# Magnetic field monitoring proposal for DARKLIGHT

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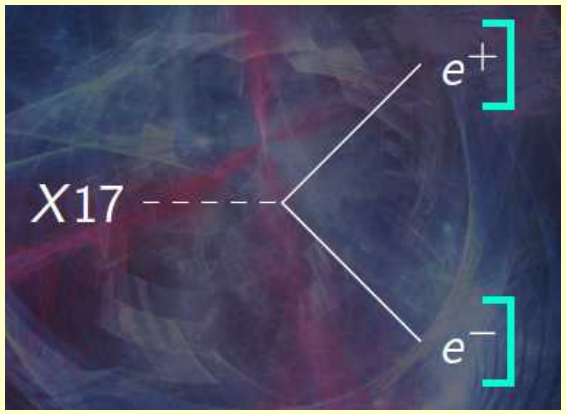
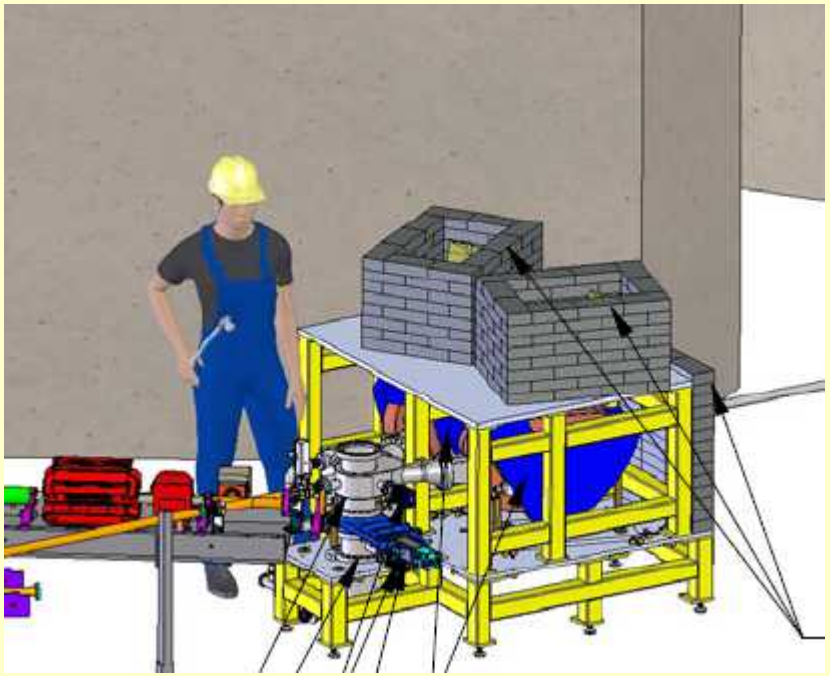
17 January 2023

How accurately do we need to measure and stabilize the magnetic fields in the two spectrometers?



The energy resolution of the two spectrometers contributes to the invariant mass resolution of the $e^+$ $e^-$ pair. For each of the two arms, and assuming the electron (positron) are highly relativistic

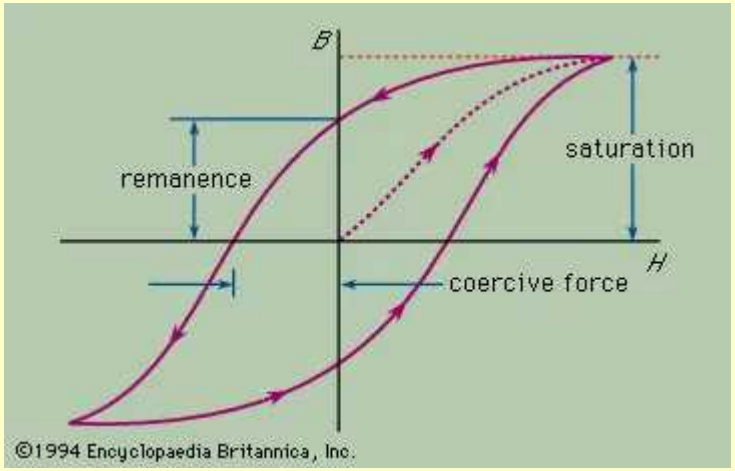
E(energy) ~ p(momentum) ~ B(magnetic field strength)

From the Oct 2022 TDR, for the 30 MeV experiment, we expect a mass resolution of ~120 keV, assuming no irreproducibility of the magnetic fields of the spectrometers between runs.

