Detection of antihydrogen in the ATHENA experiment

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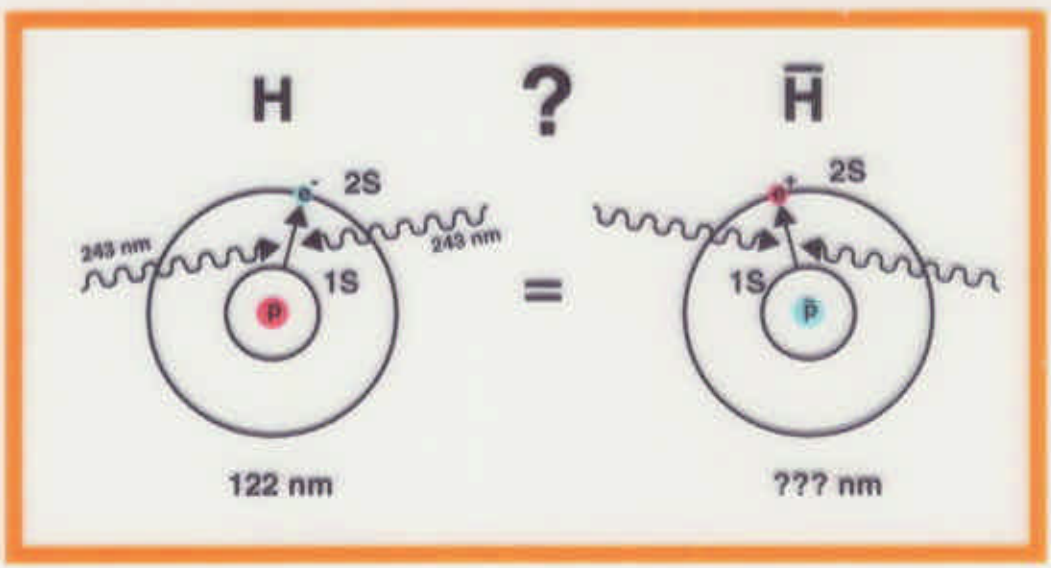
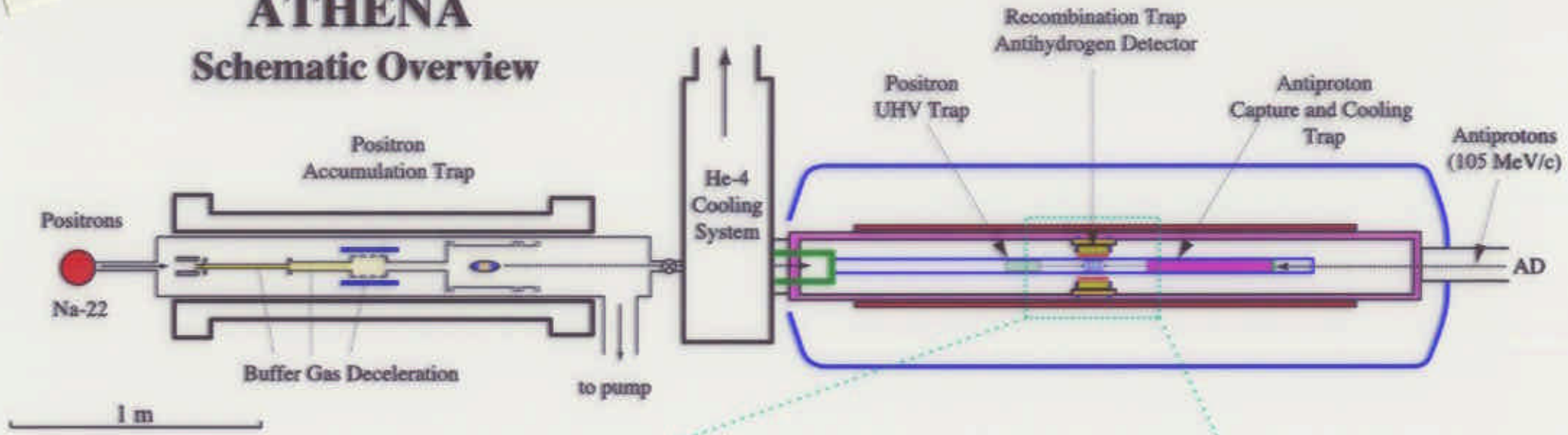
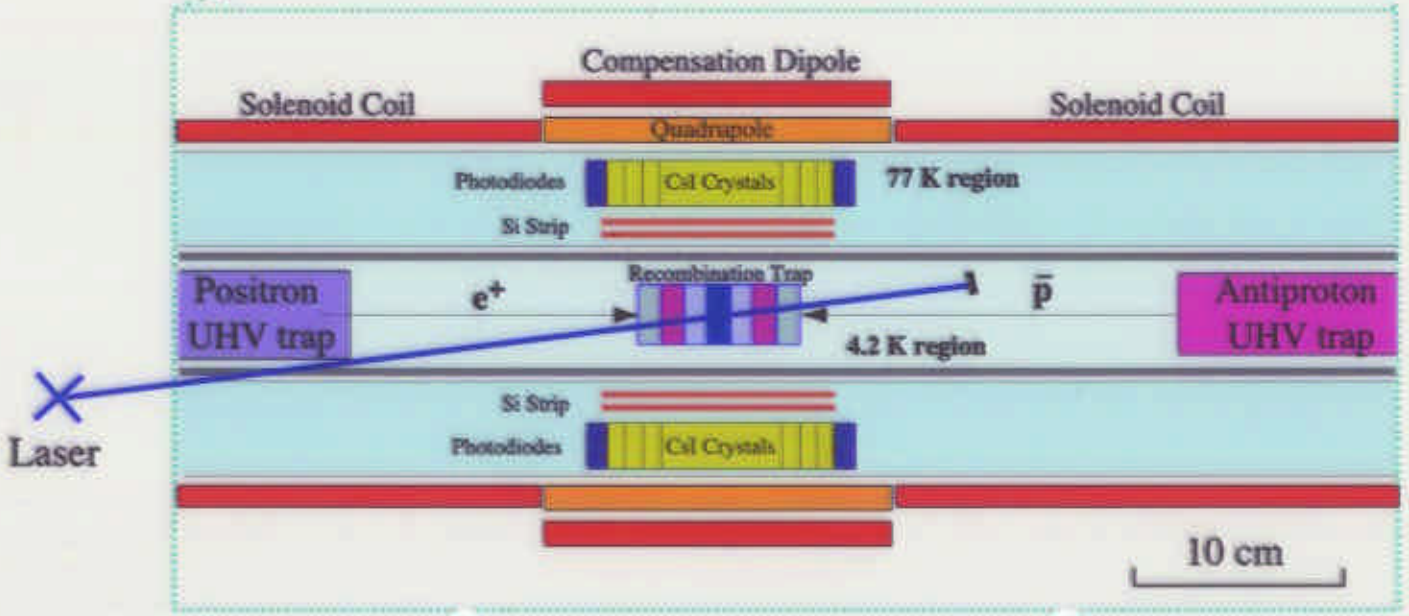
on behalf of the ATHENA collaboration

