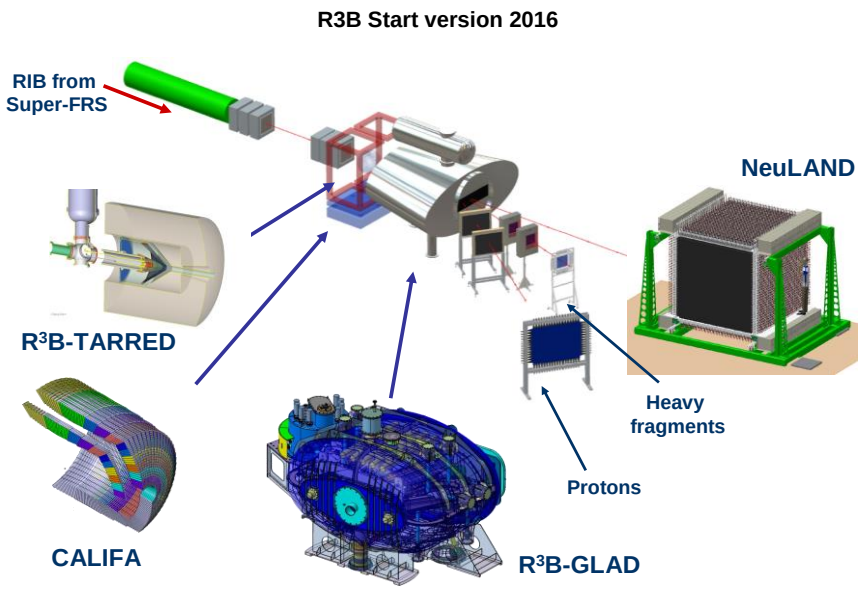
NeuLAND@R^{3}B: Status and Perspectives

- NeuLAND design goals
- status of the NeuLAND project
  - Technical Design Report
  - prototype experiment S406
  - build up of the demonstrator
  - demonstrator in GSI beam times 2014
  - ongoing production
  - NeuLAND excursion to RIKEN
- next steps

NeuLAND: The High Resolution Neutron Time-of-Flight Spectrometer for R³B



NeuLAND detector parameters:

- full active detector using RP/BC408
- face sice 250x250 cm^2
- active depth 300 cm
- 3000 scintillator bars
- 6000 PM / readout channels
- 32 tons

NeuLAND design goals:

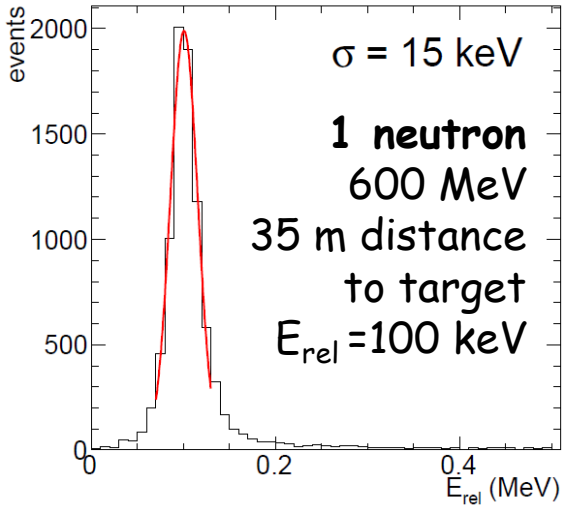
- >90% efficiency for 0.2-1.0 GeV neutrons
- Multi-hit capability for up to 5 neutrons
- invariant-mass resolution: **NeuLAND-target distance 35 m**
  ΔE < 20 keV at 100 keV above the neutron threshold

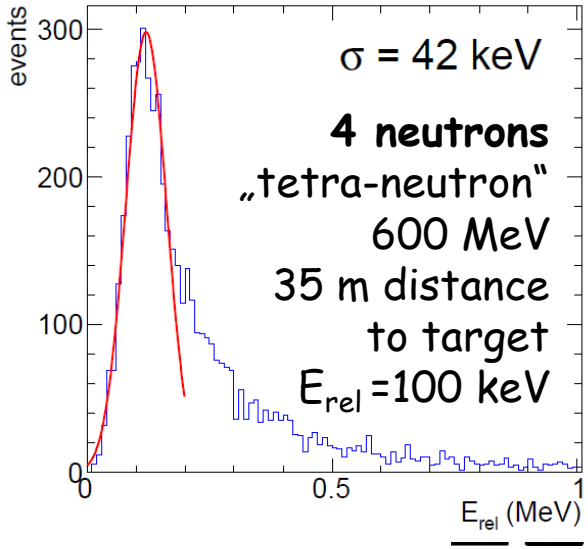
Performance Examples

high multi-neutron recognition:

		600 MeV generated				
	%	1n	2n	3n	4n	5n
detected	1n	**92**	22	2	0	0
	2n	2	**71**	32	7	1
	3n	0	6	**55**	32	9
	4n	0	0	10	**57**	50
	5n	0	1	1	4	**35**
	6n	0	0	0	0	5

high resolution at the particle threshold:

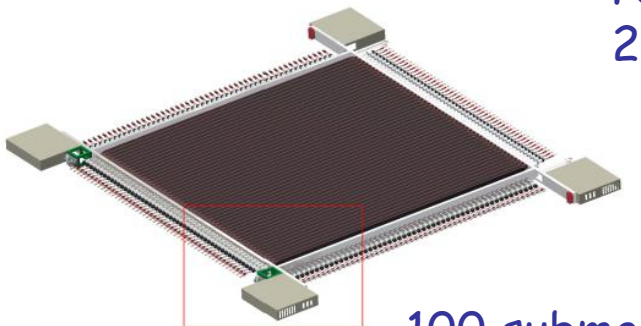




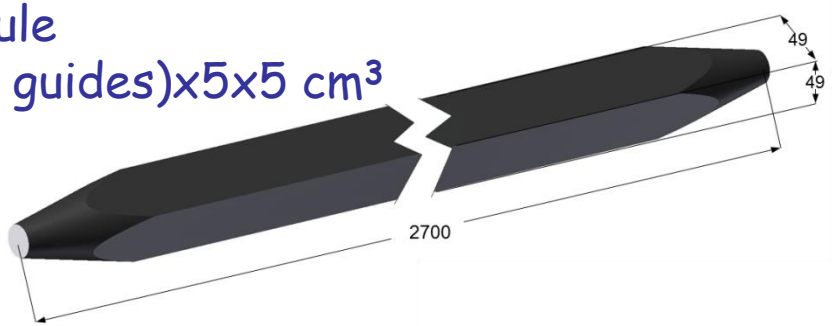
high efficiency for low neutron energies:

E_n [MeV]	Eff. [%]
50	79
100	94
150	95
200	91

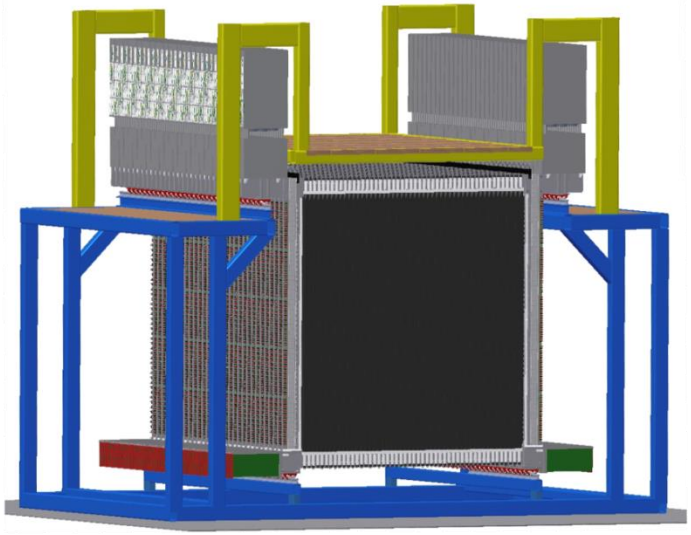
From Submodules to Complete NeuLAND



NeuLAND submodule
250(270 incl. light guides)x5x5 cm³



100 submodules
build one double-plane



30 double-plane
build up NeuLAND
face sice 250x250 cm²
active depth 300 cm

Important Stages for NeuLAND

2011
- NeuLAND design decision
- Technical Design Report handed in in Nov.

2012
- S406 experiment with Prototype (150 modules)
- Approval of Technical Design Resport

2013
- April: first double-plane built at GSI
- start of continuous production

2014
- NeuLAND demonstrator successfully tested in GSI beam times
- preseries of final HV distribution arrived

2015
- 4 double-planes installed at RIKEN
- continuation of production

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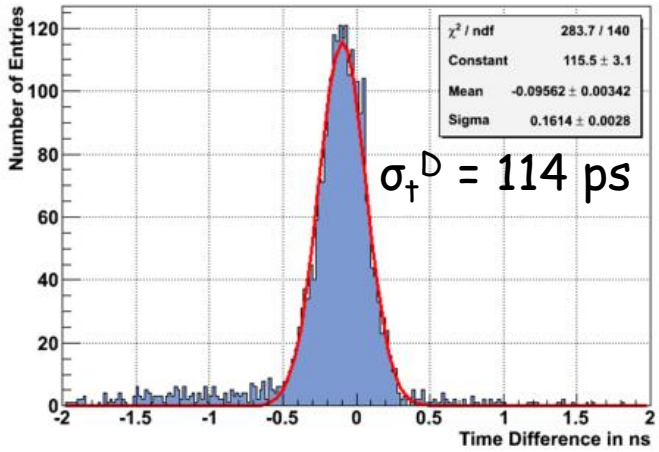
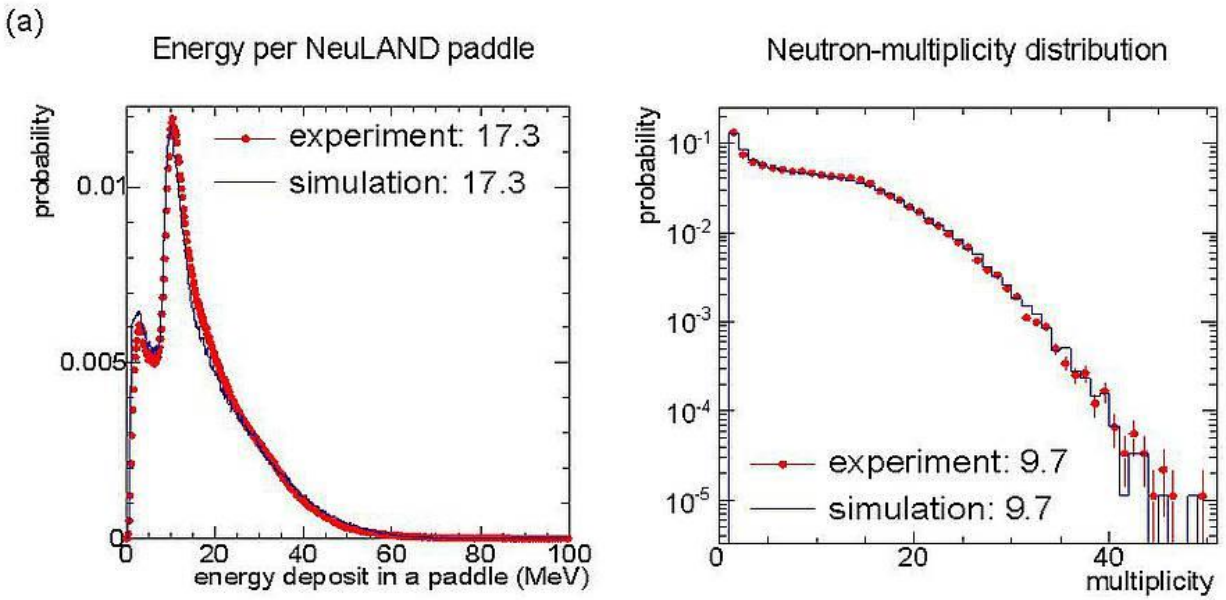
2016
- ongoing production

2017
- commissioning of NeuLAND at Cave C

S406: breakup of deuteron on CH_2 target @200 to 1500 AMeV





important feedback from data to simulations!

NeuLAND double planes

assembly of double-planes at GSI
by collaborative consortium

collaborative consortium:

GSI PMA
PNPI Gatchina
Univ. Frankfurt
Univ. Cologne
TU Darmstadt
(TU Dresden)
(ATOMKI Debrecen)

NeuLAND building blocks: Scintillator Bars

3000 bars needed

270 cm long: 250x5x5 cm^3 detector volume
+ 2x100 cm built in light guide

purchase of bars:

- frame contract: 4 years (2013-2017) at fixed price
  - 1st order: 430 bars (2013)
  - 2nd order: 200 bars (2014)
- second provider:
  - 1st order: 101 bars (2014)
- next steps:
  - in-kind contribution PNPI/Russia (V. Kuznetsov et al.)
  - future orders within frame contract from german funding

