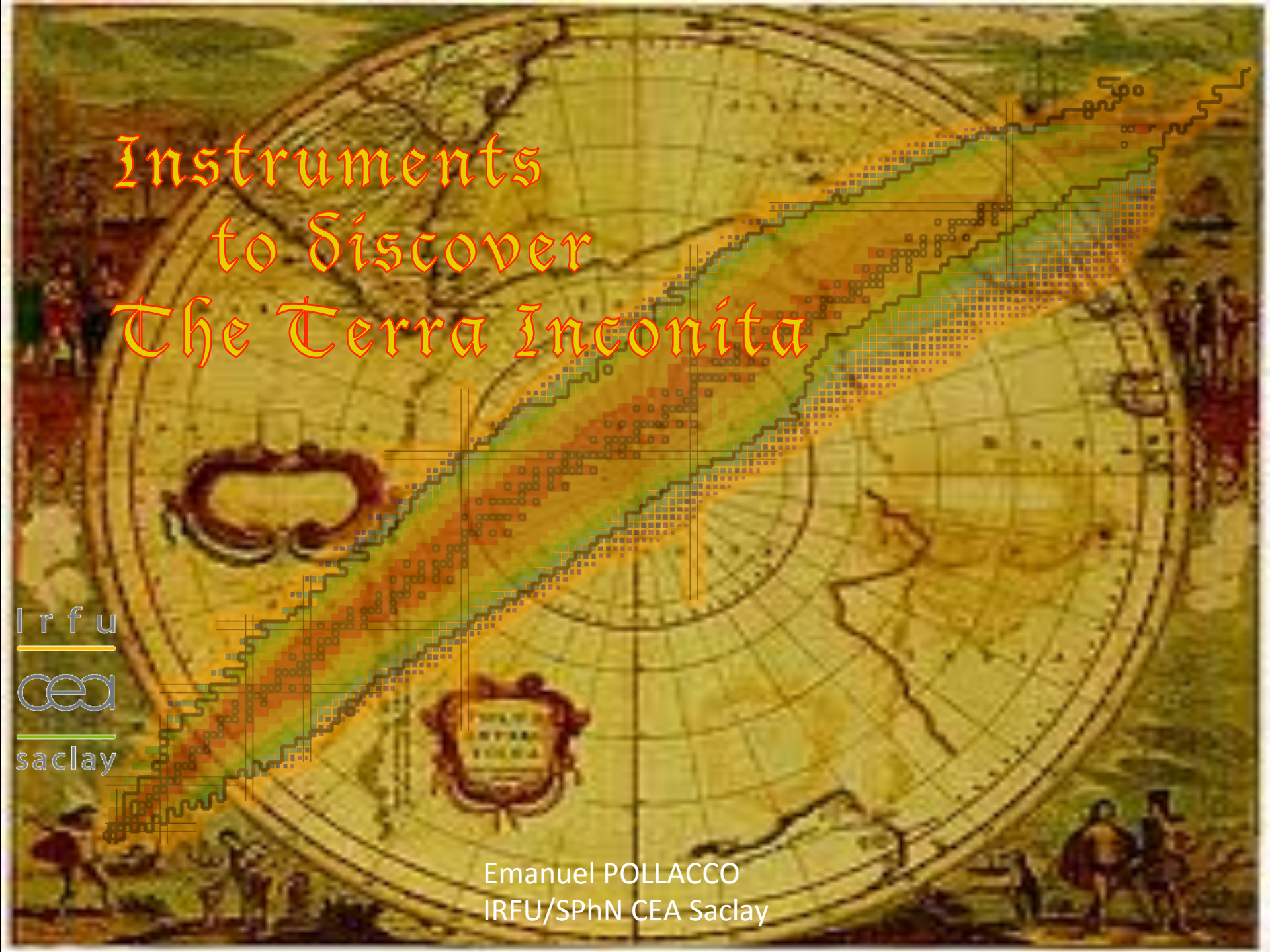


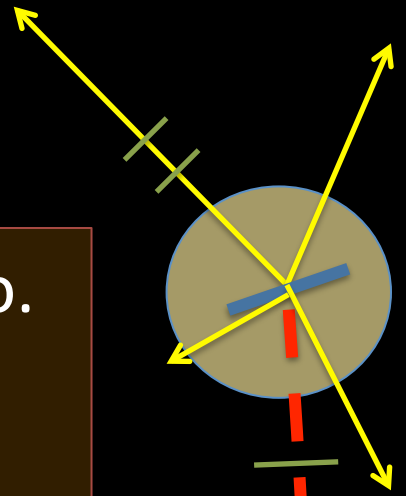
Emanuel POLLACCO
IRFU/SPhN CEA Saclay

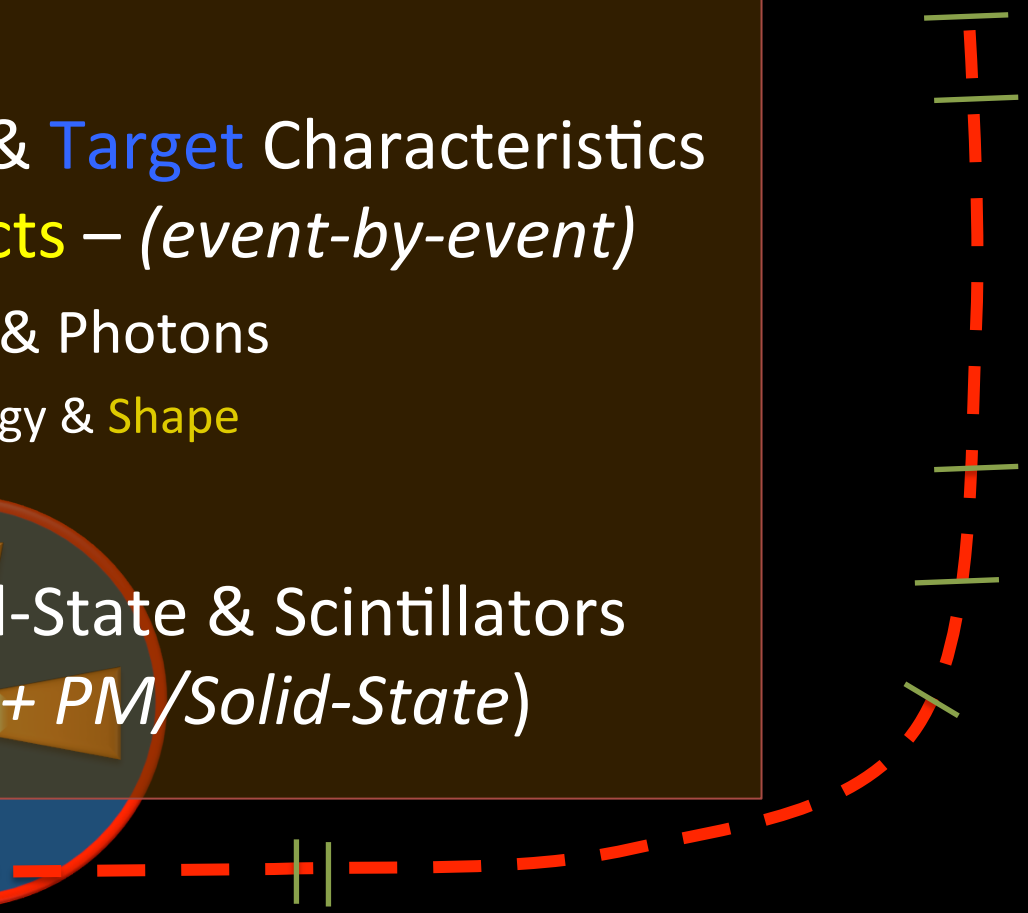
Nuclear Physic Experiments

- Systems Small & Big
  - small Experimental/Test Systems
  - BIG Granular Detectors – many channels:-
    - Beam Tracking, 4π Telescopes, Gamma Spectro, Magnetic-Spectro, Time-Projection-Chambers …
- Most experimental have combined set-ups
  - Diverse Experimental Team
  - Diverse Exp Conditions within an experiment
  - Short set-up times ➔ … 3-5 Week
- Most experiments have/need simulations
  - G4 for Low Beam energies
  - To understand the Instrument Filter
  - For Resources, for PAC, for Publications see Posters
- Limited (Eng. and Y, €, $,) …Resources

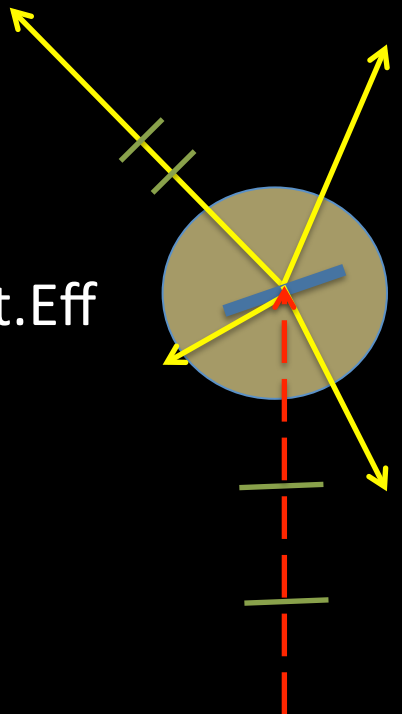
Nucl. Phys. Experiments

- Object: Study of Nucl. Reactions & Spectro. with stable & radioactive beams.
- Measures of Beam & Target Characteristics & Reaction Products – *(event-by-event)*
  - Measure:- Particles & Photons
    - Time, Position, Energy & Shape
- Medium:- Gas, Solid-State & Scintillators (*gas, liquid & solids + PM/Solid-State*)





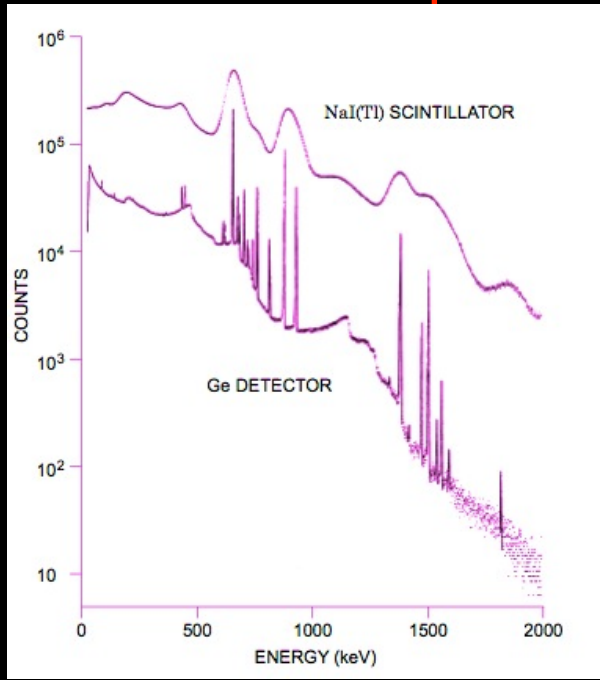
Electronic for Nucl. Phys.



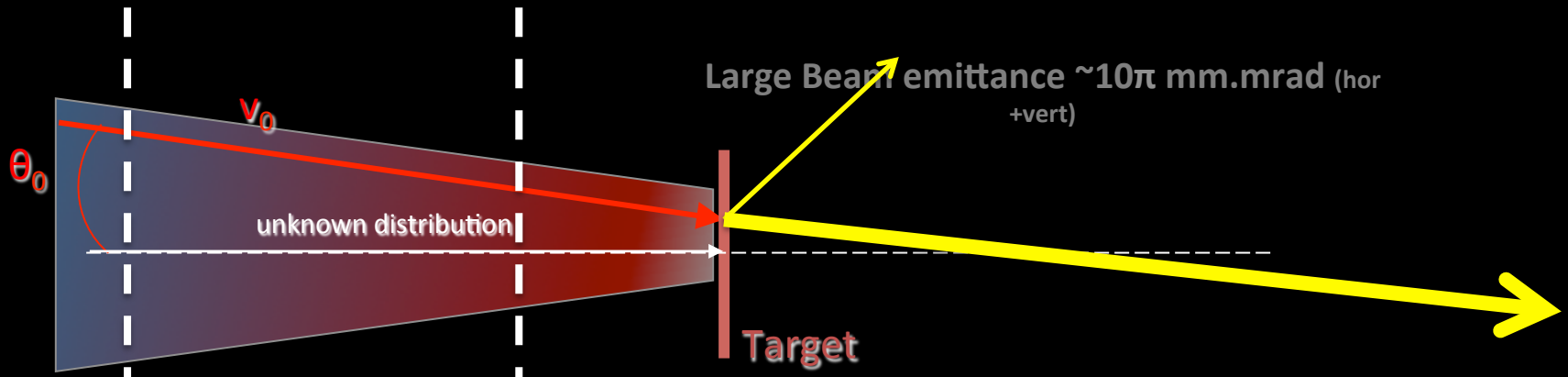
Yield = **X-section** X Target X Beam X Live-Time X Det.Eff

