Exotic atoms measurements at DAΦNE

LNF SPRING SCHOOL
"Bruno Touschek"
In Nuclear, Subnuclear and Astroparticle Physics

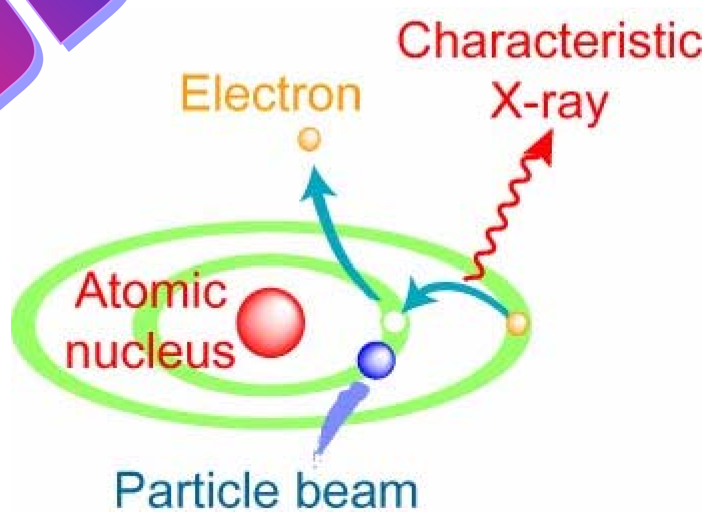
Frascati (Italy)
May 15th – 19th, 2006

Florin Sirghi on behalf of DEAR/SIDDHARTA Collaboration

DAΦNE Exotic Atom Research

DEAR

SIDDHARTA



Silicon
Drift
Detector for
Hadronic
Atom
Research by
Timing
Applications

DEAR/SIDDHARTA Collaboration

LNF- INFN, Frascati, Italy

Politecnico, Milano, Italy

Stefan Meyer Institut, Vienna, Austria

IFIN–HH, Bucharest, Romania

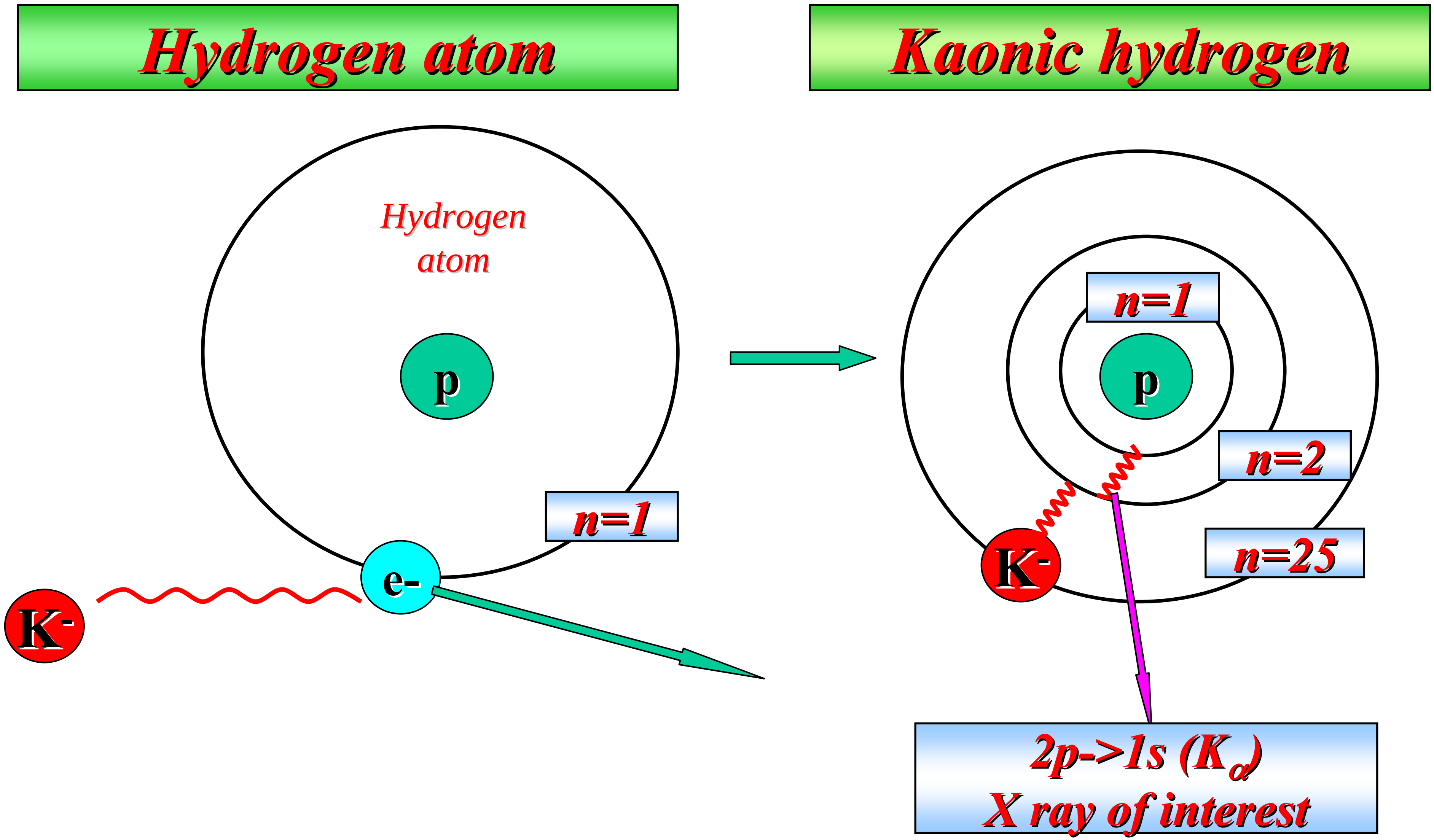
RIKEN, Japan

Victoria University, Canada

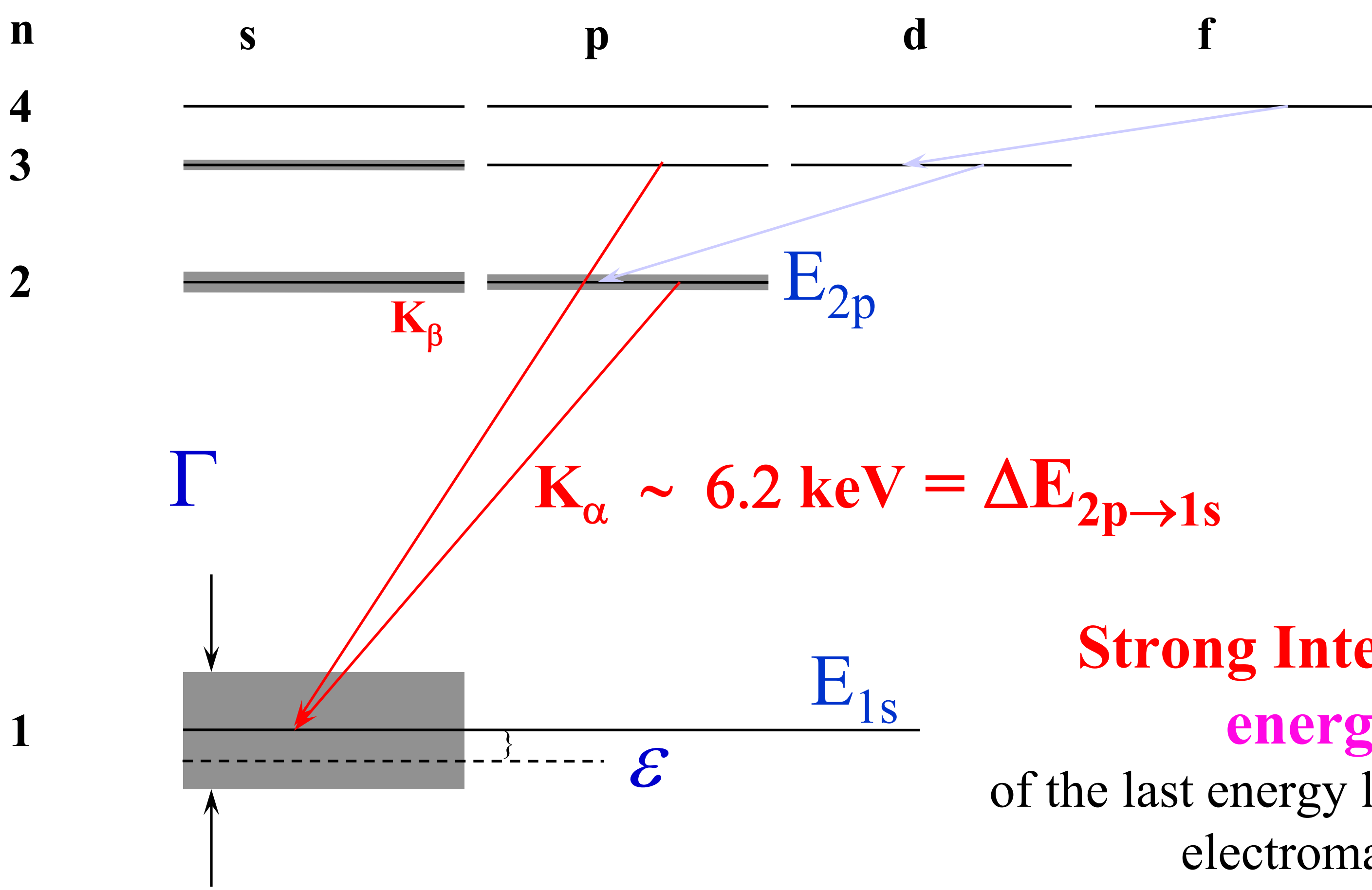
PNSensor GmbH, Munich, Germany

Max-Planck-Institute for Extraterrestrial Physics, Garching, Germany

Exotic Atom


Hydrogen atom
Kaonic hydrogen
Hydrogen
atom
p
n=1
e-
K-
n=1
p
n=2
K-
n=25
2p->1s (Kα)
X ray of interest

Kaonic cascade and the strong interaction



ε = E2p-1s(meas.) – E2p-1s(e.m.)

