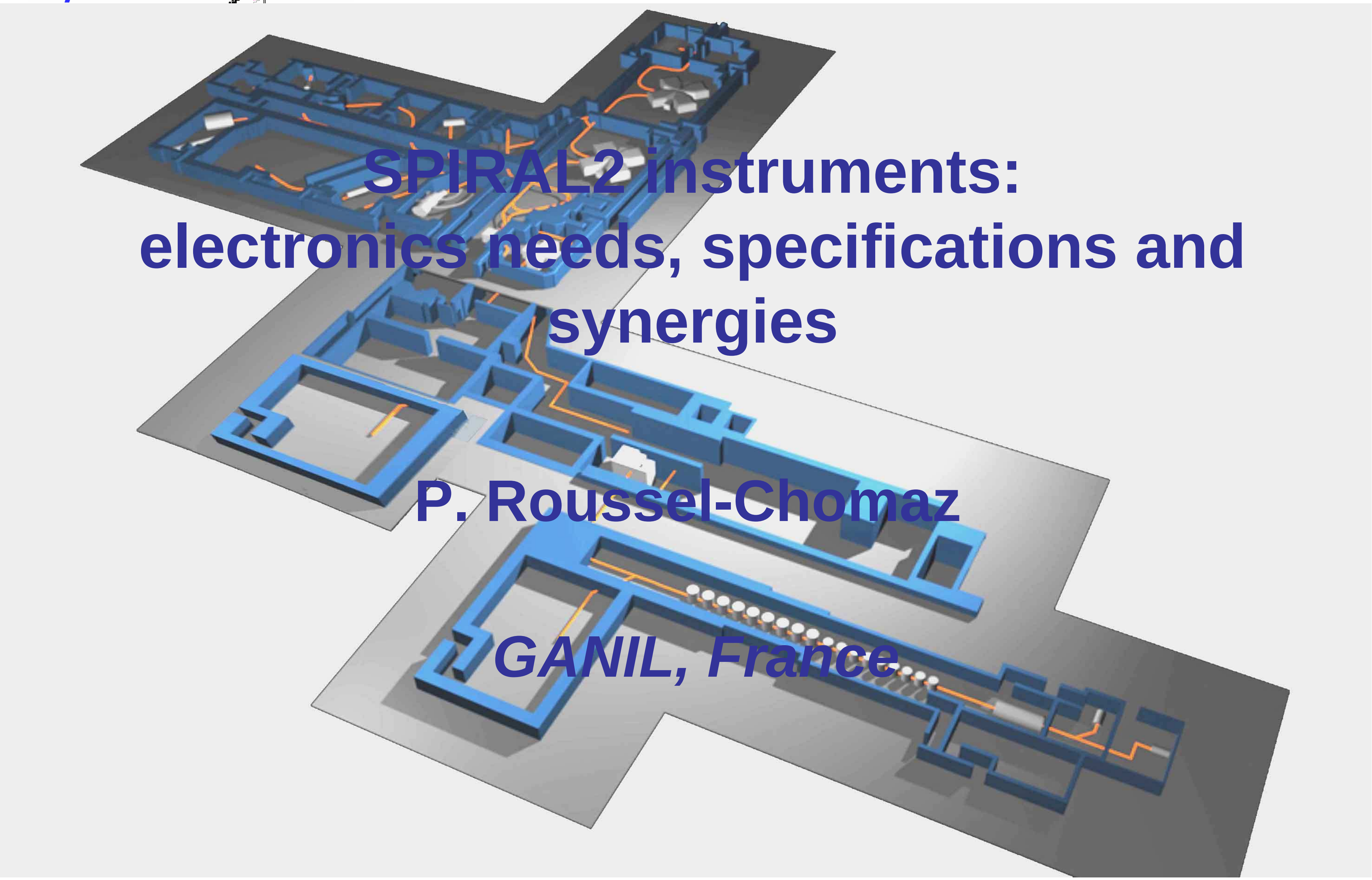
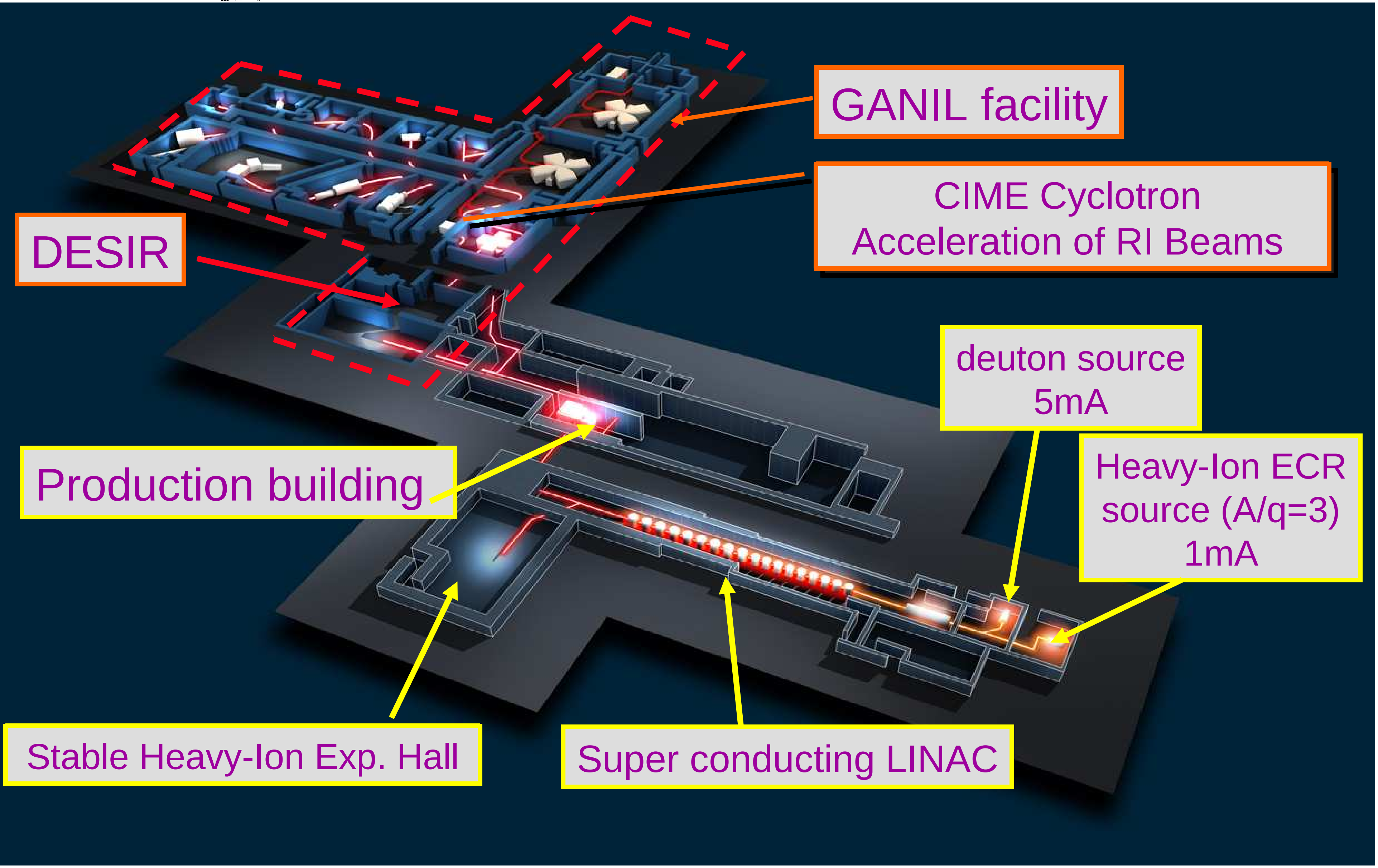


