FAIR, NUSTAR, R3B + EXL

FAIR – **F**acility for **A**ntiproton and **I**on **R**esearch
NUSTAR – **Nu**clear **St**ructure, **A**strophysics, and **R**eactions

NUSTAR:

HISPEC-DESPEC – High-Resolution In-Flight and Decay Spectroscopy
ILIMA - Schottky and Isochronos mass spectroscopy
MATS - Mass measurements with a Penning Trap
LASPEC – Laser Spectroscopy investigations
ELISE – Electron scattering in a storage ring
AIC – Antiproton Ion Collider

R3B – **Reactions** with **Relativistic Radioactive Beams**
EXL – **Exotic Light-ions** (exotic nuclei studied in light-ion induced reactions at the NESR ring)

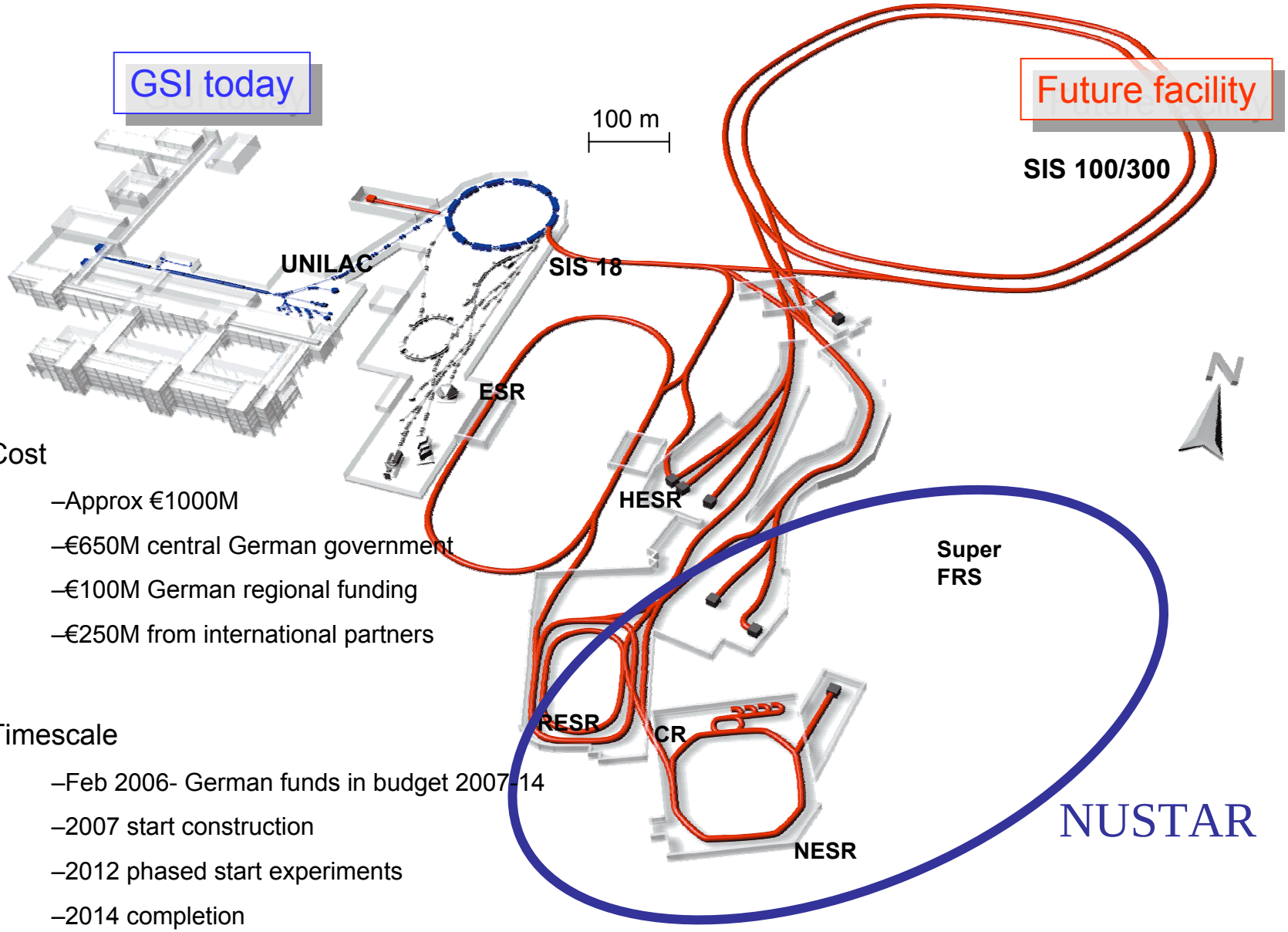
FAIR, NUSTAR, R3B + EXL

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

FAIR - Facility for Antiproton and Ion Research



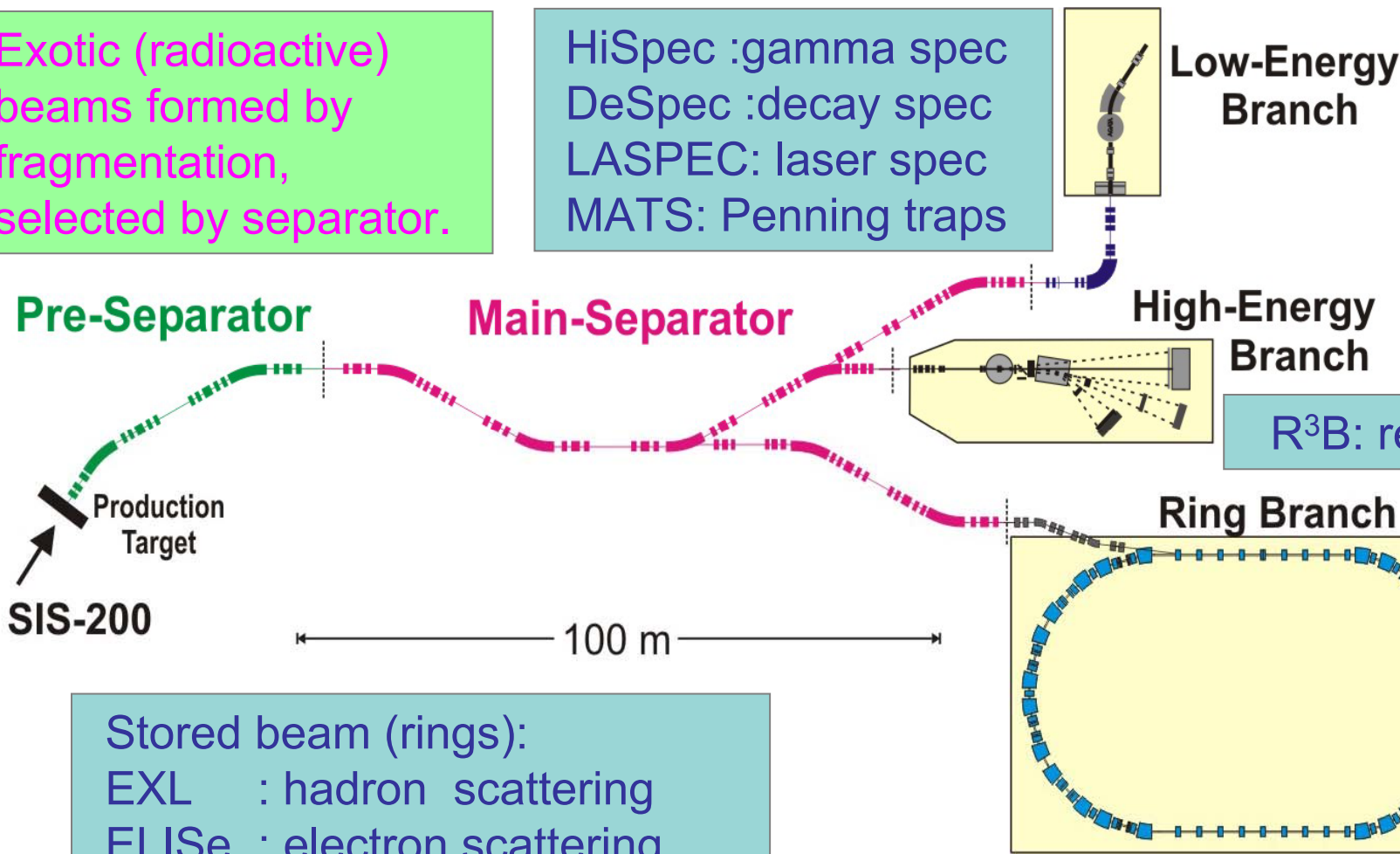
- Cost
  - –Approx €1000M
  - –€650M central German government
  - –€100M German regional funding
  - –€250M from international partners
- Timescale
  - –Feb 2006- German funds in budget 2007-14
  - –2007 start construction
  - –2012 phased start experiments
  - –2014 completion

NUSTAR facility

NUclear STructure Astrophysics and Reactions)

Exotic (radioactive) beams formed by fragmentation, selected by separator.

HiSpec :gamma spec
DeSpec :decay spec
LASPEC: laser spec
MATS: Penning traps



Stored beam (rings):
EXL : hadron scattering
ELISe : electron scattering
AIC : antiproton scattering
ILIMA : mass spectroscopy

What is missing?

