Cold FE for prototype crystal operation at LARGE

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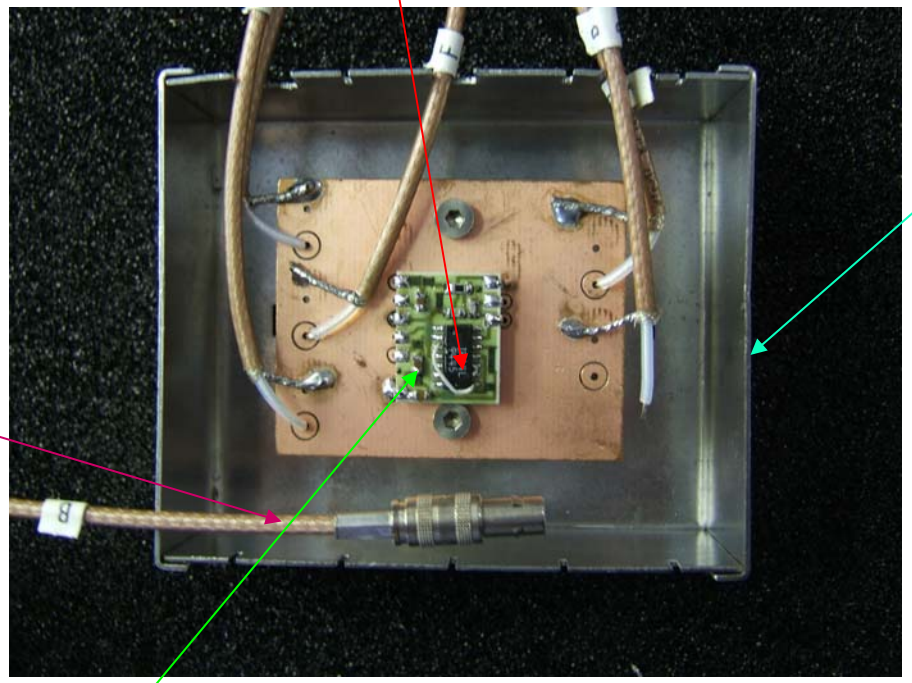
The IPA4 N-JFET monolithic preamplifier

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
τ_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, -6 V

The monolithic N-JFET preamplifier

Developed in the ’90s in a joint reasearch project between BNL, Italian MURST and INFN, for LAr, LKr calorimetry.

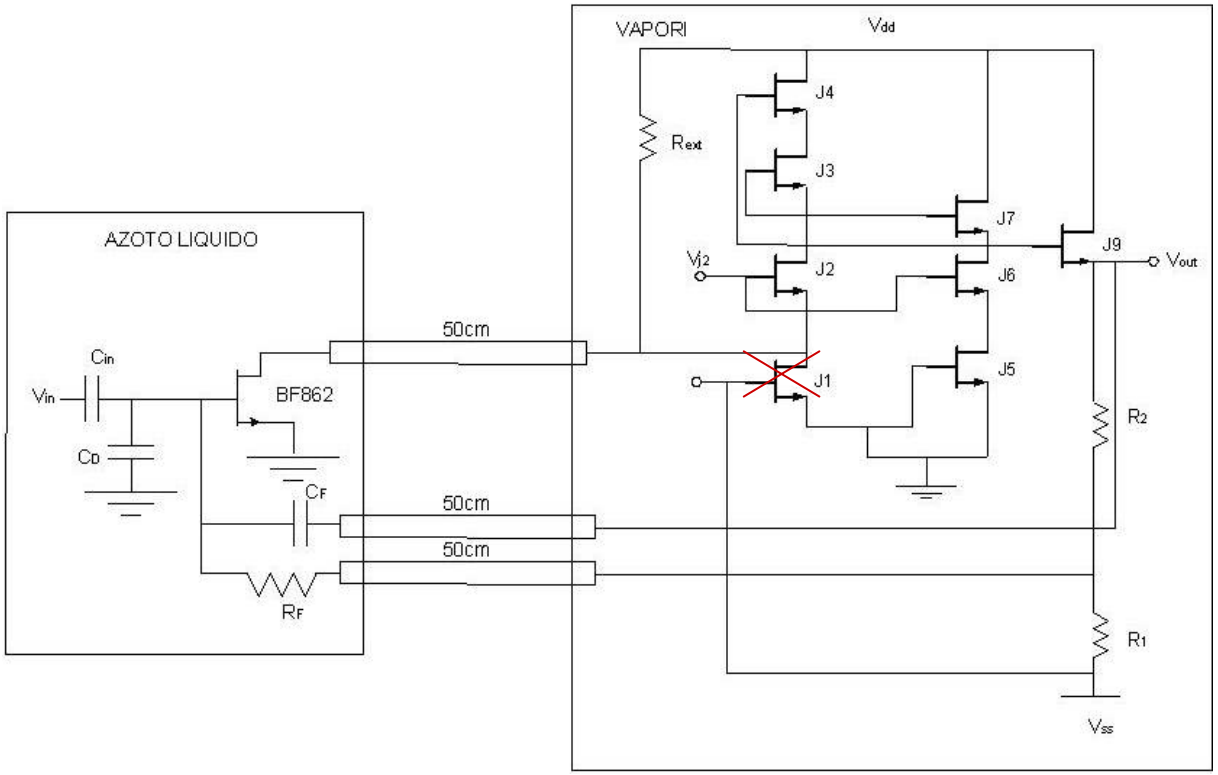


RG316 50 Ω cable

Shielding box

The IPA4 polarization circuit.
V. Re, co-author of the IPA4 circuit, provided us several IPA4 chip in SOIC plastic case + 1 polarization board, and several useful discussions.

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



Comparison of pulse fall time for IPA4 with internal and external FET.

