# **MUST II:** large solid angle light charged particle telescope for studies with radioactive beams.

Experimental Set-up Associated to:
GANIL Experiments

EXL, R3B, HiSpec

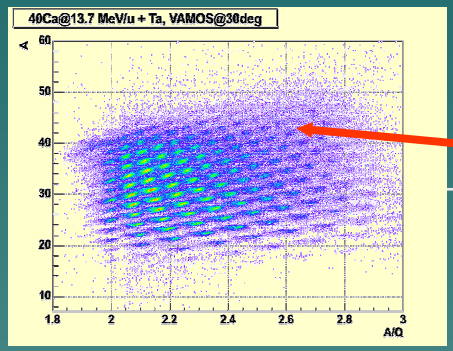
# WHO

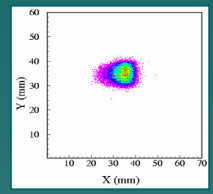

- E. Atkin[1a], F. Auger[1], P. Baron[1], J.P. Baronick[2], D Beaumel[2], Y. Blumenfeld[2], A. Boujrad[3], A. Drouart[1], P. Edelbruck[2], A. Gillibert[1] , F. Hammache[2], C. Houaner[3], L. Lavergne[2], L. Leterrier[2], L. Nalpas[1], L. Olivier[3], E. Pollacco[1], B. Raine[3], A. Richard[3], M. Rouger[1], P. Roussel-Chomaz[3], F. Saillant[3], M. Tripon[3], E. Wanlin[3]

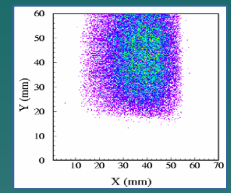
- [1]CEA Saclay, 91191Gif-sur-Yvette, France
  - ASIC R&D & Characterization & Software
- [2]IPN, IN2P3-CNRS, 91406 Orsay, France
  - Detectors & FEE
- [3]GANIL, Caen , France
  - ADC & Slow control & Software
- [a]MEPHI, Department of Electronics, Moscow, Russia

# Experimental Method: (p,d)

VAMOS/SPEG



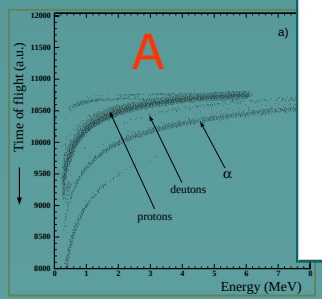



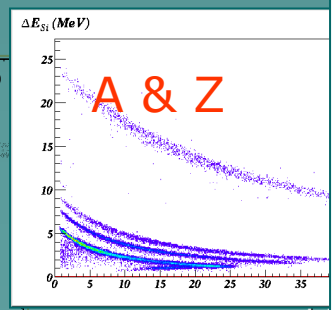

Proton target

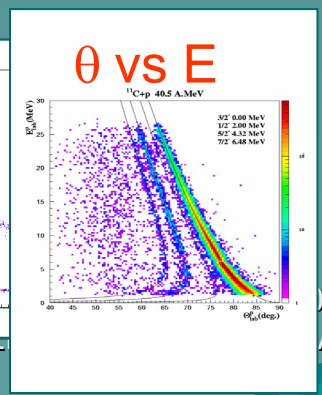
Radioactive beam

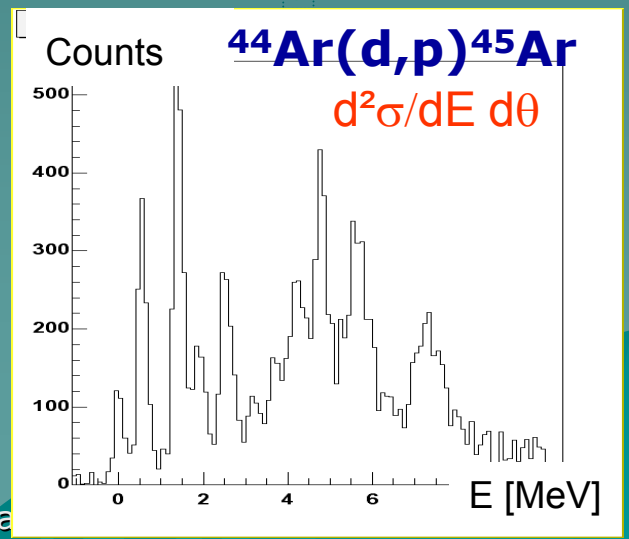
d'

