SIlicon Drift Detector for Hadronic Atom
Research by Timing Applications

SIDDHARTA - Status Report

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37th LNF Scientific Committee December 1, 2008

Content

- **Installation of the SIDDHARTA setup**
- **Degrader optimization**
- **First results of gaseous kaonic helium**
- **SIDDHARTA Programme**
- **Beam Time Request**

Installation of the SIDDHARTA setup

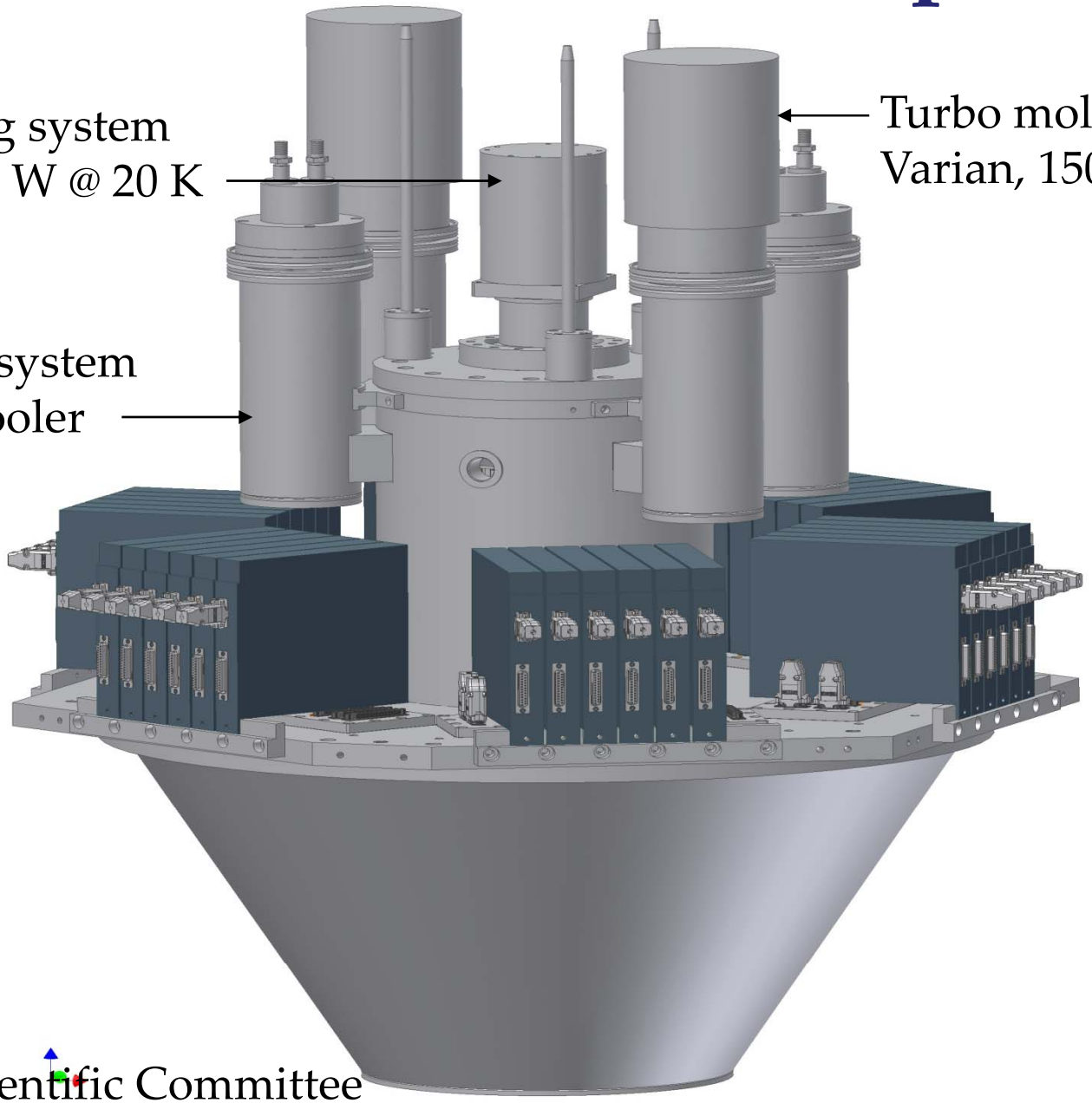
- ✓ **Aug. 15 – 30: preparation for and movement to DAΦNE**
- ✓ **Sept. 1 – 15: vacuum and cryogenic tests debugging**

