A ^{7}LiH Polarised Target for High Intensity Beams

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COSY-TOF Collaboration

Introduction
Heat conduction
Preparation
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Estimations
Summary

Introduction

- Pentaquark recently claimed to be found
- Low statistics
- Idea to measure Parity (C. Hanhart, Phys. Lett. B 590)
- Double Polarisation experiment
- Intense Proton beam (10^7 s^{-1})
- Problem: Depolarisation

Choice of Target material

- Polarisation resistance to Beam:
  2 possible candidates:
  Ammonia or even better LiH
- Calculation based on (M. Plückthun Phd Bonn) show
  for butanol: Target thickness $\simeq$ 0.2 mm
  for heat transfer
- Ammonia gaseous at RT
- LiH more easy to handle

Heat Conduction

- Beam dissipates heat inside Target
- Low temperature: phonon mismatch between target surface and He-bath

$\rightarrow$ Kapitza resistance $R_K \propto T^{-3} \propto A^{-1}$

$\rightarrow$ large surface   low thickness

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Principles

$\vartheta = \vartheta(\vec{x}, t)$ temperature field

Fourier: $\dot{\vec{q}}\,(\vec{x}, t) = -\lambda \,\mathrm{grad}\, \vartheta(\vec{x}, t)$

1st law of TD: $\frac{dU}{dt} = \dot{Q}\,(t) + P(t)$

$$\rho\, c(\vartheta)\, \dot{\vartheta} = \mathrm{div}[\lambda(\vartheta)\mathrm{grad}\vartheta] + \dot{W}\,(\vartheta, \vec{x}, t)$$

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Stationary case

$\dot{\vartheta} = 0$

$\rightarrow \quad \mathrm{div}[\lambda(\vartheta)\mathrm{grad}\vartheta] = -\dot{W}(\vartheta, \vec{x}, t)$

$\lambda = const$

$$\rightarrow \quad \lambda \nabla^2 \vartheta = -\dot{W}(\vartheta, \vec{x})$$

Boundary conditions:

1st: $\vartheta_{surf.}(\vec{x})$ 2nd: $\dot{q}(\vec{x}) = -\lambda \frac{\partial \vartheta}{\partial n}$

Inside a cooling medium:

3rd: $-\lambda \frac{\partial \vartheta}{\partial n}\Big|_{surf.} = \alpha(\vartheta_{surf.} - \vartheta_{fluid})$

α contains R_K $\rightarrow$ Nonlinearity !!

$$\lambda(\vartheta) \nabla^2 \vartheta = -\dot{W}(\vartheta, \vec{x})$$

This is now calculated in Bonn with Finite Elements

Without simplification

$$\lambda = \lambda(\vartheta)$$

$$\mathrm{div}[\lambda(\vartheta)\mathrm{grad}\vartheta] = -\dot{W}(\vartheta, \vec{x})$$

Temperature transformation leads back to

$$\Theta = \Theta_0 \frac{1}{\lambda_0} \int_{\vartheta_0}^{\vartheta} \lambda(\vartheta) d\vartheta$$

Poisson equation

not allowed for BC of 3rd kind !

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Raw material

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Lucky punch

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0,5 mm standard

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Workshop

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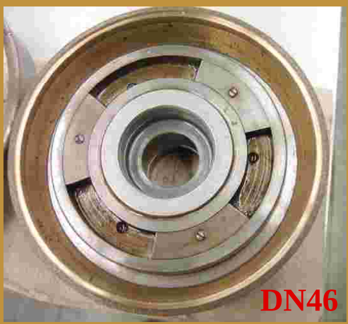
Grinding wheel



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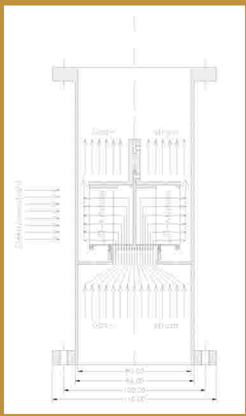
Irradiation



- e⁻ -irradiation at Bonn Linac I (see COMPASS material)
- irradiation kryostat still there not in use for 5y
- required dose investigated
- Linac I out of order untill ? ?

Expected Polarisation

Saclay, dilution

Material	T_{irr} K	Dosis 10^{17} cm^{-2}	$P_{Lith.}$ %	$P_{Prot.}$ %	B T	$t_{build-up}$ h
^{7}LiH	190	100%	30	-	2,5	3,5
^{7}LiH	180	100%	50	70	5,0	24
^{7}LiH	180	200%	47	56	2,5	6
^{7}LiH	190	200%	-42	-52	2,5	10
^{7}LiH	180	300%	44	58	2,5	11

Bonn, ^{4}He

Material	T_{irr} K	Dosis 10^{17} cm^{-2}	$P_{Prot.}$ %	ΔP %	T K	B T	$t_{build-up}$ min
^{7}LiH	160	100%	3,0 / 11,0**	0.5	1	2.5	
^{7}LiH	180	100%	11 / 14,5***	1.0	1	2.5	52
^{7}LiH	180	200%	8.5	1.0	1	2.5	
^{7}LiH	180	400%	7.0	1.0	1	2.5	
^{7}LiH	190	100%	10,0 / 10,0**	0.5	1	2.5	
^{7}LiH	200	100%	9.5	0.5	1	2.5	

„Plückthun estimate“

- Calculation for ***0,5 mm LiH cylinder*** of radius 2,5mm
- „reasonable“ values for material constants

	beam (1 mm)	no beam	bath
temperature	230mK	160mK	100mK

Sintered Target ?

- Very high surface → heat flow to medium
- In metals: ≈ 2 m^2/g
- Temperaure + pressure + H_2 -athmosphere
- Thermal conductivity reduced, but unknown

NaCl, pressed

Summary

- Distinctly increased beam resistance demanded
- Thin slices in a row
- ^{7}LiH down to 0,5 mm possible
- Calculations performed
- Irradiation facility for further work