NEPPSR Analysis Project

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New England Particle Physics Student Retreat
Craigville, 13-18 August 2006

Analysis Project

- Goals of the Project

  - Learn basic use of ROOT data analysis tool
    → Standard tool in particle physics

  - Apply statistical analysis to extract physical information (particle lifetime, mass, etc…)

  - Discriminate between signal and background events with a multivariate analysis technique

Two Analysis Projects

1. B lifetime measurement with likelihood method
2. Discrimination between signal and background with a neural network

Project I: application of maximum likelihood to measure B lifetime, see

http://people.umass.edu/willocq/neppsr/blifetime/AnalysisProject_blifetime.html

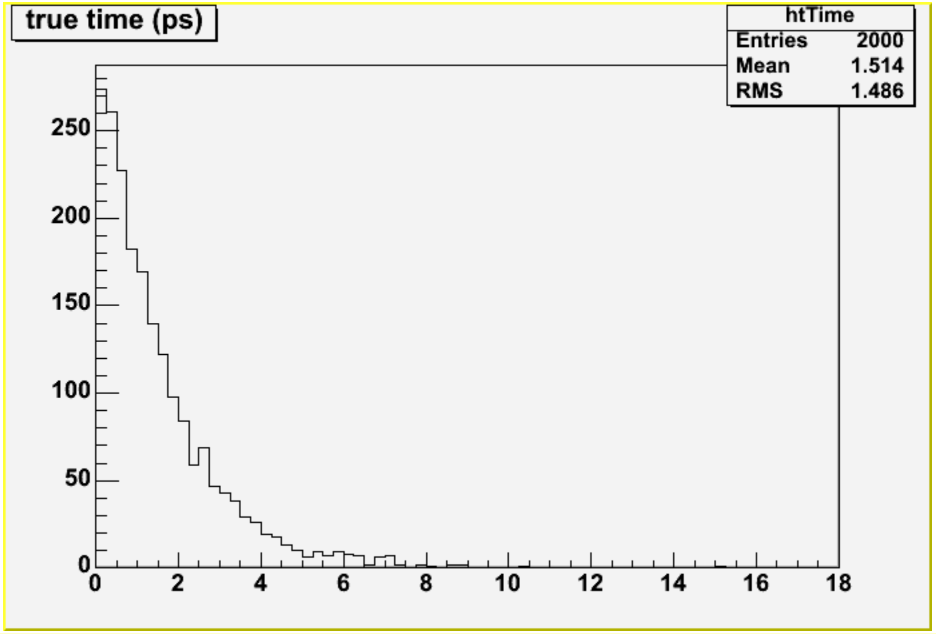
Project I: B Lifetime Analysis

- Sample

  - Simulation of the *exponential* proper time distribution of B mesons

    → Effect of limited resolution in the measured proper time simulated by smearing the true proper time with a constant Gaussian resolution

    → ROOT tuple contains: True time and measured time (in units of ps) for 2000 events



Lifetime used in the generation of the events was 1.532 ps

Project I: B Lifetime Analysis

- Project

- *Determine the B meson lifetime and its statistical uncertainty* using each of the following methods:

1) Least-squares fit to the true proper time histogram
   → Need to provide function to fit the distribution with

   $f(t) = N\,exp(-t / tau)$

   → Use ROOT built-in interface to do the chi-squared minimization

$$\chi^2 = \sum_{i=1}^{nbins} \left(\frac{\left(f(t_i) - N_i\right)^2}{\sigma_i^2} \right)$$

2) 'Unbinned' Maximum Likelihood with true proper time
   → Compute and display -log(likelihood) as a function of lifetime

3) 'Unbinned' Maximum Likelihood with reconstructed proper time
   → Need to determine time resolution
   → Compute and display -log(likelihood) as a function of lifetime

   (use ROOT's TMath::Erfc(x))

Code provided on web site

See Colin Gay's lecture

NEPPSR Analysis Project Results

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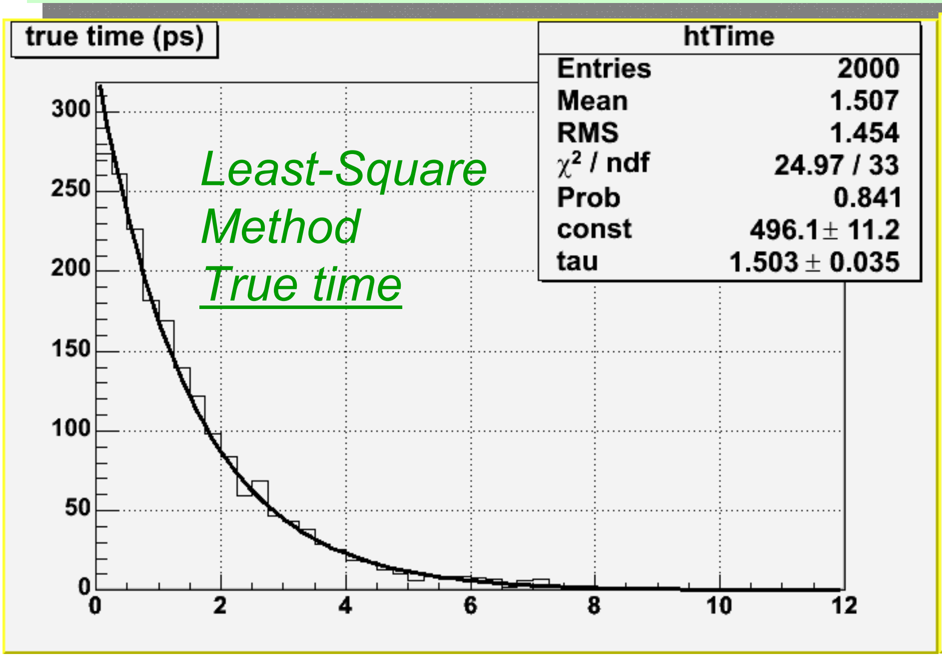
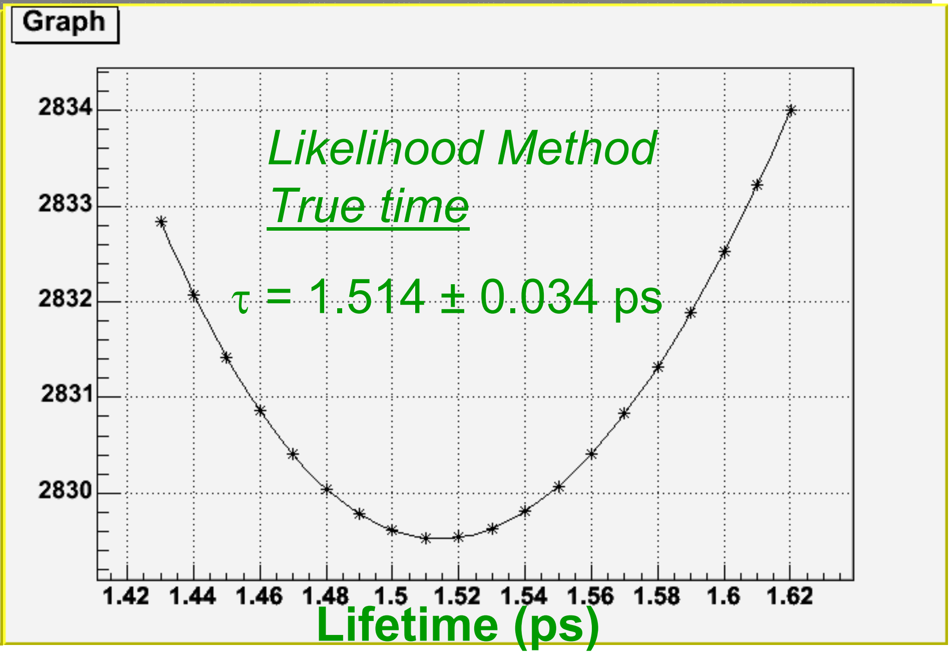
Project I: B Lifetime Measurement





