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bmb+f - Förderschwerpunkt

Astroteilchenphysik

Großgeräte der physikalischen  
Grundlagenforschung

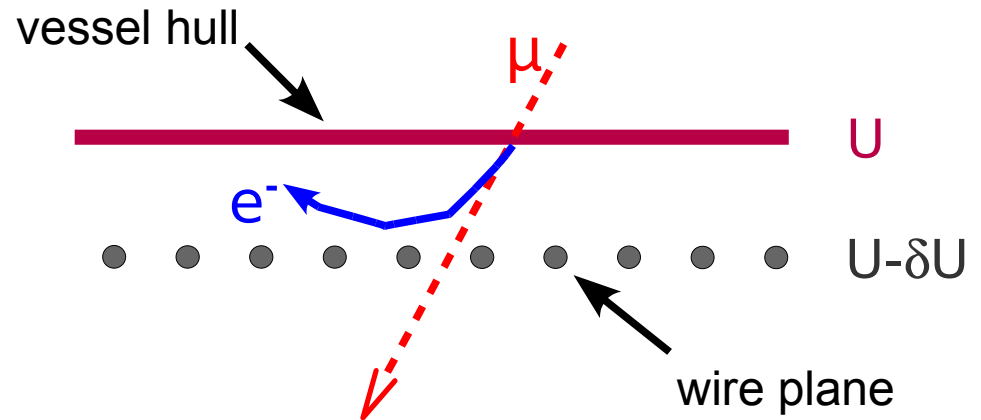
# The wire electrode system of the KATRIN experiment

V.M. Hannen for the KATRIN collaboration

Institut für Kernphysik,  
Westfälische Wilhelms-Universität Münster

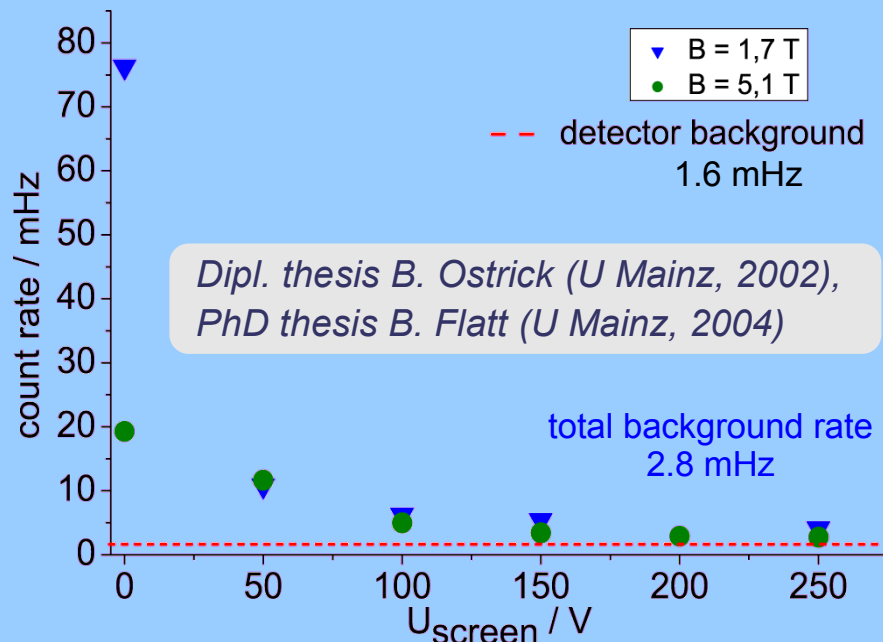
<http://www.weltderphysik.de/gebiet/teilchen/bausteine/neutrinos/experimente/katrin/>

- Cosmics and radioactive contamination produce secondary electrons that can mimic  $e^-$  in endpoint energy region
- 650 m<sup>2</sup> surface of main spectrometer  
→ ca.  $10^5 \mu / s$  + contamination
- Reduction due to B-field: factor  $10^5$ - $10^6$
- Real signal rate in the mHz region
- Additional reduction necessary !