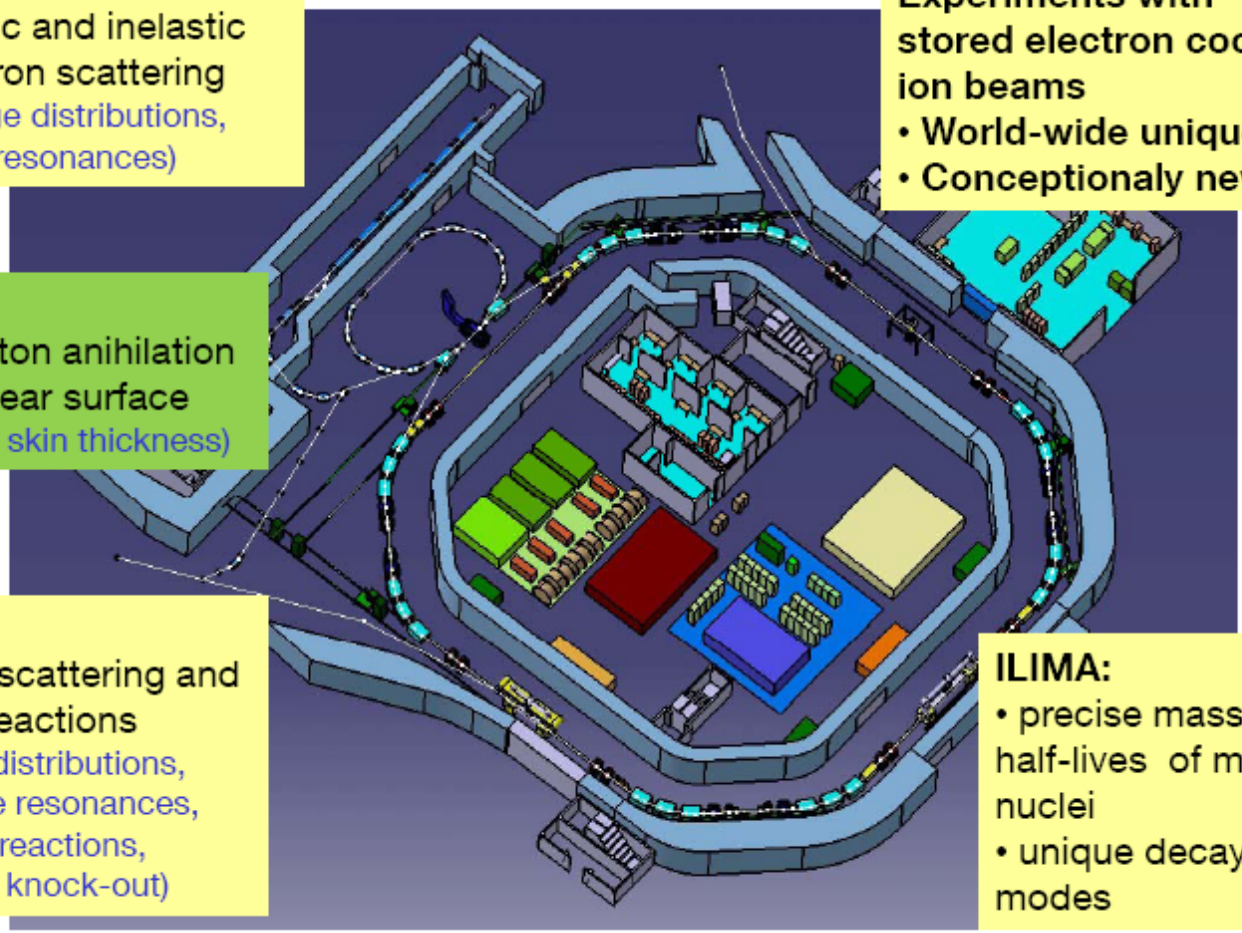
FAIR

NESR

ELISe:
Elastic and inelastic electron scattering
(charge distributions, giant resonances)

Experiments with stored electron cooled ion beams
- **World-wide unique**
- **Conceptionaly new**

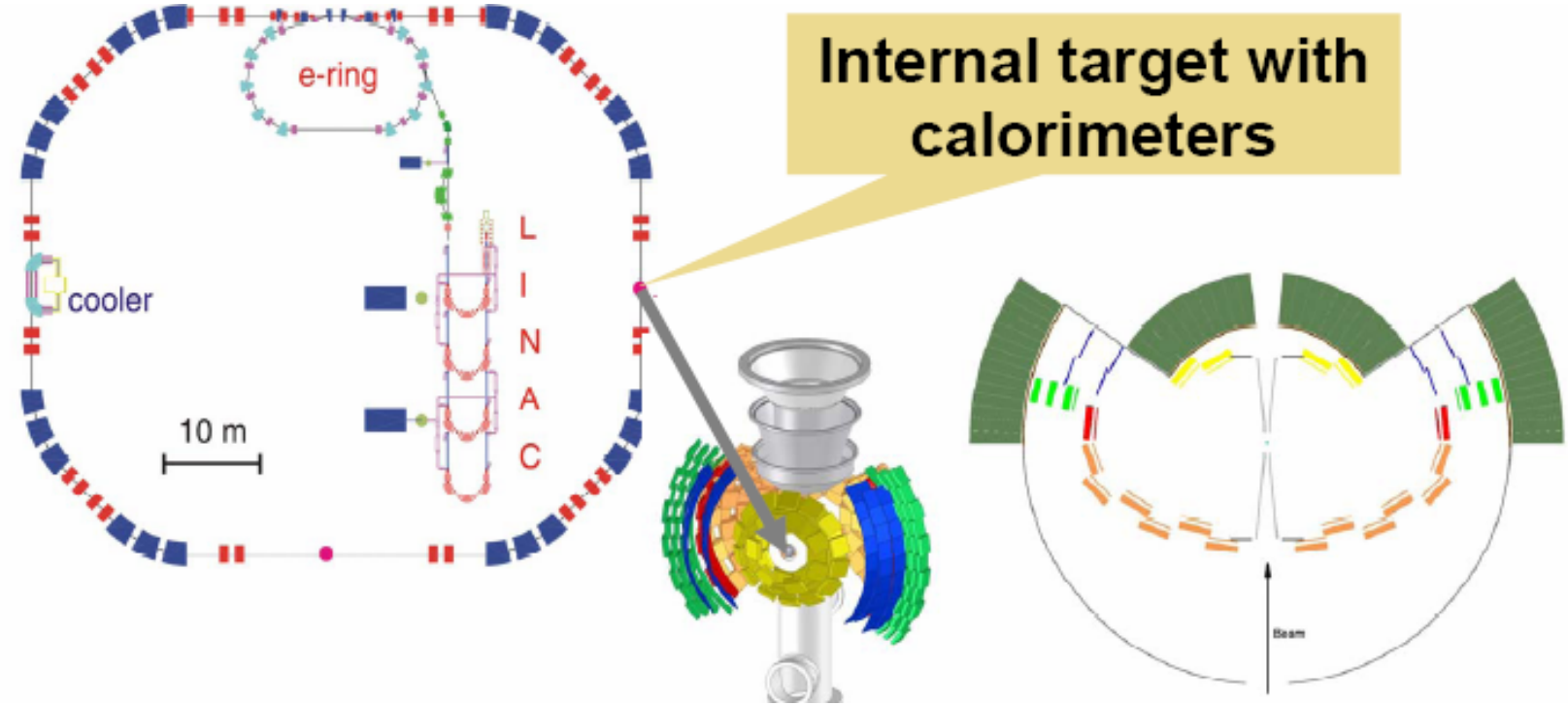
AIC:
Antiproton anihilation on nuclear surface
(neutron skin thickness)



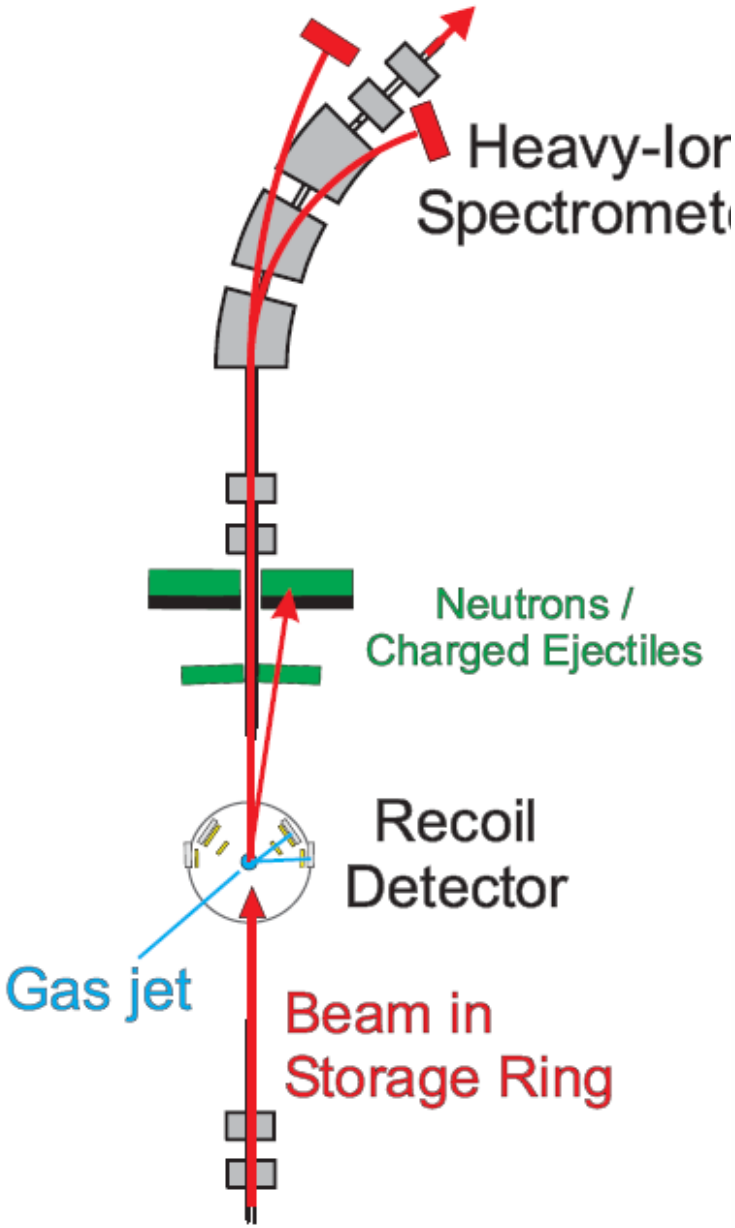
EXL:
Elastic scattering and low-q reactions
(matter distributions, monople resonances, capture reactions, trnasfer, knock-out)

