Measurement of the lifetime and of weak decay partial widths of mirror p-shell Λ-hypernuclei

International Workshop on Physics at the extended Hadron Experimental Facility of J-PARC

March 5-6, 2016, J-PARC, Tokai, Japan

Alessandro Feliciello

I.N.F.N. - Sezione di Torino

Physics motivations

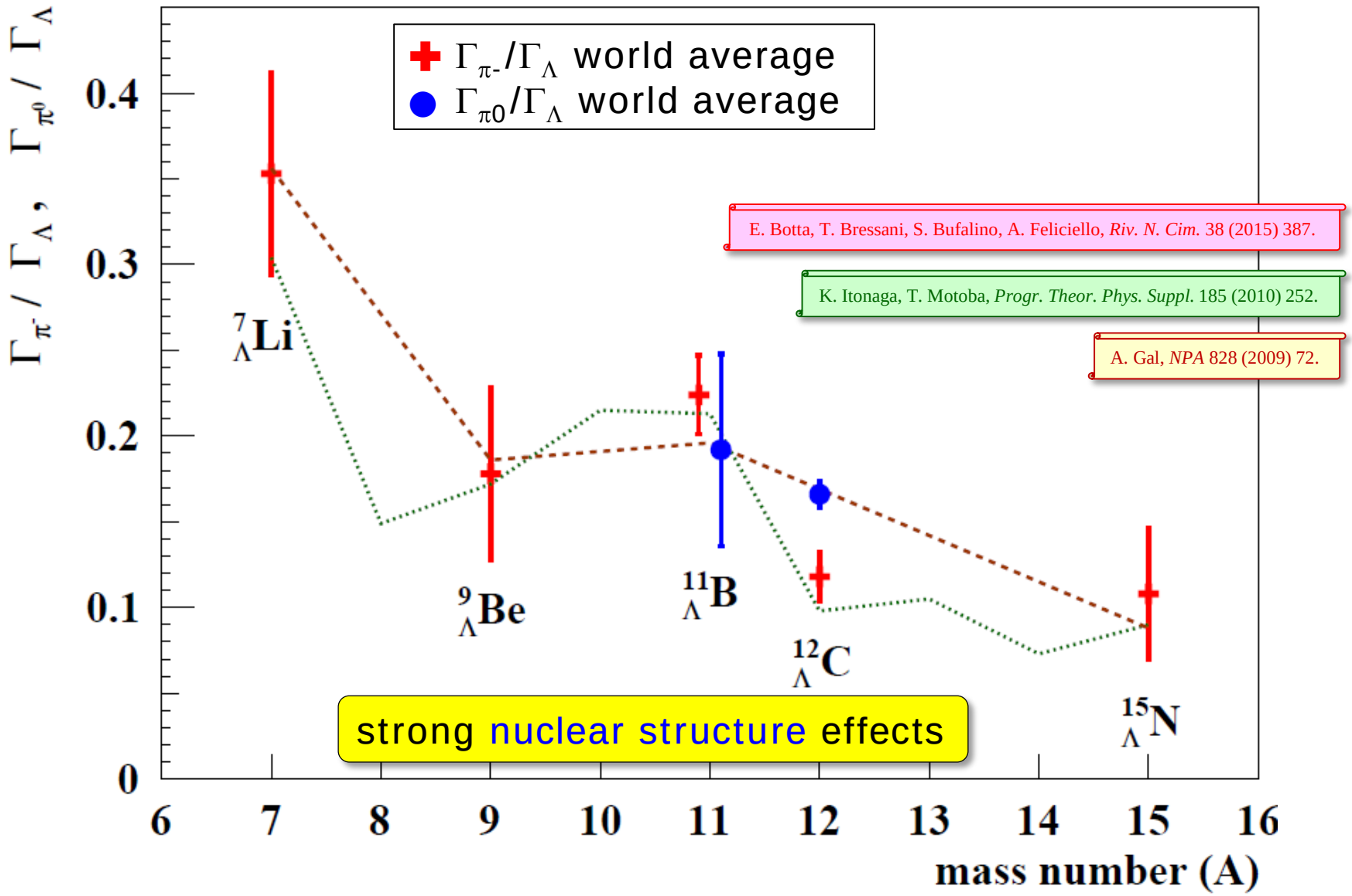
further studies of *p*-shell Λ-hypernuclei

(in particular of the neutron-rich ones, e.g. $^{12}B_{\Lambda}$)

determination of:

- $\Gamma_{tot} \equiv \hbar/\tau$
- $\Gamma\pi^-$
- $\Gamma\pi^0$ (possibly)
- Γ_p

