Beam Conditions Monitors in ATLAS

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RADMON WG
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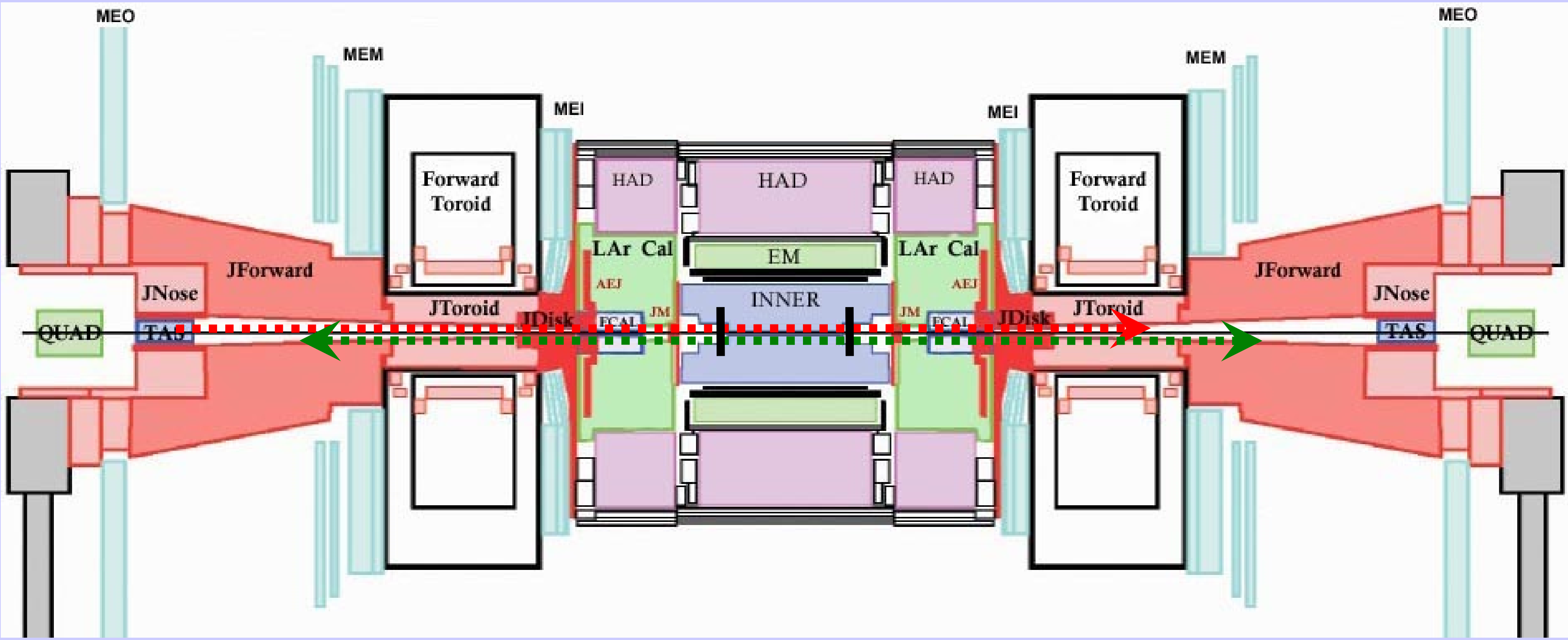
BCM group (so far):

- **JSI, Ljubljana**
  - V. Cindro, G. Kramberger, I. Mandić, M. Mikuž, M. Zavrtanik
- **CERN**
  - A. Gorišek, H. Pernegger
- **Fotec, Wiener Neustadt**
  - E. Griesmaier, H. Frais-Kölbl
- **Toronto University**
  - M. Cadabeschi, W. Trischuk
- **Collaboration with RD-42, PH-DT2 and TS-LEA**

BCM-TAS vs. Interaction Events

Instantaneous measurement of beam conditions
Conceptual design: **EDMS document *ATL-IC-ES-0012***



- 2 detector stations, symmetric in z
- TAS events: $\Delta t = 2z/c$
- Interactions: $\Delta t = 0, 25, \ldots$ ns

BCM REQUIREMENTS

Distinguish TAS events from interaction events

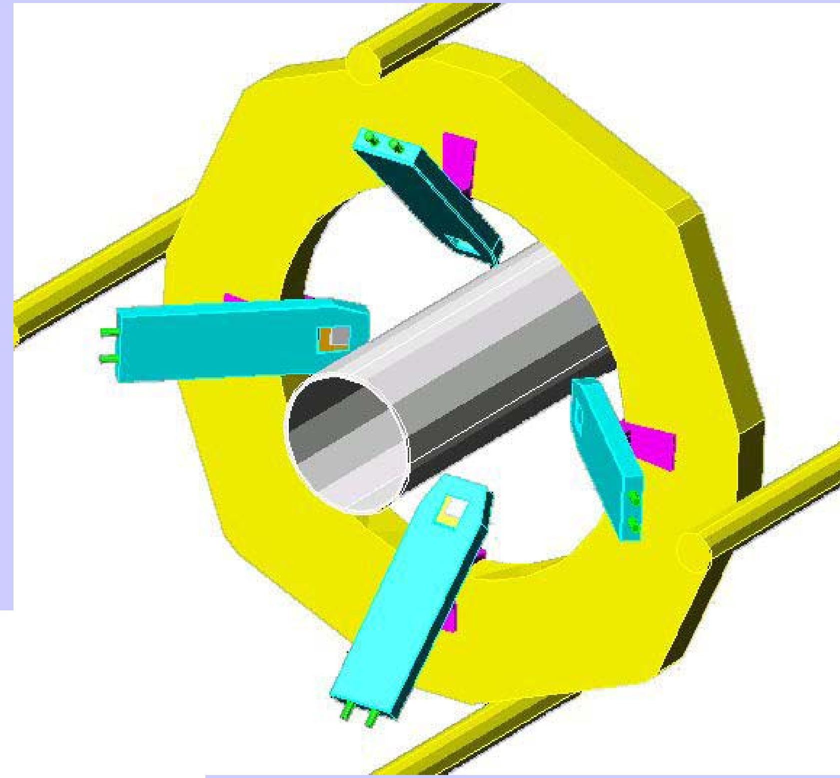
- Installation at Δt = 12.5 ns -› Δz = 3.75 m
- Rise-time < 1 ns
- Pulse-width < 3 ns
- Base-line restoration < 10 ns

