HPS experiment : Current sensitive preamplifiers's modifications to fit the APD 10×10mm^2

Outline

- Physics : coupling between PbWO4 crystals and APD $10\times10mm^2$
- Previous preamplifier used for DVCS experiment (IC Calorimeter) with APD $5\times5mm^2$
- Modification of the preamplifier N055 with APD $10\times10mm^2$
- Conclusion
- Schedule

Physics : coupling between PbW04 crystals and 10×10mm^2 APDs (1)

- HPS = 442 PbW04 crystals in truncated pyramidal shape.

- Length = 160mm
- Area at the front side (close to target) = 13mm×13mm
- Area at the back side (close to APD) = 16mm×16mm

- Energy = from 10MeV up to 3GeV
- The coupling (number of photo-electrons/MeV) between the crystal and the APD is dependent of :

- The quality of the crystal wrapping
- The quality of the APD gluing
- The quantum efficiency
- The surface ratio between the crystal and APD (active area)

Physics : coupling between PbW04 crystals and 10×10mm^2 APDs (2)

- Estimate the theoritical number of photo-electrons/MeV

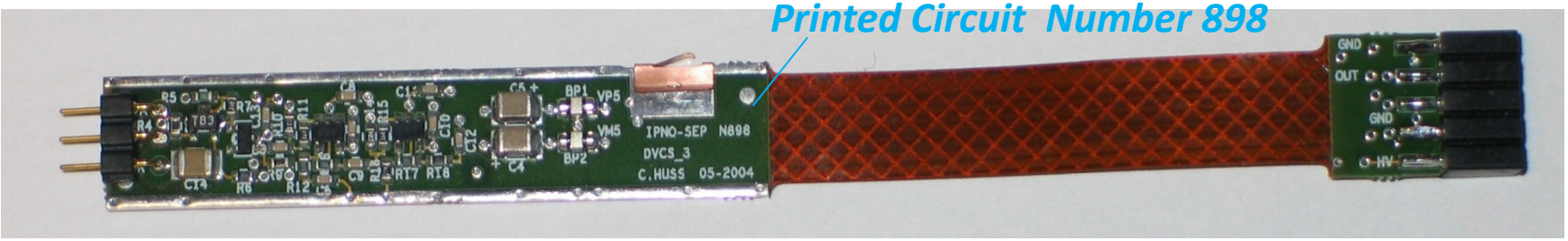
- 120 photons/MeV in the PbWO4 crystal
- Quantum efficiency = 70% for 420nm
- Surface ration = 2.56 (= (16×16)/(10×10))

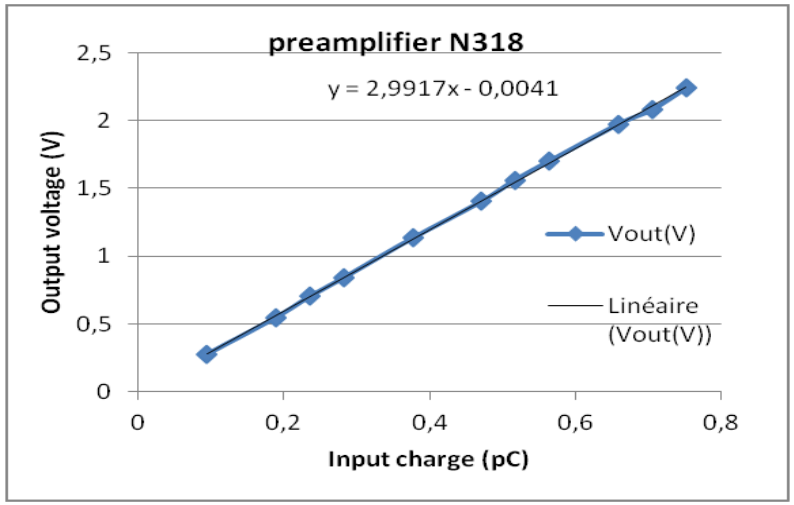
$\Rightarrow$ 35 photo-electrons/MeV (= 120×0.75/2.56)

