Proposal for the Upgrade of the DRAGON Ion Chamber

The new gas-handling system, new safety features and the improved changing between DSSSD and IC allows a simpler and safer operation of the DRAGON IC.

Goals:

1. highest possible energy resolution at low energies
   (e.g. $^{26}Al(p,\gamma)^{27}Si$ 188 keV resonance: recoil – leaky beam E difference ~1/27 = 3.7 %;
   beam contamination measurements: ^{40}Ca – ^{40}Ar dE/dx difference ~10%)
2. Minimize low-energy tails: important, since recoils have lower energy than leaky beam

Several factors are relevant for energy resolution of the IC:

$$FWHM_{total}^2 = FWHM_{el.\ noise}^2 + FWHM_{E\text{-}straggling}^2 + FWHM_{e^-statistics}^2 + \ldots$$

Possible improvements:

$FWHM_{el.\ noise}$:	minimize length of cables to preamps, reduce number of anode segments (= number of preamps)
$FWHM_{E\text{-}straggling}$:	reduce entrance window thickness, very homogeneous windows
$FWHM_{e^-statistics}$:	minimize energy loss in entrance window and dead layer, detector gas

Previous setup designed for higher energies (see A. Chen NIM B 204 (2004) 61):

55 μg/cm^2 PP or 130 μg/cm^2 Mylar windows, 5 anodes

21 MeV ^{28}Si energy resolution: 1.7%

8.12 MeV ^{28}Si energy resolution: 4.2%

= absolute energy resolution: FWHM ~350 keV

5.36 MeV ^{26}Mg, last 3 anodes: energy resolution: ~10% (see Figure 1)

Problems at low energies:

rather thick entrance window – high-energy loss (~45% for Mylar, ~24% for PP)
large energy-loss straggling

inhomogeneities of window – prominent low-energy tails

Results of tests in Nov./Dec 04:

1) Pulser on 1 preamp:
   = absolute energy resolution: FWHM ~ 40 keV
2) connected anode 1+2 and 2+3: only 2 preamps
3) 50 nm SiN (= 17 μg/cm^2) entrance window (energy loss ~ 4.5%, high homogeneity)
   size 5x5 mm^2
   2.15 MeV ^{12}C energy resolution: 3.1%
   2.86 MeV ^{16}O energy resolution: 2.6%
   = absolute energy resolution: FWHM ~ 70 keV (= 40 $\sqrt{3}$ keV)
   energy resolution is dominated by electronic noise of preamps

Proposed modifications:

1) Larger Silicon Nitride (SiN) entrance windows
    a. Large area array:
        i. Silson Ltd.:
            1. 5x5 array with 3x3 mm^2 membranes, 100 nm thickness and 0.5 mm ribs in between = 17x17 mm^2 ~80% Transmission
            2. 14x14 mm^2, 100 nm thickness, 100% Transmission