Strong Interaction causes:

energy shift ε

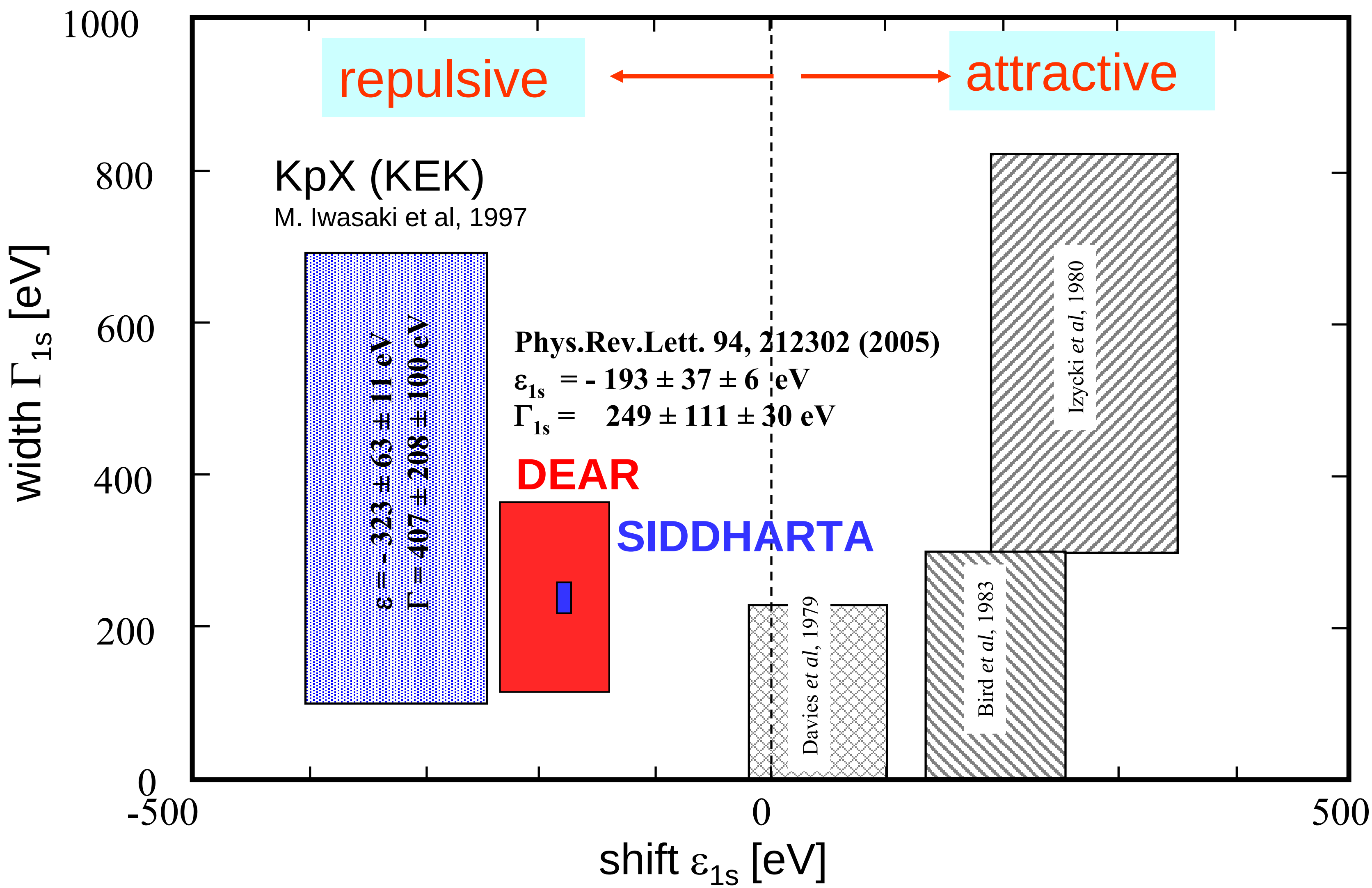
of the last energy levels form their purely electromagnetic values

AND

level width Γ

finite lifetime of the state corresponding to an increase in the observed level width

DEAR Results on Kaonic Hydrogen



A strong motivation for the community working on the low-energy kaon-nucleon interactions

DEAR/SIDDHARTA Scientific Programme

The result obtained by DEAR :

represents indeed the best measurement performed on Kaonic Hydrogen up to now

BUT

what we are aiming for is

- **few eV precision measurement of *kaonic hydrogen* 1s level shift**
- **first measurement of *kaonic deuterium***

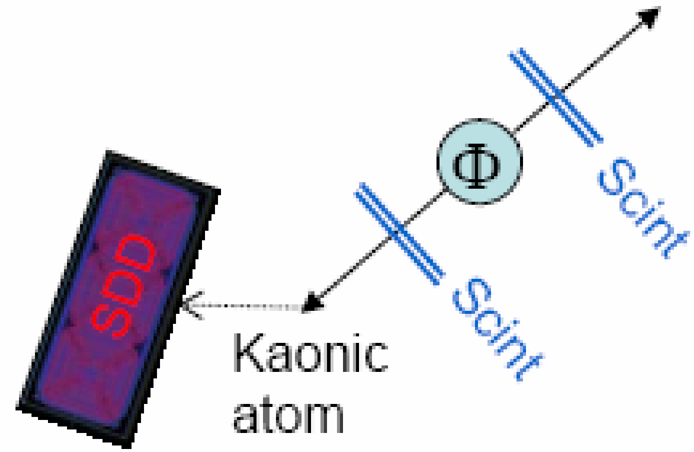
in order to determine the isospin dependent KN scattering lengths at percent level precision

The choice of the detector

- A good X-ray detector, which preserves

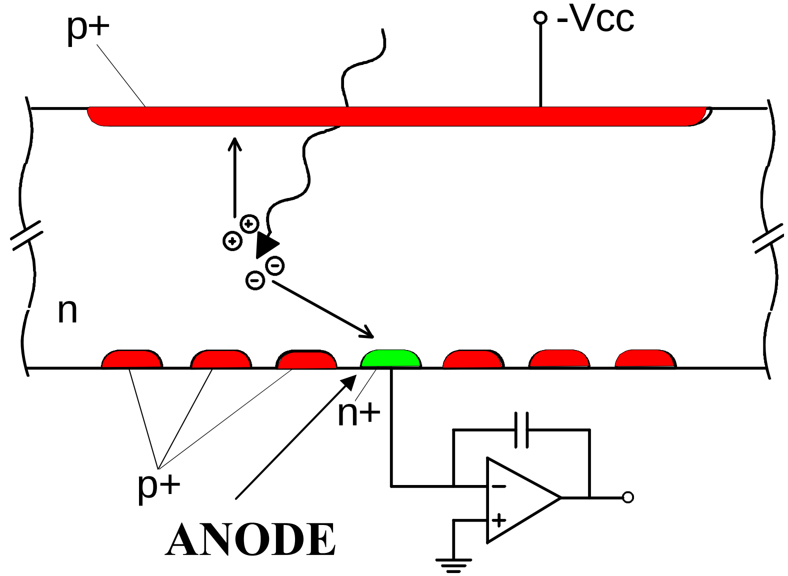
  all good features of the CCD (no timing)