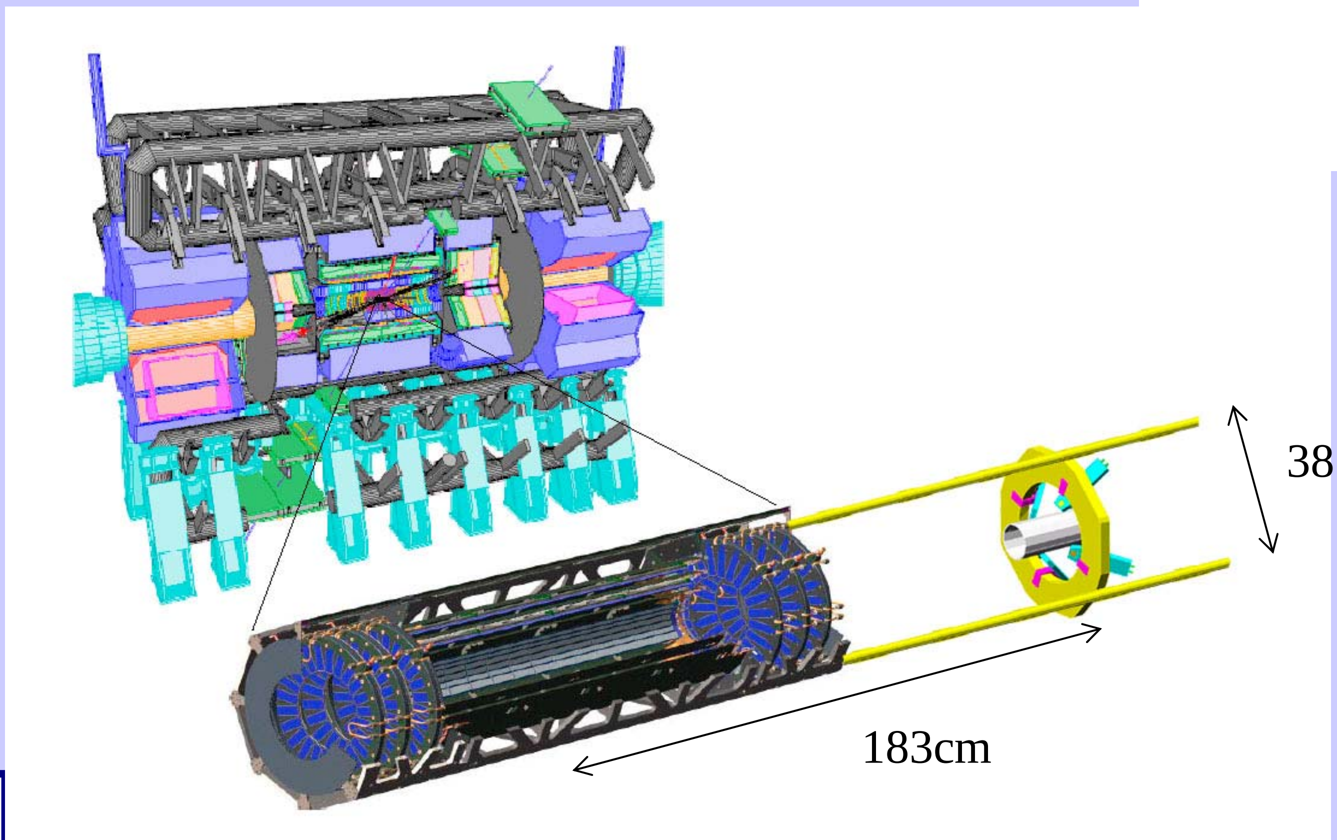
Single MIP sensitivity

- one 7 TeV proton on TAS gives ~ 1 MIP/cm2 inside PST
- Poisson with average of < 1 MIP per diamond detector
- S/N for MIP's 10:1 before irradiation
- 4 detectors per station

INSTALLATION

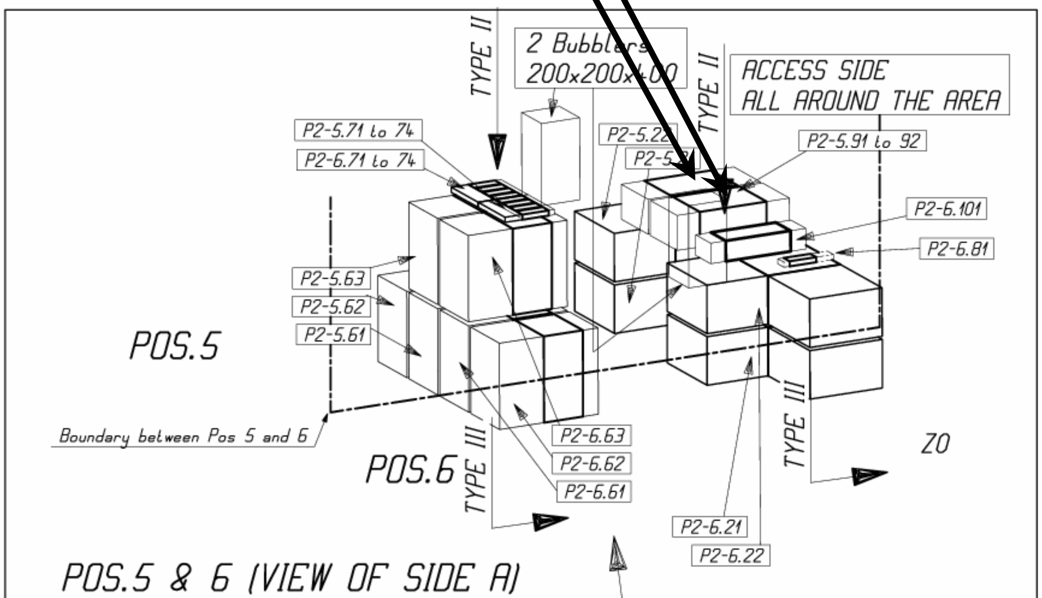
- **4 BCM** stations on each side of the Pixel detector
  - Mounted on Pixel support structure at z = +/- 183.8 cm and r = 7 cm
  - Each station: $1cm^2$ detector element + Front-end analog readout

