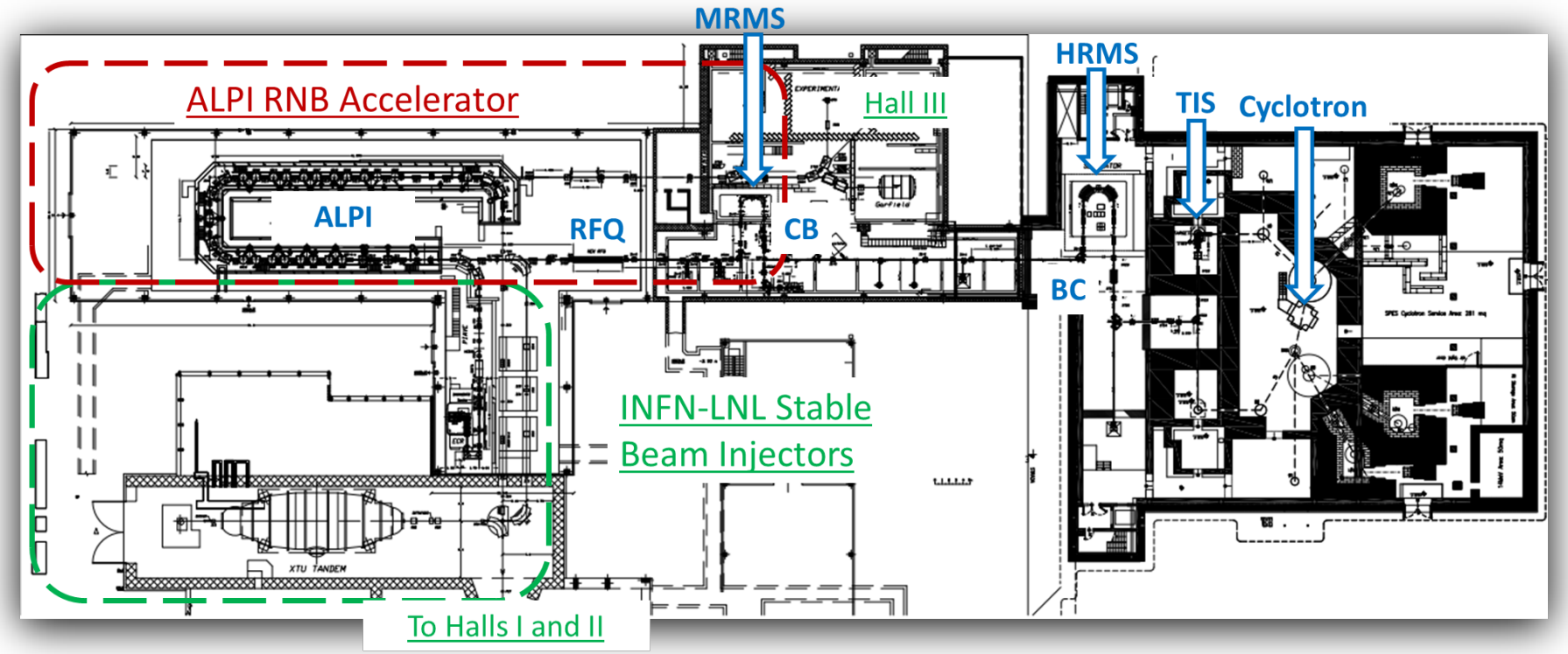




PIAVE Present Status

- SRFQs-Cryostat: baked out, conditioned at room T, cooled down at 4K; 15-29 November conditioning at 4K
- QWR-Cryostats: baked out, conditioned at room T, WK 47 cooldown to 4K, then conditioning
- Control Systems of magnets and diagnostics refurbished
- Typical hydraulic leaks on magnets and PS fixed
- Broken magnetic steerers amplifiers replaced with new ones
- ECR will be brought into operation from Nov 20 (with vacuum issue)
- **Operational from Dec 4.**

