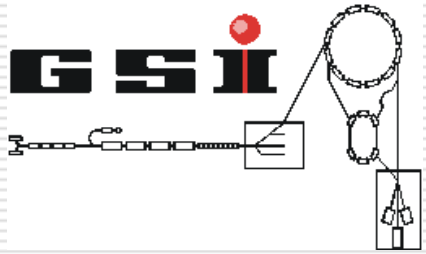
Ideas around the EXL recoil detector

O. Kiselev

Gesellschaft für Schwerionenforschung, Darmstadt

Institut für Kernchemie, Johannes Gutenberg Universität Mainz

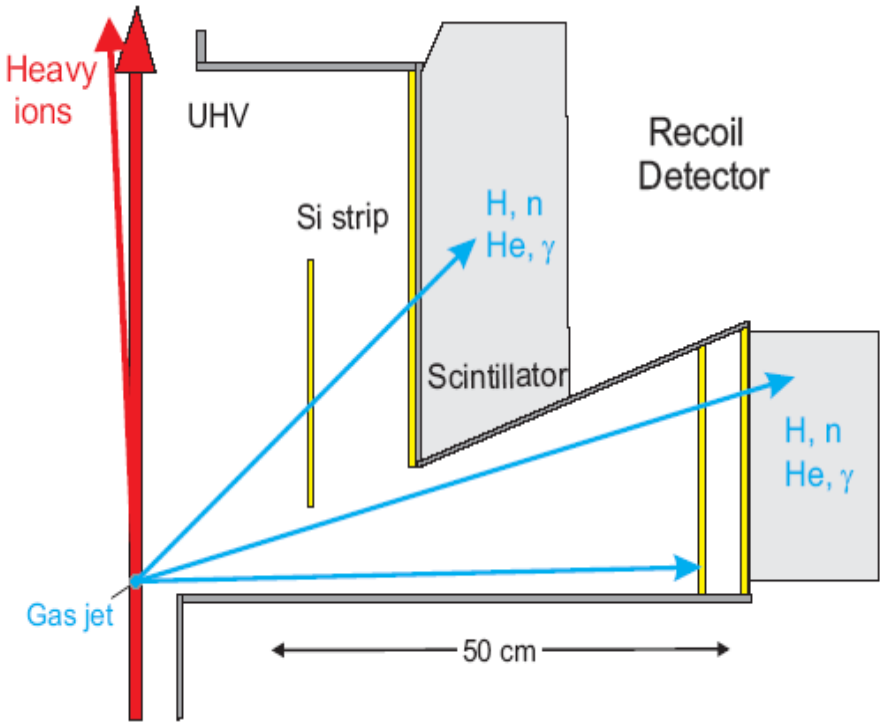


EXL collaboration meeting, University of Liverpool 22.06.04

Main goals

- ☑ *Elastic scattering*
- ☑ *Inelastic scattering*
- ☑ *Transfer reactions*
- ☑ *Charge-exchange reactions*
- ☑ *Quasi-free scattering*
- ☑ As more universal detector as possible
- ☑ Key parameters – very low energy threshold, high angular and energy resolution
- ☑ Recoil particles – from (few) 100 keV up to (few) 100 MeV