SPIRAL2 instruments: electronics needs, specifications and synergies

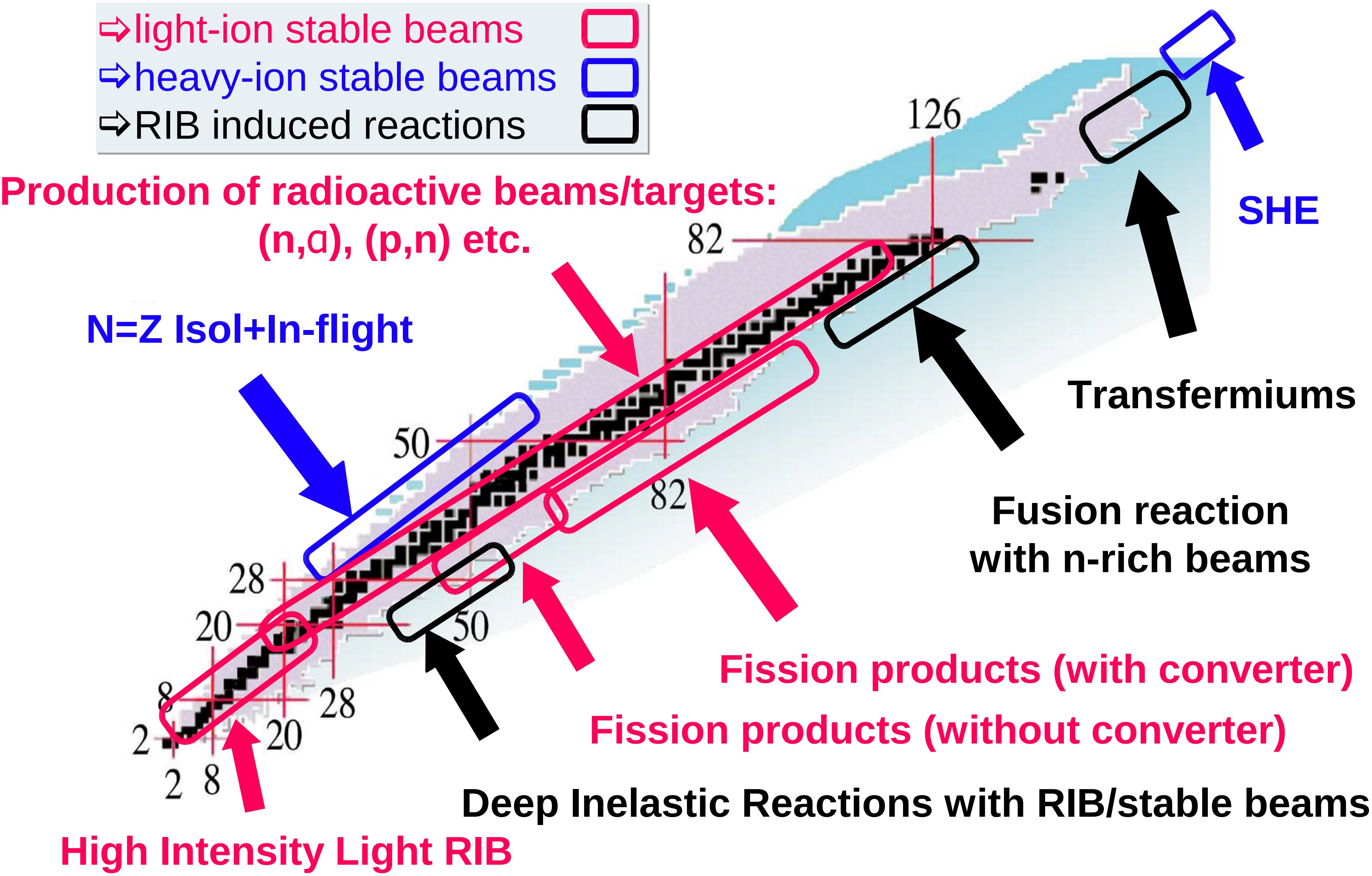
P. Roussel-Chomaz

GANIL, France

SPIRAL2 at GANIL



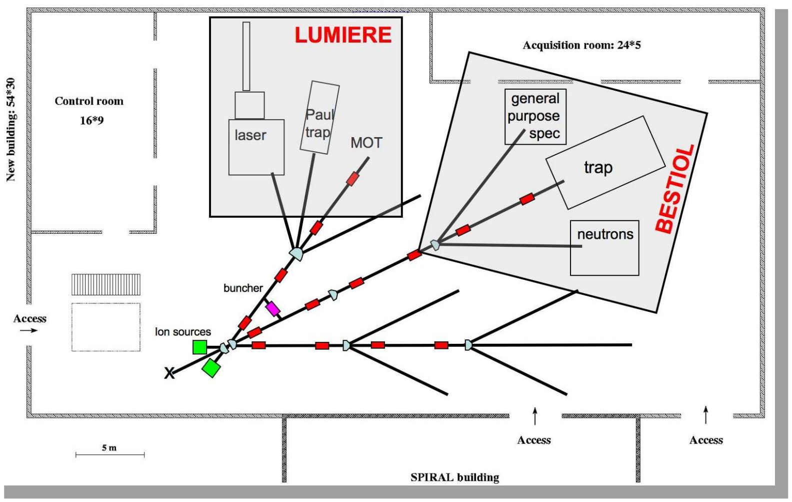
Regions of the Chart of Nuclei Accessible with SPIRAL 2 Beams : LINAG & RIB



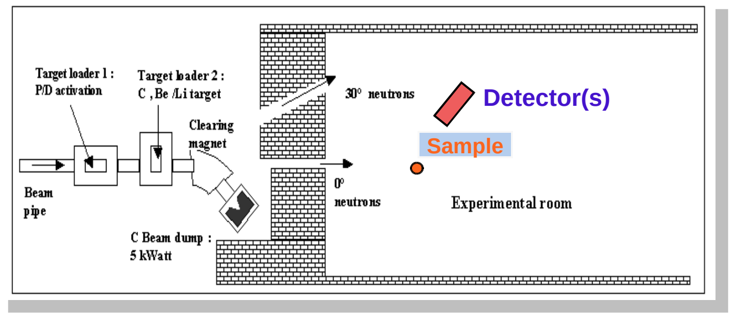
New detectors (Main Collaborations)

SPIRAL 2 Letters of Intent: 600 physicists, 34 countries

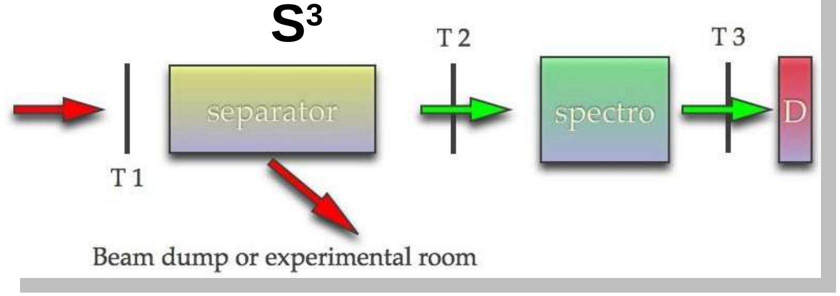
DESIR



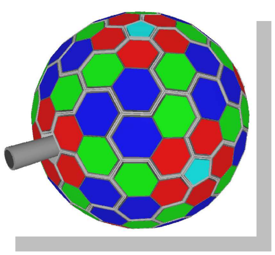
NFS (SPIRAL 2 n-tof facility)



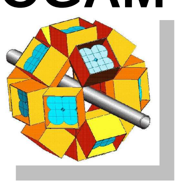
S^3



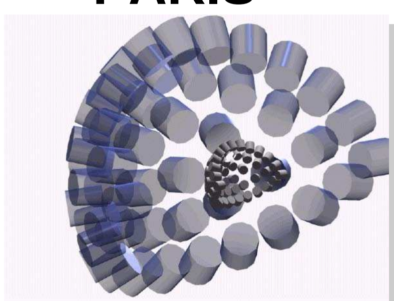
AGATA



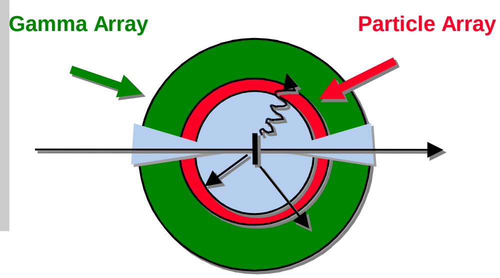
EXOGAM 2



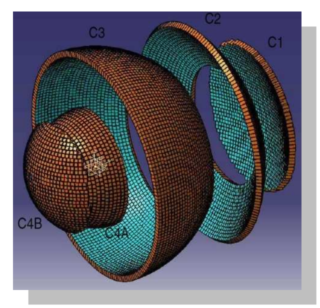
PARIS



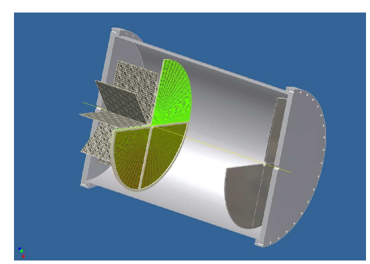
GASPARD



FAZIA



ACTAR



SPIRAL2 new detectors

Meeting on Front End Elec./DAQ for SPIRAL2 new detectors
Saclay, March 26th, 2008

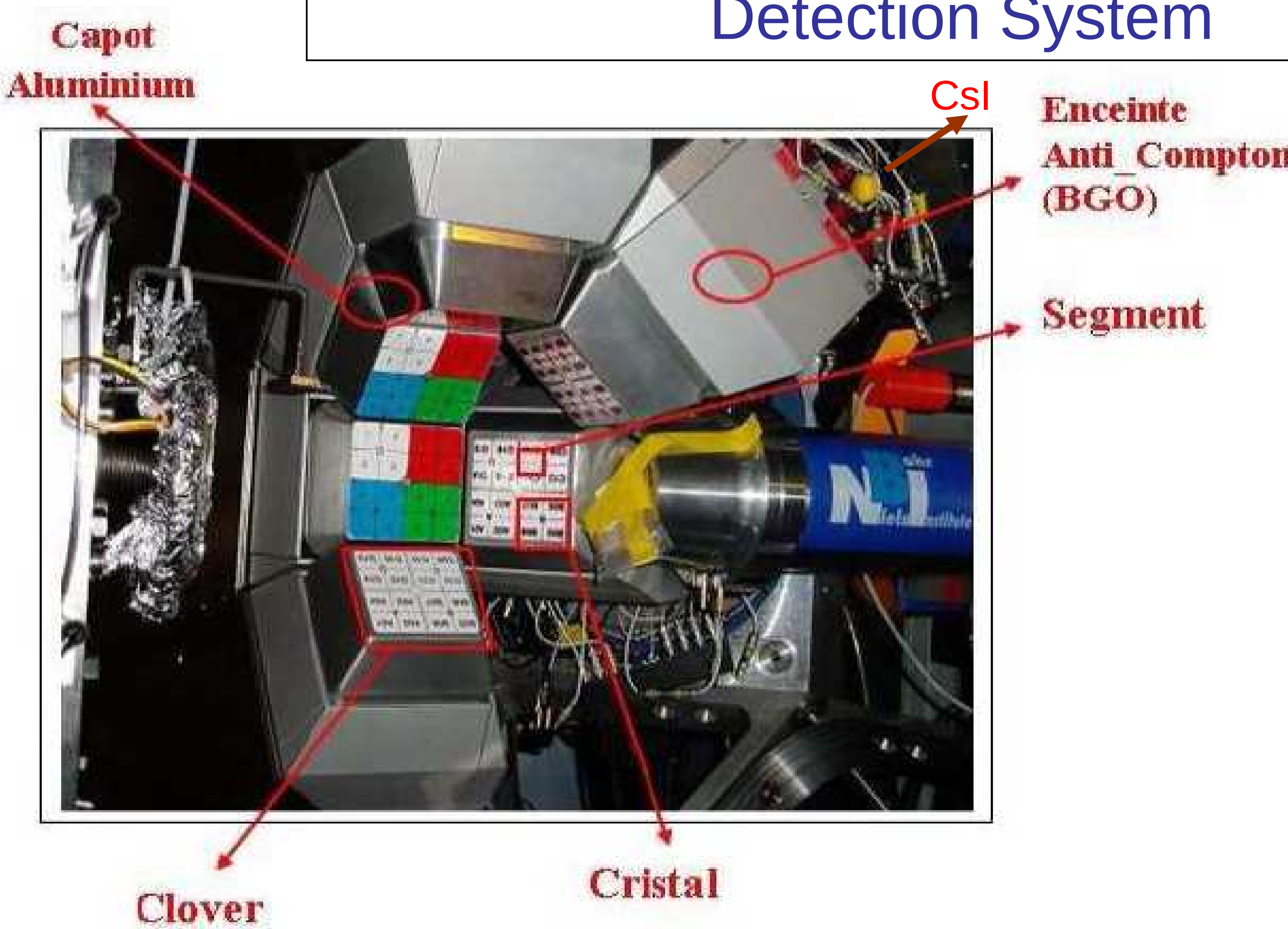
3 classes

• Those which can operate with existing electronics and acquisition: no need for specific developments
(NFS, DESIR, IREA, S3)

• Those where the developments have already been done or are under way: AGATA, EXOGAM2, FAZIA

• Those which need important developments:
ACTAR, FAZIA, GASPARD, PARIS

EXOGAM2
Global architecture
Detection System



Picture from « Rencontre des jeunes chercheurs la houche 2007», Doan Quang Tuyen

EXOGAM2

Motivations and specifications

- <u>Motivations:</u>

1) <u>Better location of gamma interactions:</u>
   => rise time and mirror charge of outer CSP signals => digital electronics.

