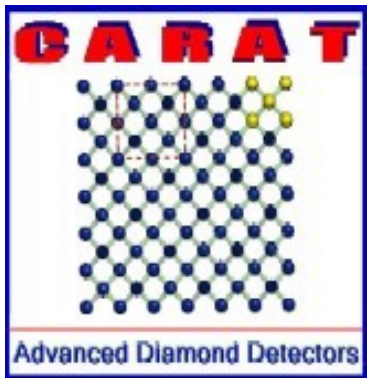
Development of A Diamond Time of Flight Detection System for the HISPEC-DESPEC program: Current status

B. S. Nara Singh



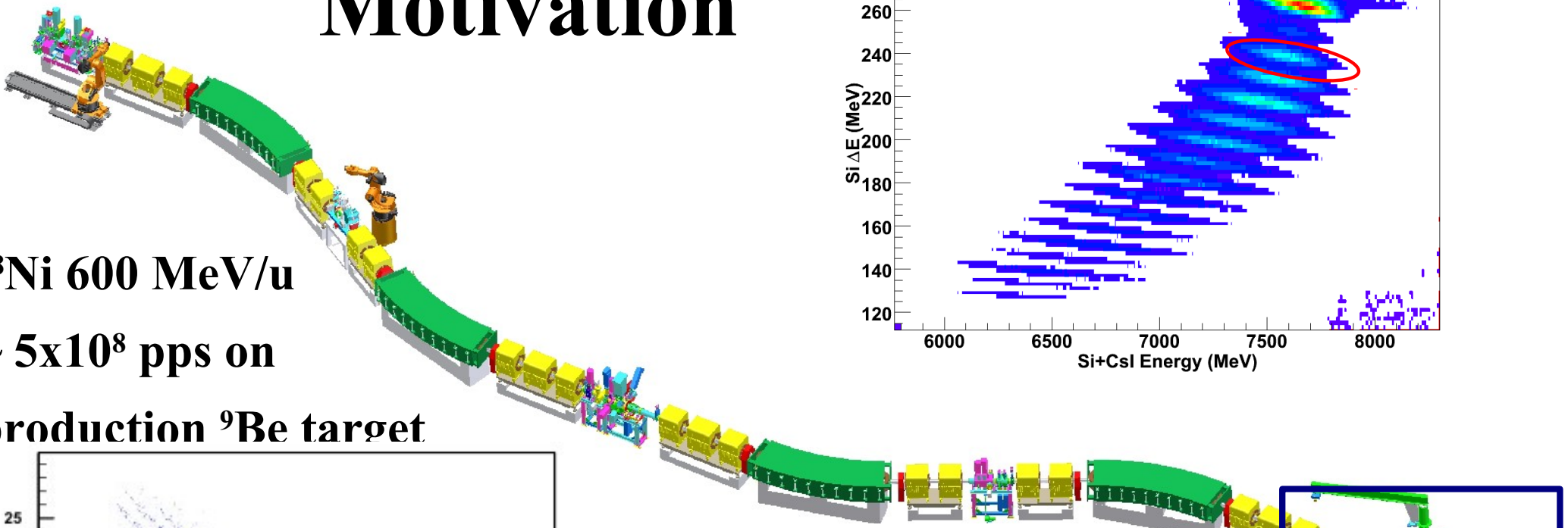
- Motivation
- Development
- Initial Results
- Future plans
- Summary

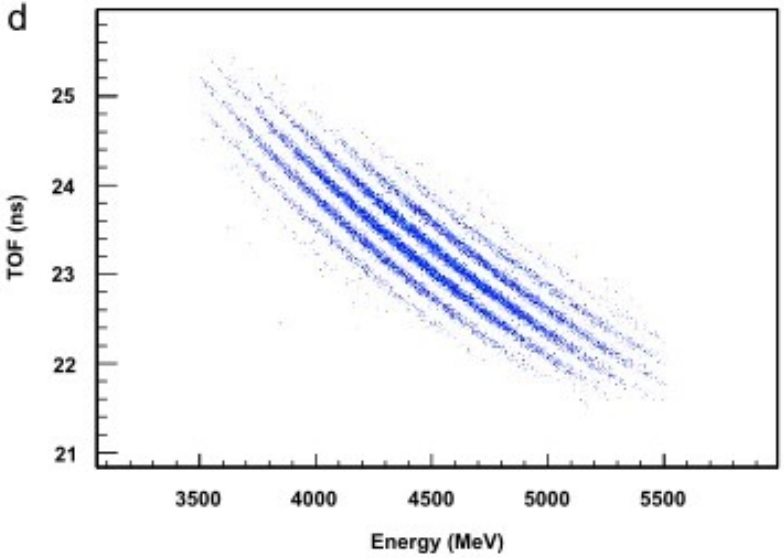
Motivation

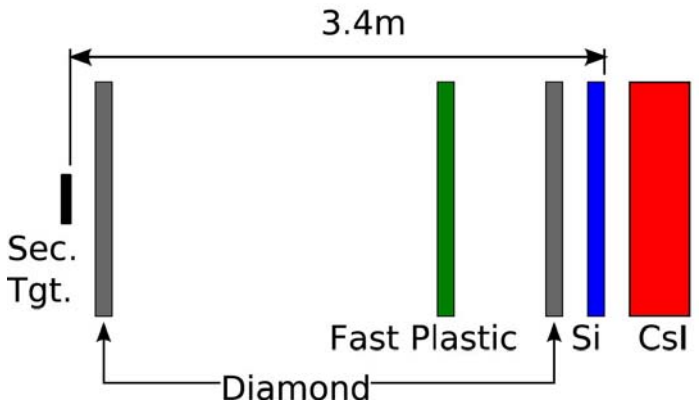
^{58}Ni 600 MeV/u

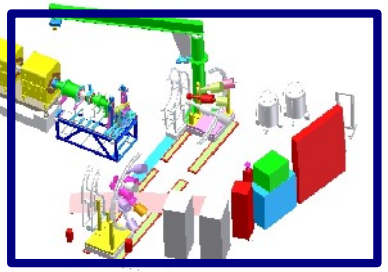
~ 5x10^{8} pps on

production ^{9}Be target





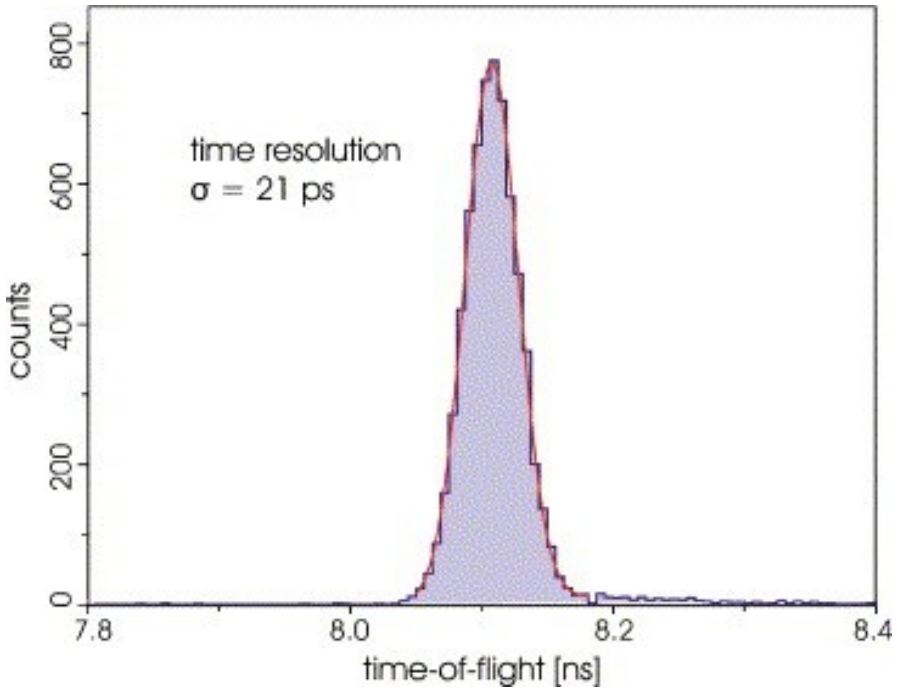




TOF detectors of 21 ps (42 ps is also o.k.) time resolution at ~3 m with each other 900 cm² large Area!

Chemical Vapour Deposition Diamonds

87 MeV/u ^{78}Kr



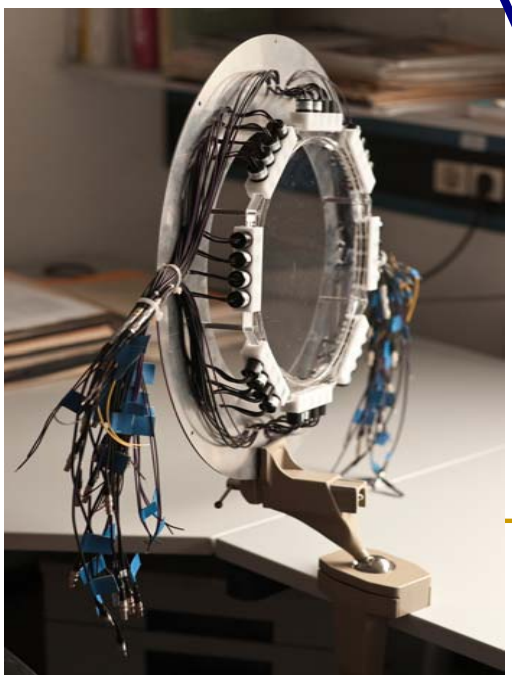
We will need large area diamonds!!

