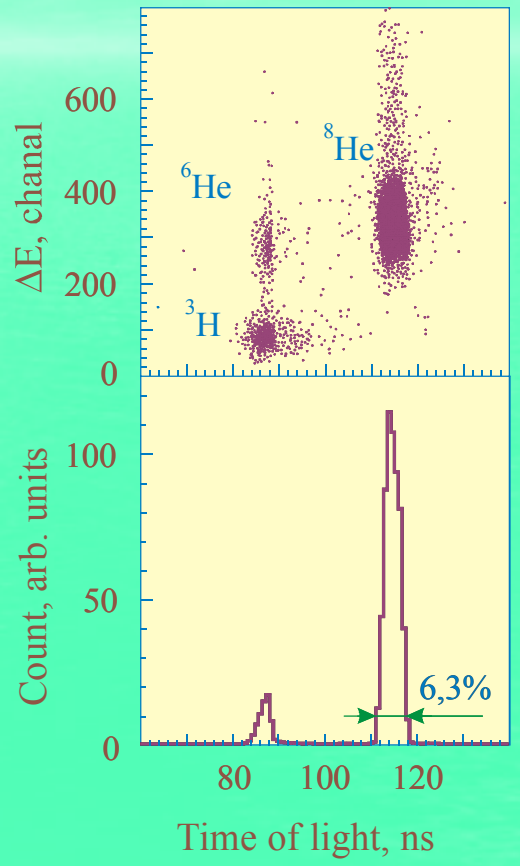
Position sensitive detector array for radioactive ion beam experiments

A.M.Rodin, A.S.Fomichev, S.V.Stepantsov, M.S.Golovkov, S.I.Sidorchuk, R.S.Slepnev, V.A.Gorshkov, A.V.Gorshkov, S.Krupko, M.L.Chelnokov, G.M.Ter-Akopian, R.Wolski, N.Zamiatin.
FLNR, JINR, Dubna, Russia

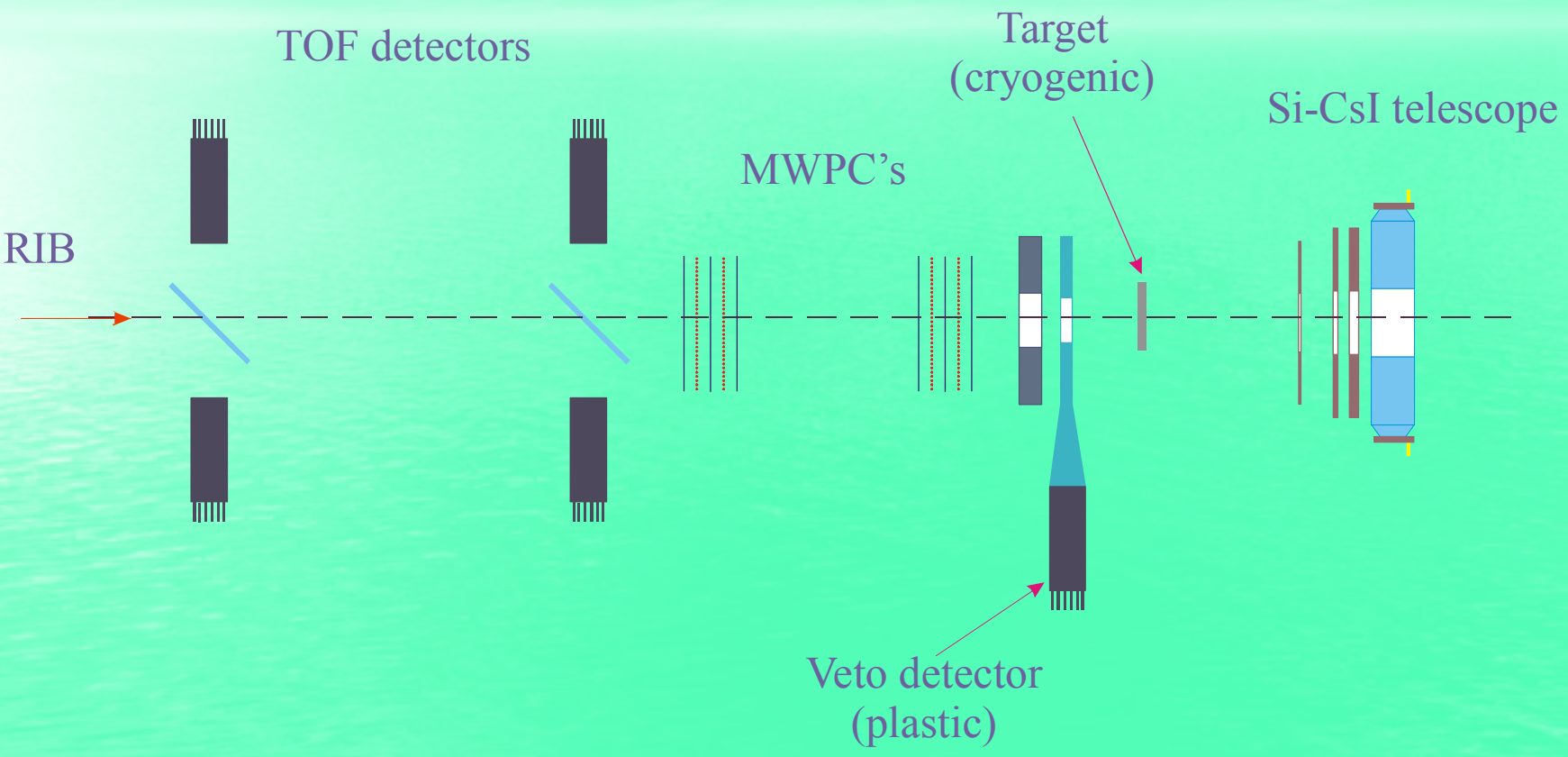
S.A.Golubkov, N.N.Egorov, K.A.Konjkov, A.I.Sidorov.
RIMST/ELMA, Zelenograd, Russia

