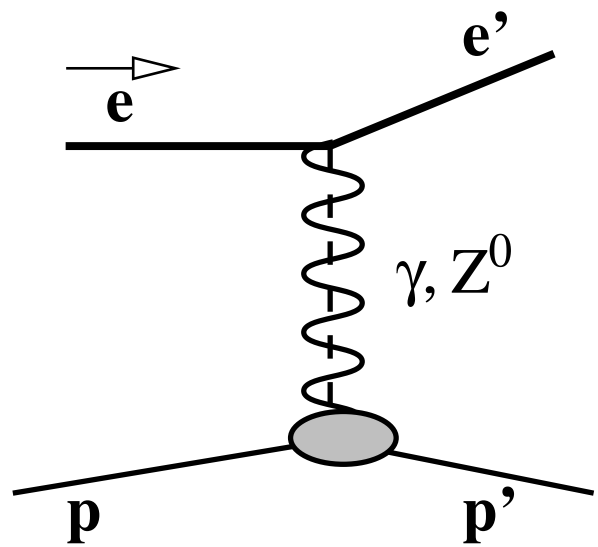
HAPPEX II

Constraining the nucleon strangeness radius with parity violating elastic e-p scattering at low Q^2



JLab, Hall A

Experimental Status at JLab

- **HAPPEX :** **Linear combination** $G_E^s + 0.39 G_M^s$ **at** $Q^2 \sim 0.48\, GeV^2$

First accurate PV measurement at JLab $\xrightarrow{\text{Strangeness?}}$

- **- Small strange effect.**
- **- Cancellation**
- **- Fast fall off with Q** ^{2}

- **HAPPEX II:** **measurement of the leading non zero moments at low Q** ^{2}**:**

Adress the contribution of the strange quark

Form Factors ~ at the origin

$$\mu_s = G_M^s(0)\,,\quad \rho_s = \frac{dG_E^s}{d\tau} = -\frac{2}{3}M_p^2\,\langle r_s^2\rangle - \mu_s\,,\quad \langle r_s^2\rangle = -6\,\frac{dF_1^s}{dQ^2} \qquad (\tau = Q^2/4M_p^2)$$

Complex dynamics of the sea,
models predictions vary widely in magnitude:

$$r_s^2 = -0.3 \to 0.3\, fm^2$$
$$\mu_s = -0.40 \to 0.03\,\mu_N$$

Measurement at low Q^2

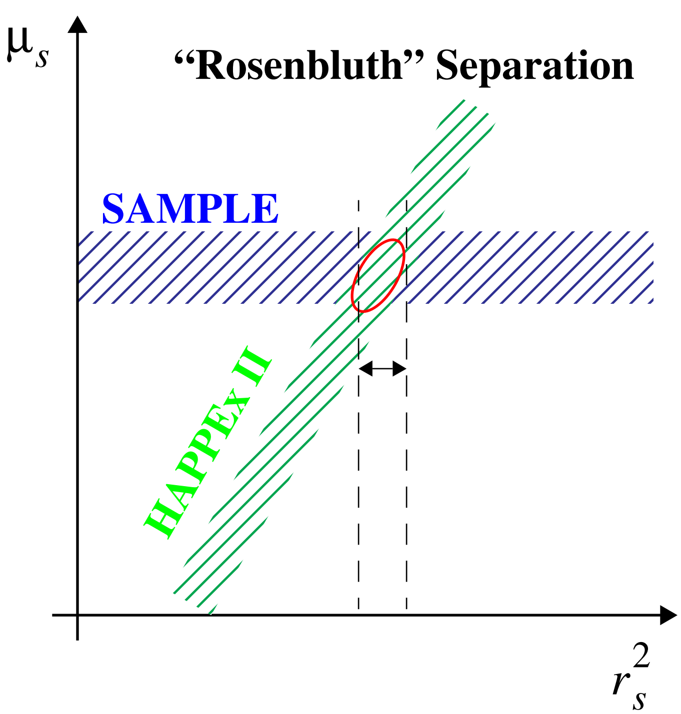
- **SAMPLE at Bates:** G_M^s **at backward angle,** $Q^2 \sim 0.1 GeV^2$

  $$G_M^s = 0.61 \pm 0.17(stat) \pm 0.21(syst) \pm 0.17(theo)$$

  nucl-exp/9702004, New data on deuteron to be analysed

- **HAPPEx II at JLab:** $G_E^s + 0.08 G_M^s$ **at forward angle,** $Q^2 \sim 0.1 GeV^2$

$$A_{LR} = -\frac{G_F Q^2}{4\pi\alpha\sqrt{2}} \times \left\{ (1 - 4\sin^2\Theta_W) + \tau[\mu_n(1-\mu_p) - \rho_s - \mu_p\mu_s] + O(\tau^2) \right\}$$



