Report of working group 5

- Materials
- Cavity design
- Cavity Fabrication
- Preparatioin & Testing
- Power coupler
- HOM coupler
- Beam line absorber
- Tuner
- Fundamental R&D items
- Most important R&D items
- 500 GeV parameters
- 1 TeV parameters

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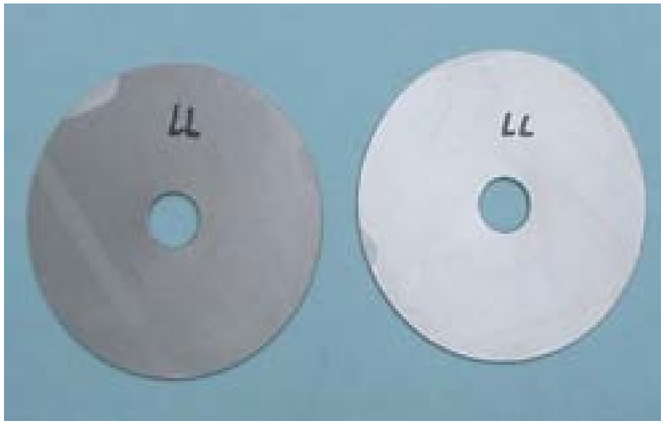
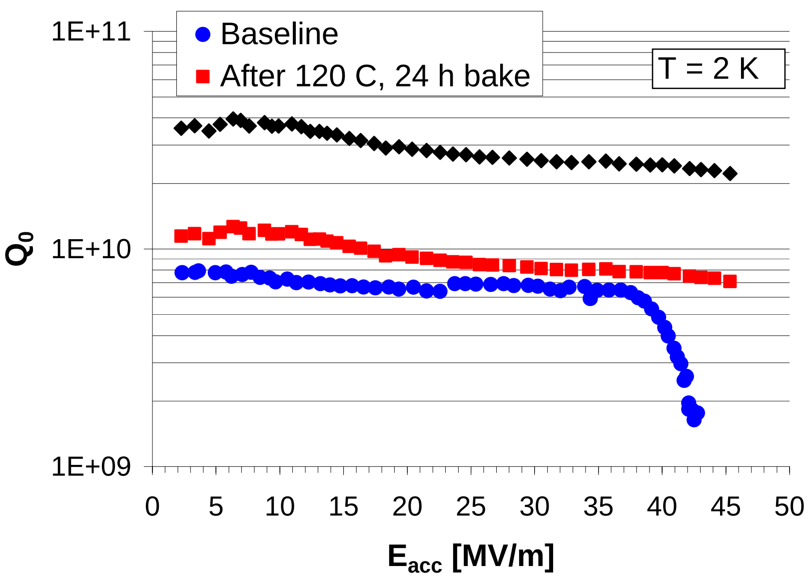
Materials

- BCD: Fine grain Nb, RRR ≥ 300
- ACD: Large grain/ single crystal ≥ 300
  - Adavantage:
    - Reduced costs
    - Improved performance
    - One most promising improvement to BCD-ILC
- ACD: NB/Cu clad material, RRR ≥ 300
  - Advantage
    - Nb cost reduction
  - Required R&D:
    - Extend positive experience to 9-cell cavity

Large grain / single crystal Nb material

Nb Discs





$E_{peak}/E_{acc} = 2.072$

$H_{peak}/E_{acc} = 3.56$ mT/MV/m

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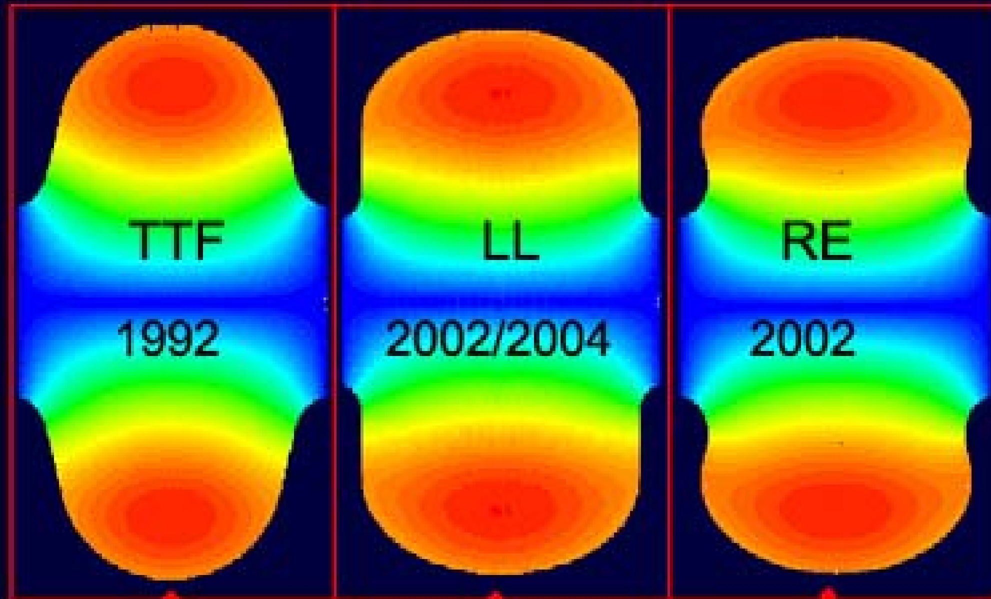
Cavity design

