Development of Polarization proton target that used copolymerization polymer

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CONTENTS

- Polarization target sample of Polymer
- Dynamic Nuclear Polarization(DNP)
- Copolymerization polymer(EPM)Material
- Polarization System
- Process of Polarization excitation

Selection of target

Polymer target

Avantage — Solid (at normal temperature) — Easy Processing
- very thin(fine)target can be made
- large surface area — Coling is easy
- The target of the aimed thickness can be made.

Dilution factor

Number expressed in Polarization Possible nucleons number/all nucleons number In material.
Hgher Value is advantageous

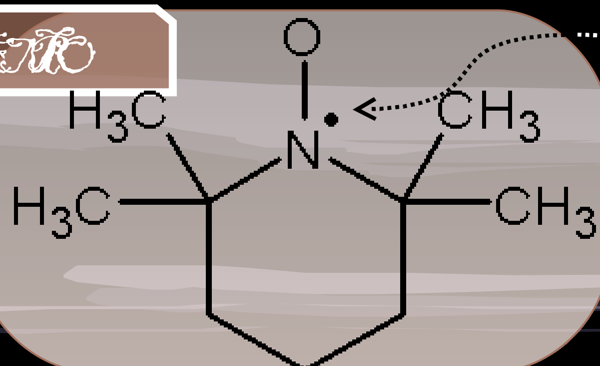
polyethylene — Dilution factor: 1/7
crystallized → It is hard to mix free radical(TEMPO)

Free Radical

Material including unpaired electron.
Indispensable to DNP

polystyrene — Dilution factor 1/13
Non crystallized → It is easy to mix free radical(TEMPO)

TEMPO



unpaired electron

2,2,6,6- tetra methyl - piperdine -1-oxyl
$C_9H_{18}NO$

M.P.
B.P.
] solid (at room temperature)

Selection of target

Polymer target

Avantage temperature) Slid (at normal temperature)

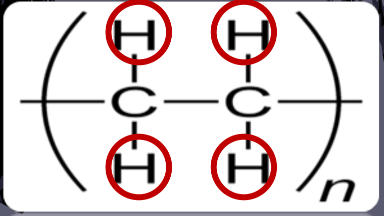
Easy Processing

- very thin(fine)target can be made
- large surface area Coling is easy
- The target of the aimed thickness can be made.

polyethylene

Dilution factor: 1/7

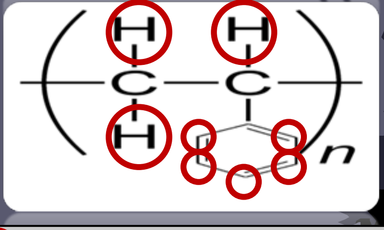
crystallized → It is **hard** to mix free radical(TEMPO)



polystyrene

Dilution factor: 1 / 13

Non crystallized → It is **easy** to mix free radical(TEMPO)



○ : Plarization object

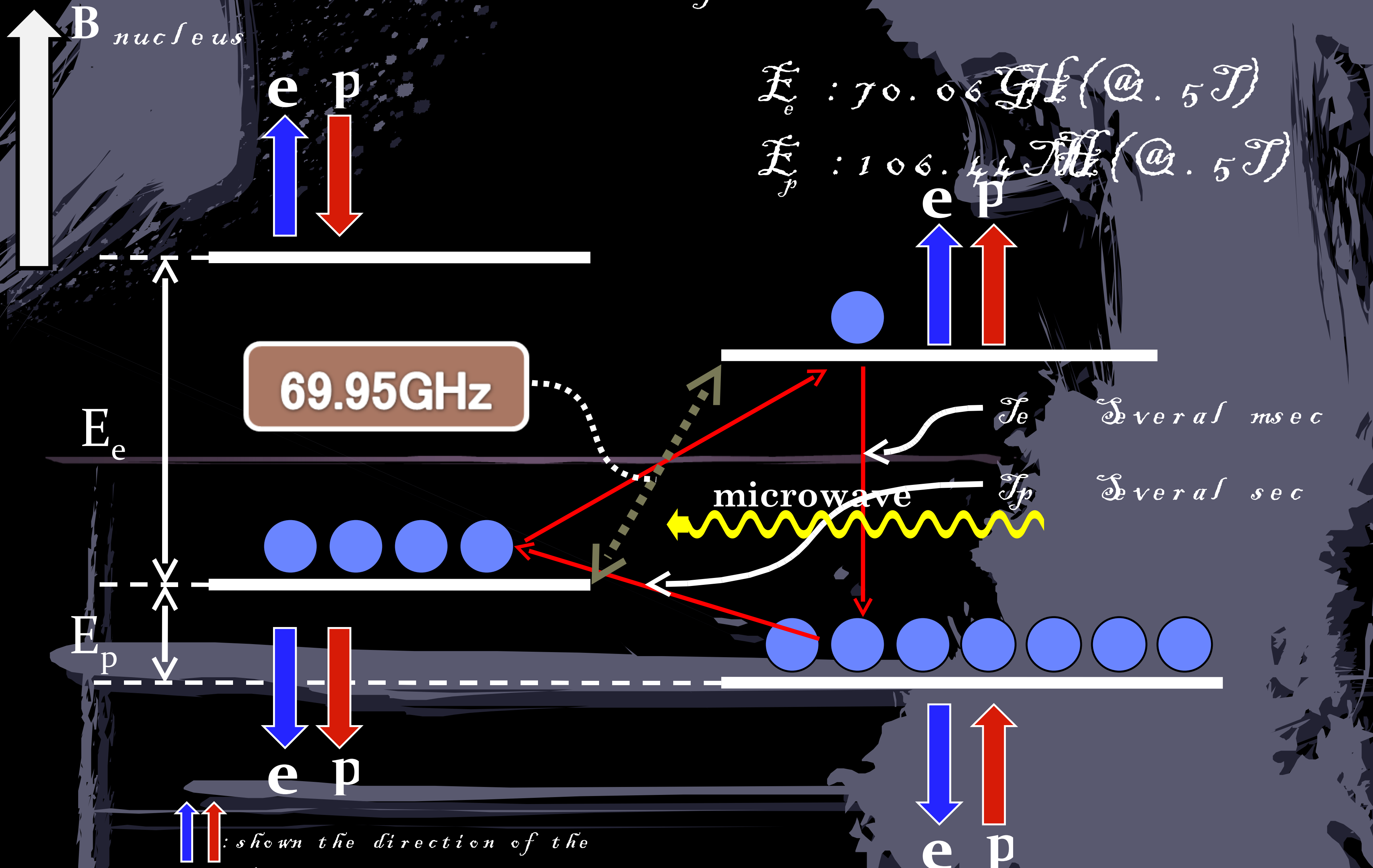
Hgh Dlution factor

easy to mix free radical

Polymer

Dynamic Nuclear Polarization(DNP)

