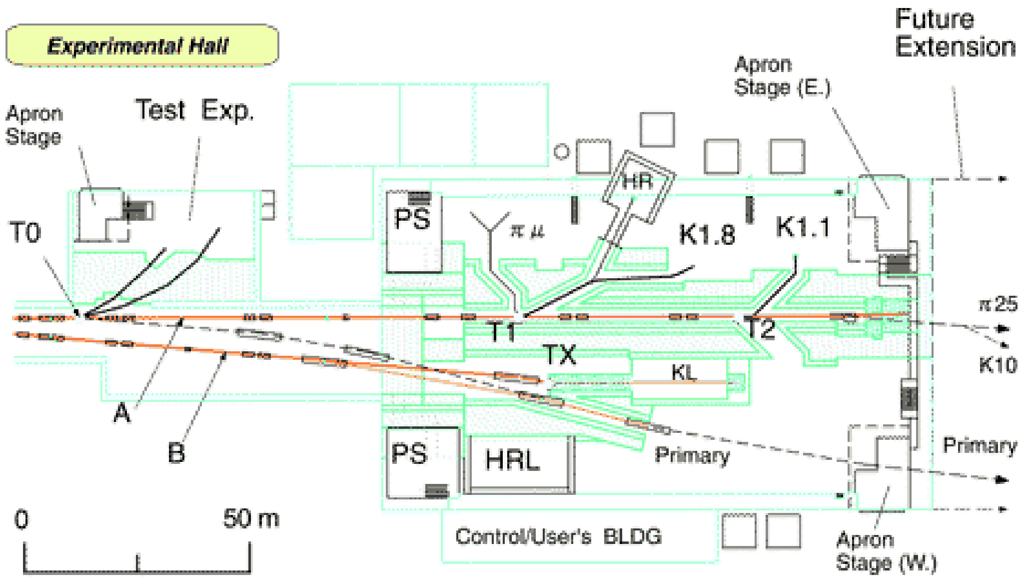
Possibility of moving the BNL-AGS D6 line to JHF

(International Workshop on Nuclear and Particle Physics at 50-GeV PS, KEK, Dec 10-12, 2001)

HOTCHI, Hideaki

Physics Department, Brookhaven National Laboratory



I BNL-AGS D6 line

II How to adapt the D6 line to the JHF environment?

III Procedure to move the D6 line to JHF

IV Possibility of cascade-hypernuclear spectroscopy by the (K^-,K^+) reaction at BNL-AGS D 6line

Physics in the JHF 2-GeV/c Kaon beam line

$1.8\ GeV/c\ (K^-, K^+)\ reaction\quad (S=-2)$

* Ξ hypernuclear spectroscopy
* Study of $\Lambda\Lambda$ hypernuclei by sequential pionic decays
* Study of $\Lambda\Lambda$ hypernuclei by Hybrid - Emulsion Technique
* γ - ray spectroscopy of $\Lambda\Lambda$ hypernuclei by Ge detector system
* Y - N scattering ($\Xi^- p$ eslastic scattering, $\Xi^- p \rightarrow \Lambda\Lambda$ reaction)

....

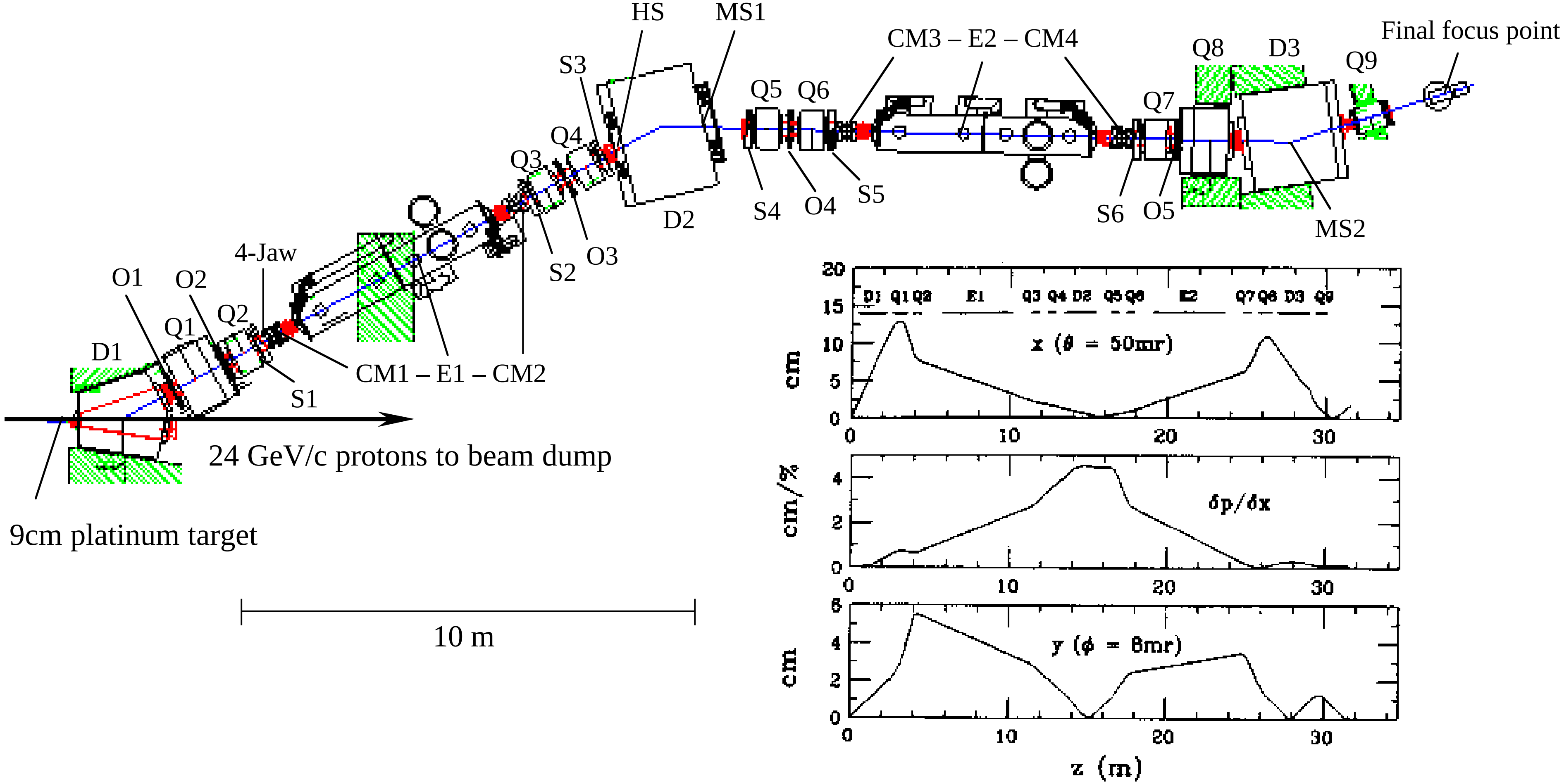
$1.8\ GeV/c\ (K^-, \pi^-)\ reaction\quad (S=-1)$