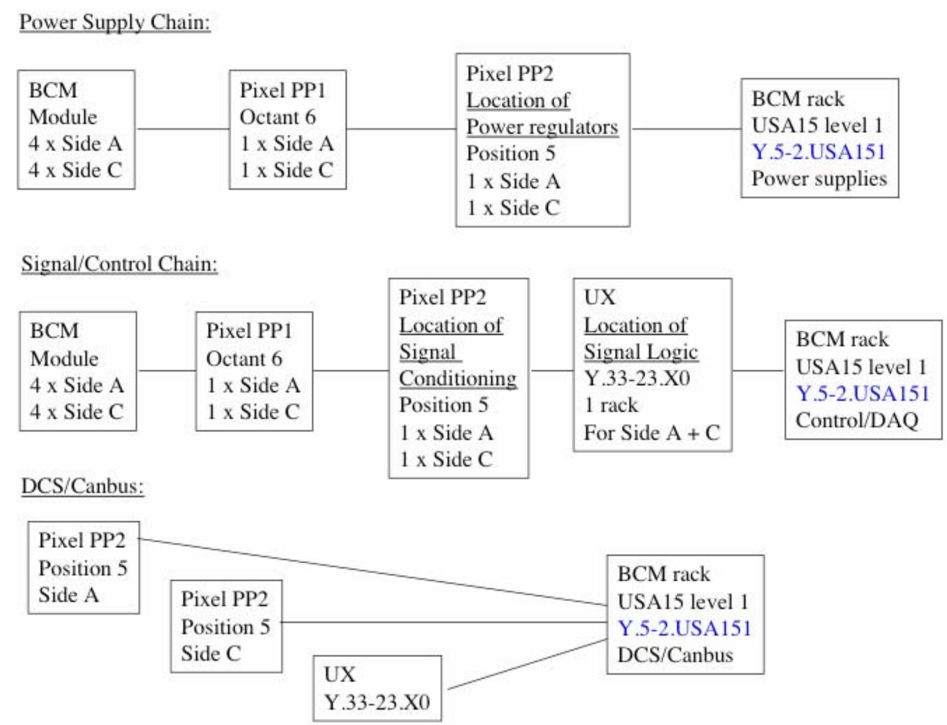




INSTALLATION 2

BCM PP2 boxes

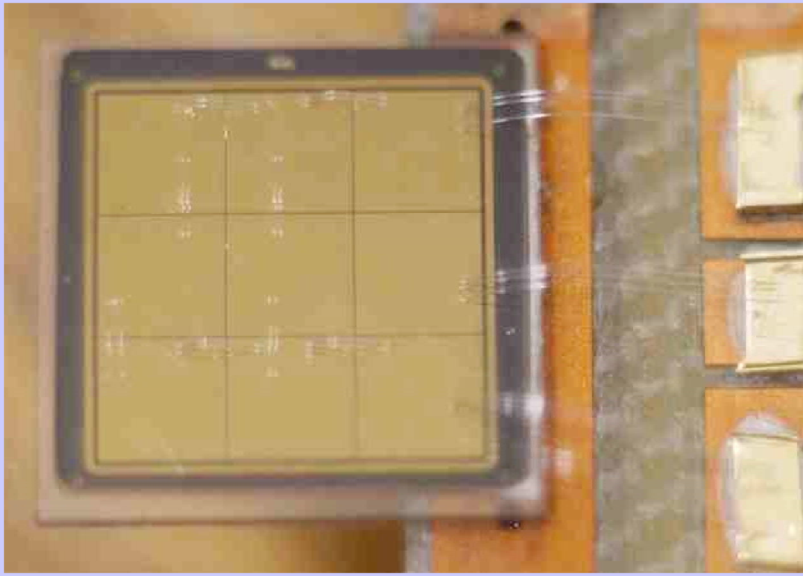


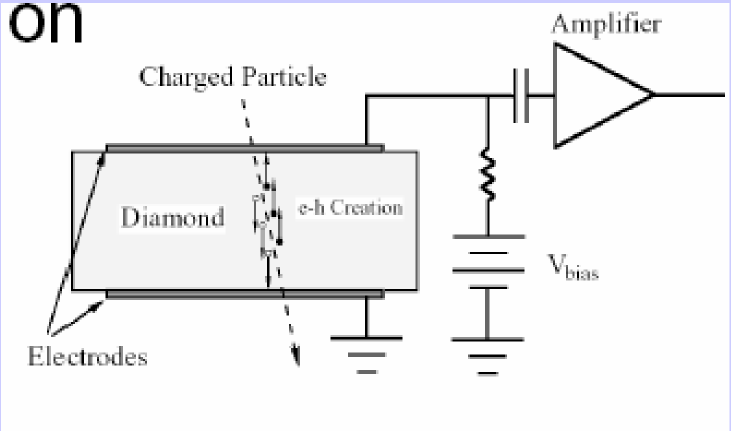


Documented in **ATL-IC-ES-0018**

DETECTOR – pCVD diamond

- Radiation hard
  - Shown to withstand > 10^{15} p/cm2
- Fast and short signal
  - High charge carrier velocity
  - Narrow pulses due to short charge lifetime
- Operates with a high drift field
  - Carrier velocity close to saturation velocity
- Very Low leakage current after irradiation
  - Does not require detector cooling

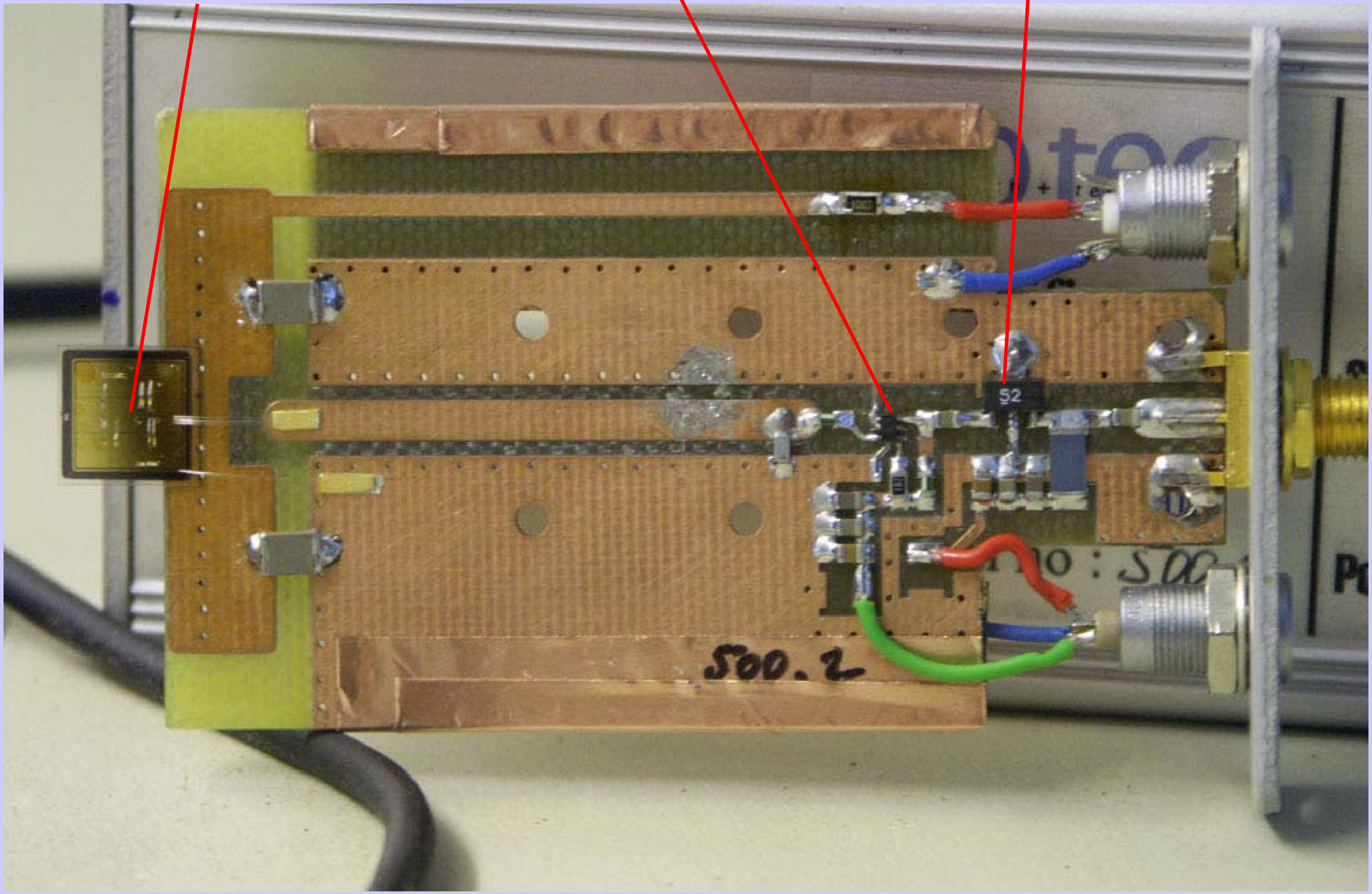




- Some parameters of BCM diamonds:
  - Developed by RD42 / Element Six Ltd.
  - Charge collection distance (ccd) 150 to 220 mm
  - Thickness range 350 to 500 mm & drift field = 2 V/mm
  - Size 10 x 10 mm^2