SIDDHARTA Setup

Target cooling system
APD-cooler 8 W @ 20 K

SDD cooling system
Pulse Tube cooler
18 W @ 150 K

Turbo molecular pump
Varian, 150 l/s



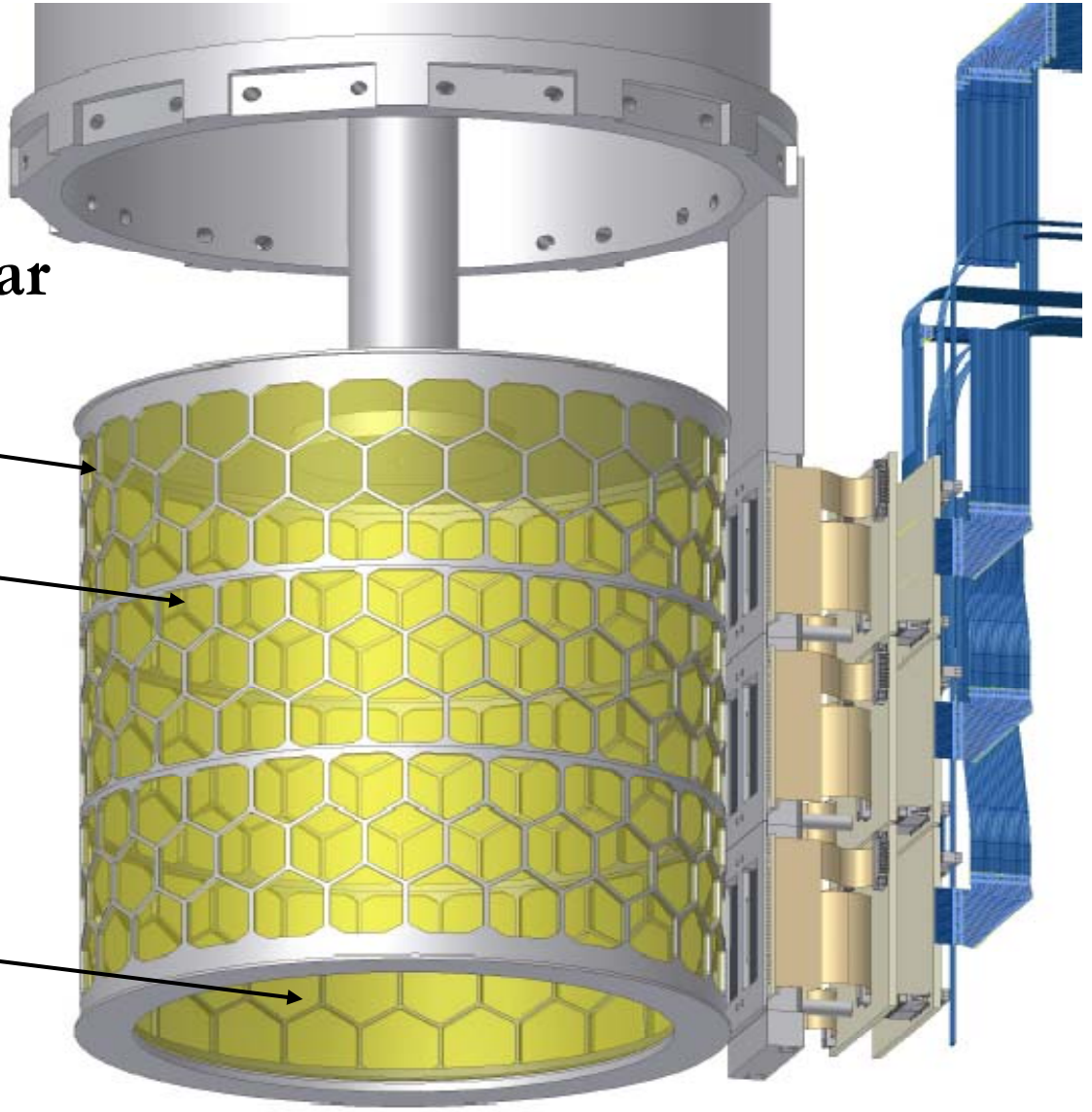
Cryogenic target cell

Working T 22 K
Working P 2.5 bar

Alu-grid

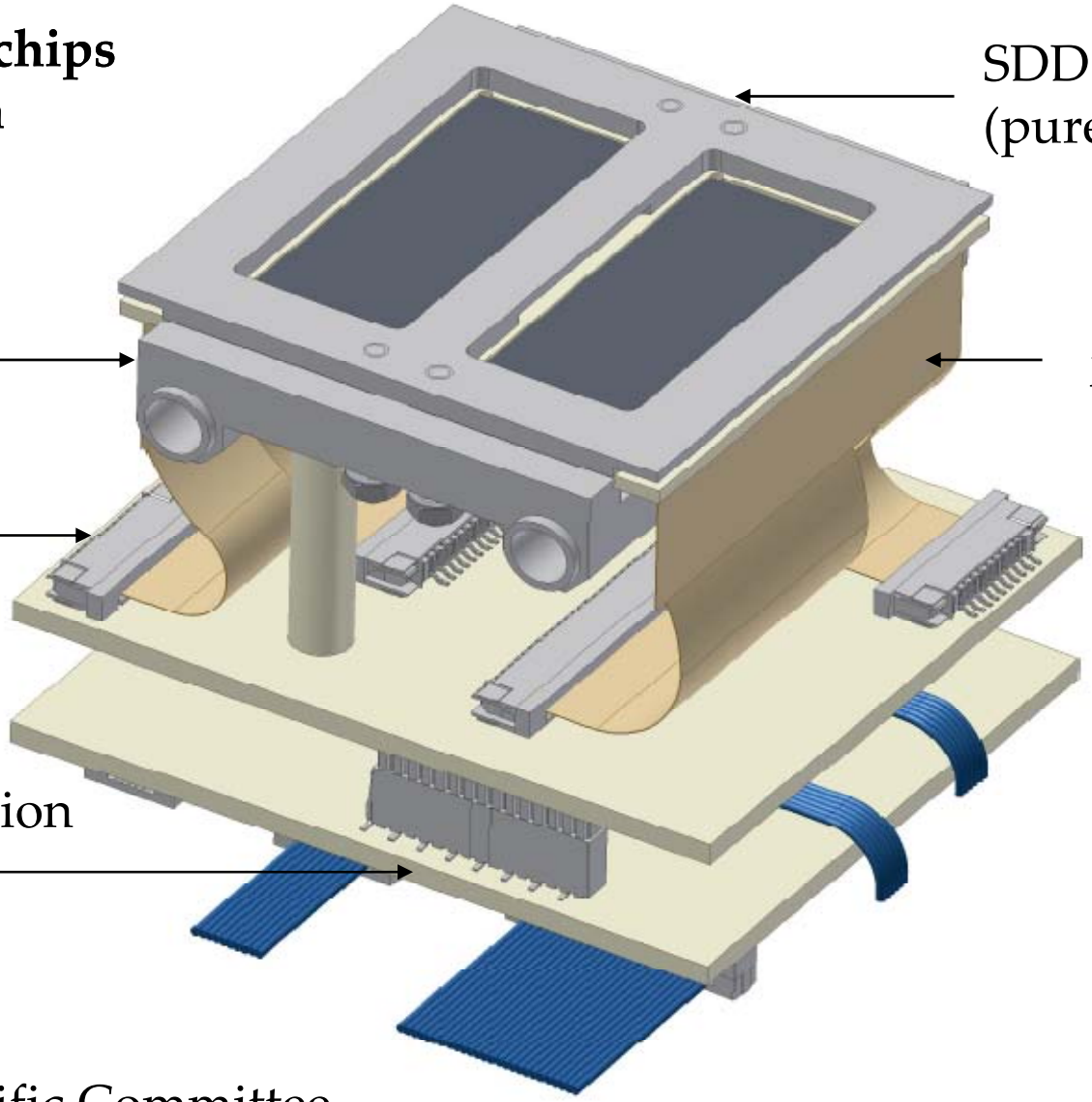
Side wall:
Kapton 50 μm

Kaon entrance
Window:
Kapton 50 μm



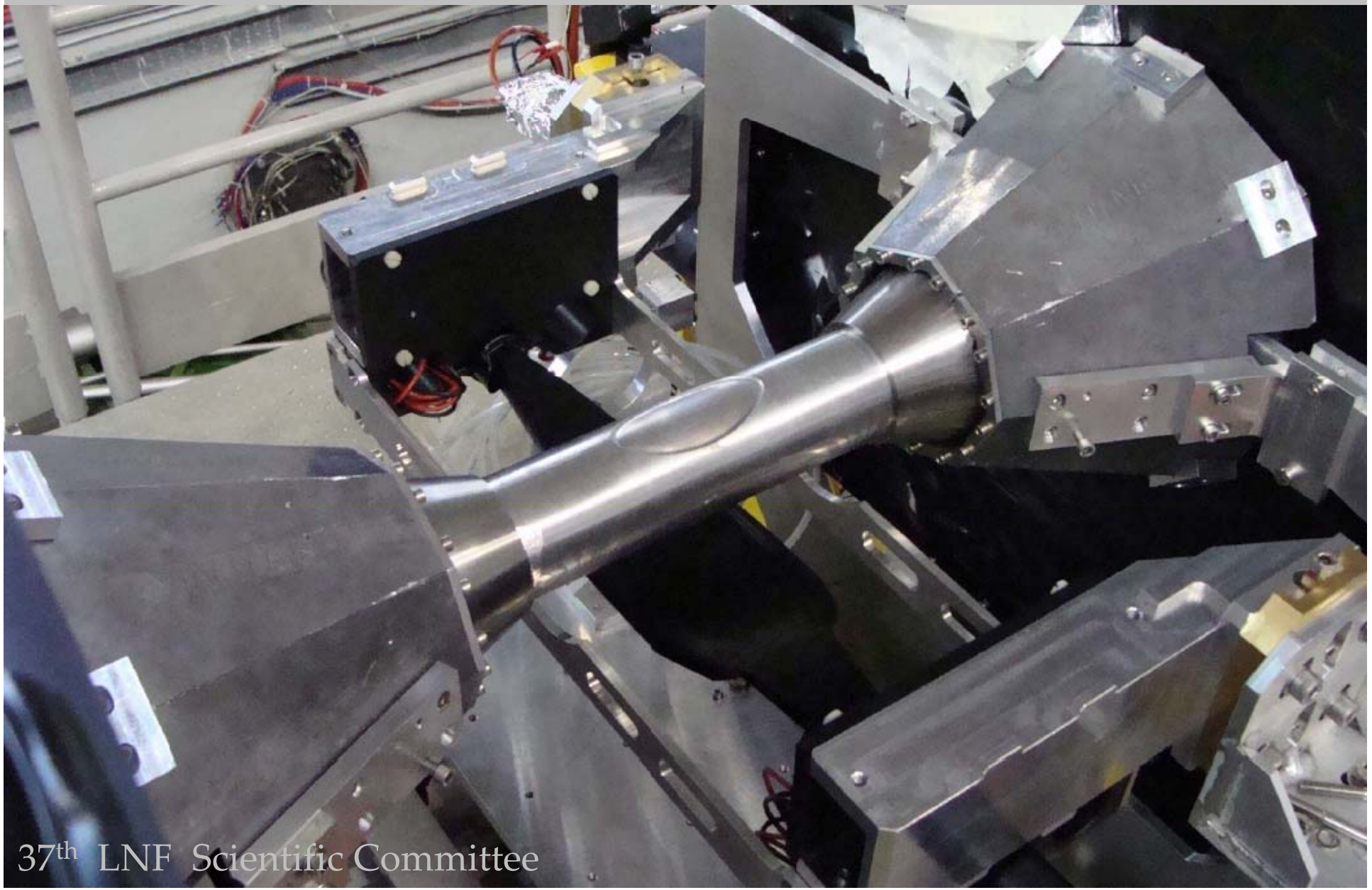
SDD – Silicon Drift Detector

unit for 2 CDD-chips
6 cm^2 active area

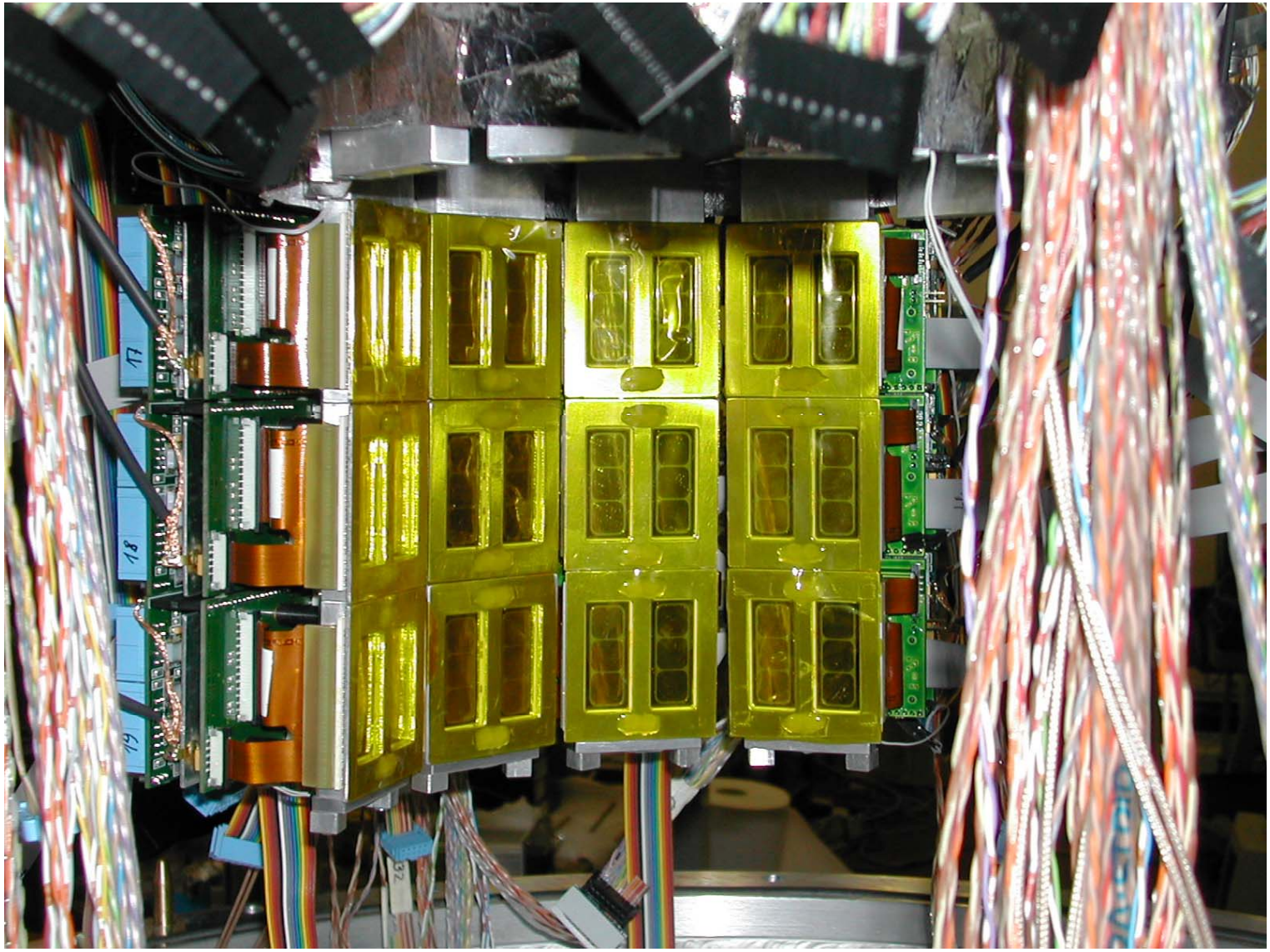


SIDDHARTA setup moved to DAΦNE