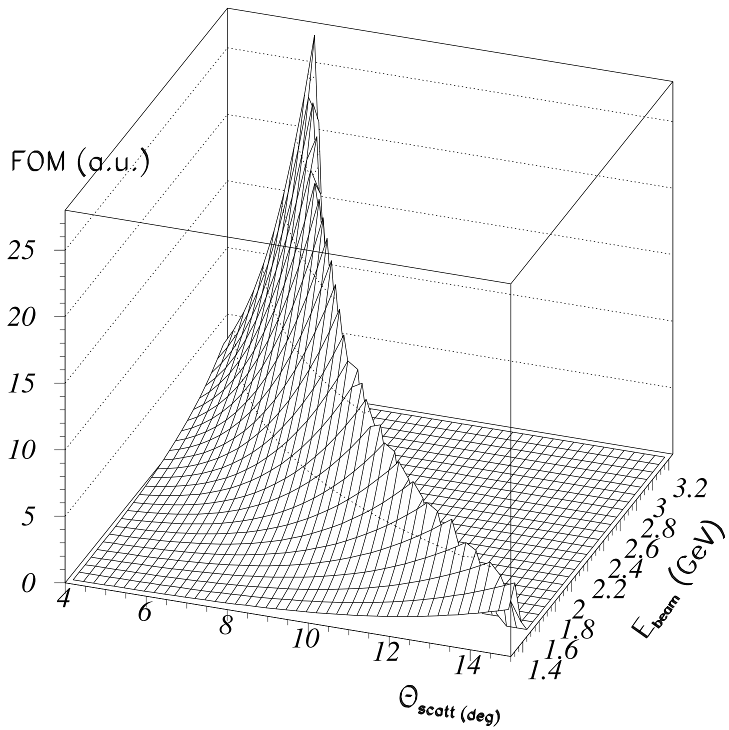
* **Cancellation ?**

$\longrightarrow$ **pure electric** G_E^s

* **Fast fall-off with Q^2 ?**

$\longrightarrow$ **Form factors at the origin**

Kinematics



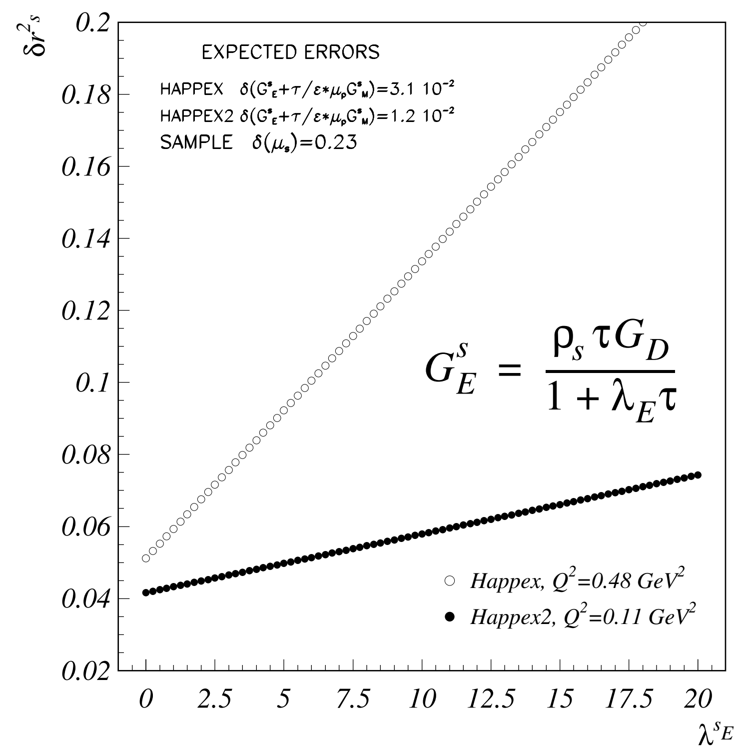
$$\langle Q^2 \rangle = 0.1 GeV^2$$

Good compromise between s-quark signal and sensitivity to Q^2 dependence

