# Summary of readout test of DSG prototype with IPA4 cold preamp

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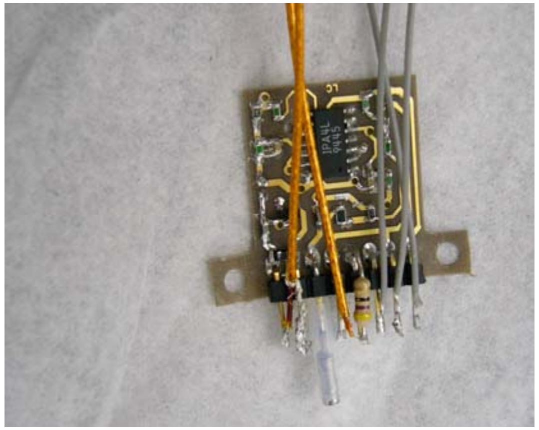
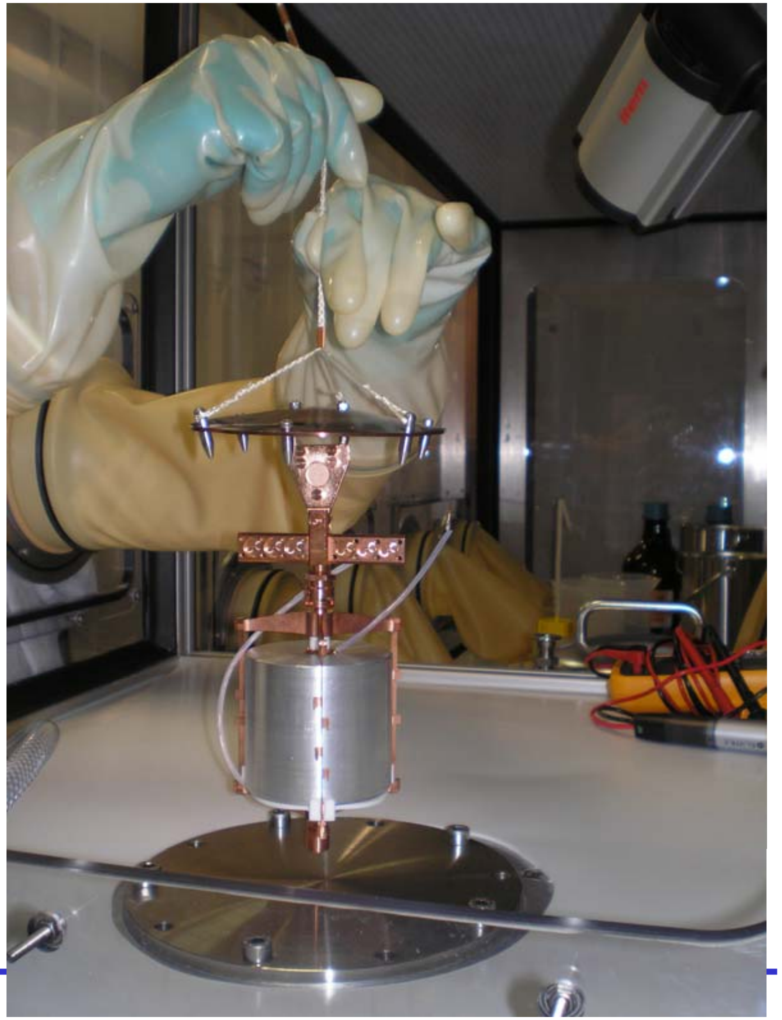
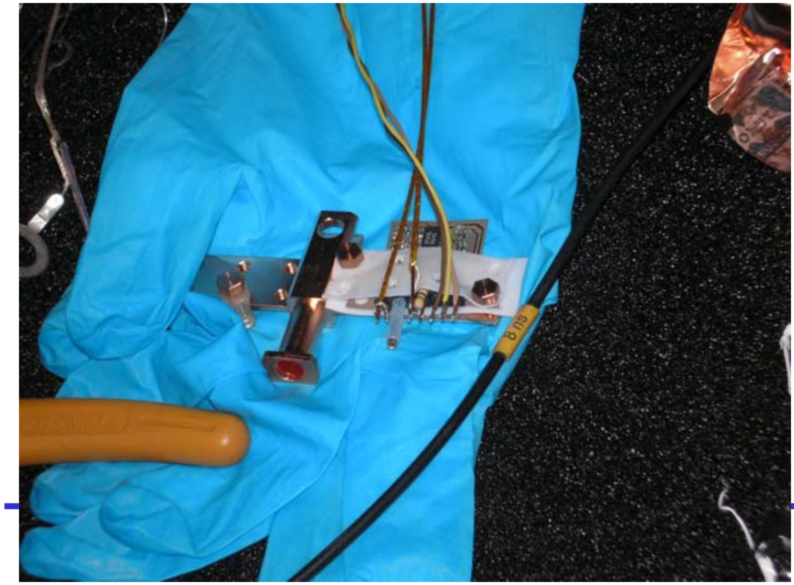






# Outline

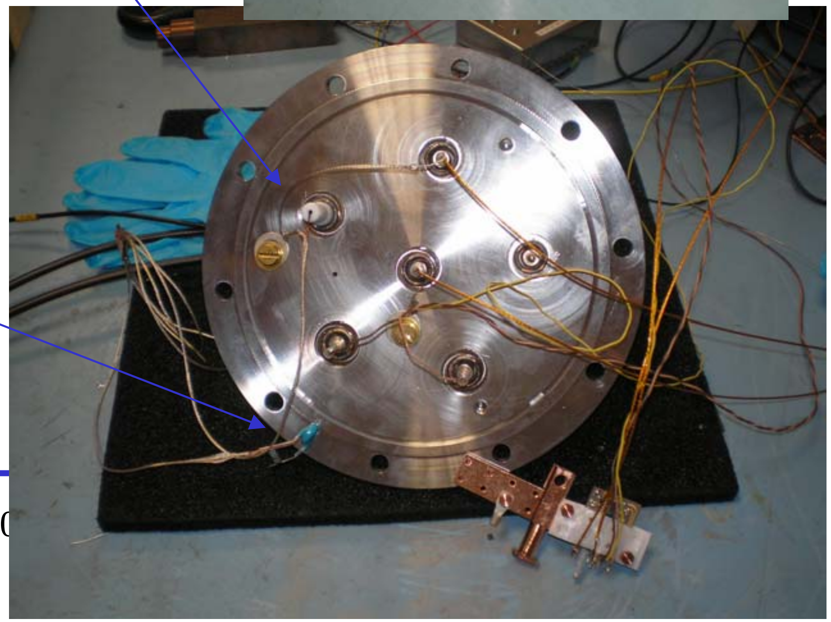
- Summary of IPA4 circuit (see Nov06 Gerda meeting)
- The GERDA preamplifier based on IPA4 circuit
- Accessories for the cold read-out: HV connectors and cables.
- Summary of the tests performed with DSG prototype crystal
  - in July-August 2006
  - in December 2006- January 2007.

# The tested setup (August 2006)

Solved problems of discharge on Ar side of HV feed-through due to proximity of HV to ground and low break-down of gas Ar.

Solution: poor HV feed-through with Stycast 2850 FT (Dielectric Strength= 14 kV/mm) properly cured.

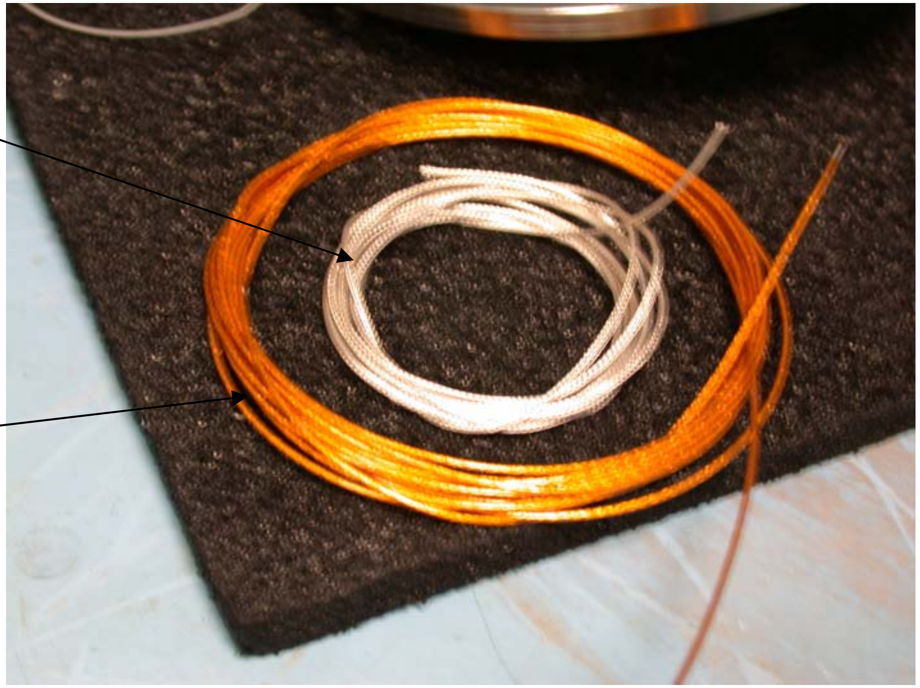
Long test of connector and cable terminated with C (1nF,7.5 kV) @ HV up to 4.5 kV overnight → OK.



