High Efficiency Klystron (HEKCW) for FCC info/status

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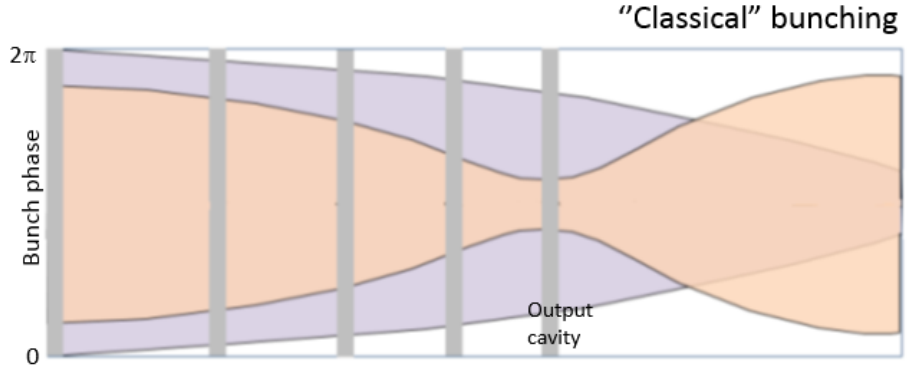
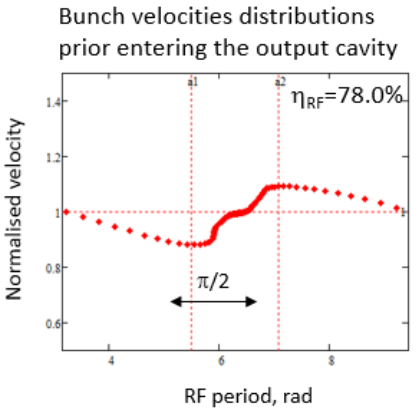
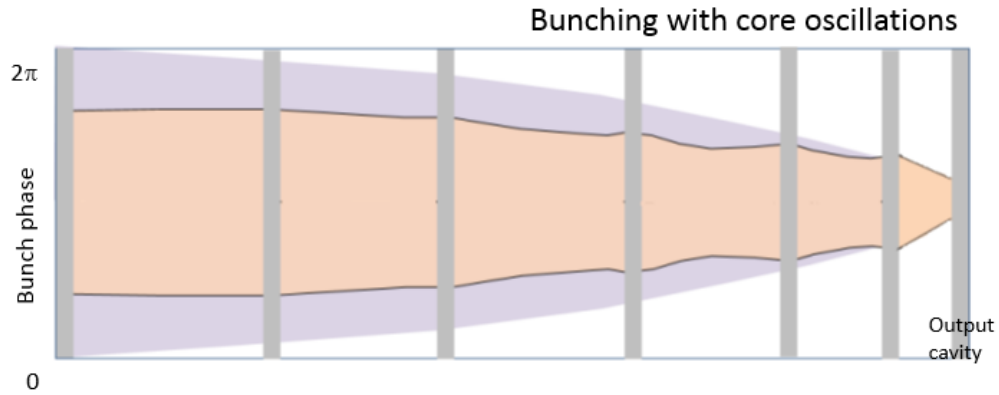
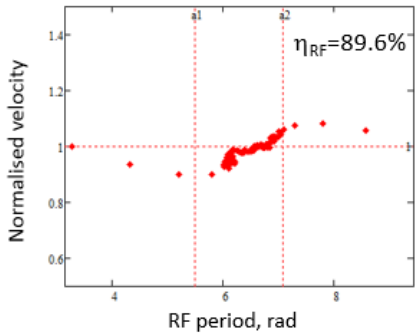
Superconducting RF R&D coordination meeting 01. CERN. 14.10.2015

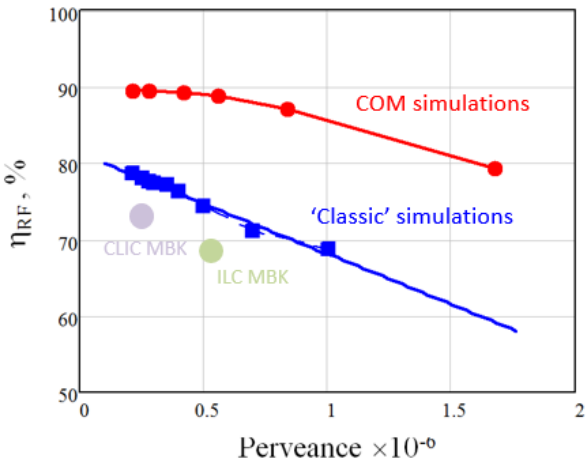
The new bunching technology has a potential to boost klystron efficiency to the 90% level.



