Quote organizers...

...we expect to obtain a multi-faced recollection of the rich historical development of Italian-Russian and Italian-Dubna collaborations as well as indications and perspectives for future developments and last but not least interesting news from ongoing research projects...

Oldest JINR–INFN collaboration:

since 1968, over 40 years

DUBNA — TORINO

A study of pion interactions with light nuclei

Beginning

Prof. Yu.Scherbakov (JINR) and
Prof. G.Piragino (INFN, Torino)

TOFRADUB (1968)

Common interest:
Investigation of pion interactions with light nuclei using Dubna and Frascati beams

Experimental device: self-shunted streamer chamber

JINR–INFN: joint experiments

Being the oldest JINR–INFN collaboration we have had, during the past 40 odd years, the time, will and possibility to actively participate in a number of experiments, the list of which follows, although I shall speak of the experiments based on the self-shunted streamer chamber technique.

JINR–INFN: list of joint experiments

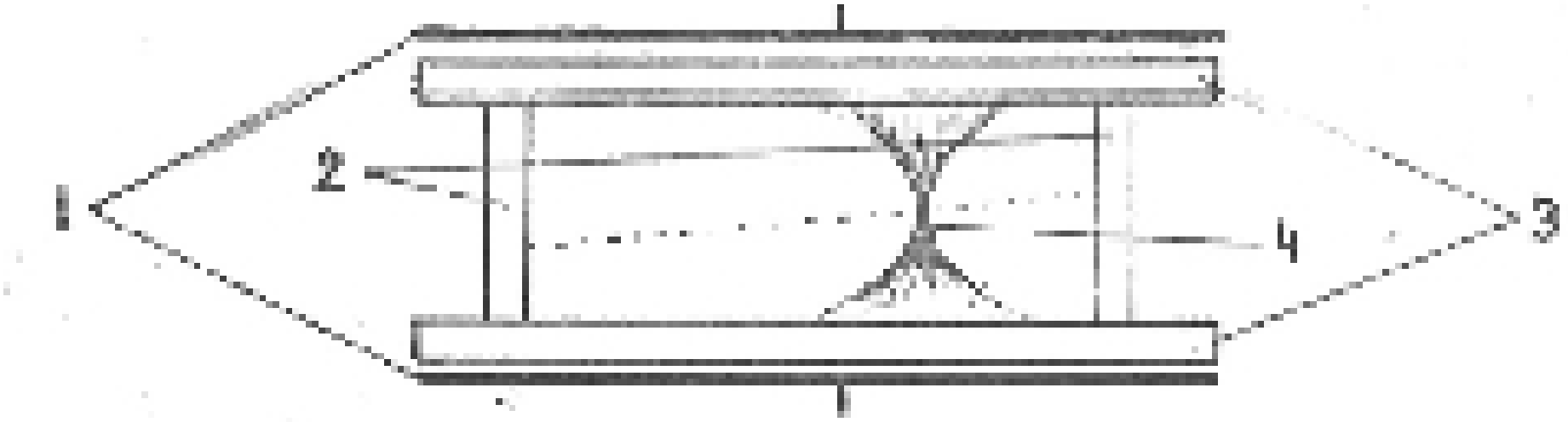
- TOFRADUB ($\pi^{\pm}$He, streamer chamber, Dubna, Frascati, 1970-ies)
- PS179 ($\bar{p}$-nucleus, streamer chamber, CERN, 1980-ies)
- PS201 (OBELIX, Exotic meson spectroscopy, CERN, 1980-ies
- DISTO (Spin and strangeness production, Saclay, 1990-ies)
- NA58 (COMPASS, Hadron spectroscopy, spin physics, CERN, under way)

Streamer chamber – properties

Streamer chamber filled with gas at low pressure ($\sim$1 atm) –

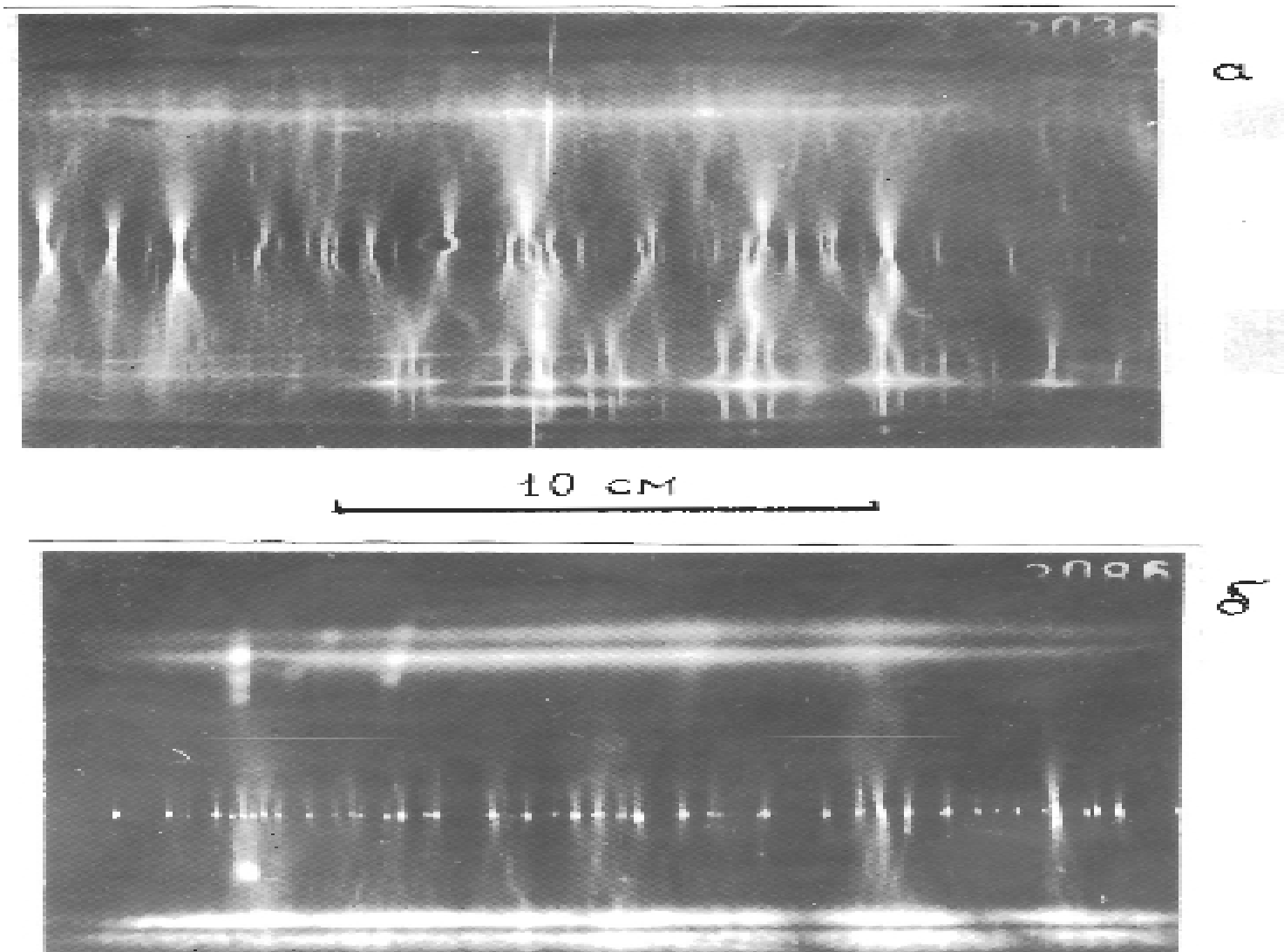
- low-density target:
  $\rho_{^4He}$=0.17 mg/cm^3,
  $R_{^4He,\ 5MeV}$=20.cm
- triggerable track detector;
- controllable memory time:
  $\tau \sim 1\,\mu$s , $l_\pi \leq 10^6\,$s^{-1}.

