



The AMADEUS experiment — precision measurements of low-energy kaon nucleon interactions

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on behalf of the AMADEUS collaboration

Antikaon
Matter
At
DAΦNE:
Experiments with
Un unraveling
Spectroscopy

Allegro.



Violino I.
Violino II.
Viola.
Violoncello
e Basso.

Introduction



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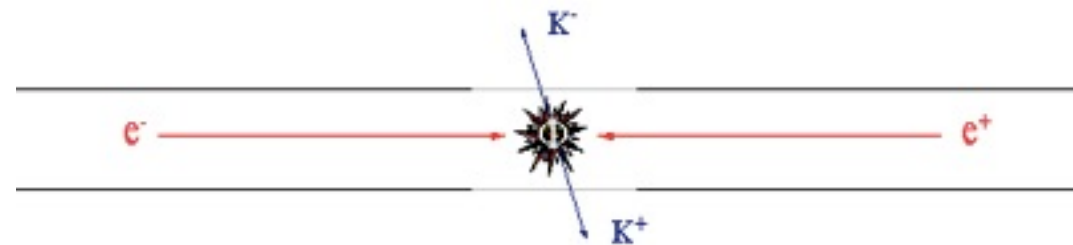
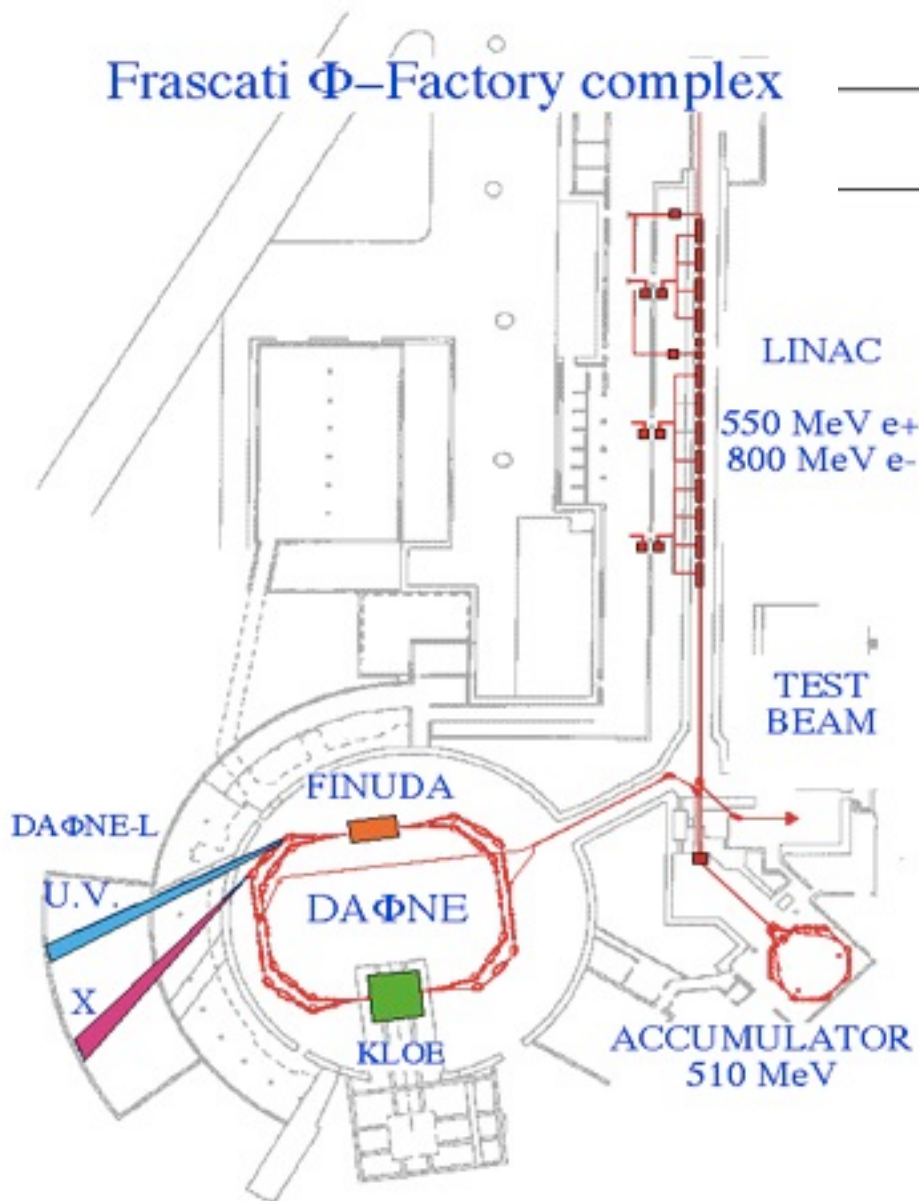