2) <u>Dead time reduction :</u>
   => fast link for data readout
   => triggerless mode

3) <u>High counting rates</u>:
   => ADONIS method for energy measurement

4) <u>Radioactive environment :</u>
   => Sensitive electronics outside the cave

5) <u>VXI electronics reliability :</u>
   => DT32 readout problems => dead time increase
   => 10 years old VXI Electronics => obsolete components, lack of experts (GOCCE, ECC, ESS, Trigger, STR8032 and STR8080)

EXOGAM2

Motivations and specifications

- <u>Specifications</u>:

1) <u>Parameters:</u>
   - Inner: E6MeV, E20MeV, Time, Time Stamping
   - Outers: E6MeV, Emirror, T30, T60, T90
   - BGO : Energy, veto
   - CSI: Energy, veto

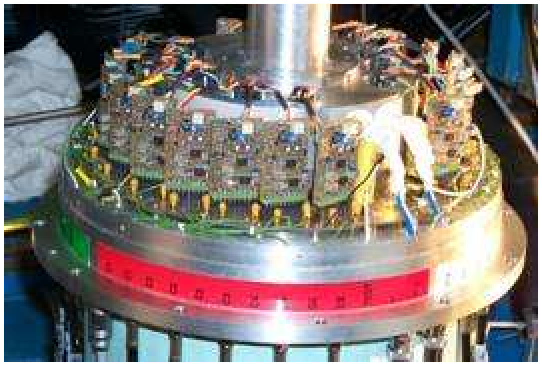
2) <u>Counting and data readout rate:</u>
   - Maximum counting rate: 100kHz per crystal
   - Maximum data readout rate, (about 30 Bytes per crystal) : 3 MB/s per crystal

3) <u>Trigger considerations:</u>
   - Triggerless: Crystal parameters validation from inner discrimination signal
   - Event trigger: Event validation from multiplicity signal
   - Common dead time: Event validation from EXOGAM2 multiplicity and ancillary detectors signals

4) <u>High counting rate spectroscopy :</u>
   - ADONIS (Algorithmic Development framewOrk for Nuclear Instrumentation and Spectrometry) : Energy processing based on a Kalman filter.
   - Main benefits: no tuning versus ICR, no balistic deficit.

EXOGAM2
Global architecture

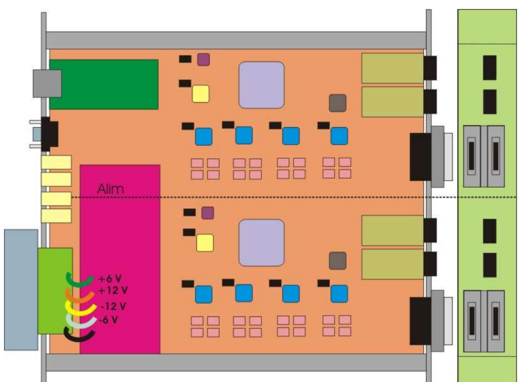
16 clovers = 64 crystals



Charge Sensitive Preamplifiers

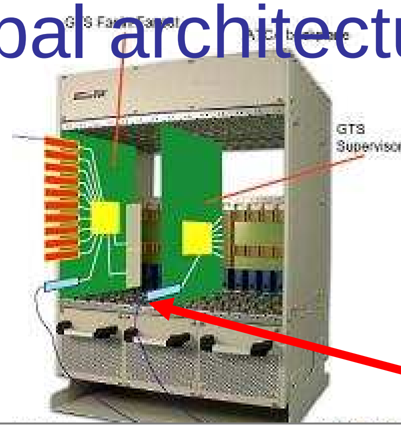
- **7 differential analog signals per crystal**
- **CR: 100kHz per crystal**

Fast Analog to Digital Conversion



2 crystals / 1 NIM board
=> 32 NIM boards

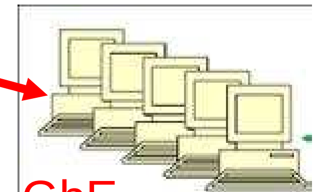
Optical links
1.4 Gb/s per ADC channel



The GTS hierarchy

1. the root node
2. the backplane
3. the fanin-fanout nodes
4. the fibre connections
5. the mezzanine interface

Global Trigger and Synchronization



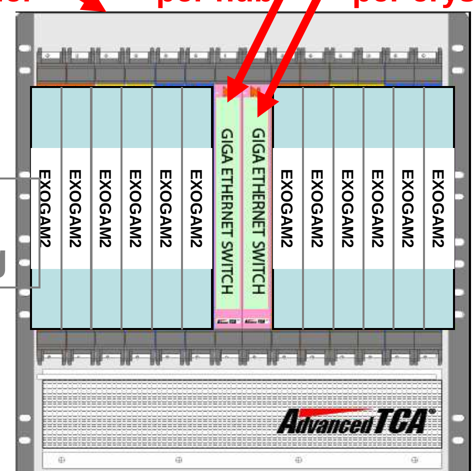
GbE

1 link per ATCA carrier

1 link per hub

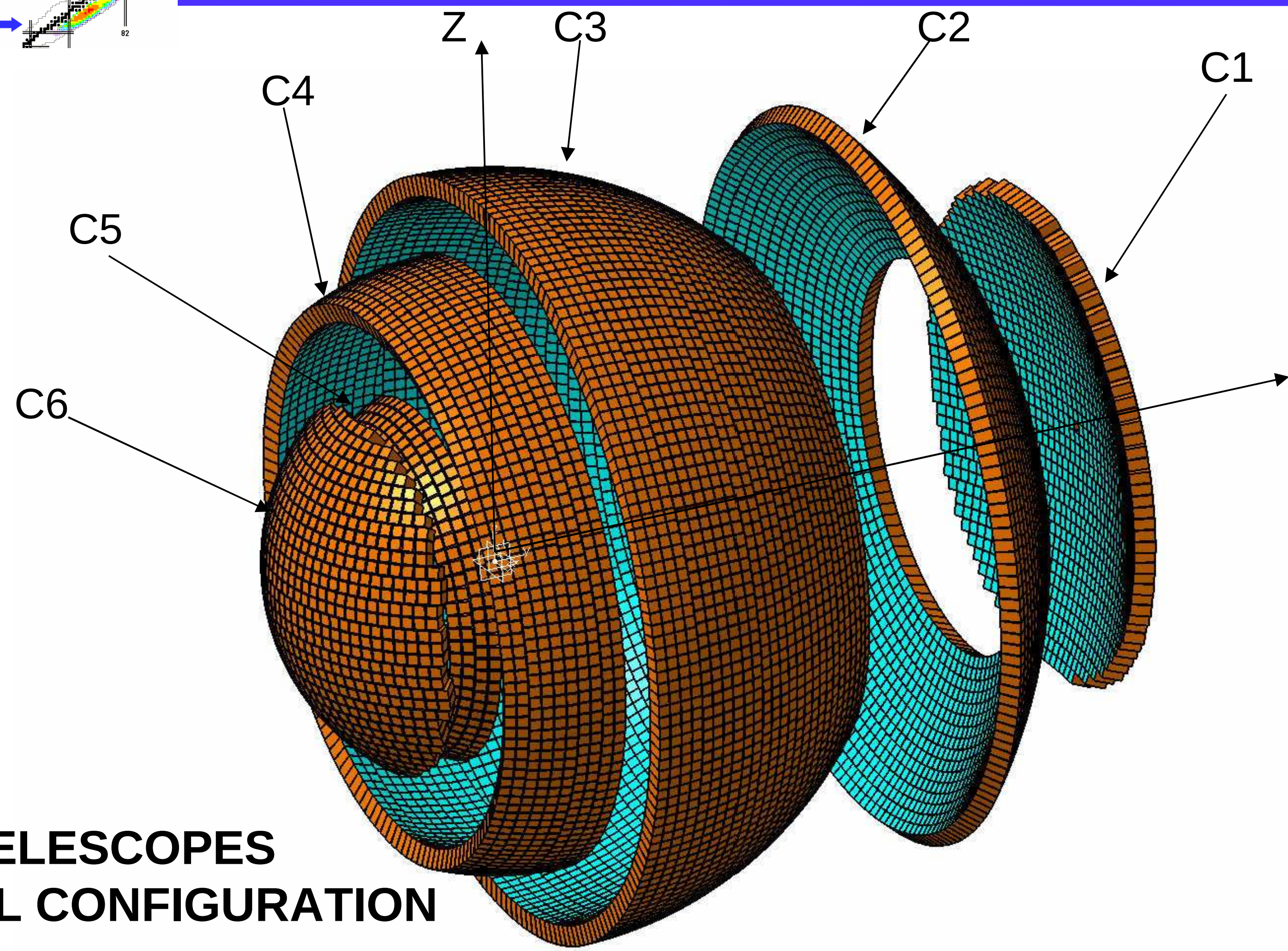
3MB/s per crystal

Digital Processing



1 clover / 1 ATCA carrier
=> 16 carriers

FAZIA



10934 TELESCOPES
EURISOL CONFIGURATION

TELESCOPE → 300µm Si + 500µm Si + CsI

FRANCE, GANIL, LPC Caen, IPN Orsay
ITALY, INFN Firenze, Bologna, Napoli, Catania
POLAND, SPAIN, ROMANIA

PLANNING OVERVIEW

PHASE 1: 2006 / 2007

TEST OF A TYPICAL TELESCOPE, PREAMPLIFIERS AND DIGITAL FRONT END ELECTRONICS

EXPERIMENT WITH 4 TELESCOPES IN LEGNARO

PHASE 2: 2008 / 2011

PROTOTYPE ARRAY R§D WITH 32 TELESCOPES

PHASE 3: 2011 / 2012

DEMONSTRATOR PI / 2 PI WITH SPIRAL / SPIRAL2

PHASE 4: FROM 2012 / 2013

FULL 4 PI ARRAY DETECTOR

R. Bougault, LPC Caen

PARIS

http://paris.ifj.edu.pl

Title: High-energy γ-rays as a probe of hot nuclei and reaction mechanisms

Spokesperson(s) *(max. 3 names, laboratory, e-mail - please underline among them one corresponding spokesperson):*
Adam Maj, IFJ PAN Krakow, Adam.Maj@ifj.edu.pl
Jean-Antoine Scarpaci, IPN Orsay, scarpaci@ipno.in2p3.fr *(EXL and R3B contact)*
David Jenkins, University of York (UK), dj4@york.ac.uk

