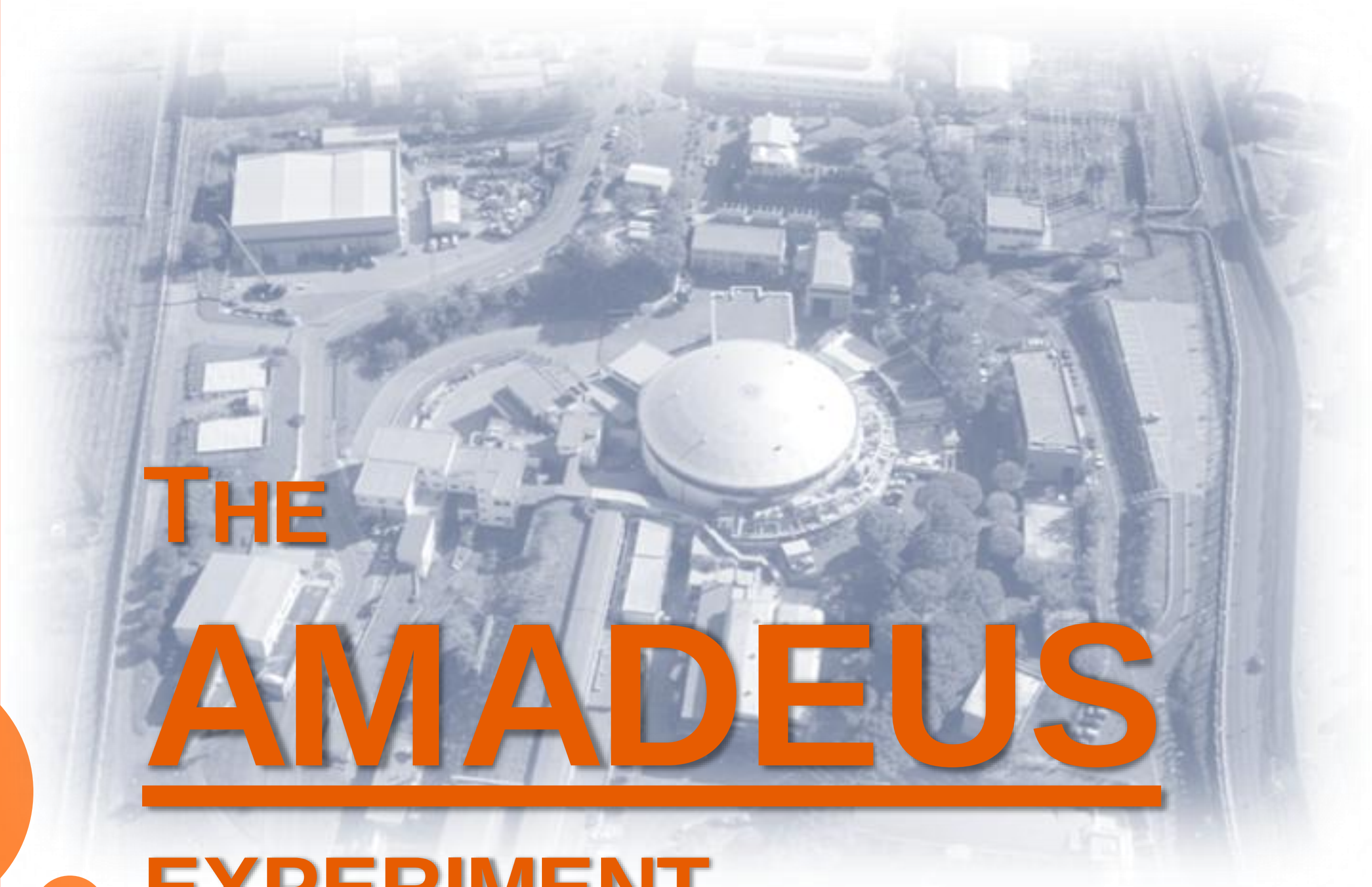


THE AMADEUS EXPERIMENT

STUDY OF THE KAONIC NUCLEAR CLUSTERS AT DAΦNE

Oton Vázquez Doce
INFN, Laboratori Nazionali di Frascati
on behalf of the AMADEUS Collaboration

