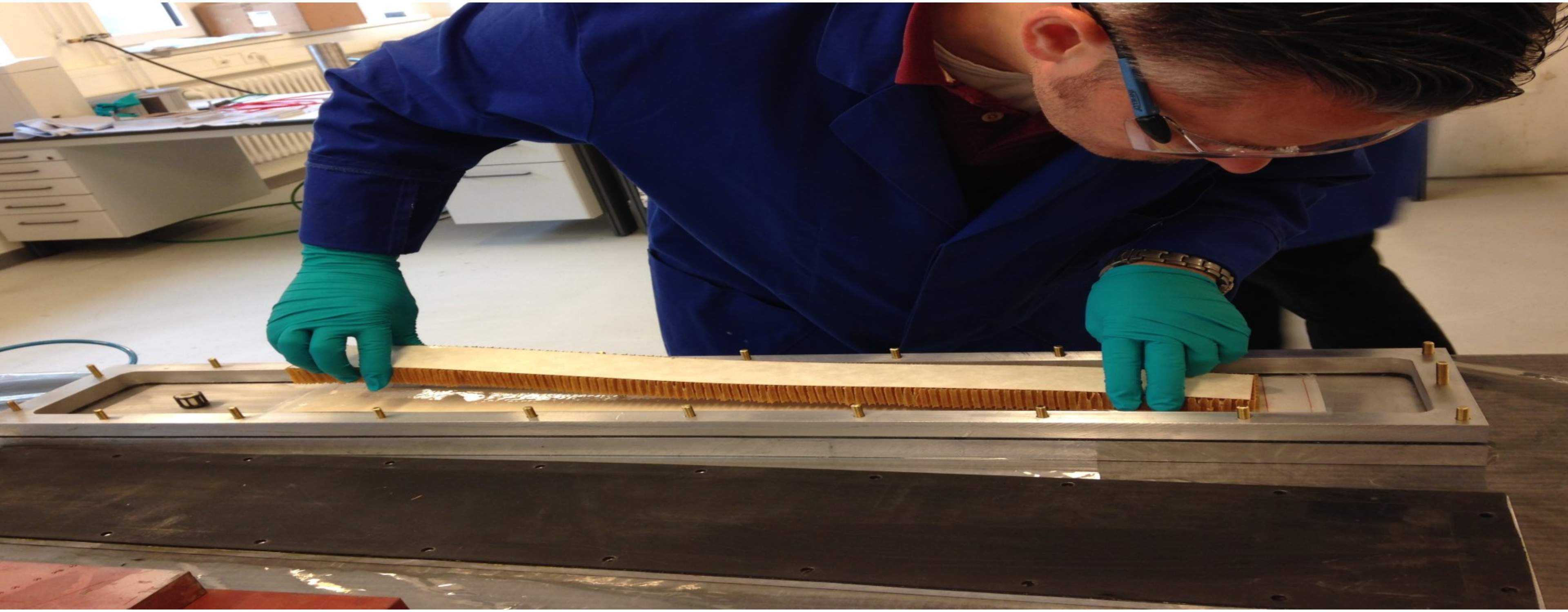
# New field cage LP2



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New field cage LP2
Santander, 31.05.2016

HELMHOLTZ ASSOCIATION



DESY

# Outline

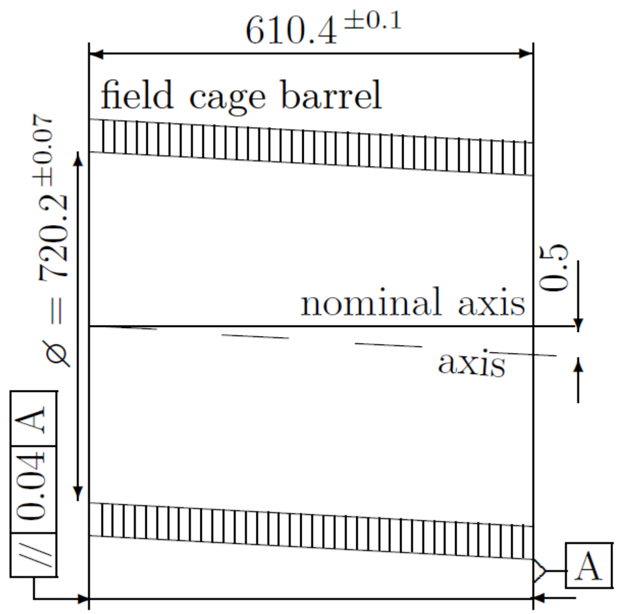
> Improvement of the second field cage
> Material study of screws and inserts
> Glue thickness study
> Bending test
> Material of the end flange
> Mandrel

