Linac4 Drift Tube Linac
LIU Day 2014

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Linac4 DTL – RF Design

- Introduction
  - Design Parameters & Constraints
  - Production Design
  - Mechanical Concept
- Manufacturing and Assembly
  - Manufacturing in Industry and at CERN
  - Quality Issues
  - Current Status
- Results of Tank1
  - Quadrupole Positioning
  - Field flatness
- Conclusions
Linac4 Drift Tube Linac
DTL design parameters:

- DTL from 3 – 50 MeV with 3 cavities and 1 LEP and 2 new klystrons
- Klystron output power at cavity port 1 MW (Tank1) and 2 MW (Tank2&3)
- Accelerating field at ~3.2 MV/m
- Peak electric field of 1.6 Kilpatrick lowered to 1.2 Kilp. over the first cells
- PMQs in vacuum
- Self supporting steel cylinders of 50 mm thickness
- Maximum segment length of 2 m
Linac4 DTL Design

Production design:

- RF design compatible with mechanical realization

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Cavity</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cells per cavity</td>
<td></td>
<td>39</td>
<td>42</td>
<td>30</td>
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<tr>
<td>Accelerating field</td>
<td></td>
<td>3.1 MV/m</td>
<td>3.3 MV/m</td>
<td>3.3 MV/m</td>
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<td>Maximum surface field</td>
<td></td>
<td>1.5 Kilp.</td>
<td>1.4 Kilp.</td>
<td>1.45 Kilp.</td>
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<tr>
<td>Synchronous phase</td>
<td></td>
<td>-35 to -24 deg</td>
<td>-24 deg</td>
<td>-24 deg</td>
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<tr>
<td>RF peak power per cavity</td>
<td></td>
<td>1.00 MW</td>
<td>2.03 MW</td>
<td>1.98 MW</td>
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<tr>
<td>Quadrupole length</td>
<td></td>
<td>45 mm</td>
<td>80 mm</td>
<td>80 mm</td>
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<tr>
<td>Flat Size</td>
<td></td>
<td>11 mm</td>
<td>7 mm</td>
<td>5 mm</td>
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<tr>
<td>Number of sections</td>
<td></td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Length per cavity</td>
<td></td>
<td>3.8958 m</td>
<td>7.3406 m</td>
<td>7.2508 m</td>
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<tr>
<td>Beam output power</td>
<td></td>
<td>11.88 MeV</td>
<td>31.45 MeV</td>
<td>50.14 MeV</td>
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</tbody>
</table>
Linac4 DTL Mechanical Design

Linac4 Drift Tube Linac Mechanical Design:

Make it as straightforward as possible:

- Mechanical Design without position adjustment of Drift Tubes
- Single Helicoflex gaskets for vacuum and RF sealing
- Coaxial water cooling in Drift Tubes
- No wires in Drift Tubes: PMQs, no instrumentation, thermal probes at top
- Rigid steel support structure, w/o welds (almost), soft Aluminium girders

Consequence:

- Precision Machining required, and tight Quality Control
“Adjust and Assemble”

- Pre-stress cylinder
- Belleville washers
- Horizontal and vertical positioning
- Cooling water out
- Thermo-probe and Leak test channel
- Cooling water in
- Leak test seal
- Vacuum seal
- Screw
- Bushing
- Base plate
Linac4 DTL Manufacturing
Linac4 Drift Tube Linac Manufacturing:

- Girder manufacturing at CADINOX, Veenstra Glazenborg & CERN
- Retendering to Mancisidor and GoiAlde, Spain → Completed June 2013
- Drift tube component machining, DMP, Spain → Completed January 2013
- Drift tube assembly, CERN → Completed November 2013
- Tank manufacturing at CADINOX, Spain → Completed February 2014
- Tank plating, CERN → 5 Segments Completed, 1 Ongoing, 4 Waiting
- Tank assembly, CERN → Tank1 Completed, Tank3 Ongoing
Tank manufacturing:

- Order started November 2010
- Manufacturing of 1 pre-series segment T1S1 completed October 2011
  - Pre-series segment fully in specification
- Machining error on deep drilled cooling channels found March 2012
Cooling channel repair

Crash program:

- Definition of analysis procedure by ultrasound
- Analysis of all segments: 9 segments out of tolerances, 2 to be repaired
- Definition of repair with inserts
- Successful test on sample pieces at manufacturer
- Ordering of dedicated machining tool
- Machining of defined channel opening
- Failed repair on tank segments at manufacturer
- Remachining of defined channel opening
- Successful repair at CERN – T3S3 sent back, T1S2 at CERN (May 2013)

Other issues:

- Other leaks (water to air) plugged
- Re-machining of segments out of tolerances
- Non-connected cooling channel
Linac4 DTL Tank Status

Tank status:
- T1S1 & T1S2 assembled and joined as Tank1 – in completion
- T3S1, T3S2 & T3S4 assembled
- T3S3 under copper plating
- T2S1-S4 at CERN

Current tasks:
- Verifications and completion of Tank1
- Copper plating of remaining segments in competition with LS1
- Assembly of segments of Tank3
- Manufacturing of wave-guide couplers & movable tuners
Linac4 DTL Tank1 Results
Linac4 DTL Tank1 Results

Quadrupole positioning: Horizontal / Longitudinal / Vertical

X avg horiz. mm
Y avg long. mm
Z avg vert mm
Tuning: E0 variation within +/- 1.35%
Conclusions:

- The Linac4 Drift Tube Linac is a prototype
- Manufacturing requires tight quality control
- Considerable quality issues have been overcome
- Almost all major components have been completed
- Last manufacturing stages are in competition with LS1
- The Drift Tube Linac is a puzzle of a thousand pieces
- Final assembly is on its way