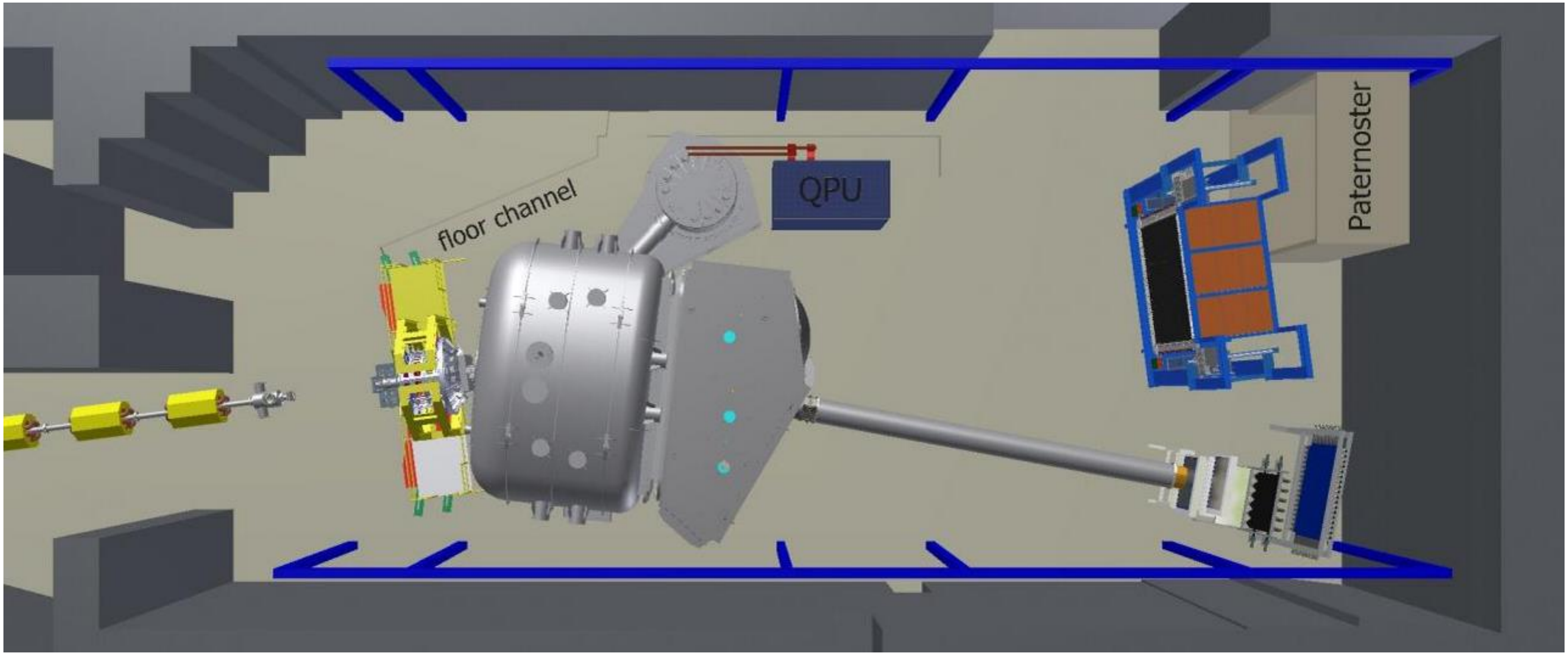
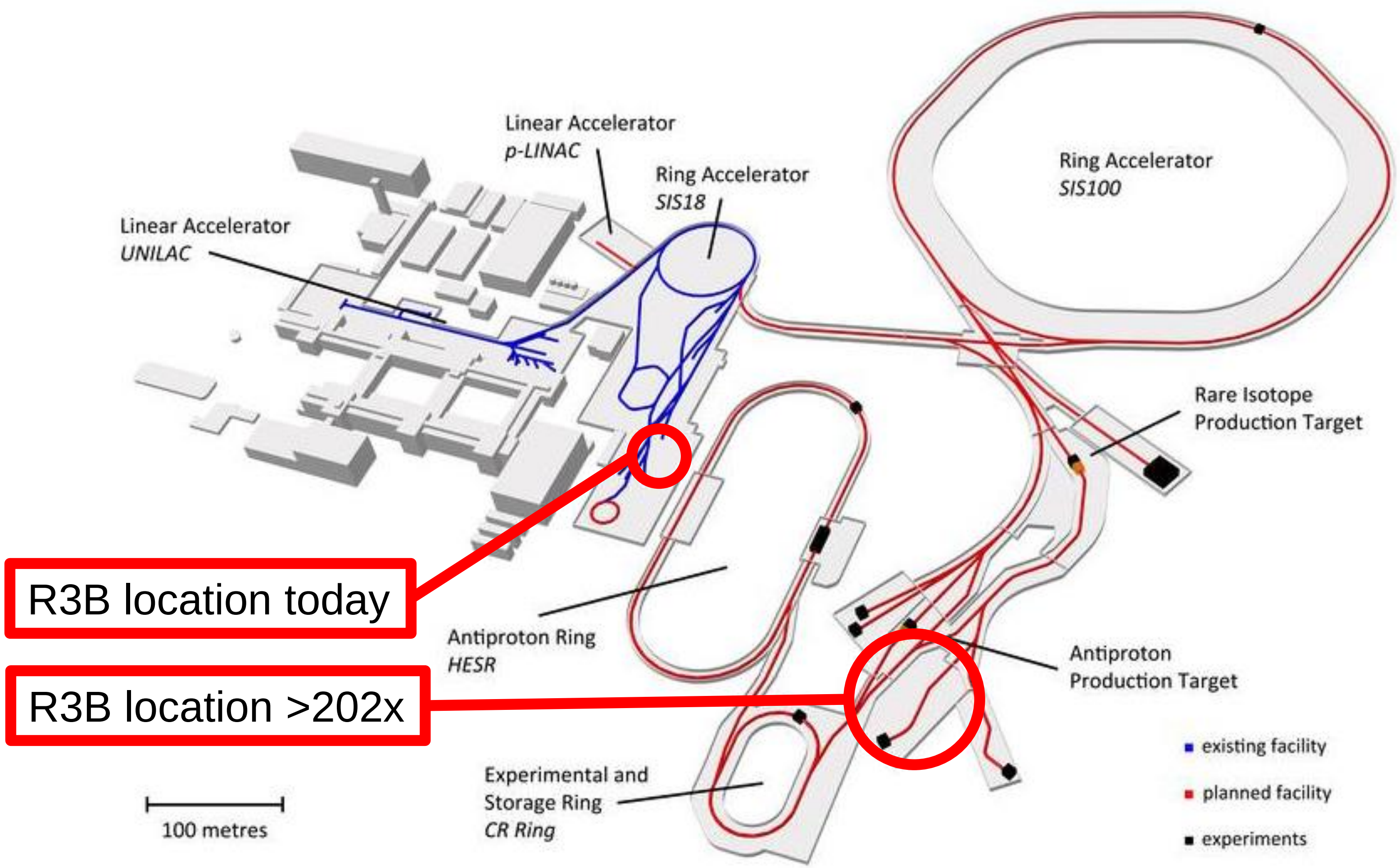
Status of symmetry-energy studies at R3B

NuSYM 2018, Busan, South Korea

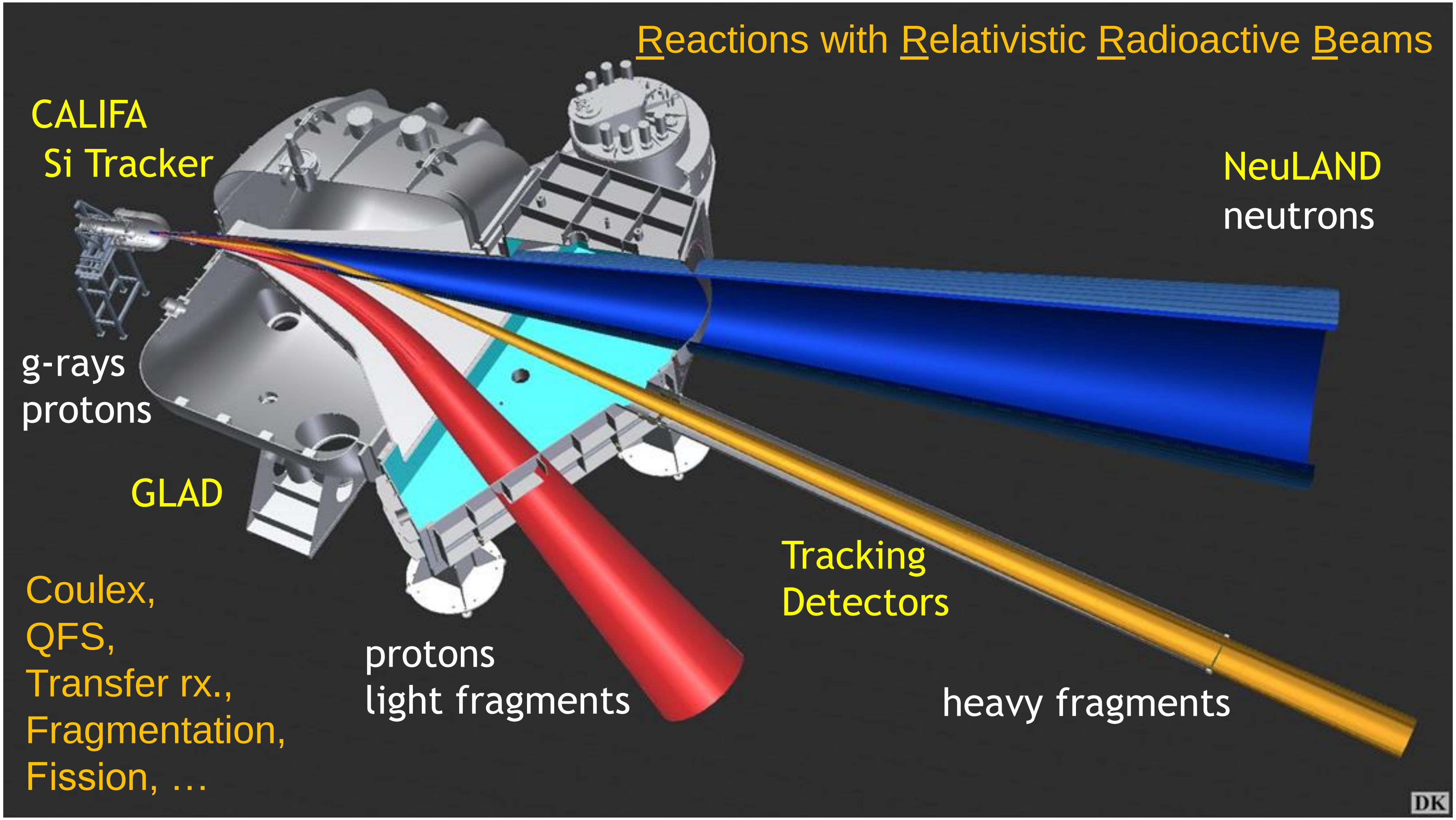
Dominic Rossi



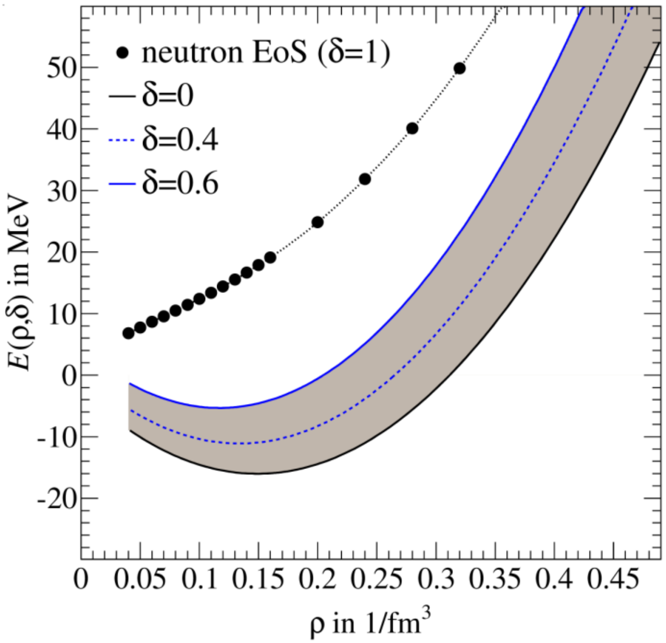
GSI and FAIR complex



R3B Overview

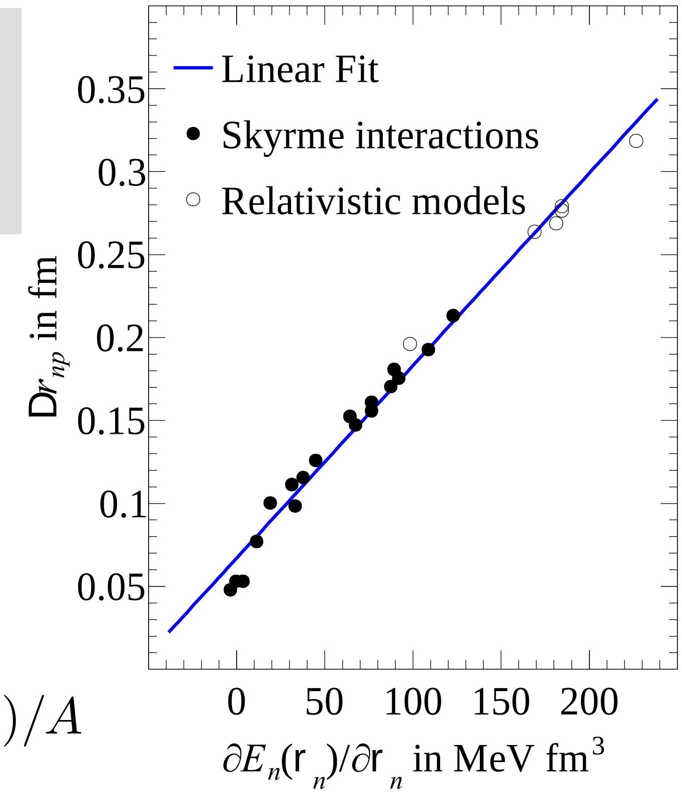


Nuclear EOS



- strong linear correlation between neutron-skin thickness and parameters (*J*, *L*)

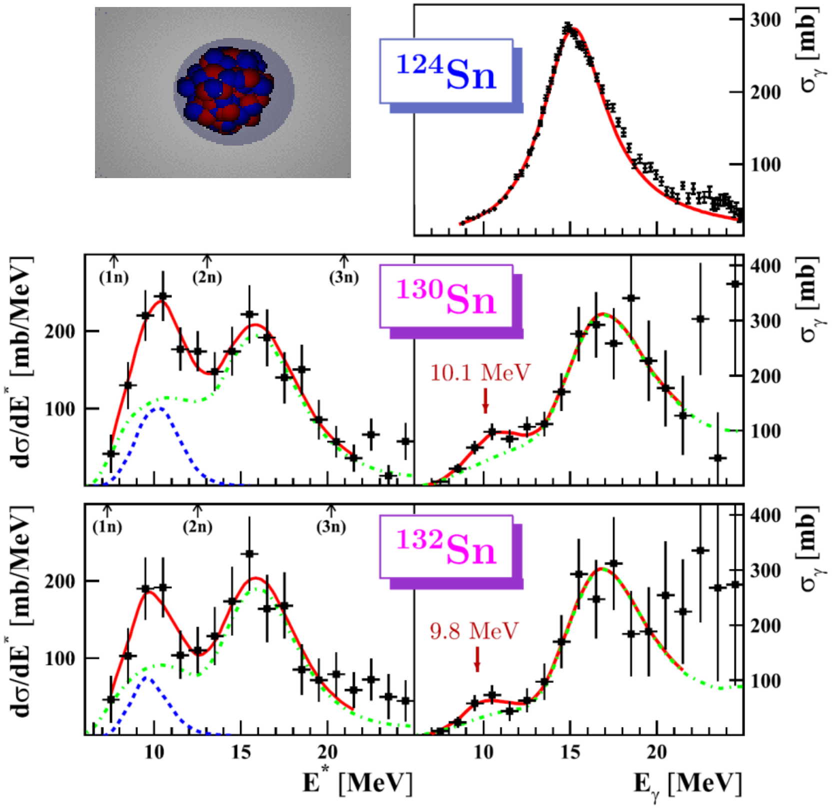
S. Typel and B.A. Brown, Phys. Rev. C ***64*** *(2001) 027302*



$$E(\rho,\delta) = E(\rho,0) + S(\rho)\delta^2 + \mathcal{O}(\delta^4) \qquad \delta = (N-Z)/A$$

$$S(\rho) \approx J + L\epsilon(\rho) + \frac{1}{2}K_{sym}\epsilon^2(\rho) \qquad \epsilon(\rho) = \frac{\rho - \rho_{sat}}{3\rho_{sat}}$$