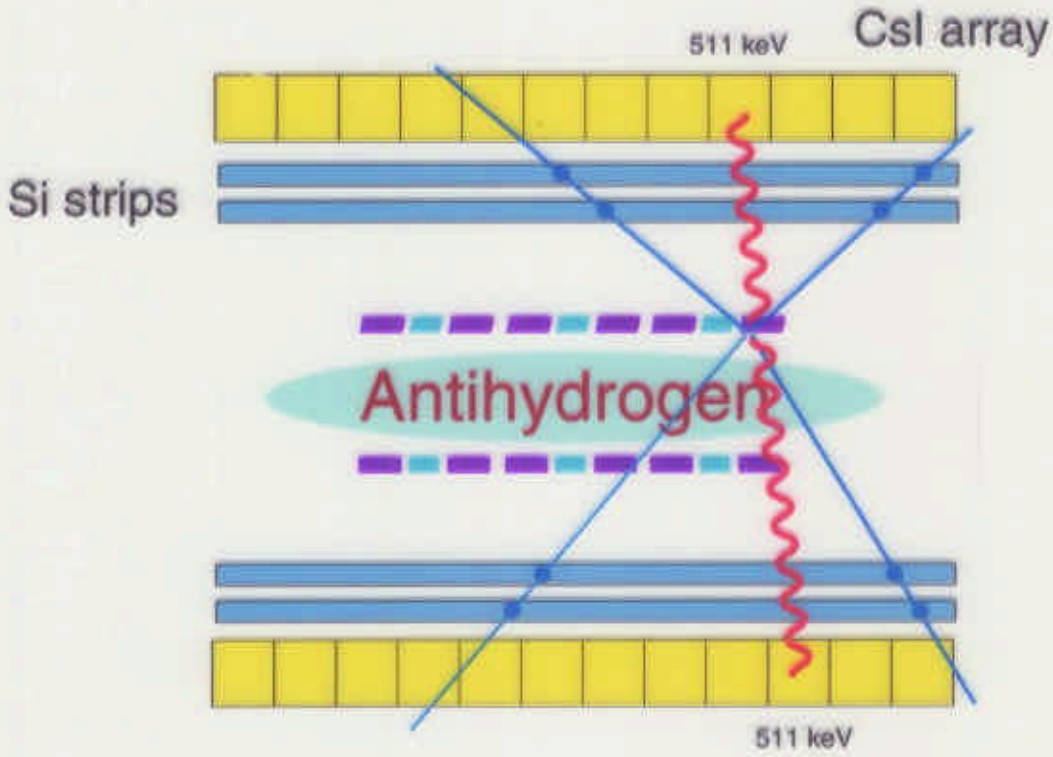


ATHENA
Schematic Overview





Antihydrogen Detection (@77 K)



Discriminate Antihydrogen Annihilation from background of Antiproton annihilation and Positron annihilation

Good spatial resolution (< 1 cm) of vertex for

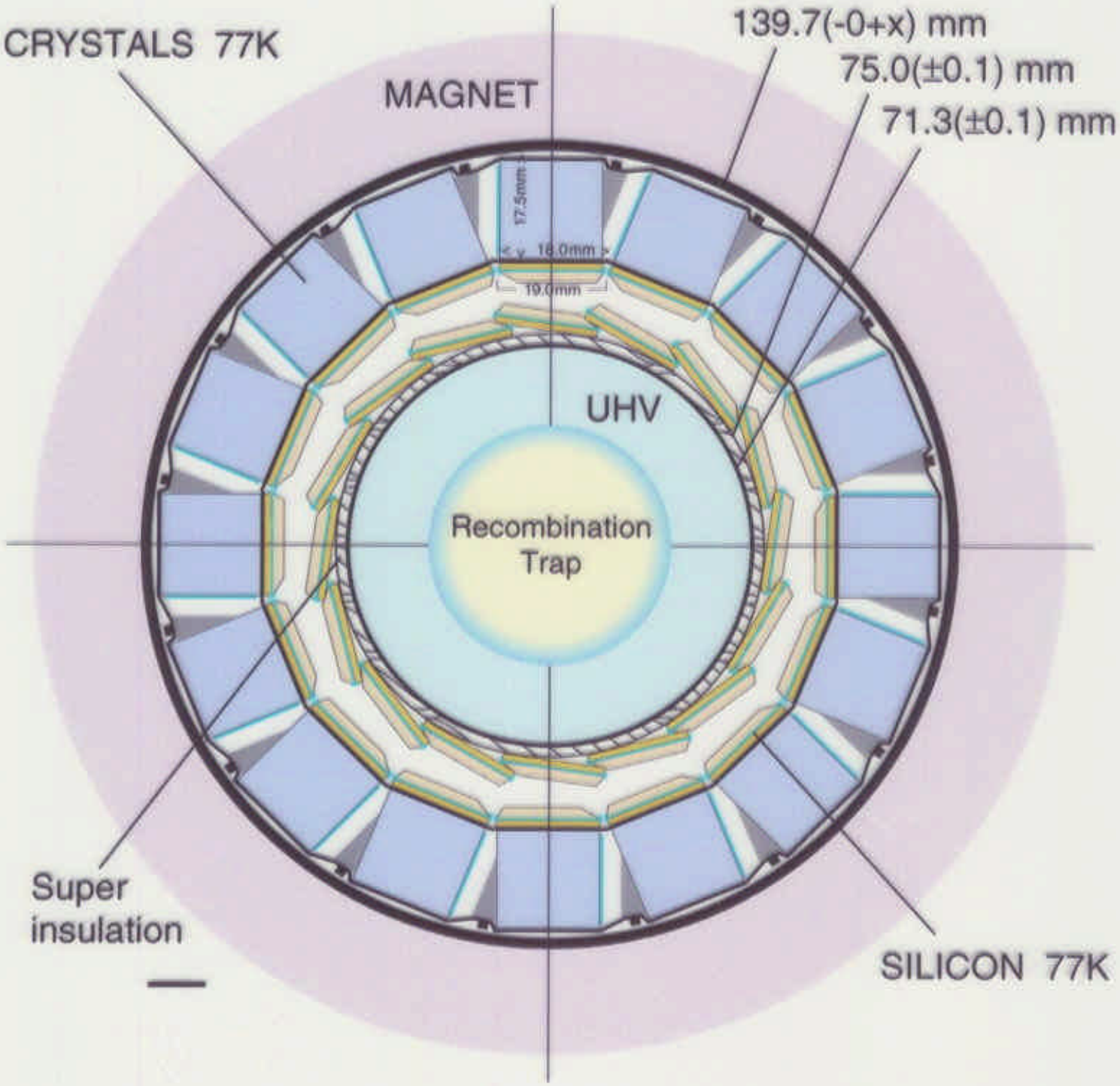
- **Antiproton Annihilation (≥ 2 prongs)**
- **Positron Annihlation (2 x 511 keV γ)**