ILIMA:
- precise masses and half-lives of many nuclei
- unique decay modes

EXL

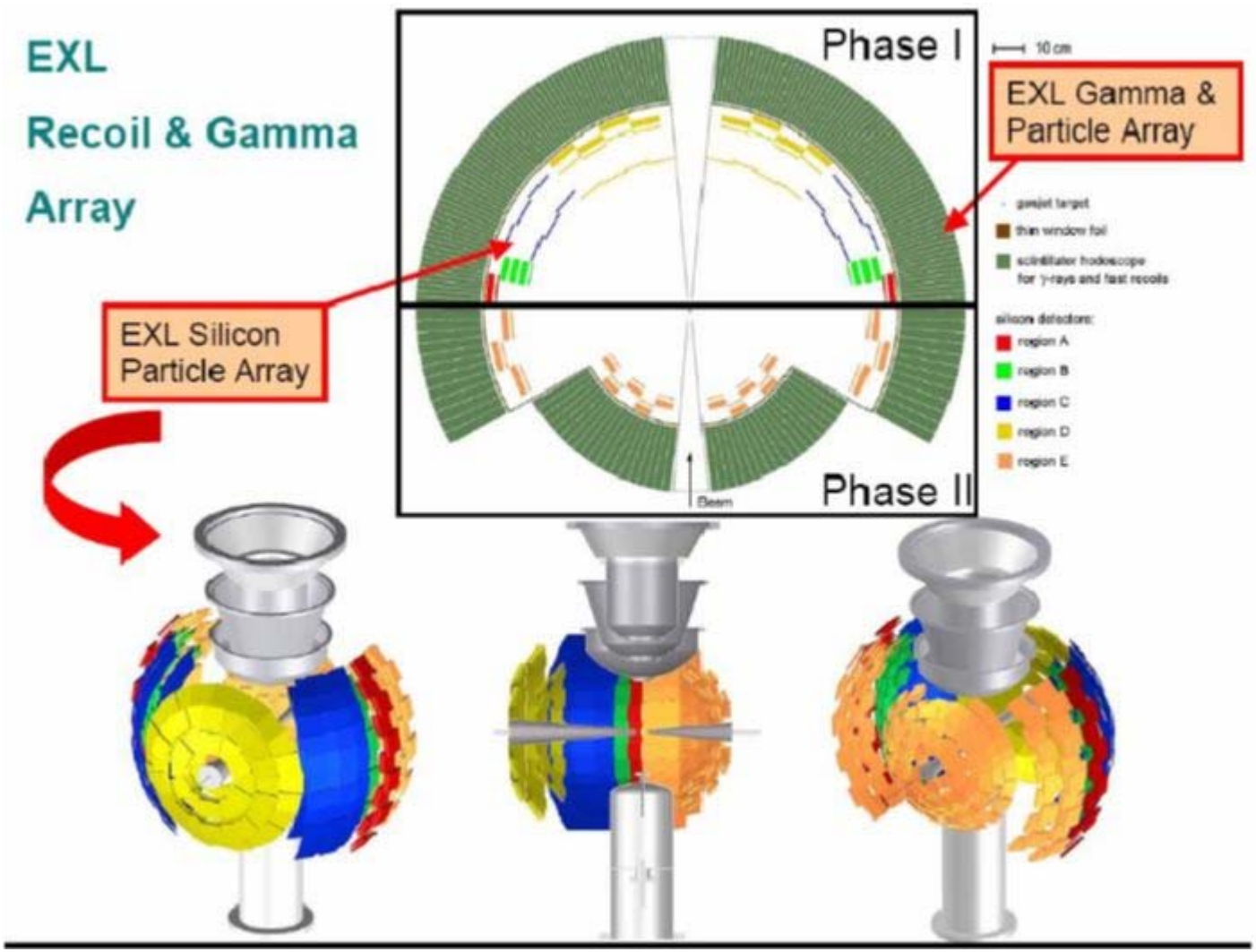

e-ring
cooler
L
I
N
A
C
10 m
Internal target with calorimeters
Beam

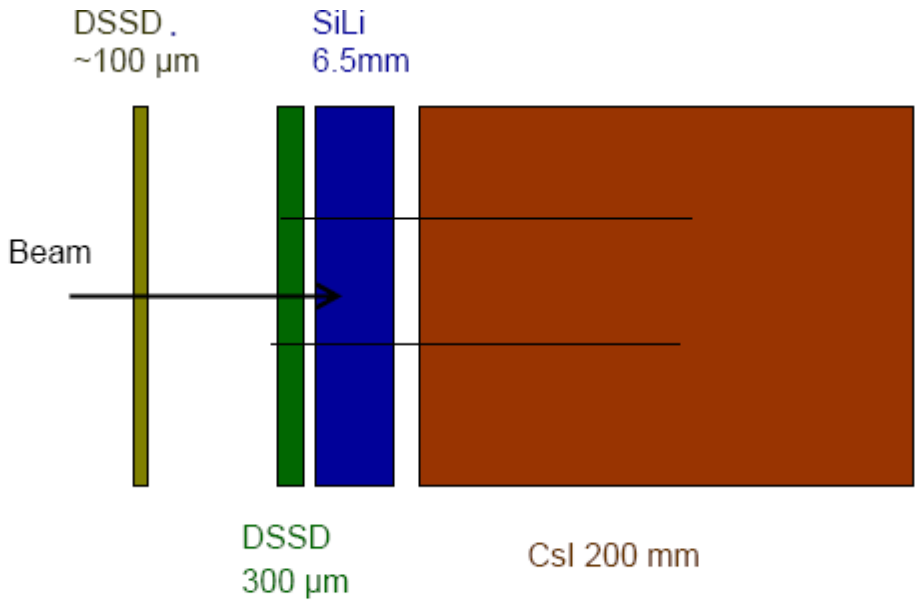
EXL setup


Heavy-Ior
Spectromet
Neutrons /
Charged Ejectiles
Recoil
Detector
Gas jet
Beam in
Storage Ring

EXL

Recoil & Gamma Array



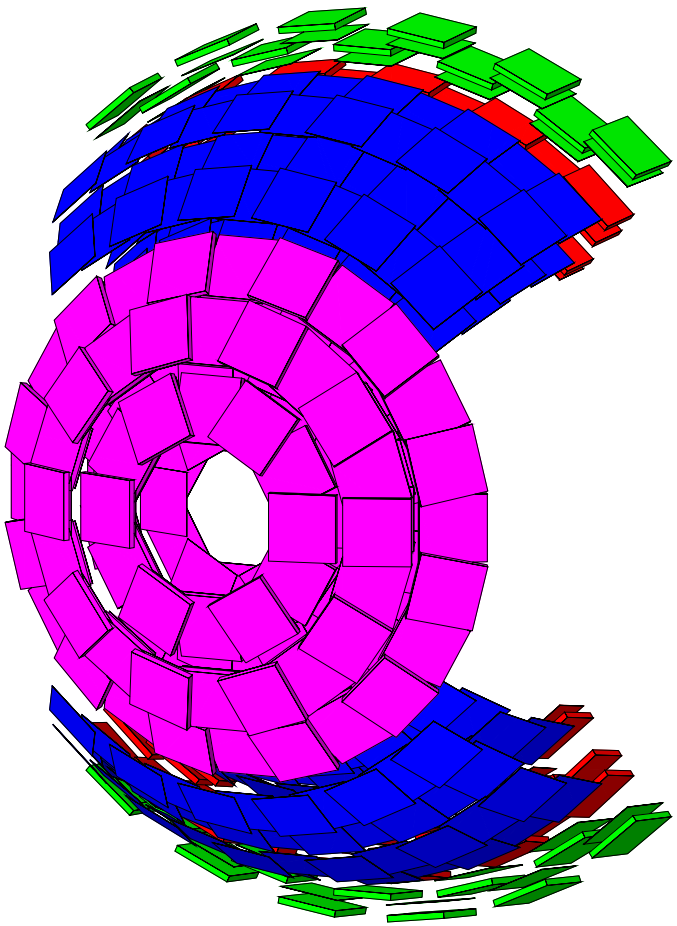


First DSSD – e.g. 2.1 x 2.1 cm^2, 0.3/1.25 mm pitch (PTI, EXL) or 0.1/0.1 mm pitch R^3B

Second DSSD – e.g 5.2 x 6.7 cm^2, 0.1/0.2 mm pitch (Micron, EXL) or 0.1/0.1 mm pitch R^3B

Si(Li) or Si – e.g. 9 x 5 cm^2, 4 x 2 pads ---- EXL

CsI – e.g. volume 3 x 3 cm^2 x 20 cm



- Si, 300 µm thick, double sided, spatial resolution better than 500 µm in X and Y, $\Delta E \approx 30$ keV (FWHM)

- Si, ≤ 100 µm thick, double sided, spatial resolution better than 100 µm in X and Y, $\Delta E \approx 30$ keV (FWHM)

- Si(Li), 9 mm thick, large area 100*100 mm^2, $\Delta E \approx 50$ keV (FWHM)

- CsI crystals, high efficiency, high resolution, 20 cm thick

- TOF resolution ≈ 1 ns (FWHM)

