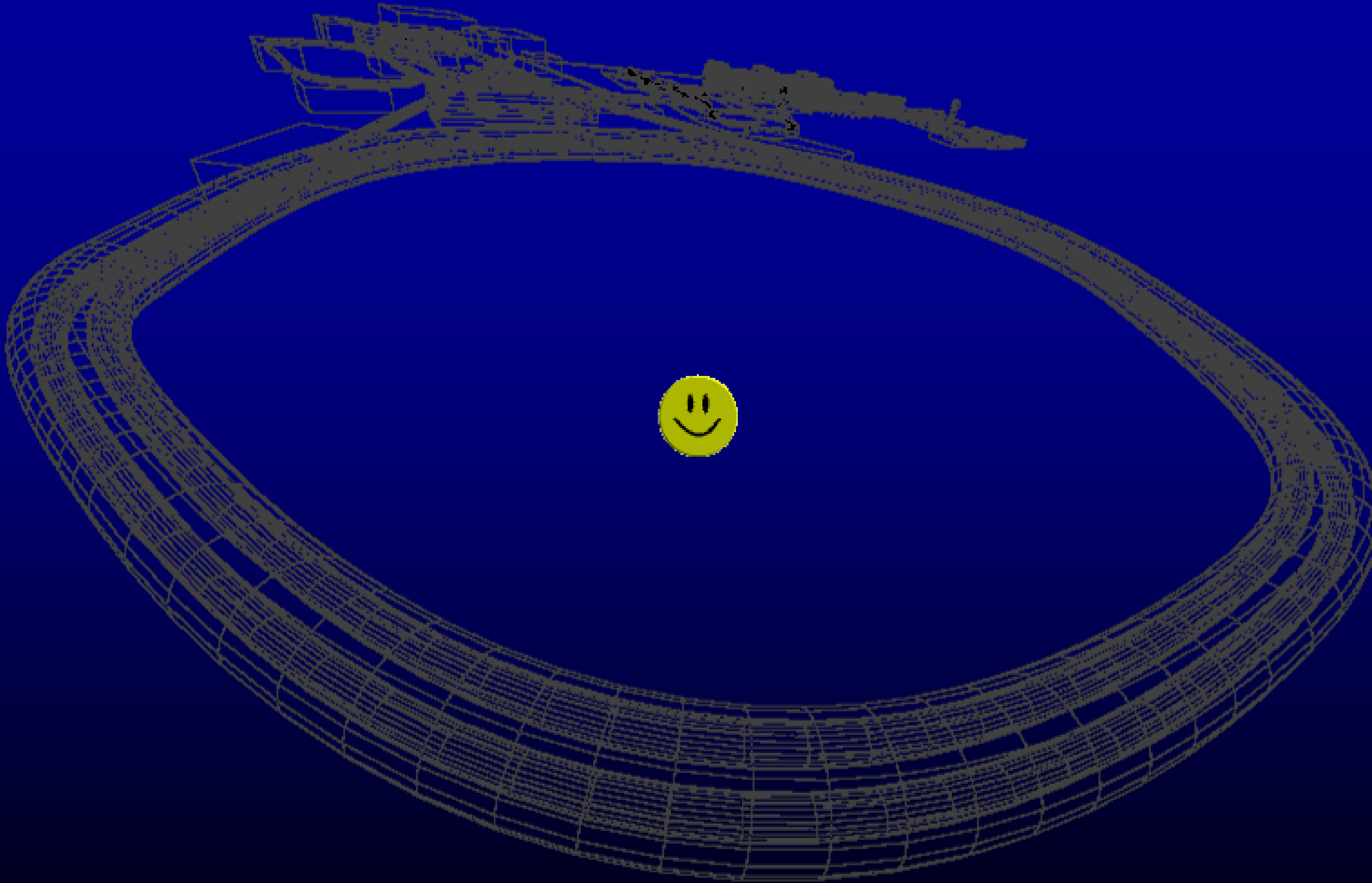
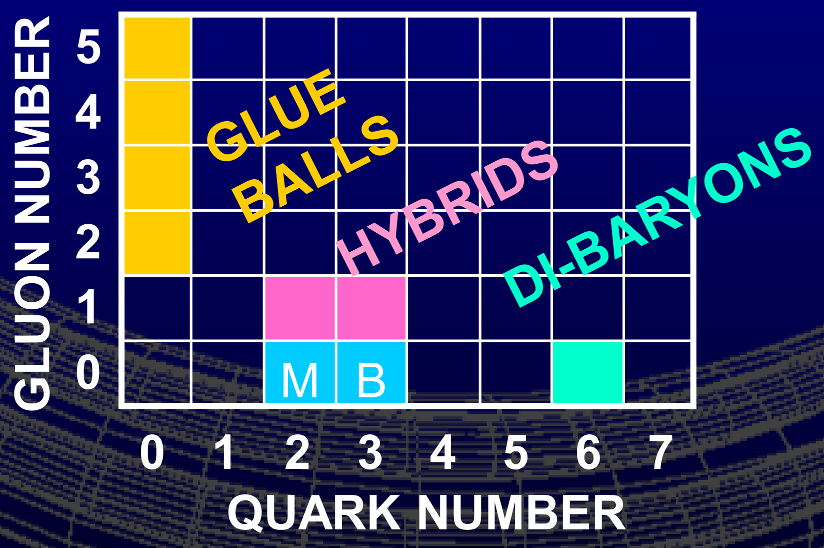


Physis with Strange Hadrons at the Storage Ring for Anti-Protons

- **Physics Highlights**
  - **Double Hypernuclei**
  - **H-Dibaryon**
  - **Properties of Baryons**
- **Experimental Details**