Presentation Scheme



1. Recovery work of **Tandem** from breakdown
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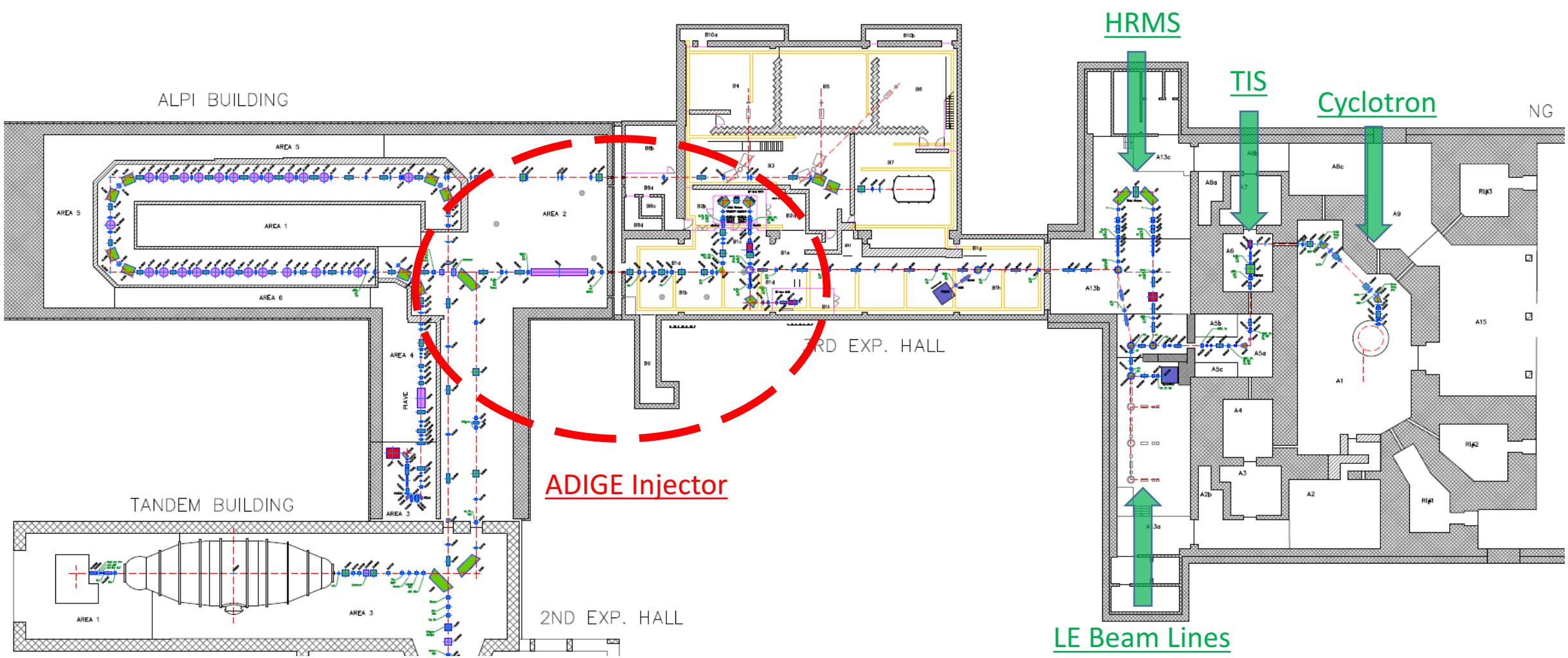
3. Completion of **PIAVE** Sp. Maint. and results
4. Status of **ADIGE** Injector Installations
5. Status of **cyclotron-TIS-LE beam lines** Installations
6. Time frame **2017-2021: operation and installations**