# Adopted Cables for LARGE tests

HV cable: Kapton coaxial cable. Tested up to 5 kV

Weight ~ 3 g/m

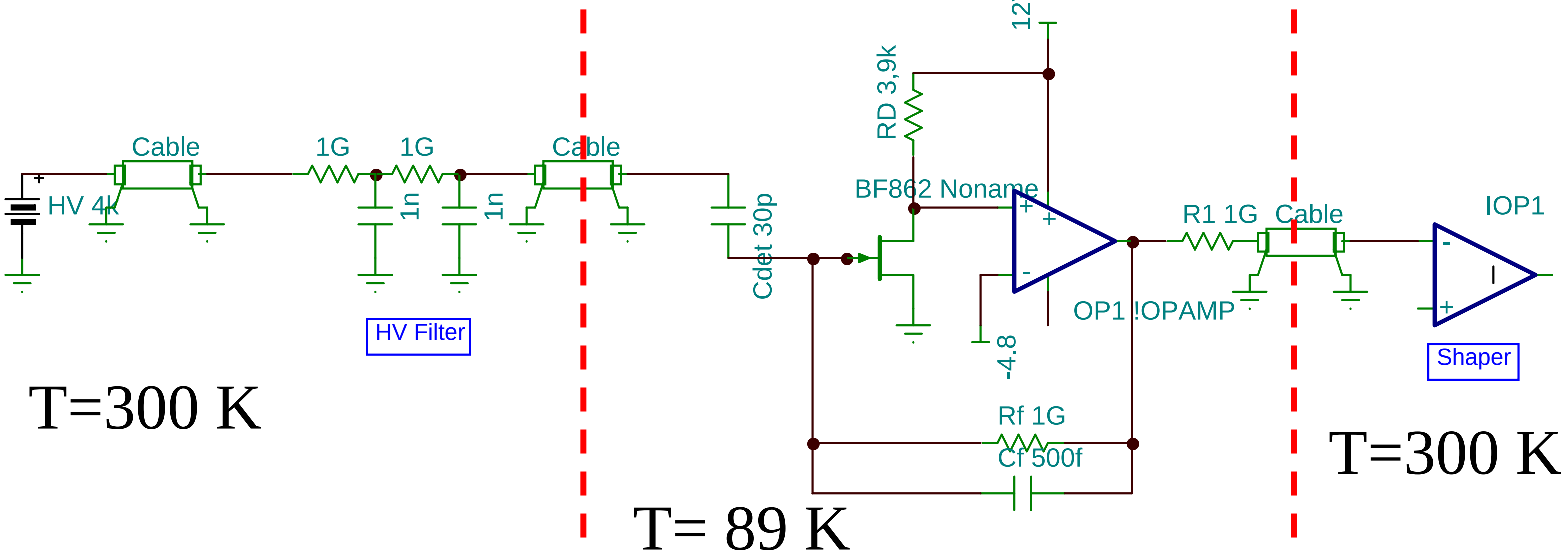


Signal: Kapton signal cable 50 W impedence at LAr (used in calorimetry)

Weight ~ 3 g/m

Assuming 10 mBq/kg (actual upper limit on γ- meas of Th and U on HV cable)→ 60 μBq from last meter of cable (nearest to electronic)

# Equivalent circuit adopted to polarize detector and CSA readout + Shaper/FADC



# Noise sources in the described chain

Electronic noise originate:

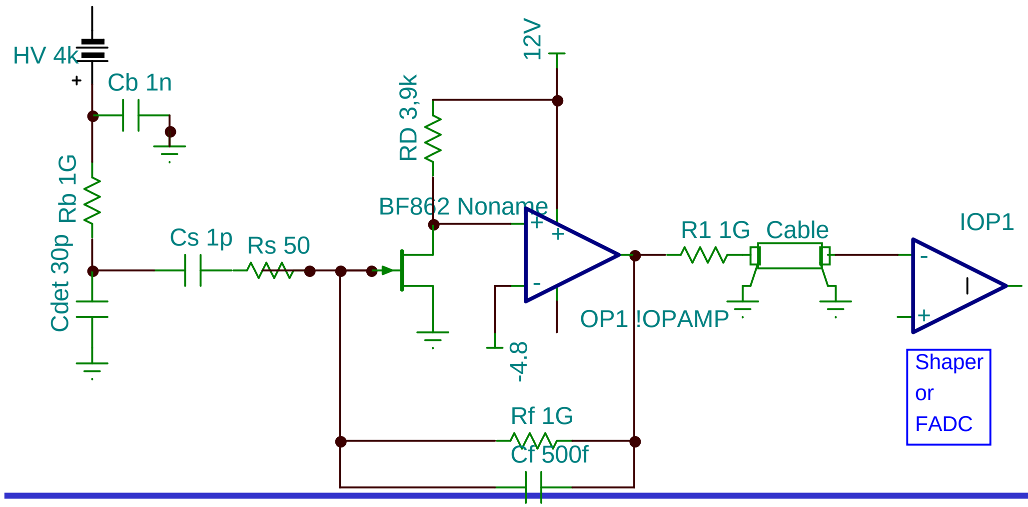
- in the detector→ parallel or shot noise
- In the series resistance→ serial noise
- in the bias resistor →
- 1/f noise

$$dPn/df \propto i^2_n = 2eI_d$$

$$e_n^2 = 4kTR_s$$

$$i_{nb}^2 = 4kT/R_b$$

$$e_{nf}^2 = A_f / f$$




+ eventually environmental noise

# .........going to numbers

$$(Q_n / e)^2 = (2eI_d + 4kT / Rb + i_{na}^2) F_i T_p +$$

$$(4kTR_s + e_{na}^2) F_v C^2 / T_p + F_{vf} A_f C^2$$

Parallel noise from detector LC

Parallel noise from bias R

$$(Q_n / e)^2 = 12[\frac{1}{nA \cdot ns}] I_d T_p + 6 \cdot 10^5 [\frac{k\Omega}{ns}] \frac{T_p}{R_b} +$$