Contents

Introduction

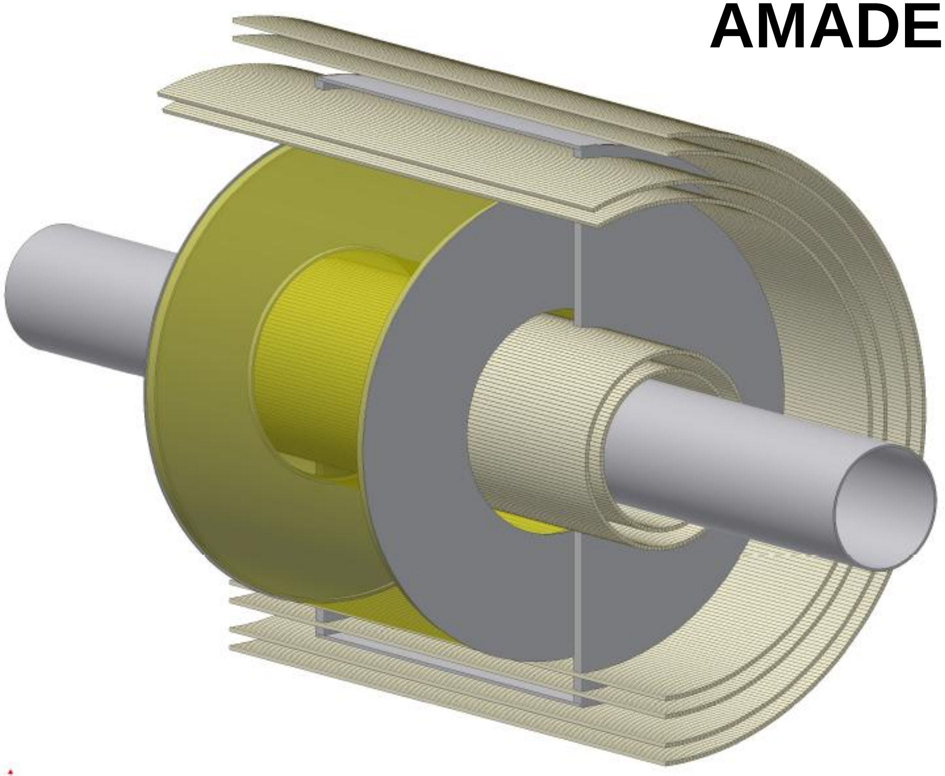
- What is AMADEUS ?
- Why to perform AMADEUS?
- What has been done up to now?
- What do we need?
- Which is the experimental setup?
- What do I have to remember?