# Requirements

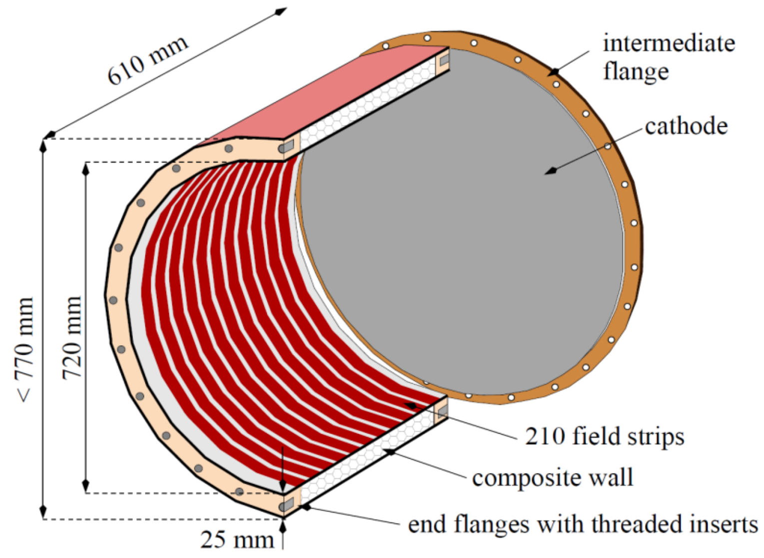
- Very high mechanical precision for field homogeneity
- High stability (self supporting between end caps)
- Very limited material budget
- (radiation length ~ 1%)
- HV stability

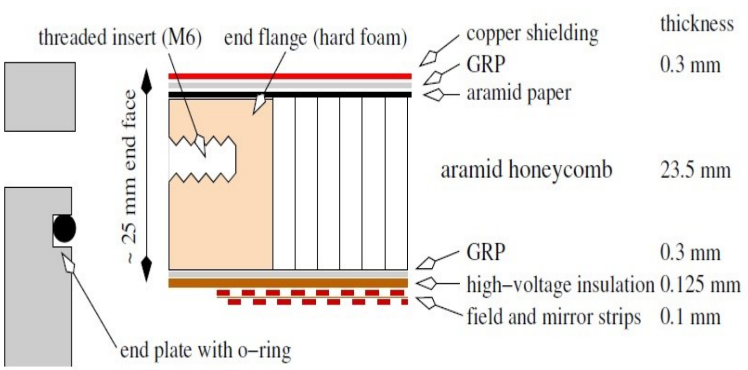
# Improvement of the second field cage

- Field cage with required accuracy
- Gain knowledge and experience of building composite components
- Second field in case of damage the first one
- Material test for TPC



# Improvement of the second field cage




(b) cross-section of the field cage wall and the end flanges

- Wall cross section as before
- One field strip foil available
  - already equipped with resistor chain
- Radiation length of LP1: 1.24%

| Material | Eff. thickness (cm) | $X/X_0$ (%) |
|---|---|---|
| Copper | 0.007 | 0.48 |
| Polyimide | 0.017 | 0.06 |
| Glass fiber | 0.04 | 0.38 |
| Aramid paper | 0.007 | 0.02 |
| Honeycomb | 2.35 | 0.17 |
| Epoxy | $\approx 0.06$ | $\approx 0.17$ |
| | $\sum$ | 1.24 |

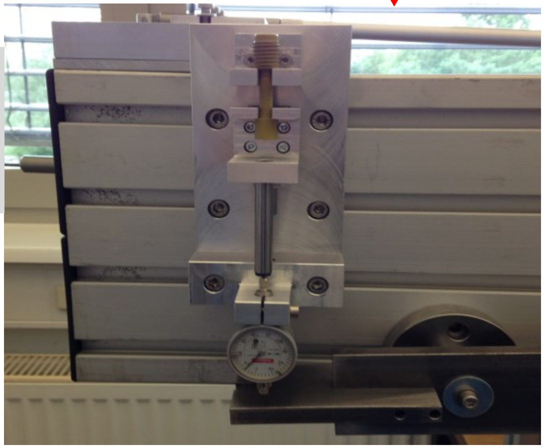
- probably too optimistic
- (epoxy thickness)
- New field cage: outer shielding of aluminum instead of copper foil?
- (shielding capabilities to be tested)

