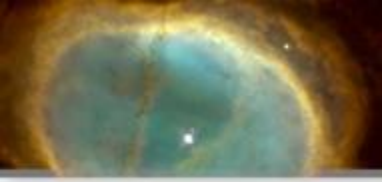
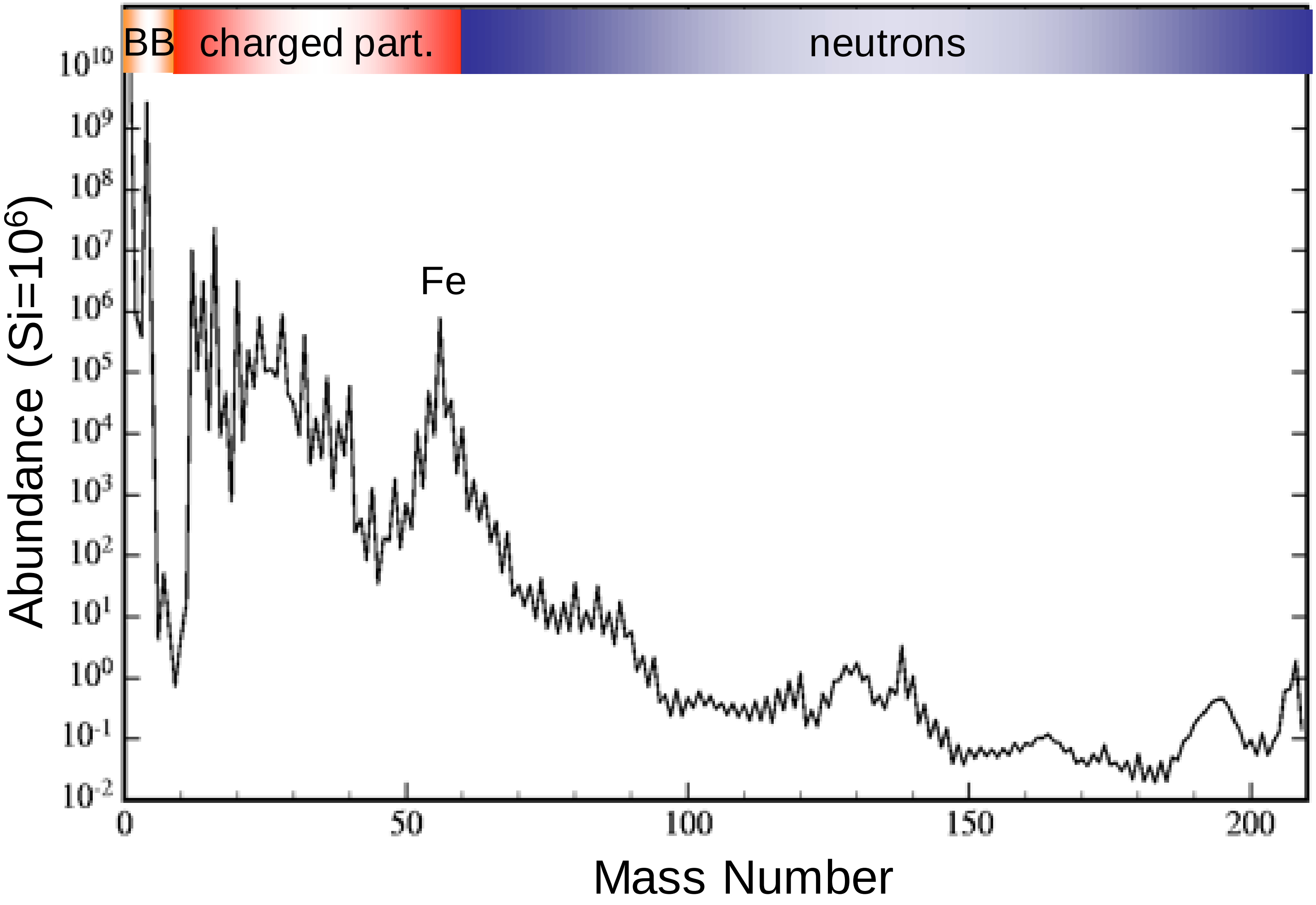


Status of the high intensity neutron source FRANZ

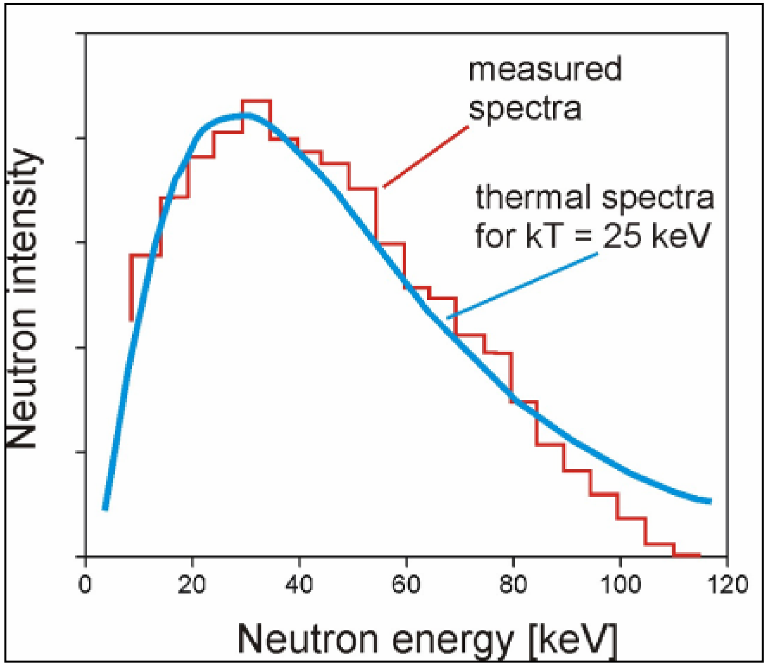
Claudia Lederer
Goethe University of Frankfurt
3rd October
ERINDA Meeting, CERN

Elemental Abundances of the Universe



Stellar neutron spectra

• Quasi-maxwellian neutron spectrum can be obtained by the reaction $^{7}Li(p,n)$ with E_p=1912 keV (Ratynski and Käppeler, 1988)



