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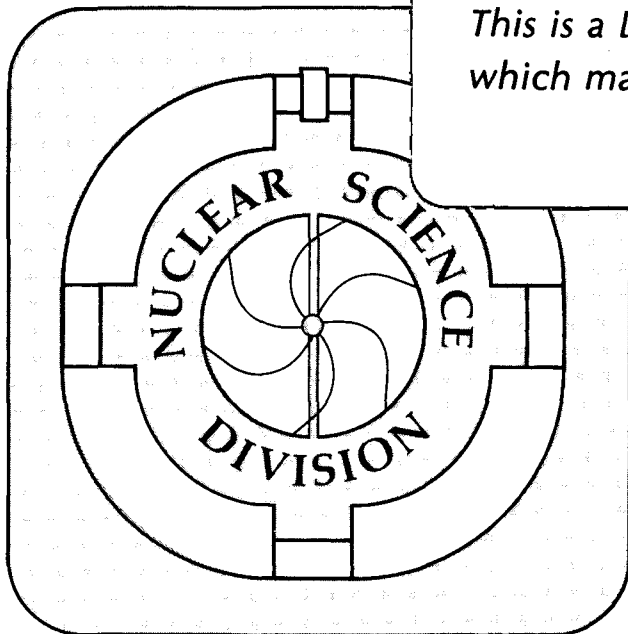
First Results on Dilepton Production at the Bevalac

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Ion Study, Lawrence Berkeley Laboratory, Berkeley, California,
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ABSTRACT

We report on preliminary results of direct electron pair measurements in p+Be at 4.9 GeV and 2.1 GeV and Ca+Ca at 1.95 GeV/A collisions at the Bevalac. The results are compared to existing data in p+Be at 12.1 GeV and π^-p at 15.9 and 16.9 GeV.

PHYSICS OBJECTIVES

The dilepton spectrometer (DLS) program deals with the study of electron pair production in p-nucleus and nucleus-nucleus collisions at the Bevalac. Dileptons have been extensively studied in hadron-hadron and hadron-nucleus collisions at high incident energies. A typical mass spectrum exhibits the vector meson resonance peaks on top of a continuum which, for the high mass domain, is well understood in term of the Drell-Yan mechanism. Below 2-3 GeV, the continuum is much larger than that calculated from the Drell-Yan formula or from the decays of known resonances. Lepton production has also been investigated in single-particle inclusive experiments. The direct lepton production rate (after subtraction of the contributions from the decays of known particles or resonances) is expressed in term of the lepton-to-pion ratio at a given Pt. The e/π ratio (electron/pion) has been measured at the level of 10^{-4} , with a rise at low Pt, for various hadronic projectile-target combinations and for energies from about 10 GeV up to the ISR domain. A low energy experiment on pp at 800 MeV (ref. 1) has observed no direct single electron signal within the sensitivity of the apparatus of $e/\pi \approx 10^{-6}$. Both low mass dileptons and low Pt single direct leptons are assumed to be of the same origin. The calculations which have been most successful in understanding the production rates and the features of the distributions are done in the framework of the soft parton models in which one considers that wee quarks and antiquarks centrally produced during the collision annihilate (with or without radiative corrections) and generate the dileptons (see for instance ref. 2).

The first objective of the DLS program follows the above considerations. It aims to establish the existence of direct electron pairs at Bevalac energies and to help in clarifying the mechanism(s) of their production. The second objective of the program is to use the dilepton

signal as a probe to gather information on the first stage of nucleus-nucleus collisions which has been well discussed in the talk by the previous speaker.

THE DILEPTON SPECTROMETER

The DLS experimental setup is installed on the Beam 30 line at the Bevalac. It consists of a segmented target (5 segments) and two symmetric arms (Fig. 1), each arm including a large aperture dipole magnet, two scintillator hodoscopes for accurate time of flight measurement and triggering purposes, two segmented gas Cerenkov counters working at one atmosphere for electron identification and three drift chamber stacks for tracking (the stack D3 on each arm has at present not been implemented). The segmentation of the detector was designed for intermediate mass systems (Ca+Ca). It will be tested in an upcoming experiment on Fe+Fe and Nb+Nb collisions. Movable arrays of lead glass blocks located behind each arms are used for the Cerenkov counter calibration (electron efficiency and pion rejection power). The conical scattering chamber provides a minimum amount of material along the particle trajectories into the spectrometer and will facilitate the installation of a multiplicity detector (which will be done in 1988). The central ray of each arm is set at 40 deg to the beam direction, which roughly corresponds to electrons emitted at 90 deg in the nucleon-nucleon center-of-mass frame (for incident energies from 1.5 to 5 GeV/A).