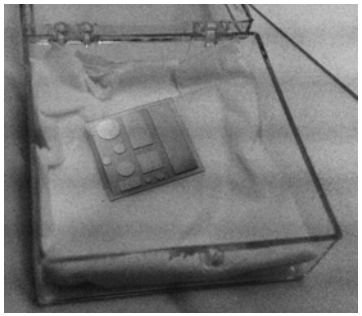
A. Stolz et al. Dia. Rel. Mat. 15 (2006) 807

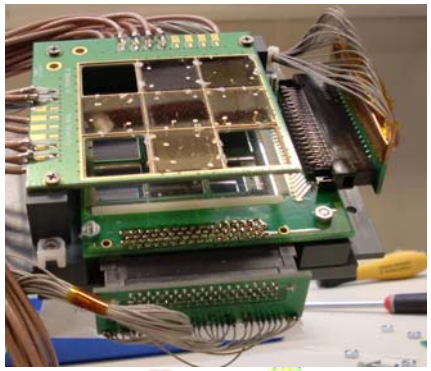
ToF system & Lund-York-Cologne Calorimeter (LYCCA), 2010

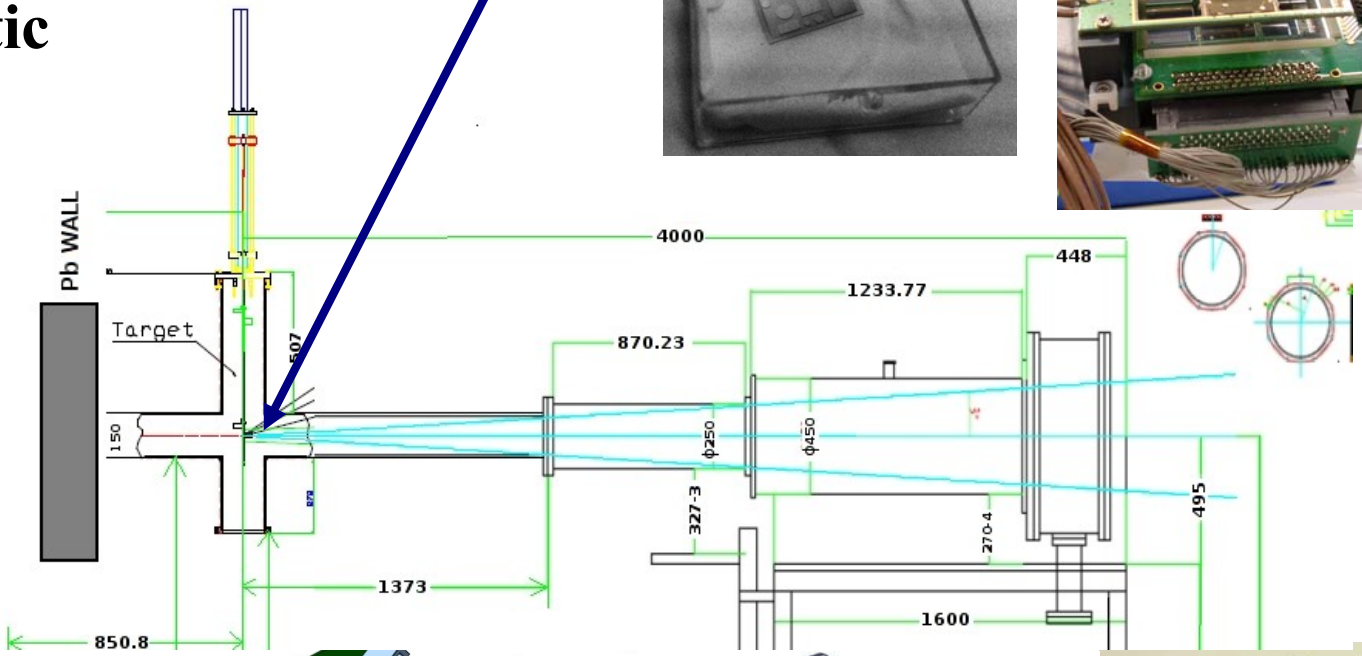
Secondary Target + DSSD (position)+Diamond (timing)

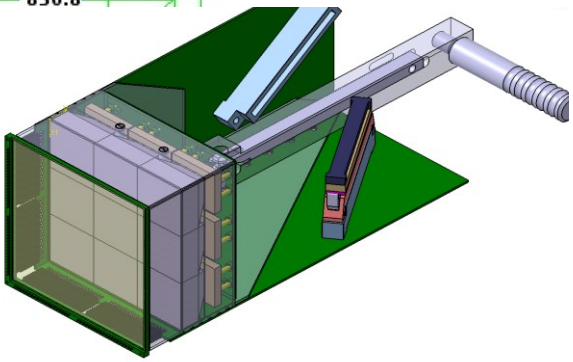
LYCCA start: Plastic (timing)

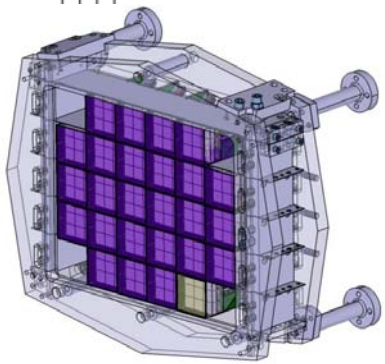


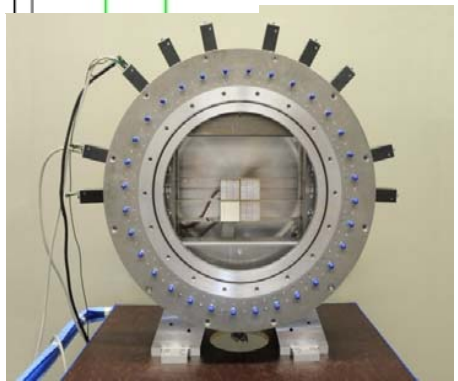






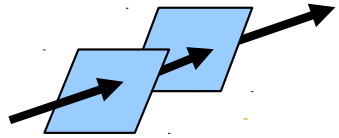






CARAT 2009 recapitulation

http://www-norhdia.gsi.de/CARAT01/CARAT01Talks/Lohstroh.pdf



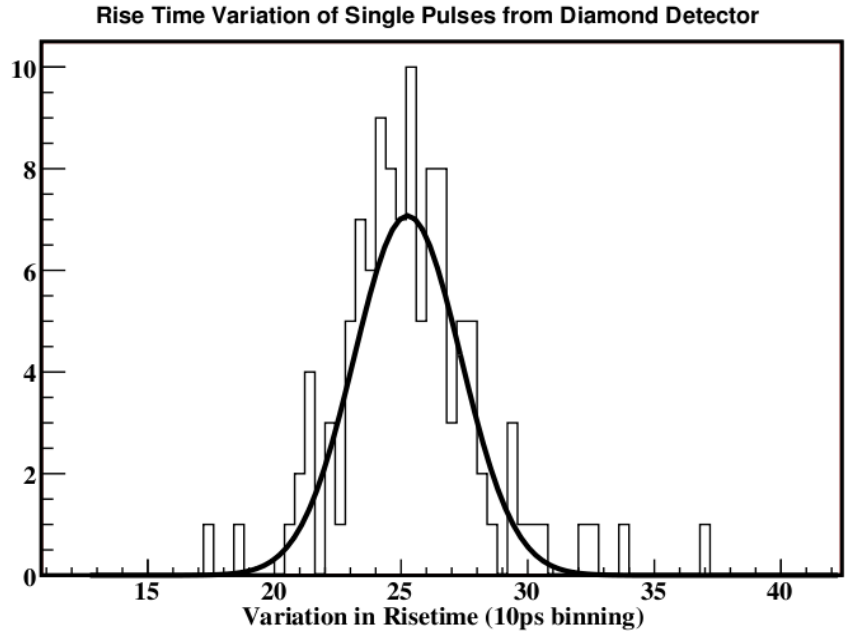
Tests on different metal contacts using 50MeV ^{3}He beam from Birmingham cyclotron

- Signals were pre-amplified with Diamond Broadband Amplifier and collected using 2.5 Ghz scope. The pulse shapes were analysed for the rise time characteristics and the time of flight between the two detectors obtained.
- Signal processing was also done utilizing a 25ps high time resolution Time to Digital Converter, V1290A and timing information was acquired using Midas Data Acquisition system.
- Resolution vs applied bias (no improvement after 1.3 V/µm), dependence on the electronic noise (low noise is essential), detector capacitance (no clear conclusions!) stability of the base line, rise time variations (walk-effect, 25 ps) were evaluated to decide on best contacts.
- The results showed ~ 150-200 ps time resolutions..!