KIT (former FZ Karlsruhe), F. Käppeler

- 3.7 MV VdG accelerator
- DC: ~100 µA
- $3*10^9$ n/s/cm^2

pulsed beam for tof

- ~2 µA
- 250 kHz
- 1 ns
- 10^4 n/s/cm^2 at sample
- 1m flight path

University of Frankfurt / Department of Physics

Campus Riedberg

IAP

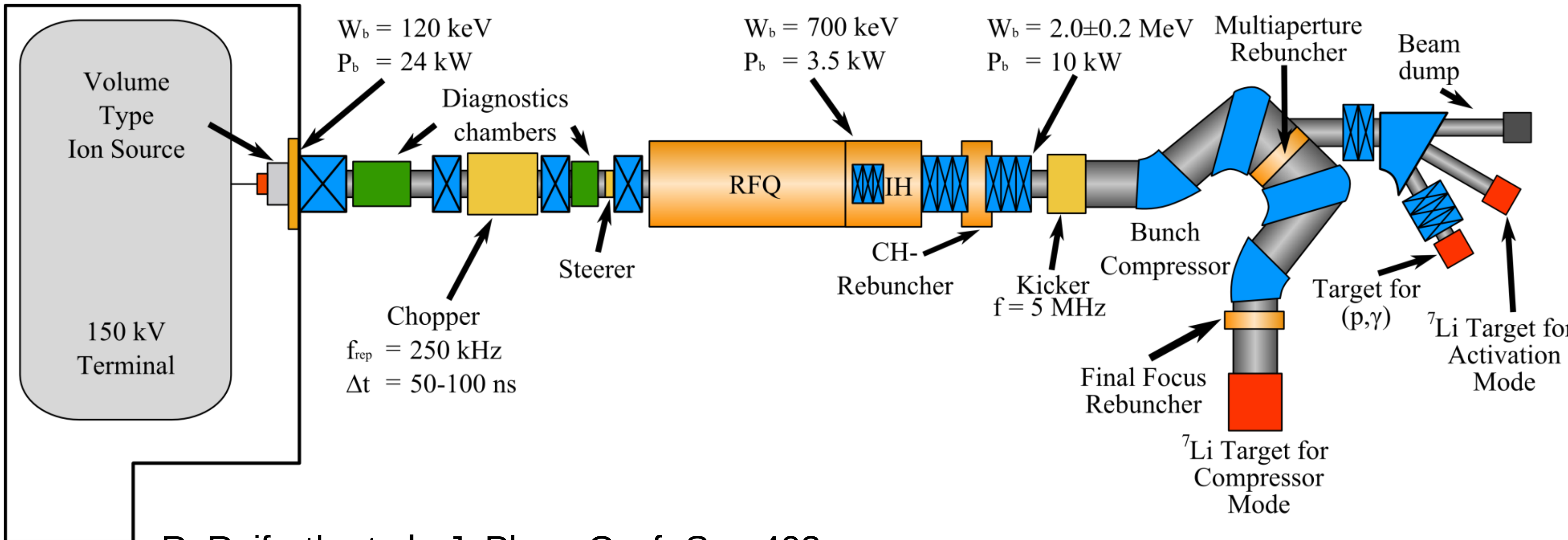
Institute for Applied Physics

Astrophysics

Accelerator Physics

Plasma Physics

Frankfurt Neutron source at Stern Gerlach Zentrum (FRANZ)



R. Reifarth et al., J. Phys. Conf. Ser. 403, 012038 (2012)

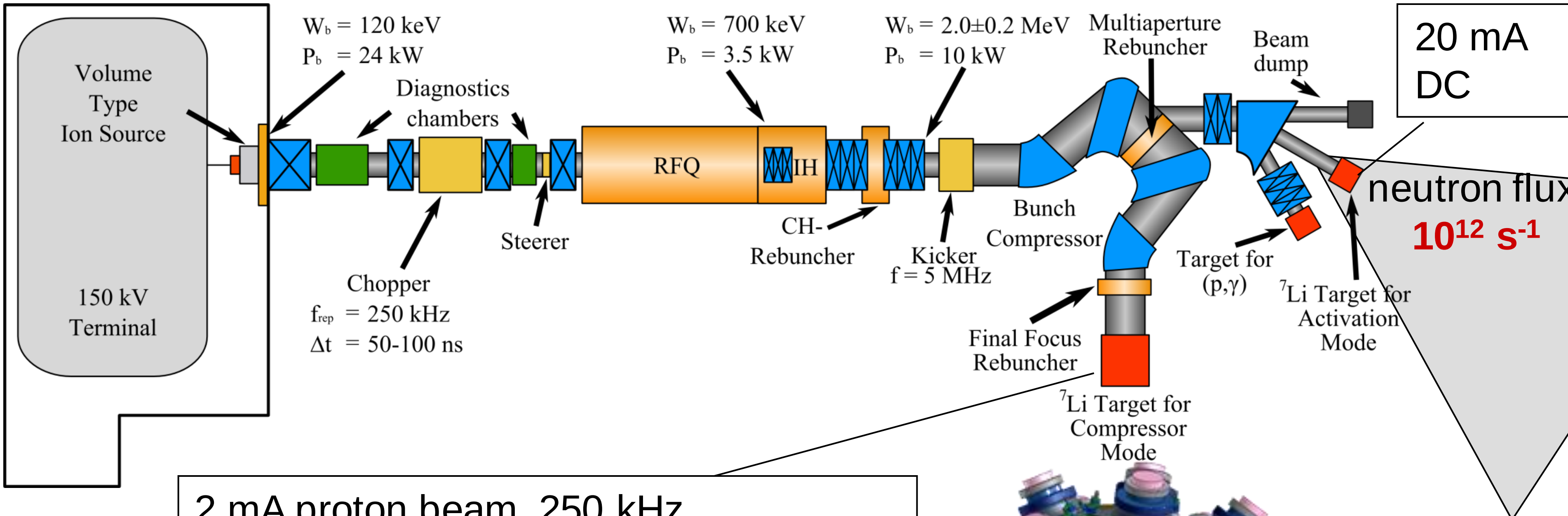
R. Reifarth et al., PASA 26, 255 (2009)

C. Wiesner et al., AIP Conference Proceedings 1265, 487 (2010)

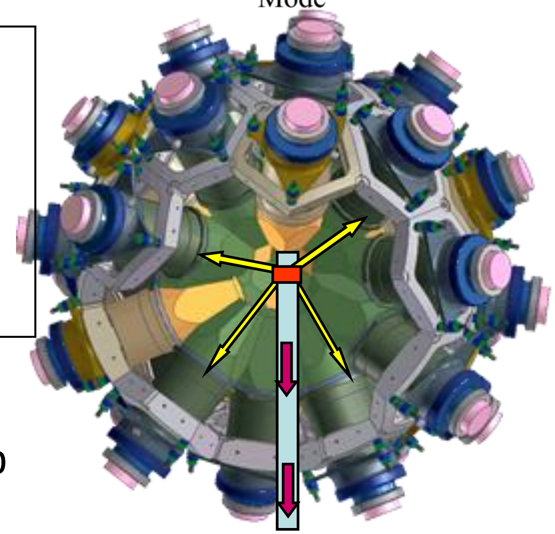
Accelerator: Accelerator Physics Group (U. Ratzinger)

Detectors & Li Target: Experimental Astrophysics Group (R. Reifarth)

Frankfurt Neutron source at Stern Gerlach Zentrum (FRANZ)



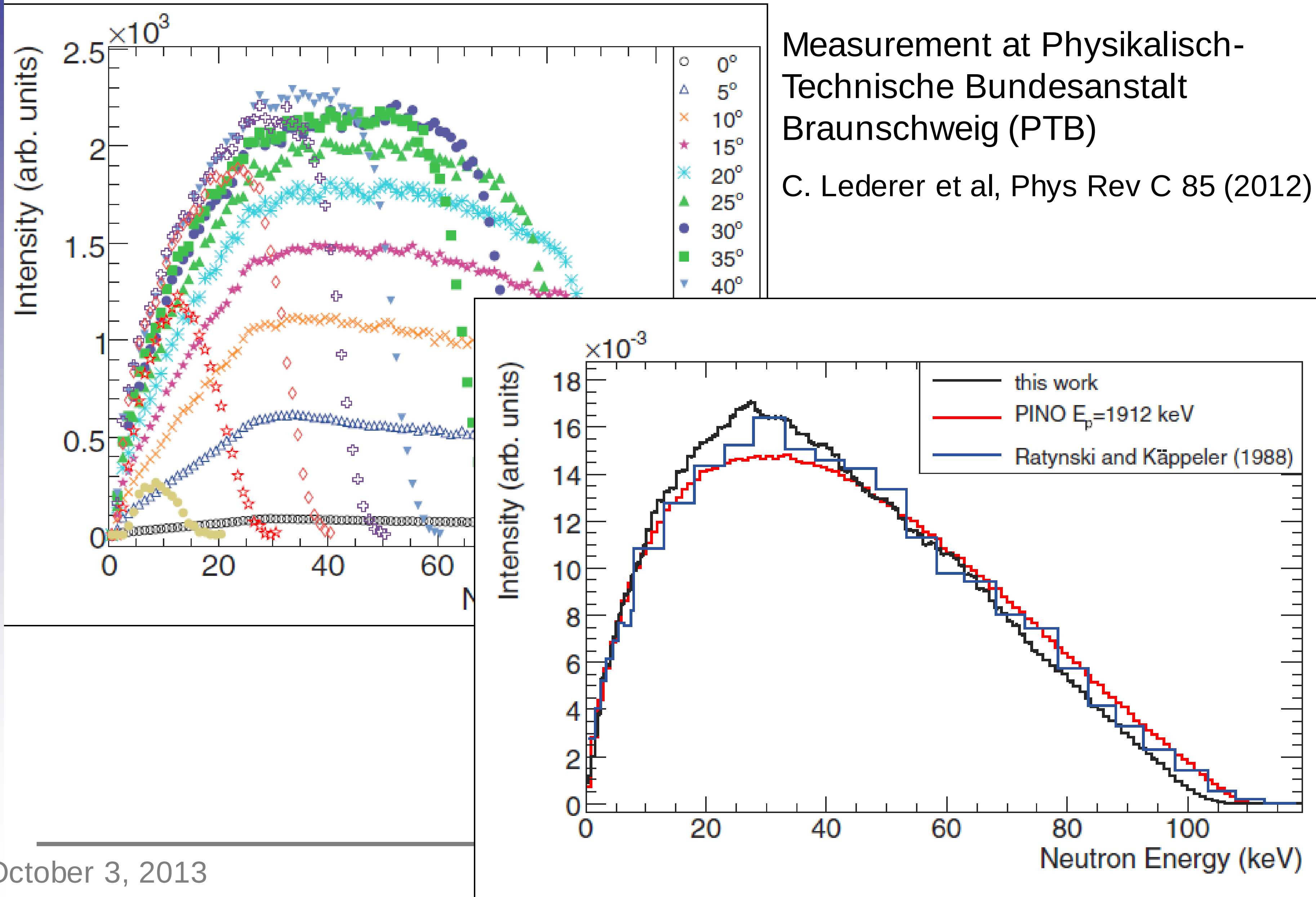
2 mA proton beam, 250 kHz
< 1ns pulse width
neutron flux at 1 m: 10^7 s^{-1} cm^{-2}
neutron flux at 0.1m: 10^9 s^{-1} cm^{-2}