$$3.6 \cdot 10^4 [\frac{ns}{pF^2 \cdot nV^2 / Hz}] e_n^2 \frac{C^2}{T_p}$$

# Measuring the intrinsic resolution of a CSA

1 MeV released in Ge correspond to 54 fC

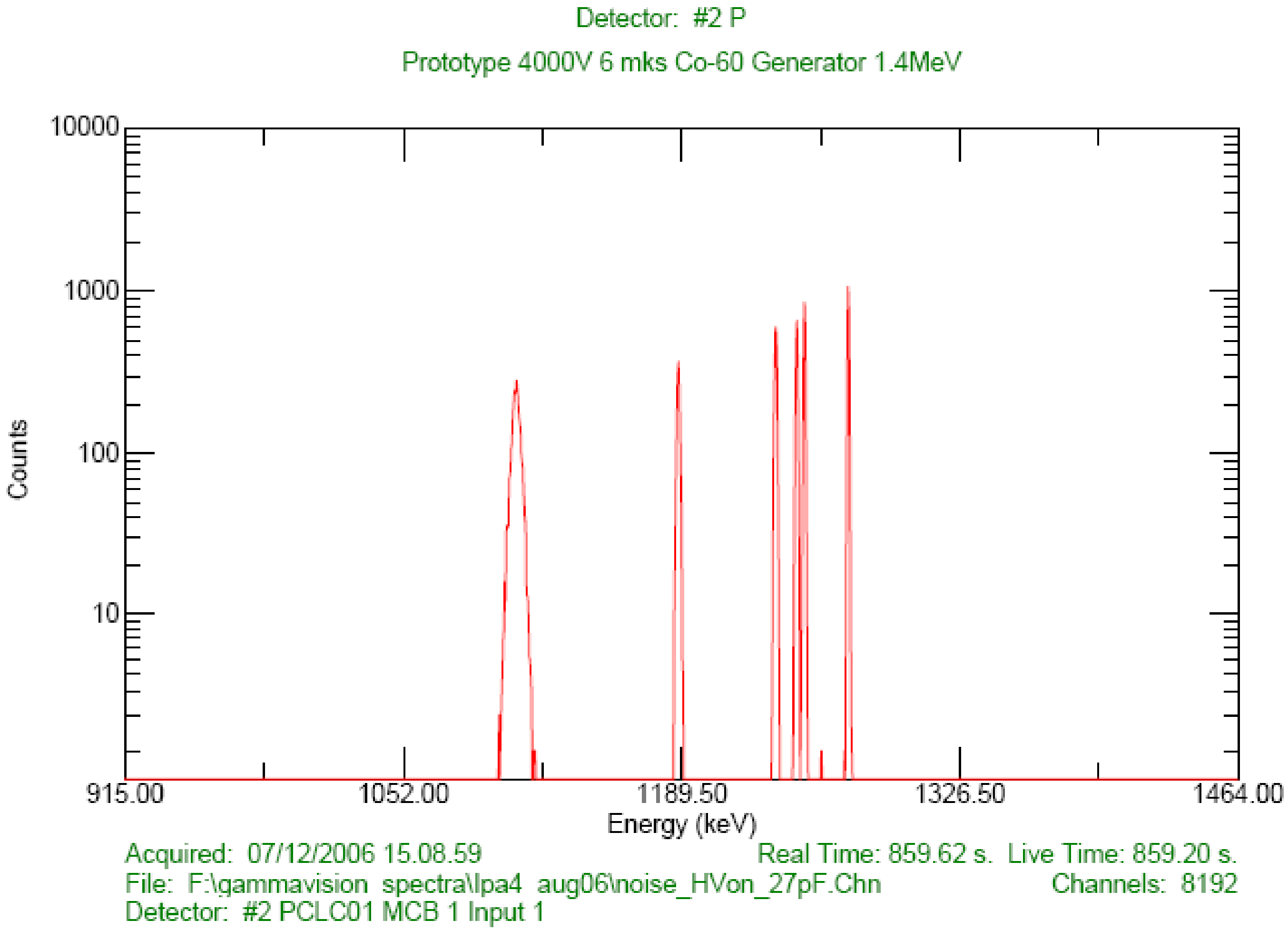
$$1MeV = (10^6 / 2.98)\ e^- = (10^6 / 2.98) \cdot 1.602 \cdot 10^{-19} C = 54\, fC$$

To inject the CSA → inject the corresponding charge into FET through the test capacitance (Test Input)

$$Q_{in} = V_{in} C_t \rightarrow\ for\, C_t = 0.5\, pF, Q_{in} = 54\, fC\ when \quad V_{in} = 108 mV$$

→ To know intrinsic R of the CSA inject with pulser equivalent charge of 1.3 MeV and see FWHM of the peak appearing in spectra

# Spectra obtained when doing intrinsic noise resolution: take position and FWHM of pulser line then do R



*July-August 2006 test*

• Before 28/07/2006: DSG crystal was working with Camberra warm CSA.

HV=4000 V

LC~ 500-600 pA -> R@ Co ~ 4.2 keV(Oleg confirm?)

• On 28/07/2006: Cold IPA4 preamp was mounted.

Measurement of noise with capacitors

Crystal connected

HV=4000 V, LC~ 5000 pA

Then reduce HV on crystal

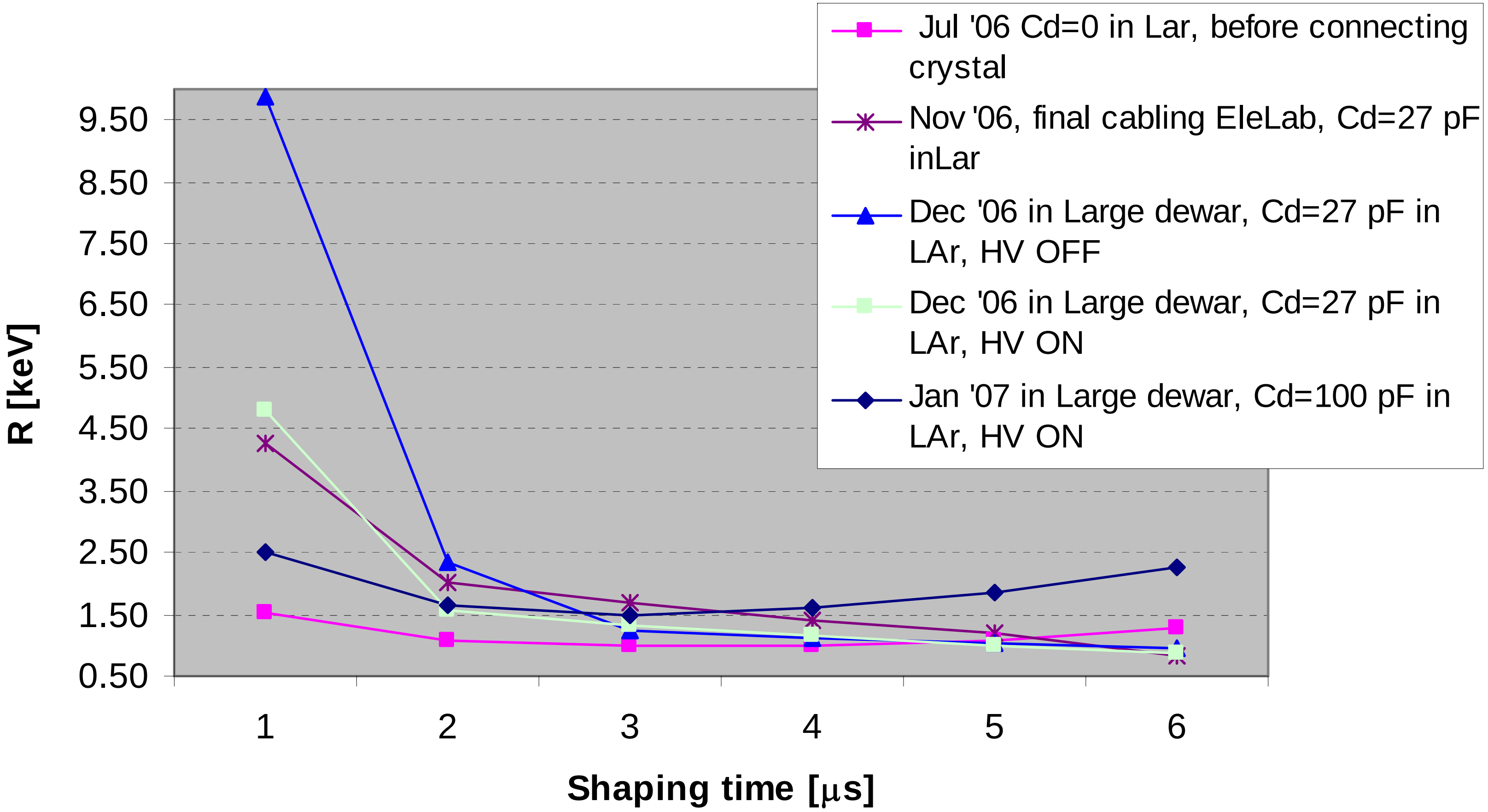
HV=3000 V →R@ Co ~ 7 keV, R@Pulser = 6 keV

• On 28/07/2006 put back warm preamp but current high, noise, Crystal send to Camberra for reprocessing of dead layer

