

# NeuLAND status

**S.G. PICKSTONE**

INSTITUTE FOR NUCLEAR PHYSICS  
UNIVERSITY OF COLOGNE

for the NeuLAND working group  
and the R<sup>3</sup>B collaboration

Supported by BMBF 06KY9136  
and the Bonn-Cologne Graduate  
School of Physics and Astronomy



GEFÖRDERT VOM



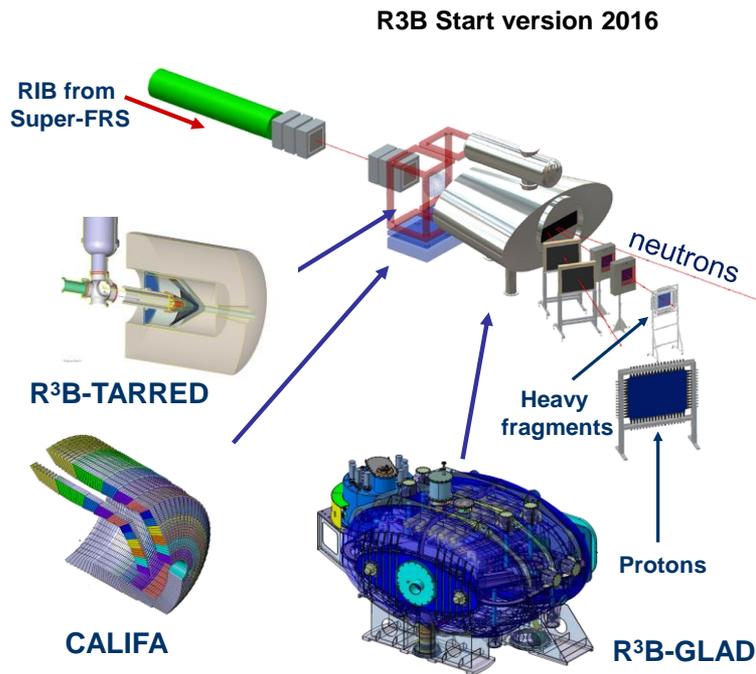
Bundesministerium  
für Bildung  
und Forschung

**NUSTAR Week 2014, València**



# Outline

- Overview of NeuLAND
- Status of construction
  - Double planes
  - HV, controls, DAQ
- Experiments
  - Nov'12: S406 – first test
  - Apr'14: S438 – commissioning (partly)
  - Oct'14: S438 continued
  - 2015: RIKEN
- Summary



NeuLAND TDR:  
submitted Nov'11  
accepted Jan'13

## NeuLAND:

- Detector for high-energy neutrons
  - Up to 1 000 MeV
- Fully active scintillator design
  - as opposed to LAND
- Time of Flight
  - Energy determination possible
- Modular design

# Design Goals of NeuLAND

- Optimised efficiency for high-E neutrons
  - 95% for one-neutron events
  - 60% for multi-neutron events
- Spatial resolution:
  - $\sigma_{x,y,z} \leq 1.5$  cm
- Time resolution:
  - $\sigma_t \leq 150$  ps
- Good excitation-energy resolution
  - *e.g.* 100 keV @ 1 AGeV for  $^{132}\text{Sn}$  in “standard mode”
  - *e.g.* 20 keV @ 1 AGeV around  $S_n$  in “high-resolution mode”