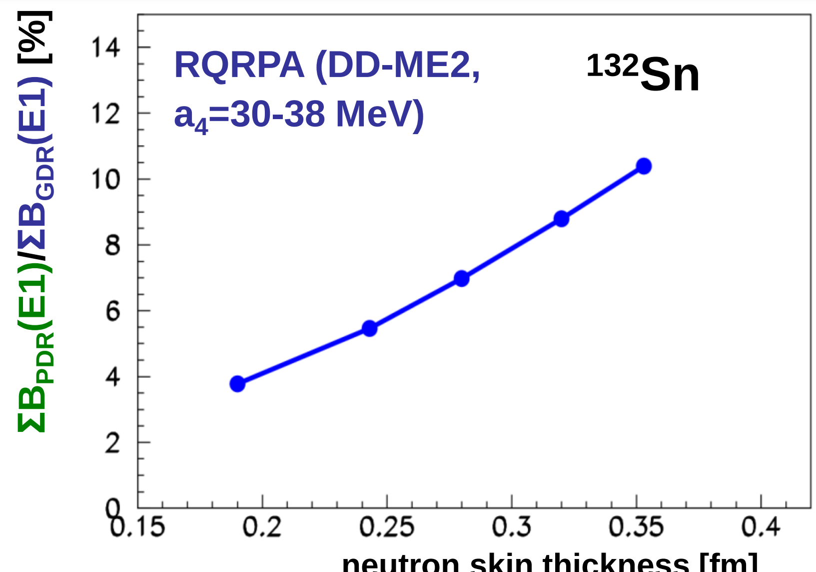
EOS from Pygmy Dipole Resonance



P. Adrich *et al.*, PRL **95**, 132501 (2005)

GDR ➔ Breit-Wigner
PDR ➔ Gaussian

- RQRPA calculations provide correlation between the measured PDR strength and the neutron skin thickness



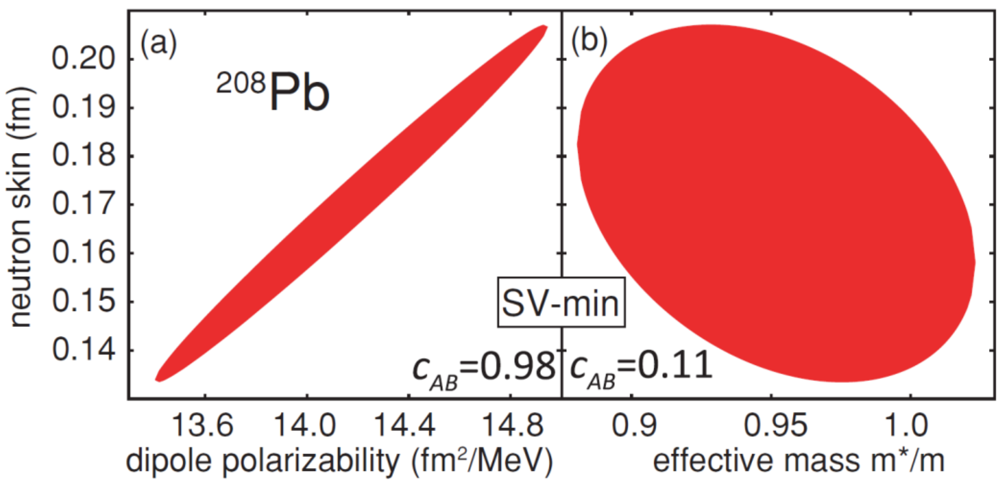
- Requires assumption of a specific line-shape of PDR and GDR
- Photoabsorption c.s. not very sensitive to low-lying E1 strength

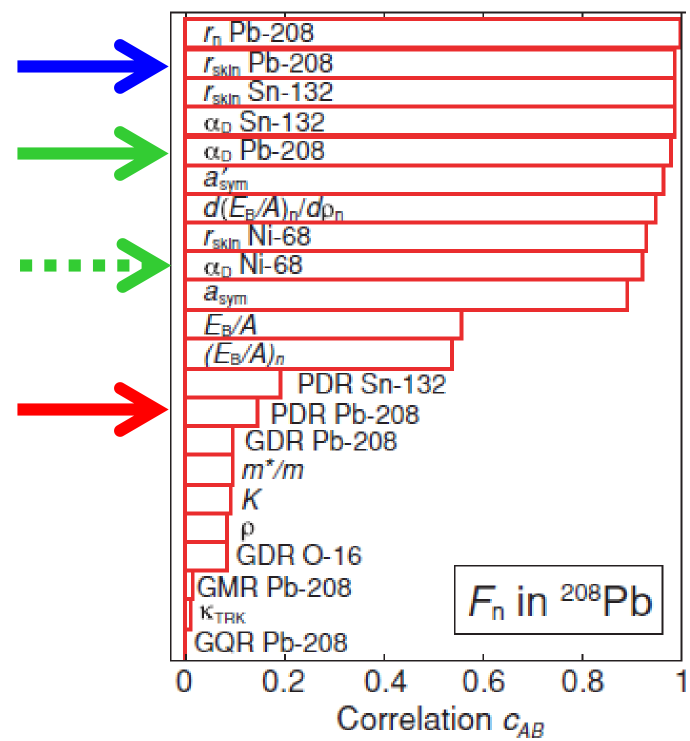
Selecting a better experimental observable

PHYSICAL REVIEW C **81**, 051303(R) (2010)

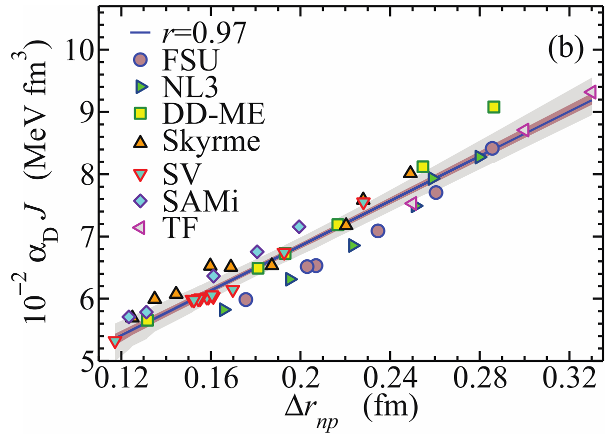
Information content of a new observable: The case of the nuclear neutron skin

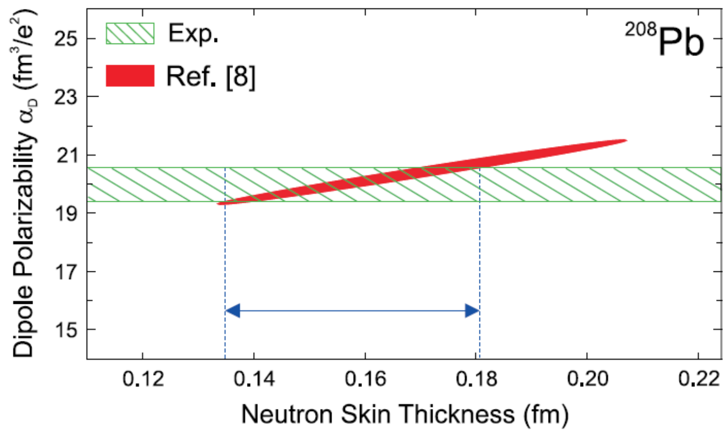
P.-G. Reinhard[1] and W. Nazarewicz[2,3,4,5]





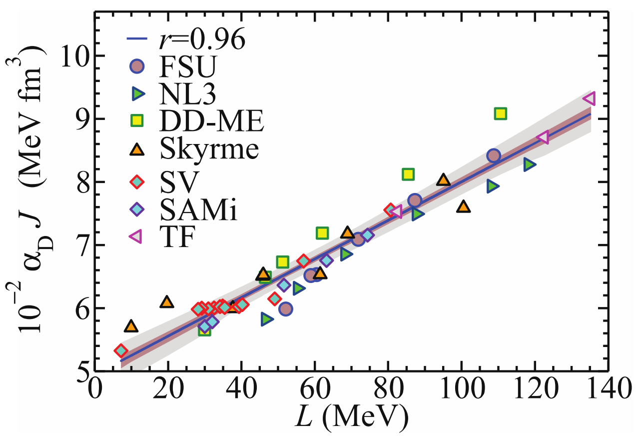
Dipole polarizability

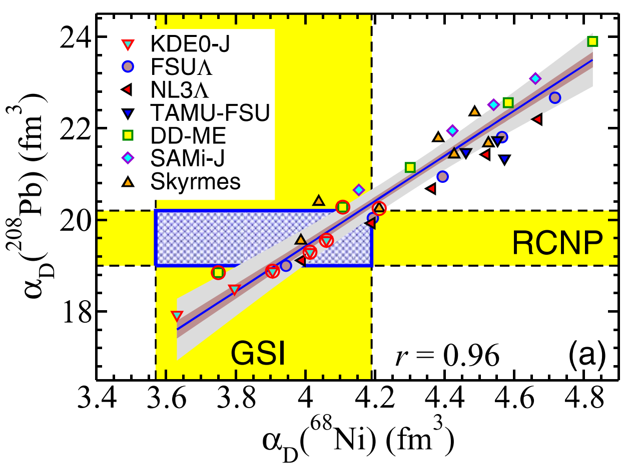




Experiment:
S. Tamii *et al.*,
PRL 107 (2011)

Theory:
P.-G. Reinhard and
W. Nazarewicz,
PRC 81 (2010)





Experiment:
RCNP: A. Tamii *et al.*
GSI: D. Rossi *et al.*,
PRL 111 (2013)

$$30 \leqslant J \leqslant 35\,\text{MeV}$$

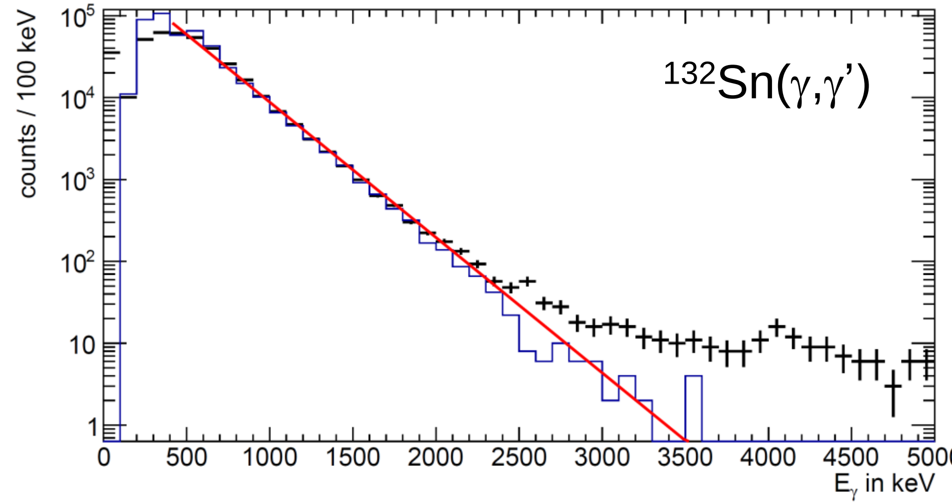
$$20 \leqslant L \leqslant 66\,\text{MeV}$$

X. Roca-Maza *et al.*, PRC 88 (2013) 024316

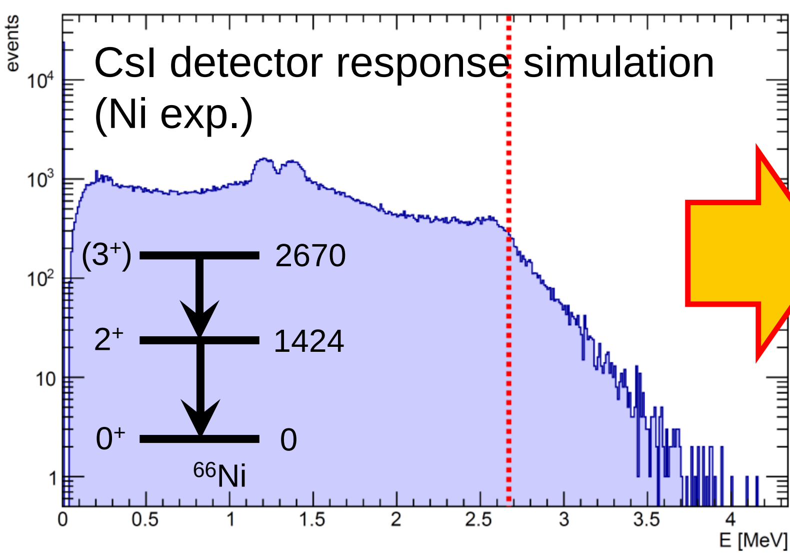
X. Roca-Maza *et al.*, PRC 92 (2015) 064304

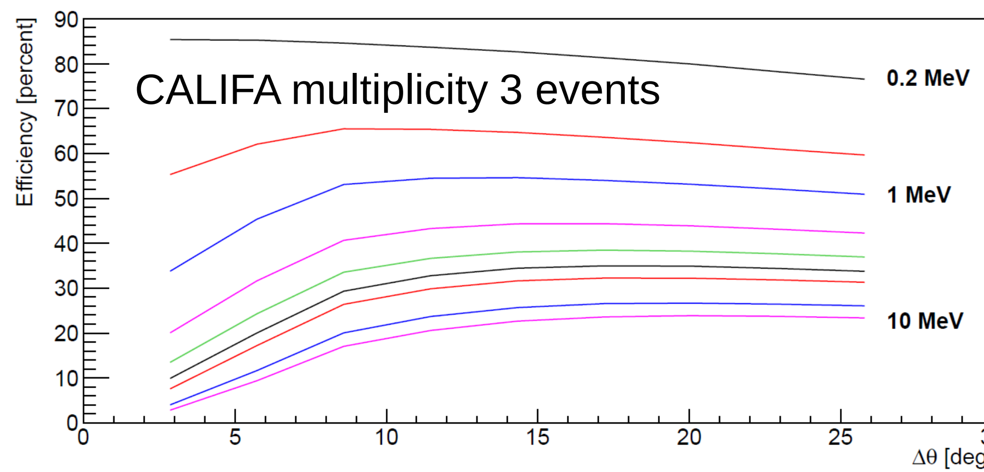
Dipole polarizability in n-rich Sn

- Experiment in 2012
- Production of $^{128\text{-}134}$Sn
- Measurement above and below neutron threshold
- Analysis still in progress



P. Schrock, PhD thesis





CALIFA TDR

GLAD: Installation in Cave C in 2016

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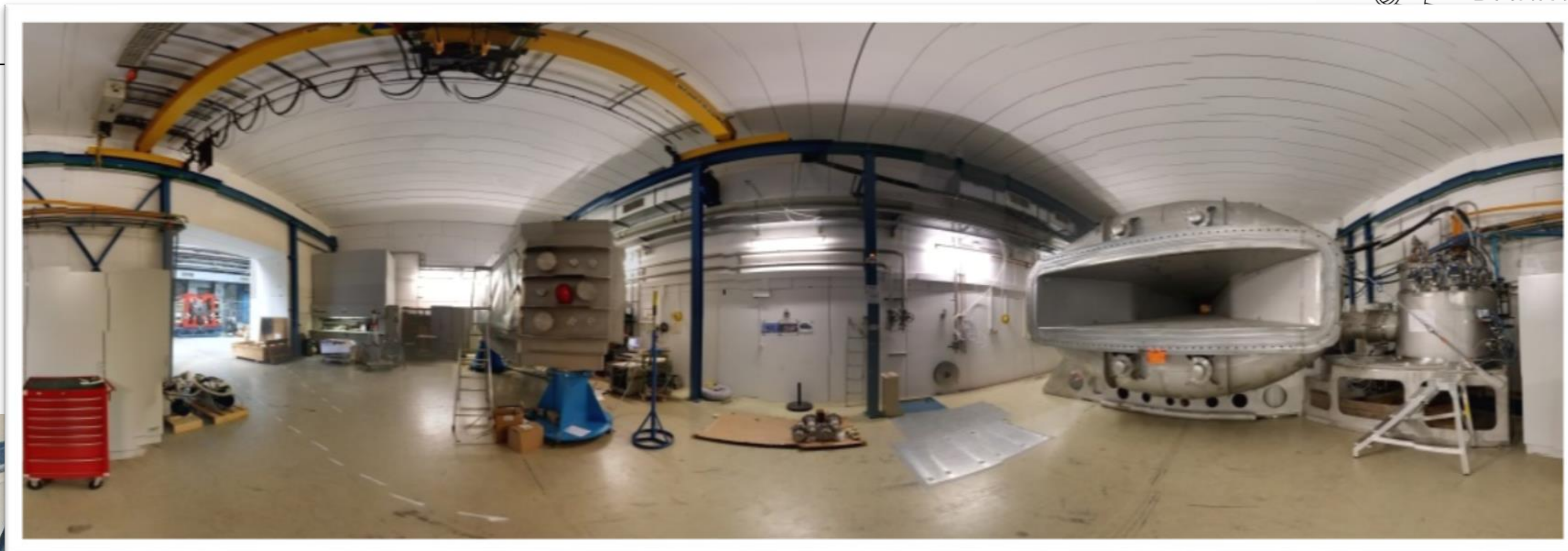
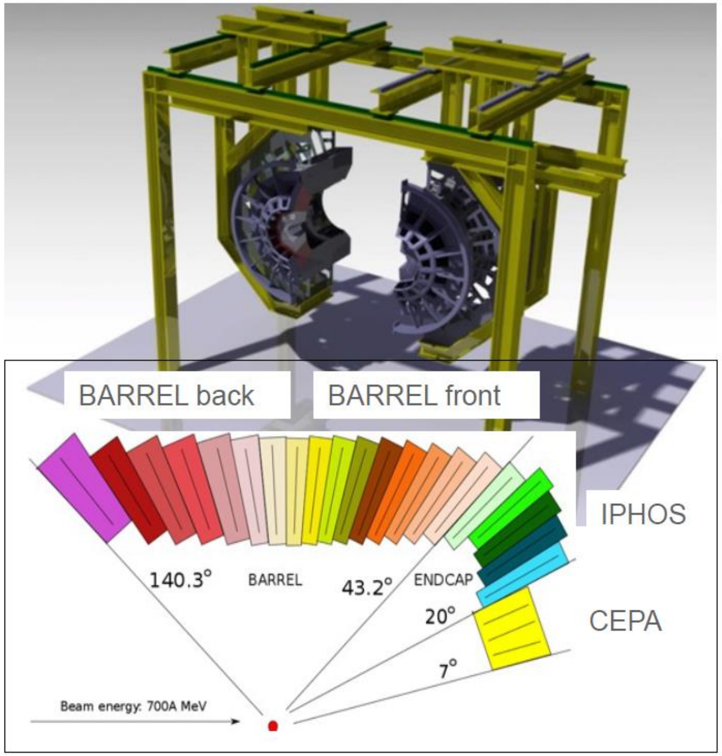
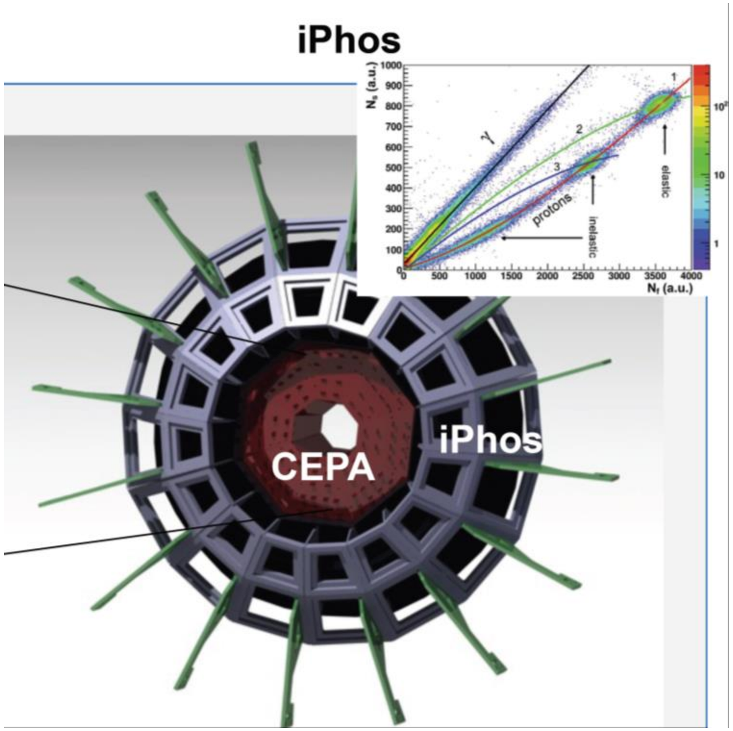


