Design and Operational Experience of the Low Level RF Control at the S-DALINAC

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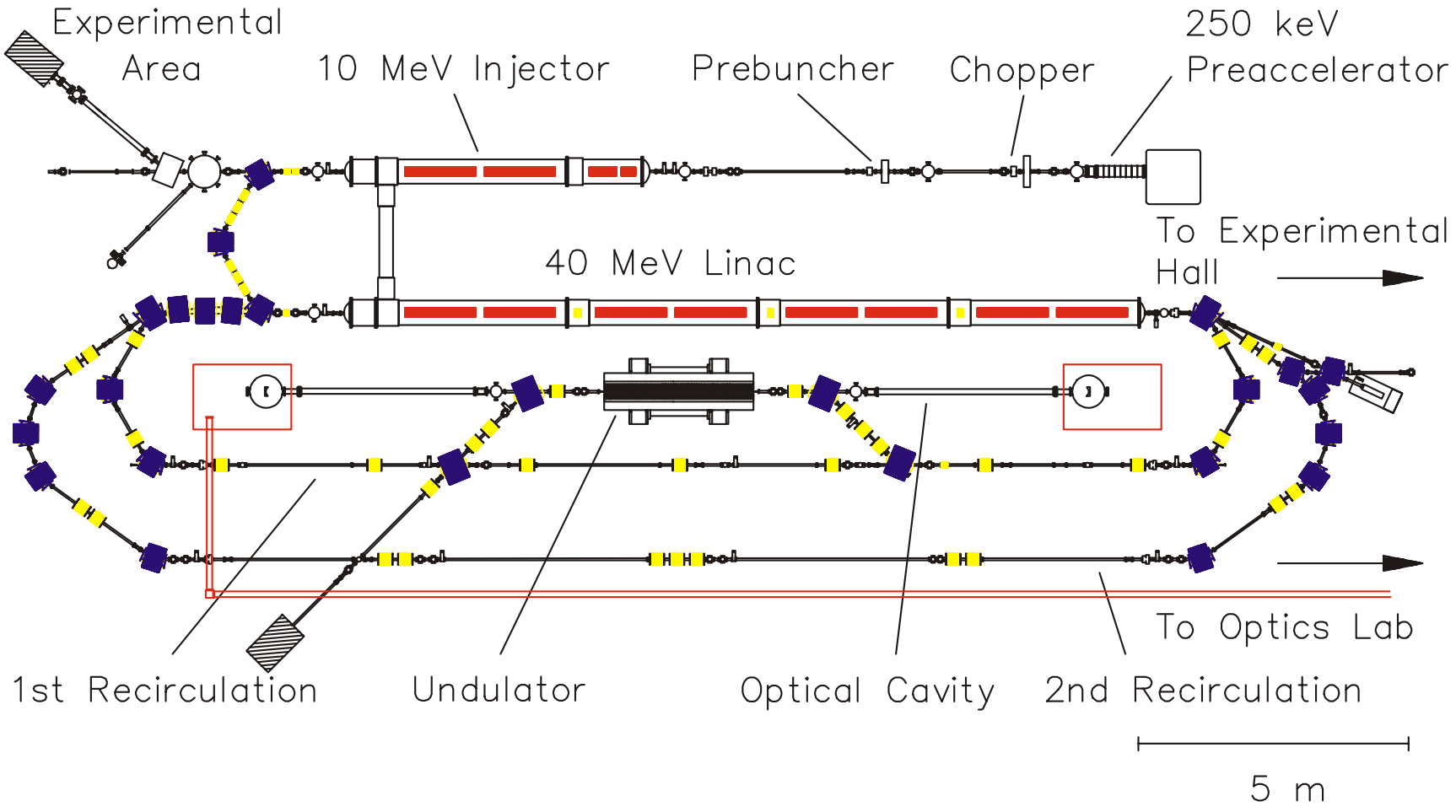
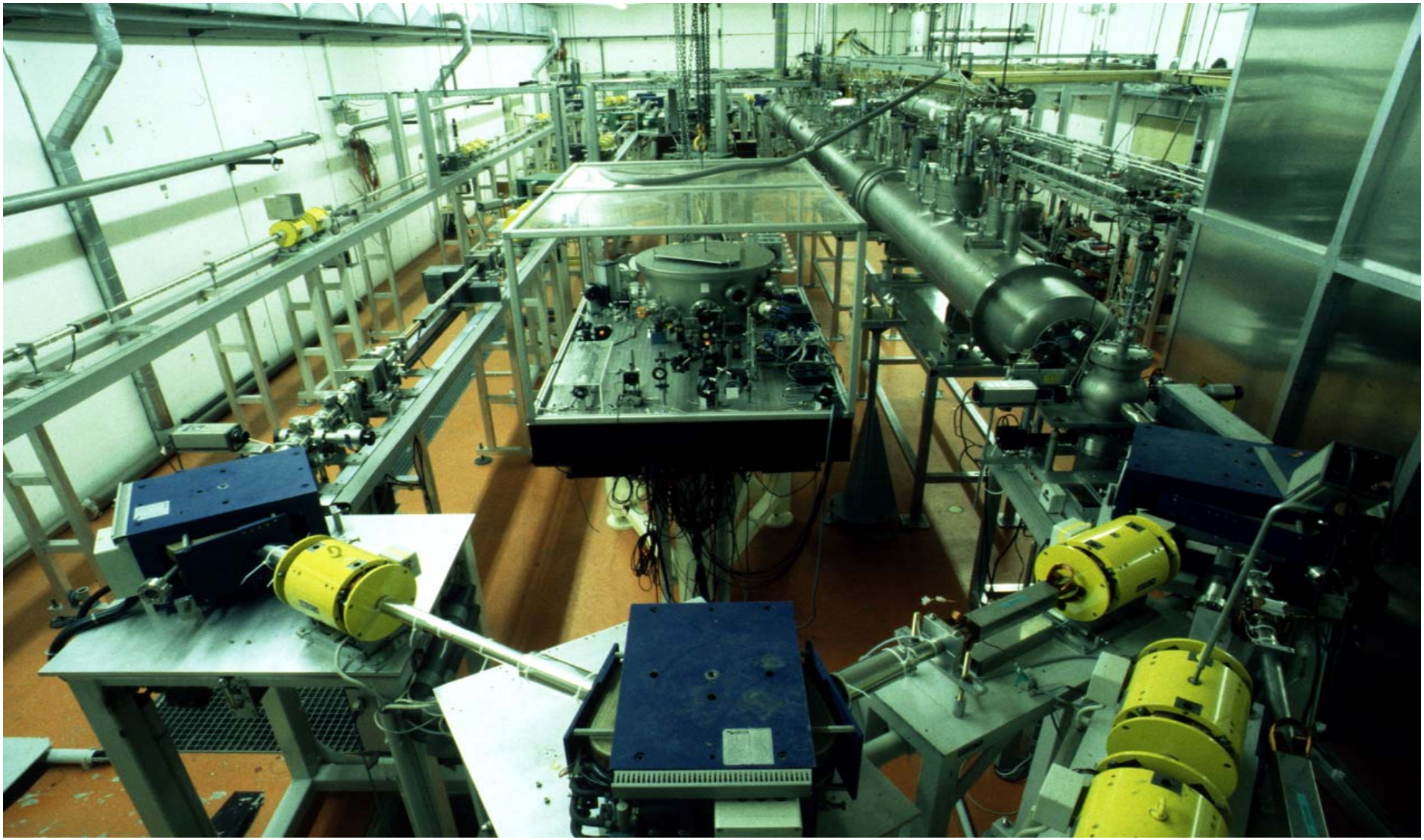
- The Accelerator
- Experiments and Requirements
- RF Control
- Outlook