Typical radioactive ion beam parameters

Beam sport diameter on a target	1-2 cm
Angular spread	1-5 degree
Momentum spread	3-8%
Beam contamination	10-20%
Typical beam intensity	$< 5\times10^5$ pps



Detector array for radioactive ion beam experiments of the separator ACCULINNA



Main parameters of MWPC's

Mechanical

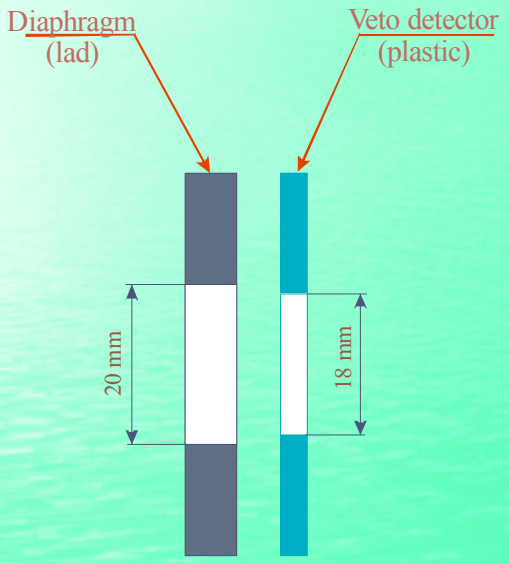
Number of wires for each plane – 32
Distance between planes – 5 mm
Step between wires – 1.25 mm
Entrance windows – capton 40 μm

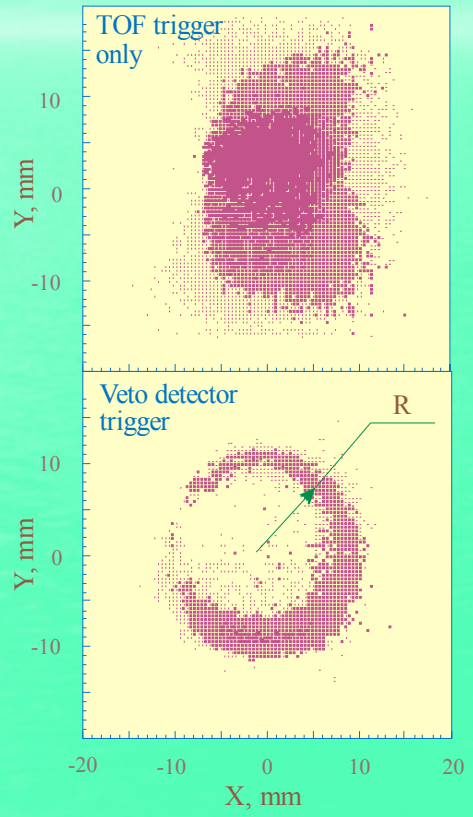
Physical

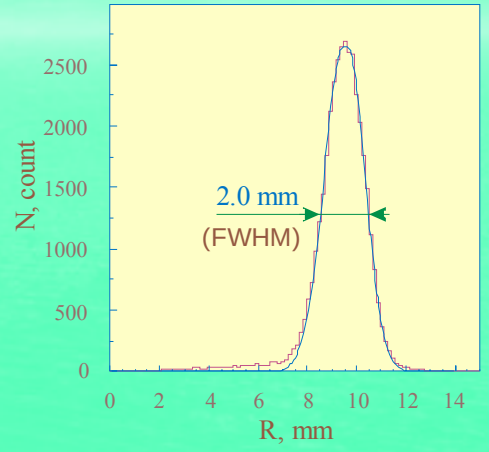
Operating gas – Ar+CH4(20%)
Operating pressure – 1 bar
Efficiency for 2 MWPC - >95% *)
Dead time - <300 ns

