ISABEL INC Model for High-Energy Hadron-Nucleus Reactions

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איזבל ISABEL

אשד תוך גרעיני

Eshed Toch Gar'ini

→ ETGAR אתגר

Etgar = Challenge

History

- R.Serber, Phys. Rev. 72, 1114 (1947)
- M.L.Goldberger, Phys. Rev. 74, 1269 (1948)
- N.Metropolis et al., Phys. Rev. 110, 185 (1958); Phys. Rev. 110, 204 (1958)
- VEGAS: K.Chen et al., Phys. Rev. 166, 949 (1968)
- ISOBAR: G.D.Harp et al., Phys. Rev. C8, 581 (1973); C10 2387 (1974)
- ISABEL: Y.Yariv and Z.Fraenkel, Phys. Rev. C20, 2227 (1979); Phys. Rev. C24, 488 (1981)
- ETGAR…

Nuclear Model

- **Continuous charge distribution – Folded Yukawa. Nucleus divided into several regions of constant density. Ratio of proton to neutron density Z/(A-Z)**
- **Momentum distribution - degenerate Fermi Gas**

$$E_{F_i} = (\hbar^2 / 2m_i)(3\pi^2 \rho_i)^{2/3}$$

$$i = proton, neutron; m_i = nucleon\_mass; \rho_i = density$$

- **Potential depth (J.N. Ginocchio, Phys. Rev. C17, 195 (1978))**

$$V_i = E_{F_i} + (Separation\_Energy)_i$$

$$V_{\Delta^{++}} = V_p; V_{\Delta^+} = V_p + \frac{(V_p + V_n)}{3}; V_{\Delta^0} + \frac{(V_p + V_n)}{3} = V_n; V_{\Delta^-} = V_n$$

Hadron-Hadron Cross Sections (1)

N+N

- σ_{tot}, σ_{inel} , σ_{el}
  G.D.Harp, Phys. Rev. **C10**, 2387 (1974)
  Arndt phase shift analysis

- $d\sigma_{el}/d\omega$
  P.C.Clements, L.Winsberg, UCRL 9043 (1960), unpublished

Hadron-Hadron Cross Sections (2)

◈ N+N → N+Δ

- Type of outgoing N, Δ determined by Isotopic Spin consideration
  Z.Fraenkel, Phys. Rev. **130**, 2407 (1963)
- Mass of Δ is chosen from distribution:

$$P(m_\Delta, E_{cm}^{N+N}) = const.*\sigma_{tot}^{\pi^+ + p}(E_{cm}^{N+N})*F(m_\Delta, E_{cm}^{N+N})$$

$$m_\pi + m_N < m_\Delta < m_\pi + m_N + 500MeV$$

  F = two body phase factor for the produced N+Δ
  S.Lindenbaum and R. Sternheimer, Phys. Rev. **105**, 1874 (1957); **109**, 1723 (1958); **123**, 333 (1961)
- $P(\cos_{cm})=.25+.75*(\cos_{cm})^2$

Hadron-Hadron Cross Sections (3)

◈ Δ+N → N+N (π capture)

- Type of outgoing N, Δ determined by Isotopic Spin consideration
- σ, $d\sigma/d\omega$ calculated from inverse process (Δ production) using the principle of “detailed balance”
- Δ production calculated using theoretical model (OPE)

Hadron-Hadron Cross Sections (4)

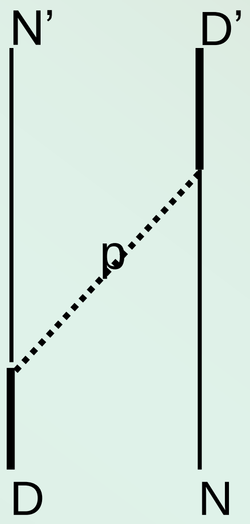
◈ Δ+N → Δ'+N' ("exchange")

- Naively two step process:
  - Decay of initial Isobar, Δ→π+N'
  - Interaction of decay π with another Nucleon, π+N→Δ'

G.D.Harp et al., Phys. Rev. **C6**, 581 (1973),

Z.Fraenkel, Nuovo Cimento **30**, 512 (1963)

Z.Fraenkel, Phys.Rev. **130**, 2407 (1963)



Hadron-Hadron Cross Sections (5)

◈ $\pi+N \rightarrow \Delta \rightarrow \pi'+N'$ (elastic & charge exchange)

- Experimental dσ/dω + isospin considerations
  G.Giacomelli et al., CERN/HERA 69-1 (1969)
- For Δ decaying without interaction proper π+N differential cross section
- Isotropic Δ decay after scattering or exchange

Hadron-Hadron Cross Sections (6)

- **$\Delta \rightarrow \pi+N$**
  - Energy dependant Δ width
    J.N. Ginocchio, Phys. Rev. **C17**, 195 (1978)

Density depletion

- **After each interaction Fermi sea density, ρ_i, is depleted**
  - **Fast rearrangement**: ρ_i of the "partner type" Fermi sea is uniformly reduced for the whole nucleus
  - **Slow rearangement**: "partner type" hole of radius *r* is punched in the position of the interaction. No interactions are allowed in the hole with particles of "partner type" .

Pauli Blocking

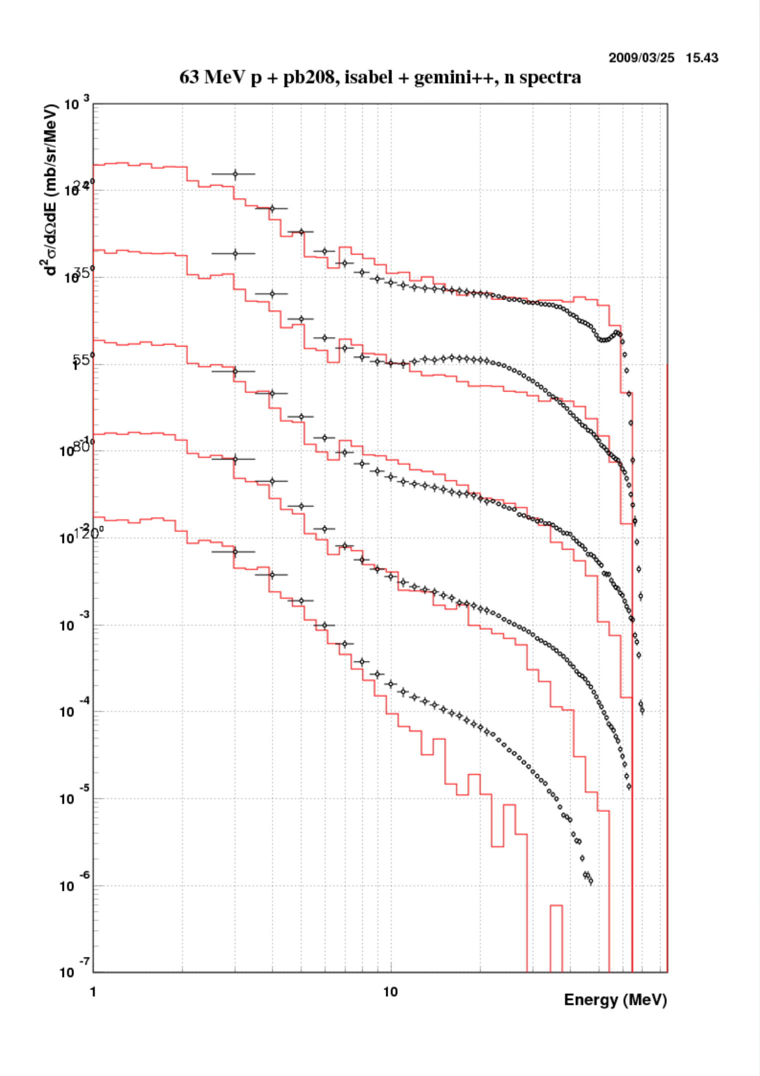
- **Options:**
  - **Full Pauli Blocking**: Interaction resulting in nucleon falling below Fermi sea is forbidden
  - **“Depleted” Pauli Blocking: Reaction resulting in nucleon falling below Fermi sea is allowed with probability of the relative depletion of the Fermi sea**

High-Energy Fragments

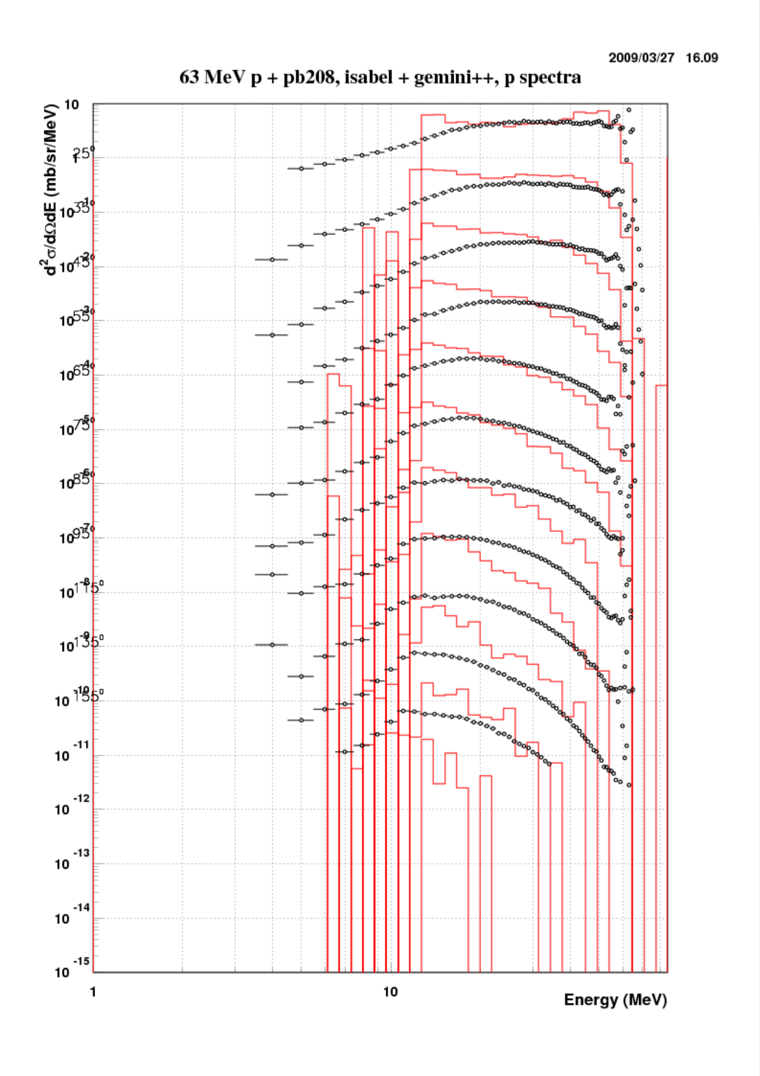
- ISABEL was used without the additional coalescence model
- No attempt was made to predict the production of high-enegy “heavy” fragments

