SPL Collaboration Meeting 3
Working Group 1

Report & Objectives

E. Ciapala

Introduction

From the Second SPL Collaboration Meeting in Vancouver:

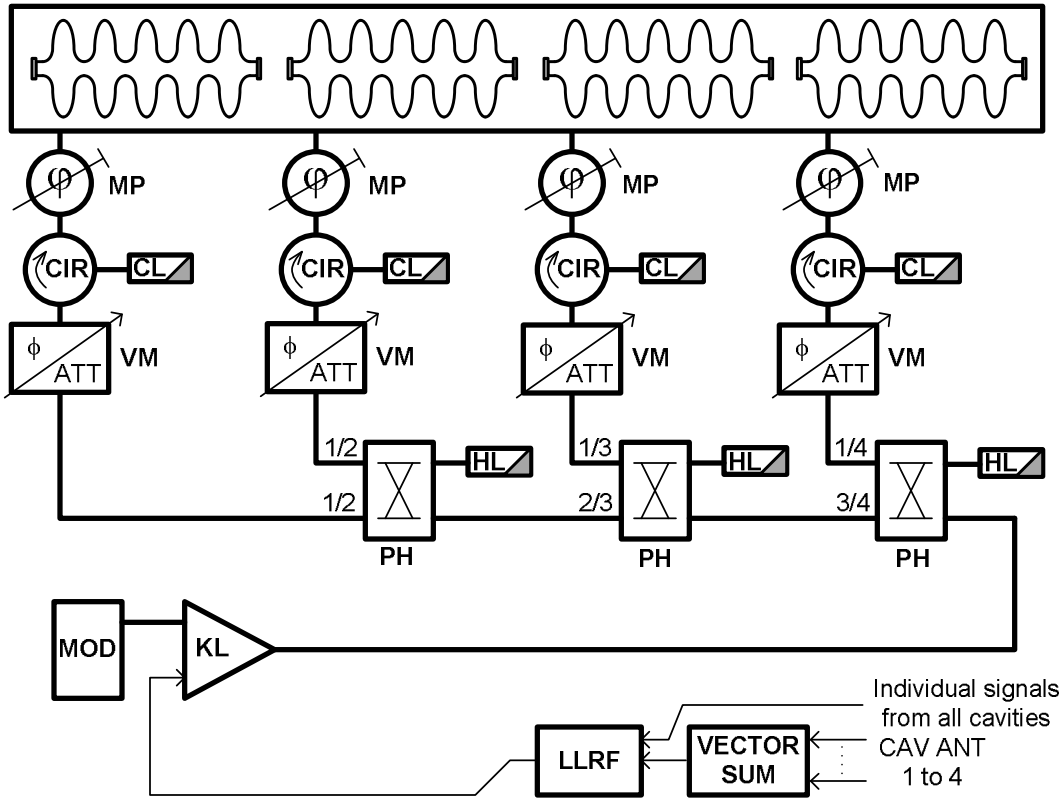
- Check RF option cost estimates in detail
- Look at power requirements for the low energy part of the Linac
- Explore use of IOTs, particularly for low energy part:

  e.g. manufacturers, users, other Labs
- Analysis of stability & feedbacks for the different layout options
- Klystron Modulator for HPSPL 50 Hz – Design, Cost, Size.
- Magnetron - (CI collaboration) proposal on PL magnetron, initial specs ?
- *Detailed Layouts – for tunnel integration, Klystron/Cavity waveguide routing*