- **BCD: TESLA Cavity**
  - Potential modification
    - Stiffening end plates to reduce Lorentz force detuning
- **ACD: Low Loss LL, reentrant RE**
  - Advantage
    - Reduced mag. surface field => higher gradient
    - Reduced cryo load
  - Required R&D
    - Multi-cell demonstration
- **ACD: superstructure**
  - Advantage
    - Cost saving: fill factor, only ½ number of couplers
  - Required R&D
    - Superconducting seal

Example: 1.3 GHz inner cells for TESLA and ILC



r_{irisb}	[mm]	35	30	33	
k_{cc}	[%]	1.9	1.52	1.8	field flatness
E_{peak}/E_{acc}	-	1.98	2.36	2.21	max gradient (E limit)
B_{peak}/E_{acc}	[mT/(MV/m)]	4.15	3.61	3.76	max gradient (B limit)
R/Q	[Ω]	113.8	133.7	126.8	stored energy
G	[Ω]	271	284	277	dissipation
R/Q*G	[Ω*Ω]	30840	37970	35123	dissipation (Cryo limit)

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Cavity fabrication

- **BCD: Standard fabrication (sheet material, EB welding)**
  - Potential modifications
    - Alternative end group fabrication for cost saving
- **ACD: Spinning, Hydro forming of bulk Nb**
  - Advantage
    - Cost impact in fabrication
  - Required R&D
    - Extend positive experience to 9-cell cavity
- **ACD: Spinning, Hydro forming of Nb-Cu clad**
  - Advantage
    - Cost impact: fabrication and Nb material
  - Required R&D
    - Extend positive experience to 9-cell cavity
  - Risk
    - Flux trap after quench, increased RF loss

Standard cavity fabrication

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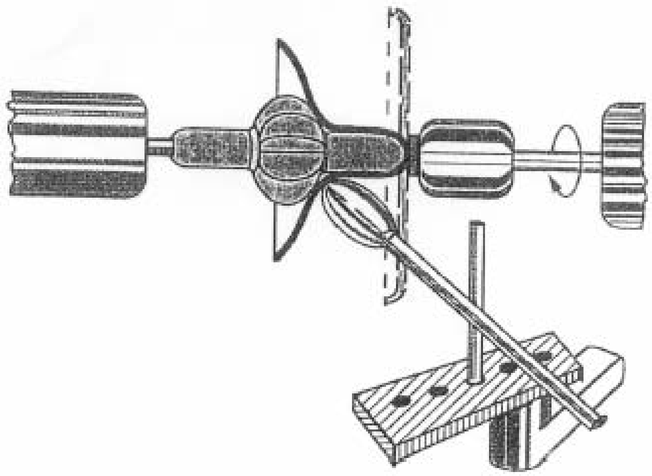
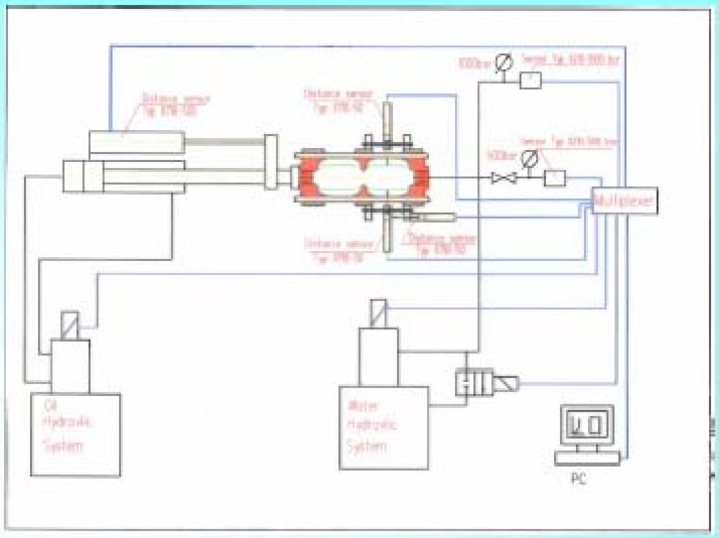
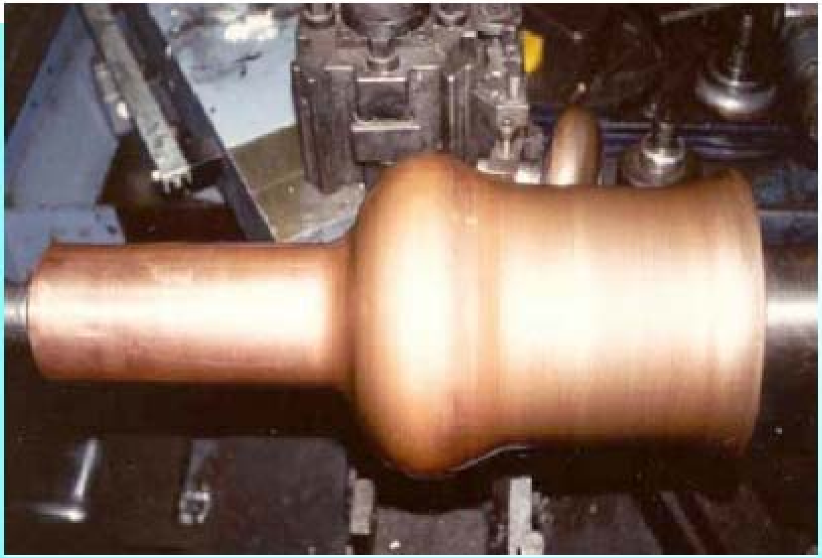
Spinning (V.Palmieri,INFN Legnaro)