* γ - ray spectroscopy of heavy Λ hypernuclei

....

I BNL-AGS D6 line

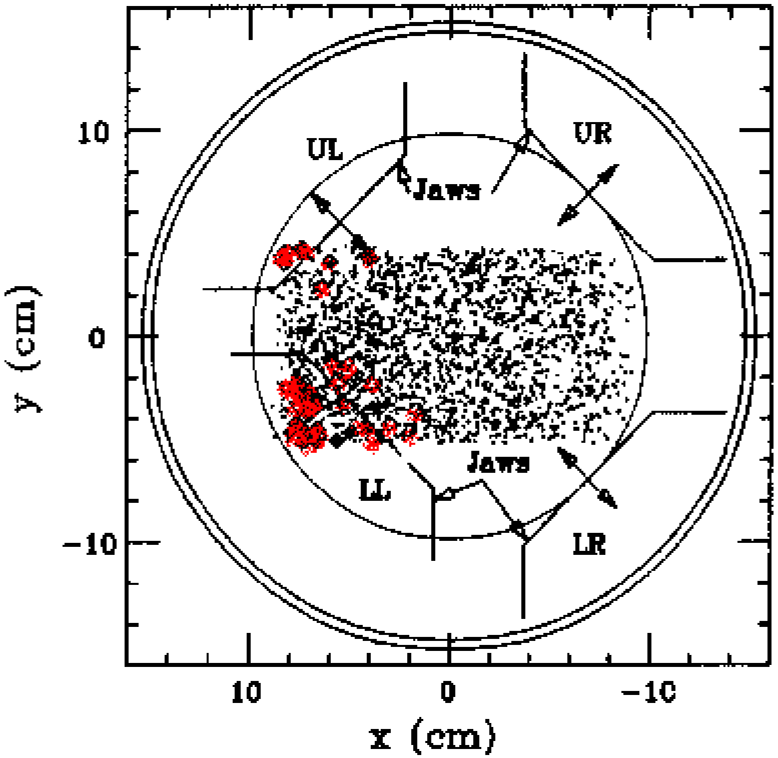
- *Constructed* ***at BNL-AGS in 1991***
- *Optimized for use in experiments that study* ***Doubly Strange Systems (S=-2)*** *with* ***(K^-,K^+)*** *reactions at* ***1.8 GeV/c***



Past experiments at the AGS D6 line

* 1991, 1992, 1993, 1995
  E813 : Search for the H - dibaryon by Ξ^- caputure on d
* 1994
  E836 : Search for the H - dibaryon
  by the (K^-, K^+) reaction on ^3He
* 1992, 1993
  E886 : Strangelet search in relativistic Si + Pt
  and Au + Pt collisions
* 1996
  E885 : Search for double Λ hypernuclei
  and the H - dibaryon by Ξ^- caputure on ^{12}C
* 1997, 1998
  E906 : Search for double Λ hypernuclei by observing
  characteristic π^- decays
* 1998
  E929 : Measurement of spin - orbit splitting
  by the $^{13}C(K^-, \pi^-\gamma)$ reaction
* 1998, 2001 ......
  E930 : High - resolution γ spectroscopy of p - shell Λ hypernuclei
  using a large - acceptance Germanium detector (Hyperball)

4-jaw collimator *(ϑ-ϕ collimator)*

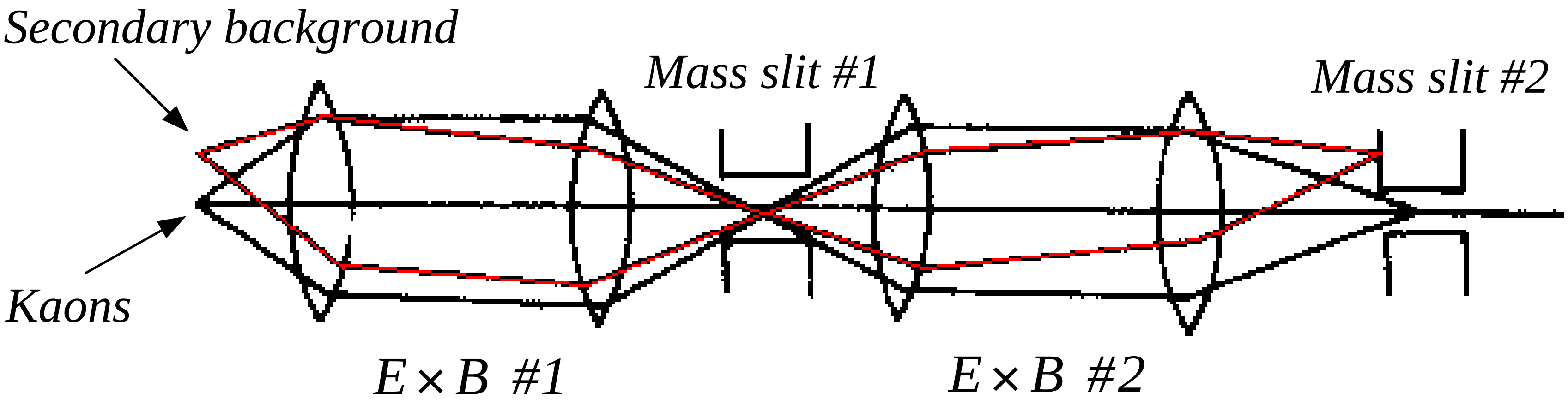


This is used to eliminate the direct pion beam contamination which can pass through the mass slits (MS1,2).