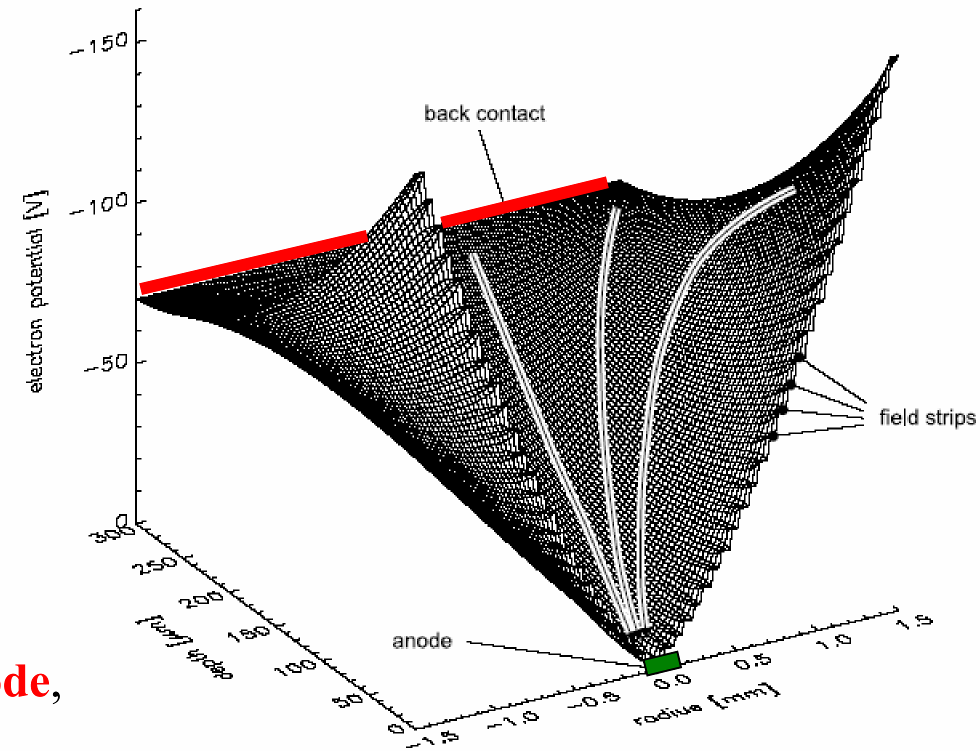
  ✓ large active area
  ✓ quantum efficiency
  ✓ energy resolution
  ✓ linearity and stability
  ✓ performance in accelerator environment



- Trigger capability (fast shaping times – 1μs) for background rejection by using the kaon - X ray time correlation

Principle of the Semiconductor Drift Detector

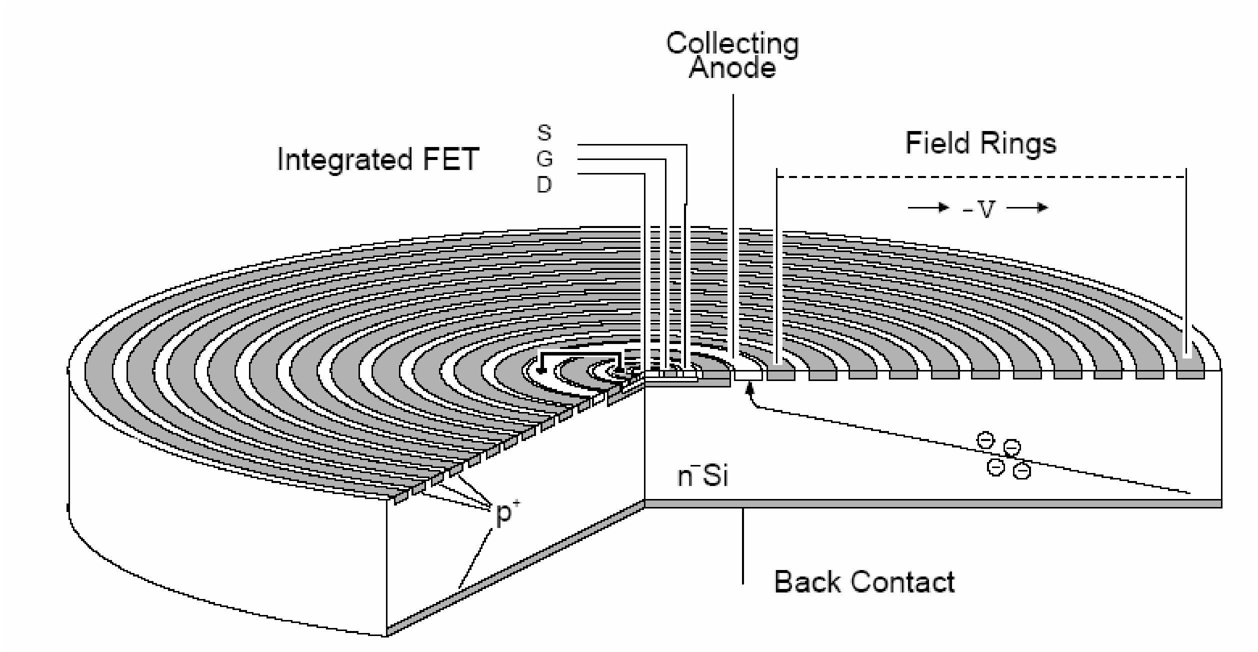


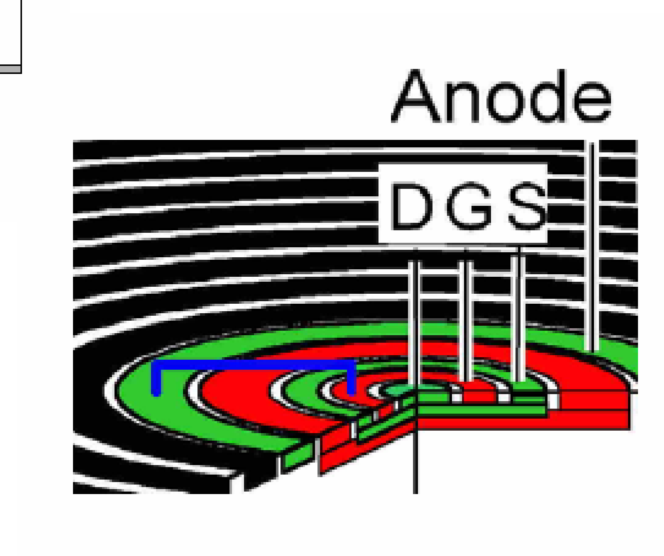


The electrons are collected by the **small anode**, characterized by a low output capacitance.

Advantages: **very high energy resolution at fast shaping times**, due to the small anode capacitance, independent of the active area of the detector