EXL recoil detector



Very preliminary scheme

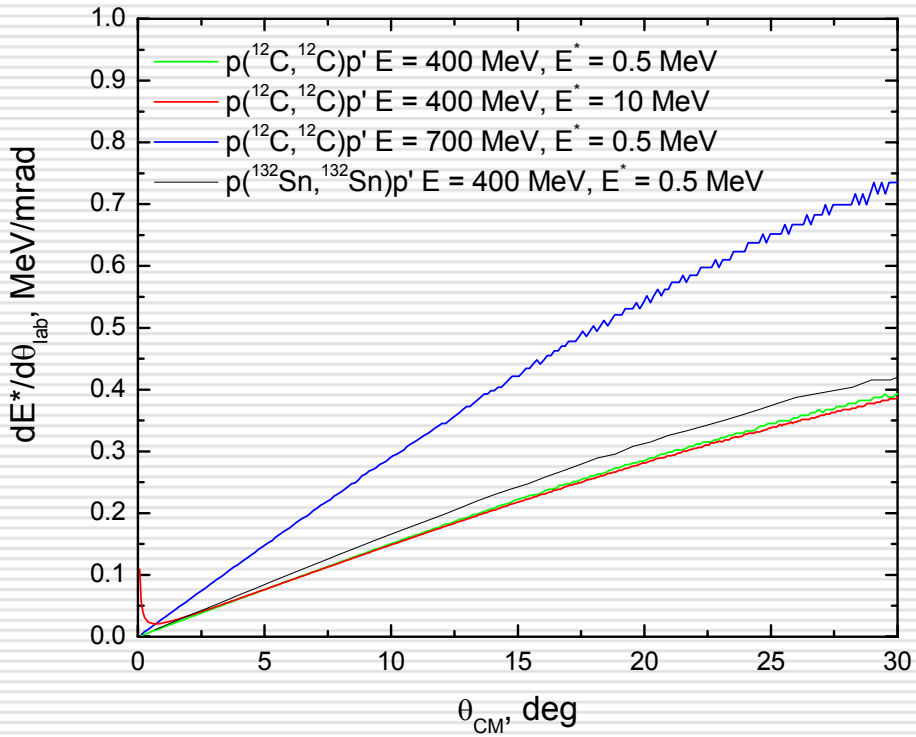
Energy, TOF, angle Measurements

Part of the setup – in UHV (10^{-9} -10^{-11} mbar)

Mostly solid state detectors

Low data rate per single detector, high – in total

Angular and energy resolution



From kinematics:

$\Delta E^* < 0.1$ MeV

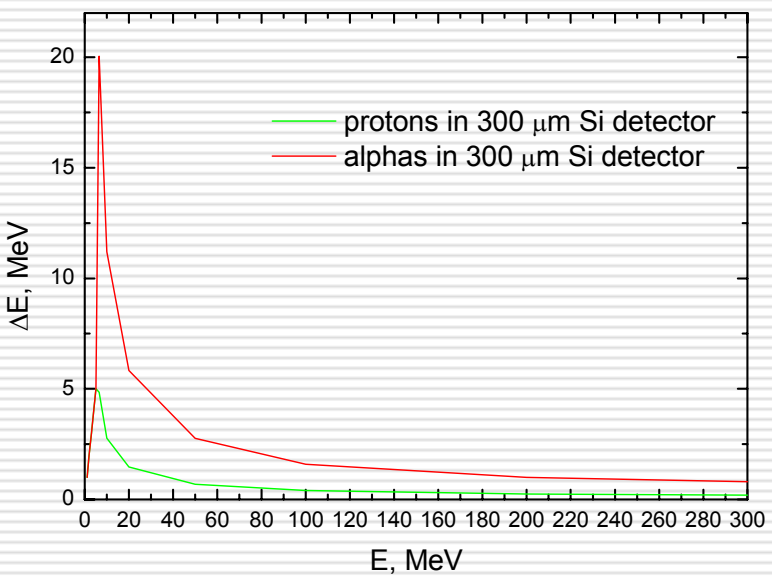
$\Delta\Theta_{CM}$ < few mrad

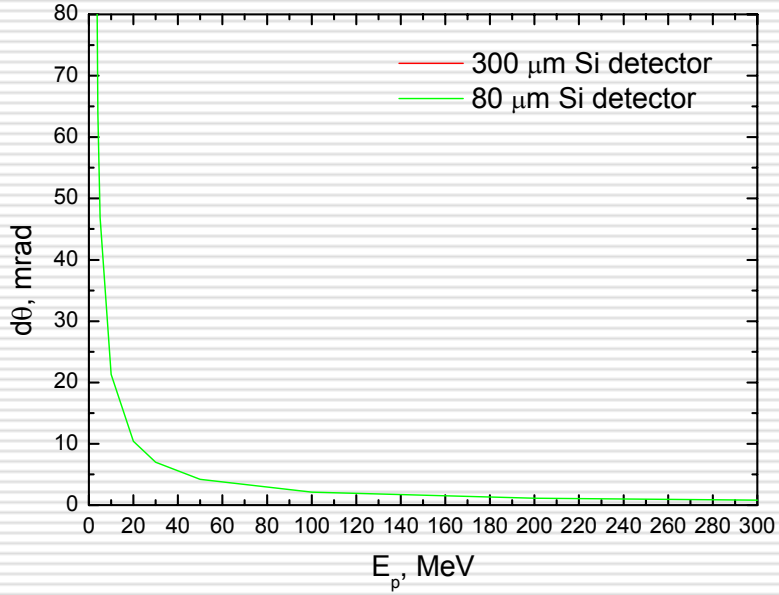
for recoils: $\Delta E_{lab} < 0.1$ MeV

$\Delta\Theta_{lab}$ < 1-2 mrad

Example of inelastic scattering

Dynamic range and multiple scattering

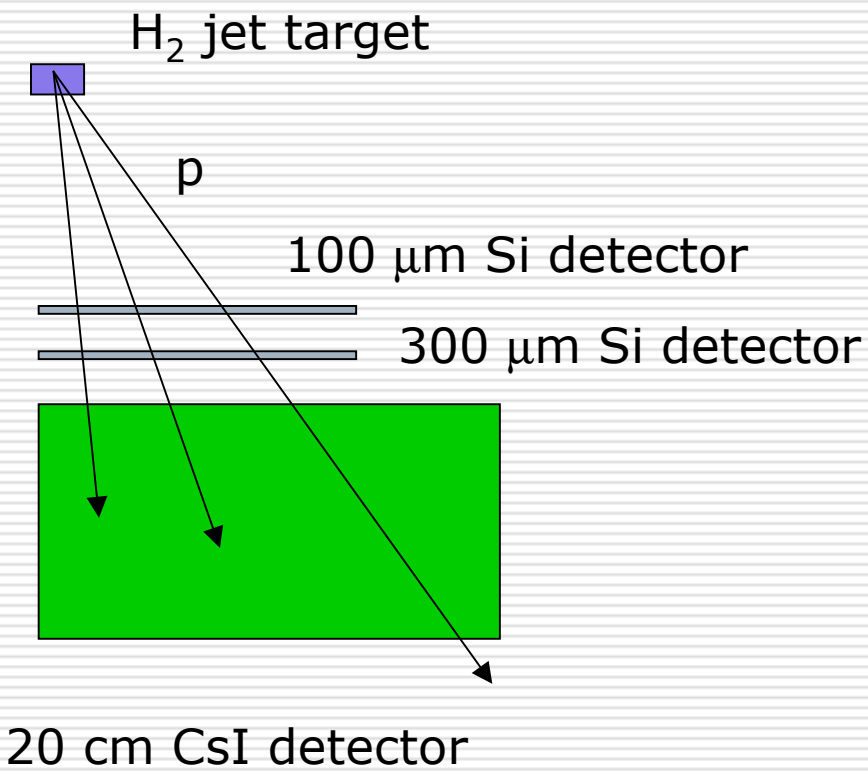




Electronics must have
quite high dynamic range –
up to 20 MeV for α-particles
Threshold – 50-70 keV (hopefully)
Dynamic range – 1:400

Only one layer of Si for protons
with E < 20 MeV
Thin detector for the first layer
in forward region

