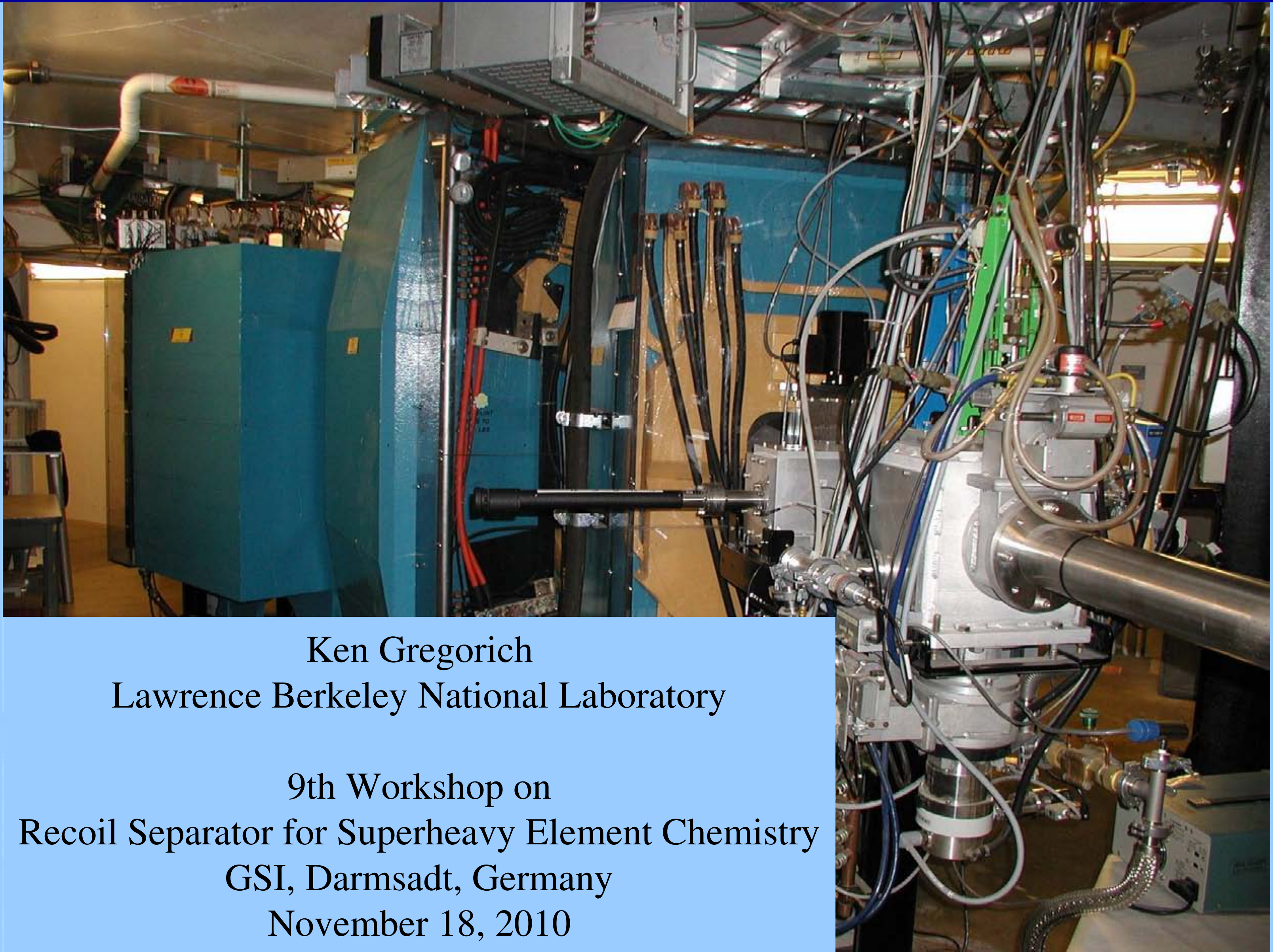
Berkeley Gas-Filled Separator Focal Plane and Beyond



Ken Gregorich

Lawrence Berkeley National Laboratory

9th Workshop on

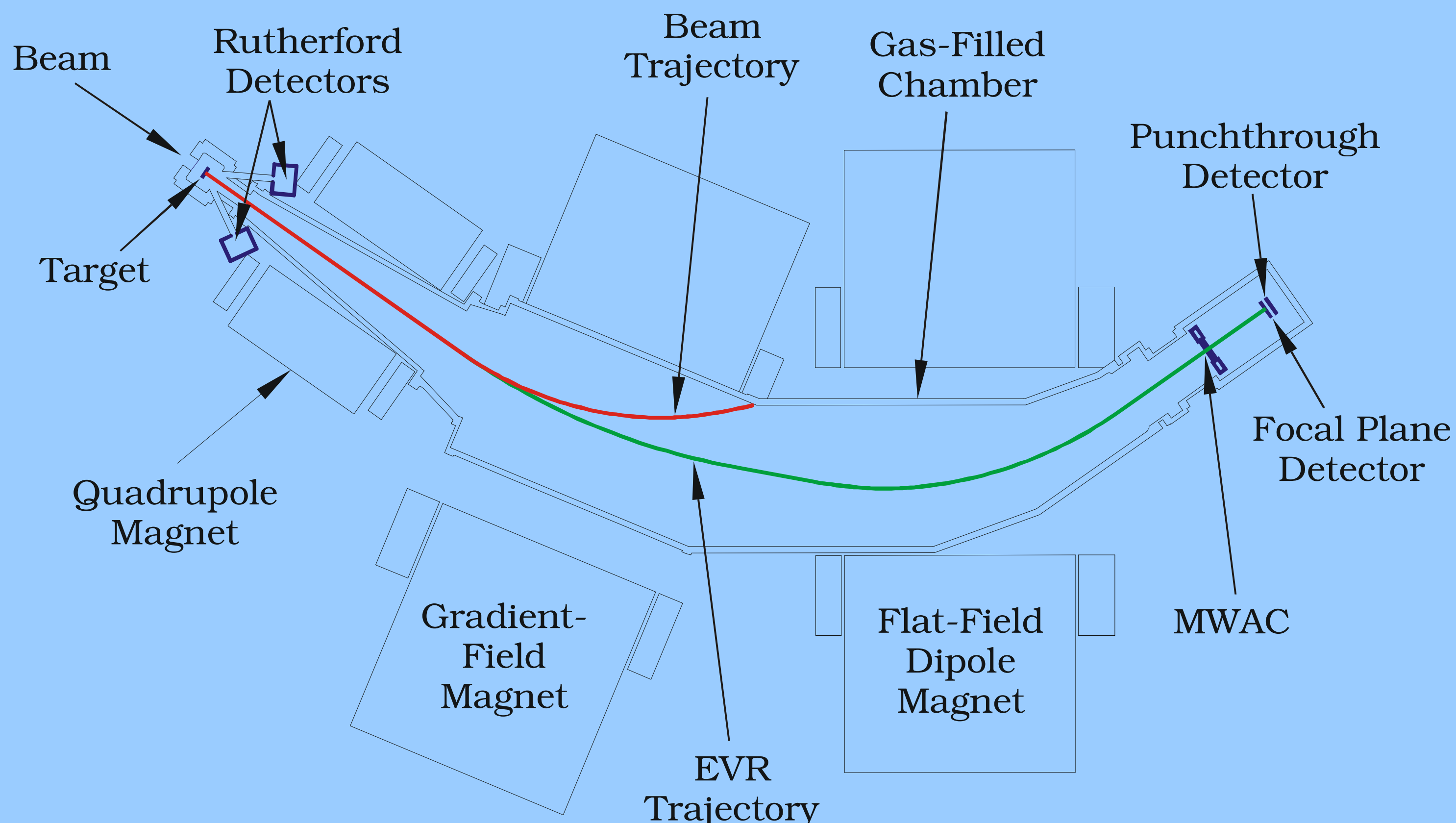
Recoil Separator for Superheavy Element Chemistry