Introduction

Letter of Intent

Study of deeply bound kaonic nuclear states at DAΦNE2

AMADEUS Collaboration

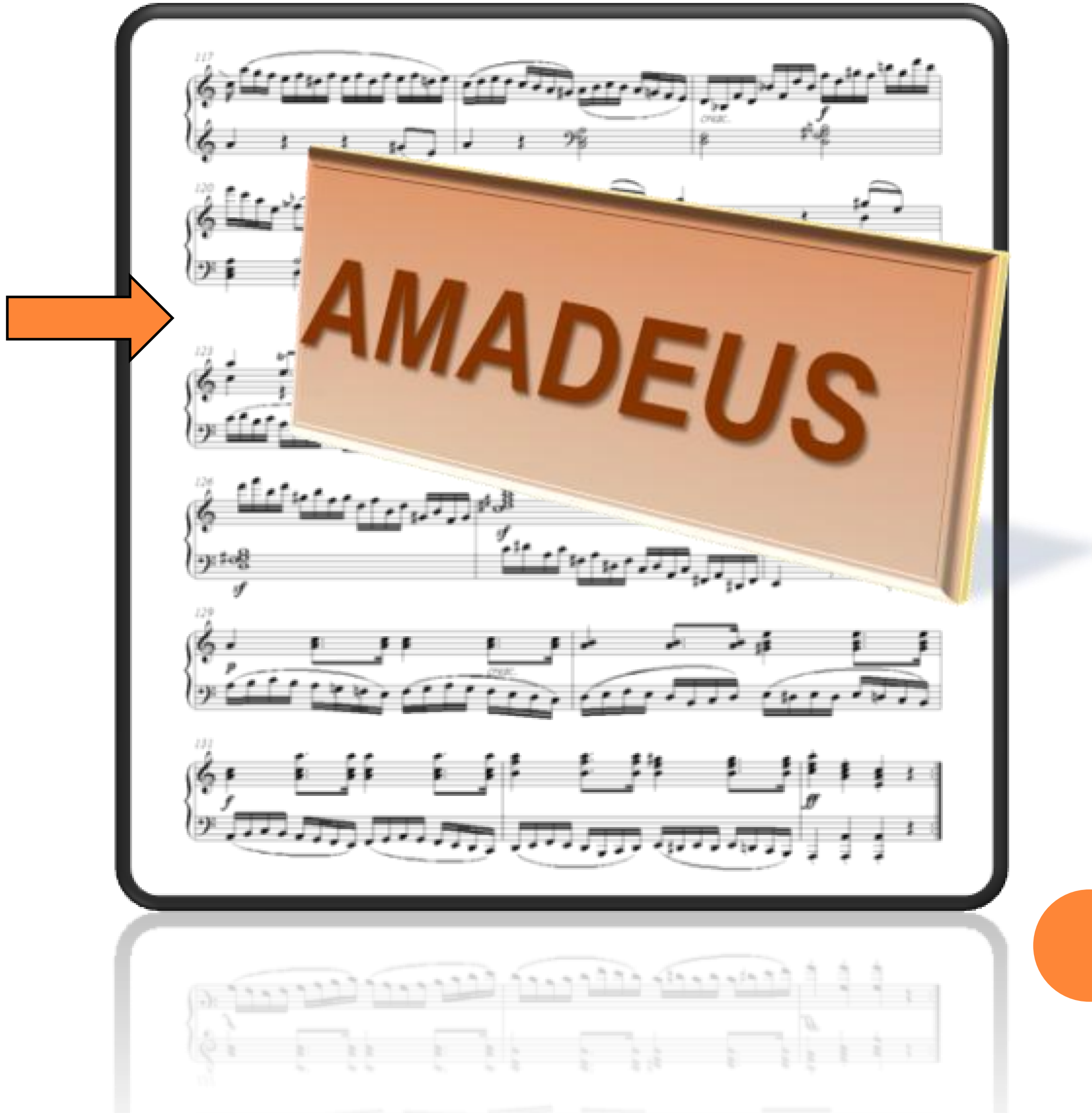


111 scientists from 33 Institutes of 13 Countries signed the LOI

March 2006

Introduction

ANTIKAONIC
MATTER
AT
DA*Φ*NE: AN
EXPERIMENT
WITH
UNRAVELING
SPECTROSCOPY



The AMADEUS scientific case

- What is AMADEUS ?
- **Why to perform AMADEUS?**
- What has been done up to now?
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The AMADEUS scientific case

Problem

How the spontaneous and explicit **chiral symmetry breaking** pattern of low energy **QCD** changes in the **nuclear environment**

How the **hadron masses** and interactions change in the **nuclear medium**

Approach

New type of **in-medium hadron mass spectroscopy**

Method

Producing **deeply bound states** from which to deduce the **hadron-nucleus potential** and the **in-medium hadron mass**

The AMADEUS scientific case

- **Deeply bound kaonic nuclear state**

in presence of strong KN attractive potential were firstly suggested by Wycech

S. Wycech, Nucl. Phys. ***A450*** *(1986) 399c*

- **A "new paradigm" in strangeness nuclear physics can be considered the work**

"Nuclear bound states in light nuclei" by Y. Akaishi and T. Yamazaki *Phys. Rev. C65 (2002) 044005*

Strong attractive I=0 KN interaction

favors discrete nuclear states bound 100-200 MeV and narrow 20-30 MeV

shrinkage effect of a K on core nuclei

The AMADEUS scientific case

Kaonic Nuclear Clusters contribution to fundamental physics

- MODIFICATION OF THE KAON MASS AND OF THE KN INTERACTION IN THE NUCLEAR MEDIUM (SYMMETRY BREAKING OF QCD)

- TRANSITION FROM THE HADRONIC PHASE TO A QUARK-GLUON PHASE (CHANGES OF VACUUM PROPERTIES OF QCD AND QUARK CONDENSATE)

- KAON CONDENSATION IN NUCLEAR MATTER (IMPLICATIONS IN ASTROPHYSICS: NEUTRON STARS, STRANGE STARS)

- NUCLEAR DYNAMICS UNDER EXTREME CONDITIONS COULD BE INVESTIGATED

The framework of AMADEUS proposal

- What is AMADEUS ?
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The framework of AMADEUS proposal

❑ Experiments

Present: KEK E471, E549, E570
DAΦNE FINUDA
GSI FOPI

others (old-Dubna…)

analyses of the recently collected data are in progress

Future: new data from FOPI, FINUDA , JPARC (-->E15), FAIR(?)