The DLS simulation program makes use of the CERN GEANT3 library. It presently includes most of the characteristics of the detectors and in particular the tracking of the Cerenkov photons. It is used for the acceptance calculations which are run both on the LBL VAX's and on the Cray X-MP at the MFE Computer Center. Fig. 2 shows the DLS acceptance for electron pairs as a function of mass and P_t , integrated over rapidity Y . Our present evaluation of the acceptance (and therefore the

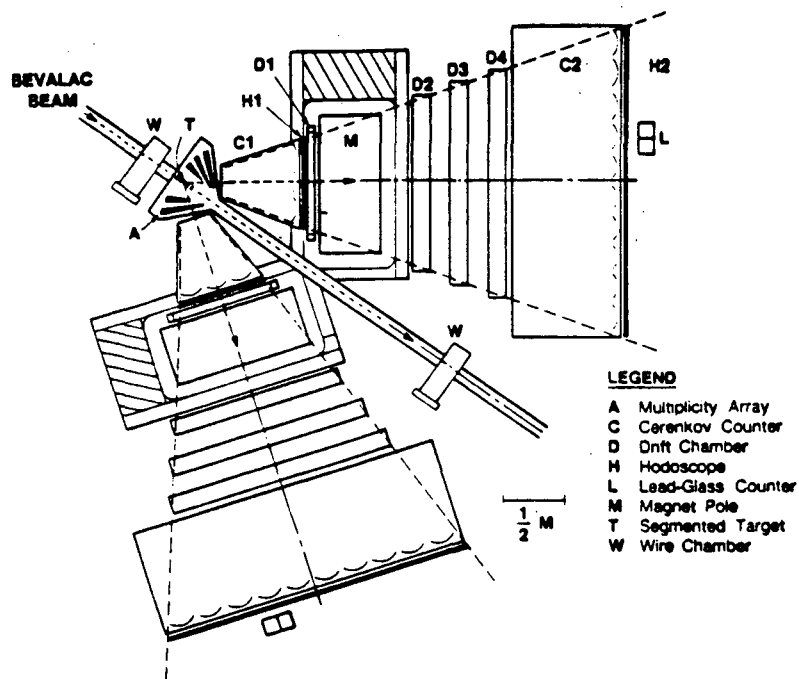


Fig. 1

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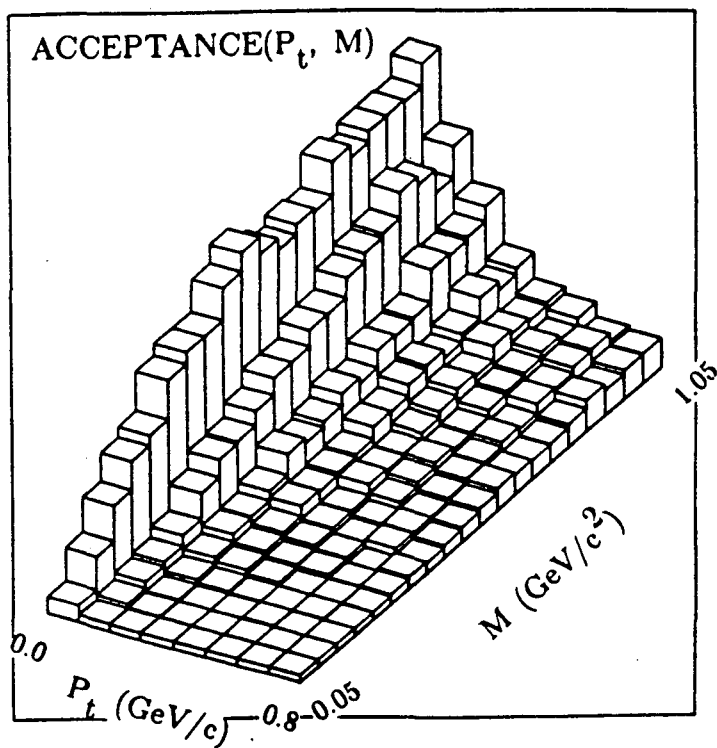


Fig. 2

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cross section) suffers from low Monte Carlo statistics in the region where the acceptance is low (at low mass and high Pt).

