Russian in-kind contribution to FAIR and NuSTAR

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ACCULINNA group
Flerov Laboratory of Nuclear Reactions
Joint Institute for Nuclear Research,
Dubna, Russia

*** NeuLAND & CALIFA status**

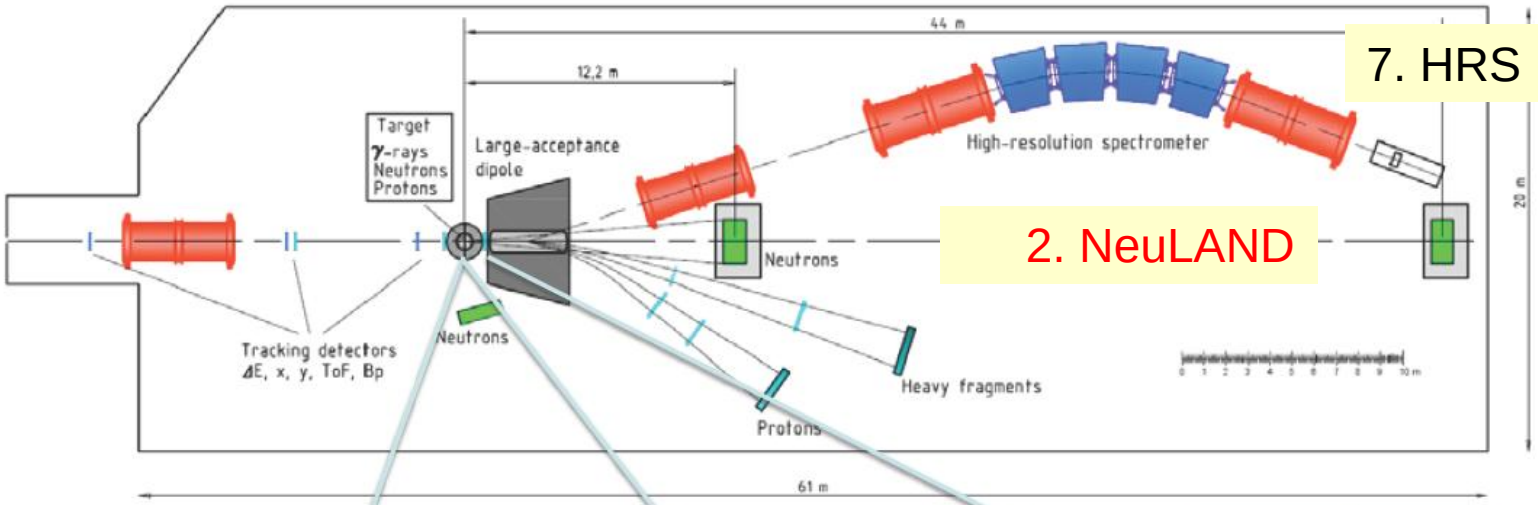
**** Day-1 experiment at SuperFRS**

***** Perspectives with RIBs at FLNR**

NuSTAR week, Helsinki, October 7-11, 2013

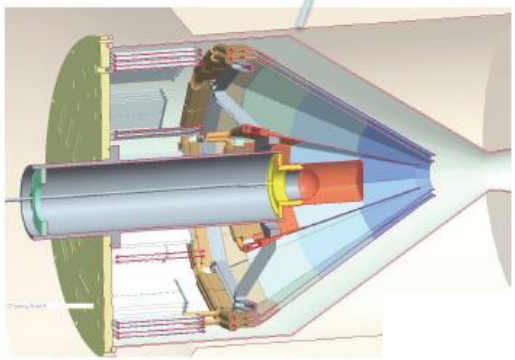
Expected Russian in-kind contribution into NuSTAR@FAIR

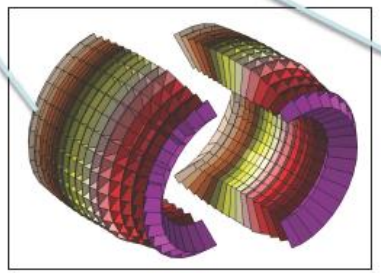
№	Institute, Response person	Experiment, PSP code	Cost book 2005, kEuro
1	PNPI Gatchina, Yuri Novikov novikov@pnpi.spb.ru	MATS 1.2.3.2, 1.2.3.6, 1.2.3.8.3, 1.2.3.9	190 500
2	PNPI Gatchina, Anatoli Krivchitch kriv@pnpi.spb.ru Viktor Golovtsov vicgol@pnpi.spb.ru	R3B, NeuLAND 1.2.5.1.2.5	1 250 000
3	PNPI Gatchina, Georgy Alkhazov alk@pnpi.spb.ru	R3B, ACTAR 1..2.5.2.3	1 105 000
4	PNPI Gatchina, Anatoli Krivchitch kriv@pnpi.spb.ru	R3B, tracking detectors (43%) 1.2.5.1.2.1	160 000
5	JINR Dubna / KI Moscow Andrey Fomichev fomichev@jinr.ru	R3B, CALIFA 1.2.5.1.2.3	960 000
6	PTI St. Petersburg / JINR Vladimir Eremin Vladimir.Eremin@cern.ch	SuperFRS, Si vs. CVD-DD 2.4.6.1.9, 2.4.6.1.10, 2.4.6.1.11	In progress
7	BINP Novosibirsk / JINR Dubna / IHEP Protvino??	R3B, High Resolution Spectrometer	Under discussion

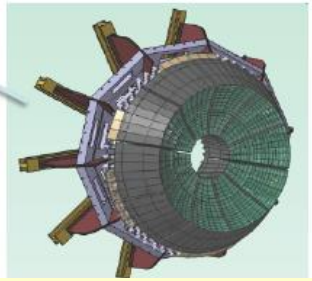


7. HRS

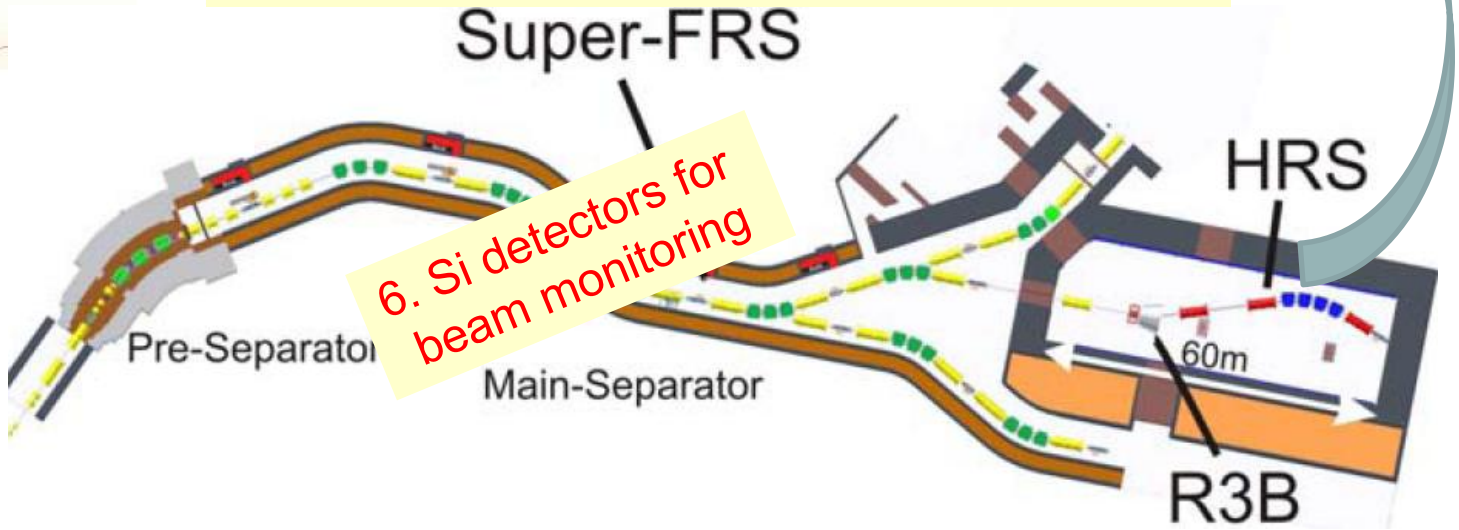
2. NeuLAND







5a) CALIFA barrel 5b) Forward Endcap



6. Si detectors for beam monitoring

NeuLAND: (i) accepted everywhere; (ii) work is going on

Intended contributions to NUSTAR work packages

June 3, 2013

Dear Prof. Rosner,

with this letter we request the official allocation of FAIR shareholder funds for the construction of the following component[1] of the NUSTAR experiment R^3B:

PSP 1.2.5.1.2.5.4 – NeuLAND HV distribution system

which is described in the approved Technical Design Report. In accordance with the cost estimate laid out in the FAIR Cost Book (V6 from October 2010), **the work package has an in-kind-contribution value of 415 kEUR** (in 2005 costs).

The following contribution (100%) to this work package is planned (all cost in EUR from 2005):

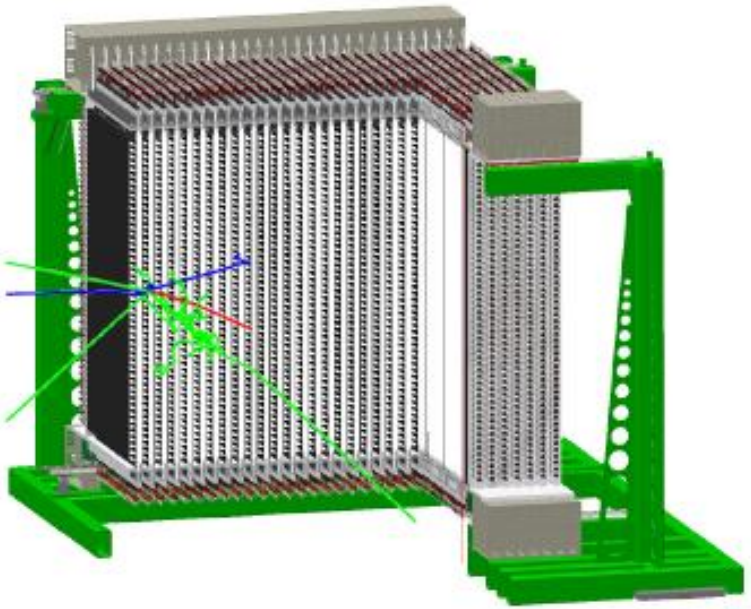
Russia, PNPI Gatchina 415 kEUR
for the High Voltage Distribution System of NeuLAND
50% to be delivered latest in 2015 and 50% latest in 2017

All items defined in the work package have to be in accordance with the technical specifications and quality requirements determined by the NUSTAR Collaboration and FAIR GmbH.

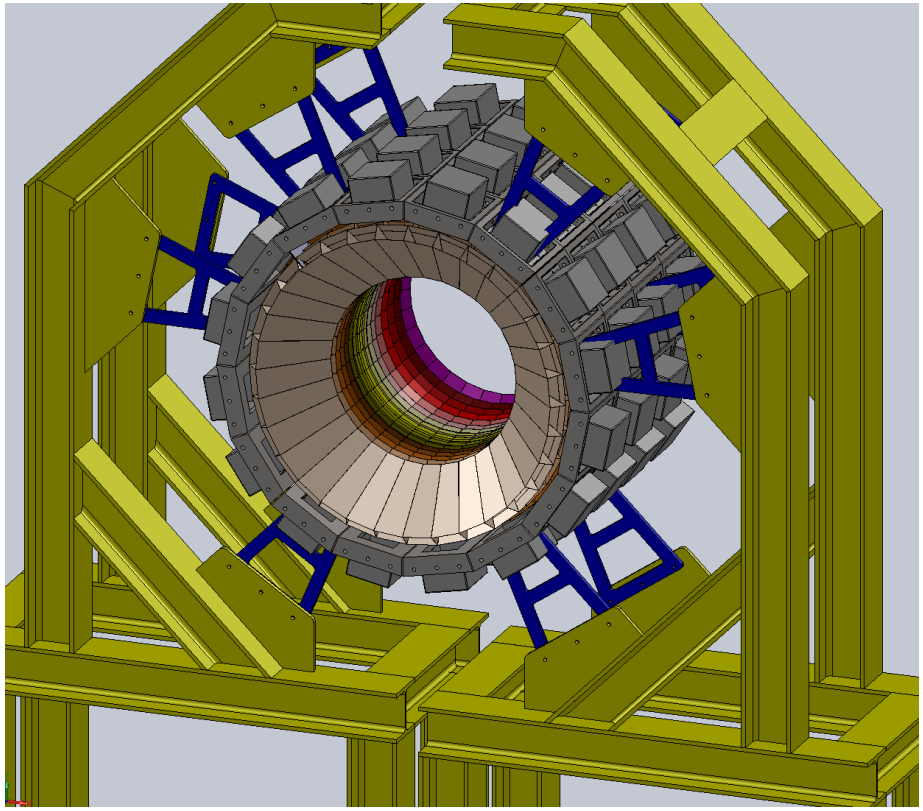
Sincerely Yours,

Alexander Herlert
NUSTAR Resource Coordinator

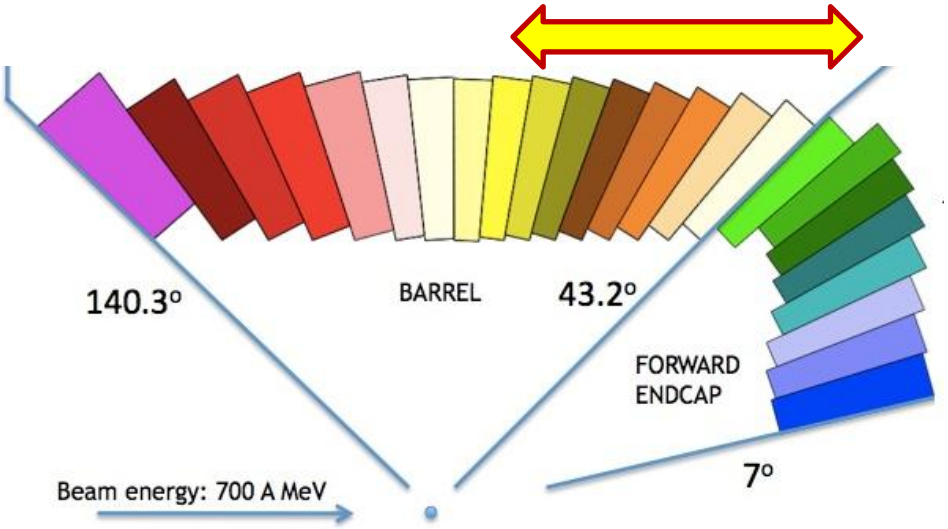
Thomas Nilsson
Spokesperson for the NUSTAR Collaboration



RF contribution into CALIFA dated on 29.05.2013



1.2.5.1.2.3.1 (barrel: 2,070 kEUR)
1.2.5.1.2.3.2 (endcap: 1,130 kEUR)



Amount of **240 kEu (25% of 960 kEu)** should be spent for the CALIFA BARREL demonstrator as a cash contribution needed for **384** crystals (**6 petals, 64 crystals per each**).