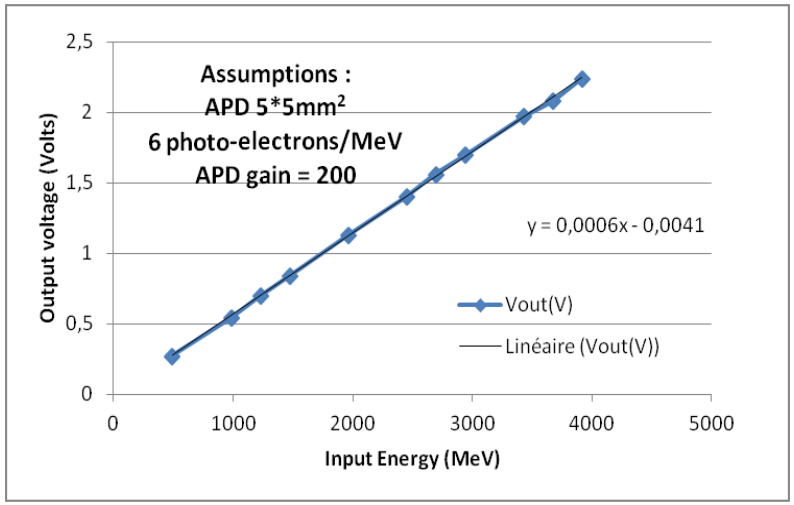
4 times more than for 5×5 mm^2 APD

- However , later , to take into account imperfections, we will use a pessimistic value = **25 photo-electrons/MeV**

Preamplifier used for DVCS IC calorimeter with 5×5mm² APD (1)

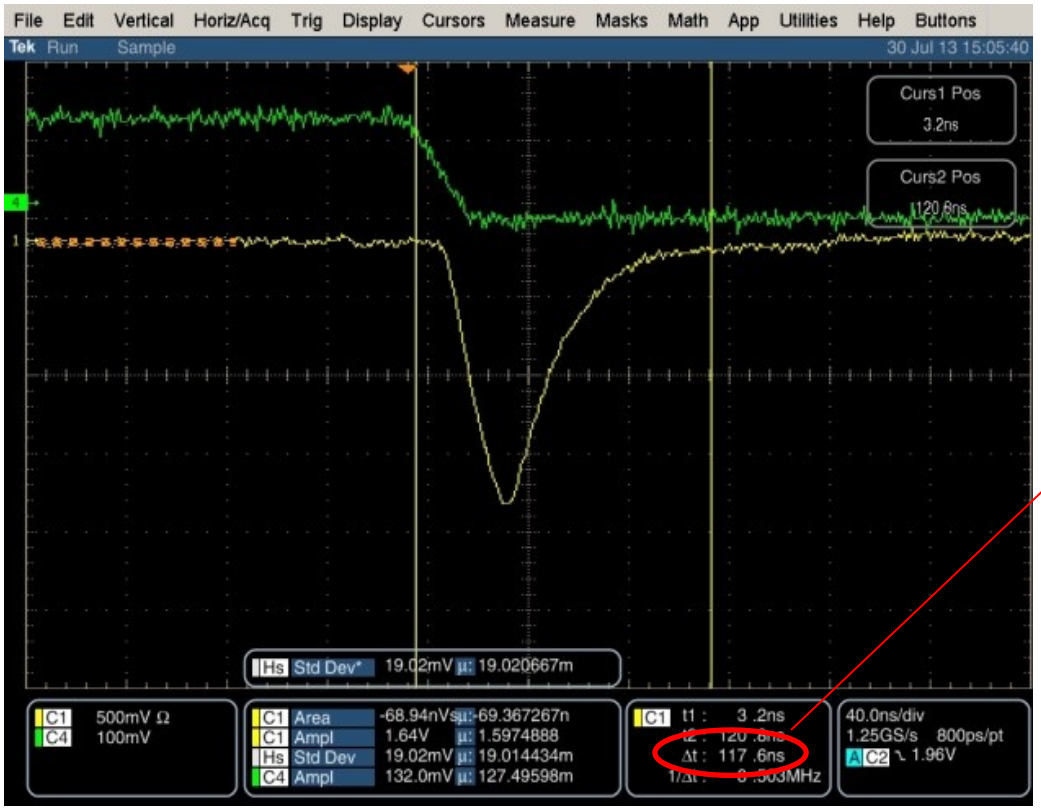






Gain = **3V/pC** (Pulse Width =20ns) or **0.6mV/MeV** (6 photo-electrons/MeV and APD gain = 200) or **2333 pC/pC** (=1.4nC/0.6pC)

