



## WG 1 Questions Addressed



- # Cavities per klystron 1, 4, 8, (16)
- Requirement for high power vector modulators
- Essential R&D to meet LHC upgrade requirement
- Essential R&D to meet  $\nu$  factory and Eurosol requirement
- Requirement for flexible power division
- Is cavity phase control as opposed to cavity vector modulation adequate for high beta cavities

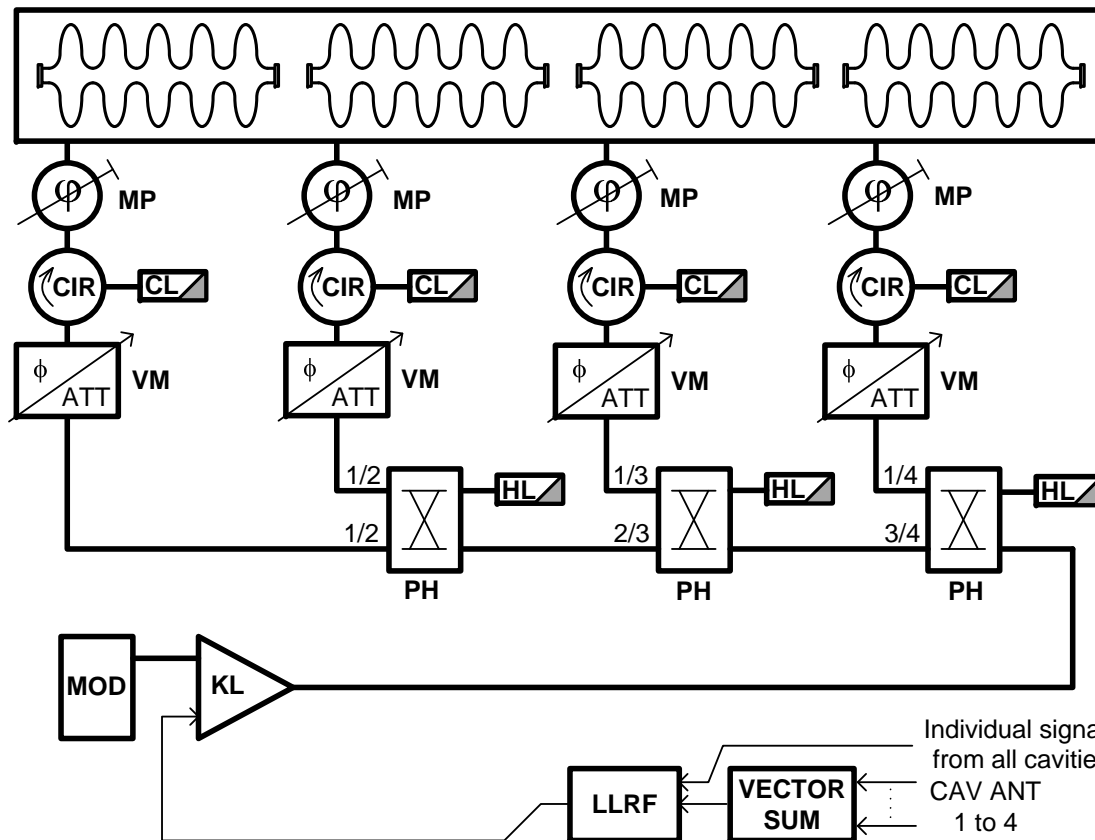


# RF distribution scheme

Daniel Valuch



- If 1 klystron/4 cavities this would be a preferred layout
  - Linear distribution using less space consuming “planar” hybrids with individually adjusted coupling
  - Vector modulators for fast phase/amplitude field control
  - Mech. phase shifters for cavity phasing or isolation



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



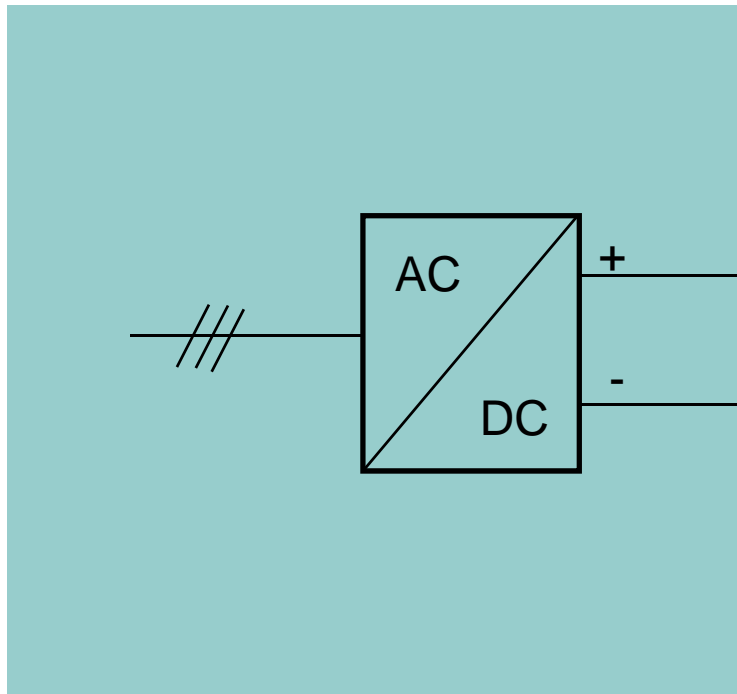
# Modulator - Proposed topology for the HP-SPL

