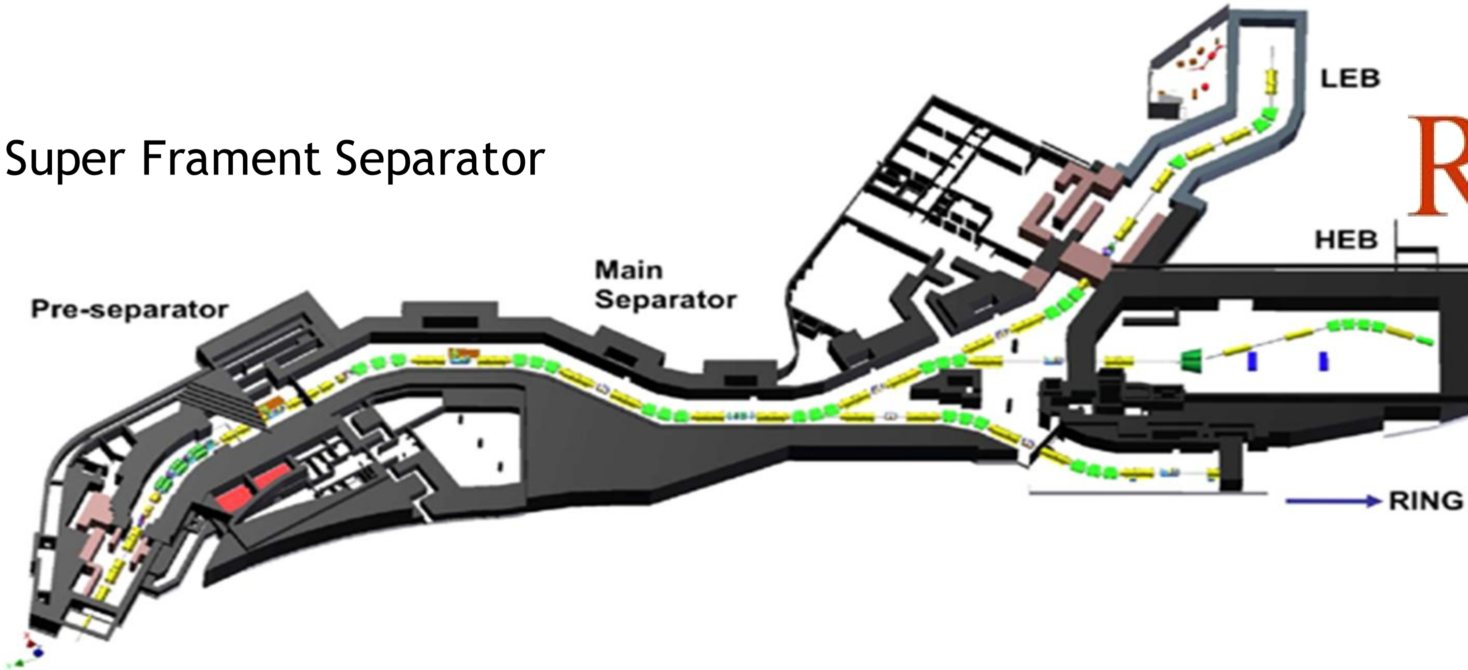
R3B Status

Lola Cortina
for the R^3B

NUSTAR Annual Meeting, Darmstadt March 1st 2017

R^{3}B in NUSTAR

Super Frament Separator



Reactions with Relativistic Radioactive Beams

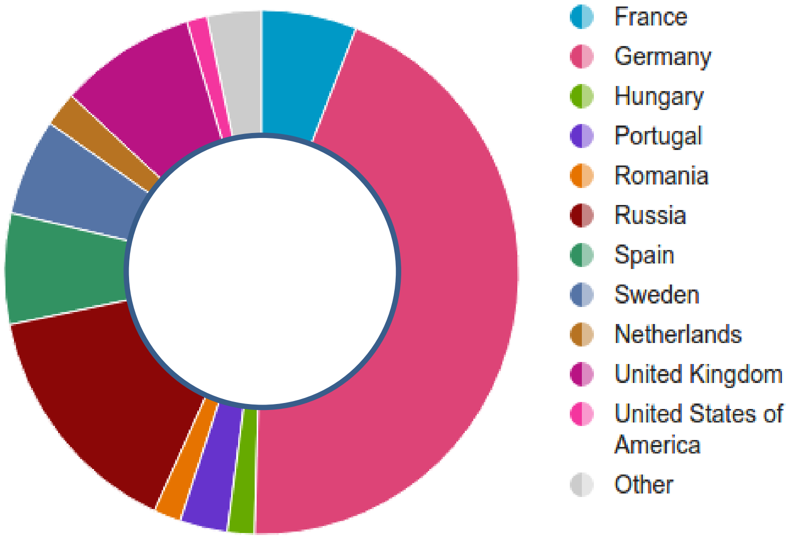
→Secondary beams at 700 A.MeV
→Fixed target reactions
→Large Acceptance Dipole Magnet
→Very performant detectors: beam, fragment, gamma, Light charge particles and neutrons

Versatile program

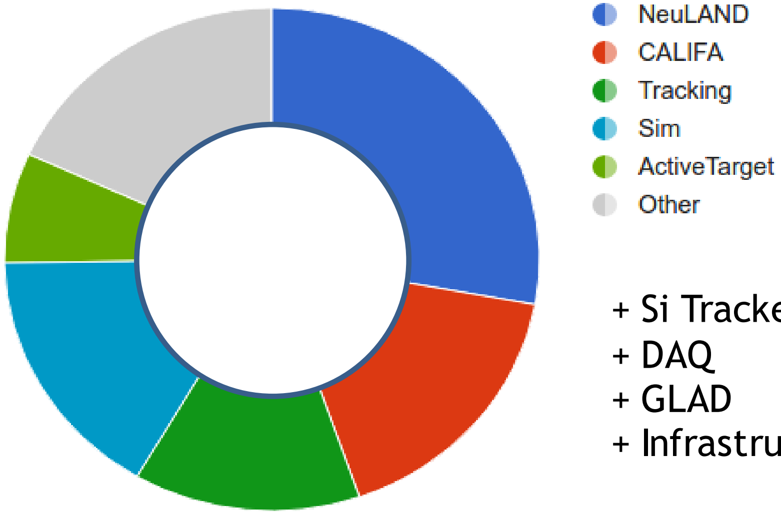
→ NN correlations and the nuclear force
→ nuclear structure far from stability
→nuclear dynamics: fission
→ EoS for high-density neutron-rich matter
→ in-medium excitation of baryon resonances
→strange matter: hypernuclei

R³B in numbers

- ~ 230 collaborators
- ~ 15 countries
- ~ 50 Institutes



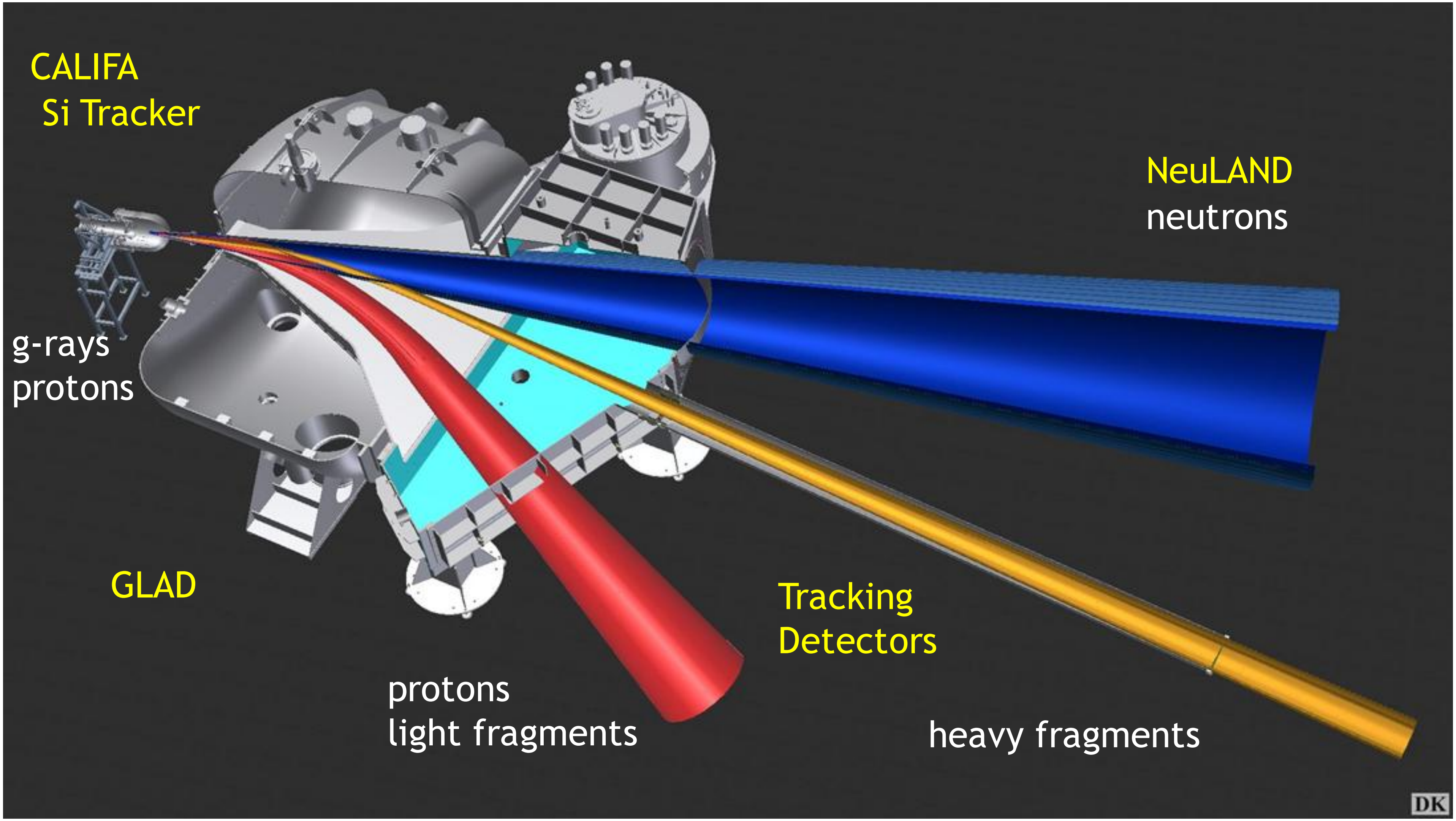
- Instrumentation developments → well structured WG´s