A method to move electronic high Polarization in an atomic nucleus



Dynamic Nuclear Polarization(DNP)

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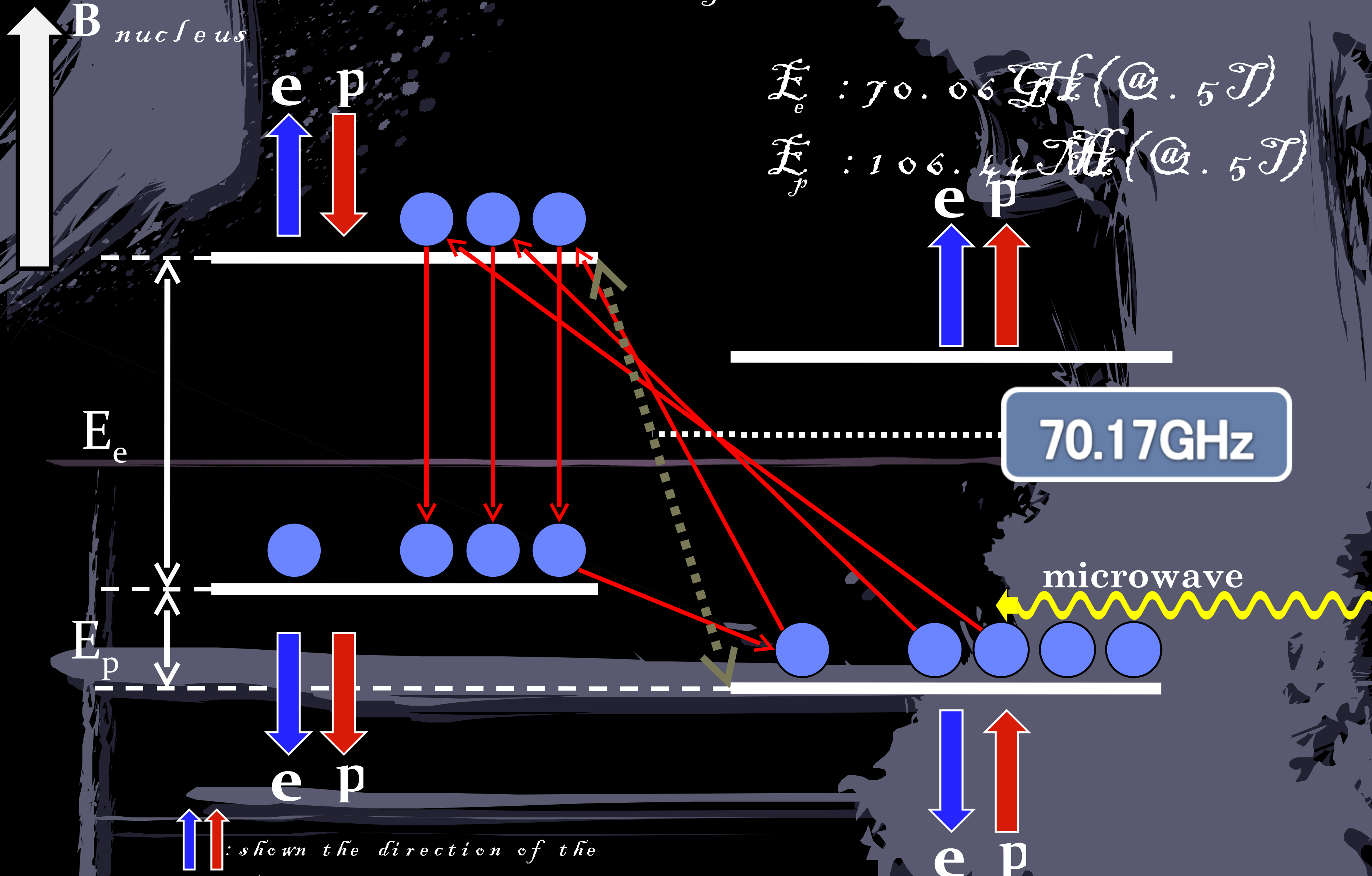

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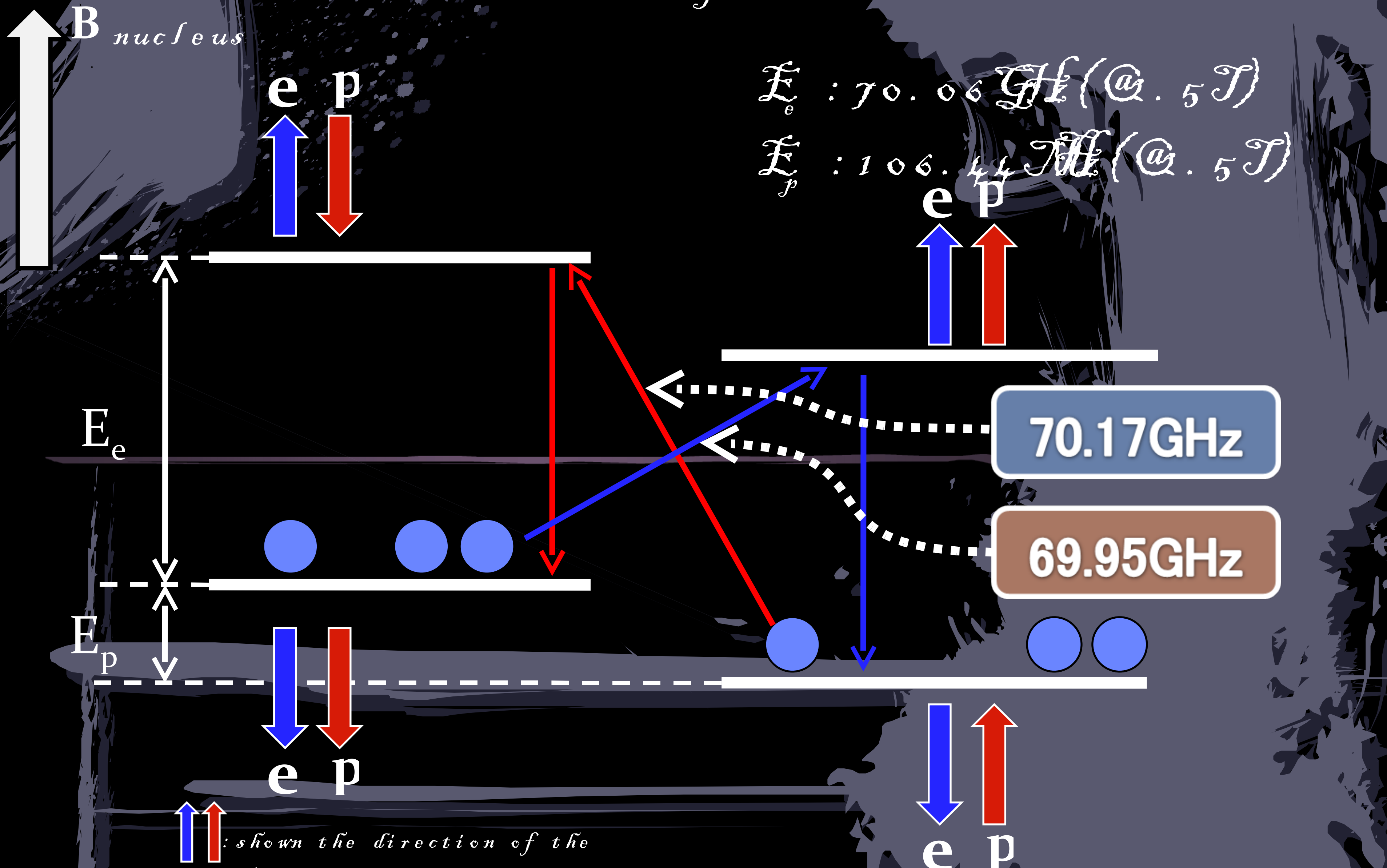