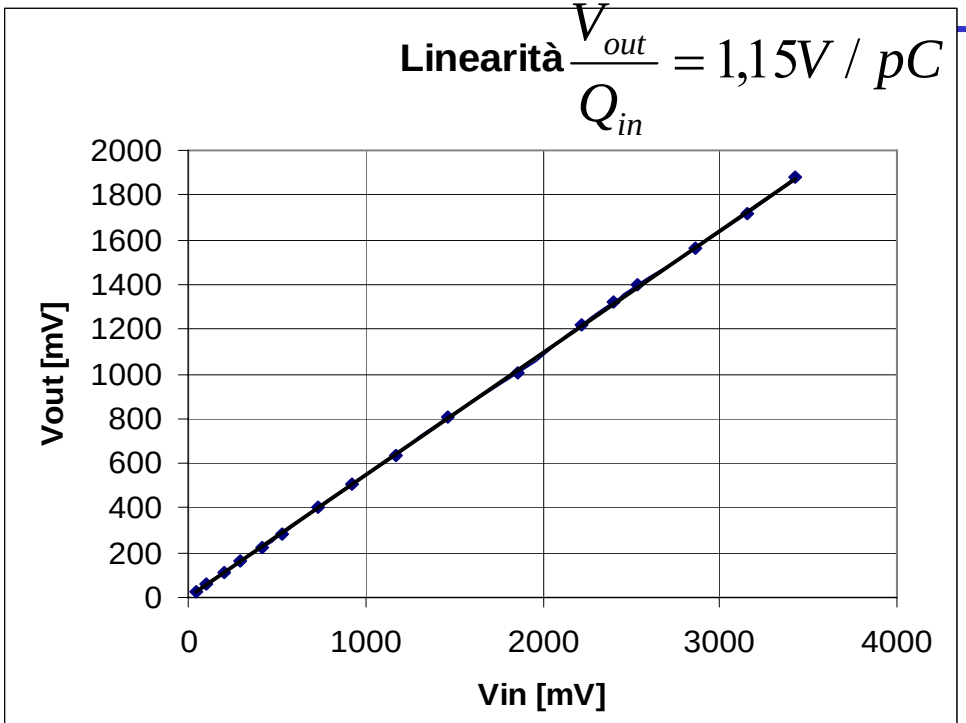
CD [pF]	τf [ns] (BF862)	τf [ns] (J1)
0	27	110
15	36	140
27	44	155

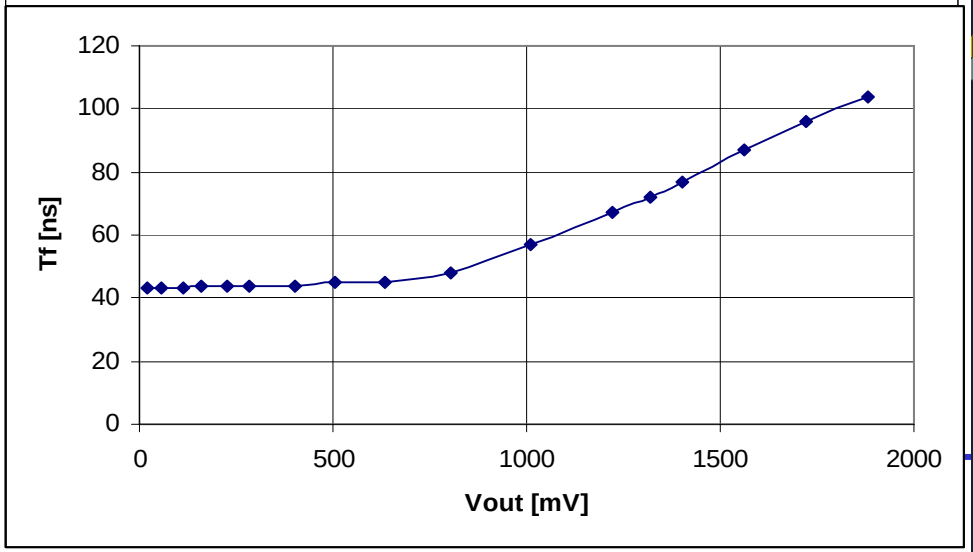
$$\tau_f = C_T \frac{C}{C_F \times g_m}$$