Time coincidence (~ 1 μsec)

High rate capability → study recombination mechanism

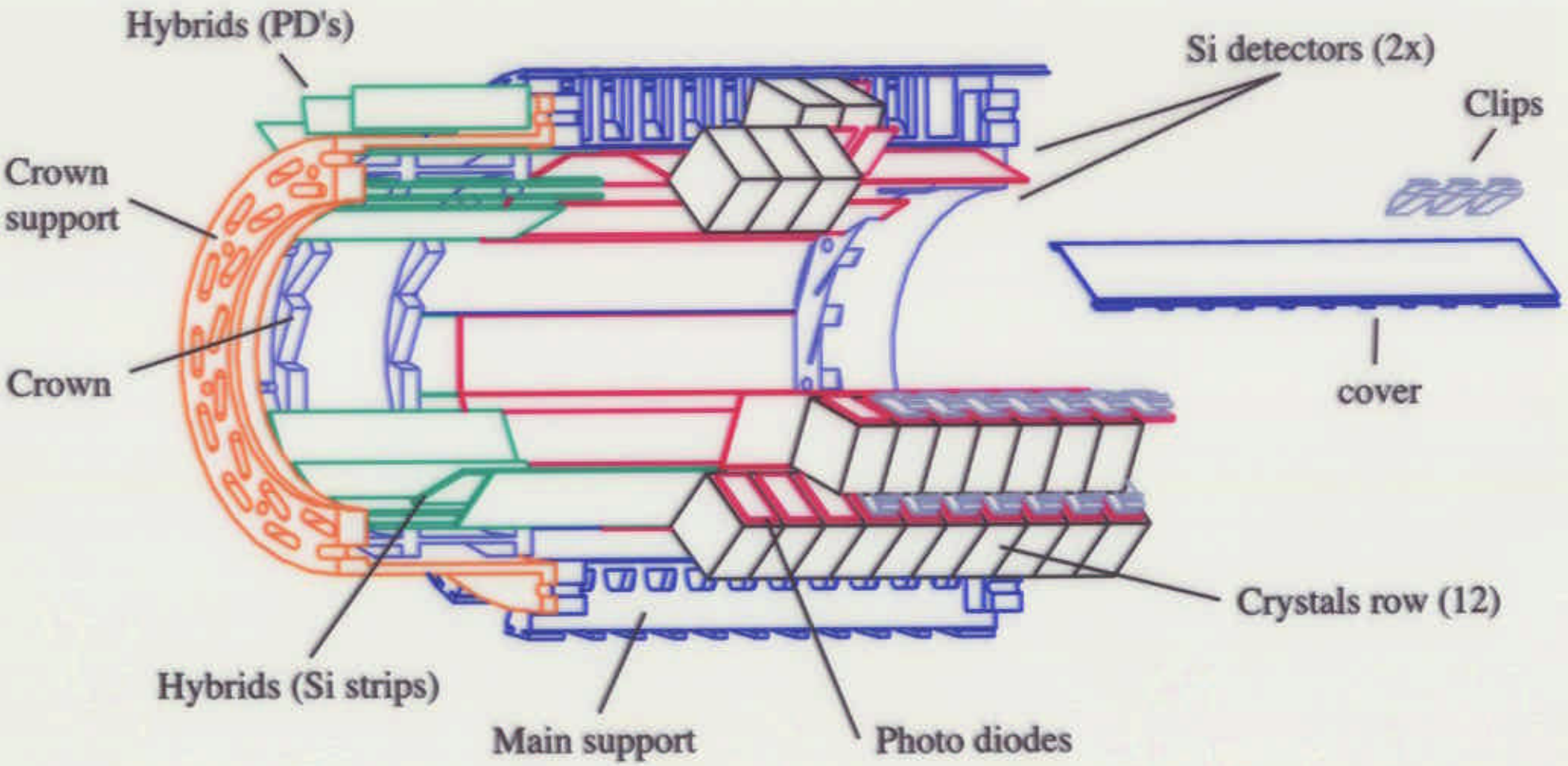
- **Si strip detector for charged vertex detection**
- **Array of (16x12) CsI crystals (@ 18x18x13 mm^3) with 4 x PD readout**