Target selection EPM

Polymer target

Avantage Solid (at normal temperature) Easy Processing [very thin(fine)target can be made
large surface area Coling is easy
The target of the aimed thickness can be made.

polyethylene

Dilution factor: 1/7
crystallized → It is **hard** to mix free radical(TEMPO)

polystyrene

Dilution factor: 1 / 13
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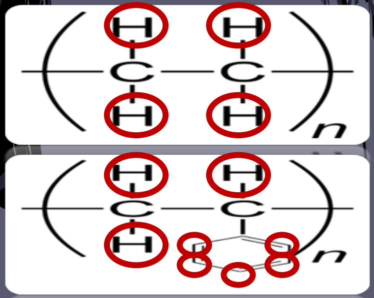


○ : Plarization object

Hgh Dlution factor

easy to mix free radical

Polymer

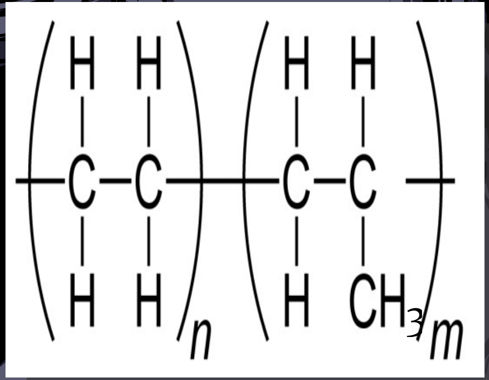
What is EPM?

Ethylene-Propylene-copolymer

A copolymer of Ethylene and Propylene (49 : 51) wt%

Dilution factor : 1 / 7 (equal with PE)

easy to mix free radical (SG 0.86 0.87 Non crystallized)



technologic In the shape of a film easily by a gummy property

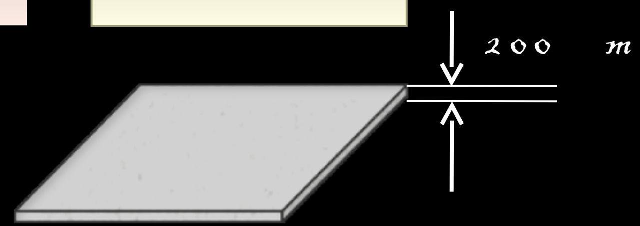
PE	PS	EPM
Heating	dissolve it in a solvent	compress by jig
compress by jig	vaporize a solvent	
	compress by jig	