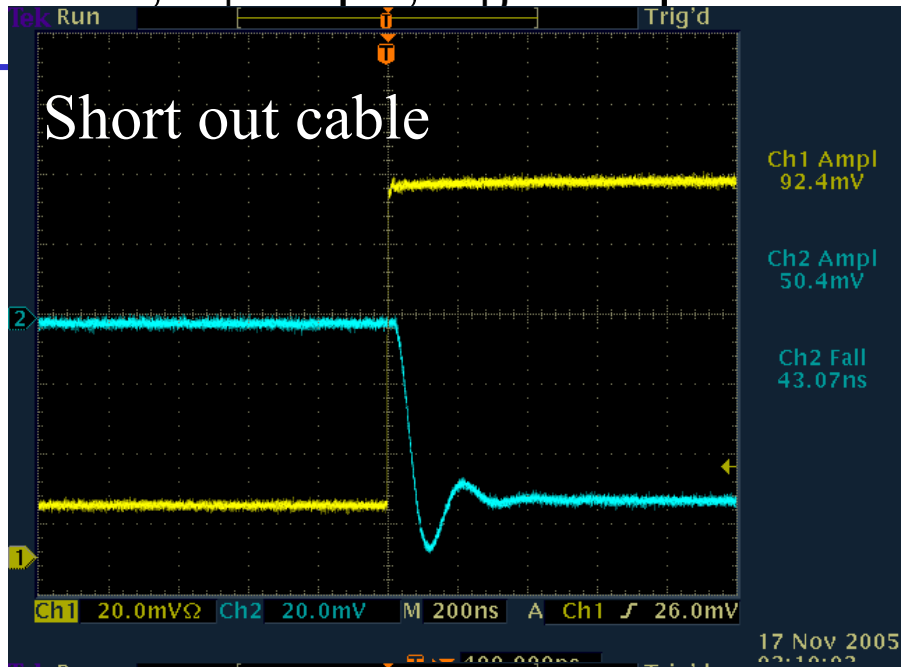
g_m J1 (I_{ds}~ 2.6 mA)= 9.7 mS

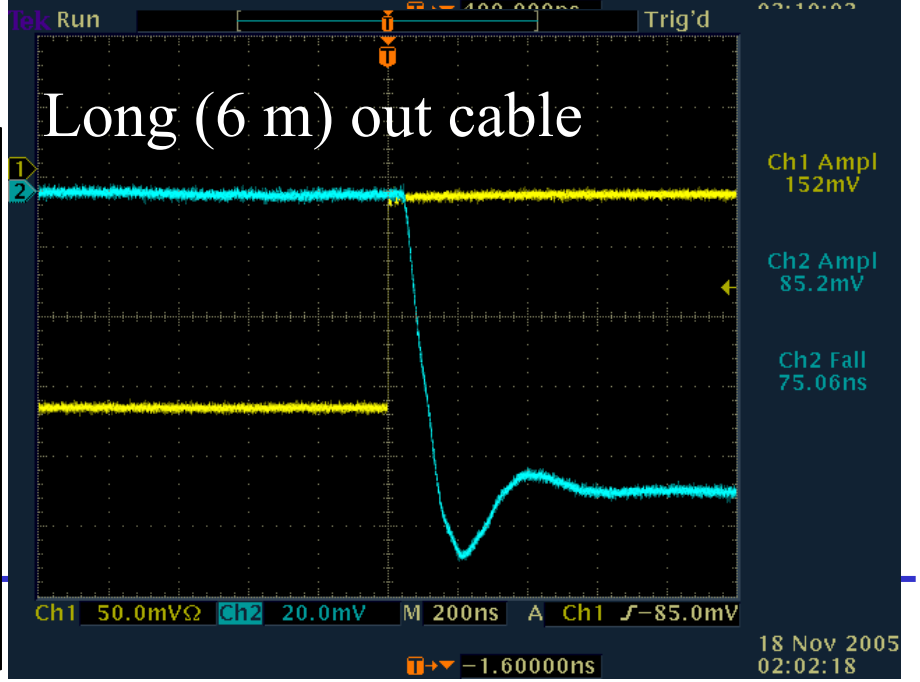
g_m BF862 (I_{ds}~ 3 mA)= 30 mS

IPA4+external FET BF862 @ 300 K, C_f = 1pF, C_D = 27 pF



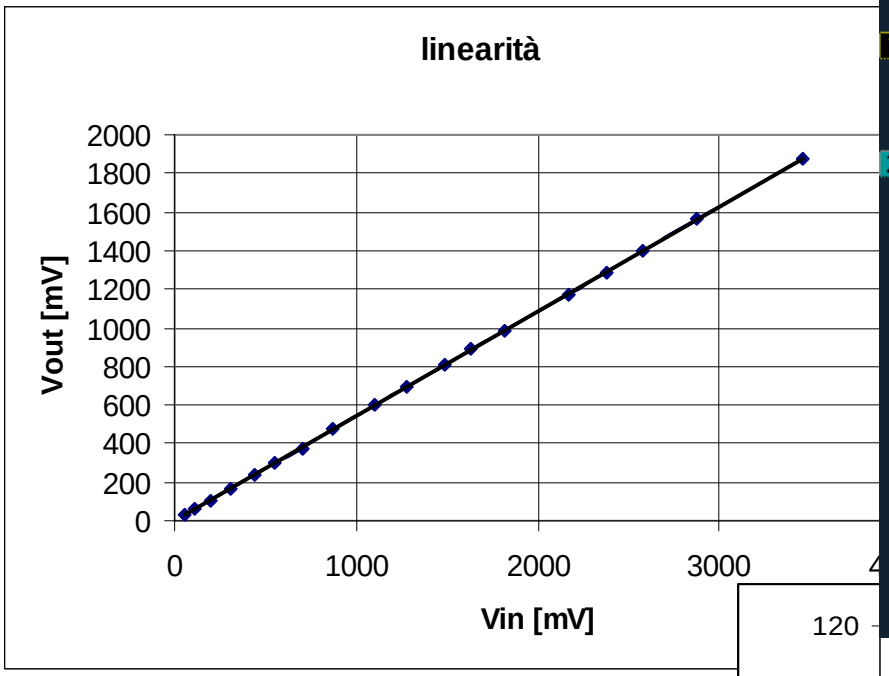


