R3B -- España

USC UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

GENP Grupo Experimental de Núcleos y Partículas

Univ. Santiago de Compostela

Universidad de Vigo

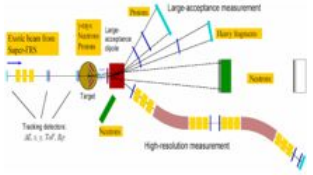
CIMA UNIVERSIDAD DE VIGO

75 AÑOS CSIC

IEM CSIC F G E N

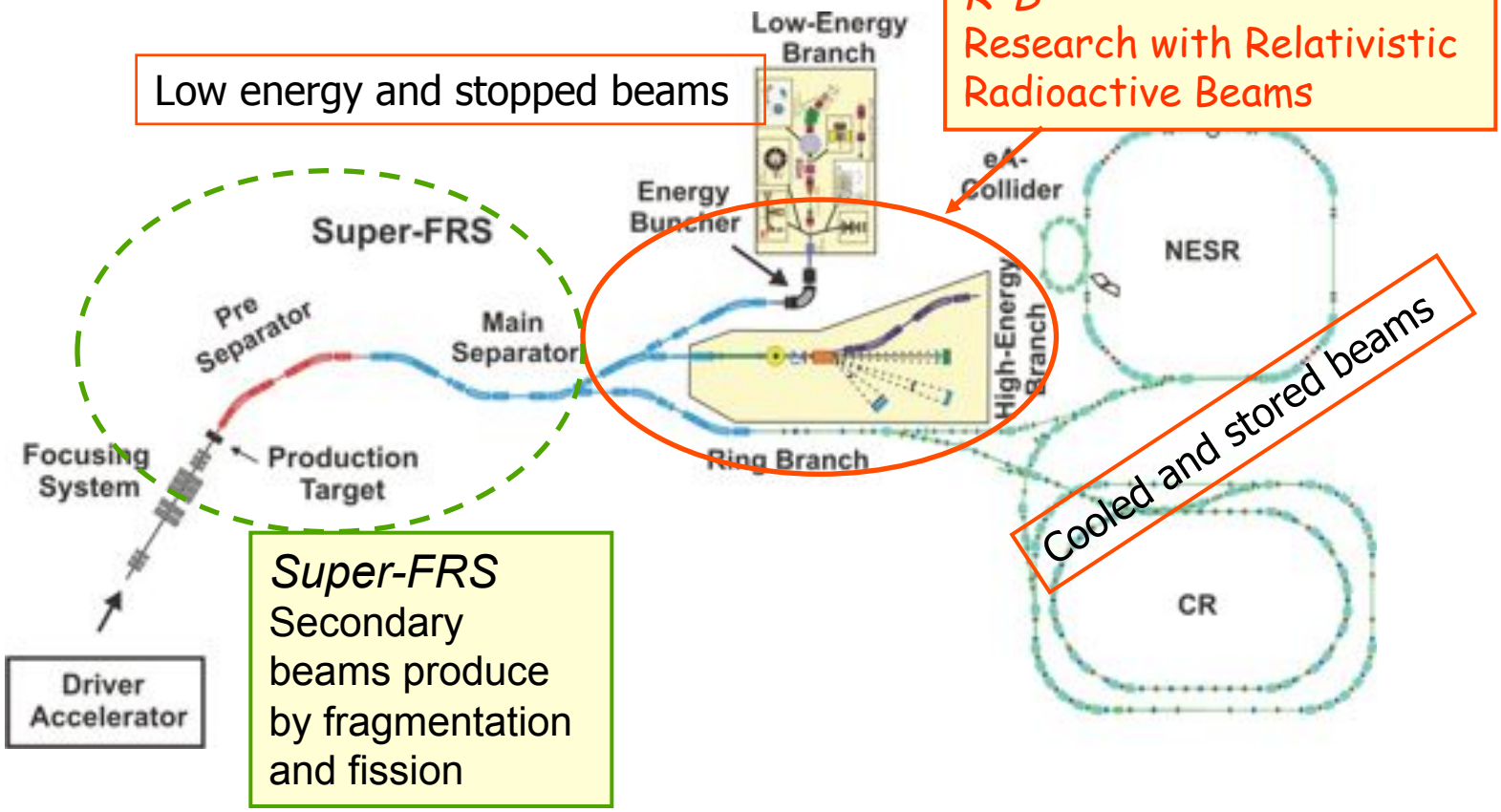
Grupo de Física Nuclear Experimental

NUSTAR – a facility for NUclear STructure & Astrophysis Research



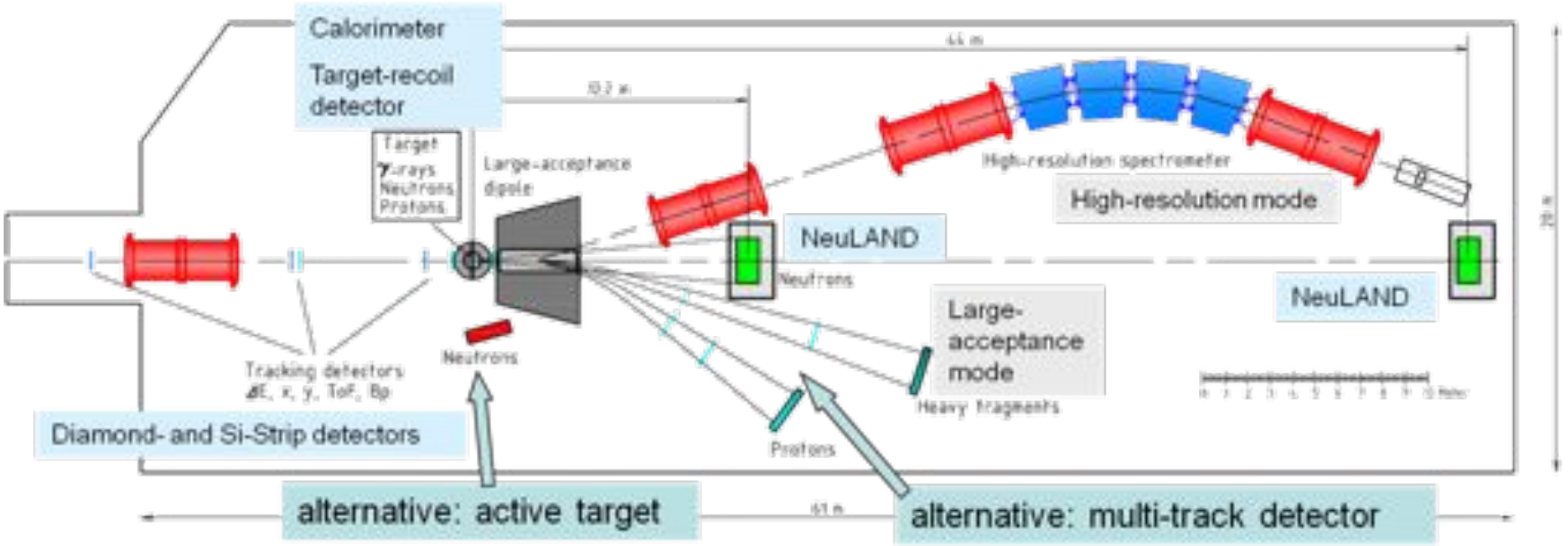
Low energy and stopped beams

R³B
Research with Relativistic Radioactive Beams



Super-FRS
Secondary beams produce by fragmentation and fission

R³B: Reactions with Relativistic Radioactive Beams



Kinematically complete measurement of reactions with high-energy secondary beams

- **Nuclear Astrophysics**
- **Structure of exotic nuclei**
- **Neutron-rich matter**

·A universal fixed-target experiment for complete inverse-kinematics reactions with relativistic RIBs (~300 – 1500 MeV/u),

·Experiments with the most exotic (<1 ion/s) and short-lived nuclei - exploring the isospin frontier at and beyond the drip-lines –