GANIL contact person
Jean-Pierre Wieleczko, GANIL, wieleczko@ganil.fr

PARIS

Specifications:
Fusion-evaporation (mainly), 5% < v/c < 20% (mainly)
But also v/c=0 and v/c=40-50% (in case we use it at FAIR)

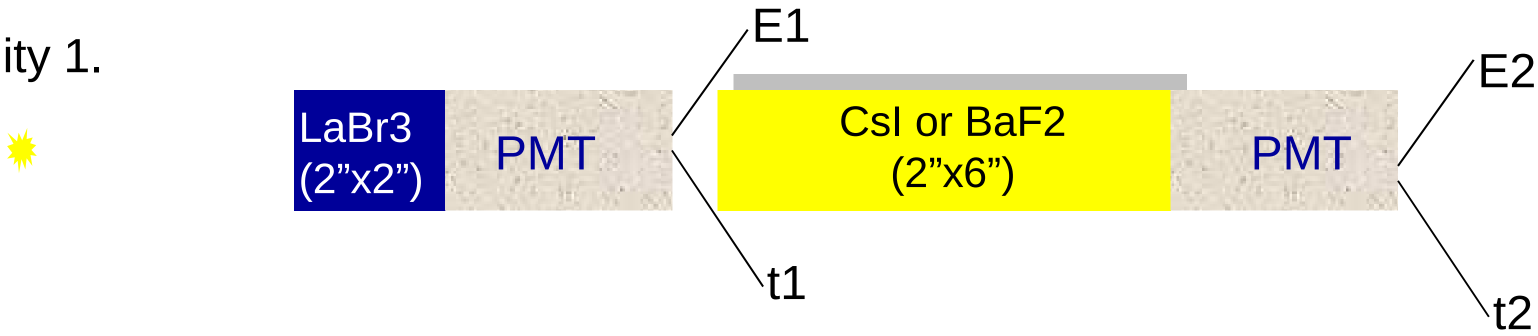
Inner sphere (gamma multiplicity, time definition, medium resolution spectroscopy 1- 10 MeV, calorimeter)
$LaBr_3$ – to obtain energy resolution ca.1% at 10 MeV (3% at 1 MeV) and time resolution better than 250 ps
Distance form target: **15-20 cm** (for n-γ ToF discrimination)
Granularity: 100-200 crystals ca. 2” long – for Doppler correction and good fold resolution
Solid angle coverage: 3π-4π

Outer sphere: high energy spectroscopy (1-50 MeV),
BaF_2, CsI(Na), - to obtain high effciency for large energy range
Distance from target: 20-35 cm (for n-gamma ToF discrimation)
Granularity: 50-200 crystals ca. 6” long
Solid angle: 2π-4π

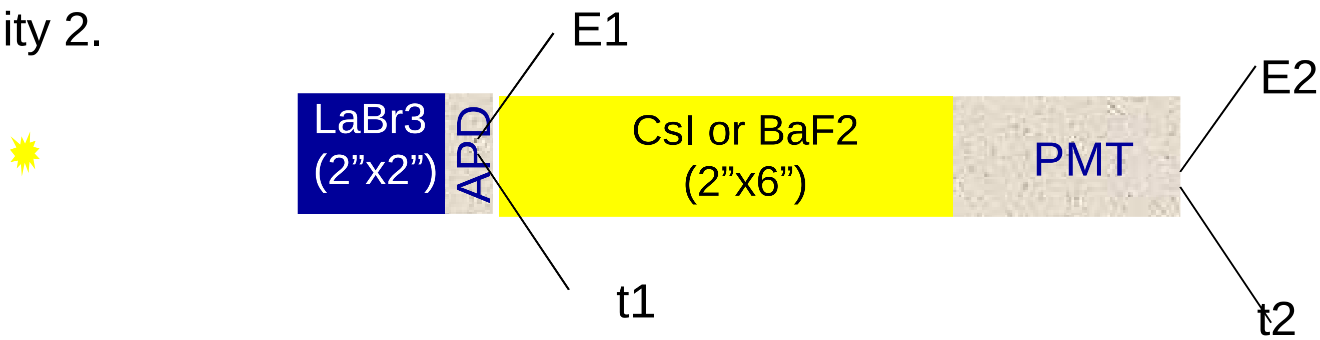
Both spheres shall be modular for easy coupling to other detectors (e.g. AGATA)

3 POSSIBILITIES FOR A „GAMMA-TELESCOPE" SEGMENT

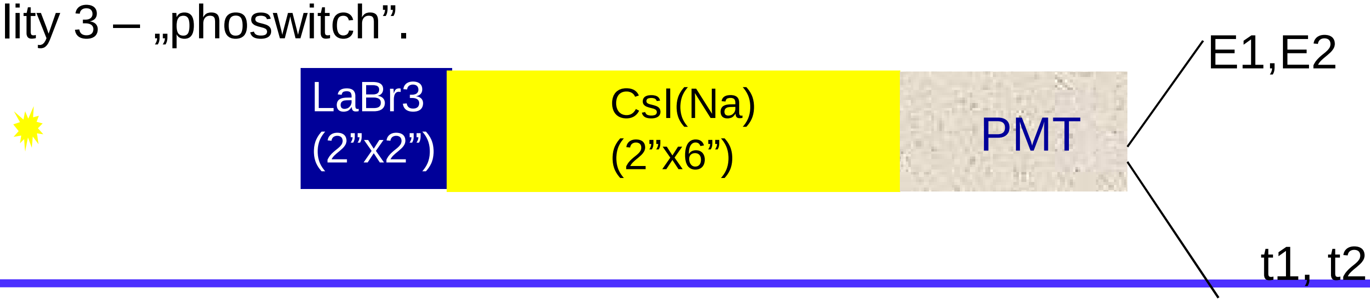
Possibility 1.



Possibility 2.

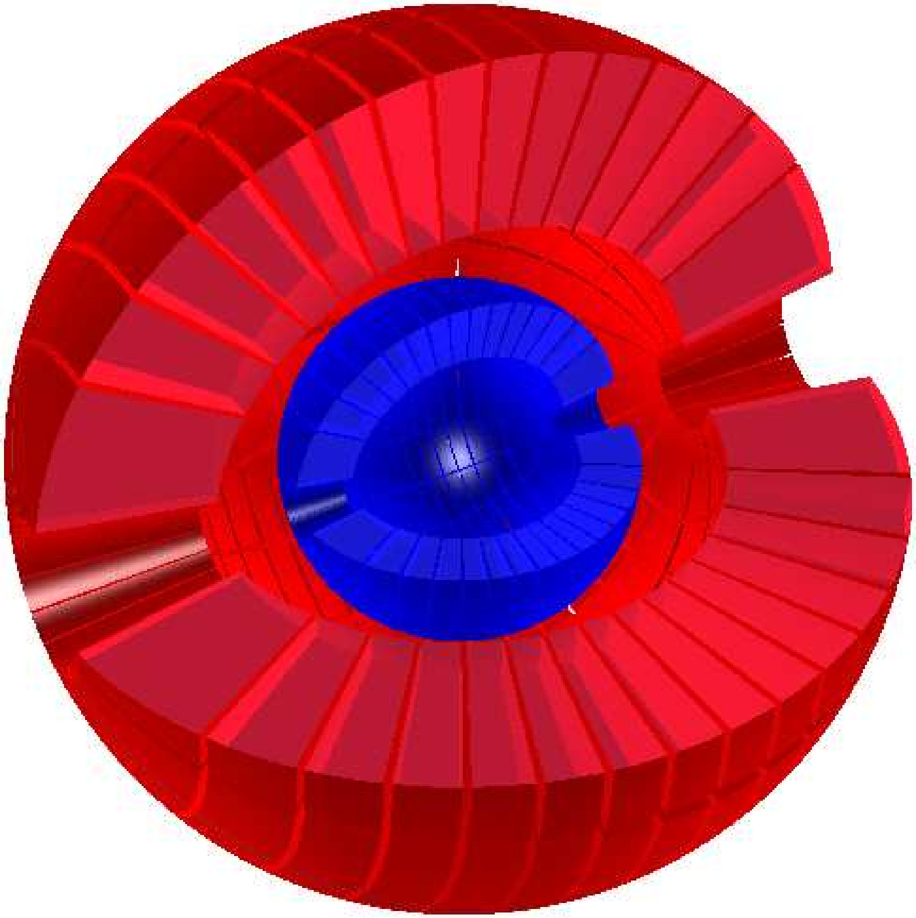


Possibility 3 – „phoswitch".



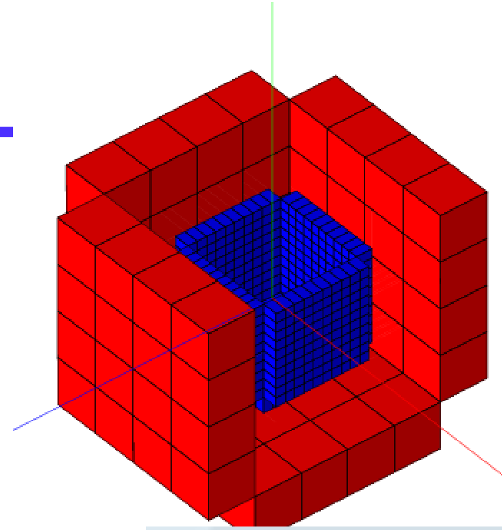
2 POSSIBLE GEOMETRIES of WHOLE PARIS

Spherical (e.g. same as AGATA modules)