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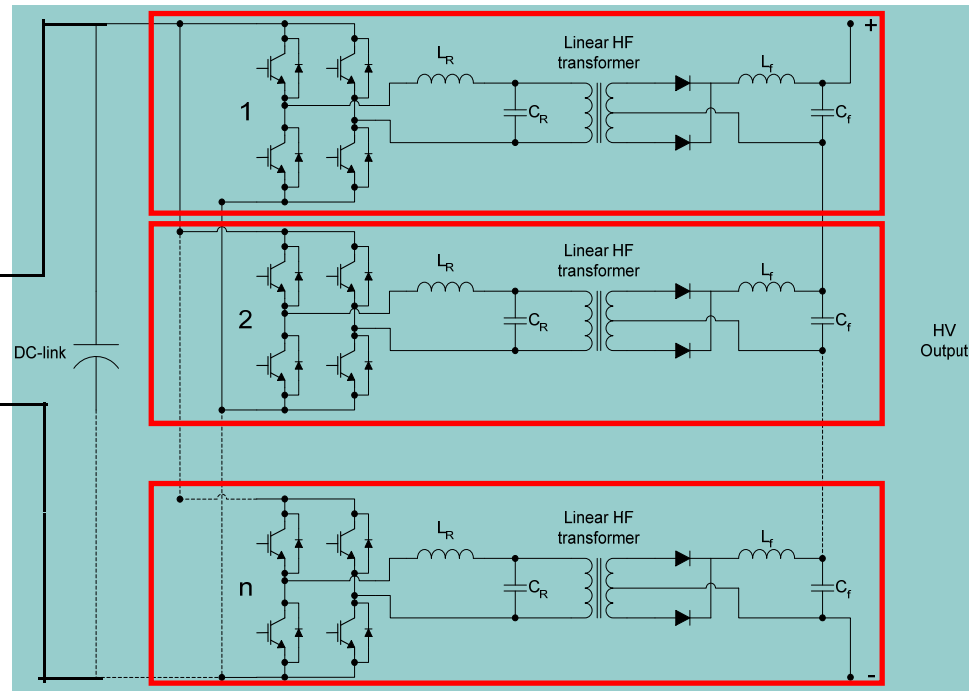


**110 kV, 91A, 2.3ms, 50 Hz (10 MWpk, 1.15 MWav)**

Capacitor charger: In surface building



Pulse former: In the tunnel



### Pulse former:

- Modular topology (4 or 5 independent modules in parallel/series);
- Easier imposition of “soft switching” in all operating points (no coupling between modules);
- However, former hard points related to the transformers, thermal management and mechanical layout remain.



- 5 MW klystron (based on SNS klystron)
- No. of Cavities / Klystron 1, 4, 8 (16) ?
  - Unit cost of klystrons & klystron modulators favours 4/8 – verify costs..
- Power splitting – Use **90° Hybrid** - Variable coupling by placing posts inside (XFEL asymmetric shunt Tee does not provide sufficient isolation)
- Need to get specs & demonstrate vector modulators (CI collab on dev of 50Hz version)
- Can we do without in LPSPL ? Specs for HPSPL
- Slow ('Manual') phase shifters – DESY design (Sliding inner plate)
- Waveguide sizing. WR1150 - HOMs
  - Do we need SF6? - Constraints with SF6
- **Integration & layout is a concern... (horizontal/vertical klystrons ?)**
- Klystron spec - Tolerable power losses, realistic power overhead for feedback loops
- Study of overall HPRF system as layout develops and characteristics of components are known - inter-cavity coupling, losses, power equality, effect of reflections, beam induced signals. (Using specs from field stability studies on phase & amplitude variations).



- Klystron Modulator – HPSPL 50 Hz is a new & very different device – complete upgrade LP to HP SPL (ESS Bilbao collab – needs definition, specs, integration – Planning of this?)
- Investigate solution using one phase locked magnetron per cavity (CI independent program)
- Develop remote variable splitting (lower priority CI activity in collab)
- Test stand for 700MHz Prototype 5MW klystron  
=> Test of w/g system and components, new klystron modulator  
Schedule ?



## Identified Work-Packages & Collaborations



- Klystron Modulator for HPSPL (ESS Bilbao)
- Phase locked magnetron (CI independent program initially)
- Remote variable splitting (lower priority CI activity)
- Vector modulator CI-CERN (50Hz high power version)
  
- ESS S Project associate to assist with CERN activities





Upgrade requirement from 2Hz (LHC) to 50Hz ( $\nu$  factory)

- Same number of cavities
- Almost same number of waveguide component
- Twice as many Klystrons (10 M€  $\rightarrow$  20 M€ )
- Four times the modulator cost (10 M€  $\rightarrow$  40 M€ ?)
- High power vector modulators beyond state of art

Likely scenario is to build for LHC upgrade and then upgrade with new modulators and extra Klystrons for  $\nu$  factory or Eurosol





## TDR Requirements



1. Settle RF distribution layout
2. Characterise components, Properly analyze system characteristics wrt specs (Isolation, losses, distribution)
3. Costing of Klystrons
4. Costing of modulators
5. Costing of other components
6. Foot print
7. Alternatives and upgrade routes