Second Workshop on

Hadron Physics in China and Opportunities with 12 GeV JLab

Program of luminosity measurement and early experiment for hadron physics at HIRFL-CSR in Lanzhou

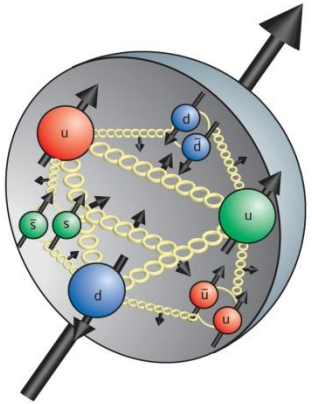
Chuan Zheng

High Energy Few Body Group

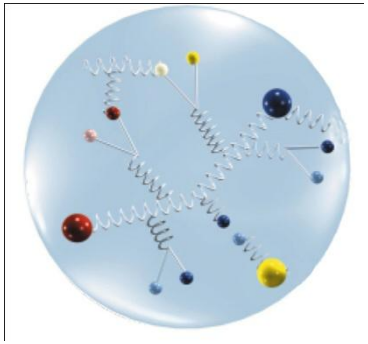
Institute of Modern Physics, CAS

July 28-31, 2010 Fragrant Hill, Beijing

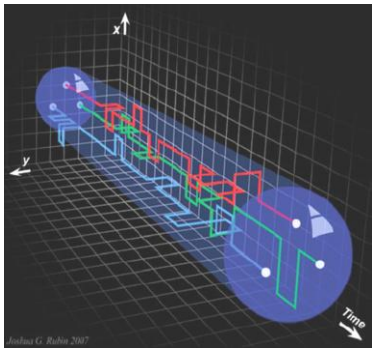
Hadron Structure



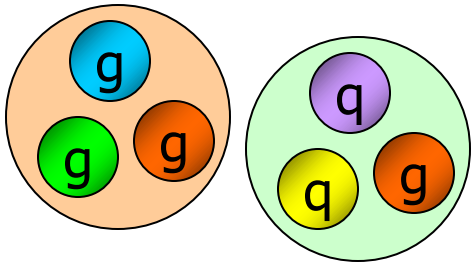
Spin structure of nucleons



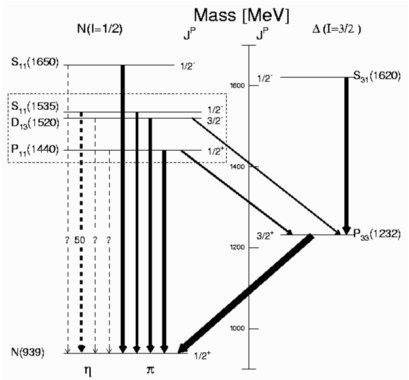
Internal landscape of nucleons



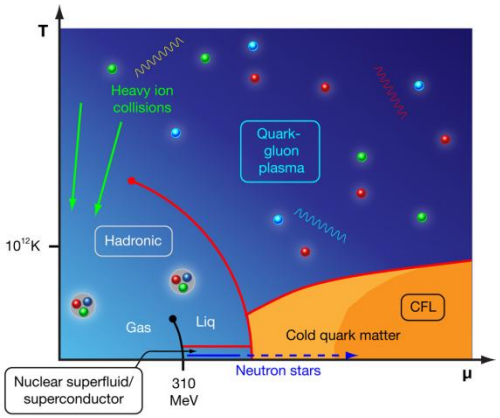
Lattice QCD



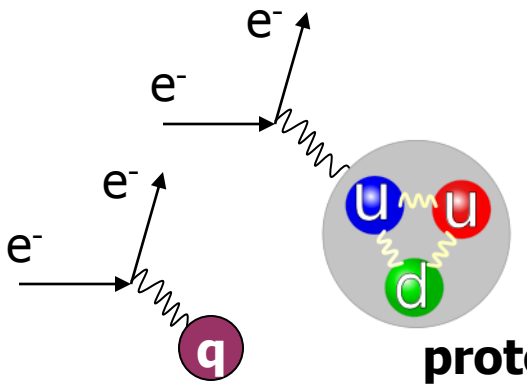
Exotic states



Excited states of nucleons



Phases of QCD



proton

Quark-hadron duality

Nuclear Matter

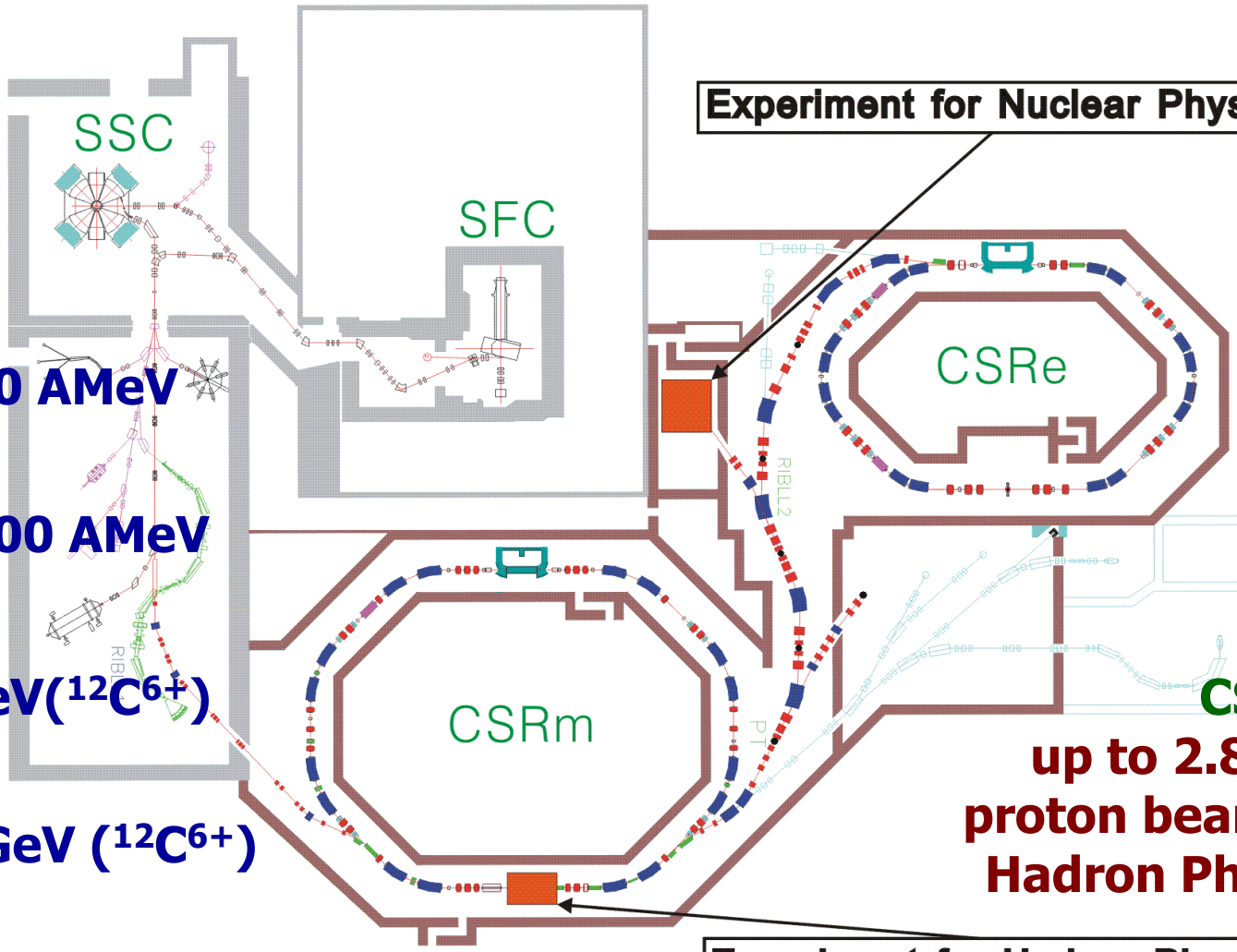
HIRFL-CSR opportunities with hadron physics

