R³B – Reactions with Relativistic Radioactive Beams
Setup and recent expeiments

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GSI

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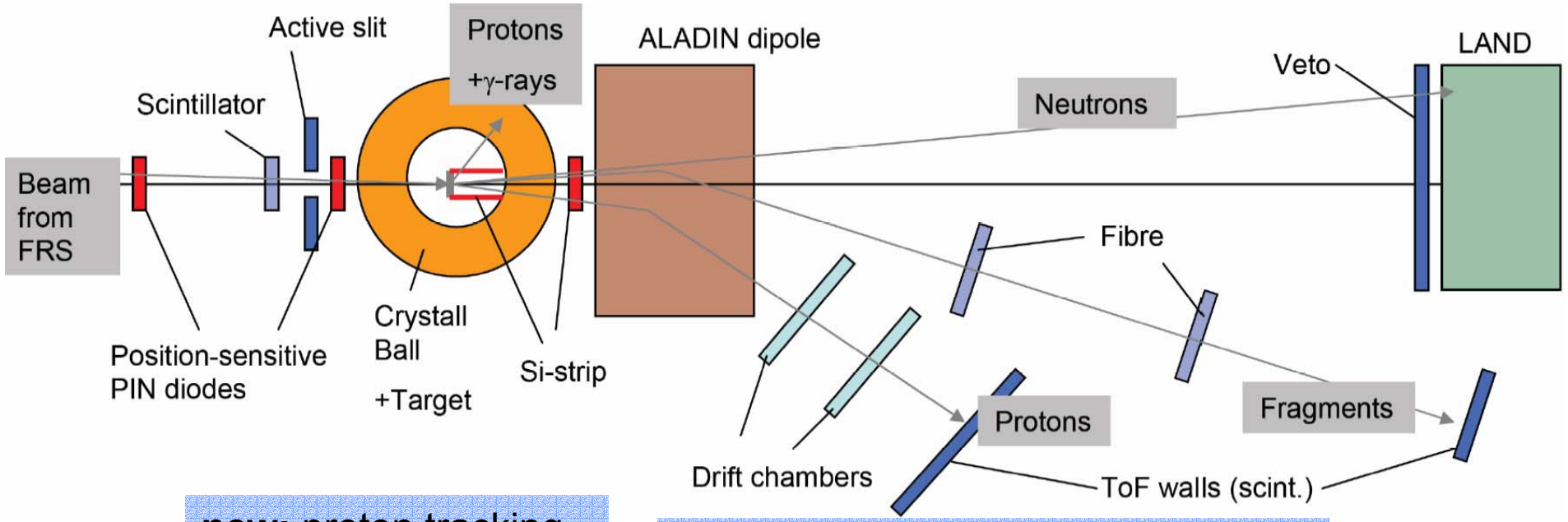
- Upgrade of setup
  - Si-strip detectors
  - Large area detectors for light charged particles
  - Proton measurement with Crystal Ball
- Experiments performed in 2007

Experimental Setup at Cave C



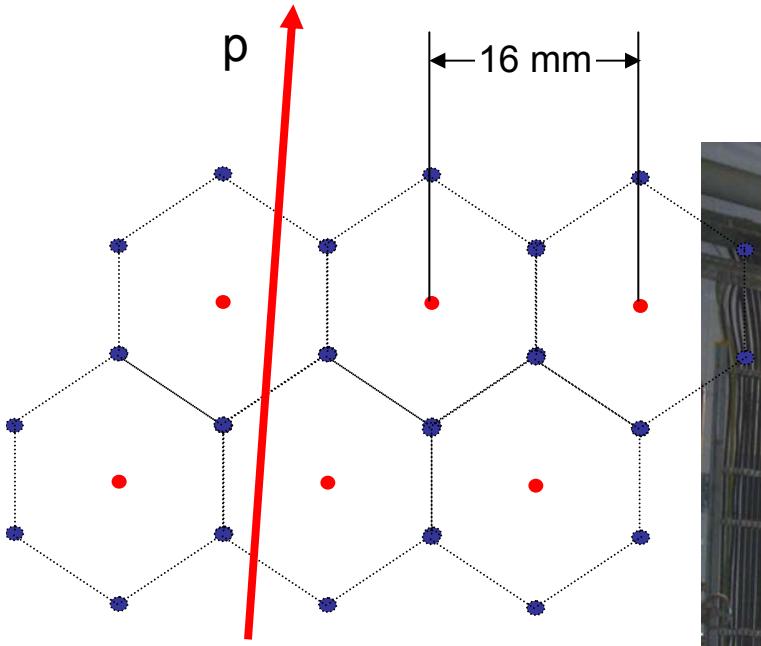
new: proton tracking around the target with Si-strip detectors