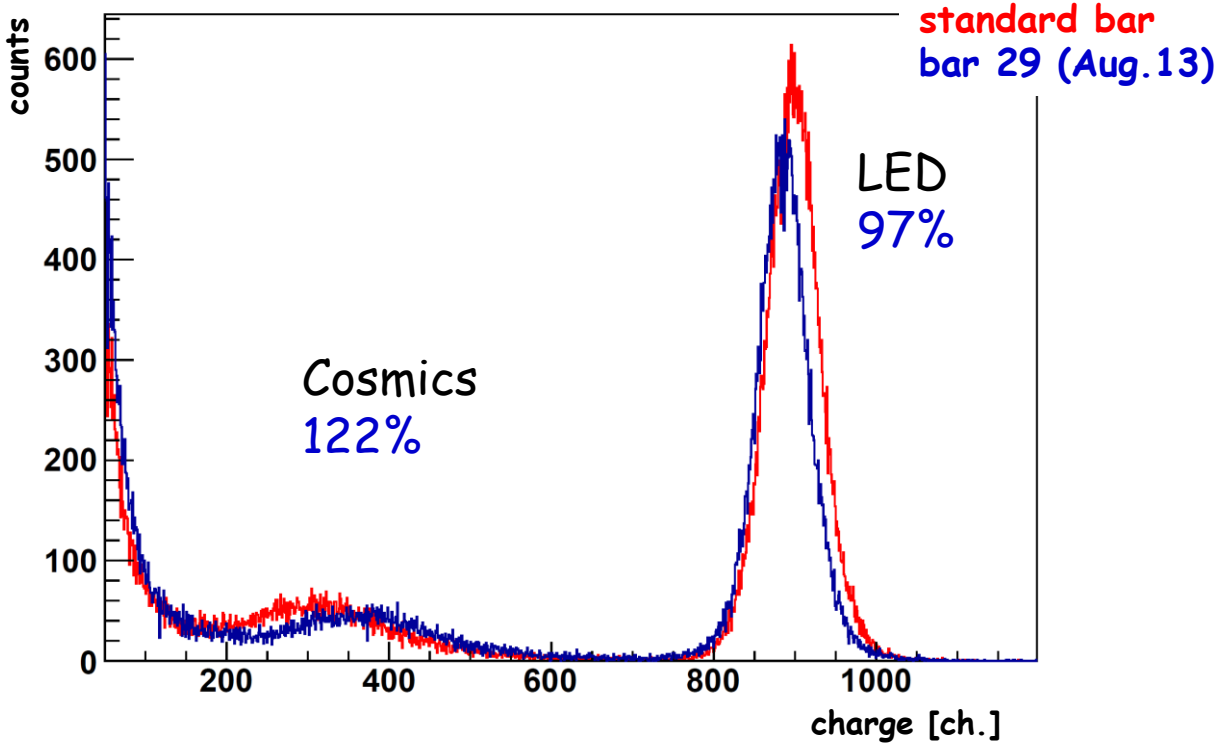
SAT Scintillator Bars: combined LED and Cosmic Test

Light-Production Measurement

- detect transversing cosmic rays
- read-out at one or two sides
- check on scintillation quality

Light-Output Measurement

- LED light from one side of bar
- read-out at far side
- check surface quality



NeuLAND building blocks: Photomultiplier

6000 PMTs needed

- state of the art readout:

  H8619 w. active voltage divider
  - ordered for in total 8 double-planes
  - „plug and play"

  frame contract (2013 -2017, fixed price)

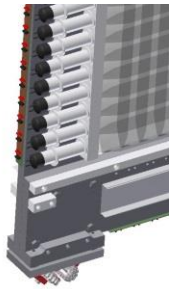
- future perspectives I: check PMTs from Russia as cost-effective alternative
- future perspectives II: development of larger Si-PMTs ongoing

(HZDR team – D. Bemmerer et al.)

NeuLAND building blocks: High Voltage Distribution System

6000 HV channels needed

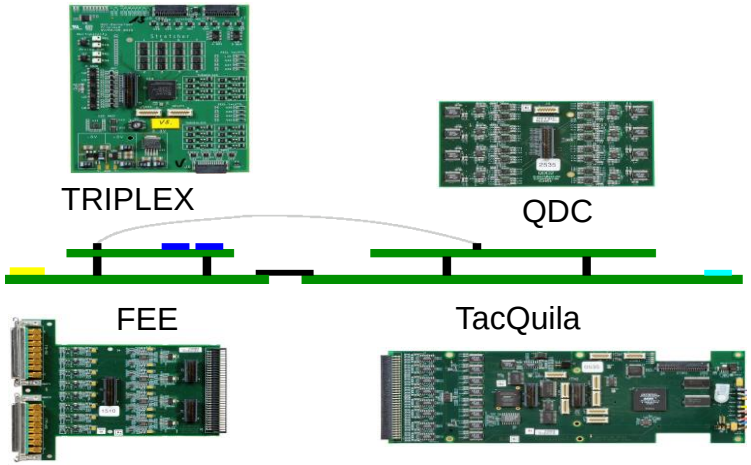
- HVDS system from PNPI (L. Uvarov et al.) is based on 2kV primary power supply with controllable dividers
- individual down-regulation of each channel
- form factor fits to NeuLAND double planes



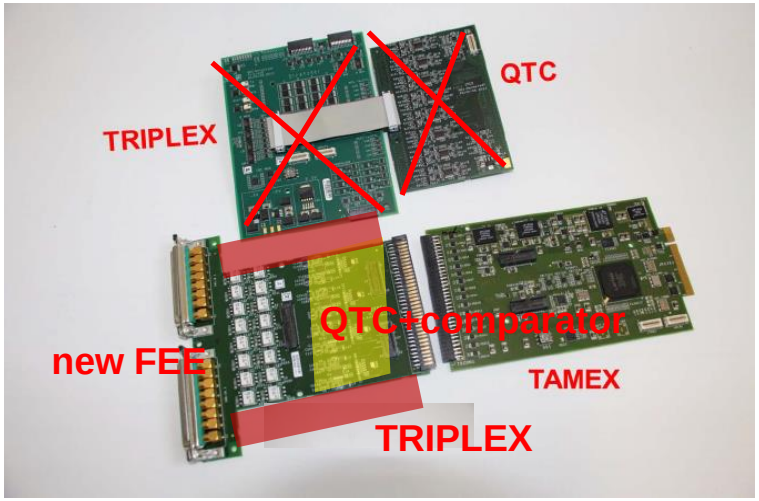
- accepted as in-kind contribution from PNPI
- pre-series (200 channels) delivered in December 2014
- Site Acceptance Test ongoing
- Delivery of full system up to 2017

NeuLAND building blocks: Electronics

transition from
LAND-TacQuila readout (ASIC based)