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- Next-generation experiments should be **exclusive**, i.e. require the measurement of formation and decay
- AMADEUS @ DAΦNE2 aims to do that with
 - **stopped** K^- in low-density gas targets (unique feature available at DAΦNE2)
 - full measurement of all decay particles, **charged** and **neutral**, using the KLOE detector

DAΦNE at LNF



Frascati Φ -Factory complex



- electron – positron collider
- collision energy tuned to the Φ resonance at 1.02 GeV
- low-momentum (**127 MeV/c**) charged kaons, DAΦNE2:
 - ~ **1200/s** at $L \approx 10^{33} \text{ cm}^{-2}\text{s}^{-1}$
- low momentum spread ($< 0.1\%$)
- K-pair production in back-to-back topology
- hadronic background intrinsically low
(different from extracted beams)

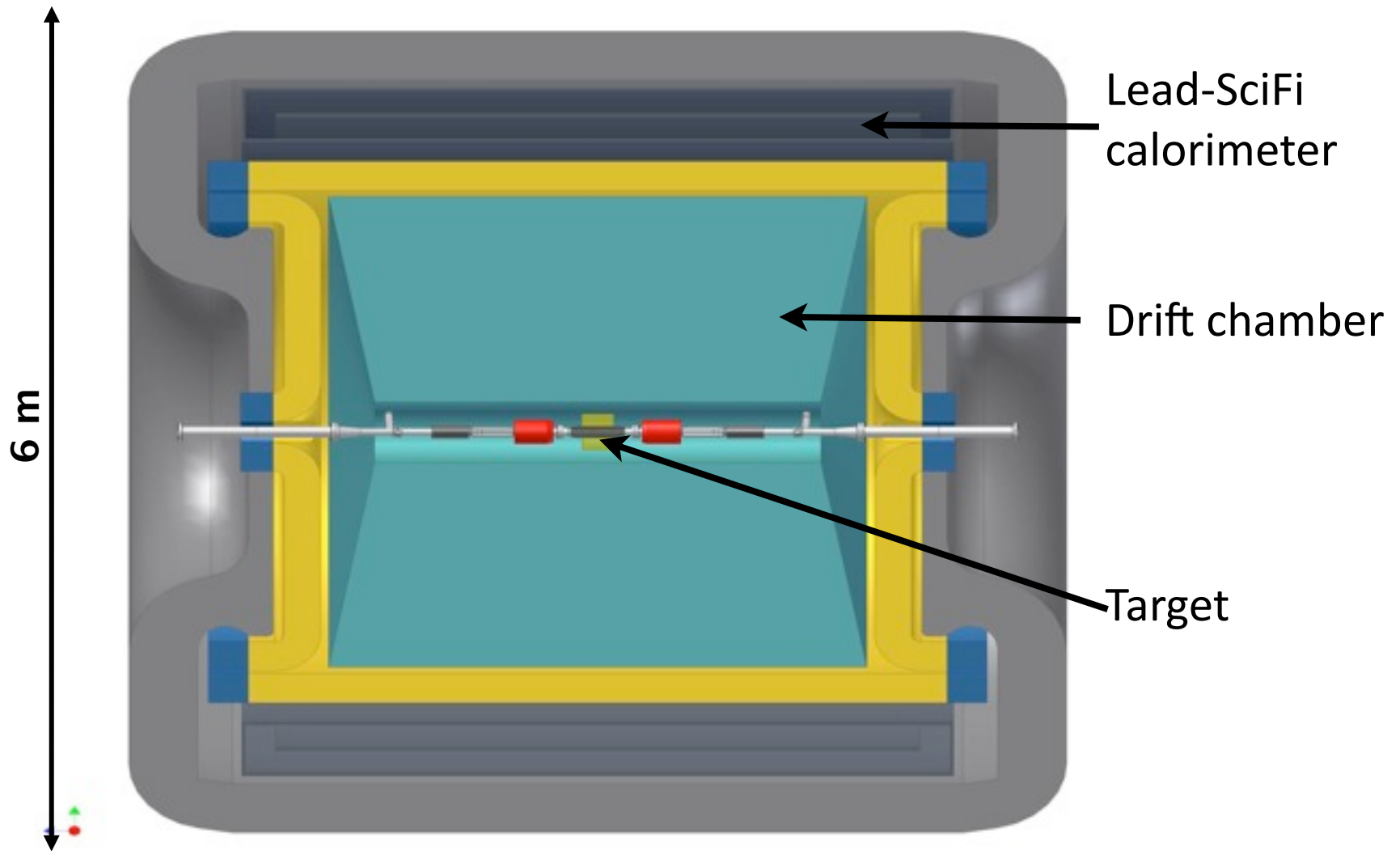
AMADEUS program I



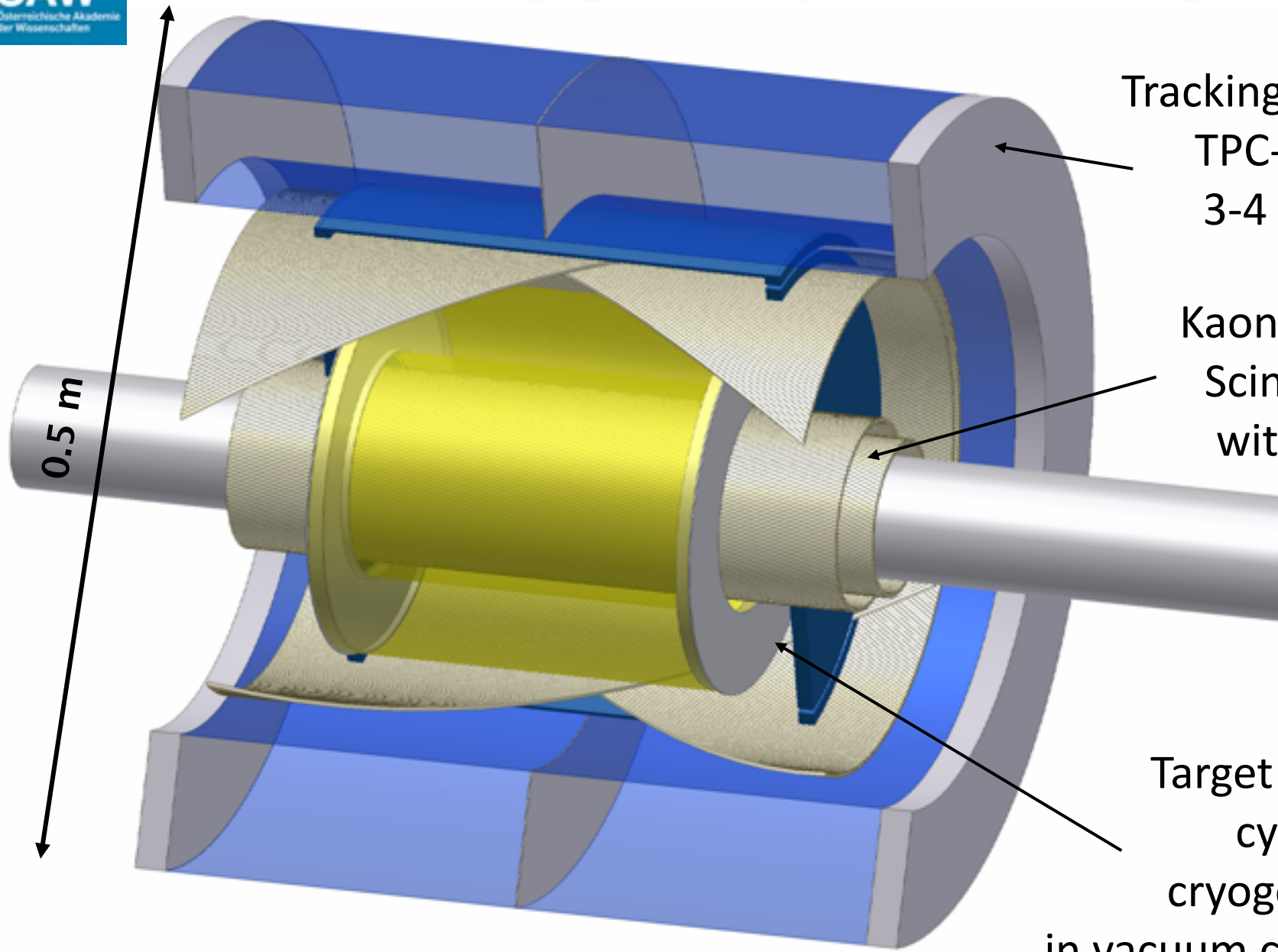
- study of the most fundamental antikaon deeply bound nuclear systems, the
kaonic dibaryon states: ppK^- and (pnK^-)
produced in a ^3He gas target
- as next step, the
kaonic 3-baryon states: $ppnK^-$ and $pnnK^-$
produced in a ^4He gas target
- in addition, we plan to extend these studies systematically over a broad range of nuclear targets, like **Li, B and Be**