+ Si Tracker
+ DAQ
+ GLAD
+ Infrastrucure

- Working groups are the collaboration motor
- Technical Board meets regularly → videoconferences once per month
- Collaboration meeting → twice a year (+ NUSTAR events)
- Collaboration Board → twice a year

R^{3}B Layout


CALIFA
Si Tracker
NeuLAND
neutrons
g-rays
protons
GLAD
Tracking
Detectors
protons
light fragments
heavy fragments
DK

R^3B TDR´s

approved	submitted	in preparation	Phase 2
6	2	3	1

Q-Triplet, NeuLAND, CALIFA-barrel, CALIFA -forward endcap, GLAD, tracking detectors

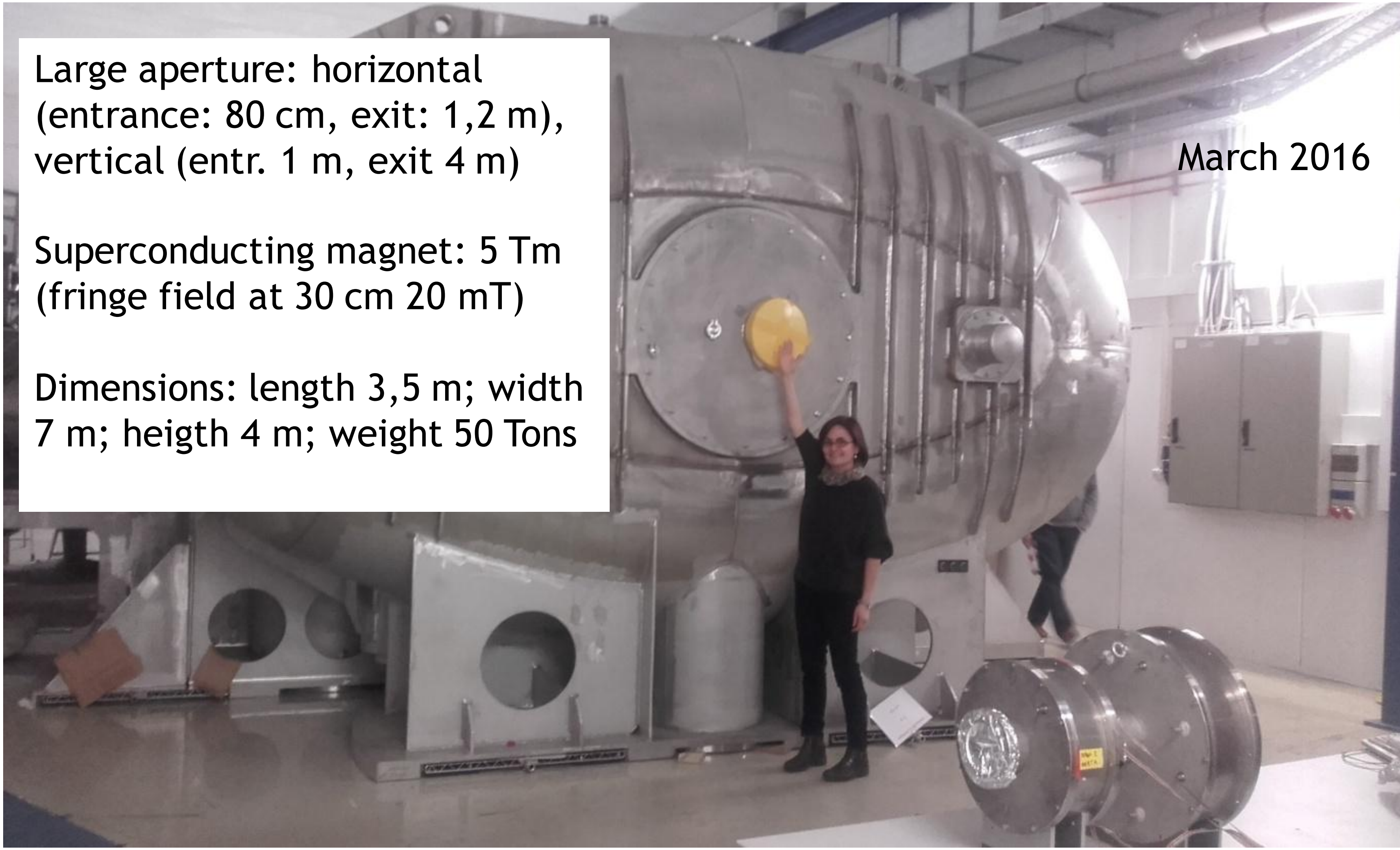
Nustar DAQ → submitted November 2016
Active target → submitted September 2015 ECE comments received

Si tracker→ expected March 2017
Vacuum Systems → expected July 2017
Infrastructure → September 2017

High resolution Spectrometer → expected May 2018

GLAD welcome to Cave C

GLAD



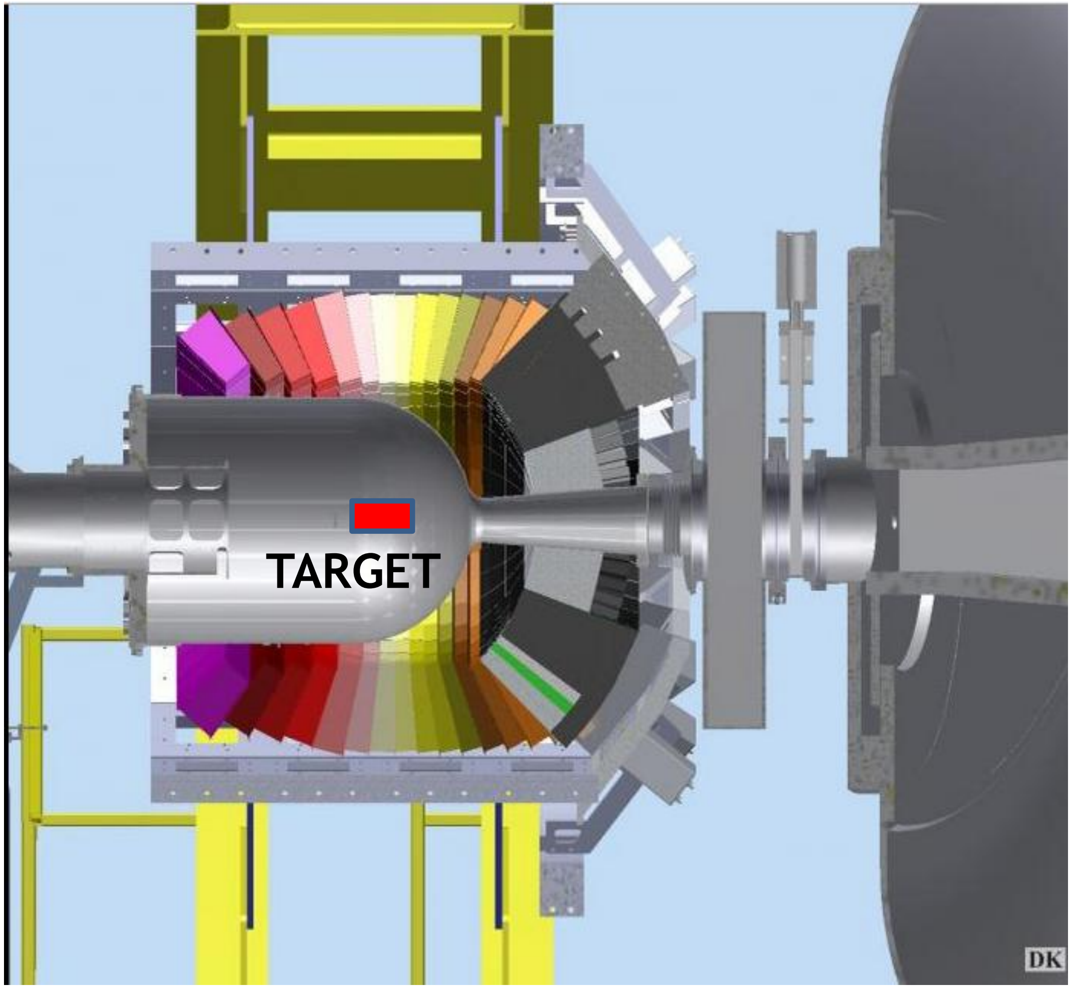
Large aperture: horizontal (entrance: 80 cm, exit: 1,2 m), vertical (entr. 1 m, exit 4 m)