SFC:
up to 10 AMeV

SSC:
up to 100 AMeV

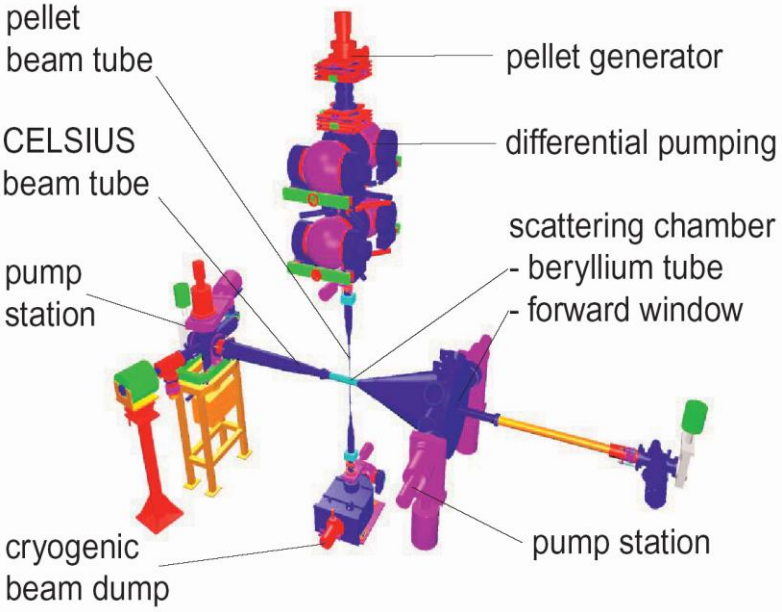
CSRm:
1.1 AGeV($^{12}C^{6+}$)

CSRe:
0.76 AGeV ($^{12}C^{6+}$)



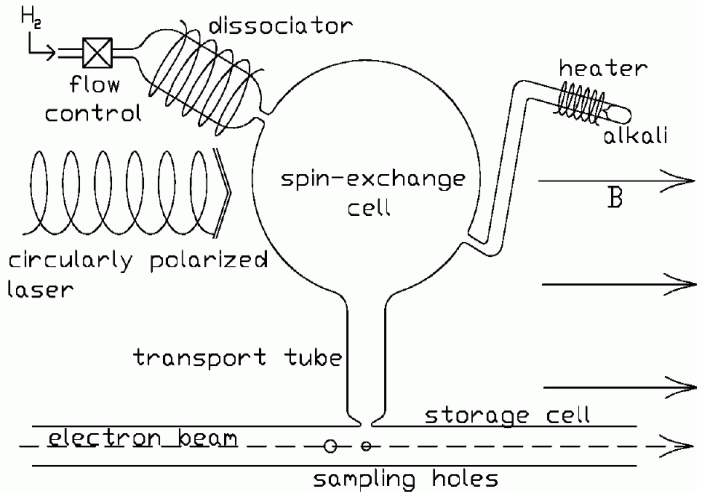
CSRm:
up to 2.8 GeV proton beam for Hadron Physics

H_2/D_2-pellet target system



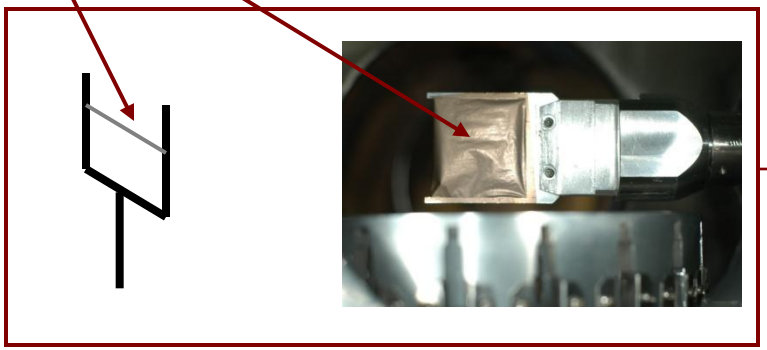
Collaborate with Uppsala University/ Sweden & WASA@COSY/Germany

Polarized H/D laser driven target

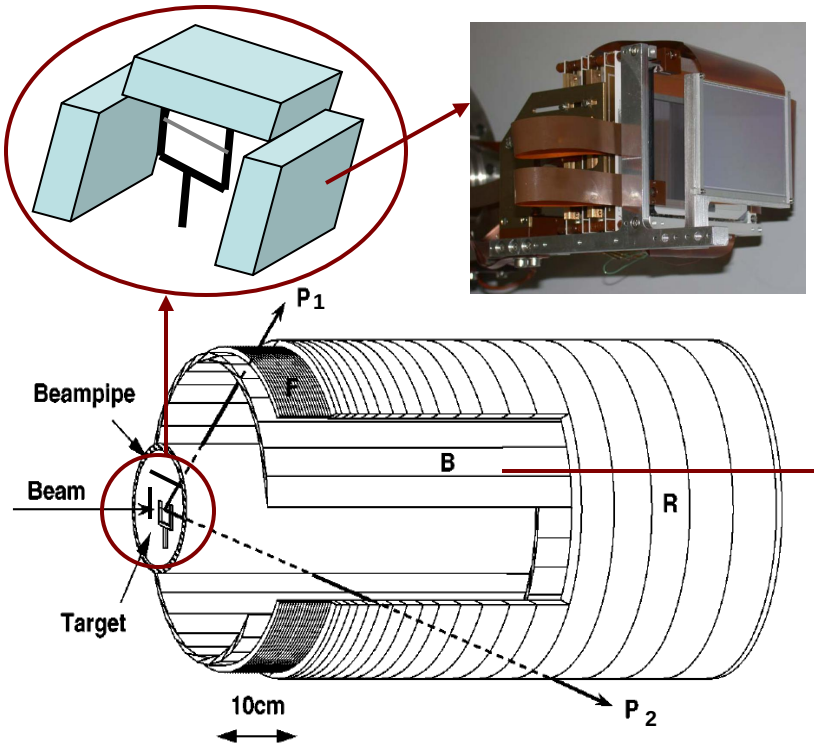


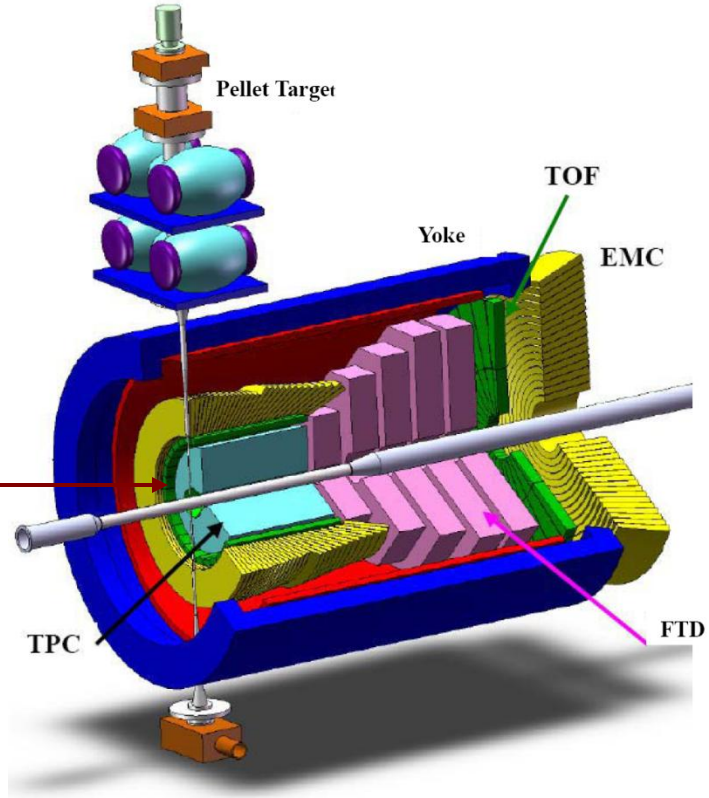
Collaborate with Prof. Haiyan Gao Duke University/USA

