CsI(Pure) detector for heavy ion under high rate condition

1

RIKEN NISHINA CENTER

SATORU TERASHIMA

Collaborators

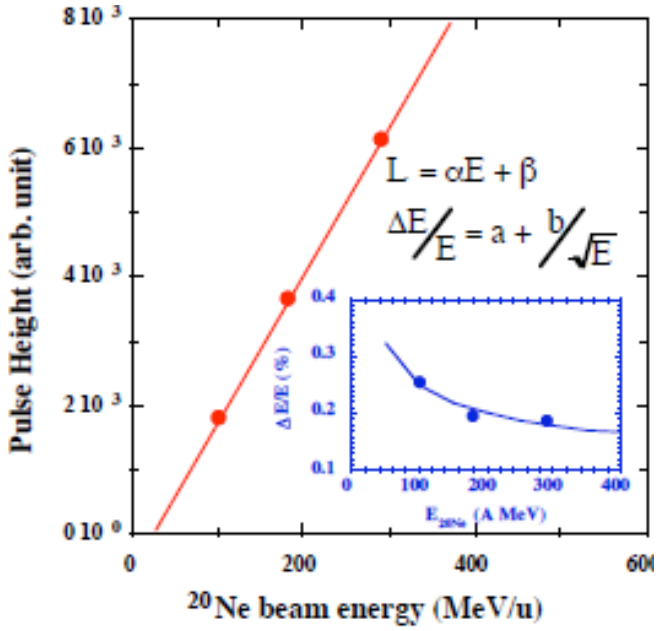
ESPRI Group

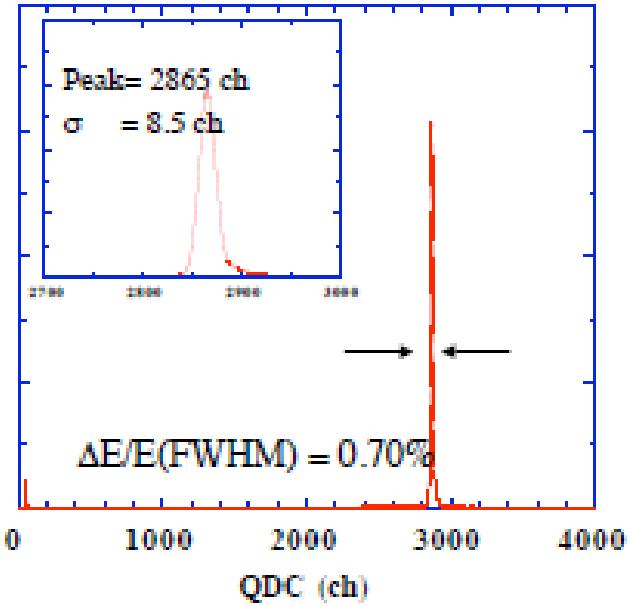
HIMAC-P179, P213 collaborations

- RIKEN H. Takeda, K. Tanaka, K. Ozeki, H. Otsu, K. Yoneda, Y. Watanabe, T. Ichihara, T. Suda
- Miyazaki University H. Sakaguchi, A. Nonaka, N. Fujita
- Kyoto University J. Zenihiro, T. Murakami,
- Tohoku University Y. Matsuda, T. Kobayashi
- Tokyo Institute of Technology Y. Sato

Motivation

- Inorganic scintillator has good energy resolution about 0.3% [σ]
- These scintillators can be operated under high rate counting?
- These detector response could satisfied to RIBF high intense beam?





From Suda-san
at RIKEN/HIMAC

Single measurement and background

Inverse kinematics + Missing mass

H_2 (HI, p[']) HI[*]

Need information of scatter HI or not?

①、Z measurement
- Quai Scattering H(^{20}O,pp)19N
- Reaction Cross Section H(^{20}O⇒otherRI,p) ⇨ performed
- Variable Break Up Reaction ??