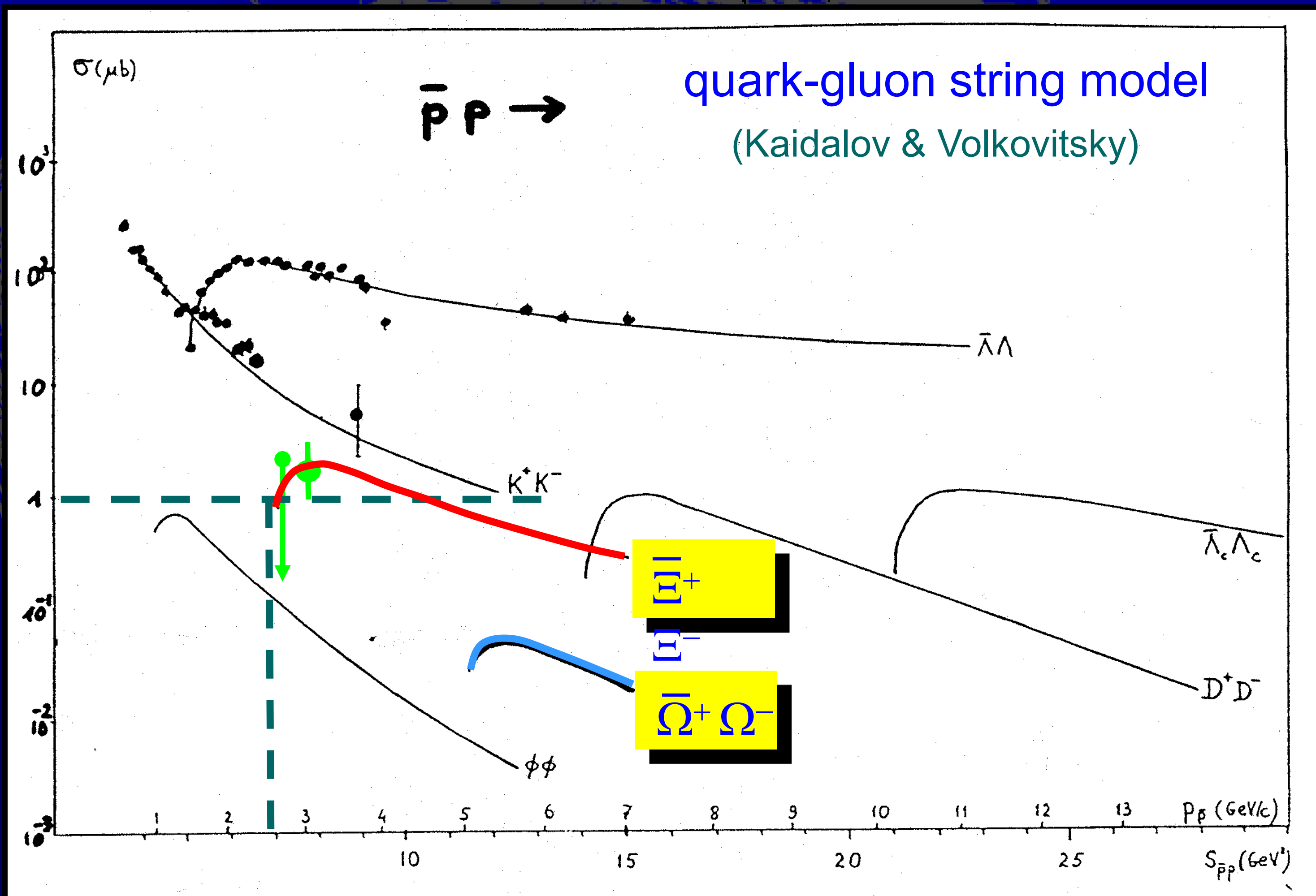
Darmstadt, 5.4.2002

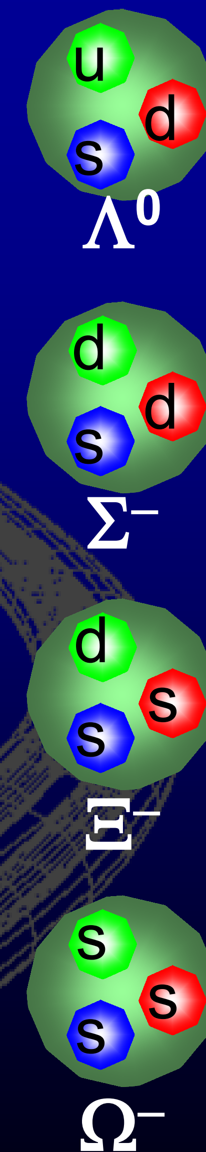
1. Physics Highlights



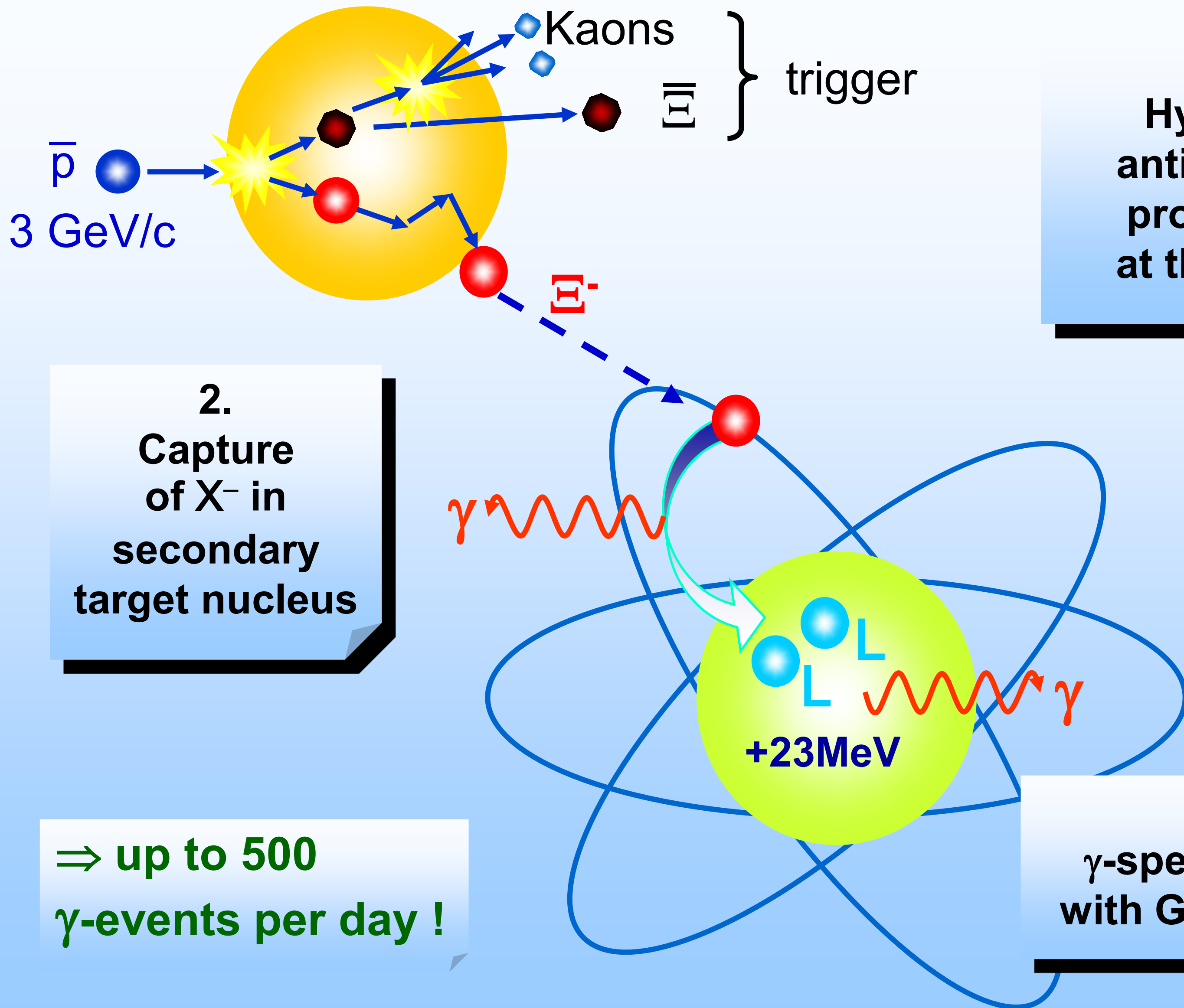
General Idea

- Use $p\bar{p}$ Interaction to produce a hyperon “beam” ($t \sim 10^{-10}$ s) which is tagged by the anithyperon or its decay products





Production of Double Hypernuclei



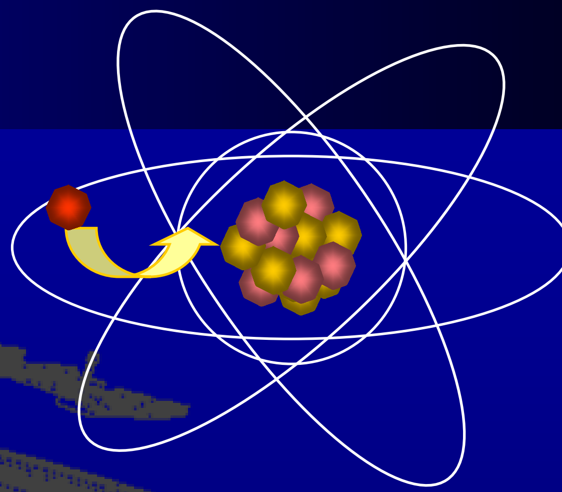
1.
Hyperon-antihyperon production at threshold

