Position Sensitive Detectors – Advantages for μSR Spectrometers

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LMU Brainstorming:

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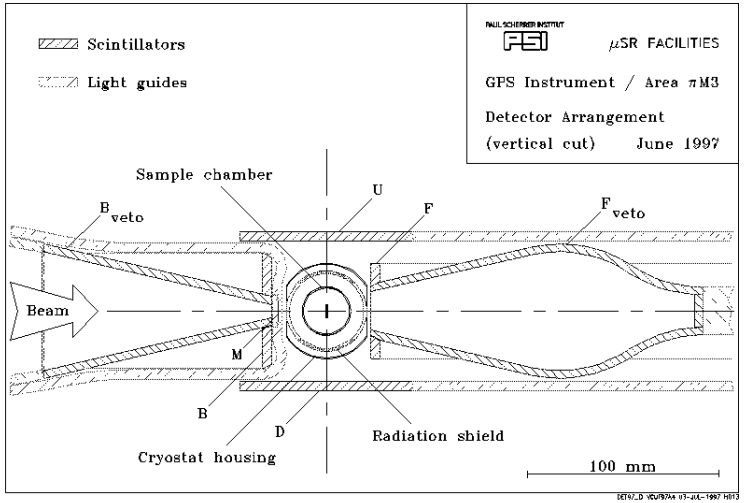
Present detectors for μSR (bulk+LE)

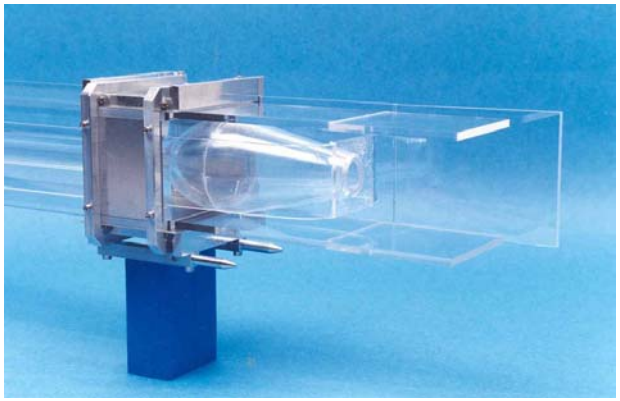
Now: Only **time correlation μ-e** measured

- Detection: plastic scintillators (200 μm-5mm) + light guides+ Photomultipliers (PM)
- Time resolution ~ 1 ns
- used for μ and e counters, veto counters

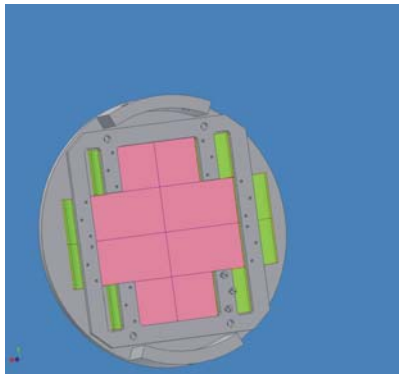
Examples:

Detectors of GPS spectrometer:





New segmented fast muon counter for LEM



(**Other detector types**: muon counter for low energy muons (C- nm foil as electron emitter coupled to Microchannel Plate)).

Limitations

Disadvantages:

- No spatial resolution
- PM's bulky, do not allow compact geometries,
- Very poor granularity (~10, solid angle 0.1 – 2 sr)
- Magnetic fields sensitive (a few G, kG for special mesh dynode PM)

Limits:

- Time resolution limits study of fast relaxation phenomena (slow fluctuations) and measurements of high internal fields (Larmor frequency in 10 T 1.35 GHz)
- Usable muon rate < 30 kHz to avoid pile-up of uncorrelated events
- Sample sizes 10-100 mm^2

New Detectors for μSR

Next detector generation:

- **Fast timing:** goal σ = 100 ps

  Possible solution: APD's (Investigated by A. Stoykov, R. Scheuermann, also necessary for high field μSR)

- Introduce **μ-e position information:** goal ~ 200 μm resolution or better for μ and e (stripe-, pixel-detectors, APD,...)

New capabilities

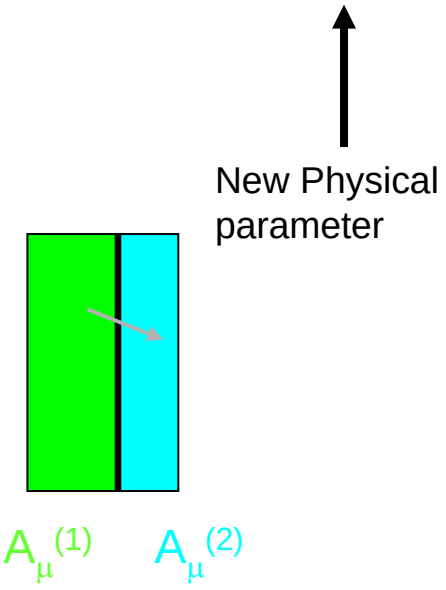
- **Position resolution (300 μm with 2 layers of 300 μm Si, 170 μm with 100 μm ?):**