SPES ADIGE Injector Installation proceeds



Acceleratore Di Ioni a Grande carica Esotici

Positioning of dipoles and quadrupoles

13-16 November 2017

C. Roncolato, M. Miglioranza

ADIGE INJECTOR Time Schedule

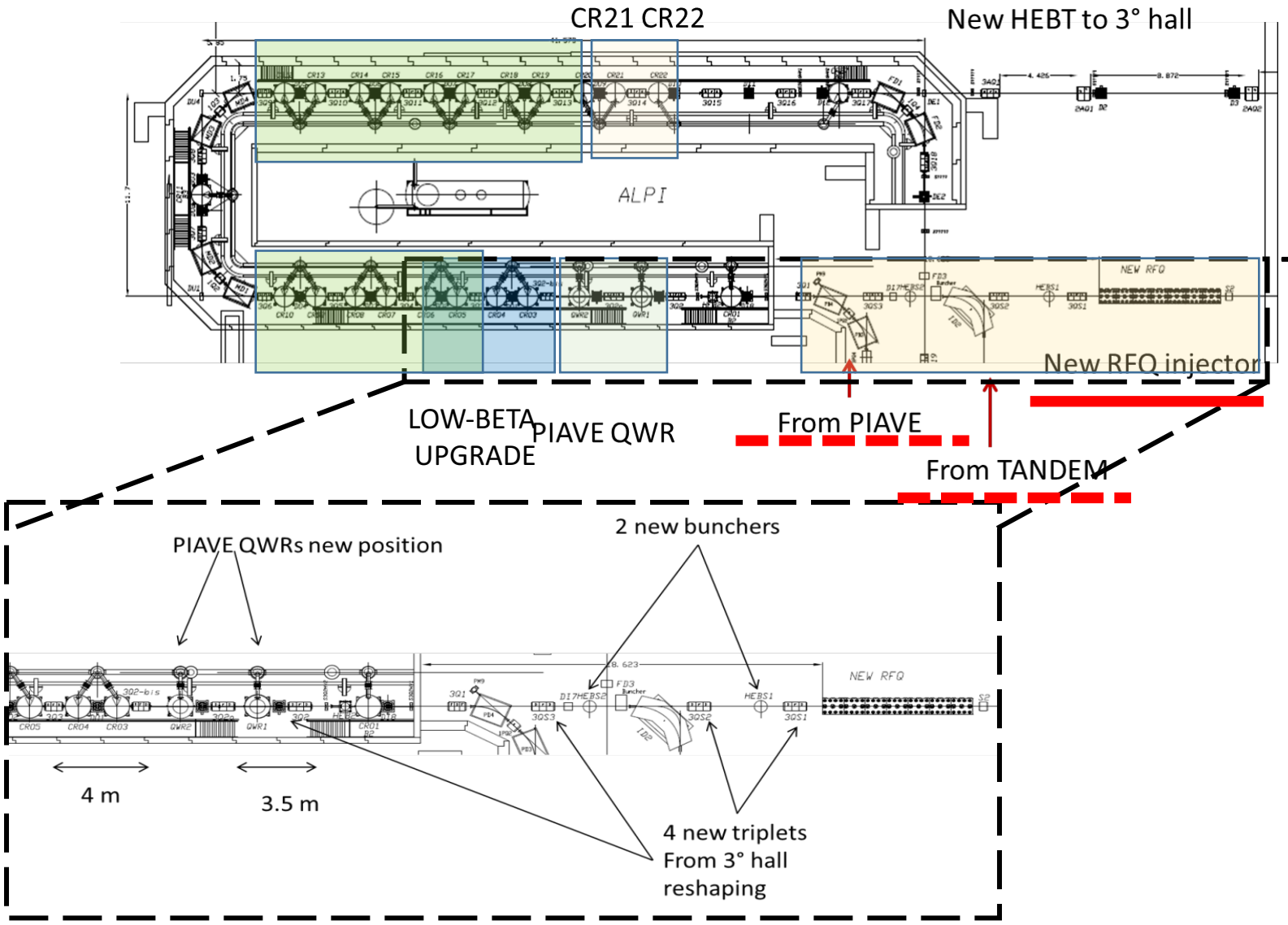
Main Tasks	2015				2016				2017				2018				2019				2020				2021			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Tests at LPSC on CB contaminants																												
ADIGE Experimental phase 1 (1+ source characterization, SIS and PIS)																												
Installation of 1+ source, CB, magnets																												
HW commissioning, control, BI																												
Experimental Phase 1 (SI+PIS before the CB)																												
ADIGE Experimental phase 2 (CB and MRMS characterization)																												
CB installation, infrastructures, HW commissioning																												
MRMS HV Platform: contract signature and construction																												
MRMS on Platform: installation and HW commissioning																												
BI and control																												
CB characterization with MRMS (no injected beam)																												
Beam line completion upstream the MRMS																												
CB characterization with MRMS (w/injected beam)																												

