Hypernuclear Physics at DAΦNE2

Tullio Bressani

Dipartimento di Fisica Sperimentale, Torino University

and I.N.F.N. – Sezione di Torino

in collaboration with

E. Botta (Torino University)

A. Feliciello (I.N.F.N. – Torino)

V. Paticchio (I.N.F.N. – Bari)

VIII International Conference on Hypernuclear and Strange Particle Physics
Jefferson Lab October 14 - 18, 2003.

Summary

- Introduction
- Ideas for DAΦNE2 (L_{peak} >10^{34} cm^{-2} s^{-1}, hopefully 10^{35} cm^{-2} s^{-1})
- A program on Hypernuclear Physics at DAΦNE2
  - Neutron rich Hypernuclei
  - Weak Decays, in particular Γ_{2N}

  } Present FINUDA

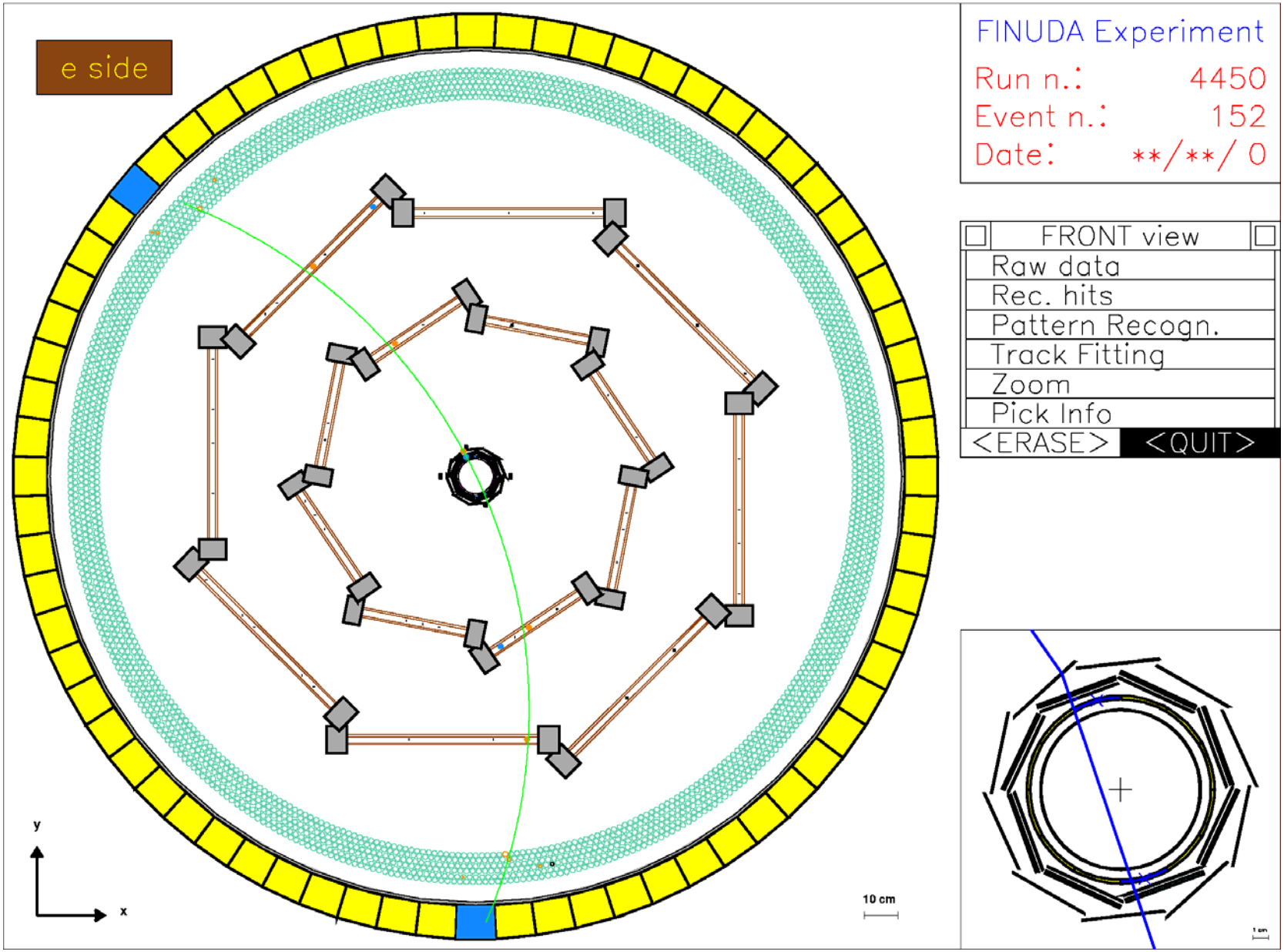
  - γ-Spectroscopy in coincidence with formation π^-