The cultural heritage: $\Gamma\pi^-$ and $\Gamma\pi^0$

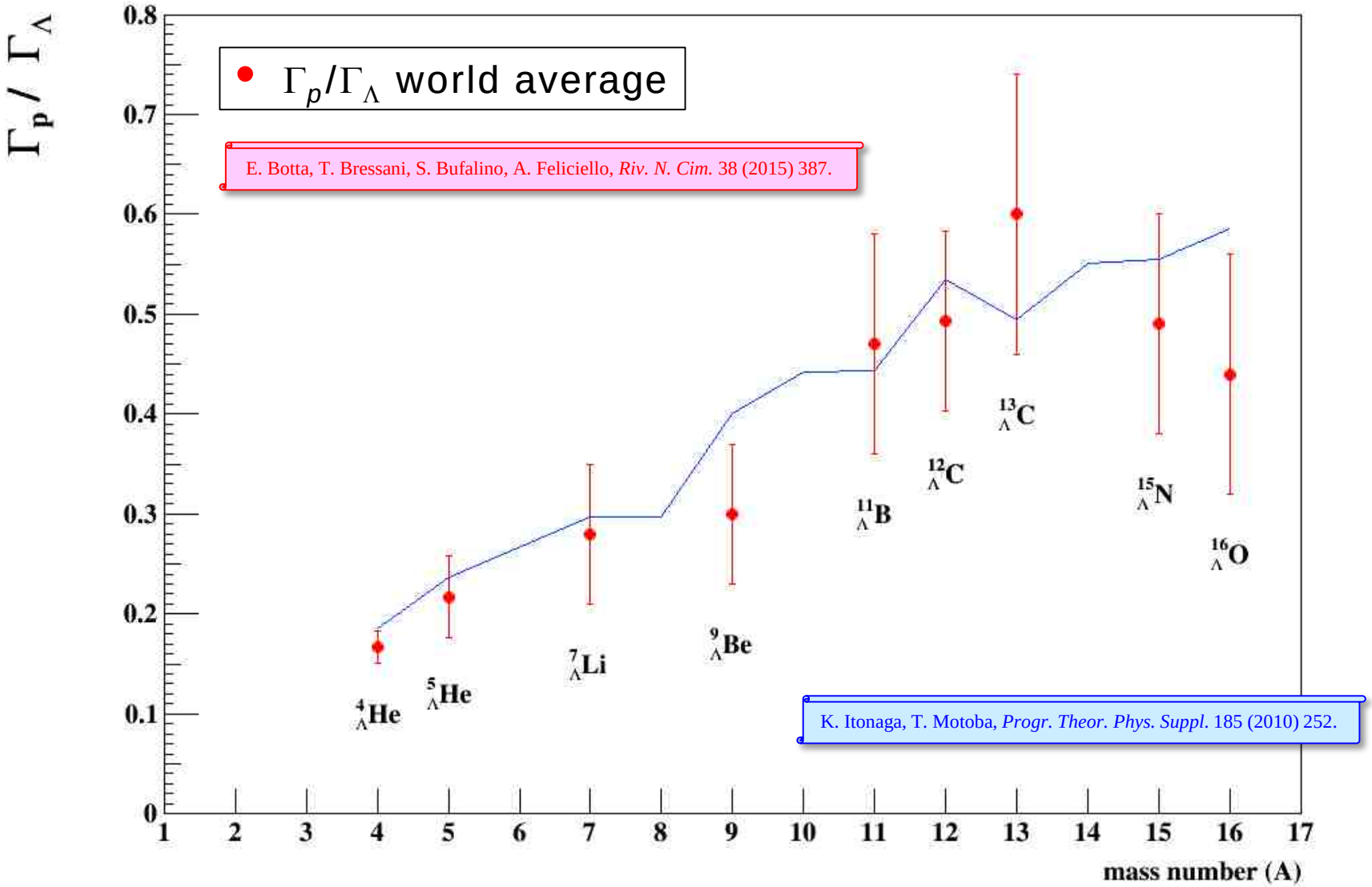


E. Botta, T. Bressani, S. Bufalino, A. Feliciello, *Riv. N. Cim.* 38 (2015) 387.

K. Itonaga, T. Motoba, *Progr. Theor. Phys. Suppl.* 185 (2010) 252.

A. Gal, *NPA* 828 (2009) 72.

First determination of Γ_p/Γ_Λ for 8 Hypernuclei



Completion of decay pattern for $^{5}_{\Lambda}He$ and $^{11}_{\Lambda}B$

	$^{5}_{\Lambda}He$	$^{11}_{\Lambda}B$	$^{12}_{\Lambda}C$	$^{12}_{\Lambda}C$
Γ_T/Γ_Λ	0.962±0.034	1.274±0.072	1.241±0.041	1.241±0.041
$\Gamma_{\pi^-}/\Gamma_\Lambda$	0.342±0.015	0.228±0.027	0.120±0.014	0.123±0.015
$\Gamma_{\pi^0}/\Gamma_\Lambda$	0.201±0.011	0.192±0.056	0.165±0.008	0.165±0.008
Γ_p/Γ_Λ	0.217±0.041	0.47±0.11	0.493±0.088	0.45±0.10
$\Gamma_{2N}/\Gamma_\Lambda$	0.078±0.034	0.169±0.077	0.178±0.076	0.27±0.13
Γ_n/Γ_Λ	0.125±0.066	0.21±0.16	0.28±0.12	0.23±0.08
Γ_n/Γ_p	0.58±0.32	0.46±0.37	0.58±0.27	0.51±0.14
Γ_n/Γ_p	0.508	0.502	0.418	

H. Bhang *et al.*, *JKPS* 59 (2011) 1461

B.H. Kang *et al.*, PRL 96 (2006) 062301: 0.45 ± 0.11

K. Itonaga, T. Motoba, PTP 185 (2010) 252

$$\Gamma_{2N}/\Gamma_p = 0.36 \pm 0.14_{\text{stat}}{}^{+0.05}_{-0.04\text{sys}}$$