Preamplifier used for DVCS IC calorimeter with 5×5mm^2 APD (2)



- Output signal for Qin=0.6pC or Ein=3GeV (PW=20ns, 6 photo-electrons/MeV and APD gain =200)

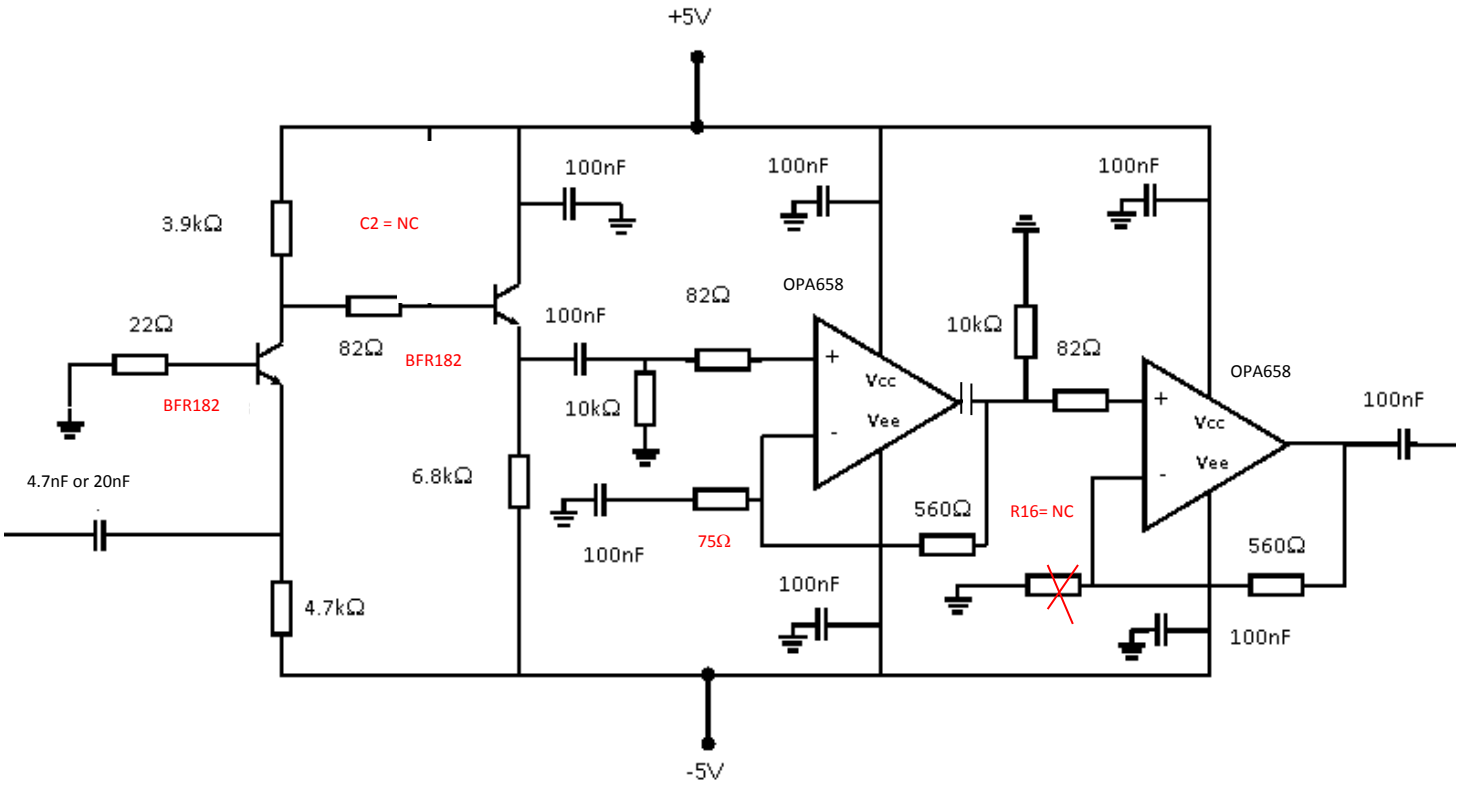
⇒Gate =120ns

