СТАТУС ПРОЕКТА NUSTAR

ЭКСПЕРИМЕНТЫ НА РЕЛЯТИВИСТКИХ

РАДИОАКТИВНЫХ ПУЧКАХ

УСКОРИТЕЛЬНОГО КОМПЛЕКСА

FAIR (GSI, DARMSTADT, GERMANY)

R3B

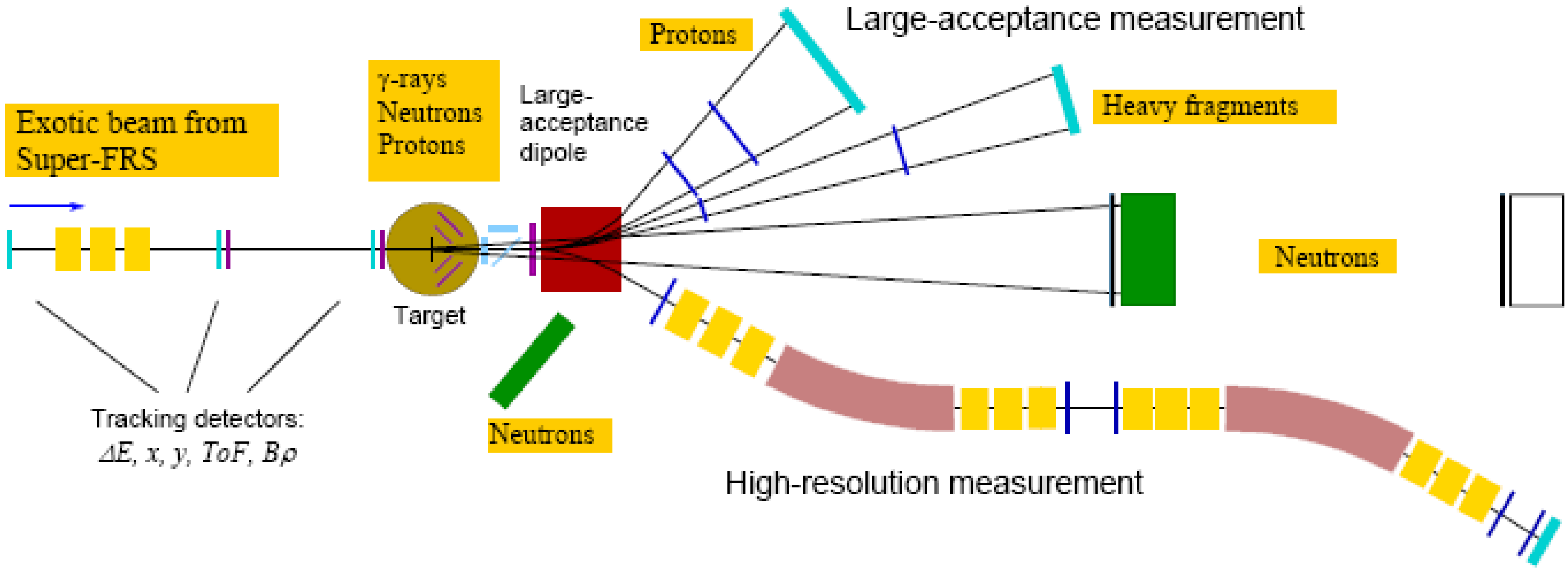
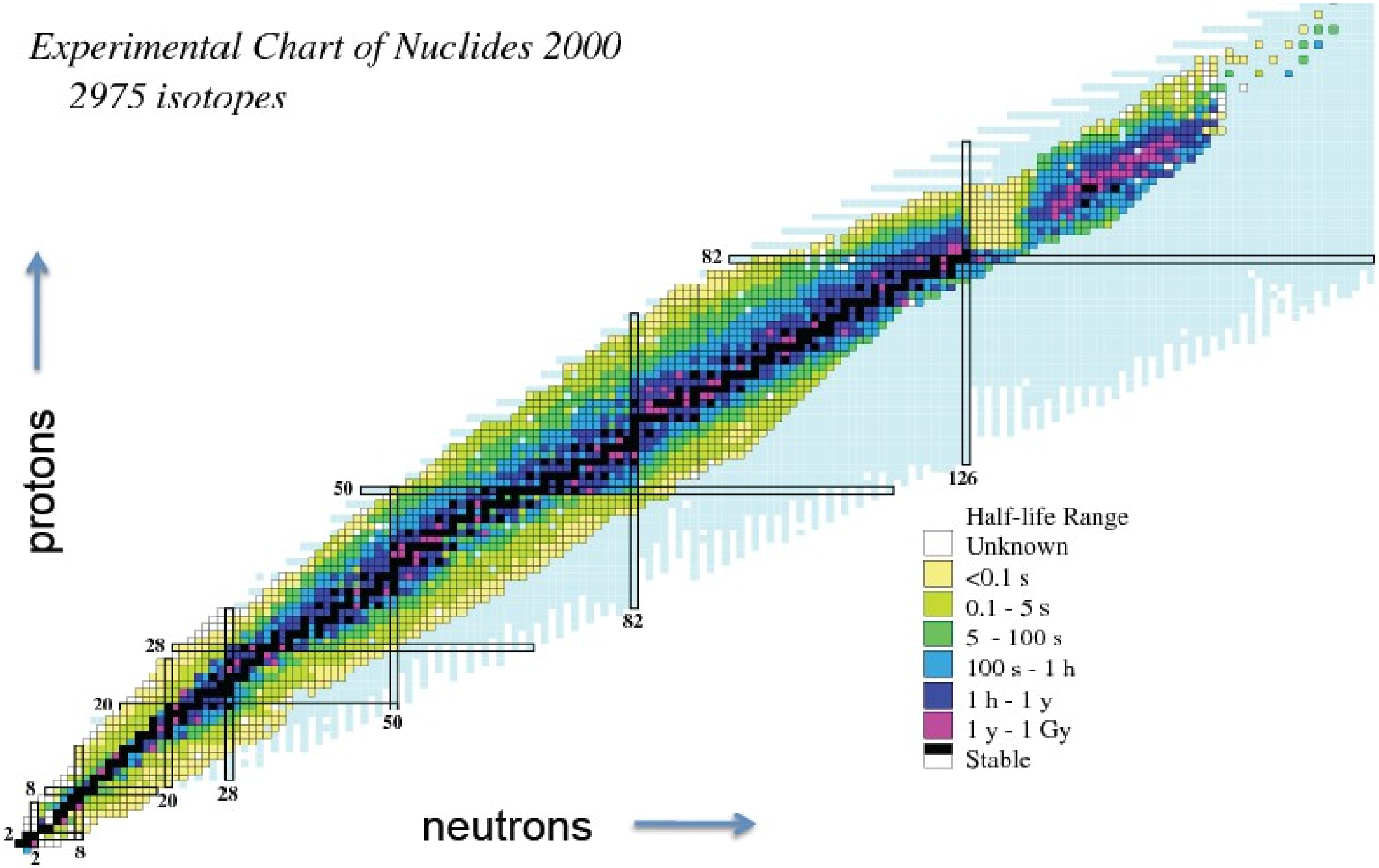


Figure 1: Schematic drawing of the experimental setup comprising γ-ray and target recoil detection, a large-acceptance dipole magnet, a high-resolution magnetic spectrometer, neutron and light-charged particle detectors, and a variety of heavy-ion detectors.

Russian participation:

Neutron detector, gamma spectrometer, active target.