2-stage velocity selector

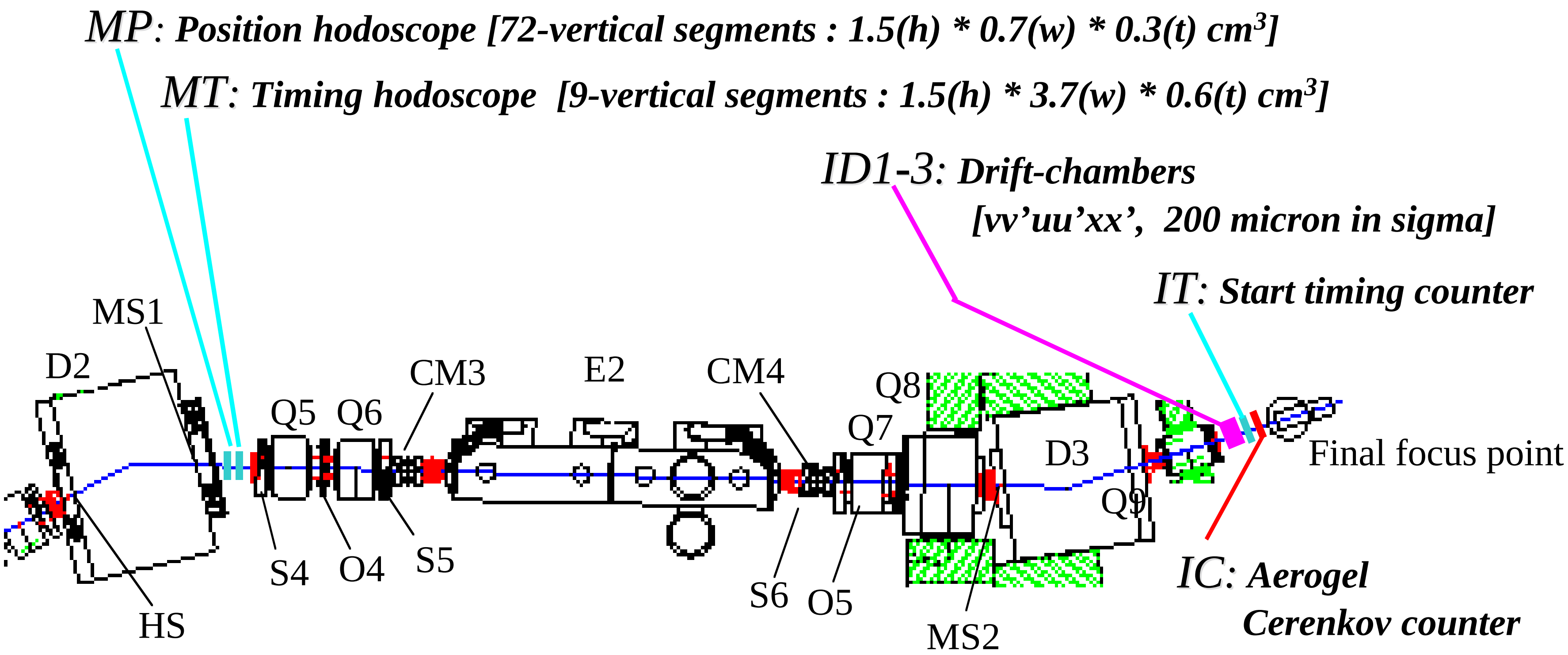
[CM1-E1-CM2]and [CM3-E2-CM4]

The electrostatic separator (E1 and E2) design is based on that of the KEK standard separator.



This 2-stage separation technique helps to eliminate secondary backgrounds, such as K^- decay in flight, as well as direct backgrounds originating from the production target.

Beam spectrometer



Momentum reconstruction:

MP (x), ID1-3 (vv'uu'xx'),
and Transport matrix

dP/P ≤ 0.1% (design value)

Particle identification:

Kbeam $\equiv$ *IT* $\times$ $\overline{IC}$ *(online trigger)*

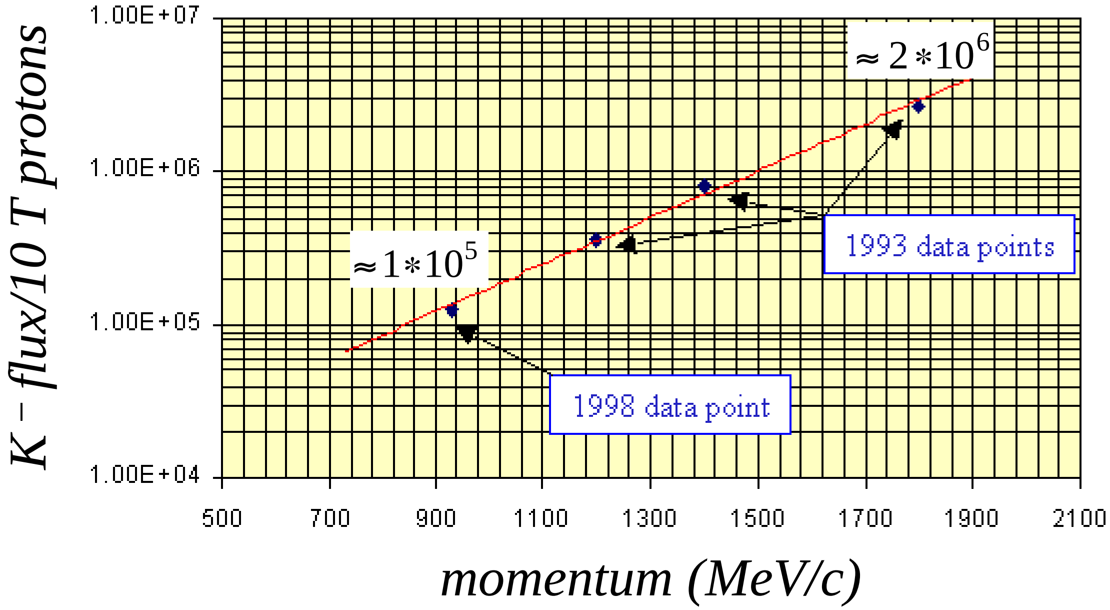
Time-of-flight information between MT and IT
(offline analysis)