Superconducting magnet: 5 Tm (fringe field at 30 cm 20 mT)

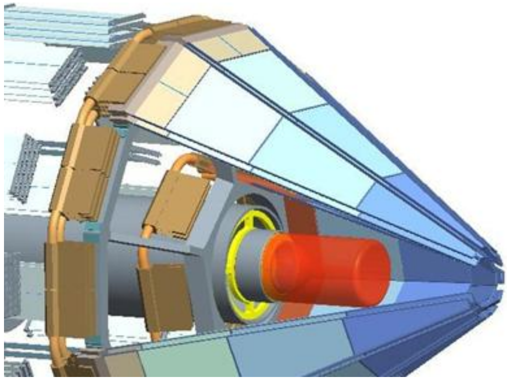
Dimensions: length 3,5 m; width 7 m; heigth 4 m; weight 50 Tons

March 2016

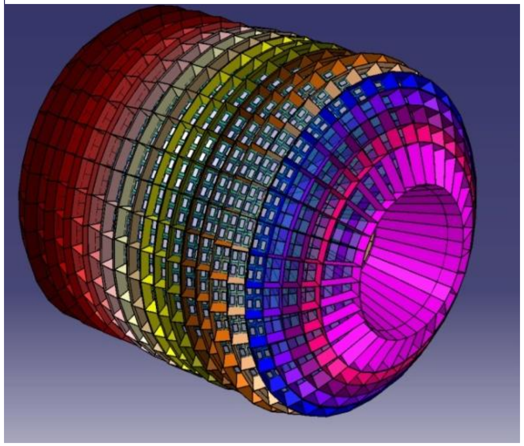
Target area



Si - Tracker

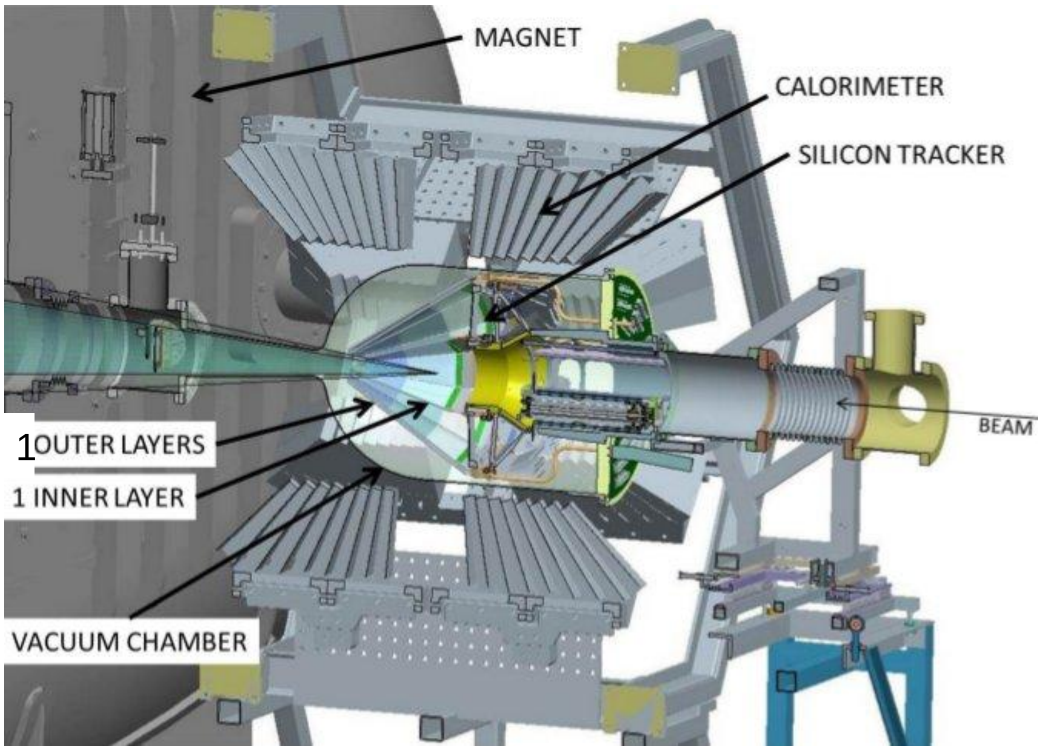


CALIFA calorimeter



Si- Tracker

Si- Tracker

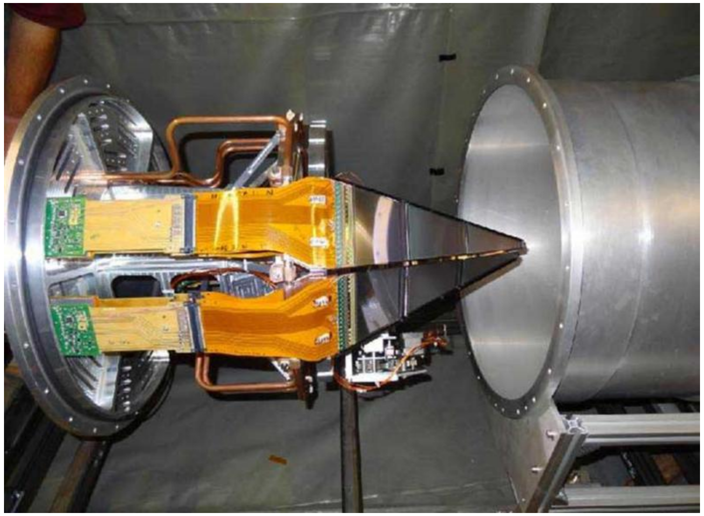


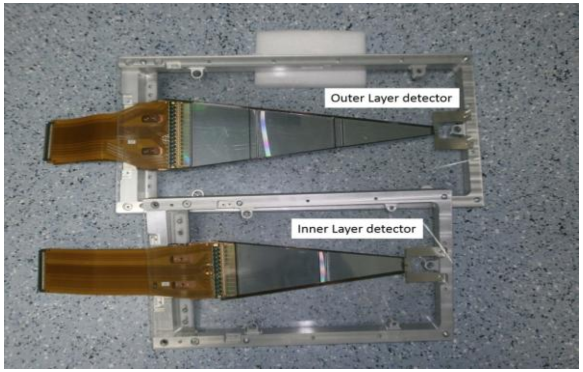
- Light-charged particles energy and multiplicity.
- Precise tracking and vertexing.
- Double-sided micro-strip Si sensors wire bounded to a custom made ASIC.
- 18 detector ladders in two conical layers 6+12.
- Strip pitch 50 mm, strip width 38 mm.
- Sensitive area 5600 cm^2.
- 912 ASICs equi. 116736 channels.
- Operated in vacuum

major funding from:
-STFC, University of Liverpool UK

Si- Tracker

Construction plans





TDR draft available end on March 2017

Mechanical assemby and ladder mounting + cooling system @Daresbury cleaning room

Readout system testing on progress

→ Tests completed early 2018

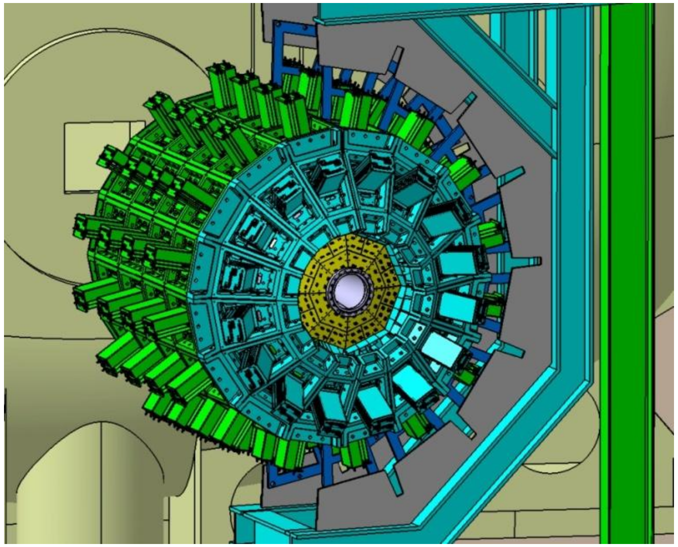
→ Moving to GSI requires infrastructure , conditioning

For 2018 -2019
Full system available at CAVE C

CALIFA

Calo. Spect.