R3B setup

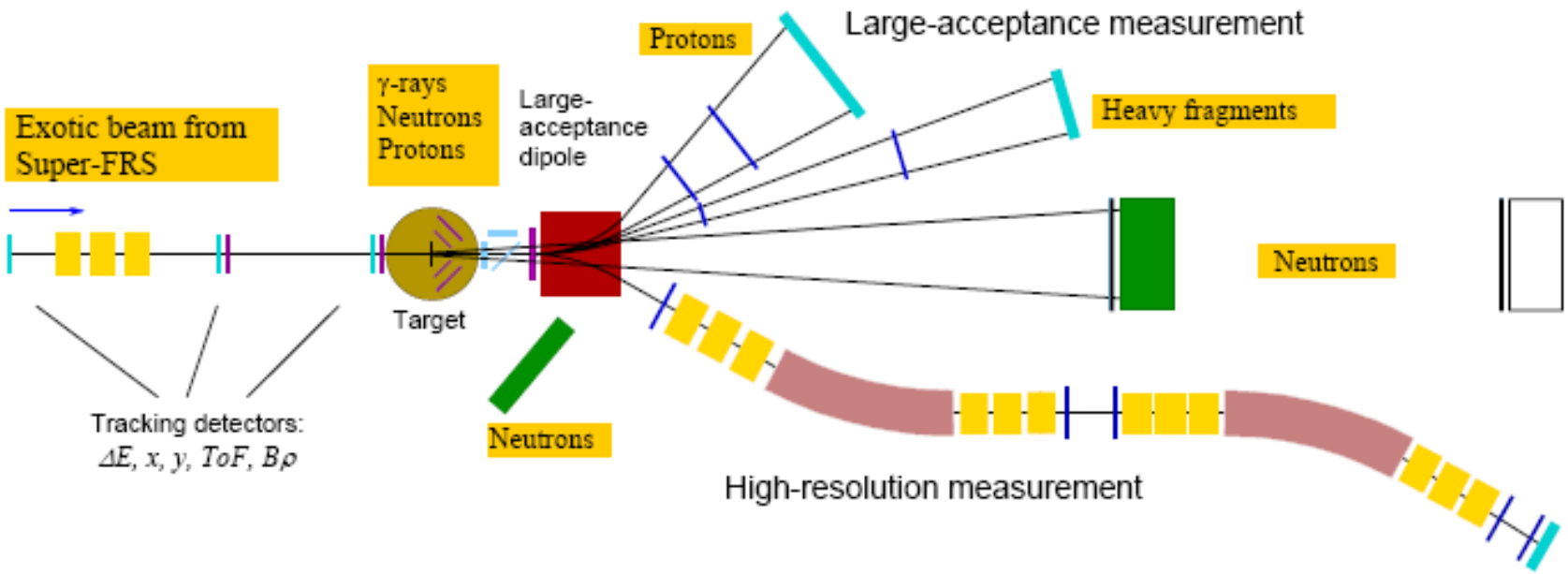
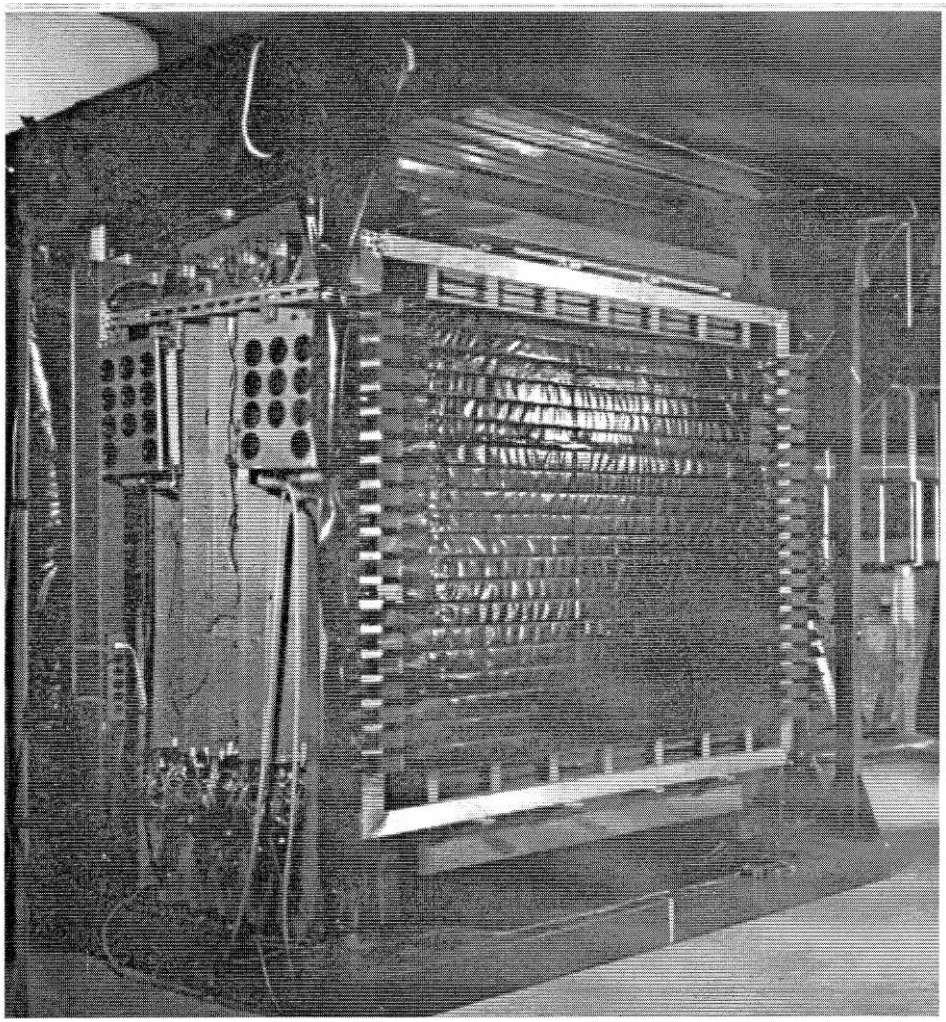


Figure 1: Schematic drawing of the experimental setup comprising γ-ray and target recoil detection, a large-acceptance dipole magnet, a high-resolution magnetic spectrometer, neutron and light-charged particle detectors, and a variety of heavy-ion detectors.

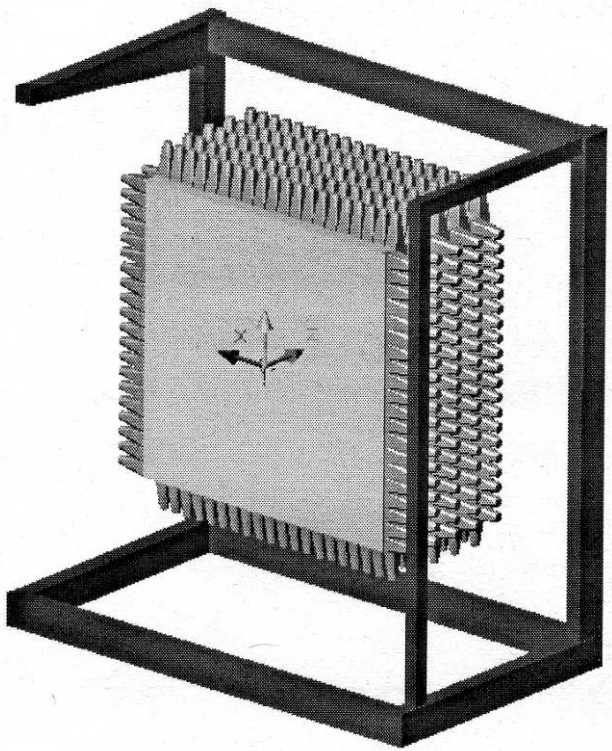


LAND – **L**arge **A**rea **N**eutron **D**etector

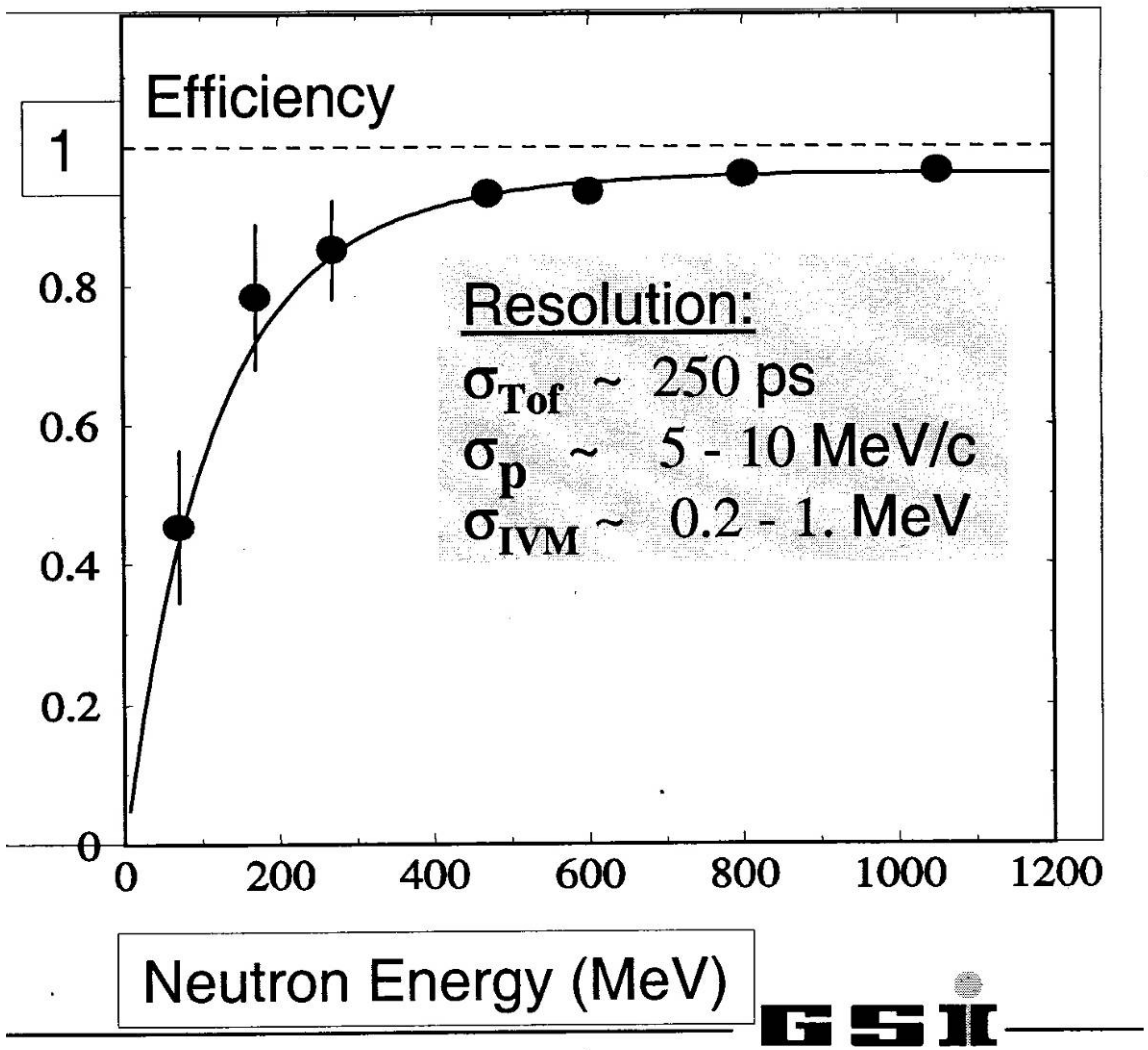
Existing LAND detector:

- $\sigma_t < 250$ ps
- $\sigma_{x,y,z} \approx 3$ cm
- Size: 2 x 2 x 1 m^3
- Plastic scintillator / Fe converter sandwich structure

Th. Blaich *et al.*, NIM A **314** (1992), 136



Land efficiency



NeuLAND design goals:

- $\sigma_t < 100$ ps
- $\sigma_{x,y,z} \approx 1$ cm
- Size : approx. 2 x 2 x 0.8 m^3
- Efficiency > 90% for 1-n hits
- Improvement of multi-n recognition

