



The MAX-lab tagged photon facility



Contributions to this talk from:

Lennart Isaksson

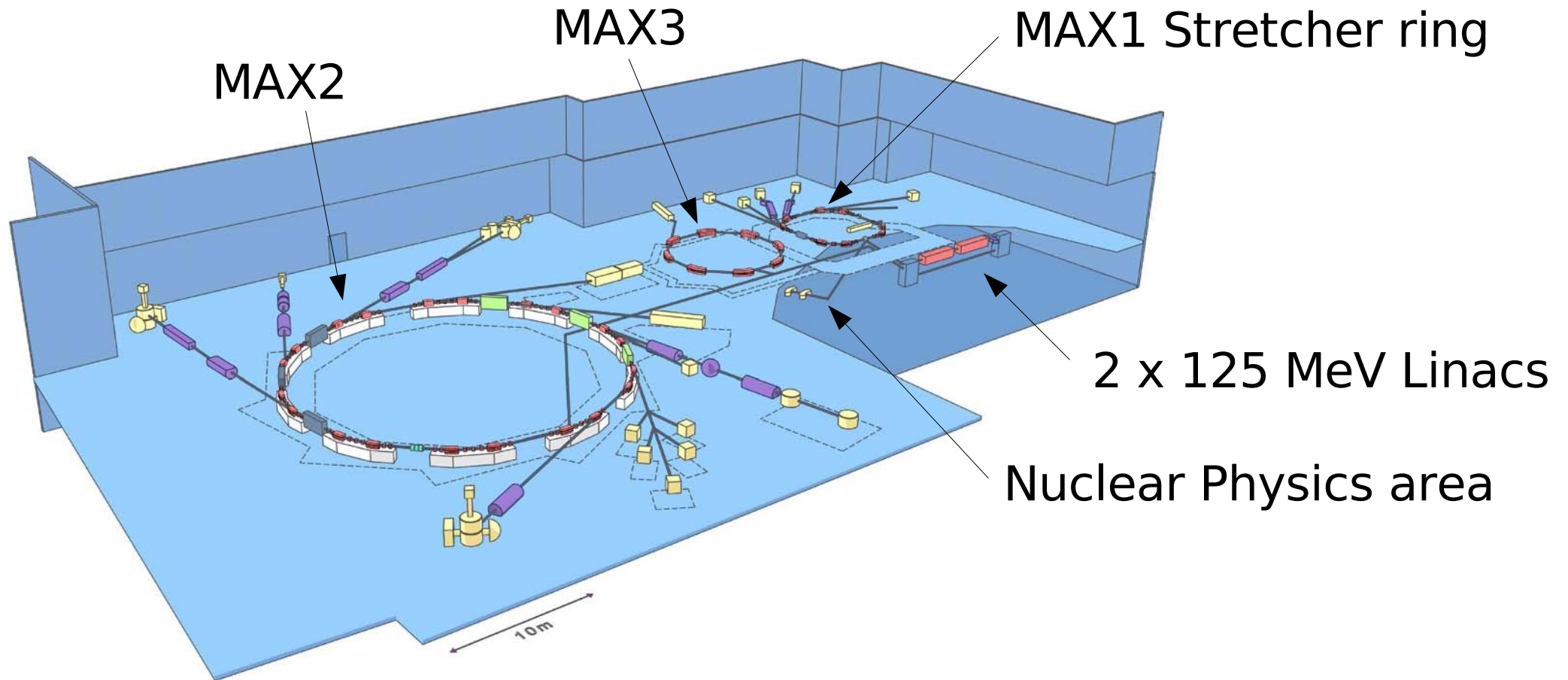
Kevin Fissum

Jason Brudvik

Bo Jakobsson

Grant O'Rielly

MAX-lab accelerator system

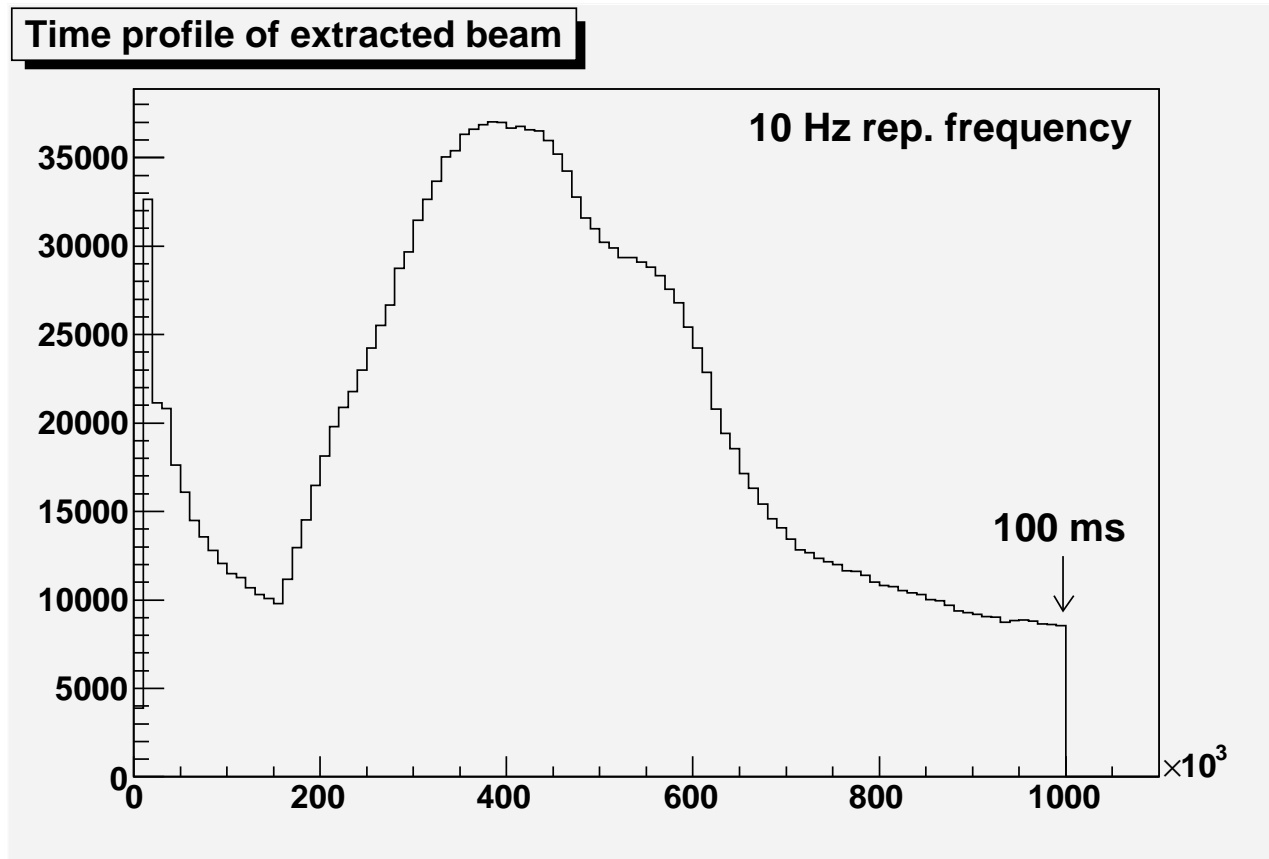


Parallel operation of the three rings

