SIDDHARTA Status Report

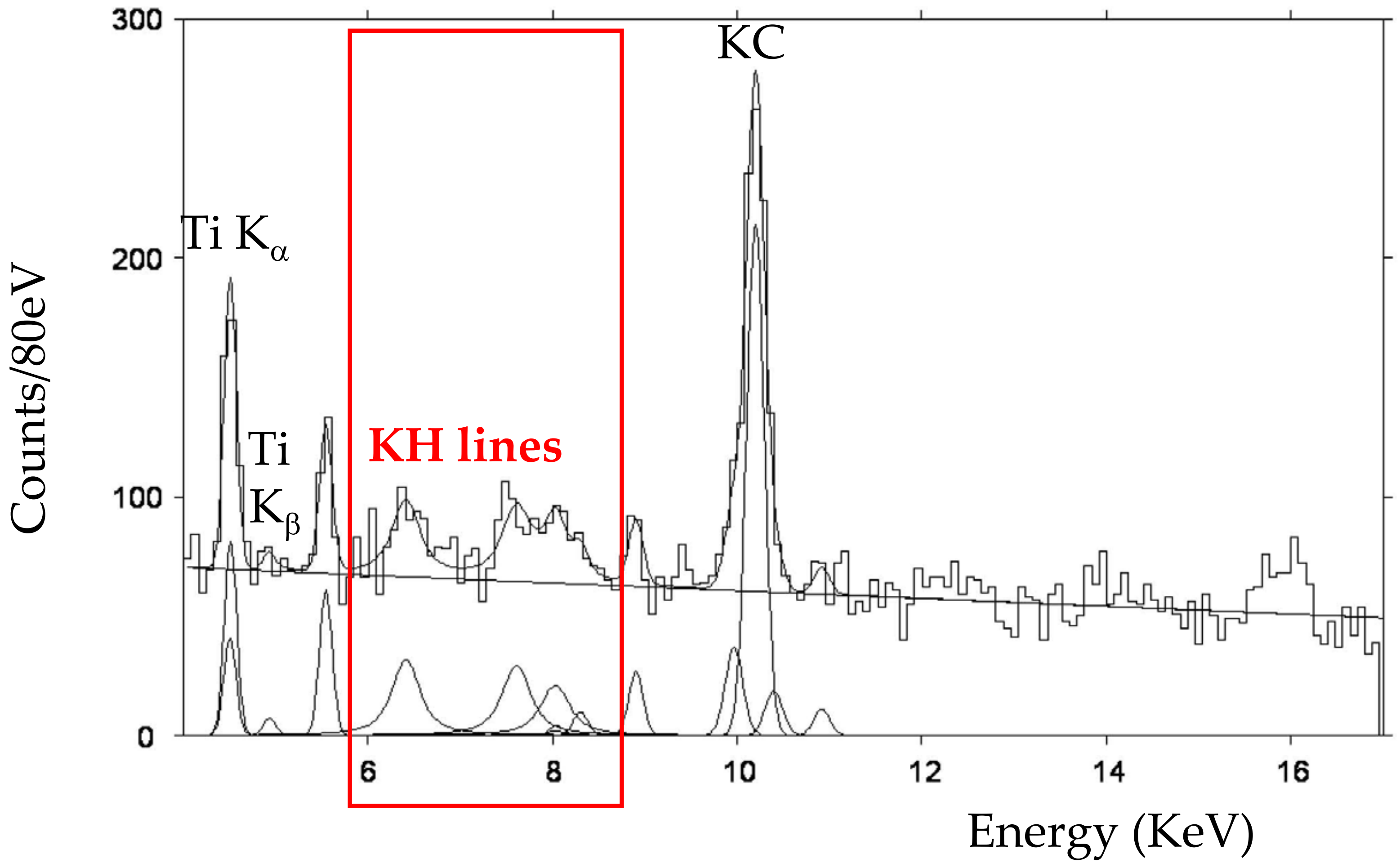
SIlicon Drift Detector for Hadronic Atom Research by Timing Applications

Catalina Curceanu, LNF-INFN

- **LNF- INFN, Frascati, Italy**
- **SMI- ÖAW, Vienna, Austria**
- **IFIN – HH, Bucharest, Romania**
- **Politecnico, Milano, Italy**
- **MPE, Garching, Germany**
- **PNSensors, Munich, Germany**
- **RIKEN, Japan**
- **Univ. Tokyo, Japan**
- **Victoria Univ., Canada**

JRA10 – FP6 - I3HP

SIDDHARTA's first kaonic hydrogen spectrum



Content

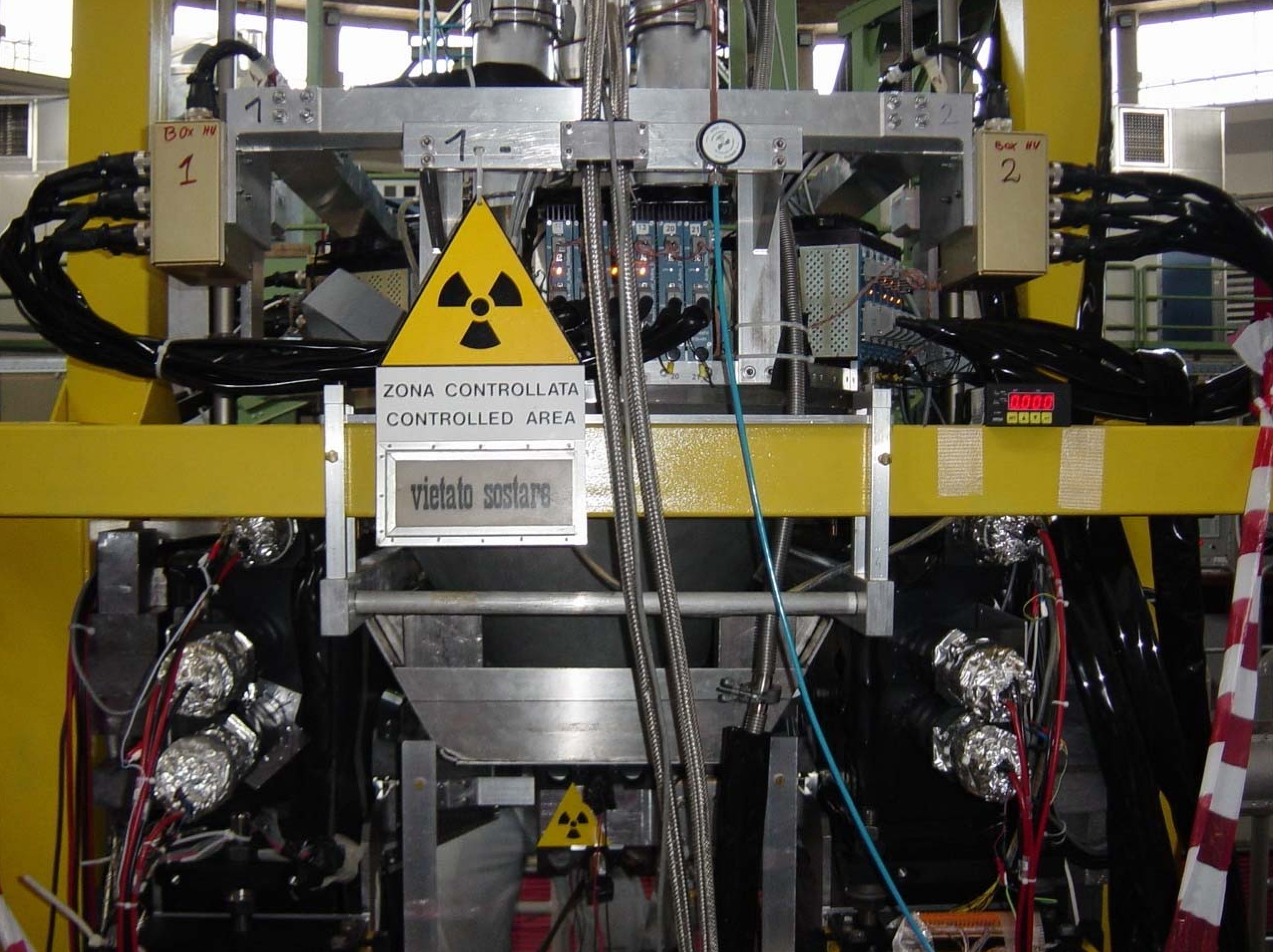
- Short reminder of 2008 activities since installation
- Activities in 2009
- Kaonic helium final results for publication
- (Very) Preliminary results for kaonic hydrogen
- SIDDHARTA scientific case and the EU FP7 HadronPhysics Network LEANNIS
- Plans and Beam Time Request

SIDDHARTA - activities in 2008

-Installation of the setup on DAFNE (including shielding): September 2008

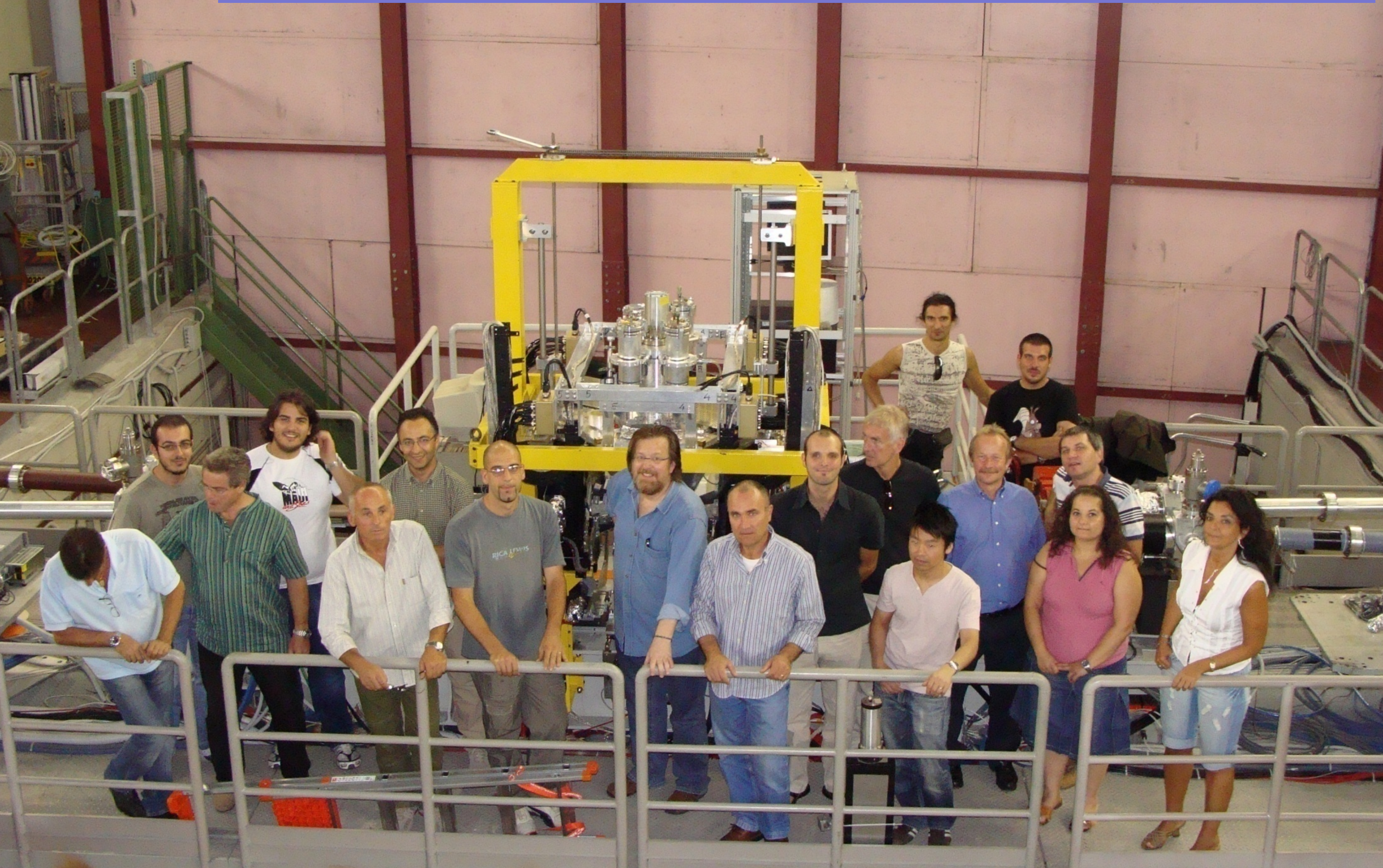
-Tests and debug: September – October 2008 (in parallel with the DAFNE restart), calibration procedure definition, trigger test