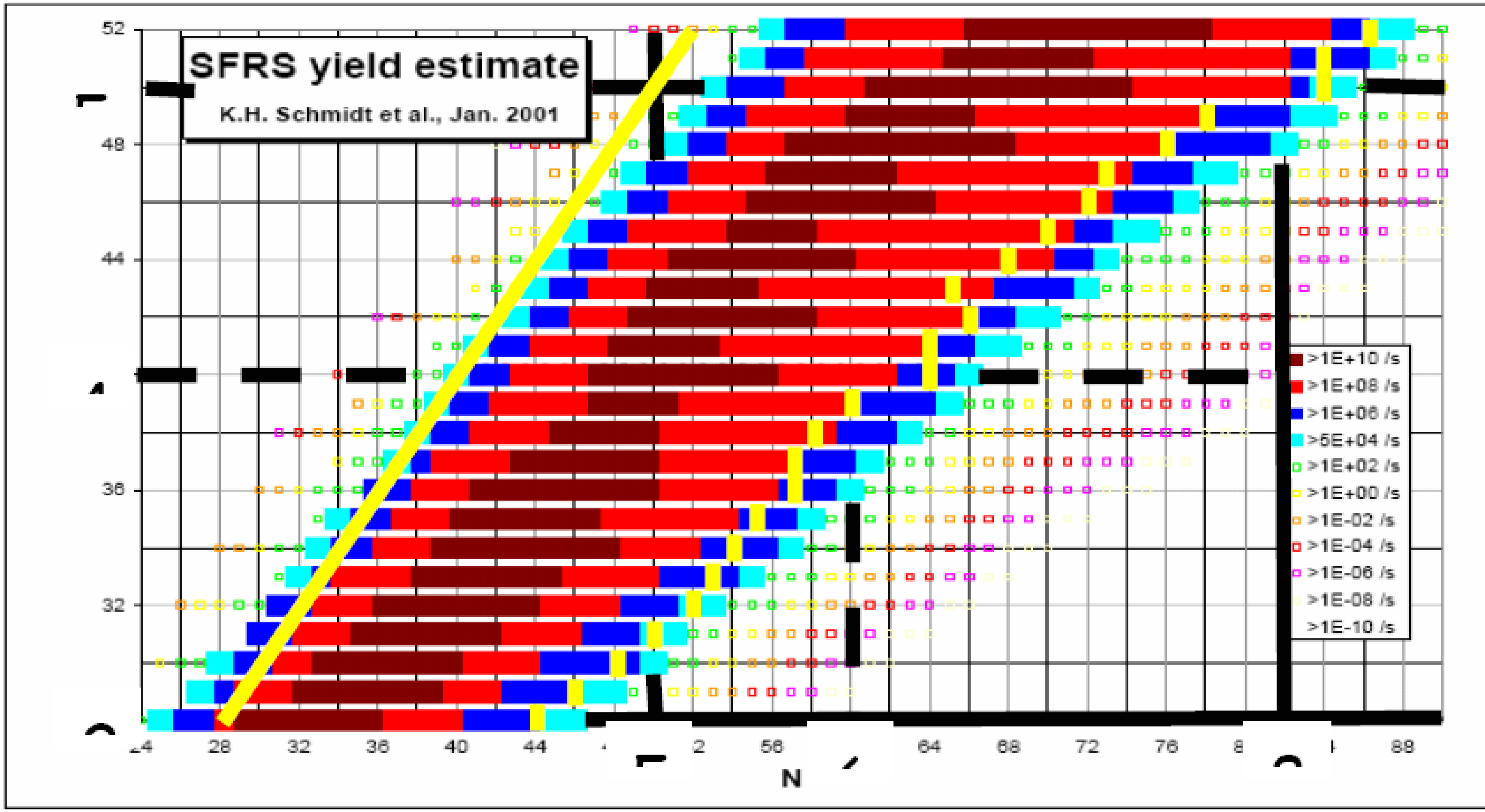
РНЦ КИ, ОИЯИ, ПИЯФ, РФЯЦ-ВНИИЭФ



GSI FAIR

FAIR

RIB production Rates at FAIR



FAIR, NUSTAR, R3B + EXL

R3B – studies at external beams of nuclei
EXL – studies at internal beams of nuclei at the NESR ring

Physics goals:
Nuclear density distributions, single-particle structure, shell-occupation probabilities, unbound states, nuclear resonances, transition strengths, astrophysical S factor, giant dipole and quadrupole strength, B(E2), deformations, Gamov-Teller strength, reaction mechanism, nuclear waste transmutation,…

Reaction type:
Elastic and inelastic pA scattering, total reaction and interaction cross sections, knockout and quasifree scattering, electromagnetic
excitation and dissociation, charge-exchange reactions, fission, spallation, fragmentation

Experiments with PNPI active targets

1.Diffraction scattering of high energy hadrons:

PNPI(Gatchina,1971-1974), IHEP(Serpuhov,1974-1977), CERN(1976-1980) and SACLEY(1980-1983).

2.Muon catalyzed pd, dd, dt, dHe3 fusion:

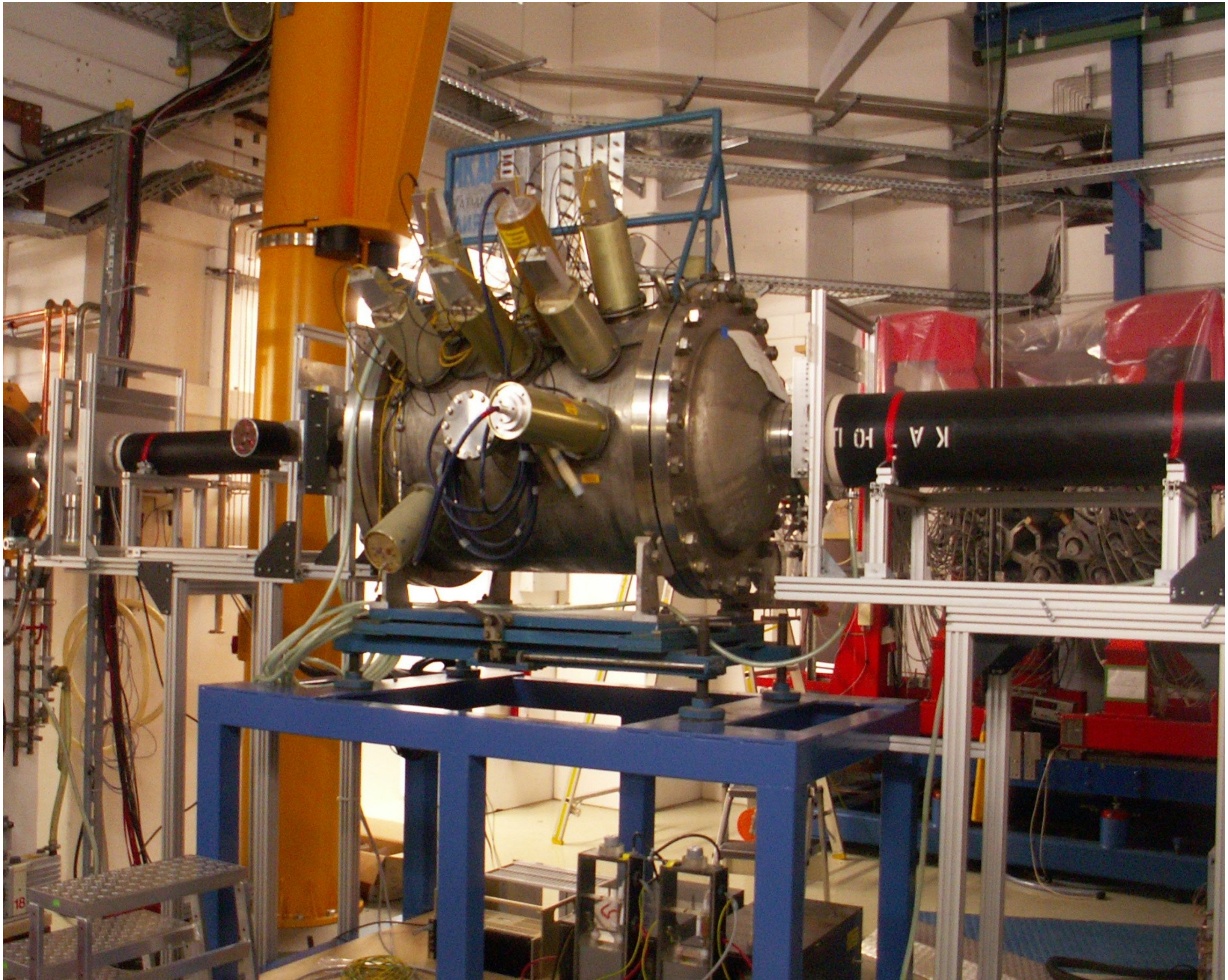
PNPI (1979-1989) and PSI (1989-1997).

3.Muon capture experiments at PSI:

Muon capture by He-3(1993), Muon capture by proton (1997-2007) and Muon capture by deuteron from 2008.

4.Proton diffraction scattering on nuclei (in inverse kine-matics) and nuclei matter distributions (GSI,from1993).

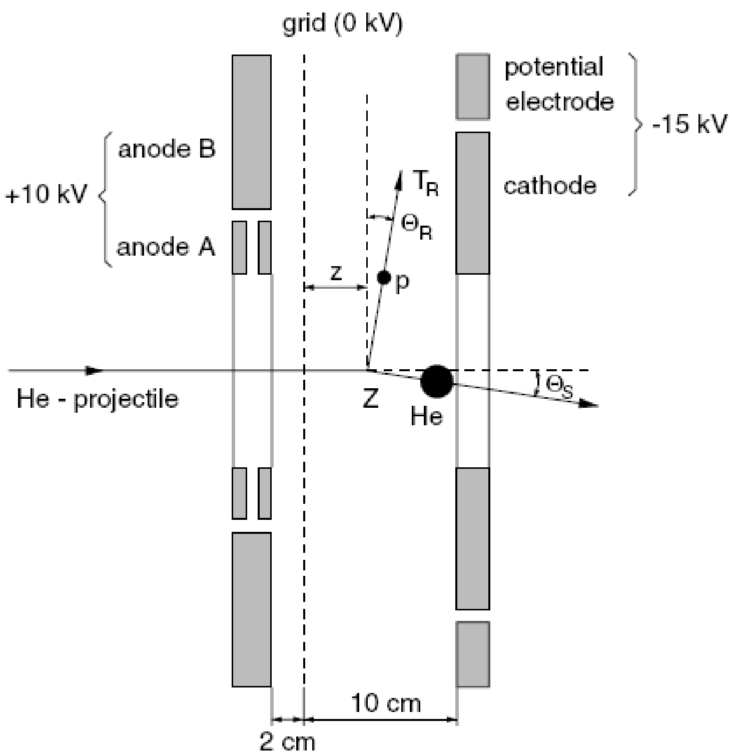
5. Nucleon polarizabilities (IKP-TUD,from 1999).

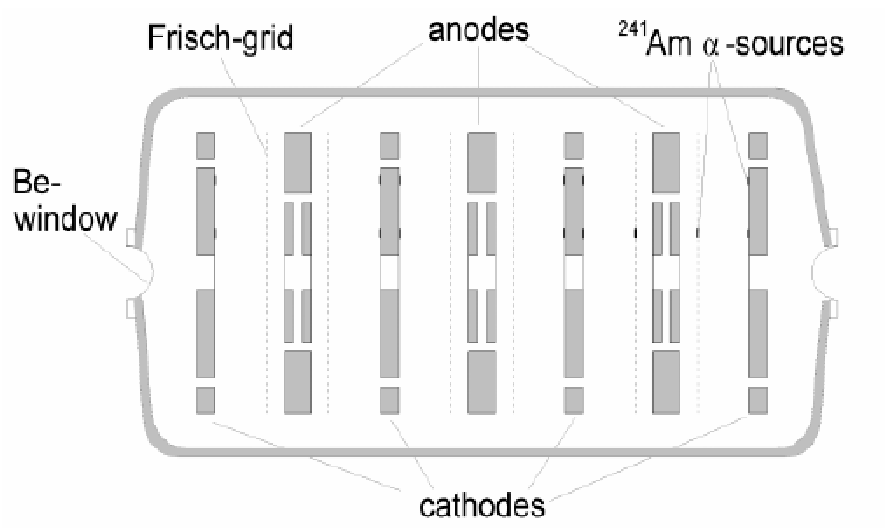


IKAR has been already used to study pHe, pLi, pBe, pB and pC elastic scattering

new IKAR can be used at FAIR for studies of small angular p-A and He-A elastic and inelastic scattering for heavier A