Nuclear Physics: ~45% of beam-time at MAX1

Pulse stretcher

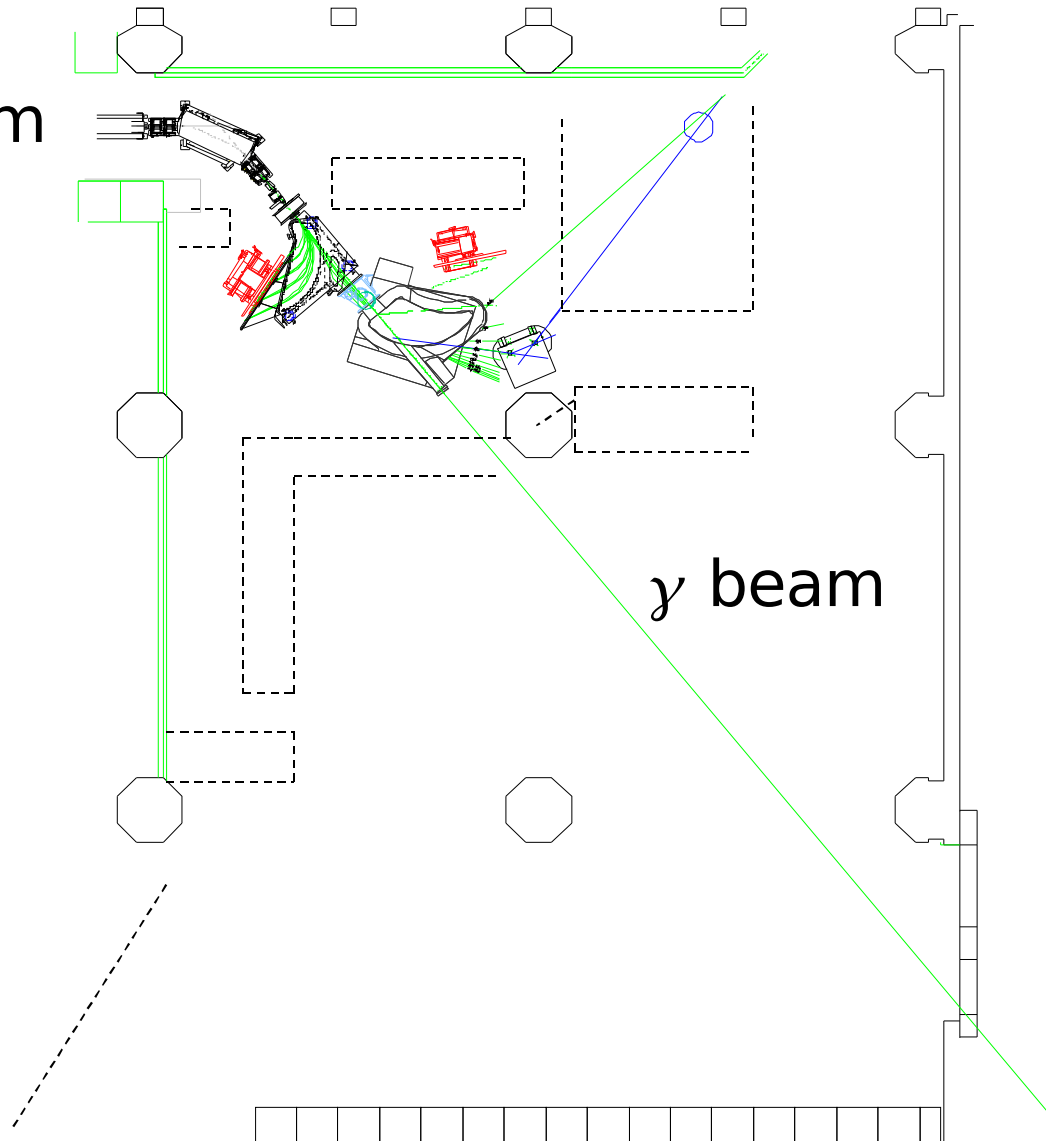
100 ns Linac pulse → 100 ms extracted pulse



40-50% duty factor

Tagged photon beam-line

Stretched e^- beam



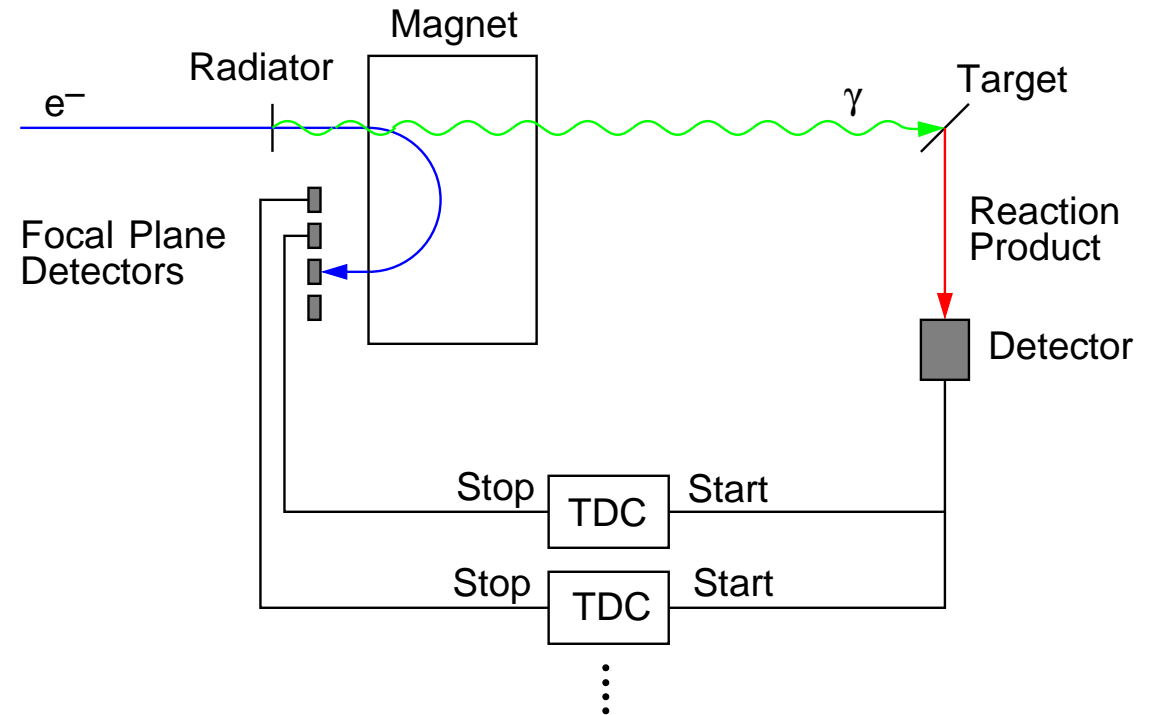
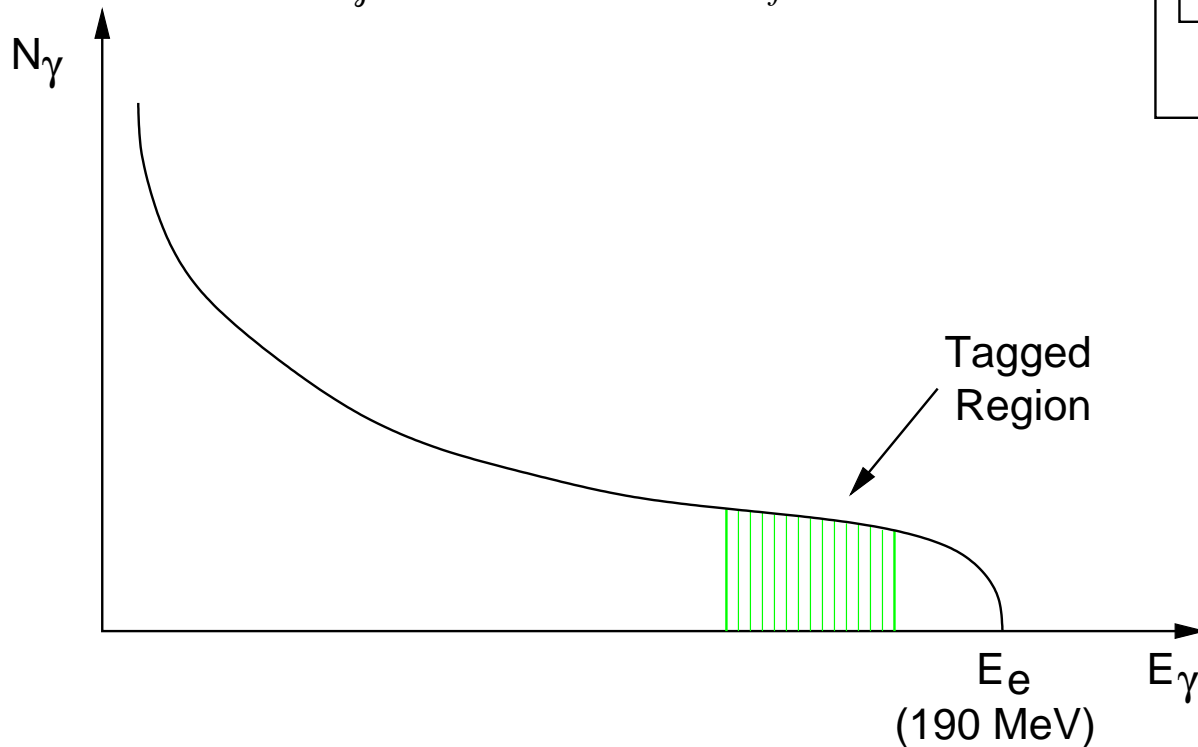
γ beam