-Degrader optimization by measurement of kaonic helium4: November – December 2008

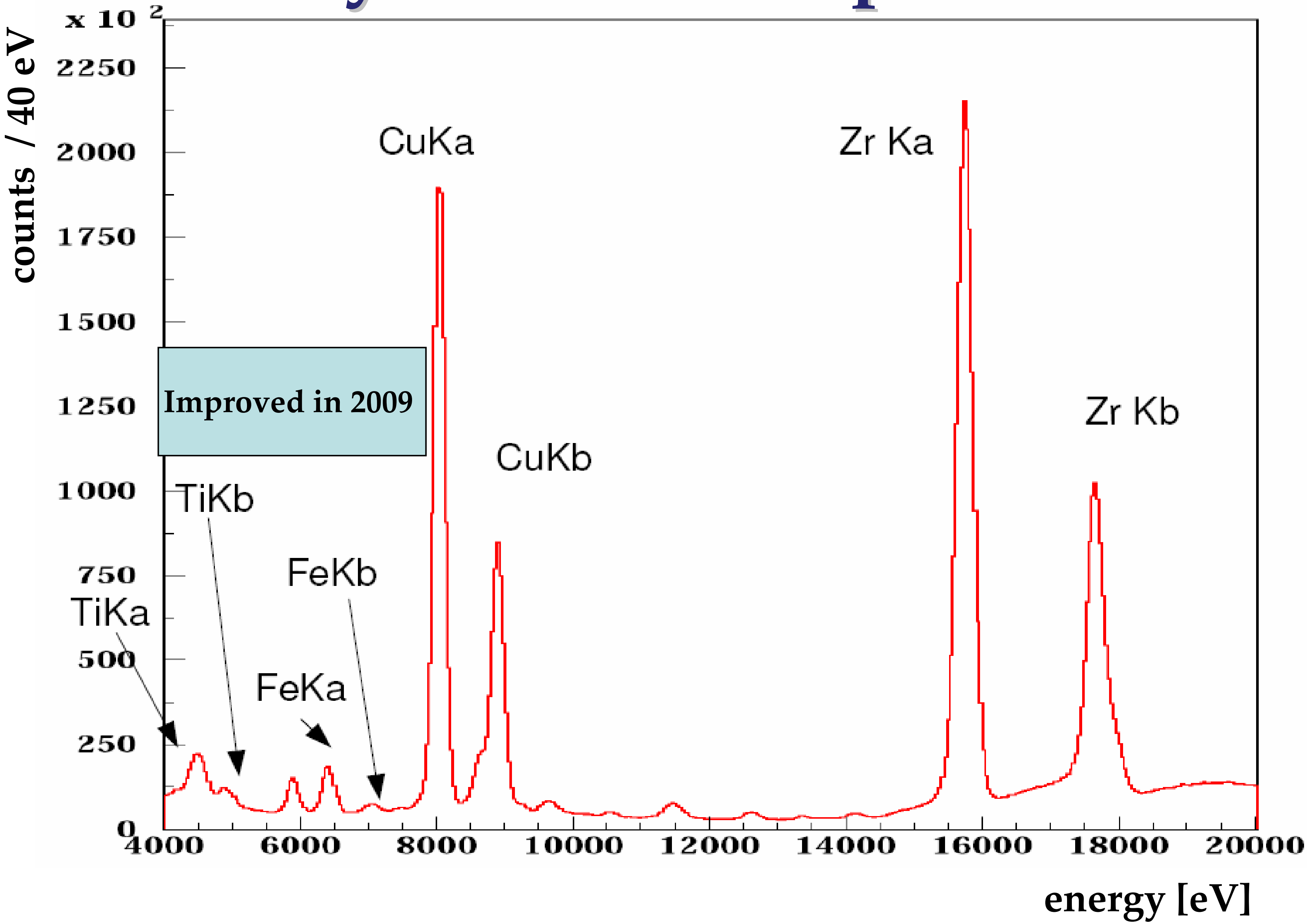

Box HV
1
Box HV
2
ZONA CONTROLLATA
CONTROLLED AREA
vietato sostare

Lead shielding of SIDDHARTA

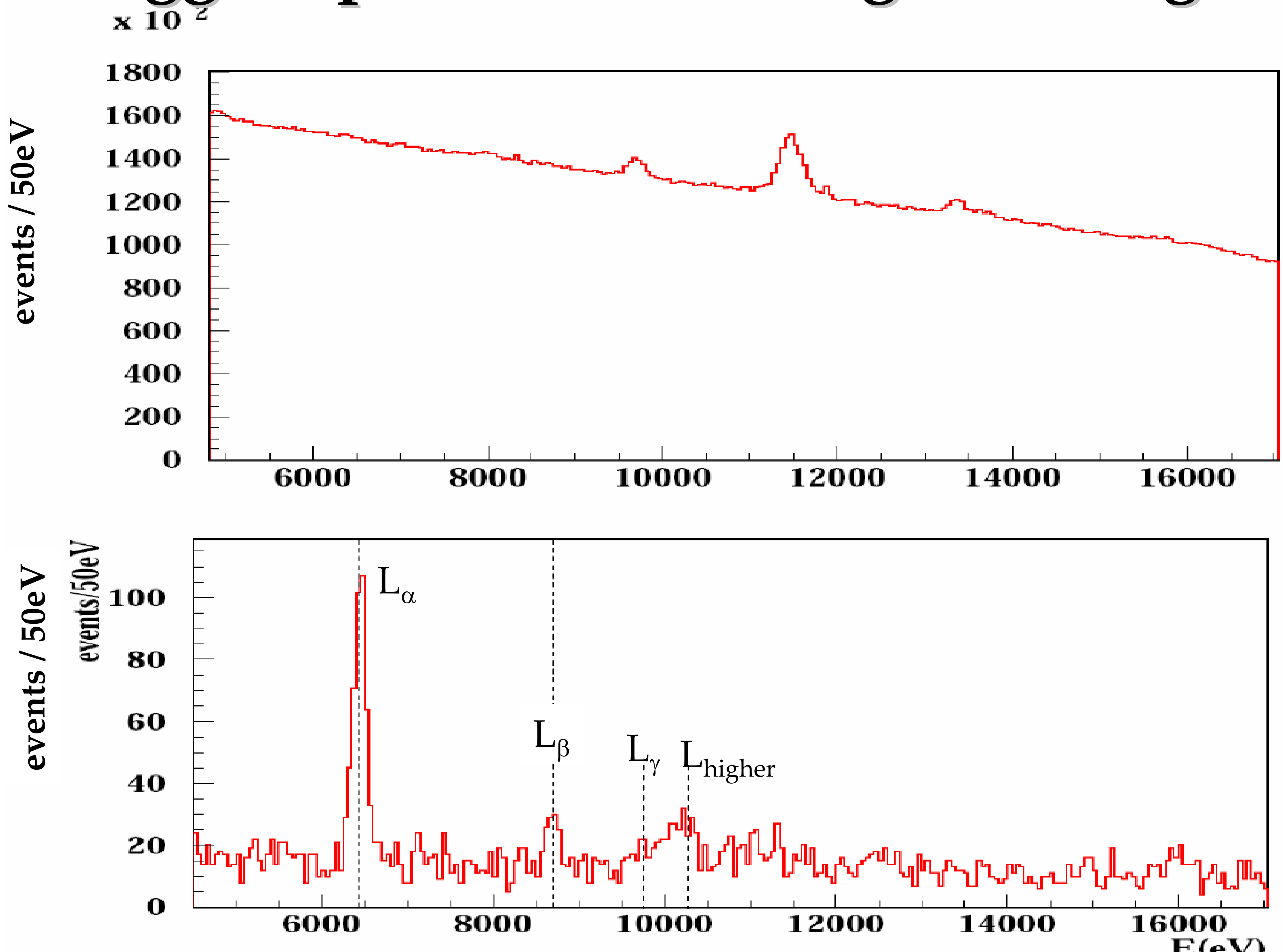
SIDDHARTA setup on DAΦNE

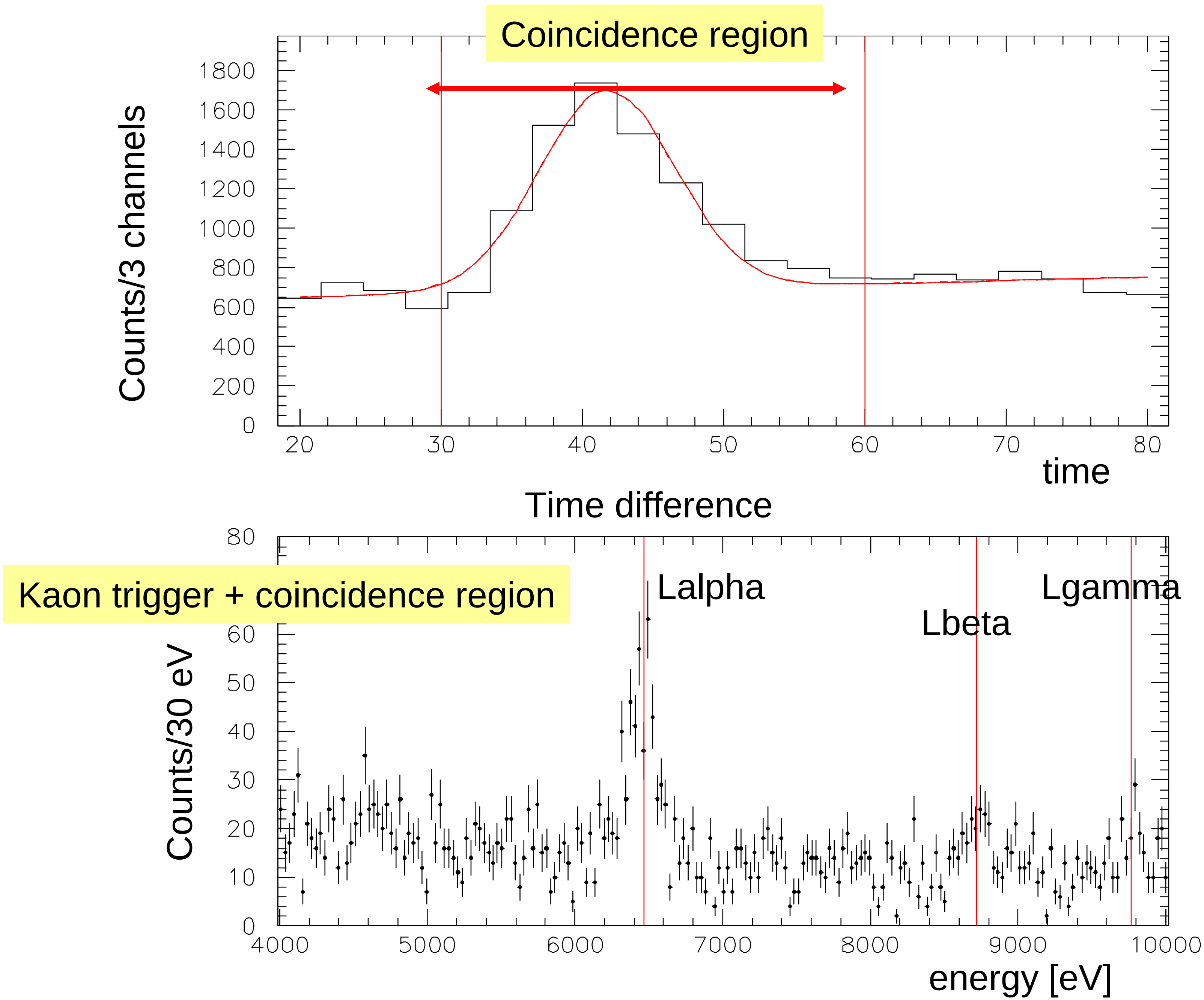


X-ray calibration spectrum



Trigger optimization using a He target





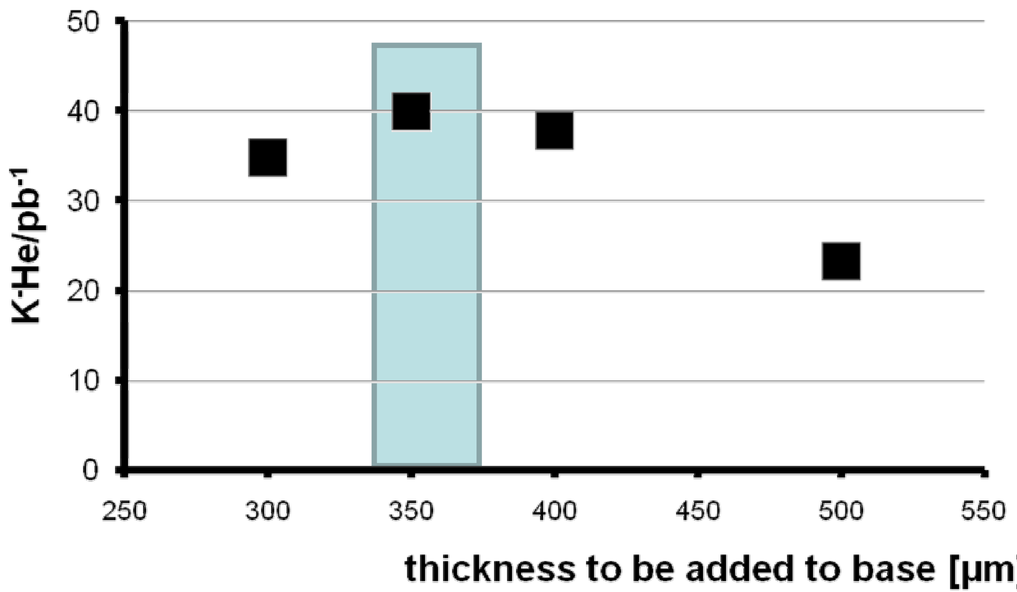
Coincidence region
Counts/3 channels
0
200
400
600
800
1000
1200
1400
1600
1800
20
30
40
50
60
70
80
time
Time difference
Kaon trigger + coincidence region
Counts/30 eV
0
10
20
30
40
50
60
80
4000
5000
6000
7000
8000
9000
10000
energy [eV]
Lalpha
Lbeta
Lgamma

Degrader optimization using a He target

	$K^{-}He(L\alpha)$	S/B ratio	I.L. [pb^{-1}]	$K^{-}He/pb^{-1}$