→ Very compact and flexible geometries. Granularity

→ Increase usable intensity (> factor 10 (ALC) to 500 TD-μSR), background reduction

  - fast measurements (time scale minutes)
  - study of **transient effects**: time-dependence of the muon signal (ex: relaxation rate P(t, t'))
  - diffusion or mixing processes on minutes timescale
  - penetration of tracer molecules through a membrane
  - Quantum Tunneling in High-Spin Molecules (memory loss)
  - Vortex creeping

→ Very small samples (few 100 μm for bulk, mm for LE)



PSI has surface muons beams (10^7-10^8 μ^+ /s) that would allow
a) μSR measurements on (few hundreds μm)^2 samples or domain sizes
b) fast measurements in minutes thus introducing a new time parameter in the experiment (measurements of non-equilibrium systems or of transient phenomena).

Muonated radical (Phenlyethanol) as tracer in different solvents or environements

(T = 35 °C, liquids)

n-octadecane $C_{18}H_{38}$

non-polar; hydrocarbon

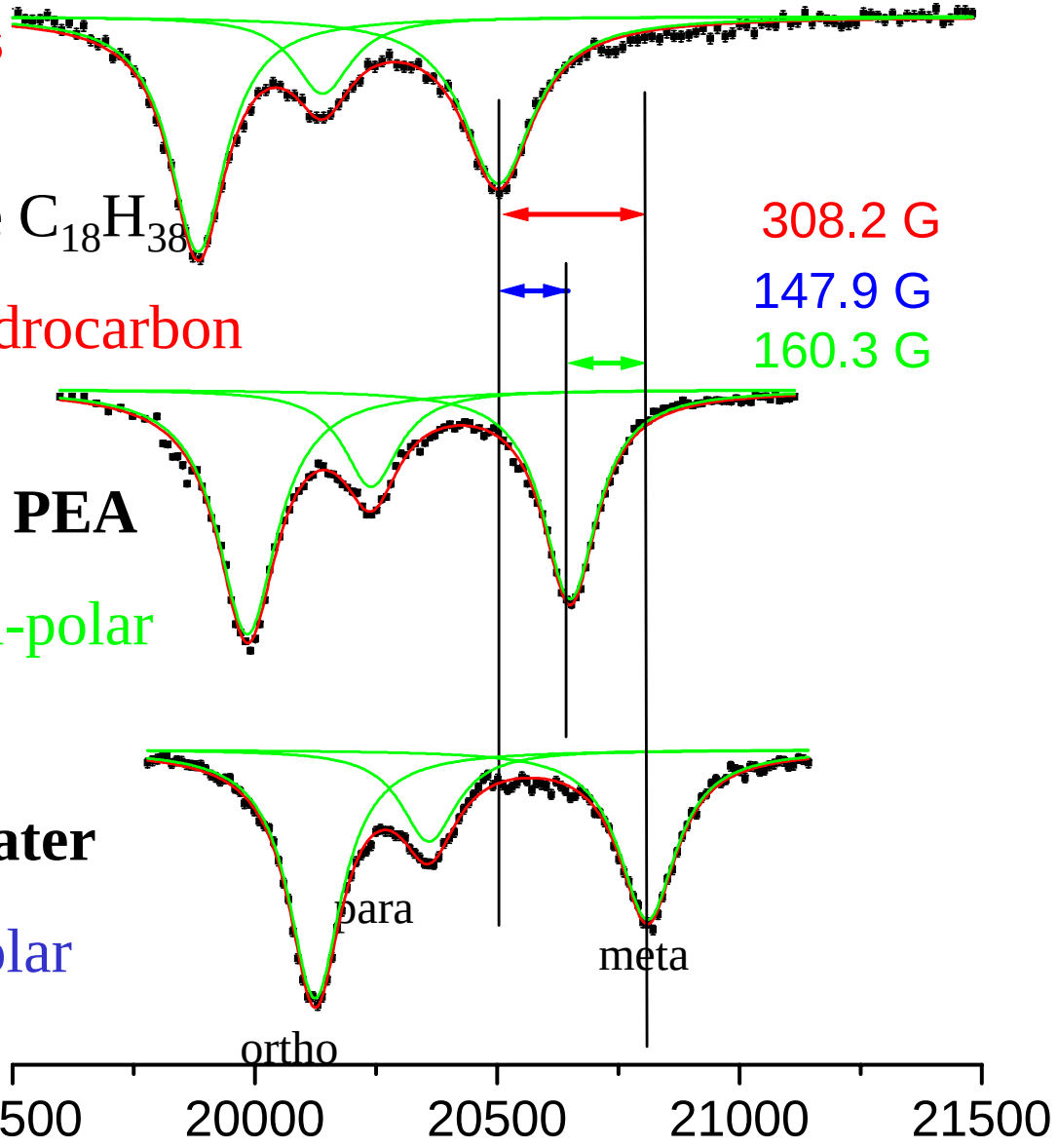
low tracer concentrations possible (<10^{-4})

bulk **PEA**

semi-polar

water

polar



NEW

▶study of mixing and flow processes

▶penetration of tracer molecules through membranes

relative line position:

depends on polarity of the medium