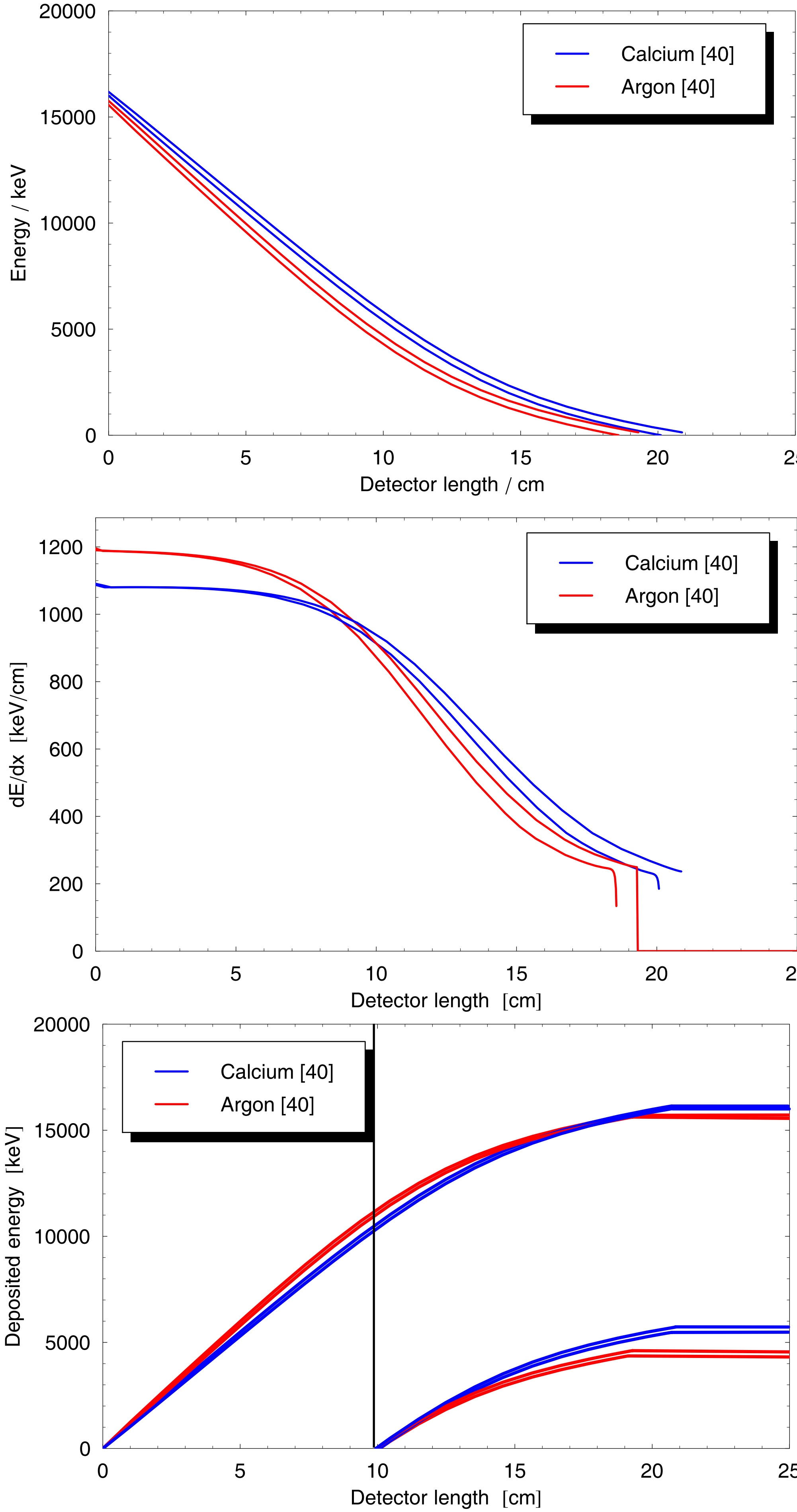
        ii. PSI/ETH Zurich: 13x13 array with 3.6x3.6 mm^2 membranes 100-230 nm thickness and 0.45 mm ribs in between = 50x50 mm^2 window for ERDA, , transmission 60-78%

2) New anode plate:
    a. 3 segments:
        i. anode 1 (10 cm) = dE
        ii. anode 2 (10 cm) = E_{rest}
        iii. anode 3 (5 cm) = confirming that all ions are stopped at anode 2, veto option
    b. Continuous anode areas (no strips) + guard ring around (on same potential to avoid leakage current)
    c. Preamps inside the chamber, directly connected to anodes
        CREMAT: CR-110 preamps + CR-150-AC-C board (used at ETH Zurich)
        Preamps can be operated at low voltage (± 6 V) which minimizes heat production (important since cooling at low pressures is reduced)