R3B

CALIFA: CALorimeter for In Flight detection of gamma rays and high-energy charged pArticles



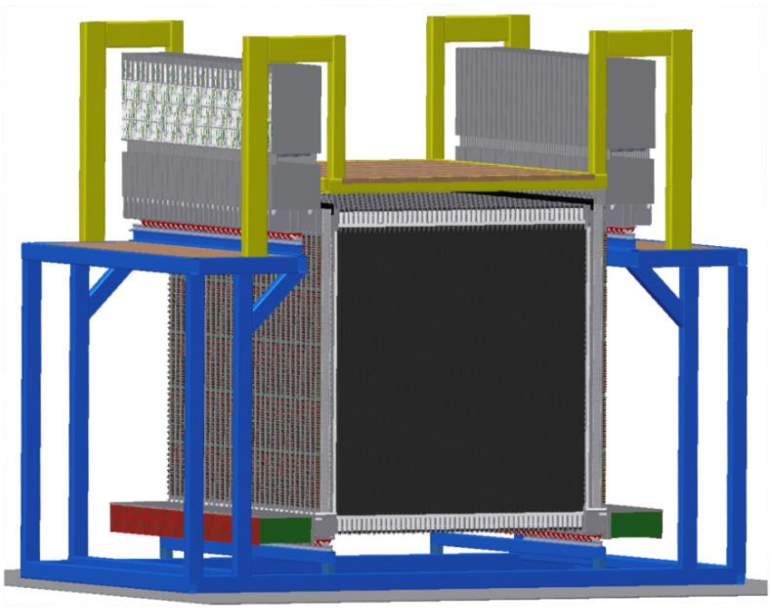


CALIFA barrel:

- Total of 1952 CsI(Tl) crystals (1152 in front half)
- 896 crystals expected to be ready end of 2018

- CEPA (CsI(Tl)): fully funded, first module built
- iPhos ($LaBr_3$/$LaCl_3$): 75% funded

NeuLAND



NeuLAND detector parameters:

- full active detector using RP/BC408
- face size 250x250 cm^2
- active depth 300 cm
- 3000 scintillator bars + 6000 PMTs
- 32 tons
- $\sigma_{x,y,z} \approx$ 1cm & σ_t < 150 ps

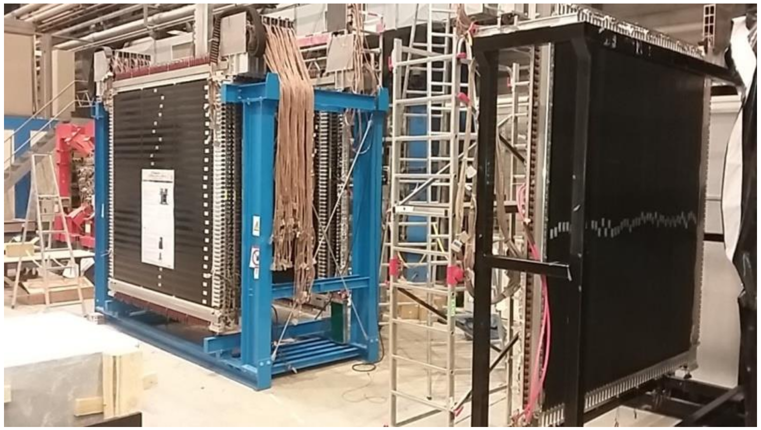
double plane 11 during bar mounting

Design goals:

- \>90% efficiency for 0.2-1.0 GeV neutrons
- multi-hit capability for up to 5 neutrons
- invariant mass resolution down to
  ΔE < 20 keV at 100 keV above thr.

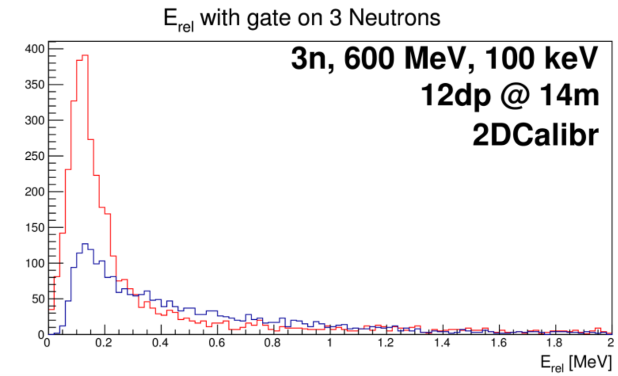
Courtesy of K. Boretzky

NeuLAND

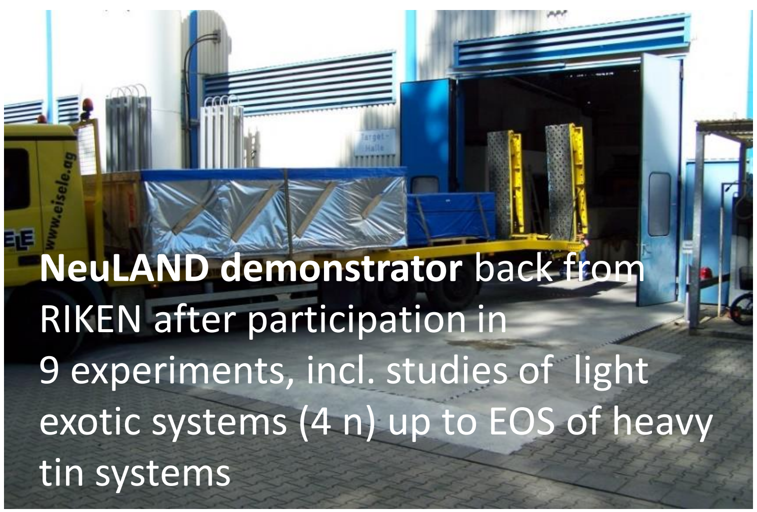


NeuLAND Phase 0

- 130 cm active depth
- 2600 channels >40% detector



simulation prediction: **reconstruction efficiency** of the order of 20% for 3 n, 10 % for 4 n (600 MeV, preliminary)



NeuLAND demonstrator back from RIKEN after participation in 9 experiments, incl. studies of light exotic systems (4 n) up to EOS of heavy tin systems

SAT test of in-house developed **NeuLAND electronics** underway:

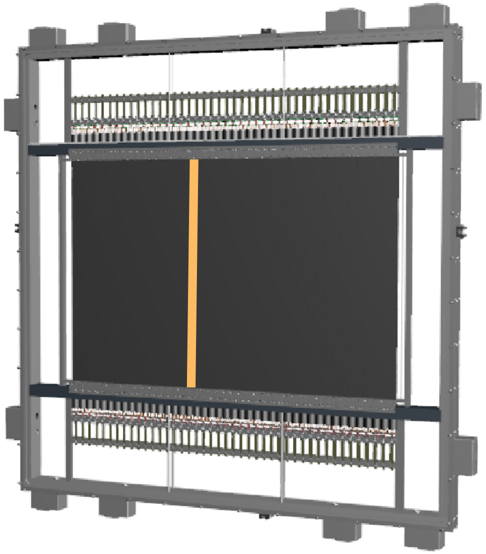
- multichannel front-end electronic card TAMEX for high-resolution time and charge measurements

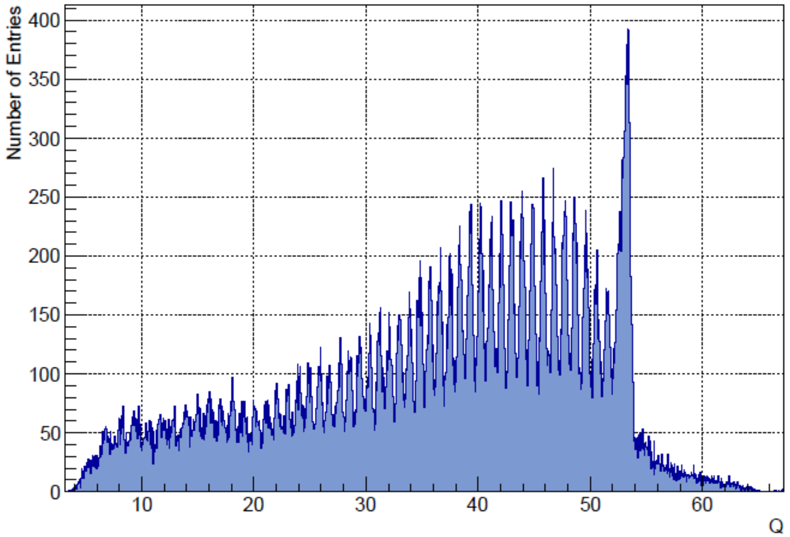
Courtesy of K. Boretzky

Tracking Detectors: TOF Wall

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

- Size: 120 x 100 cm²
- Total of 176 paddles, arranged into 4 layers
- No light guide, PMT R8619 coupled directly to scintillator
- Movable holding structure to sweep TOF wall across beam





Courtesy of M. Heil

Total n-removal cross section measurement

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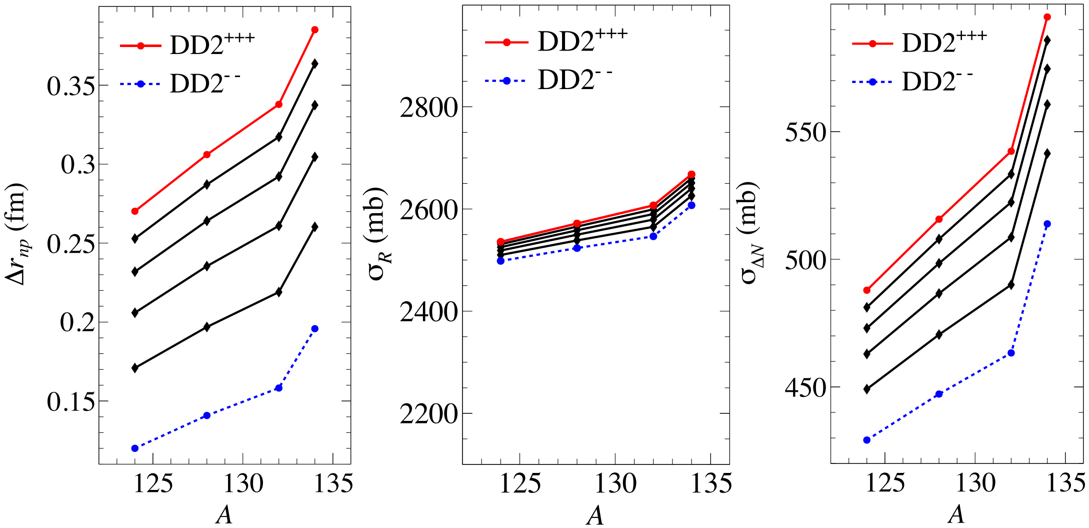
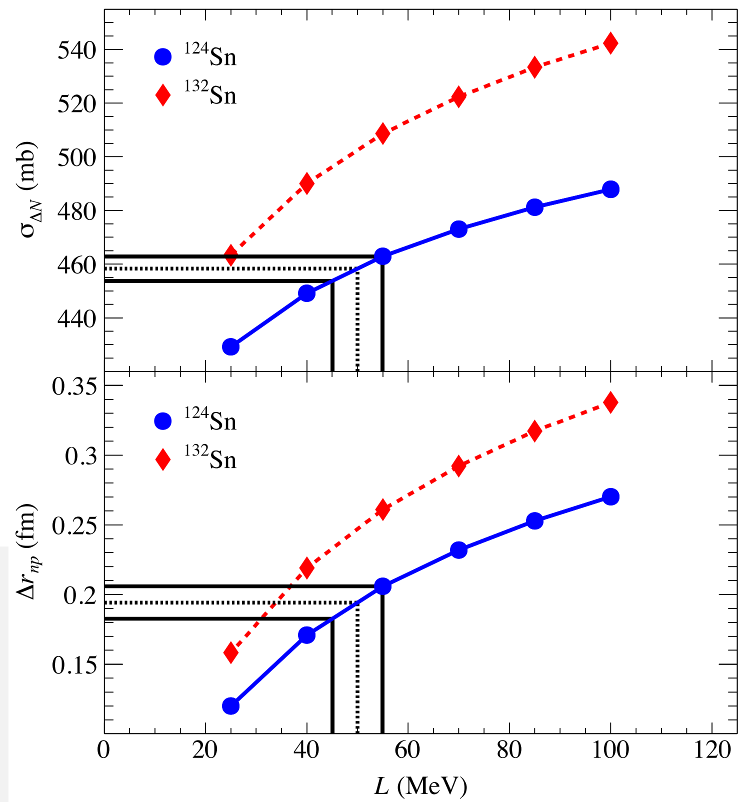




- We use RMF DD interactions with systematic variation of L
- n-skin changes accordingly by about 0.19 fm for ^{132}Sn
- Total reaction cross section changes only by 2.5%
- Total neutron-removal cross section changes by about 20%

  Variation $\delta L = \pm 5$ MeV → $\delta\Delta r_{np} \approx \pm 0.01$ fm and $\delta\sigma_{\Delta N} \approx \pm 1\%$

  → $\sigma_{\Delta N}$ very sensitive, limit given by DFT predictions reached
- But: relation of $\sigma_{\Delta N}$ to L or Δr_{np} needs reaction theory !