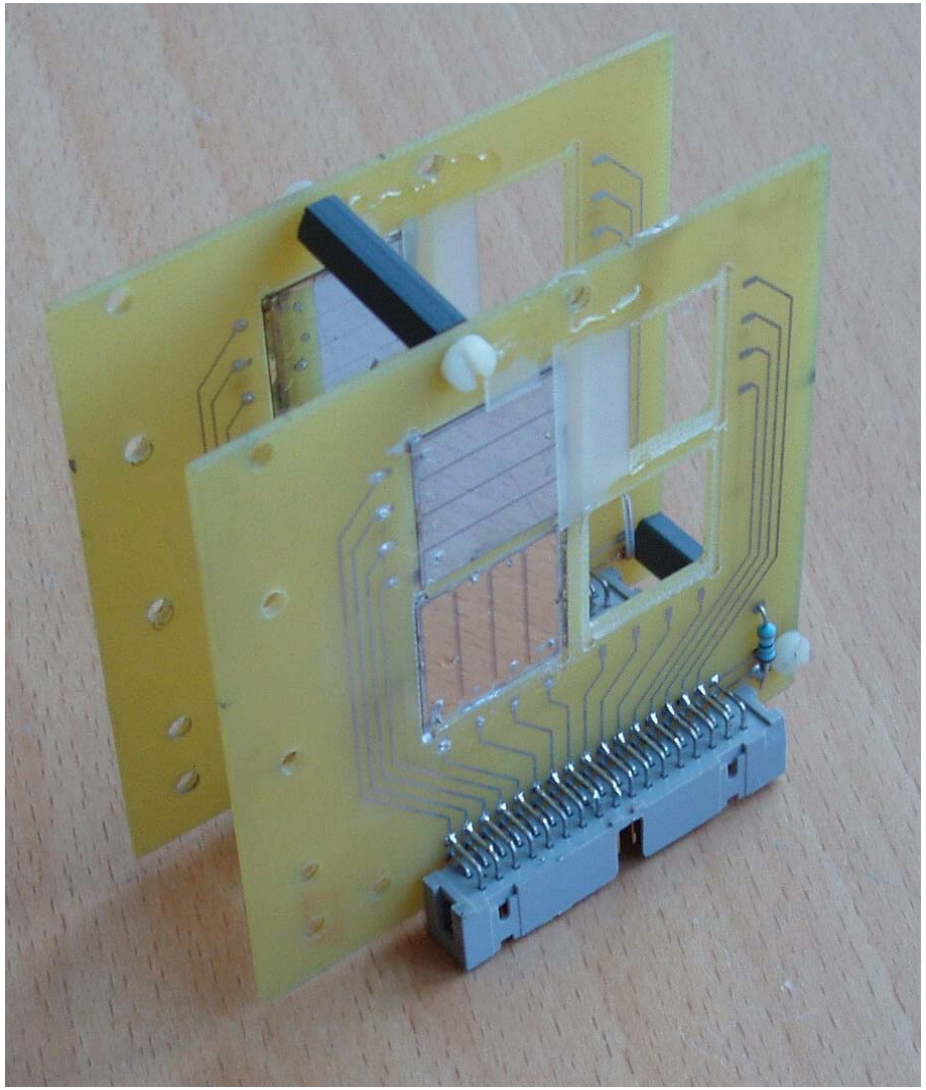
Tests on the best contacts at GSI in October 2009 using 750MeV/u U beam at relativistic velocities

- Data was only collected using V1290A, results showed ~ 200 ps time resolutions.!

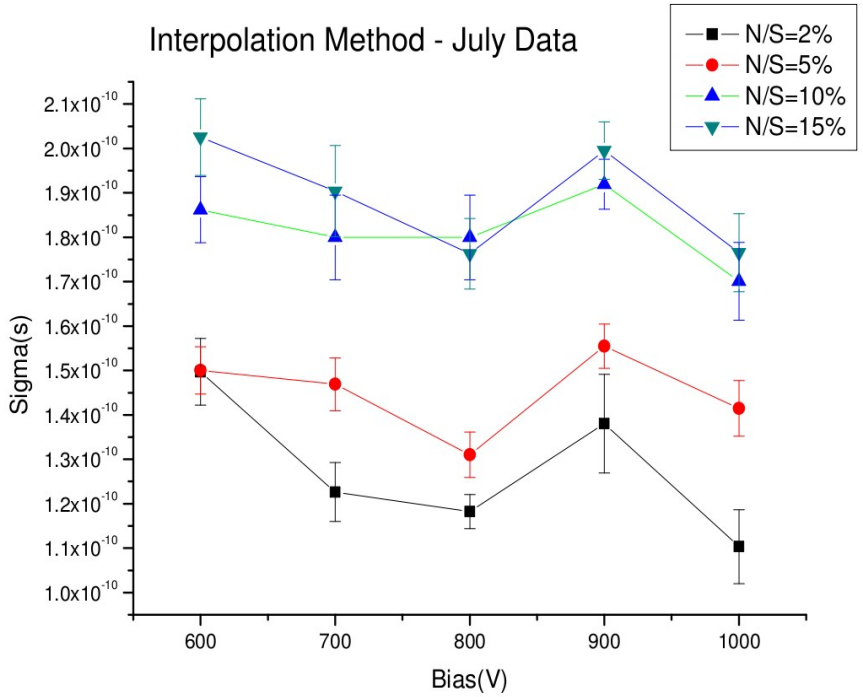
Why such bad time resolutions ?



- Uncontrolled impedance
- High frequency treatment of the signal was not taken care properly



High thresholds→big walk effects



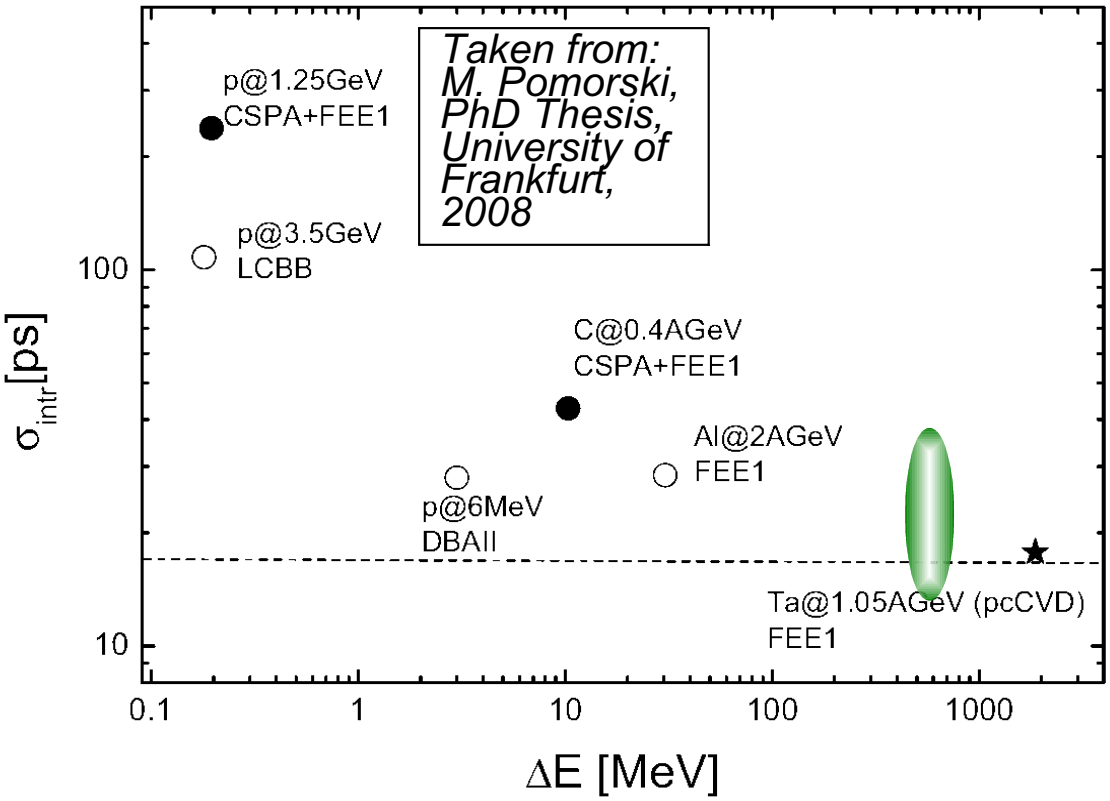
Effect of noise, S/N should be improved

Improvements

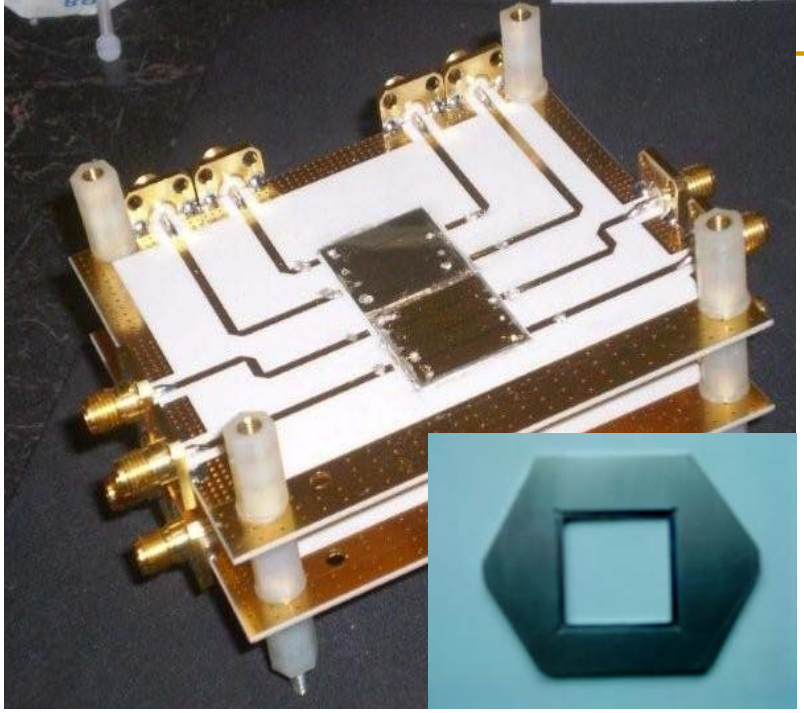
- Fabricated a 2-way Impedance controlled PCB
- Electronics, cables and signal processing optimized

Tests at TEXAS Cyclotron

- Beam energies higher than those from B'ham accelerator
- 35 MeV/u 40Ar, 25 MeV/u ^{20}Ne and ^{16}O,
- E-loss of 500 MeV in detectors similar to that expected at GSI setups..