Deg 2	397±24	4.0	11.4	34.8±2.1
Deg 3	590±30	4.6	14.8	39.9±2.0
Deg 4	420±24	4.2	11.1	37.8±2.2
Deg 5	209±19	2.6	9.0	23.2±2.1

Degrader base made of Mylar:

-60,-40 mm 100 μm
-40,-20 mm 200 μm
-20,0 mm 400 μm
0,+20 mm 600 μm
+20,+40 mm 700 μm
+40,+60 mm 800 μm



SIDDHARTA: activities in 2009

-In-beam calib. procedure – sliding mechanism (degrader / calib. Foil); stability tests

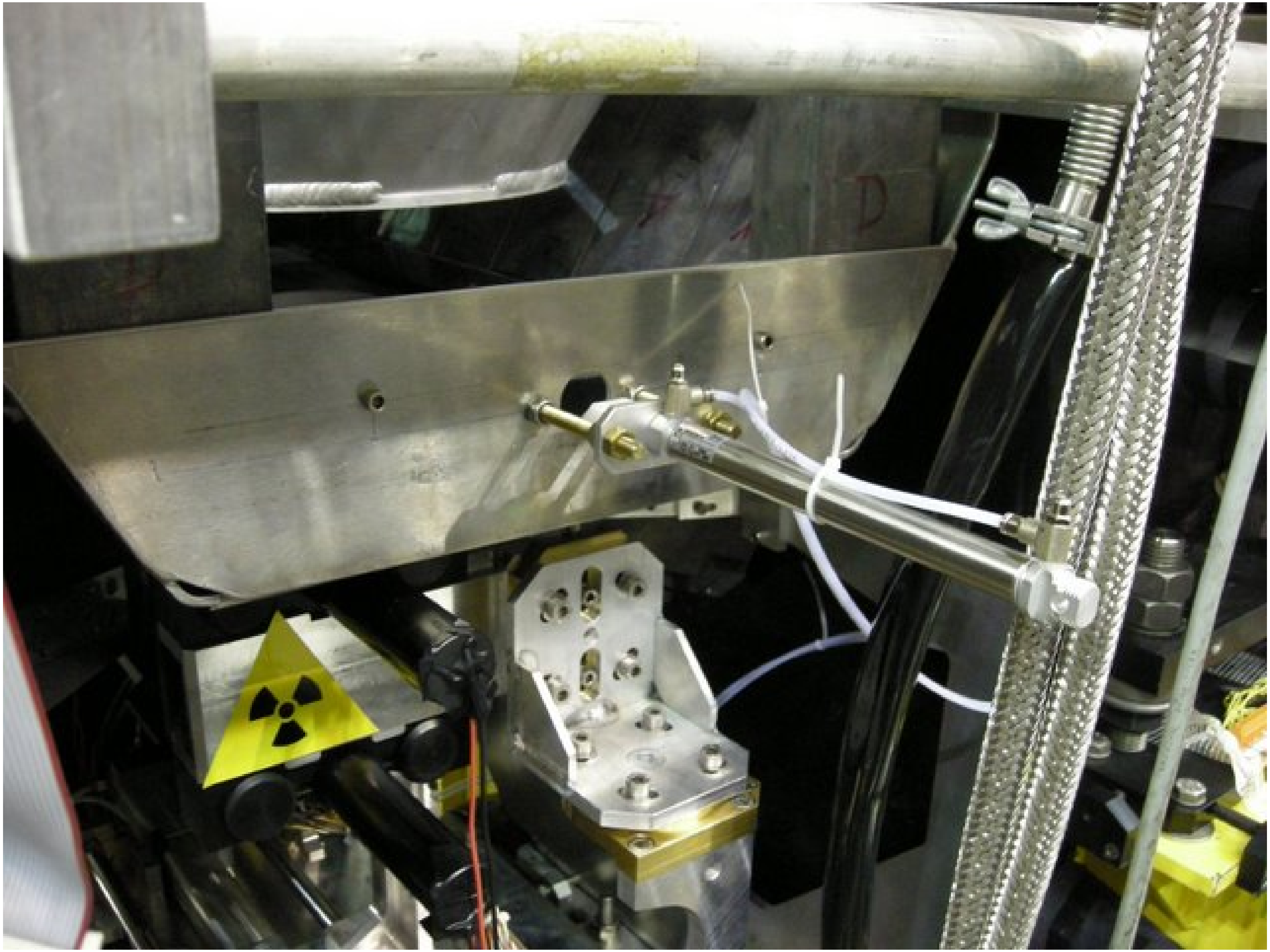
-Study of systematic errors with a 55Fe source inside setup (Mn lines versus Cu and Ti) -> 2 eV systematic error with KHe
--> data for publication

-Hydrogen filled inside target in March, KH measurement started

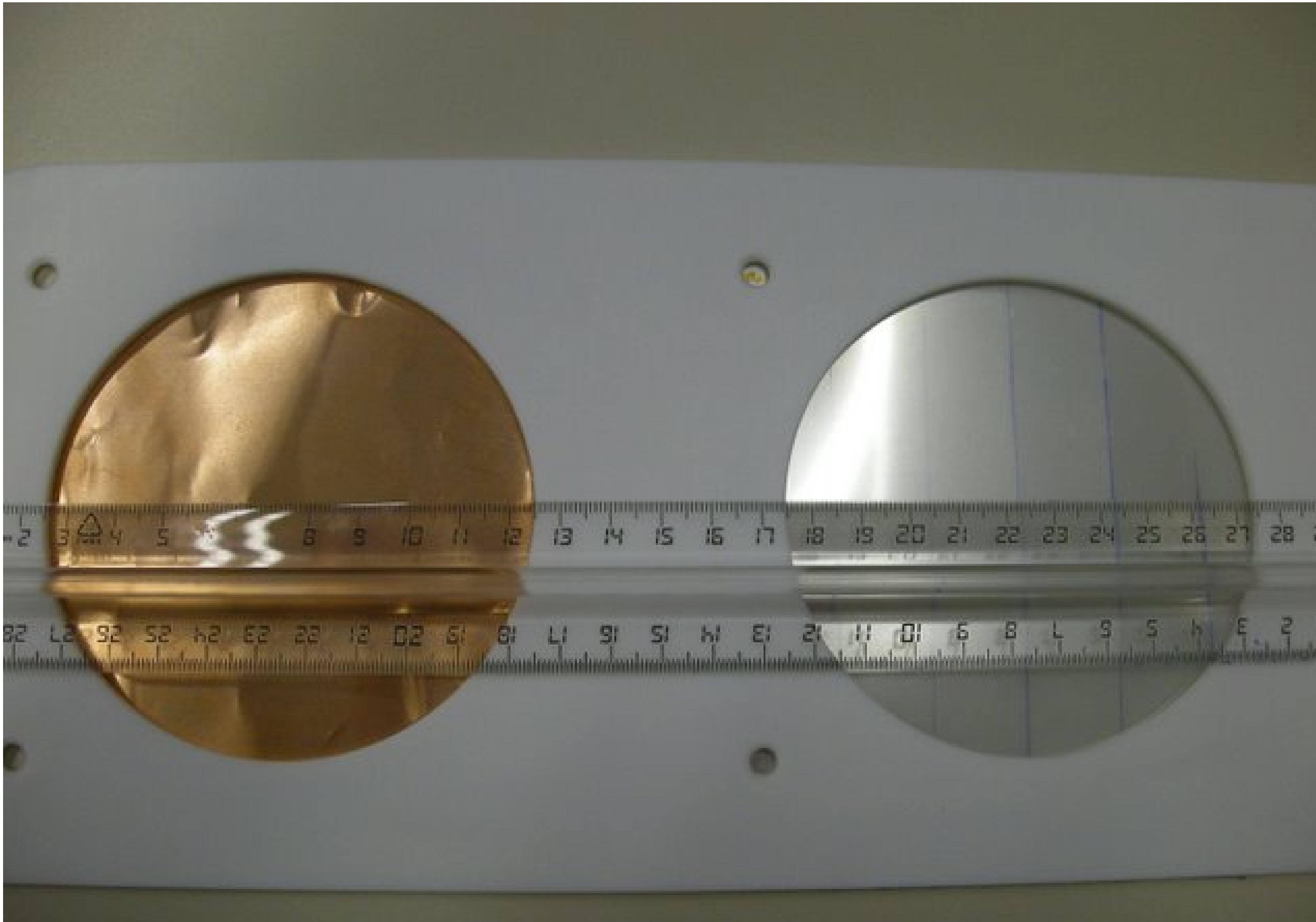
Optimization of the calibration procedure and study of the systematic errors

