

American Physical Society
DPF 2004 CONFERENCE
University of California, Riverside
August 26-31

EFFECT OF HADRONIC MATTER ON
APPARENT WIDTH OF MESON
RESONANCES

Bogdan C. Maglich

HiEnergy Technologies, Inc., 1601B Alton Parkway Irvine, California 92606



Fig. 3 Combined charged meson spectrum from 9 Missing-Mass Spectrometry experiments at CERN, all at high $|t| \geq 0.2$.

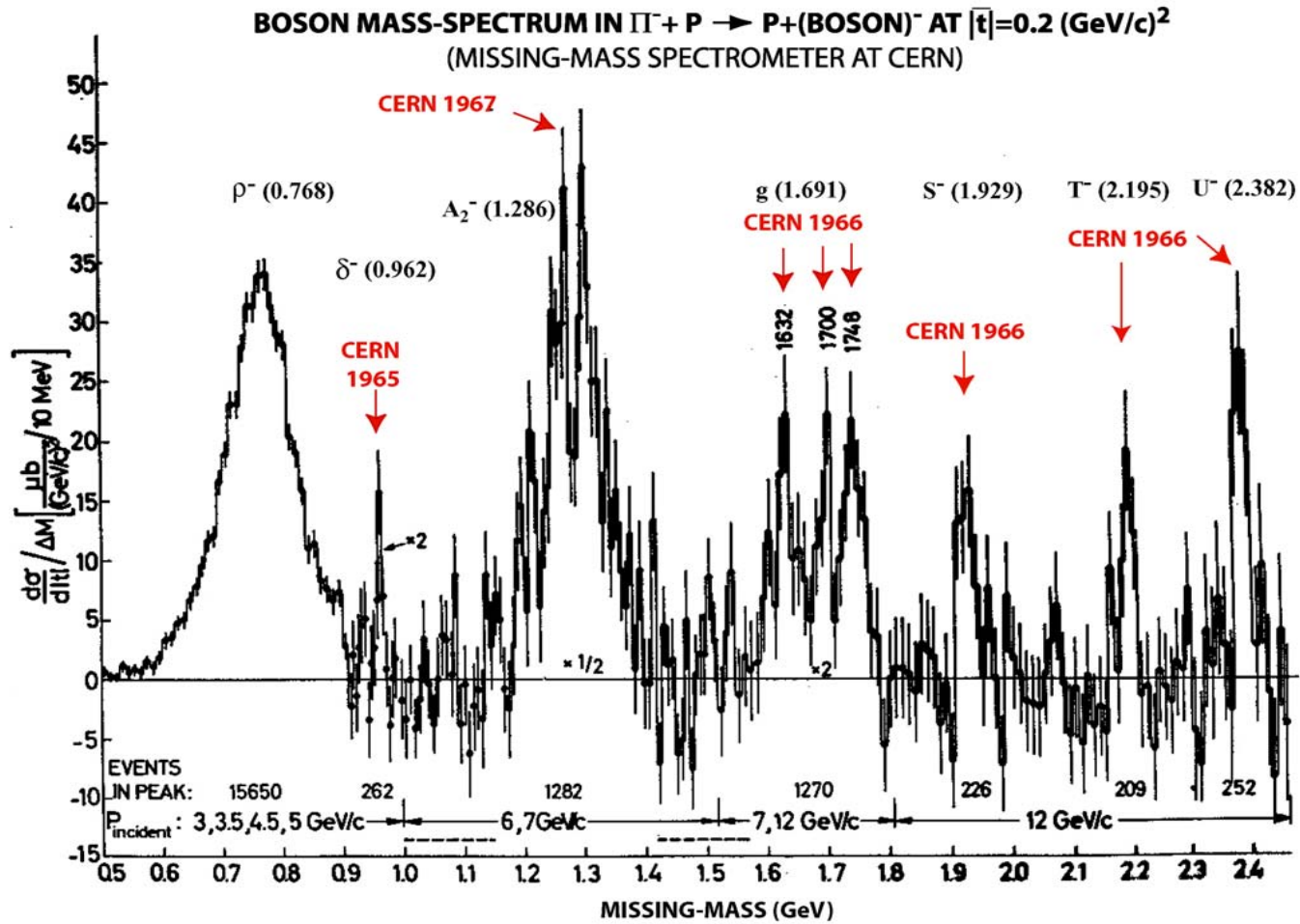
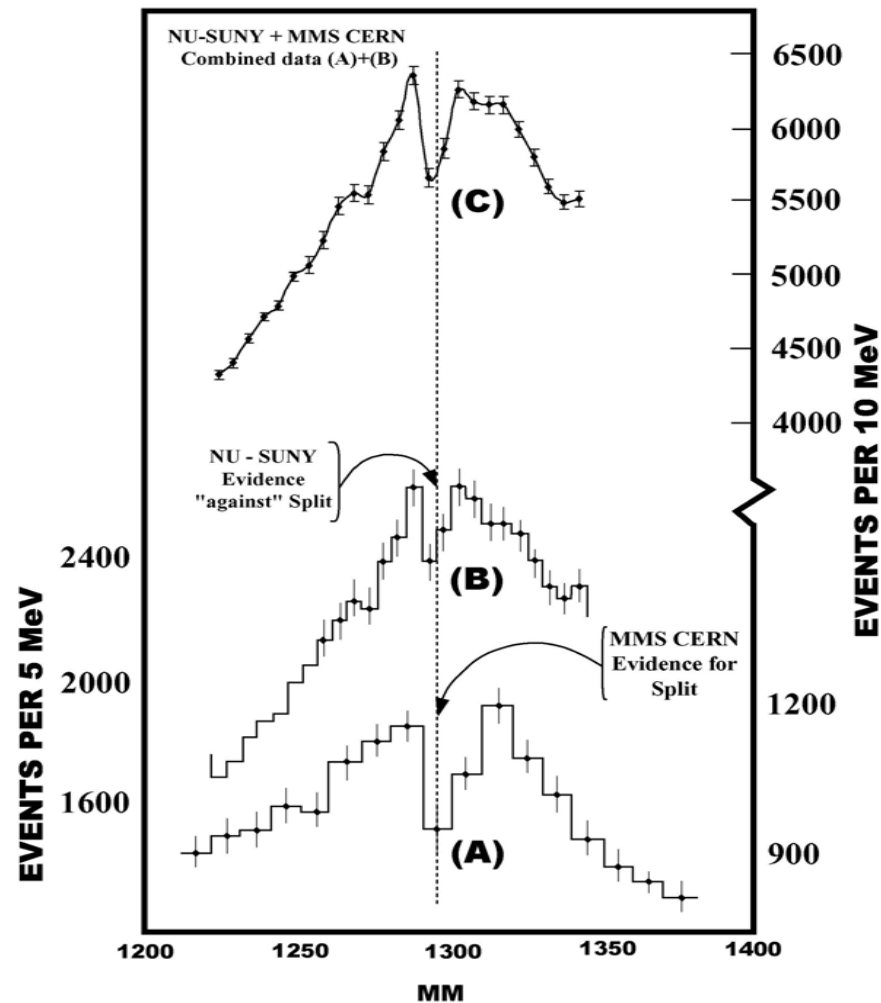