FRONT-END

- Diamond   1st stage 2nd stage



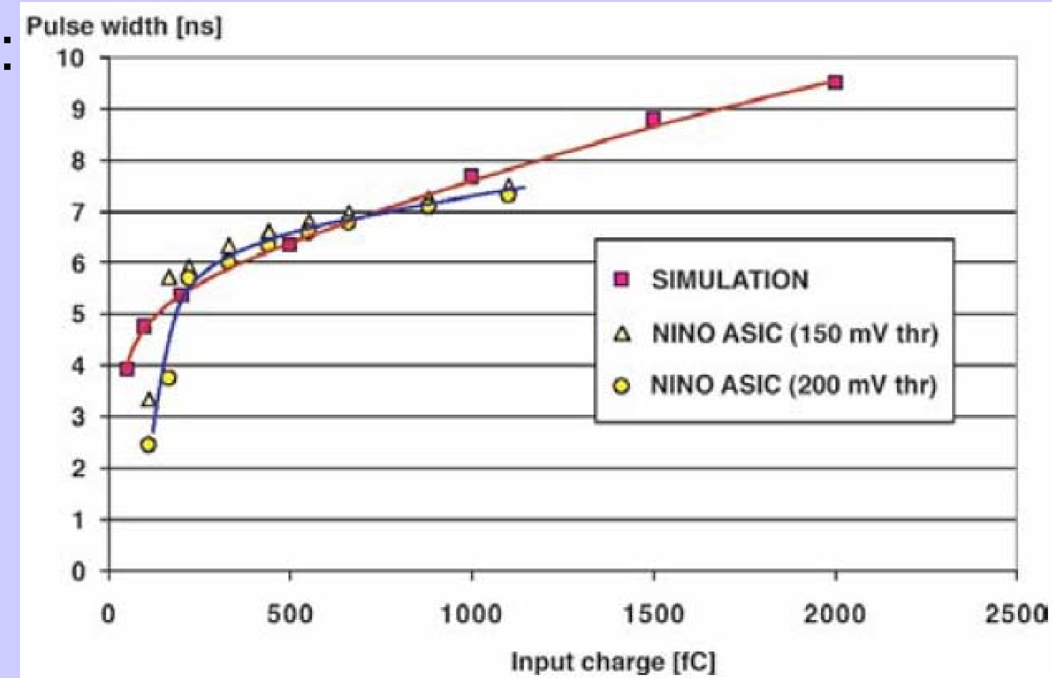
2-stage amplifier

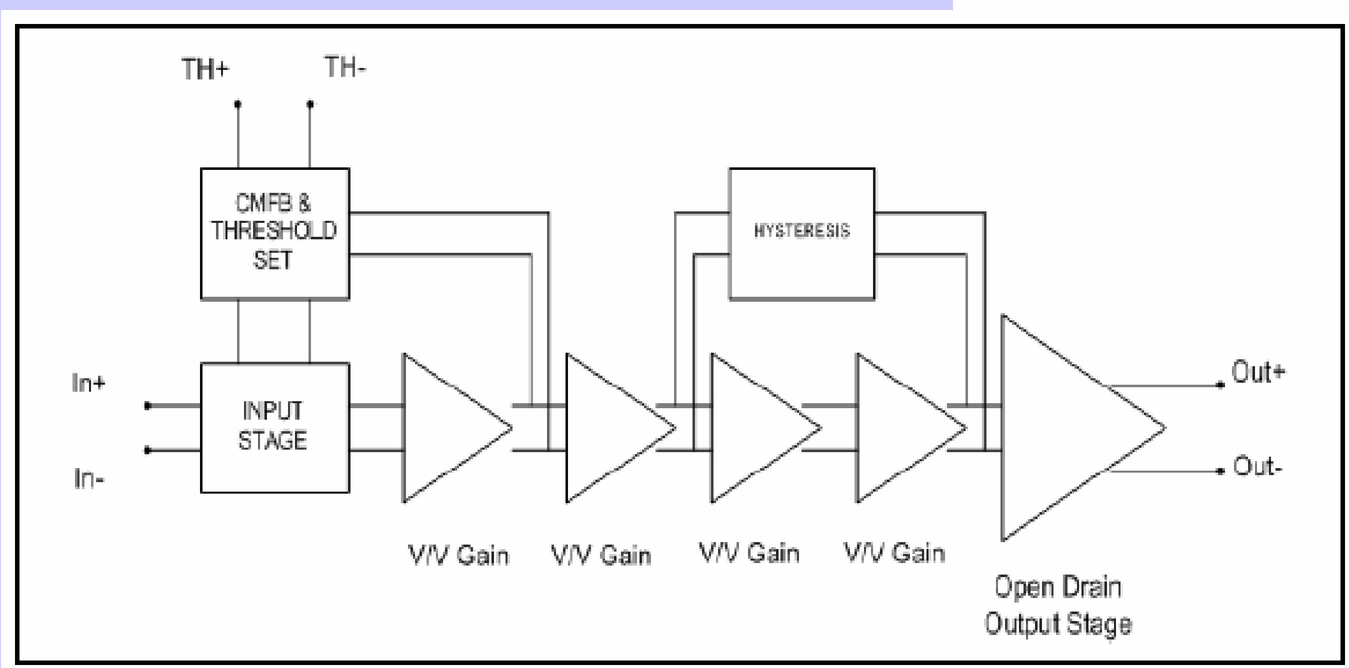
- Agilent MGA-62653 500Mhz (22 dB)
- Mini Circuits GALI-52 1 Ghz (20 dB)

BACK-END – a candidate

NINO amplifier-discriminator chip:

- IBM 0.25μm techn.
- developed for ALICE ToF
- <1ns peaking time & <25ps jitter
- min. detection threshold 10fC
- pulse width depends on input charge
- PP2





BEAM TESTS – MGH Boston

Diamond detectors

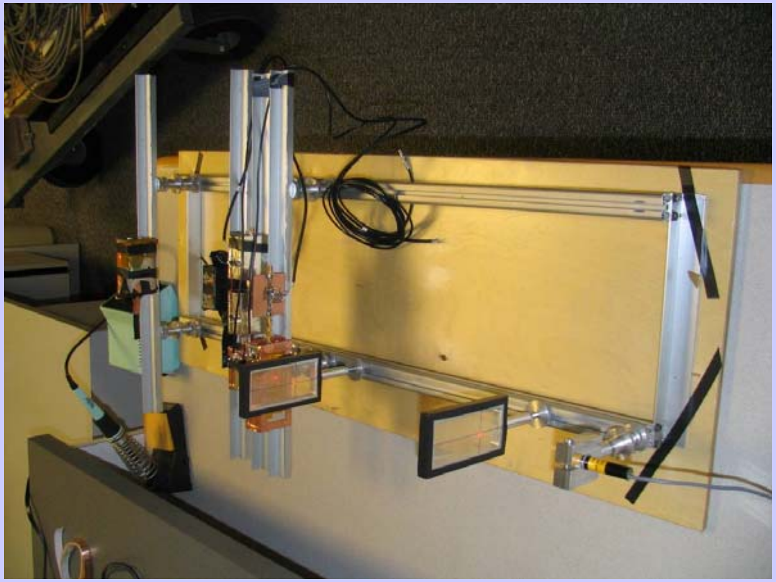
- Single : CDS110,
  w=470μm, CCD 220μm (?)
- Double-decker: CDS154+CDS155,
  w=360 μm, CCD 140μm
- HV Bias ~2 V/μm
- Placed at 0 and 45 degrees