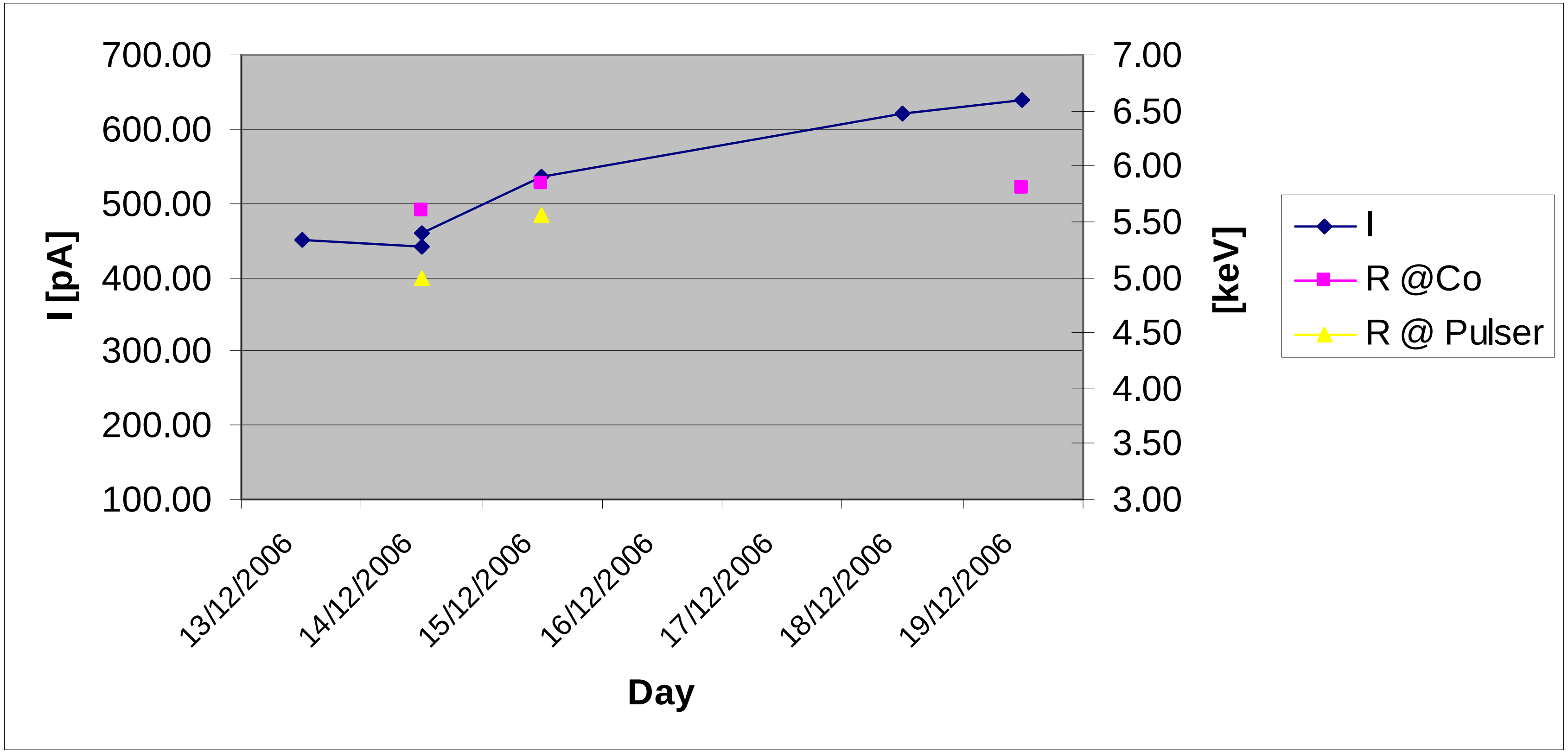
# December 2006- January 2007 test

- Test of HV connector, cable filter without crystal
- Intrinsic resolution of the full chain measured with capacitor (cabling, mounting as with crsytal)
- 13/12/2006 Crystal connected to preamp mounted on cross

