

2020-02-14 PFRC-2 Run Summary
 prepared 2020-02-(14-17) S.A. Cohen, *et al.*

RMF₀ @ **4.3 MHz**, air-gapped, two-turn antennas, 60" RG-226 transmission lines, ground plane between antennas and Lexan vessel. RMF power system: SRI->AR100LM->8KD->200kW-> hybrid splitter-> tanks. "Safety" on RMF (pulse length x power -> 1% duty factor). BB power supply and 2 Magnapower. BN-covered HTS-FCs, installed Sept 2011.

Goals: Understanding DLs

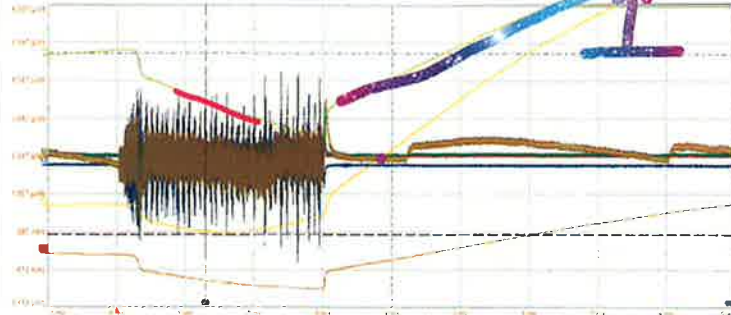
Setup:

- a) SRS: max 0.95 Volts.
- b) Estimate $f_v \sim 4.3 \times \text{MHz}$
- c) $P_r/P_f \sim 1/4 - 1\%$; max $P_f \sim 25-55 \text{ kW}$; max $P_a \sim 36\% P_f$
- d) FM: no
- e) Duration: 3-8 ms; time between pulses: 1.013 s
- f) FCs: room temp & LN2
- g) Tank circuits -> 2 antennas
- h) No antenna Rogowskis:
- i) Rotation direction: 90° throughout discharge
- j) cc Slow baratron: 0.56-0.74 mT
- k) Base vacuum: $4e-7 \text{ T}$ FEC gauge;
- l) $P_{\text{SEC}} \sim 1.8 \text{ mT}$
- m) BB: $I = 165-385 \text{ A}$; MagnaPower: $I = 181 \text{ A}$
- n) Helmholtz coils: (4+4)+4 and 4+ (4+4)
- o) Nozzle: 106 A
- p) Helicon: 17 W net seed plasma
- q) μ -wave: $\sim 1.9 \text{ MHz}$ LPF, $n_{\text{max}} \sim 1.8e12/\text{cc}$,
- r) monochromator
- s) $\phi_{\text{max}} ?? \mu\text{Vs}$ – perhaps 7 $\mu\text{Vs}!!$

Experiments: DL signals: DL1 vs external and DL1 vs 6; with and without BB; vs pulse length; with and wo LN2.

Experiment 1 – Internal (1) vs external DL (3ms)

$I_{L-2}=180\text{A}$, $P_f \sim 47 \text{ kW}$, $P_a \sim 13\text{kW}$, $p \sim 0.69\text{mT}$, DL cases grounded; $n_e \sim 0.9e12/\text{cc}$; **yellow** = external; **olive** = DL1; **brown** = DL6

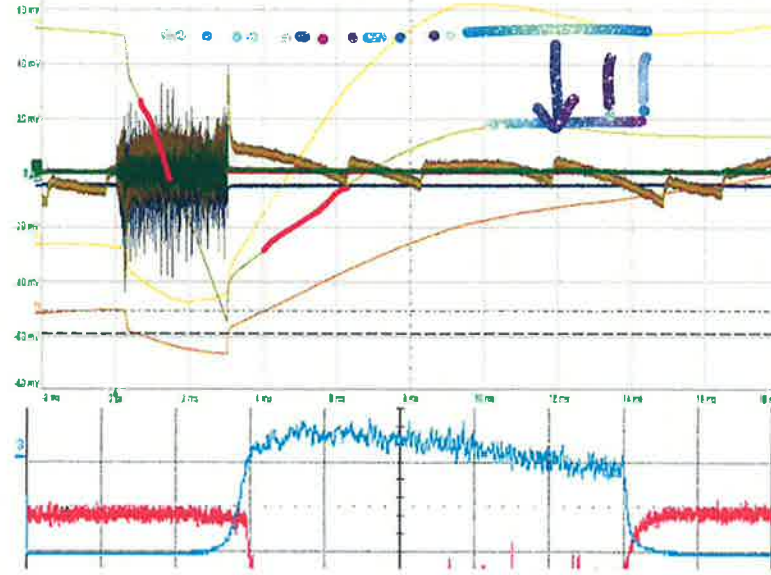


Noisy $n_e(t)$. Flat $\langle n_e \rangle$ 10 :36 :24

Observations:

- 1) DL1 shows \sim linear increase during RMF. Charles speculates capacitive coupling. **Why not real?**
- 2) All 3DLs show + signal (overshoot) after pulse. If this is flux returning through FCs then BIG flux, $> 5 \mu\text{Vs}$.
- 3) BB noise (3-phase => 360 Hz) seen in unintegrated DL.
- 4) DL6 shows the same sharp rise/fall interpreted as *diamagnetic signal* in DL1 -- **How possible so far from $z=0$?**

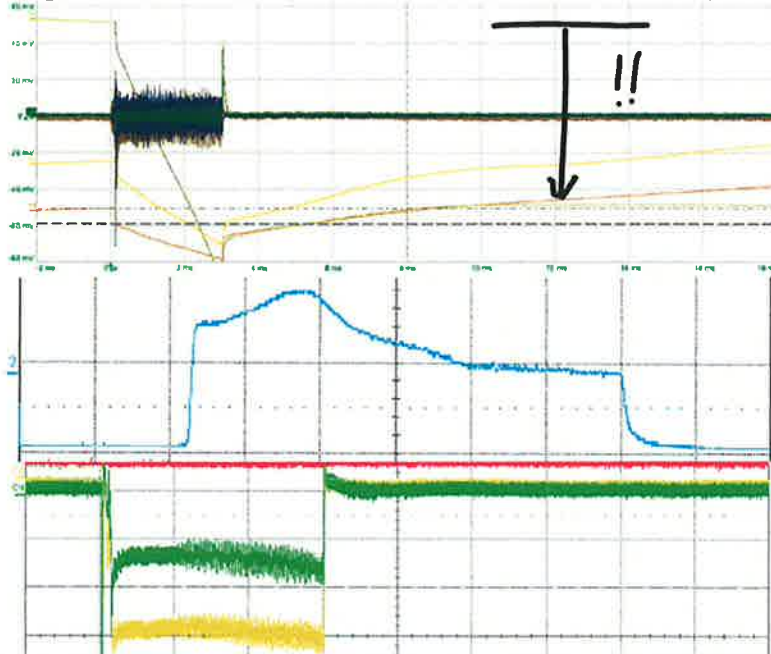
Experiment 2 – Higher B; $I_{BB}=382A$; $I_{MP} = 180A$ (3ms)



Observations: 10:43:16

- 1) DL1 rose to $5 \mu V$ s *and no* post-shot overshoot!
 - 2) External and DL6 unchanged
 - 3) Better P_a balance & higher P_a than lower BB
 - 4) Same post-shot DL1 behavior to $t = 45ms$
 - 5) note diff't DL1 slopes, during vs post shot
- 10:45:32
- 6) Grounded DL Pomona boxes – no change (not shown)

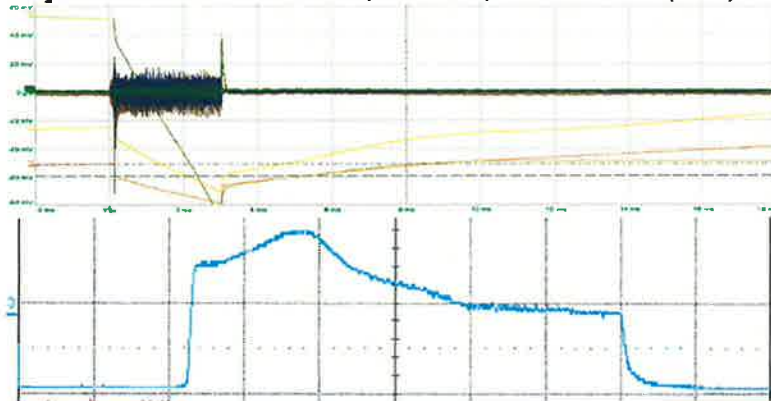
Experiment 3 – Lower B; $I_{BB}=0A$; $I_{MP} = 180A$ (3ms)