Installation

HW Commissioning

Beam Test

SPES-ALPI new upgrades in 2018



ALPI Upgrades

done

1. Low-Beta Resonator Upgrade

2018

2. N.10 Magnetic Triplets with increased gradient (20→30 T/m)
3. Relocation of PIAVE QWR Cryostats on ALPI (CR01-CR02)

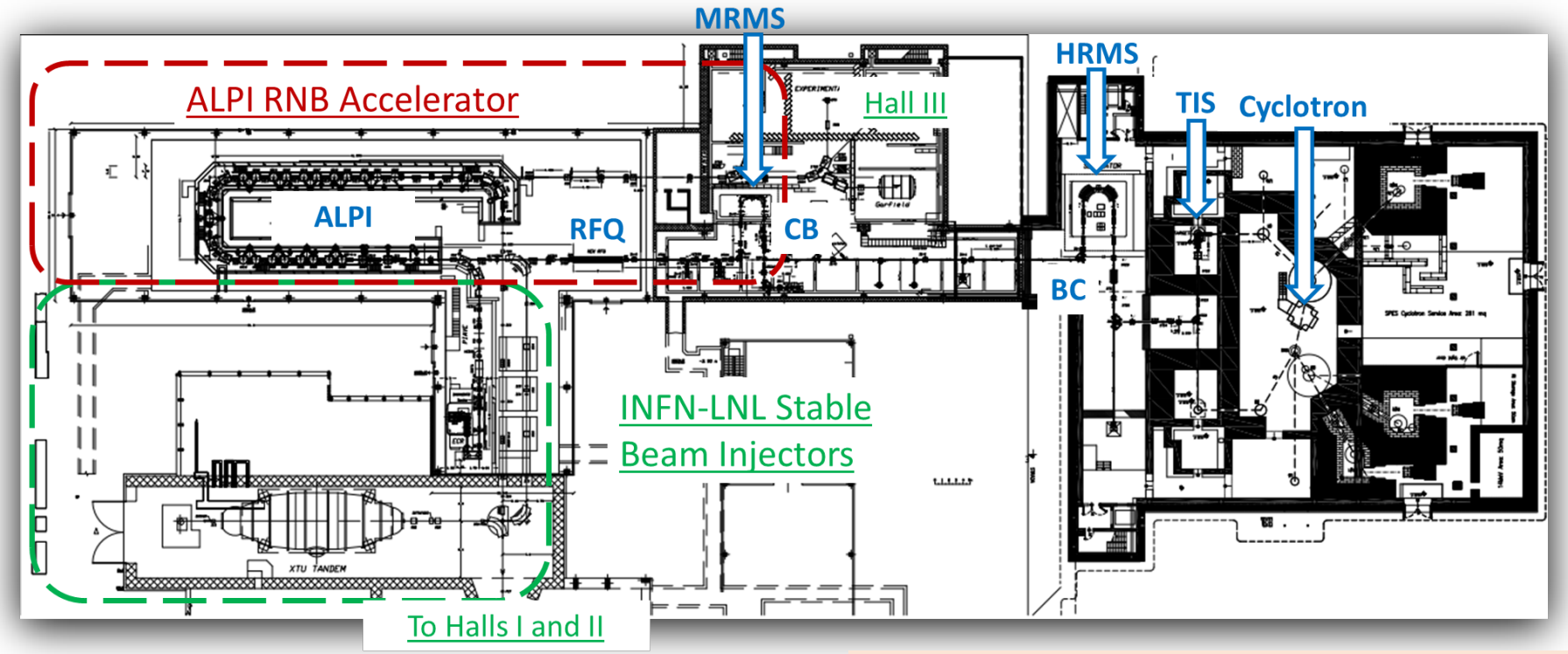
2019-20

4. Two new high energy cryostats (CR21 and CR22)
5. New RFQ and injection into ALPI

ADIGE-ALPI Plan 2018-2020

- Tandem up to May 2018, ALPI-PIAVE up to end of March 2018
- SPES Installations (installation plan in progress): 3 projects, April-December 2018
  - **ADIGE**: as explained (coordinated by A. Galatà and C. Roncolato)