$$E = 3.2 GeV \qquad \Theta = 6°$$

$$A_{LR} = -1.63 ppm$$

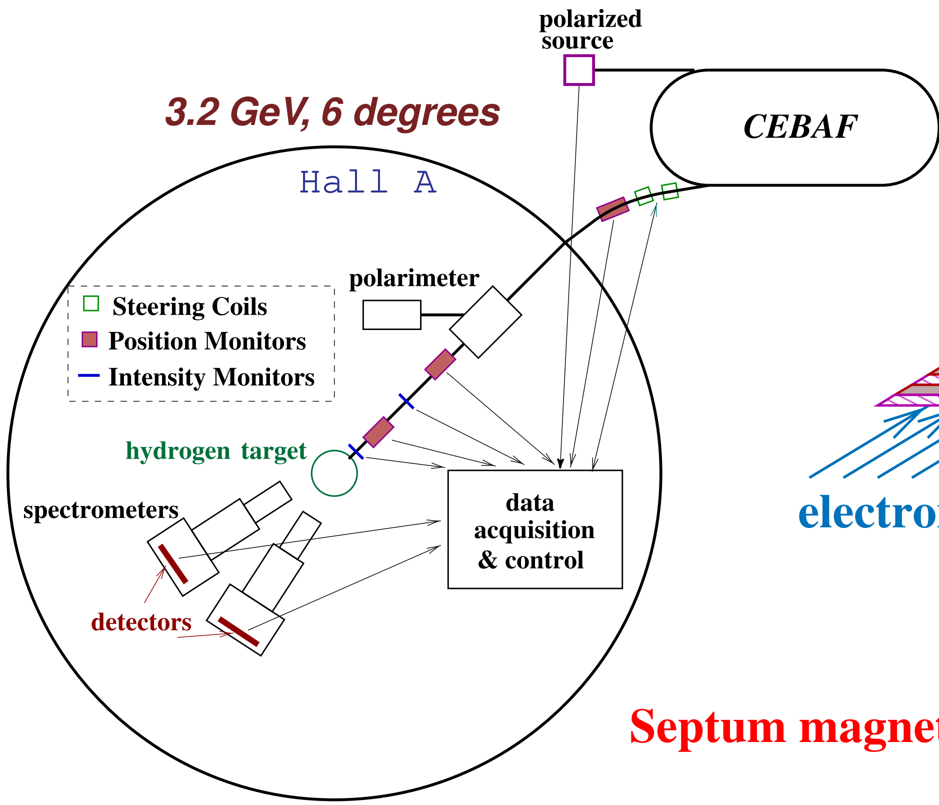
Counting rate: $2 \times 63.5 MHz$



“Table-top” experiment

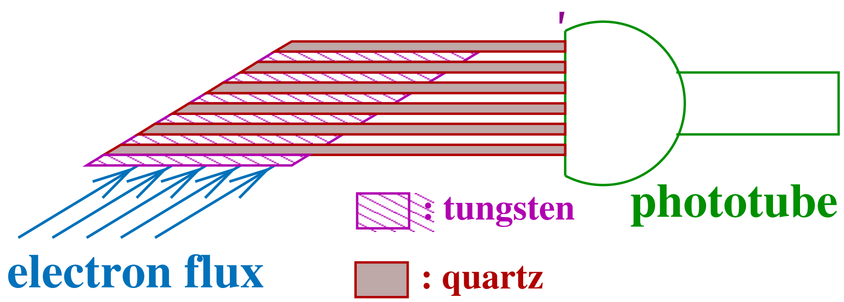
HAPPEx technology:

3.2 GeV, 6 degrees

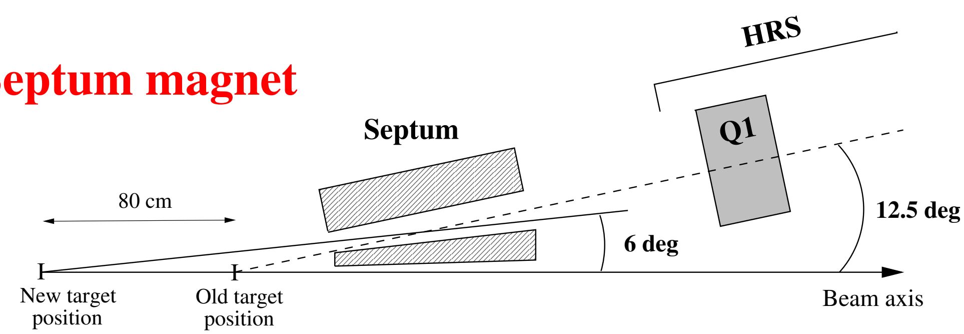


New Hardware:

Rad. hard calorimeter



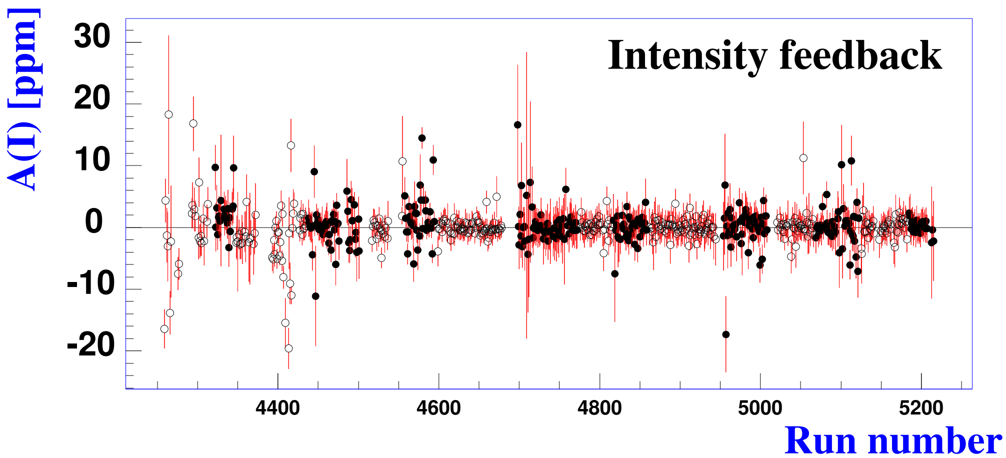
Septum magnet



Systematics

Know How from HAPPEX

Charge asymmetry



→ $\boxed{A_I < 5\times10^{-7}}$ **Already fine !**

Position differences

* **New issue related with the properties of the high polarization source**

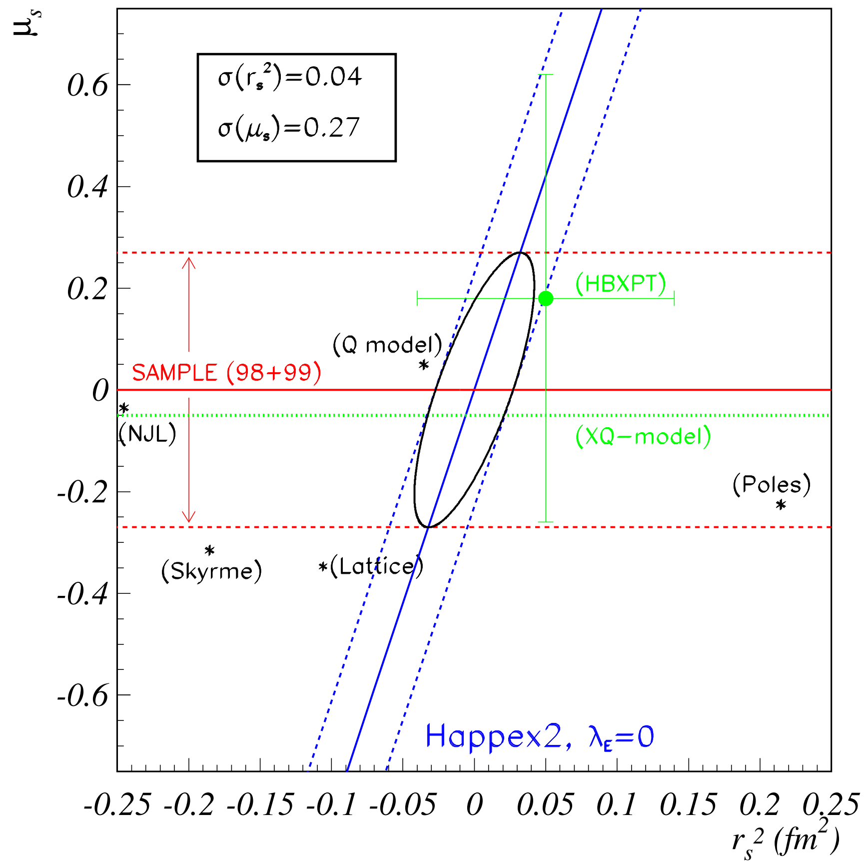
* **Already achieved in 99:**
  20 nm ⟶ 0.15 ppm correction

Our goal is a factor 5 better to keep systematics negligeable

Experimental improvement being developped at SLAC

Error Budget

Source	$\delta A^{PV}/A^{PV}$	$\delta(\rho_s+\mu_p\mu_s)$
Statistics	**4.6 %**	**0.267**
Polarimetry	**2.0 %**	**0.116**
Background	**0.9 %**	**0.052**
Q^2	**0.6 %**	**0.035**
Rad. Corrections	**1.0 %**	**0.058**
$\sin^2\Theta_W$	**0.4 %**	**0.023**
Subtotal	**5.2 %**	**0.303**
G_E^n	**(1.4) 4.8%**	**(0.081) 0.278**
Total	**(5.4) 7.1%**	**(0.314) 0.411**



→ **Powerful constraint on the charge radius** $\Delta r_s^2 = 0.04\, fm^2$

Saclay in HAPPEx II

- Co-spokesperson
- Compton polarimetry
- Radiation Hard detector
- 1 student

Summary

	2000	2001	2002	
Tasks	Detector design-test Septum Systematics at the source		Data taking Happex+Compton Analysis	
Travel expenses	180	250	300	(kf)
Investment	150	150	50	(kf)