*) measured for ^{8}He at the energy >200 MeV

Position resolution of MWPC's obtained in a plane located near the target







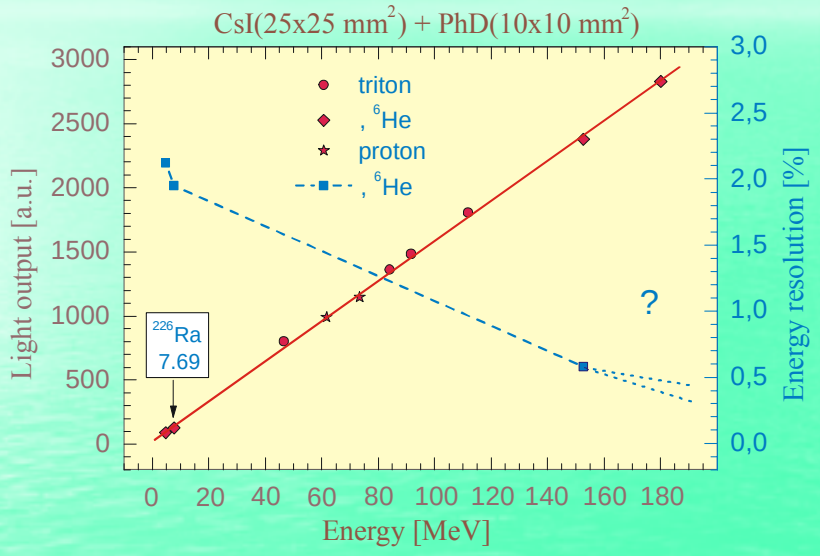
Step between wires is 1.25 mm => position resolution on Veto detector is 1.5 mm

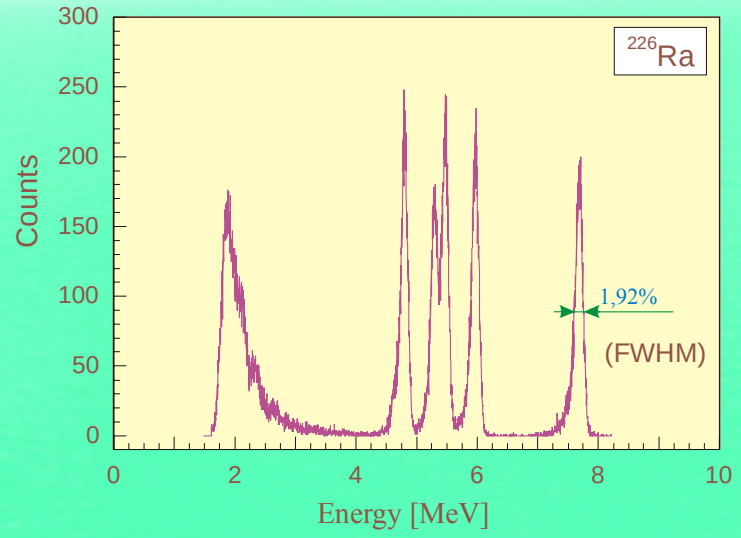
The specification of the silicon detectors for the position sensitive detector array

Silicon technology, design	Thickness, μm	Active dimension, cm^2	Number of strips	Operation voltage, V	Dark current (total), μA
Single side totally depleted silicon planar ion implanted structure on N. Trapezoid design.	40	5.3	-	<10	<0.1
Double side totally depleted silicon planar ion implanted structure P on N. Ring design.	300	62	32 rings, 64 sectors	60-100	<0.5
Single side totally depleted silicon planar ion implanted structure P on N. Ring design.	1000	62	64 sectors	500-600	<1.0

The energy resolution is characterized by 50 and 100 keV full widths at half maximum obtained for 5.5 MeV α peaks, respectively, with the 300 and 1000 μm Si detectors and with the 40 μm Si detectors.

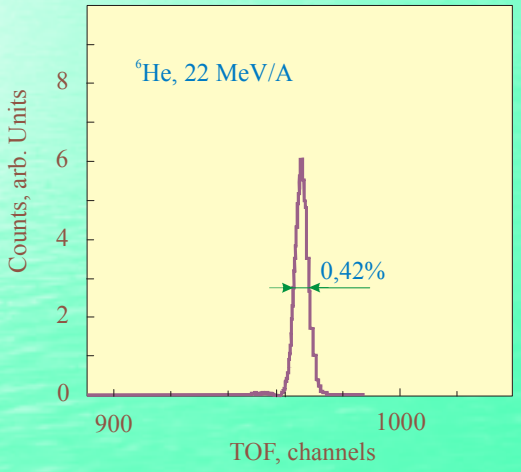
Energy resolution and light output of CsI detectors



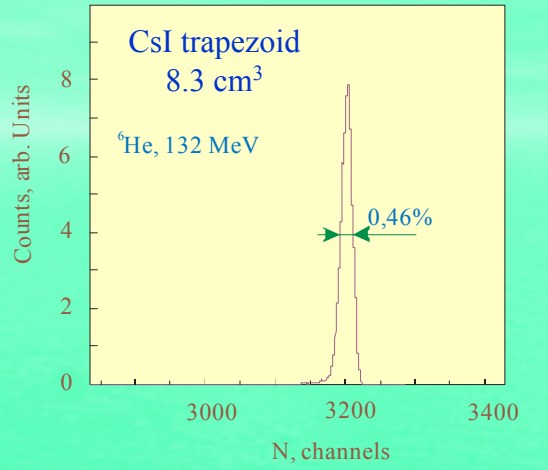


Energy resolution of CsI detectors

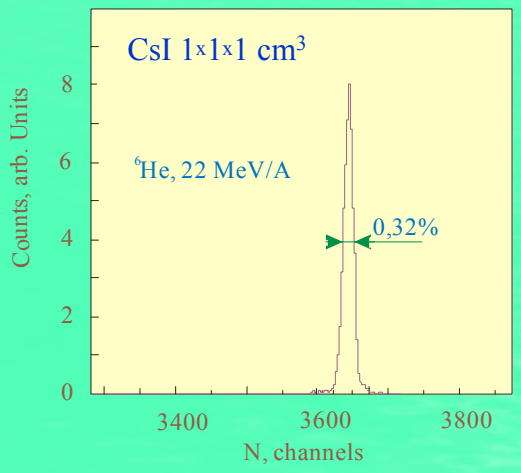
Energy spread of the ^{6}He beam was $\Delta E/E \sim 2.2 \times 10^{-3}$ (E=132 MeV)