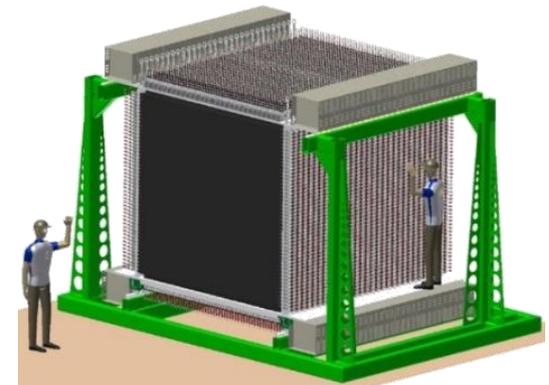
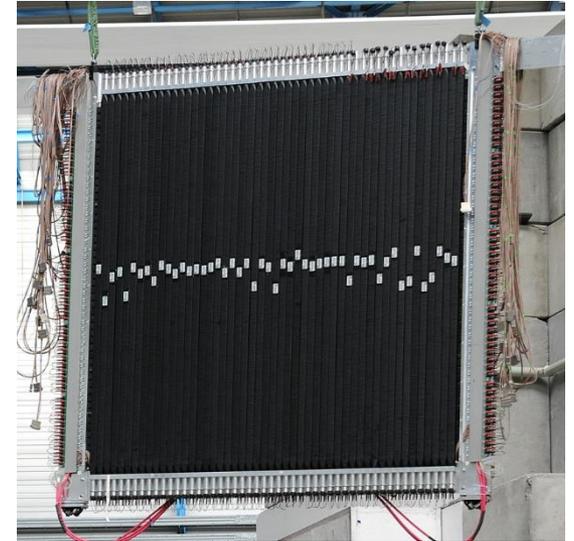
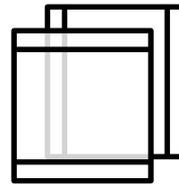
# Efficiency of NeuLAND

- Fully active scintillator for high multi-neutron efficiency
  - Different from LAND: iron + plastic
- Active volume of detector:
  - $2.5 \times 2.5 \times 3 \text{ m}^3$
- In close geometry:
  - 100% acceptance (boosted) for  $E_{n,rel.} < 5 \text{ MeV}$  emitted at 600 AMeV
- Still high efficiency down to low energy
  - 90% for 200MeV neutrons

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

# Actual Design of NeuLAND

- Plastic scintillator bars:
  - $5 \times 5 \times 250 \text{ cm}^3$
  - Series production: Factory Acceptance Test had to be developed
  - Two PMT with independent read-out and HV supply
- Double plane:
  - $10 \times 250 \times 250 \text{ cm}^3$
  - 50 horizontal bars
  - 50 vertical bars
- Detector:
  - 20% demonstrator: 6 d.p.
  - Complete detector: 30 d.p.



# Some numbers – some work

Double Planes	30
Bars	3 000
PMT=HV=Signals	6 000
Cabels	30 000
Screws	$\infty$ (61 920)

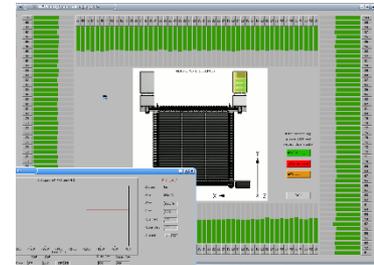
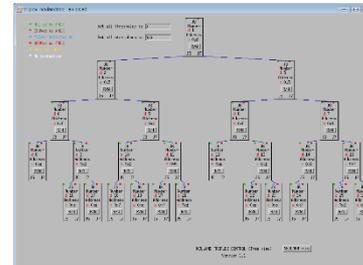


# Status of NeuLAND – double planes

- 4 double planes fully mounted and ready
- 5<sup>th</sup> double plane:
  - Recently completed
  - Just moved to cave C
- 6<sup>th</sup> double plane:
  - Currently under construction

# Status: High-voltage supply, controls

- So far, LAND HV supplies are used (CAEN SY1527)
  - Oct'14: 1 000 channels in use
- NeuLAND HV will come from Petersburg Nuclear Physics Institute
  - Contract on in-kind contribution signed in July 2014
  - Distribution system for HV, adjustable for each PMT
- Controls will be based on existing system EPICS
  - Graphical User Interface almost completed