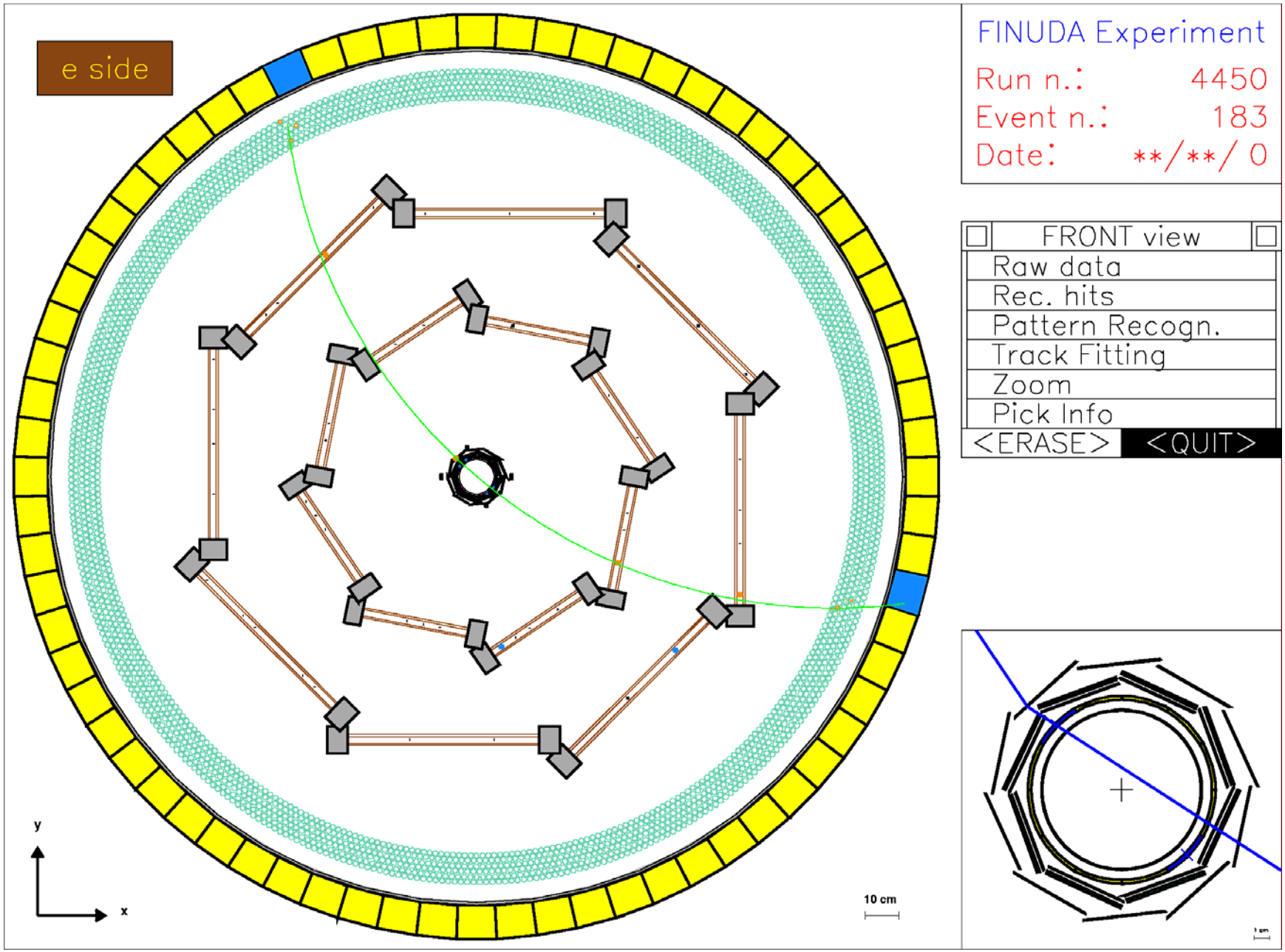
  } modified FINUDA
  modified KLOE

  - γ-Spectroscopy of Hyperfragments

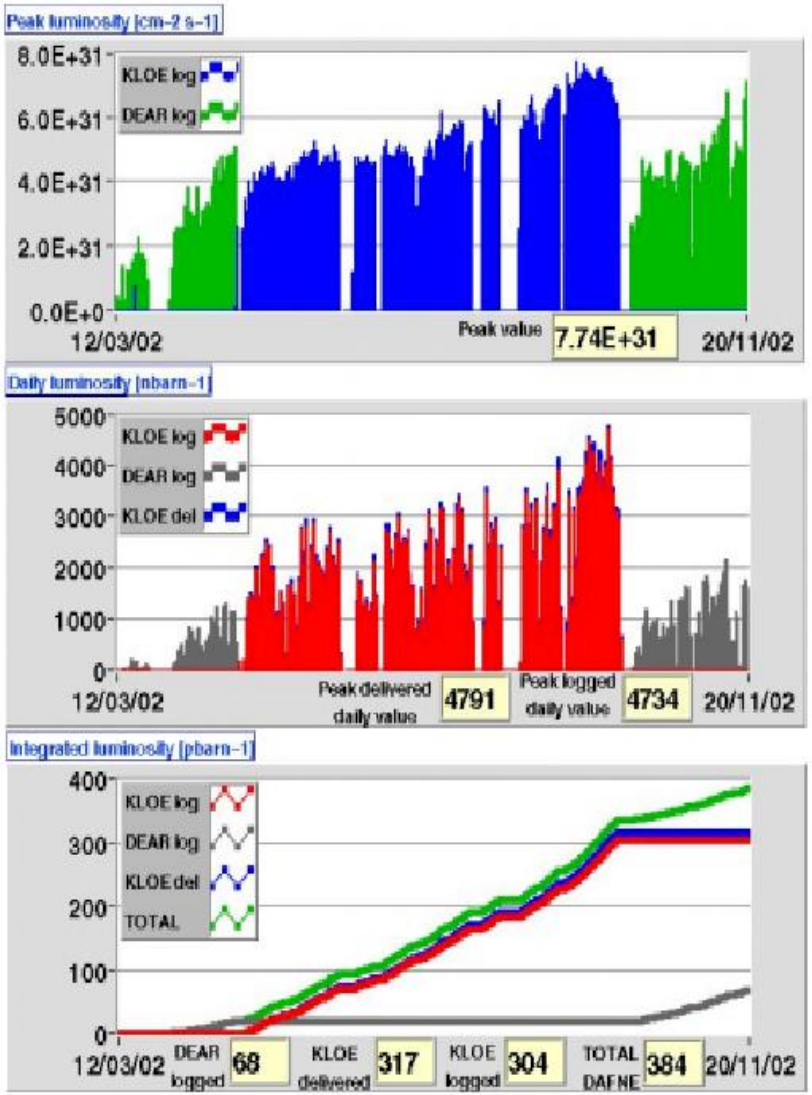
  { new detector or
  "travelling " detector

- Conclusions


e side
FINUDA Experiment
Run n.: 4450
Event n.: 152
Date: **/**/ 0
FRONT view
Raw data
Rec. hits
Pattern Recogn.
Track Fitting
Zoom
Pick Info
<ERASE>
<QUIT>
y
x
10 cm


e side
FINUDA Experiment
Run n.: 4450
Event n.: 183
Date: **/**/ 0
FRONT view
Raw data
Rec. hits
Pattern Recogn.
Track Fitting
Zoom
Pick Info
<ERASE>
<QUIT>
y
x
10 cm

Introduction



Following the

good results of DAFNE1

(L_{peak} ~ 7.7 10^{31} cm^{-2} s^{-1},

L_{int} ~ 5 pb^{-1}/day) ….