Typical Results ISABEL + GEMINI

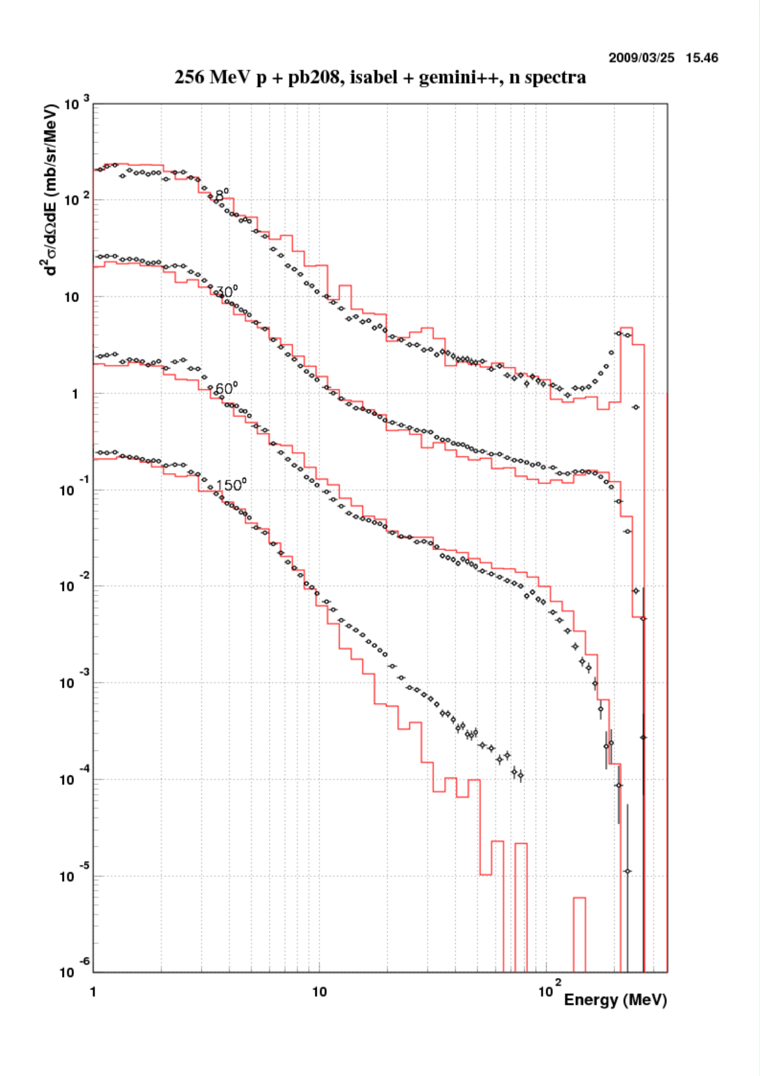
^{208}Pb(p,X)n, 63 MeV



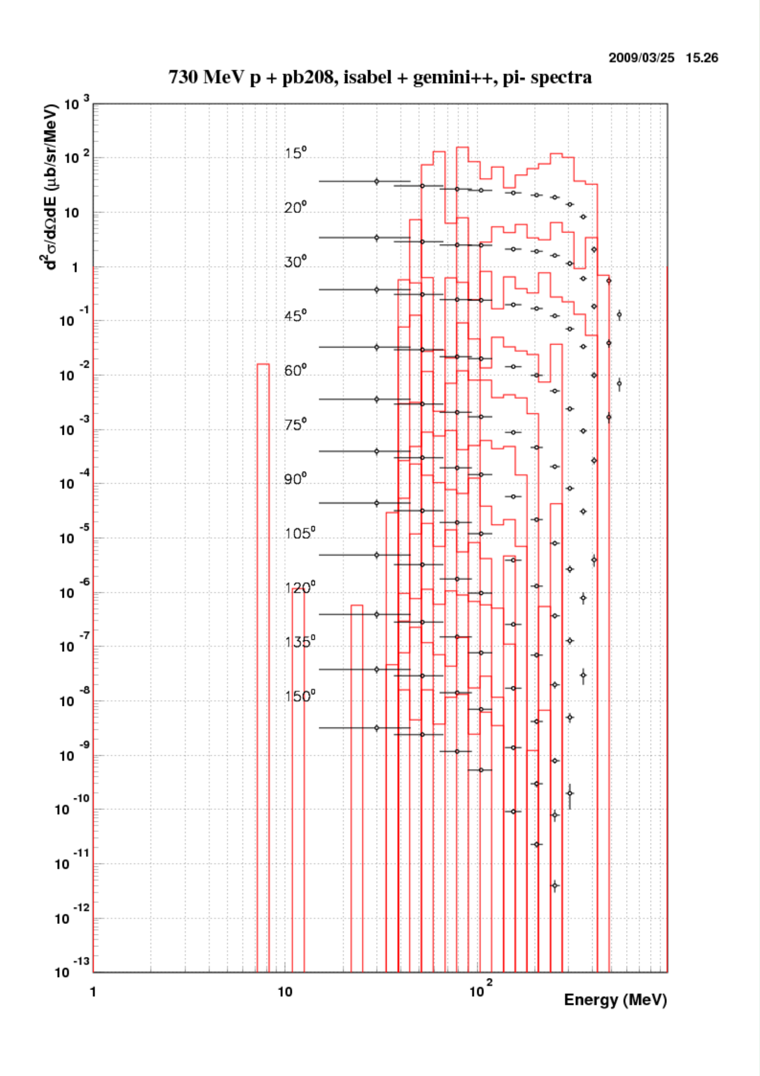
^{208}Pb(p,X)p, 63 MeV



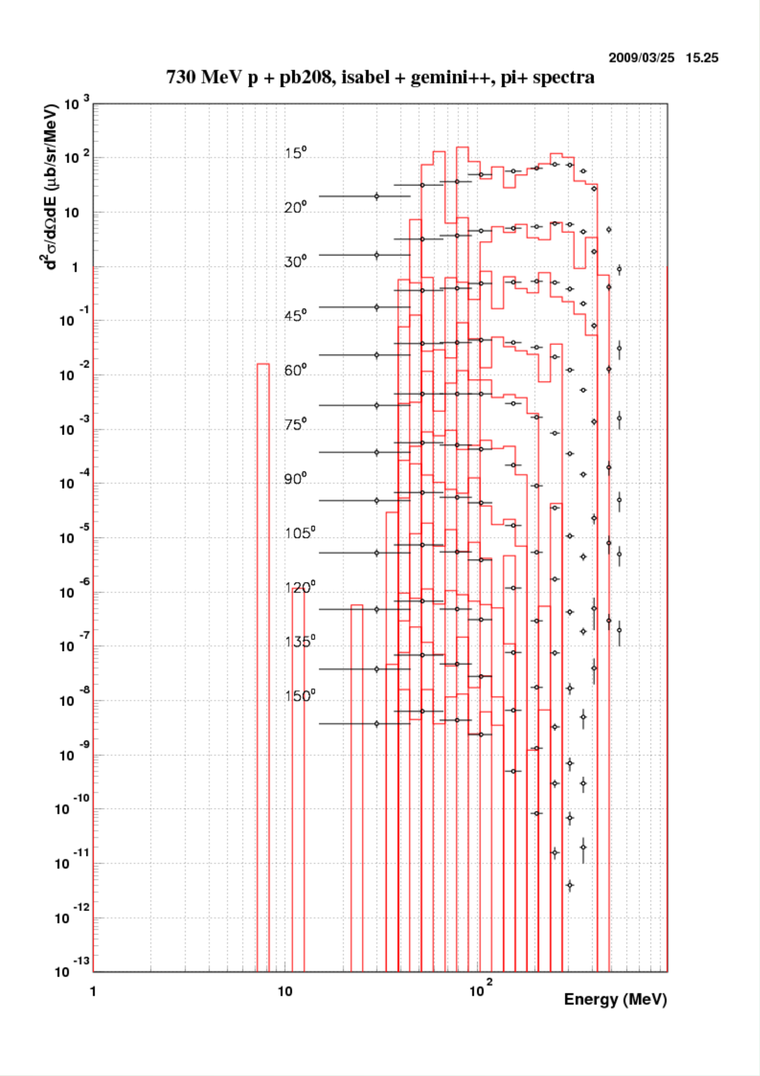
$^{208}Pb(p,X)n$, 256 MeV



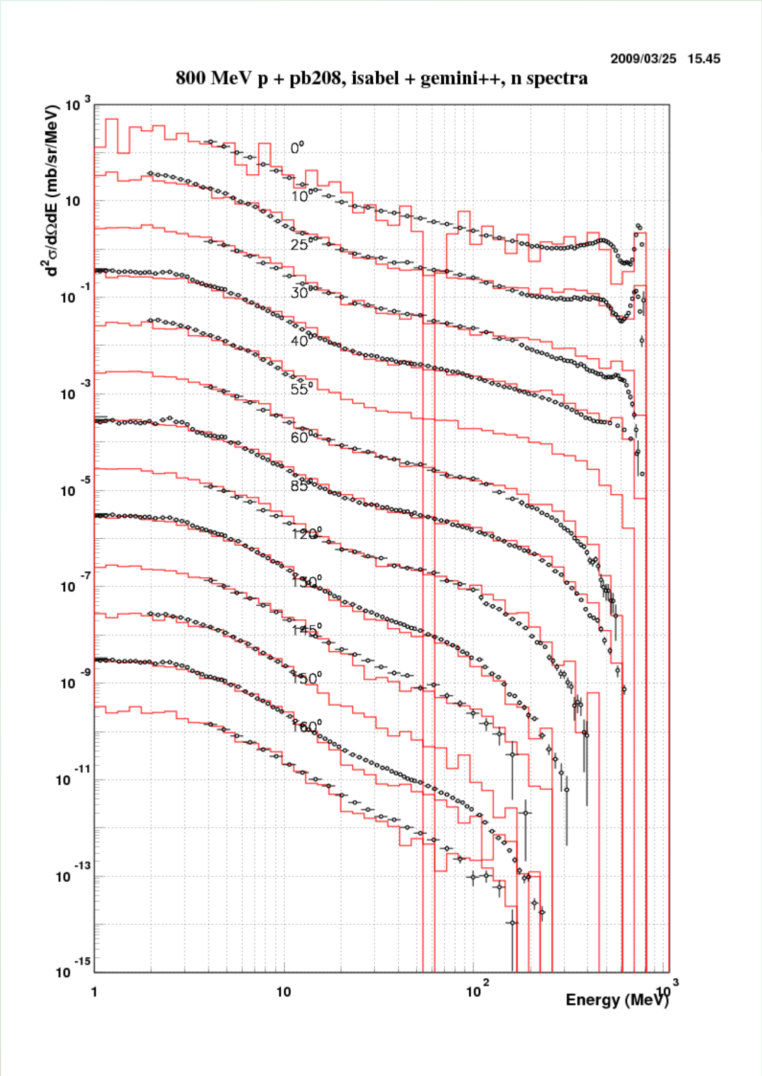
$^{208}Pb(p,X)\pi^{-}$, 730 MeV



