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What is ISA?

- ISA operates and develops the storage ring ASTRID and related facilities
- ISA staff assist internal and external users in their experiments
- ASTRID operated 5+5 weeks for ions and 18+15 weeks for SR in 2004
- ISA is used by ~150 users/per year from from Århus (1/4), DK (1/4) and abroad (1/2)

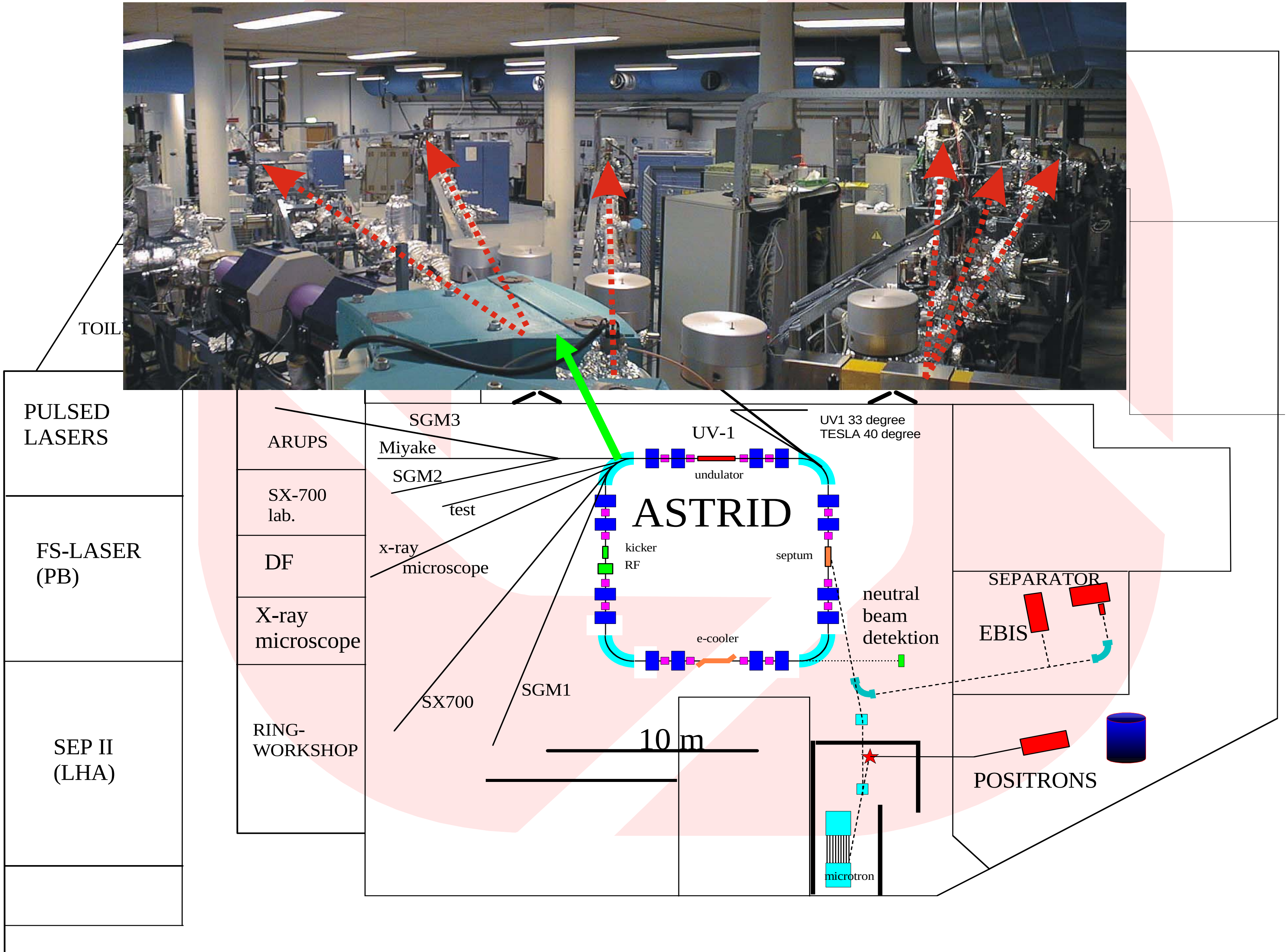
History of ISA

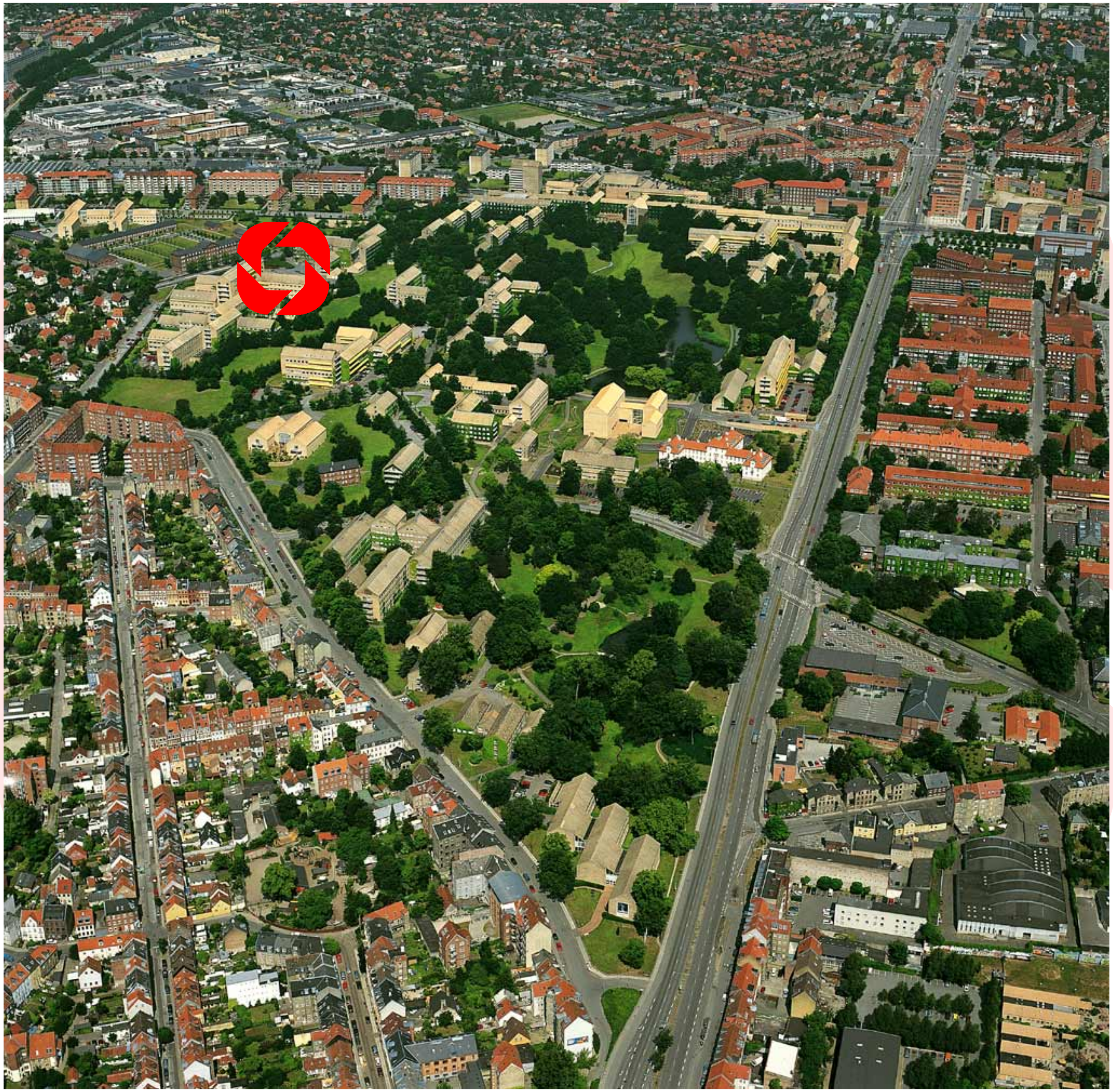
- 1983 First ideas about storage ring in Århus
- 1990 First operation with ions
- 1991 SX-700 monochromator installed at BESSY
- 1993 Inauguration synchrotron-radiation source
- 1994 SX-700 installed at ASTRID
- 1996-1999 national laboratory contract → undulator + 4 additional beamlines
- 1997 Additional laboratory space
- 2001 EC contract
  - Access to research infrastructure