# Material study of screws and inserts

- Idea: replace metal screw inserts and screws
- Two materials selected, Torlon and

  PPS Techtron 1000

  to minimize material budget
- Long term stability > constant force between the
- Field cage and Endplate
- Gluing possible
- Machinable
- Strength test with both material pieces finished
  - 2 kg force are applied in LP
  - At 25 kg: negligible lengthening
  - Tested up to 50 kg (creep behavior)
- Conclusion: both materials fulfils requirements

Tensile test setup of screw and insert shown Torlon screws

Screws made out of Torlon



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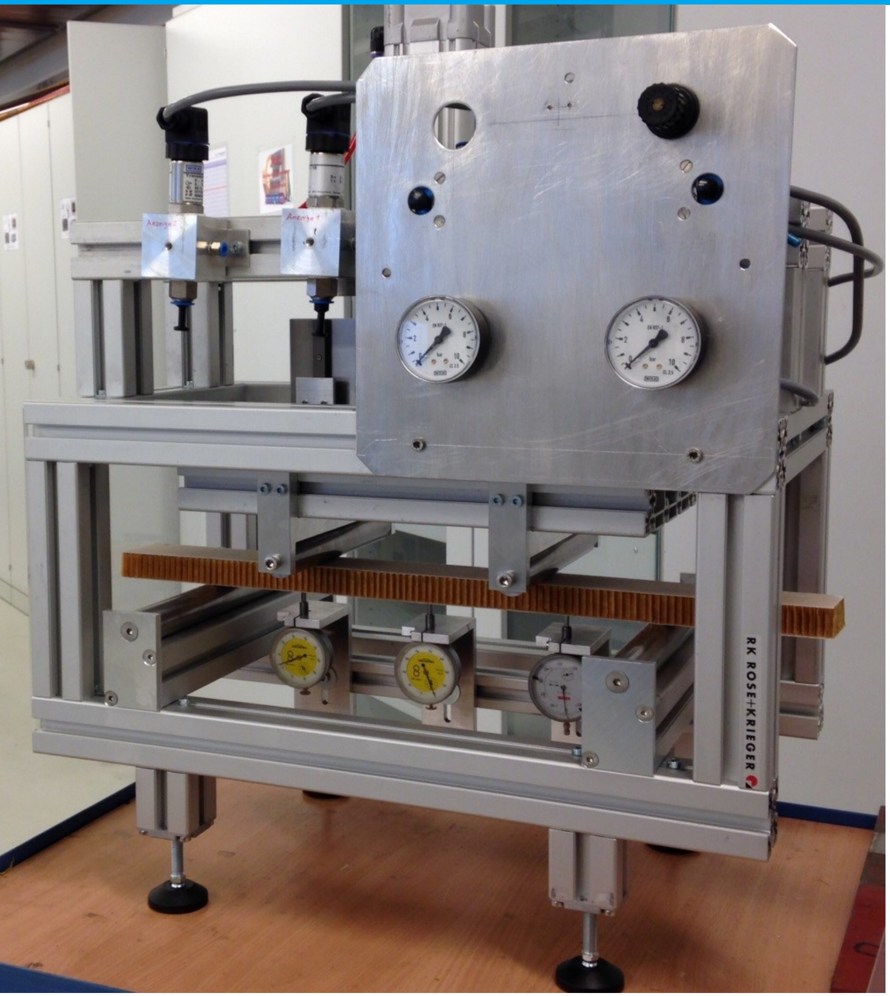
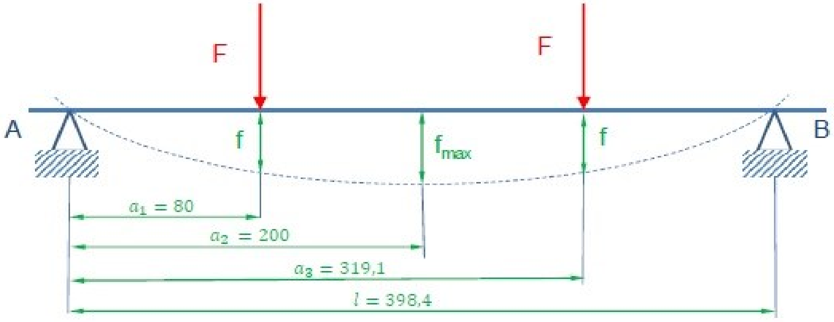
# Glue thickness study