Hydroforming, DESY, KEK







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Preparation & Testing

- **BCD:** Approved sequence of EP, 800°C heat treatment, final EP, High pressure water rinsing (HPR), in situ bake at 120°C
- **ACD:** Substitute first EP by grinding +light EP
  - Advantage
    - Cost & easy smoothening of surface
- **ACD:** Substitute in situ bake by air bake in clean room
  - Advantage
    - Simplified procedure
- **ACD**: Substitute HPR by dry ice cleaning
  - Advantage
    - No water contamination
    - Option of horizontal cleaning
  - Required R&D:
    - Encourage ongoing effort at DESY
- **ACD:** Substitute HPR by megasonic cleaning
  - Advantage
    - Shorter processing time
    - Promise of higher cleaning force than HPR
  - Required R&D
    - Establish uniform ultrasonic action on all inner surfaces

DESY EP

KEK / Nomura EP

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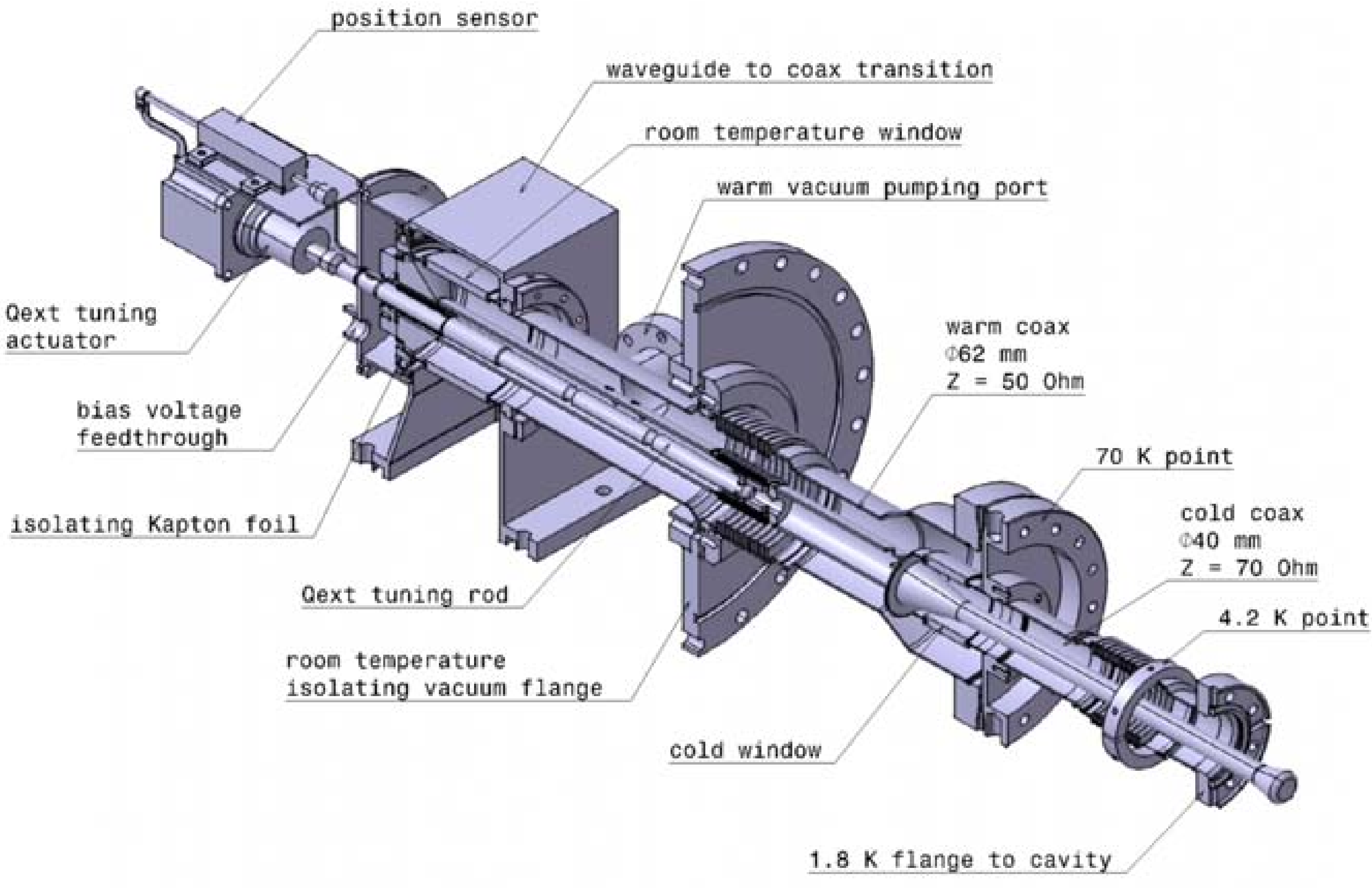
Power coupler

- BCD: TTF 3 type
- ACD: Increased RF power capability TTF3
- ACD: Capacitive or Tristan design, KEK
  - Advantage
    - Simple mechanic design
    - Easy fabrication
    - Cost impact
  - Required R&D
    - Demonstration of performance