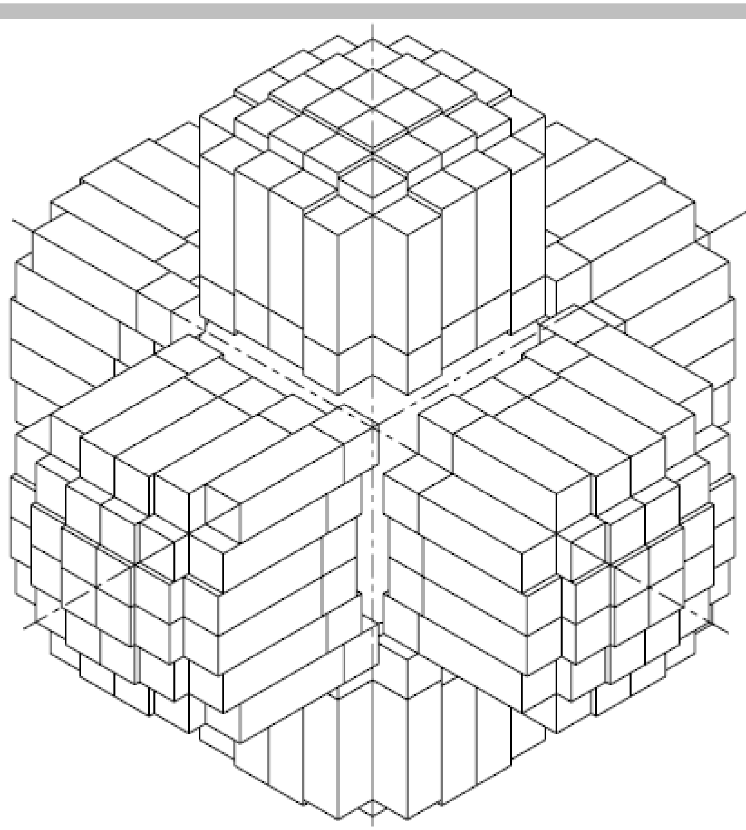


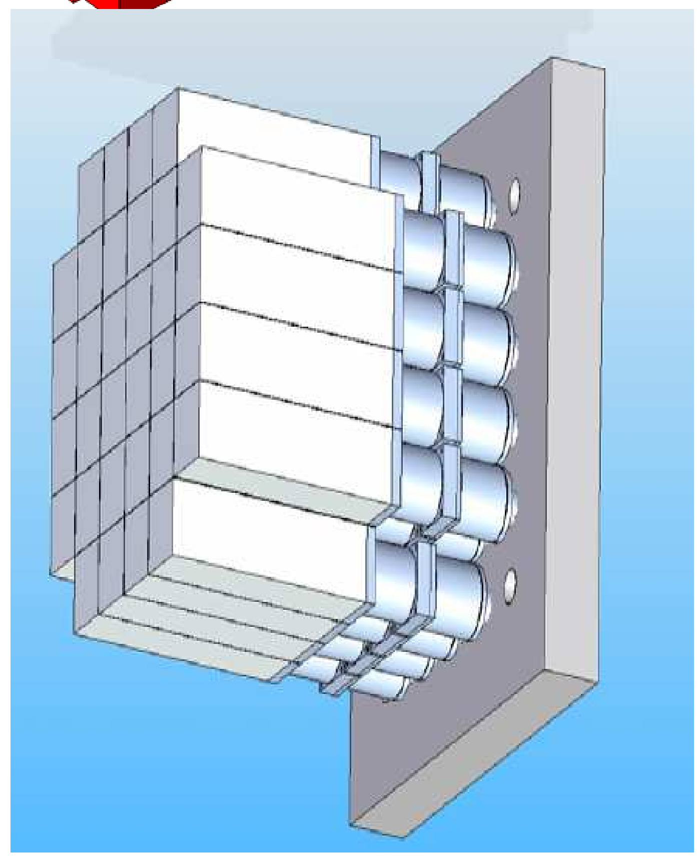
Courtesy of A. Maj for the PARIS collaboration

Cubic (offering variable geometry)



200 „phoswitches"

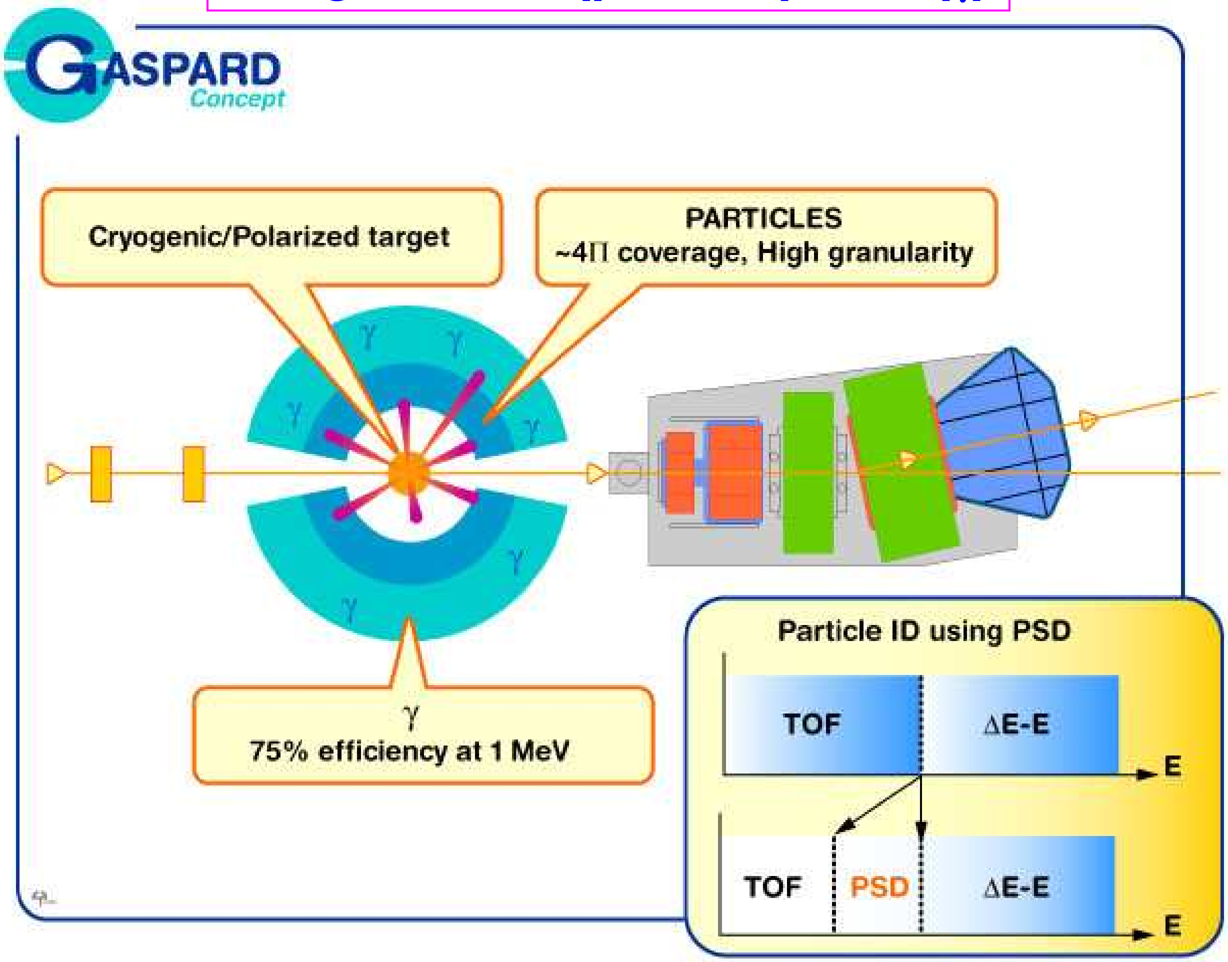




Courtesy of A. Maj for the PARIS collaboration

GASPARD

Integrated 4π (particle) + 4π (γ)



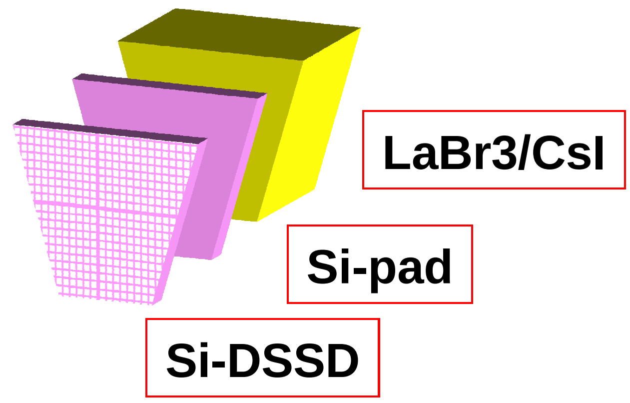
- **Energy resolution with SPIRAL2 beams Thicker targets**
- **Multireaction capab.**
- **Improve PID for low E particles**
- **Modularity Coupling with other devices (neutron, AGATA,..)**

Courtesy of D. Beaumel for the Gaspard collaboration

Particle Array Specifications

- **Position resolution**
  500 μm resolution over ~4π
  5mm for 2nd stage
  100 μm in forward direction
- **Energy resolution – dynamic range**
  < 40 keV
  100 keV – 1 GeV
  Multidynamic ranges and shaping
  low threshold
  good linearity
- **Particle ID**
  - **0.2-2MeV/u: TOF (ΔT~200ps)**
  - **PSD above 1.5-2 MeV/u**
  - **E-DE beyond punch-through**
- **Low Mass budget**
  Low γ-ray absorption in the mechanics and FEE
  but lots of electronics channels → A CHALLENGE !

3-stage concept



~ 15000 channels

Shorter flight distance → more compact !

