RADIATION FROM THIN, STRUCTERED TARGETS

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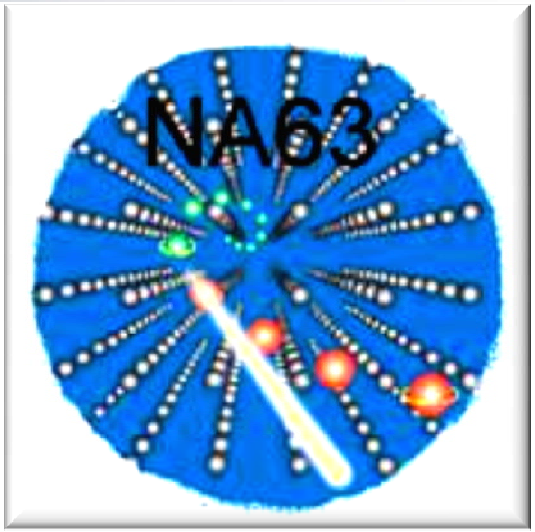
CERN NA63, Istanbul University

October, 2008

NA63

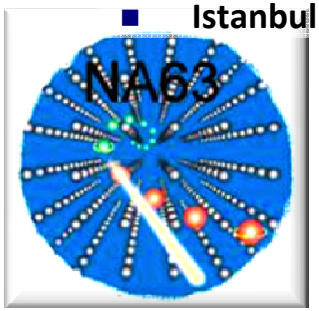
"Electromagnetic Processes in Strong Crystalline Fields"

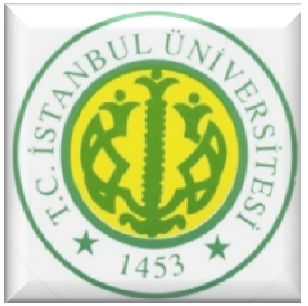


- Approved in 2007, Participants:
- Aarhus University
  - Ulrik Uggerhoej (Spokesperson), Helge Knudsen, Heine Thomsen
- University of Florence
  - Pietro Sona
- Johennesburg University
  - Simon Connell, Sergio Ballestrero
- Free University, Amsterdam
  - Tjeerd Ketel
- Universidada de Coimbra
  - Allessio Mangioretti
- Istanbul Unversity

Papers by NA63:

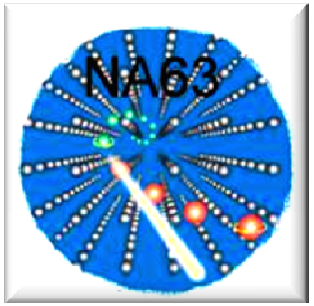
- **Direct measurement of the Chudakov effect**, Phys. Rev. Lett. 100, 164802 (2008)
- **On the macroscopic formation length for GeV photons**, submitted to Phys. Lett. B
- **Addressing the Klein paradox by trident production in strong crystalline fields**, in preparation (2008)

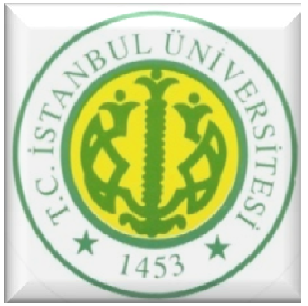




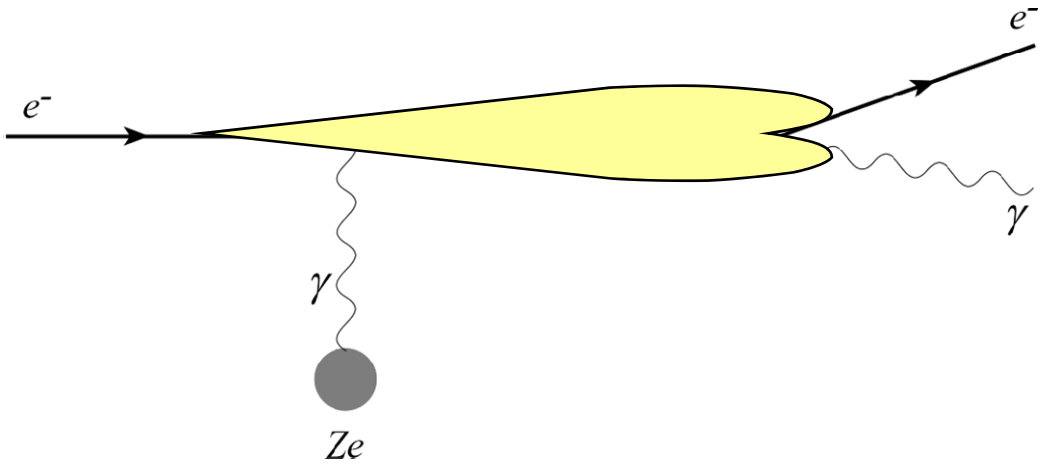
Outline

- Before 2004
  - Formation length, LPM effect and observations
  - TSF effect and observations
  - Structured targets
- CERN NA63: Experiments with thin foils
  - Aim and outcome: 2004 experiment, with test beam
  - Results from NA63, 2007
  - Preliminary “signs” from recent experiment