·Concept built on existing ALADIN-LAND experiment at GSI

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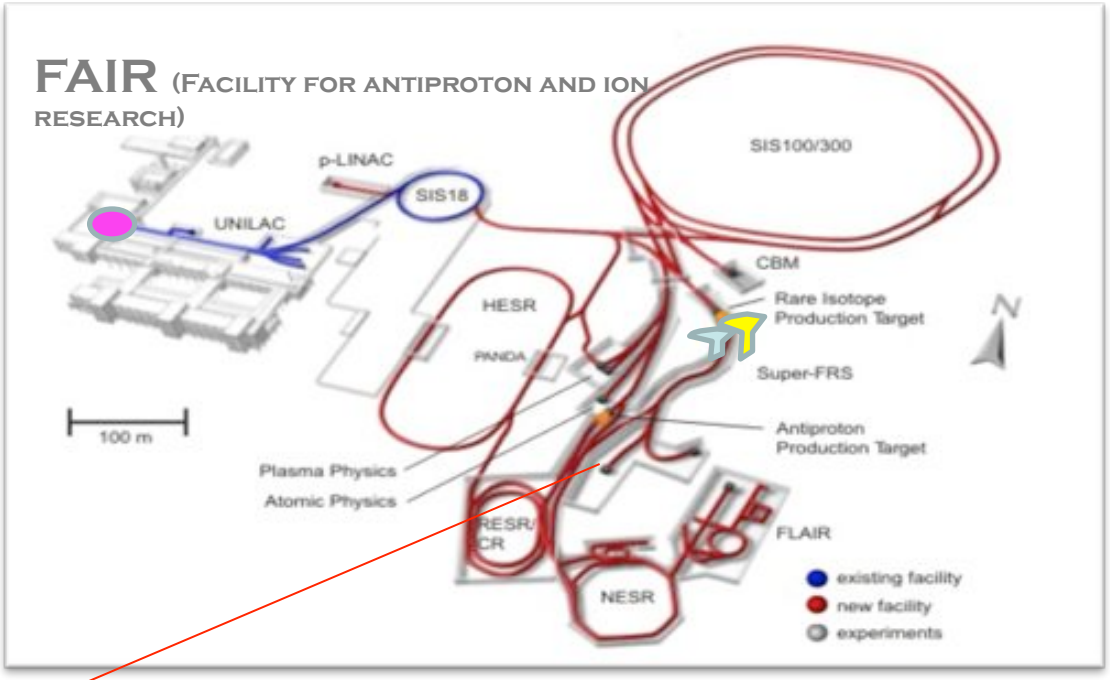
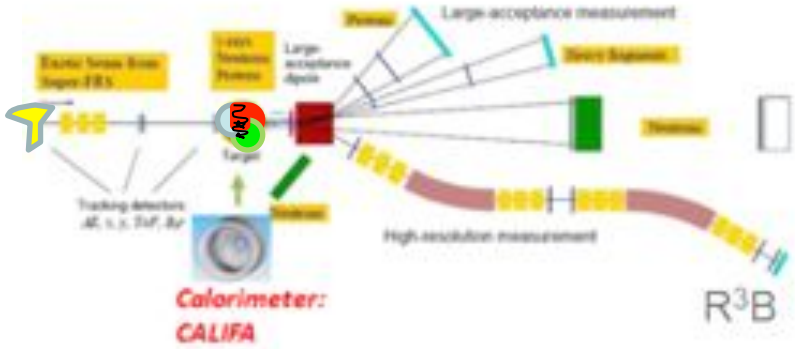
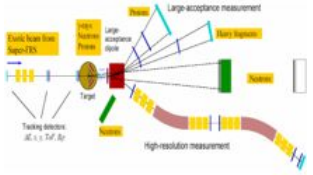
How does it work



R³B





1. Accelerated beam impact on Production Target

2. Products are separated in FRS

3. Separated isotopes directed to experiment

4. Isotope of interest impact on Reaction Target

5. Reaction fragments and gammas are detected

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Reactions with Relativistic Radioactive Beams

R³B@FAIR

RIB @ < 1 GeV/u

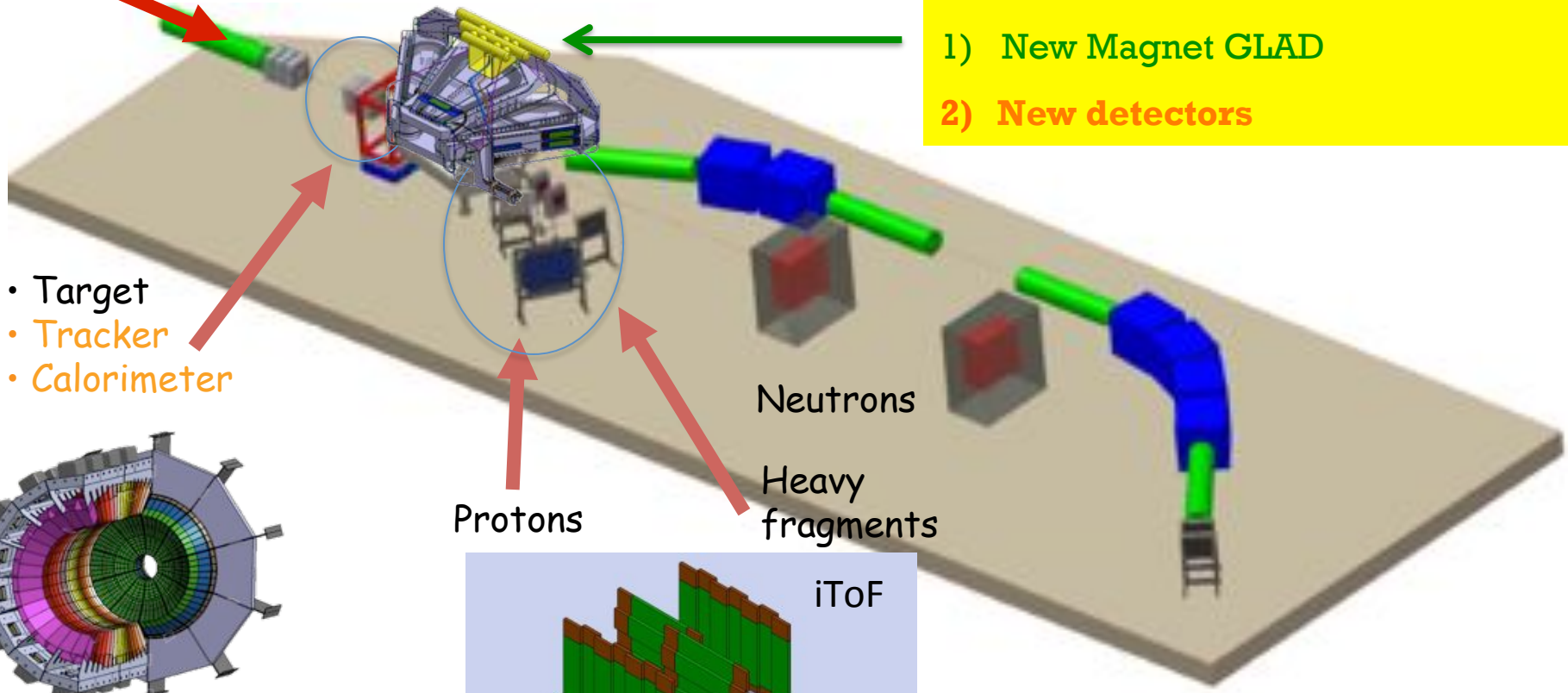
With the upgrade to FAIR we get:

Higher energy & intensity

→ we need

1) New Magnet GLAD

2) **New detectors**



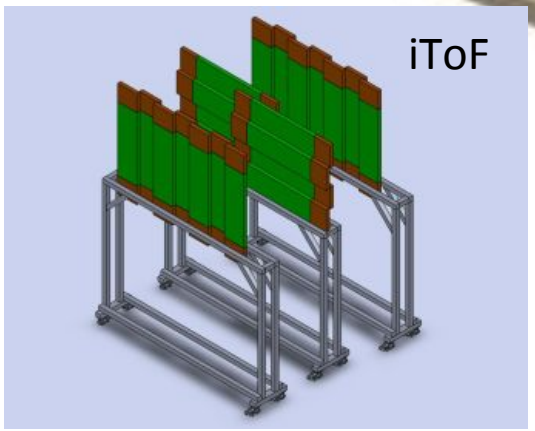
- Target
- Tracker
- Calorimeter

Neutrons

Heavy fragments

Protons

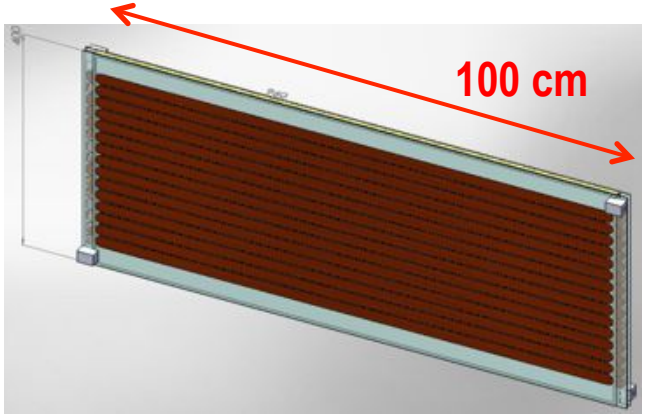
CALIFA



iToF

iToF: conceptual design

Coordination: C. Paradela USC

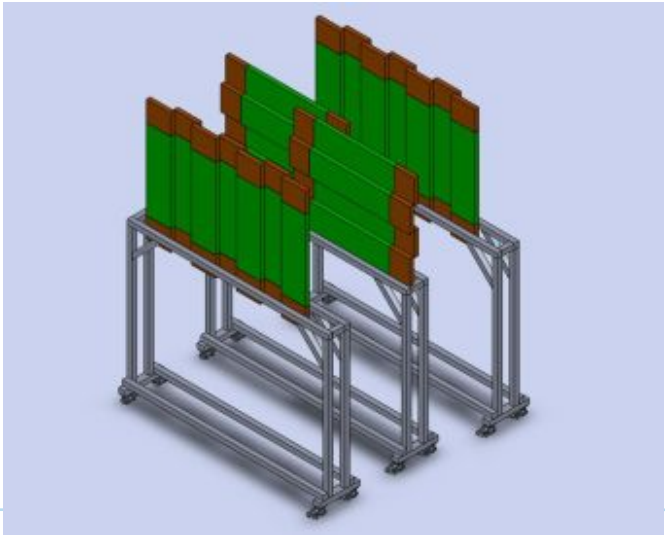


✓ Requirements:

- time resolution better than 50 ps
  (15 m flight path)
- surface about 1 x 2 m^2
- position resolution around few millimetres
- multi-hit capabilities

✓ Proposed solution:

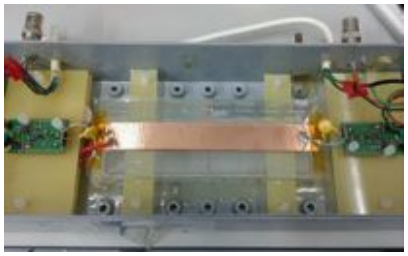
- Resistive Plate Chambers (RPCs)
- modules of 15 strips of 100 x 2.5 cm^2
- detection planes: 7-8 modules to cover 1 x 2 m^2
- three detection planes
- about 700 electronic channels

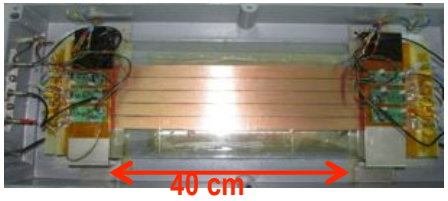


iToF: prototypes and tests

✓ Beam tests:

- Cosmic rays
- 10 – 10 MeV electrons
- 500 – 1000 A MeV ions (^{136}Xe, ^{238}U)
- three detection planes
- about 700 electronic channels



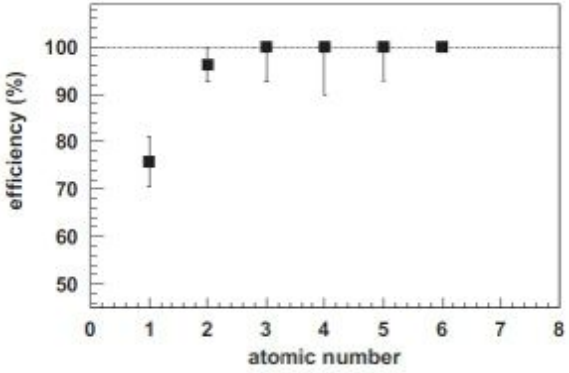


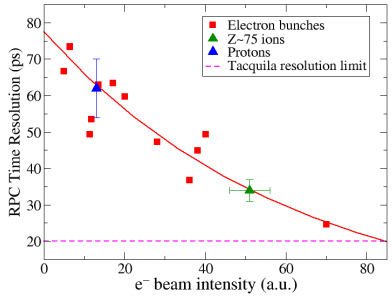
✓ Measured performances:

Y. Ayyad, PhD 2011
NIM A 661, 141 (2012)

E. Casarejos et al., NIM A 674, 39 (2012),
NIM A 661, 137 (2012) JINST 7, 11015 (2012)

C. Paradela et al., NIM A 735, 94 (2014)





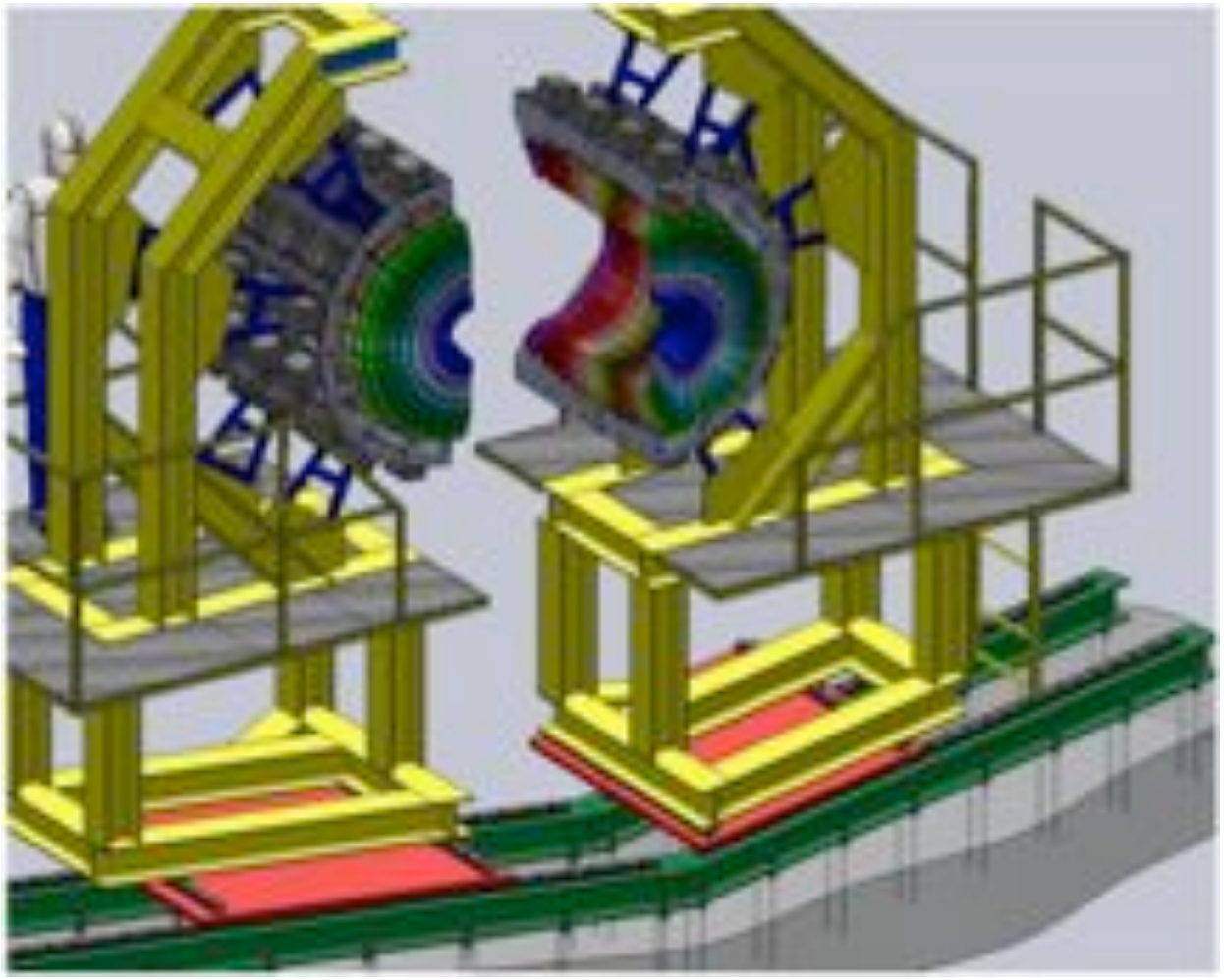
- 100 % detection efifciency for ions and 80% for protons
- 20 ps (FWHM) resolution with electrons
- 35 ps (FWHM) resolution with ions