Accelerator: Accelerator Physics Group (U. Ratzinger)

Detectors & Li Target: Experimental Astrophysics Group (R. Reifarth)

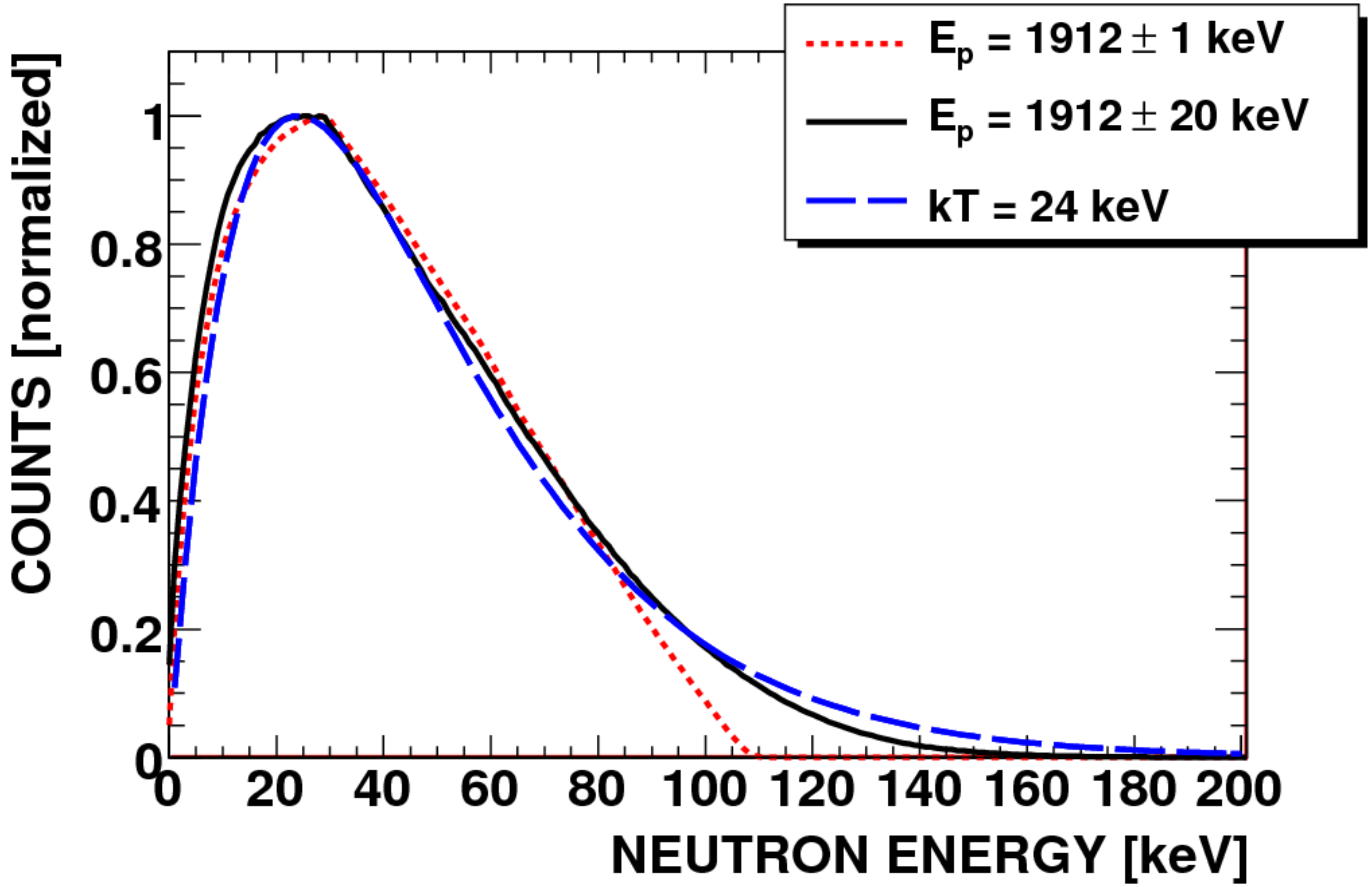
^{7}Li(p,n) neutron spectrum at E=1912±1 keV



Measurement at Physikalisch-Technische Bundesanstalt Braunschweig (PTB)

