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LNL Accelerator Facility: status, upgrades and perspectives

Francesco Grespan – ECOS2012

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- The LNL accelerator facility
- Performances and recent results
- A comparison with Argonne
- In-progress upgrades
- Future perspectives: the SPES project

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The LNL accelerator facility

The LNL accelerator facility

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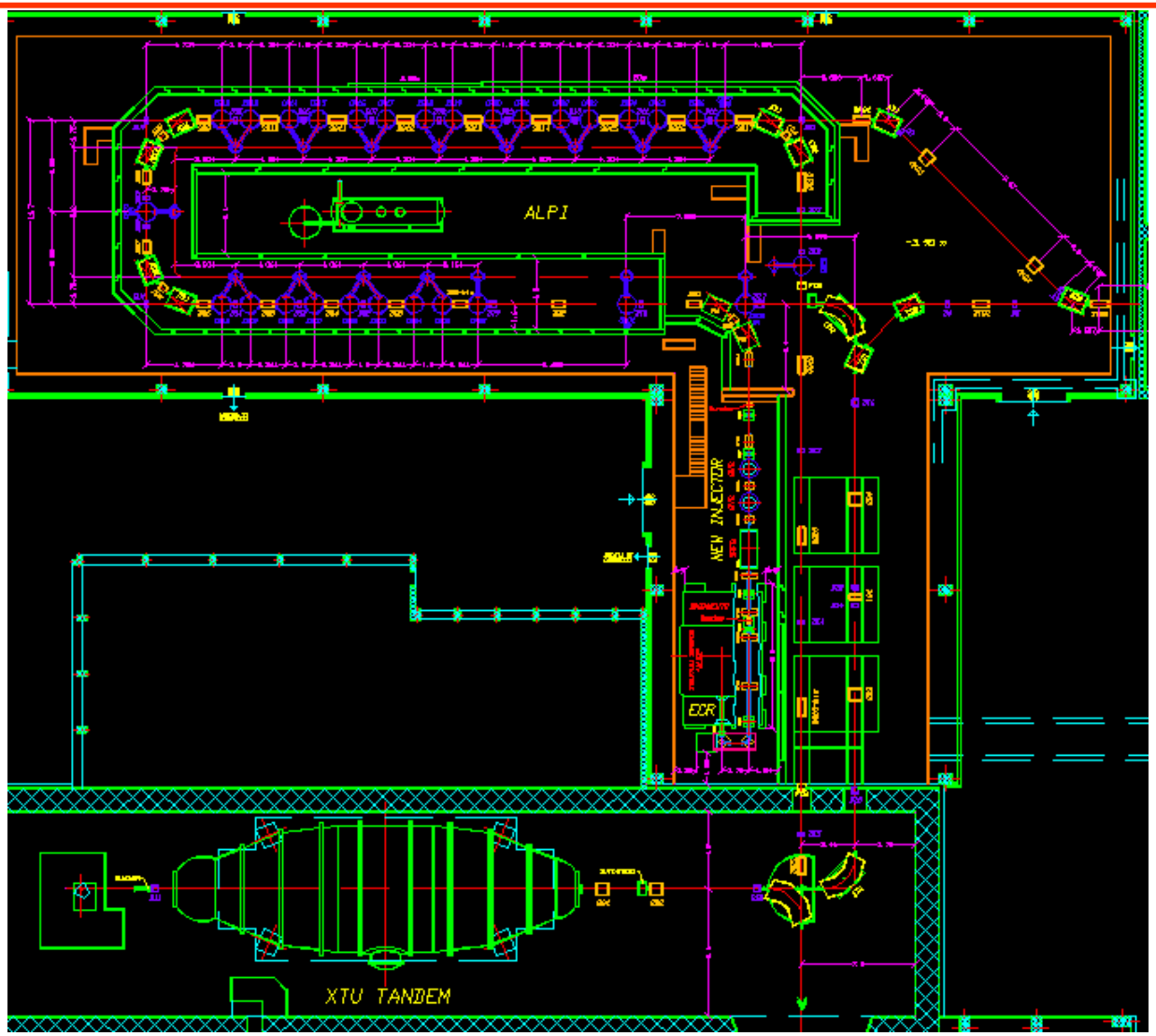
ALPI:
- 16 QWRs 80 MHz (full Nb)
- 44+8 QWRs 160 MHz (Cu/Nb)
- β=0.13

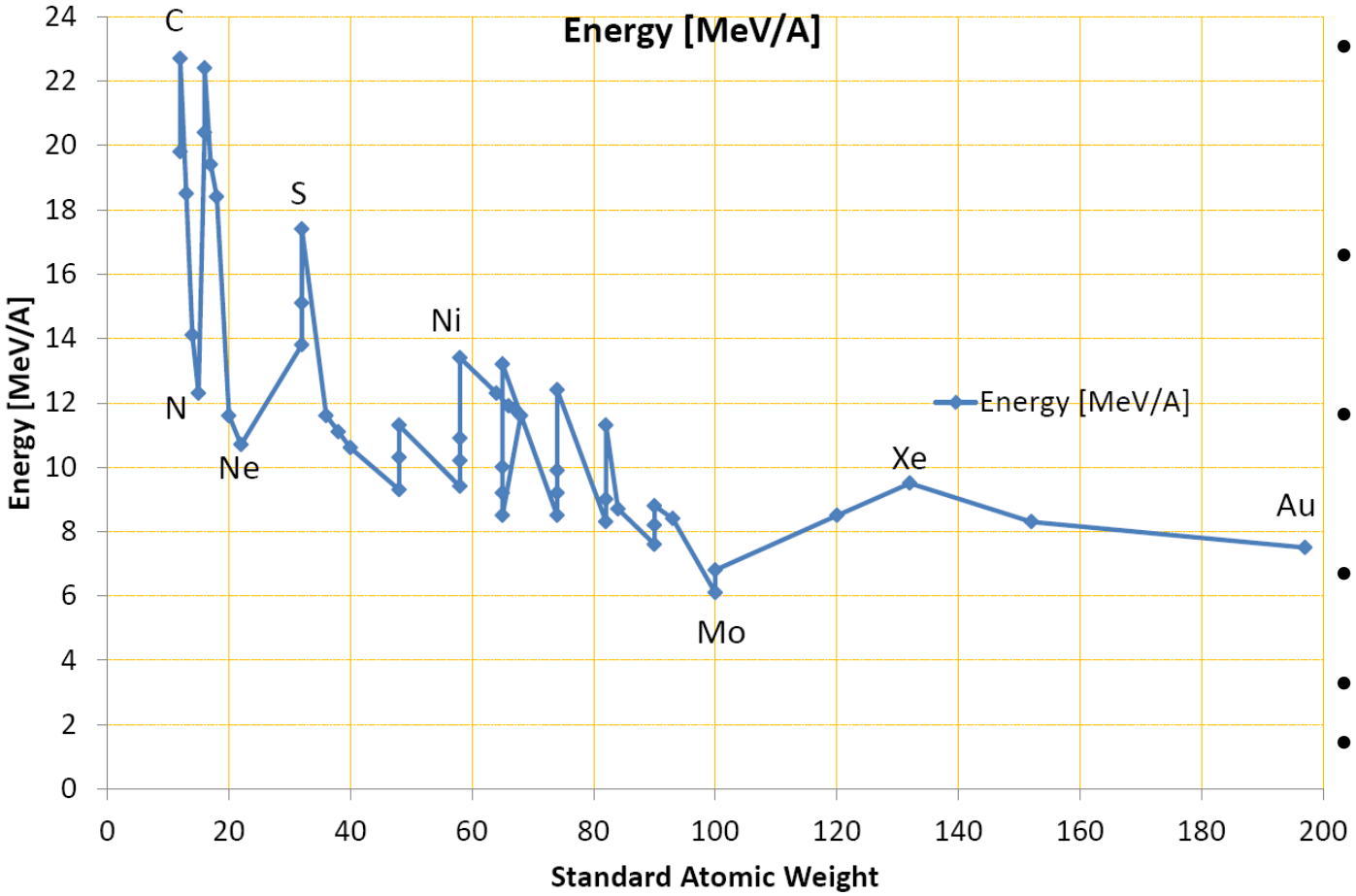


PIAVE:
- ECR source
- 2 s.c. RFQs 80 MHz (Nb bulk)
- 8 QWRs 80 MHz (full Nb)
- β=0.051