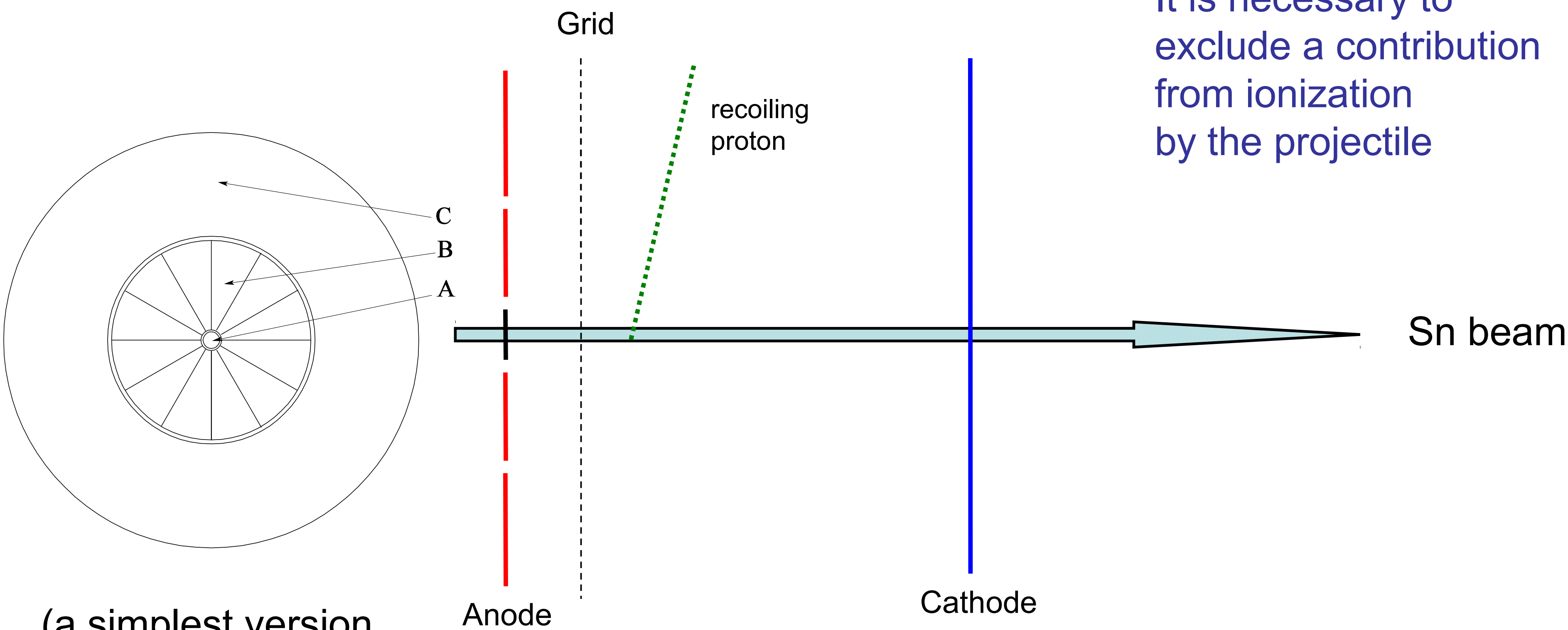
(studies at small momentum transfers)





New IKAR chamber

It is necessary to
exclude a contribution
from ionization
by the projectile



(a simplest version
of the anode)

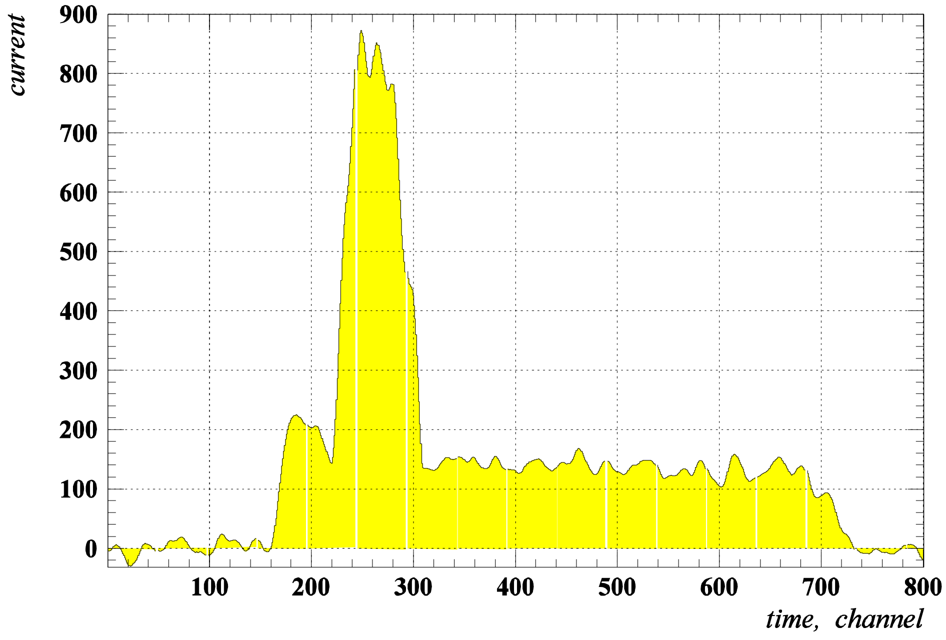
A correction on the energy lost in the central dead region

Farouk Aksouh

	Be 500 um	H2 50 cm	H2 1 m	P (bar)
ΔE	3.59	0.45	0.89	1
δE	0.1270	0.1338	0.14	
$\delta\vartheta$	0.4328	0.4439	0.4547	
ΔE	3.59	4.43	8.85	10
δE	0.1270	0.1834	0.2258	
$\delta\vartheta$	0.4328	0.5339	0.6195	
ΔE	3.59	8.85	17.7	20
δE	0.1270	0.2259	0.2925	
$\delta\vartheta$	0.4328	0.6195	0.7646	

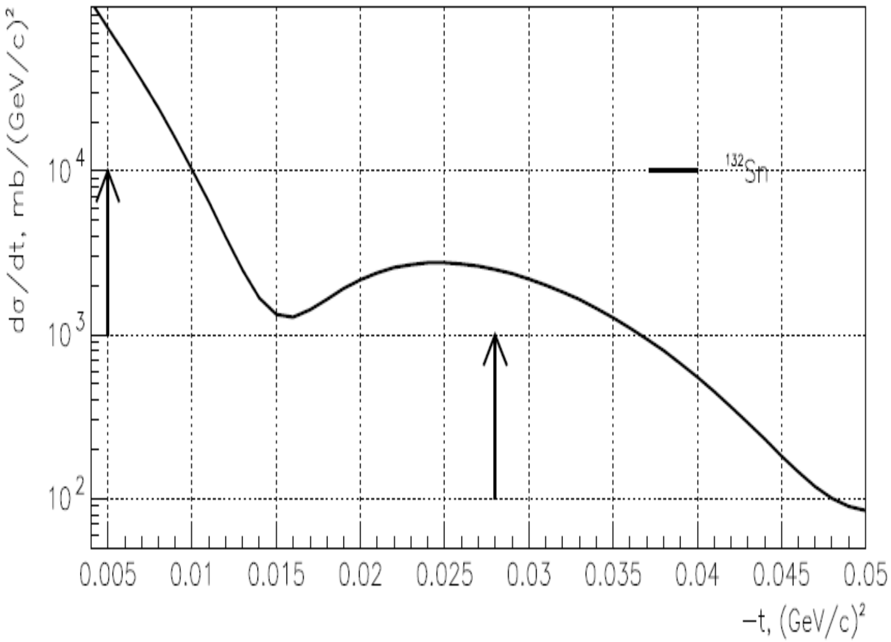
ΔE [MeV/u]
δE [MeV/u]
δθ [mrad] - cumulative

Energy loss and straggling for a ^{132}Sn beam at 700 MeV/u



Signal from the recoil proton and the pedectal signal from the projectile nucleus 17C.

Farouk Aksouh



Multiple Coulomb scattering of the projectile: δθ ~ Z/A ≈ 0.5-0.8 mrad.

