Setup for fixed target experiments at GSI and simulation studies

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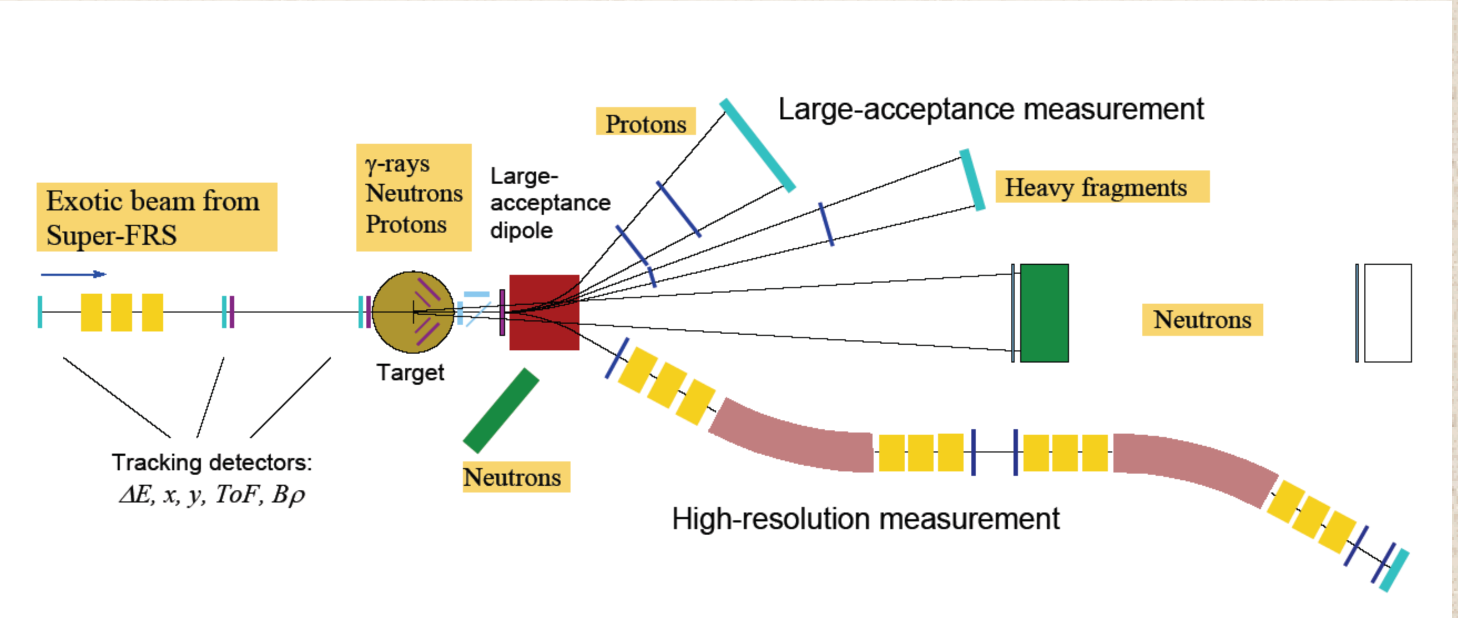
Physics with external target

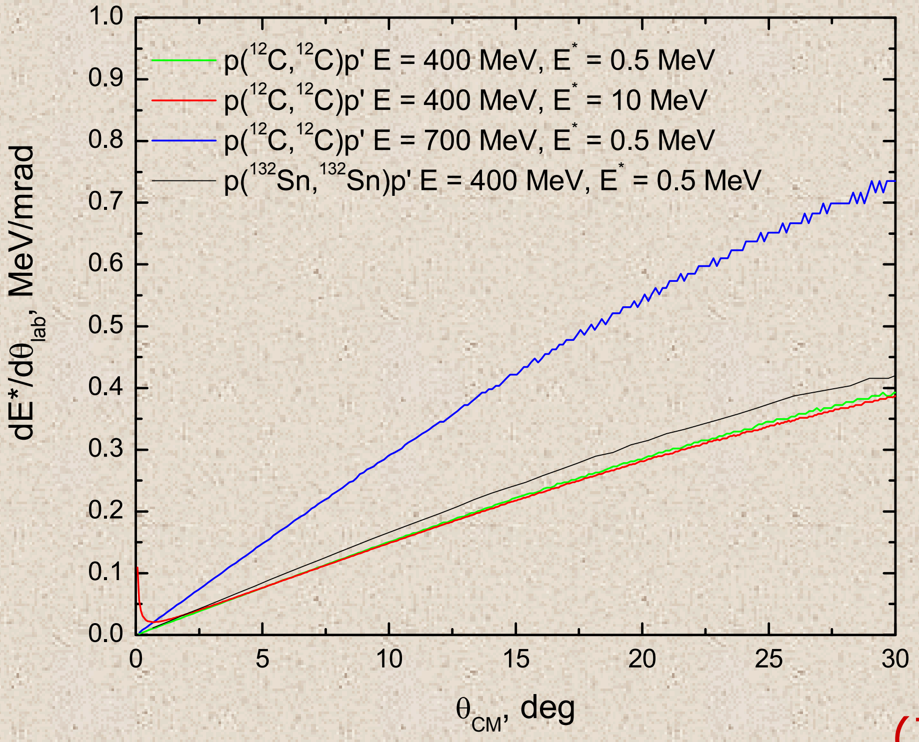
- *Elastic scattering*
- *Inelastic scattering*
- *Total absorption measurements*
- *EM excitation*
- *Spallation*
- *Fission*
- *Charge-exchange reactions*
- *Multifragmentation*
- *Quasi-free scattering*
- As more universal detector as possible
- Kinematically complete experiments

Experimental setup of R3B



Upgrade of existing LAND setup
+Higher precision
+Recoil detector
+High resolution spectrometer

