The PHENIX Multiplicity and Vertex Detector

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PHENIX

Talk Outline:

I. Motivation - Heavy Ion Physics

II. PHENIX

III. The Multiplicity and Vertex Detector

A. General Description

B. Rohacell Support Structure

C. Silicon Detectors

D. Electronics

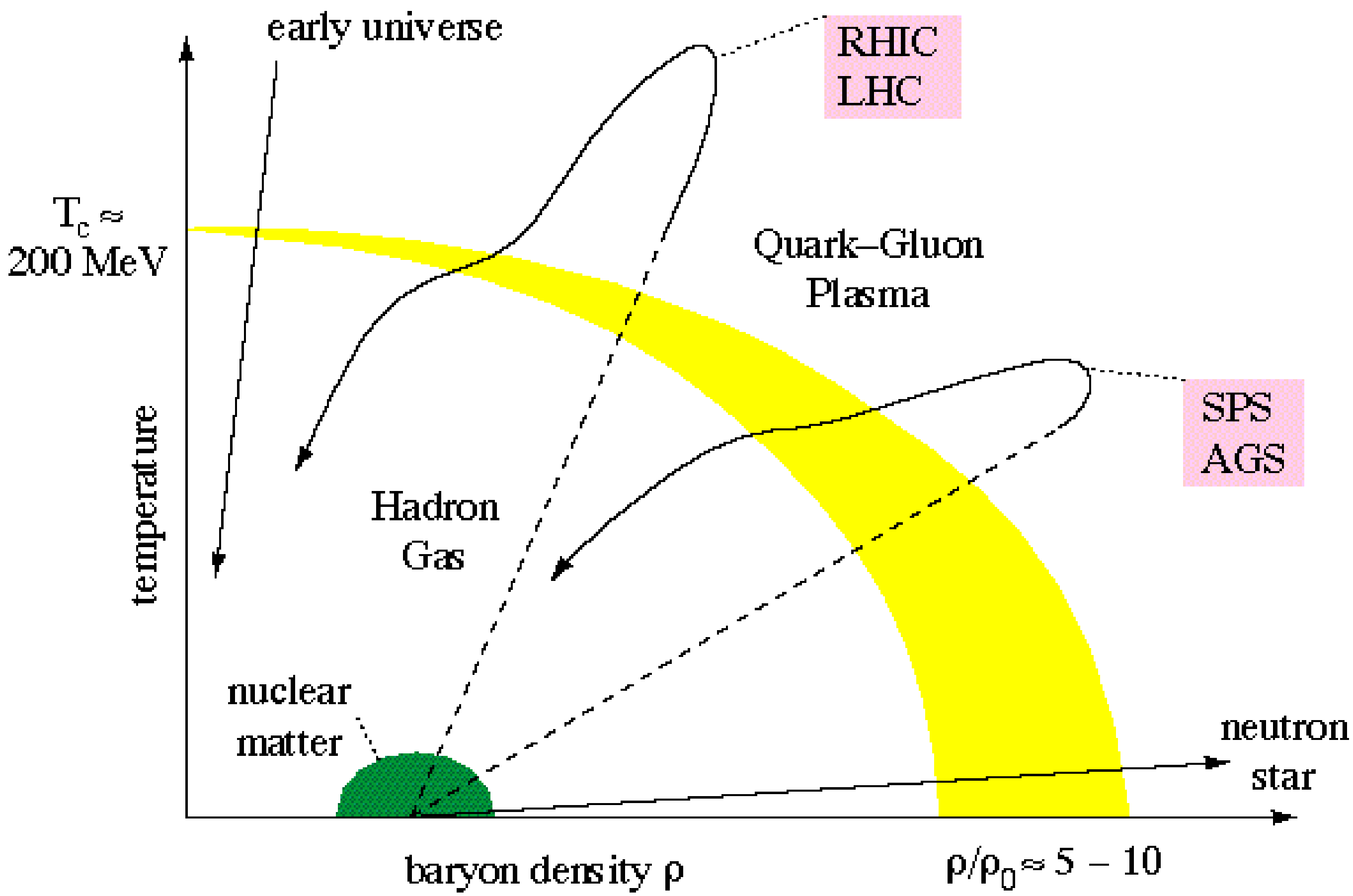
E. Beam Test

F. dN/dη simulations

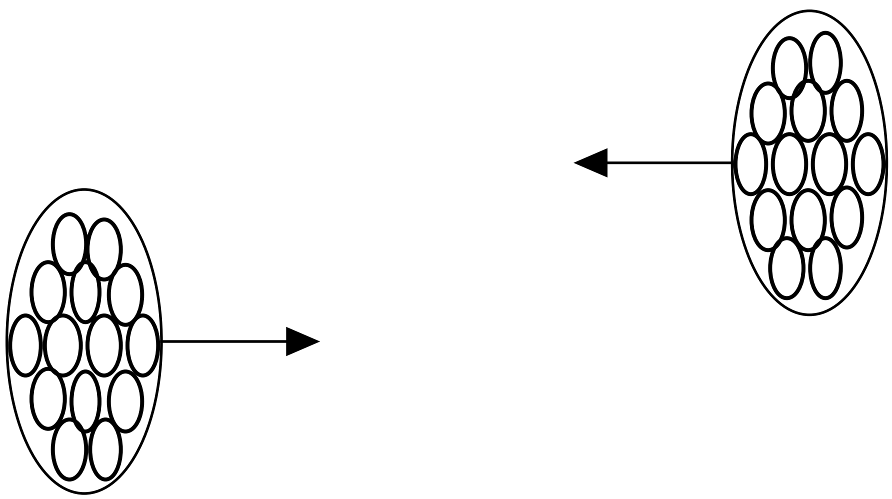
G. Vertex Finding Algorithms

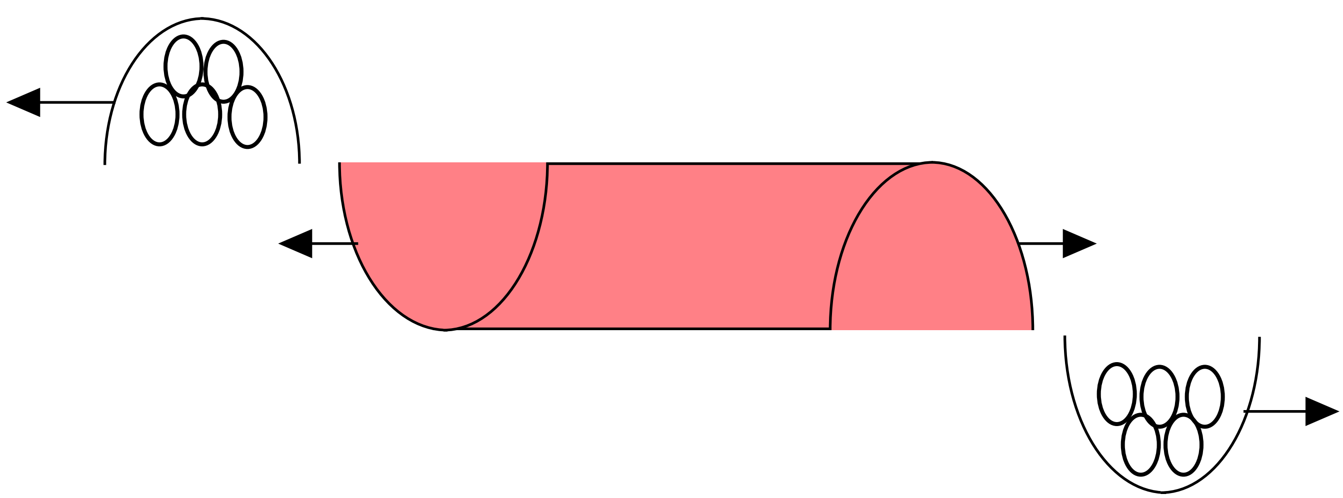
H. Construction Status

Nuclear Matter Phase Diagram



Heavy Ion Collisions:





The RHIC Accelerator:

Configuration:	Two concentric superconducting magnet rings (3.8 km circumference); 6 interaction regions	
Performance:	Au + Au	p + p
E_{beam}(max):	100 Gev/u	250 Gev/u
Luminosity:	2×10^{26} cm^{-2} s^{-1}	1.4×10^{31} cm^{-2} s^{-1}
Completion:	Expected in Spring of 1998	

Relativistic Heavy Ion Collider (RHIC)
Brookhaven National Laboratory

Scientific Objectives

Collisions of Relativistic Heavy Ion Beams create Extraordinary States of Nuclear Matter in Temperature and Density:

The Universe at a few usec after the Big Bang

Deconfinement of Quarks and Gluons = Quark Gluon Plasma
i.e., Phase transition to a New State of Matter

Experiments at RHIC

Verification of such states of Nuclear Matter
Exploration of a new phase of Matter
Study of the Quark Structure of Matter and the theory of the strong interaction of deconfined quarks (QCD)
Recreation of transitions from quarks to nucleons
 Insight into the physics of the early universe

Detectors at RHIC:

PHENIX: Axial Field, Two-Arm Central Detector & Two Muon Arms. Simulataneous detection of various phase transition phenomena
STAR: Solenoidal Geometry with Cylindrical TPC. Event-by-Event Analysis of hadrons and jets
PHOBOS: "Table Top" Two-Arm Central Spectrometer with High Resolution Silicon Detectors
BRAHMS: Small Acceptance Spectrometer with Variable Setting. Inclusive Particle production over full rapidity range.

The PHENIX Collaboration

Country	Institution	Country	Institution
Brazil	Universidade de Sao Paulo	Russia	Institute of Theoretical & Experimental Physics
Canada	McGill University	Russia	Instituteof Nuclear Research
Germany	University of Muenster	Russia	Joint Institute for Nuclear Research
India	Banaras Hindu University	Russia	Kurchatov Institute of Atomic Energy
India	Bhabha Atomic Research Centre	Russia	Petersburg Nuclear Physics Institute
Japan	Hiroshima University	Sweden	Lund University
Japan	Institute of Nuclear Study	USA	Brookhaven National Laboratory
Japan	KEK, Nat. Lab. for High Energy Phys.	USA	Columbia University
Japan	Kyoto University	USA	Florida State University
Japan	Nagasaki Institute of Applied Science	USA	Georgia State University
Japan	Natl. Inst. of Radiological Sciences	USA	Iowa State University
Japan	RIKEN	USA	Lawrence Livermore National Laboratory
Japan	Tokyo Institute of Technology	USA	Los Alamos National Laboratory
Japan	Tokyo University of Agriculture & Technology	USA	Louisiana State University
Japan	University of Tokyo	USA	Massachusetts Institute of Technology
Japan	University of Tsukuba	USA	New Mexico State University
Japan	Waseda University	USA	Oak Ridge National Laboratory
Korea	Korea University	USA	SUNY at Stony Brook
Korea	Seoul National University	USA	University of Alabama
Korea	Yonsei University	USA	University of California at Riverside
PRC	China Institute of Atomic Energy	USA	University of New Mexico
PRC	Institute of High Energy Physics	USA	University of Tennessee
PRC	Institute of Modern Physics (IMP)	USA	Vanderbilt University
Russia	Institute of High Energy Physics at Protvino	USA	Yale University