Photo Peak Eff.	40% (up to Eγ=15 MeV projectile frame)
Calorimeter for HE LCP	200-700 MeV in lab system
ΔE/E	~5-6% (FWHM at Eg=1 MeV) , ~ 3% forward
LCP resolution	~2% (stopped particles), ~ 5% (punch through)

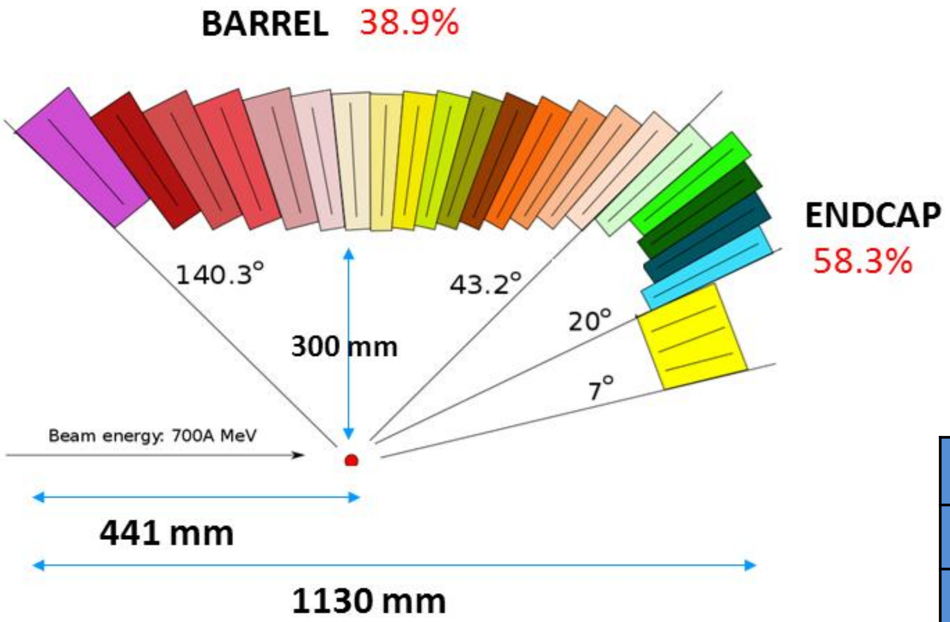


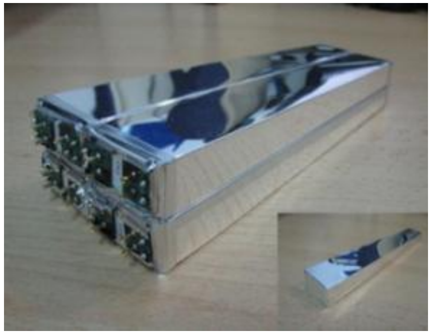
Design recently finalised

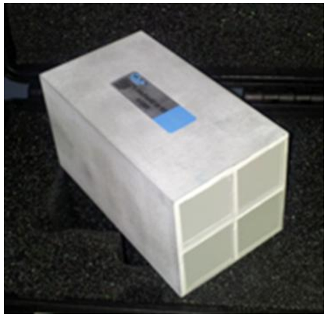
major funding from:

-USC IEM, Uvigo Spain
-ULund, Chalmers Sweden
-TUM, TUD Germany
-Dubna Russia

CALIFA



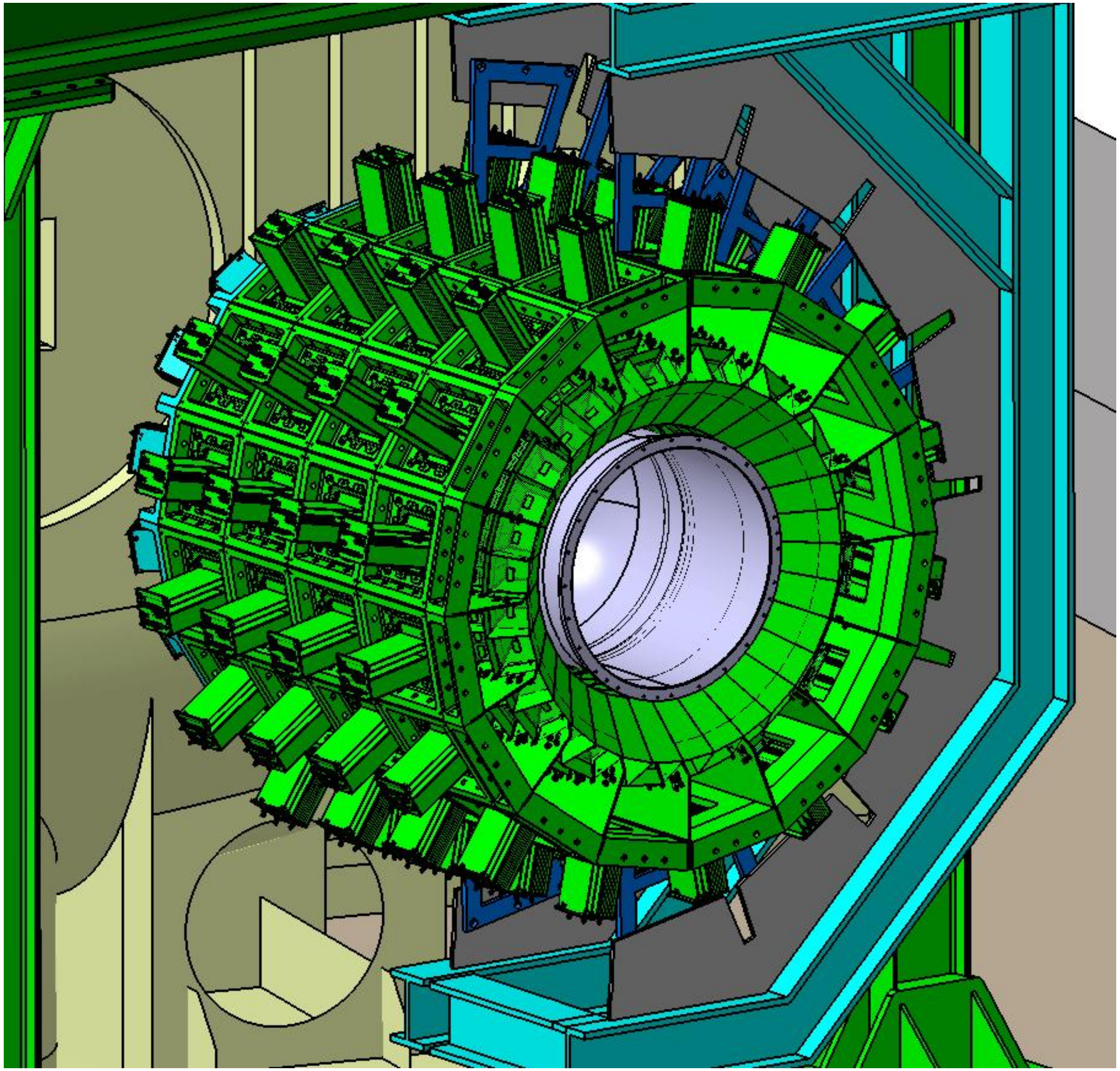




- External structure 3.5 x 4 m
- Detector volume ~ 1.3 m^3
- Detector weight ~ 2.5 Tm
- 2528 detection units

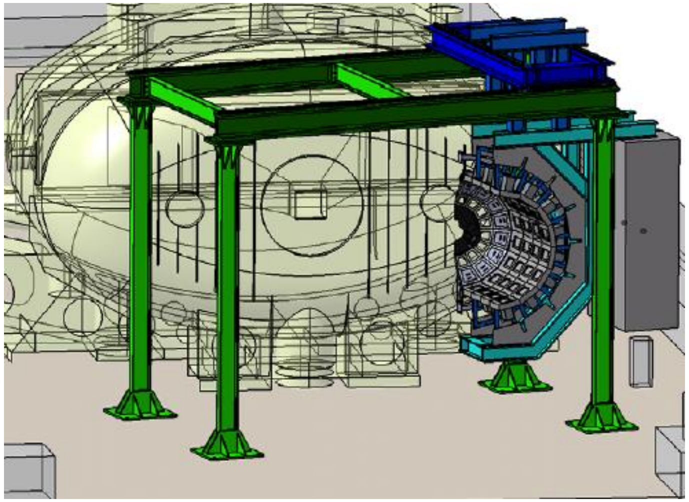
	Barrel	Endcap	
		iPhos	CEPA
Scintillator	CsI(Tl)	CsI(Tl)	LaBr/LaCl
Geom.	11	16	6
Crys. Len (cm)	15-22	22	4/7
Polar cov.	7-20º	20-43º	43-140º
Read-out	LAAPD	LAAPD	PM/SiPM
Dete.chan.	1952	480	96
Elec. chan.	1952	960	96
Weight (Kg)	~ 1500	~ 550	~ 50
Volume (cm^3)	285.000	90.000	11.000

