EDS Blois 2017

Towards Precision Measurement of Elastic Scattering at U-70

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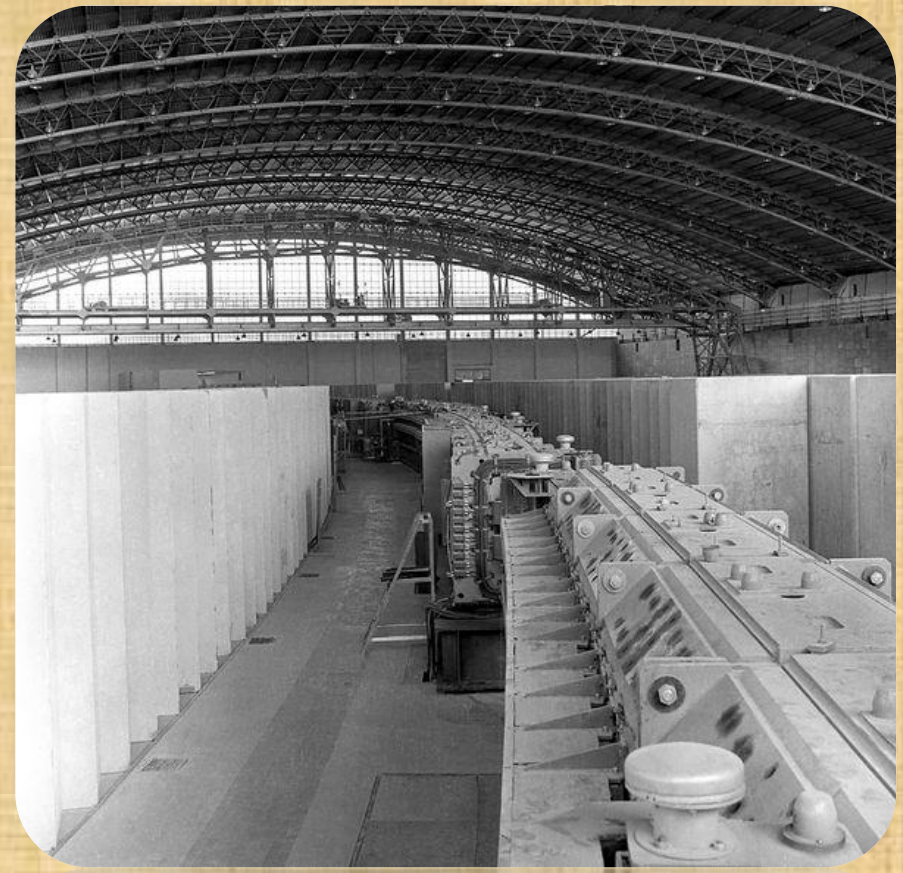
What is U-70?