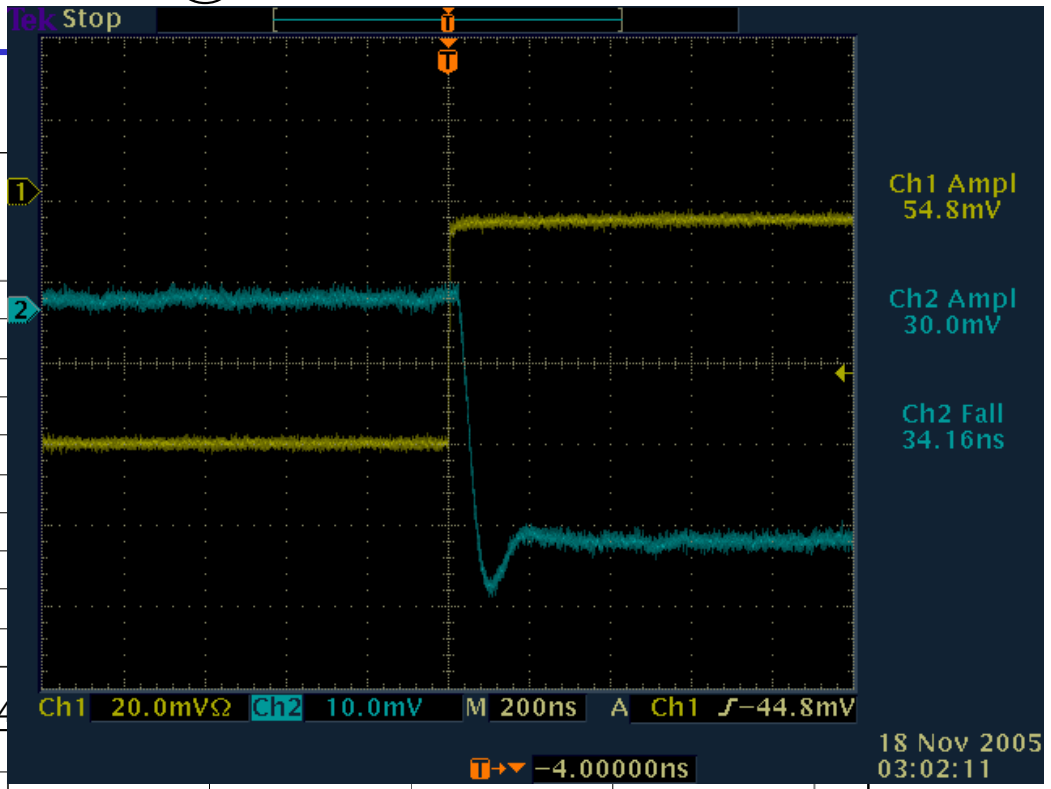




$\frac{V_{out}}{Q_{in}} = 1{,}155V / pC$

IPA4+BF862 @ LN





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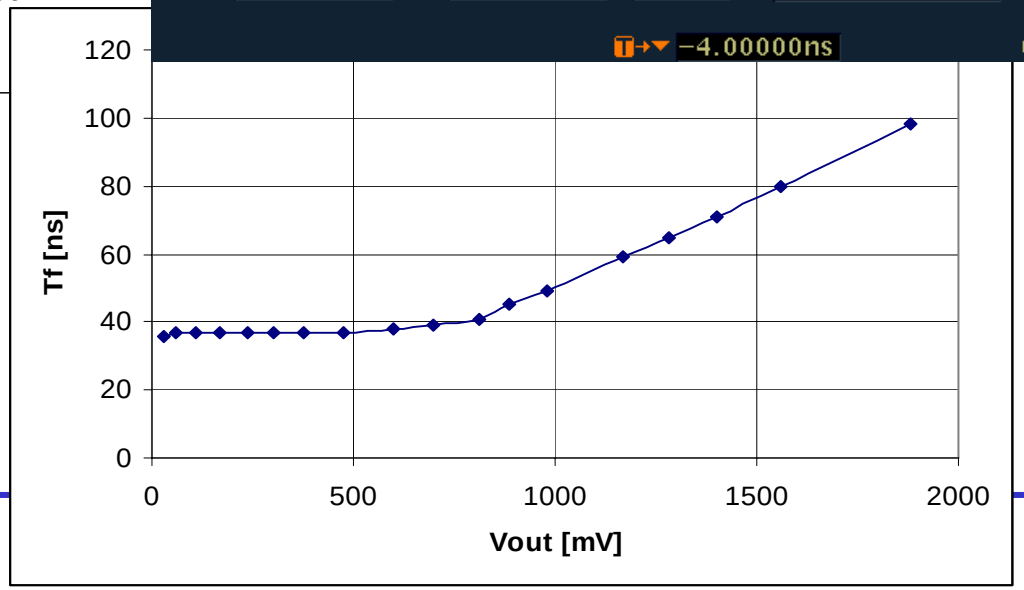
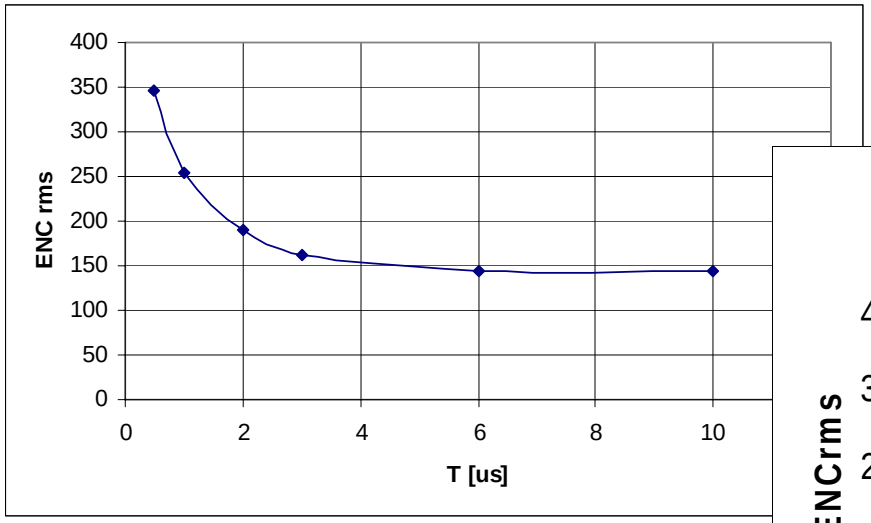
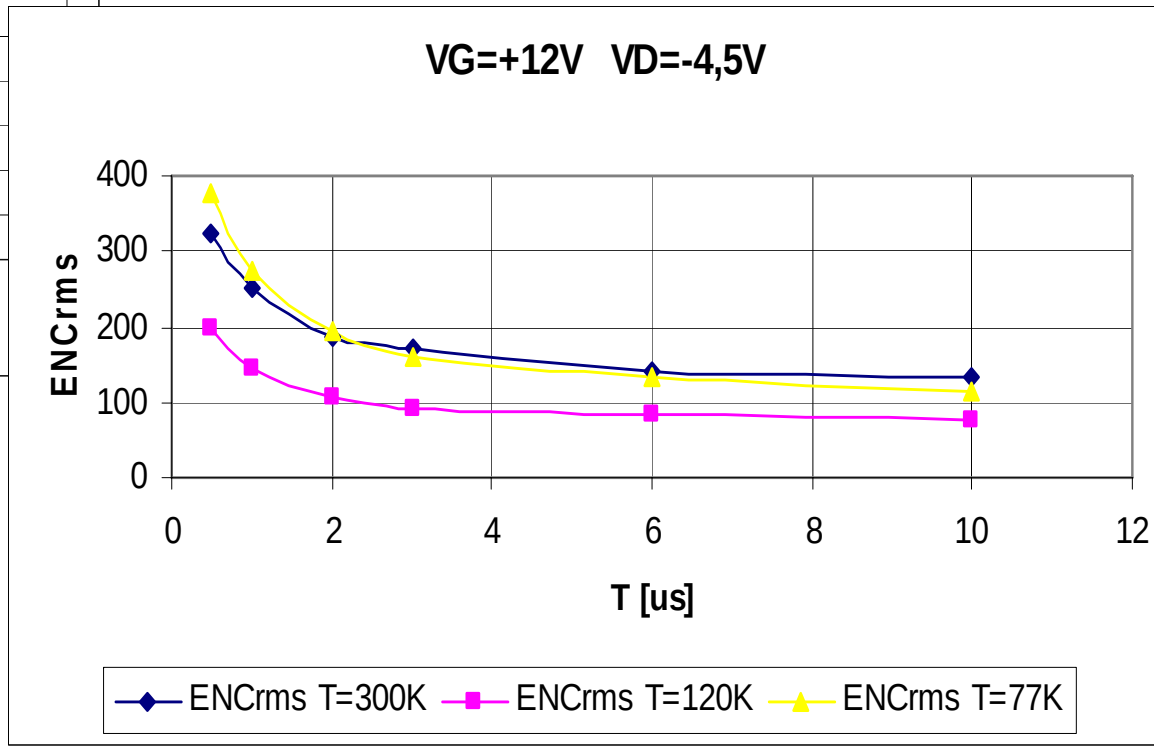