CALIFA

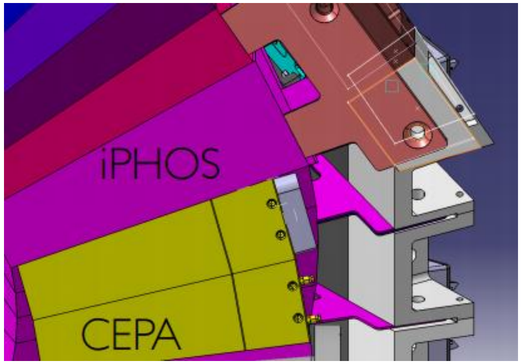


CALIFA: 2016-17 challenges

- External mechanical structure



- Fine adjustment iPhos/CEPA



Modification of the inner rings in the iPhos
→ 16 fold to 8 fold ring

- Adaptation of readout for Endcap

iPhos

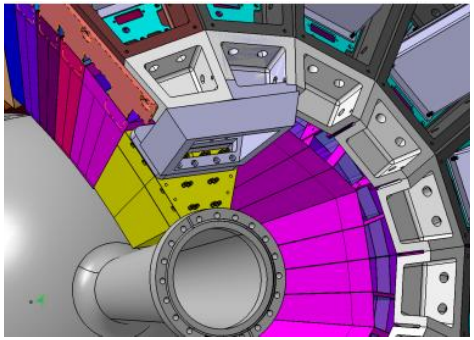
PA MPRC-16 (Mesytec) → 16 channels splitted in two branches (high and low gain) → Prototype exists

Readout : Febex4 → ADC @ 100 MHz → available

CEPA

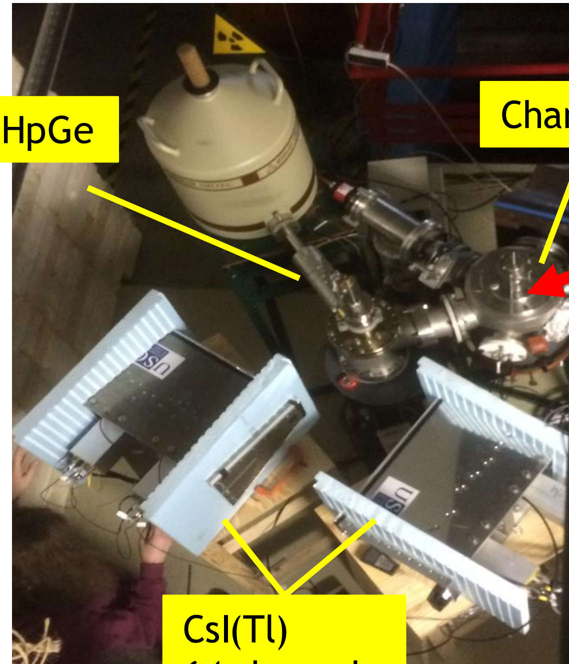
1 GHz ADC → based on the DRS4 switch capacitor (by PSI) → expected spring 2017

- CEPA mechanical support



CALIFA: 2016-17 experiments

November 2016 @ Lisbon: Benchmarking CALIFA with high-energy mono-energetic photons



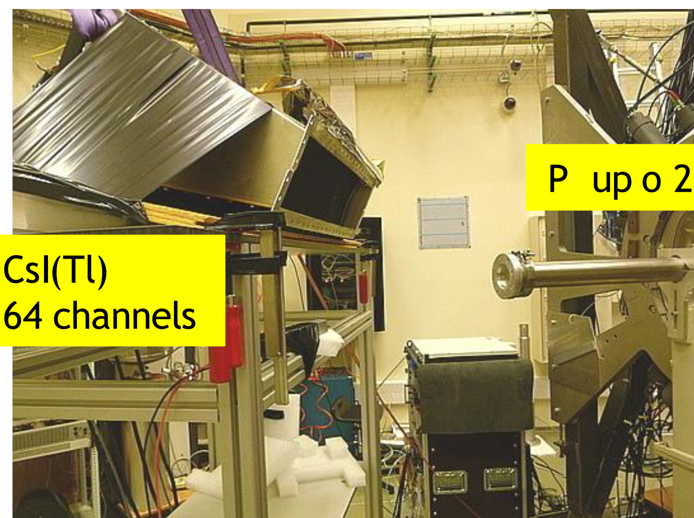
Populate resonances above 13 MeV in ^{28}Si by means of the ^{27}Al(p,γ)^{28}Si reaction.

Measured photons of about 9 and 12 MeV → benchmark the reconstruction algorithms for CALIFA at high energies.

Calibration of individual crystals up to 6.1 MeV by means of ^{19}F(p,α)^{16}O reaction→ study of calibration impact on high-energy photon

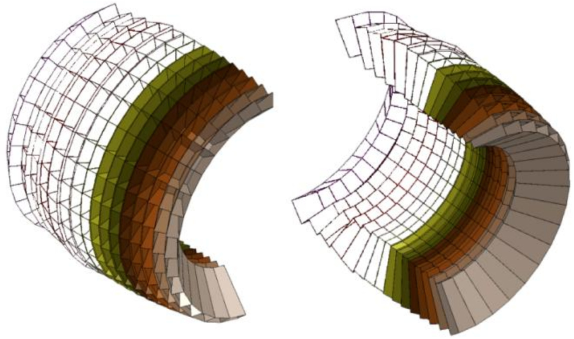
Fall 2017 @ Krakow:

Benchmarking CALIFA with high-energy mono-energetic protons

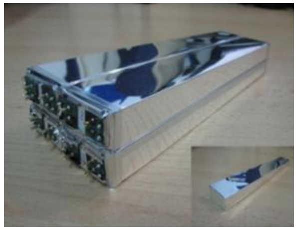


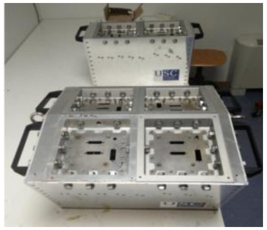
CALIFA: construction plan

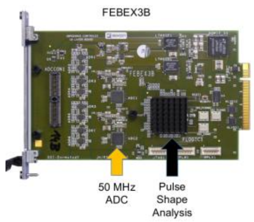
- Barrel →distributed construction



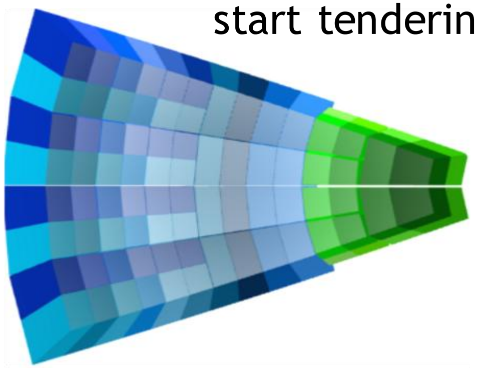
For 2018
1024 (1952) channels : CsI(Tl) +LAAPD
Intermediate Skeleton (CF) + Tiles
Analogue PA: MPRC-32 ad-hoc
Readout : Febex3B
Demonstrator frame





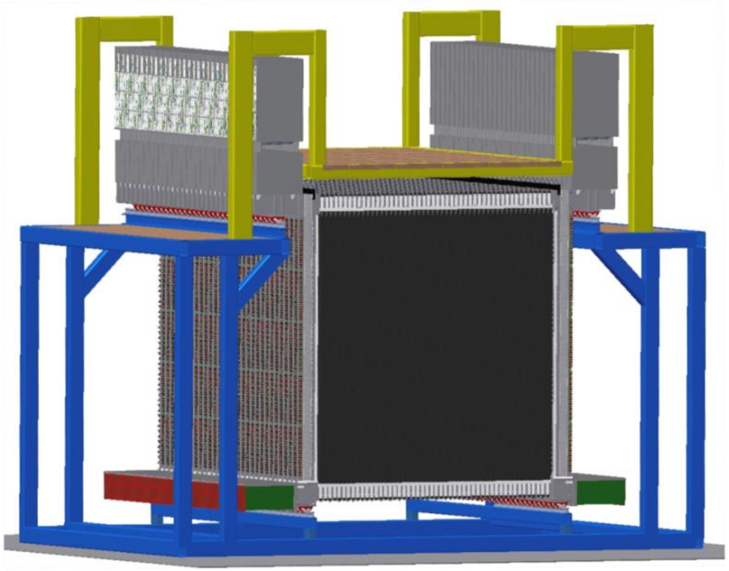
- Endcap → design recently validated
  start tendering process



For 2018 -2019
224 (480) channels : CsI(Tl) +LAAPD
Intermediate Skeleton (CF) + Tiles
Analogue PA+ readout Febex4
1 CEPA Sector (rest 2019)

NeuLAND

Efficiency 0.2-1.0 GeV n	**> 90%**
Multi-hit	Up to 5 n
Invariant mass resolution	ΔE < 20 keV at 100 keV above threshold



-full active detector using RP/BC408
-face size 250x250 cm^2
-active depth 300 cm
-3000 scintillator bars + 6000 PMTs
-32 tons
-$\sigma_{x,y,z} \approx$ 3cm and σ_t < 150 ps

