(e,e'x) and (e,e') at 180° Experiments at the S-DALINAC

QCLAM Spectrometer

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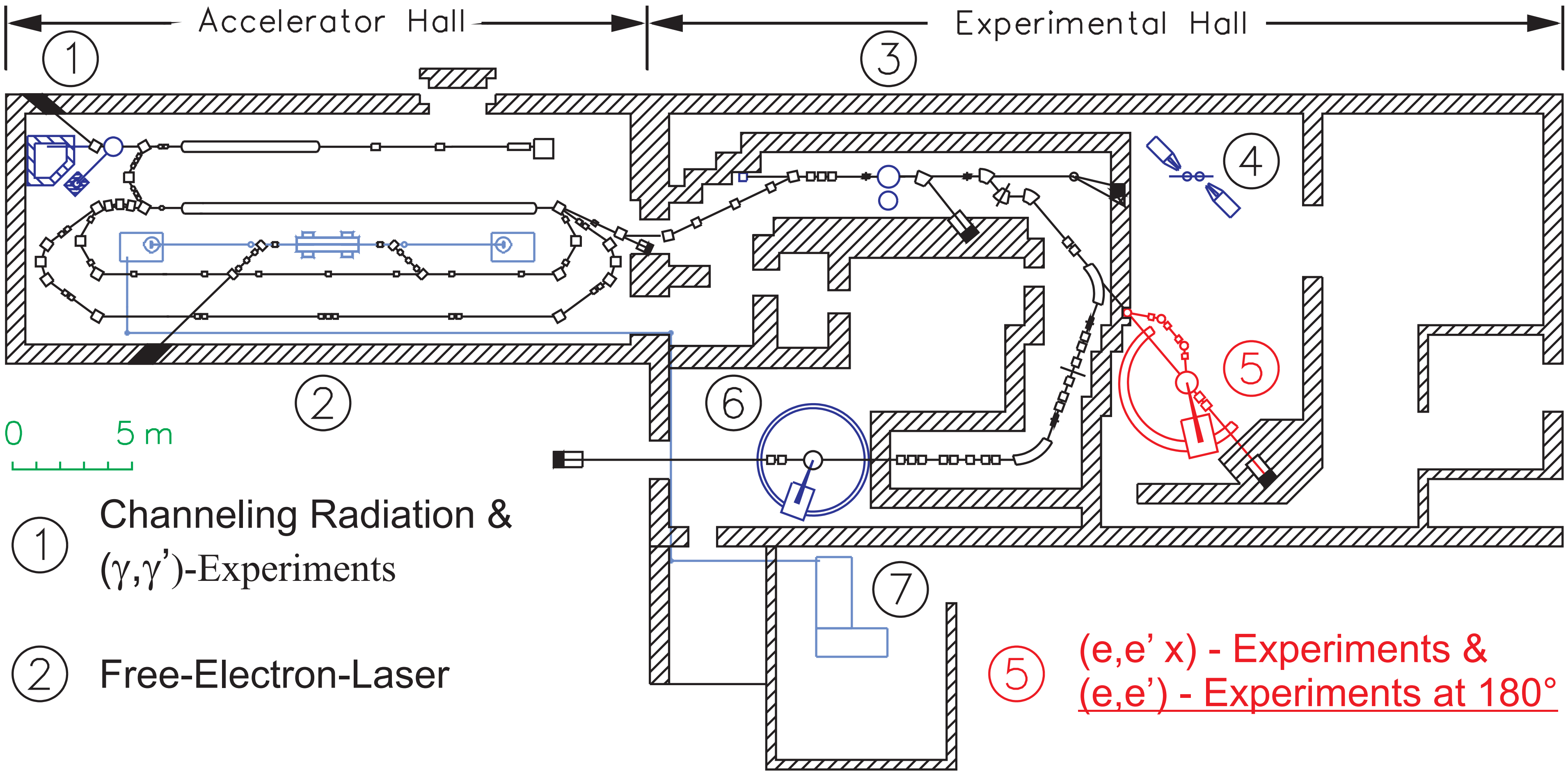
Darmstadt 2003

- Requirements for the spectrometer
- Construction and ion-optical properties
- Detector system
- 180° System
- Status and outlook