Observations: 10:53:14

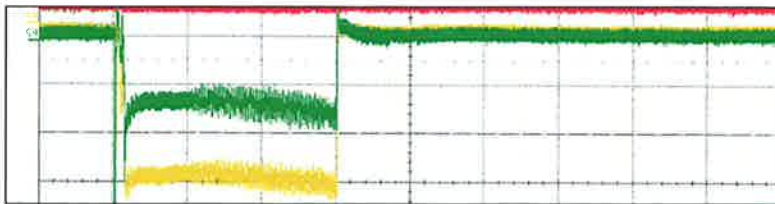
- 1) DL1 rose to $7 \mu V$ s *and no* post-shot overshoot! This is BEFORE LN2.
 - 2) External DL has small over-shoot; DL6 overshoot unchanged
 - 3) Poor P_a balance
 - 4) note diff't DL1 slopes during vs post shot
 - 5) diff't $n_e(t)$, periodic MHD after $t \sim 1.5 ms$.
- 10:51:03

Experiment 4 – With LN2; $I_{BB}=0A$; $I_{MP} = 182A$ (3ms)



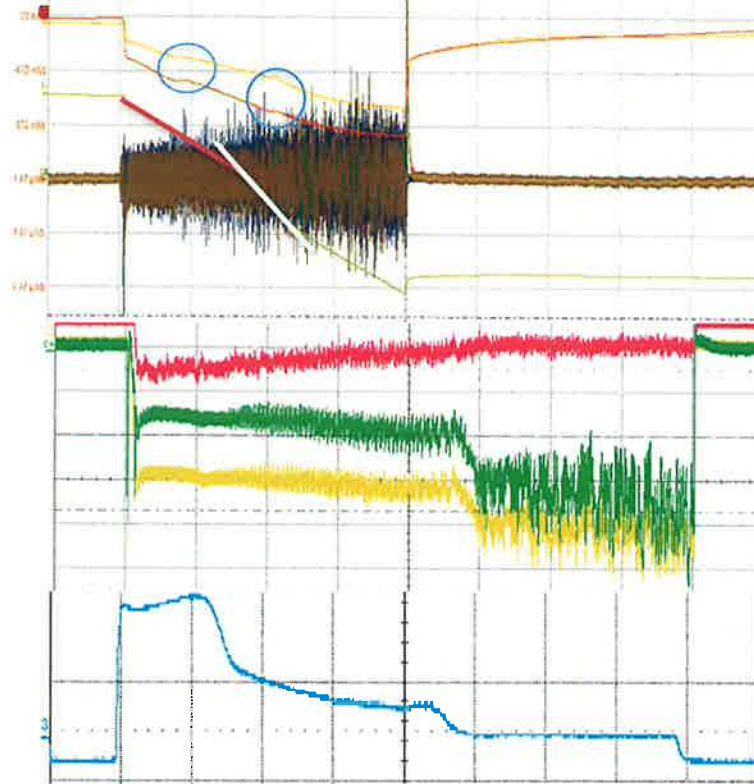
Observations: 10:53:14

- 1) For all DLs **lower** post-shot signal/overshoot!
- 2) Lower post shot External DL-less post shot overshoot; DL6 post-shot unchanged
- 3) Poor P_a balance
- 4) Note, as before, diff't DL1 slopes, during vs post shot



5) diff't $n_e(t)$, periodic MHD after $t \sim 1.5$ ms.
10:51:03

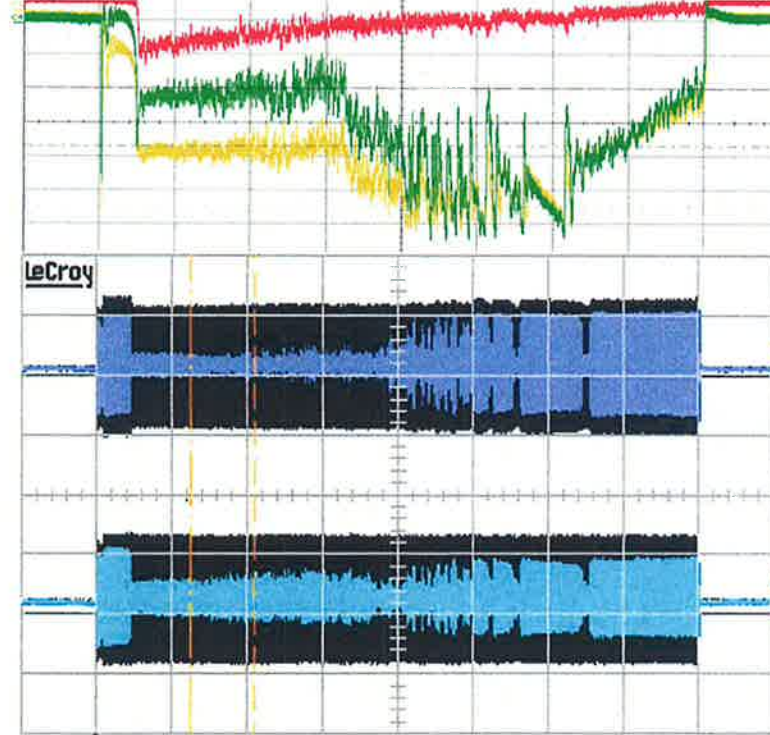
Experiment 5 – With LN2; $I_{BB}=0A$; $I_{MP} = 182A$ (8ms)