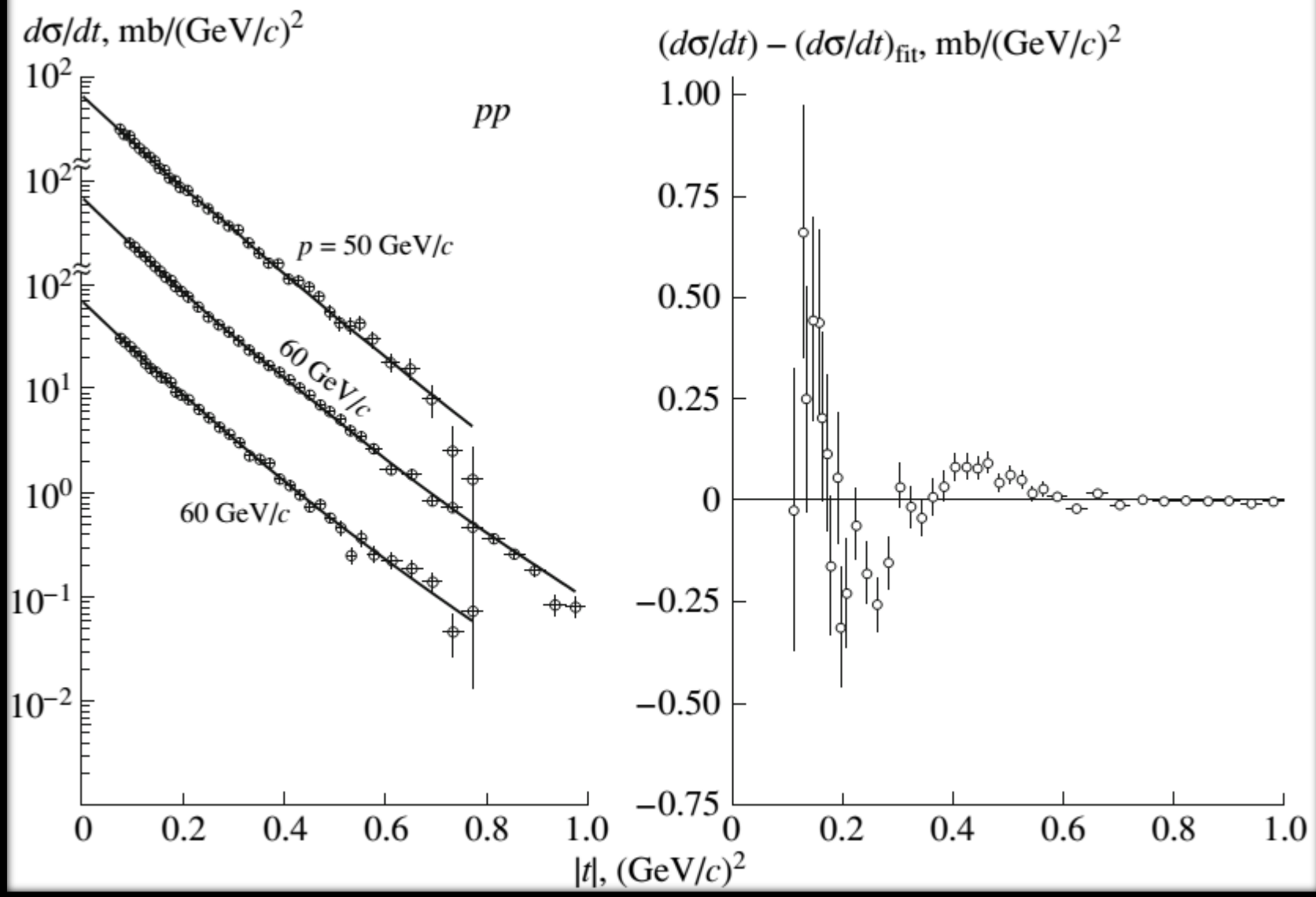
IN OPERATION SINCE 1967



Main discoveries:

- First observation of the strong-interaction cross-section growth with energy in $K^+ p$
- Scaling in hadronic inclusive spectra

Motivation (one of several)