Relativistic Mean Field Theory (DD2):
S. Typel, Phys. Rev. C **89**, 064321 (2014)

R3B

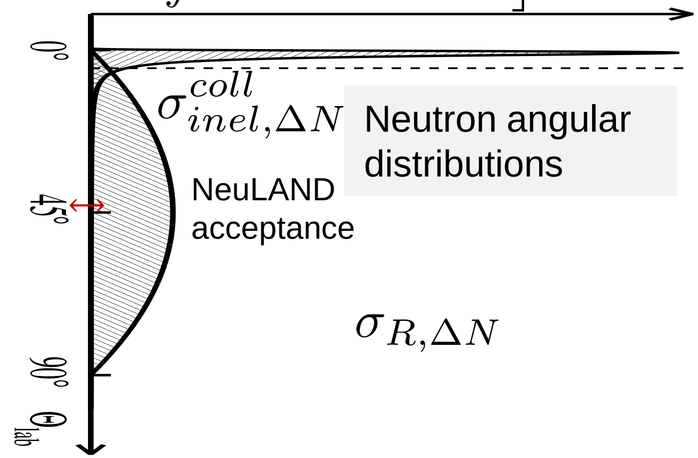
Reaction theory

$$\sigma_R = \begin{pmatrix} Z_P \\ Z \end{pmatrix} \begin{pmatrix} N_P \\ N \end{pmatrix} \int d^2b \, [1 - P_p(b)]^{Z_P - Z} \, P_p^Z(b) \times [1 - P_n(b)]^{N_P - N} \, P_n^N(b)$$

$$P_p(b) = \int dz d^2 s \rho_p^P(\mathbf{s}, z) \exp\left[-\sigma_{pp} Z_T \int d^2 s \rho_p^T(\mathbf{b} - \mathbf{s}, z) - \sigma_{pn} N_T \int d^2 s \rho_n^T(\mathbf{b} - \mathbf{s}, z) \right]$$

Input

Bertulani, Danielewicz, *Introduction to Nuclear Reactions* (CRC Press, London, 2004)



Experiment (4 independent measurements):

$$\sigma_I = \sigma_R + \sigma_{inel}^{coll \Delta N} = \sigma_{R,\Delta Z} + \sigma_{R,\Delta N} + \sigma^{coll}_{inel,\Delta N}$$

Glauber/Eikonal theory

σ^{coll}_{inel} - Collective (Coulomb + nuclear) excitation (of giant resonances) + neutron evaporation: for Sn ≈ 100 mb (20% of $\sigma_{\Delta N}$)

⇒ has to be determined experimentally

⇒ Relation $\sigma_{\Delta N} \Leftrightarrow L$

⇒ Task: Testing and quantifying uncertainties of Eikonal reaction theory

Test of Eikonal reaction theory

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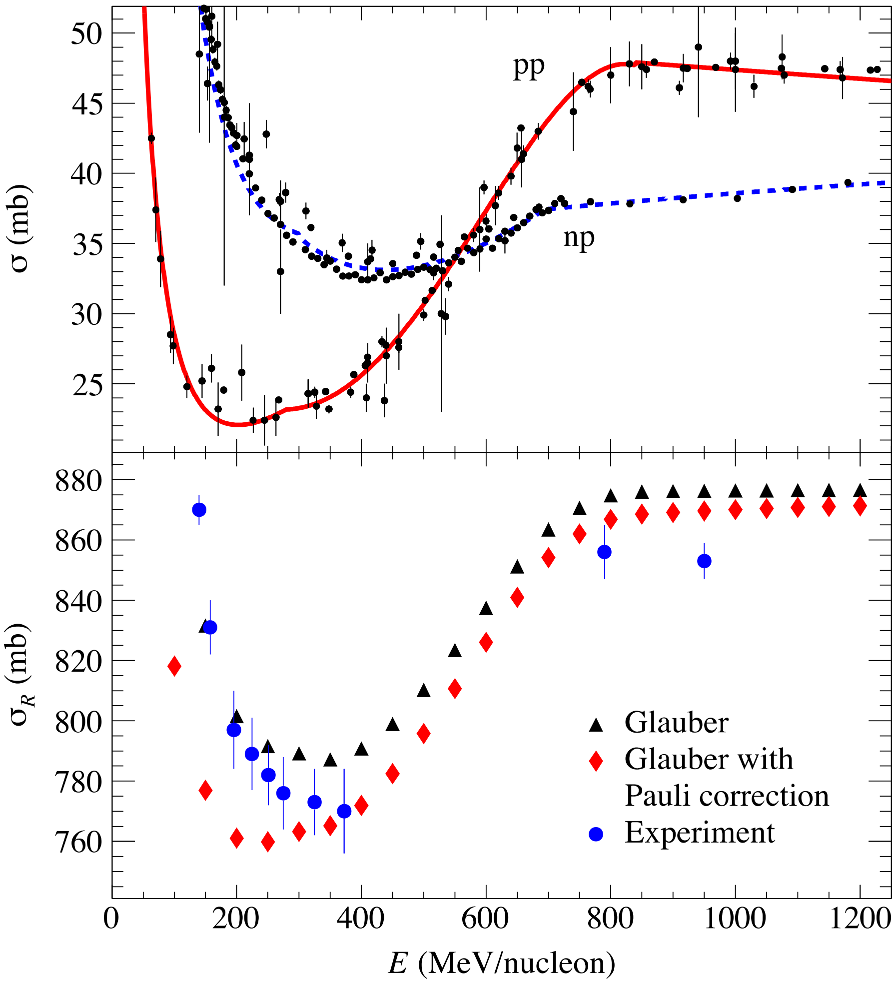


T. Aumann *et al.*, PRL 119, 262501 (2017)

<u>Test with energy dependence of $^{12}C + ^{12}C$ total reaction cross section</u>

Parameter-free Eikonal prediction overestimates cross sections

Expected deviations due to:
1) In-medium effects: Pauli blocking
2) Fermi motion
3) Higher-order
4) Collective excitations

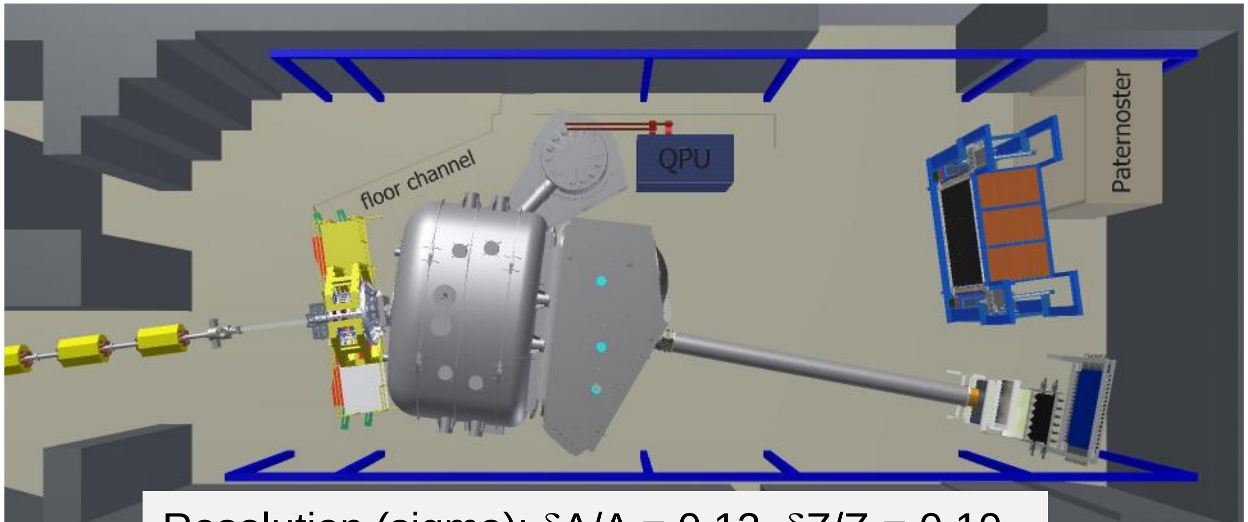
Taking into account Pauli blocking:
C.A. Bertulani, C. De Conti, PRC 81 (2010)
Higher-energy data point overestimated by ≈2%

Theoretical improvements needed

But:
only three data points in the range 0.4 to 1.2 GeV/u
→ Precise data needed incl. energy dependence

R3B

FAIR Phase-0 experiment

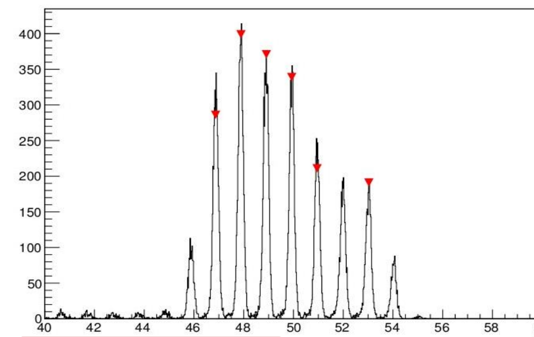


Resolution (sigma): δA/A = 0.12, δZ/Z = 0.10

Measured quantity	Method	Uncertainty
σ_I	Absorption	<1%
$\sigma_{\Delta Z}$	ΔE after target	<1%
$\sigma_{\Delta N}$	Mass spectrum	1%
$\sigma^{coll}_{inel,\Delta N}$	(A-x) fragment + x neutrons	<5%
$\sigma_{R,\Delta N} = \sigma_{\Delta N} - \sigma^{coll}_{inel,\Delta N}$		1-2%

NeuLAND:
Measure collective cross section up to three-neutron decay

Fragment spectrometer **GLAD:**
Acceptance 15%
(up to 13 neutron removal)



→ Theory
→ n-skin
→ L

T. Aumann, C.A. Bertulani, F. Schindler, S. Typel, PRL 119 (2017)

Summary

- Dipole polarizability data analysis still ongoing for n-rich Sn isotopes
- Key detectors for polarizability studies will be finalized and commissioned in the near future
- Cross section measurements for EOS studies already planned for FAIR Phase-0

The R3B Collaboration

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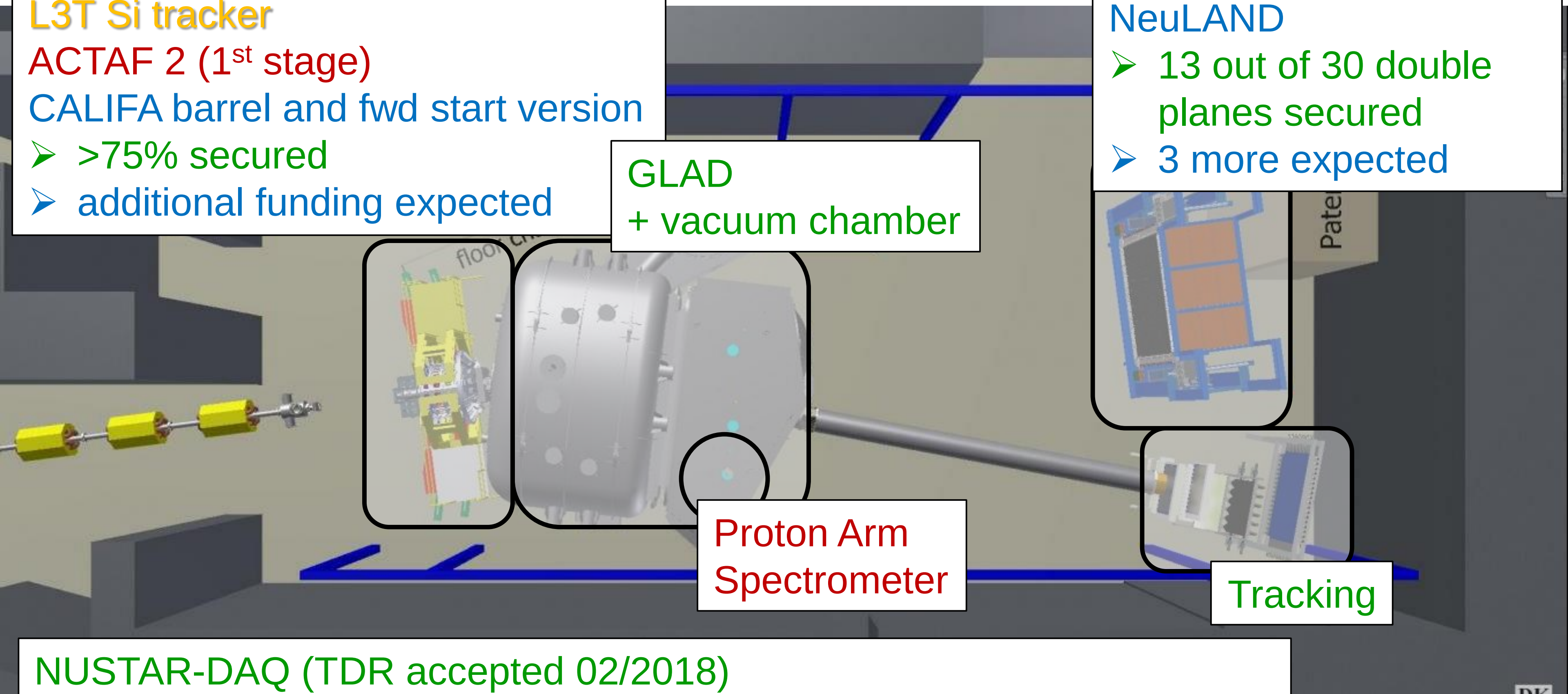
Aksouh, Farouk; Al-Khalili, Jim; Algora, Alejandro; Alkhasov, Georgij; Altstadt, Sebastian; Alvarez, Hector; Atar, Leyla; Audouin, Laurent; Aumann, Thomas; Pellereau, Eric; Martin, Julie-Fiona; Gorbinet, Thomas; Seddon, Dave; Kogimtzis, Mos; Avdeichikov, Vladimir; Barton, Charles; Bayram, Murat; Belier, Gilbert; Bemmerer, Daniel; Michael Bendel; Benlliure, Jose; Bertulani, Carlos; Bhattacharya, Sudeb; Bhattacharya, Chandana; Le Bleis, Tudi; Boilley, David; Boretzky, Konstanze; Borge, Maria Jose; Botvina, Alexander; Boudard, Alain; Boutoux, Guillaume; Boehmer, Michael; Caesar, Christoph; Calvino, Francisco; Casarejos, Enrique; Catford, Wilton; Cederkall, Joakim; Cederwall, Bo; Chapman, Robert; Alexandre Charpy; Chartier, Marielle; Chatillon, Audrey; Chen, Ruofu; Christophe, Mayri; Chulkov, Leonid; Coleman-Smith, Patrick; Cortina, Dolores; Crespo, Raquel; Csatlos, Margit; Cullen, David; Czech, Bronislaw; Danilin, Boris; Davinson, Tom; Paloma Diaz; Dillmann, Iris; Fernandez Dominguez, Beatriz; Ducret, Jean-Eric; Duran, Ignacio; Egelhof, Peter; Elekes, Zoltan; Emling, Hans; Enders, Joachim; Eremin, Vladimir; Ershov, Sergey N.; Ershova, Olga; Eronen, Simo; Estrade, Alfredo; Faestermann, Thomas; Fedorov, Dmitri; Feldmeier, Hans; Le Fevre, Arnaud; Fomichev, Andrey; Forssen, Christian; Freeman, Sean; Freer, Martin; Friese, Juergen; Fynbo, Hans; Gacsi, Zoltan; Garrido, Eduardo; Gasparic, Igor; Gastineau, Bernard; Geissel, Hans; Gelletly, William; Genolini, B.; Gerl, Juergen; Gernhaeuser, Roman; Golovkov, Mikhail; Golubev, Pavel; Grant, Alan; Grigorenko, Leonid; Grosse, Eckart; Gulyas, Janos; Goebel, Kathrin; Gorska, Magdalena; Haas, Oliver Sebastian; Haiduc, Maria; Hasegan, Dumitru; Heftrich, Tanja; Heil, Michael; Heine, Marcel; Heinz, Andreas; Ana Henriques; Hoffmann, Jan; Holl, Matthias; Hunyadi, Matyas; Ignatov, Alexander; Ignatyuk, Anatoly V.; Ilie, Cherciu Madalin; Isaak, Johann; Isaksson, Lennart; Jakobsson, Bo; Jensen, Aksel; Johansen, Jacob; Johansson, Hakan; Johnson, Ron; Jonson, Bjoern; Junghans, Arnd; Jurado, Beatriz; Jaehrling, Simon; Kailas, S.; Kalantar, Nasser; Kalliopuska, Juha; Kanungo, Rituparna; Kelic-Heil, Aleksandra; Kezzar, Khalid; Khanzadeev, Alexei; Kissel, Robert; Kisselev, Oleg; Klimkiewicz, Adam; Kmiecik, Maria; Koerper, Daniel; Kojouharov, Ivan; Korsheninnikov, Alexei; Korten, Wolfram; Krasznahorkay, Attila; Kratz, Jens Volker; Kresan, Dima; Anatoli Krivchitch; Kroell, Thorsten; Krupko, Sergey; Kruecken, Reiner; Kulessa, Reinhard; Kurz, Nikolaus; Kuzmin, Eugenii; Labiche, Marc; Langanke, Karl-Heinz; Langer, Christoph; Lapoux, Valerie; Larsson, Kristian; Laurent, Benoit; Lazarus, Ian; Le, Xuan Chung; Leifels, Yvonne; Lemmon, Roy; Lenske, Horst; Lepine-Szily, Alinka; Leray, Sylvie; Letts, Simon; Li, Songlin; Liang, Xiaoying; Lindberg, Simon; Lindsay, Scott; Litvinov, Yuri; Lukasik, Jerzy; Loeher, Bastian; Mahata, Kripamay; Maj, Adam; Marganiec, Justyna; Meister, Mikael; Mittig, Wolfgang; Movsesyan, Alina; Mutterer, Manfred; Muentz, Christian; Nacher, Enrique; Najafi, Ali; Nakamura, Takashi; Neff, Thomas; Nilsson, Thomas; Nociforo, Chiara; Nolan, Paul; Nolen, Jerry; Nyman, Goran; Obertelli, Alexandre; Obradors, Diego; Ogloblin, Aleksey; Oi, Makito; Palit, Rudrajyoti; Panin, Valerii; Paradela, Carlos; Paschalis, Stefanos; Pawlowski, Piotr; Petri, Marina; Pietralla, Norbert; Pietras, Ben; Pietri, Stephane; Plag, Ralf; Podolyak, Zsolt; Pollacco, Emanuel; Potlog, Mihai; Datta Pramanik, Ushasi; Prasad, Rajeshwari; Fraile Prieto, Luis Mario; Pucknell, Vic; Galaviz -Redondo, Daniel; Regan, Patrick; Reifarth, Rene; Reinhardt, Tobias; Reiter, Peter; Rejmund, Fanny; Ricciardi, Maria Valentina; Richter, Achim; Rigollet, Catherine; Riisager, Karsten; Rodin, Alexander; Rossi, Dominic; Roussel-Chomaz, Patricia; Gonzalez Rozas, Yago; Rubio, Berta; Roeder, Marko; Saito, Takehiko; Salsac, Marie-Delphine; Rodriguez Sanchez, Jose Luis; Santosh, Chakraborty; Savajols, Herve; Savran, Deniz; Scheit, Heiko; Schindler, Fabia; Schmidt, Karl-Heinz; Schmitt, Christelle; Schnorrenberger, Linda; Schrieder, Gerhard; Schrock, Philipp; Sharma, Manoj Kumar; Sherrill, Bradley; Shrivastava, Aradhana; Shulgina, Natalia; Sidorchuk, Sergey; Silva, Joel; Simenel, Cedric; Simon, Haik; Simpson, John; Singh, Pushpendra Pal; Sonnabend, Kerstin; Spohr, Klaus; Stanoiu, Mihai; Stevenson, Paul; Strachan, Jon; Streicher, Brano; Stroth, Joachim; Syndikus, Ina; Suemmerer, Klaus; Taieb, Julien; Tain, Jose L.; Tanihata, Isao; Tashenov, Stanislav; Tassan-Got, Laurent; Tengblad, Olof; Teubig, Pamela; Thies, Ronja; Togano, Yasuhiro; Tostevin, Jeffrey A.; Trautmann, Wolfgang; Tuboltsev, Yuri; Turrion, Manuela; Typel, Stefan; Udias-Moinelo, Jose; Vaagen, Jan; Velho, Paulo; Verbitskaya, Elena; Veselsky, Martin; Wagner, Andreas; Walus, Wladyslaw; Wamers, Felix; Weick, Helmut; Wimmer, Christine; Winfield, John; Winkler, Martin; Woods, Phil; Xu, Hushan; Yakorev, Dmitry; Zegers, Remco; Zhang, Yu-Hu; Zhukov, Mikhail; Zieblinski, Miroslaw; Zilges, Andreas;

