

Hypernuclear Physics at DAΦNE2

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

Summary

✚ Introduction

✚ Ideas for DAΦNE2 ($L_{\text{peak}} > 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$, hopefully $10^{35} \text{ cm}^{-2} \text{ s}^{-1}$)

✚ 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^-

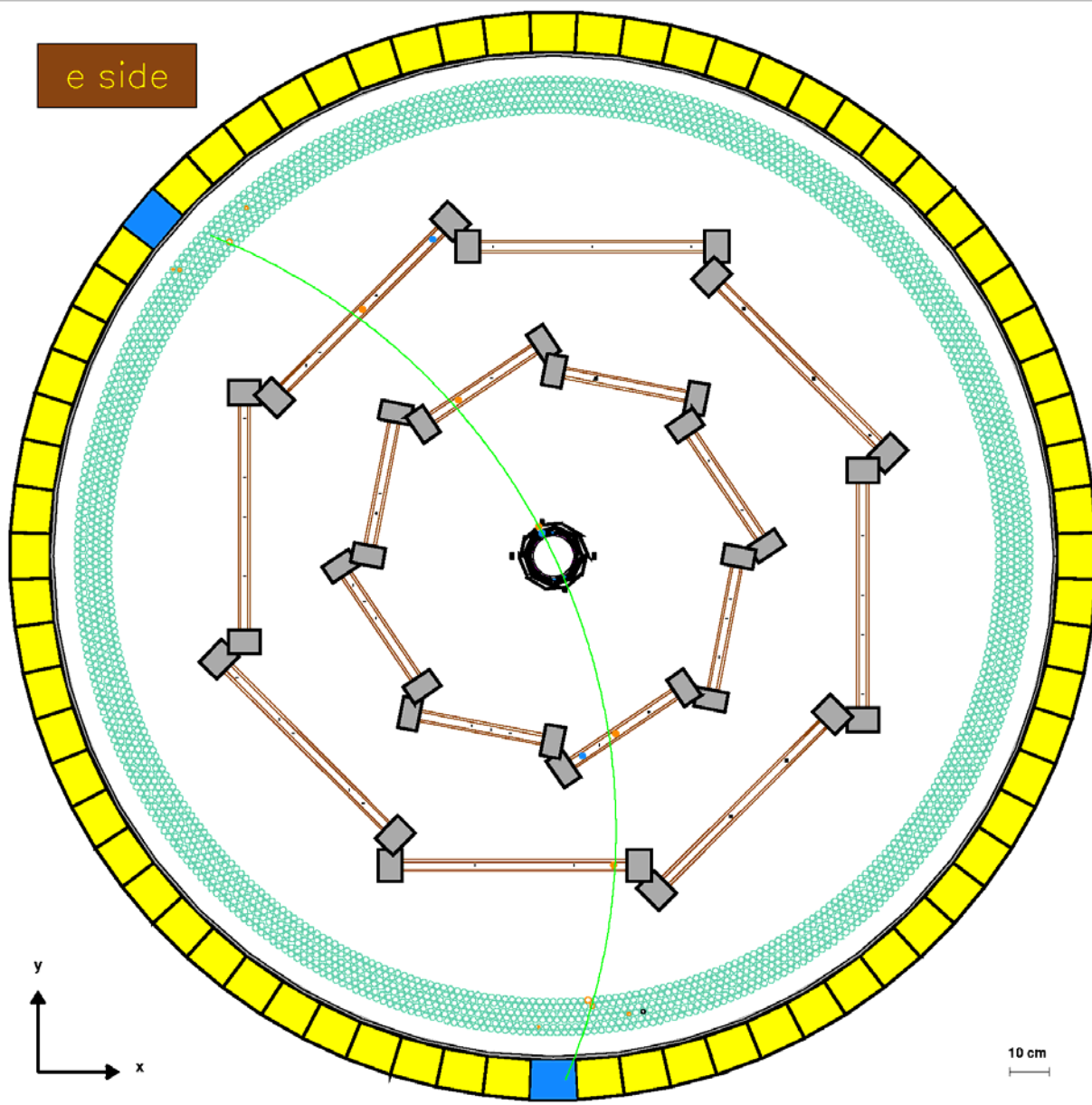
} modified FINUDA
modified KLOE

- ▶ γ -Spectroscopy of Hyperfragments

{ new detector or
"travelling " detector

✚ Conclusions

e side