S-DALINAC



① Channeling Radiation & (γ,γ')-Experiments

② Free-Electron-Laser

③ High Energy Radiation Physics

④ Compton Scattering off the Nucleon

⑤ (e,e' x) - Experiments & (e,e') - Experiments at 180°

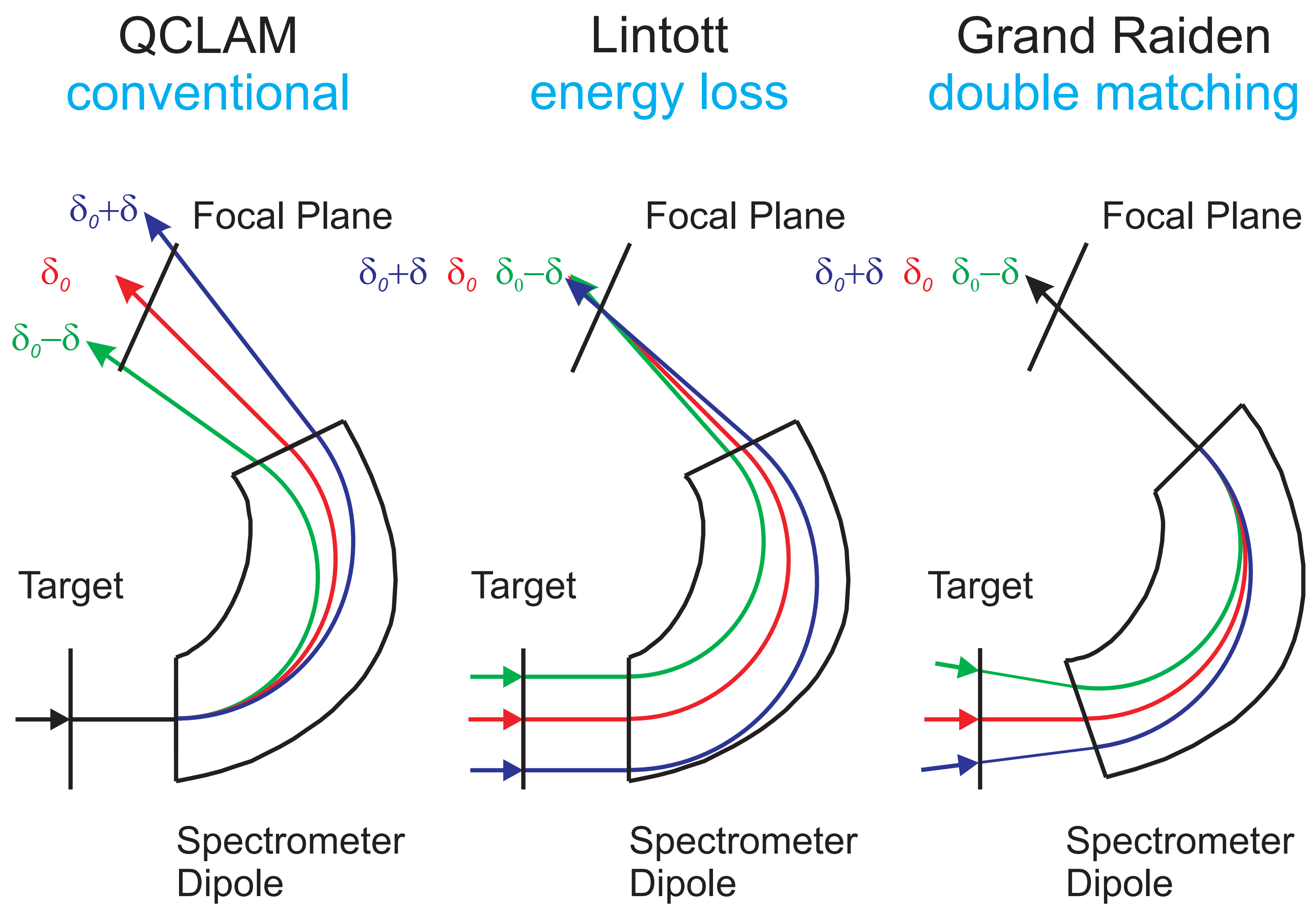
⑥ (e,e') Experiments

⑦ Optics Experiments

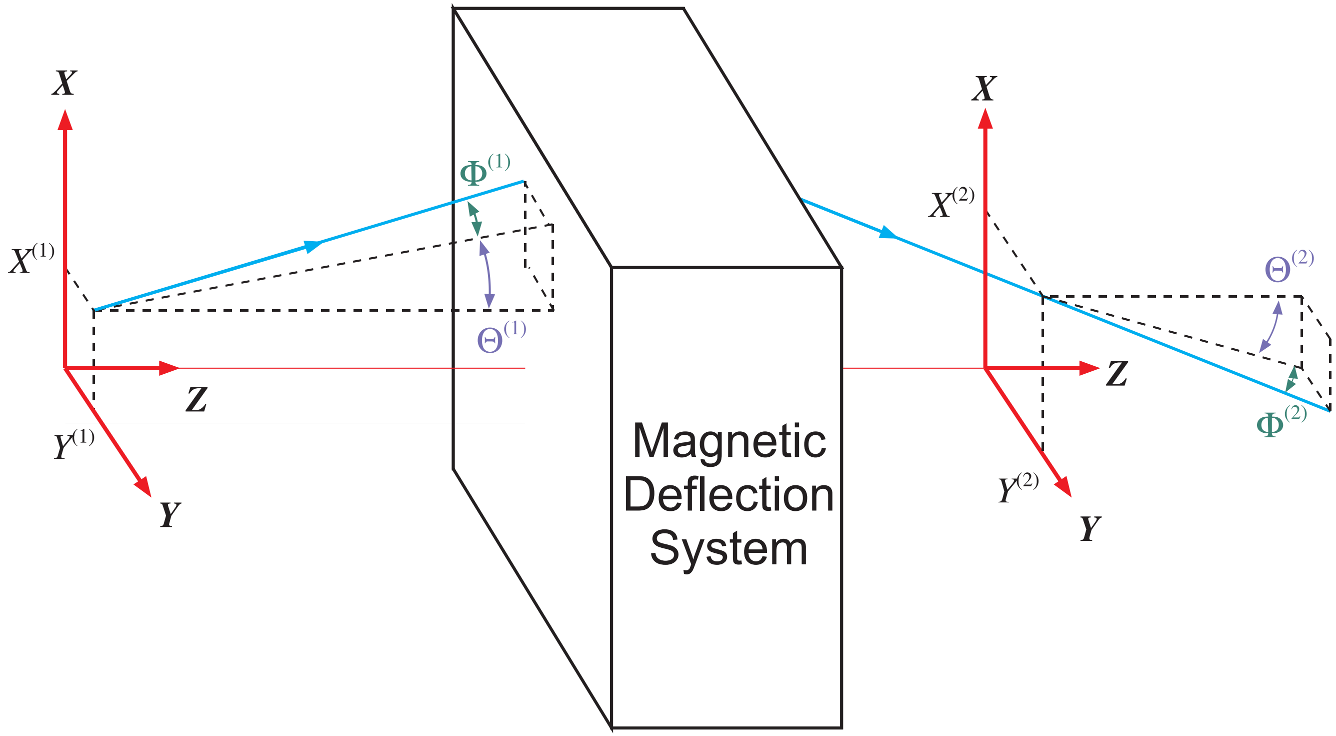
Requirements

- $E_0 = 20 \div 130$ MeV
- $\Delta E/E = 1 \cdot 10^{-4}$
- small cross sections ⇨ big acceptance
- $E_x = E_0 - cp_{cent}(p/p_{cent}) - T_{rec} - E_{targ}$ ⇨ $\Delta\Theta = 0.5^o$
- backward and forward angles

Operational Modes of Magnetic Spectrometer



Matrix Formalism



$$x_2=(x/x)x_1+(x/\Theta)\Theta_1+(x/\delta)\delta+$$

$$+(x/x_2)x_1^2+(x/x\Theta)x_1\Theta_1+(x/\Theta^2)\Theta_1^2+(x/x\delta)x_1\delta+(x/\Theta\delta)\Theta_1\delta+$$

$$+(x/\delta^2)\delta^2+(x/y^2)y^2+(x/y\Phi)y_1\Phi_1+(x/\Phi^2)\Phi_1^2+$$

+*higher order terms*

(x/x) - magnification

(x/δ) - dispersion

(x/Θ)=0, (y/Φ)=0 - focus

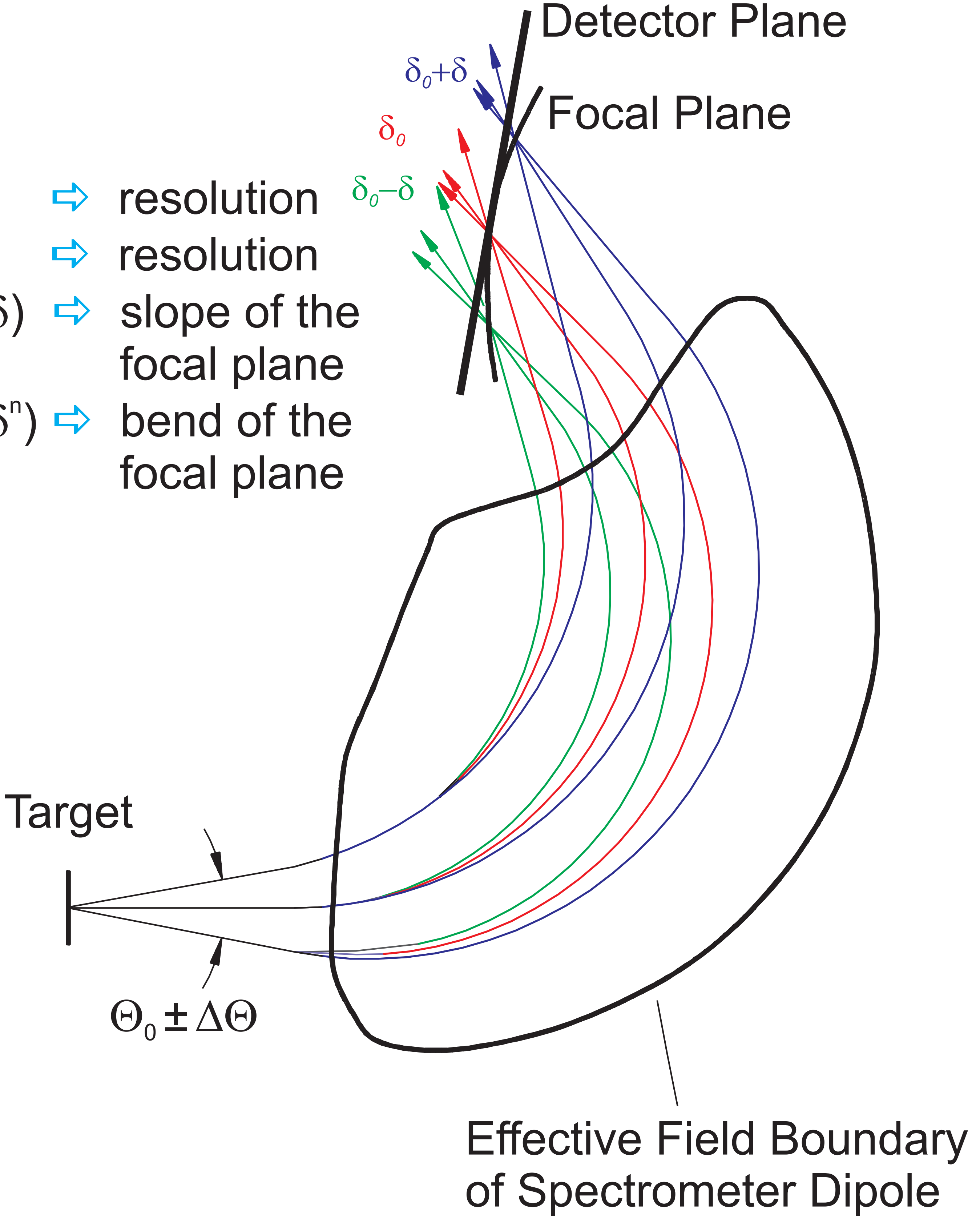
Electron Trajectories in the Spectrometer Dipole