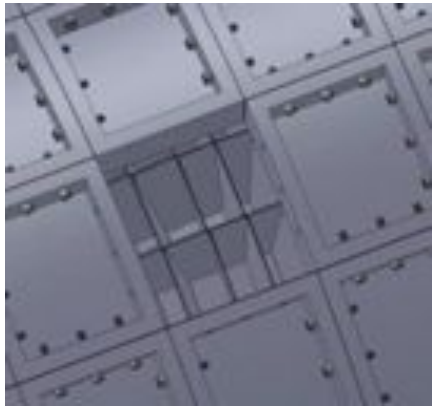
✓ Present status:

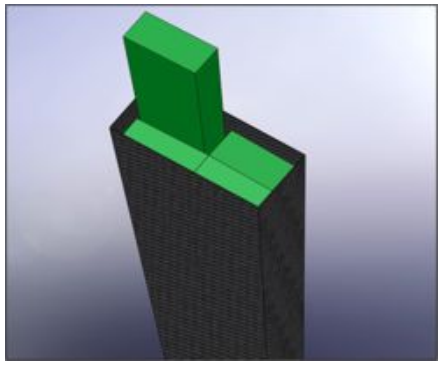
- R&D finalized
- Technical design report in preparation

Calorimeter CALIFA@R³B R&D

Engineering design and Mechanical structure → based on carbon fibre alveolus







CALIFA – design consideration

- **High-resolution γ spectrometer, relatively low-energy γ-rays (up to 2 MeV), consequently with low multiplicity (2-3). The energy resolution will be in this case the most critical parameter of CALIFA. This value has been set to be of ΔE/E < 6% for 1 MeV , which allows to distinguish most of the simple gamma cascades that come from the de-excitation of light exotic nuclei.**

knock-out reactions employing light, radioactive beams → highly Segmented

- **γ - calorimeter, very energetic γ-rays (up to 10 MeV) and associated with fragmented decays (high-multiplicity events). In this case the key parameters will be its Total absorption (intrinsic photopeak efficiency), sum energy and multiplicities. A typical reaction that will profit from**

pygme (or giant)-resonance decays → addback, little dead material

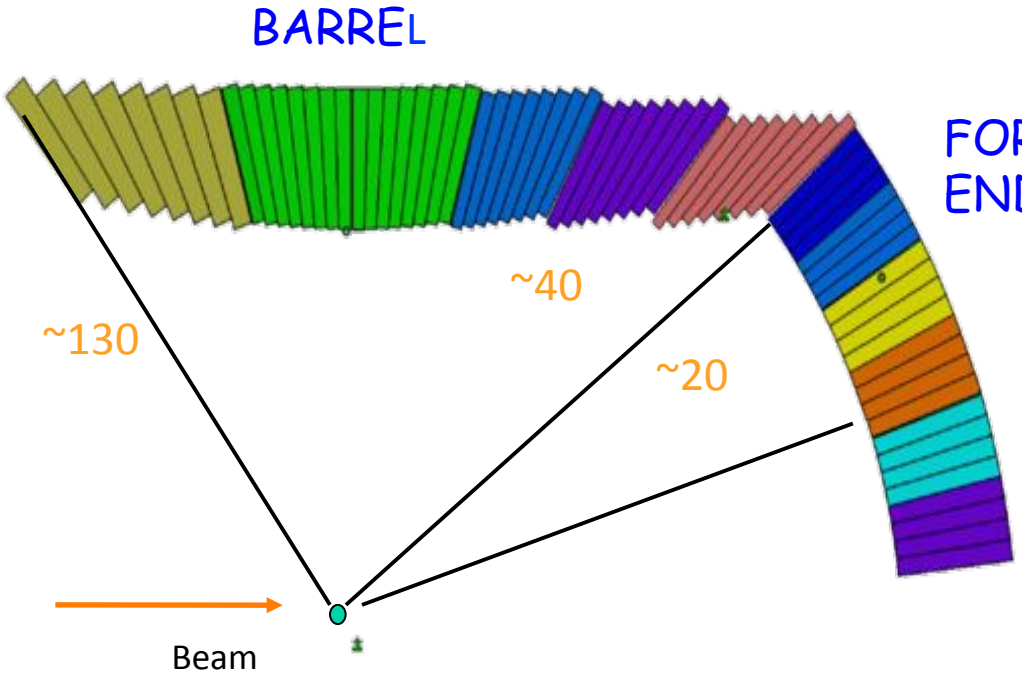
- **Hybrid detector simultaneously good calorimetric properties together with high-resolution for highly energetic light charged particles (protons up to 300 MeV)**

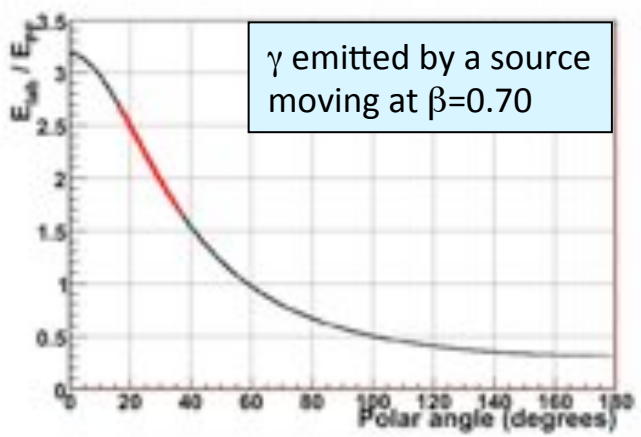
quasi-free scattering (p,2p),(p,pn)…. → good energy resolution + huge dynamic range
γ & p → Time-over-threshold

Design of CALIFA

Kinematic considerations

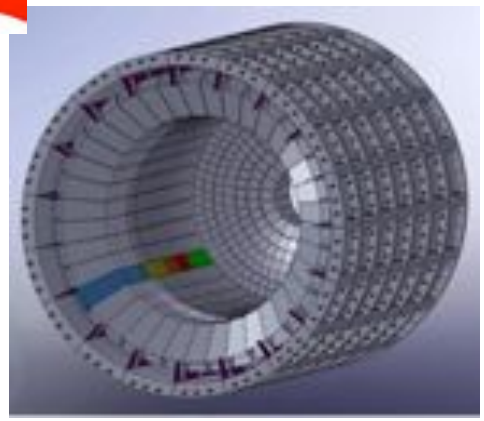
Detect with good energy resolution & high efficiency
γ < 30 MeV
p < 300 MeV





High energy reaction → forward emission

- Backward angles >130º open for access (liquid target/electronics)
- BARREL 40 – 130º → CsI(Tl) + LAAPD
- FORWARD ENDCAP 6- 40º → improved angular and energy resolution,



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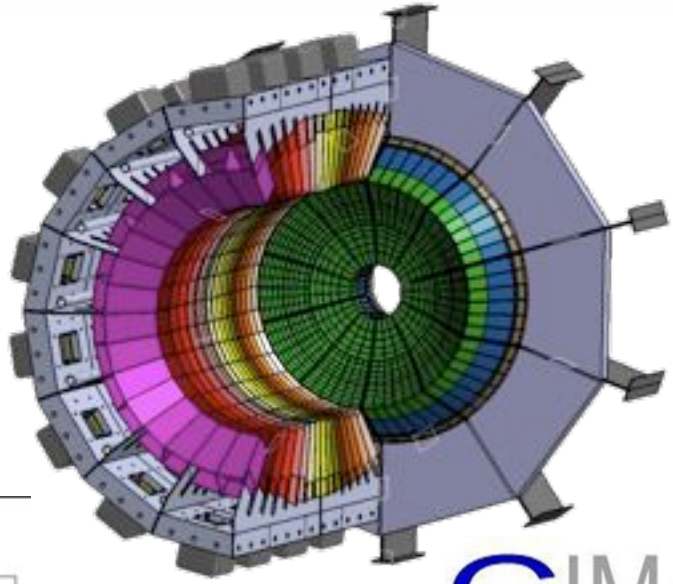