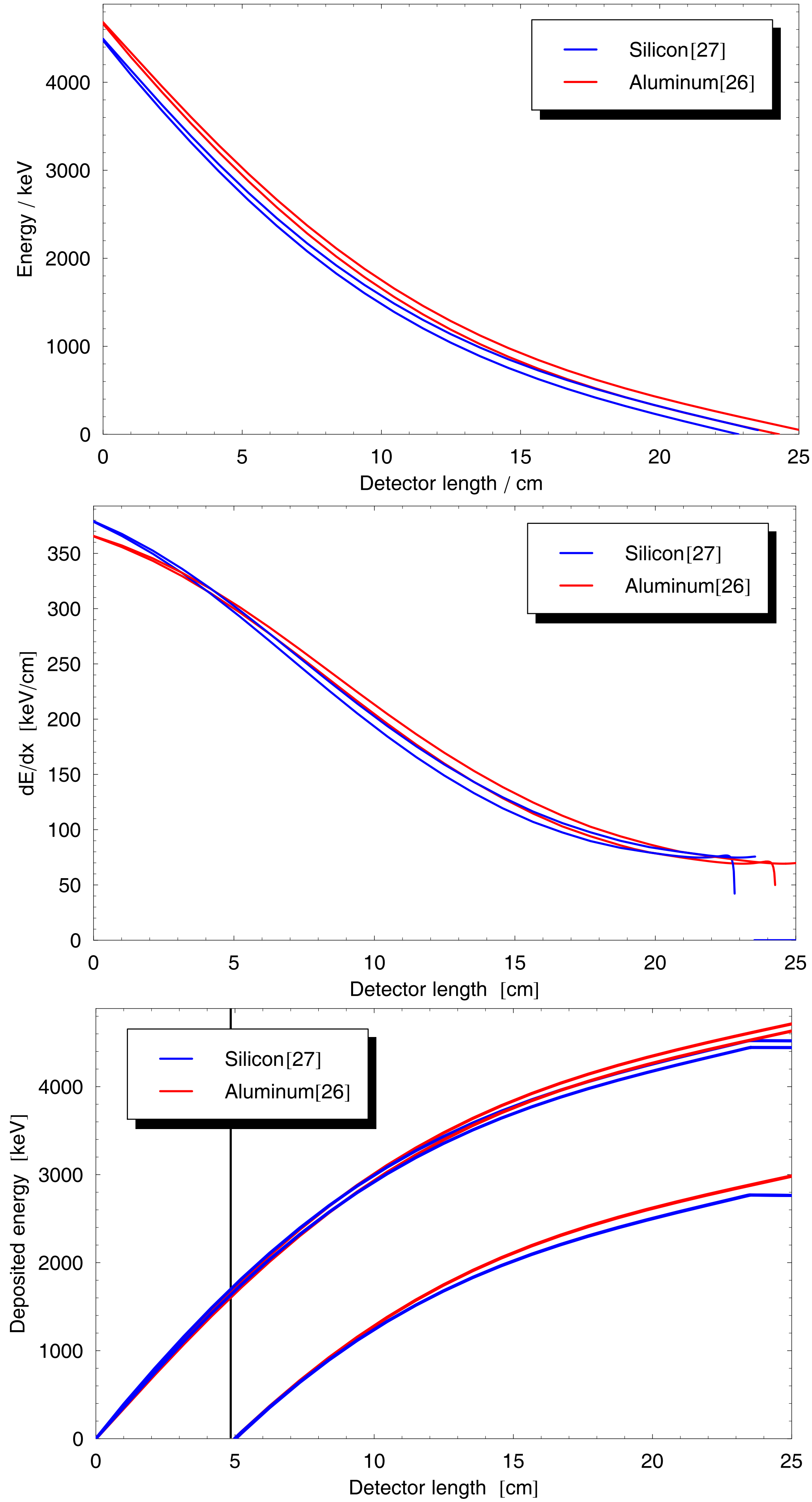
Costs:

1) Silson foils: 5 pieces minimum of 5x5 array		~ CAD 350 each
2) PSI/ETH Zurich foils: ??? (collaboration possible?)		
3) Electronics: CREMAT	preamps CR-110	USD 55 each
	board CR-150-AC-C	USD 55 each
4) New anode plate: Detector lab		
Sum (5 SiN foils, 3 preamps + boards):		~ CAD 2080