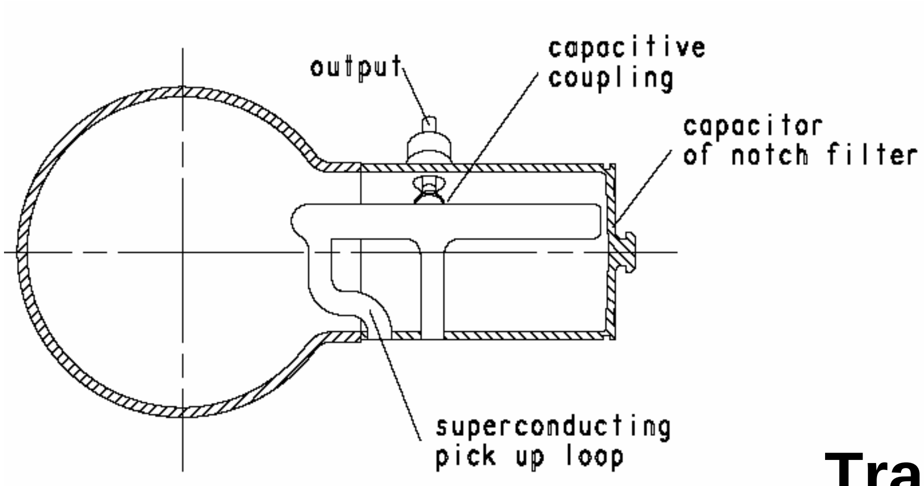
X-FEL coupler



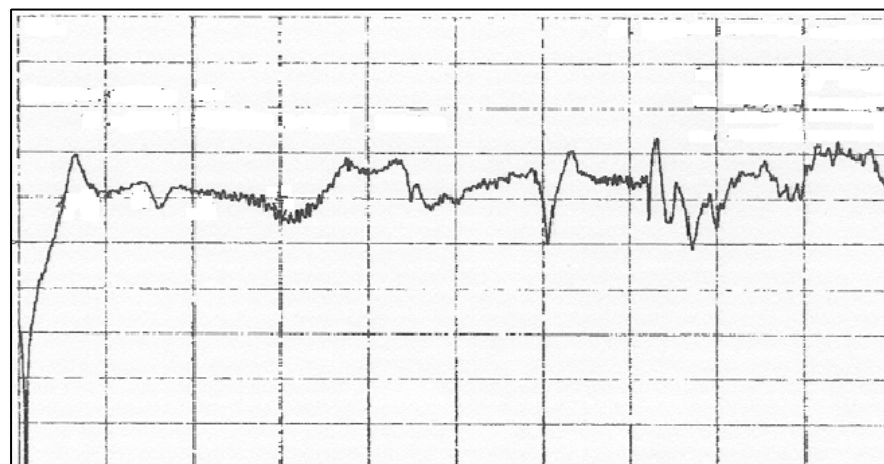
HOM coupler

- BCD: Tesla type
- ACD: Modified Tesla Type (loop, capacitor modification)
  - Advantage
    - Simpler RF and mechanics design
    - Cost impact
  - Required R&D
    - Demonstration of performance with beam
- ACD: Beam line coaxial coupler
  - Advantage
    - Easy fabrication
    - Cost impact
  - Required R&D
    - RF bench tests
    - Performance test with beam

TESLA type HOM coupler



Transfere function of coupler



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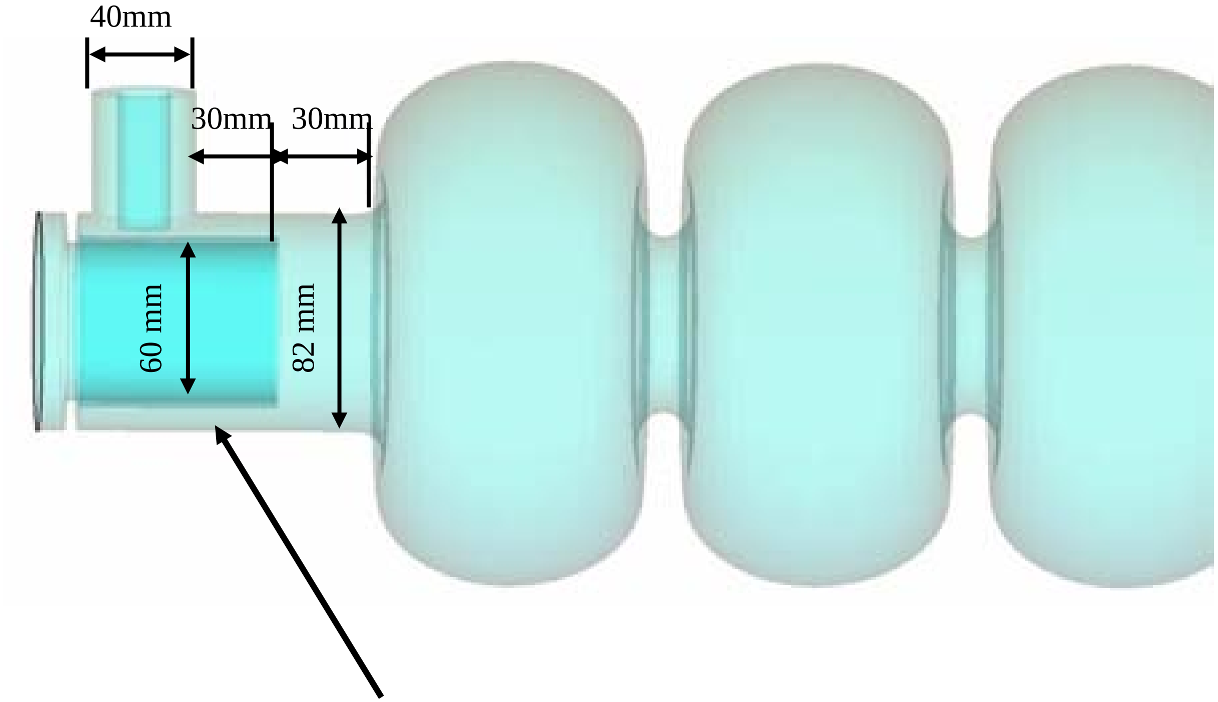
New idea for Fundamental / HOM couplers