… whishes of improving the performances of the machine were put forward

- Increase the luminosity ($L_{peak} \geq 10^{34}$ cm^{-2} s^{-1}, possibly 10^{35} cm^{-2} s^{-1})

- Increase the C.M. energy up to ~ 2.2 GeV, with $L_{peak} \cong 10^{32}$ cm^{-2} s^{-1}

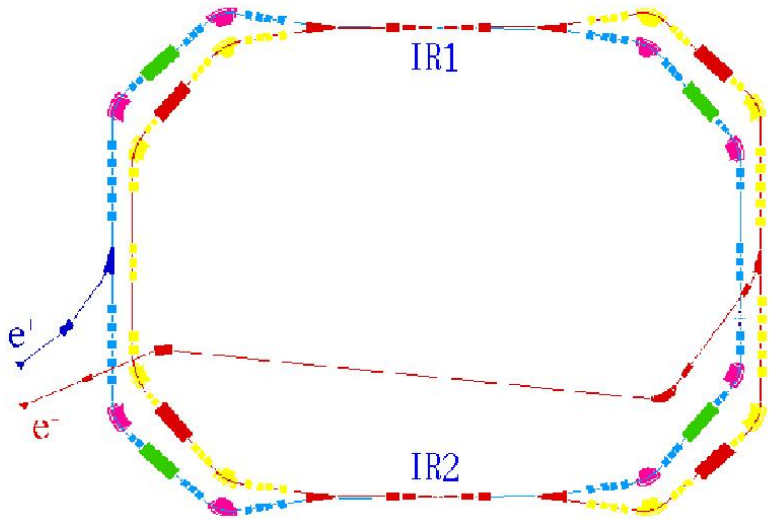
Only first option interesting for hypernuclear physics (stopped K^-)
A dedicated Workshop (ICFA) held in Alghero

Good attendance (120 researchers): both machine and Physics aspects

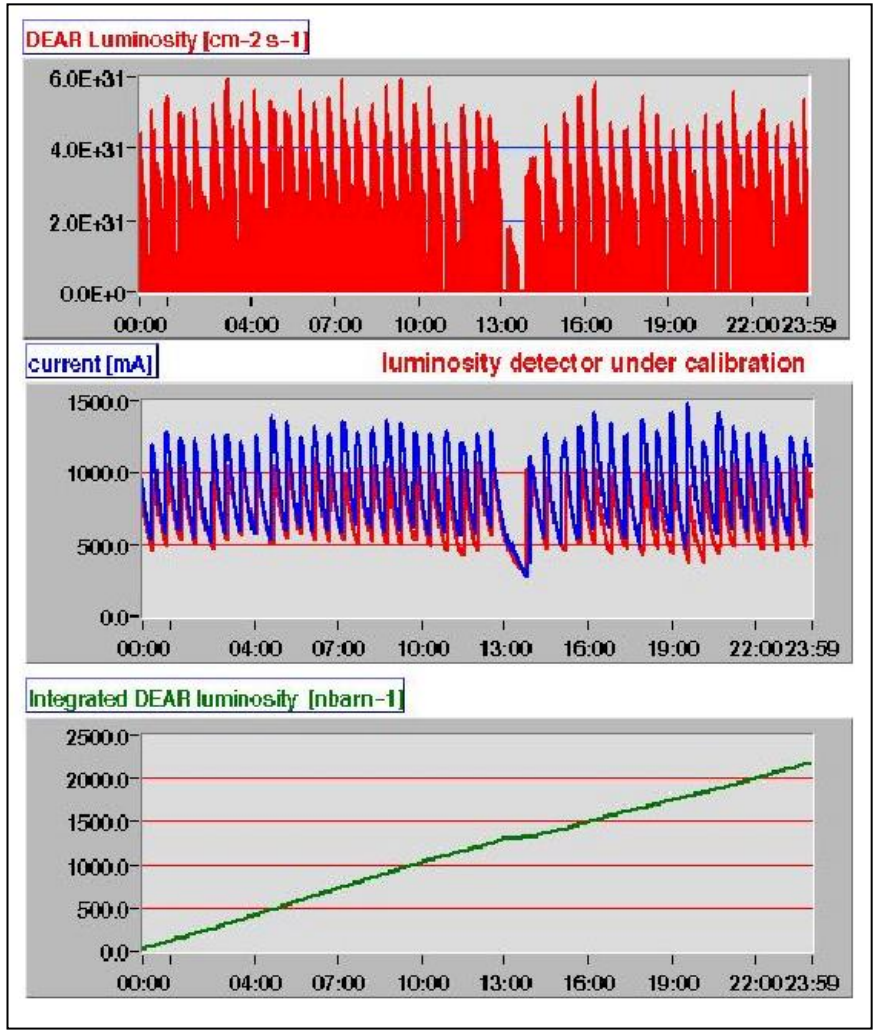
Ideas for DAΦNE2

Reminders of the features of *DAΦNE1*

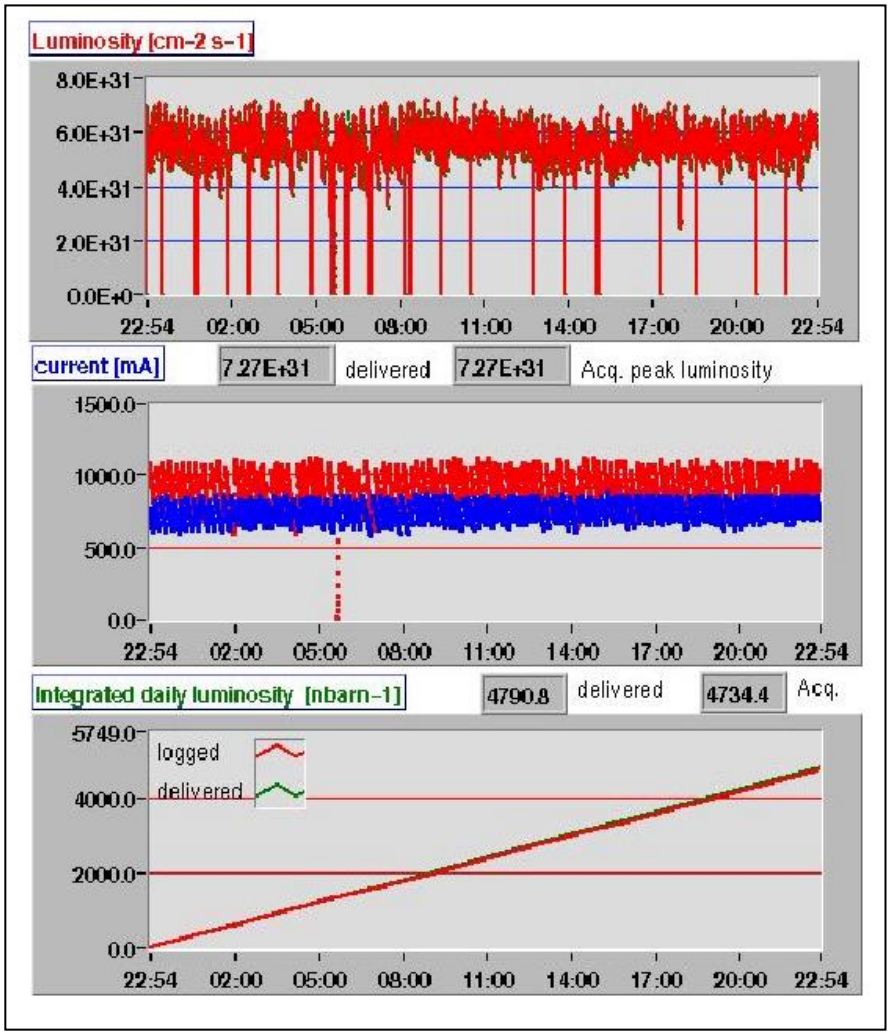
energy	510 MeV
luminosity	5 10^{32} cm^{-2} s^{-1}
σ_x (rms)	2.11 mm
σ_y (rms)	0.021 mm
σ_z (rms)	35 mm
bunch length	30 mm
crossing angle	13 mrad
frequency (max)	368.25 MHz
bunch/ring	up to 120
part./bunch	8.9 10^{10}
current/ring	5.2 A (max)



Best DEAR day



Best KLOE day



How to increase by 2 orders of magnitude the present L of DAΦNE?