ASTRID as a Synchrotron Radiation Source

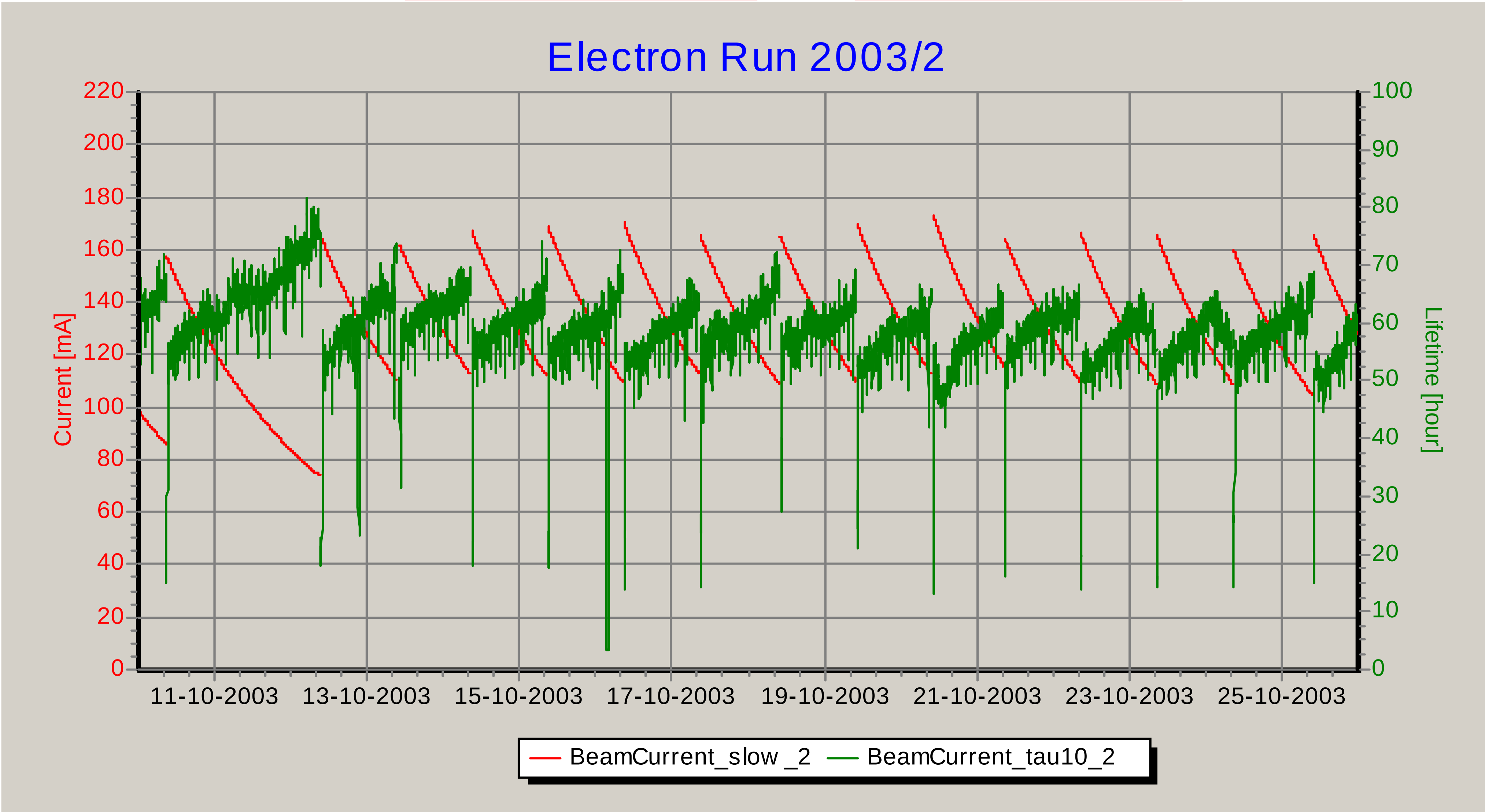
- Energy 100-580 MeV
- Injector: microtron 3 GHz, 10 mA, 1 μs, 0.2-10 Hz
- Critical energy, wavelength ε_c=360eV, λ_c=35Å
- Current 150-200 mA
- Emittance 140 ×7nm
- Lifetime 40-50 hours
- RF 105 MHz, 14 bunches, 70 kV
- One undulator 30 periods of 55 mm, min. gap 22 mm, first harmonic 11-59 eV
- 7 beamlines

