A1900 Fragment Separator
RIB Production and Diagnostics

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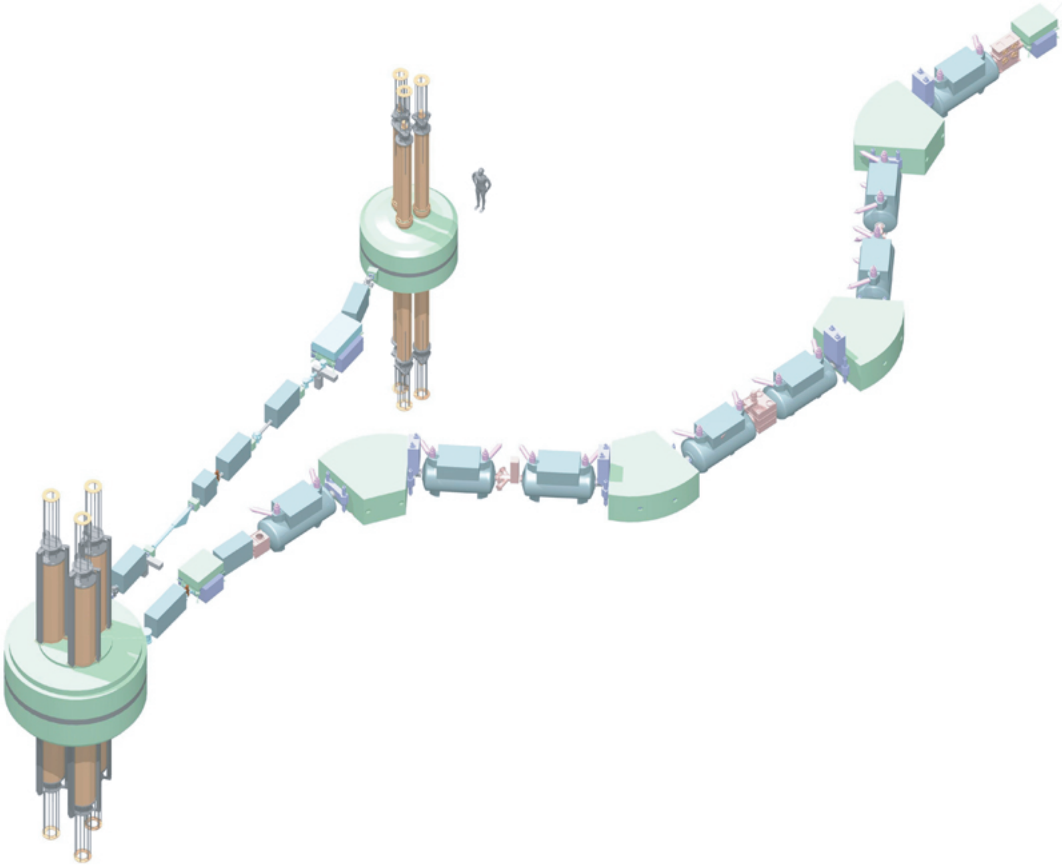
NSCL / Michigan State University

High-Mass RIB Workshop
Argonne Natianal Lab, June 2012



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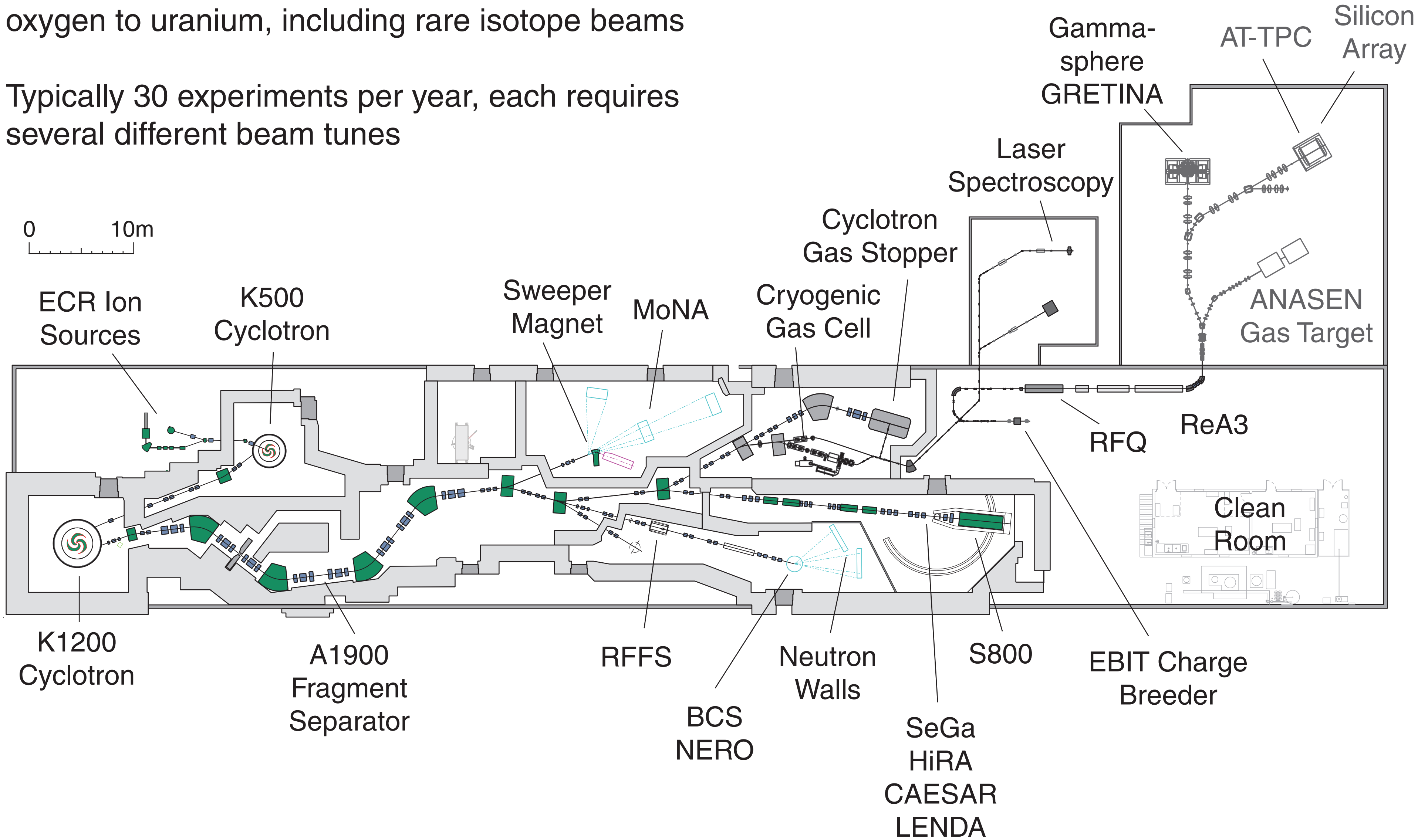
NSCL's Experimental Facility Plan

NSCL provides accelerated beams of heavy ions from oxygen to uranium, including rare isotope beams

Typically 30 experiments per year, each requires several different beam tunes



0 10m

ECR Ion Sources

K500 Cyclotron

Sweeper Magnet

MoNA

Cryogenic Gas Cell

Cyclotron Gas Stopper

Laser Spectroscopy

Gamma-sphere GRETINA

AT-TPC

Silicon Array

ANASEN Gas Target

RFQ

ReA3

Clean Room

K1200 Cyclotron

A1900 Fragment Separator

RFFS

BCS NERO

Neutron Walls

SeGa
HiRA
CAESAR
LENDA

S800

EBIT Charge Breeder

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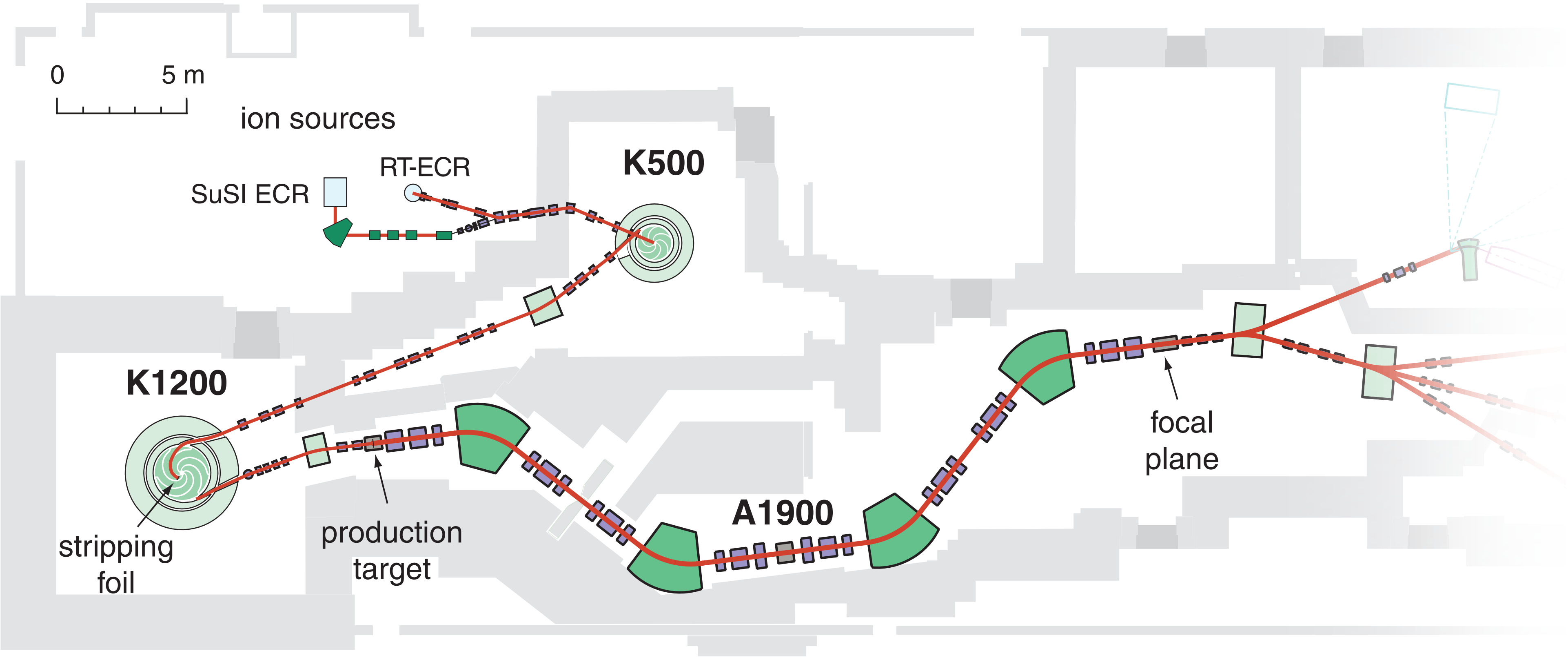
Coupled Cyclotron Facility