The Silicon Drift Detector with on-chip JFET

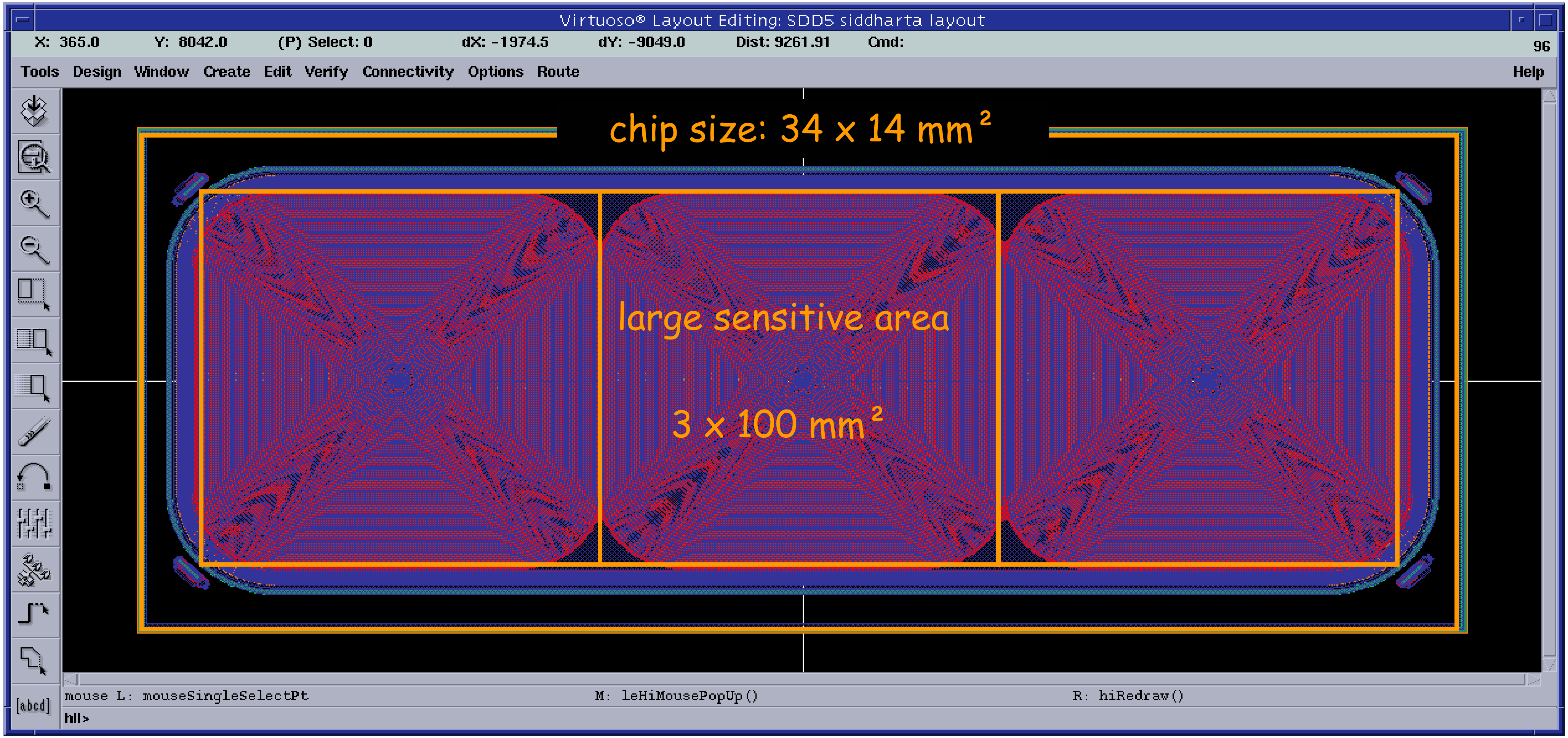




JFET integrated on the detector

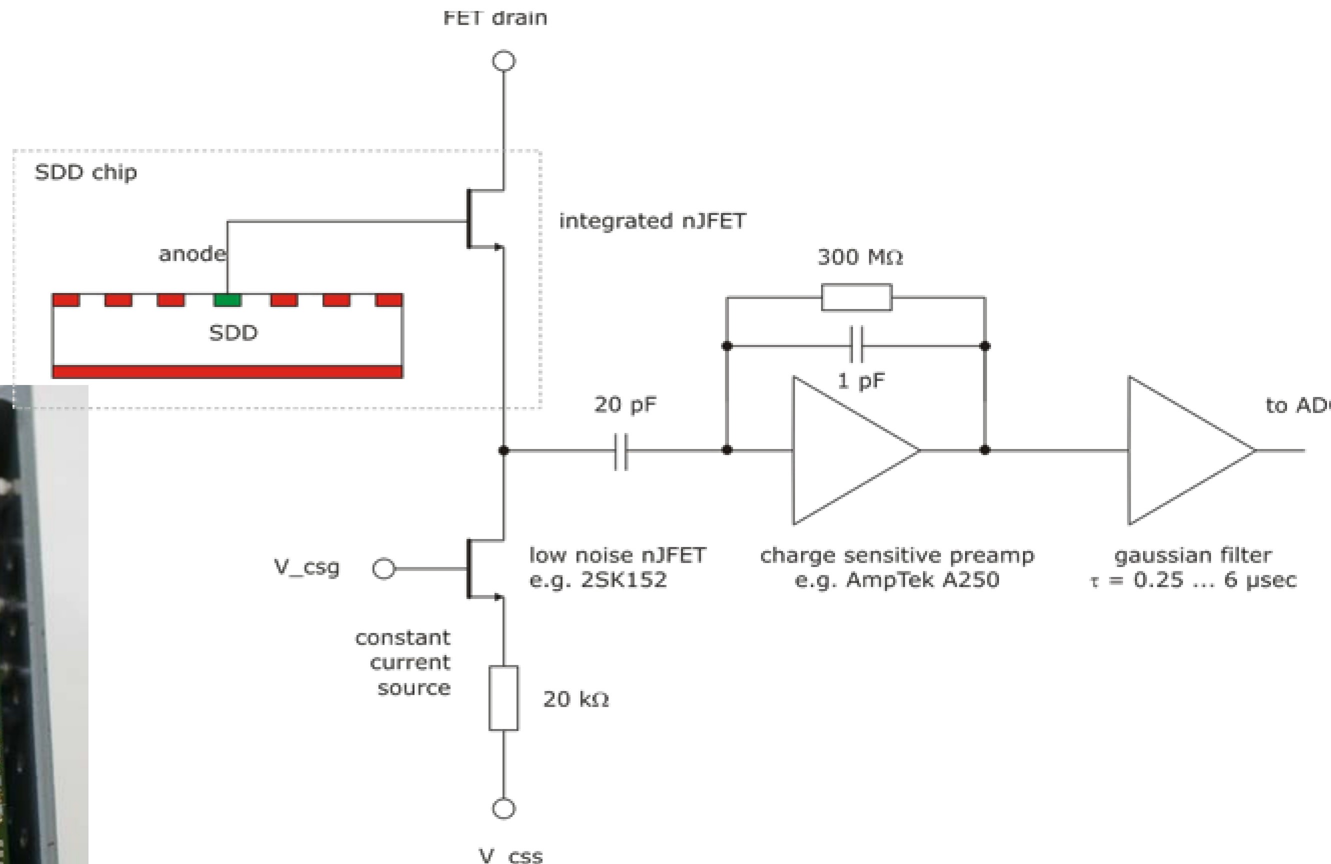
- capacitive **'matching'**: $C_{gate} = C_{detector}$
- minimization of the **parasitic capacitances**
- reduction of the **microphonic noise**
- **simple solution** for the connection detector-electronics in monolithic **arrays of several units**

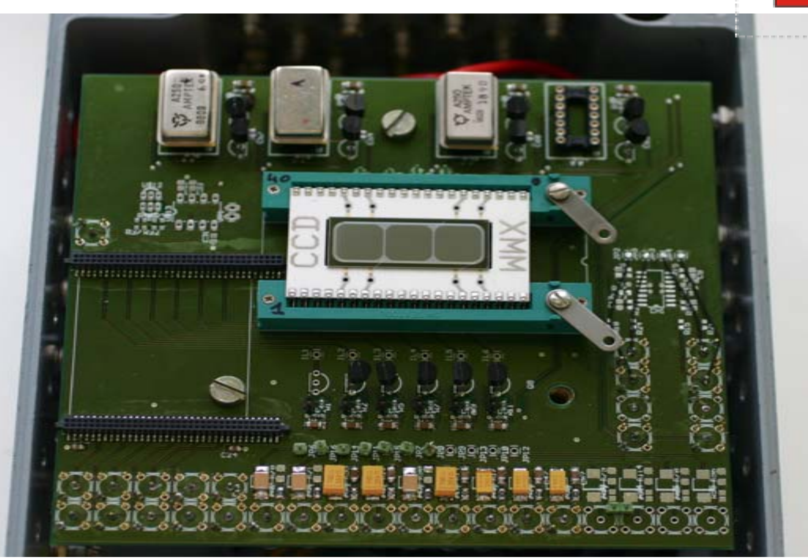
Special chip design for SIDDHARTA



Spectroscopy test

- setup
  - standard source follower configuration
  - integrated FET in continuous reset mode