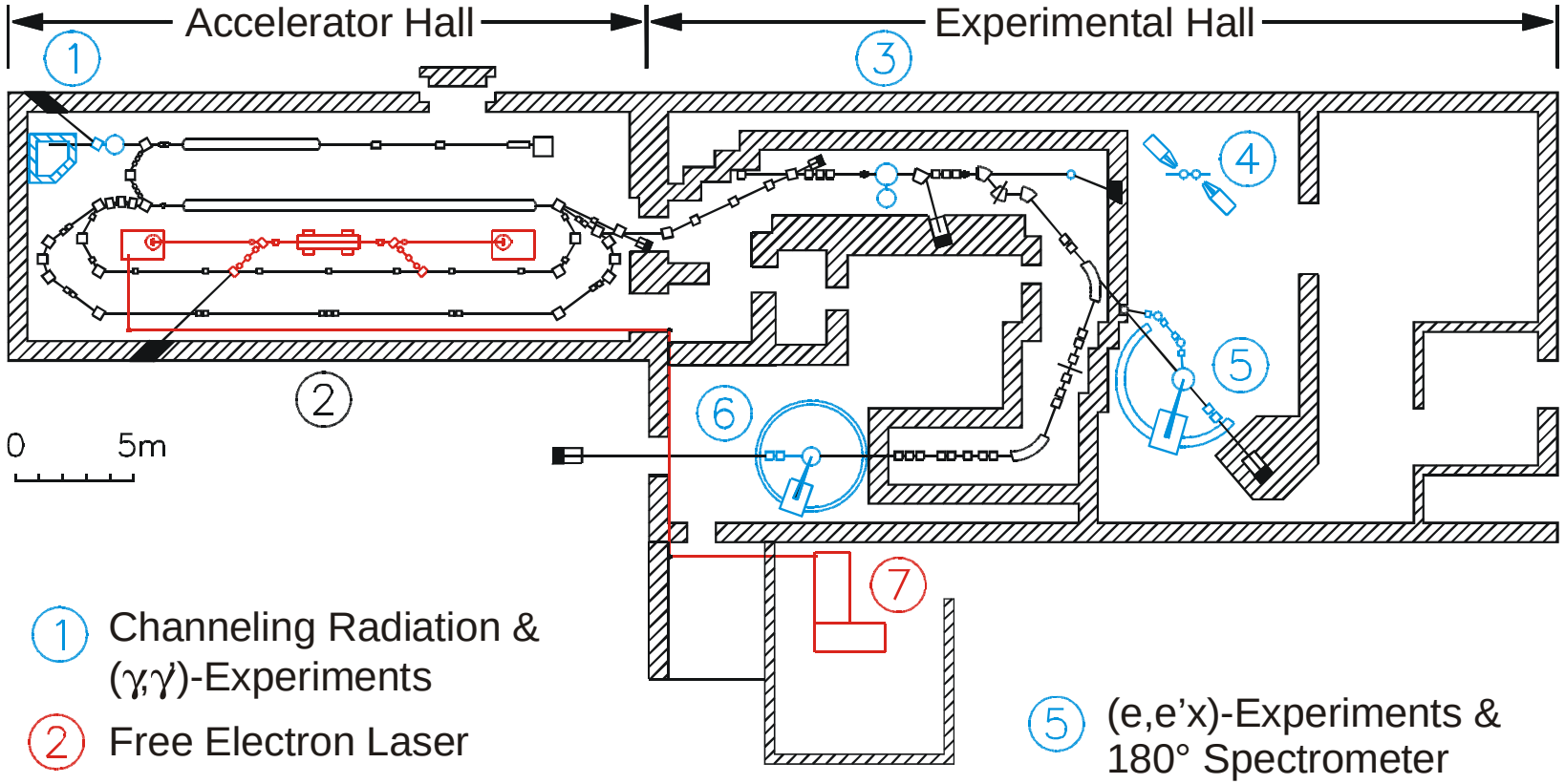
S- DALINAC


Experimental Area
10 MeV Injector
Prebuncher
Chopper
250 keV Preaccelerator
To Experimental Hall
40 MeV Linac
To Optics Lab
1st Recirculation
Undulator
Optical Cavity
2nd Recirculation
5 m

S-DALINAC



S-DALINAC and Experimental Facilities



1. Channeling Radiation & (γ,γ')-Experiments
2. Free Electron Laser
3. High Energy Radiation Physics
4. Compton Scattering off the Nucleon
5. (e,e'x)-Experiments & 180° Spectrometer
6. (e,e')-Experiments
7. Optics Experiments