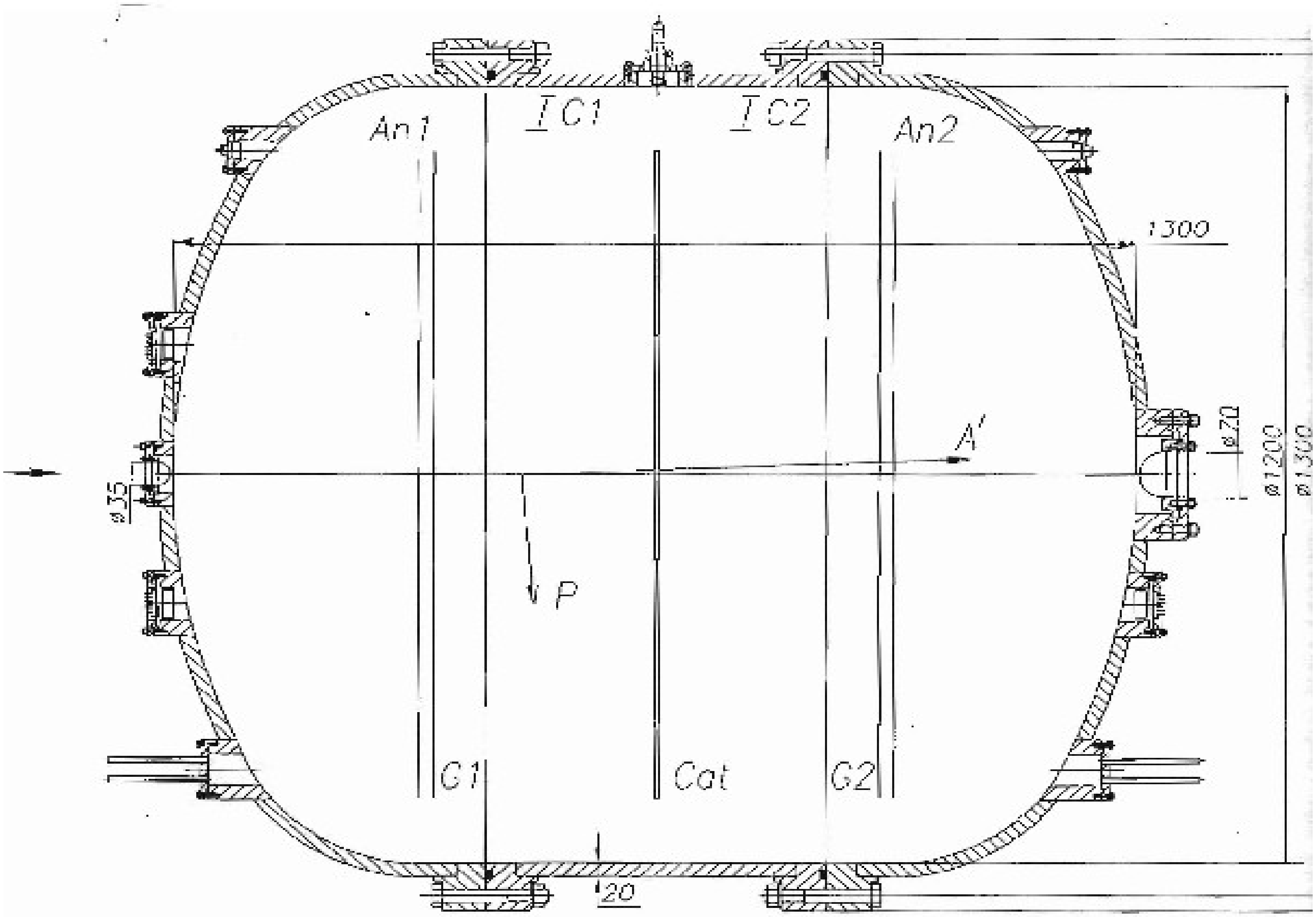
θ < 1 mrad

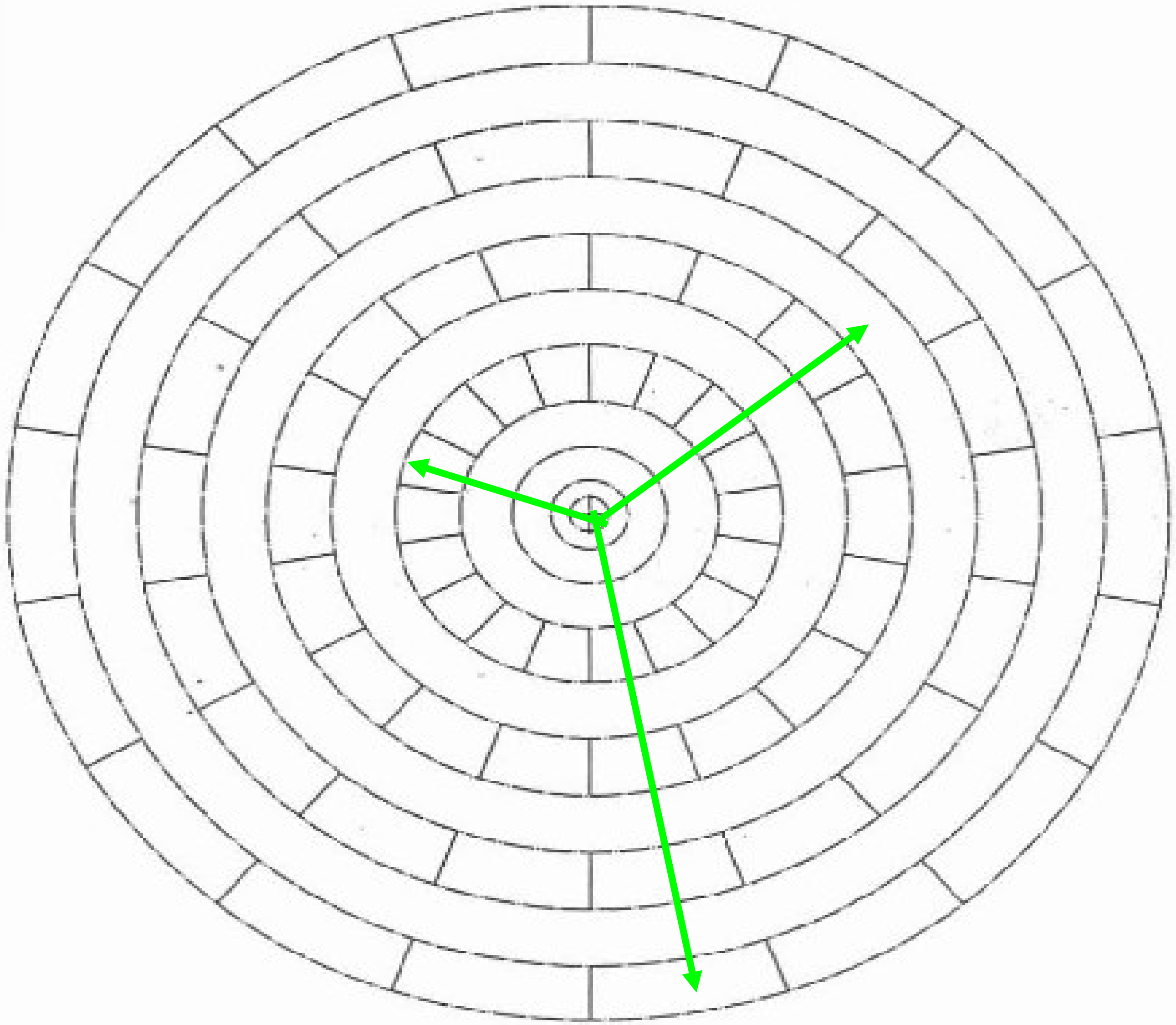
0.002 < t< 0.025 (GeV/c)2 2

E < 13 MeV

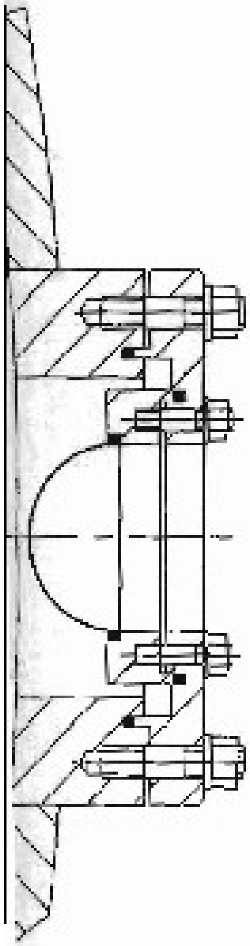
σ ≈ 600 mb (in previous exp. – 60 mb)

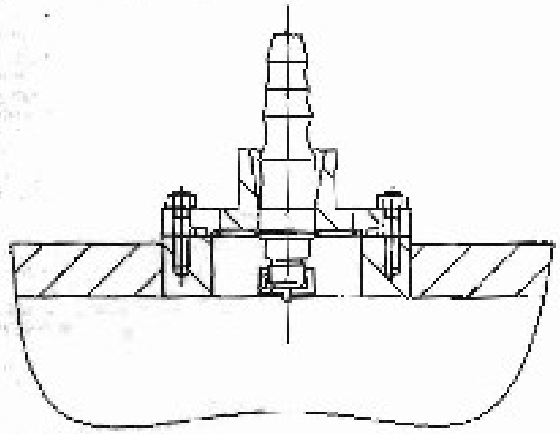
Side view of the new IKAR

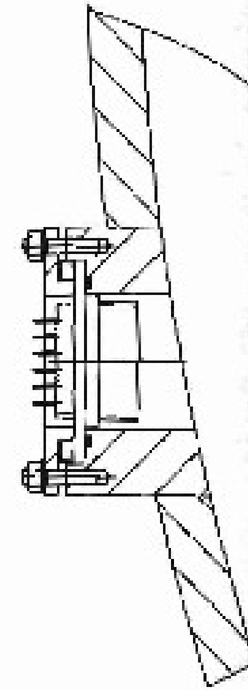


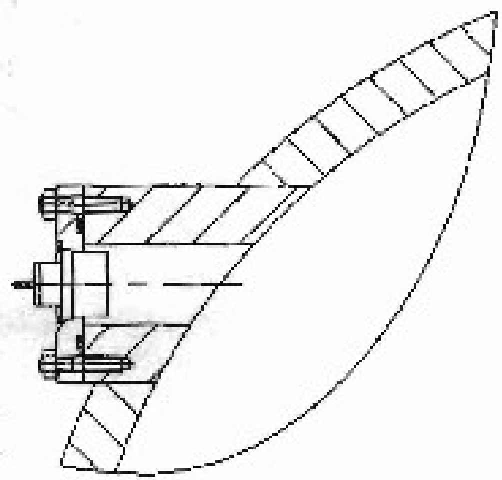


Anodes of new IKAR









Energy and angular resolution of the ionization chamber(IC)

1. Energy resolution (Eres) depends on the value of the input anode capasity (Ca) and on the amplifier pass band (Tform).

Eres(keV)=10+0.2Ca(pF), Eres~20keV (rms) at Ca=50pF.

2. Angular resolution(DFi). Angle(Fi) of recoil particle is defined by rise time(Tr) of the pulse of the anode: Tr=Lga/Va + dZ/Vc,

where,Va and Vc are the electron drift velosities in the grid-anode and grid-cathode volumes, Lga is the grid-anode distance.

dZ is the projection of the track on the IC axis: sin(Fi)=dZ/R

where, R is the recoil particle path.

Multiple Coulomb scattering of the recoil particle (DC_Fi) depends from energy and gas pressure: DC_Fi ~3-5mrad (rms).