With KHe

Sliding mechanism: degrader/calib foil(s) –January



Sliding mechanism: degrader/calib foil(s) –January



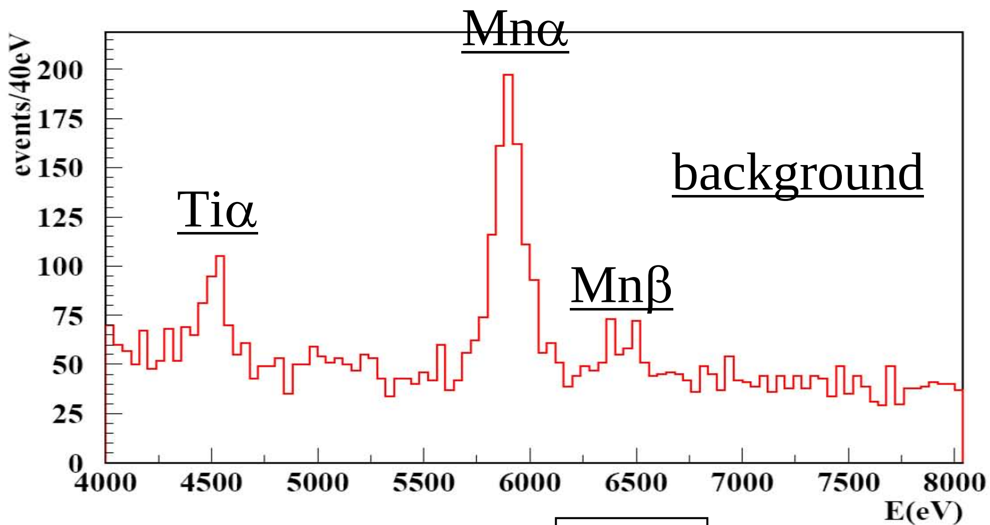
55Fe source (5.9 KeV line) inside the vacuum jacket

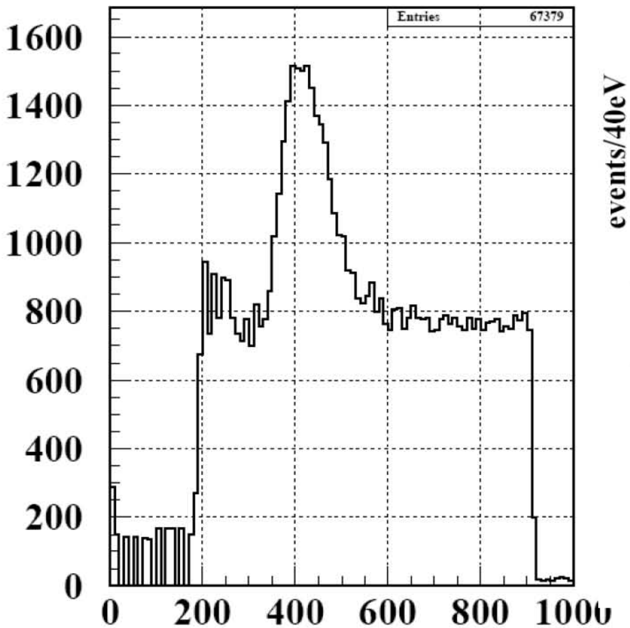
KHe spectrum

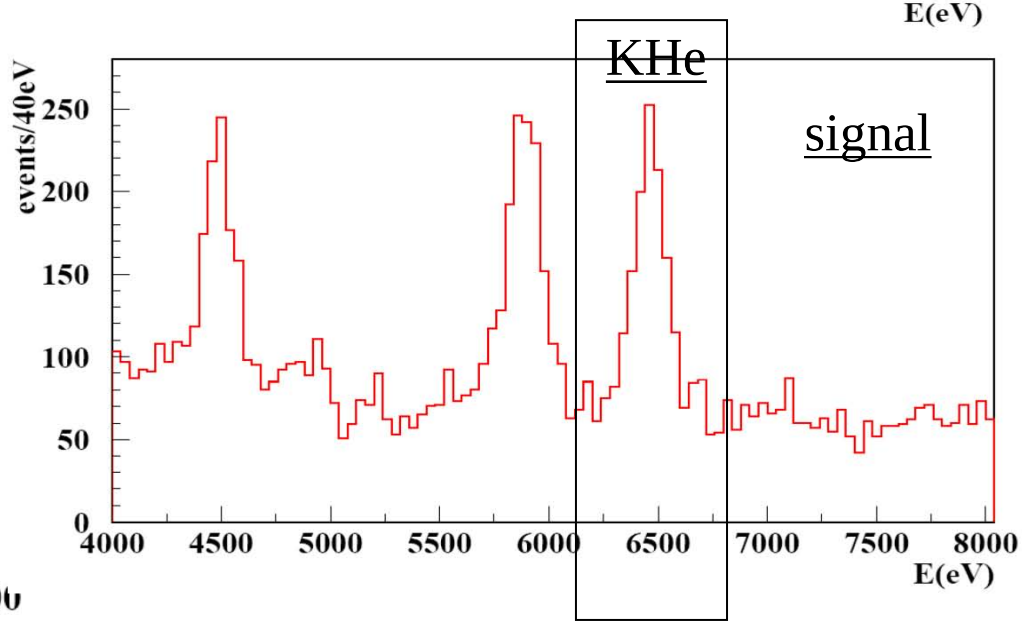
N of events = 763 +- 45

L = 25 pb**-1; 30 ev/pb**-1

S/B = 2/1 (area)



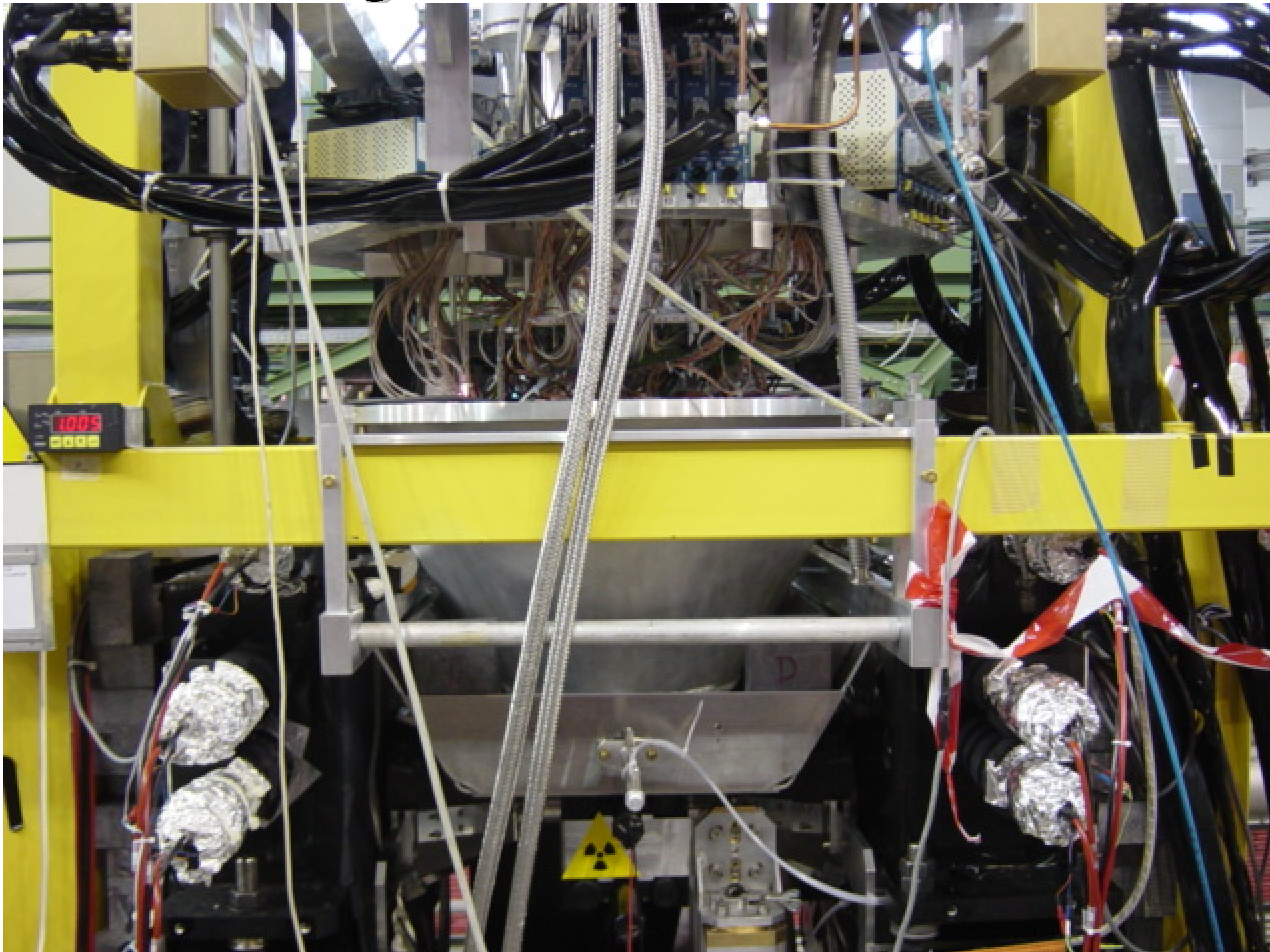




New target cell – better calibration and higher solid angle

New target cell installation (26 Feb)

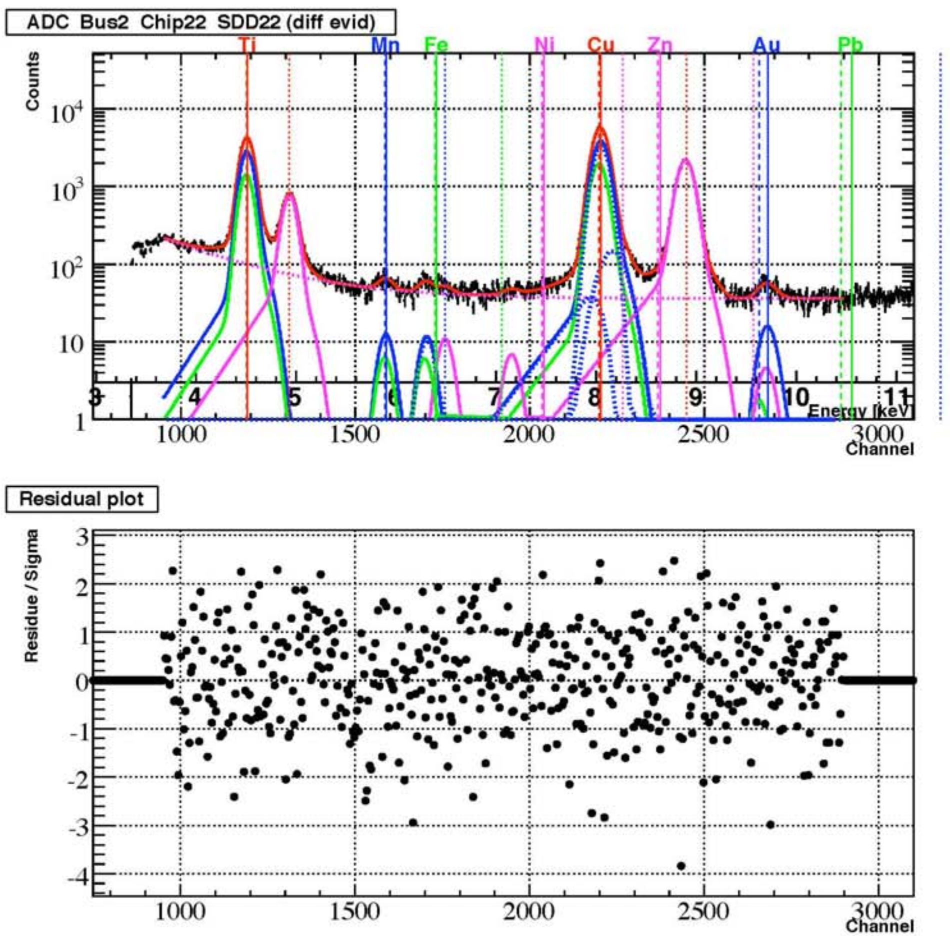
New target cell installation (26 Feb)