Two possible approaches for the likelihood method (for this specific case):

1) Analytical method:

$$\Rightarrow \quad \tau^* = \frac{1}{N}\sum_{i=1}^{N} t_i \quad (= E(t) = \overline{t} = \text{mean})$$

$$\sigma = \frac{1}{\sqrt{\left.\frac{\partial^2(-\log L)}{\partial \tau^2}\right|_{\tau=\tau^*}}} = \frac{\tau^*}{\sqrt{N}}$$

2) Numerical method:

Plot –log(likelihood) vs. lifetime & find minimum + 1-sigma range

Project I: B Lifetime Measurement

- **Fit with measured proper time:**

$$-\log L(\tau) = -\sum_{i=1}^{N} \log P(t_i \mid \tau)$$

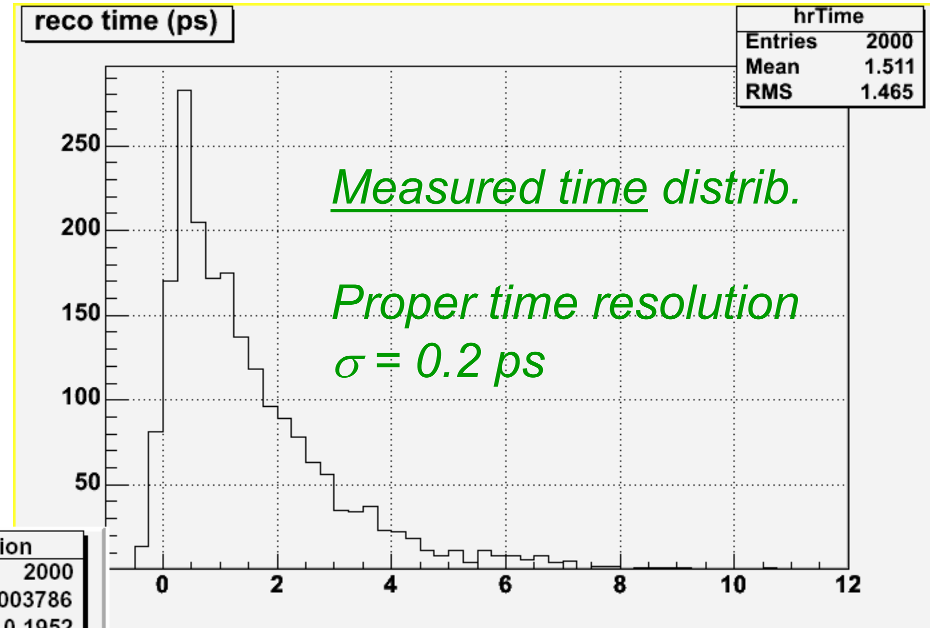
$$P(t_i \mid \tau) = \frac{1}{\tau} e^{-t_i/\tau} e^{-\frac{\sigma^2}{2\tau^2}} \frac{1}{2} erfc\left(-\frac{1}{\sqrt{2}}\left(\frac{t_i}{\sigma} - \frac{\sigma}{\tau}\right)\right)$$