Inner coax

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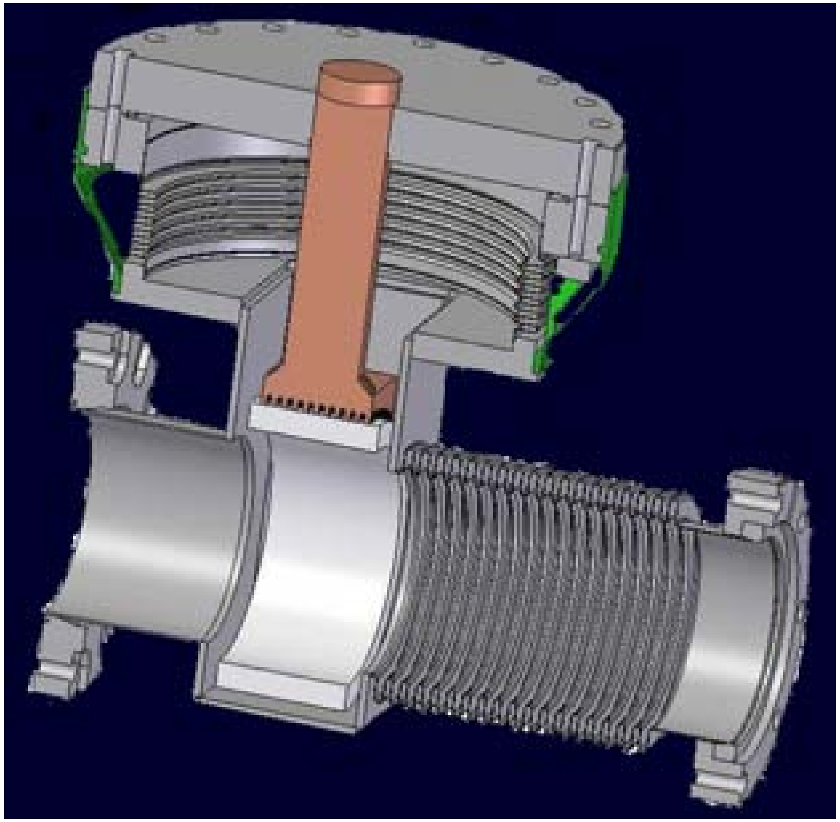
Beam line Absorber

- BCD: not avaliable
- Near to BCD: DESY prototype
  - Required R&D
    - Finish RF bench tests
    - Conduct cold tests