Let us demand that the smearing of the putative resonance peak due to magnetic field irreproducibility must
contribute less than 1/4 of this, say 30 keV, or 15 keV in each arm.

The central momenta of the electron/positron arms for the 30 MeV experiment are 11 MeV and 18 MeV, respectively, say 15 MeV average.

Reproducibility of the magnetic field of each spectrometer between runs, must be then  15 keV out of 15 MeV, or 1 part in 1000.

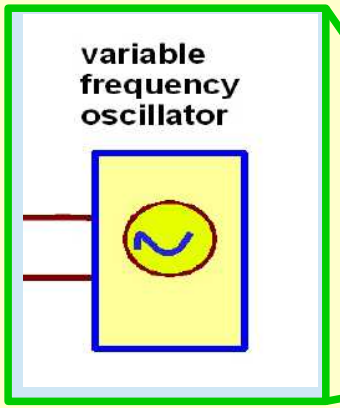


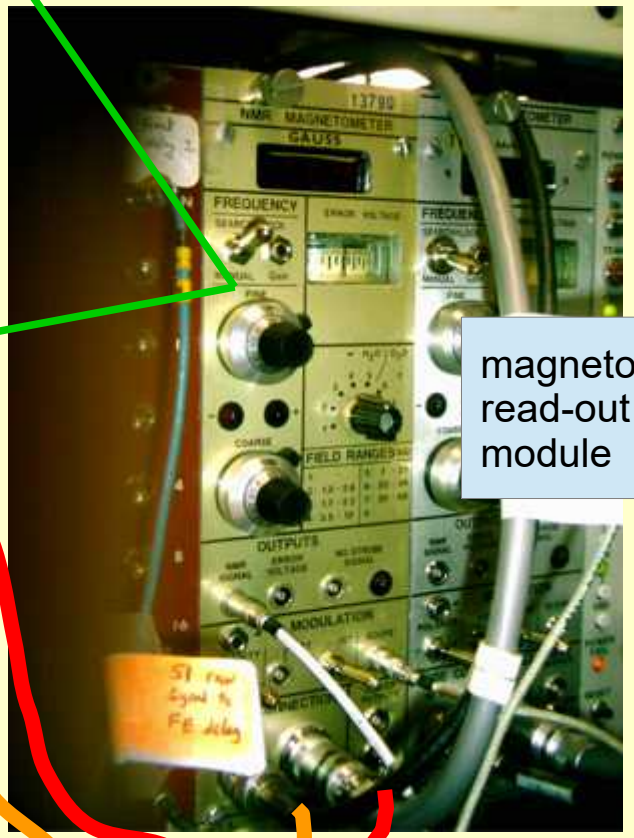

Hysteresis! The positron arm is going to have to reverse polarity periodically to calibrate it using electron scattering. Setting it to the same current will not give the same magnetic field before and after the polarity switch. How large is this effect? If 1 part in 1000 or more, we need to worry about it.

If DARKLIGHT claims discovery of a new particle, will we be able to convince people that any bump we see above a smooth background is not an artifact due to a changed B-field partway through the data taking?
How can we do this if we never directly measure the B-field, at least periodically?

Hall probes are only accurate to ~ 1%
NMR is accurate to parts per million, but not cheap – unless we get a surplus freebie.

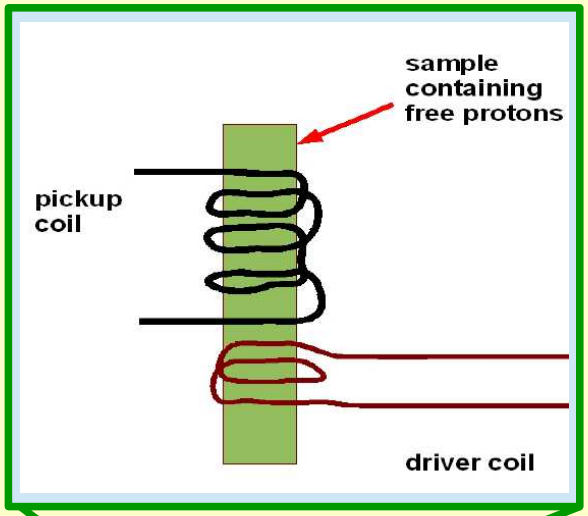
For the past 40 years, TRIUMF has used the CERN NMR design, and in the past, provided this to users.

