



RF power distribution in HINS - R. Pasquinelli



- Multiple cavities from klystron power source is the preferred option.
- Klystrons are the best choice at this frequency, choice strongly cost driven.
IOTs, solid state not real contenders. (Costs per watt)
- Waveguide system, RF distribution via chain of hybrid couplers, with vector modulators, circulators, remote trombone phase adjustment
- Layout well defined, advanced designs for the main components, testing will start.
- Must ensure waveguide components are of good quality – reliability issues, select good manufacturer, accept the cost.
- LLRF control (klystron loop, VM loops) will be modeled.



Comparison of schemes for SPL

Configuration	Cost for 4 cavity 'unit' (Eu)	For	Against
Option 1) Four cavities per Klystron	2420	Fewest power sources	Complexity, bulk, power overhead, fault tolerance...
Option 2) One Klystron per Cavity	2880	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 IOT per cavity	2520	As above, perhaps cheaper & more compact	HPSPL would need doubling of IOTs, or larger rating IOTs
Option 3) Two cavities per Klystron	2520	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	2370	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)



RF Power Distribution – Contd.



- Check costing in detail
- Single power source is the preferred option.
 - Put effort into finding best & most economical power source
 - IOT, Klystron, or Magnetron (CI collaboration).
- Collaborate with other projects, institutes & industry on IOTs.

There is general interest for many applications at CERN
- Upgrade LP to HPSPL not a big concern for the RF power systems proper,
- **6m tunnel – can we reduce ? – how to connect the tunnels**
- Klystron Modulator – HPSPL 50 Hz – Cost, Size & ‘footprints’ in klystron tunnel & surface buildings need to determined urgently.



Essential CERN activities – from first collab meeting

- **Costing of single klystron per cavity** option, also considering integration issues. (End June 09) **ONGOING**
- **Integration and Layout** of the various options. In particular layout of distribution system in the two tunnels, klystrons (vertical or horizontal) and modulator layout for HPSPL (See below) – **URGENT CERN** **Ongoing RF & TS**
- **Test stand 704 MHz, 5 MW**. Needed for HP tests of RF equipment, klystrons, waveguide proto layout, later for test of cryomodules then klystron modulator for HPSPL. (CERN) Depends on allocated resources - **Reduced options e.g SM18 cryo staging**
- **Development / construction of the LPSPL vector modulator** for test stand.



CI interests

- **Klystron Review Add IOTs & Magnetrons to this**
(CI) suggest September 2009
- **Development of a long pulse Phase Locked Magnetron** solution where one magnetron is used per cavity. Demonstrate feasibility at the 1 kW power level, develop a modulator design for high power operation, generate interest from a magnetron manufacturer to produce a 1 MW long pulse 704 MHz magnetron and perform a cost analysis. Seek further funding to complete high power development.
(CI independent program initially) **Get CI Proposal**



Continuing activities



- Check RF option costings in detail
- Detailed Layouts – for tunnel integration (Sources, VMs & circulators)
- Klystron/Cavity waveguide routing
- Klystron Modulator for HPSPL 50 Hz
Cost, Size & ‘footprints’ in klystron tunnel & surface buildings need to be determined urgently.
- Magnetron (CI collaboration) proposal on PL magnetron, initial specs
- Collaborate with other projects, institutes & industry on IOTs.



Other CERN-CI interests

- **Understand the phase and amplitude tolerances** as a function of location in the Linac and complexity of the LLRF. (CI – CERN collaboration) suggest April 2009 **June**
- **Determine a specification for the high power vector modulators** and simpler phase shifters as a function of LLRF control system and beam power. (CI – CERN collaboration) suggest April 2009 **December 09 – with AB LLRF Specialists**
- **Studies of the overall HPRF system as the layout develops** and characteristics of components become known. Consider inter-cavity coupling, losses, power equality, effect of reflections, beam induced signals etc. We would base this on a few selected topologies. (CI – CERN collaboration) suggest April 2010
- **Determine the power overhead** need by the control system to meet phase and amplitude tolerances in the presence of Lorentz detuning and microphonics.
(Not enough is known to address this issue yet) suggest July 2011
- **Develop and demonstrate vector modulators at the highest power level** and the 50Hz repetition
(CI – CERN collaboration + UK industry?) suggest December 2010
- **Develop a remote variable splitting technology.**
(lower priority CI activity) suggest December 2010 **Non off-the-shelf components - design, prototypes.**



- **ESS Bilbao interest**

Design study and development of the Klystron Modulator for HPSPL. The 50 Hz modulator for the HP SPL is a new and very different device from that of the LPSPL. Upgrade probably means complete replacement. A collaboration with CERN, ESS Bilbao and industry should look at topology, specs and the design. Integration is also an important issue.

(ESS Bilbao & CERN TE PO)

Remains **URGENT**