- Low-energy charged kaon cross section on p, d, He-3 and He-4, for K^- momentum lower than 100 MeV/c (missing today);
- The K^- nuclear interactions in Helium (poorly known – based on one paper from 1970 ...)
- Properties of Λ and charged Σ' s
for example decays in channels with a neutrino
→ astrophysics implications (cooling of compact stars)
- Resonance states as $\Lambda(1405)$ or the $\Sigma(1385)$ could be better understood with high statistics; their behaviour in nuclear medium can be studied, too.

The KLOE apparatus



AMADEUS within KLOE



Tracking device:
TPC-GEM or
3-4 C-GEMs

Kaon trigger:
Scint. fibers
with SiPMs

Target system:
cylindrical
cryogenic cell
in vacuum chamber

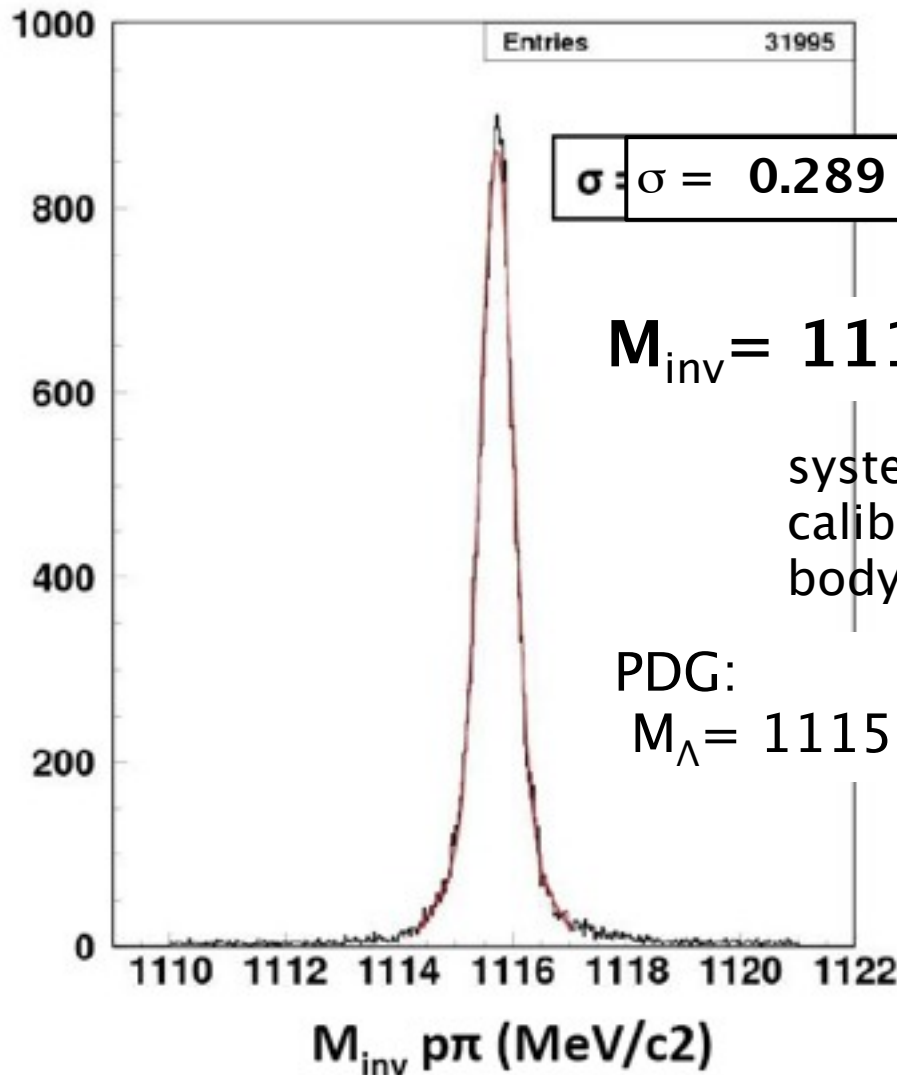
0.5 m

AMADEUS activities

- **KLOE data – feasibility analyses**
 K^- stopped in ^4He gas of KLOE DC
- **EU – Hadron Physics 2 (GEM, SiPM)**
- **R&D for AMADEUS setup: SiPM and TPC – GEM**