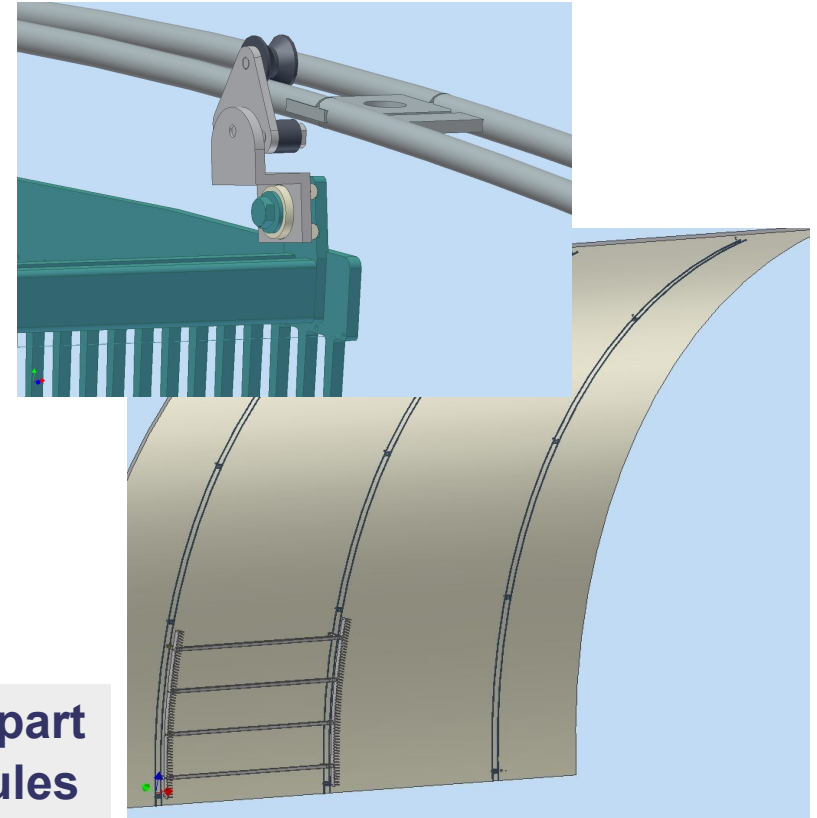
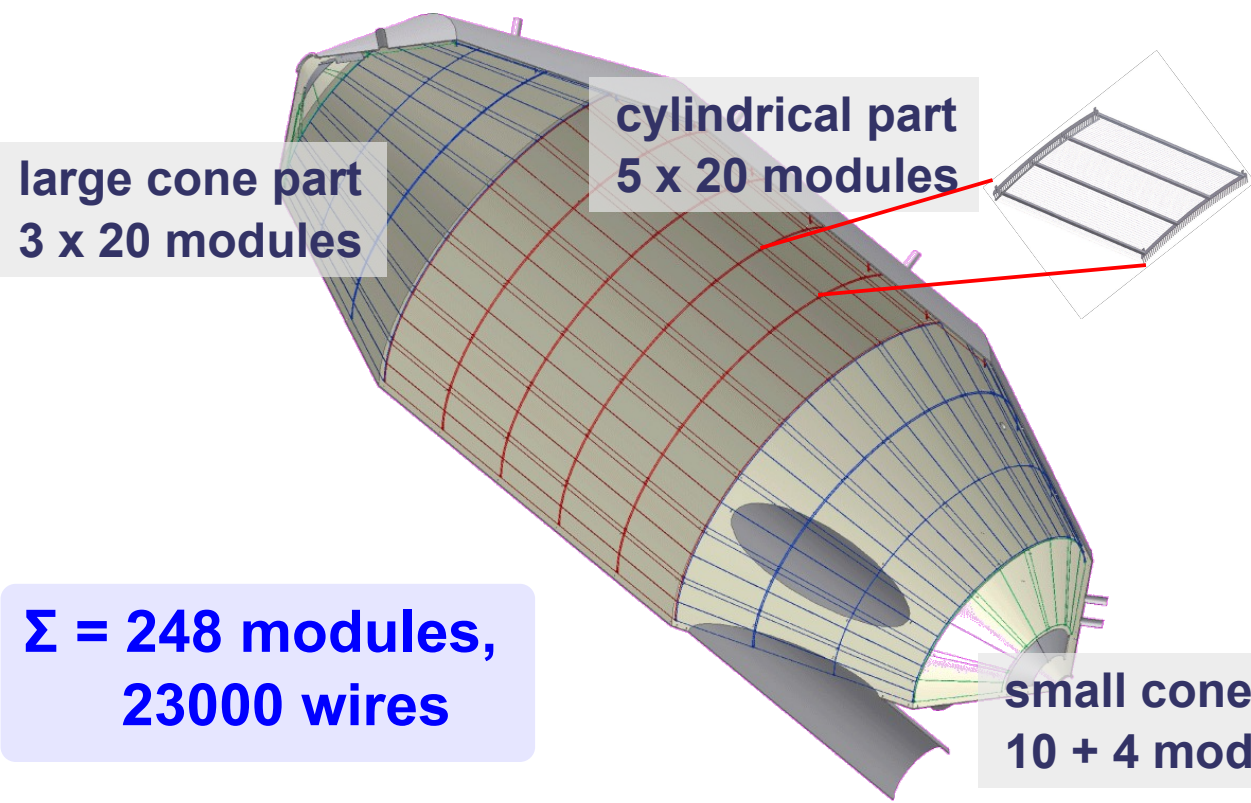