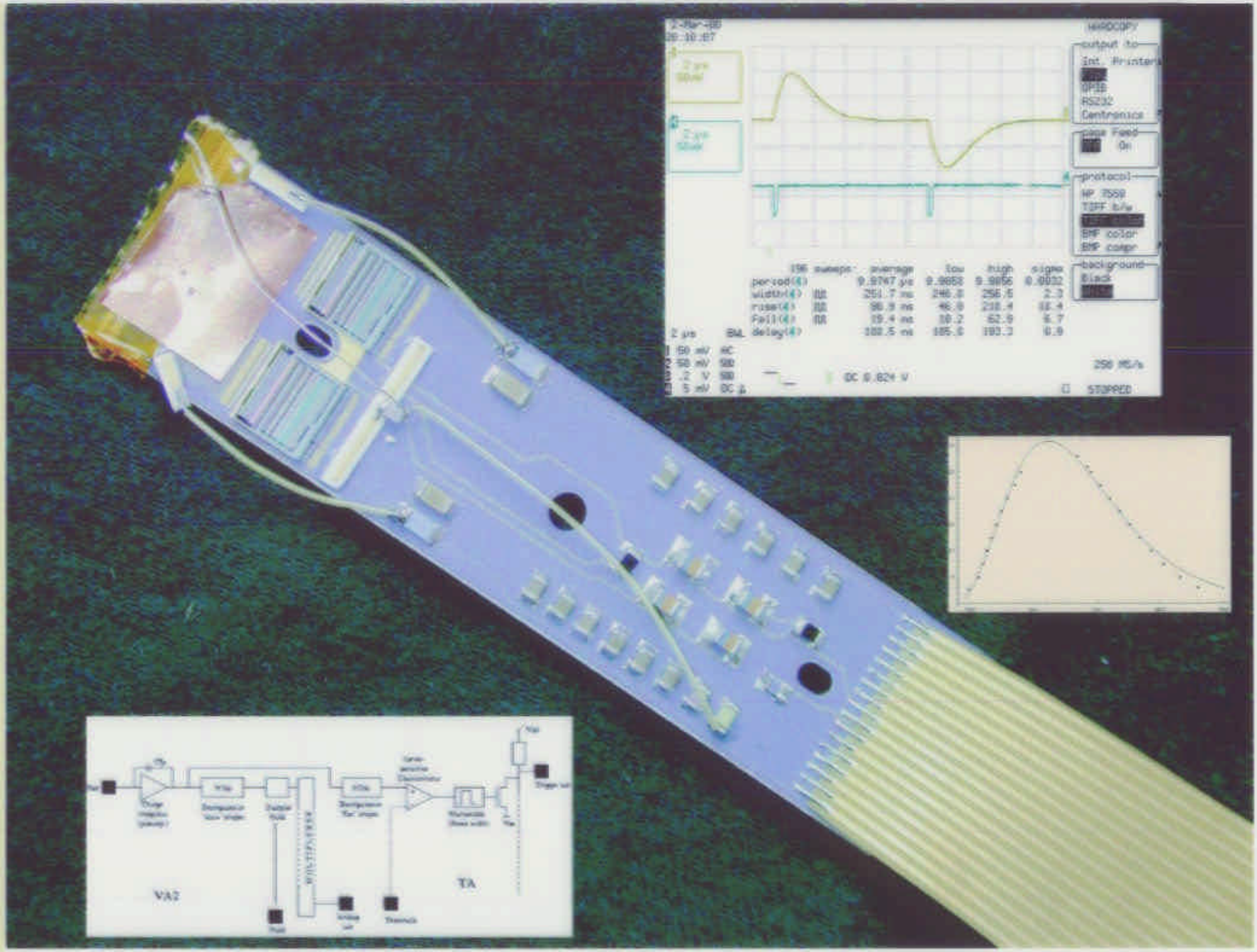
Cut through the detector



Scale 1:1

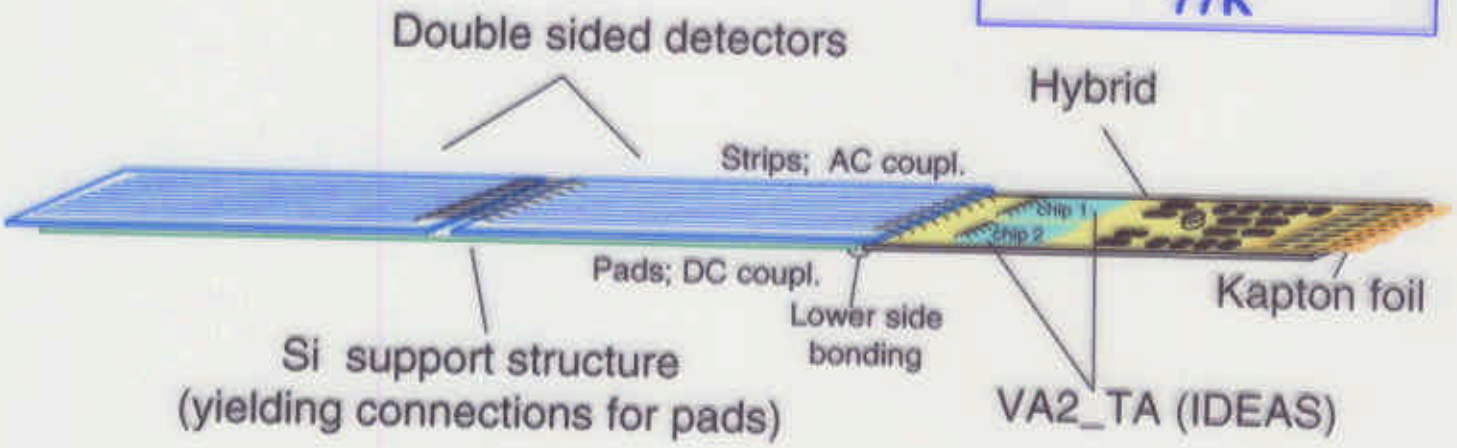
3D view of the ATHENA detector



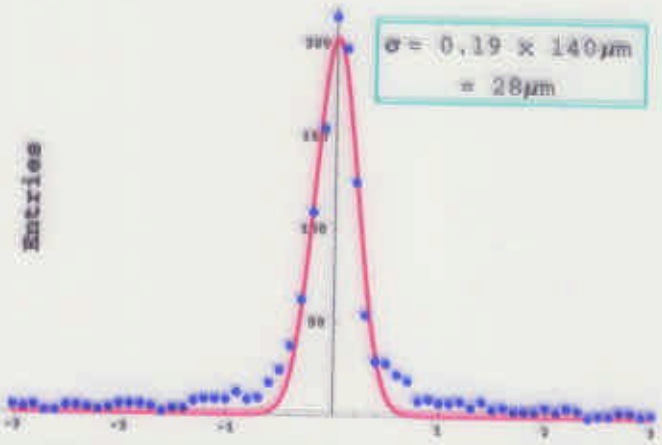

HARDCOPY
output to
Int. Printer
GPIB
RS232
Centronics
protocol
HP 7550
TIFF b/w
BMP color
BMP compr
background
Black
156 sweeps
average
low
high
sigma
period(4)
9.9767 µs
9.9853
9.9856
0.0032
width(4)
251.7 ns
246.8
256.6
2.3