Rest of **720 kEu** is considered to be requested later for the **forward endcap** after TDR accepting. The detector elements (including crystals, readout electronics, alveoli etc) will be produced and tested in Russia.

Unfortunately, this idea wasn't supported by Russian STC (let's wait a full package; no examples; possible risks)

PSP 1.2.5.1.2.3.1 – CALIFA barrel

Dear Prof. Rosner,

for the subsystem CALIFA-barrel of the NUSTAR experiment R³B (PSP 1.2.5.1.2.3.1) a staged construction is envisaged, where the respective projects are defined as:

1.2.5.1.2.3.1.1 – CALIFA-barrel stage 1 (9 petals)
1.2.5.1.2.3.1.2 – CALIFA-barrel stage 2 (9 petals)
1.2.5.1.2.3.1.3 – CALIFA-barrel stage 3 (12 petals)

The first stage of CALIFA-barrel (1.2.5.1.2.3.1.1) will provide 9 petals for the calorimeter and will be funded by contributions from (cost in 2005 EUR, German and Spanish funds are secured):

Country	Institute	In-kind value
Germany	TU Darmstadt	131
Germany	TU Munich	205
Spain	CSIC Madrid	165
Spain	Univ. Santiago	165
Sweden	Univ. Lund	399
Total (kEUR in 2005)		**1,065**

The first stage of the CALIFA barrel (also called "CALIFA Demonstrator") will be formed by 576 detector modules and will be used as a spectrometer for both gamma-rays and light charged particles. The following stages will enhance the calorimetric capabilities.

Sincerely Yours,

Alexander Herlert
NUSTAR Resource Coordinator

Thomas Nilsson
Spokesperson for the NUSTAR Collaboration

June 3, 2013

Managing Directors:
Professor Dr. Boris Y. Sharkov
Professor Dr. Günther Rosner

Registered office: Darmstadt
Amtsgericht Darmstadt HRB 89372
VAT No.: DE275595927

Commerzbank Darmstadt
BLZ 508 400 05 - Konto 13 26 30500
IBAN DE03 5084 0005 0132 6305 00
BIC COBADEFF508

As a results we are an audience…

Fortunately, not so long time.

PSP 1.2.5.1.2.3.1 – CALIFA barrel

May 28, 2013

Dear Prof. Rosner,

for the subsystem CALIFA-barrel of the NUSTAR experiment R³B (PSP 1.2.5.1.2.3.1) a staged construction is envisaged, where the respective projects are defined as:

1.2.5.1.2.3.1.1 – CALIFA-barrel stage 1 (12 petals)
1.2.5.1.2.3.1.2 – CALIFA-barrel stage 2 (9 petals)
1.2.5.1.2.3.1.3 – CALIFA-barrel stage 3 (9 petals)

The first stage of CALIFA-barrel (1.2.5.1.2.3.1.1) will provide 12 petals for the calorimeter and will be funded by contributions from (cost in 2005 EUR, German and Spanish funds are secured):

Country	Institute	In-kind value
Germany	TU Darmstadt	131
Germany	TU Munich	205
~~Russia~~	~~JINR Dubna~~	~~240~~
Spain	CSIC Madrid	165
Spain	Univ. Santiago	165
Sweden	Univ. Lund	399
Total (kEUR in 2005)		**1,305**

The first stage of CALIFA-barrel will be formed by 768 detector modules. Whereas the calorimetric properties will be limited, CALIFA-barrel stage 1 (also named CALIFA Demonstrator) will be a suitable spectrometer for both gamma-rays and light charged particles.

Managing Directors:
Professor Dr. Boris Y
Professor Dr. Günthe

Registered office: Da
Amtsgericht Darmsta
VAT No.: DE2755959

Commerzbank Darms
BLZ 508 400 05 - Kor
IBAN DE03 5084 000
BIC COBADEFF508

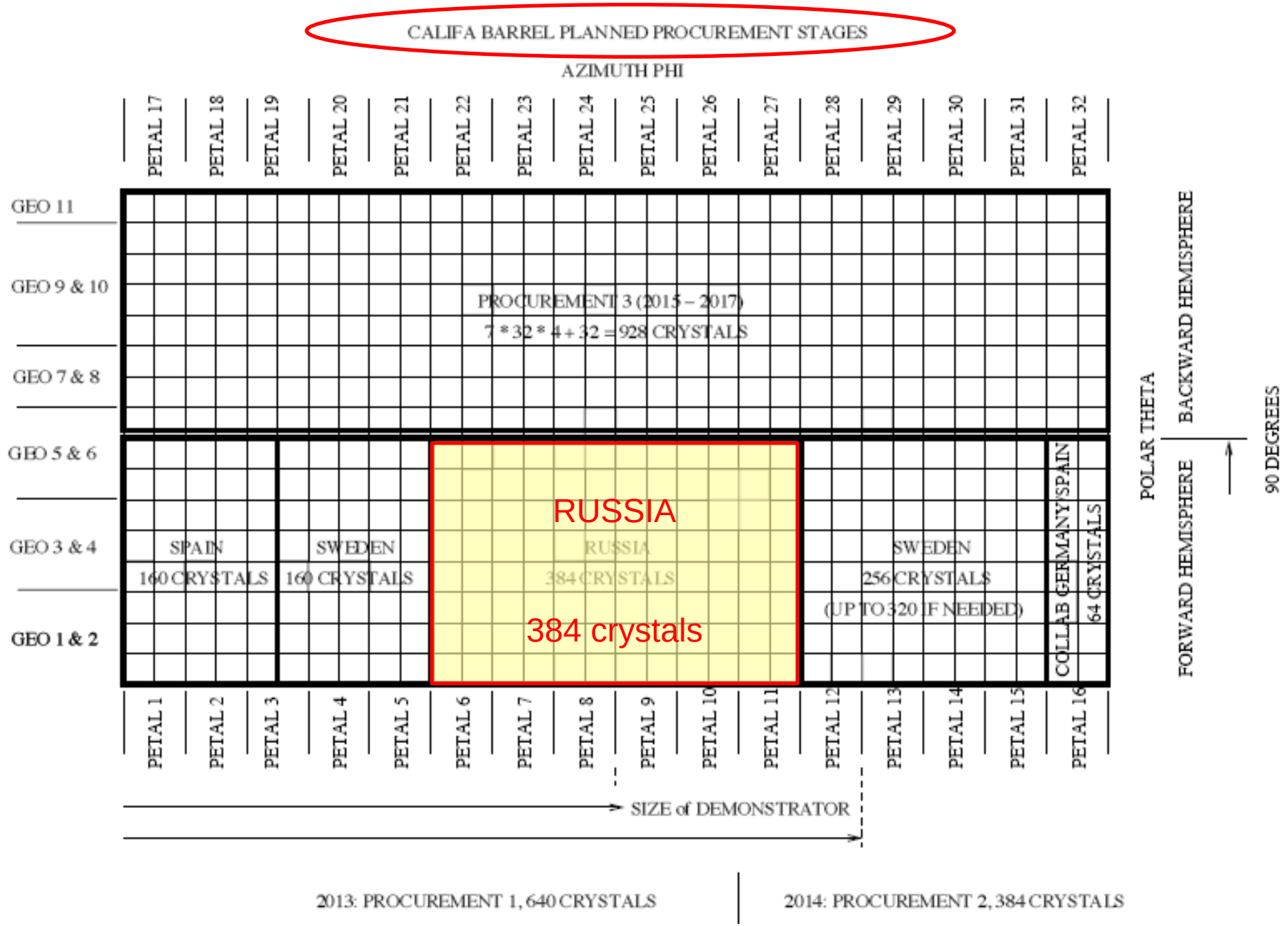
Triangle agreement between FAIR-JINR-Amcrys (Sept. 2013)