Energy resolution of CsI (own) is $\Delta E/E \sim 4.0 \times 10^{-3}$

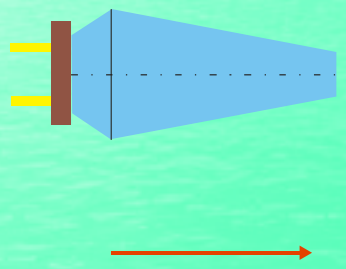


Energy resolution of CsI (own) is $\Delta E/E \sim 2.3 \times 10^{-3}$

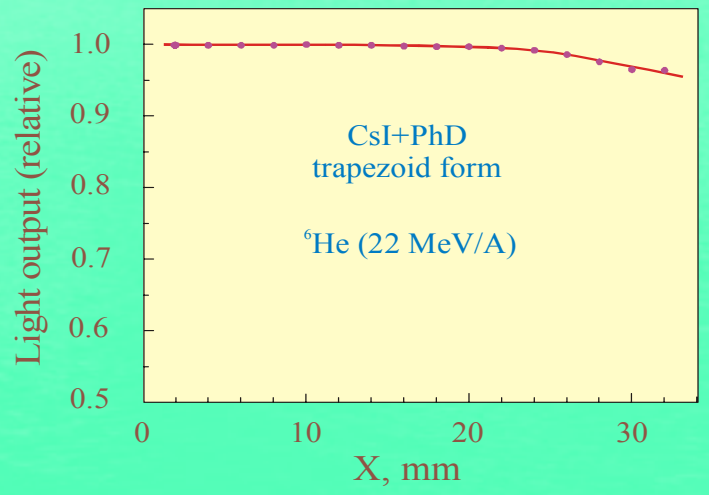


Position dependence of the light output for the CsI trapezoid detector

Measurement was performed by silicon strip detector placed before CsI



X direction



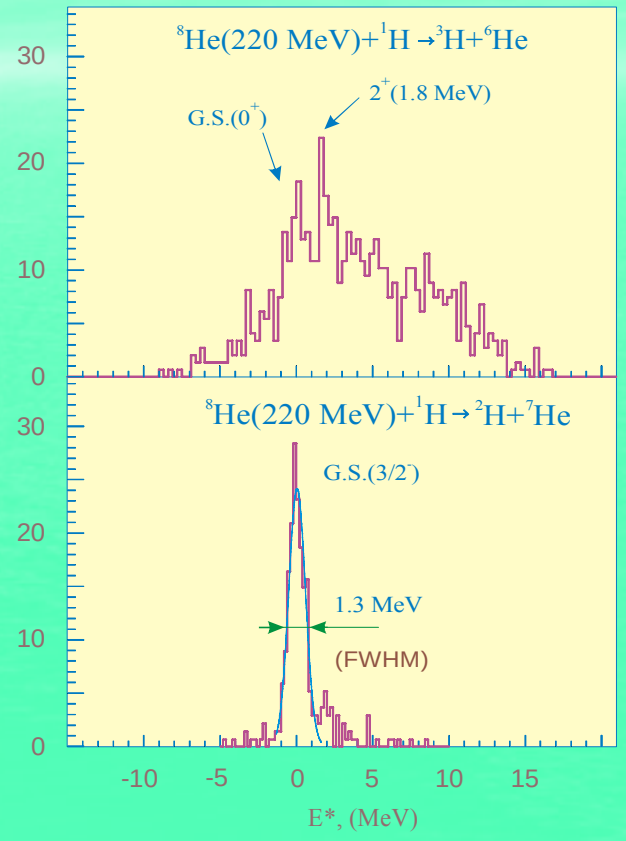
Parameters of CsI+PhD detectors