    - Proof of function with beam

Prototype of beamline absorber



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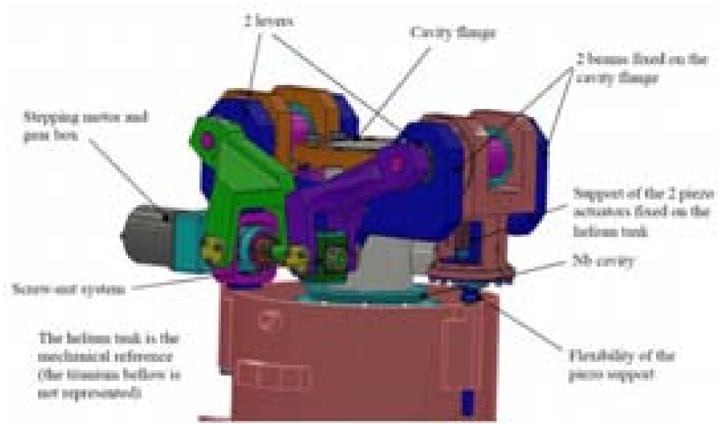
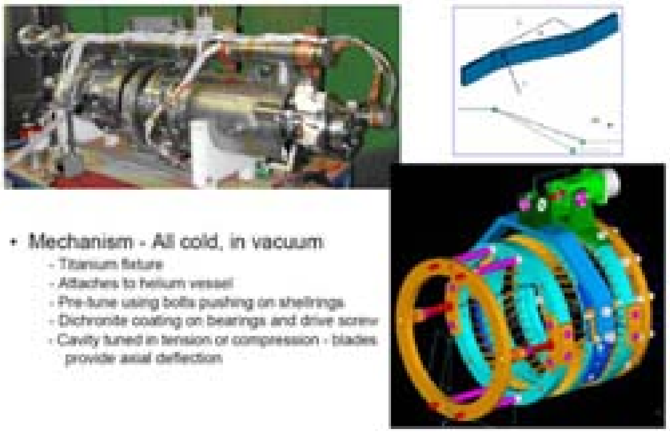
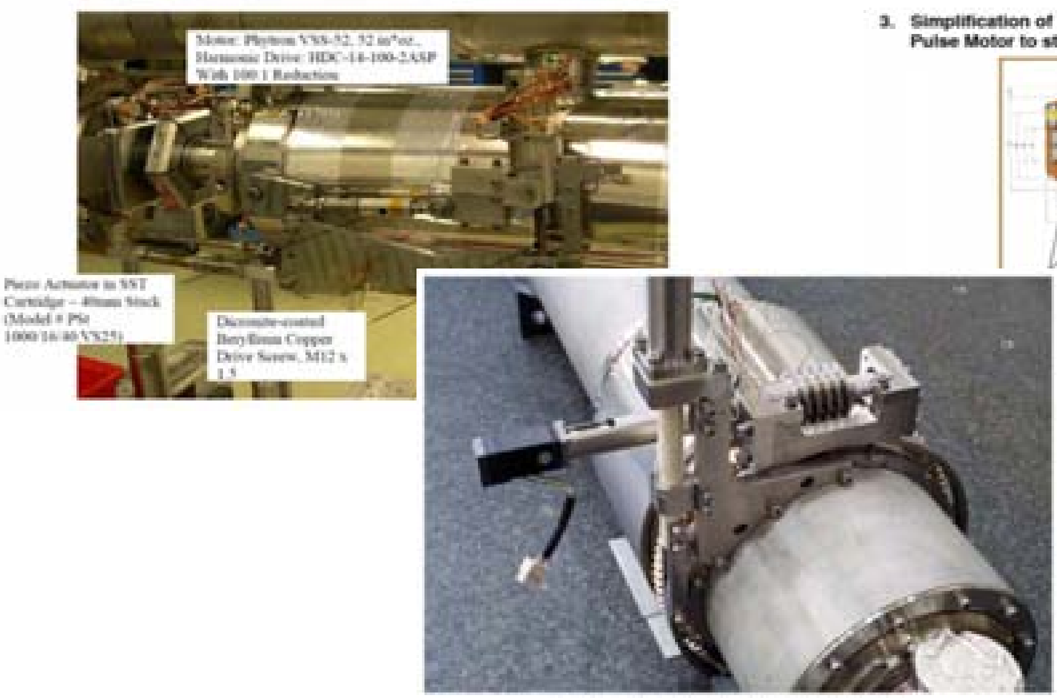
Tuner