- **Amcrys company will able to produce 384 CsI(Tl) crystals (6 petals) as an Ukraine's in-kind contribution to JINR for the year 2013 on amount ~240 kEu (253 kEu).**
- **JINR will ask ROSATOM about compensation this value due to Russian resource to FAIR.**
- **FAIR administration promised to help with paper work.**

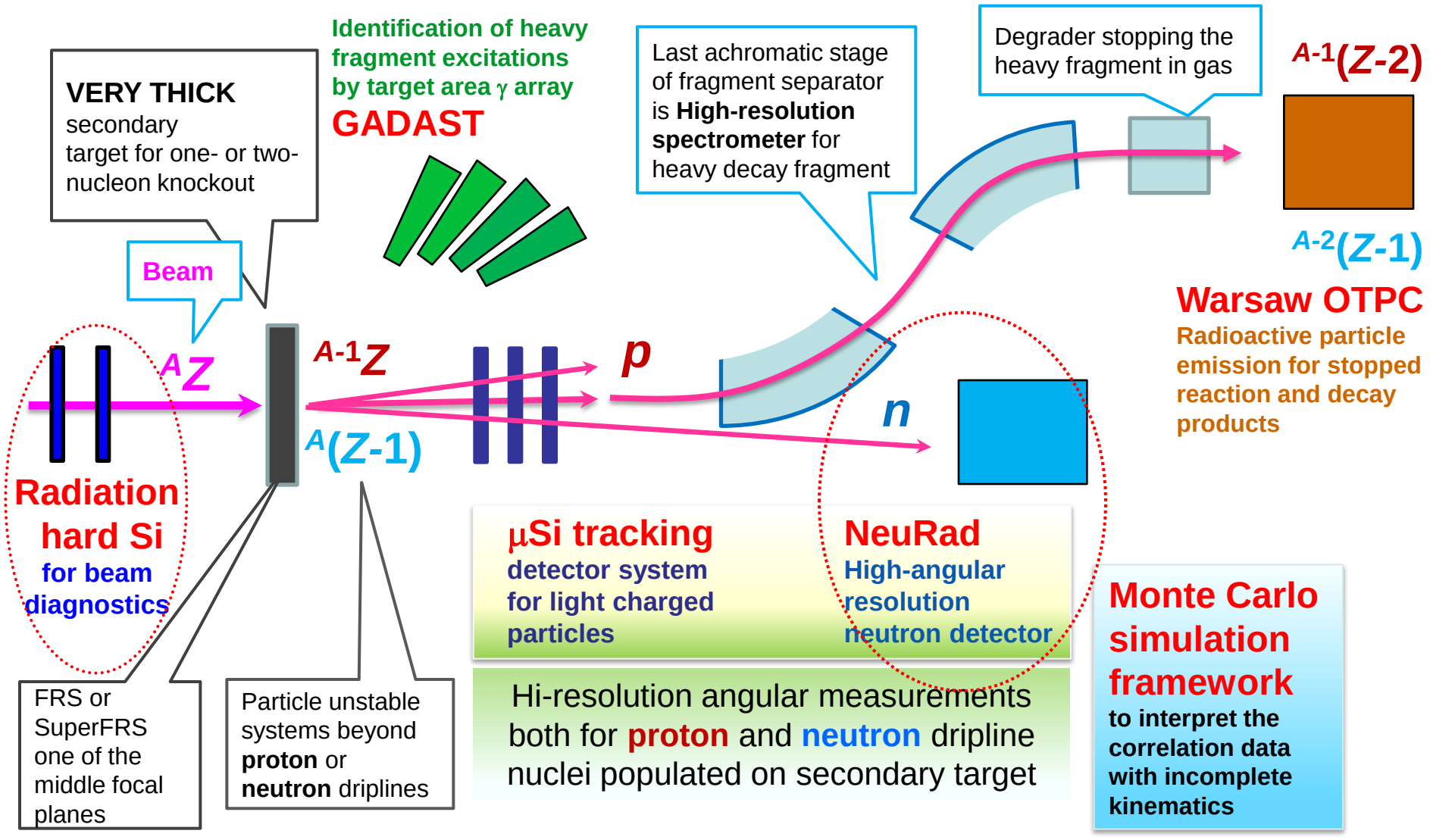
Advantages:

(i) no tender;

(ii) no customs, no additional VAT in RF: direct delivering from Kharkov to Lund (for coupling with a sensor, housing and tests);


CALIFA BARREL PLANNED PROCUREMENT STAGES
AZIMUTH PHI
PETAL 17
PETAL 18
PETAL 19
PETAL 20
PETAL 21
PETAL 22
PETAL 23
PETAL 24
PETAL 25
PETAL 26
PETAL 27
PETAL 28
PETAL 29
PETAL 30
PETAL 31
PETAL 32
GEO 11
GEO 9 & 10
GEO 7 & 8
GEO 5 & 6
GEO 3 & 4
GEO 1 & 2
PROCUREMENT 3 (2015 – 2017)
7 * 32 * 4 + 32 = 928 CRYSTALS
SPAIN
160 CRYSTALS
SWEDEN
160 CRYSTALS
RUSSIA
RUSSIA
384 CRYSTALS
384 crystals
SWEDEN
256 CRYSTALS
(UP TO 320 IF NEEDED)
COLLAB GERMANY/SPAIN
64 CRYSTALS
POLAR THETA
BACKWARD HEMISPHERE
FORWARD HEMISPHERE
90 DEGREES
PETAL 1
PETAL 2
PETAL 3
PETAL 4
PETAL 5
PETAL 6
PETAL 7
PETAL 8
PETAL 9
PETAL 10
PETAL 11
PETAL 12
PETAL 13
PETAL 14
PETAL 15
PETAL 16
SIZE of DEMONSTRATOR
2013: PROCUREMENT 1, 640 CRYSTALS
2014: PROCUREMENT 2, 384 CRYSTALS

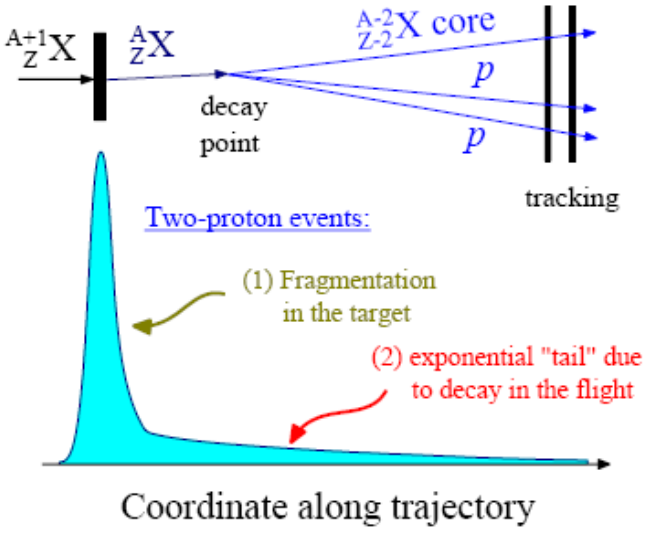
GAWP initiative for first day experiments at SuperFRS:
GSI–Acculinna(Dubna)–Warsaw–PTI(St.Petersburg) consortium