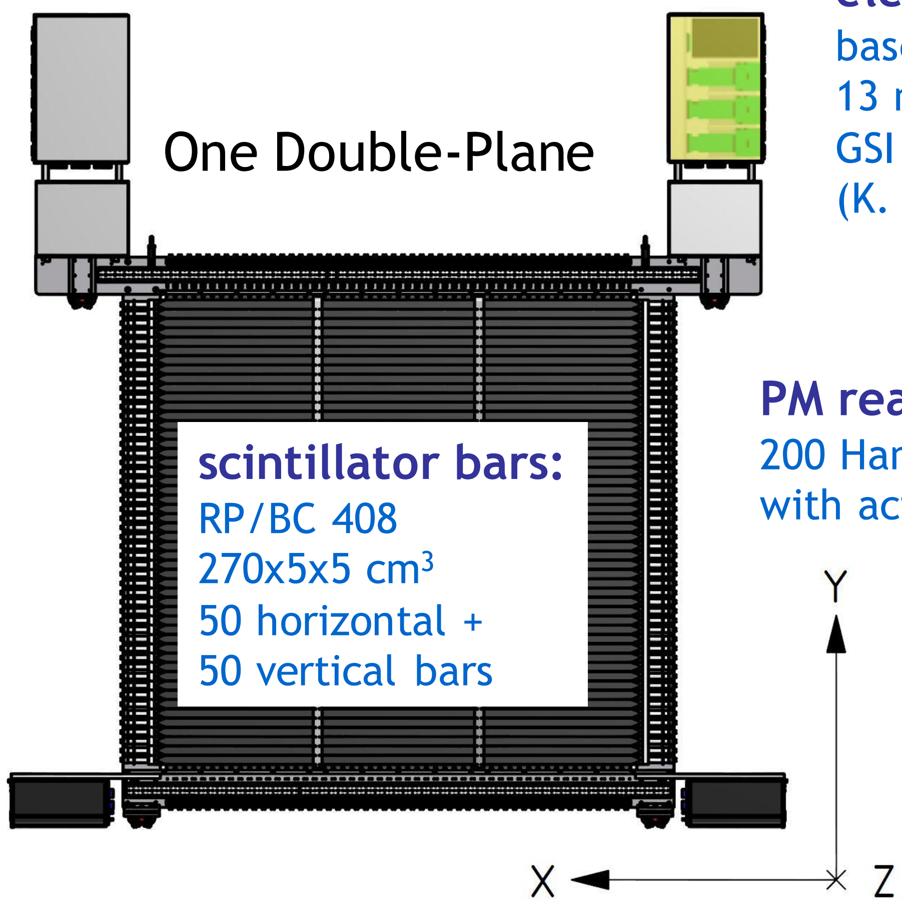
major funding from:
- GSI Darmstadt, TU Darmstadt. Univ. Frankfurt, Univ. Köln
- PNPI St. Petersburg

NeuLAND: Building blocks

Each double-plane is equipped with all auxilliaries, allowing for independent use

electronic readout:
based on TAMEX3
13 modules à 16 ch.
GSI inhouse development
(K. Koch, M. Heil et al.)

HV Dist. Syst.:
4 modules à 50 ch.
PNPI in-kind
(L. Uvarov et al.)



scintillator bars:
RP/BC 408
270x5x5 cm^3
50 horizontal +
50 vertical bars

PM readout:
200 Hamamatsu R8619
with active voltage divider

NeuLAND: Real Double planes

electronic readout:
pre-series successful
mass production started
delivery Q3/2017

photomultiplier readout

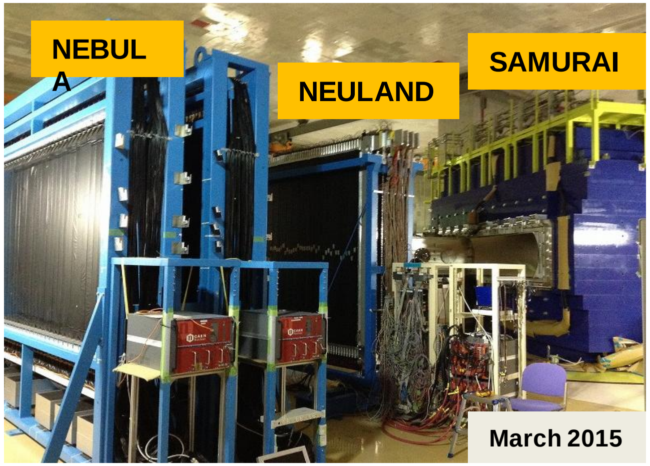
HV System
1200 ch. in-house
+2000 ch Q3/2017

NeuLAND @ RIKEN

Demonstrator (4dp's) fully functional,

2015

IMPACT campaign 7Li(p,n)
→ 1n efficiency at 110, 250 MeV,
^{28}O experiment



2016

Sπrit TPC – EOS experiment
^{31}Ne C. breakup & knock-out
Removal react. around N=16 shell closure
Lifetime ^{26}O ground-state

2017

Dipole response of neutron-rich Ca isotopes(T.Kobayashi -Y.Togano)
Dipole response of dripline nuclei (T.Aumann - T.Nakamura): ^{6,8}He, ^{24}O, ^{29}F
Tetra-neutron system: ^{8}He(p,pα)4n (S.Paschalis, D.Rossi - S.Shimoura)
^{8}He(p,2p)^{7}H (K.Kisamori- F.M.Marqués)

NeuLAND

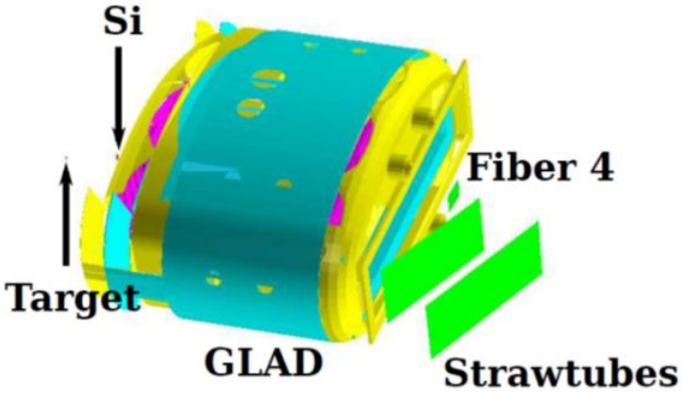
backtransport to GSI

NeuLAND@GSI

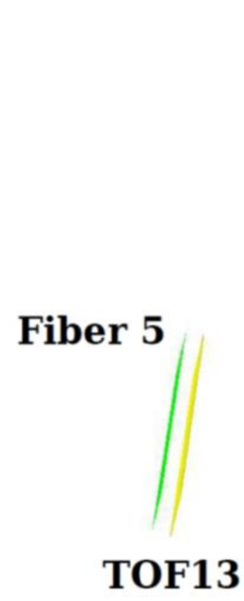
continuation of production (7 dp‘s as of today)
implementation of new electronics and
HV system

For 2018
12 double planes (40% detector)
ready for beam @ GSI

Tracking detectors



- Silicon
- Fibers
- Strawtubes
- Plastics



Different detectors for different challenges

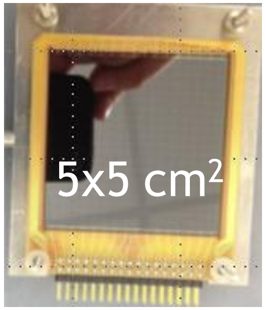
- Before target 1 LOS(plastic)+ Silicon+ Fiber detectors
- After target (Between CALIFA and GLAD) 1 Silicon or 1 LOS (Plastic)
- Heavy Fragment arm: 2 plane Fiber detectors→ Fiber 4 (41x24 cm^2, 200 μm) and Fiber 5 (80x80 cm^2, 500 μm) + TOF wall (120x80 cm^2, 5 mm plastic paddles)
- Proton Arm Spectrometer : Strawtubes (210x100 cm^2)+ TOF wall (1 cm plastic paddle)

Tracking detectors

Silicon detectors

X1 model (Bicron)

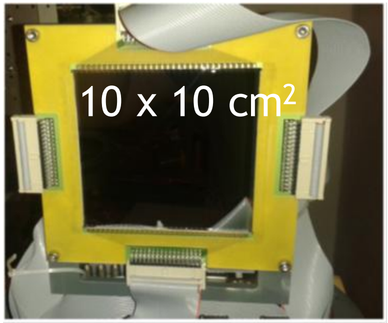
- Double side detectors, (only front side is segmented→ 32 channel and readout both ends → position)



major funding from:
TU Darmstadt Germany

New type of PSP tested (X5 Bicron)

- 32 strips on each side
- 128 channels in total



For 2018
Set of X5 detectors

Tests in 2016 with Xe and C beams

	Energy	Position
Resolution X5	2.3%	Front 200-800 μm Back 120-140 μm
requirement	0.5%	100 μm

- Too large current drawn during beam time
- Detectors sent back to producer for diagnostics

