



What's cookin' at Metrolab

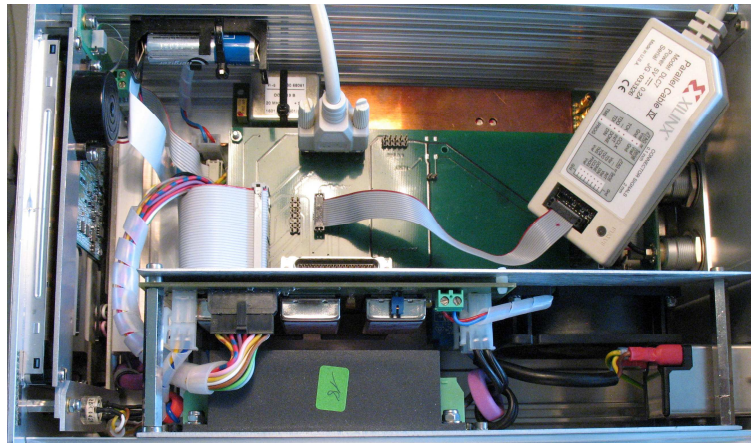
IMMW15, Fermilab, 8/21/2007

PT2026 – All-Digital NMR Teslameter

	PT2025	PT2026 (goal)
Frequencies	30-90 MHz	0.05-240 MHz, to 1 GHz effective
Meas. rate	1, 10 meas/sec	< 60 meas/sec
Stability	OCXO optional	OCXO standard
Homogeneity	< 1300 ppm/cm	< 4000 ppm/cm
Tracking rate	1%/sec	4%/sec
Channels	1	2
UIF	Knobs / buttons	Color touch screen
Interfaces	RS232, GPIB	RS232, USB, E-net
Standards	IEEE 488.1, 488.2	IEEE 488.2, VXI, USBTMC, SCPI
Mechanical	Ventilation slots	Closed case



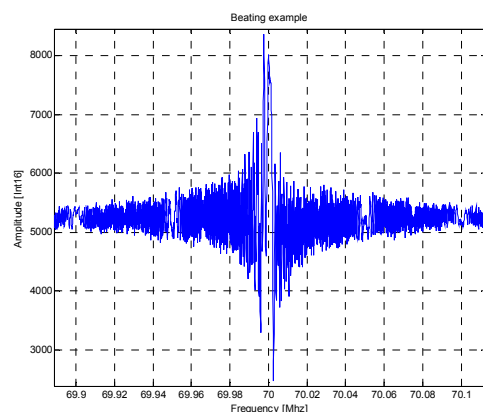
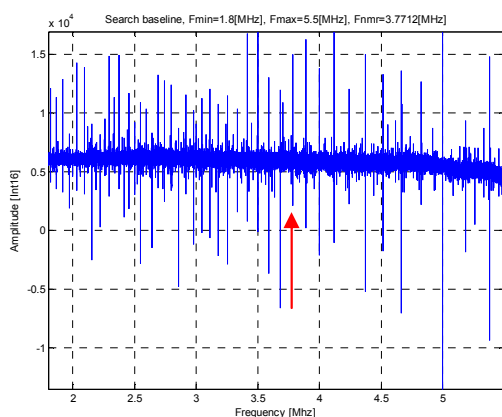
The Ugly Reality:



- Overheating: all-new mechanical design
- μ Controller-DSP interface: minor changes, but much time lost
- Analogue circuitry: noise reduction / optimization
- Firmware development: OS, drivers, tools, support libraries

... and finally ...