new: proton tracking behind magnet with drift chambers

Exclusive measurement of all interesting reaction channels

- knockout plus decay of residual system
- inelastic excitation plus proton decay (nuclear, electromagnetic)
- quasi-free scattering: (p,2p)

Large-area drift chambers for proton tracking behind the large-acceptance dipole ALADIN



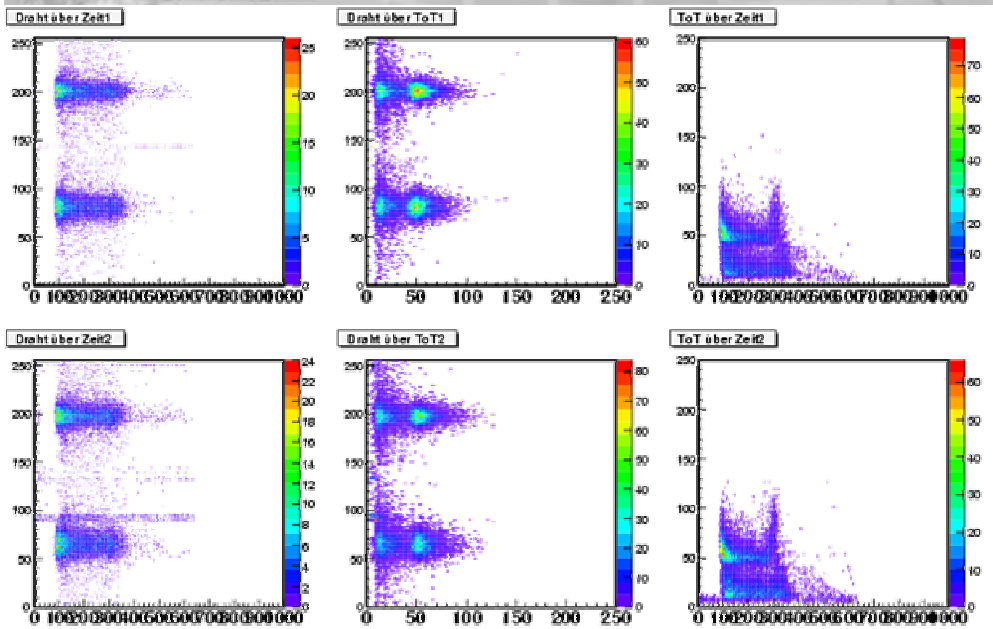
Setup for beam tests

Design parameters:

- 16 mm cell pitch
- 2 cell layers per coordinate (left right ambiguity)
- Size of the chambers: 80 ×100 cm^2, 2 × 62 × 50 cells
- Resolution: < 200 mm

GSI, Uni Frankfurt

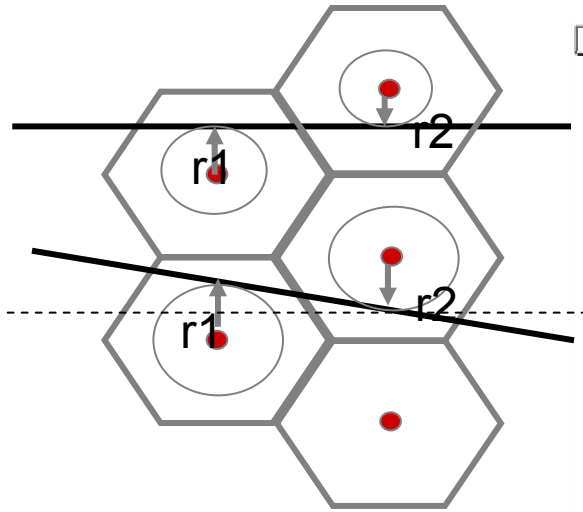
Large-area drift chambers: Results from beam tests