Fiber/foil target for early experiment



- proton-nucleon(s) reaction, C/Cu/Ag/Au fiber or foil target
- pp/pd reaction, CH_2/CD_2 fiber or foil target





Silicon Tracking Telescopes + Plastic Scintillator Barrel (Ref. ANKE & EDDA @ COSY)

- *p-p* elastic scattering
- *p-n* elastic scattering
- *p-d* elastic scattering

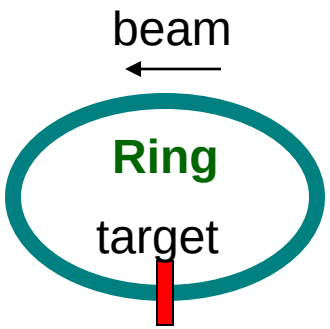
For early experiment

Concept design of HPLUS (Hadron Physics LanzhoU Spectrometer)

- Excited states of nucleons
- Strange-quark contributions
- Spin structure of nucleons
- Symmetries in non-pQCD region

Luminosity measurement

$$L = j_{\text{beam}} \cdot N_{\text{target}} \left(\text{s}^{-1}\text{cm}^{-2}\right)$$



Internal Target Exp.

L ~ 10^{31}-10^{32} $s^{-1}cm^{-2}$

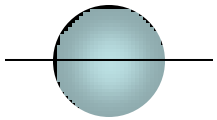
$$j_{\text{beam}} = \frac{N_C \cdot f_r}{\pi \cdot R_C{}^2}$$

N_C ~ 10^{10} particles

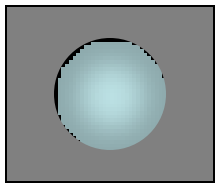
f_r ~ 1.7 MHz

R_C ~ 5 mm

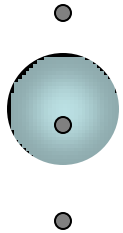
N_{target}



Fiber
ϕ ~ 5 μm



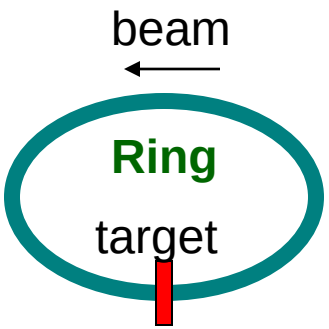
Foil ~ 15
$\mu g/cm^2$



Pellet ~
35 μm

Luminosity measurement

$$L = j_{\text{beam}} \cdot N_{\text{target}} \,(\text{s}^{-1}\text{cm}^{-2})$$



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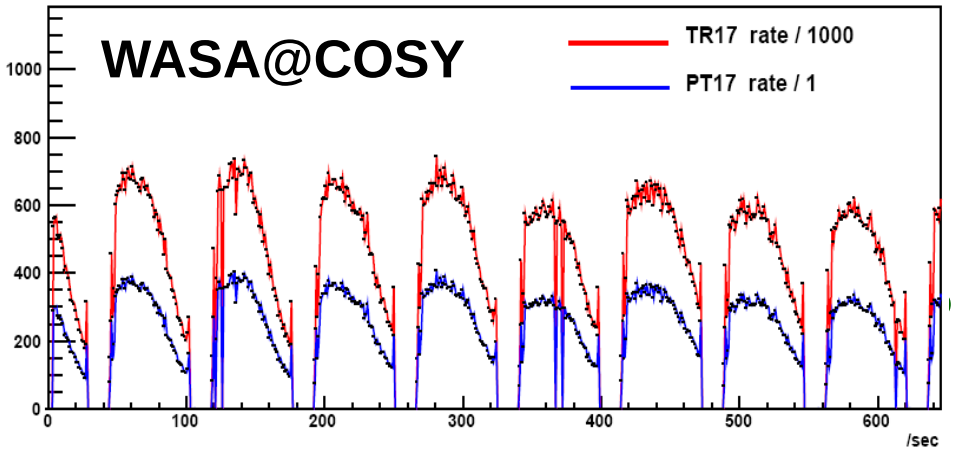
f_r ~ 1.7 MHz

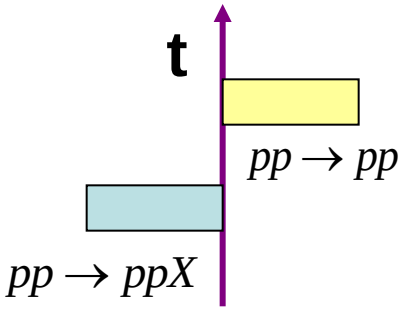
R_C ~ 5 mm



The luminosity of the internal target experiment varies during each cycle, so the effective luminosity is the average value of time.

Method to measure the effective luminosity:

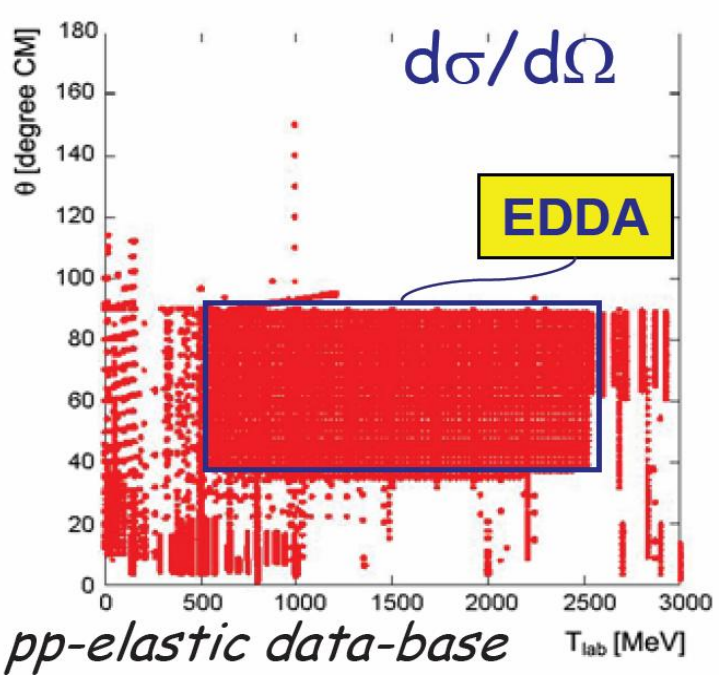
Signal Channe l

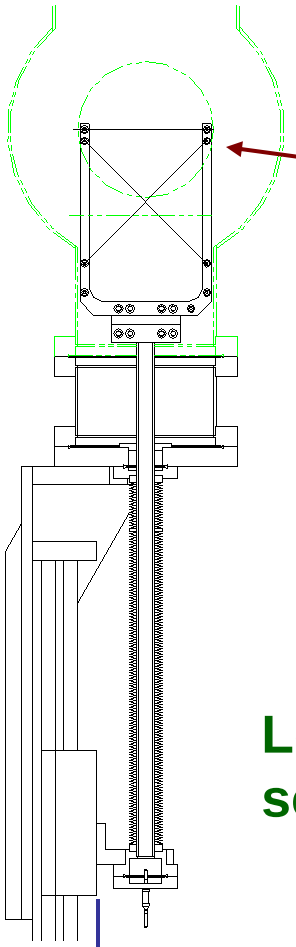


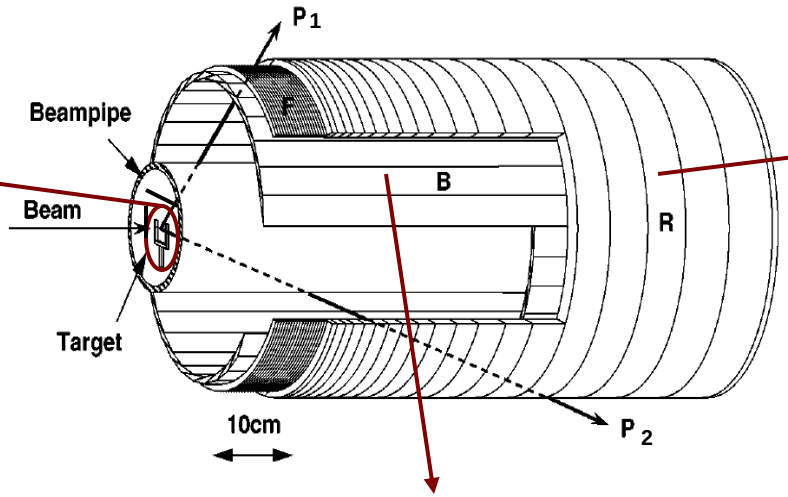
Ref. Channel
$pp \to pp$

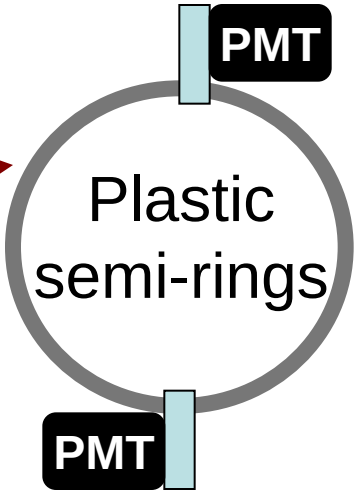
$$\left(\frac{d\sigma}{d\Omega}\right)_{unknown} = \frac{\Delta N_{pp\to ppX}}{L_{eff}}$$

$$L_{eff} = \frac{\Delta N_{pp\to pp}}{\left(\frac{d\sigma}{d\Omega}\right)_{data\_base}}$$





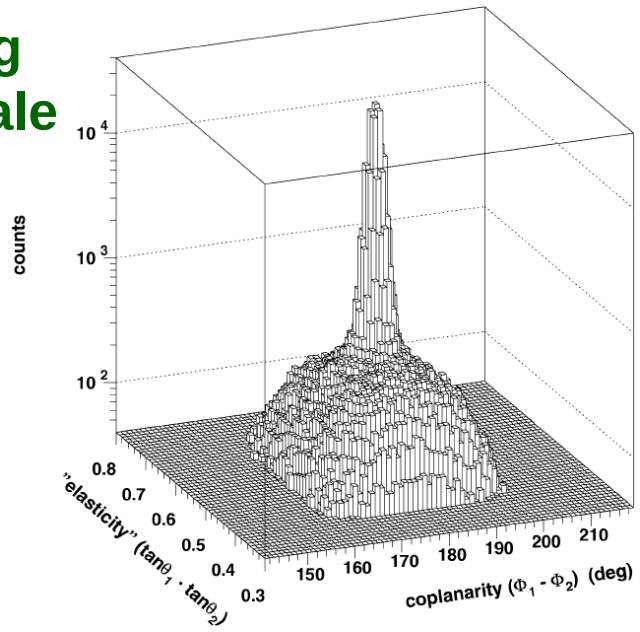




Ref.
EDDA@COSY

CSRm beam diagnostic packet → fiber/foil target driver

Log scale



pp elastic scattering identification:

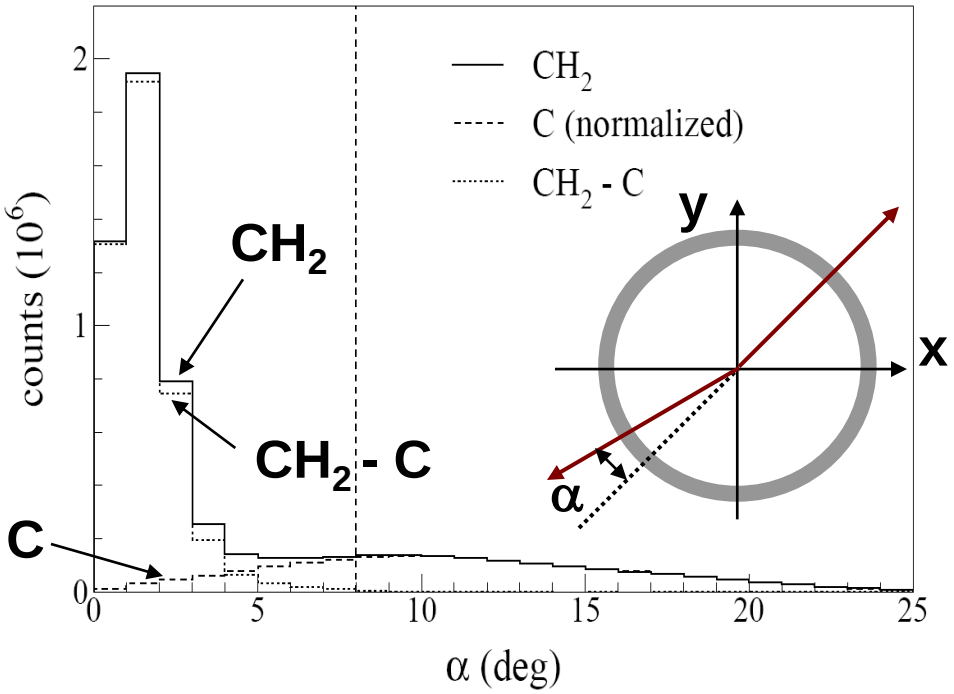
$$|\varphi_1 - \varphi_2| = 180^{o}$$

$$\tan\theta_1 \cdot \tan\theta_2 = \text{const.}$$

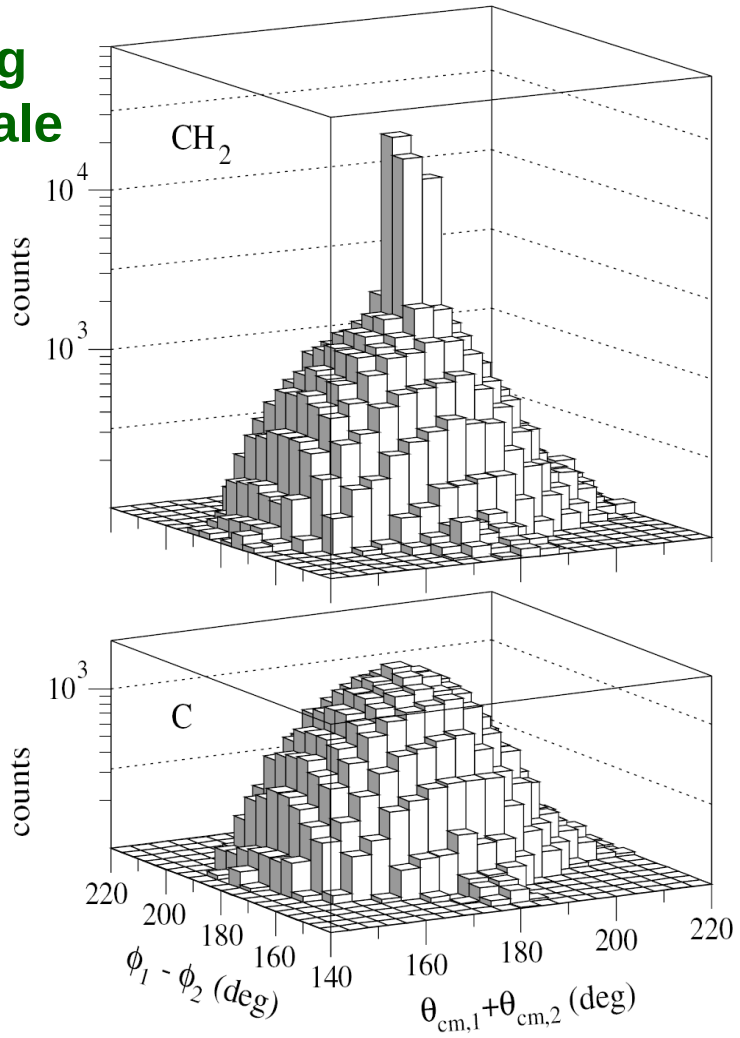
EDDA, PRL 78(1997)1652

Subtraction of carbon effect in CH_2 target:

- CH_2- and C- target individually
- Two prongs events selection
- Normalization from kinematic deficit α in the range 10° to 15°



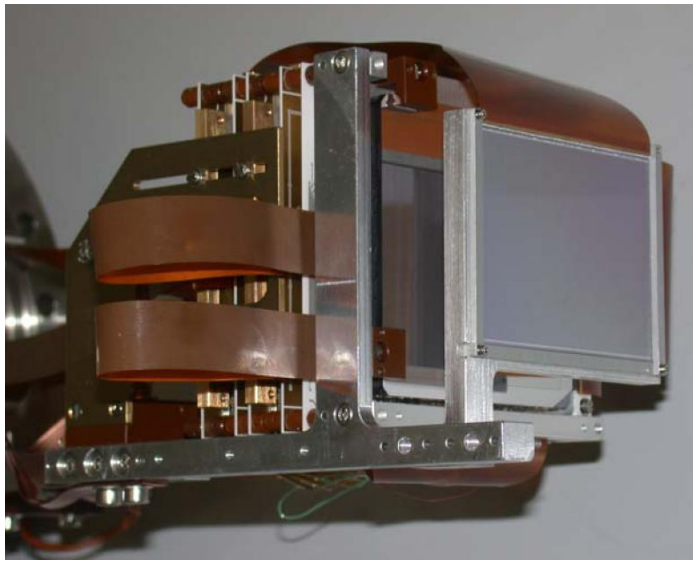
Log scale

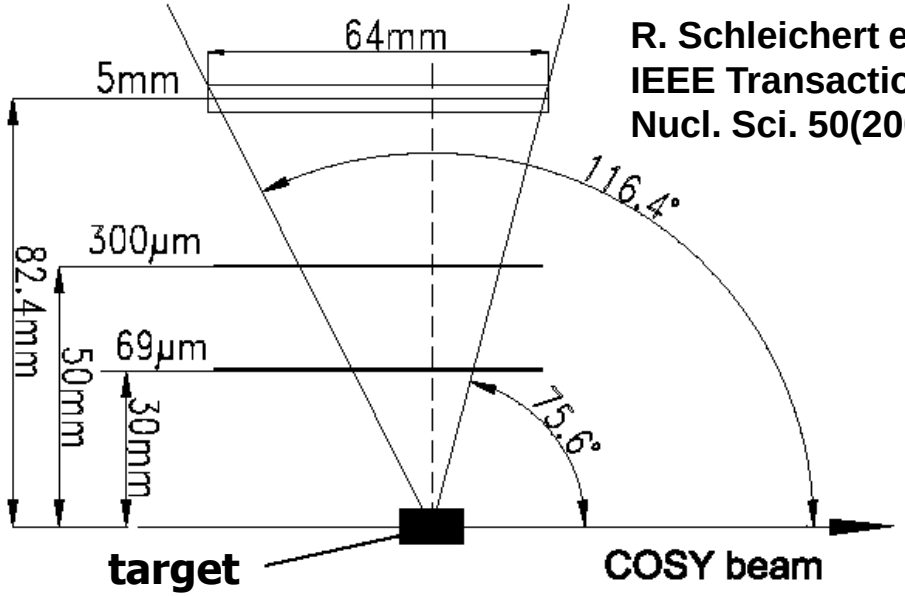


EDDA, arXiv:nucl-ex/0403043

EDDA, Eur.Phys.J. A 22(2004)125

Silicon Tracking Telescopes (STT) for the luminosity:

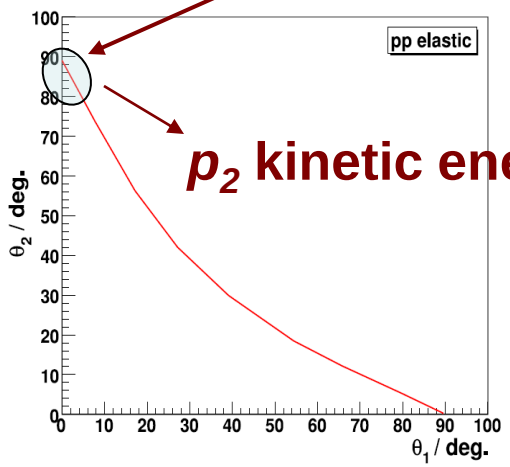




R. Schleichert et al.
IEEE Transactions on
Nucl. Sci. 50(2003)301

- Three double-sided silicon strip detectors: 69µm, 300µm, 5.1mm thickness, 64*64 mm^2
- Protons identification in the range 2.5 < Tp < 40 MeV with ΔE/E ~ 200 keV
- Angular resolution 1° to 6° upon particle type and angle

use *pp* elastic scattering with $\theta_2 > 80°$ for monitoring:

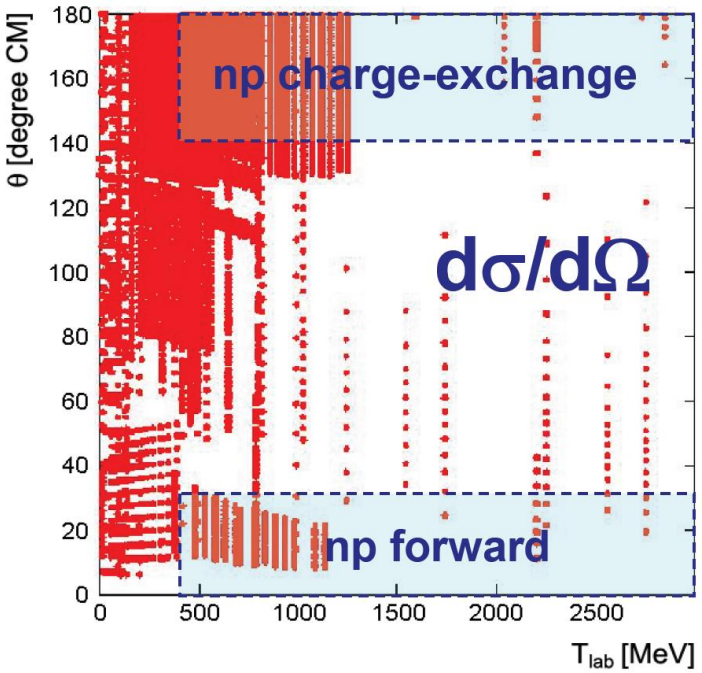


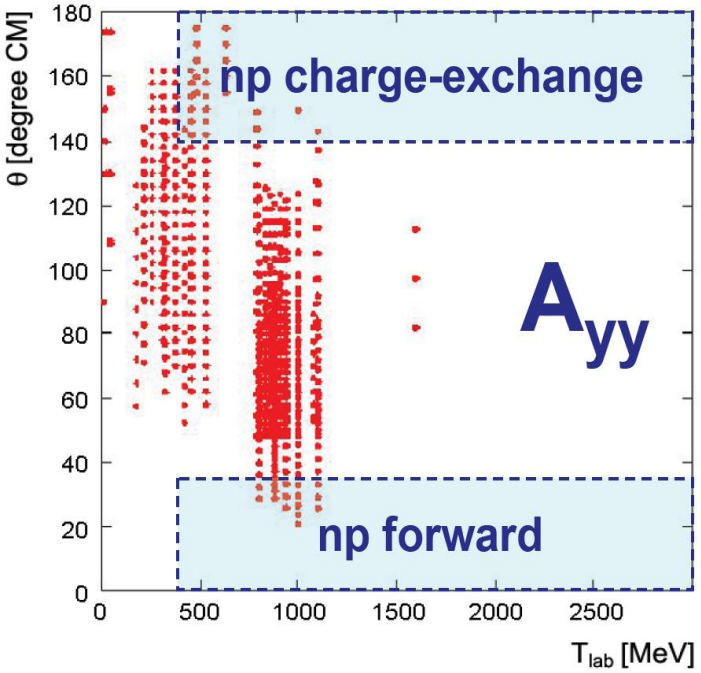
p_2 kinetic energy < 35 MeV

Early experiment (1)

np scattering with a deuteron beam/target

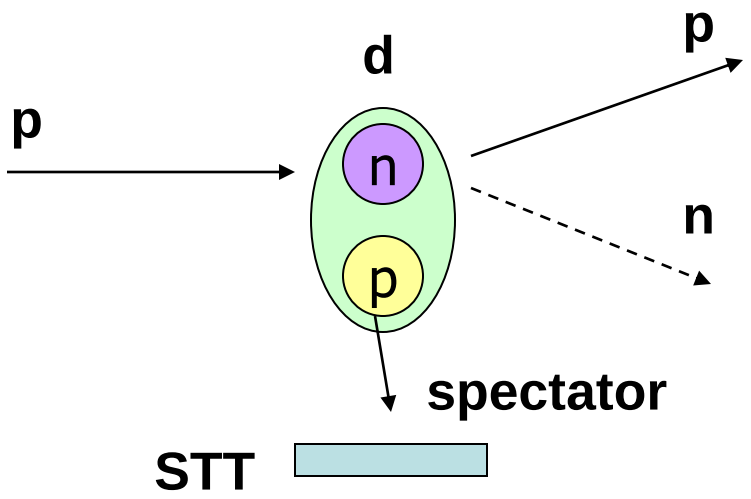
R. Arndt: "Gross misconception within the community that np amplitudes are known up to a couple of GeV. np data above 800 MeV is a DESERT for experimentalists."

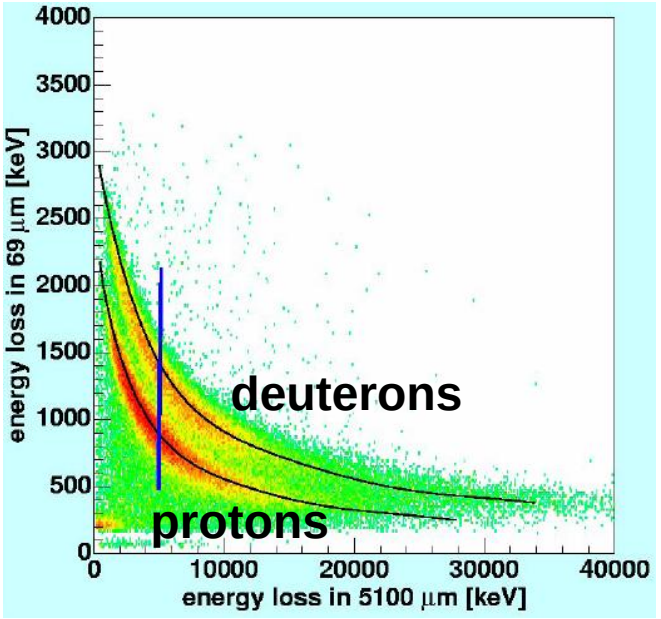


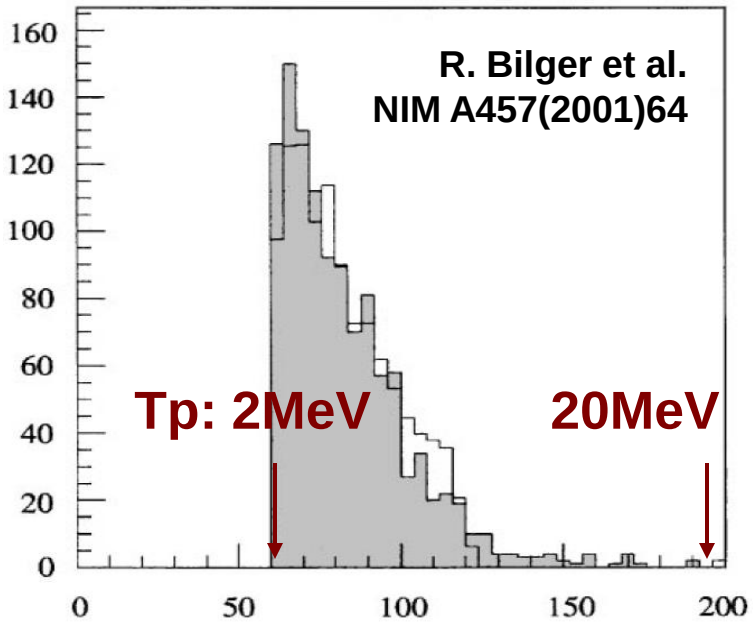


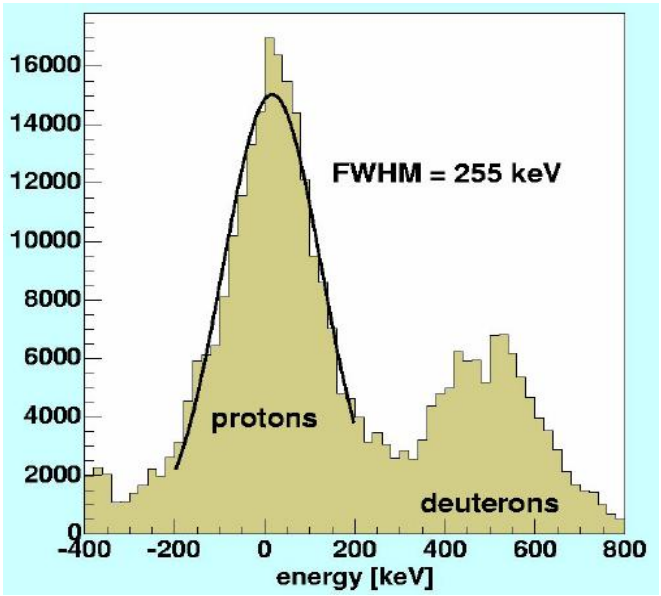
A. Kacharava, F. Rathmann and C. Wilkin, arXiv:nucl-ex/0511028