Typical calibration spectrum beam and X-ray tube

Spectrum fit results for a typical SDD

Data folder : 20090129run0016
(= 20090129_1314_1407_xraytube_only_Cu)



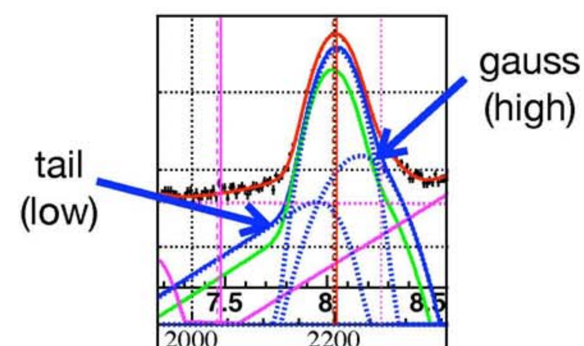
Histogram :
- Removed cross talk (within buses)
  --> see my report on 21/Jan/2009
- Rebin factor : 4

X-ray lines :
- Ti : Ka1, Ka2, Kb1
- Mn : Ka1, Ka2, Kb1 (mean fixed)
- Cu : Ka1, Ka2, Kb1

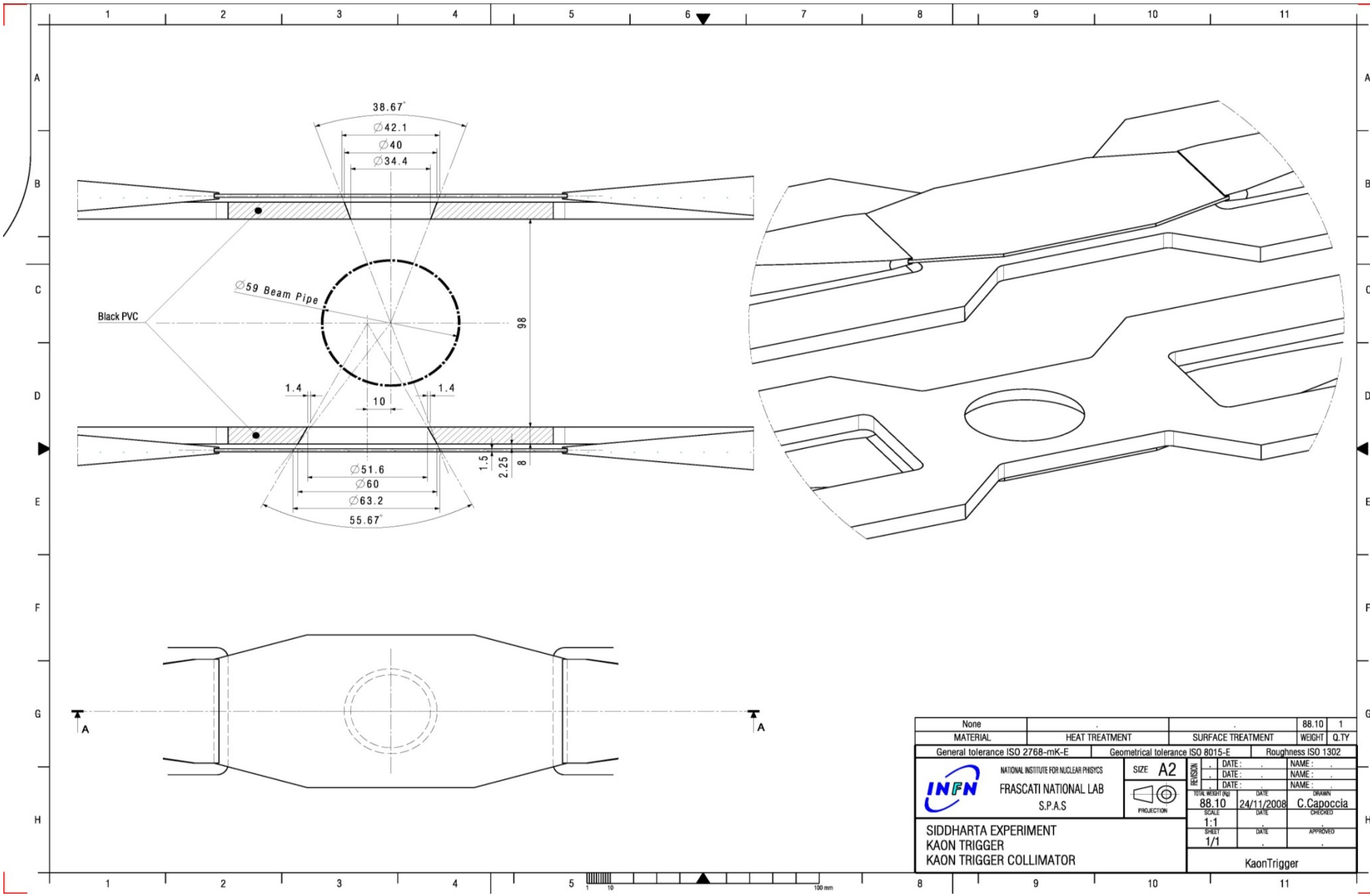
Response function :
- Main Gaussian
- Tail func. (low energy side)
- Pileup Gaussian (high energy side)
- Escape peak

Background :
- Exponential + Constant

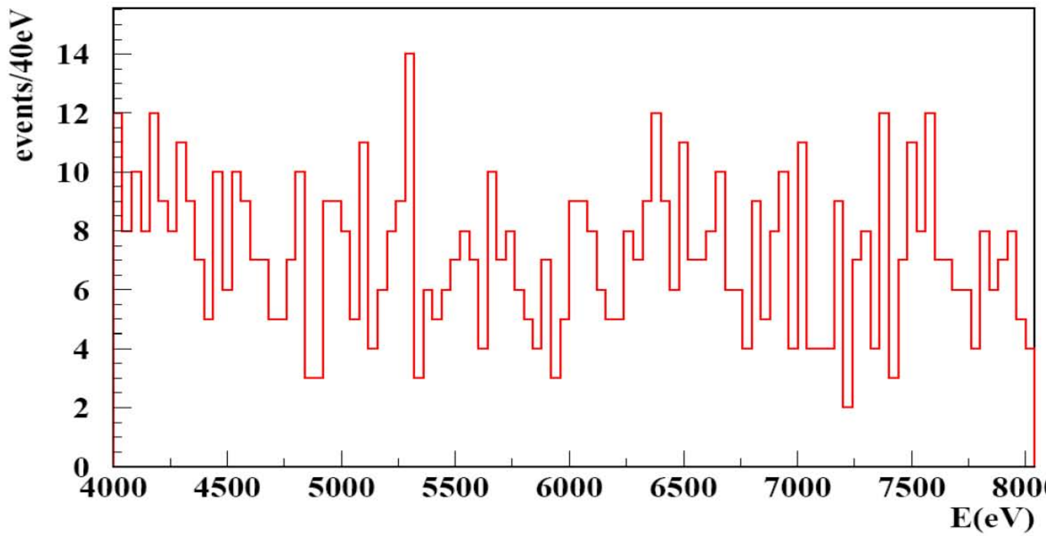
==> Chi/NDF = 525.1 / 463 = 1.13



Kaon detector collimator (factor about 1.5)

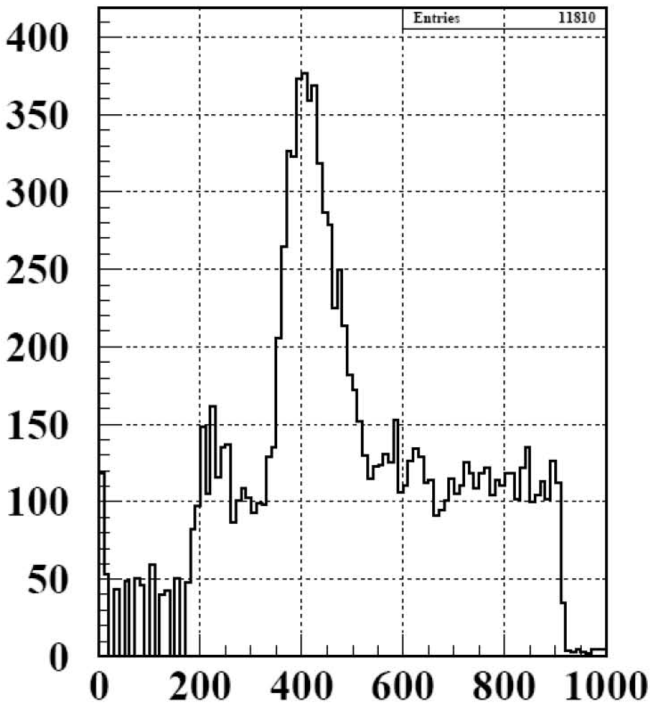


KHe spectrum with the new target cell



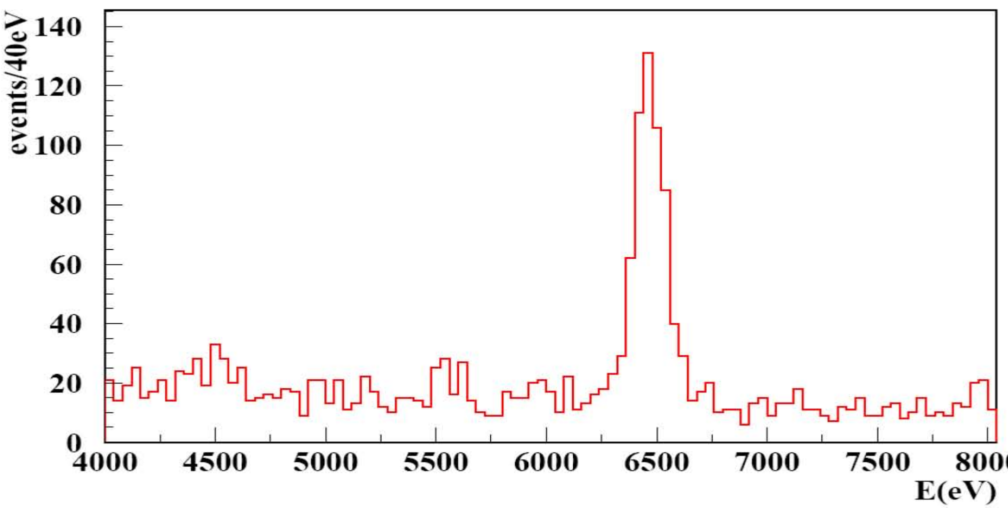
N of events = 498 +- 26

Sigma = 70 eV



L = 8-10 pb**-1 (50-60 ev/pb)_

S/B = 6/1 (area) (**gained factor 3**)