Self-shunted streamer chamber: track formation

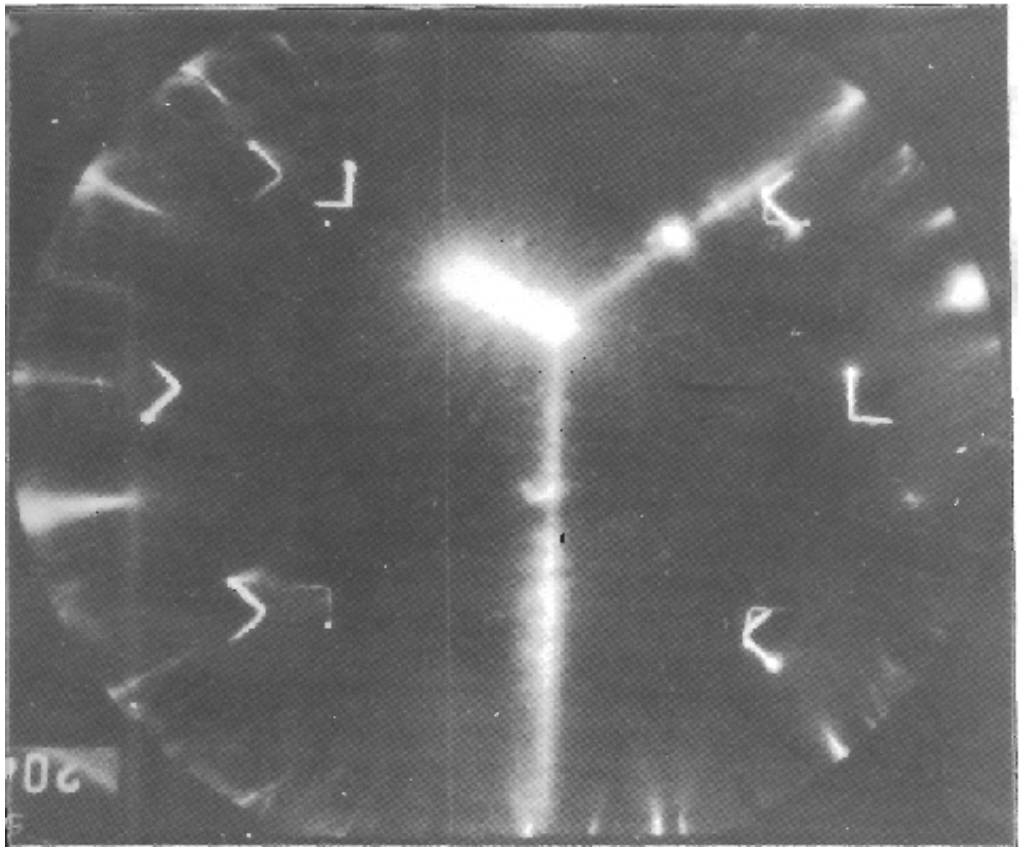


Electron tracks in: a – He;