Photon Tagging

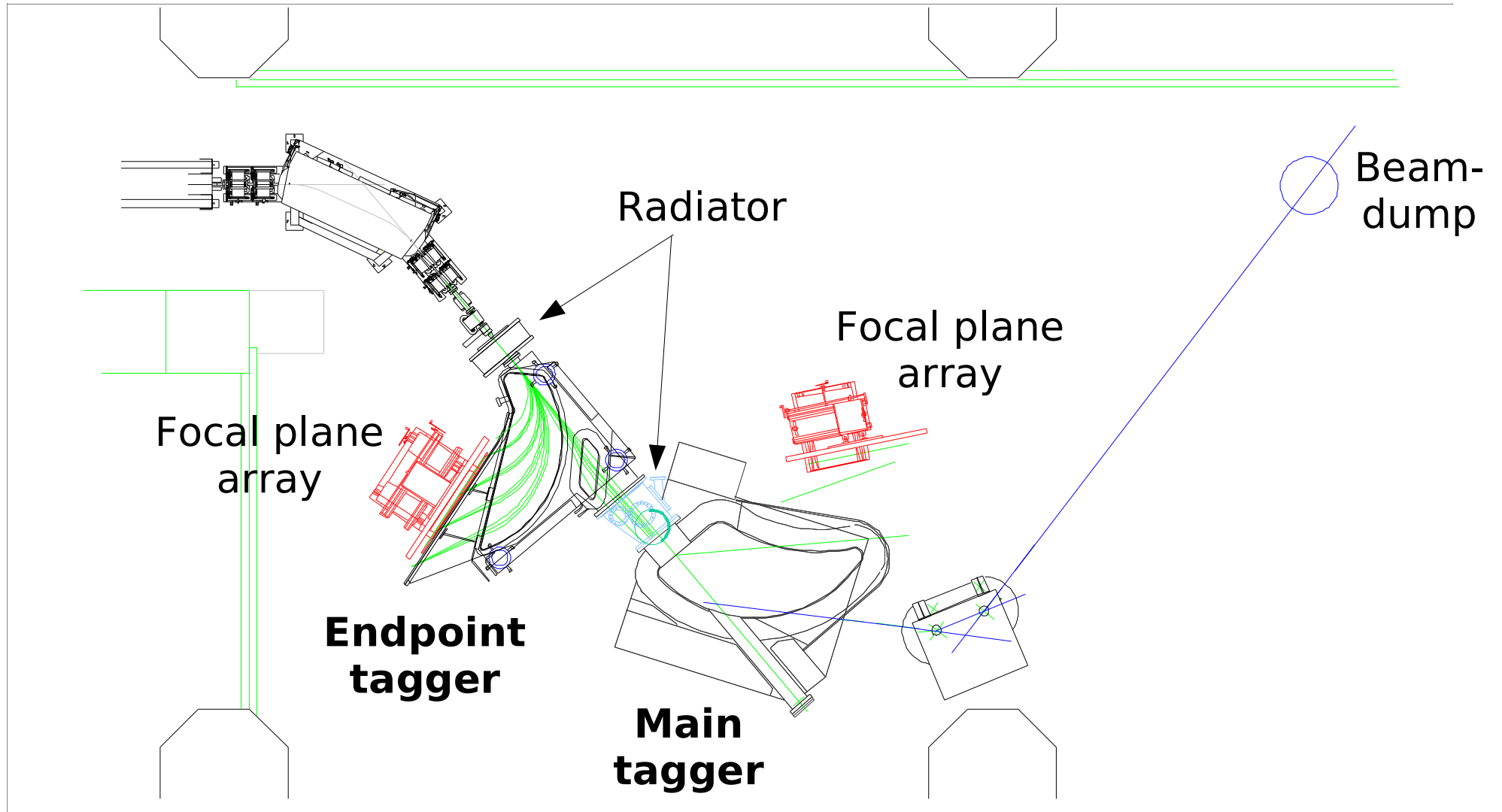
Bremsstrahlung

Determine energy of individual photons

$$E_{\gamma} = E_{initial} - E_{final}$$



Tagging spectrometers



Available energy ranges

Tagger setting	E_e (MeV)	E_γ (MeV)	ΔE_γ (MeV)
MT 460	146,3	58 - 92	0,56
	154,1	57 - 96	0,59
	163,0	64 - 103	0,62
	171,7	68 - 108	0,66
	179,2	70 - 113	0,69
	188,5	74 - 119	0,72
MT 340	146,3	26 - 73	0,76
ET	146,3	100 - 116	0,50
	188,5	162 - 175	0,42
	194	167 - 180	0,41

Anticipate increased e^- energy (~ 220 MeV)

20 nA, 50% tagg.eff. \Rightarrow 1 MHz/MeV (tagged photons)

Present experimental programme

- Compton scattering
- Pion photoproduction
- Photoreactions on He isotopes
- Total photoabsorption cross-section of $^{6,7}\text{Li}$
- Detector tests (PANDA electromagnetic calorimeter)
- Commissioning of linearly polarized photons

Participating institutes

1. Duke University, USA.
2. University of Edinburgh, UK.
3. University of Frankfurt, Germany.
4. George Washington University, USA.
5. University of Glasgow, UK.
6. University of Illinois at Urbana-Champaign, USA.
7. University of Kentucky, USA
8. Kharkov Institute of Physics and Technology, Ukraine.
9. University of Lund, Sweden.
10. University de Complutense Madrid, Spain
11. University of Mainz, Germany.
12. University of Manchester, UK.
13. Massachusetts Institute of Technology, USA
14. University of Massachusetts Dartmouth, USA.
15. University of Melbourne, Australia.
16. MAX-lab, Sweden.
17. Mount Allison University, Canada.
18. University of New Hampshire, USA.
19. Ohio University, USA.
20. Pakistan Insitute of Engineering and Science, Pakistan
21. Petersburg Nuclear Physics Institute, Russian Federation.
22. Rhodes University, South Africa.
23. Russian Academy of Science, Russian Federation.
24. University of Saskatchewan, Canada.
25. Stockholm University, Sweden.
26. Suleyman Demirel University, Turkey.
27. University of Regensburg, Germany.
28. University of Trento, Italy.
29. University of Tübingen, Germany.
30. Uppsala University, Sweden.
31. Yerevan Physics Institute, Armenia.
32. Weizmann Institute of Science, Israel

Compton Scattering programme

- Deuterium

Significantly increase the world data set

Test recent calculations

Extract neutron polarizabilities α_n and β_n

- ^4He , ^{12}C and ^{16}O

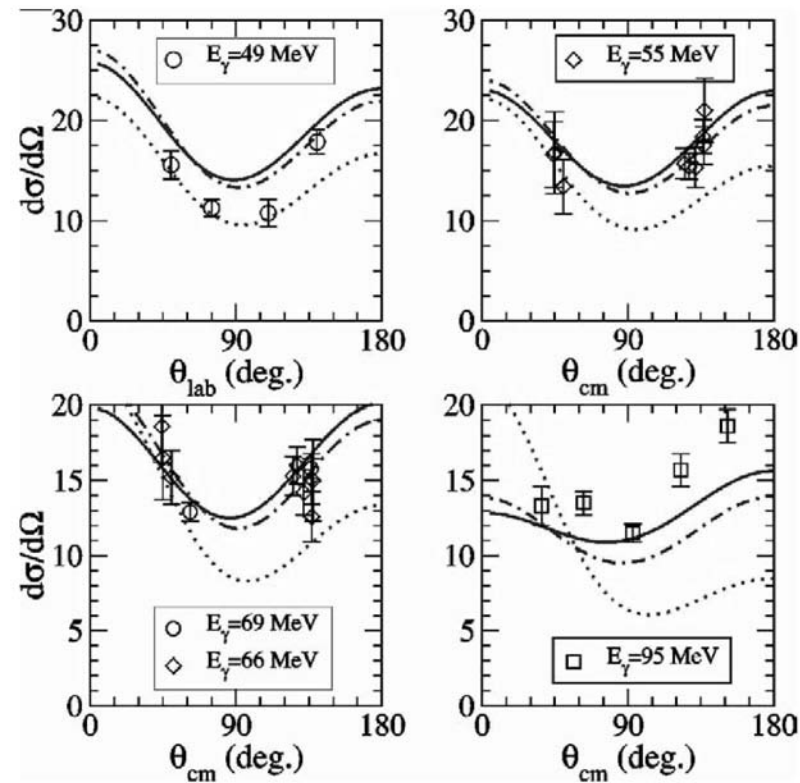
Extract polarizabilities of bound nucleons