GSI, Darmsadt, Germany

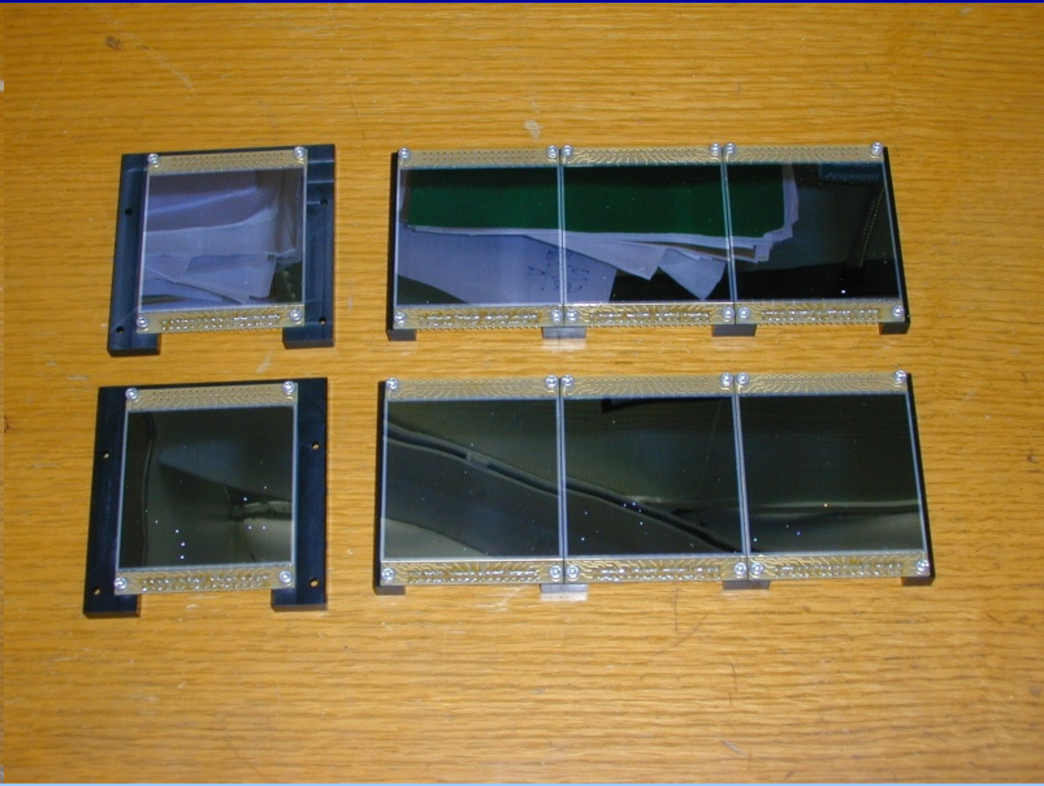
November 18, 2010

Stuff Behind the BGS

New BGS focal plane detector array
GRETINA@BGS campaign
Gas catcher, RFQ trap, and mass separator



Present PSD Assembly

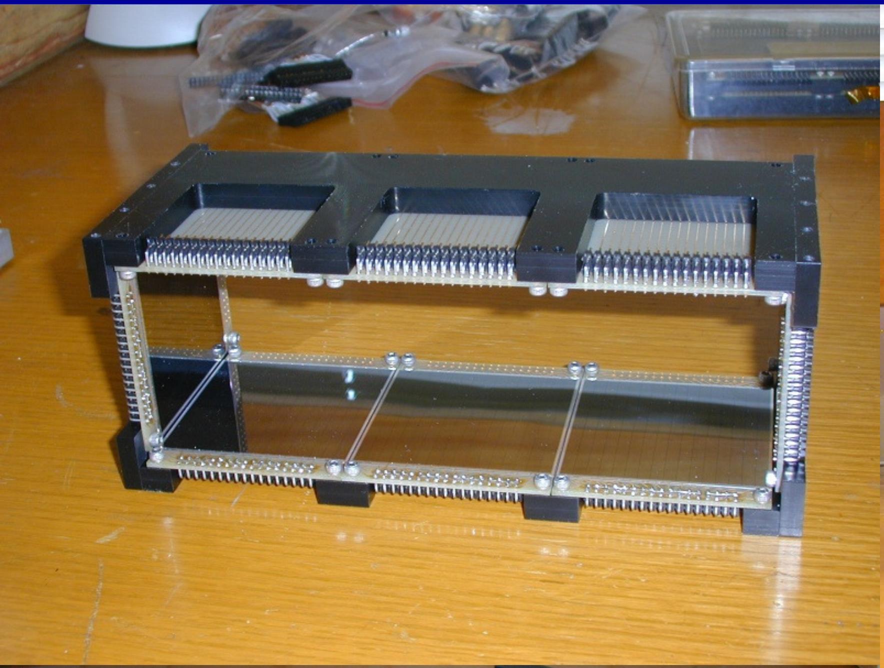


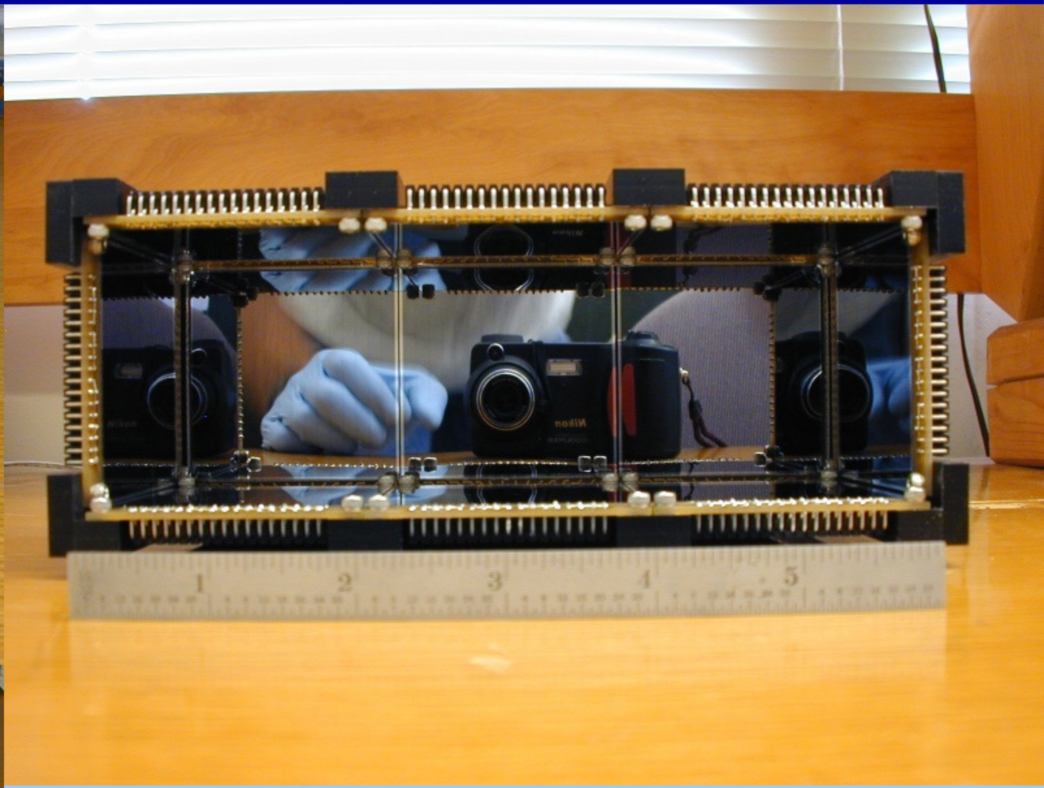
Focal plane is built from 3 6cm x 6cm chips
16 strips each with resistive charge division
~ 1000 effective "pixels"

Upstream box is built from 8 6cm x 6cm chips
32 sectors of 4 strips, no resisitive charge division