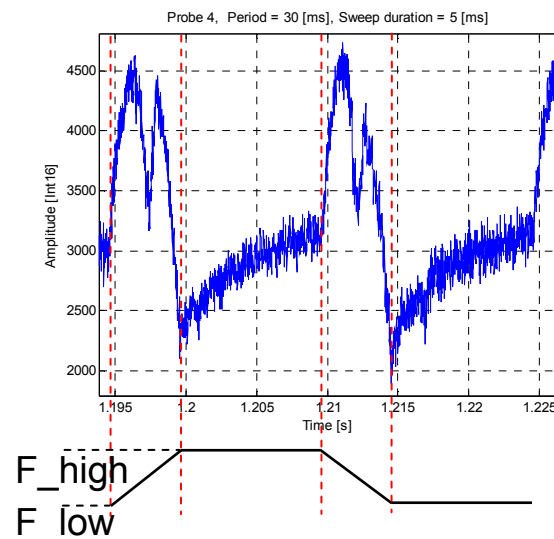
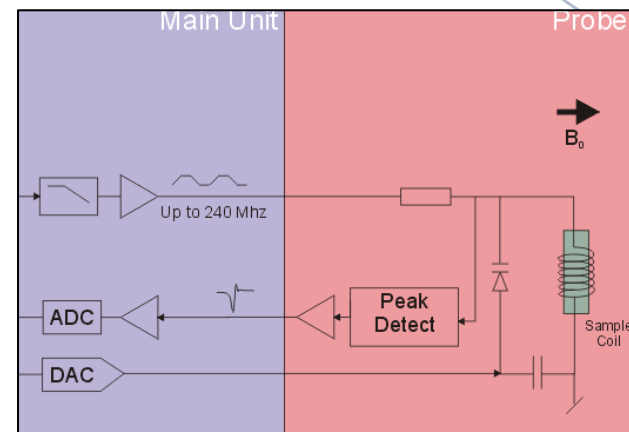
Some Fundamental Problems



- Direct Digital Synthesis (DDS)
 - Clock feed-through
- Harmonics “folded down”
 - MANY different frequencies
- Continuous-wave NMR
 - beat frequencies
 - chirp signal
 - look like NMR resonances!
- How to reject them:
 - Change DDS input clock
 - Spectral signature
 - Fixed-frequency behavior
- Longer term: pulsed NMR
 - separate transmit from receive

And Some More: Auto-Tuning

- Tune LC circuit to resonance frequency → increase SNR
- PT2025: analog regulator
PT2026: digital regulator
- Trouble:
 - Hypersensitivity to DAC
 - Rapid frequency changes vs. large RC time constants
 - Base line not flat
- Solution:
 - Analog regulator
 - Baseline extraction by DSP
- Longer term: pulsed NMR
→ less sensitive to tuning



PT2026: Status Summary

- Mechanics, electronics: OK
- Manufacturing: OK
- Firmware development tools:
 - DSP: update OK (very nice!)
 - μ Controller: update in work
- Technical:
 - Signal search: OK
 - Measurement: almost OK (excellent resolution!)
 - Auto-tuning board: in work
 - Firmware: in work
 - LabVIEW driver: in work
- Estimated delivery: Q2 2008