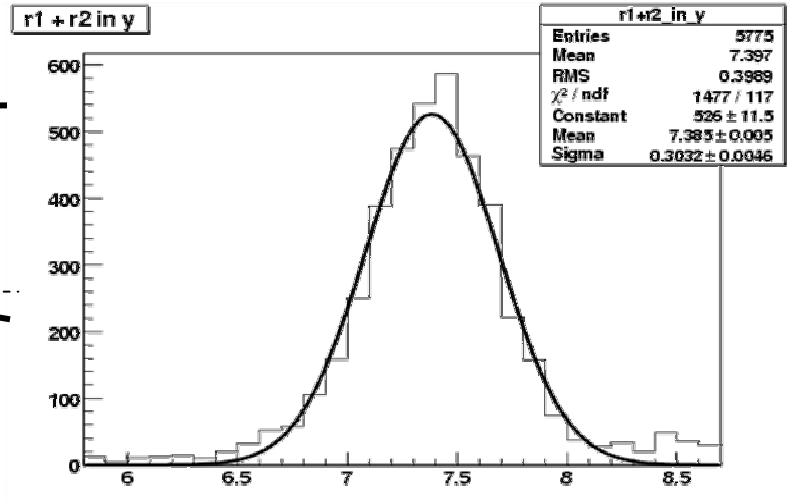


Test run with 500 MeV/nucleon ^{12}C:

time-over-threshold (pulse height) allows distinguishing signals induced by delta-electrons and ions

→ detector also usable with good resolution for light ions





Results from test run with proton beam (500MeV)

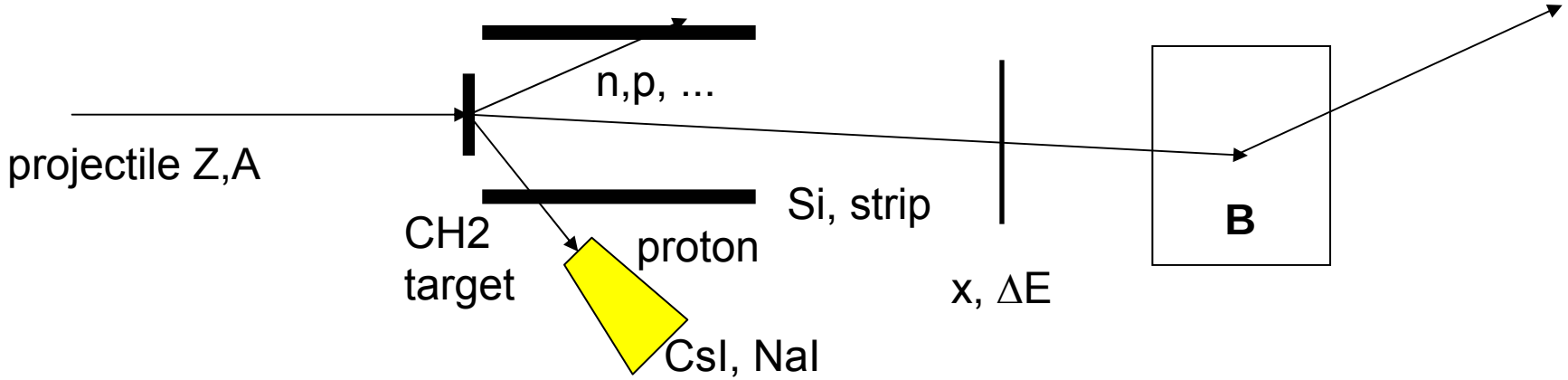
Resolution ~ 150μm

efficiency for protons ~83-89%

(full event, 4 wires)