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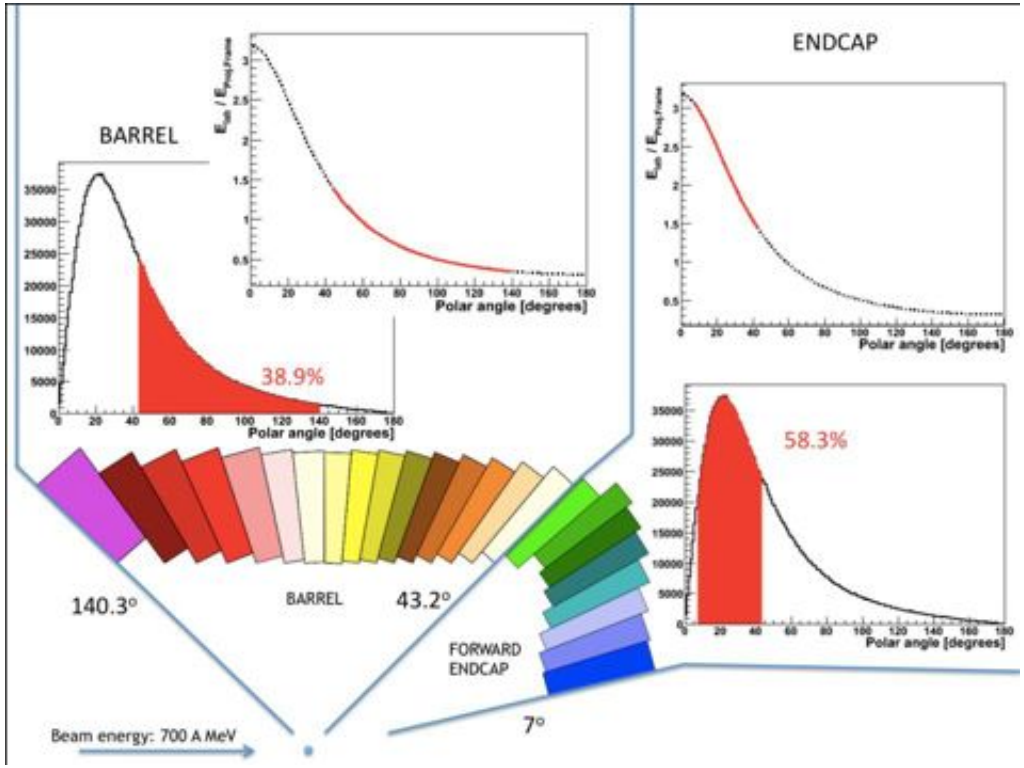

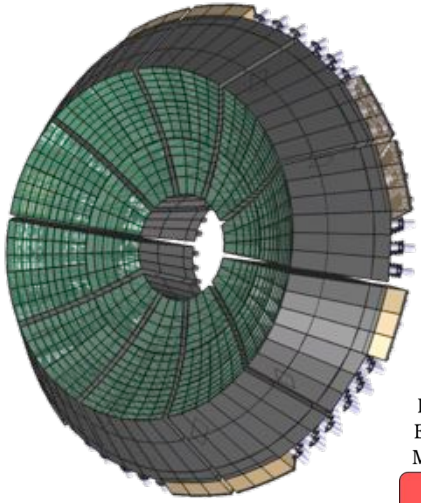

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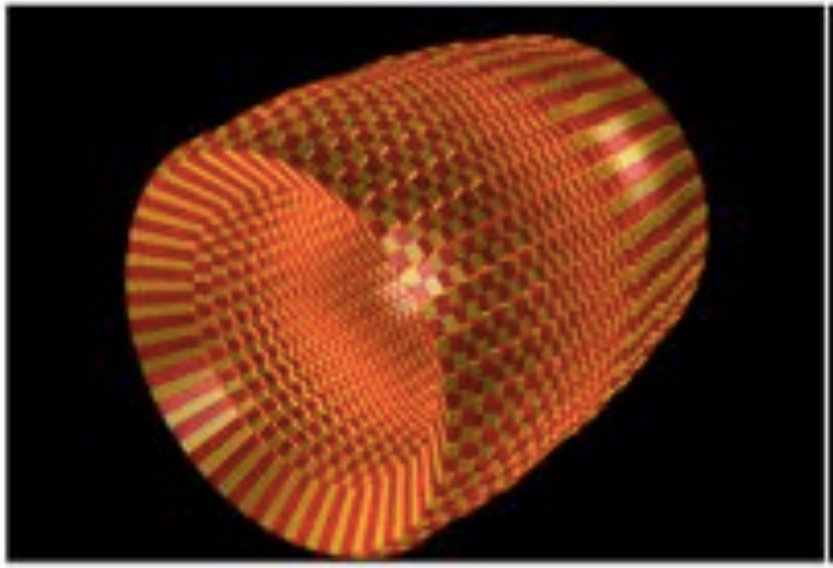
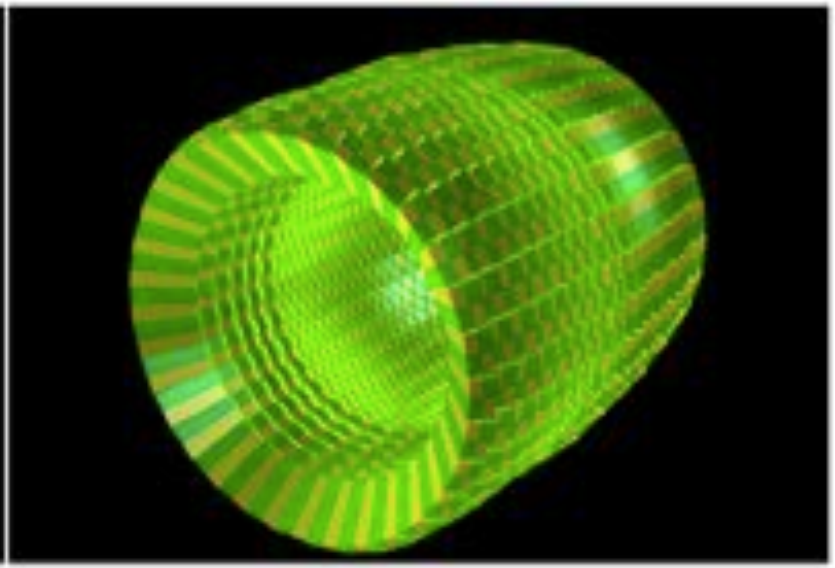
CALIFA BARREL configurations: v7.05(A), v7.07(B)

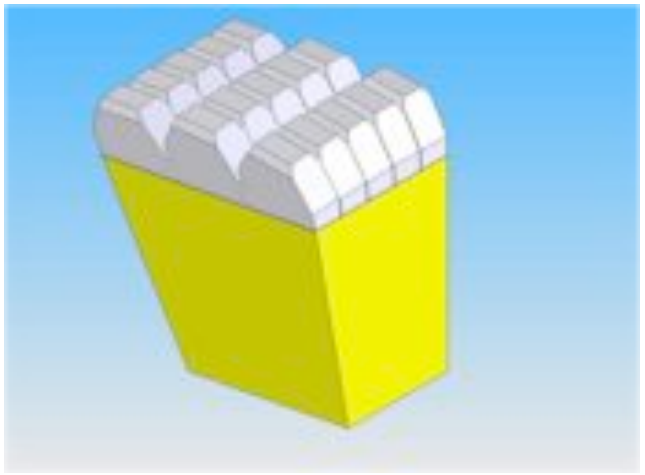
Crystals	3840
Crystals by Ring	80
Crystals by polar direction	48
Crystals by alveolus	4
Alveoli	960
Alveoli by Ring	40
Alveoli by polar direction	24