Gamma Array Specifications

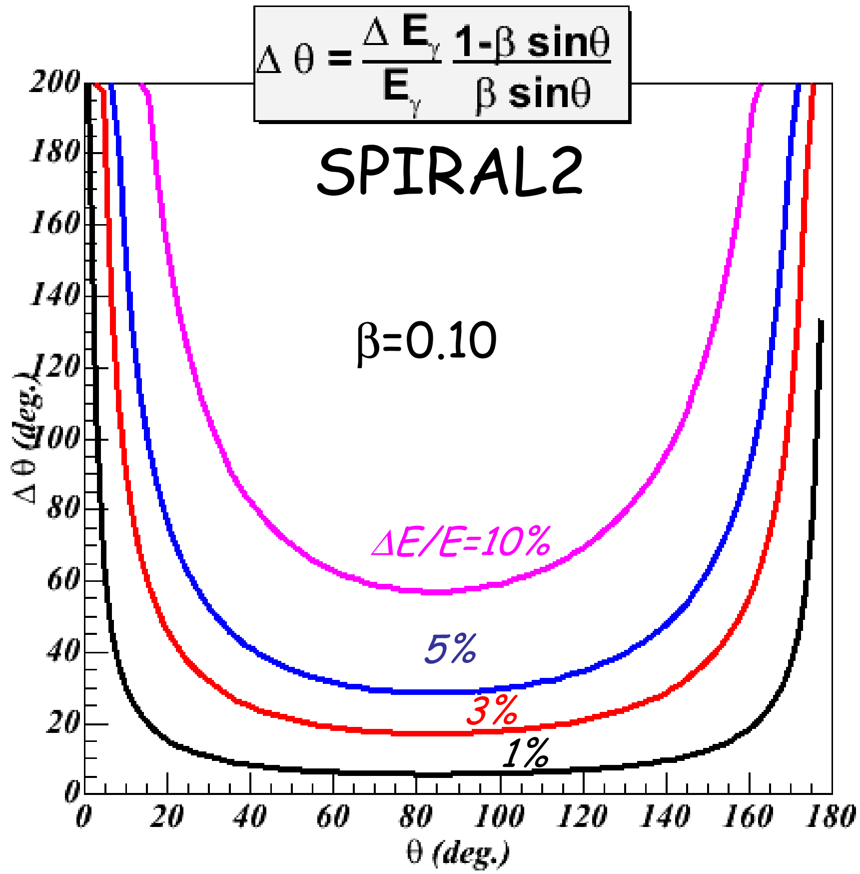
- **Energie resolution**
  - better than 50 keV (FWHM) for 1 MeV gamma-rays

- **Dynamic range**
  - 0.1 to 5 MeV for gamma-rays
  - Stops high energy light particles (~100MeV)

- **Total detection efficiency**
  - ~ 75% for 1 MeV gammas

- **Granularity**

  NOT determined by Doppler
  - Multiparticle events detection
  - Particle-gamma pile-up
  - Technical aspects (size of APD/PMT,…)

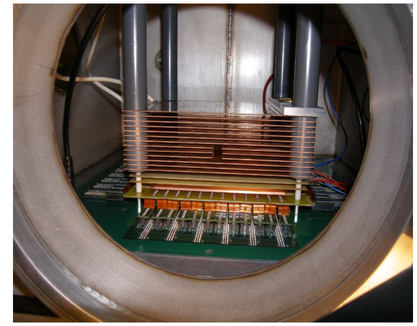


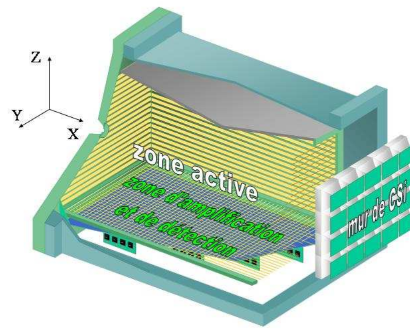
ACTAR

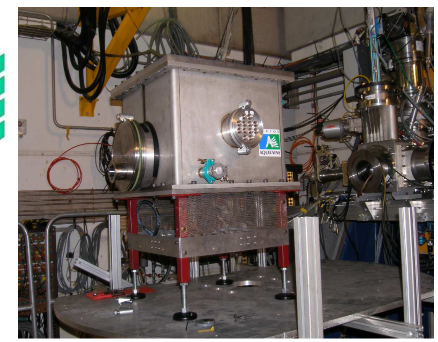
JRA (FP6) + LoI SPIRAL2 + …FP7 (EXID)

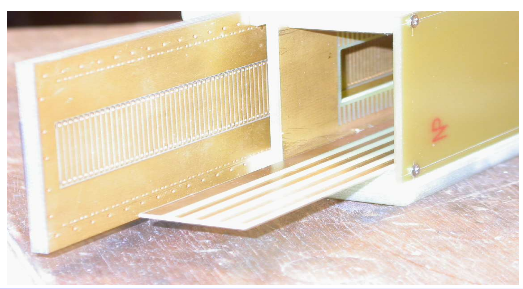
12 institutions (France, Spain, UK, Germany, Poland)

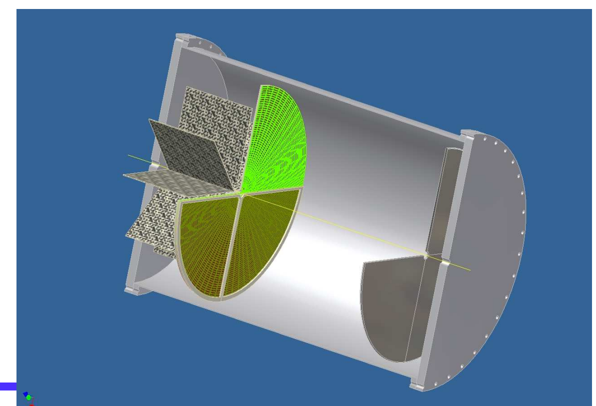
GANIL, France
CENBG Bordeaux, France
DSM/IRFU Saclay, France
IPN Orsay, France
Subatech Nantes, France
University Santiago de Compostela Spain
University Liverpool UK
Daresbury Laboratory, STFC, UK
University of York, UK
University of Birmingham, UK
GSI Darmstadt Germany
Krakow, Poland









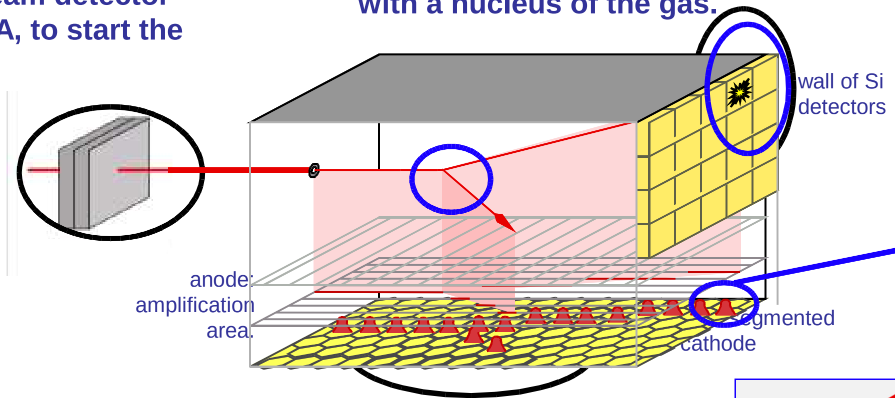


MAYA principle

there is a beam detector before MAYA, to start the DAQ.

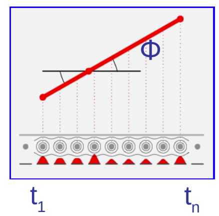
the projectile makes reaction with a nucleus of the gas.

the light scattered particles do not stop inside, and go forward to a wall made of 20 Si detectors, where they are stopped, and identified.



COG over 3 axes

the product leaves enough energy to induce an image of its trajectory in the plane of the segmented cathode.



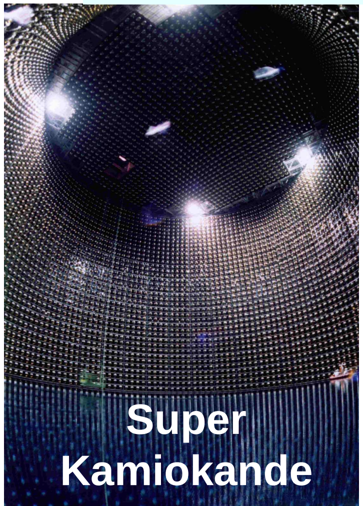
we measure the drift time up to each amplification wire. The angle of the reaction plane is calculated with these times.

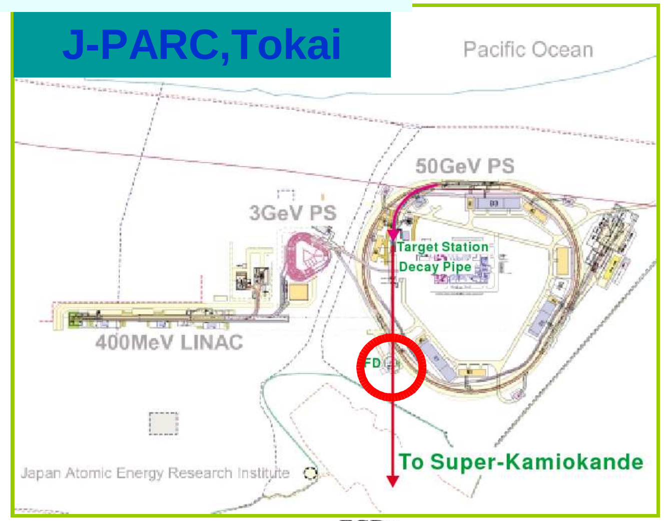
- **Si-wall (20 Si), CsI-array (20 csi)**
  Pulse height (~energy loss)
- **Anode wires**
  Pulse height,
  drift time (time from incident beam by PPAC) provide y-coordinate
- **Pads (32 x32)**
  Pulse height, provide x-z coordinates
- **Three dimensional track of a charged particle is determined from wires and pads data.**

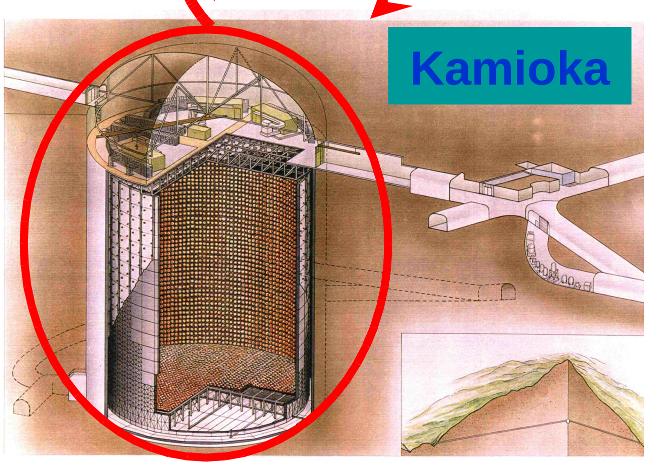
The T2K experiment

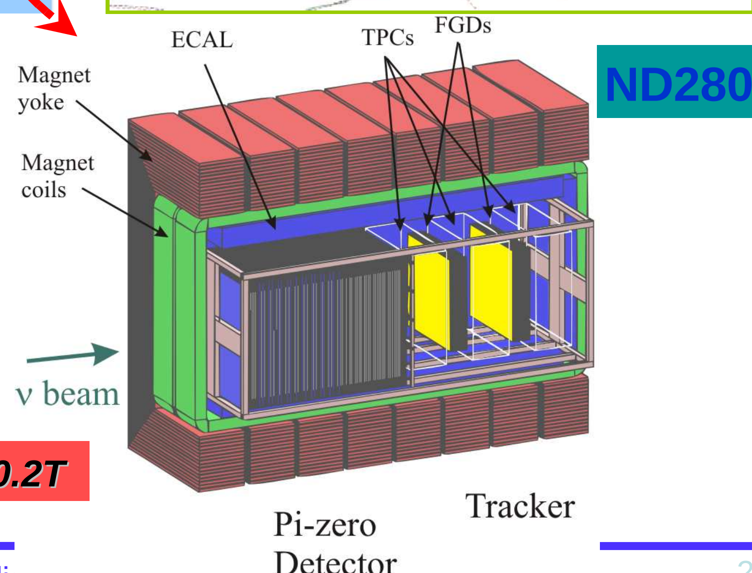
Time schedule:
Q3 2009

- **Goal: Study of neutrino oscillation**
- **J-PARC: 50GeV synchrotron (under construction)**
- **ND280m: Near detector at 280m from the neutrino production target**