2.
Capture of X⁻ in secondary target nucleus

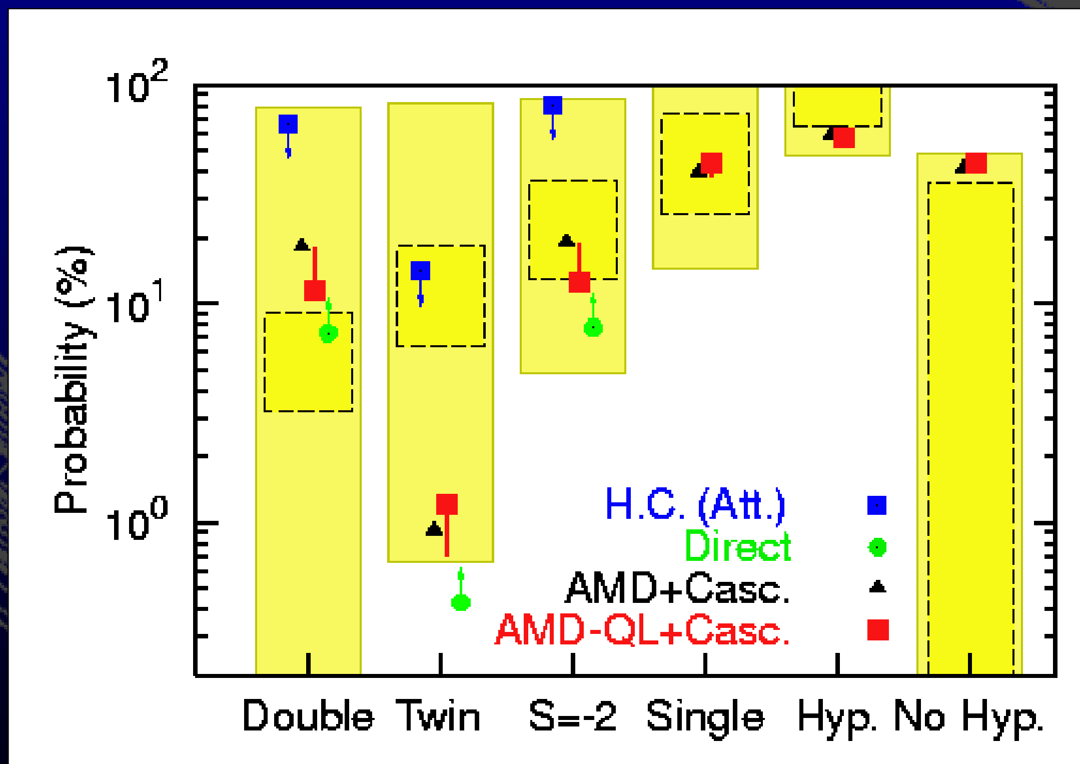
3.
γ-spectroskopy with Ge-detectors

⇒ up to 500 γ-events per day !

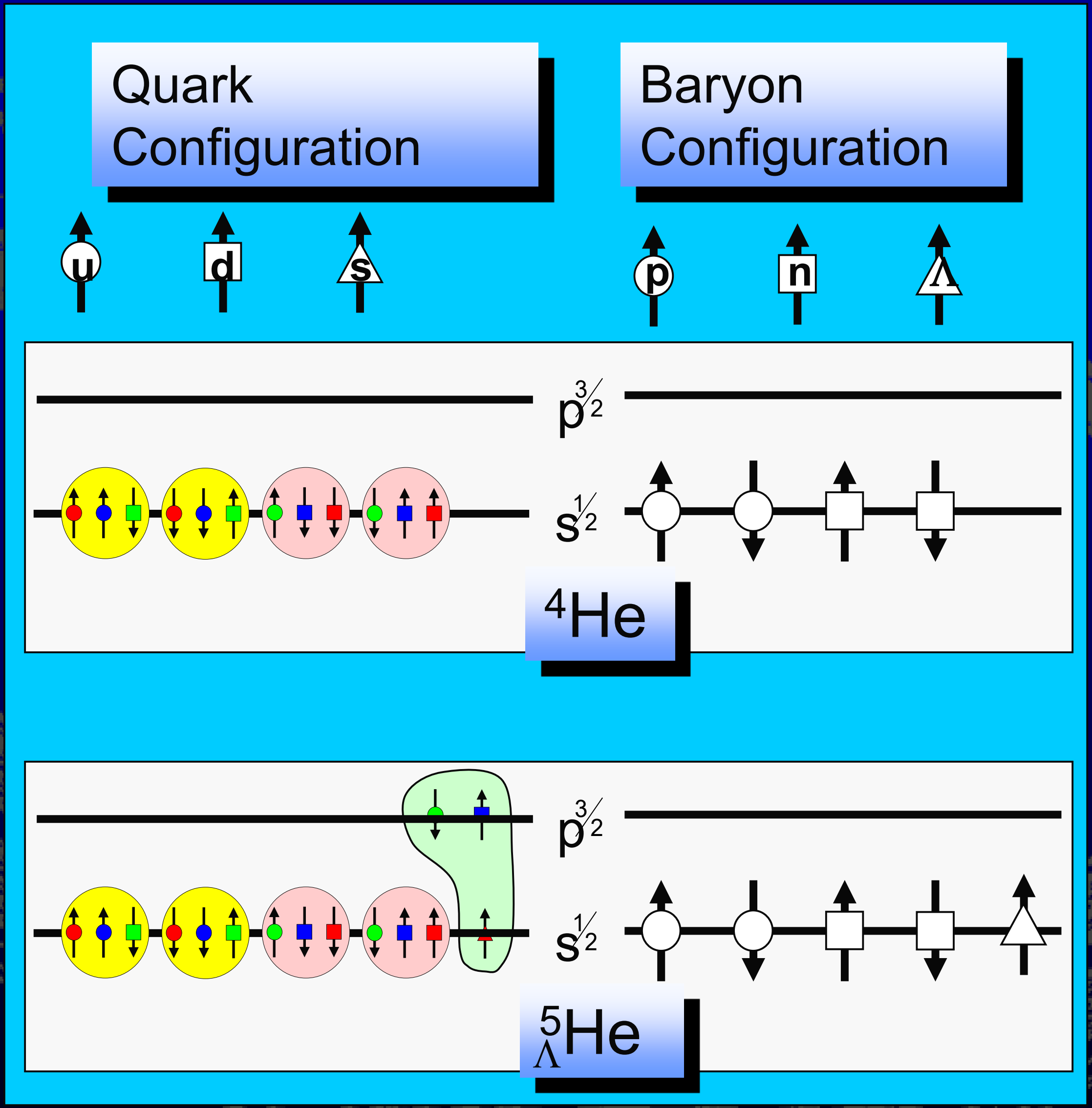
Ξ^- capture



- Ξ^--atoms: x-rays
- conversion
  - Ξ^-(dss) p(uud) Þ Λ(uds) Λ(uds)
  - ΔQ = 28 MeV
- Conversion probability approximatly 5-10%