b – He+$10^{-4}\alpha$-pinene

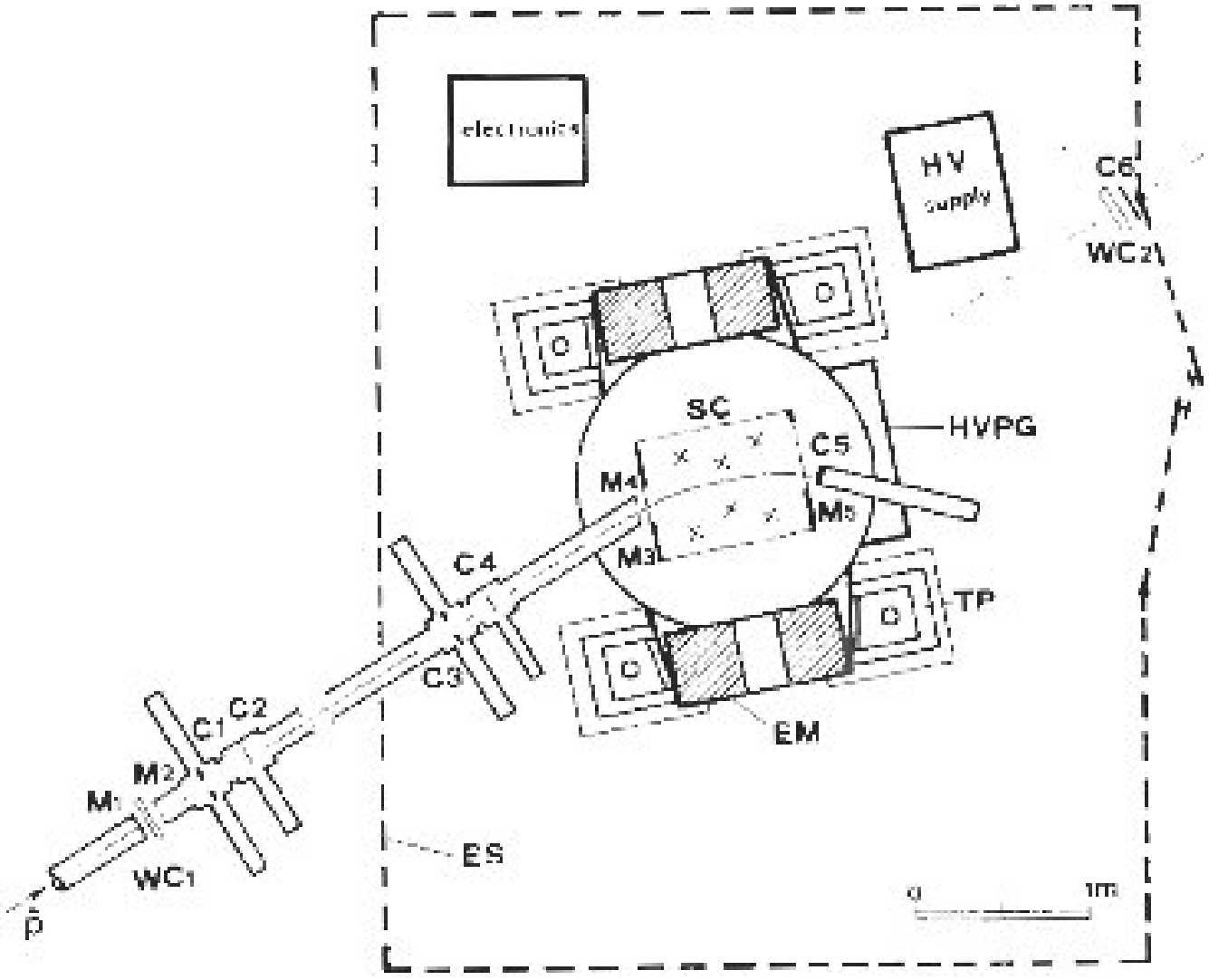


Elastic scattering: 1970-ies

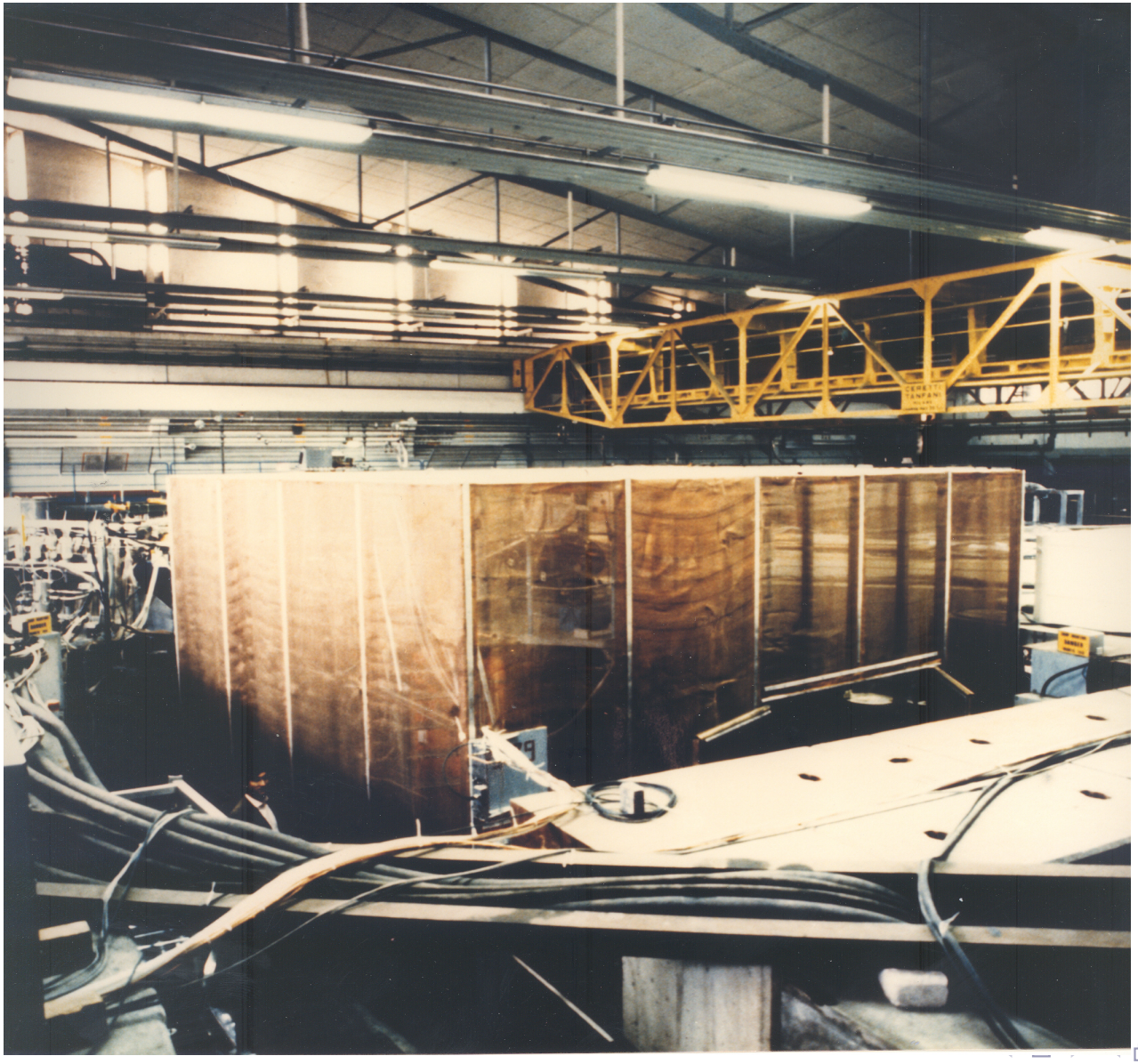


Elastic and inelastic scattering of $\pi^{\pm}$-mesons on ^{3,4}**He in the energy interval (68÷208) MeV**

PS179, CERN, LEAR, $\bar{p}^4$He, $\bar{p}^3$He, $\bar{p}^{20}$Ne: 1980-ies

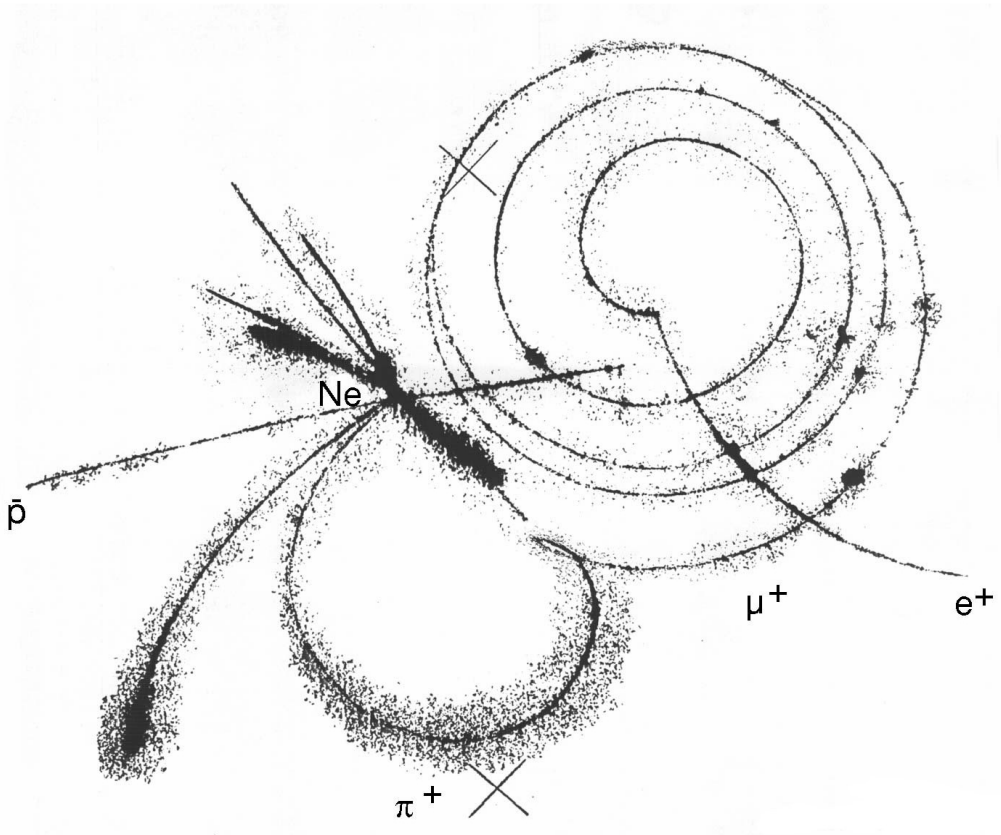


CERN, LEAR, $\bar{p}^4$He, $\bar{p}^3$He, $\bar{p}^{20}$Ne: 1980-ies



CERN, LEAR, $\bar{p}^4$He, $\bar{p}^3$He, $\bar{p}^{20}$Ne: 1980-ies

CERN, LEAR, $\bar{p}^4$He, $\bar{p}^3$He, $\bar{p}^{20}$Ne



PS179: $\pi^+ \to \mu^+\nu_\mu$, $\phi_{\pi\mu}$=**(163.0±1.0)°**, T_{π^+}=**1.98±0.02 MeV**