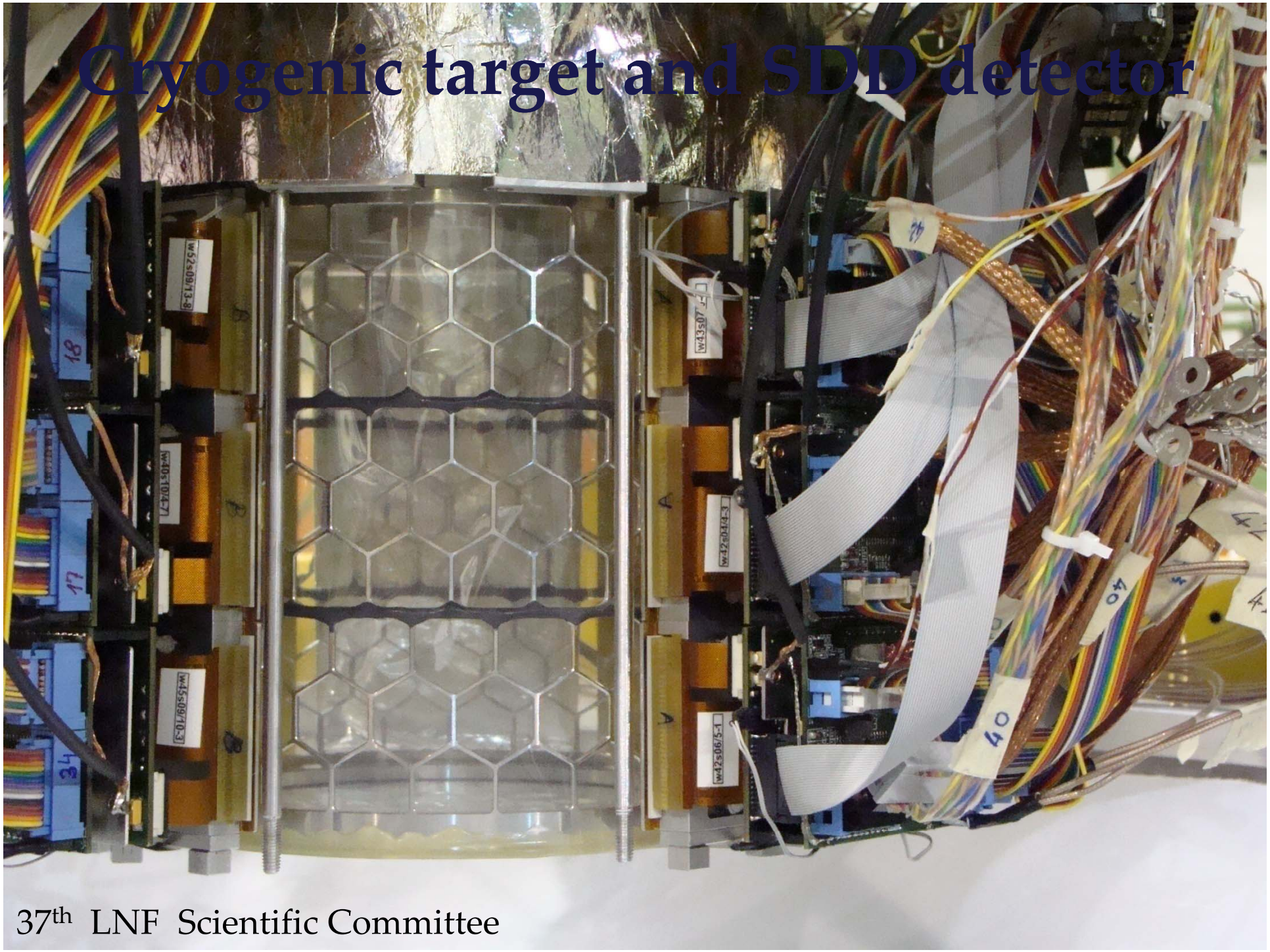
SIDDHARTA interaction region



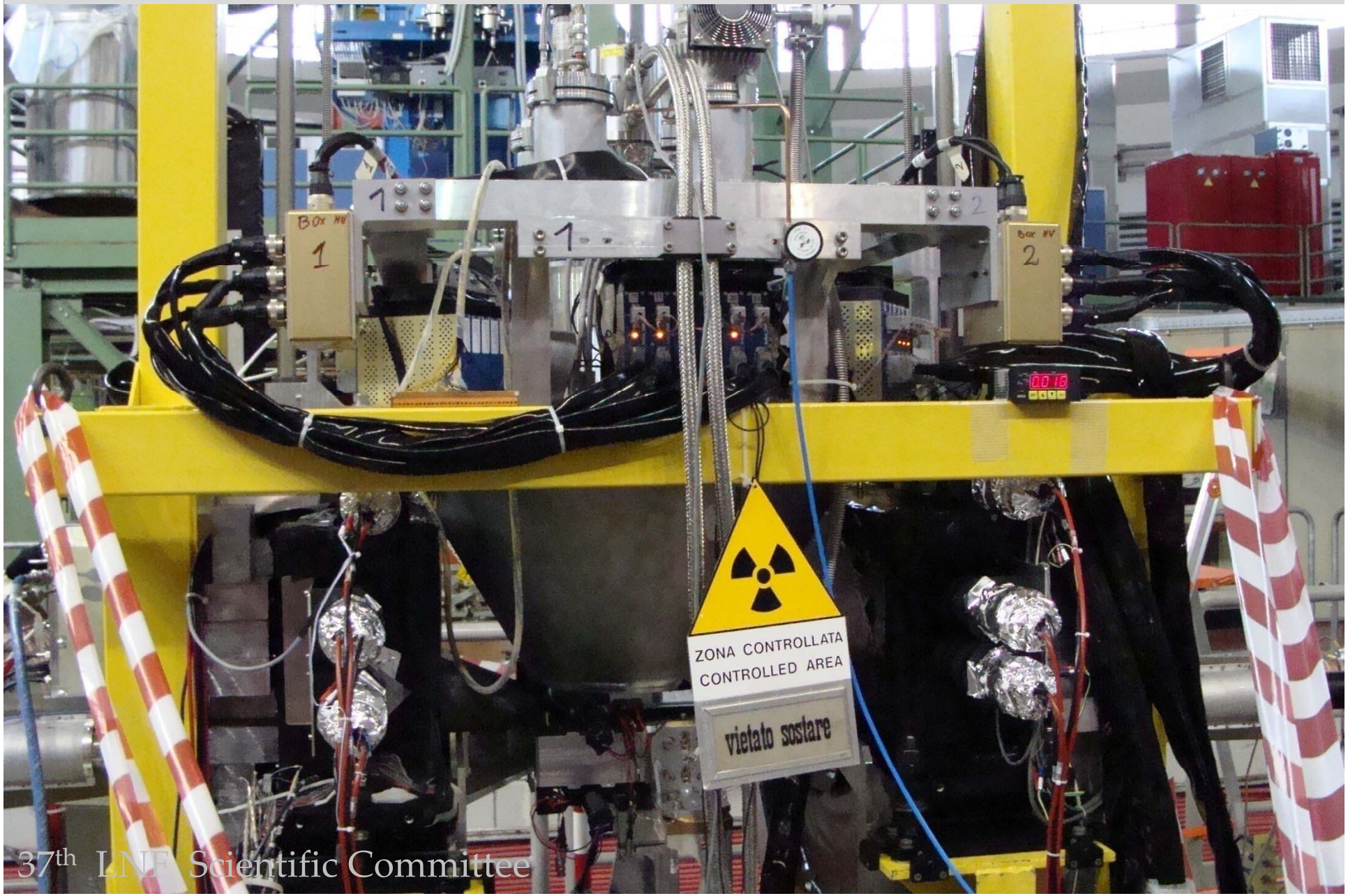
Installation of SDD detector



Cryogenic target and SDD detector



Installation finished, ready for testing



SIDDHARTA
debugging phase

Problems to be solved

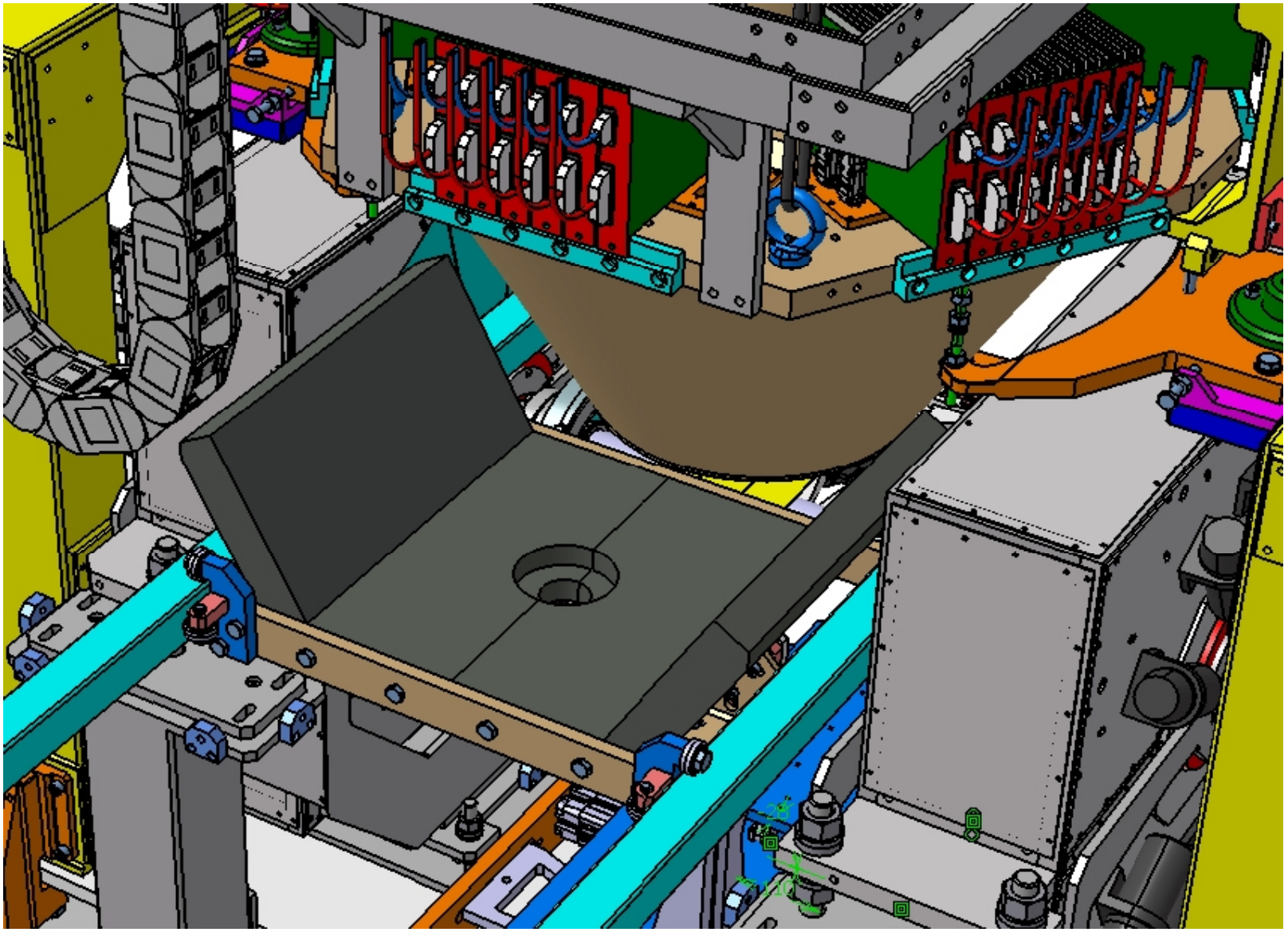
- Latch-up of SDDs
  due to high background mainly during injection
  (checked to be MHz on 1 SDD…..)

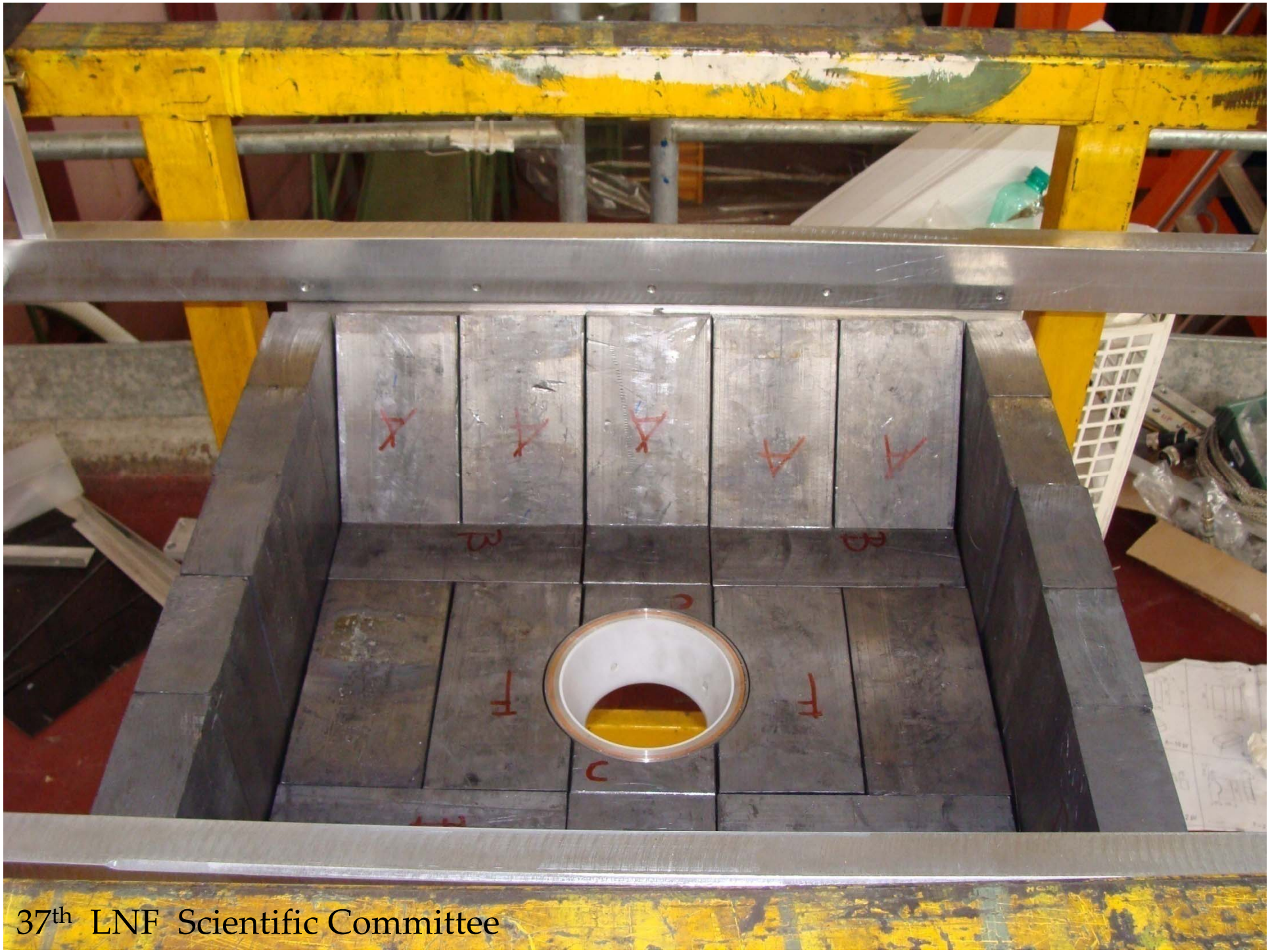
- Installation of shielding

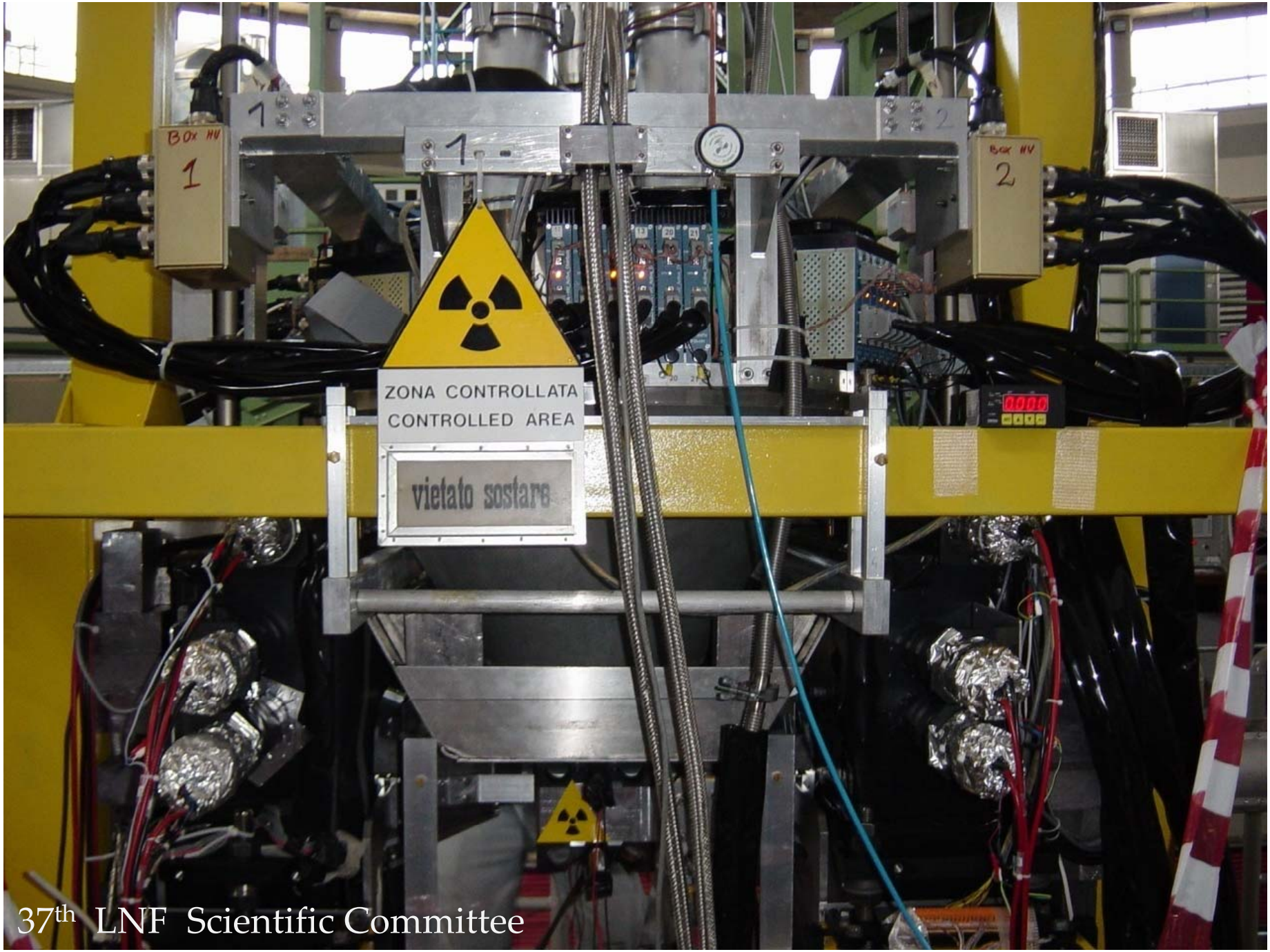
- Adapting SDD electronics for “fast recovery”