rise(4)
98.9 ns
46.9
218.4
18.4
Fall(4)
19.4 ns
10.2
62.6
6.7
delay(4)
182.5 ns
185.8
193.3
0.9
2 µs
BWL
50 mV
50 mV
.2 V
5 mV
DC 0.824 V
250 MS/s
STOPPED
VA2
TA

ATHENA tracker module

Working temperature 77K

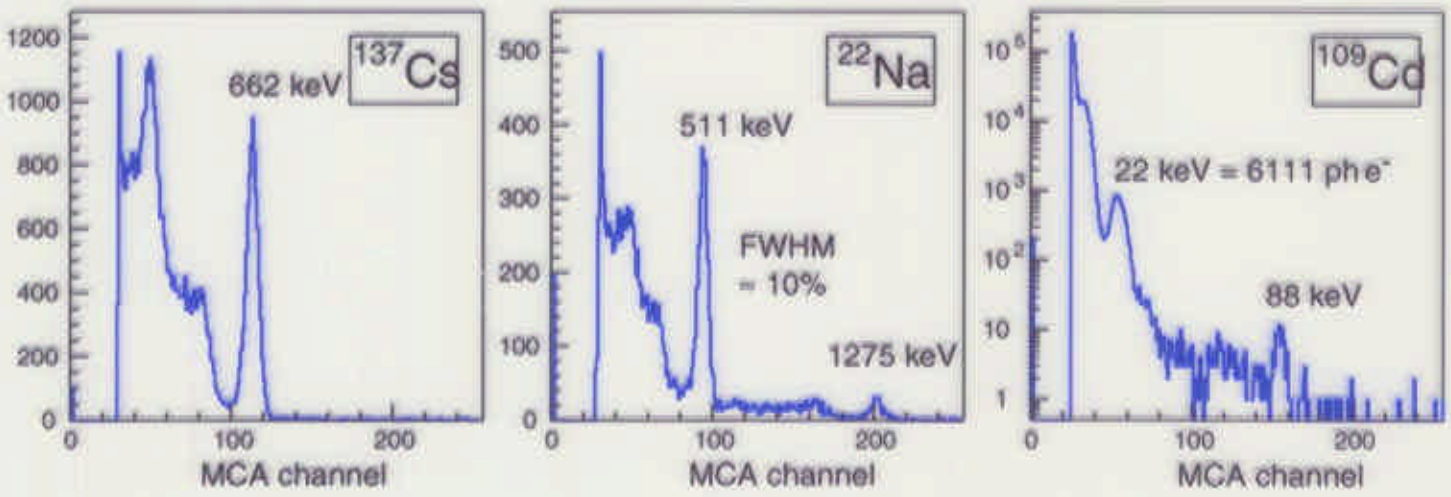


Spatial resolution

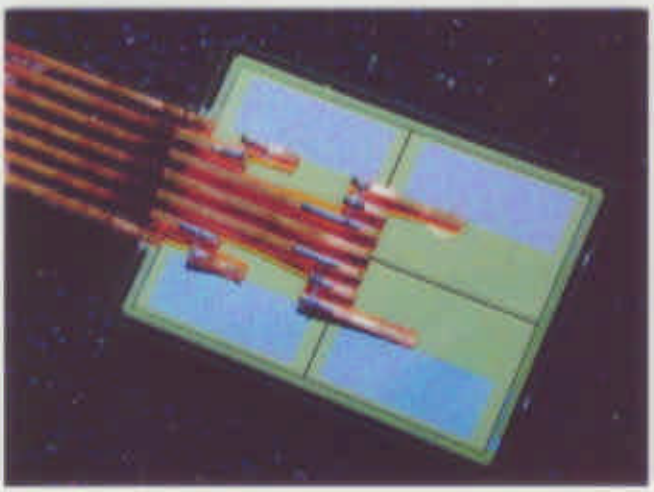


Residus to the predicted position by the beam telescope in strip units (140μm)

Pulse height spectra CsI(pure)