MUST



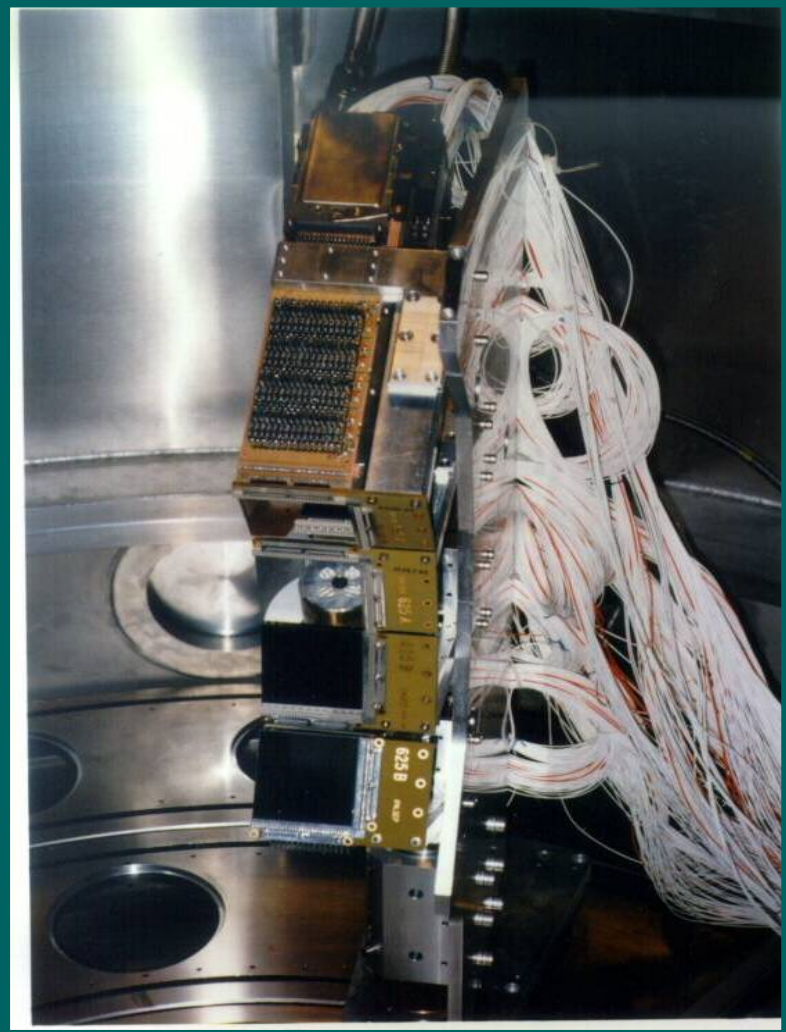




005
A Sacla

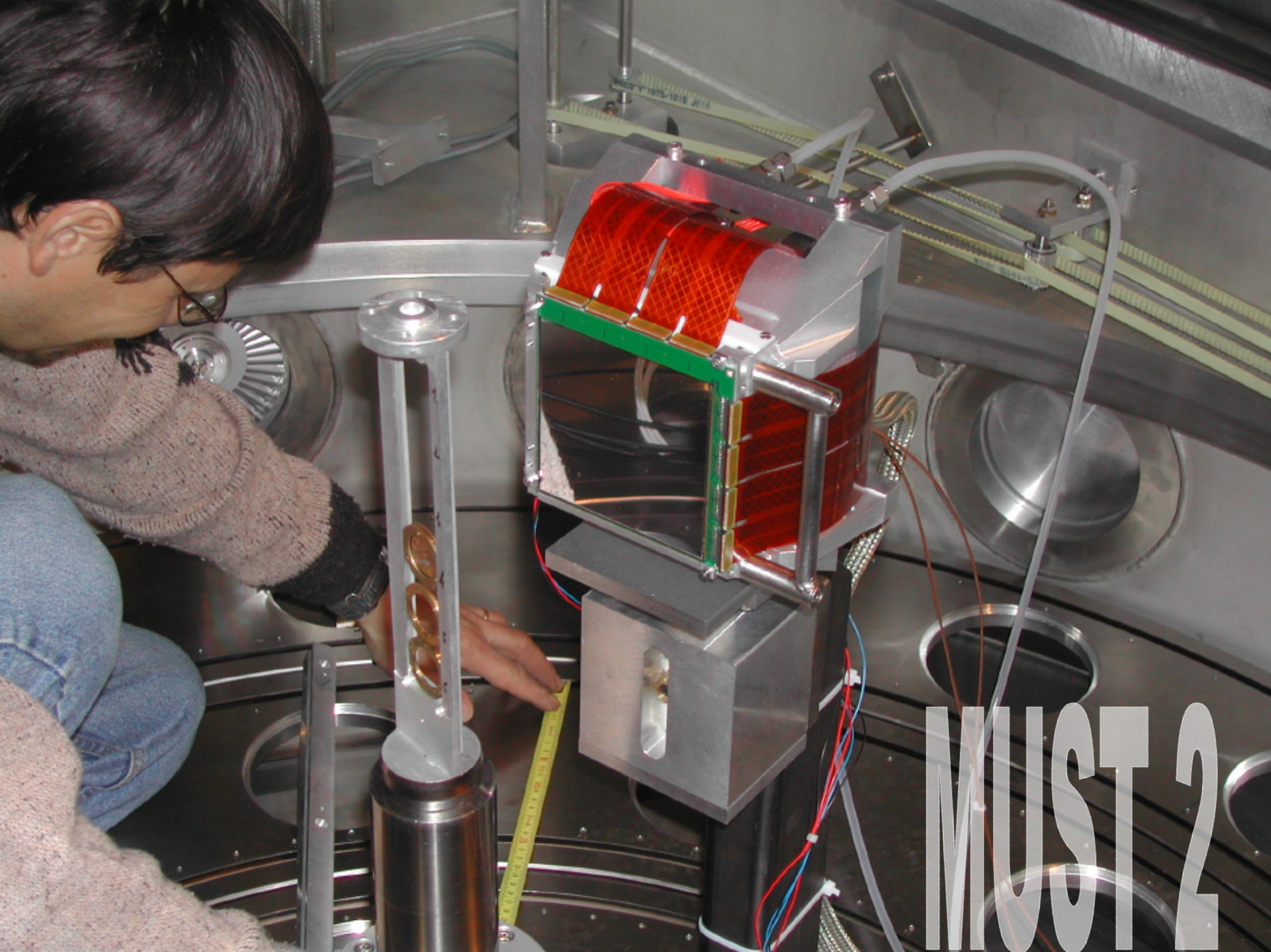
# MUST



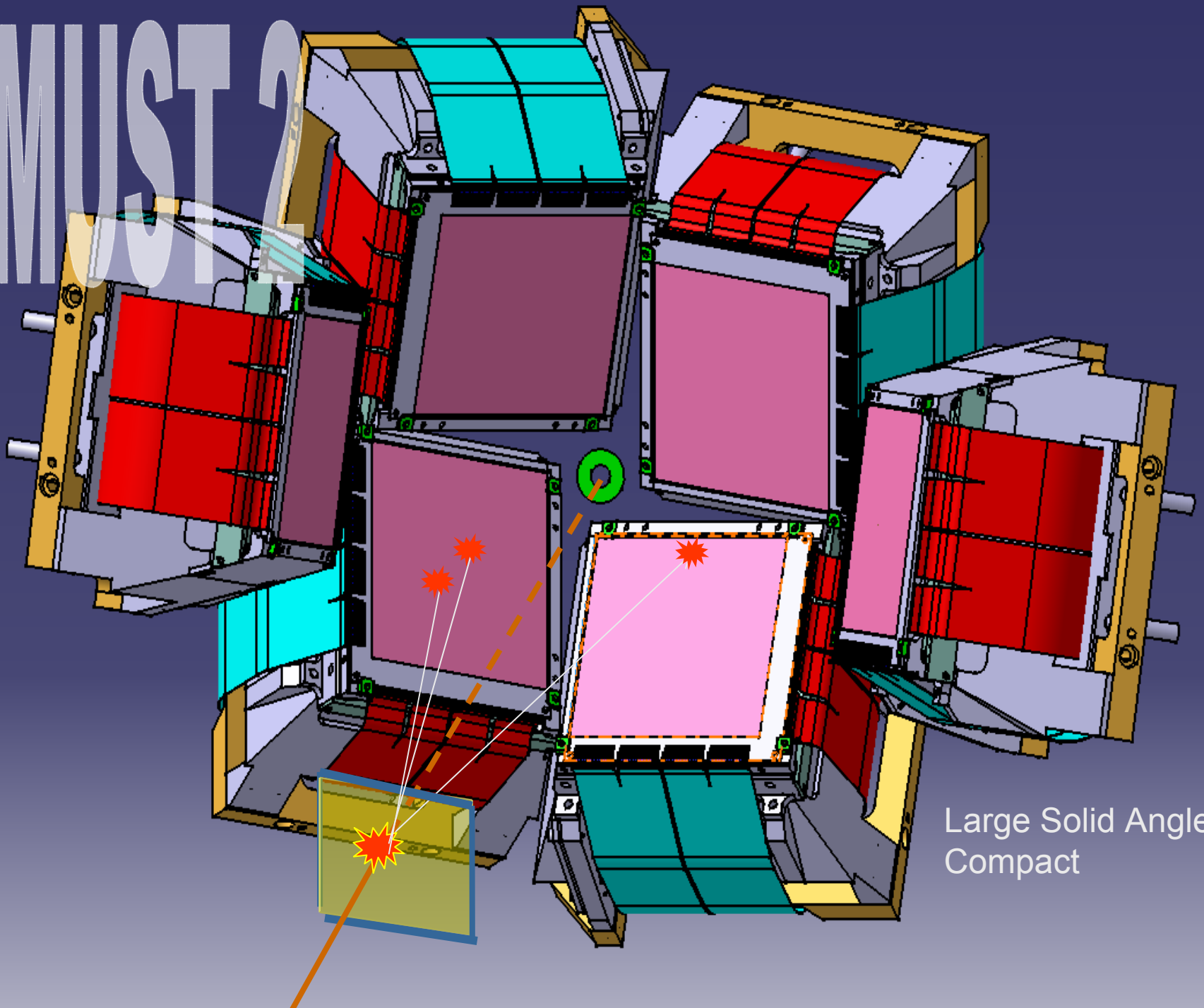
## MUST II

## NEEDS NOW

- Particle-Gamma
  - Volume occupation
- 1000 cm² at 15 cm
  - 4000 channels
- Portability
- ToF/Channel