Angular and energy resolution

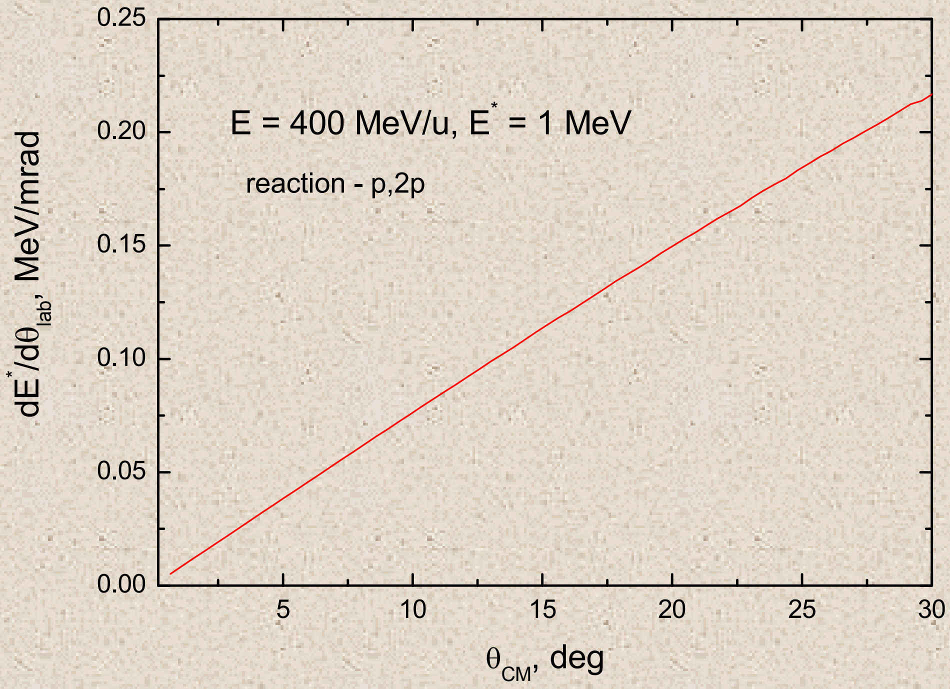


$\Delta E^* < 0.1$ MeV
$\Delta\Theta_{CM} <$ few mrad

for recoils: $\Delta E_{lab} < 0.1$ MeV
$\Delta\Theta_{lab} < 1\text{-}2$ mrad

(In)elastic scattering

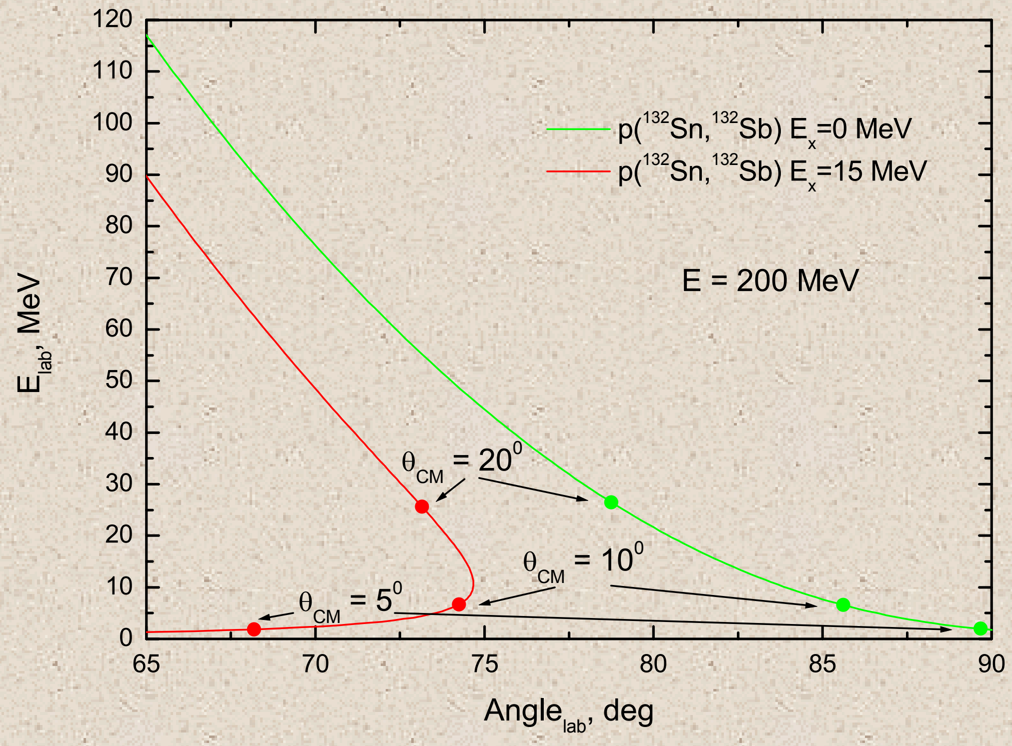
Angular and energy resolution



Example of free p,p scattering

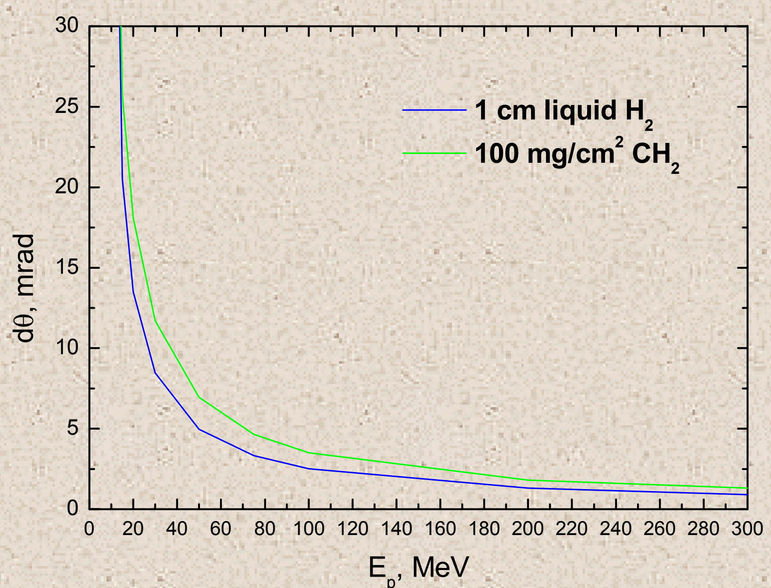
$\Delta\Theta_{lab}$ ~ few mrad

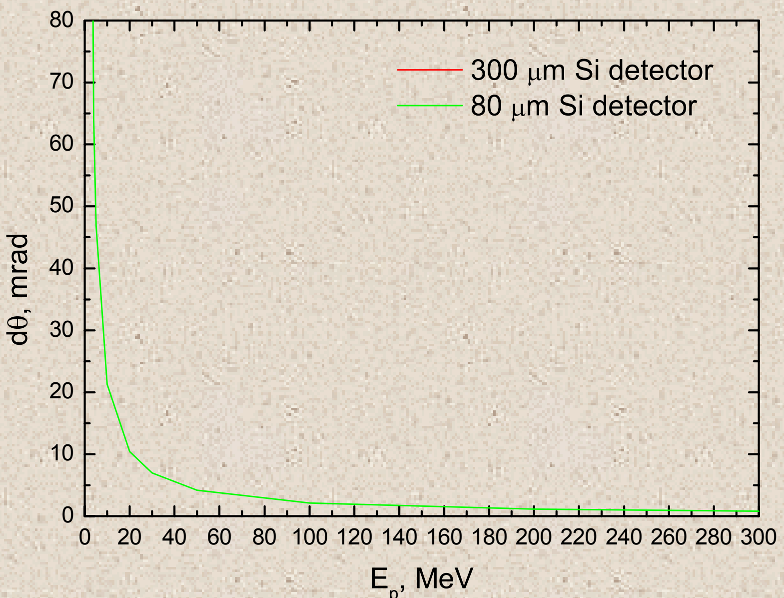
Angular and energy resolution



In case of charge-exchange or transfer reactions requirements are not so strict

Multiple scattering



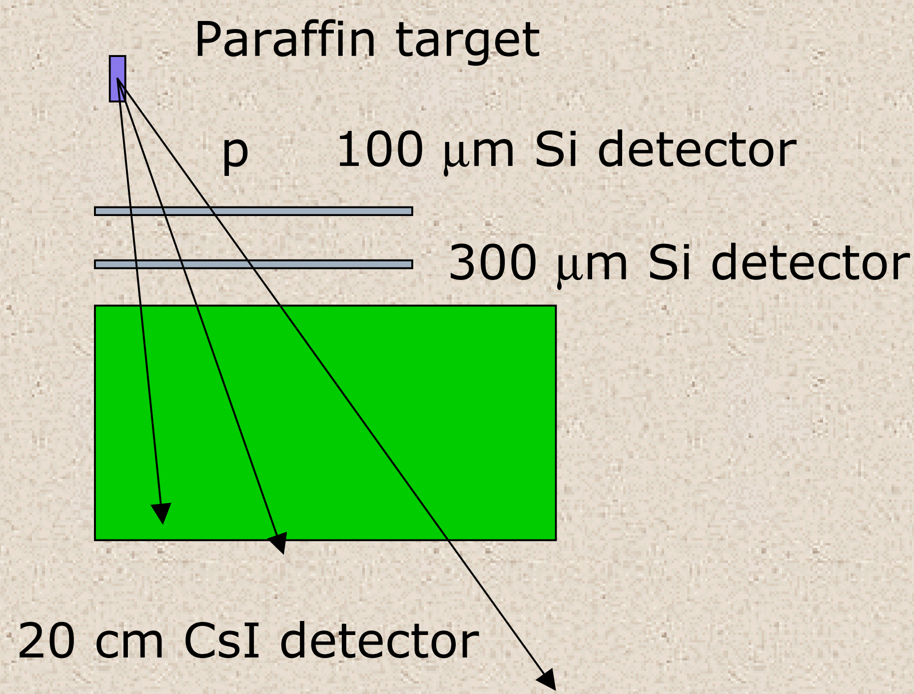


- ☑ Energy threshold – 40 MeV?
- ☑ Thin detector for the first layer – 100 (50) μm?
- ☑ Minimum thickness of double-sided Si microstrip detector – 100 μm
- ☑ New technologies should be studied

Simulation concept

- Main aim – realistic simulation framework for any kind of experiments
- All detectors for target-like, beam-like particles, neutrons and gammas should be included
- Any beam of exotic particles possible
- Easy change of any parameter like detector geometry or beam particles
- Simulation package is based on modern programming tools – GEANT4 and ROOT
- People – O. Kiselev (Mainz), K. Boretzky (GSI), N. Moreau, A. Ramus (students from Orsay University)