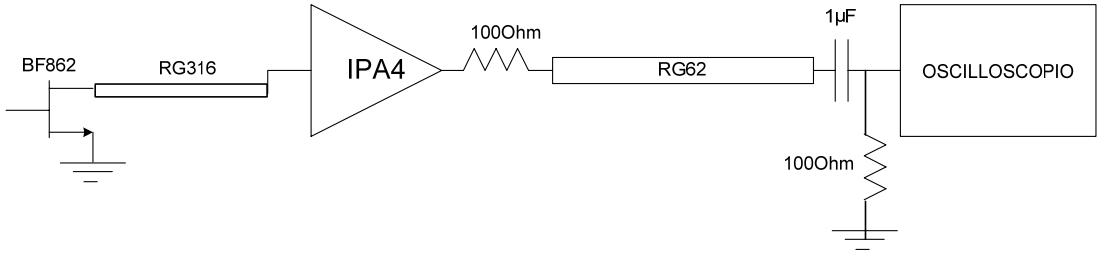
IPA4+BF862$_{ext}$ @ LN

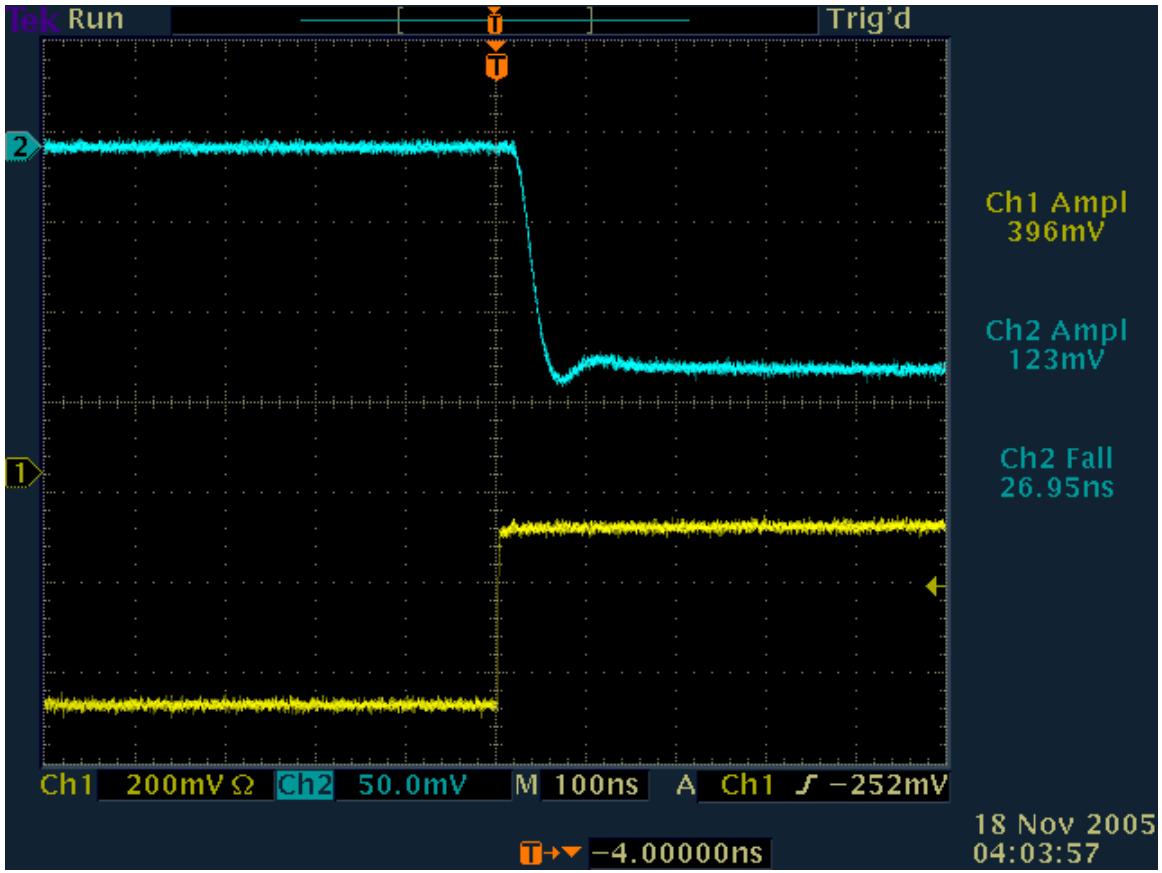


IPA4+J1$_{int}$@LN

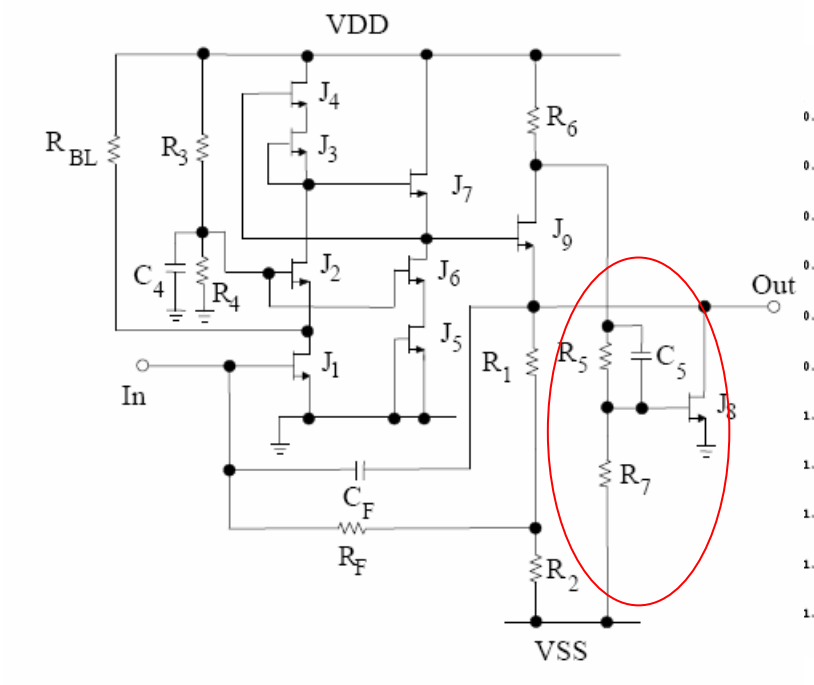


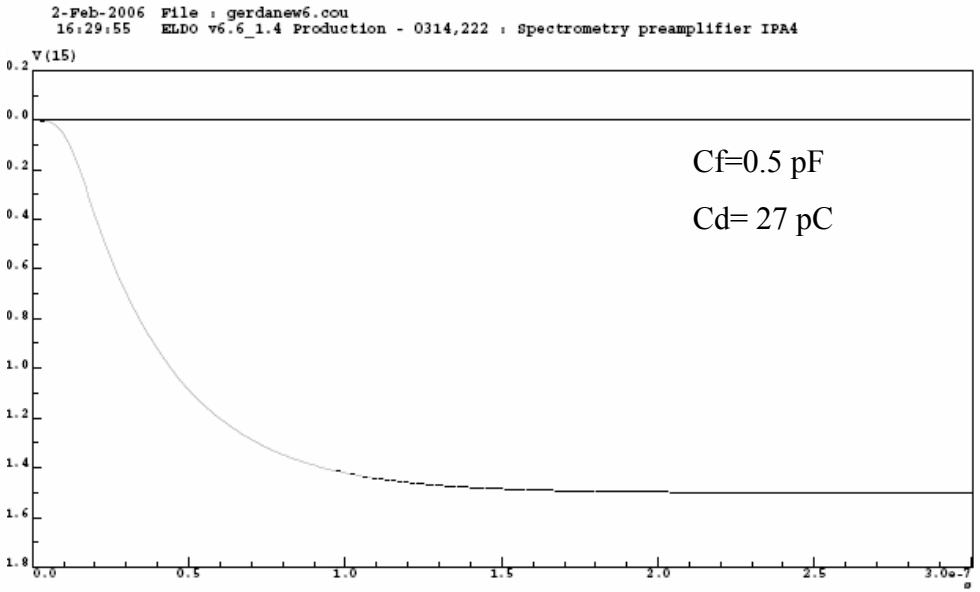
IPA4+external FET BF862 @ 300 K: adapted to 100 Ohm





IPA4 + $J1_{ext}$ + 100 Out stage: simulated pulse 50 ns fall time (@ 300 K).



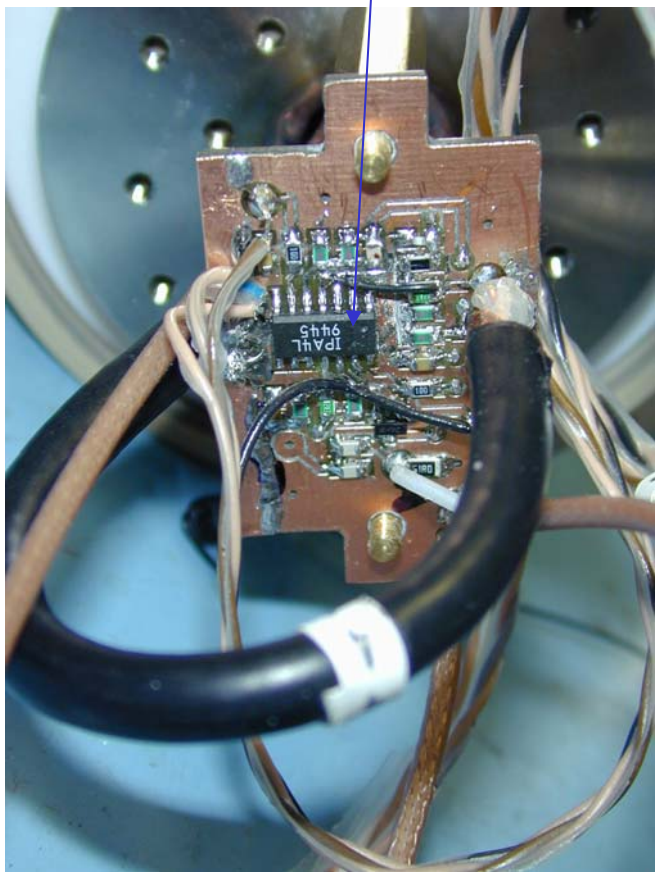


Swing to -1.5 V

IPA4 + $J1_{ext}$ + 100 Ω Out stage: the new test board.

Results: Obtained pulse shape not as expected, 2 slopes

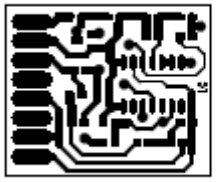
New setup for LN measurements



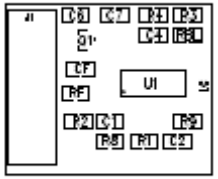
Production of 25 FE cryogenics circuits (based on IPA4 JFET monolithic circuit) for LNGS Phase I detector tests and MU