Quasi-free scattering in inverse kinematics

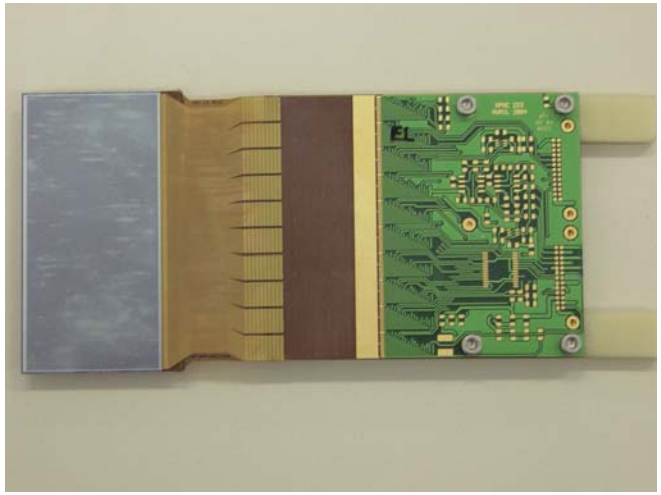
Measurement of proton recoils after knockout reactions with a CH_2 target

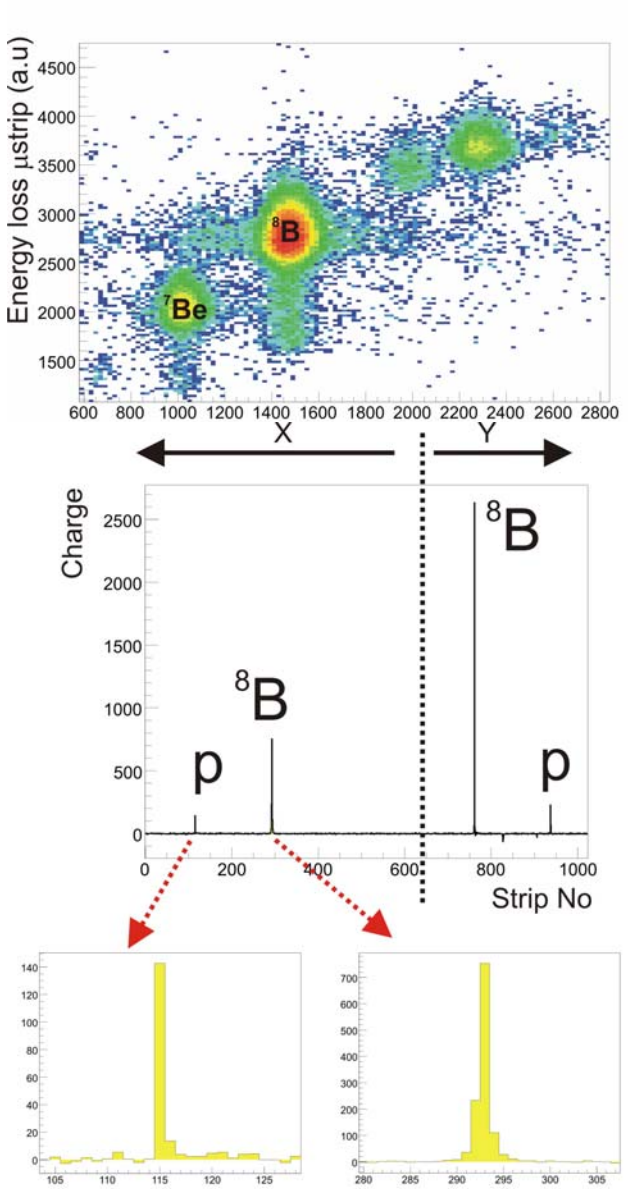


- kinematical complete measurement of
  (p,pn), (p,2p), (p,pd), (p,a), ... reactions
- redundant experimental information:
  kinematical reconstruction from proton momenta
  plus gamma rays, recoil momentum, invariant mass
- sensitivity not limited to surface
  → spectral functions
  → knockout from deeply bound states
- cluster knockout reactions