## GFK vs Nomex facings and different glue thickness

| Vergleichskriterien | Material | durchschnittl. Steigung [mm/N] | max. Kraft [N] | max. Durchbiegung [mm] |
|---|---|---|---|---|
| Biegeversuch_01 | AlMg3 600x50x8 | 0,0069 | 1197,96 | 8,00 |
| Biegeversuch_05 | AlMg3 600x50x6 | 0,0178 | 538,66 | 8,00 |
| Biegeversuch_10 | GFK 390g/m² + Honeycomb 22,5mm (C2-4,80x-29) + GFK 390g/m² + 2x Kleber 10g (L /L) | 0,0169 | 263,72 | 4,54 |
| Biegeversuch_11 | GFK 390g/m² + Honeycomb 22,5mm (C2-4,80x-29) + GFK 390g/m² + 2x Kleber 12,5g (L/L) | 0,0175 | 356,30 | 6,15 |
| Biegeversuch_12 | GFK 390g/m² + Honeycomb 22,5mm (C2-4,80x-29) + GFK 390g/m² + 2x Kleber 15g (L/L) | 0,0277 | 378,75 | 8,92 |
| Biegeversuch_13 | Nomex 410 / 0,3mm + Honeycomb 22,5mm (C2-4,80x-29) + Nomex 410 / 0,3mm + 2x Kleber 10g (L/L) | 0,0901 | 117,83 | 6,50 |
| Biegeversuch_14 | Nomex 410 / 0,3mm + Honeycomb 22,5mm (C2-4,80x-29) + Nomex 410 / 0,3mm + 2x Kleber 15g (L/L) | 0,0607 | 179,55 | 8,48 |
| Biegeversuch_15 | Nomex 410 / 0,3mm + Honeycomb 22,5mm (C2-4,80x-29) + Nomex 410 / 0,3mm + 2x Kleber 12,5g (L/L) | 0,0598 | 159,91 | 8,00 |
| Biegeversuch_16 | GFK (390g/mm² / Köper) + Honeycomb 22,5mm (C2-4,80x-29) + GFK (390g/mm² / Köper) + 2x Kleber 30g (L/L) | 0,0185 | 373,13 | 6,48 |
| Biegeversuch_17 | GFK (390g/mm² / Köper) + Honeycomb 22,5mm (C2-4,80x-29) + GFK (390g/mm² / Köper) + Nomex 410/ 0,3mm + 3x Kleber 7g (L/L) | 0,0233 | 426,44 | 9,02 |
| Biegeversuch_18 | GFK (390g/mm² / Köper) + Nomex 410/ 0,3mm + Honeycomb 22,5mm (C2-4,80x-29) + GFK (390g/mm² / Köper) + 3x Kleber 7g (L/L) | 0,0225 | 440,47 | 8,32 |
| Biegeversuch_19 | Nomex 410/ 0,3mm + Honeycomb 22,5mm (C2-4,80x-48) + Nomex 410/ 0,3mm + 2x Kleber 7g (L/L) | 0,0374 | 471,33 | 15,47 |
| Biegeversuch_20 | GFK (390g/mm² / Köper) + Honeycomb 22,5mm (C2-4,80x-48) + GFK (390g/mm² / Köper) + 2x Kleber 12,5g (L/L) | 0,0133 | 830,43 | 10,80 |
| Biegeversuch_21 | Probe 2008 elktr. Durchschlag. Köper + Honeycomb + Leinwand + Kapton | 0,0125 | 1178,32 | 14,70 |

# Bending test




$$f_x = \frac{F * l^3 * a_x^2}{2 * E * I * l^2} * \left(1 - \frac{4 * a_x}{3 * l}\right)$$

$$f_{max} = \frac{F * l^3 * a_2}{8 * E * I * l} * \left(1 - \frac{4 * a_2^2}{3 * l^2}\right)$$

$$I = \frac{b * h^3}{12} ; E = 70 \frac{kN}{mm^2}$$

| | |
|---|---|
| b= 50,000 | h= 8,000 |
| a1= 80,000 | a2= 200,000 |
| a3= 319,100 | l= 398,400 |
| E= 70000,000 | Krafteinleitung 2,000 |