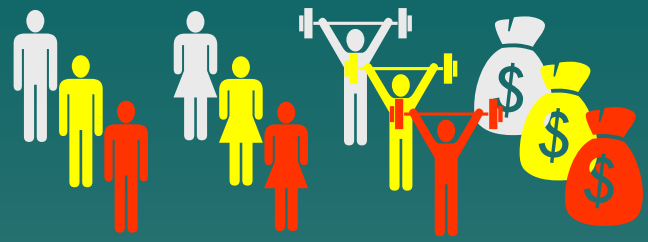

MUST 2

# MUST 2



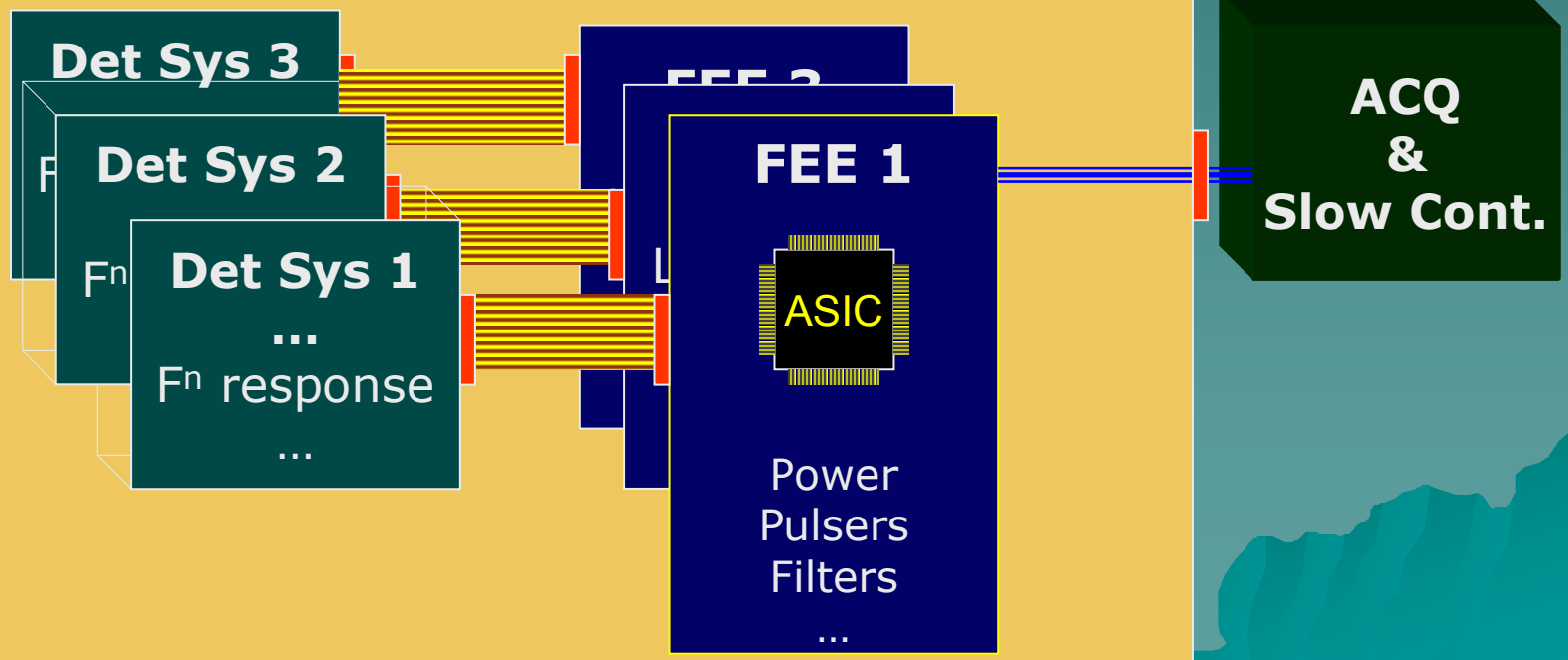
Large Solid Angle
Compact

**PHYSICS IDEA**
→ Resol$^{n}$
Dynamic range
Rate
…



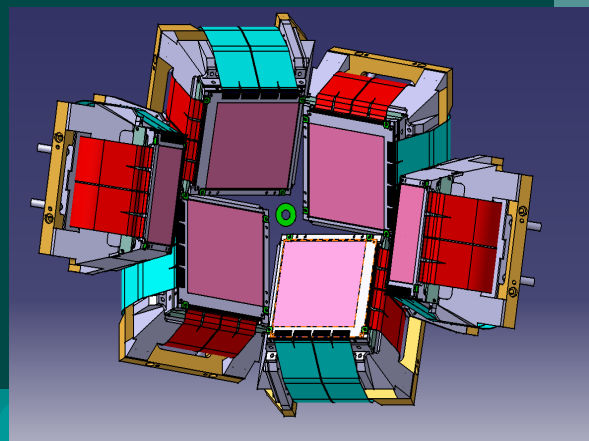
## Environment & System as a whole

Cooling/Vacuum/E-M Noise/Phonetics/magnetic fields /security/ …
Geometry & Space/Cables/Connectors/Mechanics …



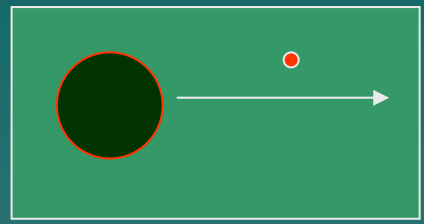
# Context & Specifications

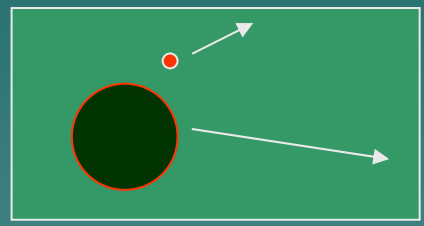
- Ensemble of Charged Particle (Z=1, 2) Spectroscopy Telescopes for Radio Active Beams studies.
  - Radio Active Beams
    - Low beam current ~ $10^3$ – $10^5$ pps
      - > Large solid angles ~ $\pi$
      - > Rates ~$10^3$ Hz at 10% dead time
    - Inverse Kinematics
      - > E = 0.4 – 200 MeV / A & Z resol$^n$.
      - > $dE/d\theta$ high
      - > Position resolution ~ 1mm²
  - Spectroscopy of light ions
    - $\Delta E/E$ ~ 20/50,000 ; 40/200,000
    - $\Delta M/M$ ~ 1/10, $\Delta Z/Z$ ~ 1/5
    - INL ~ 0.05%; DNL ~ 1%