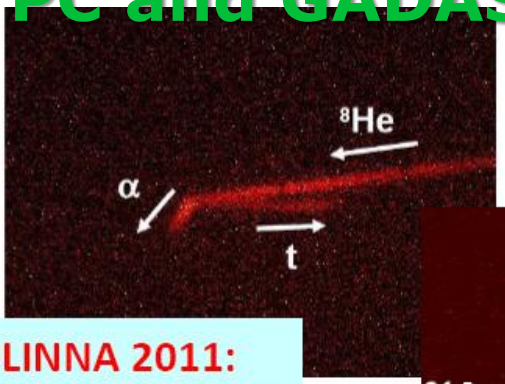


Prototype OK; R&D foreseen	Fully completed; 2014 – tests	8 units; electronics upgrade	main components OK; serious R&D	OK; Grigorenko & K	OK

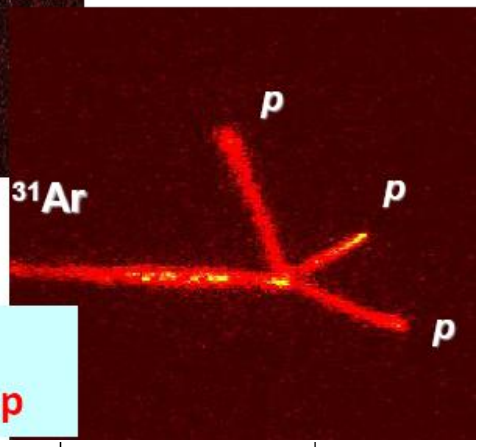
Examples of μ-DSSD, OTPC and GADAST use

GSI 2006, 2012: S271, S388

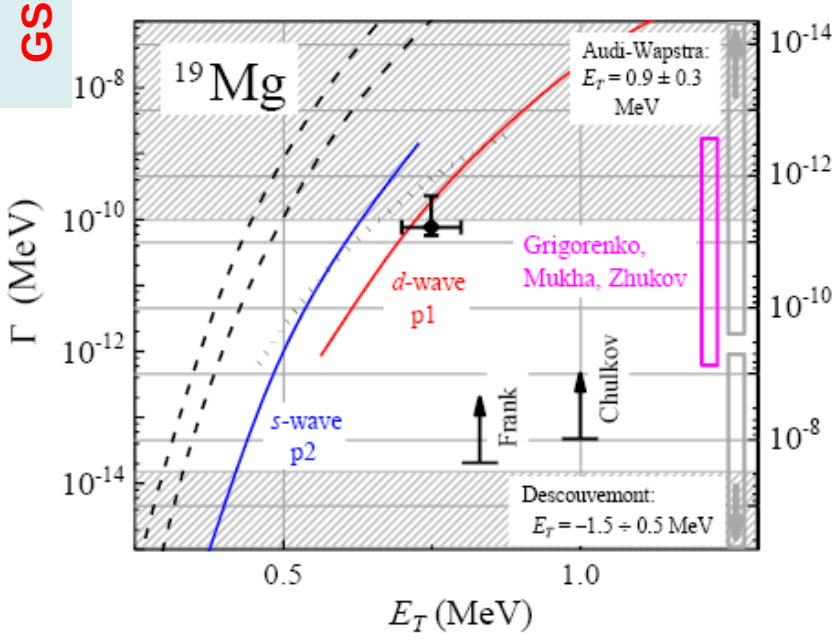




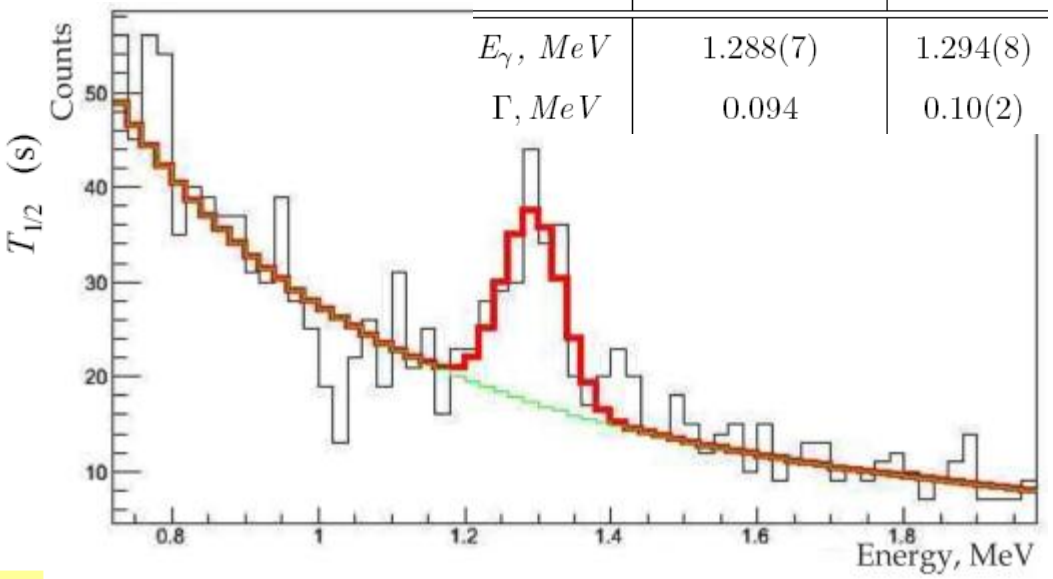
ACCULINNA 2011:
^{8}He, β-delayed α-t-n



GSI 2012: S388,
^{31}Ar, β-delayed 3p



Quantity	Reference data	Our data
E_γ, MeV	1.288(7)	1.294(8)
Γ, MeV	0.094	0.10(2)

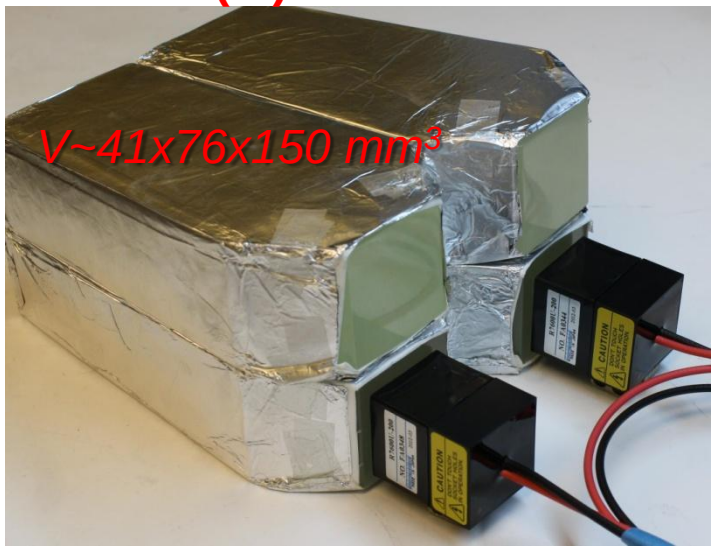


Lifetime, decay energy, projected correlations, excitation spectra are obtained all in one run!

The Doppler-corrected gamma-ray spectrum of the ^{17}Ne isotope obtained with 16 GADAST units (S388).