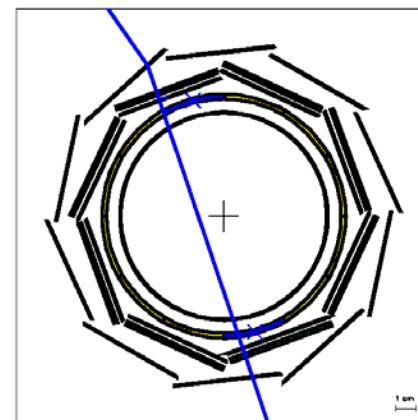
FINUDA Experiment

Run n.: 4450

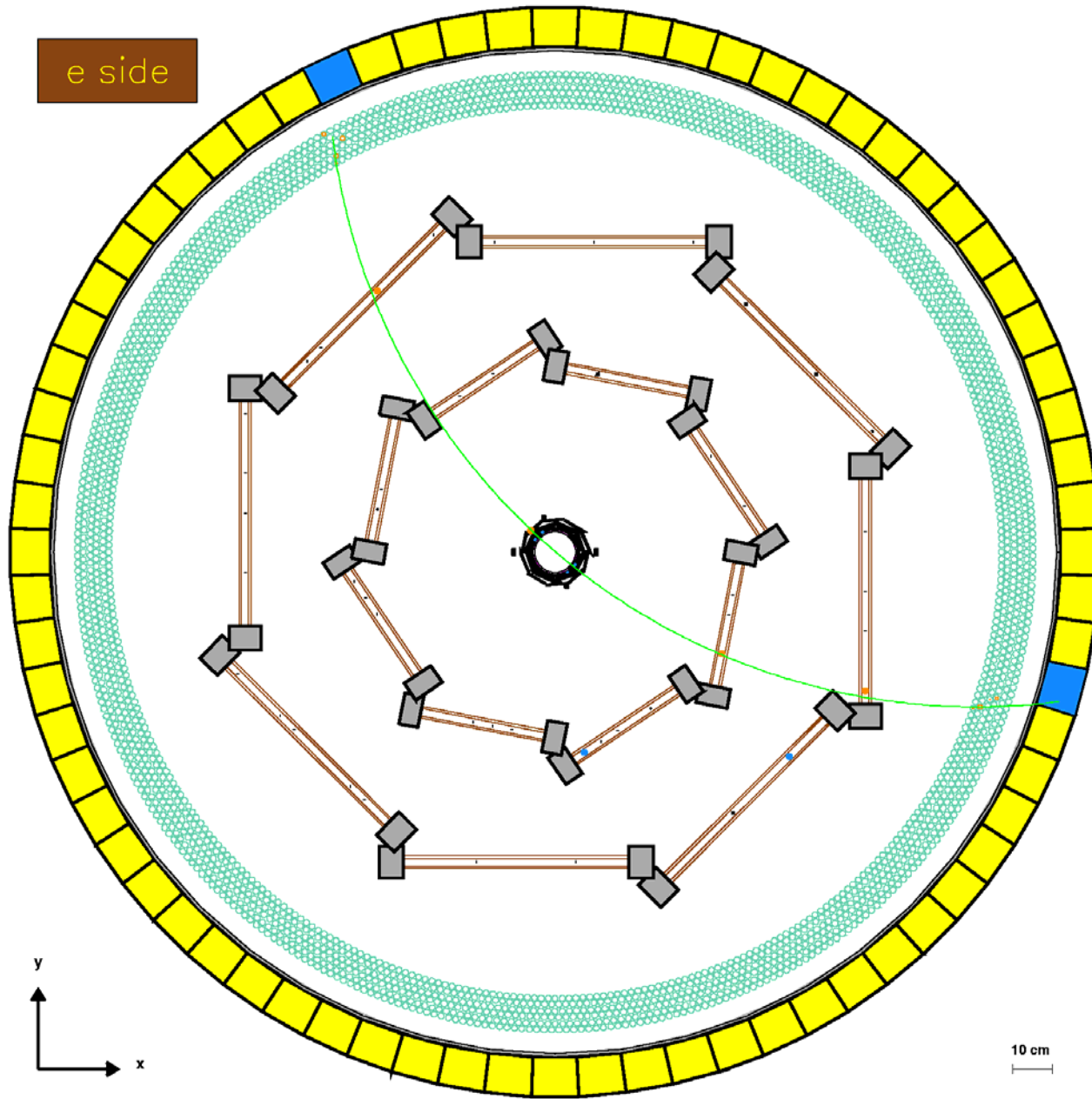
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Date: **/**/0

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e side



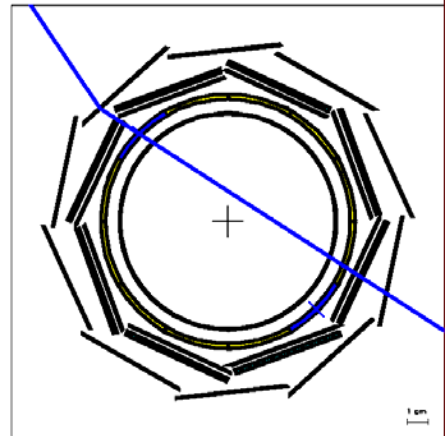
FINUDA Experiment

Run n.: 4450

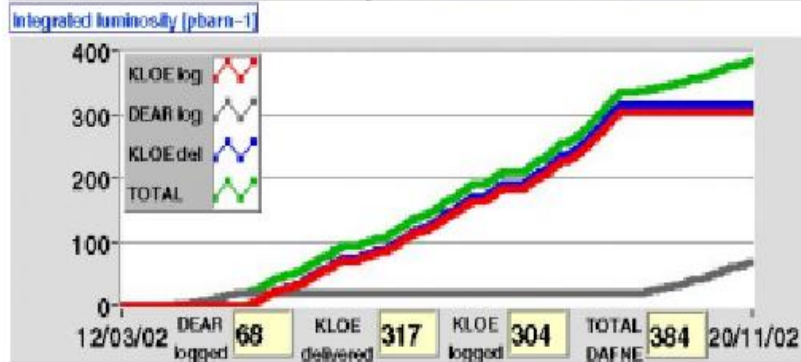
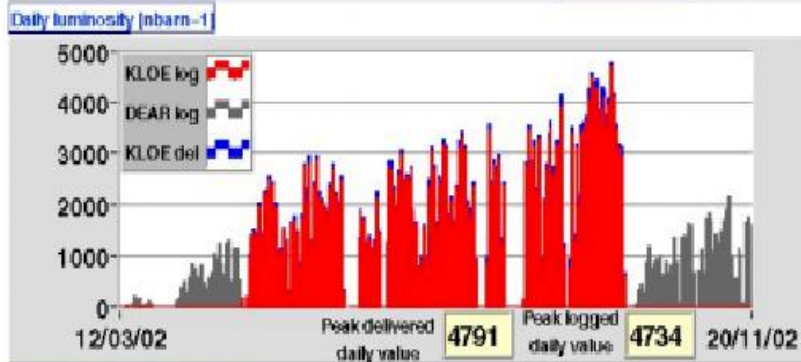
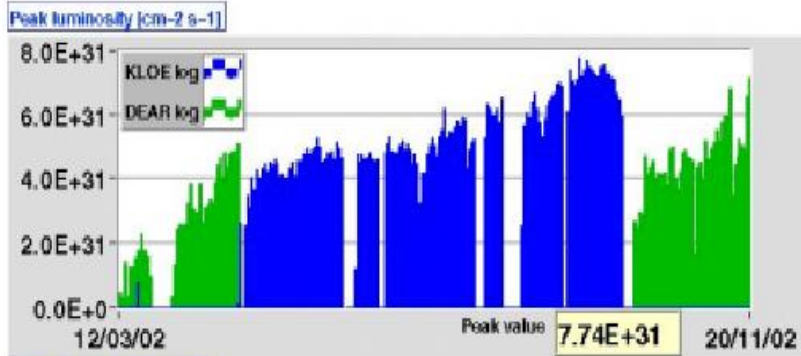
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Introduction