# Status: Data acquisition

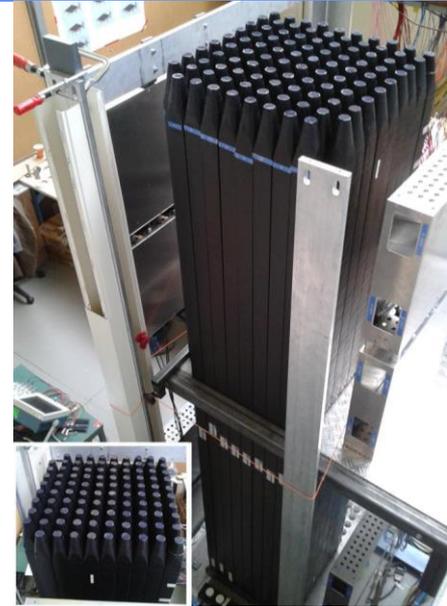
- So far, LAND DAQ is used: TacQuila
  - TAC-based TDC + QDC
- New: TAMEX
  - FPGA-based TDC + QTC
- Oct'14 experiment:
  - 4 planes will be read out by TacQuila
  - 5<sup>th</sup> plane will be read out by TAMEX
- Modified FEE and QTC have been tested in the lab and are connected to 5<sup>th</sup> d.p. right now



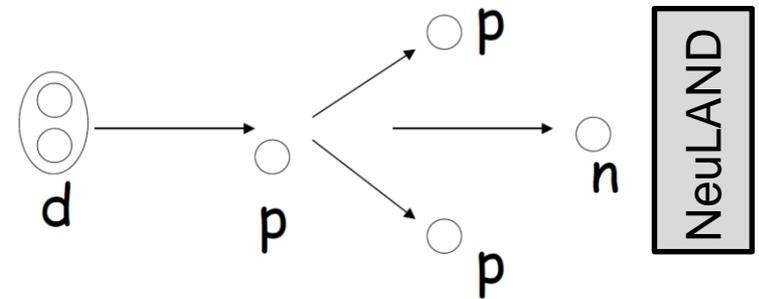
TAMEX module

# Experiment S406 - 2012

- Goal of experiment:
  - Test response of NeuLAND prototypes
- Quasi-free p scattering with d beam at 200-1500 AMeV on CH<sub>2</sub> target



- Neutrons are quasi-monoenergetic

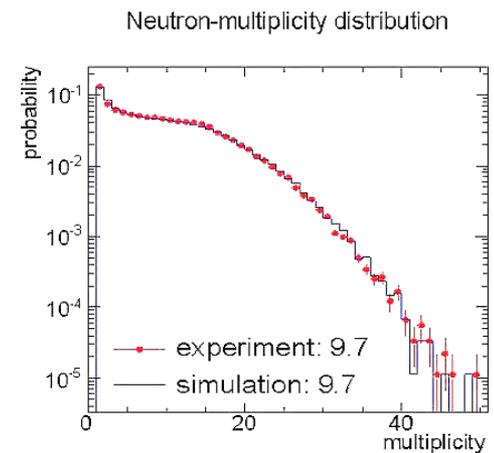
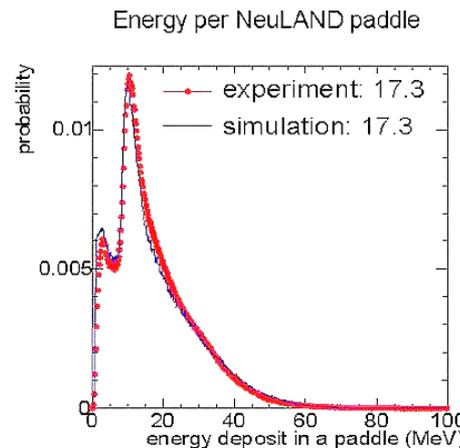
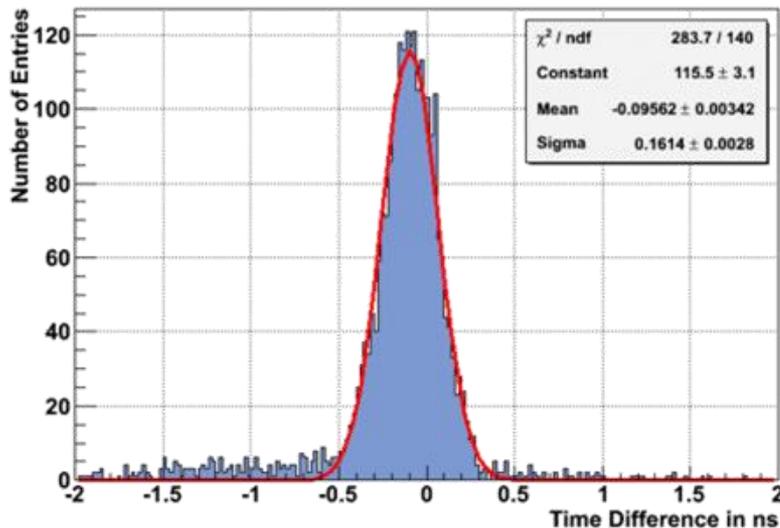