Oversimplified assumptions and ideas:

$$L \approx \frac{N^2}{\sigma_z}$$

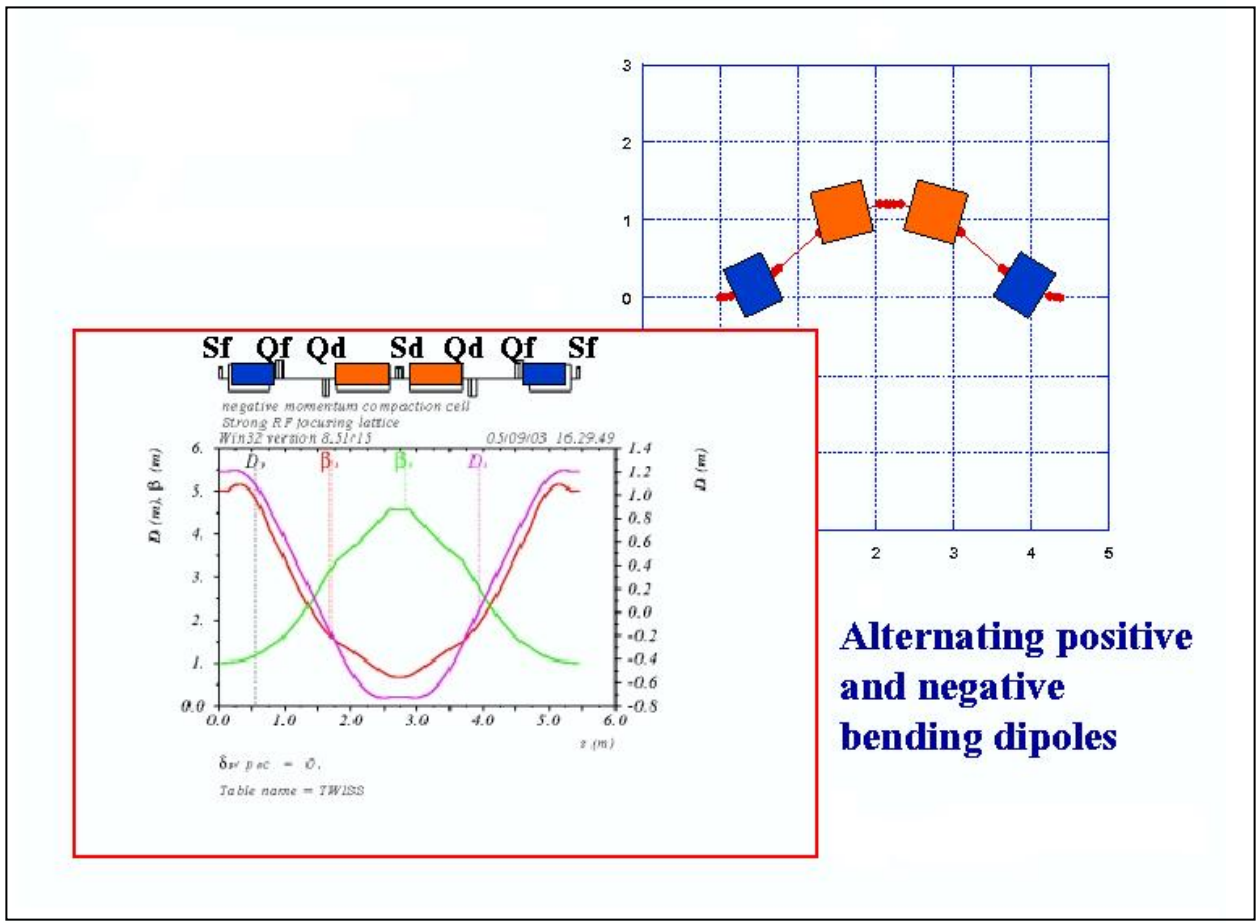
N = number of particles / bunch

σ_z = longitudinal dimension at IP

➡ One IP

➡ Decrease σ_z: high and negative momentum compaction by strong RF focusing (σ_z from ~ 3 cm to ~ 2 mm)