$m_\nu < \sqrt{-11.1 + 1.282 \cdot 12.5}MeV = 2.2MeV$ **at a 90% confidence level.**

$\bar{p}^3$He, $\bar{p}^4$, $\bar{p}^{20}$Ne annihilation cross sections at $\sim$50 MeV/c (1.33 MeV)

- $\sigma_{\bar{p}^4 He} = 1342 \pm 250$ **mb;**
- $\sigma_{\bar{p}^3 He} = 1850 \pm 700$ **mb;**
- $\sigma_{\bar{p}^{20} Ne} = 2210 \pm 1105$ **mb.**

No data at energies below 100 MeV existed for antiprotons. The cross section for ^{3}He exceeding the value for ^{4}He points to the importance of nuclear structure.

PAINUC – Authors

TOFRADUB –> DUBTO –> PAINUC

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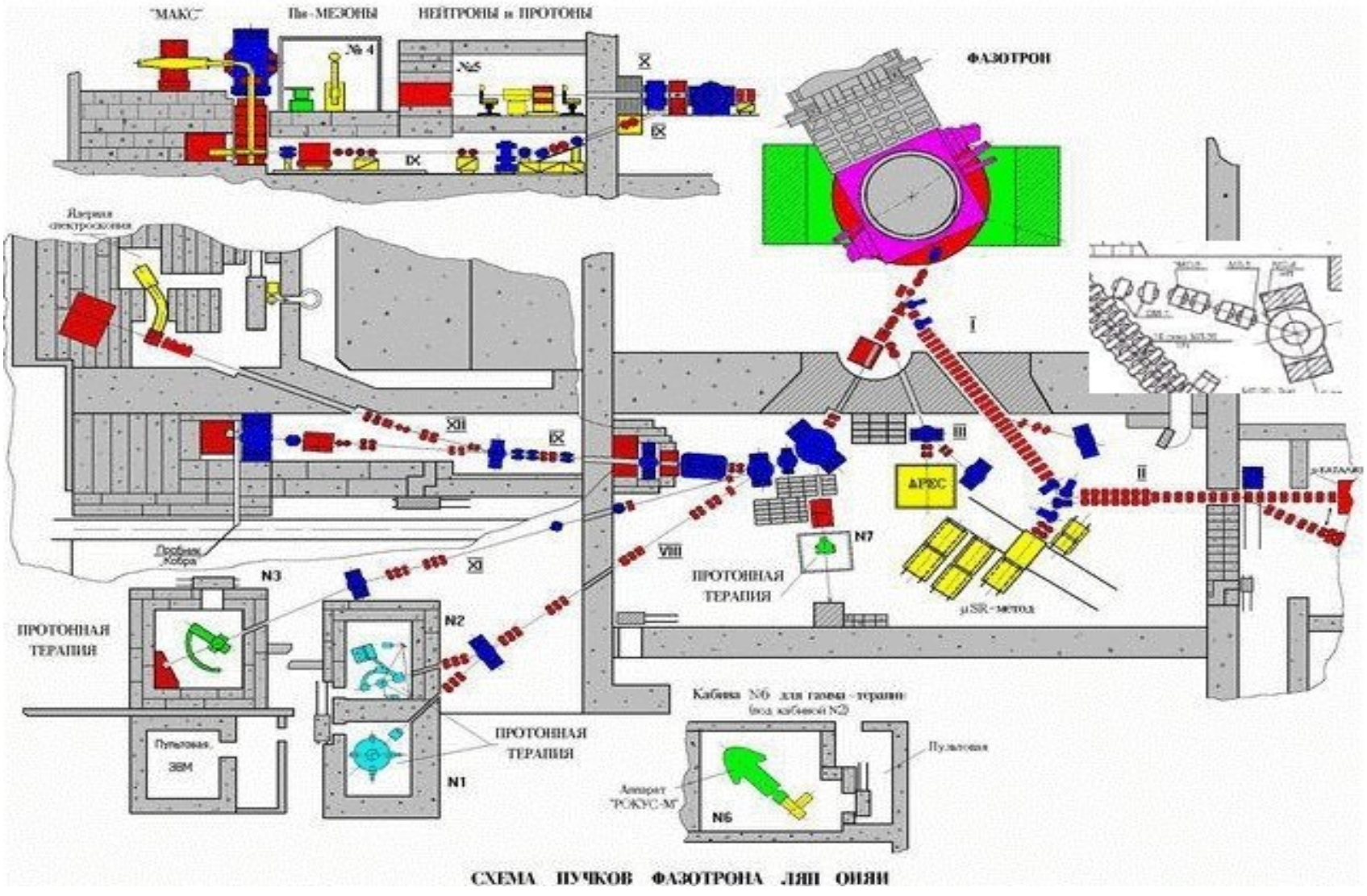
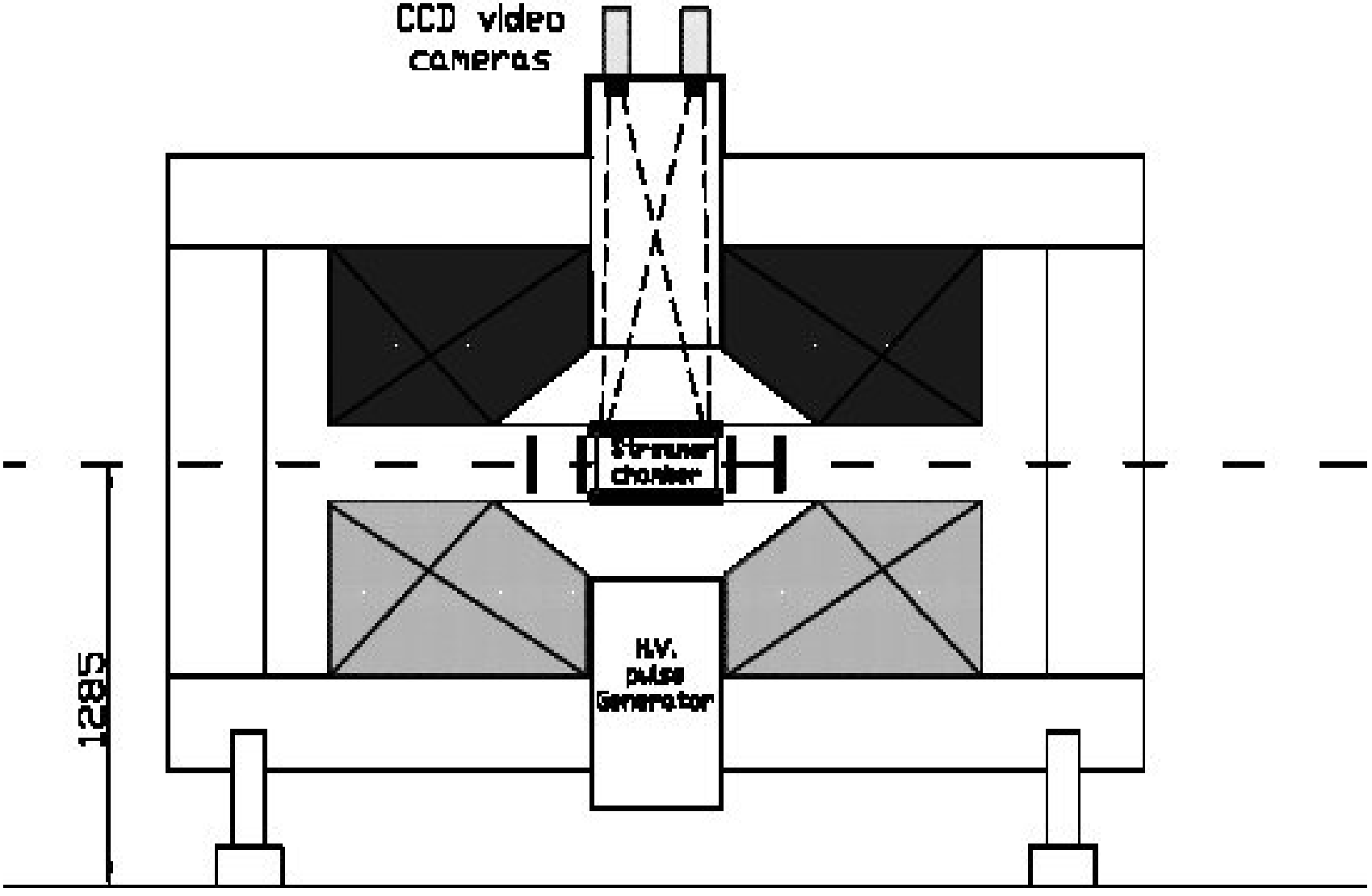
Experimental hall of LNP phasotron