First simple setup

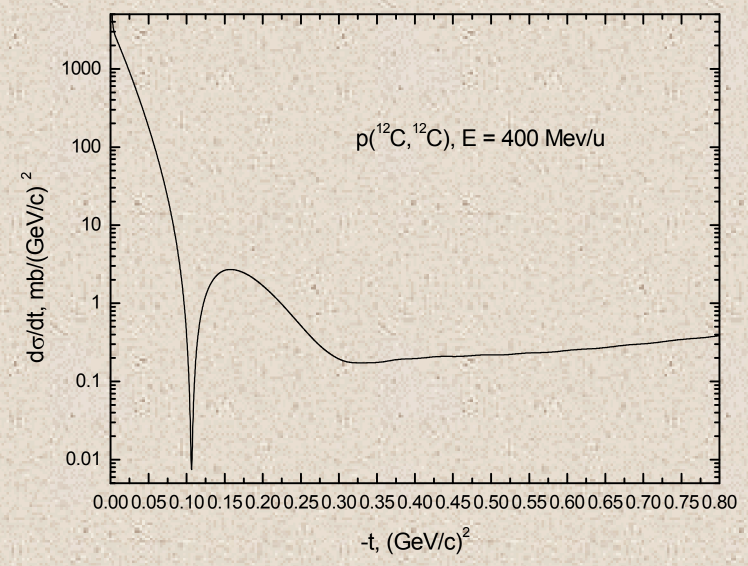


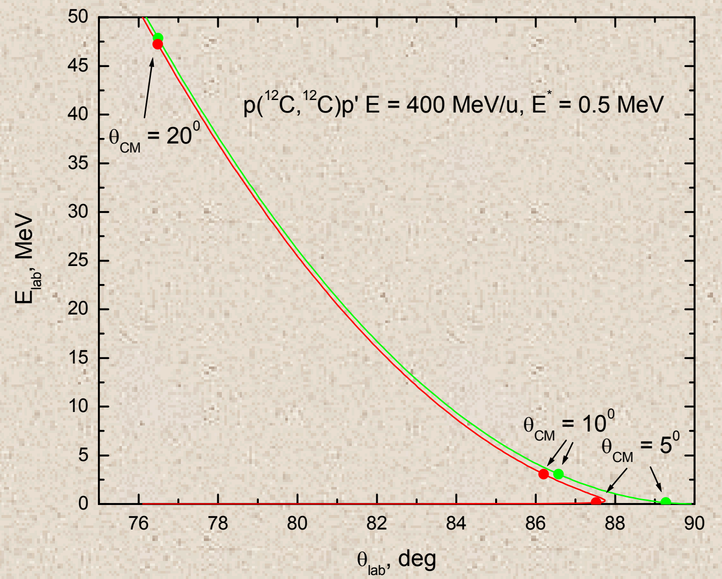
Target – Ø 2 cm, 1 mm thick

Two layers of Si detectors – 5 and 7 cm from the target
Strip pitch – 100 μm (X and Y)

CsI scintillator to measure total energy

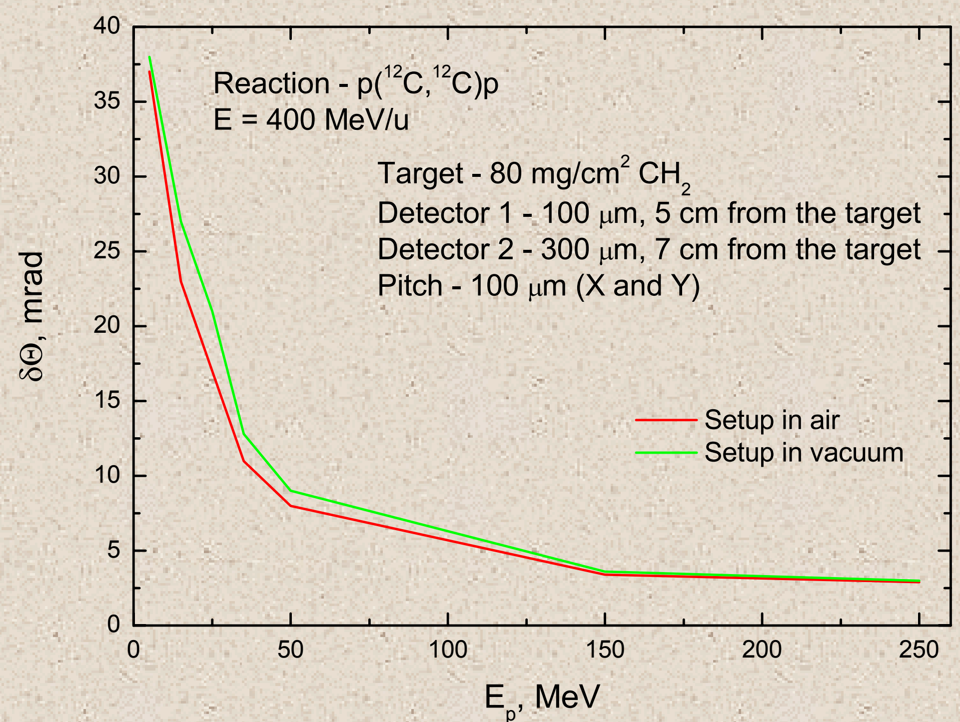
Simulation of recoil protons





Recoil protons are coming out of the target, generated according to the cross section and the kinematics for elastic and inelastic scattering on ^{12}C

Simulated angular resolution



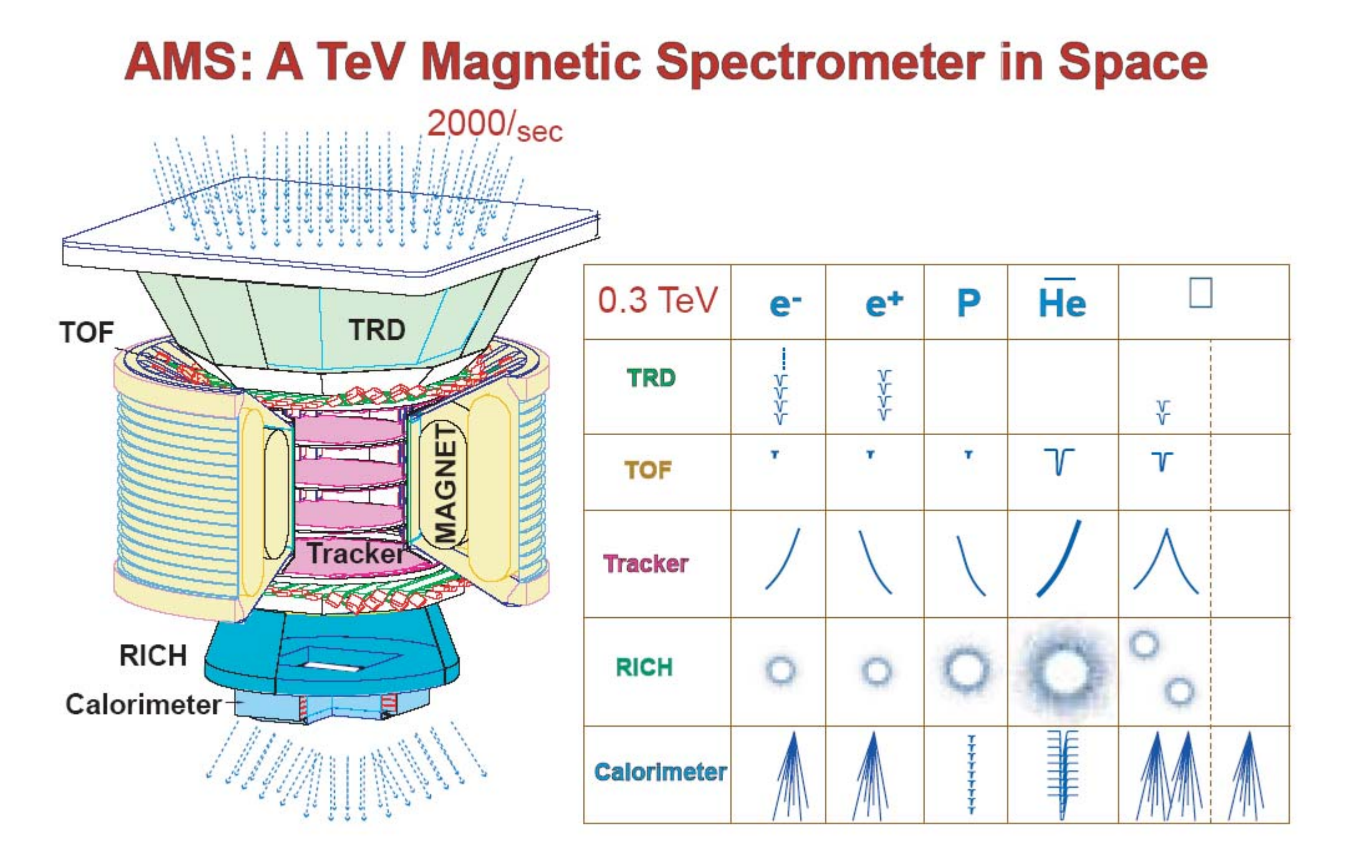
For $E_p < 50$ MeV first layer and the target must be very thin

