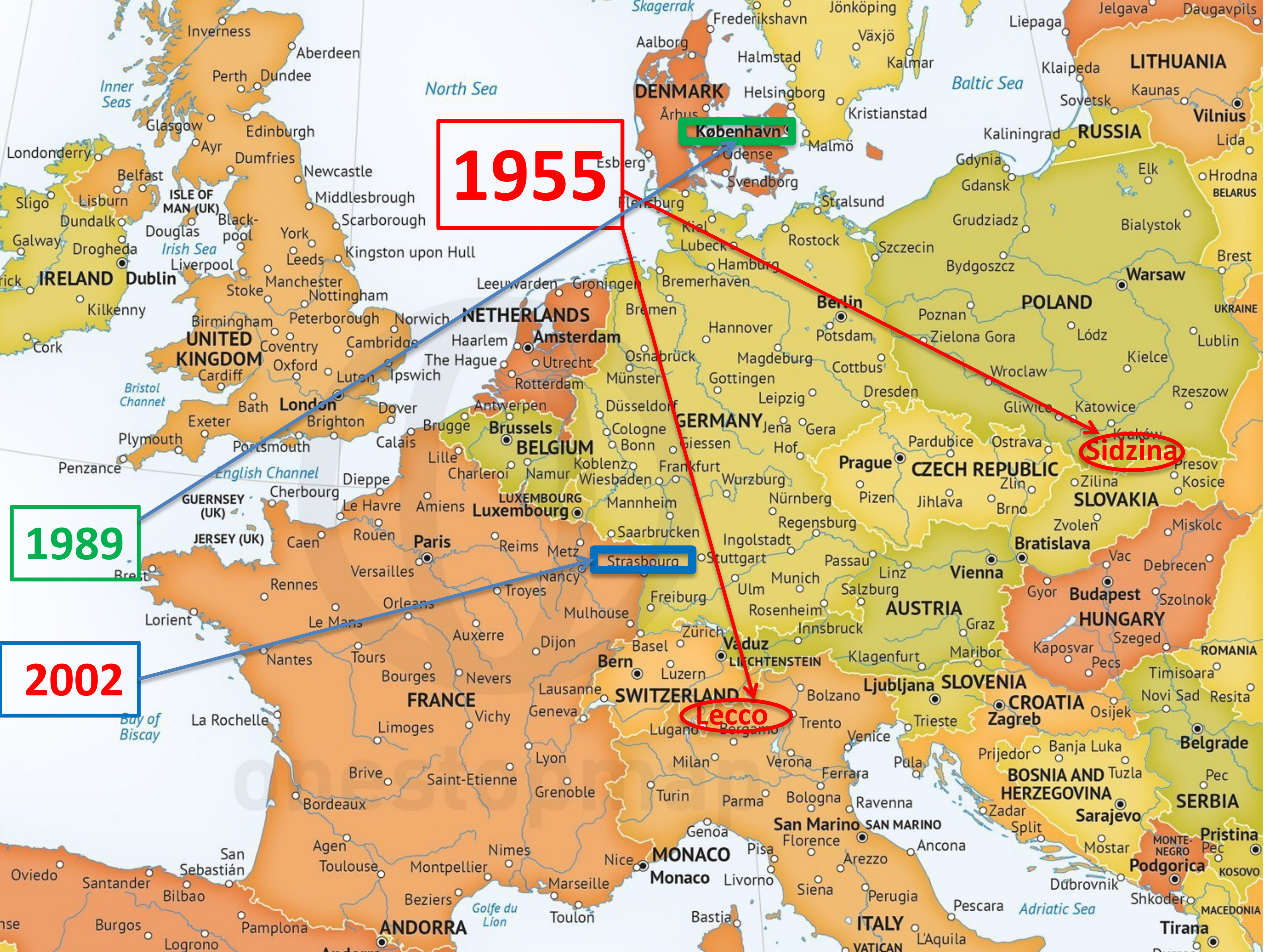
Friendship & γ-rays

Faical Azaiez (IPN-O)

IPN-LAL 60 1956-2016

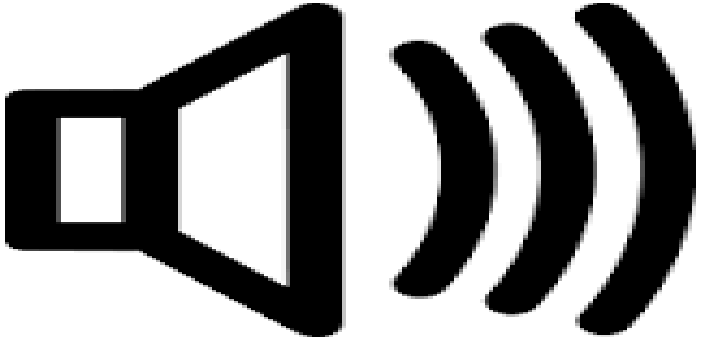
AB & AM are born with the accelerator based nuclear physics era (CERN , ORSAY etc…)

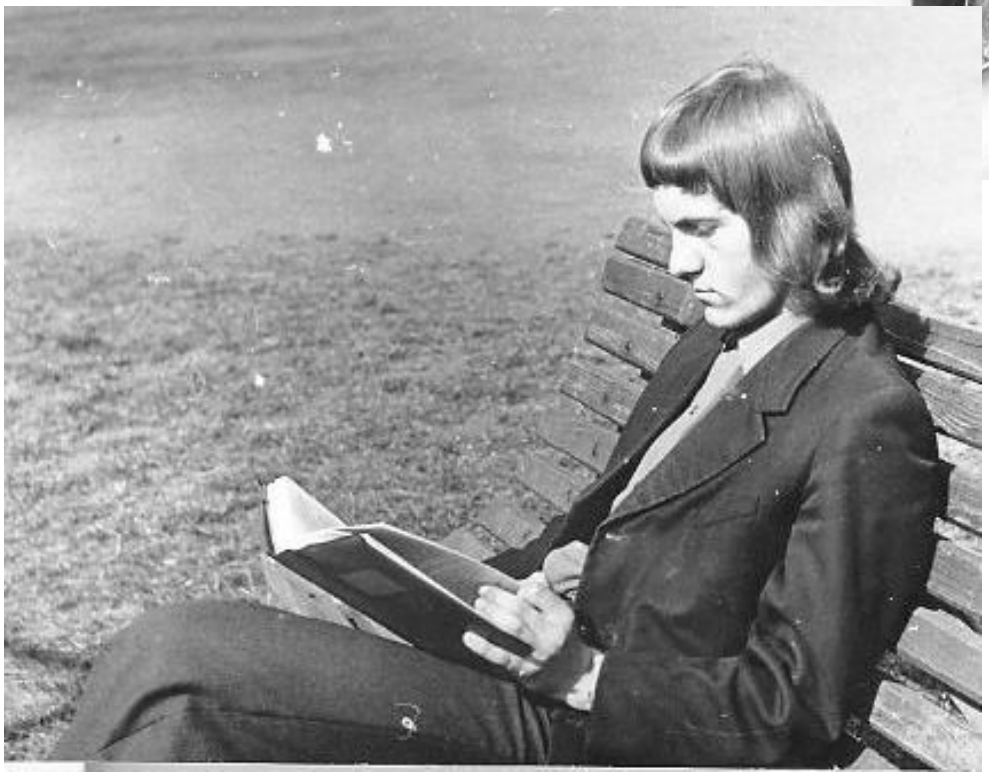


1955
1989
2002
København
Strasbourg
Lecco
Sidzina
North Sea
Baltic Sea
Skagerrak
Inner Seas
Irish Sea
Bristol Channel
English Channel
Bay of Biscay
Golfe du Lion
Adriatic Sea
IRELAND
Dublin
UNITED KINGDOM
ISLE OF MAN (UK)
GUERNSEY (UK)
JERSEY (UK)
DENMARK
NETHERLANDS
Amsterdam
BELGIUM
Brussels
LUXEMBOURG
Luxembourg
FRANCE
Paris
GERMANY
Berlin
POLAND
Warsaw
CZECH REPUBLIC
Prague
SLOVAKIA
Bratislava
AUSTRIA
Vienna
HUNGARY
Budapest
SWITZERLAND
Bern
LIECHTENSTEIN
Vaduz
SLOVENIA
Ljubljana
CROATIA
Zagreb
BOSNIA AND HERZEGOVINA
Sarajevo
SERBIA
Belgrade
MONTE-NEGRO
Podgorica
KOSOVO
Pristina
MACEDONIA
Tirana
ROMANIA
UKRAINE
BELARUS
LITHUANIA
Vilnius
RUSSIA
ITALY
VATICAN
SAN MARINO
San Marino
MONACO
Monaco
ANDORRA
Inverness
Aberdeen
Perth
Dundee
Glasgow
Edinburgh
Ayr
Dumfries
Londonderry
Belfast
Newcastle
Sligo
Lisburn
Dundalk
Galway
Drogheda
Douglas
Blackpool
Middlesbrough
Scarborough
York
Leeds
Kingston upon Hull
Liverpool
Manchester
Stoke
Nottingham
Kilkenny
Cork
Birmingham
Peterborough
Norwich
Coventry
Cambridge
Oxford
Cardiff
Luton
Ipswich
London
Bath
Exeter
Brighton
Dover
Plymouth
Portsmouth
Penzance
Calais
Brugge
Lille
Antwerpen
Leeuwarden
Groningen
Haarlem
The Hague
Utrecht
Rotterdam
Charleroi
Namur
Dieppe
Cherbourg
Le Havre
Amiens
Rouen
Caen
Reims
Metz
Nancy
Brest
Rennes
Versailles
Troyes
Orleans
Le Mans
Lorient
Nantes
Tours
Auxerre
Dijon
Mulhouse
Bourges
Nevers
Lausanne
Geneva
La Rochelle
Limoges
Vichy
Lyon
Brive
Saint-Etienne
Grenoble
Bordeaux
Agen
Toulouse
Nimes
Montpellier
Marseille
Beziers
Toulon
Nice
San Sebastián
Oviedo
Santander
Bilbao
Burgos
Pamplona
Logrono
Frederikshavn
Aalborg
Århus
Esbjerg
Odense
Svendborg
Flensburg
Kiel
Lubeck
Hamburg
Bremerhaven
Bremen
Rostock
Stralsund
Hannover
Osnabrück
Münster
Magdeburg
Potsdam
Cottbus
Gottingen
Leipzig
Dresden
Düsseldorf
Cologne
Bonn
Giessen
Jena
Gera
Hof
Koblenz
Wiesbaden
Frankfurt
Wurzburg
Mannheim
Nürnberg
Regensburg
Saarbrucken
Ingolstadt
Stuttgart
Passau
Munich
Ulm
Freiburg
Rosenheim
Basel
Zürich
Luzern
Innsbruck
Salzburg
Linz
Graz
Klagenfurt
Maribor
Helsingborg
Halmstad
Jönköping
Växjö
Kalmar
Kristianstad
Malmö
Liepaga
Jelgava
Daugavpils
Klaipeda
Sovetsk
Kaunas
Kaliningrad
Lida
Hrodna
Gdynia
Gdansk
Elk
Bialystok
Grudziadz
Szczecin
Bydgoszcz
Brest
Poznan
Zielona Gora
Lódz
Lublin
Wroclaw
Kielce
Rzeszow
Gliwice
Katowice
Kraków
Presov
Kosice
Pardubice
Ostrava
Zlin
Zilina
Pizen
Jihlava
Brno
Zvolen
Miskolc
Vac
Debrecen
Gyor
Szolnok
Kaposvar
Szeged
Pecs
Timisoara
Novi Sad
Resita
Osijek
Trieste
Bolzano
Trento
Lugano
Bergamo
Milan
Verona
Venice
Ferrara
Turin
Parma
Bologna
Ravenna
Genoa
Florence
Pisa
Livorno
Arezzo
Siena
Perugia
Ancona
Pescara
L'Aquila
Bastia
Pula
Prijedor
Banja Luka
Tuzla
Zadar
Split
Mostar
Dubrovnik
Pec
Shkoder
onestopmap