Shielding of SIDDHARTA setup

Lead shielding of SIDDHARTA






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

SIDDHARTA
X-ray calibration

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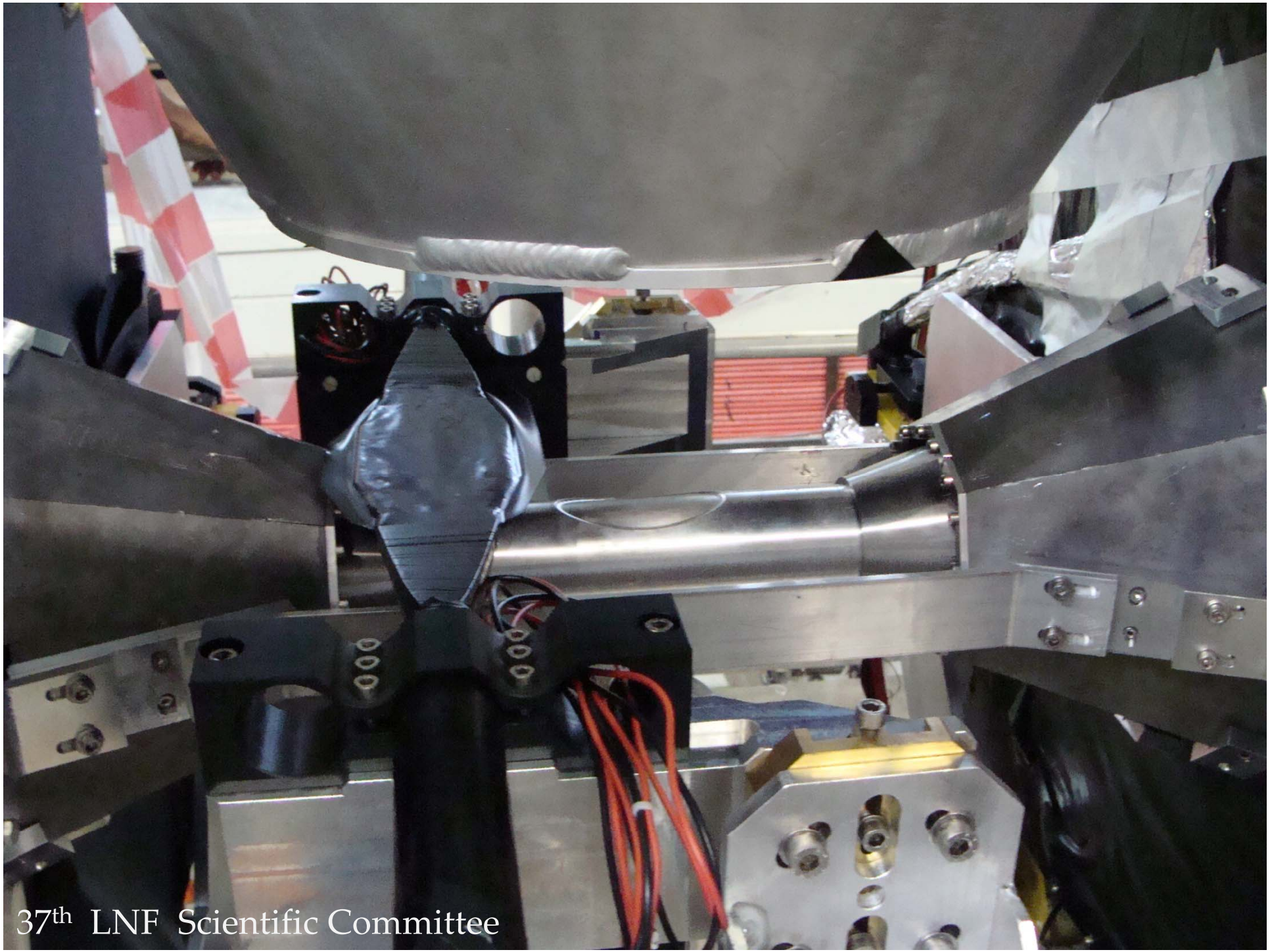
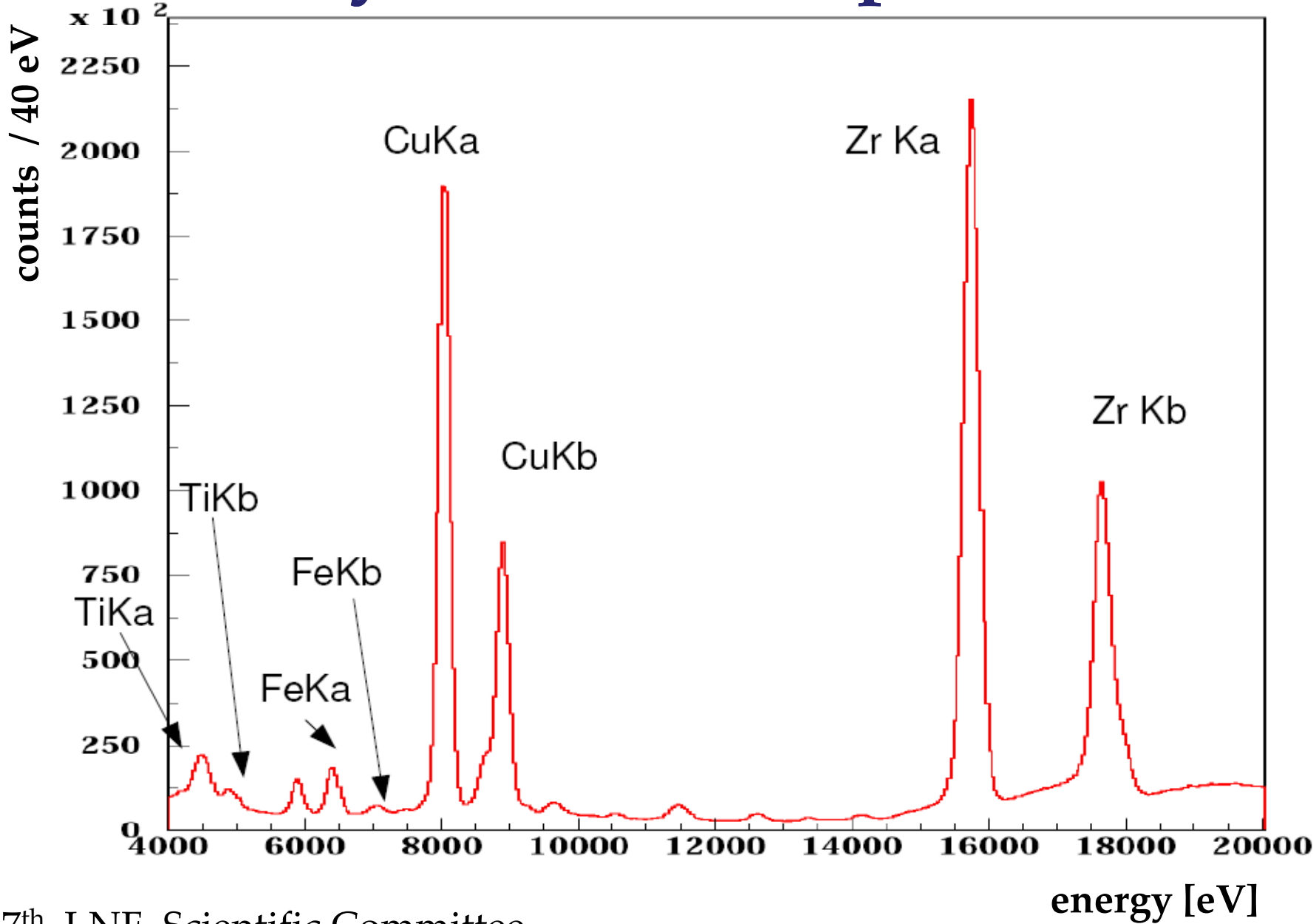

37th LNF Scientific Committee

X-ray calibration spectrum



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Kaonic helium

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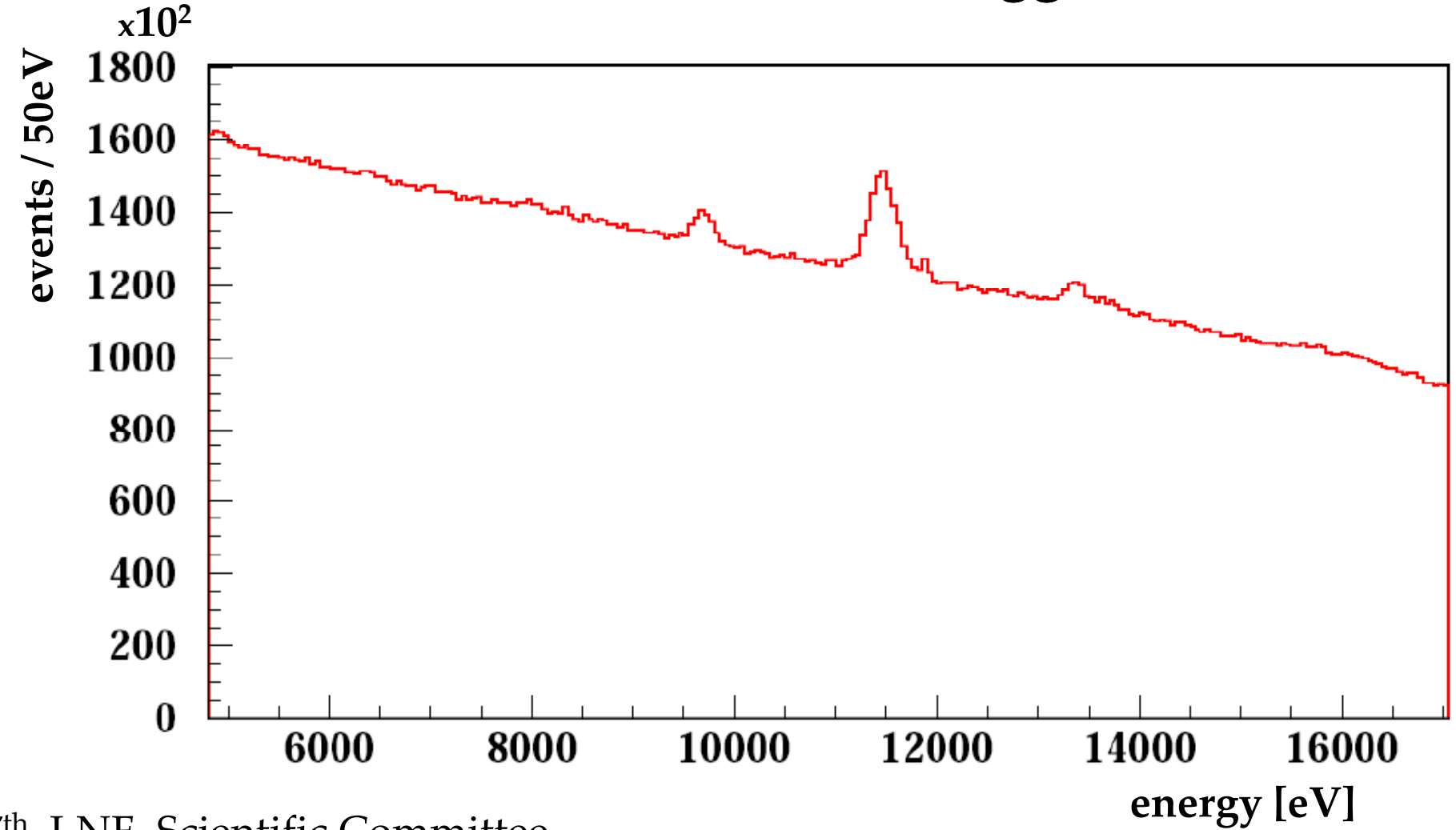
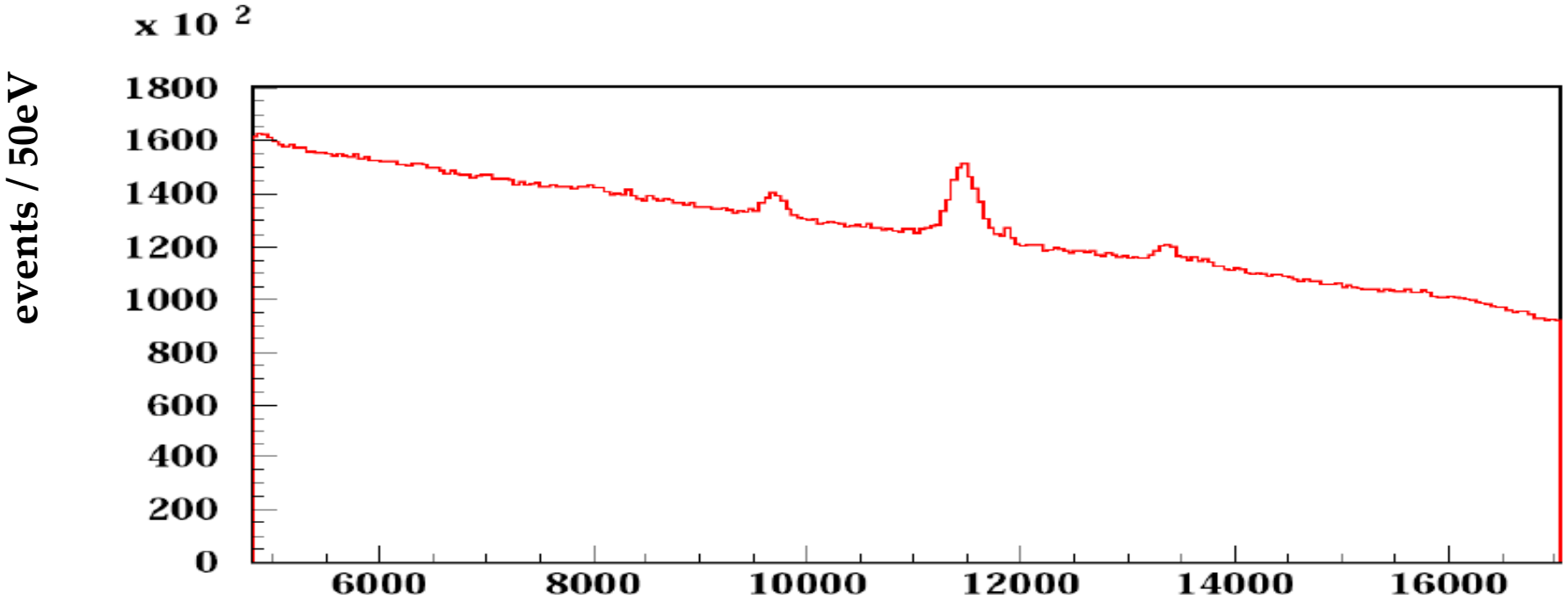
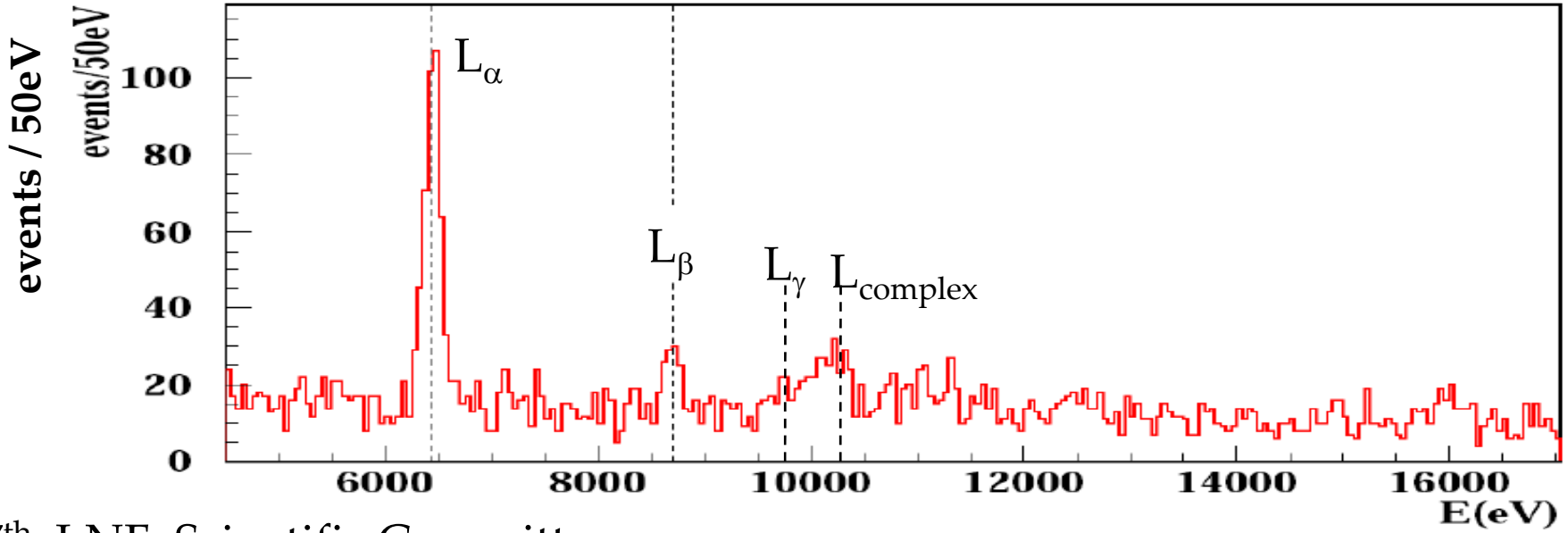
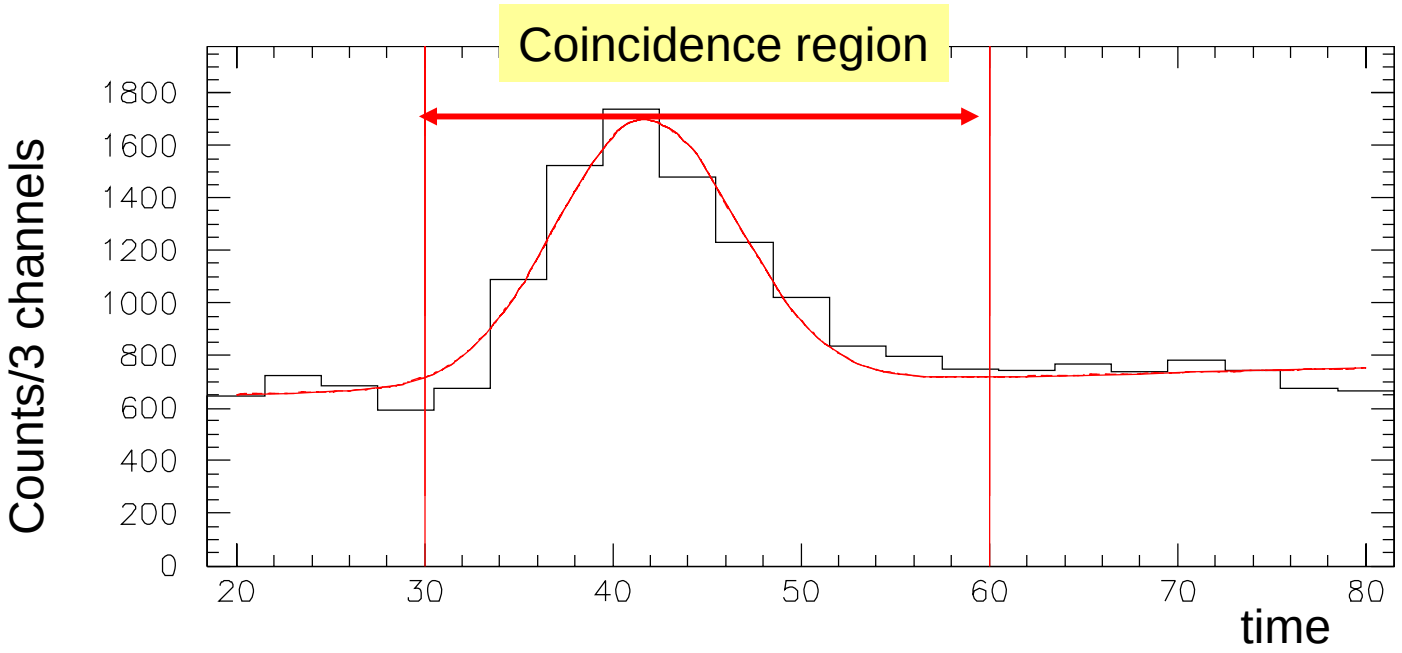
K^-He spectrum – I.L. ~ 15 pb^{-1}

