Design and Performance of ESS Phase Reference Line Output Modules

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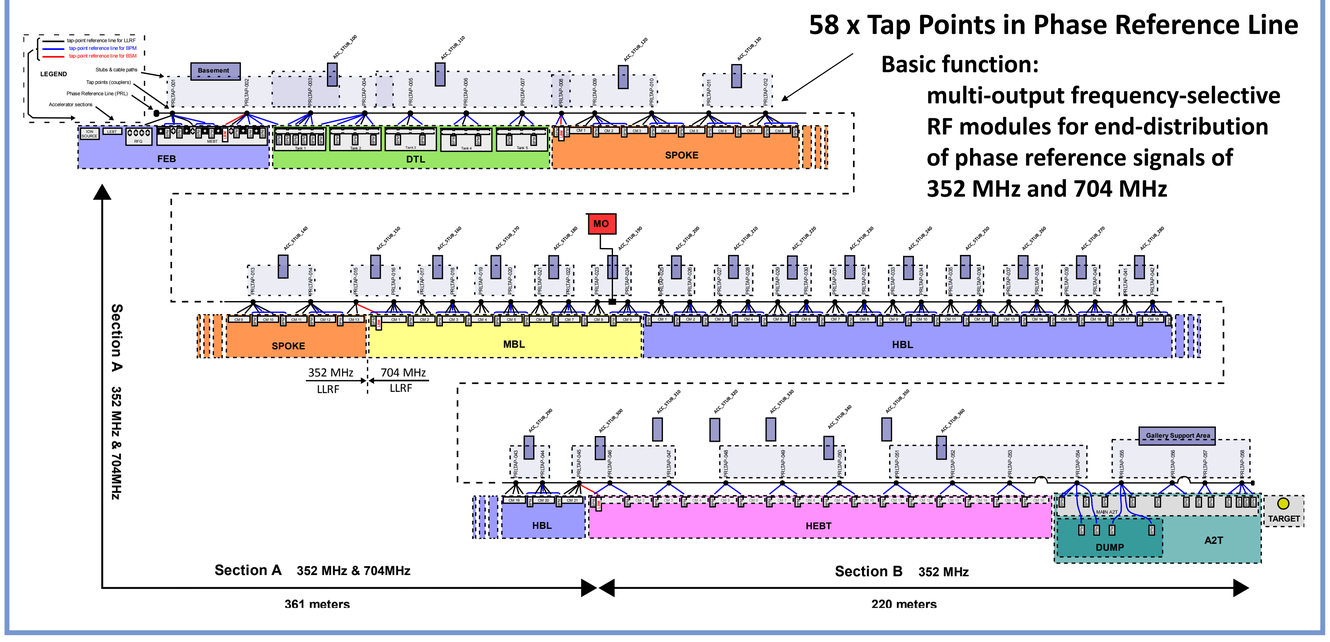
ABSTRACT

The Phase Reference Line (PRL) is a system that provides precise phase reference signals to LLRF and Beam Diagnostics systems of the European Spallation Source (ESS) linear proton accelerator.

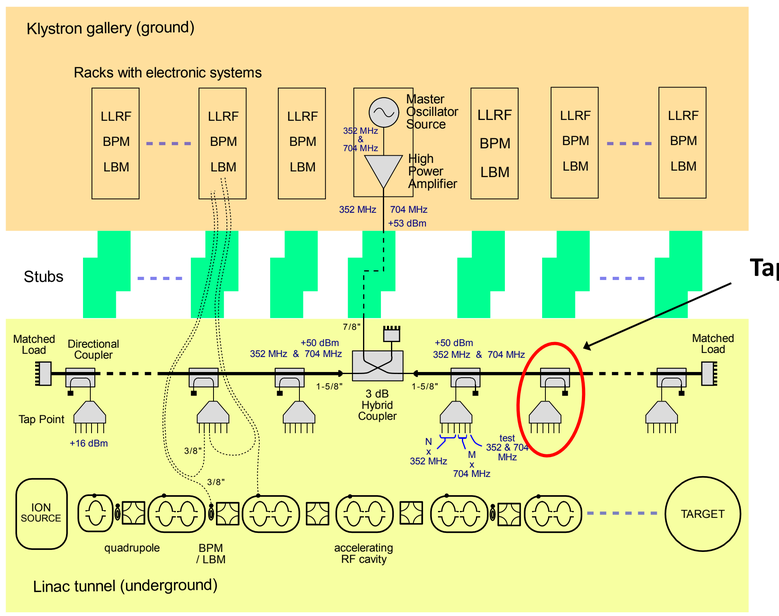
It is 580 meters long fully passive signal distribution system based on a single 1-5/8” coaxial rigid line with multiple output modules (called Tap Points) placed in the tunnel along the LINAC. The PRL distributes two reference harmonic signals of frequencies 352.21 MHz and 704.42 MHz from Master Oscillator located in the Klystron Gallery to 58 Tap Points in the tunnel. Each Tap Point consists of 1-5/8” coaxial directional coupler together with a passive multiway splitting and filtering module called Split Box. This provides locally multiple frequency-selective outputs, each with 352.21 MHz or 704.21 MHz reference signal. The total number of signal outputs from PRL is 271.