ISA/ASTRID laboratory





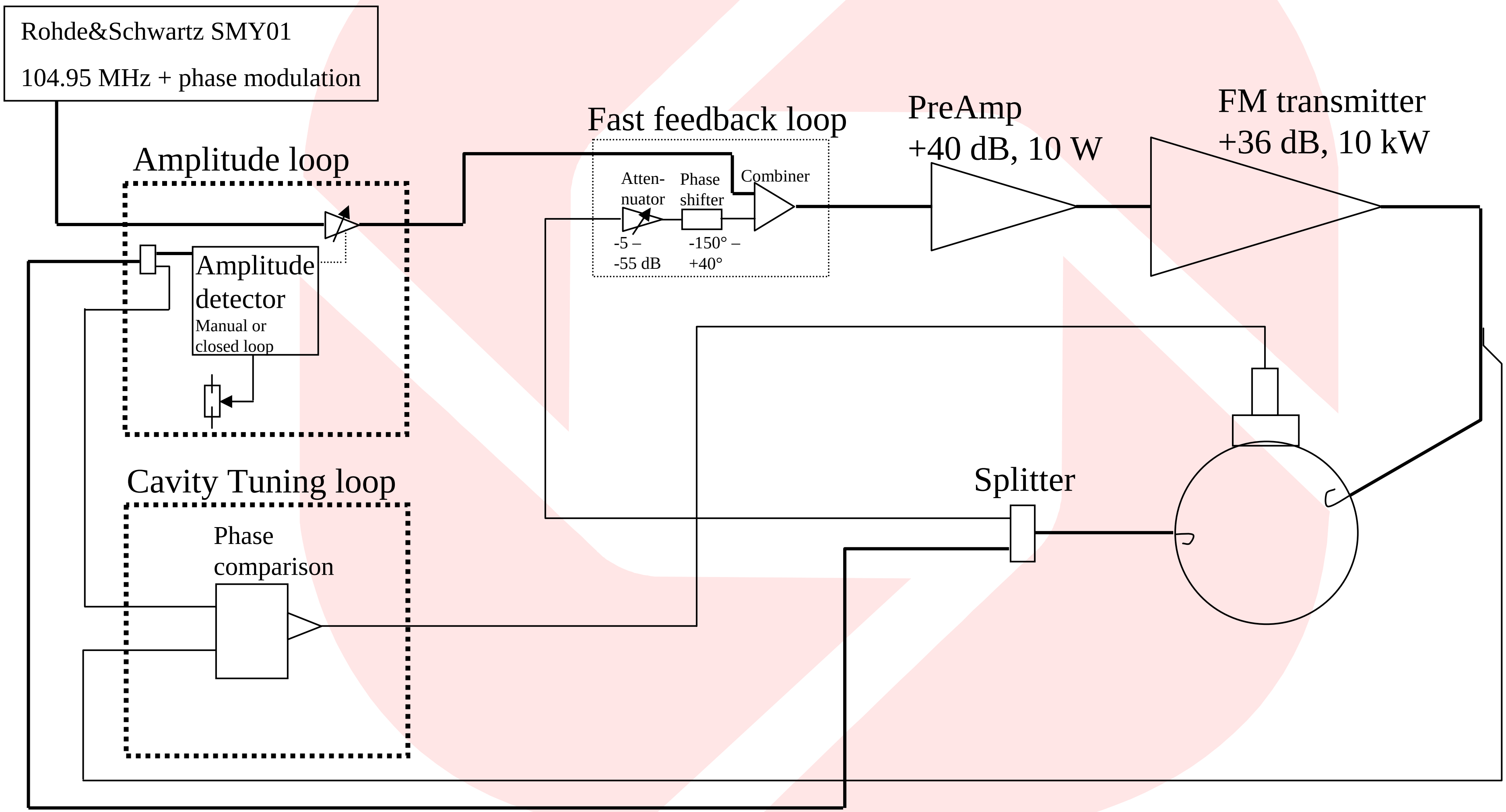
Typical current and lifetime

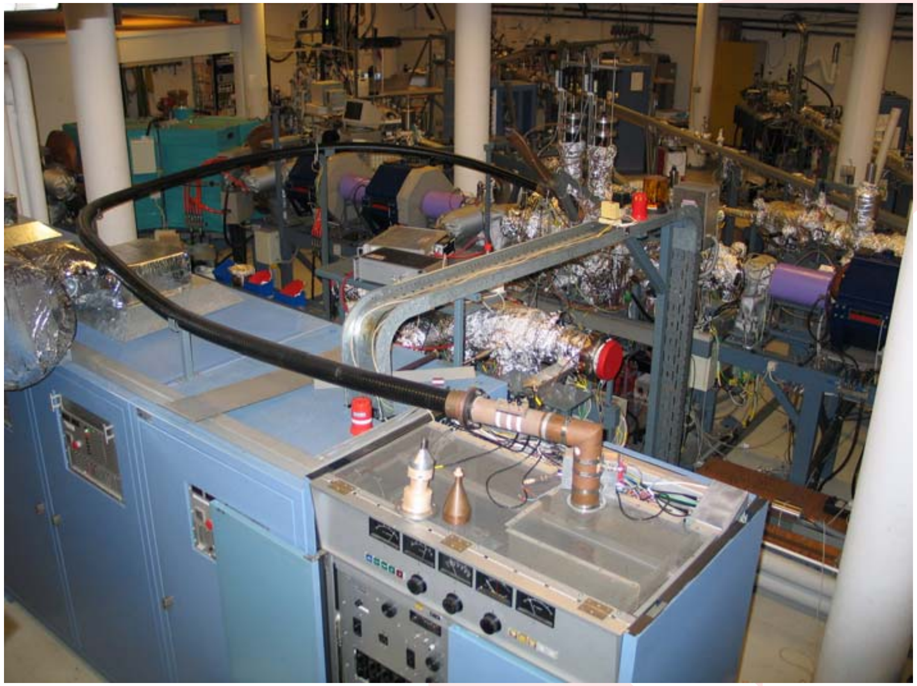


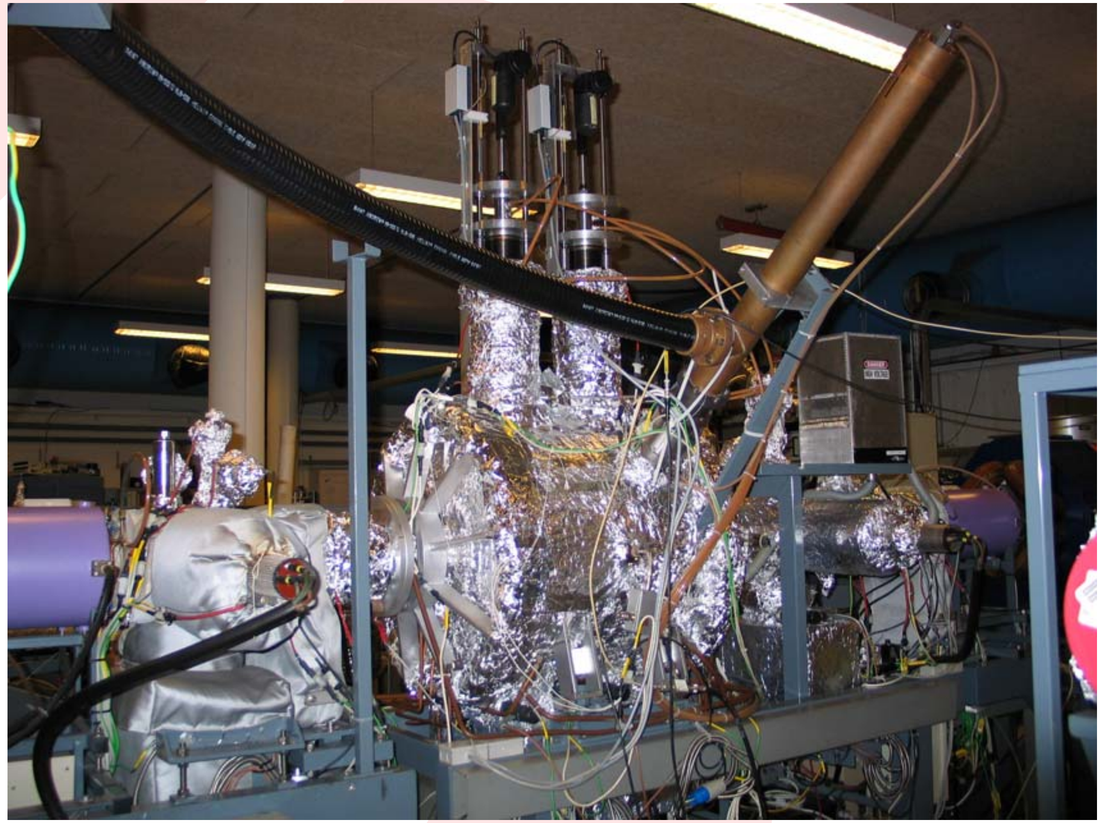
The ASTRID RF system

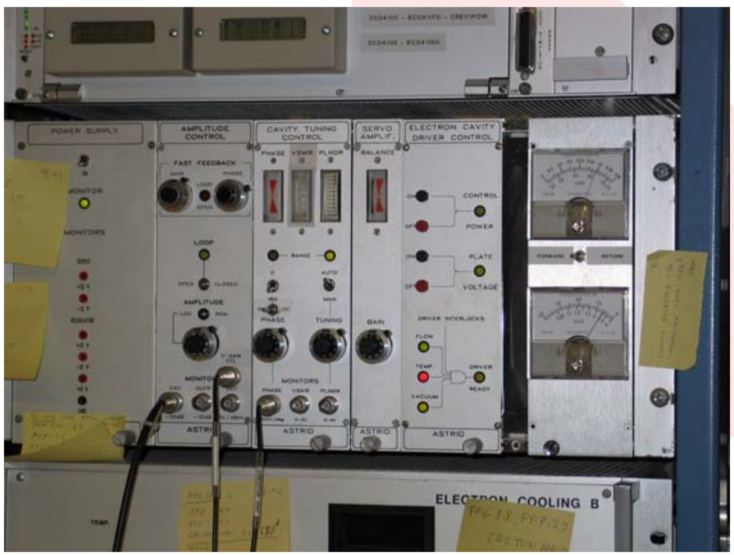
- 105 MHz system
- One cavity
  - Copper-plated Coaxial TEM cavity
- 20 kW tube based (tetrode) FM transmitter
    - The bandwidth has been increased resulting in a lower maximum output (~8 kW)
- Standard amplitude loop
- Standard cavity tuning loop
- Fast feedback loop
    - Which we are very dependent on

The ASTRID RF system



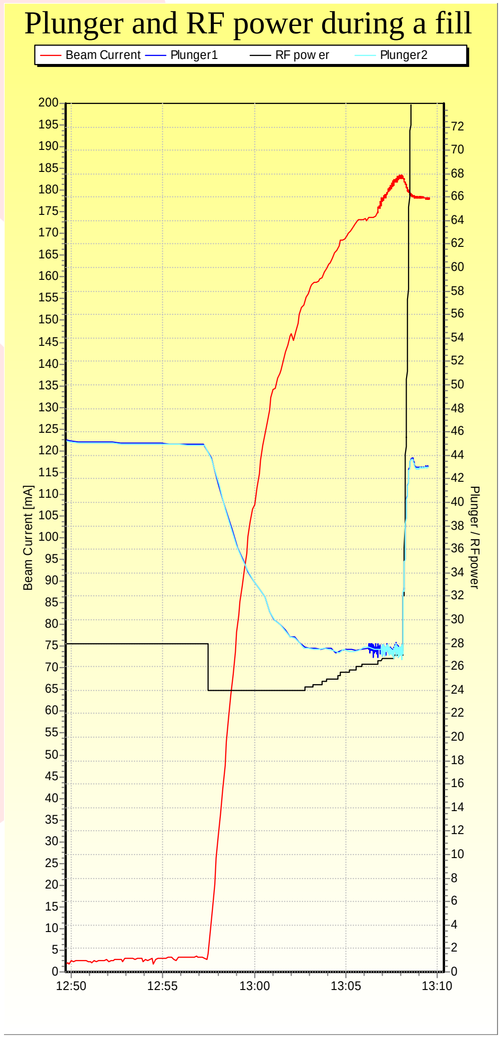





POWER SUPPLY
AMPLITUDE CONTROL
CAVITY TUNING CONTROL
SERVO AMPLIF.
ELECTRON CAVITY DRIVER CONTROL
ASTRID
ELECTRON COOLING B

RF power at Injection

- Want low RF voltage at injection
  - Inject (pulsed) DC beam from microtron
    - Induce strong synchrotron oscillations => poor capture efficiency
  - Improved lifetime
    - Too high RF power => shorter bunch => increased Touschek scattering
- Need enough RF power to overcome beamloading
    - Increase power as current increase
- Finding the balance !