Kaonic helium analysis

First measurement of KHe4 on gaseous target -to be published

Energy shift of the kaonic helium $2p$ state [8]

ΔE_{2p} (eV)	Ref.
-41 ± 33	Wiegand *et al.* [11]
-35 ± 12	Batty *et al.* [12]
-50 ± 12	Baird *et al.* [13]
-43 ± 8	Average of above [8,13]

Theoretical value around 0 eV
-> kaonic helium puzzle

Available online at www.sciencedirect.com
ScienceDirect
PHYSICS LETTERS B
Physics Letters B 653 (2007) 387–391
www.elsevier.com/locate/physletb

Precision measurement of the $3d \to 2p$ x-ray energy in kaonic ^{4}He

S. Okada [a,*], G. Beer [b], H. Bhang [c], M. Cargnelli [d], J. Chiba [e], Seonho Choi [c], C. Curceanu [f], Y. Fukuda [g], T. Hanaki [e], R.S. Hayano [h], M. Iio [a], T. Ishikawa [h], S. Ishimoto [i], T. Ishiwatari [d], K. Itahashi [a], M. Iwai [i], M. Iwasaki [a,g], B. Juhász [d], P. Kienle [d,j], J. Marton [d], Y. Matsuda [a], H. Ohnishi [a], H. Outa [a], M. Sato [g,1], P. Schmid [d], S. Suzuki [i], T. Suzuki [a], H. Tatsuno [h], D. Tomono [a], E. Widmann [d], T. Yamazaki [a,h], H. Yim [c], J. Zmeskal [d]

[a] *RIKEN Nishina Center, RIKEN, Saitama 351-0198, Japan*
[b] *Department of Physics and Astronomy, University of Victoria, British Columbia V8W 3P6, Canada*
[c] *Department of Physics, Seoul National University, Seoul 151-742, South Korea*
[d] *Stefan Meyer Institut für subatomare Physik, Austrian Academy of Sciences, A-1090 Vienna, Austria*
[e] *Department of Physics, Tokyo University of Science, Chiba 278-8510, Japan*
[f] *Laboratori Nazionali di Frascati, INFN, I-00044 Frascati, Italy*
[g] *Department of Physics, Tokyo Institute of Technology, Tokyo 152-8551, Japan*
[h] *Department of Physics, The University of Tokyo, Tokyo 113-0033, Japan*
[i] *High Energy Accelerator Research Organization (KEK), Ibaraki 305-0801, Japan*
[j] *Physik Department, Technische Universität München, D-85748 Garching, Germany*

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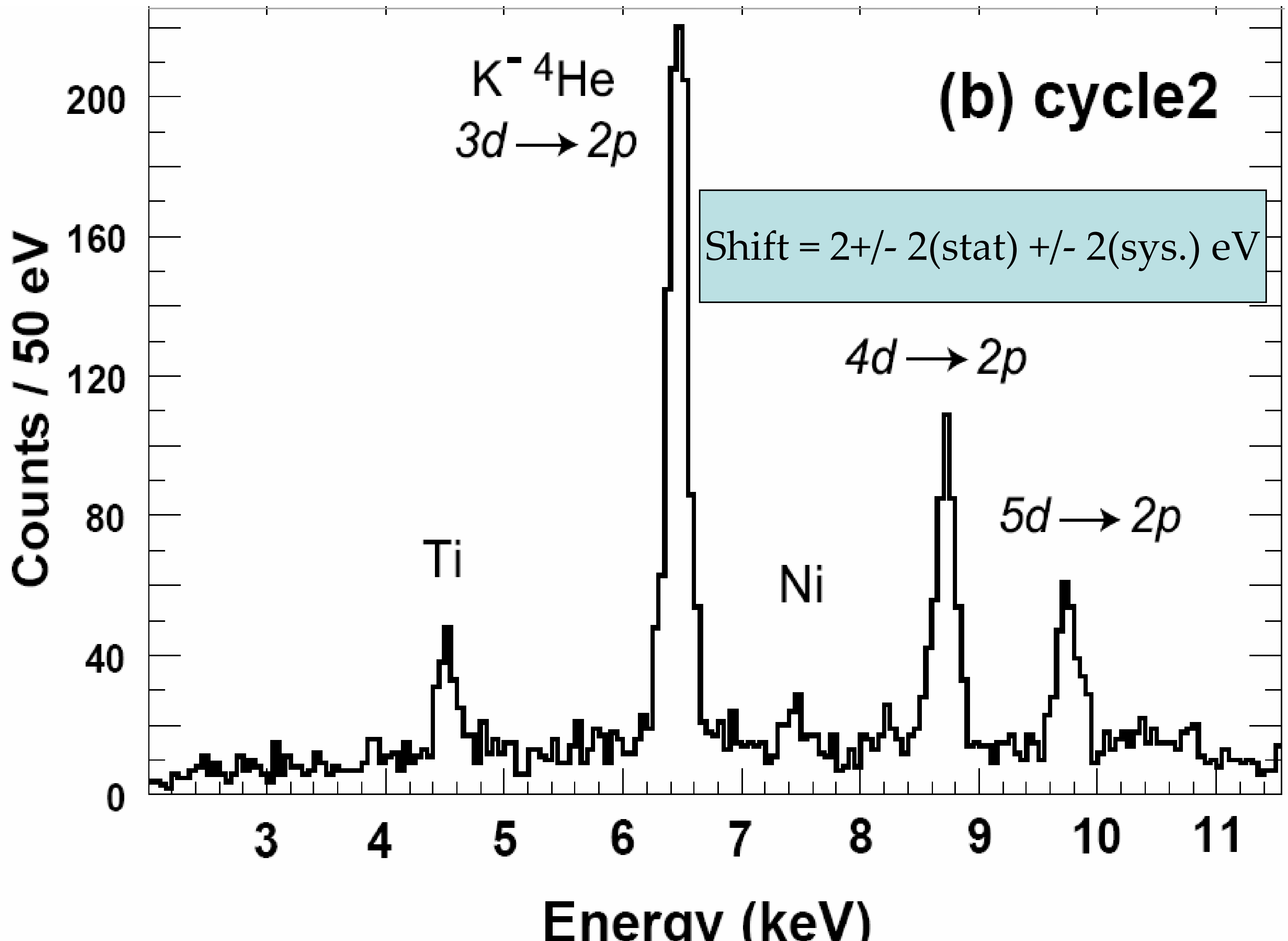
Abstract

We have measured the Balmer-series x-rays of kaonic ^{4}He atoms using novel large-area silicon drift x-ray detectors in order to study the low-energy $\bar{K}$-nucleus strong interaction. The energy of the $3d \to 2p$ transition was determined to be $6467 \pm 3(\mathrm{stat}) \pm 2(\mathrm{syst})$ eV. The resulting strong-interaction energy-level shift is in agreement with theoretical calculations, thus eliminating a long-standing discrepancy between theory and experiment.

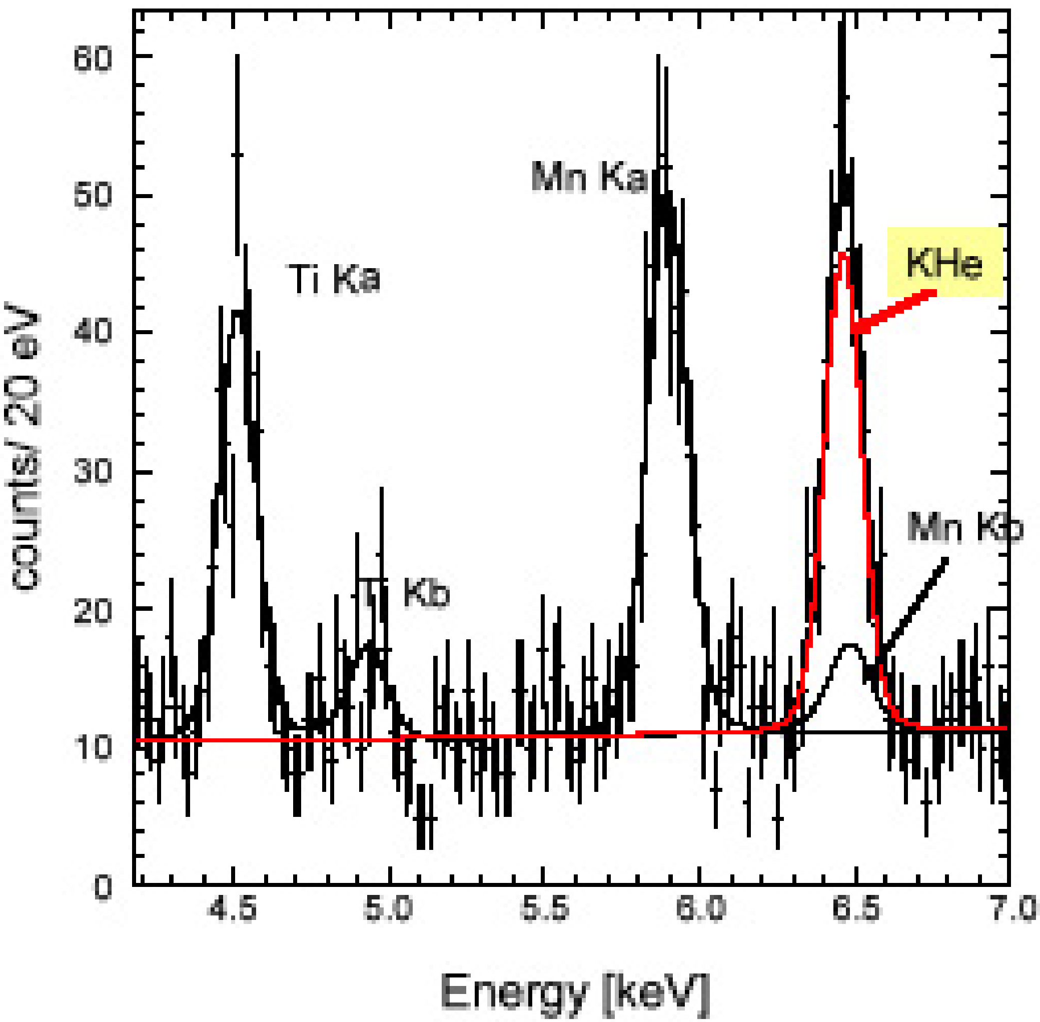
PACS: 13.75.Jz; 25.80.Nv; 36.10.Gv

Keywords: Kaonic atom; X-ray spectroscopy; Silicon drift detector

E570 at KEK: K$^-$He



SIDDHARTA: K^-He



Shift = 0+/- 6(stat) +/- 2(sys.) eV

Burial of K$^-$He puzzle:

Energy shift of the kaonic helium $2p$ state [8]