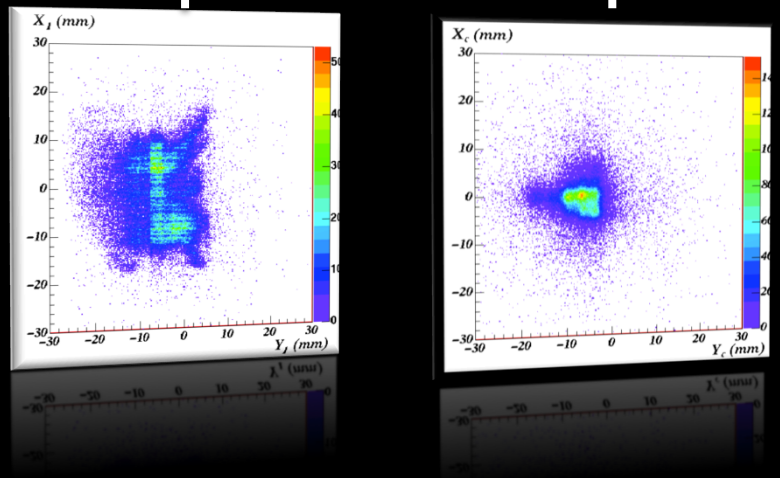
- Det Characteristics/Geometry ➔ Eff
- Det + Electronics Resoln (Beam & Ejectiles)
  - Δenergy, Δposition, Δtime & Δshape

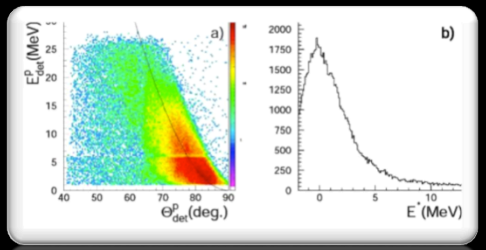
  ➔ Rel. high Resoln E, M, Z, (X,Y) ➔ X-Section
- Acquisition speed – Live-Time
  - Fast Detectors
  - A Intelligent Trigger/100% live -time systems
  - Fast ADC
  - Fast Data Reduction
  - Resourceful System Architecture
- Target – Compromise: Yield & Resoln & Background

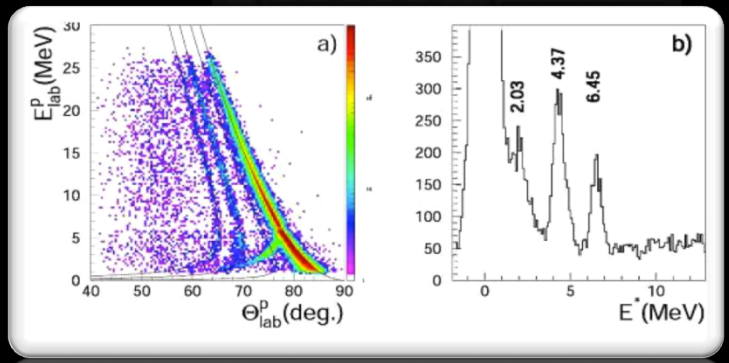


RA beams – NSCL, GSI, GANIL, RIKEN, …
need tracking in most physics (Vertex & Time)





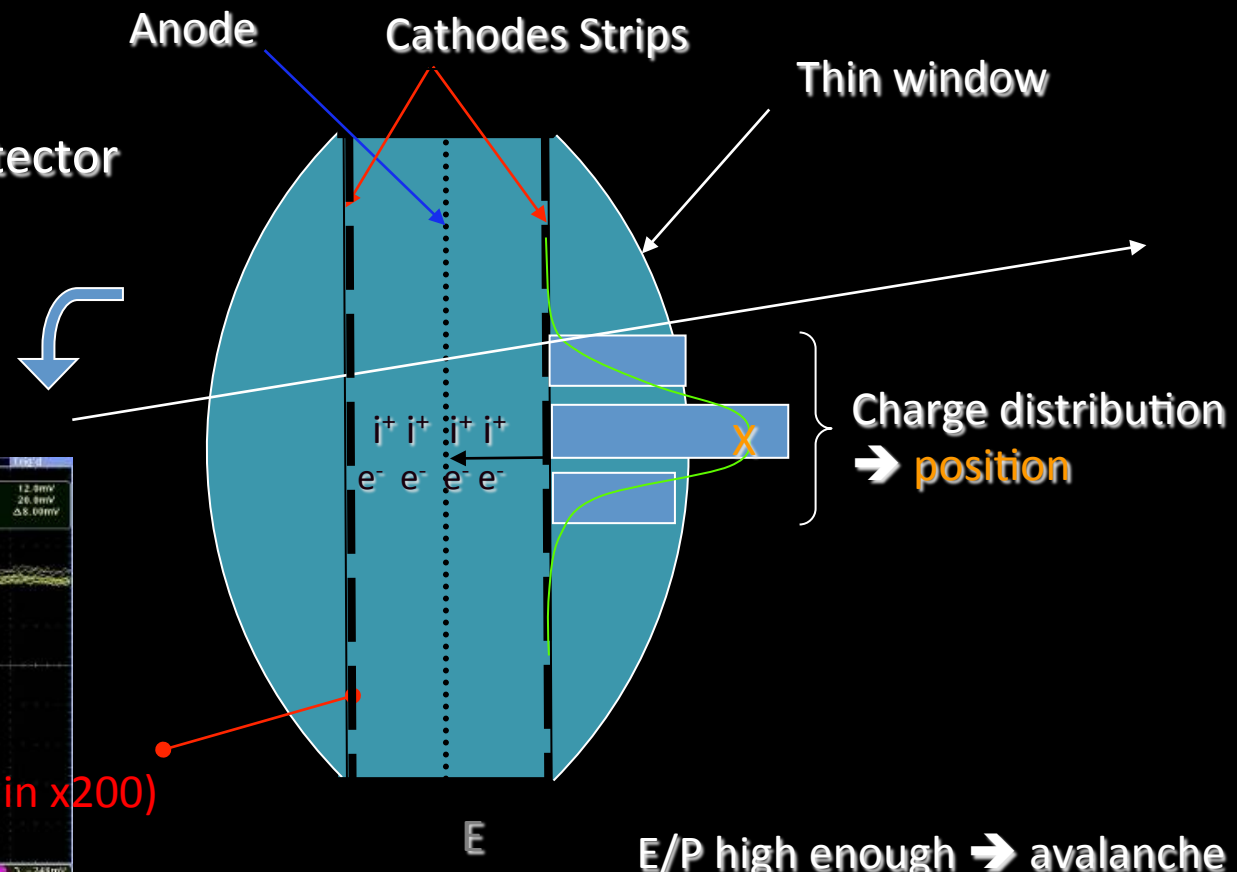




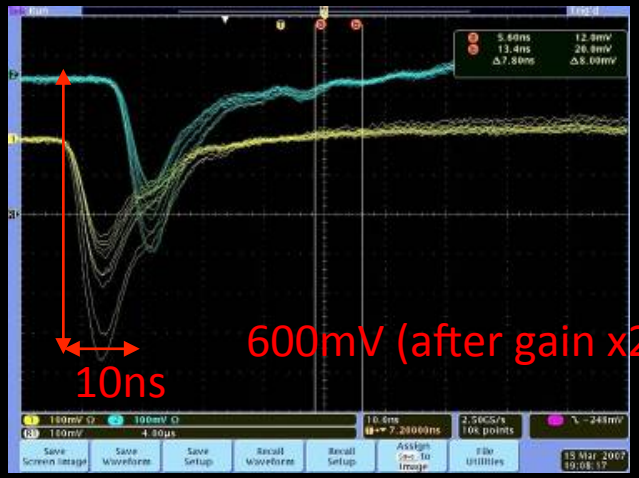
What do you use for Beam Trackers?
Beam Trackers are of Major Difficulty

Beam/Spectro Tracking Detectors
GANIL(VAMOS)- LNS(MAGNEX)-RIKEN (SHARAQ), …

Low Pressure gas detector



Charge distribution
➔ position

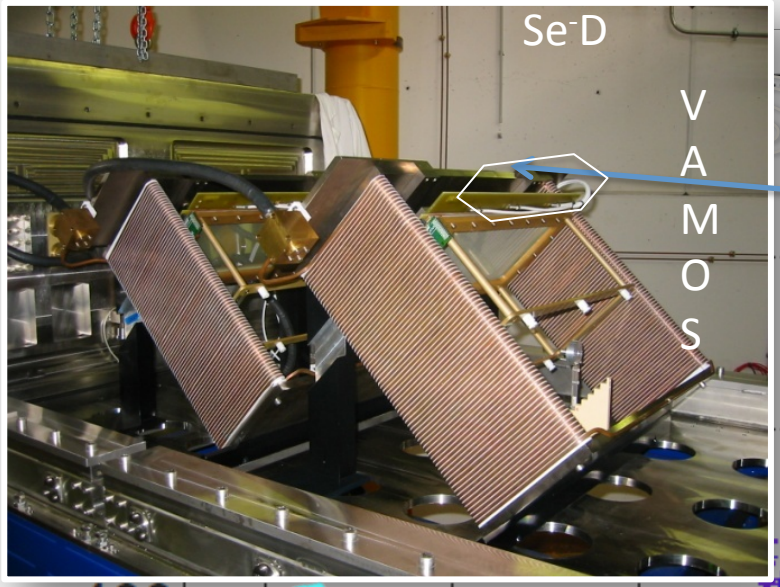


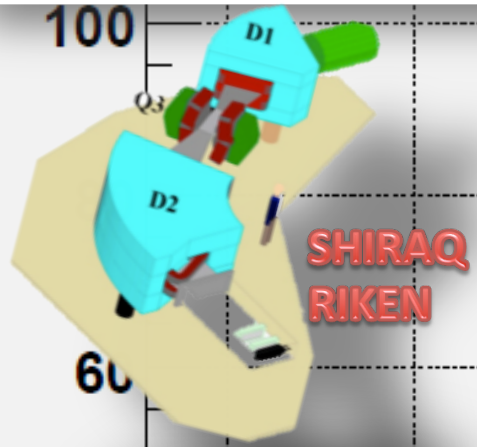
E/P high enough ➔ avalanche
(>100V/cm/Torr) ➔ amplification

