HIAT2012, ANL, Chicago

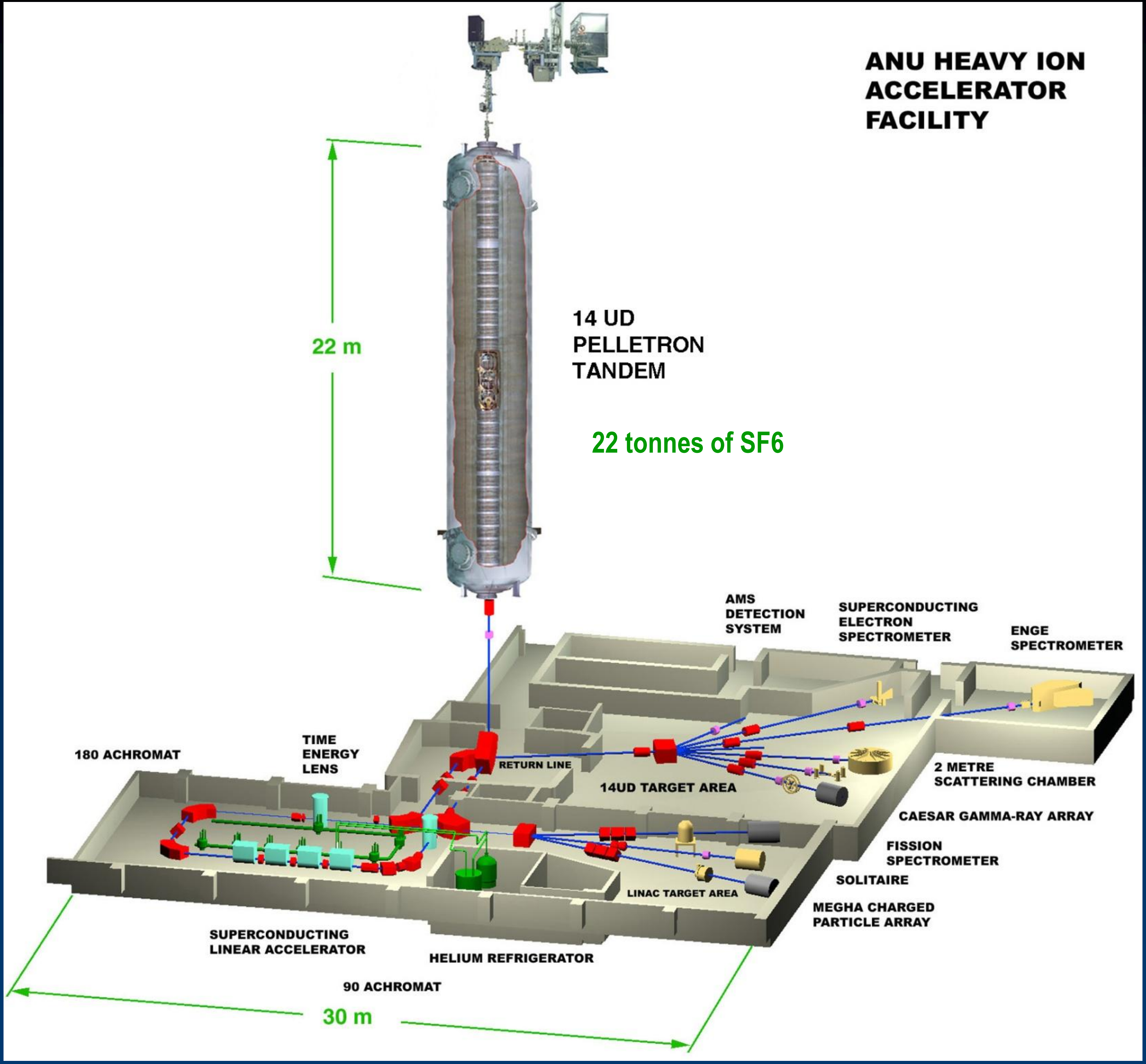
THE AUSTRALIAN NATIONAL UNIVERSITY

Terminal Voltage Stabilization of Pelletron Tandem Accelerator

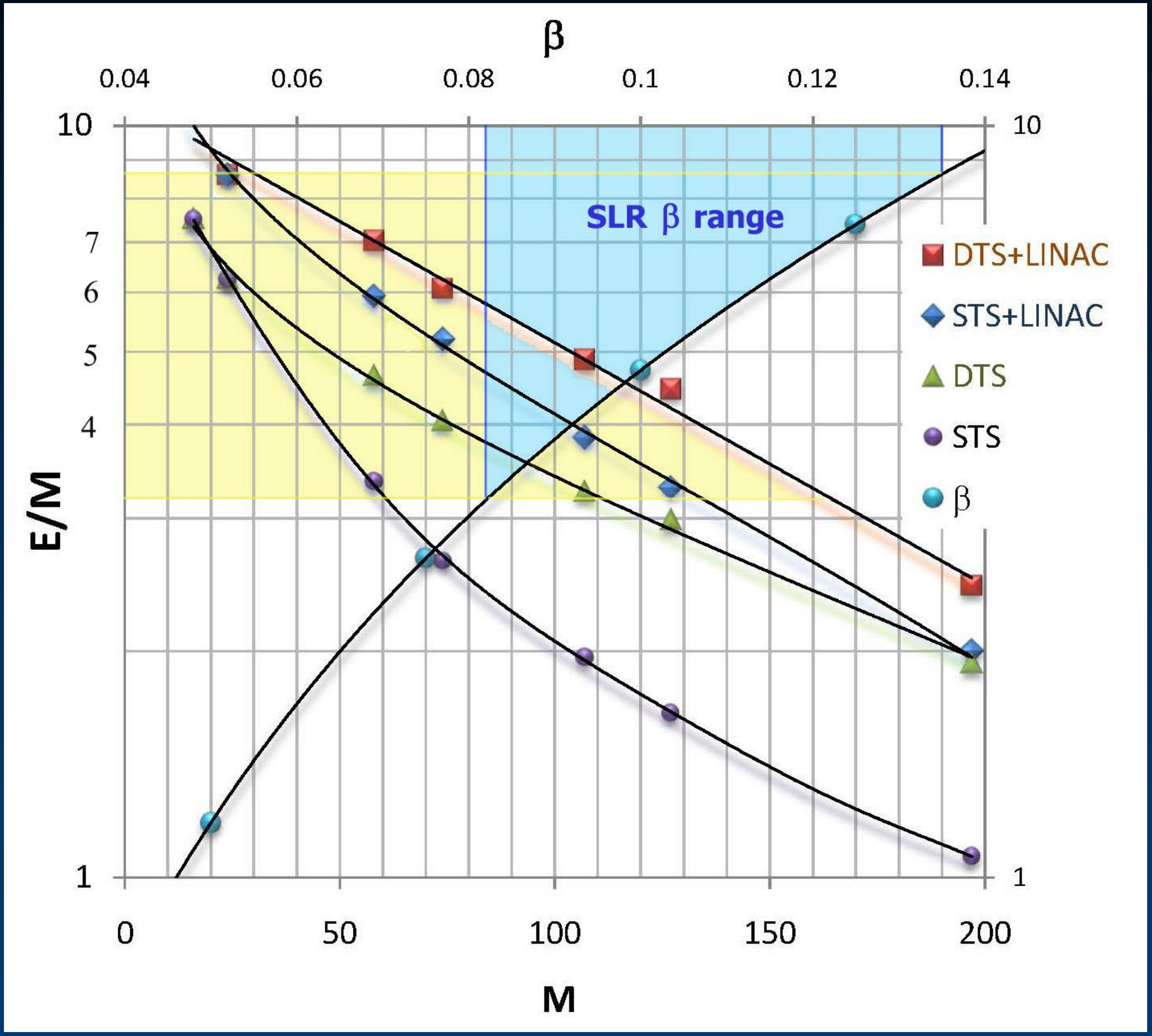
Nikolai R. Lobanov

on behalf of Accelerator Operation and Development Team

Heavy Ion Accelerator Facility


ANU HEAVY ION
ACCELERATOR
FACILITY
22 m
14 UD
PELLETRON
TANDEM
22 tonnes of SF6
AMS
DETECTION
SYSTEM
SUPERCONDUCTING
ELECTRON
SPECTROMETER
ENGE
SPECTROMETER
TIME
ENERGY
LENS
180 ACHROMAT
RETURN LINE
14UD TARGET AREA
2 METRE
SCATTERING CHAMBER
CAESAR GAMMA-RAY ARRAY
FISSION
SPECTROMETER
SOLITAIRE
LINAC TARGET AREA
MEGHA CHARGED
PARTICLE ARRAY
SUPERCONDUCTING
LINEAR ACCELERATOR
HELIUM REFRIGERATOR
90 ACHROMAT
30 m