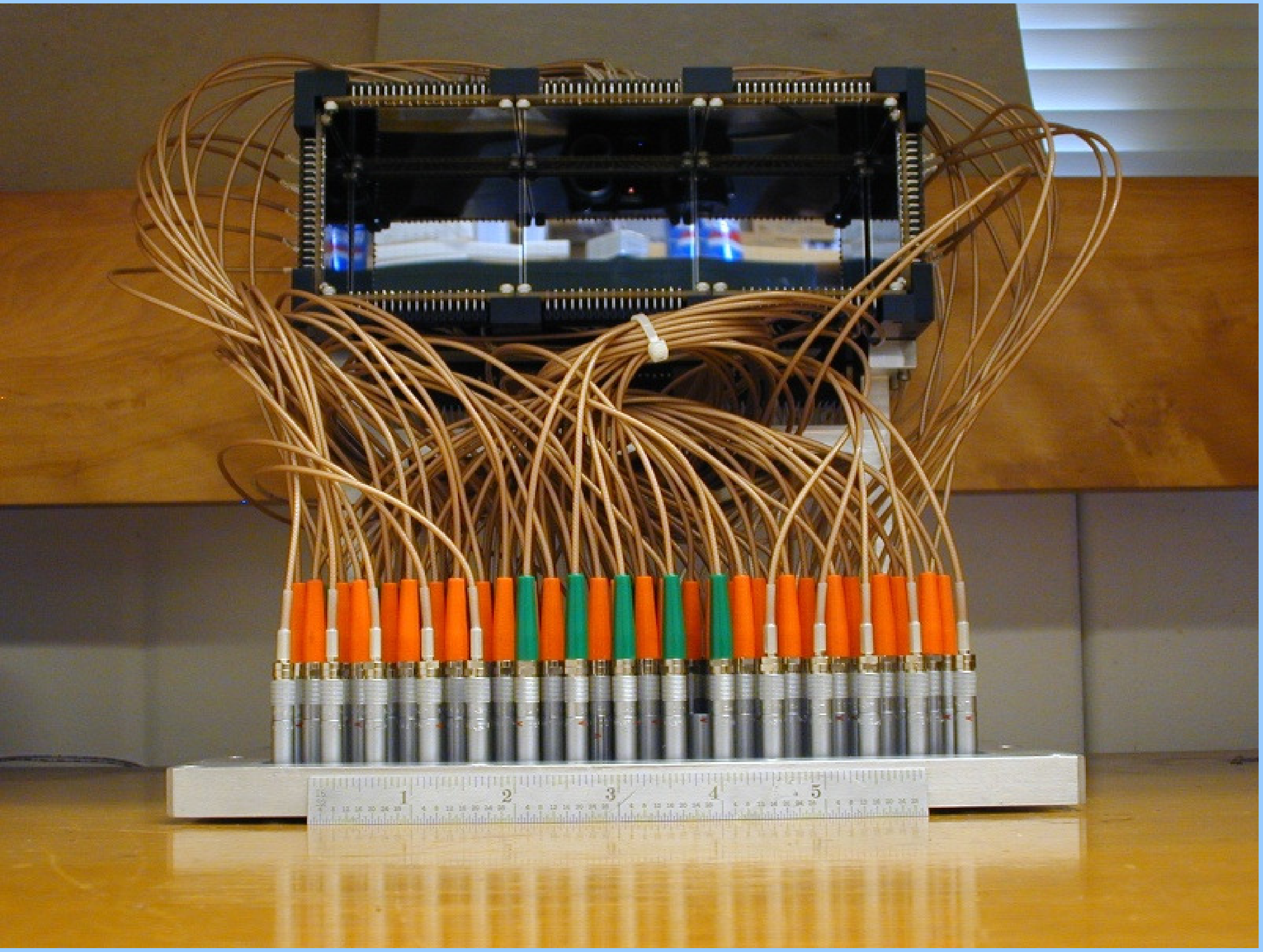
Present PSD Assembly

Berkeley Lab





Final Assembly of PSD array

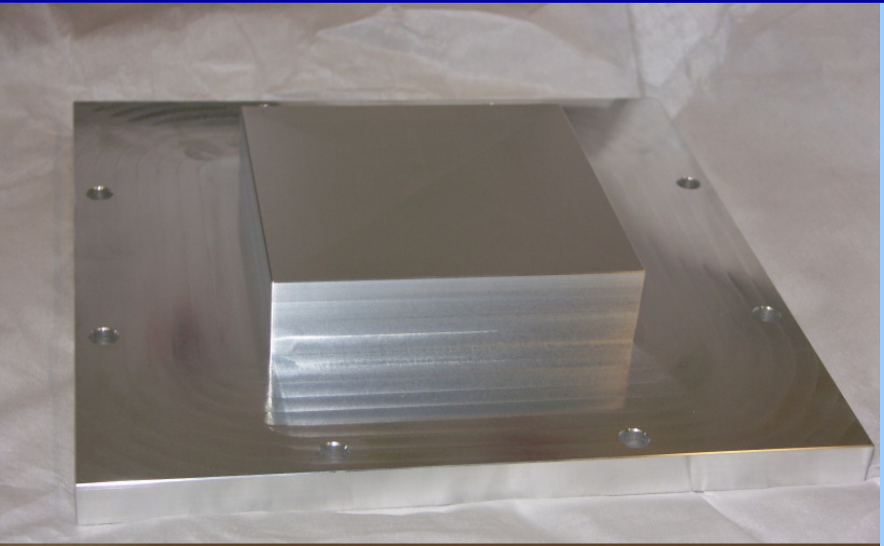


Recoil efficiency for
$^{48}Ca + ^{238}U$ = 69%
(using 15mm w x 6mm h tgt)

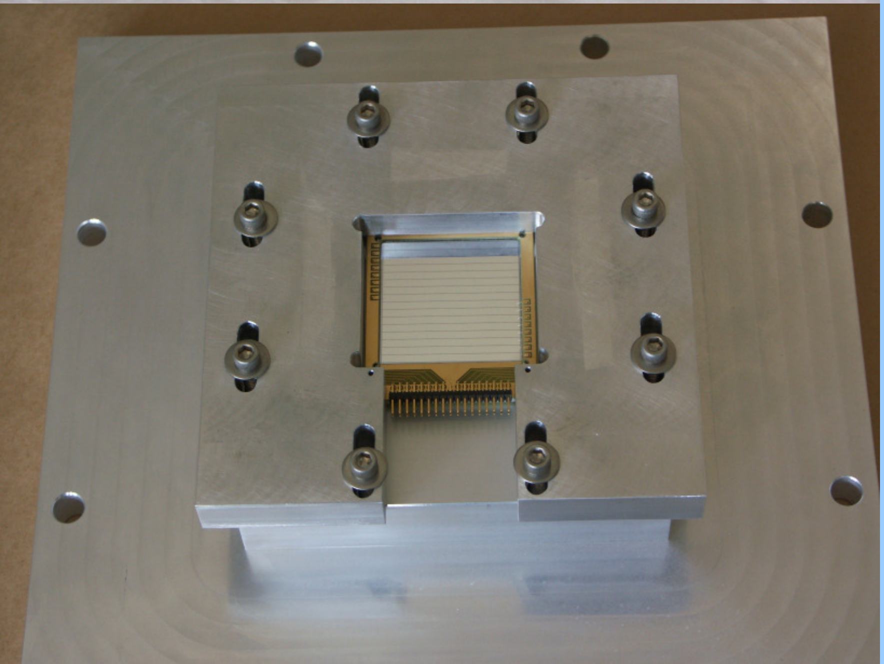
Alpha efficiency = 75%
(lower for shallow implants)

Conversion electron
efficiency is poor
~300 keV trigger level
σ_p ~ 1400 keV*mm/E
300 μm thick Si

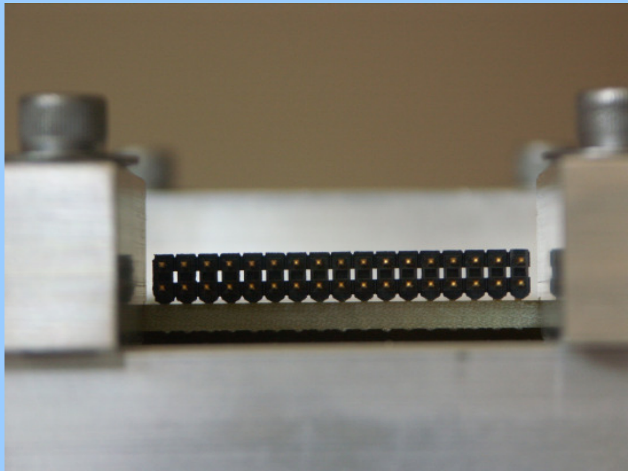
DSSD for K-isomer Studies



Re-entrant vacuum window for Ge clover
2-mm thick Al



DSSD mounted on inside of vacuum window
5 cm x 5 cm DSSD (Micron)
16 strips per side (256 pixels)
1-mm thick Si for good c.e. response



DSSD in place with Clover

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Recoil efficiency ~ 35%
alpha efficiency = 50%
122 keV γ efficiency = 16%
900 keV γ efficiency = 4%

c.e. trigger threshold = 120 keV
(limited by SCR noise)

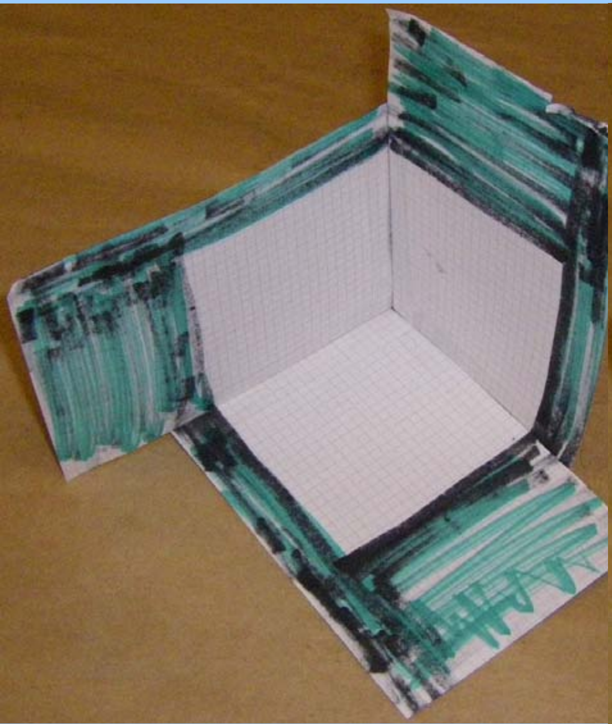
c.e. efficiency is large (1mm Si)

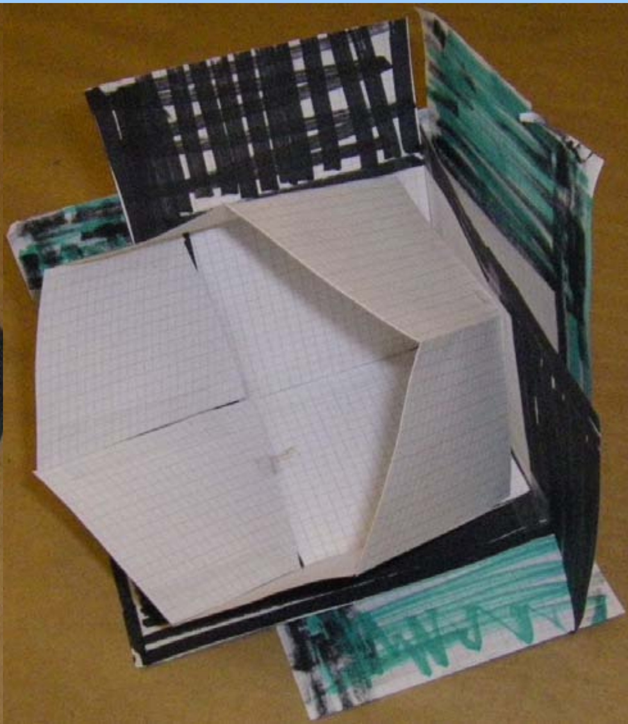
Paper Model of
New DSSD configuration

<u>Punchthru Detectors</u>
3 x 64mm x 64mm DSSDs
used as SSSDs
32 strips per side
connected in groups of 3
gives a total of 32 signals
reject fast low-ionizing particles

