



This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under GA No 101004730.

## WP 11.2

# “High-Efficiency Klystron Industrial Prototype”

I.FAST 1<sup>st</sup> Annual Meeting

CERN, May 2-6 -2022

N. Catalan-Lasheras & O. Brunner /CERN

iFAST

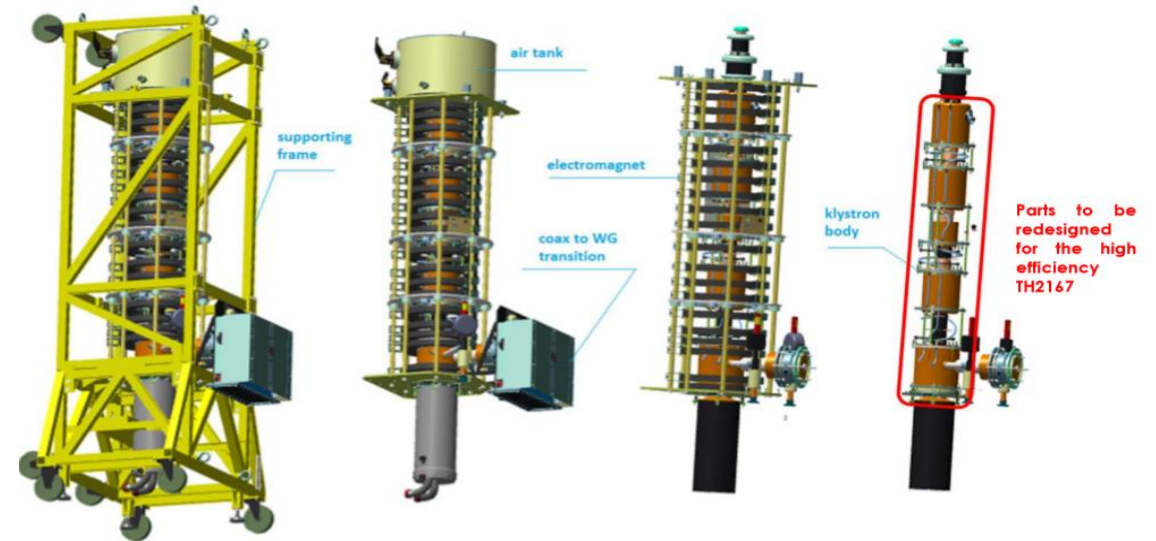


# Scope

- Design and build an industrial prototype of the LHC klystron reaching 70% efficiency, in collaboration with THALES.
- In order to control the costs, the choice was made to retrofit the existing LHC klystrons, TH2167, with the aim of reusing some components (e.g. solenoid).
- Expected gain in DC to RF conversion efficiency: + 10 - 15 %