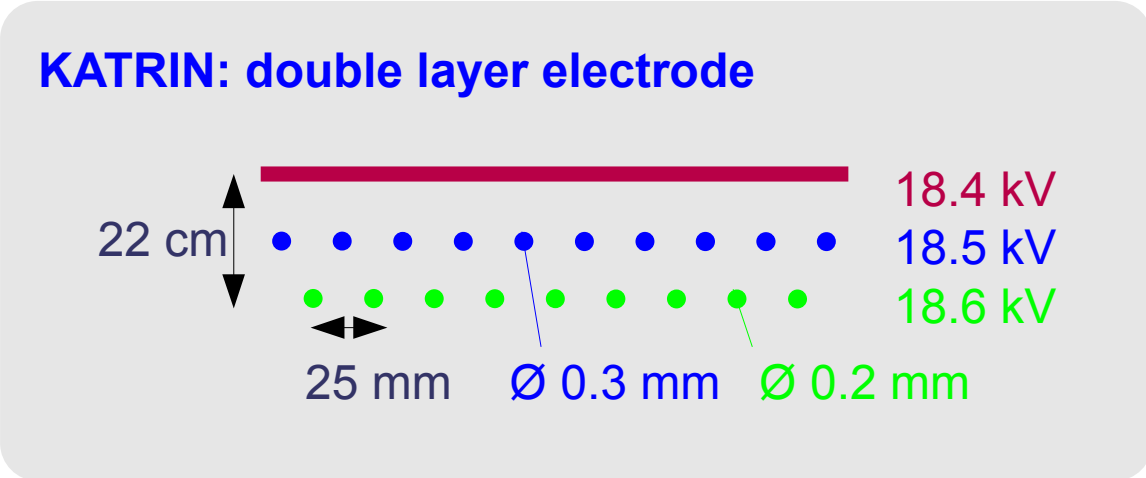
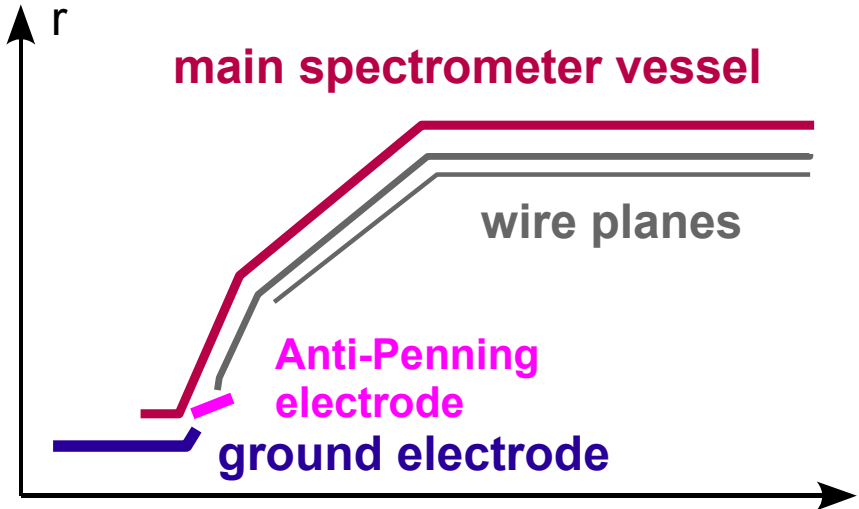