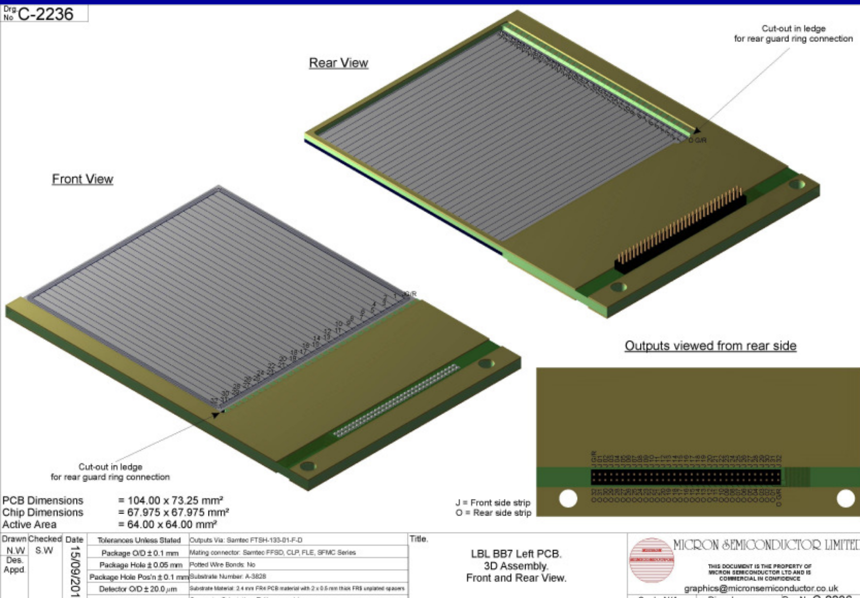
<u>Focal Plane Detectors</u>
3 x 64mm x 64mm DSSDs
32 strips per side
connected in groups of 2
gives a total of 96 signals
and 3072 pixels
α *efficiency = 74%*

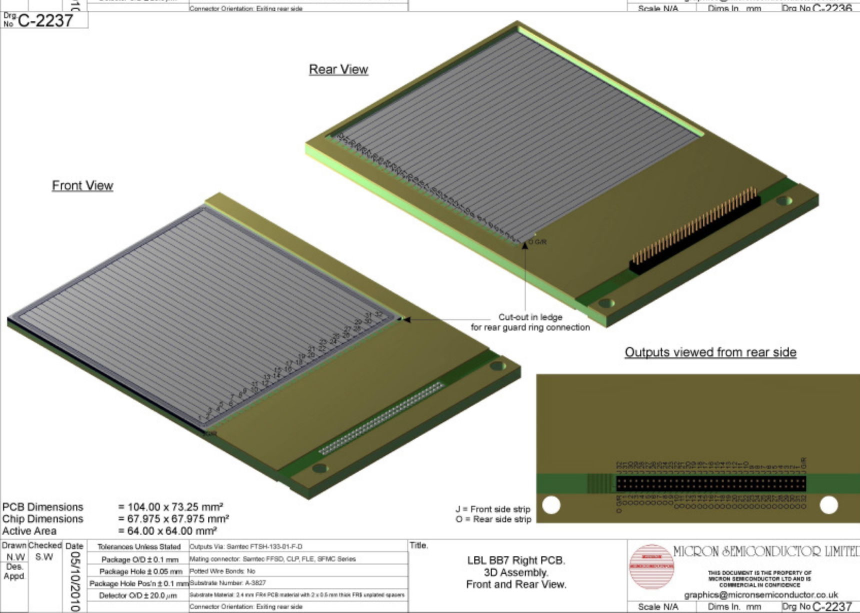
<u>Upstream Hexagonal Tunnel</u>
6 x SSSDs
end trimmed to 35.2^{O}
to fit against focal plane
4 strips per detector
total of 24 signals
increases α *efficiency to 92%*





3D Assembly Drawings of Focal Plane DSSSDs





1 mm thick Si
32 strips/side (1024 pixels each chip)
Mirror image configurations (for FP & punchthru)

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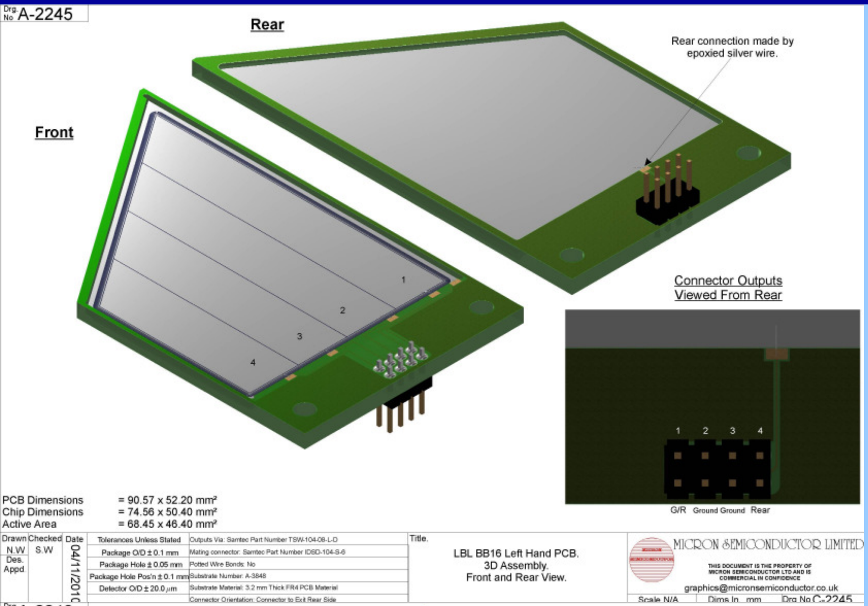
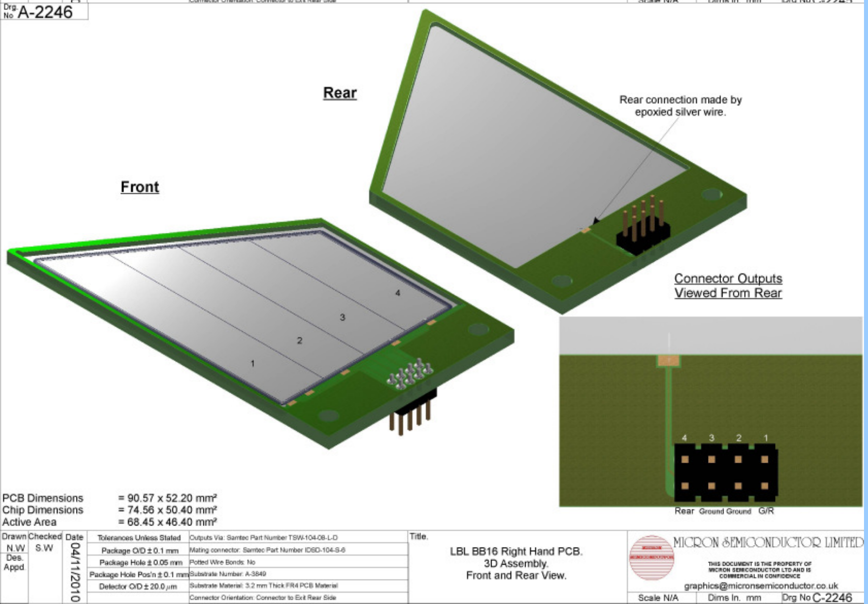
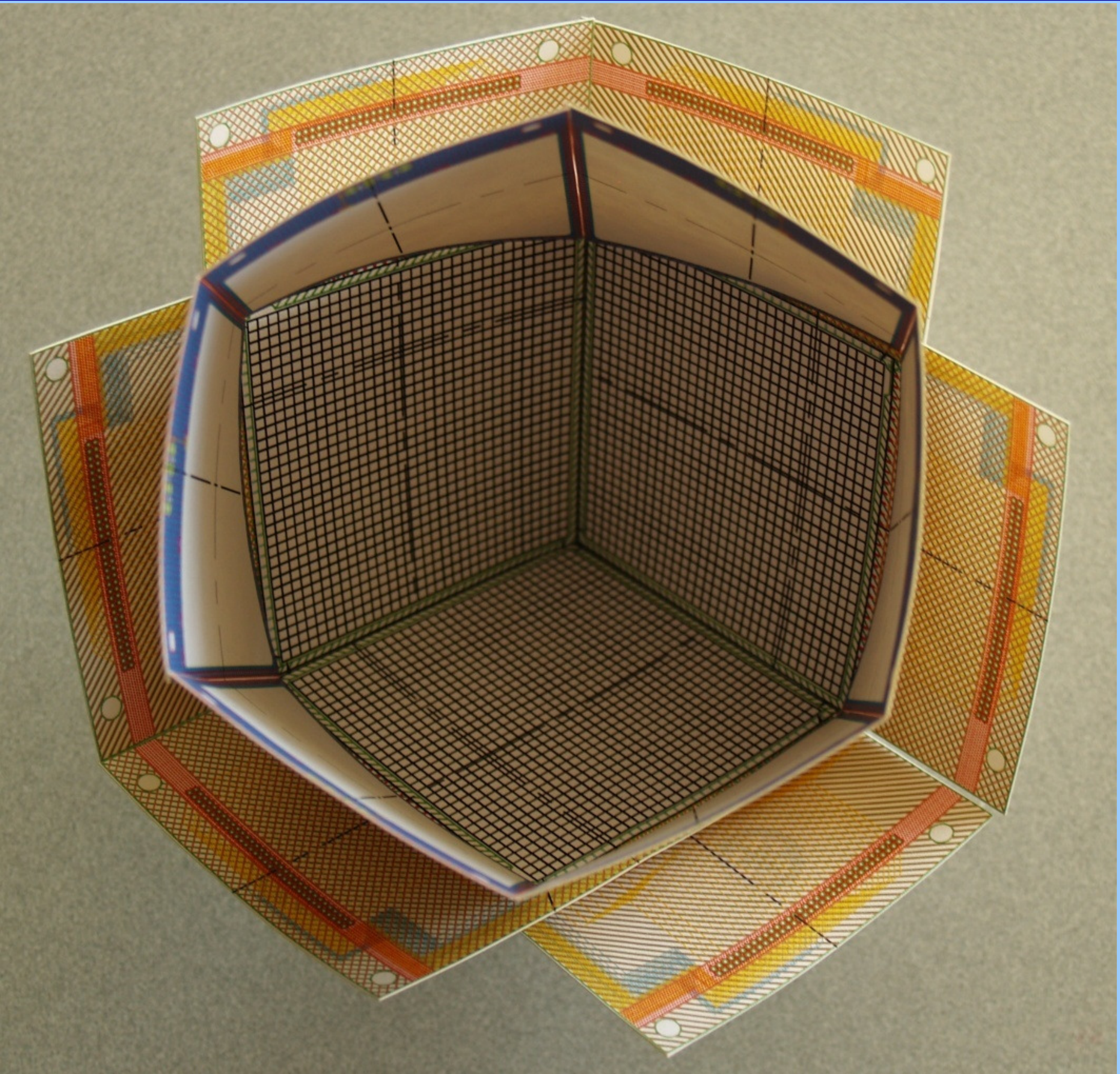
3D Assembly Drawings of Focal Plane SSSSDs