  => One w/g per cavity to linac tunnel

RF Layouts

Comparison of RF Power schemes for SPL – Option 1: 1 Klystron/4 Cavities

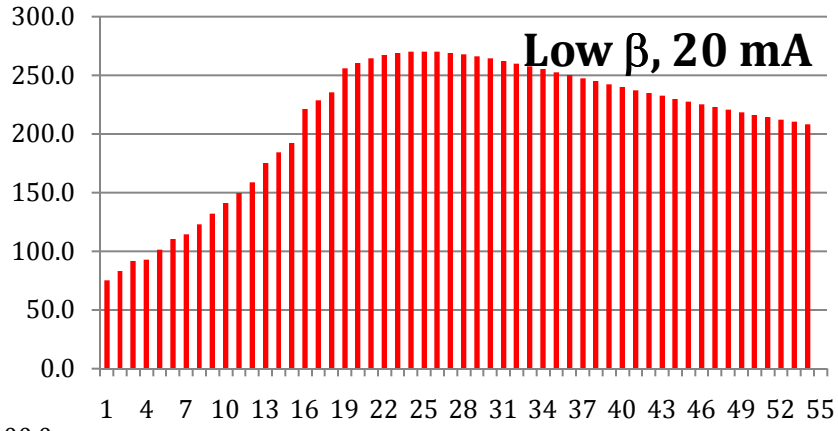


KL 5MW$_{PK}$ klystron
CIR 1MW$_{PK}$ circulator
CL 100kW$_{RMS}$ circ. Load
PH hybrid (e.g. planar 90°)
HL hybrid load
VM 1MW$_{PK}$ vector modulator
MP Mech. phase-shifter/switch
MOD Klystron modualtor

- Linear distribution, using compact "planar" hybrids with individually adjusted coupling.
- Vector modulators for fast phase/amplitude field control
- Mech. phase shifters for cavity phasing or isolation

RF Power Requirements along the LPSPL

(Assuming ideal matching for 20 mA)



Need additional power margins:

11% for 40 mA coupling settings

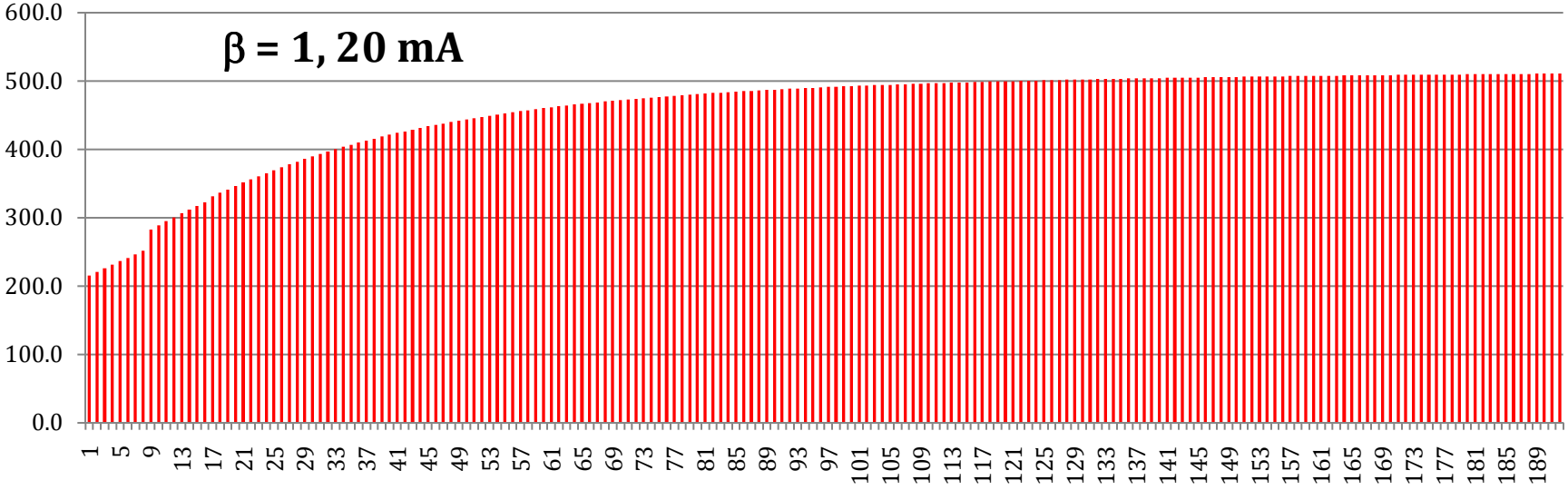
10 % for Feedbacks **(TBC)**

7% Waveguide losses

Modulator droop, (?), coupling variations

500 kW nominal on cavity =>

>700 kW from klystron



F. Gerigk

Klystron Modulator Specs

One modulator per klystron, driving 2 cavities

LP-SPL (500 kW on cavity)
flat top: 1.8 ms
rep-rate: 2 Hz
voltage: 110 kV
droop: 5%
power: 3.2-3.4 MW (500 kW per cavity) + margin for splitting and LLRF + 50% klystron efficiency)