full time   part time

Man Power

* SPhN: Parity Group

* Technical staff: (detector) Engineer: 1man-month

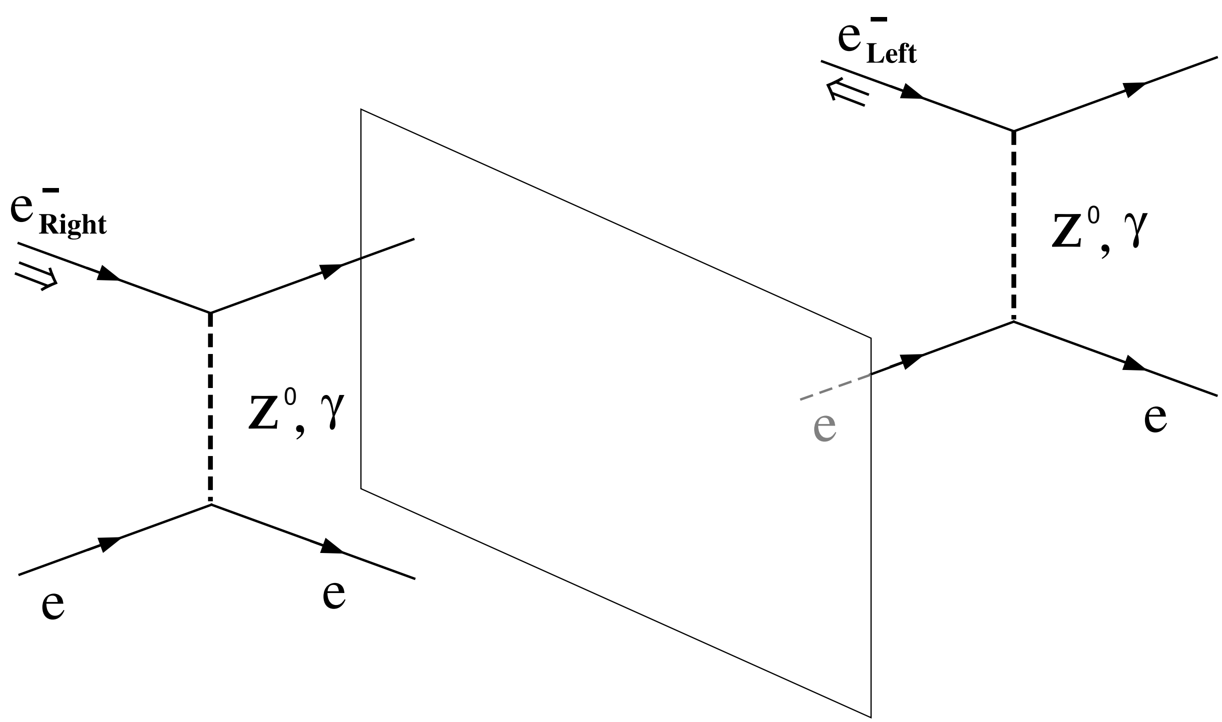
Technicians: 4 man-month

BE: 3 weeks

Parity Violation in e-e Moller Scattering

E158 Experiment at SLAC

End Station A



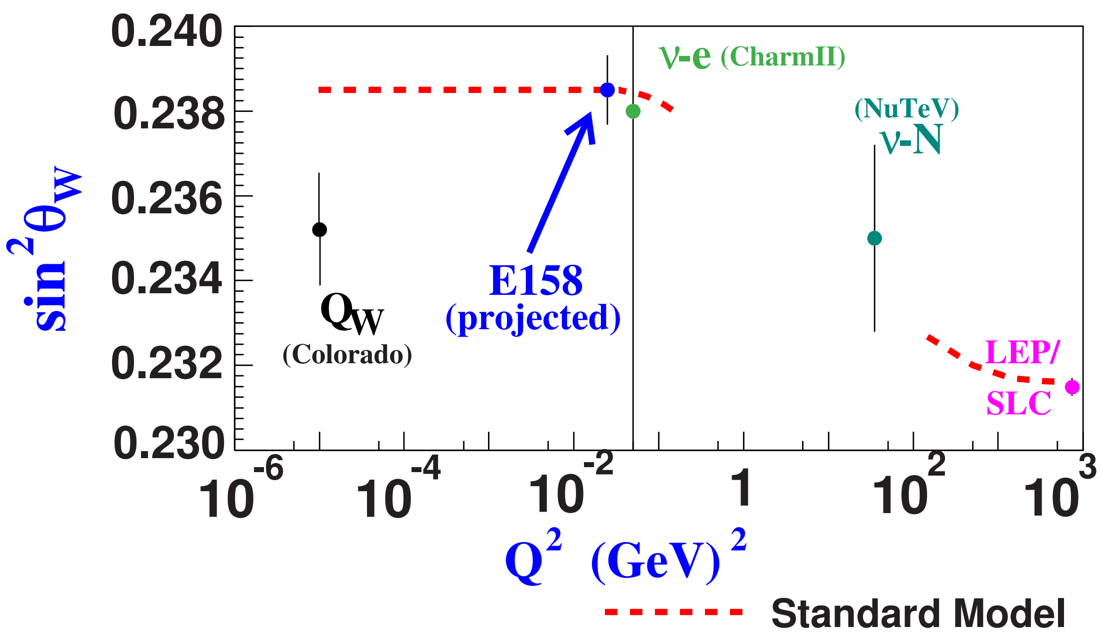
Physics Motivation

A precise measurement of the running of $\sin^2\Theta_W$

$$A_{LR} = mE\frac{G_F}{\sqrt{2}\pi\alpha} \times \frac{16\sin^2\Theta}{(3+\cos^2\Theta)^2} \times \left(\frac{1}{4} - \underline{\sin^2\Theta_W}\right)$$

$e^- e^- \rightarrow e^- e^-$: No internal structure,

pure test of the Standard Model at $Q^2 = 0.03\,GeV^2$



Establish the Q^2 evolution at the 8σ level !