Low pressure 4-10 Torr eg CF_4,

charge movement ➔ induced signal
electrons are rapid ➔ fast signal

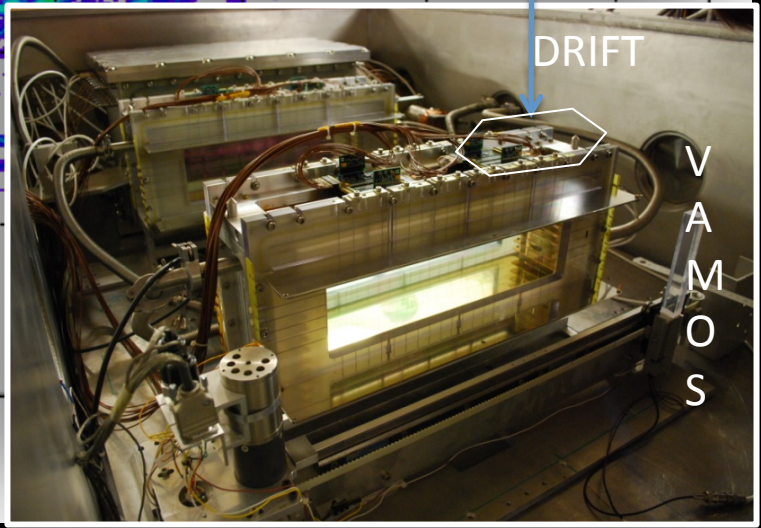
Small N° of channels 100+100 max



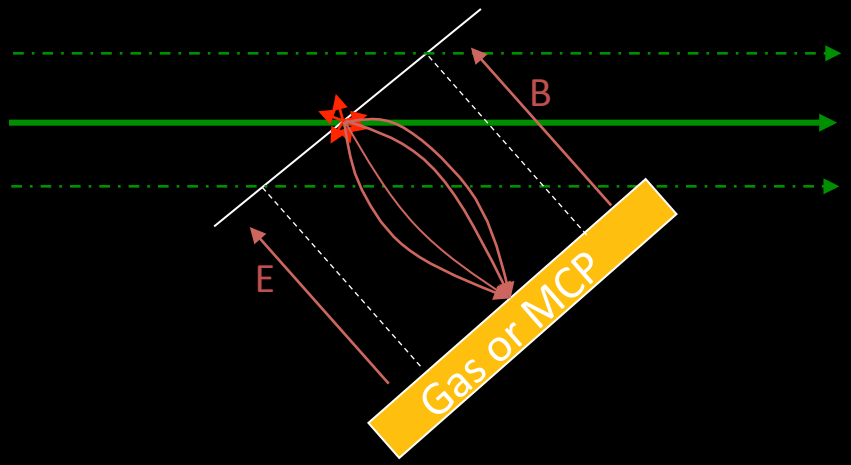


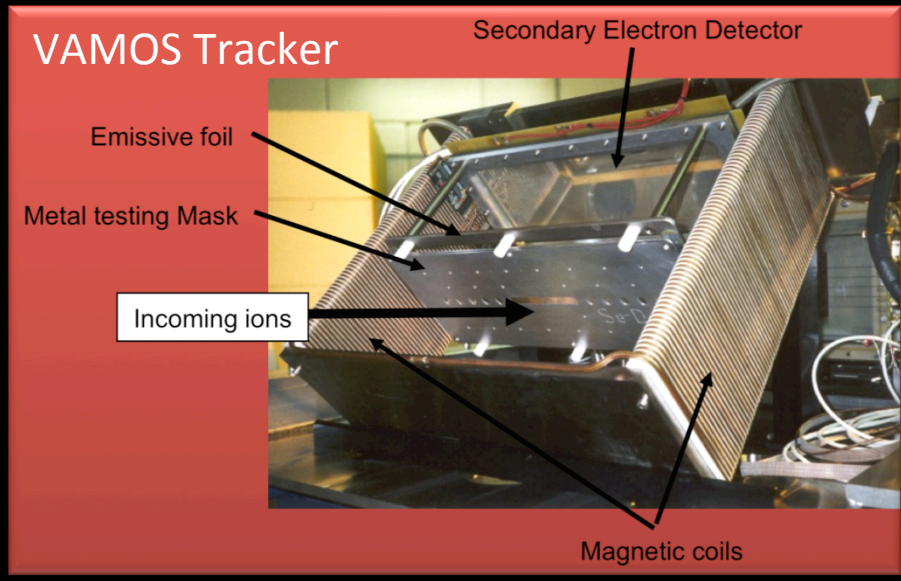
SHIRAQ
RIKEN

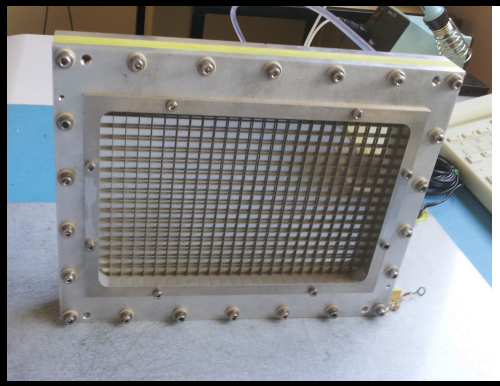
MAGNEX LNS

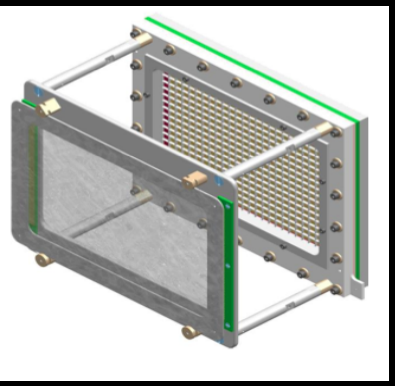


SLOW Heavy Beams









NEW

S3, HiSPEC/DESPEC Beam Tracking

Micromegas – Gas Amp

GET Based Electronics

Good Counting Rates 10^6

ΔT= 300psec (FWHM)

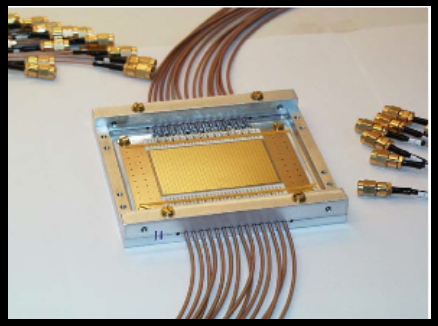
Δx & Δy = 2-3mm (FWHM)

Antoine Drouart

FAST Heavy Beams

GSI – As above but with MCP large area/HOT devices

GSI – CVD (60X40mm2) 32 strip devices



TRACKING: Detectors
Front-End & DAQ sub station

Performance Required:-

Compatible with ASIC performances

Small Number of Channels

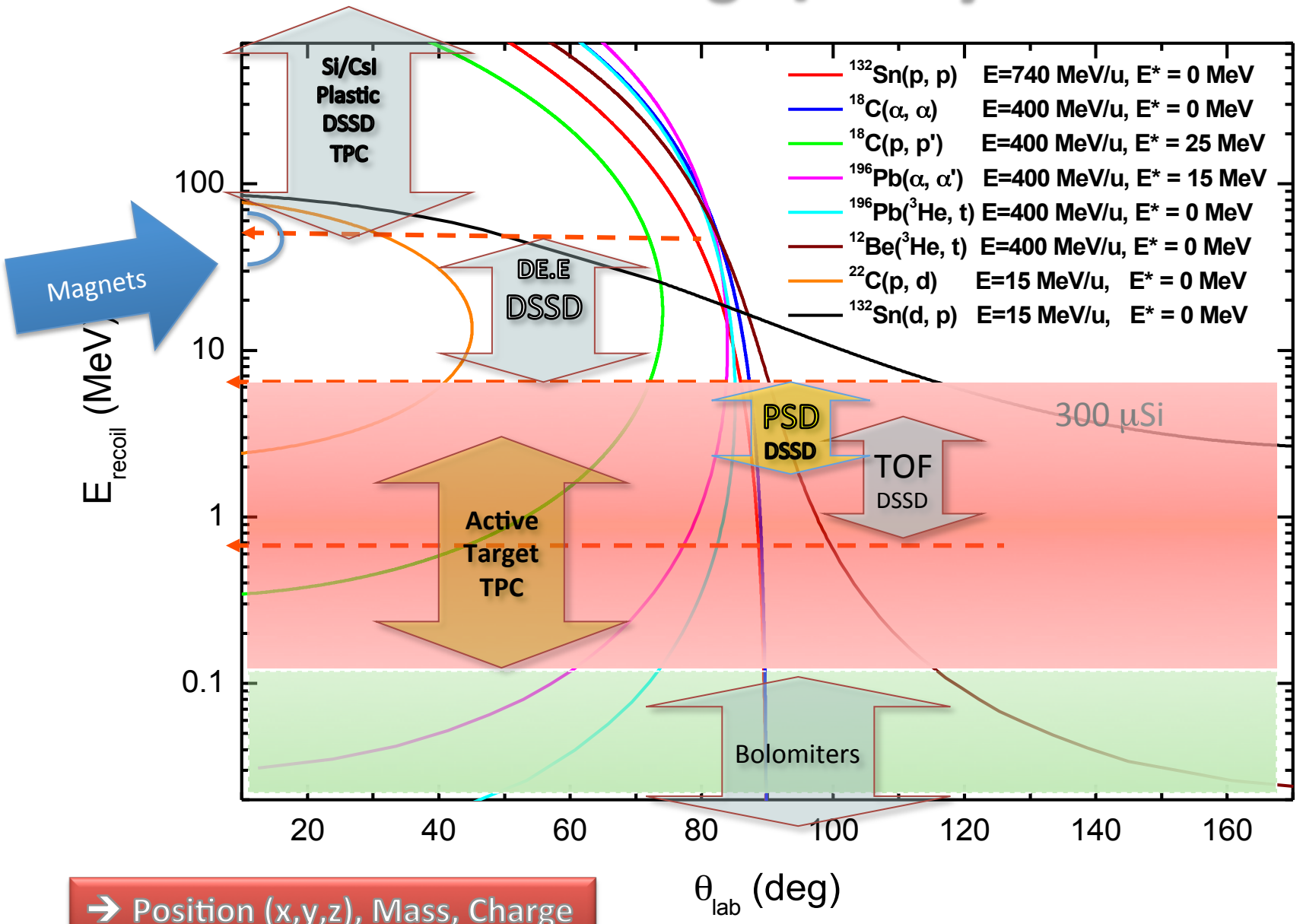
➔ **No ASIC Soln** *but if it exists already …*

Large Number of Instruments *(LNS, NSCL, SPIRAL2, HISPEC/DESPEC, RIKEN, …)*

➔ **Yes ASIC Soln (Gassiplex, AGET, …)**

➔ **A wider common effort is possible**

Reaction Kinematics Light/heavy Recoils



→ Position (x,y,z), Mass, Charge

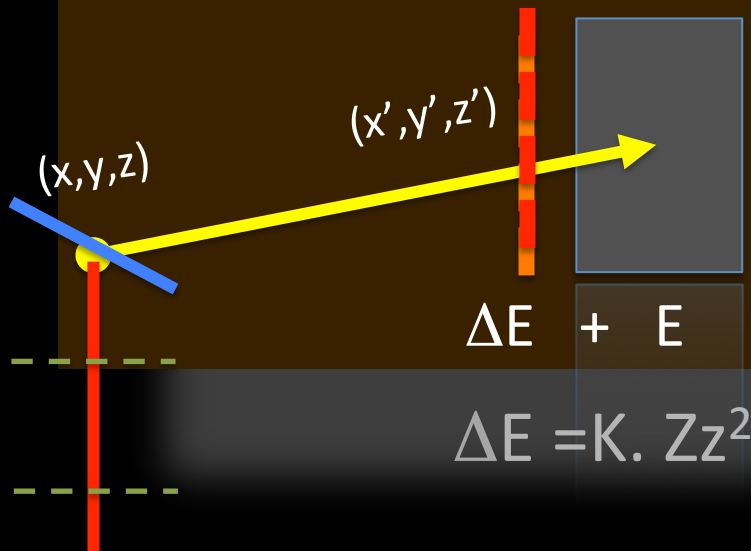
Nucl. Reactions (EoS –INDRA, FAZIA)
&
Nucl. Spectro (HIRA, MiniBall, MUST2, …)

Measurement with DSSD:-

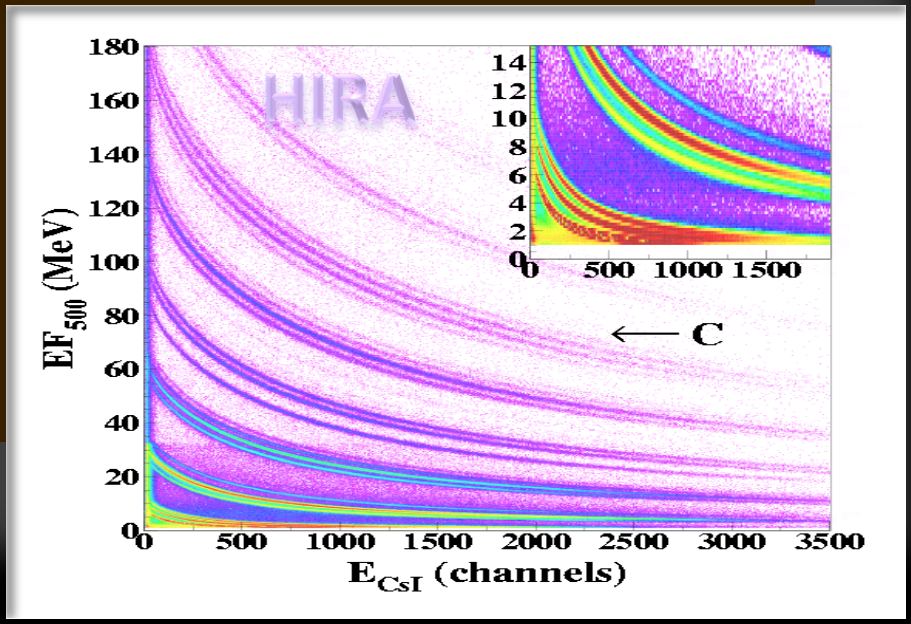
➔ Δ(x,y)=mm-μm, ΔM=1, ΔZ=1

➔ (θ,ϕ), Mass(M), Charge(Z), Energy(E),

➔ Large N° of channels (1K-2K) ➔ *ASIC FEE needed*



$\Delta E = K.\ Zz^2/E.M$



Time is an old concept-I.

- *Time is for*:- Mass & Position
  - Time of Flight ➔ Mass = Const x E x T^2
  - Position = v x T
- *Time is for*:- Time-Stamp (Ian & Gilles)
  - Each event/particle is tagged by a time range

  - Multi-subsystem integration

Byzantine Bread Stamps

- *Time is for*:- the charge signal development fn of time.
  - Position, Charge (Z) & Mass(Z) (Si, Ge, Gas det.) (Giacomo, Enrico, …)

Time is an old concept -II.

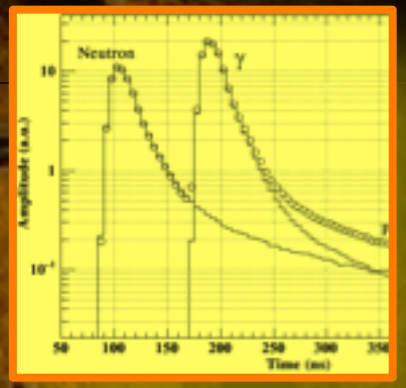
- How do we measure time?
  - Medium:
    - Gas/Mico Channel/Diamond/ Scintilators/Solid State …
  - Electrononics
    - With what Electronics … ?

- Numeric or Analogic Time pick-off (CFDs etc)?