Field Mapping: MRI Systems



Photo: Philips Achieva

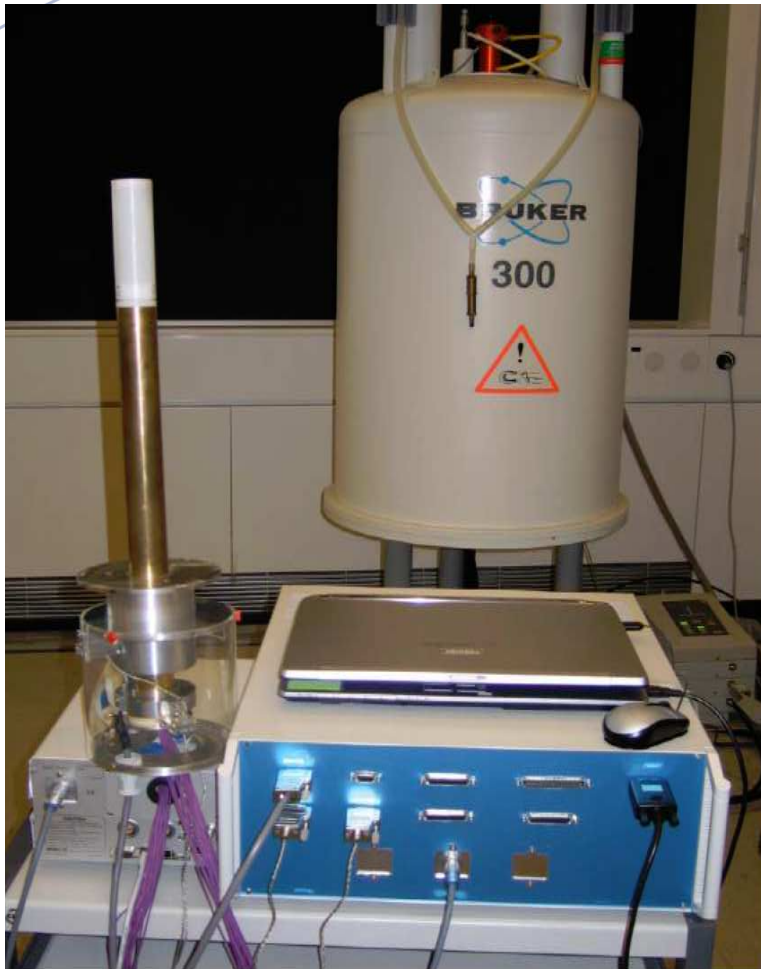
- B_0 field typically 0.2 to 7 T
- Permanent-, electro- or superconducting magnets
- Torroidal or C shape
- Inhomogeneity in imaging region: typically < a few ppm
- Field shimming:
 - Map, analyze, adjust shims / shim currents, remap, ...
 - R&D, manufacturing, installation, (service)
- Very sensitive measurement in a factory/field environment

Magnetic Field Camera (MFC)

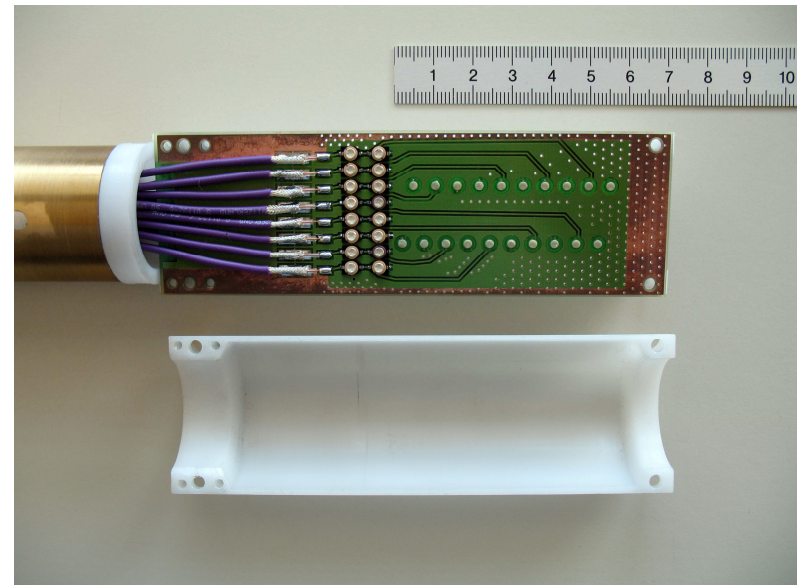


- Measures B on surface of sphere
- Inside of sphere known by Maxwell's equations...
- as long as no currents or magnetic material inside volume...
- and assuming direction of \mathbf{B} is known
- Probe array instead of single probe: minutes instead of hours
- Also note (relative) simplicity of jig!