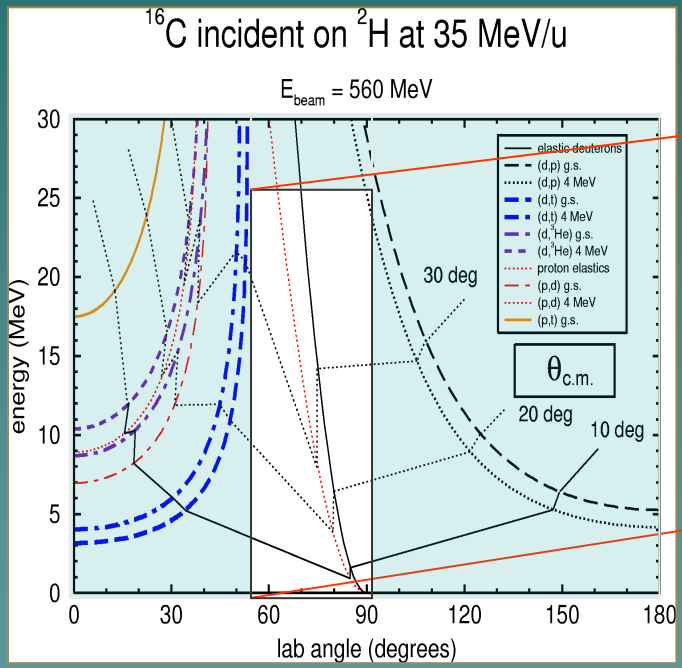


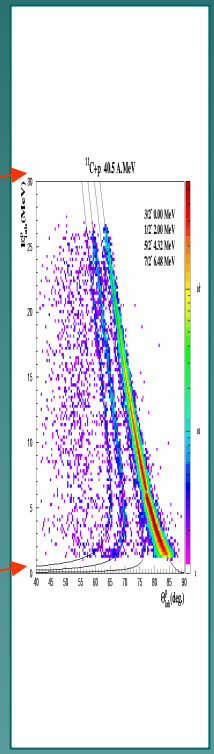
# Inverse Kinematics

## Exp. Method (p,p'), (d,p), (d,$^4$He) …







Low thresholds
Good resoln
- Angular
- Mass & Charge
- Energy

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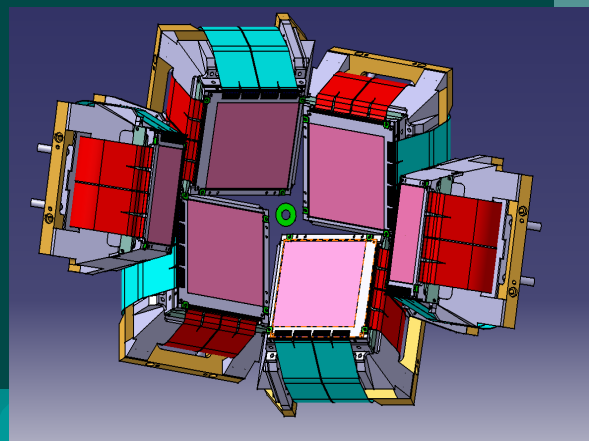


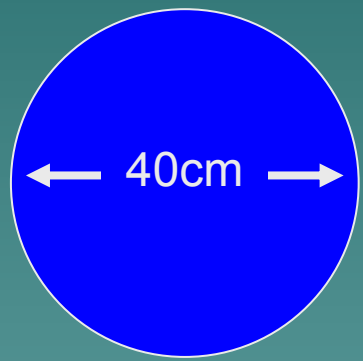
# Context & Specifications II

- Spectroscopy (cont.)
  - Stability over time ~ **20 KeV**
  - Particle-particle correlations

- Environmental/Geometry Conditions/Security
  - High noise levels
  - Vacuum ~ $10^{5\text{-}6}$ bar → Security Temp/Vacuum
  - Close proximity ~ $\phi$ = 40 cm
    → Small geometry ~ **1 liter**

- Constrains
  - Mounting & Dismounting frequent (6/year)

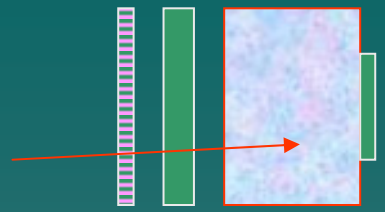
-  ~ 25MY & 1M€



# Context & Specifications III

- Slow control of parameters
  - Multi-Purpose
    - Gain & shaping & polarity (ie a bipolar system)
  - Multiplexing
  - Signal visualization
  - Pulser control
  - Measure of currents, temperature, …
  - …
- General Philosophy
  - "a trial" for the nuclear physics environment
    - Simple to implement
    - Simple to use
    - Reliable

# Adopted Solutions I

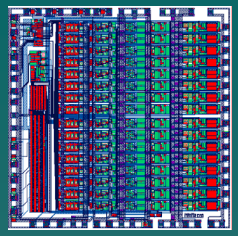


- {DE(DSSD) & TOF} . E (Si(Li)) . E(CsI)
  - Geometry
    - DSSD: 10x10cm², 300 µm, 128x128y strips
    - Si(Li): 2(5x10cm²), 5mm, 8 pads/each
    - CsI: 16 (2.5x2.5x2.5 $cm^3$)

  - Energy measure
  - Individual TOF measure
    - Electronics in proximity ~ 10 cm
    - Disc & TAC on each channel
  - Geometry & Cables & Rates
    - µ-electronics
    - 2 MHz sampling ADCs 14 bits & Time stamping/Telescope (No sparse read-out).

# Adopted Solutions II

- Environment - Vacuum
  - Ceramic encapsulation of μ-electronics
  - Water Cooling
  - Differential circuitry & insular power supplies
- Calibration & Stability
  - Four pulser functions/telescope
  - Rapid (~5 sec) & periodic stability logging
  - Temperature stabilization
- Easy mounting
  - "Plug & Play" implementation