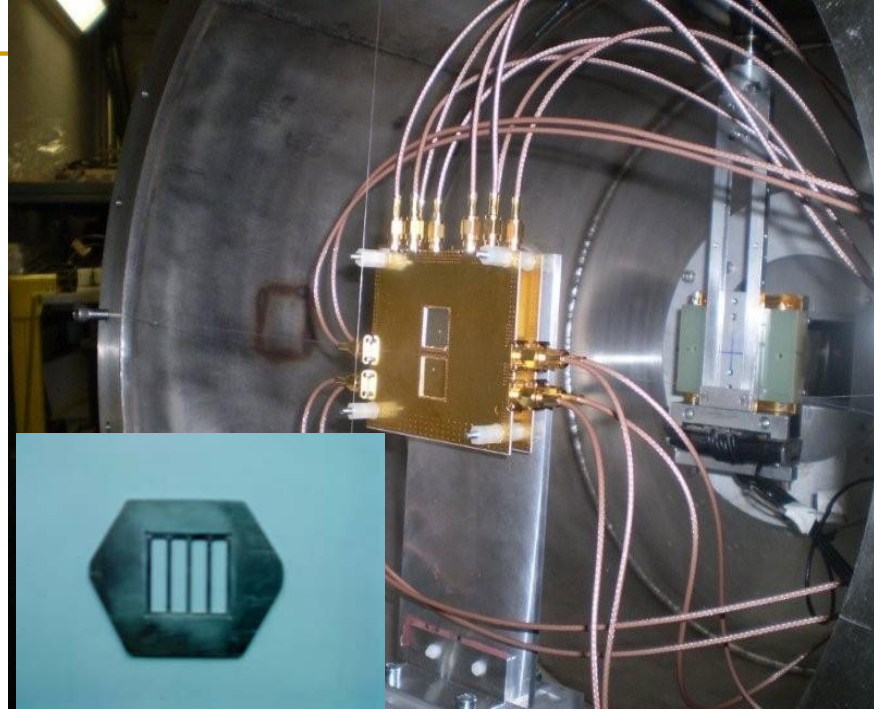


Most of the values in the graph are for single crystal CVDD!!

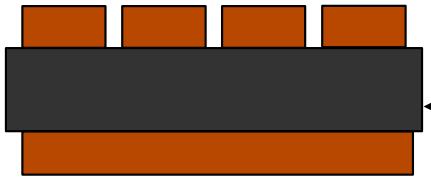


4 separate

read-outs
per wafer



4-strips of 18.0x4.5mm² 100nm Au/50nm Al

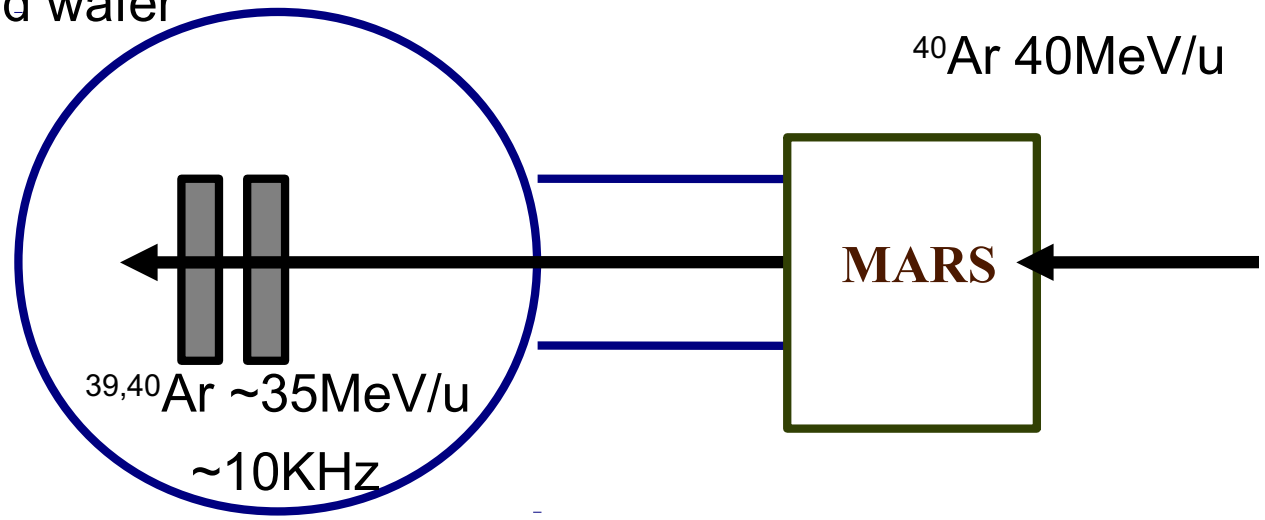


2.0x2.0x0.03 cm³
Diamond wafer

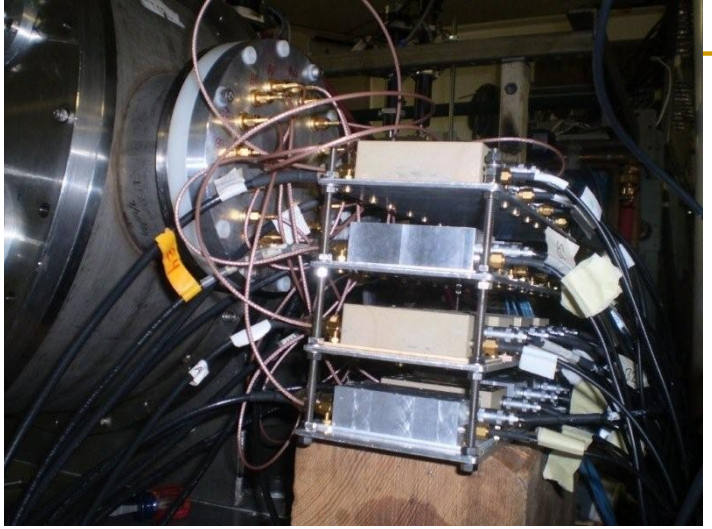
Gnd 18.0x18.0mm²

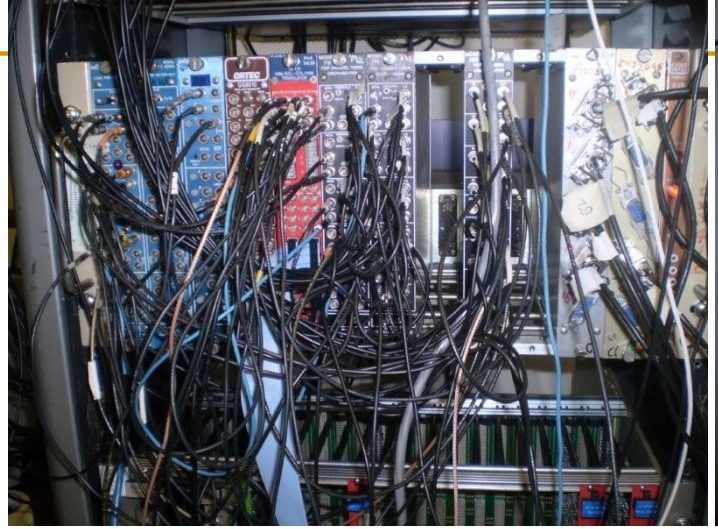
100nm Au/50nm Al

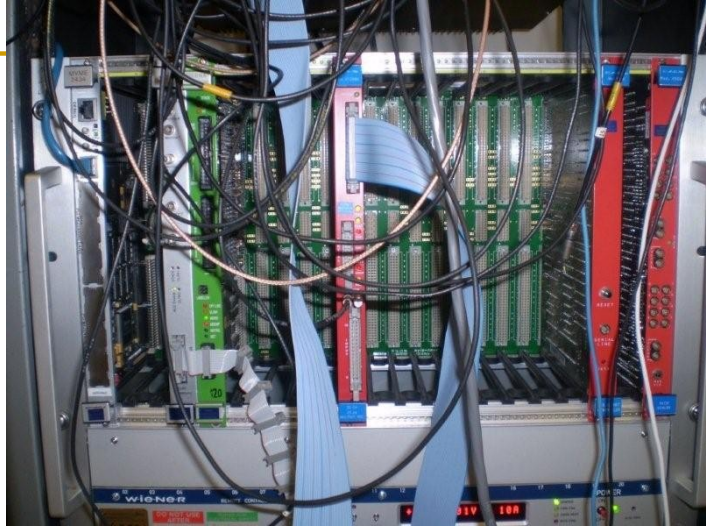
Shadow mask (sputter coating) or photo-lithography (thermal evaporation) and conductive glue bonding