Formation length



Bremsstrahlung

$$\frac{d\sigma_{BH}}{d\hbar w} \sim \frac{4}{3nX_o}\frac{1}{\hbar w}\left(1-\frac{\hbar w}{E}+\frac{3}{4}\left(\frac{\hbar w}{E}\right)^2\right)$$

$$\frac{1}{X_0} = 4n\alpha\, r_e^{\,2} Z^2 \ln(183Z^{-1/3})$$

Bethe, Heitler 1936

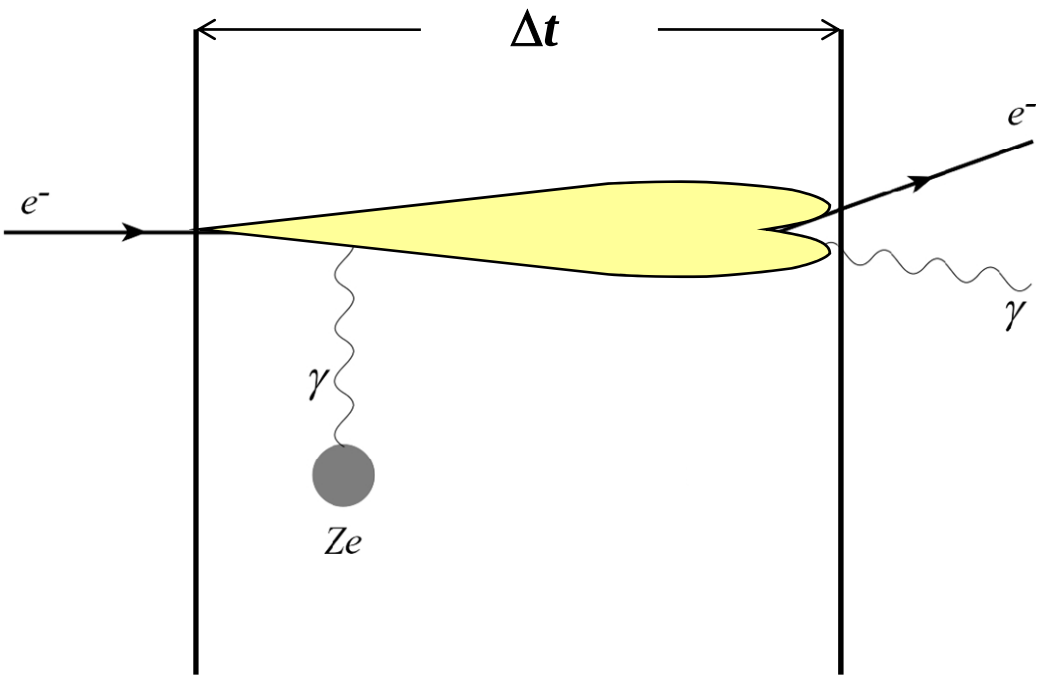
Formation length

$$l_f \sim 2\gamma^2 c/\omega$$

$$l_f = \frac{2\hbar c\gamma^2(E-\hbar\omega)}{E\hbar\omega}$$

LPM effect

"Suppression of low energy photon yield due to Multiple Scattering"



Multiple scattering length

$$l_\gamma = \frac{\alpha}{4\pi} X_0$$

LPM effect

$$l_f > l_\gamma \rightarrow k \leq \frac{E^2}{E + E_{\mathrm{LPM}}}$$

$$E_{LPM} = \frac{m^2 c^3 \alpha}{4\pi\hbar} X_0 \sim X_0 \cdot 7.7 \ \text{TeV/cm}$$