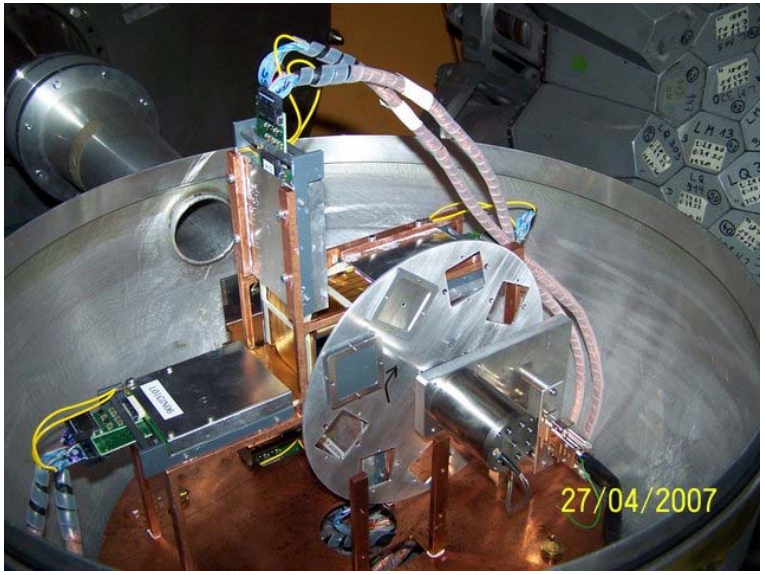
Si-strip detectors – Test ^{8}B breakup to ^{7}Be + p

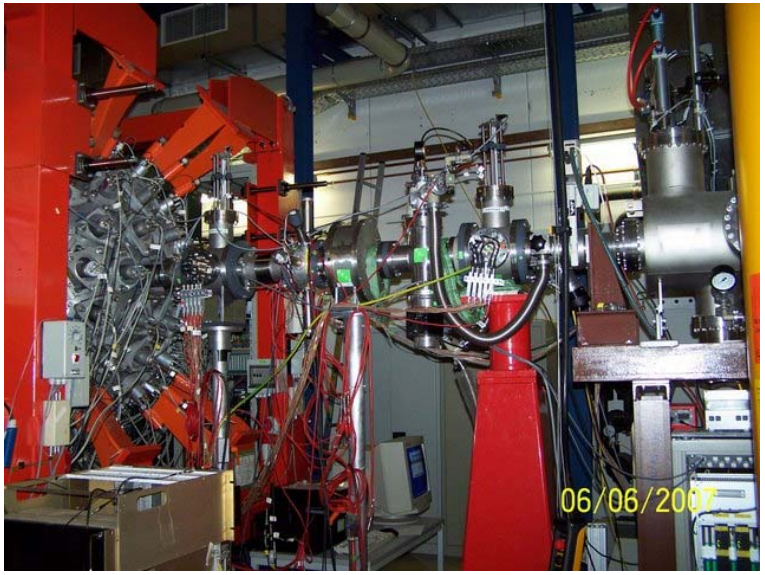
- AMS type detectors
- DSSDs, 300 μ m thick, 41 × 72 mm2
- Strip pitch 100 μm
- Readout chips – VA64HDR9a (64 ch, very low power dissipation)
- Energy resolution – 50 keV
- Dynamic range – 100 keV - 14 MeV
- 1024 readout channels/detector
- Designed to work in vacuum (total power dissipation < 3 W/detector)





Setup for quasi-free scattering experiment





Pilot Experiment:

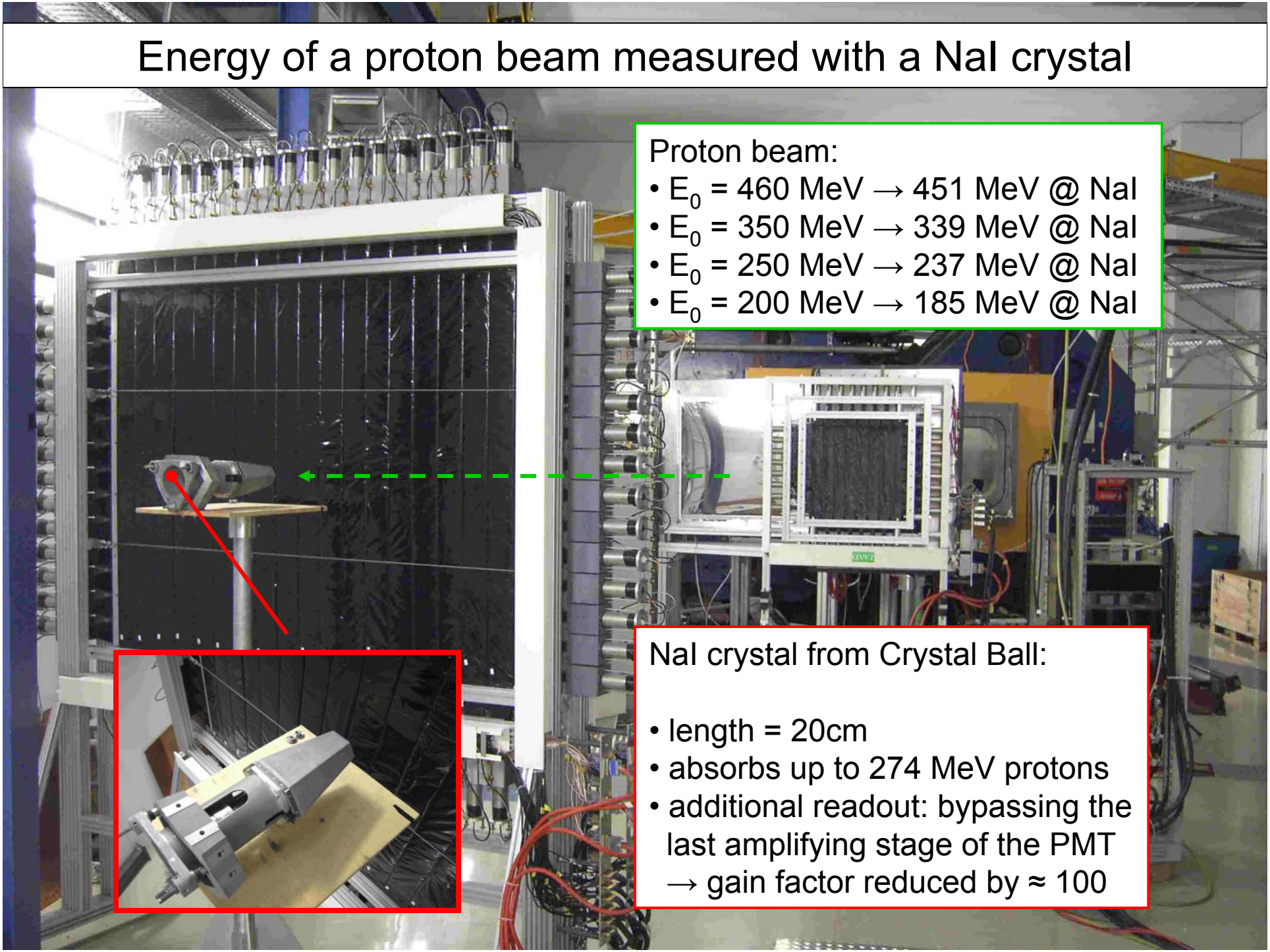
starting 23rd September 2007

^{12}C beam at energies around 500 MeV/u

(p,2p) reactions in complete kinematics

plus detection of projectile-like fragments/ejectiles

Energy of a proton beam measured with a NaI crystal