2 coupled cyclotrons

primary beams: oxygen to uranium

K500: 8 - 12 MeV/u, 2-8 eμA

K1200: 100 - 160 MeV/u, up to 2 kW

A1900 fragment separator

to produce rare isotope beams

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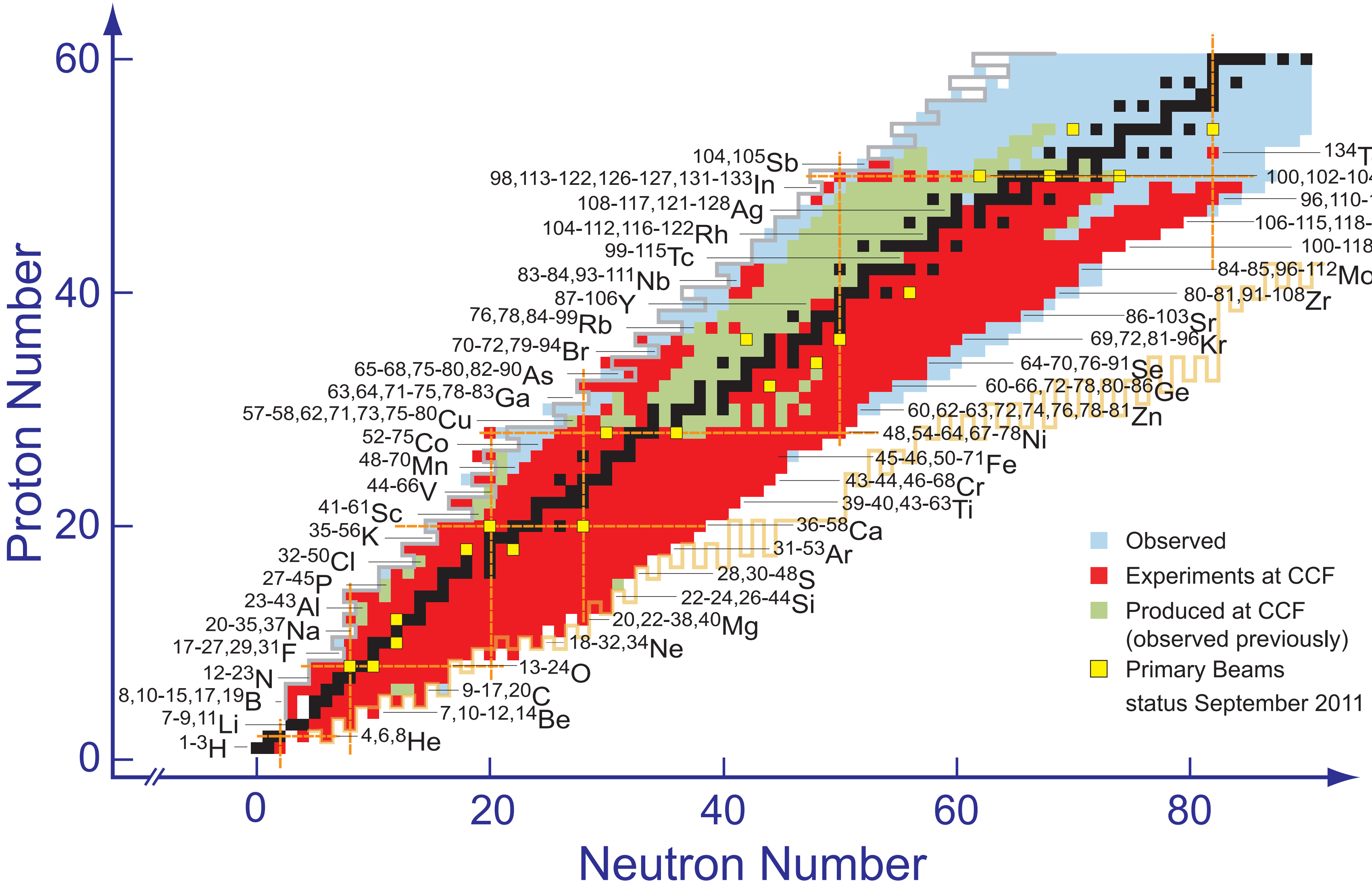
Rare Isotopes produced at NSCL

more than 1000 RIBs have been produced (2001-2012)
more than 860 have been used in experiments



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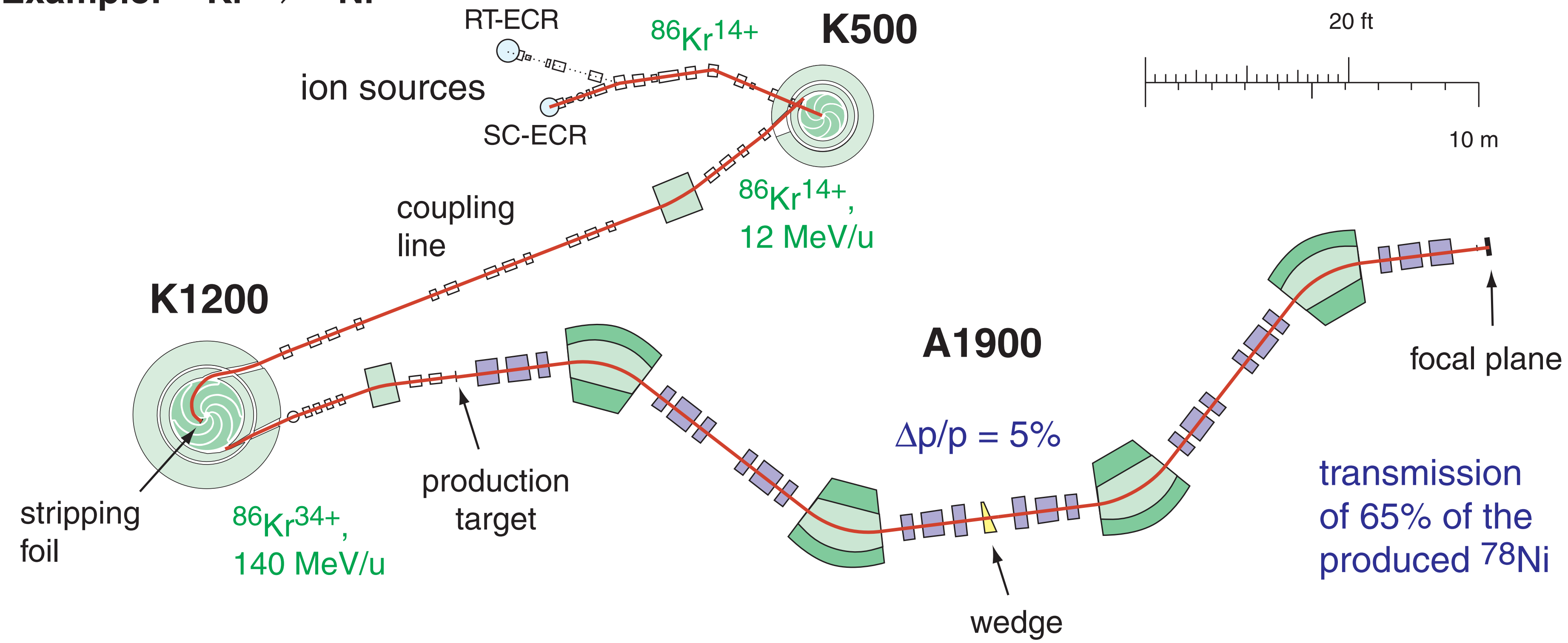
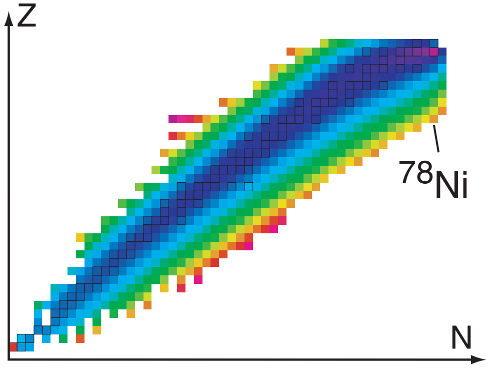
Overview of the Fragment Separation Technique

