Terminal Voltage Stabilization of Pelletron Tandem Accelerator

Nikolai R. Lobanov

on behalf of Accelerator Operation and Development Team
22 tonnes of SF6
14UD and Linac capability
One of many Superscience projects

<table>
<thead>
<tr>
<th>Project</th>
<th>Department</th>
<th>Code</th>
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</thead>
<tbody>
<tr>
<td>Upgrade high and low power coastal cables</td>
<td>EU N3</td>
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<tr>
<td>Room temperature 150 MHz superhurc - pilot project</td>
<td>MWS N3</td>
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<tr>
<td>Build three 10 kV 150 MHz resonators</td>
<td>ANU N3</td>
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<tr>
<td>Vacuum system</td>
<td>MWS N3</td>
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<tr>
<td>Facilities and services (main, water)</td>
<td>ANU N3</td>
<td></td>
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<tr>
<td>RTD RF electronics</td>
<td>EU N3</td>
<td></td>
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<tr>
<td>LVN electronica, 1x, more projects</td>
<td>EU N3</td>
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<tr>
<td>Upgrade CAD office and capabilities</td>
<td>DAD Group, IT N</td>
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<tr>
<td>Higher intensity, time stability, time resolution</td>
<td>HE, DADN</td>
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<tr>
<td>Enhanced overall system</td>
<td>Alignment laser</td>
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<tr>
<td>Digital lathe readout</td>
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<tr>
<td>Target making equipment, supplies</td>
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<tr>
<td>NIM electronics, 1x, more</td>
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<td>Improved technical efficicncy</td>
<td>DAD Group, IT N</td>
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<tr>
<td>Beamline enhancement</td>
<td>New time-energy lens and superlens</td>
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<tr>
<td>LSU precool</td>
<td>ANU N3</td>
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<tr>
<td>Build 3 cryogenic controllers</td>
<td>EU N3</td>
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<tr>
<td>Nb resonators, pilot project</td>
<td>MWS N3</td>
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<tr>
<td>Measure line temperature when tuning</td>
<td>MWS, EU N3</td>
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<tr>
<td>Build fast Faraday cup and electronics</td>
<td>MWS, EU N3</td>
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<td>Develop high sensitivity BPM</td>
<td>EU N3</td>
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<tr>
<td>Crystals upgrade, new look-down resistors</td>
<td>EU N3, MWS N3</td>
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<tr>
<td>Better time resolution, higher energy from line: longer operation</td>
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<tr>
<td>New beamline</td>
<td>10 Faraday cups and 2 BPMs</td>
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<tr>
<td>for Line-1</td>
<td>NEC N5</td>
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<tr>
<td>Line-4</td>
<td>NEC N4</td>
<td></td>
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<tr>
<td>Upgrade Line 7 Super-e</td>
<td>NEC N4</td>
<td></td>
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<tr>
<td>Hyperline</td>
<td>NEC N4</td>
<td></td>
</tr>
<tr>
<td>Line 8</td>
<td>NEC N4</td>
<td></td>
</tr>
<tr>
<td>F-pa</td>
<td>NEC N4</td>
<td></td>
</tr>
<tr>
<td>F-cup</td>
<td>NEC N4</td>
<td></td>
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<tr>
<td>Line C 2nd chamber</td>
<td></td>
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<tr>
<td>Higher capability, experiment efficiency (reduce changeover times)</td>
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AMS Enhancements

- Ion source: SNAC body
- Fast switching 2 TREXs
- Emitter lens
- Off-axis cup: Cup
- Vacuum probe
- Analyzing magnet opening
- Deflectors
- Current integrators
- Automatic computer control system and electronics

Enhanced AMS efficiency capabilities

- New RF capability
- New scanning TTD (also spare for Line 8)
- Improved high power output
- Magnetic field strength

- Target and detector chambers, mounting
- Development of new beams
- Dedicated RF capability
- Improved efficiency for secondary applications, beam scanning