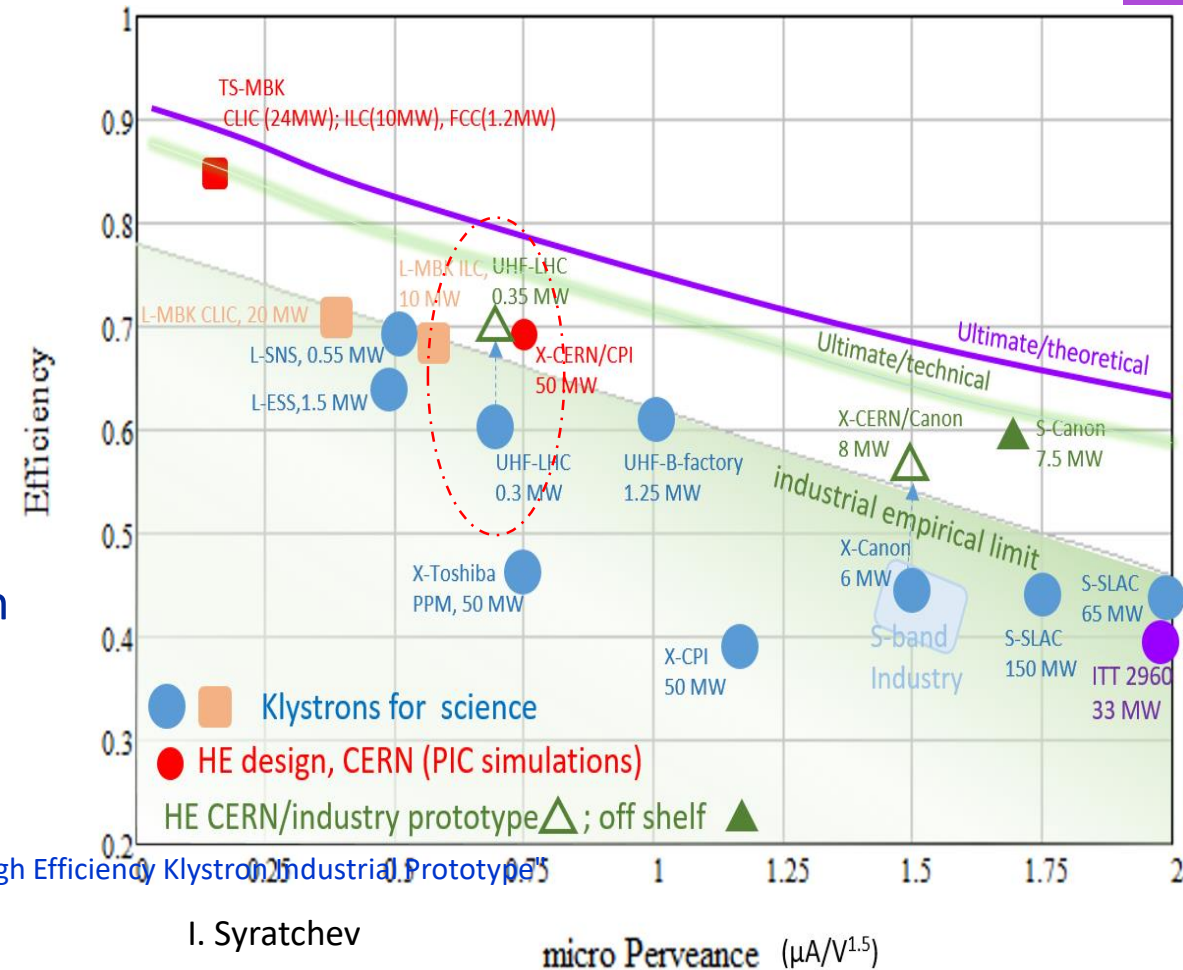


The LHC cavern UX45 with the klystron gallery.



# Higher energy efficiency is a must

- Also to all future accelerator projects.
- Impressive progress in High efficiency klystron technologies in recent years (-> I. Syrathev' s talk).
- The HE-LHC klystron will be the flagship demonstrator
  - demonstrate the performance in operation in LHC
  - reduce the electricity bill and the environmental impact
  - increase the operational margin when operating with higher intensities (“HL-LHC”).



# The teams



- CERN (Z. Un Nisa, N. Catalan-Lasheras, I. Syrathev, O. Brunner)
  - Igor is the driving force for HE Klystron & leading the HE klystron effort @ CERN.



Igor Syrathev



- Thales AVS France SAS (A. Beunas, K. Haj Khelifa, O. Mielle, G. Batto...)
  - Thales is the only European supplier for high-power klystrons



Armel Beunas

- University Lancaster (G. Burt, (J. Cai))
  - University of Lancaster, part of the Cockcroft Institute, is a productive and reliable partner - Graeme (Associate Director and Professor),
  - Jinchi (formerly CERN fellow) has developed an advanced klystron simulation code (KLyC) and is key player in the HE klystron development.