18 fold segmented prototype

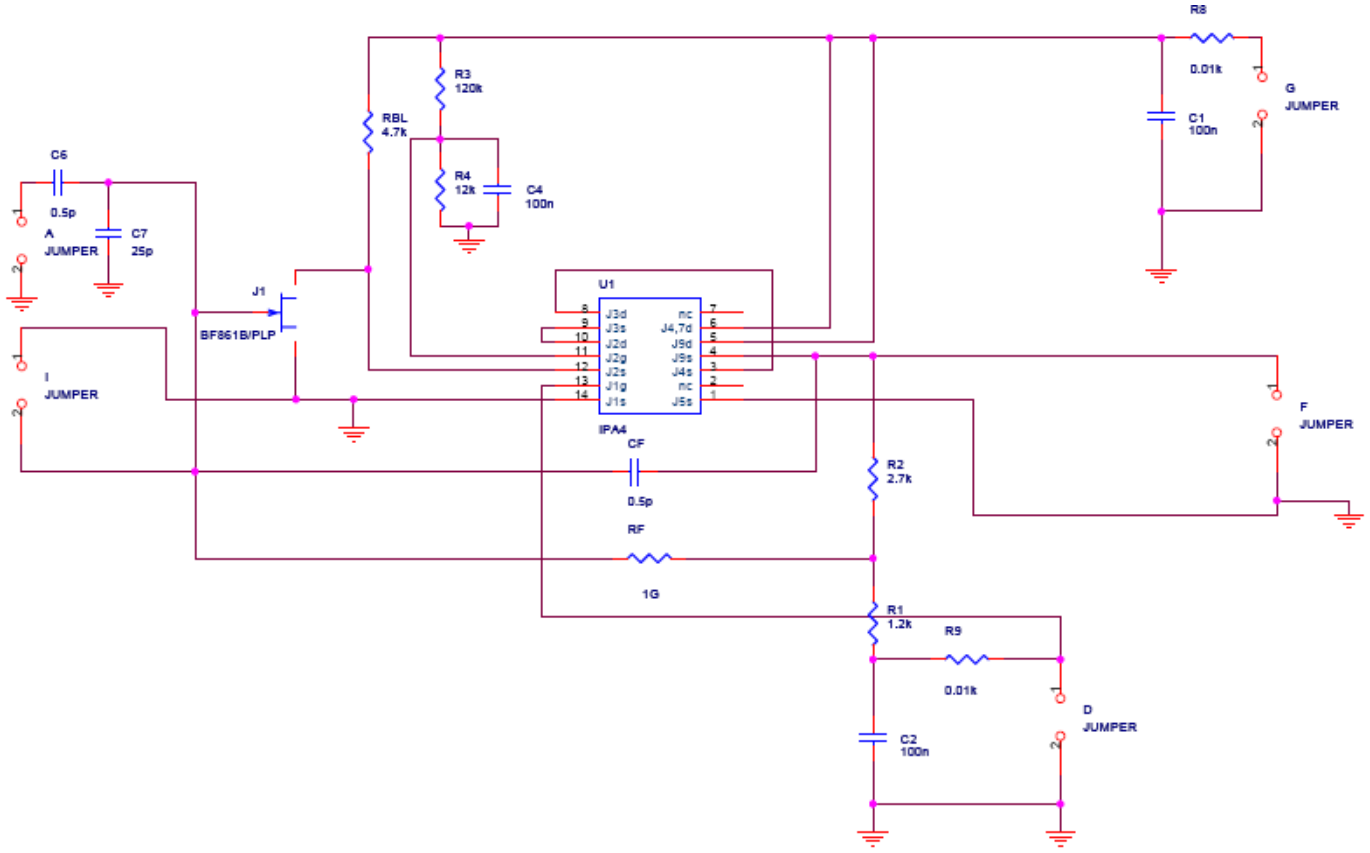
Production of PCB: 23 june at AREL, without 100 Ω output stage. PCB in DICLAD 880, 0.25 mm thick. Can be done in Kapton or PE]



IPA4+BF862 LC POS SCALA 1:1 08/05



IPA4+BF862 LC POS SCALA 1:1 08/05/06

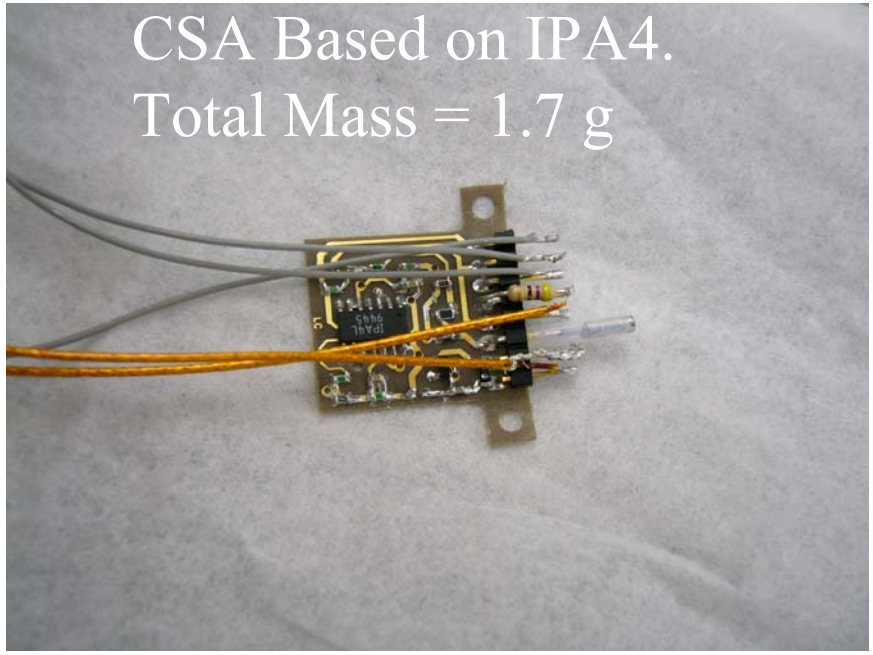


The tested CSA

- 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)

No 50Ω cold driving stage.

On top of flange warm second stage based on LM6624 or LM7171 (to match with FADC input impedence) , or directly to spectroscopy amplifier



Result: CSA not connected to crystal, connected to flange through cables (70 cm long), + PSA.

Results of measurements of CSA based on IPA4 mounted on copper cross suspension

- 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

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 ms for CD = 0 pF, FWHM = 1 keV @ 1.404 MeV → agreement with previous measurements

The tested setup (August 2006)

Discharge problems on
- filter (warm) due to construction technology →solved
- HV connector in Ar gas due to proximity of HV to ground and low break-down of gas Ar → solved by means of Stycast glue poored in the Teflon insulator subsequently applied