(x/x) ⇨ resolution

(x/δ) ⇨ resolution

$(x/\Theta\delta)$ ⇨ slope of the focal plane

$(x/\Theta\delta^n)$ ⇨ bend of the focal plane

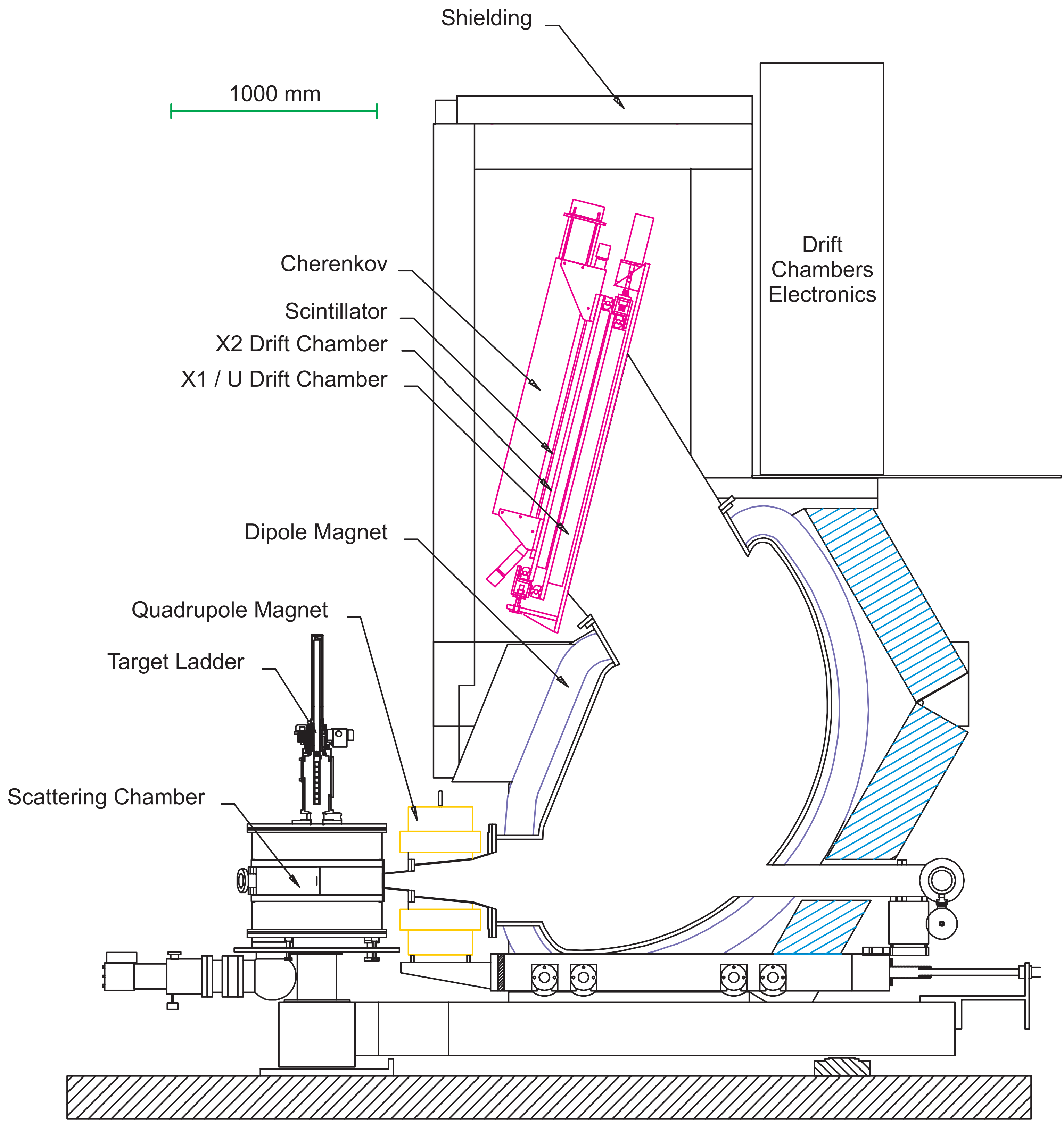


Parameters of the QCLAM Spectrometer

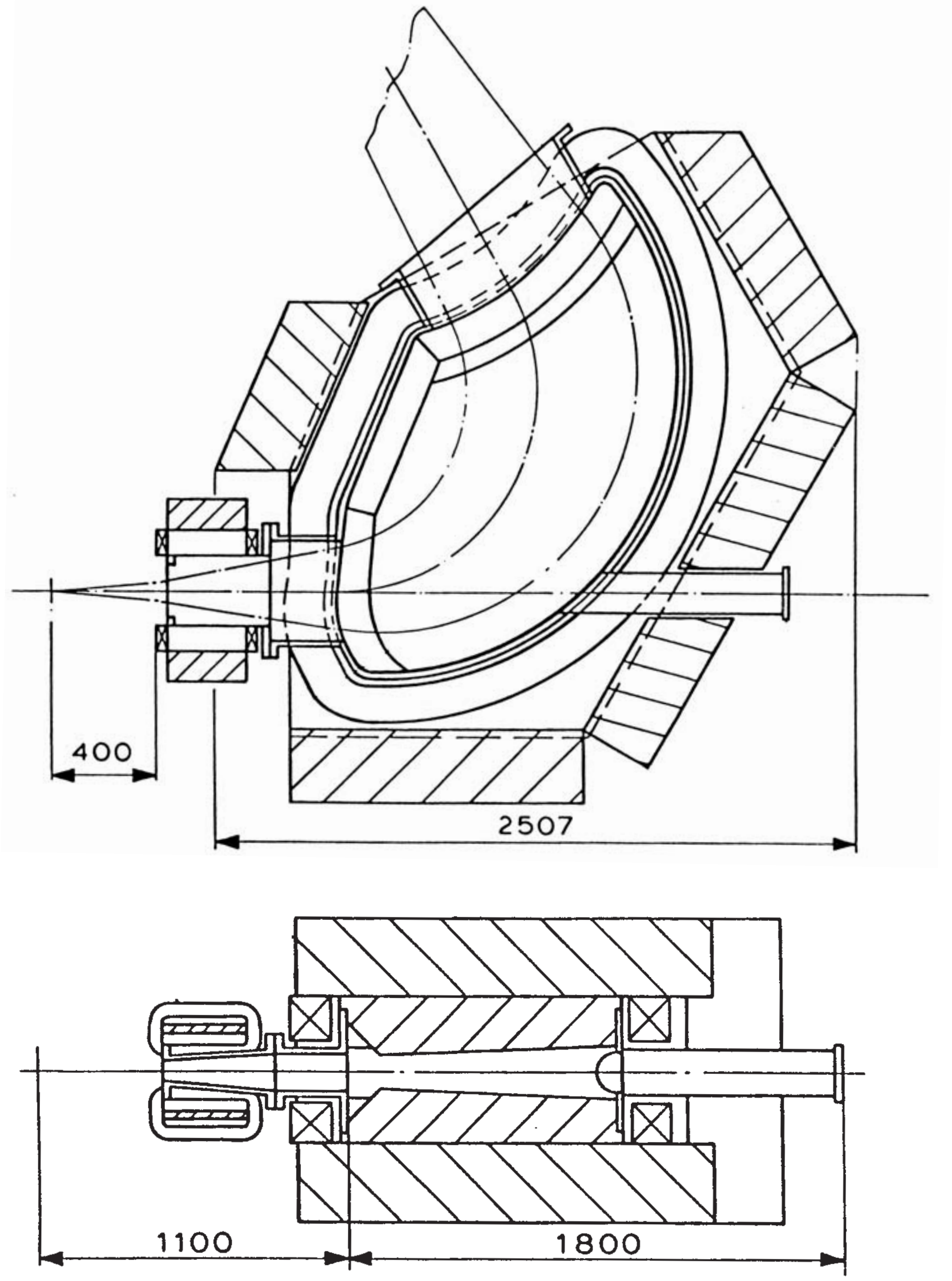
- $E_0 = 20 \div 130$ MeV ⇨ $B\rho \leq 1.2$ T m
- $\Delta E/E = 1 \cdot 10^{-4}$, $\Delta\Theta = 0.5°$ ⇨ (x/x)=-0.492, (x/δ)=2.32 cm/%,

  (Θ/x)=-23.073 mrad/cm, (Θ/Θ)=2.02, (Θ/δ)=9.42 mrad/%
- $\Delta p/p = \pm 10\%$, $\Delta\Omega = 35$ msr ⇨ **Q**uadrupole + **CLAM** shell dipole
- backward and forward angles ⇨ “vertical” spectrometer

QCLAM Spectrometer at the S-DALINAC

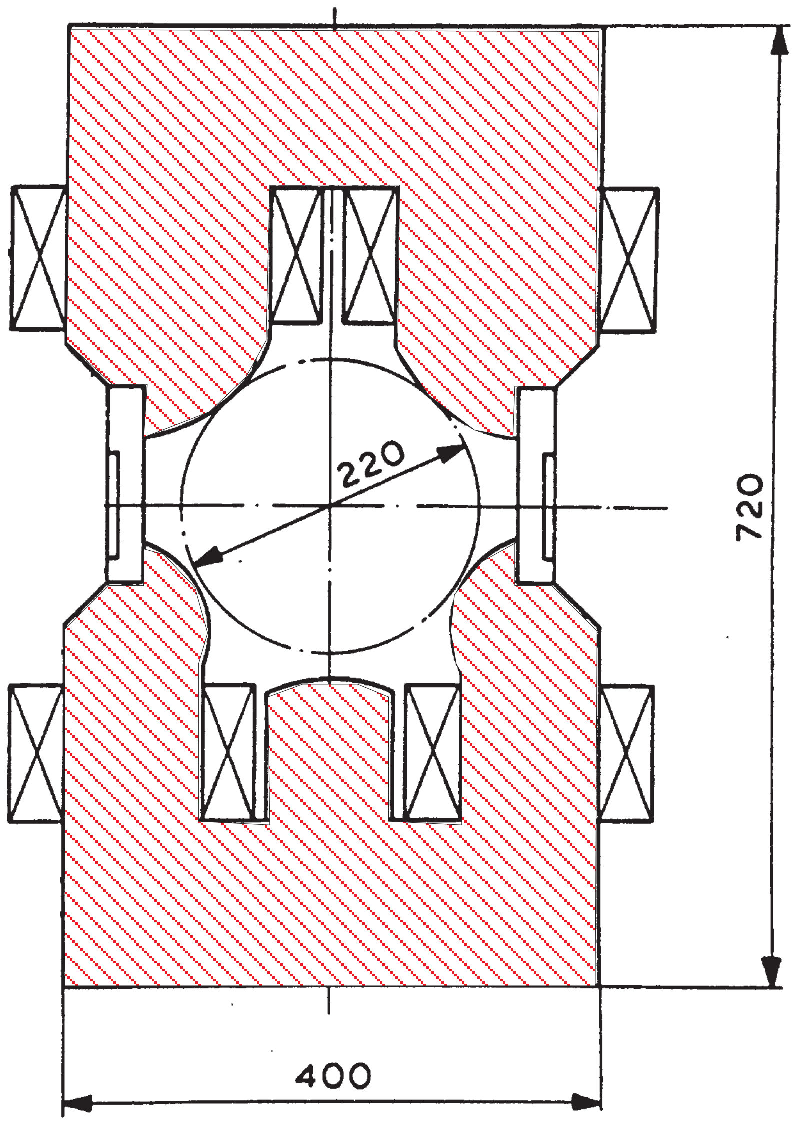


Dipole Magnet



- Pole geometry — tilted planes 2.54°
- Gap width — 120÷220 mm
- Maximal field — 1 T