Hypernuclei and Deconfinement



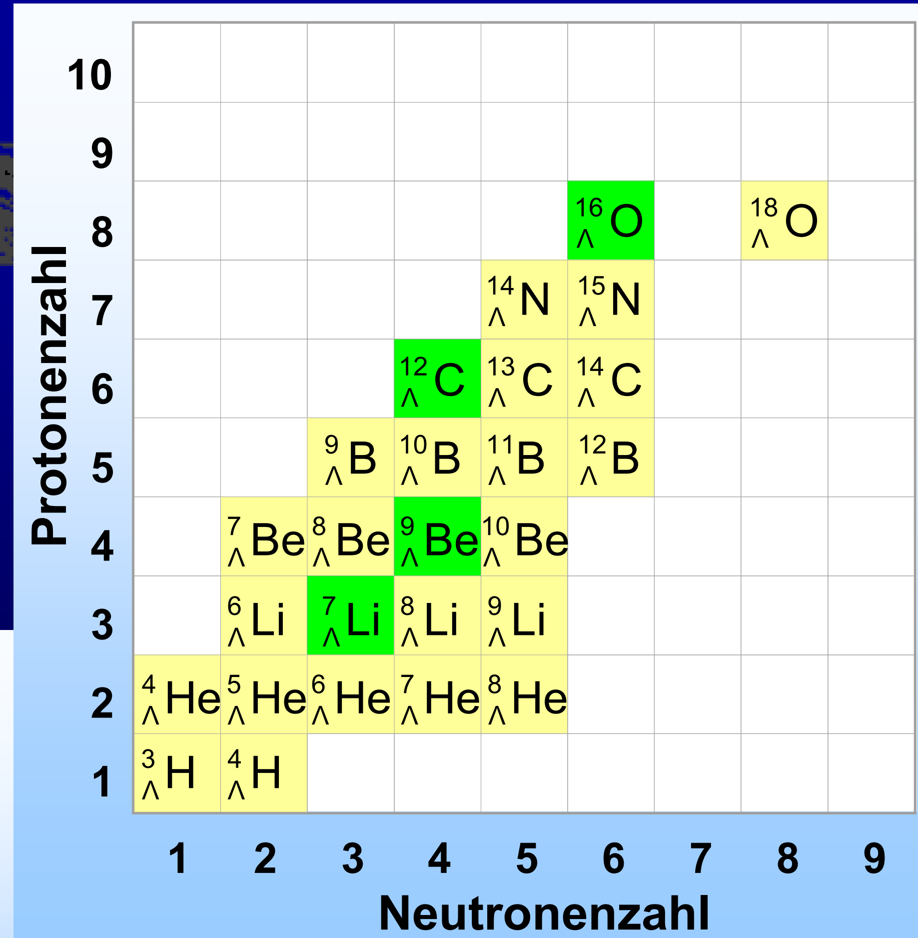
Single Hypernuclei

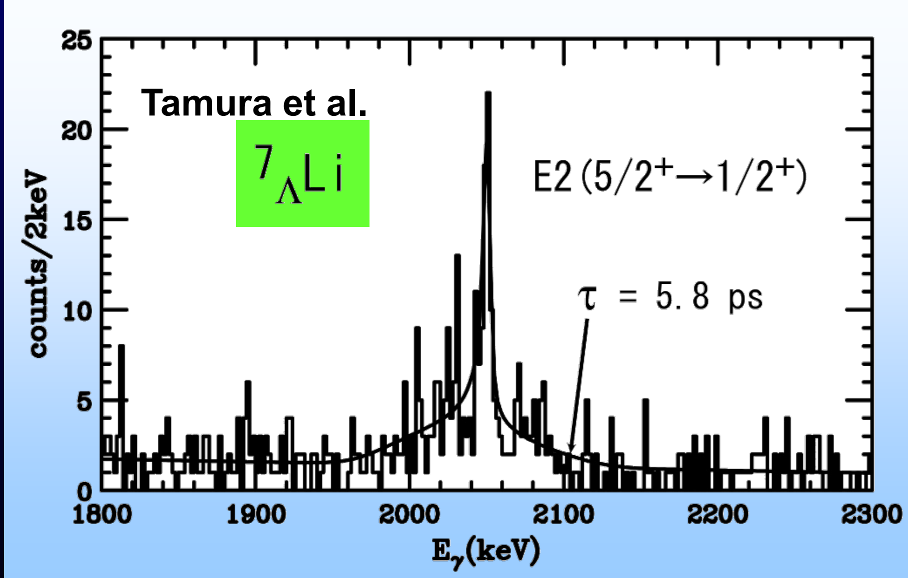
- **YN interaction in nuclear medium**
- **Nuclear structure**
- **non-mesonic weak decays**

  $\Lambda p \rightarrow pn$

  $\Lambda n \rightarrow nn$

$\Rightarrow$ weak baryon-baryon Interaction





high resolution γ-spectroskopy with germanium detectors

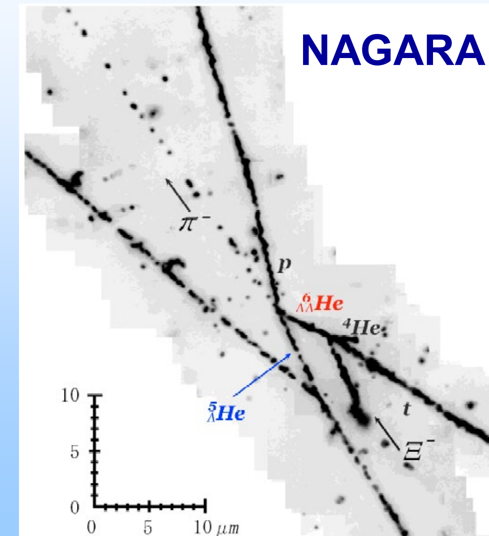
Double Hypernuclei

- **Multi-Hypernuclei are *terra incognita*, but they exist !**

1963: Danysz *et al.*	${}_{\Lambda\Lambda}^{10}Be$
1966: Prowse	${}_{\Lambda\Lambda}^{6}He$
1991: KEK-E176	${}_{\Lambda\Lambda}^{13}B$
1991: KEK-E176	3 non-mesonic decays
2001: AGS-E906	${}_{\Lambda\Lambda}^{4}H$ (~15)
2001: KEK-E373	${}_{\Lambda\Lambda}^{6}He$

$\Xi^- + {}^{12}C \rightarrow {}_{\Lambda\Lambda}^{6}He + {}^{4}He + t$

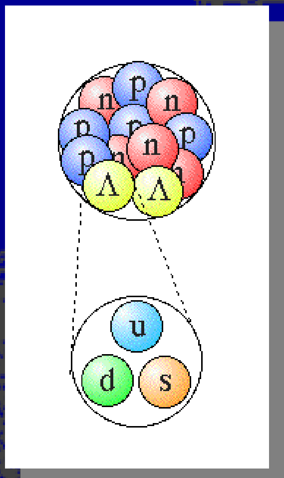
${}_{\Lambda\Lambda}^{6}He \rightarrow {}_{\Lambda}^{5}He + p + \pi^-$

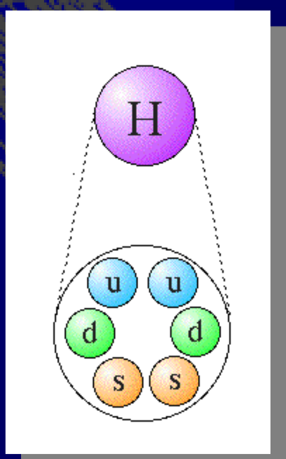


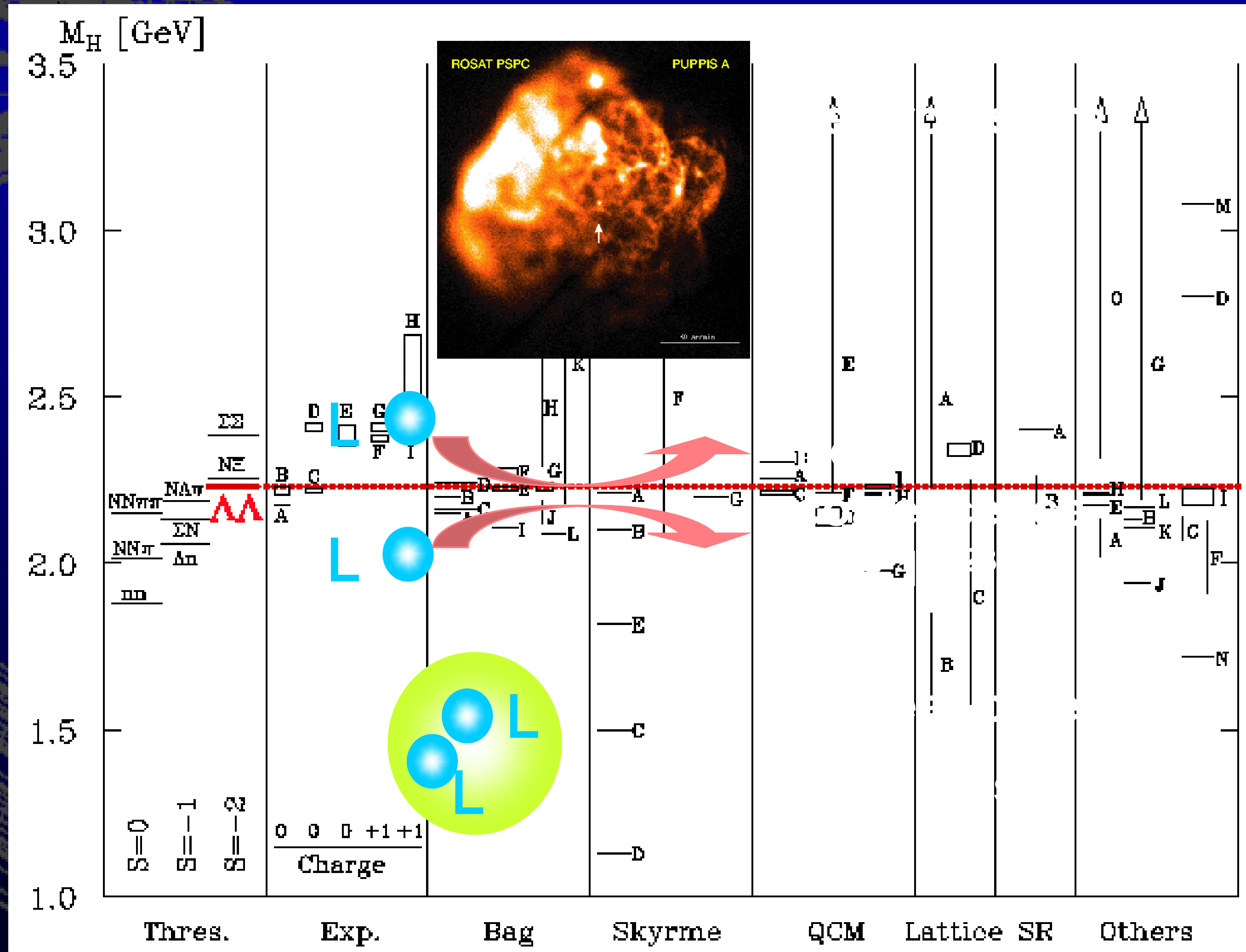
Hyperkern	$B_\Lambda({}_{\Lambda\Lambda}^{A}Z)$ (MeV)	$B_\Lambda({}_{\Lambda\Lambda}^{A-1}Z)$ (MeV)
${}_{\Lambda\Lambda}^{6}He$	4.1	3.1
${}_{\Lambda\Lambda}^{10}Be$	11.0	6.7
${}_{\Lambda\Lambda}^{13}B$	16.2	11.4