Four point bending test with constant bending moment

# Bending test


Bending test of Al reference part to check the bending device
Later: in ILD TPC use equivalent aluminum thickness for mechanical simulations

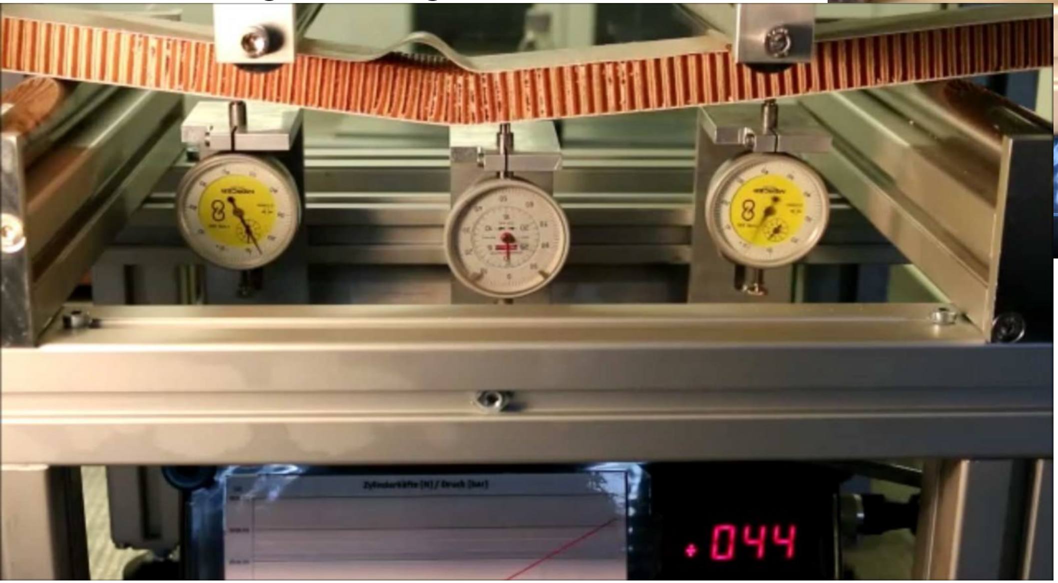
# Bending test

## Nomex facing probe

Start of the bending test



During bending test

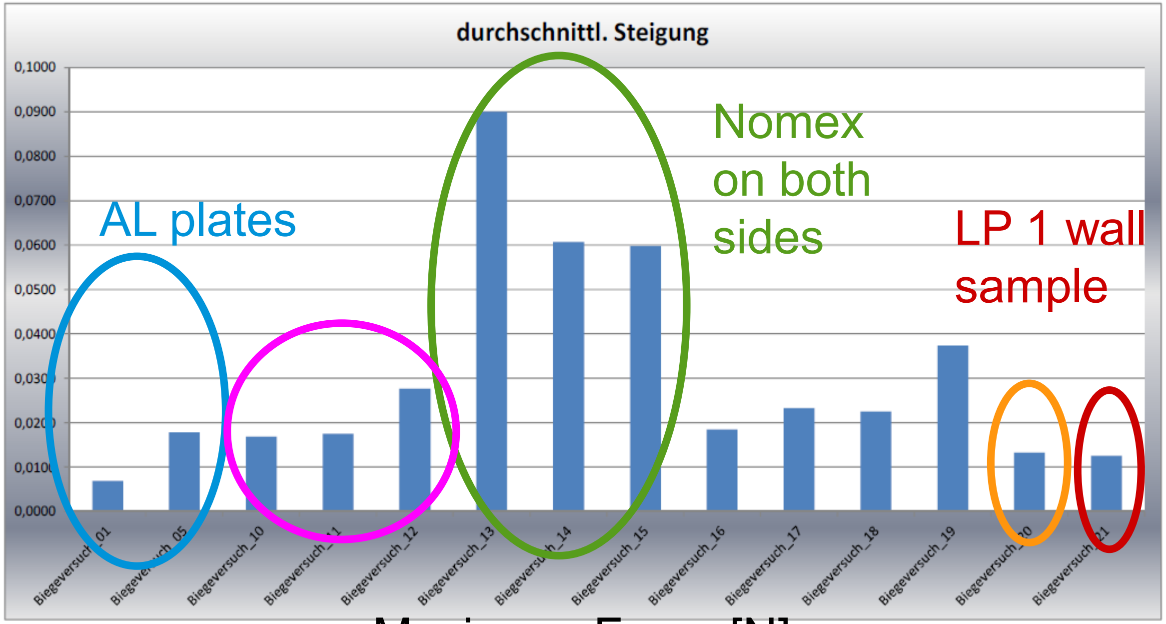



Delamination on the top surfce

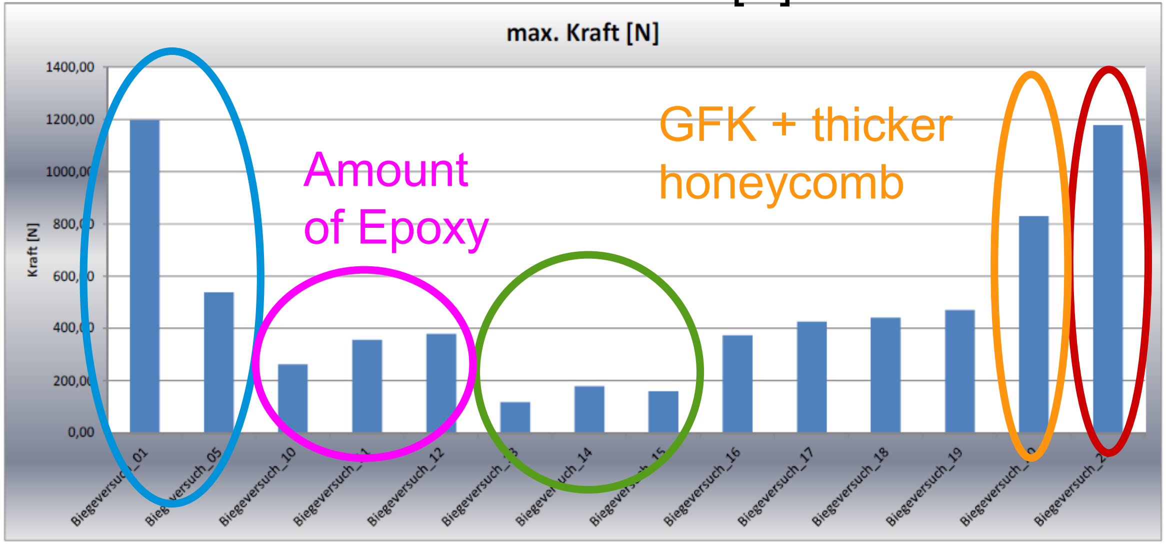
# Bending test

- Piece with stronger
- honecomb comparable
- tp LP 1 reference
- (but delamination)
- Pieces with Nomex paper
- on both sides weakest
- Amount of glue:
- Not so large impact on
- strength but on
- delamination

Average Slope: Deflection/Force [mm/N]




Maximum Force [N]



# Material of the end flange

Surface and HV-Connection at the Anode flange

The flange is glued together made out of several parts of HCP 70 and machined

**DIAB Divinycell® HCP 70 Polymer Foam**

**Categories:** Other Engineering Material; Composite Core Material; Polymer

**Material Notes:** Divinycell HCP grade has been developed to meet the demand for a high-performance, lightweight buoyancy material with excellent characteristics. It is widely used in pipelines, floatation units, diving bells and impact protection structures. As a result of its excellent hydraulic compressive properties and closed cell structure, it has very low buoyancy loss and water absorption under long-term loading conditions. HCP stands for Hydraulic Crush Point, indication the most important feature of this class of materials. HCP is defined as the point of pressure in Bar, where the material, when subjected to an increasing pressure of 1-2 Bar/sec, has lost 5% of its initial volume. The design of subsea buoyancy applications is complex and consideration has to be given to the required buoyancy loss and updrift over the expected lifetime and service conditions, with respect to long and short term hydraulic compressive creep, water absorption and hydraulic fatigue.

Operating temperature is -200 to 80°C. Lifetime must be taken into consideration for the very low and high temperatures. Maximum processing temperature is dependent on time, pressure and process conditions. Normally Divinycell HCP can be processed up to 90°C without dimensional changes.