Muons Arms

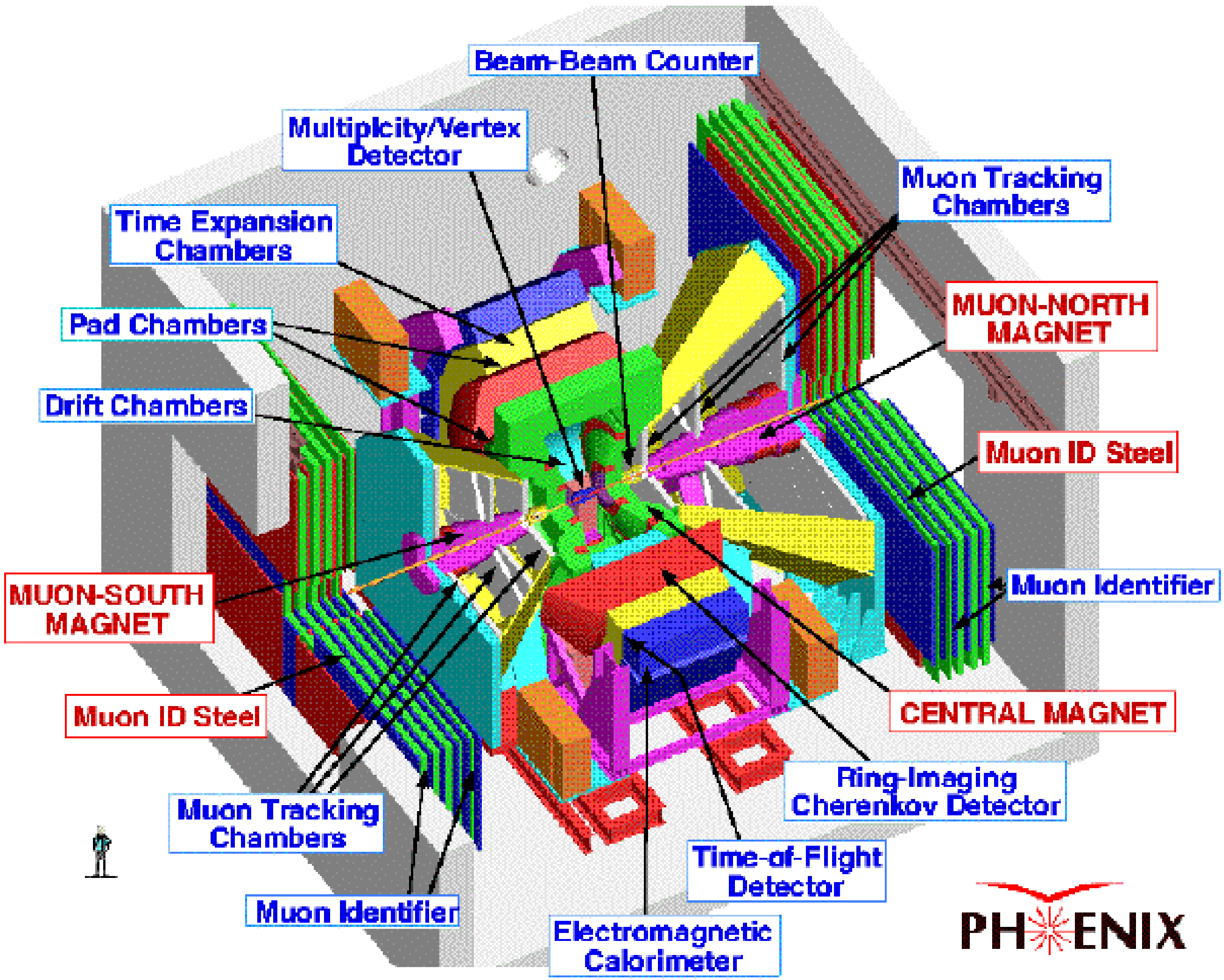
Multiplicity and Vertex Detector

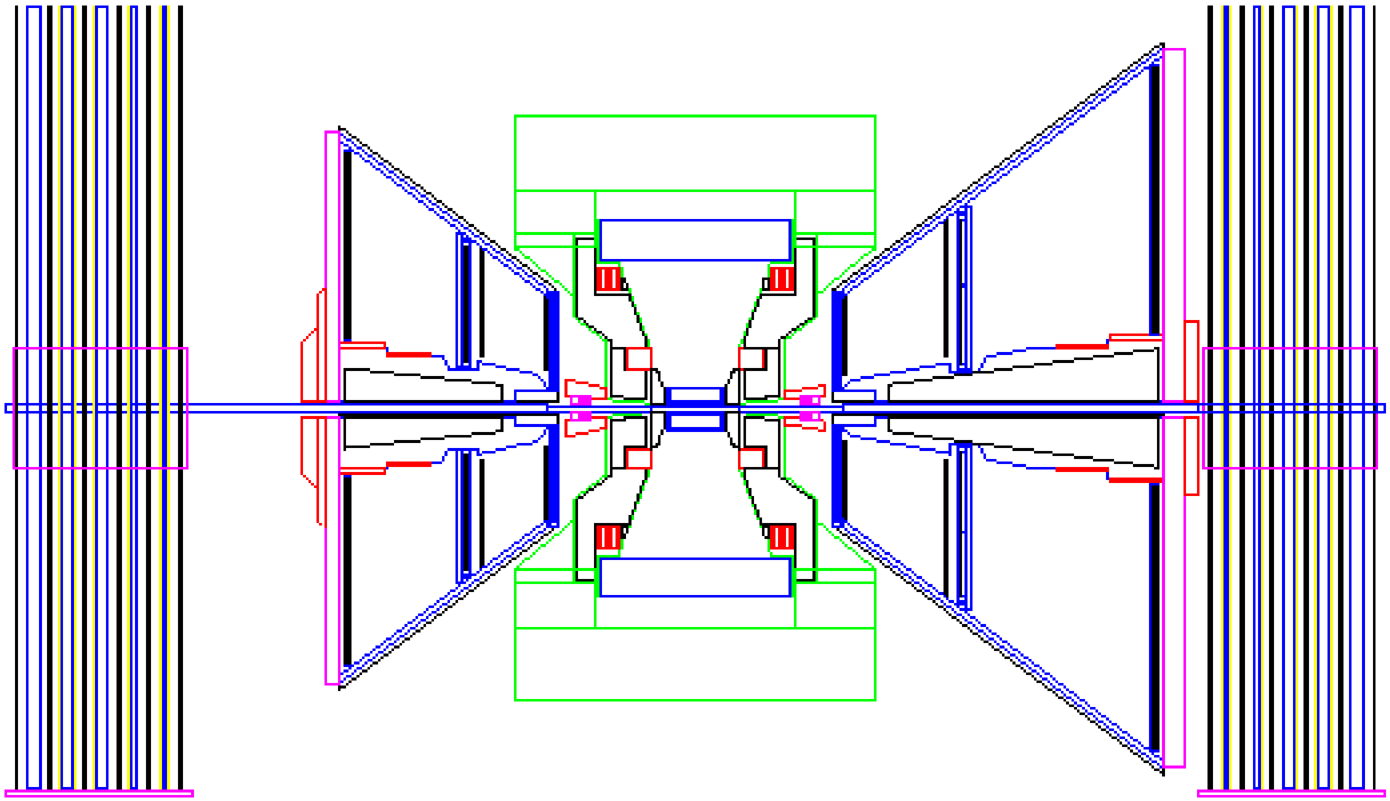
Los Alamos Is Second Largest Contributor After BNL

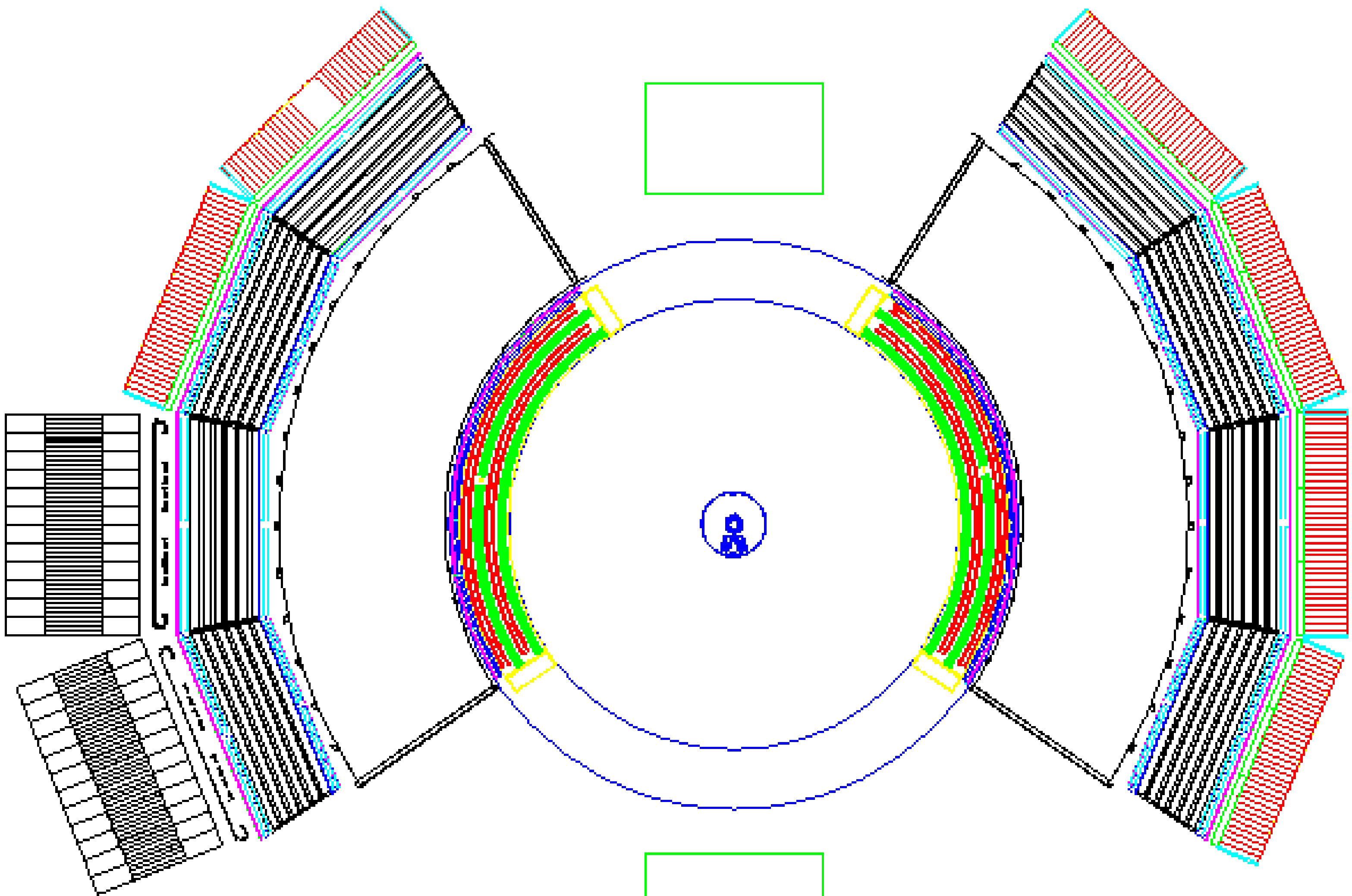
48 Institutions

422 Collaborators

PHENIX Los Alamos


Beam-Beam Counter
Multiplcity/Vertex Detector
Time Expansion Chambers
Pad Chambers
Drift Chambers
Muon Tracking Chambers
MUON-NORTH MAGNET
Muon ID Steel
Muon Identifier
MUON-SOUTH MAGNET
Muon ID Steel
CENTRAL MAGNET
Ring-Imaging Cherenkov Detector
Muon Tracking Chambers
Time-of-Flight Detector
Muon Identifier
Electromagnetic Calorimeter
PHENIX

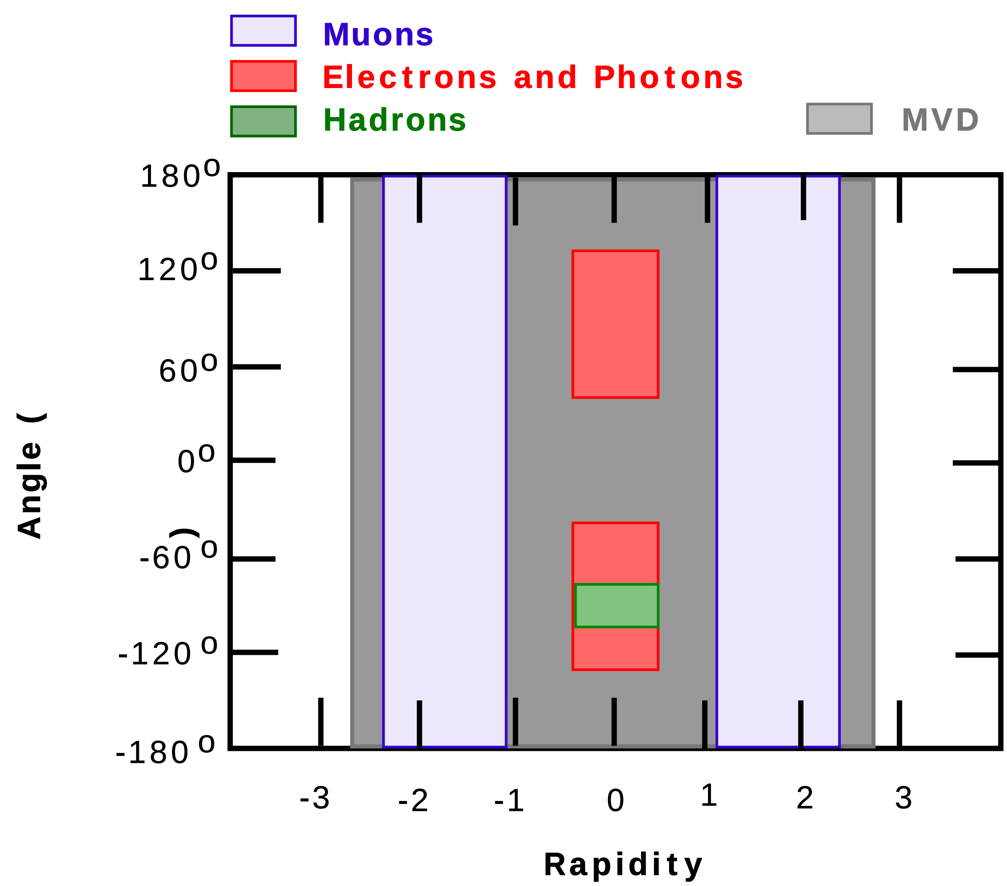




PHENIX Physics Philosophy

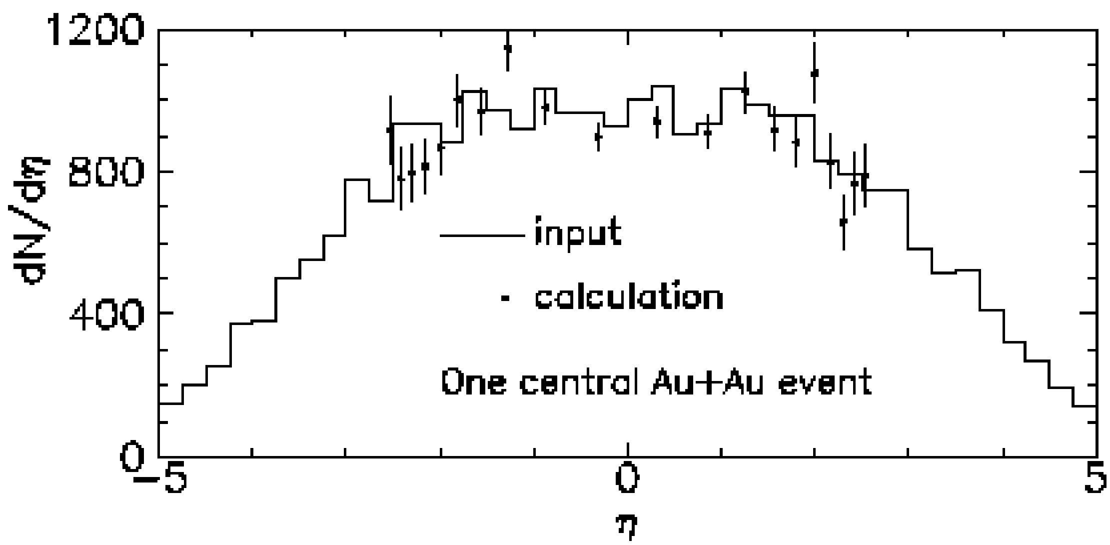
Simultaneous measurement of QGP signatures as function of energy density:
p+p, p+A, A+A

Lepton: Direct probe of plasma
Hadron: Complimentary to leptons, study hadronization



MVD Global Measurements:

$$\eta = -\ln(\tan \theta/2)$$



$$\varepsilon = \frac{dN}{d\eta} \frac{1}{\pi R_T^2 \tau_0} \sqrt{\langle p_T \rangle^2 + m_\pi^2}$$

expected $\varepsilon \approx 2$ GeV/fm^3

Pb nucleus $\varepsilon \approx 0.15$ GeV/fm^3

MVD Collaboration

Project Leader & Detector Council Member: J. Simon-Gillo (LANL)
Mechanical Coordinating Physicist: J. Simon-Gillo (LANL)
Electronics Coordinating Physicist: J.P. Sullivan (LANL)
Lead Mechanical Engineer: J. Boissevain (LANL)
Lead Silicon Design and Electronics Engineer: S. Hahn (LANL)
Lead Integrated Chip Design Engineer: C.L. Britton (ORNL)
Lead Interface Module Engineer: N. Ericson (ORNL)
Systems Integration Engineer: J. Boissevain (LANL)
Lead MCM Engineer: G. Smith (LANL)
Lead MCM Designer: Gary Richardson (LANL)
Simulation Computing: M. Bennett (LANL)
Off-line Computing: J.P. Sullivan (LANL)
On-line Computing: H. van Hecke (LANL)
Database Coordinator: M. Bennett(LANL)
Construction Manager: M. Bennett (LANL)
Silicon Produduction and Testing Coordinator: D. Jaffe (LANL)

Institutions: Los Alamos National Laboratory, OakRidge National Laboratory, University of California at Riverside, Yonsei University, University of Alabama at Huntsville.