  - «**ALPI-Criostati**»: Displacement of 2 PIAVE QWR cryostats in positions CR01 and CR02 of alpi, replaced by 1 additional 80 MHz QWR buncher in PIAVE (coordinated by P. Modanese).
  - «**ALPI-Magneti**»: new lenses and PS in ALPI, gradient from 20 to 30 T/m (coordinated by O. Carletto)
- Tandem-ALPI-PIAVE Operation: January-July 2019
- SPES Installations: RFQ and ALPI Injection (2019-2020)
- Overall beam commissioning follows

Presentation Scheme



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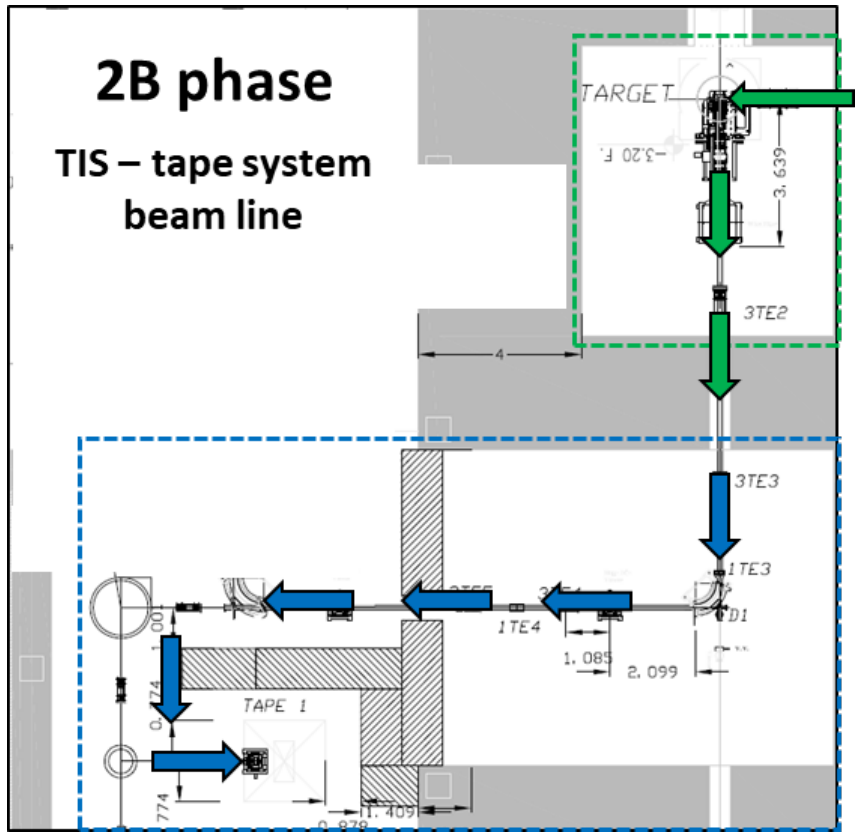
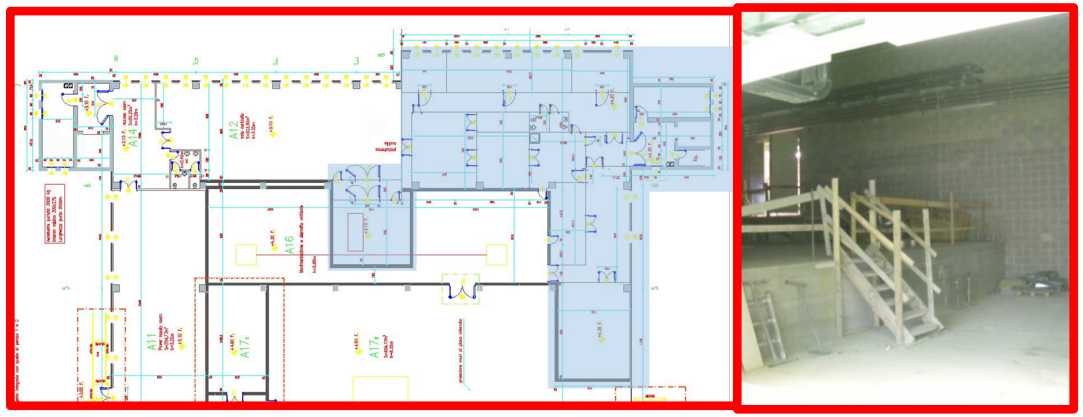
Working plan for the SPES 1+ beam line