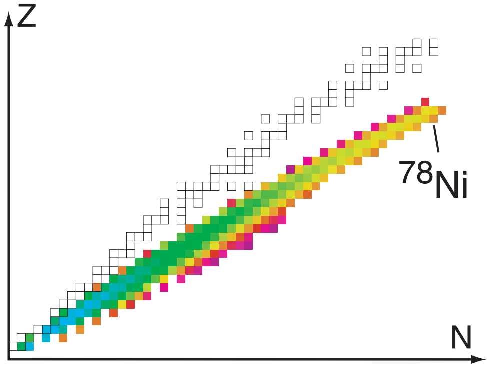
Example: ^{86}Kr → ^{78}Ni



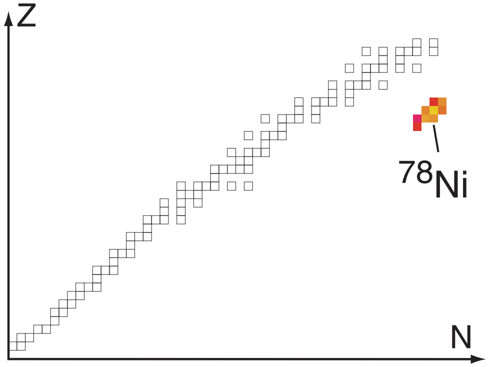
fragment yield after target



fragment yield after wedge



fragment yield at focal plane



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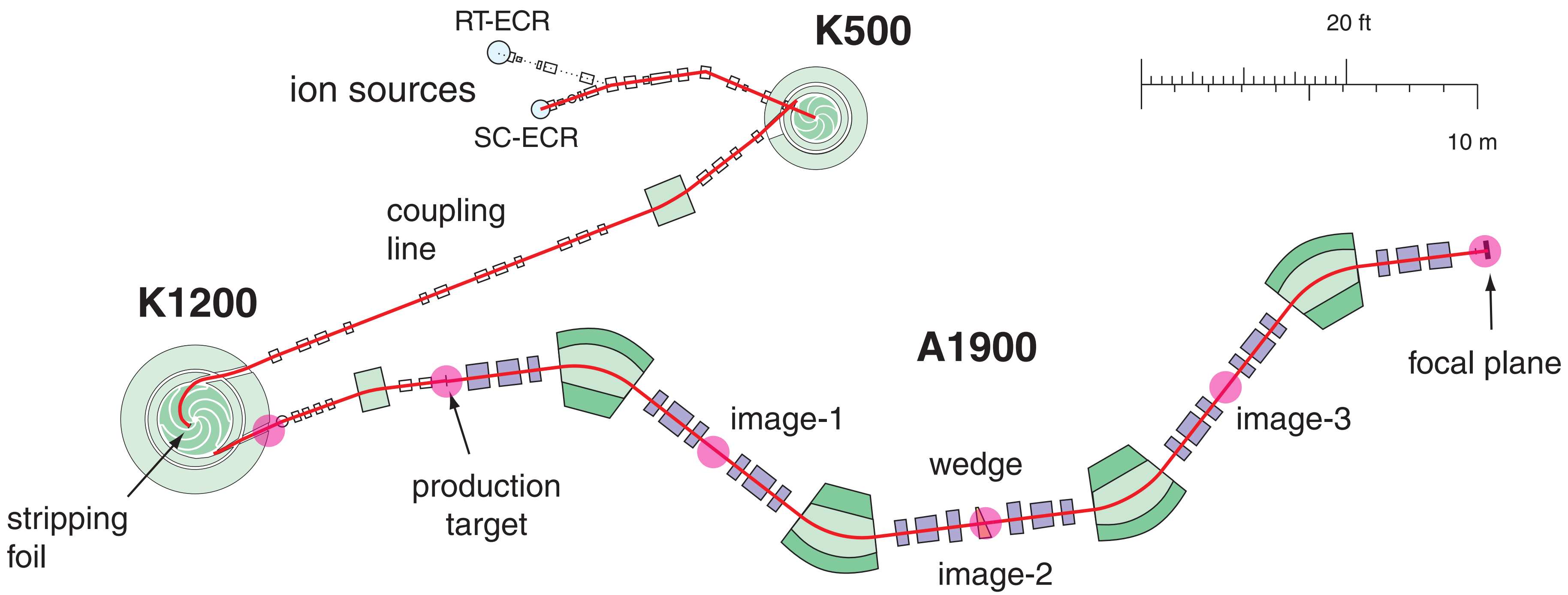
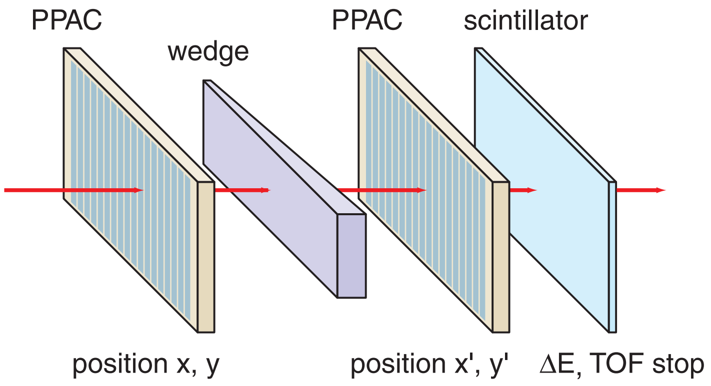
A1900 Diagnostics Setup

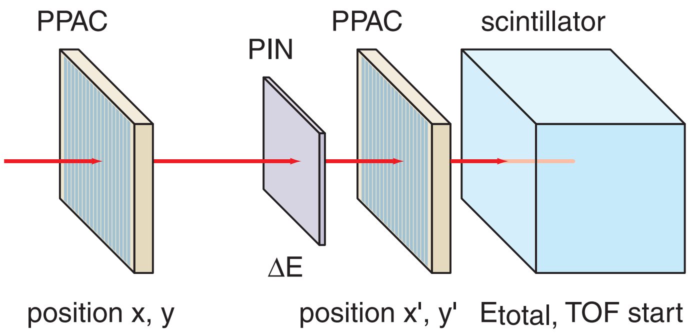


● **camera/viewer**

Image-2



Focal Plane



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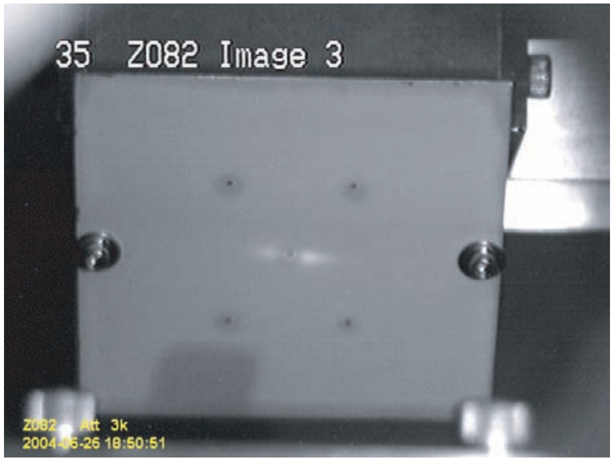
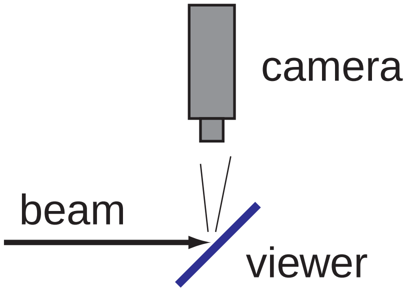
Beam Diagnostics



scintillating viewer plates
on rectractable drives
at all images in A1900
and transport beamlines



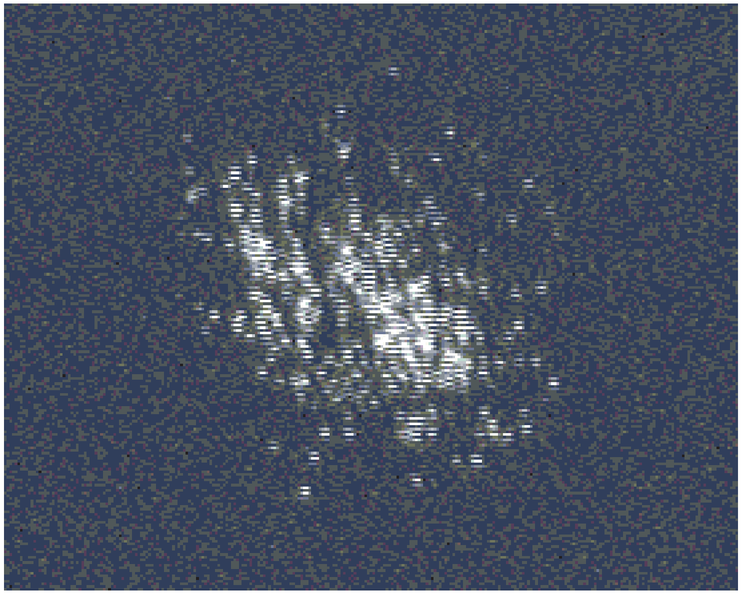
red CRT phosphor (Y_2O_2S:Eu)

ultra low light bullet type camera

KT&C KPC-EX230 HLI

0.0003 lux with 1/3" CCD sensor
lens f1.4/75mm

^{36}Ar, 40 MeV/u **10,000 particle/sec**



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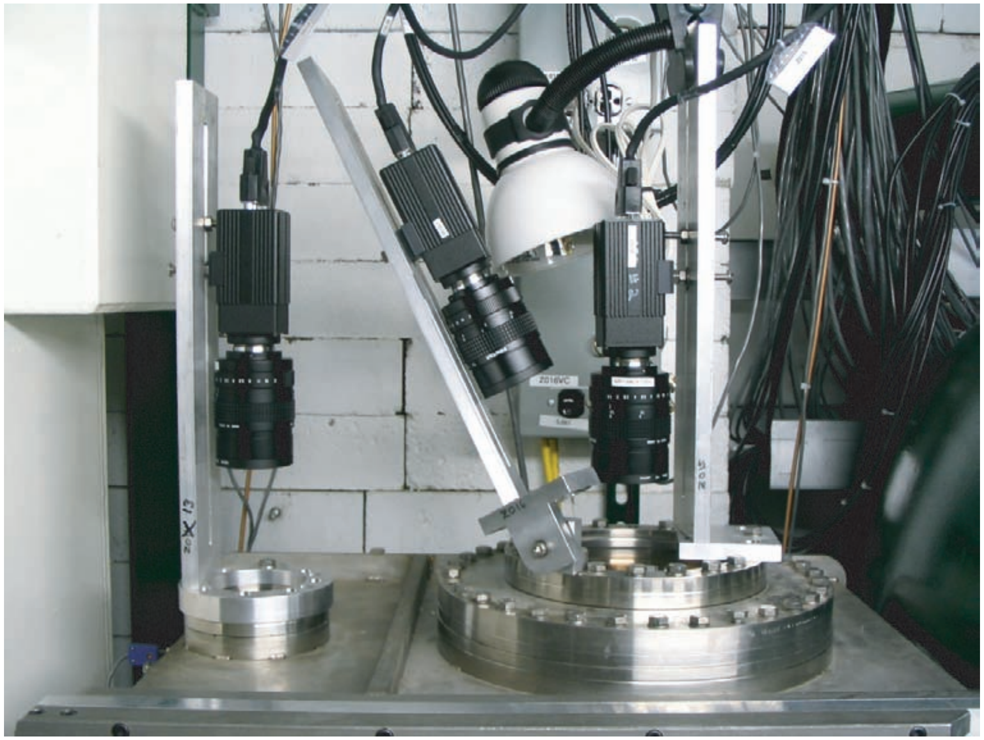
Beam Diagnostic at Production Target