↓

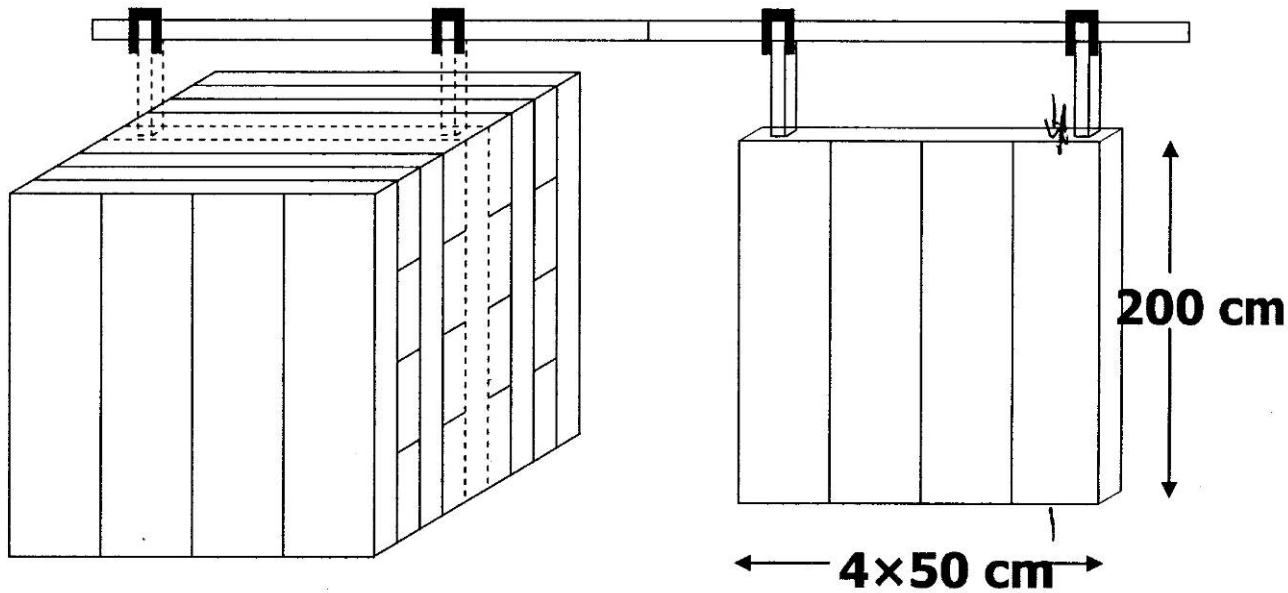
Timing RPC concept:

- Total of 140 m^2 RPC
- Approx. 10'000 channels
- Converter material: integrated in RPC structure

↓

Compared to existing RPC types:

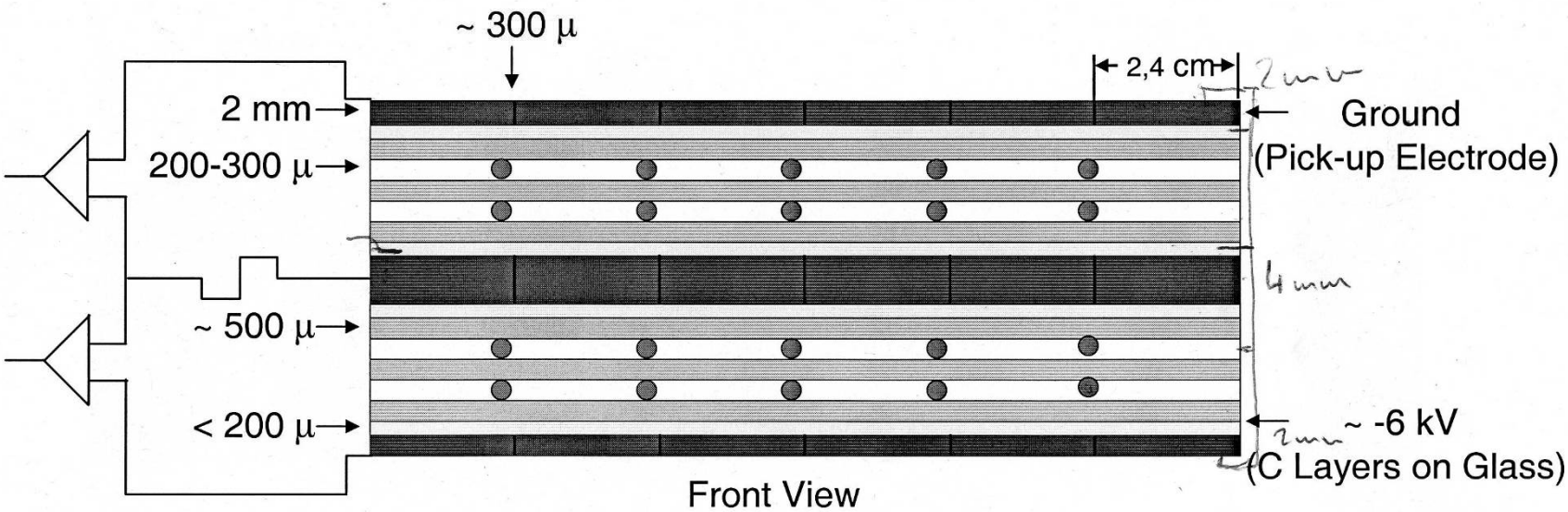
- Low count rates (< 1 Hz/cm^2)
- Massive detector for higher efficiency
- Protons at various energies (non-MIPs)



- total — 140 m^2 RPC
- approx. — 10^4 channels
- each module hanging — on slide rod
- total weight — app. 15 t

first test RPC – planned at GSI

detector size 20 × 40 cm² with 8 anode strips 2.4 × 40 cm²
converter material integrated in the detector



Fe ($\lambda_n \approx 17$ cm)

Floating Glass (~ 10^{12} Ω/cm, $\lambda_n \approx 12$ cm)

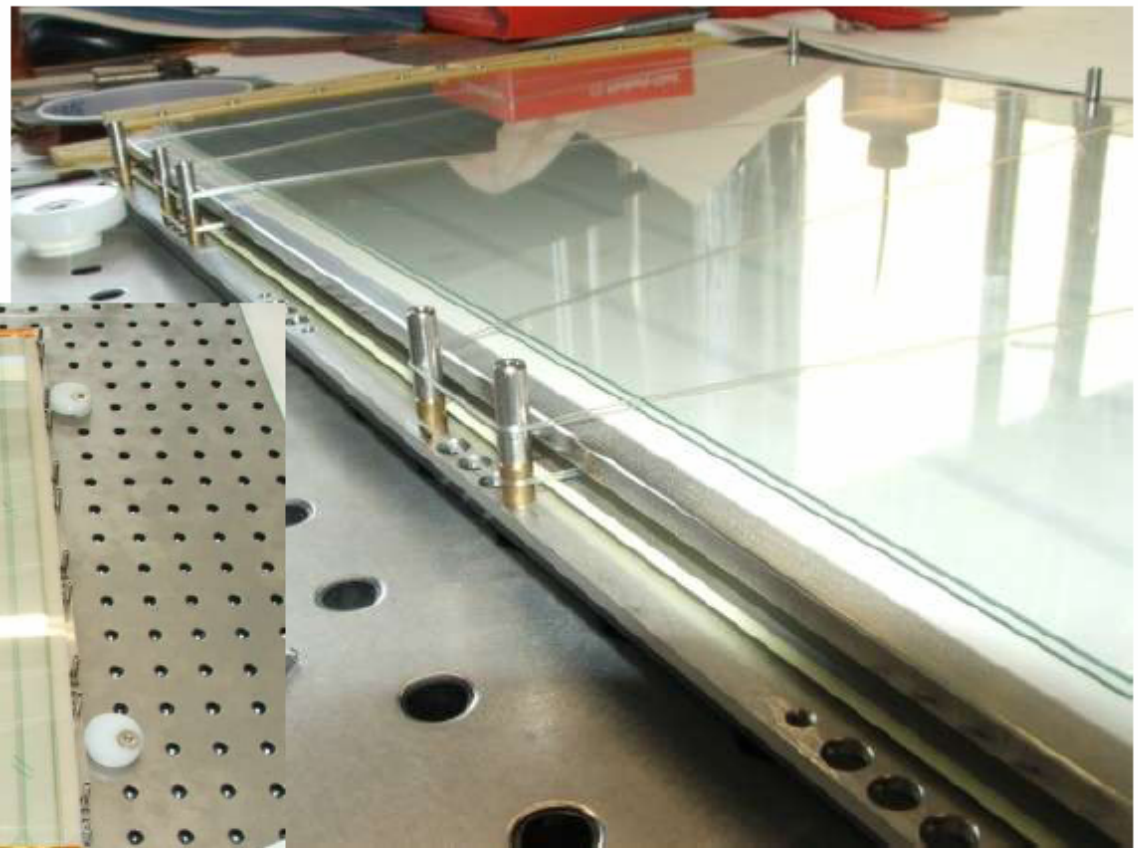
Glue

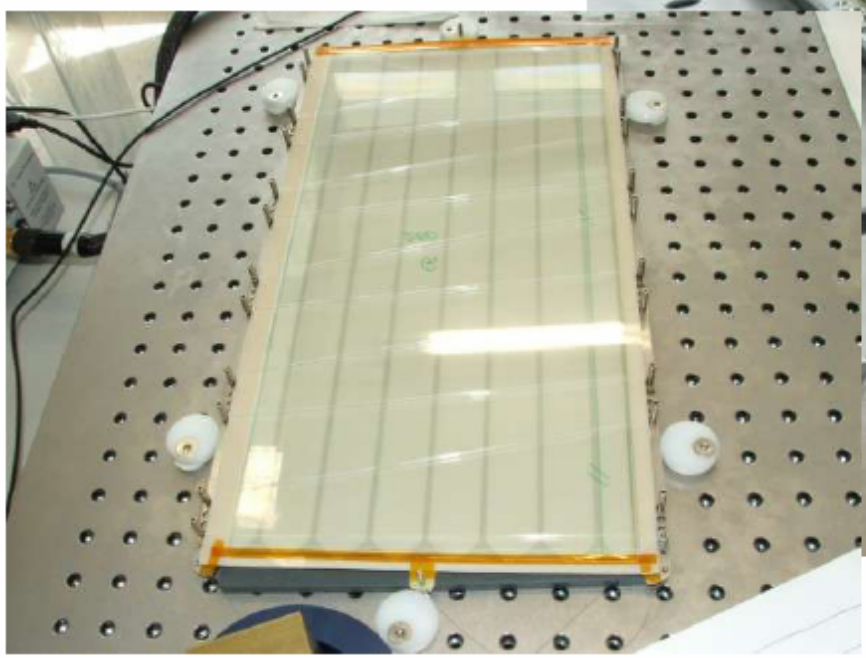
Spacer (Fishing Line)

