J-PARC beamline WS
on May 8, 2004

Hyperball Experiments

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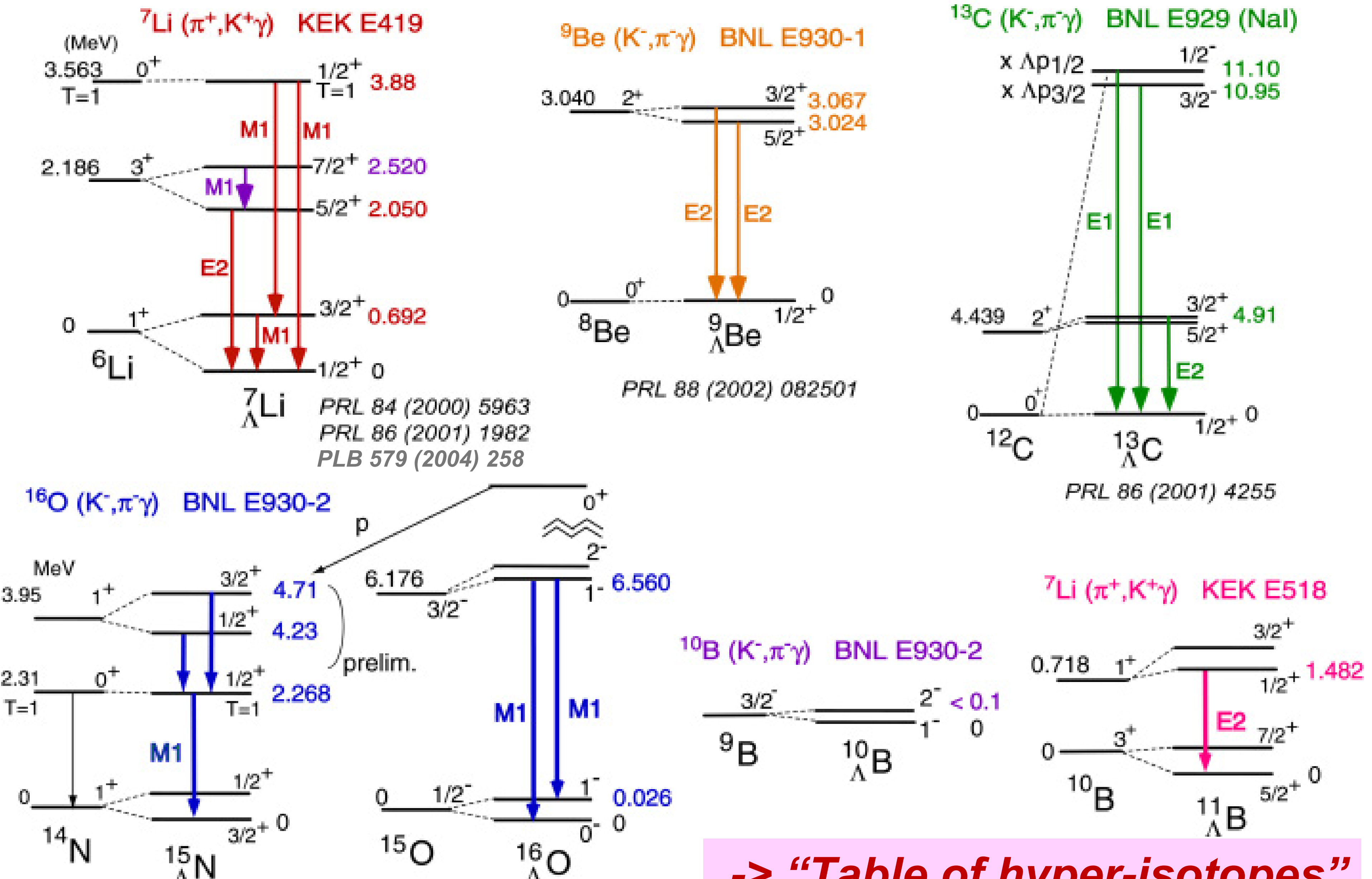
1. Present Status and Hyperball2
2. Hyperball-J and R&D
3. Experiments at J-PARC

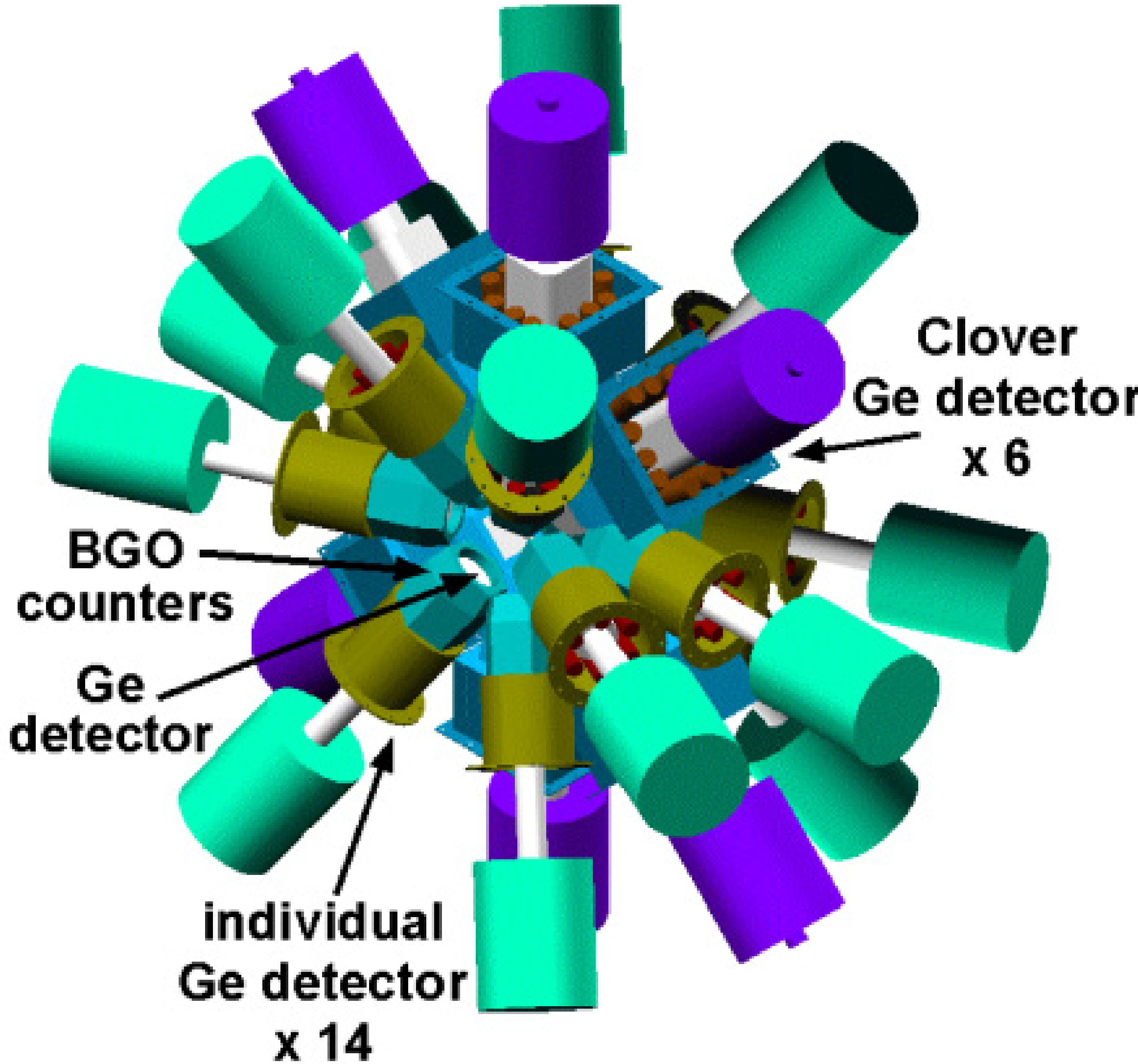
1. Present status



-> “Table of hyper-isotopes”