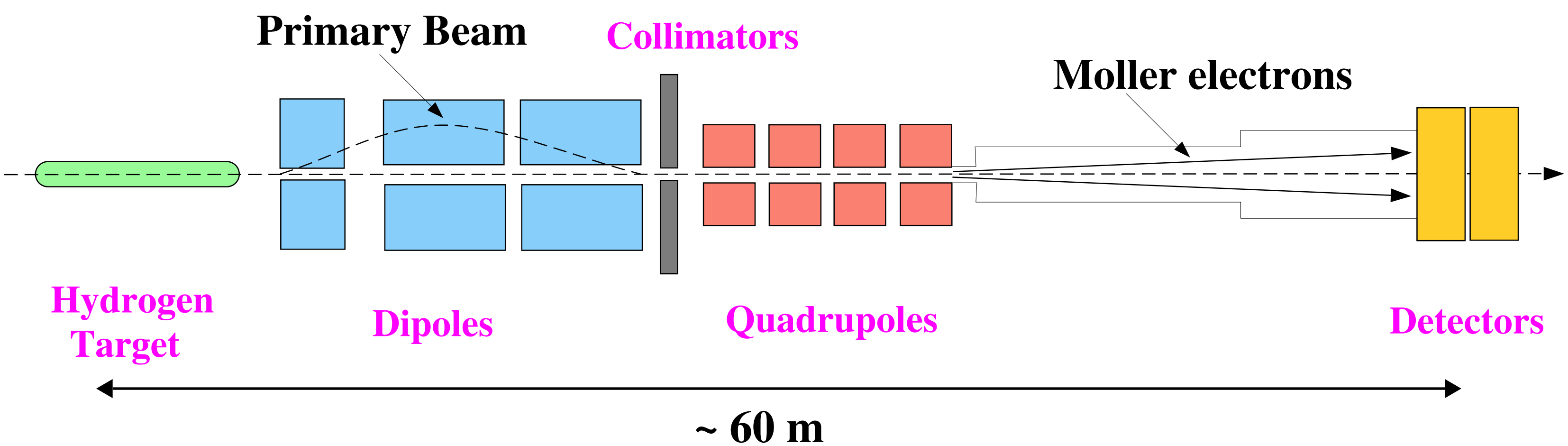
Experimental Setup

* Separation between the Moller electrons and other contributions exploiting the energy angle correlation:

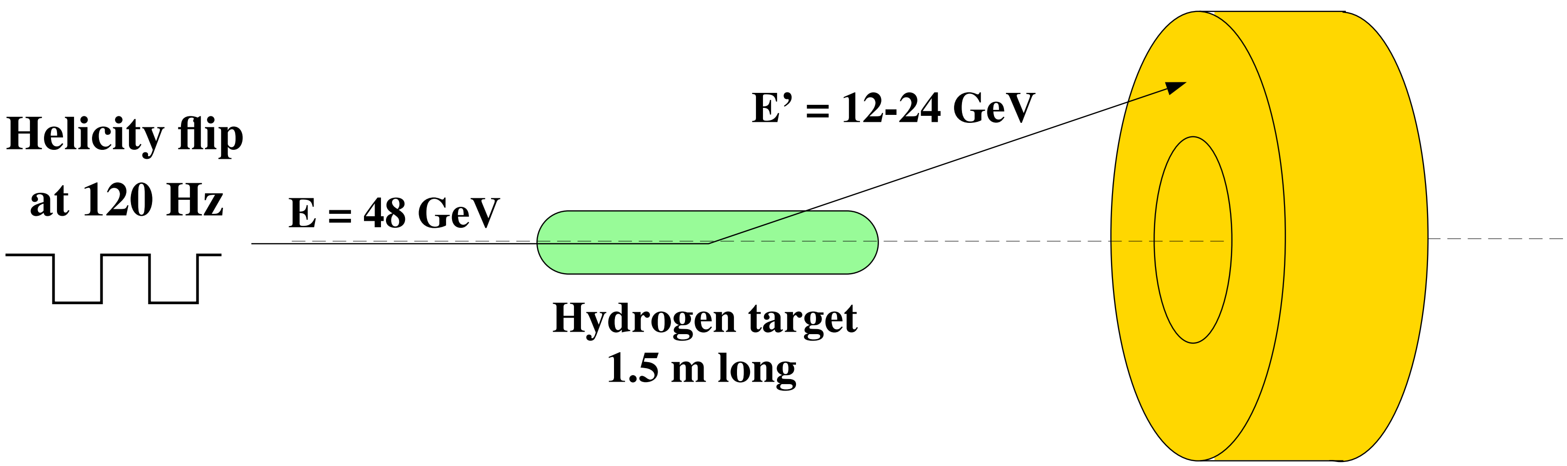
$$E' = 12\text{-}24 \text{ GeV} \longleftrightarrow \Theta = 4.5\text{-}8 \text{ mrad}$$