TANDEM:
- 14.5 MV
- from 1H to 197Au
- excluded noble gas

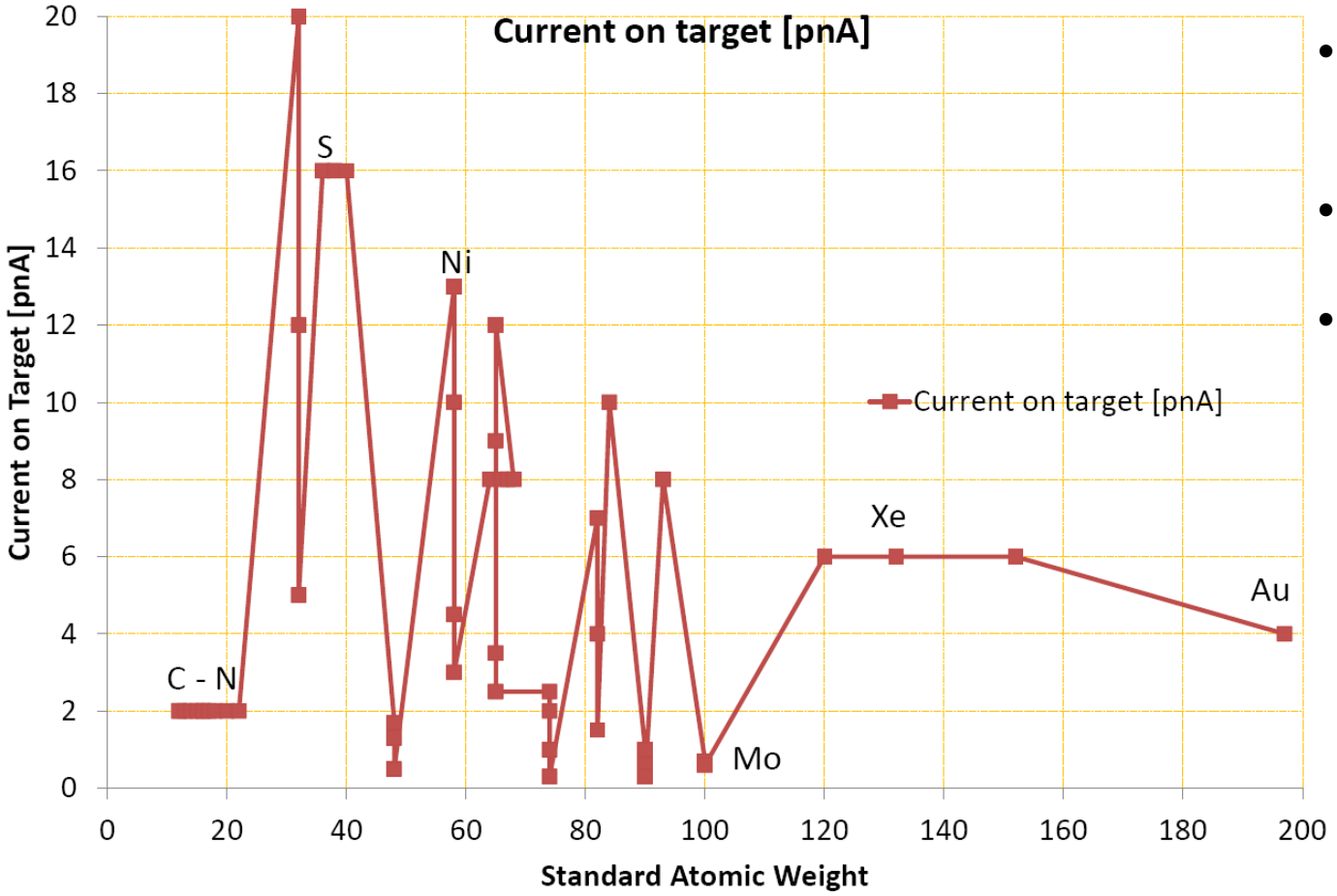
The LNL accelerator facility

Performances



- The PIAVE-ALPI complex is able to accelerate beams up to A/q = 7.
- Average gradient on Low Beta cavities of 4 MV/m.
- Average gradient on Medium Beta cavities of 4.3 MV/m.
- The CR20 is off (Margin).
- Cavity CR14-2 is off.
- The CR04 is off.

Performances



- Radiation protection requirements (2 pnA for light ions)
- Tandem stripper lifetime
- Maximum current through the superconducting RFQs (2 uA)

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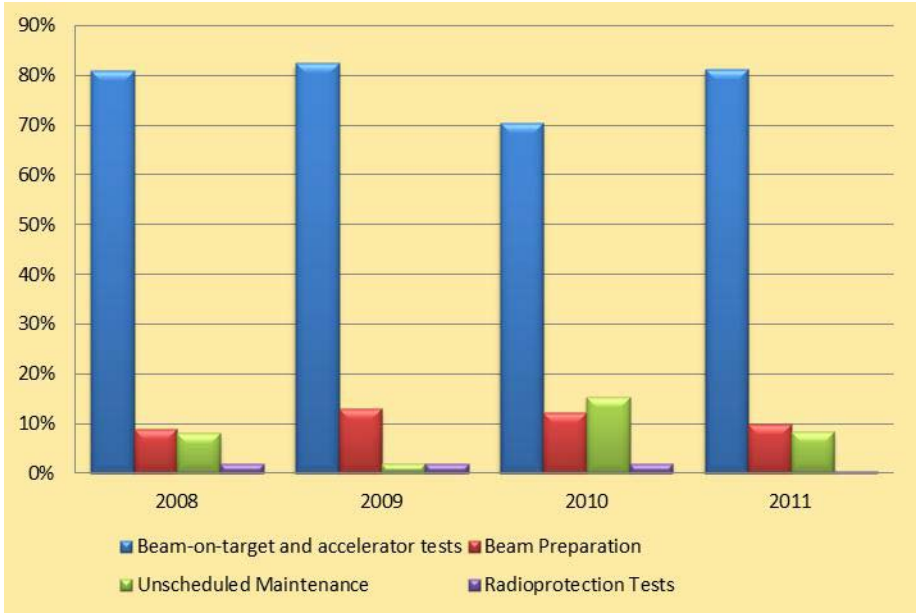
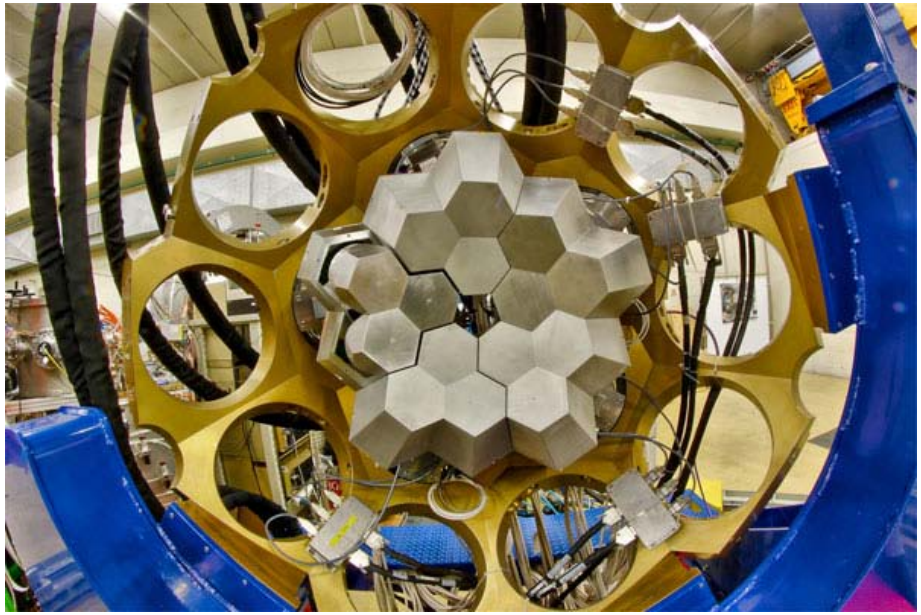
Recent results: AGATA





AGATA

- 20 experiments in 2010 and 2011
- $^{136}Xe^{26+}$ at 1130 MeV: 8.3 MeV/A, all available cavities running on
- Cryogenic power: 650 W