Quadrupole Magnet

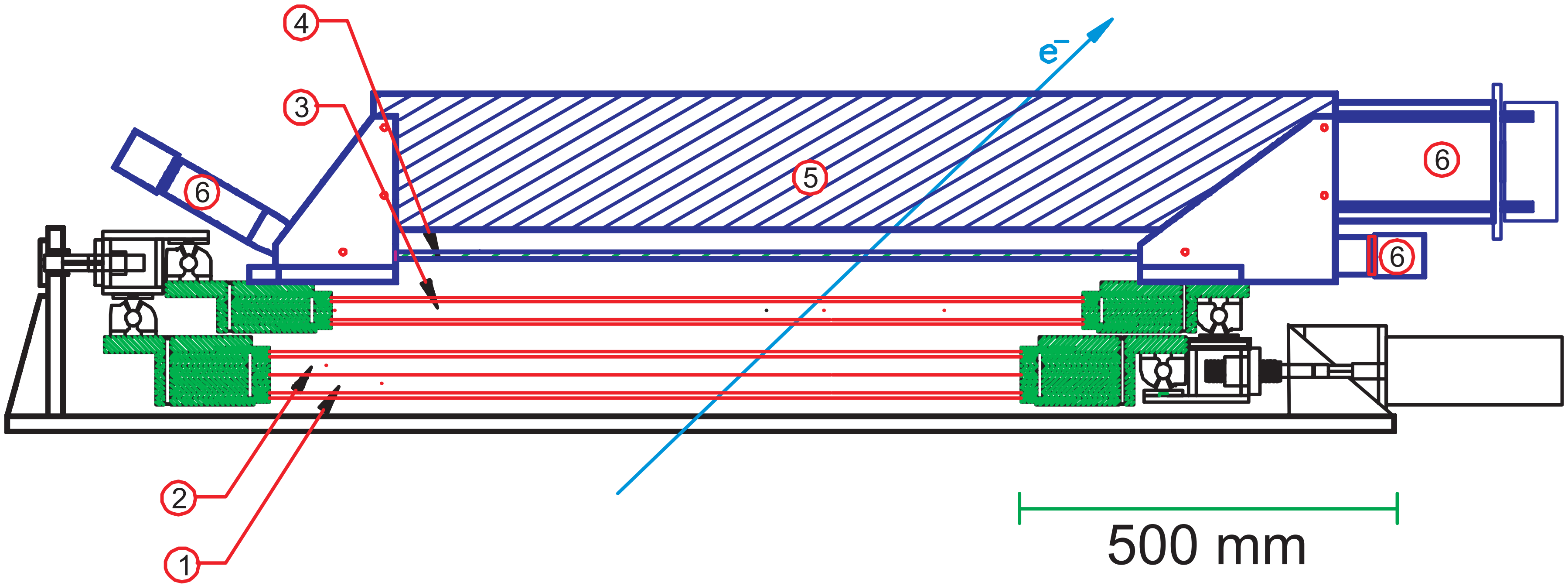


- Maximal field gradient 3 T/m
- Effective length 402 mm

Requirements for the Detector System

Energy range	*20 ÷ 130* MeV
Efficiency	100%
Length	670 mm
Width	80 mm
Angular acceptance	40º
Position resolution	0.3 mm
Angular resolution	3 mrad
Time resolution	< 1 ns

Detector System at the QCLAM Spectrometer



① VDC X1

② VDC U

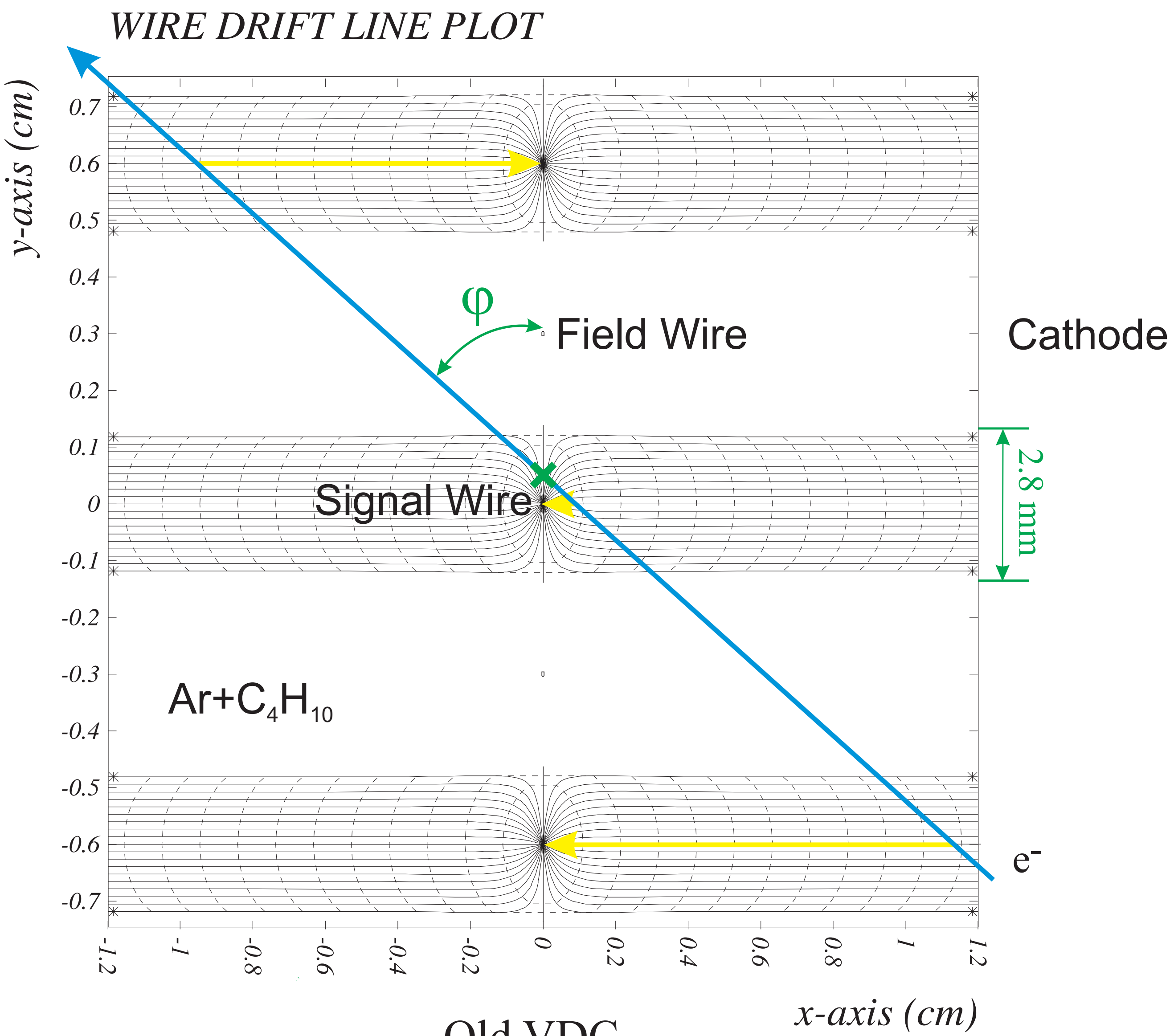
③ VDC X2

④ Scintillator

⑤ Cherenkov detector

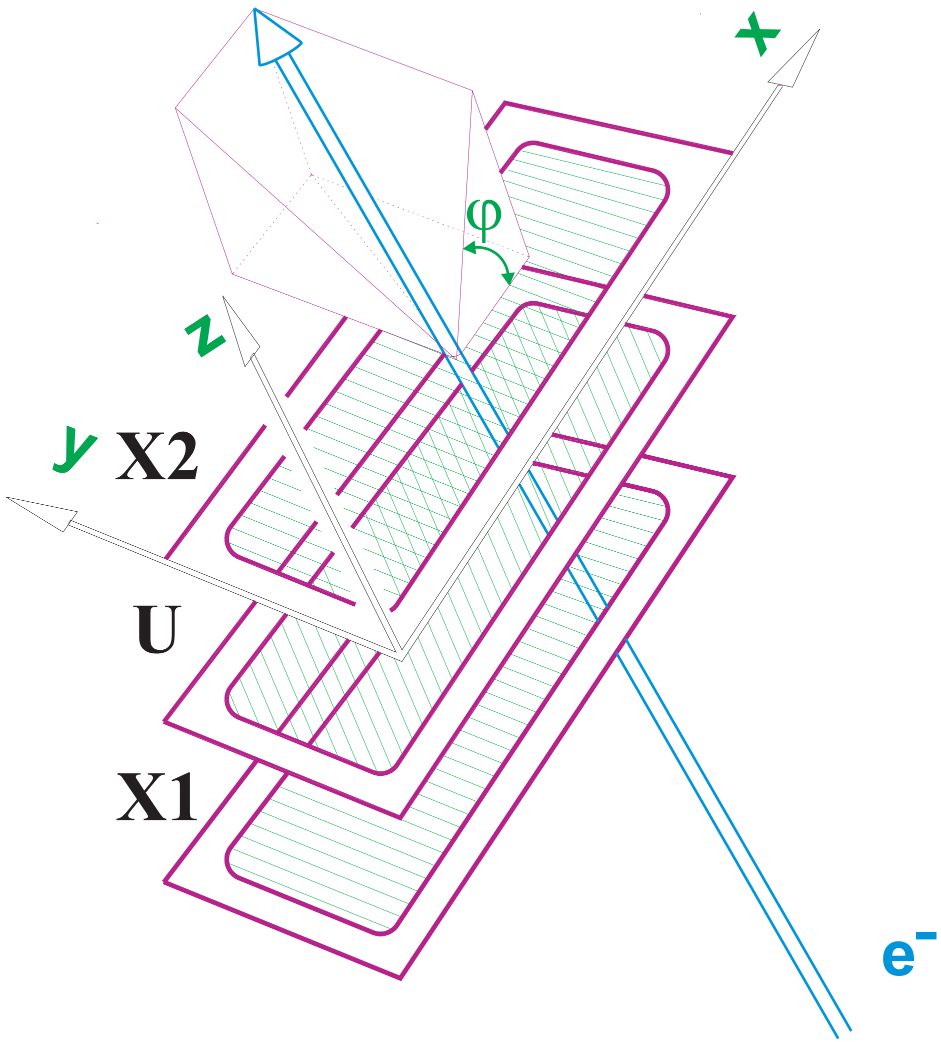
⑥ Photomultiplier

Operation of Vertical Drift Chamber



Old VDC

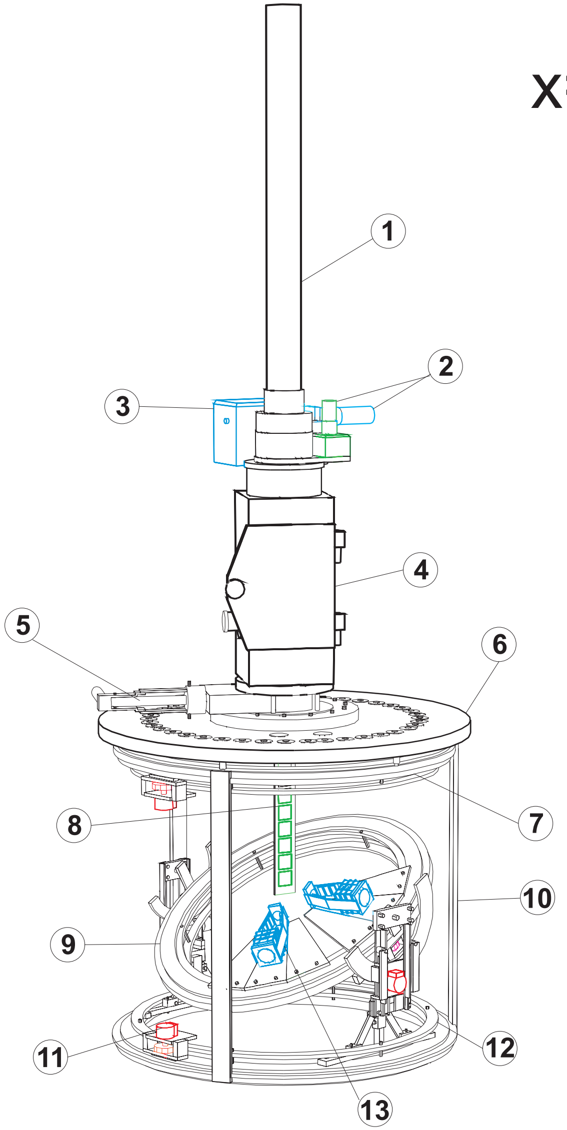
Vertical Drift Chambers at the QCLAM Spectrometer