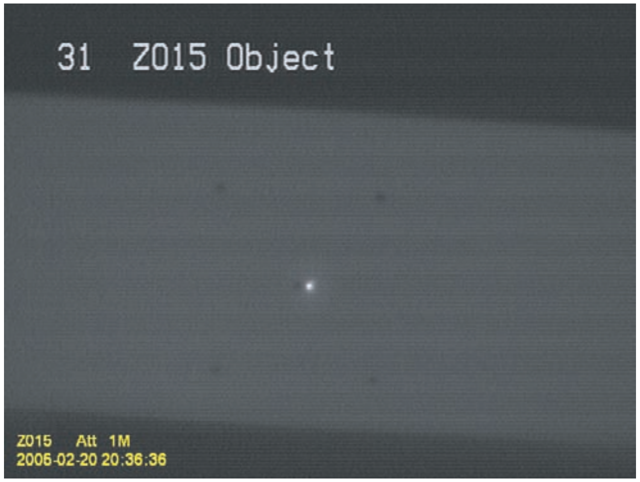
Radiation-hard CID cameras (CID8710D1M, Thermo CIDTEC)

remote electronics in shielded area

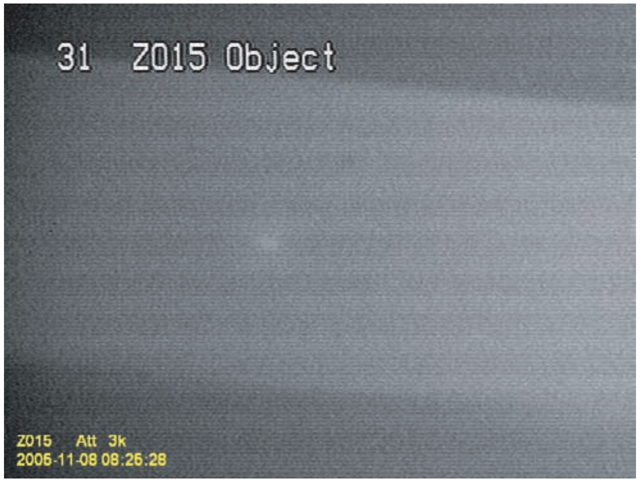
radiation tolerance: >1MRad (γ)

camera lifetime ~ 1 year

new camera



after 9 months use



radiation estimate
in target area:

neutron equiv. dose for
15pnA Kr beam (0.2 kW):

1 Rad / hour @ 50 cm distance

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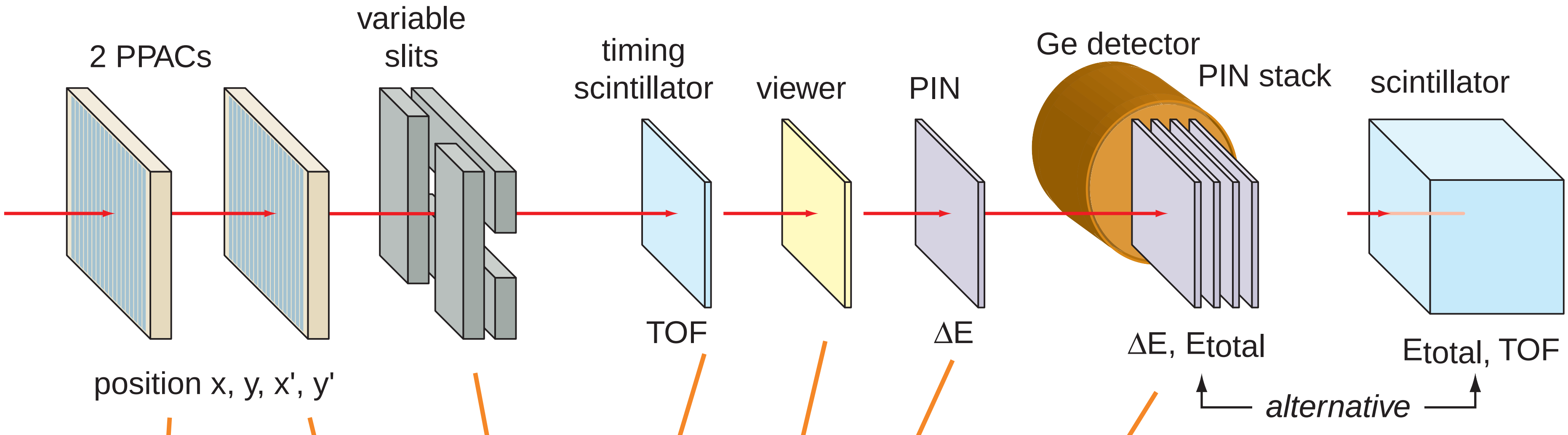
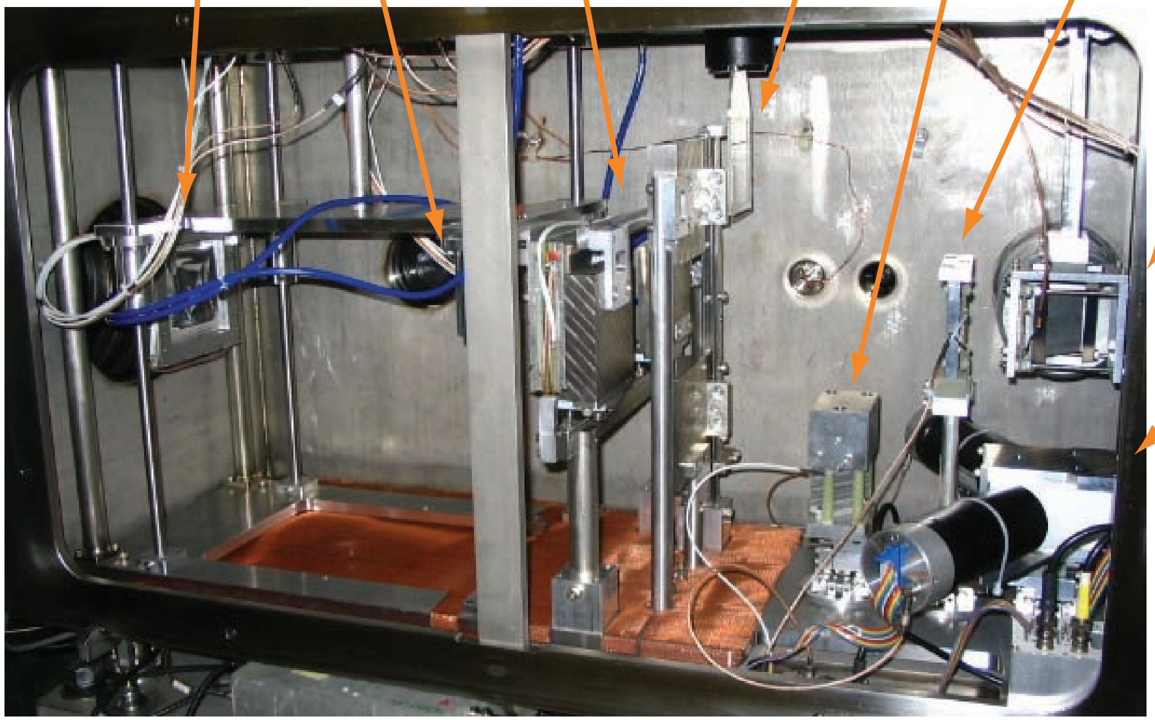
Detector Setup in new Focal Plane Box





vacuum box length: 1m

all detectors on remotely controlled drives

large access door for easy maintenance

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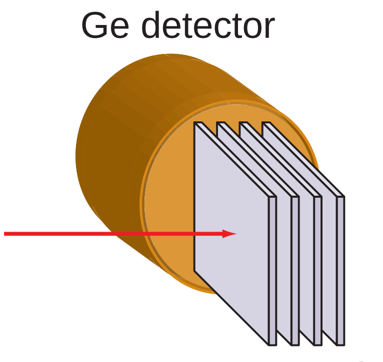
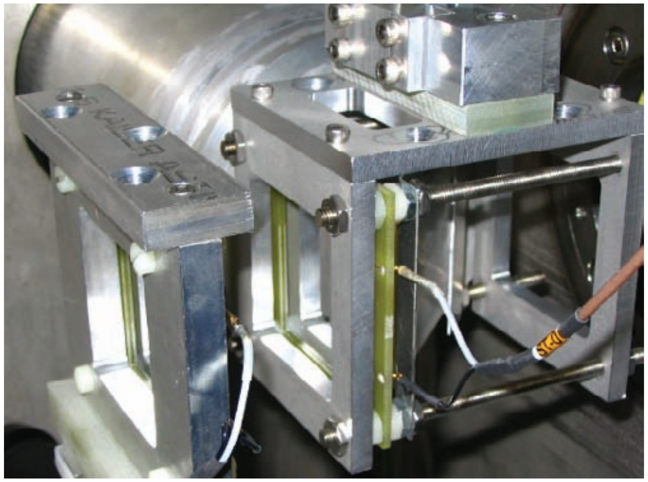
Particle ID with Microsecond Isomers...