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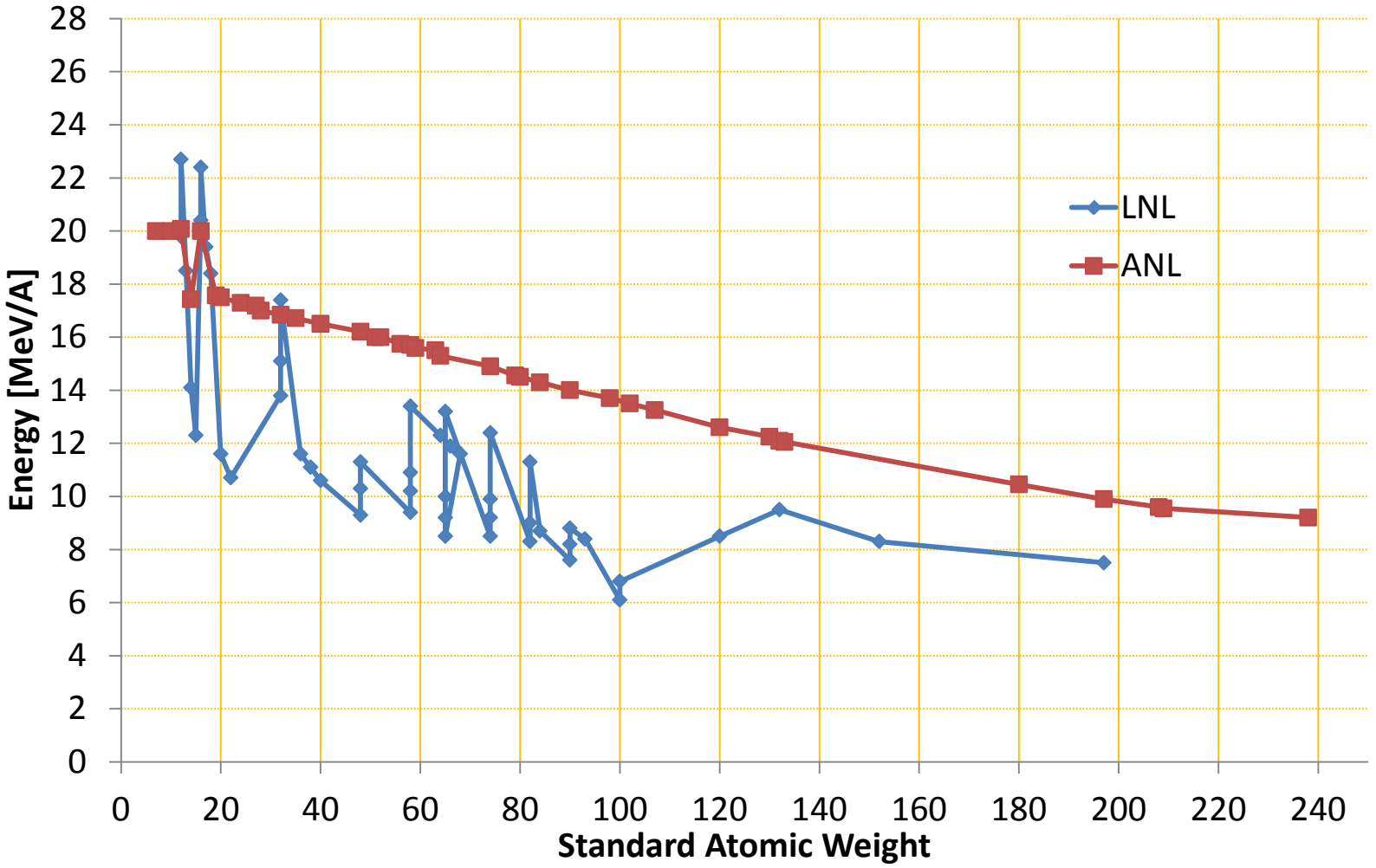
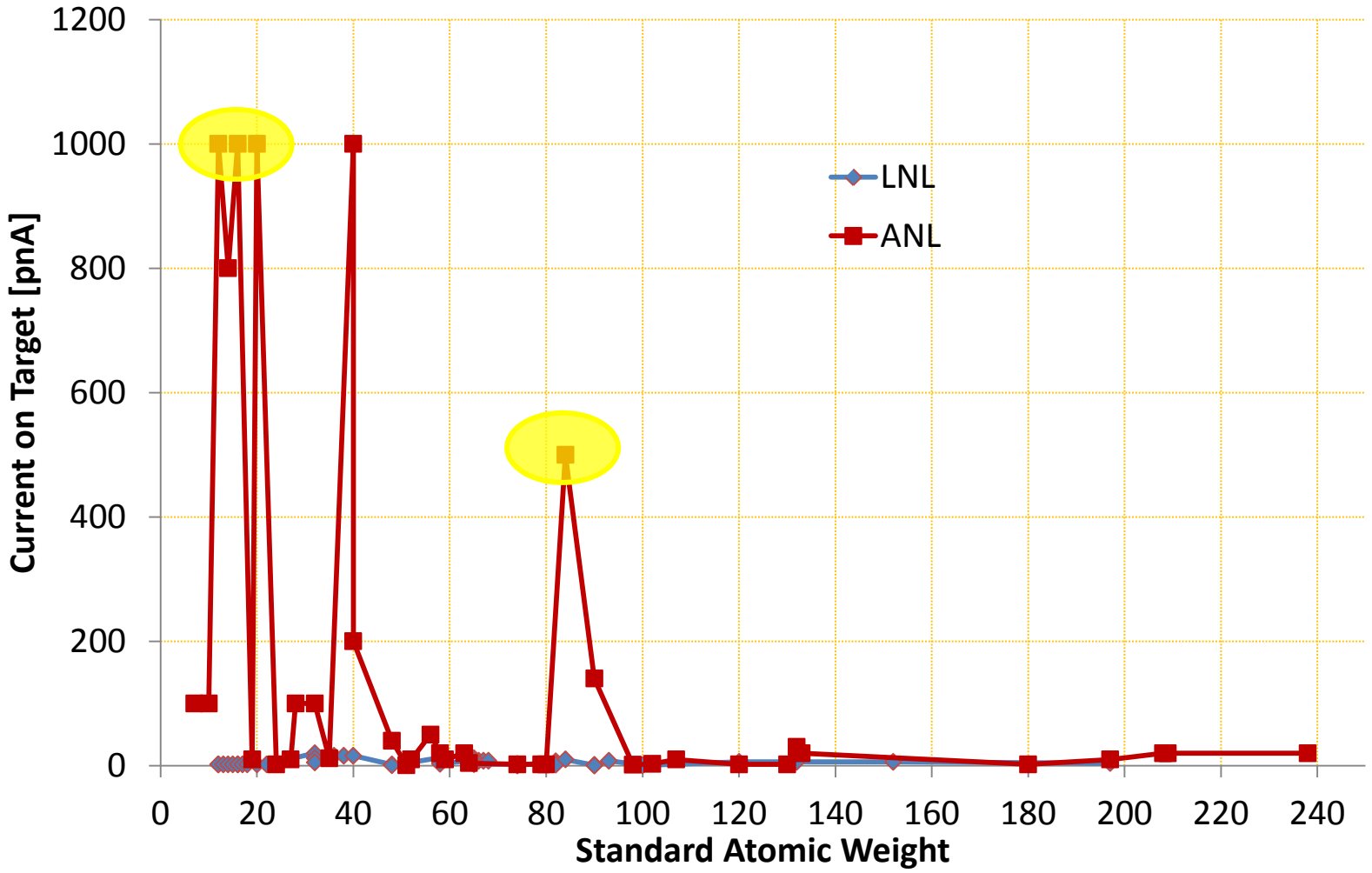
Comparison LNL-ANL

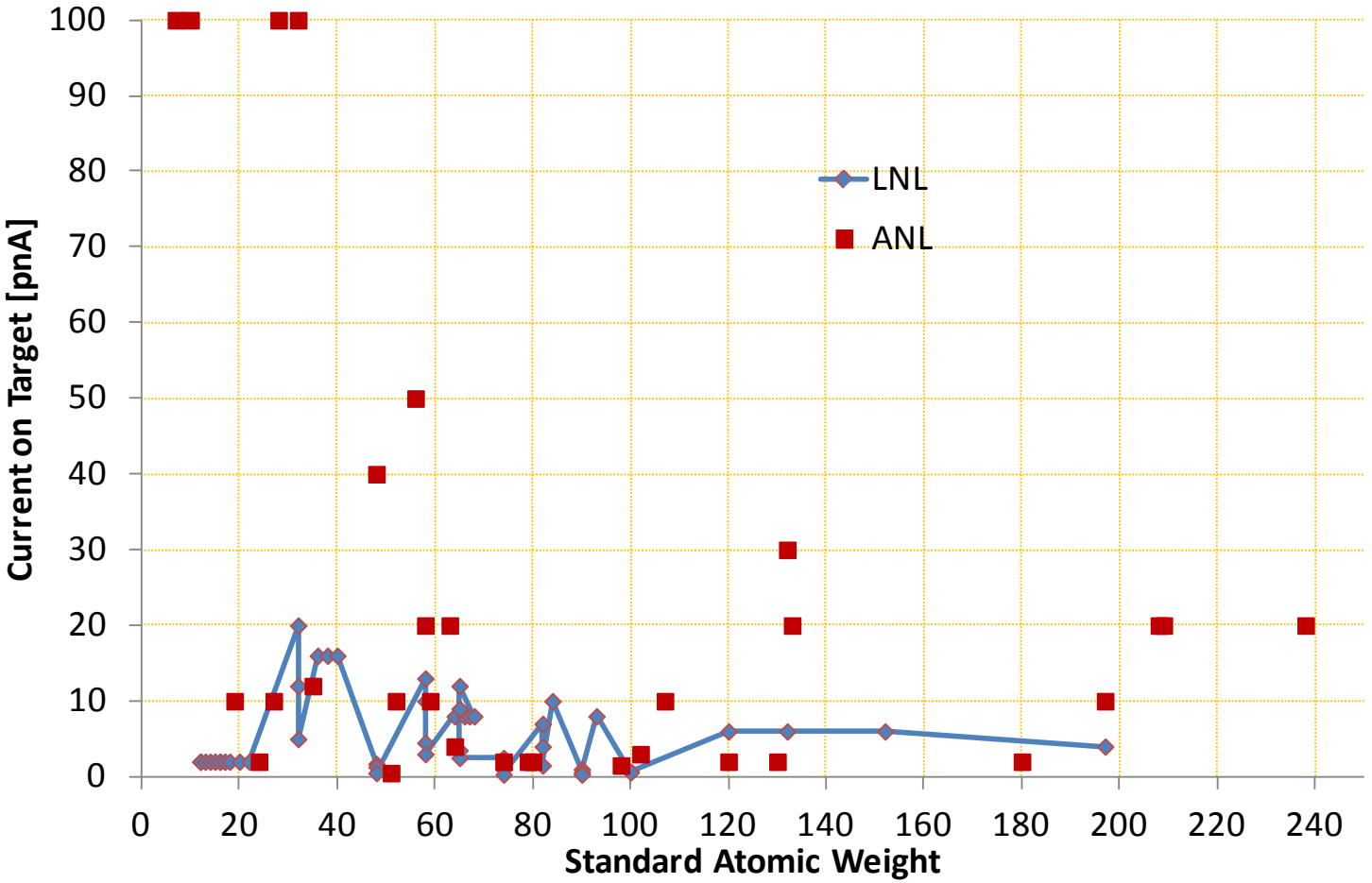


Comparison LNL-ANL



ANL: Allowed maximum radiation may limit beam current.