X1, X2 ⇨ x, φ
U, x ⇨ y

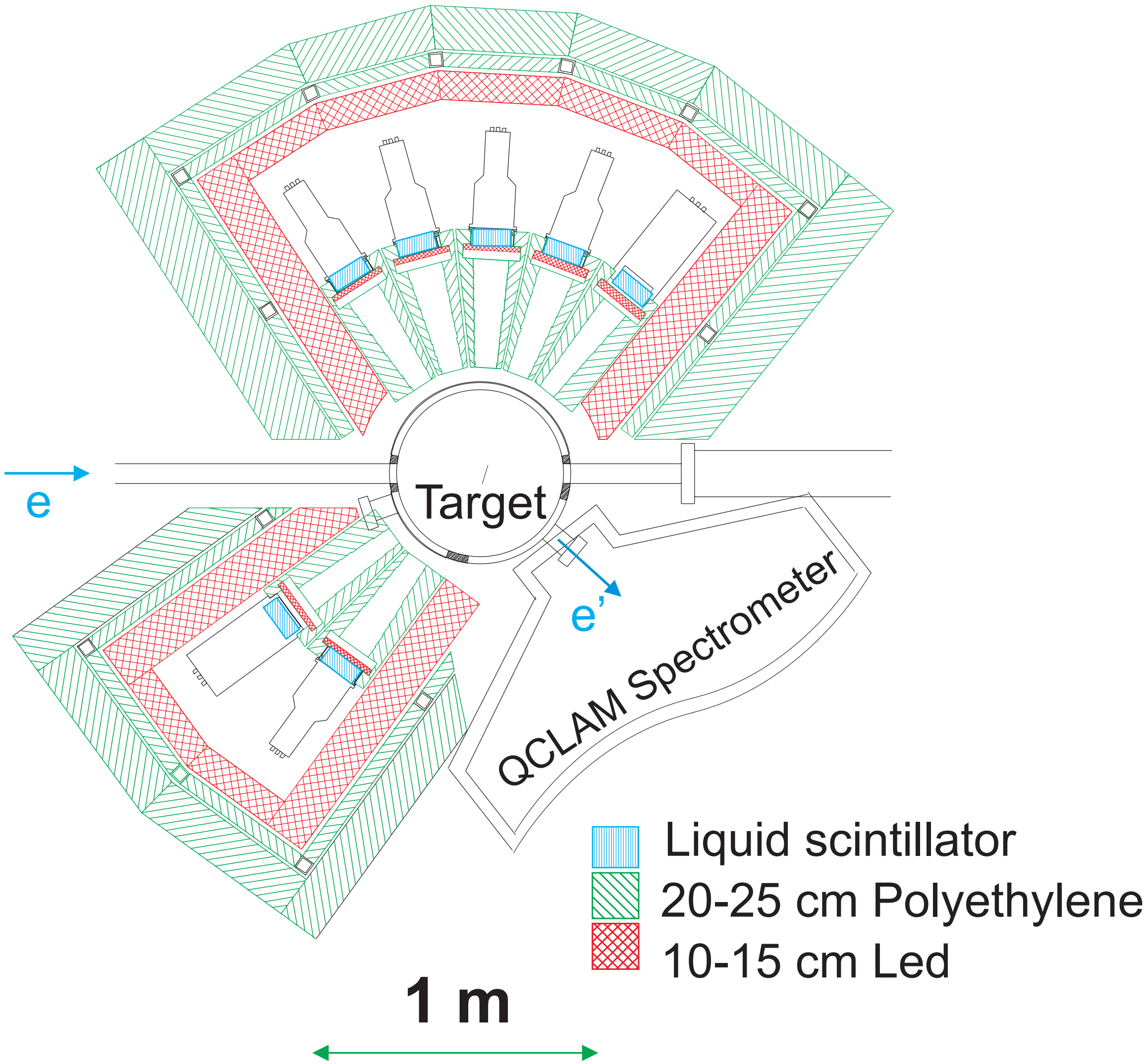
Goniometer for (e,e'x) Experiments

$x = p, d, t, \alpha, {}^3He$



1. Target ladder tube
2. Motors for target positioning
3. Vertical motion gearbox
4. Vacuum drain
5. Valve
6. Scattering chamber lid
7. Upper goniometer ring
8. Target ladder
9. Middle goniometer ring
10. Stabilizing rod
11. Optical encoder
12. Lower goniometer ring
13. Detector telescope

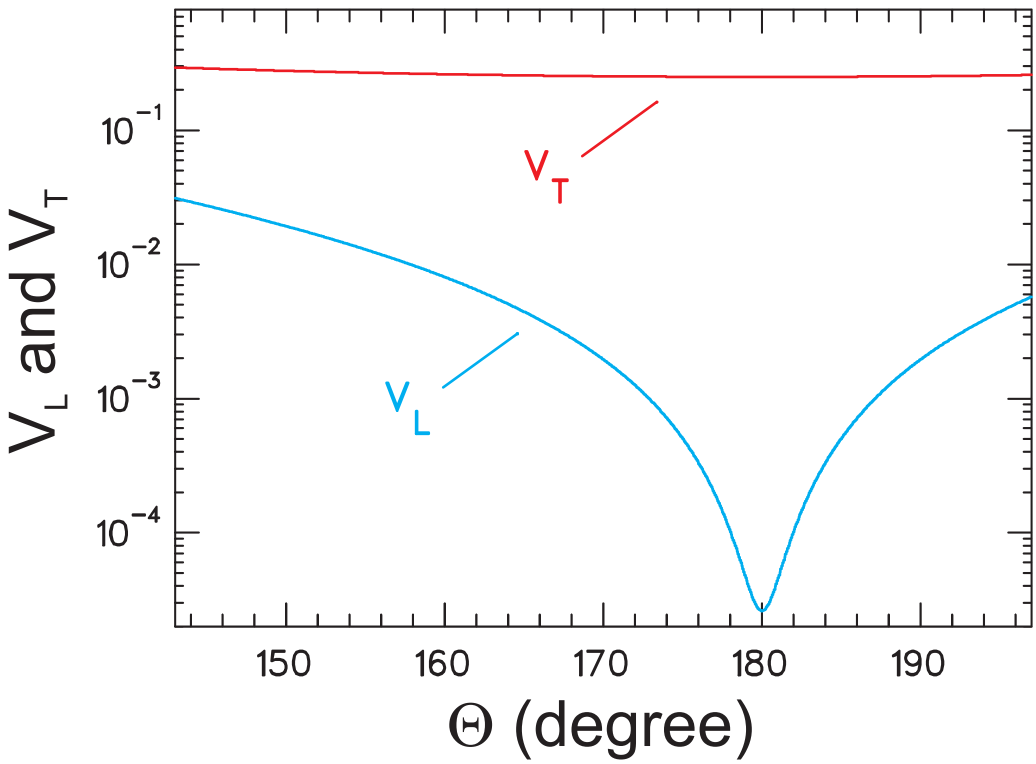
Setup for (e,e'n) Experiments



Why 180° ?