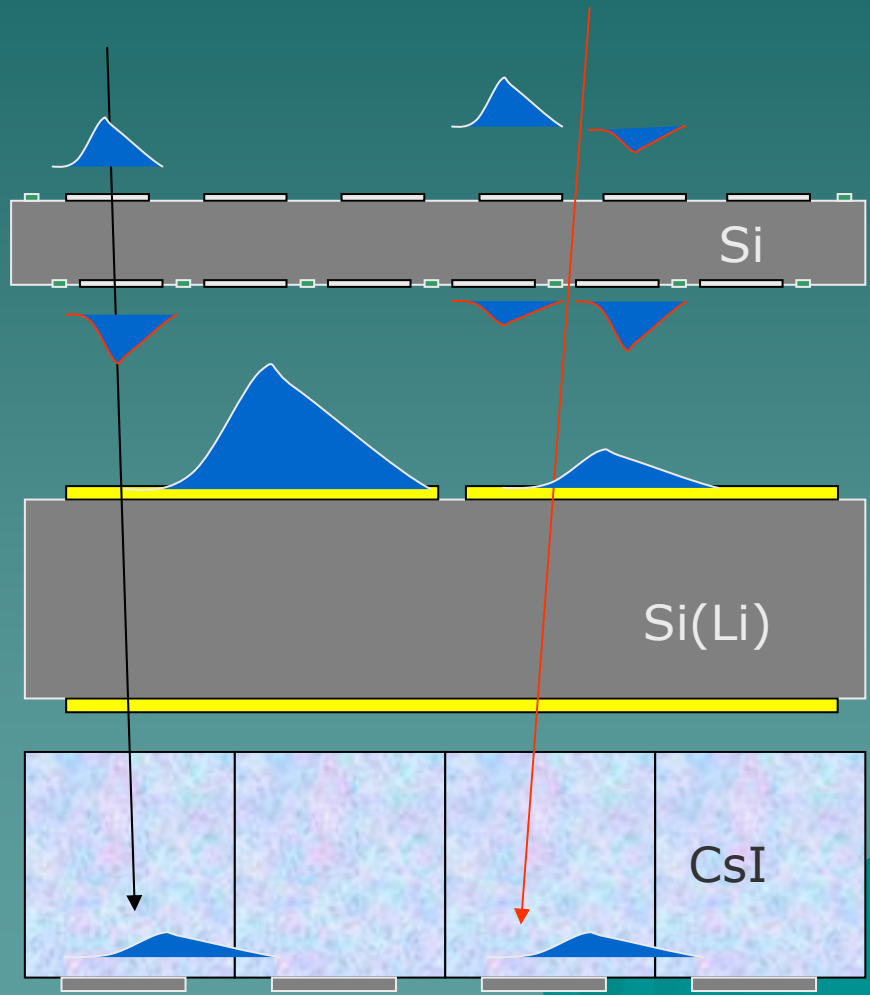
# MATE – a single ASIC

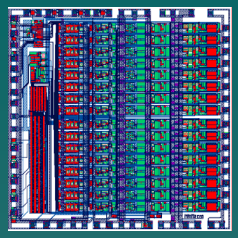
Bipolar

$E_x$, $-E_y$
0.2-50 MeV
$T_x$, $T_y$
300/600 nsec

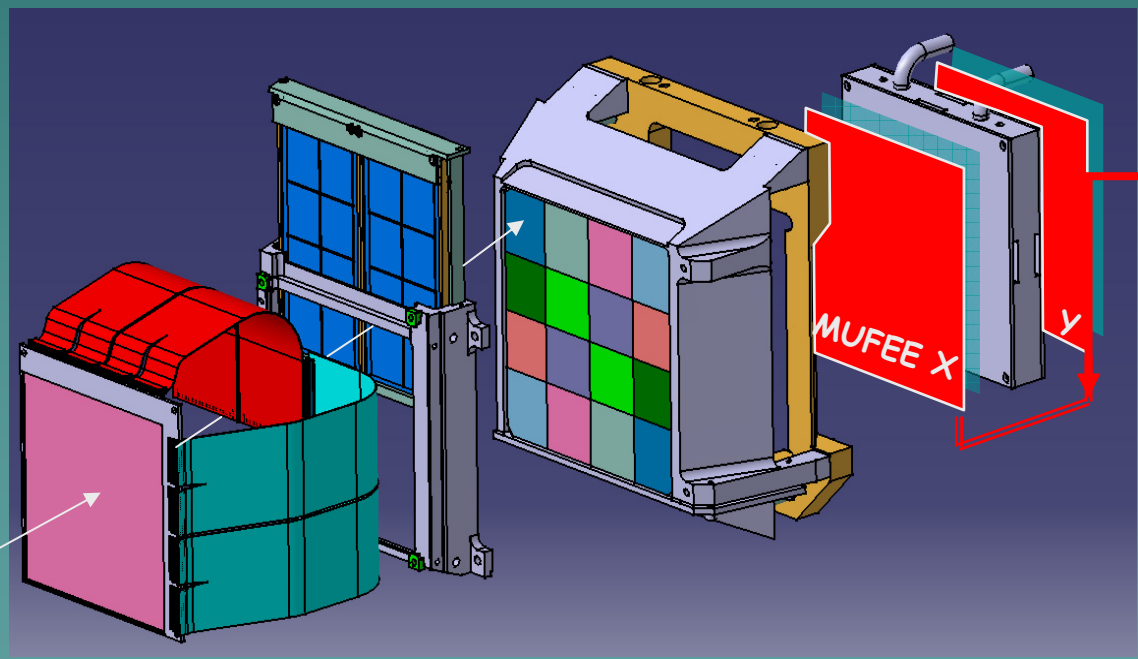
$E_{Si(Li)}$
0.2-200 MeV

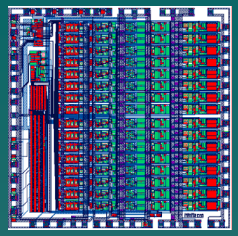
$E_{CsI}$
4-200 MeV

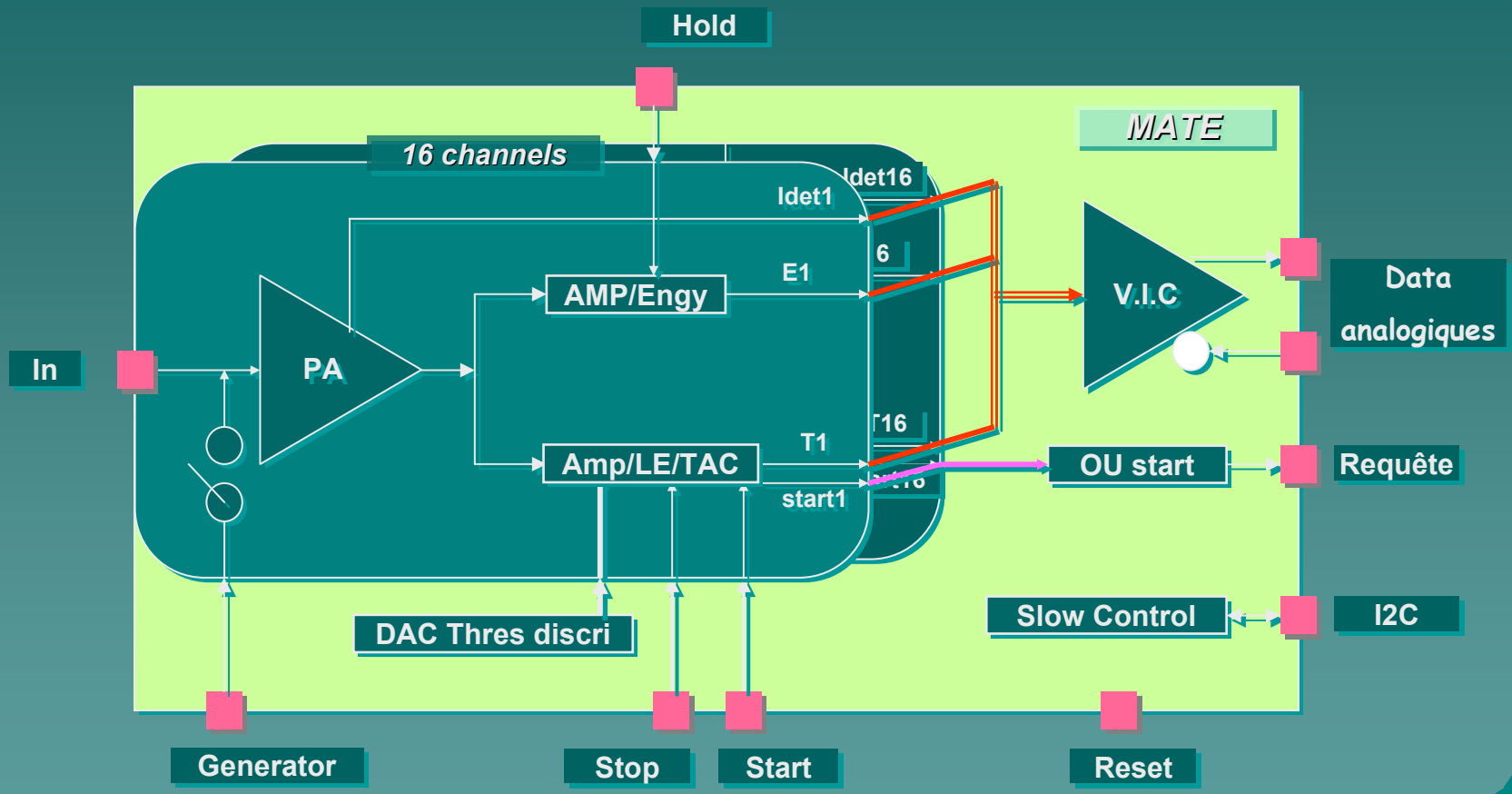




# ASIC based FEE
# &
# VXI for coding/slow control





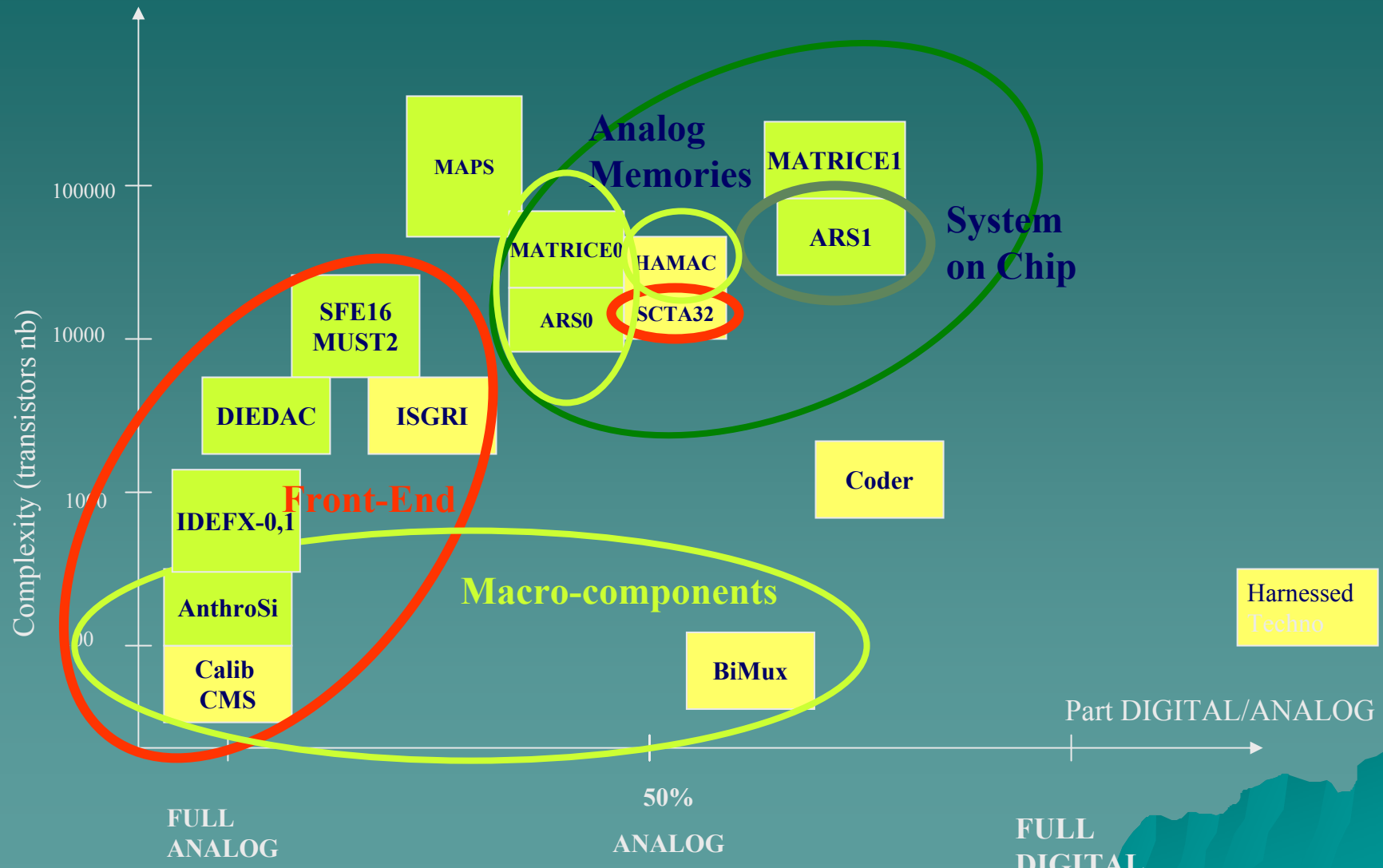