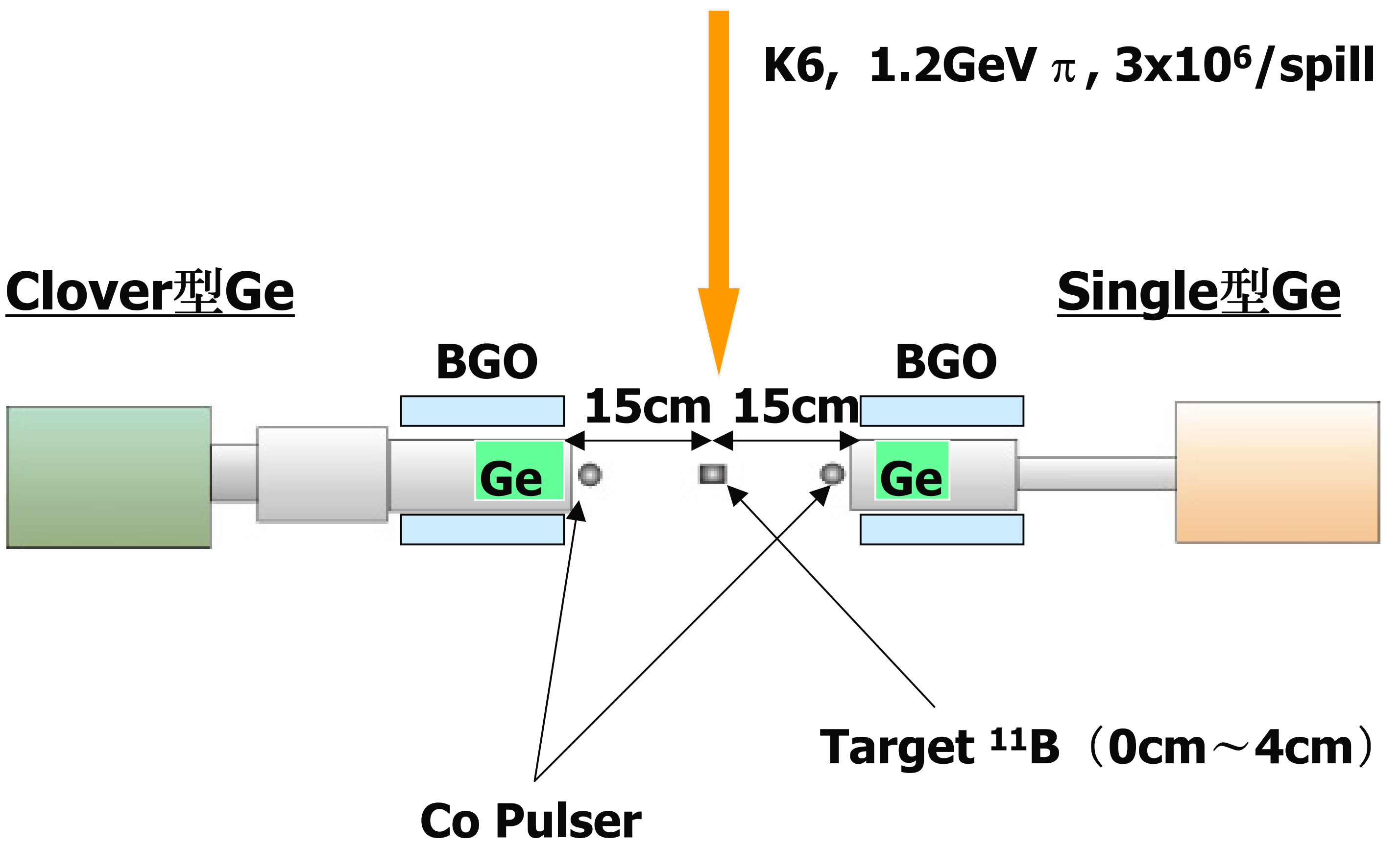
Hyperball2

- Clover Ge (r.e. >120%)
  +BGO x 6 added
- Peak eff.
  ~ 2.5% -> 5% at 1 MeV
  $\gamma\gamma$ efficiency x 4



- To be completed in Fall, 2004
- Test Exp at Tohoku Cyclotron
- To be used at KEK and/or BNL in 2005-

T536: Clover型Geテスト



Efficiencyの比較

Co-Pulserを用いたTrigger回路

↓

Beam-onとBeam-offのときのCoのPeakの数

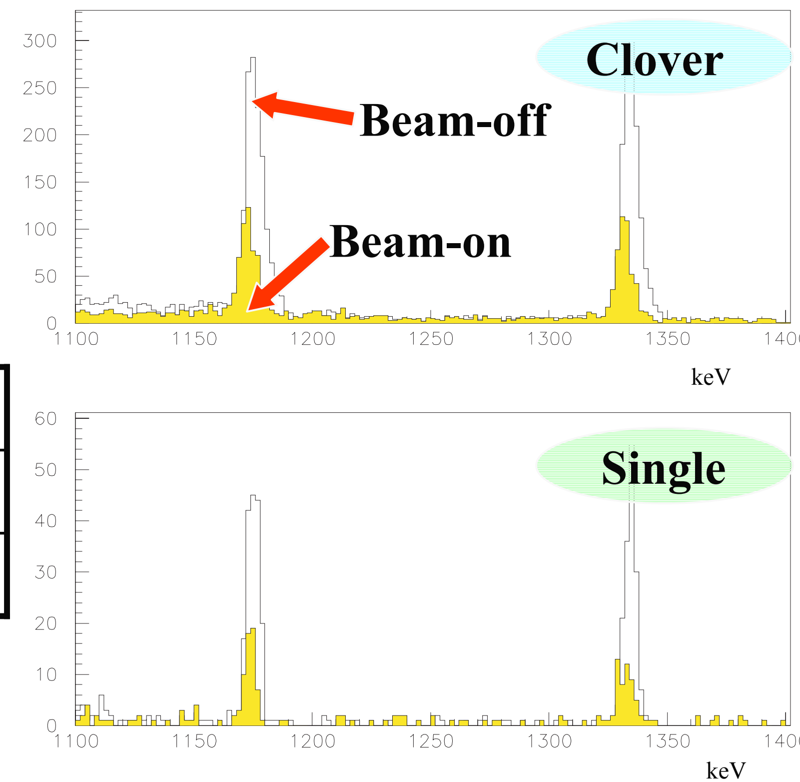
↓

Efficiency(%)：Beam−on/Beam−off

Target	0cm	2cm	4cm
Clover	61.2±1.1	50.5±2.0	44.7±1.6
Single	65.2±3.7	62.5±6.2	53.3±4.9

Cloverの方が低い？ → Trigger回路に問題が？

Ge ADC



Target　4cm

Hyperball Experiments before J-PARC

- **KEK-PS at K6**
  to be proposed in the next PAC [2005, summer?]

  $^{12}{}_{\Lambda}C$ / $^{11}{}_{\Lambda}B$: cross check, B(M1)