ΛΛ Kerne as Femtolaboratory

- ***H*-Particle** **R.L. Jaffe (1977)**



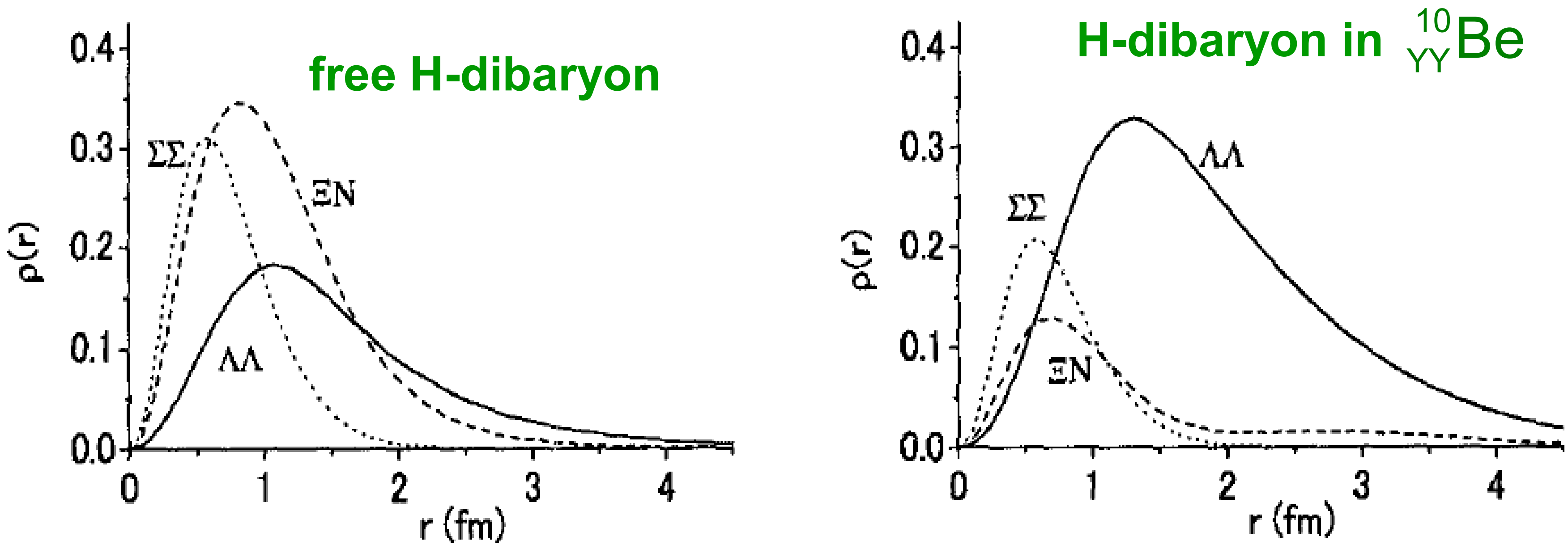




S=-2 Nuclei and H-dibaryon states

- *H*-particle in nucleus ≠ free *H*

  (see e.g. T. Yamada, NP A691 (2001) 250c; (3q)+(3q) quark cluster model)



$B_{\Lambda\Lambda}$=12.2 MeV

$B_{\Lambda\Lambda}$=24.0 MeV

Fundamental Properties of Baryons

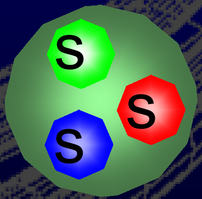
- **Contributions to *intrinsic* quadrupole moment of baryons**
  - One-gluon exchange
  - Meson exchange

$$Q_i = \int d^3 r\, \rho(r)(3z^2 - r^2)$$

- **J=1/2 baryons have no *spectroskopic* quadrupole moment**

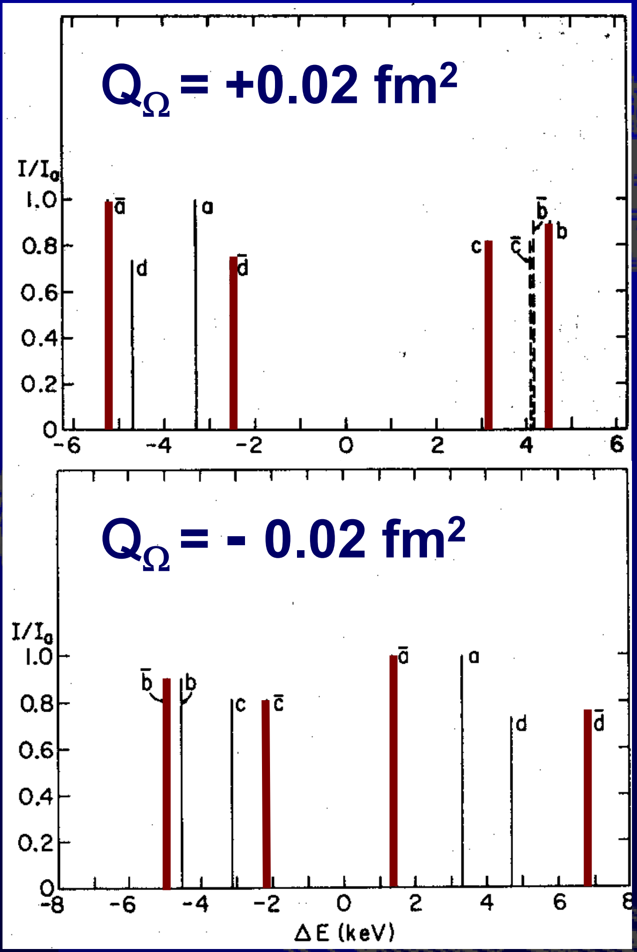
$$Q_s \propto (3J_z^2 - J(J+1)) \xrightarrow[J_z=1/2]{J=1/2} 0$$

- **Ω^- Baryon:**
  - J=3/2
  - long mean lifetime $0.82 \cdot 10^{-10}$ s
  - only one-gluon contributions to quadrupole moment