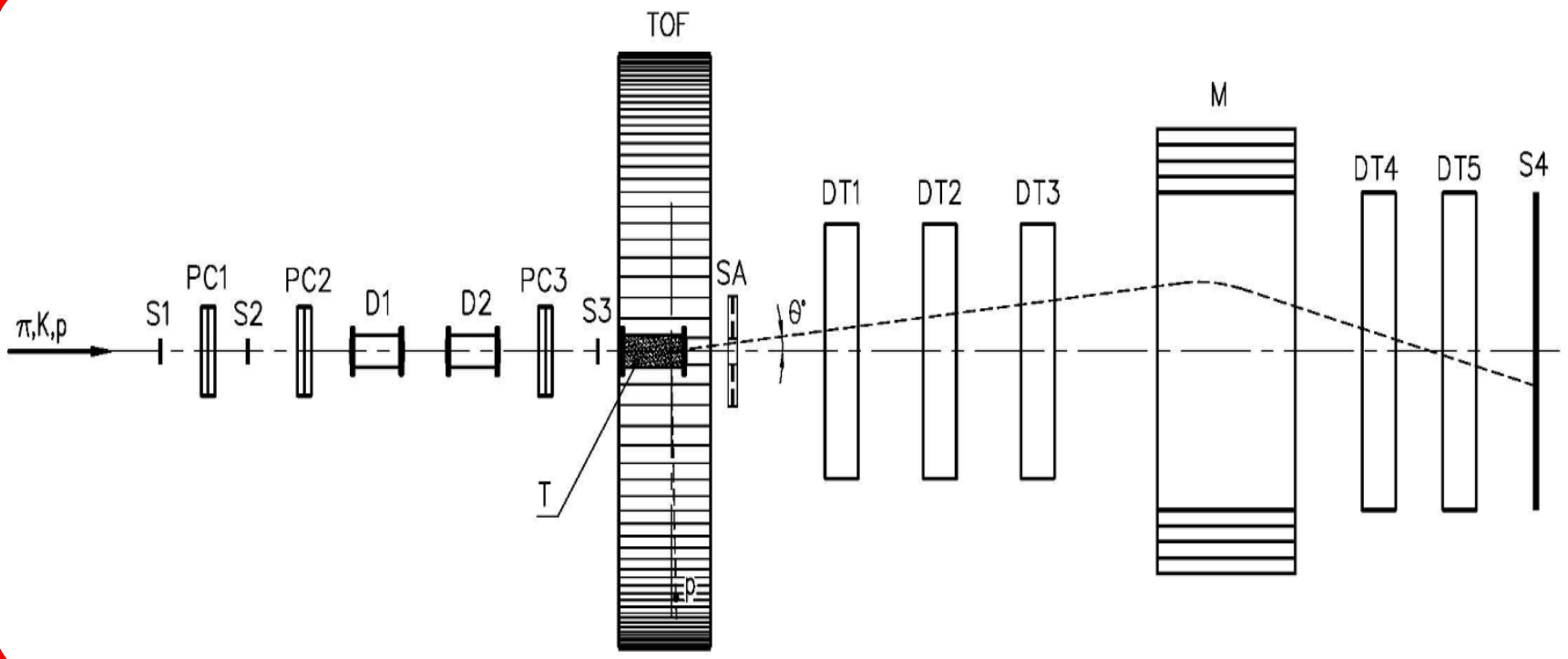


Setup

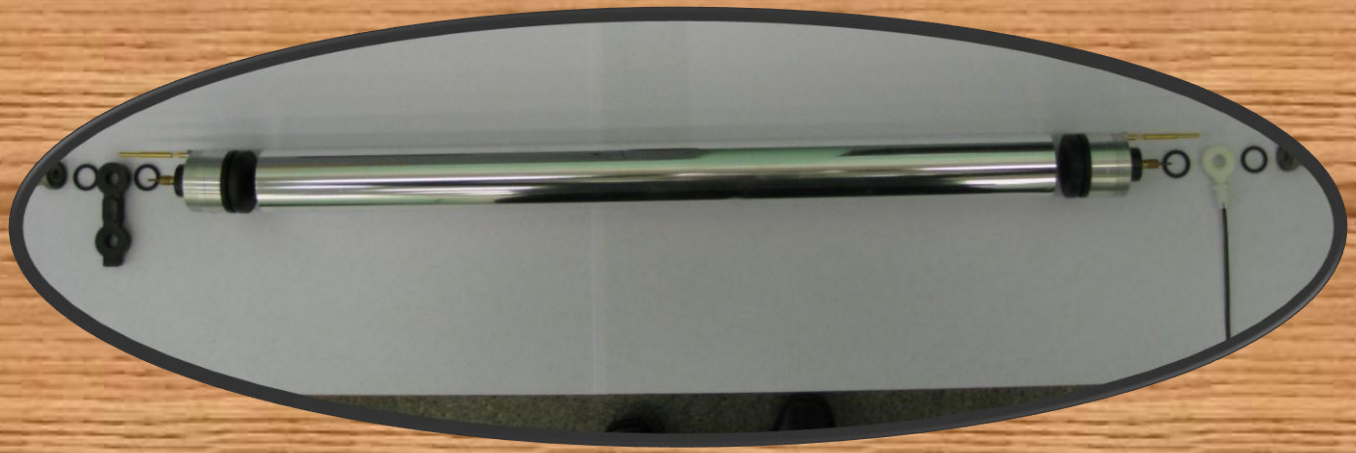
Lab. energy : 50 GeV.