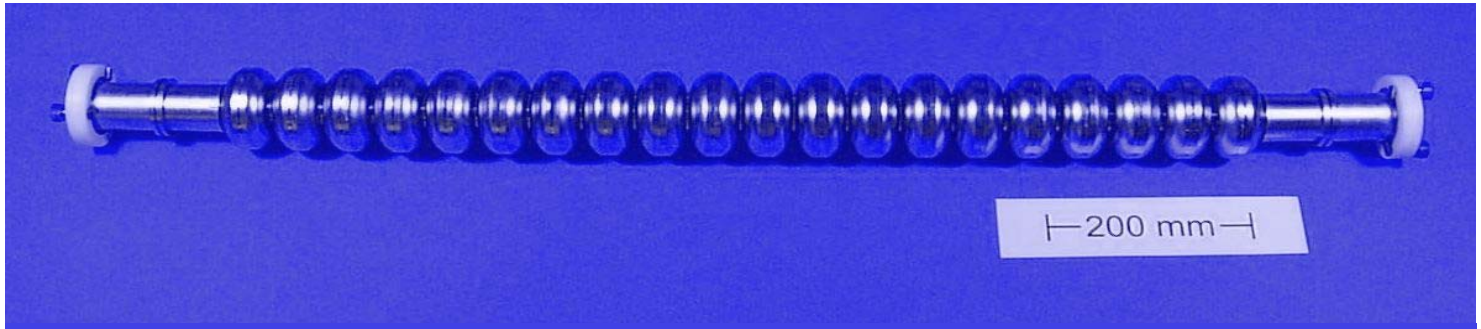
S-DALINAC Beam Parameters

Experiments	Energy (MeV)	Current (μA)	Mode	Time (h)
(γ,γ')	2.5 – 10	50	3 GHz, cw	6400
LEC, PXR	3 – 10	0.001 - 10	3 GHz, cw	2100
HEC, PXR	35 – 87	0.1	3 GHz, cw	800
(e,e'), (e,e'x)	22 – 120[1)]	5	3 GHz, cw	7800
FEL	30 – 38	2.7 A_{peak}	10 MHz, cw	2900
				Σ 20000

1) Dutycycle 33%

Resolution: ΔE_{FWHM} = 50 keV @ 85 MeV, $\Delta E/E = \pm 3 \cdot 10^{-4}$

Superconducting 20-Cell Cavity



Material:	Niobium (RRR=280)
Frequency:	3 GHz
Temperature:	2 K
Accelerating Field:	5 MV/m
Q_0/Q_L:	$3 \cdot 10^9$ / $3 \cdot 10^7$
$\Delta f/\Delta l$:	500 Hz/µm

