The SAID Database, Cross Sections, and Geant4 Models

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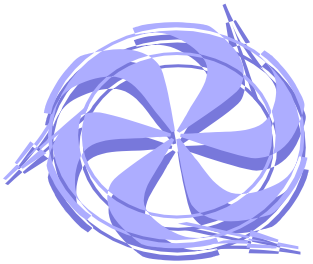
1. Background
2. The on-line facility
3. Analysis, graphics, and tabulated data
4. Processing and model construction for Geant4
5. Validation and elastic model comparisons
6. Acknowledgement and conclusion



TRIUMF

Vancouver, Canada

SAID: Scattering Analysis Interactive Dialin

- A repository of experimental data and an interactive analysis facility, allowing to compare and extract data and partial-wave solutions (PWA) for elastic scattering.
- **R. A. Arndt** (1933–2010) & **L.D. Roper**, Virginia Polytechnic
- Originated c.1980, accessed by 300bd and 1200bd dial-in.
- In the VAX era, program and database were distributed on 9-track tape to ~250 institutions.

```
Last login: Sat Sep 11 20:36:48 2010 from assa80.phys.va.gwu.edu
The following reactions are available under SAID
 nn- Nucleon-Nucleon elastic
 pn- Pion-Nucleon elastic. (includes Pi-N -> Pi-Pi-N)
 pr- Pion photo production
 epr- Pion electro- production
 kn- K+N elastic
 pd- Pion-deuteron -> proton-proton
 pde- Pion-deuteron elastic
 sim- Run Physics Simulations
 demo- Run SAID demo
 show- Look at .PCT file
 cprsol - setup/run comparisons for PR/EPR reactions
Enter the code (eg. NN) of the reaction you want to study->
```

Today…

CNS
Center for Nuclear Studies
Data Analysis Center

CNS DAC Home
Nucleon Nucleon
CNS Home
SAID Start

Analysis Options
Data Base
Observables
Partial Wave Amplitudes
Compare Different Analyses
Compare Fits to Data

Give Predictions for Observables

Choose a Solution:

- (•) Currant Solution
- ( ) SM94_0-1.6 GeV
- ( ) SP40_0-400 MeV
- ( ) Bonn Potential
- ( ) Gross/Stadler_0-350 MeV

Nijmegan Partial-Wave Analyses

Choose a Reaction Type:

( ) PP (•) NP

Choose Observable:

```
(DSG ) (P   ) (D   ) (DT  ) (AYY ) (AXX ) (AZZ ) (AZX ) (CKP ) (CKK )
(CPP ) (R   ) (RP  ) (A   ) (AP  ) (RT  ) (RPT ) (AT  ) (APT ) (MSSN)
(MKSN) (MSKN) (MKKN) (SGTE) (ALFA) (REF3) (REF2) (SGT ) (SGTL) (SGTT)
(DTRT) (AMPL) (SGEL) (SGTR) (DELT) (MTXR) (D0SS) (D0KS) (D0SK) (D0KK)
(NKNK) (NSNK) (NKNS) (NSNS) (NNKK) (MSNS) (MKNS) (MSNK) (MKNK) (NSSN)
(NKSN) (NSKN) (NKKN) (NNSK) (NNKS) (BAMP) (S00S) (K00S) (S00K) (K00K)
(A0ST) (A0KT) (KS0T) (KK0T) (MSNT) (MNST) (MNKT) (MKNT) (DSGL)

   Relationship of Observables to Bystricky Parameters
   Le Journal de Physique, Tome 39, Jan 1978:
   P=P(n000)=P(0n00)=A(00n0)=A(000n)= ....
   D=D(n0n0) ;R=D(s'0s0); A=D(s'0k0); RP=D(k'0s0), AP=D(k'0k0)
   DT=K(0nn0)=K ;RT=K(0s"s0); RPT=-K(0k"s0); AT=-K(0s"k0); APT=K(0k"k)
   AYY=A(00nn)=C(nn00); AXX=A(00ss); AZX=-A(00sk)  NOTE!!  minus sign
   CKP=C(1m00); CKK=C(mm00); CPP=C(1100)
   NNKK=N(0nkk); NNSK=N(0nsk); NNKS=N(0nks)
   MSSN=M(s'0sn); MKSN=M(k'0sn); MSKN=M(s'0kn); MKKN=M(k'0kn)
   D0SS=D(0s"0s); D0KS=D(0k"0s); D0SK=D(0s"0k); D0KK=D(0k"0k)
   NKNK=N(0k"nk); NSNK=N(0s"nk); NKNS=N(0k"ns); NSNS=N(0s"ns)
   MSNS=M(s'0ns); MKNS=M(k'0ns); MSNK=M(s'0kn); MKNK=M(k'0nk)
   NSSN=N(0s"sn); NKSN=N(0k"sn); NSKN=N(0s"kn); NKKN=N(0k"kn)
```