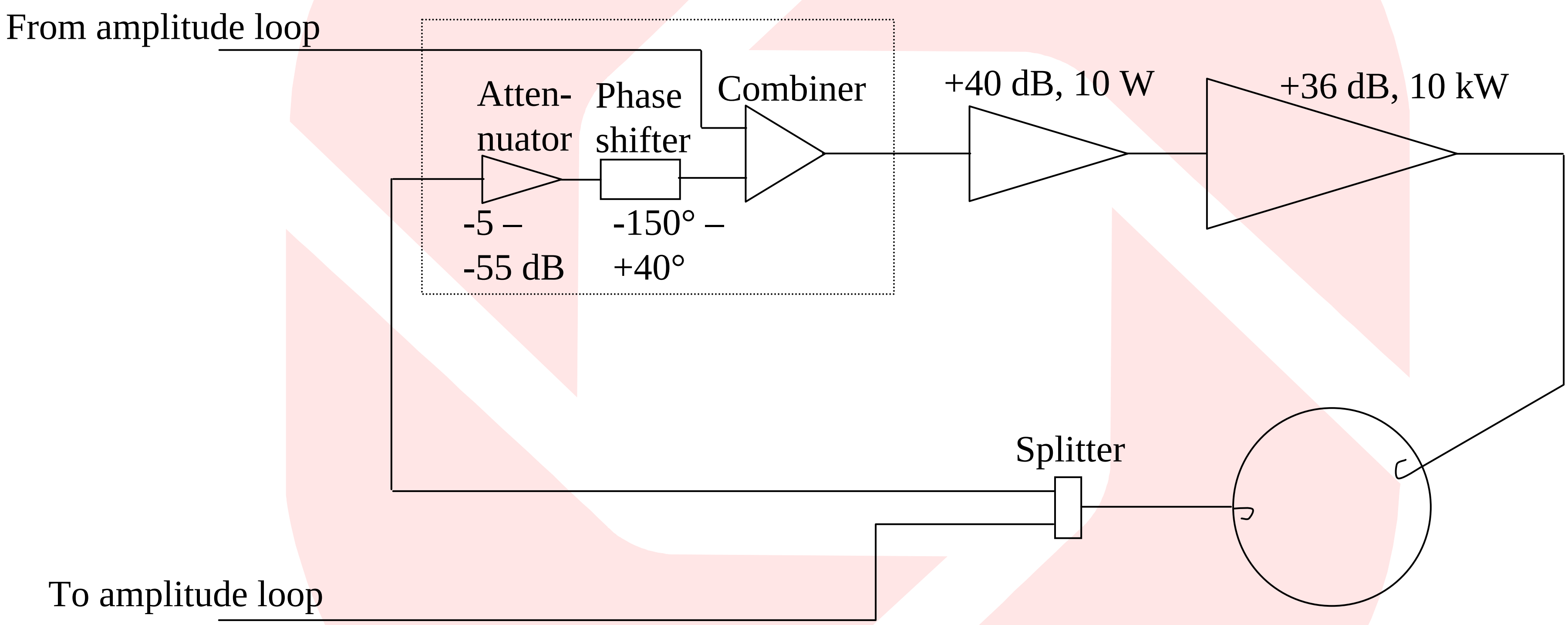


Fighting the beamloading

- Fast Feedback Loop
  - Pickup the cavity voltage and feed it back to the cavity in opposite phase.
  - This way any beam induced voltage is counteracted

- Problem:
  - Can only achieve perfect in opposition for one frequency
  - Needs to have a small group delay to have a large bandwidth

Fast Feedback Loop Principle



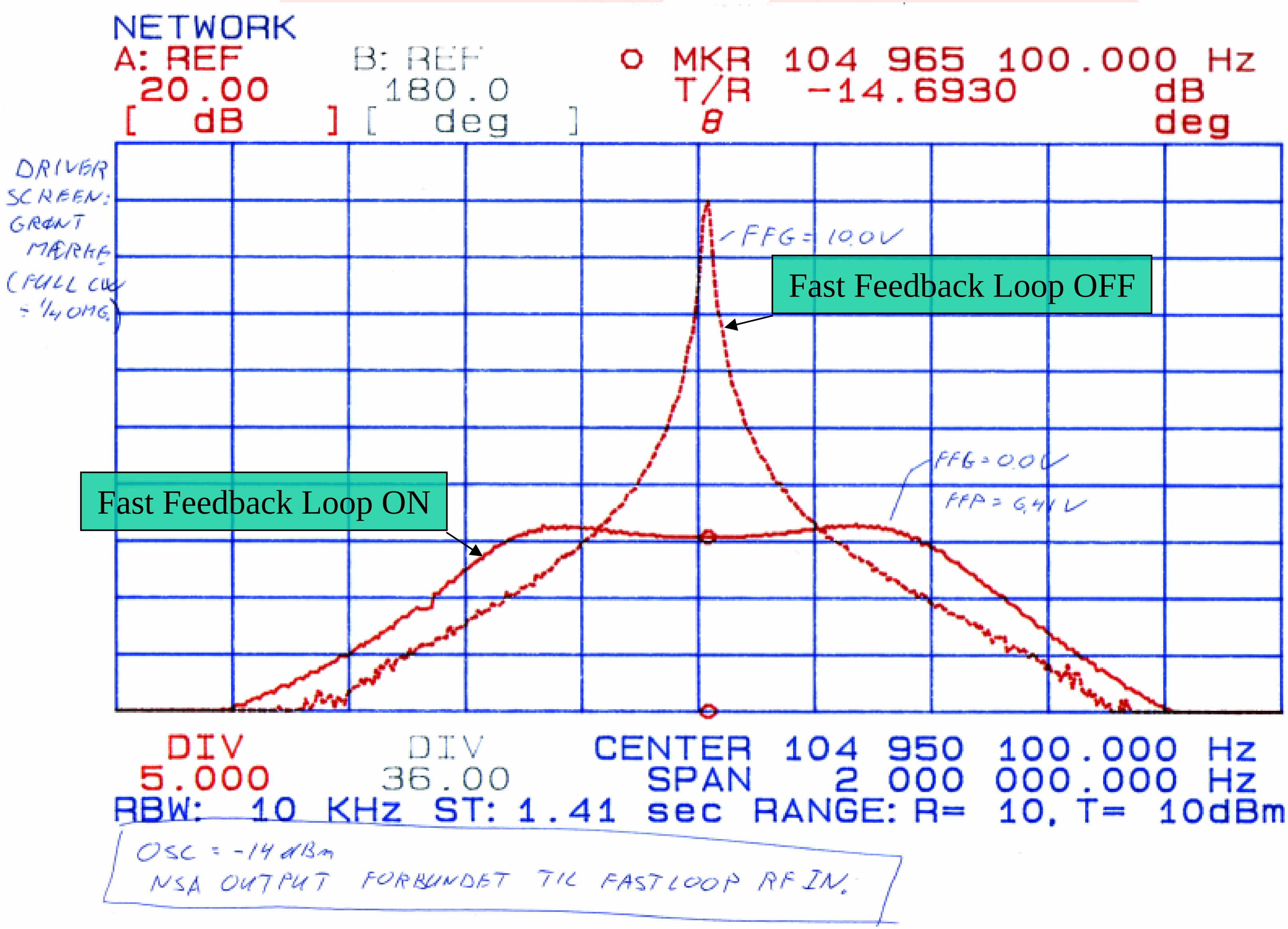
Reference: A. Gamp, "Servo Control of RF Cavities under Beam Loading" CERN 92-03, 1992
F. Perez *et.al.*, "Fast Feedback Loop for Beam Loading Compensation in the ANKA Booster"
Proc. EPAC 2000, Vienna, Austria, p 1996