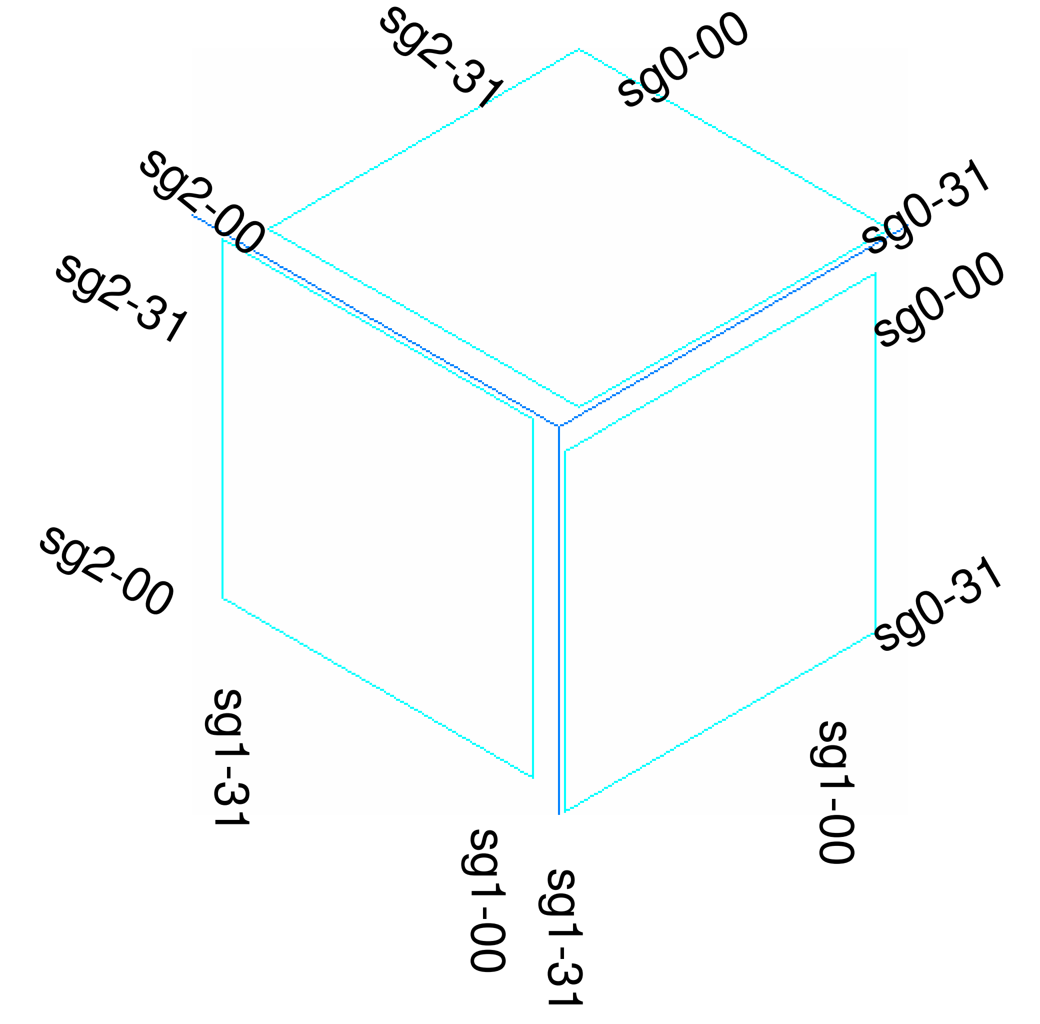


1 mm thick Si
4 strips with no position sensitivity
Mirror image configurations
Specially shaped to fit against Cube Corner

Another Paper Model



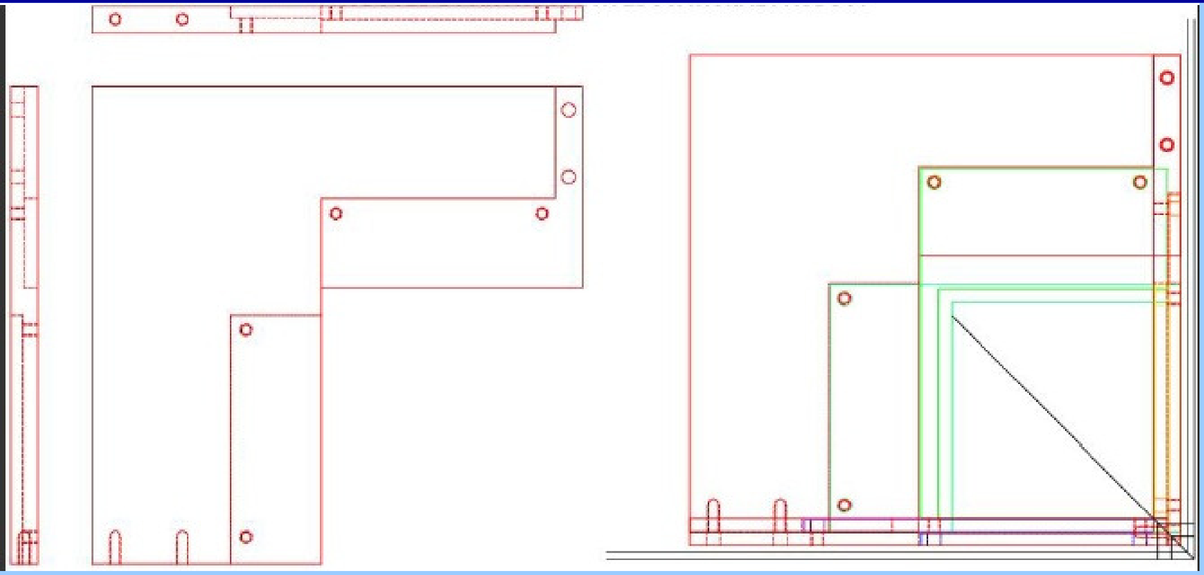
Strip Grouping in Focal Plane Array



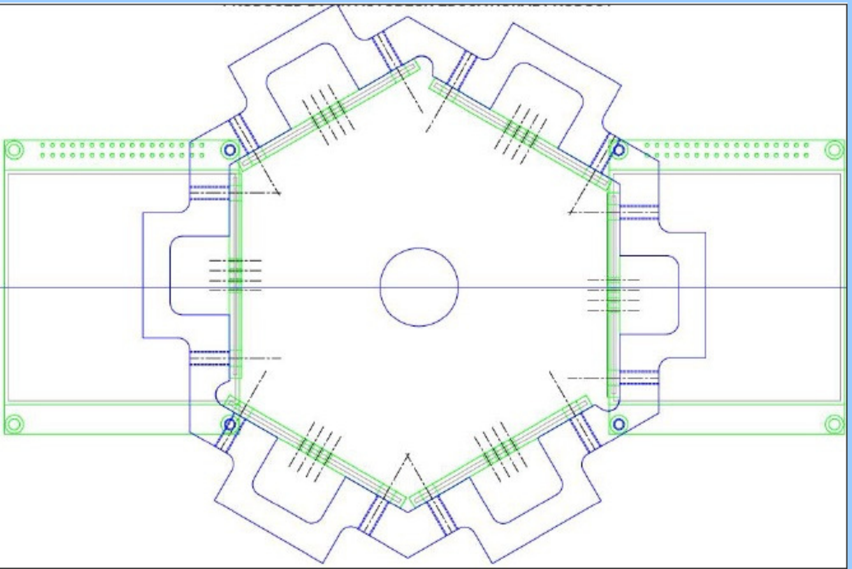
Signals are paired into three groups of 32 strips each.