PRELIMINARY PHYSICS RESULTS

The installation of the DLS was completed and tests were done in November 1986. Data were taken on the reaction p+Be at 4.9 GeV in December 1986, and p+Be at 2.1 GeV and Ca+Ca at 1.95 GeV/A in May 1987. The table below shows the pair statistics for the different runs. Because of a problem with the beam, we had to subtract an empty target contribution in the p+Be run at 2.1 GeV.

OS = number of opposite sign pairs
 LS = number of like sign pairs
 F = number of false pairs in the OS sample ($F = LS$)
 T = number of true pairs ($T = OS - LS$)
 σ_T = sigma of T

Reaction	OS	LS	T +/- σ_T	T/F	T/ σ_T
p + Be at 4.9 GeV	732	201	531+/-31	2.6	17.4
p + Be at 2.1 GeV	567	148	419+/-27	2.8	15.7
MT	144	112	32+/-16	0.3	2.0
Ca + Ca at 1.95 GeV/A	94	45	49+/-12	1.1	4.2

The acquisition times and average beam intensities were:

Reaction	Time (hrs)	Intensity (p/spill)
p + Be at 4.9 GeV	33	2 X 10**8
p + Be at 2.1 GeV	20	3 X 10**8
Ca + Ca at 1.95 GeV/A	27	2-5 X 10**7

Fig. 3 shows the cross section $d\sigma/dM$ (per nucleon, assuming an $A^{2/3}$ dependence) for the p+Be reaction at 4.9 GeV. The main features of the mass distribution are a rapidly decreasing continuum above 300 MeV, a slight enhancement in the ρ region and a shoulder at low mass. The slope of the continuum agrees with the KEK data on p+Be at 12.1 GeV (3). The shoulder below 300 MeV is still under investigation and might be