- BCD: not available
- Near to BCD: Blade type, Saclay type; but fast tuner needs certification
  - Cold operation demonstrated
  - But: integration of fast tuner is missing
  - But: reliability issue of motor, pieco & mechanics not resolved (cold vs. warm location)
- Possible alternatives
  - KEK slide jack / coaxial ball tuners
  - Both at the stage of prototyping

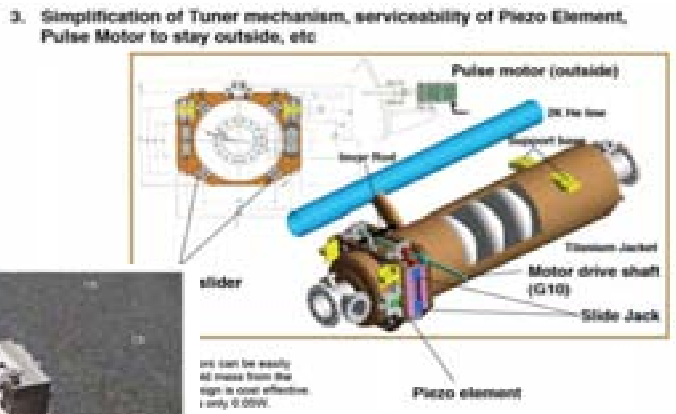
Tuner Options







Detail of slow and fast tuning mechanism



Fundamental R&D items

- What is the RF critical field
- What is the physics of „Q-drop“
- How does the surface condition/oxidation influence cavity performance

Most important technical R&D items

- **Reduction of field emission, multipacting**
- **Reduction of Scatter of cavity performance**
- New cavity shapes
- Tuner
- Beam line absorber
- Superconducting seal

Cavity Performance

- Theoretical RF magnetic limit:
  - Tesla shape: 41 MV/m
  - LL,RE shape: 47 MV/m
- Present practical limit in multi-cell cavities -10%
  - TESLA shape. 37 MV/m
  - LL, RE shape: 42.3 MV/m
- Lower end of present fabrication scatter (σ = 5%)
  - TESLA shape: 35 MV/m
  - LL, RE shape: 40 MV/m
- Operations margin -10 %
  - TESLA shape: 31.5 MV/m
  - LL, RE shape: 36 MV/m