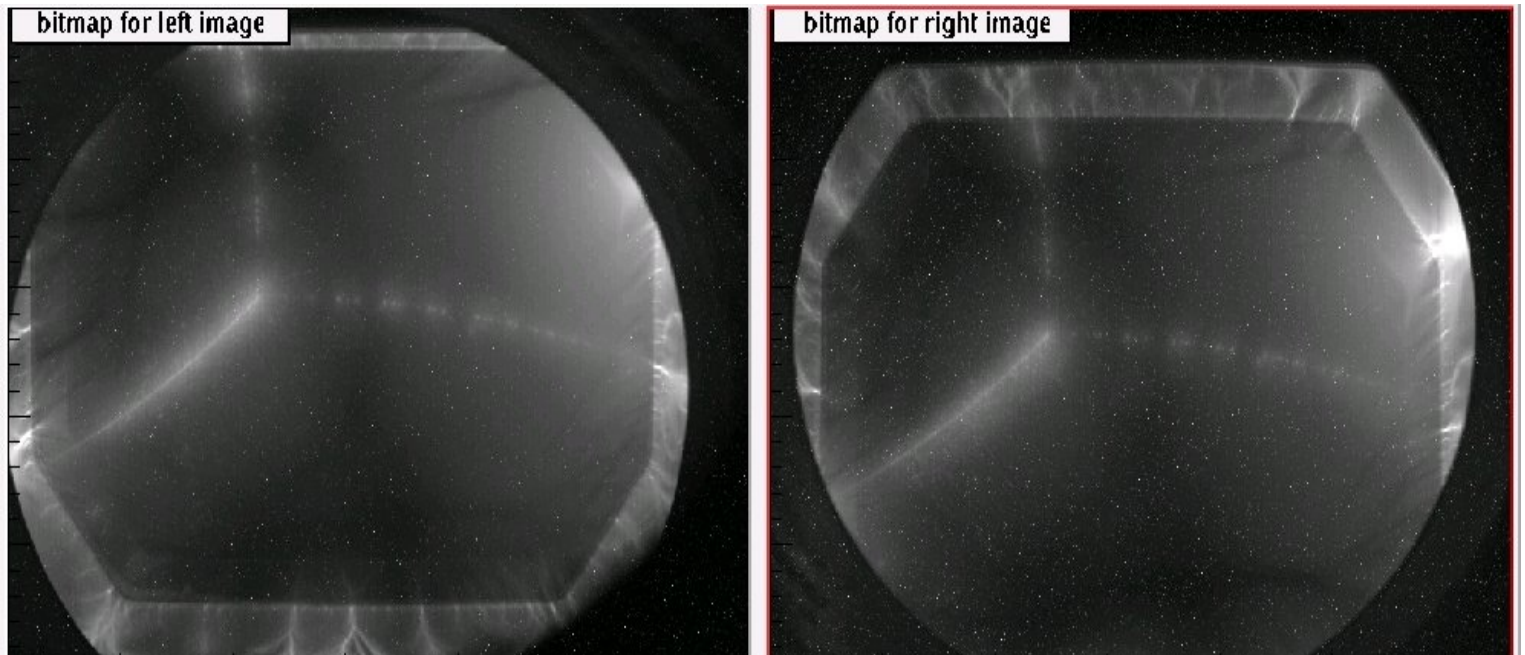
Scheme of streamer chamber



30000 events of $\pi^{\pm}{}^4$He interaction

DUBTO: 2-prong events (with π^-)

1. $\pi^- + {}^4\mathrm{He} \rightarrow \pi^- + {}^4\mathrm{He}$
2. $\rightarrow \pi^- + {}^4\mathrm{He} + \gamma$
3. $\rightarrow \pi^- + {}^3\mathrm{He} + \mathrm{n}$

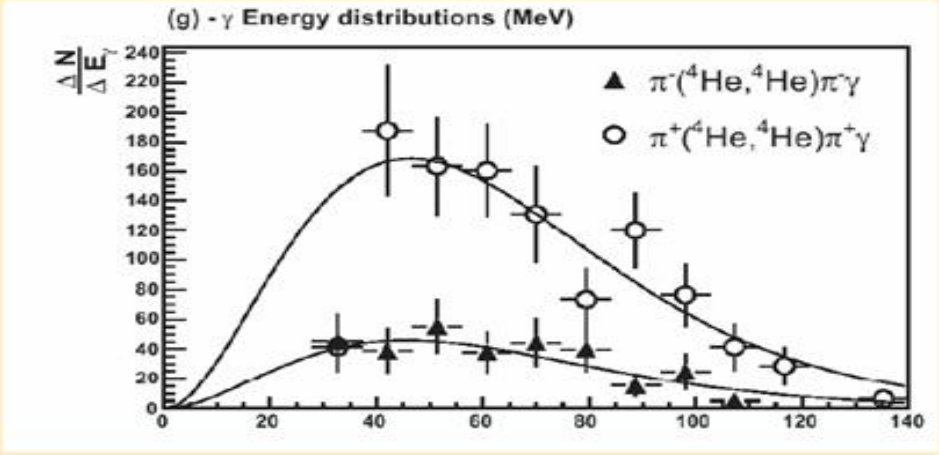


Spectrum of γ-quanta: E_0=14.4±1.6 MeV; Prompt γs ?