▪ 14UD and Linac capability



One of many Superscience projects

	Computer control, DA	New VAX emulation server (Nucserver 3)	N1
1		New EPICS computer control: basic hardware	N1
		New EPICS computer control: software	N1
		New hardware for computer control	Various
		Data acquisition: hardware	N1
		Data acquisition: software	N1
		Network infrastructure 14UD Facility	N1
		New radiation protection terminals	N1
	Migration from unsupported computer platform		
	Heavy beam enhancer	Turbo pump systems*15	
		Titanium elements for ion pumps	N2
		New leak chaser	N2
		New roughing system based on scroll pump L5	N2
		Vac Gauges, 2l/s x15, Bayard-Alpert x 4	
		Vacuum components storage facility	N2
		Portable vacuum turbo station for detectors storage	N2
		Magnet power supplies (18 Sorensen)	
		Magnet power supply 300A	DanFysik
		Magnet power supply 155A *2	DanFysik
		New Hall probes Linac 180 achromat and ENGE	Group 3 N2
2		Better accel. trans.: 150KV Entrance lens control	Glassman
		Emission compliance, new SF6 purchase	
		New chains, idlers etc	NEC
		New NMR	Drusch N2
		Top up SF6 ~5PSI	Hallmark Internat
		Spare gas cathode ion source	MWS
		Gas Source upgrade, more efficient Cs delivery	MWS N2
		Brushless generator at L5	MWS N2
		Grounding plunger and hook on GC and BoxVolts	MWS N2
		New cathode power supply for GC and immersion lens ps for Mc	Glassman N2
		New power supply for Cs reservoir McS	N2
		Upgrade safety cage around McS	MWS N2
		Upgrade water-cooling circuit and pump L5	N2
		Fast gas nitroge cooling system for Cs oven McS and GC	MWS N2
		Ar storage system for reactive source samples	MWS N8
		Replenish stock of isotopic materials for user experiments	TRACE N8
		Commissioning fast acting SF6 valves	A&N, MWS N2
		Implementation two RGA stations	SRS N2
		Implement oxygen depeletion monitor system	MicroRack N8
		Commissioning terminal voltage stabilization system	NEC N2
		New steerer power supplies (16 each)	EU N2
		New beam line valves LE, McS, GC	VAT N2
		Build 10 24 Vdc valves controllers	EU N2
		Build 15 turbo controllers	EU N2
		Build ion beam diagnostic box	MoU TRIUMF N2
		Build LE beam emittance measurement jig	MoU TRIUMF N2
		Upgrade 14UD Controle Console	N1
		Upgrade clutch system for shorting rods	MWS N2
		Eight new accelerator posts	NEC N2
		Re-stock of tube, column HV resistors	Welwyn N2
		New LE, Tank and HE Faraday cups	NEC N2
		Terminal Faraday cup and automatic scale pA	NEC N2
		New computer controlled HE object 4-jaw and two 2-jaw image sl	NEC N2
		Spare supressor/charging system power supplies	Glassman
		Entrance tube upgrade	NEC
		BPMs on all beam lines, HE,	NEC 10
	Reliable operation, better beam intensity, diagnostics, higher energy		
	Beam pulsing enhance	Slow chopper p/s from 1:2	AppPulPow
		Switching mode power supply	
3		RF resonators and phase detector	
		Chopper #1	MWS N3
		B1,3	MWS N3
		B2	MWS N3
		New vacuum system and rf diagnostics	MWS N3
		Phase detector or new 4 slits	MWS, NEC N3
		RF Electronics	
		9.375 MHz rf control loop	EU N3
		37.5 MHz rf control loop	EU N3
		18.75 MHz rf control loop	EU N3
		Main control loop based on phase detector or slits	EU N3
		Saw tooth generator- pilot project	EU N3

		Upgrade high and low power coaxial cables	EU N3
		Room temperature 150 MHz superbuncher- pilot project	
		Build three 10 kW 150 MHz resonators	MWS N3
		Vacuum system	Scitek N3
		Facilities and services (main, water)	MWS, EU N3
		RTB RF electronics	
		Low level rf control loop 150 MHz	EU N3
		150 MHz 10 kW rf amplifier	AS N3
		Interlocks and protection	EU N3
	Higher intensity, time stability, time resolution (+ helps linac beams)		
	Enhanced accel suppc	Alignment laser	
		Digital lathe readout	
8		Target making equipment, supplies	
		NIM electronics- fix,renew,more cables	
		Upgrade CAD office and capabilities	CAD Group, IT N
	Improved technical efficiency, support		
	Linac enhancement	Renew time-energy lens and superbuncher	
		LN2 precool	ANU N5
5		**Build 3 cryogenic controllers**	EU N5
		Nb resonators - pilot project	
		Measure linac time structure when tuning	
		Build fast Faraday cup and electronics	MWS, EU N5
		Develop high sensitivity BPM	EU, MWS N5
		Cryostats upgrade: new bake-out resistors	EU, MWS N5
	Better time resolution, higher energy from linac, easier operation		
	New beamlines		
		10 Faraday cups ansd 2 BPMs	NEC N6
	for	Line -1	
6	RIB	**Line 4**	MWS N6
		Upgrade Line 7 Super-e	MWS N6
	Hyperfine	Line 8	
	PAC	Line 9	
	Fus-Fis	Line C 2nd chamber	
	Wider capability, experimental efficiency (reduce changeover times)		
	AMS Enhancements		
	Ion source	SNICS body	NEC
4		Fast switching 2 TREKs	TREK N4
		Einzel lens	NEC N4
	Off-axis cups etc	Cups	NEC N4
		Vacuum box	ANU N4
		Analyzing magnet opening	ANU N4
		Deflectors	TREK
		Current integrators	NEC SYS
		Automatic computer control system and electronics	EU, ANU N4
	Enhanced AMS efficiency, capability		
	new RIB capability		
		New solenoid 7T (also is spare for Line B)	PRICE NEGOTIA
		New magnetic yoke	MWS N7
		Target and detector chamber, mounting	MWS
7		Target and detector chambers, detectors	MWS
		Electronics?	
		Development of new beams	
	Dedicated RIB capability		
	Improved efficiency for solenoid applications, reserve solenoid		

Motivation

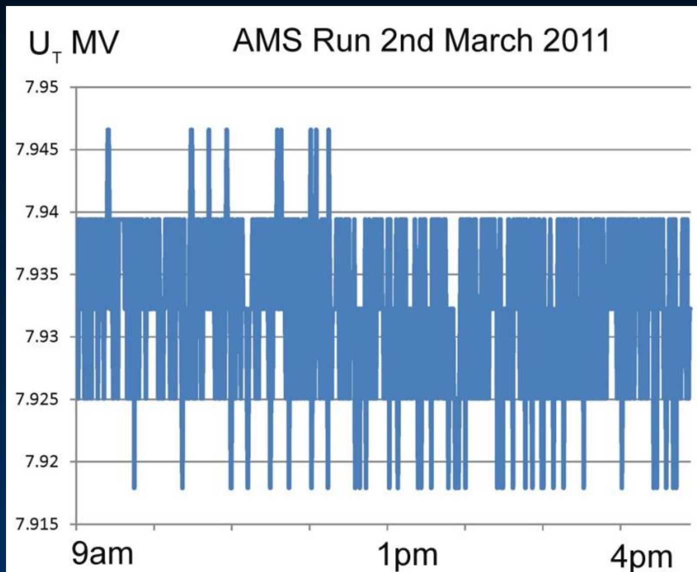
Slit controller

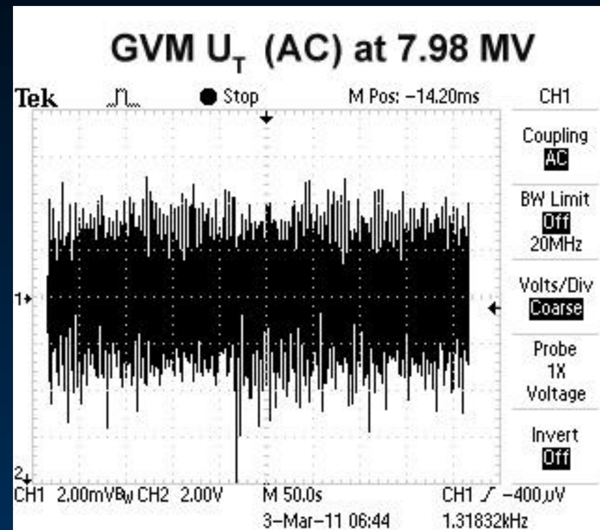
GVM controller

Corona Probe controller

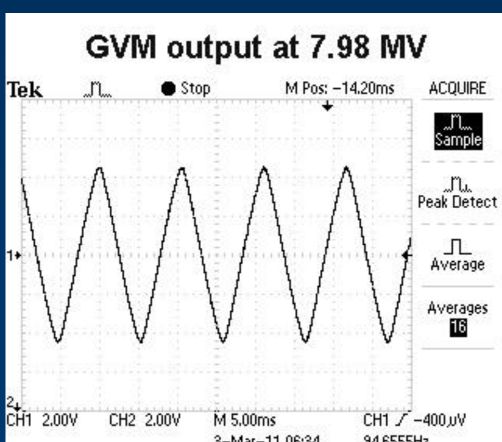
- Replace old system
- Beam energy stability better than 10^{-5}
- Beam position stability
- Beam time focus stability when injecting into LINAC or conducting TOF experiment

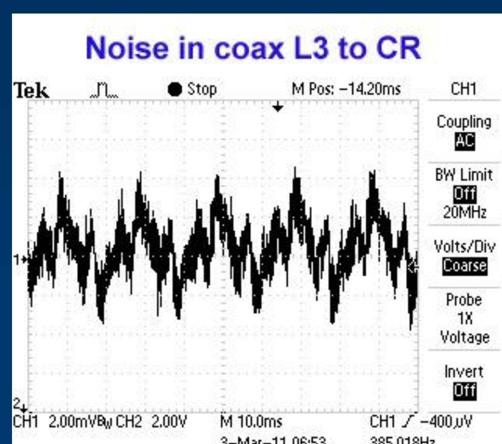
14UD Performance with old system





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

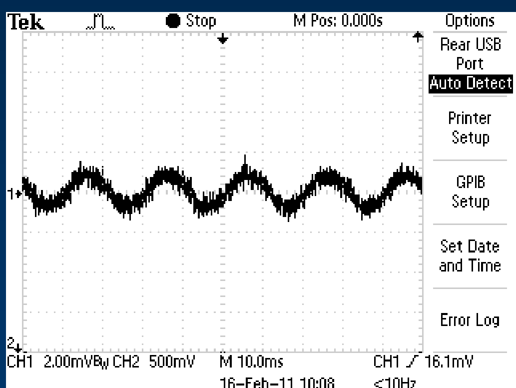




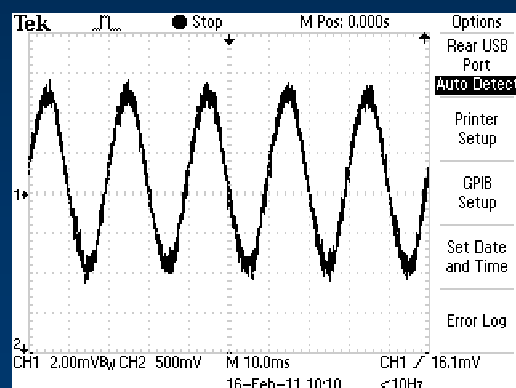
- Noise in GVM coax is at the same level as GVM U_T (AC)
- Noise in coax should be reduced and pre-amp moved to L3

CPOs calibration

- 115 VAC at 50 Hz is applied to the terminal
- Challenge: to deliver CPO signal noise-free to Control Room