  (Eric, Alberto, George[2], Chiara …)

Towards Numerizing the System

➔ Numeric Decisions & Treatment



- Difficult Environments
  - Pile-up for very fast/coincident decay
  - Coherent Noise reduction
- Versatility *(after the exp adjustment)*
  - Shaping
  - Time-pick-off
    - Precision timing (50ps FWHM)

Eric's Slid

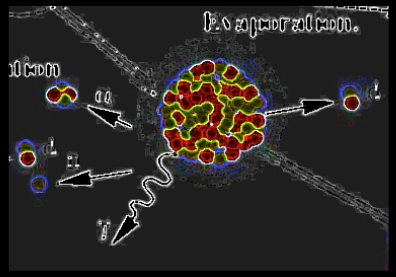
Haik Simon

- High data through-put & storage
  - (0.1 to 5GHz on 12bits on 1000det …) ➔ Challenge.
- High initial €/Y/$ … ➔ BIG MEGA Challenge

Nucl. Decay Spectroscopy

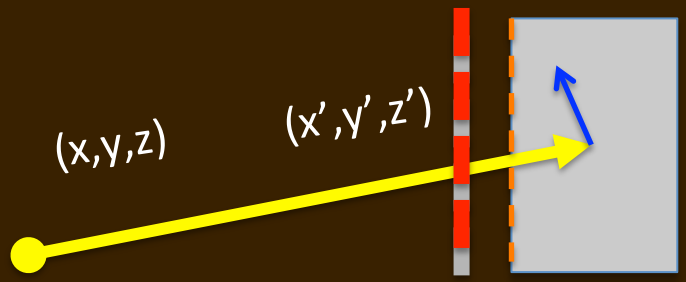
Very High Dynamic Rnge FEE

S3 (Spiral2), AIDA (UK), RIKEN

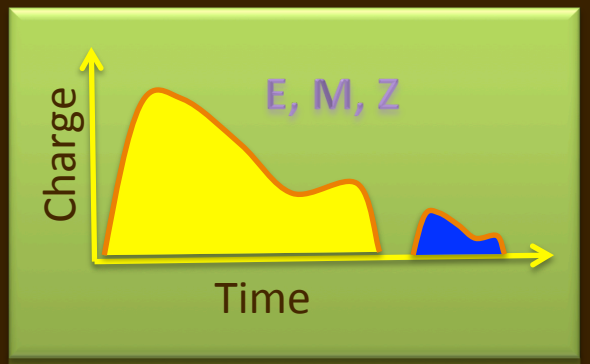


Measurement of Implanted Particle Decay:-

- Pre-Amp with very high dyn Rnge
- Very Fast Restoration Time
- Recoil Decay Tagging

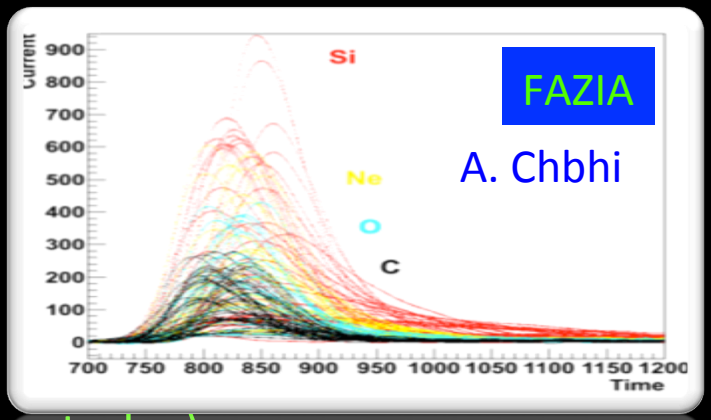


ΔE(DSSD) + E



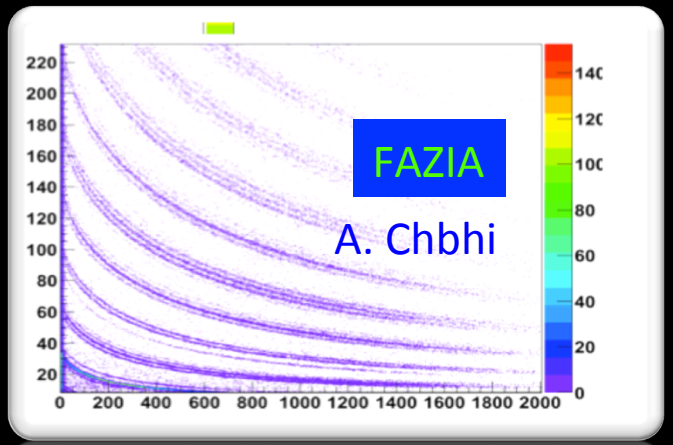
Ian(IADA) & Antoine(S3), Takatani(RIKEN), P. Vallerand (GANIL)

Shape



- Shape is of Interest
  - Characterise the Shape of V or I (pre-amp … today)

- This is new – Particle Identification in *oriented NTD-Si* – Giaccomo Poggi



Sampling :

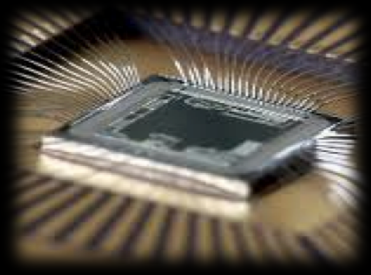
Sampling what? I, V … BW
Rise time, Shape?
Sampling Frequency?
How Many Bits?
To get M, Z, E resoln. & Dyn Rng
DSSD?

- This is new – Position Sensitive Ge - Enrico Farnea
- Resistive Micromegas position enhancement- New - Rui

ASIC based Front-End For Nuclear Physics Experiments

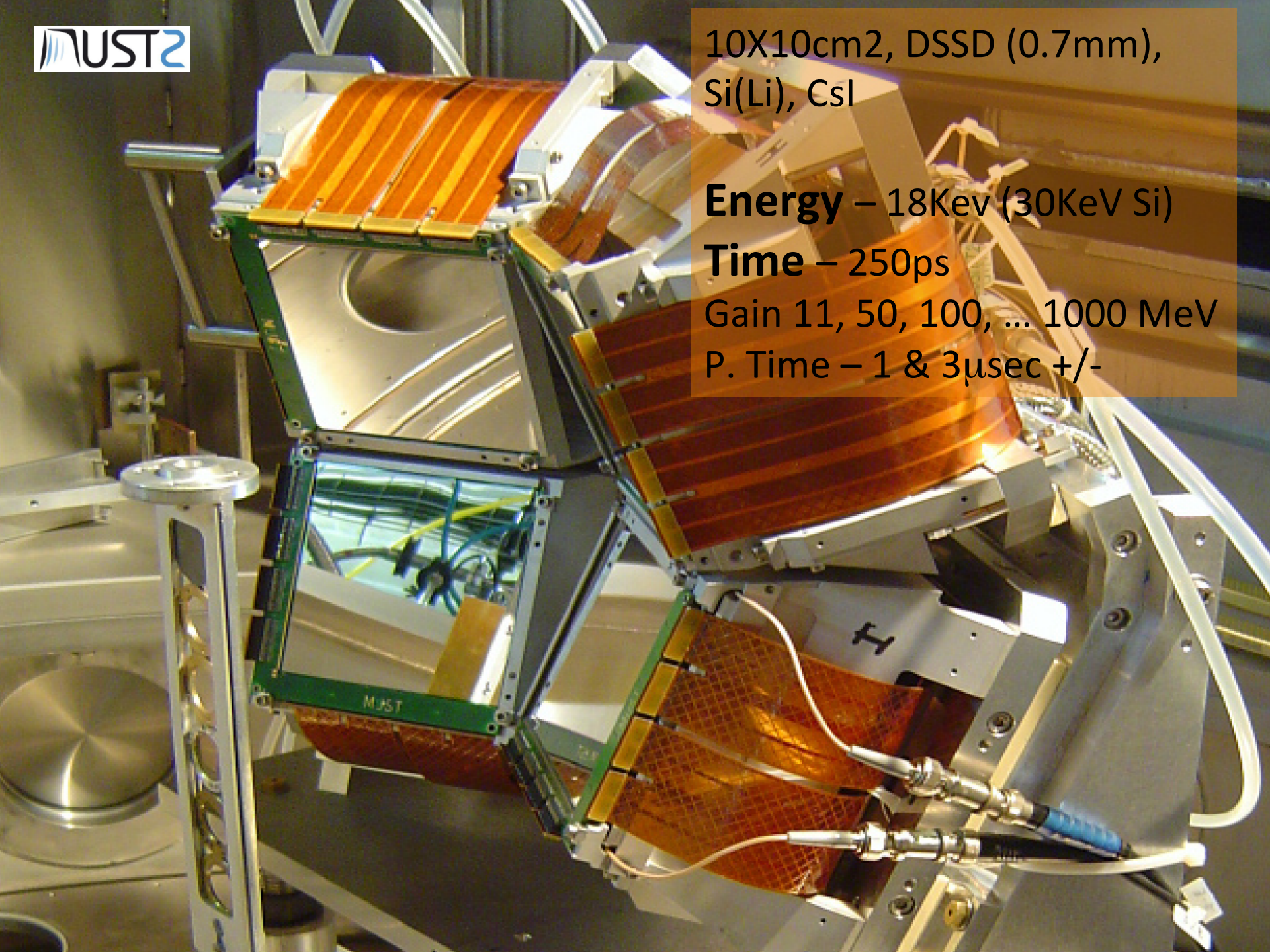
Choosing Between Hybrid vs ASIC Front-End

- Hybrid
  - Hybrid Engineering Skills
    - Hard & Soft & Firm
  - Inexpensive for small number of ch
  - Generic. PAC changes
  - Numeric Control (some)
  - Large Volume & Power
  - High Performance
    - Dyn. Range Limits?
    - ΔE & ΔT Limits?
    - Limits for what detectors

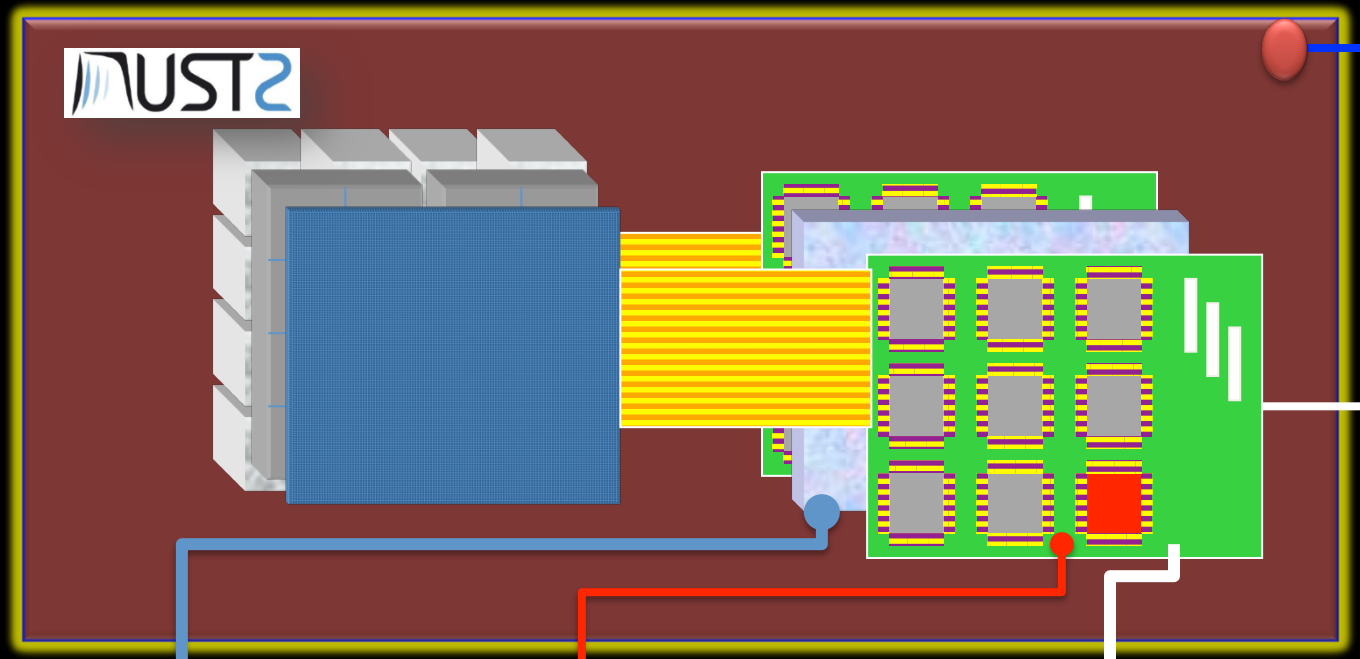


- ASIC
  - ASIC Engineering Skills
    - Hard & Soft & Firm
  - Inexpensive for large number of ch
  - Generic . Multiple PAC opt.
  - Numeric Control
  - Small Volume & Power
  - Low Performance
    - Dyn. Range Limits?
    - ΔE & ΔT Limits?
    - Limits for what detectors

George ,Alberto, Eric & John, Chiara...


MUST2
10X10cm2, DSSD (0.7mm), Si(Li), CsI
Energy – 18Kev (30KeV Si)
Time – 250ps
Gain 11, 50, 100, … 1000 MeV
P. Time – 1 & 3μsec +/-
MUST

Hard-Firm-Soft ware

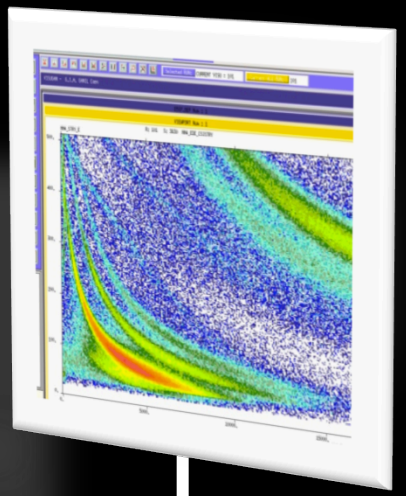


Security
AUTOMAT
Current
Tension
Temp.
Press.