MVD Overview:

Physics goals:

Charged particle multiplicity

Centrality trigger at LVL-1

Collision vertex position ($\sigma < 2$ mm)

$dN/d\eta$ $d^2N/d\eta d\varphi$

Design Criteria:

Large rapidity coverage ($\Delta\eta = 5$)

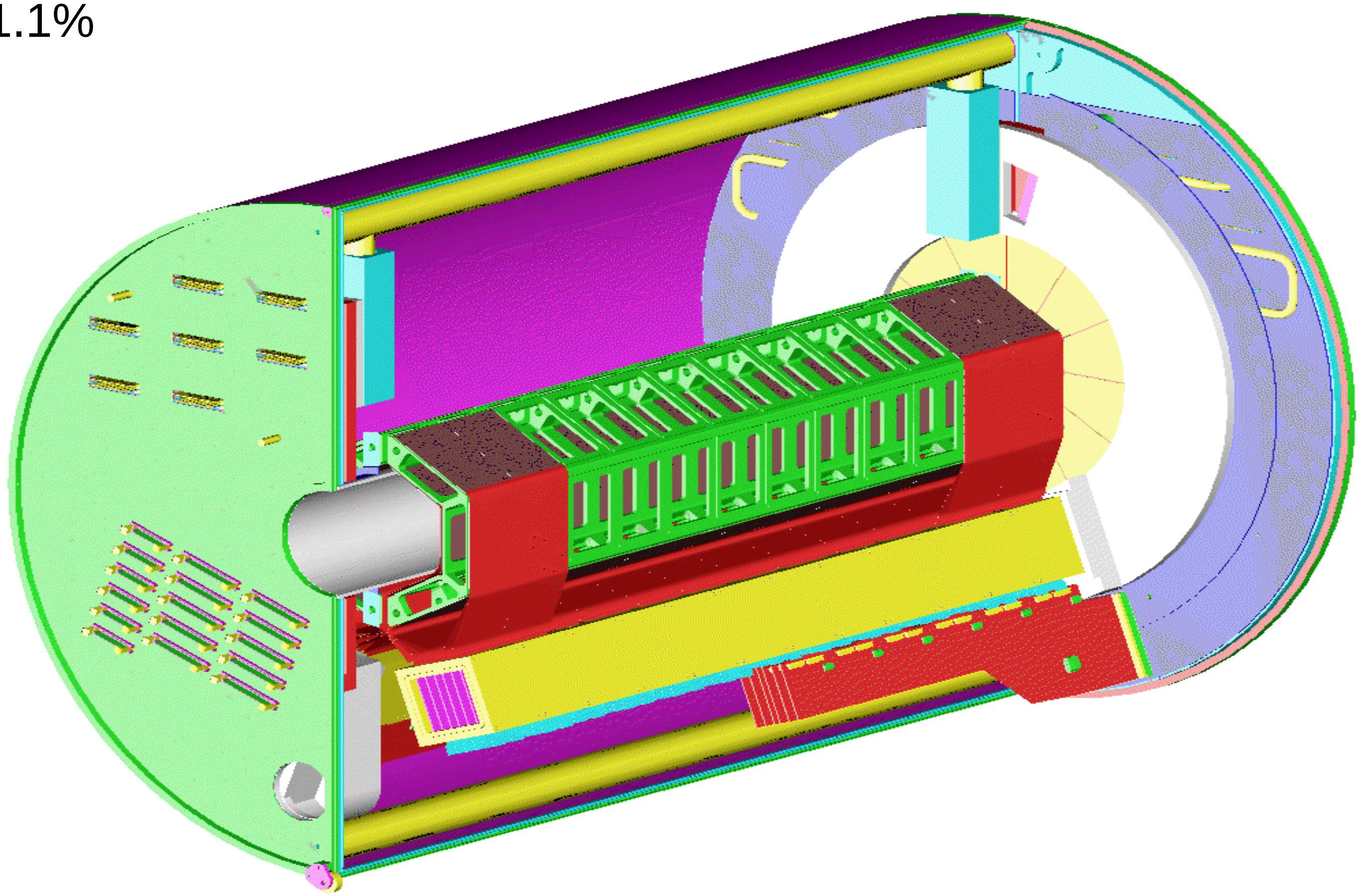
Good azimuthal coverage & granularity

Minimal material in central arms acceptance

Key MVD parameters:

dimensions:	75cm long, 30cm radius
active regions:	inner barrel: |z| < 32cm, r = 5cm
	outer barrel: |z| < 32cm, r = 7.5cm
	endcaps: r = 5-12cm at z = +-35cm
acceptance:	full azimuthal coverage
	pseudorapidity coverage: < 2.5
channels:	inner barrel: 18432
	outer barrel: 10240
	pads: 6048
	total: 34,720
weight:	11 kg, 28 lbs
radiation length:	< 1% in central arms acceptance

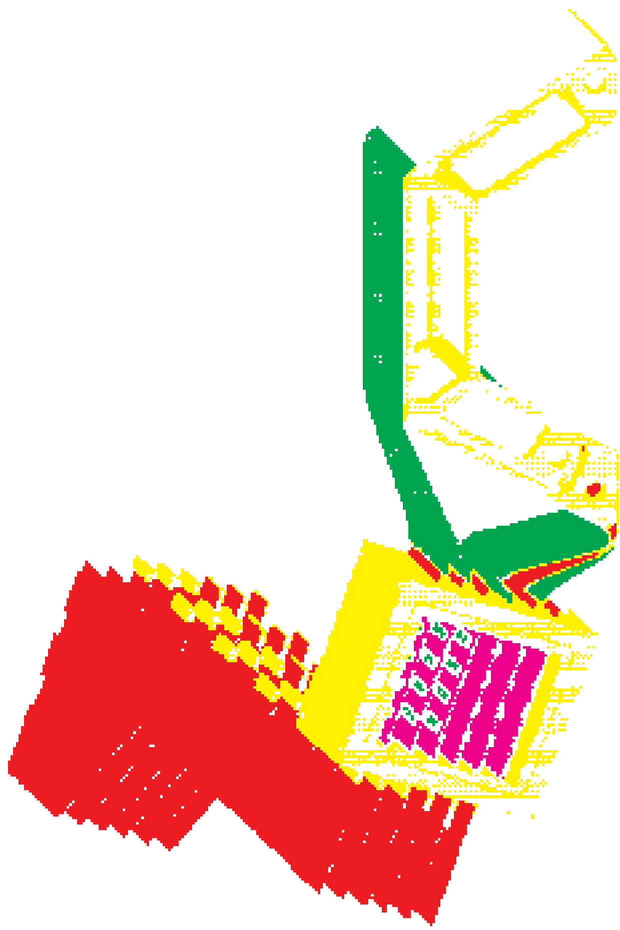
Clamshell design - mounts to magnet pole faces.
Inner and outer barrels of silicon strip detectors, 200μm, 64cm length
Silicon pad endcaps @ +/- 35cm
Rad length ≈ 1.1%
Weight < 30lb



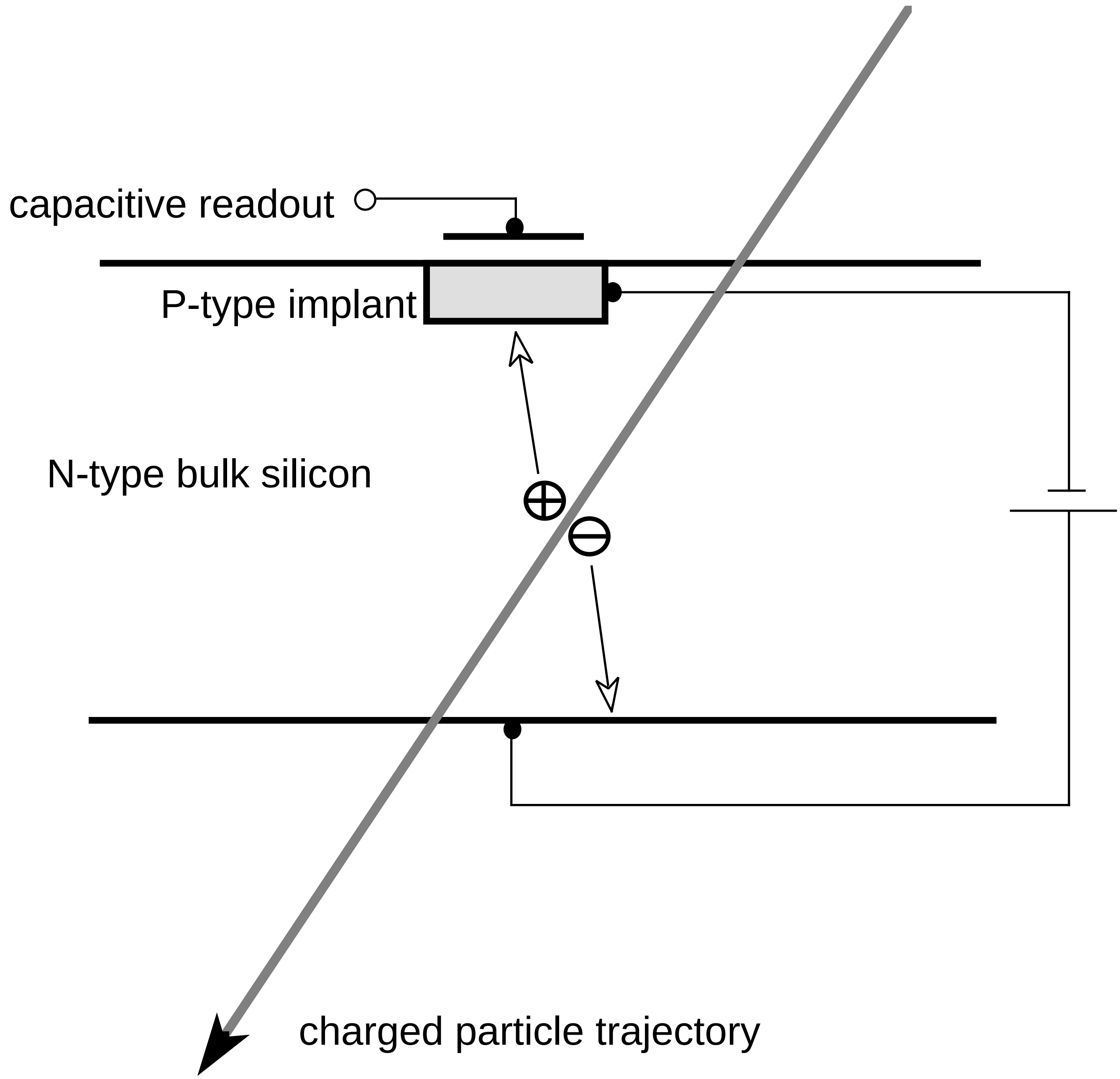
Strip electronics at bottom - Multichip Module
256 channels/detector
Channel count = 34,816

"C" shaped detector assemblies
Support Structure - Rohacell foam
50µm kapton cables: Si to MCM

6 MCM per Air-cooling plenum section
Rohacell plenum
Power & Communication Bus exit base of plenum



Silicon Detector Function:



Silicon Detector Parameters;

microstrip detectors:

53 mm x 74.5 mm (outer)

53 mm x 52 mm (inner)

300 µm thick

256 channels

200 µm pitch

pad detectors:

double metal technology

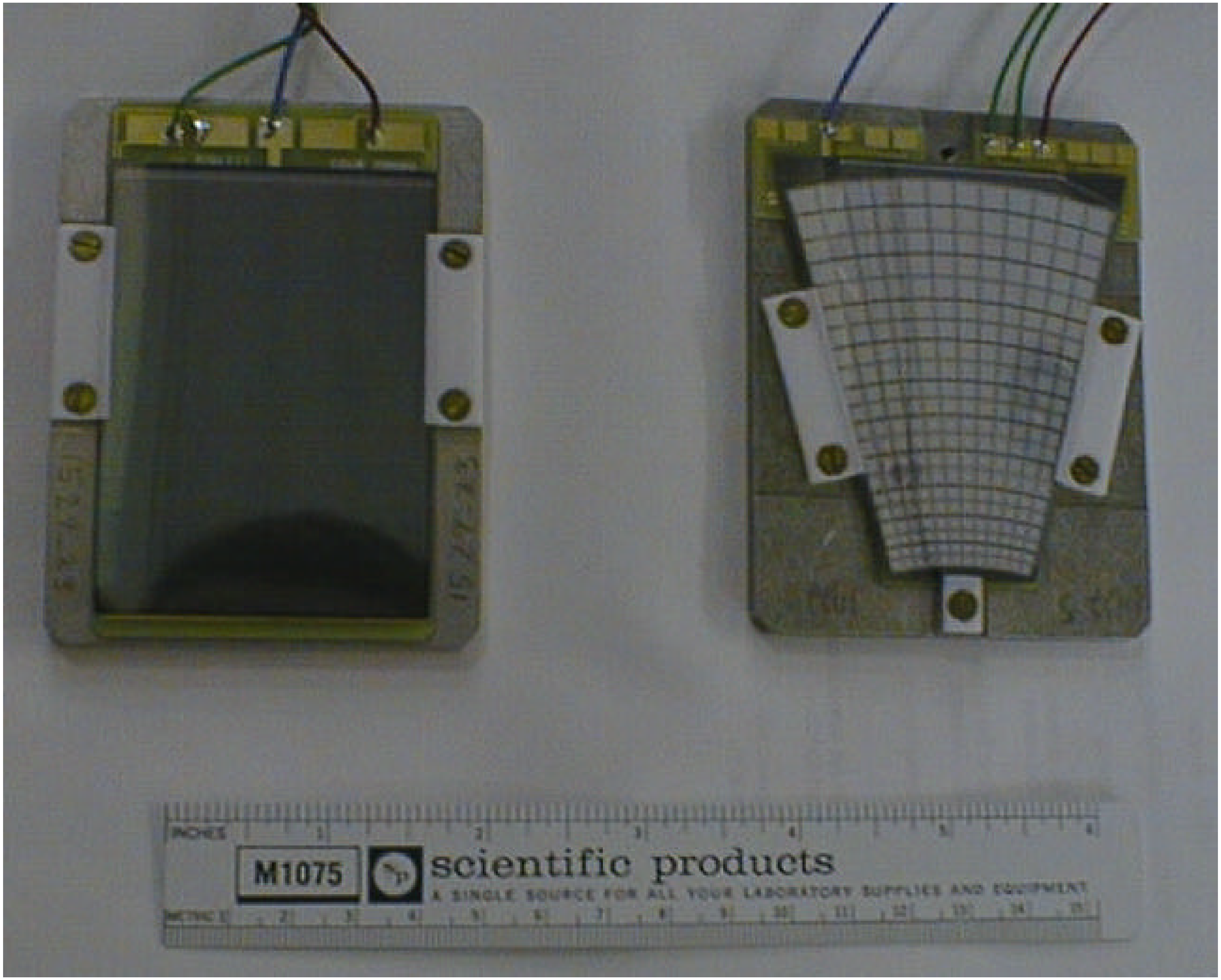
252 channels (21 x 12)

smallest pads: 2 x 2 mm

largest pads: 4.5 x 4.5 mm

φ coverage: 30 deg (each).