Detector geometry – GEANT4



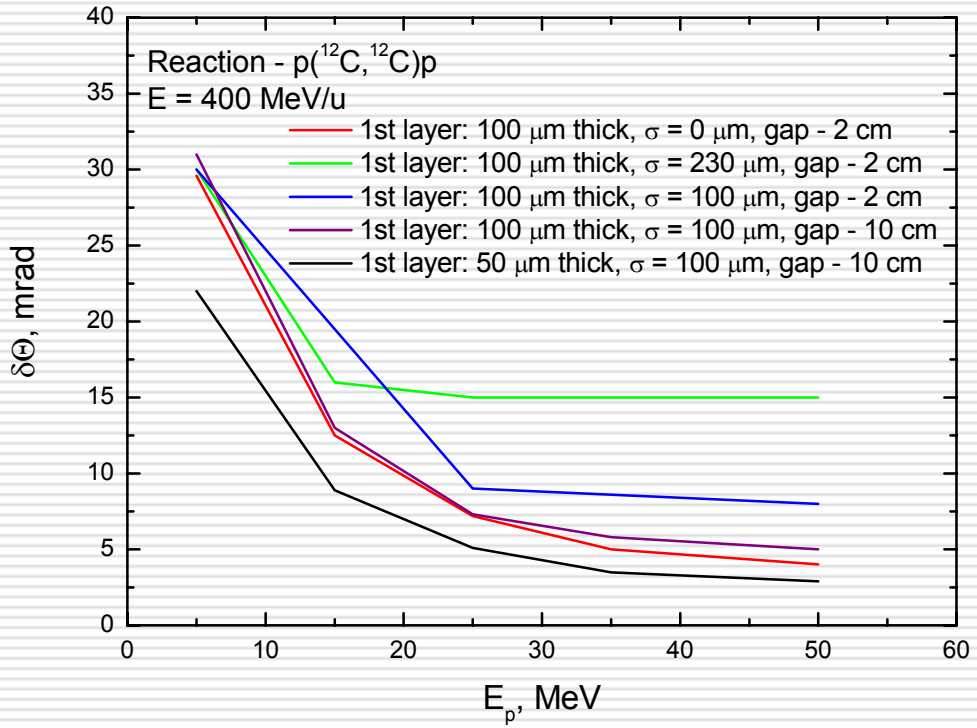
Jet target – Ø 5 mm, 1 mm height

Two layers of Si detectors – 30 and 32 cm from the target

CsI scintillator to measure total energy

Everything is in vacuum

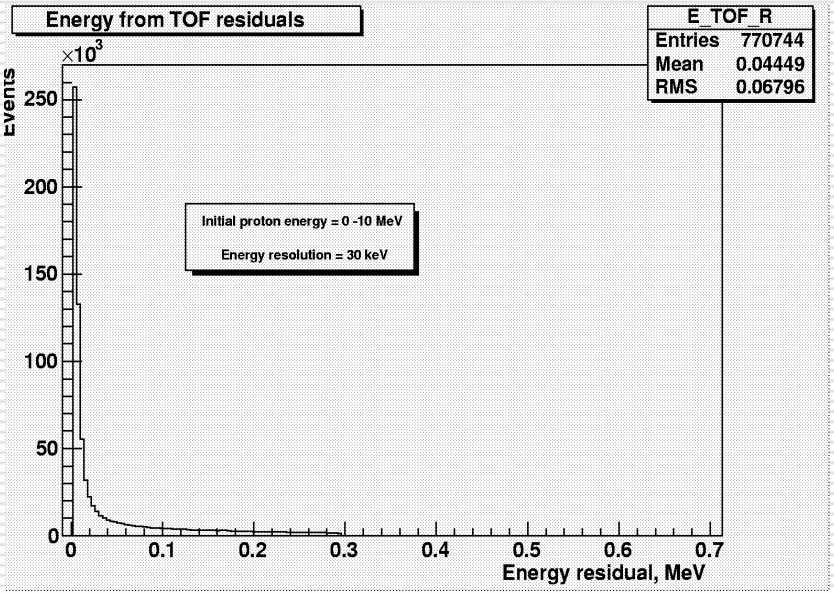
Simulated angular resolution

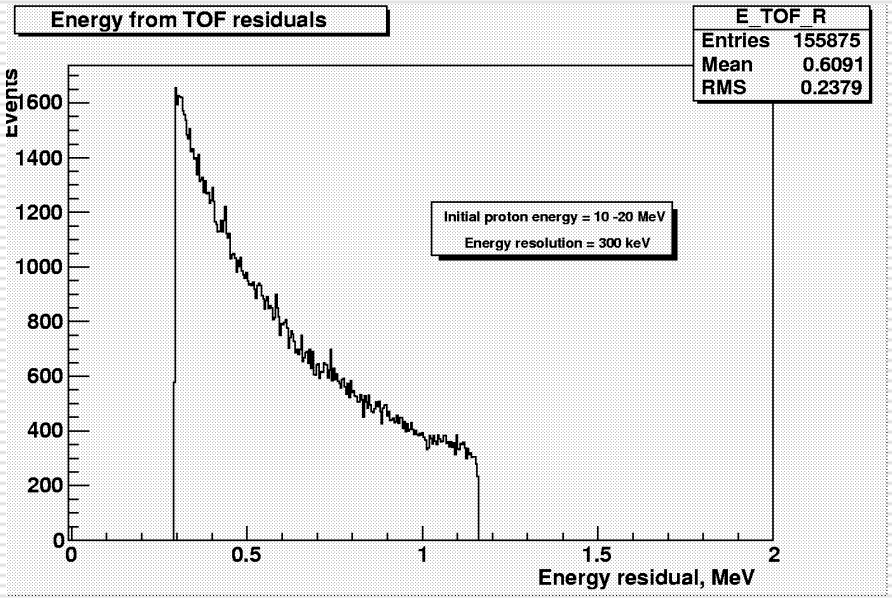