- Carbon target runs for background subtraction

# Experimental results: S406

Time resolution between  
NeuLAND bars for deuterons:  
 $\sigma = 114 \text{ ps} \leq 150 \text{ ps}$

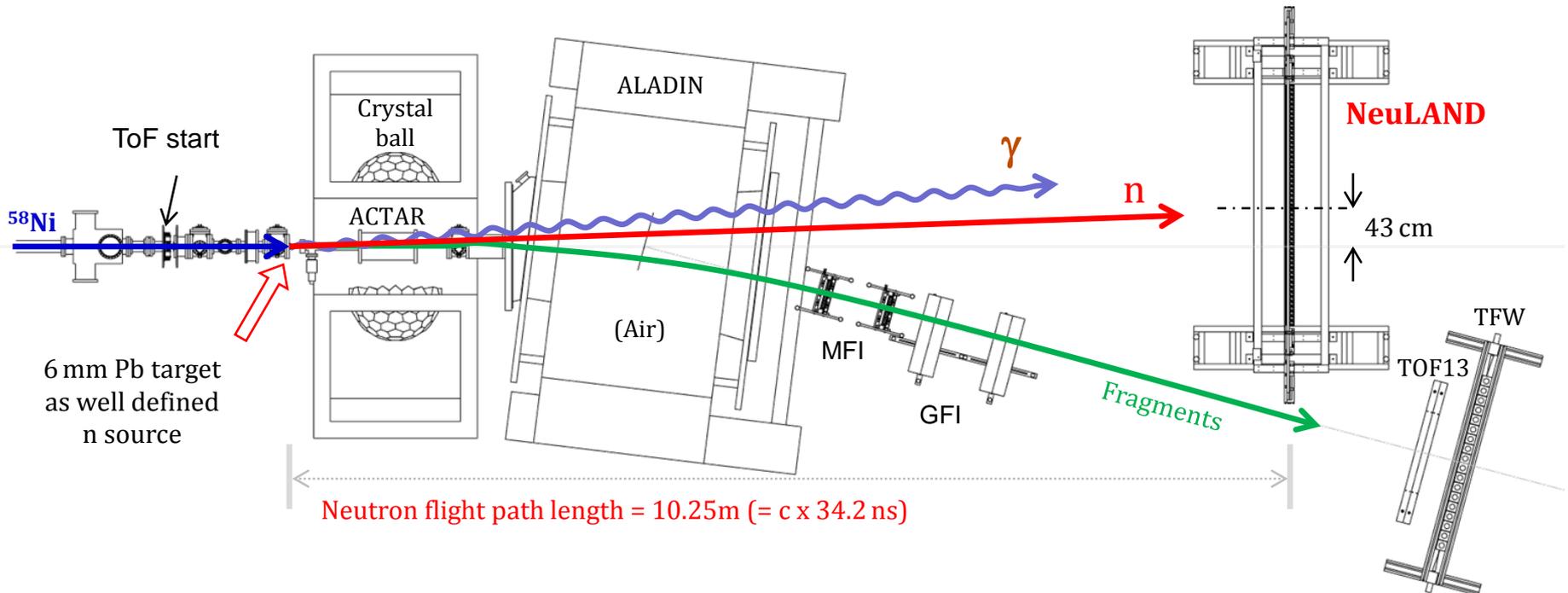
Excellent agreement  
of experiment  
and simulation