②、2 body reaction
- Quai Scattering H(^{20}O,pn)^{19}O

③、Z+A measurement ⟶ not perform [CsI(pure)??]
- Reaction Cross Section H(^{20}O⇒isotopeO,p)

④、[Subtraction from Background-Run]
- Quasi scattering from Carbon H[C](^{20}O,p)^{20}O
- Target [C] Evaporation C(^{20}O,C*⇒p)^{20}O → zero consistent
- Recoil-Cの Break Up C(^{20}O,C*⇒p)^{20}O

Specifications of typical materials

	Light [Rel.]	Decay [nsec]	Density [g/cm^3]	
• NaI(Tl)	100	230	3.67	← Otsu-san Talk
• BGO	9	300	7.13	
• CsI(Tl)	45	1300	4.51	← Otsu-san Talk
• CsI(pure)[fast]	2.3	6	4.51	
[slow]	5.6	35		
• GSO(Ce) [fast]	30	56	6.71	
[slow]	3	600		
• BaF2[fast]	2.7	0.9	4.81	
[slow]	21	630		
• LaBr3	130	16	5.29	
• Liq. Xe (-112°)	80	2,30	3.06	
• BC-408	22	2.1	1.03	

NaI(Tl) 0.2-0.3%[s]
⇒ CsI < 1-1.5% [s] expected

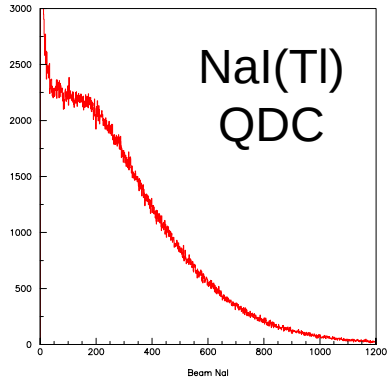
--Requirement--
Fast : High Rate
Light : High Resolution
Low price: Large Detector

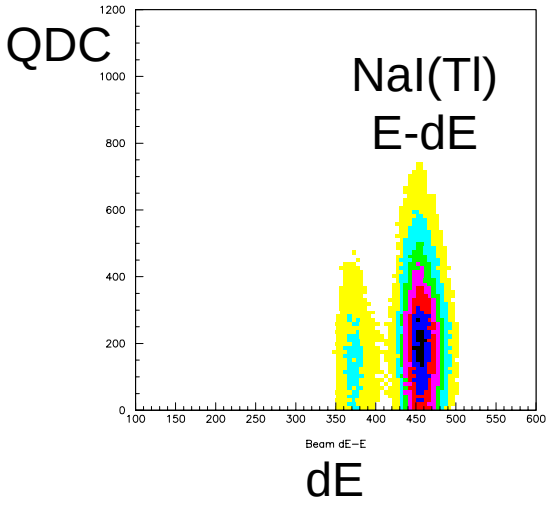
CsI(pure)

- Merit
  - Fast
  - Slightly-hygroscopic
  - Low price(?) (High-energy-people also used [KEK(E391a...), LNS(FOREST...)])
- Demerit
  - Low light output
  - Two- (Three-) components (fast, slow, very slow) 6, 35, >600 nsec

History of R&D at HIMAC

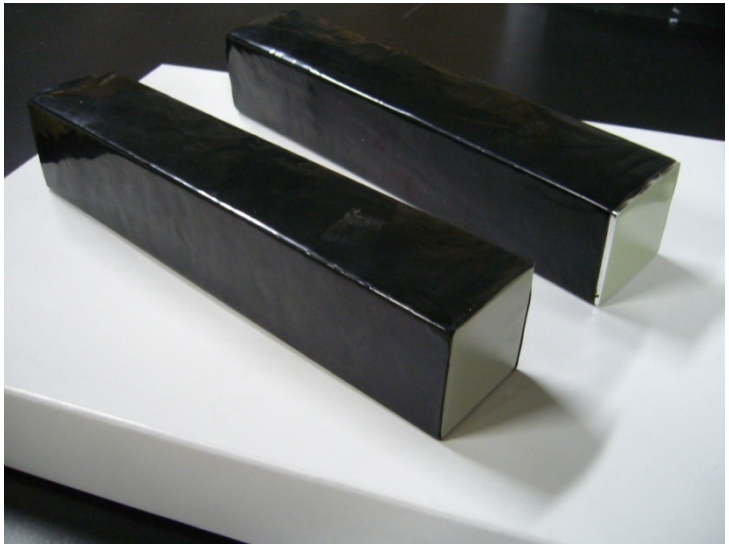
- Thick plastic for ^{20}O $10^{5\text{-}6}$Hz
  - Not operate
- NaI(Tl) with cliping for ^{20}O $10^{5\text{-}6}$Hz
  - Not operate
- CsI(pure) for ^{9}C $10^{4\text{-}5}$Hz
  - 2 x 10^4 /spill/detector Be/B/C
- CsI(pure) for ^{16}O 10^{6}Hz
  ^{20}O $10^{5\text{-}6}$Hz
  - 5 x 10^5 /spill/detector C/N/O