C. Lederer et al, Phys Rev C 85 (2012)

Effect of proton energy uncertainty

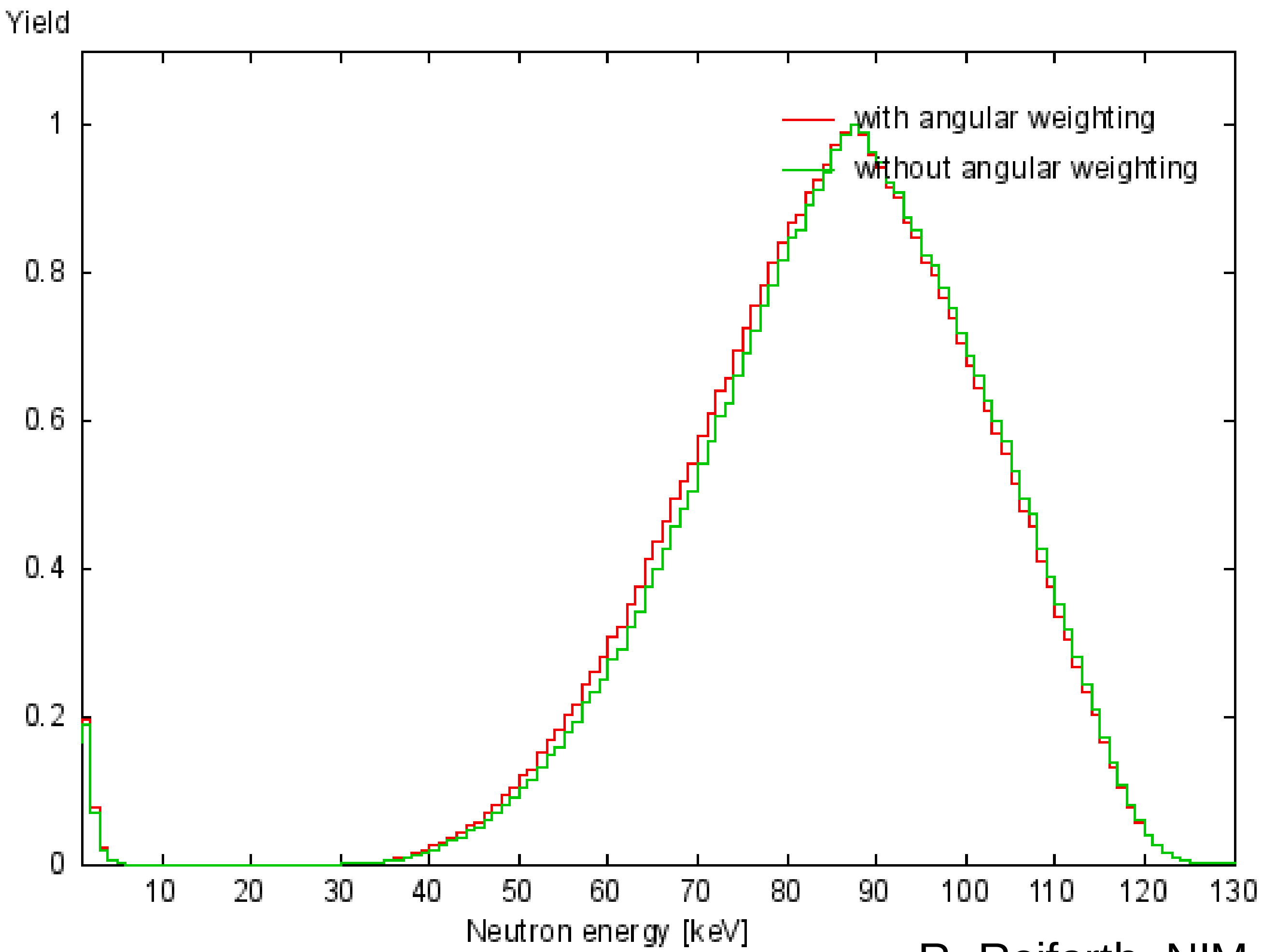


- E_p = 1912 keV
- different proton energy distributions
- 30 µm lithium

R. Reifarth, NIM A 608 (2009) 139

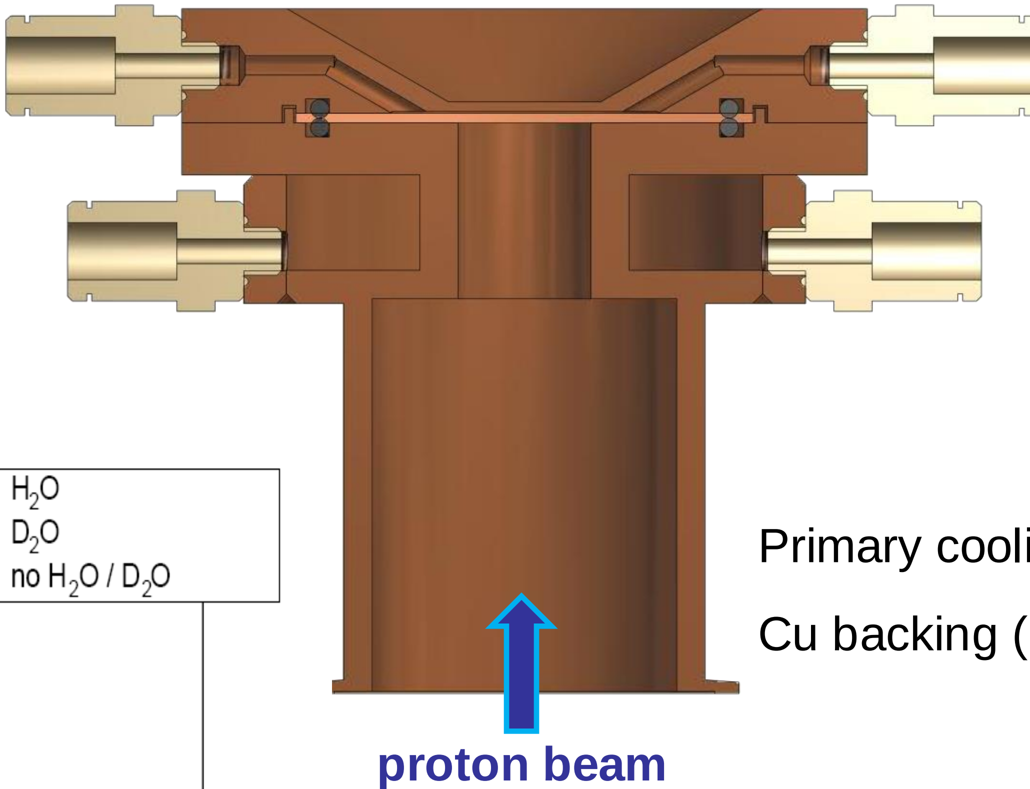
Neutron spectrum: <E> = 90 keV

- E_p=1920±1 keV, 1.15 µm Lithium, 10 mm distance



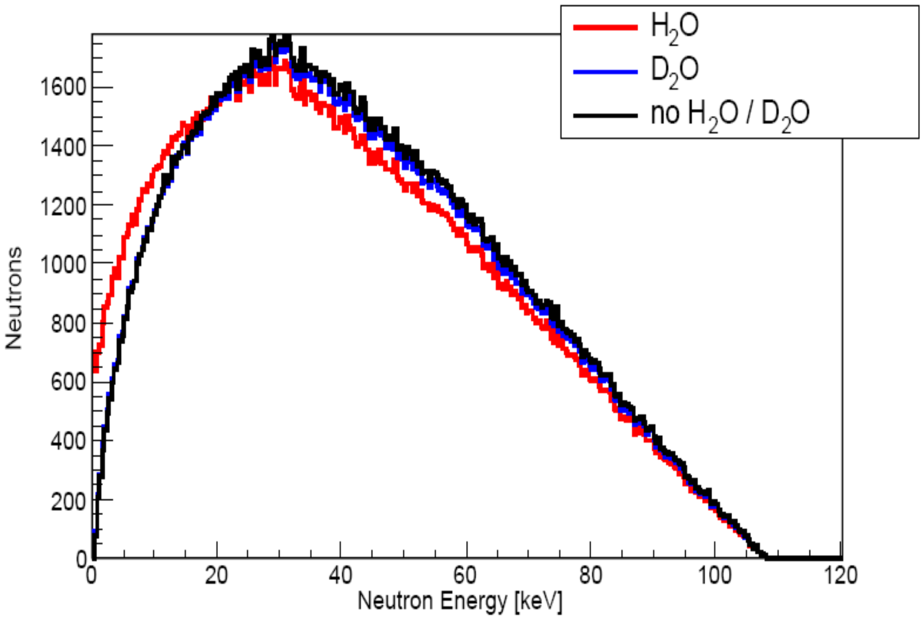
R. Reifarth, NIM A 608 (2009) 139

Neutron production target



Primary cooling 0.2 mm

Cu backing (1 mm)