Hold
MATE
16 channels
Idet16
Idet1
E1
AMP/Engy
V.I.C
Data analogiques
In
PA
T1
Amp/LE/TAC
OU start
Requête
start1
DAC Thres discri
Slow Control
I2C
Generator
Stop
Start
Reset

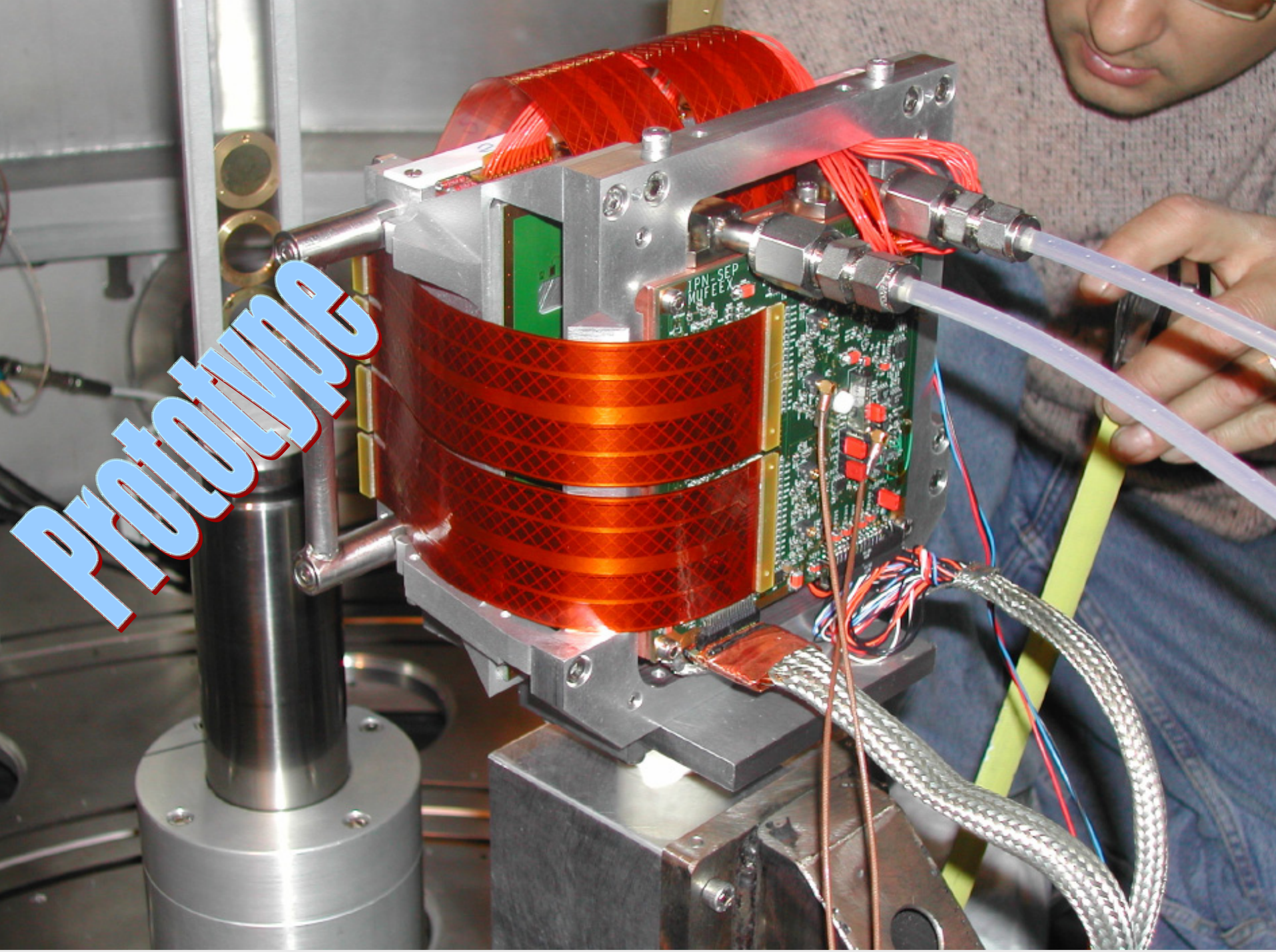
# Single ASIC Soln: Si, Si(Li) & CsI

So What is New ?
-In Nuclear Phys. Env.
-Multi purpose
-Dynamic Range
- Time & Energy