Comparison LNL-ANL



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PIAVE-ALPI In-progress upgrades

- New ECR beams
- Low-β section upgrade
- Accelerator alignment
- 3° cryogenic turbine

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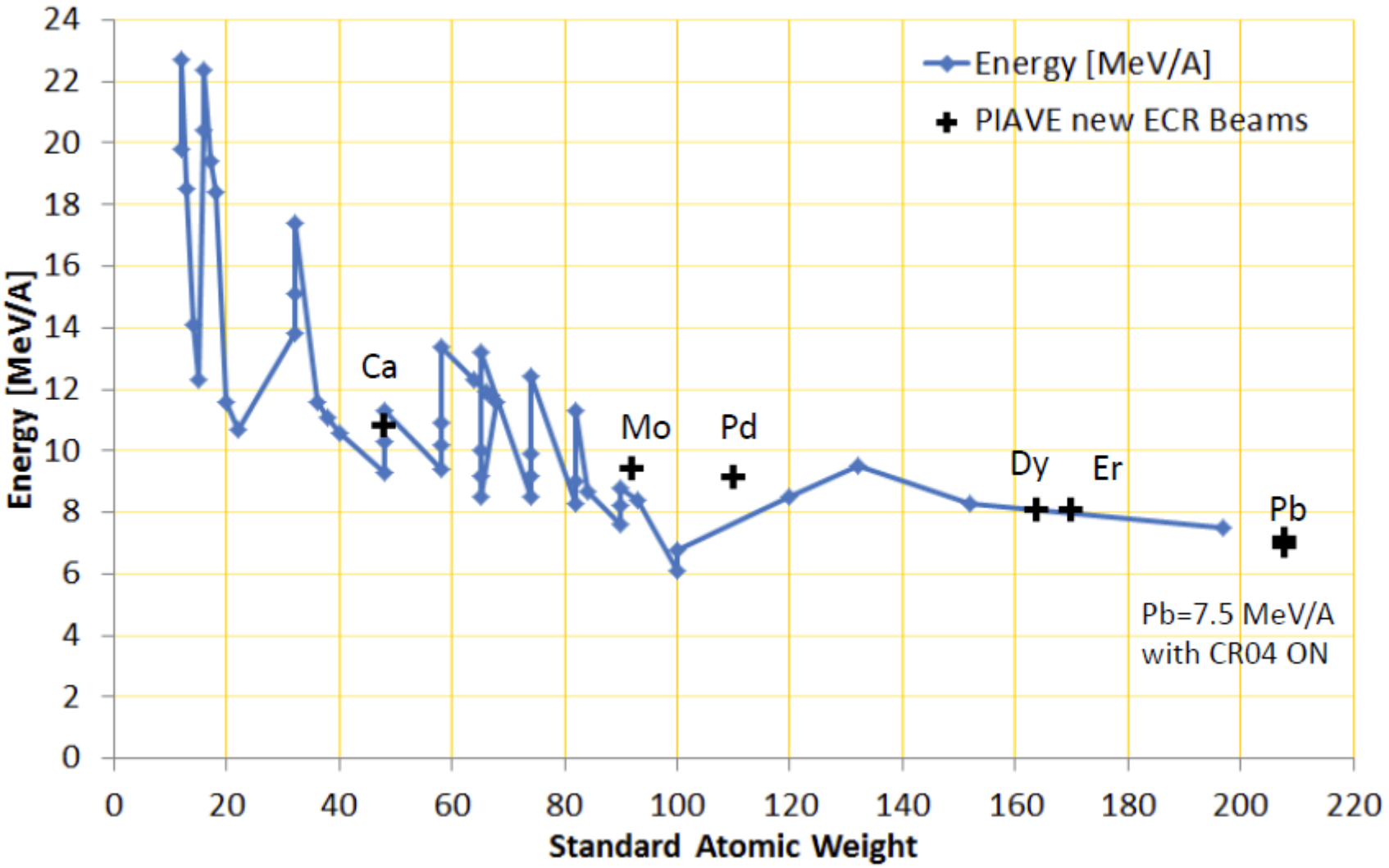
New ECR beams (energies)



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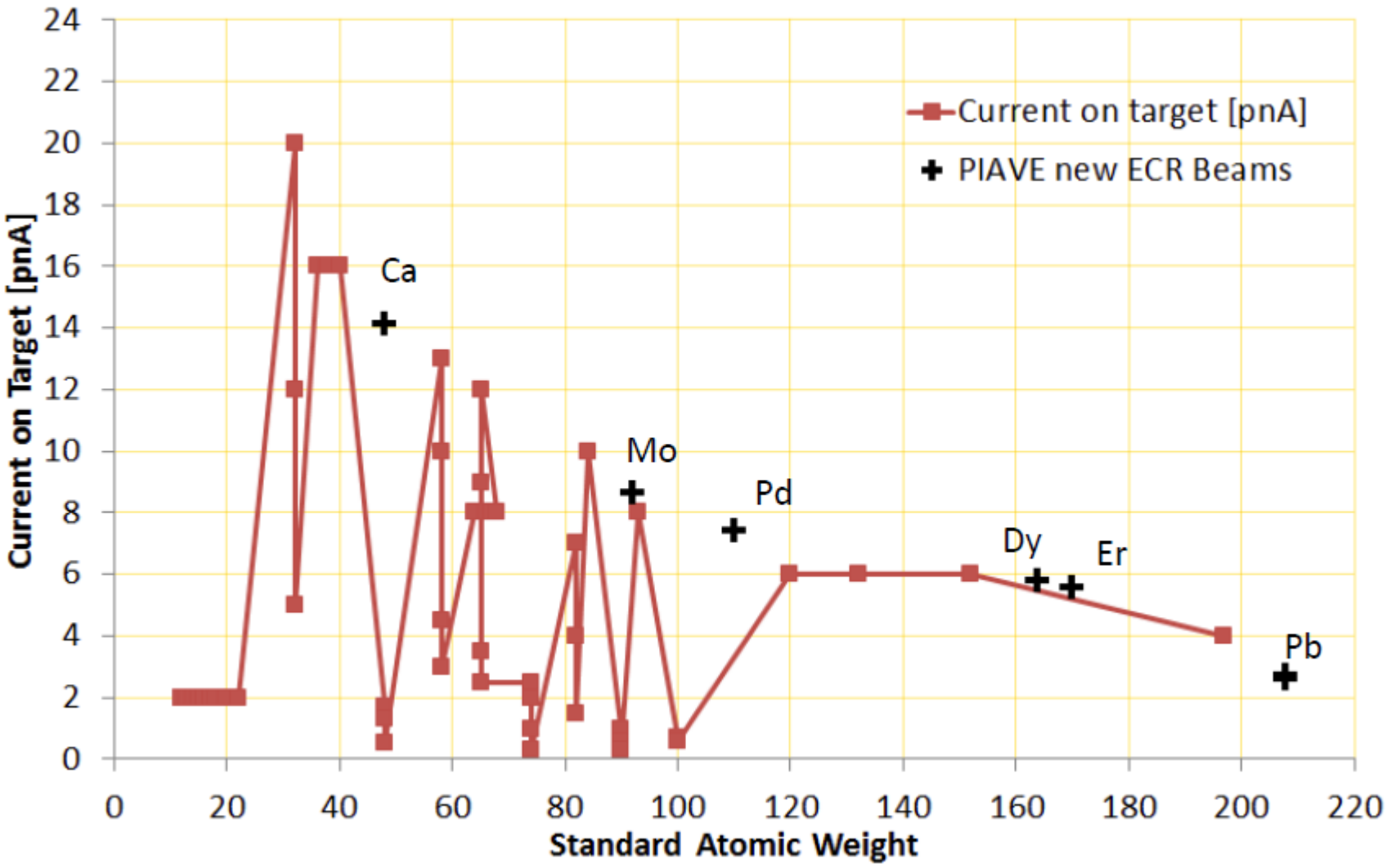
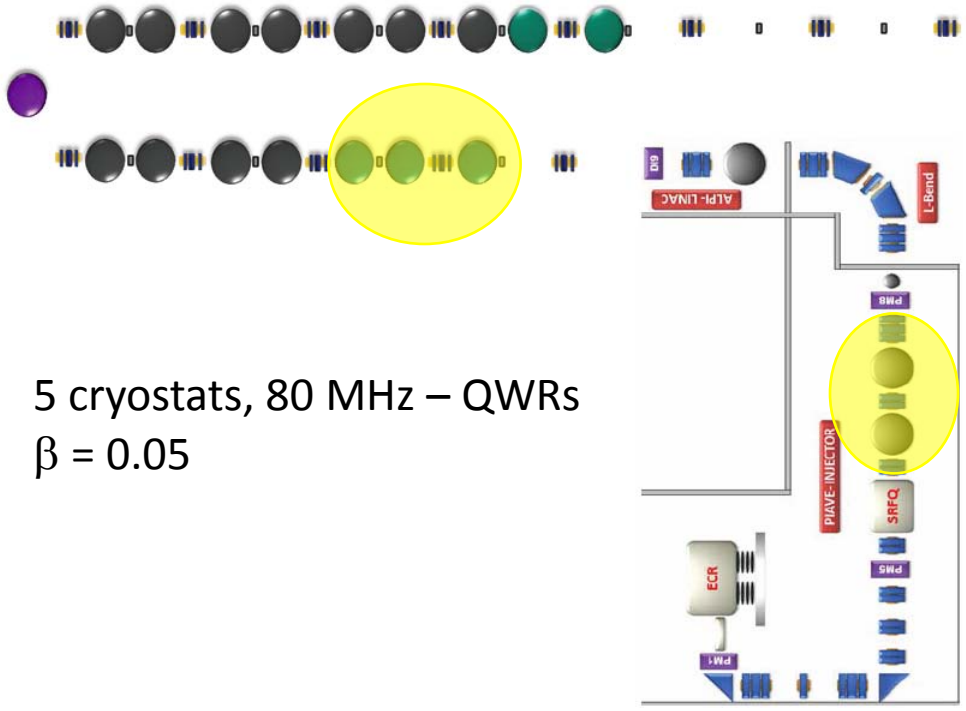
New ECR beams (currents)