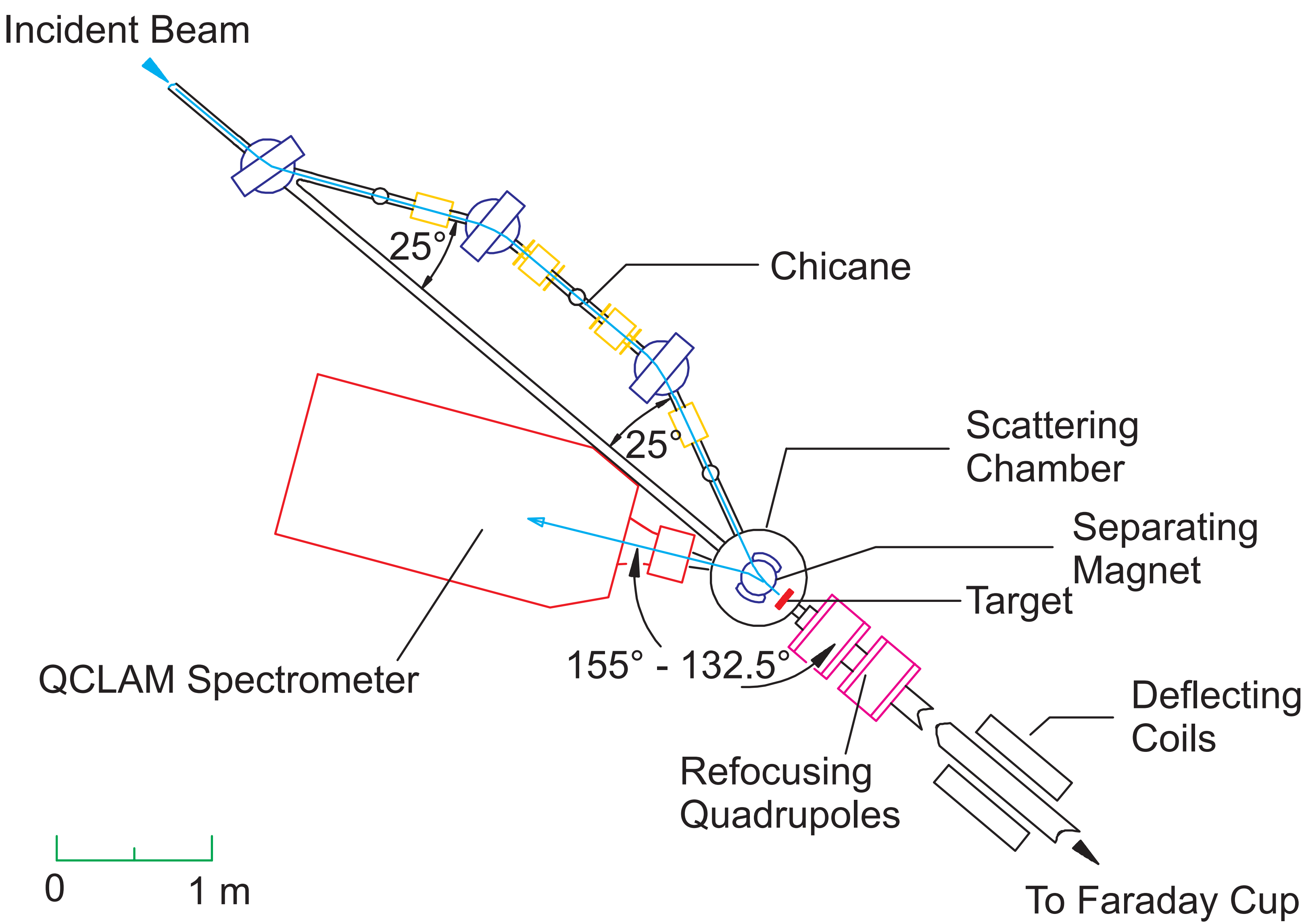
$$\left(\frac{d\sigma}{d\Omega}\right) = \left(\frac{d\sigma}{d\Omega}\right)_L + \left(\frac{d\sigma}{d\Omega}\right)_T$$

$$\left(\frac{d\sigma}{d\Omega}\right)_L \propto V_L \times |F_L(q)|^2 \quad \left(\frac{d\sigma}{d\Omega}\right)_T \propto V_T \times |F_T(q)|^2$$



- Scattering at 180° is ideal for measuring transverse excitations

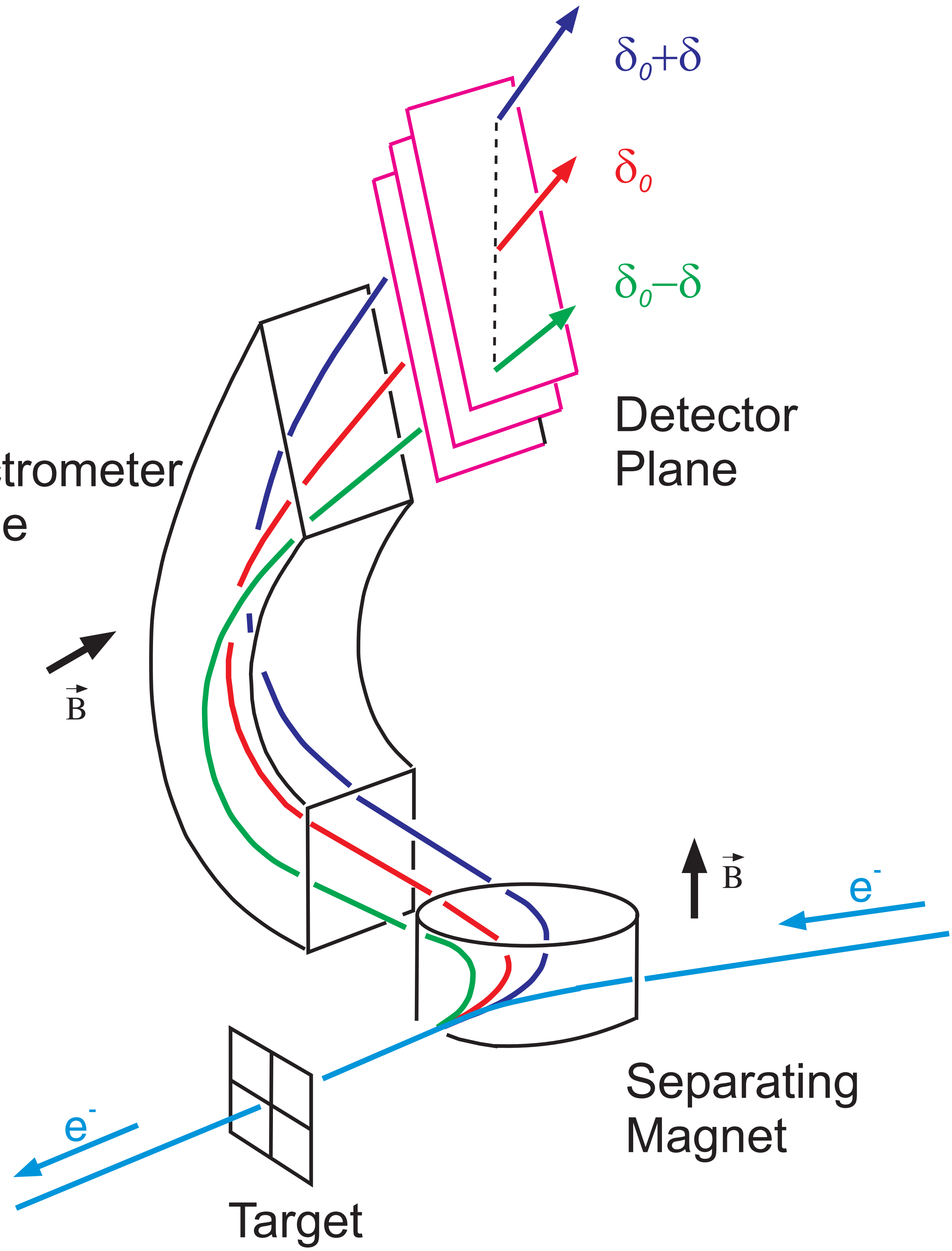
180° System at the S-DALINAC



Parameters of the 180° System at the S-DALINAC

		Full solid angle	Limited solid angle
Central energy range	MeV	25 · 85	25 · 85
Momentum acceptance	%	[- 10 ; + 10]	[- 6 ; + 8]
Effective scattering angle	deg	ca. 177.5	ca. 178
Acceptance of the horizontal scattering angle	mrad	· 60	· 40
Acceptance of the vertical scattering angle	mrad	· 40	· 40
Solid angle acceptance	msr	9.6	6.4
Momentum transfer	fm^{-1}	0.2 · 0.85	0.2 · 0.85
Intrinsic energy resolution		$2 \cdot 10^{-4}$	$2 \cdot 10^{-4}$

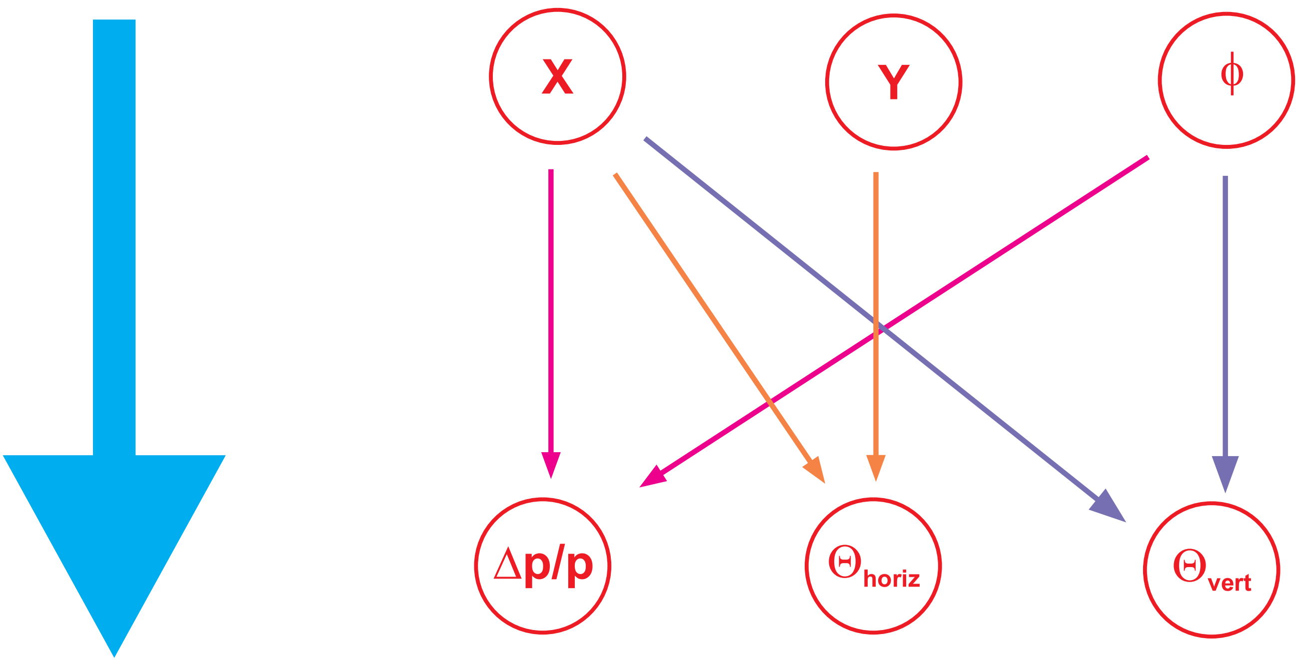
Electron Trajectories in 180° Mode



Event Reconstruction

Raw Data (MWDCs):