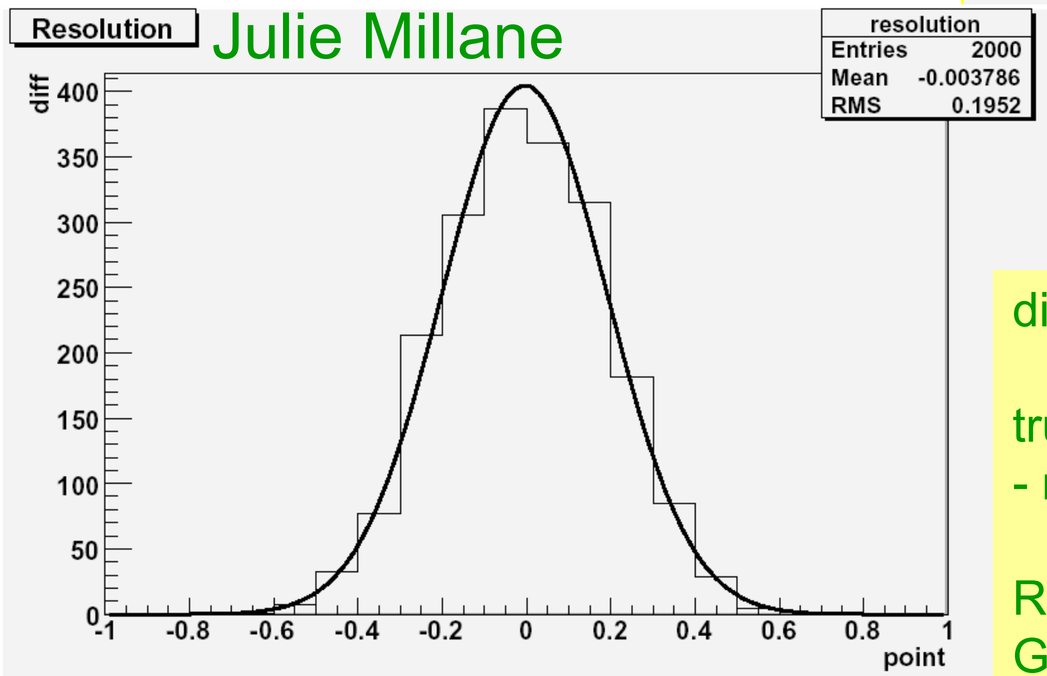
→ **STEP #1: determine resolution**

→ **STEP #2: compute –log(likelihood) for a range of lifetimes**

Project I: B Lifetime Measurement

- **STEP #1: determine resolution**





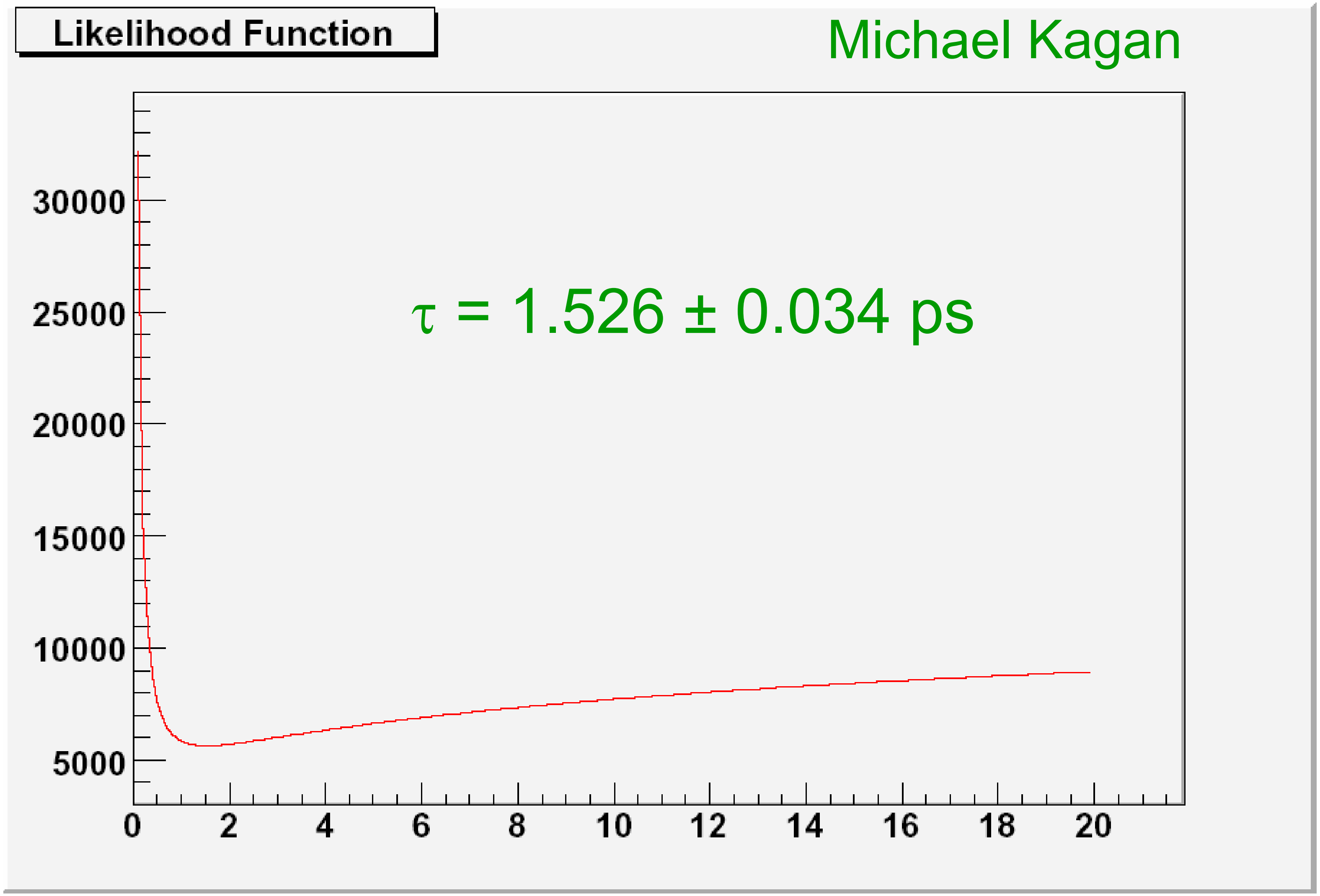
distribution of

true proper time
- measured proper time

Resolution is
Gaussian width = 0.2 ps

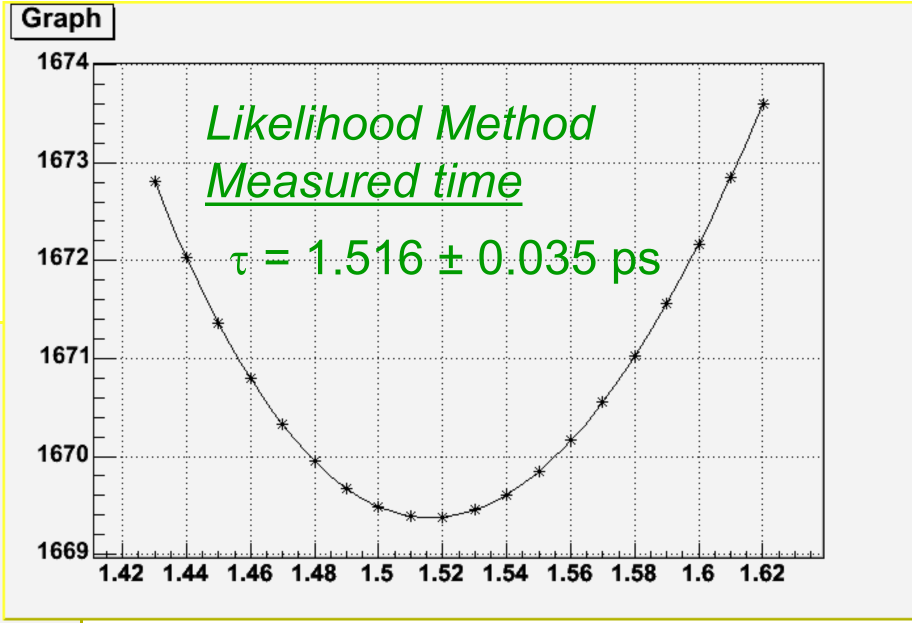
Project I: B Lifetime Measurement

- **Fit with measured proper time**

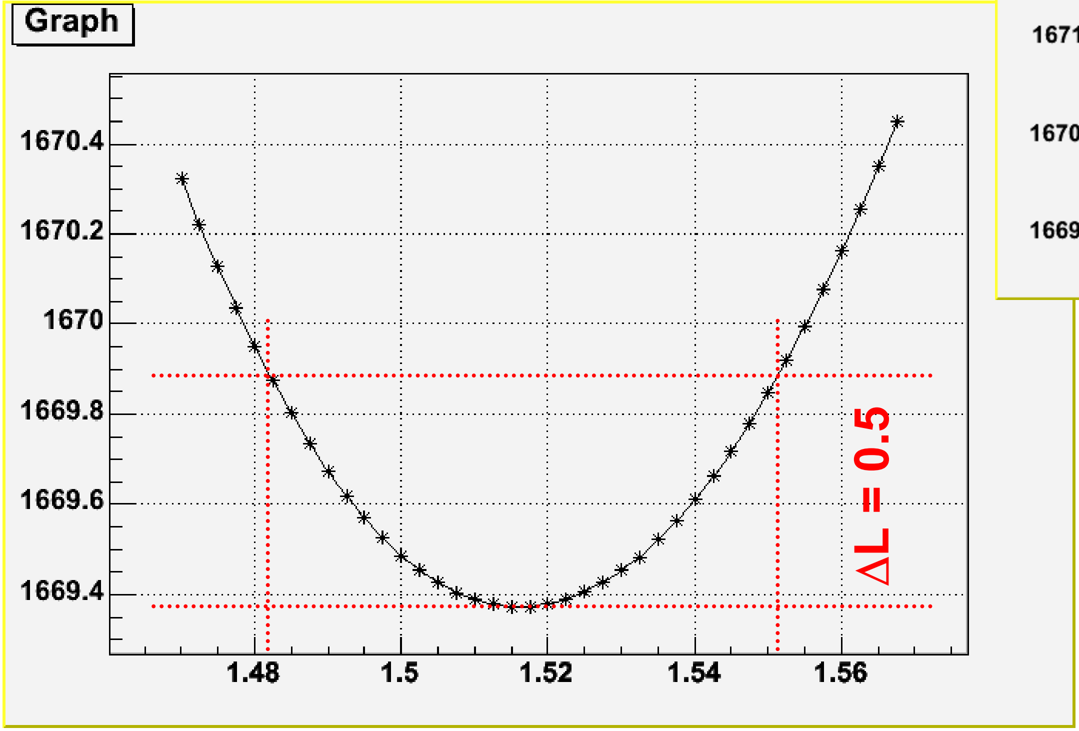


Project I: B Lifetime Measurement

- Fit with measured proper time

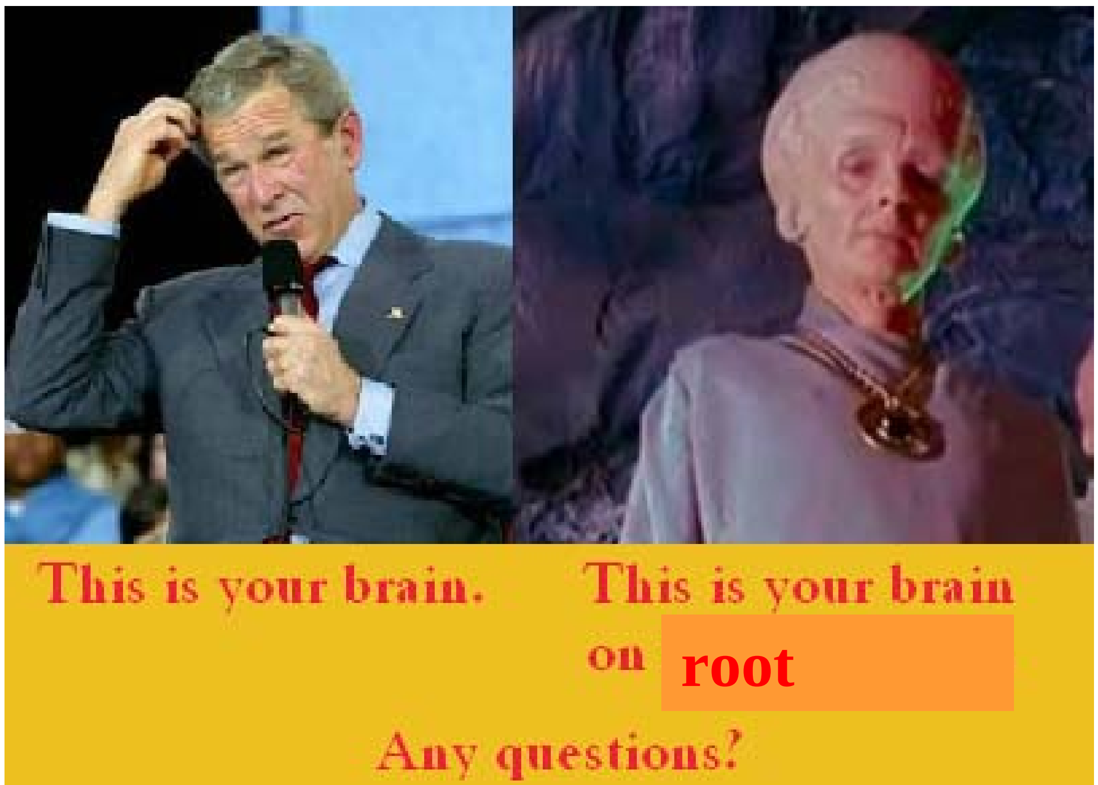


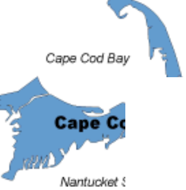
Lifetime (ps)



Lifetime (ps)

Neural Network
Analysis Project Finale

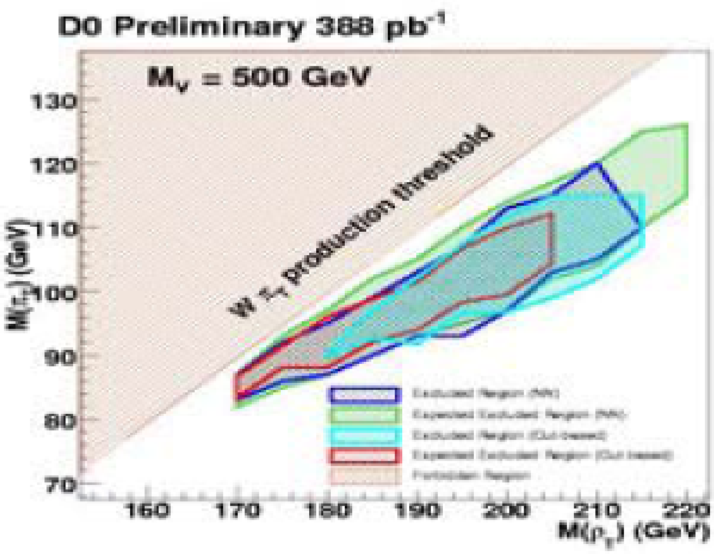