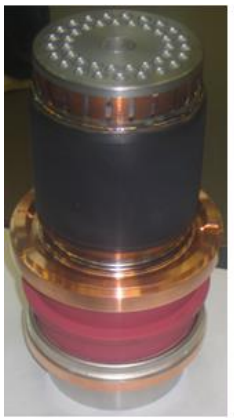


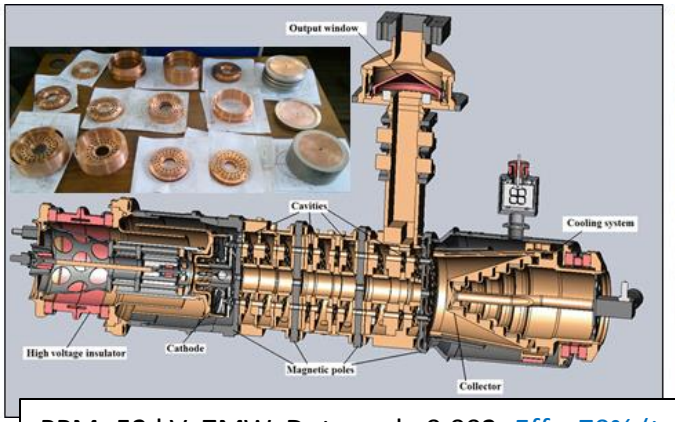






The first conceptual/ technological S-band MBK prototype is now being built in Russia.





PPM, 52 kV, 7MW, Duty cycle 0.002, Eff. >70% (to be demonstrated)

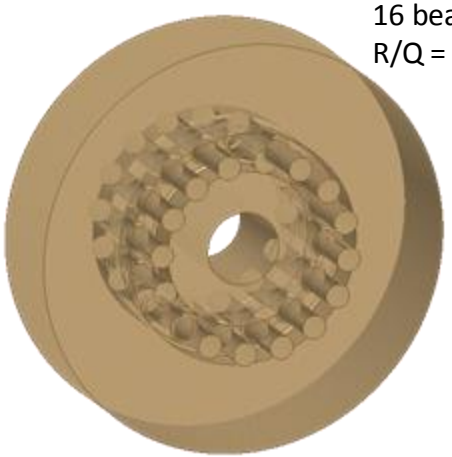
FCC e+e- CW, MBK klystron (HEKCW)

HEIKA/HEKCW working team:

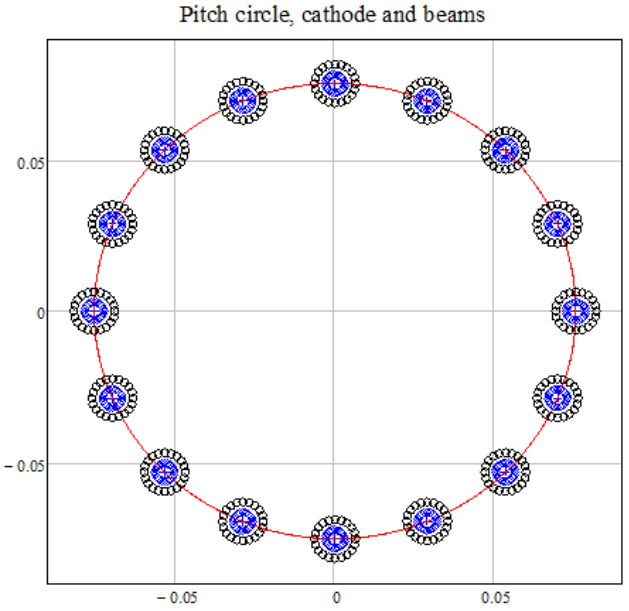
I. Syratchev (CERN)
II. G. Burt (Lancaster)
III. C. Lingwood (Lancaster)
IV. D. Constable (Lancaster)
V. V. Hill (Lancaster)
VI. R. Marchesin (Thales)
VII. Q. Vuillemin (Thales/CERN)
VIII. A. Baikov (MUFA)
IX. I. Guzilov (VDBT)
X. C. Marrelli (ESS)
XI. R. Kowalczyk (L-3com)