GAS ~ 98,5% $C_2H_2F_4$ + 1% SF_6 + 5% iso – C_4H_{10}

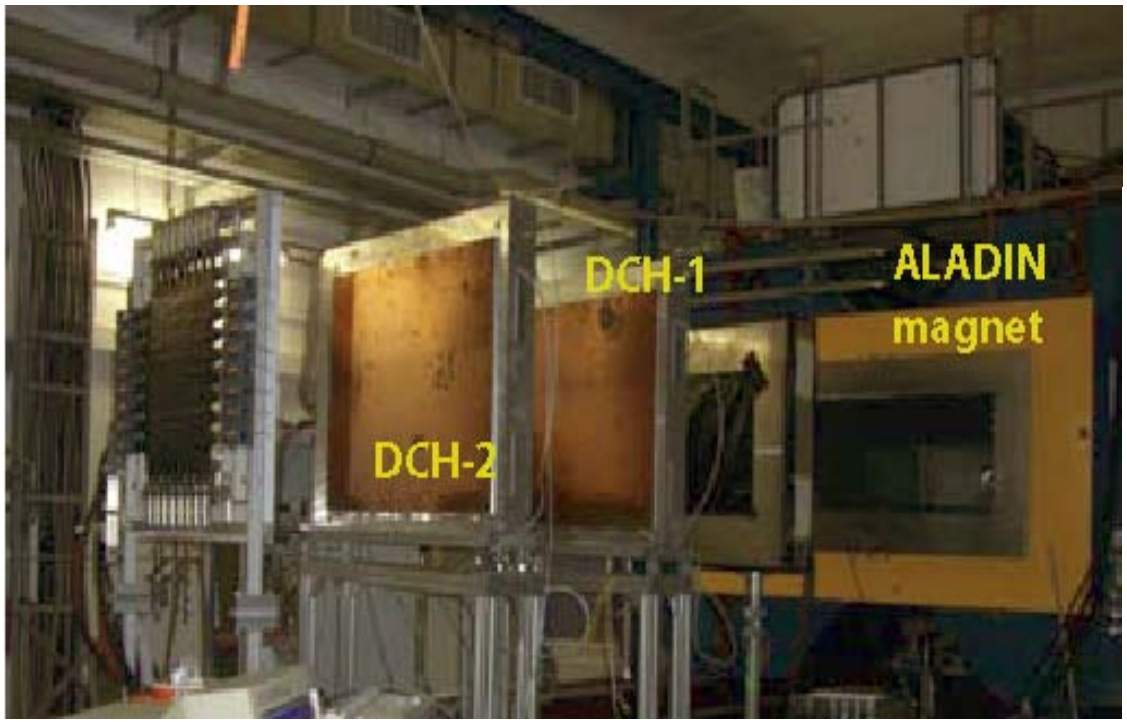
Kapton

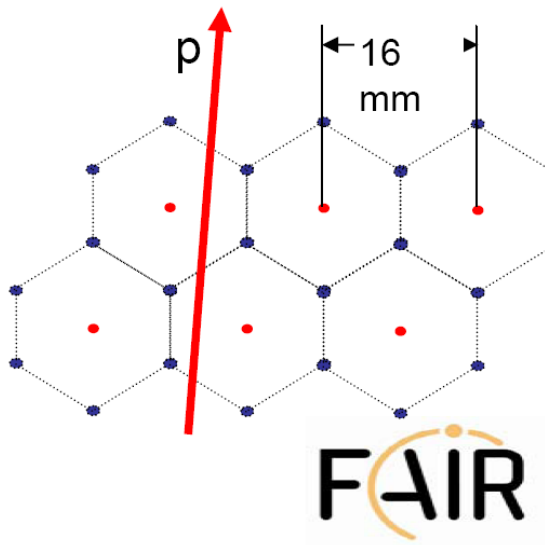
MRPC prototype developed and built at FZD: stack of glass plates





ПИЯФ уже внес свой вклад в **R3B** – две дрейфовые камеры гексагональной структуры для регистрации протонов, размером **1.2x0.8 м^2**, со считывающей электроникой **CROS3**. Каждая камера имеет 2 слоя ячеек X, и два слоя Y.
В настоящее время камеры успешно используются в эксперименте LAND.