Each event will have signals in two of the three strip groups. Provides unambiguous positions for 3072 pixels with a total of 96 signals.

Custom cabling solution from MESYTEC to eliminate “spaghetti” and improve gas purity inside BGS.

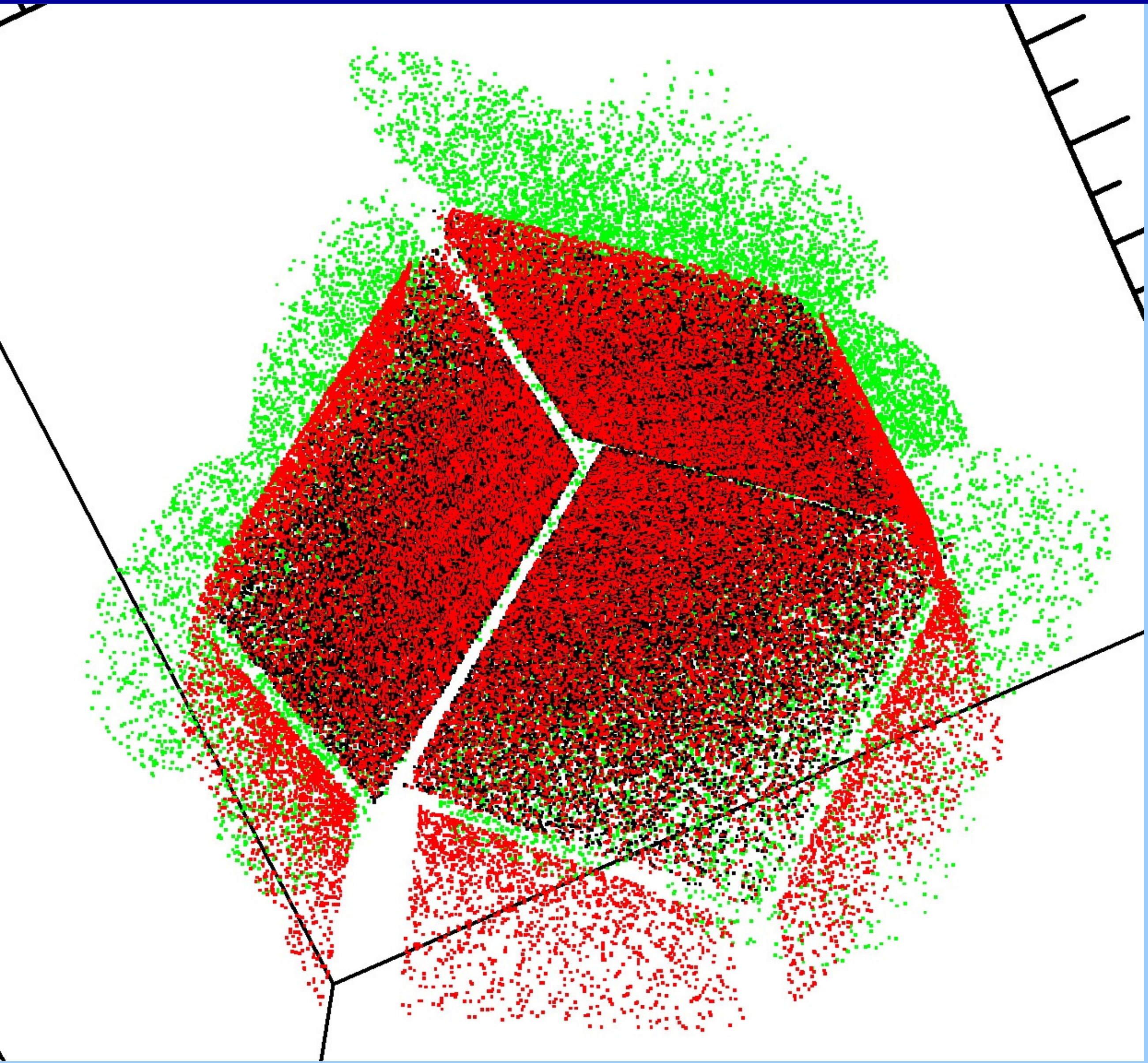


Focal plane and punchthru detector holder will be made from three identical pieces that bolt together to form the cube corner.



Upstream detector holder is a deformed hexagonal ring with capability to hold two of the Canberra 6cm x 6 cm PSDs as “wing” detectors to increase B ρ coverage.

Efficiency Simulation



Recoils eff = 87%

alphas eff = 92%

gamma solid angle = 50%
122 keV gammas eff = 30%
900 keV gammas eff = 7.5%

MESYTEC "Logarithmic" Preamplifiers and Two Amplifier Gain Ranges to Give Large Dynamic Range

6-10 MeV covers 12% of ADC range

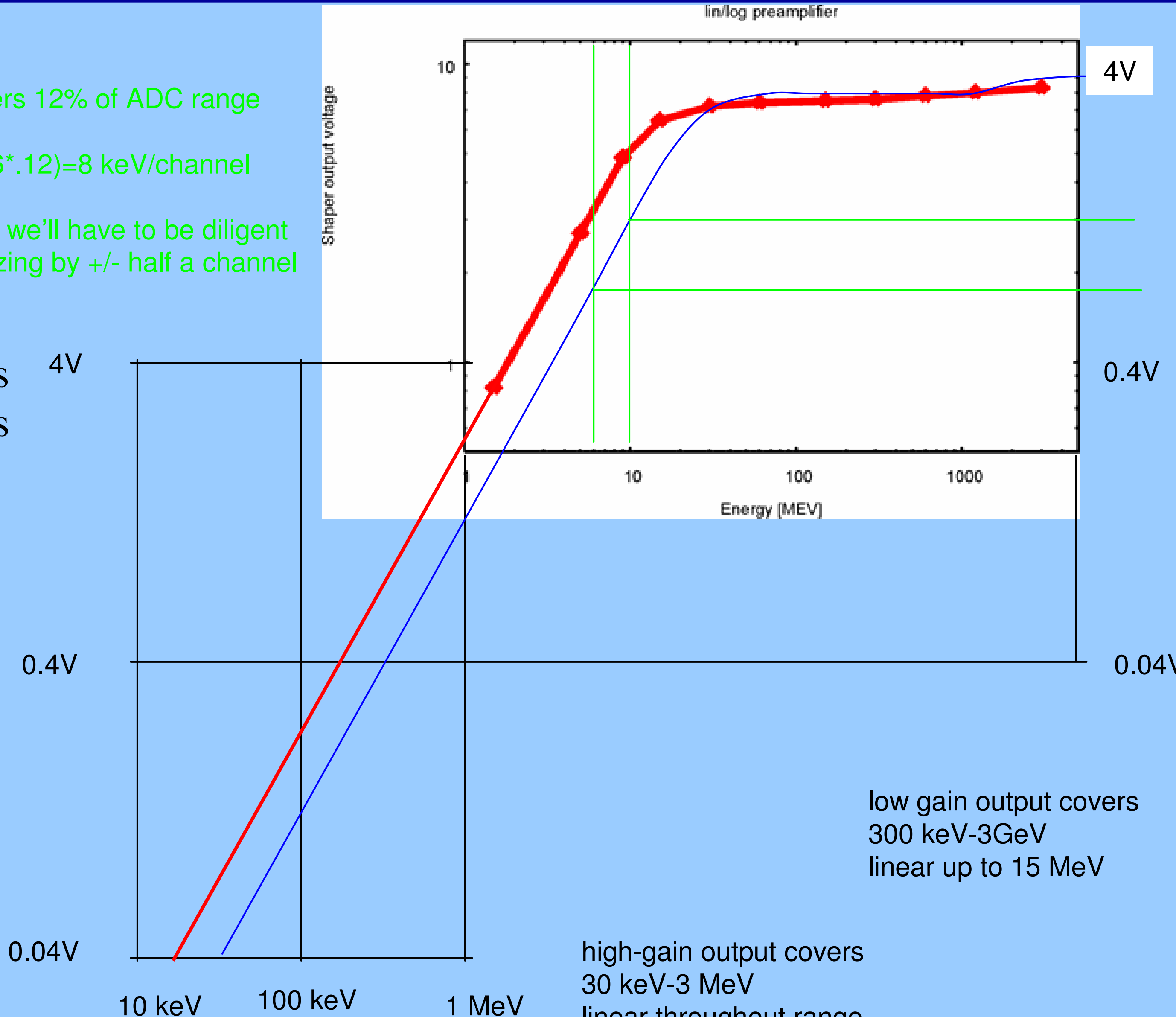
4000keV/(4096*.12)=8 keV/channel

This is OK, but we'll have to be diligent about randomizing by +/- half a channel

Analog DAQ:
Mesytec logarithmic PAs
CAEN N568B amplifiers
MSU 1806 CFDs
CAEN V785 ADCs
CAEN V775 TDC
SIS 3801, 3806 scalers