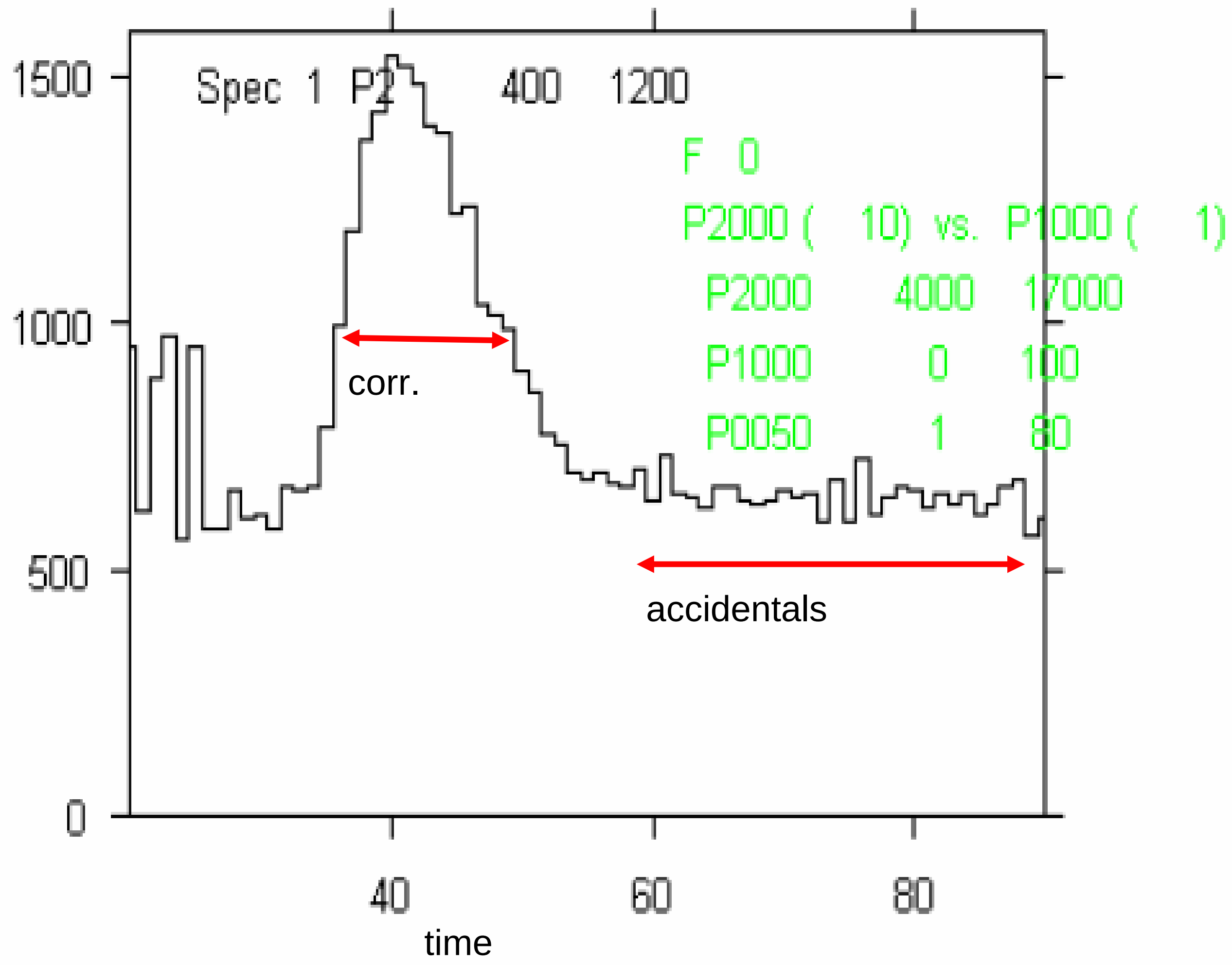
ΔE_{2p} (eV)	Ref.
-41 ± 33	Wiegand *et al.* [11]
-35 ± 12	Batty *et al.* [12]
-50 ± 12	Baird *et al.* [13]
-43 ± 8	Average of above [8,13]
$+2 \pm 2$ (stat) ± 2 (sys)	Okada *et al.* [17]
0 ± 6 (stat) ± 2 (sys)	This work

Kaonic hydrogen

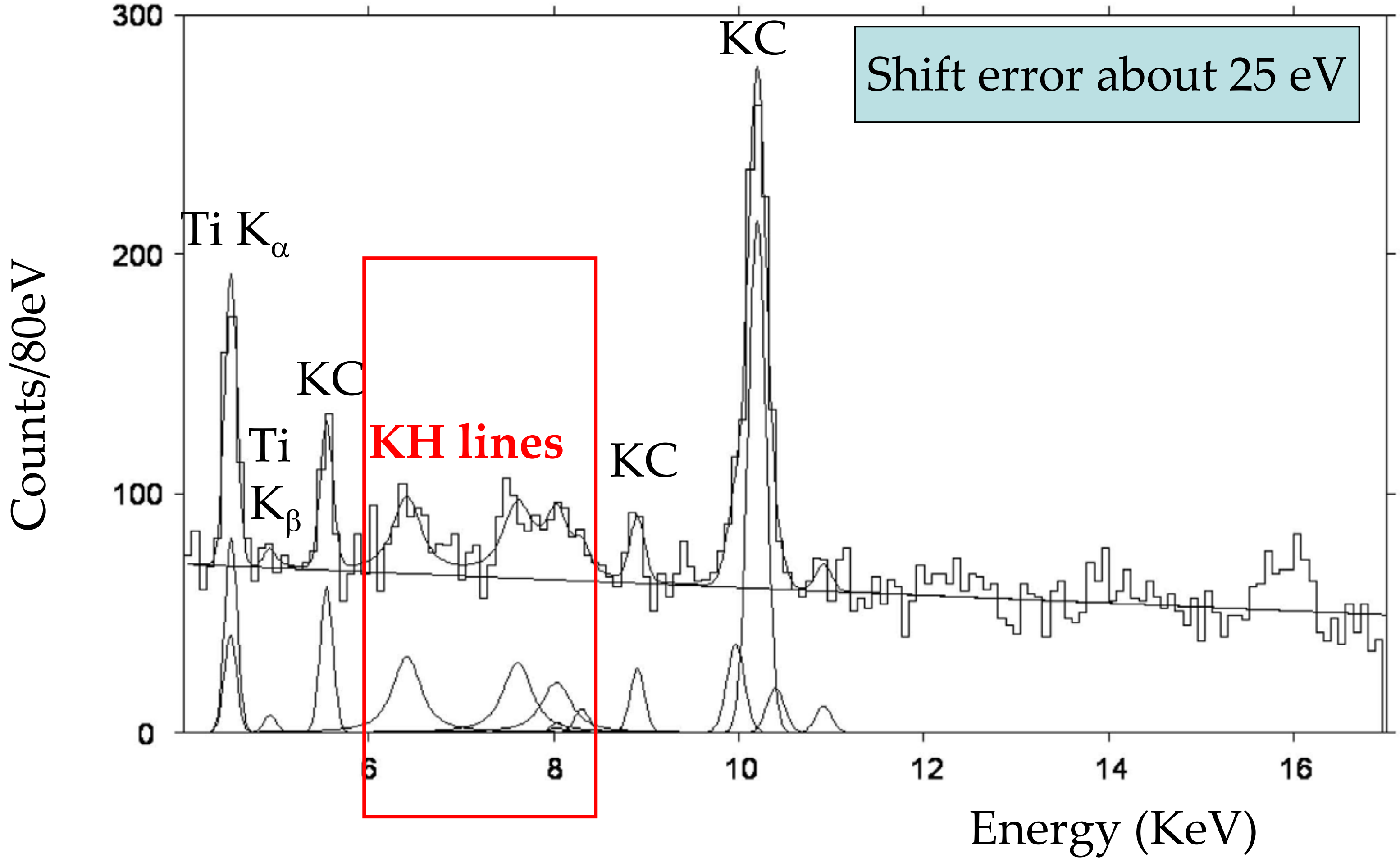
Collected about 100 pb^{-1} till end of April

(very) preliminary analyses

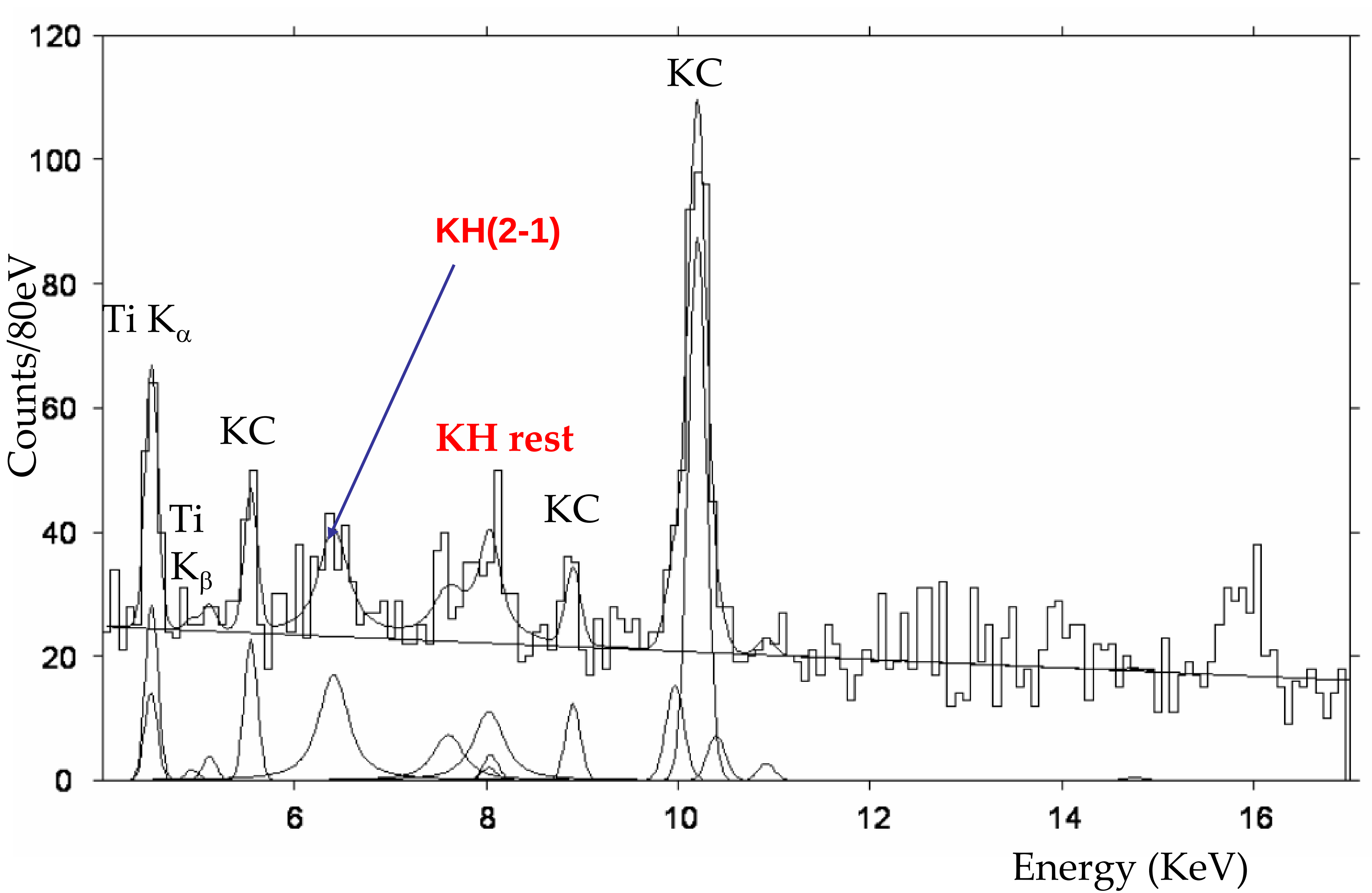
SIDDHARTA kaonic hydrogen
Drift time spectrum



