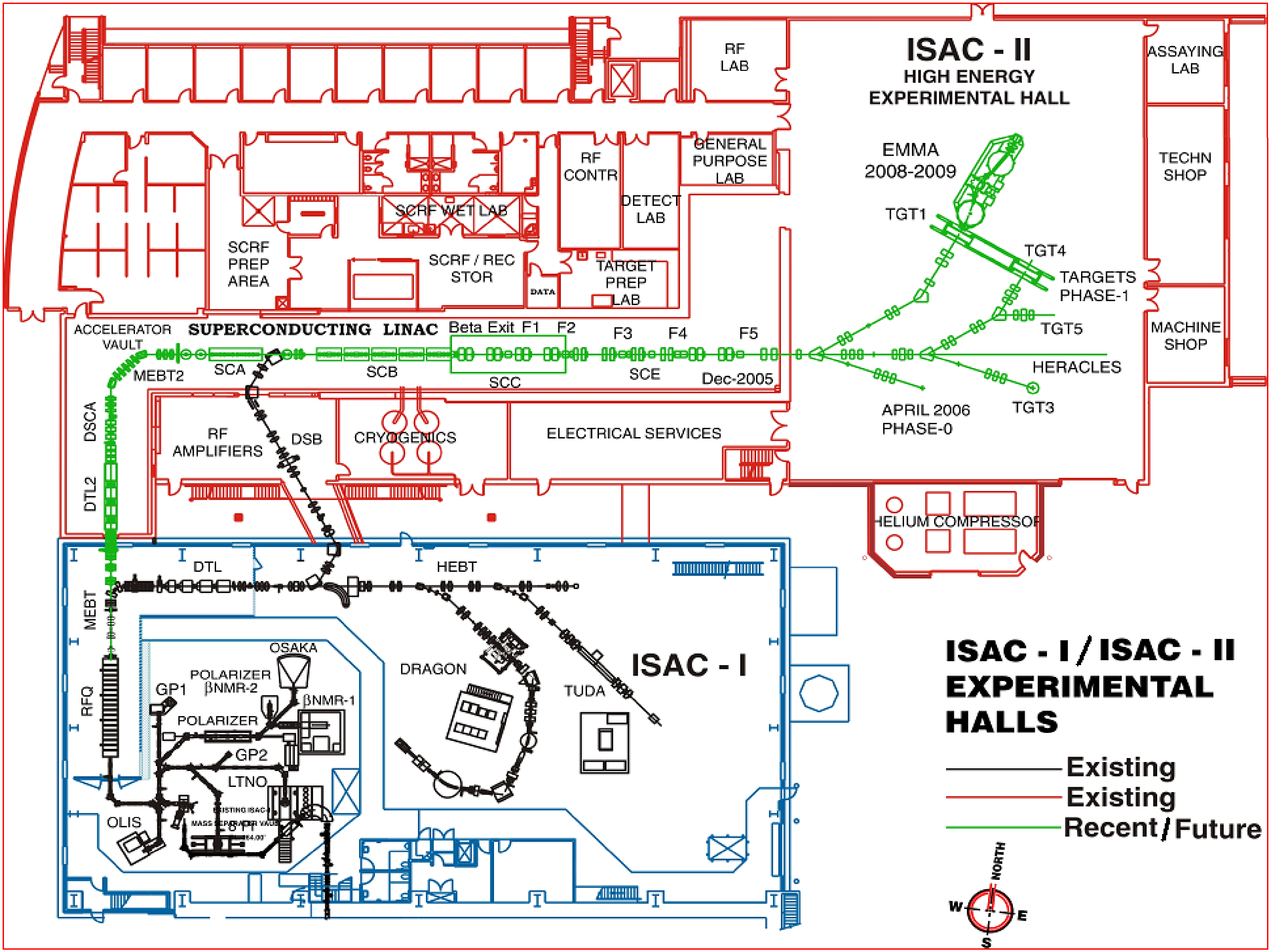
Improved Operation of ISAC RFQ

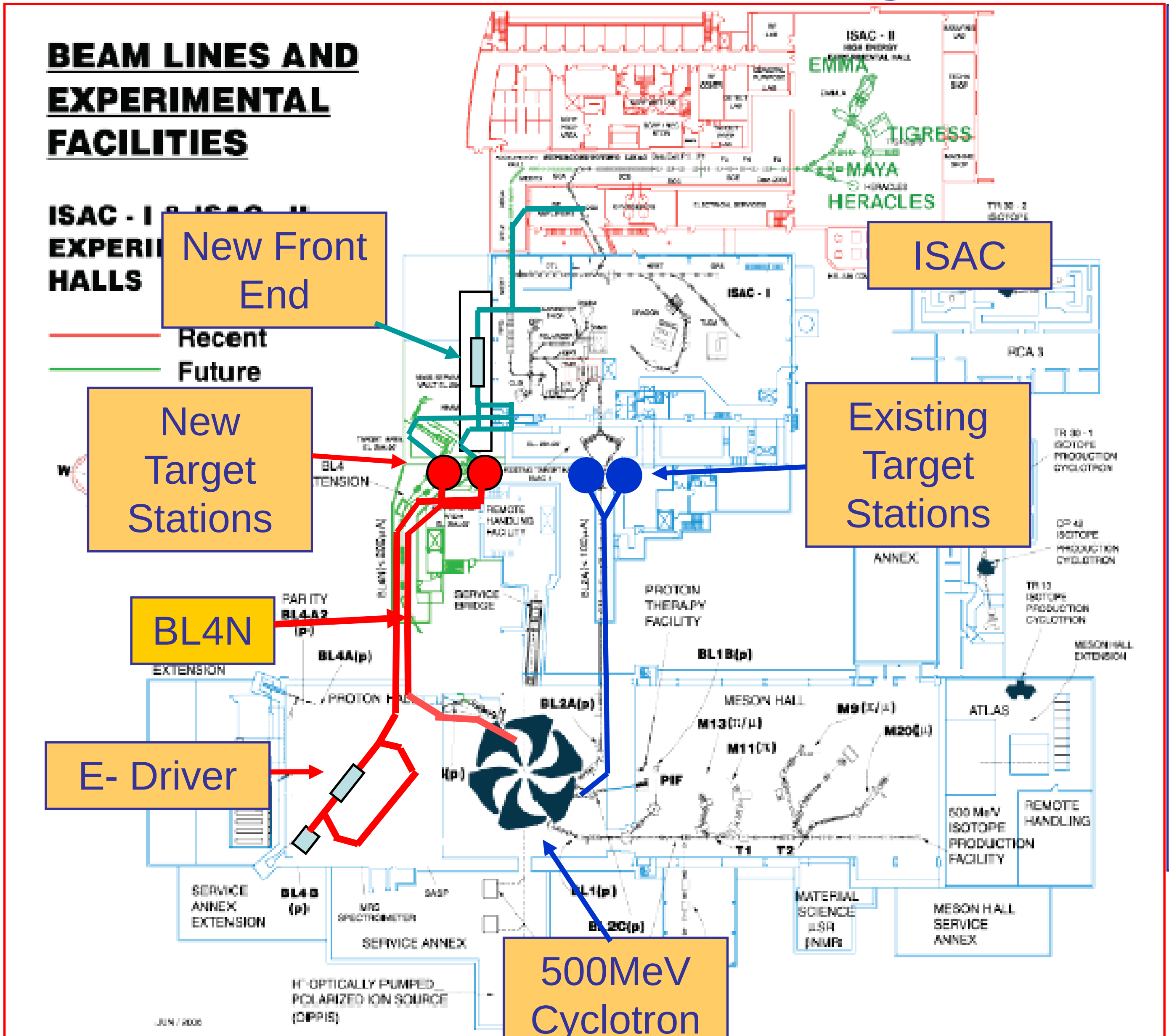
Z. Ang, Y.Bylinsky, J.Lu, A.Mitra

TRIUMF, CANADA



ISAC - II
HIGH ENERGY
EXPERIMENTAL HALL
RF
LAB
ASSAYING
LAB
TECHN
SHOP
MACHINE
SHOP
GENERAL
PURPOSE
LAB
RF
CONTR
DETECT
LAB
TARGET
PREP
LAB
SCRF WET LAB
SCRF
PREP
AREA
SCRF / REC
STOR
DATA
EMMA
2008-2009
TGT1
TGT4
TARGETS
PHASE-1
TGT5
HERACLES
TGT3
APRIL 2006
PHASE-0
ACCELERATOR
VAULT
SUPERCONDUCTING LINAC
Beta Exit F1
F2
F3
F4
F5
MEBT2
SCA
SCB
SCC
SCE
Dec-2005
DSCA
DTL2
RF
AMPLIFIERS
DSB
CRYOGENICS
ELECTRICAL SERVICES
HELIUM COMPRESSOR
DTL
HEBT
MEBT
RFQ
OSAKA
POLARIZER
βNMR-2
βNMR-1
GP1
POLARIZER
GP2
LTNO
OLIS
DRAGON
TUDA
ISAC - I
ISAC - I / ISAC - II
EXPERIMENTAL
HALLS
Existing
Existing
Recent / Future
NORTH
W
E
S