Fast Feedback Loop

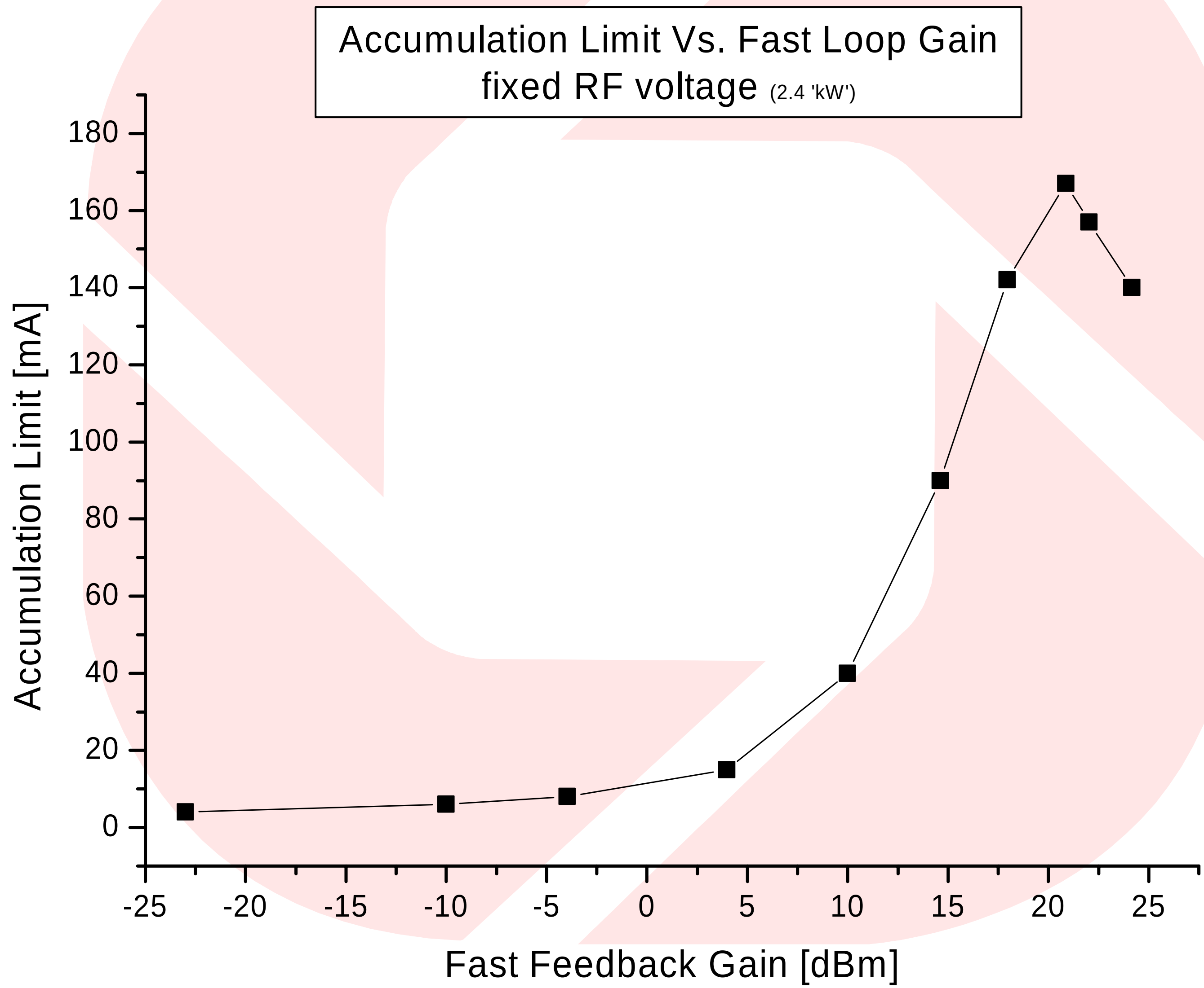
- Benefits
  - Very effective to fit beamloading
  - Cheap: Phase Shifter, Variable gain amplifier/attenuator, more low power

- Problem:
  - Can only achieve perfect in opposition for one frequency
  - Needs to have a small group delay to have a large bandwidth

Cavity Voltage with Fast Loop



Accumulation



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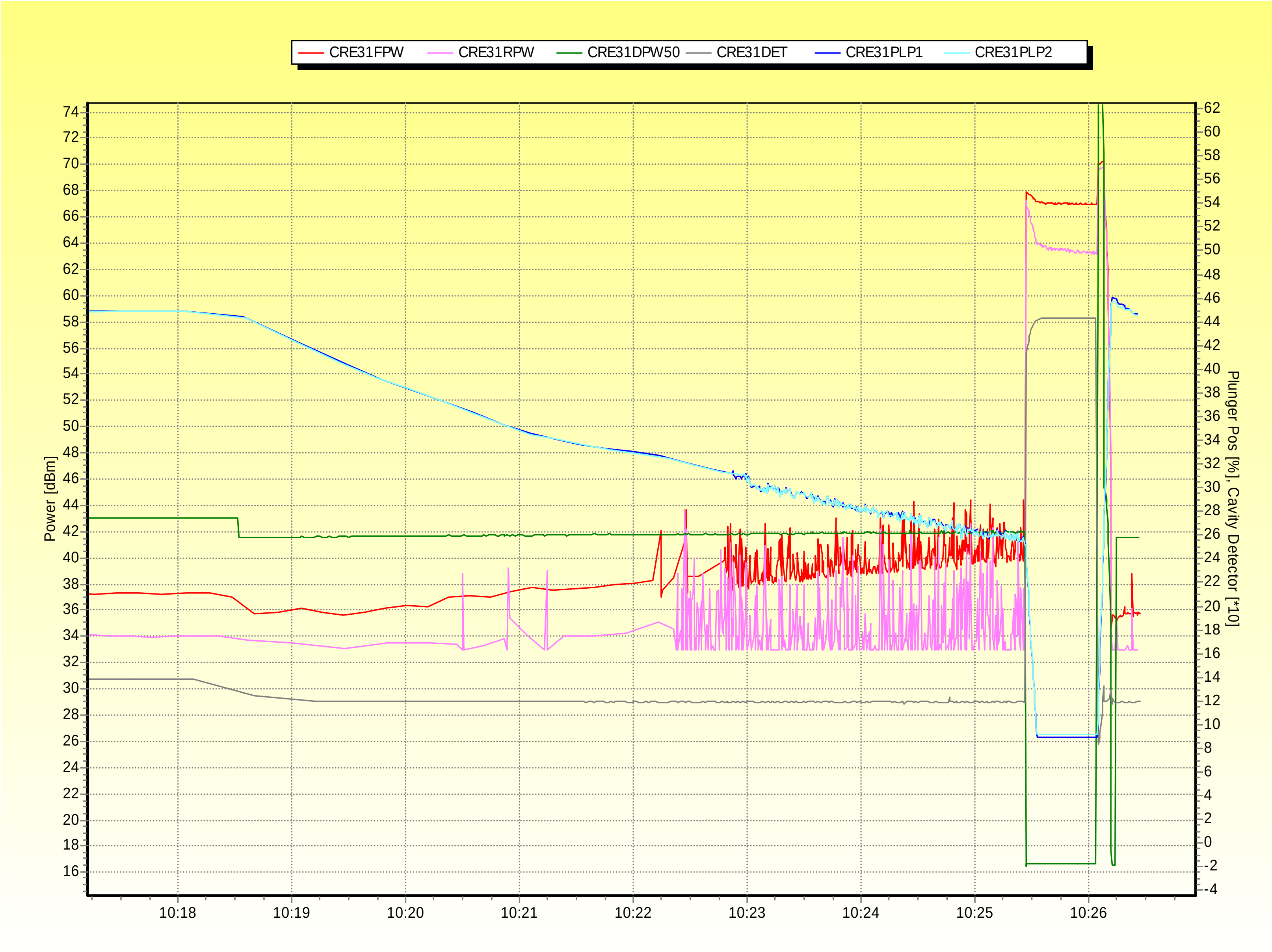
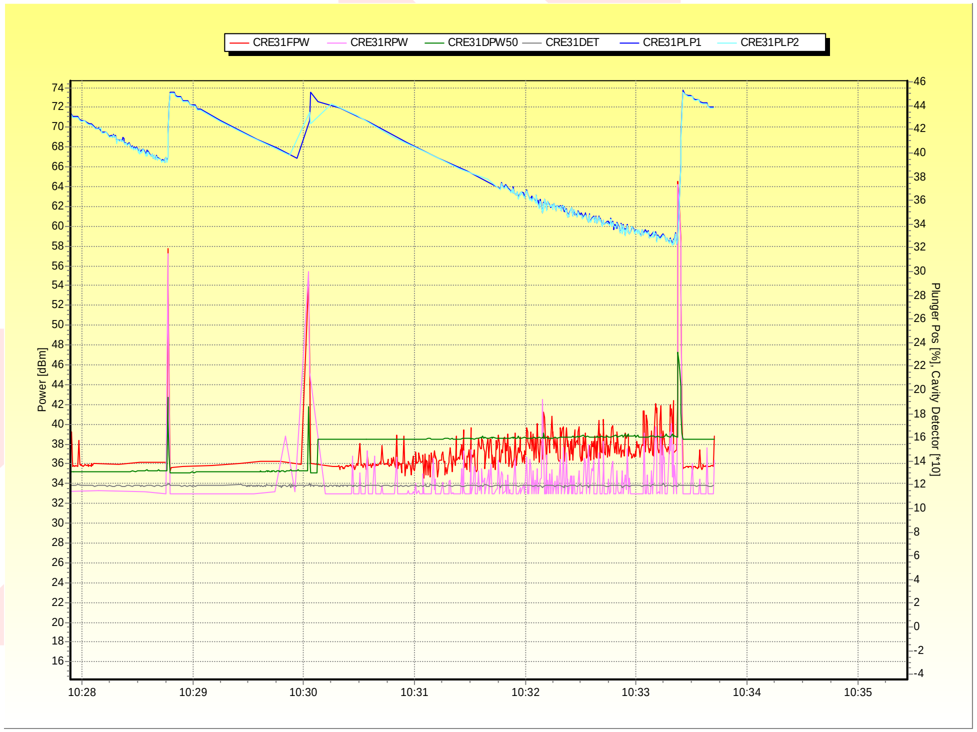
Beam drop-out