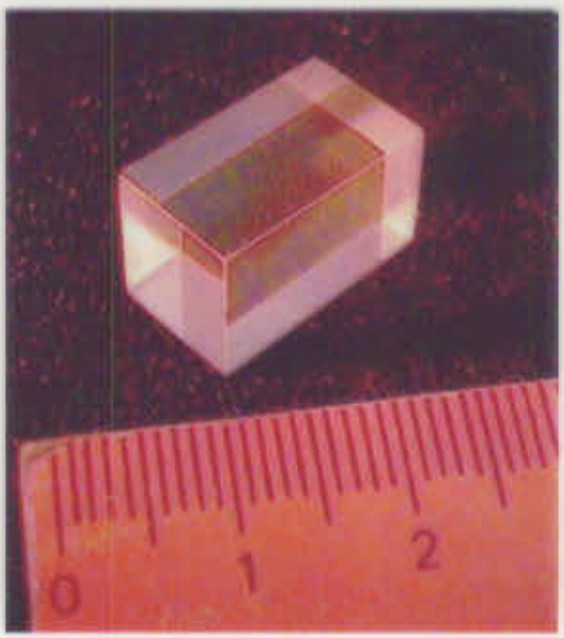


Light yield: 26500 photons / MeV



UV sensitive photodiode

CsI (pure) crystal



Two-Photon Spectroscopy of Trapped Atomic Hydrogen

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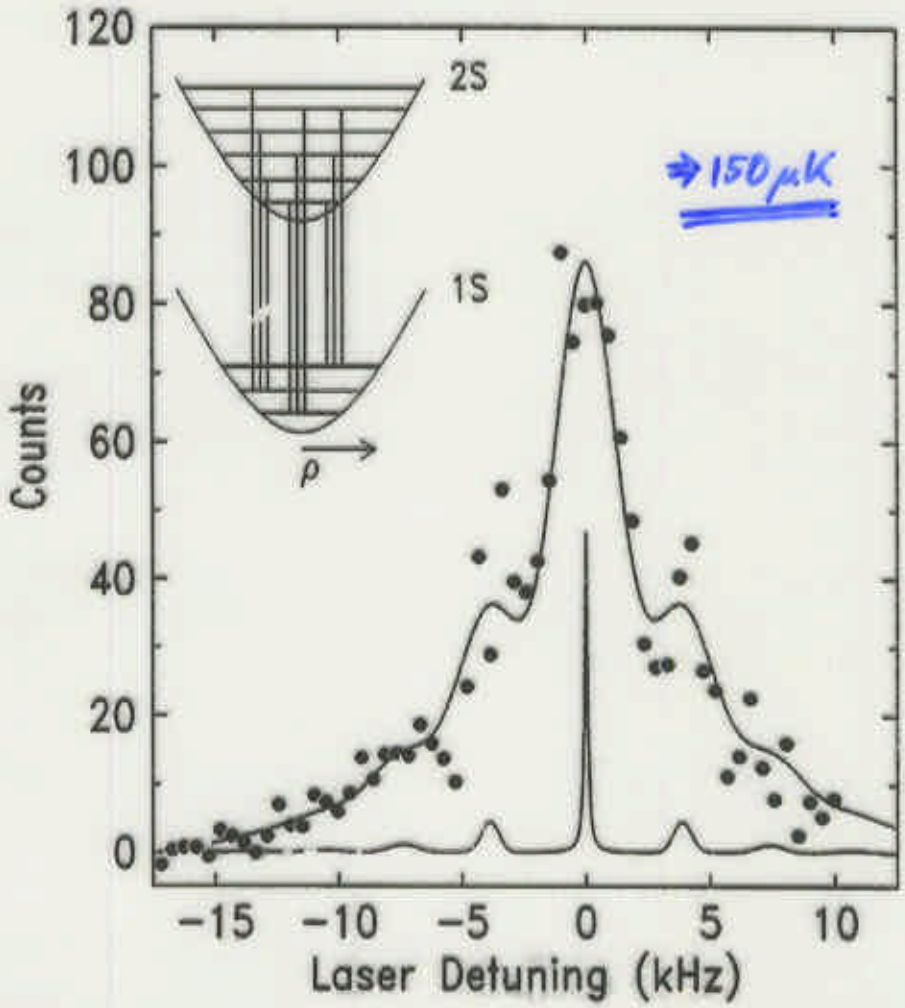
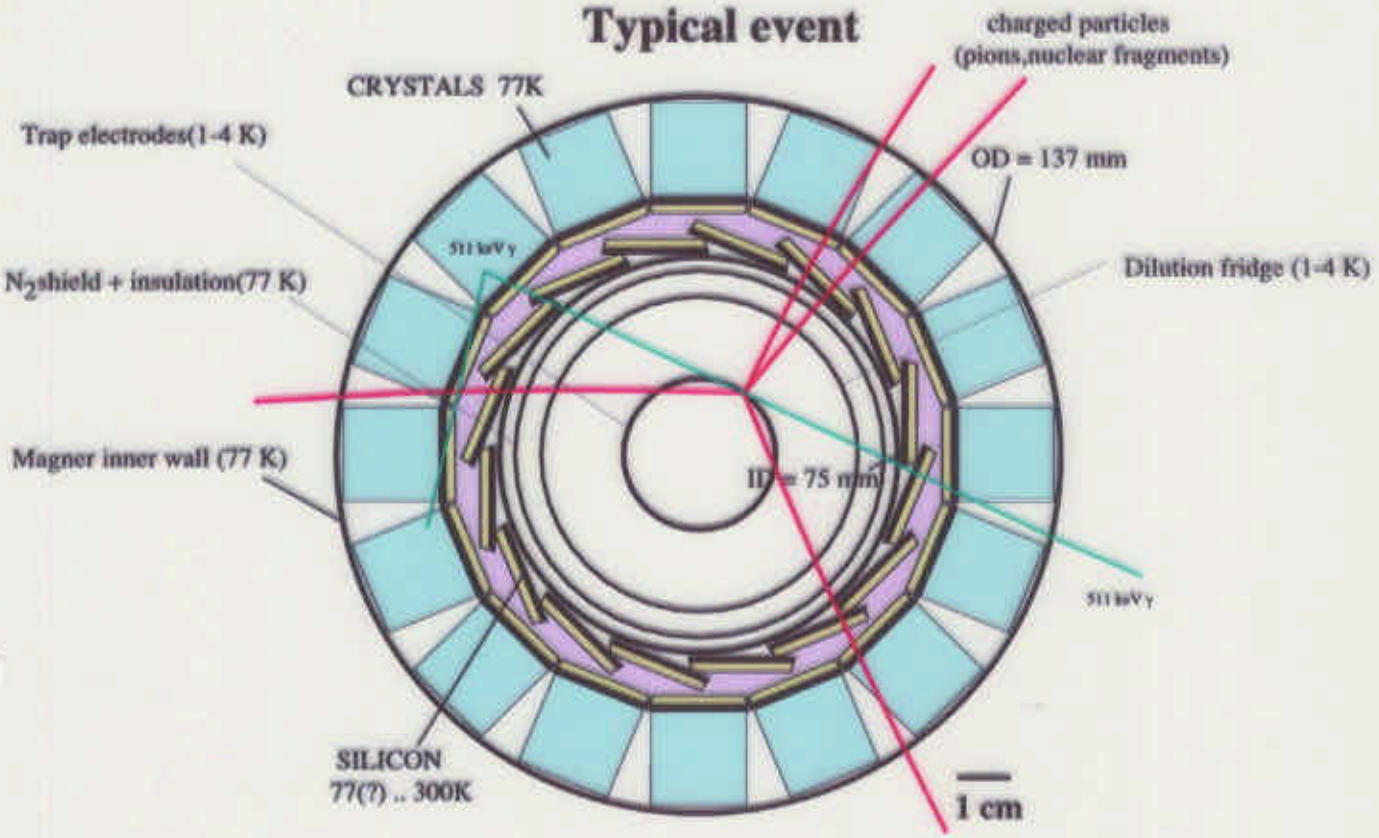
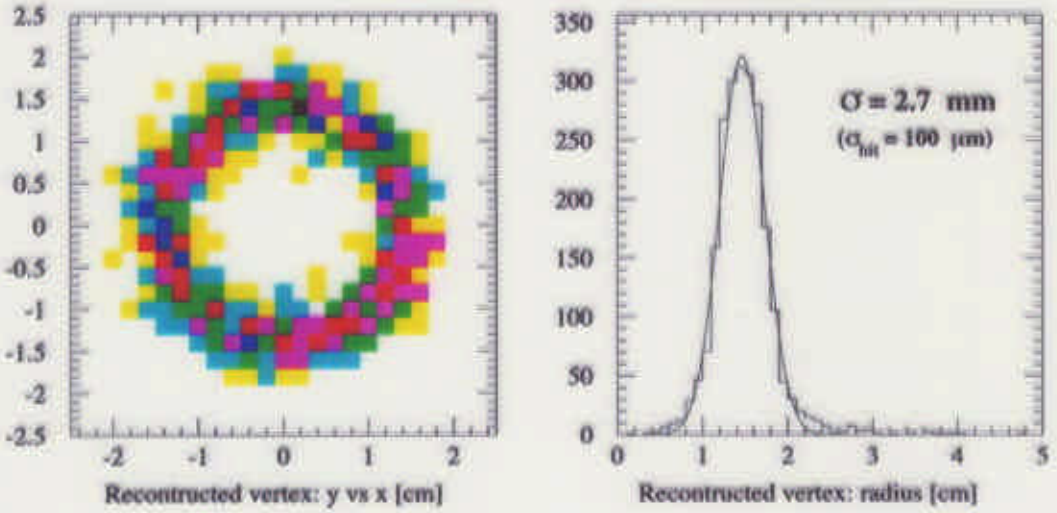
(Received 25 March 1996)