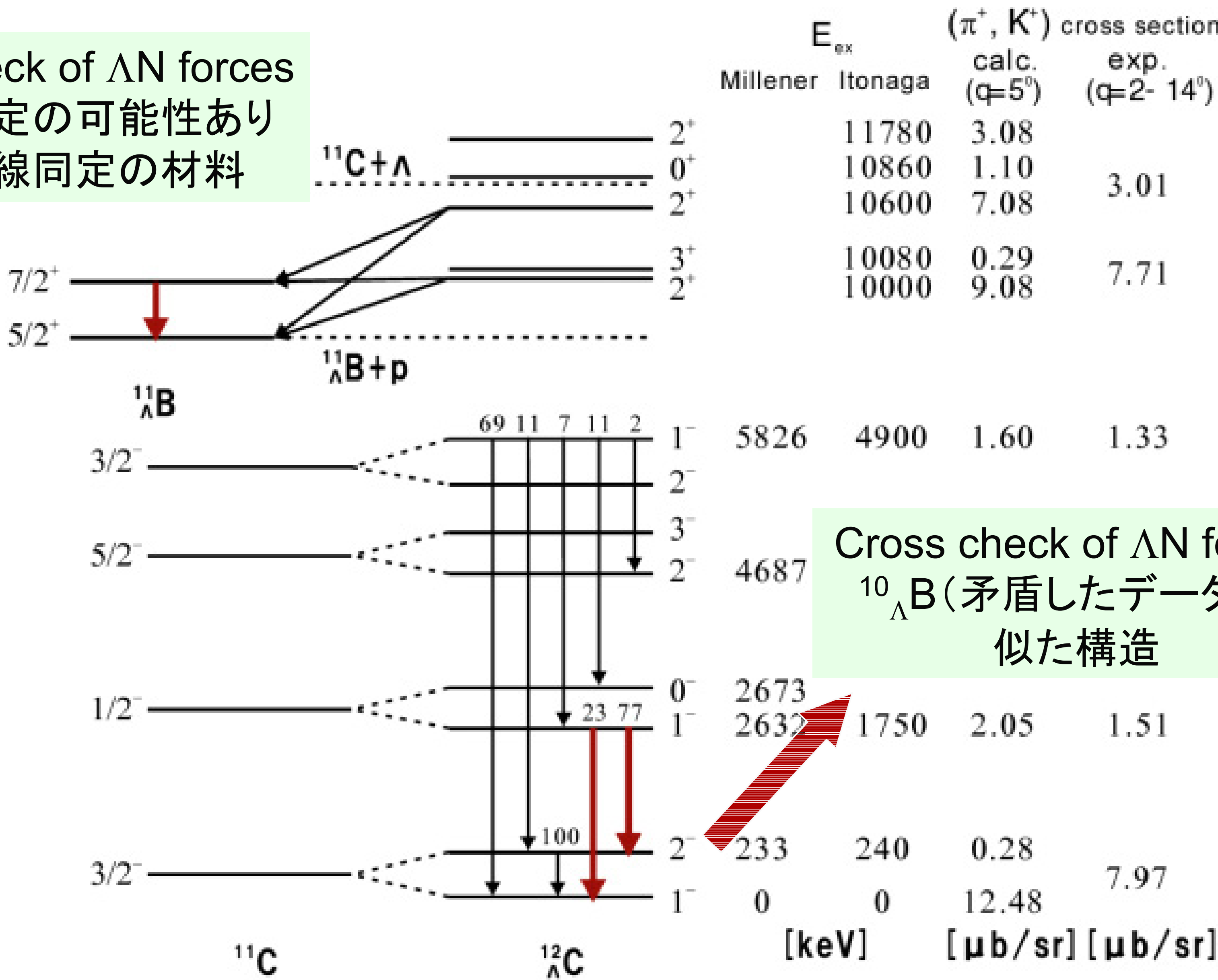
  $^{4}{}_{\Lambda}He$: CSB

- **BNL E930-3 (470 hours left)**
  More $^{12}{}_{\Lambda}C$ / $^{11}{}_{\Lambda}B$, or more ^{10}B, or $^{14}{}_{\Lambda}N$
  [after 2005??]

- **BNL E964 (Ξ-atom X rays) [after 2005??]**

$^{12}_{\Lambda}$C / $^{11}_{\Lambda}$B and $^{4}_{\Lambda}$He with K6/SKS

Cross check of ΛN forces
B(M1)測定の可能性あり
E518 γ線同定の材料

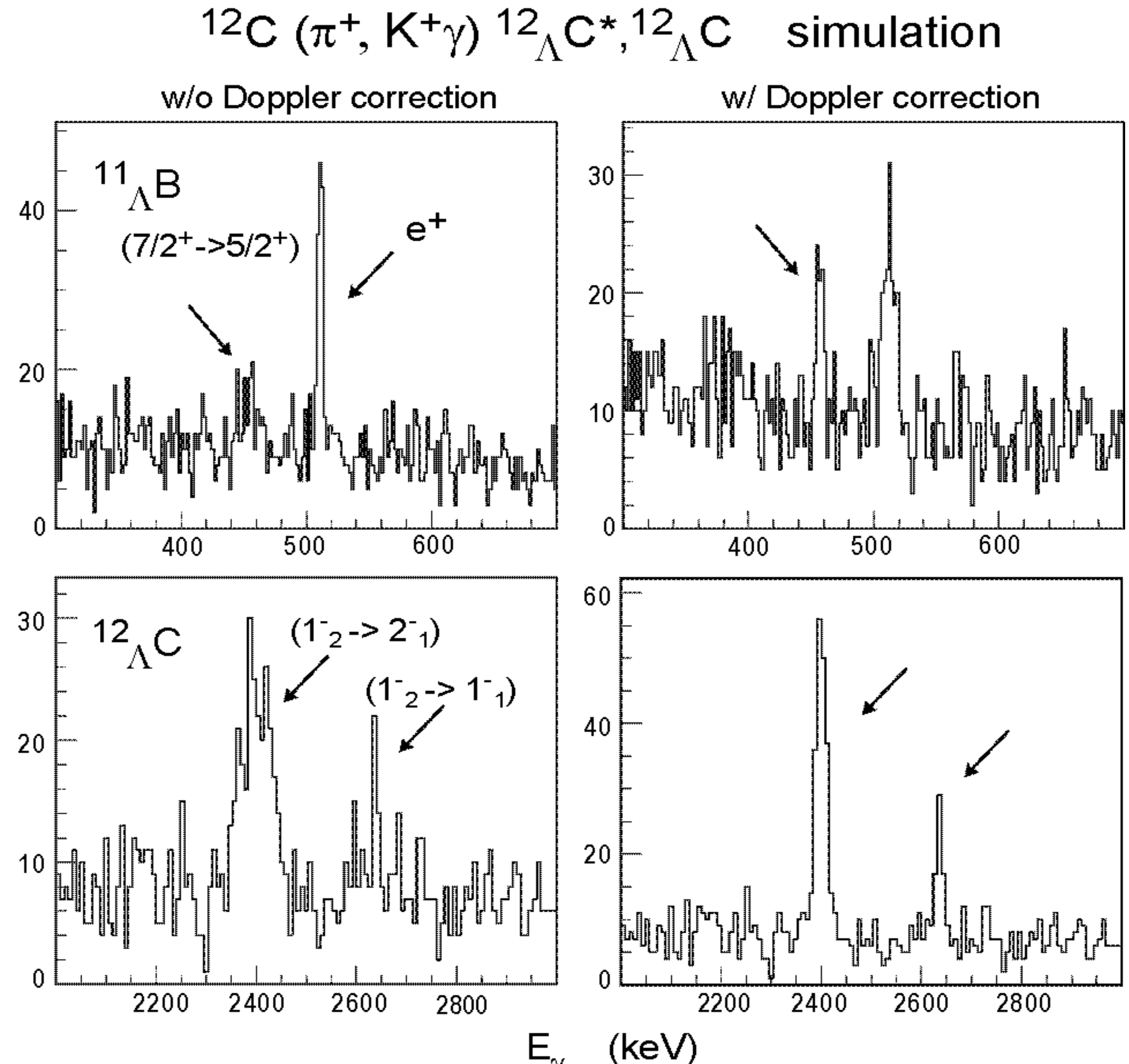


Cross check of ΛN forces
$^{10}_{\Lambda}$B（矛盾したデータ）に
似た構造

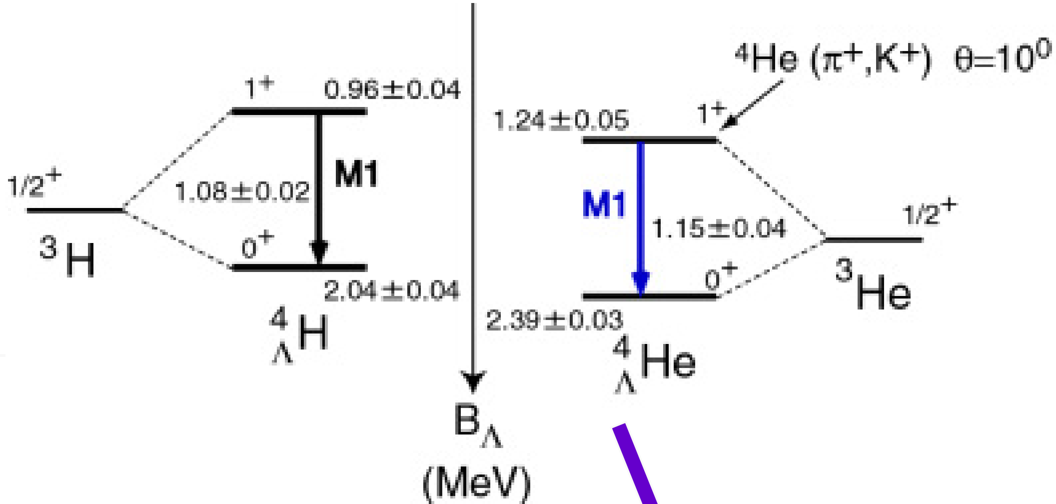
$^{12}{}_{\Lambda}C$ / $^{11}{}_{\Lambda}B$: Expected Spectra