Physics Letters B 748 (2015) 86–88

Contents lists available at ScienceDirect

Physics Letters B

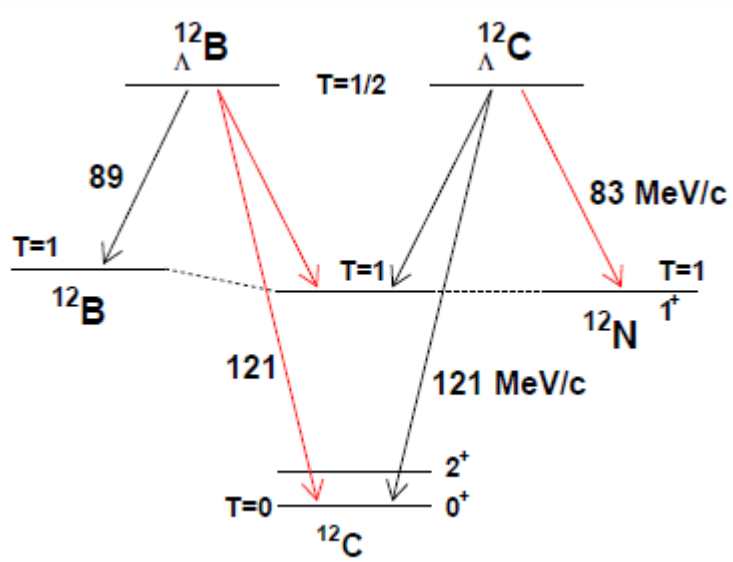
www.elsevier.com/locate/physletb

Determination of non-mesonic weak decay widths of $^{5}_{\Lambda}He$ and $^{11}_{\Lambda}B$ Hypernuclei

E. Botta[a,b], T. Bressani[a,b], S. Bufalino[a,b], A. Feliciello[b,*]

[a] Dipartimento di Fisica, Università di Torino, via P. Giuria 1, Torino, Italy
[b] INFN Sezione di Torino, via P. Giuria 1, Torino, Italy

Charge dependence effects



$$\Gamma_{\pi^-}\left({}^{12}_{\Lambda}\mathrm{B}\right)/\Gamma_{\pi^-}\left({}^{12}_{\Lambda}\mathrm{C}\right)=?$$

T. Motoba, *NPA* 547 (1992) 115c. ≈ 3

K. Itonaga, T. Motoba, *Prog. Theor. Phys. Suppl.* 185 (2010) 252. $= 2.9$

$$\frac{\Gamma_{\pi^0}\left({}^{12}_{\Lambda}\mathrm{C}\right)}{\Gamma_{\pi^-}\left({}^{12}_{\Lambda}\mathrm{C}\right)}\Big/\frac{\Gamma_{\pi^0}\left({}^{12}_{\Lambda}\mathrm{B}\right)}{\Gamma_{\pi^-}\left({}^{12}_{\Lambda}\mathrm{B}\right)}=?$$

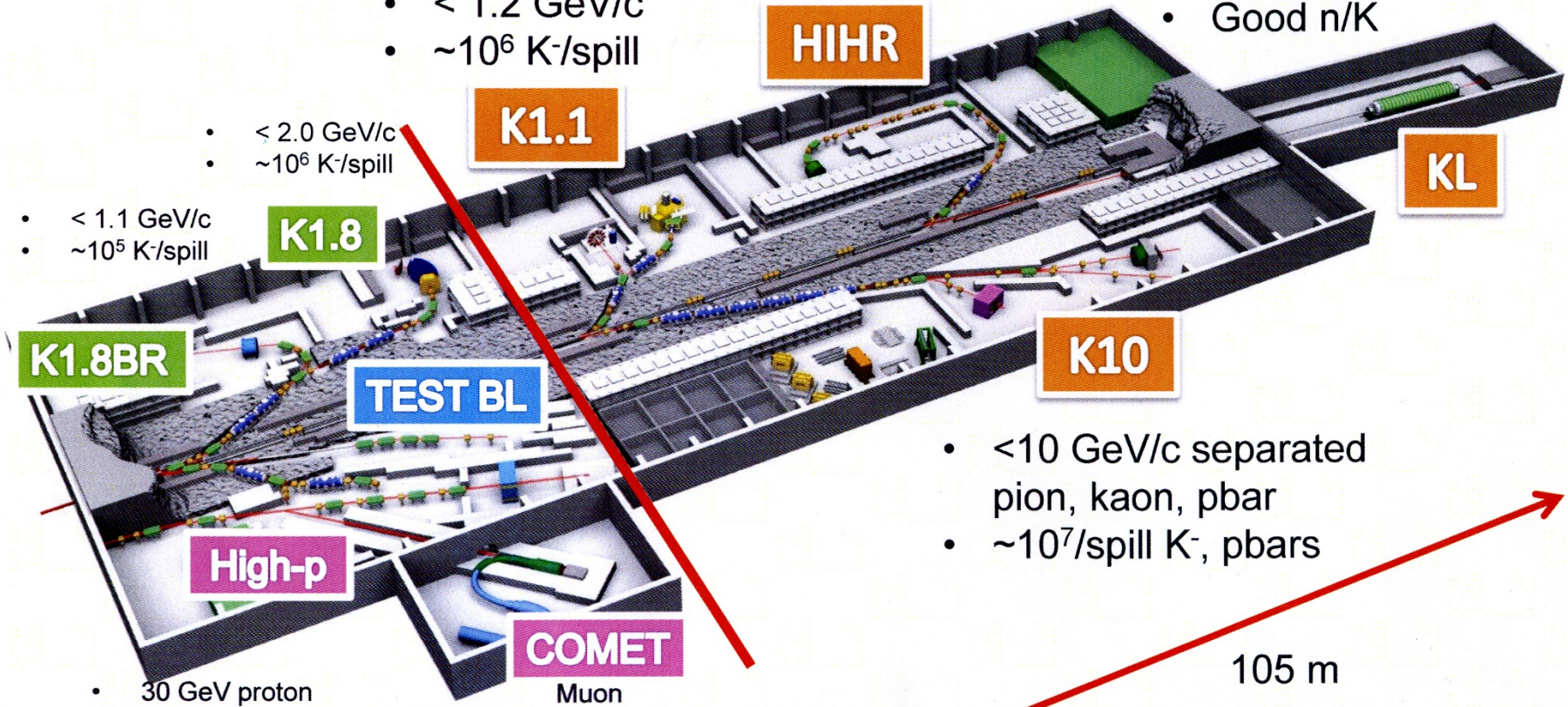
T. Motoba, *NPA* 547 (1992) 115c. ≈ 8

The rationale

- to perform new measurement
  by exploiting to a large extent
  preexisting facilities and infrastructures