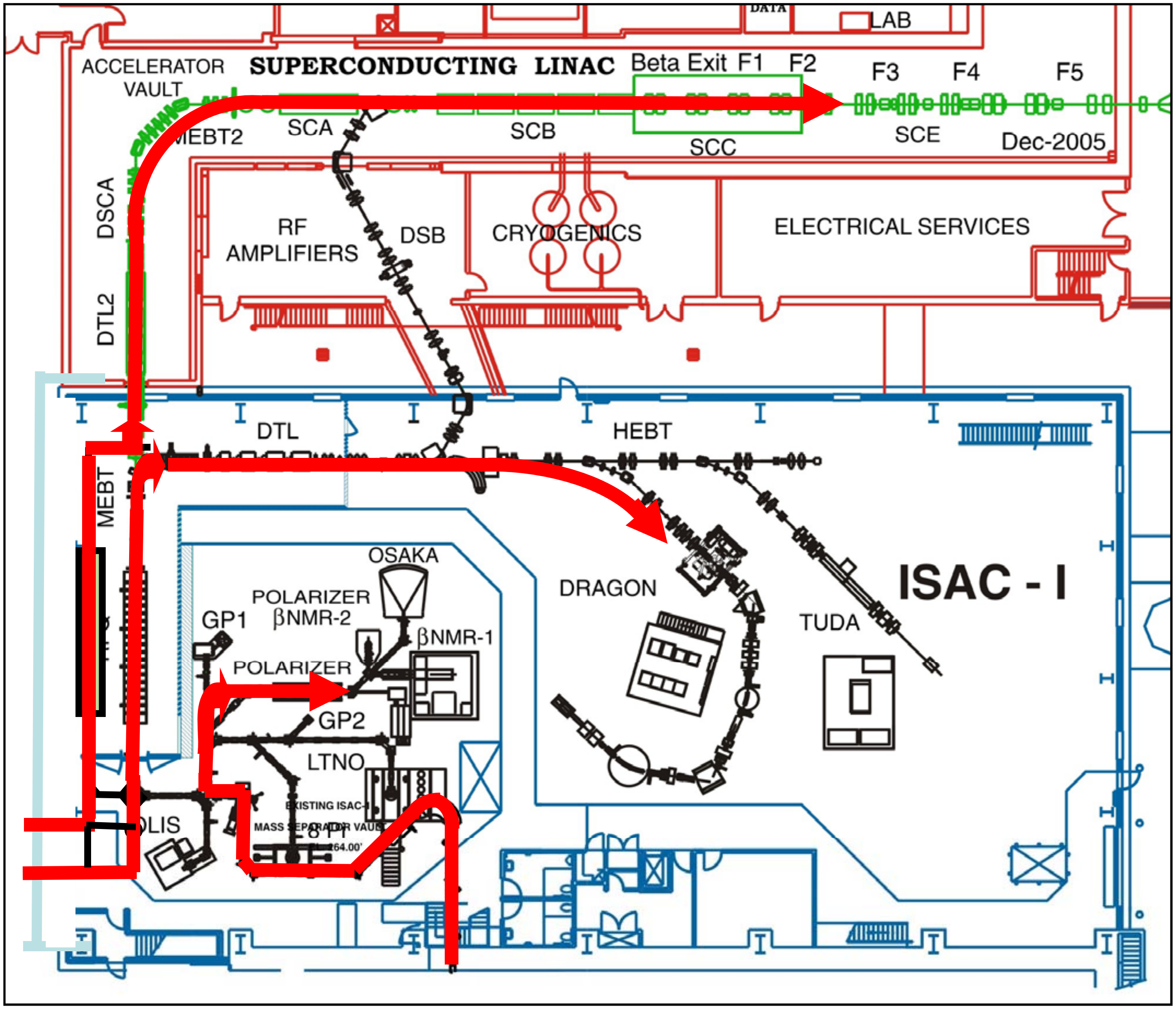
TRIUMF New Projects



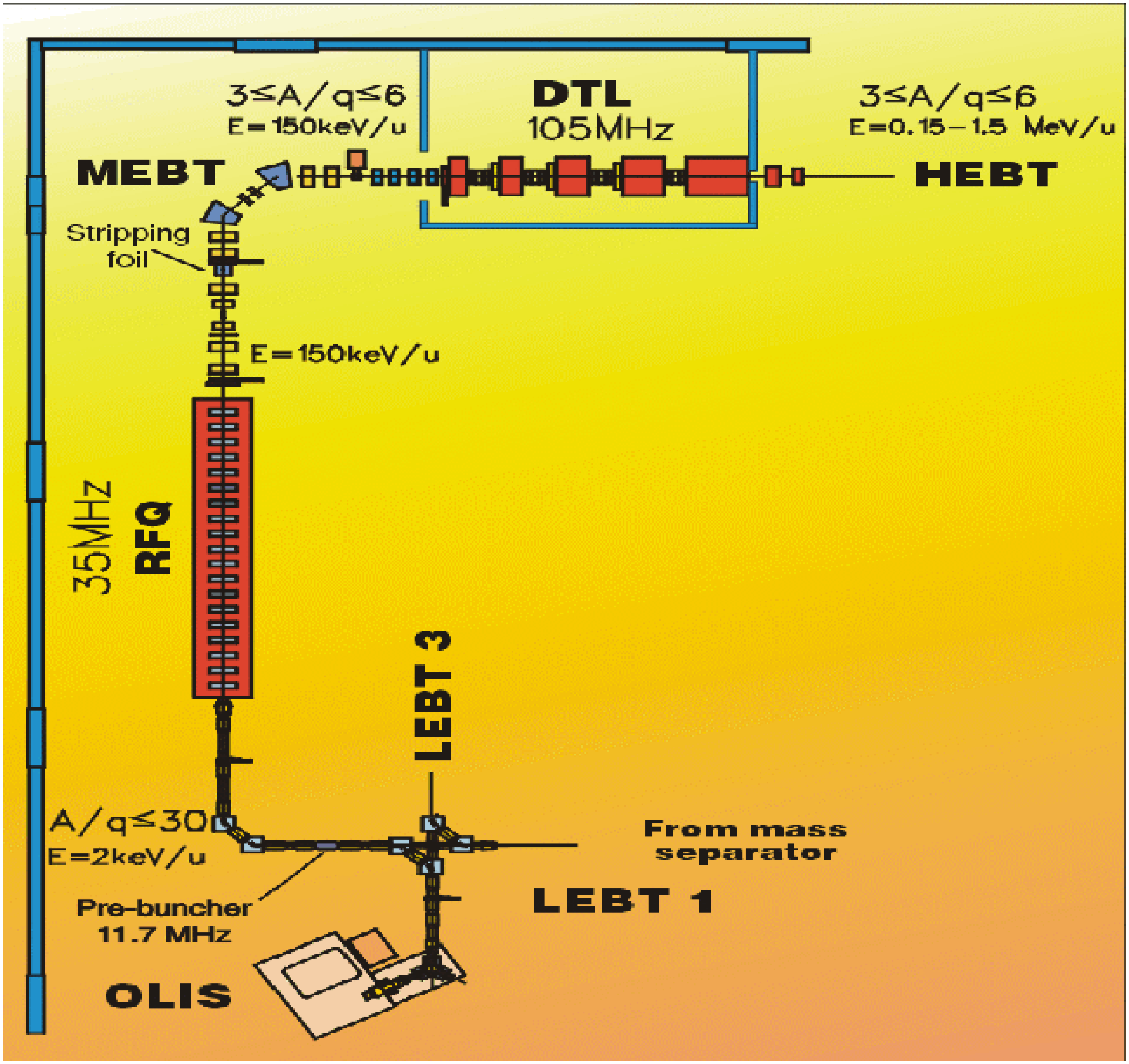
Proposal:

- **BL4N is proposed to deliver 500MeV protons to two target stations for beam production**
- **Take advantage of the shielded and unused proton hall to add an electron driver to supply electrons to the new target area via a separate beamline;**
- **Develop new ISAC front end to permit three simultaneous RIB beams (two accelerated).**

- Three simultaneous radioactive ion beams
    - One to each of the low, medium and high energy areas

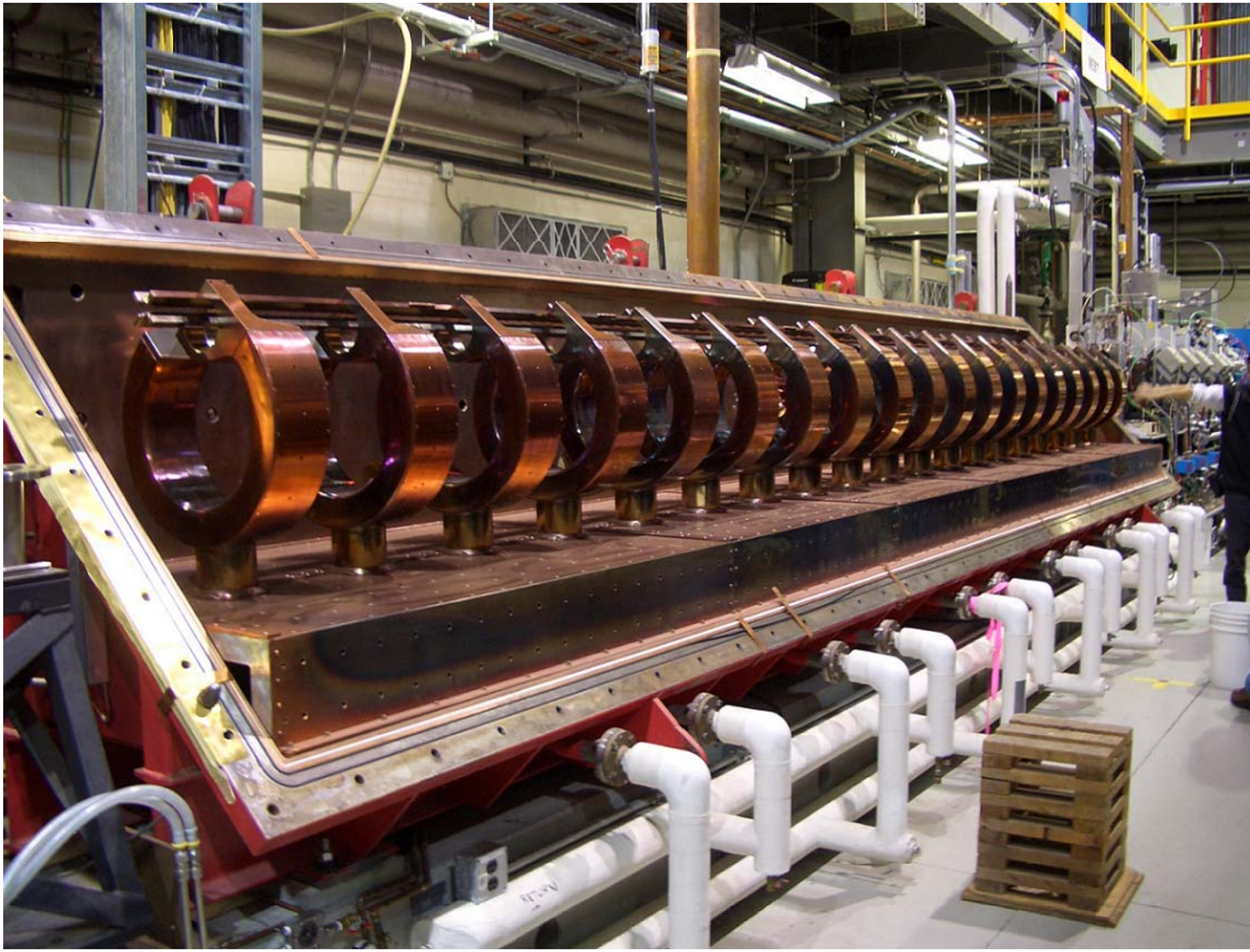


ISAC-I ACCELERATOR



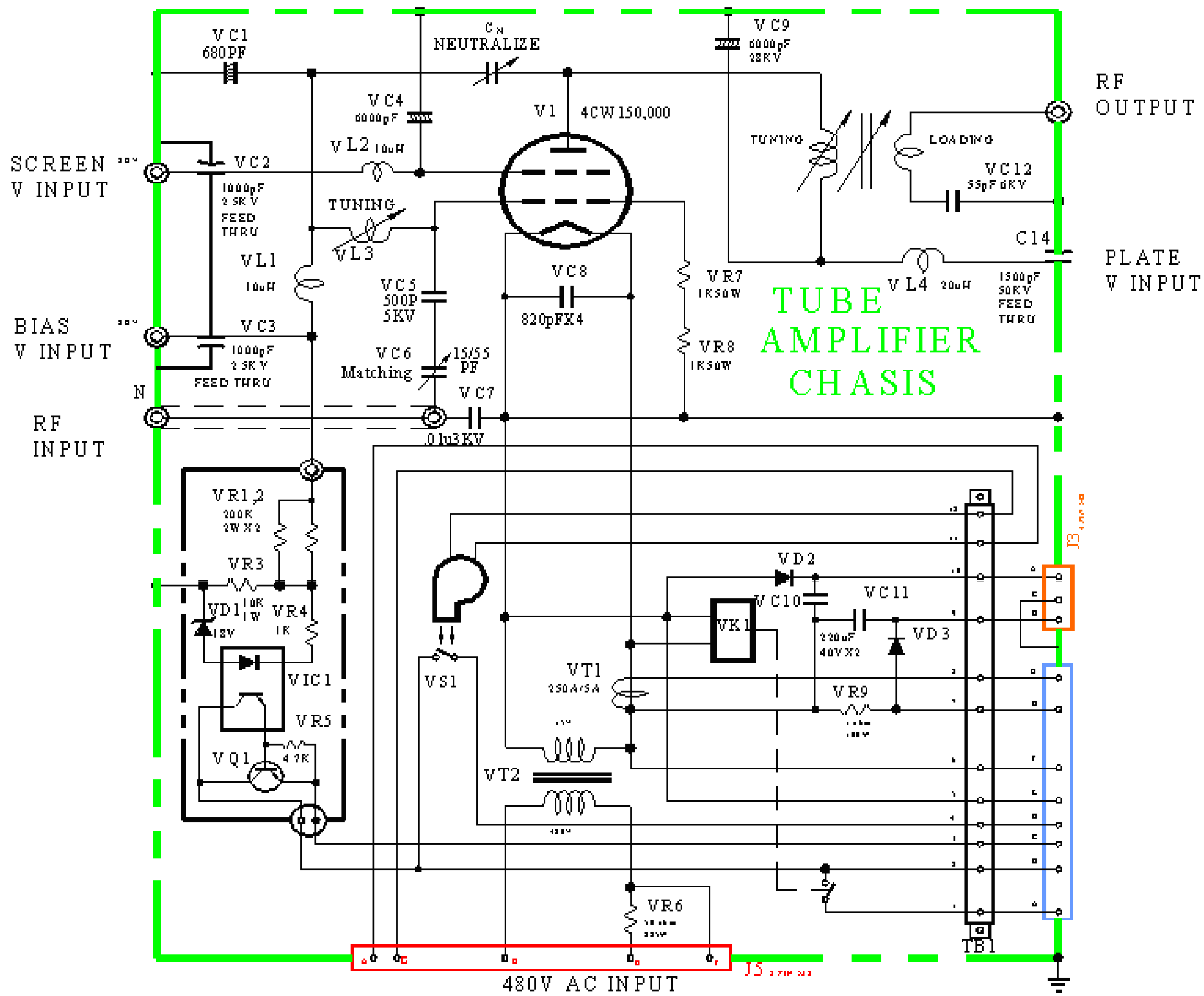
Improvements of RFQ Operation

- RFQ amplifier H-V PS soft start implementation
- Crowbar circuit improvement
- Water leaks repairing and vacuum system upgrading
- RFQ remote control application