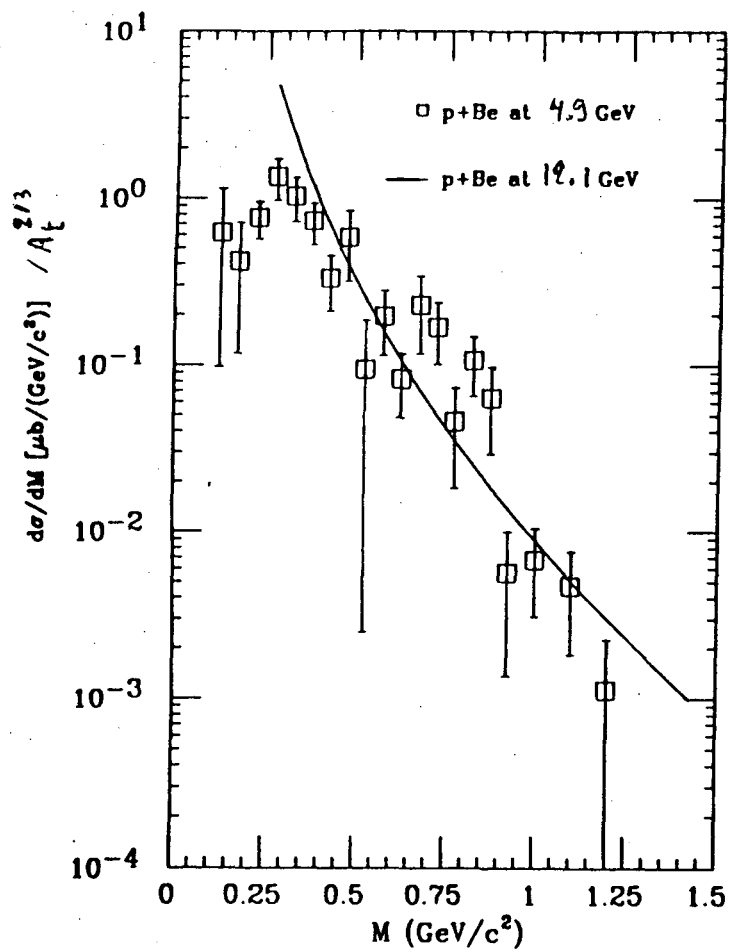


Fig. 3

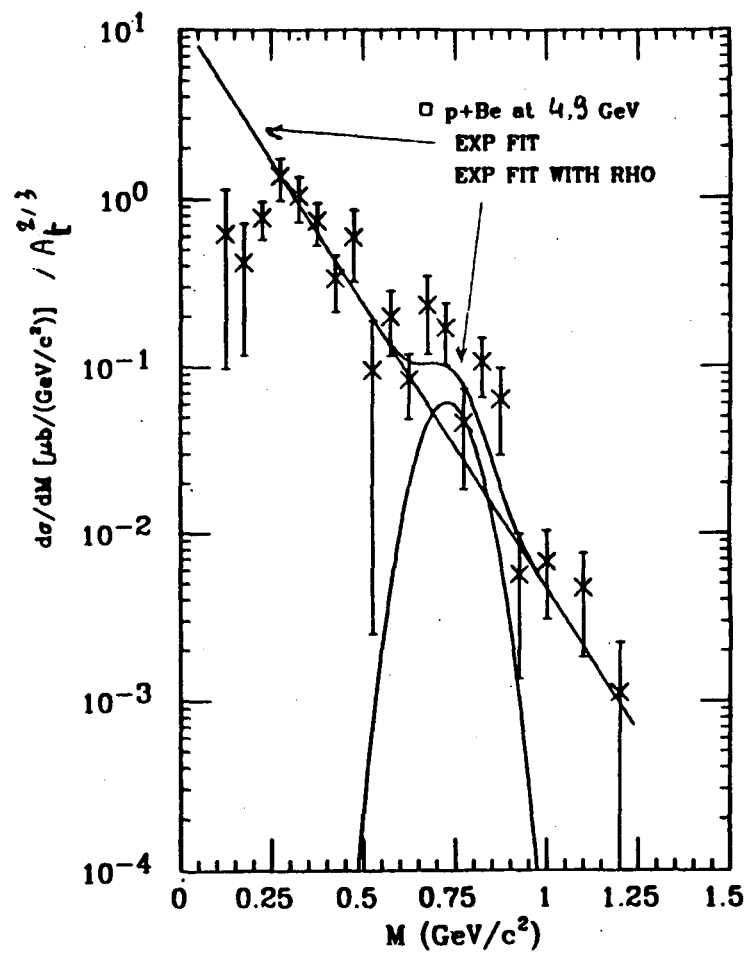


Fig. 4

due to an acceptance problem. Because of our decision to increase the DLS sensitivity and emphasize the detection of low mass pairs, the field in the dipoles was set quite low (1.5 kG) and thus the momentum resolution of the DLS was not optimized to see the ρ . We are planning a specific measurement with a higher field setting in the dipoles (3 or 5 kG). However, from the enhancement in the ρ region, we have estimated the cross section for the process $p+\text{Be} \rightarrow \rho \rightarrow e^+e^-$ (see Fig. 4). This estimate compares well with existing data as shown below.

Existing data at 5.52 GeV/c (4):

$$\begin{aligned}\sigma(pp \rightarrow \omega) &= .126 \pm .023 \text{ mb} \\ \sigma(pp \rightarrow \rho) &= .07 \pm .05 \text{ mb} \\ \implies \sigma(pp \rightarrow \left\{ \begin{smallmatrix} \omega \\ \rho \end{smallmatrix} \right\} \rightarrow e^+e^-) &= 11.6 \pm 3. \text{ nb}\end{aligned}$$

DLS at 4.9 GeV (5.8 GeV/c):

$$\sigma(pN \rightarrow \left\{ \begin{smallmatrix} \omega \\ \rho \end{smallmatrix} \right\} \rightarrow e^+e^-) = 10.4 \pm 5. \text{ nb}$$

Fig. 5 compares the cross section per nucleon $d\sigma/dPt^2$ from our measurement at 4.9 GeV (5.8 GeV/c) to the data points of Blockus et al. (ref. 5: π^-p at 15.9 GeV) and to a fit given by Adams et al. (ref. 6: π^-p at 16.9 GeV, fit given in arbitrary units). Both sets of data points have similar general features.