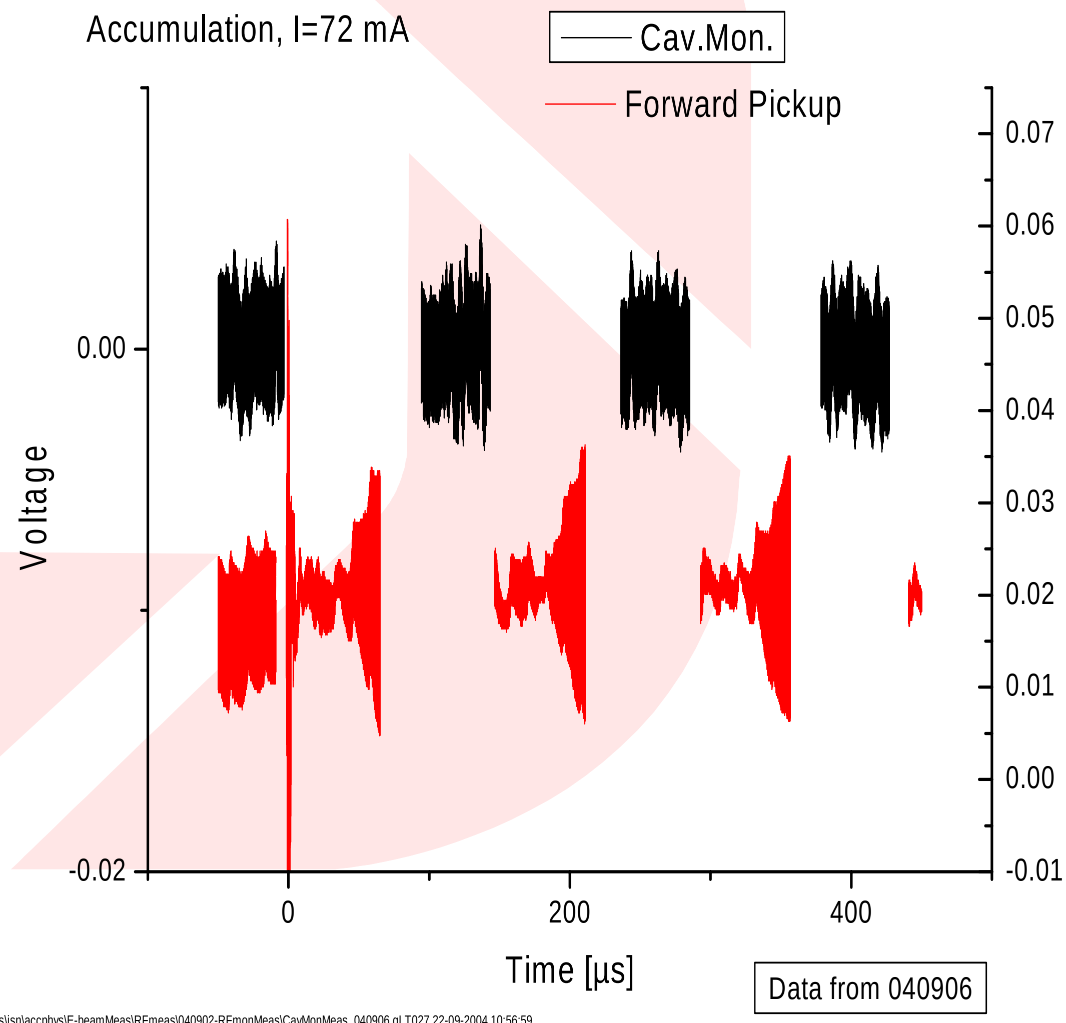
Why is the Beam dropping out?

- Good question, which we would very much like to know the answer to.
  - Is it because the Fast Loop is ringing, or is the ringing just because the detuning is so large when the beam drops out?
    - At lower Fast Feedback Gain, we see the beam drop-out without the fast loop ringing.
  - Why the large variation in forward and reverse power?
    - Is it a signature of the fast loop working, or is it a problem?
  - Could we get some warning?

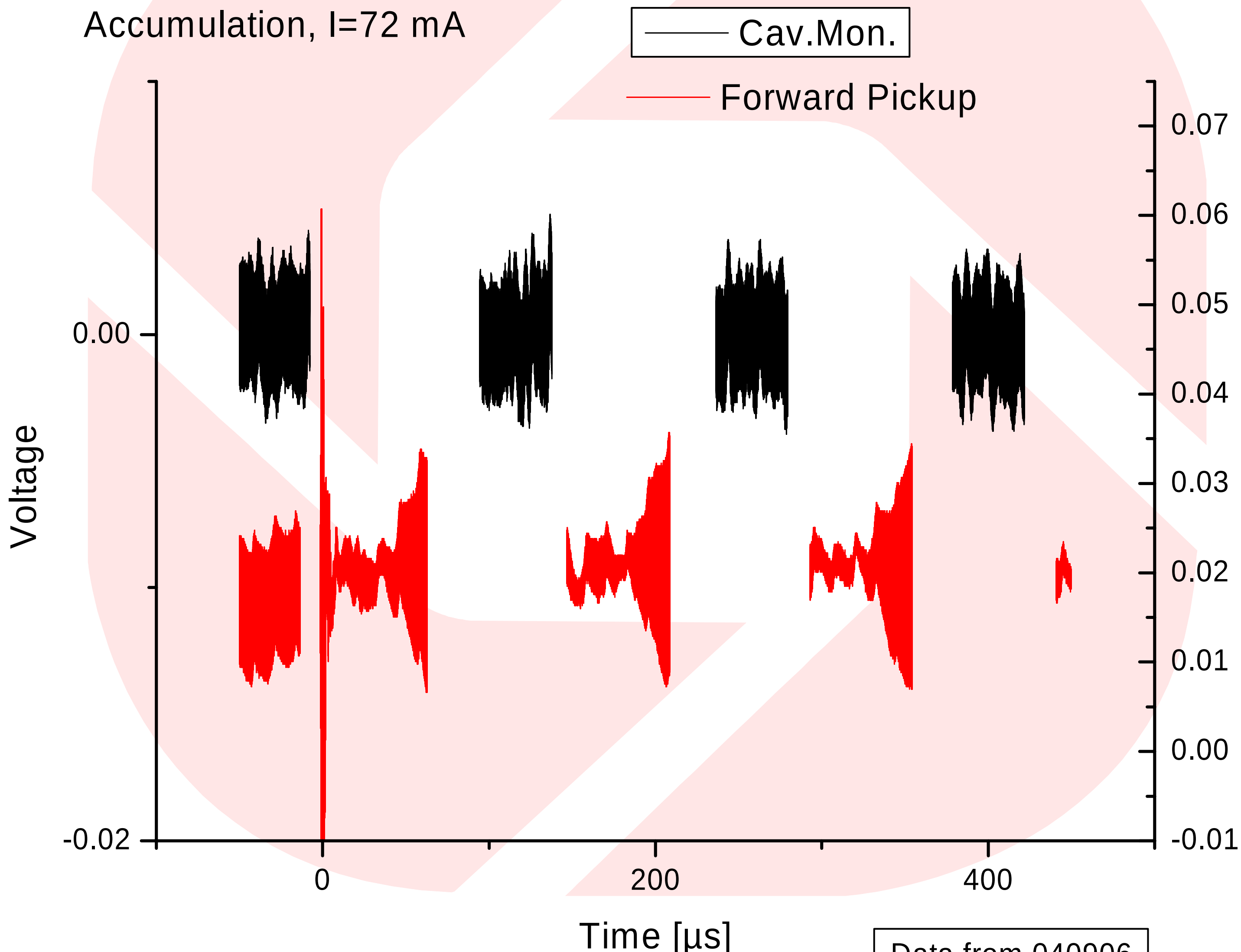


Modulation of Forward Power

- Just after a pulse from the microtron, we see a strong modulation on the forward (and reverse) power
  - We believe that the modulation is at the synchrotron frequency
  - The modulation period gets longer with more current
  - We only see it with the Fast Feedback Loop on
  - Partly induced by the kicker
  - Could be due to a small modulation of the cavity voltage (induced by the beam), which is strongly amplified by the Fast Loop