PHASE REFERENCE LINE IN ESS

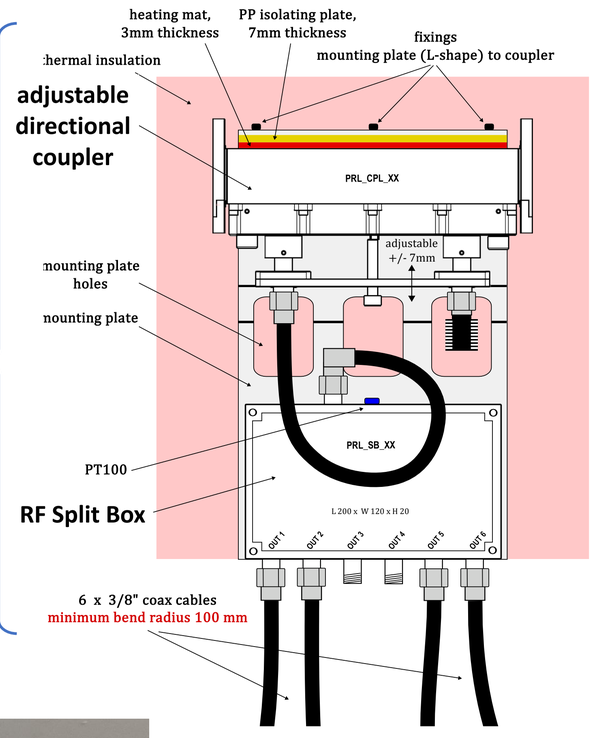


TAP POINT

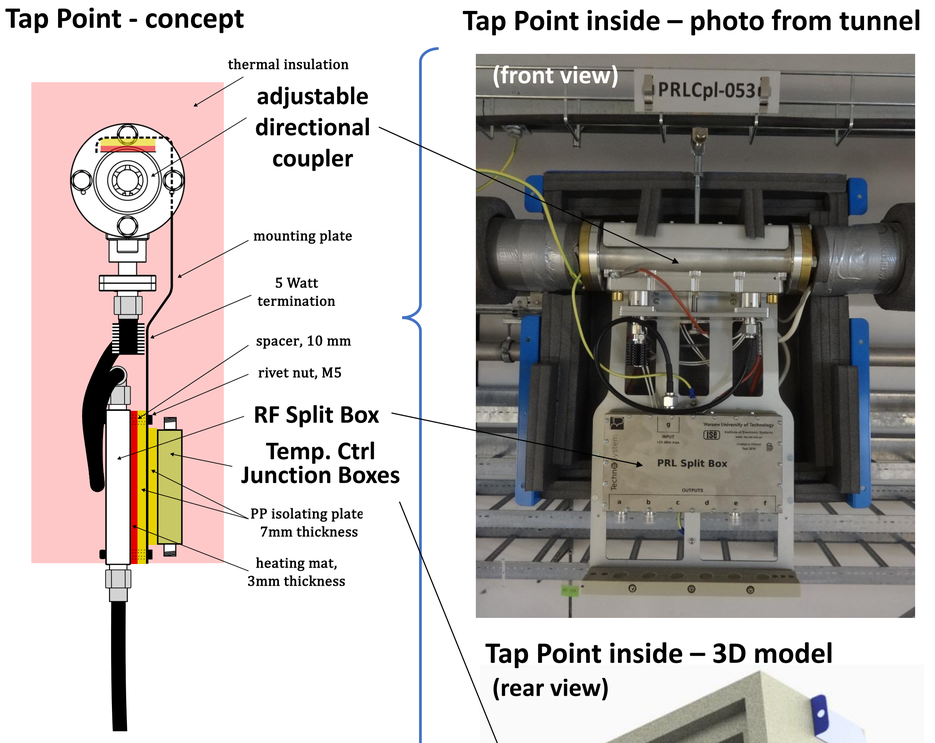
Phase Reference Distribution - system concept