Adam , 1972

… as a drummer in a rock band…

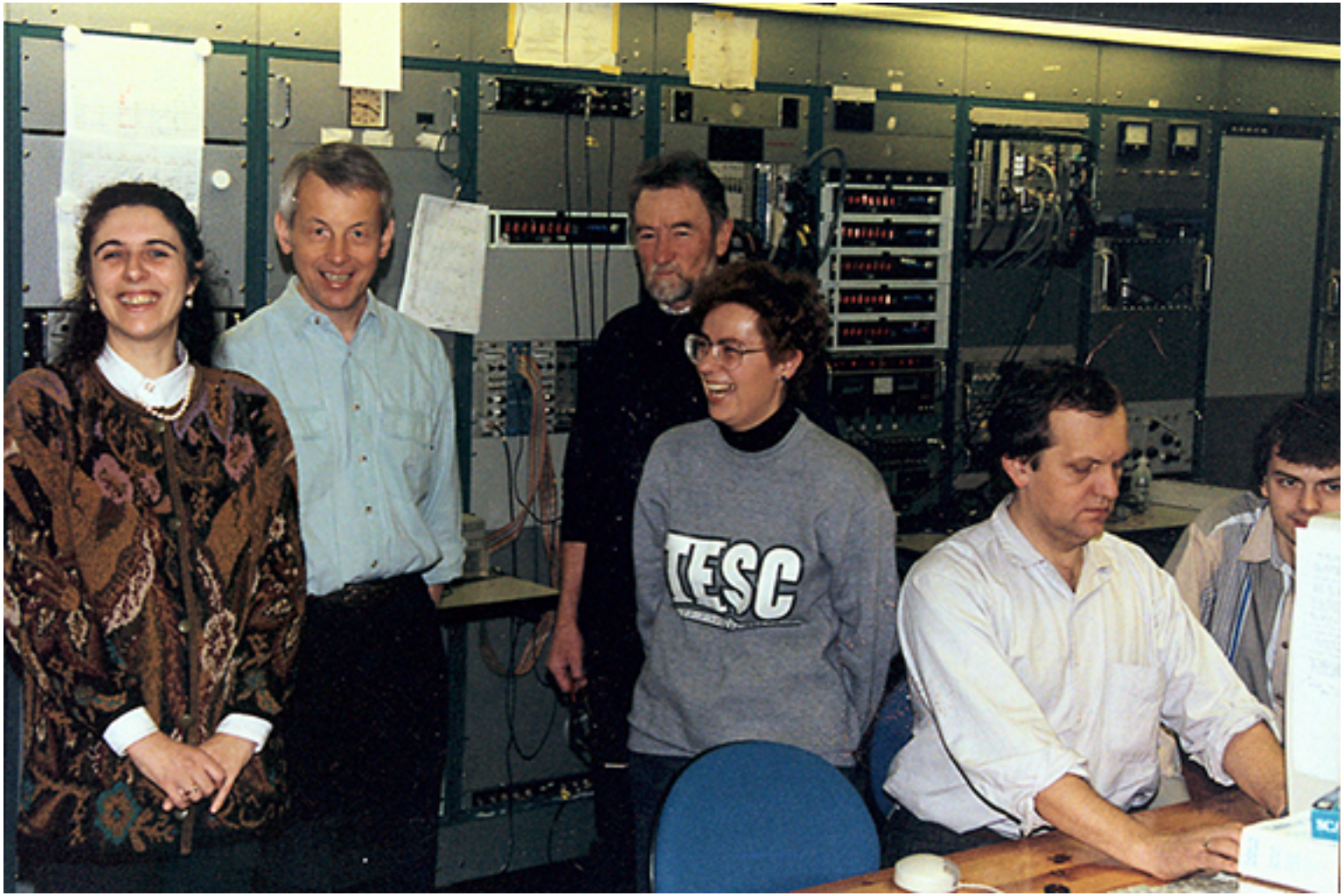




… and reading Feynmann in a free time.

COPENHAGUE ERA

EXPERIMENTS AT NBI DENMARK

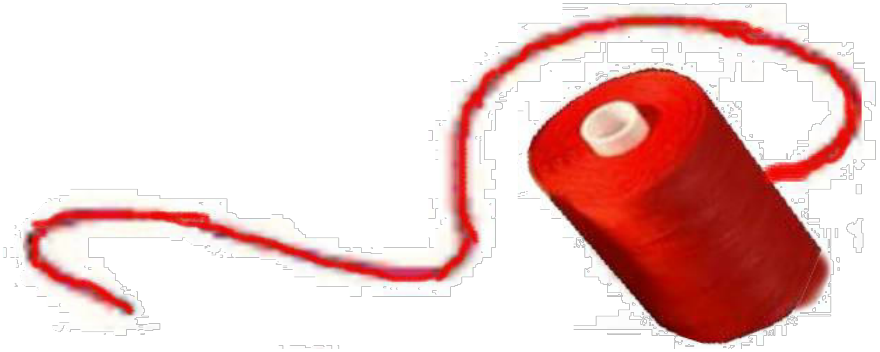


Strong on-going Milano-Krakow collaboration (since the late 80's)

+ *Collective excitations at the extremes of*
  SPIN, TEMPERATURE, ISOSPIN

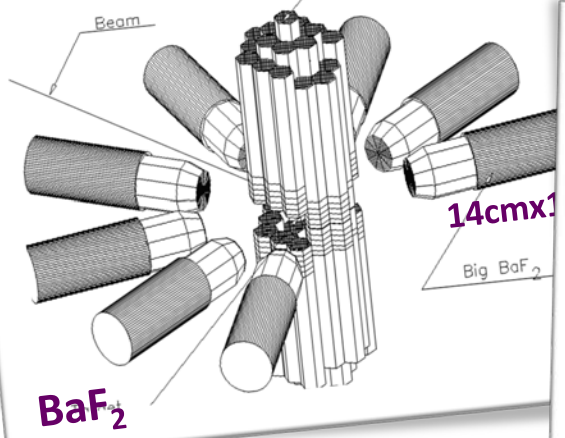
+ *Complex Detector Systems*
  Large Volume Scintillators (BaF_2/$LaBr_3$)+ Ge Arrays + Ancillaries
  HECTOR