^{12}C target 11 g/cm^2

1.2x10^{12} π^+ (60 shifts)



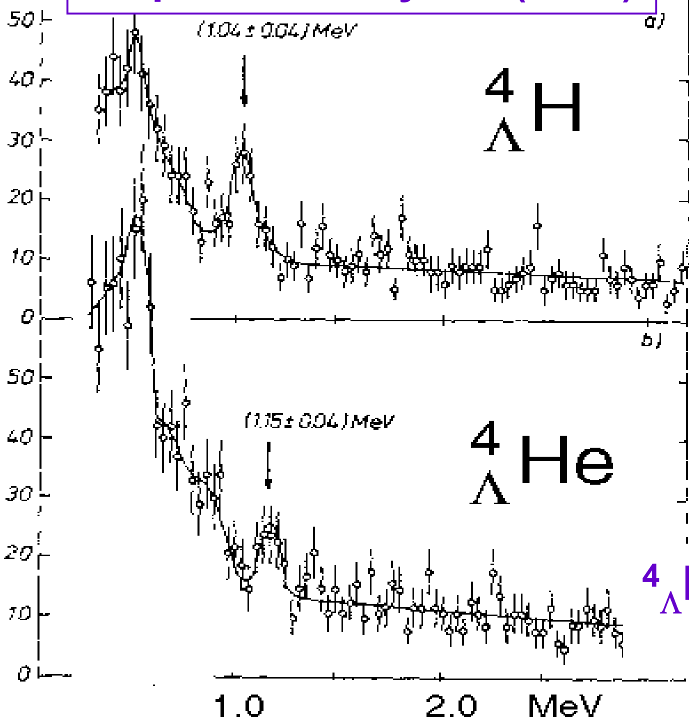
γ Spectroscopy of $^4_\Lambda He$



Observed CSB looks spin-independent.

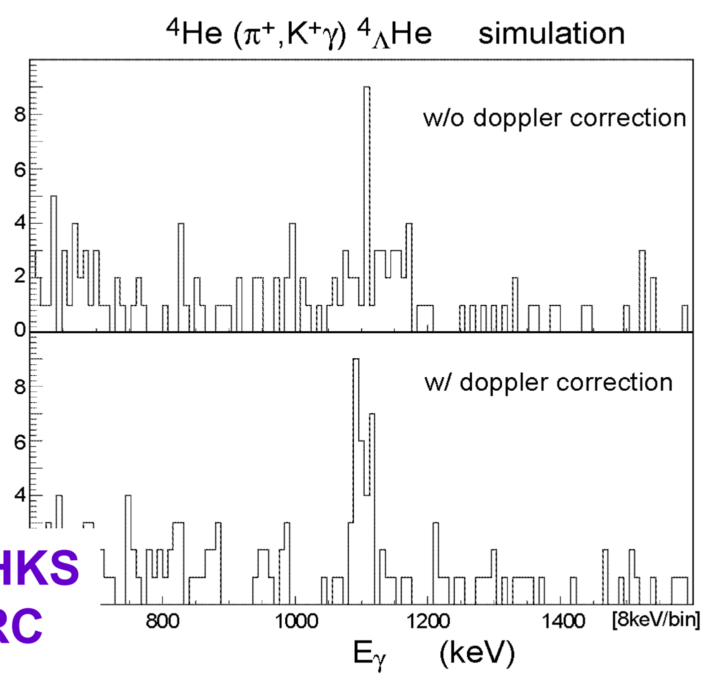
ΛN-ΣN coupling gives spin-dependent CSB.

stop K^- on ^6Li by NaI (1979)