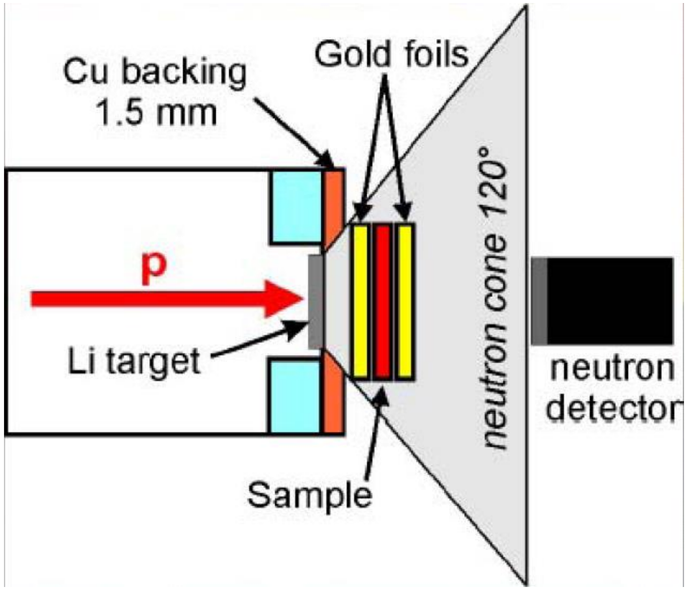


S. Schmidt, PhD thesis ongoing

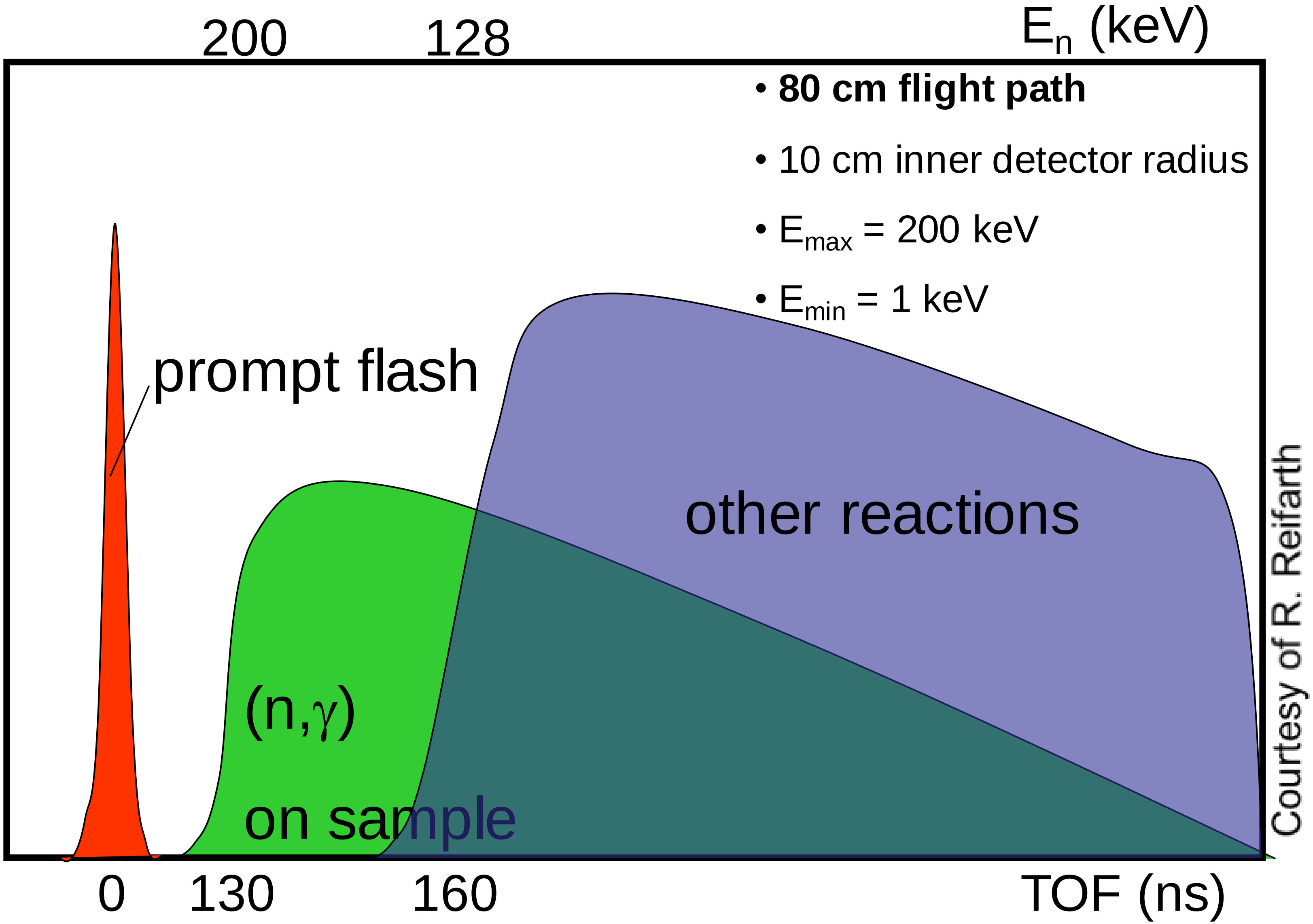
S. Fiebiger, B.Sc. thesis

Activation setup

- Several irradiations are possible simultaneously (sandwich)
- Spectra are under control via MC-simulations
- Shape & mean of the n-spectrum adjustable via p-energy & Li-thickness
- p-energy resolution ~1%
- Starting intensities ~ 1 mA (10^{10} - 10^{11} n/cm^2/s)
- available: first neutrons ~2014



Schematic TOF spectrum



TOF setup

GOETHE UNIVERSITÄT FRANKFURT AM MAIN

- 1 keV – 400 keV
- Flight path: 5 cm – 1 m
- Optimize foreground/background via TOF and different proton energies, Li thickness
- 4π γ-Detector with FADC will be available (BaF2)
- Fission detectors (in addition or single) are possible, probably not provided through Frankfurt
- Starting intensities ~ 1 mA
  - 10^7 n/cm^2/s @ 1 m
  - 10^9 n/cm^2/s @ 10 cm

Hardware:

γ-calorimeter

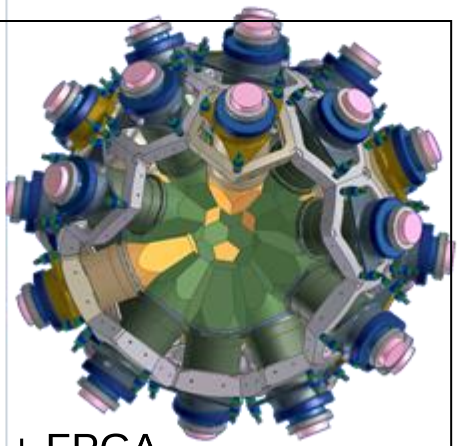
15 cm thick

$\varepsilon_{\gamma, total}$ ~ 90 %

$\varepsilon_{casc, total}$ ~ 98 %

$\varepsilon_{casc, peak}$ ~ 50 %

96 channels 1GS/s FADC + FPGA



New facilities / upgrades

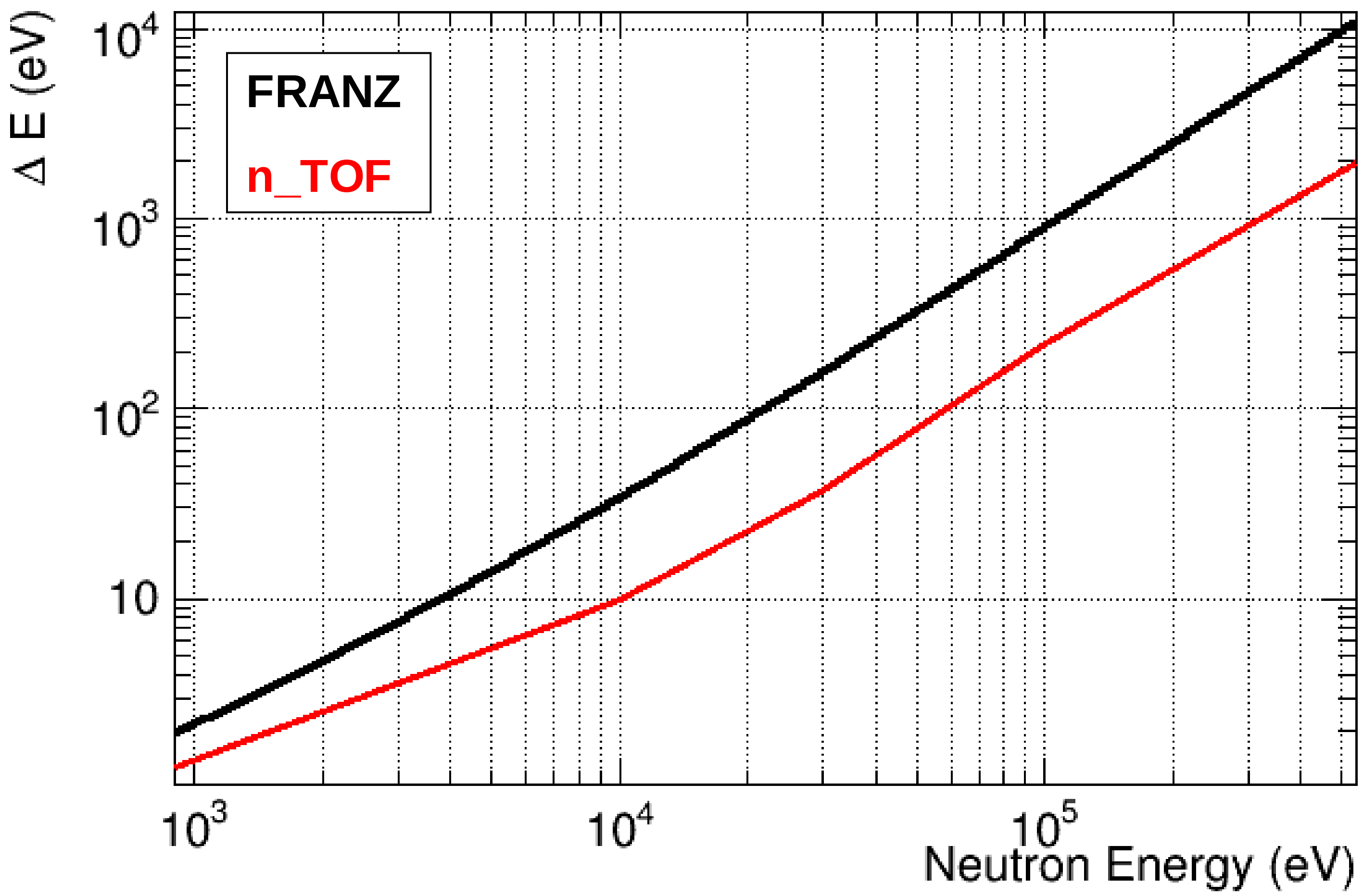
Current facilities

	type	E_n (eV)	L_{TOF} (m)	Φ_n	
				(n/cm^2/dec/sec)	(n/cm^2/dec/pulse)
GELINA	(γ,f)	10 - 4x10^6	20-50	4x10^4	50
LANSCE	spallation	1 - 10^8	20	3x10^5	1.5x10^4
n_TOF	spallation	0.03 - 10^8	185	4x10^4	10^5
ORELA	(γ,f)	10 - 5x10^6	40	4x10^4	50

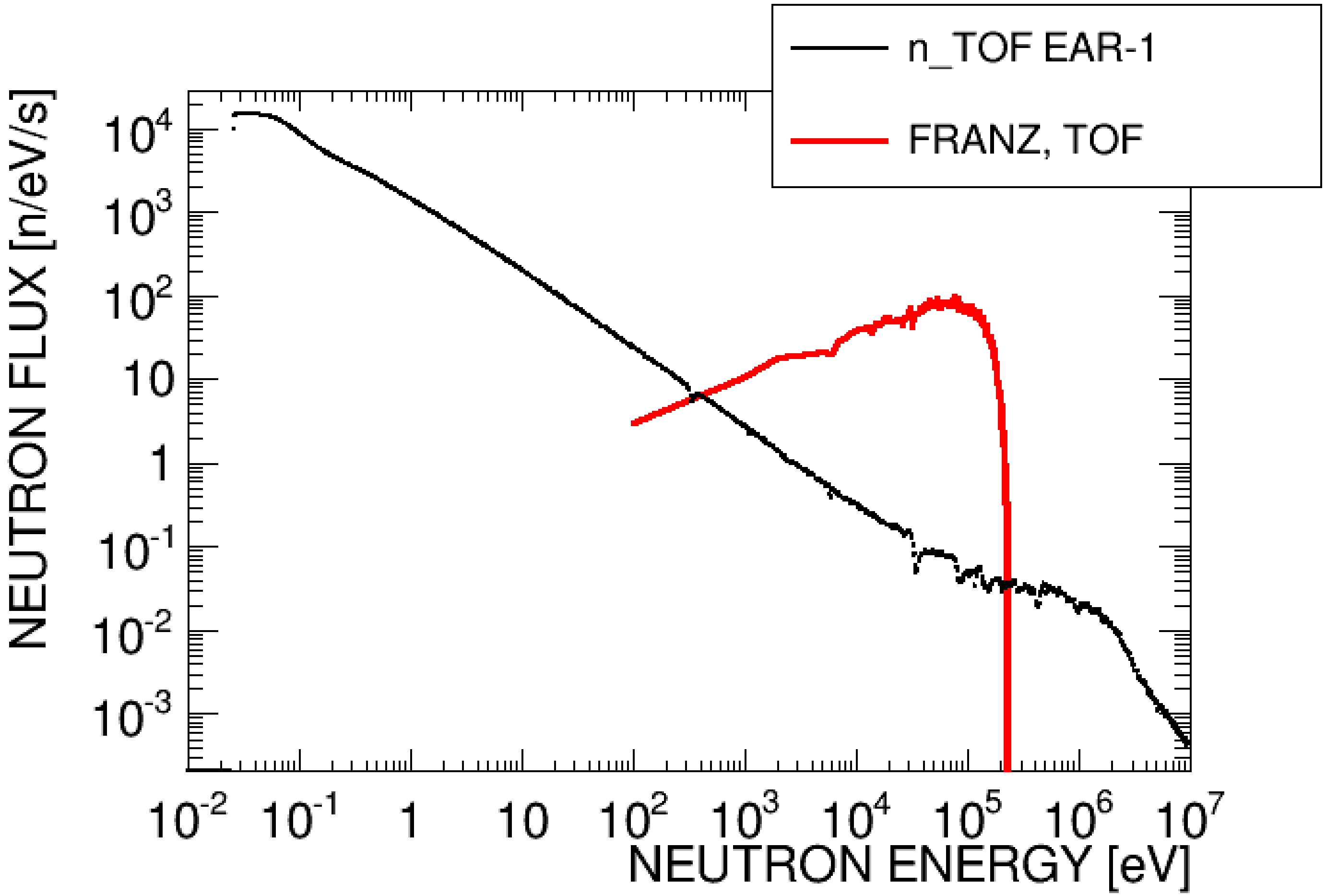
Upgrades/new facilities

	type	E_n (eV)	L_{TOF} (m)	Φ_n	
n_TOF	spallation	0.03 - 10^8	20	10^6	3x10^6
FRANZ	^{7}Li(p,n)	10^3-5x10^5	1	**10^7**	40