(A.J. Buchmann Z. Naturforsch. **52** (1997) 877-940)

A very strange Atom



- Ω atoms by $\Omega\bar{\Omega}$ produktion
- hyperfine splitting in Ω-atom

  ⇒ electric quadrupole moment of Ω

spin-orbit	$\Delta E_{\ell s} \sim (\alpha Z)^4\, \ell m_\Omega$
quadrupole	$\Delta E_Q \sim (\alpha Z)^4 Q_\Omega m^3_\Omega$

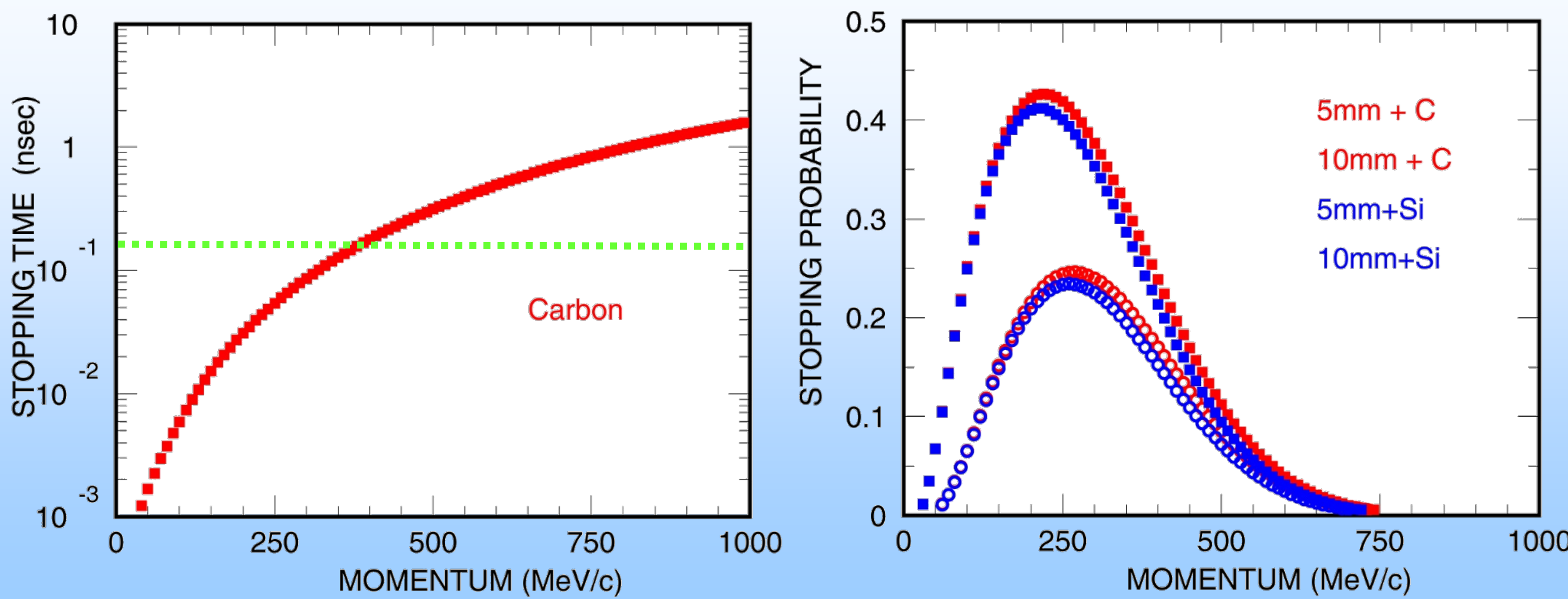
- prediction $Q_\Omega = (0 - 3.1)\ 10^{-2}\ \text{fm}^2$
- $\Delta E(\ell=10 \rightarrow \ell=9) \sim 515$ keV
- $\Delta E_Q \sim$ few keV for Pb

⇒ high resolution γ-spectroscopy

Experimental Details

Ξ⁻ properties

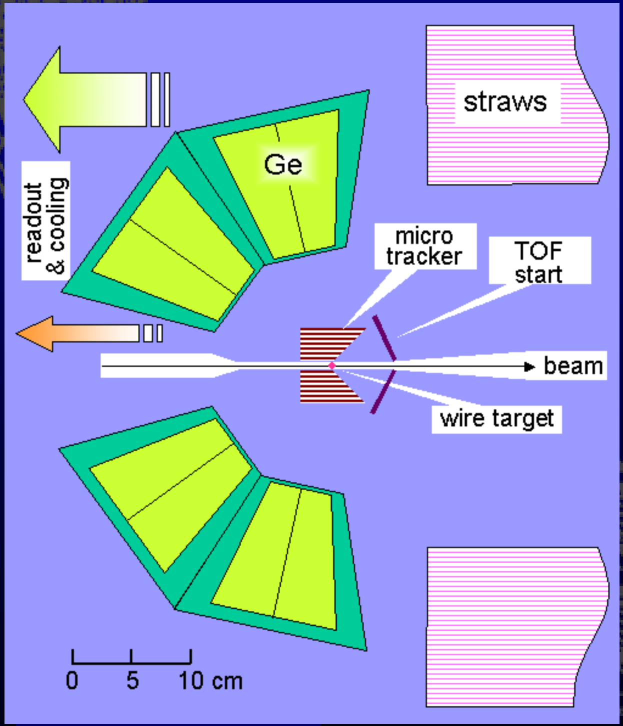
- Ξ^- mean lifetime 0.164 ns

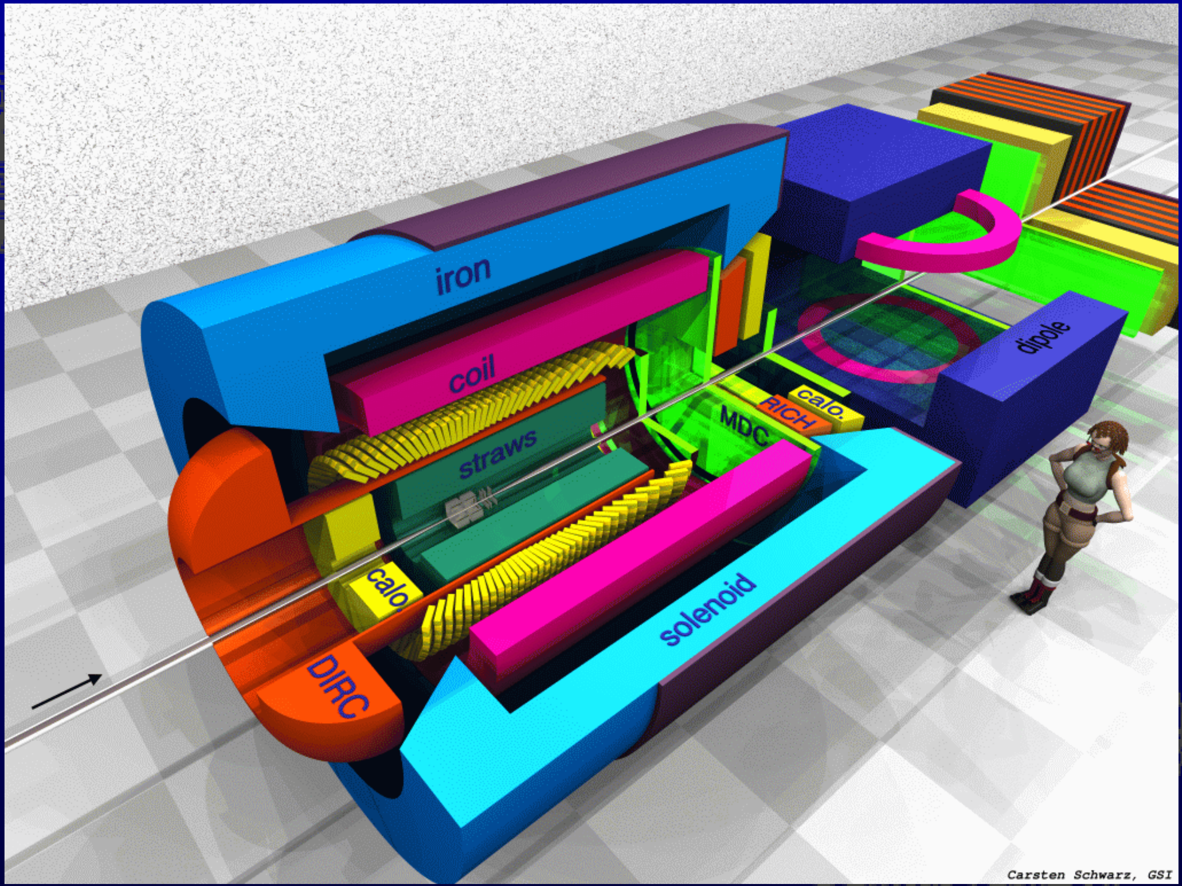


- minimal distance production ↔ capture
- initial momentum 100-500 MeV/c → range ~ few g/cm^2