Following the
good results of DAFNE1

$$(L_{\text{peak}} \sim 7.7 \cdot 10^{31} \text{ cm}^{-2} \text{ s}^{-1}, \\ L_{\text{int}} \sim 5 \text{ pb}^{-1}/\text{day}) \dots$$

... wishes of improving the performances of the machine were put forward

- **Increase the luminosity** ($L_{\text{peak}} \geq 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$, possibly $10^{35} \text{ cm}^{-2} \text{ s}^{-1}$)
- **Increase the C.M. energy** up to $\sim 2.2 \text{ GeV}$, with $L_{\text{peak}} \cong 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$

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

Workshop on
 $e^+ e^-$ in the 1-2 GeV range:
Physics and Accelerator Prospects
 ICFA Mini-workshop - Working Group on High Luminosity e^+e^- Colliders

10-13 September 2003, Alghero (SS), Italy

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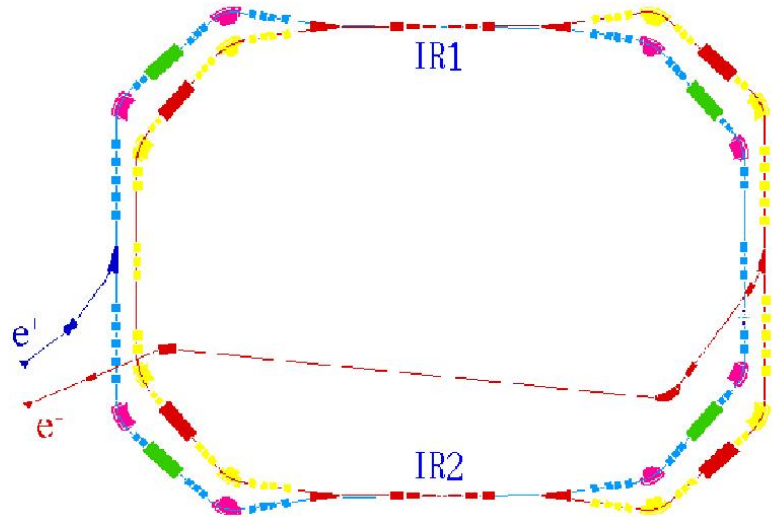
<http://www.lnf.infn.it/conference/d2/>

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

Ideas for DA Φ NE2

Reminders of the features of DA Φ NE1

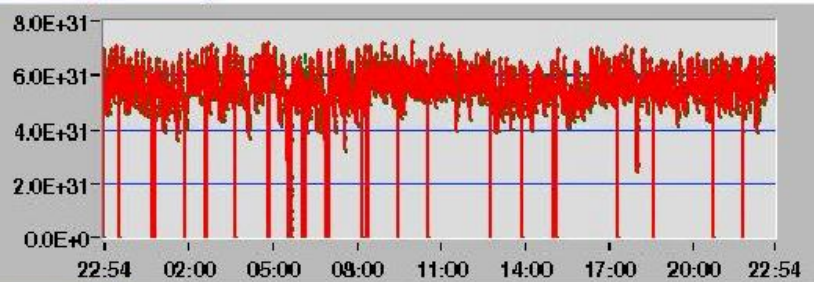
energy	510 MeV
luminosity	$5 \cdot 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$
σ_x (rms)	2.11 mm
σ_y (rms)	0.021 mm
σ_z (rms)	35 mm
bunch length	30 mm
crossing angle	13 mrad
frequency (max)	368.25 MHz
bunch/ring	up to 120
part./bunch	$8.9 \cdot 10^{10}$
current/ring	5.2 A (max)



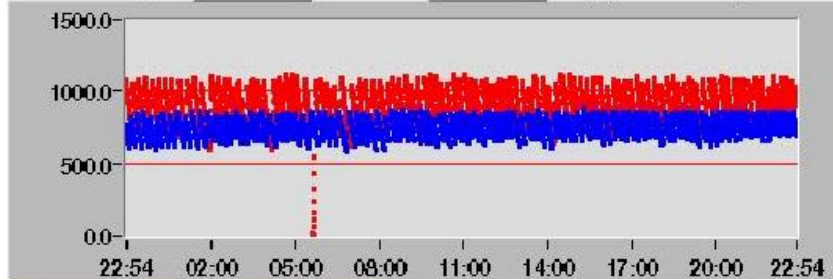
Best DEAR day

Best KLOE day

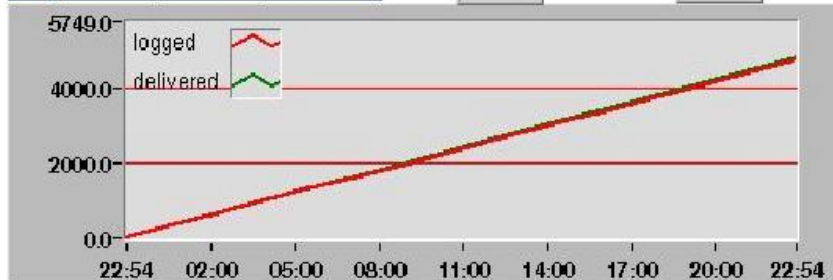
Luminosity [cm⁻² s⁻¹]



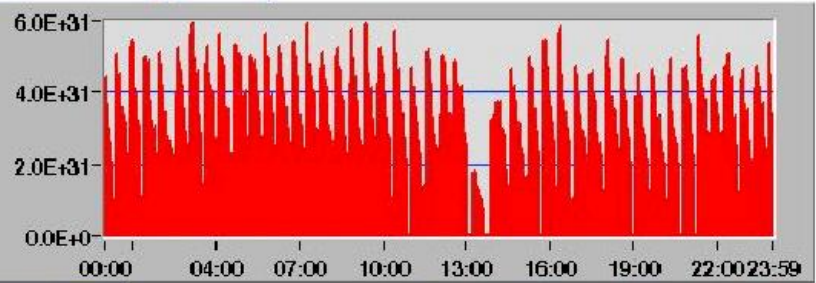
current [mA] delivered Acq. peak luminosity



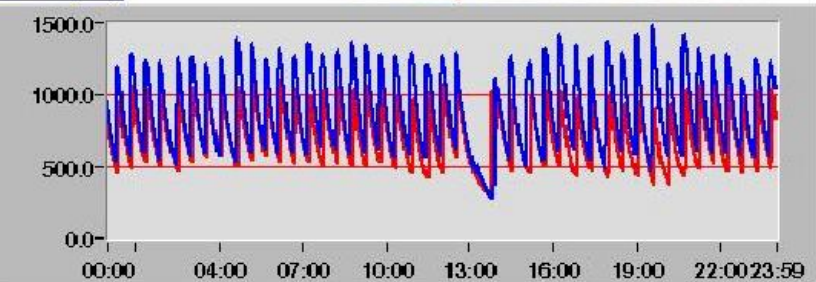
Integrated daily luminosity [nbarn⁻¹] delivered Acq.