For E_p < 20 - 25 MeV – no first layer, tracking based on the size of interaction point (<2 mm) and position resolution of single Si detector

For E_p > 25 MeV first layer must be very thing (50 μm or less)

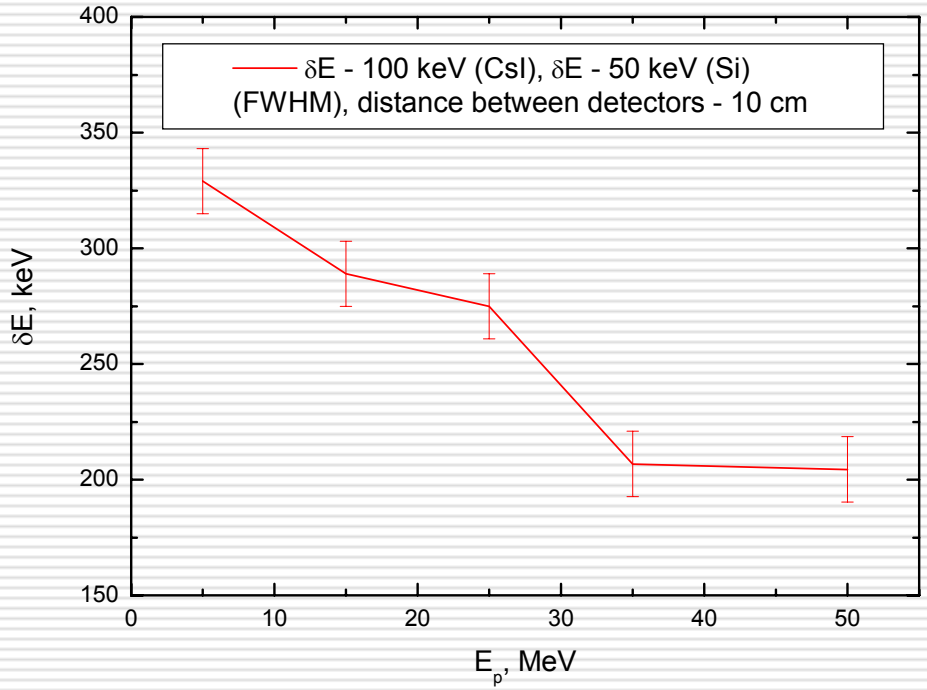
Simulated energy resolution (via TOF)





Time resolution of the detectors is not yet included
Energy via TOF is possible for very slow protons (0 – 10 MeV)