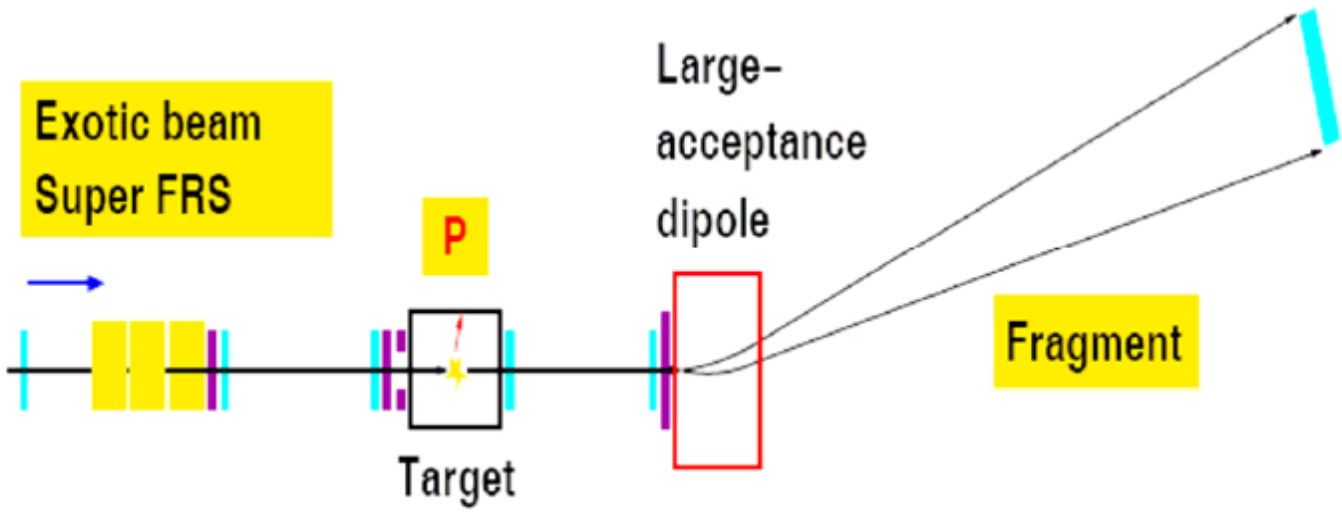




Наши камеры – DCH1 и DCH2

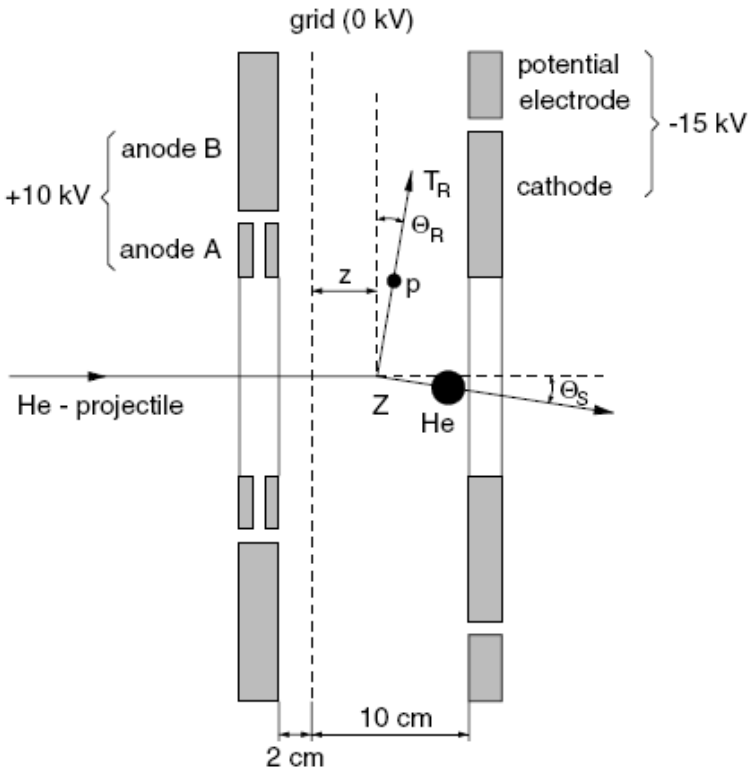
ACTAR

ACTAR at R3B

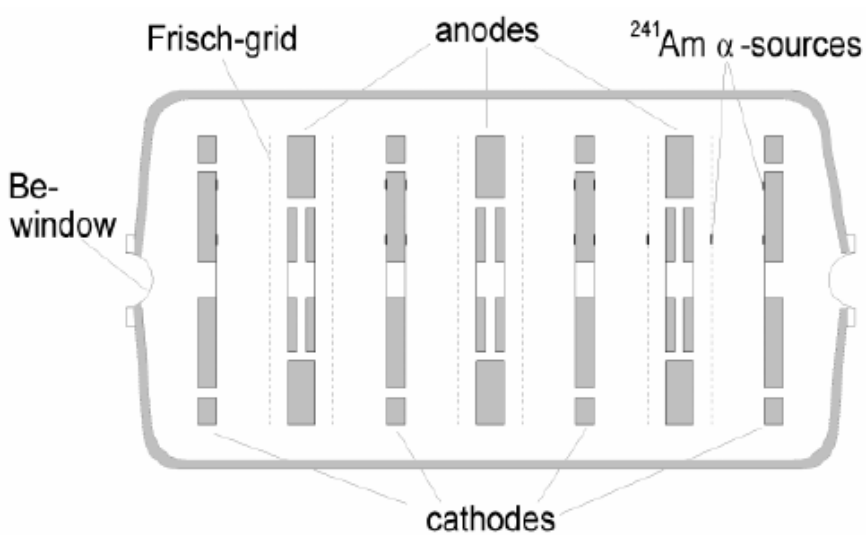


Preliminary study of $^{132}Sn(p,p)^{132}Sn$ at 700 A.MeV

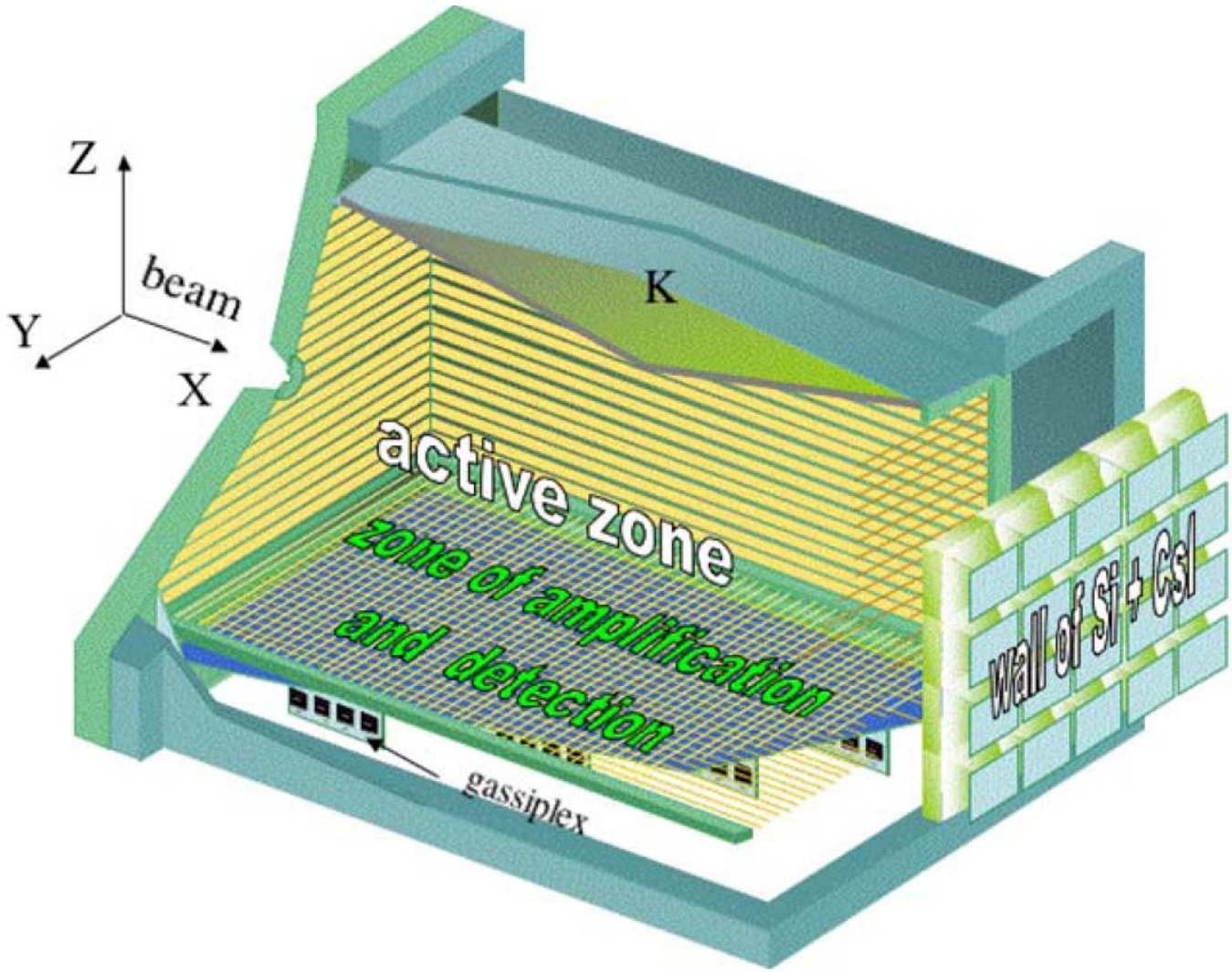
ACTAR


grid (0 kV)
potential
electrode
-15 kV
anode B
+10 kV
anode A
cathode
T_R
Θ_R
z
p
He - projectile
Z
He
Θ_S
10 cm
2 cm

IKAR


Frisch-grid
anodes
^{241}Am α -sources
Be-
window
cathodes

ACTAR


Z
beam
Y
X
K
active zone
zone of amplification
and detection
gassiplex
wall of Si + CsI

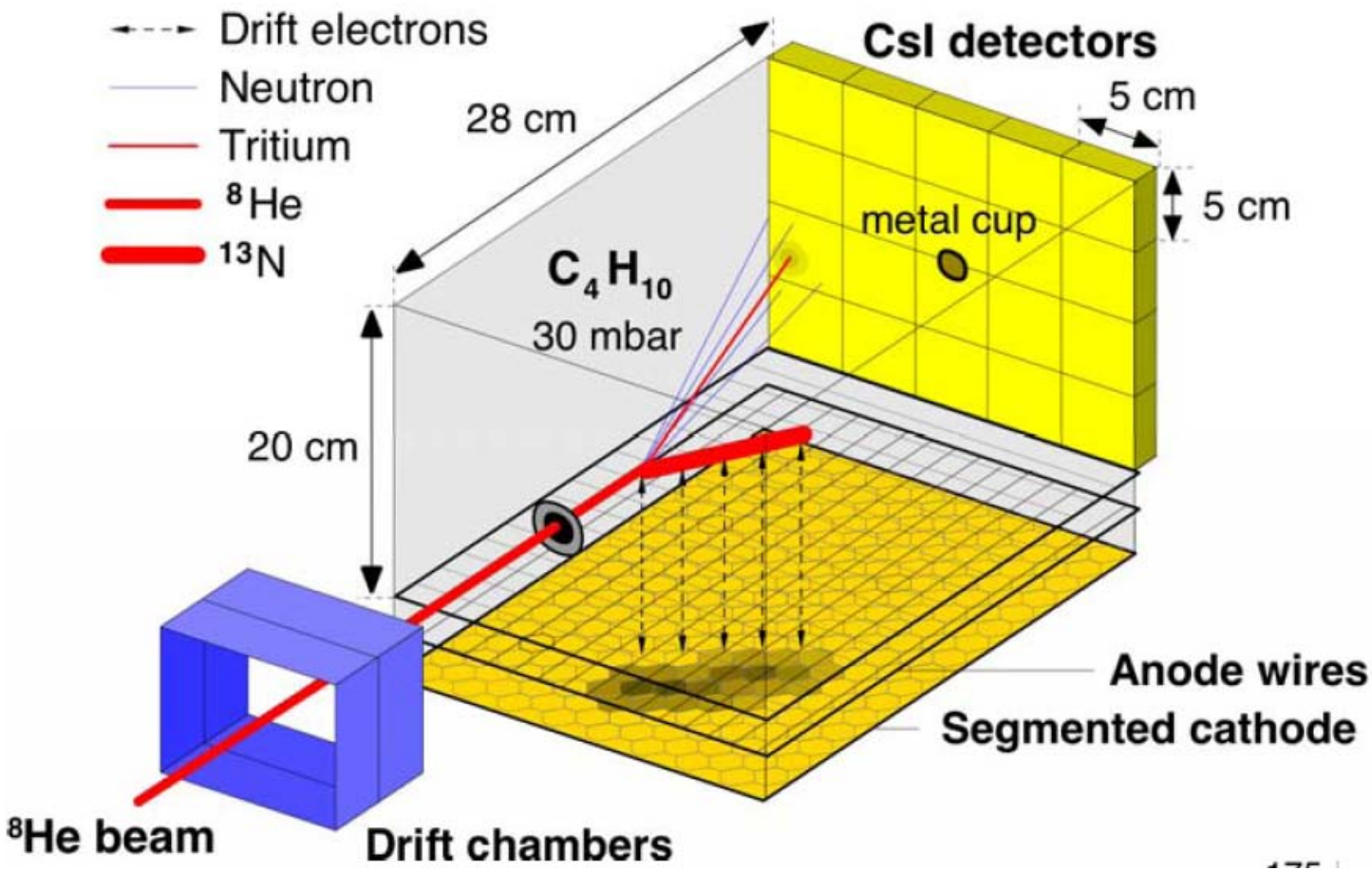
Resonance State in ^{7}H

MAYA: C. E. Demonchy *et al.* NIM A 583(2007) 341.

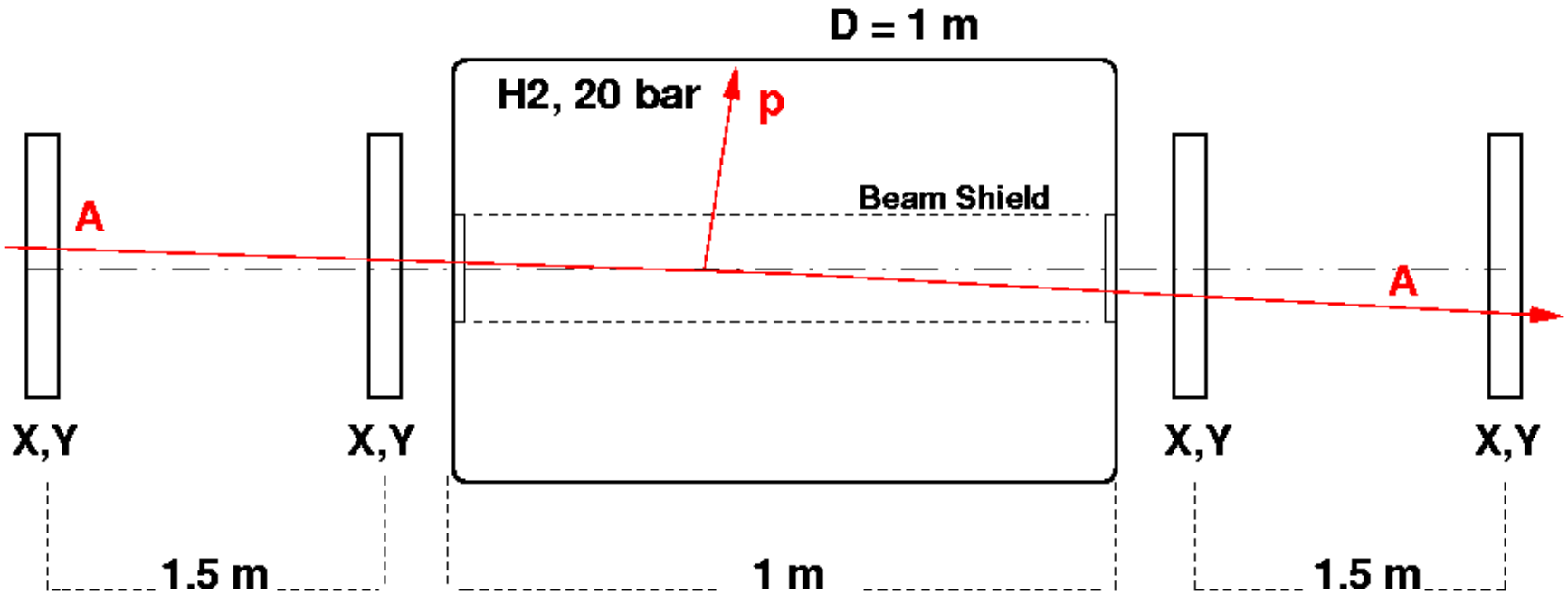
$^{8}He(^{12}C,^{13}N)^{7}H \rightarrow {}^{3}H+4n$