GADAST status

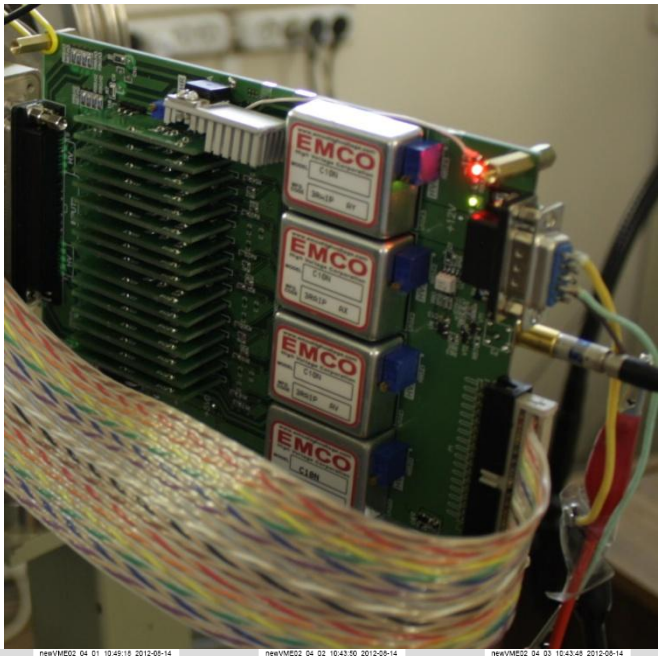
CsI(Tl) / R7600U-200

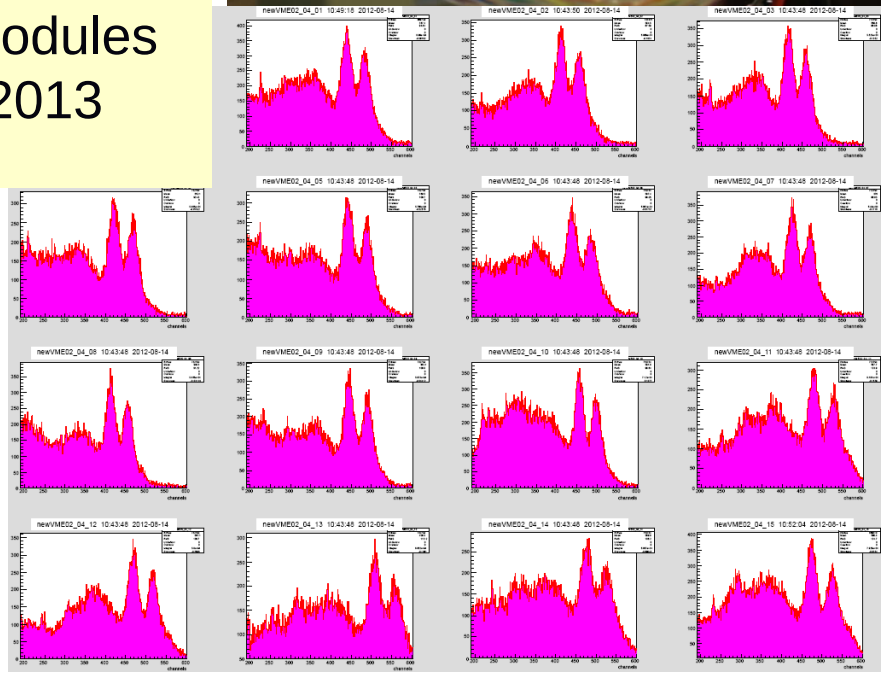


1x4 cluster
covered by thermo
plastic 300 mkm;
4 clusters → 16 ch.

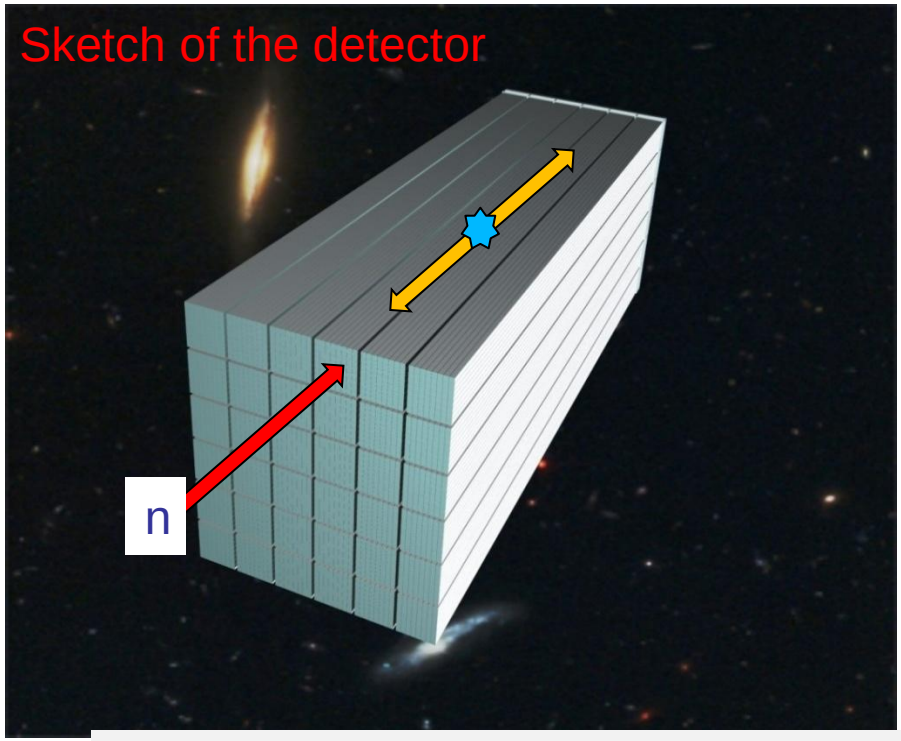
ΔE/E ~ 7% (^{60}Co),
E_{th} ~ 70 keV,
+12V → HV, delay,
shaping, trigger;

3x16=48 modules
in the end 2013





Neutron detector with a high spatial resolution **NeuRad**



Basic components:

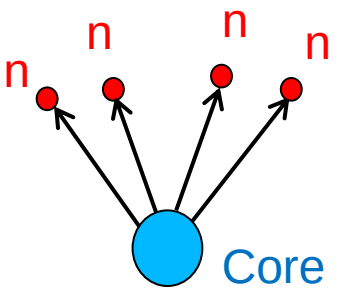
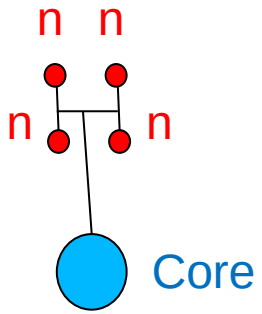
- array of ~14 000 scintillation fibers, each is a squared 2x2 mm^2 , 1m-long rod and coupled with 8x8 multianode PMT H8500;
- ~8000 channels to read-out both sides of fibers;
- 5 GHz pipe-line digitizers.

Transverse resolution of **0.2 cm**
Timing of **200 ps,** $E_{threshold}$ **< 0.5 MeV**
Z coordinate is defined by time difference of opposite-side readouts

Main **NeuRad** components (scintillating fibers+PMT+electronics) are in house.
The prototype (3%) is under construction at JINR. Supported by a BMBF grant.
Test of the prototype at Acc/Acc-2 with $^{5}H \rightarrow ^{3}H+n+n$ decays in 2014 and
$^{7}H \rightarrow ^{3}H+n+n+n+n$ in 2015-2018.
To be assembled and ready for FRS tests in 2015 (e.g., $^{10}Li \rightarrow ^{9}Li+n$).