Parameters of the D6 line

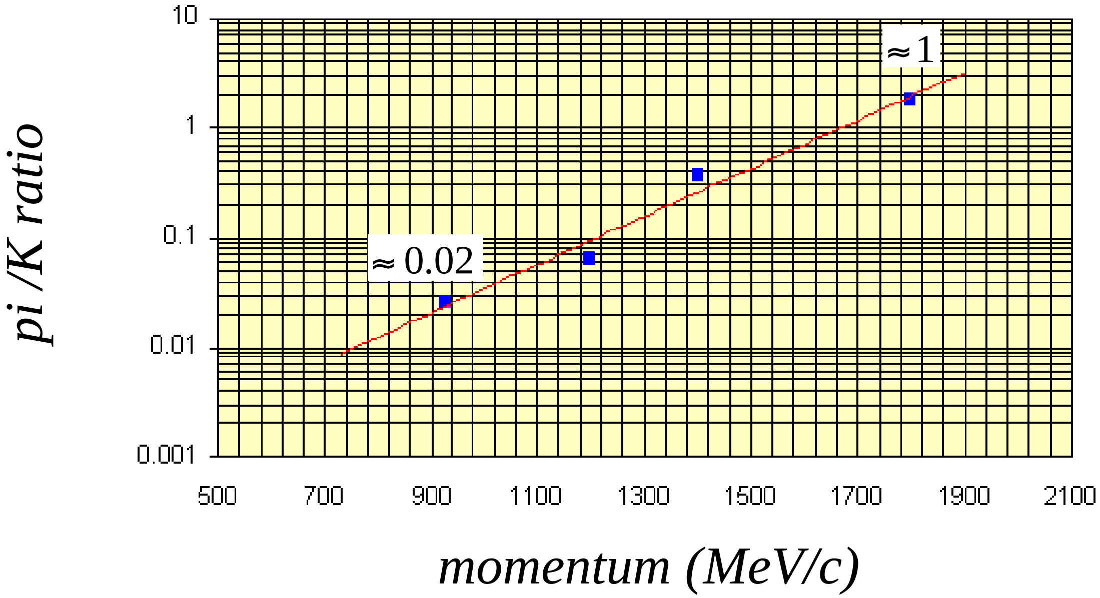
- $*$ Target : $9\,(length) \times 0.7\,(width) \times 1.0\,(height)\,cm^3$ platinum
- $*$ Central production angle : 5 deg
- $*$ Beam line lenght : 31.6 m
- $*$ Anguler acceptance : 1.6 msr
- $*$ Momentum range : up to 1.9 GeV/c
- $*$ Momentum acceptance : 6% (FWHM)
- $*$ Dispersion : 4.5 cm/% at the first vertical focus point
- $*$ K^- flux per 10^{13} protons :

$$2.0 \times 10^6\ (\pi\ /K\ ratio \approx 1)\ at\ 1.8\ GeV/c$$

$$1.0 \times 10^5\ (\pi\ /K\ ratio \approx 0.02)\ at\ 0.9\ GeV/c$$



K⁻ flux/10 T protons
1.00E+07
1.00E+06
1.00E+05
1.00E+04
≈ 2*10^6
≈1*10^5
1993 data points
1998 data point
500
700
900
1100
1300
1500
1700
1900
2100
momentum (MeV/c)



pi /K ratio
10
1
0.1
0.01
0.001
≈1
≈ 0.02
500
700
900
1100
1300
1500
1700
1900
2100
momentum (MeV/c)

II How to adopt the D6 line to the JHF environment ?

50-GeV proton beam : 300 Tp / pulse (750 kW)

* *Provision against* ***huge heat deposit and radiation damage to the beam line elements near to the production target***

(D1, Q1, collimator……)

- *radiation-resistant coils and cables*
- *water-cooled magnet yoke*
- *water-cooled collimator downstream of the production target*

……

* *Provision against* ***radiation induced problems with the first separator***

- *secondary beam should be properly collimated prior to being transmitted to the separator : place collimator and/or Q-doublet upstream of the separator …...*

* *Provision against **high rate problem***

- *beam spectrometer should be added downstream of the second mass slit to minimize the high rate problem.*

  ………

III Procedure to move the D6 line to JHF

This attempt can take place in the case that DOE drops support for medium energy experiments at BNL and the D6-line program is terminated.