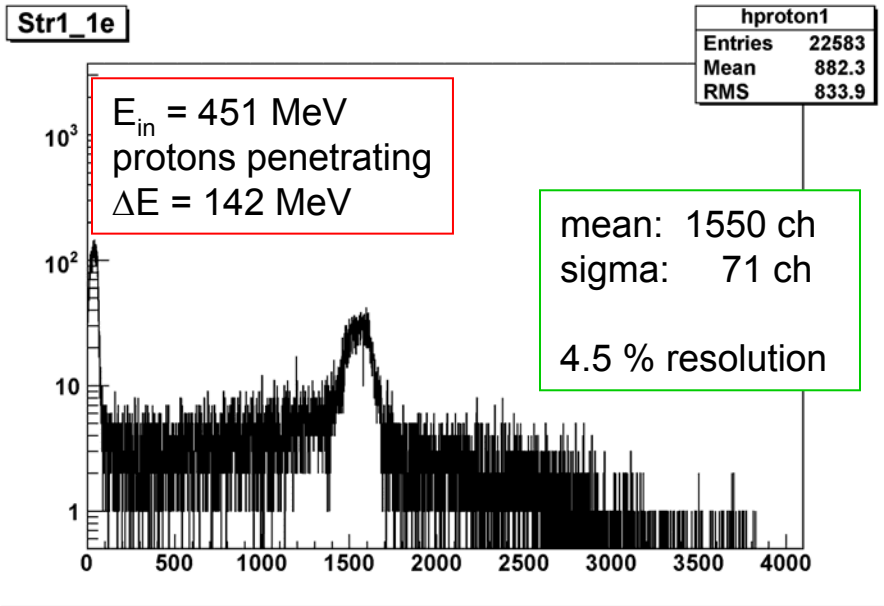
Proton beam:

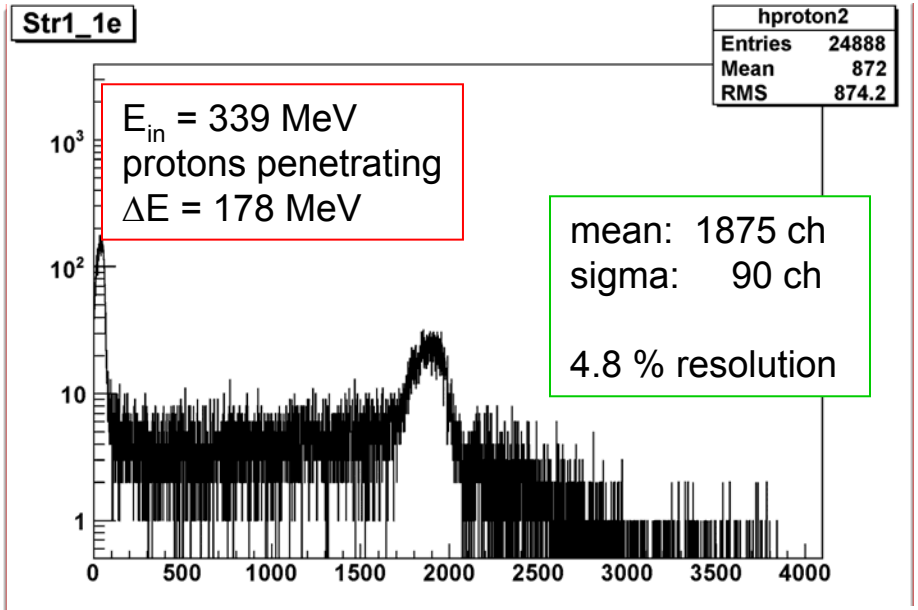
- E_0 = 460 MeV → 451 MeV @ NaI
- E_0 = 350 MeV → 339 MeV @ NaI
- E_0 = 250 MeV → 237 MeV @ NaI
- E_0 = 200 MeV → 185 MeV @ NaI