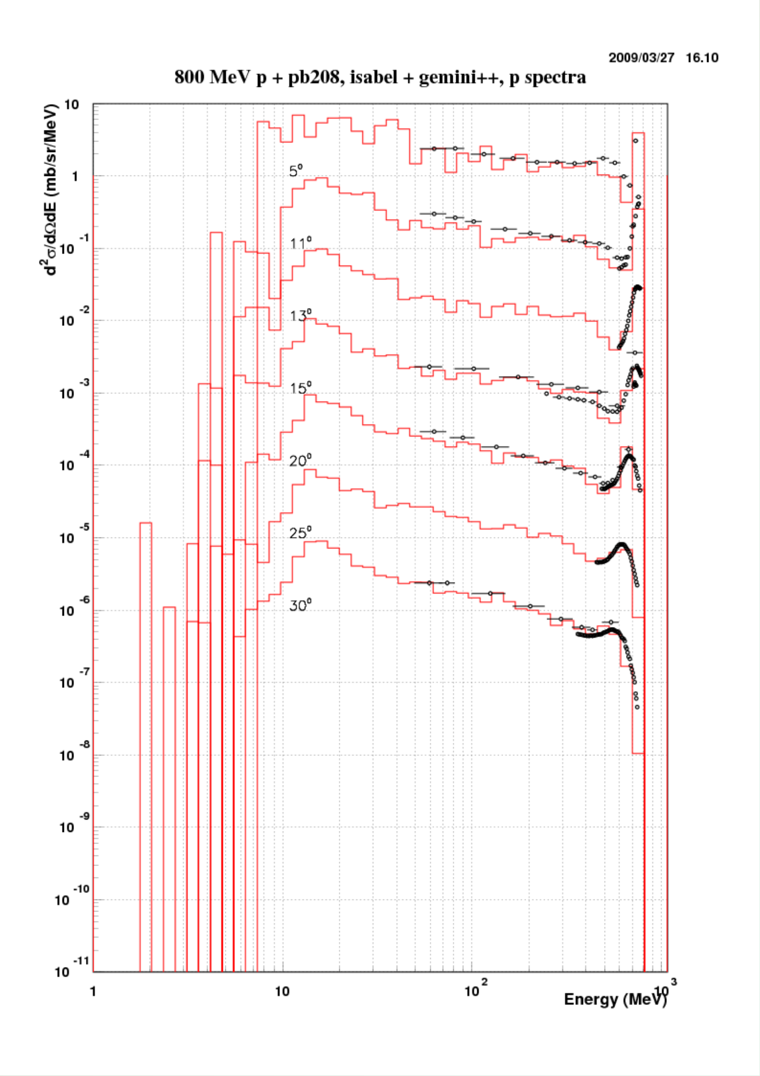
$^{208}Pb(p,X)\pi^+$, 730 MeV



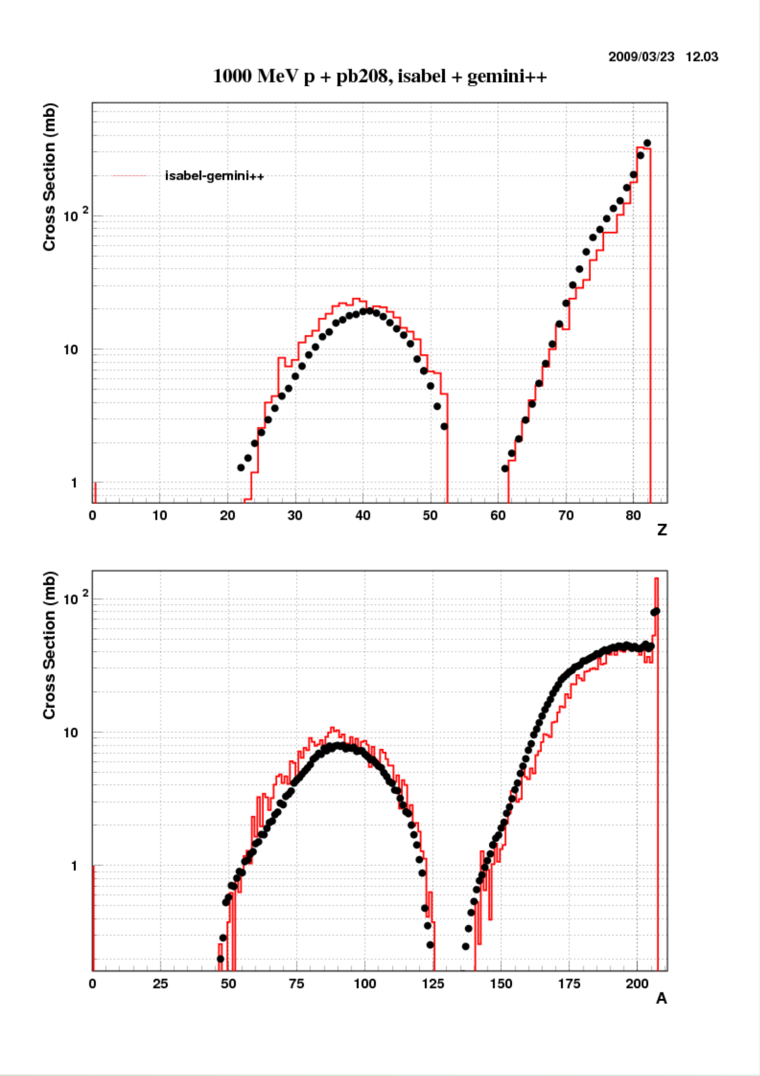
$^{208}Pb(p,X)n$, 800 MeV



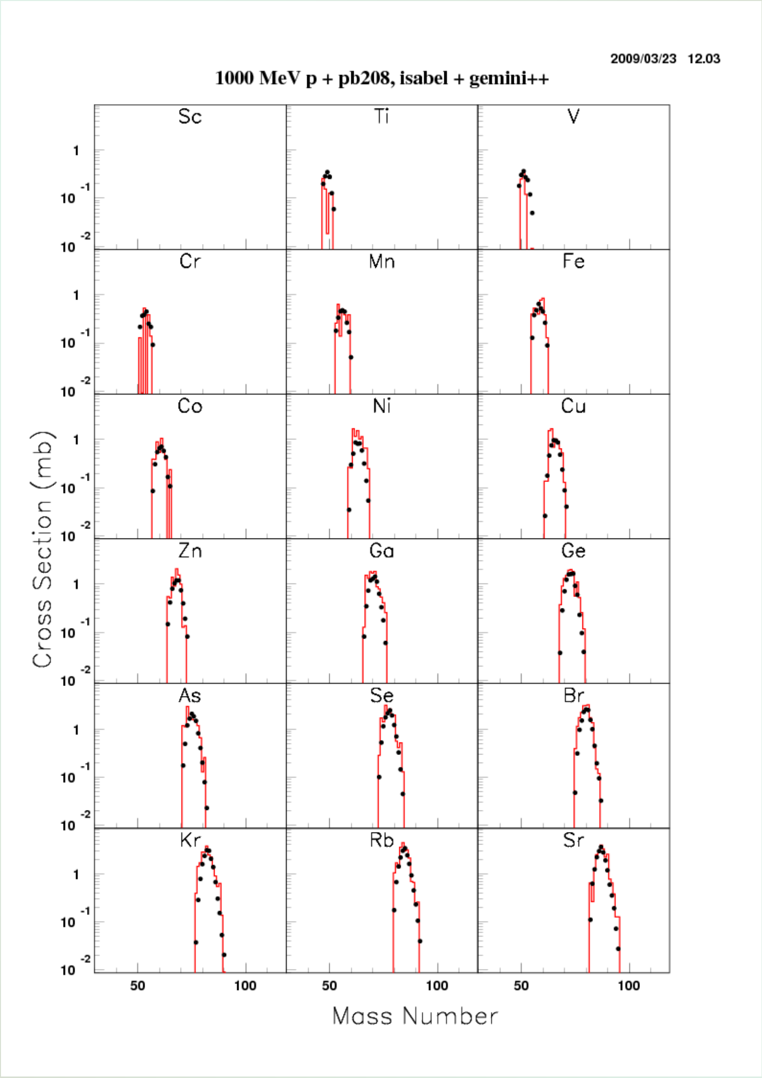
^{208}Pb(p,X)p, 800 MeV



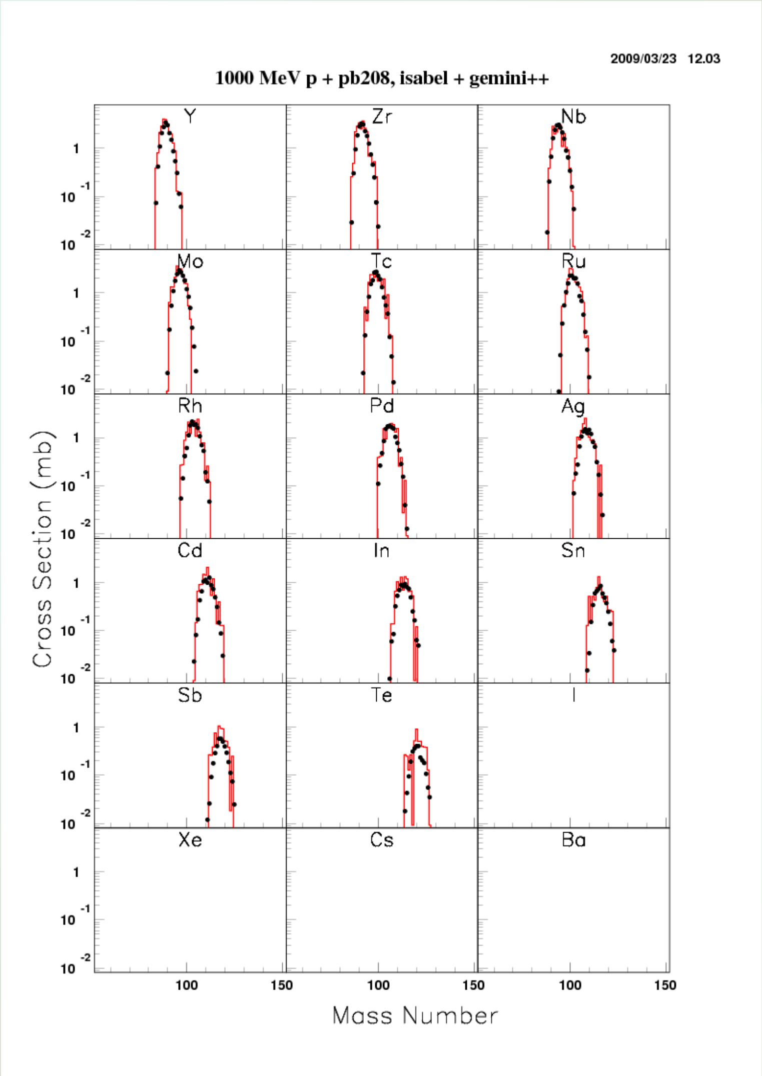
^{208}Pb(p,X), 1000 MeV



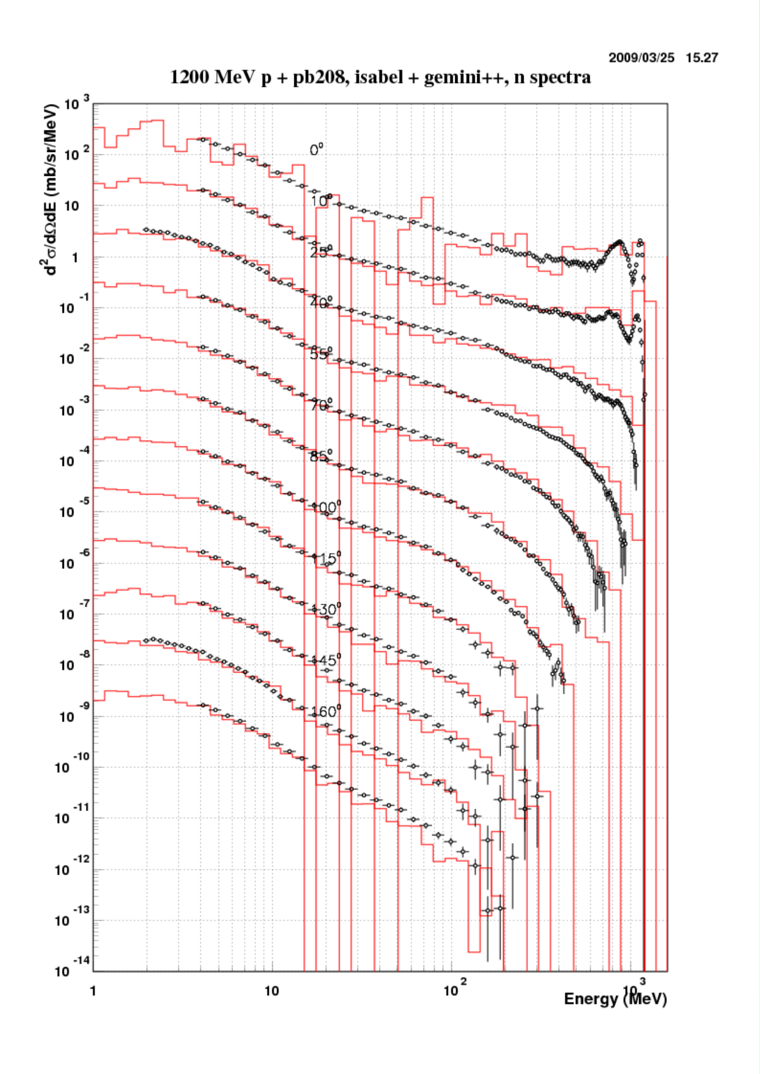
$^{208}Pb(p,X)$, 1000 MeV