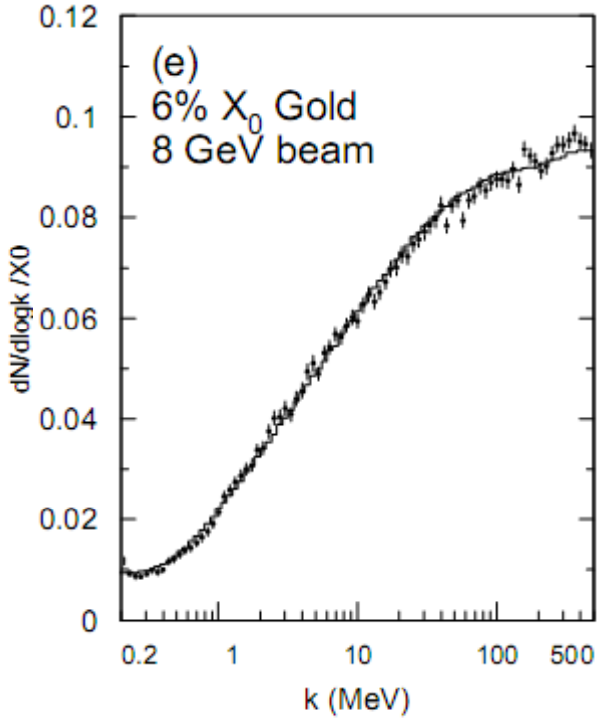
Landau, Pomeranchuk 1953

Condition for LPM effect

$$l_\gamma < l_f < \Delta t$$

LPM effect observations

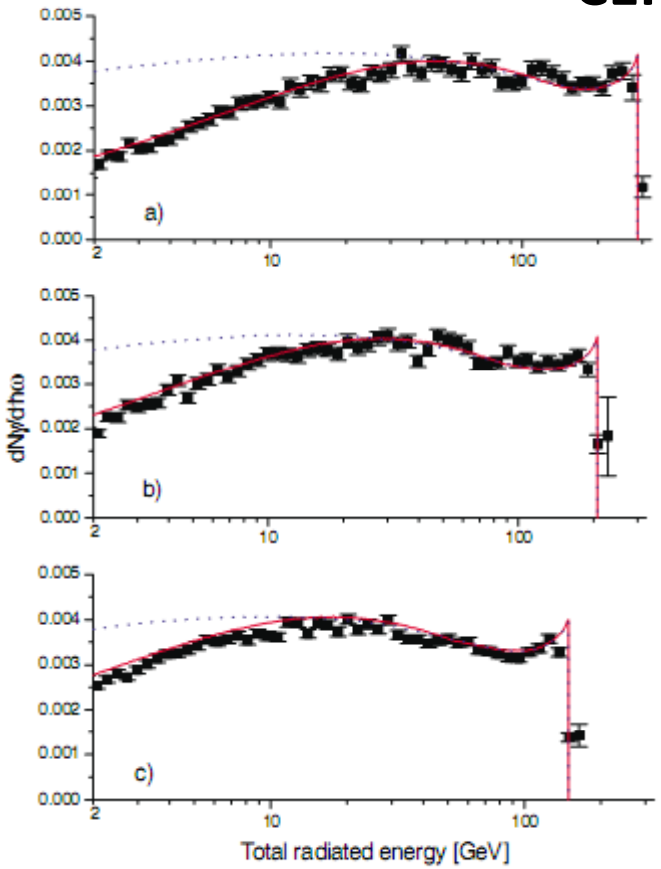
SLAC, 1994



Physical Review Letters, 75(10), 1949, (1995)

6% X_o Au 8GeV beam

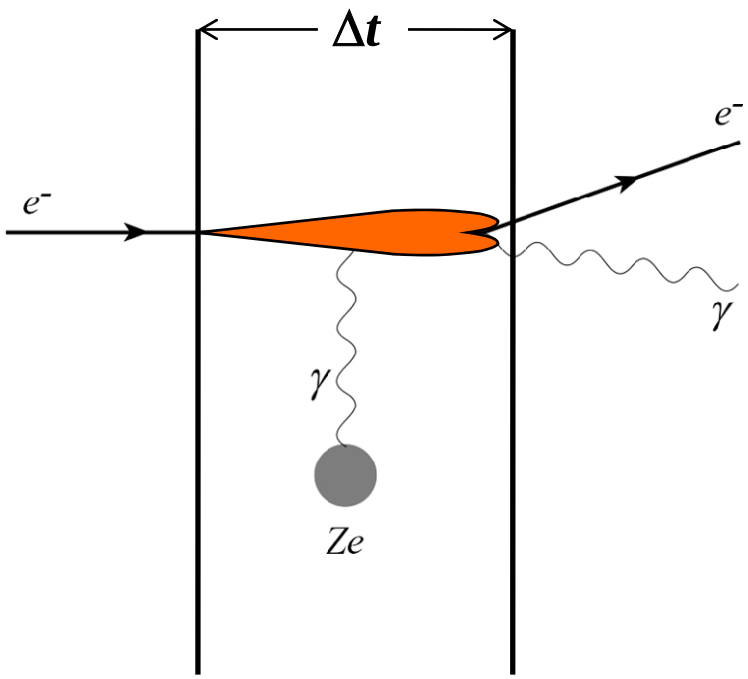
CERN, 2001



Physical Review Letters, 91(1), 014801, (2003)

4.36% X_o Ir 287,249,207 GeV beam

TSF effect



Reduced multiple scattering: "Suppression of bremsstrahlung in a thin layer of matter"