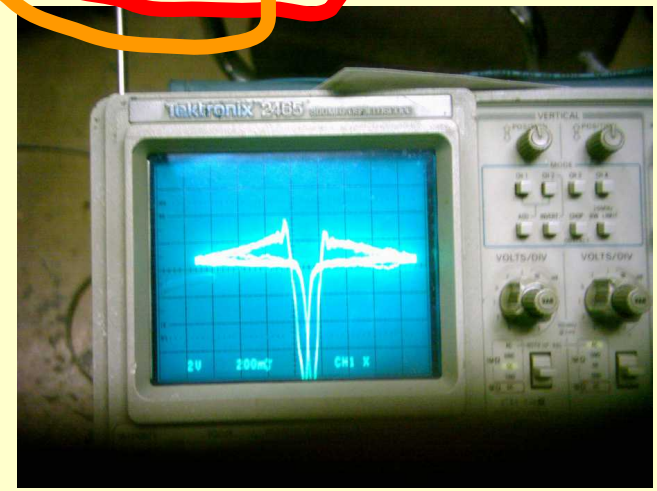



magnetometer read-out module

pre-amp




probe

resonance signal displayed on oscilloscope

Different probes are needed for different ranges in B-field

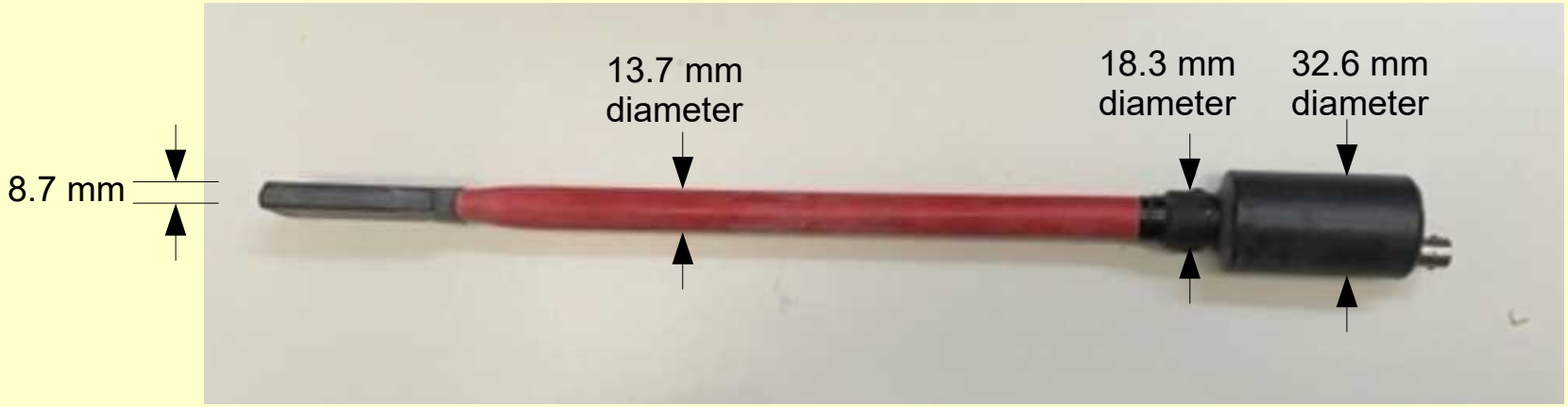
Probe 2  1.0 – 2.6 kG  (0.1 – 0.26 T)
Probe 3  1.7 – 5.2 kG  (0.17 – 0.52 T)

For 30 MeV DARKLIGHT,  B = 0.13 T  (electron arm), 0.21 T (positron arm)
so we need both probes 2 and 3.

The NMR magnetometer readout modules are mostly falling apart, not being maintained any more, we use at our own risk --- but they are free.