- 35 MHz CW mode
- Vane-shaped rods, 19 rings space 40 cm apart, 8m long
- Max. inter-vane voltage is 74 KV
- accelerates ions A/q up to 30 from 2KeV/u ~ 150 KeV/u

RFQ Power Amplifier Schematic

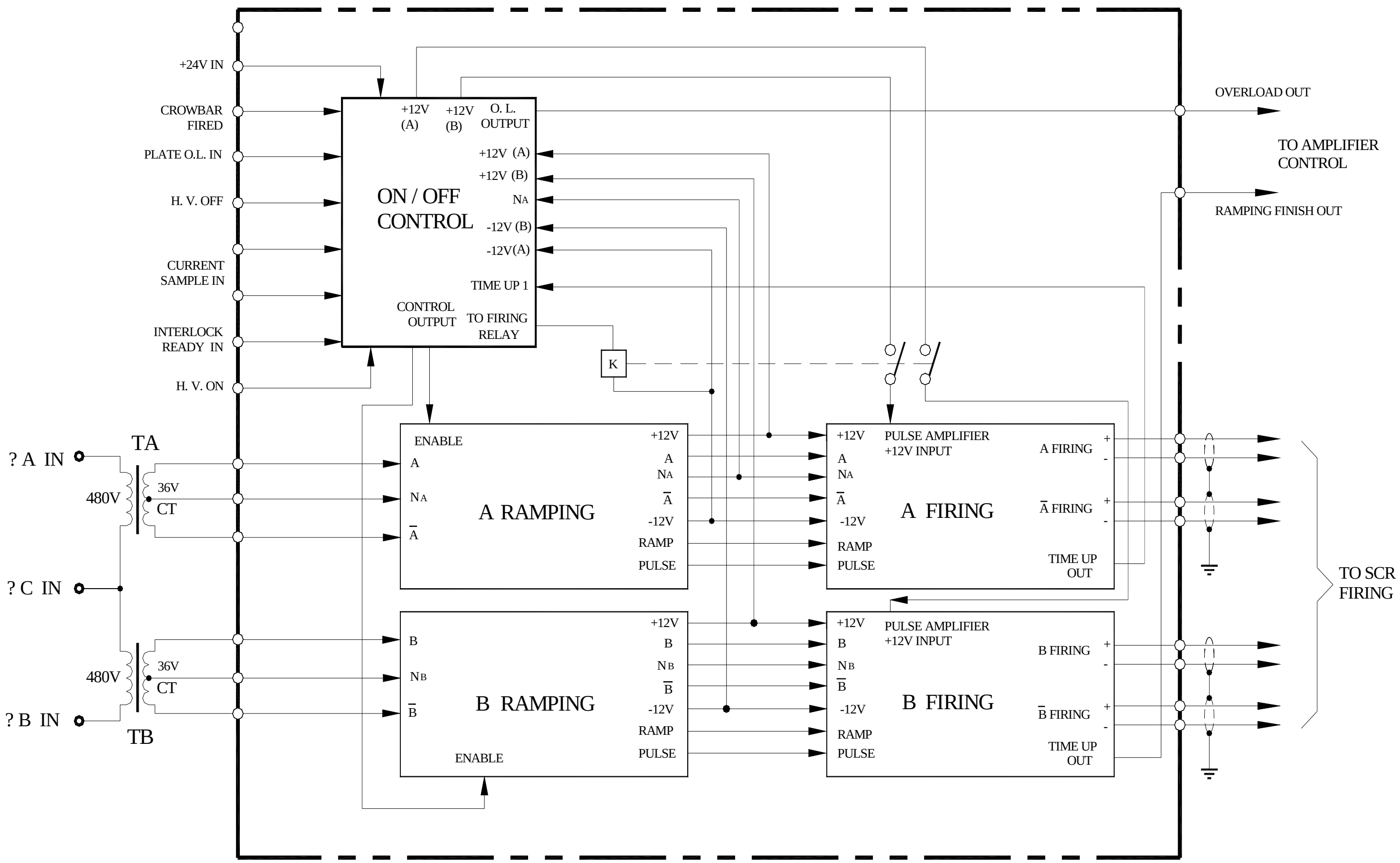


- **4CW150,000 Tetrode Gain=23dB**
- **Grounded cathode, grid driving, solid state driver power: 400 W, and 1000W in pulse conditioning**
- **V_{Plt}= 17 KV, I_{Plt}=16 A; V_{scrn}=1000 V; V_{Bias} = - 450 V; $V_{Filament}$ = 12.5 V , $I_{Filament}$ = 210 A**

Problems of Switching on H-V PS

- Implementation of new ramping circuit for smooth start up of the H-V power supply (hard start in original design)
- Reduced inrush current (limit setting @ 400 A) while turn on the plate voltage (hard start inrush current > 8000 amperes)
- Slow voltage rise to prevent high inrush currents and very fast cut off (8 ms compared to 24 ms in the mechanical switch)
- Mechanic switcher reliable now (once failure)
- Much less trips for switch gear (very tough for operations before). Turn off H-V, keep mechanic switcher on while overload