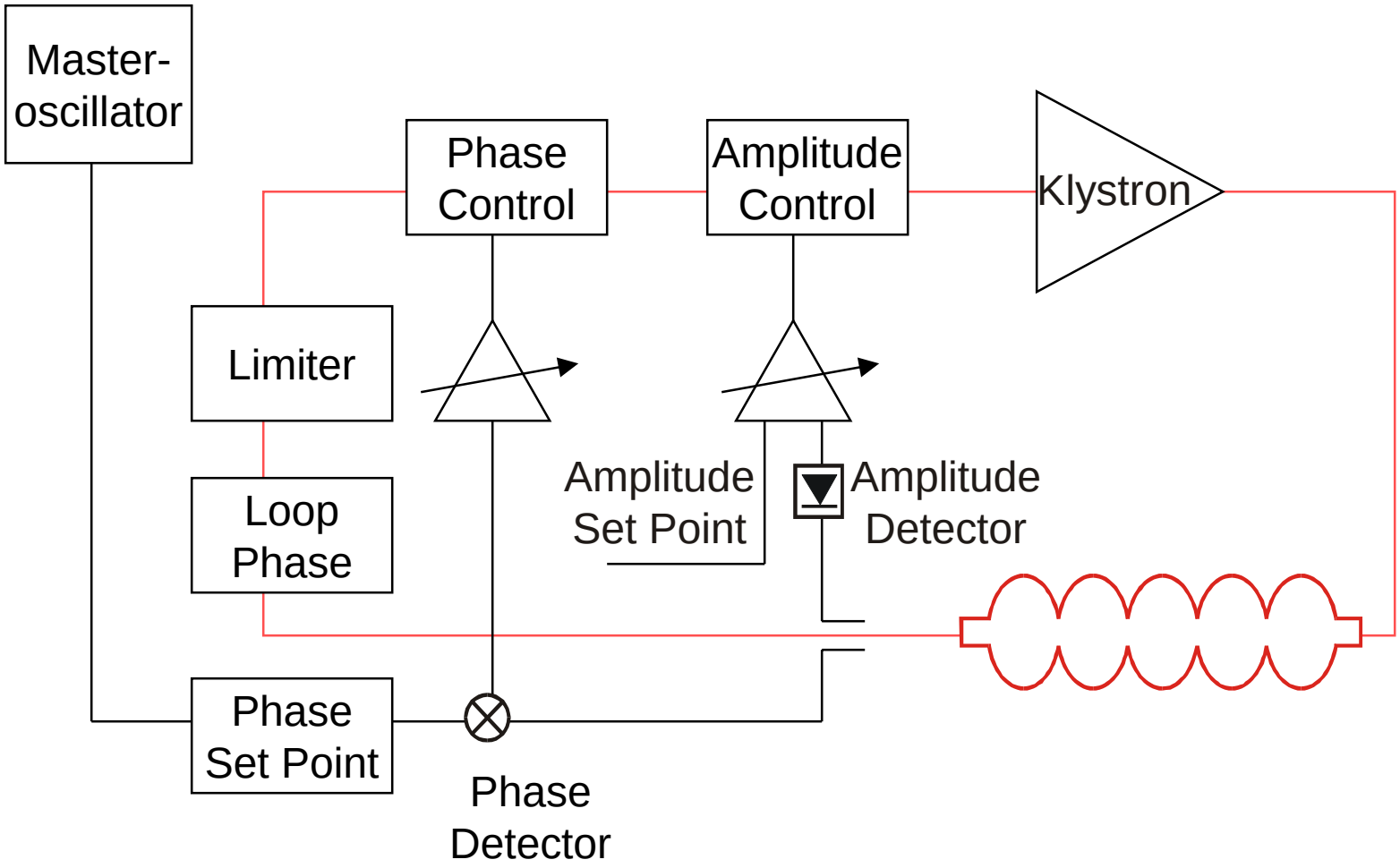
Specification

- Energy spread: $\Delta E/E = \pm 10^{-4}$ (fwhm)
- Concept: Isochronous acceleration on crest

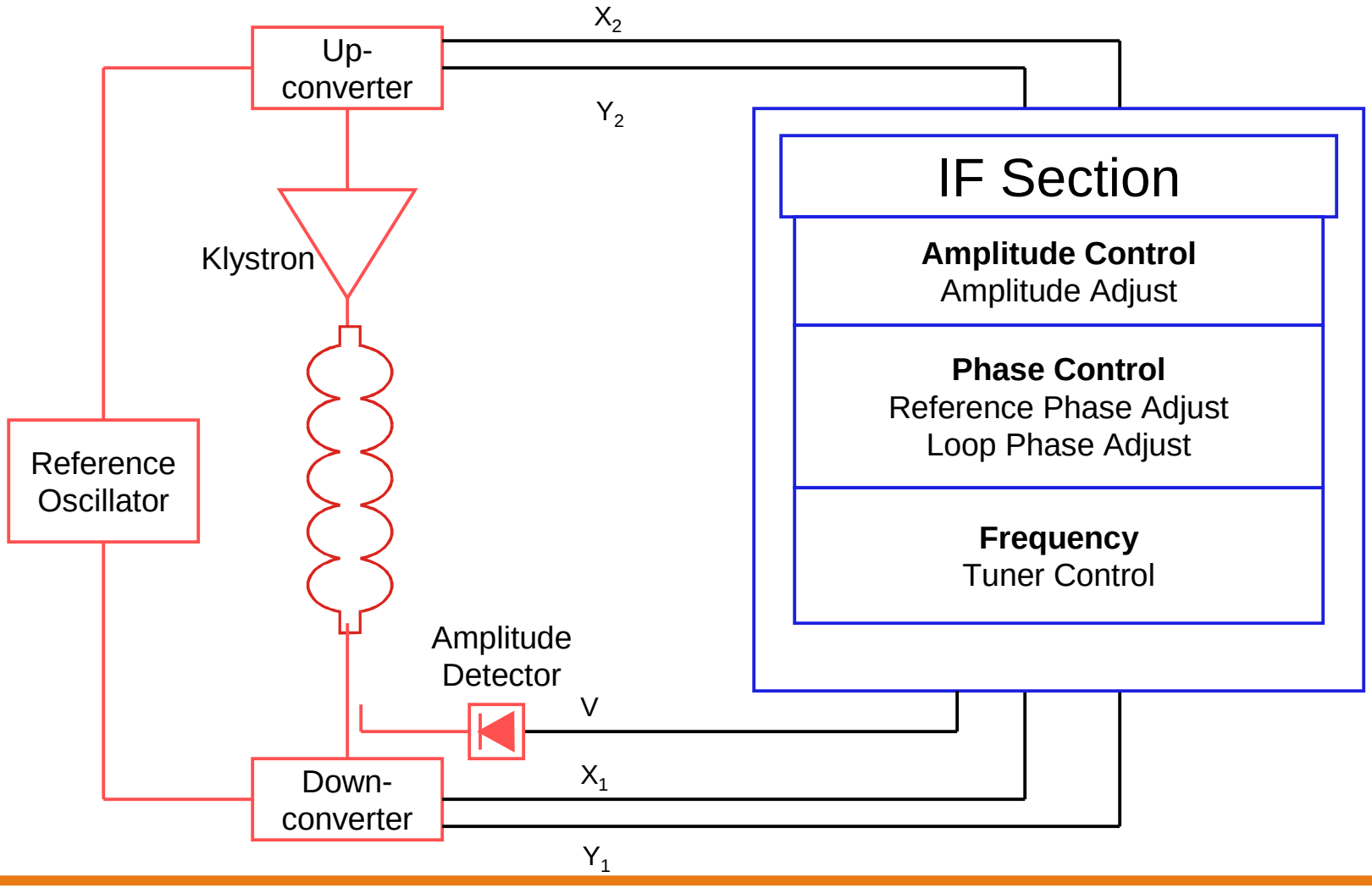
- Contributions to energy spread
  - –Bunch length: $2° \rightarrow 1.5 \cdot 10^{-4}$
  - –Amplitude jitter: $< 10^{-4}$ ($\Delta l < 2$ nm)
  - –Phase jitter: $< \pm 0.5°$ ($\Delta l < 1.1$ nm)