- *This has to be coordinated through the BNL upper management (T. Kirk/P. Paul) and approved by DOE*

What part of the elements should be moved ??
Expense ??
Man power?? – contribution from BNL people ??
(P. Pile, A. Rusek, ME group…)

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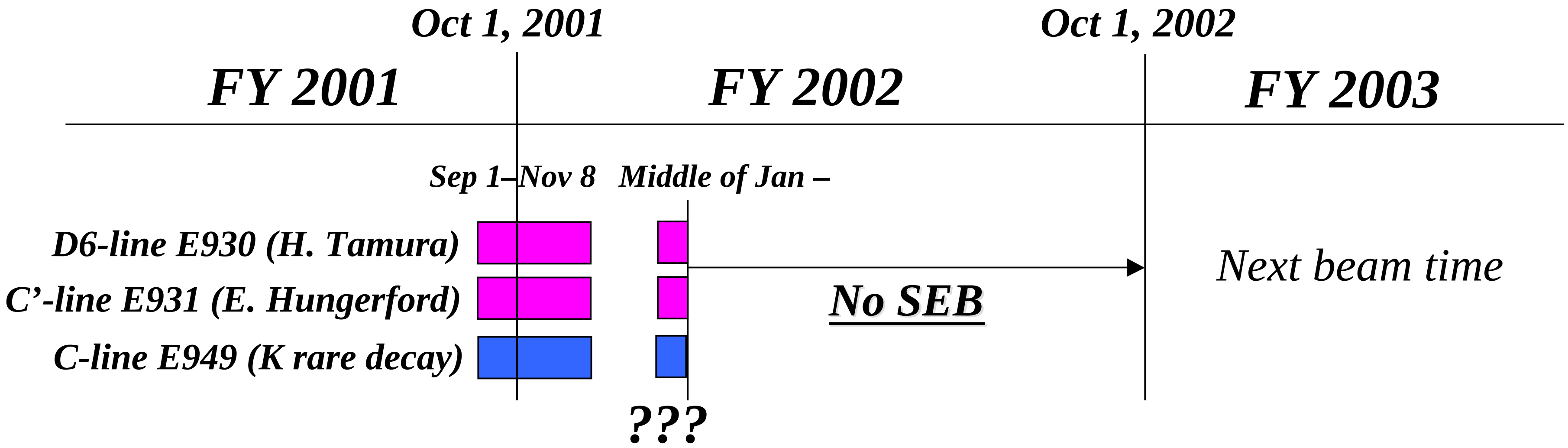
Beam schedule at BNL-AGS (SEB)



$*$ *Approved experiments :*

D6 - line E964 : Study of $\Lambda\Lambda$ hypernuclei by Hibrid - Emulsion Technique

- K. Nakazawa, K. Imai, H. Tamura

$*$ *Proposals :*

D6 - line : Study of $\Lambda\Lambda$ hypernuclei by Sequncial Pionic Decays

- T. Fukuda, A. Rusek, R. Chrien

D6 - line : Study of Kaonic nuclei - T. Kishimoto

IV Possibility of Ξ hypernuclear spectroscopy by the (K^-,K^+) reaction at BNL-AGS D6 line

- ***No data which confirm the existence of Ξ hypernuclei***
- ***Very little information on the depth and the shape of Ξ - nucleus potential***

** Dover and Gal : Emulsion data*

- $V_{0\Xi} = 21 - 24$ MeV

** KEK - E176 : Emulsion data*

- $V_{0\Xi} = 16 - 17$ MeV

** KEK - E224 (K^-,K^+) reactions on a scintillating fiber target*

- $V_{0\Xi} \approx 16$ MeV

** BNL - E885 $^{12}C(K^-,K^+)$ reactions*

- $V_{0\Xi} \approx 14$ MeV

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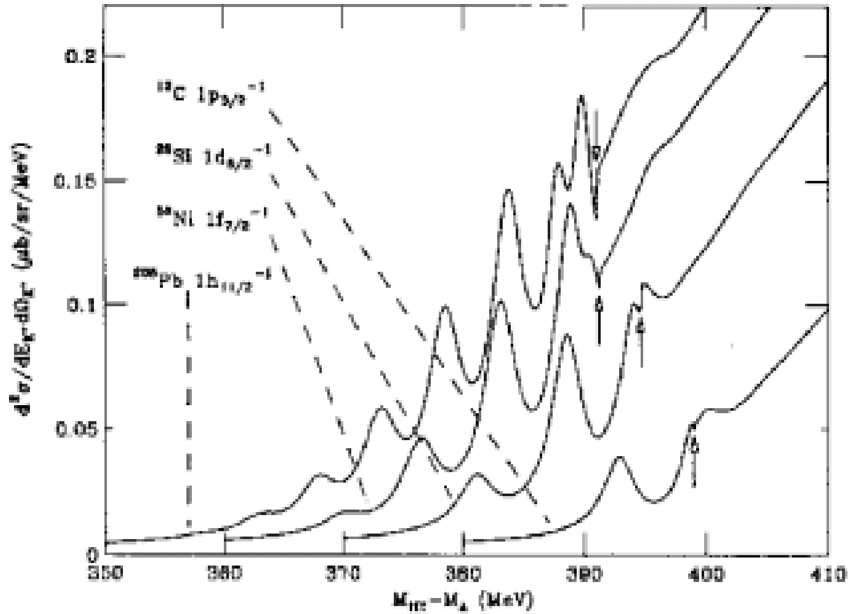
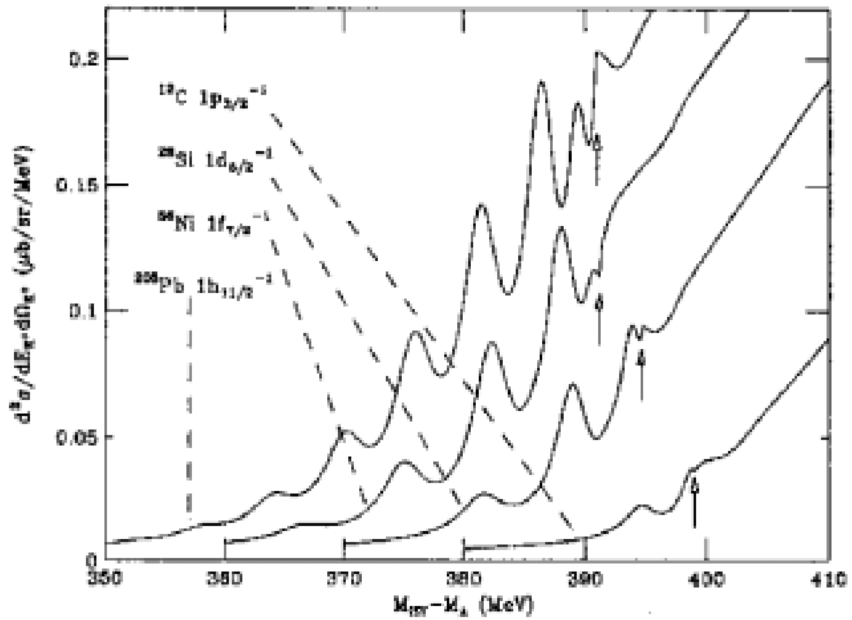
$\Xi N \rightarrow \Lambda\Lambda$ conversion - expected width $\leq$ a few MeV