Enter one of the above observable types:

DSG (Upper Case)

Enter independent variable:

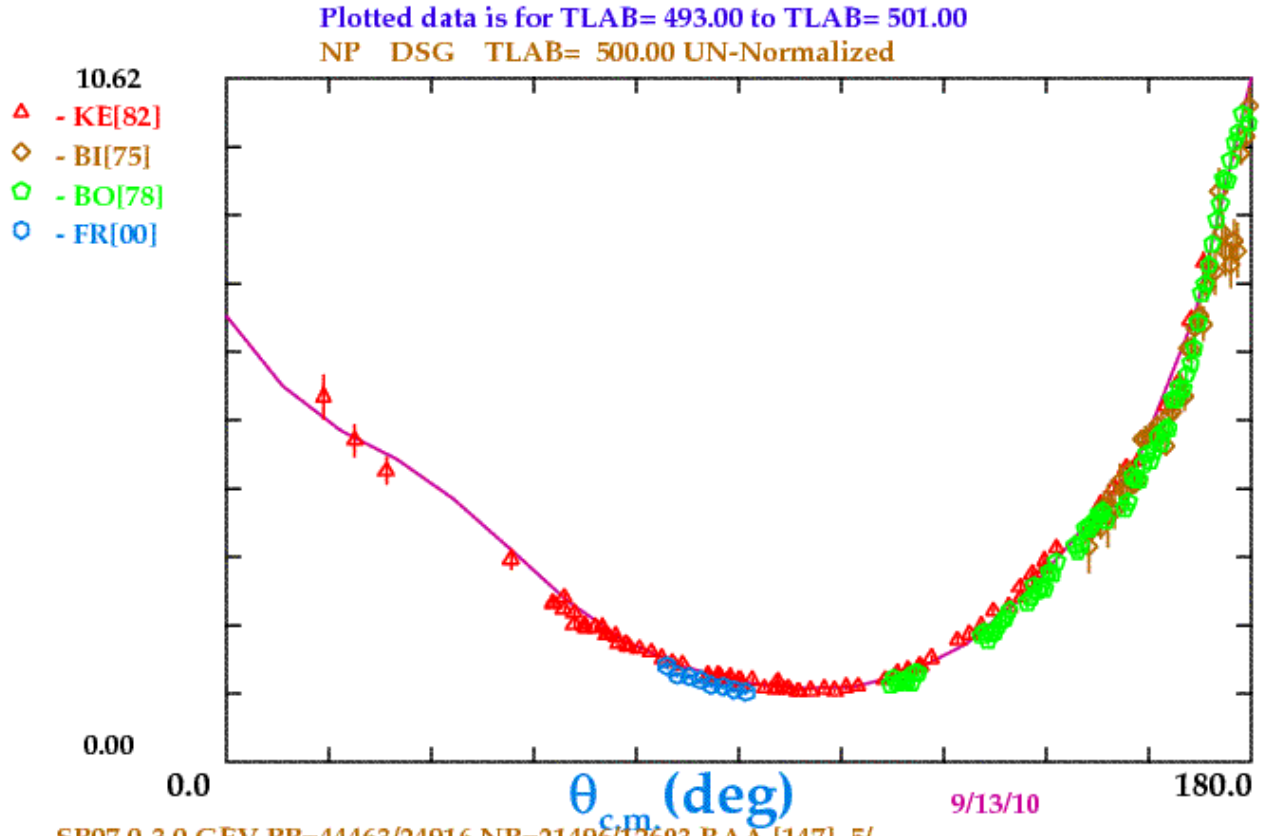
(•) Acm ( ) Alab ( ) Tlab ( ) Plab ( ) Wcm