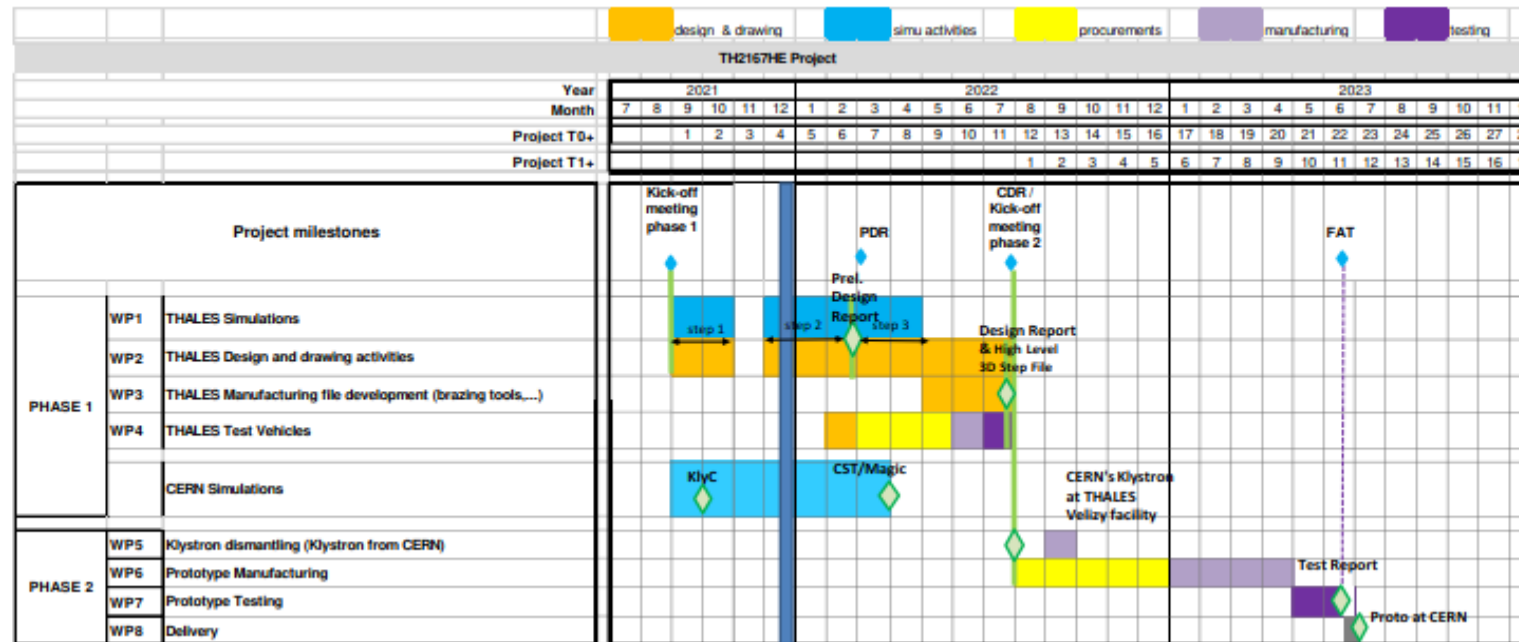


GRAEME BURT  
Lancaster University  
BBC BREAKFAST



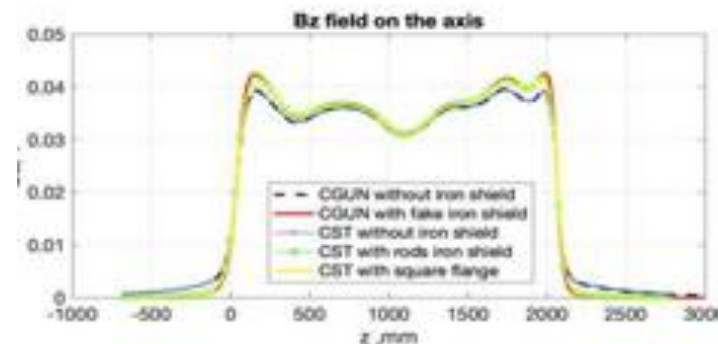
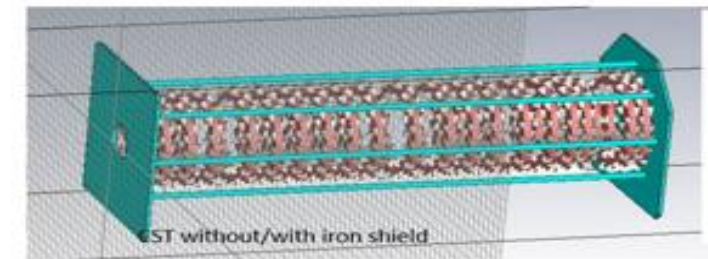
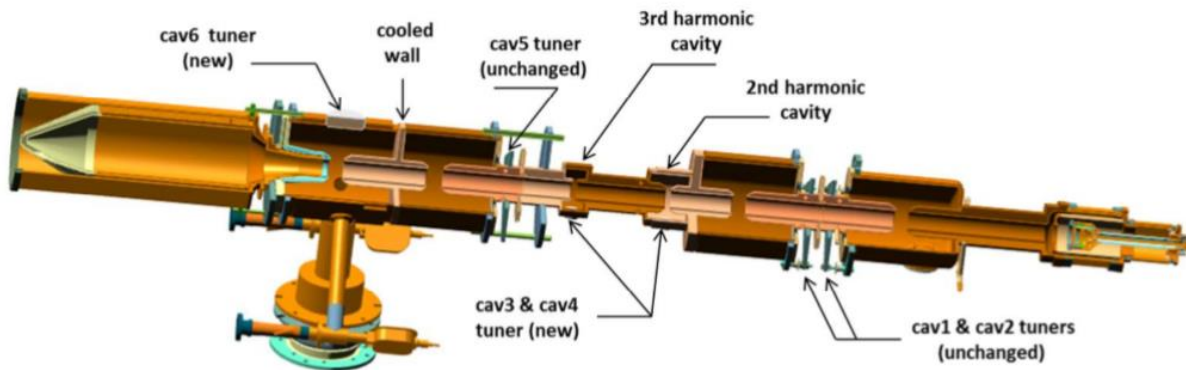
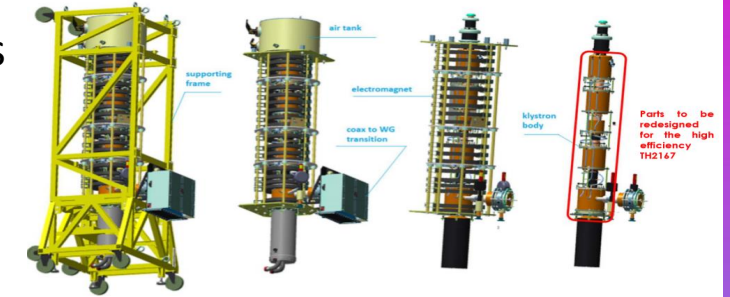
# Where do we stand?

- A collaboration agreement CERN/Thales was elaborated and signed last year
- The HE LHC Klystron Kick Off Meeting took place on the 2<sup>nd</sup> of September 2021
- The Preliminary Design Review (“PDR”) took place early January 2022
- DESIGN REPORT IN PREPARATION
- The construction shall start during the Summer ‘22



# What has been done (1)?

- The first assembly drawing of the new RF structure and an internal progress report was produced.
  - Re-uses housing, electron gun and solenoid (also efficient!)
- The magnetic profile of the klystron was optimized in order to:
  - Reduce the required coil current –and therefore dissipated heat-
  - Optimize the power distribution in the collector and avoid backscattered electrons on the tube