## Inner wire electrode

- screening of background electrons from vessel material by a wire grid on negative potential
- The grid has to be 'massless' to avoid background from the grid itself
- proof of concept at the Mainz setup  
→ reduced background by factor **10**
- improved two layer design of KATRIN electrode → expect reduction factor  $\leq 100$
- Shaping of the spectrometer electric field



# Wire electrode: modular design



## Module components (for central part):

- 2 stainless steel combs
- 4 C-shaped rods
- 2 x 60 wires per module
- 240 ceramics for wire fixation

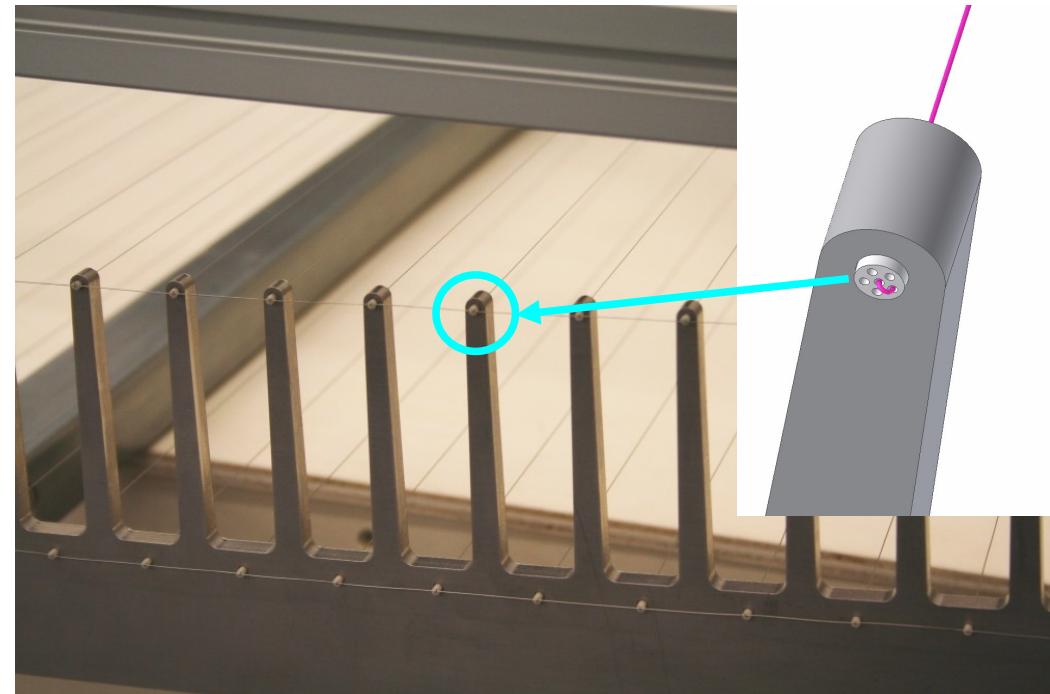


## Overall numbers:

- Total module surface: 440 m<sup>2</sup>
- Total wire surface: 0.015 m<sup>2</sup>
- Total ceramic surface: 3.65 m<sup>2</sup>
- Total weight: 4.2 tons

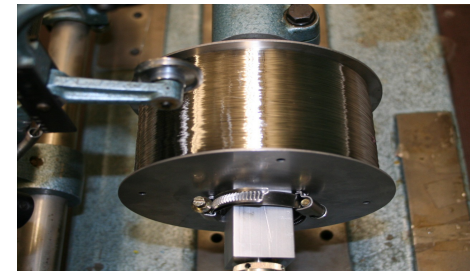
Including HV connections and rail mounts:  $\geq 130000$  parts

→ complete system needs to be compatible with  $10^{-11}$  mbar UHV and bakeable to 350 °C



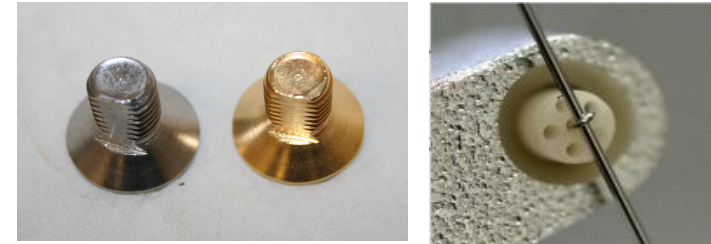
## Requirements:

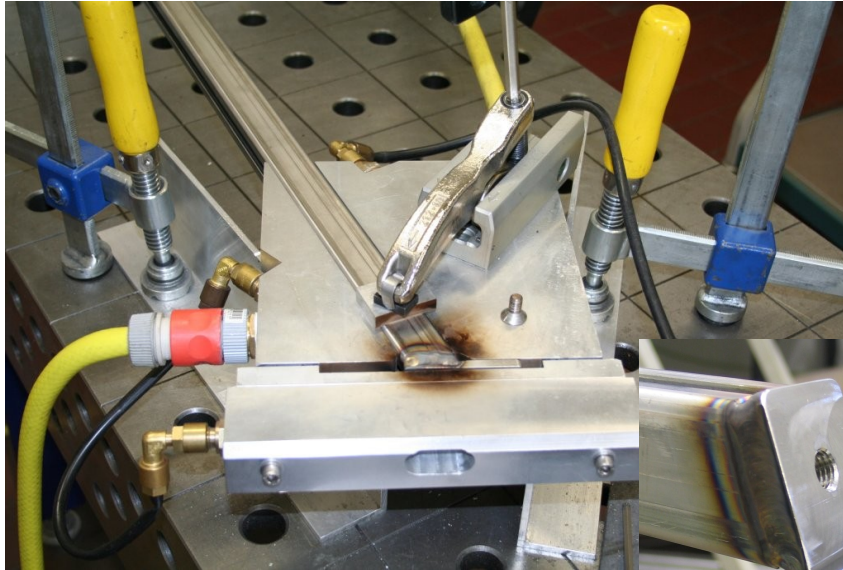
- outgassing rate  $< 1 \times 10^{-12}$  mbar l / s cm<sup>2</sup>
  - magnetic permeability:  $\mu_r \approx 1.02$  (may be relaxed for wire material)
  - low radioactivity (especially for the wire material)
  - wire positioning  $\Delta x = \pm 0.1$  mm; wire sag  $< 0.2$  mm
- many test and screening measurements performed on prototype modules and materials



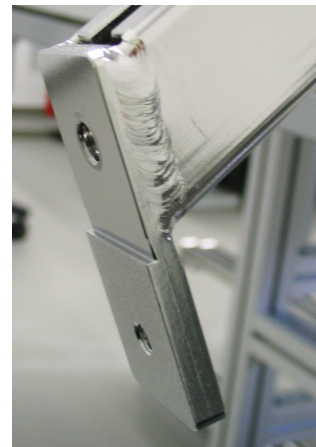
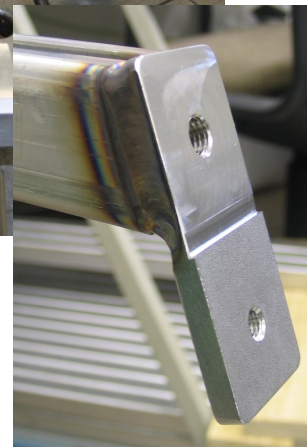
## Materials:

- stainless steel (1.4429, 1.4435, 14404)
- oxygen-free copper, copper-beryllium (CuBe2)
- Inconel (nickel-chromium based alloy), hardened
- Ceramics (FRIATEC AL23, pure Al<sub>2</sub>O<sub>3</sub>)
- Gold-plated stainless steel screws (1.4404)

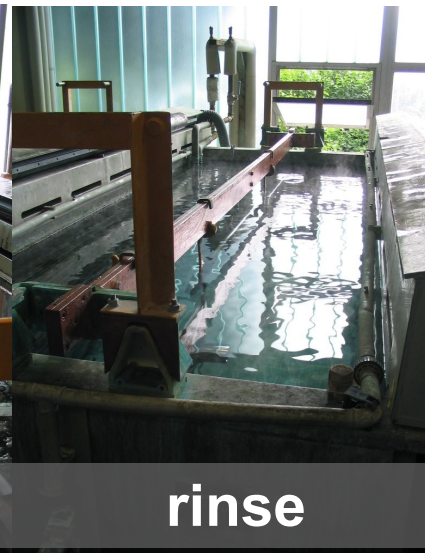
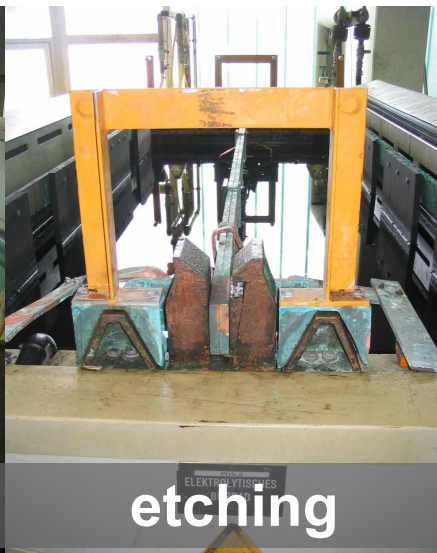




- Parts are welded in custom made cooled aluminum block under inert gas flow on both sides of the weld for UHV compatibility



- Electropolishing of all stainless steel parts at company Mauden
- Electropolishing of other materials (copper) at company Poligrat





- Insets for ultrasonic cleaning of wires

- US bath dimensions 2.0 x 0.4 x 0.3 m<sup>3</sup>
- 2 US generators, each with 1,5 kW
- 4 reservoirs for cleaning agents:
  - Axarel 9100
  - P3 Almeco 36
  - Tickopur
  - ultrapure water (5 MOhm/cm)
- multistage centrifugal pumps
- flow rate of jet nozzles in US bath: ~ 30 l/min
- air filtering system for blow-dryer
- complete LabView computer control of pumps and sensors

## Assembly of modules in class 10000 cleanroom:

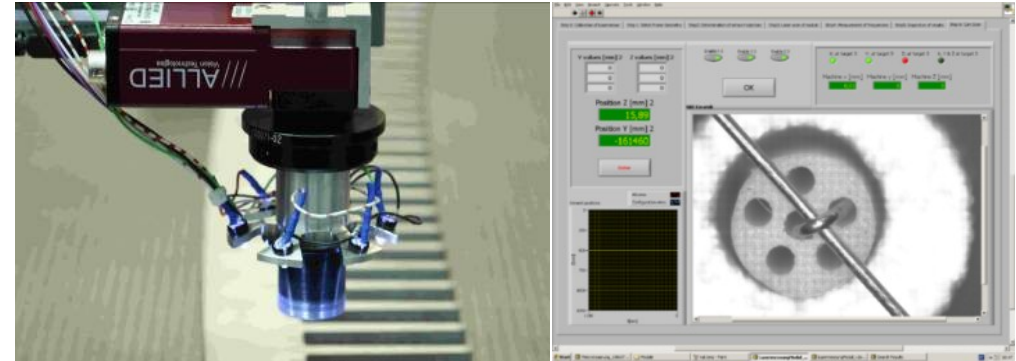
- QA of 'combs': check positions of all drill holes to  $\pm 0.05$  mm
- cut wires under defined load to precise length  $\pm 0.1$  mm
- pre-bending of combs
- mount of first ceramic
- insertion of wires into combs
- mount second ceramic
- insert electrical connection wires
- assembly of module and rods
- stress test of all wires
- QA of finished module