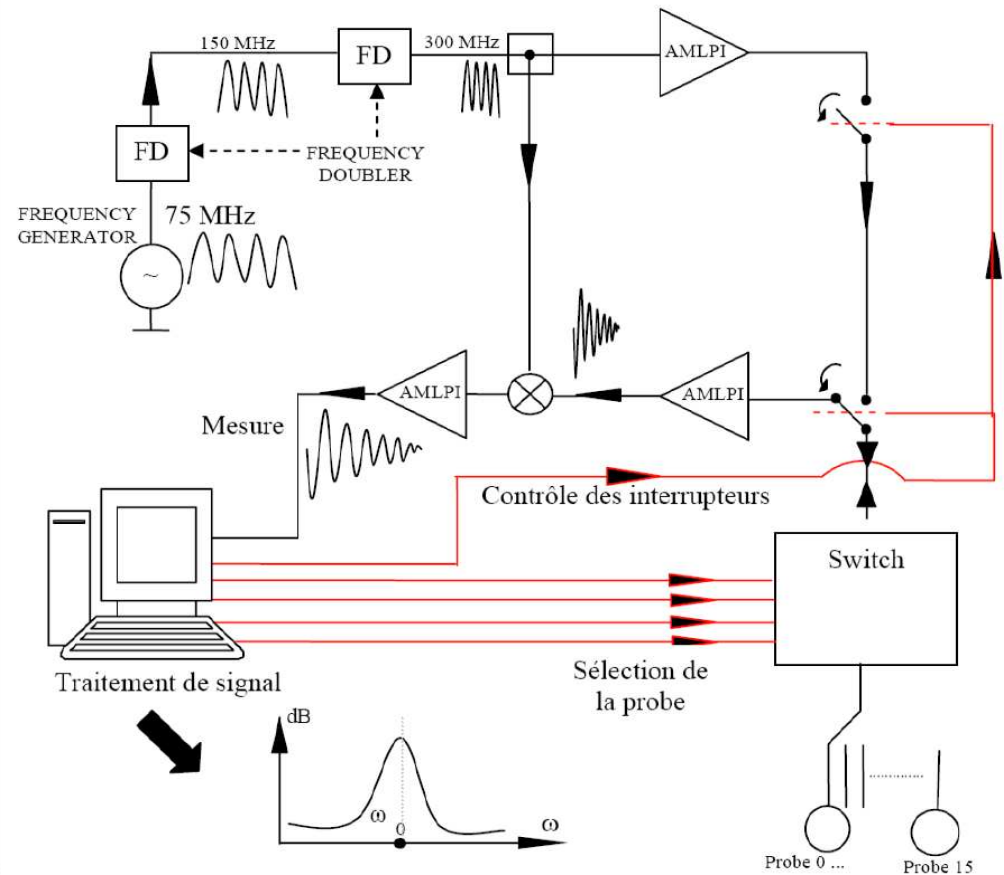
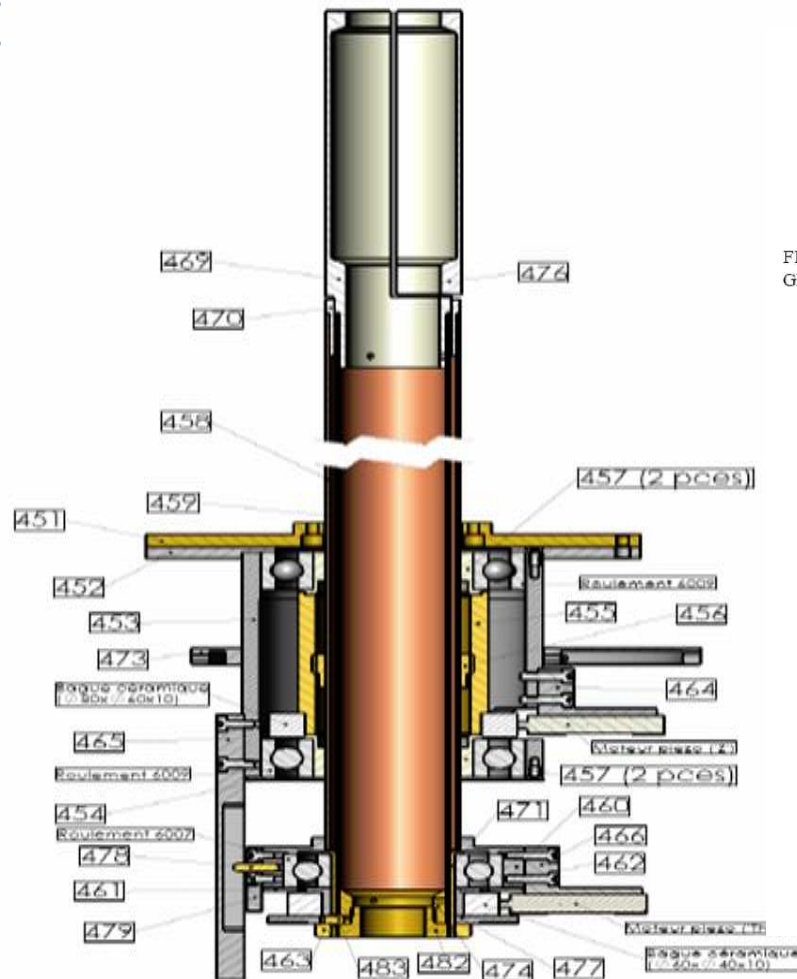
Mini-MFC Prototype