❑ Theory

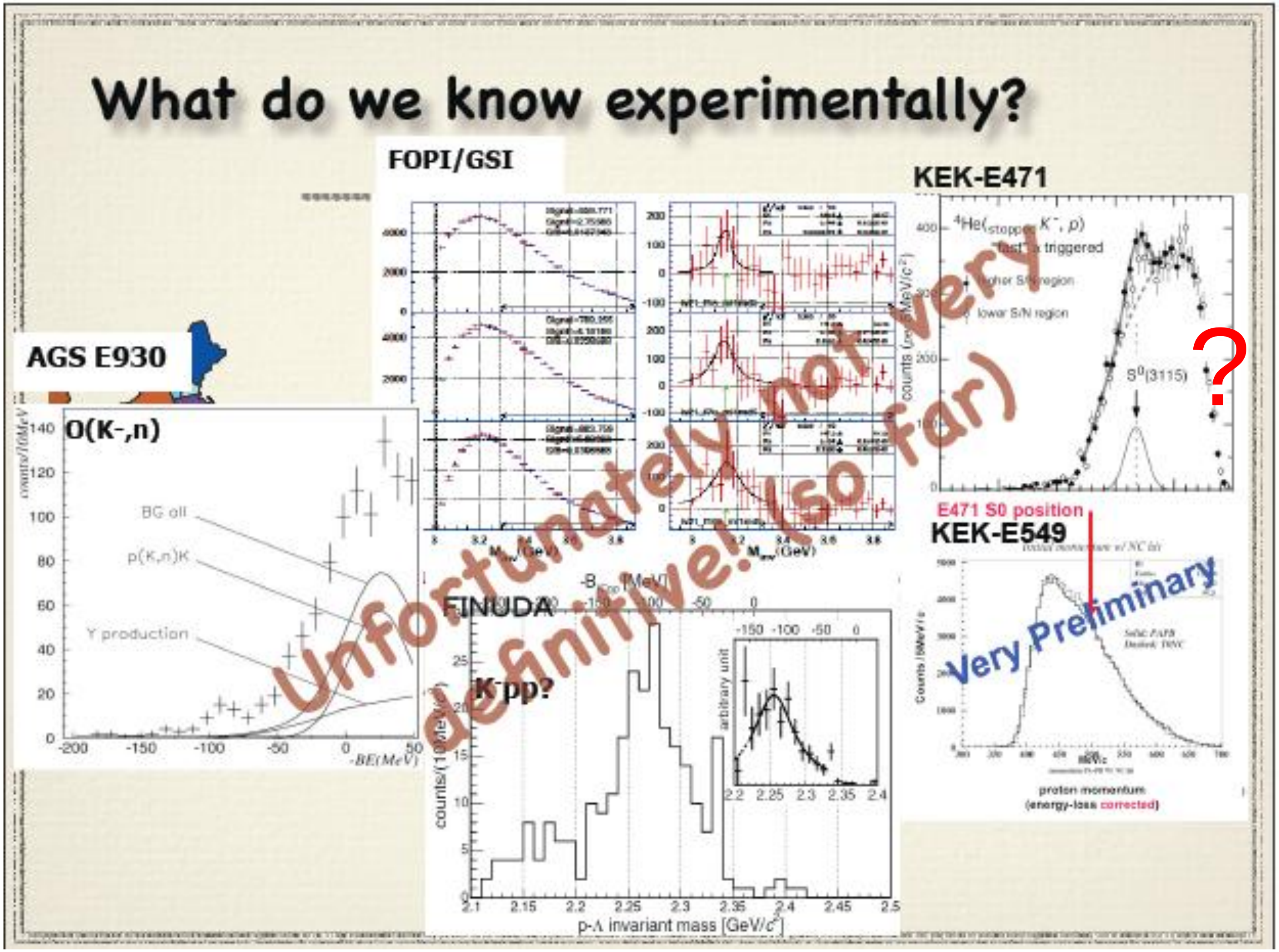
- Debate in progress,
including alternative interpretations of the data so far obtained