Only one data
Bad quality

Liq. ^4He 10cm (1.25 g/cm^2)
0.4×10^{12} π^+ (20 shifts)
SKS 0 deg

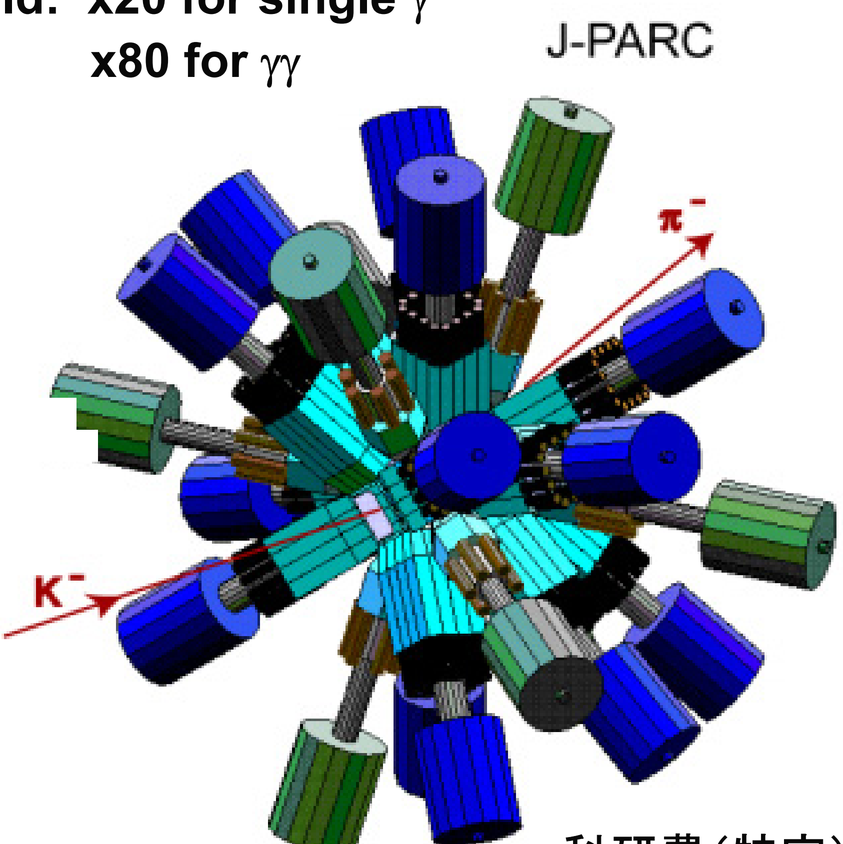


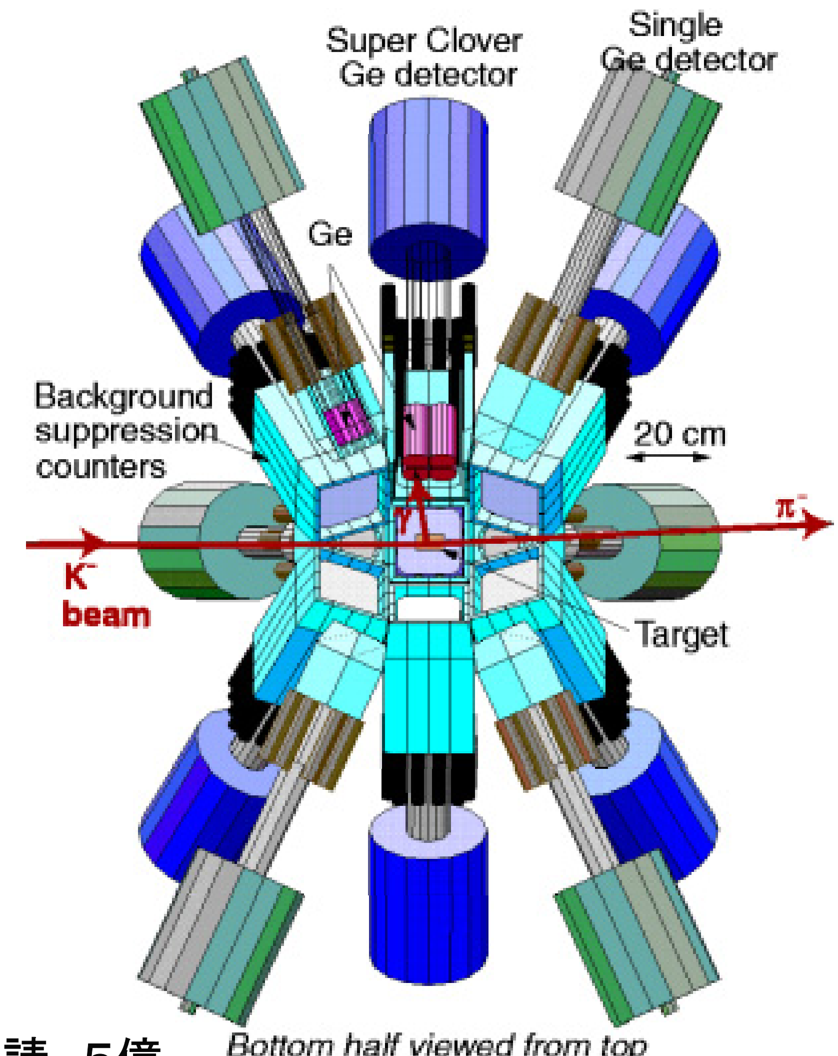
$^4_\Lambda H^*$: (e,e'K^+) at Jlab/HKS
(K^-,$\pi^0\gamma$) at J-PARC

2. Hyperball-J

- ε > 10% at 1 MeV
  (x4 of Hyperball)
- Rate limit
  ~2x10[7] particles /s (x5)
- Yield: x20 for single γ
  x80 for γγ

- (Segmented) Super Clover (350%) x 14
  (or normal x 32?) + old normal (60%) x8
- Waveform readout
- Fast suppression counters (BGO=>PWO/ LSO?)





科研費(特定)申請 5億

R&D for Hyperball-J

- **Waveform readout method** -----新Postdoc

  現在のbeam limit: 3x10^6/sec -> K1.8/K1.1: 1.5x10^7/sec

  pileup分解、baseline補正により、5倍(目標)レートに強くする

  （single rate:100->500kHz, energy rate 0.5->2.5TeV/s）

高精度**Wavefor digitizer**によるテスト

（LeCroy 12bit,5MHz→13bit,10MHzが必要 —谷田 ）

CAEN（12bit,40MHz）でテスト開始予定

KEK回路室で開発中、XIA module for DPS（14bit,40MHz）

Analysis softwareの開発　:分解能とrateの関係

高速**Daq**の検討 **---** $N_{sample}(\pm 20\mu s, 500) \times N_{mult}(10) \times N_{trig}(10^3) = 10MB/s$

Triggerの検討

Lower-gain transistor-reset preamplifiers

Other problems to be studied

- **LN2-free cooling**
  小型冷凍機の検討

- **Radiation damage** (最も深刻な問題)
  効率的なアニ―ル方法の研究
  Plastic部品，Indium contact を使わない設計―より高温に
  Li 以外のn+電極?? ―さらに高温に??

Faster suppressor

BGO: 高計数率では使えない
現状（overkill ～5−10%）の数倍で限界

結晶	密度 [g/cm3]	放射長 [cm]	崩壊定数 [ns]	光量 [% NaI]	光量/崩壊定数
PWO	8.28	0.89	~6	1	~0.2
BGO	7.23	1.12	300	15	~0.05
NaI(Tl)	3.67	2.59	250	100	
CsI(Tl)	4.53	1.85	565	40	

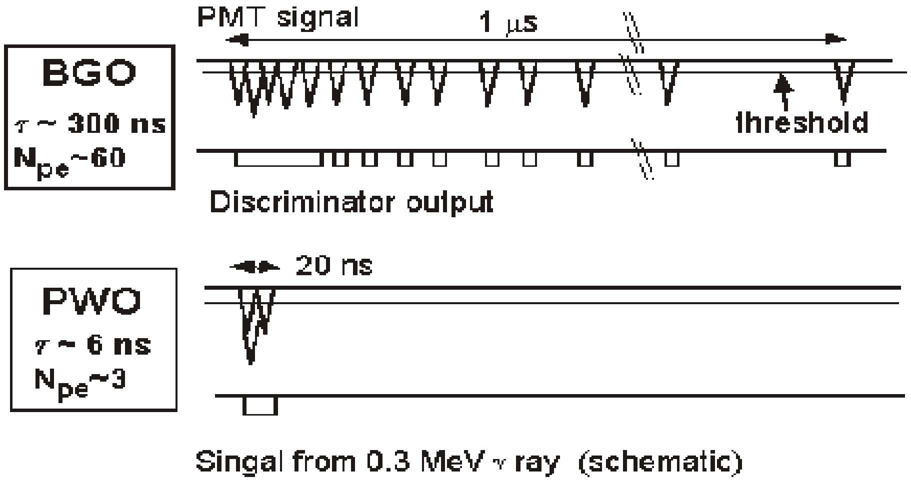
より速いsuppressorの候補
PWO, **LSO, BSO, LaBr ..**

PWO

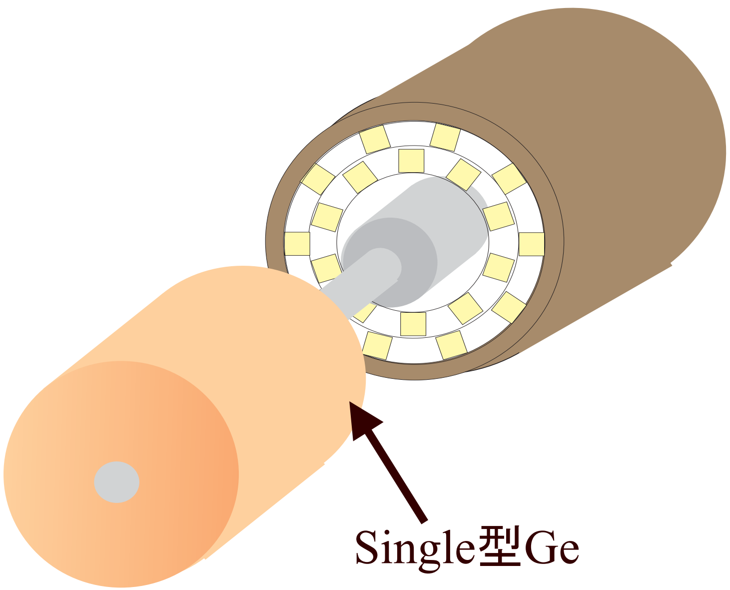
- 光量/崩壊定数　は十分良い
- 安価（**BGO**の数分の一）
- 光量が少ない　**(< 1 p.e./0.1 MeV)**