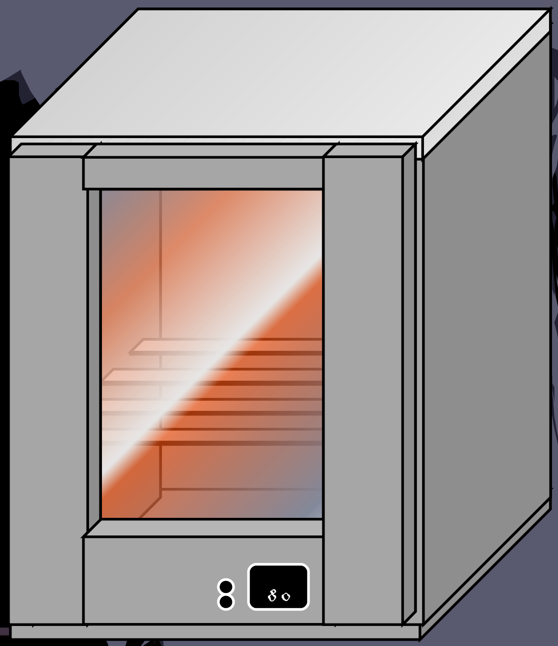
general processing method

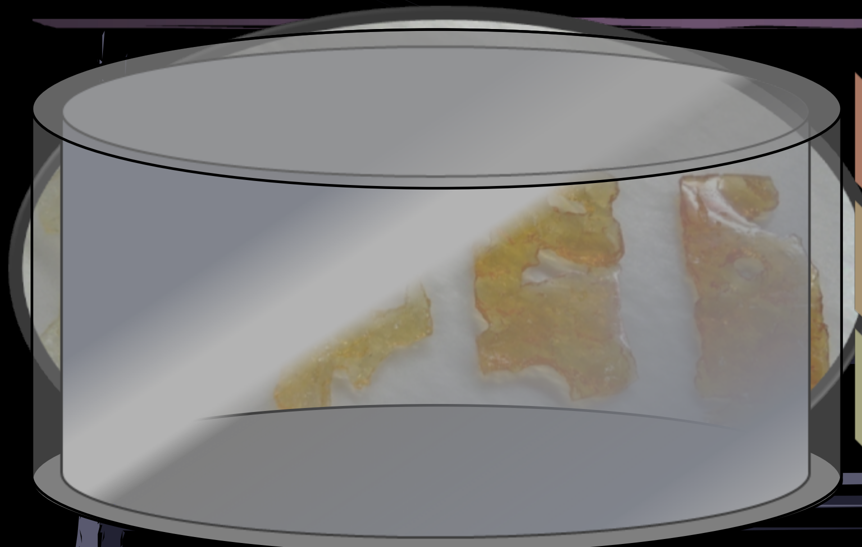
Mixture of Free radical to EPM

Diffusion mixture method

TEMPO (Free radical) + EPM

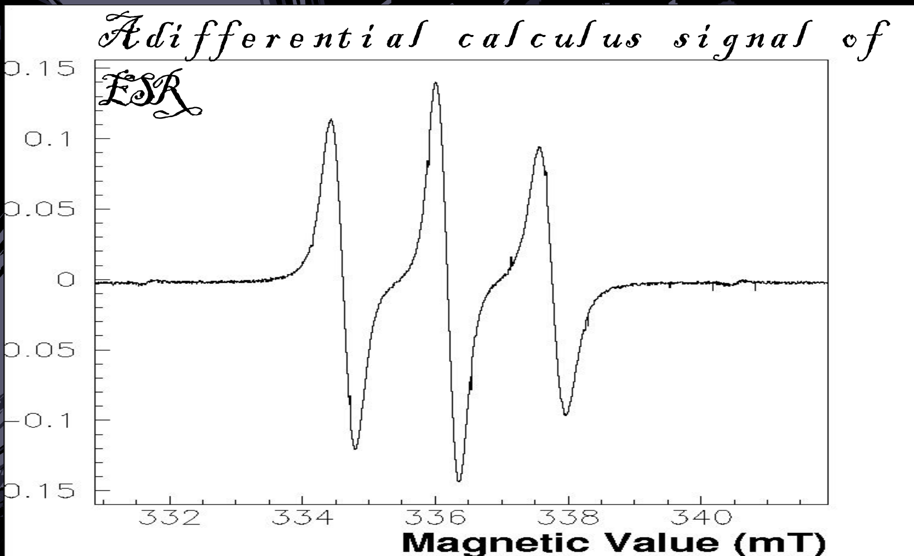


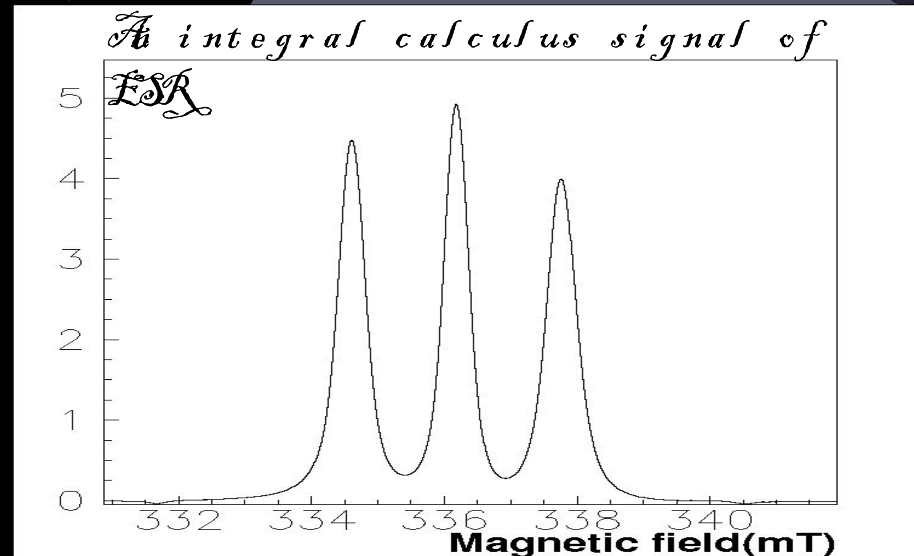




1. · Put TEMPO and EPM in a glass container
2. · heat with constant temperature tank of 80℃
3. · 18 hours later, I take it out