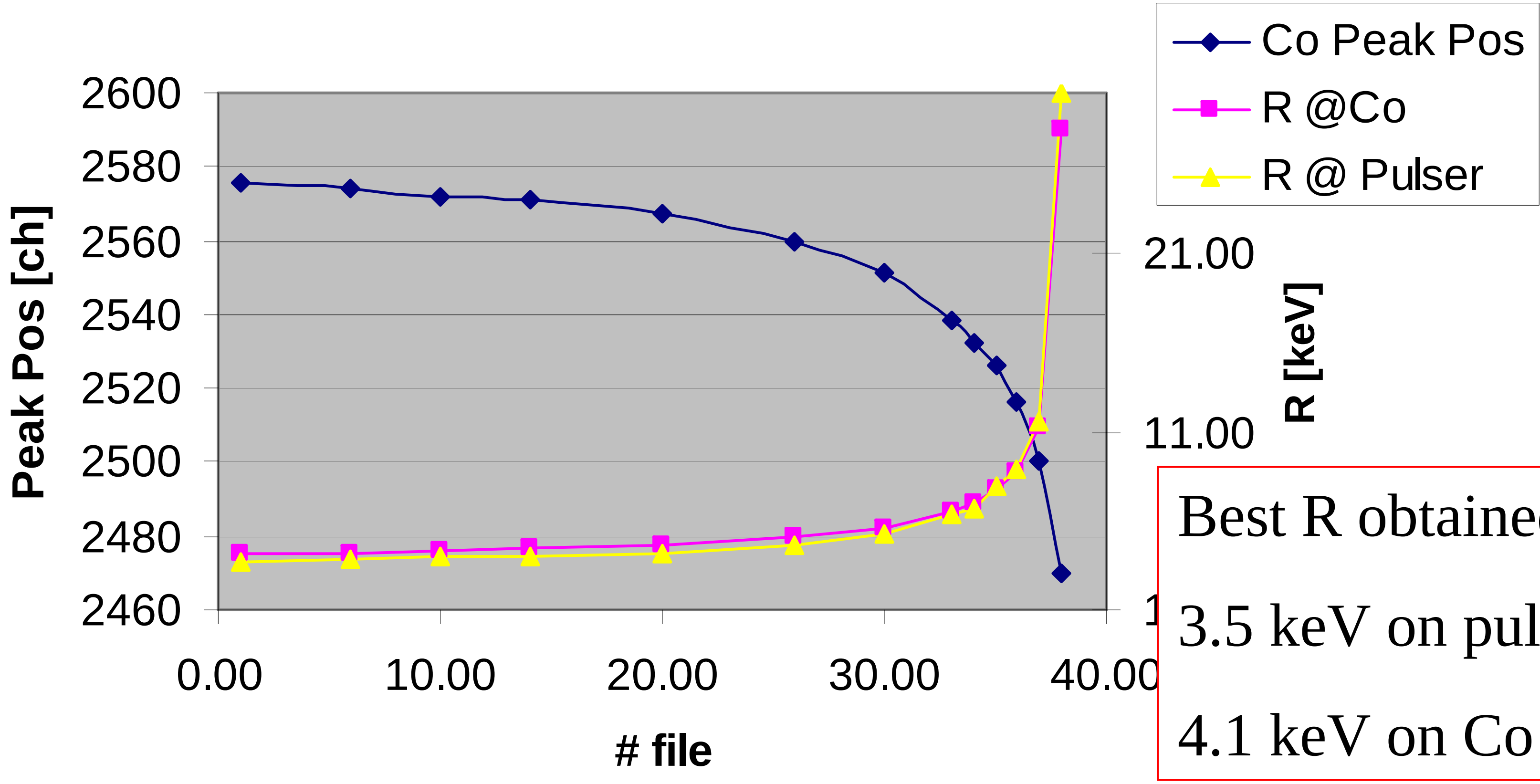
# Intrinsic Resolution of IPA4 cold CSA



# Trend of meas LC and R of DSG crystal vs time @ 4000V December 2006



# Co peak Pos and R from 22/12/2006 to 29/12/2006

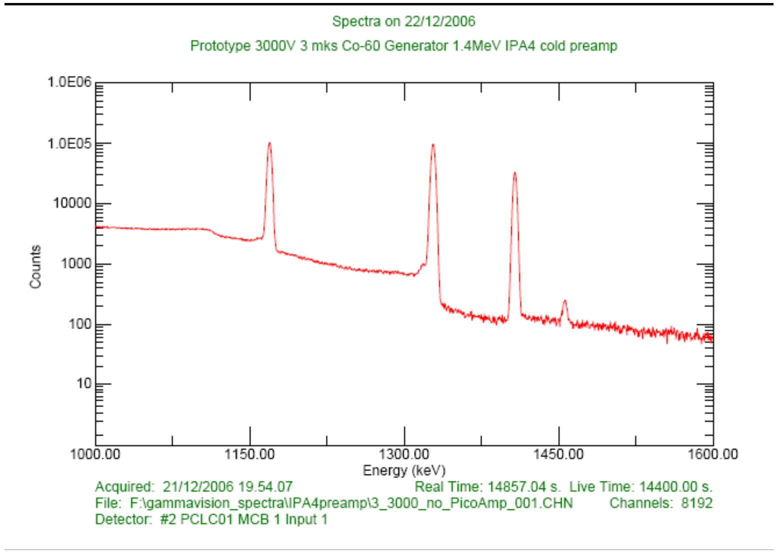


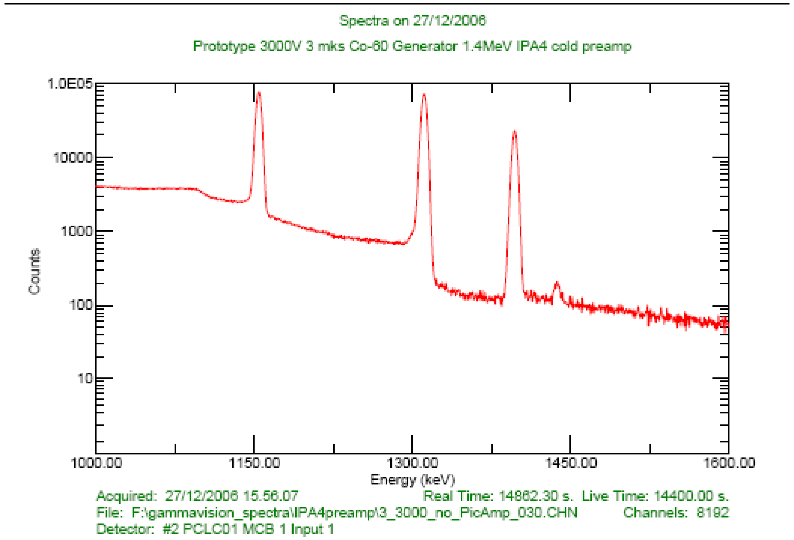

Best R obtained

3.5 keV on pulser

4.1 keV on Co line

1 file = 4 hours


Spectra on 22/12/2006
Prototype 3000V 3 mks Co-60 Generator 1.4MeV IPA4 cold preamp
1.0E06
1.0E05
10000
1000
100
10
Counts
1000.00
1150.00
1300.00
1450.00
1600.00
Energy (keV)
Acquired: 21/12/2006 19.54.07
Real Time: 14857.04 s. Live Time: 14400.00 s.
File: F:\gammavision_spectra\IPA4preamp\3_3000_no_PicoAmp_001.CHN
Channels: 8192
Detector: #2 PCLC01 MCB 1 Input 1


Spectra on 27/12/2006
Prototype 3000V 3 mks Co-60 Generator 1.4MeV IPA4 cold preamp
1.0E05
10000
1000
100
10
Counts
1000.00
1150.00
1300.00
1450.00
1600.00
Energy (keV)
Acquired: 27/12/2006 15.56.07
Real Time: 14862.30 s. Live Time: 14400.00 s.
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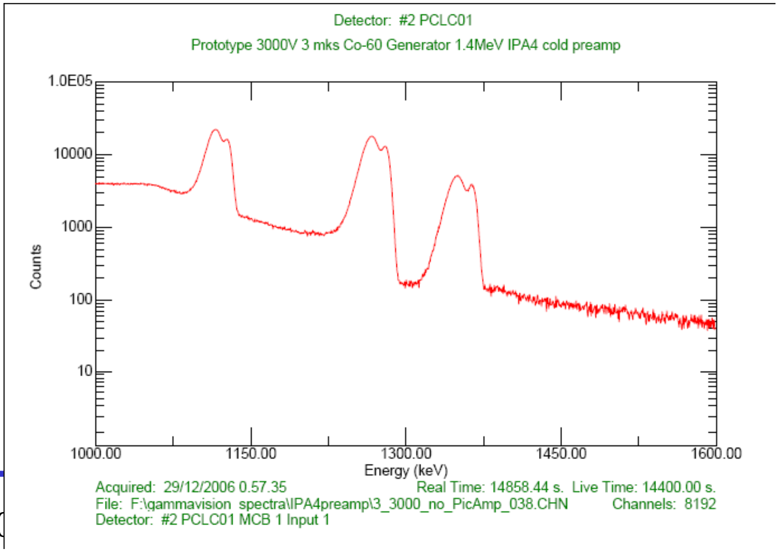
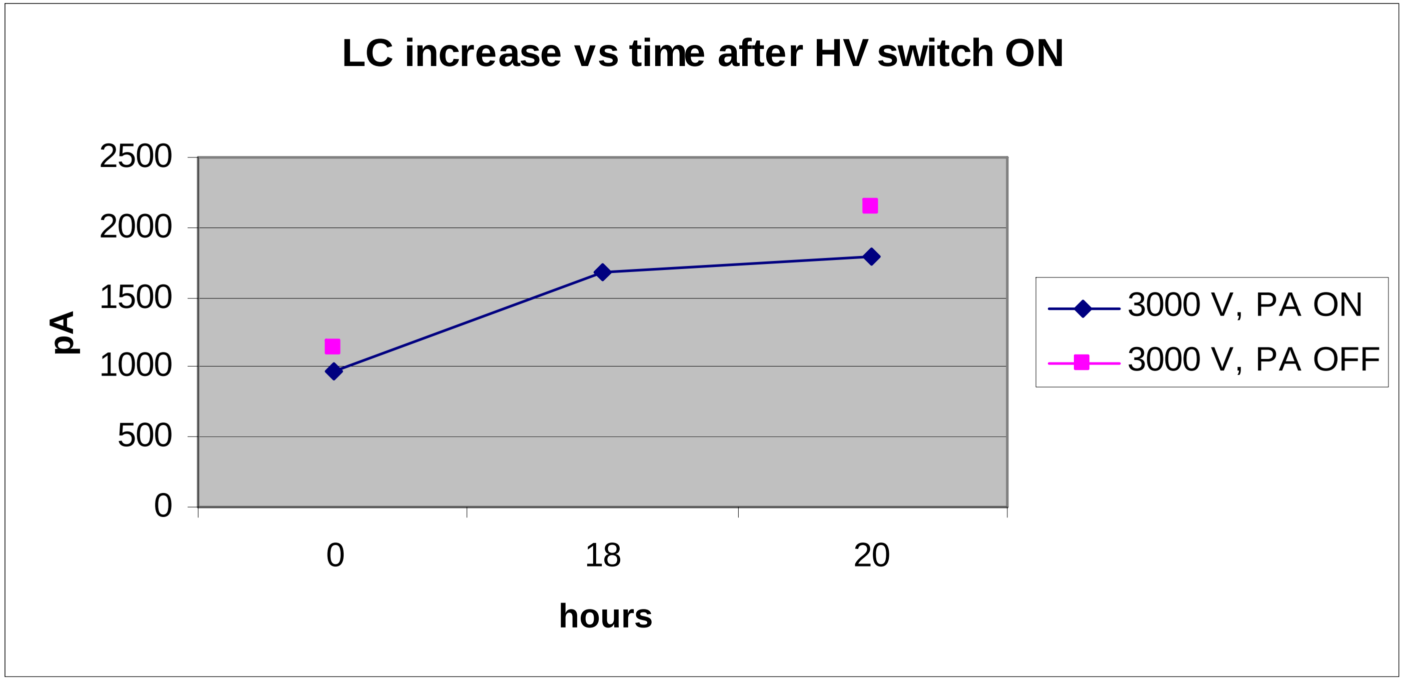
Channels: 8192
Detector: #2 PCLC01 MCB 1 Input 1