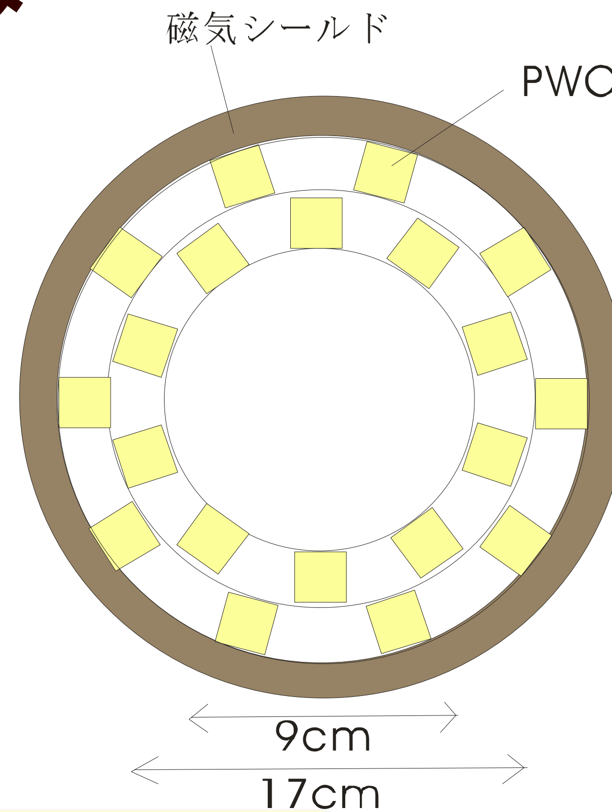
-->　低エネルギーγの検出効率悪い

コンプトンサプレッサーとしての性能は？
ハイパー核実験（主なバックグランドは **high energy** γ）では**OK**かも？



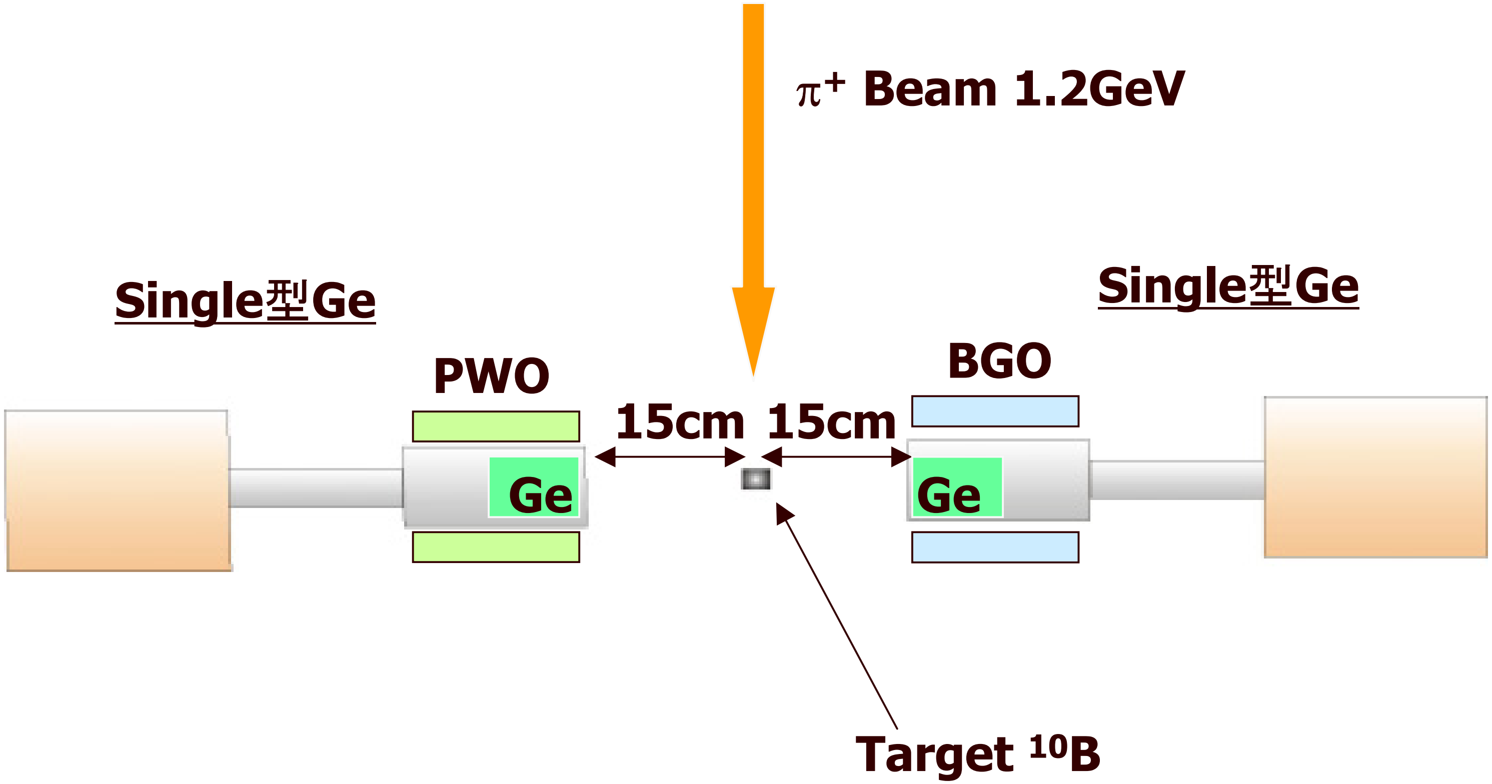
テスト用PWOカウンター





- PWO-Crystal（2x2x20cm）20個
- テスト実験用に<u>できる限り</u>Ge-Cristal全体を覆うように配置

T536:セットアップ2（PWO検出器テスト）

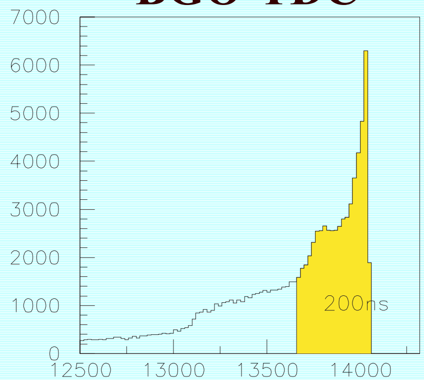


PWO検出器の性能評価

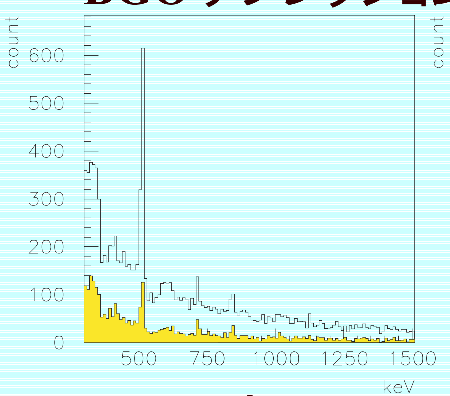
（BGOとPWOでは、Geを取り囲むジオメトリーが異なるが）

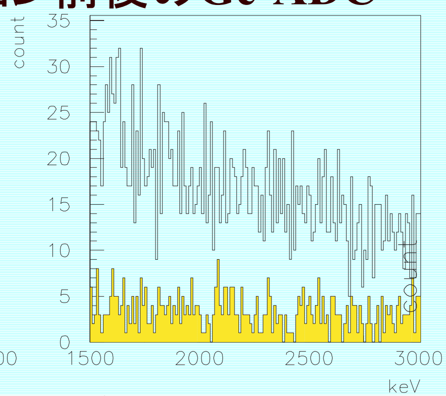
高エネルギー側 (>1 MeV)ではサプレッション能力に大きな差はない

BGO-TDC

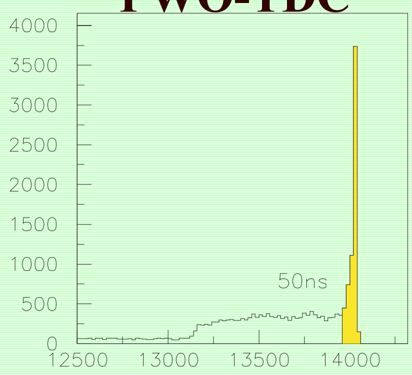


BGOサプレッション前後のGe-ADC

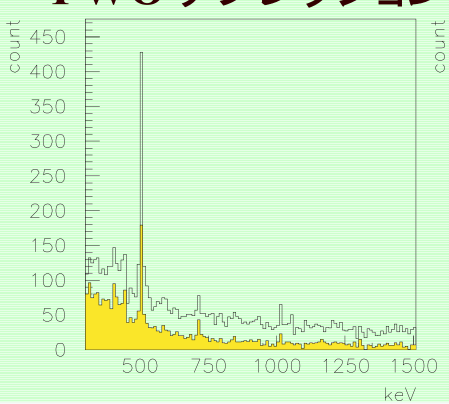


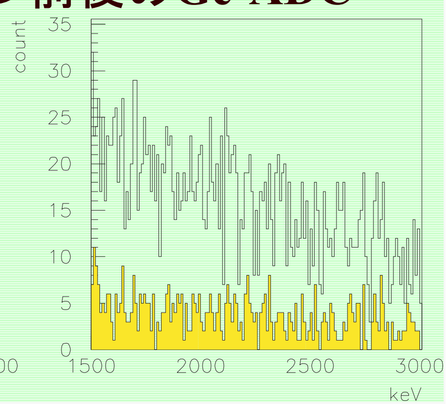


PWO-TDC

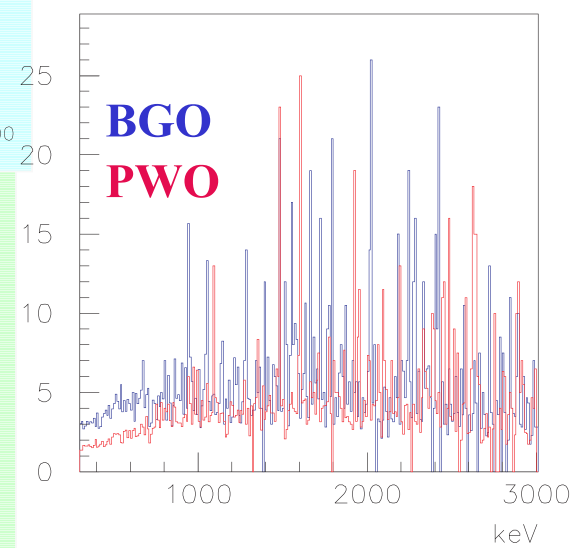


PWOサプレッション前後のGe-ADC

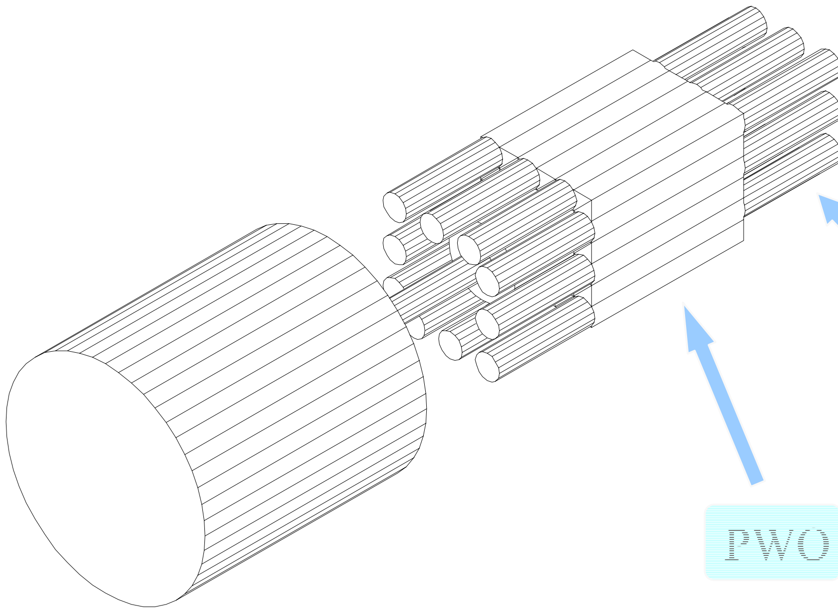


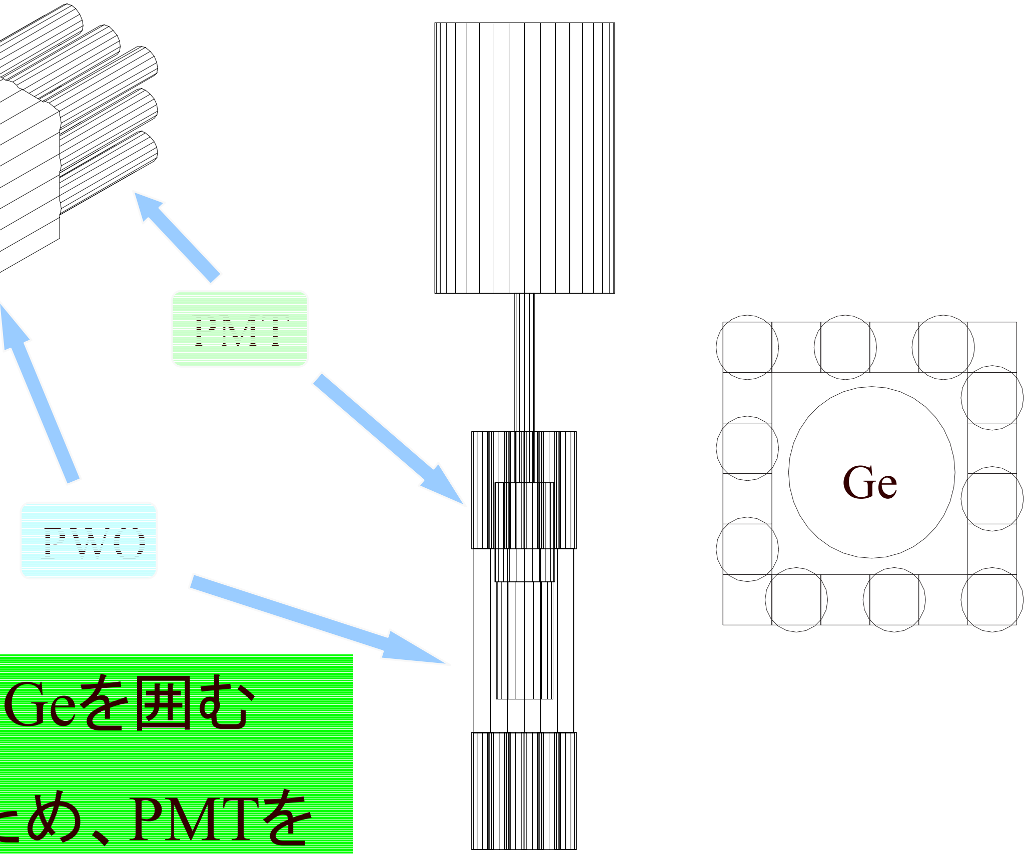