Spectator proton identification :

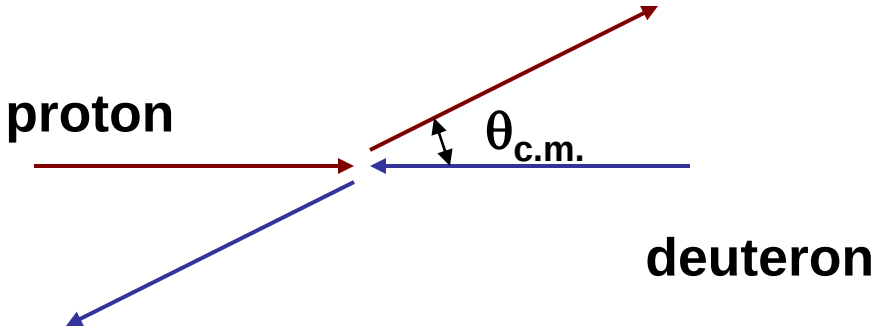




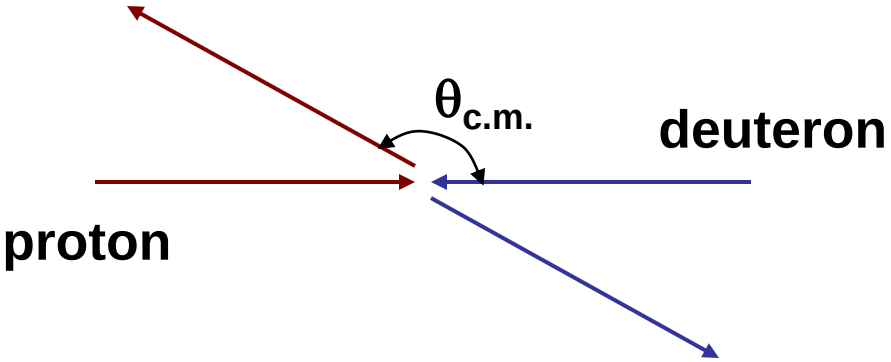




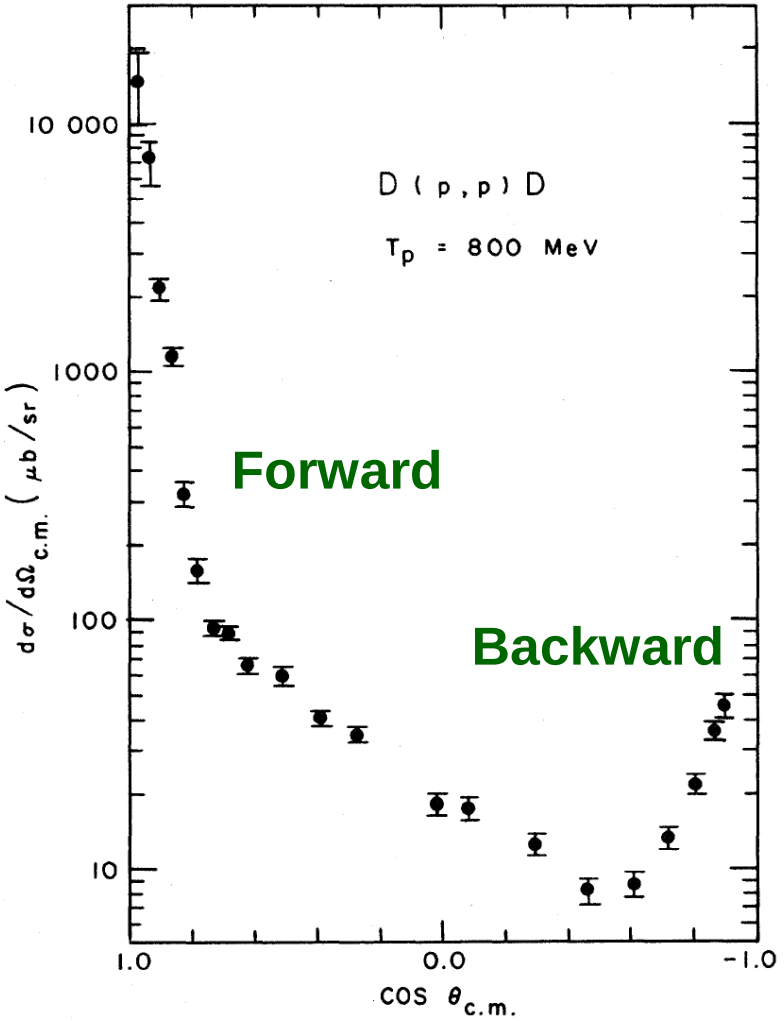
Early experiment (2)