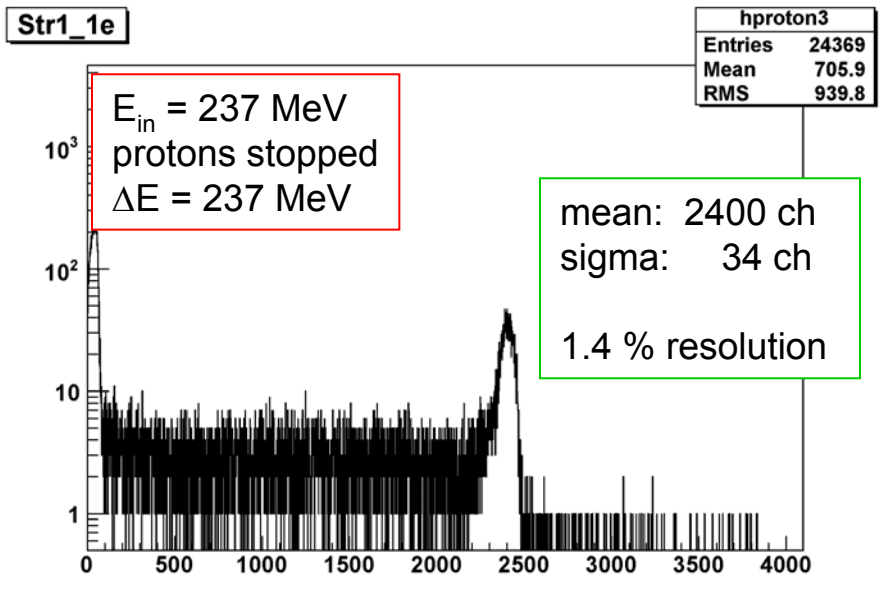
NaI crystal from Crystal Ball:

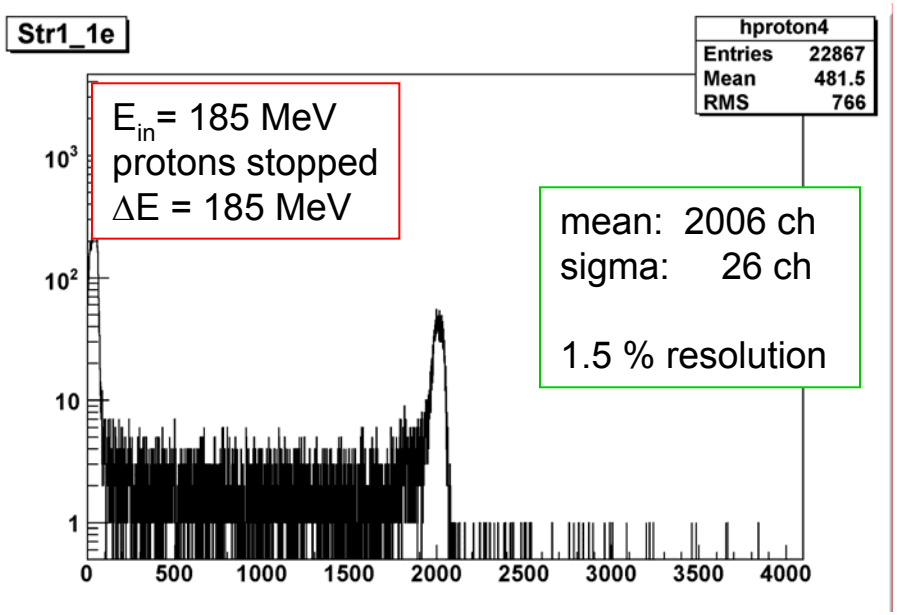
- length = 20cm
- absorbs up to 274 MeV protons
- additional readout: bypassing the last amplifying stage of the PMT → gain factor reduced by ≈ 100

Raw spectra of protons in NaI crystal









Recent Experiments

Experiments in 2007

- Reactions of astrophysical interest
  Experiment S223: Coulomb breakup of $^{27}P \rightarrow {}^{26}Si$ (p,γ)
  Klaus Sümmerer et al.

- The Borromean 2p Halo Nucleus ^{17}Ne
  Experiment S318, Björn Jonson et al.
  Coulomb breakup, Nuclear breakup, knockout and quasifree scattering

- Pilot experiment on quasi-free scattering
  Experiment S296, Roy Lemmon et al.
  12C primary beam, (p,2p), (p,pn), ...

Plans for 2008:

- Pygmy resonance in p-rich Ar isotopes
  Konstanze Boretzky et al.
- Neutron-rich nuclei in the island of inversion around N=20
  Ushasi Datta Pramanik et al.
- Dismount setup: free Cave C for experiments from other group: Ducret, Saito