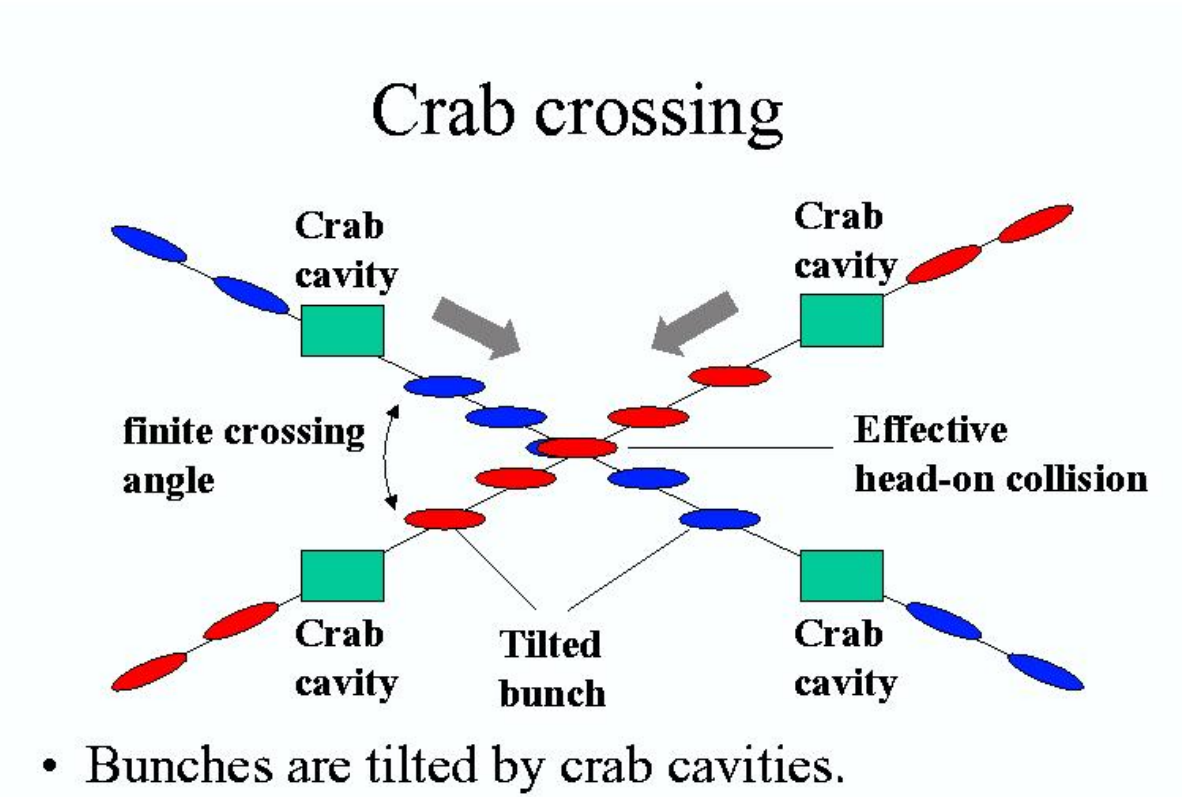
➡ Increase N : “all wiggler” machine



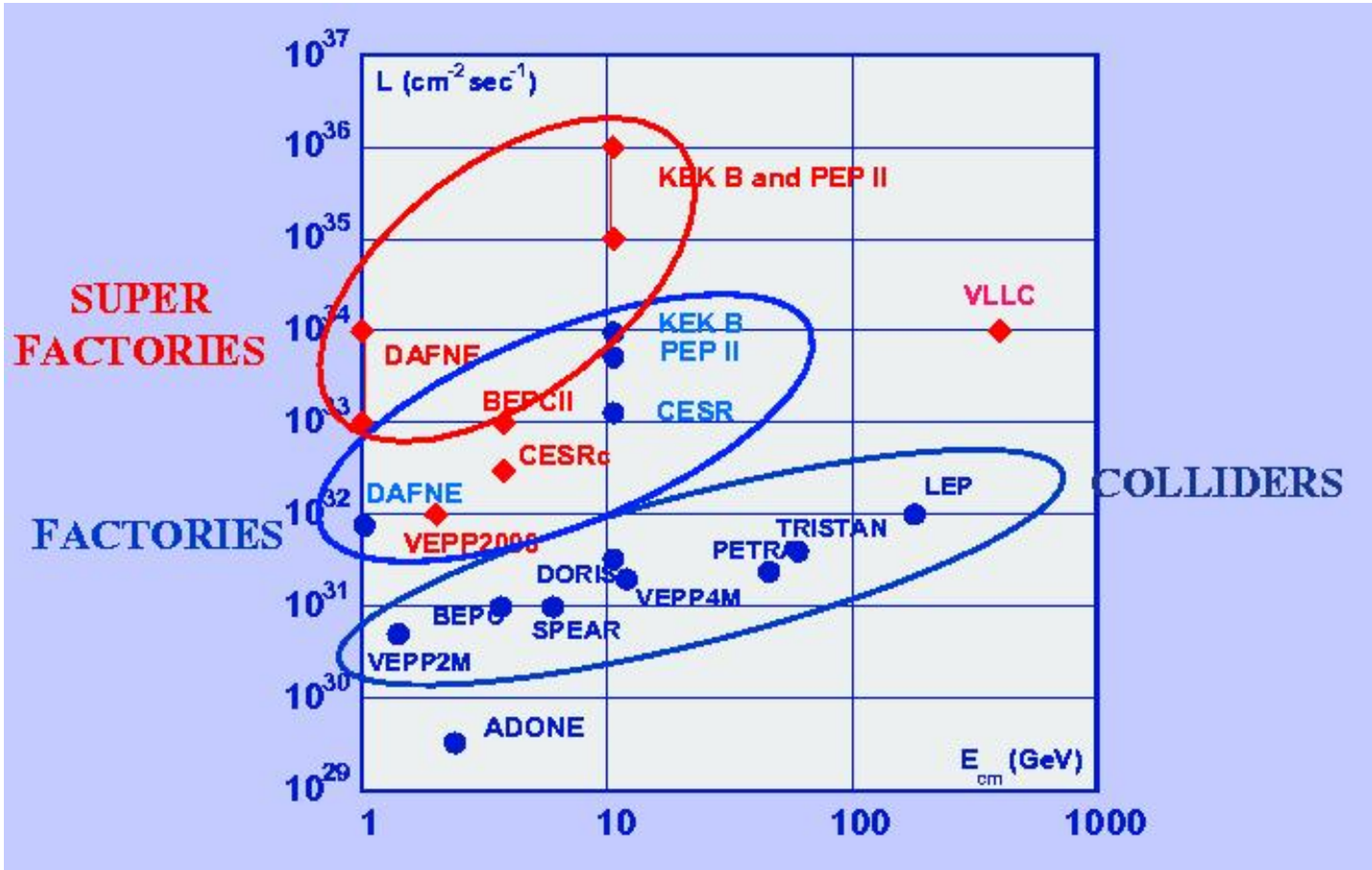
More ambition?

from $L_{peak} = 10^{34}$ cm^{-2} s^{-1} to $L_{peak} = 10^{35}$ cm^{-2} s^{-1}

Higher energy beams and high crossing angle: L is increasing with E

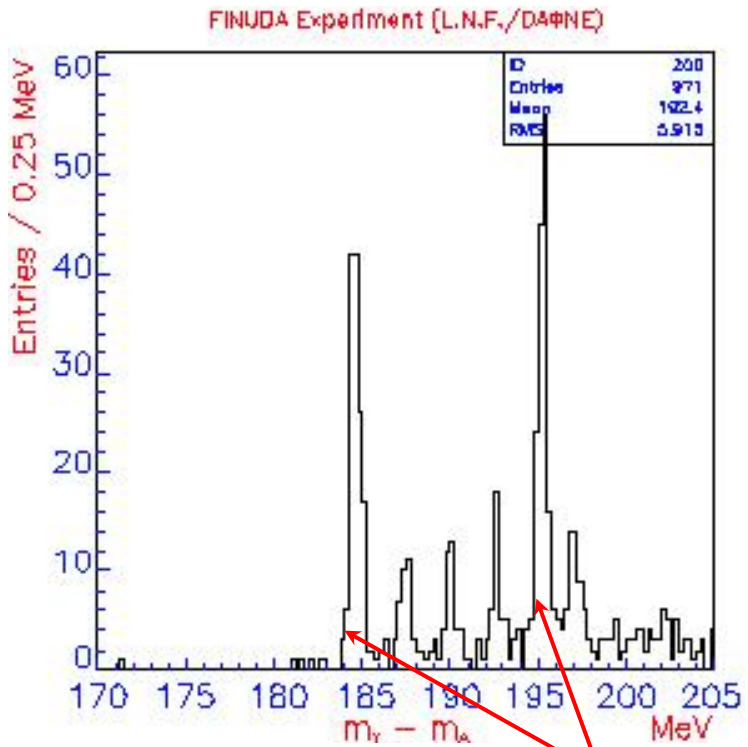


DAΦNE2 would be placed in the rank of "SuperFactories"