+ *Milano Theory Group*



HECTOR at NBI

Late 80's

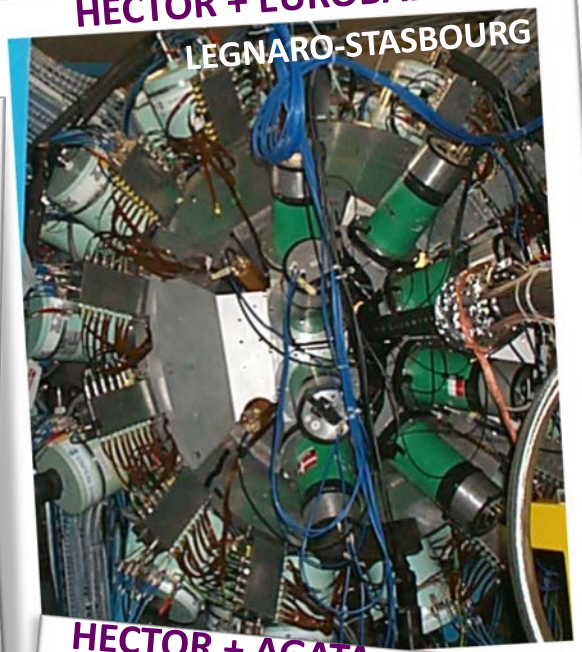


A. Bracco, F. Camera,
A. Maj, J.J. Gaardhøje, …

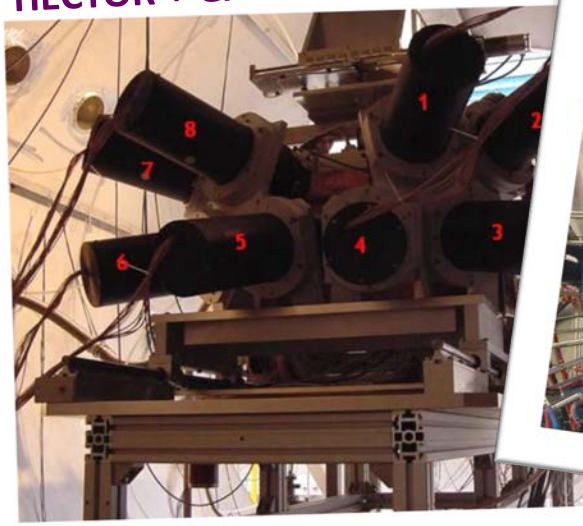
HECTOR in LEGNARO

HECTOR + EUROBALL

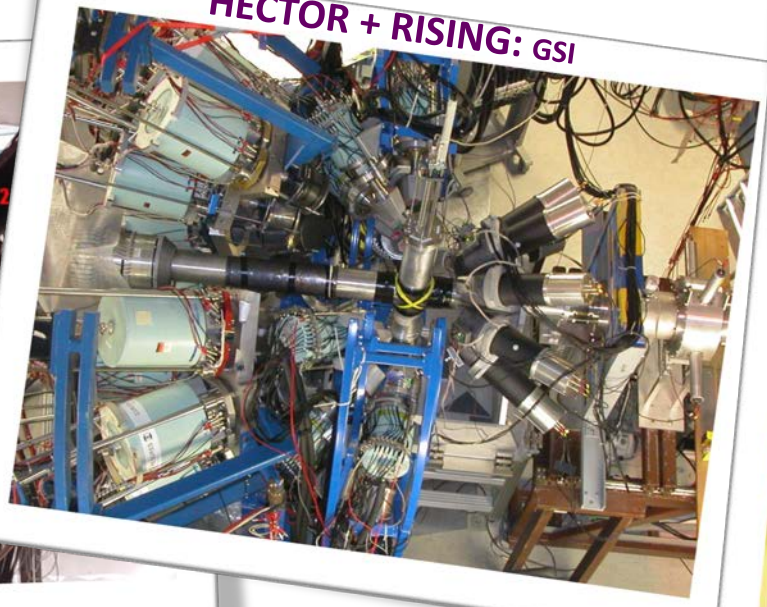
LEGNARO-STASBOURG



HECTOR + GARFIELD: LEGNARO



HECTOR + RISING: GSI



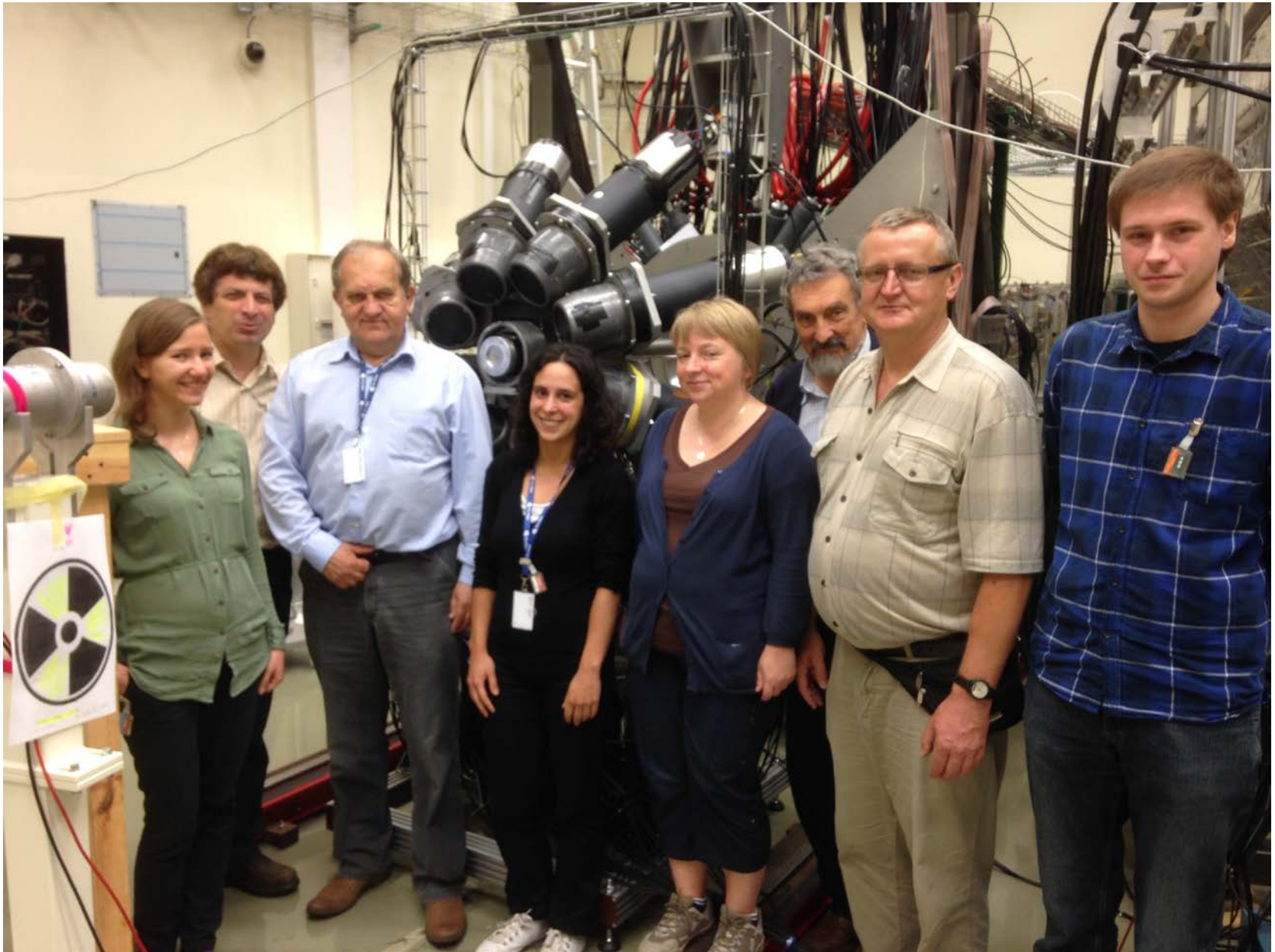
HECTOR + AGATA: LEGNARO/GSI

2011-2014

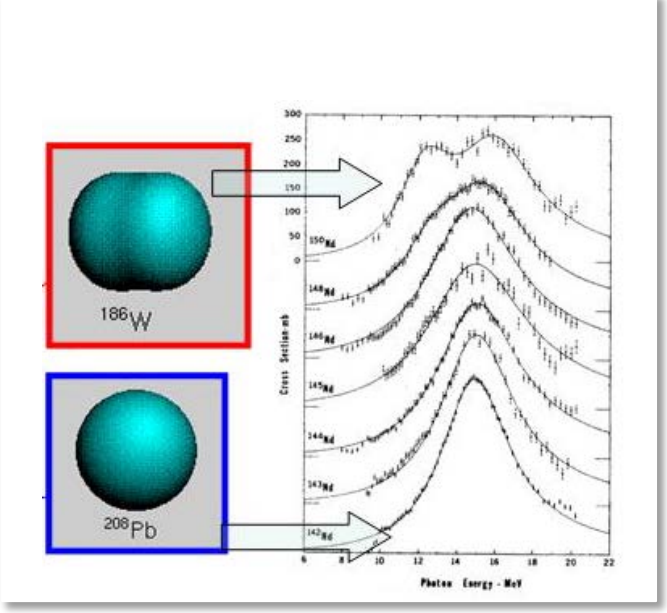
HECTOR in Krakow

Since 2014

Setting up the HECTOR array in Krakow
(Krakow-Milano collaboration)



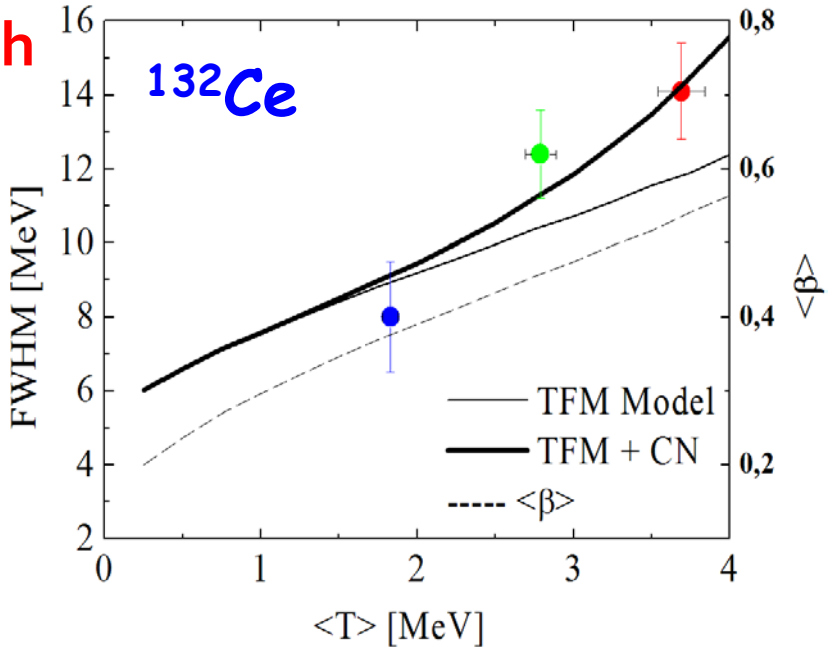
The DIPOLE Response In Nuclei



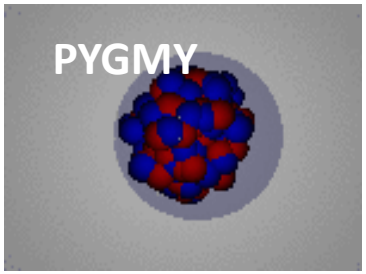
Temperature Dependence of GDR Width

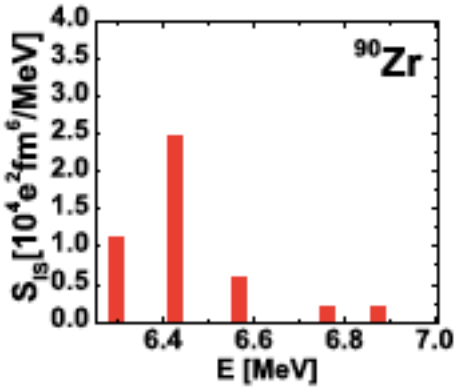
Measurements of γ-rays and charged particles from HOT Nucleus

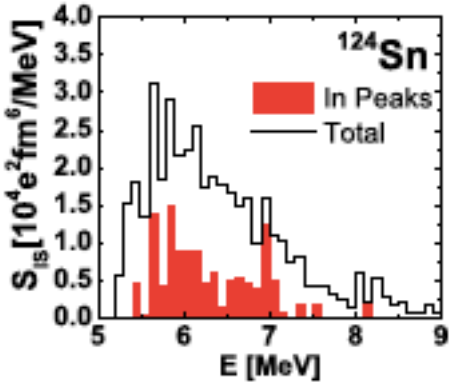
Garfield + Hector Setup

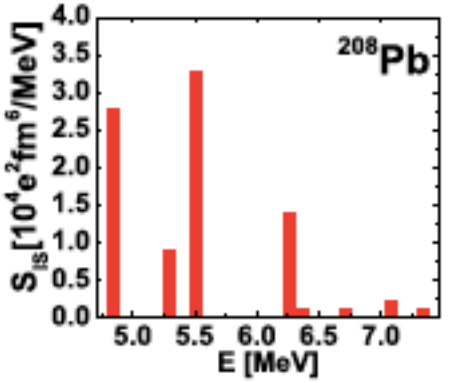


Pygmy Resonances in STABLE NUCLEI
Inelastic Scattering of Heavy Ions – AGATA@LEGNARO