Tube parameters:

- Voltage: 40 kV
- Power: 1.5 MW
- Total current: 42A
- N beams: 16
- μK/beam : 0.33
- N cavities: 7
- Bunching methods COM/BAC
- Cathode loading: 2 A/cm^2
- Beam radius: 3 mm
  - Filling factor 8 mm
- Length: 2.3 m
- Beam circle radius: 75 mm
- Solenoid field (2x): 600 G
- Solenoid radius: 150 mm
- Collector: common
  - Nominal load: 170 kW



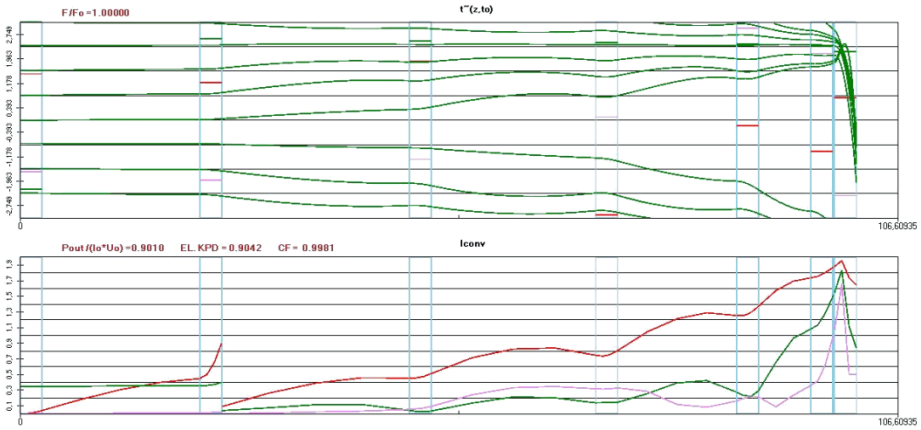
16 beams MBK cavity
R/Q = 22 Ohm/beam



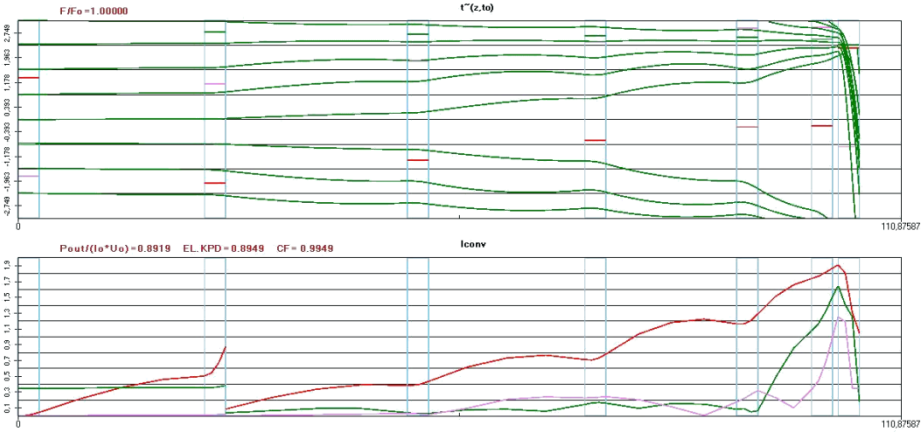
HEKCW RF COM circuit optimisation

Few tubes were optimised using **KlypWin** (1D code). Two of them were selected for further study.