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<td>Computer control DA</td>
<td>New VXI simulation server [Tresenier 3]</td>
<td>M1</td>
</tr>
<tr>
<td>New EPOS computer control board hardware</td>
<td>M1</td>
<td></td>
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<tr>
<td>New EPOS computer control software</td>
<td>M1</td>
<td></td>
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<tr>
<td>New hardware for computer control</td>
<td>Various</td>
<td></td>
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<tr>
<td>Data acquisition hardware</td>
<td>M1</td>
<td></td>
</tr>
<tr>
<td>Data acquisition software</td>
<td>M1</td>
<td></td>
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<tr>
<td>Network infrastructure 14LD Facility</td>
<td>M1</td>
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<tr>
<td>New radiation protection terminals</td>
<td>M1</td>
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Motivation

- Replace old system
- Beam energy stability better than $10^{-5}$
- Beam position stability
- Beam time focus stability when injecting into LINAC or conducting TOF experiment
14UD Performance with old system

- Based on GVM, terminal voltage stability is ~ 0.2%, much higher than NEC specs of 0.02%.

- Noise in GVM coax is at the same level as GVM $U_T$ (AC).

- Noise in coax should be reduced and pre-amp moved to L3.
CPOs calibration

- 115 VAC at 50 Hz is applied to the terminal

- Challenge: to deliver CPO signal noise-free to Control Room

- Raw signal on CPO, 16 μV/V

- CPO signal after pre-amp, 70 μV/V

OPTION: increase diameter of CPO
Beam position stability

Automated tuning of the beam transport. Compensation of daily ion source displacement.

Ion source (L5) moves up to 1.5 mm in relation to 14UD tank due to accelerator tower temperature gradient.
Limitation to time focus: formation longitudinal phase space behind the 1\textsuperscript{st} stripper

Energy spread

- Stripper limited
- Buncher voltage modulation dominated

Source spread dominated Aberration limited

Terminal Time Spread, ps

Injection Energy, MeV

Phase Space Product and Beam Energy Spread after Stripper

1F buncher, M=50

- $\Delta \tau_T$, ps
- $\Phi_T$, keV x ns
- $\Delta E_T$, keV
Commercial control systems

- New Terminal Potential Stabilisation system TPS 6.0 (NEC) including GVM, Slits and CPO amplifiers and corona probe controller

Corona Probe Controller and CPO amplifier
New High Energy remotely operated slits

NEC BDS8 slits

All slits with 24 VDC motor drives, Ta elements
Controllers are build in-house
Beam energy stabilization

Also "predictive fluctuation" compensation

- SLOW
  - corona discharge
  - down charge
  - up charge

- FAST
  - Vary load with e-beam
  - C-liner
  - Foil modulation
  - HE tube
  - Target
NEC Voltage control system
Open loop response

1 V Step Input, time constant=10.2 s.

Measurement delay time
\[ \tau_d = 31 \text{ ms} \]
Corona Controller Bode plots

Voltage and phase response to frequency produced by sine wave measurements

Voltage response with curve fitting

Phase response with curve fitting

Stability requirement: \( \Sigma \) phase shift < 180°
Pelletron charge transport

Terminal shorted through 1 MΩ resistor
Chain oscillations

suppressor
under tank
twist
Unit #21 stiff
Chains mechanical modes low frequency

Low frequency band measured with $CPO_{\Sigma}$

0.72 Hz is the chain revolution frequency due to misalignment between pellets
Chains mechanical modes “high” frequency

High frequency band measured with inductive pick-offs
9.68 Hz is the pulley revolution frequency and 19.4 Hz is its 2nd harmonic
$f_n = n(c^2-v^2)/2le$, $n = 0, 1, 2, \ldots$, where $c = (S/\rho)^{1/2} = 22.8 \text{ m/s}$, as $S$ is the tension in the chain, $\rho = 0.99 \text{ kg/m}$ is mass per unit length, $v = 14.5 \text{ m/s}$ is the velocity and $l$ is the free length of the chain. The chain tension is 525 N. This yields with $l = 2.8 \text{ m}$ $f_n = 2.42, 4.84, 7.26, 9.68 \text{ Hz}$. $9.68 \text{ Hz}$ is nearly equal to the pulley frequency of $9.75 \text{ Hz}$. 
Control system performance

Terminal voltage distribution with optimum control:

- Fast variation
- Slow voltage variation
Recovery after spark event
Slits cross-talk

Slits current for $\sigma/L = 0.5$

A: no e-suppression  
B: e-suppression

Simulation for normal distribution
New Fast Control Loop

[Diagram of a control loop system]
Acknowledgement

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Motivated and skillful technical staff

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Accelerator Guru: David Weisser