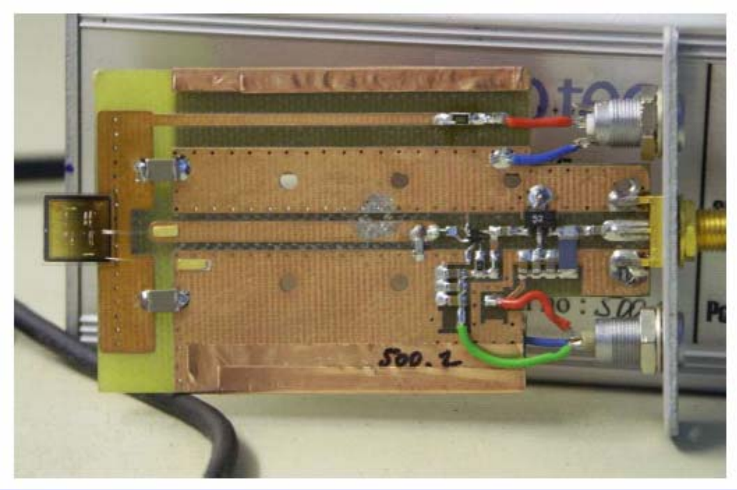
2 scintillators for trigger

LeCroy 4 GHz scope

Proton beam 200MeV and 125MeV

Signal ≥ **2.3 MIPs**





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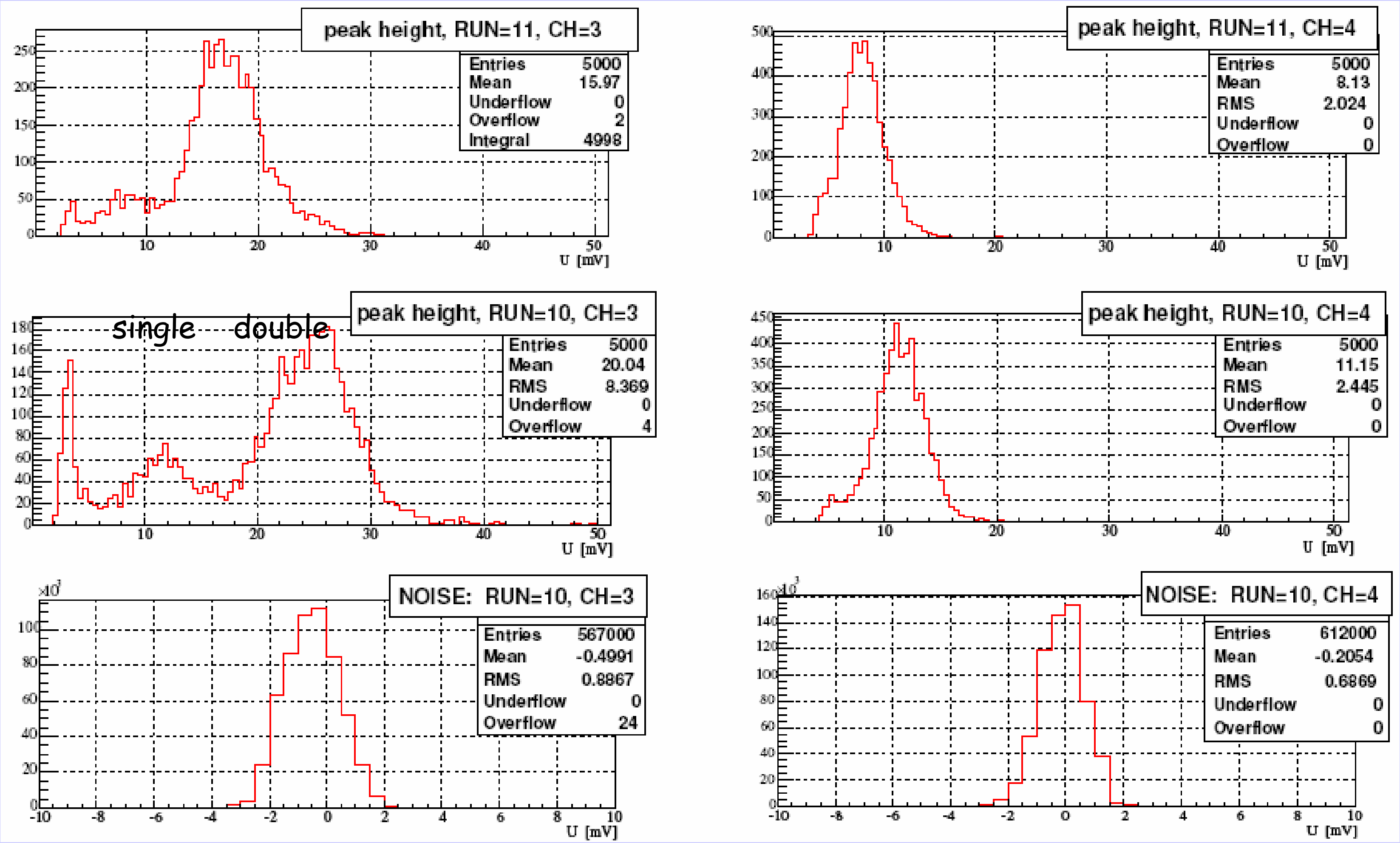
RESULTS-BOSTON

Double-decker | **Single diamond**



0 deg

45 deg

Signal increase 0->45 deg by ~ √2

Signal increase in double-decker by 2, noise by 1.3

BEAM-TEST CERN-SPS

Diamond detectors

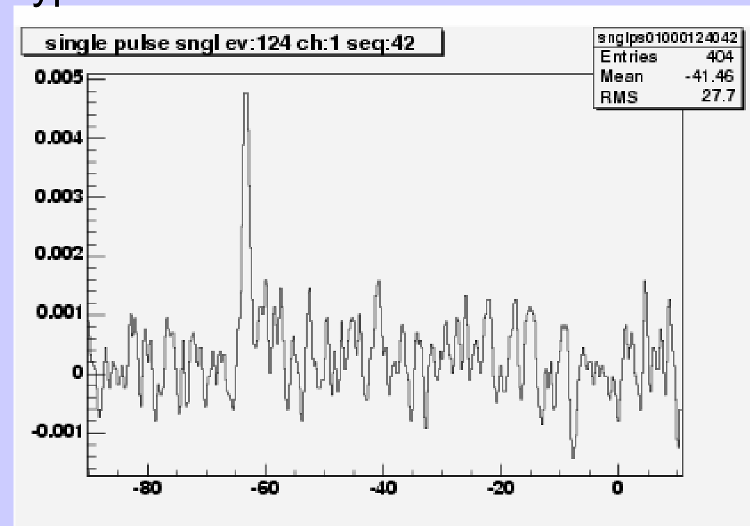
- 2 Double-deckers:
  - CDS154+CDS155, w=360 μm
  - CDS159+CDS160, w=515 μm
- HV Bias ~2 V/μm
- Placed at 0 and 45 degrees

