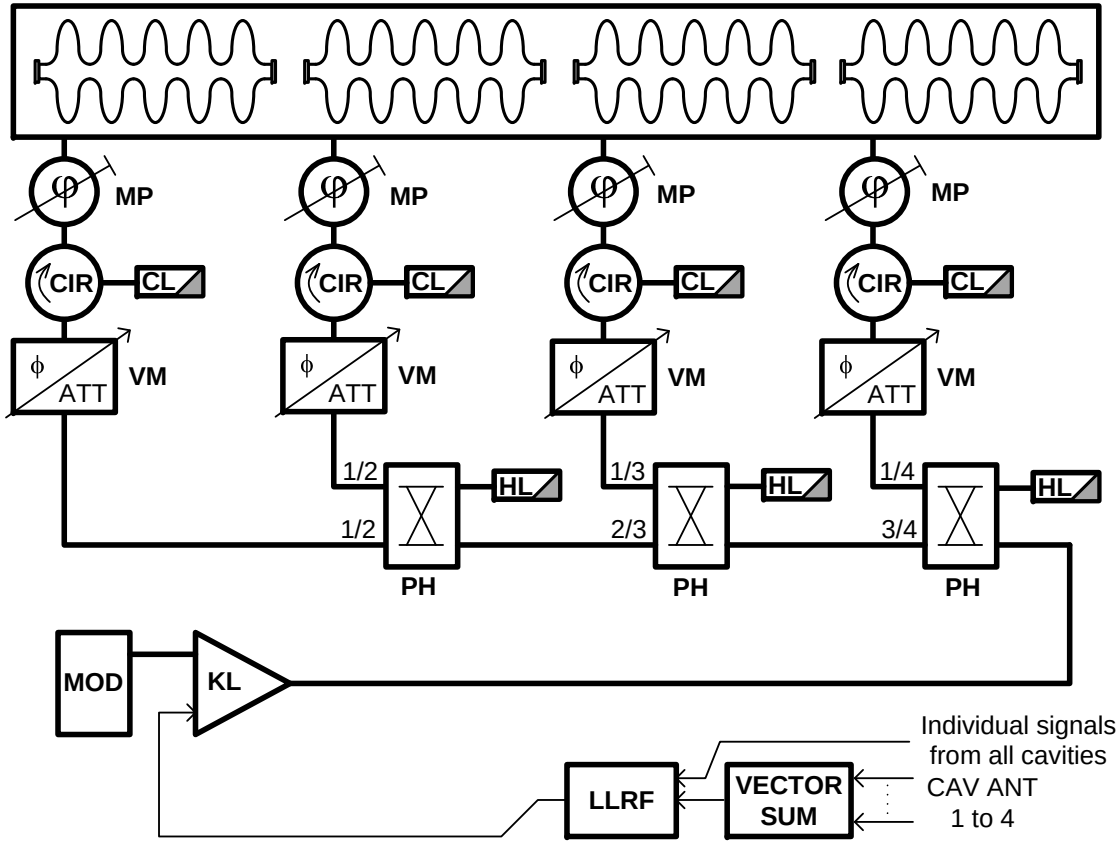
# Questions Addressed

- Klystrons per cavity
- 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** $5MW_{PK}$ 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