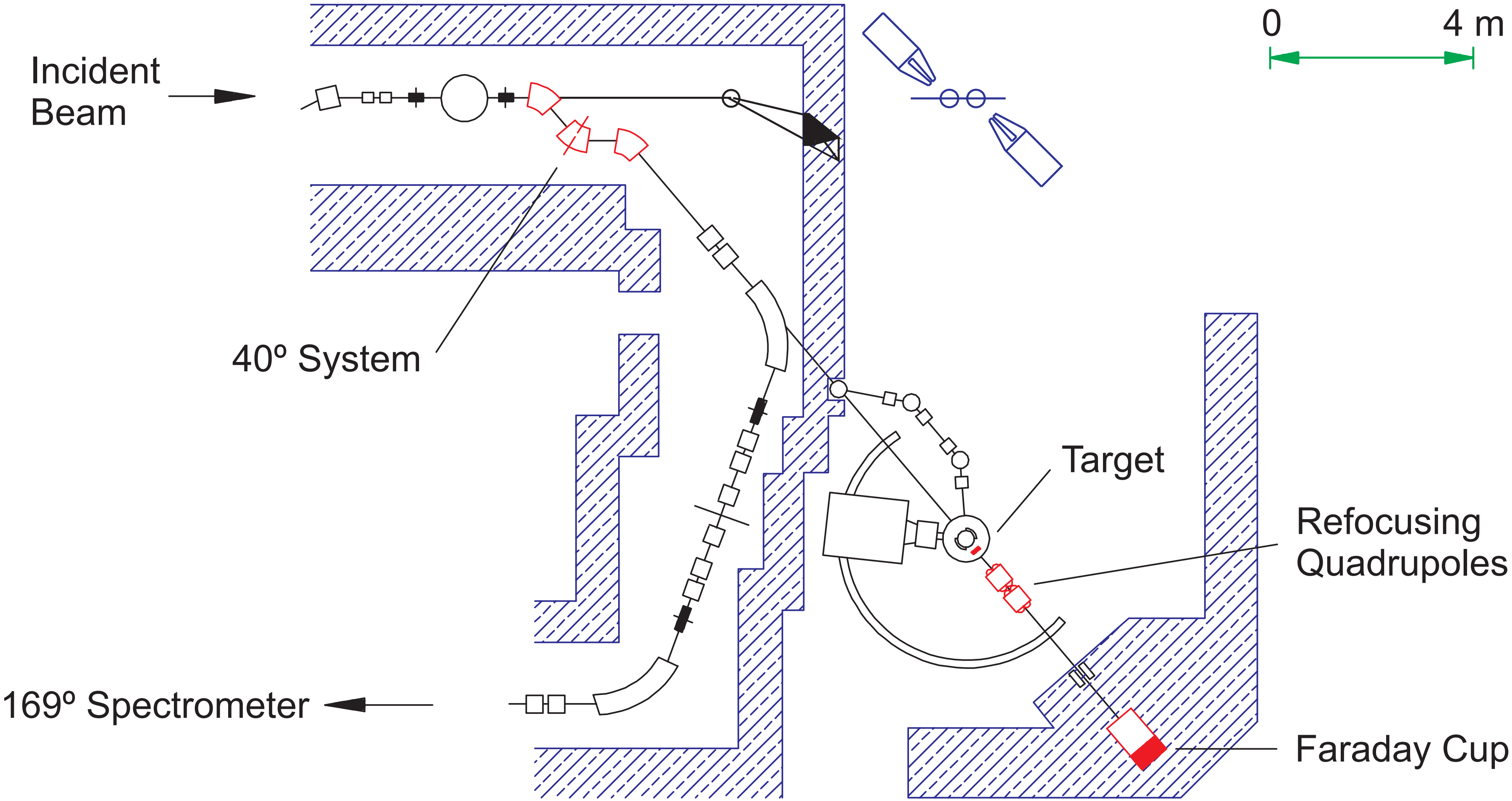
- x = dispersive coordinate at the detector plane
- y = non-dispersive coordinate
- ϕ = vertical intersection angle at the detector plane



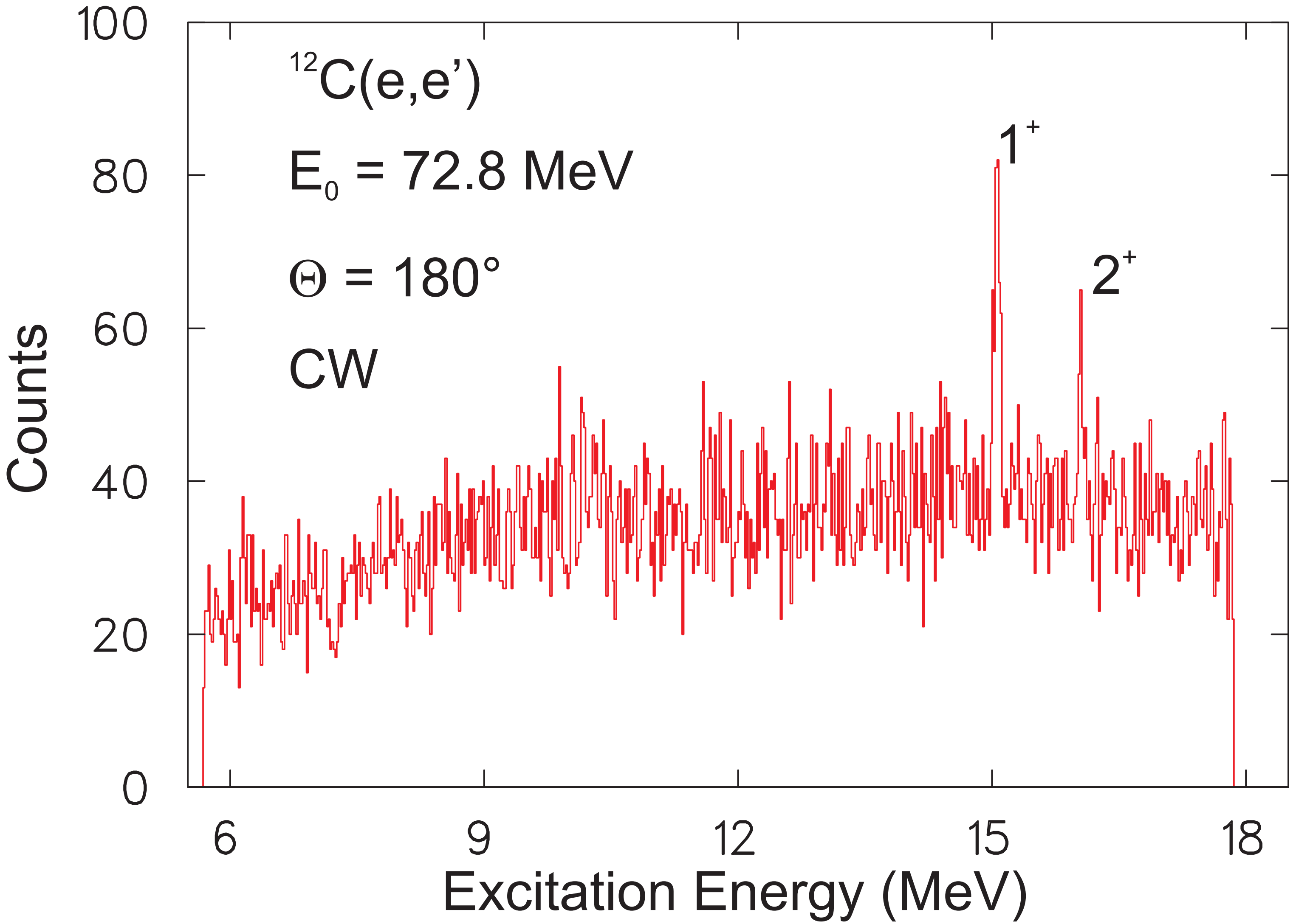
Physical Information:

- $\Delta p/p$ = relative momentum ⇨ E_x
- Θ_{horiz} = horizontal angle at the target
- Θ_{vert} = vertical angle at the target