Working plan and follow-up for the three main working programmes:

1) RIB Bunker operation
2) 1+ beam line operation
3) SPES ISOL laboratories construction and operation (upper floor)



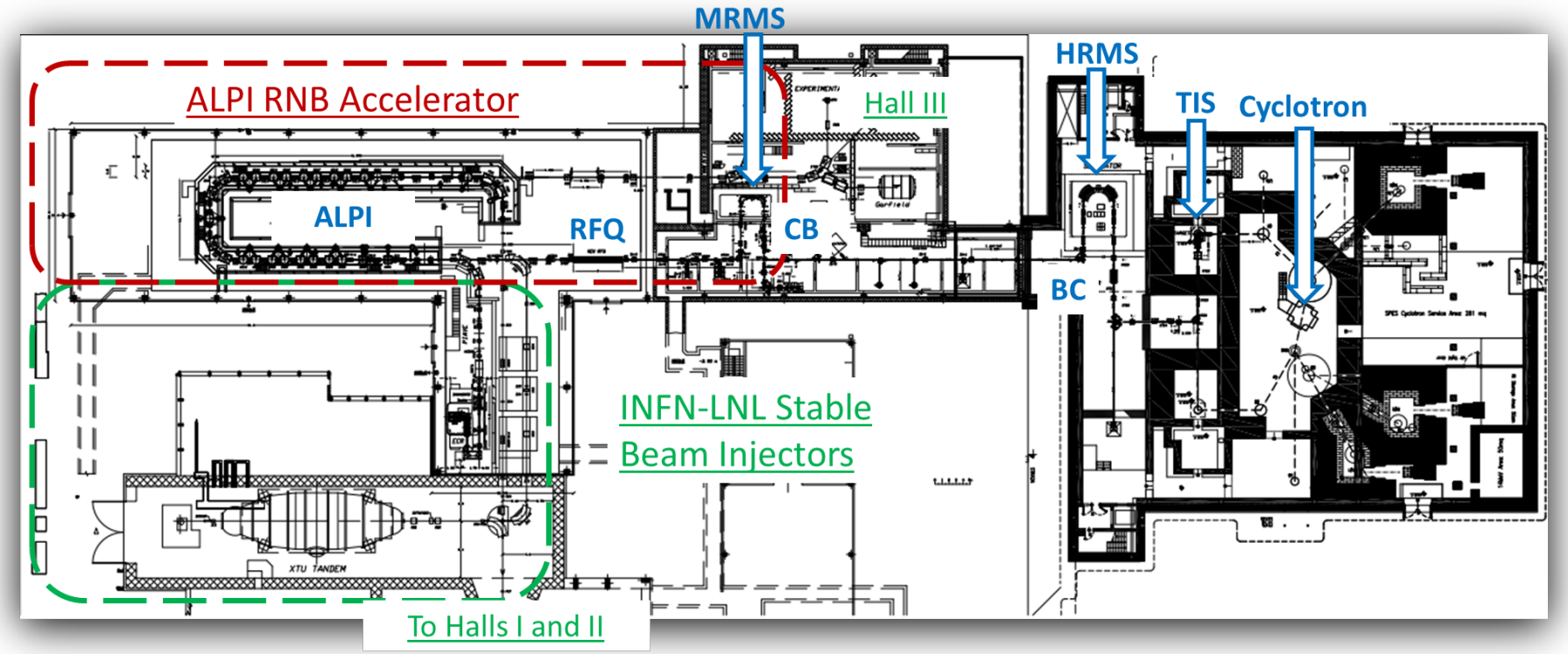
D. Scarpa

1+ beam line time schedule

Main Tasks	2017				2018				2019				2020			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
A6 room (bunker)																
installation of the main plants and subsystems required in the ISOL rooms																
mechanical installation of the primary/proton beam line and of the protonic front-end																
mechanical installation of the front-end, of the Wien filter, of the electrostatic quadrupole triplet and of all the																
cabling & piping for the apparati inside the A6 room																
primary beam line test with low intensity proton beam in the high power Faraday cup																
secondary beam line test with stable ion beams																
primary and secondary beam lines commissioning																
A5 and A13 rooms (experimental hall)																
completion of the general 1+ beam line design & layout																
construction of the electrostatic dipoles (SPES design) → production @ LNL and preliminary test at the SPES off-line front-end laboratory																
construction of the electrostatic triplets (SPES design) and of the beam diagnostic boxes → external company																
magnetic dipole construction																
mechanical installation of the main components (magnetic dipole, electrostatic dipoles, electrostatic																
cabling & piping for the apparati inside the A5 and A13 rooms																
operation with stable ion beams along the 1+ beam line																
1+ beam line commissioning with stable beams up to TS																
SPES facility																
RIBs delivered at the tape system																