- to strength the international collaboration
  and the synergy with
  the J-PARC experimental Groups

Extended Hadron Hall



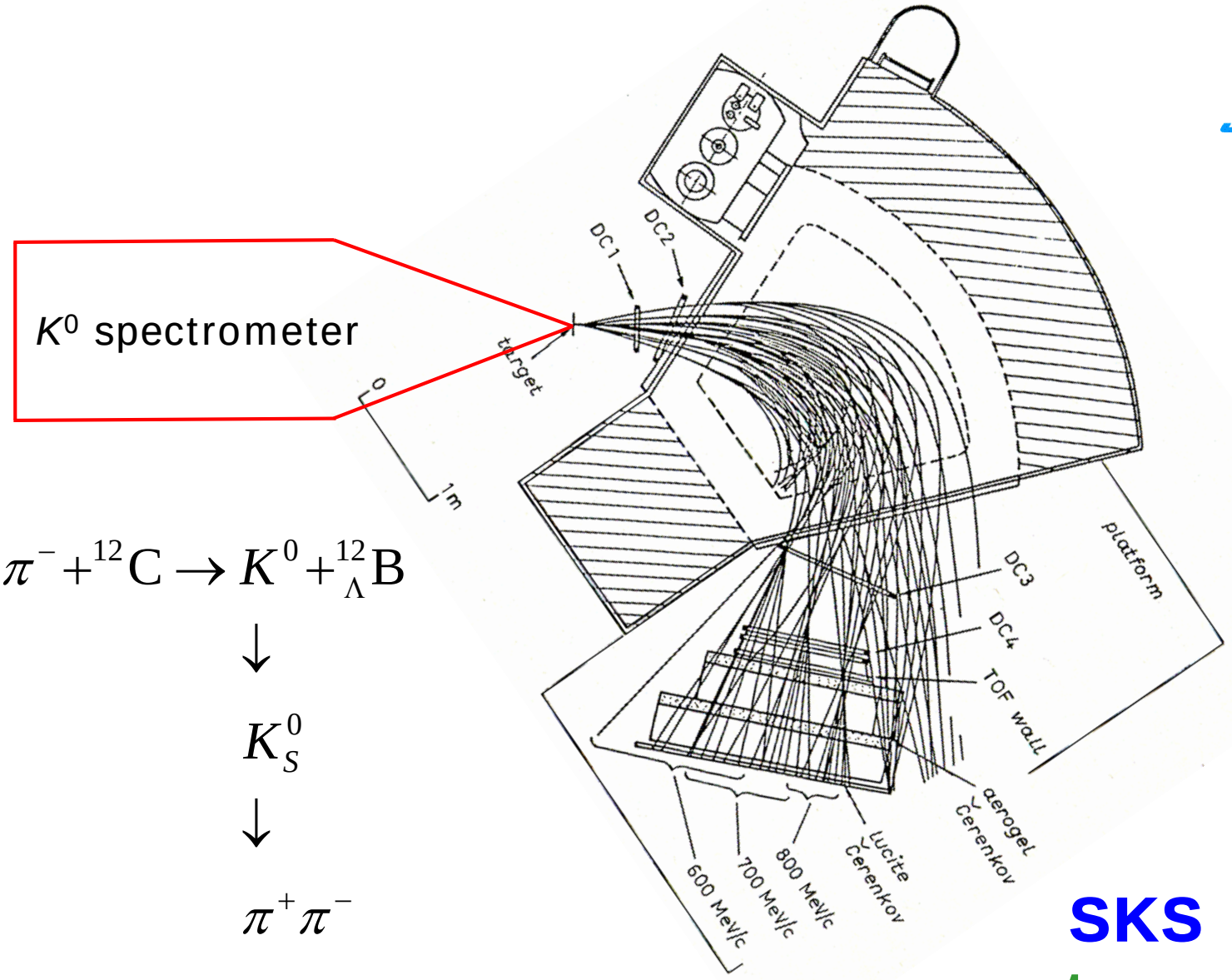
courtesy of T. Takahashi

Features and physics scopes: K1.1

- kaon (~1.1GeV/c) and pion (- ~1.2GeV/c) beams
  - 1.9 m-long separators x 2
  - 28 m length
  - 300k K^-(1.1) /spill and K/p ~1:1 with 5e+13 ppp
- good resolution spectrometers: Beam and SKS
- studies on Λ-hypernuclei and ΣN interaction
  - γ-ray spectroscopy by the (K^-,$\pi^-\gamma$) reaction
  - weak decays: (π^+,K^+) / (π^-, K^0)
  - ΣN scattering: (K^-,$\pi^\pm$), ($\pi^\pm$,K^+)