Thursday, August 17, 2006

Fermilab Result of the Week

Searching for a fifth force

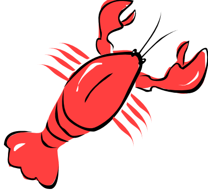


Plot of ρ techni-mass versus π techni-mass. The contours show the sensitivity of the search and the region excluded by DZero.

In the standard model, the masses of particles are believed to be acquired via the Higgs mechanism. This theoretical

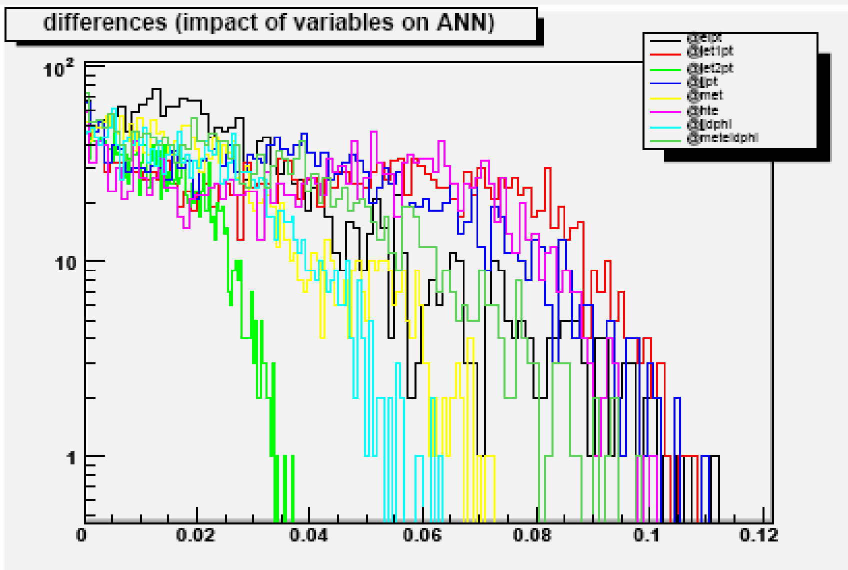
DooKee Cho (Boston University), Lorenzo Feligioni (Boston University graduate student, now at CPPM, Marseille), Meenakshi Narain (Boston University), and Suyong Choi (SungKyunKwan University, Korea) performed the experimental search. The experimental group consulted theorist Kenneth Lane (Boston University) during the analysis.

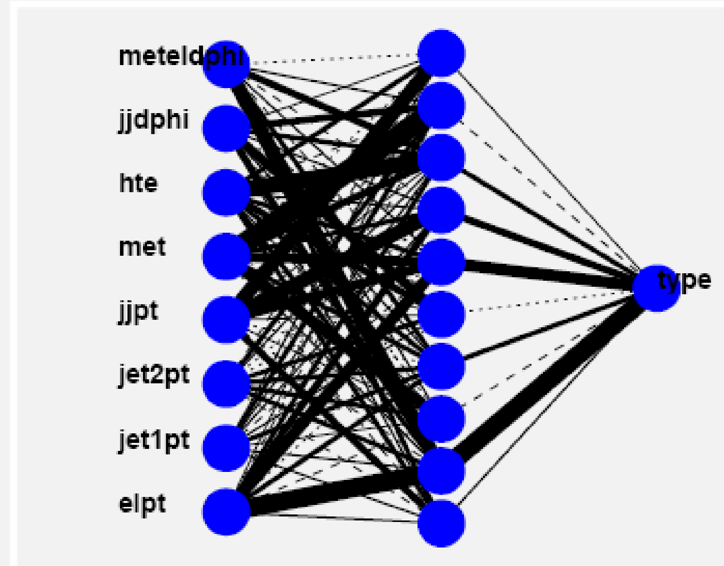
D’Oh!