background about 10 x K^-H DEAR
→ but, we have the "kaon-trigger" !!!



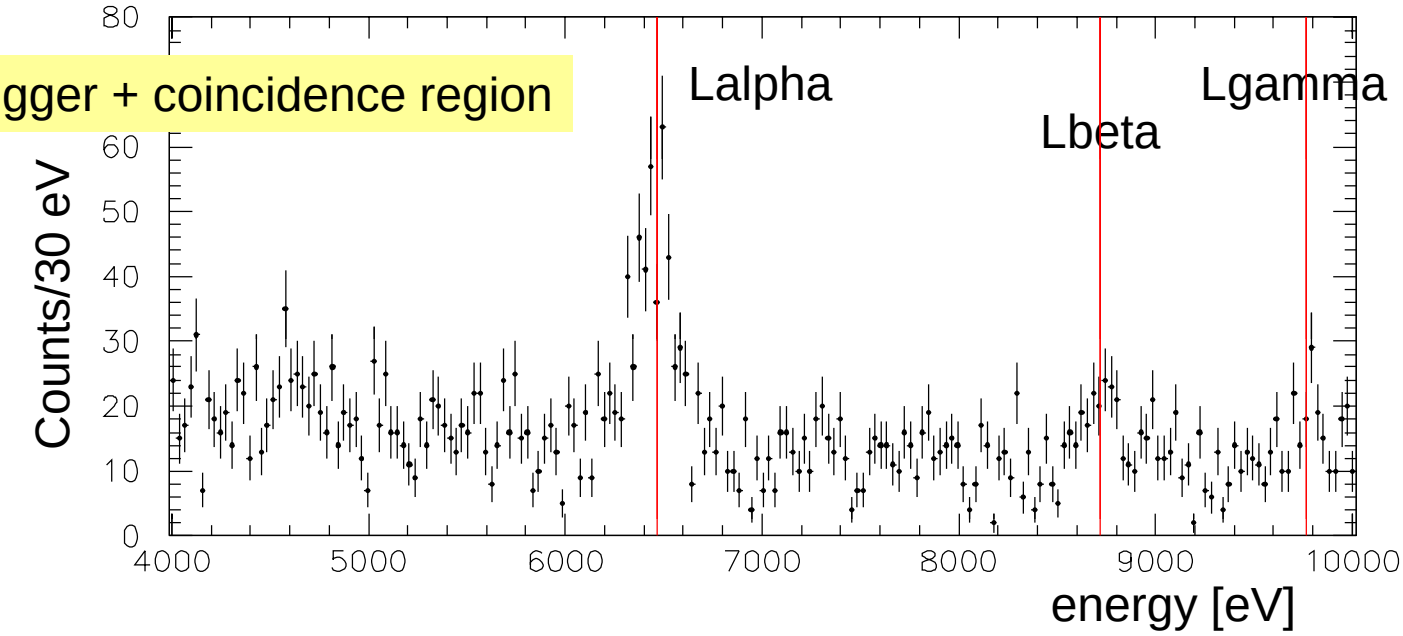

x 10 2
events / 50eV
1800
1600
1400
1200
1000
800
600
400
200
0
6000
8000
10000
12000
14000
16000

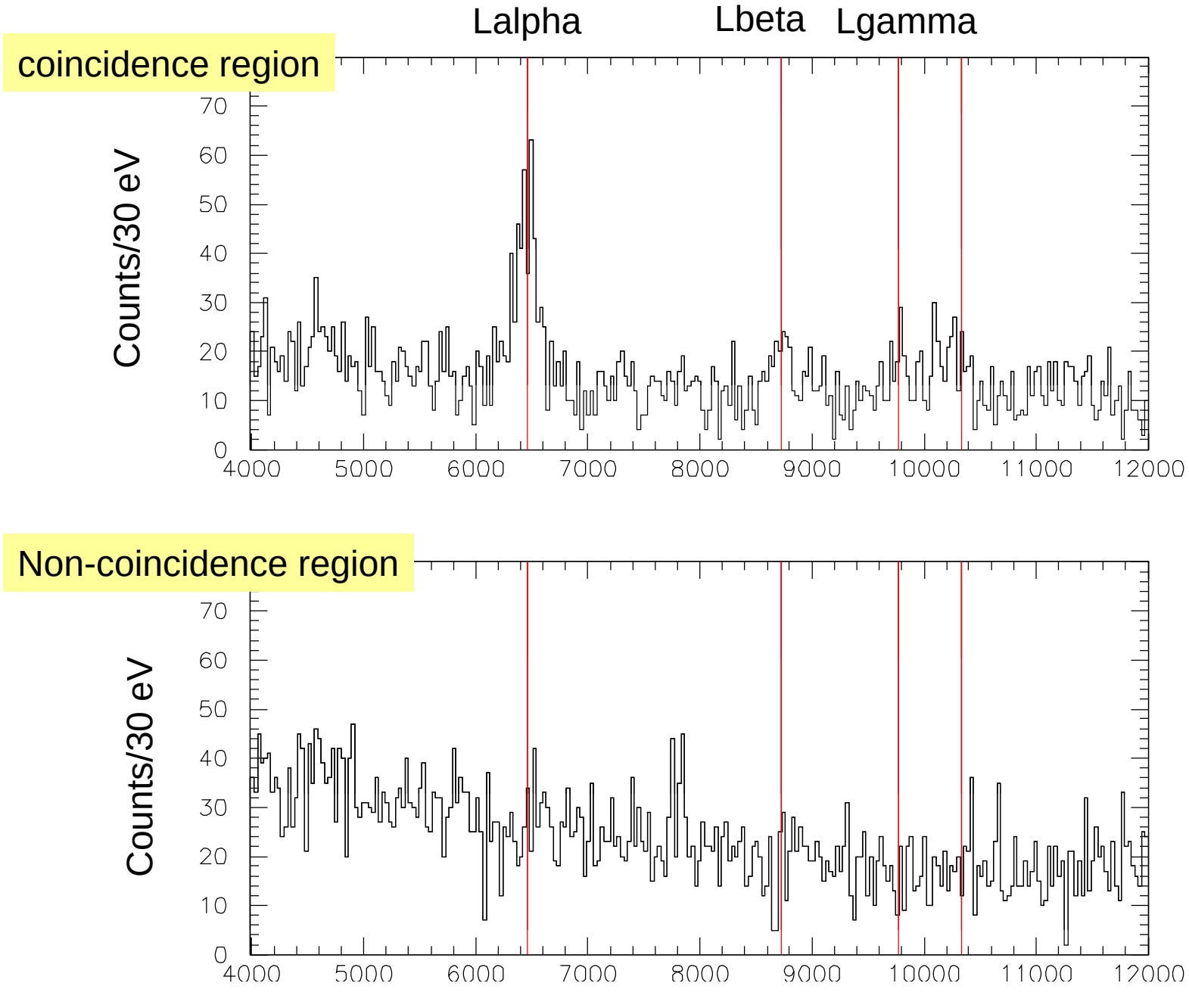

events / 50eV
events/50eV
100
80
60
40
20
0
L_α
L_β
L_γ
$L_{complex}$
6000
8000
10000
12000
14000
16000
E(eV)



Time difference

Kaon trigger + coincidence region




Lalpha
Lbeta
Lgamma
coincidence region
Counts/30 eV
0
10
20
30
40
50
60
70
4000
5000
6000
7000
8000
9000
10000
11000
12000
Non-coincidence region
Counts/30 eV
X-ray energy [eV]