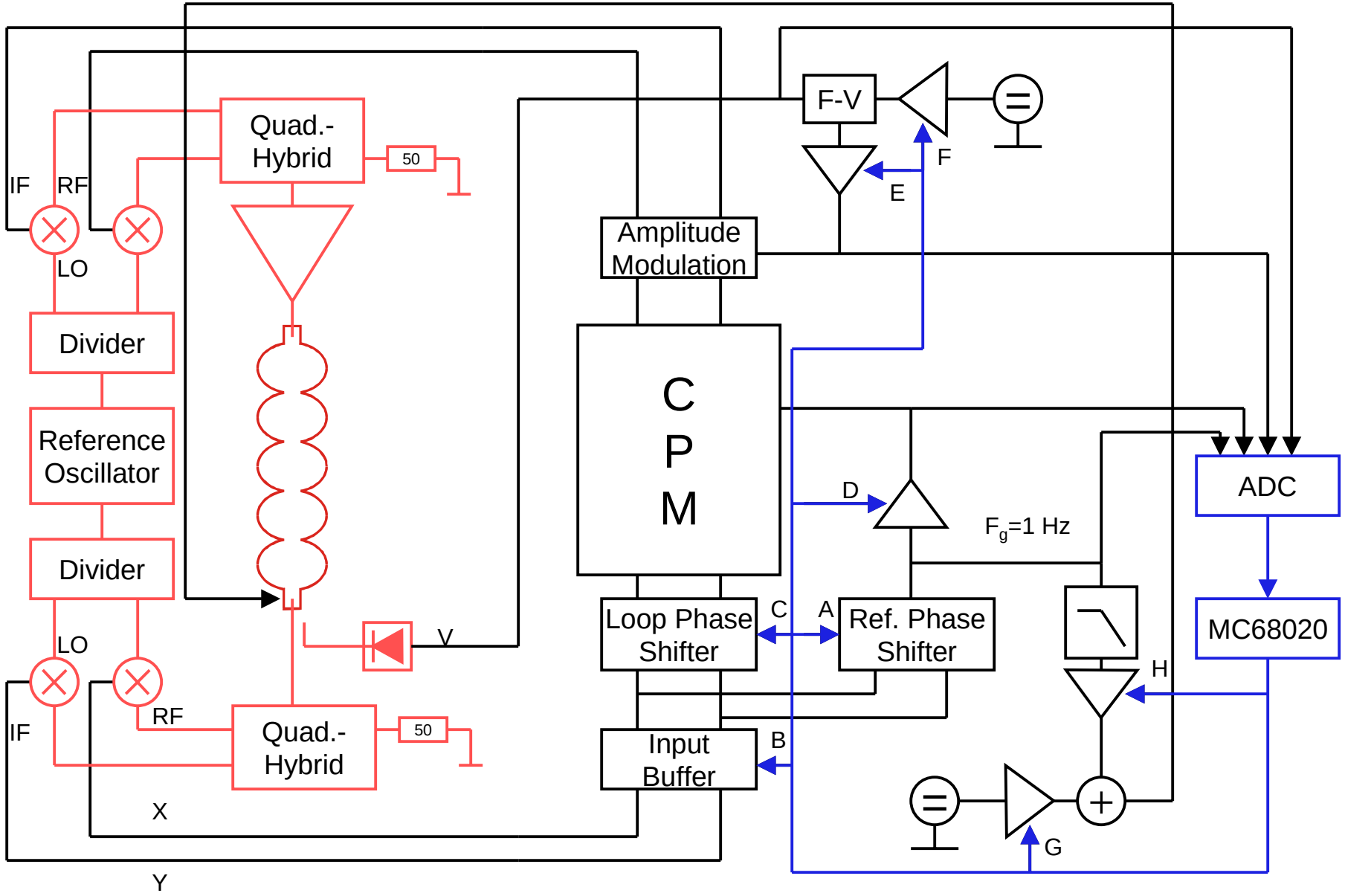
RF Control required !!