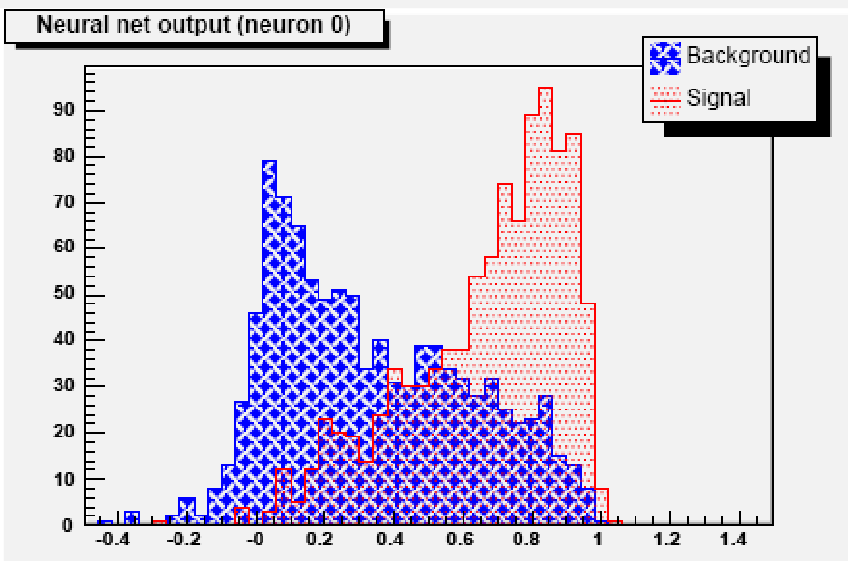


- There was a bug in mlp_data.C that cunningly evaded detection in my testing but was found immediately by many of you
  - Training was OK but evaluation could have problems
  - Good experience for using ATLAS and CMS software
- The fix was provided by root wizard Jen Raaf – thanks!
- If you’d like to try this again, the v 2.0 code is available from the same web site

@elpt,@jet1pt,@jet2pt,@jjpt,@met,@hte,@jjdphi,@meteldphi:10:type







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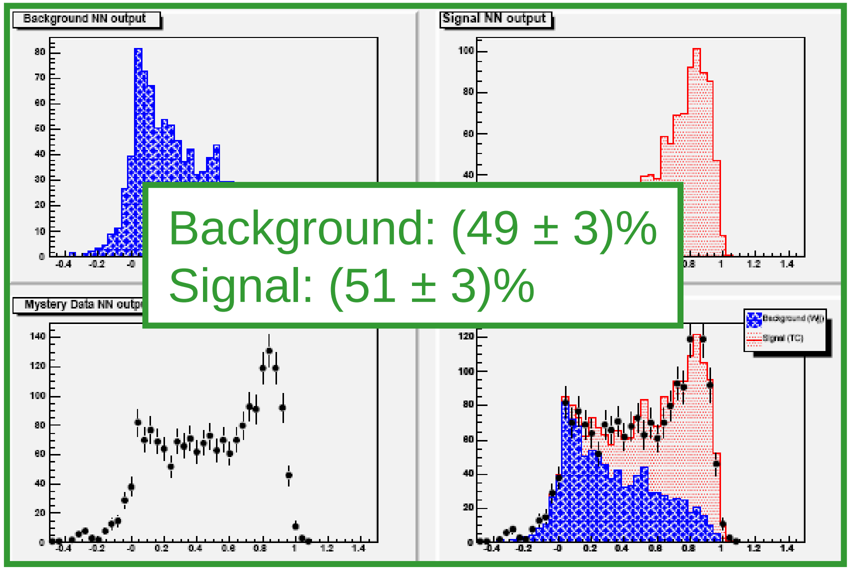
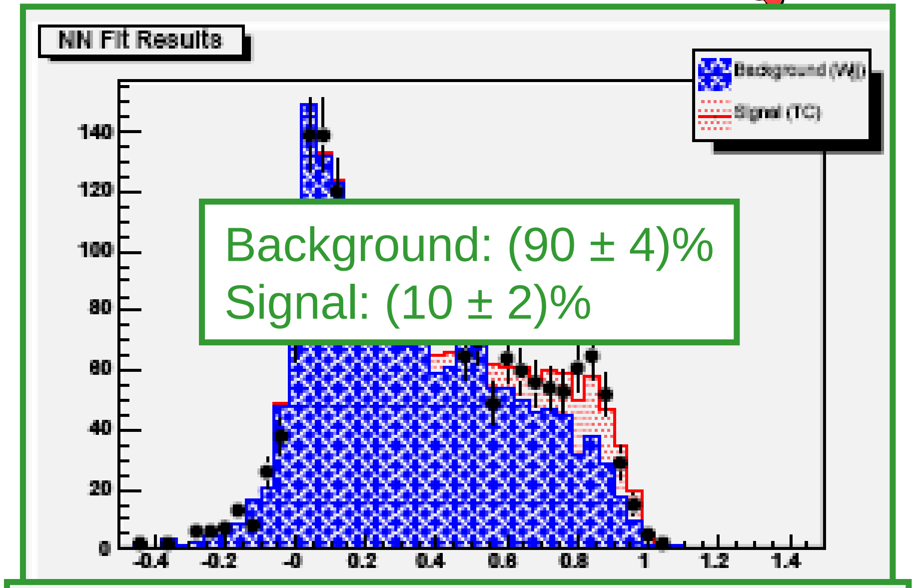
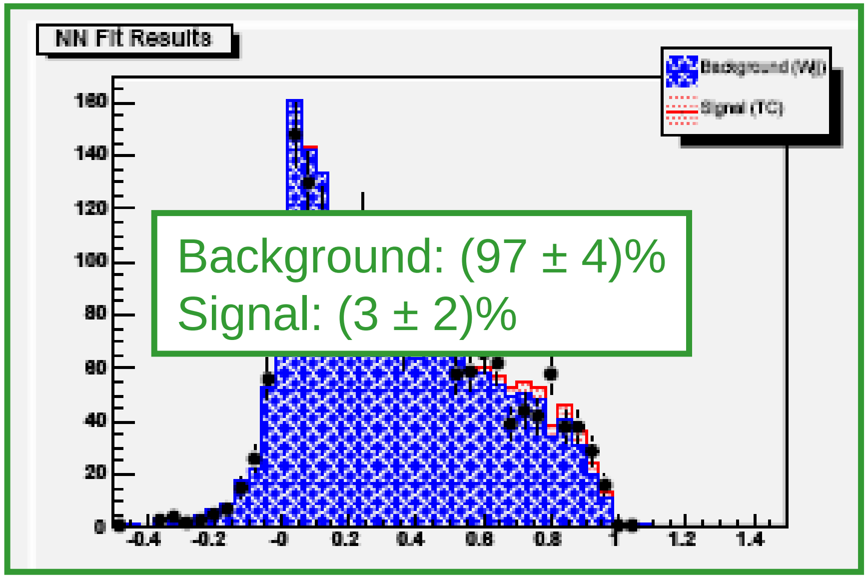
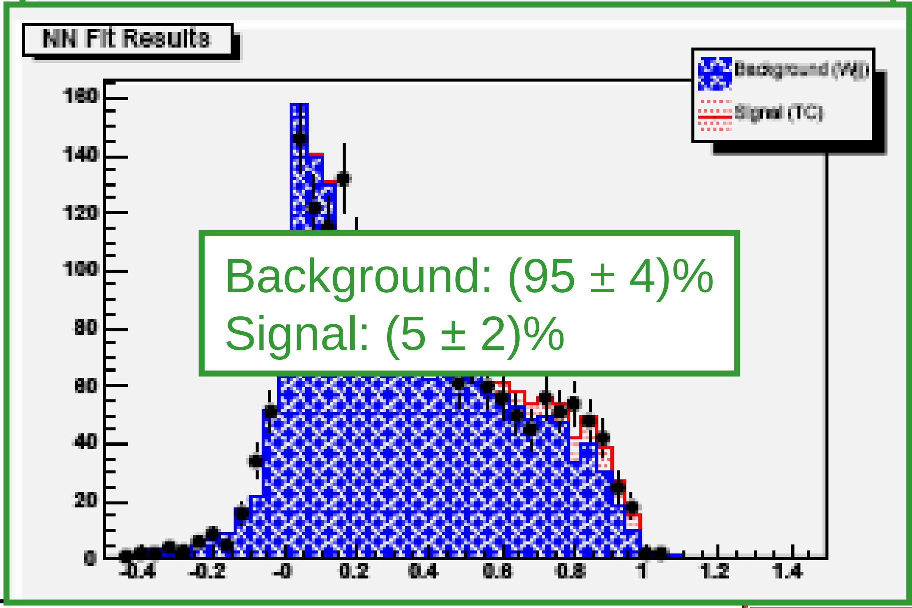
jb plots