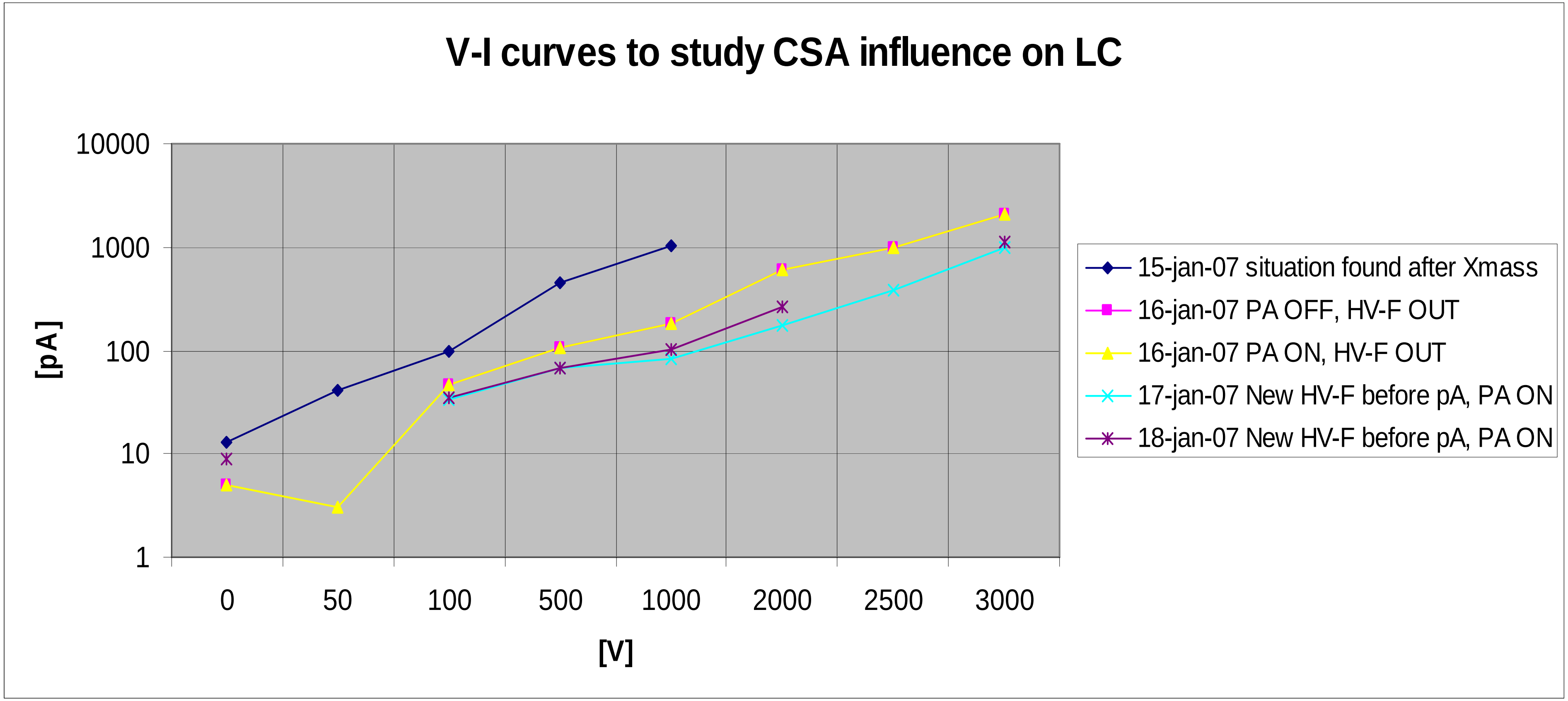

Detector: #2 PCLC01
Prototype 3000V 3 mks Co-60 Generator 1.4MeV IPA4 cold preamp
1.0E05
10000
1000
100
10
Counts
1000.00
1150.00
1300.00
1450.00
1600.00
Energy (keV)
Acquired: 29/12/2006 0.57.35
Real Time: 14858.44 s. Live Time: 14400.00 s.
File: F:\gammavision spectra\IPA4preamp\3_3000_no_PicAmp_038.CHN
Channels: 8192
Detector: #2 PCLC01 MCB 1 Input 1

# Test performed in January to study influence of cold CSA on the observed LC.

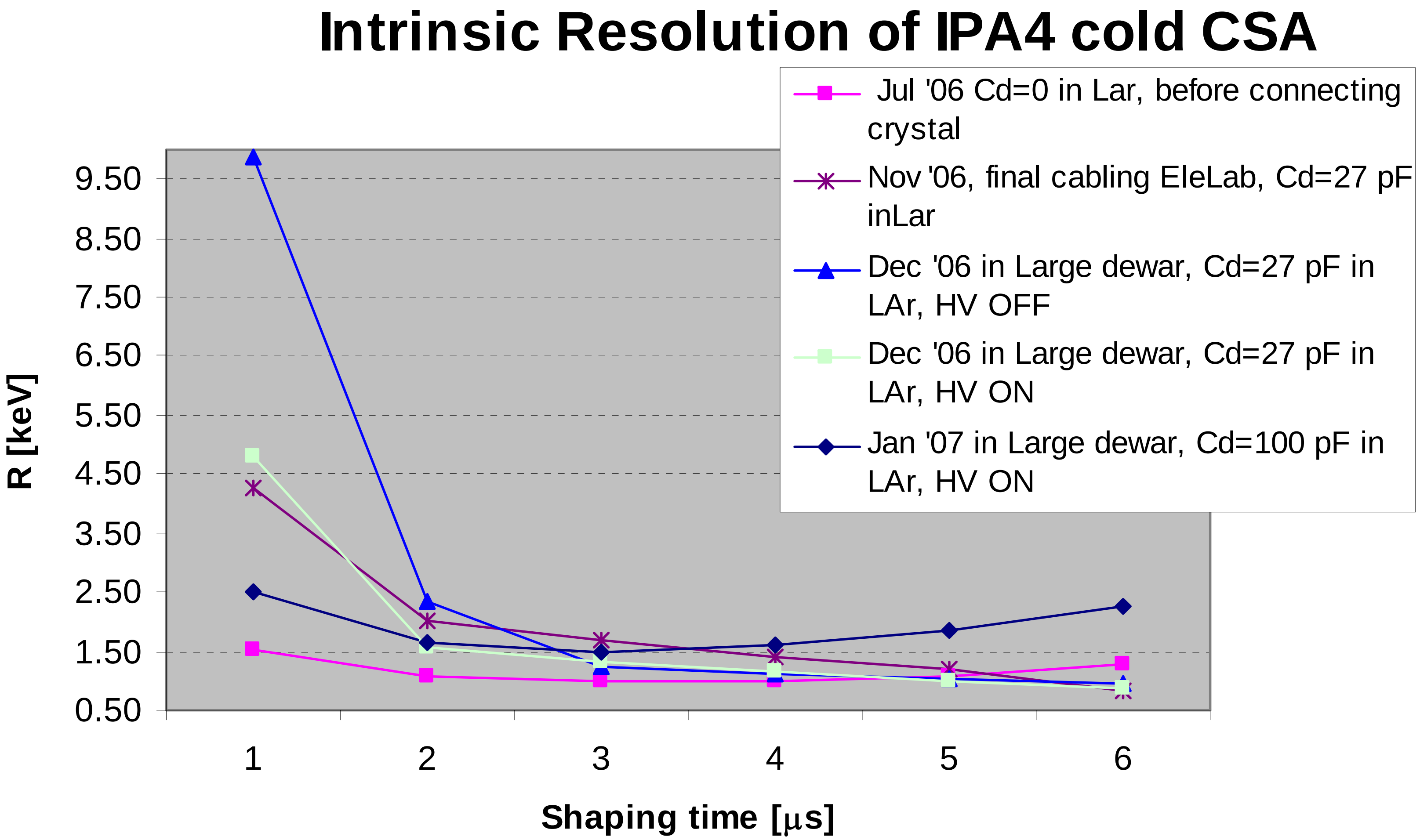
Survey and Compare LC with PA On and OFF