...[Lower]...[Increment]...[Upper]...Range of Independent Variable

0 | 10 | 180

(Web interface to the existing Fortran back-end)

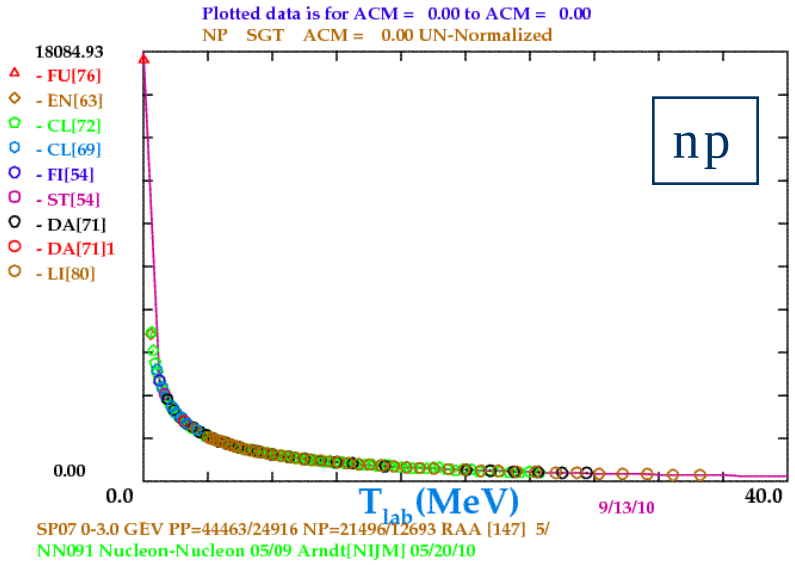
Analysis, graphics and data retrieval

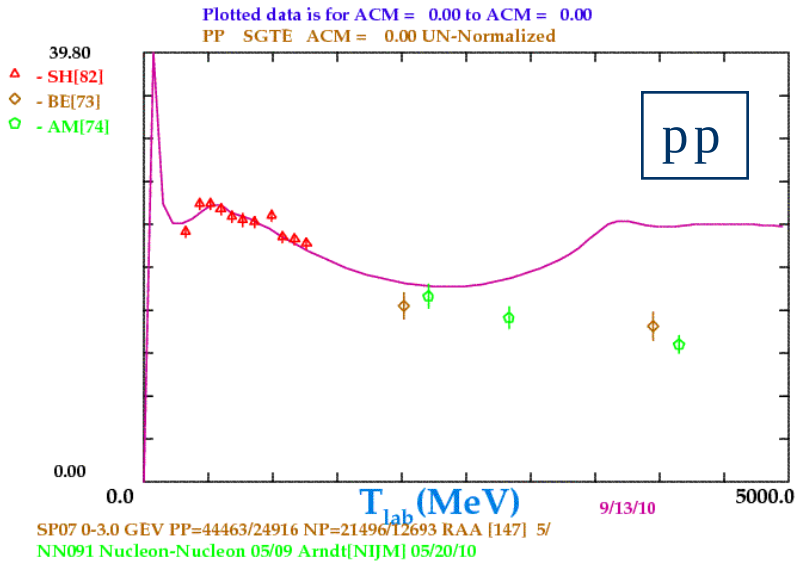


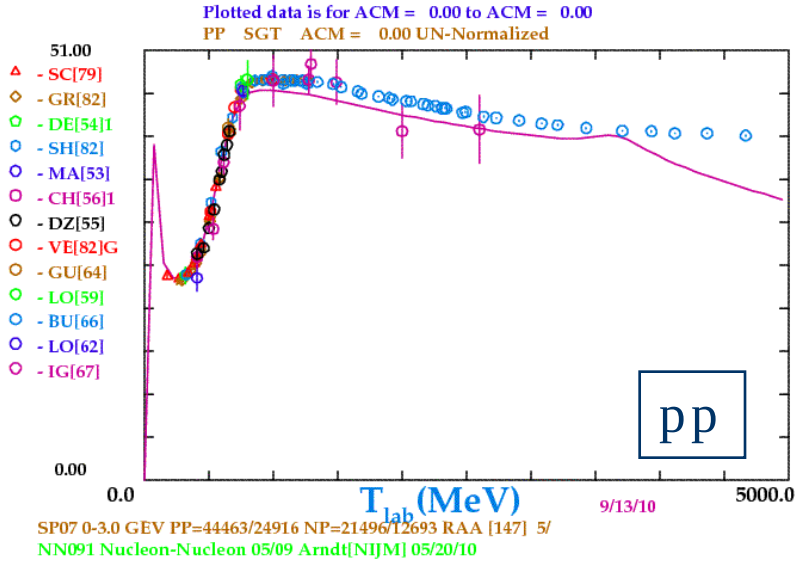
SP07 0-3.0 GEV PP=44463/24916 NP=21496/12693 RAA [147] 5/
NN091 Nucleon-Nucleon 05/09 Arndt[NIJM] 05/20/10

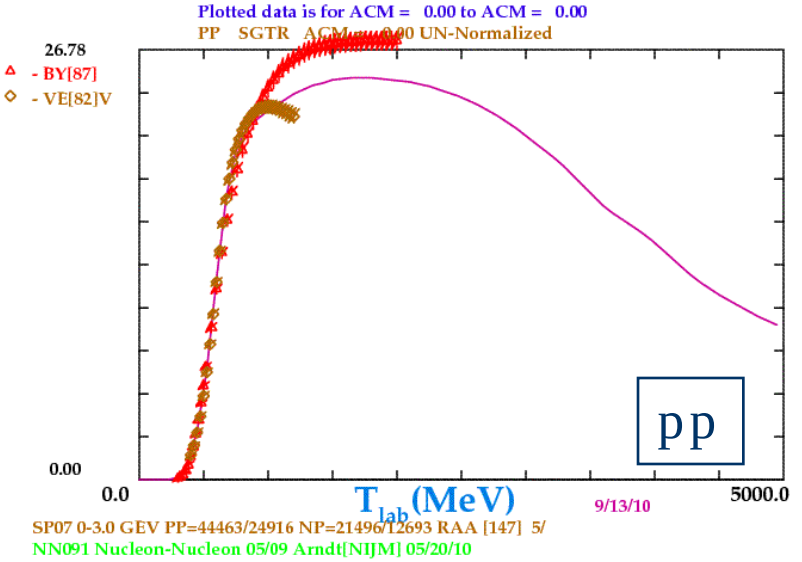
```
T=  493.000 Nd=   6  KE(82)   TRIU  KEELER, NPA377, 529(82)  RsF= 1.000
    17.06  0.56720E+01  0.32200E+00
    22.59  0.49950E+01  0.23700E+00
    28.12  0.45230E+01  0.20100E+00
    50.01  0.31540E+01  0.14000E+00
    66.03  0.21090E+01  0.99000E-01
    96.75  0.12560E+01  0.79000E-01
T=  494.600 Nd=  43  BI(75)   SATU  BIZARD, NPB85, 14(75)    RsF= 1.000
   151.46  0.33510E+01  0.41000E+00
   152.13  0.36130E+01  0.16200E+00
```