^{208}**Pb:** F.C.L. Crespi, A. Bracco et al., PRL113 (2014) 012501

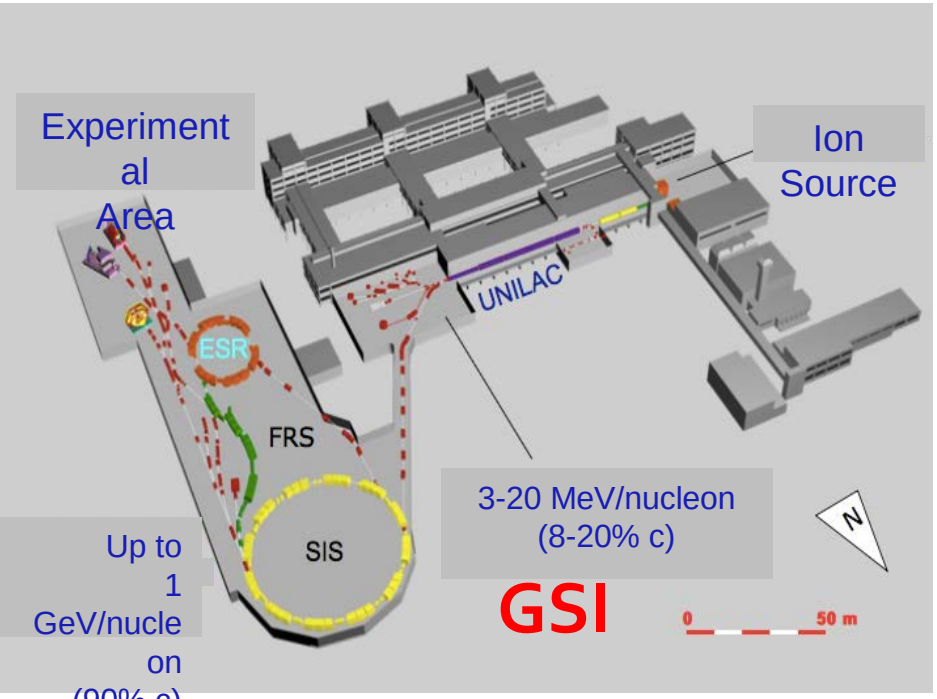
^{124}**Sn:** L. Pellegri, A. Bracco et al., PLB738 (2014)519

^{90}**Zr:** F.C.L. Crespi et al, PRC 91 (2015) 024323

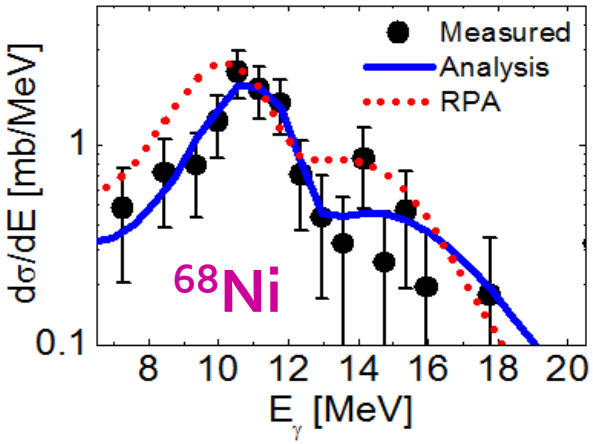
^{140}**Ce:** Analysis by Krakow Group of A. Maj et al.

Pygmy Resonances in EXOTIC NUCLEI

Relativistic Coulomb Excitation



2005 FIRST Case:
RISING Setup
(EUROBALL Clusters + BaF2)



PYGMY Strength: 5-9 % EWSR

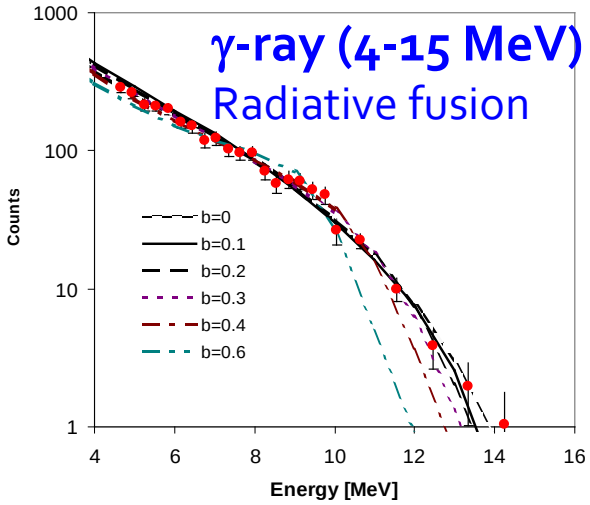
Fission properties of PROTON-rich Nuclei at $E^* \approx B_f$

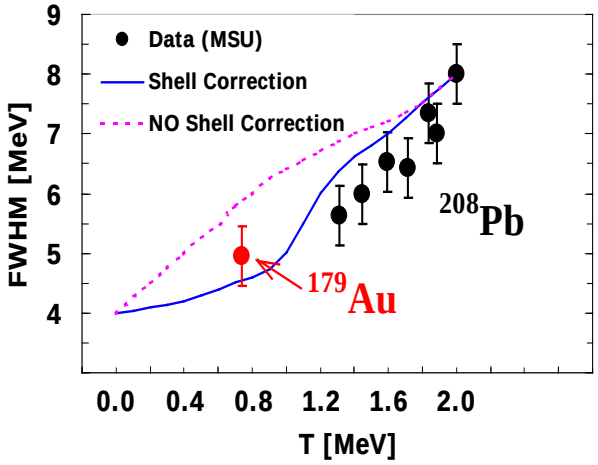
FISSION PROBED BY Giant Dipole Resonance

Cold Reaction : T = 0.7 MeV, E* = 26 MeV

Radiative Fusion: **Only γ emission**

$^{90}Zr + ^{90}Zr\ (^{89}Y) \rightarrow ^{179}Au$





Main Results of Quasi-Continuum Spectroscopy

- Evidence for rotational damping

  B. Herskind et al., PRL68 (1992)3008

  T. Døssing et al., Phys. Rep. 268 (1996)1

- Sensitivity to the residual interaction

  S. Leoni et al., Eur. Phys. J. A4, 229 (1999)

- Mass dependence

  S. Frattini et al., PRL83 (1999)5234

- Collectivity with thermal energy

  S. Frattini et al., PRL81 (1998)2659

- Compound and Rotational Damping Width

  S. Leoni et al., PRL93 (2004)022501

- Onset of Chaos: vanishing of selection rules

  S. Leoni etal., PRC72 (2005)034307

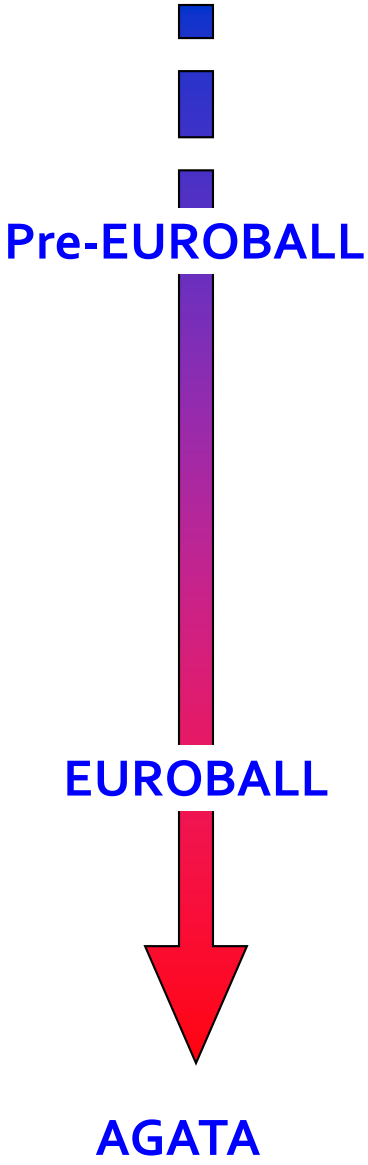
  V. Vandone et al., PRC88(2013) 034312

- Order-to-Chaos in SuperDeformed Nuclei

  G. Benzoni et al., PRC75 (2007)047301

  S. Leoni et al., PRL101 (2008)142502

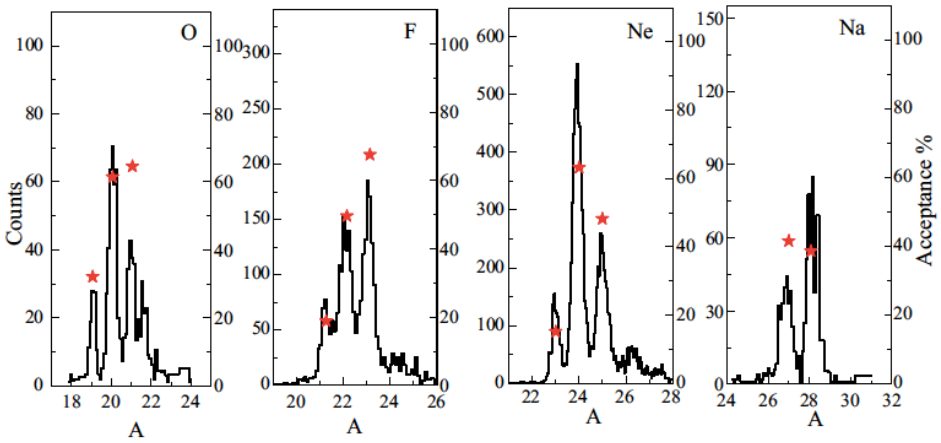
  S. Leoni et al., PRC79(2009)064306 and 064307



FIRST EXAMPLE of
Multi-Nucleon transfer with A RadioActive Beam

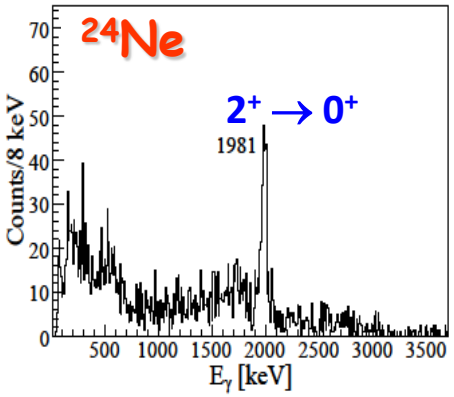
^{24}Ne + ^{208}Pb @ 7.9 MeV/A

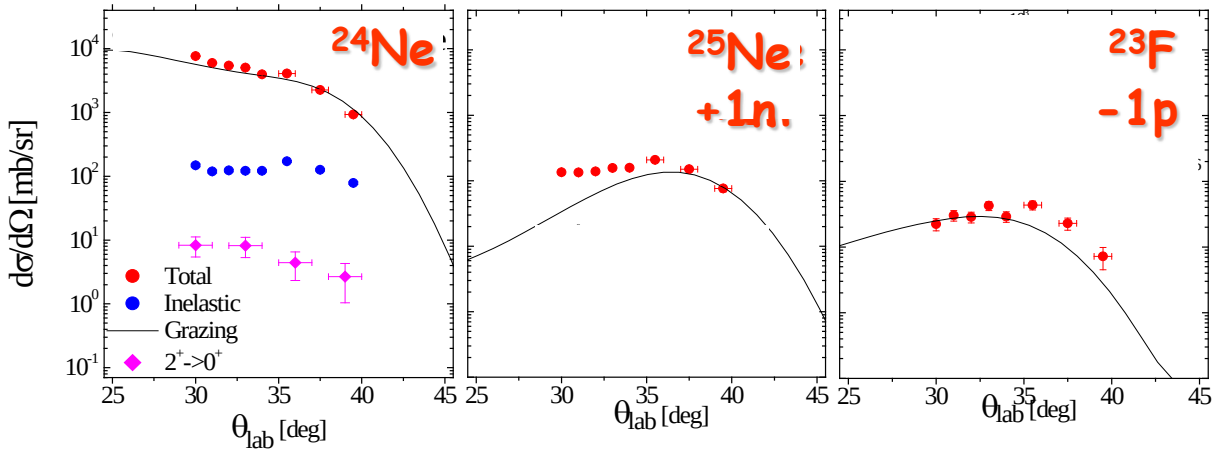
EXOGAM + VAMOS



SPIRAL Beam ^{24}Ne ~ 1.5 10^5 pps

Study of Reaction Dynamics and First excited states mostly in one nucleon transfer channels due to limited statistics