Fig. 5 (A) split A2 peak as measured by CERN Missing-Mass Spectrometer7 (MMS) at $|t| \geq 0.2$ (GeV/c). (B) Same measured at BNL13, the resolution of which was 30% poorer than that at CERN. (C) Combined data (A) + (B) reject one-peak hypothesis.

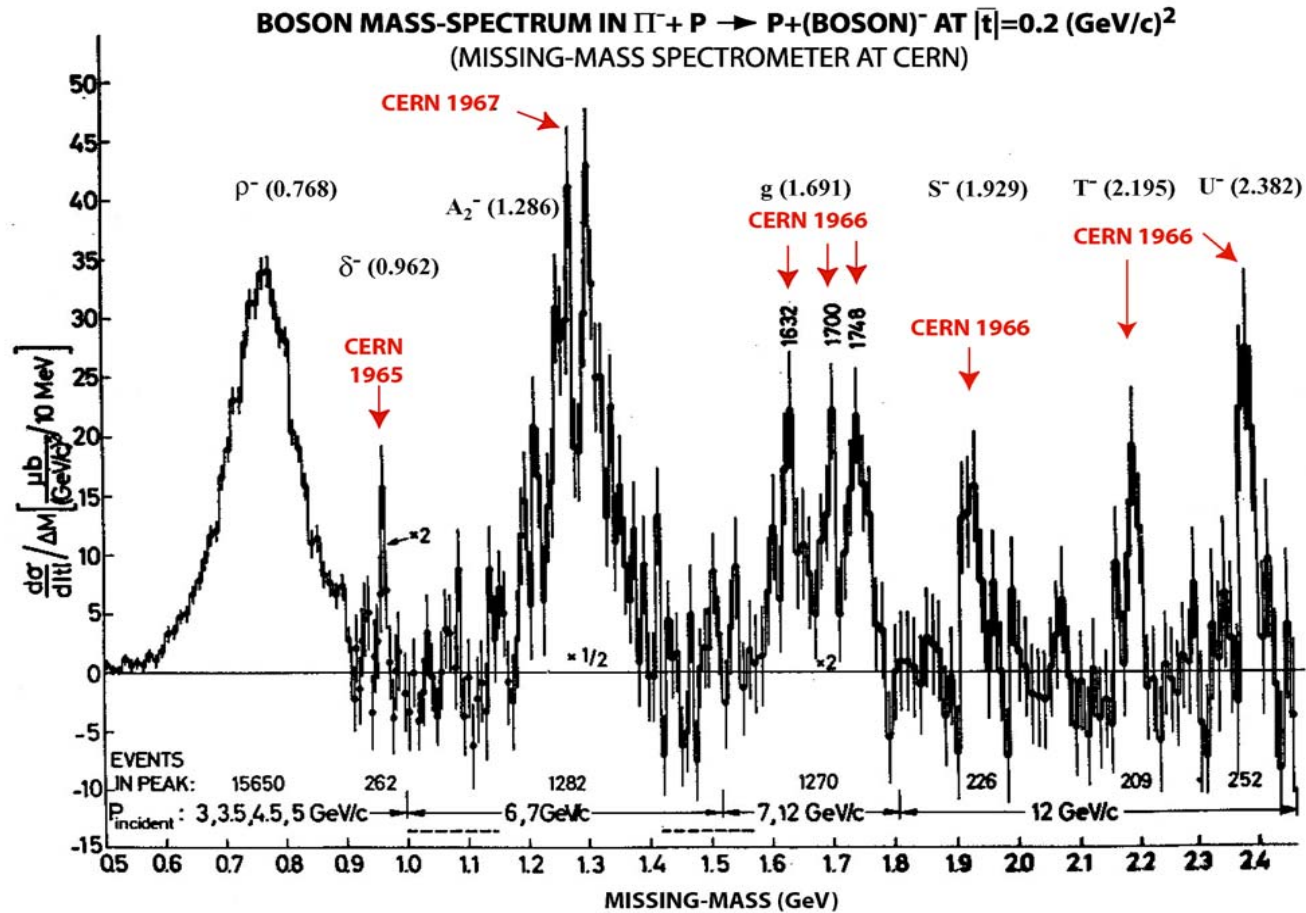


When the split in A2 began to show up in the Brookhaven Missing-Mass Spectrometer however, the experiment¹³ was summarily stopped.

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- > Evidence for two A2 mesons, renamed a1 and a2, reported in 97 measurements at low t ; a very broad a1 has spin 1 (28 papers), a2 has spin 2 (69 papers)
 - > The two A2 mesons, a1 and a2 with $J=1$ and $J=2$, fits the Constituent Quark Model nicely.