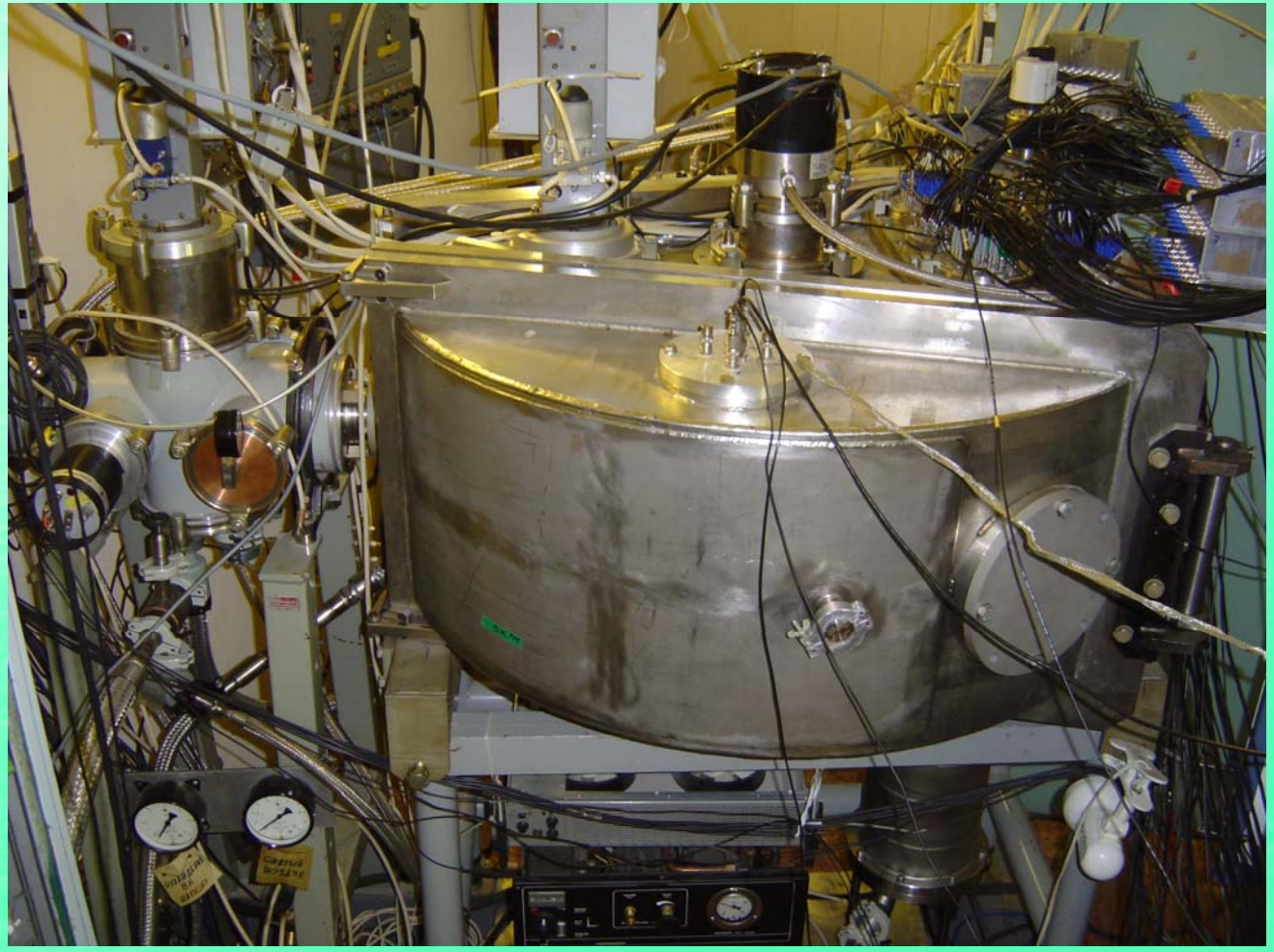
CsI cjnfiguration (mm^3)	Design of PhD (mm^2)	Light output (relative)	Position sensitivity of the light outpuit	Energy resolution (E_α=7.7 MeV)	Energy resolution for E(^{6}He)=132 MeV)
10∗10∗10	10.5∗11.5	100%	<0.3%	1.7%	<0.3%
20∗20∗15	10.5∗11.5	65%	<0.5%	2.0%	0.6%
25∗25∗25	10.5∗11.5	70%	<0.4%	1.9%	0.5%
25∗25∗50	21∗21	68%	<0.5%	2.1%	<0.6%
25∗25∗100	21∗21	60%	<0.5%	2.2%	~0.6%
Trapezoid (8.3 cm^3)	10.5∗11.5	88%	<4.0%	1.8%	~0.4%