R3B Overview



Tracking
L3T Si tracker
ACTAF 2 (1st stage)
CALIFA barrel and fwd start version

- >75% secured
- additional funding expected

GLAD
+ vacuum chamber

NeuLAND

- 13 out of 30 double planes secured
- 3 more expected

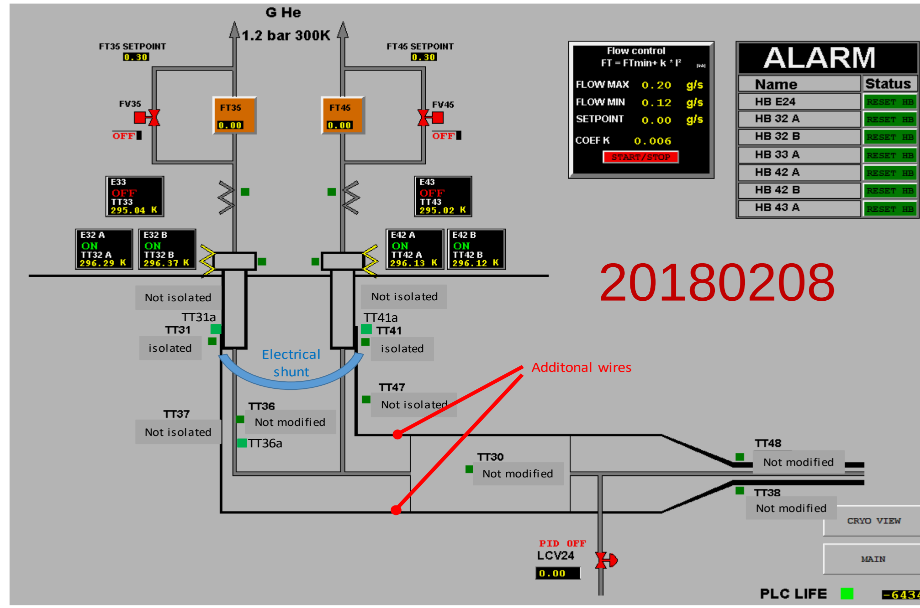
Proton Arm Spectrometer

Tracking

NUSTAR-DAQ (TDR accepted 02/2018)
-Time stamps (first implementation)/local trigger logics/readout libraries
-Online analysis R³B-Root ← FAIR-Root

Courtesy of H. Simon

GLAD Commissioning



Open issues:

- Current lead foot cooling insufficient (20171115)

➔ **new cl design**

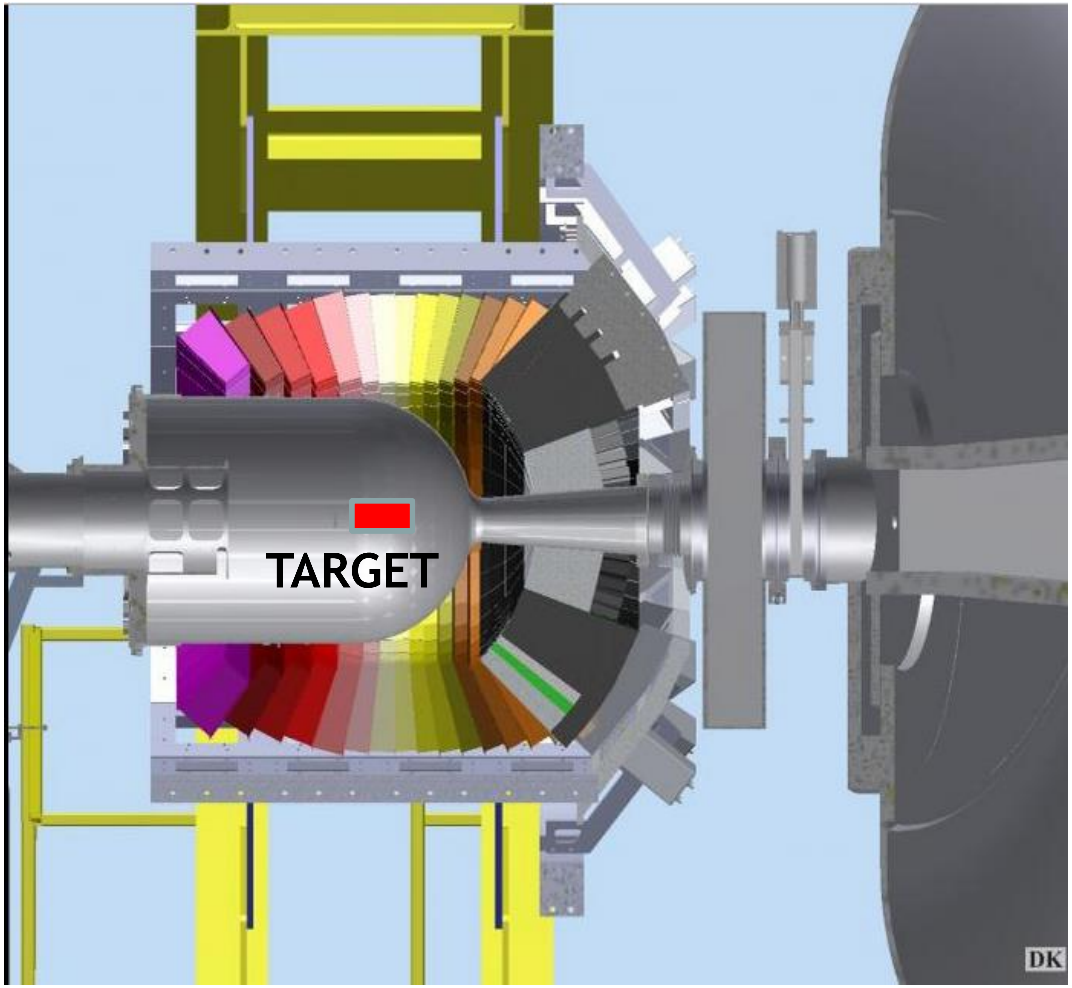
- current tests 20180222 with 3.5 kA

  → outcome in agreement with calculations (cl ok !)

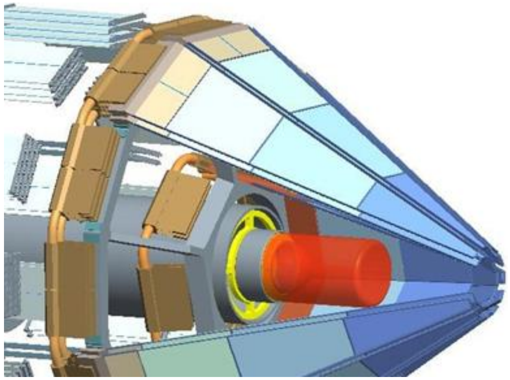
- Modification in Satellite foreseen (decision on new cl's within next week…)
- GLAD expected to be ready in Q2/2018!

Courtesy of H. Simon

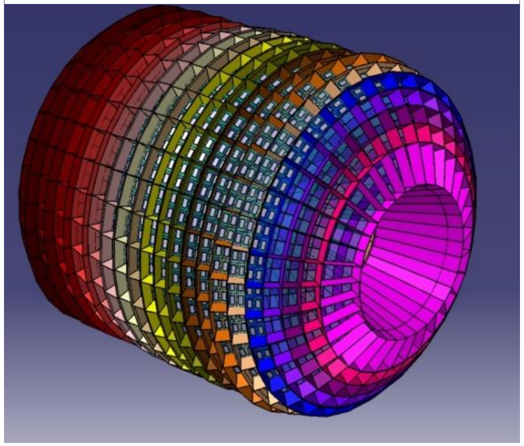
Target Area



Si - Tracker



CALIFA calorimeter



Courtesy of D. Cortina

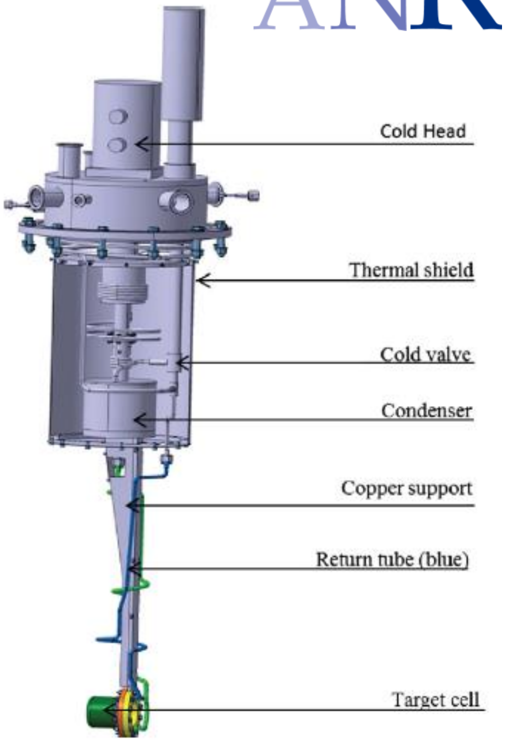
Liquid Hydrogen Target

- Pure LH_2 target for Quasi-Free scattering program at R^3B
- 4 cm diameter, 1.5 to 15 cm length
- Granted by French Research Agency (COCOTIER grant, 2017)
- Construction started in Oct. 2017 at CEA/IRFU
- Ready for 2019 campaign at GSI

Needed for 2019 R3B experiments!

Irfu - CEA Saclay
Institut de recherche sur les lois fondamentales de l'Univers

Agence Nationale de la Recherche ANR



Courtesy of A. Corsi

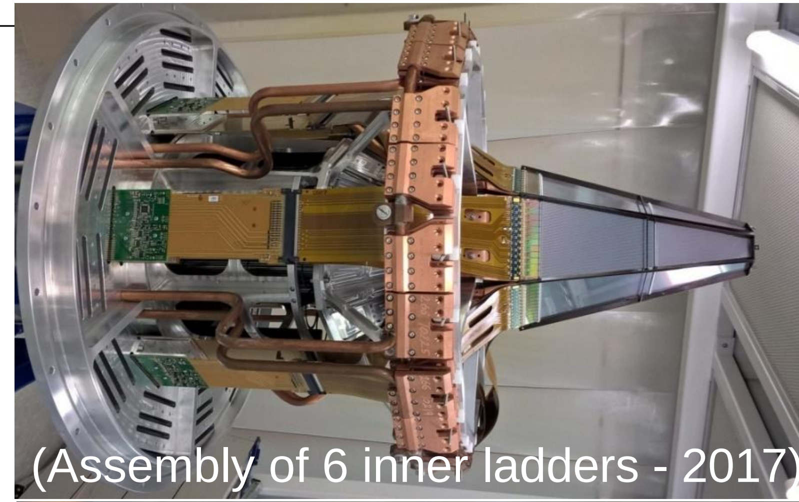
Si Tracker

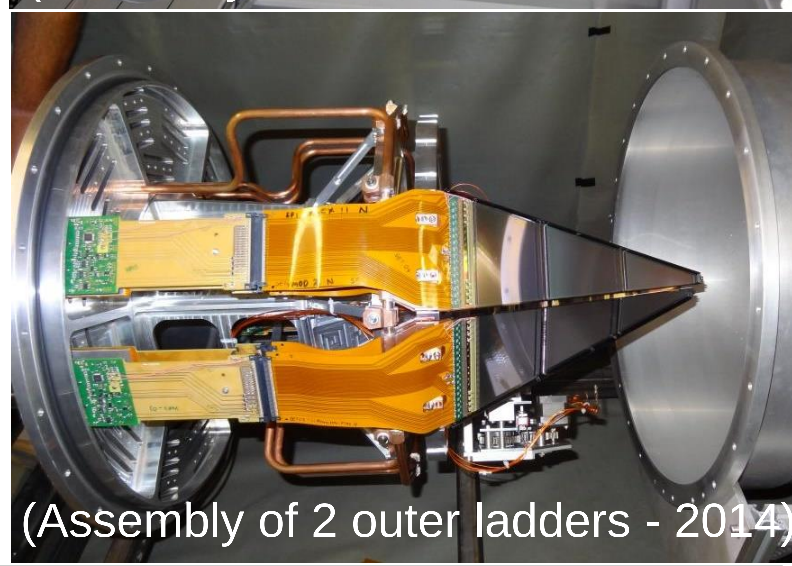
Two layers of trapezoidal DSSSD with 50 mm stereoscopic strips:

- Inner layer:
  - 6 ladders (+ 3 spares) delivered at DL, ~3k strips per ladder, 300mm thick.
- Outer layer:
  - 12 ladders (+ 3 spares) delivered at DL, ~4k strips per ladder, 300mm thick.

Readout Electronics + Cables:

- Asics Readout
- All ready to mount 6 inner ladders + 12 outer ladders


(Assembly of 6 inner ladders - 2017)


(Assembly of 2 outer ladders - 2014)

Courtesy of M. Labiche

Si Tracker

Inner layer tests at DL:

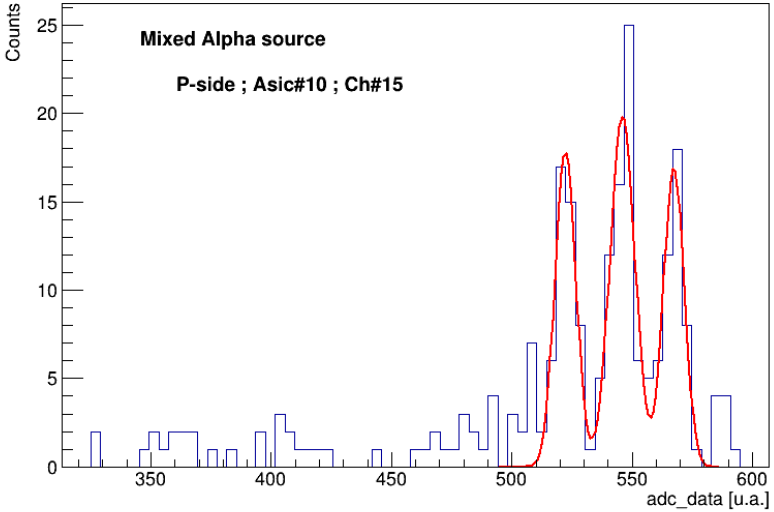
- Test with Mixed-Alpha source is ongoing
- Resolution (FWHM) ~150 keV on short strips but a noise issue for longest strips still to be solved !

Outer layer:

- Foreseen to be assembled in March

Both layers to be tested with cosmics in March/April.

+ Still lots of fine tuning to do ….