Fig. 6 shows the cross section per nucleon $d\sigma/dM$ for the $p+\text{Be}$ reaction at 2.1 GeV. There may be a shoulder at low mass. The ρ contribution is no longer visible (note that the threshold in a free nucleon-nucleon collision is at 1.86 GeV incident kinetic energy). The shape of the continuum above 300 MeV is in qualitative agreement with the KEK data. Fig. 7 shows $d\sigma/dPt^2$ as a function of Pt^2 for the reaction $\text{Ca}+\text{Ca}$ at 1.95 GeV/A. Adams' fit is also given on the figure for comparison.

Finally, the total cross sections have been obtained by integration of our differential cross section $d\sigma/dM$ above 100 MeV. The given values

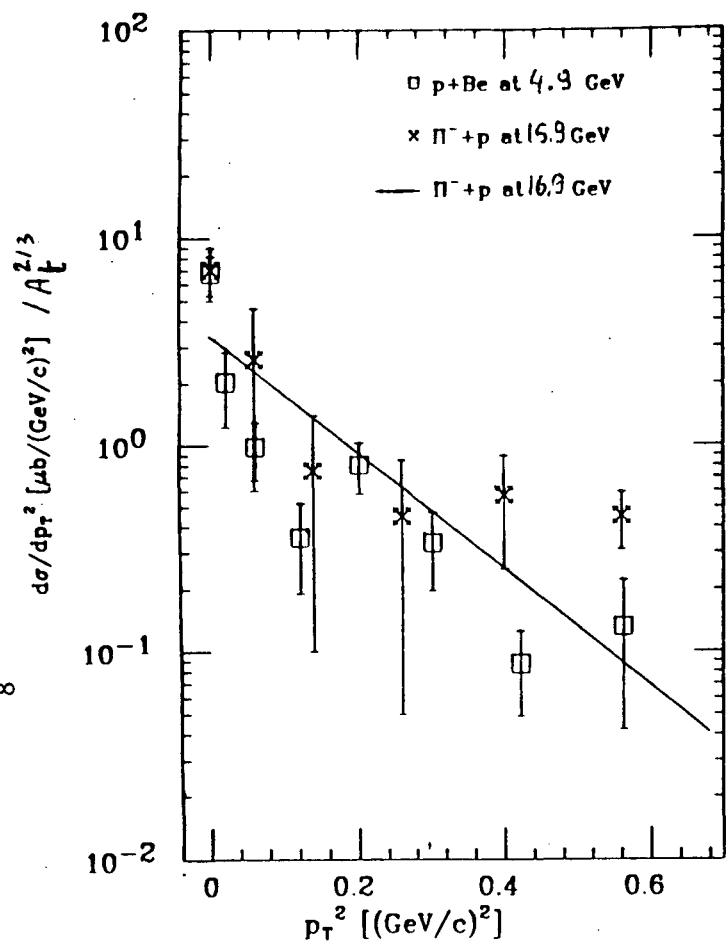


Fig. 5

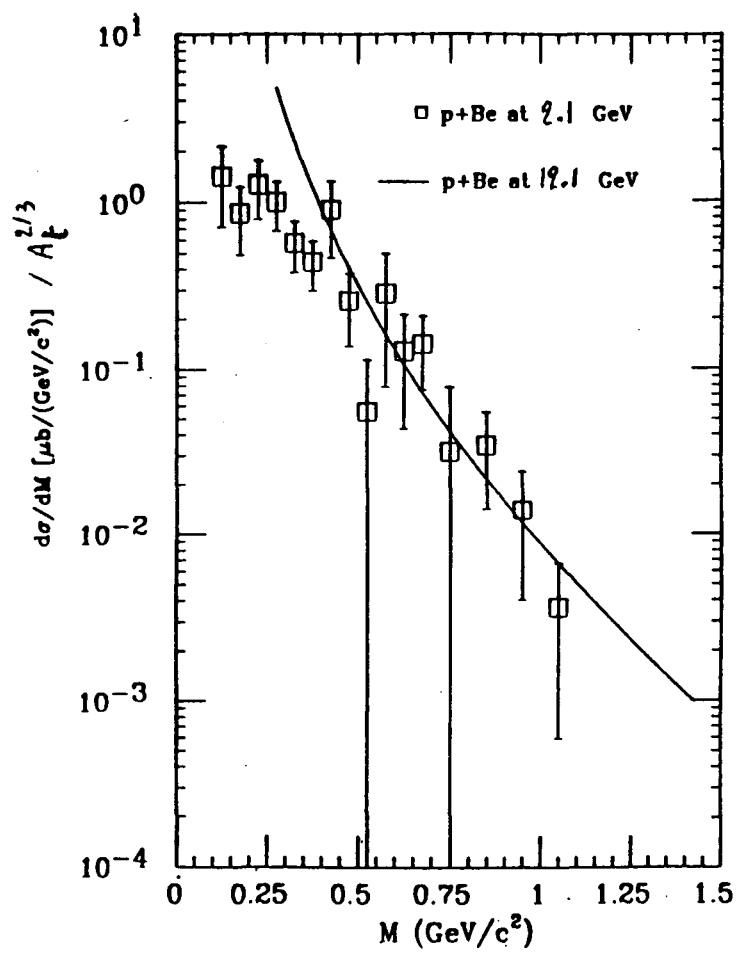


Fig. 6

below are actually the cross sections divided by $A_p \times A_t^{2/3}$, where A_p is the projectile mass and A_t the target mass. For comparison, we report the KEK cross section given in the paper and an estimate calculated from their fit.