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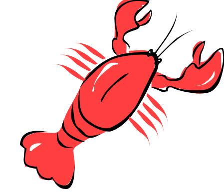
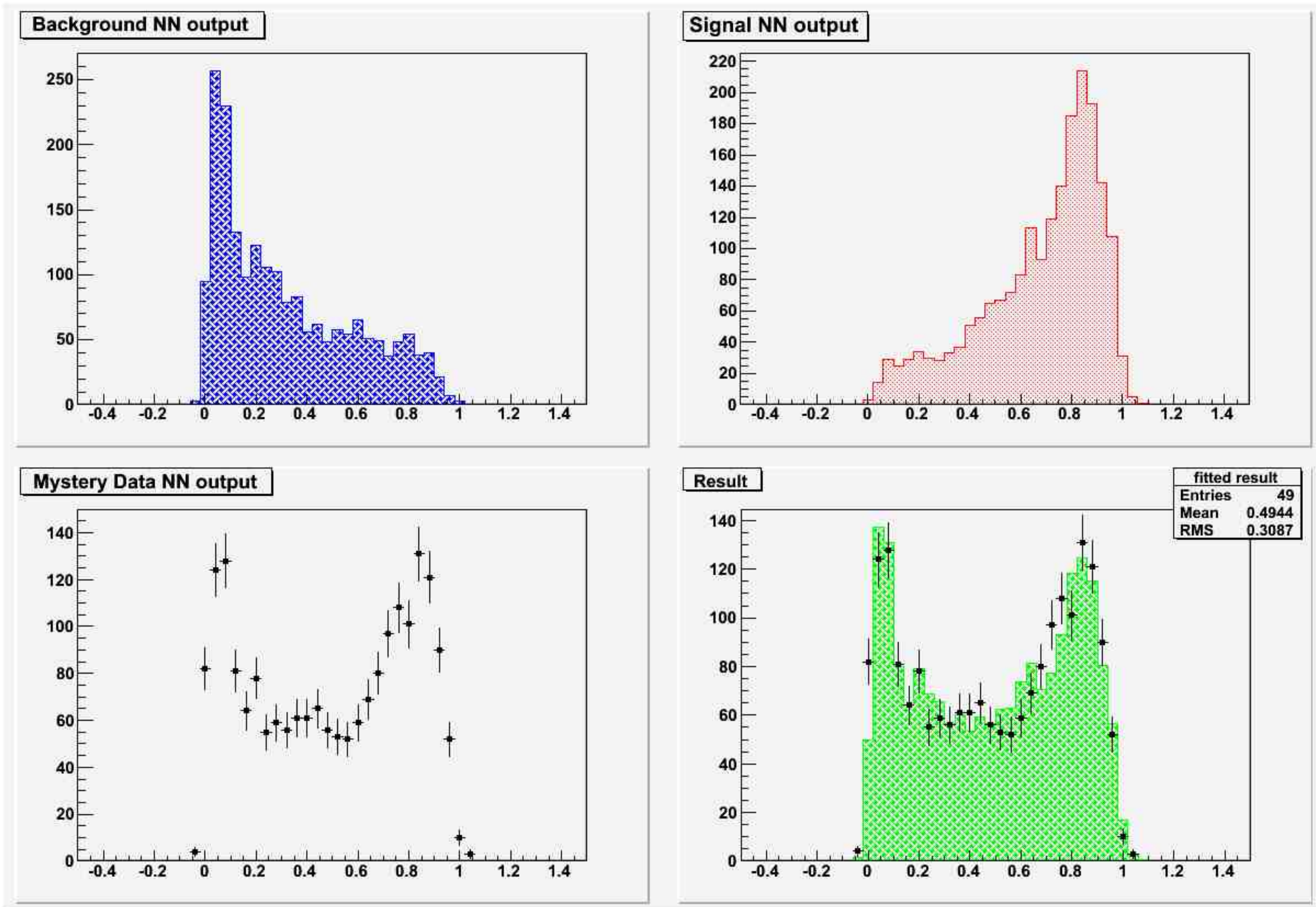
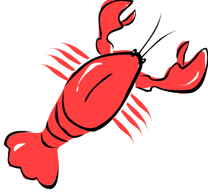
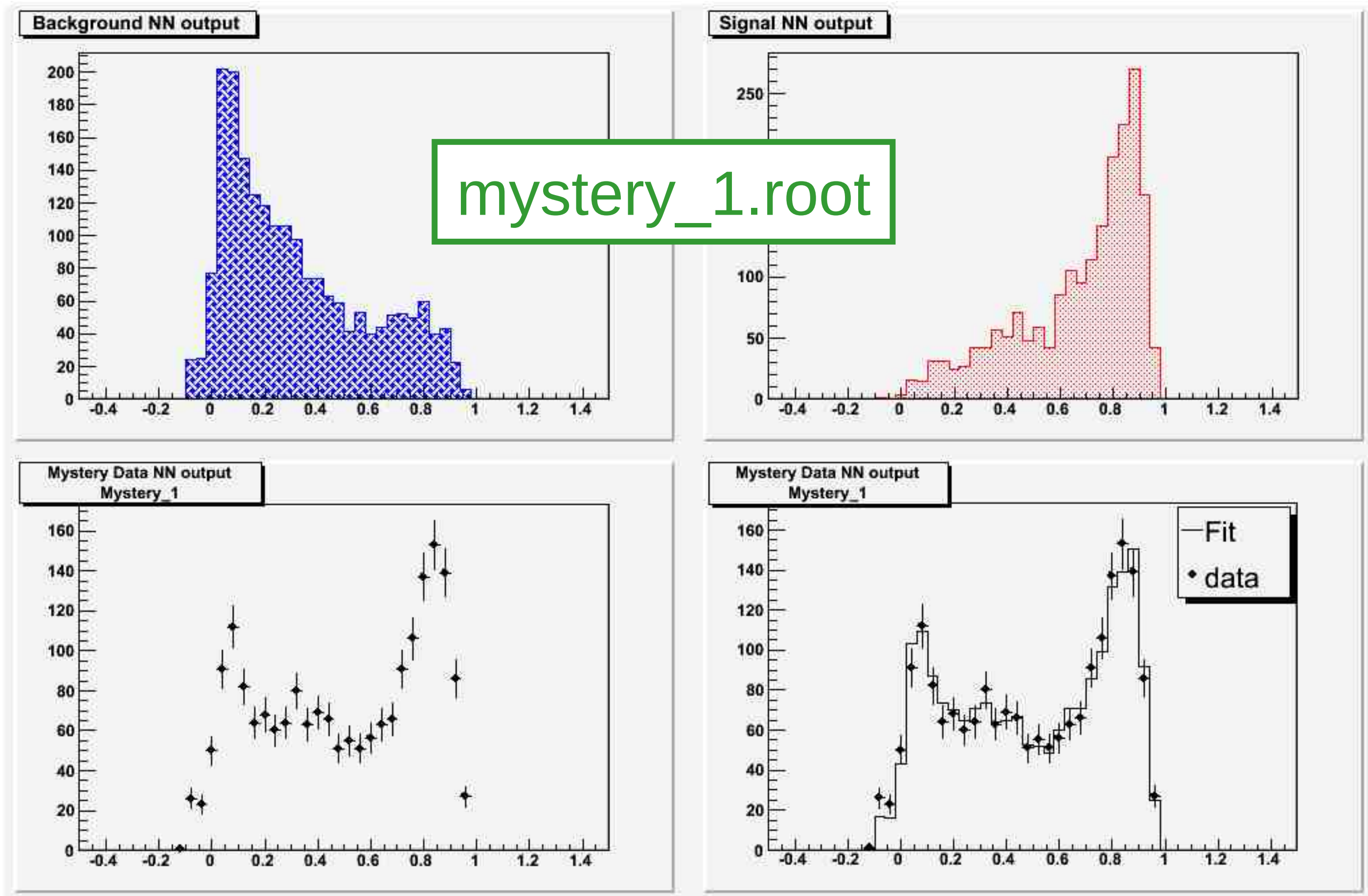
Samvel Khalatian