2 scintillators for triggering

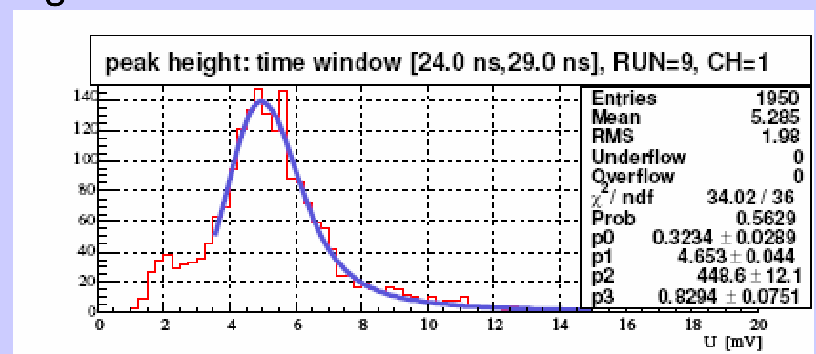
LeCroy 1 GHz scope

SPS H8 pion beam - MIP's

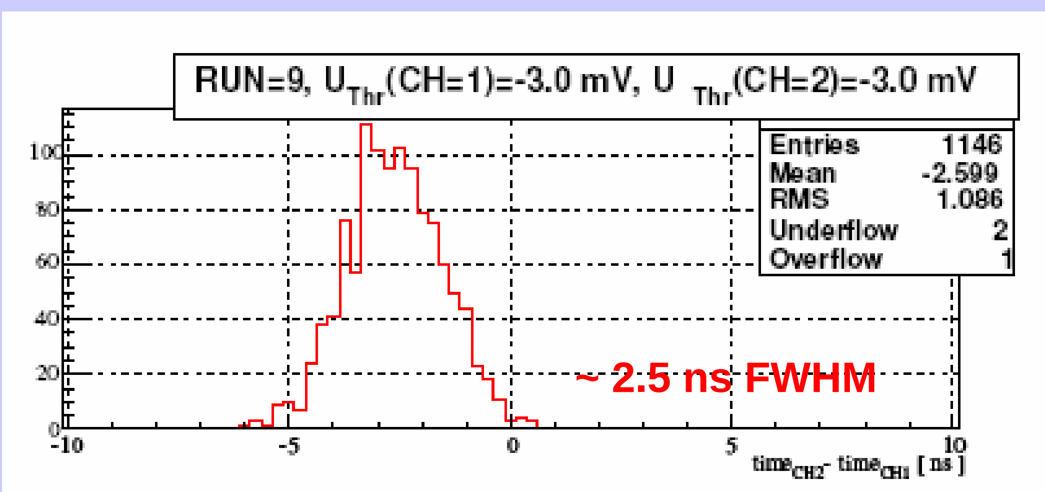
typical event



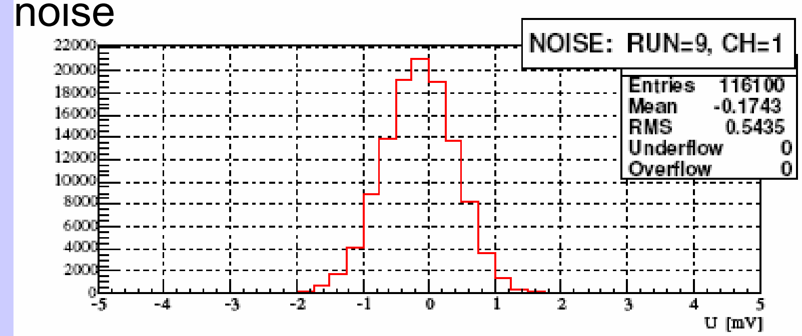
signals



time resolution



noise

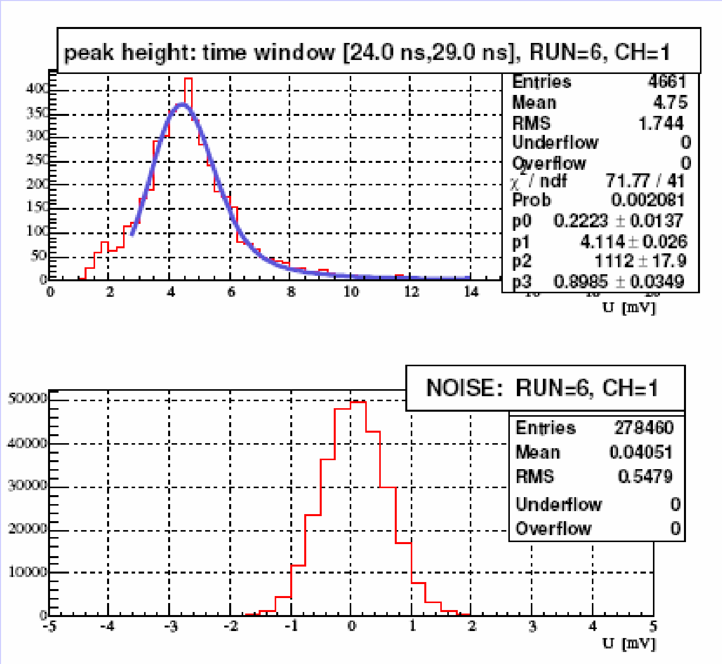


S/N ~ 8.5:1

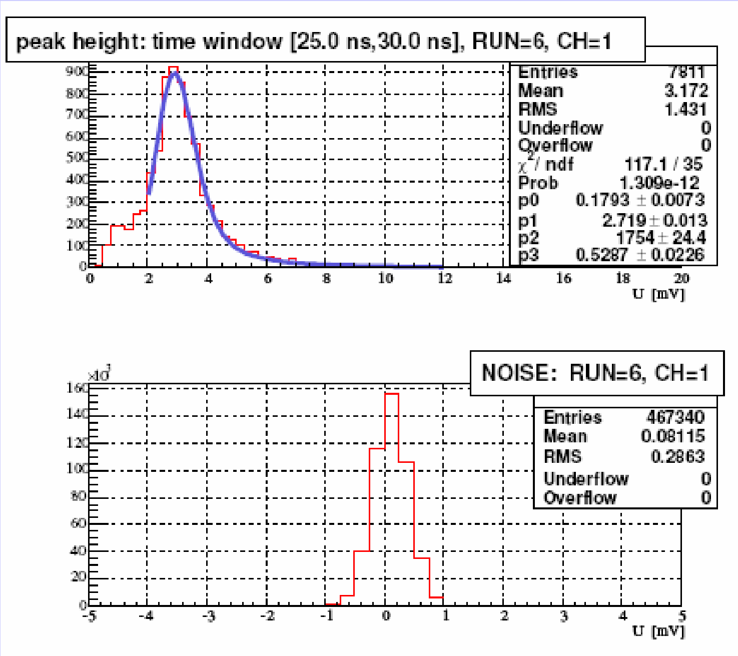
BEAM-TEST CERN-SPS - 2

Limiting bandwidth on scope to 200 MHz **improves** S/N

No bandwidth limit



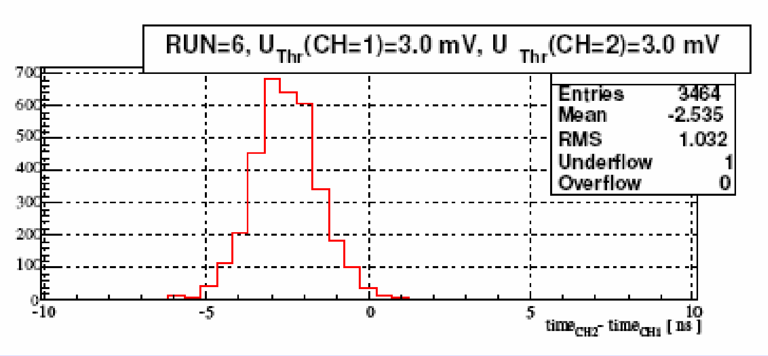
200 MHz bandwidth limit

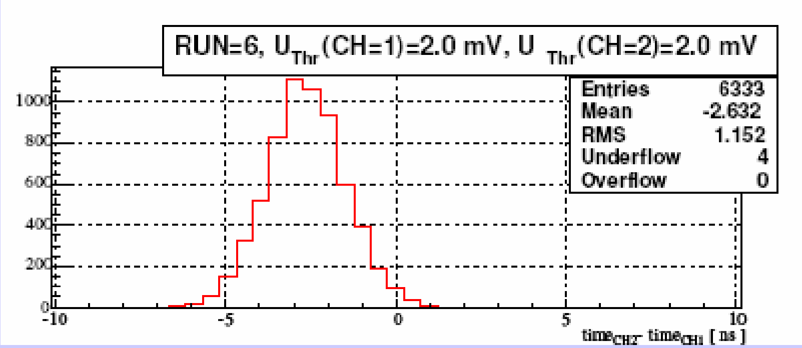


10 % worse timing

S/N ~ 7.5:1

S/N ~ 9.2:1





Subsequent analysis confirmed that 200 MHz cut-off is optimal

Amplifier Radiation Tests

Devices

- Mini Circuits Gali 52 In GaP HBT broad band microwave amplifier