PNPI can fabricate a new IKAR setup with the relevant electronics

Main parameters of the new IKAR:

anode and cathode diameter – 1.0 m, volume ~1000 l,
pressure – from 1 bar up to 25 bar,
2 sections with the cathode-grid distance of 25 cm,
highly segmented anodes: 10 rings of 5 cm width,
divided on 20 segments in the azimuthal angle,
total number of anodes ~200 channels.

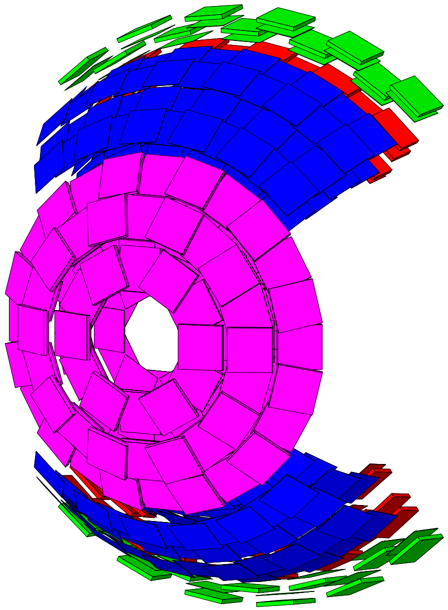
The chamber can be filled with H , D , He, He.

Effective target length – 40 cm
Effective target thickness – 4*10 cm
Luminosity (I = 10 s) – 4*10 cm s
E (max) = 15 MeV, t = 0.03 (GeV/c) (H , 25 bar)

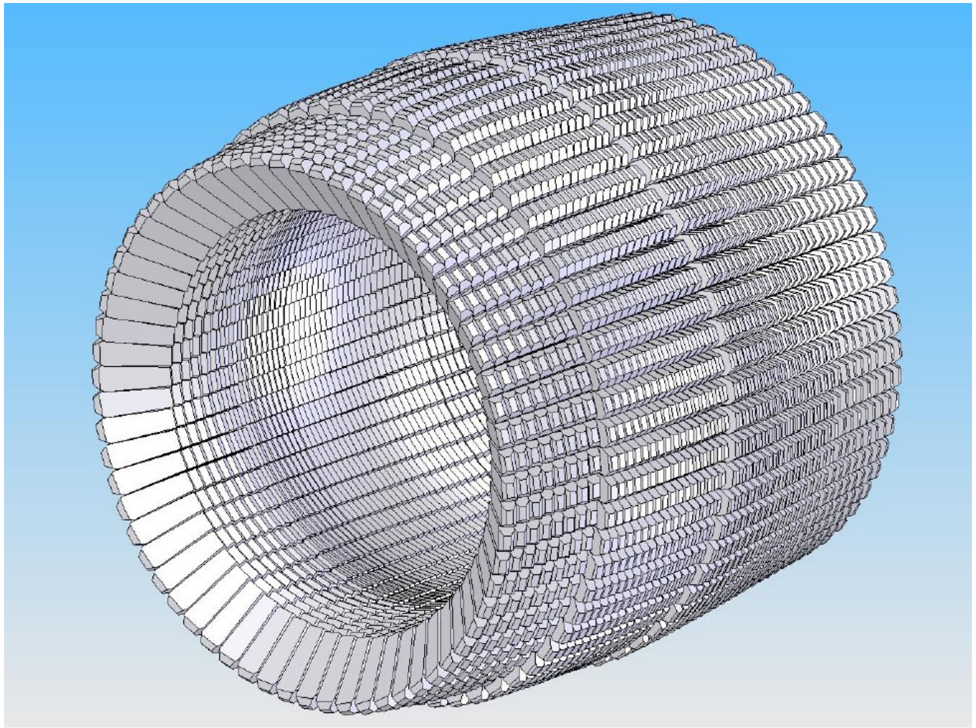
(He,He') inelastic scattering

Active target from PSI muon capture experiment (MuCap).

PNPI TPC in coincidence with Gamma spectrometer (CALIFA).