# Study of the influence of cold CSA and HV filter on observed LC

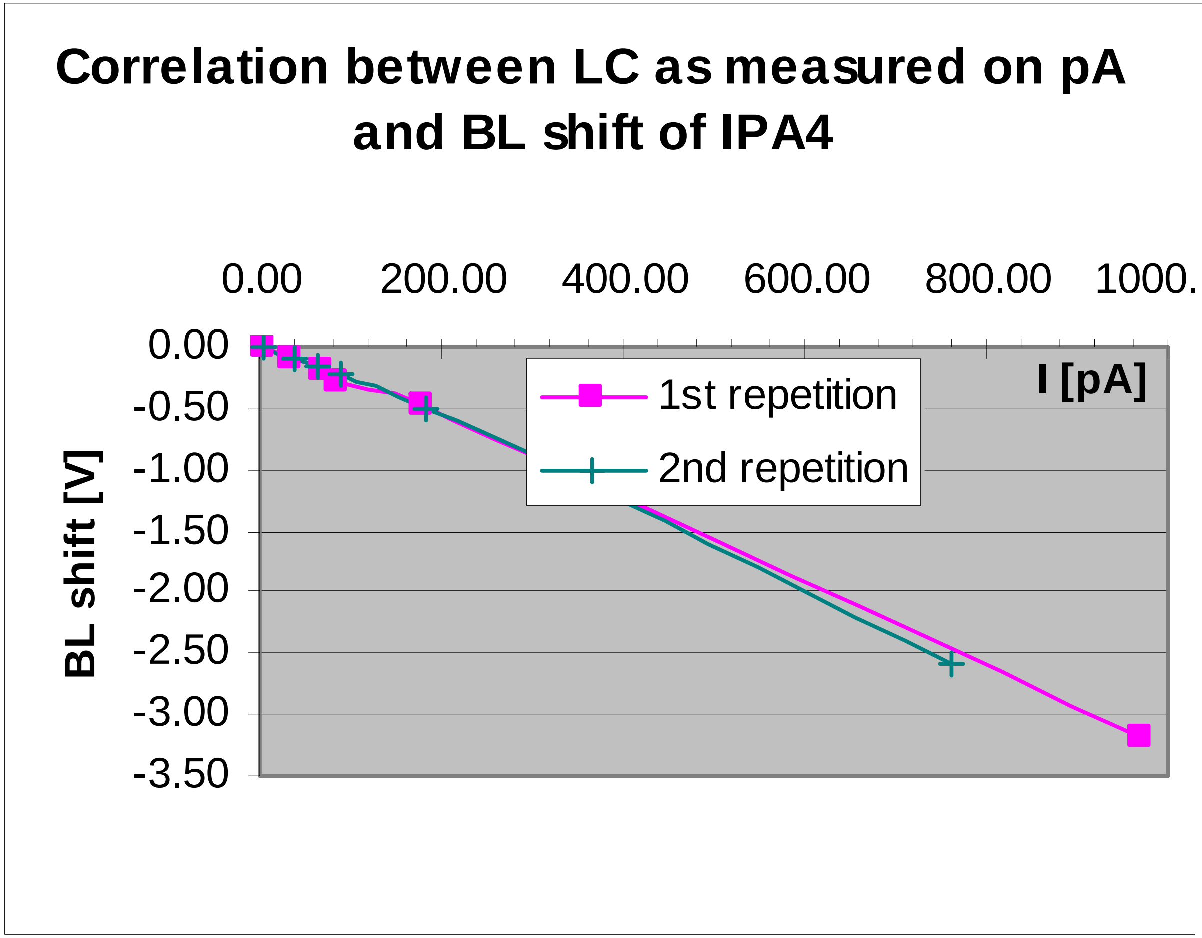


# ……last test to do: remove Crystal and test CSA cabled with HV C to simulate crystal




→ Intrinsic noise of the PA is found to be consistent with the previous measurements, and properly scales with Cd

# To measure crystal LC monitor the BL level shift




Problem:

$I_{(\text{BL shift of IPA4})} / I_{\text{pA}} = 3 \div 4$.

This possible only if

Rf @89K= 3 ÷ 4 nominal value. Unconsistent with measured pulse reset time (800 ms). Need further check.

# Comparison of measured resolution with measured LC

- Starting from the mentioned formula,1 nA LC lead to a R degradation of 1.9 keV.
- R obtained never better than 4.1 keV (Co), and 3.5 keV (Pulser). R unconsistent with LC (300-400 pA)

→ noise pick up (observed noise at the scope@ 3 μs, not able to remove, but this noise is not present with Capacitor test with same cabling LV and HV PS, same mounting, same dewar… )

$$(Q_n / e)^2 = 12[\frac{1}{nA \cdot ns}] I_d T_p$$

= 1.9 keV for $I_d$=1 nA

# Conclusion

- IPA4 chip and CSA mounted around it are robust, never failed after >10 termic cycles. Bonding wire of the chip never break, PCB and chhosen components OK.
- Two test done connecting it with crystal, but high LC appeared both times
- Cold circuit connection not responsible for the increase of LC in crystal
- Measured resolution limited by LC (parallel noise) and HF noise observed

Open issues

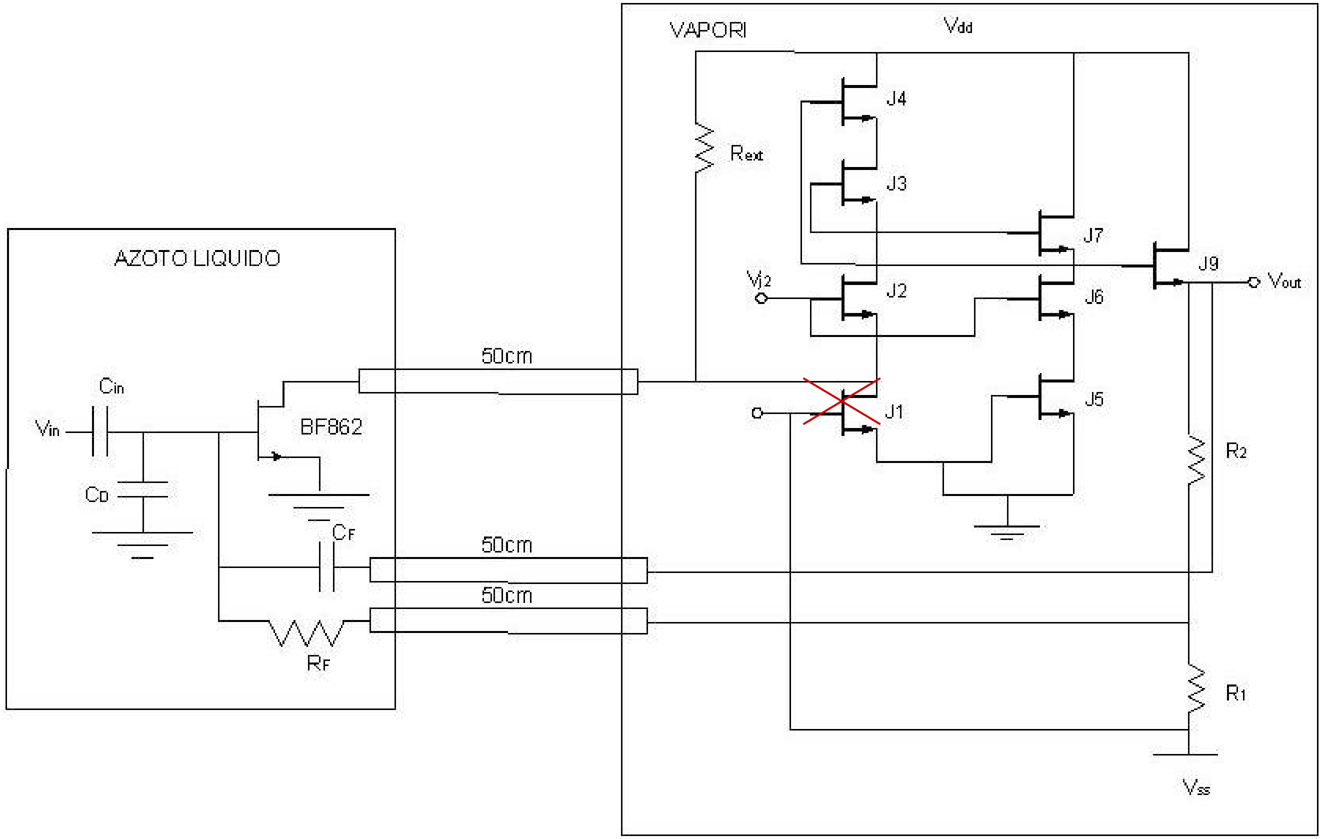
Dedicated test bench to test electronic to reduce handling on crystal

Source of HF noise

# The IPA4 N-JFET monolithic preamplifier

| | |
|---|---|
| Sensitivity | ~ 2 V/pC with $C_f$ = 0.5 pF → 108 mV/1 MeV in Ge |
| A(f) | 75 dB – 60 dB (depending on the adopted configuration) |
| $g_m^{J1}$ | 9.7 mA/V |
| W,L of J1 | 1820 μm, 15 μm |
| $S_f$ of J1 | 1.52 nV/Hz$^{1/2}$ |
| $C_i$ | 9 pF |
| $\tau_r$ | 400 ns with $C_f$ = 0.5 pF |
| Output | Single ended. Do not drive 50 Ω load. |
| Power consumption | ~ 100 mW |
| Polarity | positive and Negative |
| V+,V- | +12 V, -4.8 V |