- Challenges:
  - Geometrical: asymmetry in SSD hits/beam profile
  - Non-carbon background

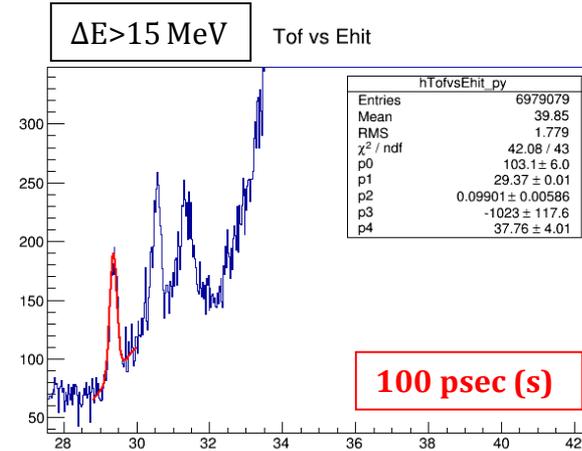
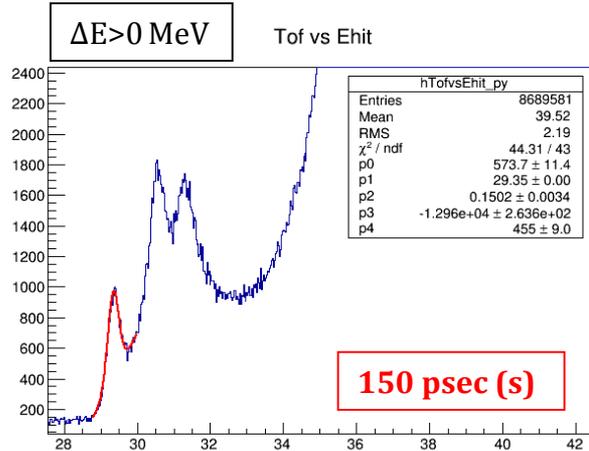
# Experiment S438 – April 2014

- $^{58}\text{Ni}+\text{Pb}$  at 500-800 AMeV
- Commissioning experiment for one double plane
  - Time resolution?
  - Background conditions?



# Results of S438

- Time resolution for  $\gamma$ -rays:



- Time calibration and gain matching successful
- Background was very prominent
  - Quantitatively understood using R<sup>3</sup>BRoot simulations
  - Origin: many detectors tested simultaneously in the beam path and air along the projectile fragment trajectory

# Future experiment: Oct'14

- 5 d.p., 4x TacQuila, 1x Tamex
- Study of 1n and 2n events from  $^{48}\text{Ca}$  on C at 500 AMeV
  - Requires tracking (Z,A)
  - Other R<sup>3</sup>B setups will also be commissioned
  - High rates due to thick carbon target
- Measure neutrons from fission of  $^{236}\text{U}$ 
  - NeuLAND joins SOFIA experiment
  - Chance to observe multi-neutron events ( $\sim 4\text{n}$ )

# NeuLAND shipping to RIKEN

- After October beamtime, four completed planes will be shipped to RIKEN to measure for two years
- Scientific program:
  - Spectroscopy of unbound  $^{27,28}\text{O}$  isotopes
  - Investigation of the  $4n$  system
    - at SAMURAI by measuring  $(p,p\alpha)$  quasi-free scattering
  - Electric dipole response in neutron-rich Ca isotopes

# Summary

- 20% demonstrator almost completed
- Read-out electronics, high-voltage supply, and control software still under development
- First test experiments successful, analysis ongoing
- Additional tests planned
  - 2014: GSI, 2015: RIKEN
- Ongoing production of the full detector