Preliminary SIDDHARTA kaonic hydrogen spectrum



KH preliminary analyses
Selection of cleanest data subset



For 100 pb^{-1} precision in shift about 25 eV

-> for 400 pb^{-1}

Expected precision in shift about 10 eV

SIDDHARTA scientific programme
EU dimension

The scientific aim

the precision determination of the ***isospin dependent***
KN scattering lengths through a
~ eV measurement of the shift **and** ***of the width***

of the K_α line of **kaonic hydrogen** and
the *first (similar) measurement* of **kaonic deuterium**

LEANNIS Network
in FP7 HadronPhysics2

1. **Breakthrough in the *low-energy* $\bar{K}N$ *phenomenology*;**
2. **Threshold amplitude in QCD**
3. **Information on Λ(1405)**

LEANNIS

HadronPhysics2

Study of Strongly Interacting Matter

- 12 participating institutions from
- 5 EU countries: Austria, Finland Germany, Italy, Poland,
- Associated country: Japan

Low Energy Antikaon-Nucleon (Nucleus) Interaction Studies

THE UNIVERSITY OF TOKYO

SMI

TUM Technische Universität München

INFN Istituto Nazionale di Fisica Nucleare

Laboratori Nazionali di Frascati

universitätbonn

HELSINKI INSTITUTE OF PHYSICS

INSTYTUT PROBLEMÓW JĄDROWYCH im. Andrzeja Sołtana

THE ANDRZEJ SOLTAN INSTITUTE FOR NUCLEAR STUDIES

Forschungszentrum Jülich in der Helmholtz-Gemeinschaft

Research objectives

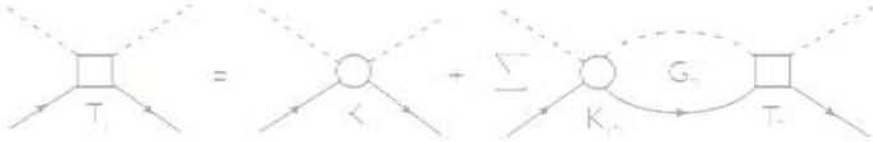
• **Precise determination of the isospin dependent antikaon-nucleon scattering** lengths using kaonic atom X-ray spectroscopy with new technlogy followed by theoretical extraction and interpretation.

• **Precision X-ray spectroscopy of kaonic atoms with light nuclei**, such as ^{3}He and ^{4}He for determination of the antikaon-nucleus interaction including its theoretical interpretation.

• **Further developments and applications of theoretical methods**: chiral perturbation theory, effective field theory with strangeness, chiral SU(3) dynamics with coupled channels, antikaon-nuclear few-body theory; comparisons with data from high-precision experiments.

• **Search for deeply bound antikaonic nuclear states** using various reactions and fully exclusive determination of the reaction and decay products.

LEANNIS Tasks

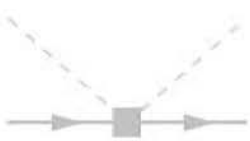


$T = (1 - K \cdot G)^{-1} K$

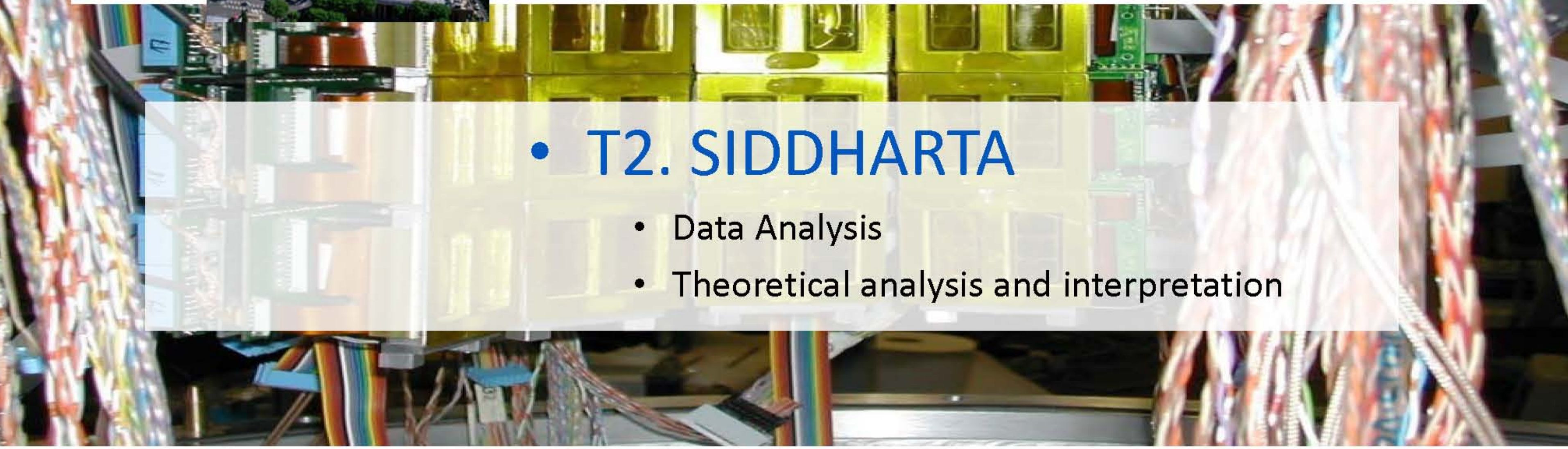
- **T1 Theoretical investigations in strangeness-nuclear physics**
  - Computation of antikaon-nucleon scattering lengths using SU(3) effective field theory approach
  - Three-body calculations for the analysis of K-d system near threshold
  - Systematic theoretical approaches to antikaon-nuclear quasibound states

direct and crossed Born terms

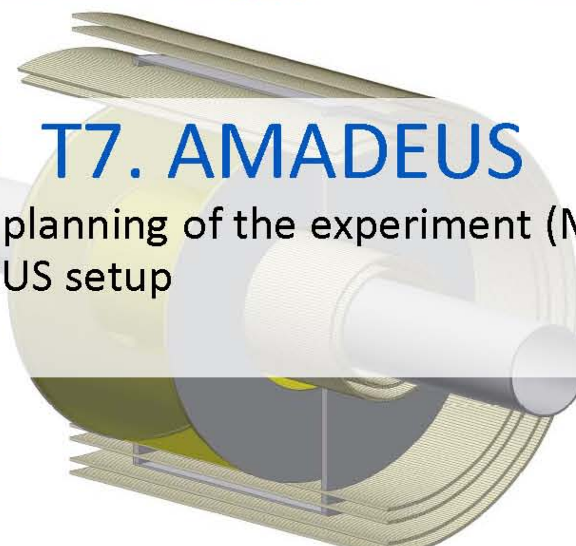
next-to-leading order (NLO):



LEANNIS Tasks



- **T2. SIDDHARTA**
  - Data Analysis
  - Theoretical analysis and interpretation



- **T7. AMADEUS**

- Theoretical impact for planning of the experiment (Monte Carlo)
- Preparation of AMADEUS setup
- Data taking

SIDDHARTA plans and beam time request

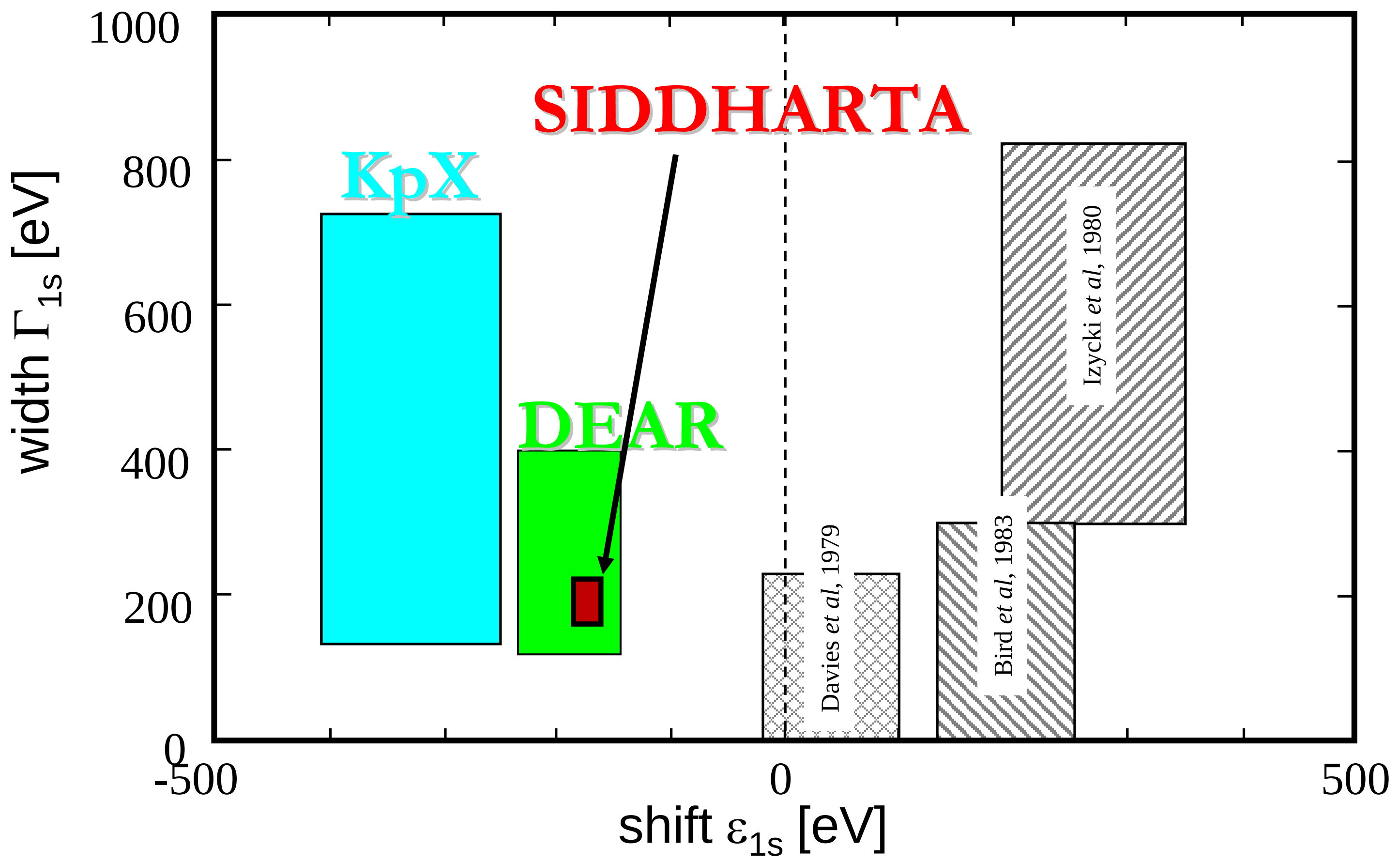
1) 10 eV level precision measurement of kaonic hydrogen: 400 pb^{-1}, about 300 pb^{-1} to be still collected

2) 2009: first measurement of kaonic deuterium, for 600 pb^{-1}
(represents as well background measurement for KH)

3) Further option: precision Kaonic helium measurement (He3), need 50-100 pb^{-1}

Expected SIDDHARTA result

- **Kaonic hydrogen precision estimated using the kaonic helium measurement**
  error in shift: better than ± 10 eV
  error in width: better than ± 35 eV



We wish to express our

THANKS TO

- **Director LNF, Mario Calvetti**
- **DAΦNE machine staff, in particular Pantaleo Raimondi and Claudio Sanelli**
- **G.Corradi, D. Tagnani (Electronics)**
- **B. Dulach, C. Capoccia (Mech. Design, Installation)**
- **Staff of the mechanical workshop (M.A. Franceschi, G. Bisogni)**