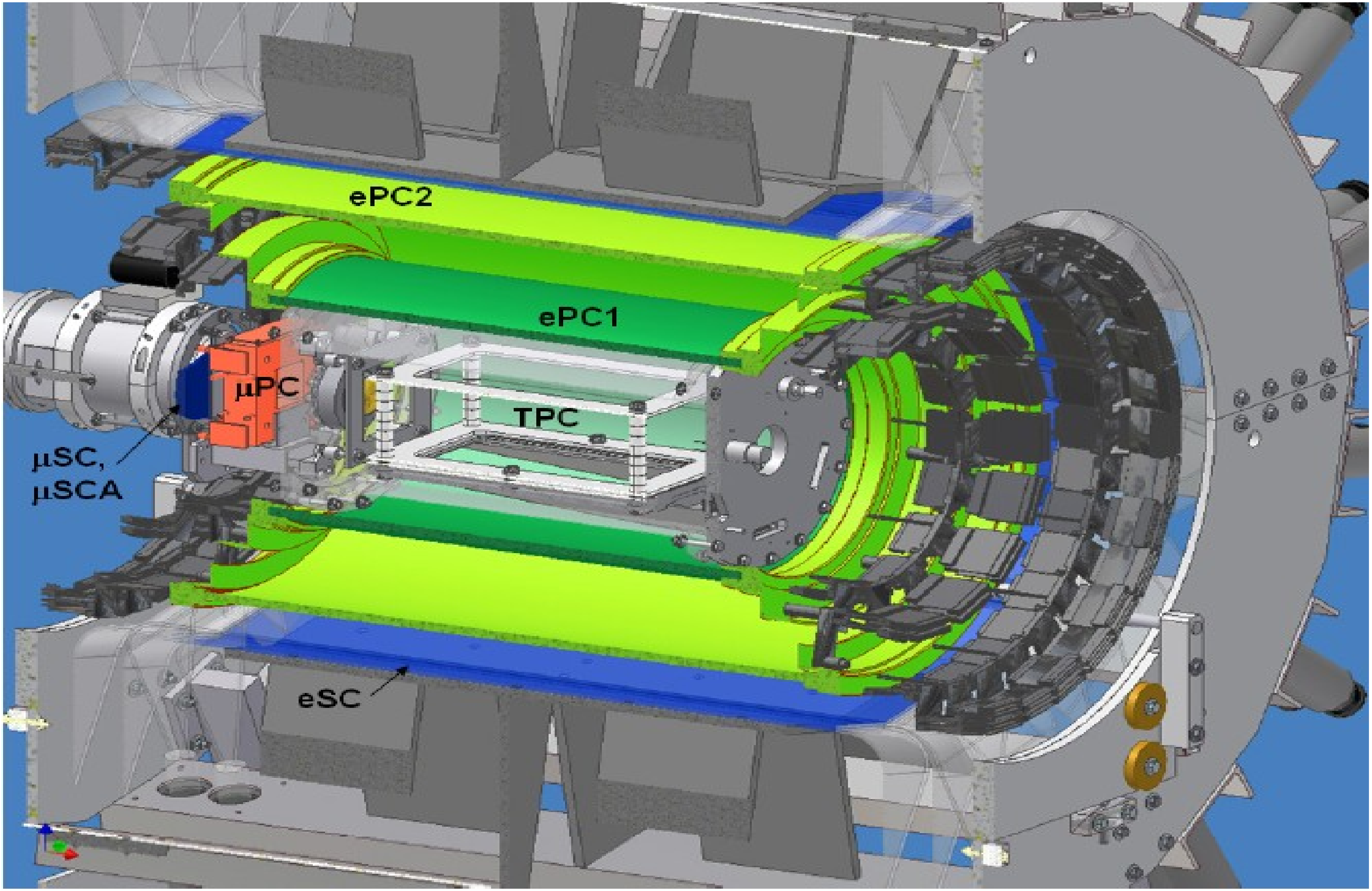


Particle-recoil semiconductor detector



Gamma-detector

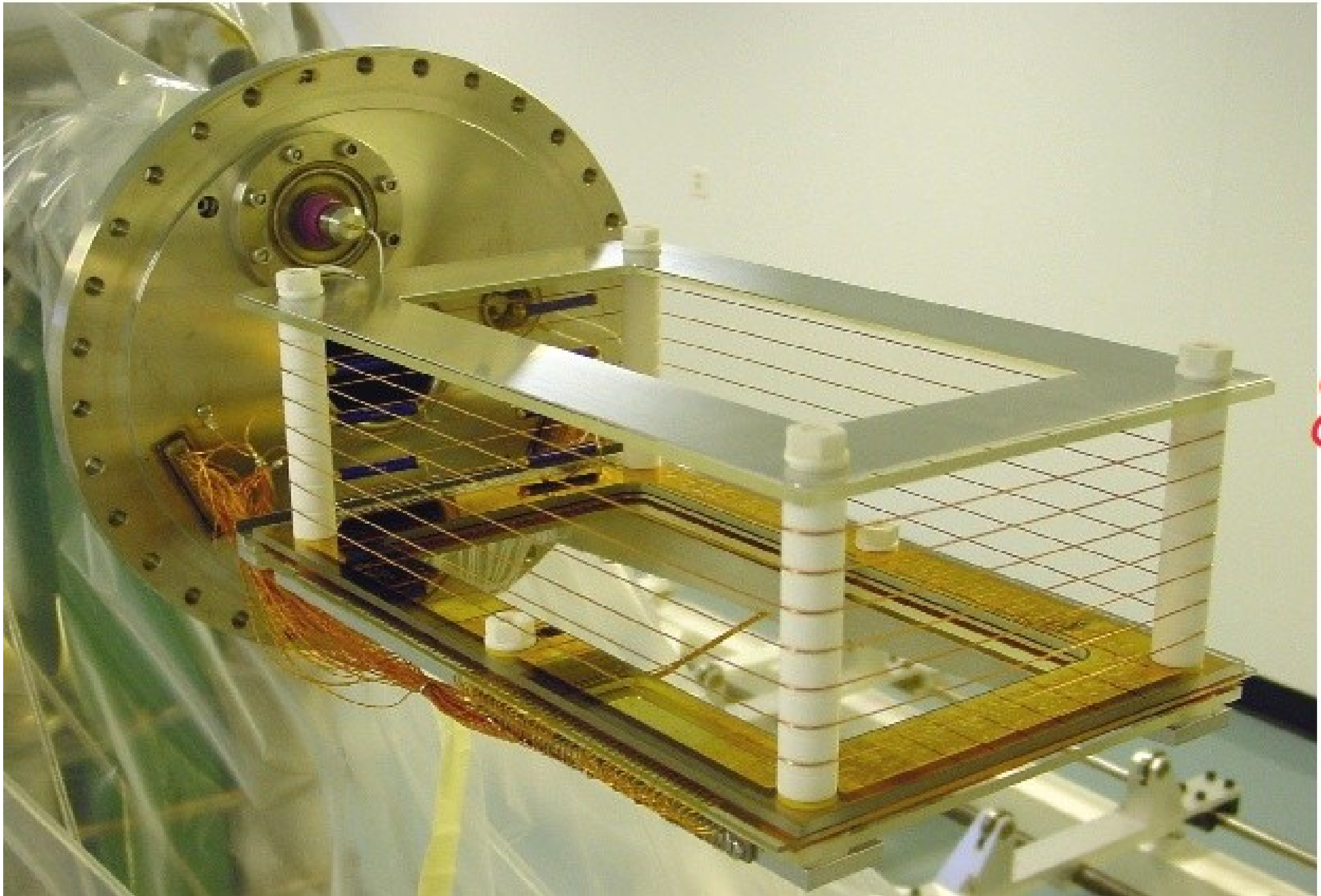
for EXL and R3B



Cross-sectional diagram of the MuCap detector

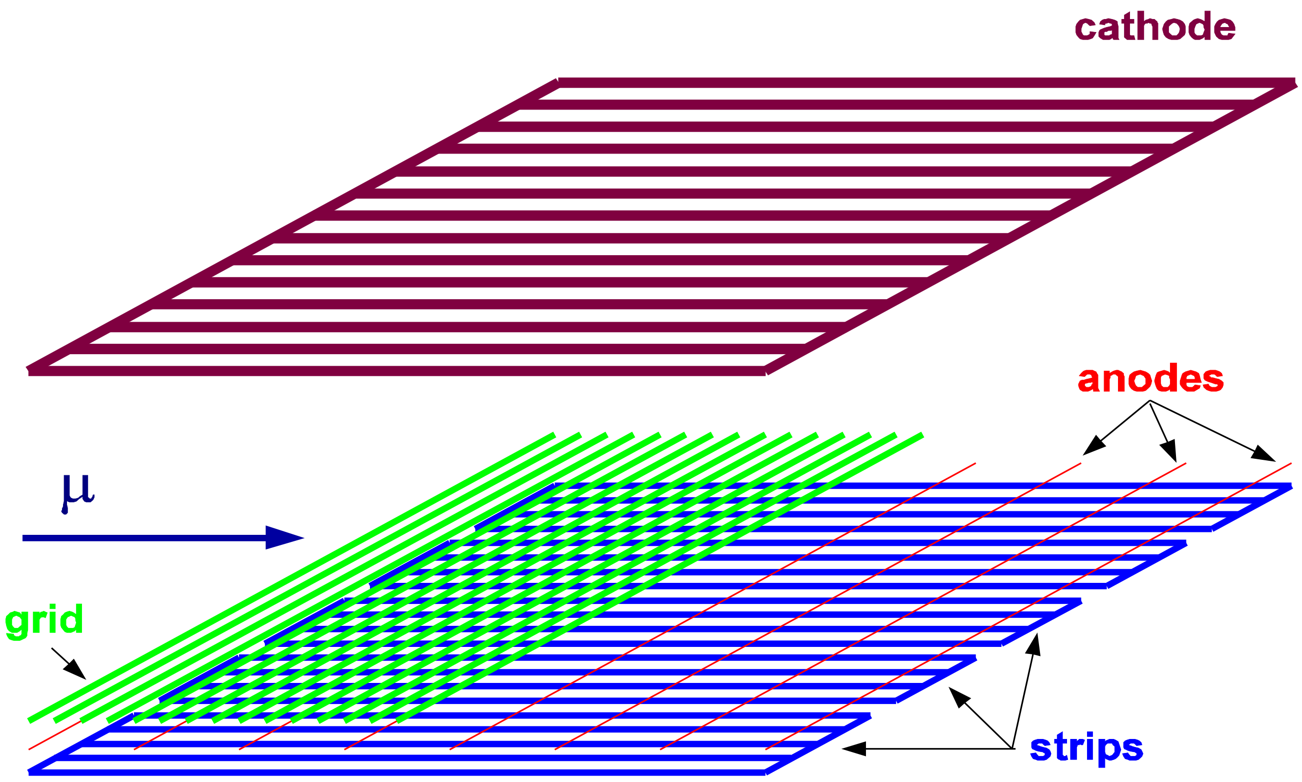
the new Hydrogen TPC at PSI

status report, Gatchina meeting June 14-17, 2004
by Malte Hildebrandt and Claude Petitjean

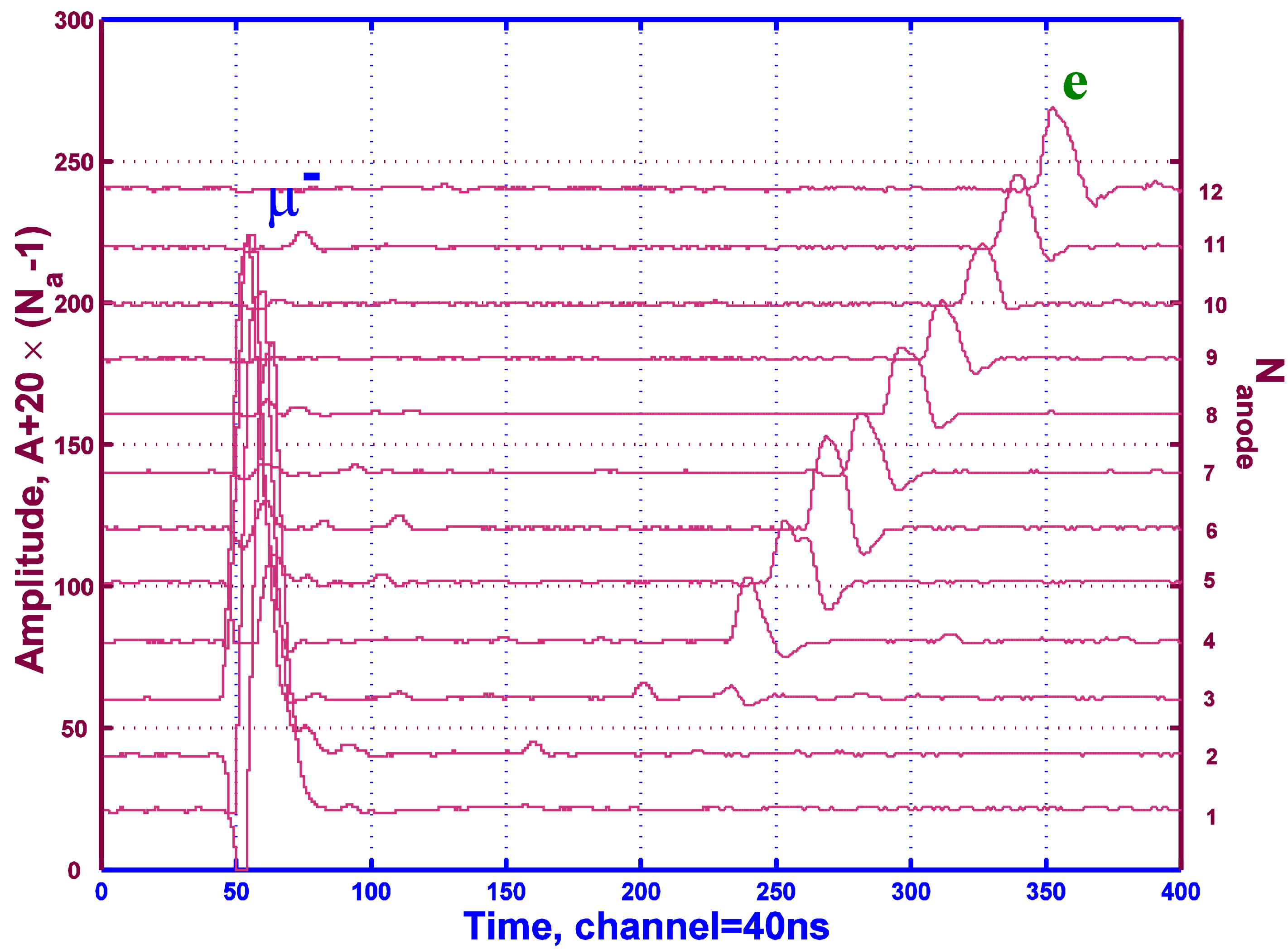


the TPC
at first
assembly
Oct 2002

Schematic view of the TPC



The trajectories of charged particles are measured in 3D space with resolution (rms) 2-3 mm.