A state of TEMPO in EPM

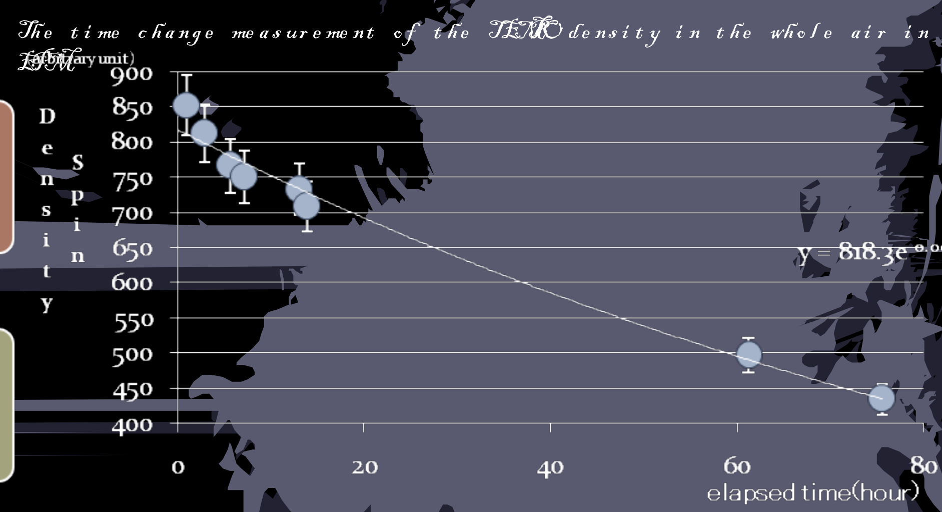




Spin density

1.64×10^{20} spin/cc

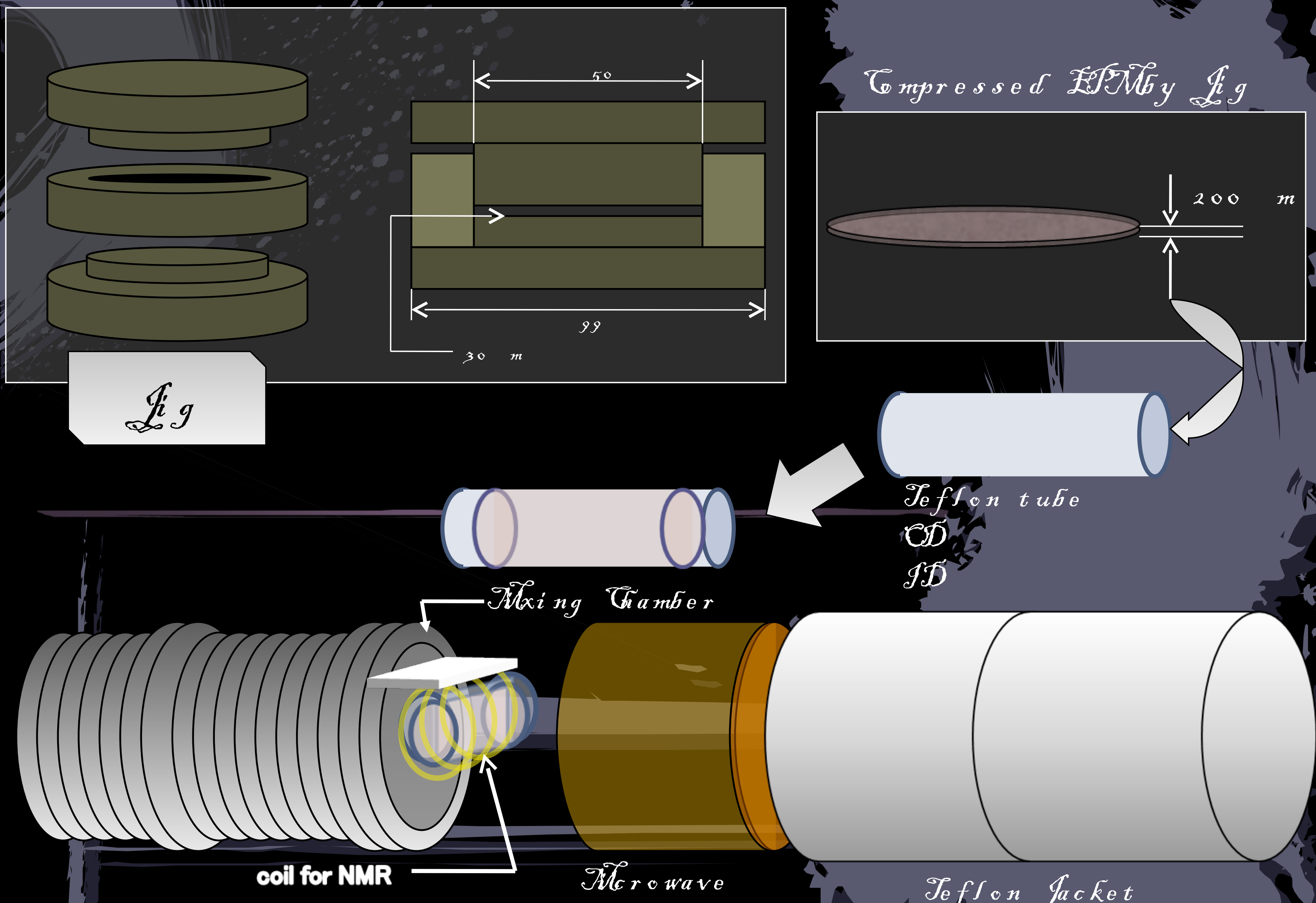
TEMPO is distributed uniformly



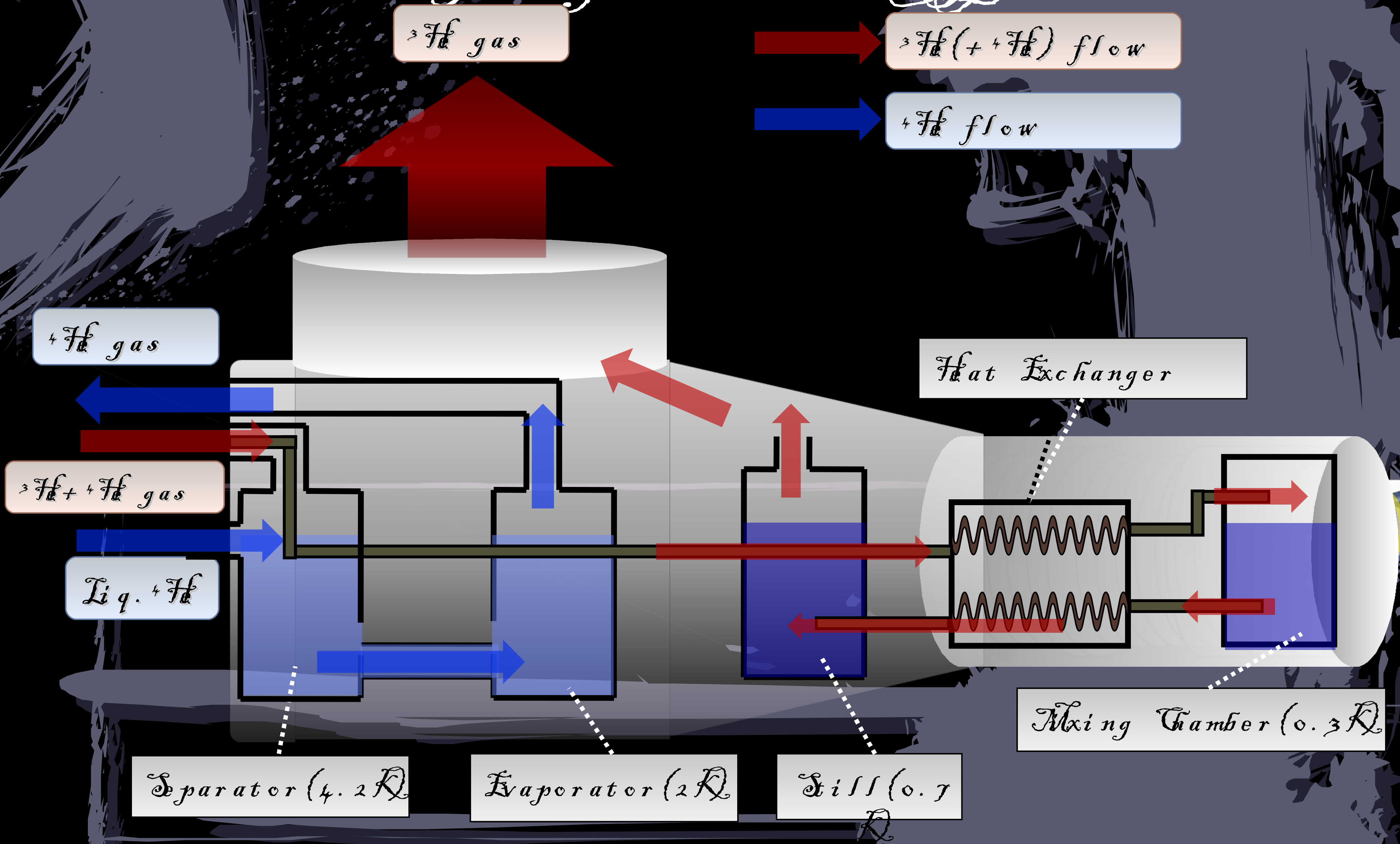
TEMPO content decrease with progress in time