Ternovskii 1960, Shul'ga, Fomin 1978

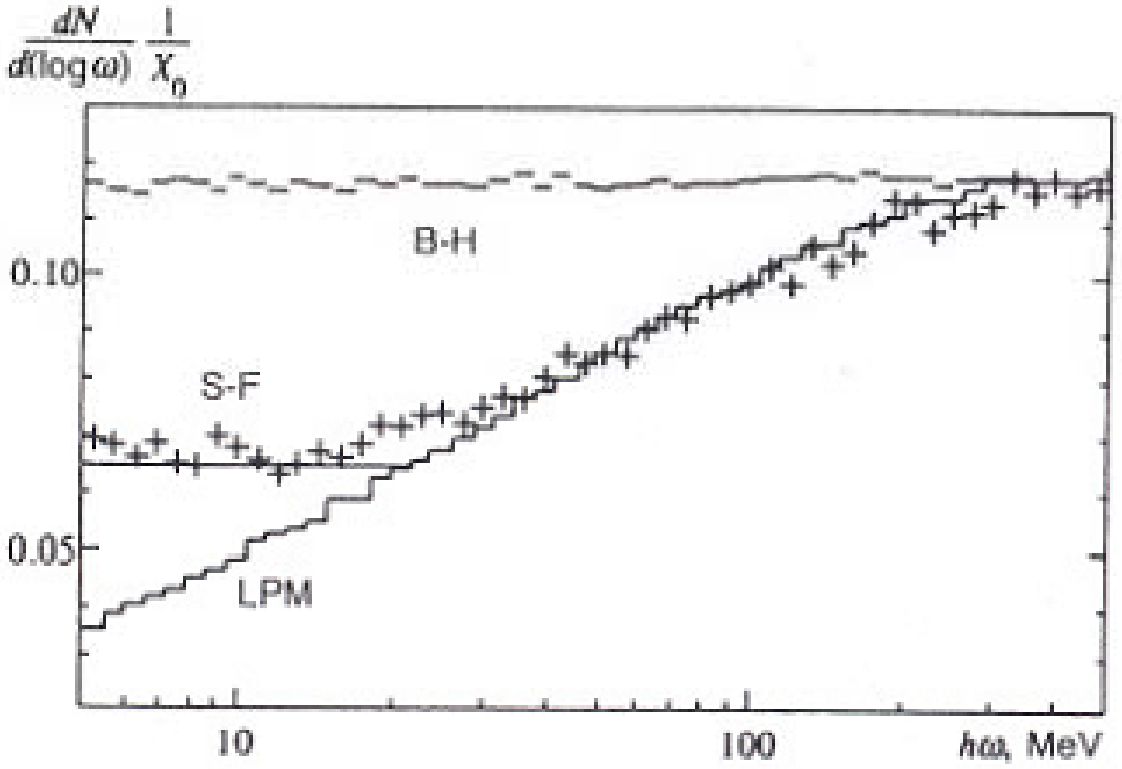
Condition for TSF effect

$$l_\gamma < \Delta t < l_f$$

$$\hbar\omega < \hbar\omega_{\mathrm{TSF}} = \frac{E}{1+\dfrac{\Delta t}{2\gamma\lambda_c}}$$

…approximately, recoil not included

TSF effect observation



SLAC 1994 Data, 0.7% X_o Au 25GeV beam

Shul'ga, Fomin: JETP, 86(1), 32 (1998)

Radiation from

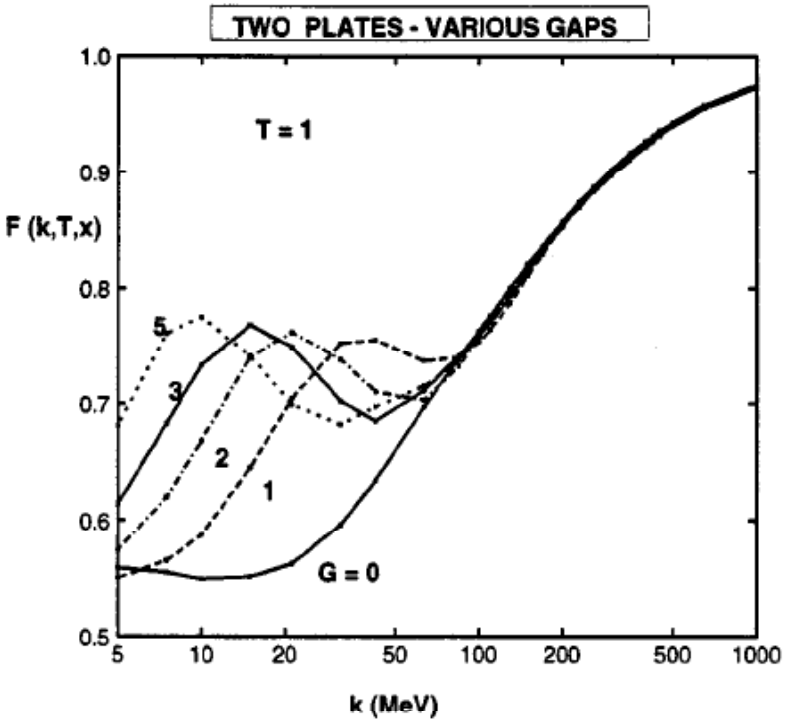
Structured Targets: “Sandwich”

- “Radiators composed of seperated plates or of a medium varying radiation length can exhibit coherence maxima and minima in their photon spectra”

  Blankenbecler, Drell: PRD 55, 190, (1997)

- “The interference pattern appears when the formation length is longer than the thickness of one plate”

  Baier, Katkov: PRD 60, 076001, (1999)



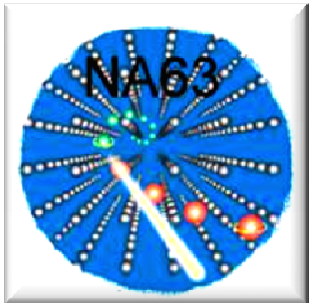
2 foils, 0.7%X_o Gold, 25 GeV

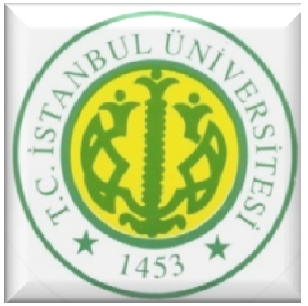
CERN NA63 Experiment

"Electromagnetic processes in strong crystalline fields"

- Questions 2004:
  - Is it possible to regain BH spectrum with thinner foils? i.e. behaving as a single scatterer…
  - What if $l_\gamma \approx \Delta t < l_f$?
  - Au: X_o= 3.344mm, l_γ = 1.942μm