In case of precise beam tracking and thing CH_2 target – one layer of Si with good resolution

Simulations – next steps

- Optimization of the Si detector thickness
- Different distance from the target
- Energy measurement by CsI and Si
- Different strip pitch (100, 50 μm)
- More detectors in forward part – cover maximum solid angle
- Primary beam of exotic particles
- Simulation of quasi-free scattering
- Optimized setup – end of 2004 – Technical proposal

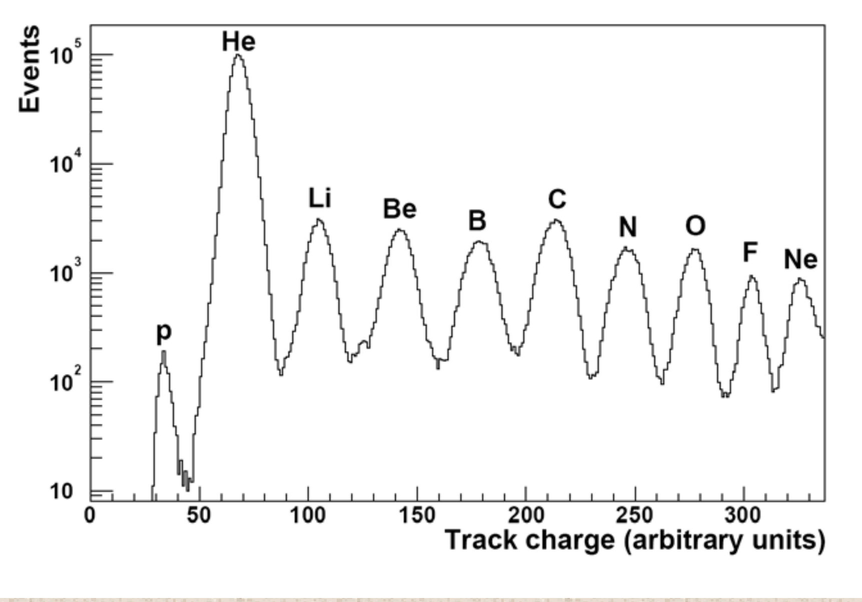
Alpha Magnetic Spectrometer



Si detectors for AMS tracker

- Tracker designed for high energy particles – 8 layers of DSSD
- Total number of sensors – 2500
- Whole tracker is in magnetic field – charge and momentum measurement
- Position resolution of the tracker – 30 μm (single point, $Z > 4$)
- Identification of particles in silicon – from $Z = 1$ up to $Z = 13$
- Dynamic range – ±70 MIPs
- Noise level – 2-3 ADC counts (MIP has 30 ADC counts) ⇒ signal/noise ratio at least 10 for protons
- Size of one sensor size is 4×7 cm^2