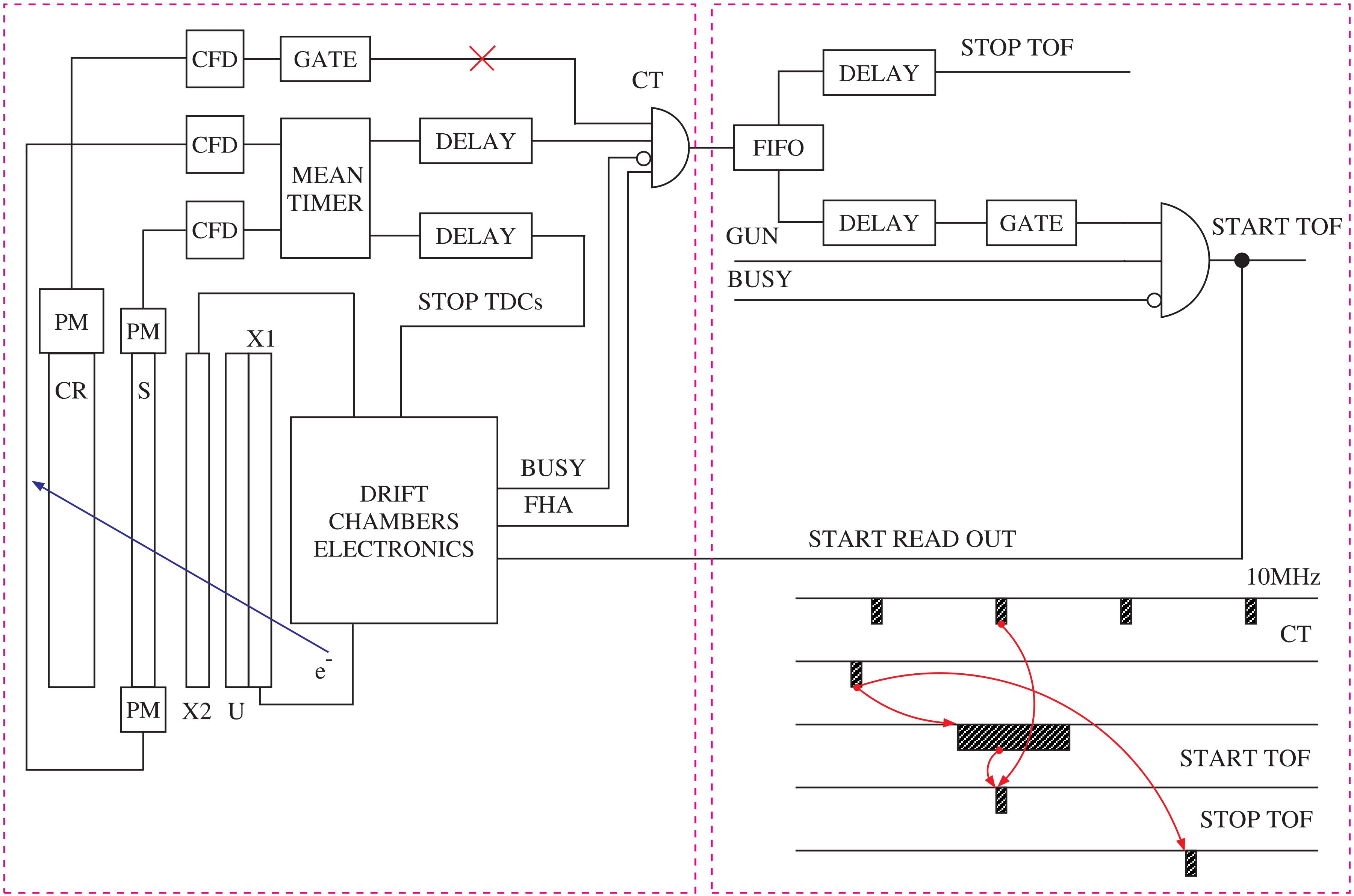
Background Sources in 180º Mode



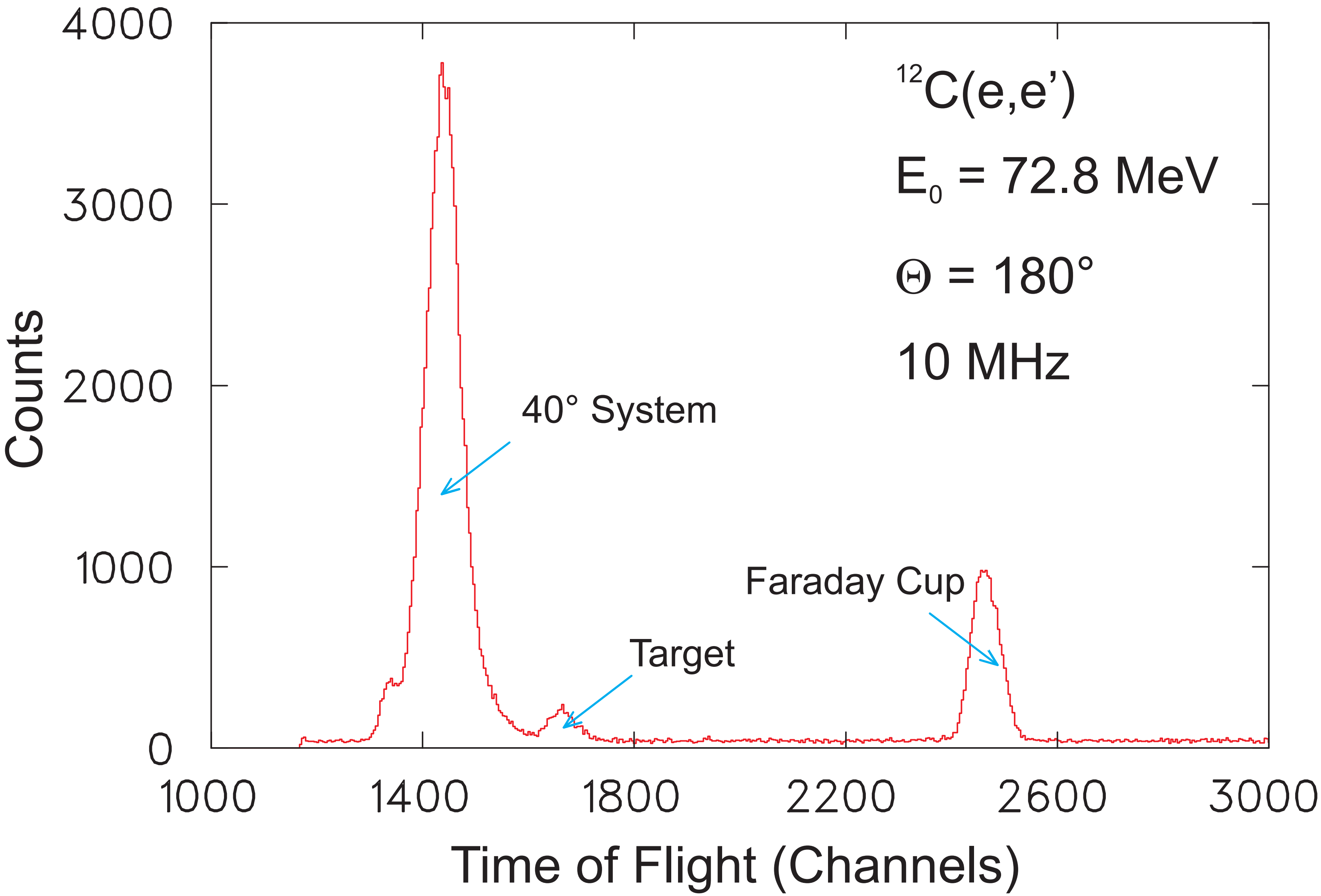
Excitation Energy Spectrum of ^{12}C



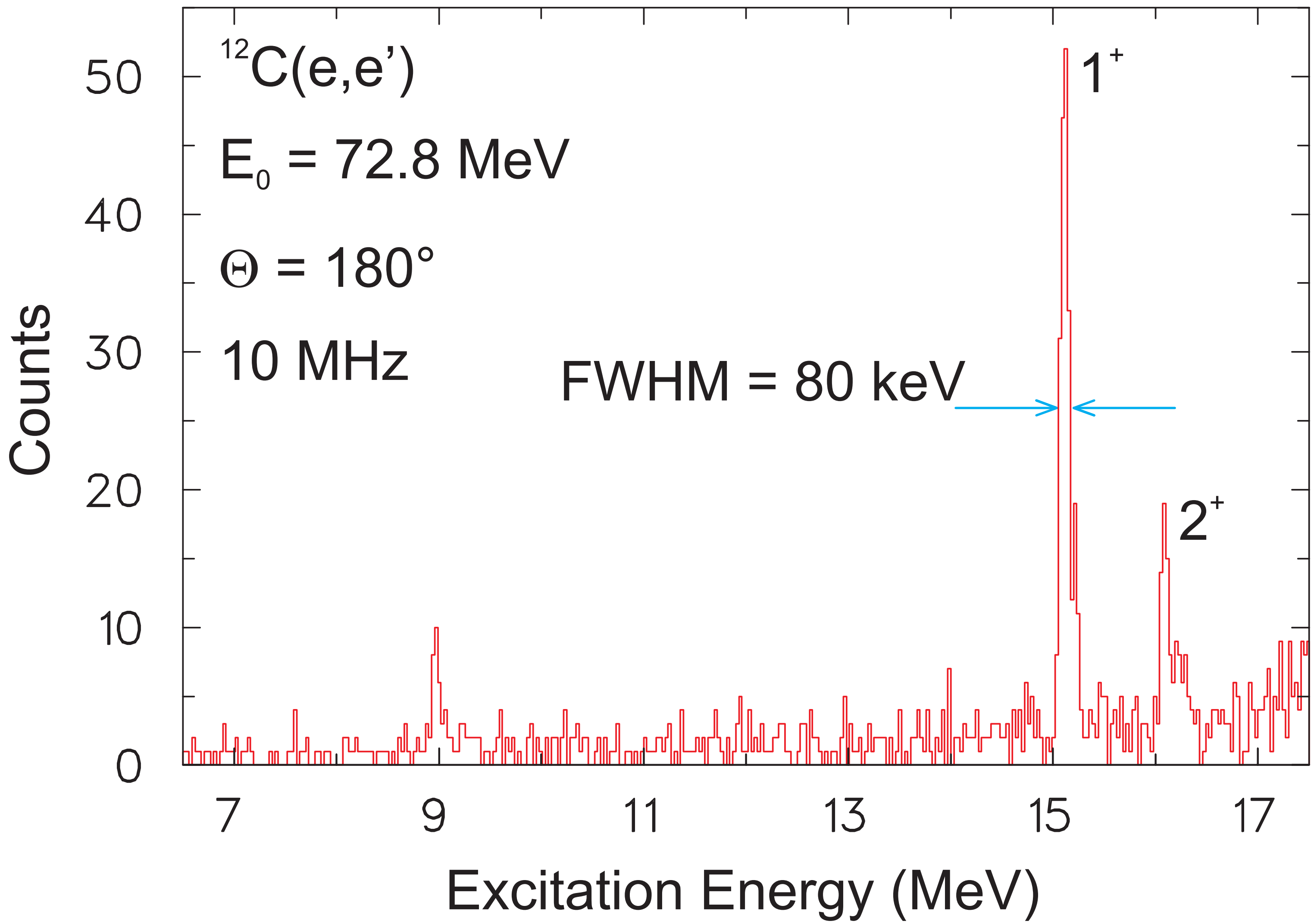
Trigger Electronics



Time Spectrum of Electrons



Excitation Energy Spectrum of ^{12}C



Status and Outlook

- Larger momentum acceptance than that of any previous 180º system
- Unprecedented capabilities for solid angle definition
- Effective background suppression
- Possibilities for alignment and monitoring of the system
- New separating magnet
  - ⇨ higher momentum transfer
  - ⇨ better background suppression
- New VDCs
  - ⇨ improvement of the event reconstruction