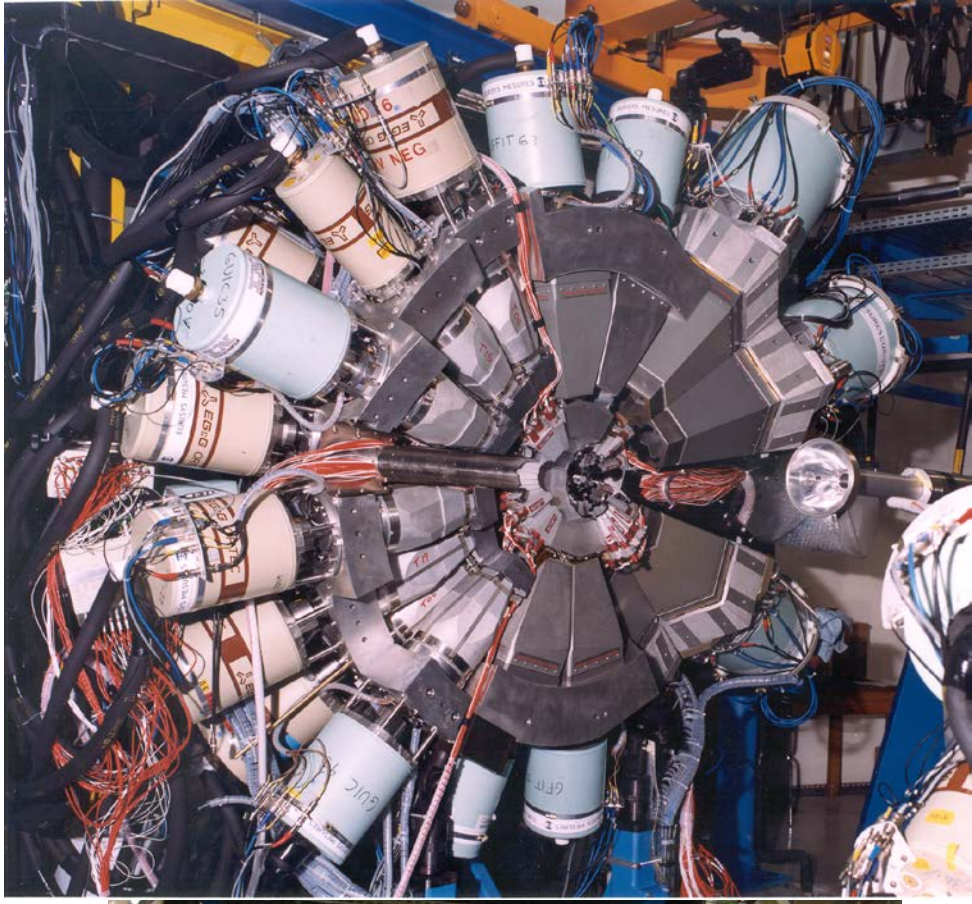
Study of collisions of the radioactive ^{24}Ne beam at 7.9 MeV/u on ^{208}Pb

Eur. Phys. J. A 45, 287–292 (2010)

G. Benzoni[1,a], F. Azaiez[2], G.I. Stefan[2,3], S. Franchoo[2], S. Battacharyya[3], R. Borcea[4], A. Bracco[1,5], L. Corradi[6], D. Curien[7], G. De France[3], Zs. Dombradi[8], E. Fioretto[6], S. Grevy[3], F. Ibrahim[3], S. Leoni[1,5], D. Montanari[1,5], G. Mukherjee[3], G. Pollarolo[9], N. Redon[10], P.H. Regan[11], C. Schmitt[3,10], G. Sletten[12], D. Sohler[8], M. Stanoiu[2,4], S. Szilner[13], and D. Verney[2]


ESTINTORE

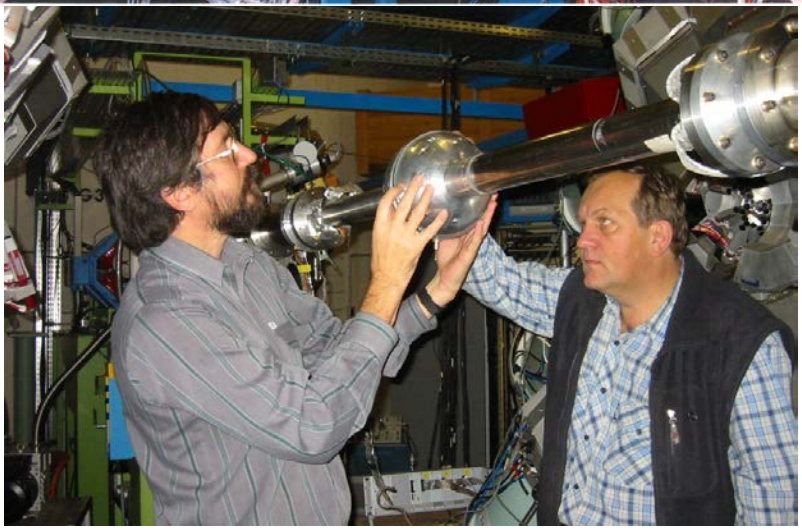
The Vivitron/Strasbourg Episode



EUROBALL Strasbourg

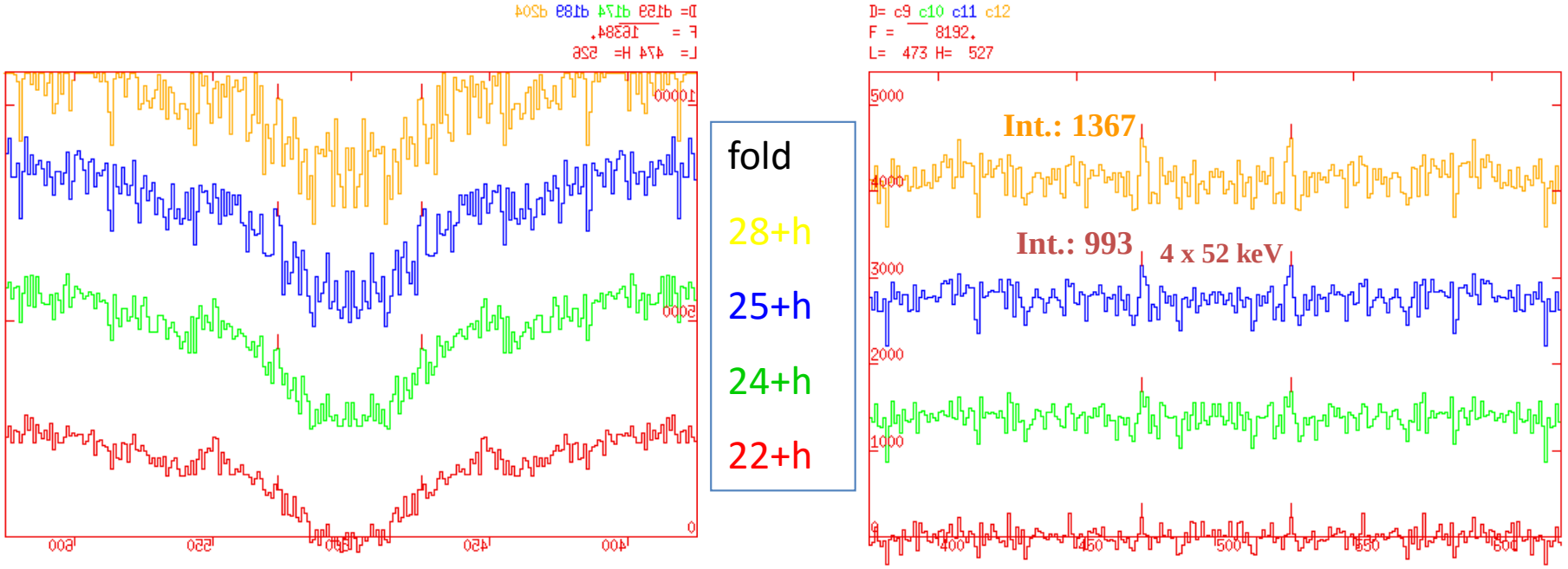
"The HLHD Experiment"

- Accelerator: **Vivitron**
- Reaction: $^{64}Ni(^{64}Ni,xn)^{128-x}Ba$ at 255 and 261 MeV,
  Target: ~500 µg/cm^2
- Beam time: 30 days, ~1.5 pnA
- Trigger: 3 Ge's and 11 BGO's; Events: 12 x 10^9
- Additional detector: DIAMANT



HLHD Experiment
EUROBALL: ^{64}Ni + ^{64}Ni

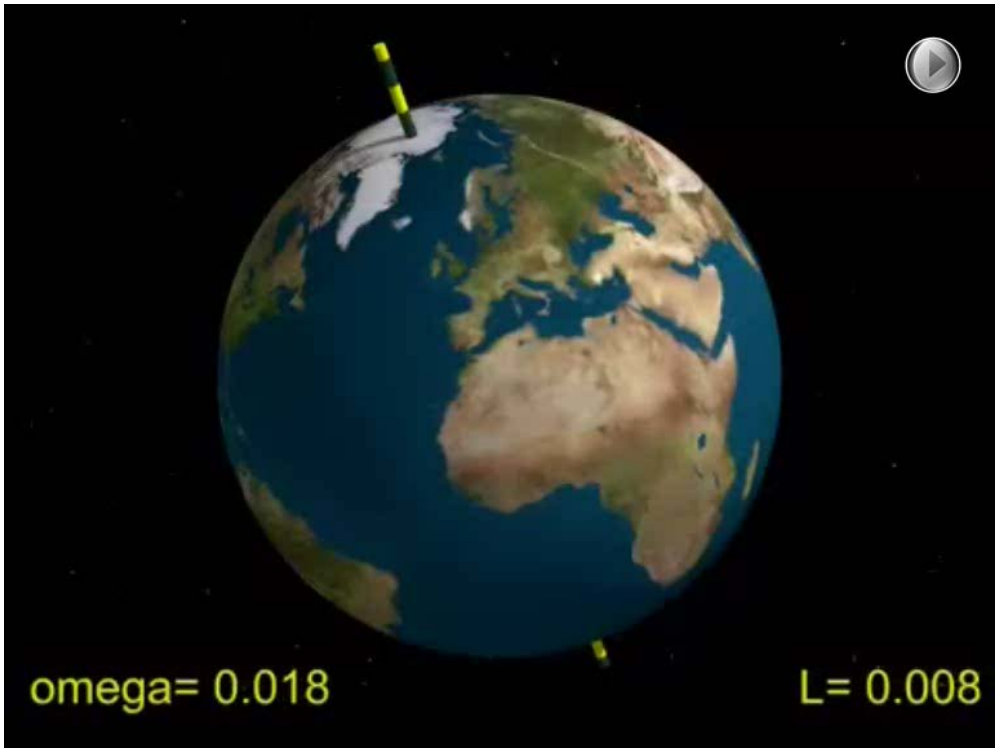
- 255 MeV: NO clear 52 keV ridge structure
- 261 MeV: 52 keV ridge appears



HD' ridge structures with intensities of ~5 x 10^{-5} of reaction channel are composed >10 bands: individual bands below detection limit of EB and GS?