Total cross sections

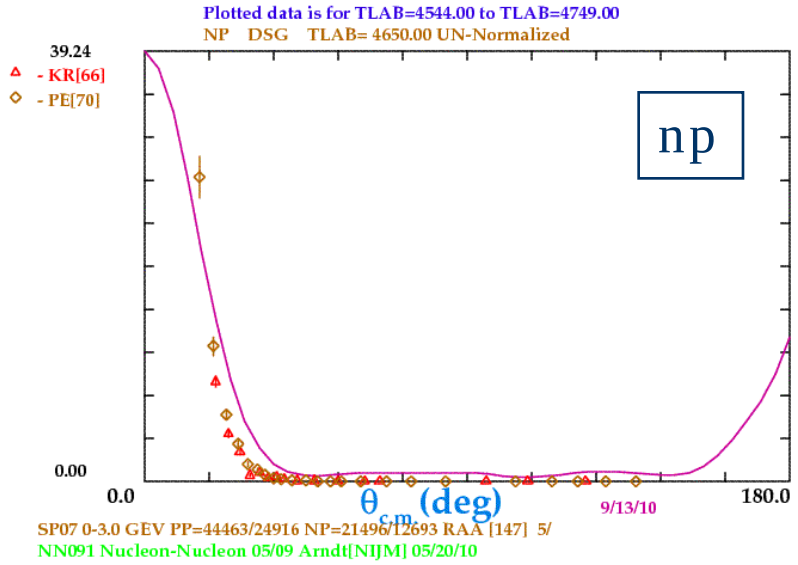


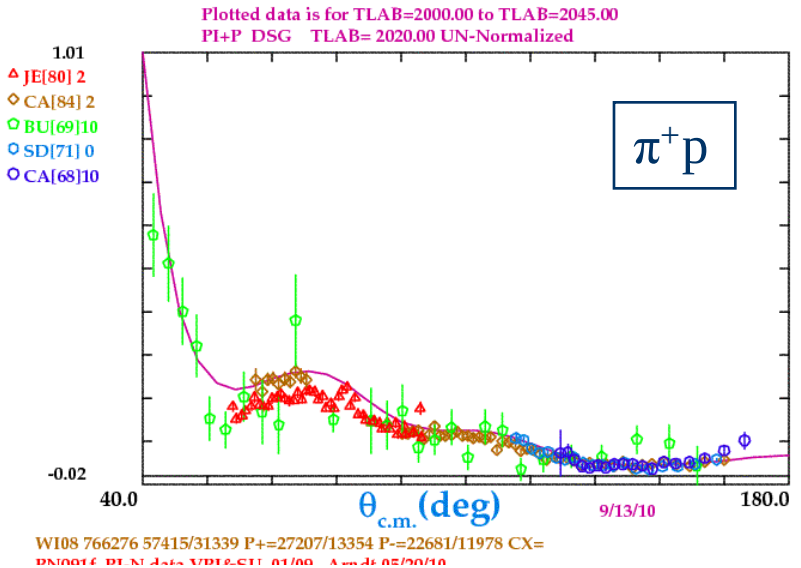


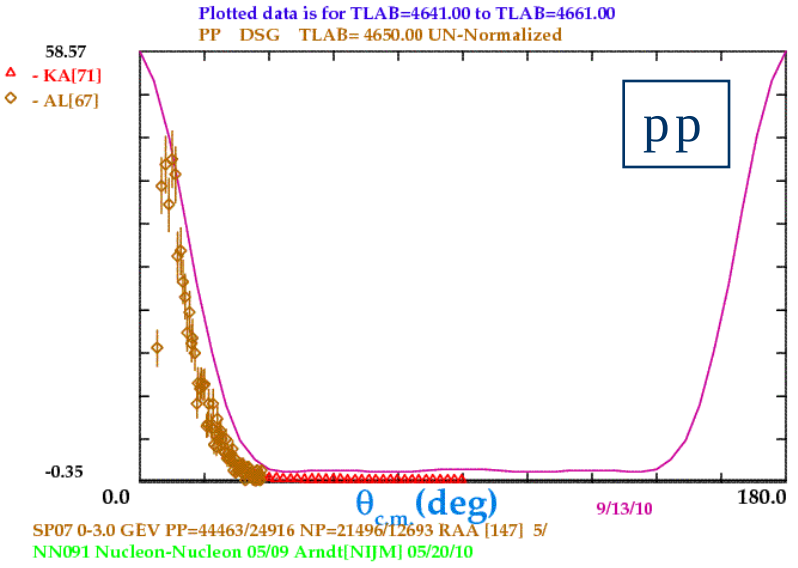


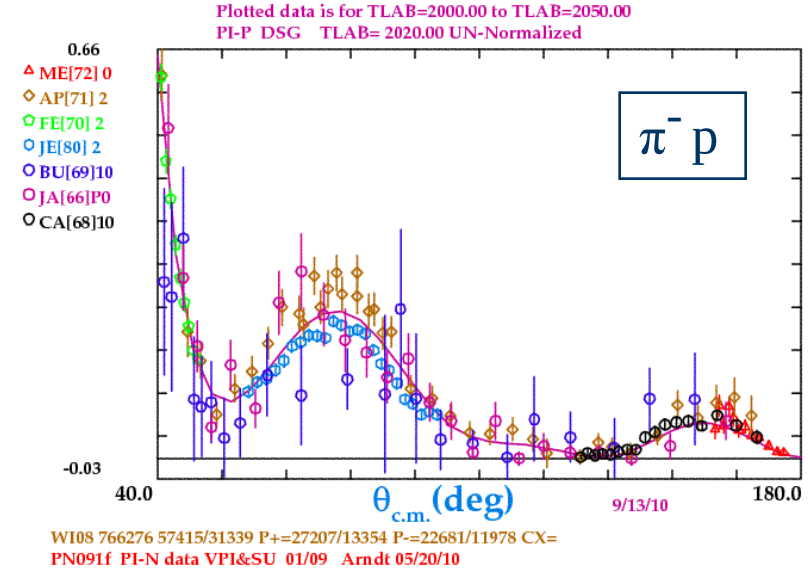


Energy range of differential cross section data





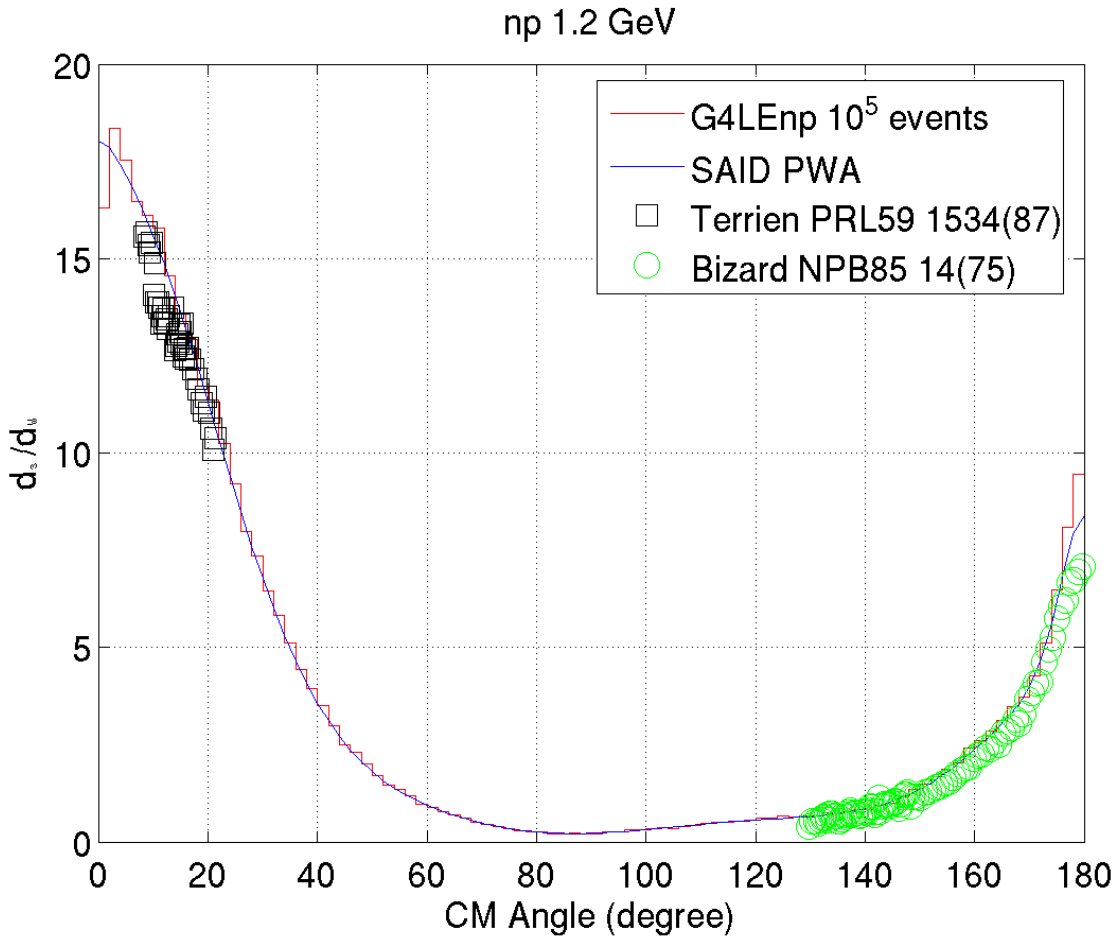




Data Extraction and Processing for Geant4 models

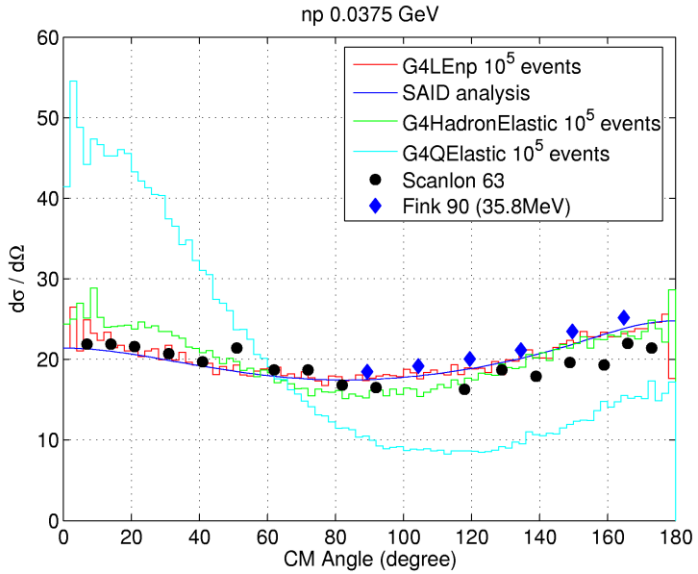
- Hadronic Models for elastic scattering **G4LEnp** and **G4LEpp** were constructed from SAID differential cross sections at energies from 10 MeV to 1.2 GeV (Wellisch-Greeniaus-Jones TRIUMF/UofA).
- Recently we extended the energy range to 5 GeV, the upper limit of the supporting data (Kwan-Jones TRIUMF).
- **G4LEnp** cross section includes charge exchange.
- By default **G4LEpp** omits Coulomb scattering effects and hence can also be used for *n*-*n* scattering.
- Total cross sections from SAID are not used in Geant4.
- Some MATLAB scripts were developed to provide a semi-automatic procedure for data extraction, integration, normalisation, and generation of C++ code.
- **G4LEnp** and **G4LEpp** are only occasionally found in user applications. The main use is internally in Binary Cascade!