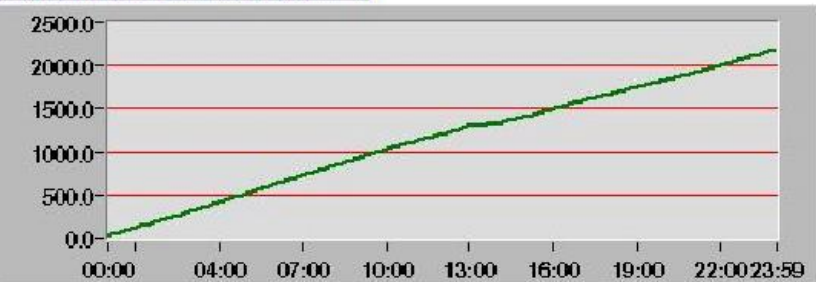
DEAR Luminosity [cm⁻² s⁻¹]



current [mA] luminosity detector under calibration



Integrated DEAR luminosity [nbarn⁻¹]



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

Oversimplified assumptions and ideas:

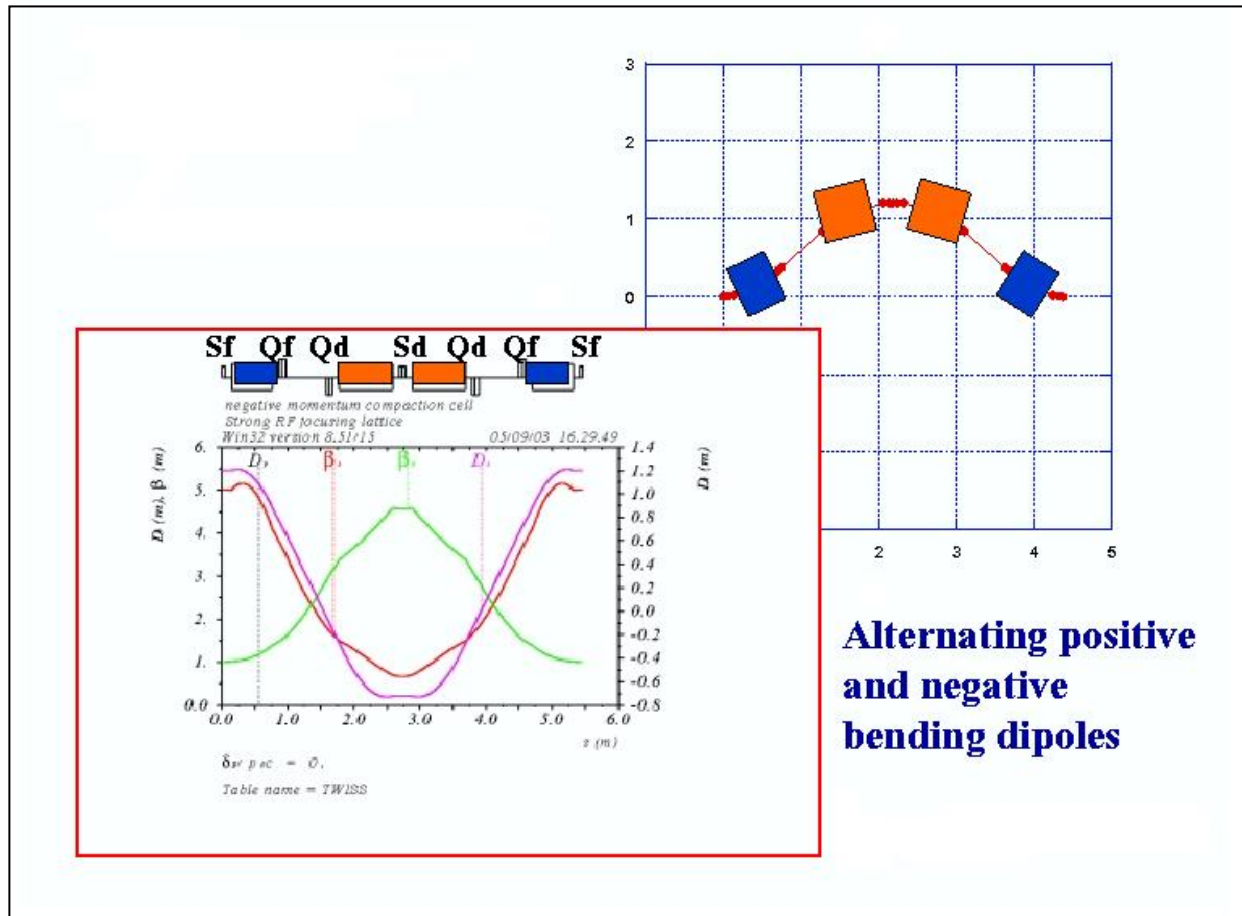
$$L \approx \frac{N^2}{\sigma_z}$$

$\left\{ \begin{array}{l} N = \text{number of particles / bunch} \\ \sigma_z = \text{longitudinal dimension at IP} \end{array} \right.$