The γs energy distribution shows a Planck thermal behaviour:

$$\frac{dI}{dE} \propto E^3 e^{-E/T}$$

with T=14.4±1.6 MeV



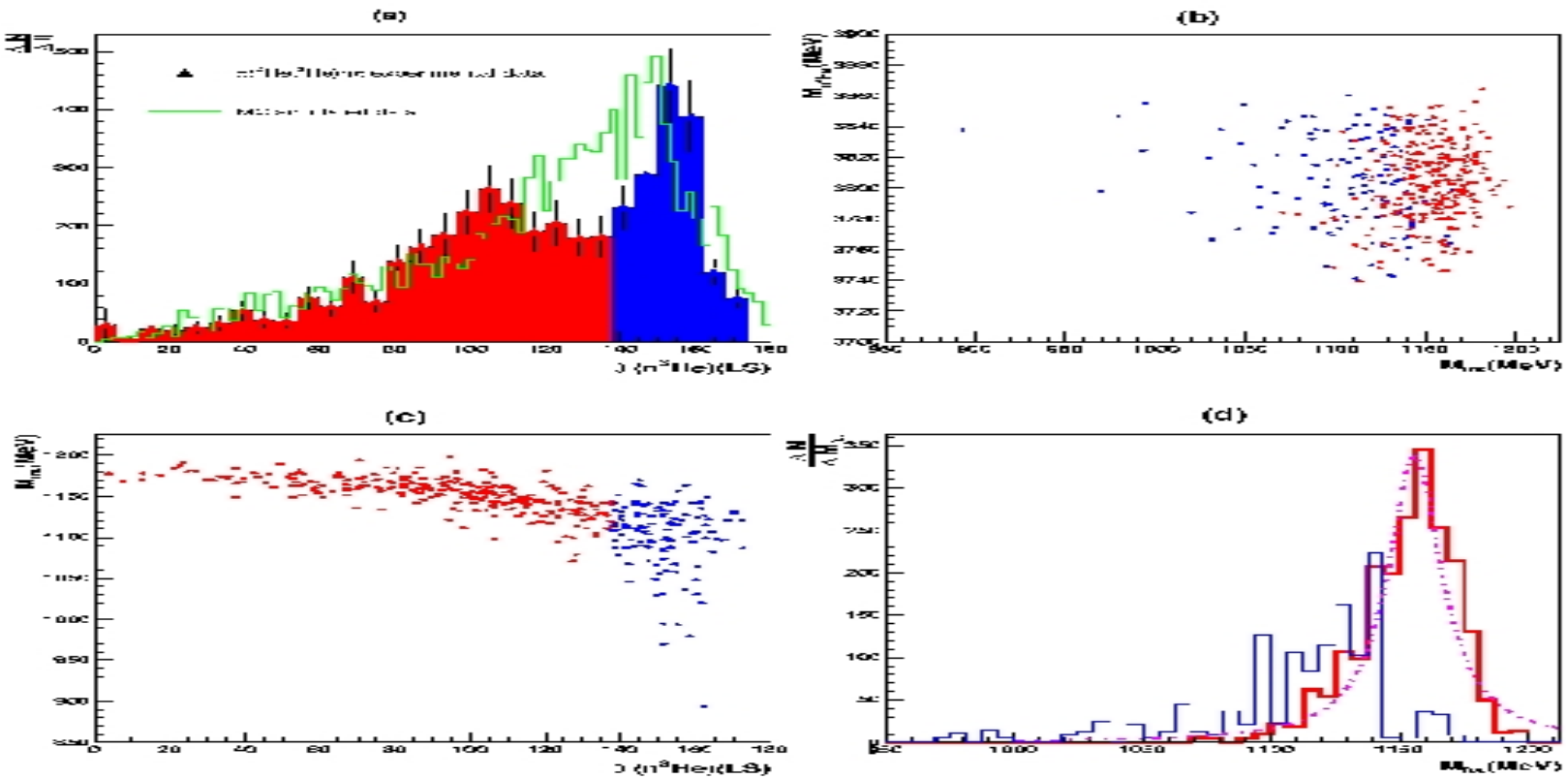
. . . and can give information on the dense (deep) nuclear matter

angle(nHe3), M(pi-n)

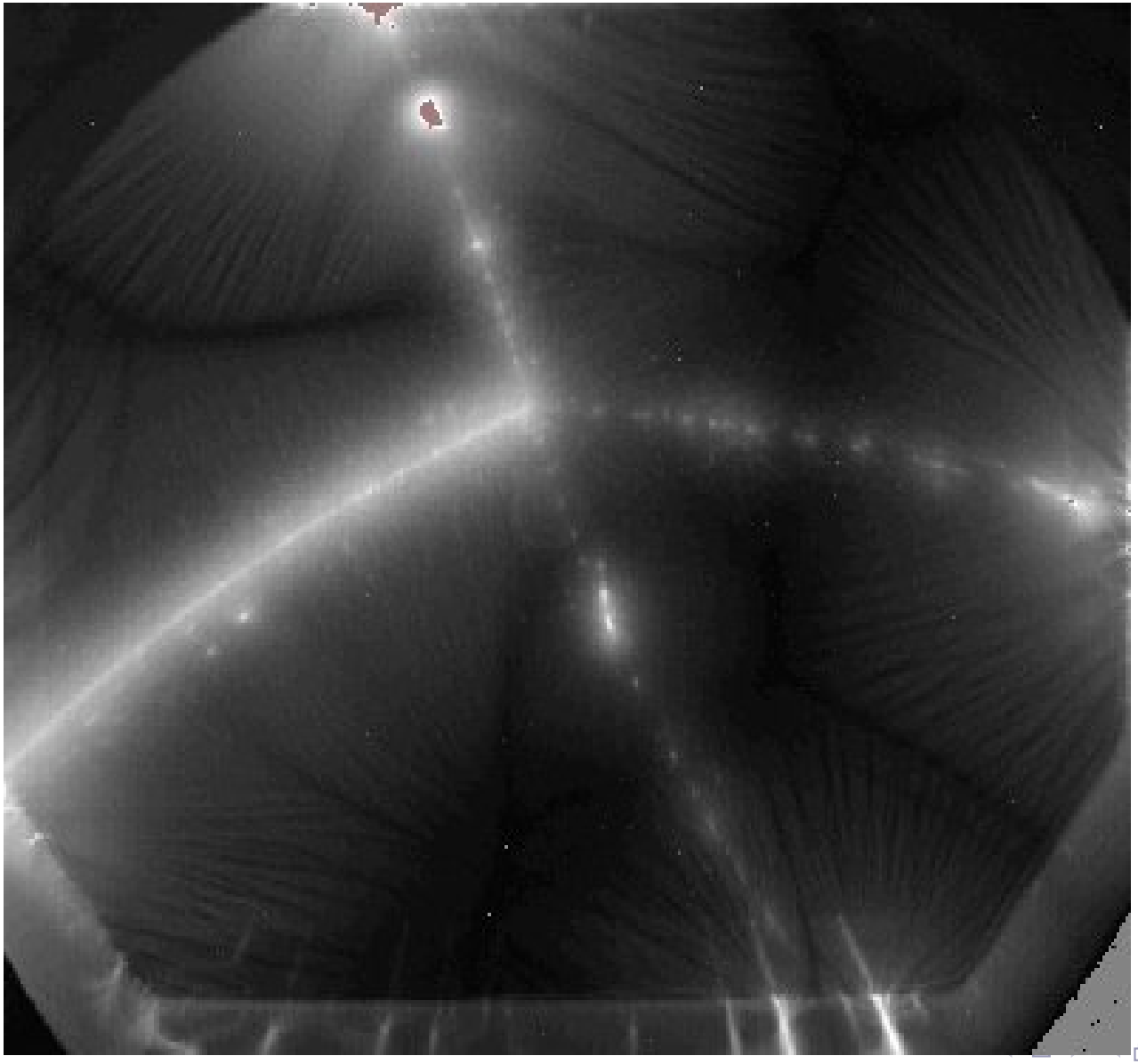
$\pi^- + {}^4\mathbf{He} \rightarrow \pi^- + {}^3\mathbf{He} + \mathbf{n};$