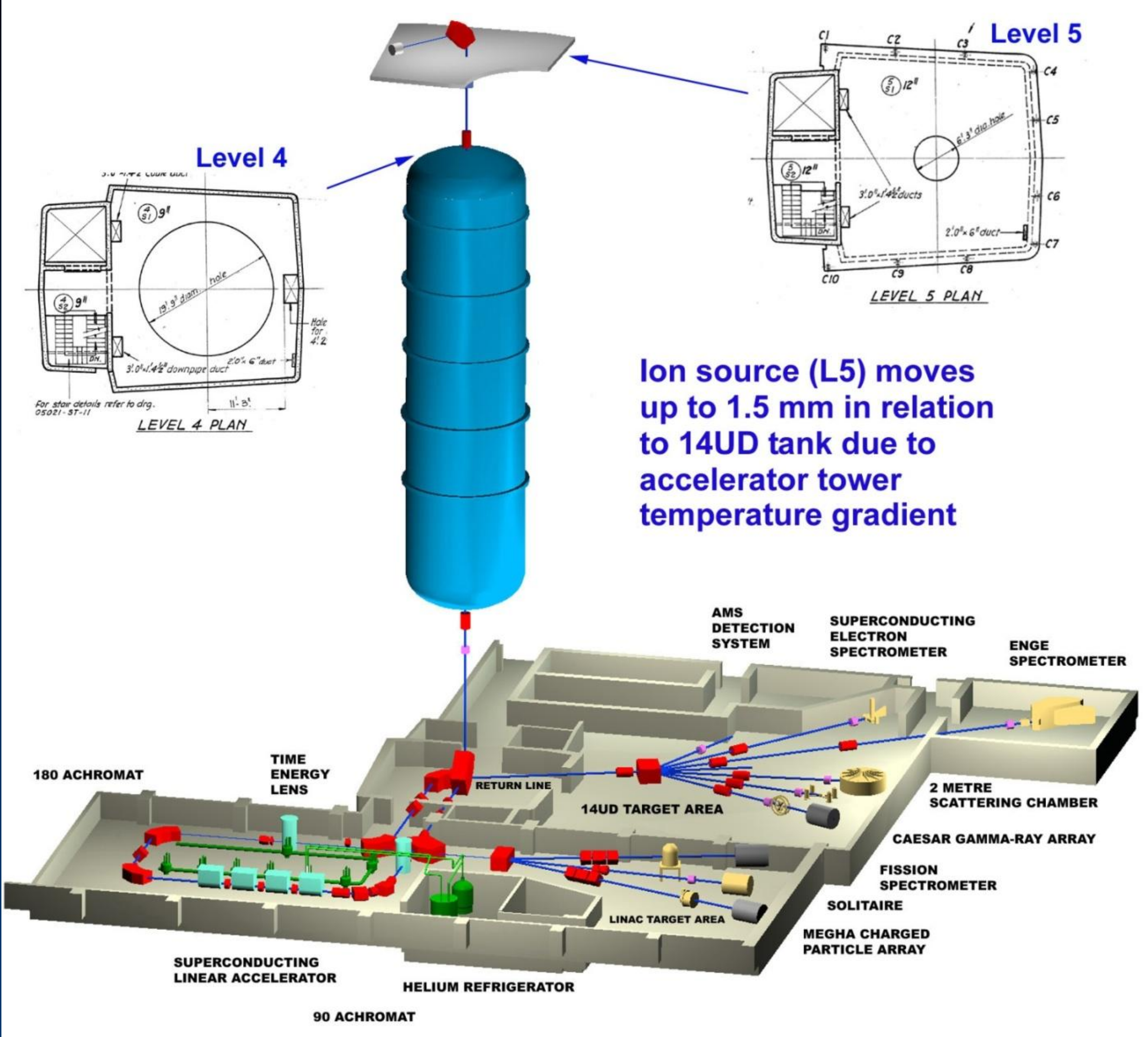
- Raw signal on CPO, 16 μV/V



- CPO signal after pre-amp, 70 μV/V

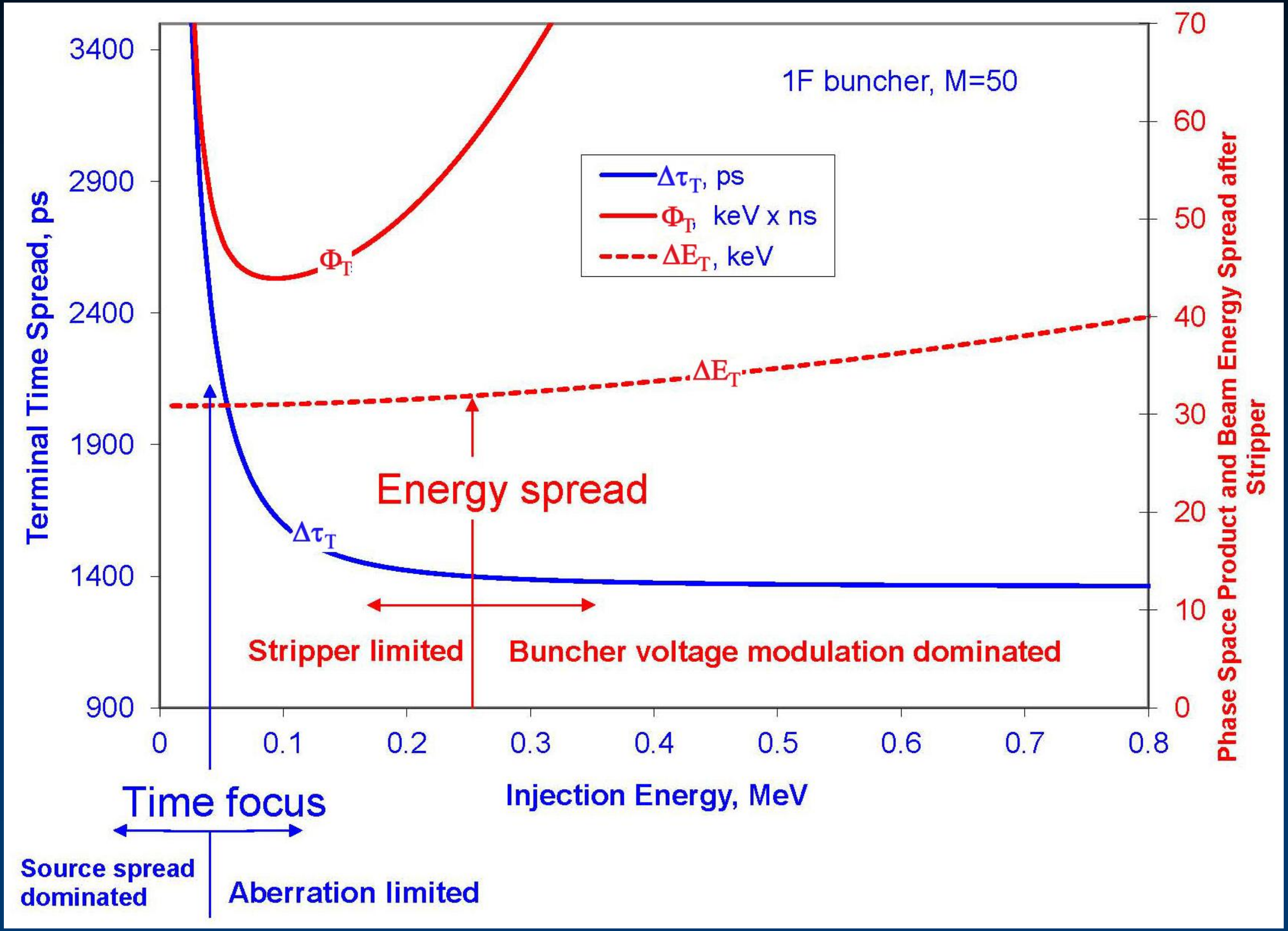
OPTION: increase diameter of CPO

Beam position stability



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

Limitation to time focus: formation longitudinal phase space behind the 1st stripper



ANU

Commercial control systems

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

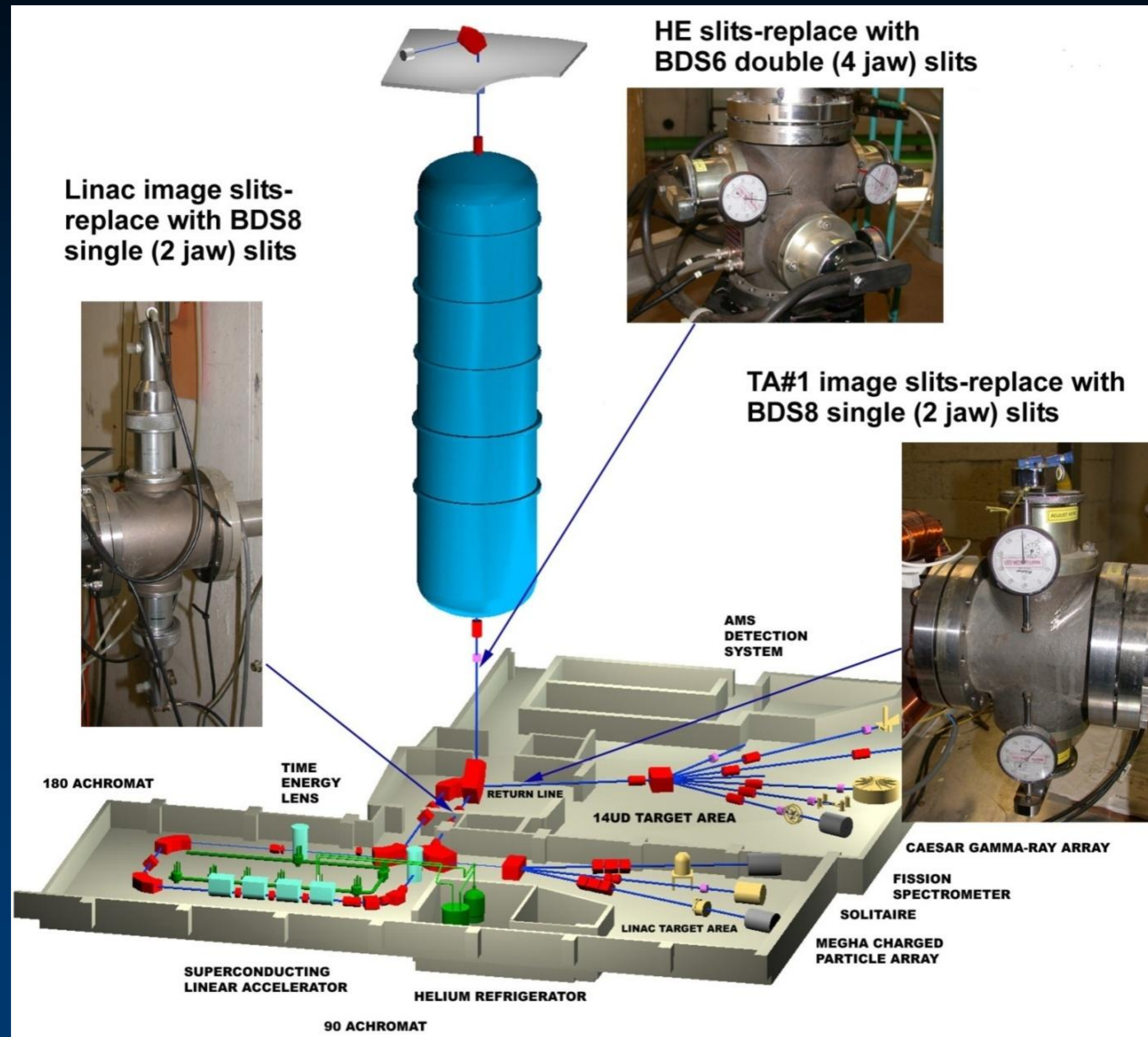
Corona Probe Controller and CPO amplifier