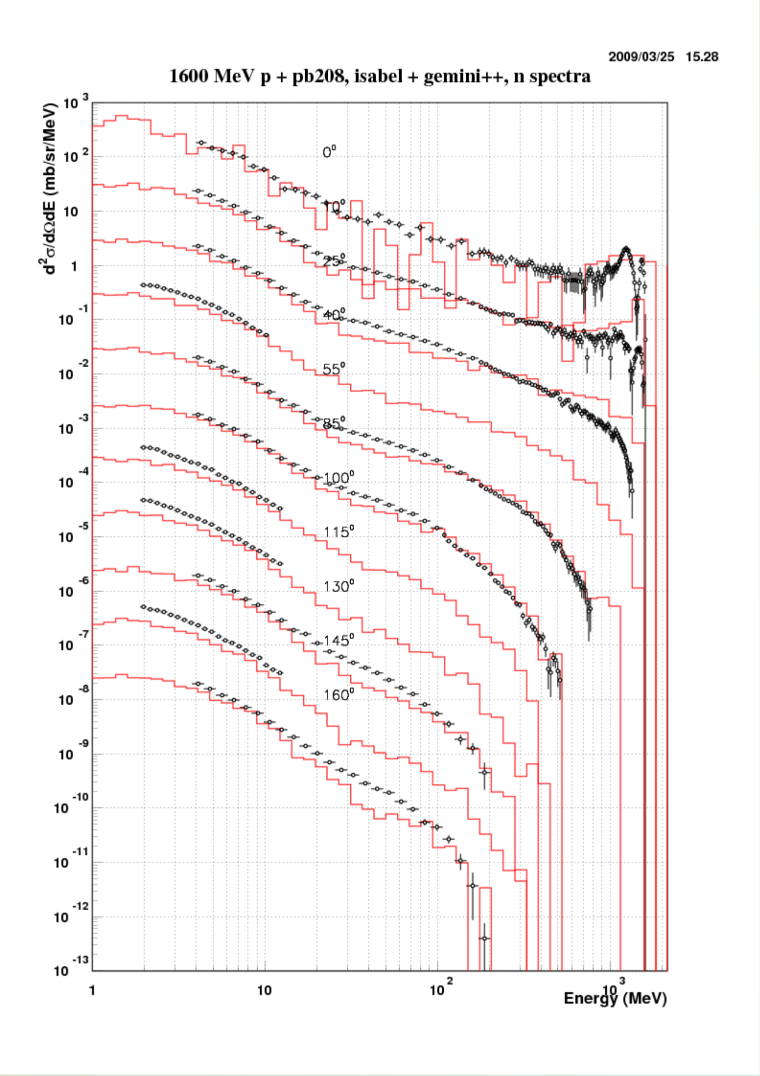
$^{208}Pb(p,X)$, 1000 MeV



^{208}Pb(p,X)n, 1200 MeV



$^{208}Pb(p,X)n$, 1600 MeV



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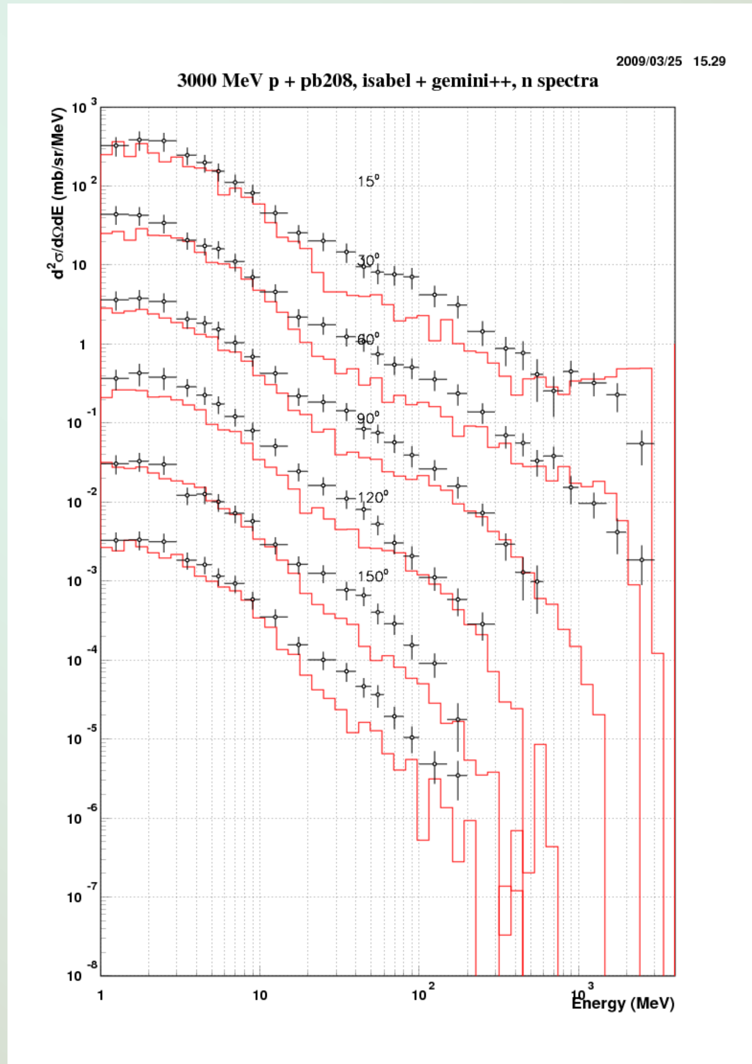
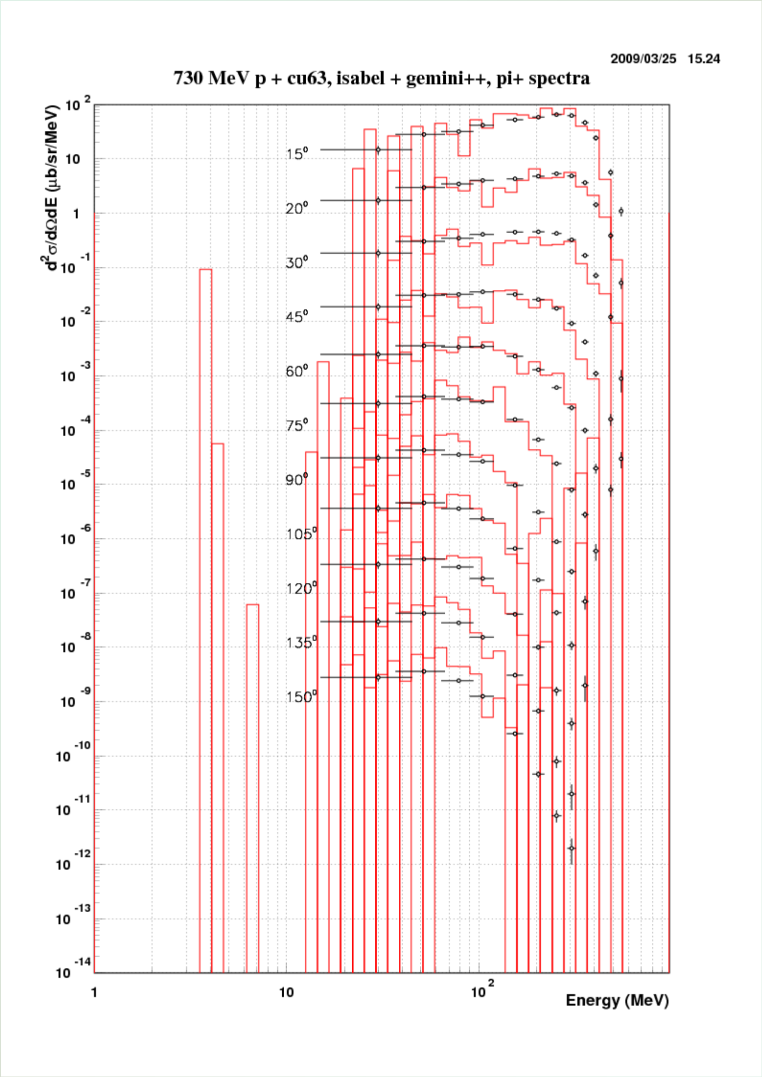
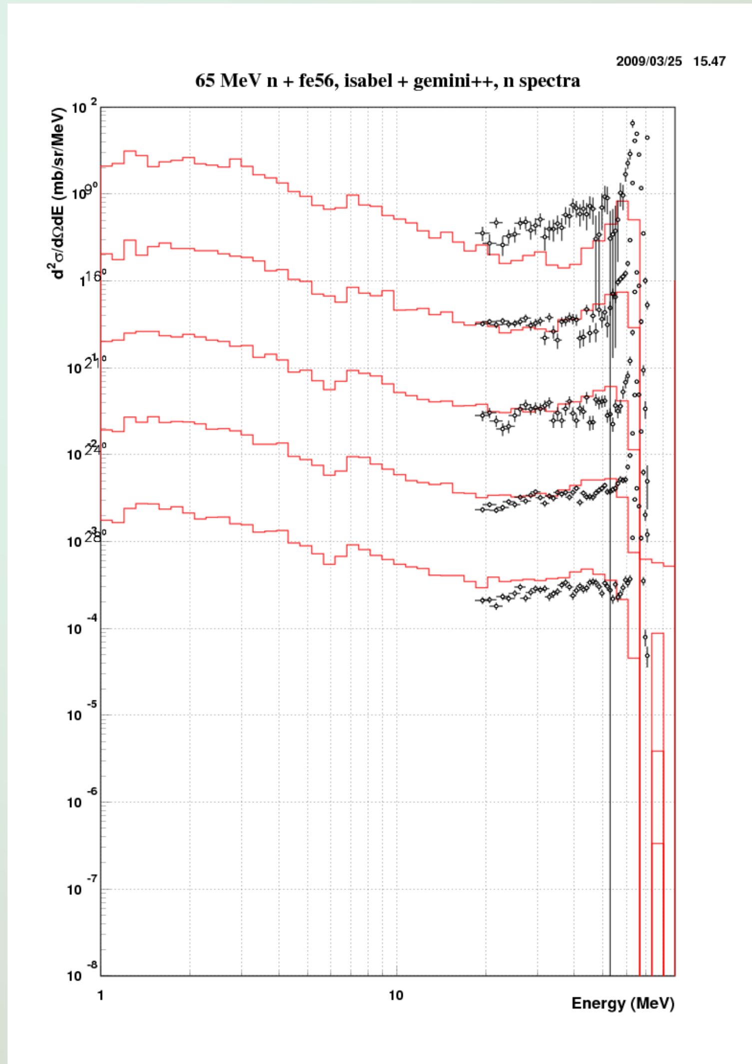
^{208}Pb(p,X)n, 3000 MeV