Crystals	2560
Crystals by Ring	64
Crystals by polar direction	40
Crystals by alveolus	4
Alveoli	640
Alveoli by Ring	32
Alveoli by polar direction	20

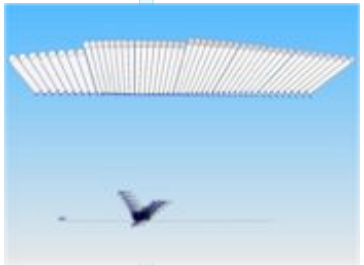


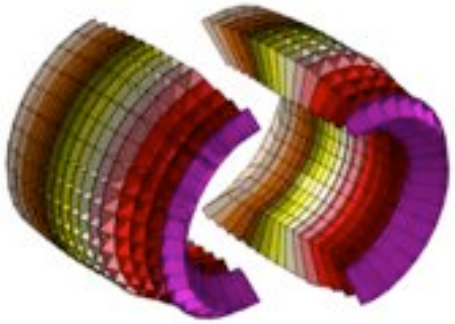


Design/Simulations R3Broot

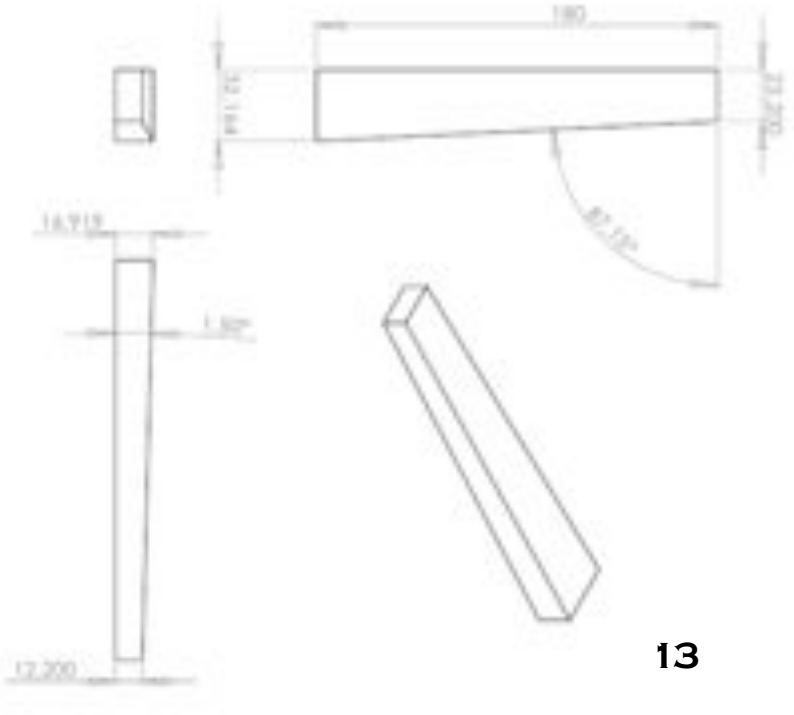


H. Alvarez-Pol (Univ. Santiago de Compostela, Spain)
Design and simulation of a calorimeter/spectrometer for the R3B setup:
the CALIFA BARREL

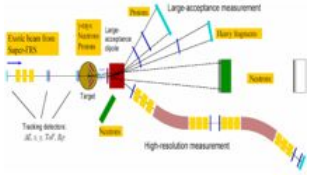




Inner radius	30 cm
Numb. of crystals	1952
Diff. crystal geometries	31
Crystal weight (CsI(Tl))	≈ 2000 kg



Forward end cap → possible Phoswich solution



In the Forward direction the high energy combined the exponential behavior of the Lorentz boost makes a special solution needed;

Possible solution → Two high resolution & high efficiency scintillator crystals in a phoswich configuration with a common readout

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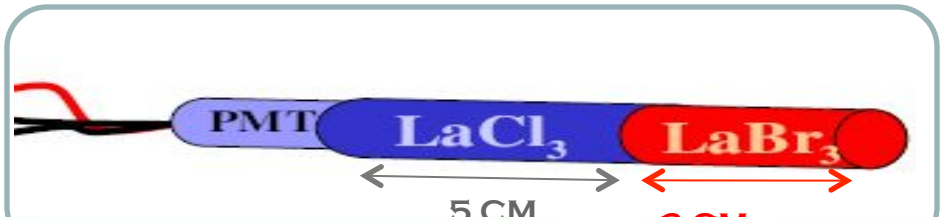
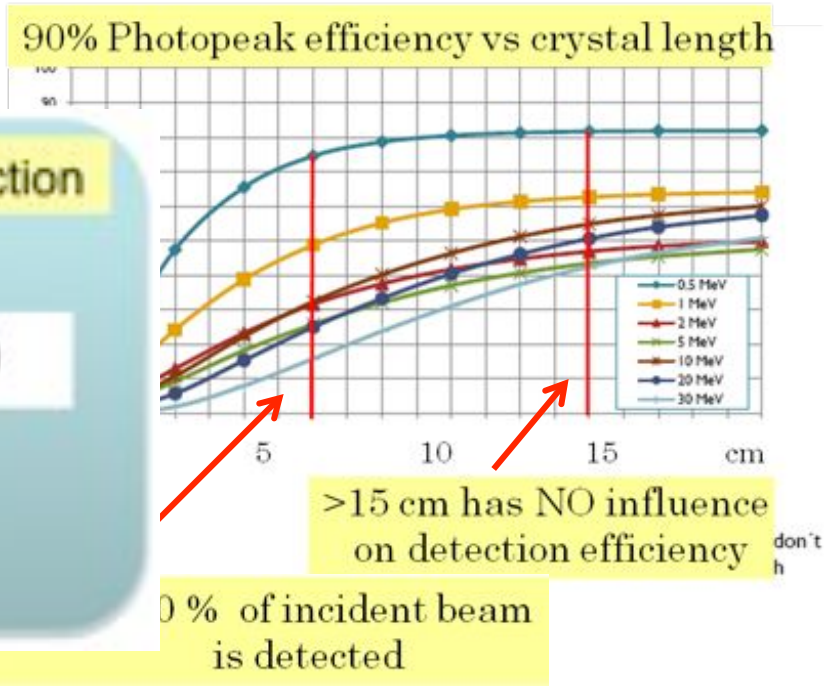
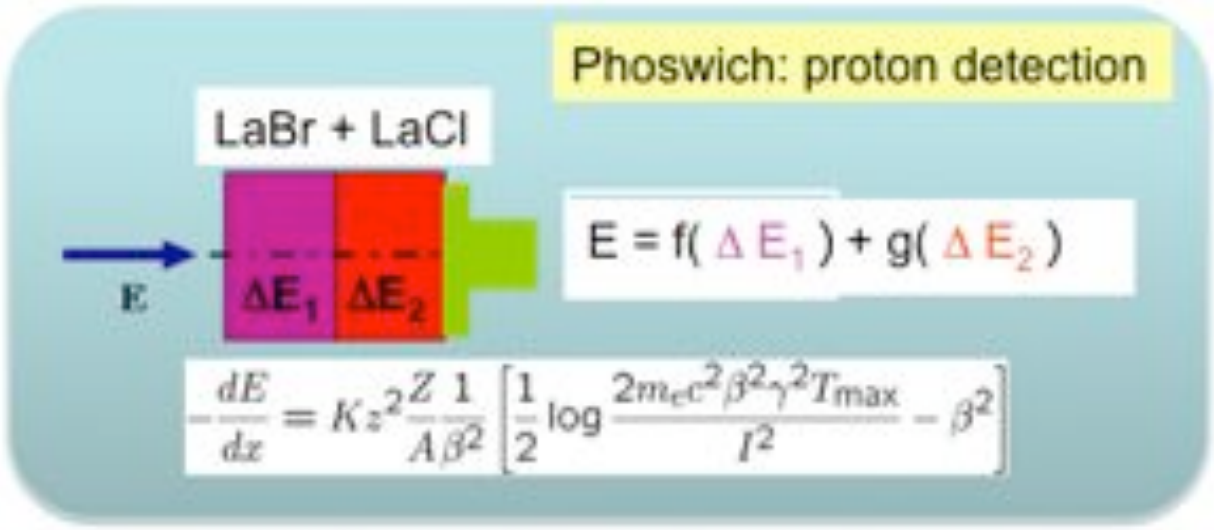