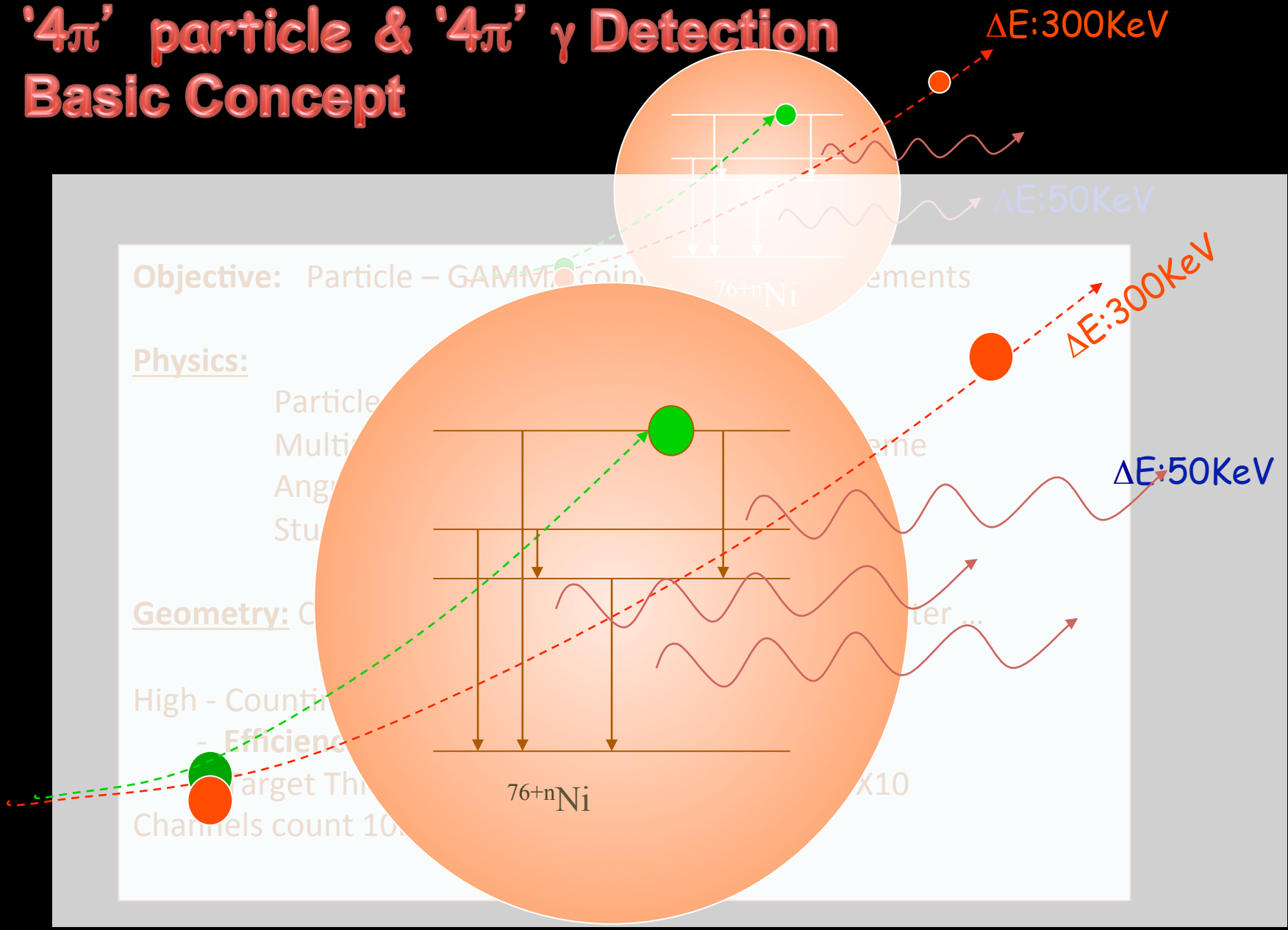
Cooling
Unit

Power supply

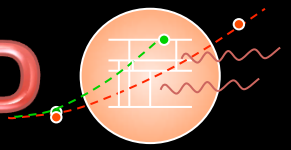
-Trigger (Gilles)
-Control (Kolb)
DAQ(Enrico, Baba, Xavier)



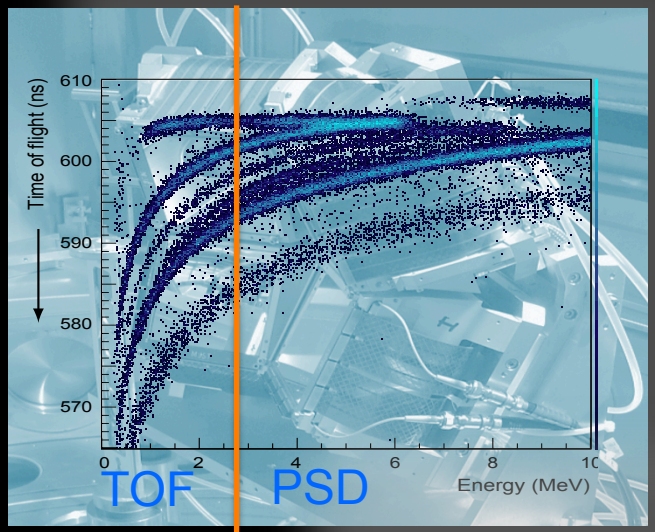
'4π' particle & '4π' γ Detection
Basic Concept

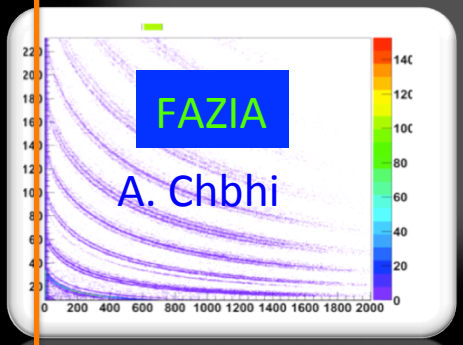


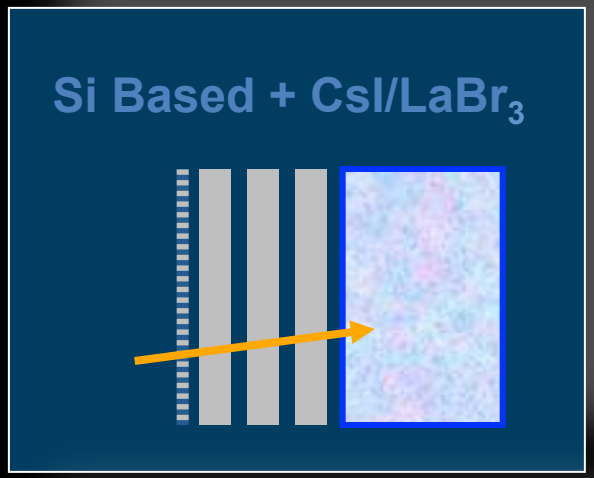
ToF + PID + DE-E Telescope - DSSD



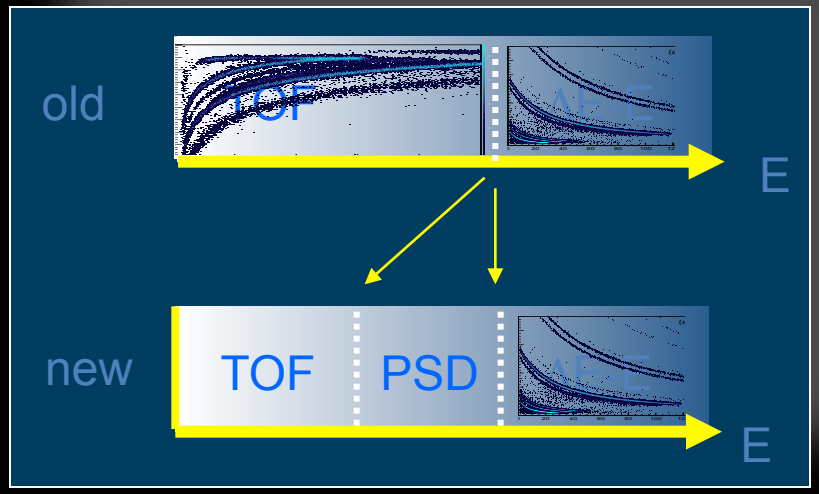
GASPARD & HYDE



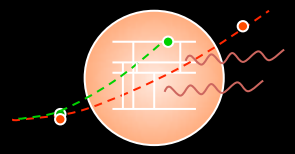




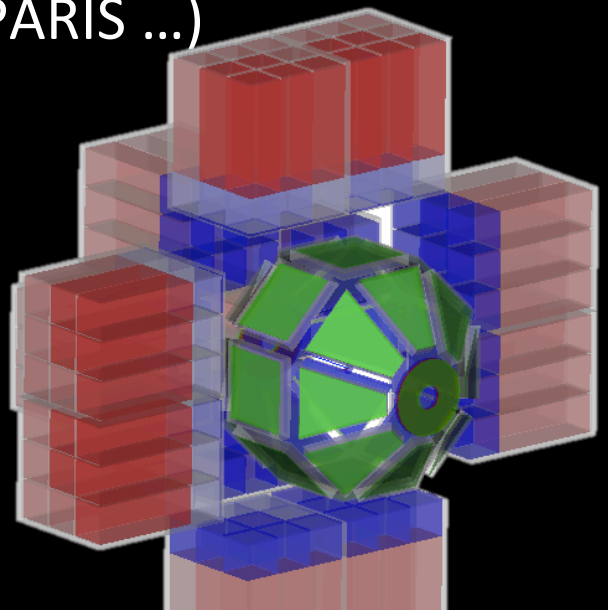
J.Duenas

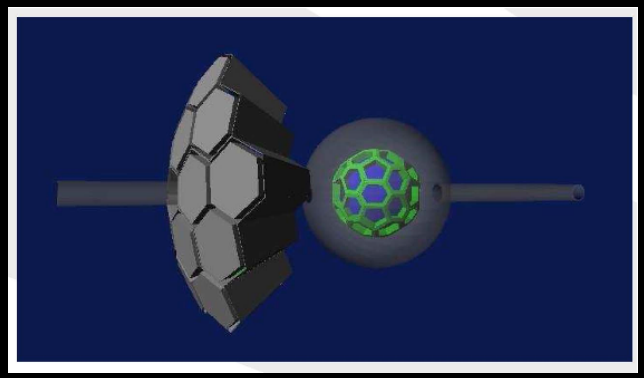


Particle-Gamma full Cover devices
From ToF to Shape in DSSDs
'EUCLIDES' & 'HYDE' & 'GASPARD' …



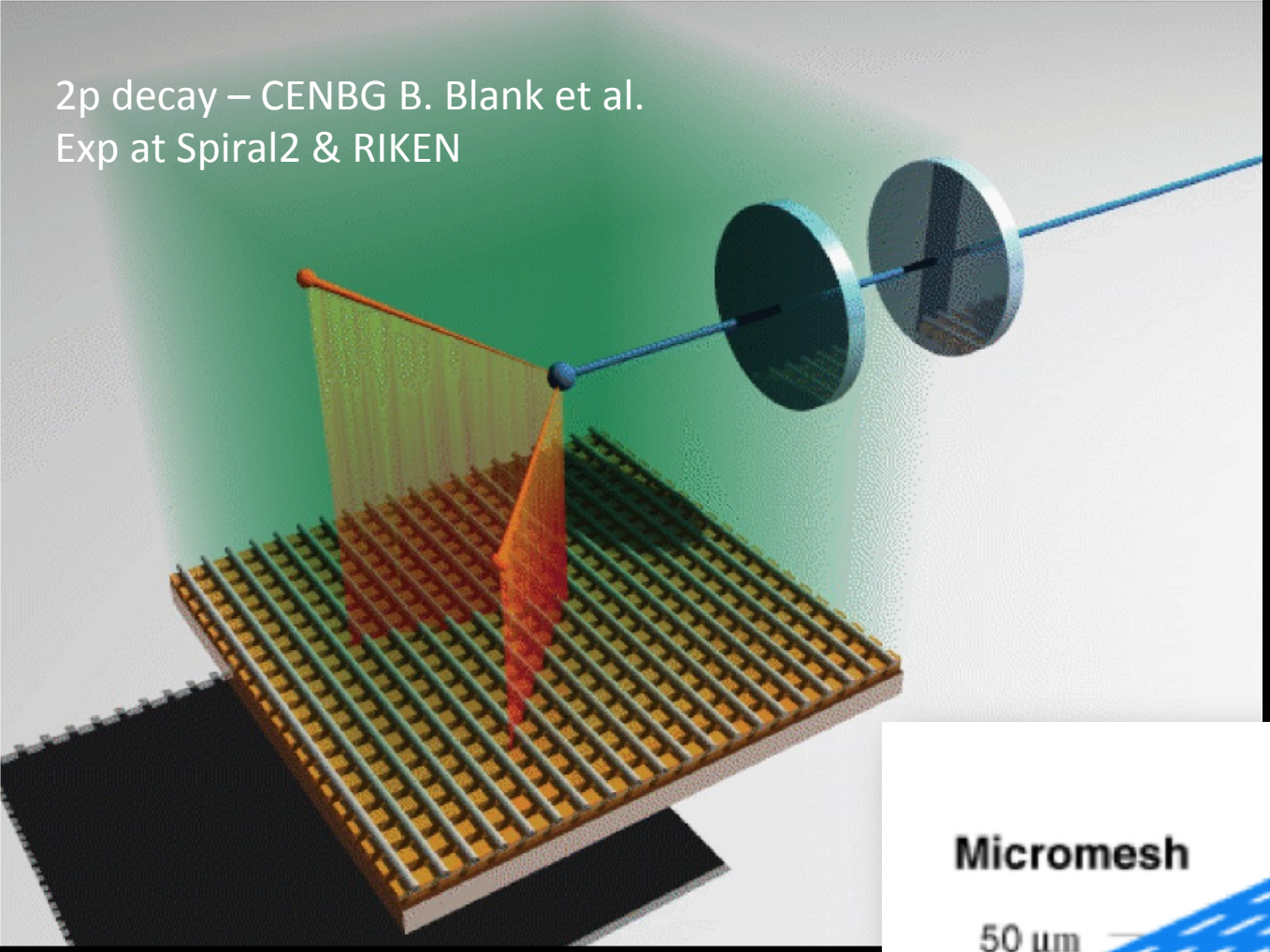
- Mass & Charge for for Quasi-Projectile (forward angles) & Light Ions in 4pi
  - Challenge for the DSSDs oriented NTD-Si
- Challenge ➔ reach good cover/eff - γ (AGATA, GRETA, PARIS …)