MBS software with home-baked f_user.c and f_mbs_anal.c

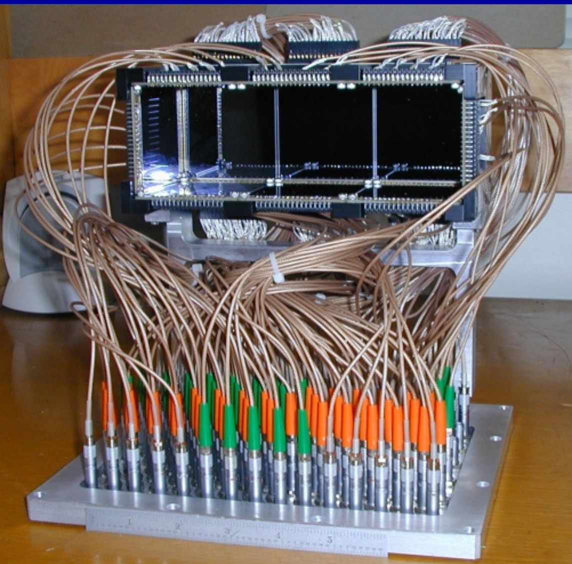
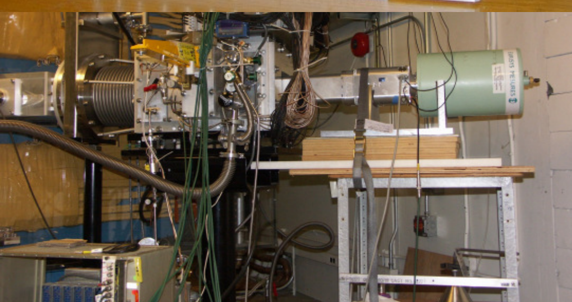
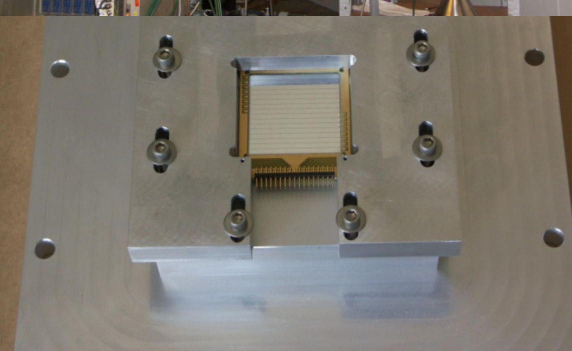
Minimum time between events ~ 14 µs



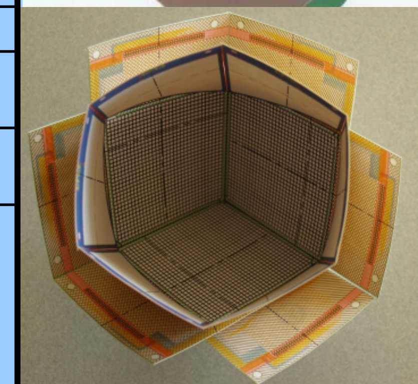
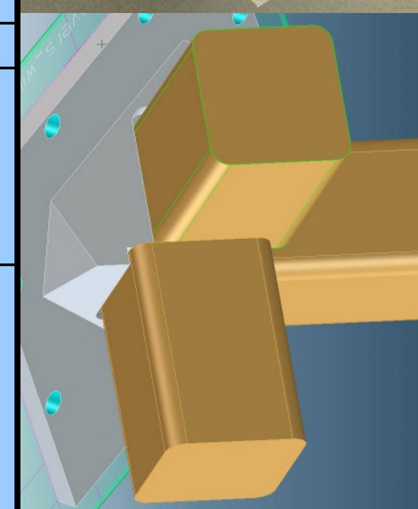
low gain output covers
300 keV-3GeV
linear up to 15 MeV

high-gain output covers
30 keV-3 MeV
linear throughout range

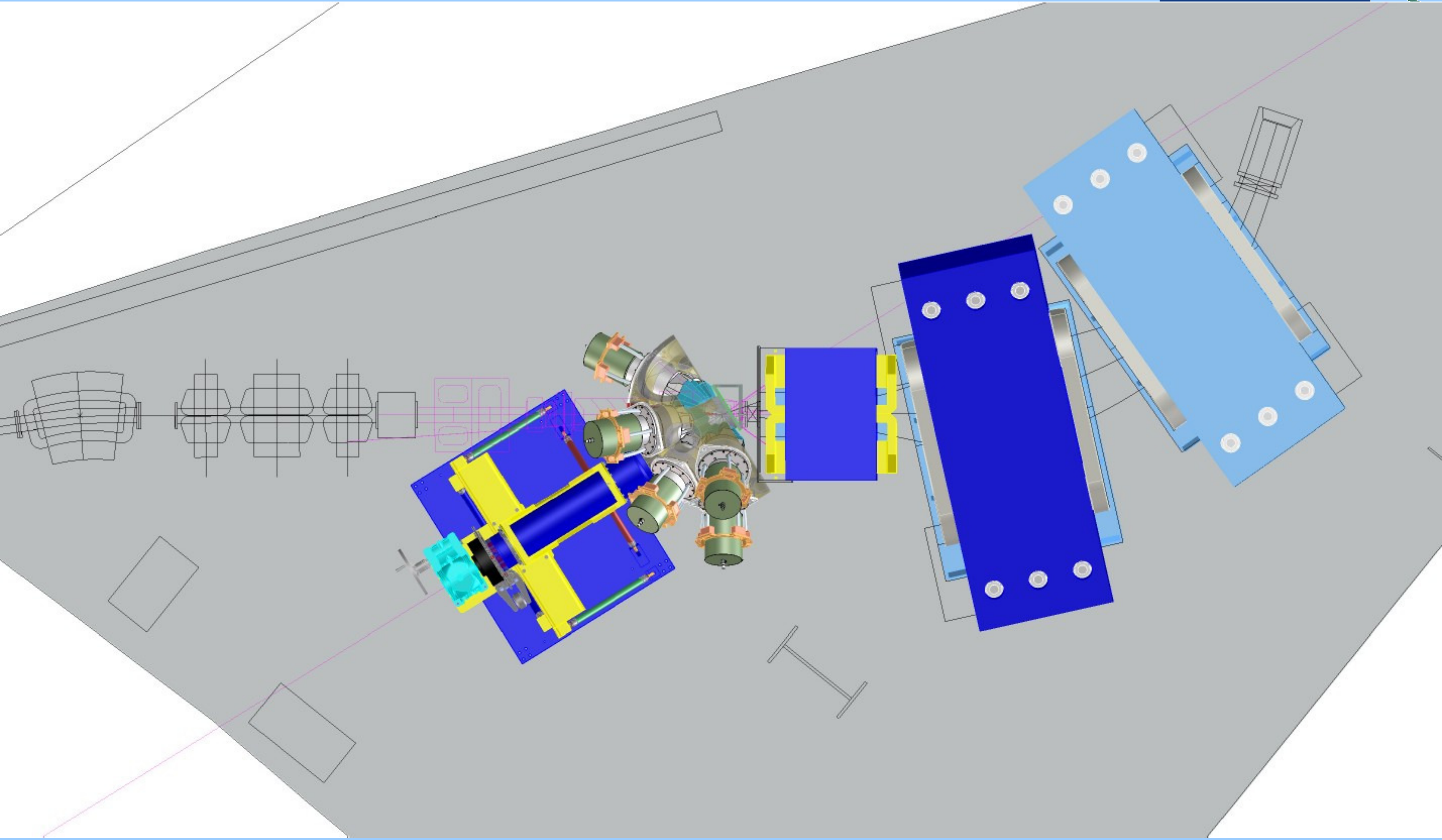
Efficiency gains with new DSSD configuration