→ 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



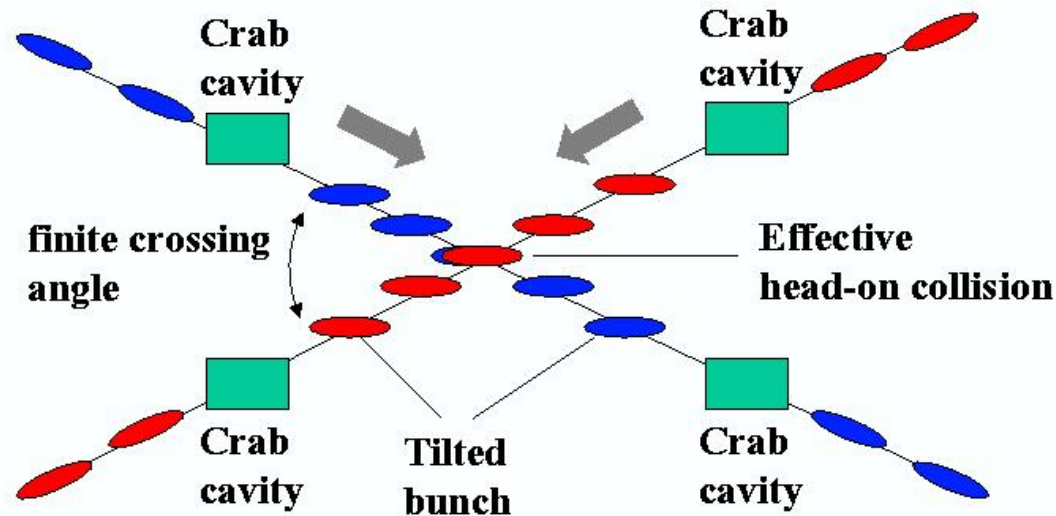
**Alternating positive
and negative
bending dipoles**

More ambition?

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

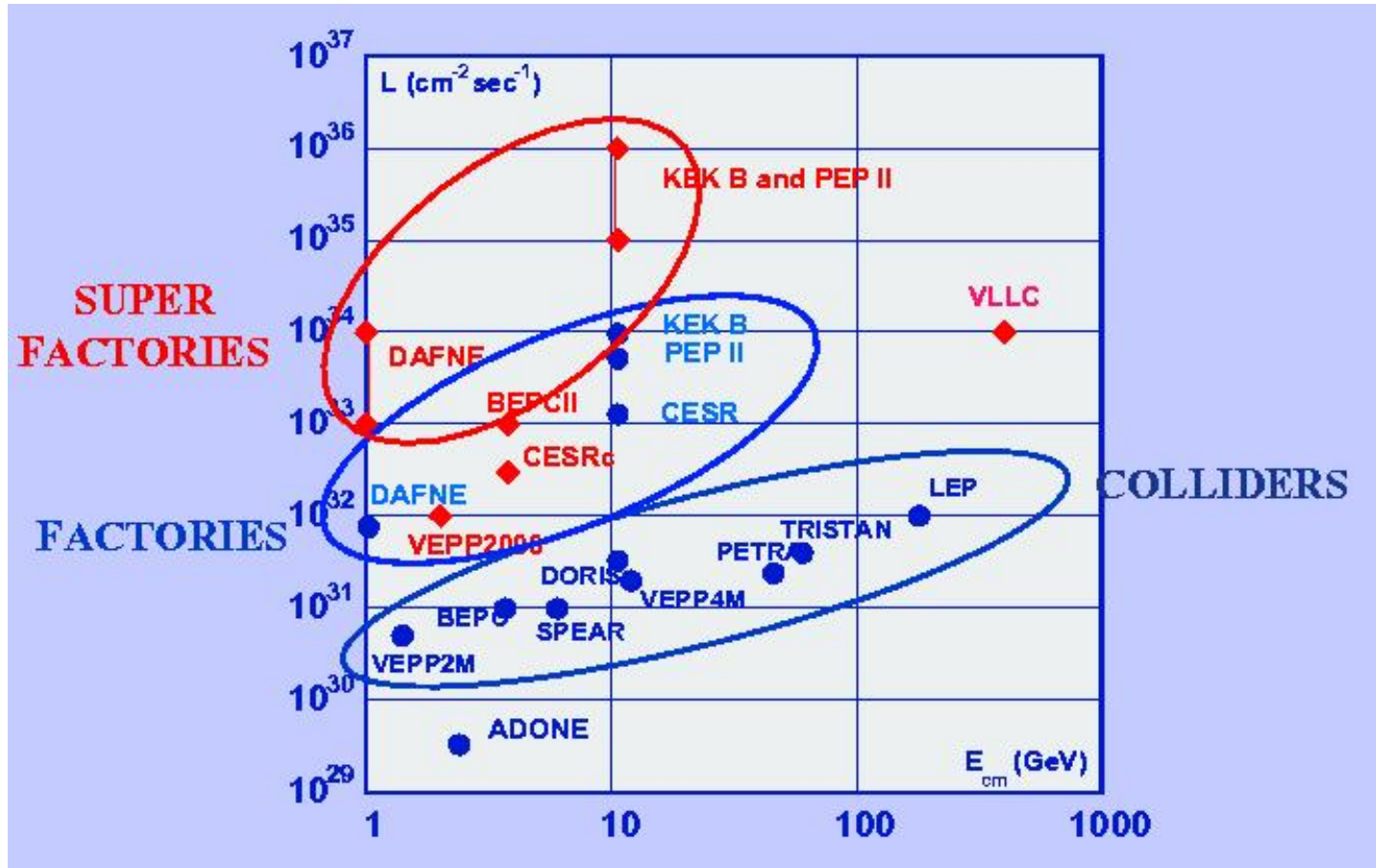
Higher energy beams and high crossing angle: L is increasing with E

Crab crossing



- Bunches are tilted by crab cavities.