ORTEC 120% or 80% Ge detector

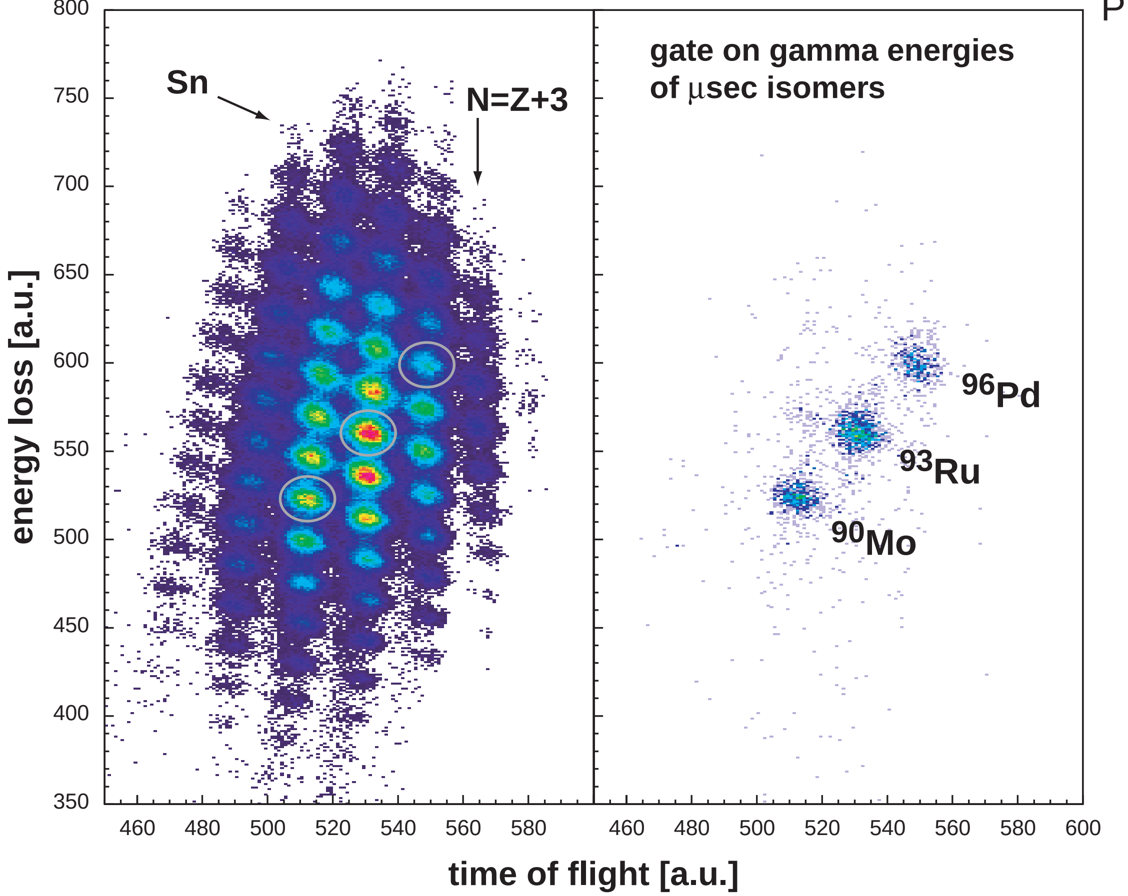
mounted in retractable, re-entrant can

close geometry to silicon PIN stack

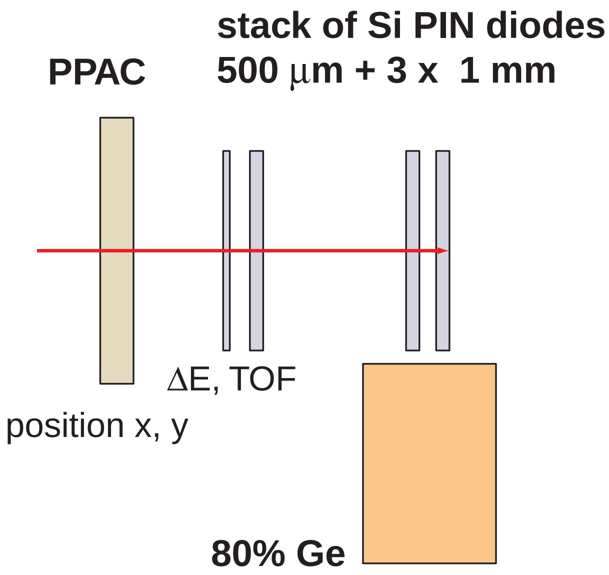




^{124}Xe (140 MeV/u) + ^{9}Be (390 mg/cm^{2})



Detector setup at focal plane



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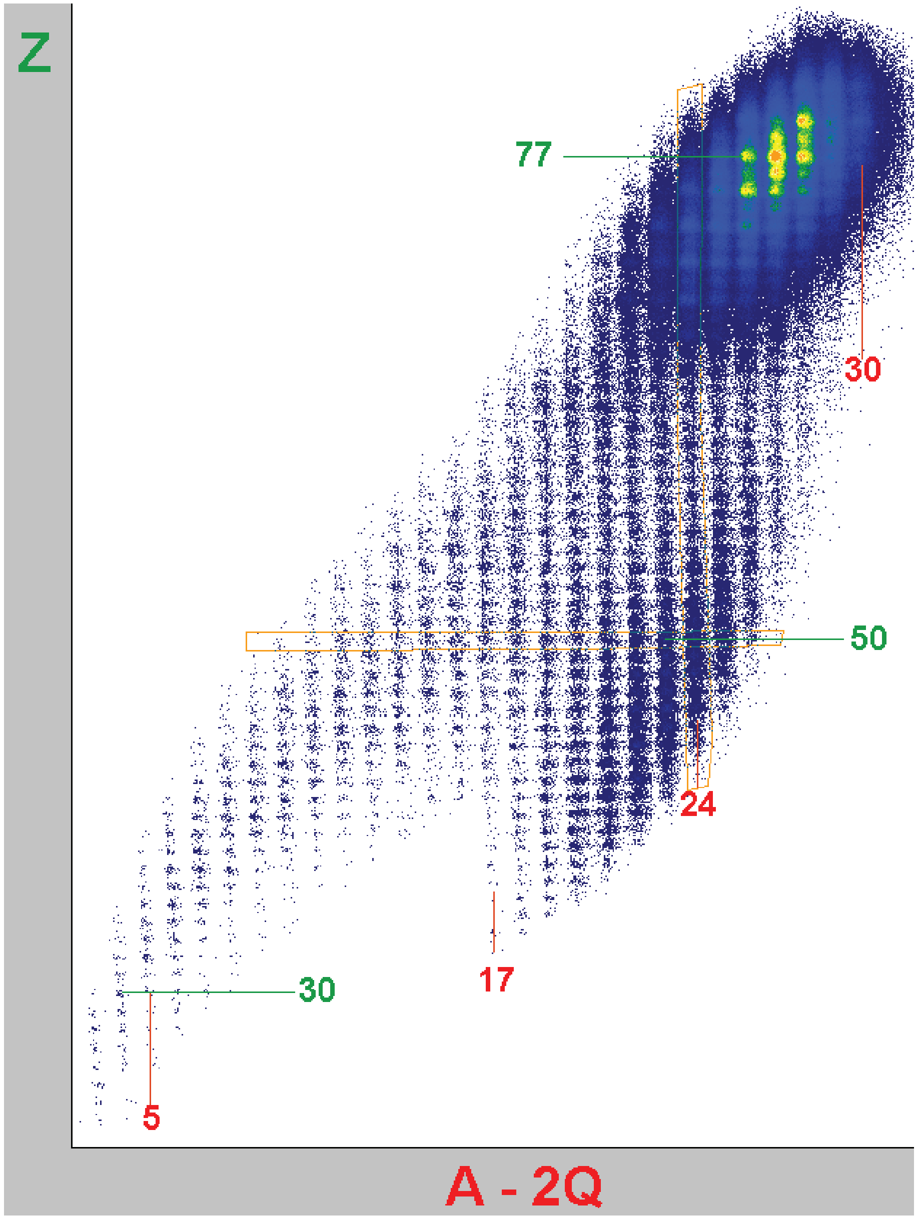
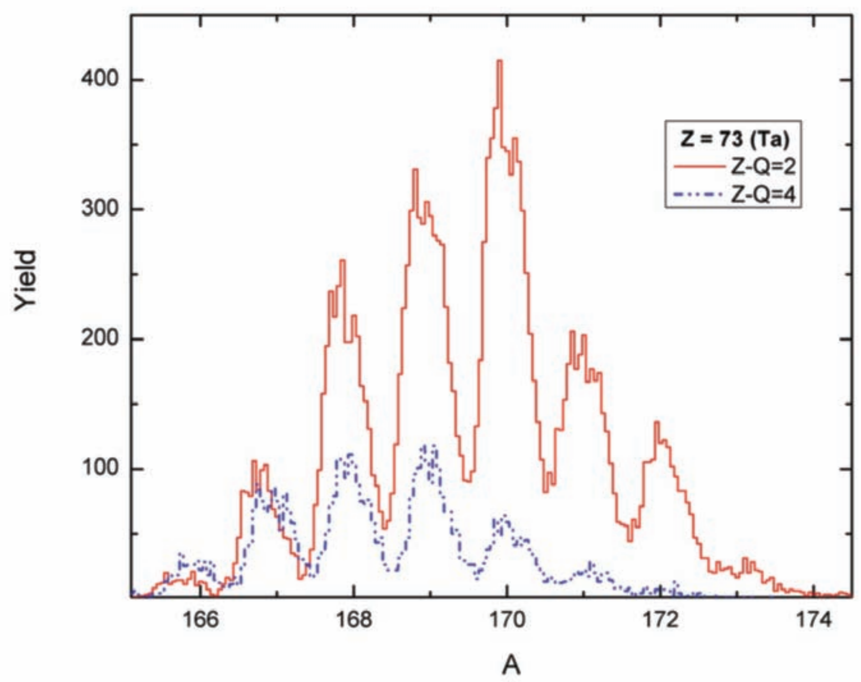
Particle Identification in A1900