⇒ Amplitude = 1.6V

⇒ Output charge = 1.4nC

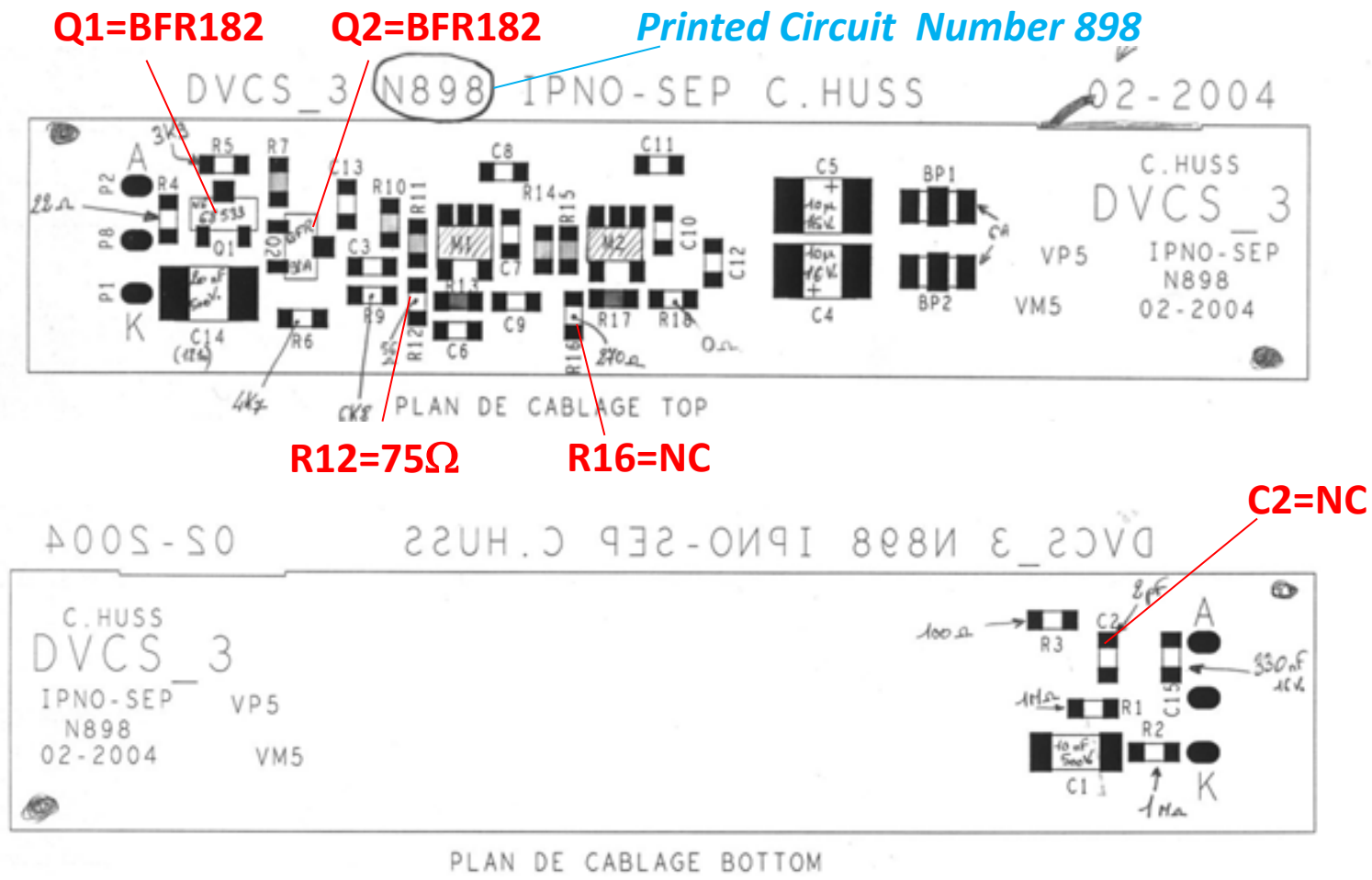
⇒ Input noise = 7.5MeV

Modification of the N055 preamplifier to use 10×10mm² APD : sch in red

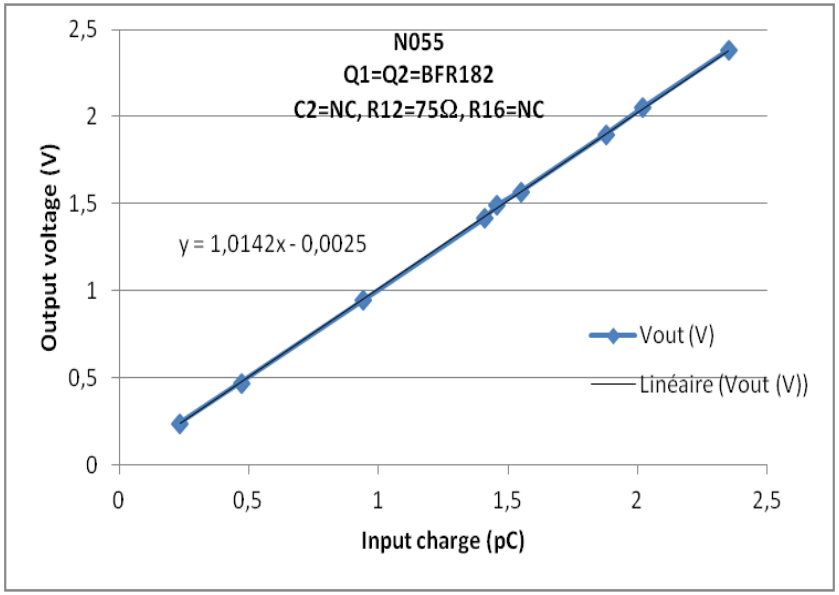