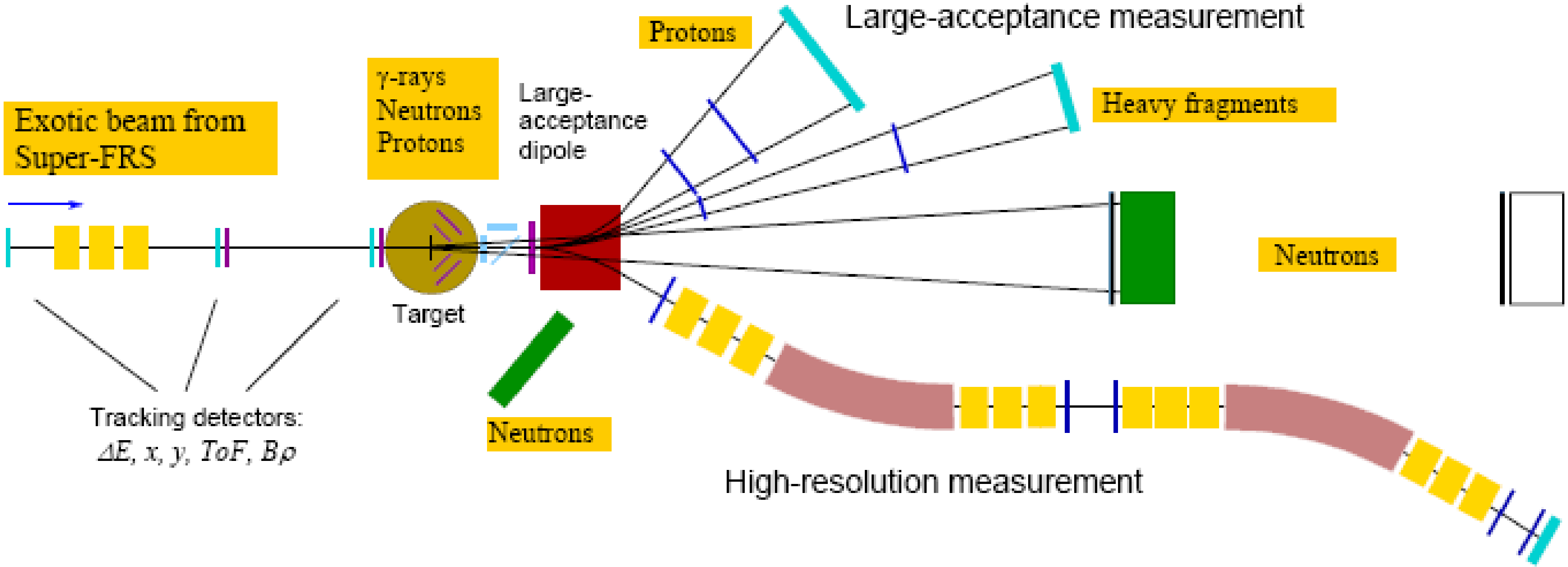


The signal on TPC anode wires from μ-e decay event

Properties of an active targets - ionization chambers

1. Filling gas--H2, D2, He3, He4… at pressure 1-25 bar.
2. Registration of all charged particles (p,d,t, He3,He4) inside of an active target with the energy in the range of 1-15 MeV.
3. Energy resolution 20-30 keV(rms).
4. Efficiency of detection charge particles (T>1MeV) is ~100%.
5. Measurements of the interaction point inside of the gas volume with resolution of ~0.5 mm (rms).
6. Angular resolution ~5 mrad (rms) for recoil particles.
7. Avoiding the wall effects on the level of less than 0.1%.

R3B



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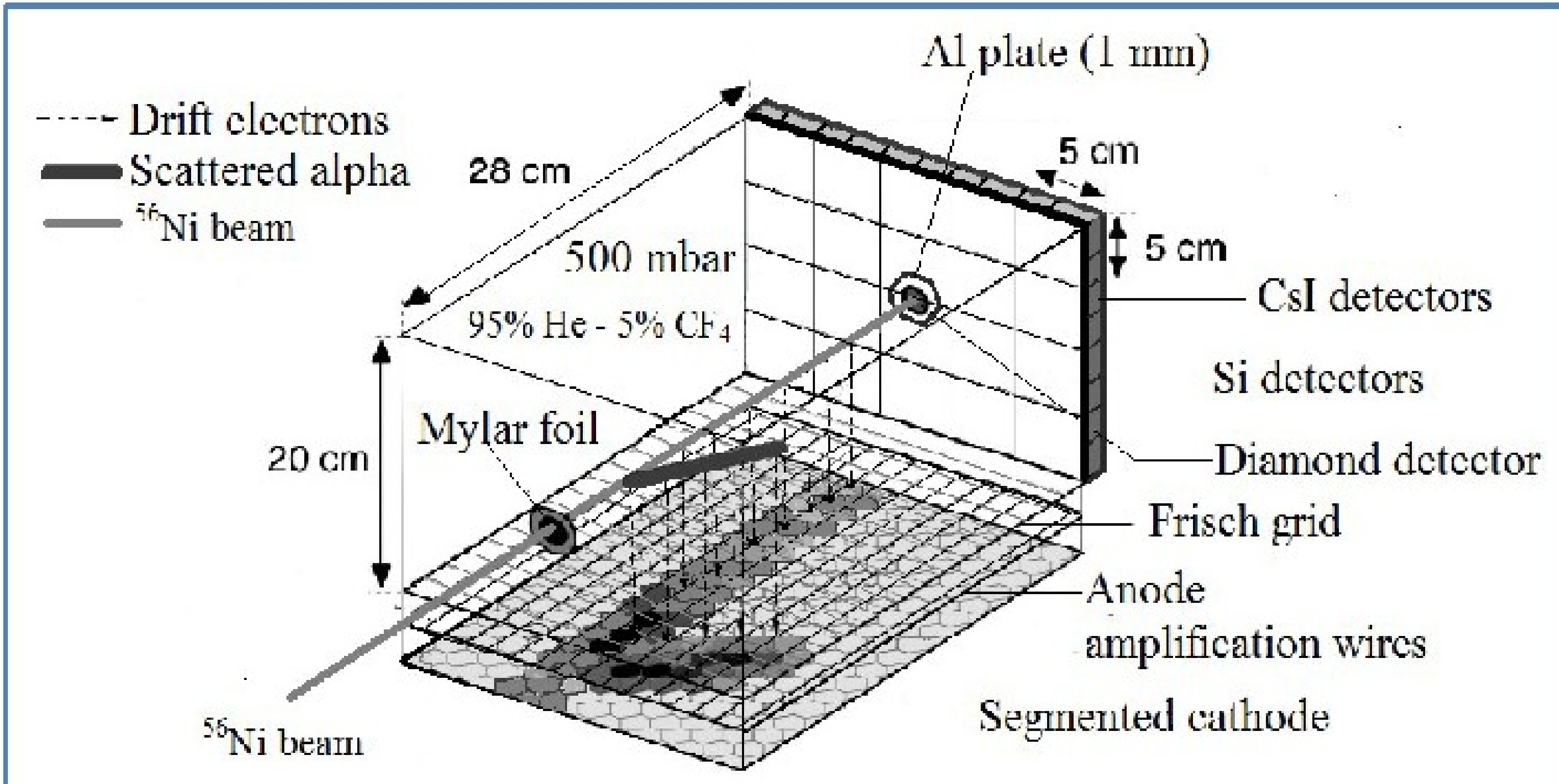
РНЦ КИ, ОИЯИ, ПИЯФ, РФЯЦ-ВНИИЭФ

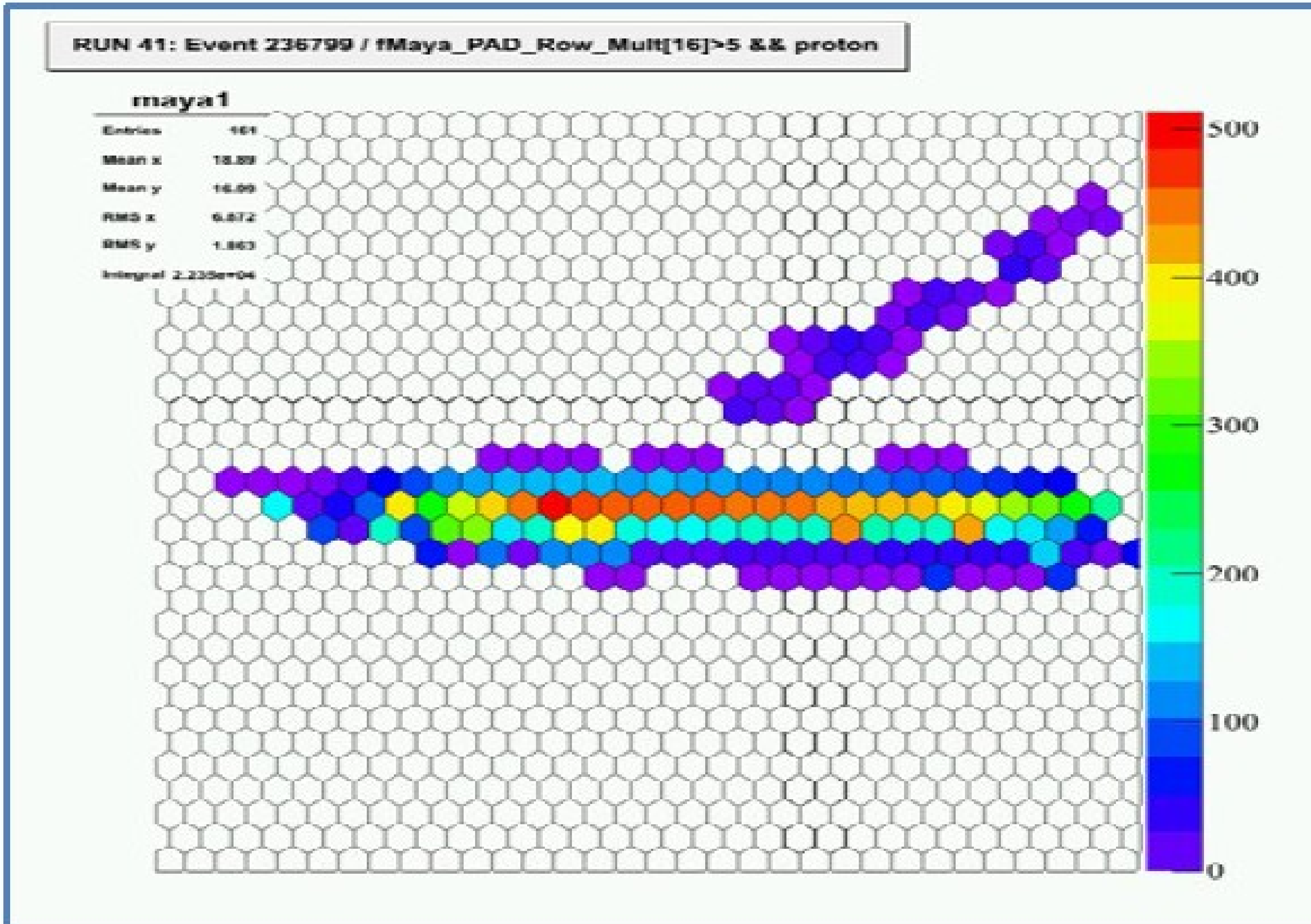
Запрос на финансирование для экспериментов NuStar