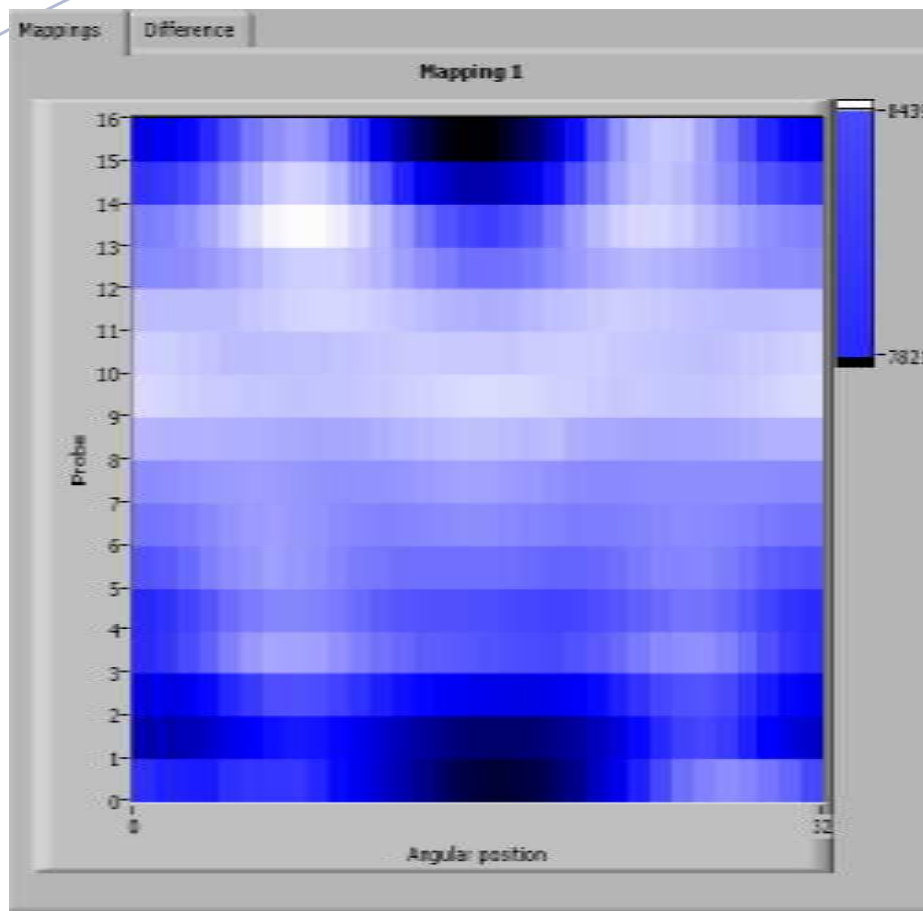
- Vertical small-bore torroids
- B_0 field typically > 7 T
- Superconducting
- Research: NMR/EPR spectroscopy, animal imaging...