V_0= -16MeV, W_0= -1MeV,
Assumed spectrometer resolution: 2 MeV



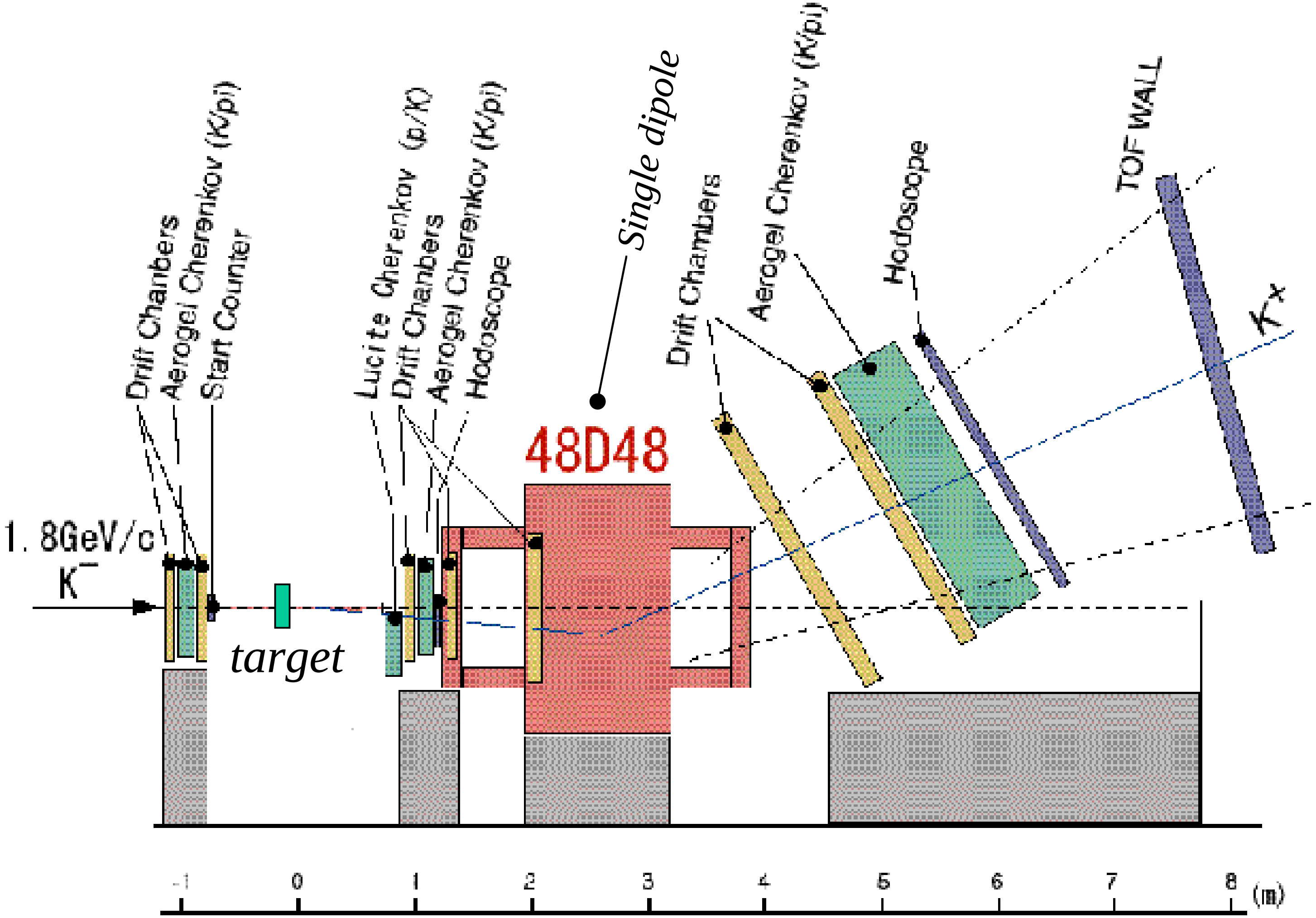
Woods-Saxon potential



Folding potential using Shinmura's Xi-N interaction