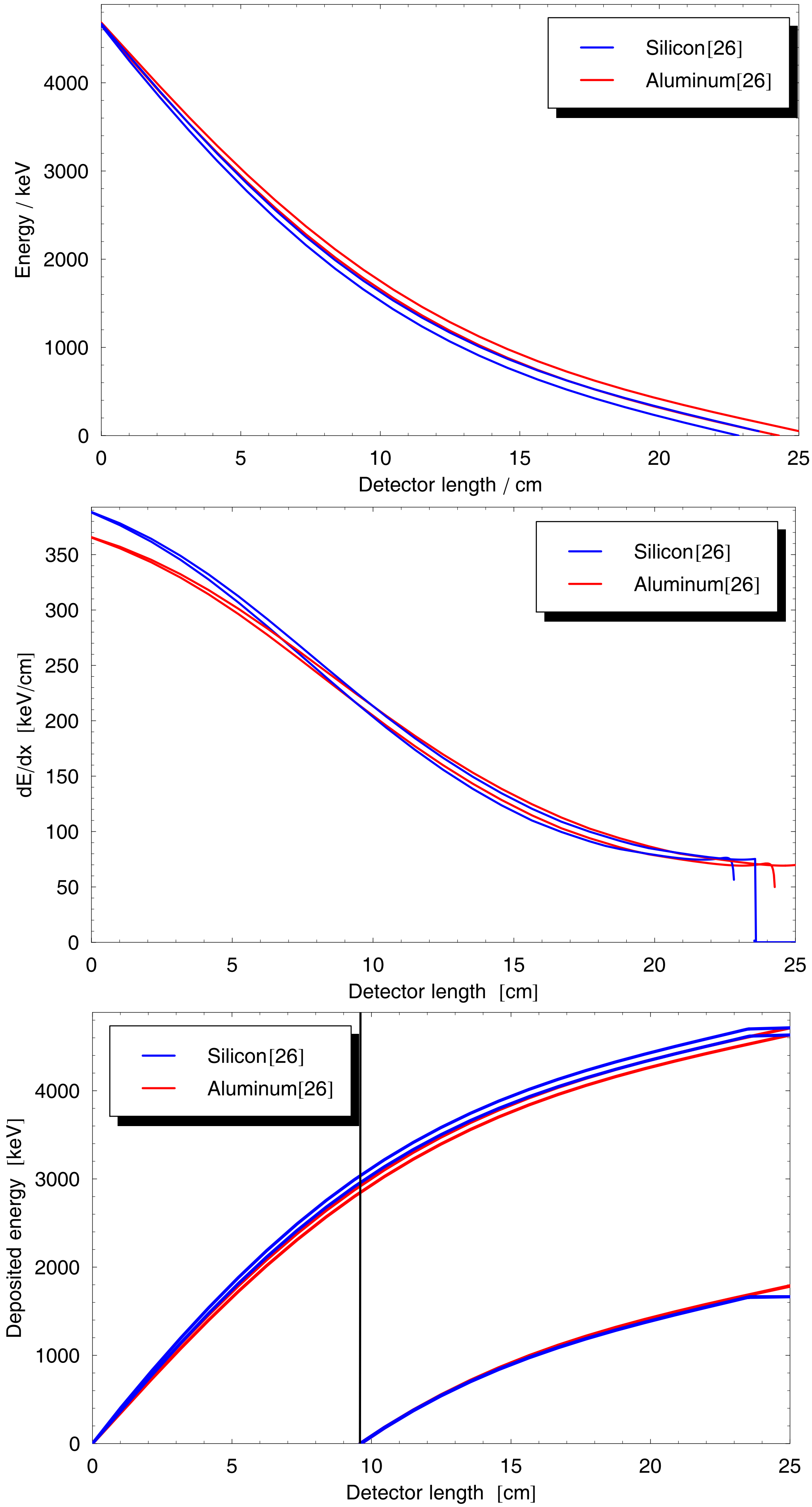
^{40}Ca - ^{40}Ar, 500 keV/u, 130 nm Mylar window, 20 Torr



^{26}Al -^{27}Si, 188 keV/u, 50 nm SiN window, 10 Torr



^{26}Al - ^{26}Si, 188 keV/u, 50 nm SiN window, 10 Torr



^{26}Al -^{27}Si, 188 keV/u, different windows, 10 Torr