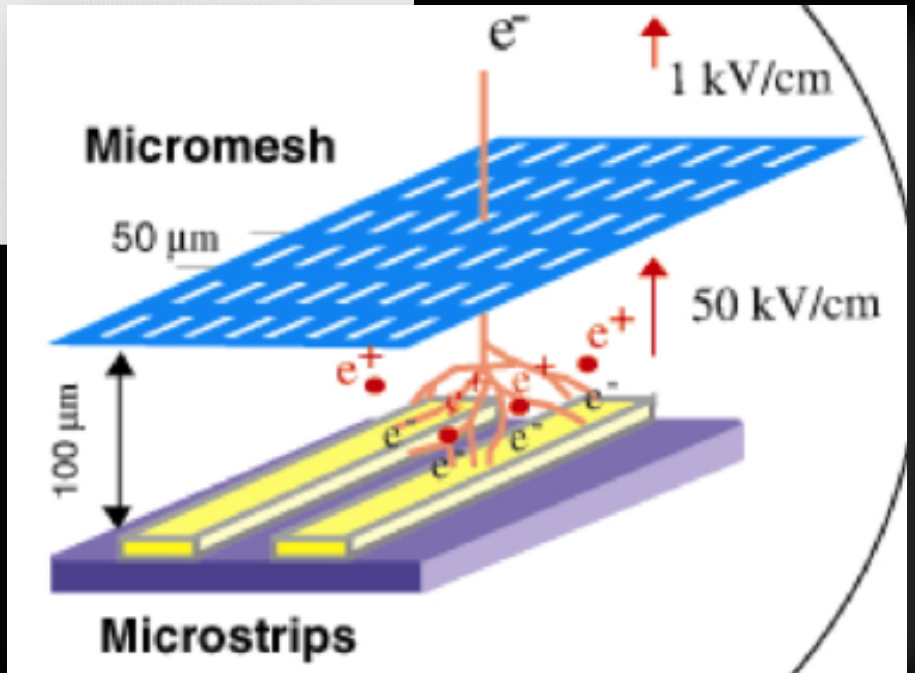




E.Farnena (AGATA), Anna Corsi(IRFU), Duenas(Huelva)

2p decay – CENBG B. Blank et al.
Exp at Spiral2 & RIKEN

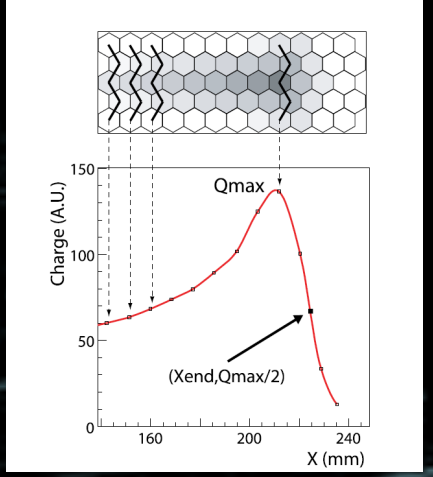




Solutions via Active Targets
- Time-Projection Chambers
- VERY High Channel Counts
- Gaseous Micropattern Det.

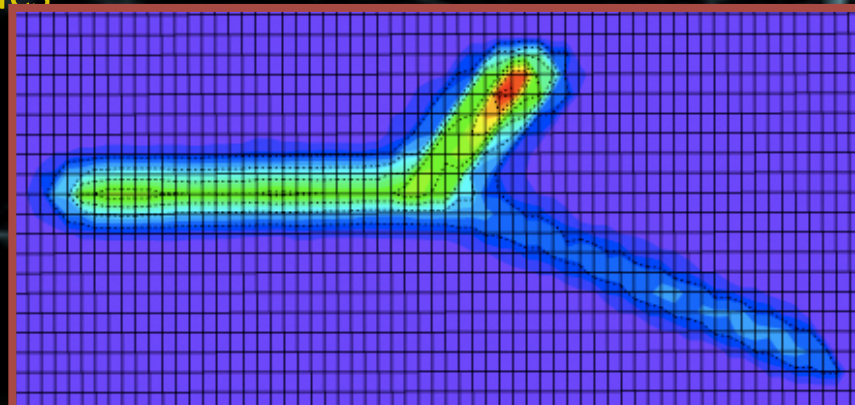
Rui de Olivera (CERN) & T. Isobe(RIKEN)

Active Targets – A challenge



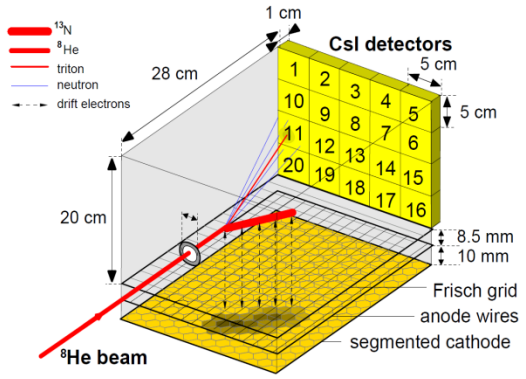
An old idea refreshed for Slow Heavy Ions

- Needs new Techno. & Sizing for Nucl. Phys.
- Magnetic field & Range $\propto E^2/MZ^2$
- Fine pad structure (25pad/cm^2) L. Andricek (MPI)
- Gaseous Micropattern Detectors Rui(CERN)
- Electronics
  - Electronic channels (10-20K) adopted for Nucl. Phys.
  - Trigger & data rates Gilles Wittwer(GANIL)
  - Dynamic ranges (ΔE like Z^2) electronics

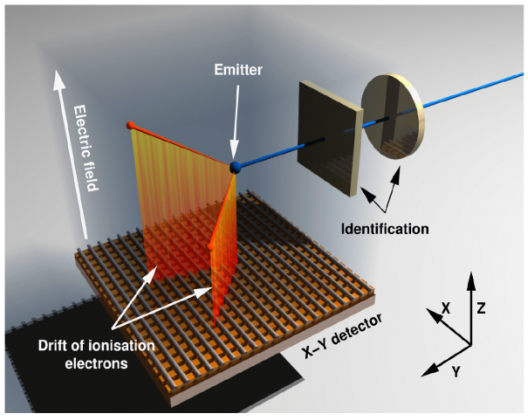


Results - Physics cases

MAYA



CENBG TPC



- Production of the most exotic systems:

  $^{12}C(^{8}He,^{13}N)^{7}H$

  M. Caamaño et al., PRL 99 (2007) 062502

- n-n correlation in halos:

  $^{11}Li(p,t)^{9}Li$

  I. Tanihata et al., PRL 100 (2008) 192592

- Nuclear incompressibility:

  $^{56}Ni(d,d')$

  C. Monrozeau et al., PRL 100 (2008) 042501

- New radioactivity:

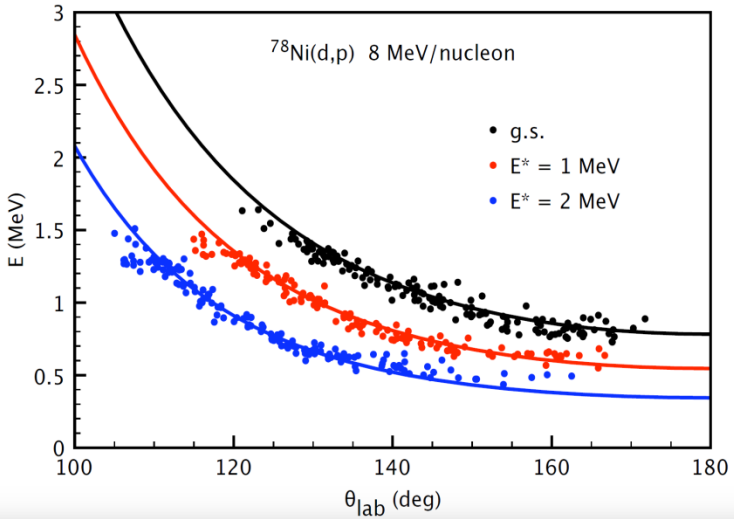
  2-proton decay of ^{45}Fe

  J. Giovinazzo et al., PRL 99 (2007) 102501

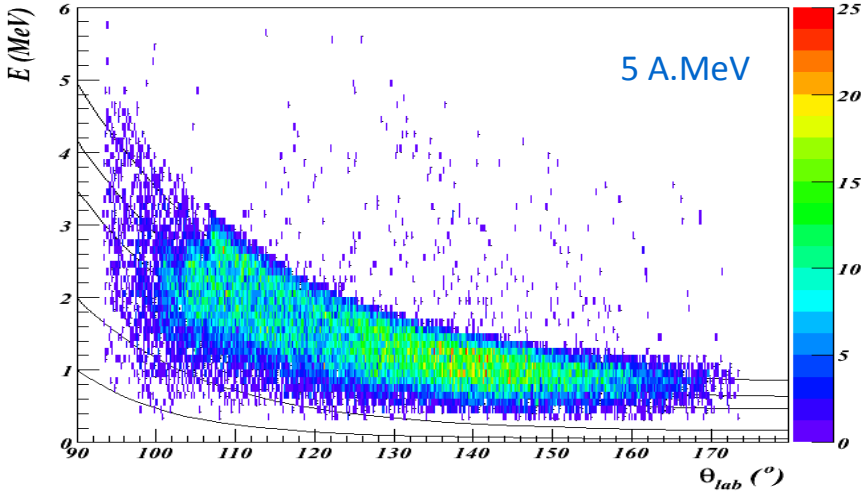
Physics cases – 1

Spectroscopy of nuclei near closed shells with one-nucleon transfer reactions

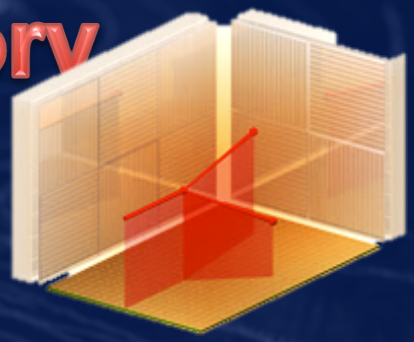
- ^{78}Ni(d,p) at 8 MeV/nucleon
- Backward protons stopped in gas or in charged-particle telescopes
- Resolution ≈250 keV
- Efficiency, target thickness



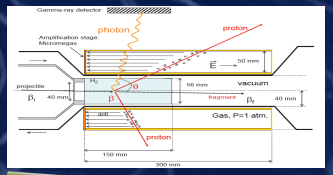
Factor 10 to 100 better
than using a solid target
Feasible with beam intensity 10^3 pps

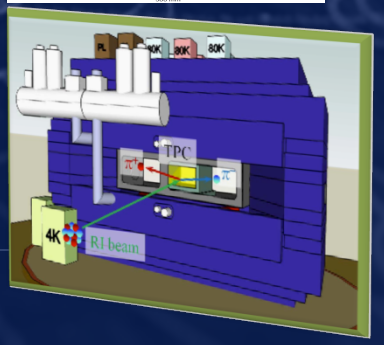


Multi-Project & Multi-Laboratory



1. ACTAR-TPC
   - Active Target
   - IRFU & GANIL & Darsebury, Compostel, GSI, York …
2. AT-TPC
   - Fragmentation (π^+,π^-) & Active-Target – ***Magnet***
   - NSCL, …
3. MINOS
   - (P,2p,γ)
   - IRFU, RIKEN, IPNO, …
4. SAMURAI-TPC
   - Fragmentation (π^+,π^-) - ***Magnet***
   - Riken, Kyoto University, MSCL…