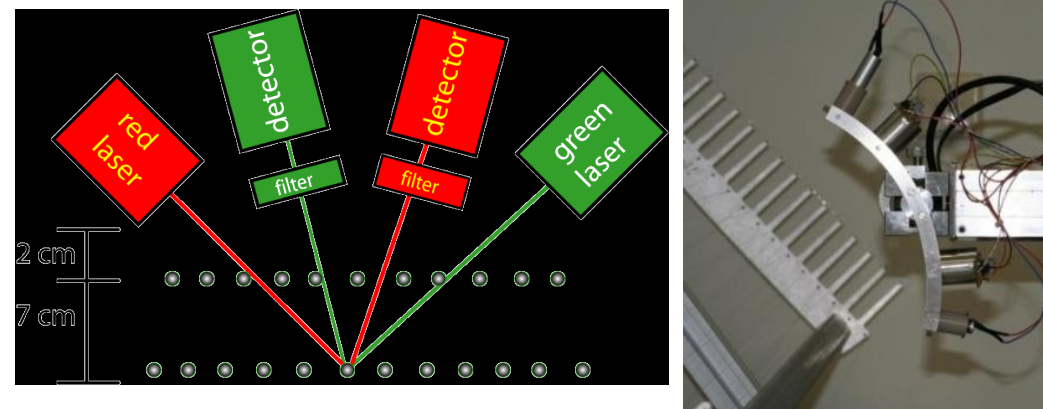


Automated 3D measurement table in clean room with 2 sensor heads:

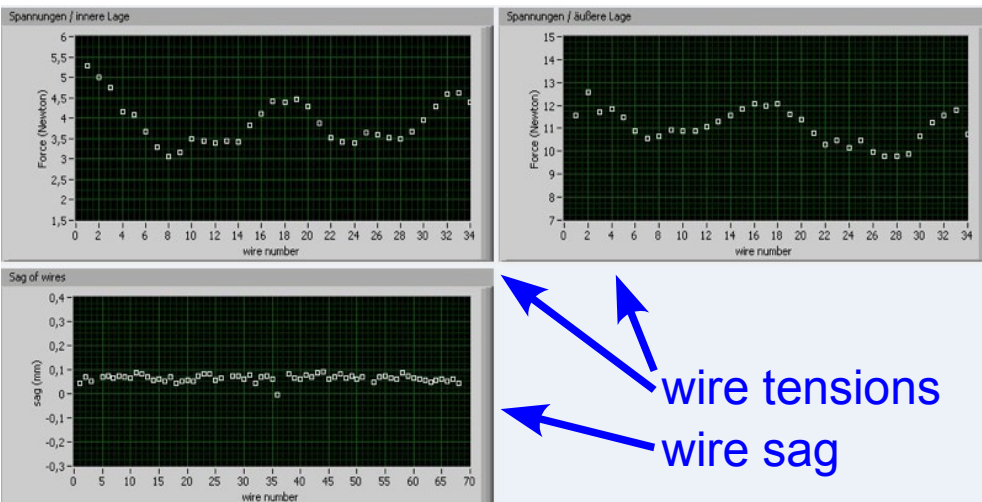
- **Camera:** (hole positions, ceramics)