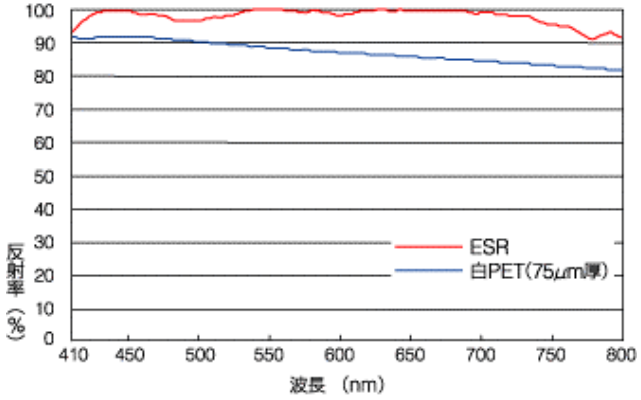


CsI(pure)

- 20 x 4 x 4 cm^3 made by HORIBA
  From Murakami-san Kyoto Univ.

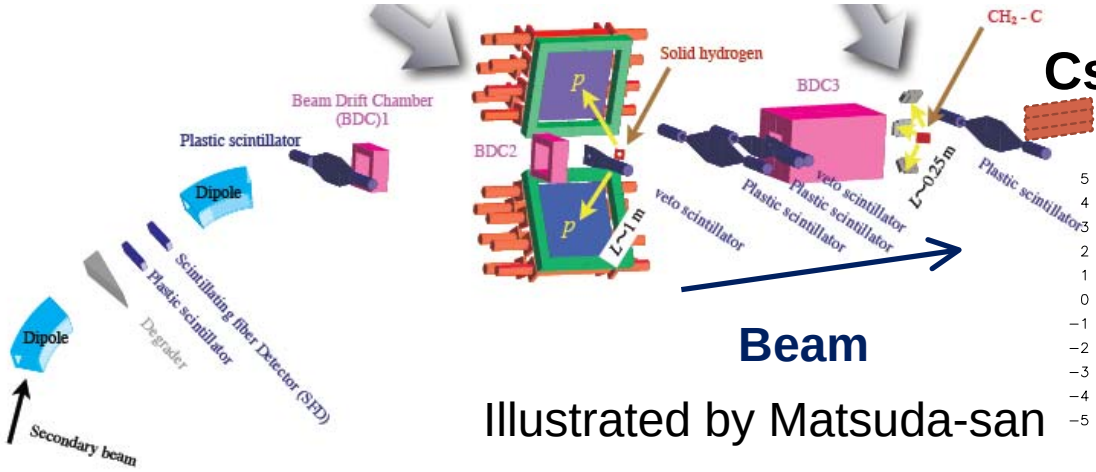


- Read out: PMT
  - HAMAMATSU R7056(1-1/8 inch)
- Entrance window for the beam:
  - Al sheet + 100um Black Sheet
- Reflection material
  Teflon sheet + Al sheet
  (or 3M ESR sheet)



Set up [^{9}C]

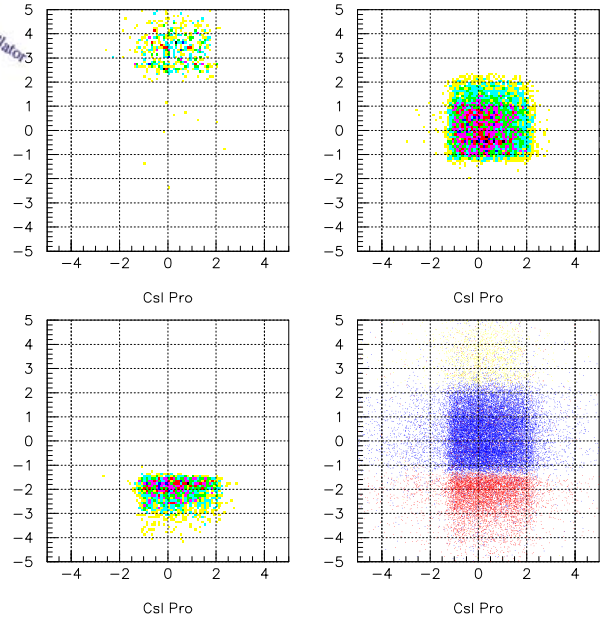
- By product experiment
  - ^{9}C (,^{8}Be, ^{7}B) ~10^{5} /spill