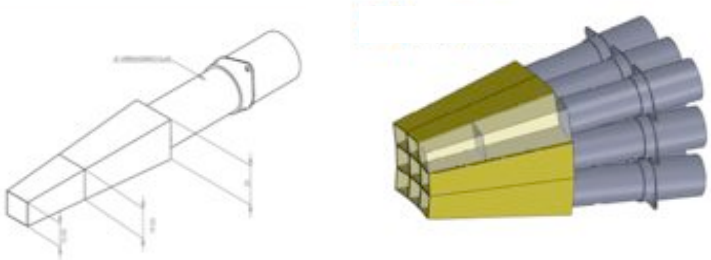
Geant 4 simulations

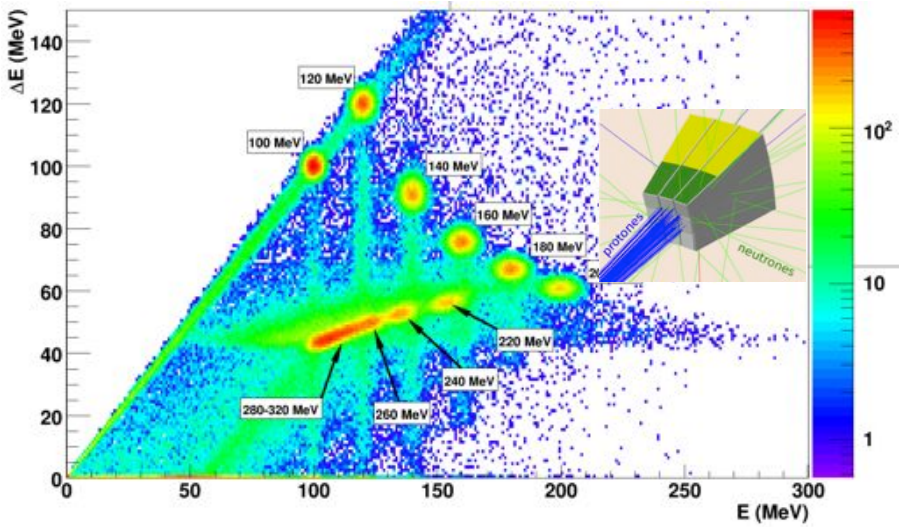




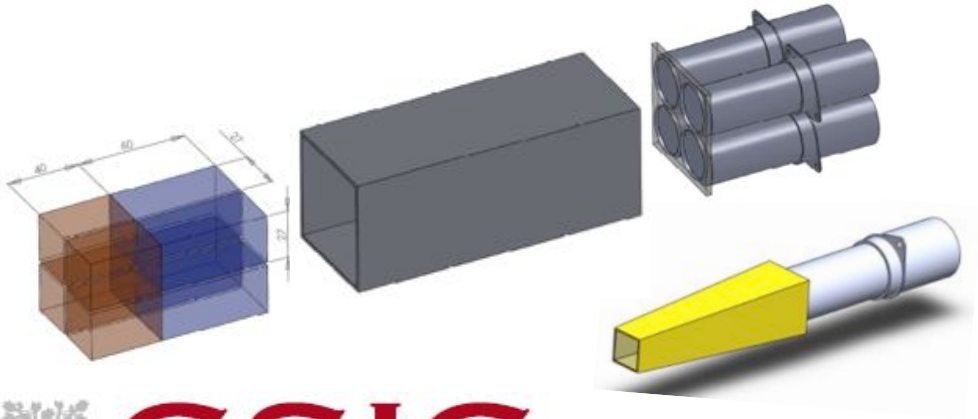
CEPA4: phoswich array demonstrator

- What we wanted…





- What we got.. CEPA4



- 4 phoswich units in an Al (0.5mm) can
- $LaBr_3$ (4 cm) + $LaCl_3$ (6 cm) and 27 x 27 mm^2 entrance window
- 1 mm of Teflon between crystals
- optical insulated

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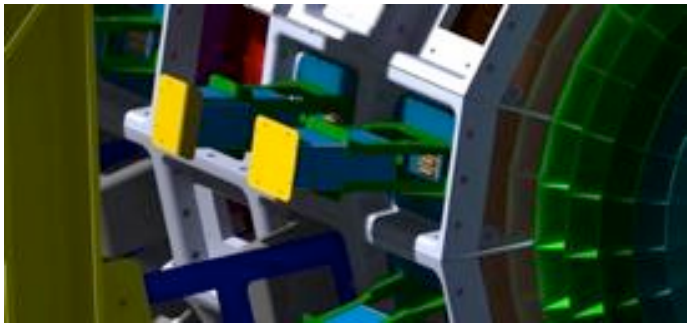
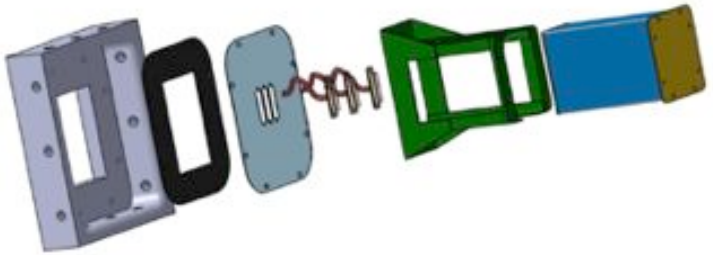
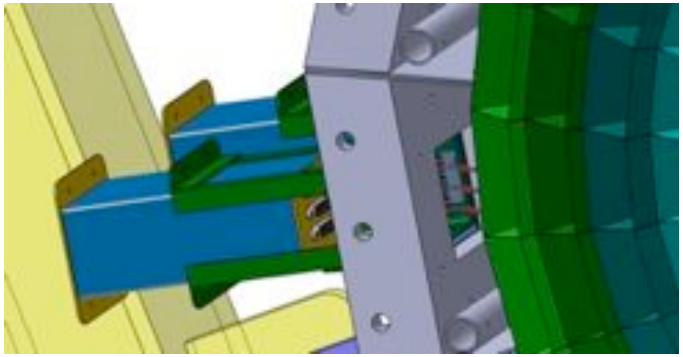
PreAmp solution