# IPA4+external FET BF862: J1 ($g_m$= 9.7 mA/V) is blocked and substituted by external BF862 ($g_m$= 30 mA/V which can be kept at 0- 60 cm from the CSA amplifying circuit

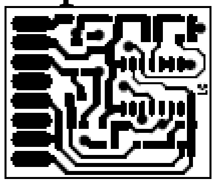



IMPORTANT: With this modification $\tau_f$ ~ 50-60 ns in LAr

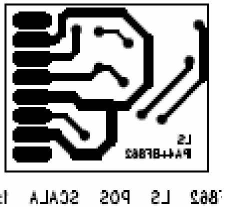
External FET can be put on same or separate PCB

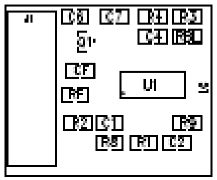
# Production of 25 FE cryogenics circuits (based on IPA4 JFET monolithic circuit) for LNGS Phase I detector tests and MU 18 fold segmented prototype

Production of PCB: 23 june at AREL, without 100 Ω output stage. PCB in DICLAD 880, 0.25 mm thick. Can be done in Kapton o

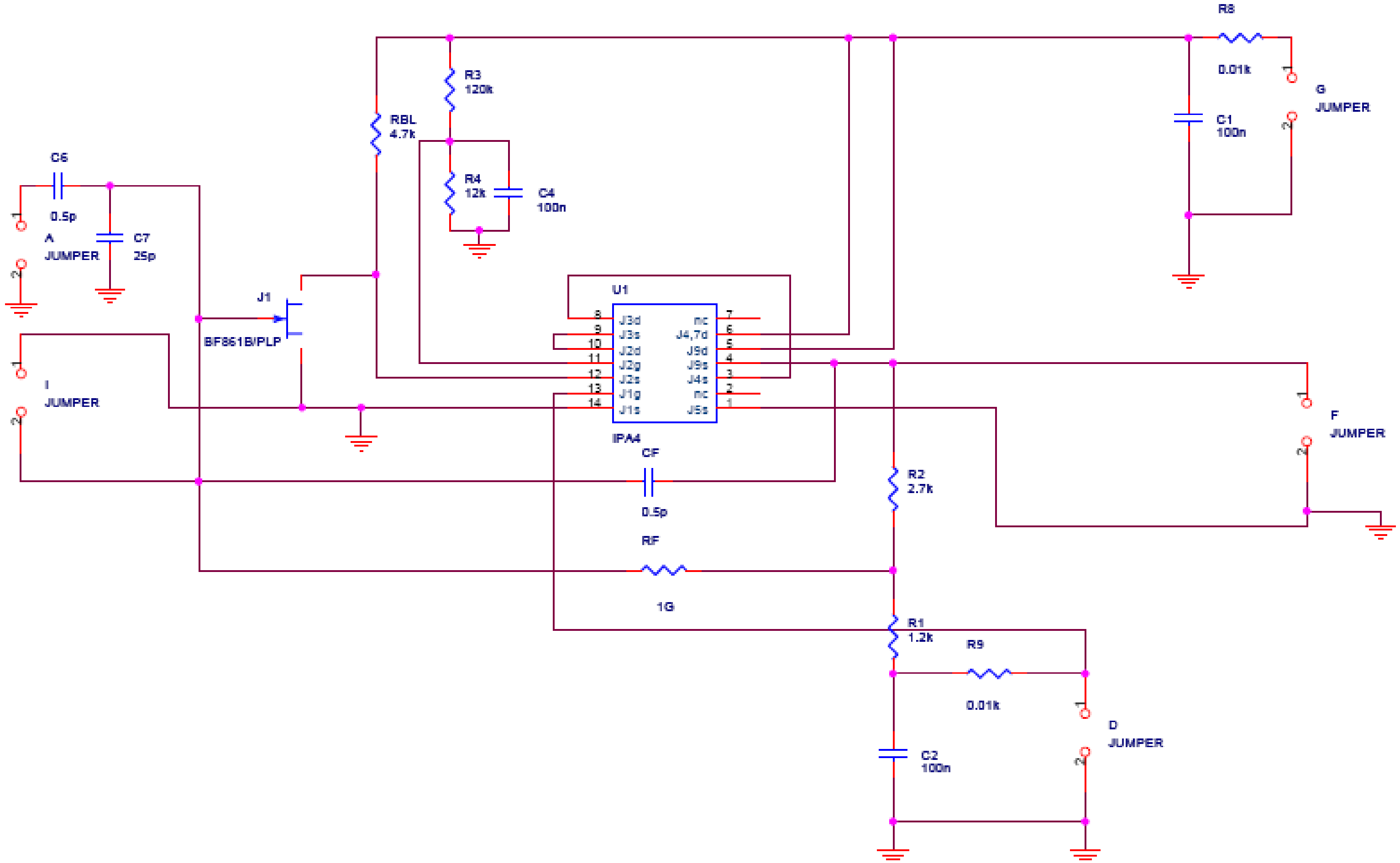


IPA4+BF862 LC POS SCALA 1:1 08,



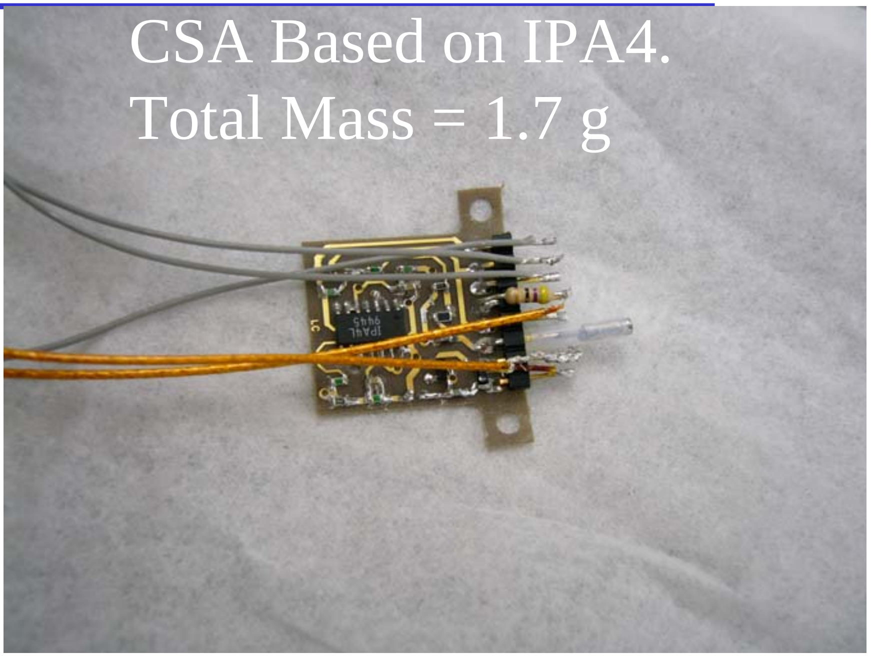



IPA4+BF862 LC POS SCALA 1:1 08



# The tested CSA

- PCB: DICLAD 880 0.25mm thick (MPCB= 0.57 g)
- IPA4 Chip in plastic SOIC14 case (MIPA4= 0.13 g)
- 9 HF pins for HF connection (Mpins = 0.45 g)



# July – August 2006 tests: Intrinsic resolution of IPA4 CSA mounted on copper cross suspension with cabling etc.

- Measuring conditions as with crystal connected
  - HV off
  - Crystal disconnected
  - CSA connected to flange through cables (70 cm long)
  - PSA (semi-Gaussion ORTEC mod. 572) + ADC +MCA
  - Vin= 80 fC = 1.4 MeV

| Shaping time [μs] | FWHM | | E |
|---|---|---|---|
| | [keV] | Rel [%] | |
| 0.5 | 1.51 | 0.121 | 1244.85 |
| 1.0 | 1.07 | 0.08 | 1337.6 |
| 2 | 0.98 | 0.07 | 1392.85 |
| 3 | 1 | 0.071 | 1404.72 |
| 6 | 1.07 | 0.076 | 1411.17 |
| 10 | 1.2 | 0.089 | 1439.03 |

Conclusion: Minimun of ENC found at 3 μs for CD = 27 pF, FWHM = 1 keV @ 1.404 MeV → agreement with previous measurements