Expected statistics : 10^9 events.

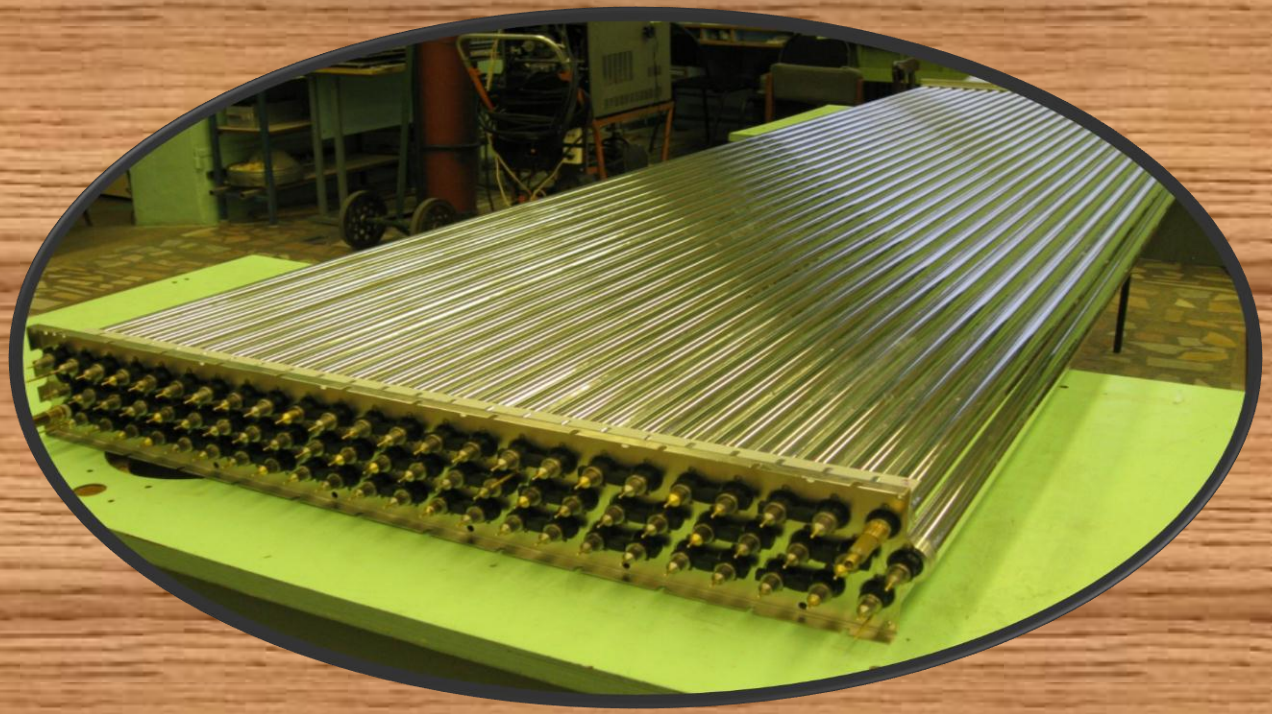
High (several percent) resolution in the momentum transfer