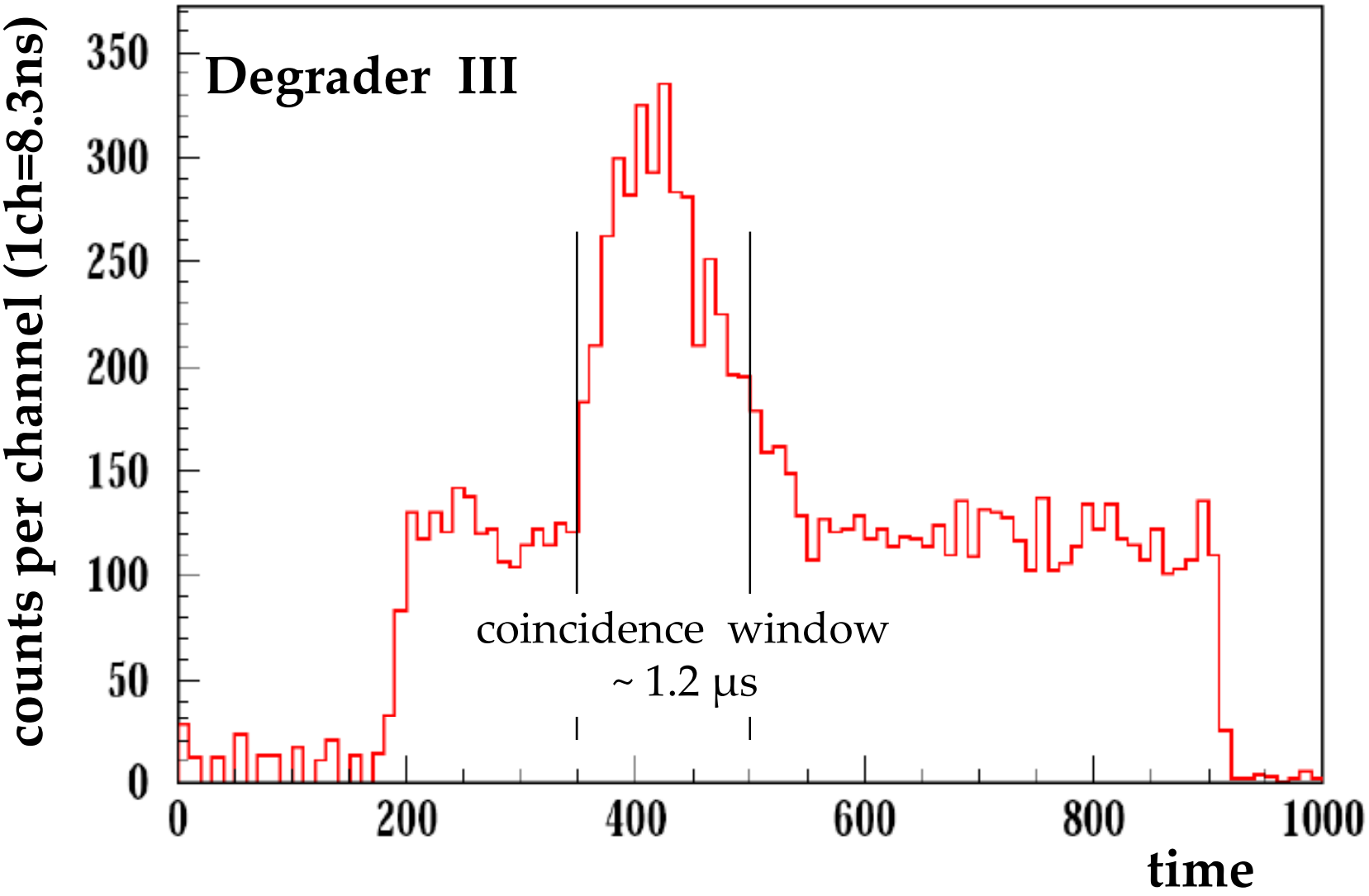
Degrader studies - optimization

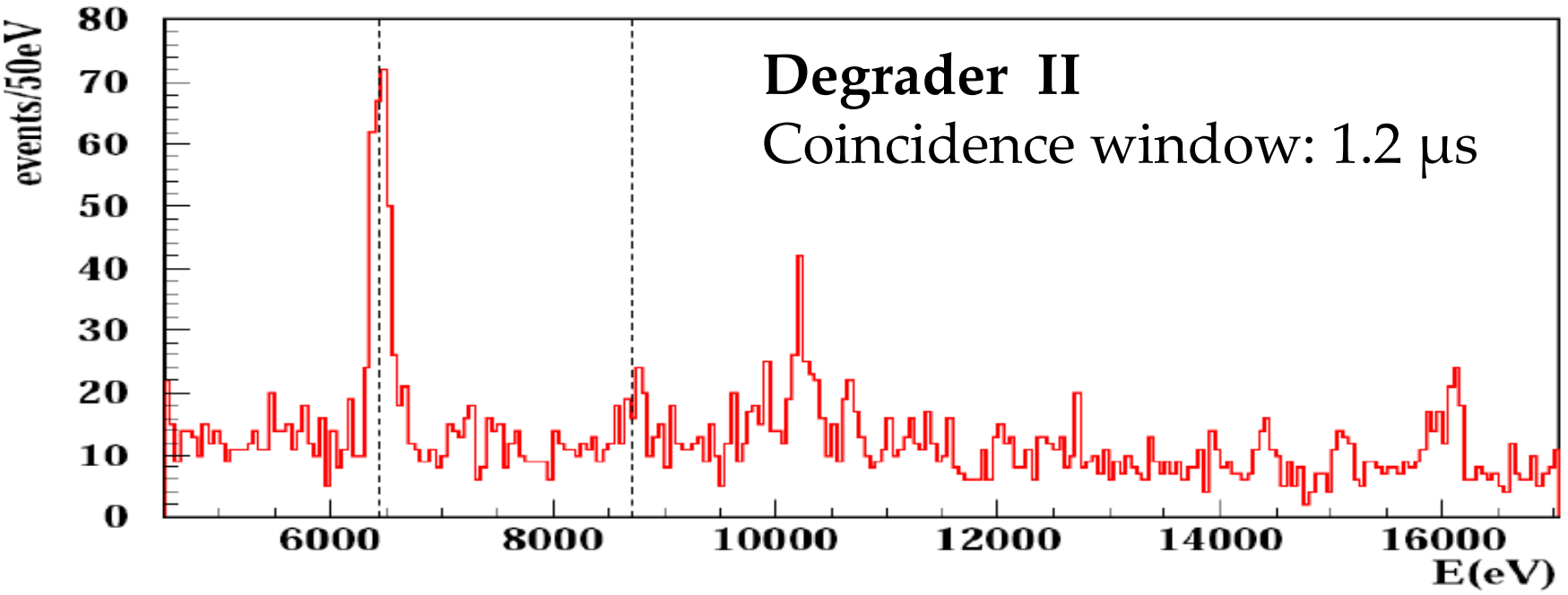
- **Measurements started on November 6, and 5 different degrader were used**

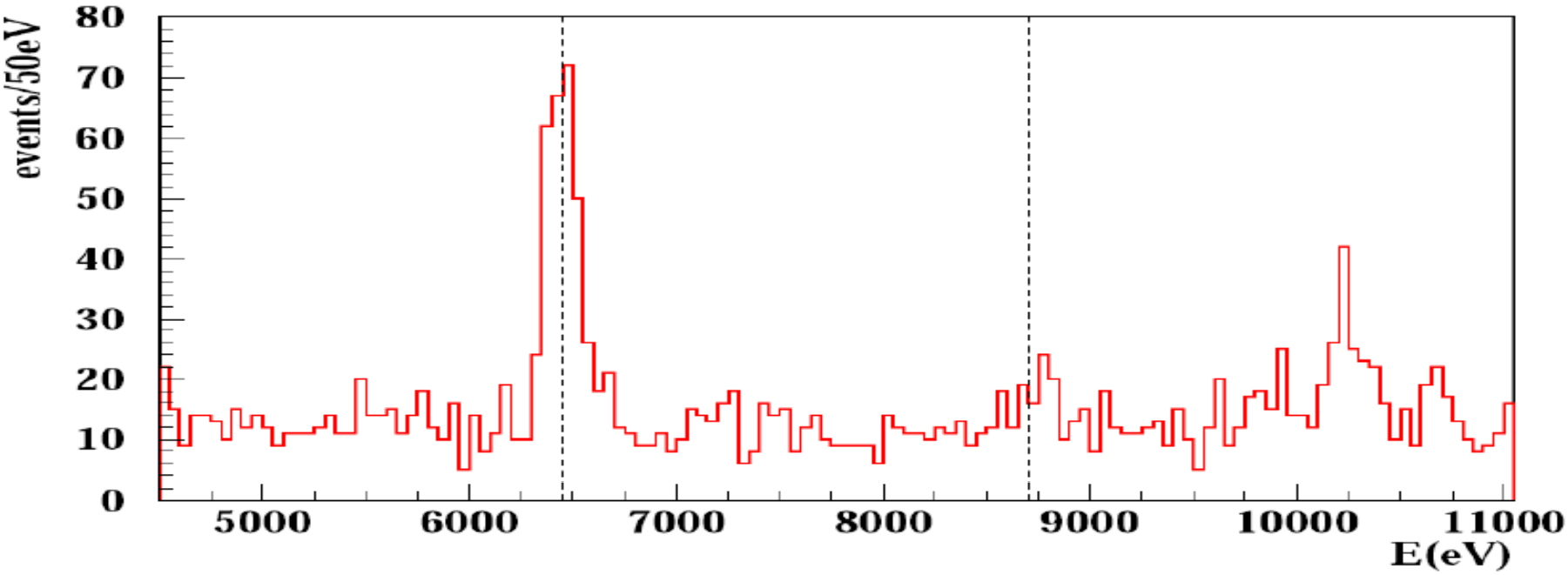
  - ✓ **optimal degrader thickness found**
  - ✓ **window of safe operations**
    (+/- 50 microns around optimal degrader, about 2% of total material budget)

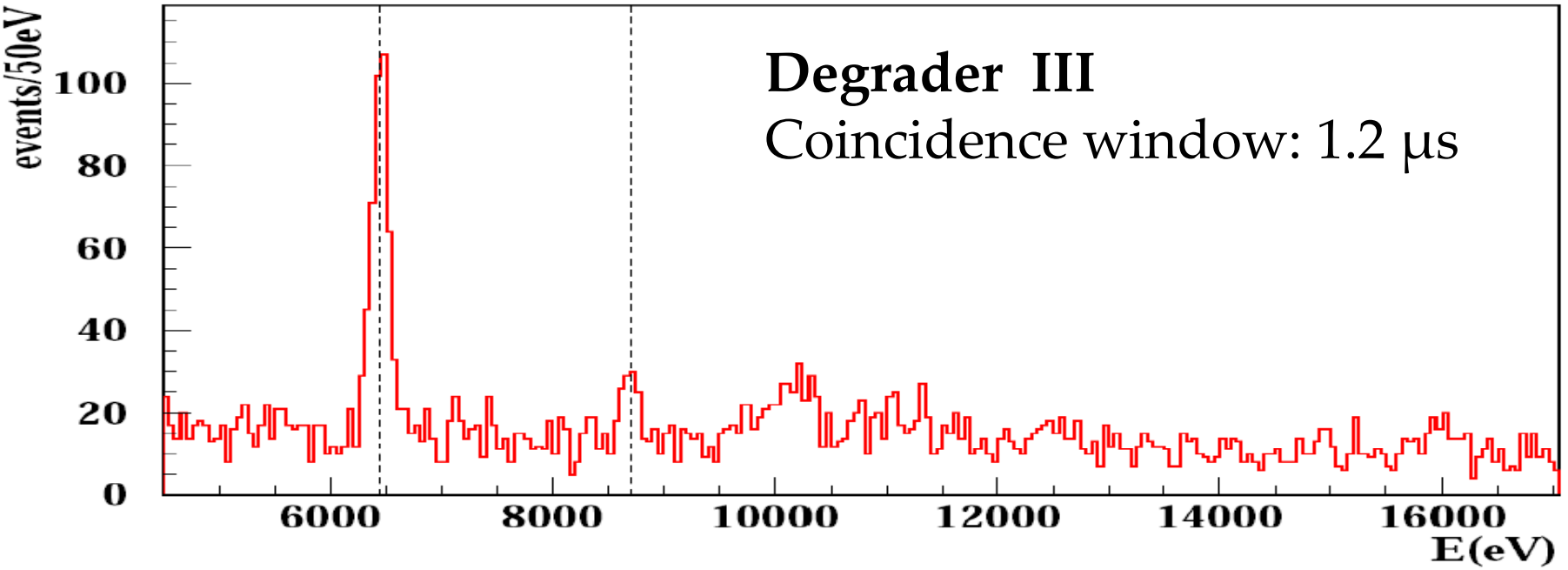
  - **350 microns less than optimal degrader**
    → K^-Al X-rays seen (solid targets?)