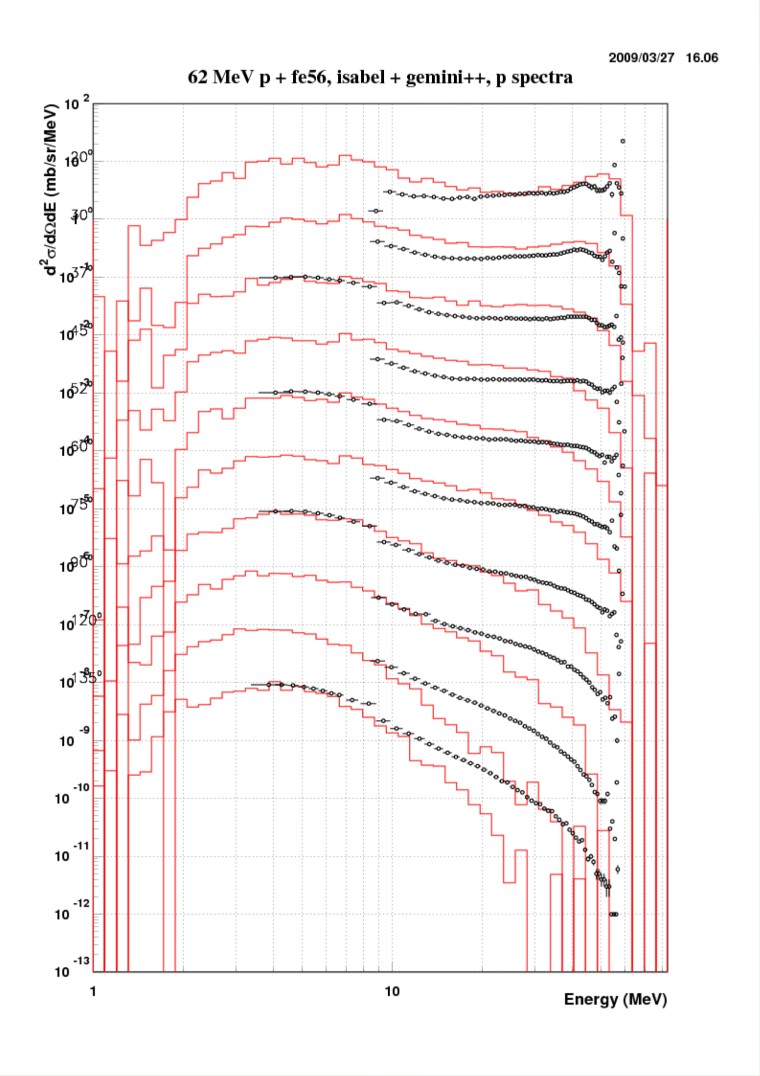
$^{63}Cu(p,X)\pi^+$, 730 MeV



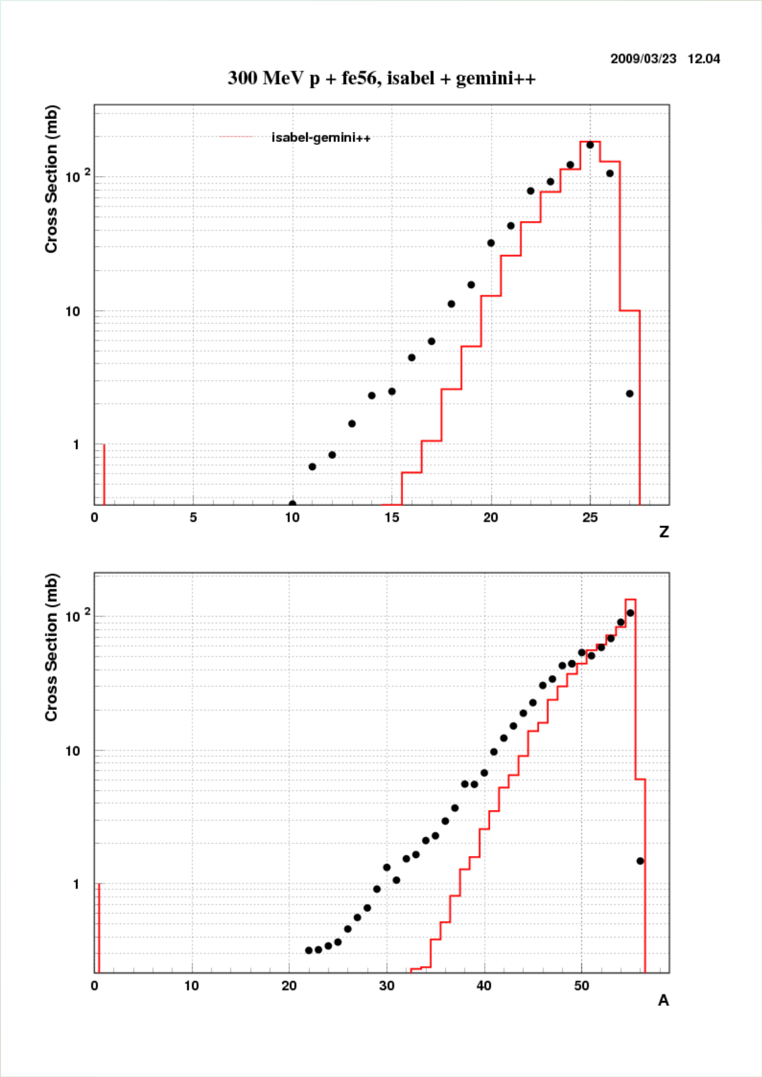
$^{56}Fe(n,X)n$, 65 MeV



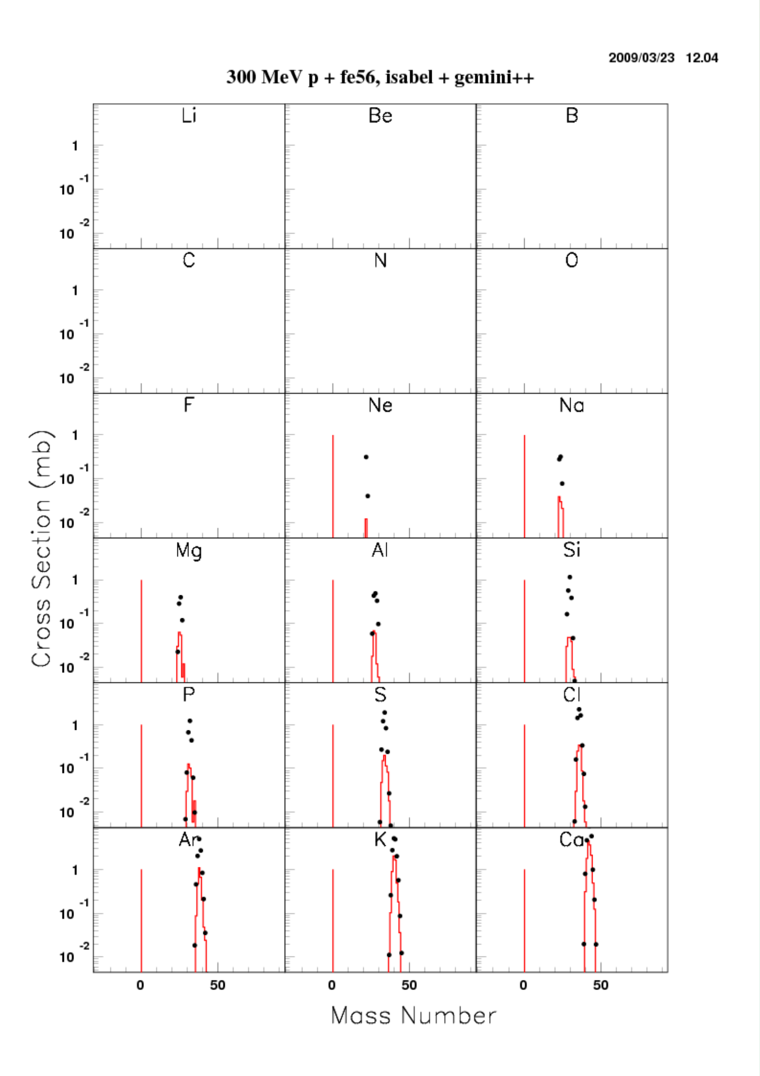
$^{62}Fe(p,X)p$, 62 MeV



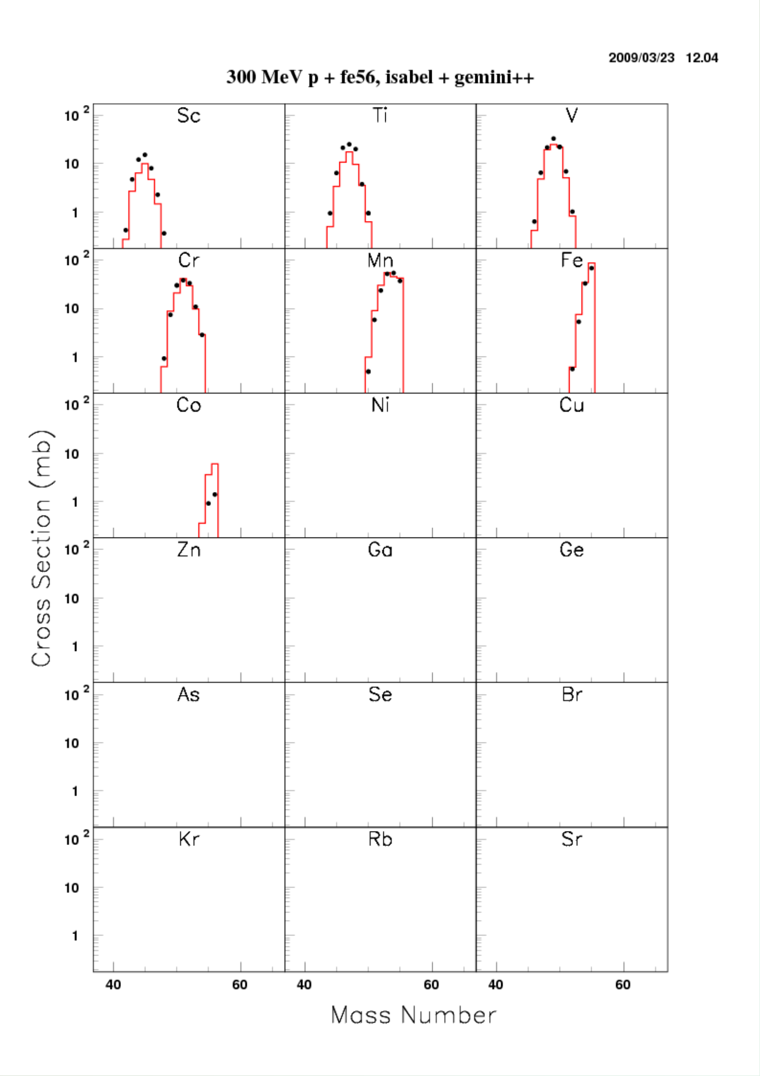