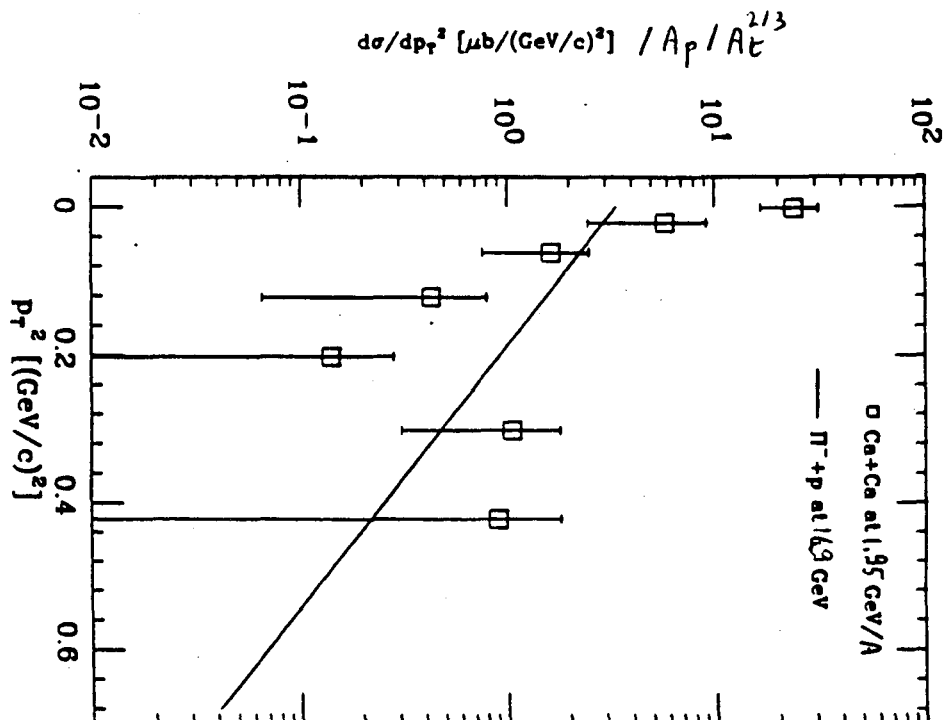
Reaction	Total cross section (μb)
p + Be at 4.9 GeV	0.343 \pm 0.045
p + Be at 2.1 GeV	0.372 \pm 0.105
Ca + Ca at 1.95 GeV/A	0.771 \pm 0.196

KEK data: p + Be at 12.1 GeV

paper \rightarrow .38 \pm .14 μb for $0.3 < \text{mass} < 0.7 \text{ GeV}$

integration of their fit above 0.2 GeV \rightarrow 0.50 μb

Fig. 7



CONCLUSION

We have established the existence of a direct electron pair signal down to about 2 GeV incident kinetic energy per nucleon, for both incident protons and Calcium nuclei. The cross sections are similar to what has been measured at higher energies. More work has to be done on the DLS acceptance and efficiency calculations before the figures are finalized and we can perform detailed comparisons and interpretation. The Ca+Ca data supports the feasibility of measurement of intermediate mass systems in 100 to 150 hrs of Bevalac beam time.

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