HP-SPL (1 MW on cavity)
flat top: <2.1 ms
rep-rate: 50 Hz
voltage: 110 kV
droop: 5%
power: 6.4-6.8 MW (1 MW per cavity + margin for splitting and LLRF + 50% klystron efficiency

RF Power Sources

Klystrons vs. IOTs

- Power: IOTs reaching klystron levels - 600kW feasible**.. (TBC)**
- Efficiency; IOTs 75%, Klystron 55-60% (70% limit)
- HV requirements IOTs lower ~ 40kV (may not need HV oil)
- Size IOTs shorter
- Cost IOTs lower (30% ?)
- Lifetime IOT Not known for high power, low power as klystrons
- Drive Requirements Klystron gain 35db, IOT 20dB – need more powerful driver
- Characteristic Klystron gain reduces at high drive, IOT saturates

Possibility of 1MW+ IOT for HPSPL ?

Magnetrons

- Efficiency high, but can we get the power we need?
- Phase locking needed, in development by CI
- Response in a feedback loop? Bandwidth, Amplitude control, group delay..
- Cost, HV requirements, size ? ***A. Dexter Presentation WG1 this p.m.***

SPL RF Power Distribution – Costing

Costing of Major Components

Item	Cost/item kCHF
6 MW Klystron	700
3 MW Klystron	600
1.5 MW Klystron	500
700 kW Klystron	400
1MW Circulator	50
500kW Circulator	35
Circulator load 100kW	40
Circulator load 50kW	25
Hybrid	20
Hybrid load 100kW	40
Hybrid load 50kW	25
Waveguides - per cavity 30m	60
Phase shifter (mechanical)	30
Vector Modulator 1MWp	75
Klystron Modulator 6 MW pk	600
Klystron Modulator 3 MW pk	300
Klystron Modulator 1.5 MW pk	175

Item	Cost/item kCHF
IOT 700 kW	400
IOT 350 kW	250
Local Water Distribution - Klystrons & modulator	30
Driver for klystron	20
Driver for IOT	60
LLRF for 1 klystron, VME, incl. signal treatments	45
LLRF per cavity, incl. signal distribution & treatment	30
Controls - per klystron	20
Controls - per cavity	20
Cabling - Klystron HV, RF, Controls - per klystron	70
Cabling - Cavity RF, HV, Controls - per cavity	70
Installation - per klystron	60
Installation - per cavity	60

SPL RF Power Distribution – Costing

Comparison of RF Power schemes for LPSPL

Configuration	Revised Cost per Cavity (kCHF)	For	Against
Option 1) Four cavities per 3 MW Klystron	780	Fewest power sources	Complexity, bulk, power overhead, fault tolerance…
Option 2) One ~700 kW Klystron per Cavity	1150	Reduced hardware inventory, minimum R&D, fully independent control, minimum RF power overhead, best fault tolerance, easy upgrade to HPSPL	Number of power sources
Option 2a) One 700kW (?) IOT per cavity	1130	As above, perhaps cheaper & more compact	HPSPL would need doubling of IOTs, or larger rating IOTs
Option 2a LB0) One 300 kW IOT per cavity in LB section	712	Cheaper & more compact	300kW per IOT
Option 3) Two cavities per Klystron	935	Half the number of klystrons	Need full hardware set, associated R&D, Power overhead, Reduced flexibility wrt option 2
Option 3a) Two cavities per Klystron Without VMs	900	Half the number of klystrons, more economical than Option 3	Risk for higher intensity?

"Options 2 ,2a are the most attractive (single power source per cavity)"

But cost requires us to look closely at Options 3 & even 1……

Key Issues for WG1 at this meeting

- **RF Layout** - Performance of the different layout options, in order to confirm baseline layout.
  - Cavity / tuner characterization & measurements at SACLAY
  - Ongoing work on estimates of stability attainable in presence of microphonics, Lorenz detuning, detuned cavities, modulator droop ….
  - => Feedback system requirements & tuner characteristics,

(Talks: G. Devanz, W. Hofle, M. Hernandez Flano, D. Valuch)

- **Klystron Modulator** specs and design options

(Talk: ESS)

- **Power Coupler options** – High power spec probably needed !

Existing design & experience, overall review, design considerations for higher power

(Talks: A. Falou, L. Lukovac, G. Devanz, E. Montesinos)

- **Power Sources** – Magnetrons JLAB & Cockroft

(Talk: A. Dexter)