Heat input into target material for the COMPASS future program

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Rech
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Contents

Physics motivation

to be published in Compass-note
by Dubna and Torino Groups

COMPASS

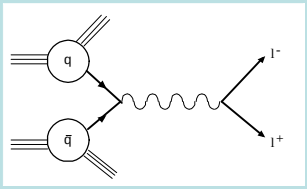
-muon program : pol. muon beam + pol. nucleon target

-hadron program : unpol. hadron beam + unpol. target

⇨ unpol. hadron beam + pol. nucleon target (SSA)

Drell-Yan process

Two leptons outcoming



⇨ Sivers function : relating to quark orbital angular momentum

Transversity distribution in nucleons

Transversely polarized target is needed

Requirement to target

-High intensity hadron beam

~10^8 hadrons/spill, 1 spill is ~5 sec

-Frozen spin mode with 0.42T

-Smaller diameter target

-Proton target

with high polarization and high dilution factor

Investigate the possibility of

-smaller beam focus size and target cell

-higher beam intensity

via

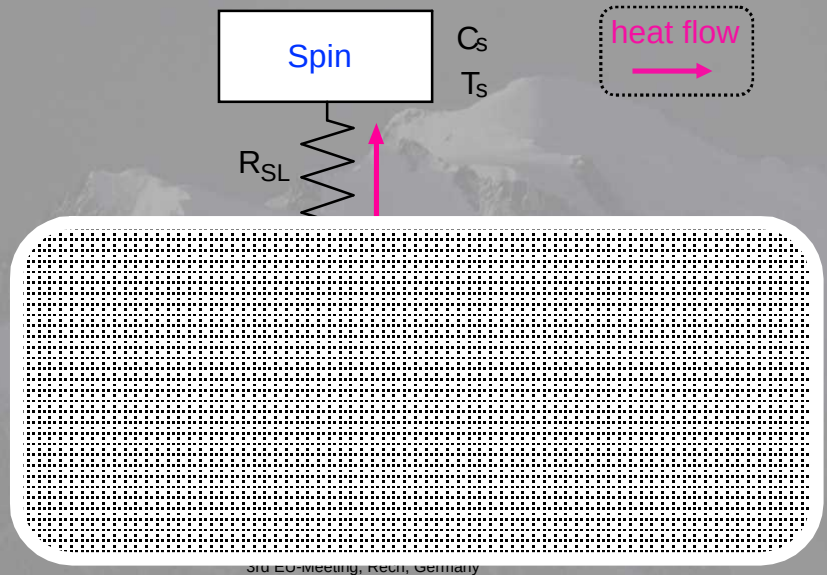
-temperature variation of the material

-total heat input into MC

with

-NH_3

Heat flow diagram



Specific Heat

$$C_L = C_{phonon} + C_{electron} + C_{cryocrystal} + C_{non\text{-}crystal}$$

$$C_{phonon}(T) = \frac{12}{5}\pi^4 N_0 k_B \left(\frac{T}{\theta_D}\right)^3$$

θ_D : Debye temperature
^{7}LiH ~1190K
^{7}LiD ~1030K
$^{14}NH_3$ ~235K

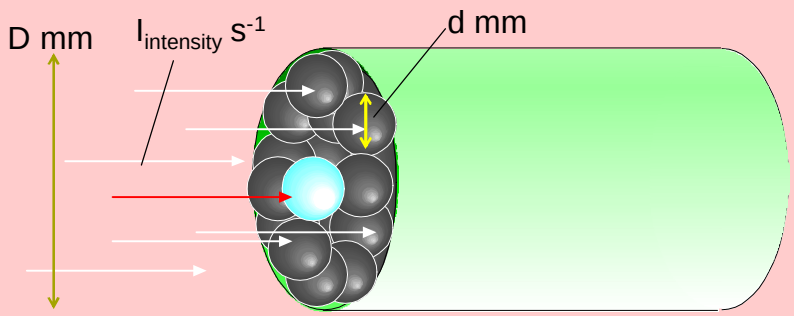
$$C_{electron}(T) = \gamma T$$

γ : Li 1.63 mJ/mol K²

$C_{cryocrystal}(T)$ = ?? For NH_3, ND_3

$C_{non\text{-}crystal}(T)$ = ?? For butanol?, CH_2, CD_2

Model for calculation of temp. variation



Target material : spherical shape, LiD: d=4 mm, NH_3: d=3 mm

Beam focus = target size: circular cross section, D=30mm for muon program

Beam interval for one bead : ν $\quad \frac{1}{\nu} = \frac{d^2}{D^2} \cdot I_{intensity} \cdot N_{2nd}$