In ^{126}Ba no 'HD' ridges at 255 MeV beam energy, but nice ridges at 261 MeV: small entrance window where the highest-spin states survive fission

Experiment on **Jacobi shape transition** in ^{46}Ti performed at IRES Strasbourg



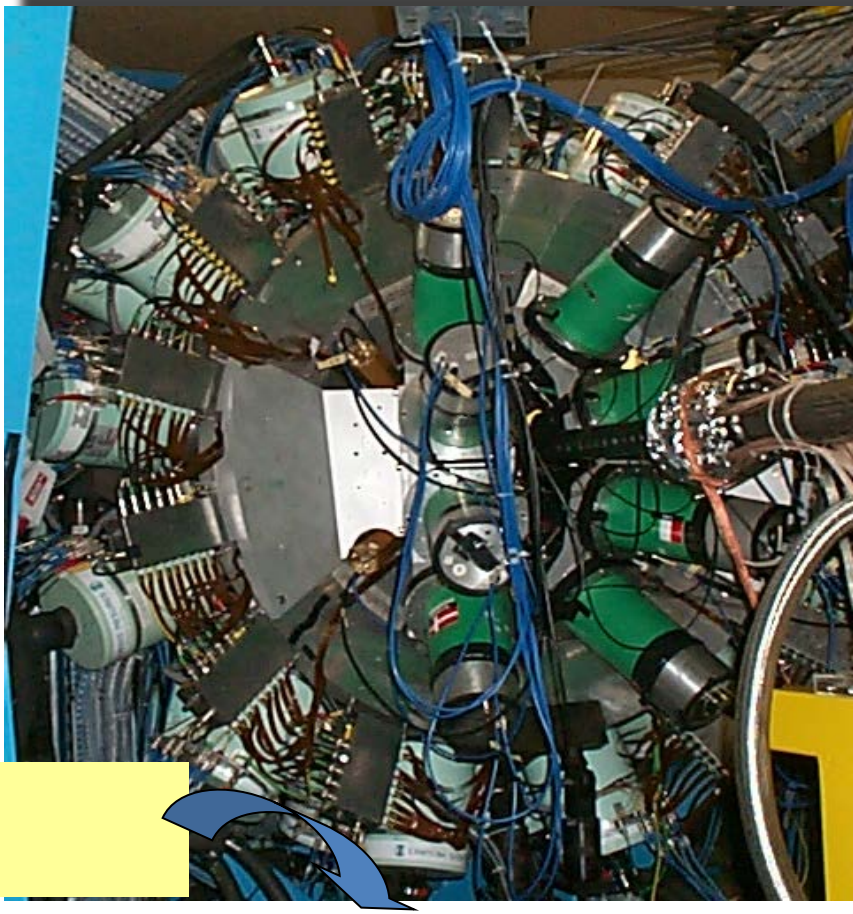
The experiment at VIVITRON

105 MeV $^{18}O + ^{28}Si \Rightarrow ^{46}Ti^*$

$l_{max} \approx 35$ hbar, $E^* = 88$ MeV

$^{41,42}Ca$ (2pxn)
$^{39,40,41}K$ (3pxn)
$^{36,37,38,39}Ar$ (2αxn, α2pxn)
$^{35,36,37}Cl$ (2αpxn)
……

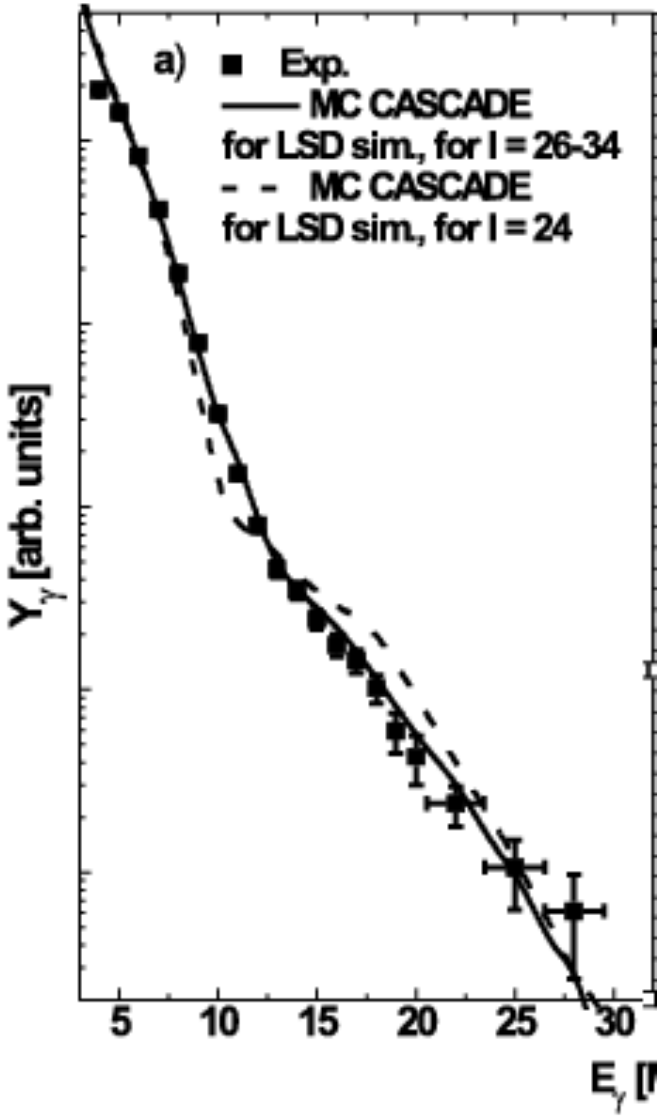
- **EUROBALL IV** (26 clovers + 15 clusters + 75% InnerBall)
- **HECTOR** (8 big BaF_2 + 4 small BaF_2)
- **EUCLIDES** (40 Si telescopes)



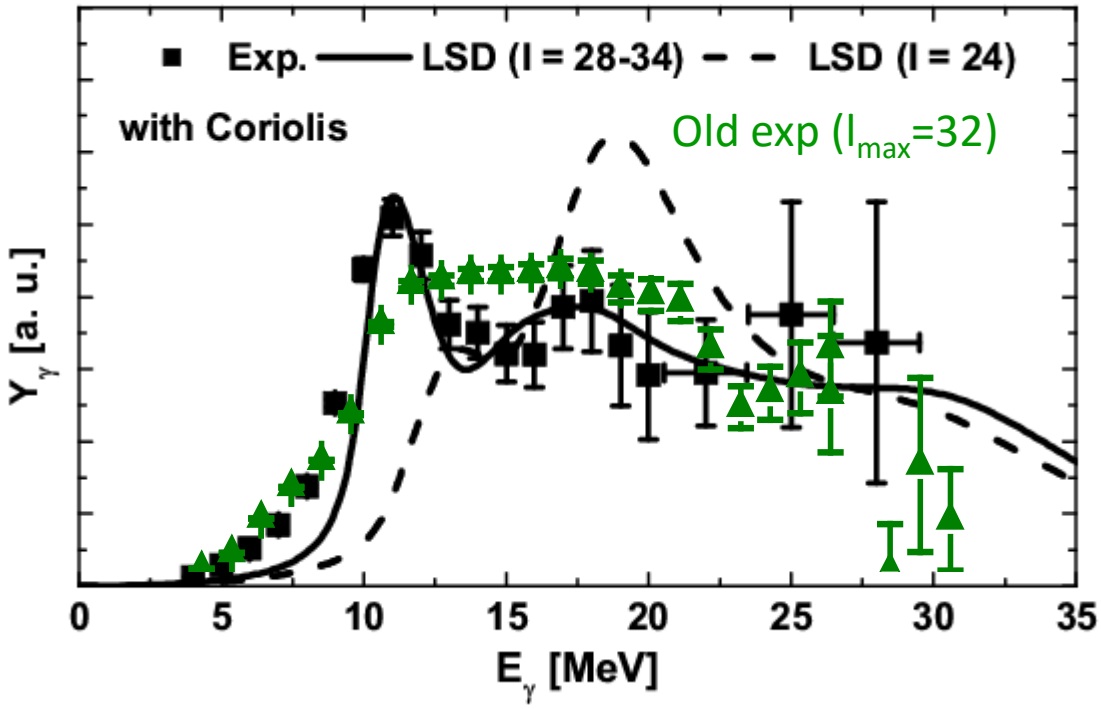
Master trigger:
2 clean Ge ∧ 1 big BaF ∧ 1 small BaF ∧ IB fold >3