A program on Hypernuclear Physics at DAΦNE2

- Production rate



@ $L=10^{34}$ cm^{-2} s^{-1} obtained in less than 10 minutes

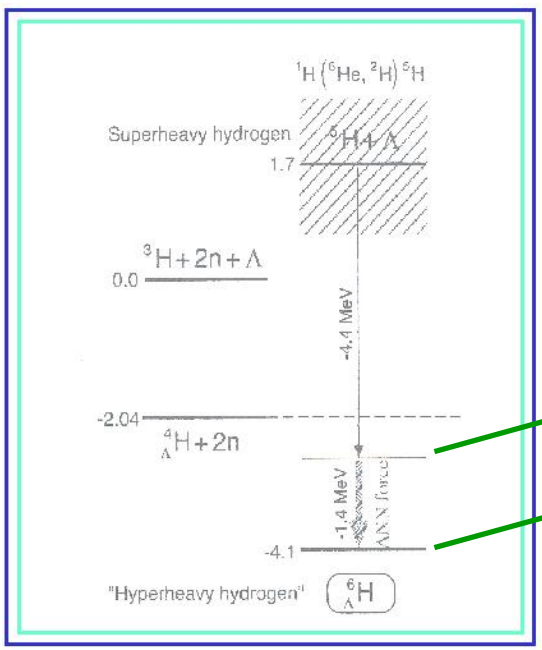
capture rate ~ 10^{-3} /stopped K^-

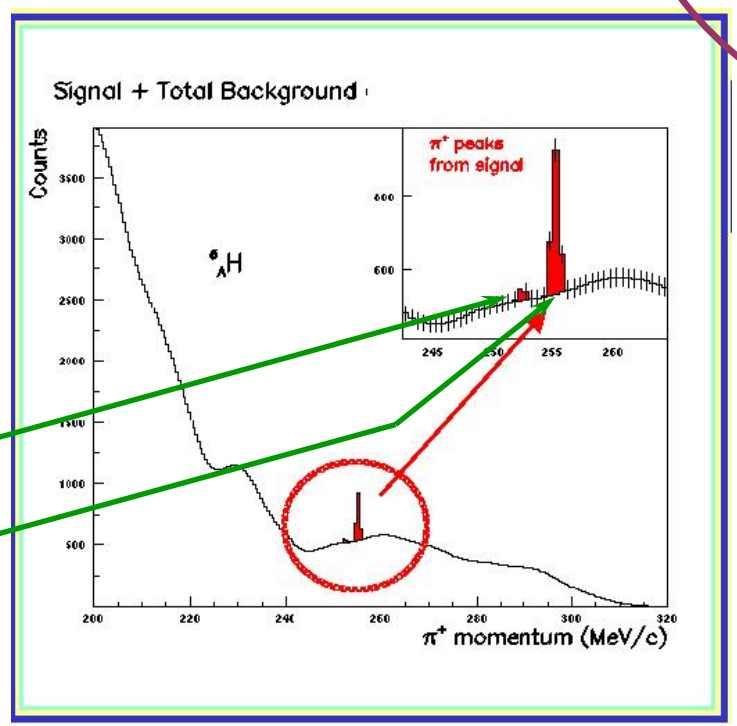
Neutron-rich Hypernuclei

- Not yet identified
- With (K^-, π^+) expected capture rates between 10^{-5} and 10^{-6} per stopped K^-
- Hopes for ^{6}Li(K^-, π^+) $^{6}_{\Lambda}$H at 10^{-4} ?

If so …

one hour of data taking





- Attempt to measure Γ_n, Γ_p, Γ_π: possible with the previous rates

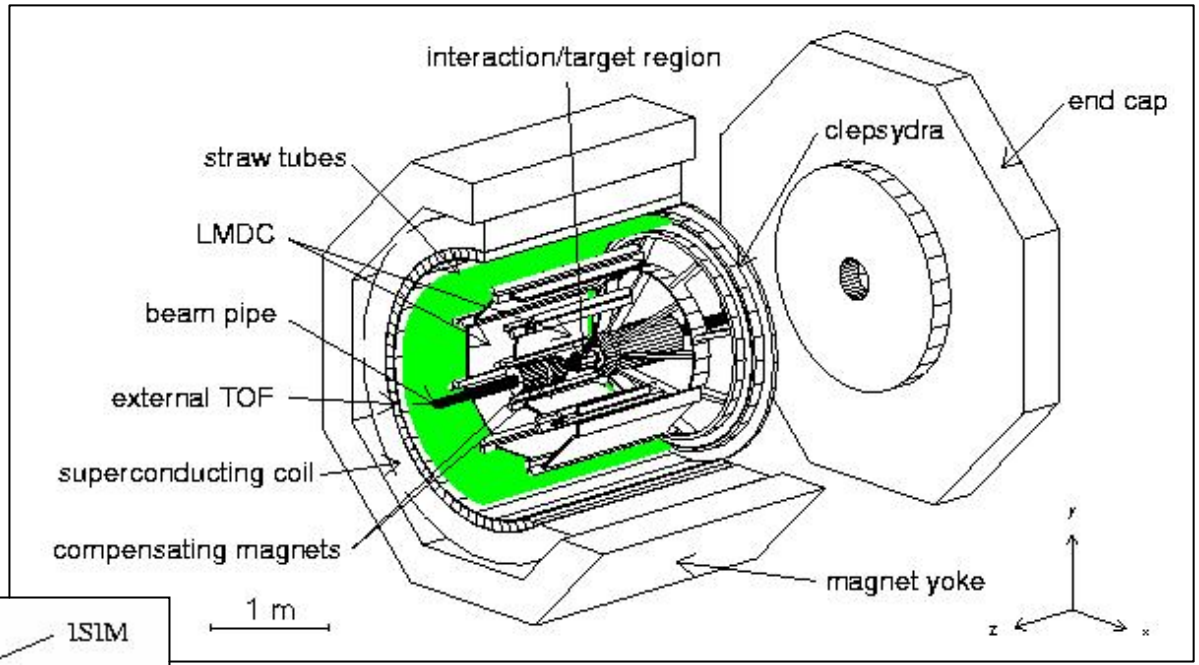
- Measurement of the Γ_{2N} decay width: $\Lambda+(N+N) \rightarrow N+N+N$