- **Slow Controls and DAQ – with KLOE**
- **Neutron efficiency of KLOE Calorimeter – KLONE**
- ❖ **Agreement between KLOE and AMADEUS**

Lambda invariant mass

(determined using existing KLOE data)



$$M_{inv} = 1115,723 \pm 0.003_{stat} \text{ (MeV/c}^2\text{)}$$

systematic dependents on momentum calibration, has to be evaluated using 2-body decays: $K^{\pm} \rightarrow \mu^{\pm} \nu$ and $K^{\pm} \rightarrow \pi^{\pm} \pi^0$

PDG:

$$M_{\Lambda} = 1115,683 \pm 0.006_{stat} \pm 0.006_{syst} \text{ (MeV/c}^2\text{)}$$

Sigma0-pi0

- $\pi^-p \rightarrow K^0 \Sigma^0 \pi^0$ (solid line) PDG
- $K^-p \rightarrow \pi^+ \pi^- \Sigma^+ \pi^-$ (dotted line) PDG
- $pp \rightarrow p K^+ Y^0$ (points with errors) 2007

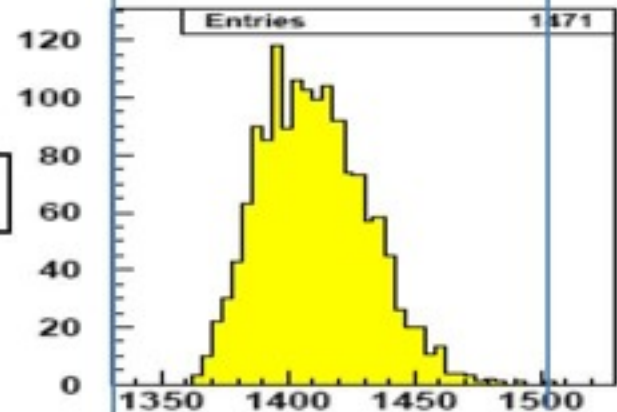
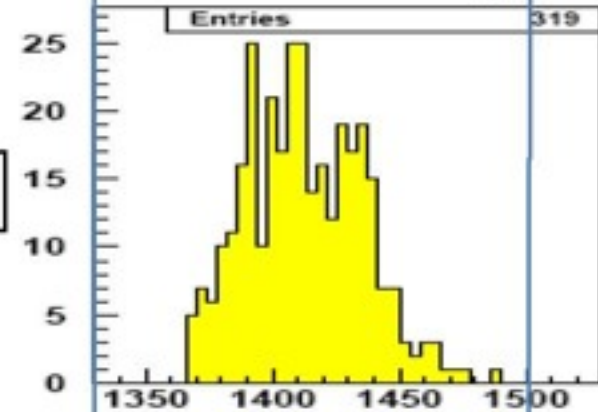
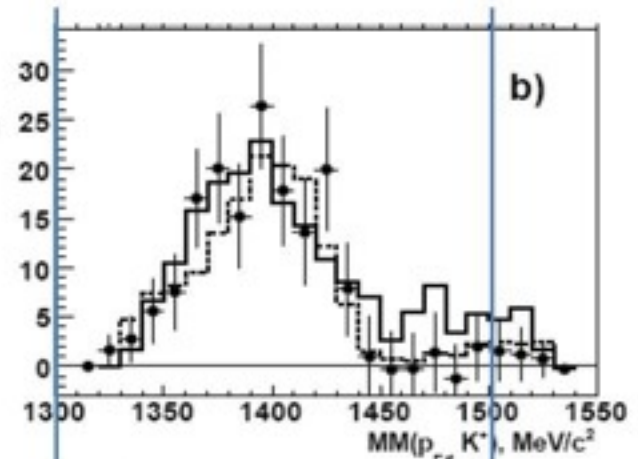
Comparison with available experimental data