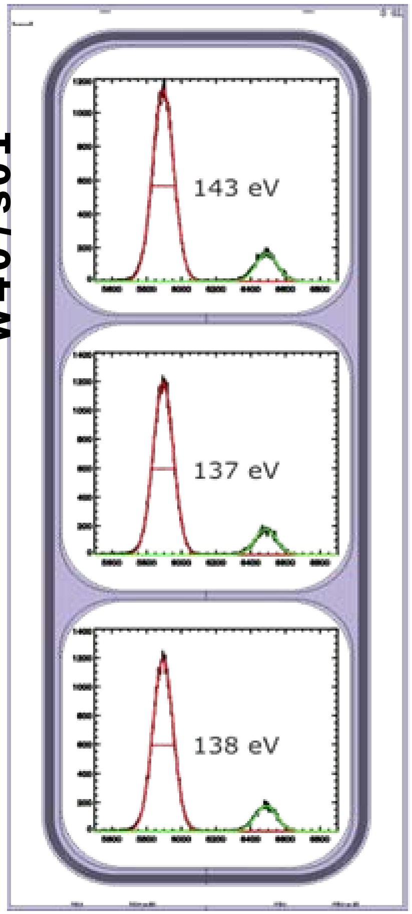




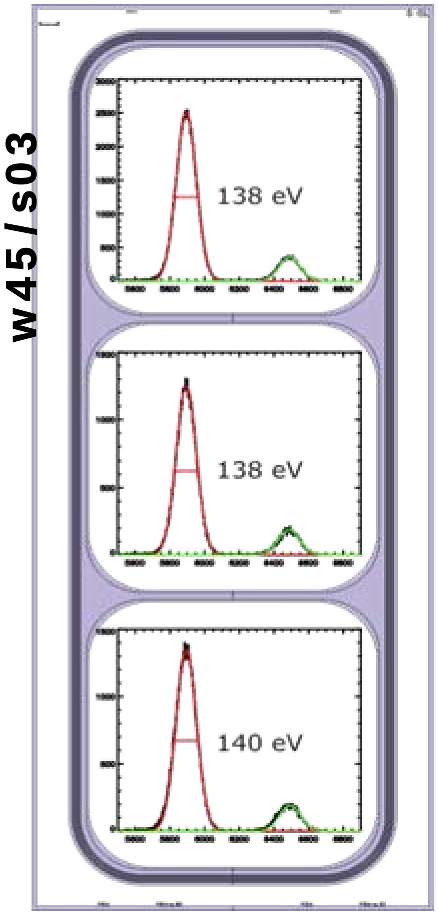
Spectroscopy test

- T = -60 °C, τ = 1 μsec

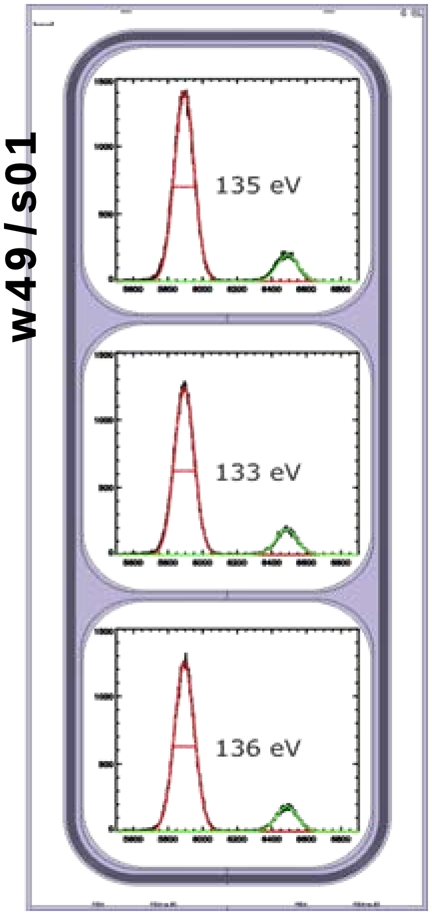
w40 / s01



w45 / s03

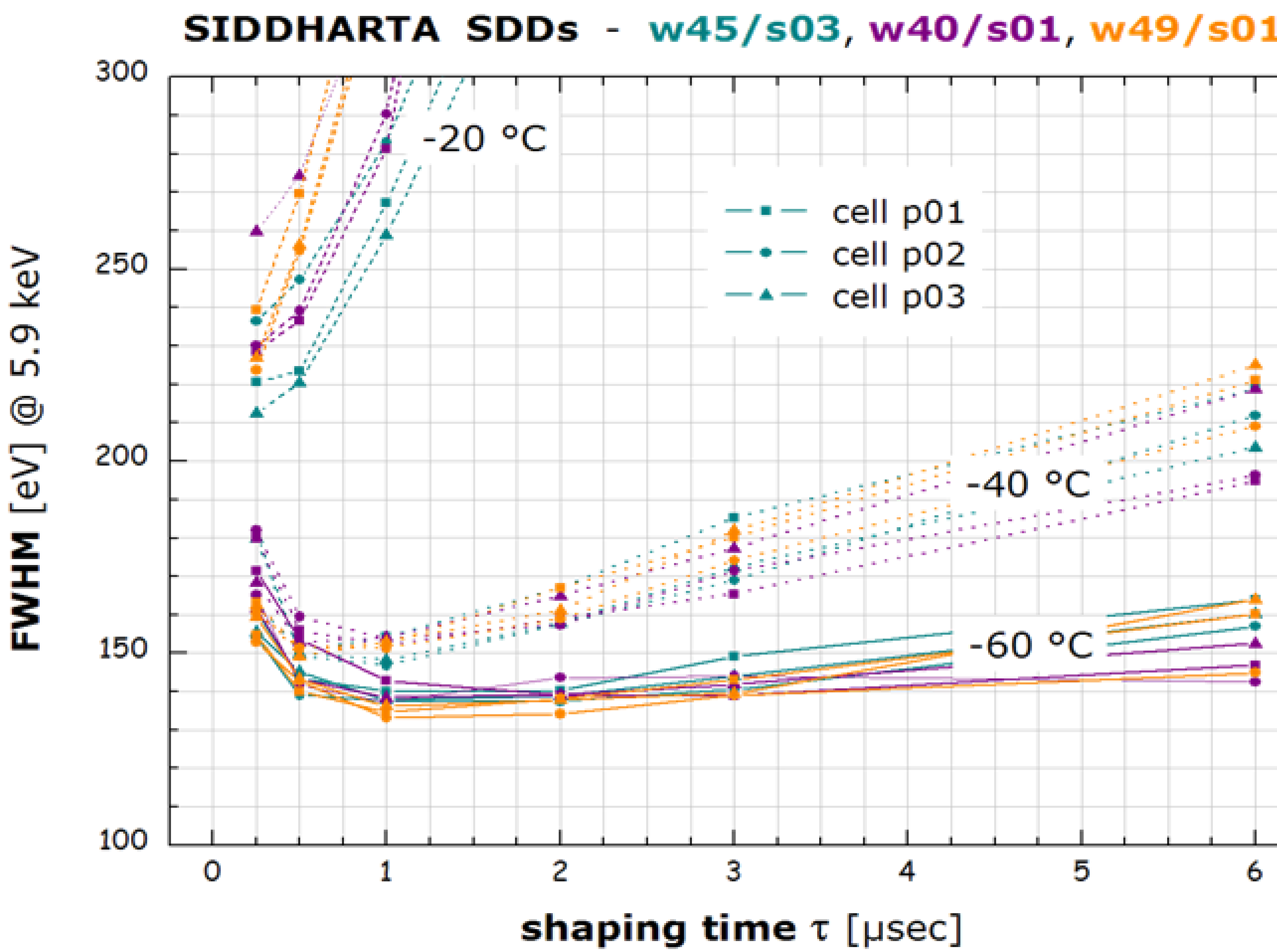


w49 / s01

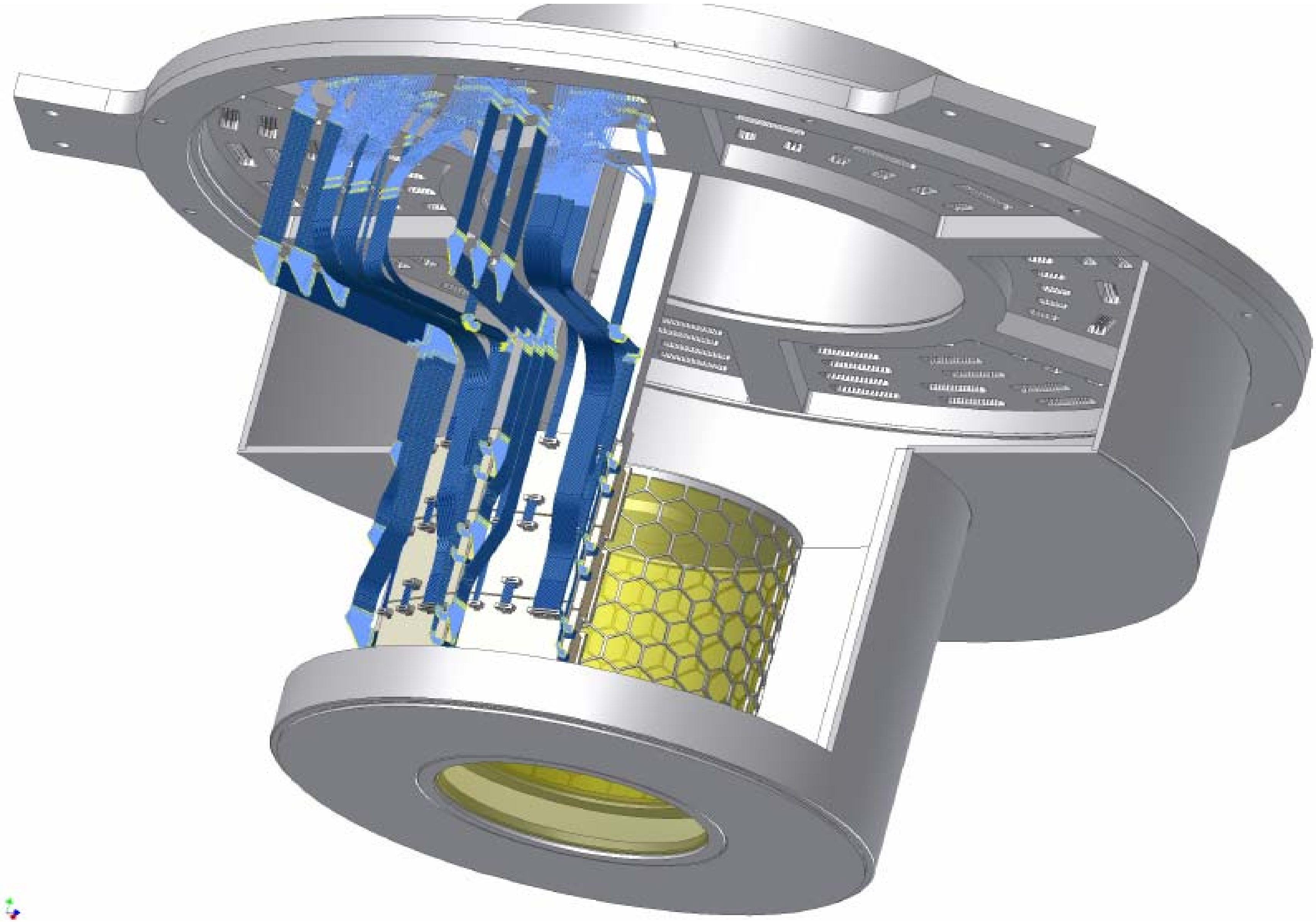


Spectroscopy test

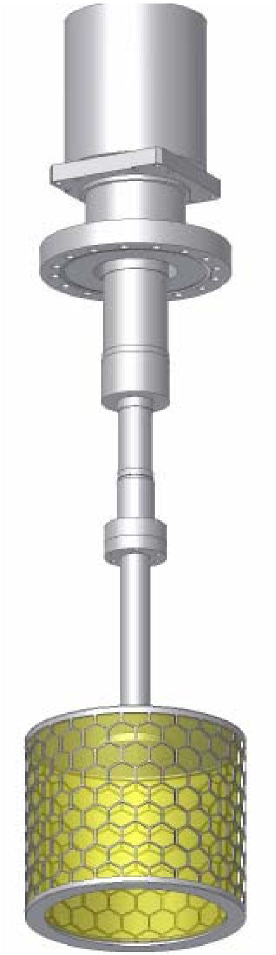
- SIDDHARTA SDDs
- temperature & shaping time scan