Roadmap

Comparison of the fragment-correlation (NeuRAD) and invariant-mass (NeuLAND) methods

Experimental method	Correlations of fragments	Invariant-mass
Correlations to be studied:		
Observables to measure:	Angular correlations between **one neutron** and **a heavy fragment.** ***No cross-talk !***	Complete correlations between **four neutrons** and **a heavy fragment.** ***Large cross-talk for 4n***
Physics case:	Neutron radioactivity	Multi-neutron clusters
Typical Detector:	Dimensions ~0.4*0.4*1.0 m^3 δ (X,Y) ~**0.2 cm** Int. per one 4n-decay ~**1.2**	Volume ~2.0*2.0*2.0 m^3 δ (X,Y) ~**1.5 cm** Eff. (4n event) ~**0.5** *due to cross-talk at low energy*
Range of energy:	0.1-200 keV	0.1-20 MeV

Both methods are complementary

Map of day-1 experiments for SuperFRS:

2p/4p, 2n/4n radioactivity, excitations of very HI ($^{90\text{-}214}$Pb etc)

☻ **Compact, portable setups, only fragment separator is required**

☺ **Can be fully "tested" at ACCULINNA and FRS and ready to use from the first day of SuperFRS**

☻ **Small beam time request (*very thick target*). Effective for broad dripline "scans"**

☺ **Works well on the poor "cocktail" beams (precise identification of the heavy fragment)**

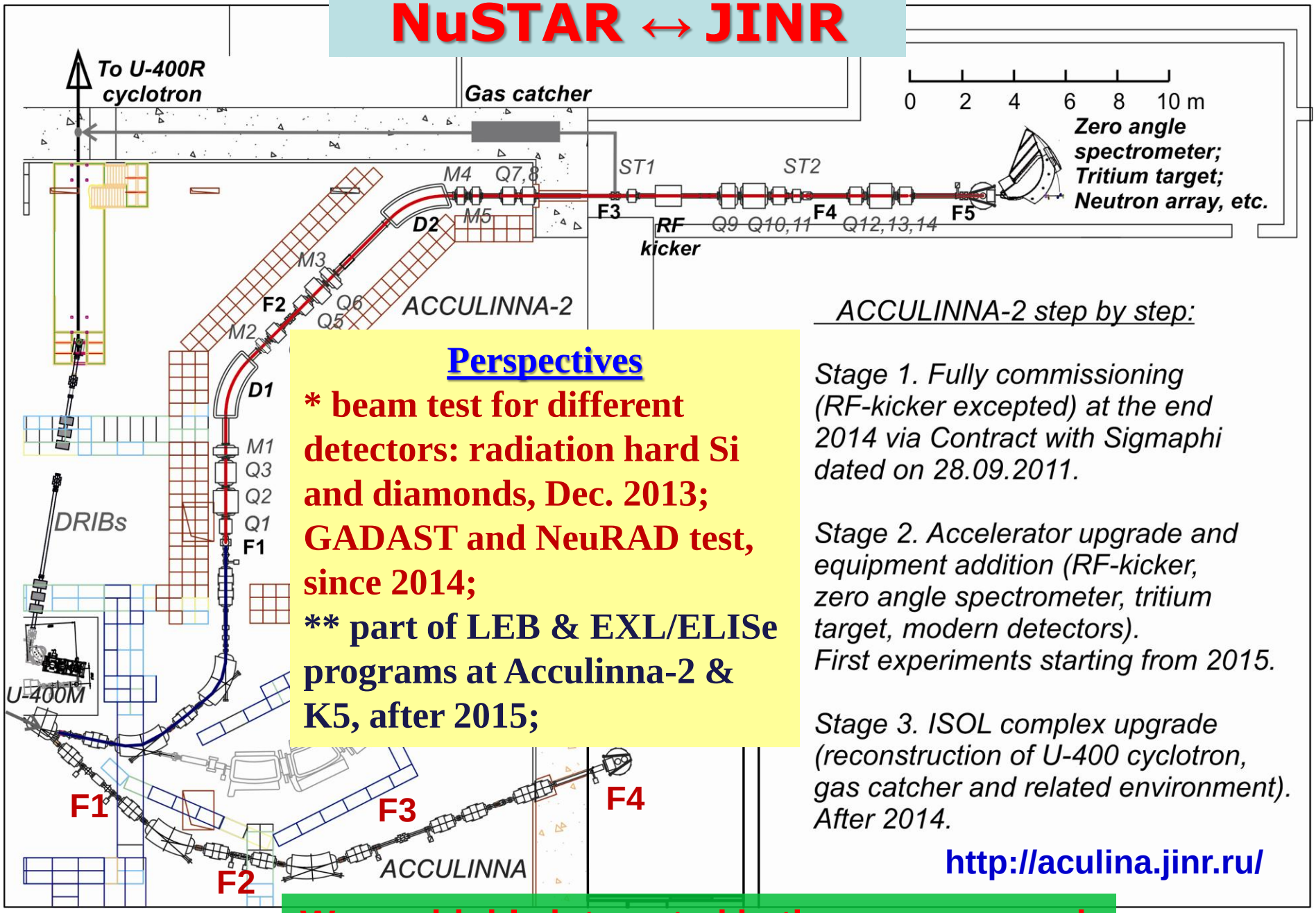
☻ **Several experimental purposes can be attained simultaneously (low risk experiments)**

☺ **Exploratory studies (estimates the experimental conditions for more detailed experiments, say at R3B)**

☻ **Unique for certain types of radioactive decay studies. Unique information can be obtained in certain cases of excited state decays**

Pro: Unique for radioactive decays, robust for exploratory studies of the *n*-, *p*- driplines

NuSTAR ↔ JINR



Perspectives

*** beam test for different detectors: radiation hard Si and diamonds, Dec. 2013; GADAST and NeuRAD test, since 2014;**

**** part of LEB & EXL/ELISe programs at Acculinna-2 & K5, after 2015;**

ACCULINNA-2 step by step:

Stage 1. Fully commissioning (RF-kicker excepted) at the end 2014 via Contract with Sigmaphi dated on 28.09.2011.

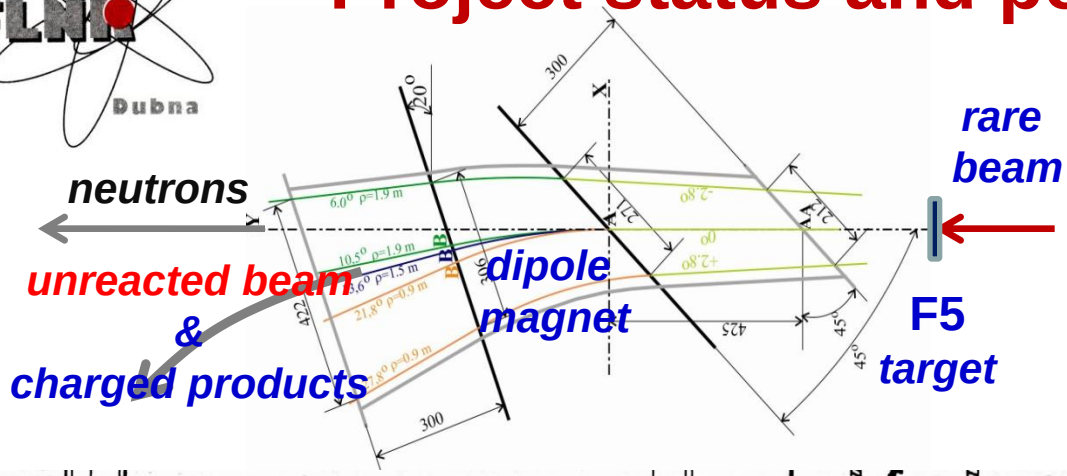
Stage 2. Accelerator upgrade and equipment addition (RF-kicker, zero angle spectrometer, tritium target, modern detectors). First experiments starting from 2015.