DC volume

PRELIMINARY

Next steps
 more fine tuning of analysis
 total statistics: x2

DC wall



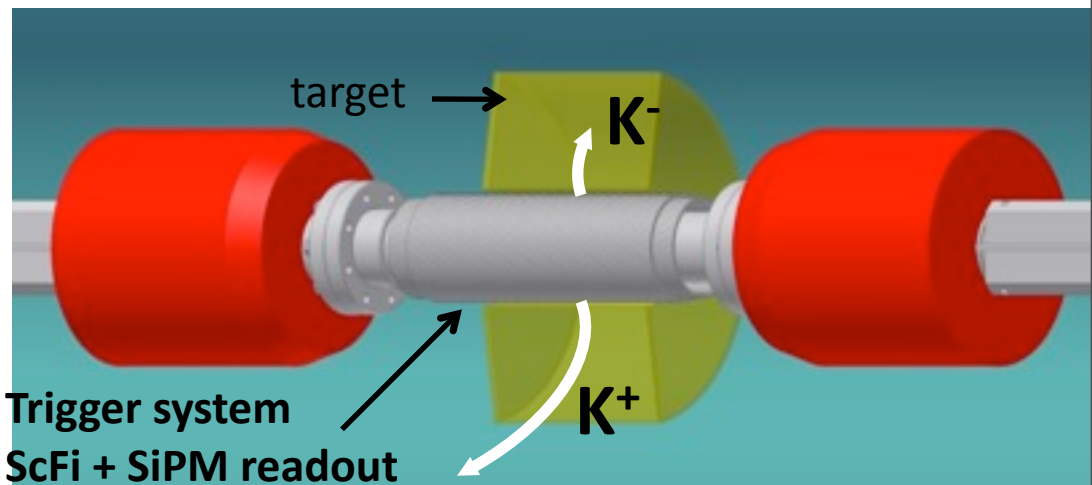
The AMADEUS trigger system

• **Inner tracker** (eventually, a first tracking stage before the DC)