r coverage: 5 - 12 cm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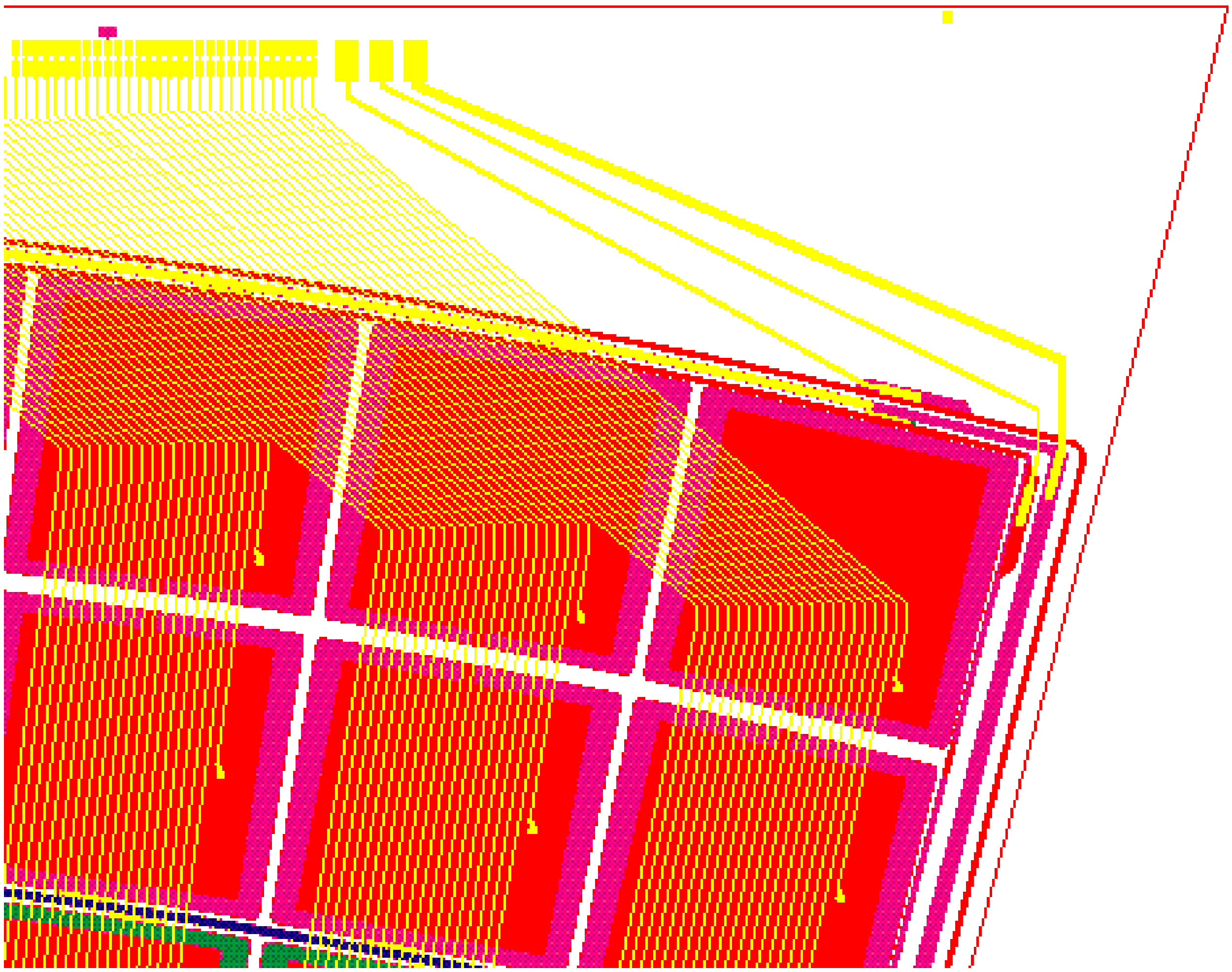
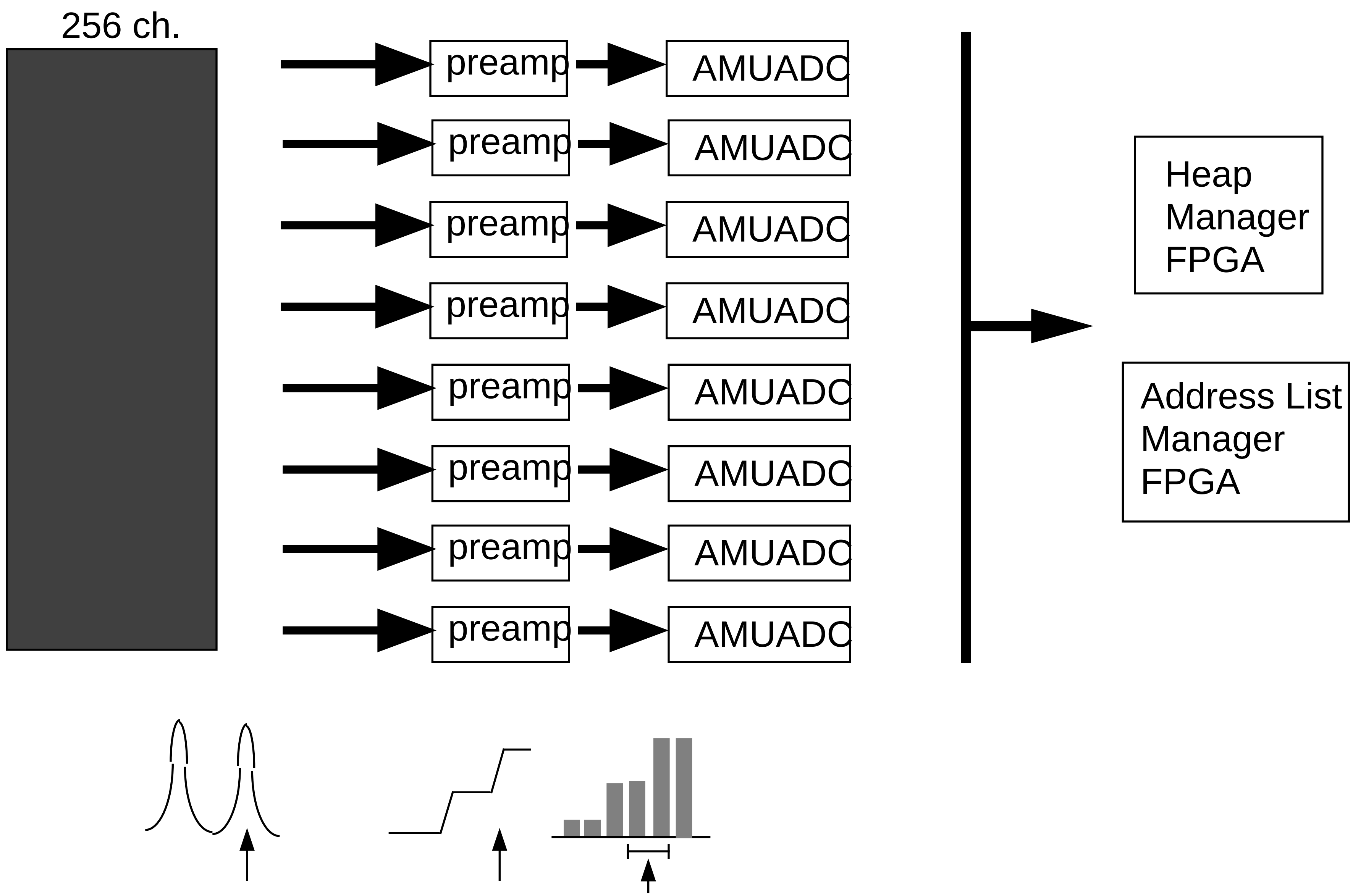
A SINGLE SOURCE FOR ALL YOUR LABORATORY SUPPLIES AND EQUIPMENT
METRIC

Double Metal Pad Detector



* Eliminates specialized kapton cable
* Reduces wirebonding
* Facilitates detector probing
* Facilitates assembly, handling
* Increases yield
* Sequential readout

Front End Electronics:



Final MCM:

Design at LANL/NIS
Lead Engineer - Gary Smith
Lead Designer - Gary Richardson

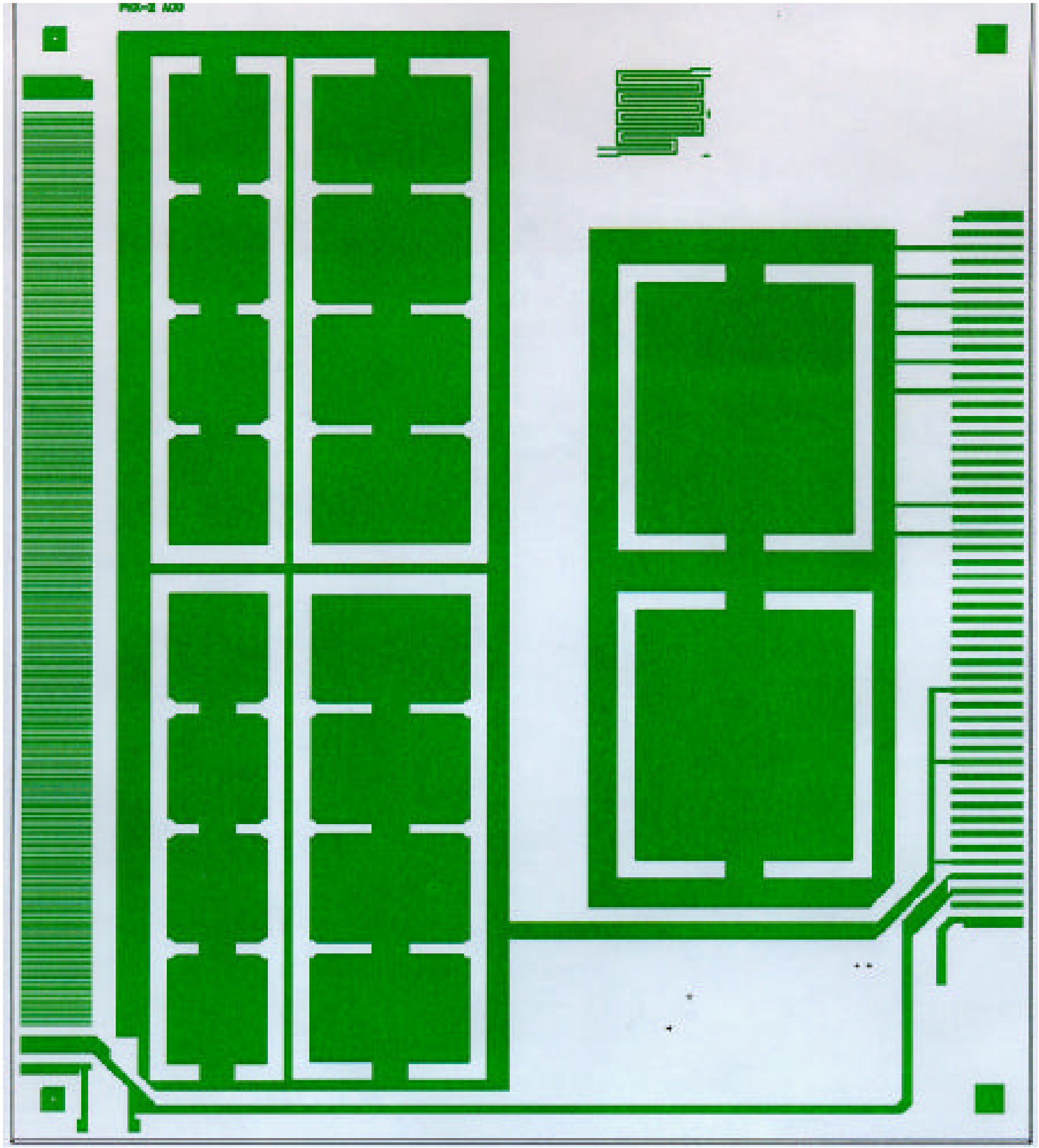
1 MCM: 256 channels
8 preamps
8 AMUADCs
2 Xilinx 4010
1 opamp
1 Temp sensor

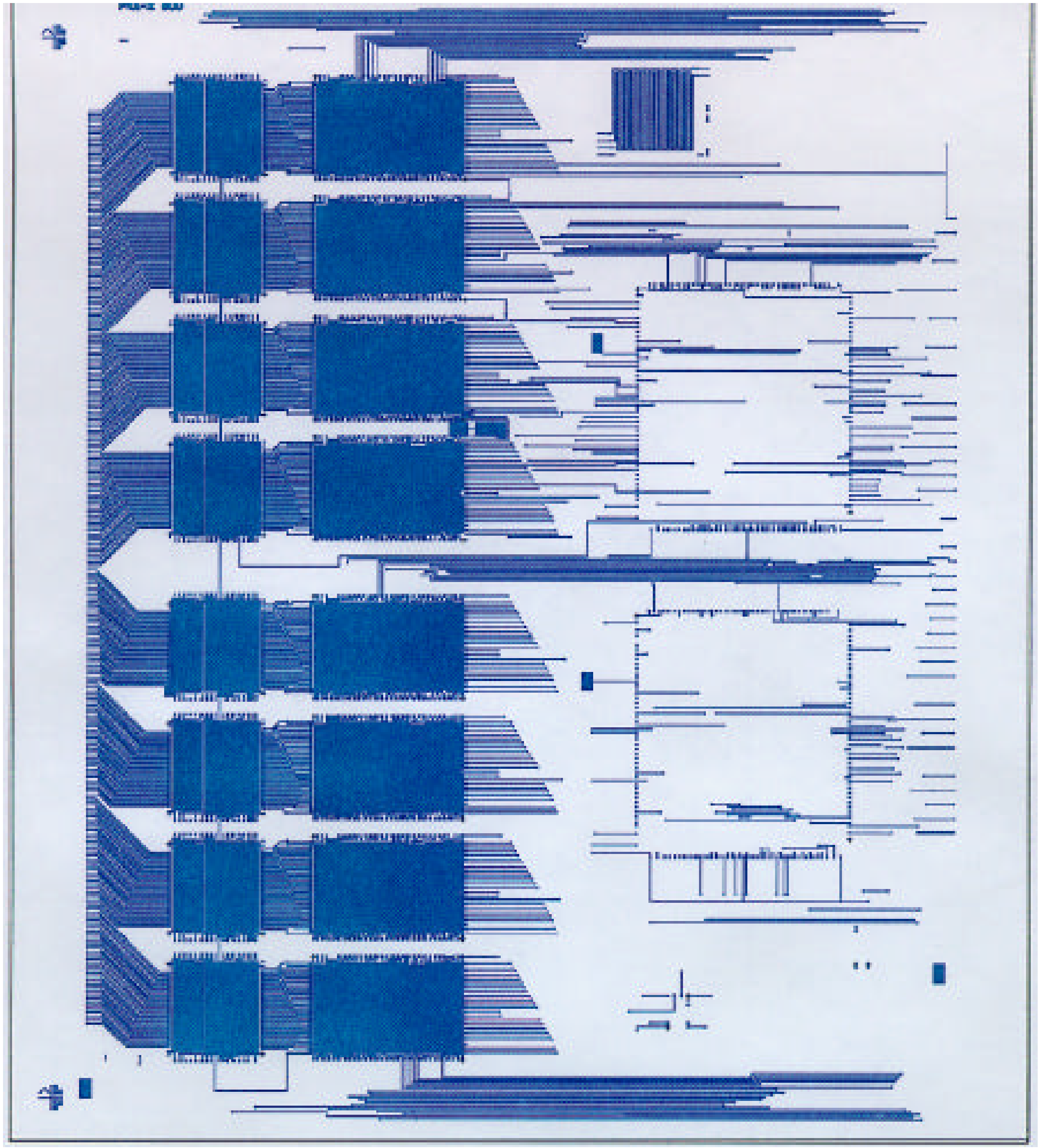
Trace pitch = 54 μm
Line width = 43 μm
I/O pad pitch = 150 μm