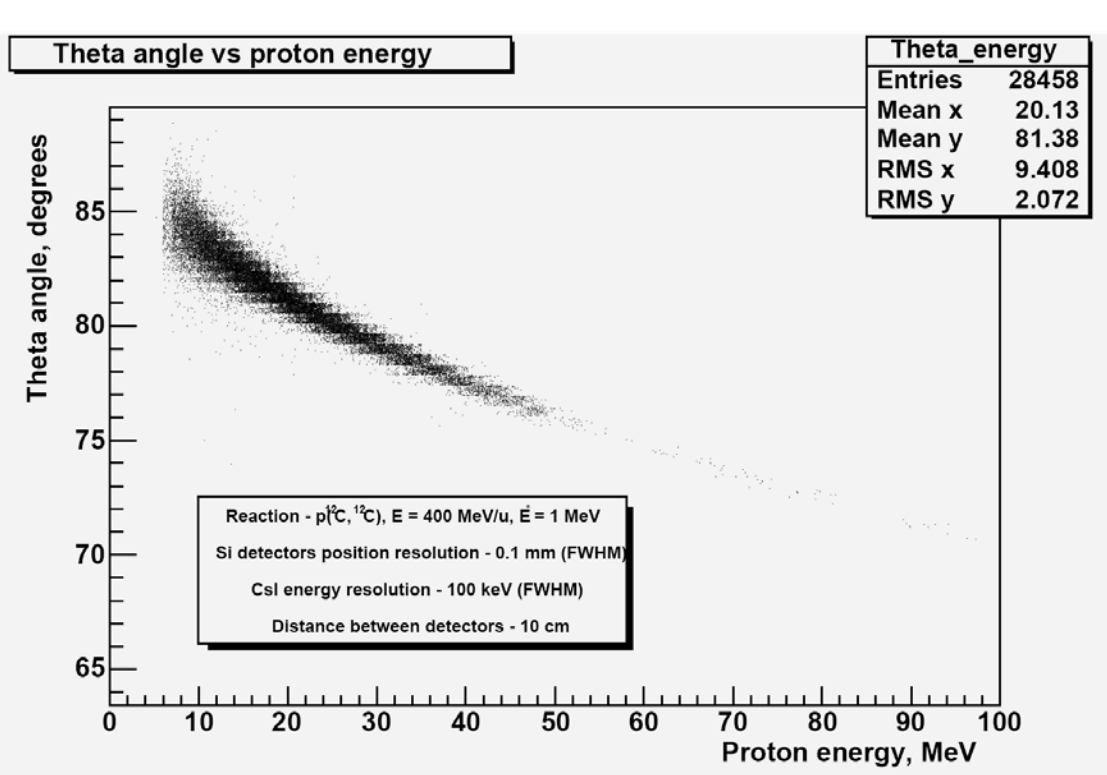
Simulated energy resolution



For Ep < 20 - 25 MeV – energy straggling is too high ⇒ no first layer

For Ep > 25 MeV thing first layer but the energy resolution of all detectors must be very good