New High Energy remotely operated slits

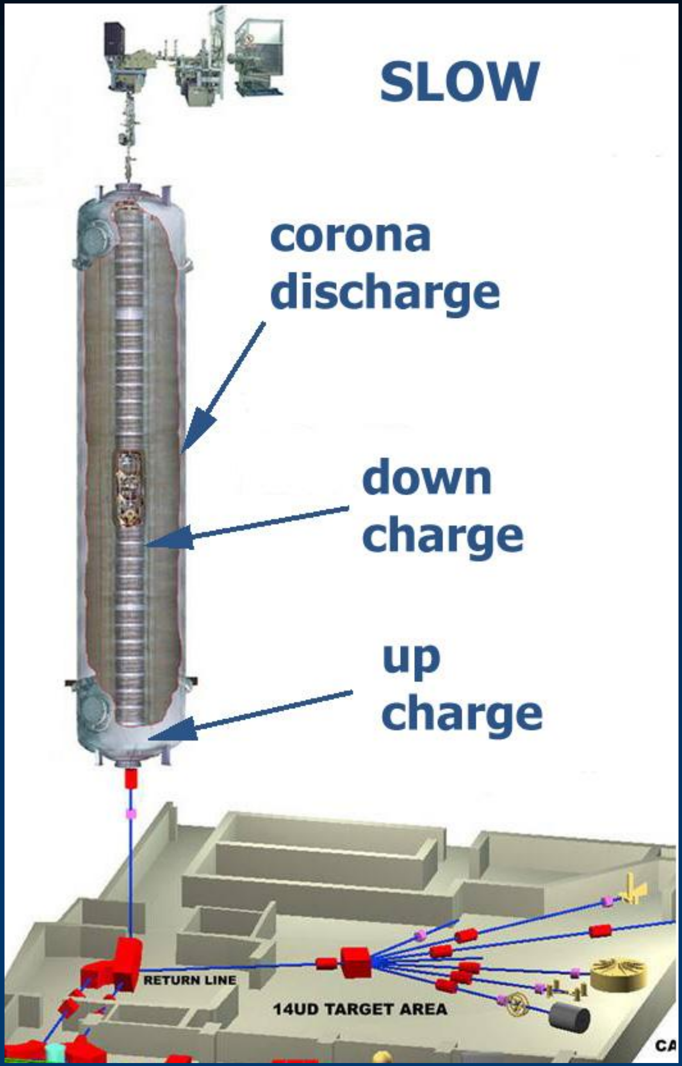
NEC BDS8 slits

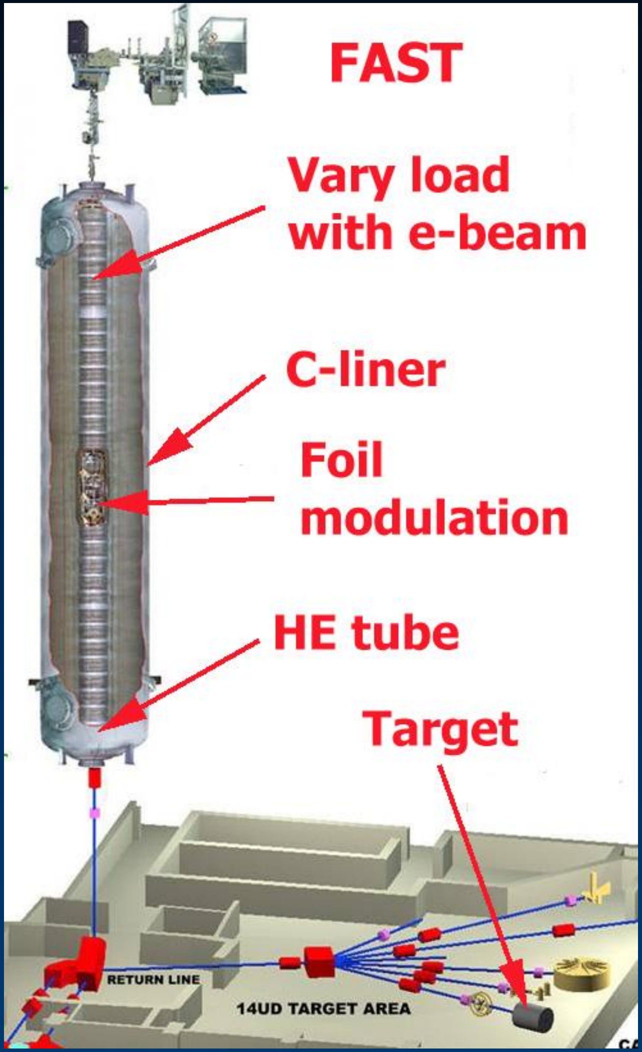
All slits with 24 VDC motor drives, Ta elements