Low β section upgrade

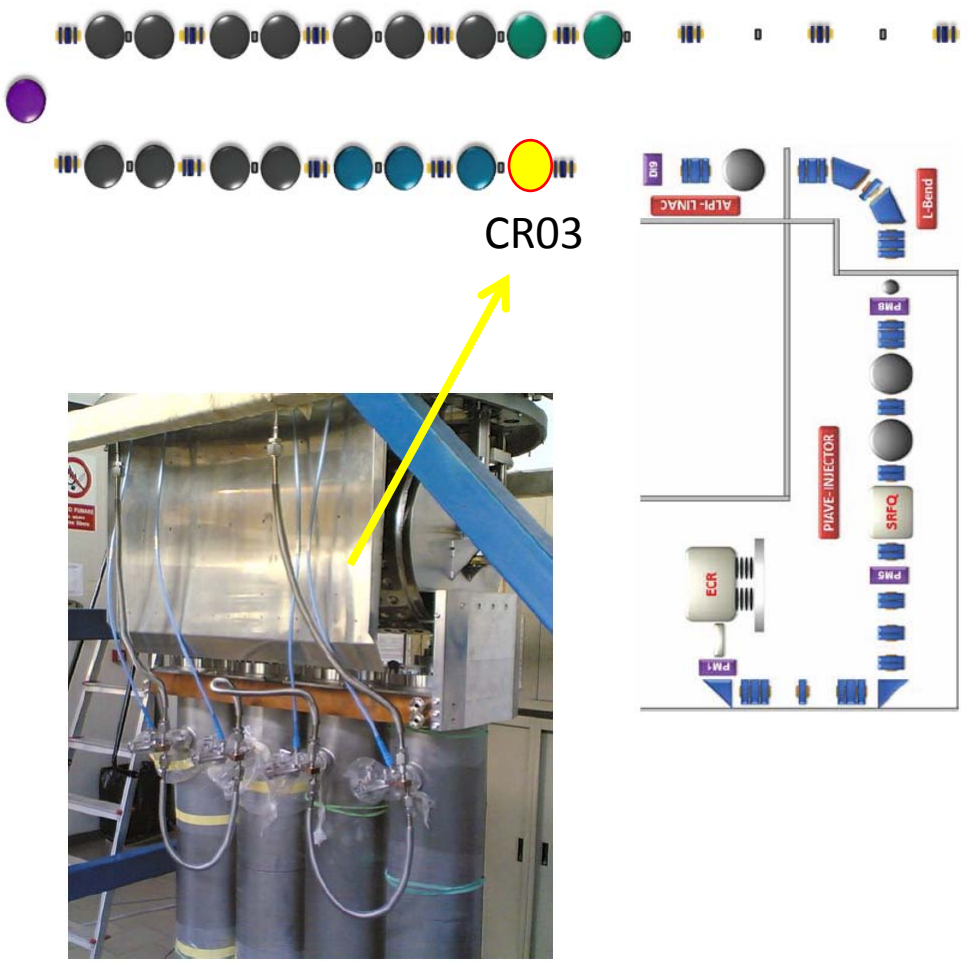


5 cryostats, 80 MHz – QWRs
β = 0.05

- High A/q ions suffer from a too low injection energy to the medium-β cryostats
- Reliable operation of the cavities in the presence of environmental noise and Helium pressure fluctuations

Low β section upgrade

- ✓ replacement of all RF amplifiers 150W->1kW
- ✓ construction, installation and testing of the first upgraded cryostat with N-liquid cooled coupler (CR03-2011)
- ✓ E_{acc} : 3MV/m ->5MV/m
- Funded and in-progress the upgrade of the 5 remaining low-β cryostats with the cooled couplers



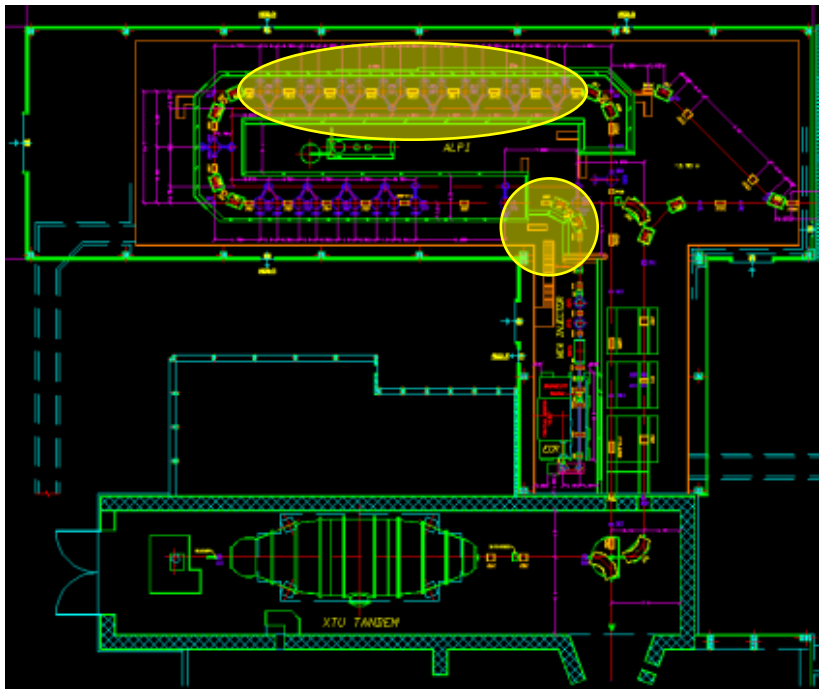
Medium β section upgrade

- β=0.11, 160 MHz:
  - new beam port design
  - rounded shorting plate
  - capacitive coupler
  - no holes in high current regions
  - no brazing in the outer resonator body
  - E_{acc}: 4.5MV/m -> 6 MV/m at 7 W (CR15)

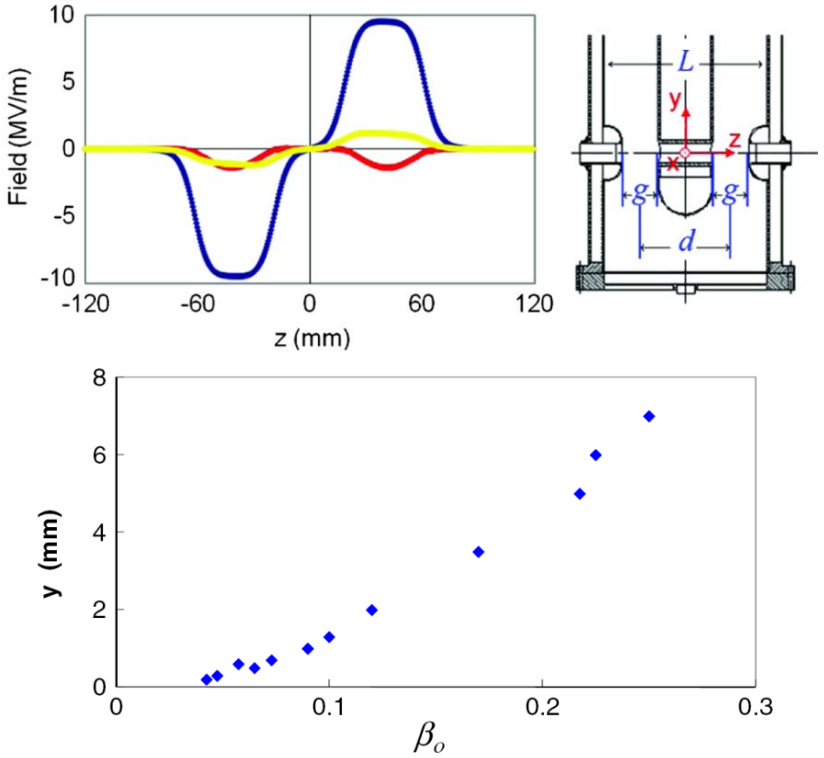
Priority use of the facility to deliver beams to the experimental stations for a large fraction of the time.

Alignment with Laser Tracker

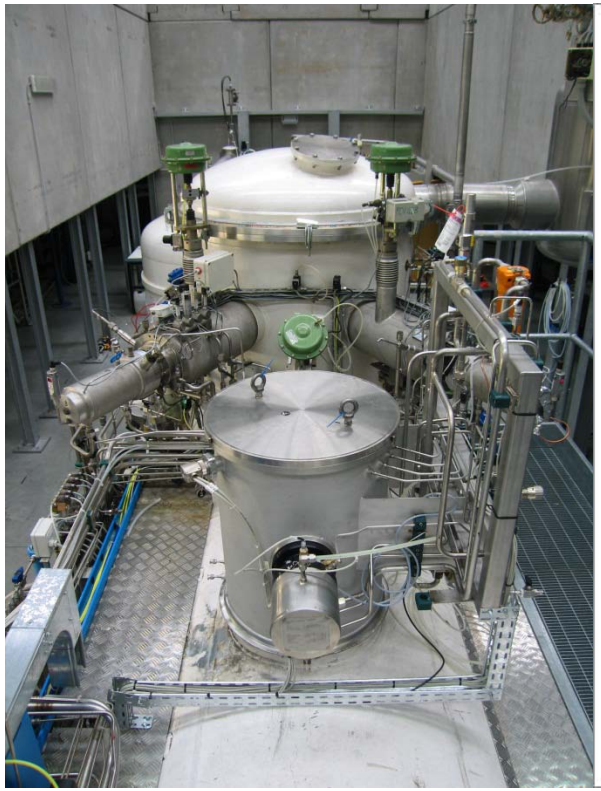
- Correction element misalignments of elements along beam line (~ mm!)