take it out just before Target wearing

Wearing of Polarization Target EPM

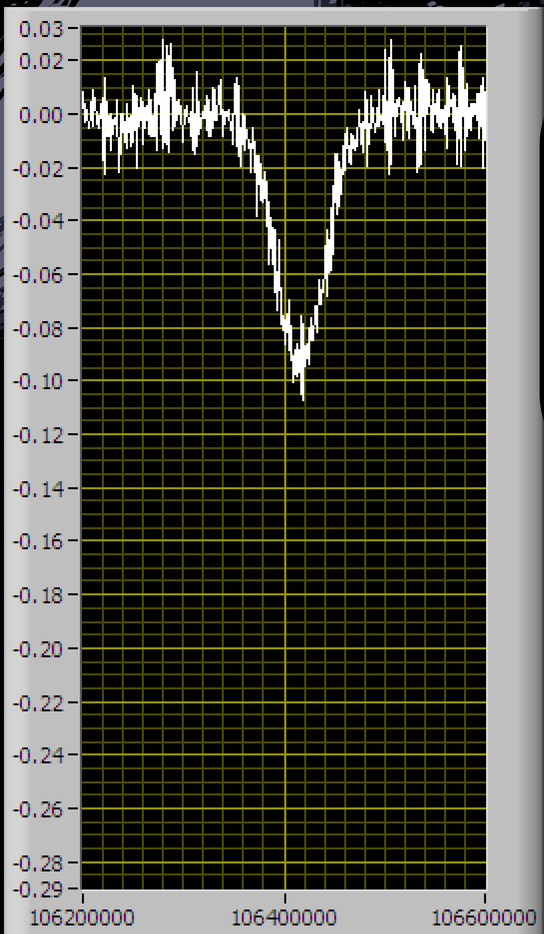


Coling System(CRYOSTAT)

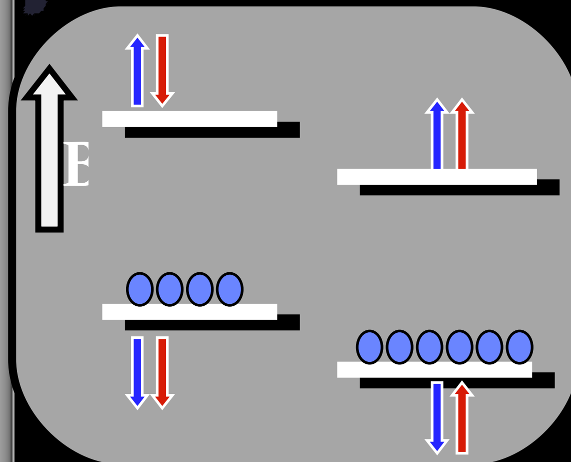


The TE signal measurement of EPM

8.88K



Polarization 0.028%



engaged in Boltzmann distribution

depend on temperature

NMR

f=106.44MHz , B=2.5T

Polarization of TE(spin=1/2)

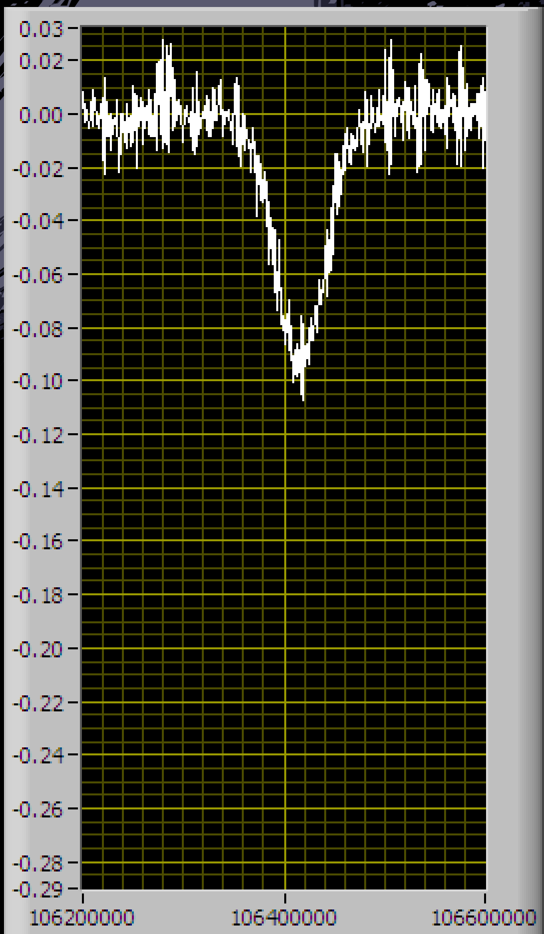
$$P_{TE} = \frac{e^{-\frac{(-\mu B)}{kT}} - e^{-\frac{\mu B}{kT}}}{e^{-\frac{(-\mu B)}{kT}} + e^{-\frac{\mu B}{kT}}} = \frac{2\sinh\left(\frac{\mu B}{kT}\right)}{2\cosh\left(\frac{\mu B}{kT}\right)}$$