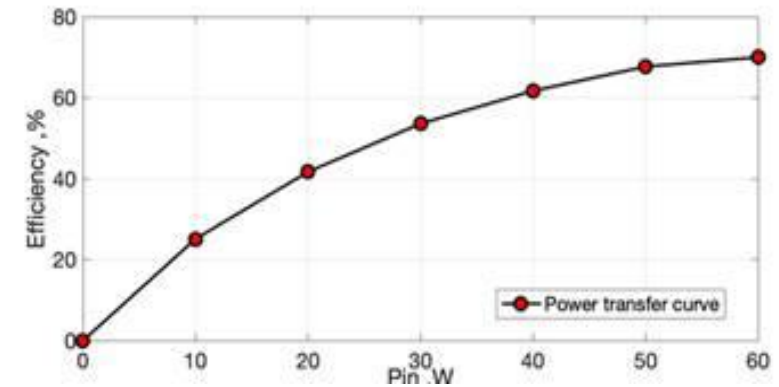
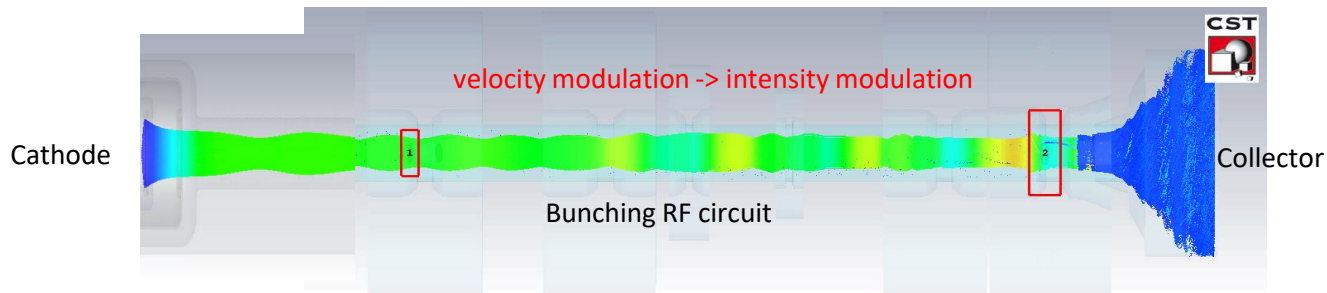


Cut-off view of the LHC CSM klystron

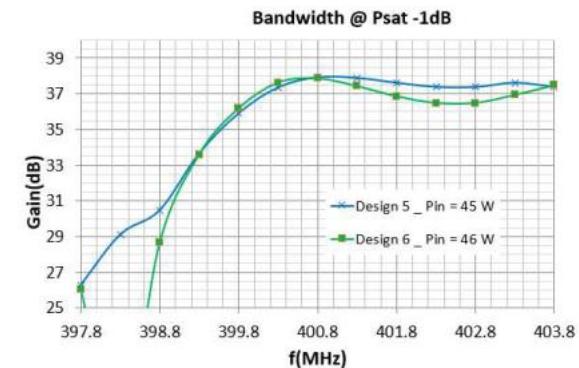
THALES

# What has been done (2)?

- The collector geometry is optimized to reduce the power density across the collector surface and the output cavity redesign to cope with the increased output RF power
- New interaction region (cathode + solenoid + RF circuit + collector): the full 3D PIC simulated performance is quite satisfactory in terms of RF power, stability, bandwidth and efficiency
  - No modulation of the output power is observed and the operating point of the klystron is safe with saturation at 60W drive power.



	LHC/CSM	LHC/Thales
Frequency, GHz	0.4	0.4
Beam power, MW	0.5	0.5
Perveance,	0.72	0.72
RF power, MW	<b>0.35</b>	<b>0.30</b>
Efficiency, %	70	60



# Conclusions and next steps

- The development of the TH2167HE klystron prototype for LHC is ongoing according to plan
  - Fine tuning of technical details



*the hydraulic inlet/outlet positioning*

- Now heading towards the start of the construction phase which shall start during the summer
- In the meantime the RF design will be reconfirmed and the detailed thermal simulations and mechanical design of the assembly completed and validated



iFAST

*I hope this was efficient !*

*Thanks!*



This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under GA No 101004730.