AMS tracker performance



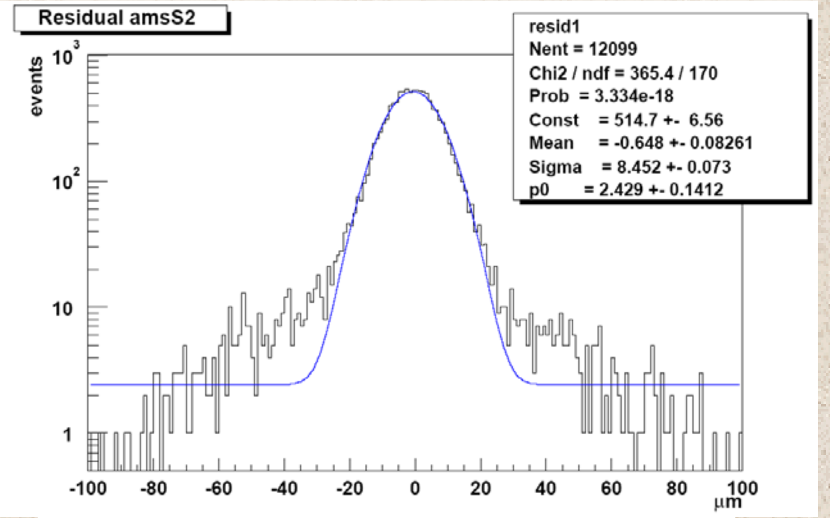
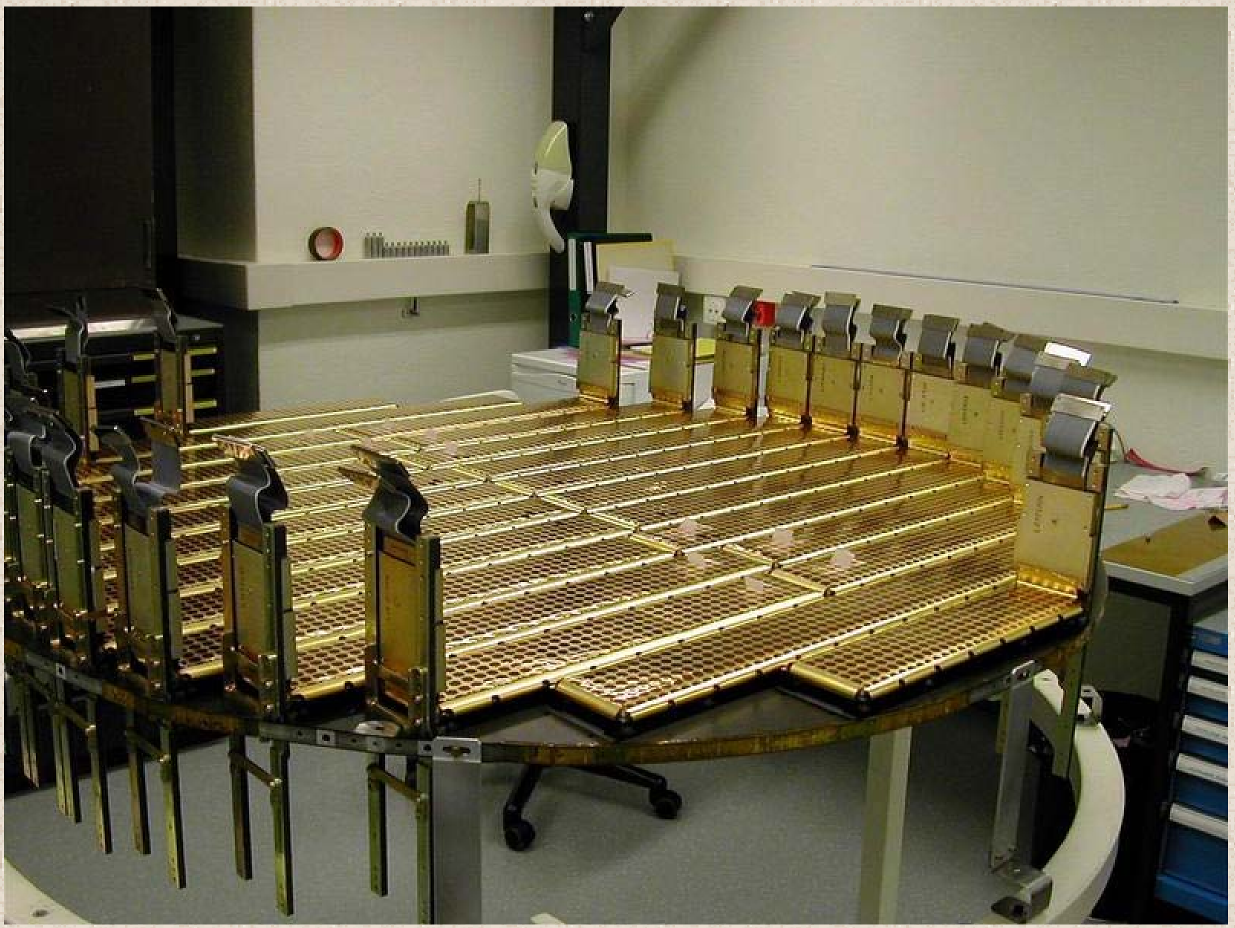


Table 1. Spatial resolution summary table

Particle	p-side	n-side
μ 400 GeV	$8.5\mu m$	$29.5\mu m$
p 20 GeV	$11.6\mu m$	$29.2\mu m$
He 20 GeV/A	$7.1\mu m$	$22.1\mu m$

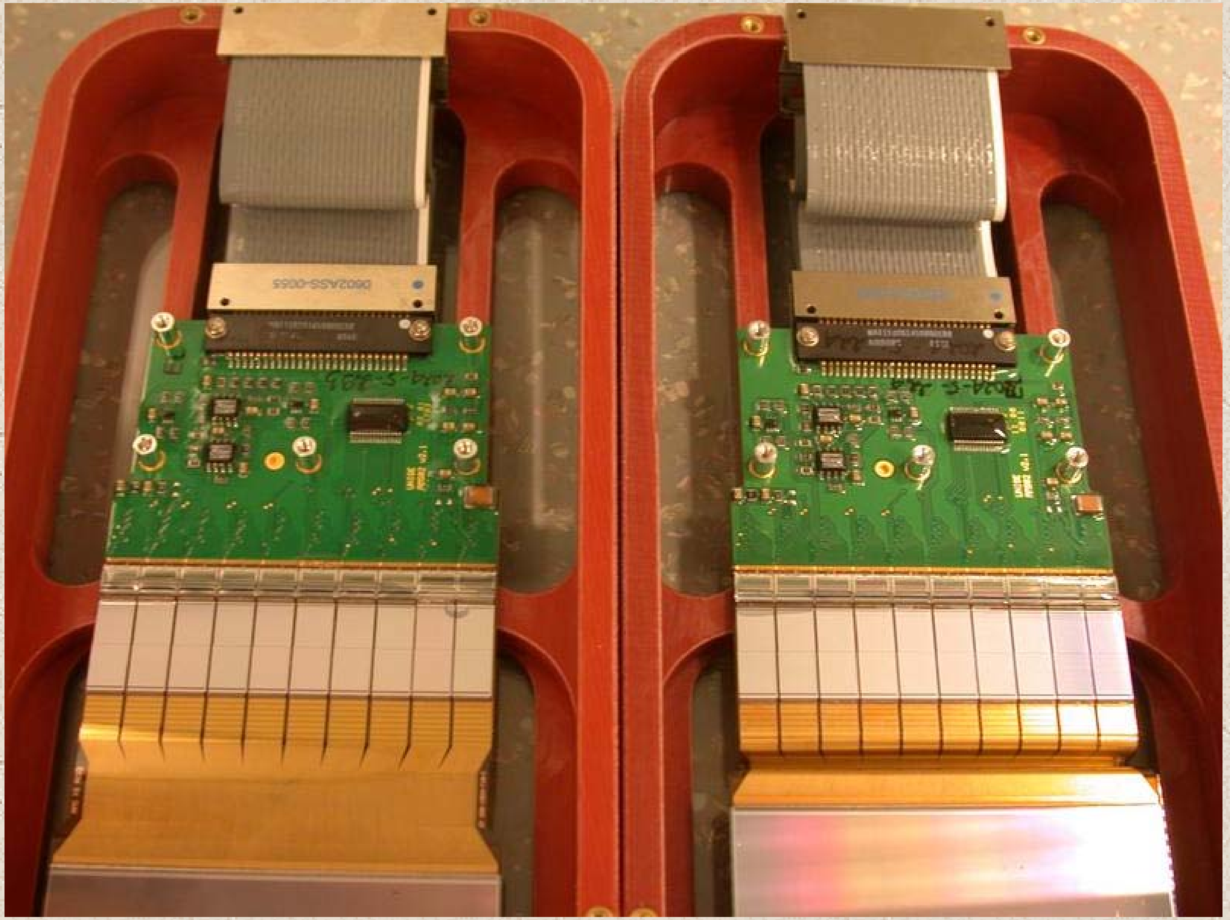
Elements produced by fragmentation of high energy Pb