$$P_{TE} = \tanh\left(\frac{\mu B}{k_B T}\right)$$

If an NMR signal grows big, Polarization grows big

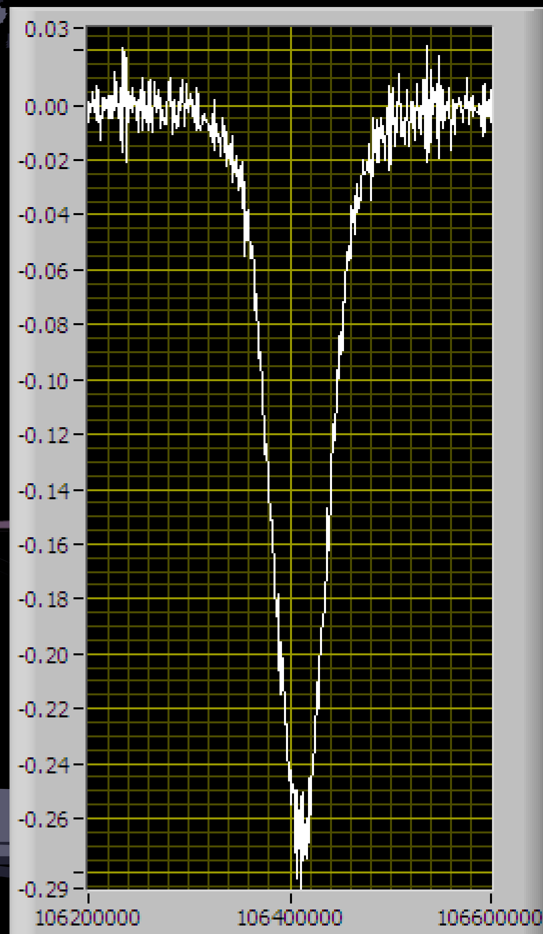
The TE signal measurement of EPM

8.88K



Polarization
0.039%

1.45K



Polarization
0.176%

NMR

f=106.44MHz , B=2.5T

Polarization of TE(spin=1/2)

$$P_{TE} = \frac{e^{-\frac{(-\mu B)}{kT}} - e^{-\frac{\mu B}{kT}}}{e^{-\frac{(-\mu B)}{kT}} + e^{-\frac{\mu B}{kT}}} = \frac{2\sinh\left(\frac{\mu B}{kT}\right)}{2\cosh\left(\frac{\mu B}{kT}\right)}$$

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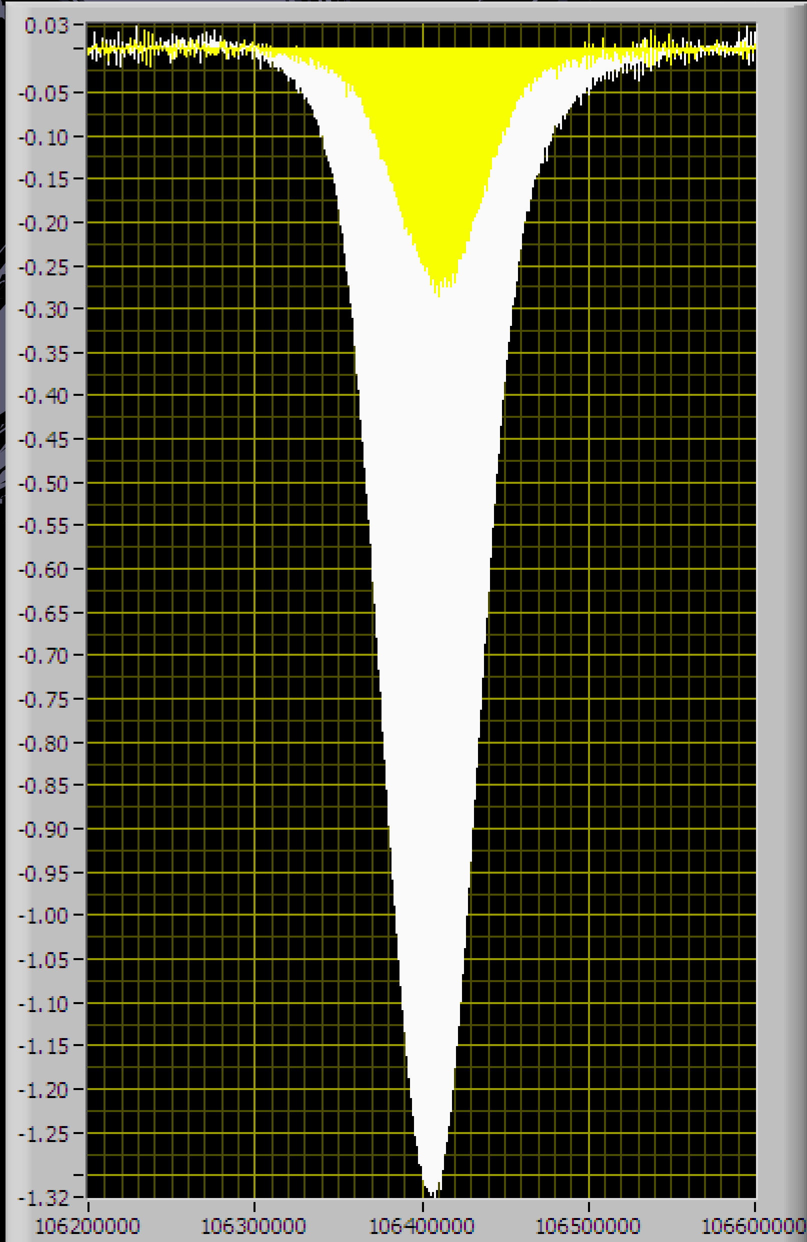
- If an NMR signal grows big, Polarization grows big

TE Signal changes in correspondence with temperature

Polarization of EPM by DNP(1)



TE (1.47K)

DNP [positive polarize] (1.52K)