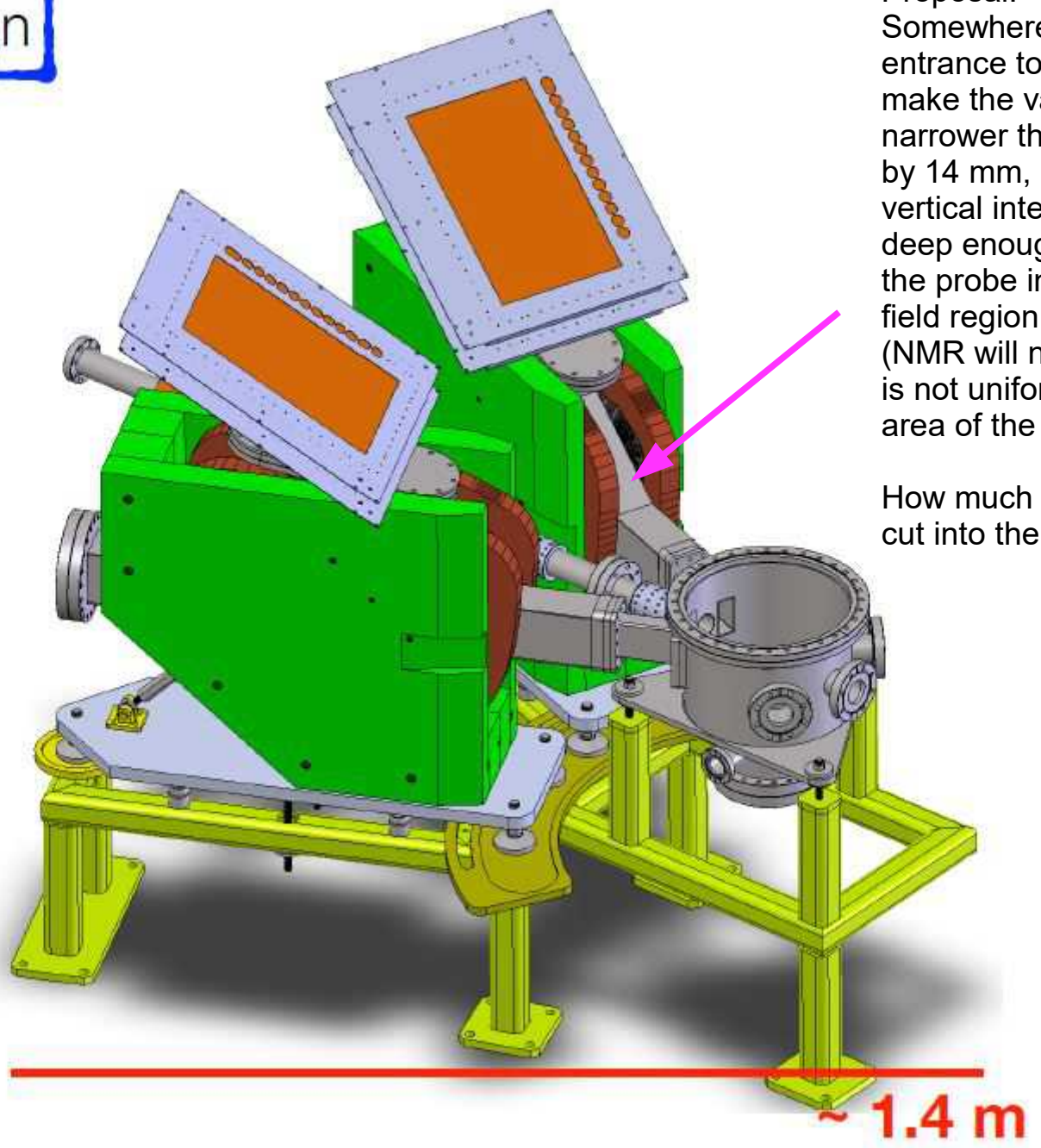
Here's what the NMR probes look like:

Dimensions of NMR Probe #2  (Probe #3 is more or less the same size)


Lemo
BNC

# Preliminary design




Proposal:
Somewhere at the entrance to the dipole, make the vacuum box narrower than pole gap by 14 mm, over a 32mm vertical interval, and deep enough to insert the probe into the uniform field region.
(NMR will not work if field is not uniform over the area of the probe).

How much does this cut into the acceptance?