Layout of the AMS tracker

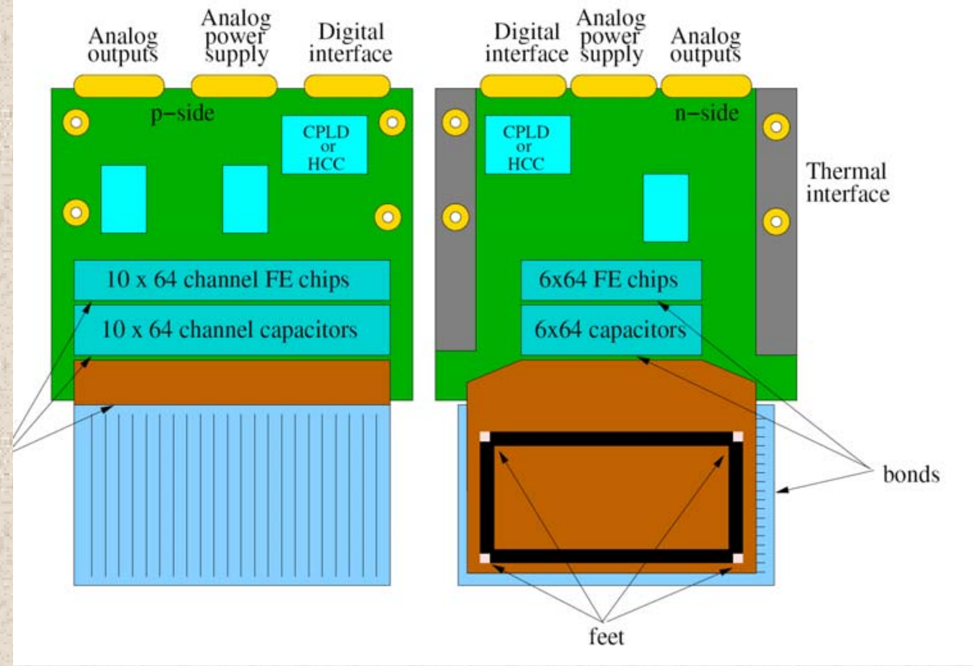


Ladders with Si detectors

Ladders with connectors



Detector prototype for fixed target



Parameter			Units
Device area		72×41.3	mm^2
Thickness		300 ± 15	μm
Active width	J-side	70565	μm
	Ω-side	39832	μm
Number of strips	J-side	2568	
	Ω-side	384	
Strip pitch	J-side	27.5	μm
	Ω-side	104	μm
Readout strips	J-side	1284	
	Ω-side	384	
Readout pitch	J-side	55 (110)	μm
	Ω-side	104	μm
Full Depletion Voltage		50 (max)	V
Total Leakage current		2000	nA

Readout chips – VA_hdr9 (IDEAS)

Detector prototypes – AMS type

- ✓Position resolution of one layer ≤ 100 μm (for MIP)
- ✓Energy resolution – 30 – 40 keV
- ✓Dynamic range – 100 keV - 14 MeV
- ✓Several detectors will be available, total area - 250 cm2
- ✓Test setup with 6 detectors, CH_2 target, beam test – 2005
- ✓1000 channels/sensor, 4 byte/channel ⇒ 4kB/detector per event, 24 kB per 6 detectors; for 100 Hz event rate – 2.4 Mb/sec ⇒ DAQ, data storage
- ✓Mechanical construction

LAND setup at Cave C

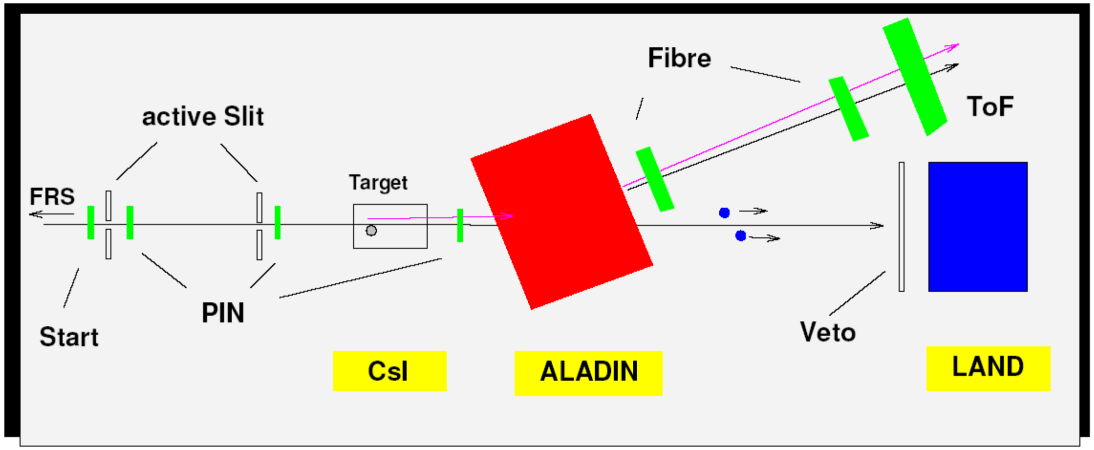
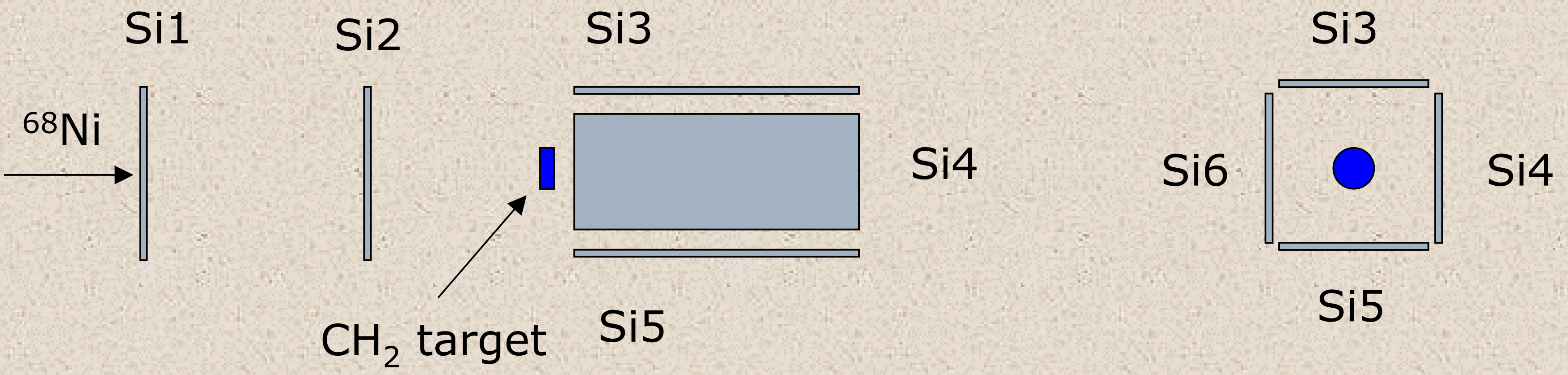