* Placement of the detectors out of the line-of-sight of the target

* Monitoring of the remaining background



Detection



$$\boxed{A_{LR} \approx 3.2 \cdot 10^{-7}}$$

Challenges: - **Keep the systematics at the level of few 10^{-9}**

- **Radhard detection**

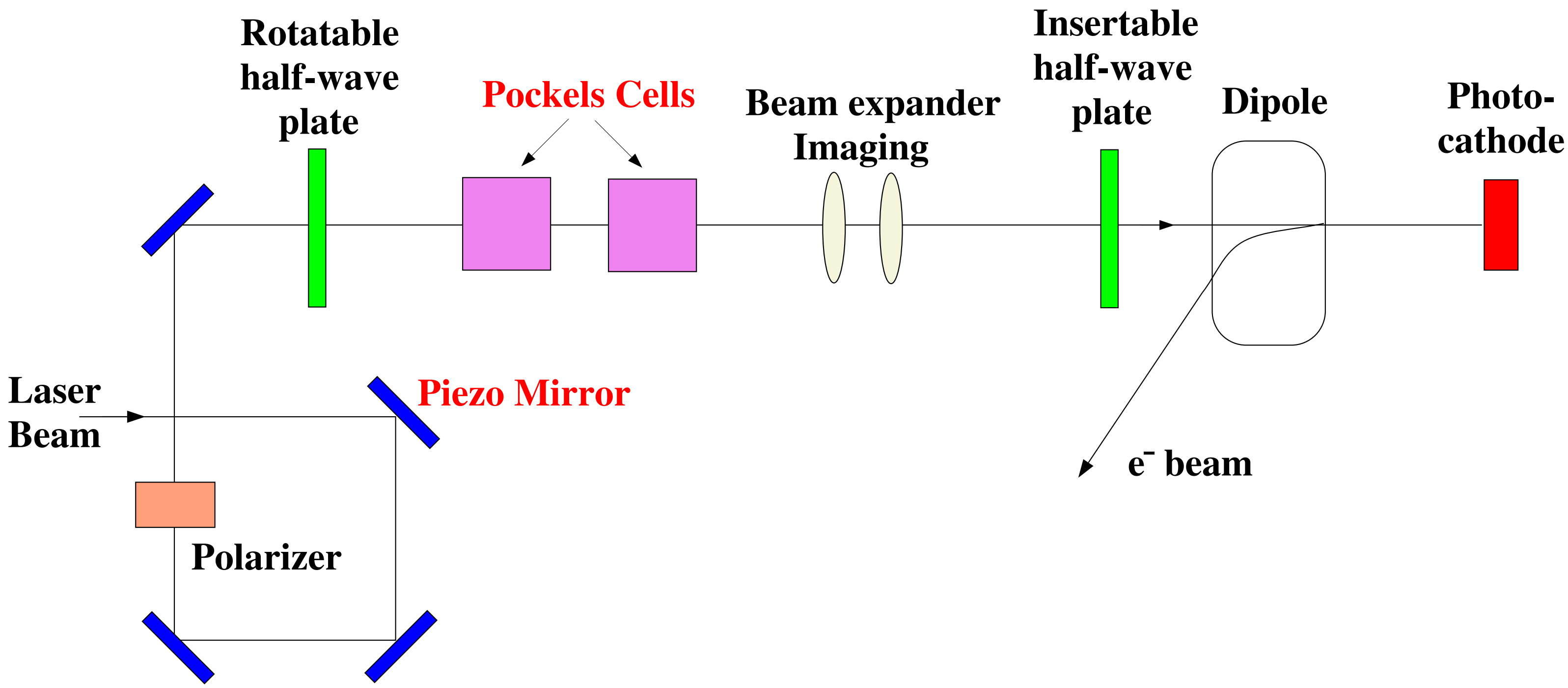
E158-HAPPEx : **Same technology, Same people**

→ **Opportunity to give new insight in a different physics field**

New developpements usefull for HAPPExII

Helicity correlations

Polarized Source



Technology to be transfered at Cebaf for HAPPExII

E158 Milestone requirements:

Charge asymmetry 2.10^{-6} on size, 10^{-9} accuracy on the correction!