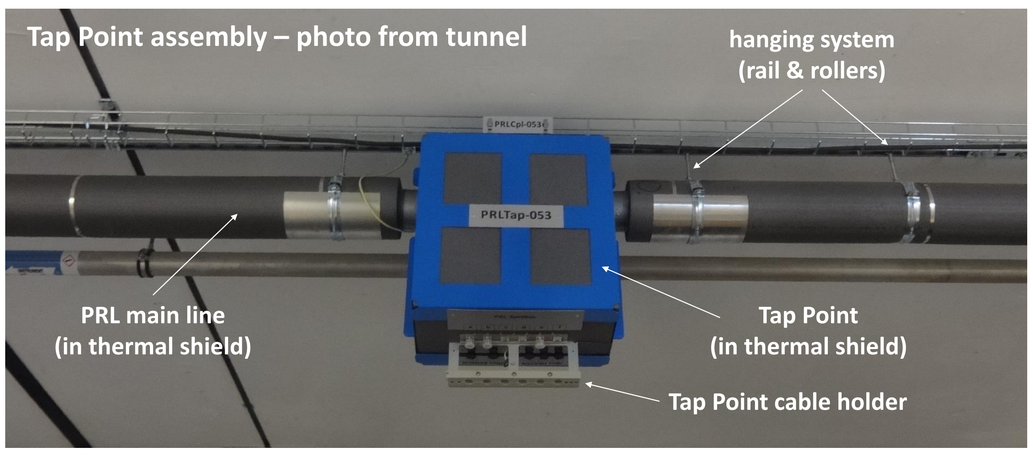
Tap Point - concept



Tap Point inside – photo from tunnel



Tap Point assembly – photo from tunnel

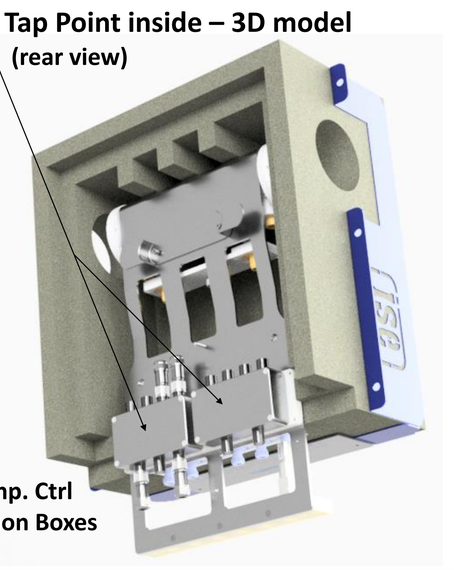


Tap Point from system point of view:

- RF signal end-distribution & filtering (RF performance)
- thermal boundary conditioning (temp. stability -> heat transfers)
- local node for RF and temperature control system interconnections (modularity, space limitation, mechanical restrictions)
- local grounding point for Phase Reference Line
- cabling and maintenance node (ergonomics, cabling, servicing)

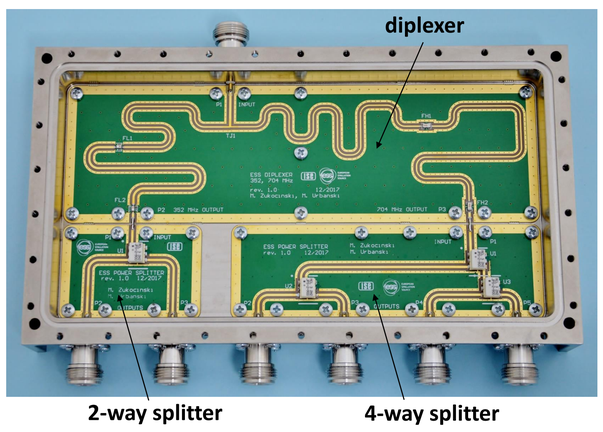
58 Tap Points in PRL provide 271 outputs (Pout > +16 dBm each):
103 outputs @ 352 MHz & 168 outputs @ 704 MHz

Tap Point inside – 3D model (rear view)

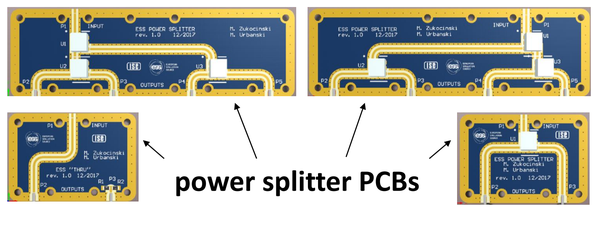


RF SPLIT BOX

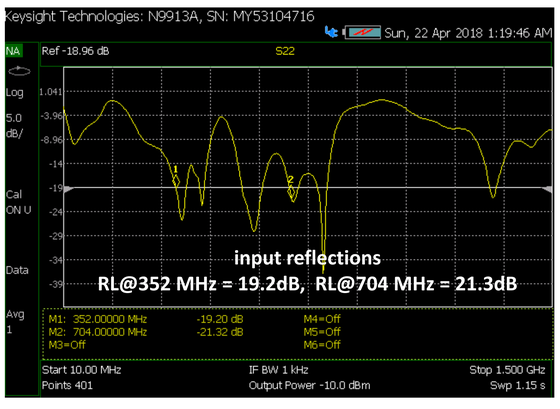
Multi-output frequency-selective RF modules for end-distribution of 352 MHz and 704 MHz