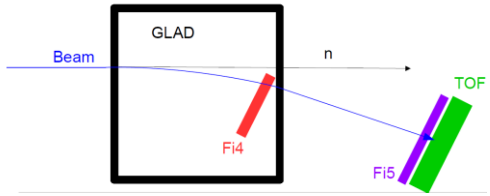
Tracking detectors

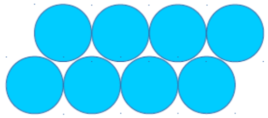
Fiber detectors

Use of 200 μm square fiber too difficult for large detectors

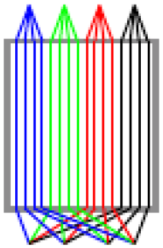
- 200 μm round fiber for FIB4 (in vacuum)
- 500 μm round fiber for FIB5

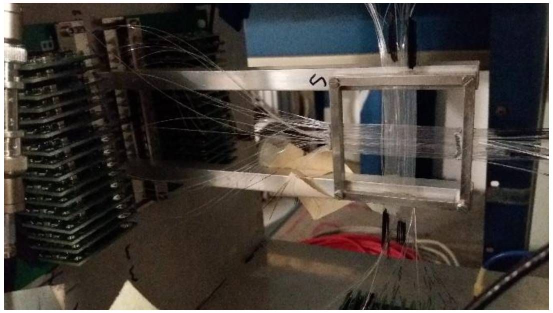
major funding from:
TU Darmstadt Germany





- Fiber bundling will be necessary to reduce number of read-out channels
- Read-out: GEMEX or FPGA-TDC based read-out
- Sensors:
  - FIB4: MPPCs (SensL vs.Hamamatsu) (or MAPMT μ–shielded)
  - FIB5: Multi-Anode PMT





For 2018
FIB4 41x24 cm^2
FIB5 80x80 cm^2

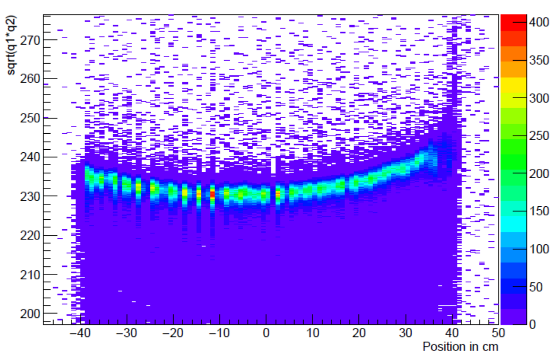
Tracking detectors

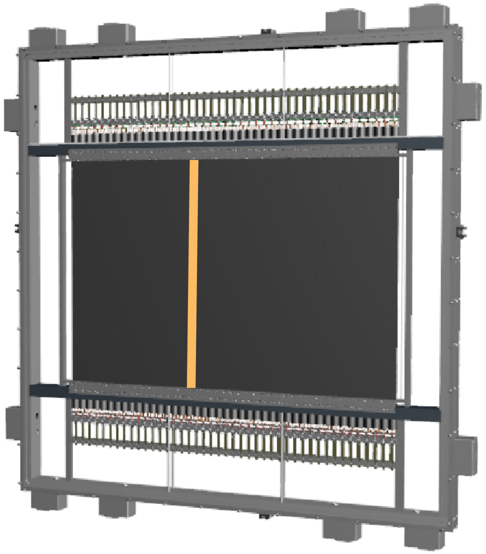
ToF wall

2 planes with 3 mm plastic scintillator, EJ-204.
2 planes with 5 mm plastic scintillator
Each plane→ 44 scintillators 800x27x3(5) mm^3

Z separation	$\sigma_E < 1\%$
A separation	$\sigma_t < 38$ ps
Rate	1 MHz

- Size: 120 x 100 cm^2
- No light guide, PMT R8619 coupled directly to scintillator
- Movable holding structure to sweep TOF wall across beam



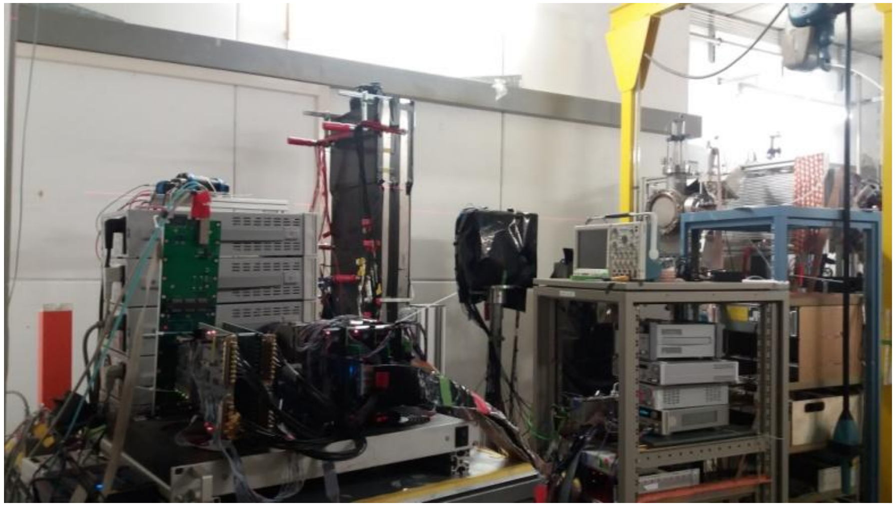


major funding from:
TU Darmstadt

Tracking detectors

Tests in 2016 with Xe and C beams at 600 AMeV (U beam at 300 AMeV).

Prototype detector
- 4 planes
- 6 scintillator per plane.



- Layers 1 and 2 → 3 mm scintillators.
- Layers 3 and4 → 5 mm scintillators.
- Wrappings: Al foil, black foil
- No light guide

Results should be considered as lower limits

Energy precision $\sigma_E < 0.65\%$ (goal < 1%).
Time resolution of $\sigma_t = 11$ ps (goal < 38 ps)

For 2018
ToF wall 4 planes
120x80 cm^2

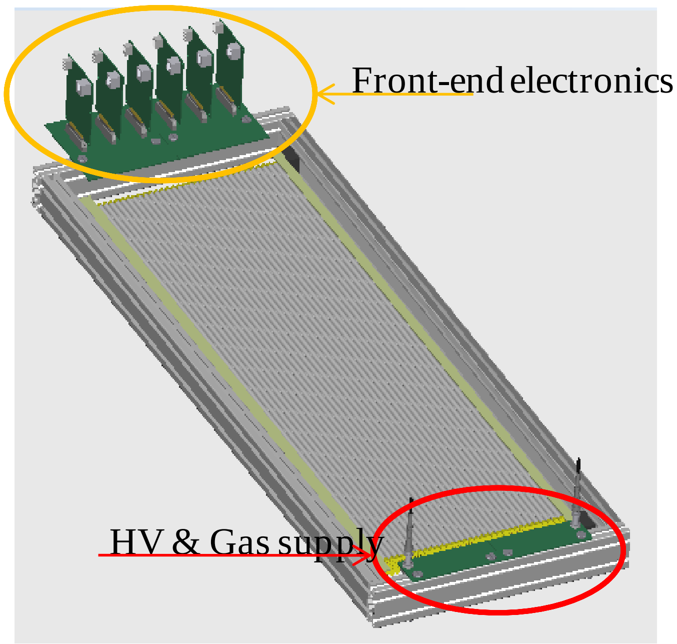
Tracking detectors

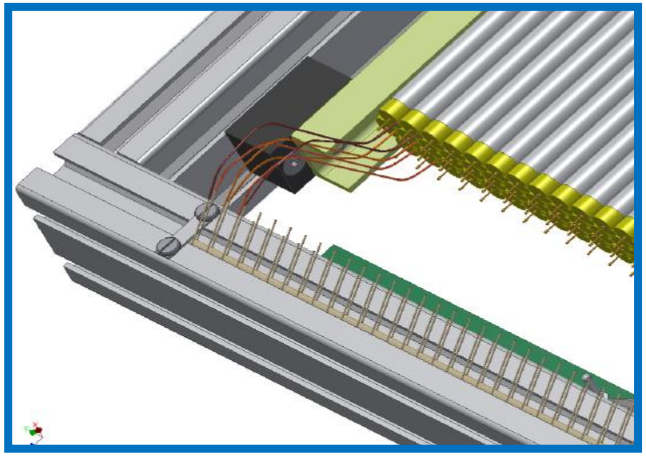
Proton Arm Spectrometer

- Large area detectors: 2.1 x 1.0 m^2
- 2000 straws of 10 mm diameter
- 4 planes, 2 x, 2 -y-oriented.

major funding from:
Russian in kind contribution (FAIR)

Efficiency 500-1000 GeV p	**>95%**





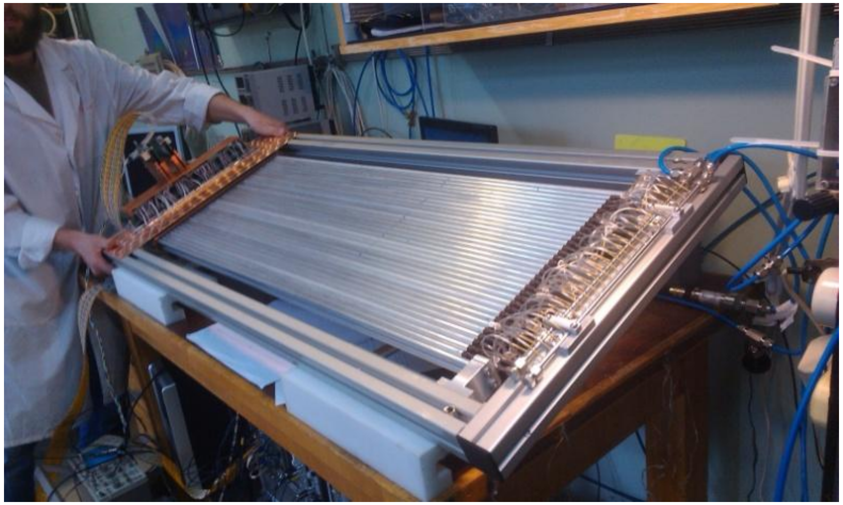
The first plane (x) will contain mylar or kapton straws, all others will be thin Al tubes.