Observations: 11:35:32

- 1) DL1 signal still grows linearly with time. 11:34:32
- 2) All DLs post-shot – no overshoot
- 3) Poor P_a balance 12:09:16
- 4) P_a noisy and high after 5 ms - 16kW/55kW
- 5) 3-plateau $n_e(t)$ 12:09:13
- 6) Periodic MHD $t=2-5$ ms. 10:51:03
- 7) Note, as before, diff't DL1 slopes, during vs post shot
- 8) Note **diff't** DL behaviors a plateau changes. DL6 and DL_{ext} smaller; DL1 bigger

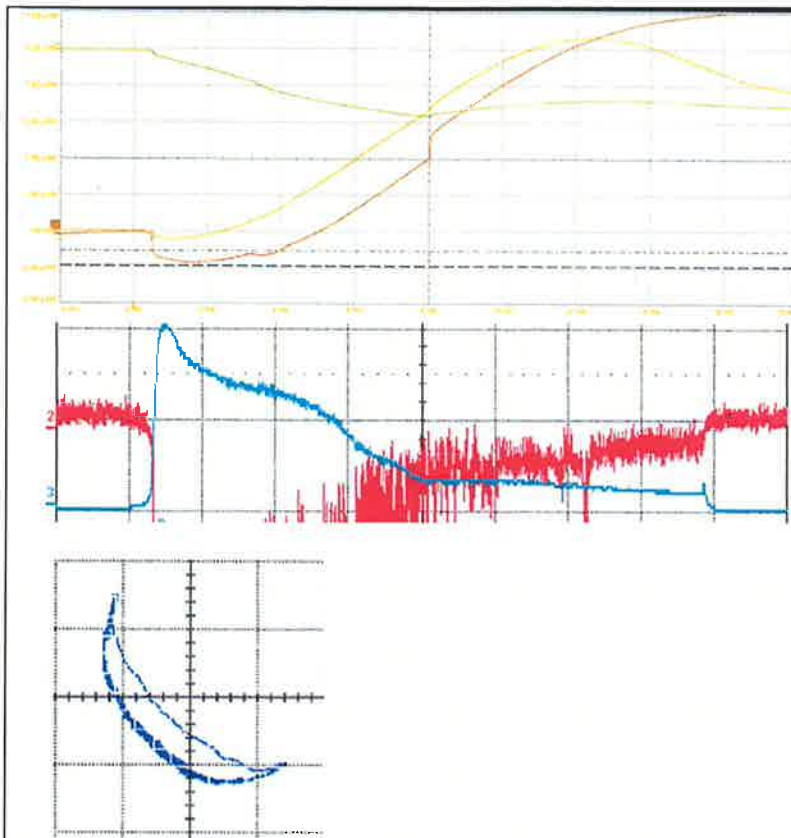
Experiment 6 – With LN2; $I_{BB}=210A$; $I_{MP} = 182A$ (8ms)



Observations: $t > 12:12$

- 1) Very noisy P_a To 20kW/55kW
- 2) P_r rises at ~ 4 ms
- 3) Smaller DL signals than at lower B
- 4) DL6 does not increase as steeply for $t > 4$ ms.
- 5) Density falls a lot after $t \sim 2.5$ ms

Soon after ARCING South cable, inside box, in fiting



Conclusions/recommendations/questions

1. Can get no DL overshoot both with and without LN2. Cause of overshoot still a mystery.
2. Don't know if sharp DL rise and fall at pulse's beginning & end are real!!
3. Don't know if linear DL rise during pulse is real.
4. Why DL6 signal at all?
5. RC of cable plus scope? $R_{\text{scope}} \sim 1 \text{ M}\Omega$, $C \sim 1\text{e-}8 \rightarrow RC \sim 10^{-2} \text{ s}$. Hmmm. But $R_{\text{DL}} < 1\Omega$.
6. Operate Magnapower in constant current mode
7. Gas puff
8. Test additional DLs, even ones not encircling plasma
9. Model DL signal with PSpice, include capacitive coupling
10. Take notes on grounding Pomona boxes.
10. Measure DL temps during run (quickly).
11. Preamp on DLs.