^{208}Pb, 85 MeV/u + ^{9}Be

PID with PIN stack detector

O. Tarasov et al., NSCL experiment 05120

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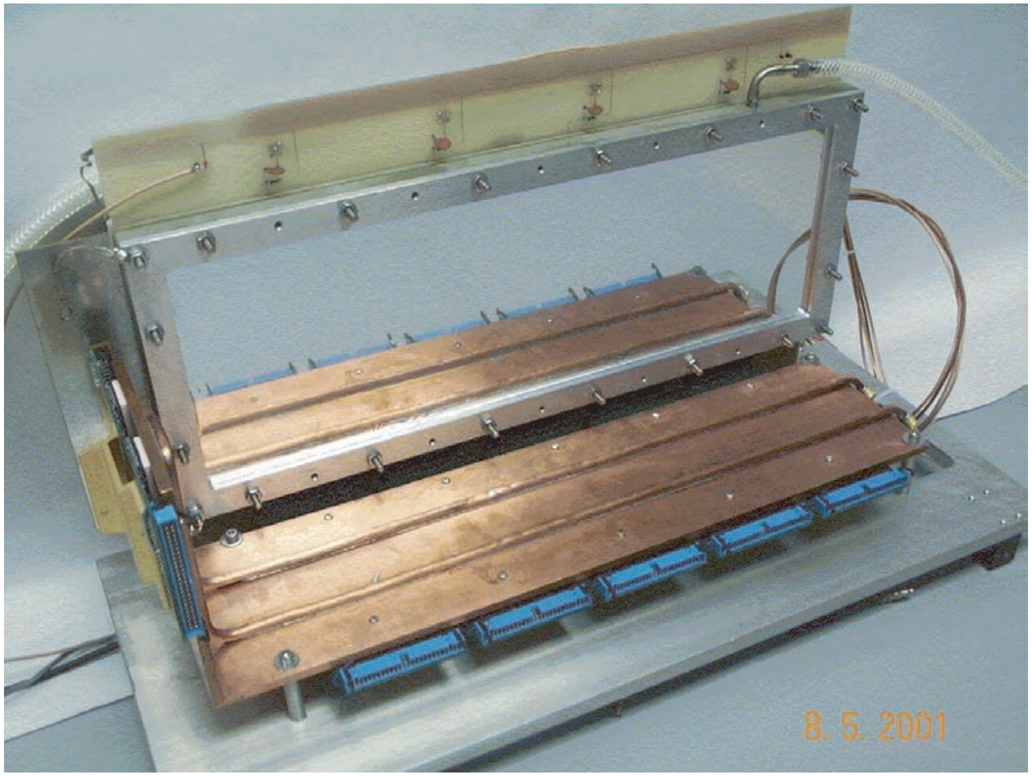
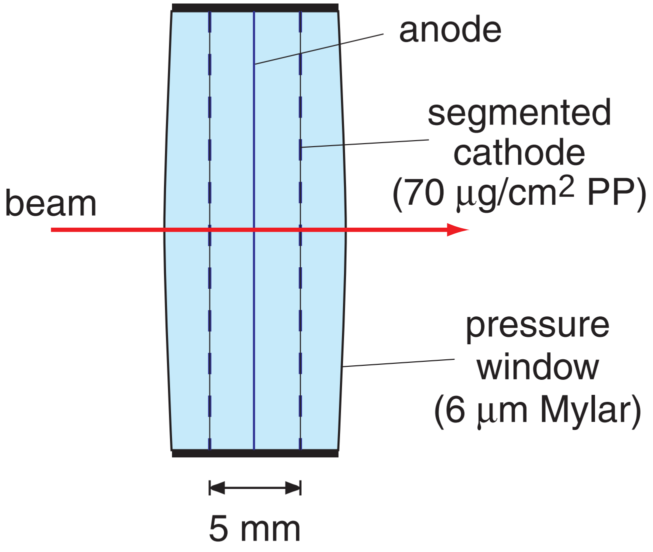
NSCL Large Area High Rate PPAC Detector


8. 5. 2001

- large active area: 400 x 100 mm^2
- segmented cathodes: 160 x 32 strips
- individual strip cathode readout,
  (FE electronics from STAR TPC)
- homogenous low mass thickness
  (2.2 mg/cm^2 Al equivalent)
- streched PP foils with Au strips
- isobutane, pressure 5 Torr



- **position resolution: 2.5 mm**
- **high count rate stability:**
  800 kHz tested

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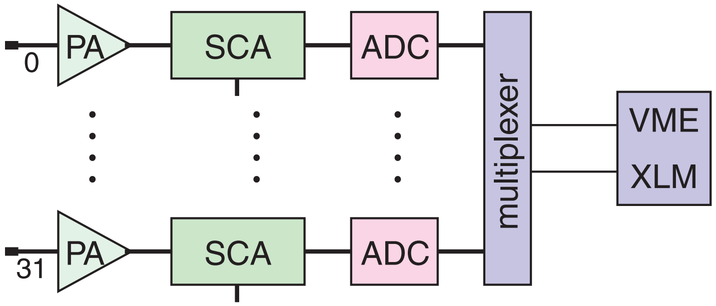
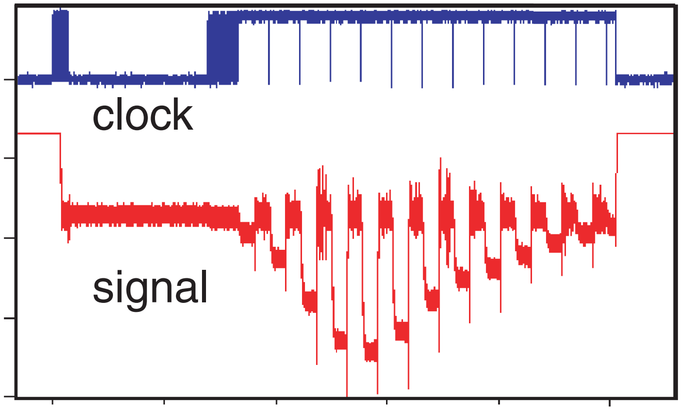
NSCL PPAC Detector Readout

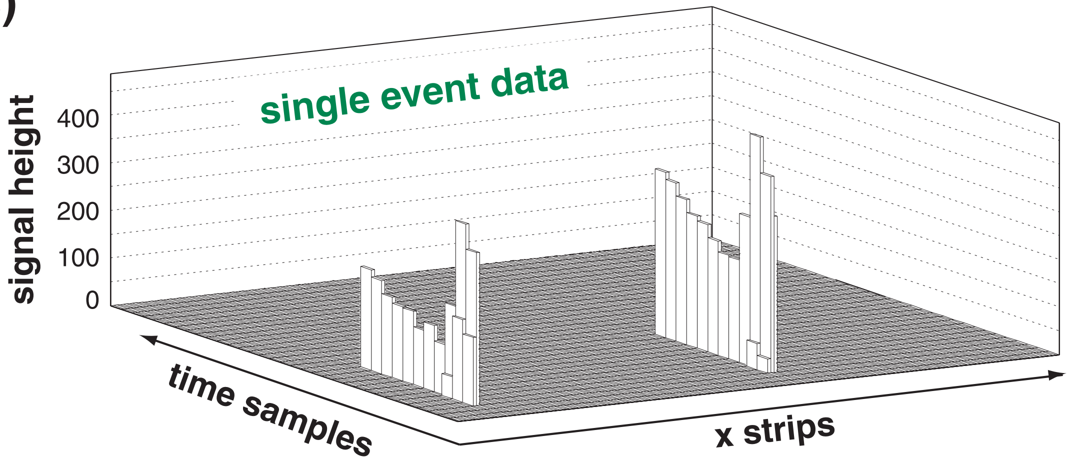
STAR TPC front end electronic



SCA = switched capacitor array



- **continous sampling into switched capacitor array (512 capacitors/channel, 10 MHz sampling freq.)**
- **delayed readout trigger (up to 40 μs)**
- **double hit resolution possible**



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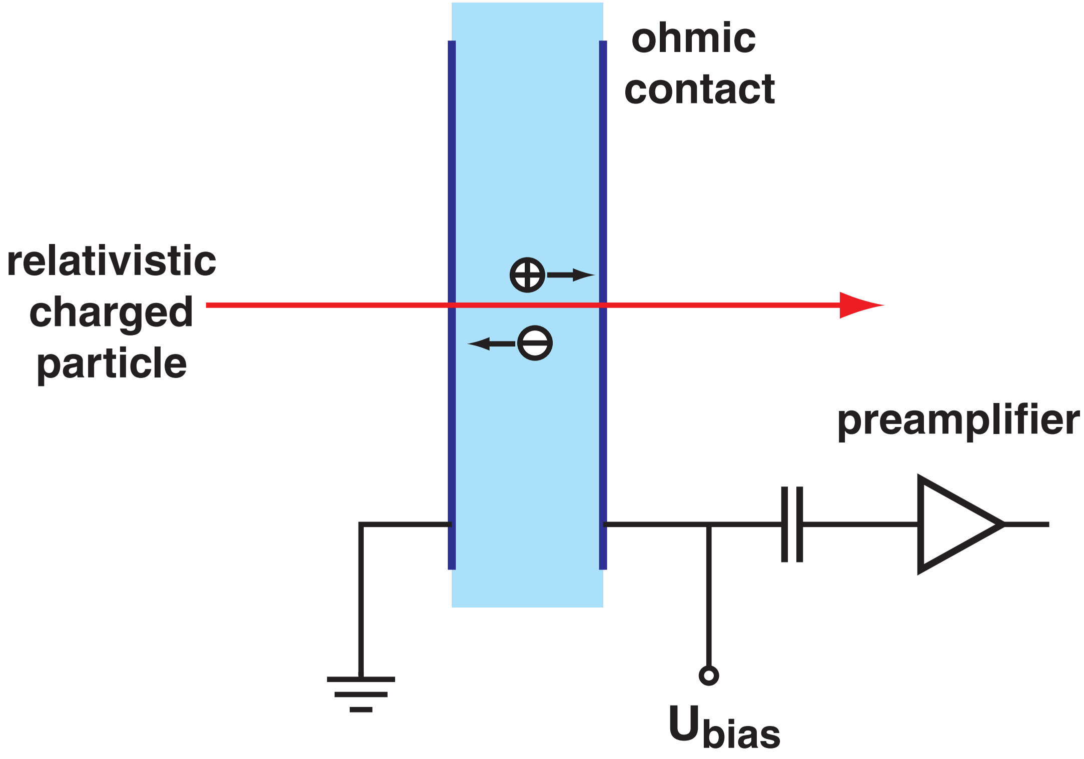
Diamond as Particle Detector



drift field: ~ 2V / μm

drift velocity: 200 μm / ns

diamond band gap: 5.5 eV
→ no need for pn-junction

"Solid-State Ion Chamber"

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Why Diamond?