A. Andrighetto

Presentation Scheme



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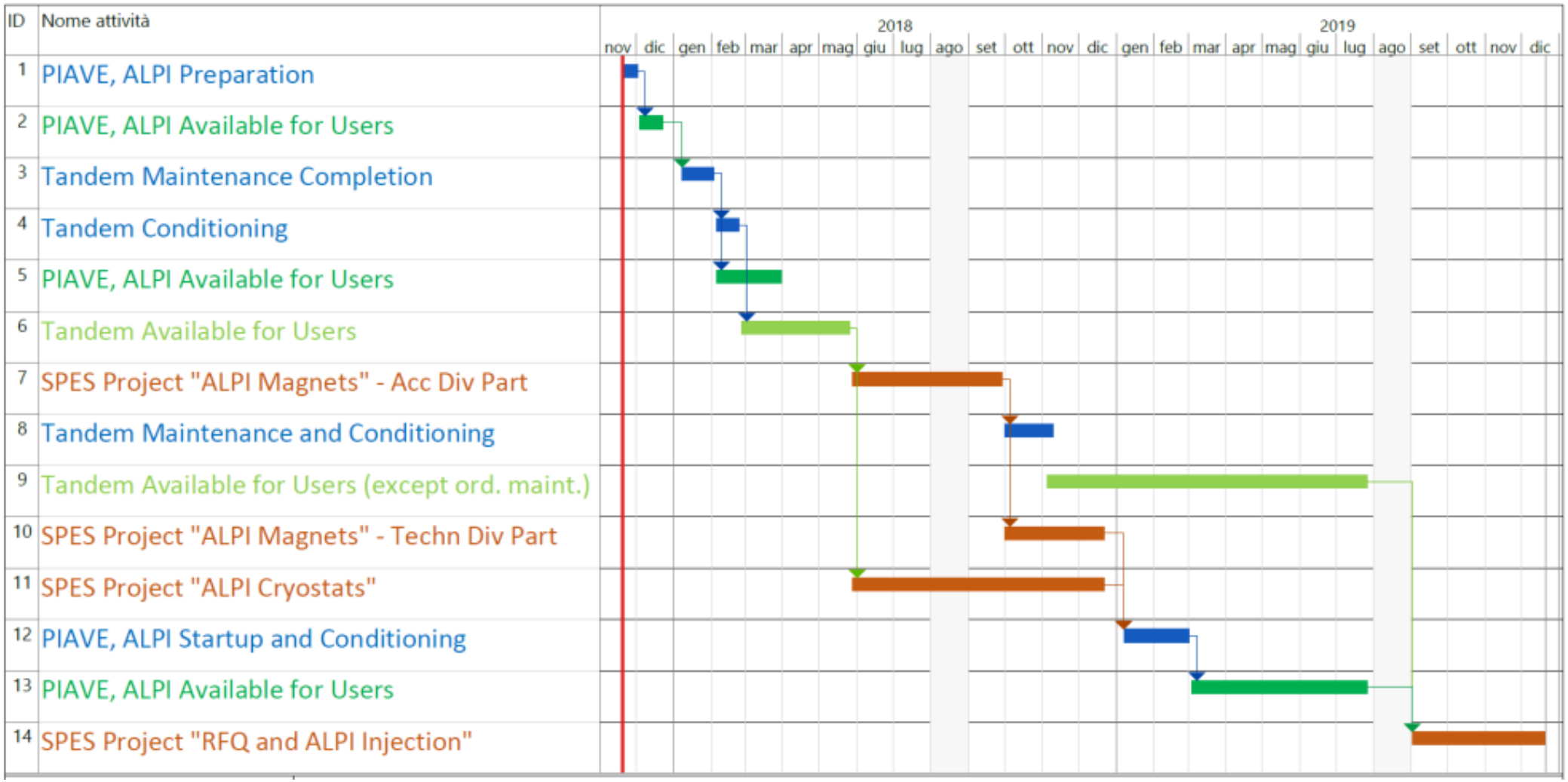
Tap operations and adige installations plan

TAP activities	2017				2018				2019				2020				2021			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Tandem Sp. Maint. and availability																				
PIAVE Sp. Maint. (since 2015) and availability																				
ALPI Repl.of the cryog. CS and availability																				
TAP operators on ADIGE transport																				
SPES-"ALPI Cryostats" - CR01 and CR02 fro P to A																				
SPES-"ALPI Magnets" - 10 new QM in A																				
ADIGE Injector preparation																				
Experimental Phase 1 (SI+PIS before the CB)																				
CB characterization with MRMS (no injected beam)																				
CB characterization with MRMS (w/injected beam)																				
Beam injection tests to RFQ Input																				
Installation from RFQ to ALPI																				
RFQ Installation																				
RFQ HW Commissioning																				
Beam Commissioning Phase 3a. (RFQ-to-ALPI)																				
Overall Beam Injection CB into ALPI																				
First RNB beams in ALPI																				
GRAPPA Injector preparation																				
Preparation of TIS including LE Beam Lines																				
LE Exotic Beam Available																				

Detailed Plan 2018-2019 (if T ok)



Conclusion

- Operation on PIAVE-ALPI will be resumed on Dec 4, 2017 after successful upgrades
- Tandem restoration will be completed in January, operational (if…) from the end of February 2018 (meanwhile PIAVE-ALPI beams from Feb 5)
- PIAVE-ALPI will continue operation till end of March 2018, followed by SPES installations «ALPI-Criostati» and «ALPI-Magneti» till end of 2018.
- Tandem will continue operation till end of May 2018, followed by SPES installations «ALPI-Magneti» carried out by the operation group till end of 2018.
- January-July 2019: TAP operation.
- SPES final installations will follow.
- First low energy RNB beams in 2020, first reaccelerated beams in 2021, according to present schedule.