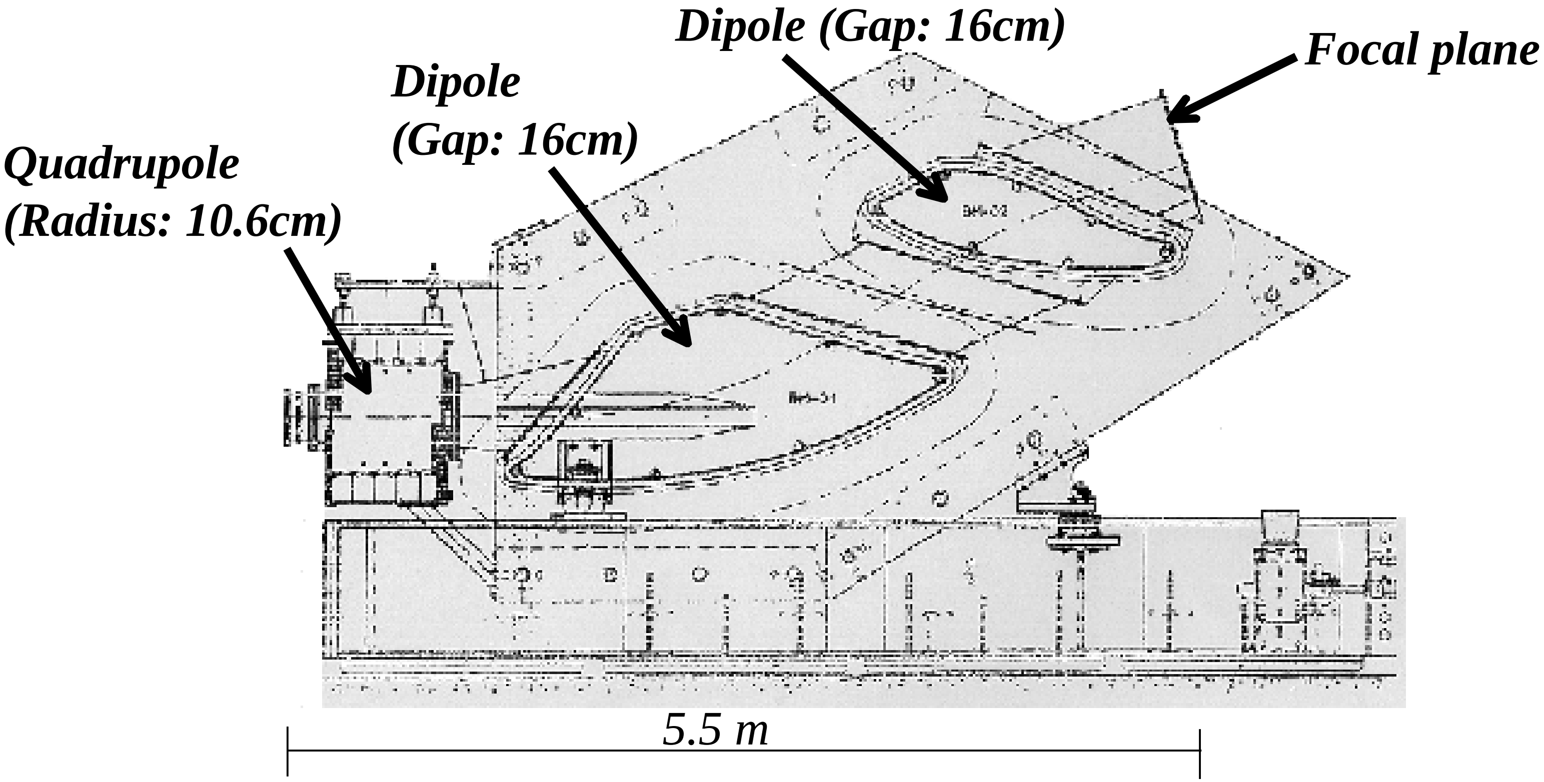
Resolution : < 3 MeV

Current $K^{\pm}$ spectrometer system in the D6-line area



Poor momentum resolution

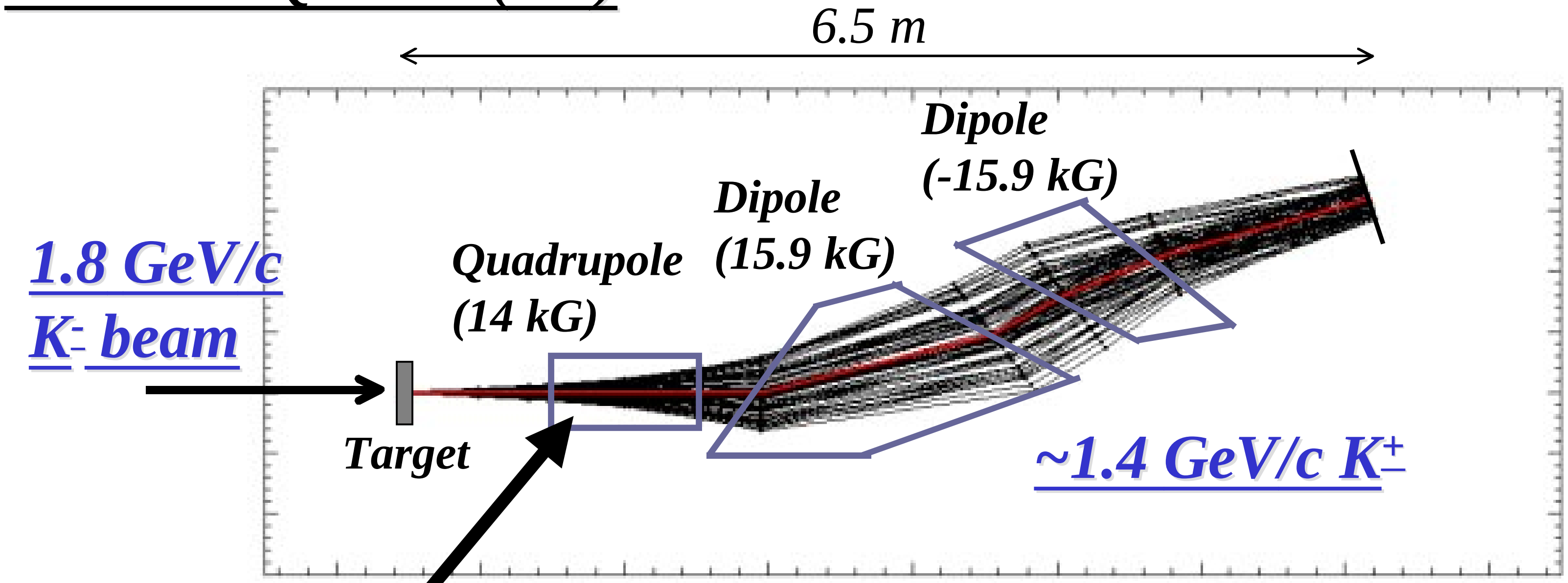
LANL MRS spectrometer: QD(-D)