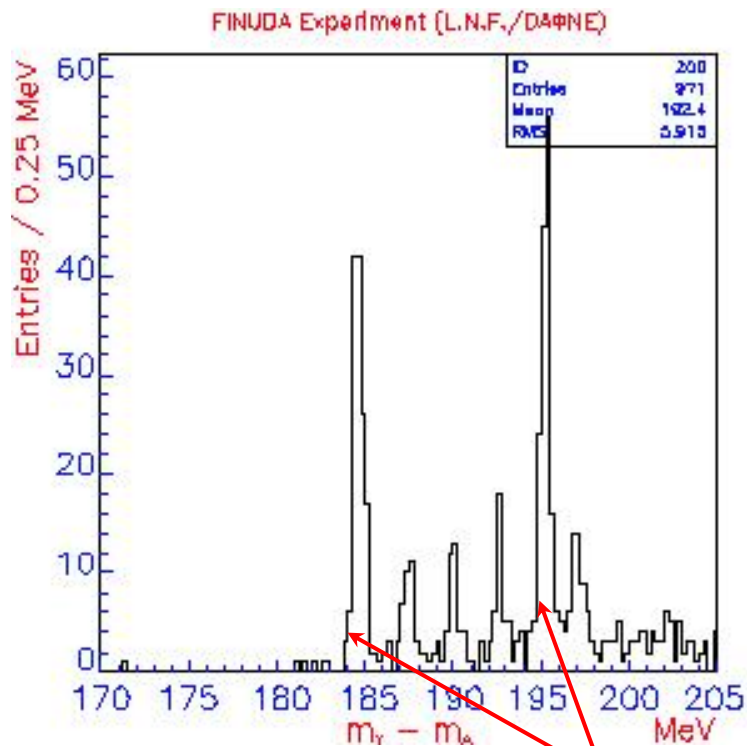
DAΦNE2 would be placed in the rank of “SuperFactories”



A program on *Hypernuclear Physics*

at *DAΦNE2*

Production rate



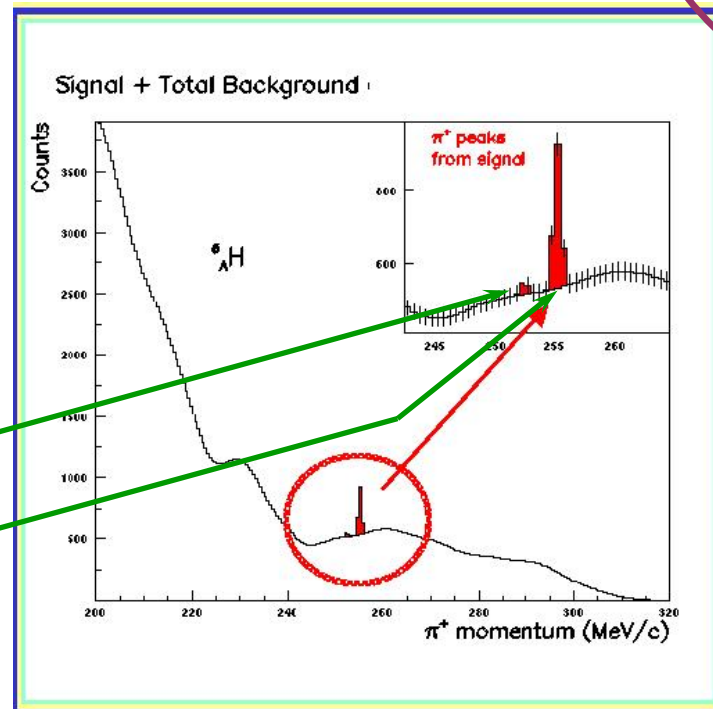
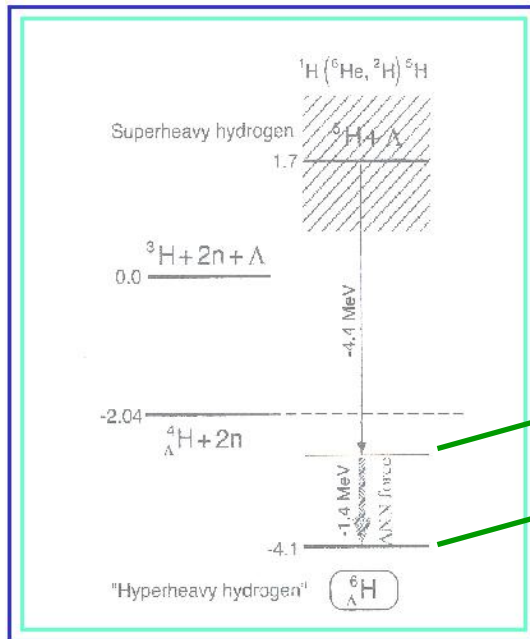
@ $L=10^{34} \text{ cm}^{-2} \text{ s}^{-1}$
obtained in less
than 10 minutes

capture rate $\sim 10^{-3}$ /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 ${}^6\text{Li}(K^-, \pi^+) {}^6_{\Lambda}\text{H}$ at 10^{-4} ?
- If so ...

one hour of data taking



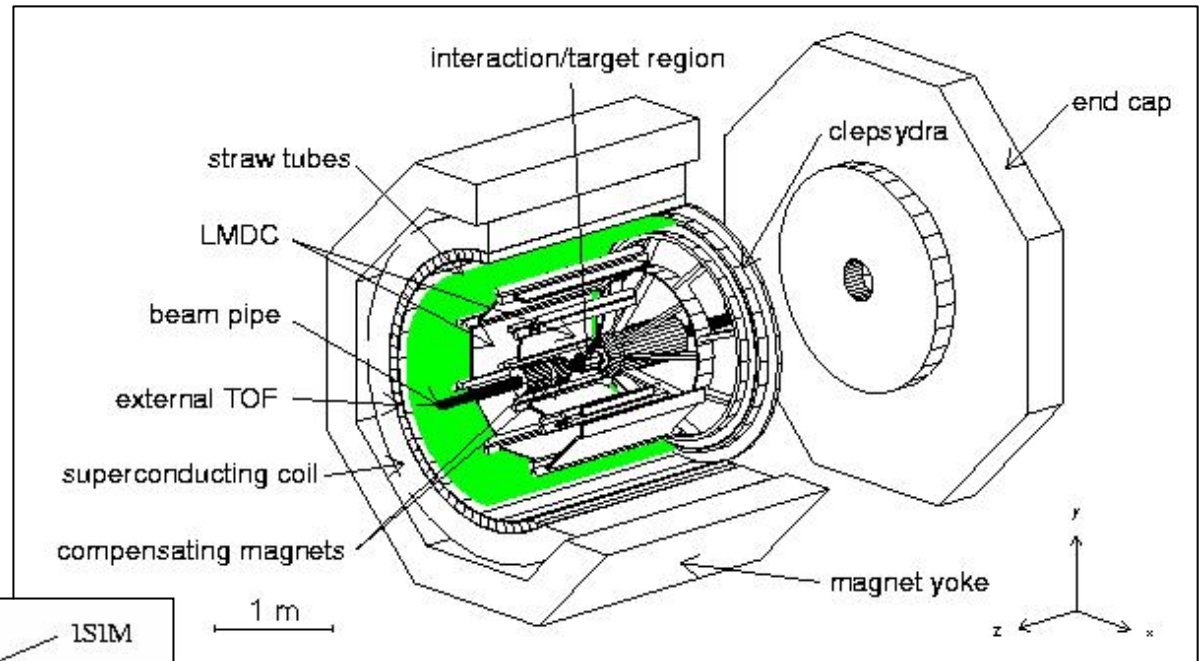
✚ Attempt to measure Γ_n , Γ_p , Γ_π : possible with the previous rates