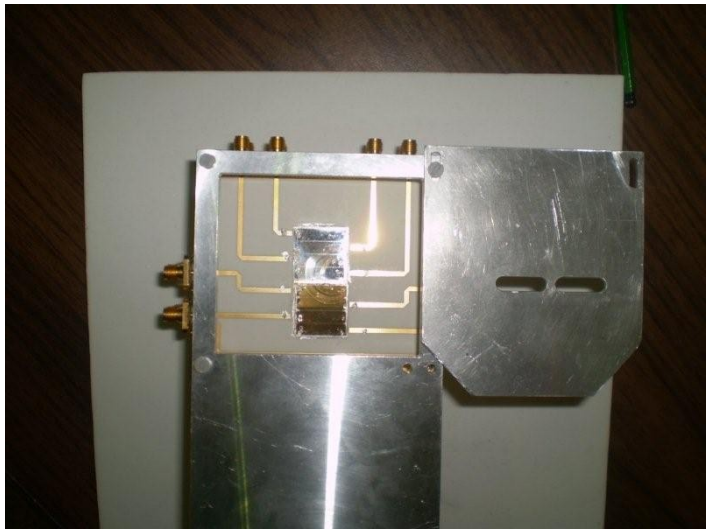


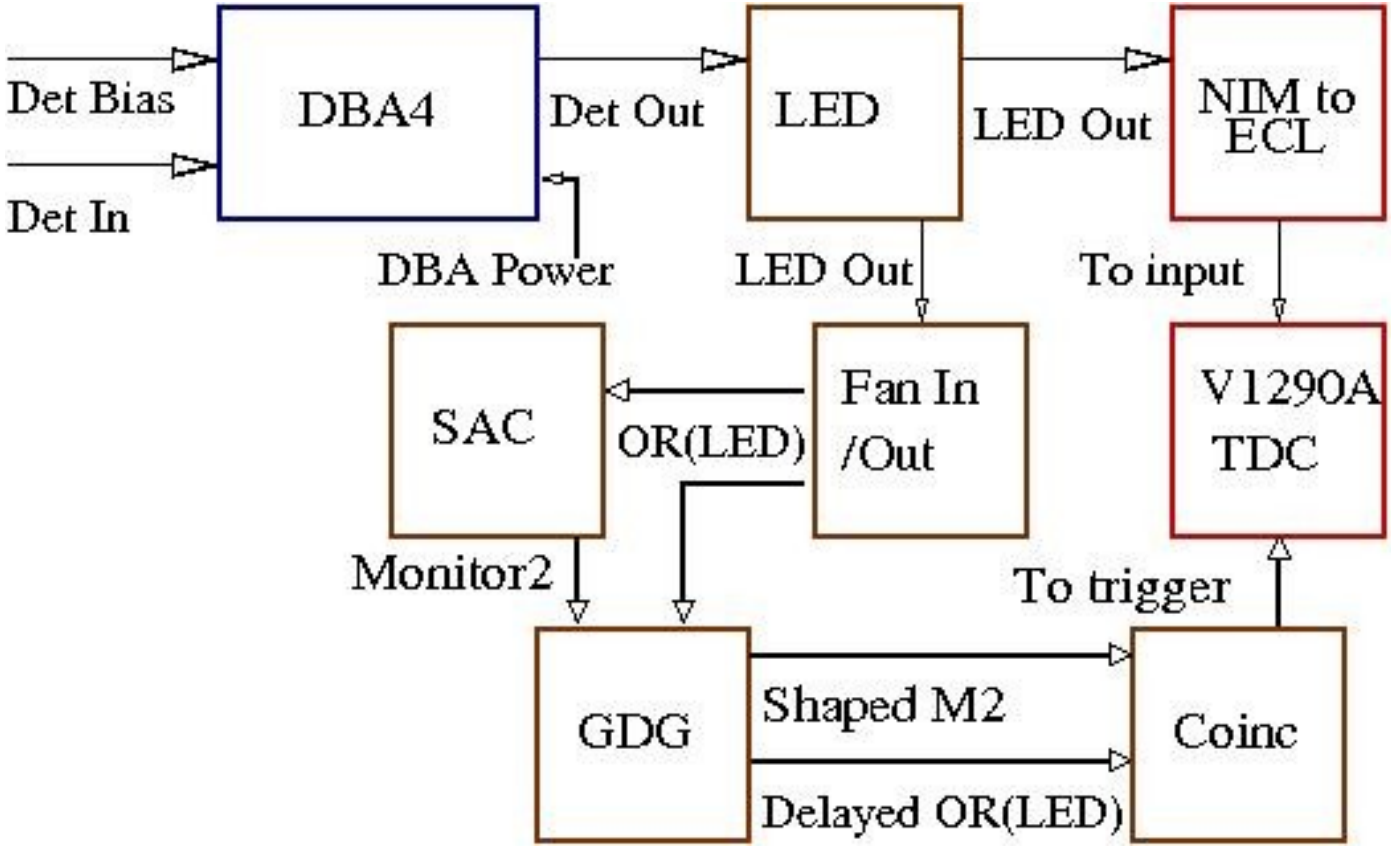
Texas Set-up










Det Bias
Det In
DBA4
Det Out
DBA Power
LED
LED Out
LED Out
NIM to ECL
To input
SAC
OR(LED)
Fan In /Out
V1290A TDC
Monitor2
To trigger
GDG
Shaped M2
Delayed OR(LED)
Coinc

Texas Set-up

V1290A TDC non-linearity

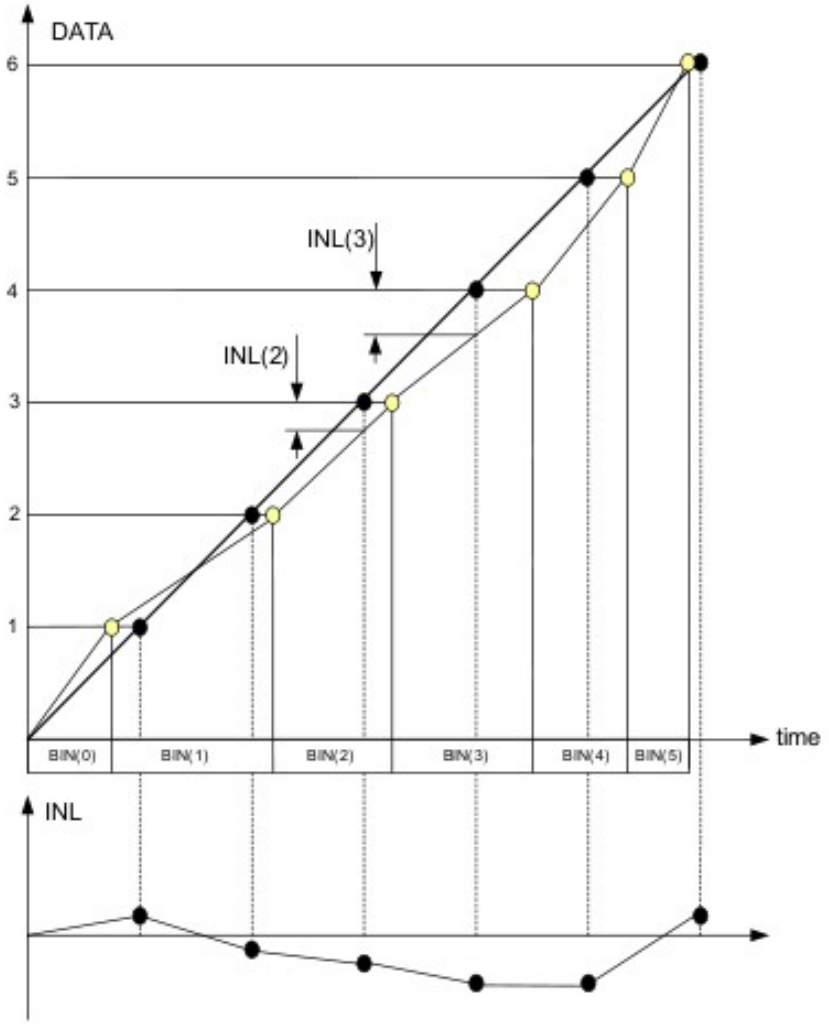
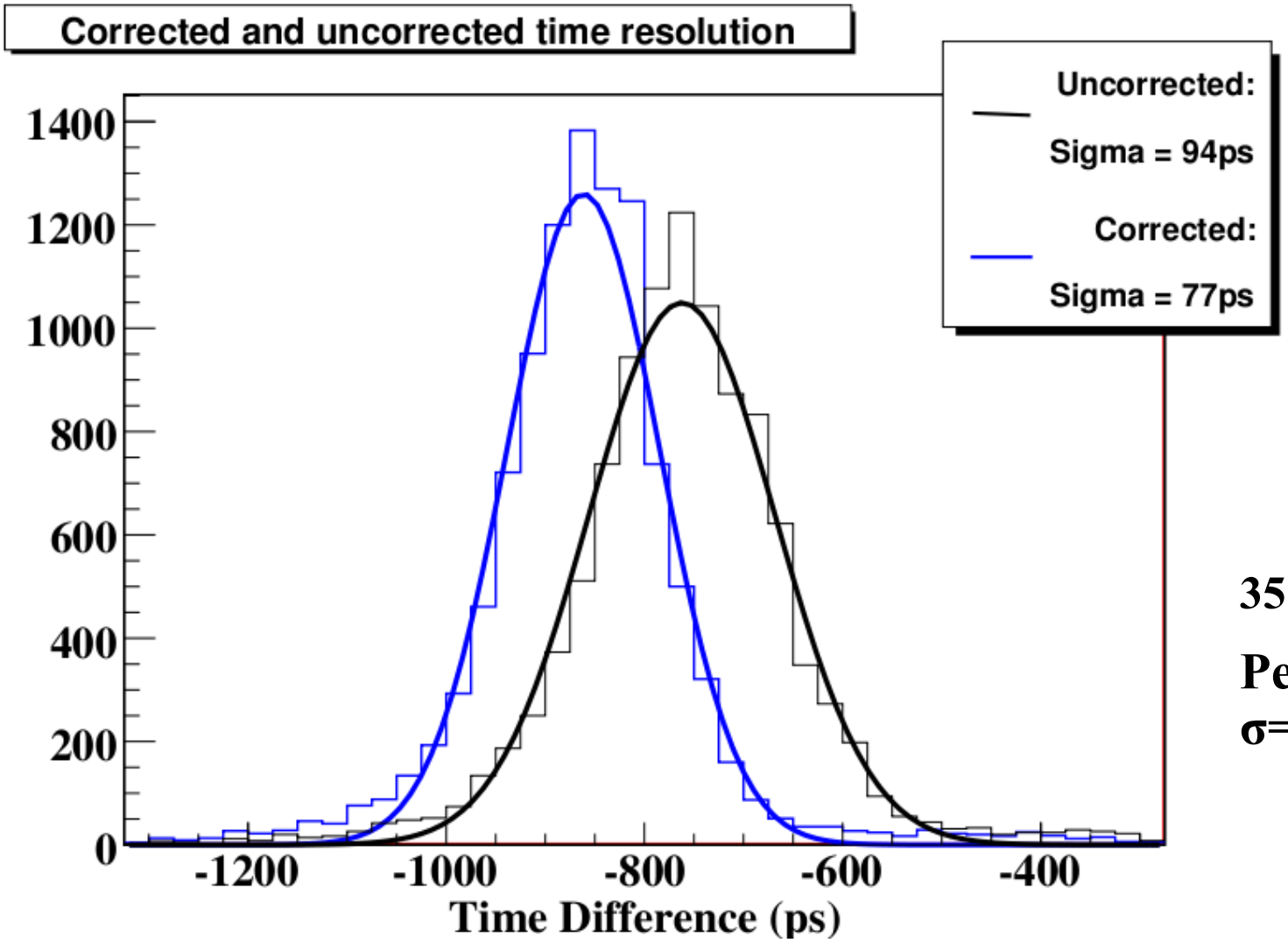