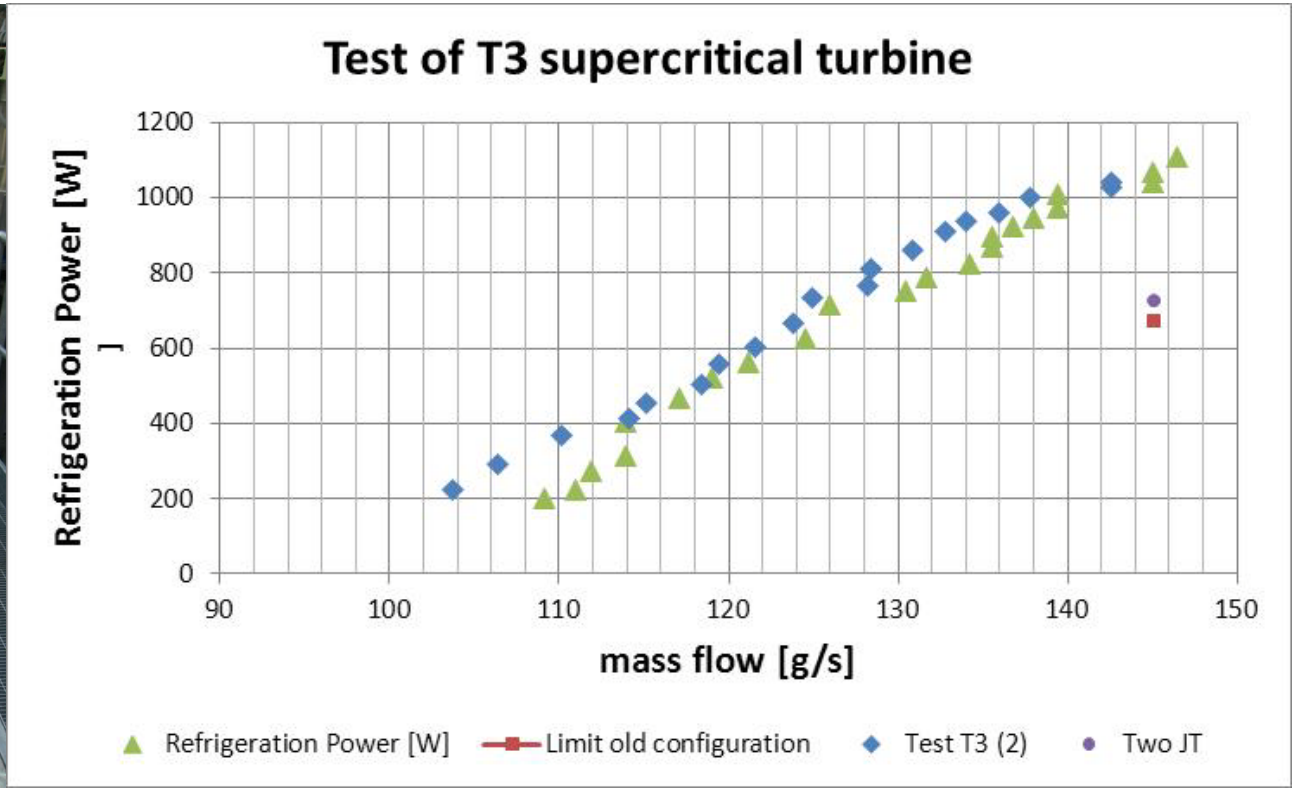


- Correction of the QWR beam steering effect by offset beam axis



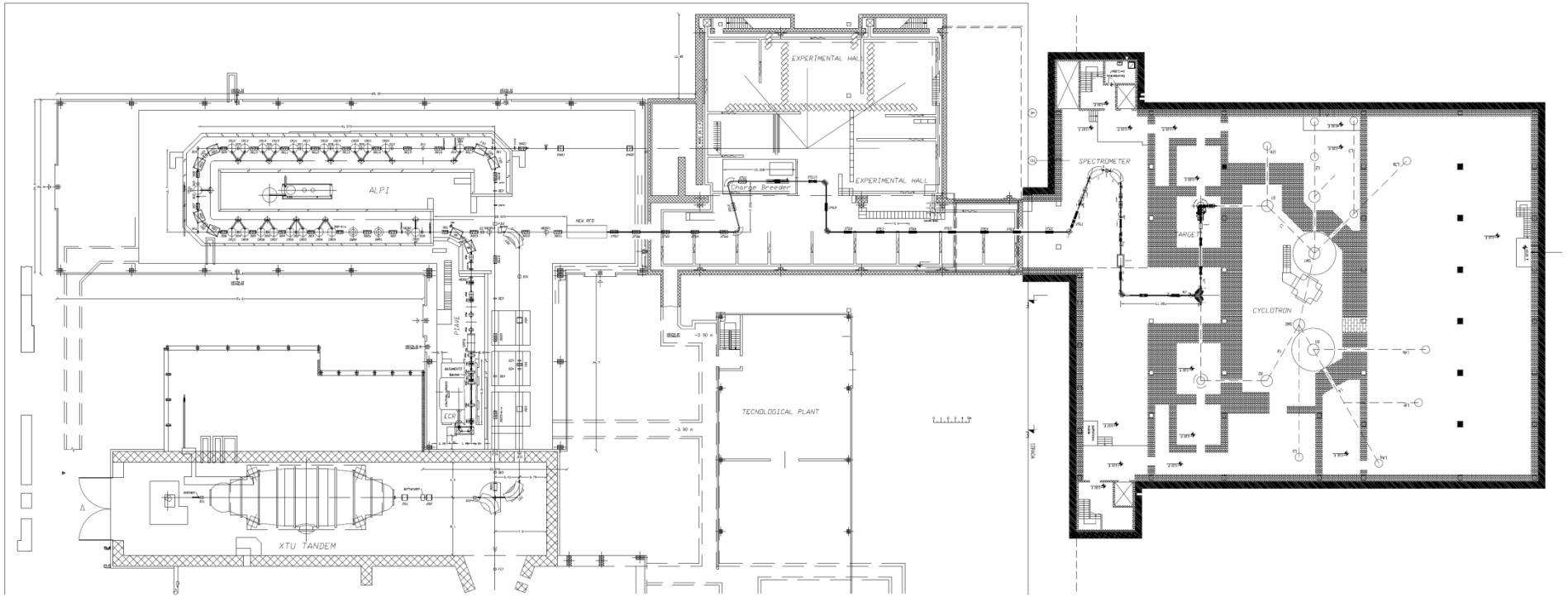
Cryogenic upgrade: 3rd turbine





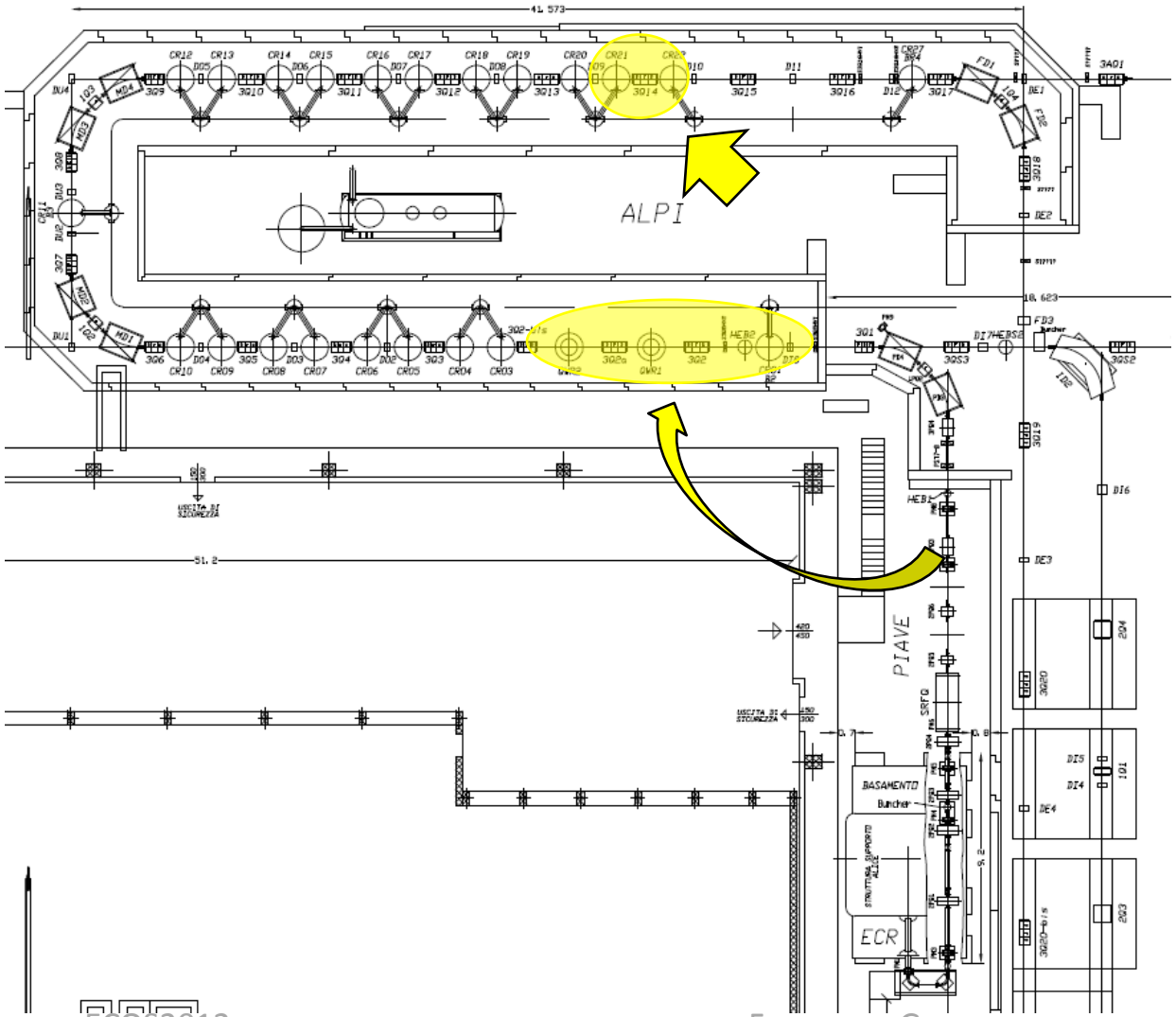
Increase the refrigeration capacity at 4.5 K:
300 W = 200 W [redundancy] + 100 W [dissipation]