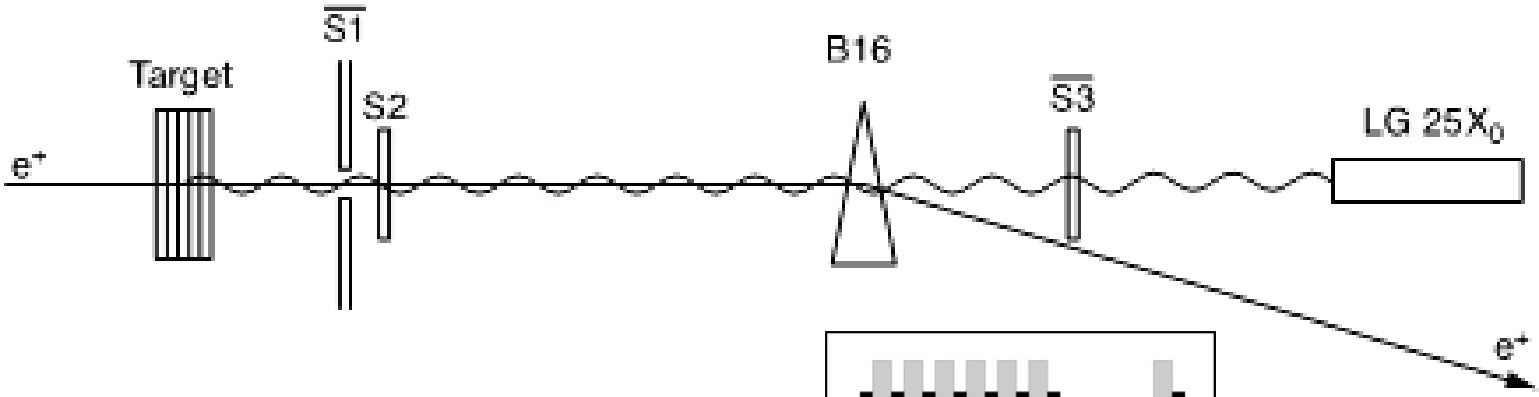
    →Choose 2μm Au, 0.06% X_o
  - What about the "sandwich" effect?



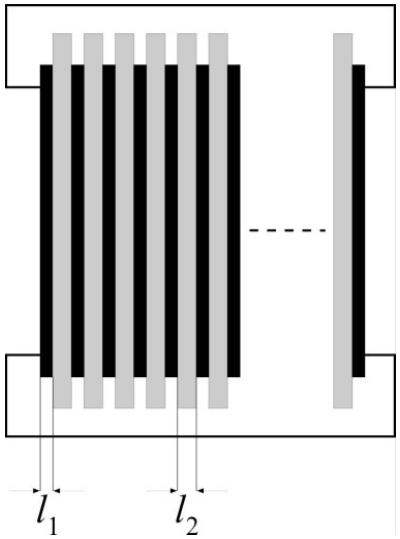


NA63 Setup

- Setup for “sandwich” experiments



- Background: ~3% X_o
- And the target:
  - 53(2μmAu+30μmLDPE)
  - Au ~3.39% X_o
  - LDPE ~0.4% X_o

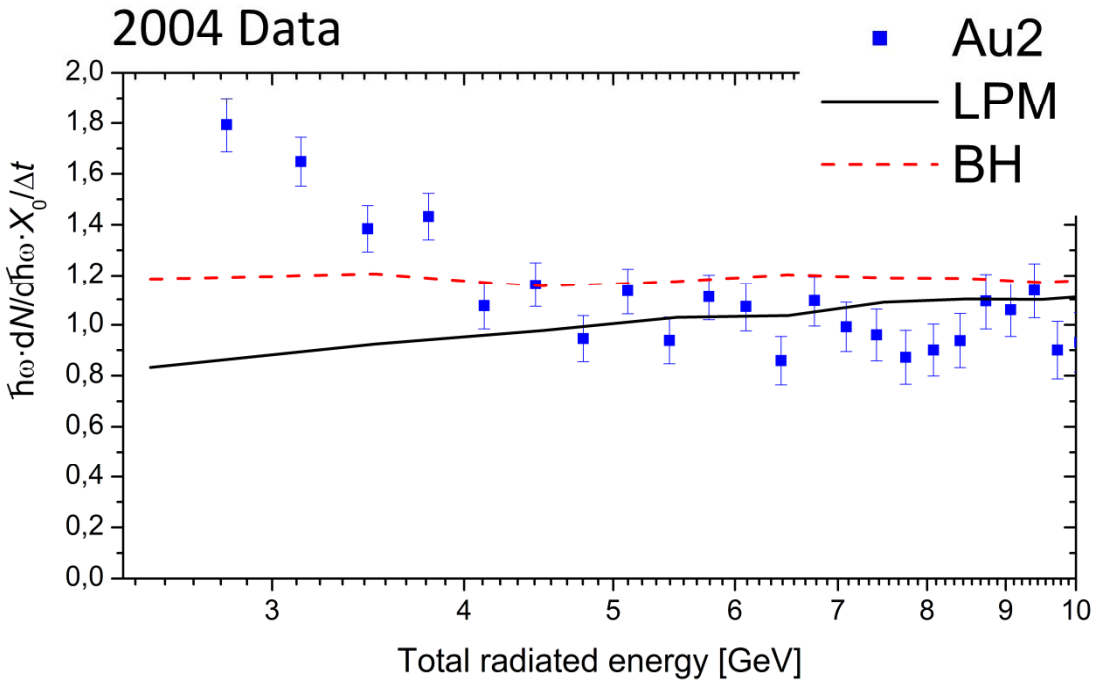


Is there any “sandwich” effect?