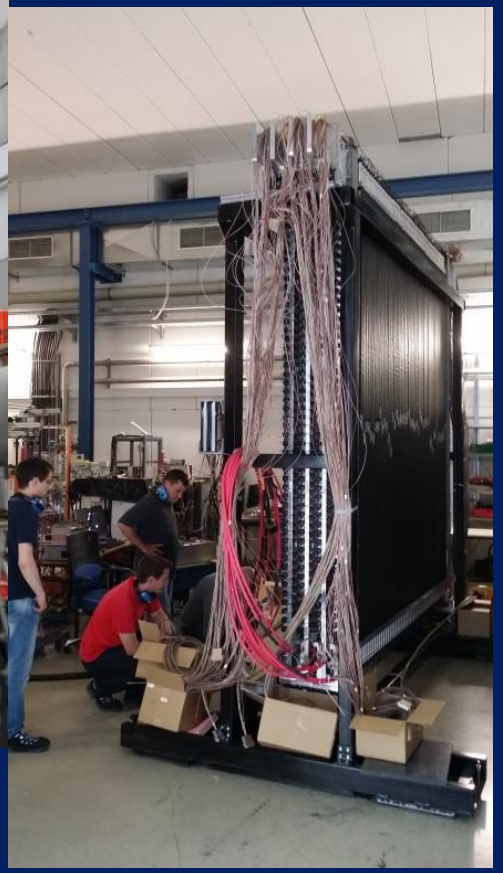
to TAMEX2 (FPGA based)
final layout in development
by GSI RBEE



NeuLAND for April beam time at GSI

Foto Gaby Otto

NeuLAND June to October 2014
GSI beam times

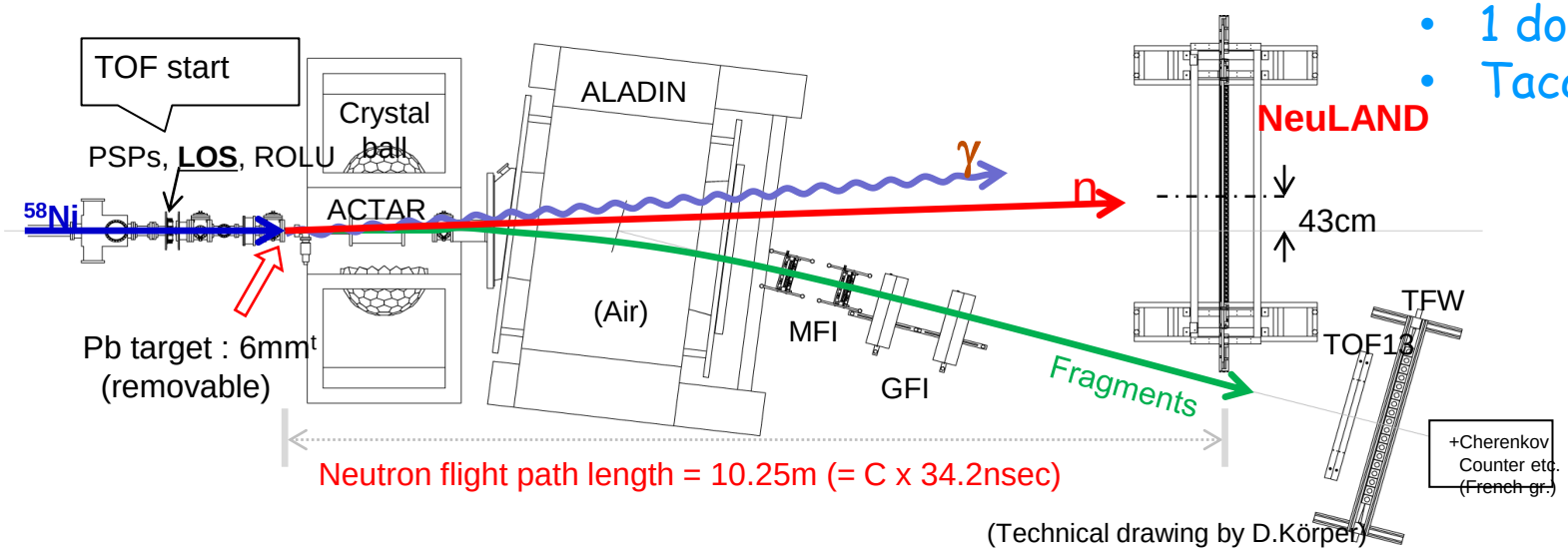


Three GSI Beam Times

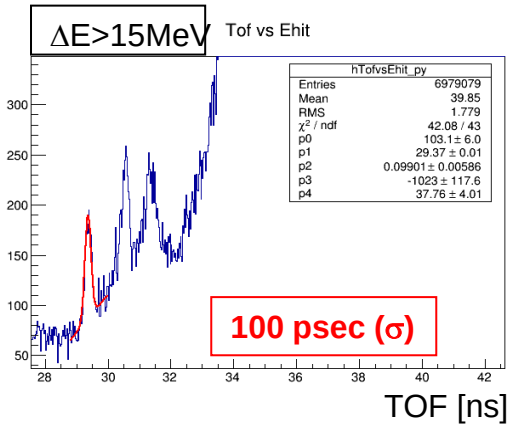
- S438a – April'14:
  - 1 double-plane, Tacquila readout
  - neutrons from Coulomb breakup of Ni
- S438b – Oct'14:
  - 4 double-planes, Tacquila readout
  - 2 single-planes, TAMEX readout
  - neutrons from nuclear breakup of Ca
- S438c – Oct'14:
  - as before but
  - neutrons from fission of ^{236}U and others