$^{62}Fe(p,X)$, 300 MeV



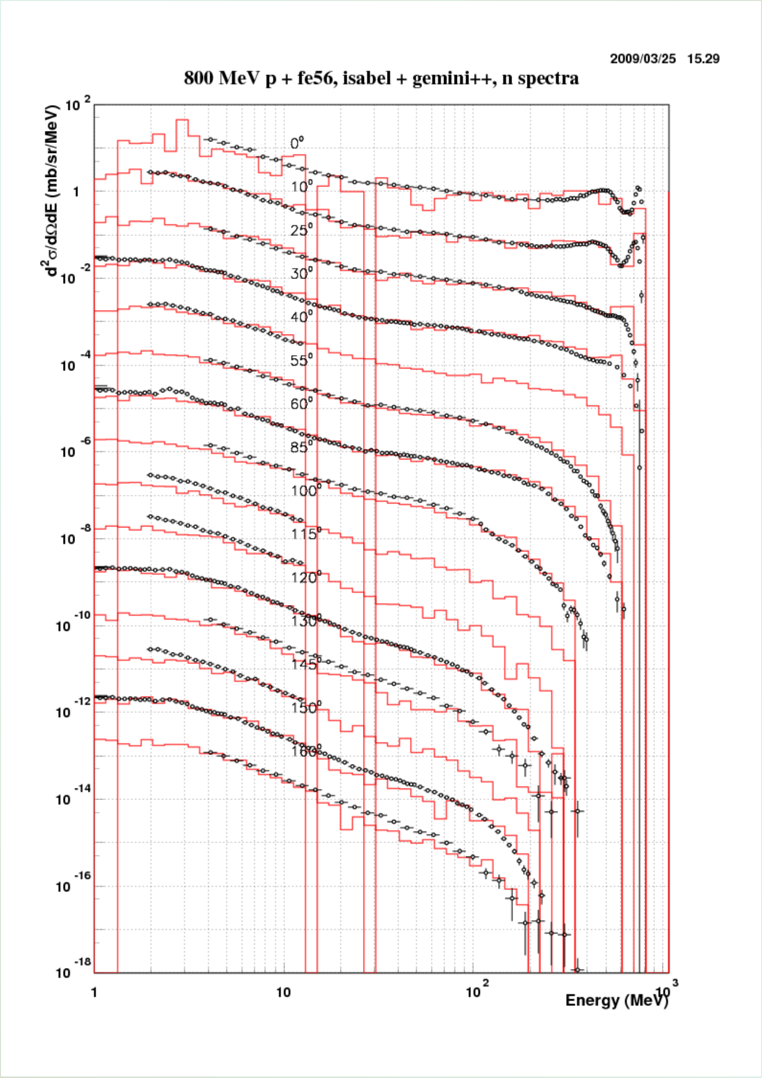
$^{62}Fe(p,X)$, 300 MeV



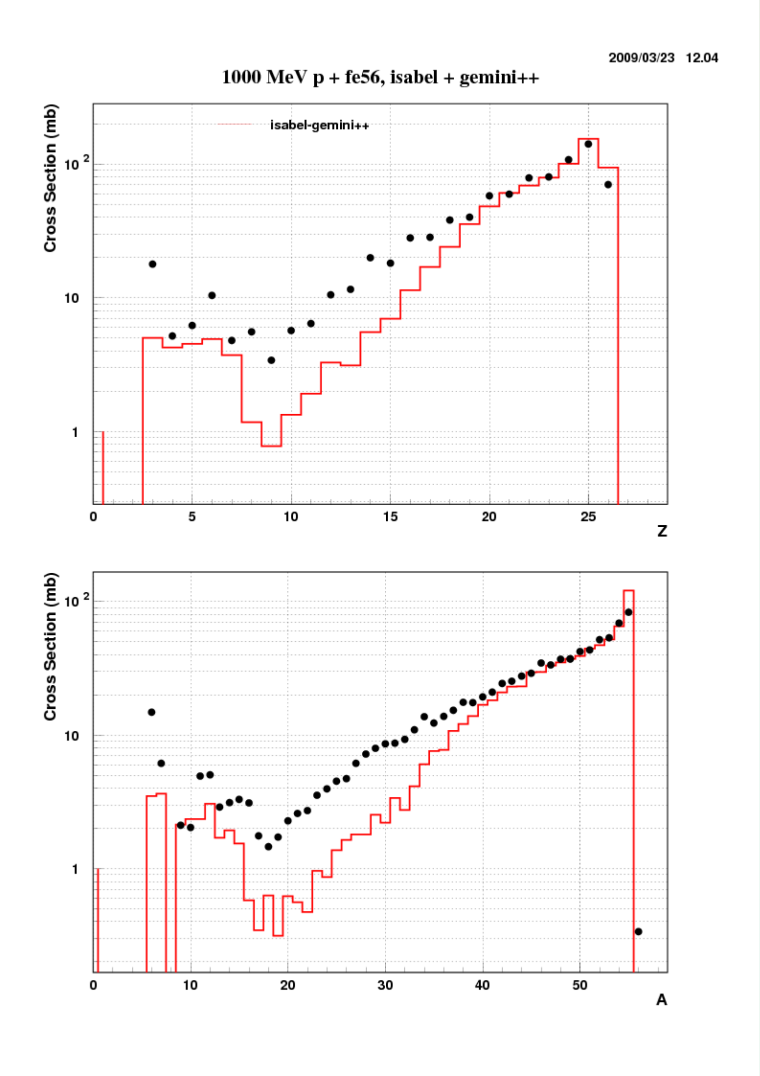
^{62}Fe(p,X), 300 MeV



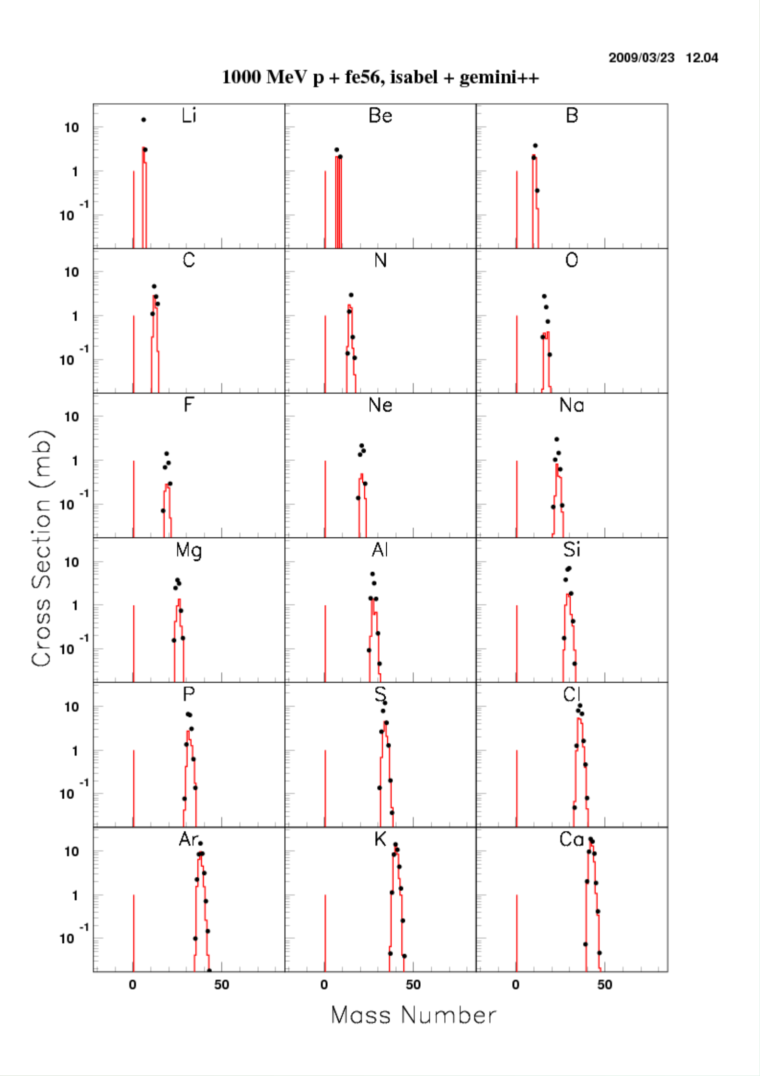
$^{62}Fe(p,X)n$, 800 MeV