Recent χ PT calculations

Beane *et al.*, Nucl.Phys.A747(2005)311

Hildebrandt *et al.*, Nucl.Phys.A748(2005)573

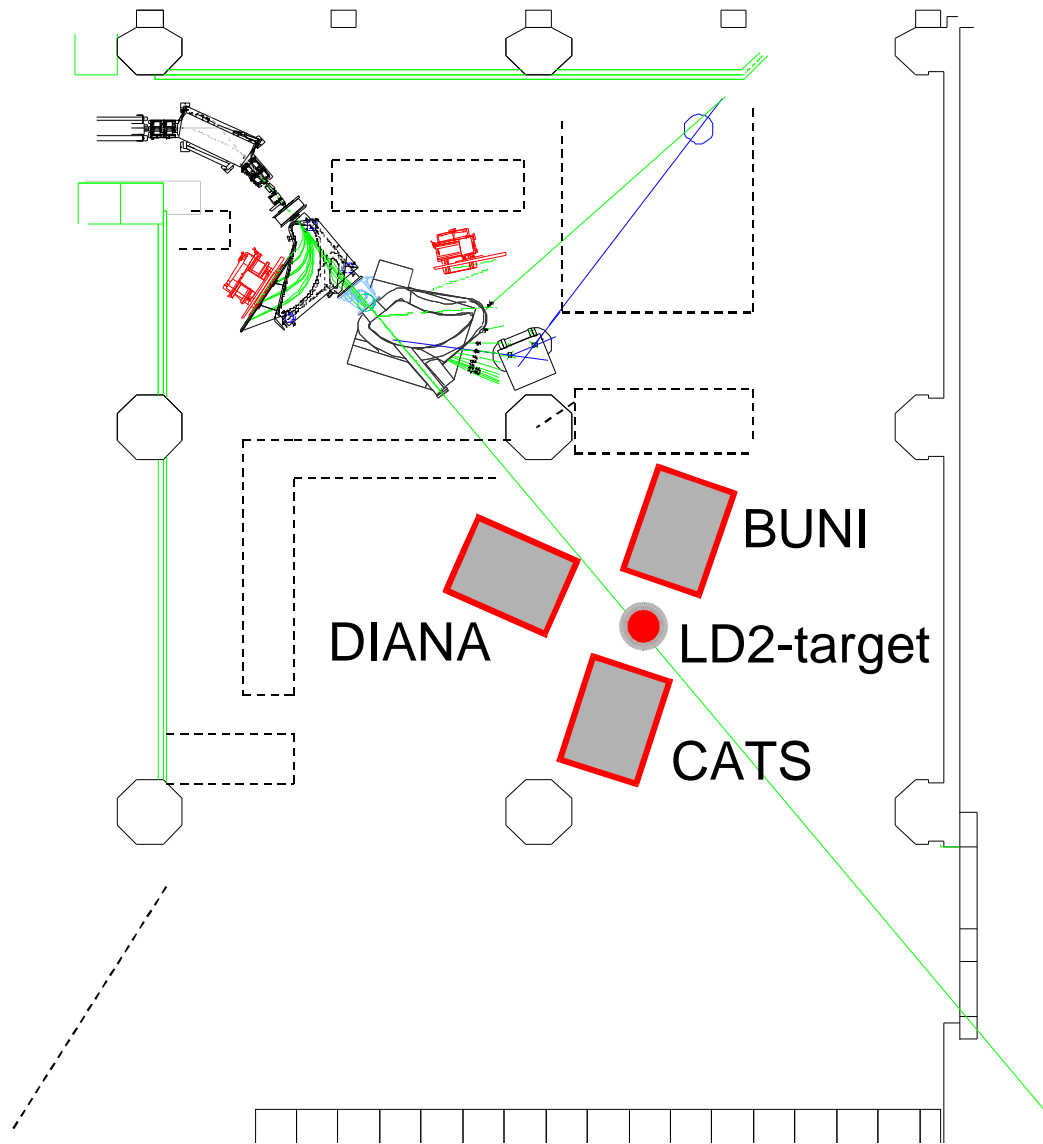
...



Beane *et al.*

Need higher quality data

Compton set-up



NaI detectors

Three of the largest
NaI-detectors worldwide:

CATS (Mainz)
BUNI (Boston)
DIANA (Kentucky)