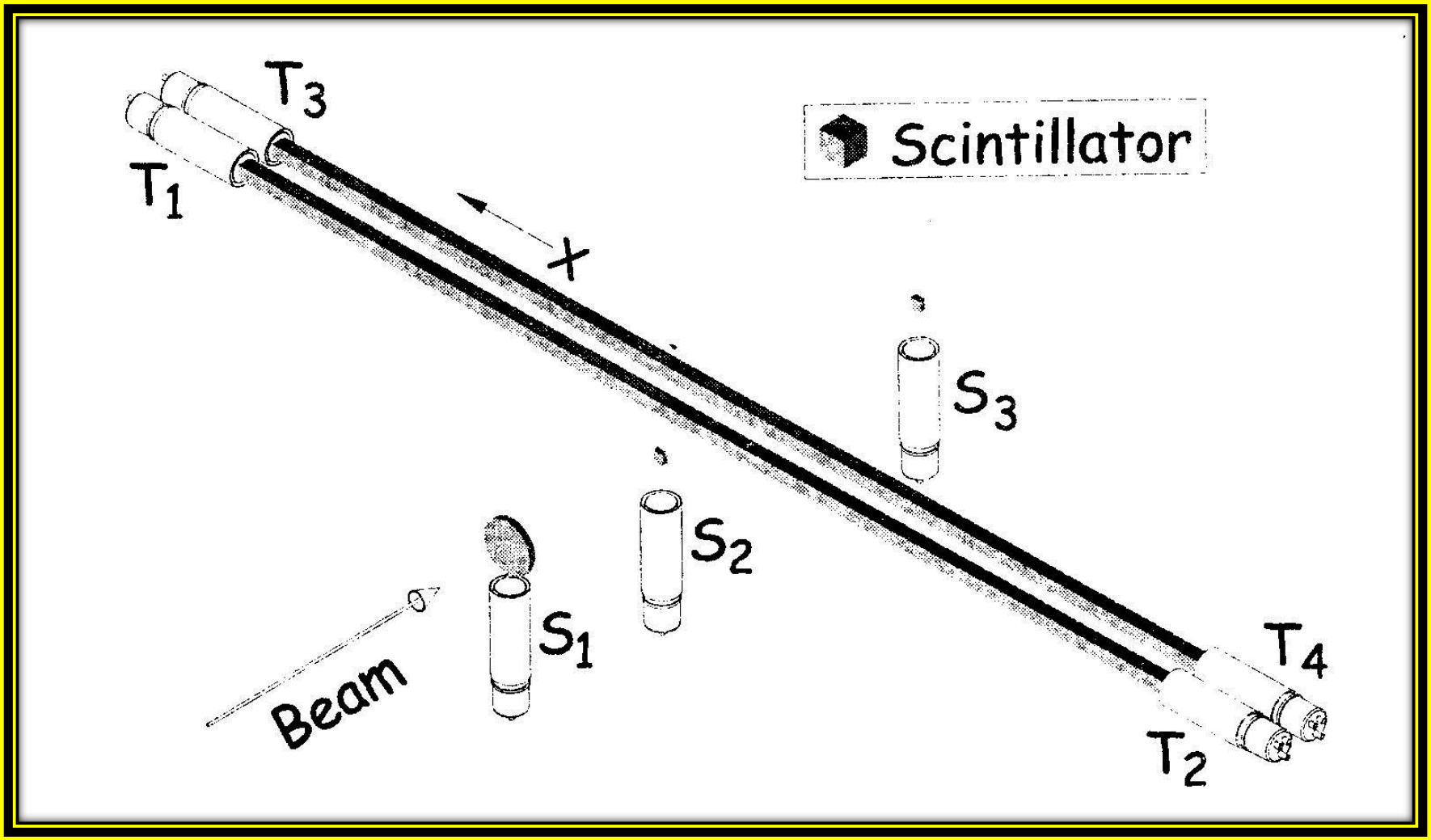
S1-S4 –SCINTILLATION COUNTERS; SA – ANTICOINCIDENCE COUNTER, PC1-PC3 –PROPORTIONAL CHAMBERS; D1, D2 – DIFFERENTIAL CHERENKOV COUNTERS; DT1-DT5 –DRIFT TUBES STATIONS; T –HYDROGEN TARGET; TOF – SCINTILLATION COUNTERS FOR MEASURING THE RECOIL PROTON TOF ; M –SPECTROMETRIC MAGNET.