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- > Unpredicted f.s. kept appearing at high $|t|$.
 - > G meson (g for Geneva), discovered with the MM Spectrometer at CERN as a broad peak was split into three peaks when the statistics and resolution improved.
 - > To this date, 46 reported measurements at low $|t|$ identified at least 8 overlapping $l=1$ resonances in g-meson region (1600-1750MeV). In the 2000-2450 MeV mass region, where we observed T and U at least 5 mesons confirmed in independent low $|t|$ experiments, their spins ranging from 1 to 6.

Fig. 3 Combined charged meson spectrum from 9 Missing-Mass Spectrometry experiments at CERN, all at high $|t| \geq 0.2$.



The issue left unresolved is that of the widths.

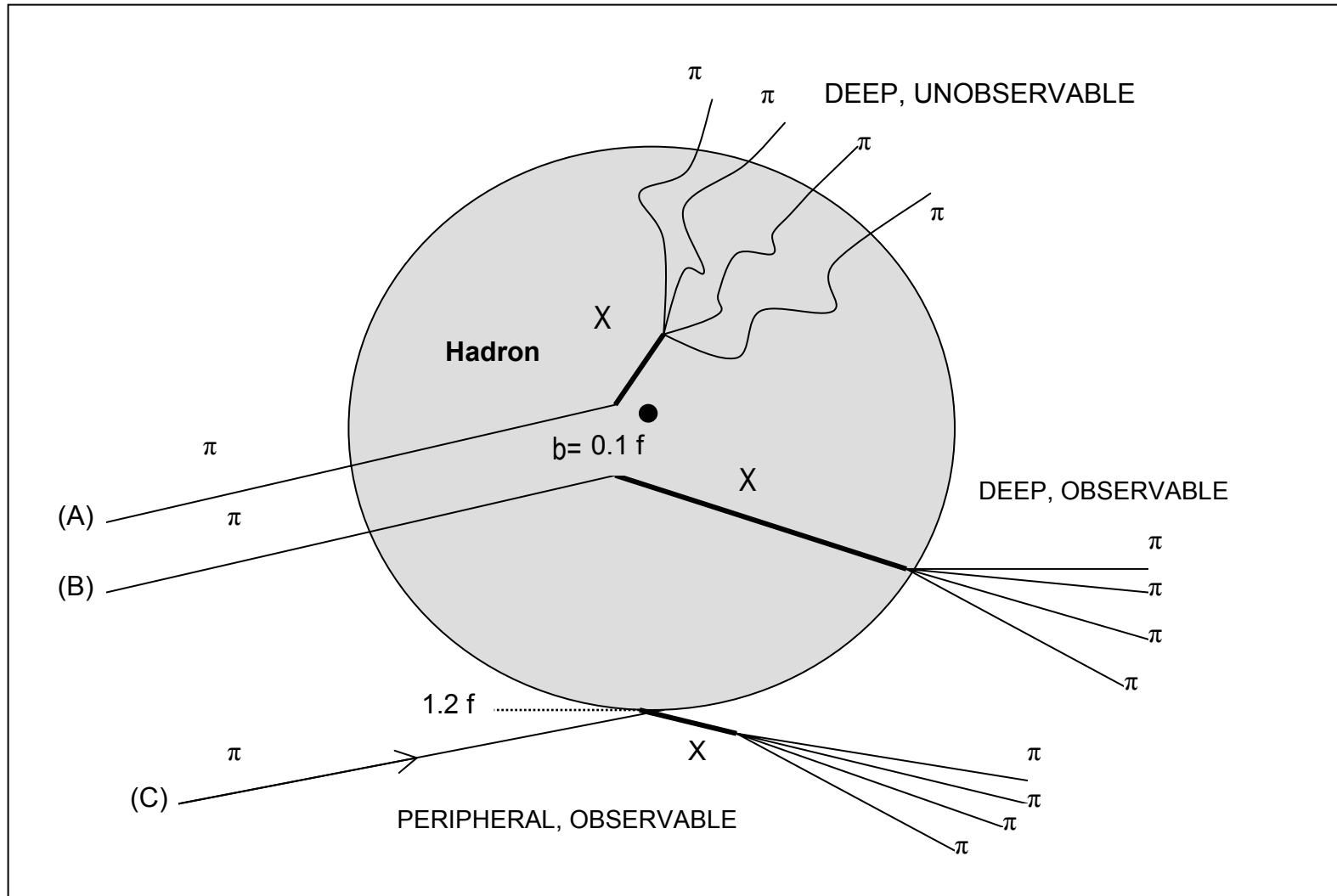
- > Our experience in measuring and living with meson spectra leads us to the following empirical observation: the apparent (observable) widths of meson resonances depend on $|t|$. The true physical widths are observed at $|t| \rightarrow 0$ (peripheral).
- Physical widths, Γ_0 , of all meson resonances are broad and are observed as such only at lowest $|t| < 0.01$. They are subject to narrowing as the $|t|$ increases and become very narrow at the $|t|_{\max} > 0.2$ GeV/c.
 - Since the observable widths are inversely proportional to $|t|$ and since the production cross sections is also inversely proportional to $|t|$, all the observed samples are produced at lowest $|t| < 0.01$ and thus are broad as expected from strong c.c.
 - There has been no systematic study of Γ vs. $|t|$. There were only two experiments at highest $|t| > 0.2$ GeV/c (kinematic maximum, corresponds to 180° recoil).
 - Rumors $\Gamma_\phi = 4\text{MeV} \rightarrow 2\text{ MeV}$ at high $|t|$ (RHIC)
Throughout the entire history of meson resonances.