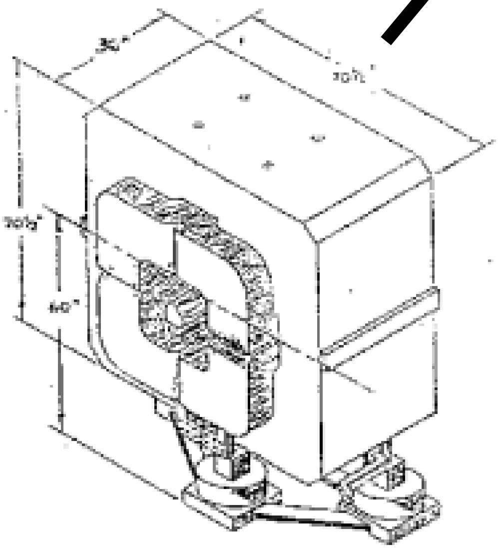


Parameters of MRS system

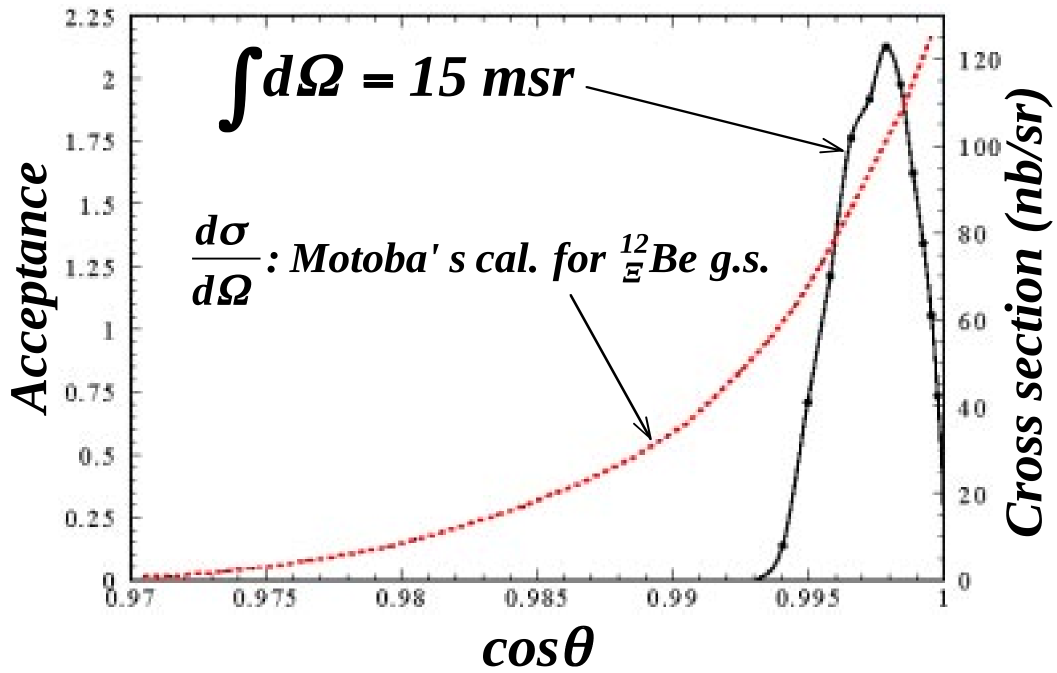
* Spectrometer length : 7.5 m (target to focal plane)
* Maximum central momentum : 1.5 GeV/c @ 17kG
* Momentum acceptance : ± 20%
* Horizontal acceptance angles : ± 60 mrad
* Vertical acceptance angles : ± 40mrad
* Solid angle : 9 mrs → **4 msr in assuming the actual beam size 4cm(H) * 0.6cm(V) in FWHM**
* Net bend angle : 18 deg
* Dispersion at the focal plane : 0.96%/cm

MRS: 18Q36+D(-D)





BNL 18Q36 magnet



Energy resolution

- *Momentum resolution of the MRS :* **0.1 %** *in assuming the tracking devices with 250 micron (rms) position resolution*
- *Momentum resolution of the beam spectrometer :* **< 0.1 % (design value)**
- *Energy loss fluctuation in* **5g/cm^2 carbon target** *:* **1.6 MeV (FWHM)**

2.8 MeV (FWHM)

Yield estimation for the $^{12}C(K^-, K^+)^{12}_{\Xi}Be$ *reaction*

- *5 g/cm^2 carbon target*
- *K^+ survival rate :* **0.49** *(1.4 GeV/c K^+, fright path length=7.5m)*
- *Spectrometer acceptance :* **15 msr**
- *Cross section of the ground state considered :*
  Motoba's angular distribution for the $^{12}{}_{\Xi}$Be ground state (V_{Ξ}=14 MeV)
- *Overall detector efficiency considered :* **0.5**
- *K^- beam flux :* **10^{13}** *for* **10^7 K^-/pulse, 10^3 pulses/hour, 10^3 hours**
  (Dedicated proton beam : 45 Tp / 2 sec pulse)

Ground state yield: 934 counts / 10^3 hours

(280 counts/10^3 hours even for ordinary beam condition :3*10^6 K^-/pulse)

Things under consideration

** To gain spectrometer acceptance*

- *Add another Quadrupole: QD(-D) to QQD(-D)*
- *Bend horizontally instead of vertically*

** To improve momentum resolution*

- *Reverse polarity of the second Dipole to gain dispersion: D(-D) to DD*

** Provision for high rate (10^7 / pulse)*

- *High rate tracking device*
- *Trigger*

** Target ?*

- *carbon?, heavier target?*

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