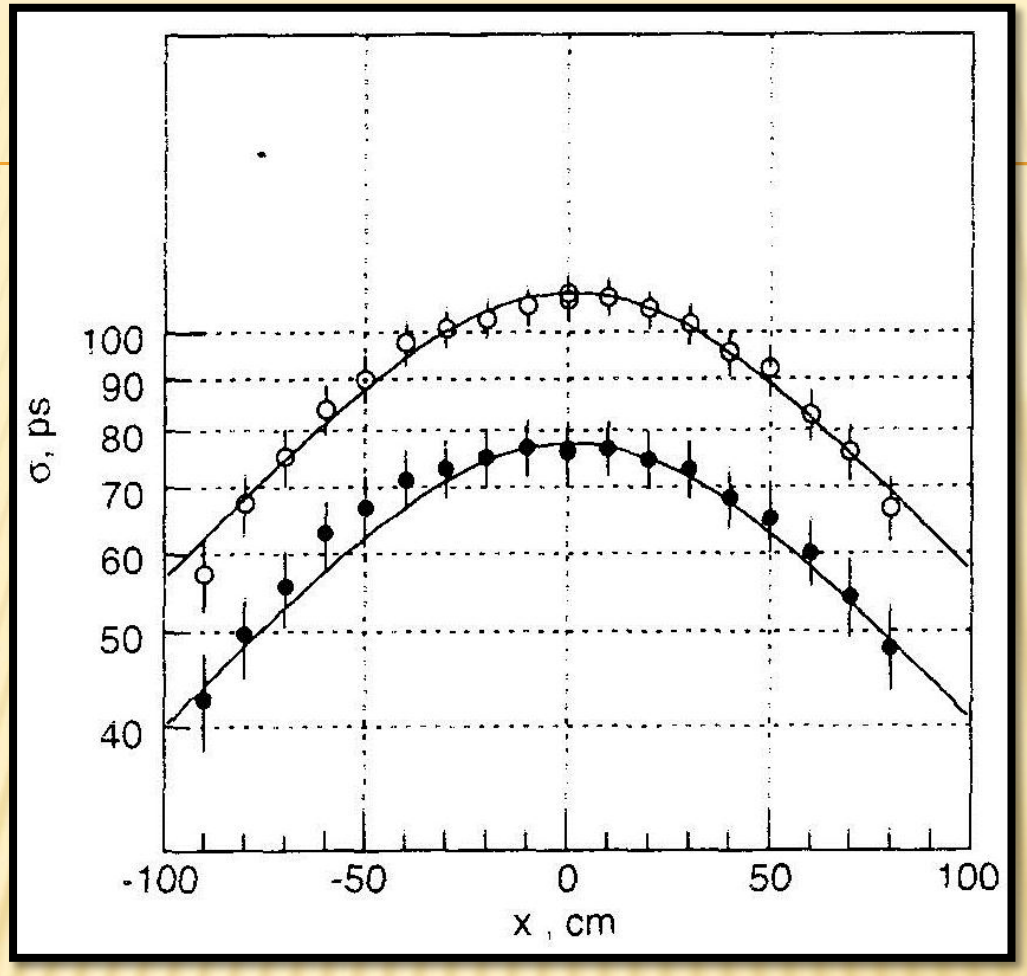
Maylar drift tube



Drift chamber



S_1-S_3 – beam counters,
T_1-T_4 – photomultipliers of scintillation counters



Time resolution of one and two 2-m counters featuring HR2020 photomultiplier tubes versus the locus of particle propagation.