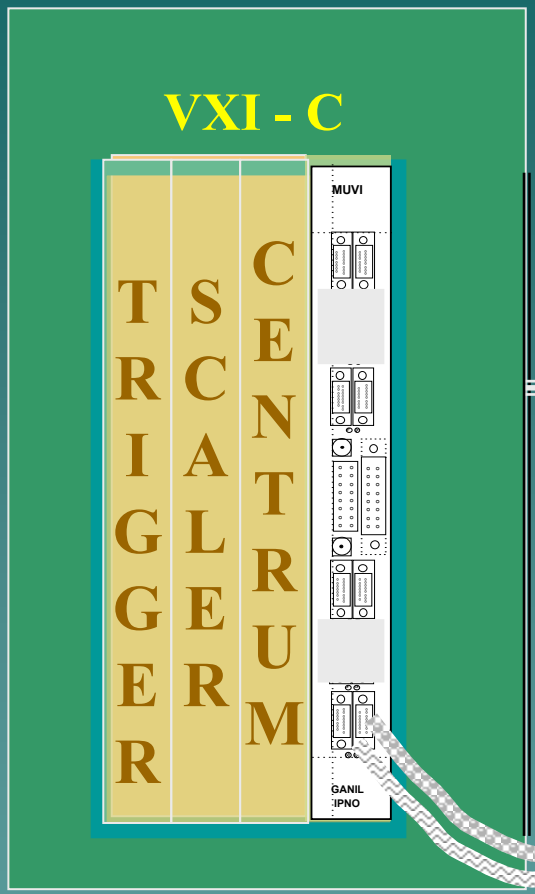
- Channels 16 (Fast & Slow)
  - Full Bipolar
  - Slow Control – I2C
  - Energy
    - 1μs/3μs RC-CR
    - 11,22,50, 100, 200,500,1000 MeV
    - 8 keV resoln. for 50 MeV
    - T/H
  - Time
    - Disc Leading Edge
    - TAC (300 or 600 nsec)
    - Common stop
    - 100 psec jitter
- Chip 36mm²
  - 16K transistors & 35mW/Ch
- Serial output 2 MHz

# Exemples of ASIC Realization



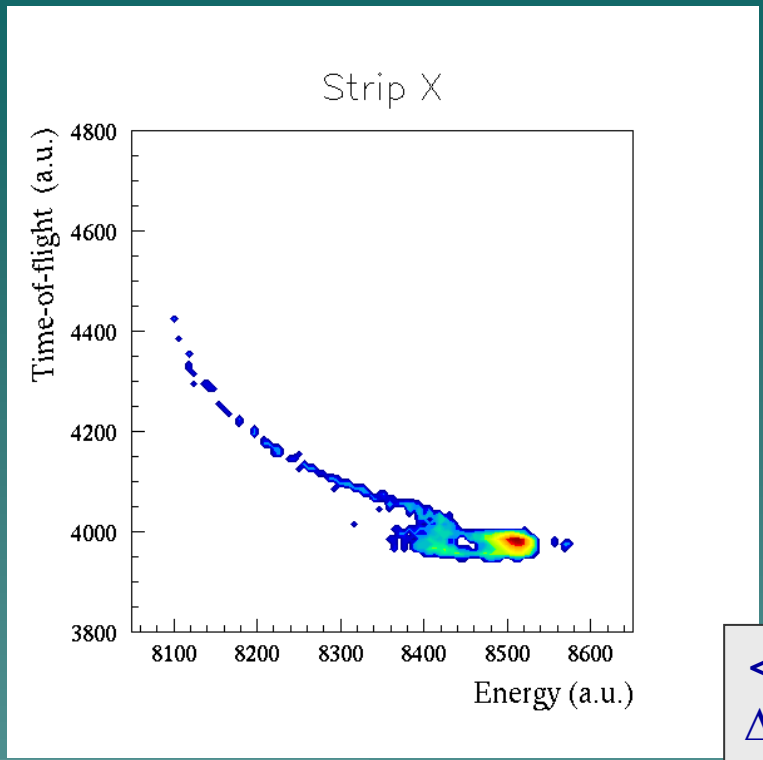

Prototype
IPN-SEP
MUFEEX

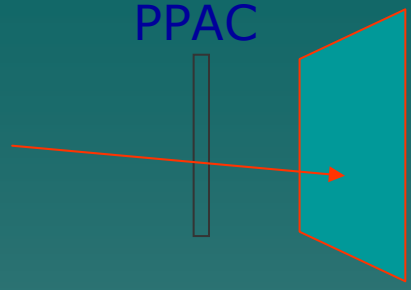
# Electronics Si+Si(Li)+CsI

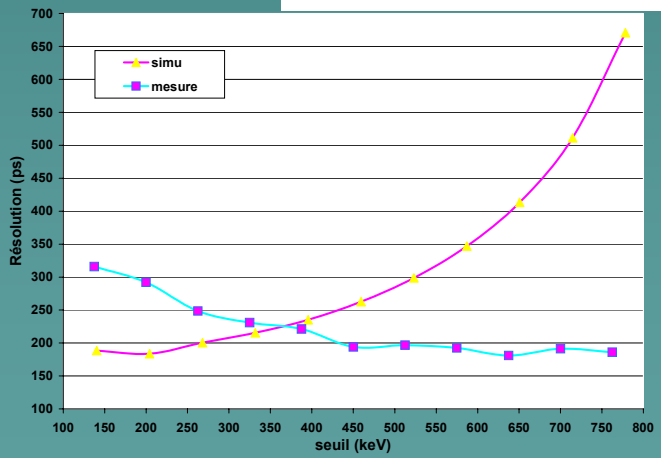



15 Wires

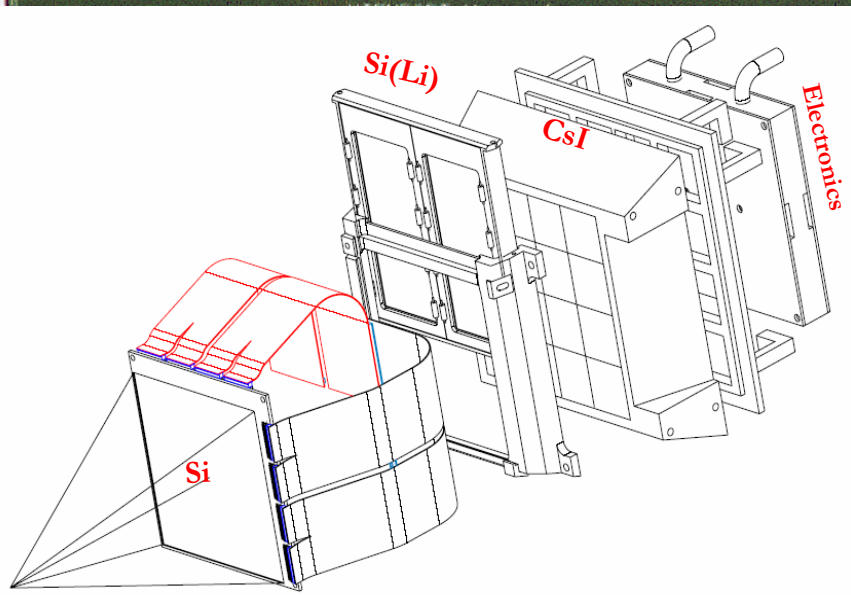
- TRIGGER - TRIGGER
  - Individual tel. Dead Time & Common
- Time-Stamp (CENTRUM – 100MHz)
- ADC's at 2MHz – 14bits
- Zero Suppression, Caibration … (DSP)
- On boards Pulsers – "Automatic Calibration" – 4 pulsers/telescope
- Plug & Play implementation