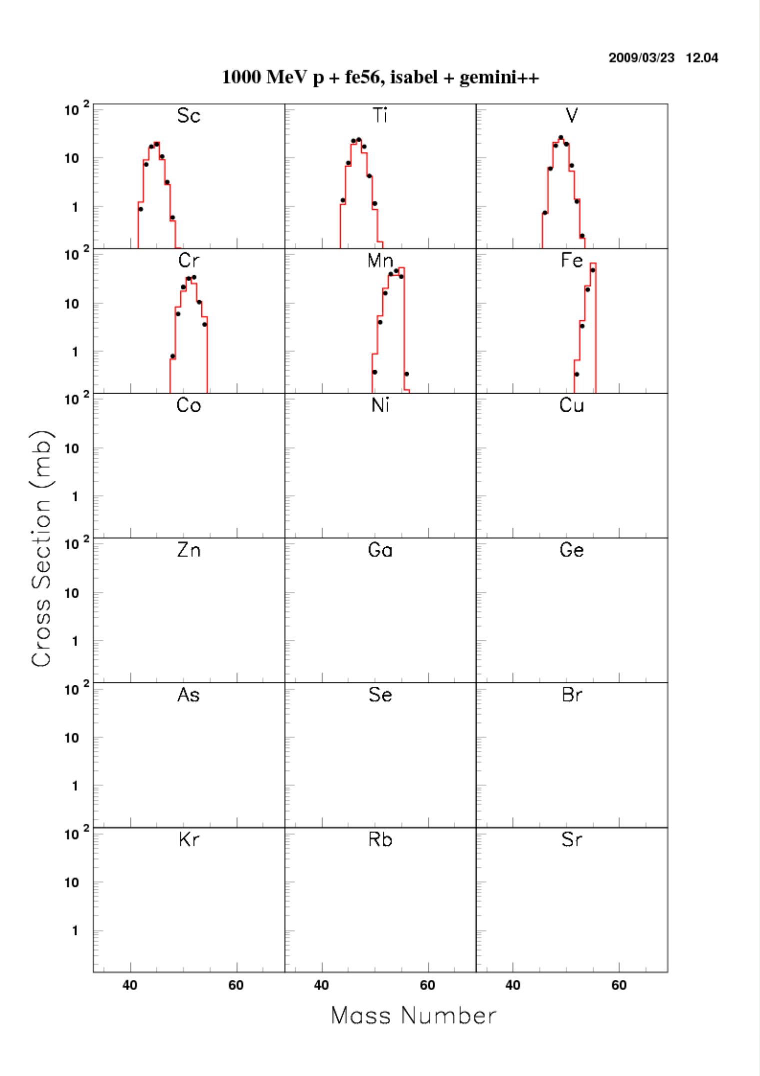
^{62}Fe(p,X), 1000 MeV



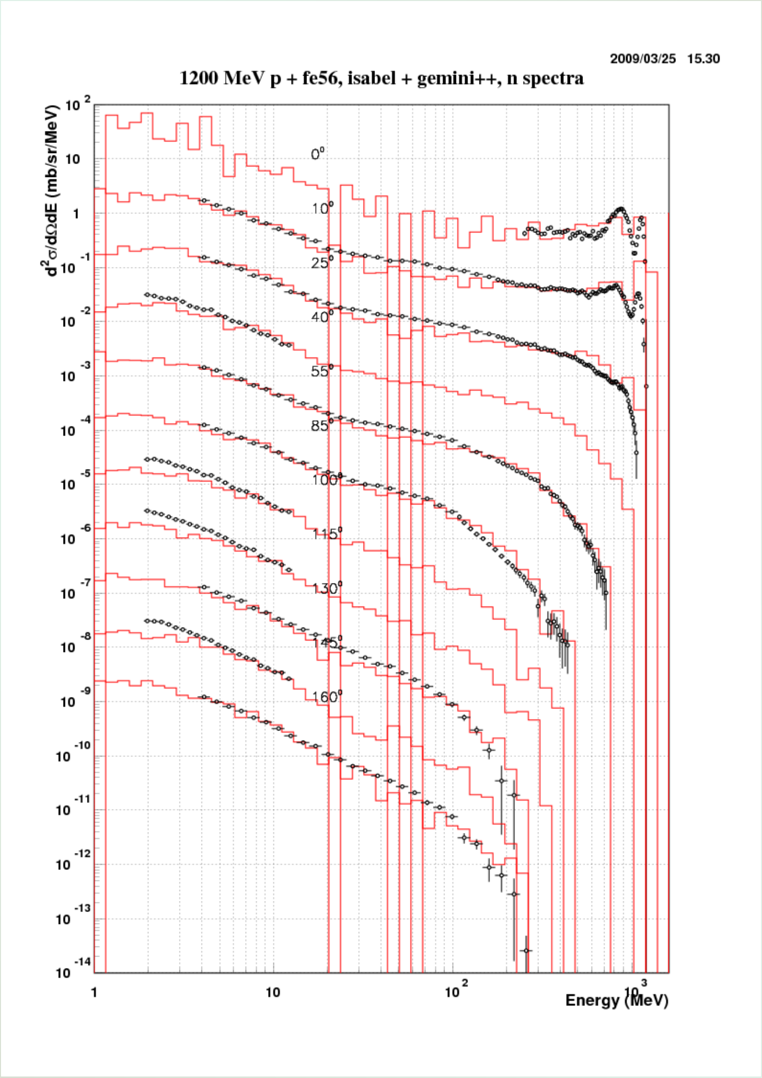
$^{62}Fe(p,X)$, 1000 MeV



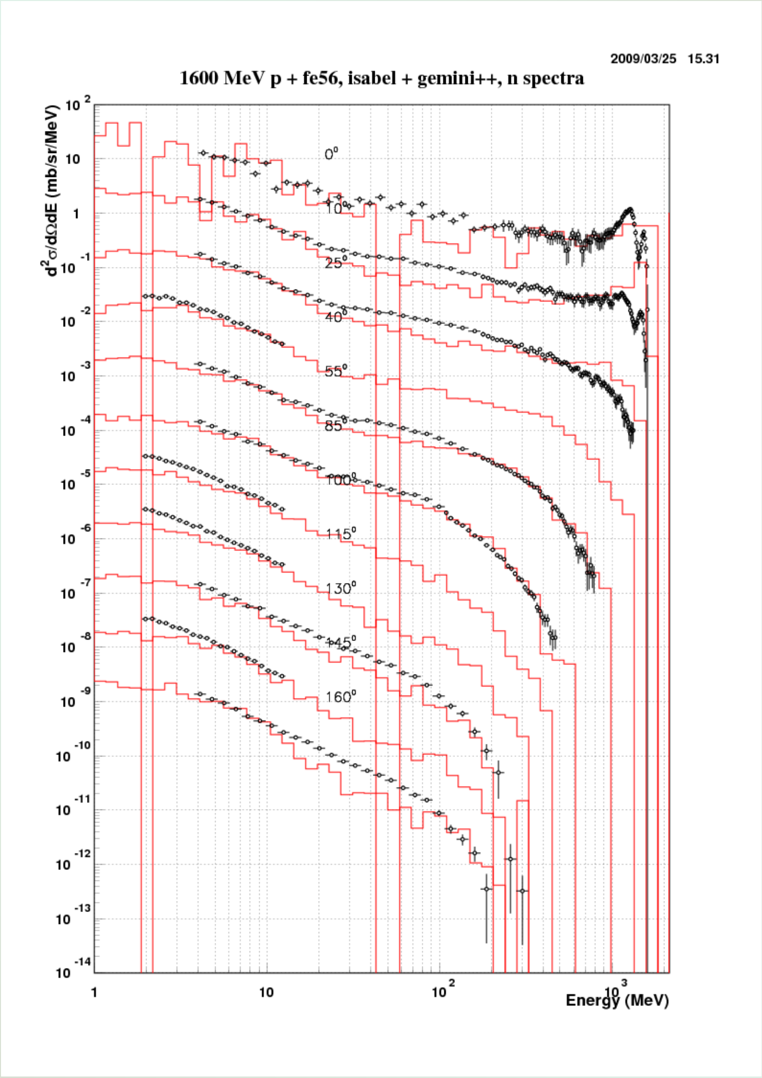
$^{62}Fe(p,X)$, 1000 MeV



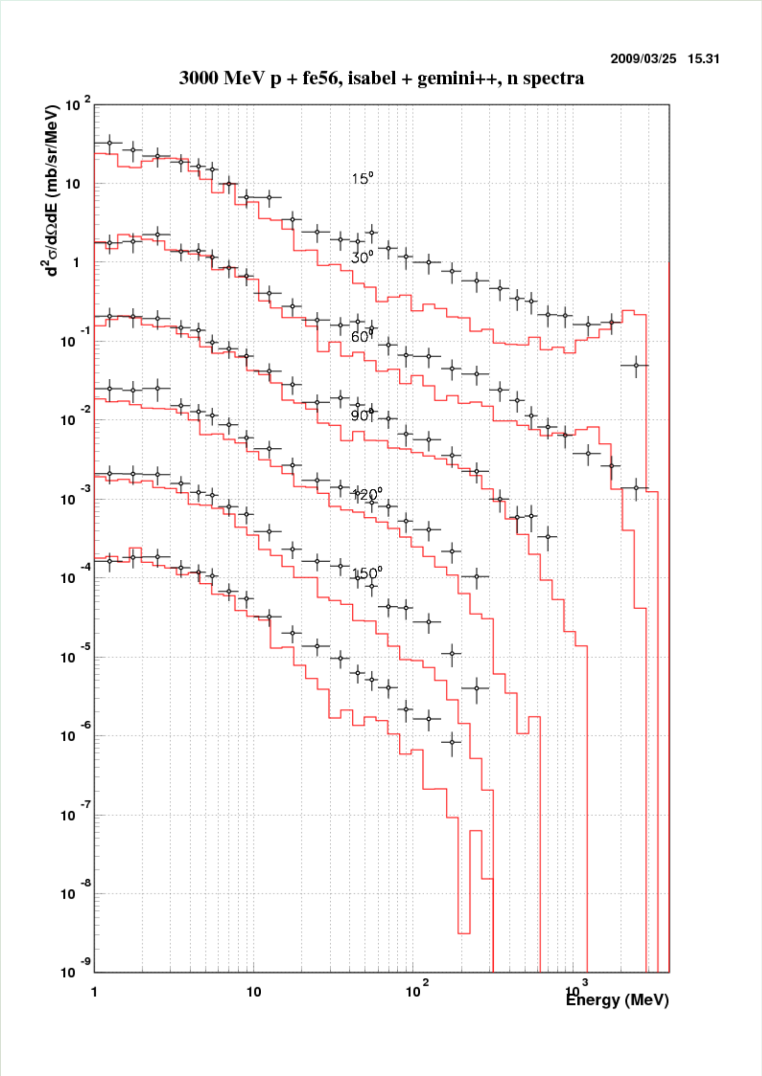
