X-Band Klystron Activity and Plan in 1998-1999 at KEK

KEK

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SLAC
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Present Status and Plan

Main activities since July 1998

- Testing of XB72K No.10 started in January
  ◆ For details of status and schedule --> Fukuda
- Remodeling of BINP PPM
  ◆ For details of redesign plan --> Matsumoto
- Design of the XBPPM-1 (still in progress)
  ◆ For details of design --> Matsumoto
- Study of RF instability using MAGIC 3D
  ◆ For details --> Matsumoto
- New gun simulation code DGUN from BINP
- Study of PPM configuration for larger magnetic field
  and for easier manufacturing
  ◆ For details --> Mizuno

Activity plan in 1999

- Completion of the design of the XBPPM-1
- Design of the XBPPM-2
- Manufacturing and testing of the XBPPM-1 and -2 klystrons by the end of 1999 fiscal year.
- Testing of the remodeled BINP PPM klystron
- Establishment of 3-D simulation of klystron for instability analysis
Schedule of Klystron Development
by Y. H. Chin, January 19, 1999
Testing of XB72K No. 10

- XB72K No. 10 (the last solenoid-focused klystron in XB72K series) was delivered to KEK on December 24, 1998.
- The testing started from January 4, 1999.
- Predicted performance:

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak power</td>
<td>122 MW</td>
</tr>
<tr>
<td>Beam voltage</td>
<td>550 kV</td>
</tr>
<tr>
<td>Efficiency</td>
<td>47%</td>
</tr>
<tr>
<td>Max. field gradient in TW</td>
<td>~ 80 MV/m</td>
</tr>
<tr>
<td>Pulse length</td>
<td>1.5 μs or longer</td>
</tr>
<tr>
<td>Band-width</td>
<td>100 MHz</td>
</tr>
<tr>
<td>Gain</td>
<td>53 dB</td>
</tr>
</tbody>
</table>

- Testing is scheduled until the end of May 1999.
Predicted Output Power for XB72K No. 10

Output Power (MW) vs. Beam Voltage (kV) chart showing MAGIC simulations.
Remodeling of BINP PPM

■ Measurement results:

- RF power becomes unstable at voltage higher than 500 kV.
- RF instability (transverse?) observed with and without RF at 19, 21,..GHz.
- 20% particle loss observed with RF on.

<table>
<thead>
<tr>
<th></th>
<th>55 / 77.4 MW</th>
<th>Beam voltage</th>
<th>500 / 550 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulse length</td>
<td>430 / 100 ns</td>
<td>Efficiency</td>
<td>33 / 38 %</td>
</tr>
</tbody>
</table>

■ Simulation results

- Predicted power = 88 MW (η=42%) at 550 kV, 377A (0.93 peaveance).
- About 20% of particle interception just after the final cell of the output cavity
  - The interception is caused by lack of focusing for particles that drop to the stop-band voltage after losing energy to the traveling-wave.
Movable Shield

Beam Collector (Fender Cup)

RFin

RFout

\( E \text{ Stabi} \) \( E \text{- Mag} \) \( \text{Gun} \) 
\( \text{Hatching Section} \) 
\( \text{Adjustable} \)
Simulation and Measurement Results for BINP PPM

![Graph showing output power vs. beam voltage](image)
Evolution of DC and RF Beam Current in BINP PPM

DC and RF Beam Current (A)

Z (mm)

Output Power = 78.1 MW
Beam Current Rescaled: Per = 0.93
Caption: PHASESPACE Plot 1 at Time 8.732 ns

Processing: Particle Species: ALL

BinP PPM @ 550kV

Remarks: Output system
Remarks: 550kV/100W ppm9101

Organization:
KEK

Author: V. Teryoew

Date: 08/19/93
Time: 10:08

File: output.mgp

Run No. 1
Page: 32
Beam transmission simulation
@ Russian PPM klystron

- The transmission rate are calculated by MAGIC.
- Designed magnetic fields are used for the calculation.
- MAGIC has a same tendency to the experimental transmission rate (with original magnetic fields).
- STOP-BAND is observed below 300 kV in the simulation. The simulation will be done with experimental mag. Fields.
Output Power vs. Beam Voltage

Beam Voltage (kV)

Output Power (MW)

M = 544 kV
P_t = 77.4 MW

June 3-4, 1998

BKEK#1 klystron
Modification items in the rebuilding are:

- Improvement of buncher for a larger RF current
- Change in the magnetic field at the output cavity to a unidirectional one by using a coil or hybrid magnet (coil + PM).
- Adjustment of output cavity shape and its impedance to increase the efficiency and for possible reduction of RF instability
- Use of Stainless-steel in the buncher and the output cavity

The rebuilt BINP PPM is scheduled to be delivered to KEK by the end of July 1999, and the testing will start from August.
Lense Current

$I^*W=20kA$

$P_{out} = 84.8 \text{ MW}$

$I^*W=25kA$

$P_{out} = 75.0 \text{ MW}$

$I^*W=30kA$

$P_{out} = 70.7 \text{ MW}$
Design of the XBPPM-1

- Design of XBPPM-1 is in progress
  - Gun design in collaboration with Toshiba, BINP and PAL using EGUN, DGUN and MAGIC.
  - Study of PPM configuration for a larger magnetic field and for easier manufacturing
    - Longer pitch near the output cavity?
    - Periodic magnet still at the output cavity?
  - Measurement method of magnetic field
  - PPM manufacturing study with Toshiba and a magnet company (about to start).
  - Study of clam shell in collaboration with BINP

- We are aiming at fishing of design by the end of March 1999.
Both at the BINP PPM and XP-1, the RF instability is the limiting factor for the maximum power and the pulse length.

We started the study of RF instability using the MAGIC3D and HFSS codes in October 1998.

- Focusing to the beam behavior at the output cavity
- Identifying deflection modes using MAGIC and HFSS
- Investigating the threshold RF current at the frequency of deflecting mode to cause a significant build-up of HOM power during a given pulse length.