Modulation of Forward Power



Data from 040906

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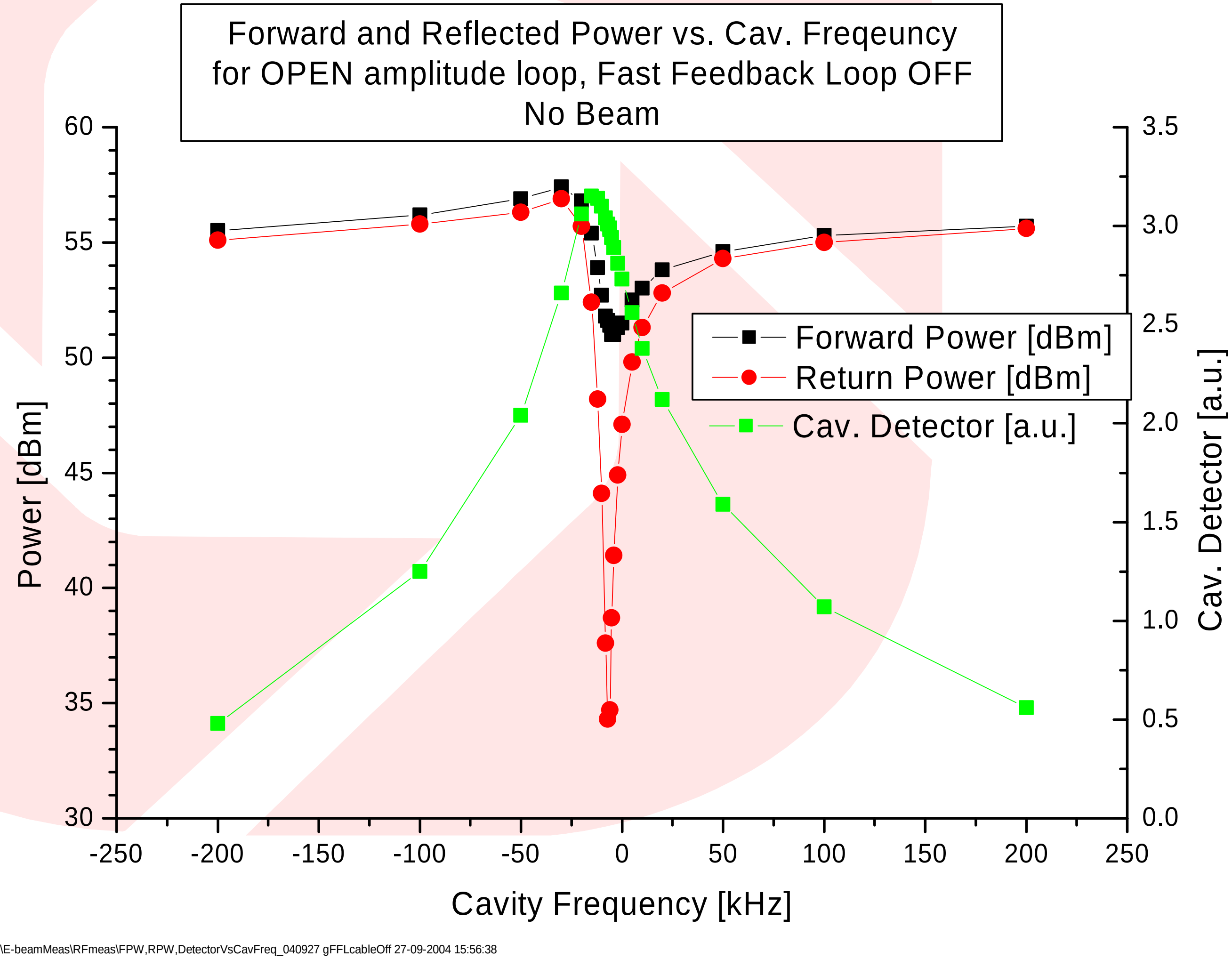
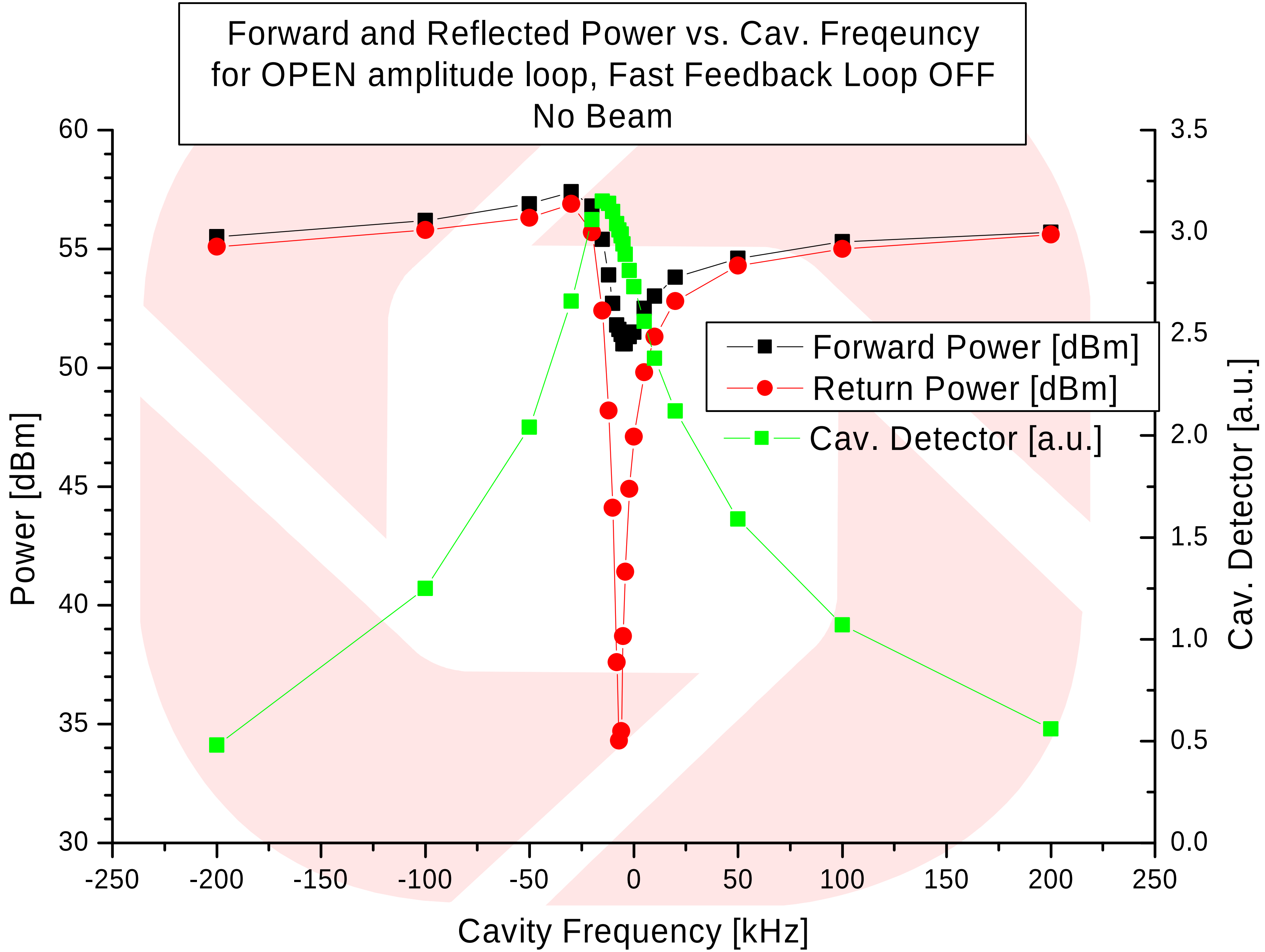
Forward Power Variation