S438a – Coulomb Breakup of 58Ni
April 2014

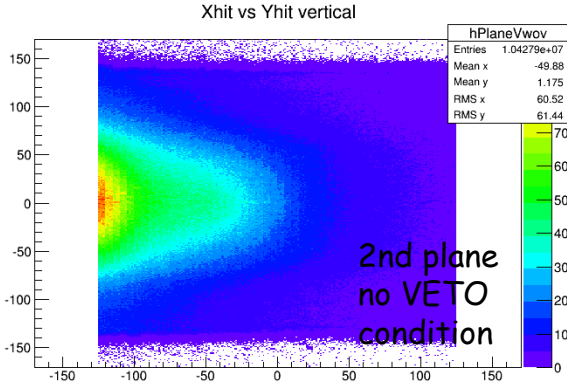
- 1 double-plane
- Tacquila readout

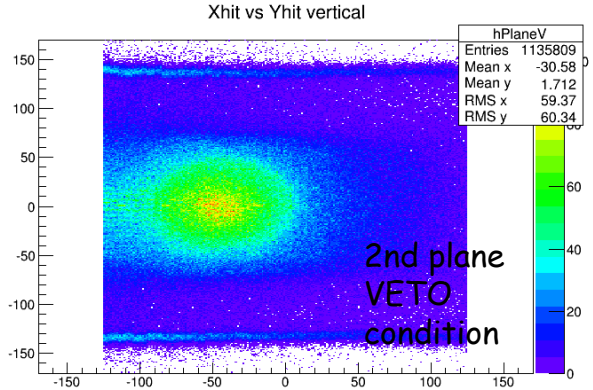


→ time resolution σ = 100-150 ps

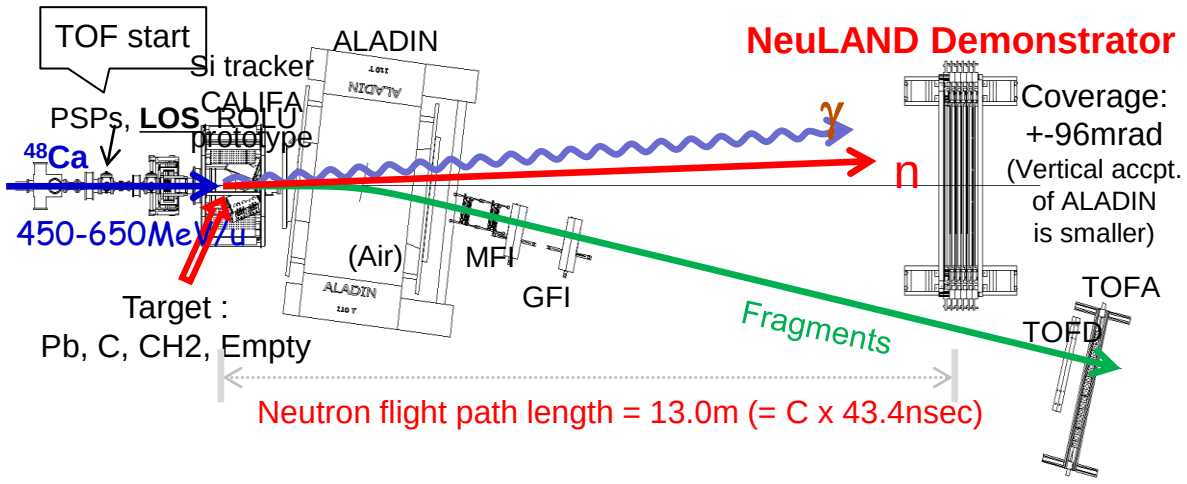


→ study of background situation





S438b – Nuclear Breakup of ^{48}Ca Oct 2014



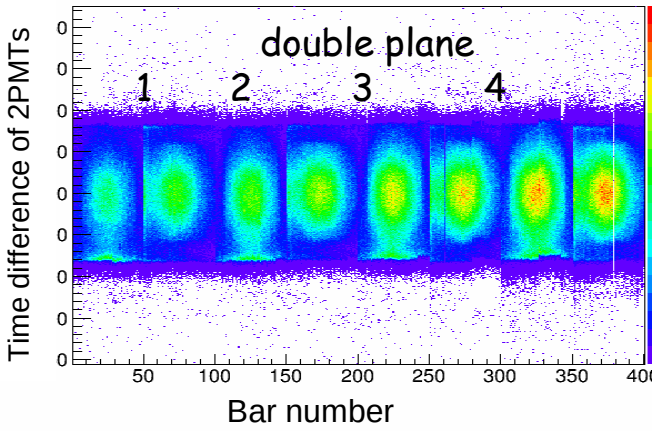
(Technical drawing by D.Körper)

Demonstrator
1/6 of final NeuLAND
50 cm depth:

- 4 double-planes, Tacquila readout
- 2 single-planes, TAMEX readout

→ confirmed time resolution
→ background in accordance to simulation
→ pattern studies