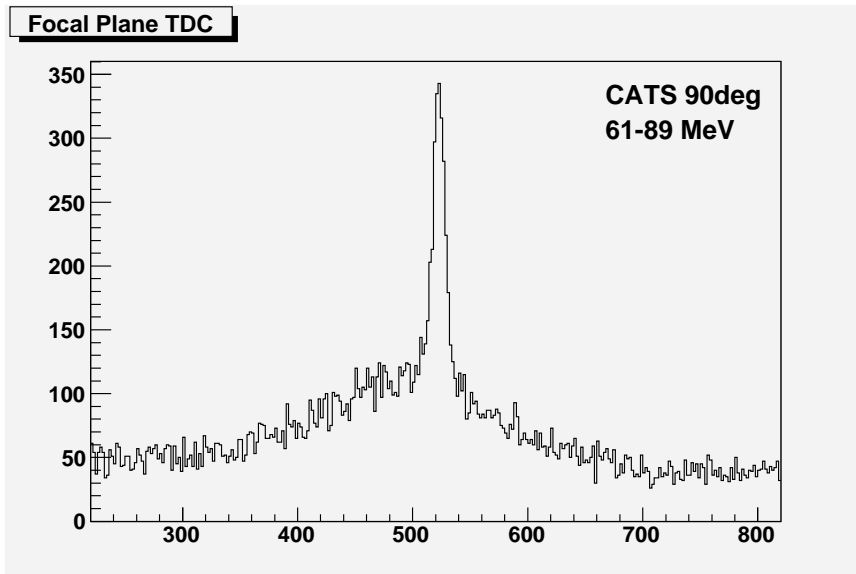


CATS NaI: $\phi 19'' \times 25''$

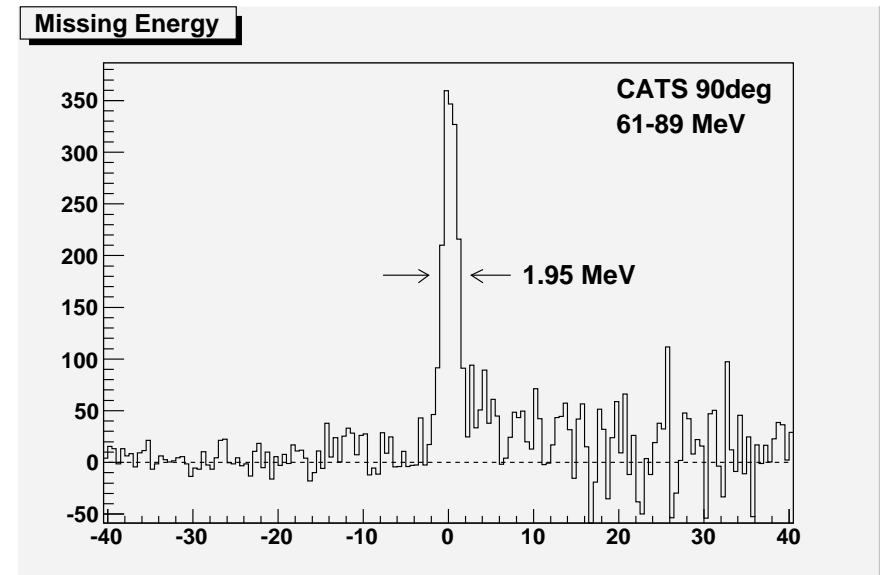
Carbon test measurement

Easier target

20 times larger cross-section

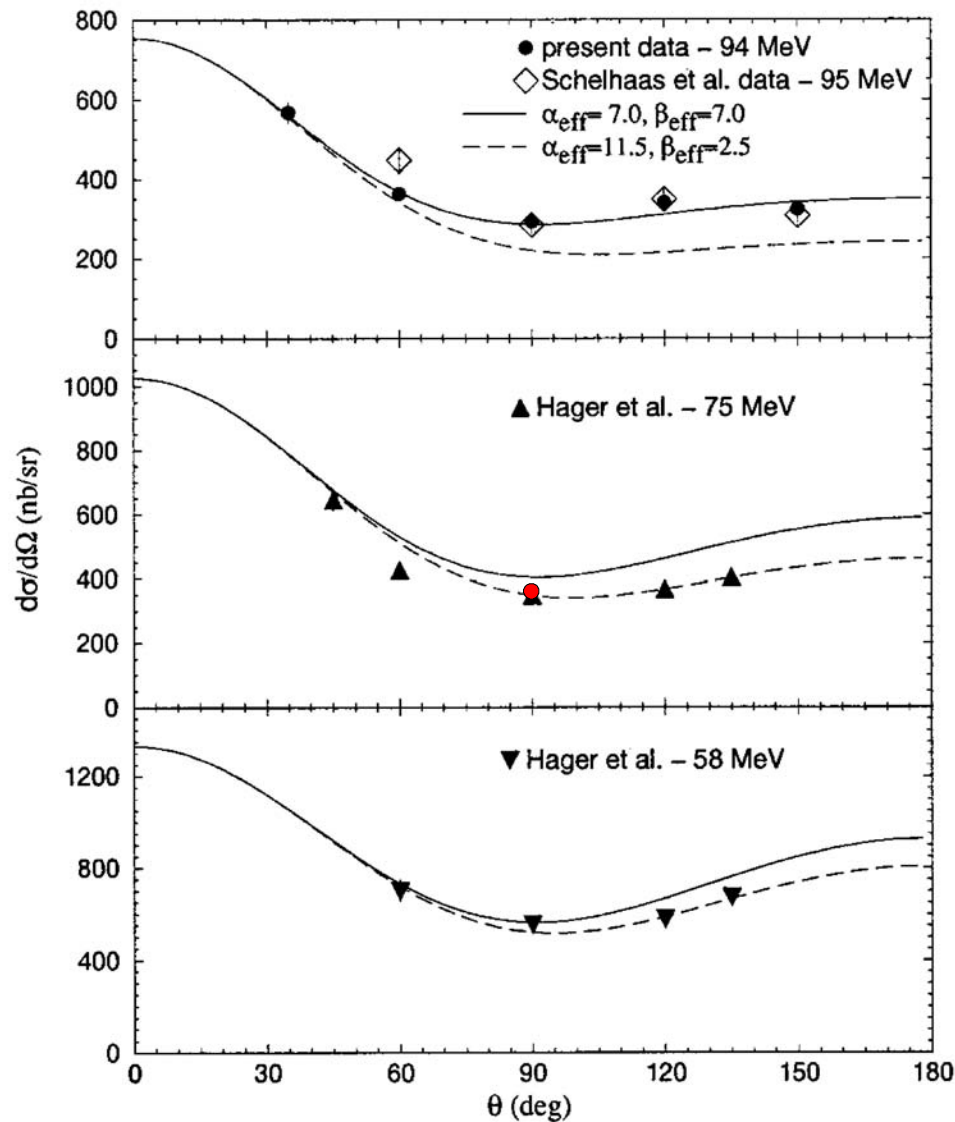


Tagger coincidences



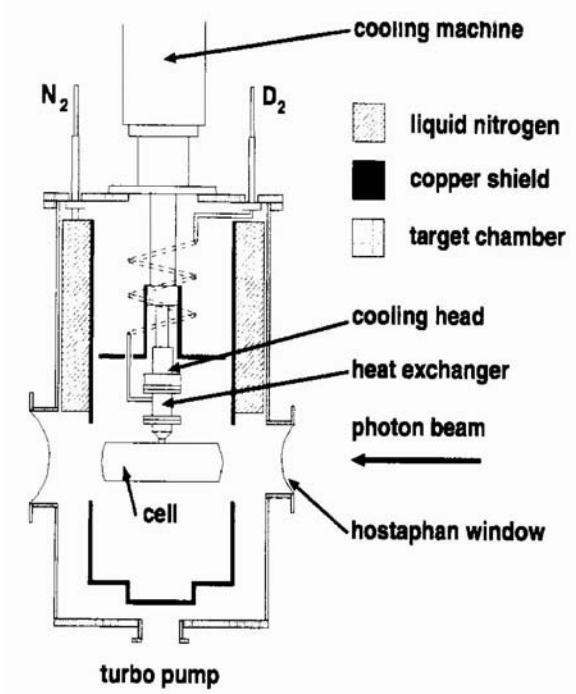
Missing energy

Carbon cross-section



- Warkentin *et al.*, SAL
94 MeV 292 ± 5 nb/sr
- ▲ Häger *et al.*, Lund
75 MeV 348 ± 11 nb/sr
- This measurement
75 MeV 367 ± 19 nb/sr
(Preliminary)

Deuterium measurement



LD2-target



Target cell

8 weeks of production runs to date

Analysis in progress

Pion photoproduction programme

So far, most effort on the (γ, π^+) reaction:

Fill large gap in world data set
(no existing data between threshold and 180 MeV)

4 independent set-ups:

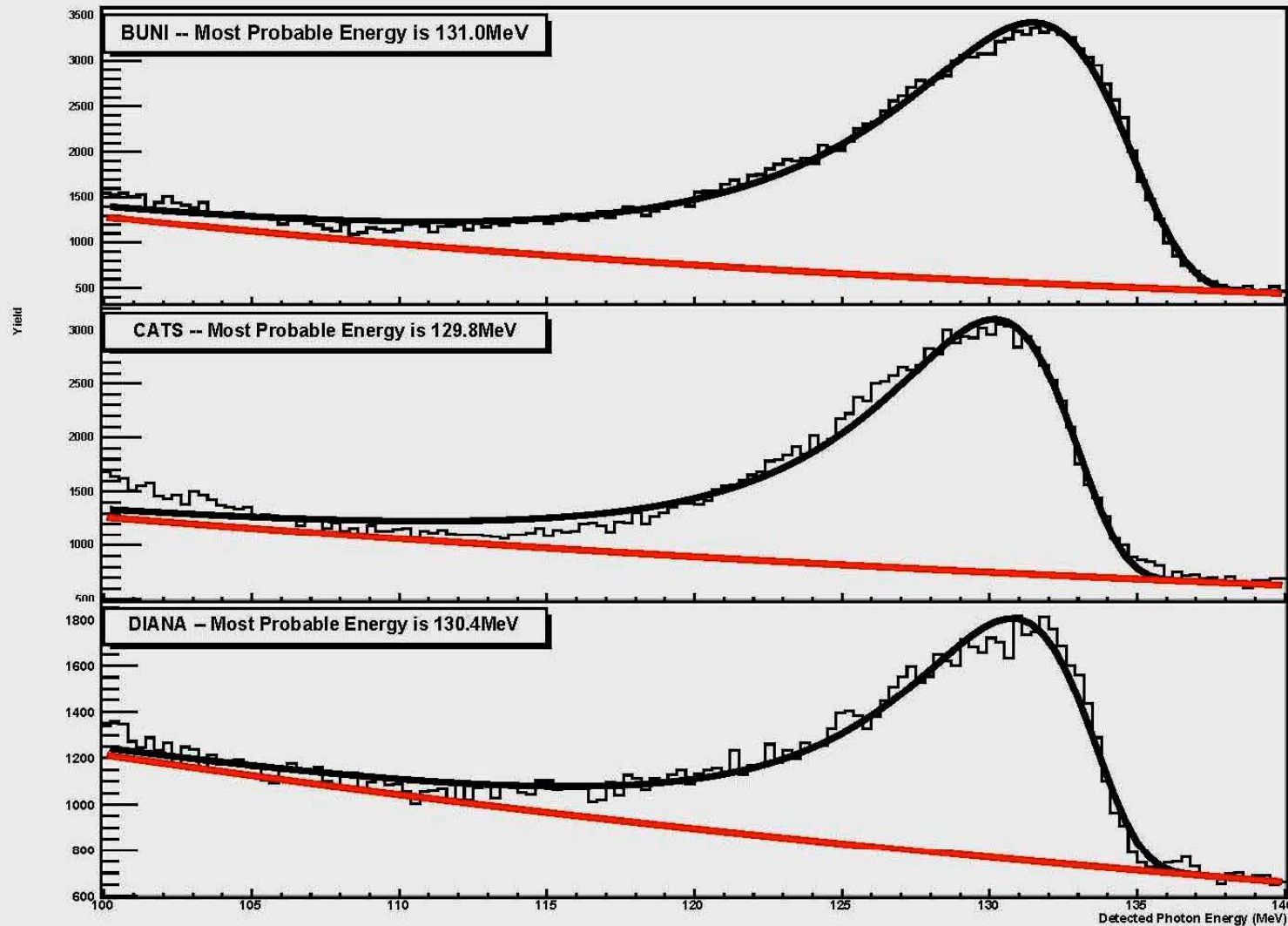
- CsI/SSD telescope (Si-strip ΔE – CsI E)
- xSAL telescopes (plastic ΔE -E)
- Range telescopes (plastic $\Delta E(\times 4)$ -E)
- Ge6 telescopes (Si-strip ΔE – Ge E)