CsI x 3

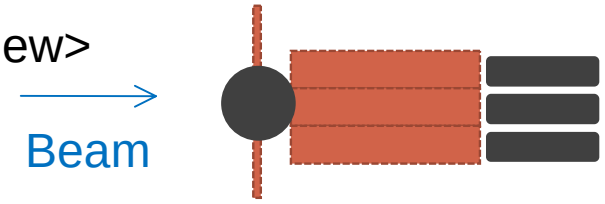
Position Tracking using Drift Chamber

Illustrated by Matsuda-san



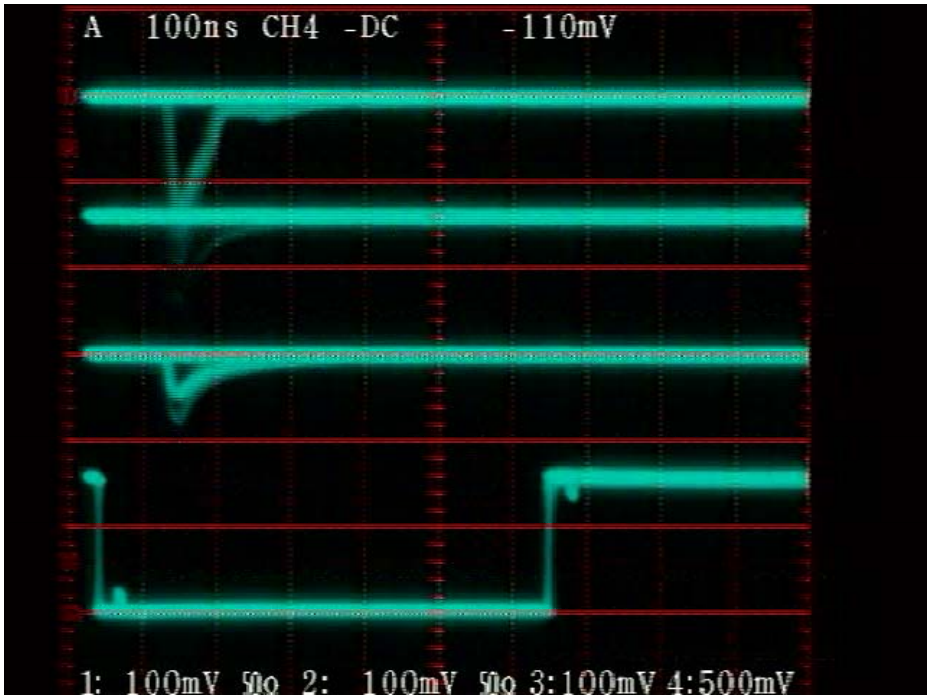
- dE[Plastic 5mm] – E [CsI 20cm]

<Side view>



^{9}C experiment

<Raw signals from PMTs>



--PMT(~1inch) specifications--

	↑	→	↓	
H6533	0.7	10	0.16	nsec
R7056	1.7	16	0.5	nsec
R7056				

<Circuit>
CsI-PMT-DCamp-QDC (2249W)