HEKCW #11-02 (highest efficiency) η= 90.1%

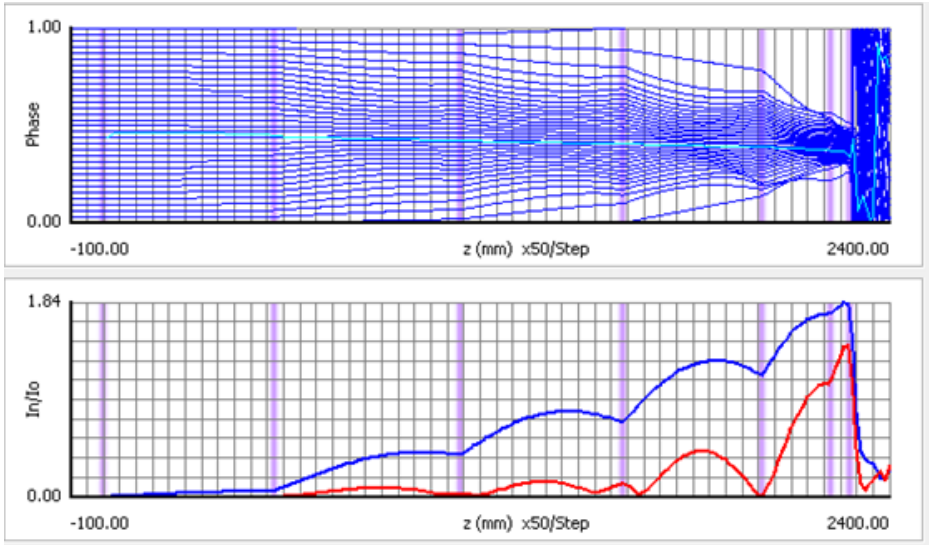


HEKCW #11-07 ('cleanest' phase trajectories) η=89.2%

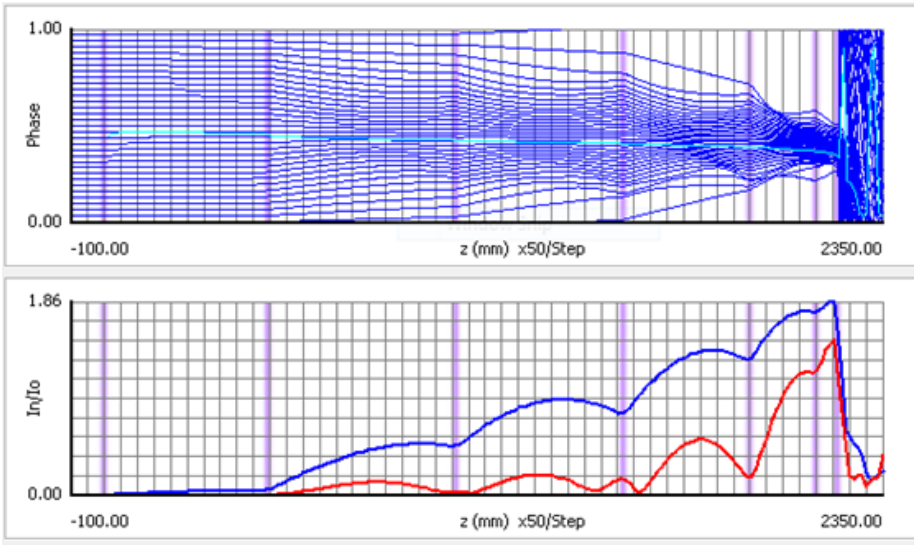


High efficiency confirmed by another non-commercial 1D code **AJDisk**