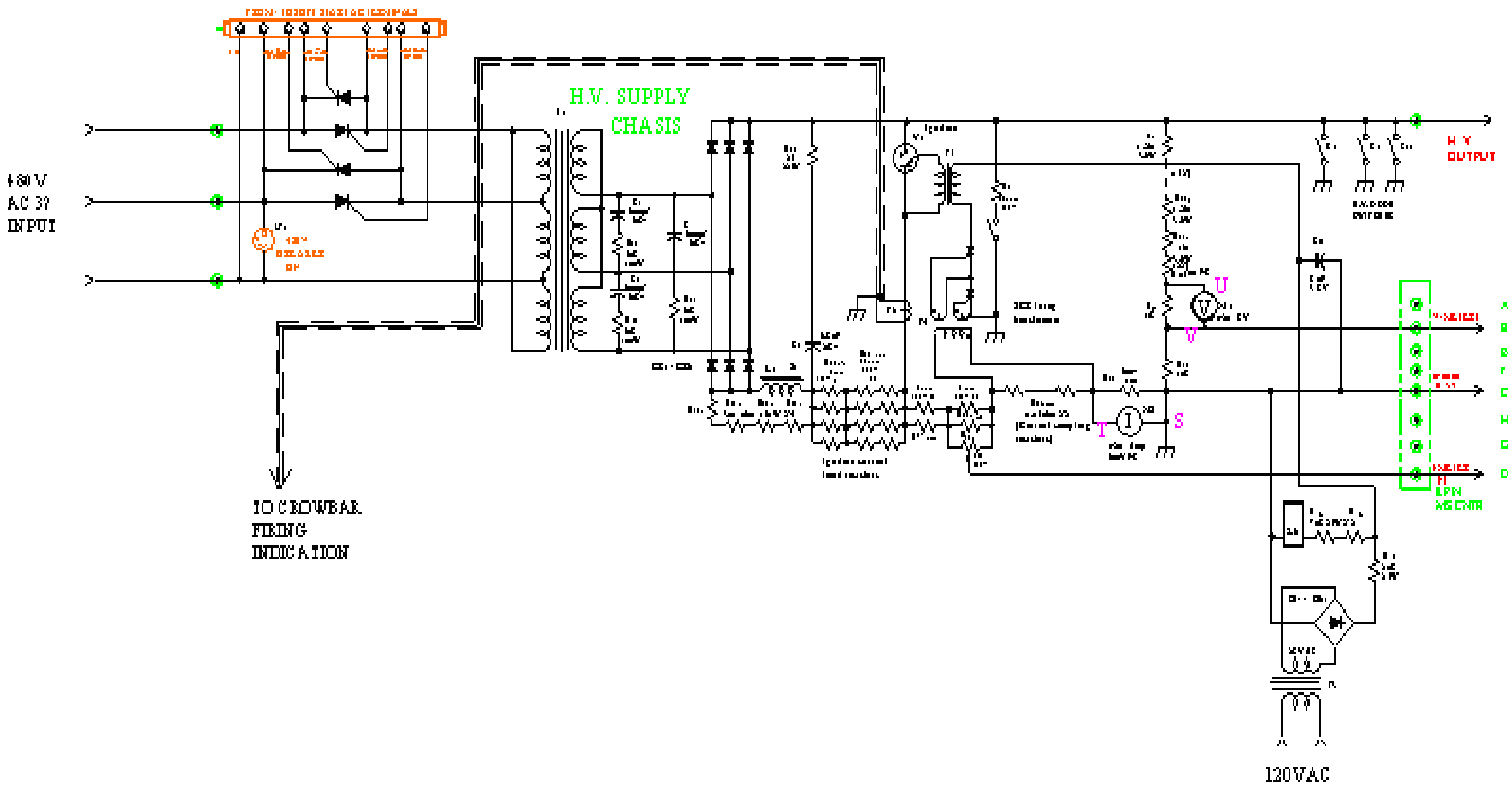
H-V SOFT START BLOCK DIAGRAM



Problem in Crowbar Circuits

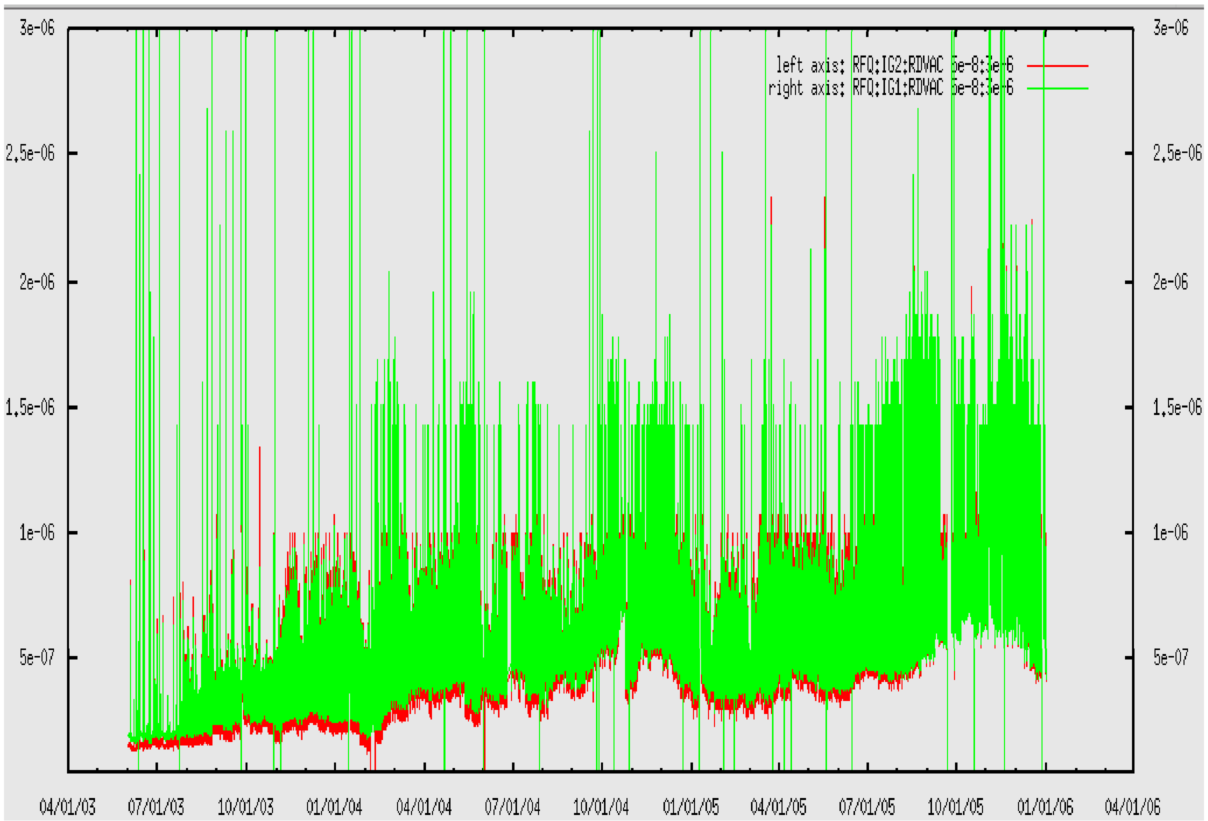
- **Frequently failures of the spark gap (PerkinElmer's Mini-Triggered Spark Gaps model GP-486) brought RFQ a lot beam down time. Last one worked deficiency only a year**
- **30 Joules dump to the spark gap while crowbar fired, that caused it fails often**
- **A new SCRs trigger circuit and home made transformer to replace the original spark gap (model GP-486 and its matched trigger transformer TR-2189). SCRs can take over 1000 Joules**
- **Rf interference to GP-486, but not to SCRs circuits (less crowbar firing now while in pulse high power conditioning).**

H-V Crowbar Circuit Schematic



- Two SCRs (in series) in crowbar fire circuit works reliable over 1 year,
- Most time of the year working at Max. A/q (26~30),
- Much less crowbar happened (from rf interference).

RFQ Water leak repairs



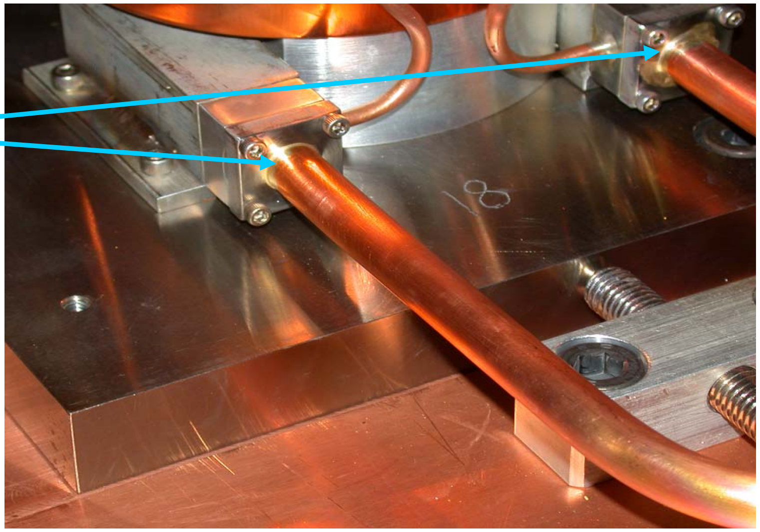
- **RFQ was in operation since 2001**
- **The vacuum pressure had deteriorated from** 2.0 x 10^{-7} Torr to 2.0 x 10^{-6} **Torr**
- **Water leaks into vacuum volume started in July 2003**
- **Dedicated period for the repair started in September 2006, about 2 months spent**

RFQ leaks localization and repairing

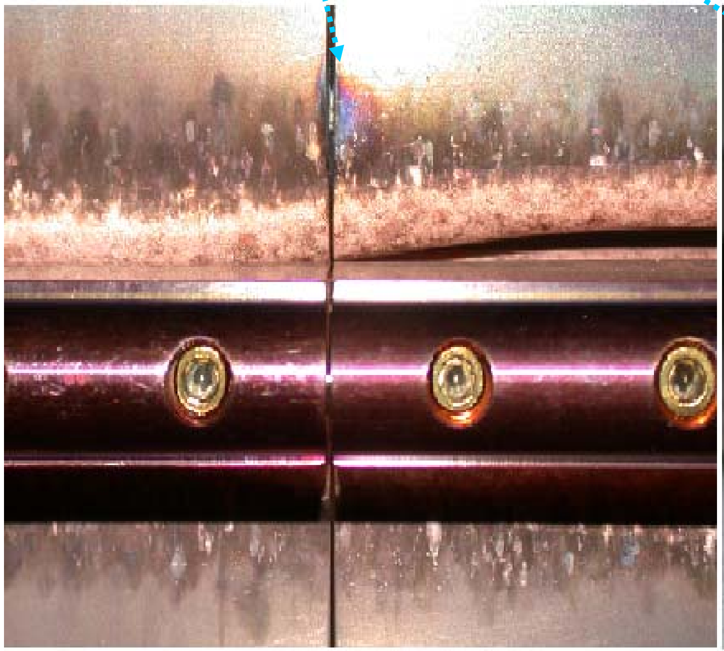
- **3 leaking circuits found, Removed RFQ lid**
- **RFQ was covered for dusty free**
- **All 6 shrouds were removed to localize the exact leak spots.**