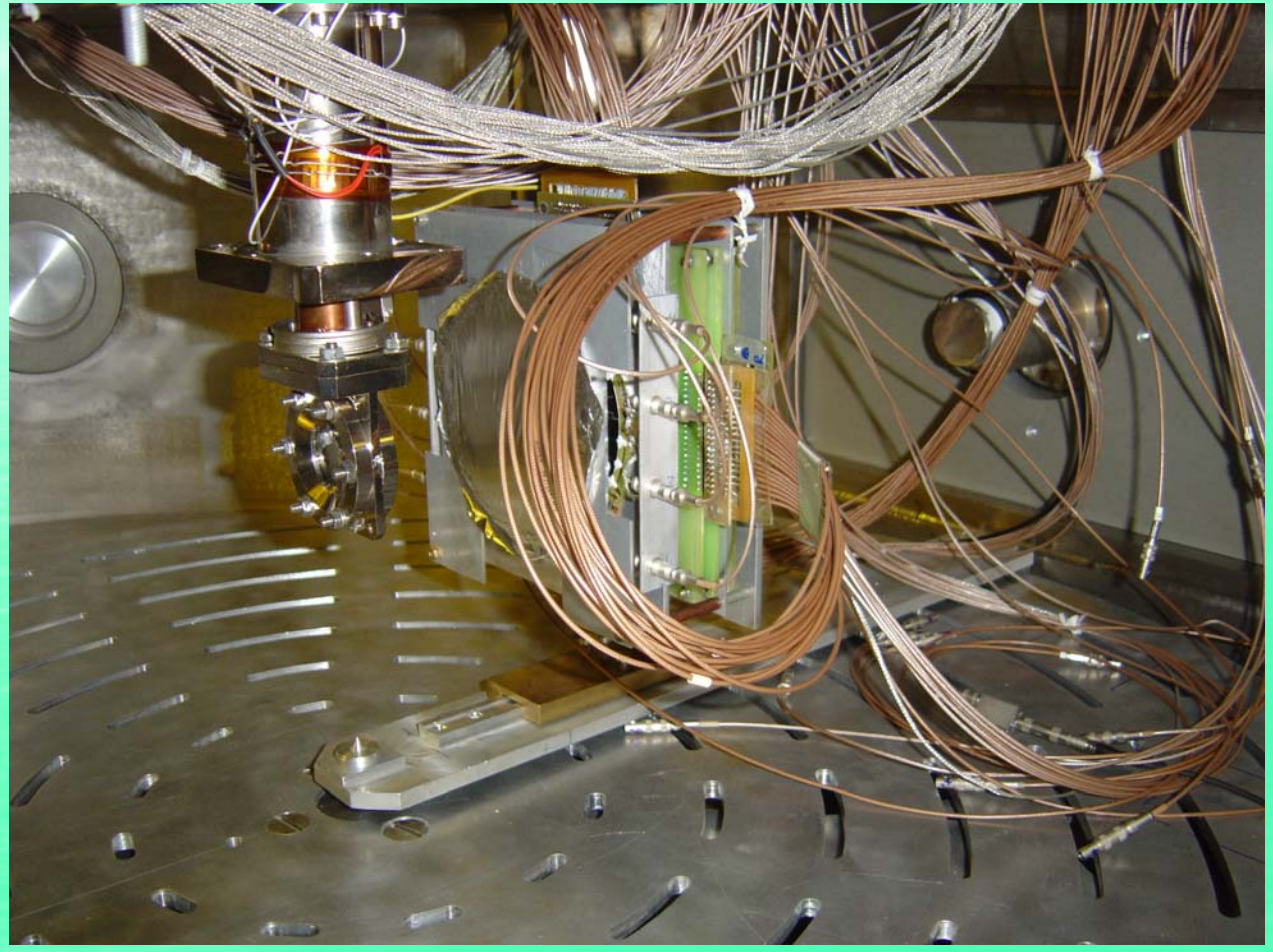
Examples of two reactions

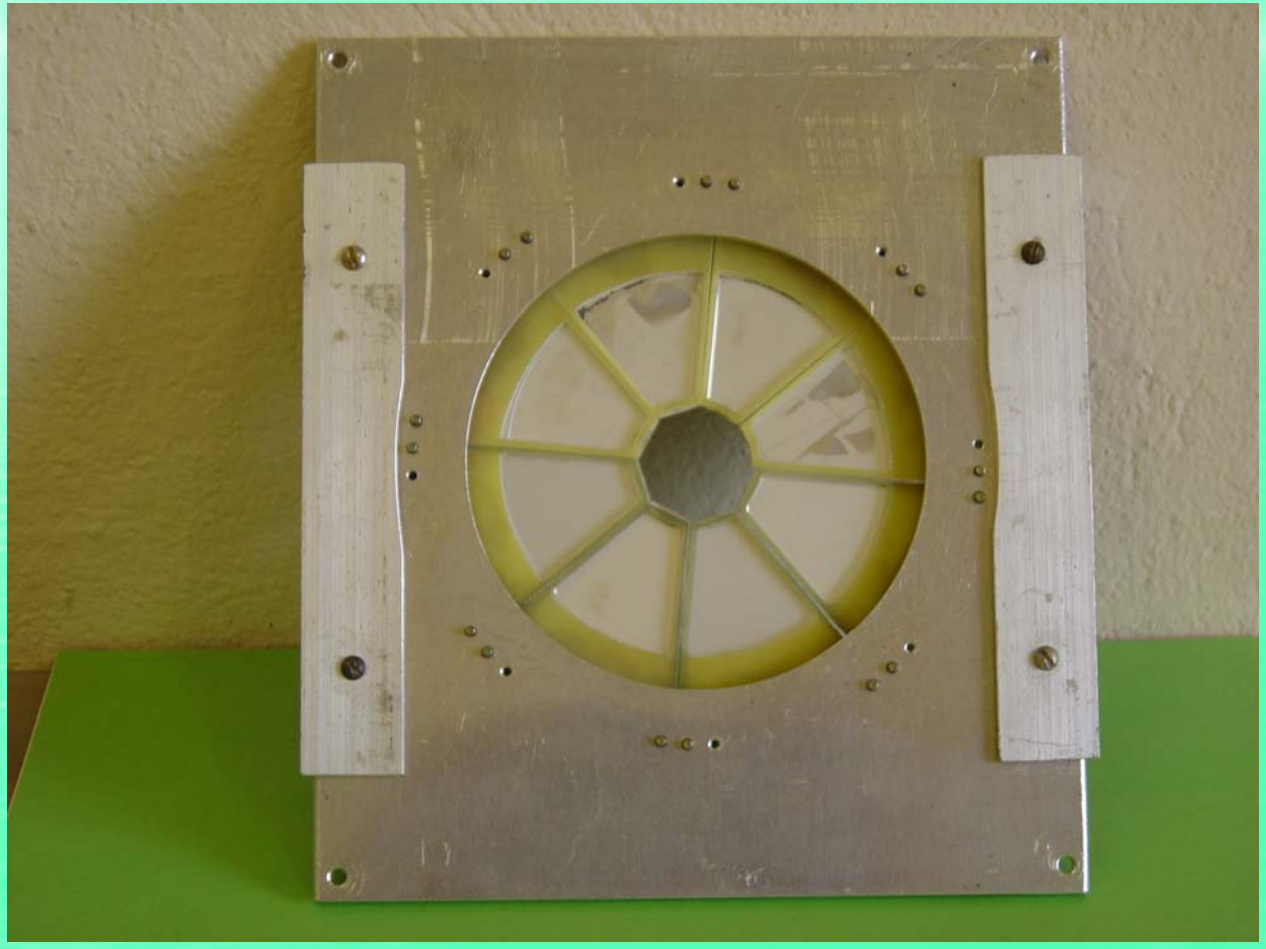
Measurement was performed by forward telescope at the experiment
$^{8}He+d \rightarrow {}^{7}H+{}^{3}He$