- Agilent MGA-62563 GaAs MMIC Low noise amplifier

Irradiations

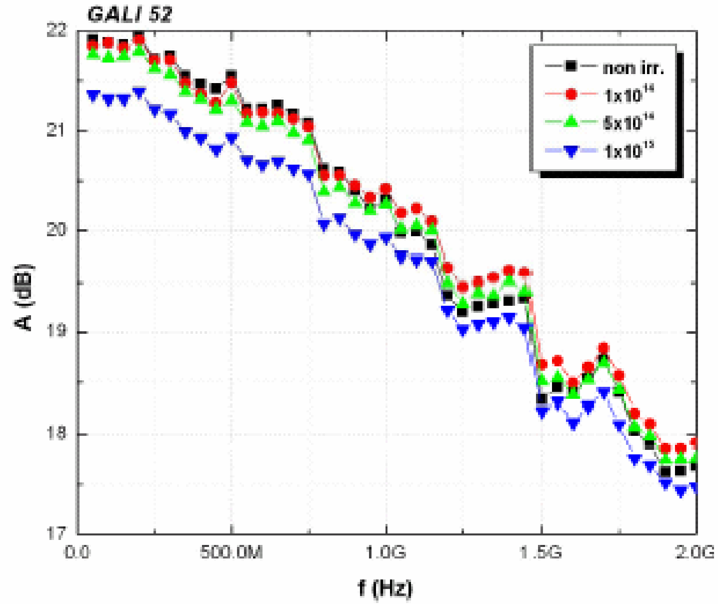
- n: TRIGA nuclear reactor at J. Stefan Institute in Ljubljana
- p: CERN PS 24 GeV/c
- γ: TRIGA nuclear reactor at J. Stefan Institute in Ljubljana

Measurements:

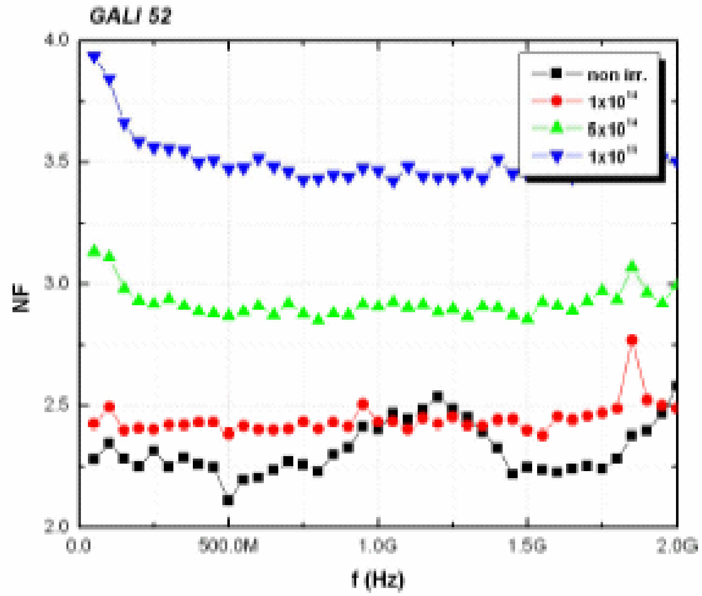
- S parameter set and/or NF-Gain measurements:
  - Anritsu 37369C Vector Network Analyzer
  - Agilent N8973A Noise figure Analyzer

Amplifier Radiation Tests - 2

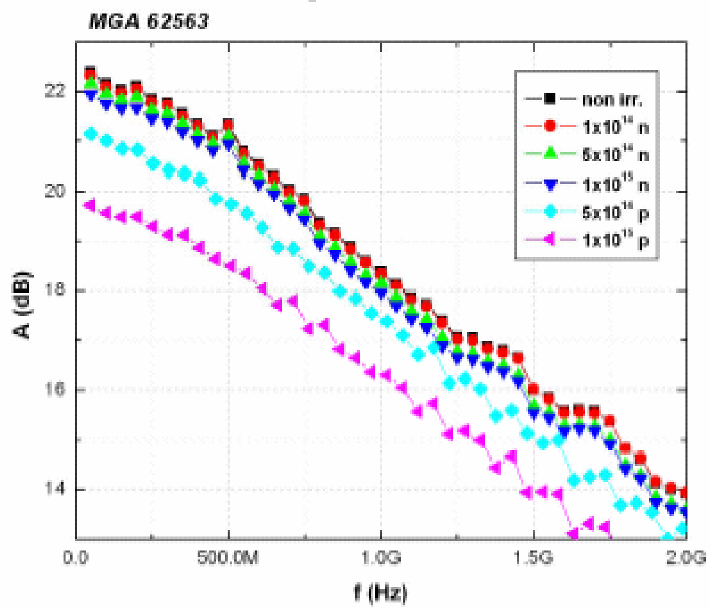
Gali 52 A vs neutron irradiation



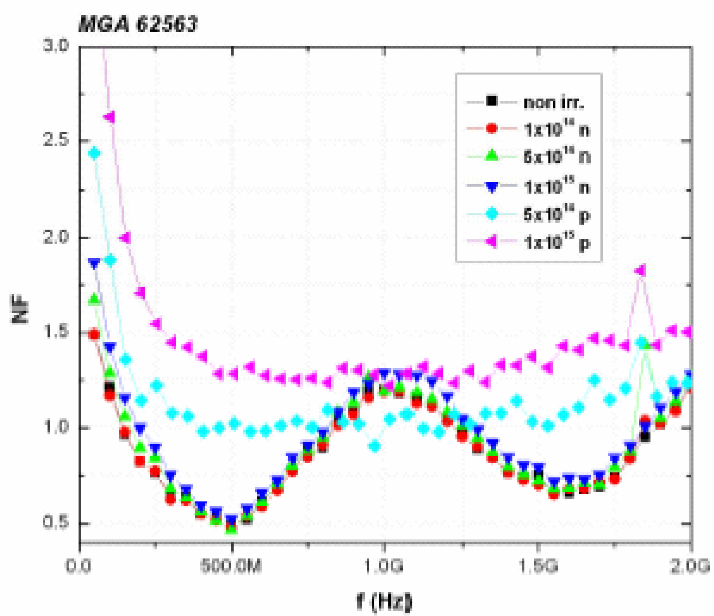
Gali 52 NF vs neutron irradiation



MGA 62563 A @ neutron and proton irradiation



MGA 62563 NF @ neutron and proton irradiation



Amplifier still usable after 10^{15} n/cm2

BENCH-TEST

Source (Sr90 30MBq)