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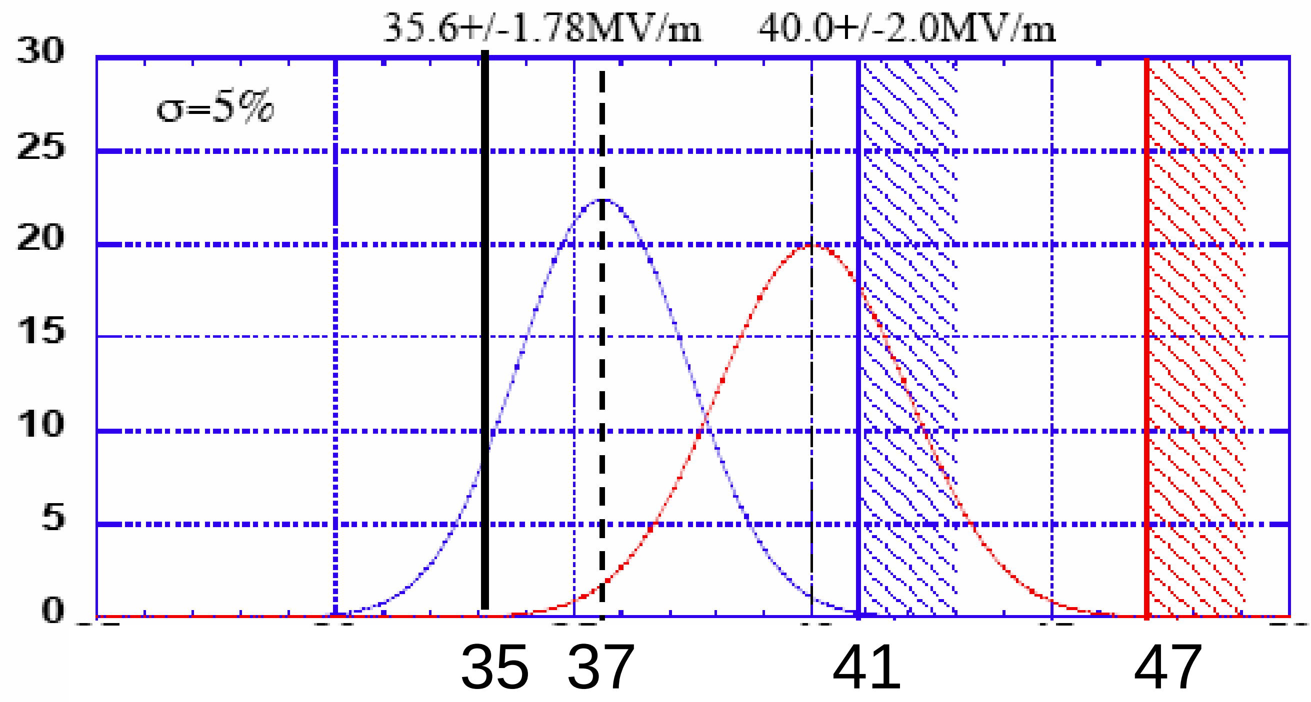
Assume cavities can reach avg of 90% of limit with 5%rms in Vert dewar (The plot distributions show 85%)

Most Tesla cavities should be able to reach 35MV/m accept
Most LL/RE cavities should be able to reach 40 MV/m accept
But note there is a low energy tail that fails



500 GeV: Gradient and Q

Based on BCD cavity shape (TESLA cavity)

- BCD: Linac operating performance

  Eacc = **31,5** MV/m; Q = **$1x10^{10}$**

- BCD: Installed performance

  Eacc ≥ **35** MV/m; Q ≥ **$0.8x10^{10}$**

  – Required R&D
    - Reduction of field emission and multipacting
    - Reduction of scatter of cavity performance

500 GeV: Gradient and Q

Based on ACD cavity shape (LL, RE)

- ACD: Linac operating performance

  $E_{acc} = 36$ MV/m; $Q = 1 \times 10^{10}$

- ACD: Installed performance

  $E_{acc} \geq 40$ MV/m; $Q \geq 0.8 \times 10^{10}$

  - Required R&D
    - Reduction of field emission and multipacting
    - Reduction of scatter of cavity performance

1 TeV upgrade: Gradient and Q
second half of linac

Based on cavity shape (LL, RE)

- BCD: Linac operating performance

  Eacc = 36 MV/m; Q = 1×10^{10}

- BCD: Installed performance

  Eacc ≥ 40 MV/m; Q ≥ 0.8×10^{10}

  – Required R&D
    - Reduction of field emission and multipacting
    - Reduction of scatter of cavity performance

Ultimate Dreams

- Single crystal Nb material
- Low loss (LL) & Re-entrant(RE) shape
- Superstructure

- Reproducible cavity performance
- Gradients near critical superconducting field
- High performance of auxiliaries