- $t \in [a, b]$

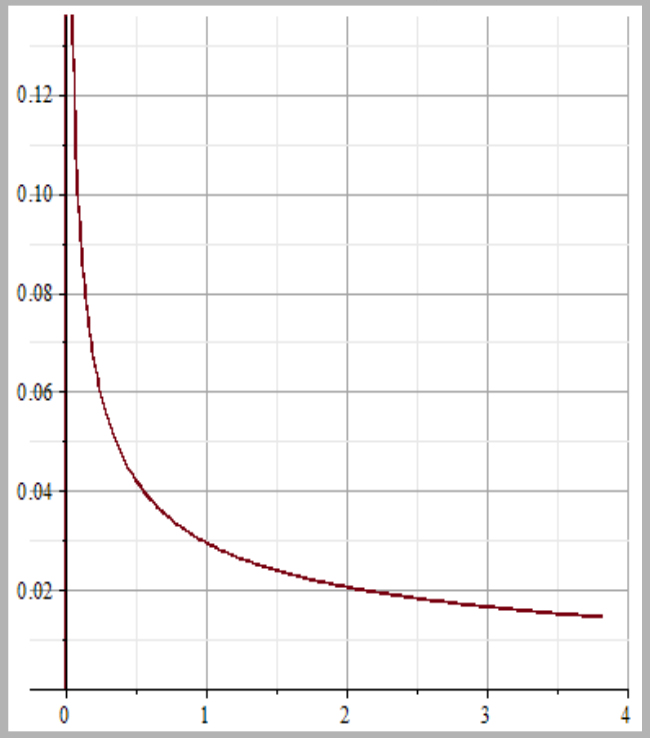
t-resolution, $\sigma(a, b)$ N, number of events/one run(20 days)

a, $(GeV/c)^2$	b, $(GeV/c)^2$	σ (a, b), mb	N
0.001	0.01	0.96	$1.83 \cdot 10^{8}$
0.01	0.1	4.03	$7.66 \cdot 10^{8}$
0. 1	1.0	2.62	$4.98 \cdot 10^{8}$
1.0	2.0	$9.89 \cdot 10^{-4}$	$1.88 \cdot 10^{5}$
2.0	3.0	$8.79 \cdot 10^{-5}$	$1.67 \cdot 10^{4}$
3.0	4.0	$9.75 \cdot 10^{-6}$	1852
4.0	5.0	$9.89 \cdot 10^{-7}$	188
5.0	6.0	$1.28 \cdot 10^{-7}$	25

Effective length = 1.5 m;
p_{Hydr} = 20 atm
(with account of the event registration efficiency)