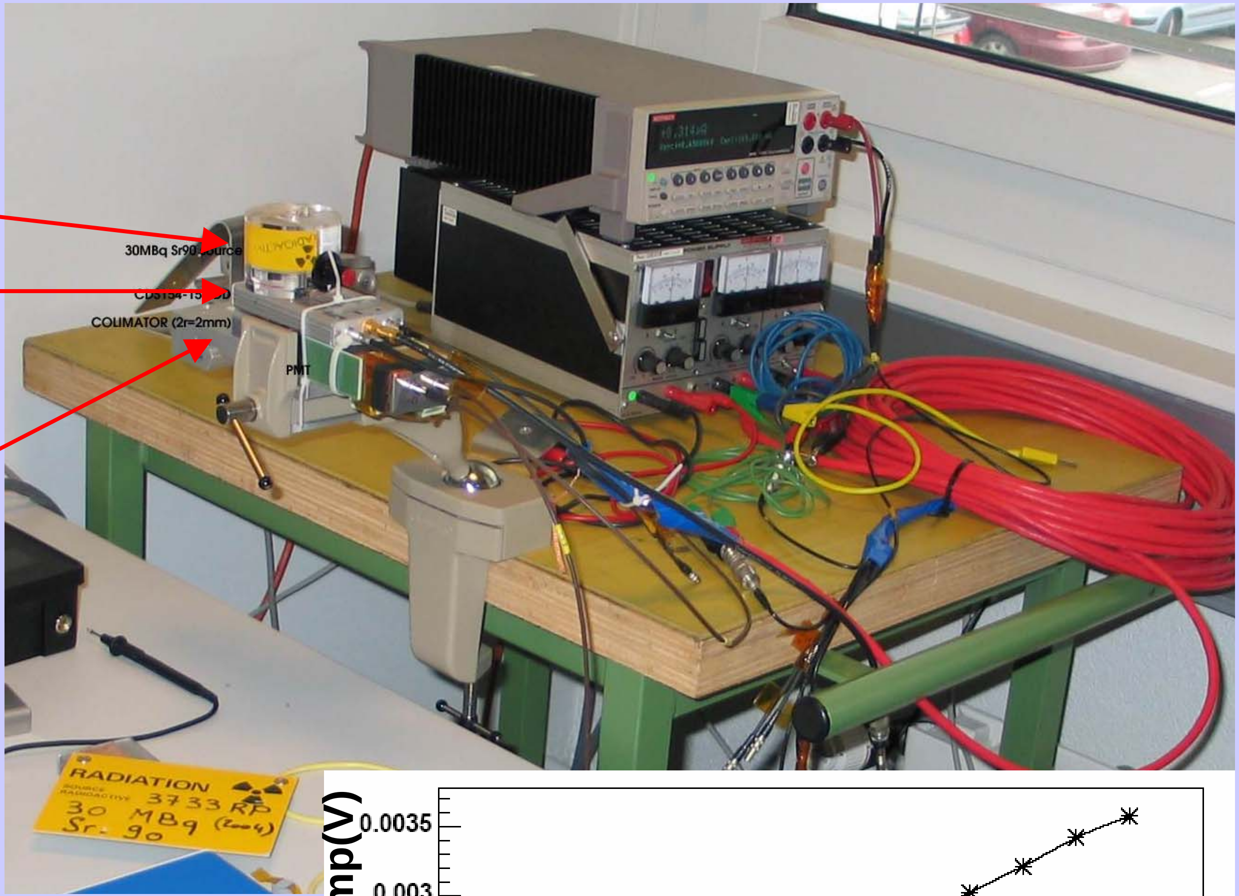
DD CVD diamond detector:

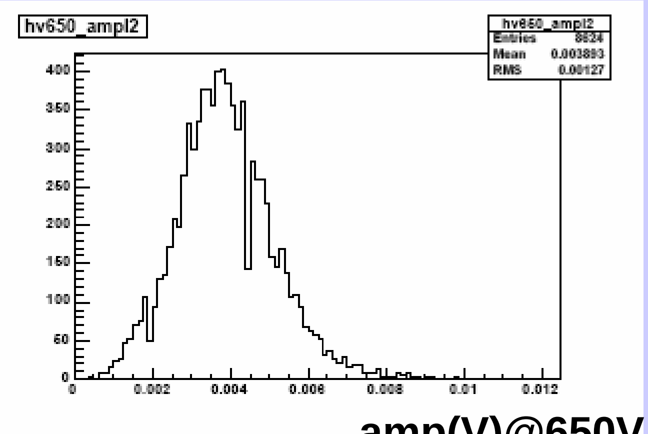
- CDS154+CDS155, w=360 µm
- same front-end as beam-tests

Collimator

Scintillator-PMT

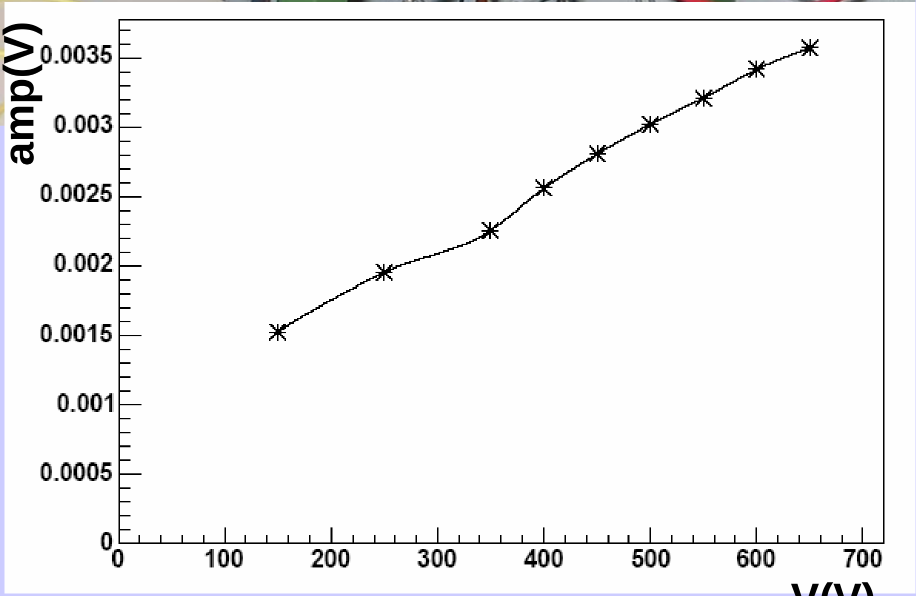
LeCroy 1 GHz scope





amp(V)@650V

HV scan



SUMMARY

pCVD diamond detectors will be used as a BCM for ATLAS

FRONT-END electronics defined

BACK-END electronics – testing

Promising results both in beam-tests and on the bench test