Detektorkonzept

- hermetic (4π)
- high rate
- PID (γ, e, μ, π, K, p)
- trigger (e, μ, K, D, Λ)
- compact (€)
- modular





- Solid state-micro-tracker
  - thickness ~ 3 cm
- High rate Germanium detector

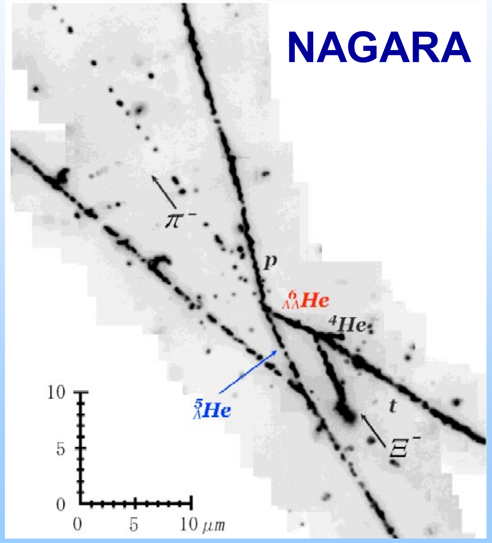
The Solid State Micro Tracker

- **electronic „emulsion“ detector**
- **real time tracking of**
  - incoming Ξ^-
  - decay products (p,π)
- **different absorbers as secondary target**

- **two posibilities**
  - capillar detector (2D)
  - pixel detector (3D)

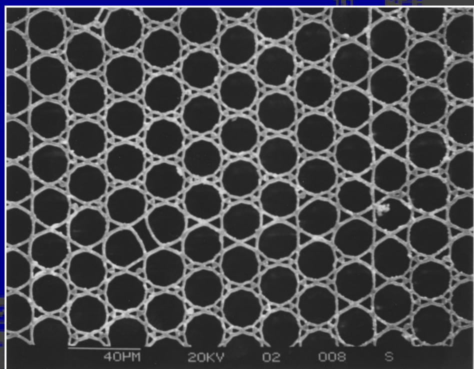
$$\Xi^- + {}^{12}C \rightarrow {}^{6}_{\Lambda\Lambda}He + {}^{4}He + t$$

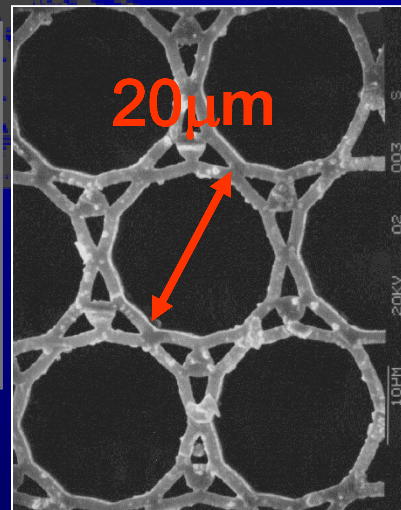
$$^{6}_{\Lambda\Lambda}He \rightarrow {}^{5}_{\Lambda}He + p + \pi^-$$