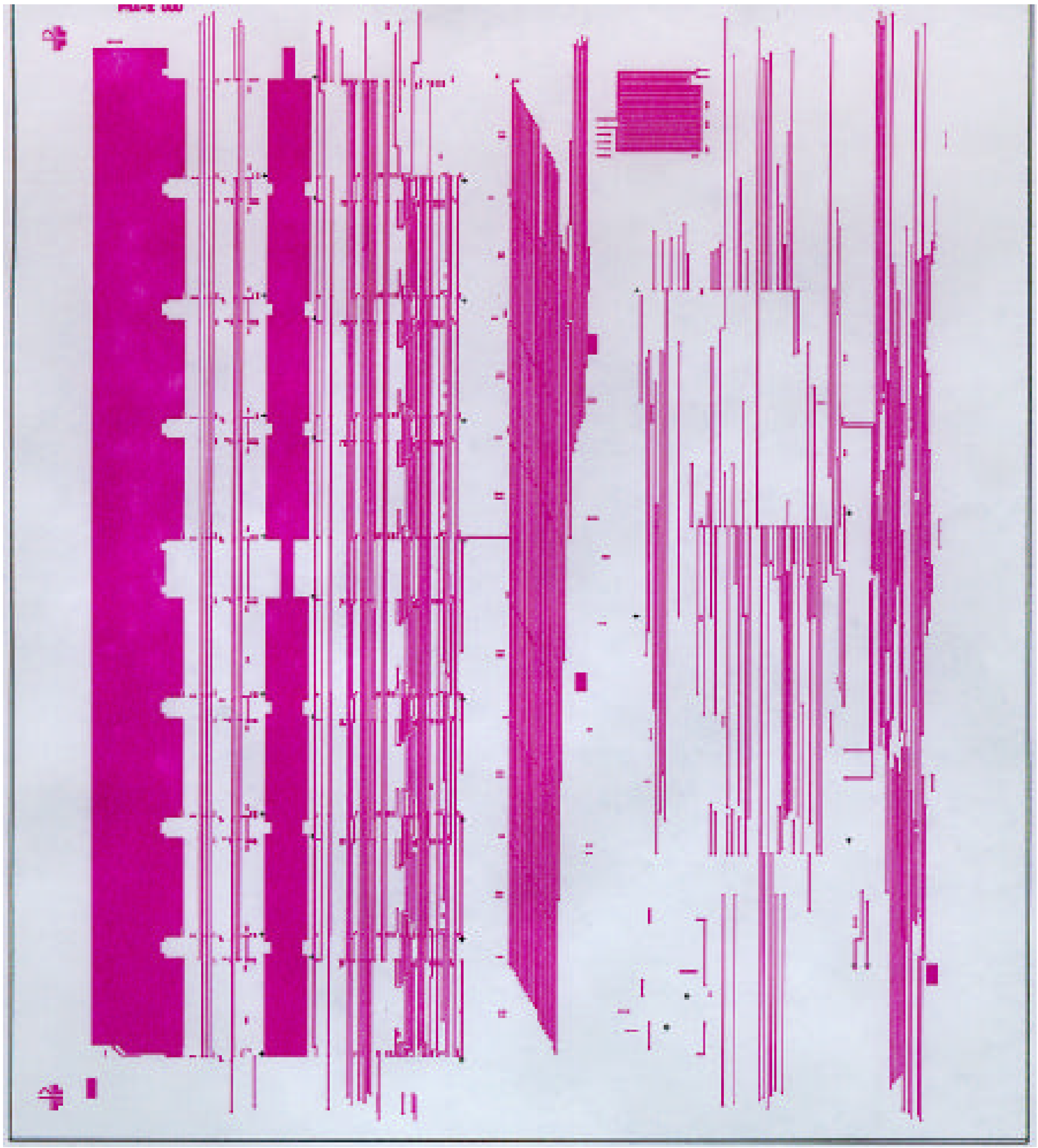
I/O pads gold sputtered for wire bonding

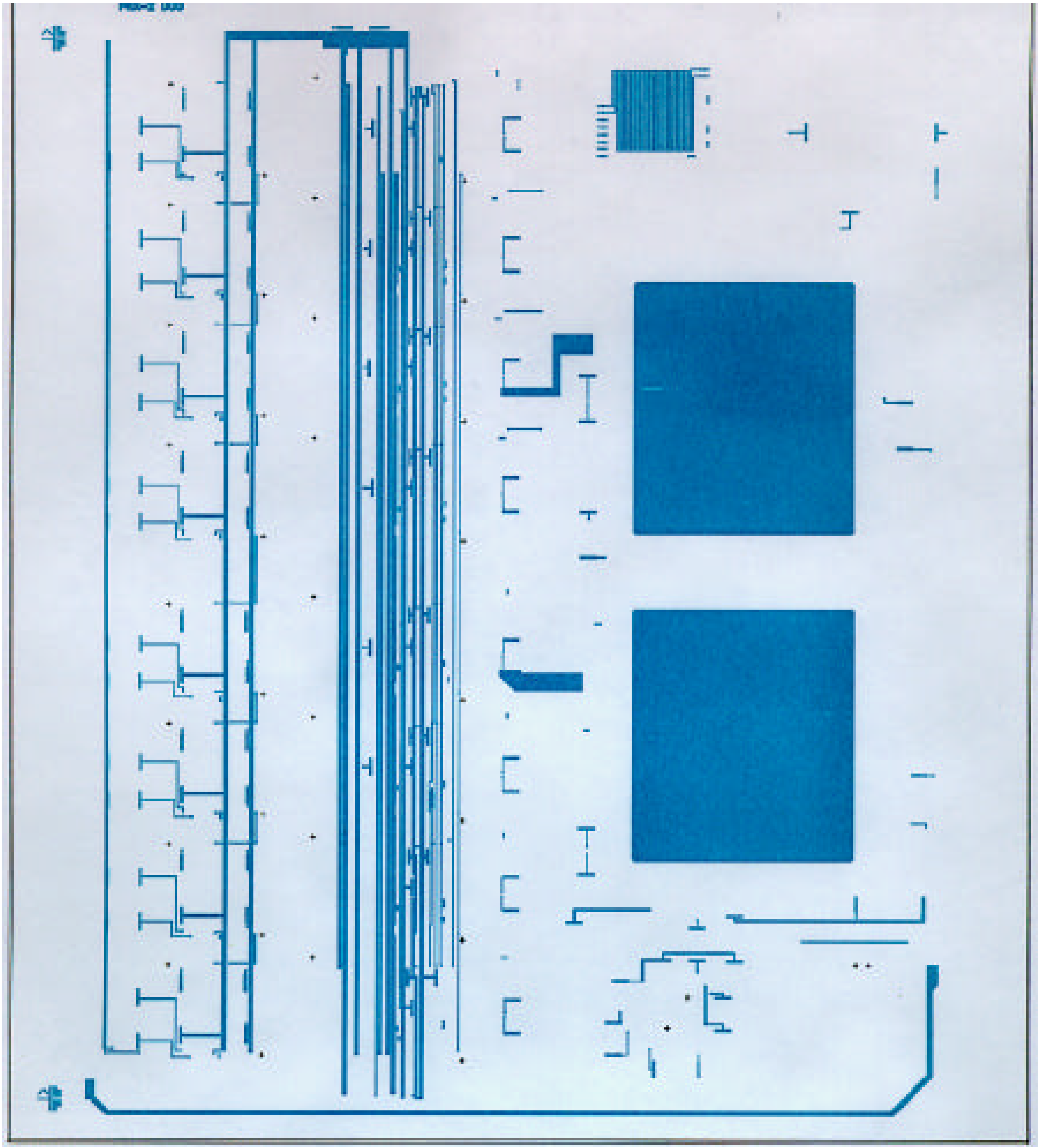
base metal + 4 trace layers = Ti - Cu - Ti

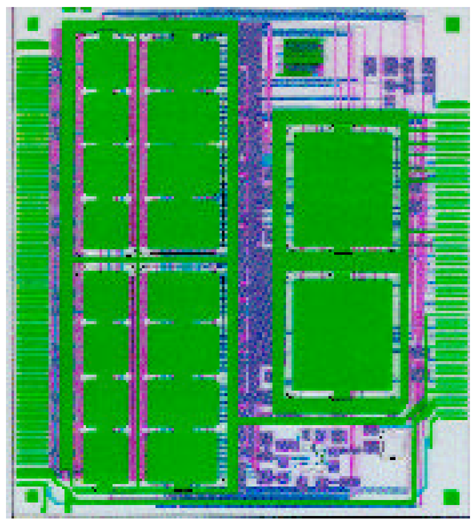
M1 = signals, all connections off IC chips
M2 = bus lines
M3 = power lines
M4 = surface mount components



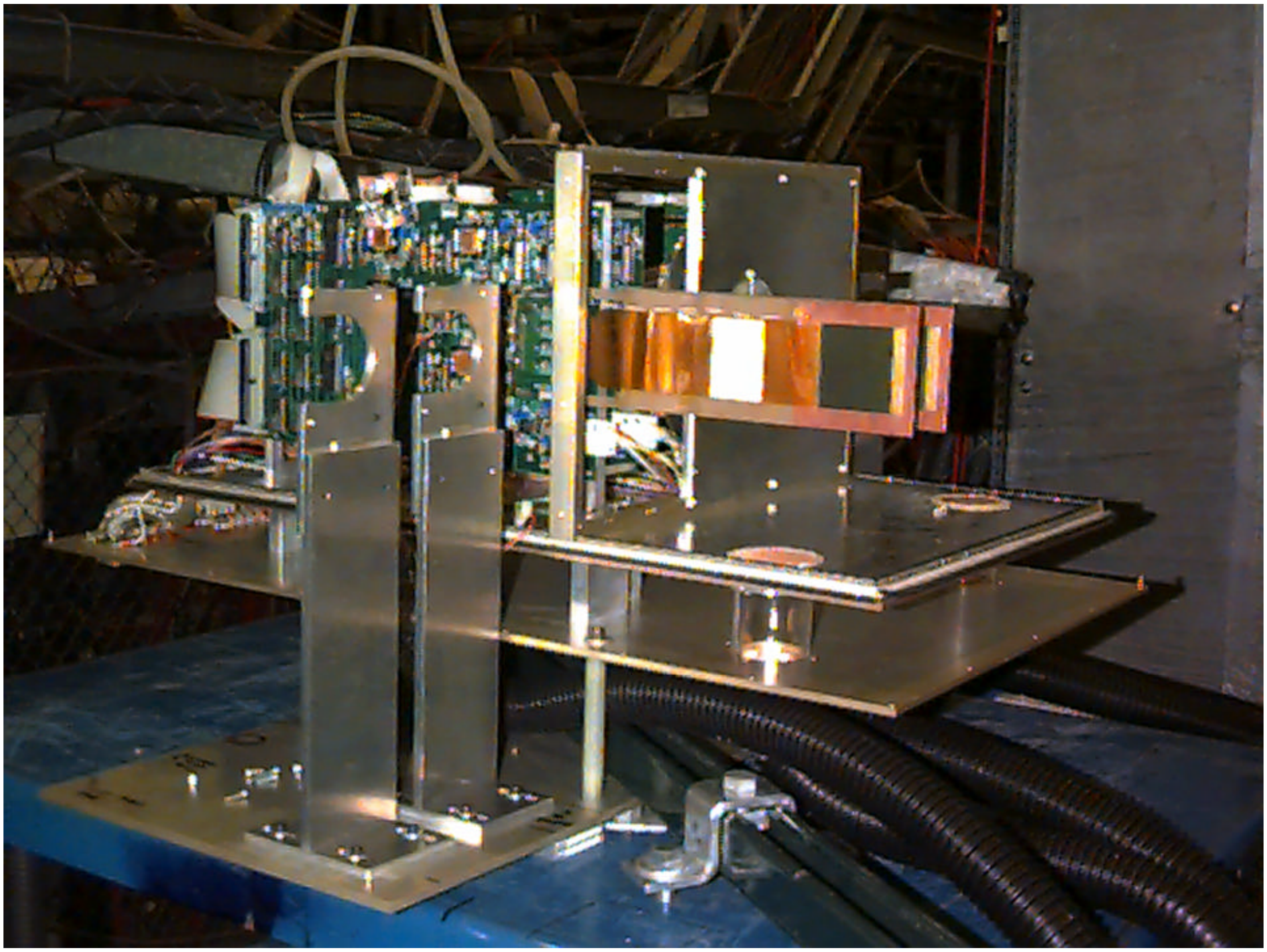








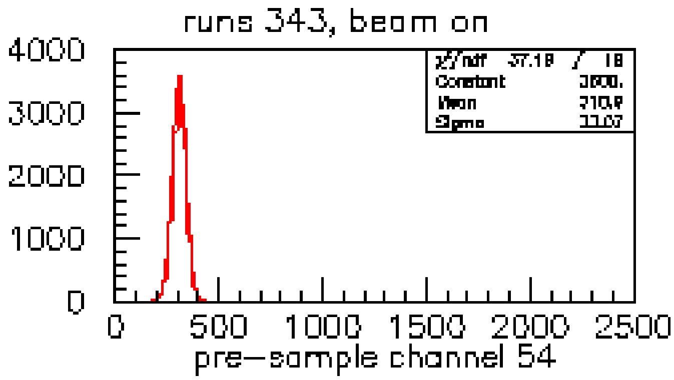
AGS Beam Test - April '96



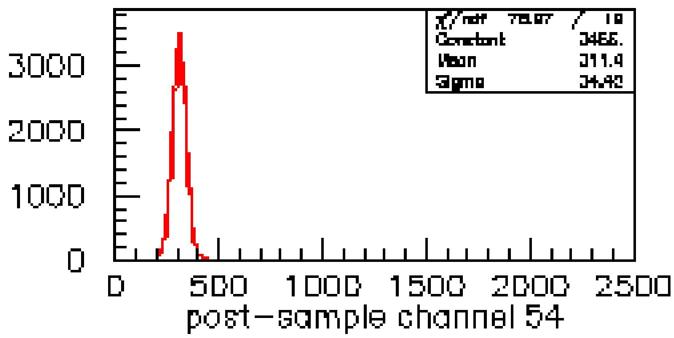
Prototype electronics (8 chan custom die), DAQ
Prototype Si strip detectors, kapton cables
Prototype RF enclosure