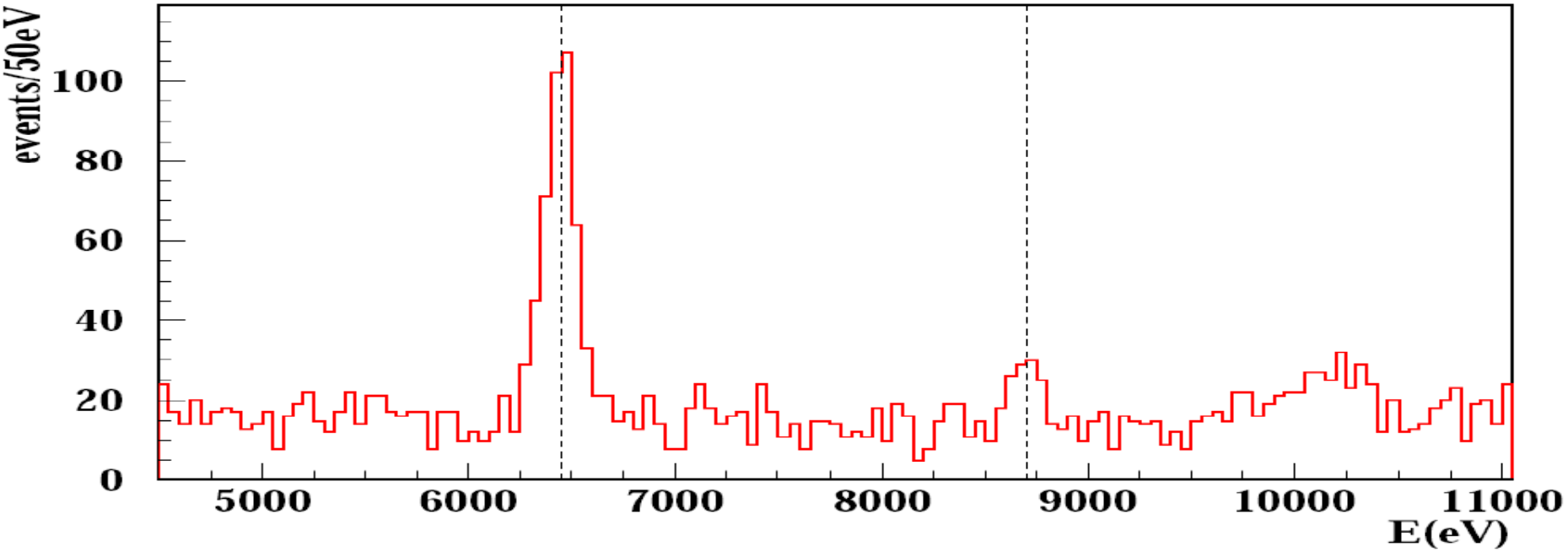
Time correlation kaon –X-ray signal

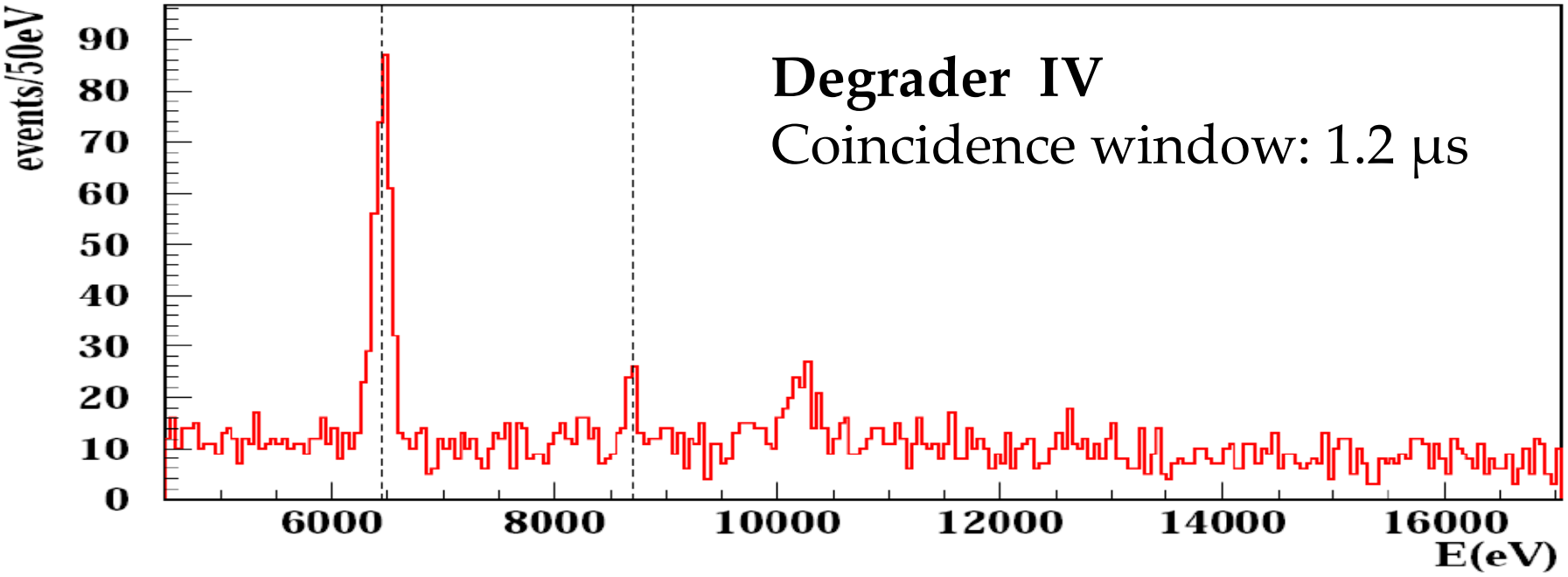


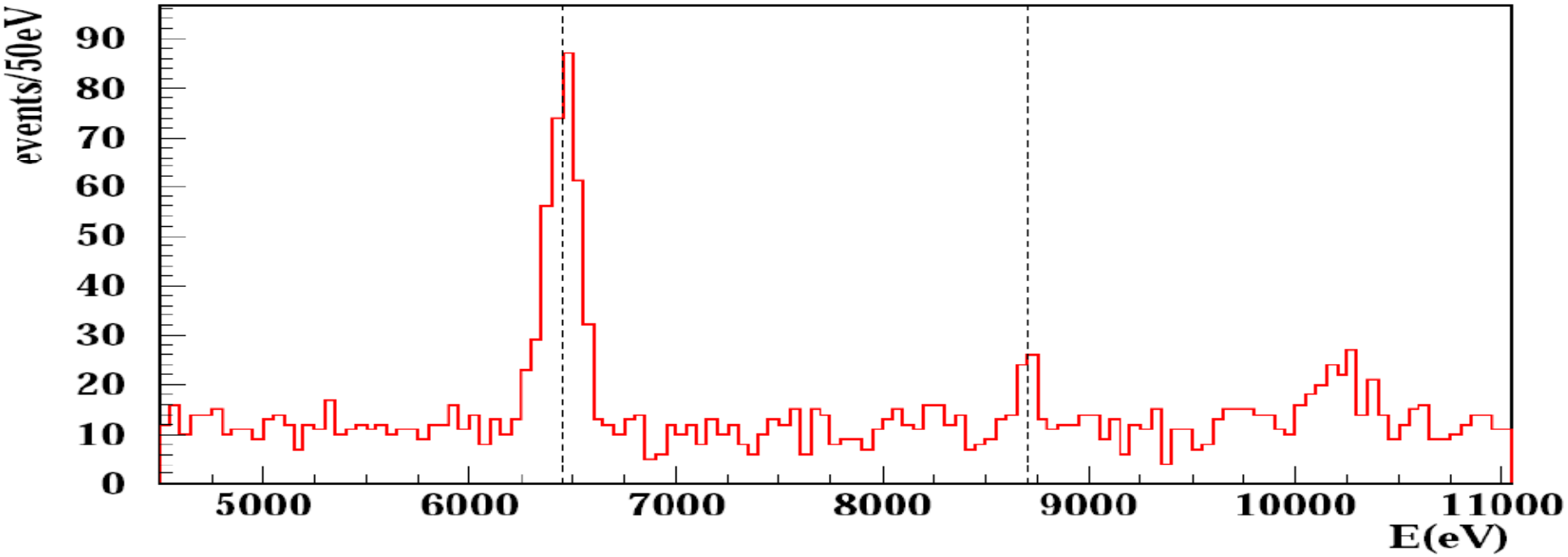

Degrader II
Coincidence window: 1.2 μs
events/50eV
E(eV)


events/50eV
E(eV)


Degrader III
Coincidence window: 1.2 μs
events/50eV
100
80
60
40
20
0
6000
8000
10000
12000
14000
16000
E(eV)

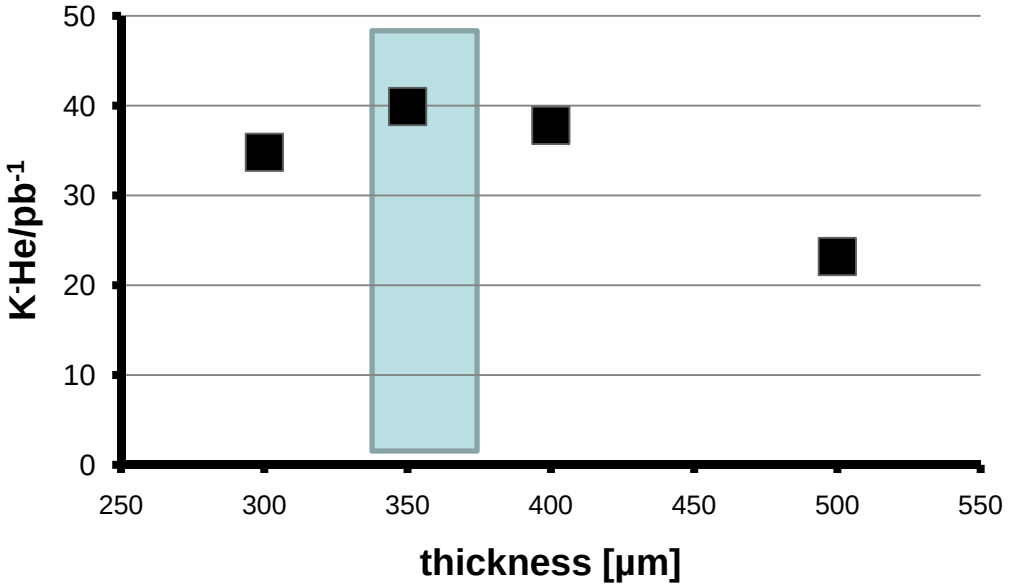

events/50eV
100
80
60
40
20
0
5000
6000
7000
8000
9000
10000
11000
E(eV)


Degrader IV
Coincidence window: 1.2 μs
events/50eV
E(eV)

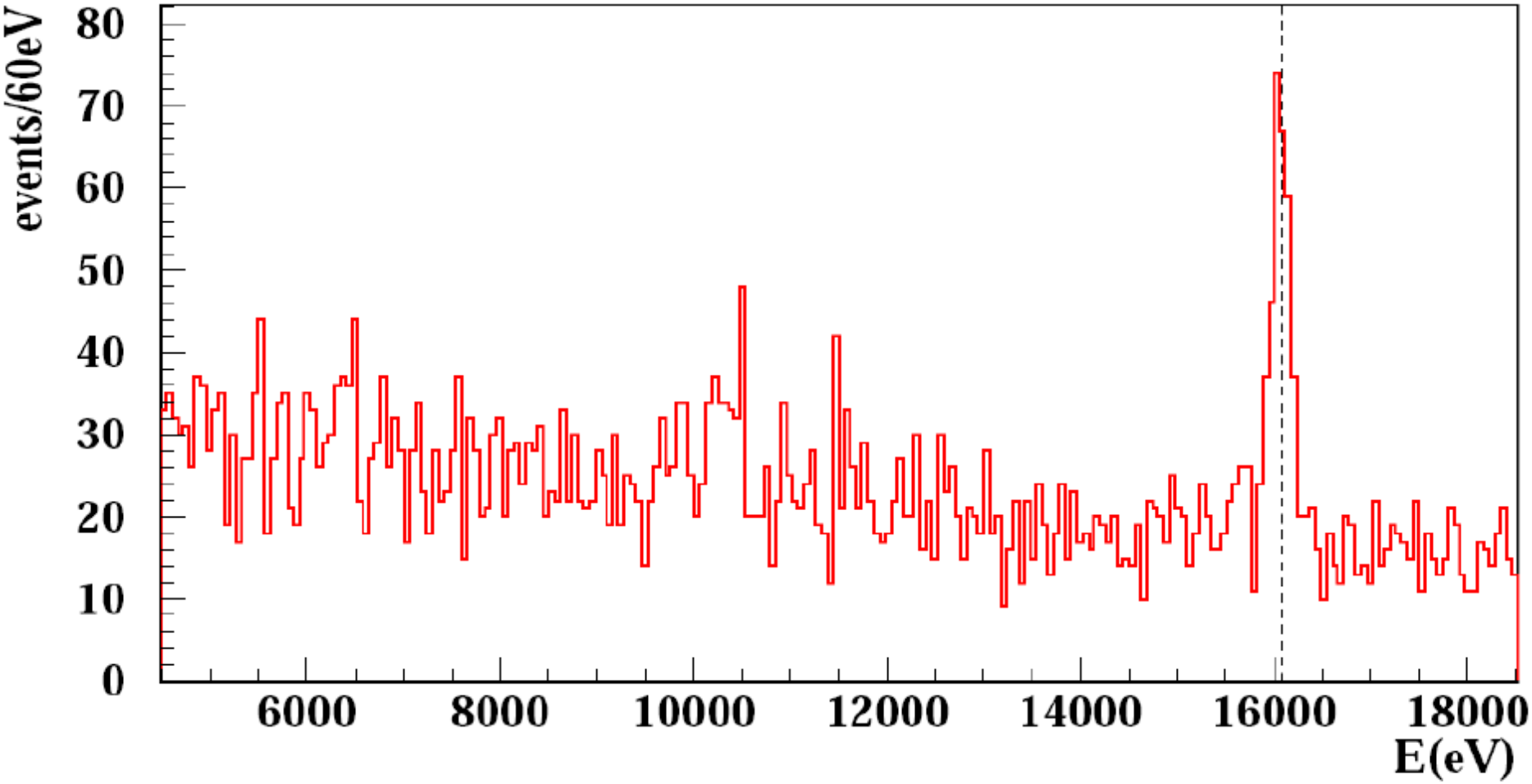

events/50eV
E(eV)

