

Development, fabrication and testing of the new High Efficiency klystron prototype in collaboration between CERN and Thales

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Introduction.

The new klystron bunching technologies were recently evaluated and further developed at CERN and HEIKA collaboration. It was clearly shown that these methods have potential to increase the klystron RF power production efficiency above 80%. The FCC type 0.8 GHz 1.4 MW klystron with operating voltage of 133 kV and beam current 12.6 A has been chosen as a candidate for the experimental demonstration of high efficiency klystron technology. To mitigate the fabrication risks and production cost, the CSM bunching method in a single beam tube was selected to be verified in a HE prototype. This bunching method comprises harmonic cavities and thus it has rather short RF circuit length – 1.72 m, compared to 5.75 m in original COM method. Example of the bunching processes in R-Z and Pz-Z phase spaces simulated by PIC code (MAGIC) for one of our designs are shown in Fig 1. In this simulations the power production efficiency was as high as 82.8% (cf. 84.7% in the COM tube).

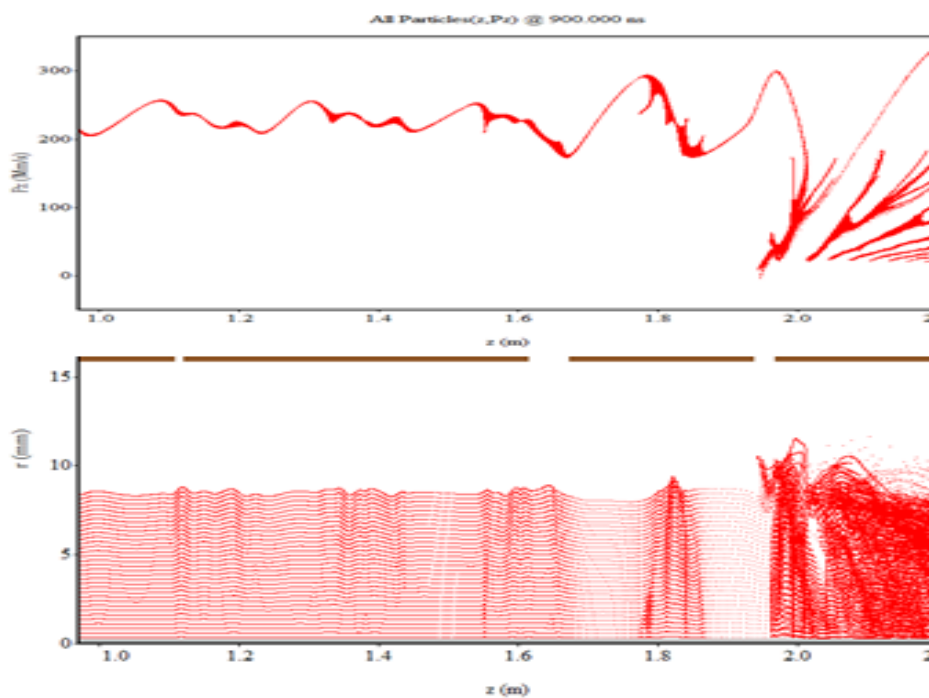


Figure 1. Snapshot of the bunching process in R-Z and Pz-Z phase spaces simulated by 2D PIC code (MAGIC).

Complementary to this activity, we have developed the new scaling procedure (PSP/GSP), which allows to scale any tube to the different perveance, frequency, number of beams, peak power etc., and to preserve the bunching processes, thus to maintain high efficiency. For more details please see: <http://indico.cern.ch/event/577810/contributions/2485022/>.

Fabrication of the new HE efficiency prototype will require consolidated efforts between CERN and industry. Thales is well known for its high reputation in the field and long standing collaboration with CERN. We anticipate that HE klystron collaboration between CERN and Thales is a natural way to proceed with this development.

Tentative planning of the CERN/Thales collaboration for fabrication of prototype of the high efficiency L-band klystron for accelerators.

1. Preliminary phase. April-May 2017.

The first extended CERN/Thales technical meeting will take place at CERN during the second week of April [13.04.2017]:

- Igor will make short review of the HE klystron activity at CERN (HEIKA) and will present the updated RF design and simulations of the CSM 2L3B1S tube that was selected as a candidate for prototype development.
- The tube parameters (V, I, uK, P peak, F) shall be openly discussed and, if necessary, they can be modified in agreement with all accepted recommendations. Should be mentioned that if modification happen, it will require scaling and post-optimisation efforts at CERN.
- The development program, schedules, resources, parties' contributions and responsibilities shall be discussed as well.

The existing CERN/Thales NDA extension and collaboration agreement (if needed) for the PHASE 1 of the project will be prepared and signed by the end of May 2017.

The final tube RF design report based on extensive simulations using PIC codes (MAGIC and CST) will be prepared and distributed by CERN experts by the end of May 2017.

2. PHASE 1. June – October 2017.

Based on RF design submitted by CERN, Thales experts will develop specifications and particular designs of RF cavities, RF couplers, cathode, collector and solenoid. This study and design efforts will be done in close collaboration and communication with CERN colleagues. At the last stage CERN team will perform full 3D (CST) simulations of entire tube including all subsystems and issue the internal collaboration report.

During Phase 1 the work will be based on in-kind contribution, so that both parties will delegate all necessary resources and cover the cost.

The financial Contract between CERN and Thales for the prototype fabrication shall be issued by the end of October 2017.

3. PHASE 2. November 2017 – November 2018.

- Based on the final tube design, the complete set of technical drawings will be prepared by Thales by the end of January 2018.
- All the rough material and components for the tube fabrication will be purchased by Thales by the end of June 2018.
- The tube fabrication will start at July 2018 and will be completed by the end of October 2018.
- The HE klystron prototype diode testing will be held at Thales in November 2018.
- The acceptance RF test of the HE klystron at CERN will start in November 2018.

The schedule of the Phase 2 is accounting enough margins, especially for components purchasing that will normally follow the complete technical design and fabrication drawings.