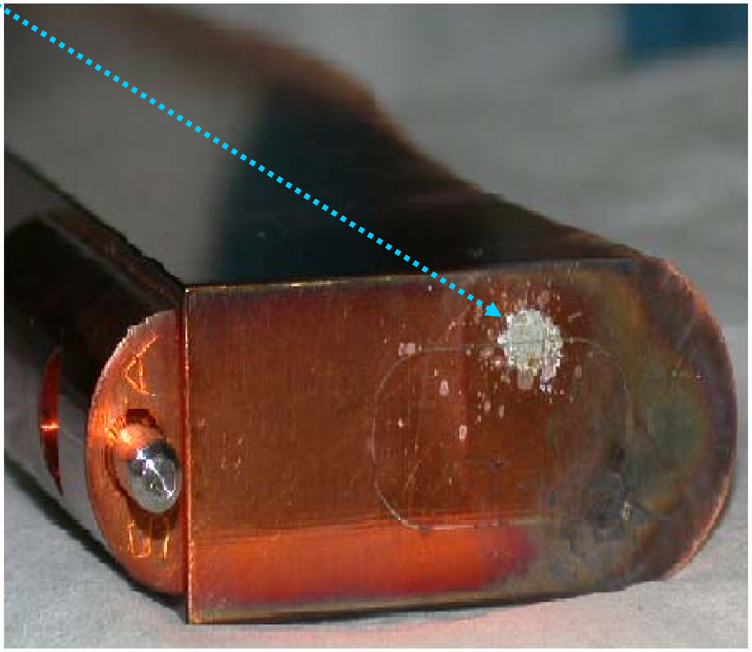
Electrodes and Brazed joints leaks

- leaks at cooling supply and return brazed joints (in 5 the detachable lines)
- Leak in electrode



The water leaks due to manufacturing issues (aggressive soldering flux)



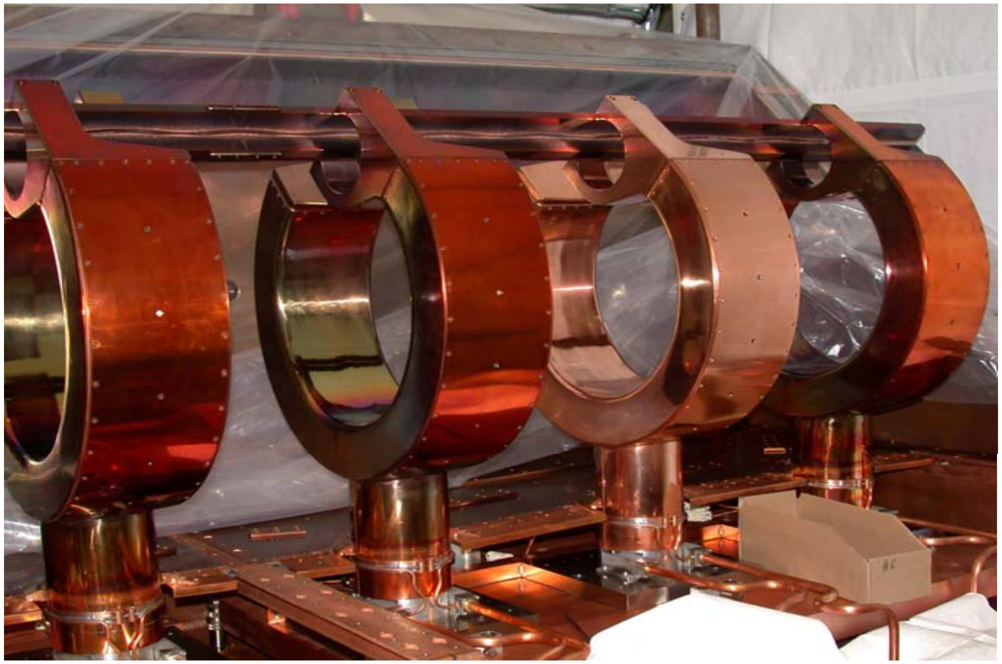


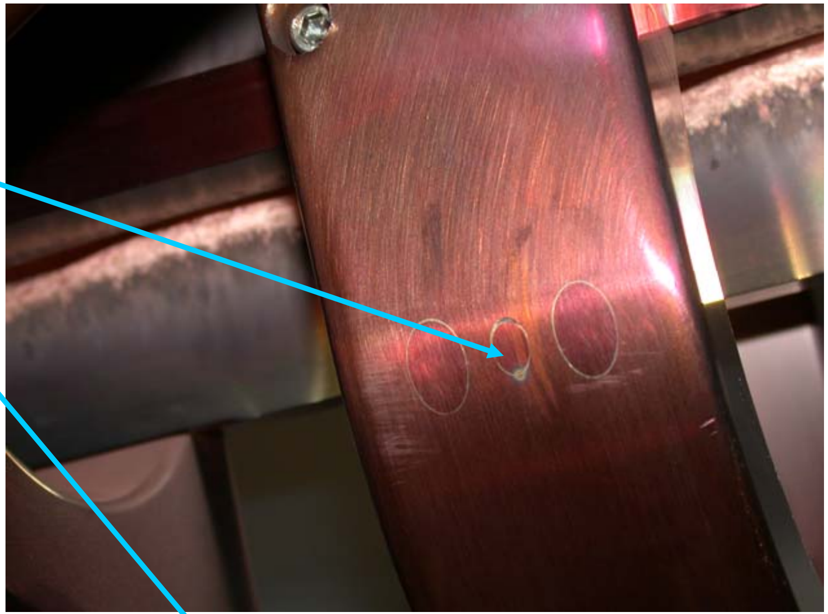
Rings #8 and #18 replaced

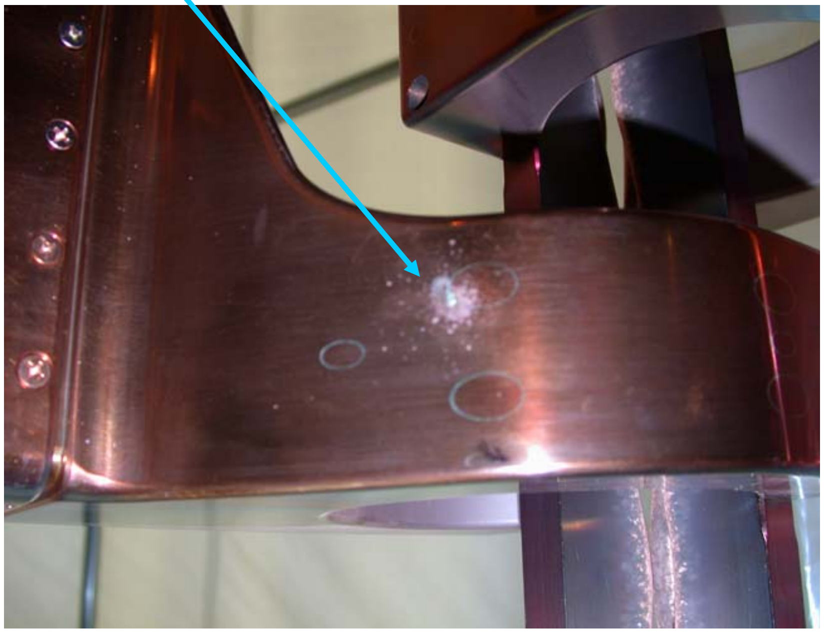
- Plugs at the claws leaking in rings #8 & #18
- Two new rings replaced

All leaks are associated with manufacturing process deficiencies (aggressive soldering flux had been eliminated from manufacturing in 2002