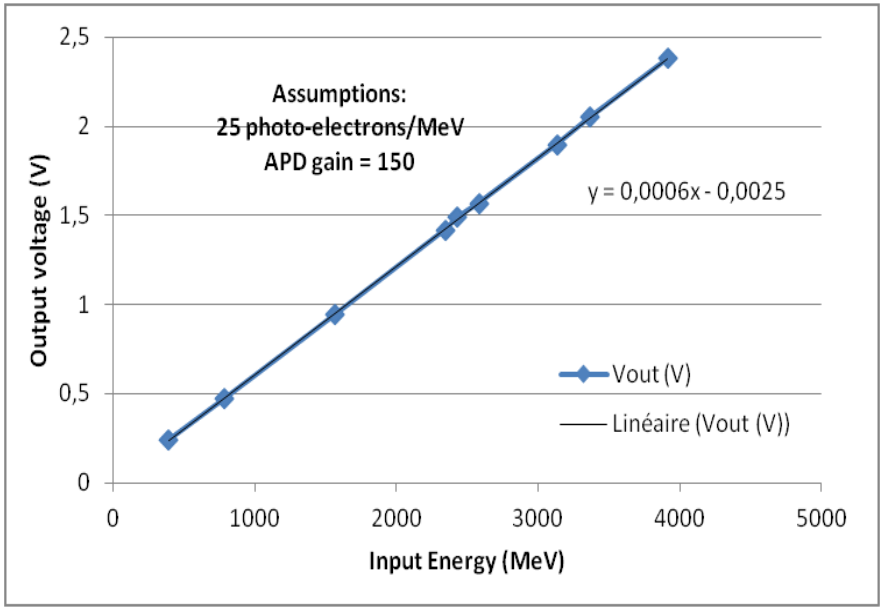
- C2 = Not connected ⇒ bandwidth increase
- Transistor = BFR182 ⇒ noise improvement
- Reduction of the gain (factor 4) : Gth = 132878 V/A ⇒ 33020 V/A