✚ 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

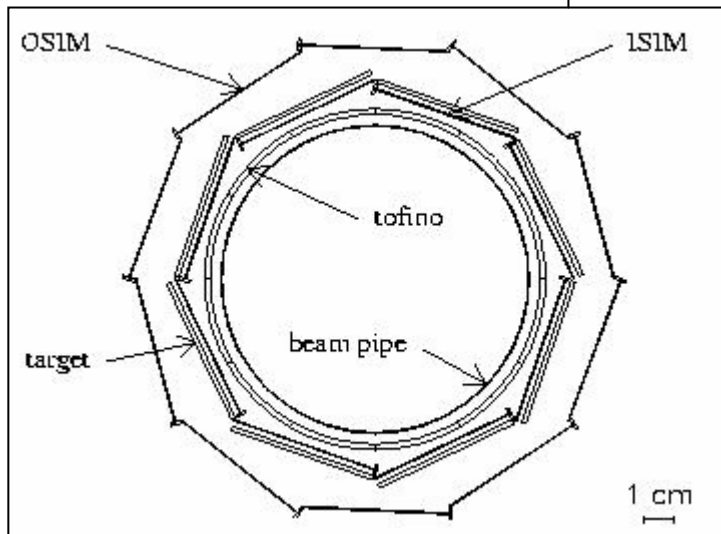
✚ Coincidence rates (π^- , 3N) of the order of a few/hour

Detector: the present FINUDA mainframe

Global view



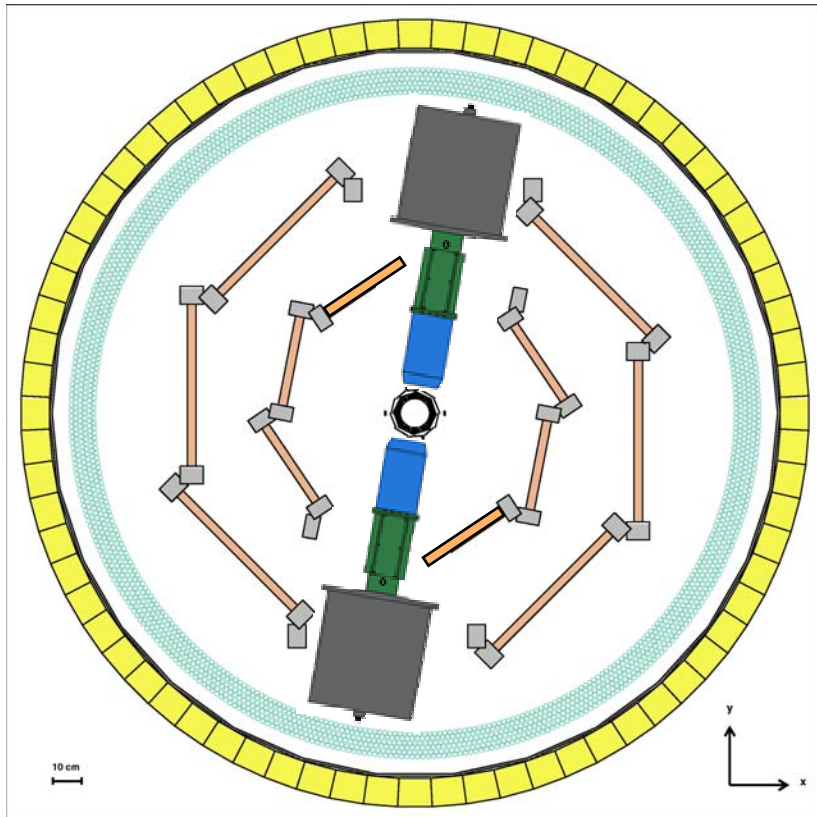
Interaction region



- new DAQ
- replacement of aged detectors

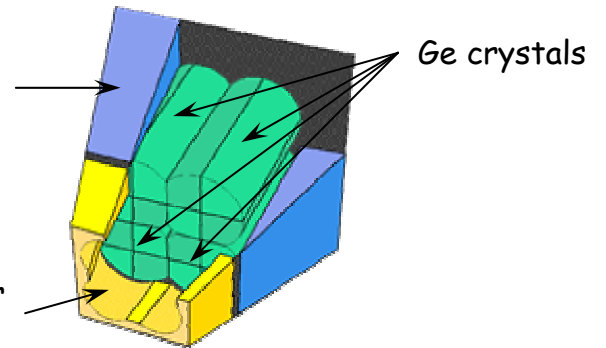
Detector: the FINUDA2 mainframe

The Segmented Clover Detector



BGO Compton
suppression shield

active collimator
(scintillator)