Fig. 2.9 INL I/O Characteristic

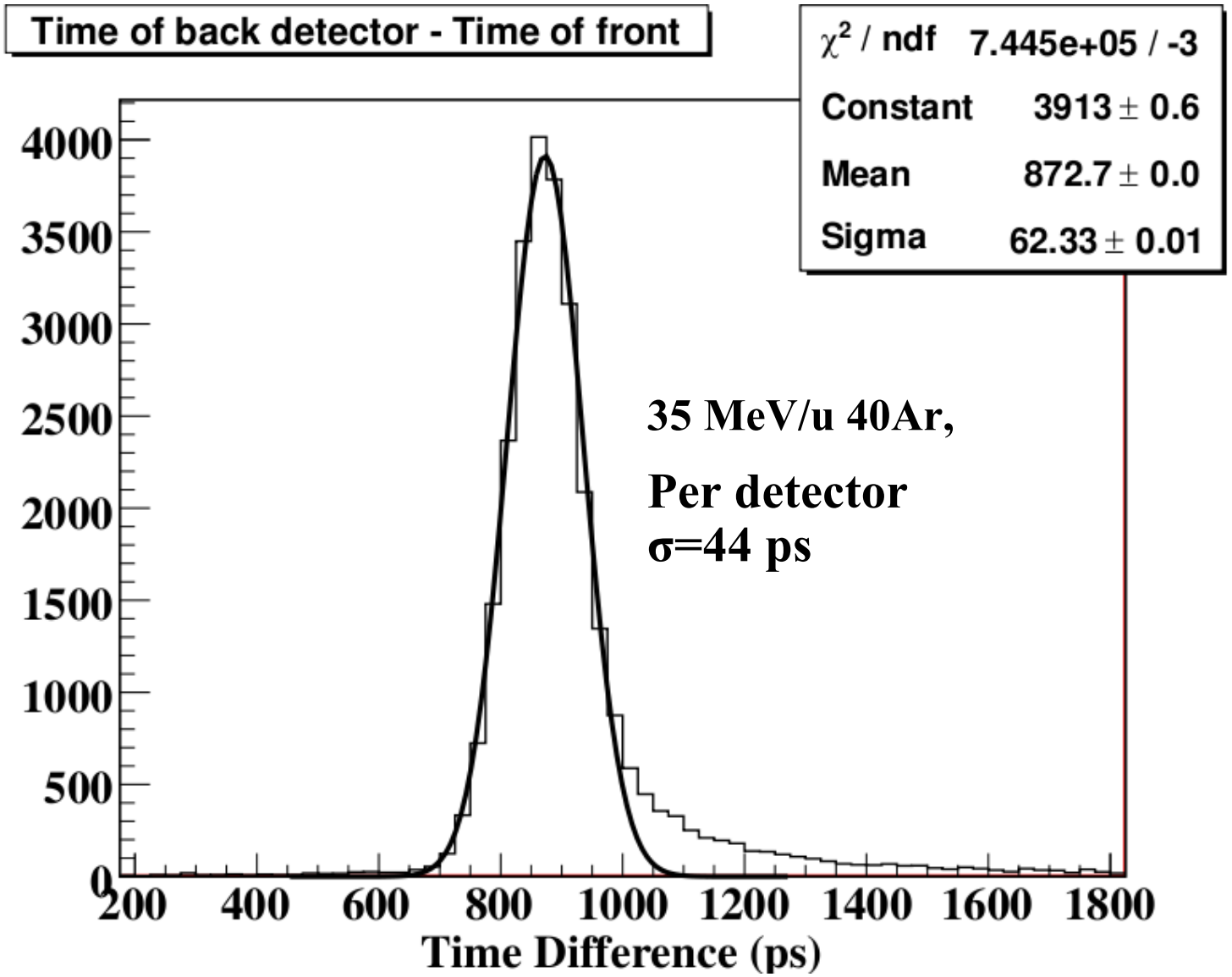
Corrected versus uncorrected



35 MeV/u 40Ar,

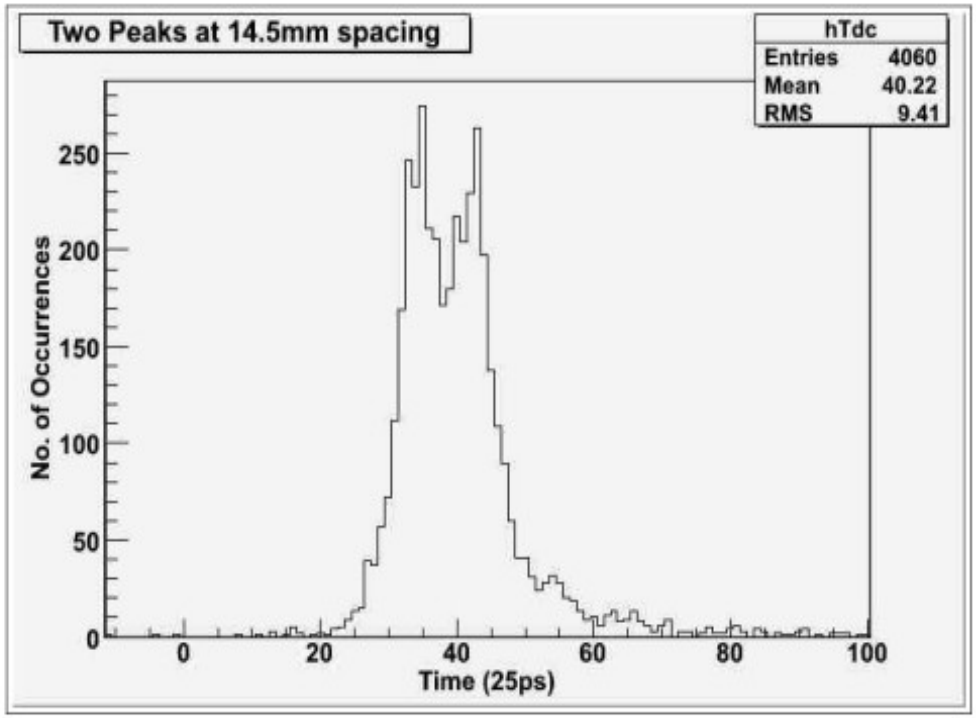
Per detector
σ=54 ps

Results

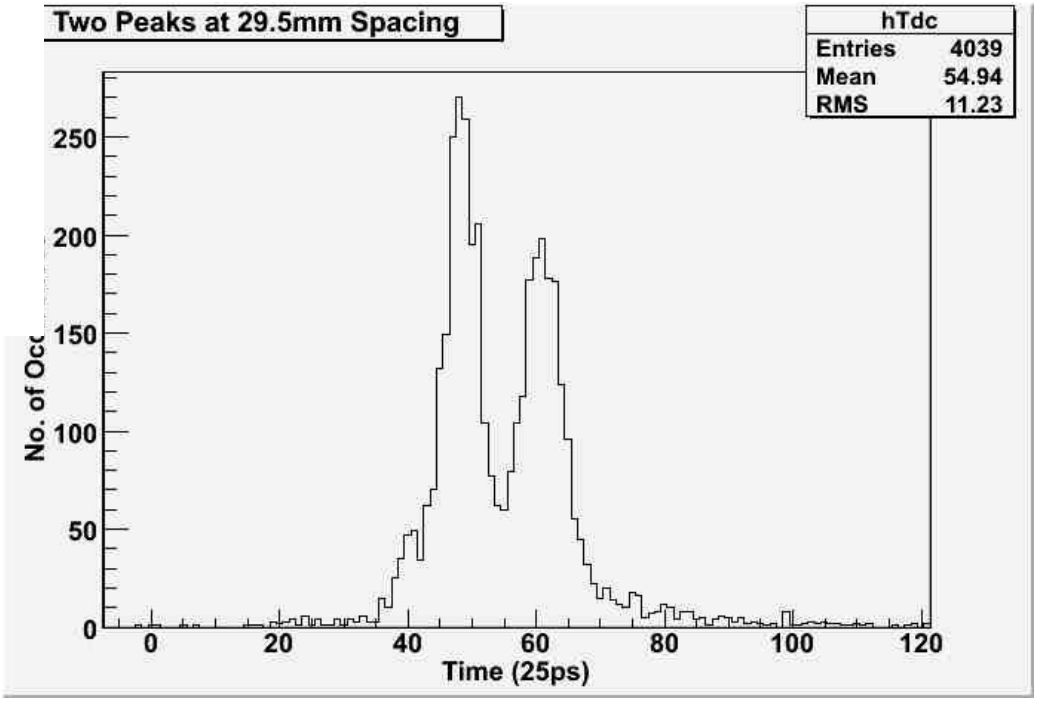


50 ps per strip is a typical value

Results



25 MeV/u ^{20}Ne and ^{16}O

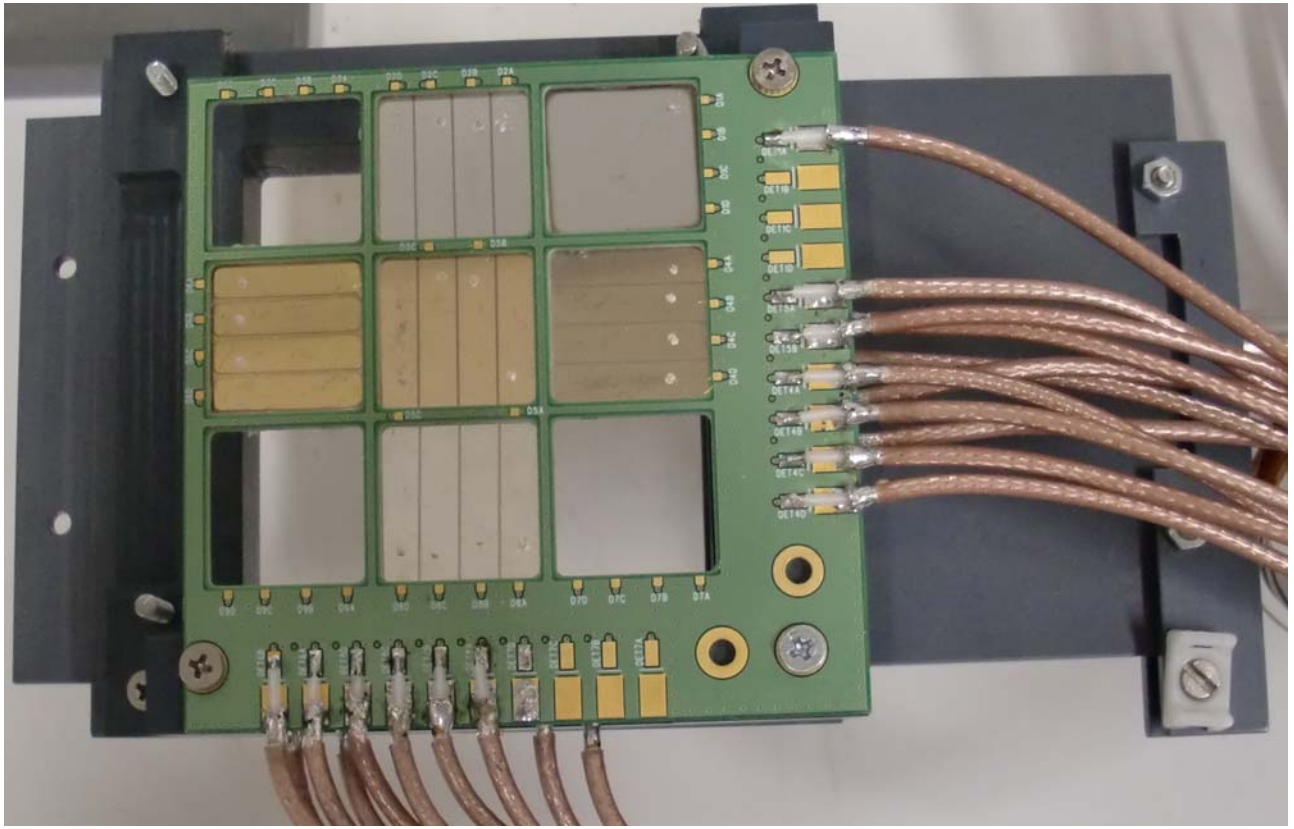


ToF identification using large area diamonds for the first time ?

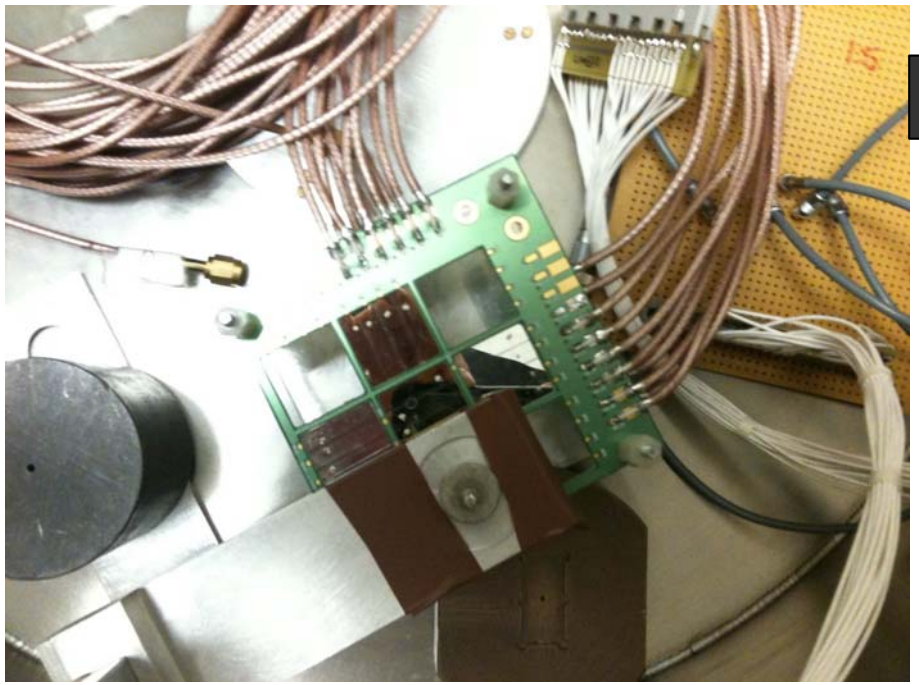
Room for improvements

- Noise levels were 40 mV, at GSI should be a factor lower
- Different Z components were not distinguished, GSI LYCCA setup would help distinguishing different Z
- No position corrections, at GSI DSSDs will provide position information
- Thinner detectors ? It was a compromise to mechanical handling of the detectors, we plan for thinner detectors (polarization effects in-beam..any experience?)
- Blew DBA4: we will work towards a stable system, voltage stability, wire-bonding, contact adhesion etc..

Impedance controlled PCB for GSI 2010



Am source tests using charge sensitive preamp



Different contacts with similar characteristics were installed:

Au (100nm) - Au (100nm)

Ti/Pt/Au (30/20/50nm) - Ti/Pt/Au (30/20/50nm)

Al (80nm) - Ti/Pt/Au (30/20/50nm)