Preliminary tests have been performed on
the (γ, π^0) and (γ, π^-) reactions

$$\gamma + n \rightarrow \pi^- + p$$

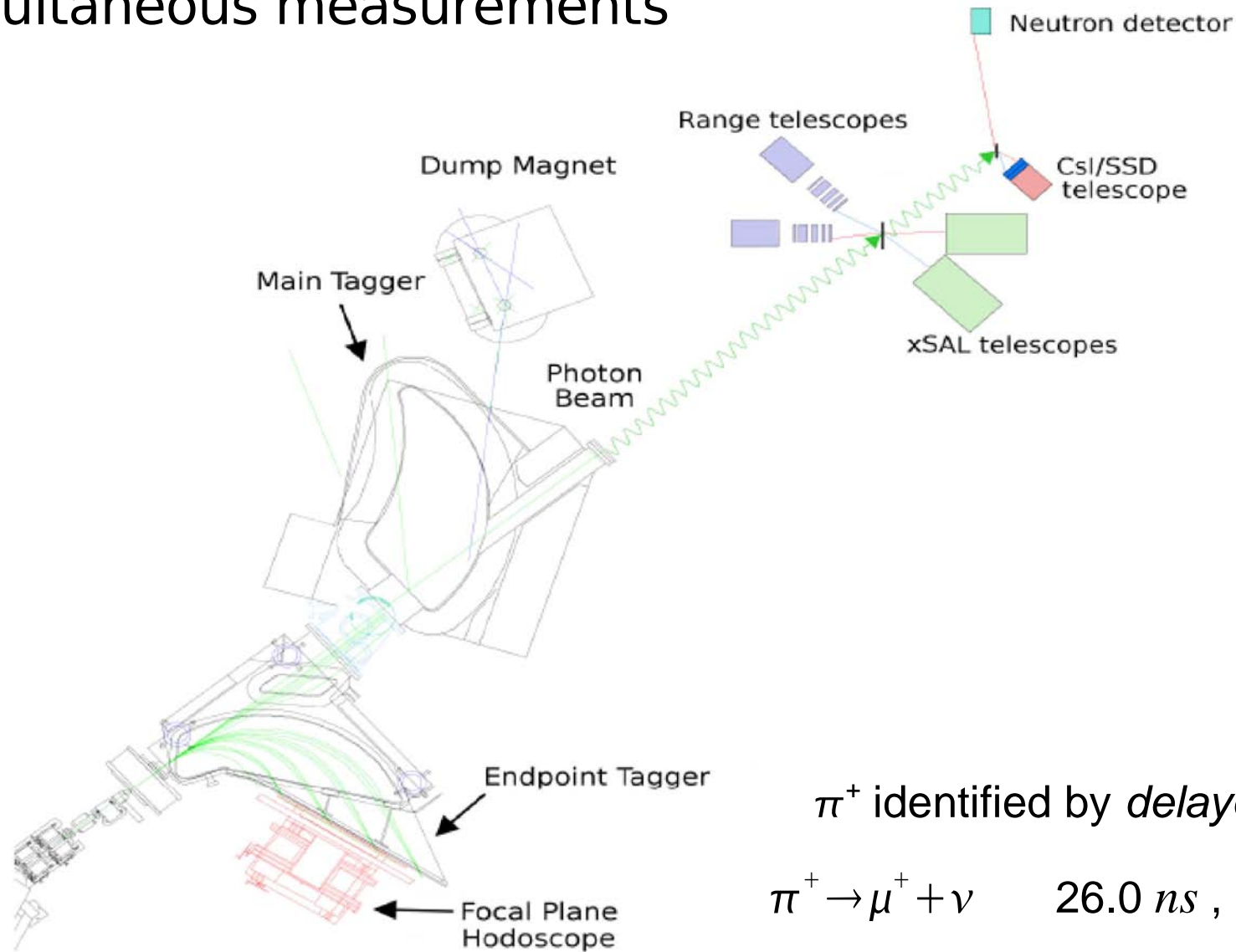
Preliminary measurements of $\gamma + n \rightarrow \pi^- + p$ via $\pi^- + d \rightarrow 2n + \gamma$ the CATS, BUNI and DIANA NaI detectors were used to identify the photons resulting from the π^- capture on deuterium taken in parallel with Compton Scattering measurements.

Detection of Decay γ in the NaI Detectors



(γ, π^+) set-up

3 simultaneous measurements

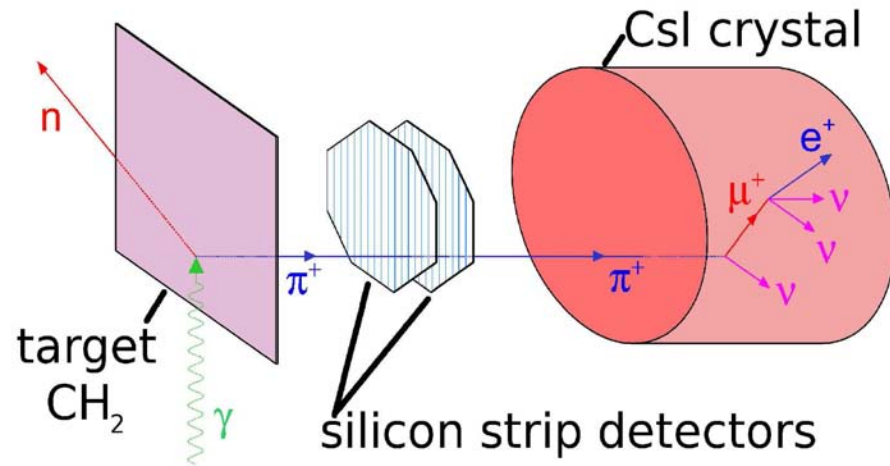


π^+ identified by *delayed pulses*:

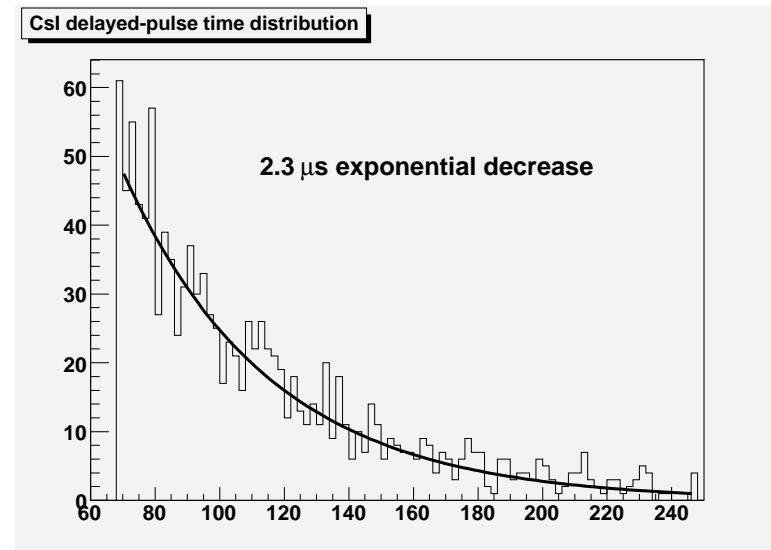
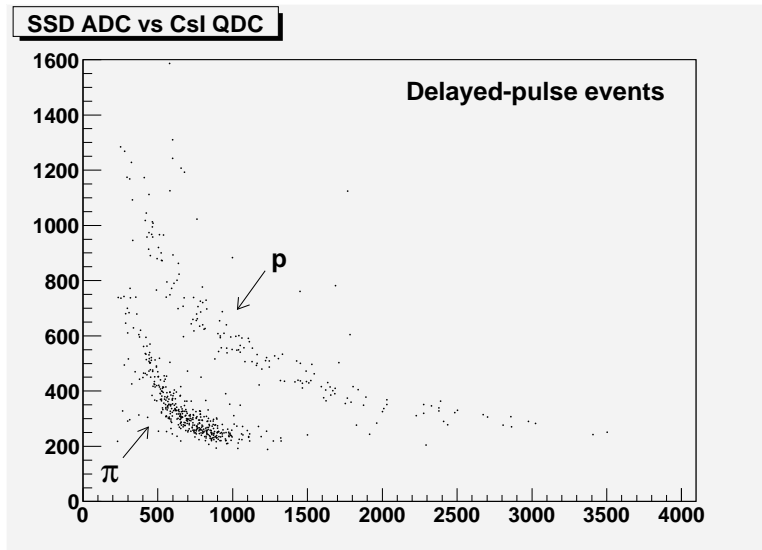
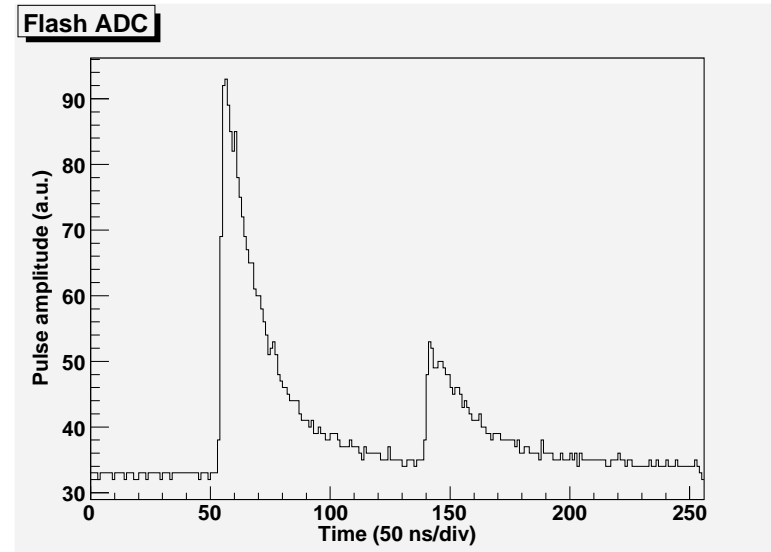
$$\pi^+ \rightarrow \mu^+ + \nu \quad 26.0 \text{ ns}, \quad E_{\mu^+}: 4.12 \text{ MeV}$$

$$\mu^+ \rightarrow e^+ + 2\nu \quad 2.197 \text{ } \mu\text{s}, \quad E_{e^+}: \sim 5\text{-}50 \text{ MeV}$$

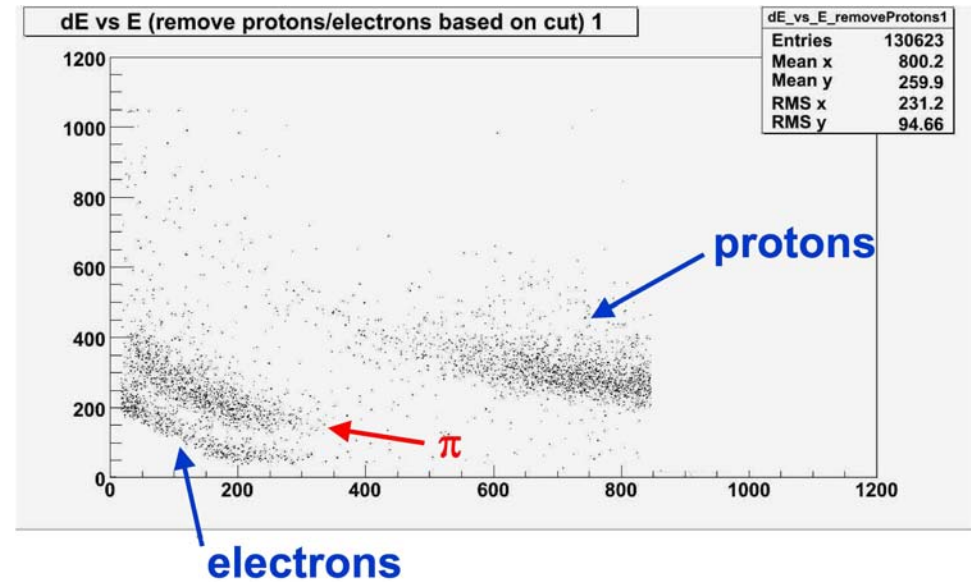
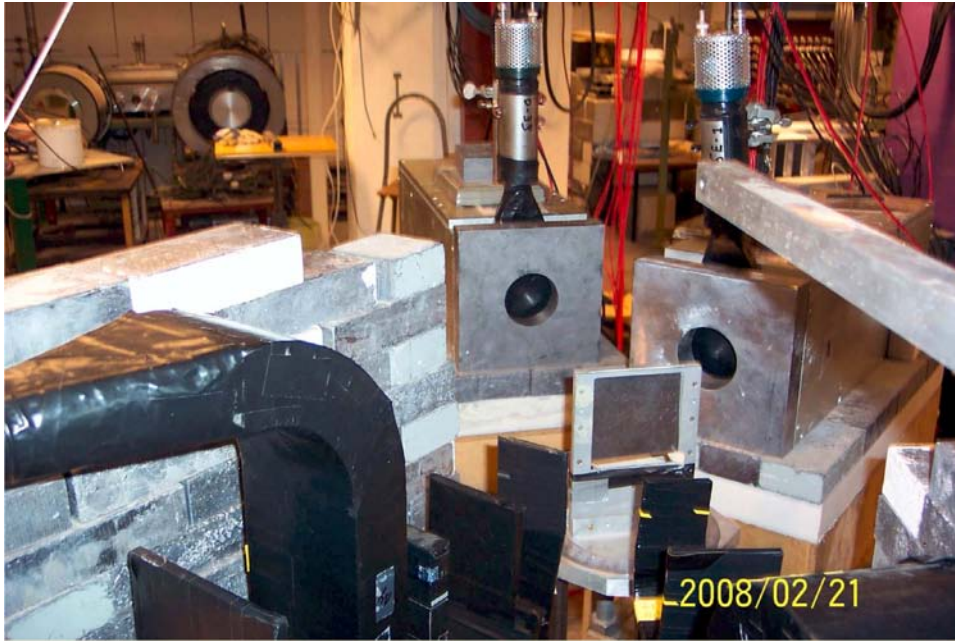
CsI/SSD telescope