The SIDDHARTA Setup



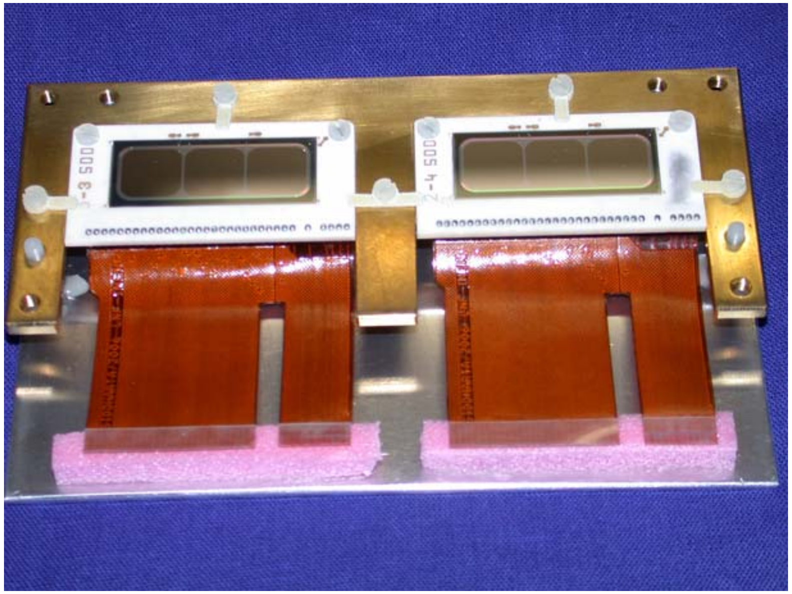
The Cryogenic Target Cell



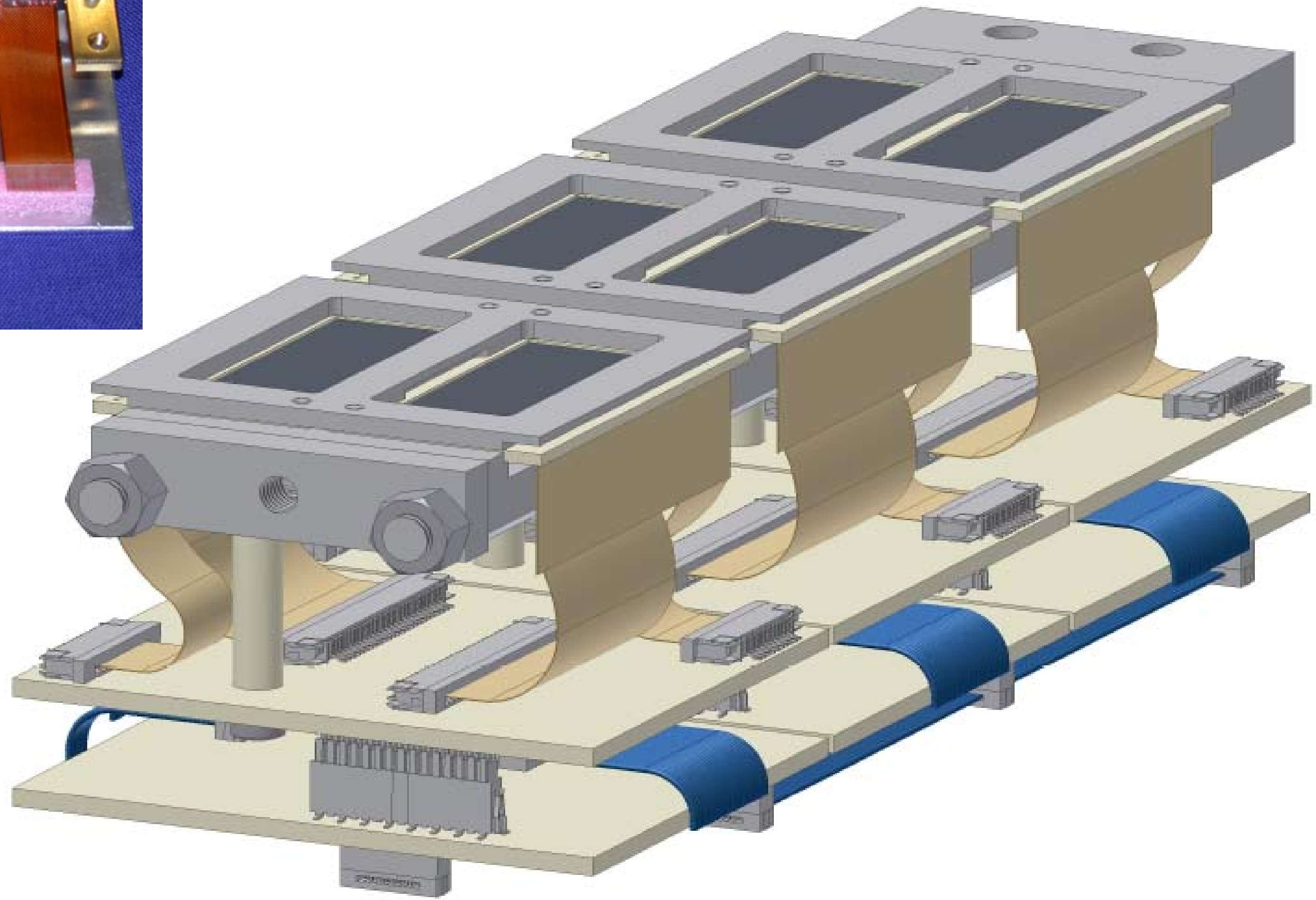
APD 2-stage cryo cooler
with 8 watt @ 20K

Cryogenic target cell
75 µm Kapton within
a pure aluminum grid
$P_{max.}$ ~ 5 bar