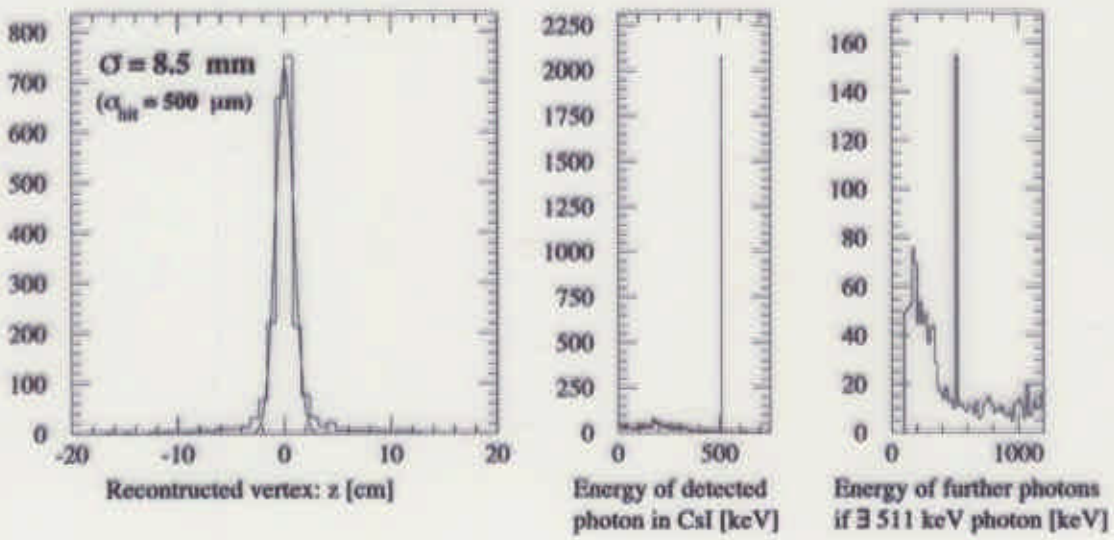
We report observation of the 1*S*-2*S* two-photon transition in hydrogen confined in a magnetic trap at submillikelvin temperatures. The excitation spectrum can display a sharp central feature arising from periodic motion of the trapped atoms. The metastable 2*S* atoms remain trapped, and have a lifetime close to the natural lifetime of 122 ms. These developments open the way to achieving the transition's natural linewidth. We have also demonstrated that the temperature of the gas can be determined from the line shape, providing an important tool for the study of cold trapped hydrogen. The resolution in these experiments appears to be limited by laser stability, currently 3 kHz. [S0031-9007(96)00604-7]