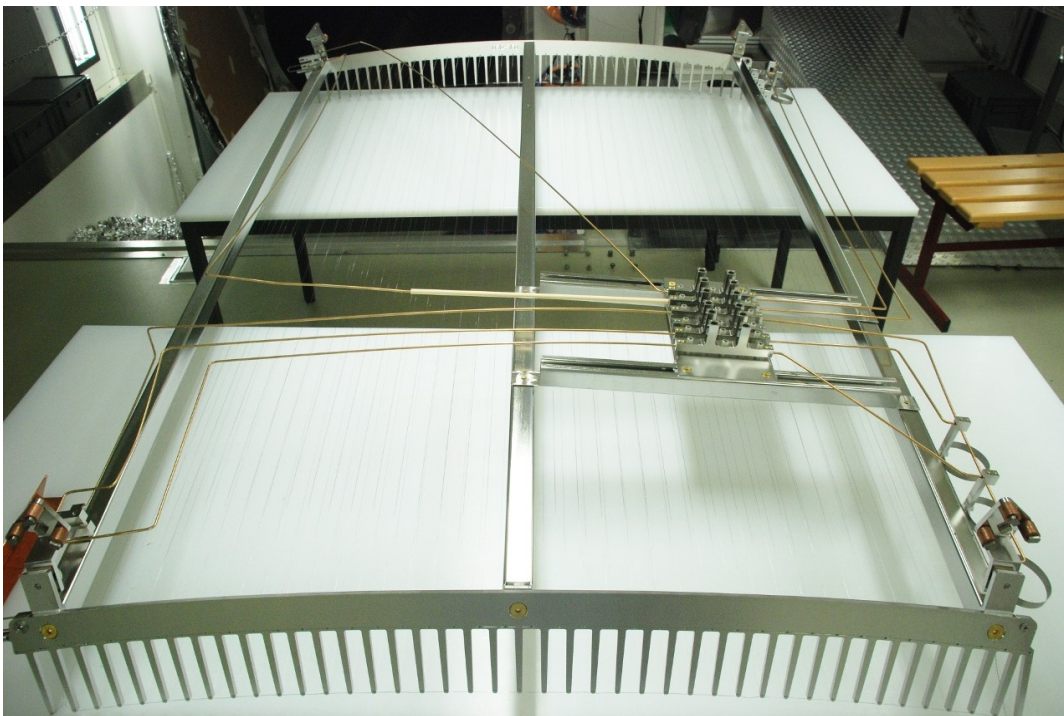
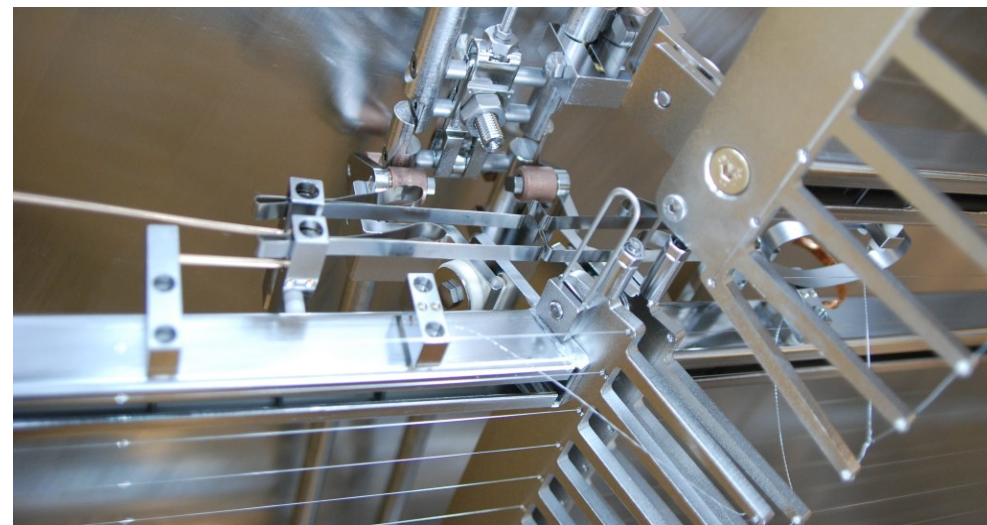
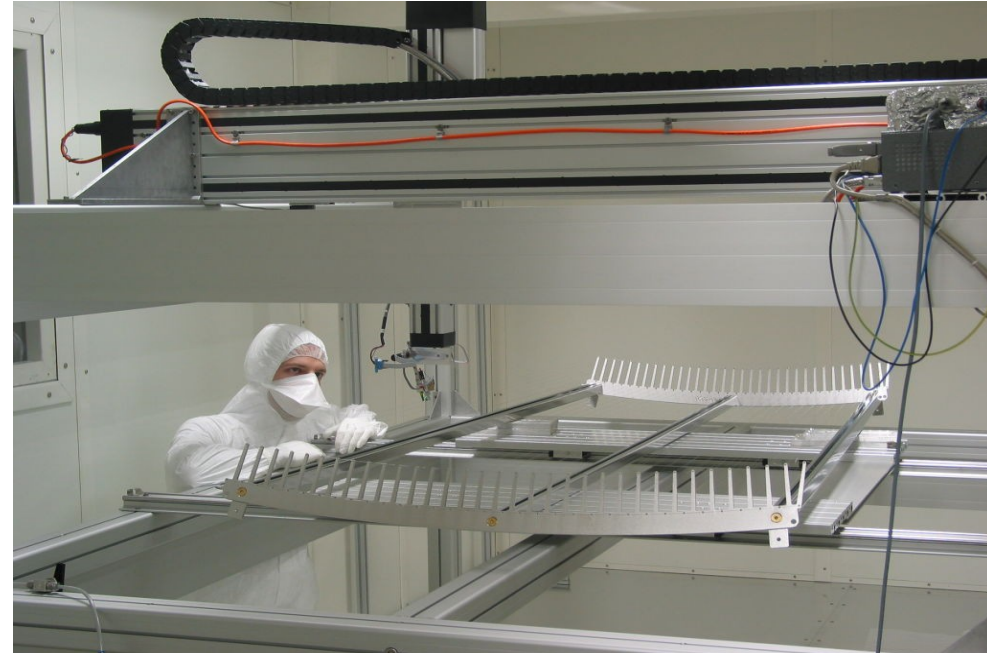
- **Custom laser sensor:**
  - measure wire coordinates to  $\pm 10 \mu\text{m}$
  - measure wire tensions to  $\pm 0.04 \text{ N}$