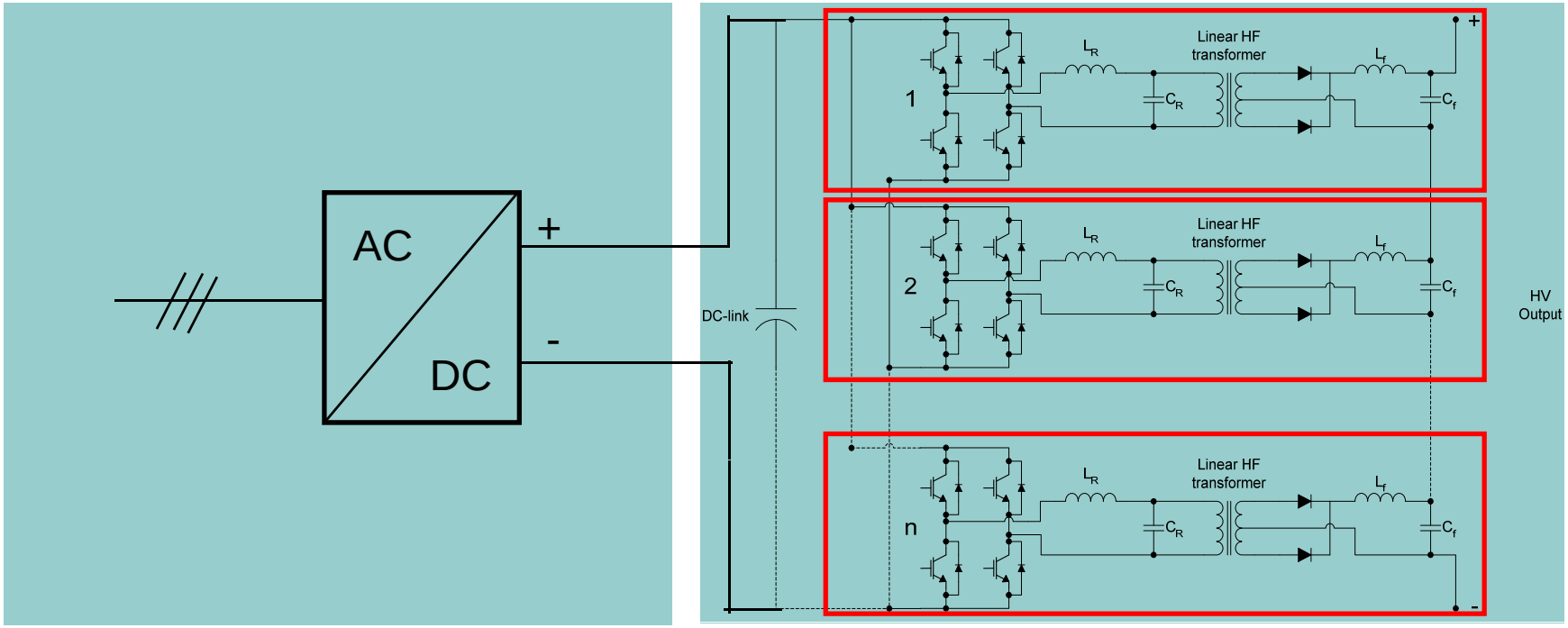
# Modulator - Proposed topology for the HP-SPL

Carlos DE ALMEIDA MARTINS

**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
- No. of Cavities / Klystron 1, 4, 8 (16) ?

  Unit cost of klystrons & klystron modulators favours 4/8
- 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)

  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…**
- Tolerable power losses, realistic power overhead for feedback loops
- Study of overall HPRF system Intercavity coupling due to reflections, Beam induced signals,.

  (related to field stability studies)
- Modulator – HPSPL 50 Hz is a new & very different device – complete upgrade LP to HP SPL (ESS Bilbao collab)

# Primary

1. Model string of four cavities with its control system to determine the minimum requirement for high power vector modulation
2. Develop high power RF vector modulation (1 MW – 50 Hz)
3. Develop technology for 50 Hz 10 MW Klystron Modulator
4. Understand power overhead for microphonics and Lorentz detuning
5. Impact of Lorentz detuning with respect to 50 Hz operation

# Secondary

1. Investigate solution using one phase locked magnetron per cavity
2. Develop remote variable splitting

Working Group 1

~~Upgrade requirement from 2Hz (LHC) to 50Hz (ν factory)~~

- Same number of cavities
- Almost same number of waveguide component
- Twice as many Klystrons (10 M€ → 20 M€ )
- Four times the modulator cost (10 M€ → 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 ν factory or Eurosol

# TDR Requirements

1. Costing of Klystrons
2. Costing of modulators
3. Costing of other components
4. Foot print
5. Alternatives and upgrade routes