Simulated angle – energy correlation

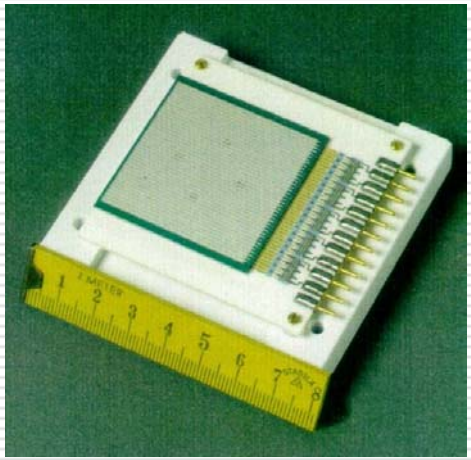


Two types of reactions – elastic and inelastic (E* = 1 MeV) scattering

Simulations – next steps

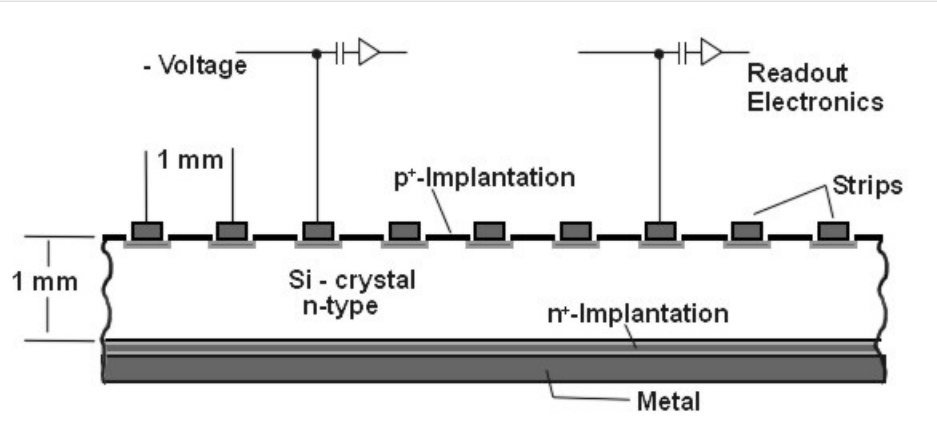
- Optimization of the Si detector thickness
- Different distance from the target
- Division of the setup on two parts – for low (up to 25 MeV) and high energy protons
- Different strip pitch (100, 50 μm)
- More detectors in forward part – cover maximum solid angle
- Primary beam of exotic particles
- Different type of experiments
- More optimized setup – end of 2004

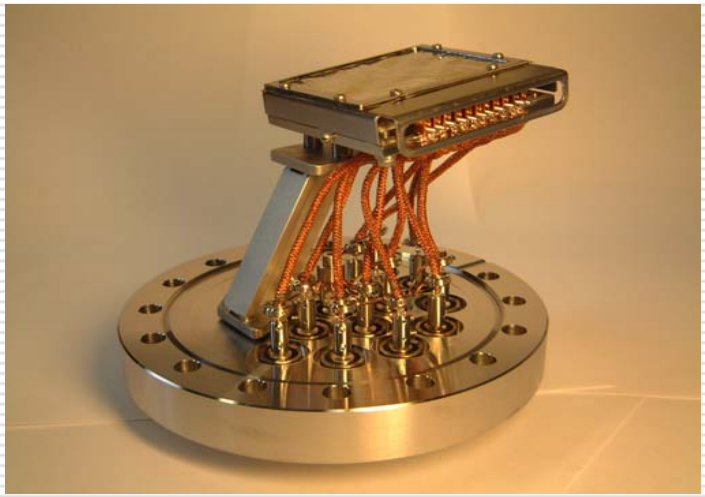
Detector prototype



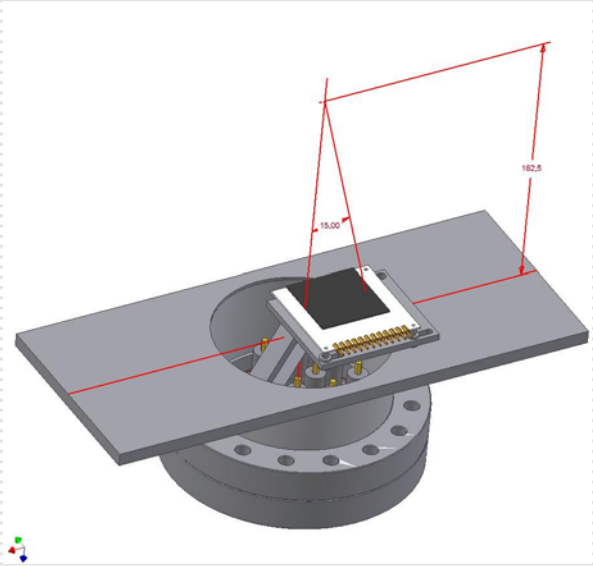
- **Active area: 40×40 mm^2**
- **Thickness: 1 mm**
- **40 Strips (Pitch: 1 mm) connected for read-out in groups of 8, each one with two output pins**