Secondly particle productions probability factor

Algorithm for the calculation

Beam interval: $t_i - t_{i-1} = \nu$ sec

$E_{deposit} = m\, C_L(T(t_{i-1}))\, (T(t_i) - T'(t_{i-1}))$ ⇨ $T(t_i)$

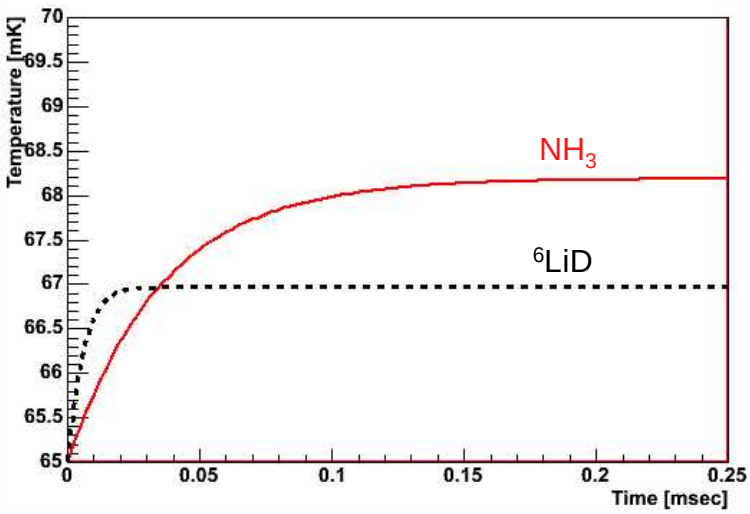
$$\int_0^{\nu} \dot{Q}\, dt = \int_0^{\nu} \frac{A}{R_K} (T(t_{i-1})^4 - T_0^4)\, dt$$

T_0 = 65 mK

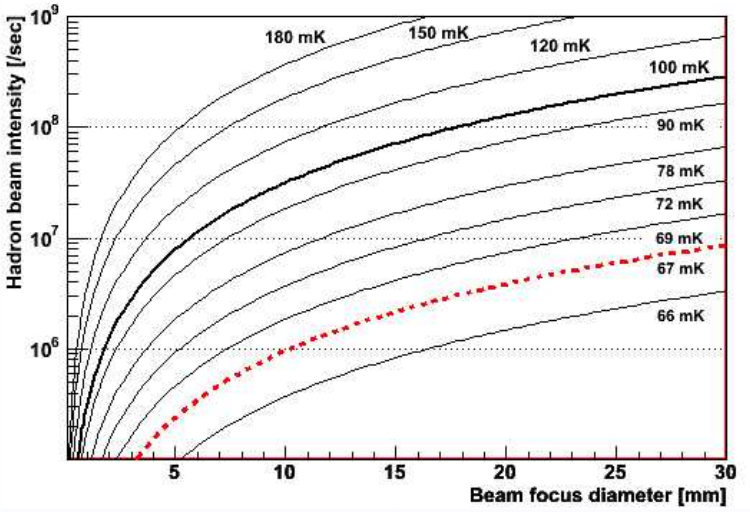
R_K = 50 cm^2K^4/W (CrK crystal - ^4He)

$$T'(t_i) = \frac{E_{deposit} - Q}{m\, C_L(T(t_{i-1}))} + T(t_{i-1})$$

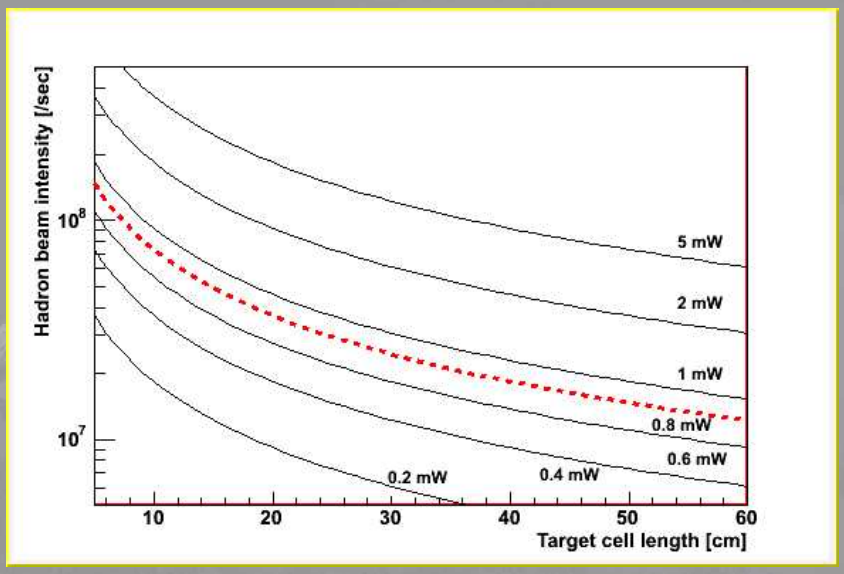
Temperature variation in muon program setup