Mini-MFC: Mechanics & Electronics



Mini-MFC: Summary



- Frequencies: < 1 GHz (trials @ 300, 400 MHz)
- Range: typically $\pm 1\%$
- Resolution: < 3 Hz (10 ppb)
- Probe array: 16 probes
13.2 mm x 37.5 mm
(near minimal dimensions)
- Sample material:
cis-polyisoprene (rubber)
- Minimize paramagnetic effects
- Motors: piezo-electric
- Angular resolution: 0.04°
- Complete map: < 5 minutes

3-Axis Handheld Magnetometer



- THM7025: world's only handheld 3-axis magnetometer
- Ranges: 0.02, 0.2, 2 T
- Auto-ranging or manual
- Precision: $\pm 2\%$
- Temperature-compensated
- Measurement rate: 2.5/sec
- Interface: RS-232
- Designed for MRI safety: reliably find 5G line
- Increasingly used for mapping, trouble-shooting

The Next Generation: THM1176



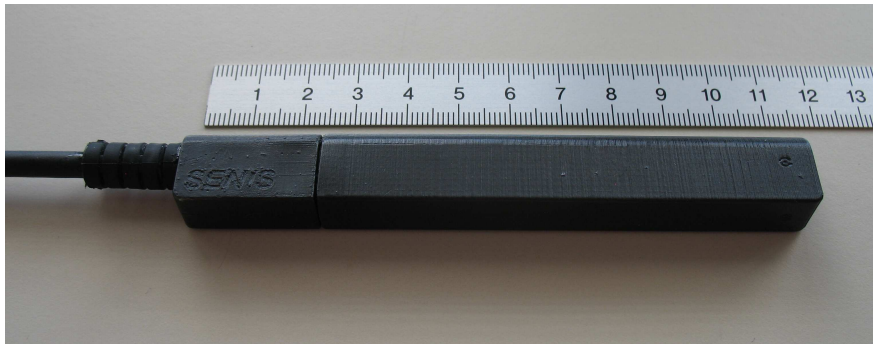
- Ranges: 0.1, 0.5, 3, 20T
- Auto-ranging or manual
- Precision: $\pm 1\%$
- Temperature-compensated
- Low offset, offset drift
- Measurement rate: $< 2000/\text{sec}$
- Interface: USBTMC, SCPI
- User Interface:
 - Hi-res color touch screen
 - Numeric, graphic, or vector
 - Hold, Max, Zero
- Other: PDA apps, WiFi, Bluetooth, SD/MMC slot

Optional Configurations

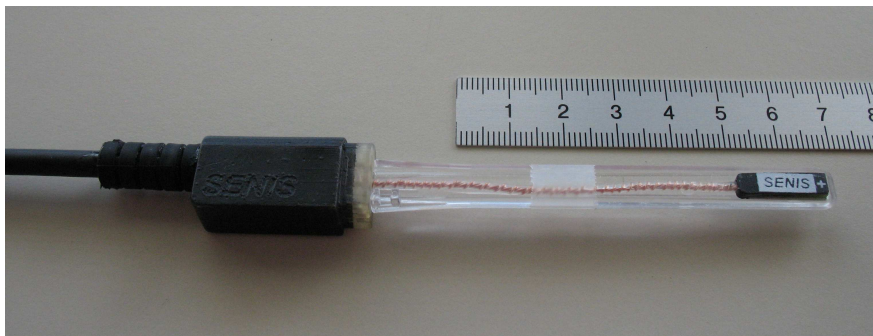


- Direct connection to PC:
 - Any USBTMC/488.2 standard class driver (NI-VISA from ni.com !)
 - LabVIEW UIF / API
 - Perfect for mapping
- Ruggedized version:
 - Water-, shock-, sand-, dust-, vibration-, altitude-, heat- and cold-proof (!)
 - Rubberized case
 - Backlit controls