D. Jaffe, et al., "Results of the PHENIX MVD Prototype Detector and Electronics Beam Test", submitted to NIMA, 2/98

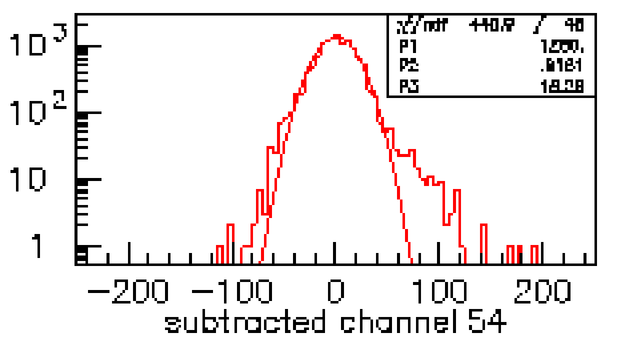
Beam Test Data



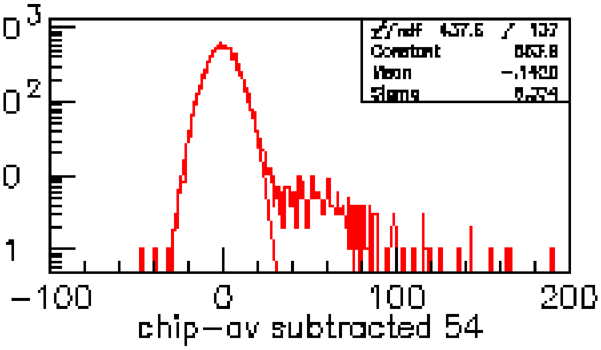
Presample:
ADC values before event
Includes high & low freq noise



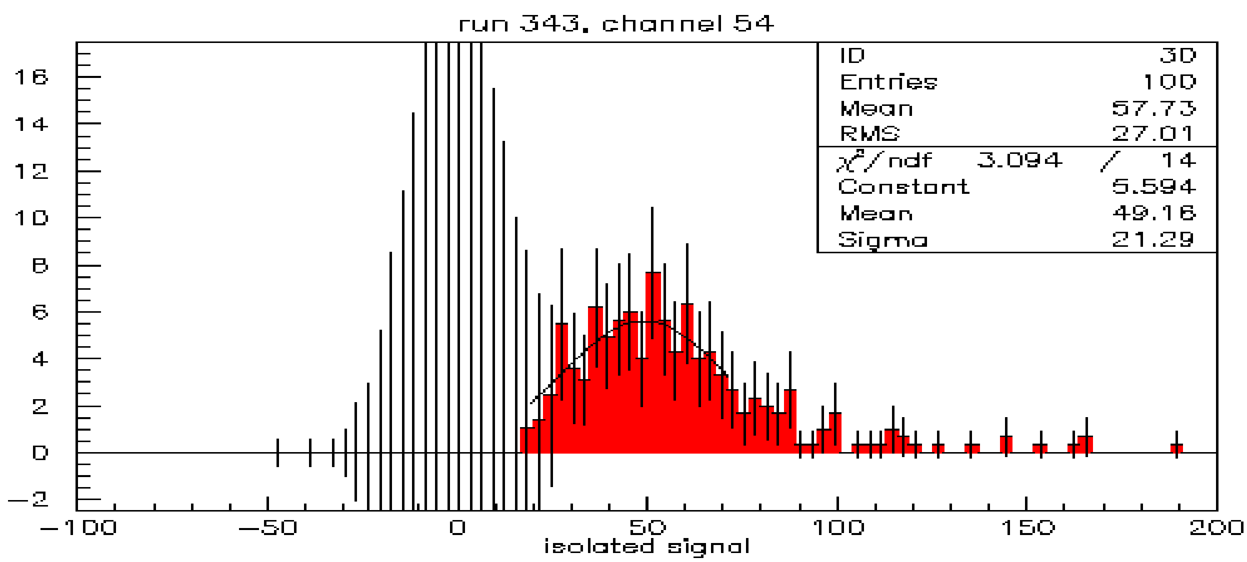
Post-sample:
ADC values after event
Includes high & low freq noise



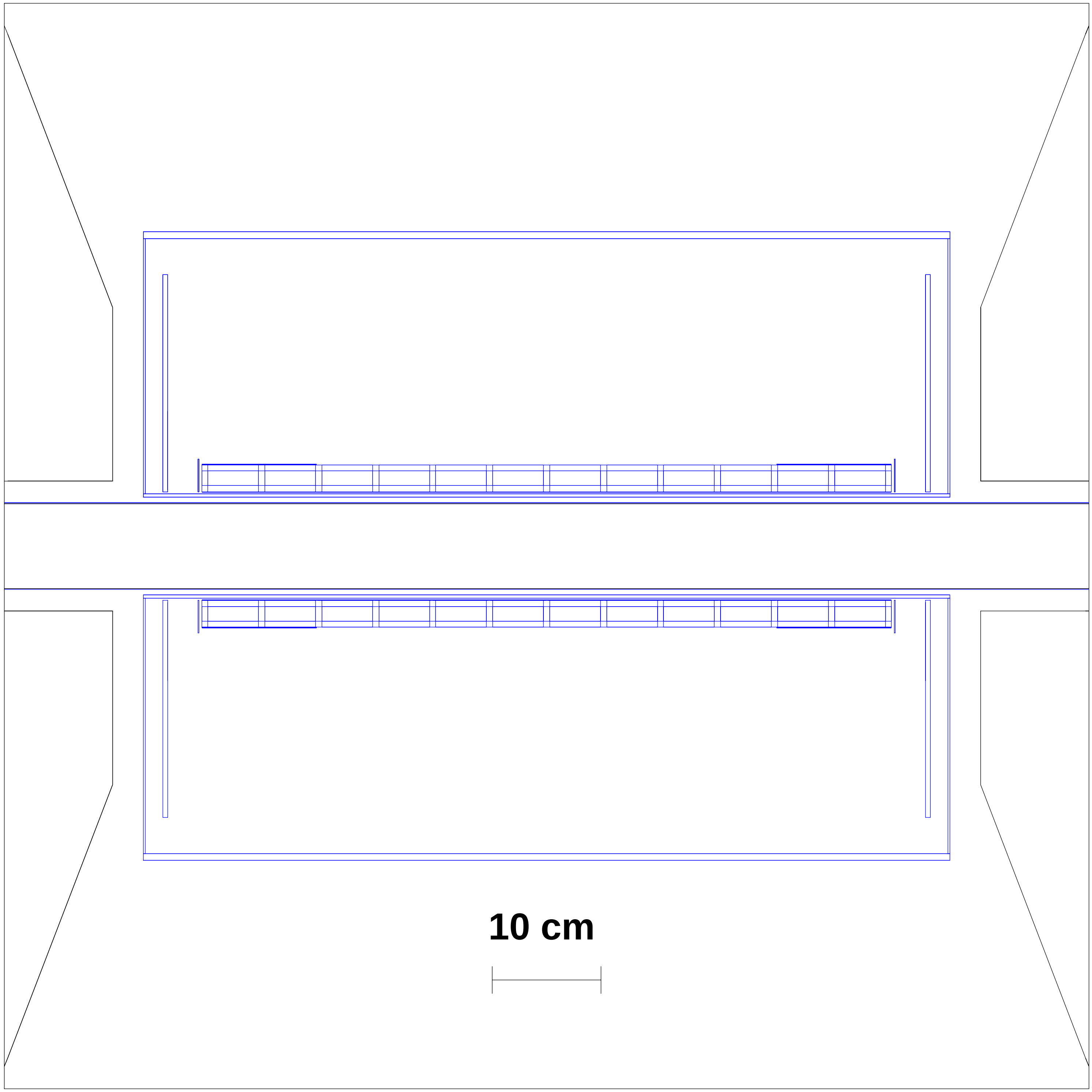
Post-pre:
Subtract ped and low freq noise
High freq noise remains

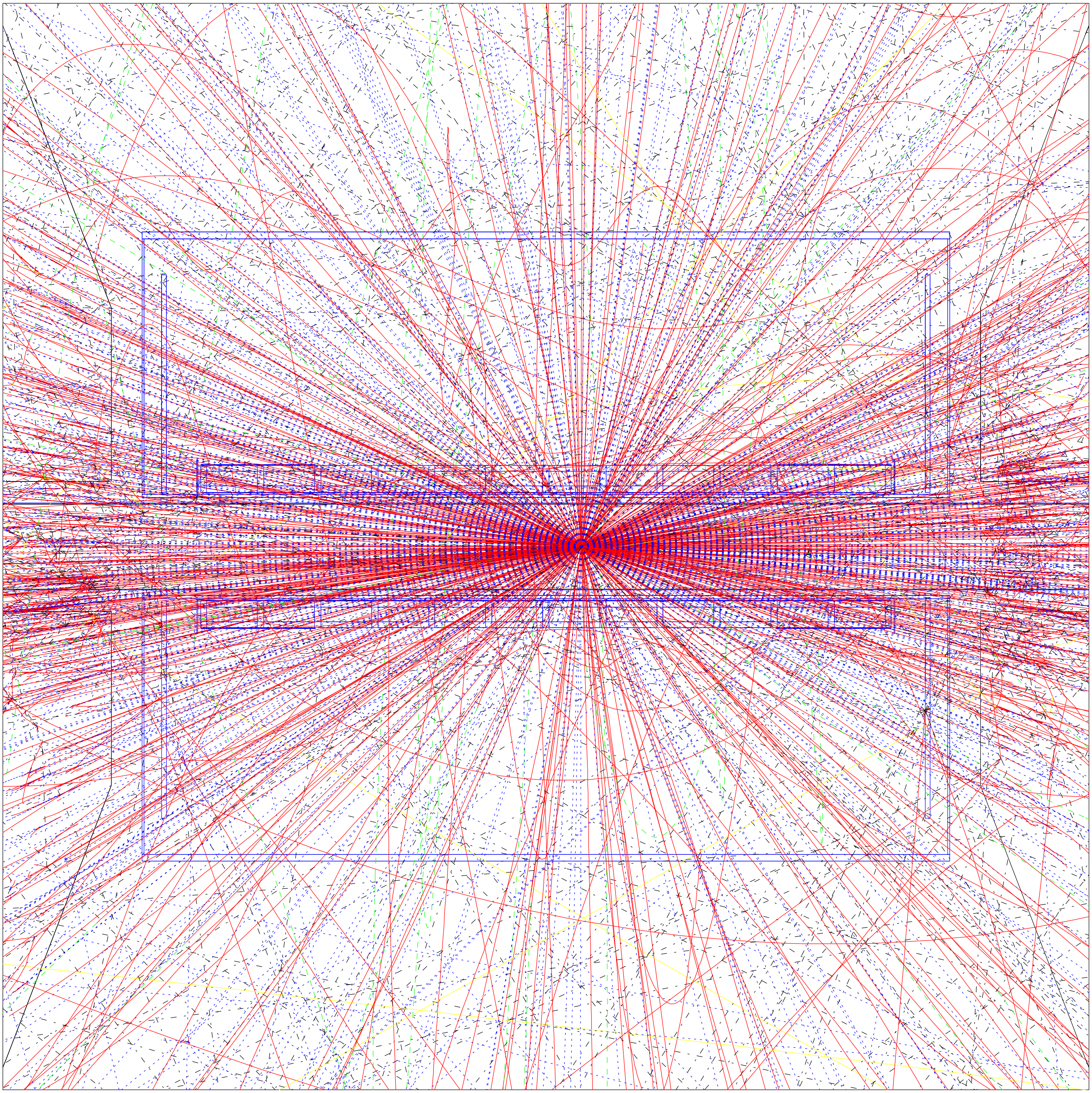


<Chip> subtraction:
Removes high freq noise
Remaining width due to ADC rresolution

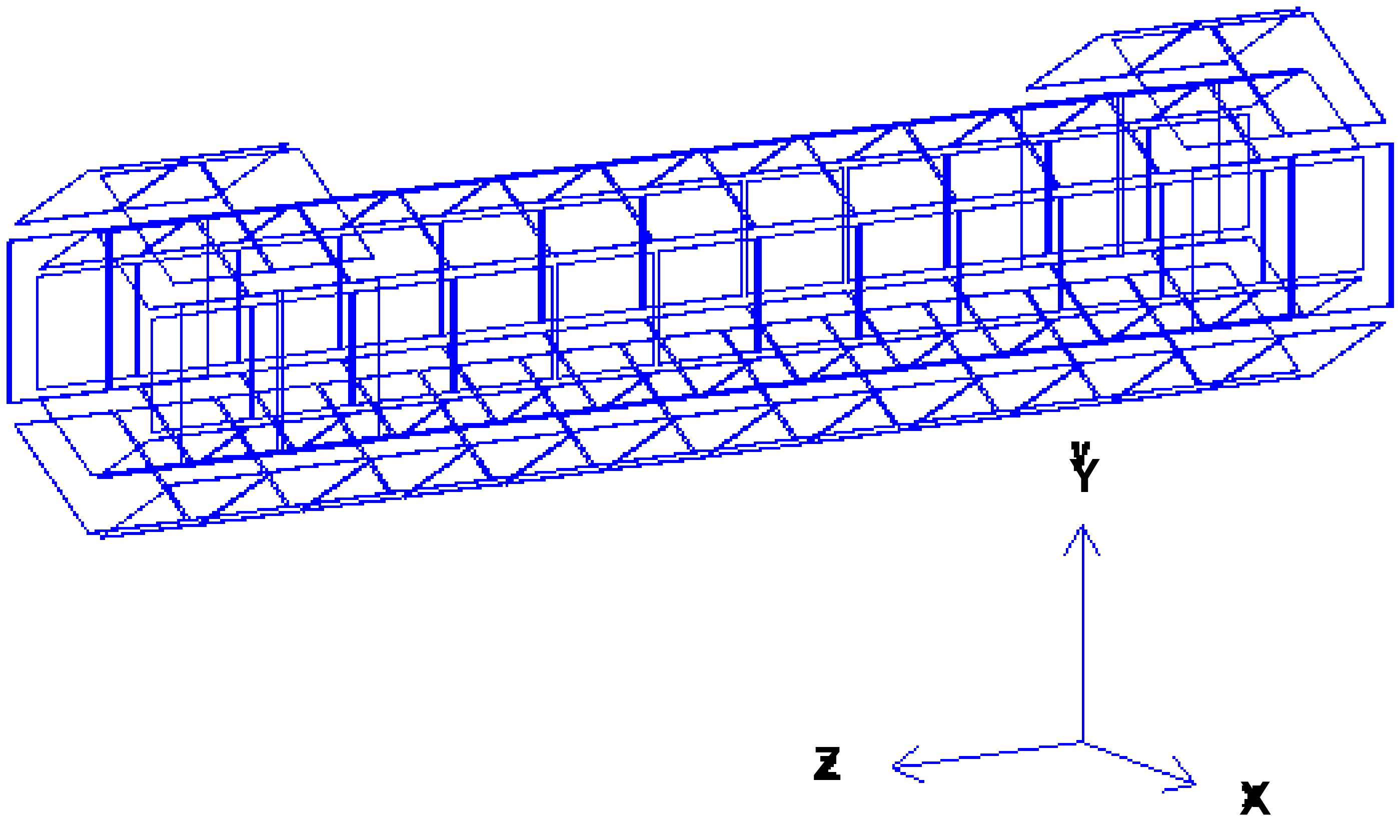


run 343, channel 54
ID 30
Entries 100
Mean 57.73
RMS 27.01
χ^2/ndf 3.094 / 14
Constant 5.594
Mean 49.16
Sigma 21.29
isolated signal