SDD-subunit

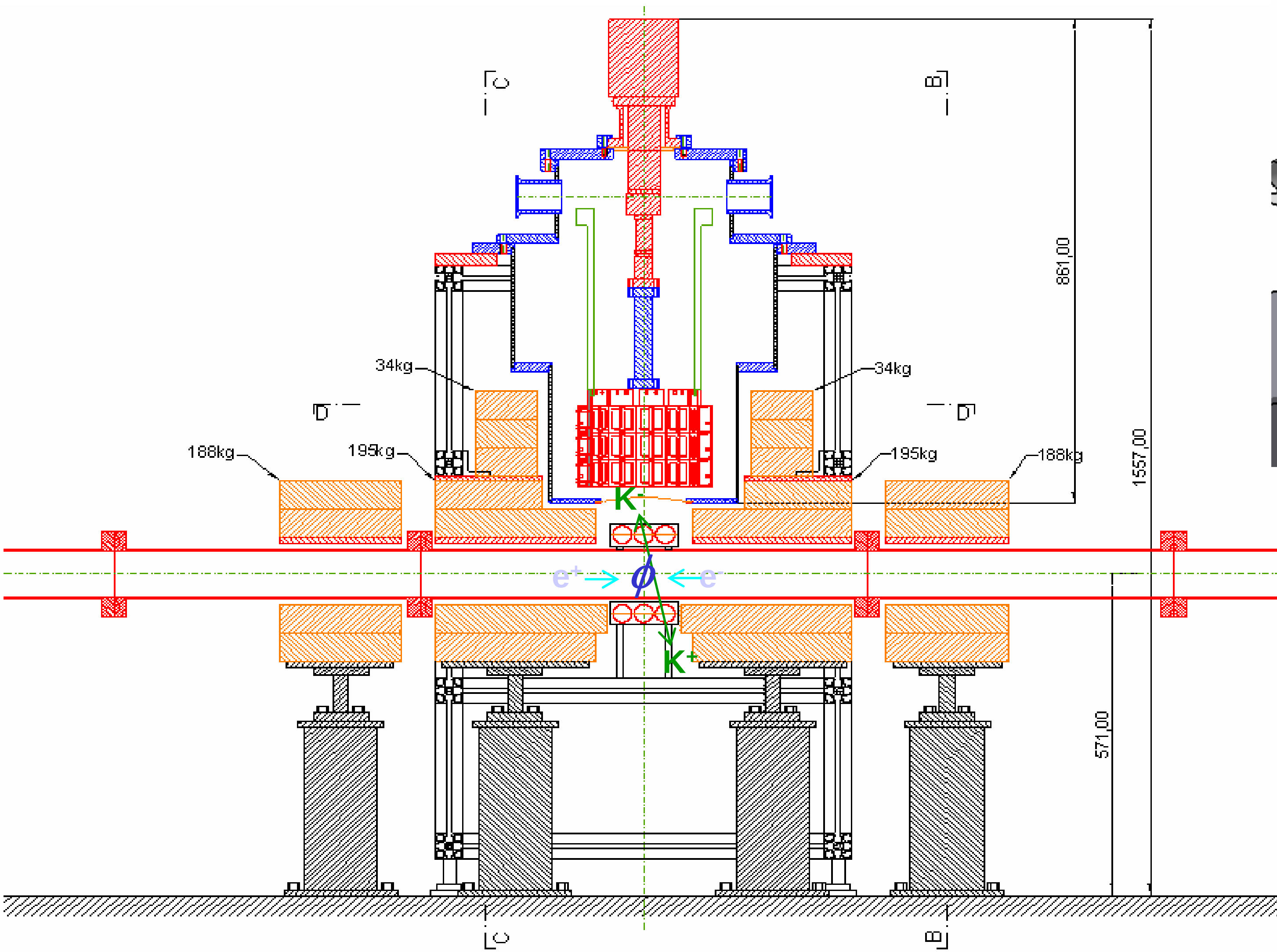


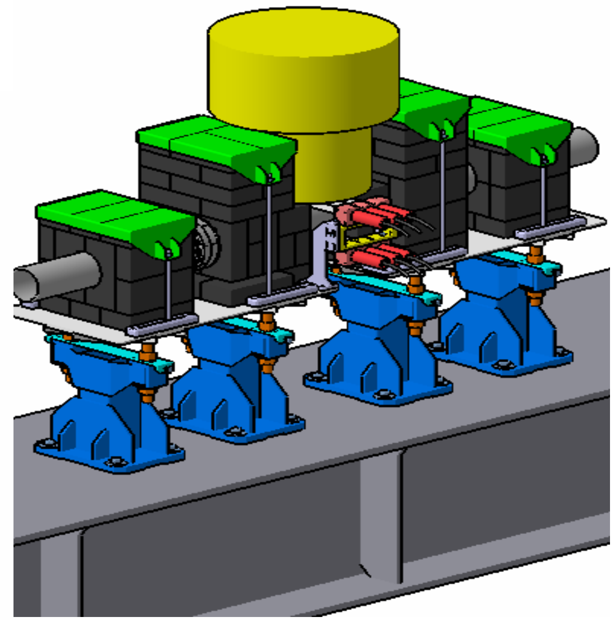
2 array of 3 cm^2 SDD



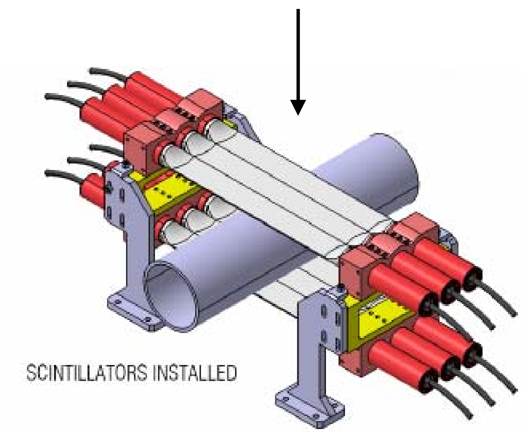
18 cm^2 SDD unit

The SIDDHARTA setup in DAΦNE





Beam pipe and trigger system



Background reduction with triggered acquisition

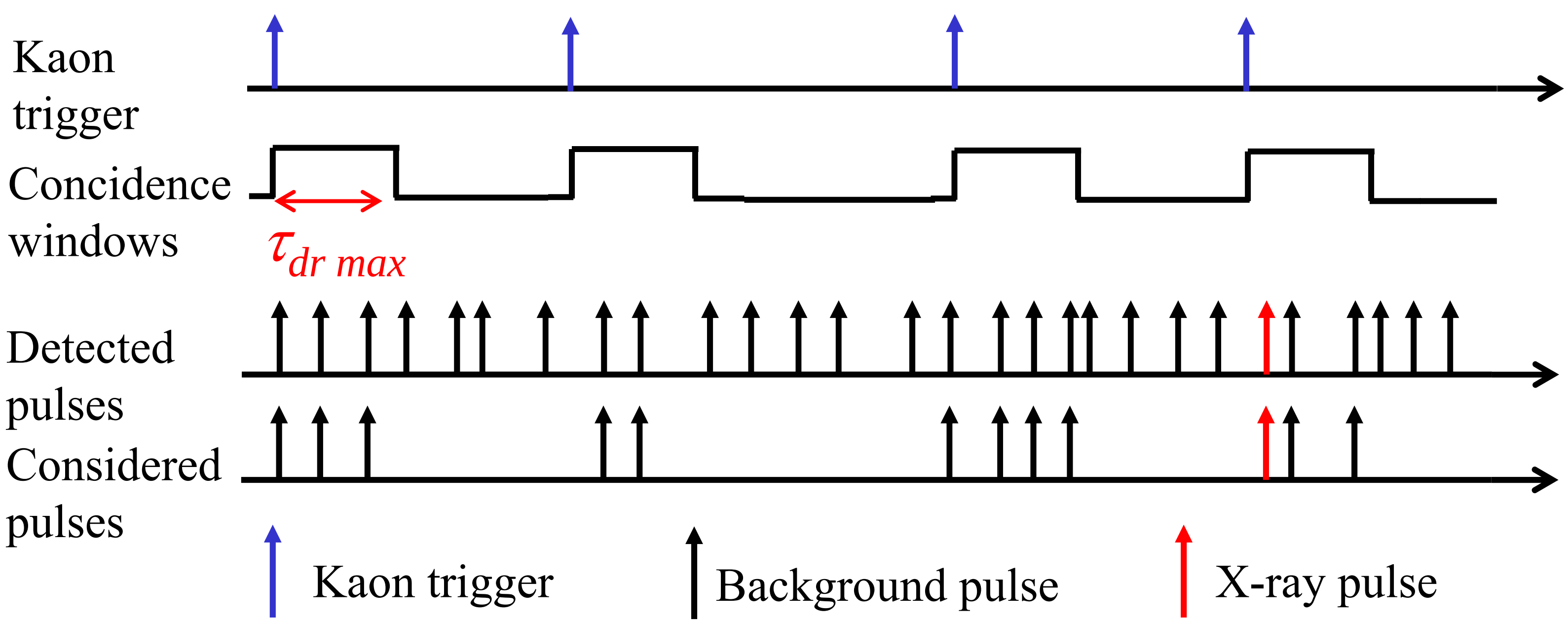
ρ =number of detected kaons per detected X-ray = 0.5×10^3

B_r=background rate = 10^3 events/s

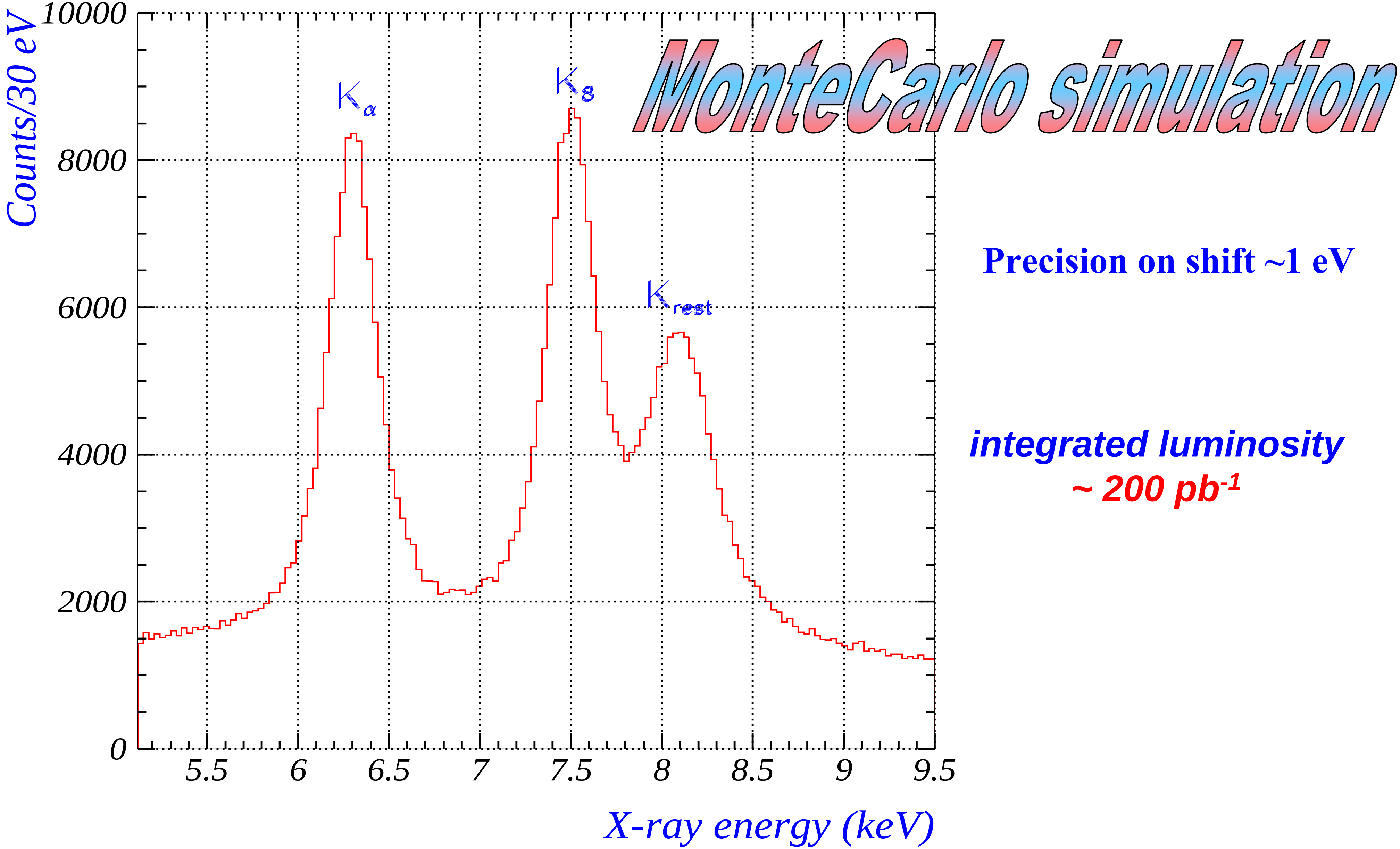
T_w=sinchronization window

$$T_w = \rho \times \tau_{drift\ max} = 0.5 \times 10^3 \times 1\ \mu s = 0.5 ms$$