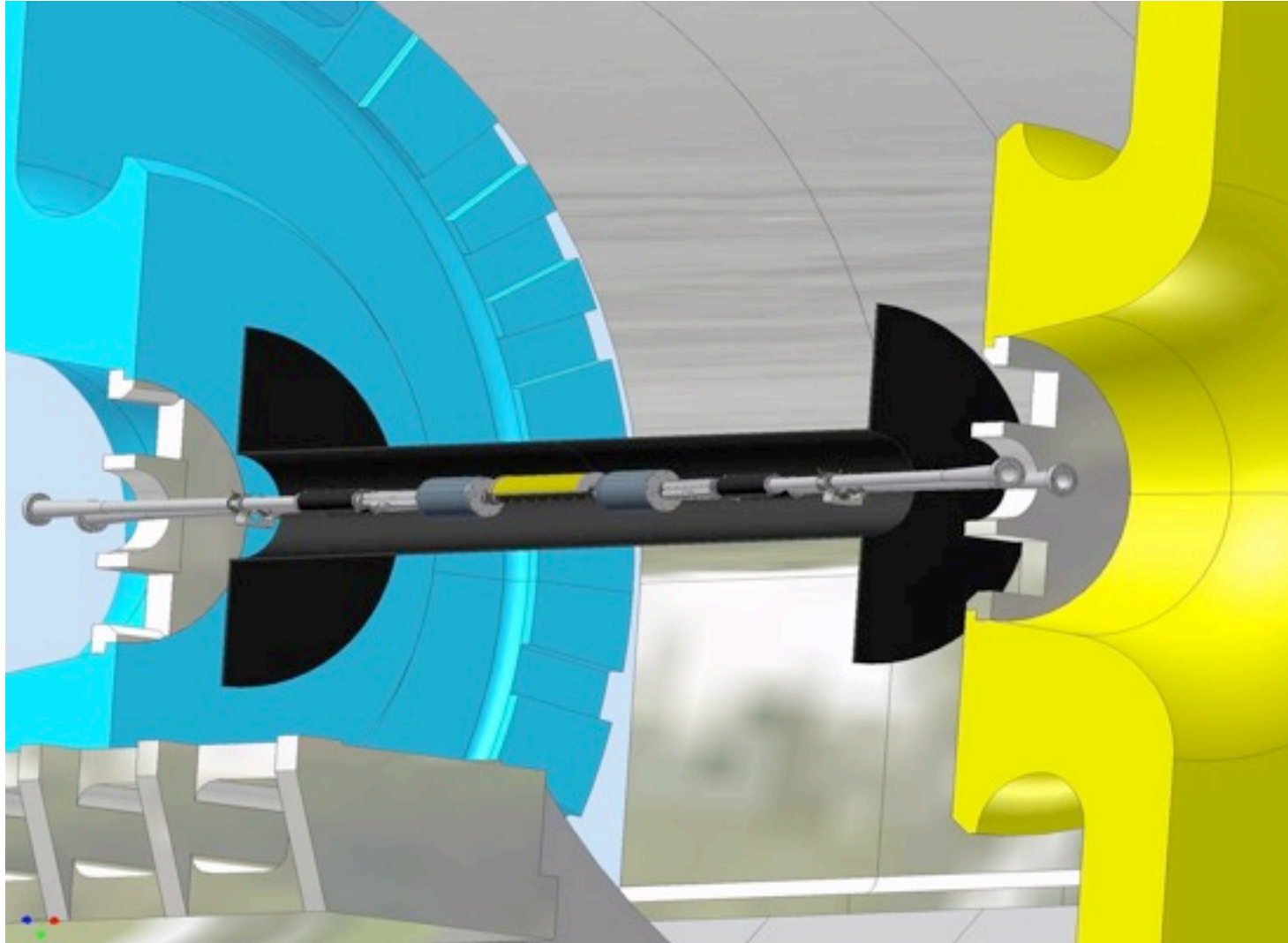
• **Target** (A gaseous He target for a first phase of study)

• **Trigger** (1 or 2 layers of ScFi surrounding the interaction point)

- Cylindrical layer of scintillating fibers surrounding the beam pipe to **trigger K^+ K^- in opposite directions**
- Readout to be done by **SiPM**



Study on possible solution for KLOE-AMADEUS beam-pipe



AMADEUS time schedule

- **AMADEUS R&D, construction and tests**
the R&D for AMADEUS are ongoing,
construction, assembly and tests have to be
finished within 2010
- **roll-in of AMADEUS**
roll-in 2011, compatible with KLOE end of step 0
- **AMADEUS data taking**
for an integrated luminosity of about 4 fb^{-1}

Conclusion



The goal of AMADEUS is to perform a **complete measurement** – formation and decay processes – of di – and tri-baryon antikaon-mediated bound nuclear systems in ${}^3\text{He}$ and ${}^4\text{He}$ using stopped K^-

It will give a definite answer to the controversial item of the existence of **antikaon-mediated bound nuclear systems** in light systems.

The antikaon – nucleus interaction will be studied in detail with AMADEUS.

AMADEUS collaboration



- **LNF:** beam-pipe definition; Slow Controls and DAQ; trigger; SiPM electronics; inner tracker (GEM); mechanics
- **SMI-Vienna:** target system; SiPM; inner tracker (TP C-GEM); Monte Carlo simulations
- ITEP Moscow: SiPM tests
- JINR: trigger definition, data analyses algorithm
- TU Munich: inner tracker (TPG) system
- Inst. Physics Cracow: trigger and DAQ
- IFIN-HH Bucharest: Slow Control System (target) and SiPM
- Ist. Superiore Sanita' Roma: SiPM development
- PoliMilano, Italy: front-end electronics (SiPM, inner tracker)
- TRIUMF Canada: target system
- GSI: SiPM system
- RIKEN, Japan: target definition
- **University of Zagreb, Croatia**