Building a common: FEE+DAQ - GET

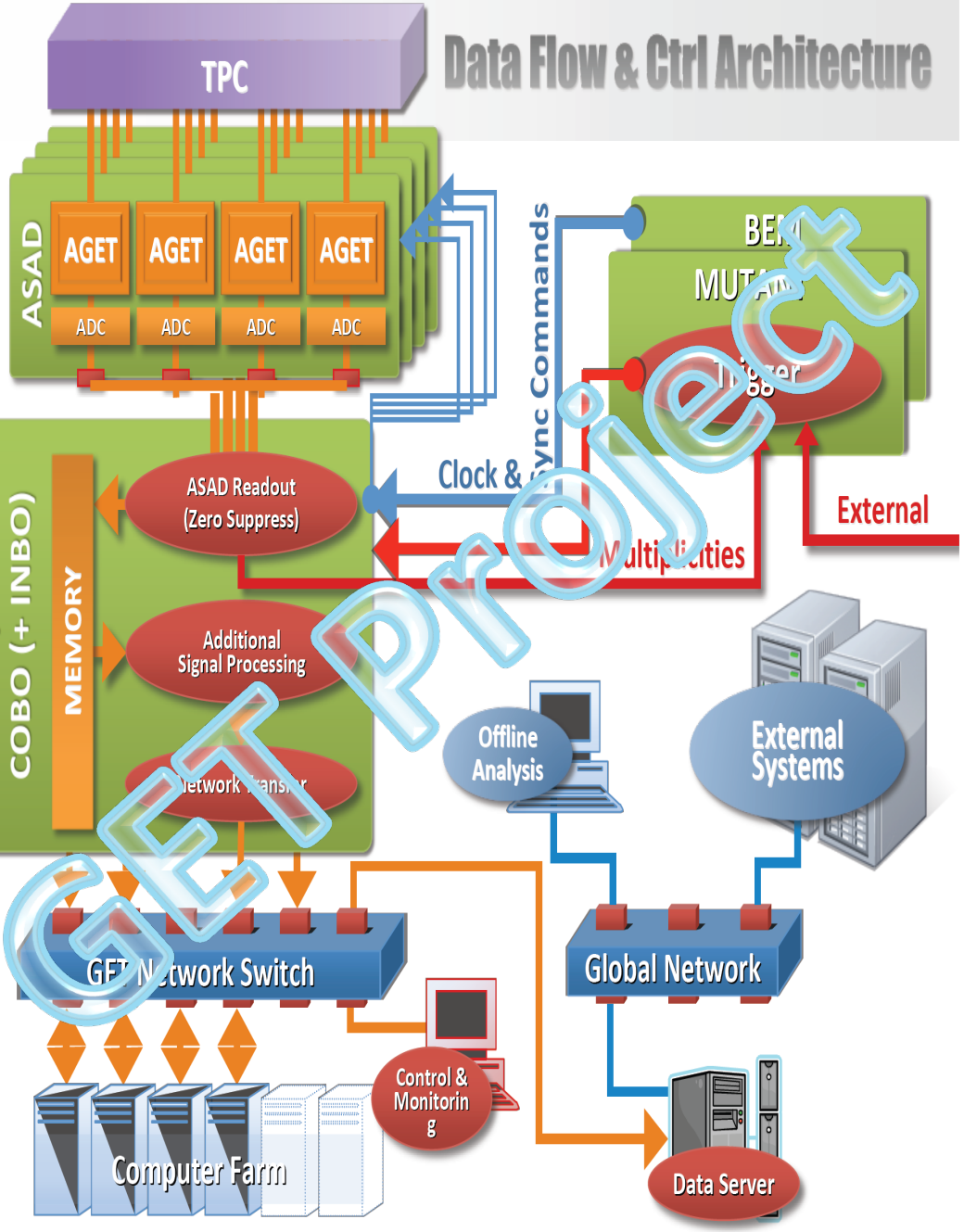
Individually, the labs will not be able to build the instruments to perform the experiments- Costs/engineers

irfu

cea

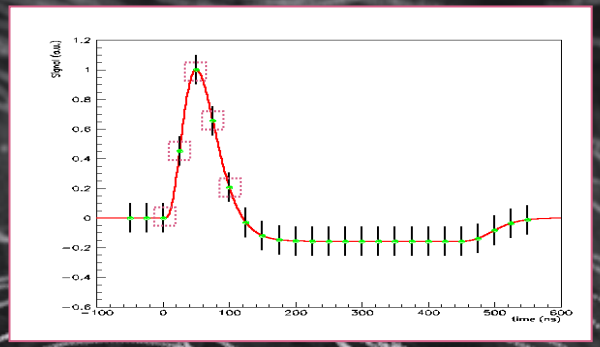
saclay

Data Flow & Ctrl Architecture



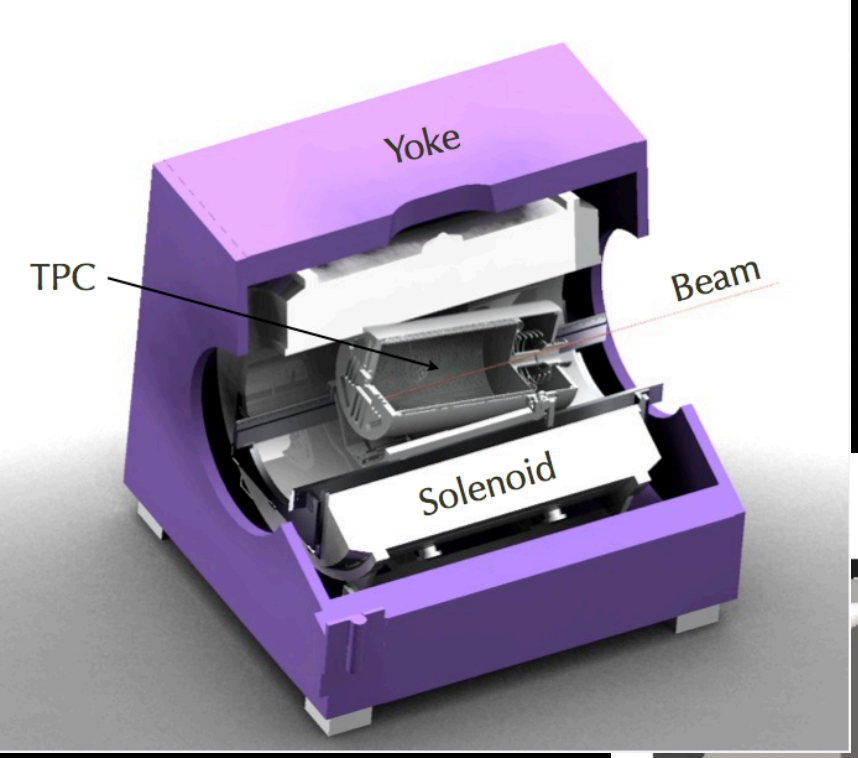
Eric & Lolly(IRFU)

Measure Q(t), X, Y per Pad Sampling ADC



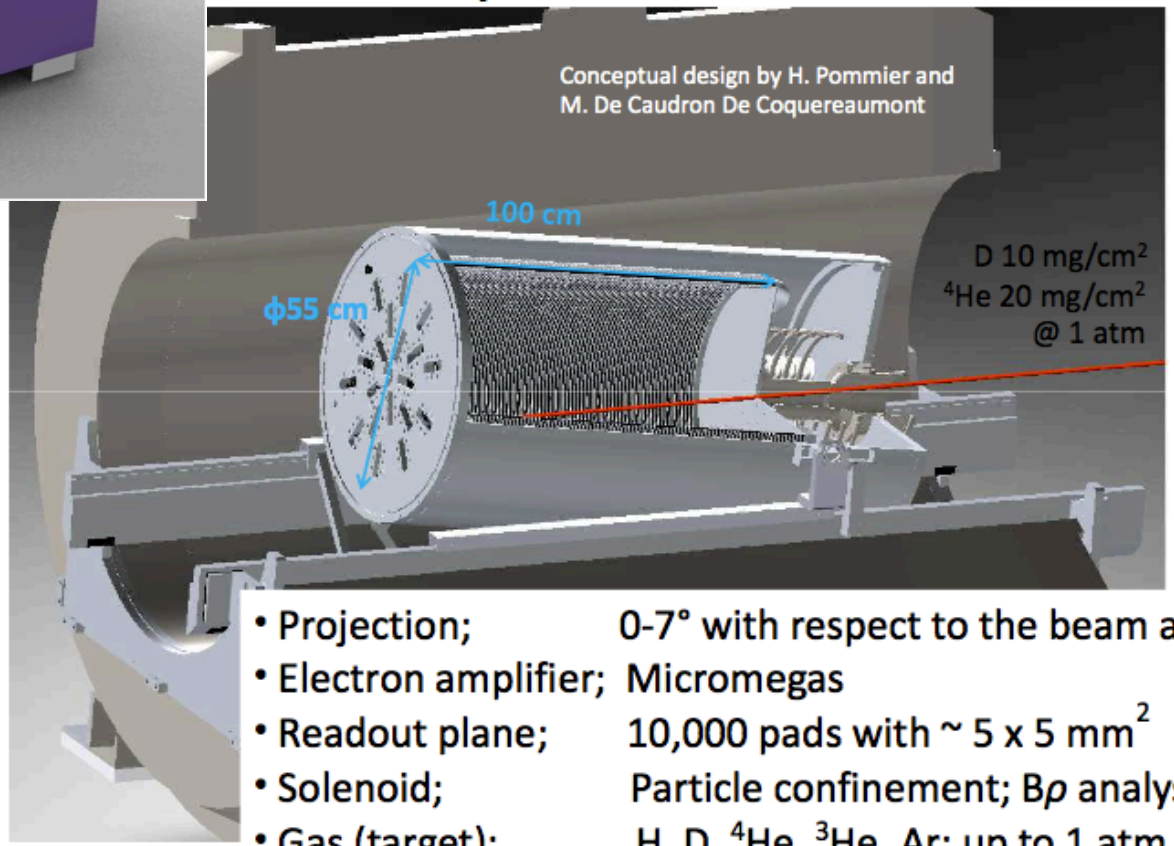
- **High through-put 10Gb/s**
- **Full Numeric Trigger**
- **Selective Readout**
- **Zero Suppress**
  - Base-Line Correction
  - Time Stamp
  - Automated Calibration