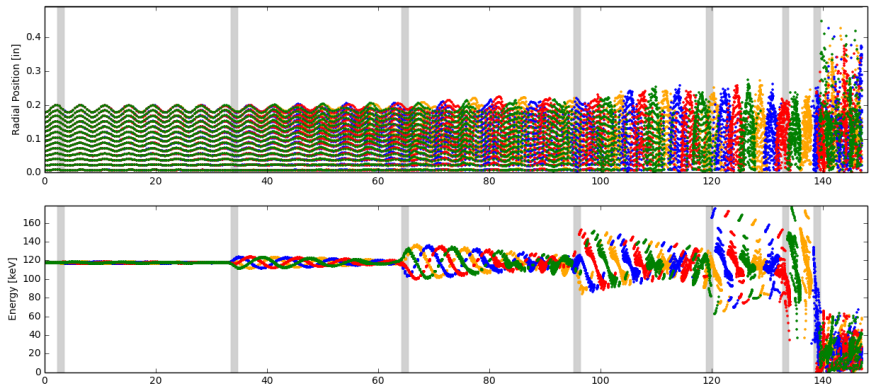
η= 88.0%

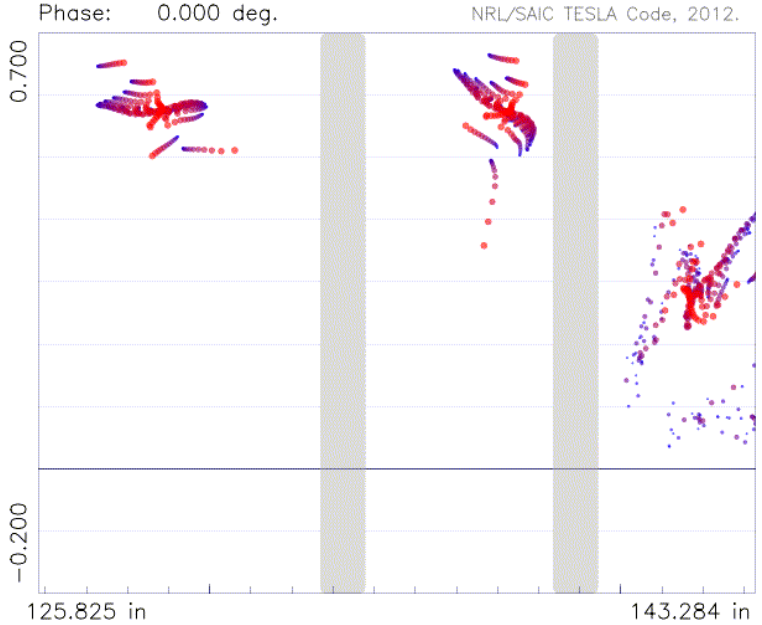


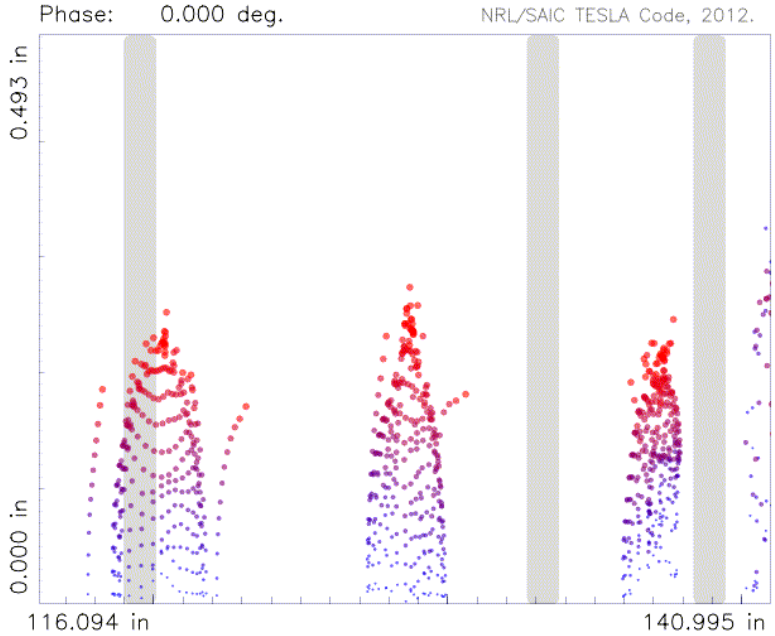
η= 87.5%



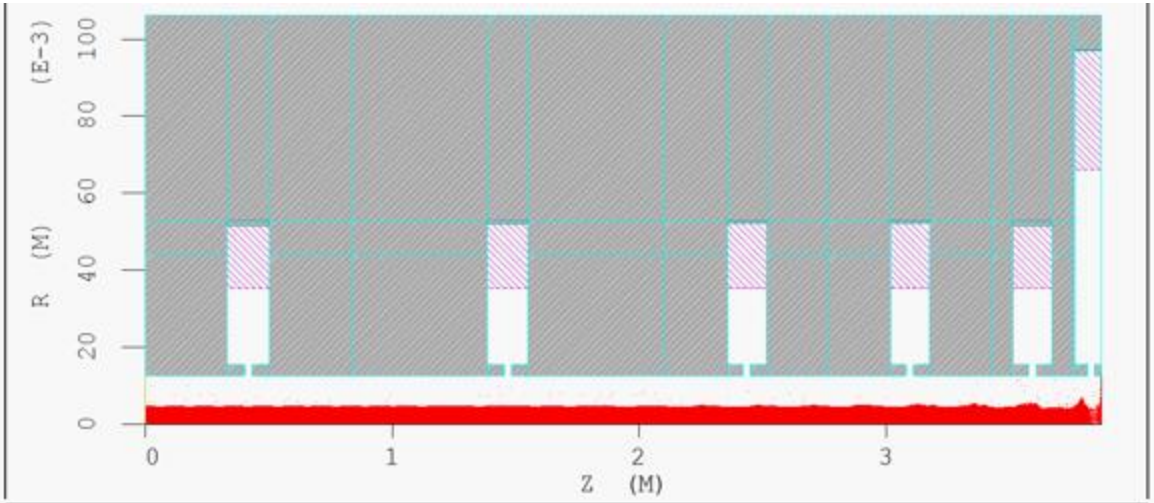
NRL/SAIC TESLA (2.5D). Tube is slightly re-tuned (stability issues). Efficiency 80%.