⇩

until new complete experimental results are available

The framework of AMADEUS proposal

SUMMARY OF THE SEARCH FOR DEEPLY BOUND KAONIC STATES



The framework of AMADEUS proposal

AMADEUS design considerations

The only way to **confirm**, or **deny**, the exotic states is to perform a **good measurement** using a **high performance detector** on the **most suitable accelerator**

a measurement NOT performed until now

⇩

complete determination of all **formation** and **decay** channels

⇩

binding energies, widths, angular momenta, isospin, sizes, densities…

→Detection of charged and neutral particles, up to about 800 MeV/c in 4π geometry with high efficiency and resolution

Requirements satisfied by KLOE detector

The framework of AMADEUS proposal

Requirements for the setup performance imposed by the formation process

$K^- + {}^4He \rightarrow p + (K^-pnn)$; p ~ 550 MeV/c

$K^- + {}^4He \rightarrow n + (K^-ppn)$; n ~ 510 MeV/c

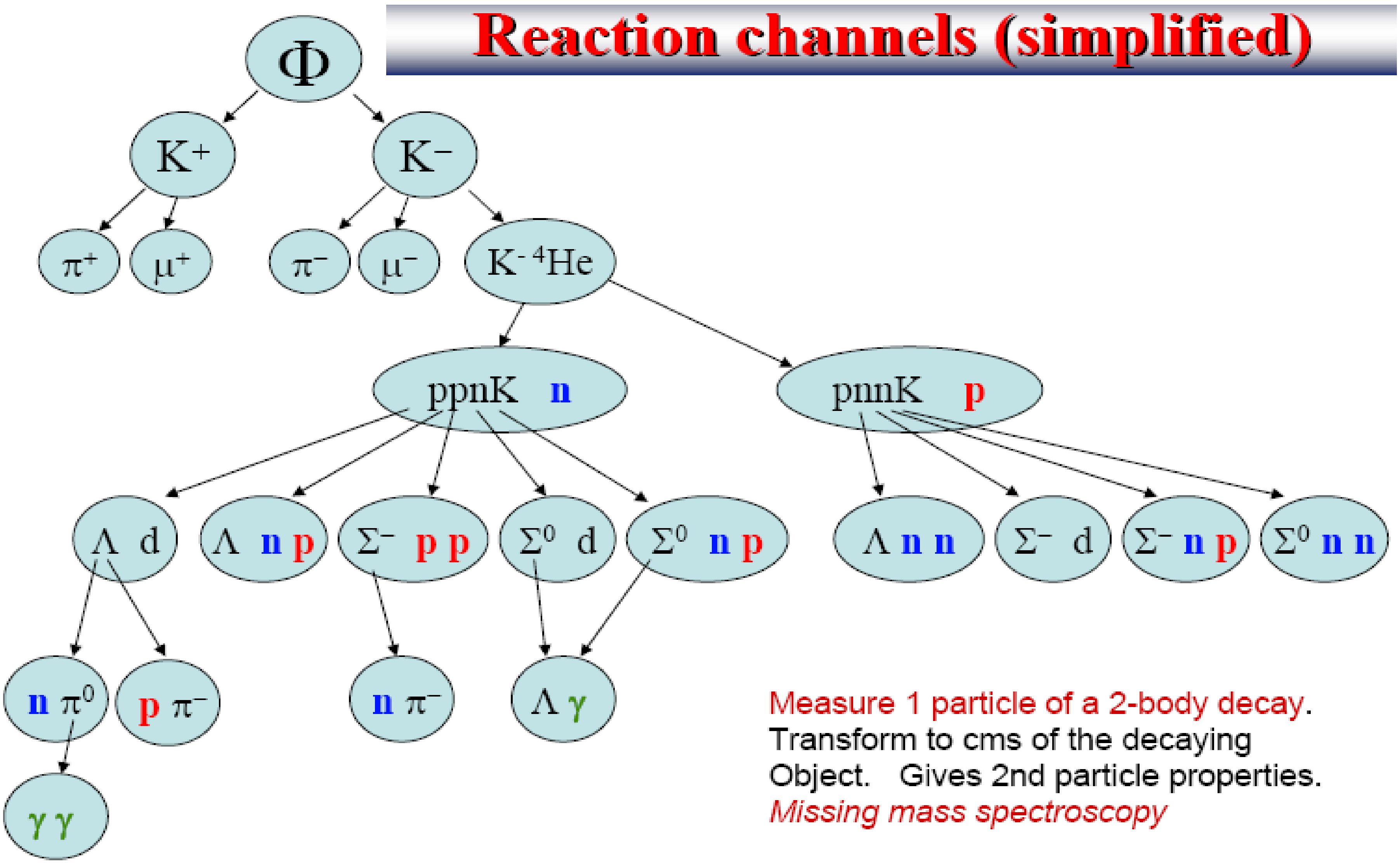
Exotic states produced with (K^-, N) reactions will be observed by the energy distribution of the ***ejected protons and neutrons*** via the **missing mass spectra** of the (K^-, p) and (K^-, n) reactions.