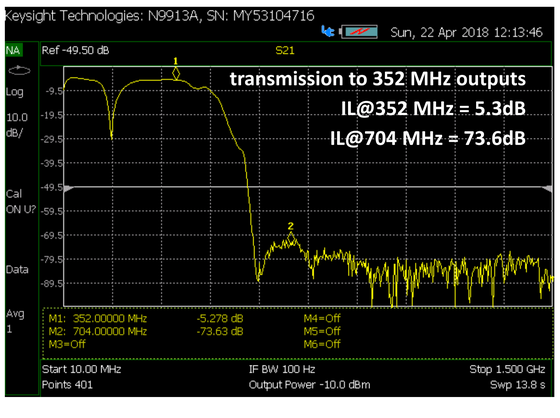


- PCB-based modular design
- diplexer + selection of splitters (1,2,4-way)
- output signals separation > 60 dBc



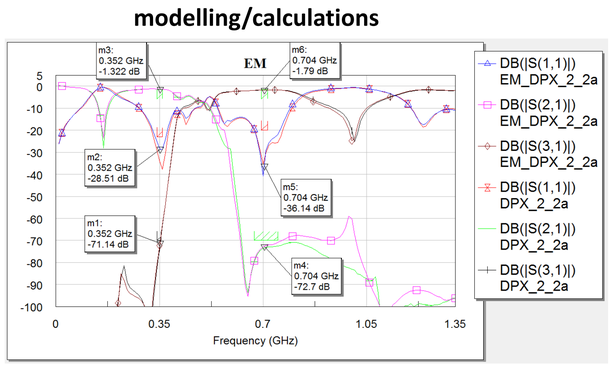
measurements

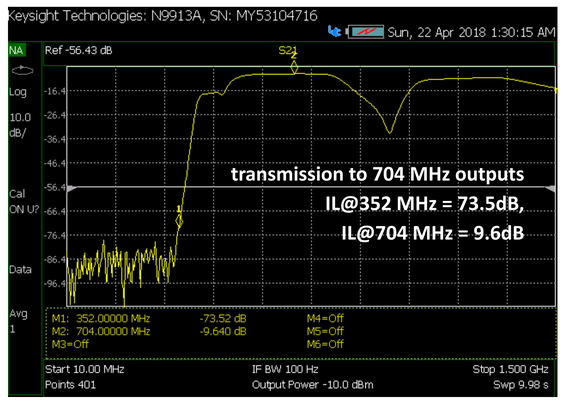




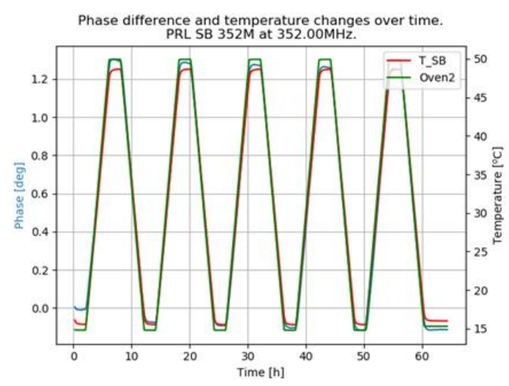
Split Box S-parameter results

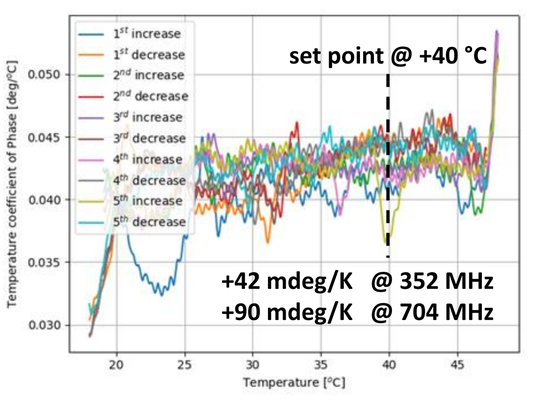
modelling/calculations





Split Box phase drift test results





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