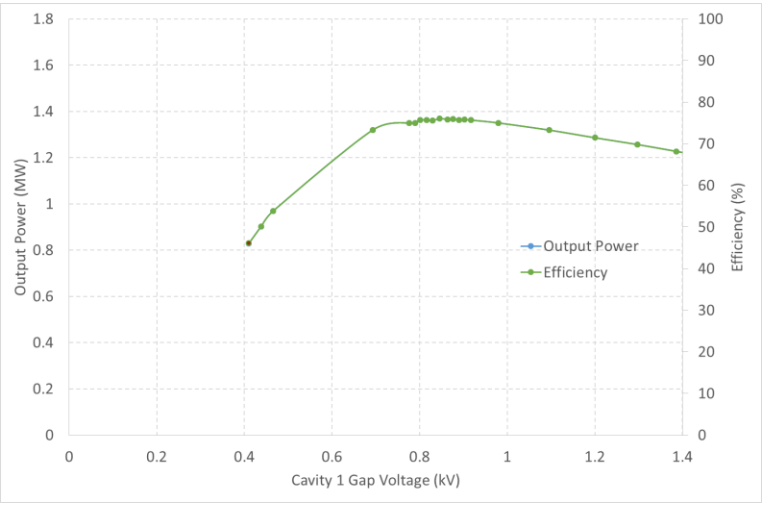


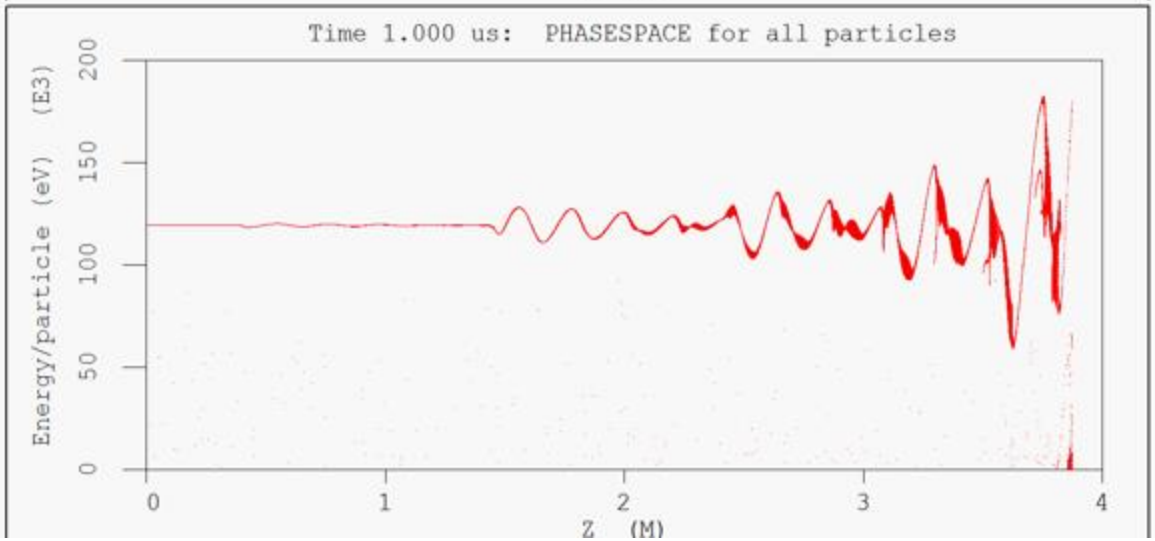


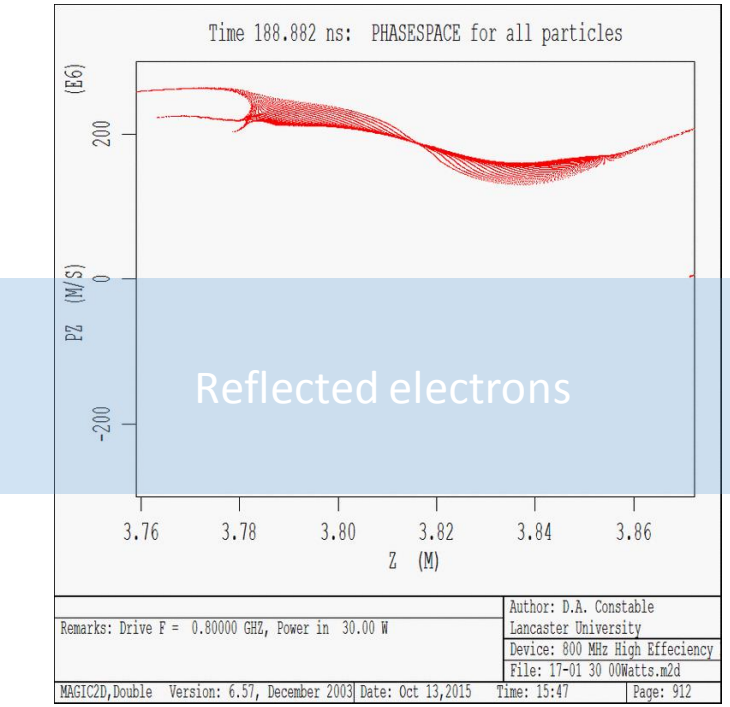


MAGIC (2.5D). Tube is shortened (6 gaps) (reflected electrons issues). Efficiency 78%.
(yet in a progress)









HEKCW 'preparatory' activities. ~Needs and ~schedules.

1. **Computer simulations** (1D, 2D, 3D). Development/improving of the klystron circuit (COM/BAC/new methods) and exploring the new ideas (electron beam mixing technique, hollow beams etc.).

-Target: robust MBK klystron design with efficiency above 80%.

- Resources:

CERN: I. Syratchev, Q. Vuillemin (PhD. CERN/Thales)

Others: HEIKA team contribution.

- Needs: Dedicated computer facility (Lancaster U). Investment: computer cluster ~30 kCHF.
- Schedule: Ongoing activity (+ 3 years?)

2. **HEKCW prototyping**. GSP (scaled) tubes.

- Target: Inexpensive experimental demonstrators of the HEKCW concept(s) at a lower power (different frequency (3 GHz)). 3-4(+) tubes.

- Resources:

CERN: I. Syratchev, Fellow or equal (for testing).

Others: HEIKA team contribution

Industry (on the collaborative bases)

Needs: General purpose test stand (XBOX area (?)), LLRF/ 'flexible' modulator; app. 150 kCHF.

- Investment (industry): klystrons/(solenoid) fabrications; app. 200 kCHF. Total 350 kCHF.
- Schedule: Starts from ~mid. 2016. Two years program.

3. **Alternative/advanced technologies**:

- Other than klystron. IOT with extra bunching cavity(ies). The existing 0.53 GHz,10 kW tube (called Tristrod. Developer: "Kontact", Russia) operates routinely at 90% efficiency.
- Cathodes:
  * Gated (low voltage controlled) cathode. Overall system efficiency improvement.
  * Hollow beam cathodes (MIG, cold emission…). Reaching the ultimately high efficiency (90%).
- Resources, needs and schedules are not yet specified. For now covered by HEIKA.

Fabrication and testing of the final HEKCW prototype.

- The choice of final circuit configuration and computer detailed design. HEIKA team.
- Technical design of the klystron (including all subsystems). Industry.
- Efficiency demonstration (target: 85%) in pulsed mode. CERN/X(S)BOX modulators.

If accepted, could be started not before late 2017. Overall project duration is about 3 years (tests at 2021). Anticipating reduced NRE expenses in industry, the projected cost is 500 kCHF.