Neutron hit distribution in 8 layers

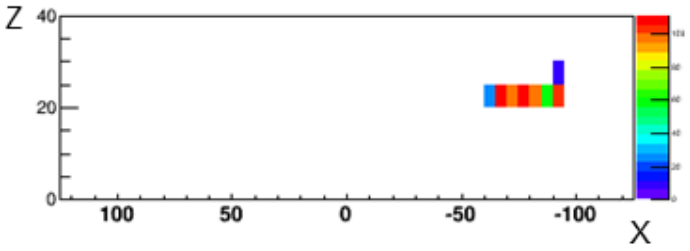


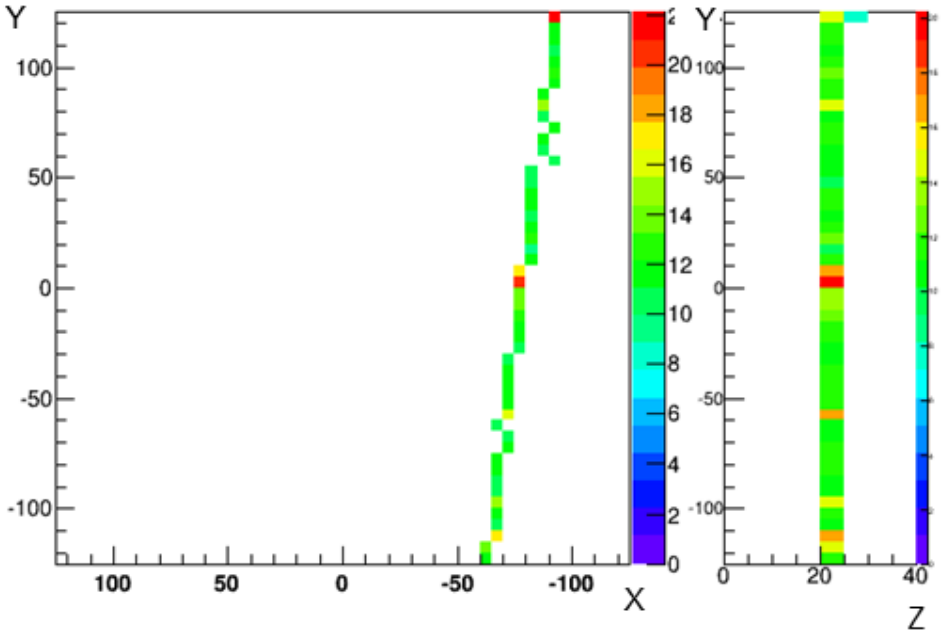
NeuLAND Event Display
Cosmic Event

by courtesy of Kenjiro Miki

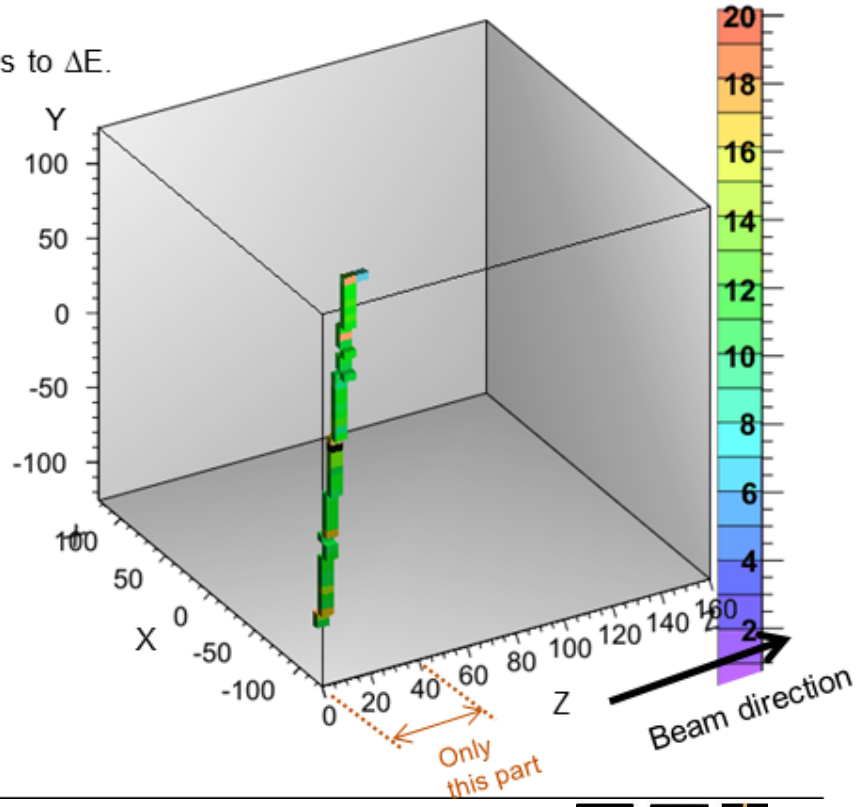
- Off-spill

Gates:
- Trig = 2 (off-spill)
- # of hit bars > 20
- # of hit bars in Plane 1,8=0 (to select vertical rays)
- ΔE in each bar > 2MeV





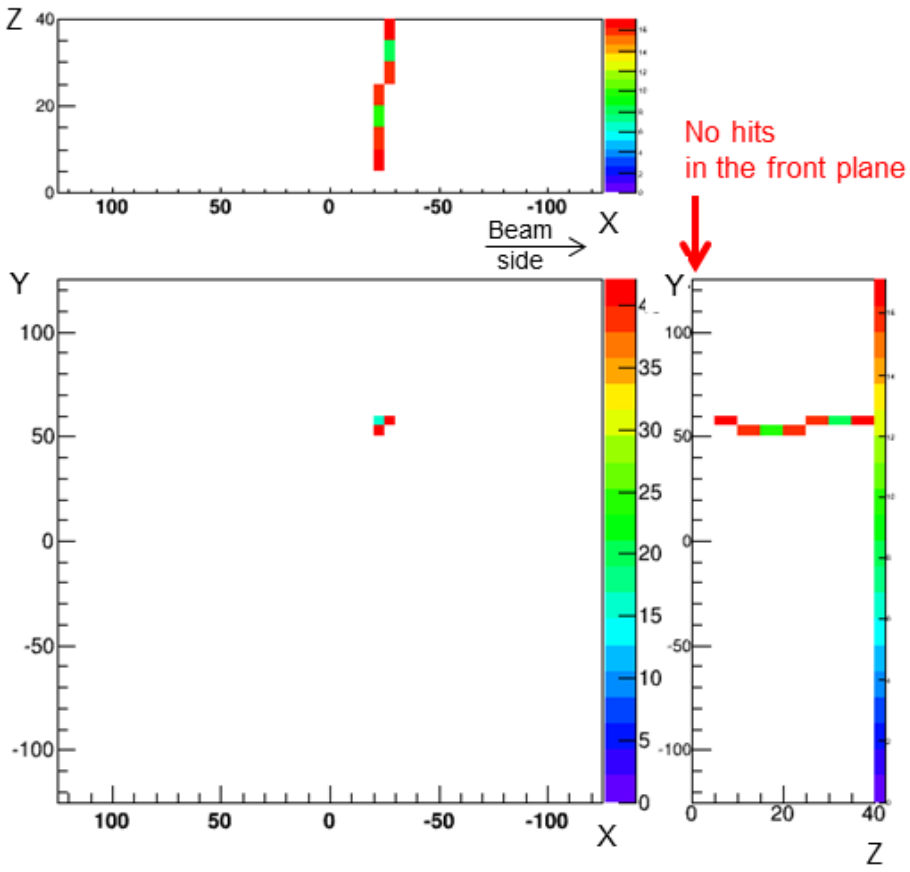
Colors corresponds to ΔE.