courtesy of T. Takahashi

A possible apparatus concept layout



$$\pi^- + {}^{12}\mathrm{C} \rightarrow K^0 + {}^{12}_{\Lambda}\mathrm{B}$$

$$\downarrow$$

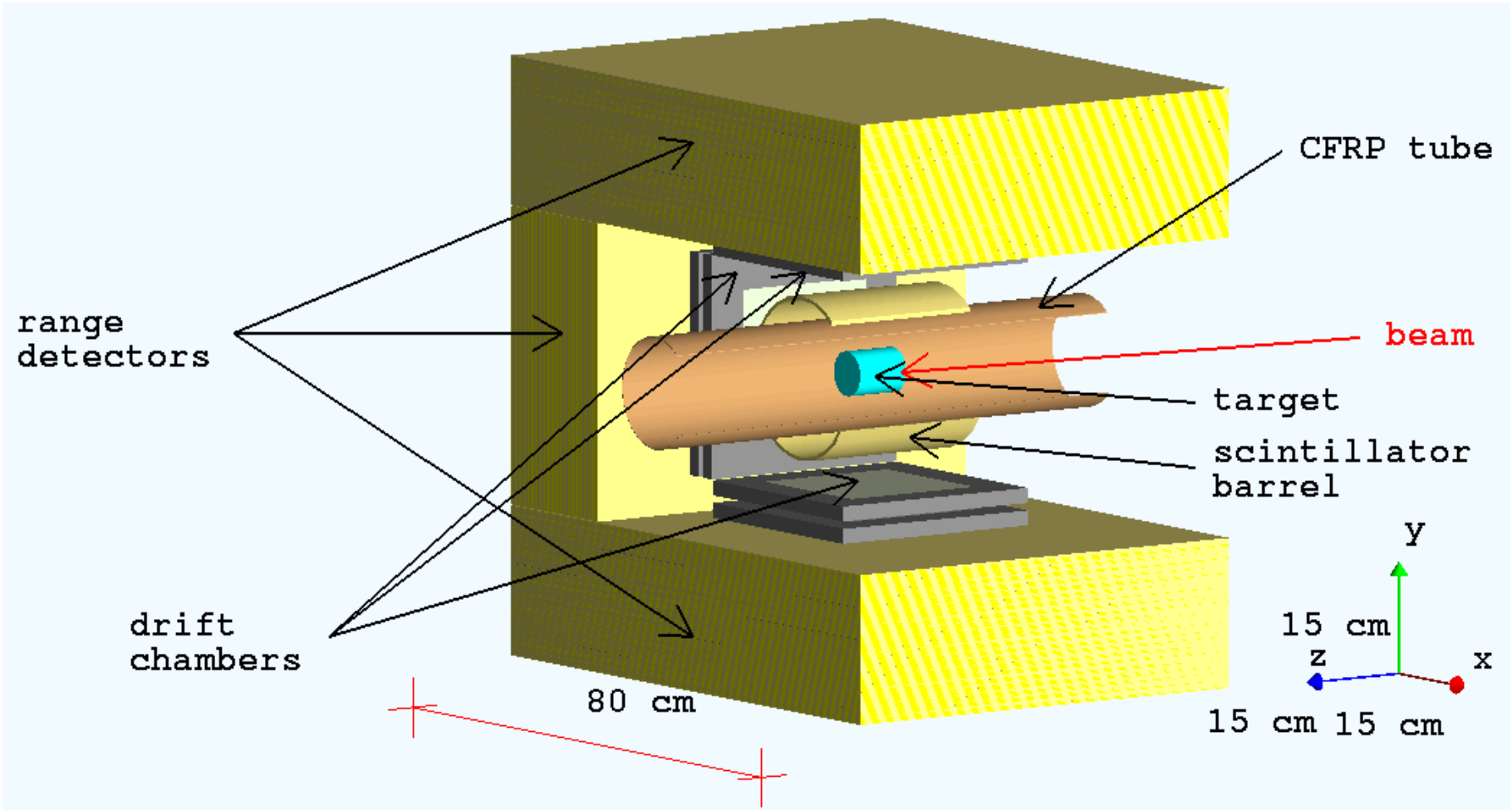
$$K^0_S$$

$$\downarrow$$

$$\pi^+\pi^-$$

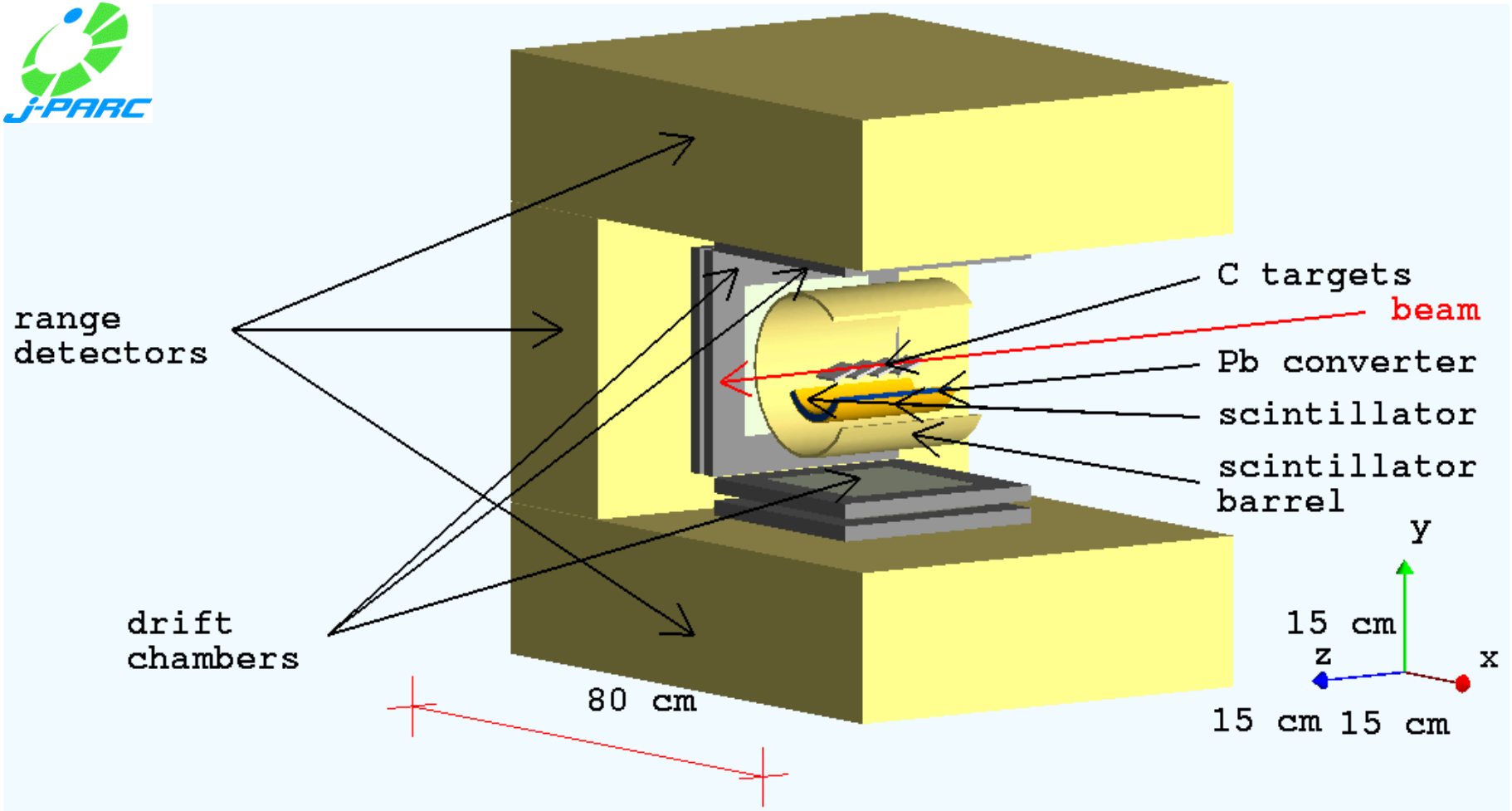
SKS spectrometer

Concept design



Concept design