FIG. 3: Schematic view of the experimental setup (not on scale).
active slit: 4-jaw slit, organic scintillator, remote control, vetoing beam halos
Start: thin organic scintillator, time of flight ($\sigma_{Tof} \sim 30$ ps)
PIN: p-i-n silicon diode, 5 x 5 cm^2, 2-dim. position readout ($\sigma_{x,y} \sim 0.2$ mm), energy-loss ($\sigma_Z \sim 0.2$e)
Fibre: scintillating fibre array, 50 x 50 cm^2, 500 fibres
CsI: segmented CsI(Tl) detector, γ-ray detection in $\sim 2\pi$
ALADIN: Large gap dipole magnet
Veto/LAND: Neutron-detector, 2 x 2 m^2, ($\sigma_{Tof} \sim 200$ ps; $\sigma_{x,y} \sim 3$ cm)
ToF: array 14 + 18 organic scintillators, 1.8 x 1.4 m^2, ($\sigma_{Tof} \sim 100$ ps), energy-loss measurement

Possible layout of the test setup for knock-out/QFS experiment



Target and detectors Si3 – Si6 are inside CsI ball

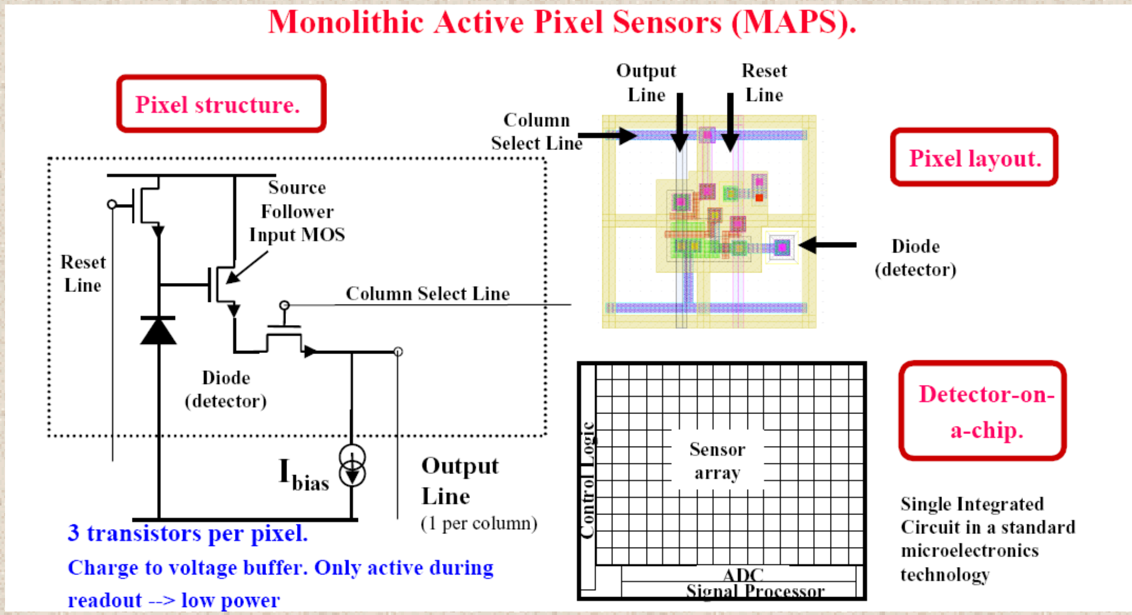
Inner diameter of CsI – 50 cm, size of one PCB with Si detector ~ 14 14 cm^2

Angular coverage – 90° - 35°

Open questions

- Target - CH_2 or liH_2?
- One layer of Si far from the target ⇒ small solid angle or two layers of Si?
- All is inside CsI ball or Si tracker + some scintillators behind them to measure E_{total}?
- How to measure energy for protons ~ 200-300 Mev – thick scintillator/degraders?
- Optimum energy of a beam – 400 MeV?
- First candidate - ^{68}Ni or …?

Thin Si detectors



- +Detector and readout electronics on the same Si crystal
- +Thickness 20 - 50 μm
- +Position resolution – 2 μm
- +Pixel size – up to 10 μm
  - –Small size - ~cm
  - –Slow readout

IReS/LEPSI, IN2P3/ULP, Strasbourg

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 cm2, 44000 pixels per sensor, zero suppression on board
- ✓ ATLAS (LHC) – 4 layers of silicon tracker + pixel detectors
- ✓SLD (SLAC) – central tracking – 3 1 0 8 pixels
- ✓ALICE (LHC), LHCB (LHC) – central tracker - Si microstrips
- ✓Other experiments in High Energy Physics, also at FAIR – CBM, PANDA