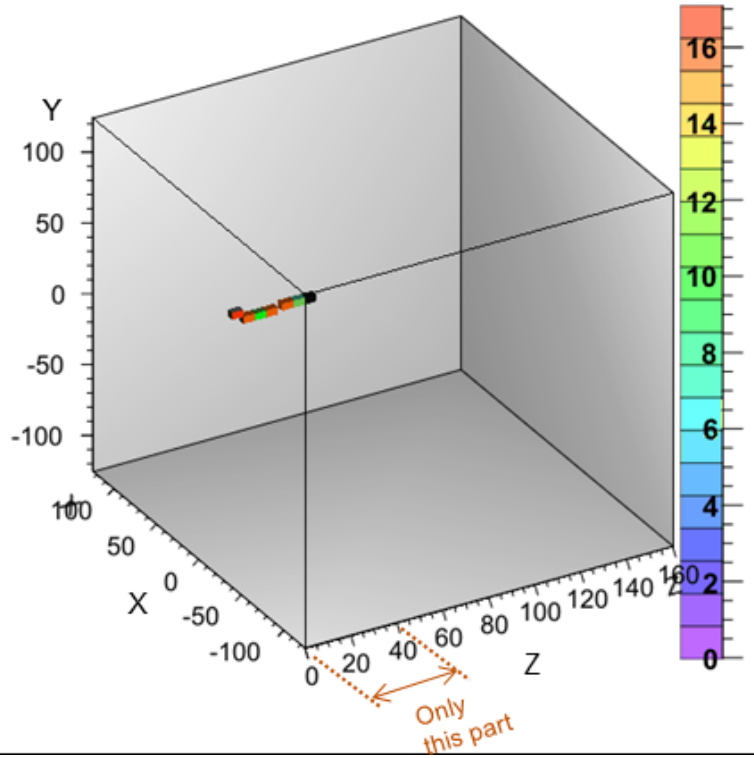
NeuLAND Event Display
One Neutron Event

by courtesy of Kenjiro Miki

- On-spill



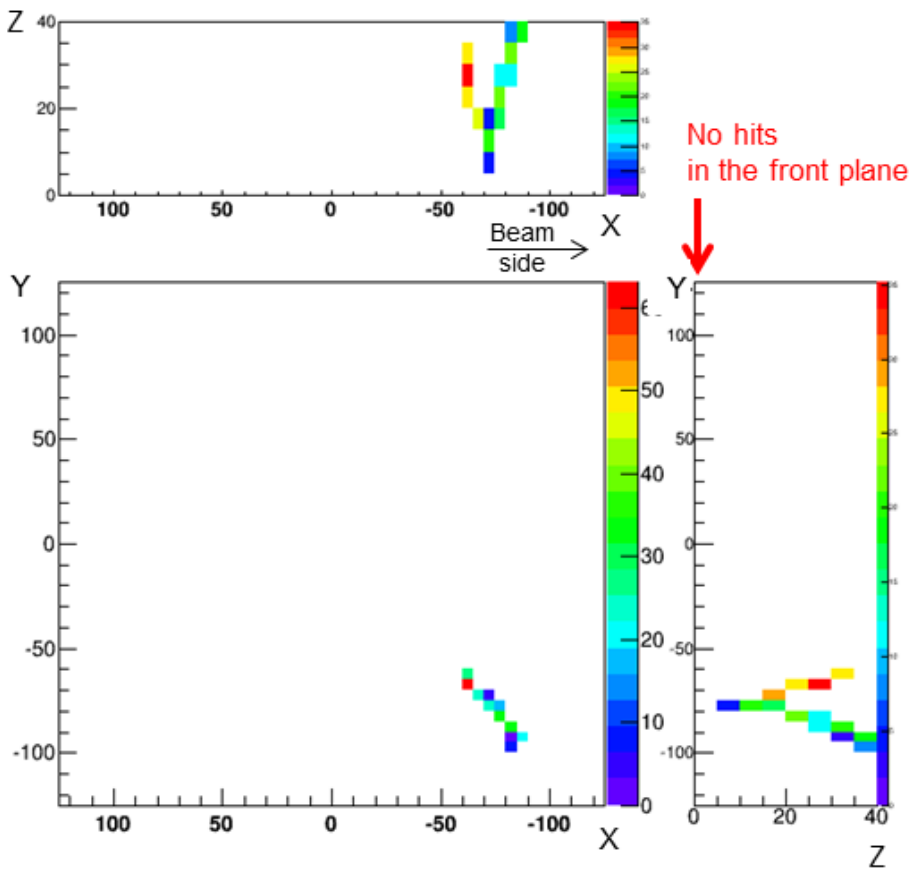
Gates:
- Trig = 1 (on-spill)
- # of cluster == 1 && cluster size >=7
- ΔE in each bar > 3MeV
- **CP Veto**



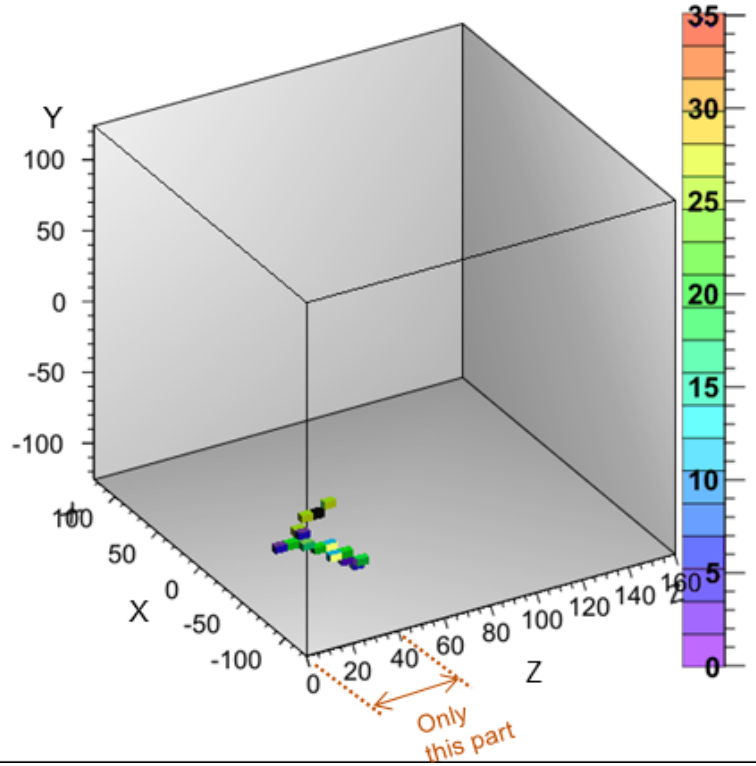
NeuLAND Event Display
One Neutron Event

by courtesy of Kenjiro Miki

- On-spill



Gates:
- Trig = 1 (on-spill)
- # of cluster == 1 && cluster size >=15
- ΔE in each bar > 3MeV
- **CP Veto**