Controllers are build in-house



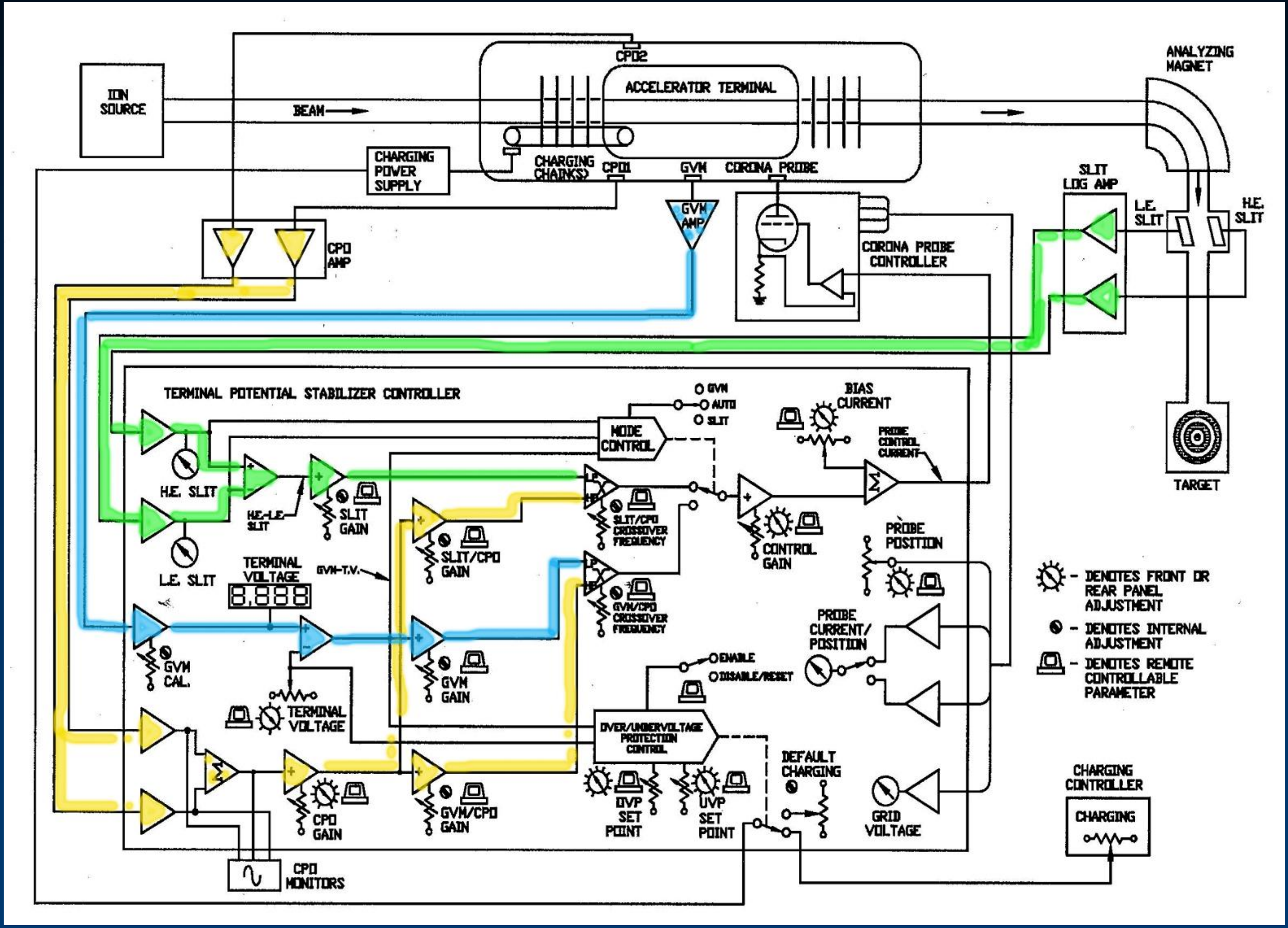
Beam energy stabilization



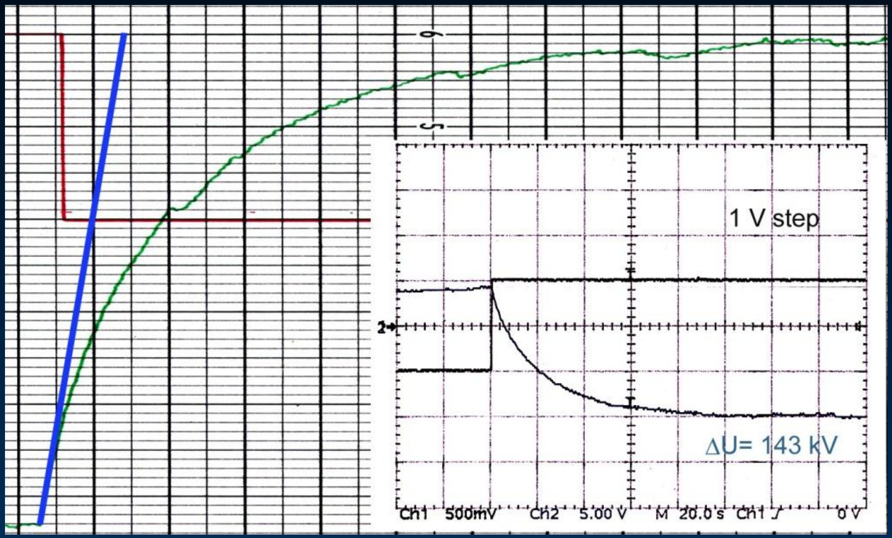


Also "predictive fluctuation" compensation

NEC Voltage control system



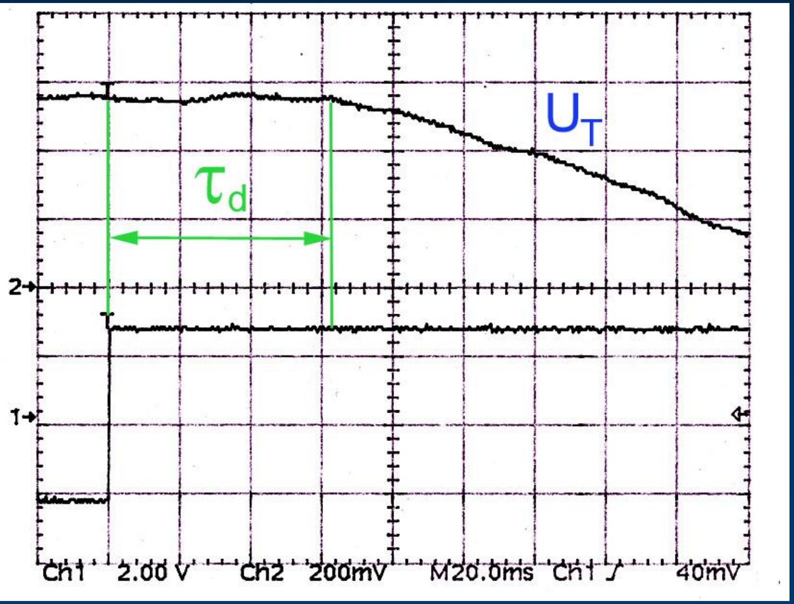
Open loop response



1 V Step Input,
time constant=10.2 s.

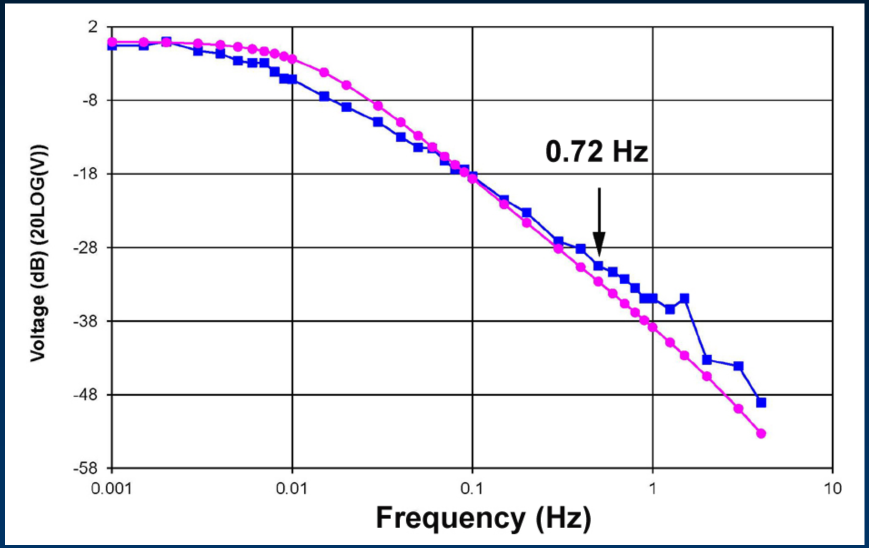
Measurement delay time

τ_d = 31 ms

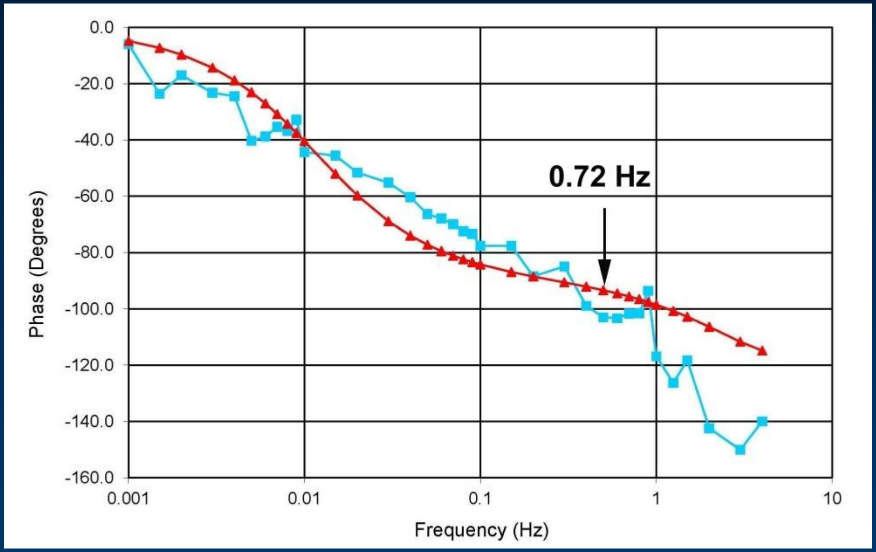


Corona Controller Bode plots

voltage and phase response to frequency produced by sine wave measurements



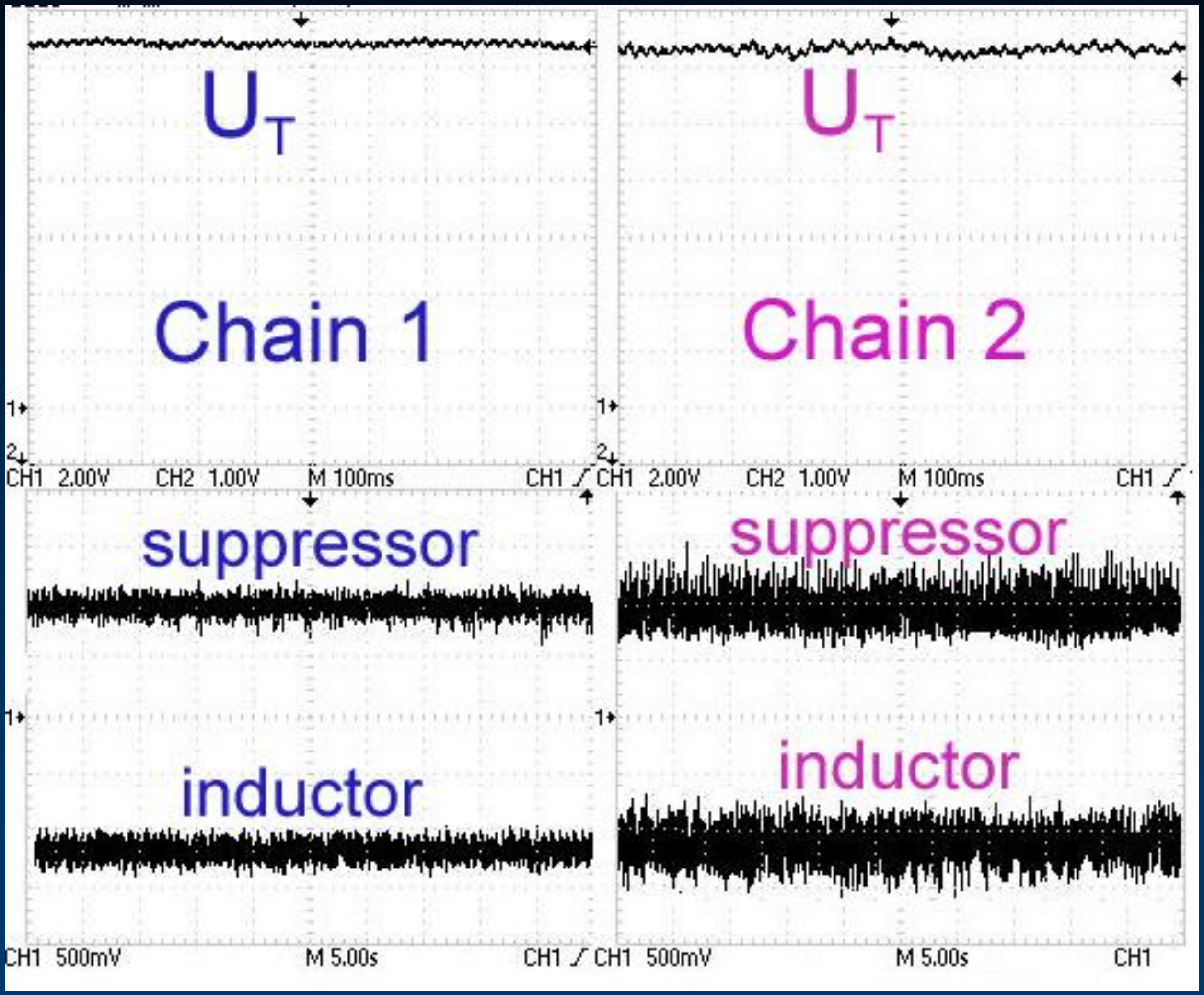
Voltage response with curve fitting



Phase response with curve fitting

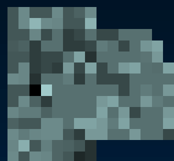
Stability requirement: Σ phase shift < 180°