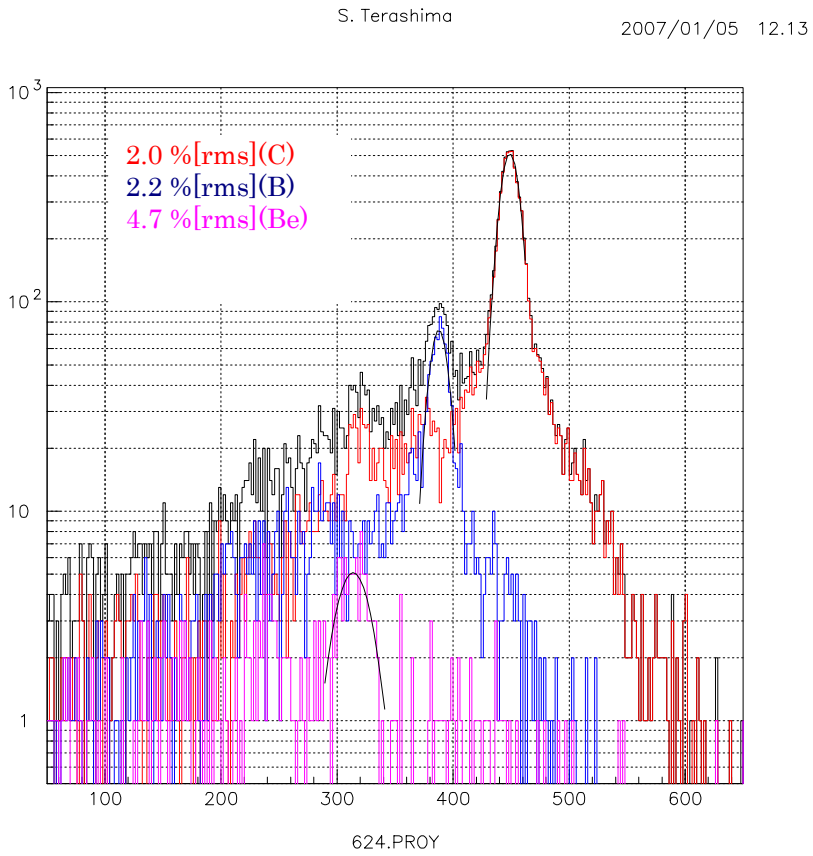
^{9}C experiment

Momentum correction using
the plastic scintillator at F1

Hit position is selected
by the drift chamber.

Beam trigger

--Fit Results--
2.0 % [s] for ^{9}C
2.2 % [s] for ^{8}B
4.7 % [s] for ^{7}Be



Set up [^{20}O]

- Higher rate up to several 10^5 Hz
- Higher total energy (A=9 ⇒A=20)
- PMT changed from R7056 to H6522
  - UV region [~310nm] sensitive
  - 1 inch to 2 inch [photo collection is twice]

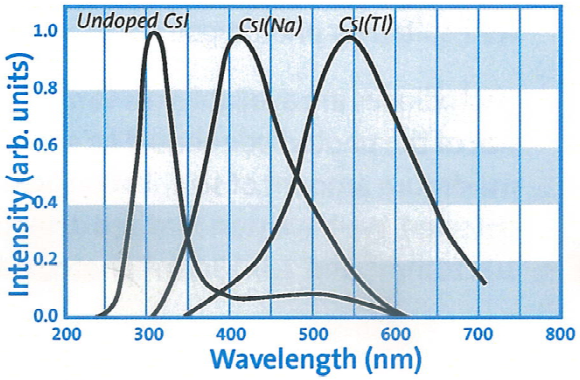
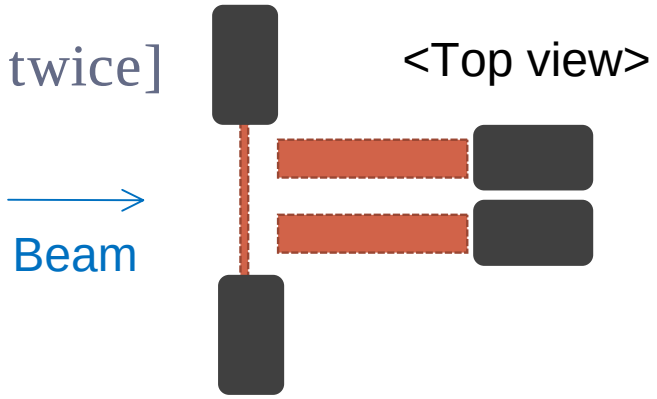
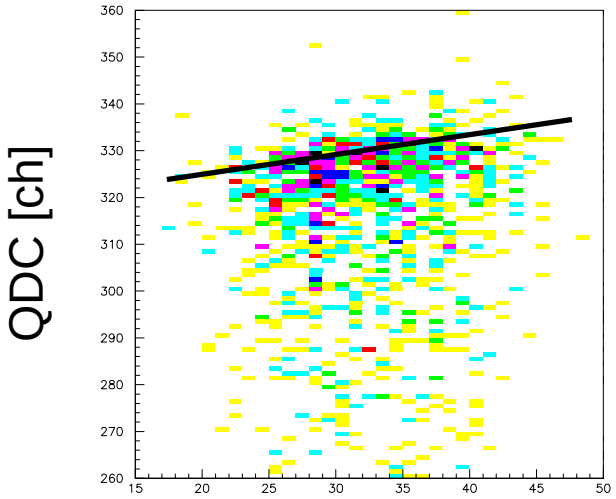