NeuLAND Event Display
Two Neutron Event

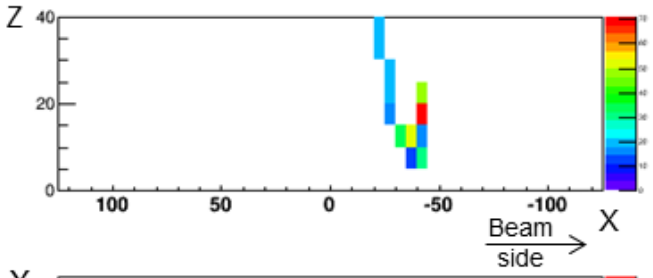
by courtesy of Kenjiro Miki

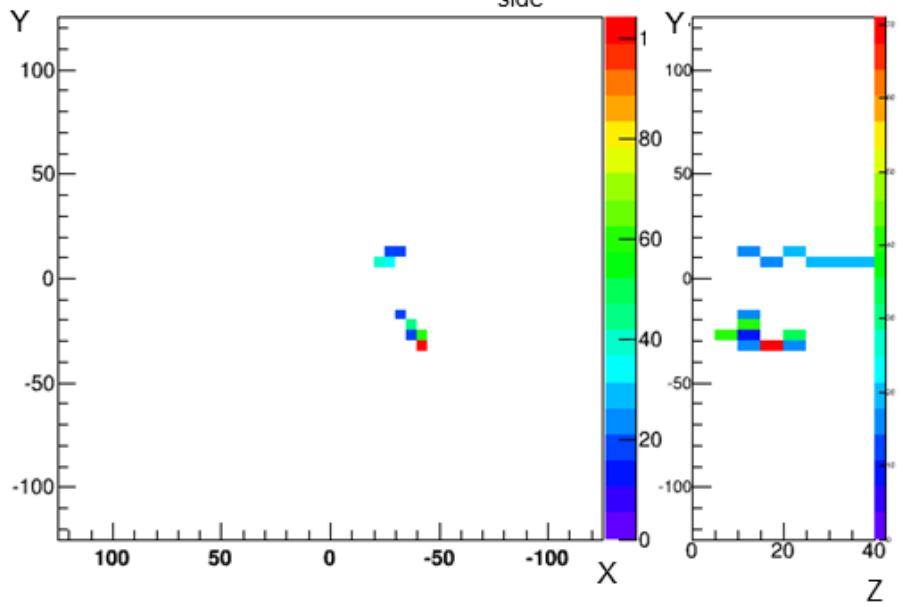
- On-spill

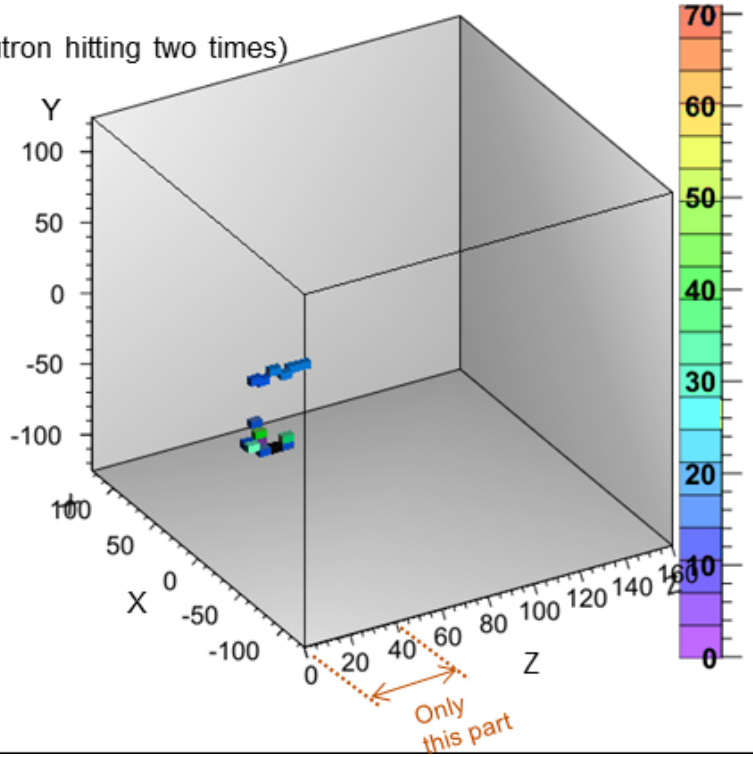
Gates:
- Trig = 1 (on-spill)
- # of cluster == **2** && cluster size >=7
- ΔE in each bar > 3MeV
- CP Veto
- **Causality**
  (To reject one neutron hitting two times)

Causality cut:
Two hits are separated beyond the causality

d > c x | T1-T2 |

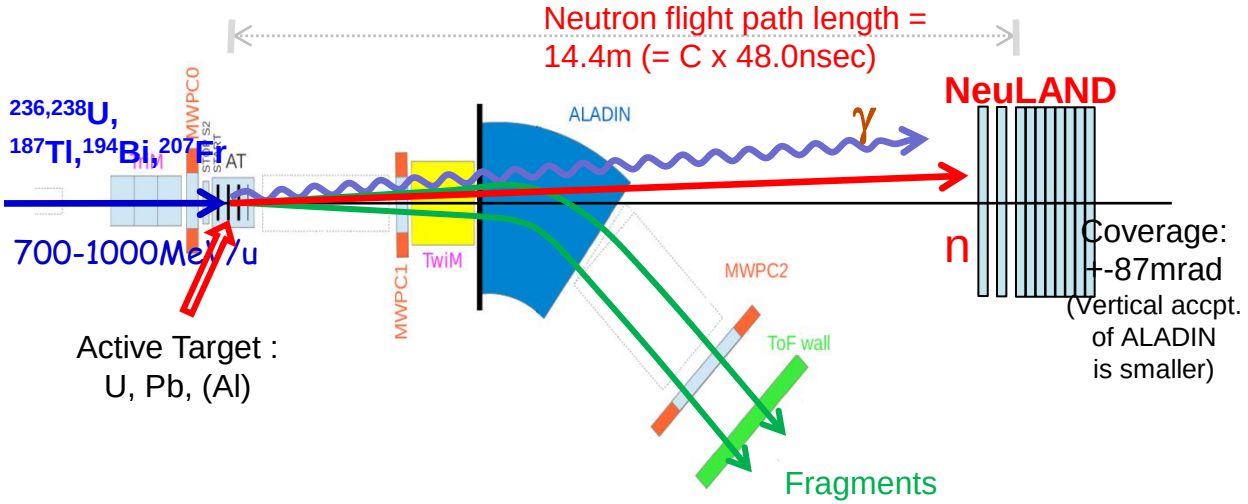


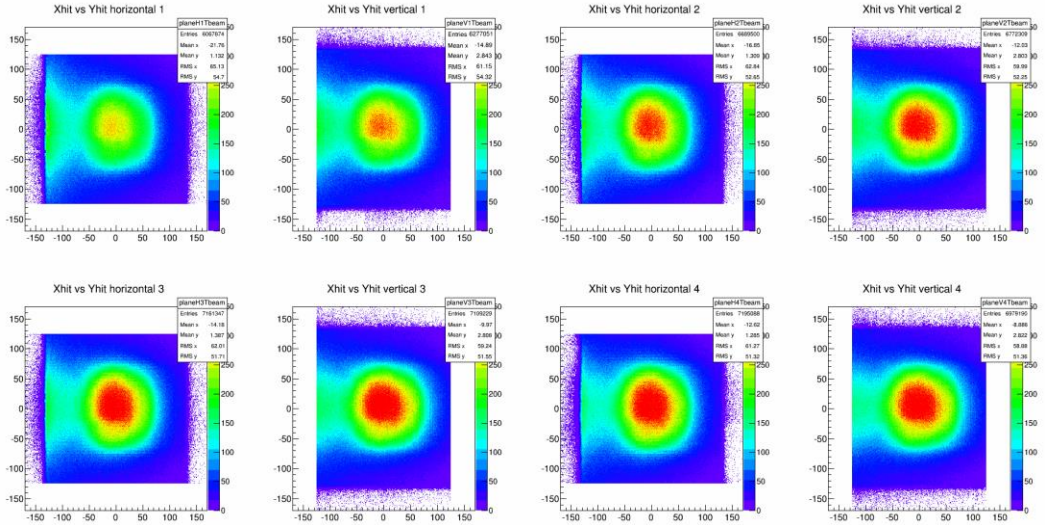




S438c: SOFIA Experiment
Fission of ^{236}U et al. - Oct 2014

(Picture by T. Gorbinet taken from ELOG)





→ little background due to SOFIA trigger

→ all 800 modules functional and well calibrated

→ pattern studies of multi-neutron events

GSI → RIKEN

4 double-planes sent to RIKEN for 2 years

transport box
5.75 tons
401 x 344 x 128 cm^3

participation in several experiments during 2015 to 2017.

Summary

- NeuLAND demonstrator built and tested
- data collected to work on simulation and analysis code
- production ongoing
- goal: up to 1 double-plane per month
  → complete detector during 2017
- Cave C can host the full-size detector
- goal: commissioning in late 2017
  first physics experiment in 2018