Information Provided by DIAB

**Vendors:** No vendors are listed for this material. Please click here if you are a supplier and would like information on how to add your listing to this material.

| Physical Properties | Metric | English | Comments |
|---|---|---|---|
| Density | 0.300 g/cc | 0.0108 lb/in³ | ISO 845 |

| Mechanical Properties | Metric | English | Comments |
|---|---|---|---|
| Tensile Strength, Ultimate | 11.0 MPa | 1600 psi | Perpendicular to the plane; ASTM D1623 |
| Elongation at Break | 40 % | 40 % | In Shear; ASTM C273 |
| Tensile Modulus | 0.450 GPa | 65.3 ksi | Extensometer; Perpendicular to plane; ASTM D1621 |
| Compressive Strength | 7.60 MPa | 1100 psi | Perpendicular to the plane; ASTM D1621 |
| Shear Modulus | 0.140 GPa | 20.3 ksi | ASTM C273 |
| Shear Strength | 5.20 MPa | 754 psi | ASTM C273 |

| Thermal Properties | Metric | English | Comments |
|---|---|---|---|
| CTE, linear | 20.6 µm/m-°C | 11.4 µin/in-°F | |
| Maximum Service Temperature, Air | 80.0 °C | 176 °F | Continuous |
| Minimum Service Temperature, Air | -200 °C | -328 °F | Continuous |

| Descriptive Properties | |
|---|---|
| Hydraulic Crush Point (Bar) | 70-79 |

Technical data of the endflange material

Corecell:
rho=0.21g/cm3, X0 = 43.66 g/cm2

# Old Mandrel

- not reusable
- hard to align due to missing central axis
- machining after a new pre alignment not successful

Adjustment screws on both sides

Mandrel during machining

Mandrel of LP1

Recess for resistor chain



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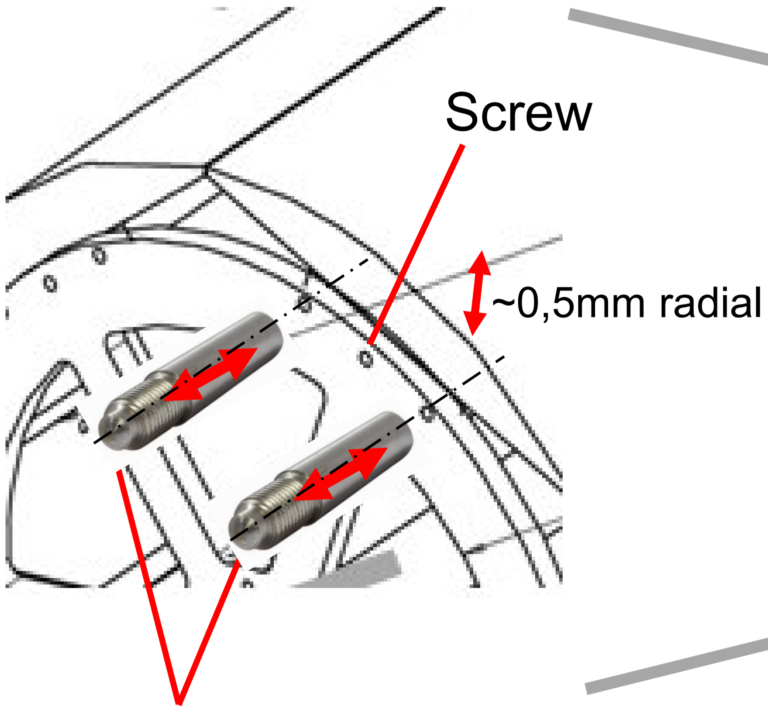
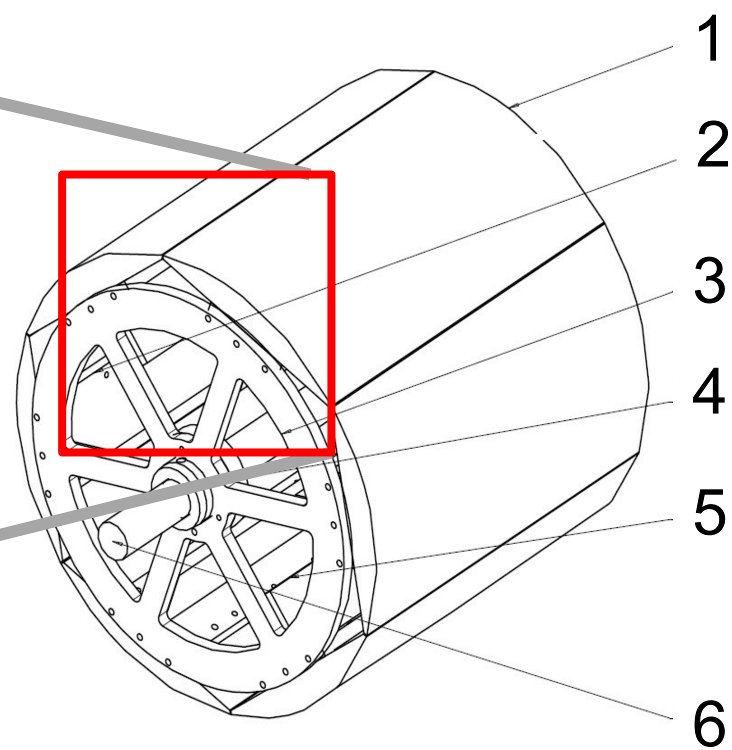
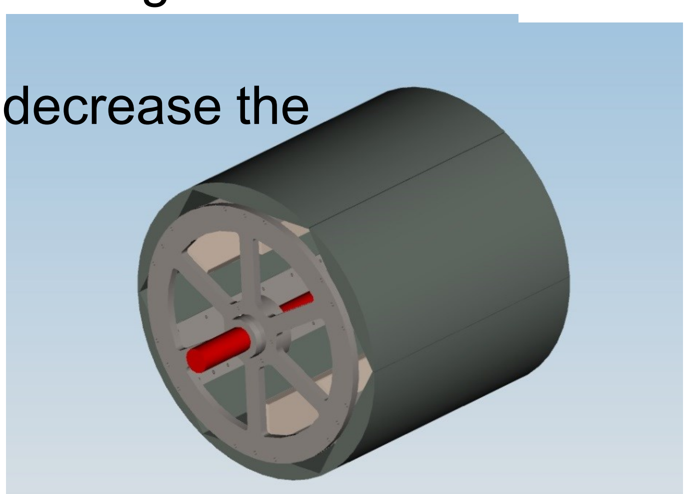
# New mandrel