$\rightarrow \Delta^- + {}^3\mathbf{He};\ \Delta^- \rightarrow \pi^- + \mathbf{n};$ **(1160 МэВ)**

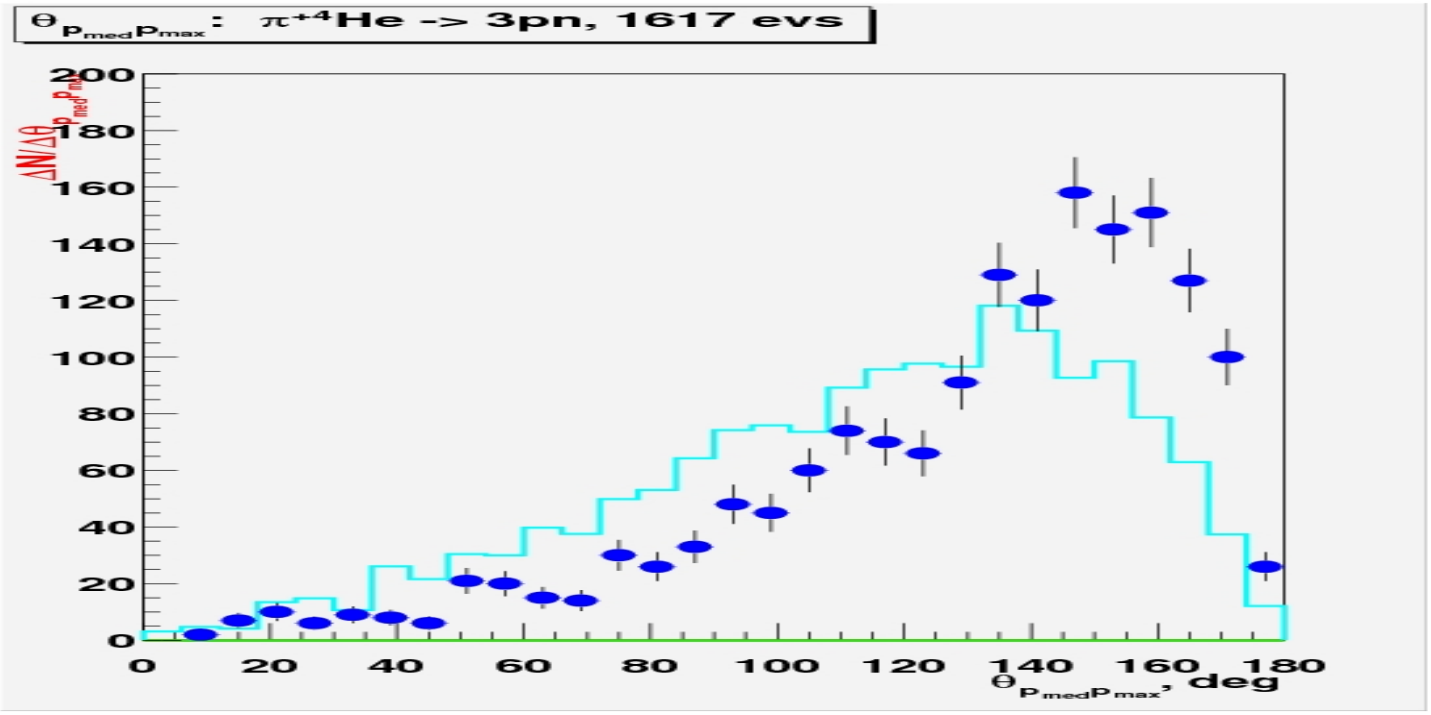
θ_{n^3He}, $\mathbf{M}_{n^3He}\mathbf{.vs.}\mathbf{M}_{n\pi}$, $\mathbf{M}_{n\pi}\mathbf{.vs.}\theta_{n^3He}$, $\mathbf{M}_{n\pi}$