Selection of high spins

^{46}Ti – experimental results



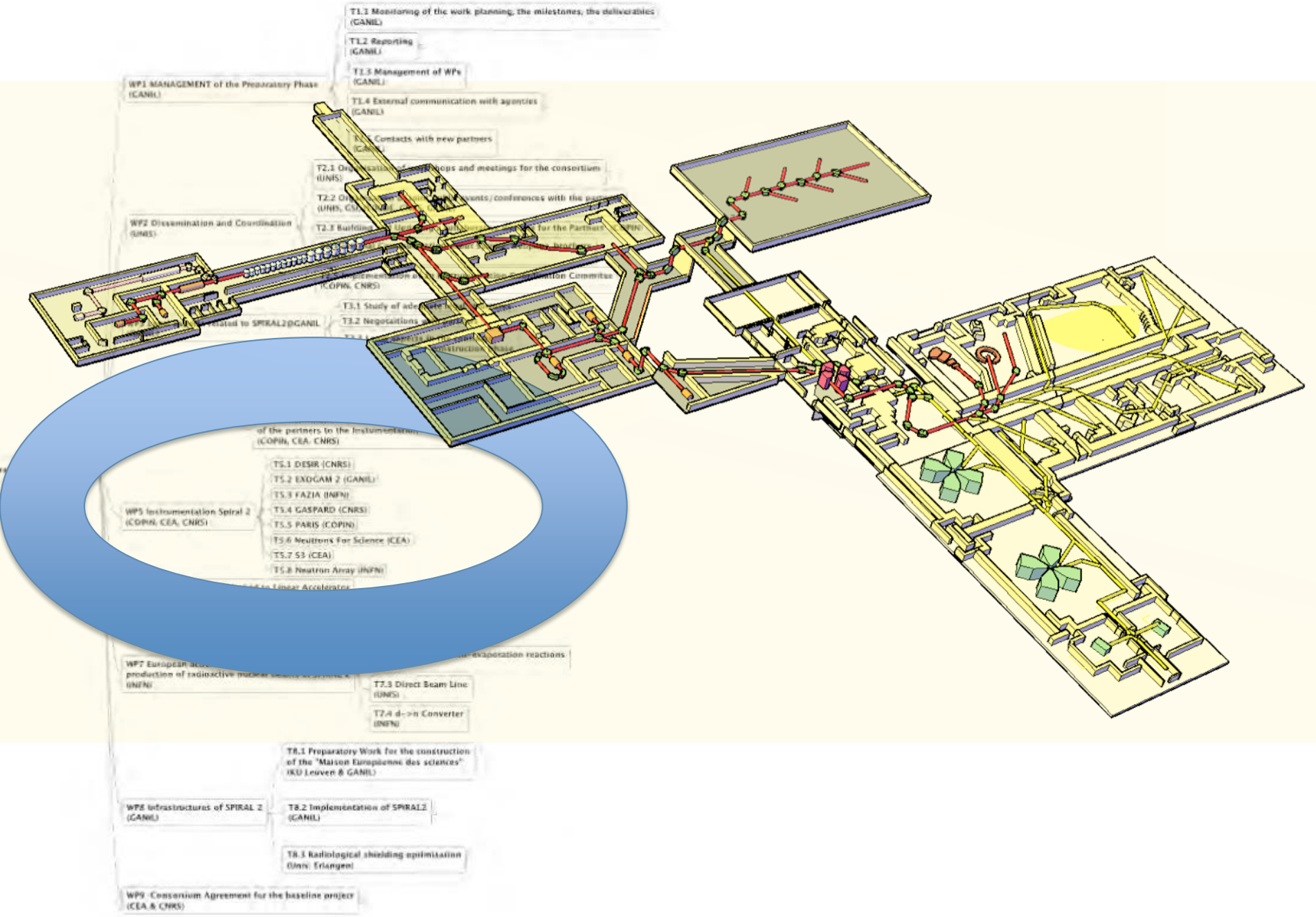
Indication of the Jacobi shape transition and (for the first time) of the Coriolis splitting



AFTER THE VIVITRON EPISODE
TOWARD THE SPIRAL-ALTO-SPIRAL2

Preparatory Phase

Structure of the SPIRAL 2 Preparatory Phase project



SPIRAL2

NFS: neutron beam

DESIR: low-energy radioactive beams

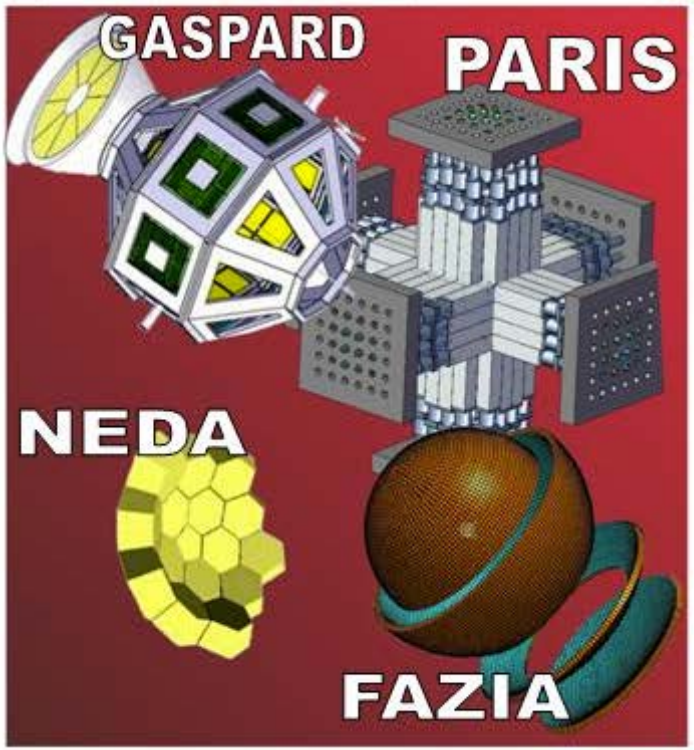
S^3: super separator spectrometer

LINAC driver: p - 33MeV, d - 40 MeV, heavy ions - 14.5 AMeV

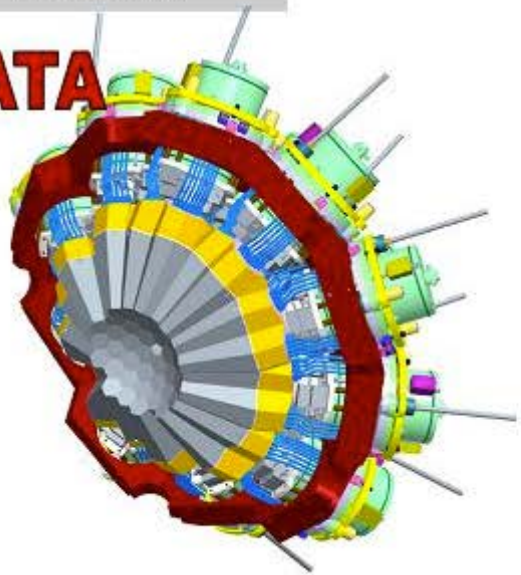
GANIL/SPIRAL1: existing infrastructure

Ion sources: I > 1 mA

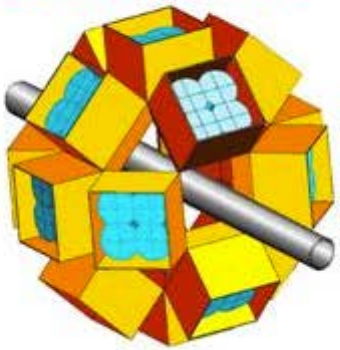
Radioactive beams production cave: 10^{14} fissions/s



AGATA



EXOGAM2



Adam Maj
Faical Azaiez
Bijan Saghai

Total request: 1 265 k€

Manpower: 800 k€

Technical travels: 115 k€

Materials: 350 k€

The PARIS Project

Main physics cases require that PARIS has to

- be modular (to be connected with other detectors: AGATA, EXOGAM, GASPARD, NEDA, FAZIA, ACTAR ...)
- have high granulation (multiplicity measurement, Doppler correction,...)
- have very high efficiency for high-energy γ-rays
- have good timing resolution (<500 ps)
- have energy resolution as good as possible
- have some position sensitivity
- be transportable (SPIRAL2/GANIL will be the primary site, but experimental campaigns are planned in other facilities: ALTO, Warsaw, Krakow, SPES, HIE-ISLODE,…)

PARIS desing concepts:

Design and build high efficiency detector consisting of 2 shells *(or 1 phoswich shell)* for medium resolution spectroscopy and calorimetry of γ-rays in large energy range

Inner sphere, highly granular, made of new crystals (LaBr3(Ce)), to be used as a multiplicity filter of high resolution, sum-energy detector (calorimeter), detector for the gamma-transition up 10 MeV with medium energy resolution. It may serve also for fast timing application.

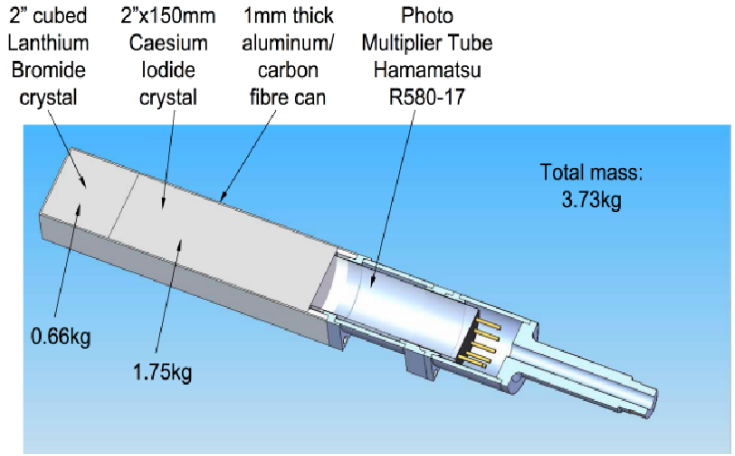
Outer sphere, with high volume detectors, made of conventional crystals (BaF2 or NaI), to be used for high-energy photons measurement or as an active shield for the inner shell..

2-shell or phoswich concept, in addition to being more economic, shall help to distinguish a high-energy photon from a cascade of low energy gamma transitions in fusion evaporation reactions

Science & Technology Facilities Council

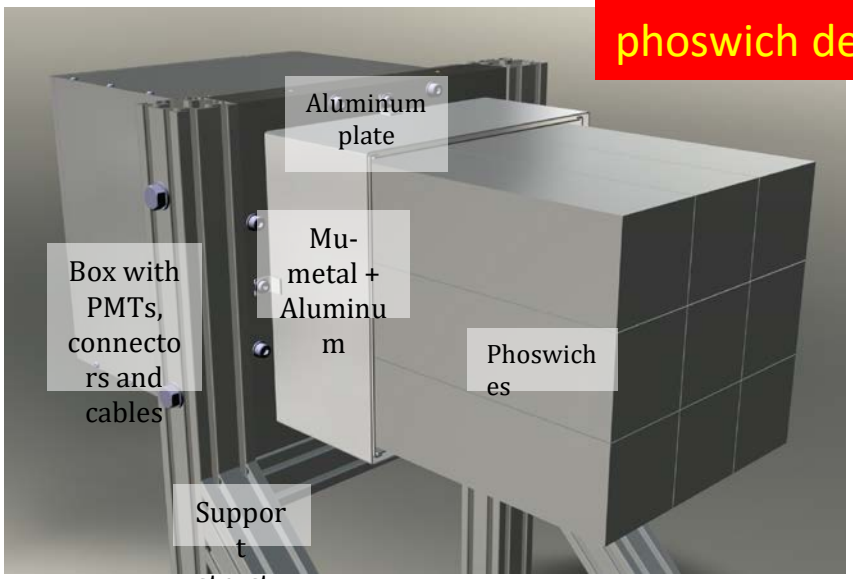
Paris

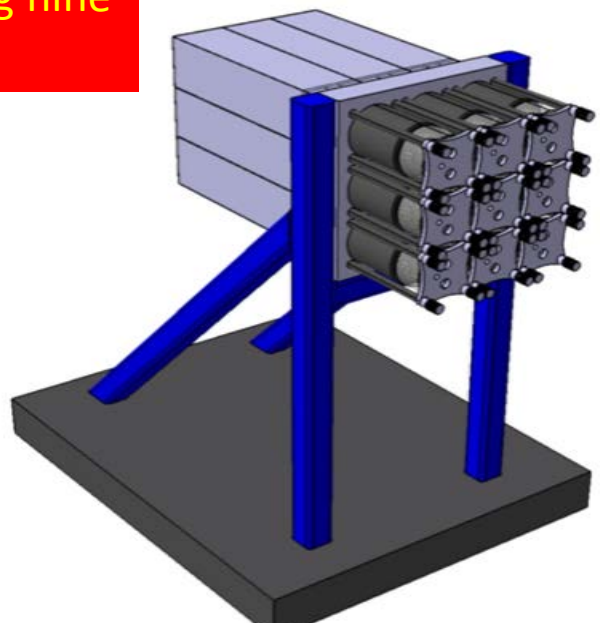
Designs made
in IPN Orsay and in Daresbury