- With Amplitude Loop off, we see a change in Forward Power when scanning the RF frequency across the cavity resonance
- True or not? (crosstalk in the directional couplers?)
- Properly due to back reflection from the transmitter due to lack of circulator
- Problem or not?
  - Maybe increases the fast loop off resonance power





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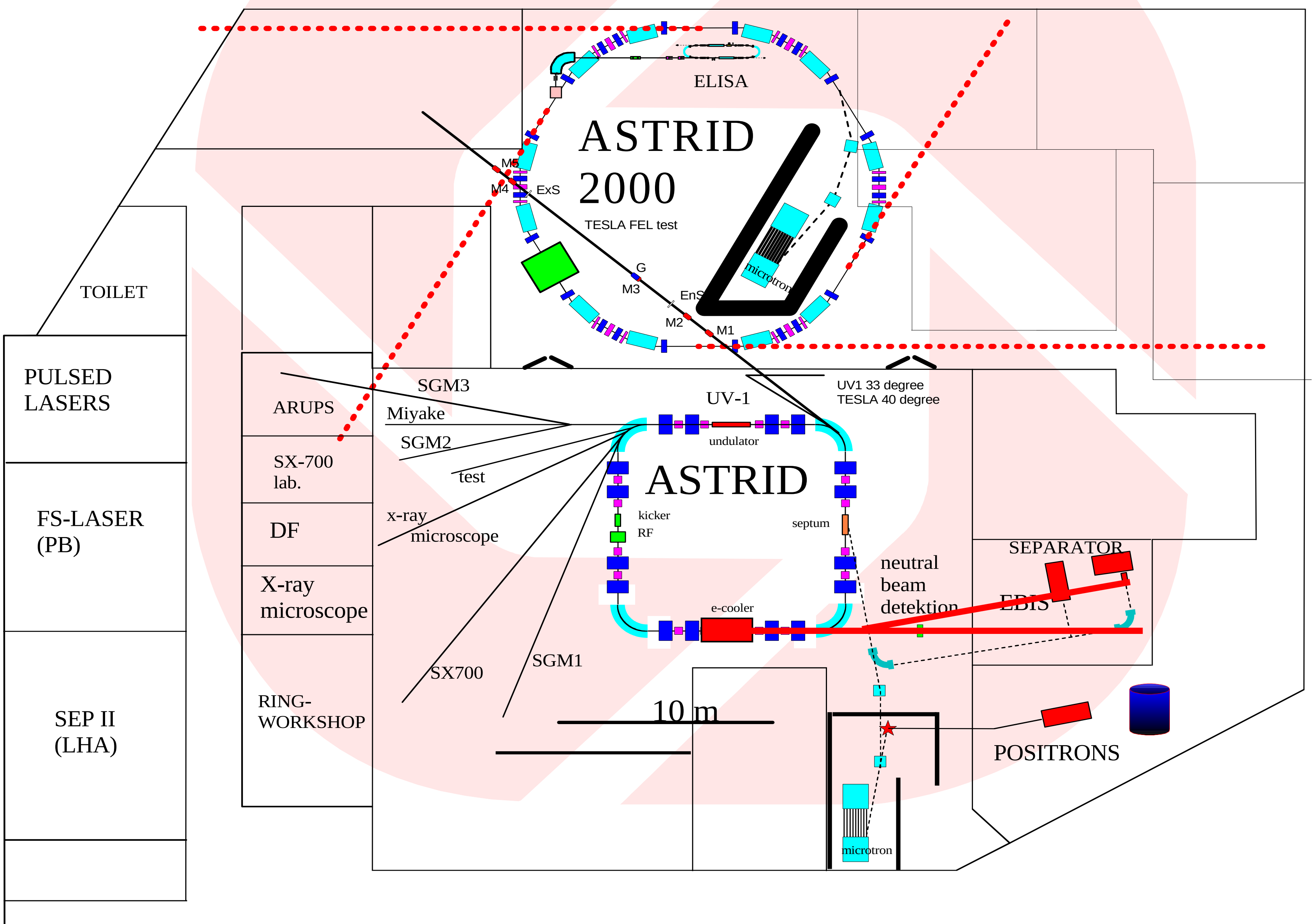
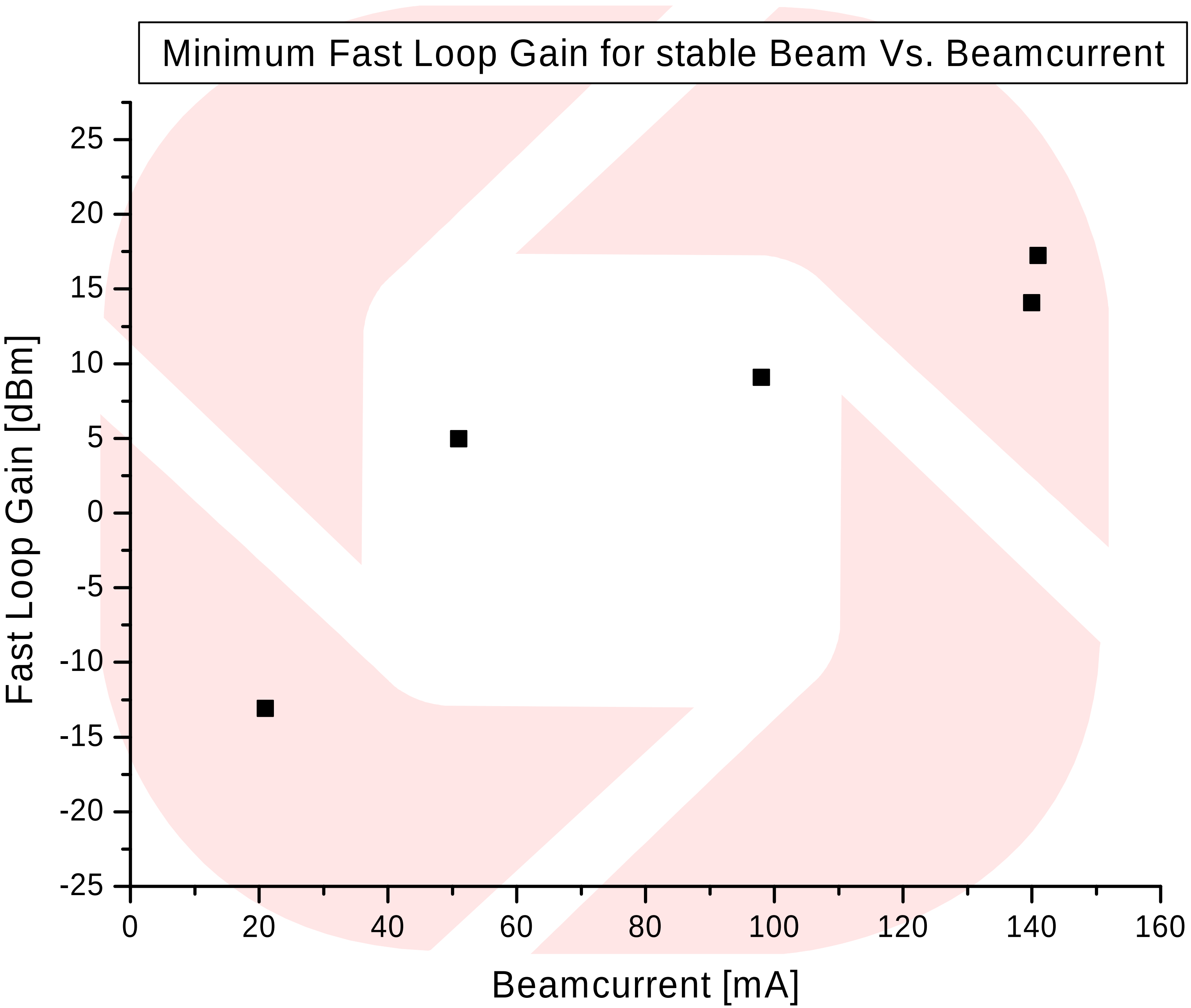
The future of ISA?



Conclusions

- Shown you ASTRID and its RF system
- Shown you our Fast Feedback Loop
- Shown you some issues, which we believe are part of the limitations to the attainable current



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