Forward *pd* elastic scattering



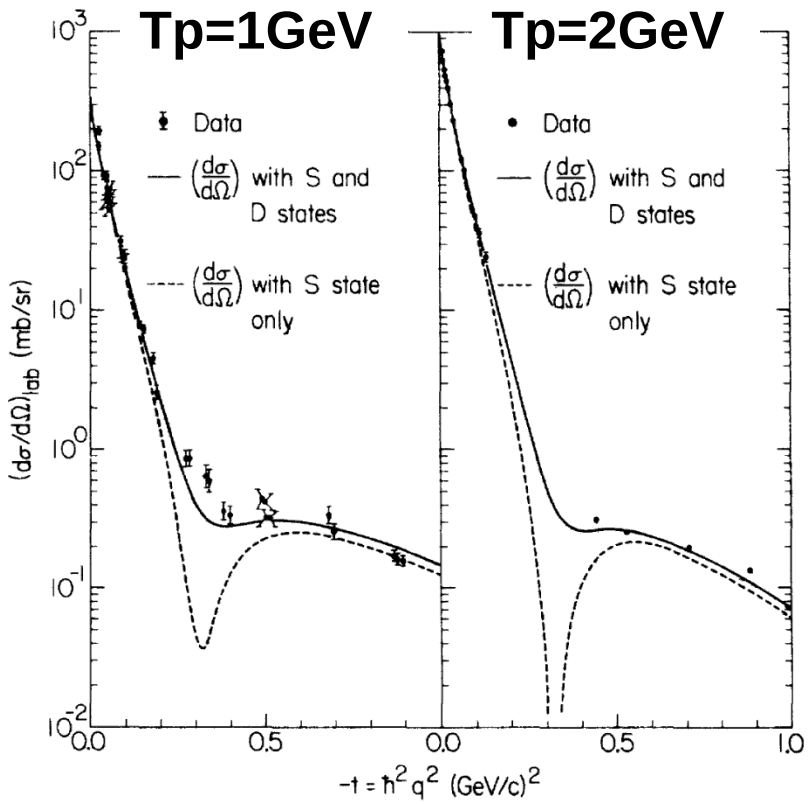
Backward *pd* elastic scattering



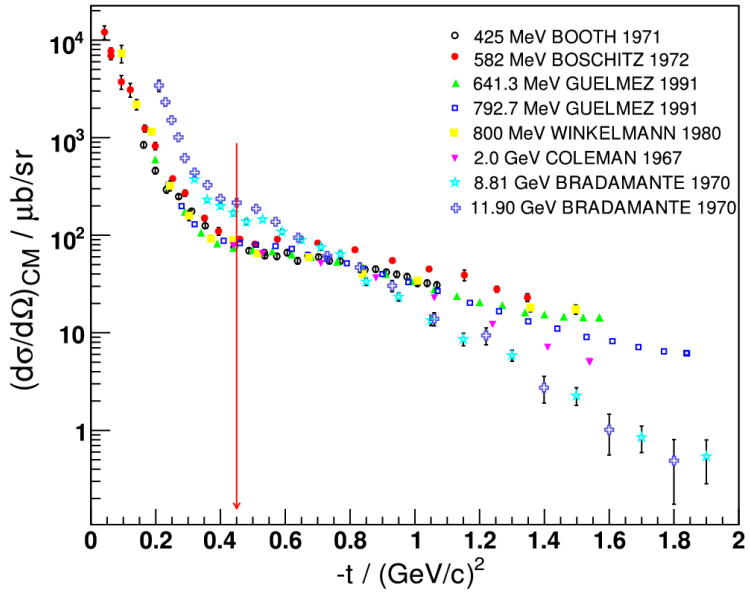
E. Winkelmann et al. PRC 21(1980)2535

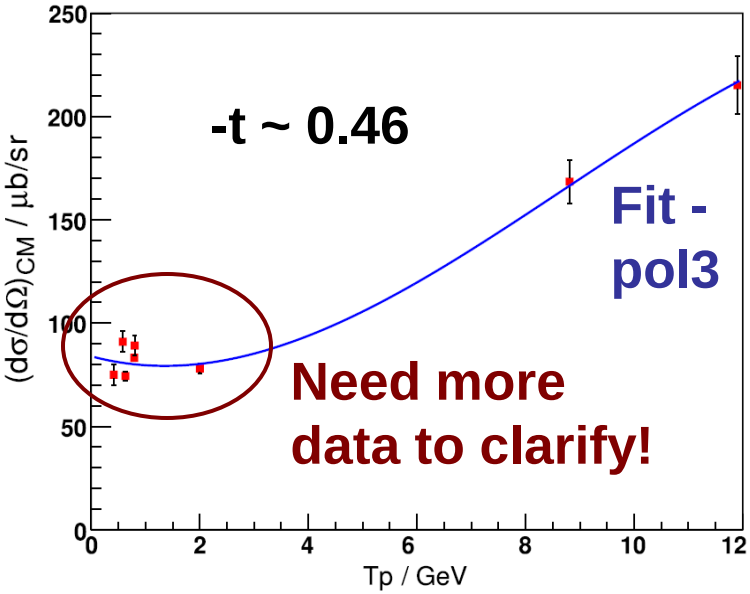
Forward *pd* elastic scattering:

- Deuteron as a double scatterer
- Single- and double-collision amplitudes interfering
- *d*-state admixture in deuteron



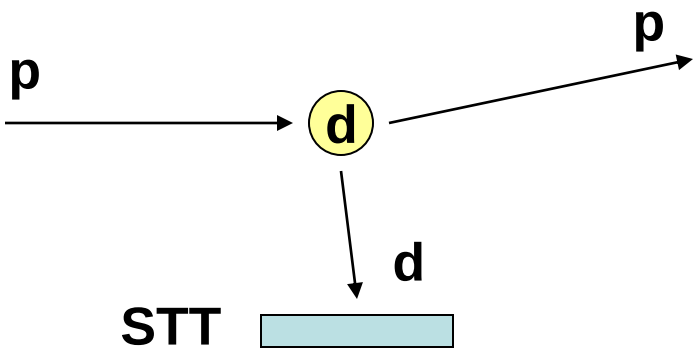
V. Franco and R.J. Glauber PRL 22(1969)370

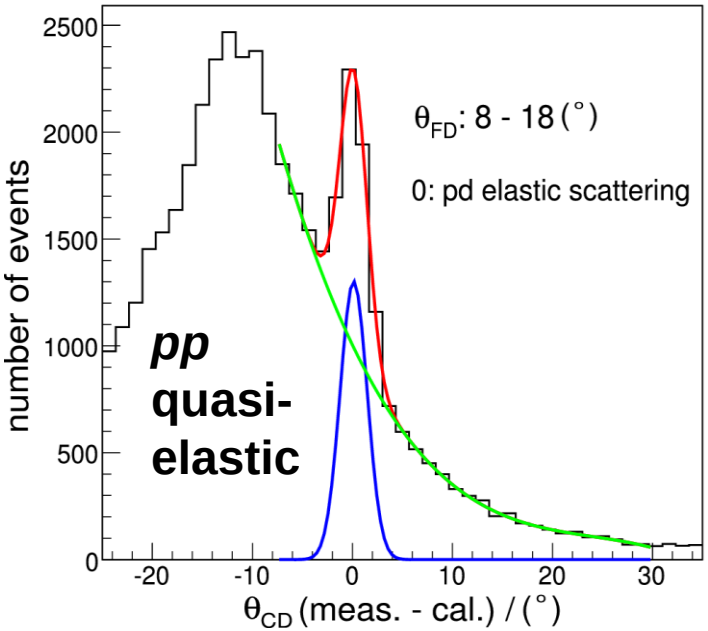


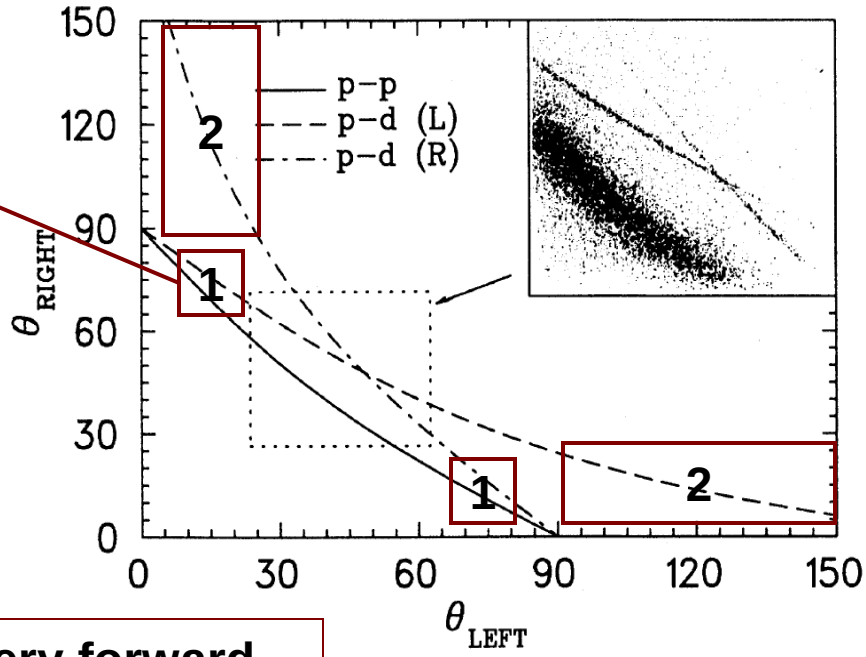


Identification of *pd* elastic scattering:

- **Forward *pd* scattering needs good *p/d* identification**
- **Backward is easy to identify, but has lower x-sections and needs more beam time**







WASA@COSY

1: very forward
2: very backward

Summary

- HIRFL-CSR opportunities with hadron physics
- Luminosity measurement - *pp* scattering
- Early experiment (1) - *np* elastic scattering
- Early experiment (2) - *pd* elastic scattering
- Silicon Tracking Telescopes (STT) plays an essential role in the early experiment.


Thanks!