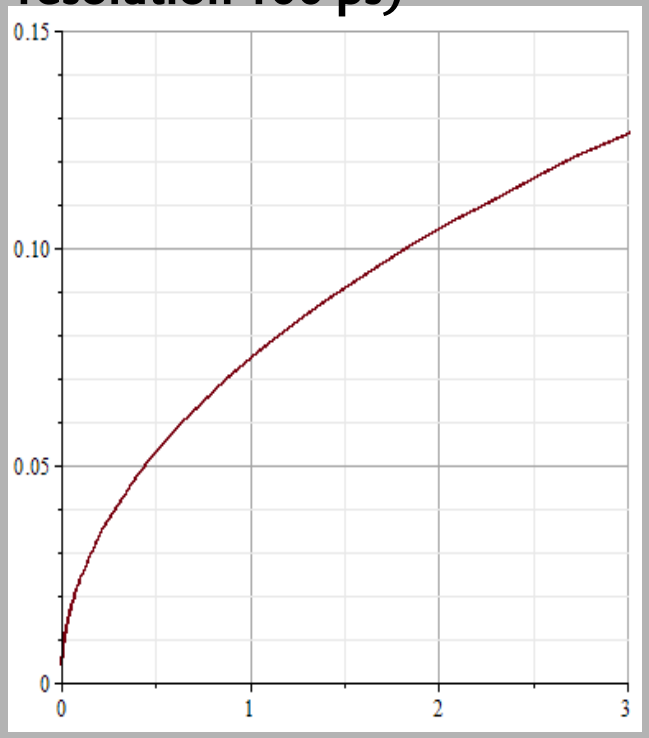
σ(t)/t

(from the scattering angle, resolution 0.3 mrad)



σ(t)/t

(from the recoil proton TOF, resolution 100 ps)



-t, $(GeV/c)^2$

Possible development

1. Elastic *pp* -scattering in the region of diffraction peak at various energies
2. πp - and Kp - scattering
3. Precision measurements in the region of Coulomb-nuclear interference
4. Elastic scattering at large transferred momenta
5. Elastic scattering of protons and nuclei off nuclei with use of gaseous low-pressure targets
6. Diffraction dissociation

Coulomb Nuclear Interference

- Aim: extraction of a maximally possible information on the strong-interaction phase.

$$\frac{d\sigma^{obs}}{dt} = \frac{d\sigma^{Coulomb}}{dt} + \frac{d\sigma^{N}}{dt} + 2\cos\Psi \cdot \sqrt{\frac{d\sigma^{Coulomb}}{dt} \cdot \frac{d\sigma^{N}}{dt}}$$

$$\Psi(s,t) = \Phi^{N}(s,t) + \frac{\alpha_{em}}{4\pi}\Delta\phi^{CN}$$

- Why?

$$\langle b^2\rangle_{tot} = 2B(s,0) + ctg\ \Phi^{N}(s,0)\frac{\partial\Phi^{N}(s,0)}{\partial t}$$

$$\langle b^2\rangle_{el} = 4\langle(-t)B(s,t)\rangle + 4\langle(-t)\left[\frac{\partial\Phi^{N}(s,t)}{\partial t}\right]^2\rangle$$

$$\langle\Delta x_{||}^{*}\rangle_{el} = \sqrt{s-4m^2}\ \langle\frac{\partial\Phi^{N}(s,t)}{\partial t}\rangle$$

Coulomb Nuclear Interference

- **The only change in the facility : the change of target and the system of TOF counters.**

  Target: a 2m long vessel of D = 1m with thin windows on the path of the beam filled with H_2

  (at p =1 atm.)

  TOF counters to be installed inside the target

  at ~ 40 cm from its axis. The pressure of hydrogen in the target is defined by give-and –take between statistics and the lowest value of |t|.

Basic attractive features of the proposal

1. High beam intensity (10^7 p/cycle)
2. 4π geometry
3. High angular resolution both for beam and scattered particles (~0.1 mrad)
4. High TOF resolution (50 ps for beam protons , 100 ps for recoil protons)
5. Recoil proton velocity from TOF, energy from ionization energy loss
6. Recoil proton coordinates resolution 1cm from the time difference of signal arriving from photomultipliers
7. High granularity (100/2 π) in angle φ of the recoil proton
8. Scattered proton energy resolution ~1%.

Present Status of the Project

- All the necessary methodic work and all detector investigation, and also full MC simulation with use of GEANT4 are completed.

- There are the system of the proton abortion with help of the bent crystal, beam channel and spectroscopic magnet.
- Drift tubes and relevant electronics are being produced.
- There is scintillator for all counters, but only a half of photomultipliers (HAMAMTSU).
- A half of the necessary amount of electronics (CAEN) for amplitude ant time analysis of signals from photomultipliers are purchased.
- Production of the HV system for PMTs is in progress.

We need a1.5 year and some 200 k$ for completion of the facilituy.

For the studies in the CN region we have got practically everything and physical run can start in a year.