final goal:
SKS Λ-hypernucleus MM resolution
≤ 3 MeV (FWHM)



detector performance: solid angle coverage 50-60%

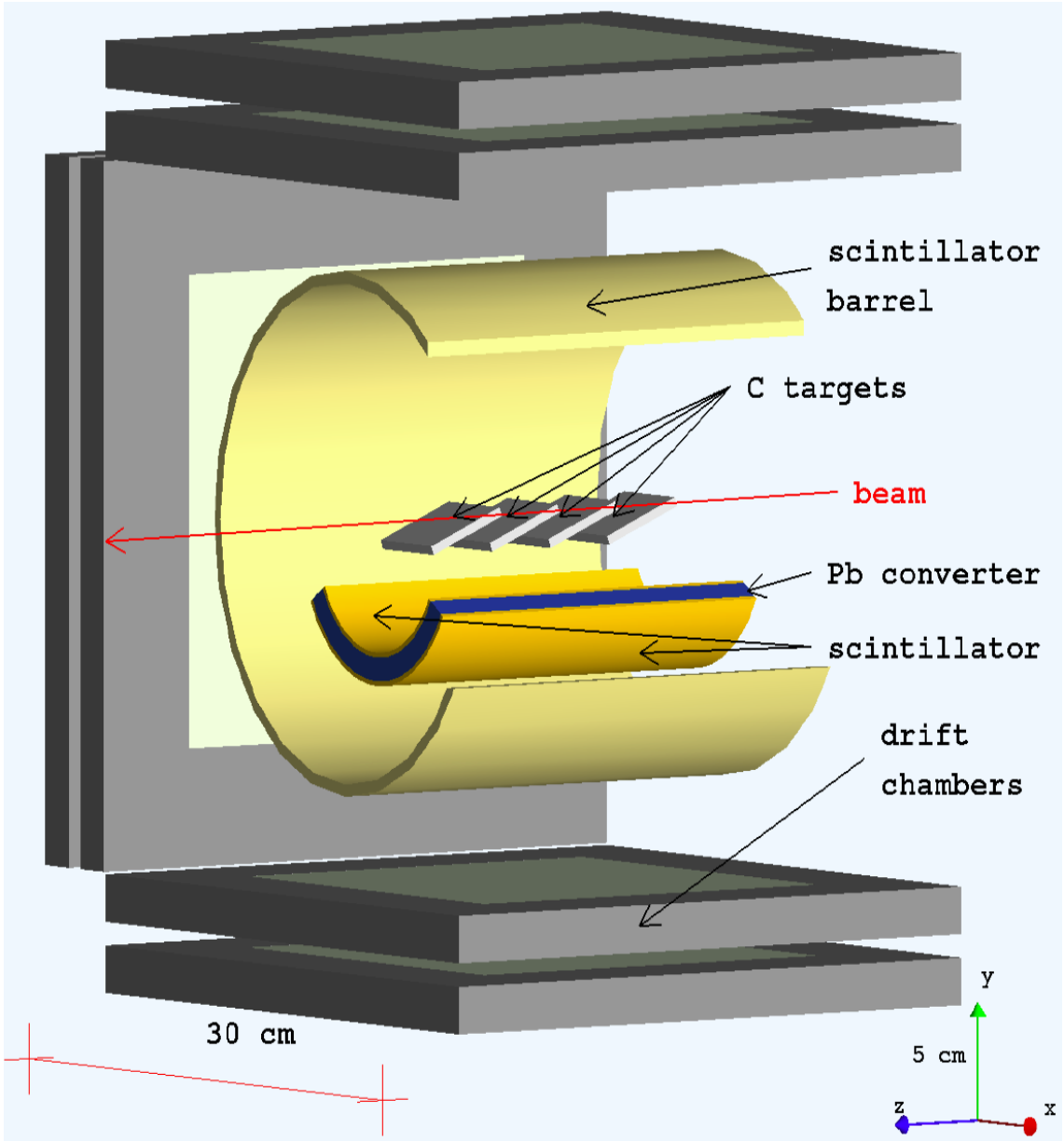
range detector

- energy resolution on π^- ≤ 2 MeV (FWHM)
- angular resolution ≤ 100 mrad

drift chambers

spatial resolution ≤ 300 μm

Concept design



C target thickness:

0.7 gr/cm^2

along the beam:

1.0 gr/cm^2

possible alternatives:

^{6}Li

^{7}Li

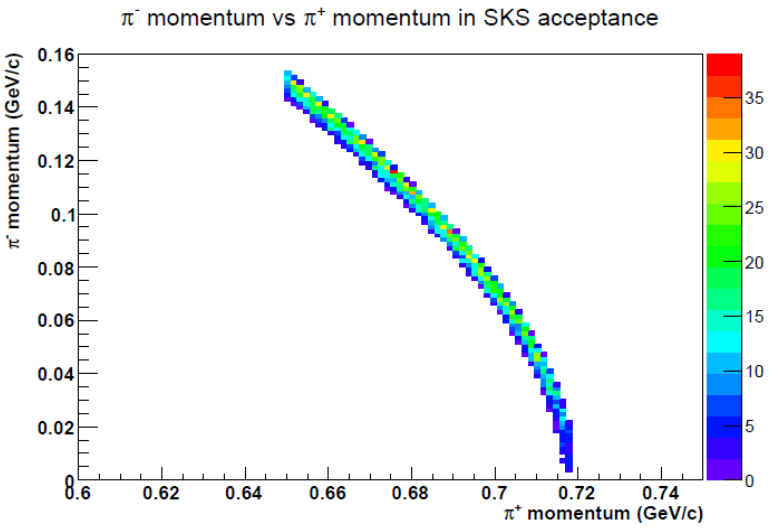
^{9}Be

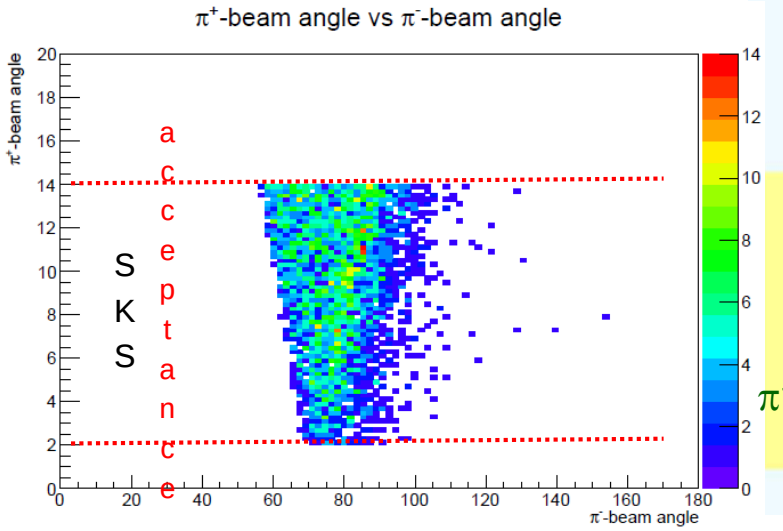
^{16}O

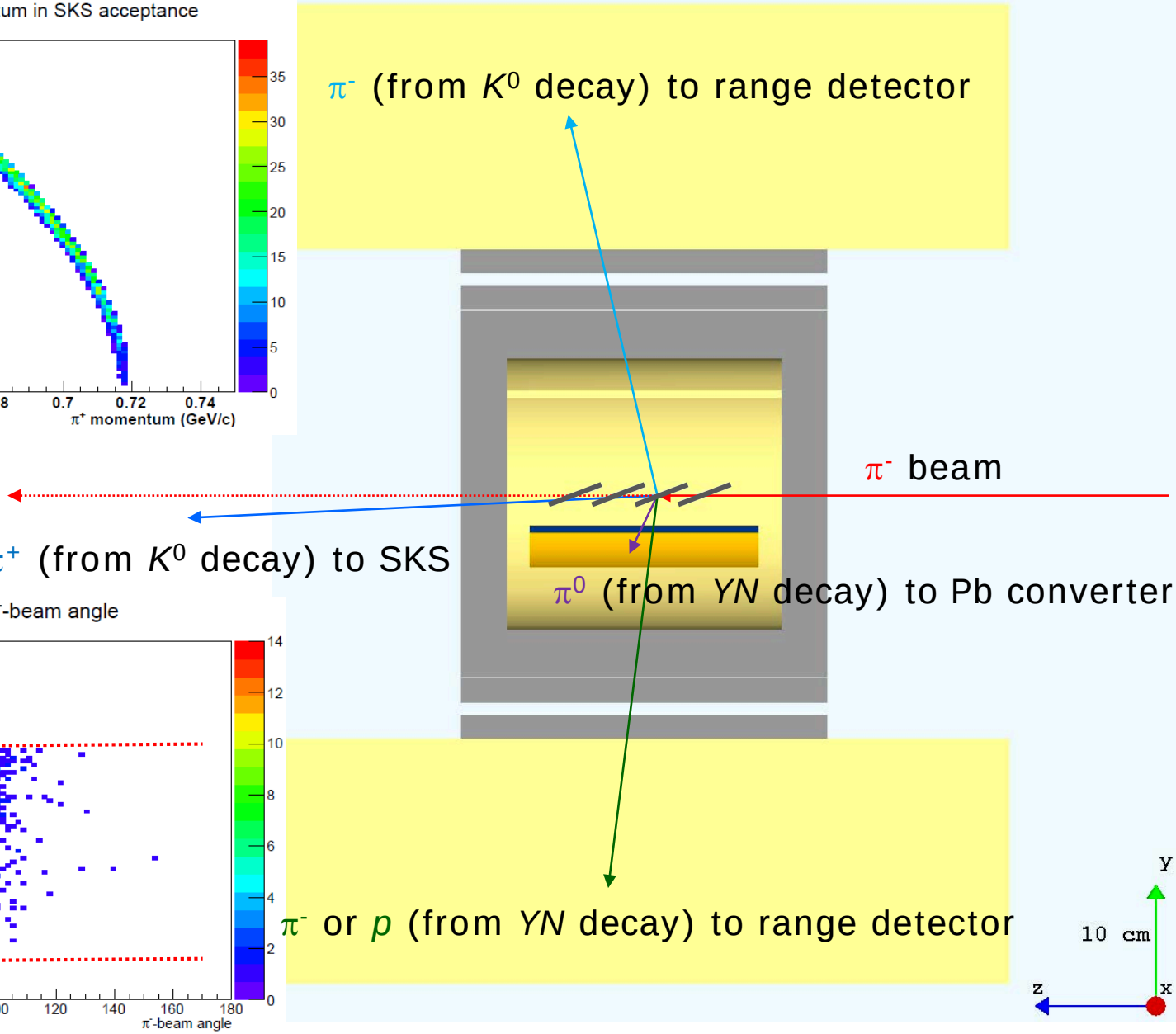