Important contribution (15% following Alberico and Garbarino), to be measured for an understanding of the full pattern of the Λ–N weak interaction

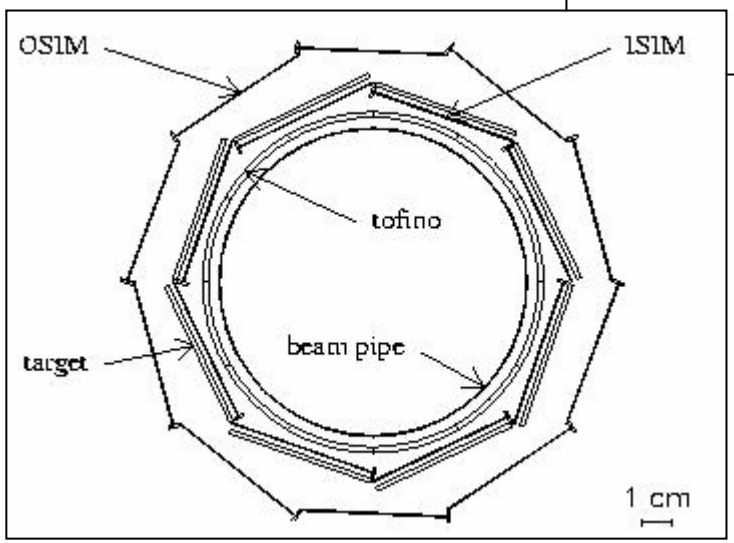
- Coincidence rates (π^-, 3N) of the order of a few/hour