3-prong events – knockout, breakup, absorption

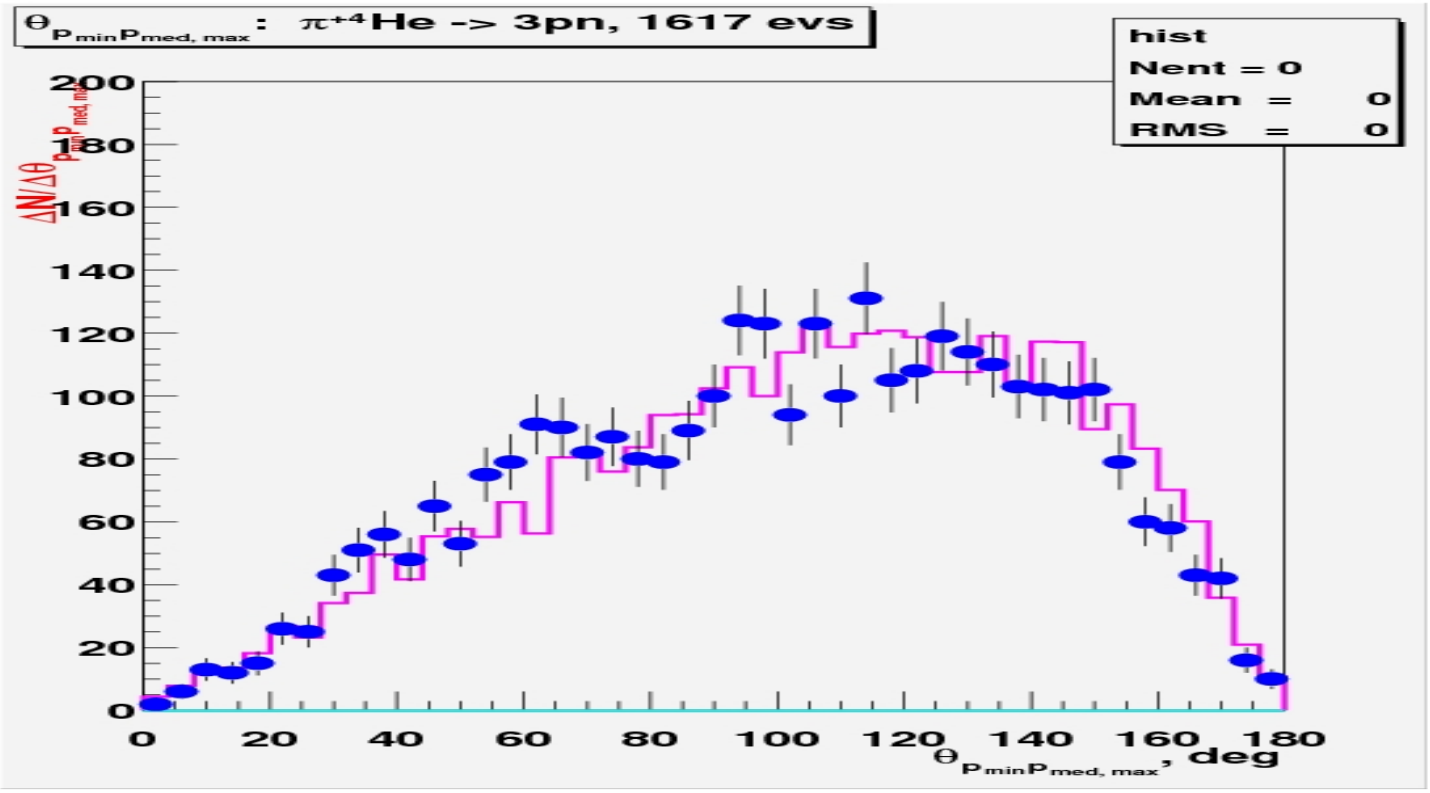


3-prong events – absorption, complete kinematics



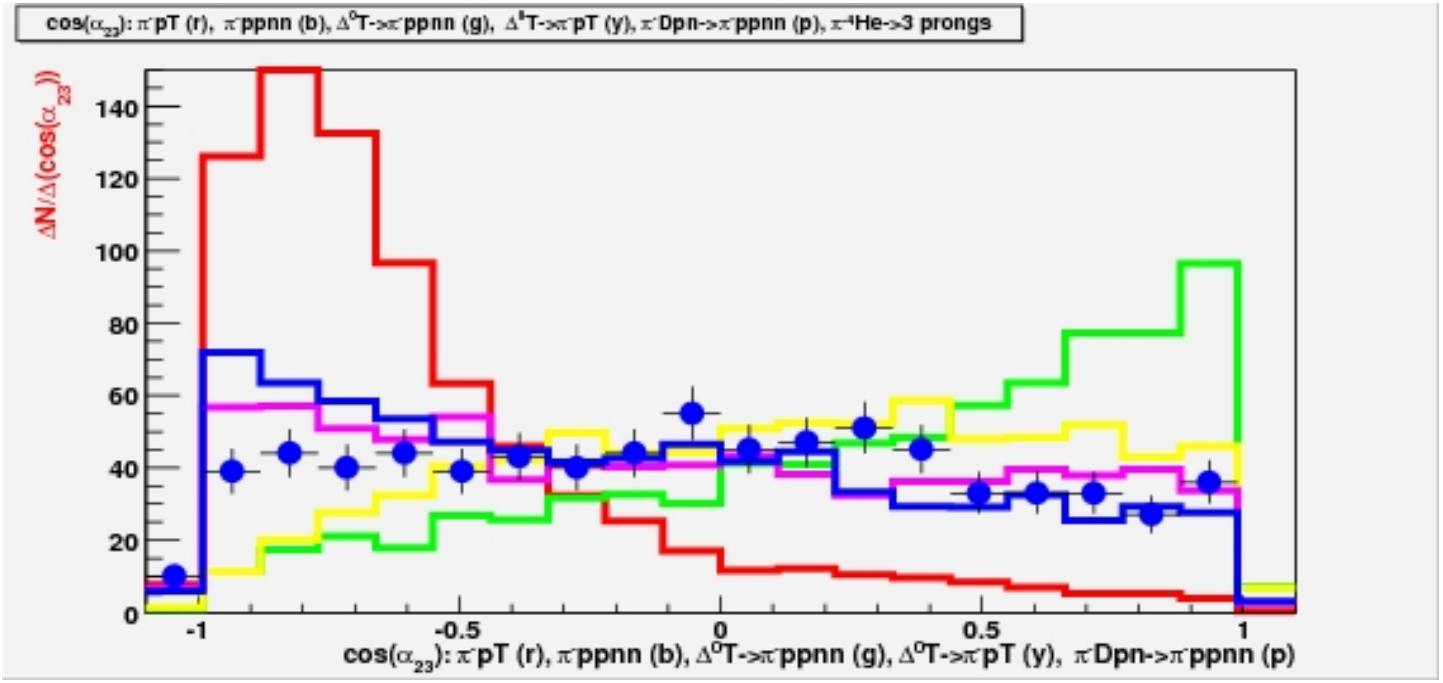
Distribution of angle between the 2 fastest secondary protons in absorption π^{+4}He$\rightarrow$pppn. MC histogram takes into account experimental measurement errors. All charged secondaries are measured!.

Absorption, angle slow–fast



Distribution of angles between slow and the 2 fast protons in absorption π^{+4}He$\rightarrow$pppn.

DUBTO, Distribution of $\cos(\alpha_{23})$
π^-pT (r), π^-ppnn (b), Δ^0T$\rightarrow \pi^-$ppnn (g),
Δ^0T$\rightarrow \pi^-$pT (y), π^-Dpn$\rightarrow \pi^-$ppnn (p)



$\pi^-{}^4$He$\rightarrow \pi^-$p^{3}H or $\pi^-{}^4$He$\rightarrow \pi^-$ppnn.
Reaction proceeds via intermediate state!

Thus, latest results...

Thus, the latest PAINUC results include

- **the first observation in π^{-4}He scattering of single γ-quanta;**
- **the first observation of the Δ^{-}-resonance in π^{-4}He interactions at energies well below the pion production threshold;**
- **revelation of three-prong π^{-4}He reactions proceeding via an intermediate state.**

It is to be mentioned, also, that the JINR-INFN collaboration has seriously contributed to COMPASS having obtained good new results, for instance, in a study of the pion polarizability.

Conclusion

The JINR–INFN 40-year-long collaboration has proved very positive and fruitful, both from scientific and human points of view.

We are very grateful for the support rendered by the Turin University, the Fermi Center and, last, but not least, the Italian Ministry of foreign affairs.