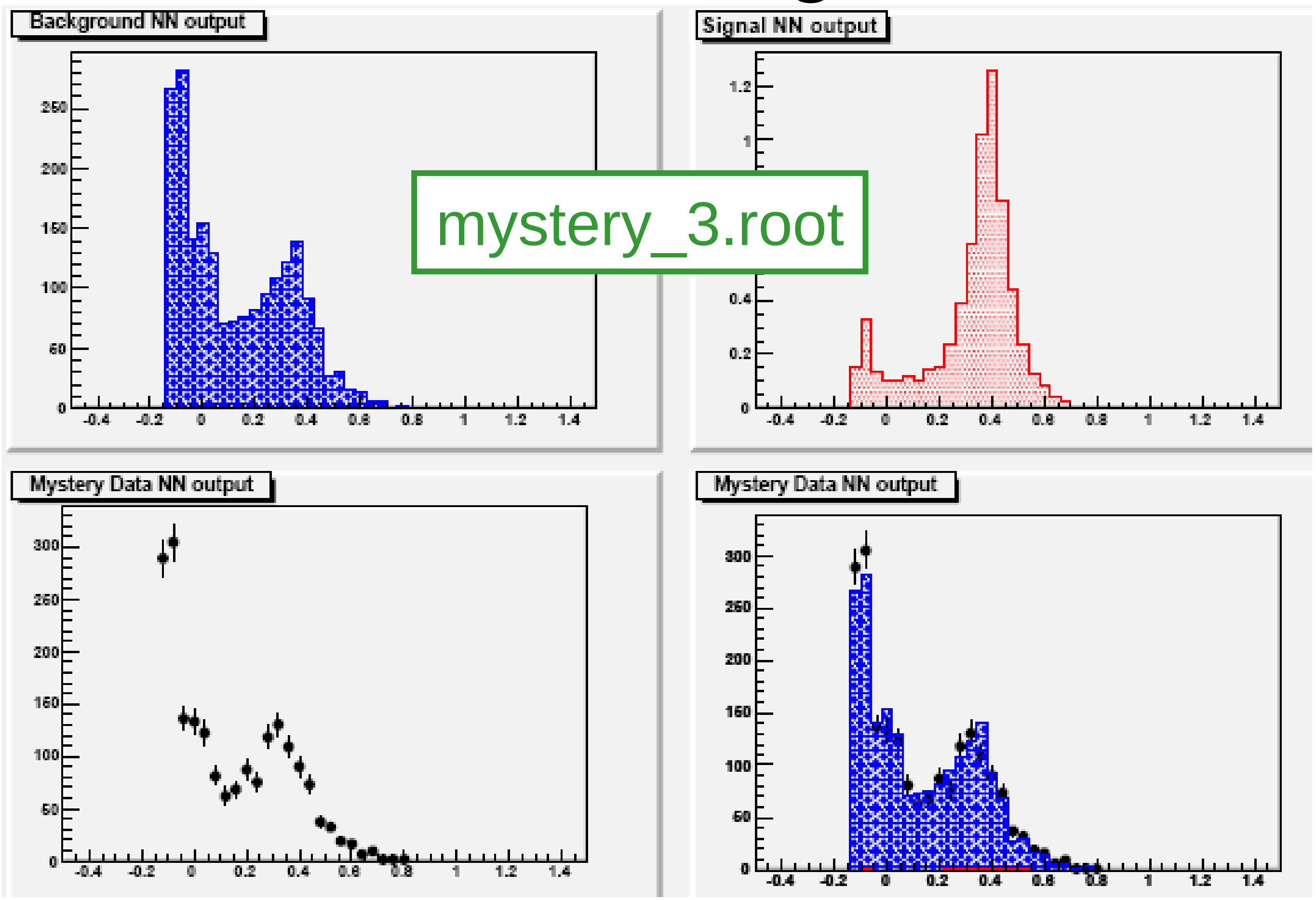
Steven Cavanaugh





	Bkgd(%)	+/-	Signal (%)	+/-
Mystery 1	49.3	1.6	50.3	1.6
Mystery 2	89.7	2.1	10.2	1.4
Mystery 3	97.8	2.1	2.3	1.3
Mystery 4	96.4	2.1	3.6	1.3