Detector: the present FINUDA mainframe

Global view

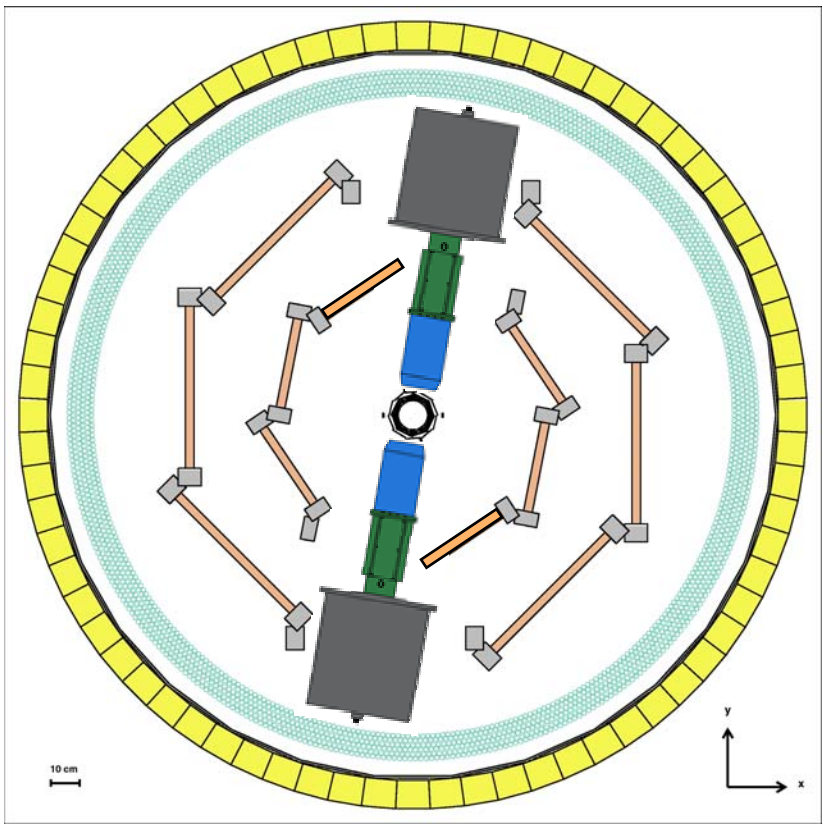


Interaction region

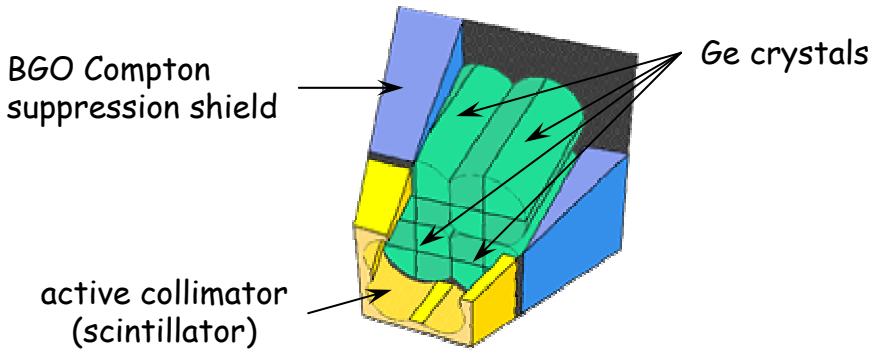


- new DAQ
- replacement of aged detectors

Detector: the FINUDA2 mainframe



The Segmented Clover Detector



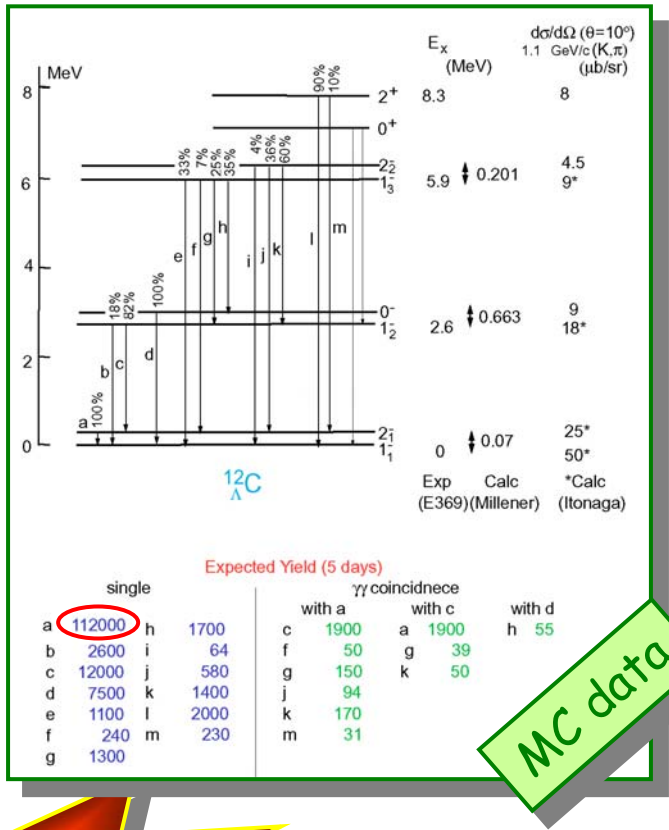
Geometrical acceptance
reduced to 72%

γ-Spectroscopy in coincidence with formation π^-

@ $\mathcal{L} = 10^{34}$ cm^{-2} s^{-1} FINUDA can observe ~ 1.6×10^4 ev/h from YN g.s.

- machine duty cycle: 75%
- spectrometer acceptance: 72%

~ 1.87×10^4 ev/d

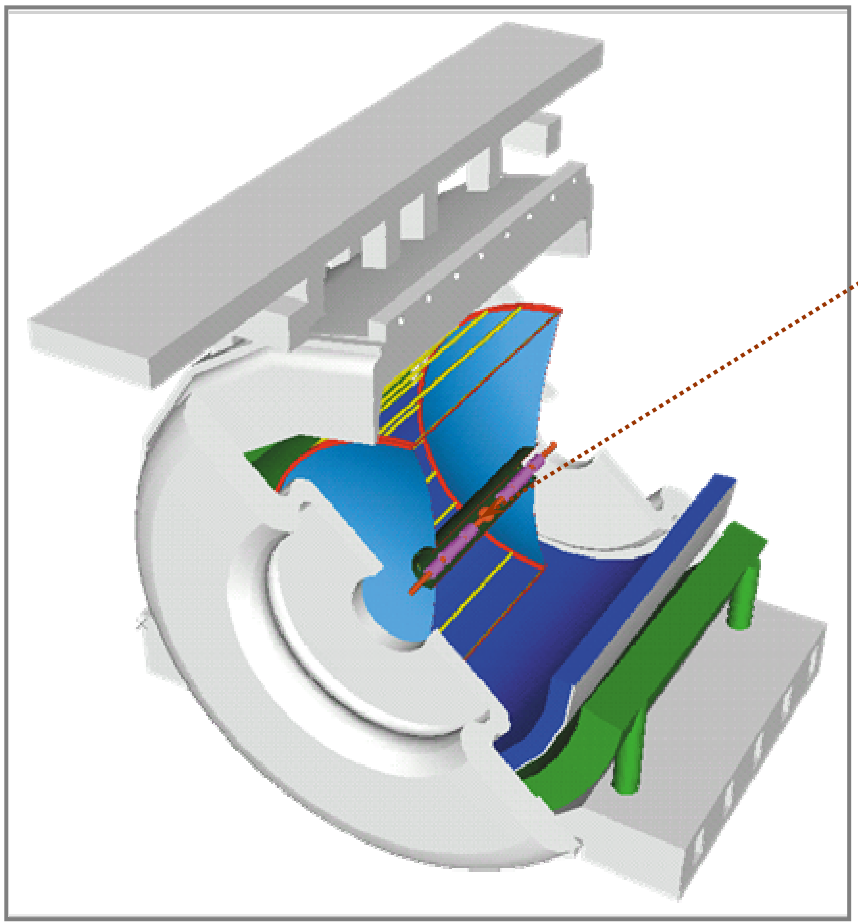


5 day data taking

~ 9.33×10^4 ev

- γ-Spectroscopy in coincidence with formation π^-

"YKLOE"



Ge
detector(s)
+
t.o.f.

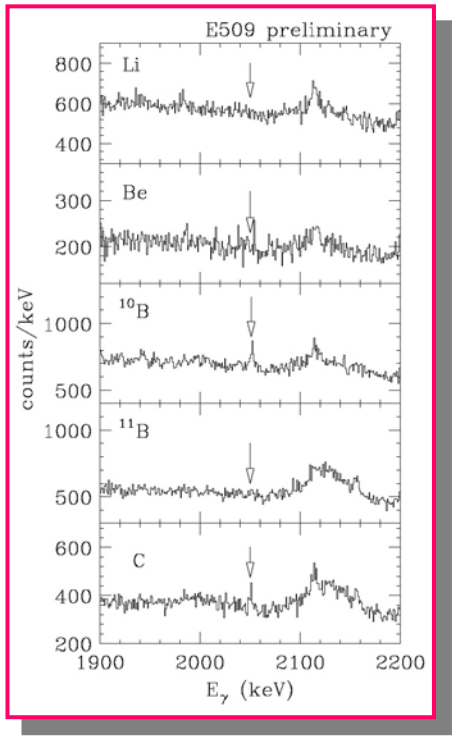
Spectroscopy of Hyperfragments

hypernuclear species are limited by target availability

stopped K^- induced reactions
are the most efficient way
to produce hypernuclei
high level of background

high resolution spectrometer no longer needed
in order to identify the hypersystem produced
(→ low or no magnetic field required)

spectrum of experimental solutions
- dedicated apparatus
- travelling detector



Production of hyperfragments extends
the possibility of hypernuclear γ-ray measurements

Expected Hyperfragments Yield

@ DAΦNE2 ($\mathcal{L}$ = 10^{34} cm^{-2} s^{-1})	@ JPARC (K1.1 line)
ϕ/d = 2.85 10^{9}	
K^-/d = 1.40 10^{9}	K^-/d = 6.67 $\times 10^{8}$
stopped K^-/d = 0.9 · 1.40 10^{9} = 1.26 10^{9}	*stopped* K^-/d = 0.2 6.68 10^{8} = 1.33 10^{8}
YN/d = 0.1 · 1.26 10^{9} = 1.26 10^{8}	YN/d = 0.1 · 1.33 10^{8} = 1.33 10^{7}

3.77 $\times 10^{8}$

4.00 $\times 10^{7}$ *

3 day data taking

* initial conditions

Conclusions

An Hypernuclear Physics Program is **conceivable** at **DAΦNE2**, with rates comparable to that expected at **J-PARC**.

The realization is however linked to many questions:

- DAΦNE2 will be built?
- At which time?
- There will be room for an Hypernuclear Physics Program?
- There will be enough people willing to do this program?
- ……
- ……