$$B = B_r \times T_w = 10^3\ s^{-1} \times 0.5 \times 10^{-3}\ s = 0.5$$



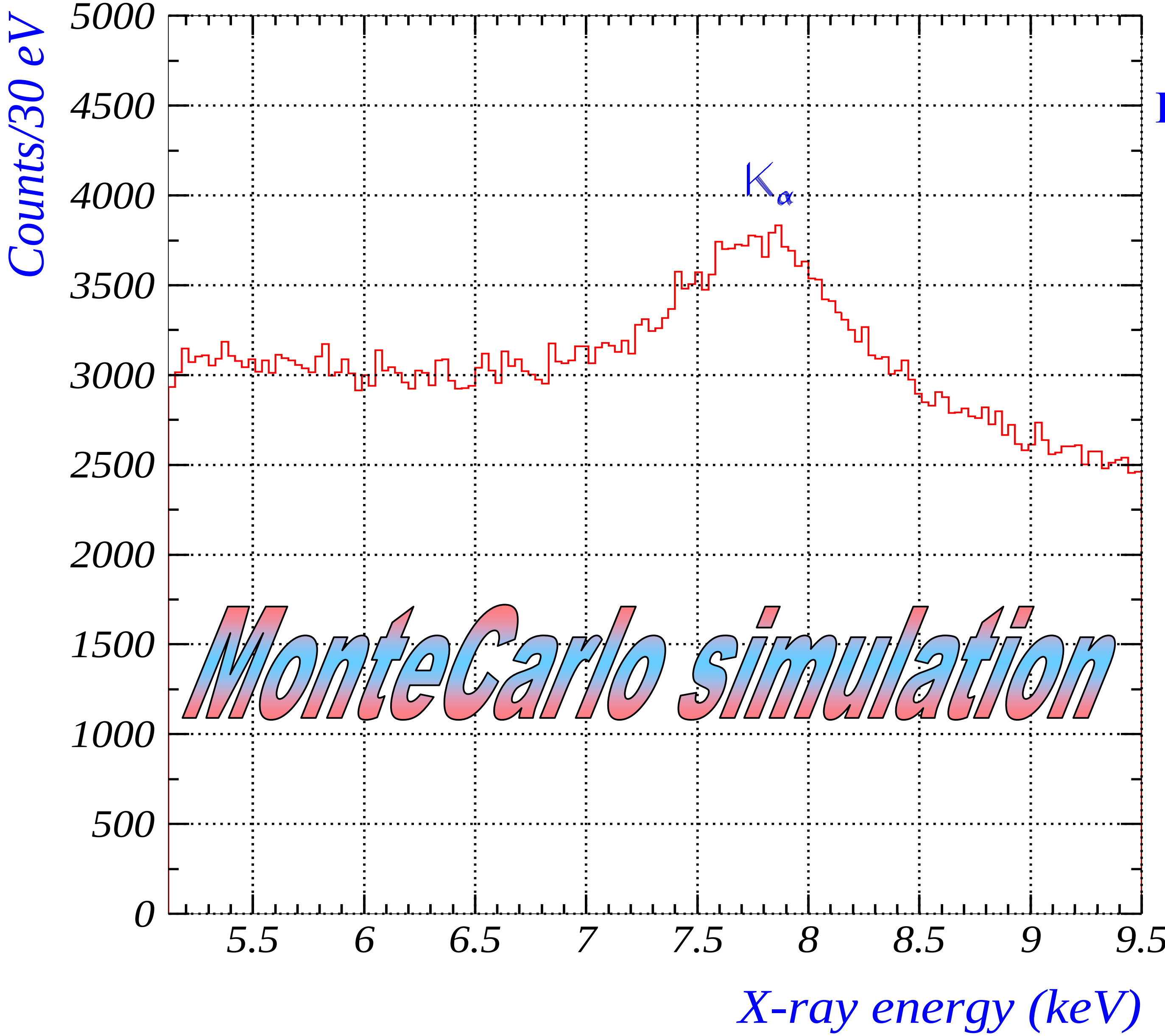
SIDDHARTA Kaonic hydrogen simulated spectrum



Precision on shift ~1 eV

integrated luminosity
~ 200 pb^{-1}

SIDDHARTA Kaonic deuterium simulated spectrum



Precision on shift < 10 eV

integrated luminosity

500 pb^{-1}

Conclusion

2006

Characterization of large area SDDs

End of front-end electronics production and characterization

Assemby of the SDD large area detectors in the setup

Slow-controls system

2007

Installing of the final setup on DAFNE and DAQ

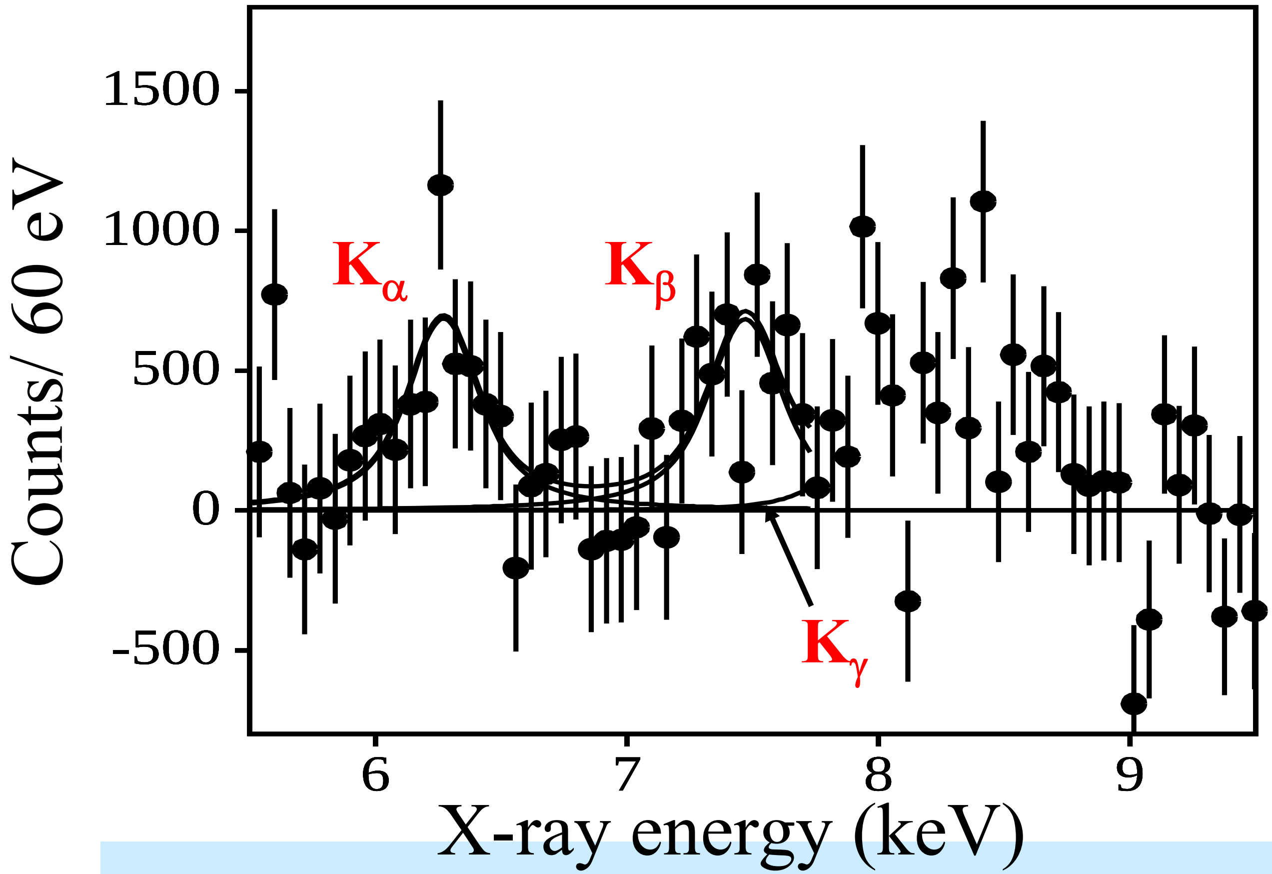
SIDDHARTA future plans

Kaonic helium measurement towards the study of deeply bound nuclear kaonic state.

Other light kaonic atoms measurement (Li, Be…).

Charged kaon mass precision measurement.

Results on the shift and width for kaonic hydrogen



represents the best measurement performed on Kaonic Hydrogen up to now

Shift: ε_{1s} = - 193 ± 37 (stat.) ± 6 (syst.) eV

Width: Γ_{1s} = 249 ± 111 (stat.) ± 30 (syst.) eV

DEAR
Cryogenic setup