Pelletron charge transport



Terminal shorted through 1 MΩ resistor

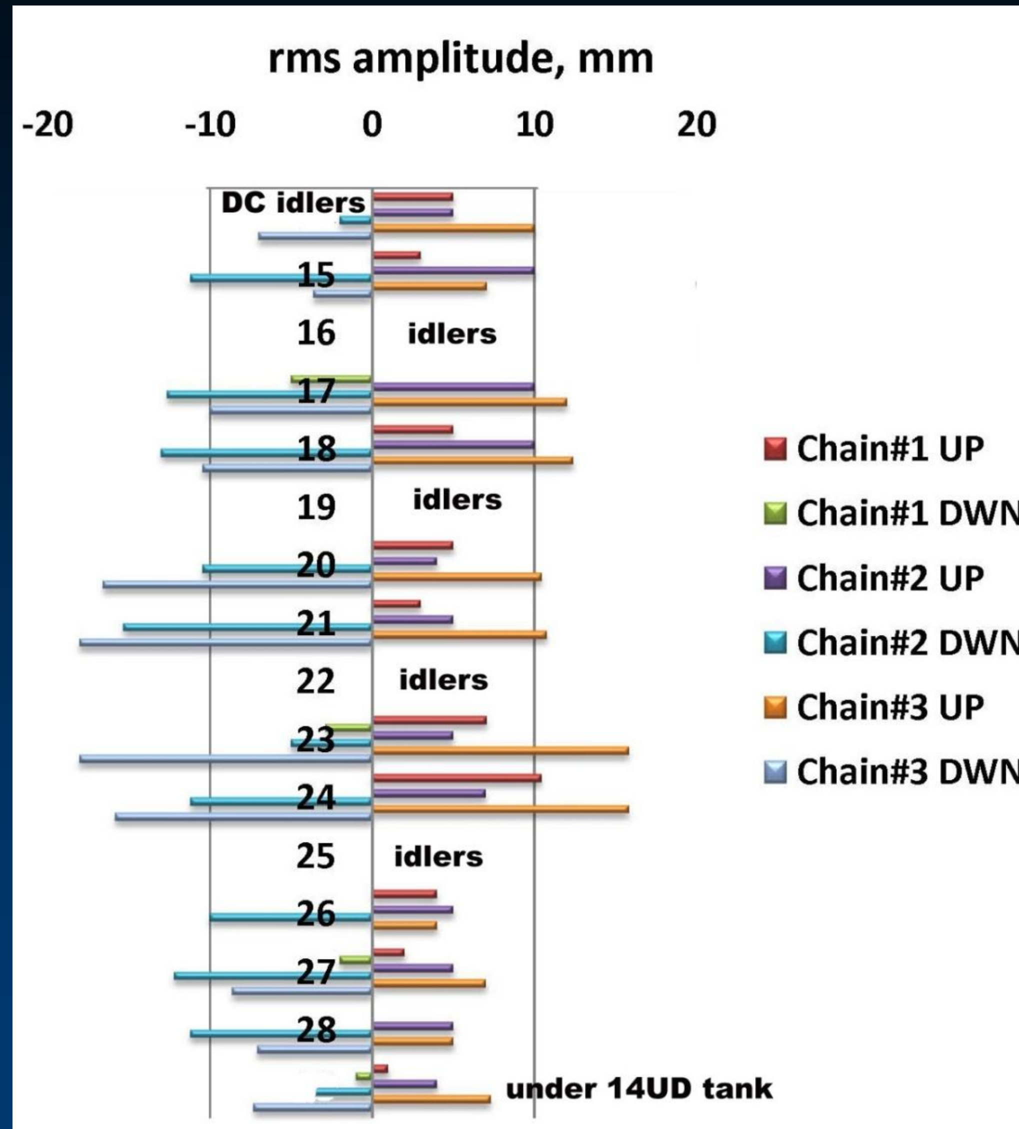
Chain oscillations



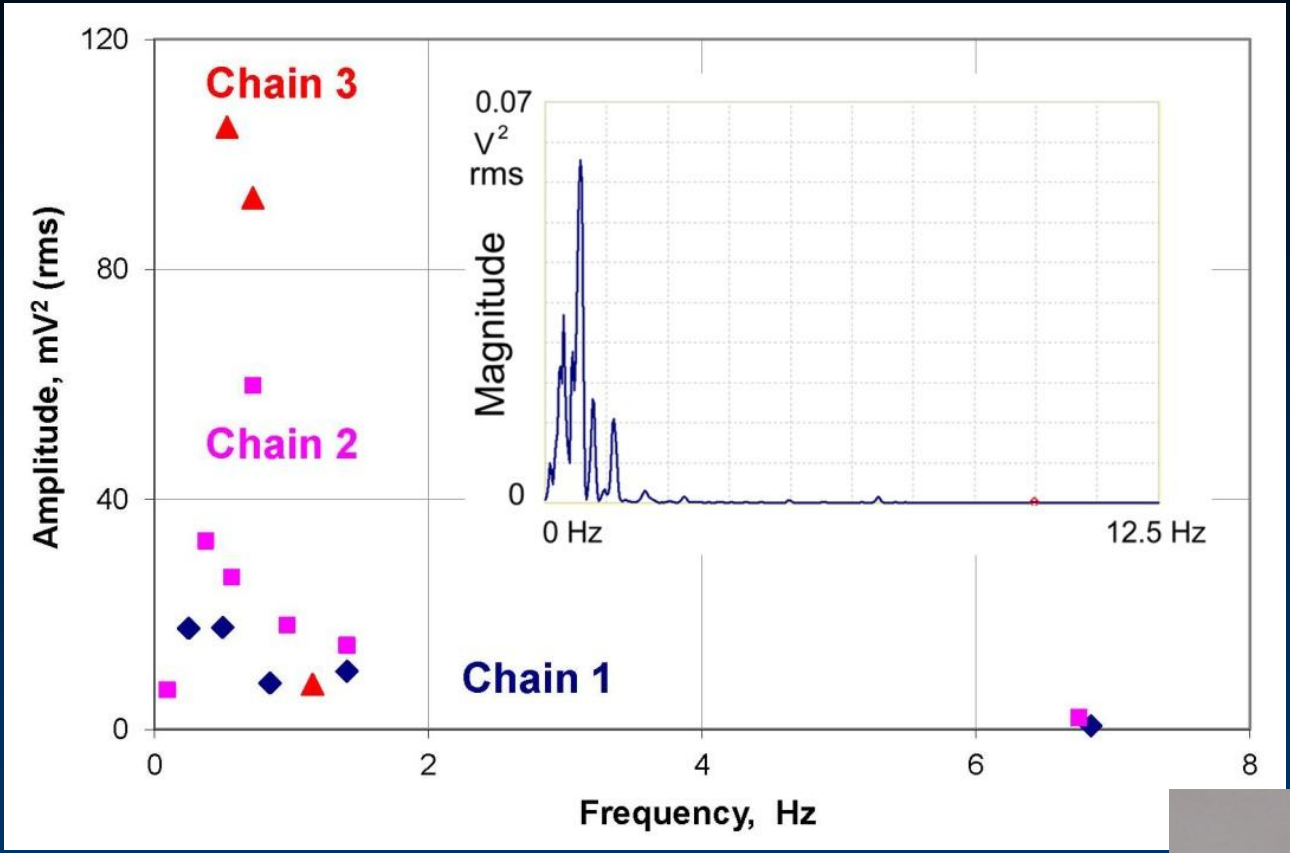
suppressor
under tank

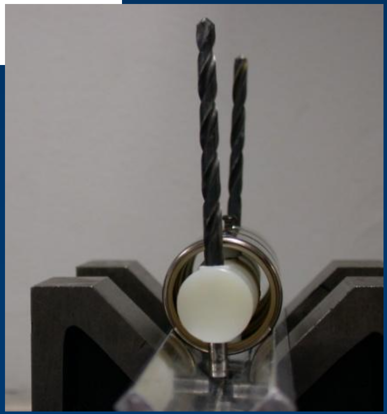
twist

Unit #21 stiff



Chains mechanical modes low frequency

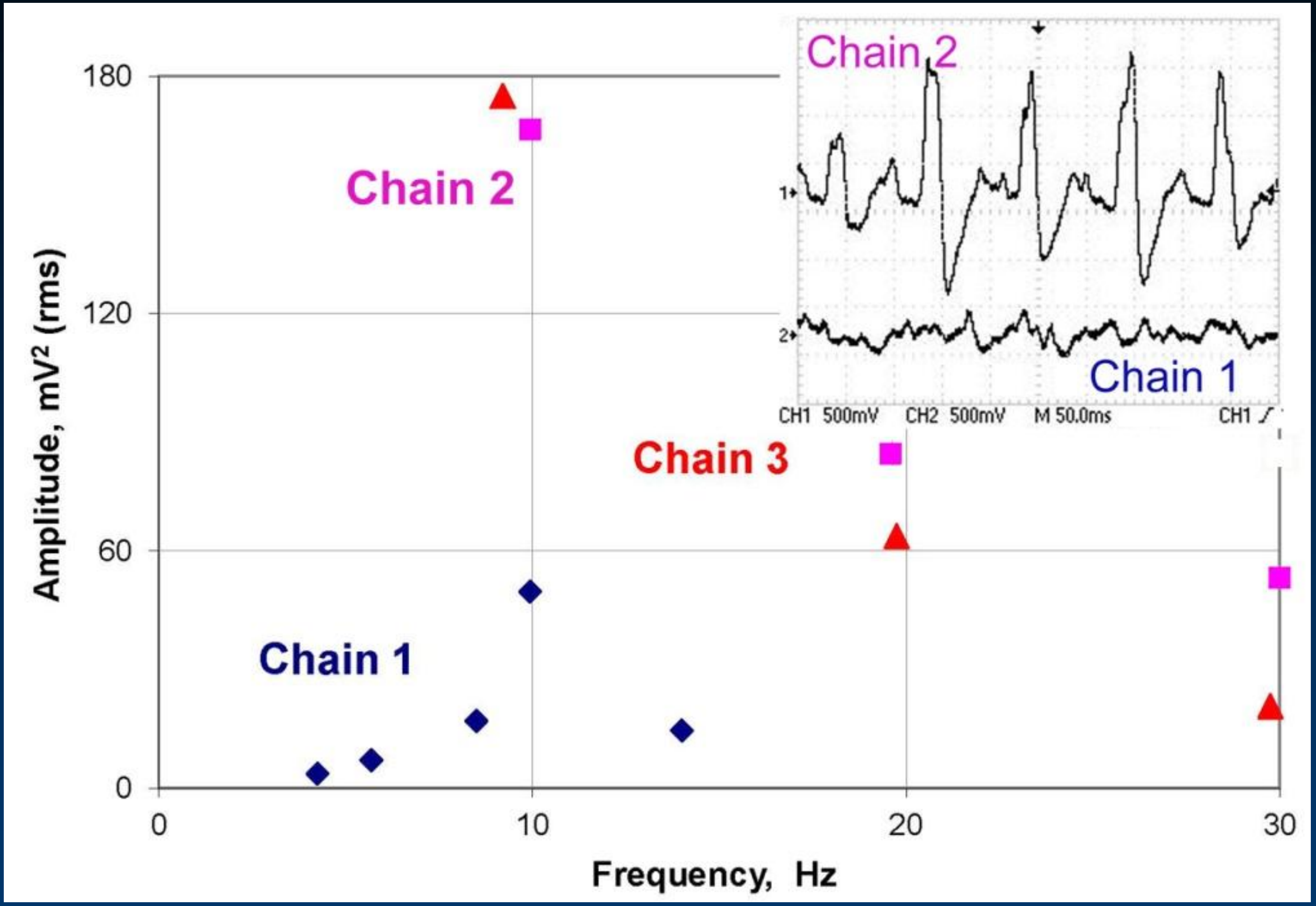




Low frequency band measured with CPO_{Σ}

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

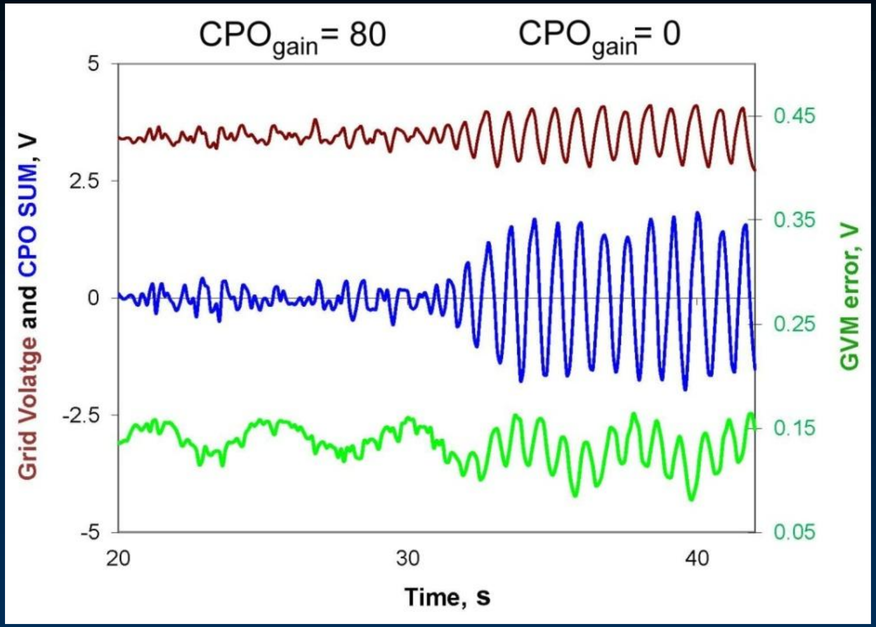
9.68 Hz is the pulley revolution frequency and 19.4 Hz is its 2nd harmonic

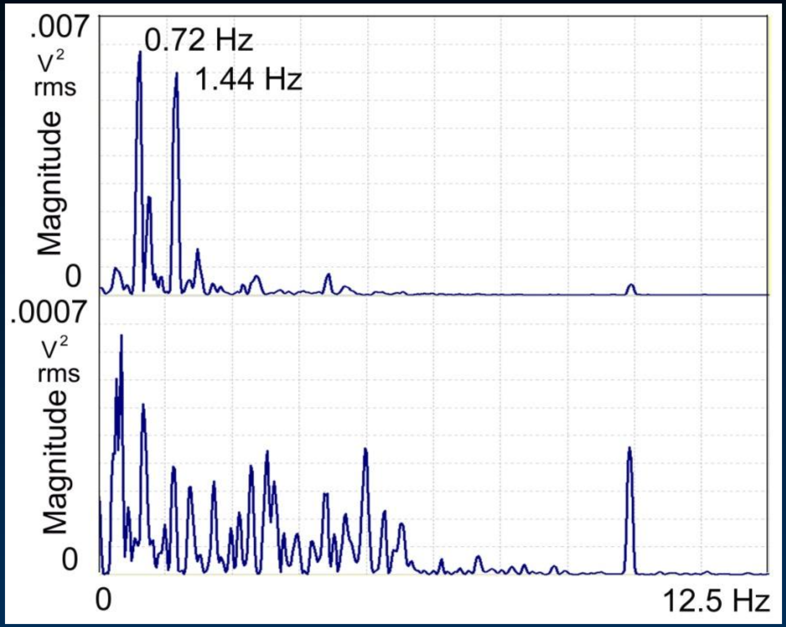