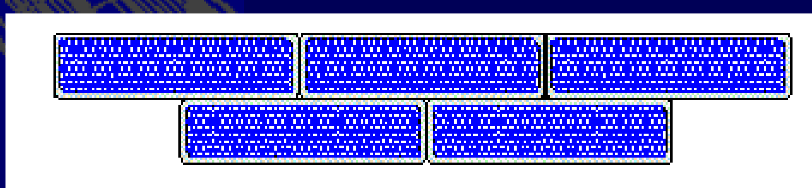


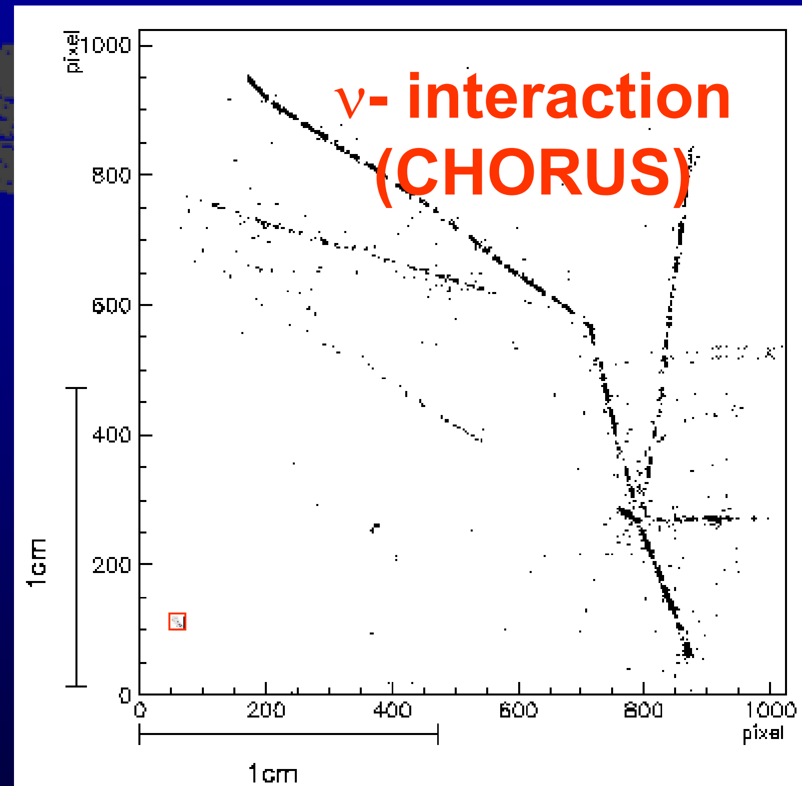
Capillary-Detektor

- glas capillary filled with liquid scintillator





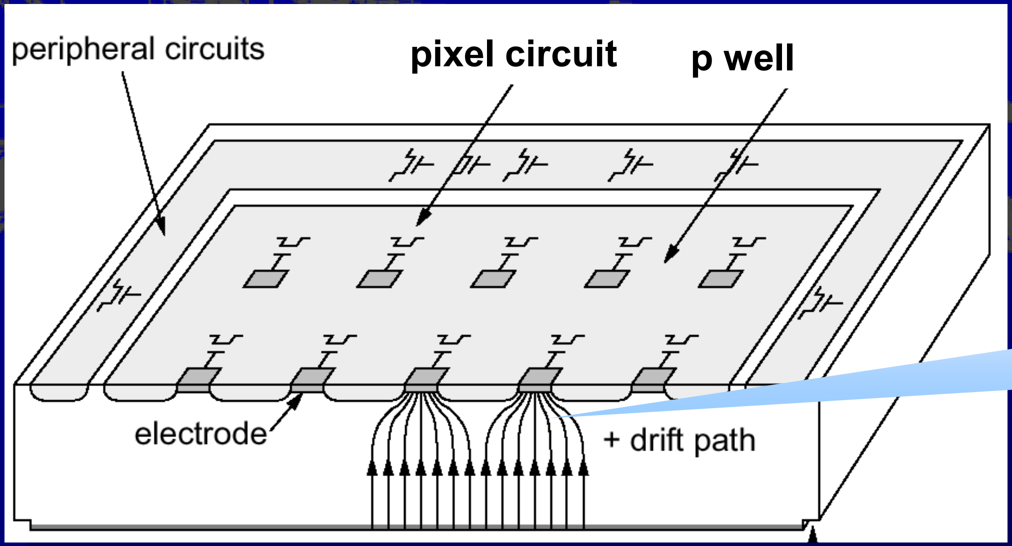




- fast readout: hybrid-photomultiplier+ALICE pixel chip ?!
- only 2D projection

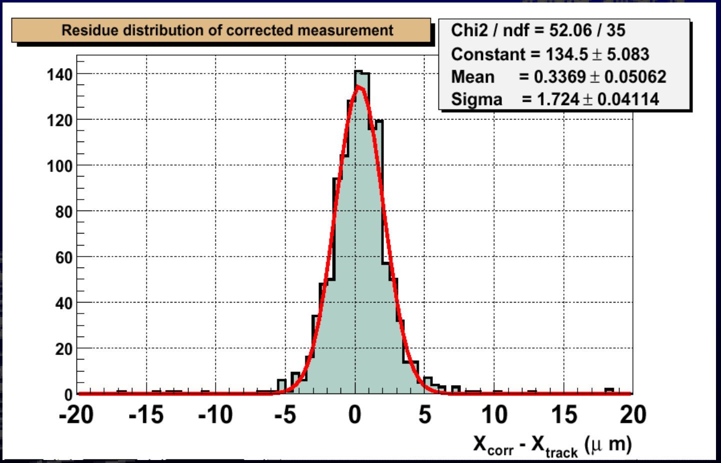
CMOS Monolythic Active Pixel Sensor

- Technology borrowed from digital still and video cameras



charge collection by diffusion time 100-150 ns

- industrial fabrication process (low cost)
- system-on-a-chip (amplifier, ADC...)
- good spatial resolution (~1μm)
- thin (20-50 μm seems possible)



- example: MIMOSA Chip (IReS/LEPSI)

Prospects for MAPS

Yu. Gornushkin 7th International Conference on Advanced Technology and Particle Physics, 17 /10/2001

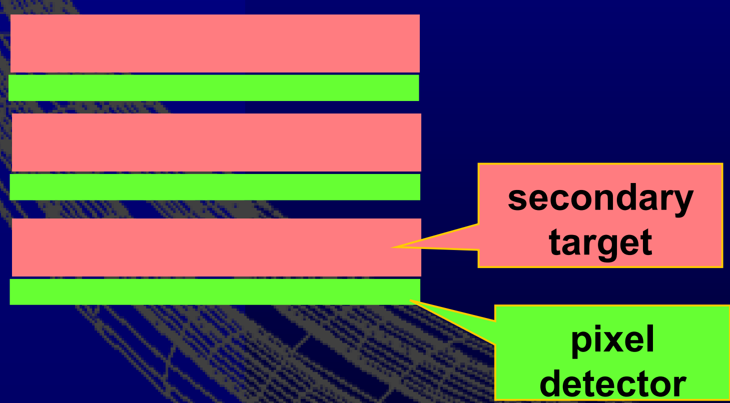
- ✓ The good performance of CMOS MAPS in charge particle detection has been successfully demonstrated with small scale prototypes:

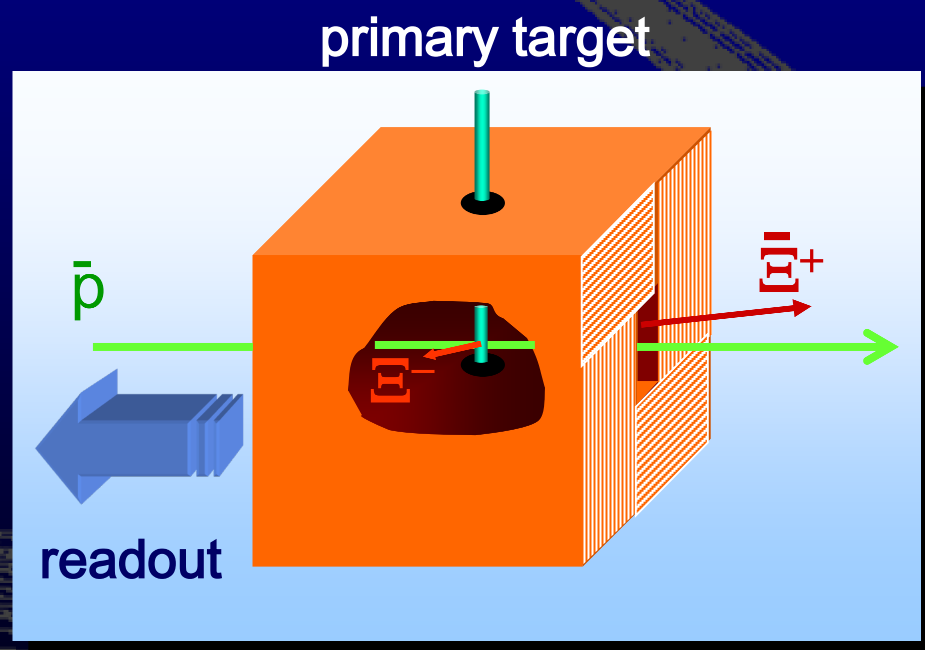
  ε ~99%, σ~1.5-2.5 μm, S/N~20-40

- ✓ Further optimization of the sensitive element design is under way
- ✓ Large scale prototype sensors (2x2 cm2 - 12x2 cm2) are expected soon (0.6 mm AMS process)
- 8 Development of an advanced design of processing electronics with more functionalities at a pixel and chip levels, more data processing 'on-chip', data sparsification – a major task
- 8 Sensor radiation hardness is expected to be improved via design studies
- R&D program on CMOS MAPS TESLA VD in a collaboration with several other centers just started – aim for the detector design by 2004.

Setup

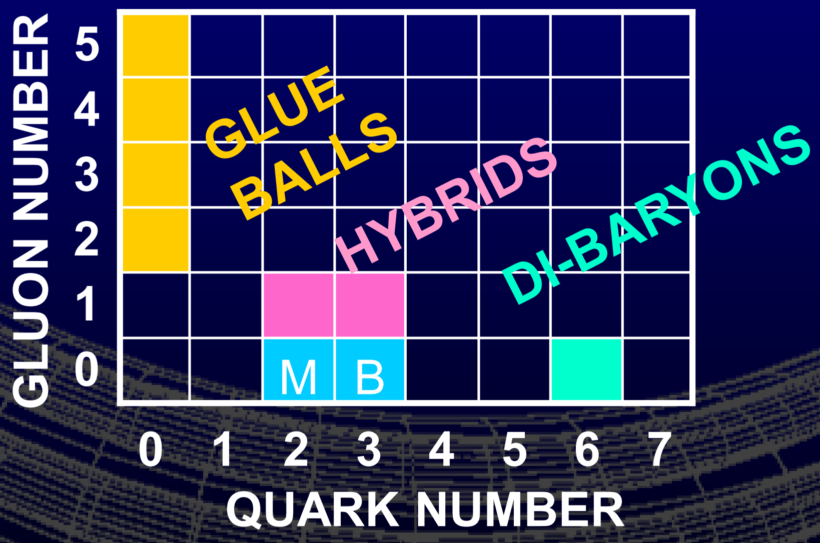
- beam: 3 GeV/c, ∅ ≈ 1mm; no halo (roman pots?)
- Tracking detector for Ξ^-
  - 2-3 cm thick
  - sandwich structure (50μm+150μm)
  - secondary target ⇒ support, cooling





Conclusion

- **Strange baryons offer a unique and important complement to the presented program at the Storage ring for Anti Protons.**
- **Many interesting technical challenges:**
  - Solid state micro tracker
  - high rate germanium array



Das HESR Team

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„Quarks, quarks, quarks."