2004 Data

- Power spectrum for E = 180 GeV
- BH, LPM curves Geant* simulations
- Δt = 1.45 ± 0.02μm from BH fit, ~30%
- TSF effect? NO!
- Transition radiation?

→May be…



•Geant simulation recompiled with LPM effect calculation

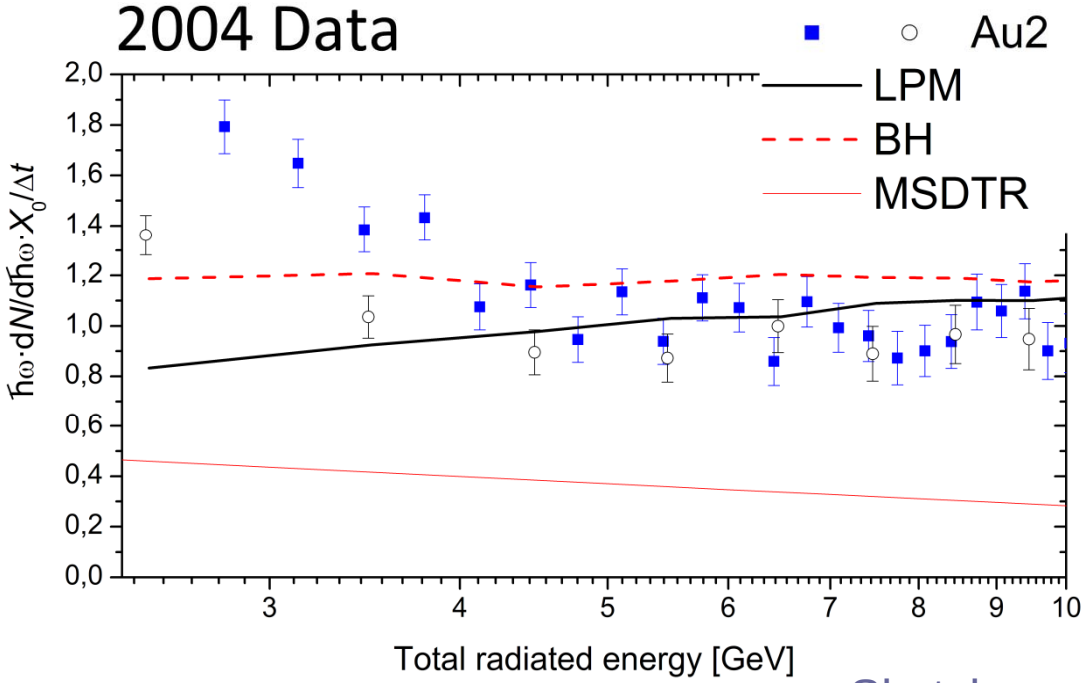
Physical Review D (72), 112001,(2005)

2004 Data

- Transition radiation in the very soft part, BUT:

  "Multiple scattering dominated transition radiation (MSDTR)"

  →***Baier, Katkov: PRD (56), 1998***



- Results: 1. LPM suppression dissapears
  2. MSDTR?
  3. "Sandwich" effect?
  4. Target problems…

Sketch

Range

2007 Data

- E=206 GeV
- Target:

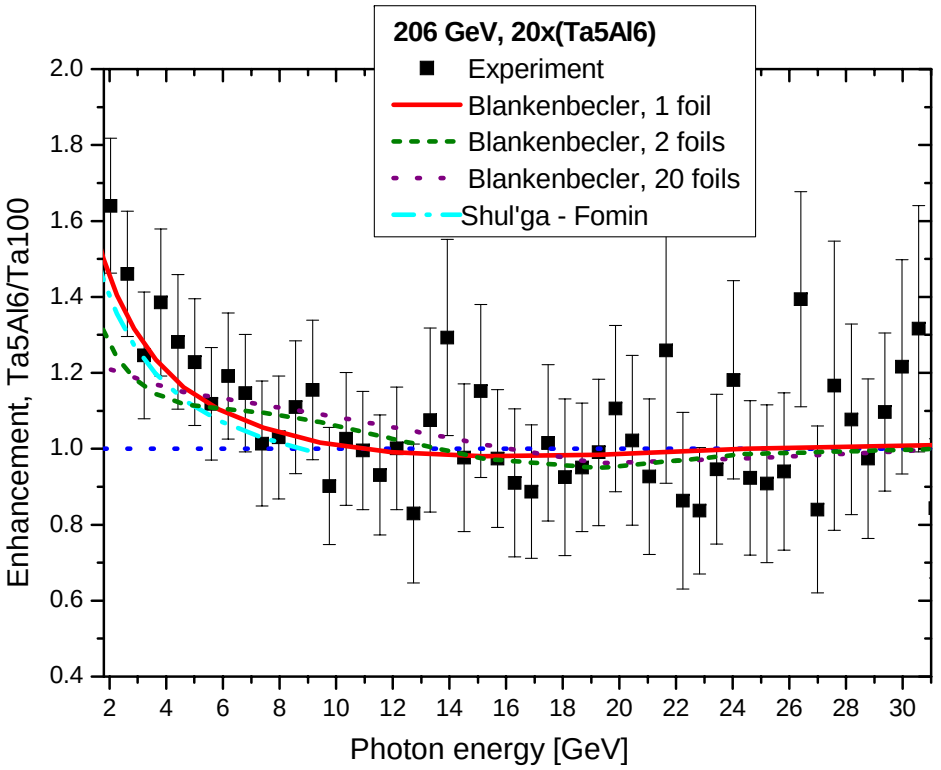
Ta: X_o= 4.094mm, l_γ = 2.378μm

→Choose 5μm Ta, 0.12% X_o

Firmer spacer: Aluminium

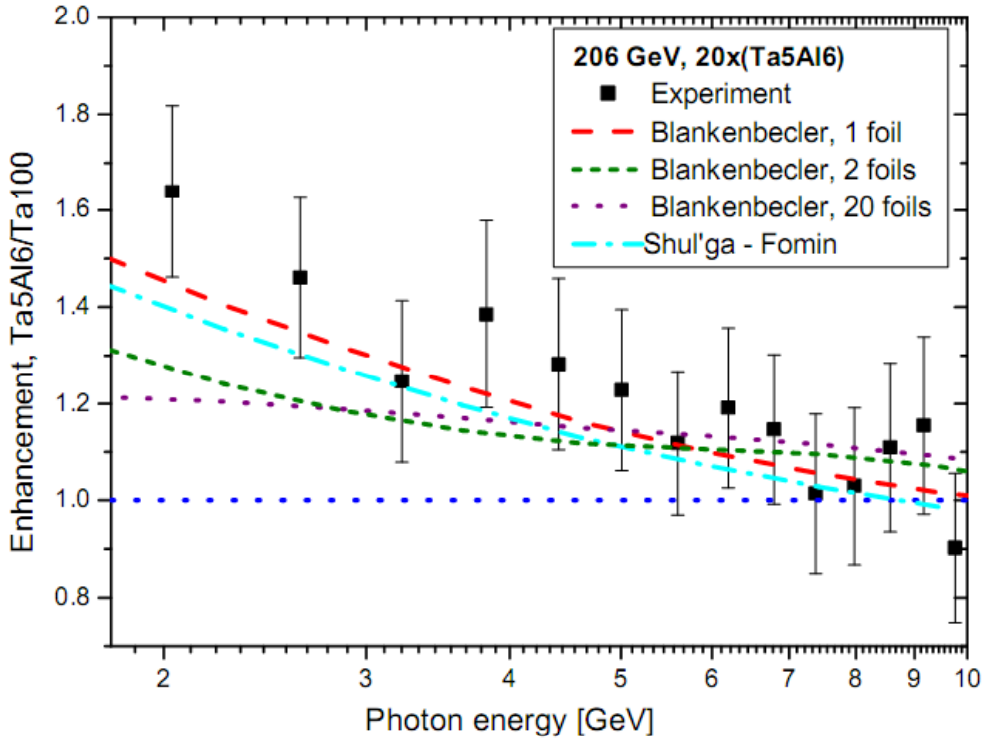
20(5μmTa+6μmAl)