Small Probe: a Big Deal



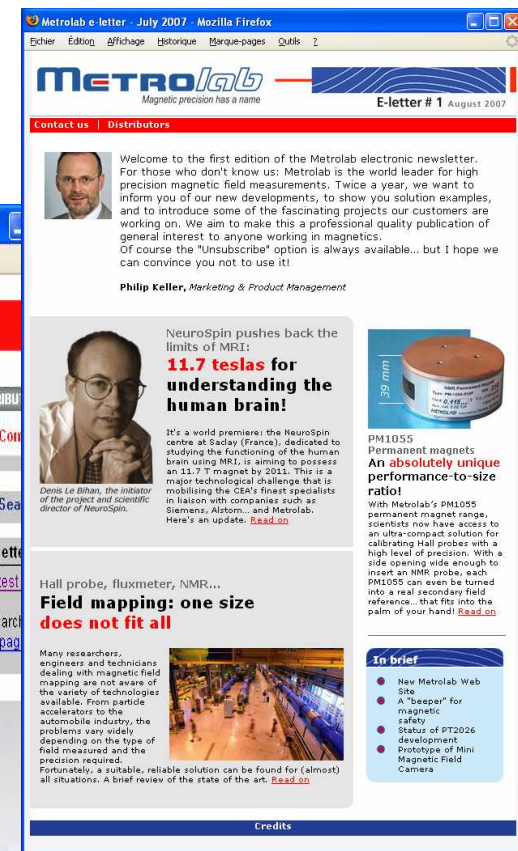
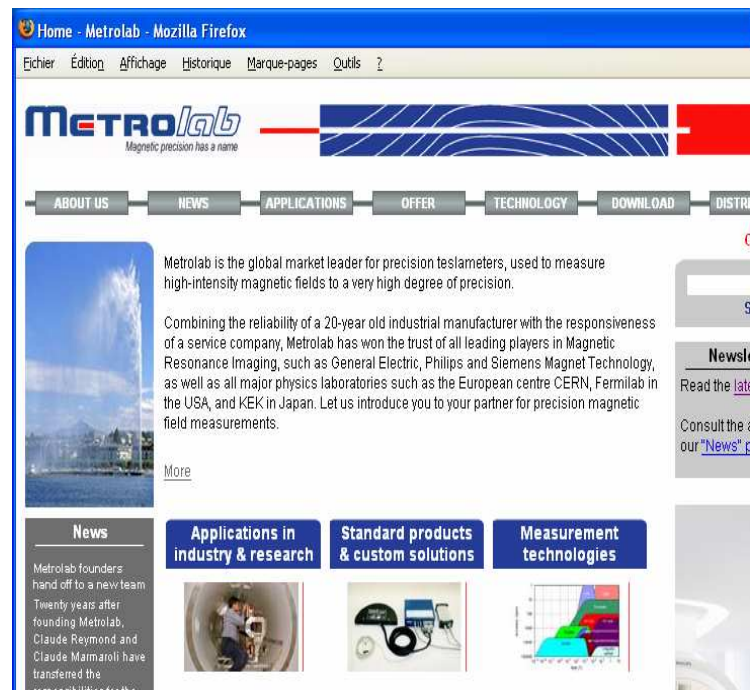
- Probe:
 $114 \times 16 \times 10 \text{ mm}^3$
- Without cap:
 $68 \times 8 \times 4 \text{ mm}^3$
screw hole for fixed installation



- Sensor IC:
 $16.5 \times 4 \times 2 \text{ mm}^3$
- Active volume:
 $0.15 \times 0.15 \times 0.01 \text{ mm}^3$ (!)

A Quick Plug

- www.metrolab.com
- Bi-annual Metrolab newsletter
- Real information, not just marketing!



Questions?