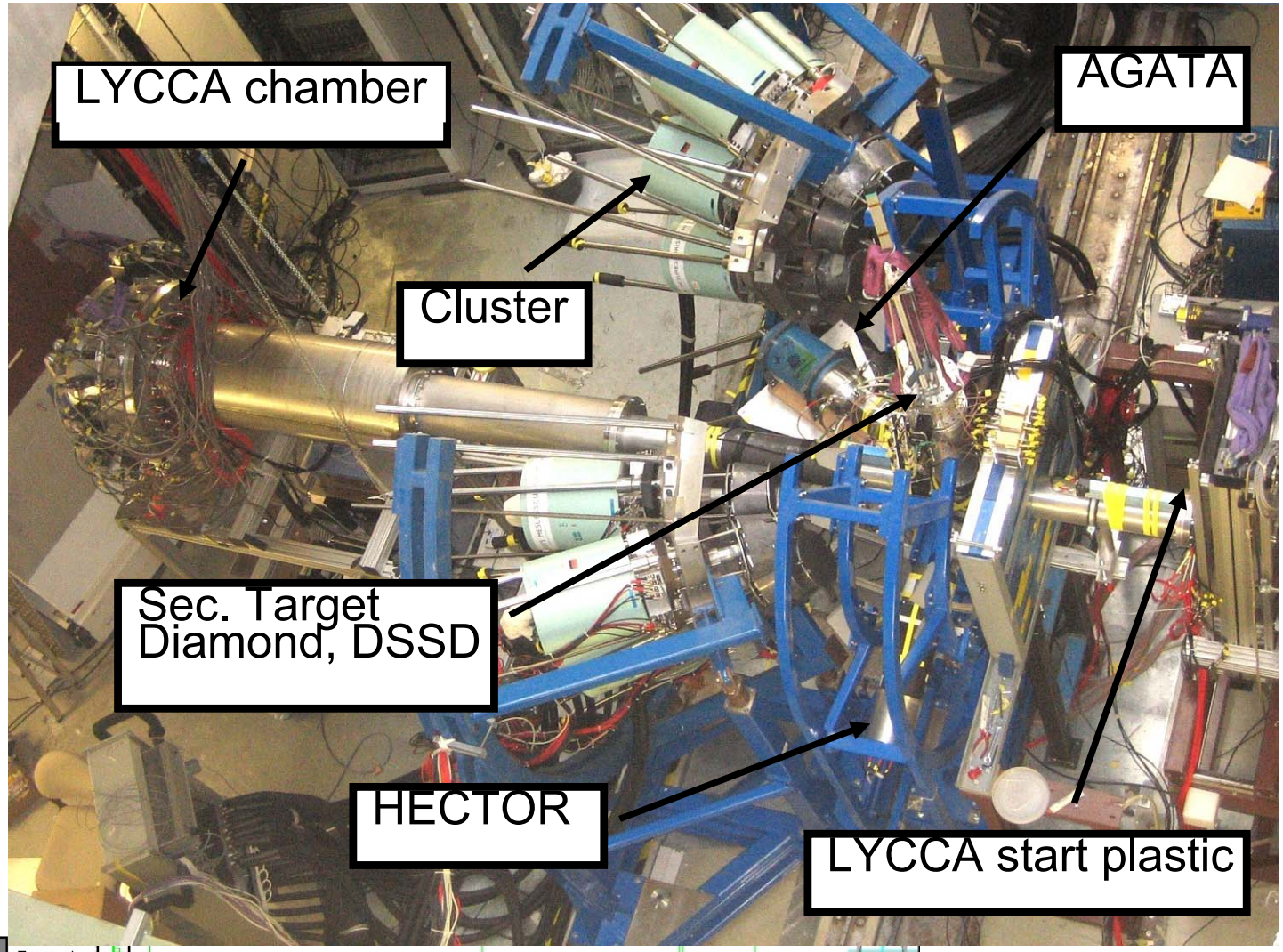
Ti/Pt (30/50nm) - Ti/Pt (30/50nm)

Al (80nm) - Ti/Pt/Au (30/20/50nm) gave best results on:

stability of the base line/dark current

charge collection efficiency/signal amplitude

ToF system commissioning run at GSI September 2010



^{64}Ni 550 MeV/u

~ 2.10^{3} to 10^{7}pps on production

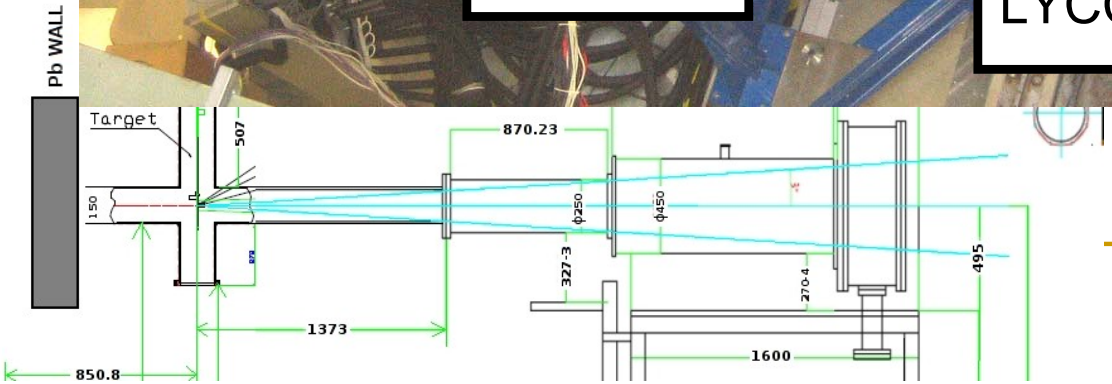
^{9}Be target

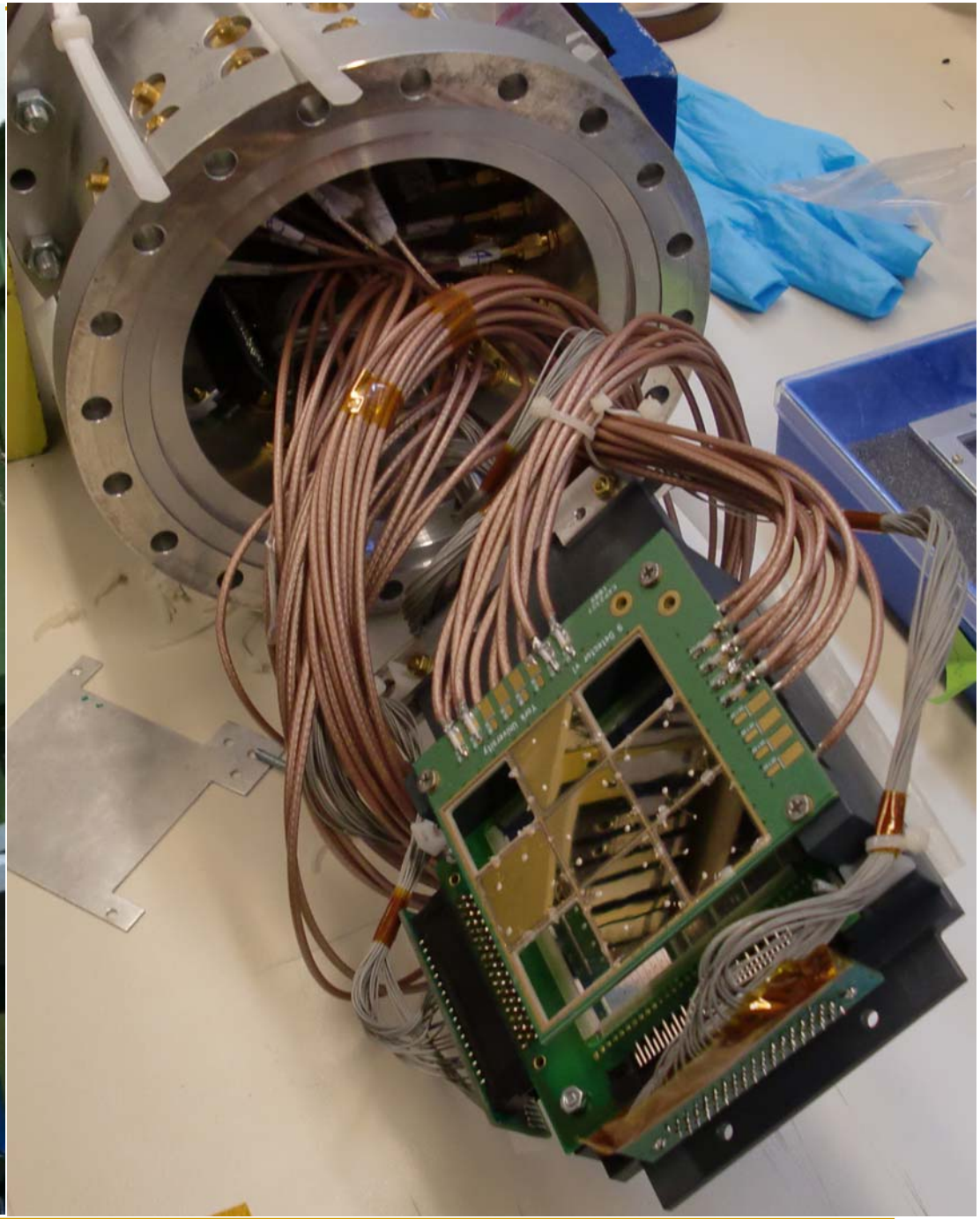
^{63}Co 164 MeV/u

~ 10.10^{3} pps on Secondary

Au target

125 MeV/u at CSI





The potential of September 2010 GSI data

FWHM~150 ps (σ ~ 64ps) per detector from online spectra

The full data analysis is under progress that will utilize the following facts..Lot to improve upon

- **Noise levels were 20 mV and larger signal amplitudes**
- **Different Z can be distinguished from energy loss in the DSSD and energy in the CSI detectors**
- **Position corrections and tracking information from the DSSDs and CSI modules will be available that should take away any position dependence**
- **Accurate energy information on the fragments will help to correct for the walk efffects.**

Future

TOF experiment at the cyclotron in Birmingham Jan 11

Capacitance effects using various sizes for the contacts

Test the DDL type contacts

Further developments

- **Working with DDL to produce 6 cm x 6 cm diamond detector prototype by beginning of 2012: Larger area, thinner samples, Design of PCB, improved signal read-out system**
- **Walk corrections**

Summary

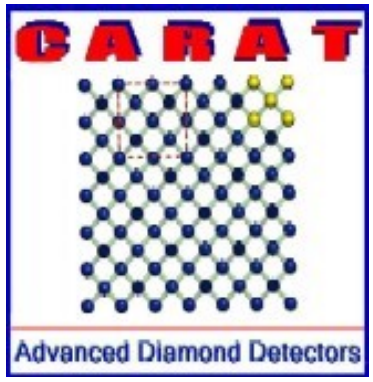
- B'ham initial work and GSI test
- Texas tests
- GSI Sep 2010 commissioning run
- Future plans

Collaboration

York: B. S. Nara Singh, L. Scruton, M. Bentley, S. Fox

Surrey: A. Lohstroh, F. Schirru, A.W. Davies, P.J. Sellin

& Lund + Cologne + Birmingham+Texas + GSI ..



Thank You