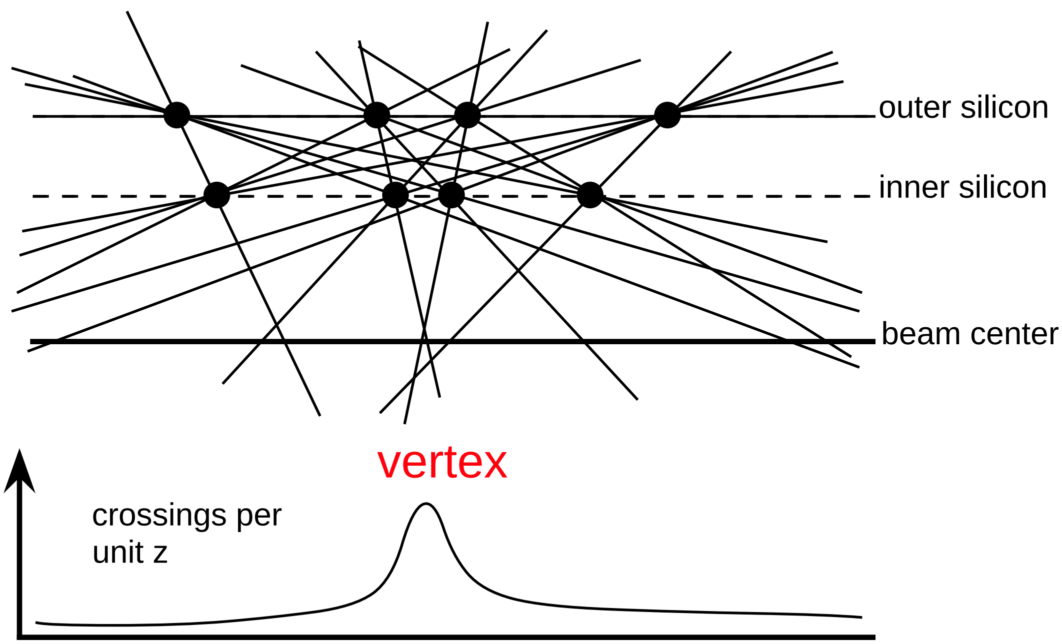

10 cm



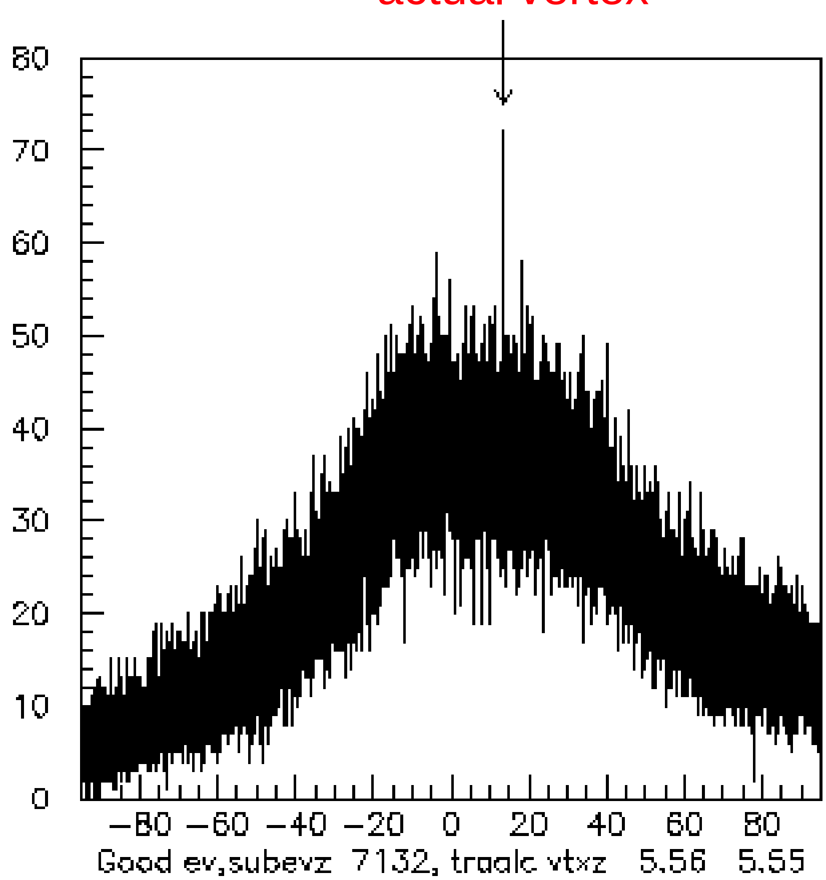
Silicon microstrip detector coverage:



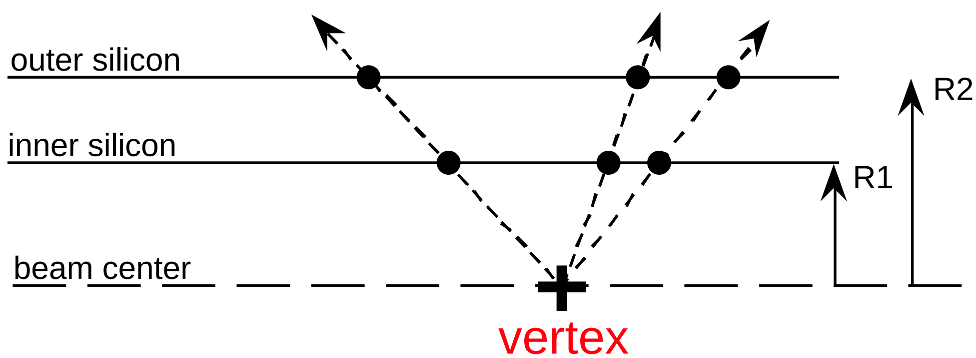
The pseudo-tracking algorithm:



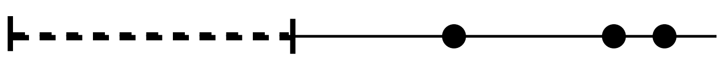
Pseudo-tracking results:



The correlation algorithm:



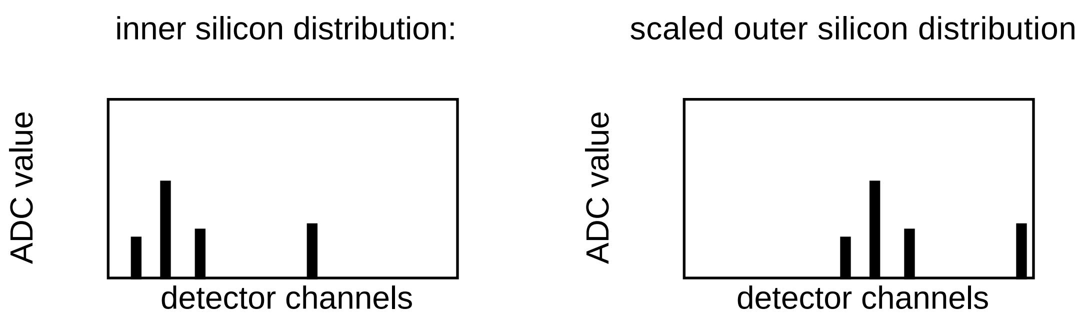
offset + outer silicon hits scaled by $\frac{R1}{R2}$



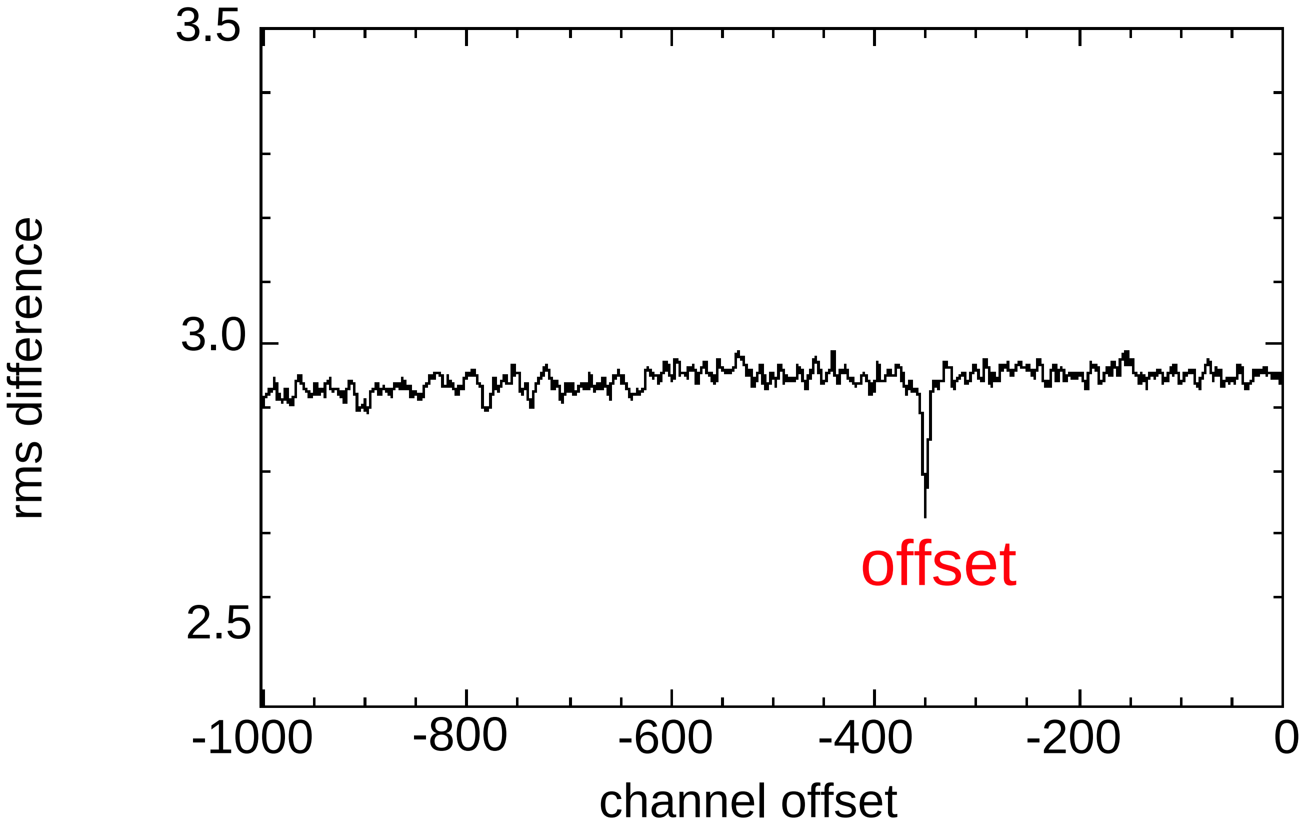
offset scaled by $\frac{R2}{R1}$ = vertex position

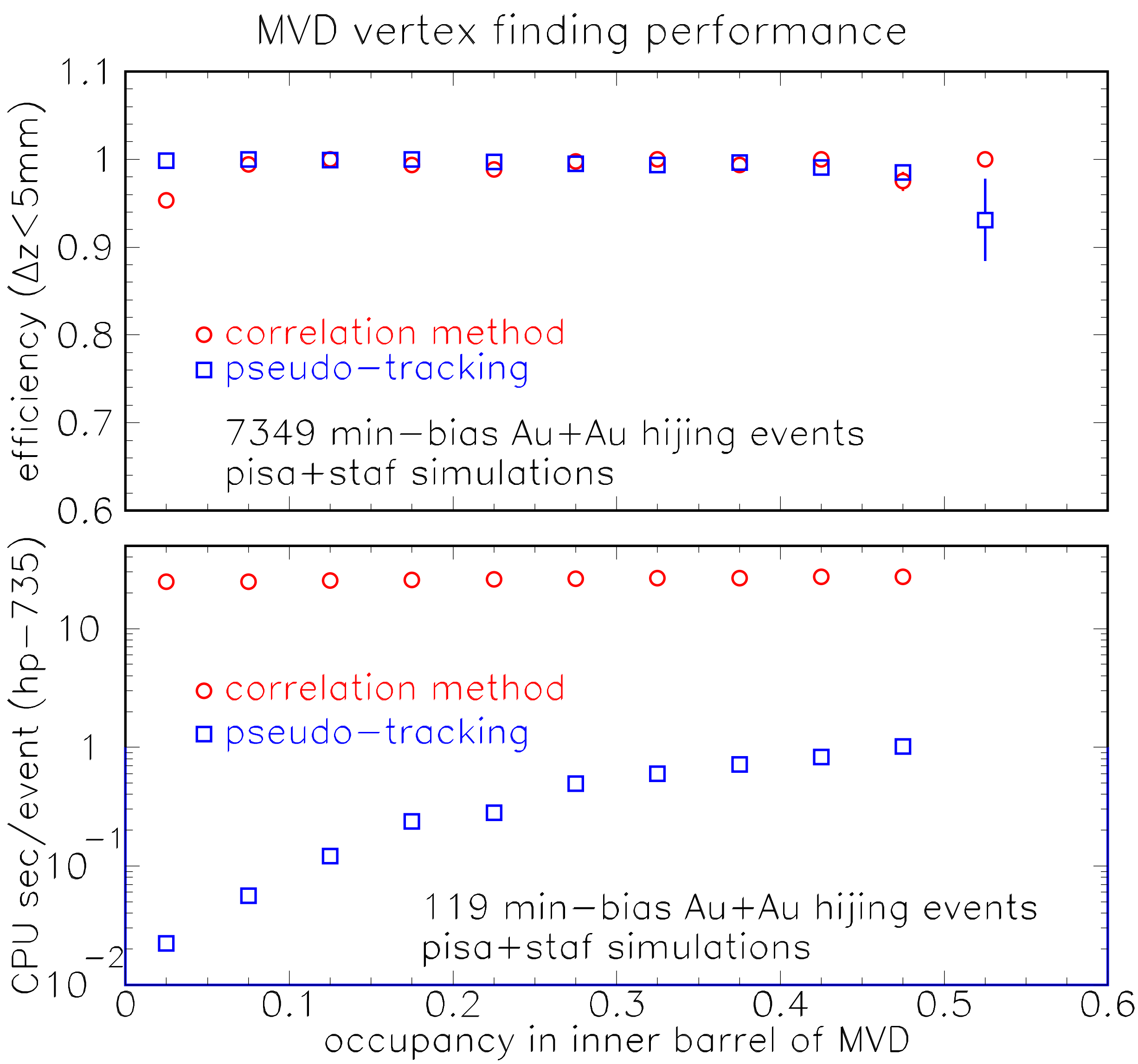
The correlation algorithm (cont.):

ADC distributions:



offset determination:

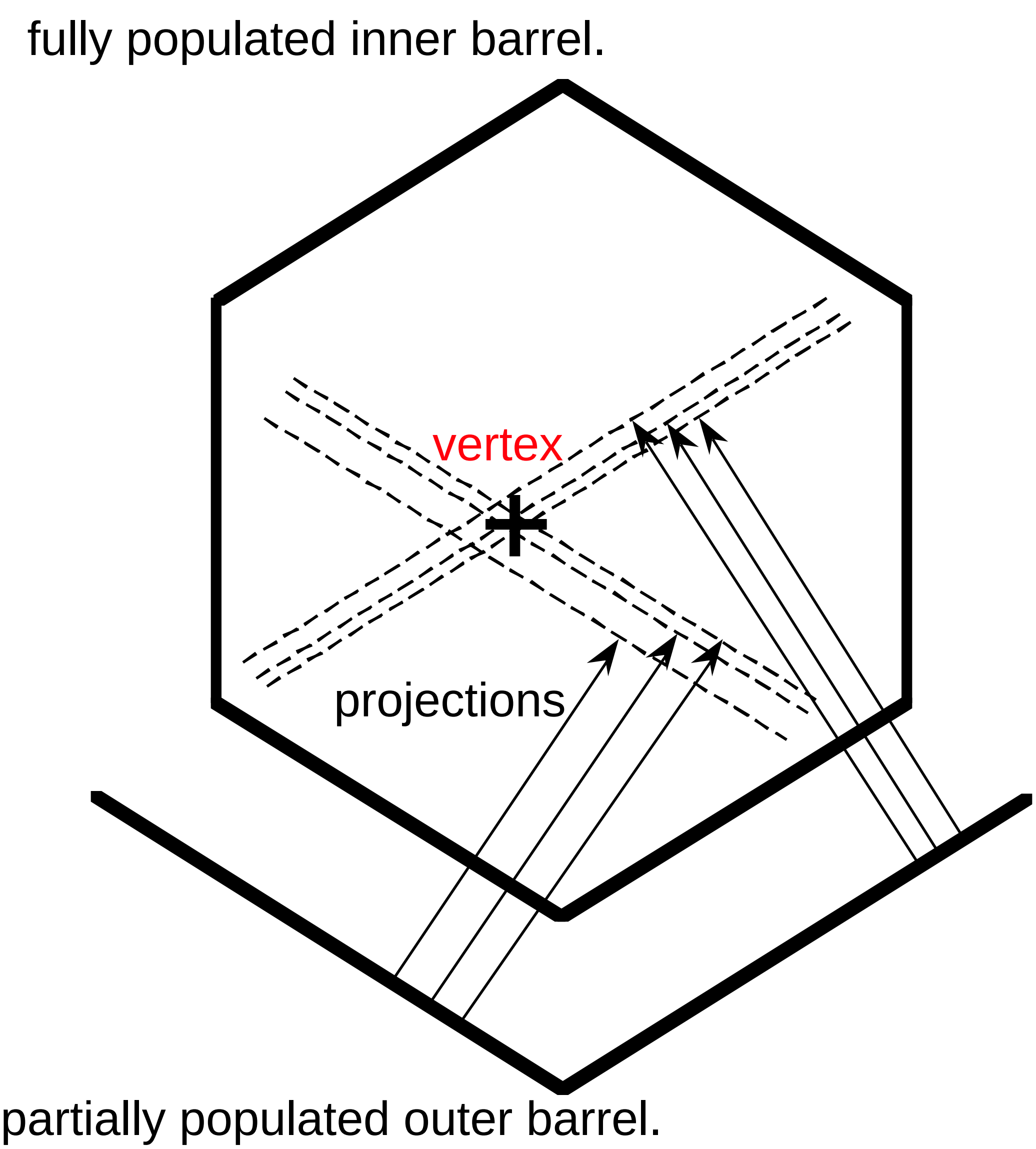


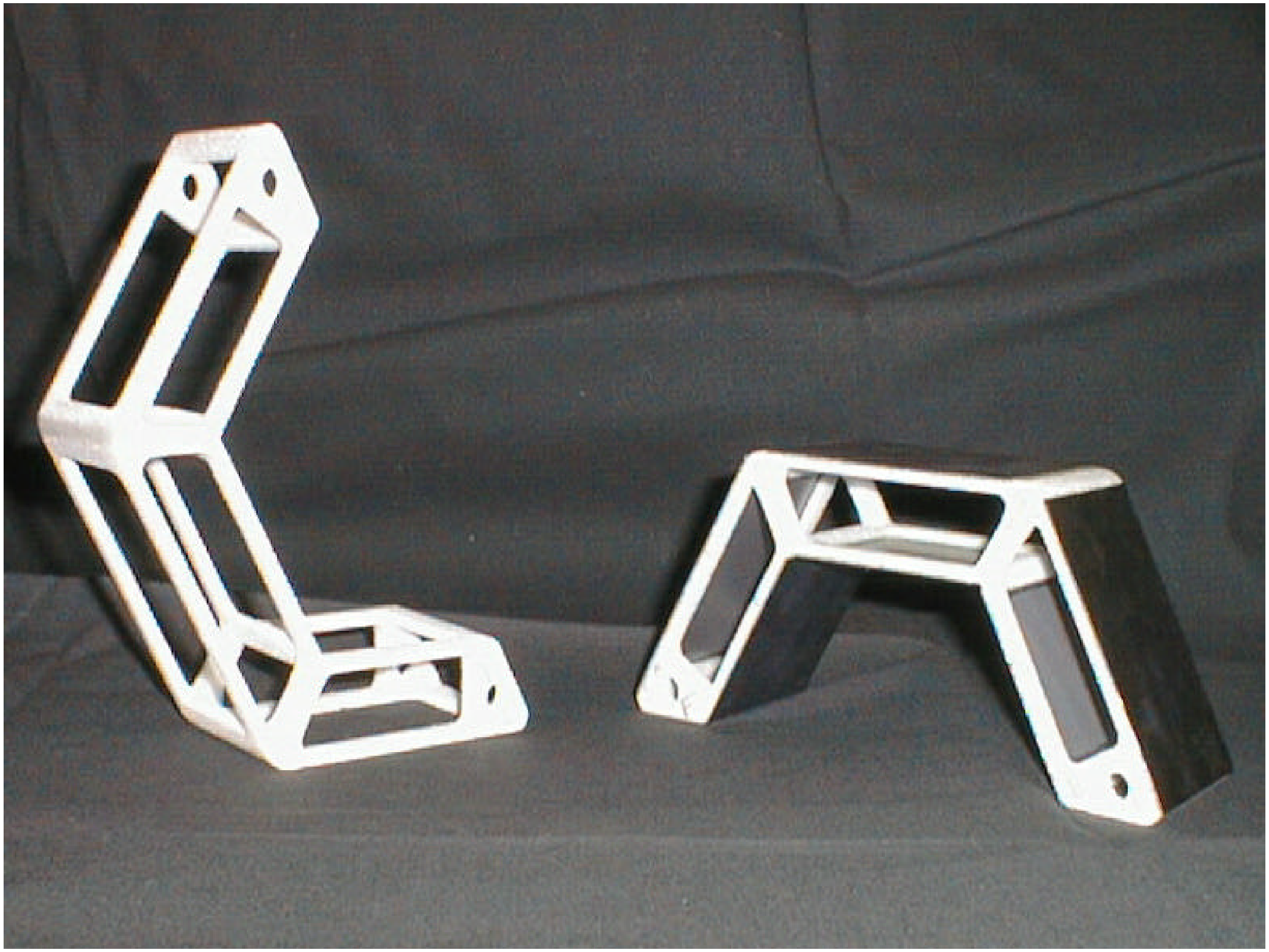


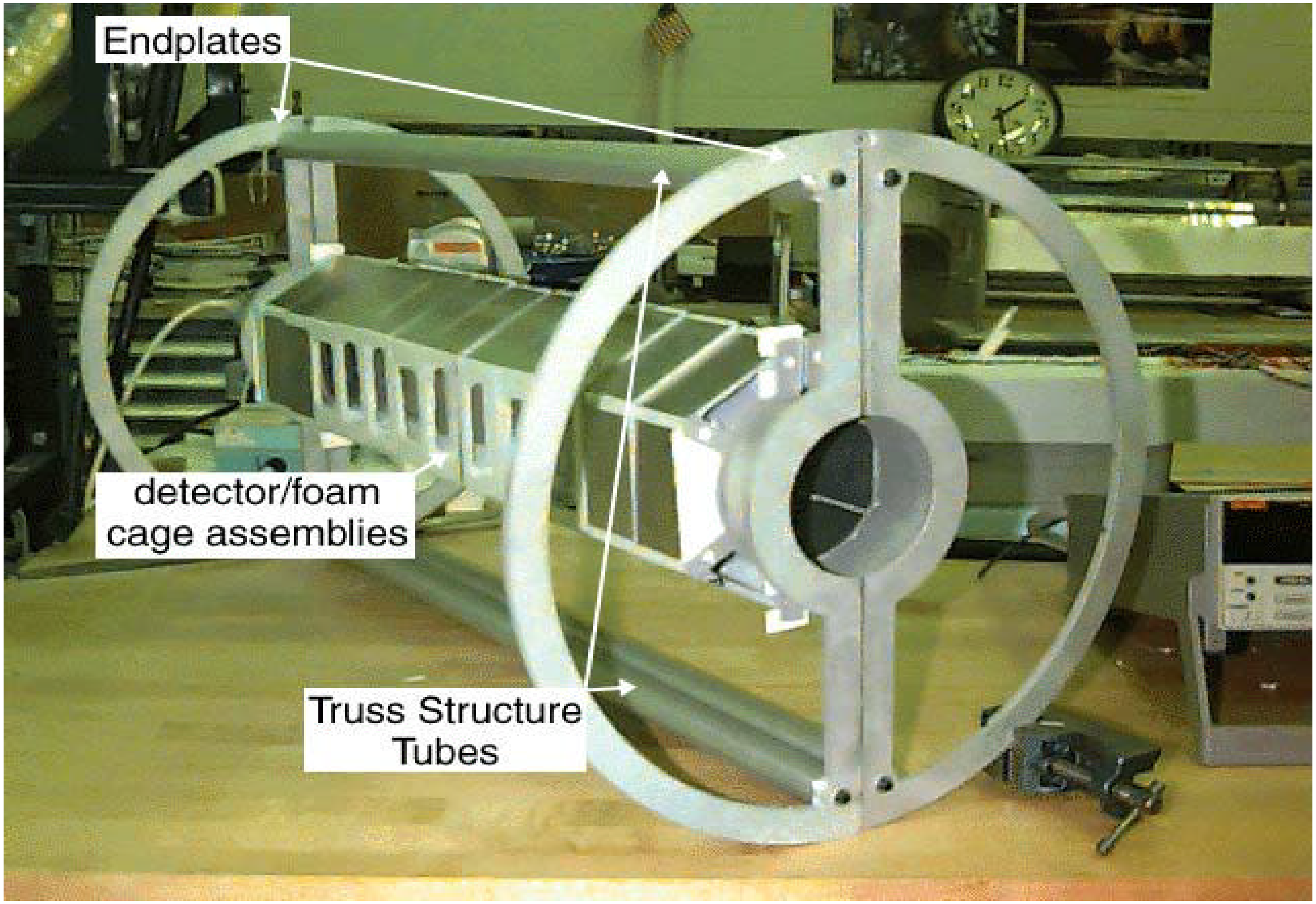
9−Apr−98 /p2hp4/usr3/sullivan/phenix/doc/eff_time.kumac

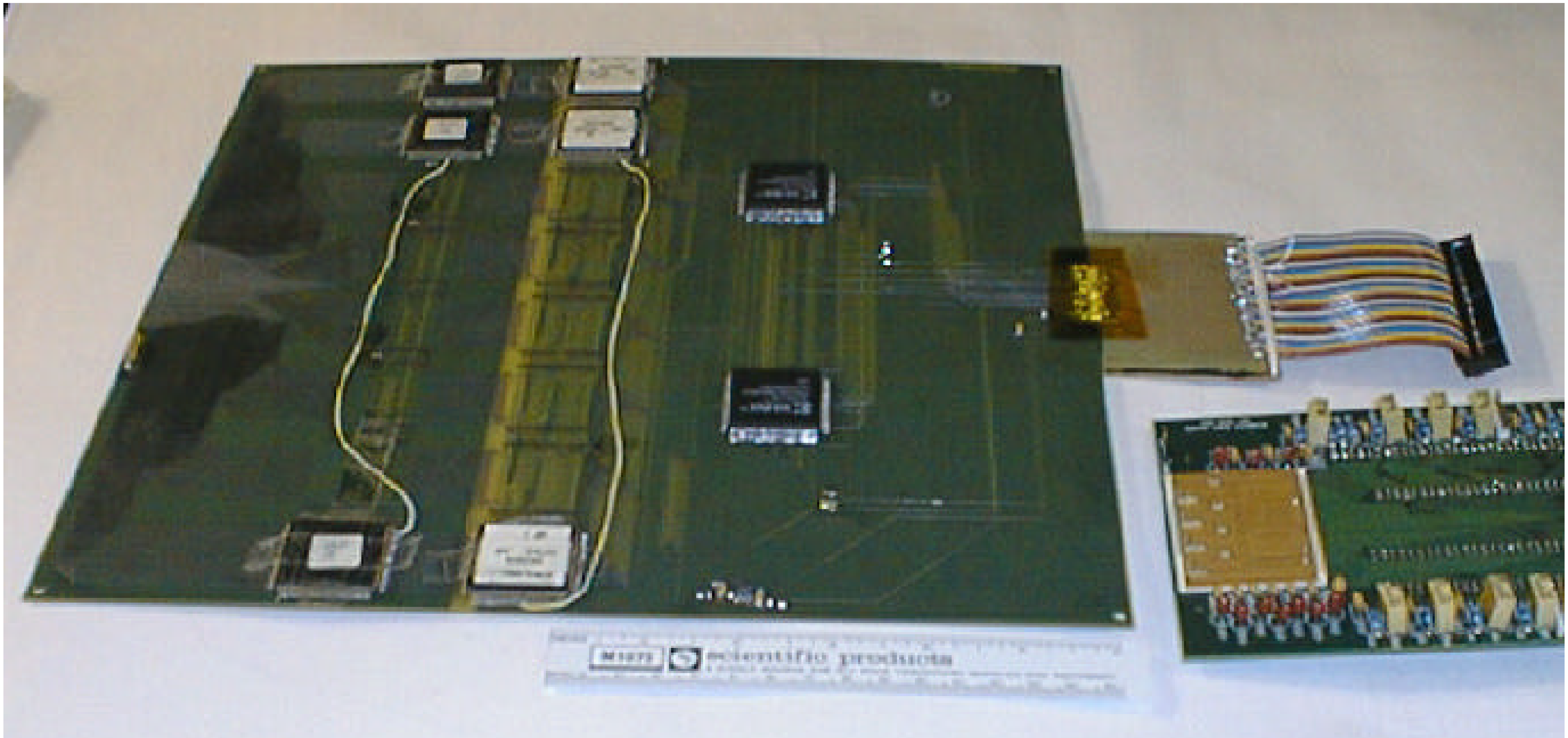
3D Vertex Finding:

Z-plane determined by previous step.






Endplates
detector/foam cage assemblies
Truss Structure Tubes



Printed circuit board version of MCM shown with a pre-prototype MCM.

MVD Construction Status:

All mechanical and electrical components prototyped or in fabrication.

Si pad detectors starting production.

Si microstrip detectors in production.

Rohacell C-cages in production at UCR.

All custom die are manufactured - KGD testing.

MCM delivery to start in mid-May.

All custom electronics boards are in fabrication.

All kapton cables are in production.

Cooling system components being procured.

Construction Complete at LANL in spring of '99.

Installation in PHENIX in June '99.

First heavy-ion beam in Oct. '99.