Energy resolution 35 ± 5 keV for α-particles with E = 5.5 MeV

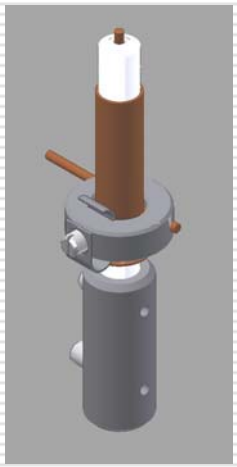




Detector details



Detector in the vacuum chamber of ESR

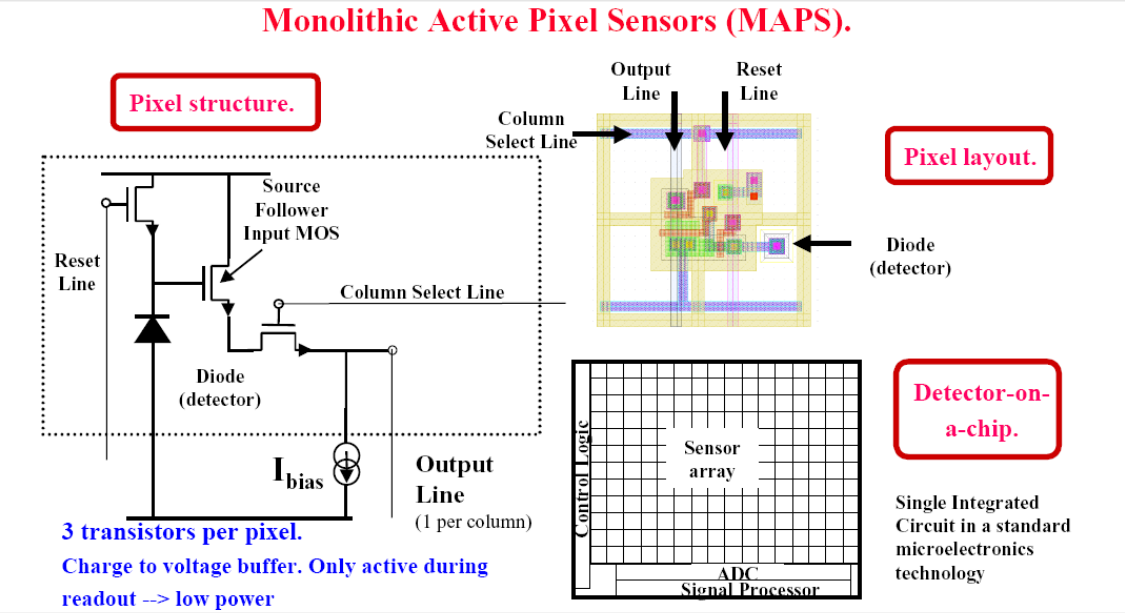


Cabling only
Cu, ceramics

Experiments – next steps

- One UHV compatible Si strip detector installed in the ESR, test beam of ^{12}C – Fall 2004?
- This detector might be considered as a prototype for the low energy part
- Setup with more detectors near the internal target and outside the vacuum – feasibility tests during 2005?
- Investigation of thin detectors – task Nr. 1, possible candidate – Monolithic Active Pixel Sensor (MAPS)

Monolithic Active Pixel Sensors



+Detector and readout electronics on the same Si crystal

+Thickness 20 - 50 μm

+Position resolution – 2 μm

+Pixel size – up to 10 μm

IReS/LEPSI, IN2P3/ULP, Strasbourg

–Small size
–Slow readout, 1 ms readout now, goal: 50 μs – in 4 years

Si strip & pixel detectors - world experience

- CMS (LHC) – 24000 sensors, single and double sided, strip detectors, 1 sensor from 6” wafer
- CMS (LHC) – pixel detectors 1.6 6.4 cm^2, 44000 pixels per sensor, zero suppression on board
- ATLAS (LHC) – 4 layers of silicon tracker + pixel detectors
- SLD (SLAC) – central tracking – 3 10^8 pixels
- CHICSi UHV detectors - 1 1 cm^2, good energy resolution, no strips
- MUST/MUST2 - good energy resolution, strip (not microstrip) detectors, custom electronics, vacuum compatible