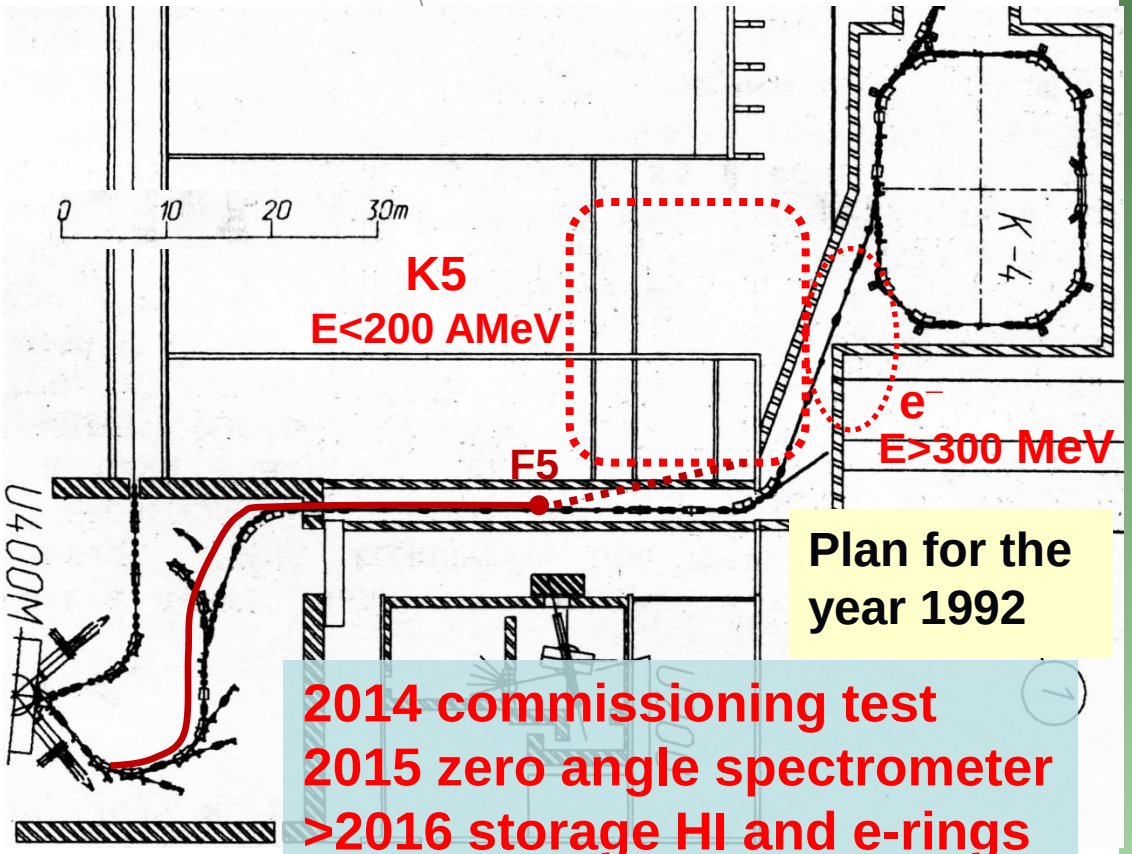
Stage 3. ISOL complex upgrade (reconstruction of U-400 cyclotron, gas catcher and related environment). After 2014.

http://aculina.jinr.ru/

We are highly interested in the common work

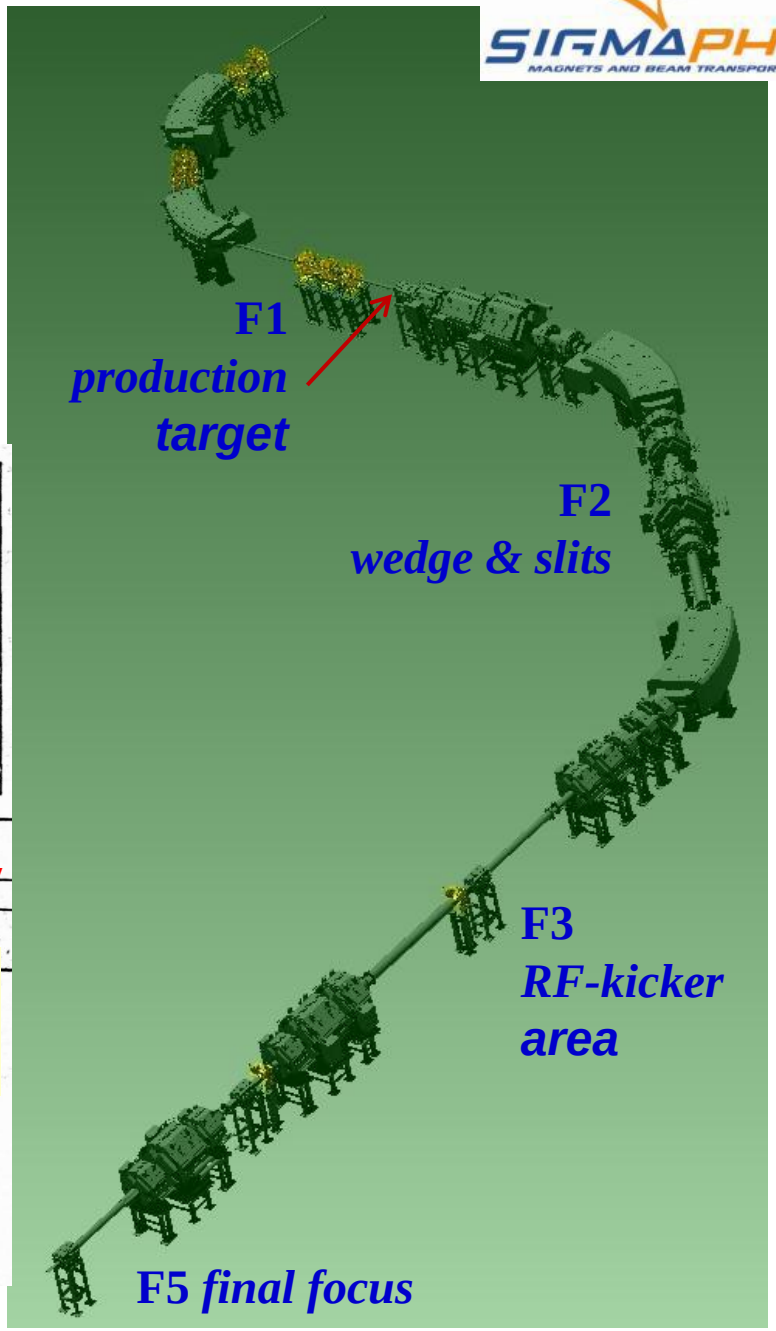
Project status and perspectives





Plan for the year 1992

2014 commissioning test
2015 zero angle spectrometer
>2016 storage HI and e-rings



* Summary and outlook *

No barriers for NeuLAND components to be manufactured in time.
The crystals for the CALIFA barrel will be produced in the frame of triangle agreement. R&D work for the CALIFA forward endcap is foreseen.
Beam tests of Si, diamond and other detectors are in the plan for Acculinna.

The scientific program for the day one experiments at SuperFRS can be extended via GAWP initiative. It was recently supported by a Rosatom-Helmholtz grant for young scientists.

A new more powerful facility ACCULINNA-2 intended for the radioactive ion beams production is going on and will be put into operation in 2015.
A conceptual design report for A-e collisions is under preparation to be realized in 2017-2023, consultations with experts for technical realization of nontrivial issues are obviously needed.

The scientific program with RIB at Acc-2 which implies an extensive use of advantages of low energy RIB's (E~10-50A MeV), cryogenic gaseous targets (including tritium) and modern technique for the study of light exotic nuclei with Z<20 could include a part of LEB@FAIR and EXL/ELISe in the future too.
Welcome with proposals!