Self Excited Loop



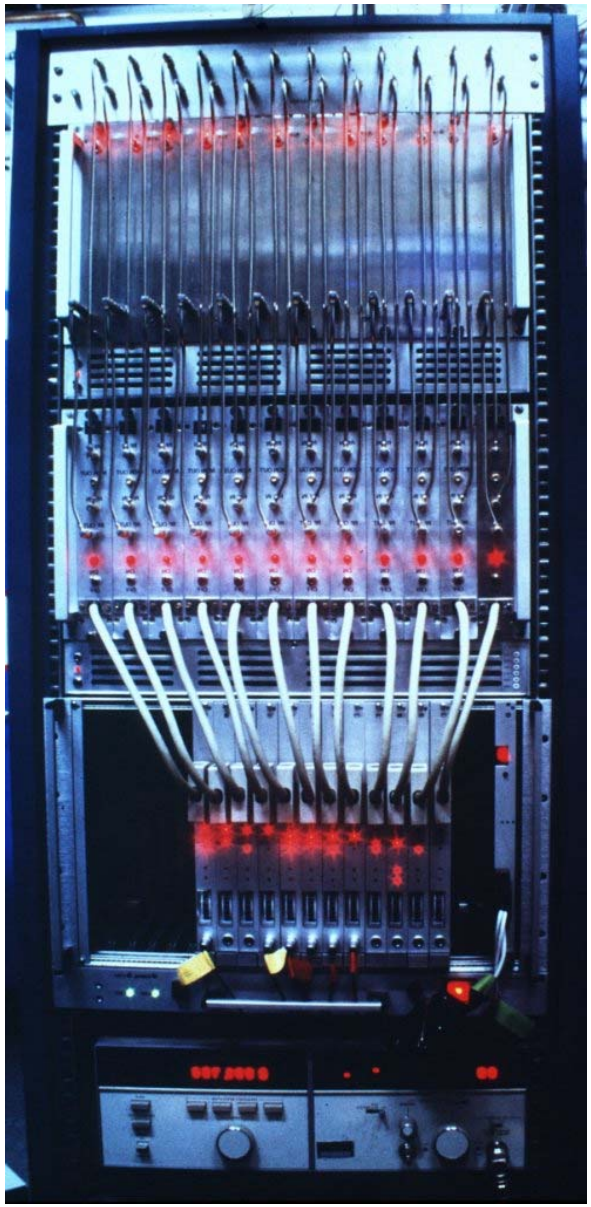
Principle of the RF Control




Quad.-
Hybrid
50
IF
RF
LO
Divider
Reference
Oscillator
Divider
LO
IF
RF
Quad.-
Hybrid
50
V
X
Y
F-V
F
E
Amplitude
Modulation
C
P
M
D
F_g=1 Hz
ADC
MC68020
Loop Phase
Shifter
C
A
Ref. Phase
Shifter
H
Input
Buffer
B
G

Presently achieved

- Amplitude stability: $\Delta E/E = 1 \cdot 10^{-3}$
- Phase jitter: $\Delta\theta/\theta = \pm 0.3°$



The phase control matches the specification, the amplitude control does not!

Outlook

- Improvement on the RF side
  - Rebuild the up- and down converter with modern components
  - Implement a seperated signal and control path for the amplitude signal
  - Temperature stabilization
- IF Section
  - Replace the existing analog control by a DSP based system
  - Reproduce the existing IF board in software
  - Implement features of a digital control, e.g. lookup tables for correcting nonlinear characteristics of components

The Future RF Control ?