PACS numbers: 39.30.+w, 06.30.Ft, 32.30.Jc, 32.80.Pj

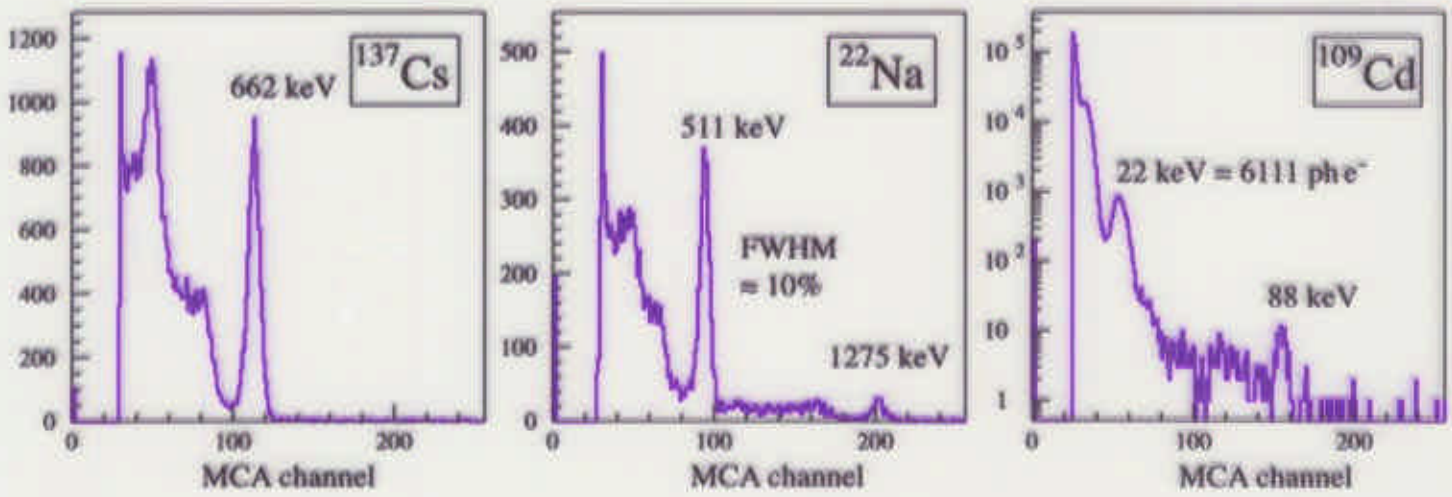



Typical event
charged particles
(pions,nuclear fragments)
CRYSTALS 77K
Trap electrodes(1-4 K)
OD = 137 mm
511 keV γ
N_2shield + insulation(77 K)
Dilution fridge (1-4 K)
Magner inner wall (77 K)
ID = 75 mm
511 keV γ
SILICON
77(?) .. 300K
1 cm


Recontructed vertex: y vs x [cm]
σ = 2.7 mm
(σ_hit = 100 μm)
Recontructed vertex: radius [cm]


σ = 8.5 mm
(σ_hit = 500 μm)
Recontructed vertex: z [cm]
Energy of detected
photon in CsI [keV]
Energy of further photons
if ∃ 511 keV photon [keV]

Pulse height spectra CsI(pure)

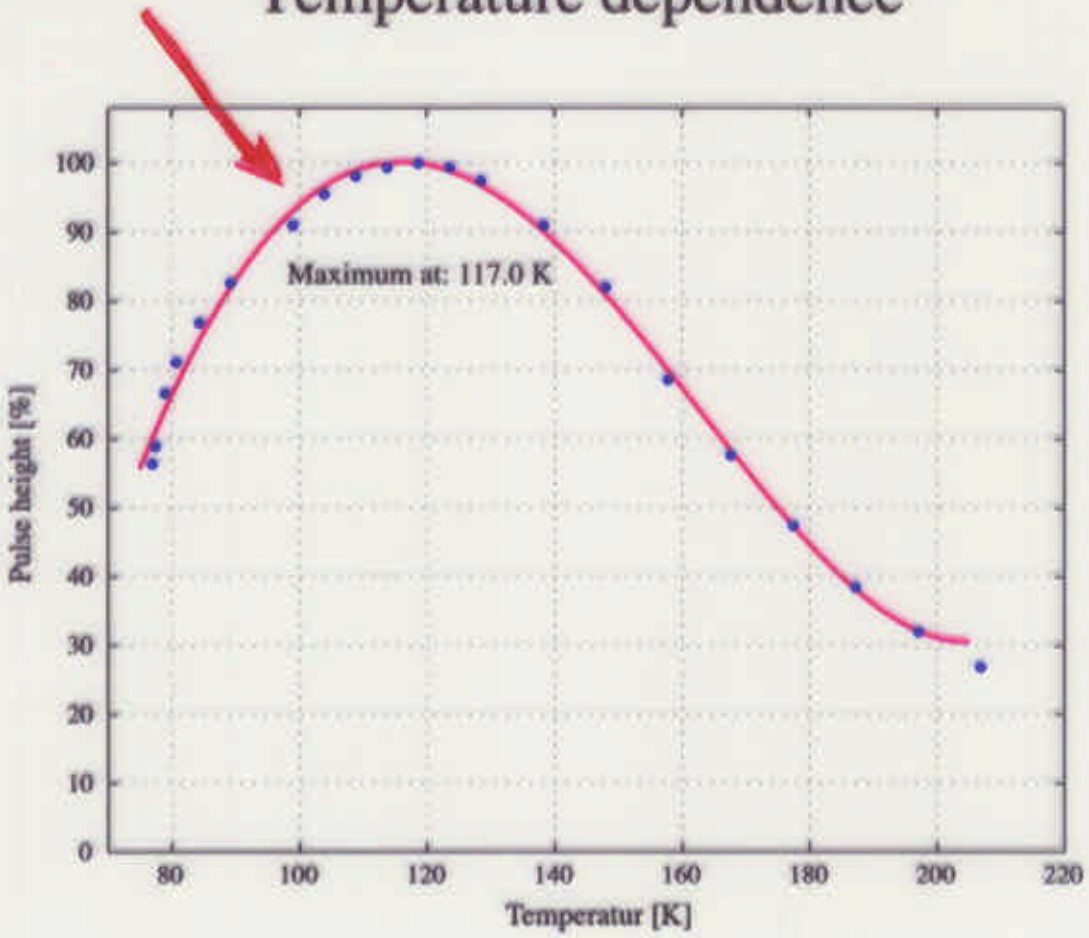


Offset: channel #19

Light yield: 26500 photons / MeV

cut off of PD

Temperature dependence



Outlook

- Development and prototyping finished
- Module construction on the way
- Testing of full assembled detector (9/2000)
- Implementation in the experiment (10/2000)
- First physics expected mid 10/2000