Modification of the N055 preamplifier to use 10×10mm^2 APD : **in red**



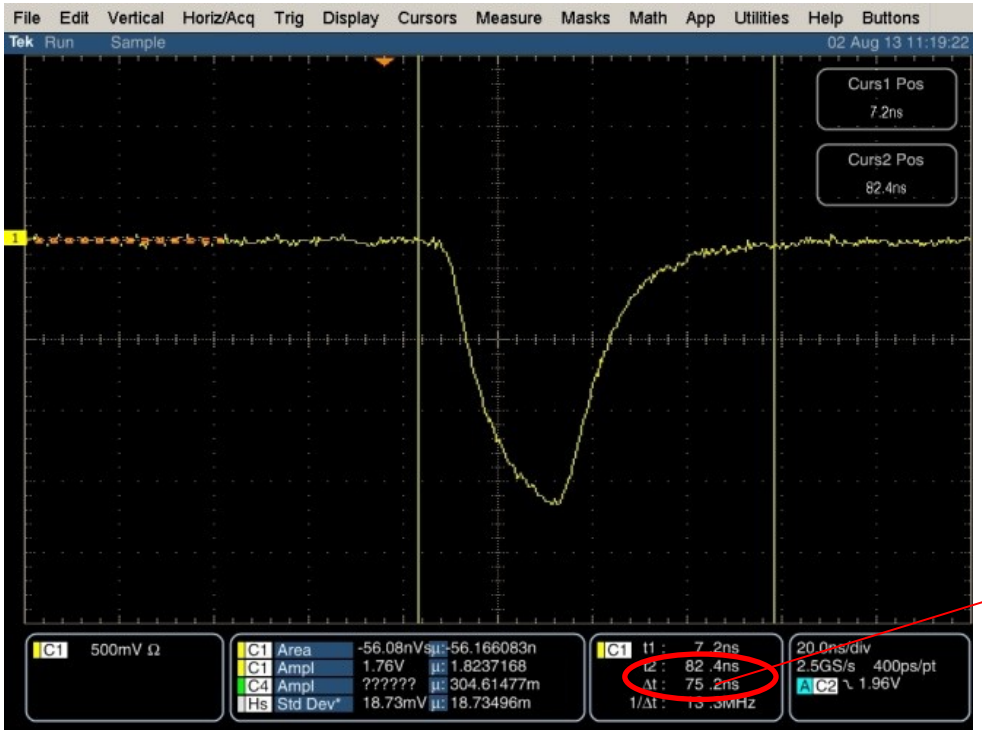
Modification of the N055 preamplifier to use 10×10mm^2 APD : gains





- Gain =**1V/pC** (PW = 20ns) or **0.6mV/MeV** (25 photo-electrons/MeV and APD gain = 150) or **611 pC/pC**(=1.1nC/1.8pC)

Modification of the N055 preamplifier to use 10×10mm^2 APD : signal



- Output signal for Qin=1.8pC or Ein=3GeV (PW=20ns, 25 photo-electrons/MeV and APD gain =150)

⇒Gate =75ns down to 65ns

⇒Amplitude = 1.8V

⇒Output charge = 1.1nC

⇒Input noise = 4.2MeV

Conclusion

- With the modified preamplifier, the integration gate could reach 65 ns
- 3GeV corresponds to 1.8V (25 photo-electrons/MeV and APD gain = 150)
- The noise is improved with the modified preamplifier due to new transistors BFR182 (10%) and APD 10×10mm^2 (90%)

Schedule

- November-december 2013 $\Rightarrow$ the 500 preamplifiers will be sent to IPN-Orsay
- November 2013 $\Rightarrow$ order of 1000 BFR182 and 500 resistances 75 Ω with the ANR account
- January-february 2014 $\Rightarrow$ quick test of the 500 preamps to check if they are working

If not, order of new components (OPA658 are obsolete to be replaced by OPA694)

- February-march 2014 $\Rightarrow$ modification of the 500 preamps
- April-may 2014 $\Rightarrow$ detailed tests of the 500 preamps together with a test report
- May 2014 $\Rightarrow$ send back to JLAB