Neutron energy resolution

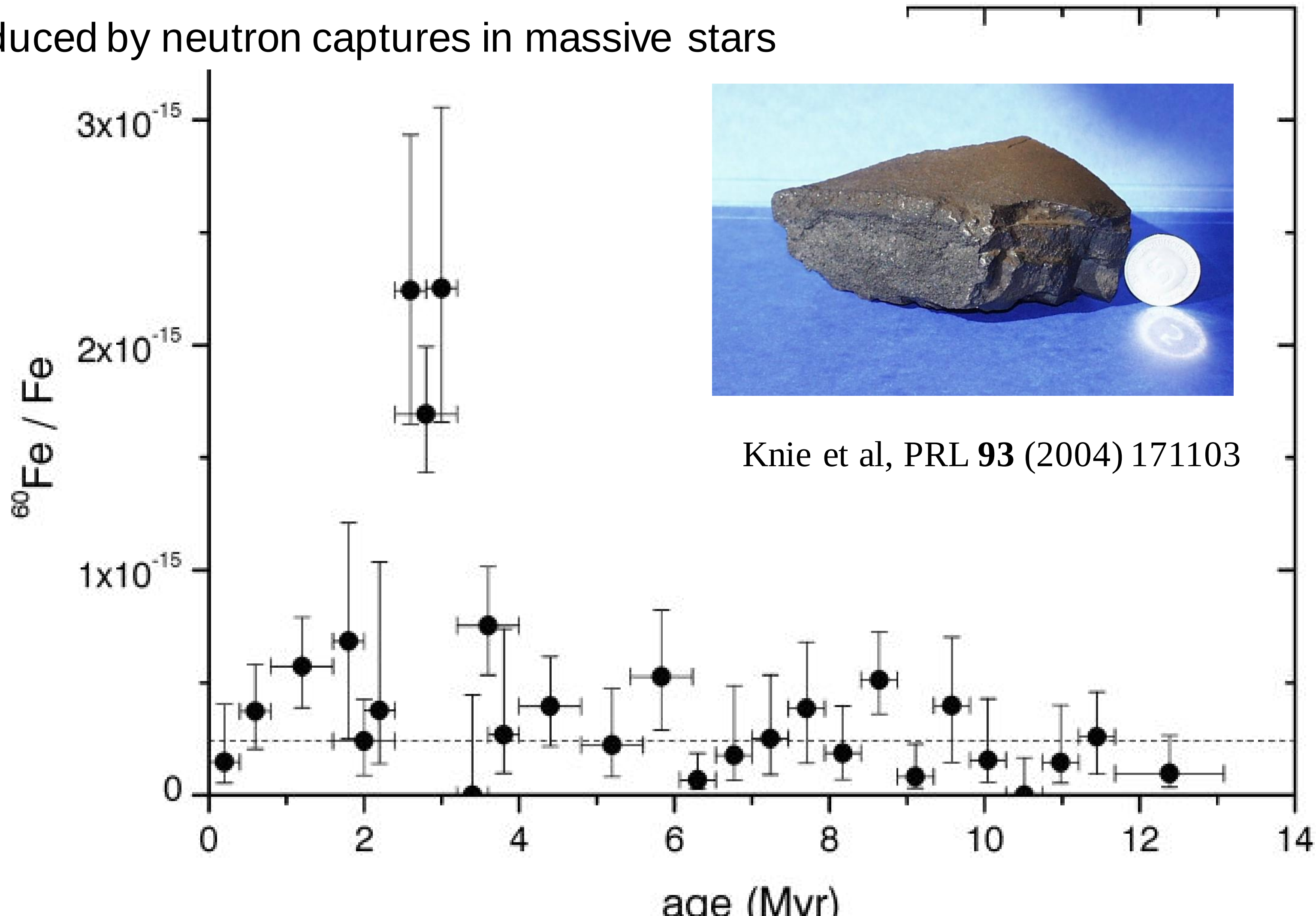


Neutron flux



SN produced material on earth

- $T_{1/2}(^{60}Fe) \sim 2.6$ Ma
- produced by neutron captures in massive stars

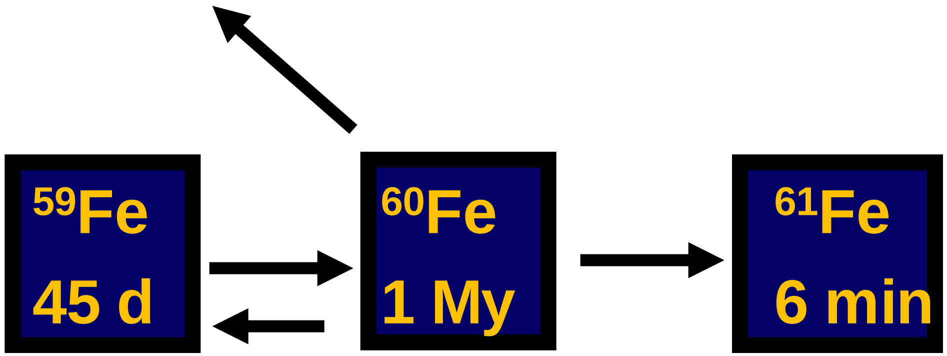


Knie et al, PRL **93** (2004) 171103

Production and destruction of ^{60}Fe

$^{60}Fe(\beta-)$

G. Rugel et al. PRL 103 (2009)



$^{59}Fe(n,\gamma)$:

Extremely difficult

$^{60}Fe(\gamma,n)$:

Coulomb dissociation, experiment performed (T. Heftrich et al.; E Uberseder et al.)

$^{60}Fe(n,\gamma)$:

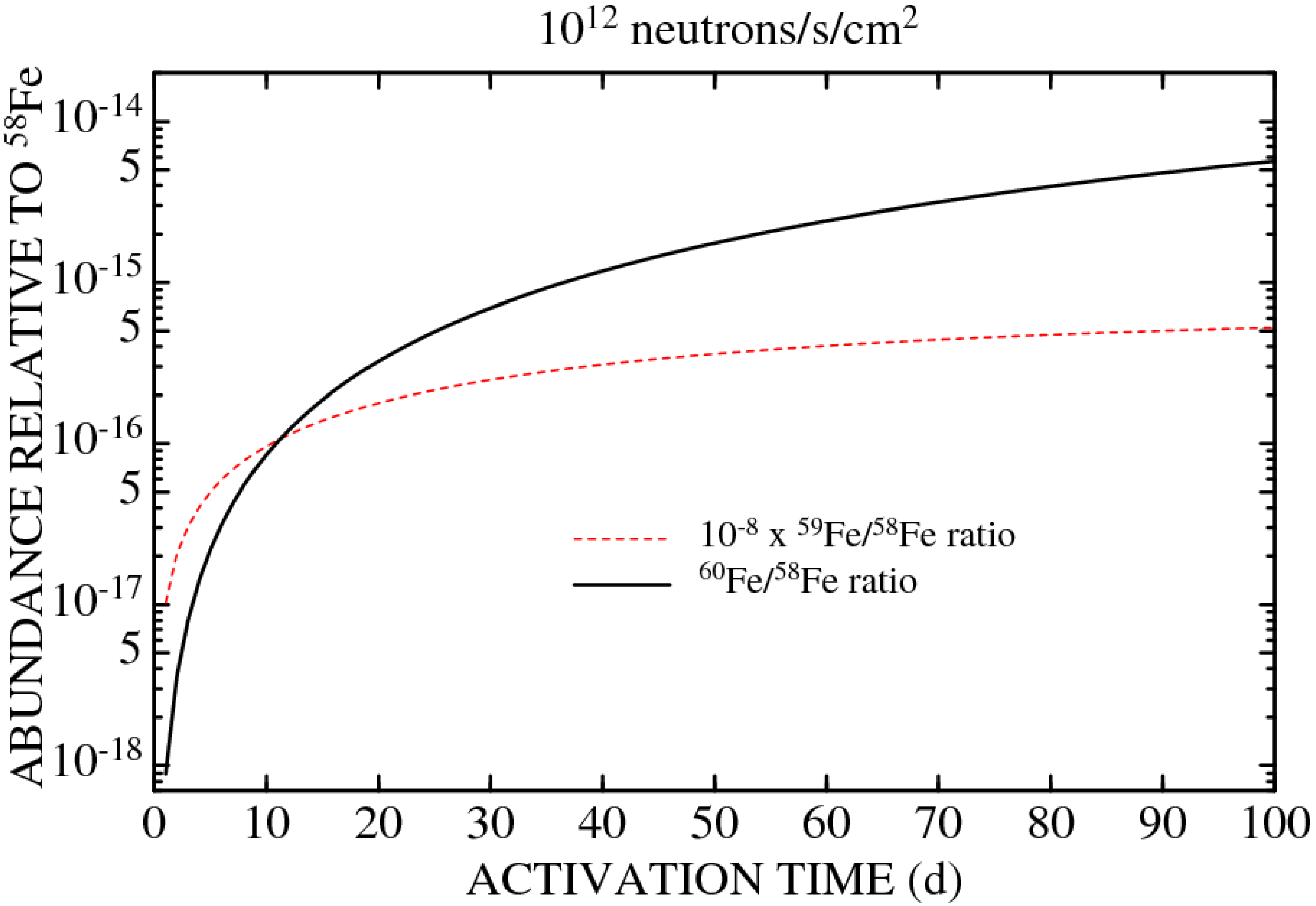
25 keV: E. Uberseder et al., PRL 102 (2009)

25 meV: experiment performed (T. Heftrich et al.)

