HYDROSTATIC LEVELLING SENSORS
BASED ON EXTRINSIC FIBRE
FABRY-PEROT INTERFEROMETER
TECHNOLOGY
**AIM**

- upgrade luminosity of LHC
- increase collisions by factor 10
- lifetime of inner triplets reached by 2023 @ 300 fb^{-1}

**ALIGNMENT CONSEQUENCES**

- maintain alignment concept with hydrostatic levelling for vertical and roll
- larger zone to be covered by monitoring systems
**Sensor Requirements**

- **HL-LHC:**
  - Remote DAQ:
    - $> 200 \text{ M}$
  - $< 30 \text{ M}$

**Annual Radiation Dose**

- HL-LHC:
  - $100 \text{ kGy}$
  - $16 \text{ kGy}$

**Sensor Characteristics**

- **Range:**
  - $0 \text{ mm}$ to $12 \text{ mm}$

- **Repeatability**
  - $\text{mm}$

- **Interchangeability**
  - $\text{mm}$

- **Resolution**
  - $\text{mm}$
RANGE AND LINEARITY

5 ml = 249 µm
repeat & multiples within ±1 µm

time (s)

level (µm)

INCLINATION TOLERANCE

3 sensor network: 2 horizontal, 1 inclined
tested at four azimuths, max 1.3°
injection and extraction of liquid
interferometric HLS (iHLS)

HLS-LINES

separated water/air system
both sensors see same variation

differences of ~5 µm – coupling to rock

different measurement principle

none of them can be classified to be better
capacitive HLS (cHLS)

interferometric HLS (iHLS)

main hydraulic network

TRANSFER TUNNEL 1 (TT1)
CERN
**SENSITIVITY**

- Injection of 20 ml water
- Both sensor types see 3 µm shift in wavefront corresponds to position

**LINEARITY**

- Extraction and injection of water to main network
- Difference between cHLS and iHLS ~8%
- Hypothesis: protective oil layer on iHLS causes shift

\[ \Delta h \sim 8\% \]
STABILITY

- Instability on central iHLS sensor
- Earth tides on all sensors – coherent with theory
- Linearity difference on measurement data confirmed
- EAST support is subject to true movements

Stability fixed after cleaning of sensor
- Dust on optics?
- Mechanical problem?
- Tilt of support?
SUMMARY

3 years: idea, design and development

laboratory:
- range, linearity calibration
- inclination tolerance

two test installations:
- stability
- comparison to other sensors
- linearity scale factor

complies to most specification requests

PERSPECTIVES

Relative use already possible for tilt monitoring applications in geophysics

CERN: HL-LHC
- absolute sensor (external, geodetic reference)
- suppress protective oil layer, cancel scale factor
- configuration with more sensors
- radiation tests on system components
TO ALL PERSONS INVOLVED IN THE PROJECT

THANK YOU FOR YOUR HELPING HANDS, BRILLIANT IDEAS AND YOUR UNDERSTANDING!