One new ring installed



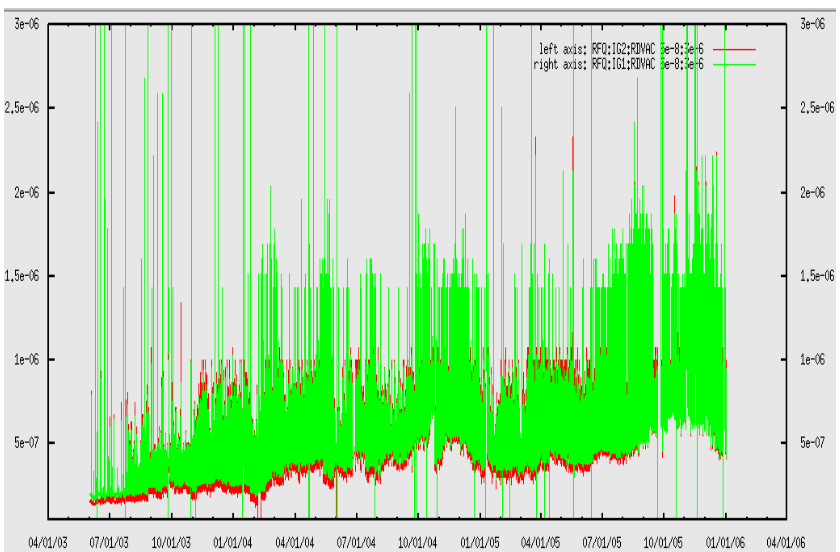


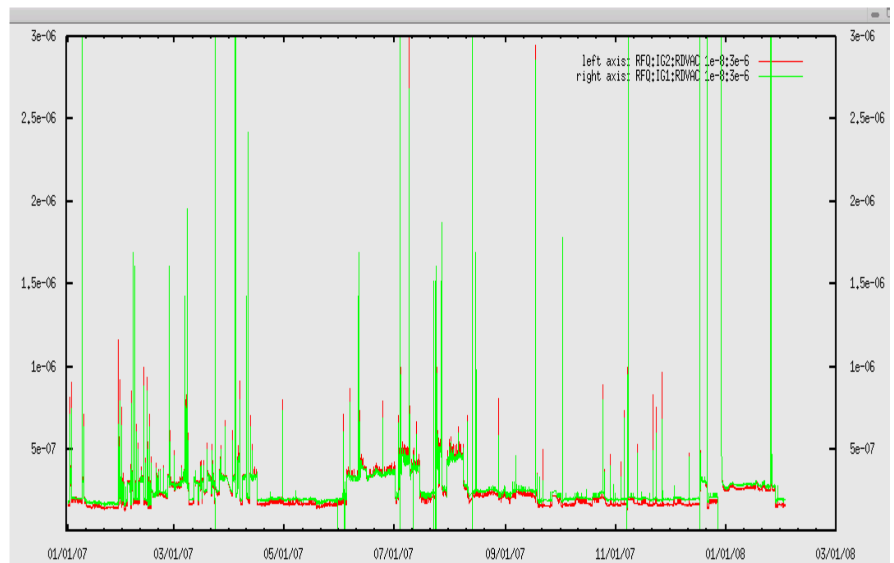


Vacuum improvement after leak repairing

- **All Turbo pumps were equipped with protective RF shield**
- **Installed extra cryo-pump**
- **Baking RFQ over weekend**
- **Vacuum pressure 1.8x 10^{-7} Torr @ Max. voltage after rf conditioning (now 1.5 x 10^{-7} Torr)**

Baking RFQ at 65 degrees for 60 hr.s



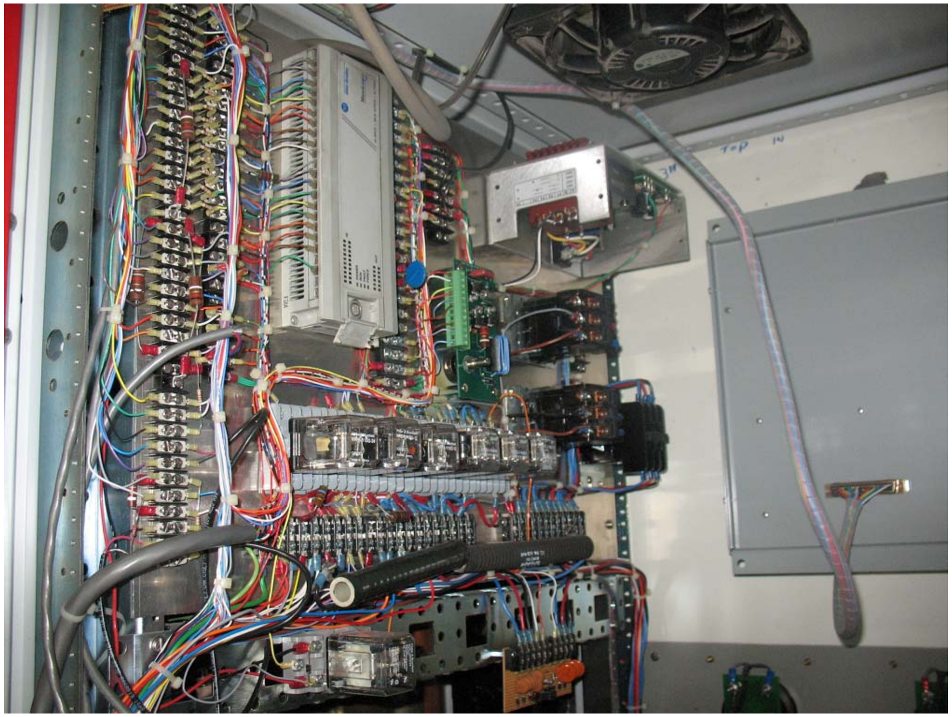


RFQ Remote Control Implementation

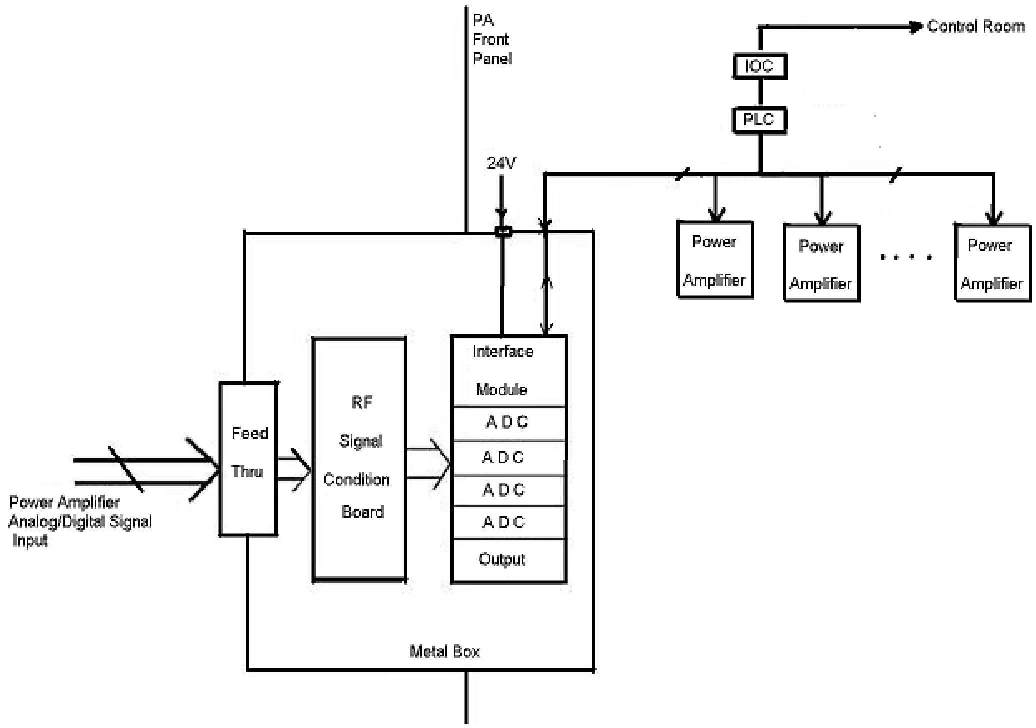
- Upgrading the Amplifier controller
- Added various signal samples (Voltage, currents and status) of the amplifier and re-wiring for new controller
- Parameters calibrations for indications and archives
- New PLC code and EPICS for RFQ remote control start for routine operation now

RFQ Amplifier Remote Control

- **Upgrading the PLC for the amplifier control**
- **Various signals of PA/RF preparing and re-wiring**
- **New PLC code and EPICS for RFQ remote control being done**