Mixed concept with analog bias regulated PA , followed by digital electronics



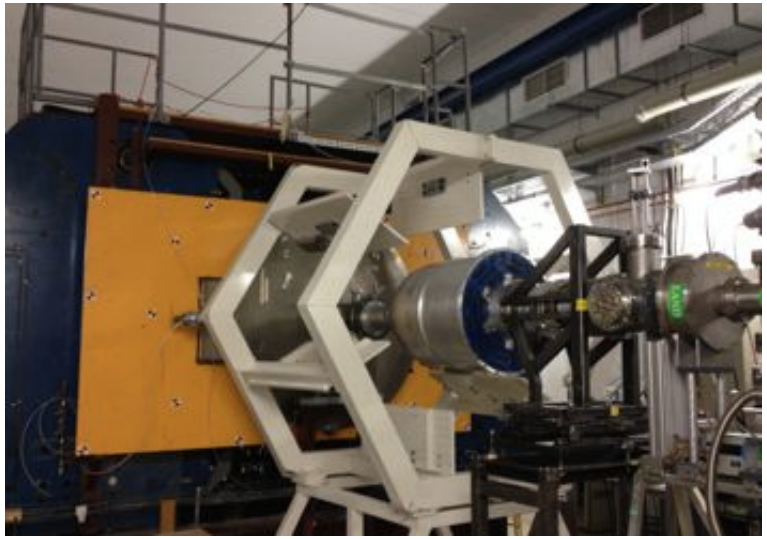


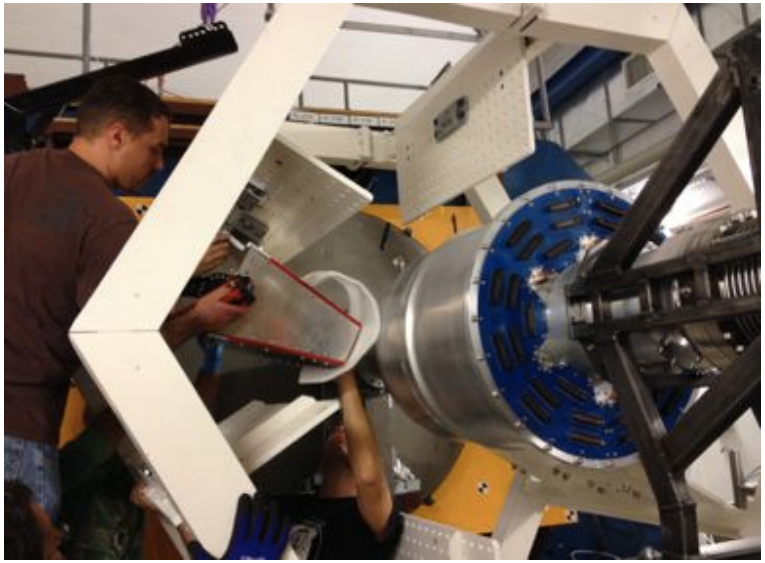


MPRB-32 **32 channel charge sensitive preamplifier with integrated bias voltage generators.**

- **Remote controllable via mesytec control bus**
- **Voltages integrated individually for each channel in 100 mV steps, up to 600 V.**
- **Temperature sensor to compensate the APD gain drift with temperature by regulating the bias voltage.**

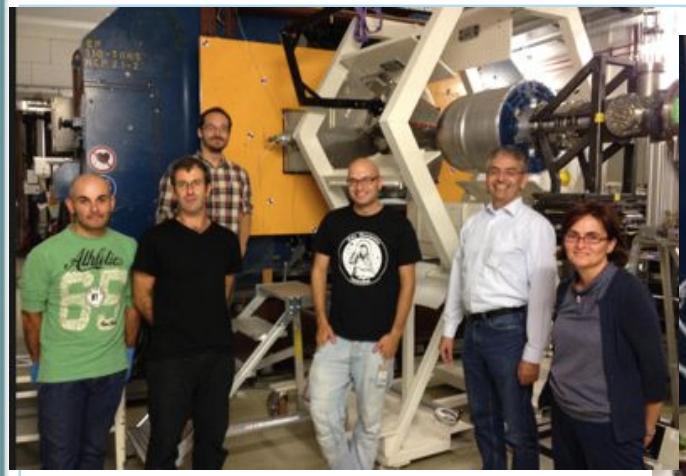
CALIFA Demonstrator Mechanical design

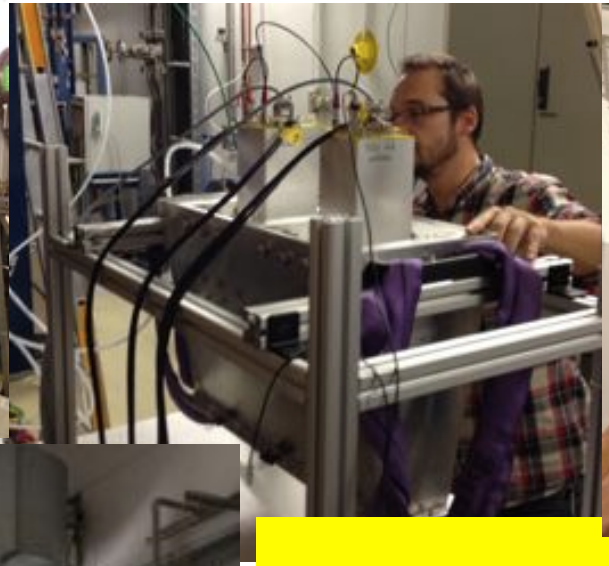


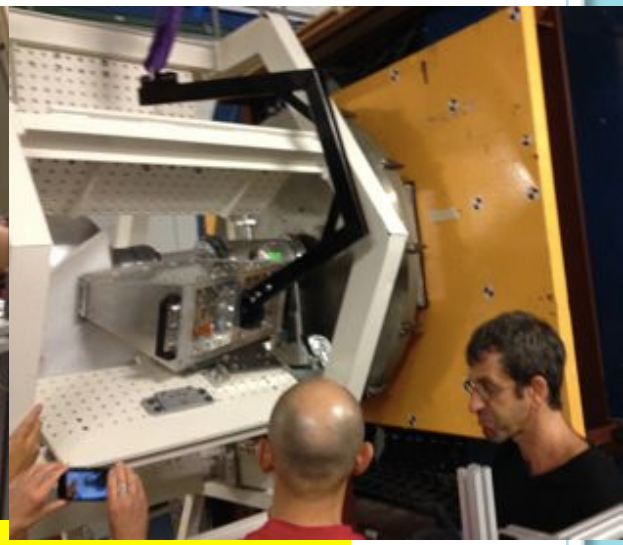


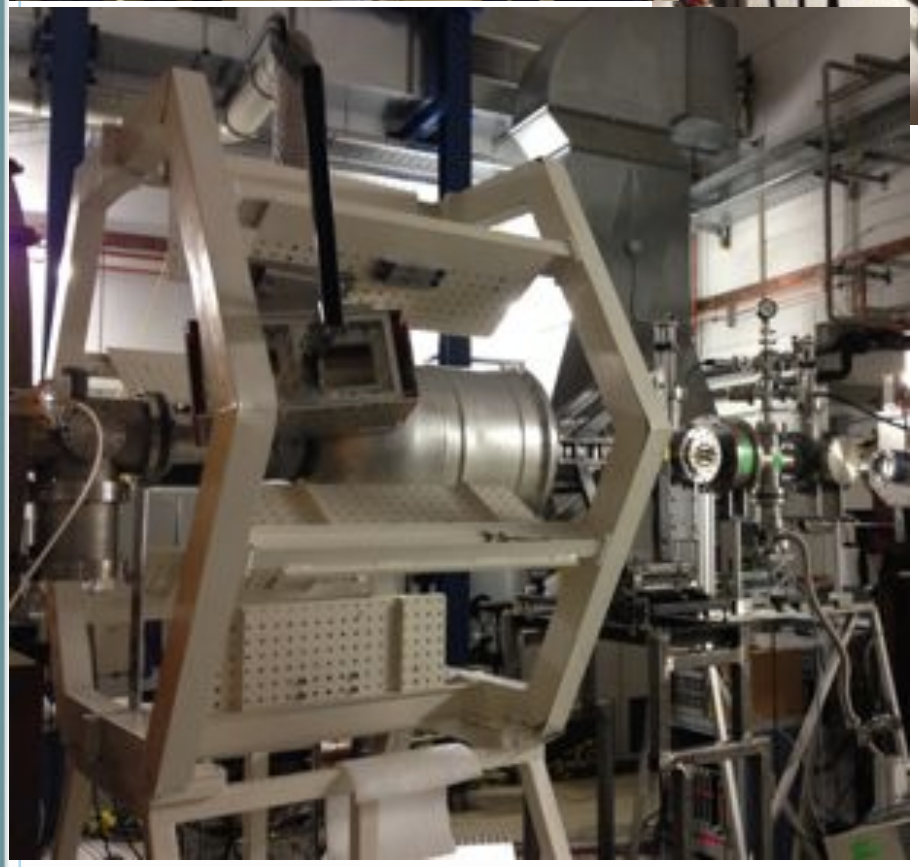
✓ **Present status:**

➢ Installed in CAVE C ready for beam









Cave C last week

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NUPNET ERA-NET for Nuclear Physics Infrastructures

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CPAN Ingenio 2010

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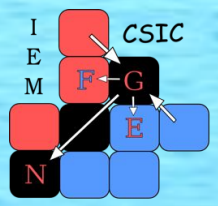
CAPACITIES

ENSAR

-- Collaboration



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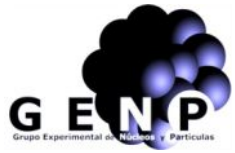

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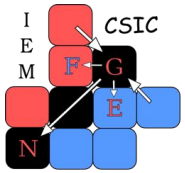

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