Initial concept of a phoswich detector element (presently CsI is replaced by NaI)

A cluster module comprising nine phoswich detectors

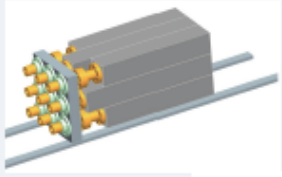
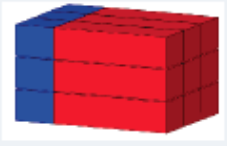
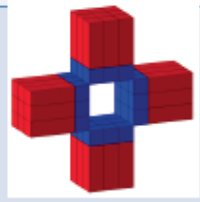
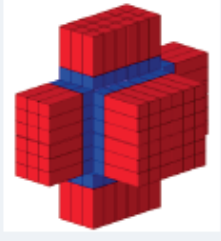
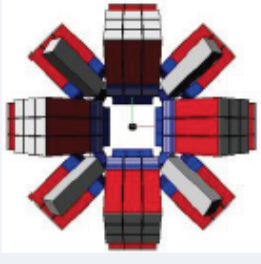
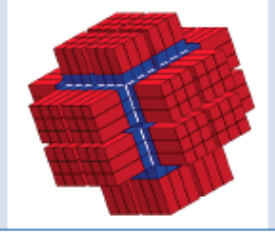
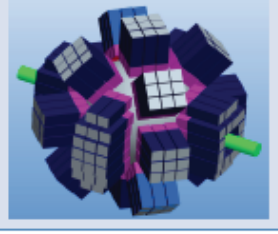




PARIS Demonstrator MoU

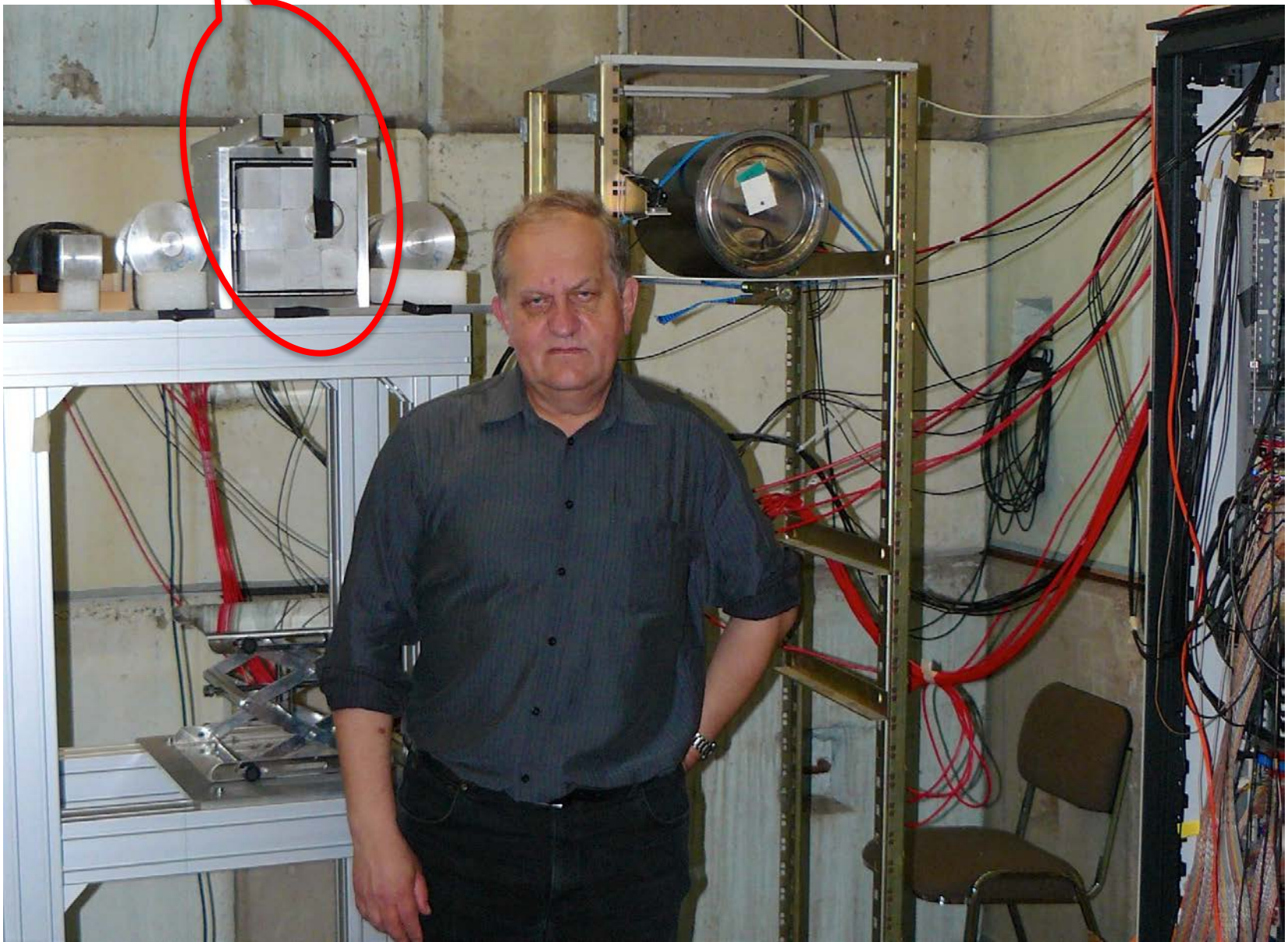
MoU on PARIS Demonstrator (Phase 2) was prepared and agreed to be signed by IN2P3 (France), COPIN (Poland), GANIL/SPIRAL2 (France), TIFR/BARC/VECC (India), IFIN HH (Romania), INFN (Italy), U. York (UK), Turkey, U. Surrey (UK).

PARIS phases and cost estimates

Phase 1 **2011/2012** PARIS cluster	1 cluster: 9 phoswiches	 	250 k€	**Decided** Funds: SP2PP, ANR, Orsay, Strasbourg, Kraków, Mumbai Tests in-beam and with sources
Phase 2 **2015** **PARIS Demonstrator**	5 clusters: 45 phoswiches		1100 k€	**Only if Phase1 validated** Funds: MoU Ph1Day1 exp@S3
Phase 3 **2017** **PARIS 2π**	12 clusters: 108 phoswiches	 	≈ 2 M€	**Only if Phase2 validated** Funds: MoU, PARIS consortium Ph2Day1 exp. with AGATA and GASPARD Other exp.
Phase 4 **≈2019** **PARIS 4π**	≥24 clusters: ≥216 phoswiches	 	≈ 4 M€	**Only if Phase3 validated** Funds: PARIS consortium Regular experiments in various labs

First tests of the PARIS cluster at the ELBE gamma-facility in Rossendorf (December 2013)

Testing 1st **PARIS cluster** with the neutron beam from LICORNE at IPN Orsay (May 2015)



DEBRECEN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JAPAN-RIKEN


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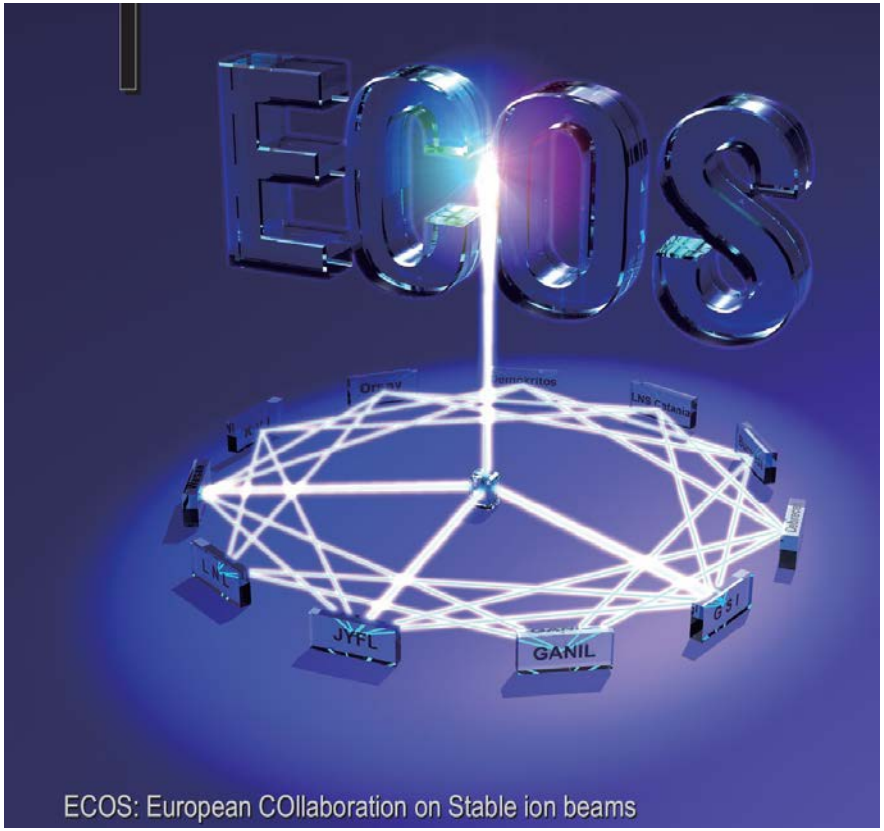
ECOS


ECOS
JYFL
GANIL
GSI
ECOS: European COllaboration on Stable ion beams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ZAKOPANE


ZAKOPANE 2004


ZAKOPANE 2006


ZAKOPANE 2010

KRAKOW


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2008/05/17 19:18

First CCB-IAC meeting: 30.08.2013

Cyclotron Center of Bronowice (CCB).

Beam at the target for the first time: February 21, 2013

IFMIF-ELAMAT initiative in Rzeszow (Poland)
Scientific Commitee chaired by Adam Maj

Adam 2015 – beginning of a golf era?

Dear Angela, Dear Adam

I would like to convey to both of You my best wishes and my sincere congratulations on the occasion of Your sixty birthday. I would also like to remember in this occasion the many years we have been working together (running experiments, installing instruments, participating to committees etc.) and to mention the great contribution both of You have given to the nuclear physics community, not only providing new achievements in science but also making the subject alive and attractive with new ideas.

I wish You all the best in the future, both in the professional and in the private life.

Giacomo

Happy birthday to both of you and hope to see at your next symposium in 2025