Microwave Power : 10 mW

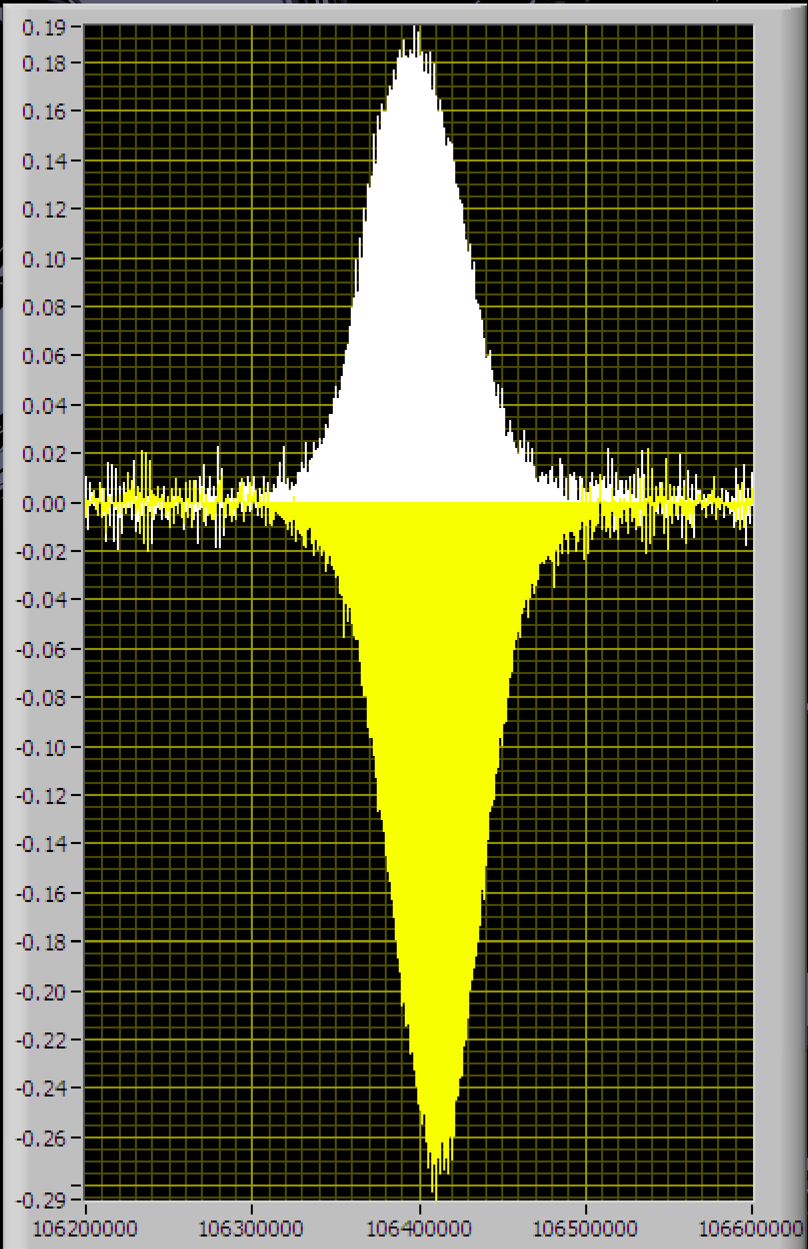
Micro Wave Frequency: 69.918 GHz

Enhance

5.1 times of TE

Polarization 0.90%

Polarization of EPM by DNP(2)



TE (1.47K)

DNP[negative polarize] (1.50K)

Mcrowave Power : 10 mW

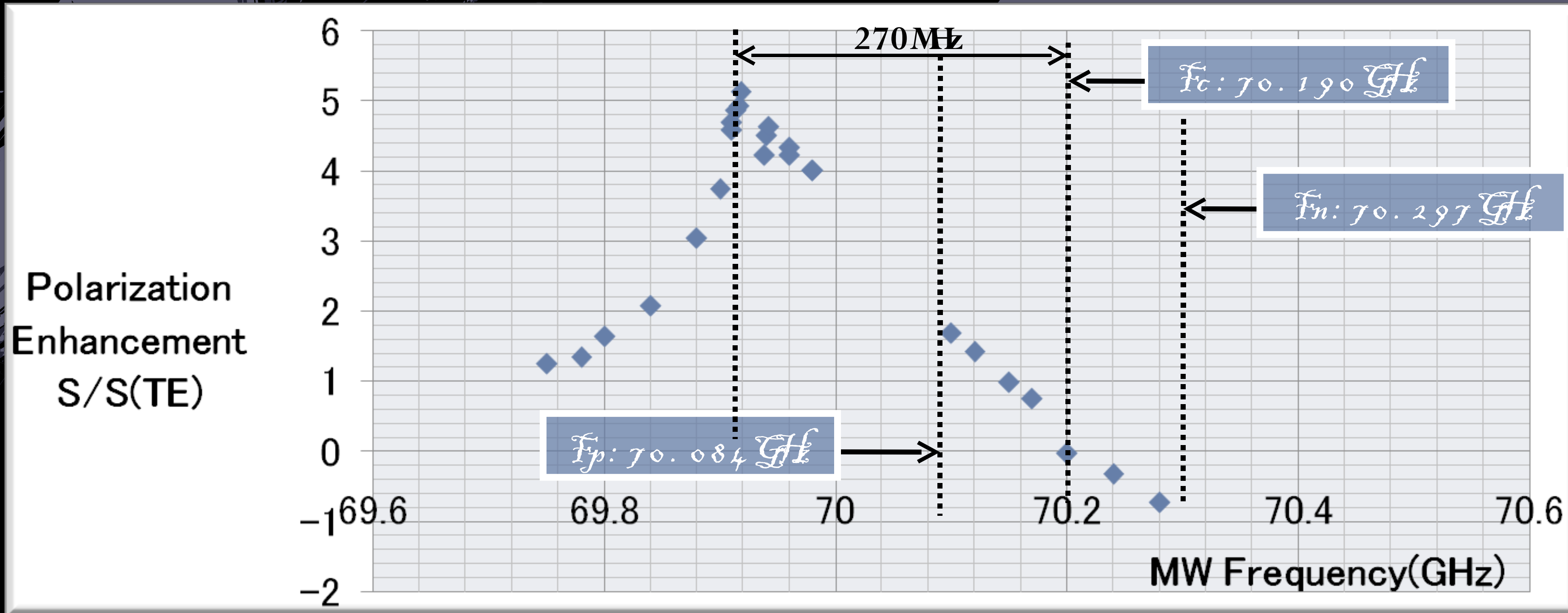
Mcro Wve Frequency: 70.280 GH

Enhance

-0.72 times of TE

Polarization -0.12%

depend on MW frequency in DNP



Fc: Electronic(TEMPO) center frequency(@2.5T)

Fp: Frequency of Max Positive polarization(calculation value)

Fn: Frequency of Max Negative polarization(calculation value)

MAX positive polarization

: 69.92GHz

Enhancement in Fc → 0

A summary and a challenges for the future

Summary

- The establishment of the TEMPO mixture method to EPM For spin density of radical adjustment possibility
- confirm Polarization excitation of proton in EPM for the first time

  Positive Polarization 0.90%

challenges

- Optimization of the spin density
- optimize the ratio of ^3He and ^4He Dilution freezing

  test it at low temperature more

  give ability for cooling

  incident by a more extreme loud microwave


END