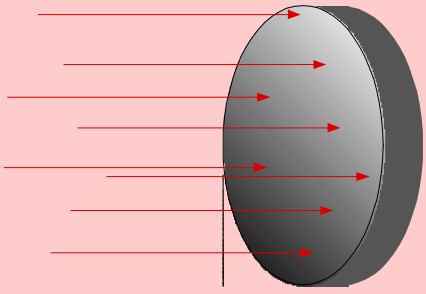
Hadron beam vs beam focus size for NH_3



Total heat input for NH_3



Model for COSY-TOF



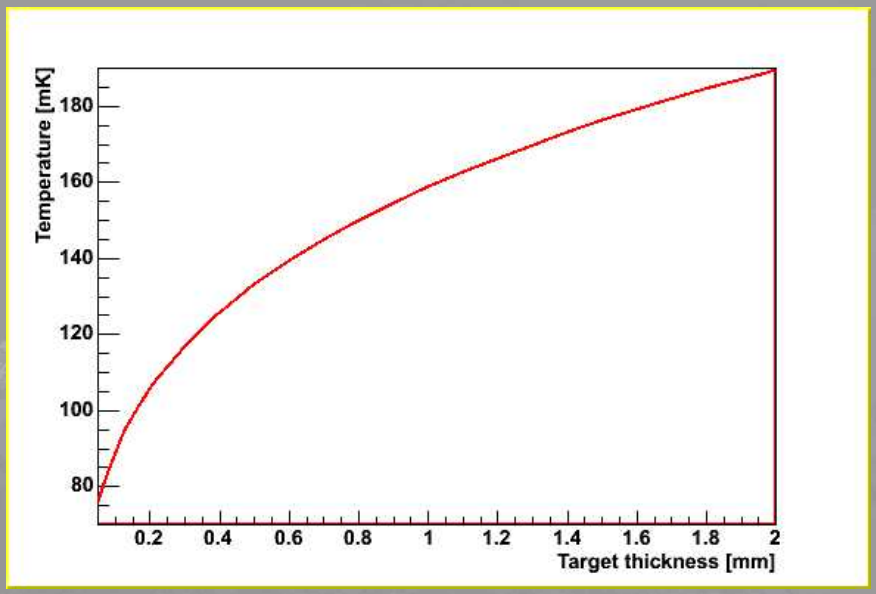
Beam focus size = target cross section = 1mm^2

Beam intensity : 10^7 protons/sec

Heat flow : front and end faces

^{7}LiH target, N_{2nd} = 1, T_0 = 60 mK

Temperature vs Target thickness



For the future

-Consistent to the experimental data??
MC temperature, cooling power and spin relaxation time

-Estimation of the spin relaxation speed in the frozen mode with different beam intensity.

Jaakko COMPASS-note

-Specific heat

Ammonia : $C_{cryocrystal}$

Butanol : Debye temperature, $C_{cryocrystal}$ or $C_{noncrystal}$

-Kapitza resistance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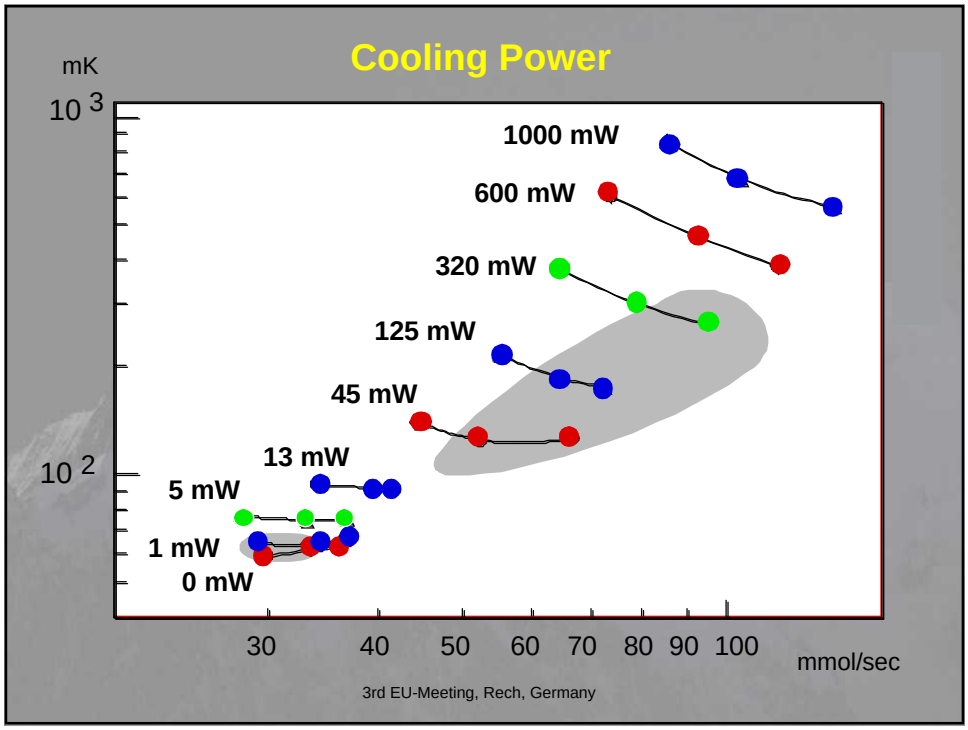
Cooling Power
mK
10 3
10 2
1000 mW
600 mW
320 mW
125 mW
45 mW
13 mW
5 mW
1 mW
0 mW
30
40
50
60
70
80
90
100
mmol/sec
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