theoretical advice required

Kinematics

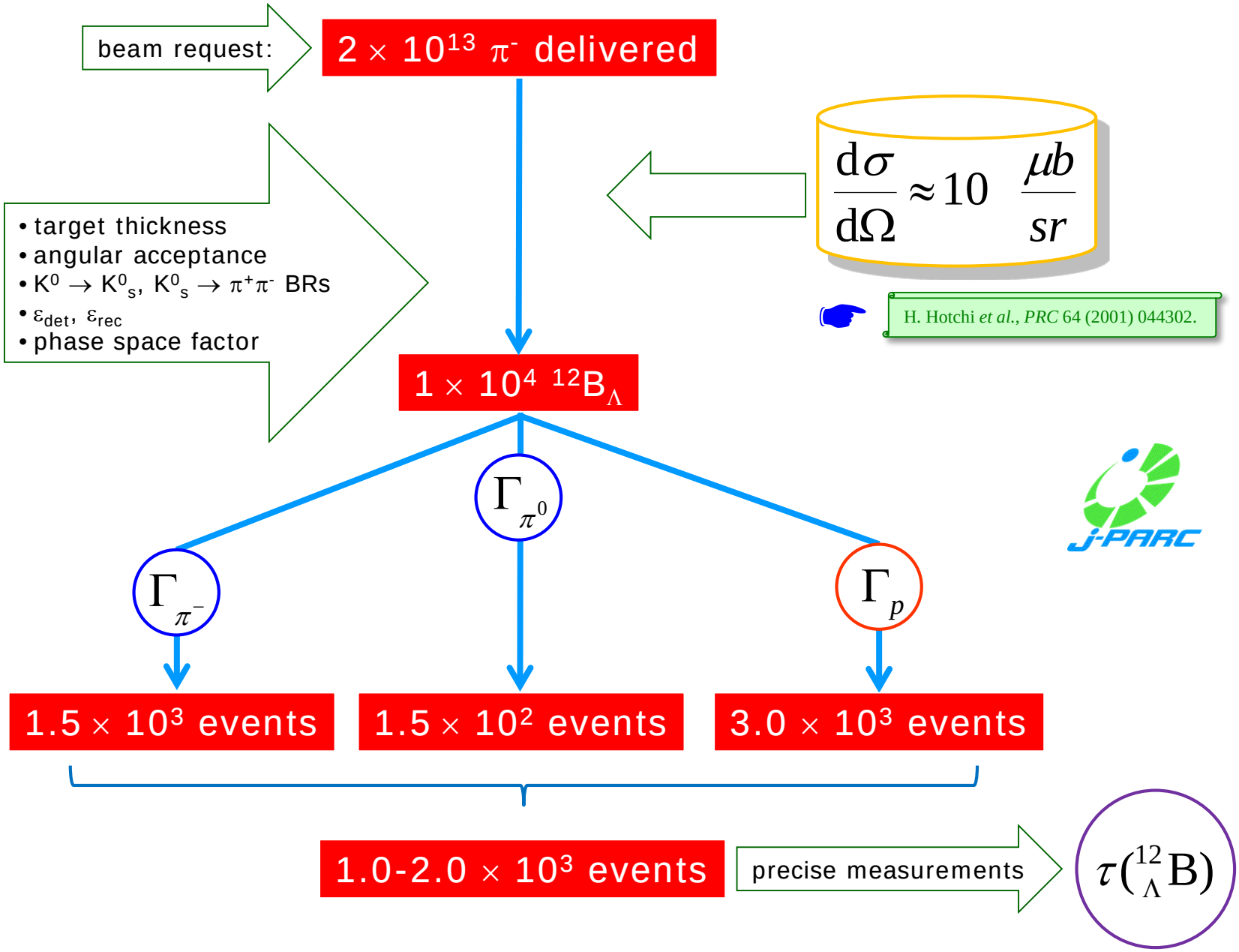
$$\pi^- + {}^{12}\mathrm{C} \rightarrow K^0 + {}^{12}_{\Lambda}\mathrm{B}$$







Expected rates (preliminary estimate)



Thank you!

どうも　ありがとう