Future perspectives: SPES



- Cyclotron (70 MeV, 0.75 mA)
- Direct Target (UCx, 10^{13} fission/s, A= 80-130)
- Wien filter & RFQ cooler
- High resolution spectrometer (1/40000)
- Charge Breeder (5.7 keV/u)
- New RFQ (80 MHz, 5.6m, 727.3 KeV/A)

New PIAVE-ALPI layout



- Stable beams from PIAVE and Tandem
- PIAVE current: 5 uA
- 2 further cryostats in high β (7 MV/m)
- PIAVE QWRs moved into ALPI line, with quadrupole in between
- Low β: 5 MV/m (upgraded)
- Medium β: 4.5 MV/m (not upgraded)
- Magnetic Quad: 20 T/m.

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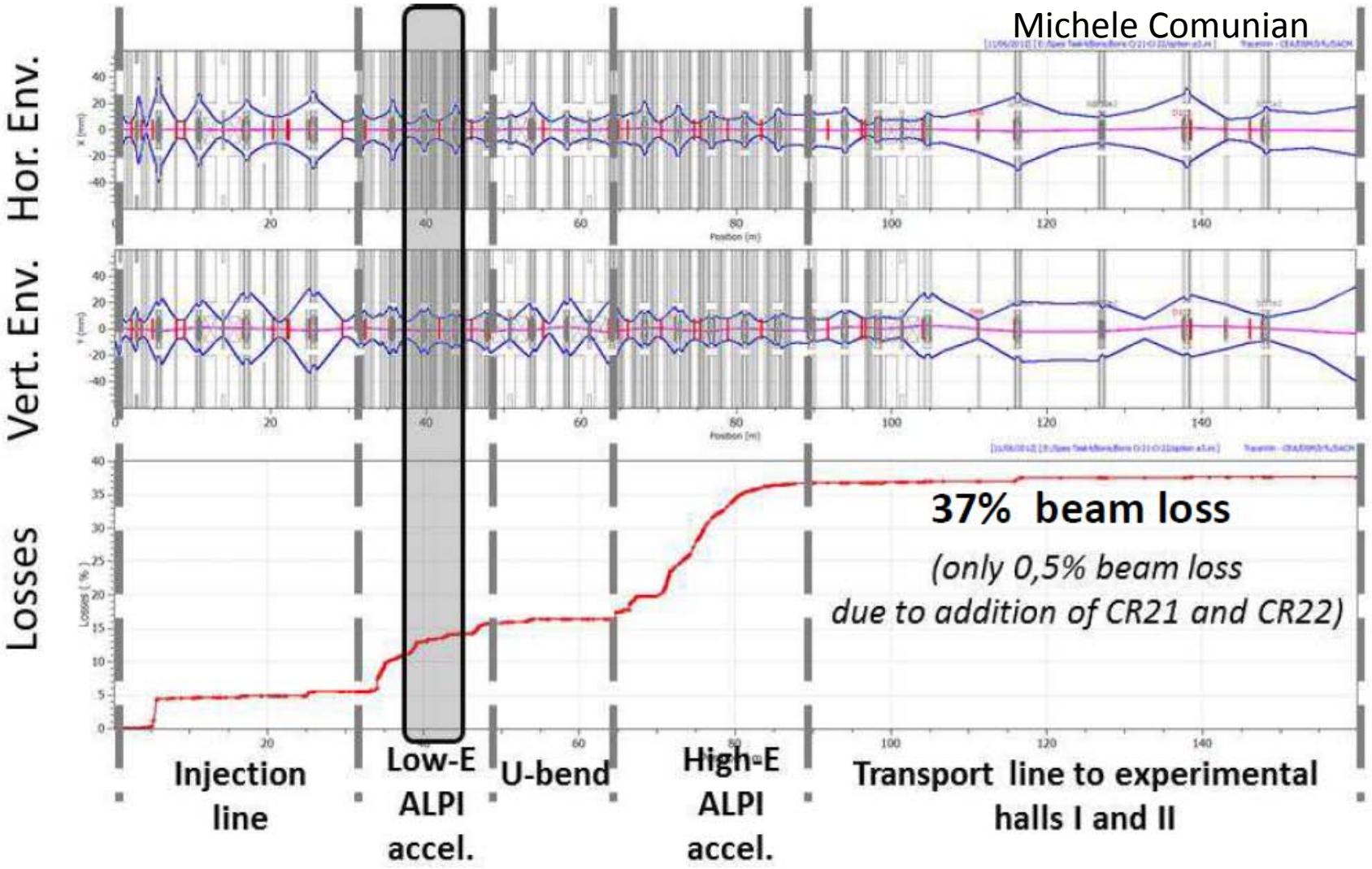
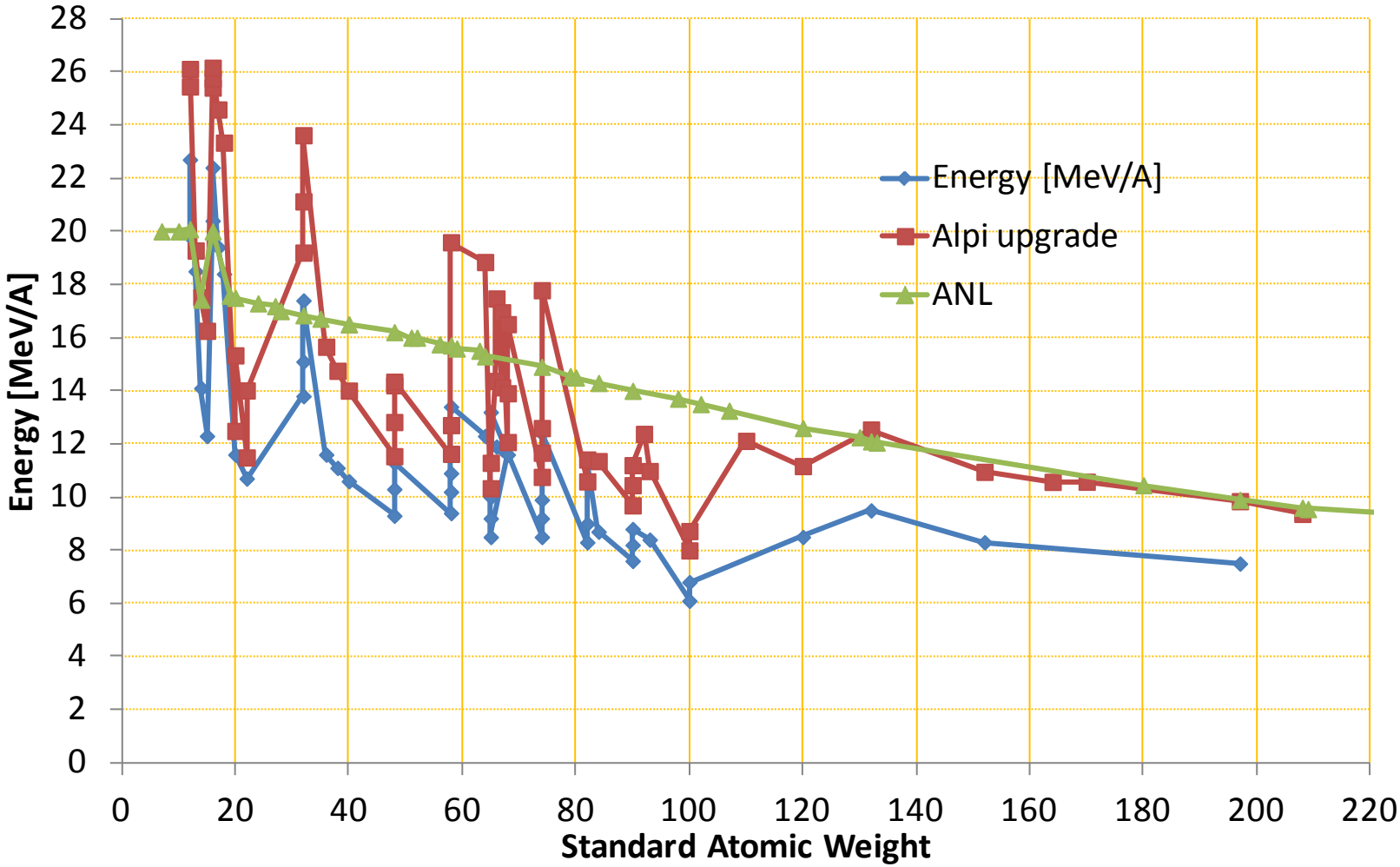
$^{208}Pb^{30+}$ on the modified Linac