⇒ **The setup should be capable to measure:**

- Outgoing **p** up to **600 MeV/c**
- Outgoing **n** up to **600 MeV/c**

Stopped KAONS!!!

The framework of AMADEUS proposal



Measure 1 particle of a 2-body decay.
Transform to cms of the decaying Object. Gives 2nd particle properties.
Missing mass spectroscopy

Measure all outgoing particles to obtain the total cms energy = *invariant mass of the object*

Performing AMADEUS

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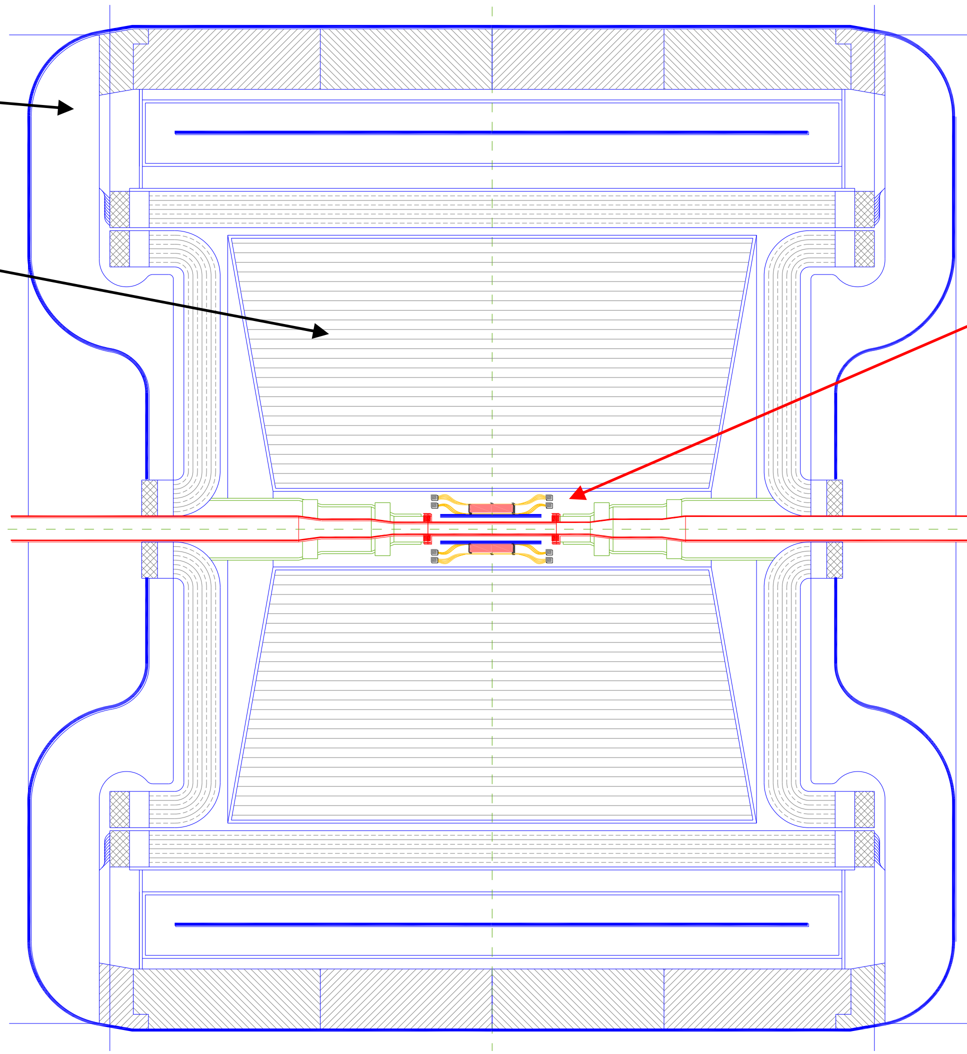
Performing AMADEUS