サプレッション前後の計数比



現在テスト中のPWOカウンター





- 20個のPWO結晶で隙間なくGeを囲む
- 結晶より大きいPMTを使うため、PMTを交互に取り付ける(→実用上は問題)

⇒ 低エネルギーγに対するコンプトンサプレッションの性能テスト

3. J-PARC Experiments

Letter Of Intent → Full proposal

subject	reaction	p(GeV/c)	Beamline	Apparatus	Intensity

S = -1

(1-a) **Light** (survey) $(K^-, \pi^- \gamma)$ 1.1 and 0.8 K1.1 Mag.Sepc. Low (<1/10)

- A=4--30 all possible targets

(1-b) **Light** (detailed) $(K^-, \pi^- \gamma)$ 1.1 and 0.8 K1.1 Mag.Sepc. Med (1/10-1/2)

- $\gamma\gamma$、$\gamma\pi/\gamma\gamma$ correlation, pol, B(E2), etc.
  for some important hypernuclei ($^{12}_{\Lambda}C$, $^{20}_{\Lambda}Ne$, $^{28}_{\Lambda}Si$, ..)

(2) **Medium and heavy** $(K^-, \pi^- \gamma)$ 1.8--0.8 K1.8/ K1.1 Mag.Sepc. Med

- E1(p_Λ->s_Λ) for $^{89}_{\Lambda}Y$, $^{139}_{\Lambda}La$, $^{208}_{\Lambda}Pb$ etc.