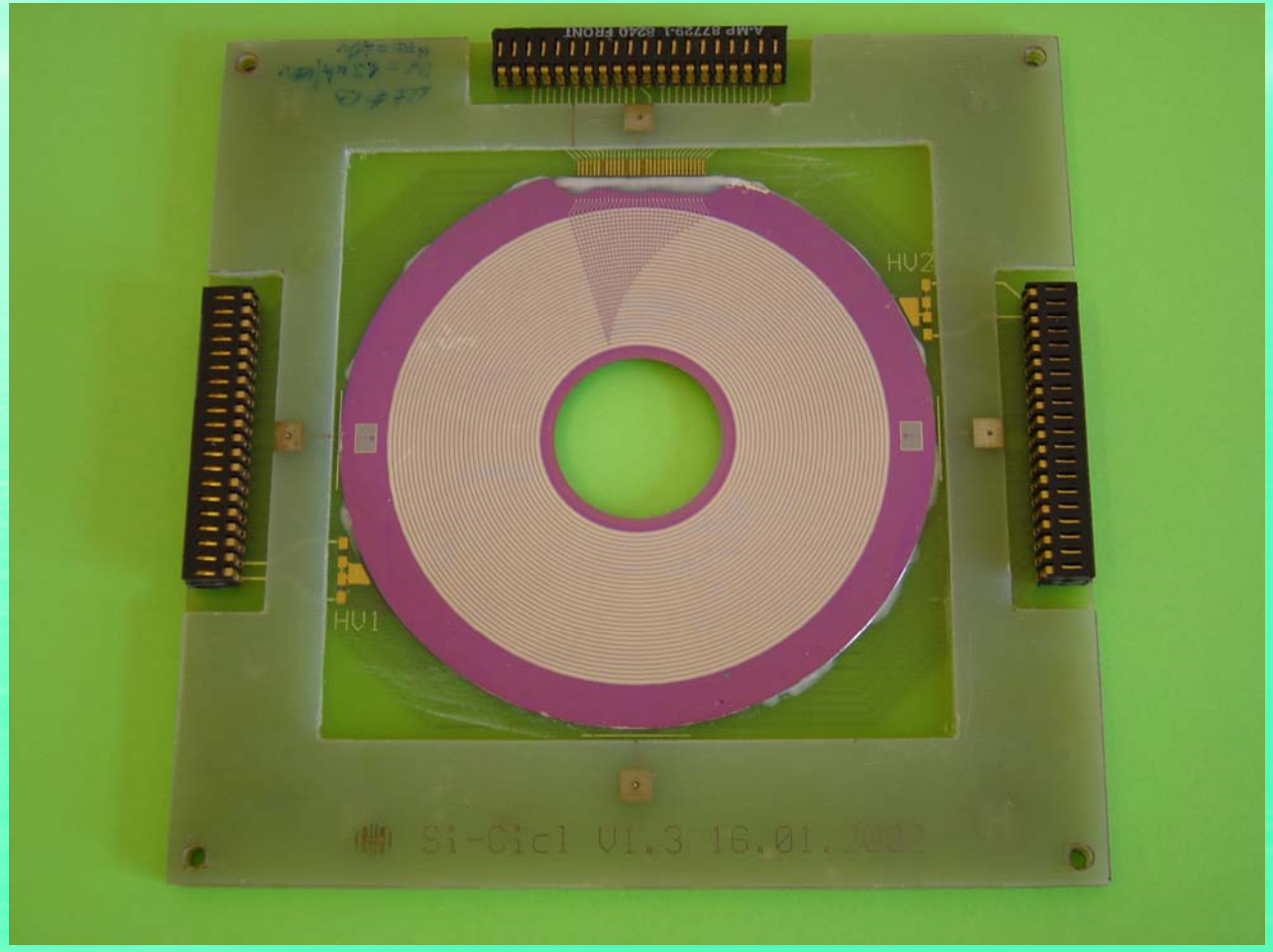
These two reactions was measured as a test of the detector set up