R3B		
Нейтронный спектрометр	ПИЯФ	1400 k€
Гамма спектрометр	РНЦ КИ, ОИЯИ, РФЯЦ-ВНИИЭФ	1000 k €
Активная мишень	ПИЯФ	1238 k€
EXL		
Нейтрон. спектрометр	ПИЯФ	2800 k€
Кремниевые планарн. детекторы	ФТИ, ЗАО НИИМВ, ПИЯФ	5880 k€
Толстые Si Li-дрейф. детекторы	ПИЯФ	1000 k€
Электроника к детекторам	ФТИ, ЗАО НИИМВ	1500 k€
Гамма спектрометр	РНЦ КИ, ОИЯИ, РФЯЦ-ВНИИЭФ	3626 k€
Трек. детект	ПИЯФ	224 к€
MATS		
Блок калибровки	ПИЯФ	275 к€
Детекторы медлен. частиц	ПИЯФ	174 к€
ILIMA		
Кремниевые детекторы	ПИЯФ	210 к€
ELISe		
Монитор светимости	РНЦ КИ, ИЯИ	45 к€
Детекторы LAHReS	ИЯИ	425 к€

Schematic view of MAYA active target detector



Tracks on the cathode pads



30.10.11

GIANT RESONANCE

- Collective oscillations of all protons and all neutrons in a nucleus in phase (isoscalar) or out of phase (isovector).
- Characterized by multipolarity, spin and isospin.

	ΔS=0, ΔT=0	ΔS 0, ΔT 1	ΔS 0, ΔT 1	ΔS=1, ΔT=1	ΔS=1, ΔT=1
L 0: Monopole	ISGMR $r^2 Y_0$	IAS τY_0	IVGMR $\tau r^2 Y_0$	GTR $\tau \sigma Y_0$	IVSGMR $\tau \sigma r^2 Y_0$
L 1: Dipole	ISGDR $r^3 Y_1$		IVGDR $\tau r Y_1$		IVSGDR $\tau \sigma r Y_1$
L 2: Quadrupole	ISGQR $r^2 Y_2$		IVGQR $\tau r^2 Y_2$		IVSGQR $\tau \sigma r^2 Y_2$

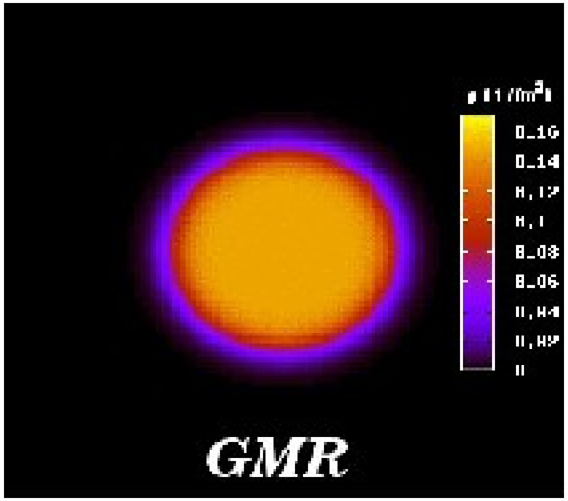
Why ISGDR (ISGMR) and how?

- Provides to determine experimentally the nucleus incompressibility.

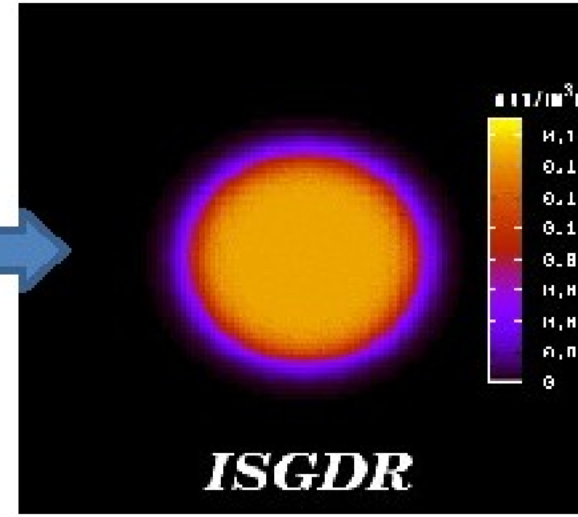
$$E_{ISGMR} = \hbar\sqrt{\frac{K_A}{m < r^2 >}}$$

$$E_{ISGDR} = \hbar\sqrt{\frac{7}{3}\frac{K_A + \frac{27}{25}\varepsilon_F}{m < r^2 >}}$$

- The EoS of nuclear matter governs the supernovae explosions and formation of neutron



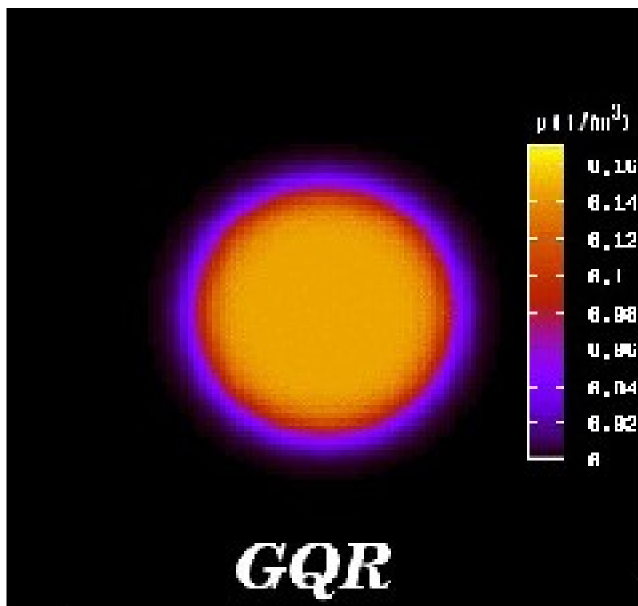
Hydrodynamical
Density
Oscillation



Breathing Mode

M. Itoh

Squeezing Mode



No density variation
Shape Change

30.10.11

NUSTAR

NUSTAR Nu St A R

HISPEC-DESPEC –
ILIMA -
MATS -
LASPEC –
ELISE –
AIC –
R3B R R R B
EXL Ex L

R3B, MATS, ILIMA, EXL, ELISE

R3B, MATS, - modules 1-3
EXL, ELISE, ILIMA – modules 4-5

РНЦ КИ, ОИЯИ, РФЯЦ-ВНИИЭФ, ЗАО НИИМВ,
ФТИ РАН, ИЯИ РАН, ПИЯФ

Work Group

- Daresbury (R. Lemmon)
- Liverpool (M. Chartier)
- Santiago (D. Cortina?)
- KVI (N. Kalantar)
- Leuven (R. Raabe)
- St. Petersburg (G. Alkhazov)
- TUD (T. Kröll?)
- Edinburgh (P. Woods?)
- GSI (D. Savran)

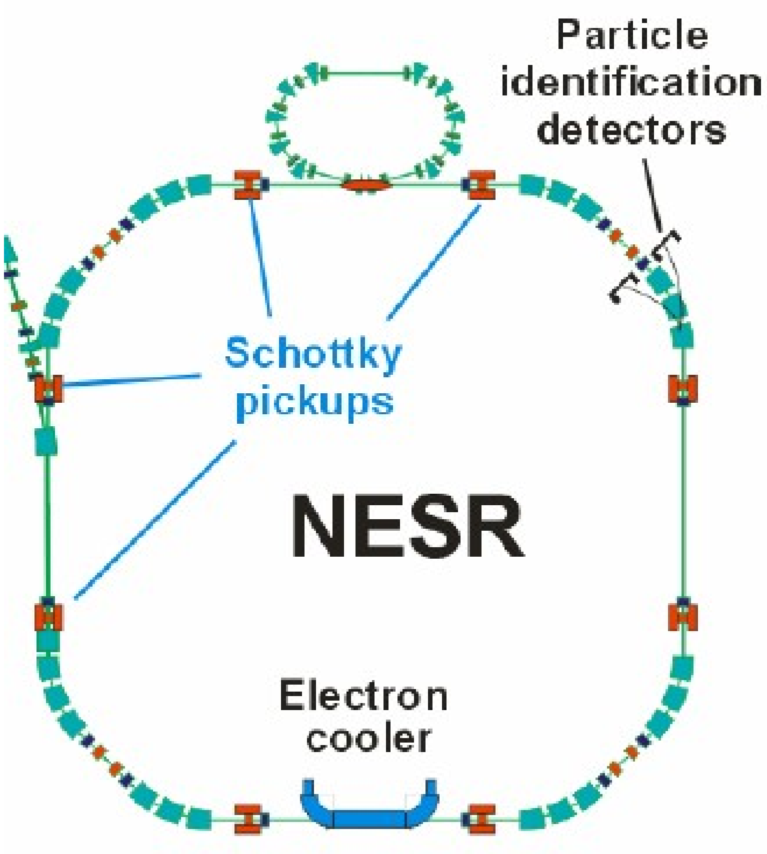
Прецизионные измерения масс (и времен жизни) ядер
(эксперименты ILIMA и MATS)

Цели работы:

Тесты ядерных моделей,
получение данных для астрофизики (для расчетов r- и rp- процессов),
более точная проверка унитарности матрицы СКМ

Mass measurements in the storage ring (ILIMA)

Schottky mass spectrometry



ПИЯФ ILIMA (NESR)

MATS ПИЯФ :
измерение масс ядер
в ловушках Пеннинга