SUPPORTED BY ANR



NSCL

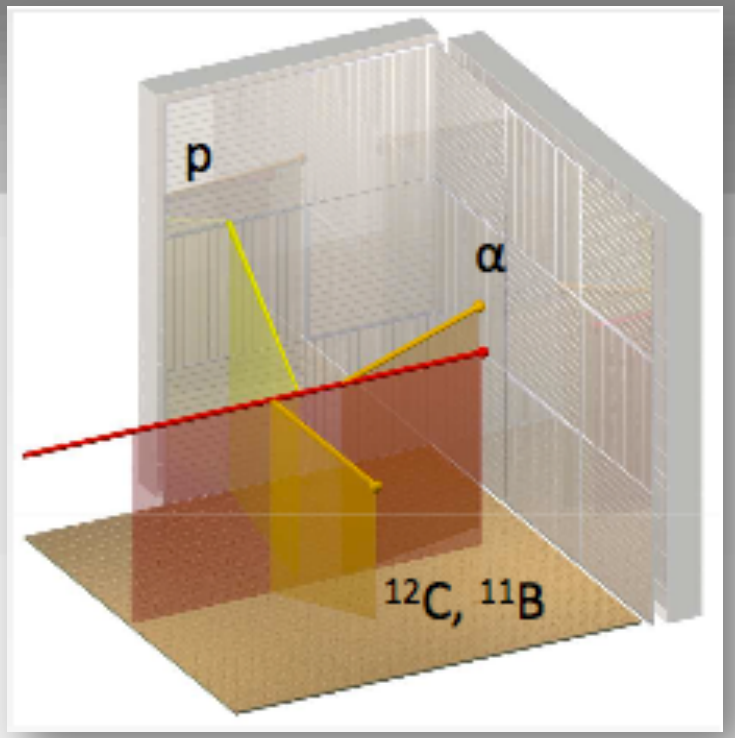
Concept of the AT-TPC

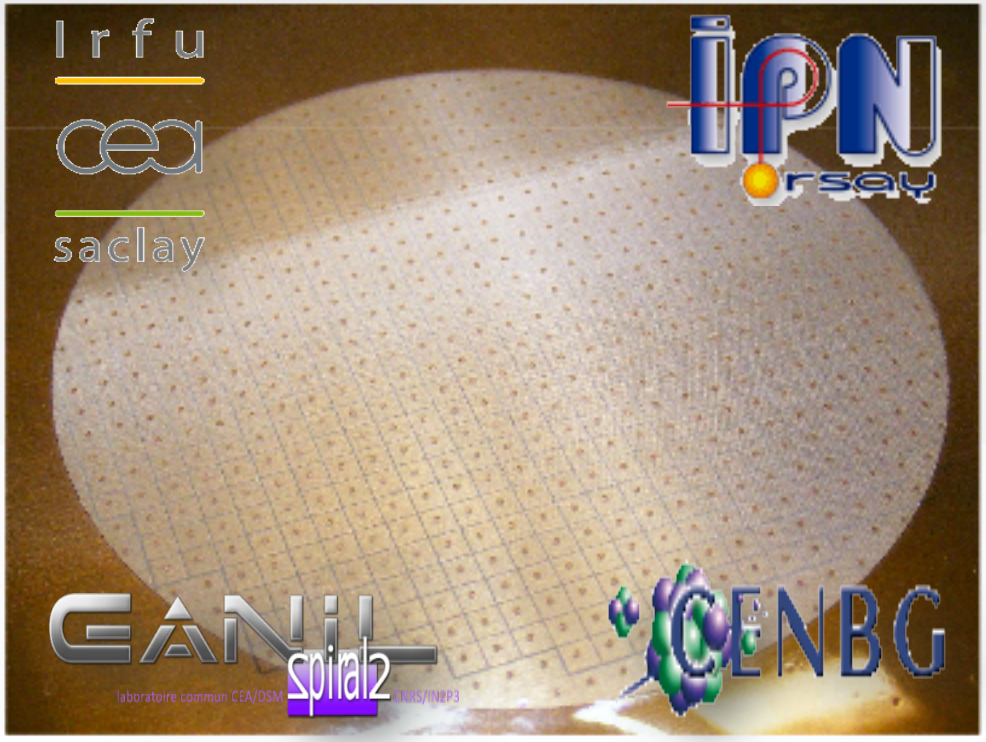


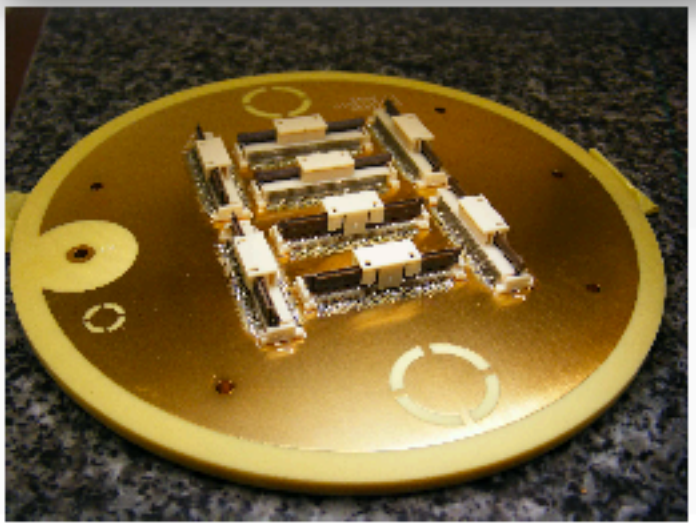
- Projection; 0-7° with respect to the beam axis
- Electron amplifier; Micromegas
- Readout plane; 10,000 pads with ~ 5 x 5 mm^2
- Solenoid; Particle confinement; Bρ analysis
- Gas (target); H, D, ^{4}He, ^{3}He, Ar; up to 1 atm

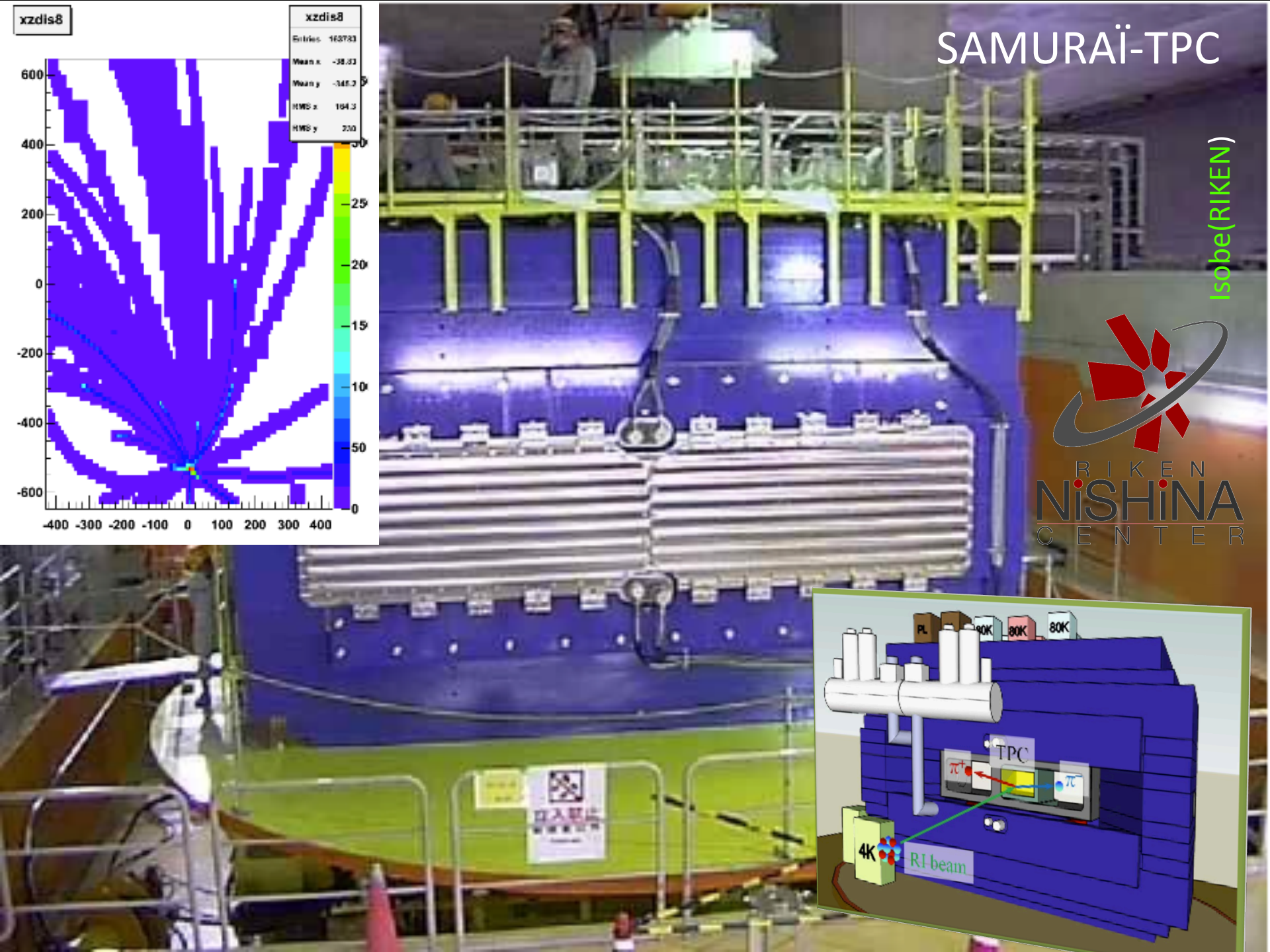
ACTAR TPC Prototype

- 576 channel prototype
  - Pad pitch 2 x 2 mm^2
  - Connections @ IPN Orsay (Jan-Feb 2011)
  - Source tests @ GANIL (now)



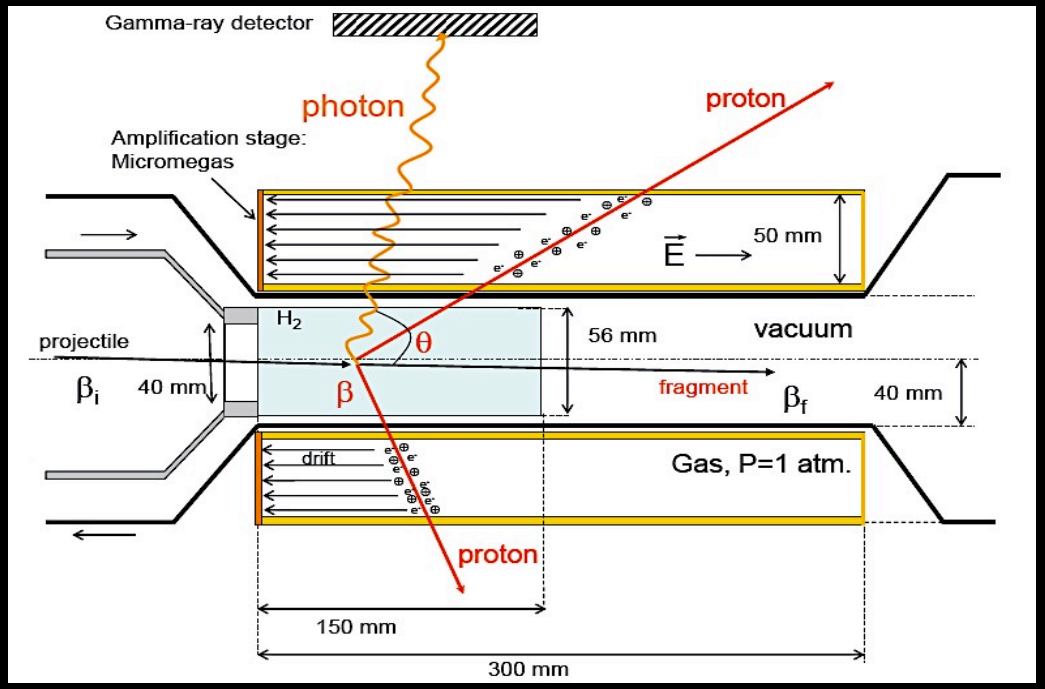





xzdis8
xzdis8
Entries 163783
600
400
200
0
-200
-400
-600
-400 -300 -200 -100 0 100 200 300 400
50
25
20
15
10
50
0
SAMURAÏ-TPC
Isobe(RIKEN)
RIKEN
NiSHiNA
CENTER
PL
80K
80K
80K
TPC
4K
RI beam

MINOS & R3B – 'Active Targets' @ RIKEN & FAIR (GSI)

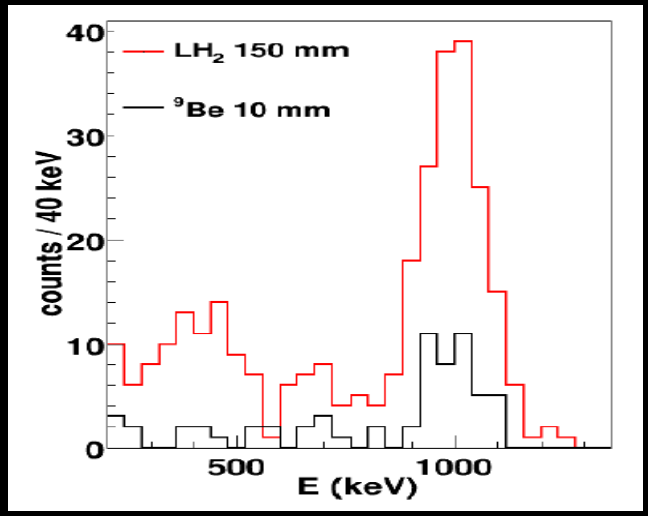
MINOS-IRFU



Laurent Audirac (IRFU)

5K Channels of GET electronics

Simulation

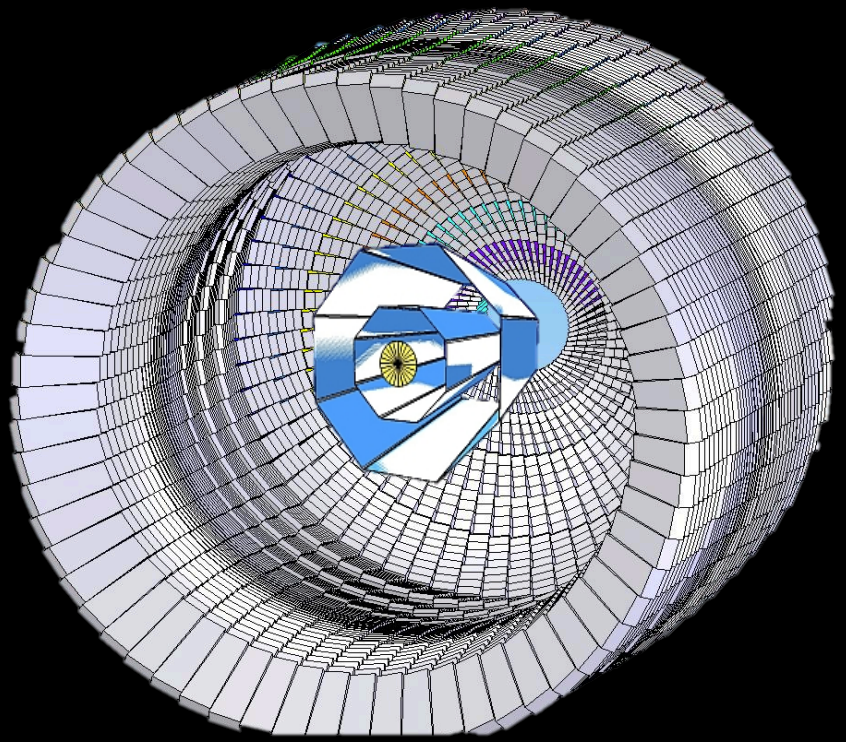


Reactions:

(p, 2p,γ), (p, 2n,γ) & … (p,p,α,γ)

R3B – 'Active Targets'

R3B Si Tracker



CALIFA - CsI

Instruments To Discover The Terra Incognita

- Did not mention all developments.
- New instruments are being considered, simulated and built.
- Progress in exchange and common projects from different lab.
- Technological and Standards Changes are in progress in the area of Front-End Electronics & DAQ
  - Large number of channels
  - Control
  - Speed of the systems