3 cases of production of resonance X in $nN \rightarrow N + X$:

(A) Both produced and decays deep inside hadron matter, $(t) \geq 0.2$.

(B) Produced deep but decays at the periphery and

(C) Both produced and decayed at periphery $(t) \leq 0.005$



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- > Assuming that the peripherally produced meson moves in free space outside the hadron volume with velocity βc , where β of the meson is determined by the kinematics, we can write down: the transit time through hadron matter:

$$t = \frac{b}{\beta c}$$

- > where b is the collision impact parameter and $\hbar = 6.6 \times 10^{-22} \text{ MeV s}$. For peripheral collisions, $b \geq 1.2 \text{ f}$, and $\beta \approx 1$, we expect $\Gamma = \Delta E = \beta \hbar / b > 164 \text{ MeV}$, which is in agreement with most observations (except for those that are narrower via the centrifugal barrier, e.g. ω).
- > Velocity of meson resonance in hadronic medium is lower than at periphery:

$$\beta c \rightarrow \frac{\beta c}{H}$$

- > The time of propagation through the hadron, t is longer.
- > Hence, the TIME UNCERTAINTY, Δt , must be greater.

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- > Since Δt is greater, $\Delta E = \Gamma$ must be narrower:

$$\Delta E \Delta t = \Gamma (bH) / (\beta c) > \hbar, \text{ with } b = r_0$$

$$\Gamma > \frac{\beta \hbar c}{H} = \frac{165 \text{ MeV}}{H}$$

- > For peripheral decay in vacuum $r_0 = 1.2 \text{ f}$ and $H = 1$, and we get $\Gamma > 165 \text{ MeV}$, as observed and expected. For $H = 10-50$, we get $16 > \Gamma > 3 \text{ MeV}$. Hence, Eq. (3) opens the way for determination of the overall hadronic matter constant, H , by measuring Γ vs. $|t|$.
- > From the reportedly observed widths at max $|t|$, $\Gamma = 2-10 \text{ MeV}$, we obtain an order of magnitude limits to the ad hoc overall hadronic matter constant to be:

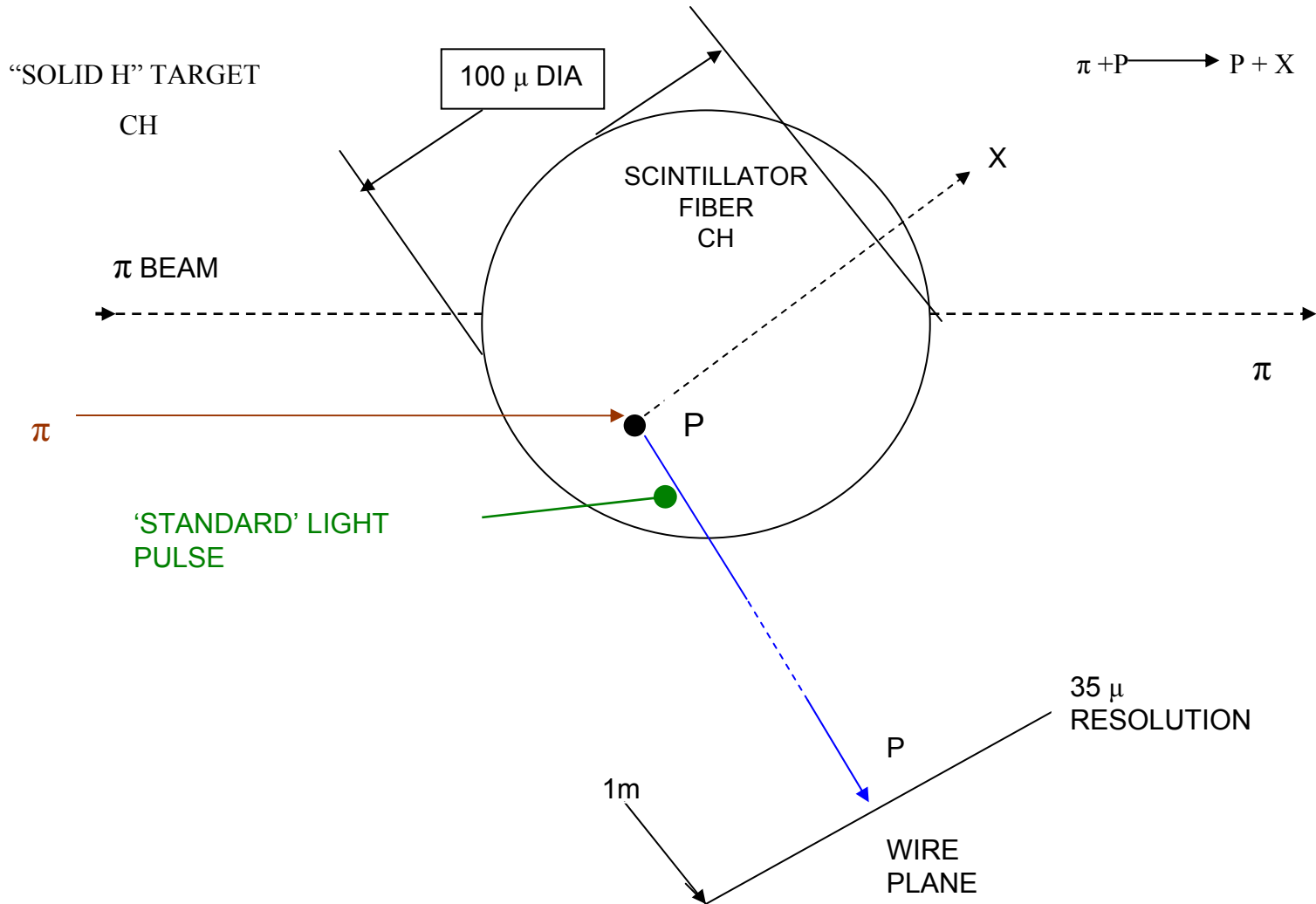
$$10 < H < 100.$$

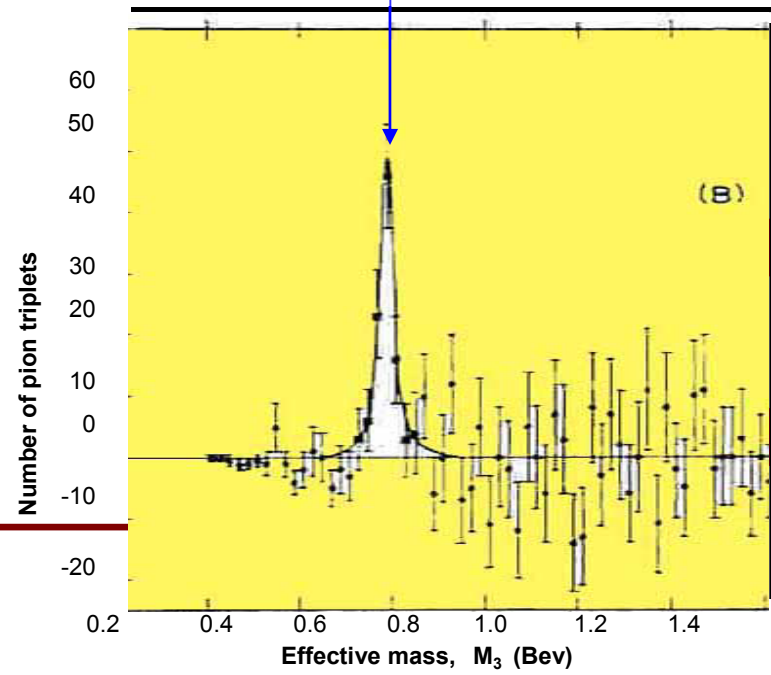
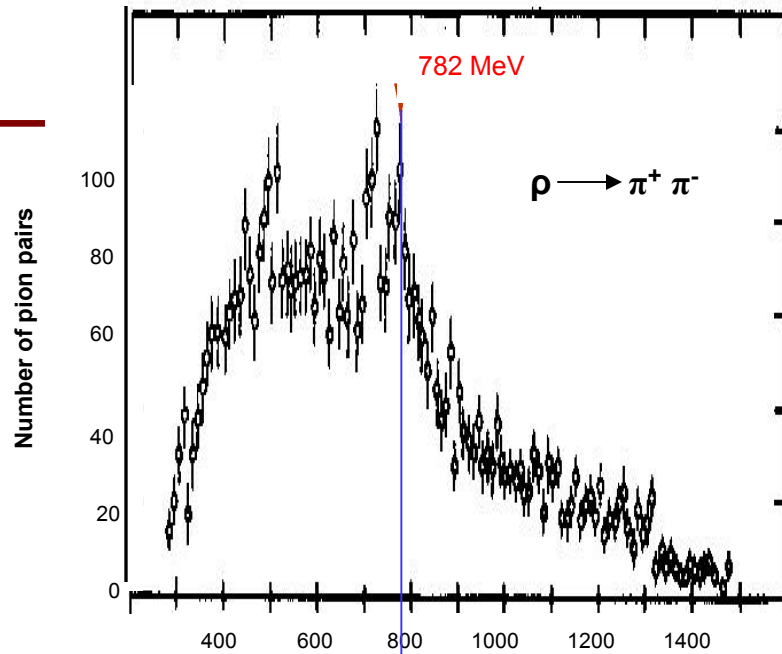
- > We need Γ vs. $|t|$ experiments and a quantitative theoretical connection between the hadron matter constant, H , and the 3 physics parameters of the hadron matter as a function of $|t|$, the hadron constant and the dielectric and diamagnetic constants.

Point Of This Talk:

- > Ultra-high resolution $\Gamma_{\text{res}} \sim 0.1$ MeV needed
- > In every spectroscopy in history:
 - Better Resolution \longrightarrow New Fine Structures
- > Why not so in Hadron Spectroscopy?
 - Strong C.C. \longrightarrow $\Gamma > 100$ MeV only
- > Counter Argument No. 1:
 - $\Gamma = 1$ MeV η
8 MeV ω
4 MeV ϕ
- > Counter Argument No. 2:
 - 99% of Expts: Low $|t| \sim 0.01$ Broad Γ
 - 1% of Expts: High $|t| \sim 0.25$ Narrow Γ
- > **Proposed:**
Principle for novel Ultra-high Resolution Hadron Spectrometer
- Propose to:**
Organize feasibility study team

INTERACTIVE SOLID STATE HYDROGEN TARGET





Hi*Energy*
technologies, inc.