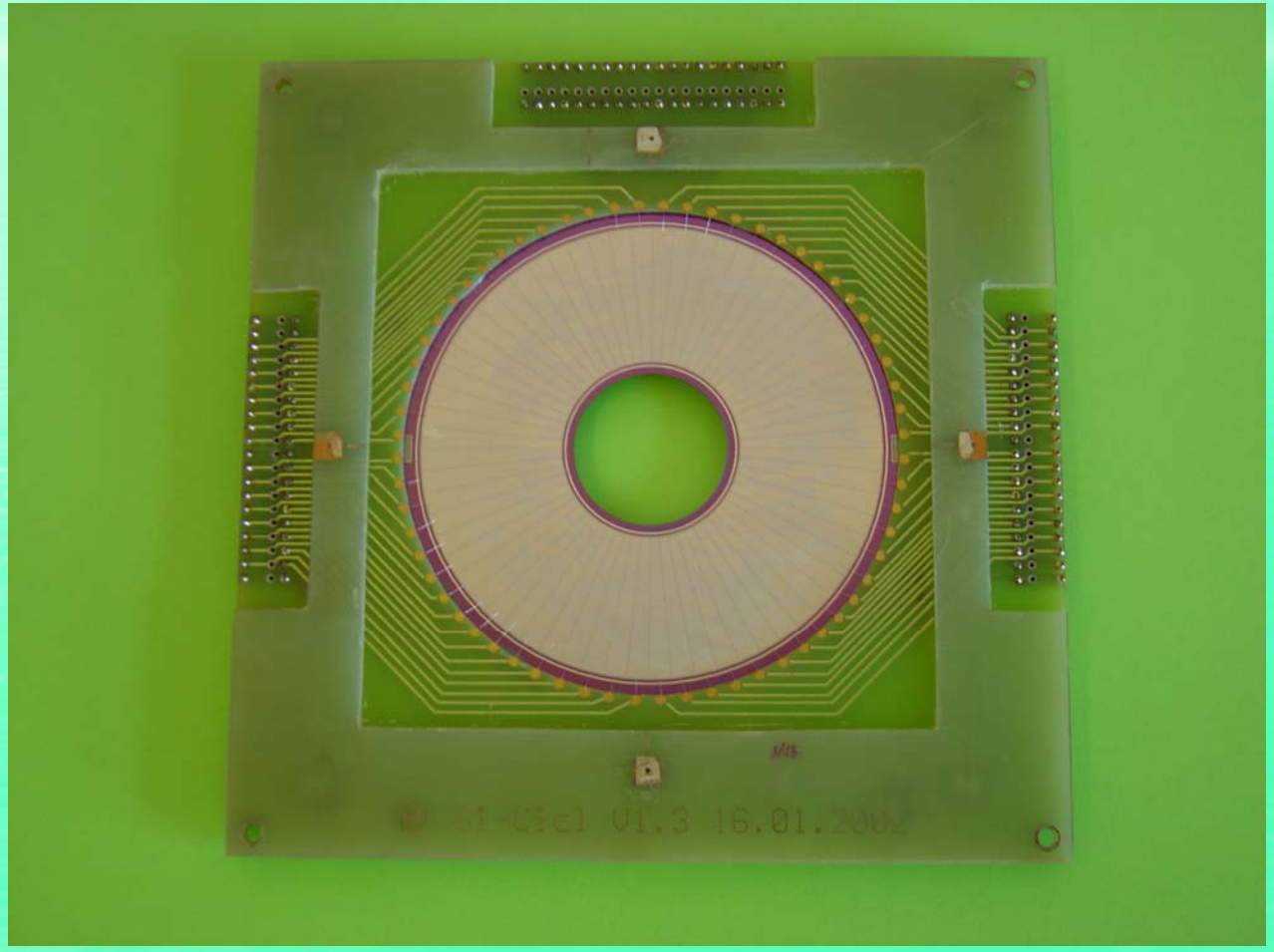









HV2
HV1
Si-Cicl V1.3 16.01.2002


Si-Ciel V1.3 16.01.2002


MM 1 2 3 4 5 6 7 8 9 10 11 12

Conclusion

- Position sensitive detector array built for the work with the beam of radioactive nuclei delivered by the separator ACCULINNA. Detector array has TOF detectots, two MWPC's and silicon - CsI of charge particle telescope.

- The two MWPC's working together provide for a 95 % detection efficiency for the beam nuclei of ^{6}He and ^{8}He. These chambers can deal with a maximum beam intensity approaching 5×10^{5} pps. Position resolution on a target is 1.5 mm.

- By means of the telescope one can well detect and identify nuclei with atomic numbers from Z=1 to Z=6 having energy in a range from 1.5 to 70 MeV/A.

- Energy resolution of CsI+PhD detectors is equal 0.5% for the ^{6}He at energy 132 MeV. It opens a good perspectives for quasi-free scattering experiments.