Ge crystals

Geometrical acceptance
reduced to 72%

γ-Spectroscopy in coincidence with formation π^-

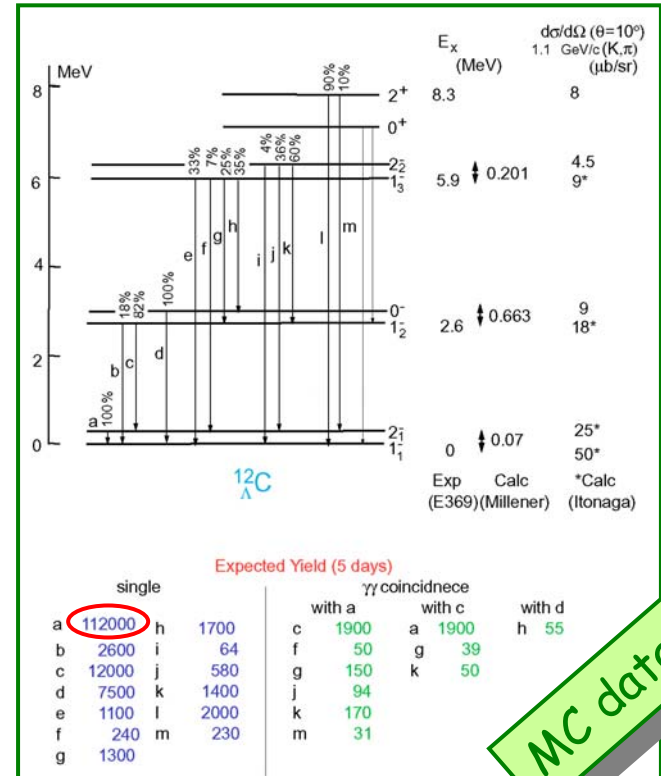
@ $\mathcal{L} = 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ FINUDA can observe $\sim 1.6 \times 10^4 \text{ ev/h}$ from ΥN g.s.

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

$\sim 1.87 \times 10^4 \text{ ev/d}$

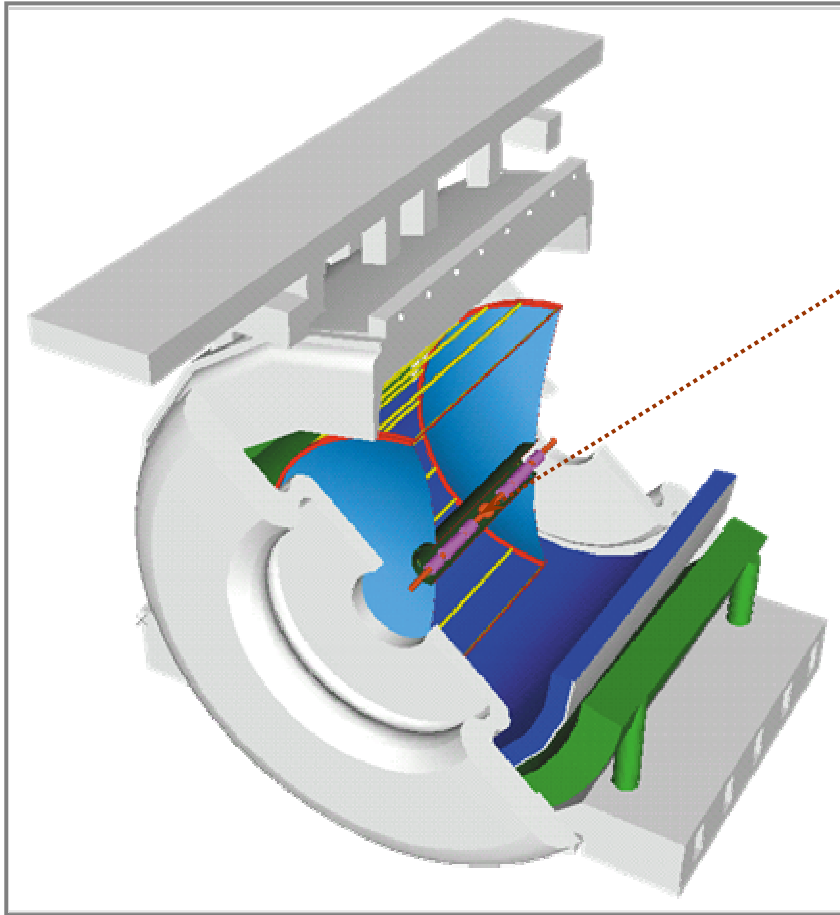
5 day data taking

$\sim 9.33 \times 10^4 \text{ ev}$



✚ γ -Spectroscopy in coincidence with formation π^-

“YKLOE”



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

⚡ Spectroscopy of Hyperfragments

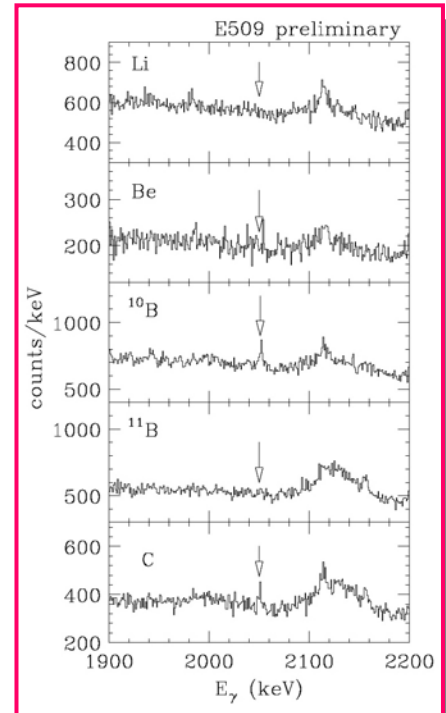
hypernuclear species are **limited** by **target availability**

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 ($\mathcal{L} = 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$)

- $\phi/d = 2.85 \cdot 10^9$
- $K^-/d = 1.40 \cdot 10^9$
- *stopped* $K^-/d = 0.9 \cdot 1.40 \cdot 10^9$
 $= 1.26 \cdot 10^9$
- $\Upsilon N/d = 0.1 \cdot 1.26 \cdot 10^9$
 $= 1.26 \cdot 10^8$

3.77×10^8

3 day data taking

@ JPARC (K1.1 line)

* initial conditions

- $K^-/d = 6.67 \times 10^8$
- *stopped* $K^-/d = 0.2 \cdot 6.68 \cdot 10^8$
 $= 1.33 \cdot 10^8$
- $\Upsilon N/d = 0.1 \cdot 1.33 \cdot 10^8$
 $= 1.33 \cdot 10^7$

4.00×10^7 *

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?
- ⊕
- ⊕