The new HV filter


The flange for cold CSA

Adopted Cables for LARGE tests

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

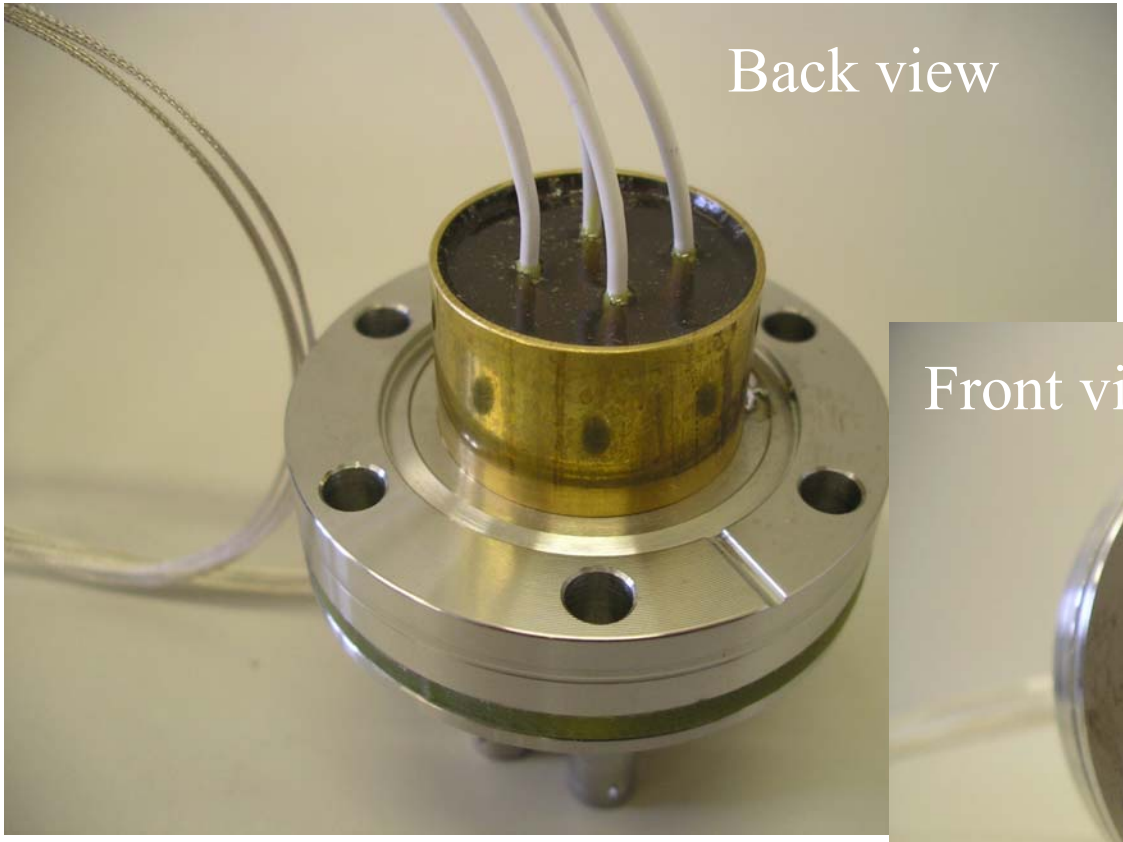
Weight ~ 3 g/m

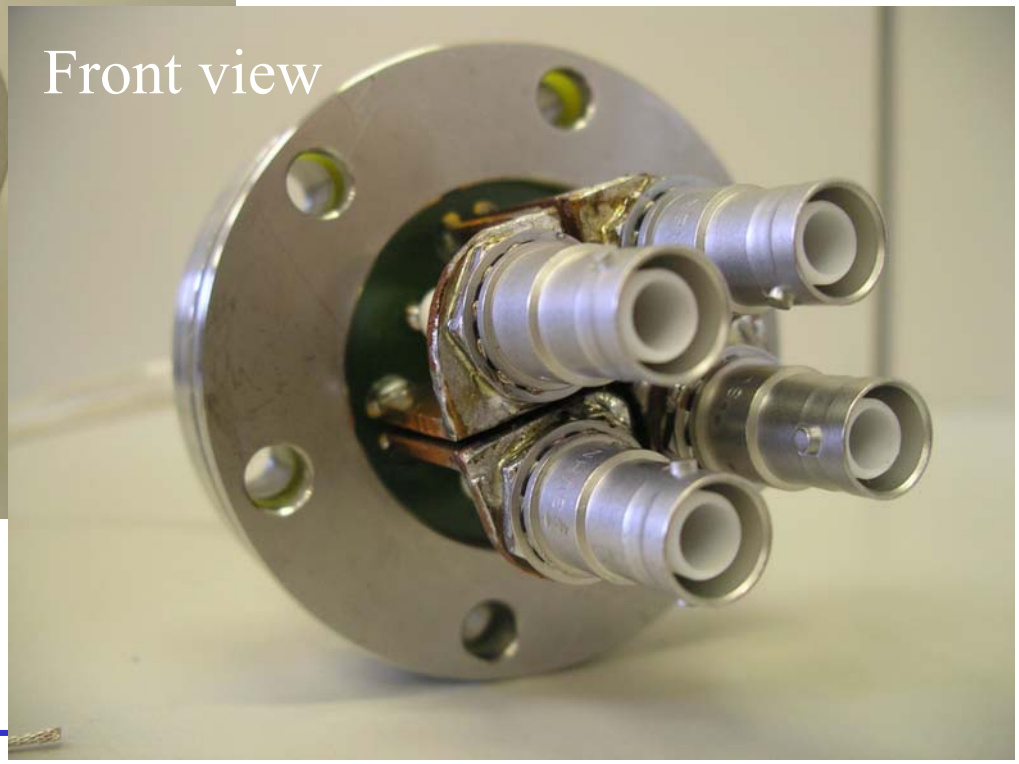
Signal: Kapton signal cable 50 W impedence at LAr (used in calorimetry)

Weight ~ 3 g/m

Assuming 10 mBq/kg (actual upper limit on γ- meas of Th and U on HV cable)→ 600 μBq from last meter of cable (nearest to electronic)

HV flanges against discharges: Developped and patented by INFN PD





Conclusions on IPA4 based CSA and next steps

- CSA based on IPA4 is ready for testing with prototype non – enriched crystal at LARGE.
- Performances of sensitivity and bandwidth adequates.
- For PA mounted with crystal mounting
  - ENC rms (@ C_D=0 , τ = 3 μs) = 110 e^- = 0.7 keV FWHM
  - ENC rms (@ C_D=33, τ = 3 μs) = 170 e^- = 1.1 keV FWHM
- Flanges and other parts necessary to operate cold FE
  - Flange 1 available 1 new in preparation at LNGS workshop with SHV connectors insulated by teflon + Stycast
  - HV Filter available → OK tested
  - Low noise PS for cold FE → available
- 1 new crystal insertion system + lock in preparation at LNGS to dedicate one test line (1 non-enriched crystal) to test cold FE (ASIC, semi-integrated) in same conditions with crystal connection.

Other possible not ASIC solutions for LARGE Tests (^{nonenr}Crystals) and experimental program with ^{enr} Crystals.

Circuits that demonstrated to work

- Mi-ASIC with external feed-back components
- Agata warm preamplifiers with cold FET (minimize and background M_{tot} $^{inner\ electronics}$ ~ cables), demonstrated to be feasible, superior performances presented 1 year ago and pubblished. (see GERDA Scientific Report Oct 2005)
- AMPTEK A250 + BF862
- Hd – J. Kiko preamp.

Test program for comparative analysis of various FE solutions @ same conditions TBD

- Where : LNGS
- When : first time slot: 1-15 december
- What? …… TBD within TG3

Needs to integrate with ASIC program