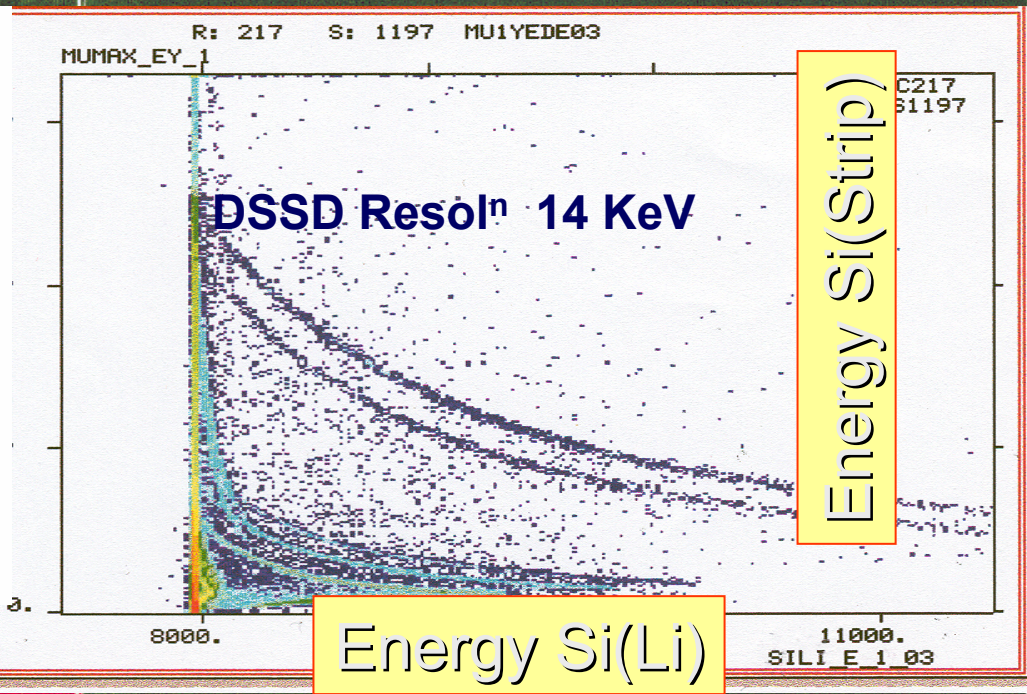


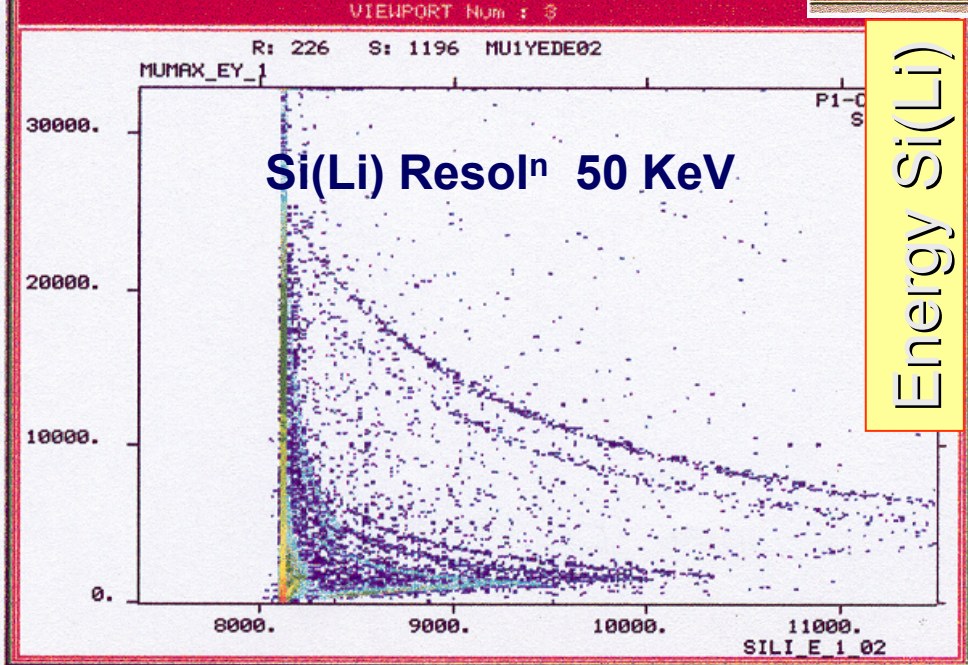



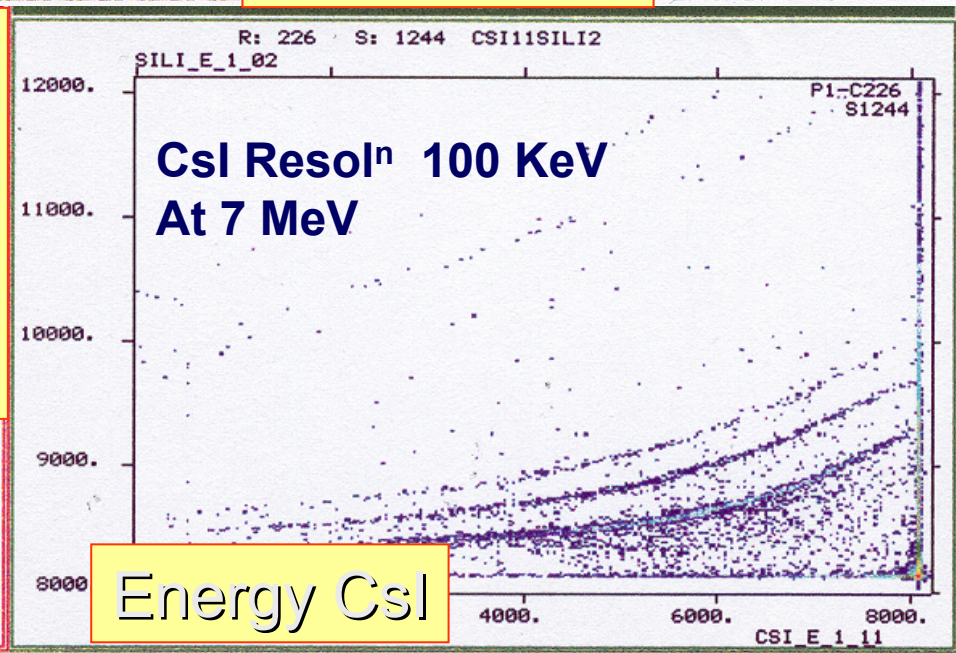

<200 psec FWHM
ΔA/A ~ 1/10  15cm & 4 MeV


Si(Li)
CsI
Electronics
Si

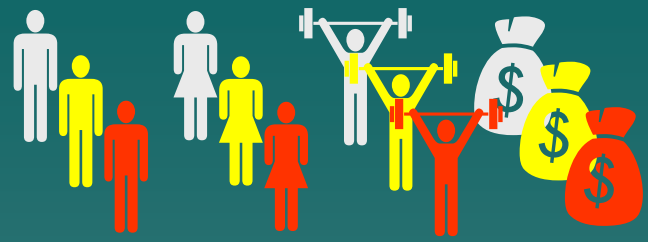

R: 217 S: 1197 MU1YEDE03
MUMAX_EY_1
DSSD Resoln 14 KeV
Energy Si(Strip)
Energy Si(Li)
8000.
11000.
SILI_E_1_03


VIEWPORT Num : 3
R: 226 S: 1196 MU1YEDE02
MUMAX_EY_1
Si(Li) Resoln 50 KeV
30000.
20000.
10000.
0.
8000.
9000.
10000.
11000.
SILI_E_1_02

Energy Si(Li)


R: 226 S: 1244 CSI11SILI2
SILI_E_1_02
CsI Resoln 100 KeV
At 7 MeV
Energy CsI
12000.
11000.
10000.
9000.
8000
4000.
6000.
8000.
CSI_E_1_11

**PHYSICS IDEA**
→ Resol$^{n}$
Dynamic range
Rate
…



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