Figure 1. Scintillation emission spectrum of CsI



^{20}O experiment

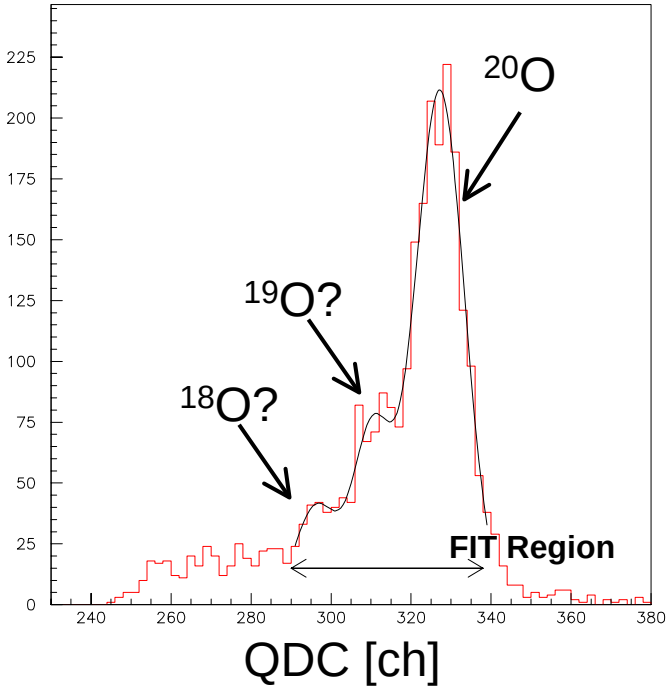


Momentum correction using
the SFD at F1 ← Matsuda-kun Talk

Position dependent is not completed.

Self TDC Gate
Z selected by the window discri. at F3 scinti.

c2/ndf=21.0/16



--Fit Results--
1.87(9) % [s] for ^{20}O
1.57(37)% [s] for ^{19}O?
1.77(52)% [s] for ^{18}O?

Energy resolution

- Energy spread of beam itself.

  ← momentum measurement : OK.

- Energy struggling
  - Many material due to by-product experiment

    Plastic, SHT, Polyethylene, Air, ...

    ← But $\delta E_{struggling} <$ sub % (σ) : OK.

- Temperature dependence?

If cooling CsI(pure)

	Decay const.	Output	Wave length
• NaI(Tl)	230 nsec	100	415 nm
• CsI(pure) R. T.	6/35 nsec	2.3/5.6	305 nm
• CsI(pure) Liq. N_2	600 nsec	217	400 nm

Cited from LEO

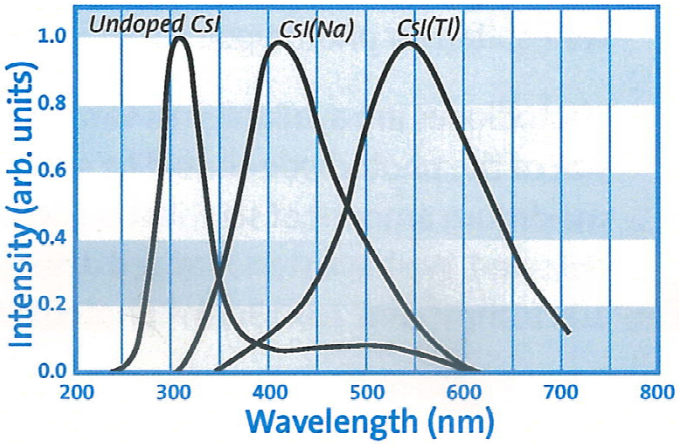


Figure 1. Scintillation emission spectrum of CsI

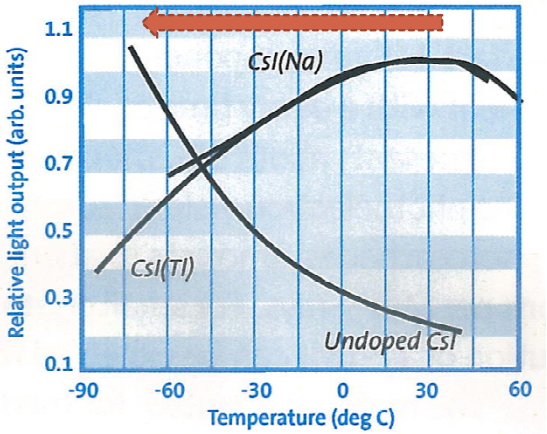


Figure 2. Relative light output as a function of temperature for CsI

Cited from Bicron

Summary and Perspective

- We have confirmed the total E detector the under high rate counting.
- Energy resolution is about 1-2% for several GeV energy.
- We will estimate bottleneck of this energy resolution.
- Cooling or other material?
  - (Liq. N ? Gain NaI x 2 but Decay constant NaI x 3)
  - Next GSO?, LaBr3? (but expensive)
  - or PWO?(relatively low price but lower light output)