Outstanding properties of diamond

Extreme mechanical hardness (90 GPa)

Highest known value of thermal conductivity at room temperature
(2×10^3 W / m / K)

Broad optical transparency from the deep UV to the far IR
(detectors are not light sensitive)

Diamond is a semiconductor (bandgap 5.45 eV)
very high room temperature resistivity (~ 10^{16} Ohm cm)
(detectors need no cooling, no pn-junction needed)

High charge carrier mobility (~ 2000 cm^2/Vs)
(fast rise time of detector signals)

High energy needed to remove carbon atom from lattice (80 eV)
(detector are radiation hard, difficult to destroy with beam)

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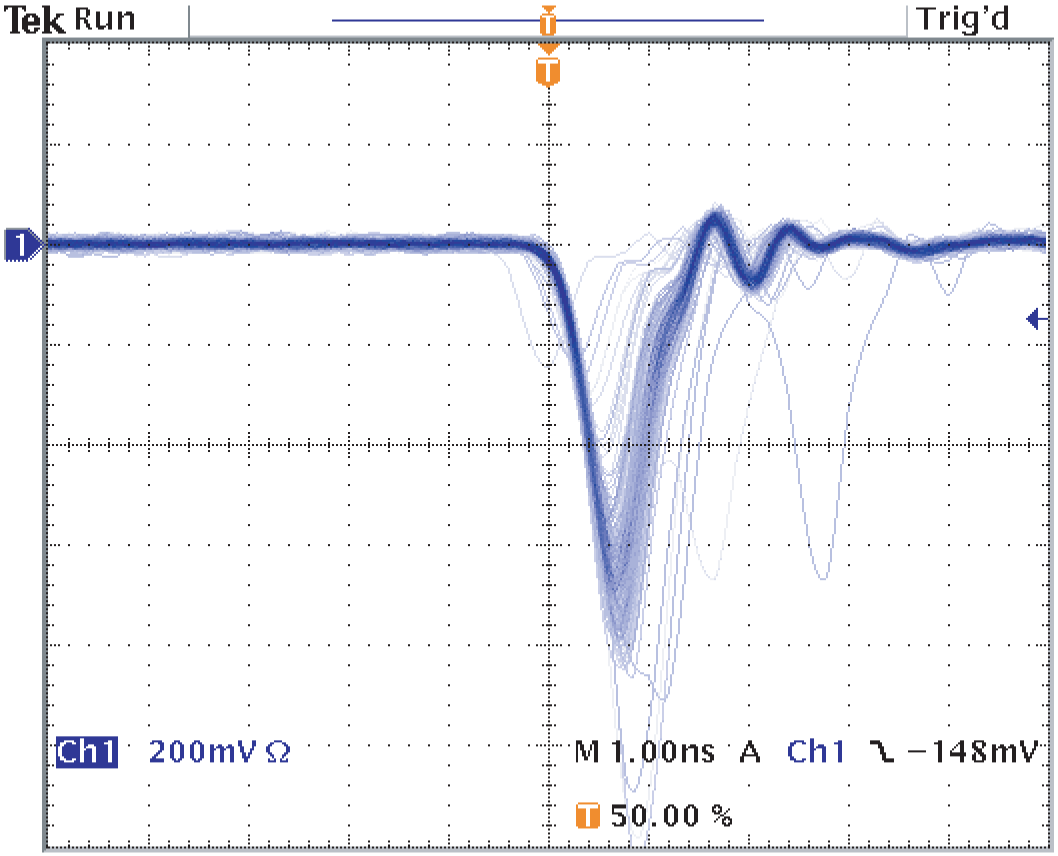
Single-Crystal Diamond Detector

^{76}Ge, 100 MeV/u, 10^6 particles/sec

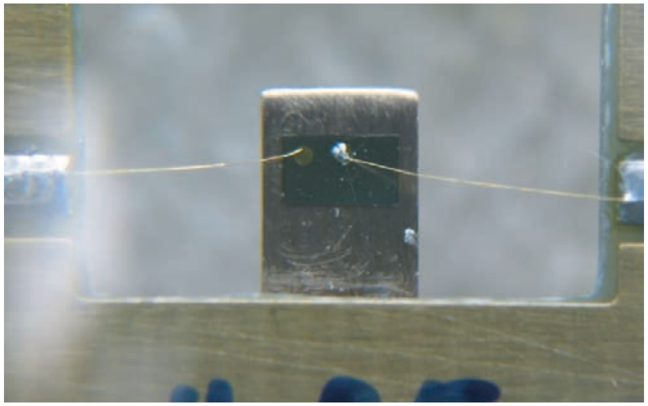


grown at MSU (B. Golding)

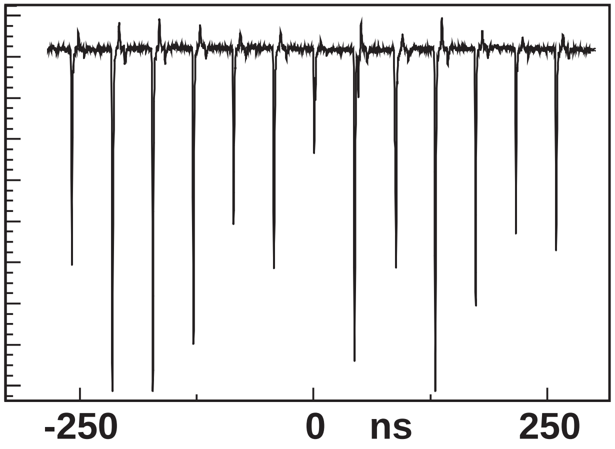
hetero-epitaxie CVD

thickness 20 μm

Ir back layer (300 Å)



beam structure from cyclotron (frequency ~25 MHz)



preamp signal rise time ~ 0.5 nsec

low-noise, broadband (2GHz) preamps

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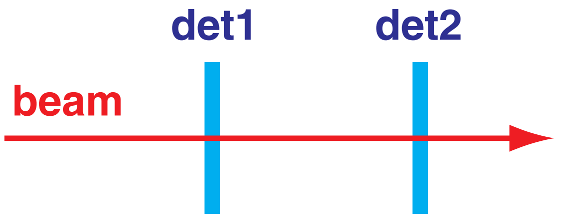
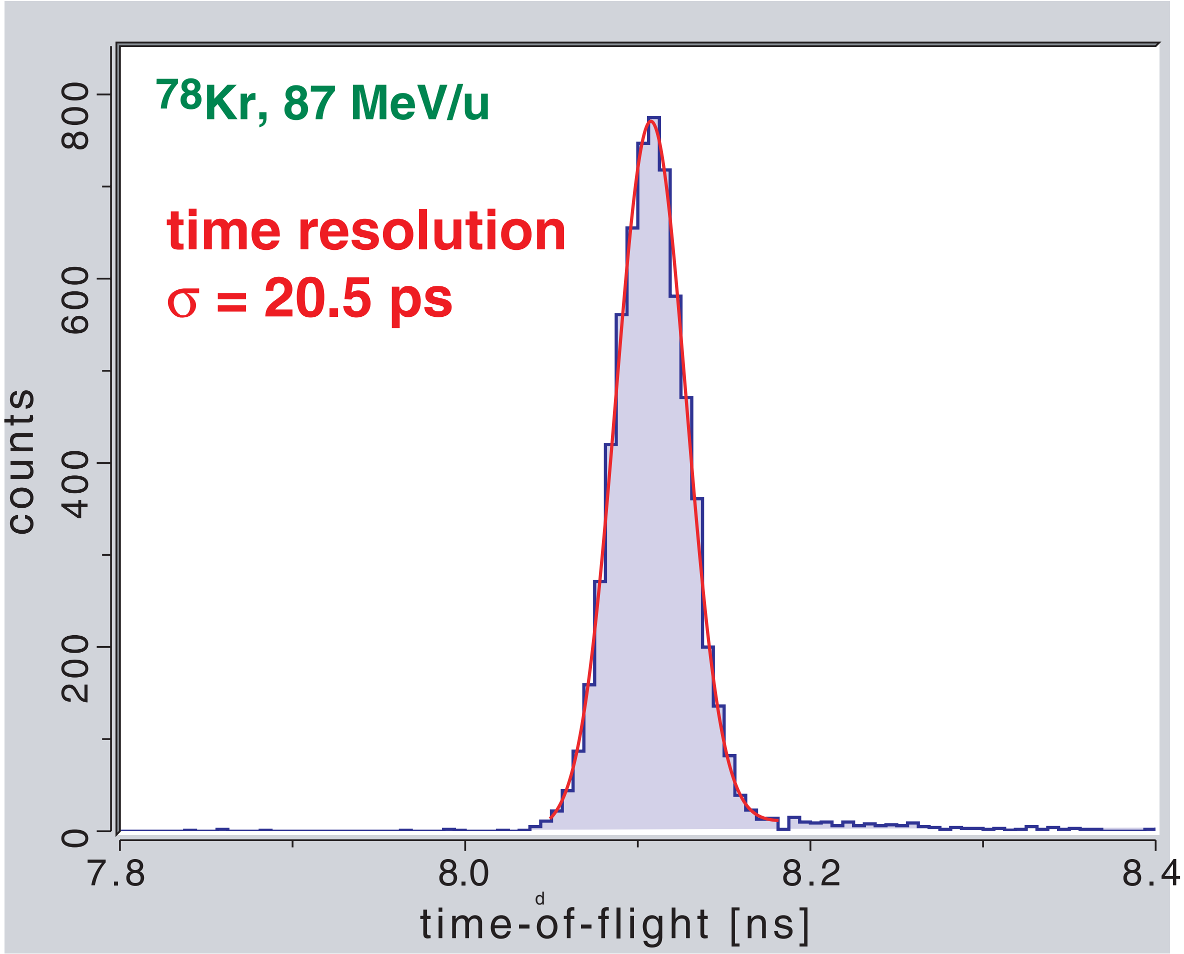
Diamond Detector - Time Resolution

2 single-crystal diamond detectors (20 µm + 35 µm) in transmission mount



no degradation of time resolution up to rates of $2 \cdot 10^6$ particles/sec $= 10^7$ particles/(sec mm^2)