(3) **Hyperfragments** $(K^-_{stop}, \gamma\gamma)$ / $(K^-, \gamma\pi^-)$ 0.8--0.6 K1.1 (simple Mag.Sepc.) Low

- n-rich/ p-rich hypernuclei, A=8

(4) **Mirror / n-rich** $(K^-, \pi^0\gamma)$ 1.1 and 0.8 K1.1 π^0 sepc. High (>1/2)

- CSB: $^{4}_{\Lambda}H$($^{4}_{\Lambda}He$) , $^{12}_{\Lambda}B$($^{12}_{\Lambda}C$), $^{16}_{\Lambda}N$($^{16}_{\Lambda}O$)
- Shrinkage of n-halo: $^{7}_{\Lambda}He$

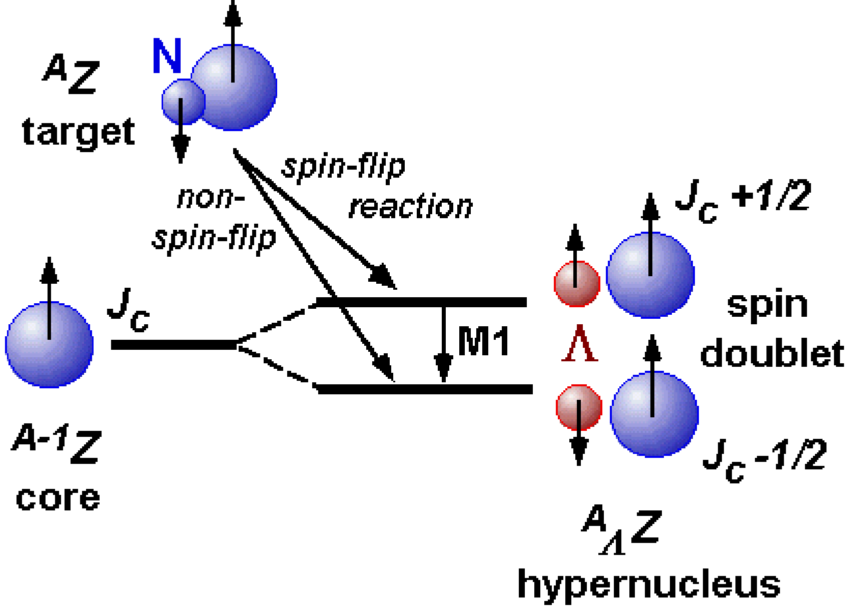
subject	reaction	P(GeV/c)	Beamline	Apparatus	Intensity
(5) **B(M1) by DSAM**	$(\pi^+, K^+\gamma)$	1.05	K1.1(K1.8)	Mag.Sepc.	Low
	$(K^-, \pi^-\gamma)$	1.1	K1.1	Mag.Sepc.	Med
・ $^{11}{}_{\Lambda}B$, $^{7}{}_{\Lambda}Li$					
(6) **B(M1) by γ-weak**	$(K^-, \pi^-\gamma$ weak)	1.1 or 0.8	K1.1	Mag.Sepc.+Decay arm	High
・ $^{12}{}_{\Lambda}C$, heavier					

S = -2

subject	reaction	P(GeV/c)	Beamline	Apparatus	Intensity
(7) **Ξ atom**	$(K^-, K^+\gamma)$	1.8	K1.8	Mag.Sepc.	Med
・ wide range of A					
(8) **ΛΛ–nuclei**	$(K^-, K^+\gamma)$	1.8	K1.8	Mag.Sepc.+CDS?	High
・several p-shell targets					

- **Full proposal は K1.8+SKS (p =1.8, 1.5 GeV/c) として考えるか？**
- **K1.1建設の作戦は？**

K⁻ Beam momentum

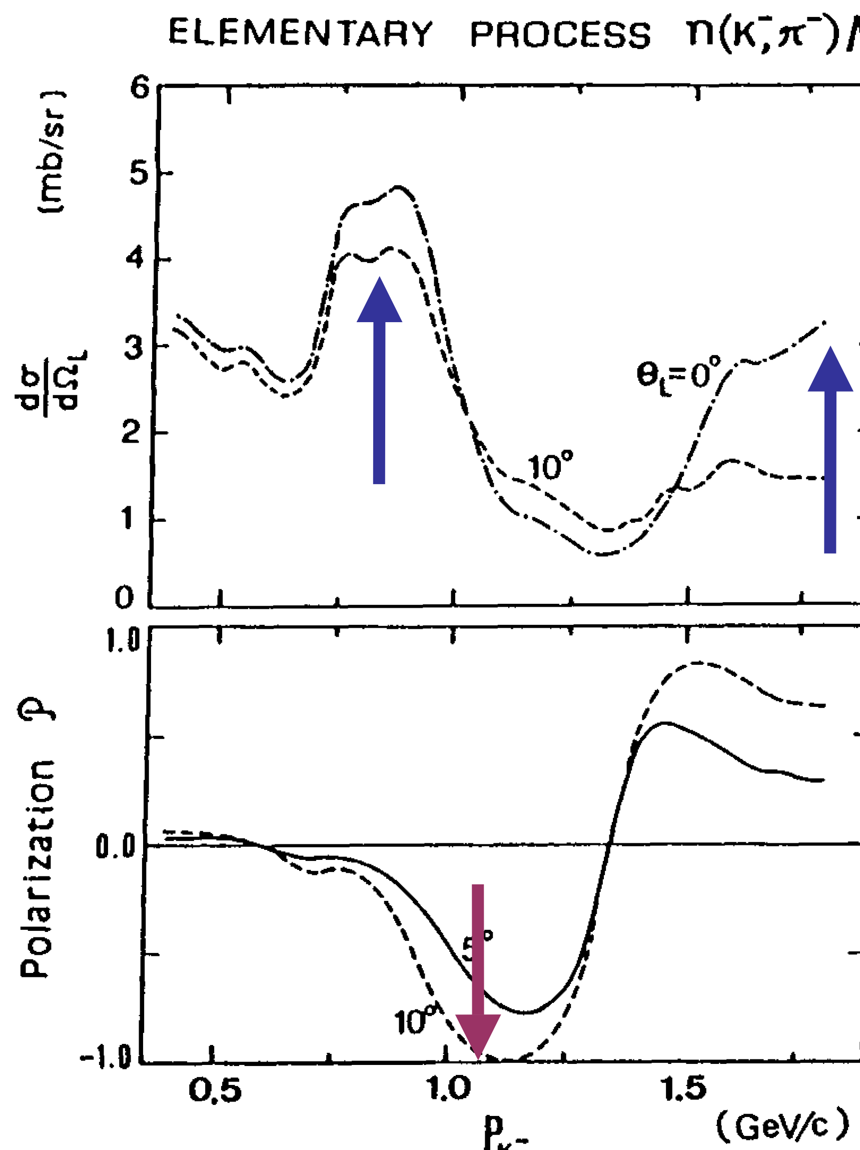


0.8, 1.8 GeV/c (K^-,π^-)
= large σ and non-spin-flip

+

1.1 GeV/c (K^-,π^-)
= spin-flip

→
- **Reveal all the levels**
- **Level assignment**
- **Spin-flip B(M1) -> μ_Λ**



Comparison of K1.1, K1.1BR, and K1.8

Subjects (1), (2), (4), (5), (6) require production of spin-flip states by 1.1 GeV/c (K^-,π^-) reaction.

S/N~1/10, Doppler ~1.5

Beamline	K1.1	K1.1BR	K1.8		*K6*
Momentum	1.1	1.1	1.1	1.5	
K^- intensity /spill	1.2×10^7	1.1×10^7	0.049×10^7	0.5×10^7	
K/π	> 1 / 1	~ 1 / 5 ?	> 1 / 1	> 1 / 1	*3×10^6 π/spill*

eg. $^7_\Lambda$Li ($3/2^+$) (spin-flip state): $d\sigma/d\Omega$ = 17 μb/sr @10^0,1.1 GeV/c

7.1 μb/sr @10^0,1.5 GeV/c

	K1.1	K1.1BR	K1.8		*K6*
Ω (msr)	20 (SPESII)		100->50 (SKS)		
γ yield (counts/hour) (Ge no limit)	161	147	17	72	*0.2 (E419)*
γ yield (counts/hour) (Ge limit = 2×10^7/spill)	134	45	17	72	
Ge damage/hour (relative)	6.7	6.7	0.3	3	*1*
Ge damage/yield (relative)	0.010	0.03	0.004	0.008	*1*