Tracking detectors

Some concerns regarding the readout

- Basic requirement: TDC with time resolution better than 1 ns
- Must fit into R3B DAQ concept → GSI developments

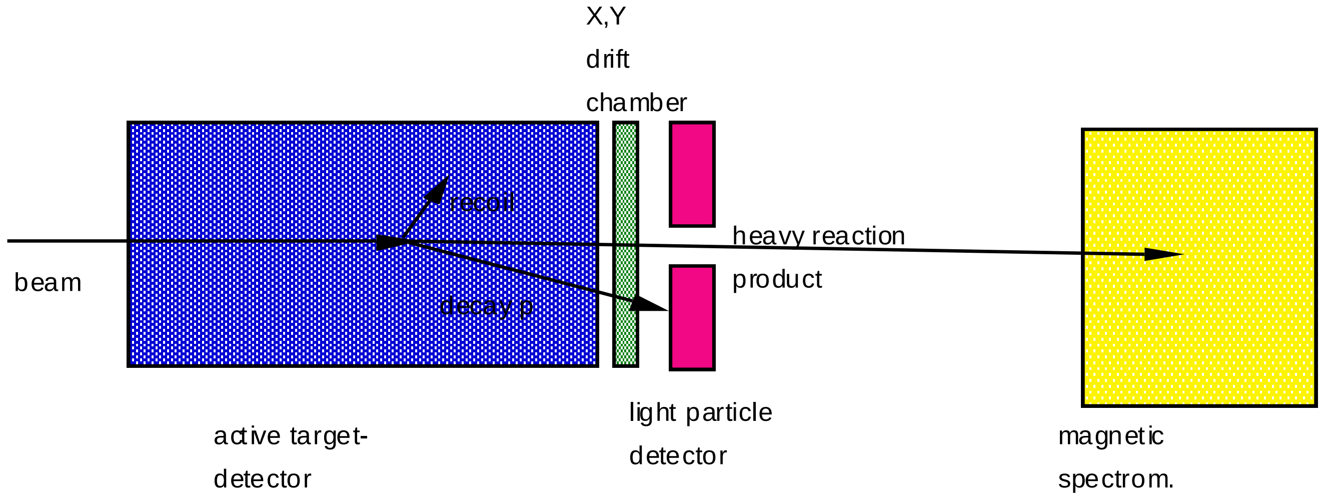
Tests and prototypes



Consists of **96** ultrathin tubes

For 2019-2020
1 STW unit
(vertical Al tubes)

Active Target



⇒ advantage:

- low threshold
- high detection efficiency (rel. thick target)

⇒ well suited as alternative technique to EXL for:

- short lifetimes (T ≤ 1 sec)
- low RIB intensities (≤ 10^5 sec^{-1})

TDR submitted 2015 in review

Feasibility study 2014 and 2016
(Ni and Xe)

For 2018
Prototype ready
- ($\alpha,\alpha\gamma$) → need a part of CALIFA
- proto elastic → new set up

Simulation and analysis

R3BRoot https://www.r3broot.gsi.de

- Based on the Virtual Monte Carlo (VMC) concept using Geant4 and Geant3.
- **UCESB** for the data unpacking and sorting →possible online extensions.
- Includes parameter handling, event display, ROOT file and data management...

	LOS	PSPX	TOFd	NeuLAND	Si Tracker	CALIFA	Straw tubes
Mapped					***	***	
CAL							
HIT							

Mapped - raw data delivered from Ucesb to R3BRoot and stored
CAL - calibrated data: time [ns], charge [MeV]
HIT - physical hits, time [ns], charge [MeV], position [cm], all synchronized

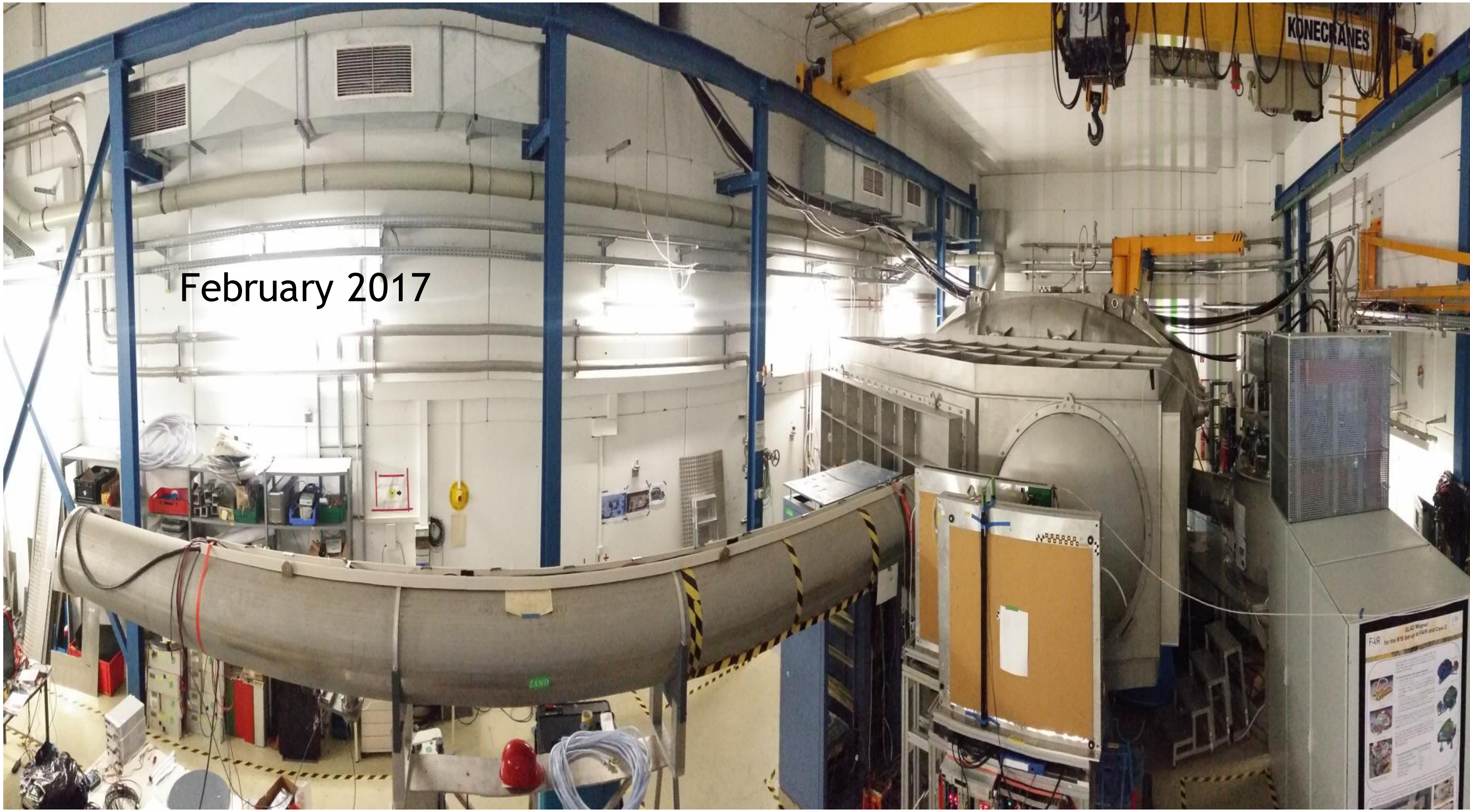
2nd R3BRoot workshop 7-9 March 2017 at GSI.

Experimental Program- FAIR Phase 0

- The R3B collaboration has done a enormous work to design and build this unique setup (~ 15 years)
- Very intense activity to be ready for 2018 -2019 experiments
  - Construction of the detectors
  - Development of common simulation and analysis tools
  - Discussions to define the experimental program→ Internal ¨PAC¨ next April
  - Conditioning of the CAVE C :
    - Cleaning of the CAVE C
    - Hosting GLAD → related infrastructure (QPU, Cryo –plant, cryo –lines, current, Power supply)
    - Vacuum tests in the big GLAD chamber and Fragment tube (5×10^{-6} mbar)

Cave C- FAIR Phase 0

Cave C- FAIR Phase 0




Future looks promissing
Thanks for your attention