Mechanical modes simulation

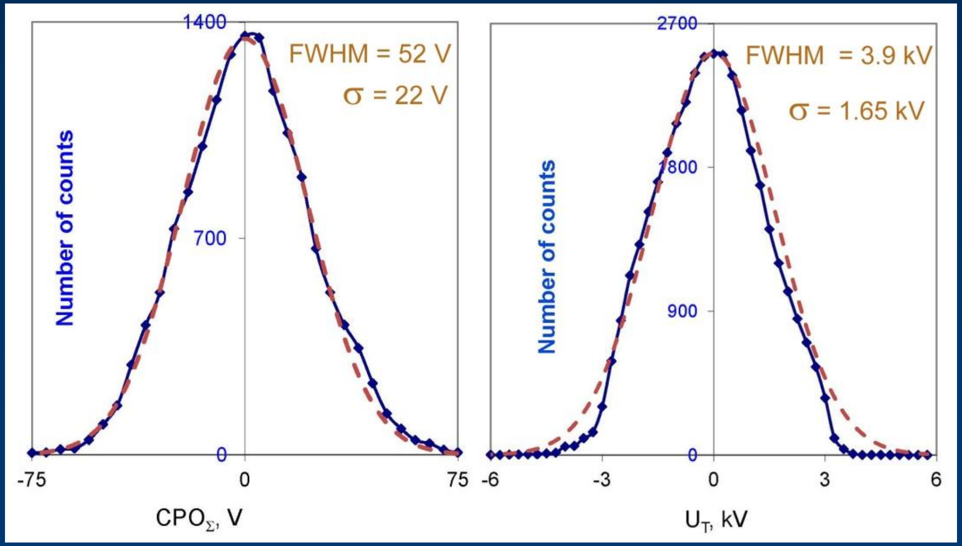
$f_n = n(c^2 - v^2)/2lc$, $n = 0, 1, 2, ..$,
where $c = (S/\rho)^{1/2} = 22.8$ m/s,
as S is the tension in the chain,
$\rho = 0.99$ kg/m is mass per unit length,
$v = 14.5$ m/s is the velocity and
l is the free length of the chain.
The chain tension is 525 N.
This yields with $l = 2.8$ m
$f_n = 2.42, 4.84, 7.26, 9.68$ Hz.

9.68 Hz is nearly equal to the
pulley frequency of 9.75 Hz.

Control system performance





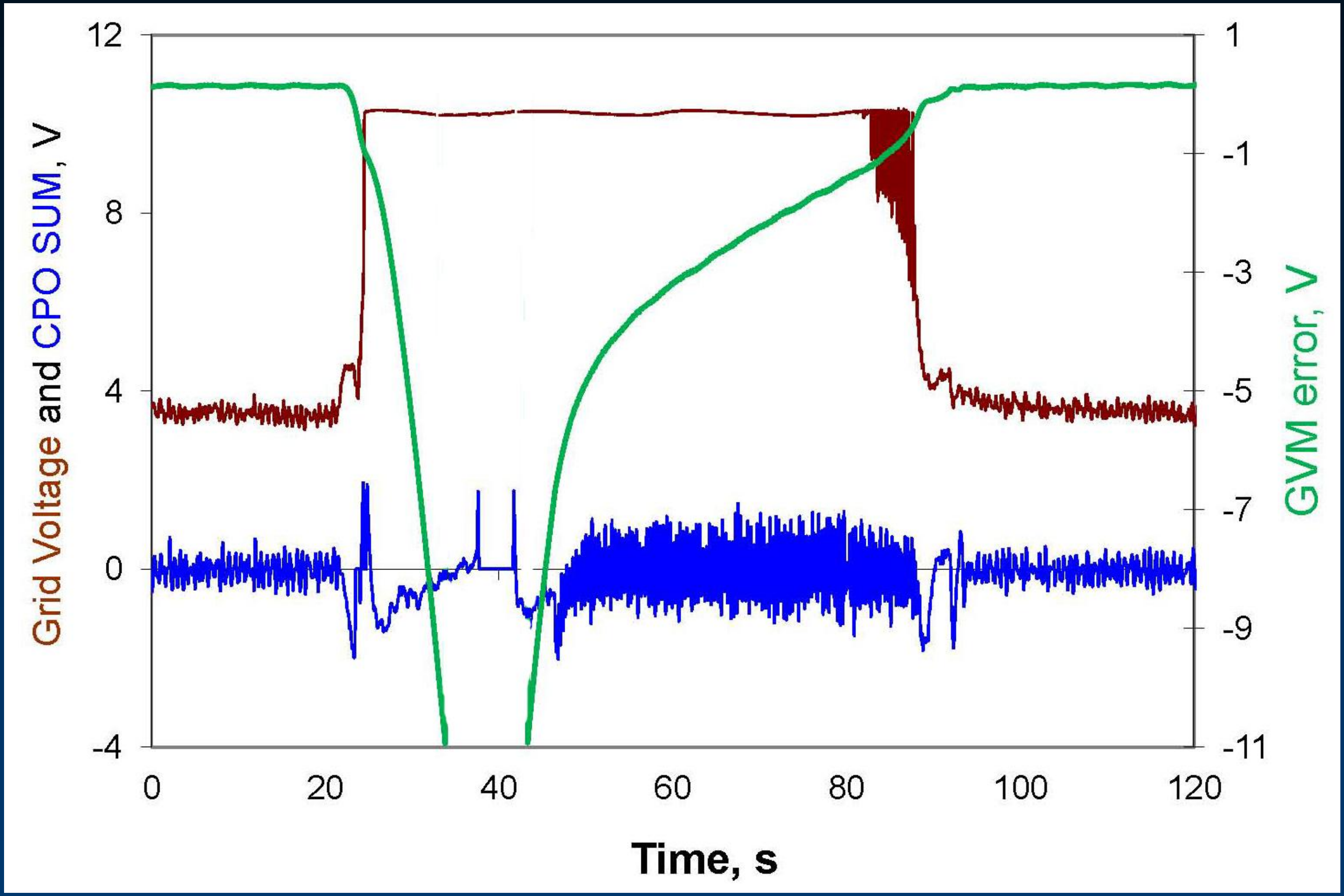


Terminal voltage distribution with optimum control:

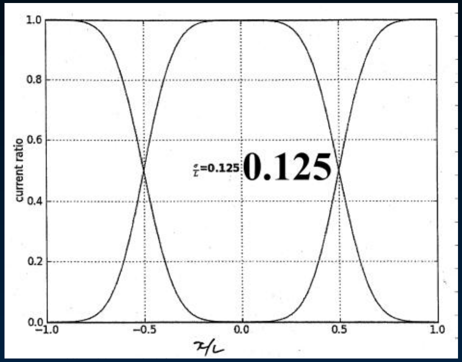
Fast variation

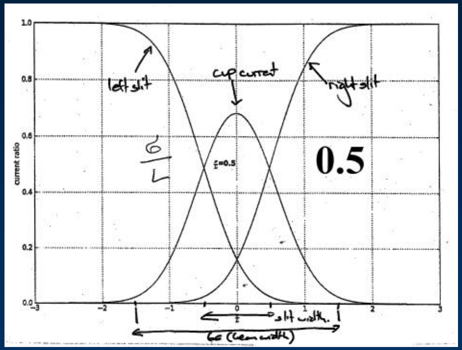
Slow voltage variation

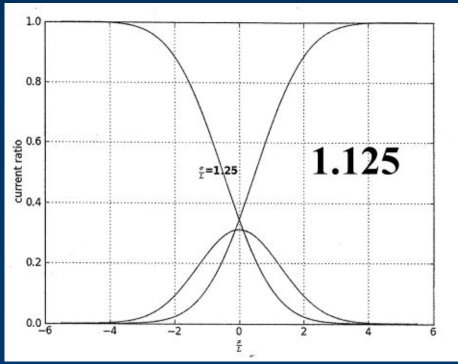
Recovery after spark event



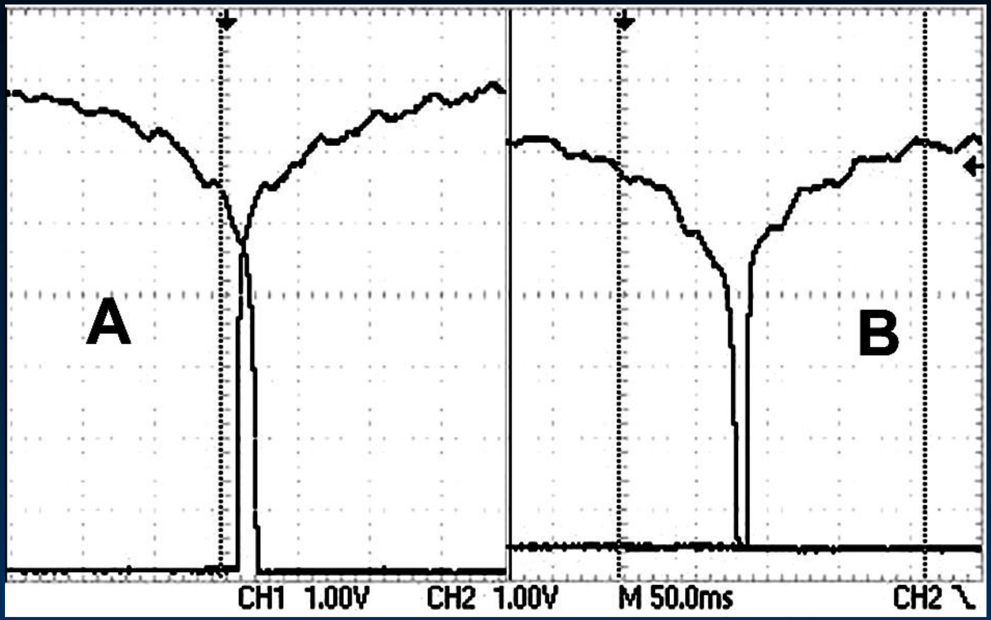
Slits cross-talk







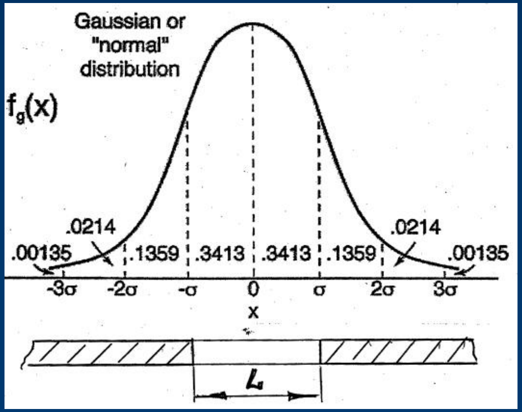
Simulation for normal distribution



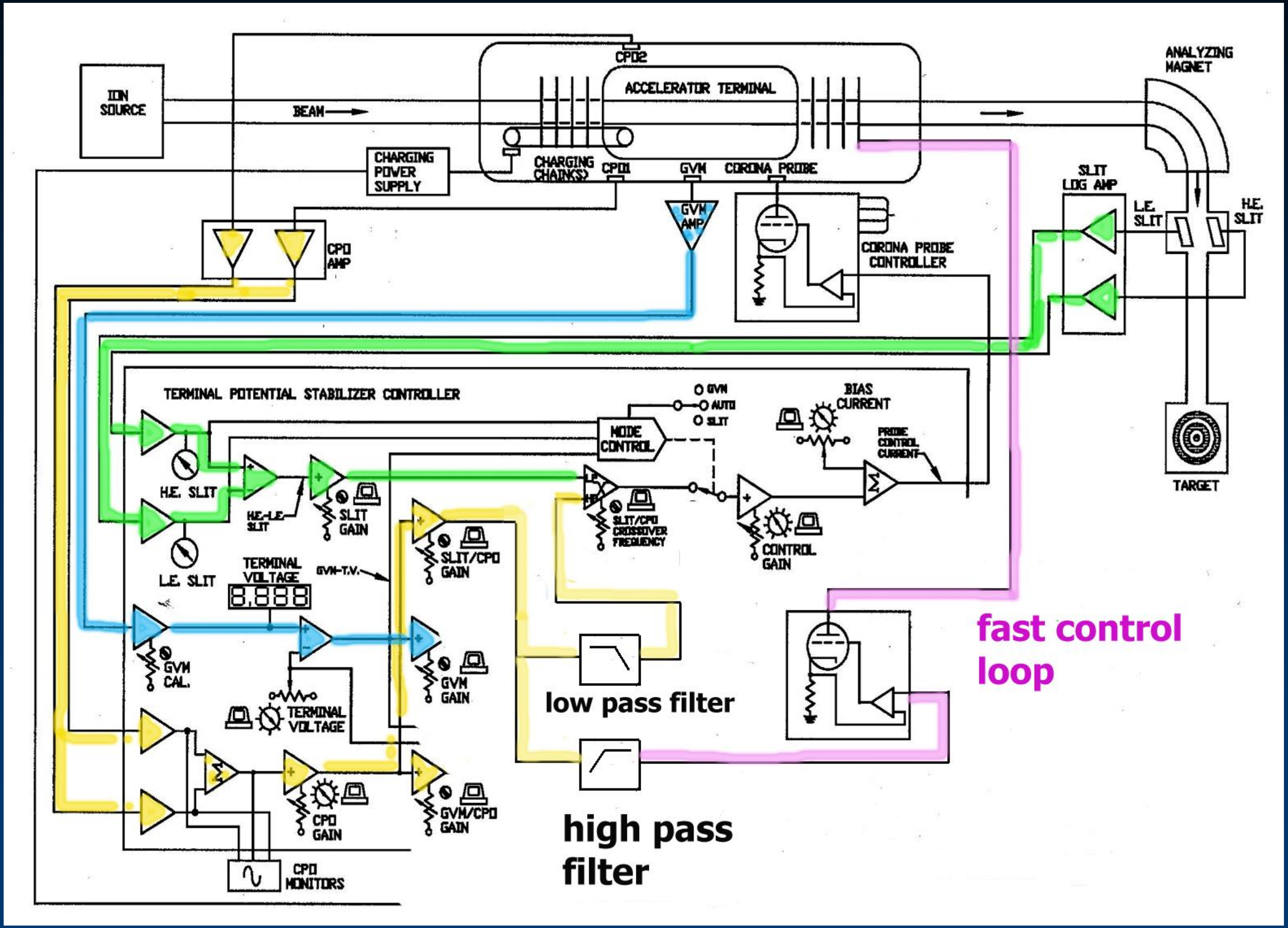
Slits current for σ/L = 0.5

A: no e-suppression

B: e-suppression



New Fast Control Loop



Acknowledgement

Motivated and skillful technical staff

Technical Staff:

A. Cooper, A. Muirhead, J. Bockwinkel,
A. Harding, G. Crook, T. Kitchen,
T. Tunningley, C.Gudu, L. Larioza

IT Staff:

D. Tsifacis, A. Grafton

EU Staff:

D. Gibson, D. Tempra,
D. Anderson, D. Kelly
T. Steele

Accelerator Director: Keith Fifield

Accelerator Guru: David Weisser

ANU

Q