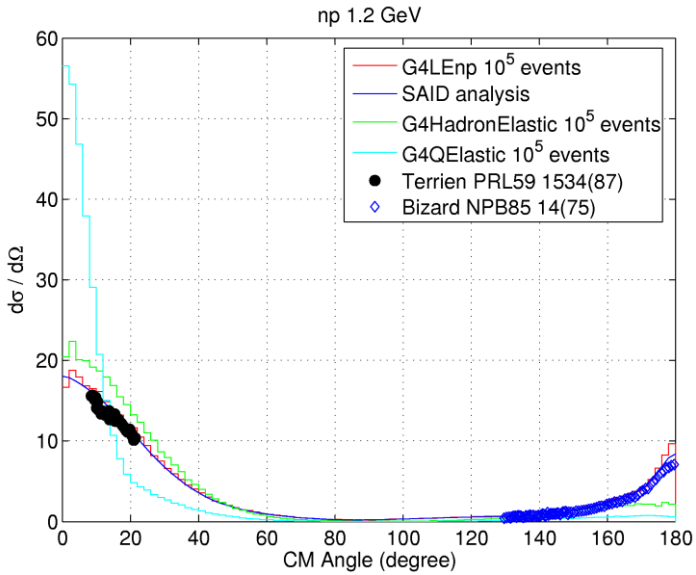
Validation

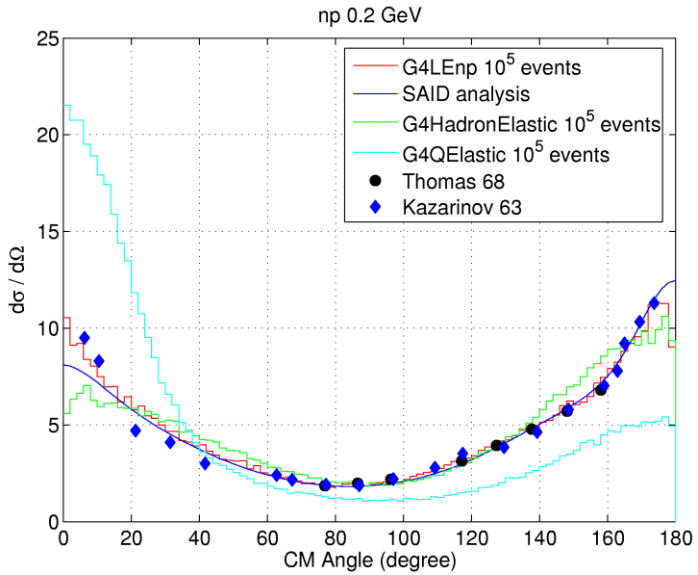


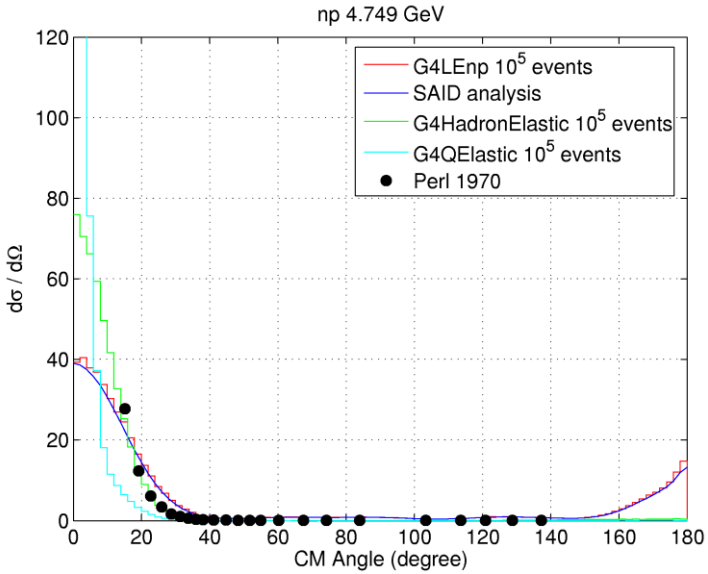
SAID provides both the model and the validation.

Comparisons with other elastic models









Acknowledgment & Conclusion

Exceptional help and advice was given by:

- Richard. A. Arndt (1933–2010), Virginia Polytechnic
- Ron Workman, George Washington University

Conclusions:

- SAID provides extensive hadron elastic and charge-exchange scattering data as well as partial wave solutions which can be readily implemented as validated Geant4 models.
- SAID data extraction and processing have been revived and N-N elastic scattering models have been extended to 5 GeV.
- Mechanism needed to engage these models for Hydrogen (only).
- Further data are available, in particular π-N and K-N in the few-GeV region.
- This kind of development becomes much more difficult as the number of experts diminishes!