AMADEUS setup within KLOE

KLOE – EMC

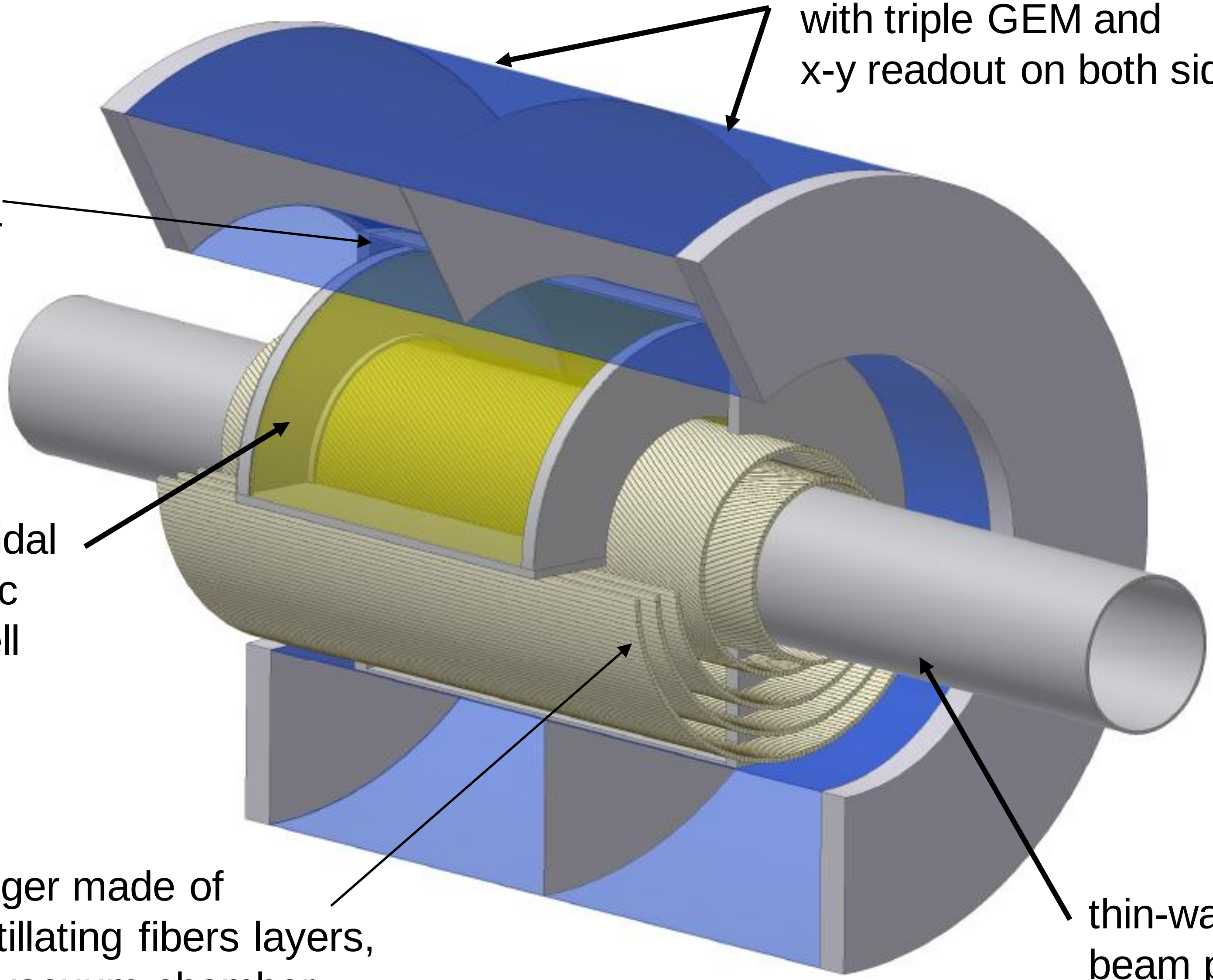
KLOE – Drift Chamber



Possible setup for AMADEUS within KLOE:

Cryogenic target
Inner tracker
Kaon trigger

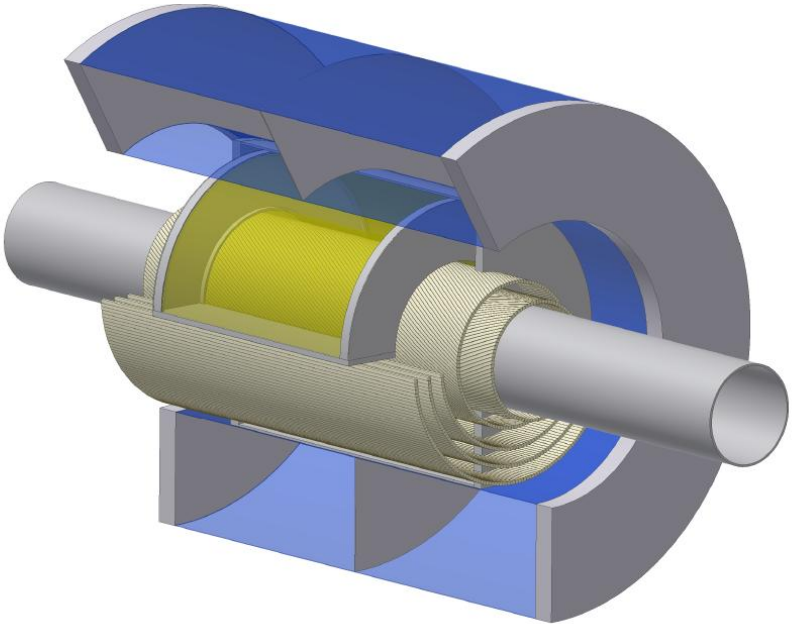
Performing AMADEUS



AMADEUS inner region setup

A tracking/vertex detector (a Time Projection Chamber (TPC) with GEM-readout in this example) is surrounding the half toroidal cryogenic target cell with the (previous) kaon trigger configuration.

- **Alternative, if the background rate is too high (to be checked with FINUDA inner-tracker) a multi-layer cylindrical GEM detector is in discussion: might be necessary**



Performing AMADEUS

Preliminary MonteCarlo simulations with optimized degrader and cryotarget

Φ production cross section

peak luminosity

branching ratio for $K^{\pm}$

$$R = L \sigma b = 1500\ s^{-1}$$

$10^{33}\ cm^{-2}s^{-1}$

$3 \times 10^{-30}\ cm^{2}$

0.49

production rate for charged kaon pairs

produced $K^{\pm}$ per month: 31×10^{8}
(80% duty cycle assumed)

40% are stopped in the cryogenic He gas target (15% liq. He density, ~ 5 cm thick)
$\rightarrow 12.5 \times 10^{8}$ $K^{-}\ {}^{4}He$ atoms per month

for 10^{-3} cluster formation yield:

12.5×10^{5} kaonic clusters formed in one month

•*Efficiency* of tracking & identification $K^{\pm}$ & detection of decay products $\rightarrow$

~ **10^{5} events per month** ***(~ 1000 pb^{-1})***

Conclusions

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Conclusions

From AMADEUS LOI:

In conclusion, an initial programme based on the study of the ^{3}He and the ^{4}He targets, to investigate dibaryonic and the T=0,1 tribaryonic states, would require an integrated luminosity from 2 to 6 fb^{-1}, according to depth of the investigation.

Further requests (other targets) depend on the results of these first measurements

Conclusions

From AMADEUS LOI:

In conclusion, an initial programme based on the study of the ^{3}He and the ^{4}He targets, to investigate dibaryonic and the T=0,1 tribaryonic states, would require an integrated luminosity from 2 to 6 fb^{-1}, according to depth of the investigation.

Possible at DAΦNE with Luminosity upgrade (before J-PARC, FOPI, FAIR)

Further requests (other targets) depend on the results of these first measurements

Conclusions

- **The AMADEUS Collaboration aims to perform the most complete experimental effort ever done so far in searching for deeply bound kaonic nuclear clusters using, for the first time, a 4π dedicated detector capable of detecting all charged and neutral particles created in both formation and decay of kaonic clusters.**