Ta ~2.44% X_o ,Al ~0.12% X_o



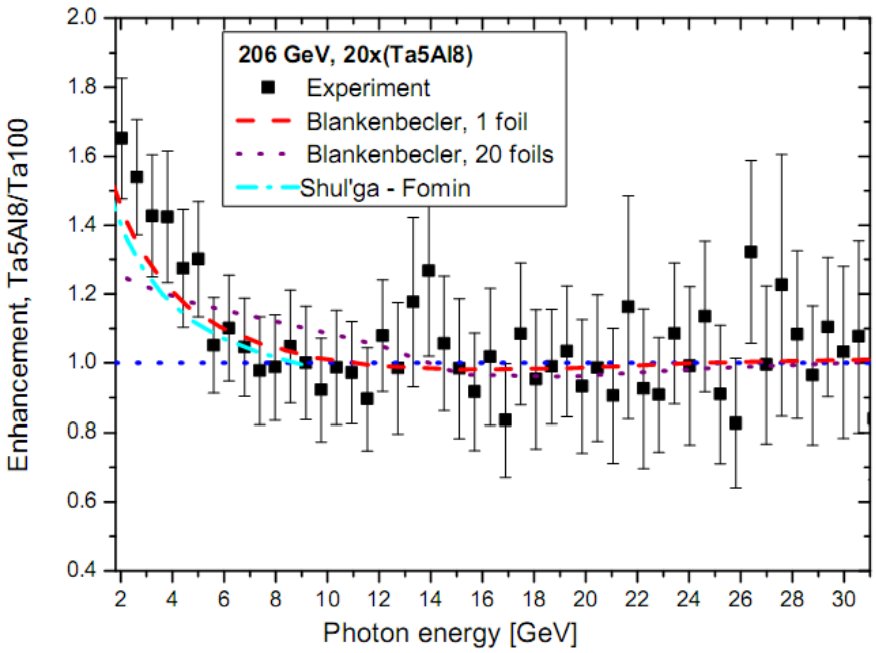
2007 Data

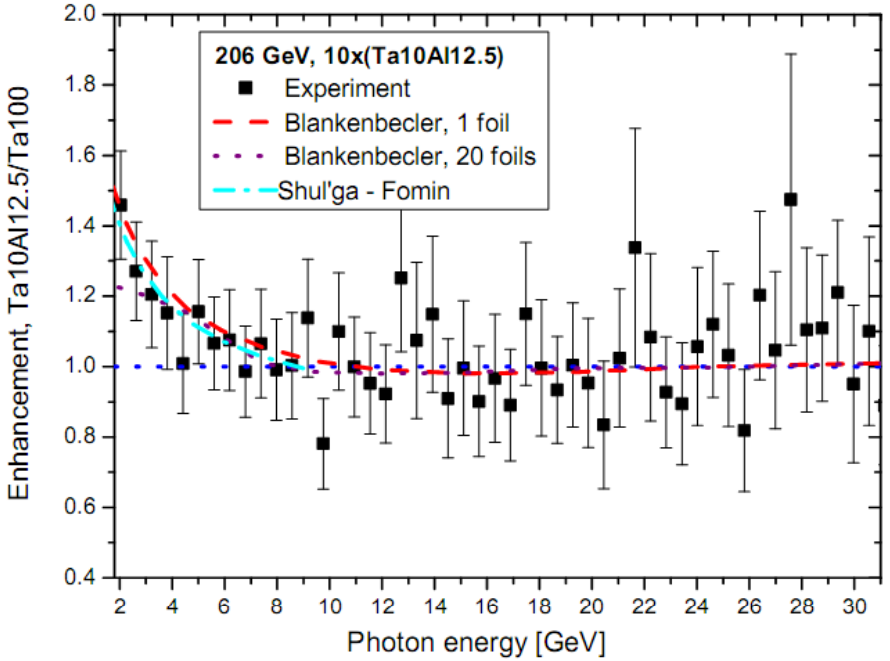
- Results:
  1. MSDTR negligable
  2. $\hbar\omega_{\mathrm{TSF}}$ ~12GeV
  3. Structure ?



2007 Data

- Similar results with different targets

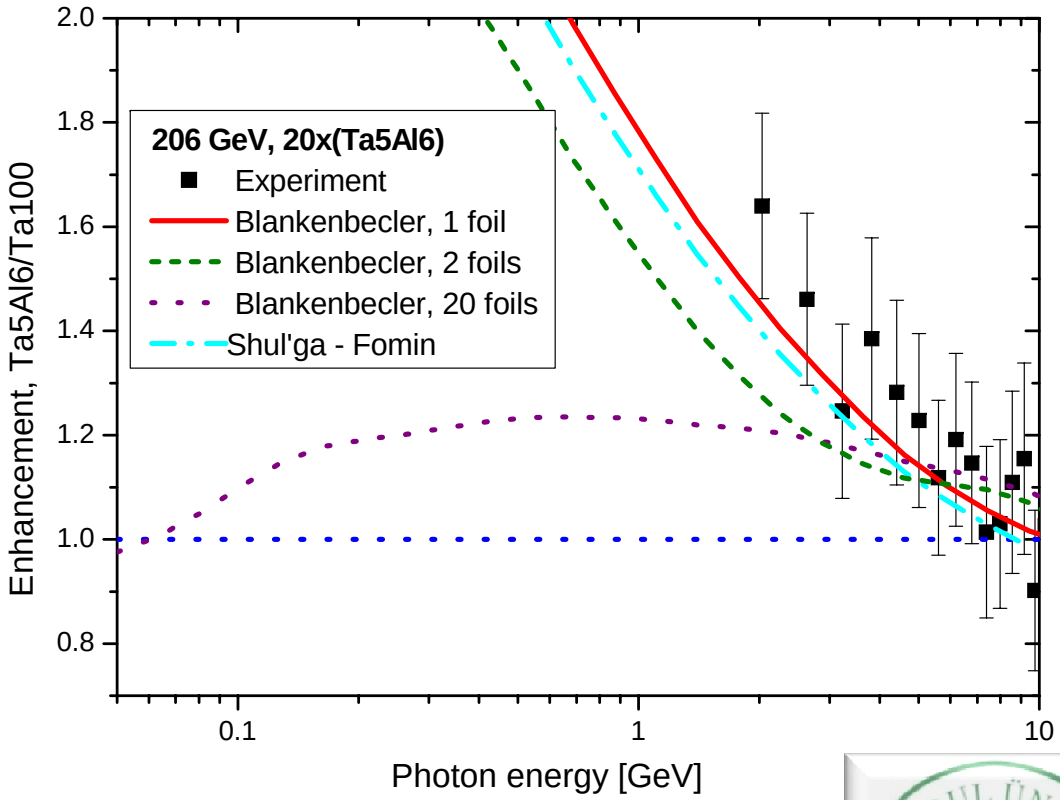




234GeV Graph

2007 Data: Result

- Change to BGO, go lower energies.
- 2008 Experiments done…



Thanks to…

- Our group members.
- Organizers…
- For your attention.