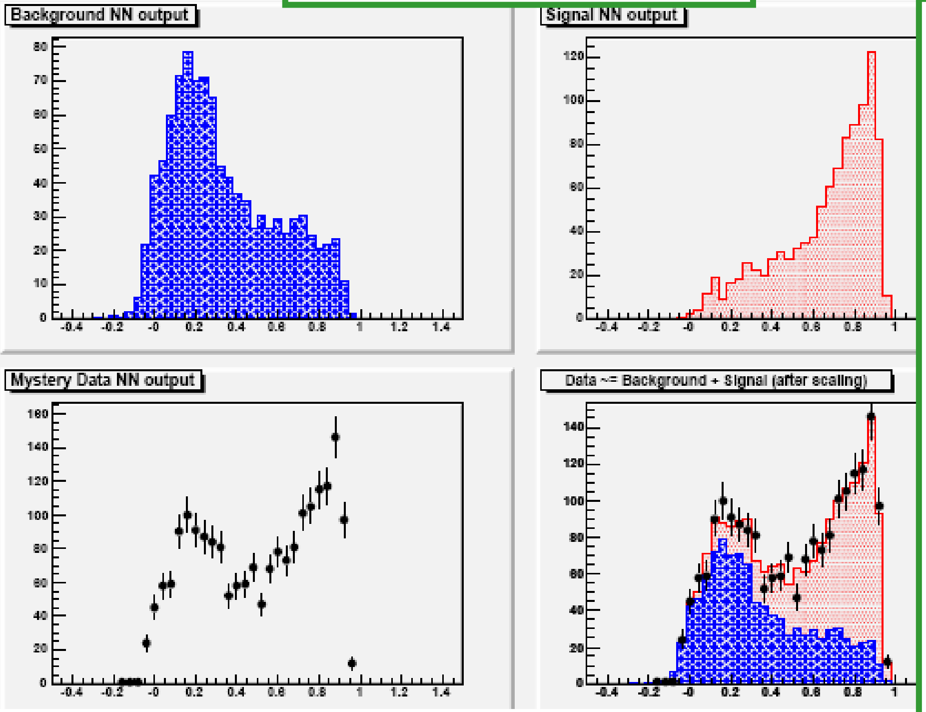
Michael Kagan



Signal Fraction
mystery_1: 49.7 +/- 3.2 %
mystery_2: 9.4 +/- 2.8 %
mystery_3: 0.3 +/- 2.3 %
mystery_4: 1.5 +/- 2.8 %

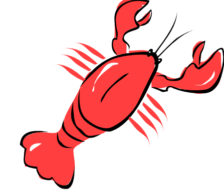
Aram Avetisyan

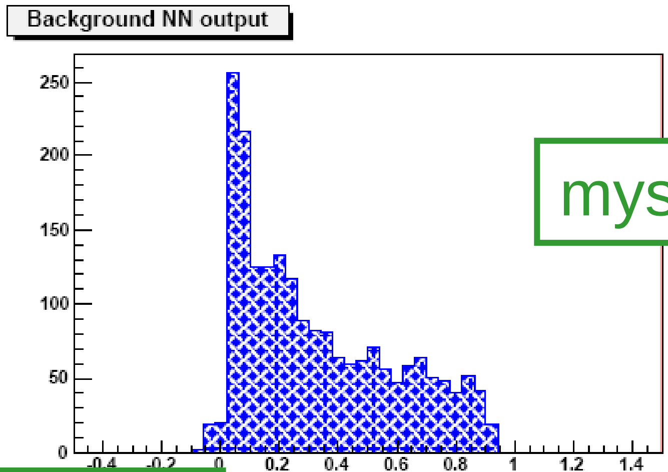
mystery_1.root

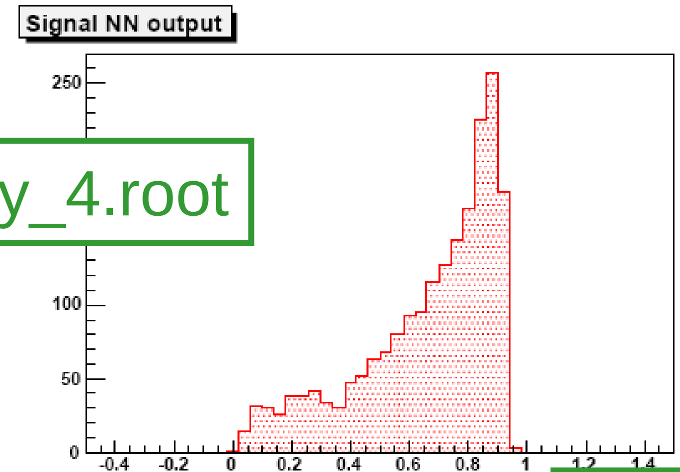


mystery_1
Signal Fraction: 0.507952+/-0.0284142
Background Fraction: 0.492047+/-0.0281343
mystery_2
Signal Fraction: 0.0969365+/-0.0234247
Background Fraction: 0.903068+/-0.0367383
mystery_3
Signal Fraction: 0.0205682+/-0.022819
Background Fraction: 0.979452+/-0.0383891
mystery_4
Signal Fraction: 0.0345576+/-0.0229088
Background Fraction: 0.965441+/-0.0380773

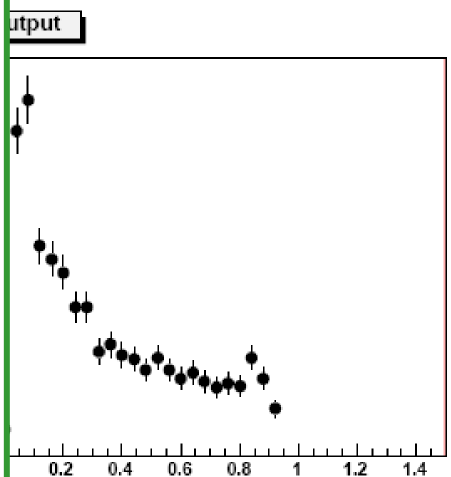
Michael Litos

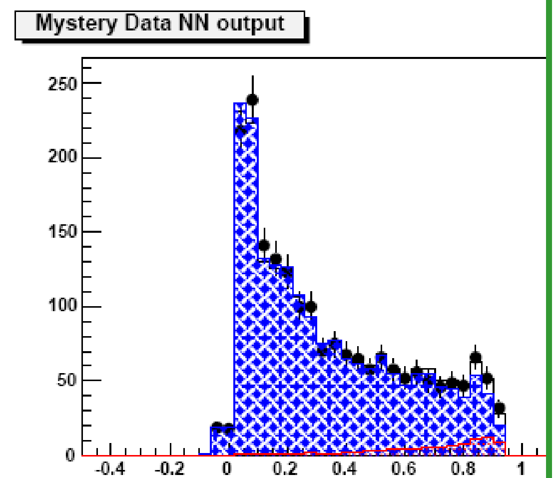






mystery_4.root





Mystery_1
Signal: .49966
SigErr: .0278621
Backgd: .500355
BkgErr: .0278744
ChiSqr: 16.6743

Mystery_2
Signal: .100864
SigErr: .0359343
Backgd: .899129
BkgErr: .0359343
ChiSqr: 29.2299

Mystery_3
Signal: .0231674
SigErr: .0223896
Backgd: .976845
BkgErr: .0380685
ChiSqr: 30.2056

Mystery_4
Signal: .0459162
SigErr: .0216809
Backgd: .954077
BkgErr: .0370547
ChiSqr: 17.0798

Find new physics when it is there

Don’t find new physics when it is there

Where x = J/ψ,…

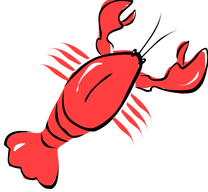
Eventually find new physics when it is there

Carlo's

Physics

Camp

And the (not so) intelligent designer said…



- Is it time to call the New York Times yet?
- mystery_1
  - Background = 50%, Signal = 50% ➔ Stockholm here I come!
- mystery_2
  - Background = 90%, Signal = 10% ➔ Stockholm here I come!
- mystery_3
  - Background = 100%, Signal = 0% ➔ Carlo's Camp!
- mystery_4
  - Background = 99%, Signal = 1% ➔ I missed the J/Ψ!