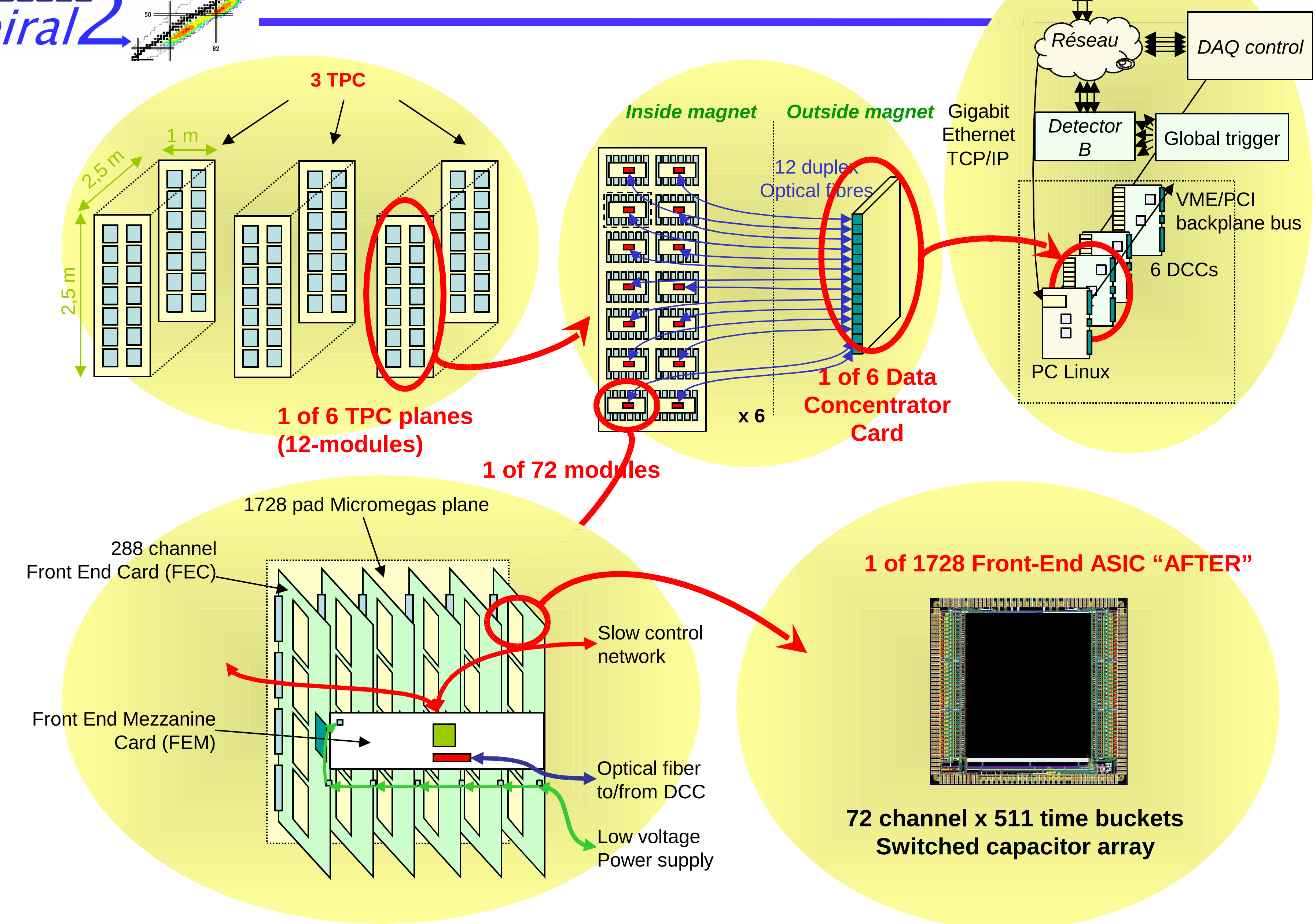




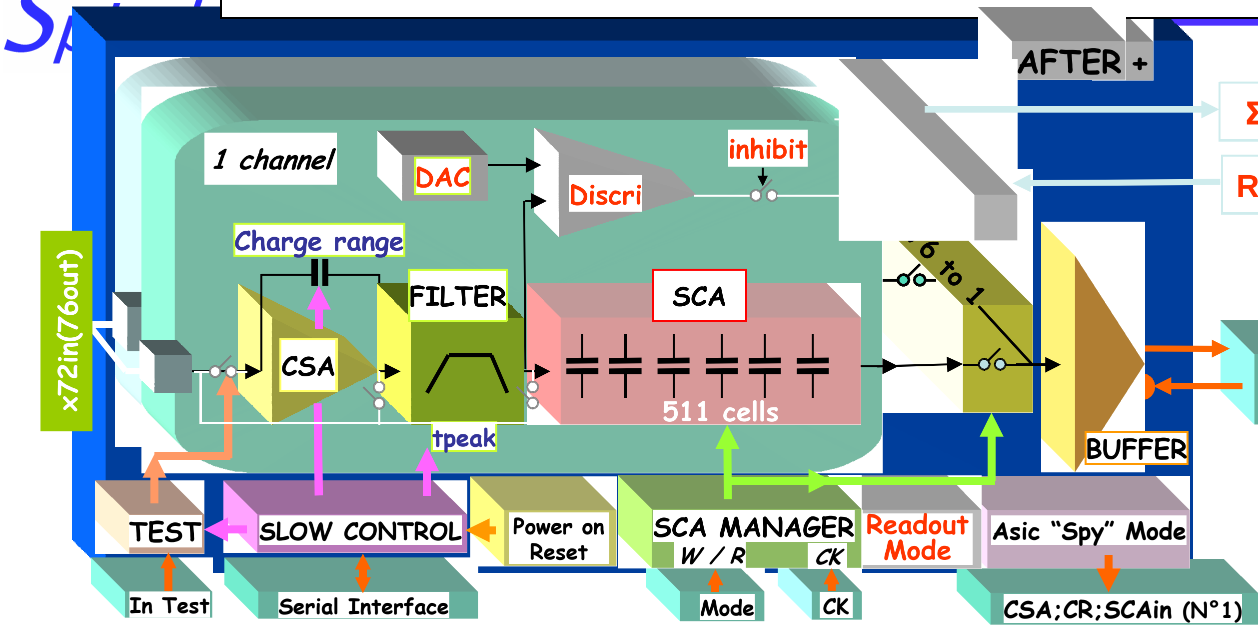


Magnet Field: 0.2T

T2K Read-out Architecture



AFTER(+) Architecture



external 12-bit ADC [AD9229]

Main features for AFTER:

- **Input Current Polarity: positive or negative**
- **72 Analog Channels**
- **4 Charge Ranges: 120fC to 600fC**
- **16 Peaking Time values: (100ns to 2µs)**
- **511 analog memory cells / Channel:**

Fwrite: 1MHz-50MHz(100MHz);

Fread: 20MHz

- **Readout mode: 76*511 SCA cells**

Additional features for AFTER+:

- **Charge Ranges: 120fC to 10pC**
- **Auto Triggering:**
- **discriminator + threshold (DAC) per channel**
- **Analog OR of the 72 discriminator outputs.**
- **Address of the hit channel**
- **Readout mode:**
- **76*511 SCA cells**
- **Hit channel**
- **Number of N channels**
- **SCA cells: 511, 256 or 128.**
- **Possibility to bypass the CSA => Filter or SCA input.**

ACTAR Read-out Architecture

• Readout plane

T2K module:

- **36 cm x 34 cm; 1726 pads (9.65 mm x 6.85 mm)**

ACTAR readout plane:

- **20 cm x 20 cm; 10000 pads (2 mm x 2 mm)**

• Event Rate

T2K:

- **0.3 Hz**

ACTAR:

- **1 kHz**

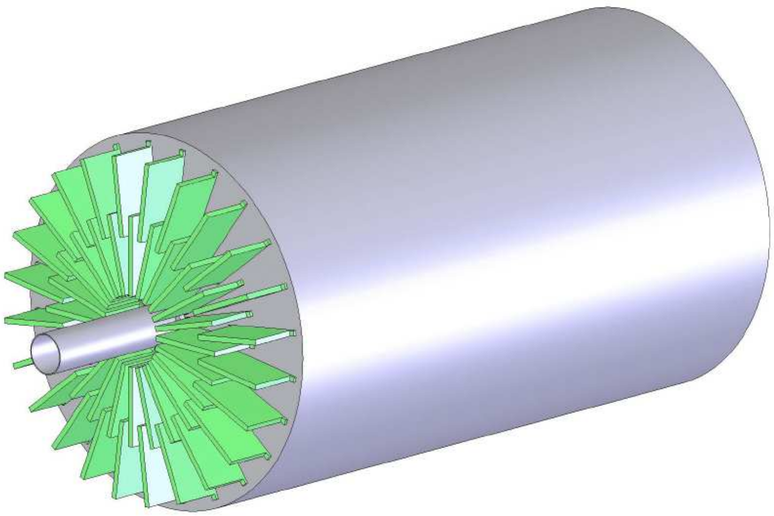
• Readout management

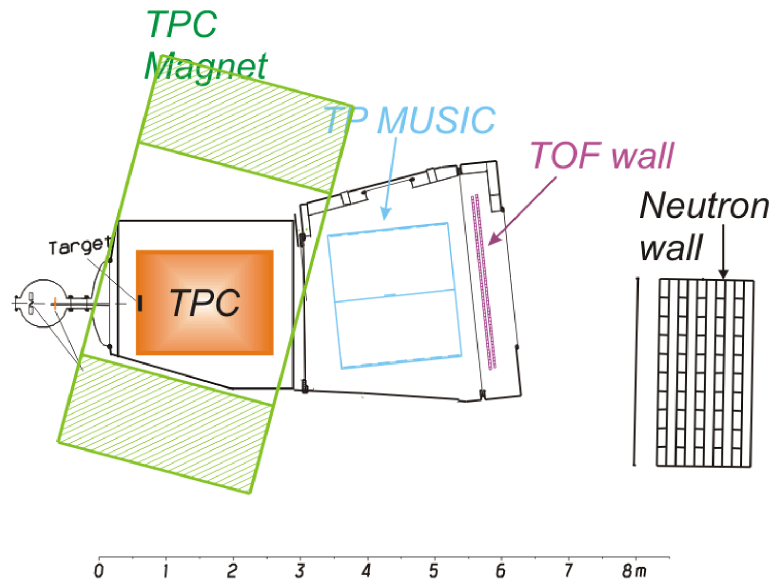
ACTAR:

- **Multiplicity**
- **Selective readout (specific channels)**

=> not compatible with the T2K architecture

Synergies…

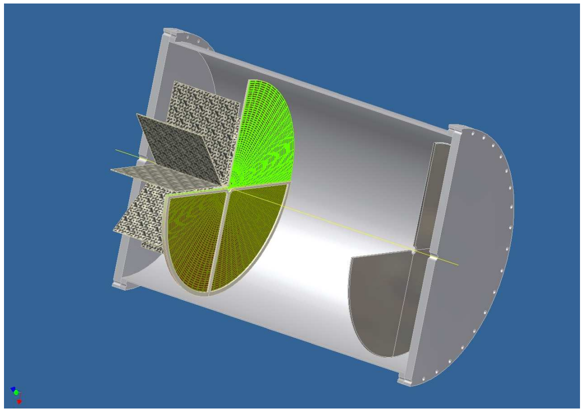


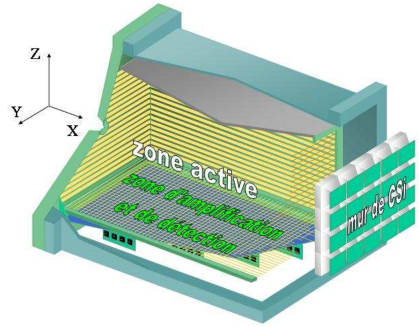


SAMURAI TPC, RIKEN

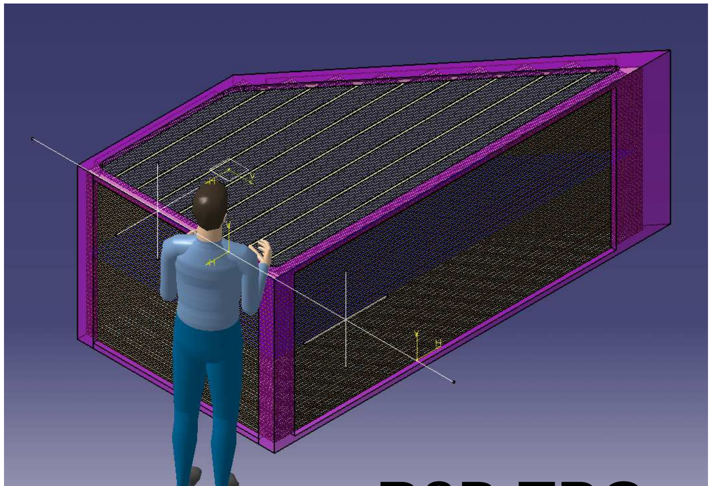
Fig. 1

AT/TPC MSU





ACTAR?



R3B TPC

Specifications summary

	ExogamII	DESIR	ACTAR	PARIS	AGATA	FAZIA	GASPARD	S3
1.Number of Channels (+/- 20%)	512	A few hundred	10000	1000	6840	5000-20000	15000	1603
2.How many detector types are you considering?	HPGe (BGO, CsI)	Plastic scintillators , gas, Ge, Si, BaF2, NaI…etc	Gas detector (Si, CsI, LaBr)	Scintillators: LaBr3, CsI(Na) or BaF2	AGATA (will be coupled to additional Detectors)	Si/Si/CsI(Tl)	Thin DSSD,Si, LaBr3	Si (<1000) Ge(<100) Tr(<503)
Capacitance Min & Max	10 pF		~0.1 pF per pad	–		100-500 pF	1-100 pF	?
Radiation damage for electronics – is this a problem?	To be studied	No	No	No	No	No	No	No
Gamma absorption – is this a problem?	No	No	Possibly	Possible	Yes (add. Detectors)	No	Yes	Yes
In what environment for the electronics	–	–	–	?	–	–	–	–
Vacuum	No	No			No	Yes	Yes	Yes
Gas (flammable?)	No	No			No	No	No	he/h2 if gas sep.

Specifications summary

	ExogamII	DESIR	ACTAR	PARIS	AGATA	FAZIA	GASPAR	S3
Where will you put the electronics?	Preamps in the detector modules. Digitizers in NIM crates at 5-10m. Preprocessing (ATCA) at any dist.	In air	Outside the gas volume, in air (preamp in gas ???)	In air	Preamps in the detector modules. Digitizers at 5-10 meters. Preprocessing (ATCA) at any distance.	FEE in Vaccum + cooling	Preamp close to detectors, rest at the back of the last stage	Si possibly in chamber, Ge outside, Tr in chamber
Channel polarization +/- ve	+3500V for core electrode, 0 for segments	Both	Both	Both	+5000 for core elect. 0 for segments	+100-300	50-300	?
Current drawn	<< 1nA			?	<< 1nA	< 1µA	1-100nA	?
Mean event rate on detector	Not applicable	Not more than 1000 pps	1000 to 100000	1000 to 100000	Few Khz	<1000 per s	Few 100 -few 10e4	Si,Tr 10-10000, Ge 1-1000
Total data rate	3Mb/s per Crystal → 30Mb/s (10 Crystals)	1000 pps	< 1000	< 1000	100 MB/s (after tracking)	< Gb/s		?
Max counting rate/channel	100 Khz	1000 pps	100	100- 1000	10-50 Khz	<5000 per s	Few 100	Si, Tr:100, Ge:10
Average rate/channel	–	10-100 pps	Few /s	few/s	10 Khz	< 100 per s	02/10/2012	Si, Tr:1

Specifications summary

	ExogamII	DESIR	ACTAR	PARIS	AGATA	FAZIA	GASPAR	S3
Are you considering RDT?	Yes	No	No	Possibly	Yes	?		Yes
What kind of Pre-amp Current or Charge	PAC	Mainly Charge	Charge	?	Charge	Current & charge	Both	Current & Charge
Resolution needed	1.2 keV for 200 KeV 2.3 KeV for 1.33 MeV	1/10000	600 e rms	?	1/1000	50 to 100 KeV	(2 KeV-30 KeV/Si) (<50KeV / 1MeV)	Si : ~1 ns,Ge:1ns, Tr:10% (charge) & 100ps (time)
Integral non linearity	5 LSB		< 2 %	< 5 %		< 0.001	Few 10e4	?
Differential non linearity	2.5 LSB	5,00E-005			5,00E-005	? LSB		Ge:5e-5
Coding – into how many channels?	512	4k			6840	20000		16384
information type (wave form, Energy, time….)	W, E, T	E, T maybe W	W, E, T	W, E, T	W, E, T	W, E, ToF	W, E, T	Si(W,E,T), Ge(E,T,W possible)

Specifications summary

	ExogamII	DESIR	ACTAR	PARIS	AGATA	FAZIA	GASPAR	S3
Min charge/keV/na	~ 40 KeV	10 KeV	0.1 pCb	100 KeV(1 MeV)	< 5 KeV	0.5 MeV	100 KeV	Si <50 KeV,Ge & Tr ~few KeV,
Max charge/keV/na	~ 6 MeV or 20 MeV (Two gains for Core contact)	10MeV	10 pCb	10 MeV (50 MeV)	20 MeV (150 MeV using TOT)	2 GeV	1 GeV	Si:20MeV, Ge:5MeV,Tr:1MeV
Characteristic collection time (ns or µs)	100 ns	ms	100ns up to 2 µs	100ns up to 2 µs	100 ns	Few 100ns	Few 100ns	Si & Ge:100ns, Tr:50ns
Are you considering sampling?	Yes	Yes	Yes	Yes	Yes	Yes	Yes (PSA)	Si & Ge:PSA
At what frequency?	100 Mhz	10-100Mhz	10 -100Mhz	10-100Mhz	100 Mhz	100Mhz (Charg) 1Ghz (Curr.)	100 Mhz (Charge) 1Ghz (Current)	Si > 100Mhz, Ge:100Mhz
3. Precision on the clock?	40 ps	100 pps	2 ns	2 ns	40 pps p-p	< 10ps	< 10ps	<100ps
4. How many bits?	14 bits				14	14 (Ch.) 10 (Curr.)	14 (Ch.) 10 (Current)	14

Specifications summary

	ExogamII	DESIR	ACTAR	PARIS	AGATA	FAZIA	GASPAR	S3
How many significant bits?	11,7 bits	12	12 bits	12 bits	12,3			12 to13
Over what time range?	Continuous	10 ms	5 μs to 50 μs	5 μs to 50 μs	Continuous	20 μ s(Ch.) 2 μ s(Curr.)	20 μ s(Charge) 2 μ s(Current)	Max 10 μs
What dead time are you requiring?	Full pipe-Lined system	Full pipe-Lined system	< 1ms	< 1ms	No dead time. Full pipe-lined system	Very low	Very low	No dead time
Do you have a discriminator/channel?	Digital discriminator	Yes	Yes	Yes	Digital discriminator	Yes	Yes	Si,Tr:yes, Ge:possibl
How many disc/channel	1 per Core signal	A few	One	One	1/ Crystal	2 (L & H) 3 (L & M & H)	One per strip/pad/crystal	1
Do you consider different level triggers		No	1 or/and 2	1 or/and 2		Yes		
Precision of the time stamping in psec?	10 ns	1 ns	< 2 ns	< 2 ns	10 ns	<50 ps (ToF)	<50 ps (ToF)	10 ps
Acceptable dead time	As Agata	1 ms	1 ms	1 ms	None	< 20%	< 30%	None

Specifications summary

- Number of channels: from 100 to 20 000
- Type of detectors: Si, CsI, NaI, BGO, BaF_2, LaBr, Ge, gas,plastic scintillators…
- Max event rate on detector: up to 100 kHz
- Max data rate: up to 100 Mbytes/s
- Information type: waveform, Energy, Time
- Sampling frequency: 100 MHz
- Dynamic range: 10^3, up to 10^4
- Characteristic collection time: 100ns-1 ms
- Maximum dead time: 1 ms