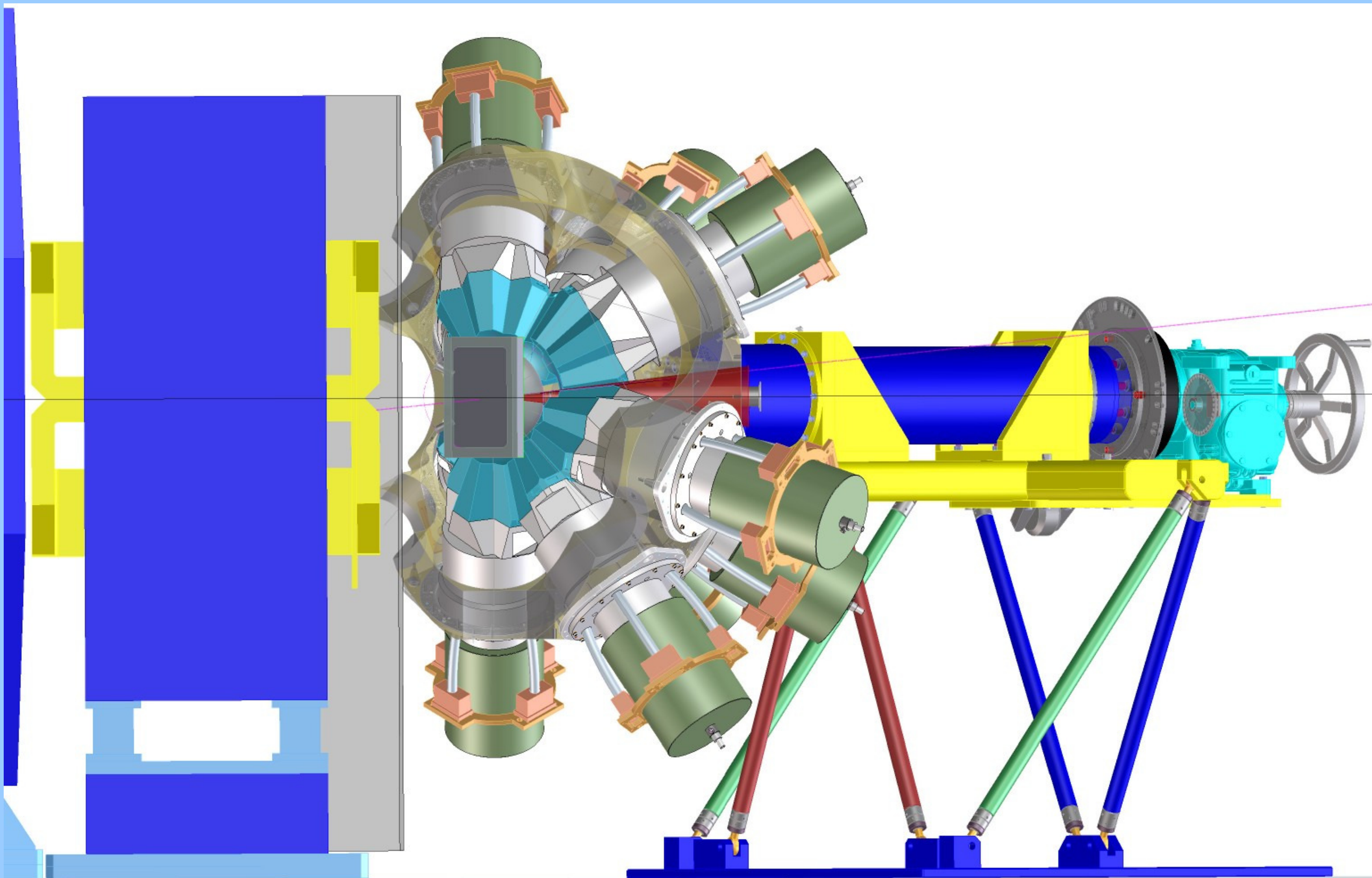
event type	eff. 1 DSSD 1 clover	C^3 eff. 3 DSSDs 3 clovers	eff. gain
recoil	35%	87%	2.48
α	50%	92%	1.84
122 keV Kx 900 keV γ	16% 4.0%	30% 7.5%	1.88
recoil-γ_{900}-α (K-isomer)	0.7%	6.0%	**8.6**
Recoil- α-Kx (SHE Z id.)	2.8%	24.%	**8.6**

GRETINA@BGS Experiment Campaign, Fall 2011



Side view of GRETINA@BGS



GRETINA@BGS Experiments

DAQ test with $^{24}Mg^{5+}$ + something, $^{48}Ca^{10+}$ + ^{206}Pb

$^{24}Mg^{5+}$ is co-resonant with $^{48}Ca^{12+}$ for fast switching

High statistics $^{48}Ca^{11+}$ + ^{208}Pb

up to 100 x statistics compared to expriments at ANL, JYFL

In-beam spectroscopy with ^{50}Ti + ^{208}Pb

. . .

Interesting collaboration model

Mass Analysis Detector Facility Layout

C^3 detector station

Trochoid separator

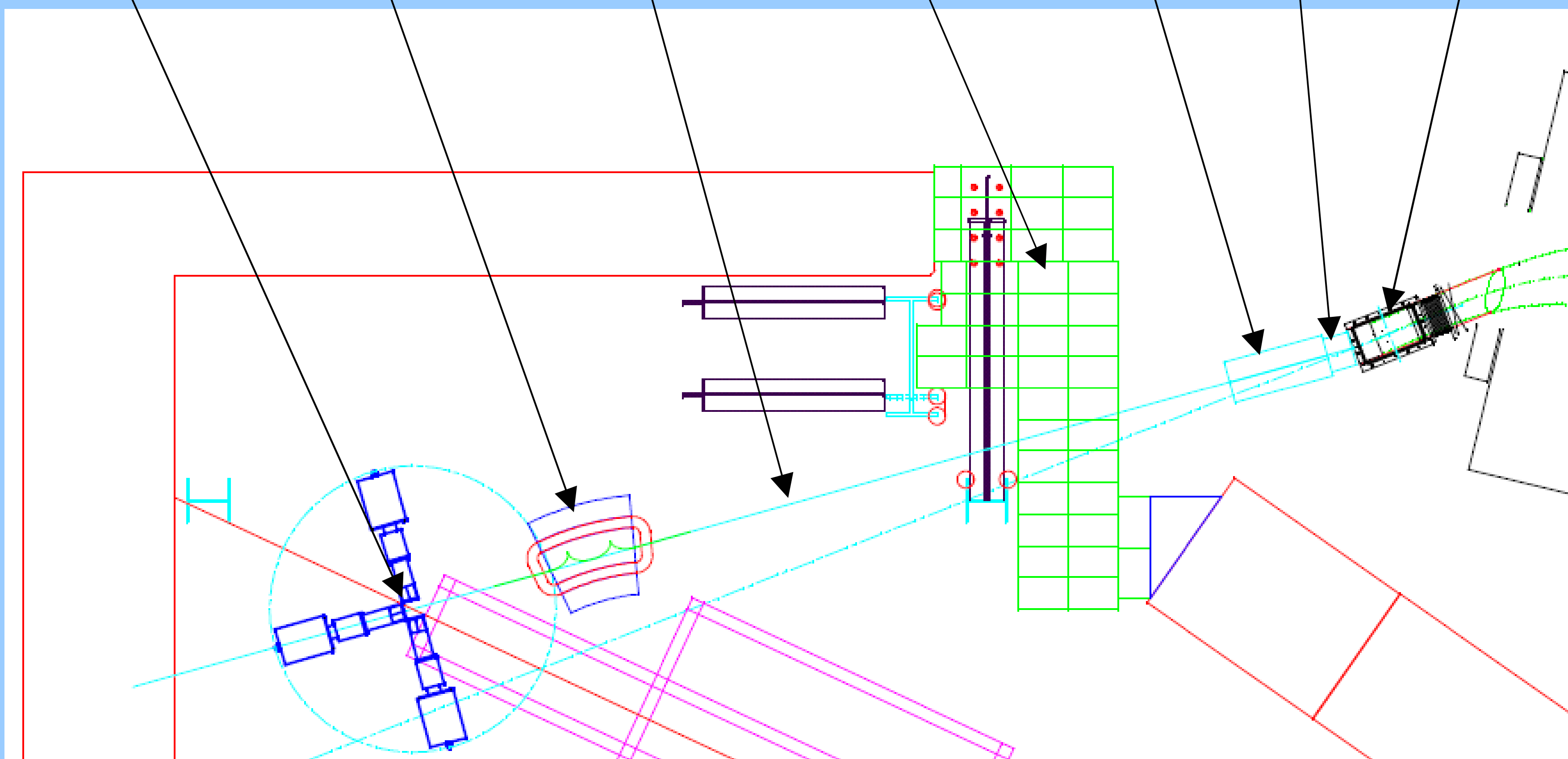
6^0 beamline

re-configured cave wall

RFQ trap

RF catcher

BGS det. box



MADF Headline Experiment

Simultaneous determination of SHE A and Z:

Produce SHE in reaction such as ^{244}Pu(^{48}Ca,3n)^{289}114

Isolate with Berkeley Gas-filled Separator

SHE ion passes through HAVAR window and stops in high-purity He (retains 1+ charge)

Focusing DC & RF field directs 1+ ion toward exit orifice, where it is carried by gas flow

Gas skimming and differential pumping results in “beam” of 1+ ions

1+ ions are trapped and cooled in RFQ trap

1+ ion is sent through trochiod mass analyzer for determination of A

1+ ion is stopped in C^3 detector system for measurement of α- γ coincidences

α-decay of odd-N SHE populates analog state in daughter.
Internal conversion of analog state γ-decay produces k X-ray

k X-ray of daughter is detected in coincidence with α-decay, providing Z identification

Mass separation and delivery to a low-background counting facility on a 10-ms timescale will enable a broad and enduring Nuclear Physics research program

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Some Examples:

Determination of single-particle states in heavy and superheavy element isotopes will refine models of nuclear structure (Macroscopic-Microscopic, Hartree-Fock-Bogoliubov, Relativistic-Mean-Field).

Identification of spontaneous fission (SF) activities in the actinides and transactinides will clean up many of the questionable Z and A assignments, providing a more solid foundation for understanding SF systematics.

Identification of fission fragments can provide information on neutron multiplicity, fission fragment nuclear structure, and spin distribution in SF.

α - γ coincidence measurements can be used to measure nuclear structure and nuclear shapes in the region between the N=152 and N=162 deformed nuclear shells.

X-ray – γ coincidence measurements can be used to study electron-capture decay, providing low-lying nuclear structure information in neutron-deficient nuclides throughout the upper half of the nuclear chart.

Electron-capture-delayed fission and electron-capture to states above the fission barrier can provide information on fission barriers, fission isomers, and continuum states.