Courtesy of M. Labiche

CALIFA

CALorimeter for **I**n **F**light detection of γ-rays and light charged p**A**rticles

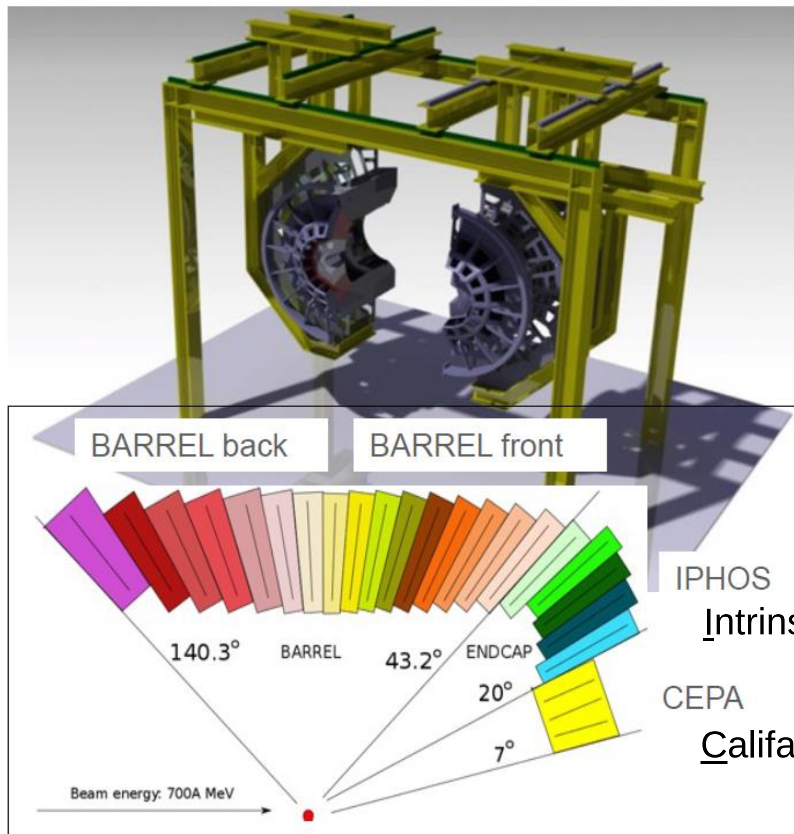
Surrounds the R^3B target, 7° to 140.3°. The inner volume of CALIFA is designed to fit a vacuum chamber with a Si tracker system and LH target.

Broad experimental program:

- Nuclear structure far from stability
- Fission studies
- Reactions of astrophysical interest
- EOS of asymmetric nuclear matter

CALIFA will be the key detector in many of these experiments.

Contributing institutions:
Chalmers - Gothenburg (SE)
IEM – Madrid (ES)
JINR – Dubna (RU)
Lund University (SE, WG lead)
TU Darmstadt (DE, dpy WG lead)
TU Munich (DE)
USC – Santiago (ES)
University of Vigo (ES)



Intrinsic PHOSwich detectors

Califa End-cap Phoswich Array

Courtesy of J. Cederkall

CALIFA: Barrel

Start version:

As of January 2018:

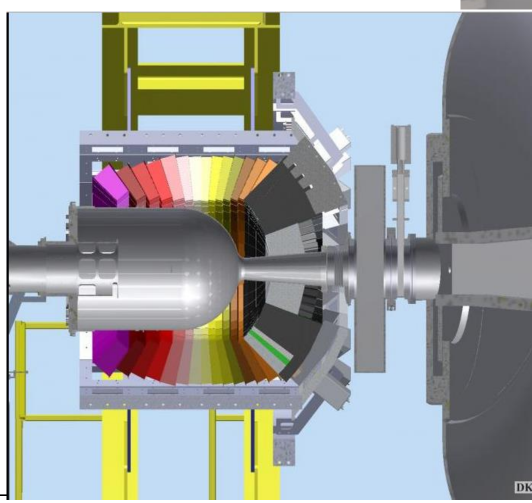
APDs

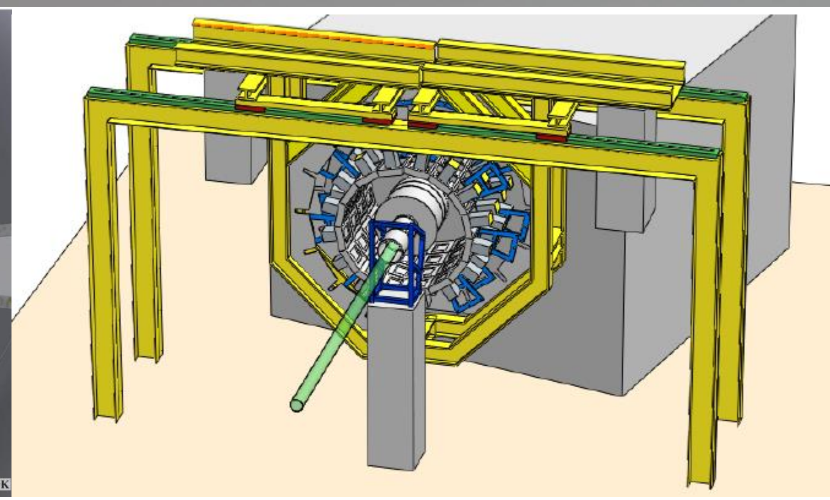
#	Institute
200	IEM
250	LU
360	TUD
320	USC
1130	Total

Crystals and wrapping

# delivered	# tested	Institute
480	450	LU
212	79	TUD
320	192	USC
1012	721	Total

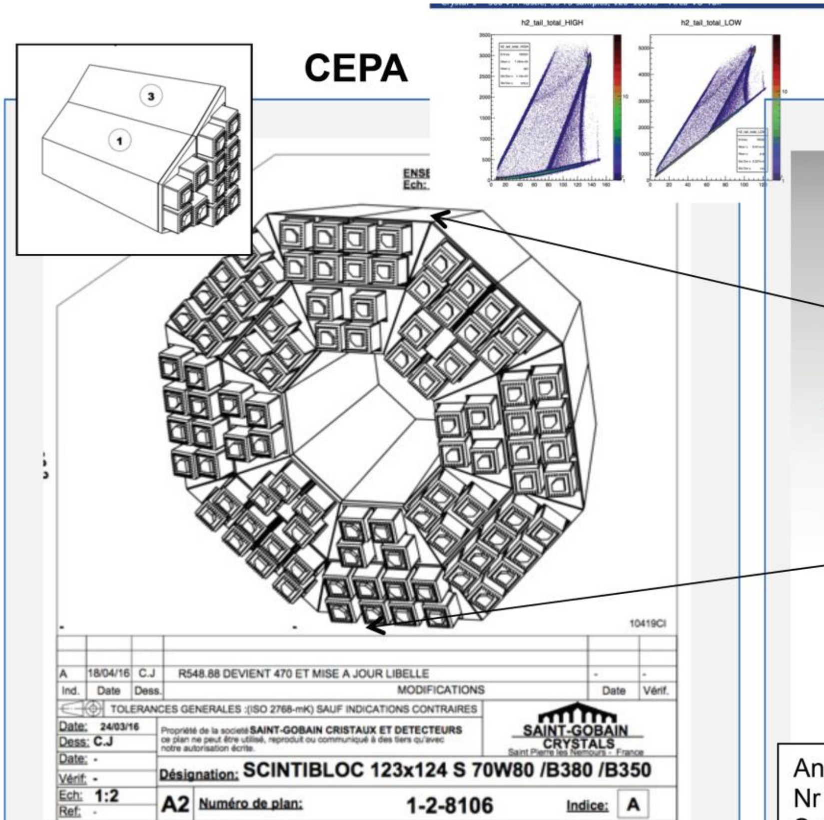
Full detector:

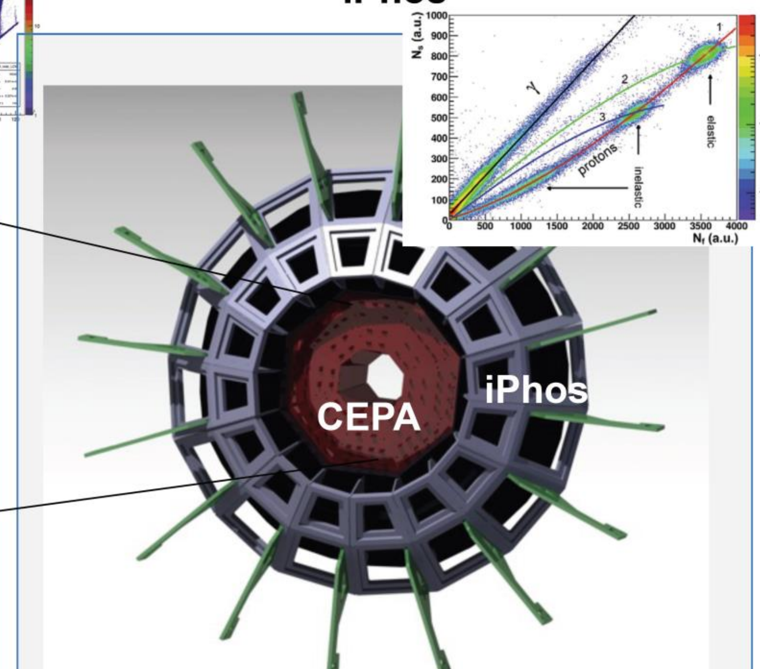




Courtesy of J. Cederkall

CALIFA: CEPA and iPhos





Angular cover:	7 – 20 deg.
Nr of crystals:	2 x 96
Scintillators:	LaBr/LaCl

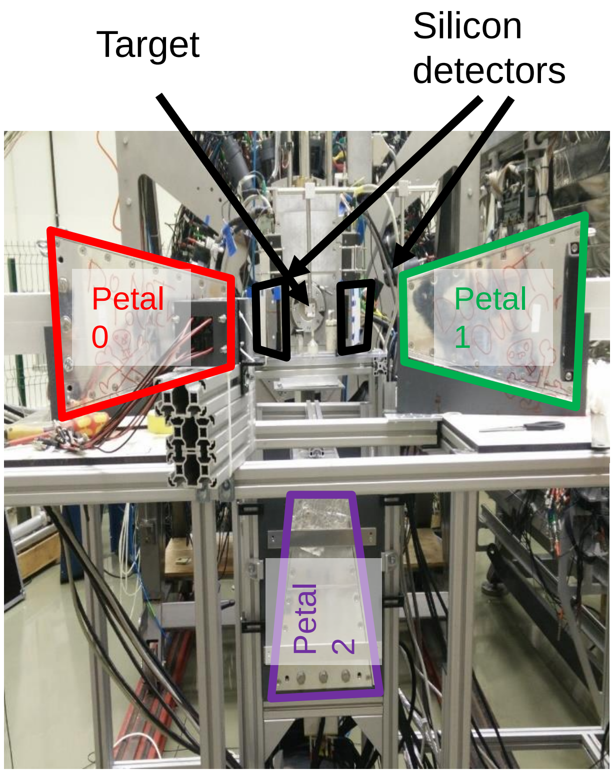
Fully funded via Chalmers. First segment module produced.

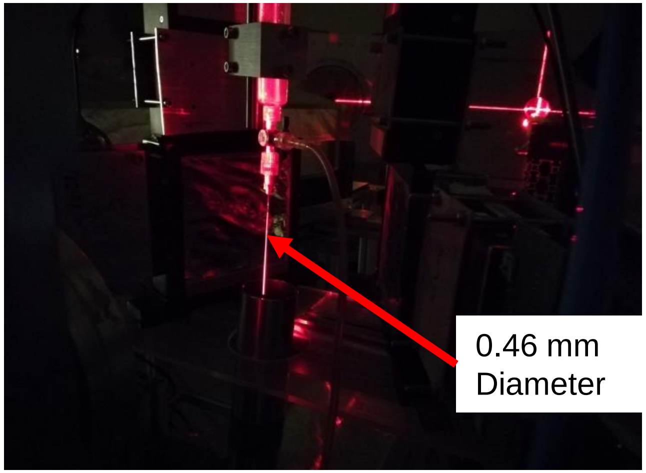
Angular cover:	20 – 43 deg.
Nr of crystals:	480
Sectors:	8
Scintillator:	CsI(TI) with PSA

The outer part of five sectors are covered by JINR. Two sectors are covered by TUD and one by USC. This makes iPhos 75% funded as of today.

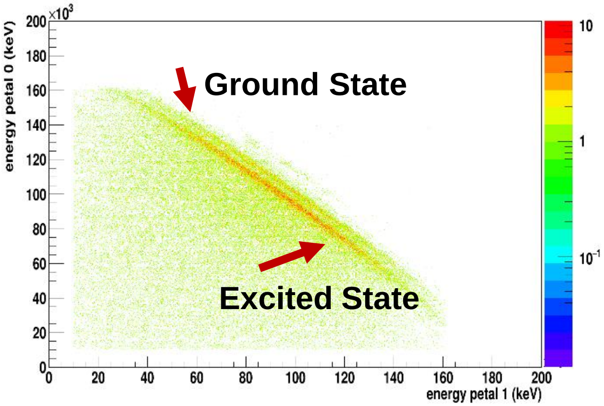
Courtesy of J. Cederkall

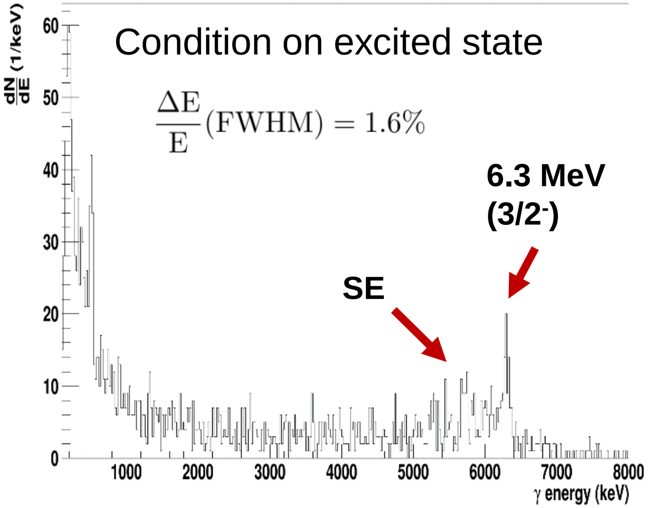
CALIFA Demonstrator Experiment in Krakow





- $^{16}O(p,2p)^{15}N$ with a water target and 200 MeV protons
- Normal kinematics
- Measure γ in coincidence





Courtesy of R. Gernhäuser / B. Heiss

NeuLAND

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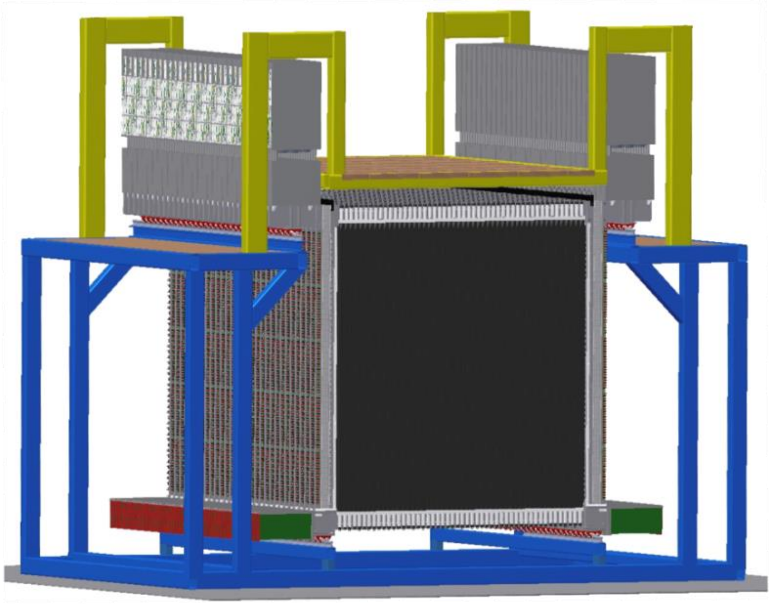


NeuLAND detector parameters:

- full active detector using RP/BC408
- face size 250x250 cm^2
- active depth 300 cm
- 3000 scintillator bars + 6000 PMTs
- 32 tons
- $\sigma_{x,y,z} \approx$ 1cm & σ_t < 150 ps

Design goals:

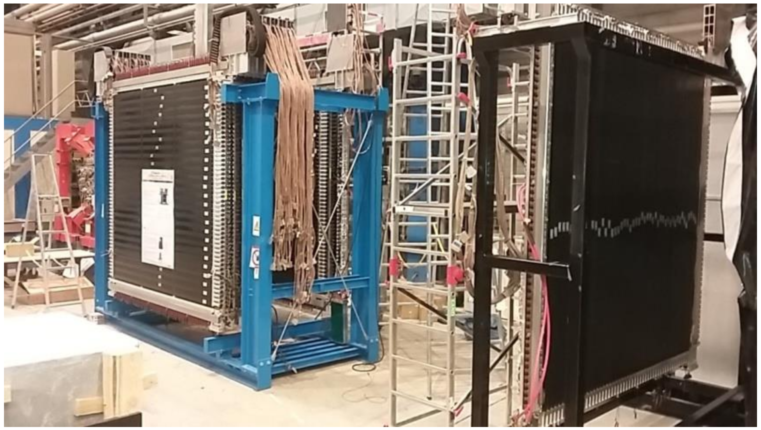
- >90% efficiency for 0.2-1.0 GeV neutrons
- multi-hit capability for up to 5 neutrons
- invariant mass resolution down to ΔE < 20 keV at 100 keV above thr.

double plane 11 during bar mounting

Courtesy of K. Boretzky

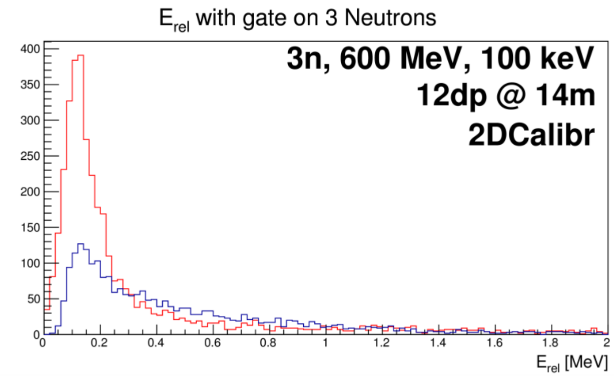
R3B

NeuLAND



NeuLAND Phase 0 Ok Q2-2018

- 130 cm active depth
- 2600 channels >40% detector



simulation prediction: **reconstruction efficiency** of the order of 20% for 3 n, 10 % for 4 n (600 MeV, preliminary)