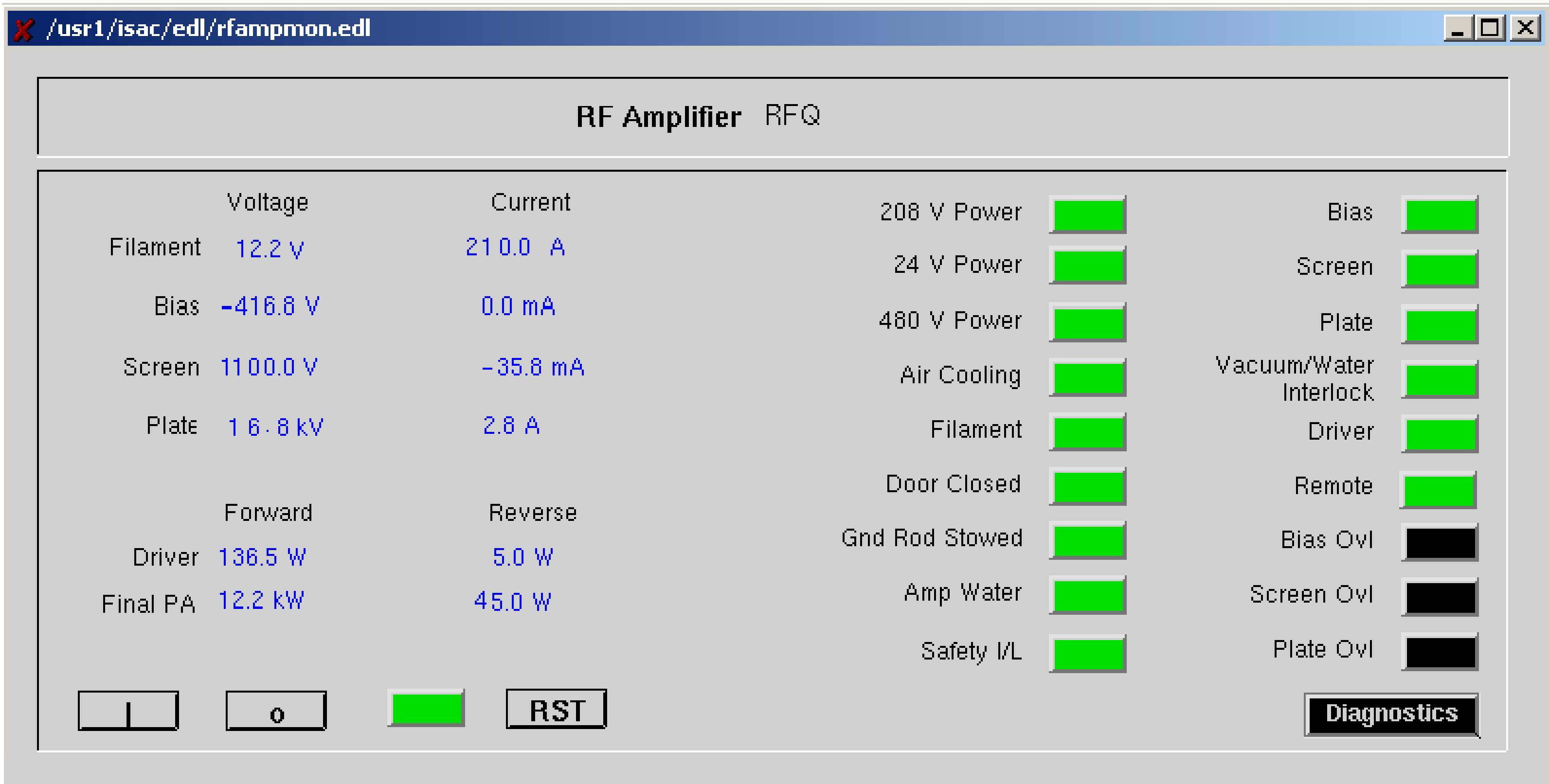


Power Amplifier Control Block Diagram



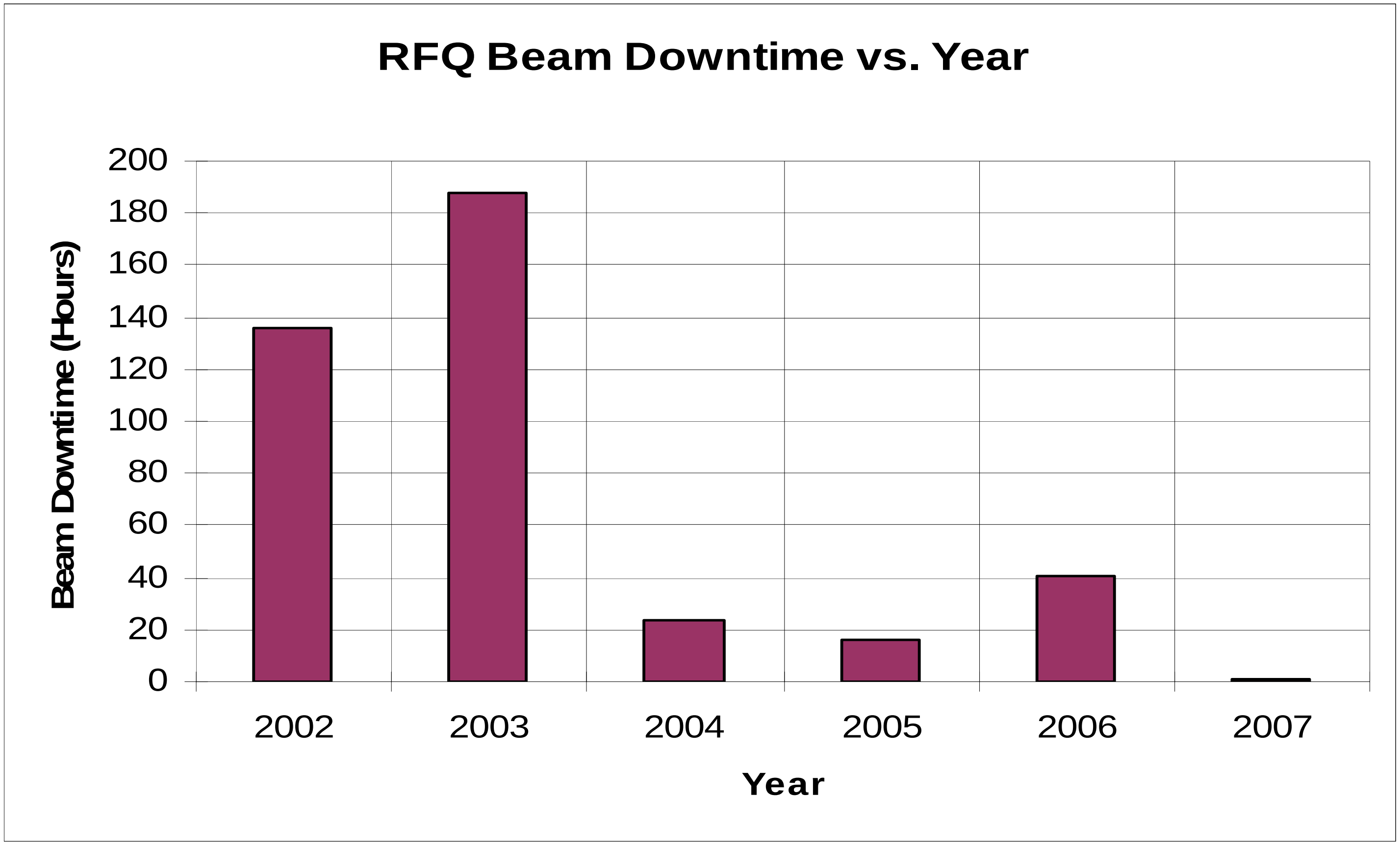
- All ISAC-I power amplifiers share one PLC
- About 30 signals in each amplifier
- Each amplifier uses 4 ADC, one interface module and one signal condition board

PA Parameters Control Page



- New PLC code and EPICs in use
- Amplifier working status on line for troubleshooting
- All parameter in archives for analysis

RFQ Beam Down Time Statistic



- **Beams with max. mass were accelerated late in 2006 (2007)**
- **Spark gaps failed and replaced by SCRs at beginning of 2007**

TRIUMF ISAC

Summary

- **Shorter RF conditioning period for max. mass beams (to eliminate the dark current)**
- **RFQ routine operation is much easy and reliable (much less crowbar fires). RFQ no beam downtime in a year**
- **Vacuum pressure is at 1.5 x 10^{-7} Torr at max. inter-vane voltage**
- **RFQ PA and RF remote operation is easy**

THANK YOU