15.4 A MeV (SPIRAL)

H. Savajols *et al.*



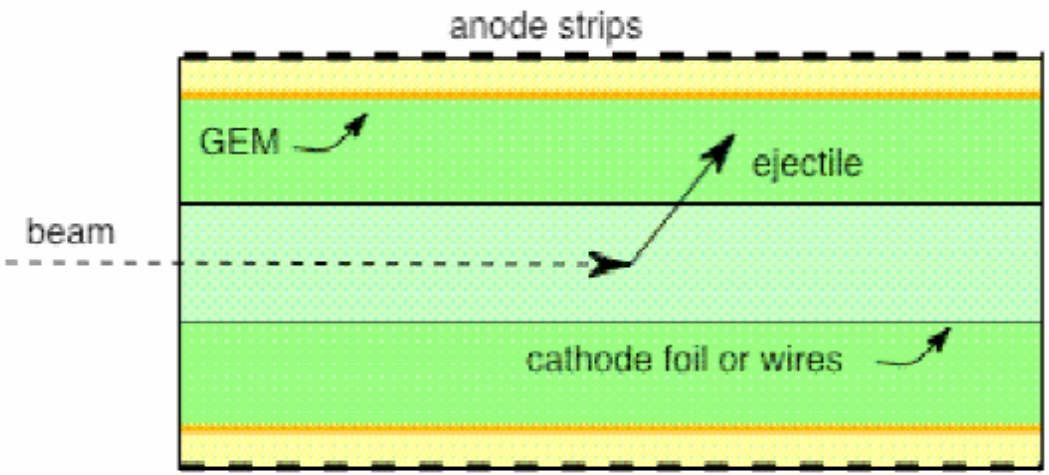
p,A elastic scattering scheme

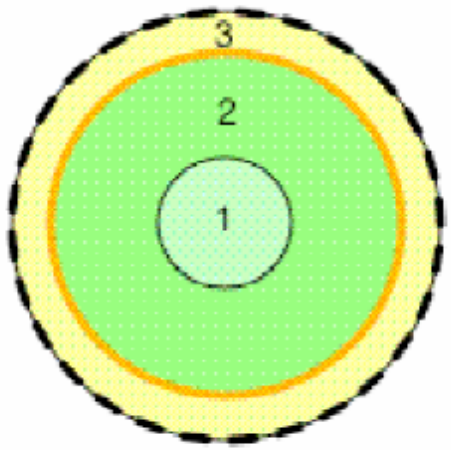


- Cylinder with Be windows 500 um
- Beam shield d = 2 cm
- Beam tracking + vertex reconstruction
- Pressure P in the range 10 to 20 bar

ACTAR

How is it going to work?





90% helium 10% CO2 gas mixture
Pressure of a few hundred mbar
Drift voltage ~100V/cm

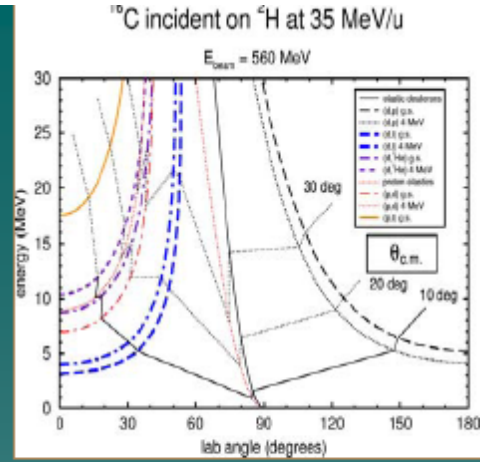
3-D Reaction Reconstruction

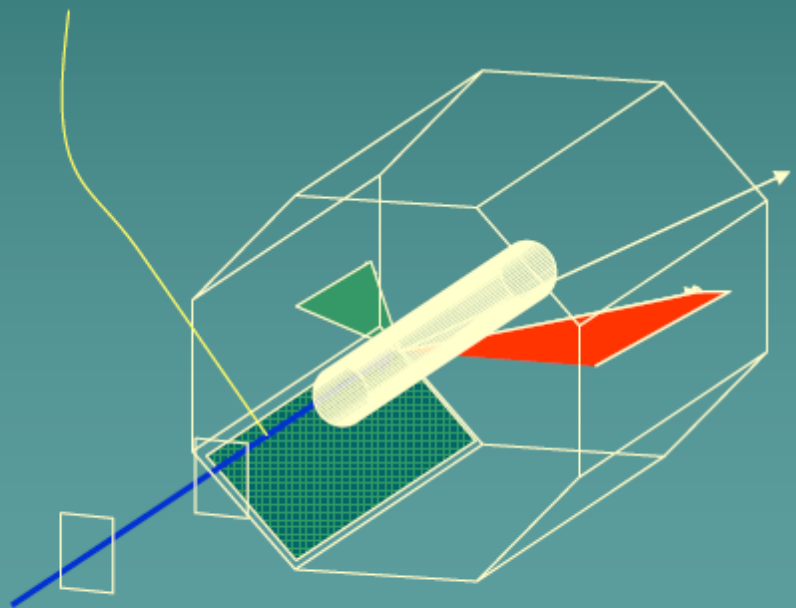
A cylindrical Symmetry – 4π eff.

Axial Magnetic field Possible

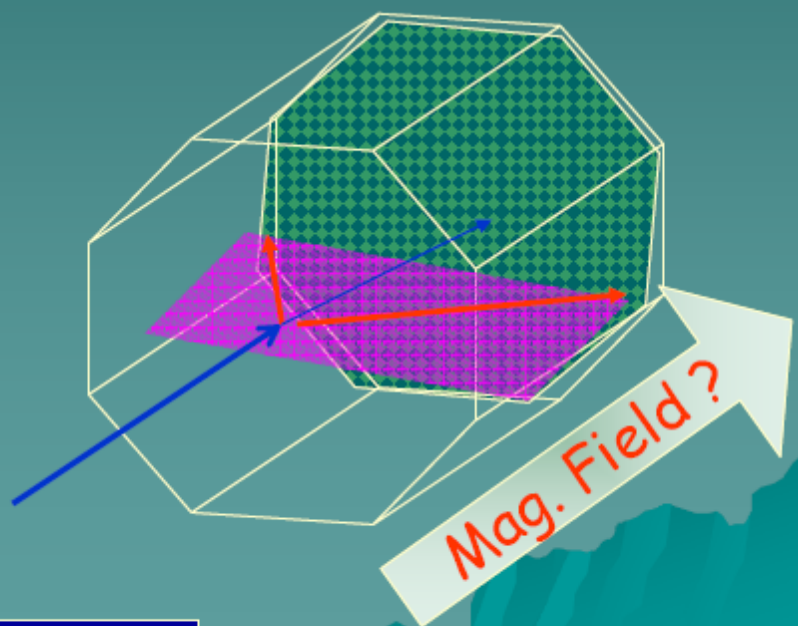
Beam 'insensitive' via cage

MICROMEGAS PLATES Detectors 8



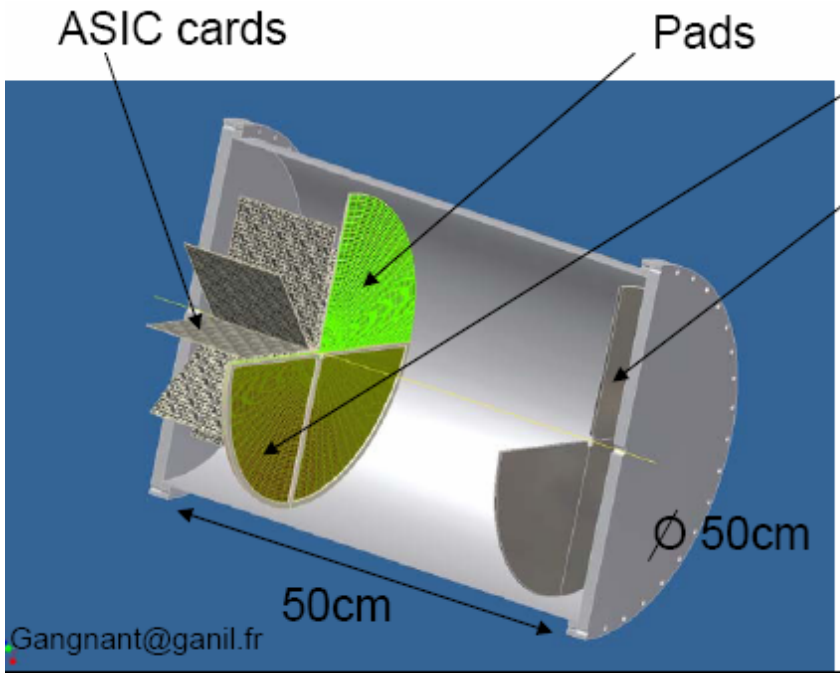


Sidways Reactions



For / Back wards focused reactions

ACTAR



Symmetry around the beam axis
E // beam axis, uniform
Projection on the endcap of the cylinder
B // beam axis

Quantities to be measured:
Curvature radius, collected charge, range, angles.
For 0.5 mm position resolution, $\Delta E/E=2\Delta R/R$,
expected energy resolution≈100 keV for θ_{cm}>20°