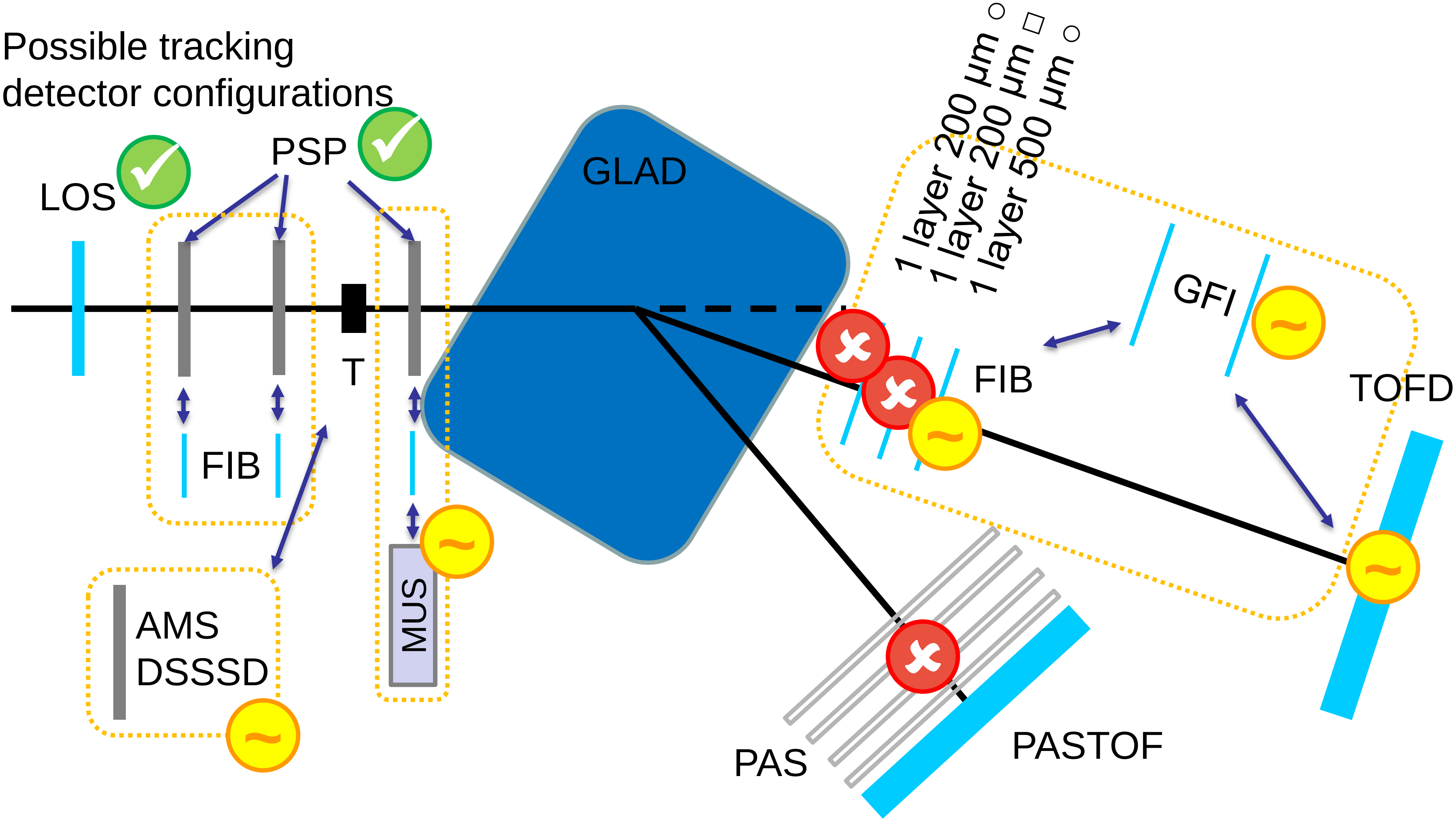
SAT test of in-house developed **NeuLAND electronics** underway:

- multichannel front-end electronic card TAMEX for high-resolution time and charge measurements

Courtesy of K. Boretzky

Status of tracking detectors

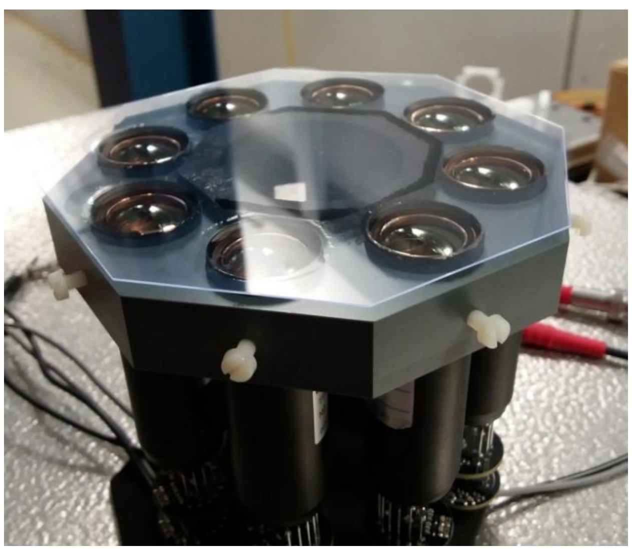
Possible tracking detector configurations

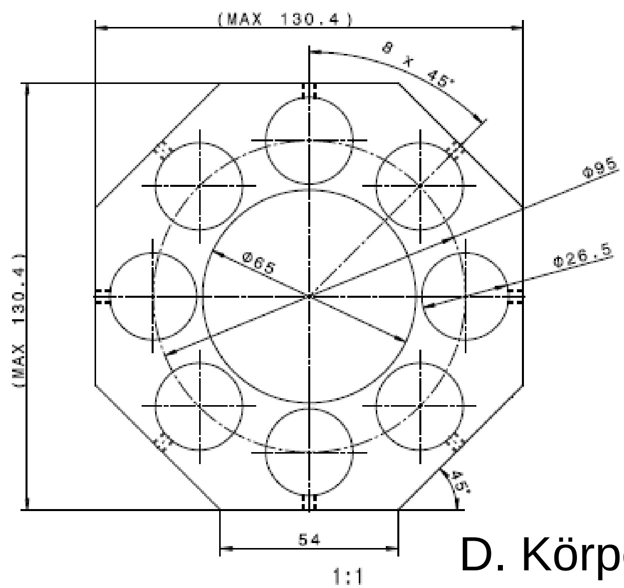


Tracking Detectors: LOS

- Scintillator foils read out on rear surface instead of edges
- Better light collection
- Use of thin foils possible
- Better stability

Z separation	**σ_E < 1%**
A separation	**σ_t < 10ps**
Rate	**1 MHz**





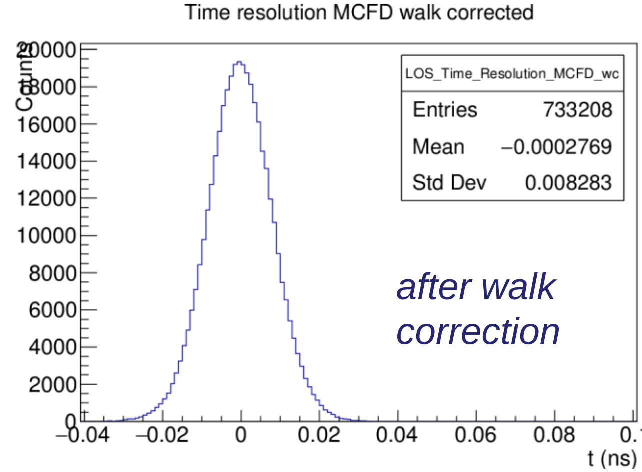
D. Körper

Tracking Detectors: LOS

Correction of saturation effect of PMTs.

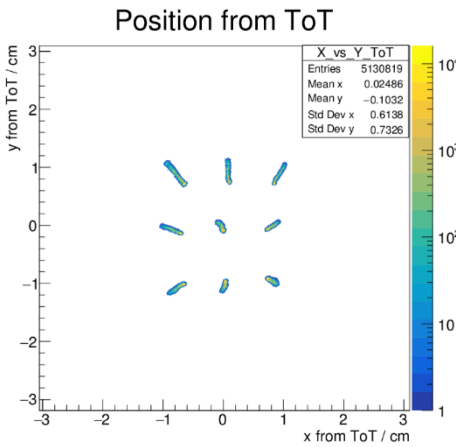
Walk corrections now included.

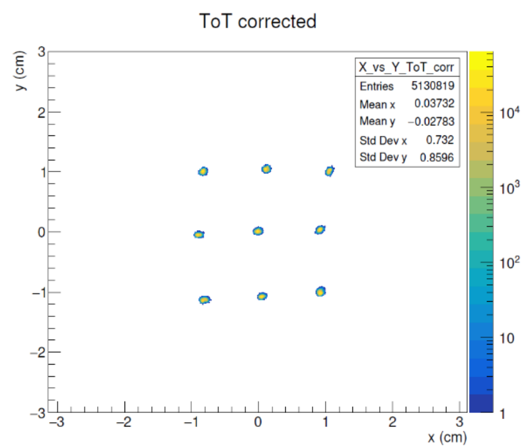
Correction for light transport ($E=\sqrt{E_1 \cdot E_2}$) does not work).



Achievements with laser for illumination of a point / full detector:

- Time precision of σ_t = 7.1 ps / 16 ps -> σ_t = 6.8 ps / 8.3 ps
- Position precision σ_{xy} = 150 µm / 380 µm -> σ_{xy} = 150 µm / 230 µm
- Charge precision σ_Q = 0.12 % / 0.6 % -> σ_Q = 0.09 % / 0.1 %





Courtesy of M. Heil

Tracking Detectors: PSP X5

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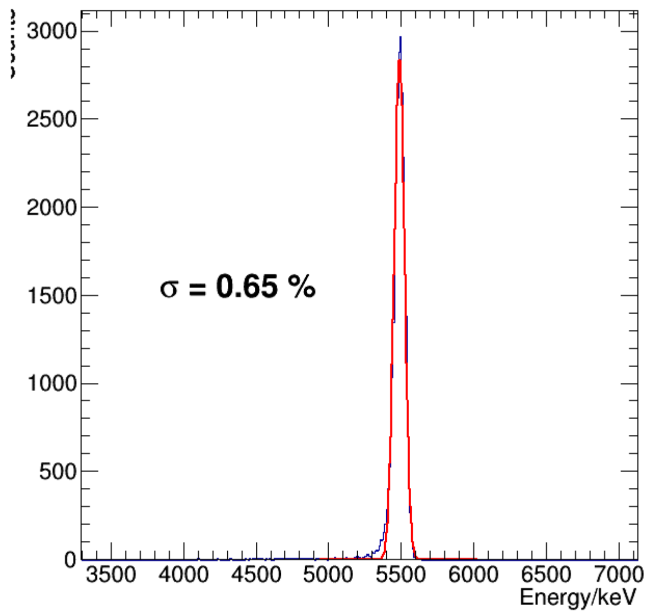
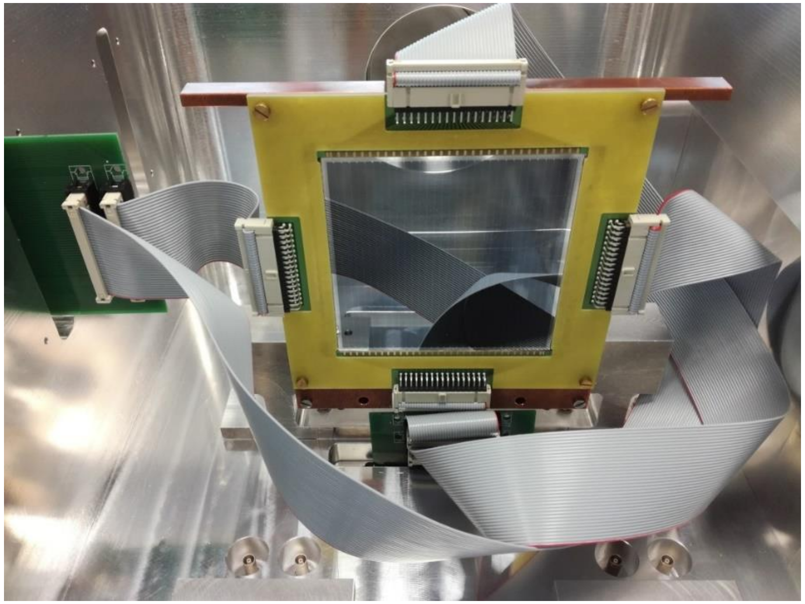
- 32-strip (resistive), double-sided Si detector, 10 x 10 cm^2
- All strips read out on both ends
- 1x 200um (+1x 200um + 1x 300um) detectors available

Z separation	$\sigma_E < 0.5\%$
Position x y	$\sigma_x < 100\mu m$
Rate	0.1 MHz/strip

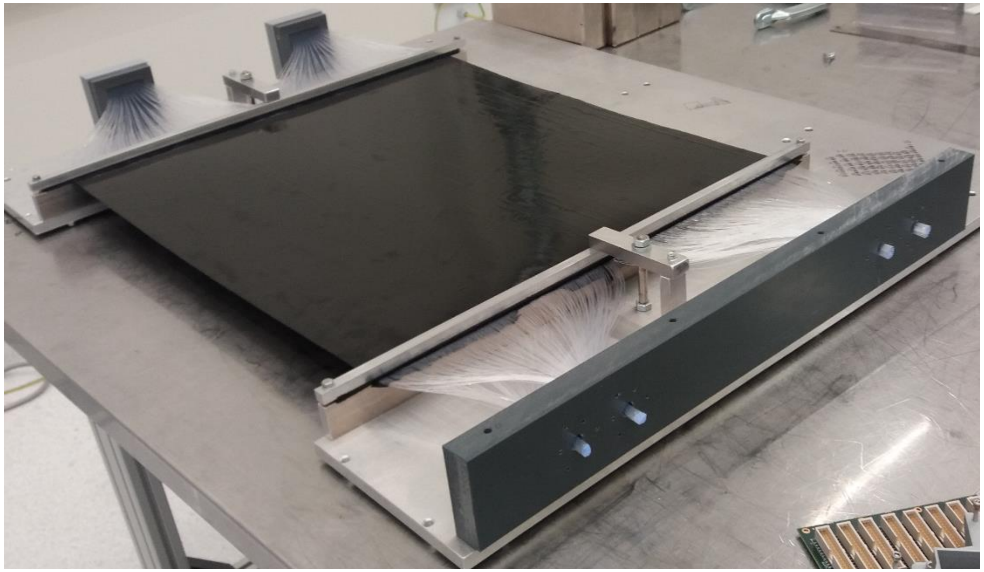




R3B

Tracking Detectors: Fiber Detectors

- 1 GFI to be refurbished for 2018 experiments: new MAPMT + new read-out electronics (PADI + FPGA-based TDC) (GSI development)
- Various prototypes in construction/test phase:
  - 50x50 cm² 500um round fiber
  - 25x40 cm² 200um square fiber
  - 50x50 cm² 200um round fiber
- Sensors:
  - Hamamatsu H13700 16x16 Multi-Anode PMT
  - SensL 1x1 mm² SiPM



Tracking Detectors: Fiber Detectors

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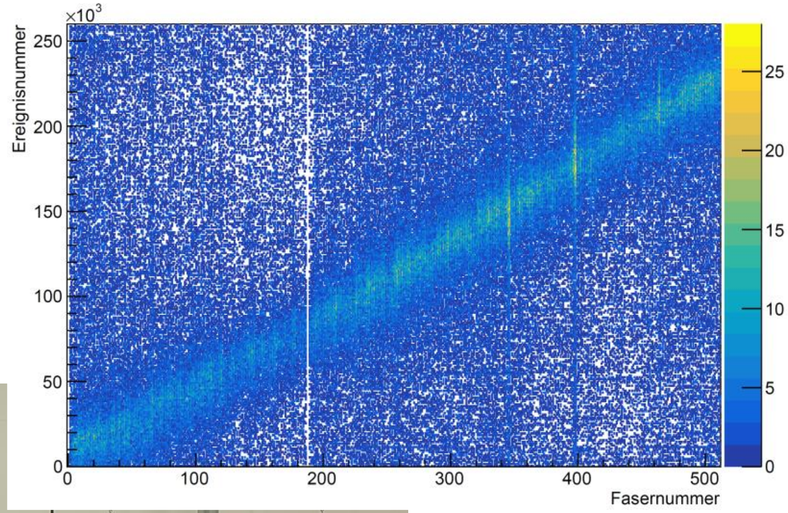
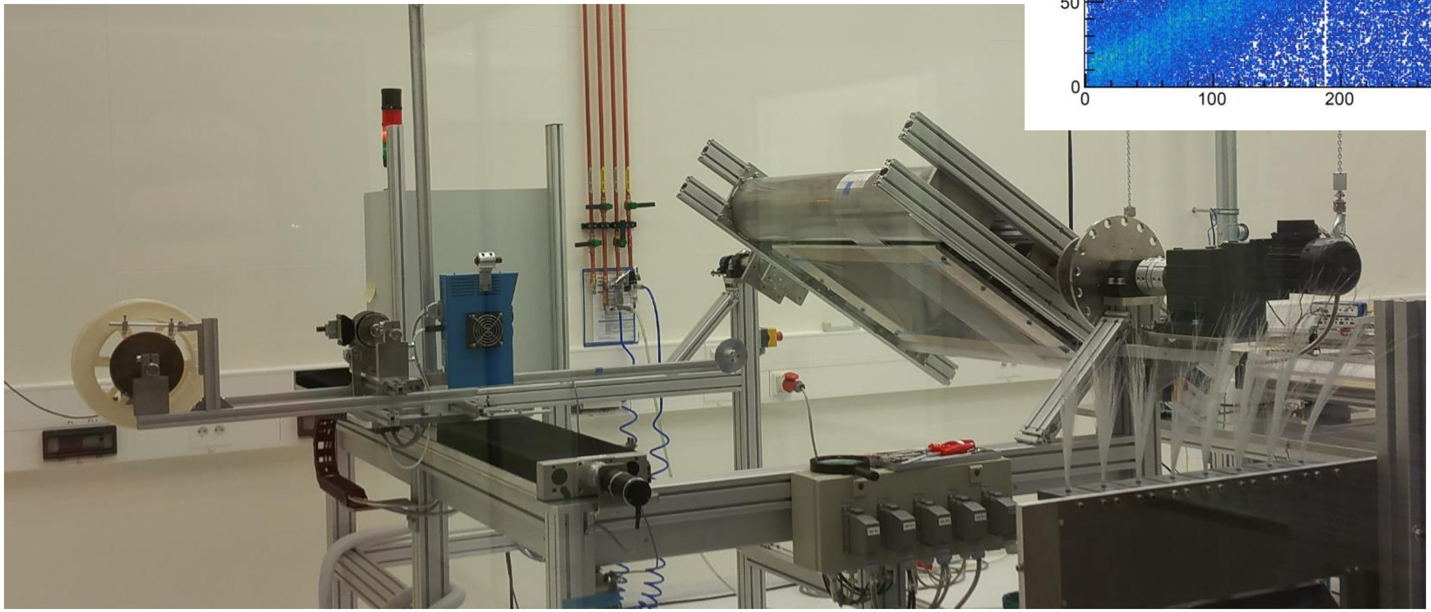
- 500um round FIB: test with ^{90}Sr source
  - Collimated source scanned automatically across detector surface
  - Correlation between fiber and event no.