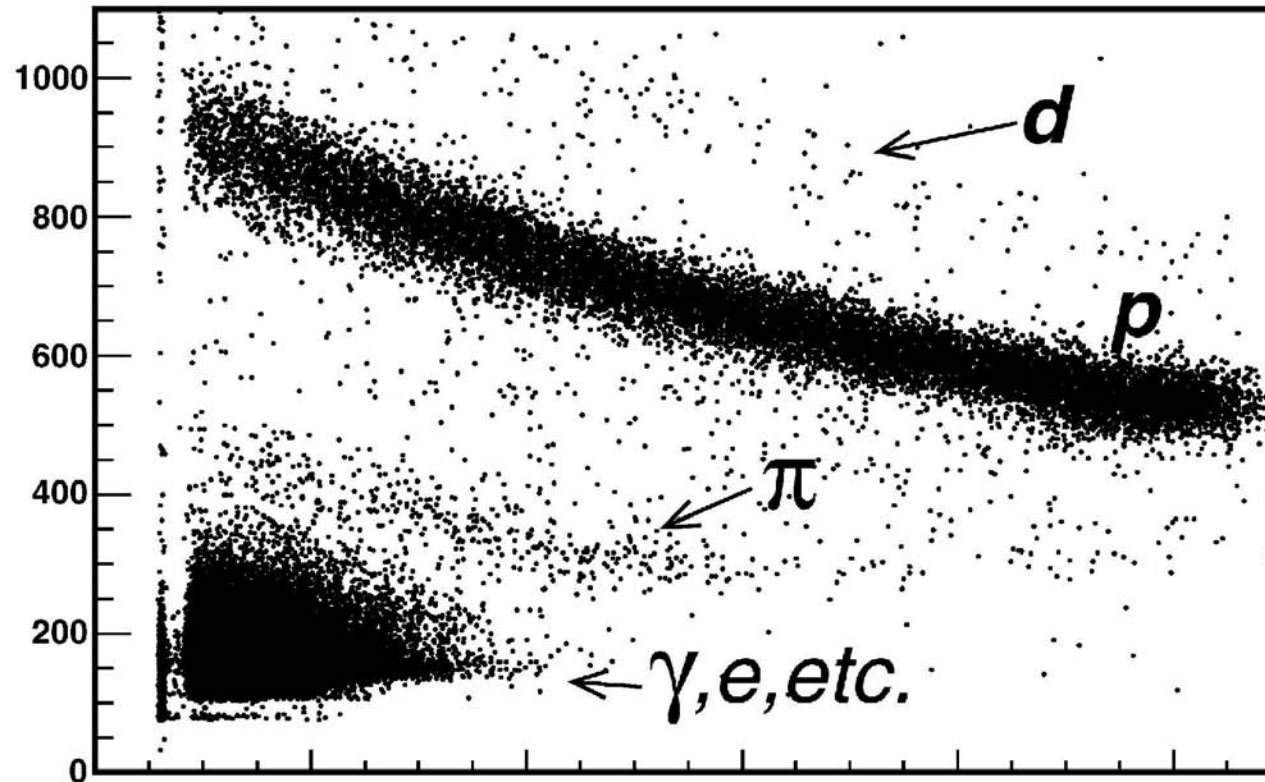
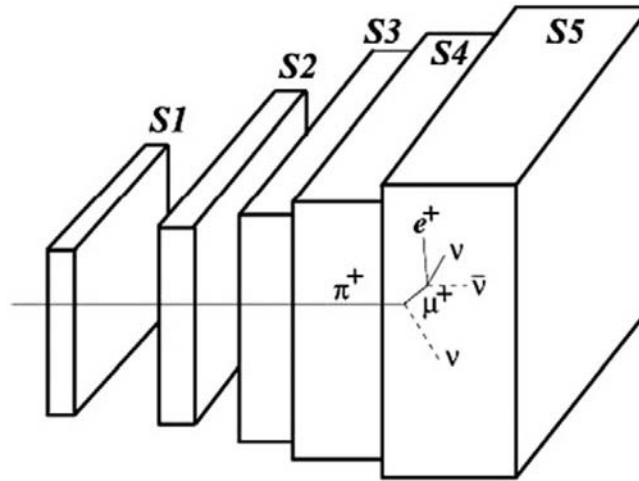
Example of candidate π^+ event



xSAL telescopes

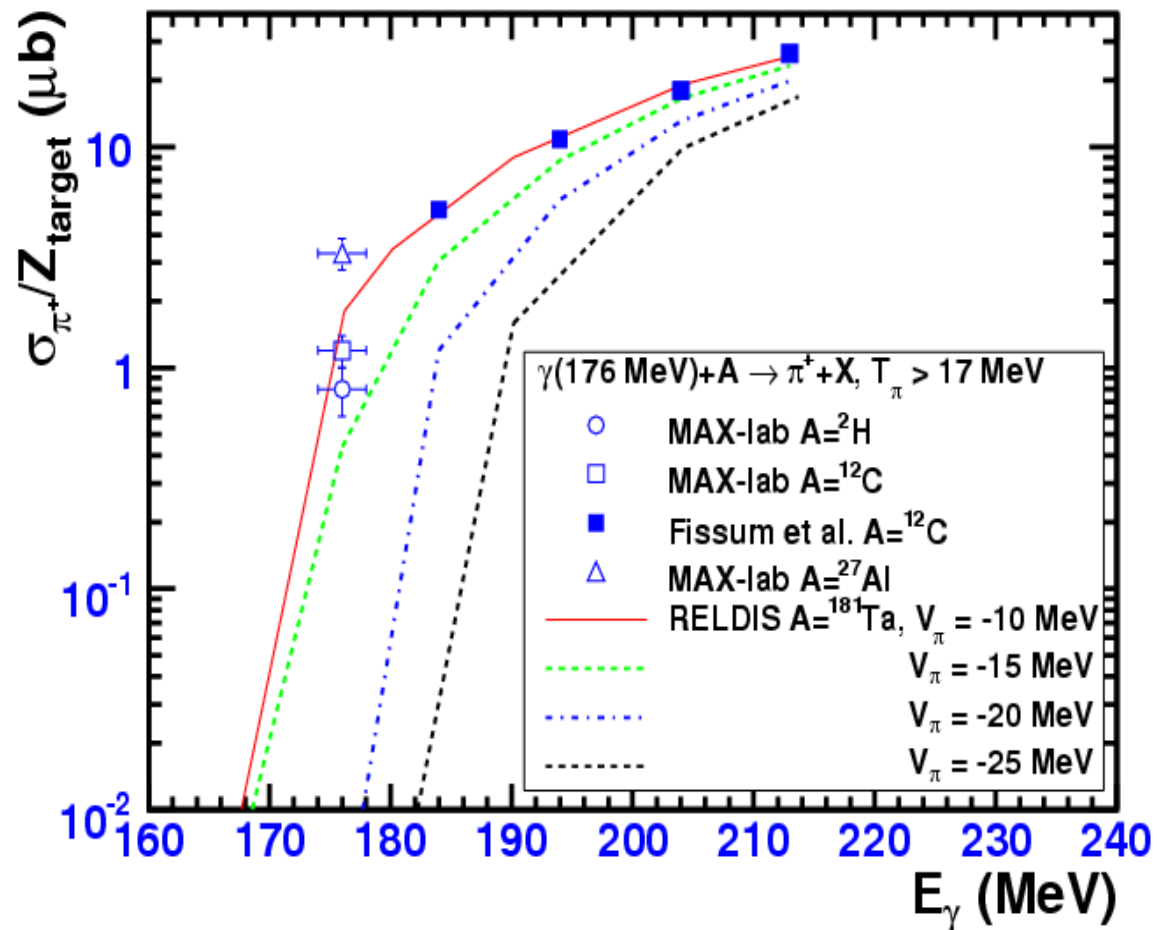


Range telescopes



The MAX-lab tagged photon facility

Total yield of π^+ with $T_\pi > 17$ MeV as a function of gamma energy. Points represent early data from light-target experiments at MAX-lab without energy-tagging [1] and from SAL with tagging [2]. Curves represent RELDIS calculations (I. Pshenichnov) with various optical potentials for the proposed reaction to be studied at MAX-lab, $\gamma + {}^{181}\text{Ta}$. (Bo Jakobsson)



[1] P. Golubev et al., Nucl. Phys. A 806 (2008) 216.

[2] K. Fissum et al., Phys. Rev. C53 (1996) 1278.

Looking Forward to MAX-4



- Preliminary planning is underway to install a laser backscattering in MAX-4
- Discussions have taken place with Andy Sandorfi
- Proposal has been submitted to the Swedish Funding Agency (VR)

Summary

- The upgraded tagged photon beam at MAX-lab is in routine operation
- Several experiments are in production phase
- New experiments are being commissioned
- Preliminary planning is underway to install a laser backscattering in MAX-4