Degrader optimization

	$K^-He(L\alpha)$	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

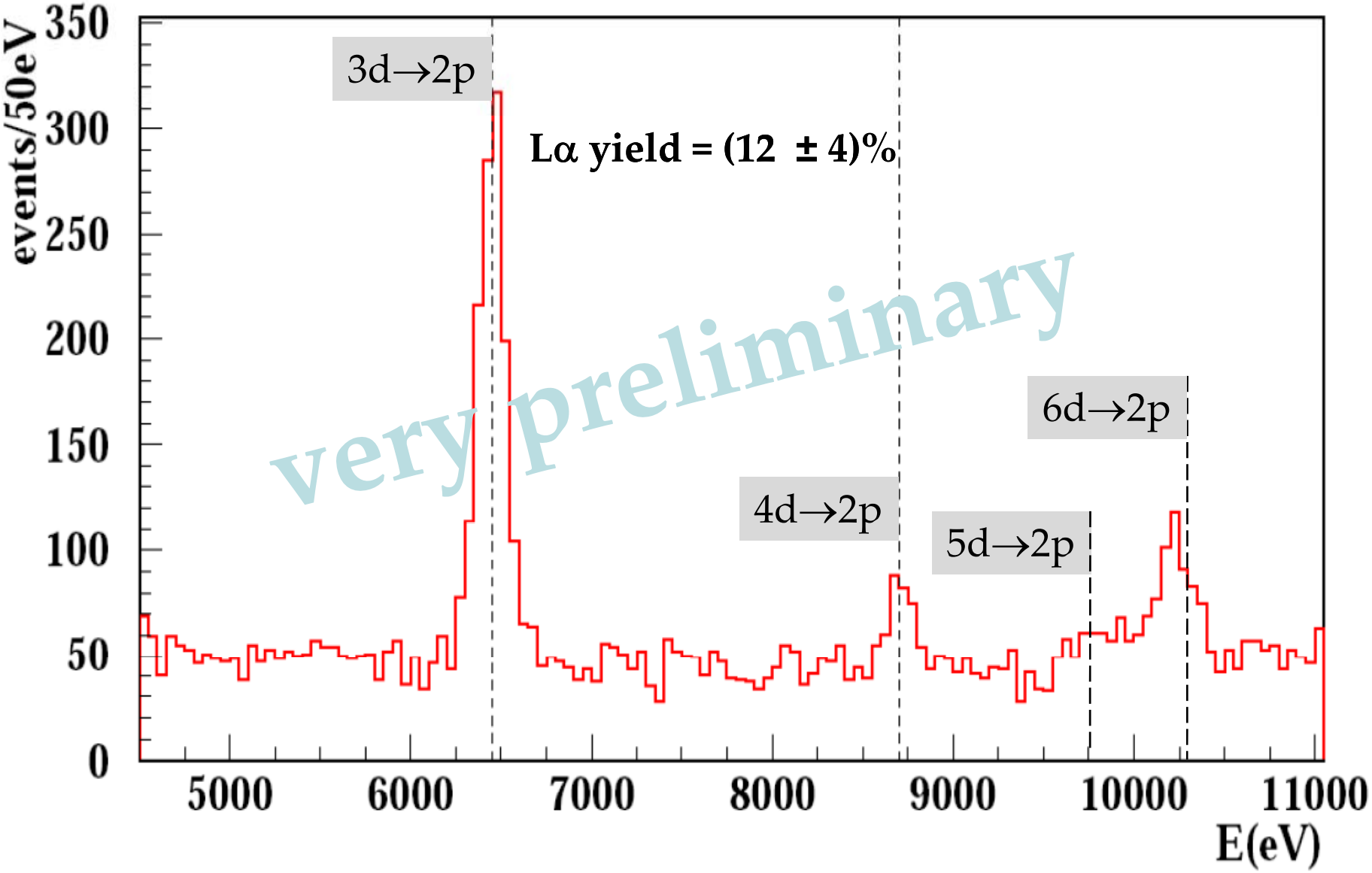


Best degrader -350μm: K^-Al
Coincidence window: 1.2 μs



Kaonic helium

SIDDHARTA K⁻He



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

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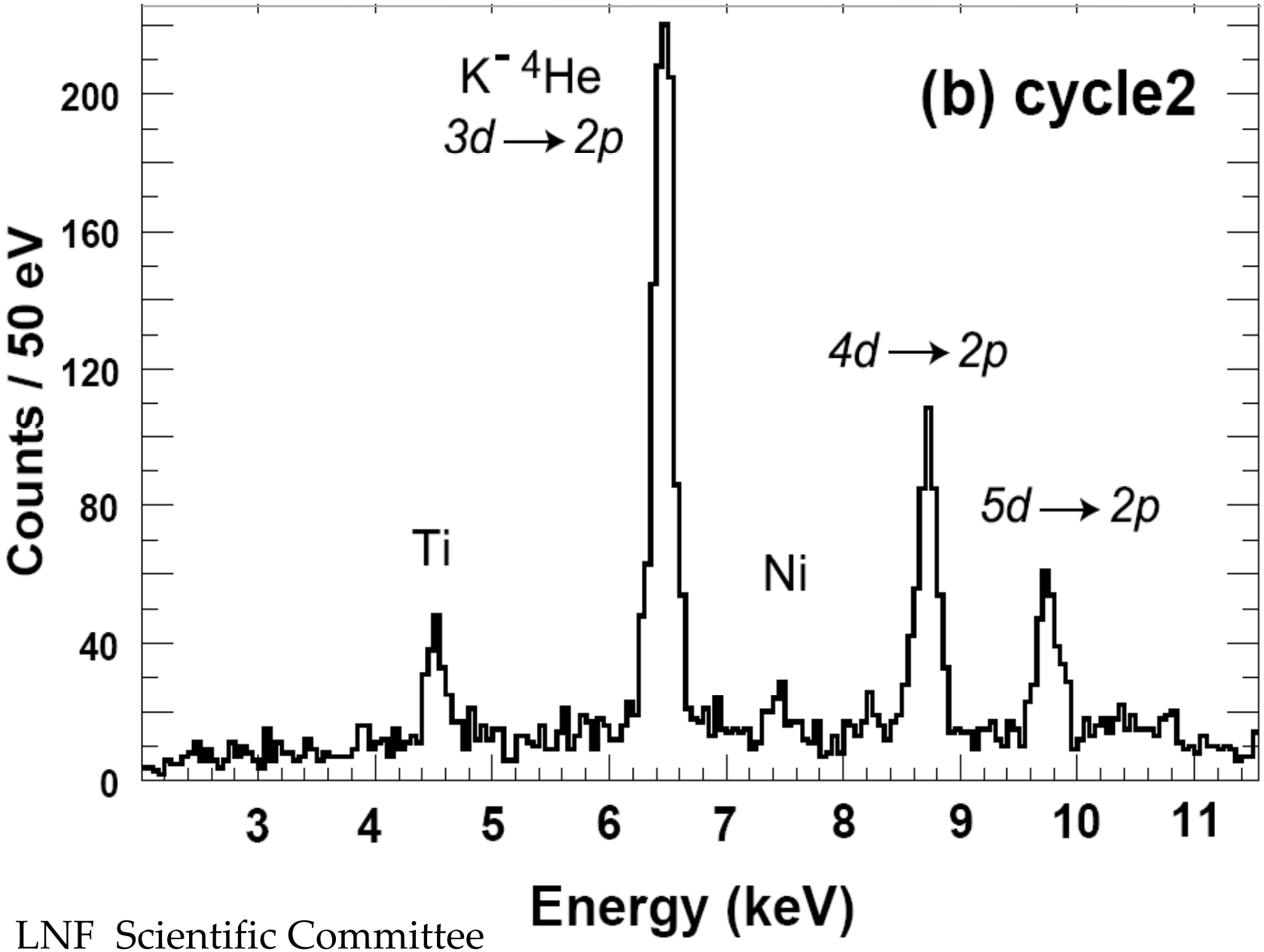
(Dated: February 10, 2008)

We have measured the Balmer-series x-rays of kaonic ^{4}He atoms using novel large-area silicon drift x-ray detectors to study the low-energy $\bar{K}$-nucleus strong interaction. The energy of the $3d \rightarrow 2p$ transition was determined to be 6467.0 ± 2.6 (stat) ± 2.2 (syst) eV. The strong-interaction shift of the $2p$-state was deduced as 2.4 ± 2.1 (stat) ± 2.2 (syst) eV from three transition energies, and the upper limit of the strong-interaction width was determined to be 18 eV with 95% confidence level. The measured shift and width are in agreement with optical-model calculations, thus eliminating a long-standing discrepancy between theory and experiment. The L_α x-ray yield per number of stopped kaons was estimated to be 7.1 ± 0.1 (stat) $^{+0.2}_{-0.5}$ (syst) %. The relative yields (L_β/L_α) and (L_γ/L_α) were $35.8 \pm 1.7 \pm 1.4$ % and $20.8 \pm 1.2 \pm 1.2$ % respectively.

KEK: E570 K^-He


K⁻ ⁴He
3d → 2p
(b) cycle2
4d → 2p
5d → 2p
Ti
Ni
Counts / 50 eV
Energy (keV)
0
40
80
120
160
200
3
4
5
6
7
8
9
10
11

TRIUMF Headline Story:
Awards & Honours: **The 2008 Nishina Memorial Prize**

Ryu Hayano
Member of SIDDHARTA collaboration
KEK: Kaonic Helium
CERN-AD: Antiprotonic Helium

SIDDHARTA programme

37th LNF Scientific Committee

K^-H S/B extrapolation using K^-He measurement

- **K_α yield of K^-H is a factor 10 - 20 less than the K^-He L_α yield and the K^-H width is a factor 1.5 bigger**

  $\Rightarrow$ S/B for K^-H will be 1/ 2.5

  1/5

S/B = 1/3 -> precision: 6 eV

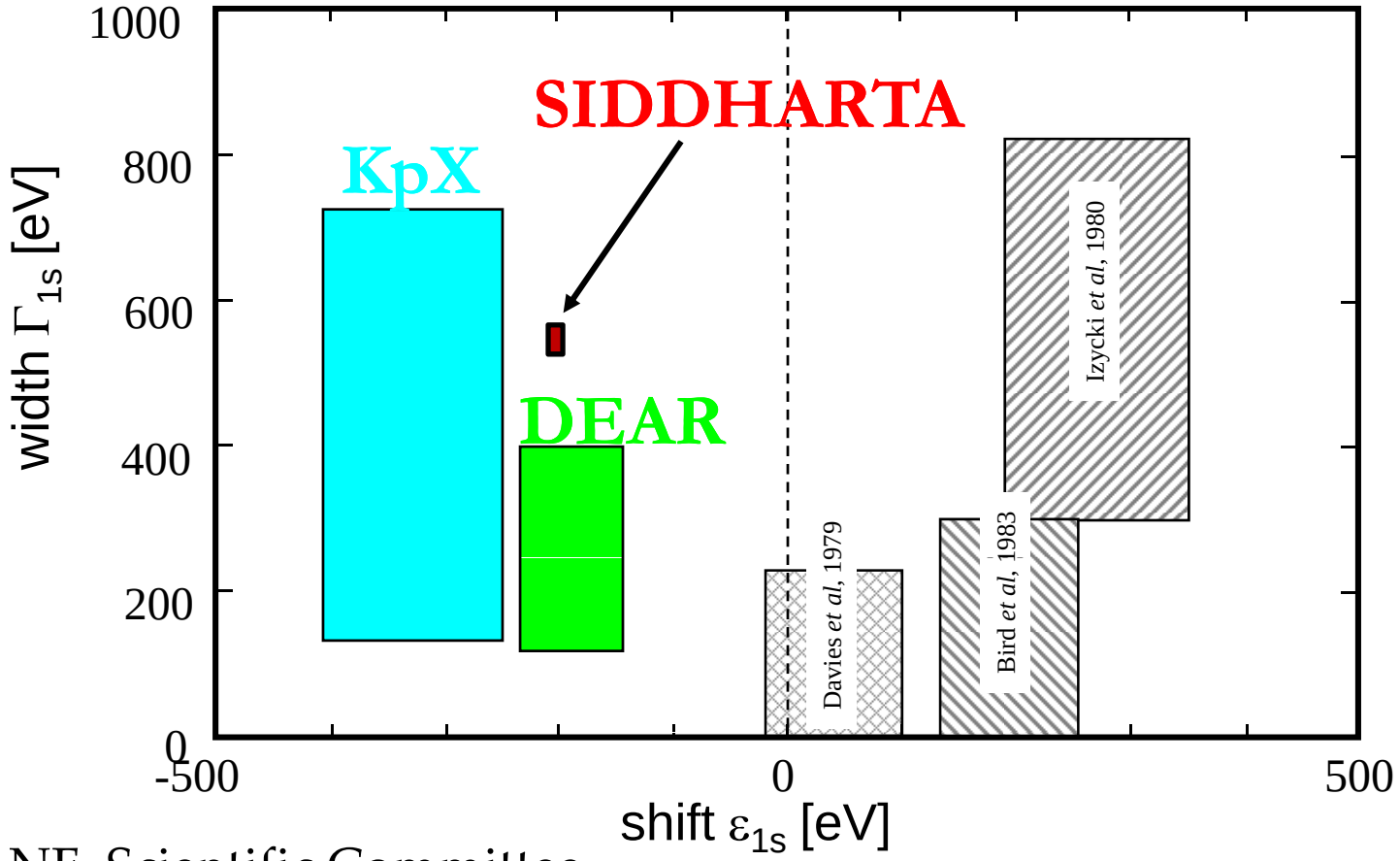
S/B = 1/5 -> precision: 8 eV

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



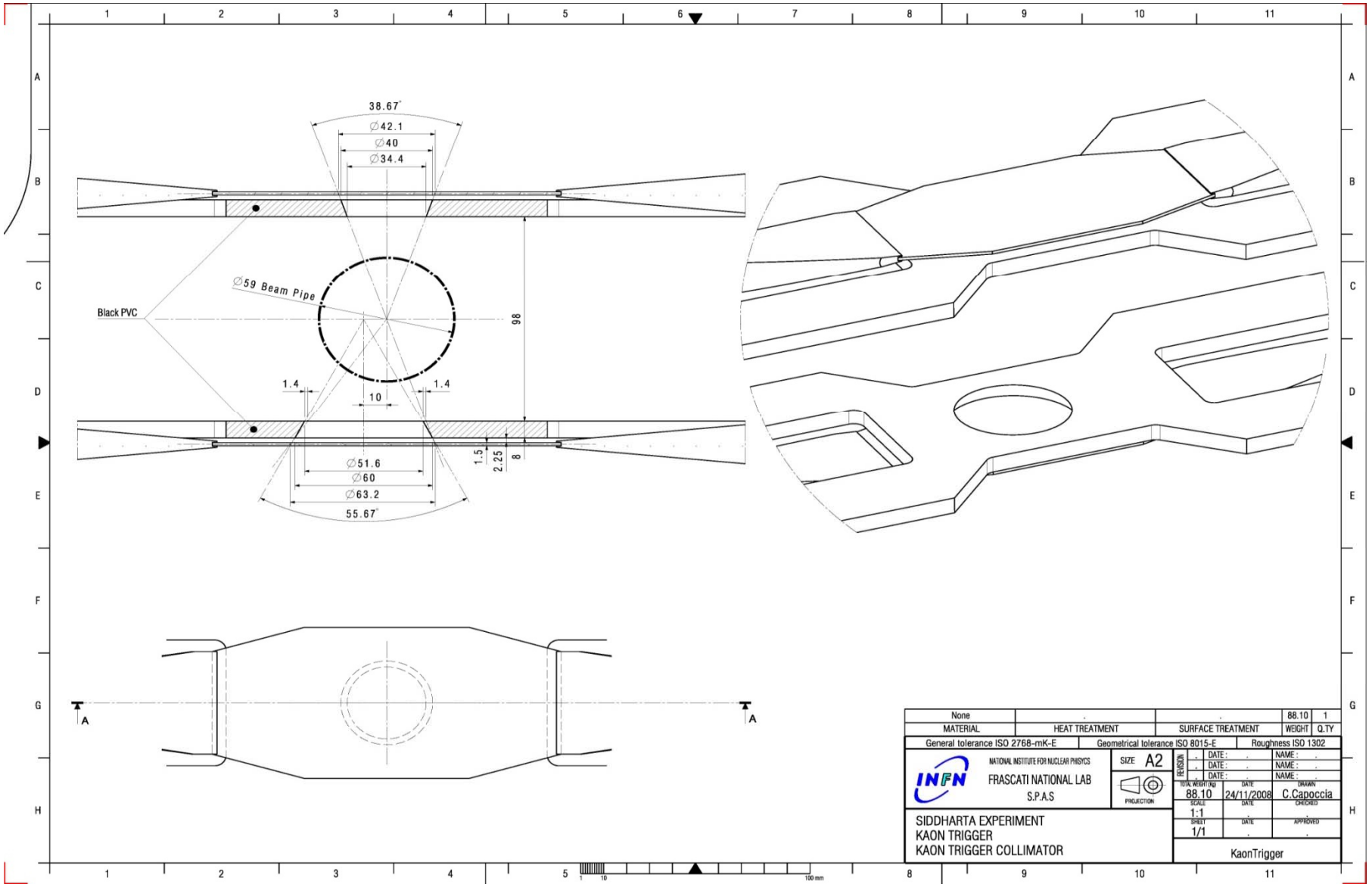
Plans for December 2008

- Measurement of K^-He until mid of December
  -> data for publication
  (yield and position of L-lines)

- Collimator test for kaon monitor: expected background reduction by a factor of ~2

$\Rightarrow$ a first test with hydrogen might be possible

Kaon detector collimator



Dedicated SIDDHARTA run 2009

- Stable, dedicated working conditions
- Better electron injection (background)
- Optimization of the duty-cycle → integrated luminosity

- Precision measurement of kaonic hydrogen **400 pb^{-1}**
  (with 10 pb^{-1}/day and 70 % duty-cycle: 60-80 days)
- Measurement of kaonic deuterium **600 pb^{-1}**
  (first measurement: might need new shielding)

Further options/experiments are under evaluation

We wish to express our

THANKS TO

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