- Insert conical pins for fixing the shelf plates
- Remove the pins to decrease the diameter



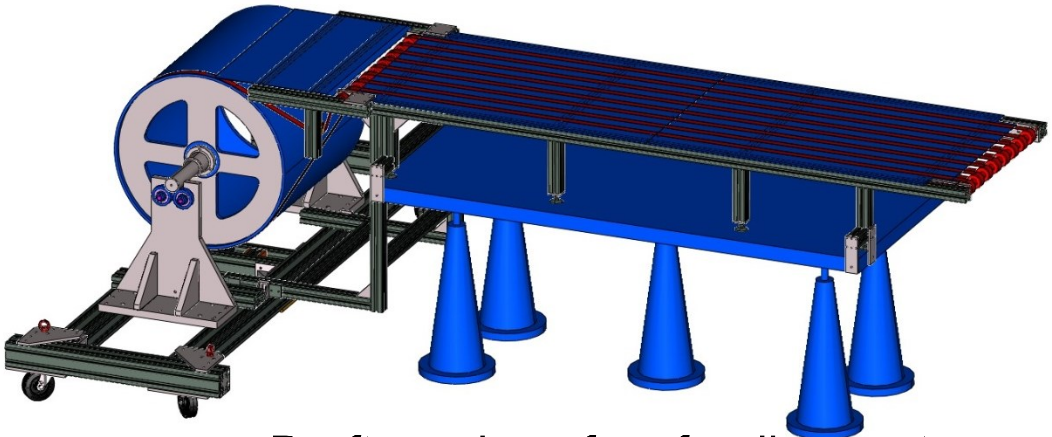
Part 1: Movable shelf plate
Part 2: Connector strut
Part 3: Stiff front and back disk
Part 4: Fixation ring
Part 5: Shelf plate stiffner
Part 6: Central main shaft

# Production Schedule

**A detailed schedule for the new LP2 Field cage is now in preparation**
raw overview of the schedule

- Tooling plan
  - Mandrel fabrication and machining of the parts
  - Mandrel support tooling
  - Kind of hand tools
  - …

- Material plan
  - List of materials and quantity
  - Precutting and machining
  - …



Draft version of an feeding system

- Curing plan
  - Field cage vessel, facings …
  - End flanges
  - Facings and foils
  - …

Some steps are now under discussion

# Fin

Thanks for your attention!