$^{62}Fe(p,X)n$, 1200 MeV



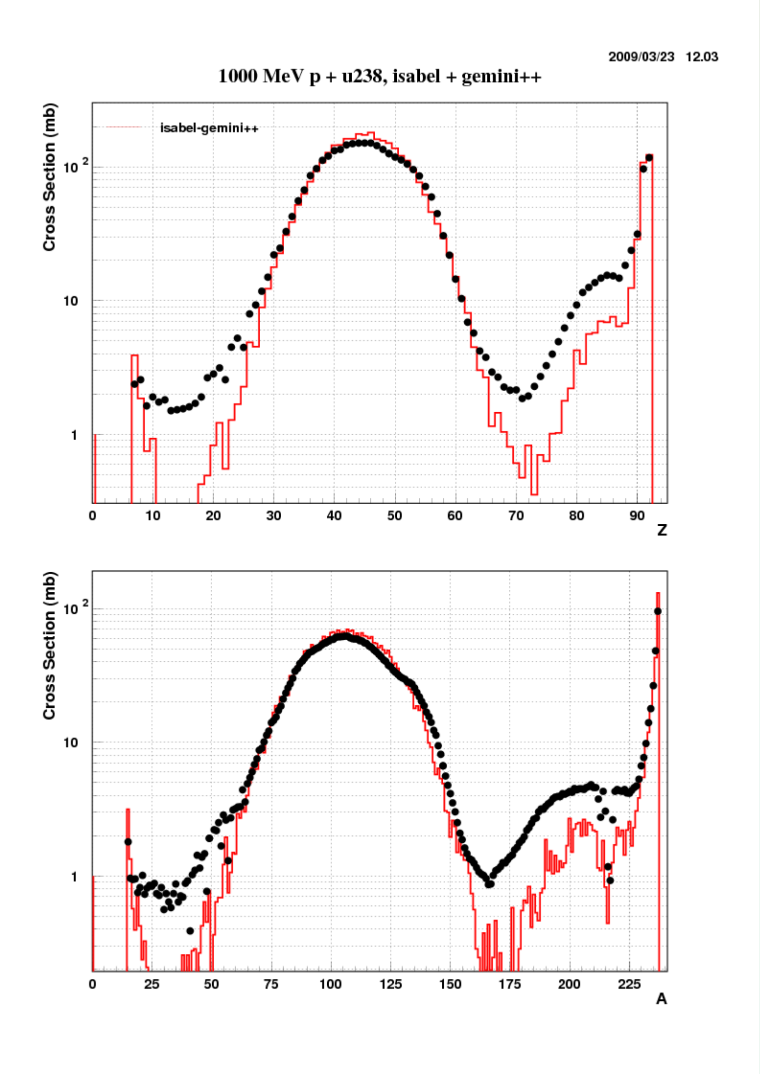
$^{62}Fe(p,X)n$, 1600 MeV



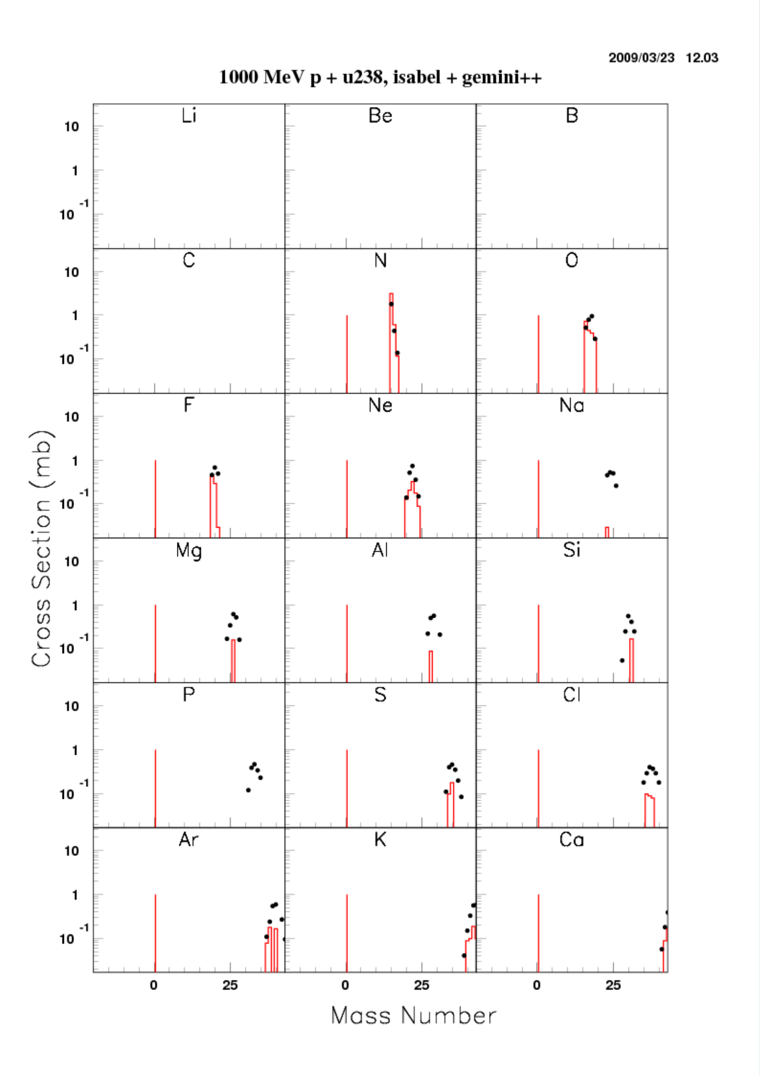
$^{62}Fe(p,X)n$, 3000 MeV



^{238}U(p,X), 1000 MeV



$^{238}U(p,X)$, 1000 MeV



Thank You!

Questions, Remarks?