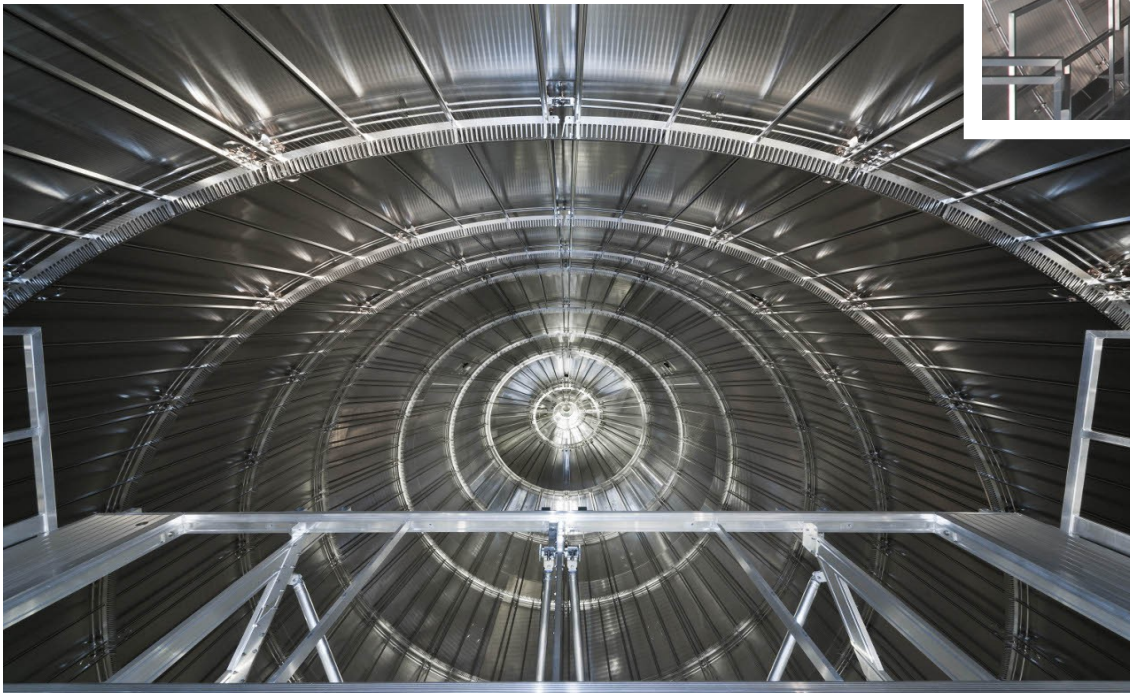
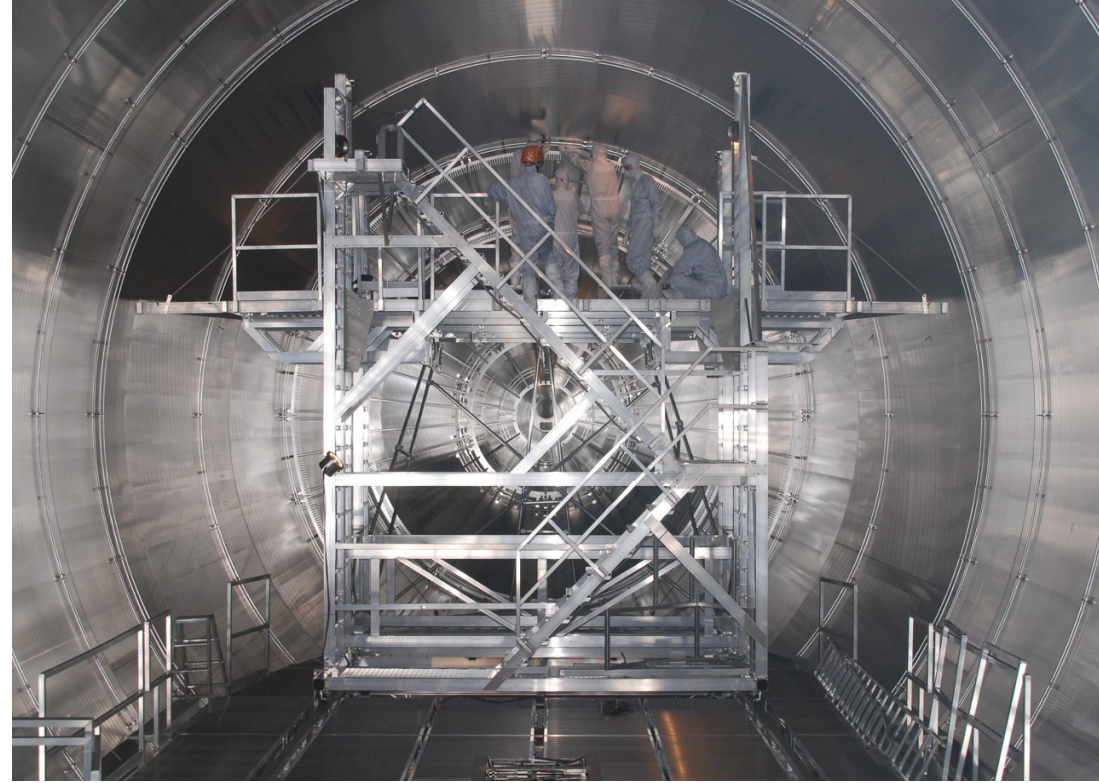
- MySQL database of all geometrical measurements and close up photographs



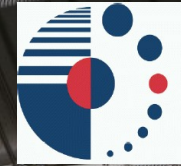
- After transport to KIT the wire modules were re-checked for wire tension (2D measurement table build by FH Fulda, custom laser sensor from Münster)
- Modules are equipped with HV connections
- Special modules get routing platforms to distribute HV lines to module rings
- All actions are documented in QA database



- Installation of electrode modules on rails using a movable intervention system
- lots of work invested to achieve positioning of the modules with the desired accuracy
- regular monitoring of HV lines (resistance measurements)
- bake-out expected for summer '12



# Thanks for your attention !!



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