intrinsic detector resolution σ = 15 ps

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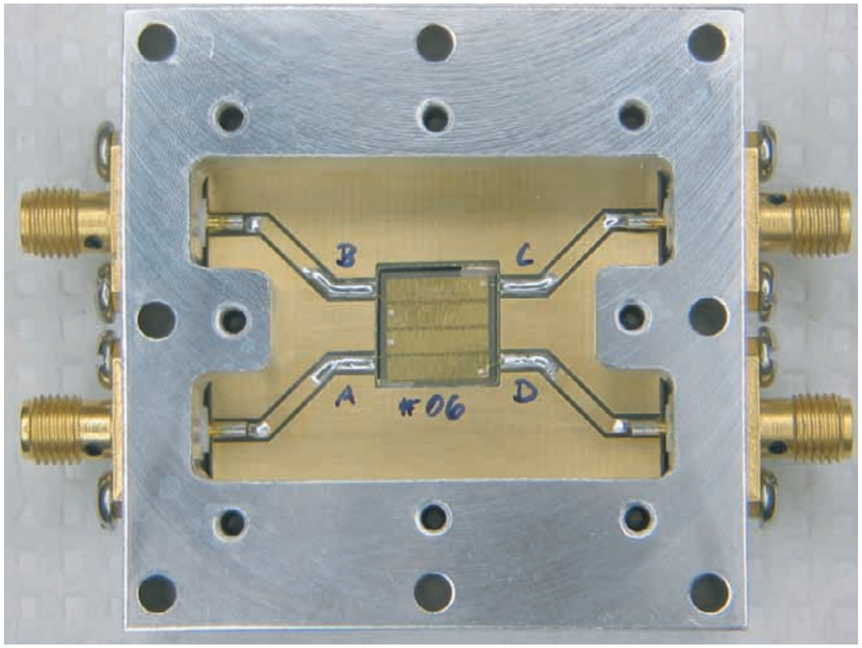
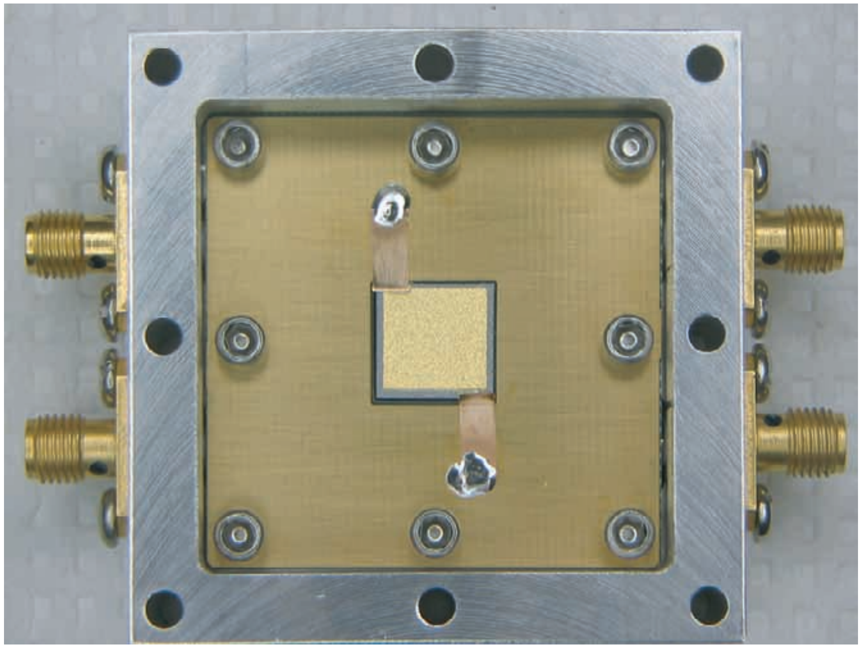
Diamond Strip Detector

Poly-crystalline CFD diamond
active area 9 x 9 mm^2
thickness 100 μm (35 mg/cm^2)
4-fold segmented cathode, common anode
single-strip readout





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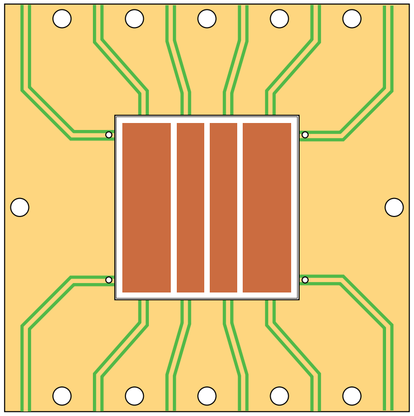
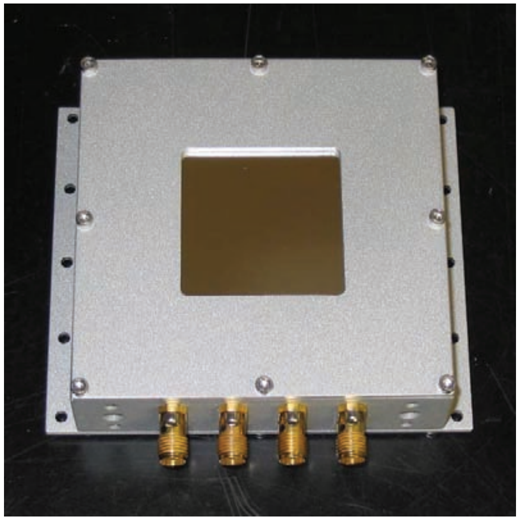
Diamond Beamline Timing Detector

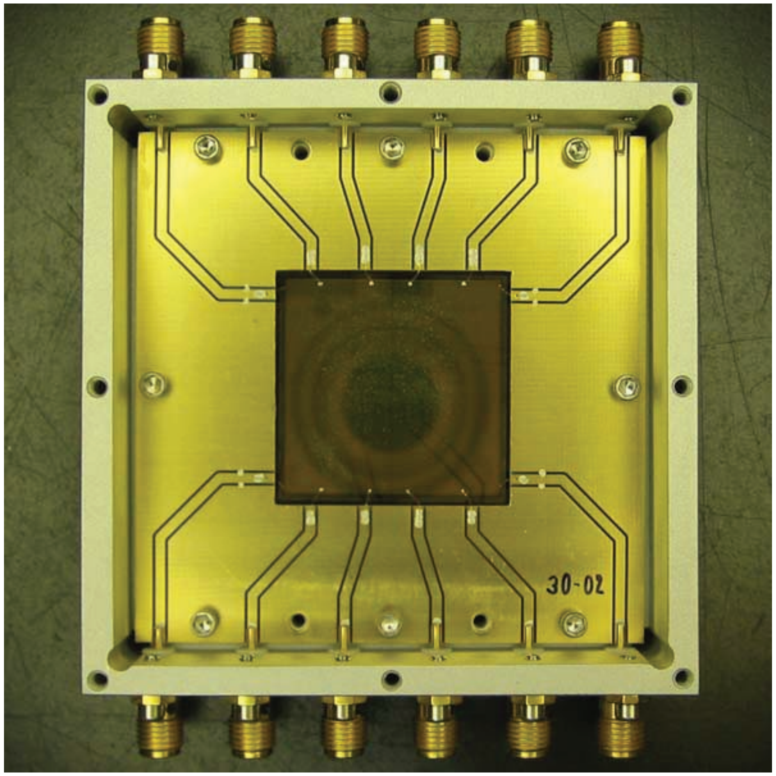
active area 28 x 28 mm^2, 200 um thick

front side:4-fold segmentation

back side: no segmentation







readout from both strip sides:
investigate position resolution
(time difference)

investigate thickness homogeniety over active area: can detector be used at dispersive focus?

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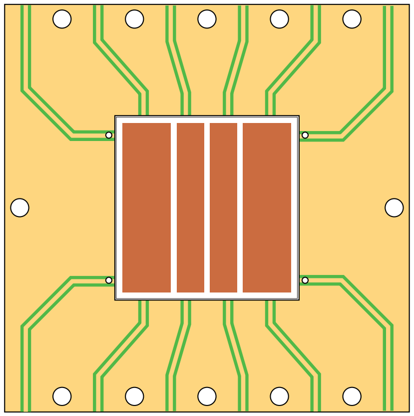
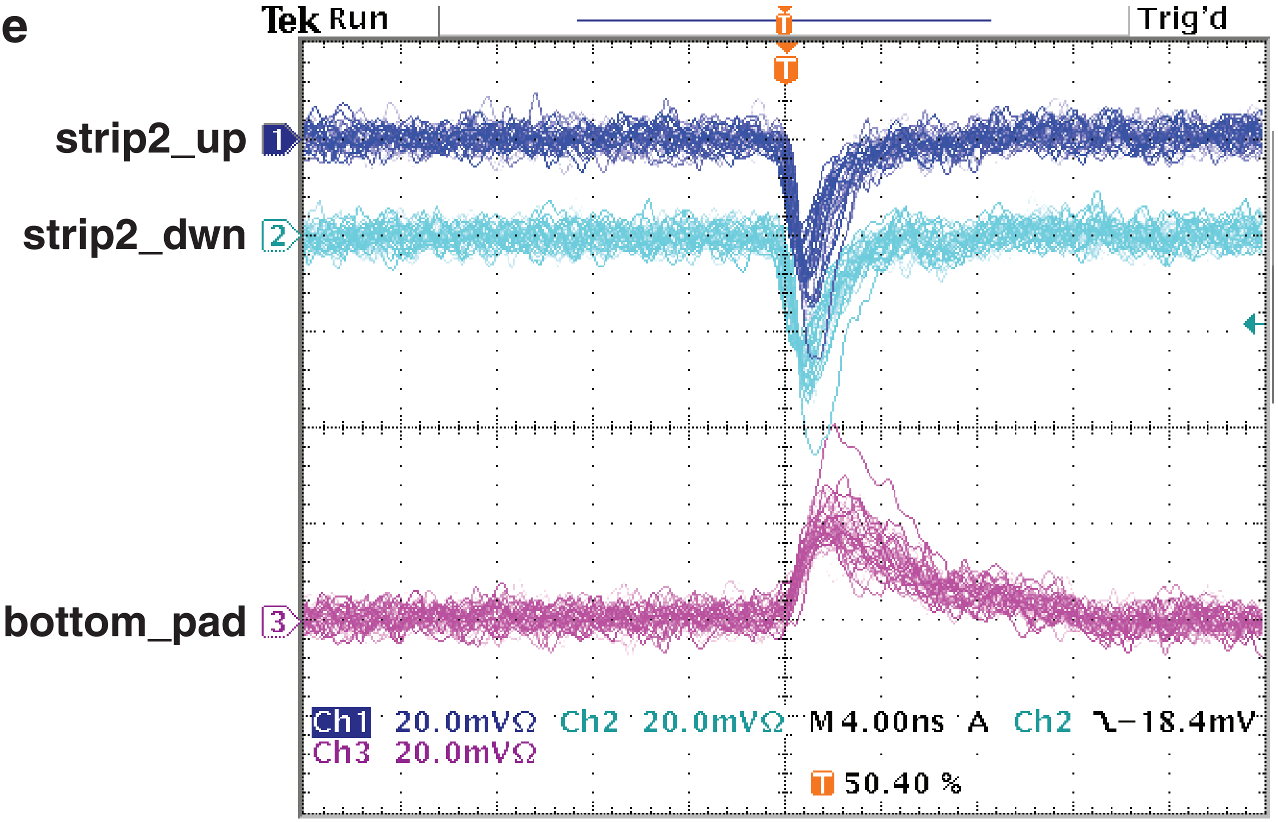
Diamond Beamline Timing Detector

First tests with alpha-source





Tek Run Trig'd

Ch1 20.0mVΩ Ch2 20.0mVΩ M 4.00ns A Ch2 ⟍ −18.4mV
Ch3 20.0mVΩ
T 50.40 %

U-232 alpha-source, U_{bias}=-400V

readout from both strip sides:
investigate position resolution
(by measuring time difference)

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