Position asymmetry < 100nm

Saclay's Contribution

DAQ

Control programs

- Control of the coil-pulsing magnets

- Monitoring of the feedback on the beam parameters

Online Analysis

- Sample data stream

- Display of control parameters and relevant physical quantities

$\longrightarrow$ "Core" of the off-line analysis

First versions has to run mid-2000

Other possible contribution

Pion detector

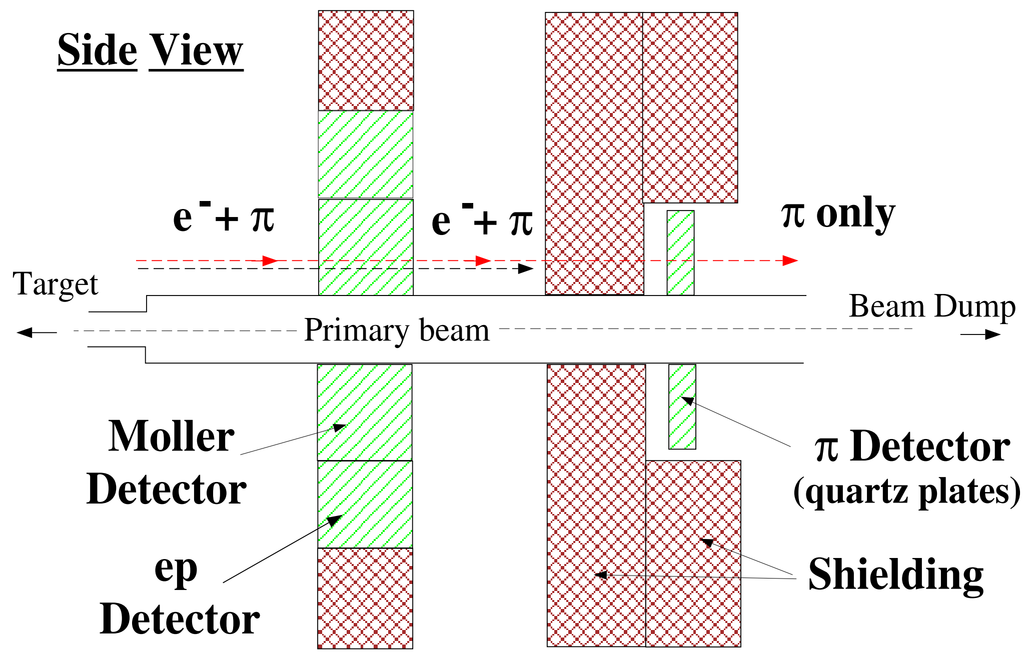
e flux = 10^9 /s

π flux < 10^6 /s

< 0.1 % of the Moller signal

But asym is ~100 times bigger

→ Up to 10% contribution



* Measurement of an unknown and potentially important systematic

* Funded by SLAC

Dead line = April 2001, possible tests with beam in Feb and Oct. 2000.

Summary

	2000	2001	2002
Tasks	DAQ ←—— – – – – – – – – → Detector design-test ← – – – – – – – – – – – – →	Data taking ←——→	Analysis – – – – – – →
Travel expenses	100	300	50 (kf)

—— full time – – – part time

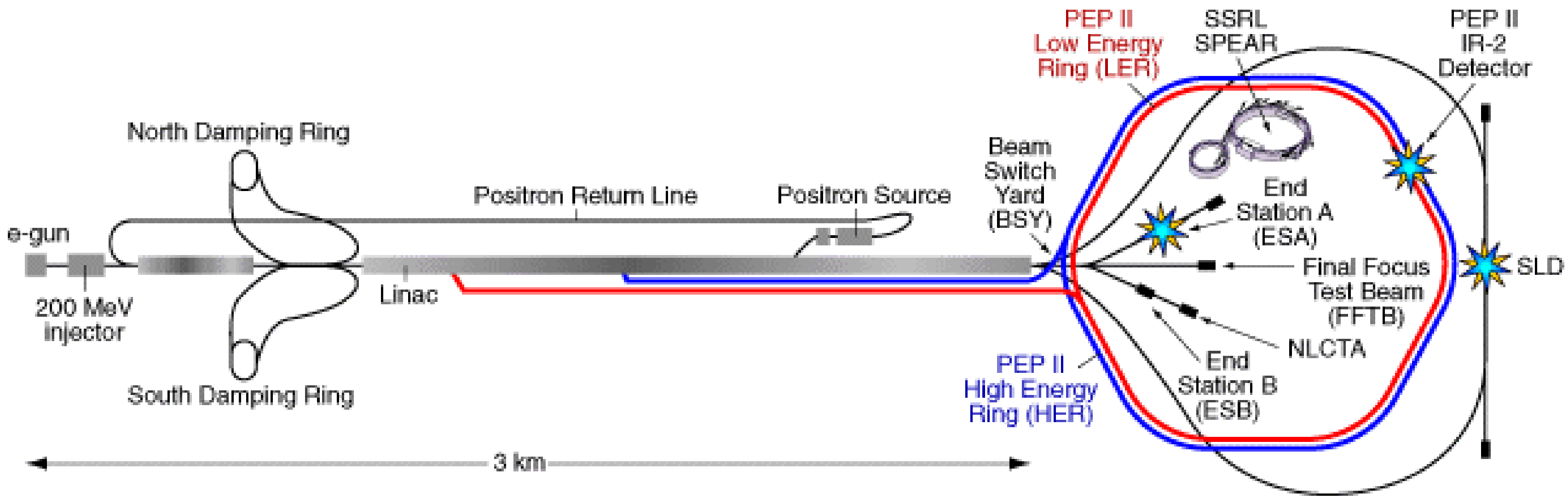
Man Power

* SPhN: 6 Physicists

* Technical staff: (detector) BE: 8 (+8) weeks

Follow-up: 1 man-month

SLAC accelerator



E158 : End Station A (ESA), fixed target

BaBar: PEP II, B factory, e^+e^- collider