Performances of the modified Linac



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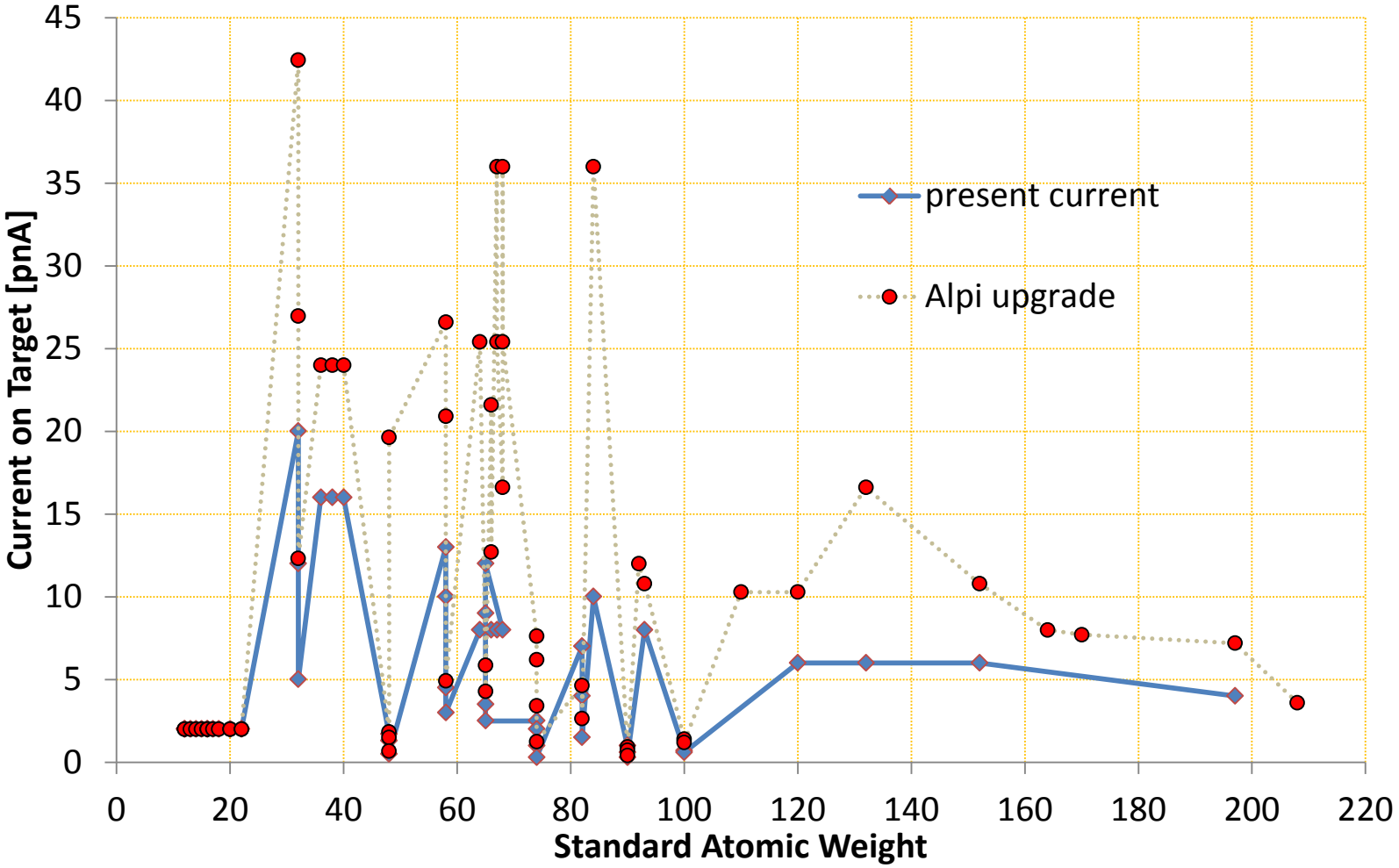
Performances of the modified Linac



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Conclusions

- In-progress upgrades → immediate benefits (beam species, machine reliability, factor 2 in current)
- Cryostat reshuffling → higher final energies (A/q≈7, 10 MeV/A)

- ECR Source test stand → additional ion species, charge state, higher source currents
- Higher magnet gradient and shorter accelerating period → higher transmission and beam quality

Synergies between LNL and other facilities for recent upgrades

- ECR R&D
- Ganil
- Resonator development
  - Cavity shape
  - Construction technologies (sputtering, welding, surface finishing)
- MSU, CERN
- Vacuum & Cryogenic system
- CERN
- Beam dynamic studies
- ITEP Moscow, IFMIF collaboration

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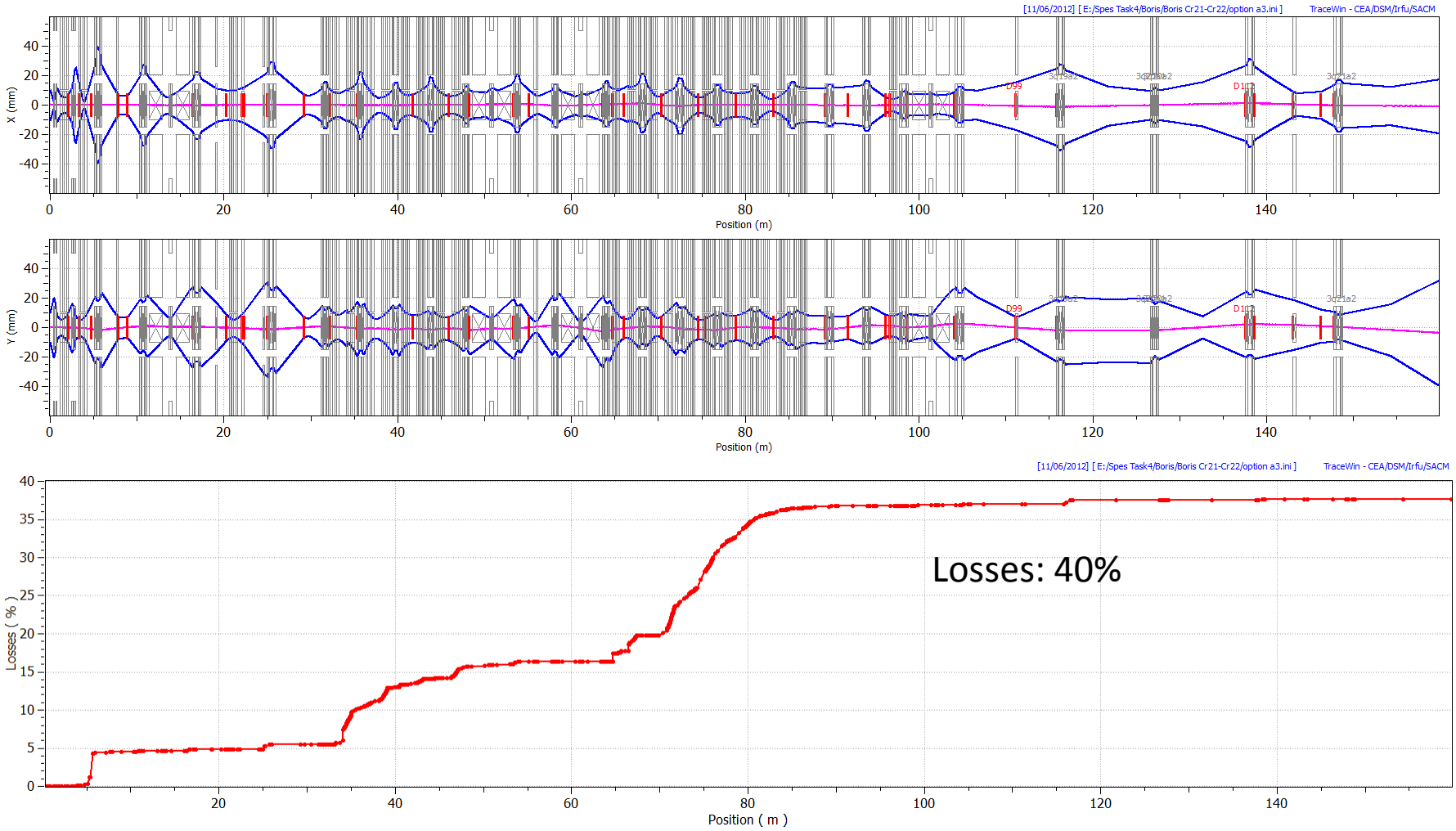
Comparison LNL-ANL

	ANL	LNL
Tandem	9 MV	14.5 MV
Injector Linac	12 MV	9 MV
Linac	40 MV	45 MV
N resonators	62	80
Available Isotopes	30	35
Source currents (pnA)	$^{16}O^{7+}$= 38000 $^{84}Kr^{15+}$=5700	$^{16}O^{7+}$= 280 (T-A) $^{84}Kr^{15+}$= 330
I target (pnA)	$^{16}O^{7+}$= 1000 $^{84}Kr^{15+}$= 500	$^{16}O^{7+}$= 2 (T-A) $^{84}Kr^{15+}$= 10
E target (MeV/A)	$^{16}O^{7+}$= 20 $^{84}Kr^{15+}$= 14.3*	$^{16}O^{7+}$= 20.4 (T-A) $^{84}Kr^{15+}$= 8.7
Hours/year	6000	4000

*V_{eq}=80 MV… new cryo-module?

A.Galatà and R. Vondrasek

$^{208}Pb^{30+}$ on the modified linac



The final energy of the $^{208}Pb^{30+}$ beam increases up to 9.8 MeV/A.