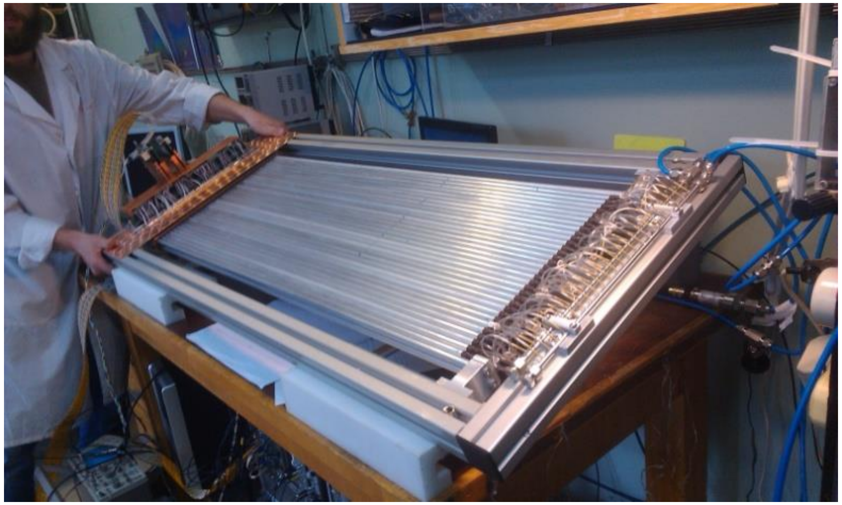




R³B

Proton Arm Spectrometer

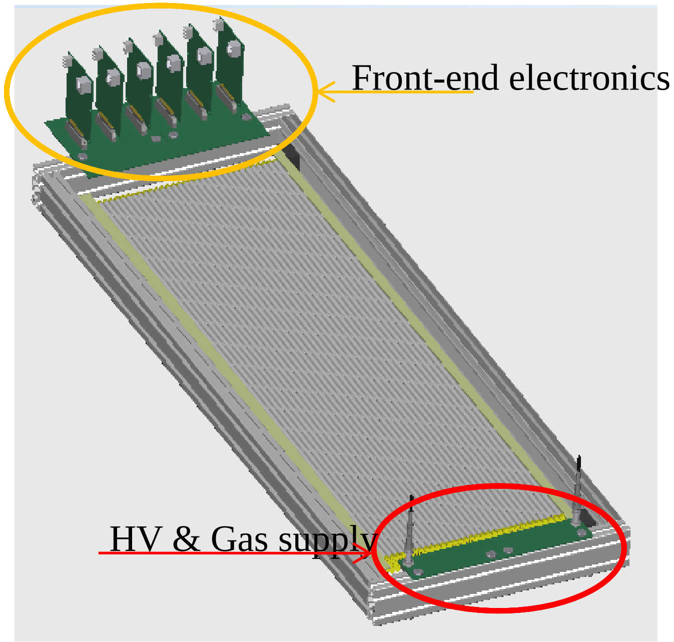
- Large area detectors: 2.1 x 1.0 m^2
- 2000 straws of 10 mm diameter
- 4 planes, 2 x, 2 -y-oriented.



Read-out
- Front-ends to be produced by PNPI
- Digitizers to be provided by GSI

Funding status:
- In-Kind contract with PNPI ready to be signed
- Sub-contract with GSI for digitizers also ready

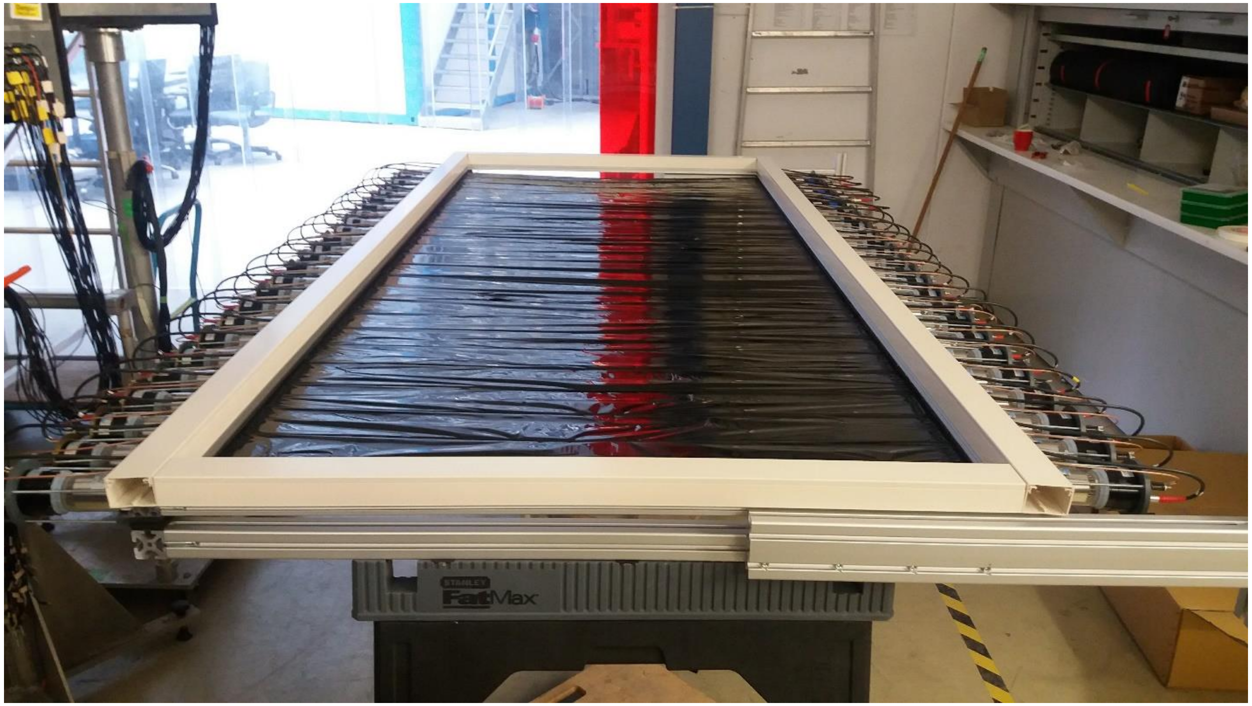
Efficiency 500-1000 MeV p	>95%



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

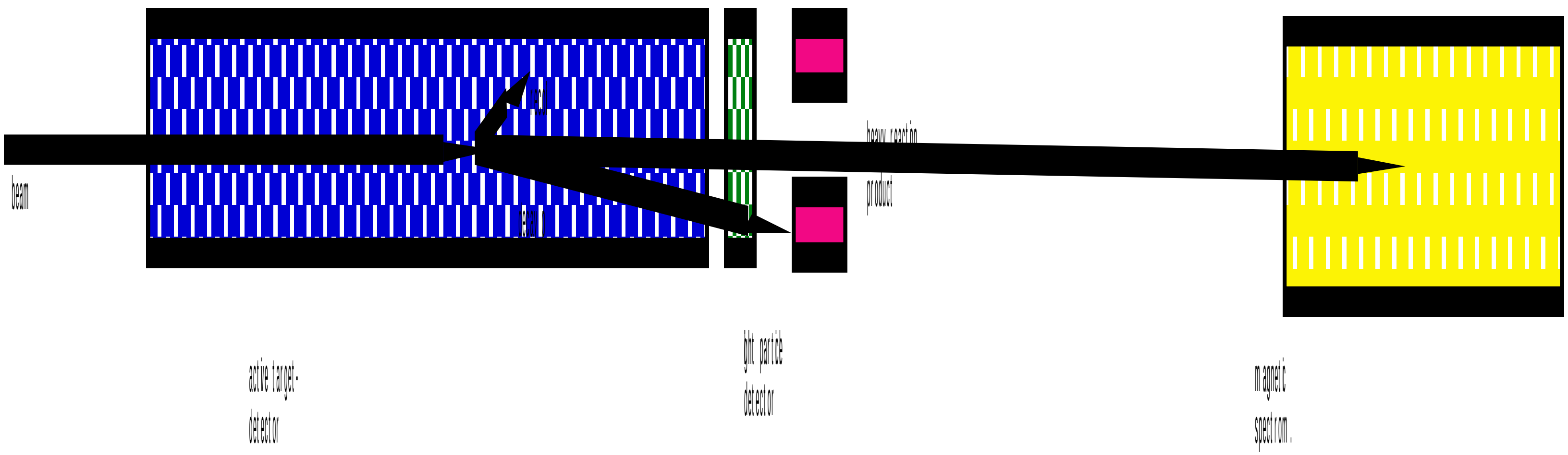
PASTOF

- 1 cm thick plastic scintillator, 10 cm wide, arranged in 2 layers
- Use of unused scintillator (initially for LAND) and PMTs
- Will provide trigger for PAS



Active Target

Active Target: Target = Detector



⇒ 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})

Active Target Type 1:

⇒ for (p,p), (α,α`). (^{3}He,t), (d,^{2}He) etc. measurement

Active Target Type 2:

⇒ for (α,α`γ) measurements

(to be used in coincidence with CALIFA)

Current status:

- TDR passed Council in 12.2017
- FAIR-PNPI In-Kind contract in preparation

- Prototype used in e-p scatt. at MAMI and μ-p scatt. at CERN
- Prototype ready for FAIR phase-0

Courtesy of P. Egelhof

Data Analysis and Simulation

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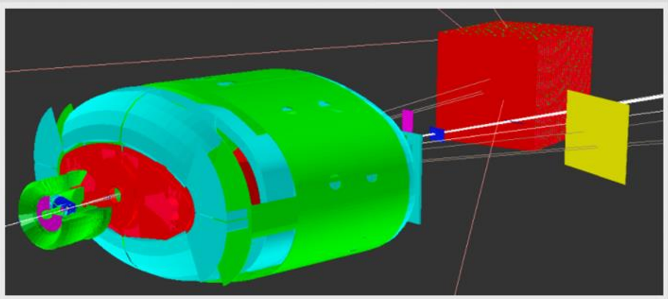
R3BRoot Simulations and Data Analysis for R3B

Home | Installation | Documentation | Repository | Meetings | Workshops | Disclaimer | About



Event display

Visualisation of the detector geometry in simulation. As an option, particles trajectories and hits can also be displayed

1 2 3

https://github.com/R3BRootGroup/R3BRoot.git

R3BRoot is a software framework developed at GSI, used for simulations and data analysis of R3B experiments. It inherits basic framework functionality from FairRoot, extending it with R3B-specific detectors and algorithms implementation. R3BRoot has a modular design with shared libraries, which are loaded on demand. The simulation part is based on the Virtual Monte Carlo (VMC) concept. For the description of detector geometry and input for the simulation, multiple formats are supported. It also includes parameter handling, event display, etc.

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E-Mail Contact Form
Forum
Issue Tracker (protected)

Announcements:

Release of R3BRoot apr17

Submitted by kresan on Thu, 04/27/2017 - 09:50

New stable version of R3BRoot is now available: "apr17". The release notes, compatibility issues and a download link can be found on the corresponding GitHub page. Note: master branch was updated as well.

Read more | kresan's blog

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Username *
hapol

Password *
•••••••

- Request new password

Log in

Courtesy of H. Alvarez-Pol

Data Analysis and Simulation

- R3BRoot: ~ 300 000 total code lines (88880 lines in implementation files, 65670 lines in header files, 112920 total lines in C macros (mainly geo generators), 11793 lines in txt files, 20439 lines in root files, ...). Unpacker stage using UCESB + Readers.
- Active development in GitHub, 35 commits since July 2017 by 8 developers.
- Still many automatic procedures for calibration and parameter containers not ready for production. Tests required for software tools.

	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

Courtesy of H. Alvarez-Pol

Summary

- Minimal R3B setup is expected to be ready for start of FAIR phase-0 in 2018:
  - GLAD: crucial system for R3B operation
  - CALIFA barrel: partially
  - NeuLAND: >10 double-planes
  - Tracking detectors: minimal set of detectors, no redundancy
- Additional systems expected to be ready for 2019:
  - LH2 target
  - Si tracker

- Manpower problems in all R3B Working Groups

Experimental setup response function

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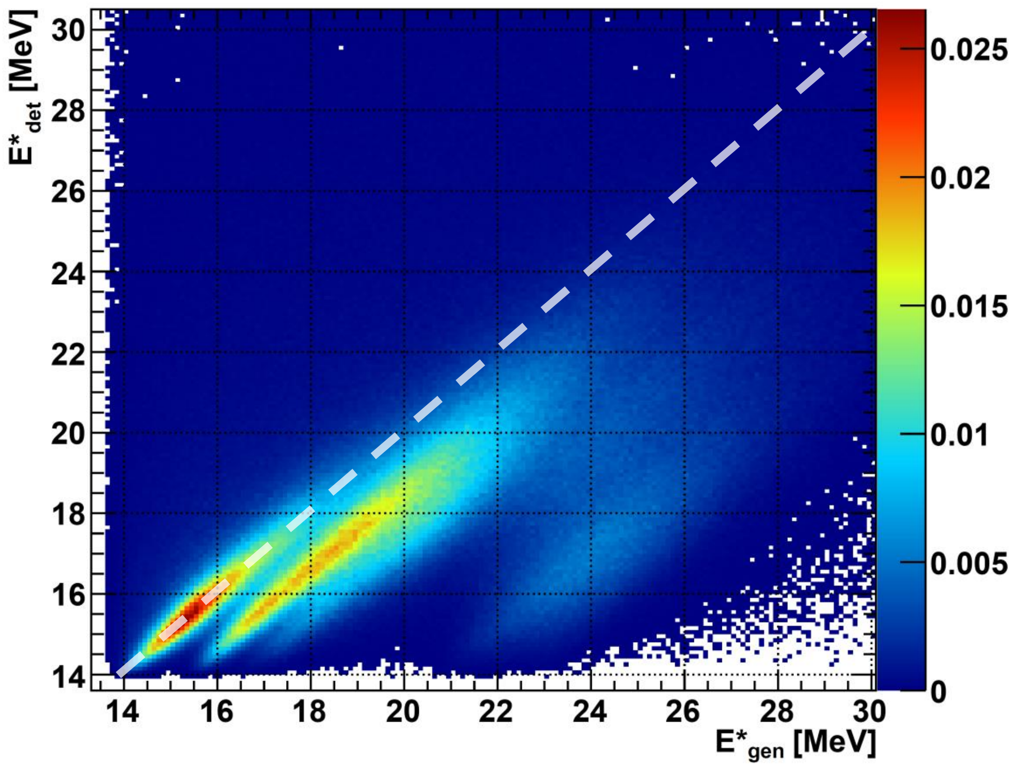
Statistical decay simulation using realistic detector descriptions

Example for $^{68}Ni(\gamma^*,2n)^{66}Ni$



- Strong experimental response (broadening + distortion) due to complex detectors
- Removal of response requires precise response matrices
- One matrix per channel and observable
- Iterative procedure
  - Folding of trial input
  - Calculate c2 from comparison with data
  - Adjustment of trial input

R3B