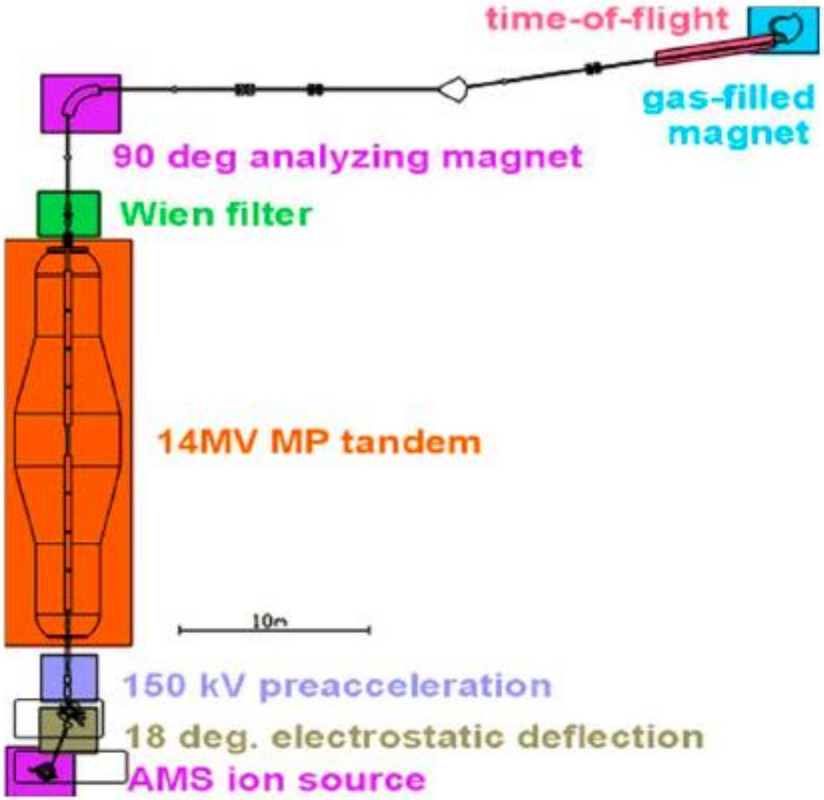
90 keV: FRANZ

$^{59}Fe(n,\gamma)$ at FRANZ ($t_{1/2}$=45 d)

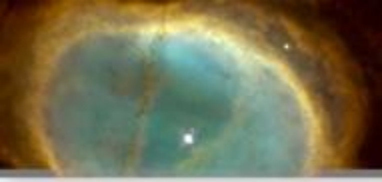
- activate ^{58}Fe, wait for 2nd neutron capture
- measure $^{60}Fe/^{58}Fe$ ratio via AMS



AMS at TU Munich



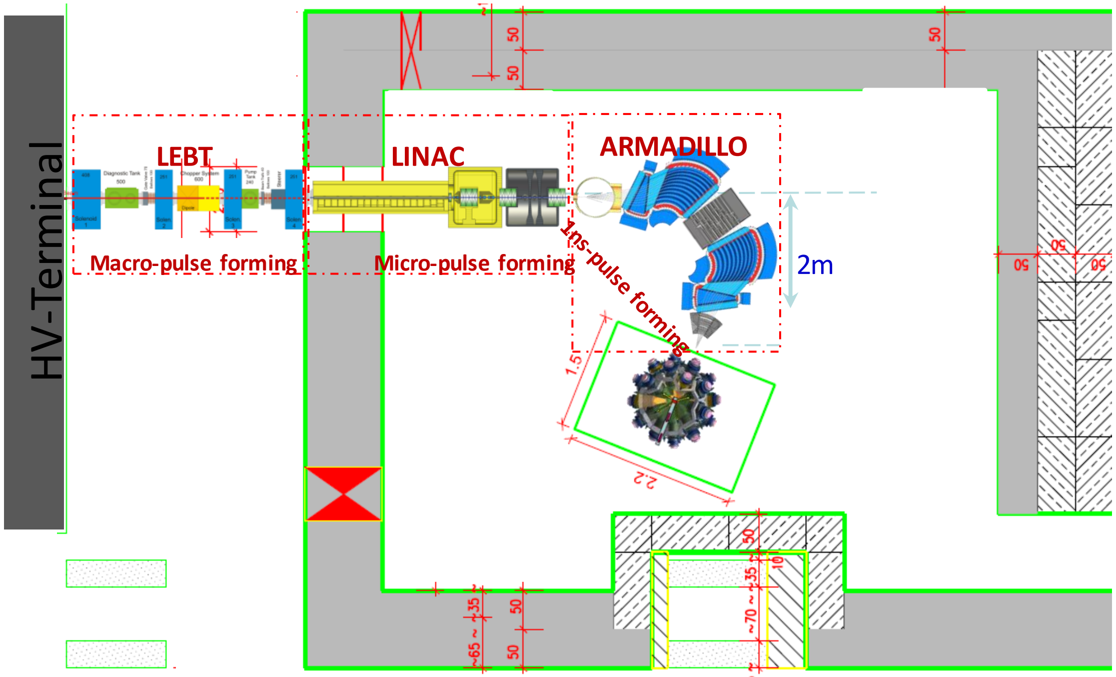
Courtesy of TU Munich



Thank you for your attention

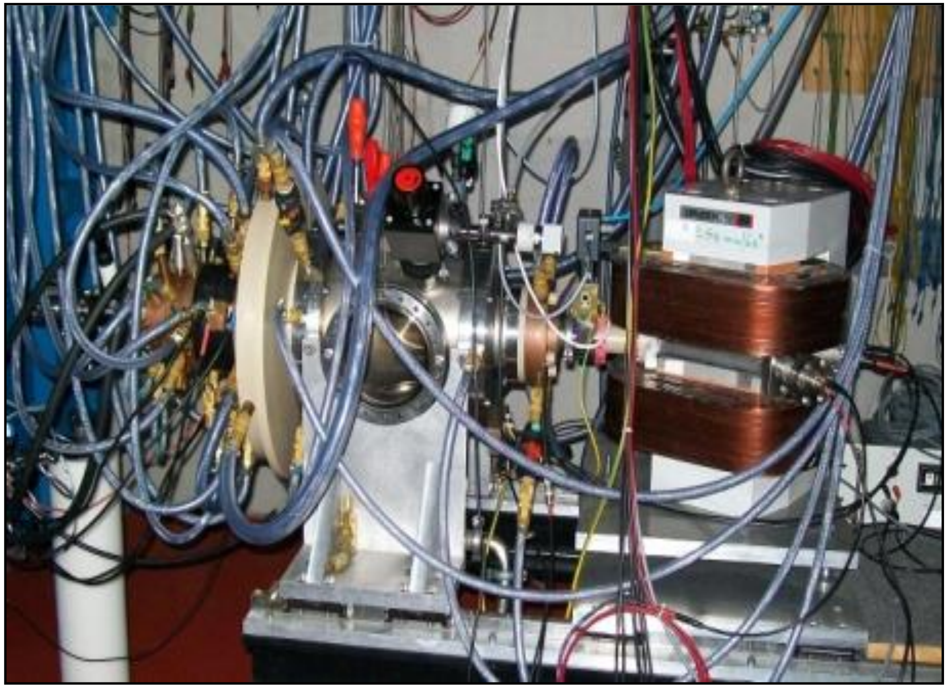

IAP

Satisfying the need for more neutrons

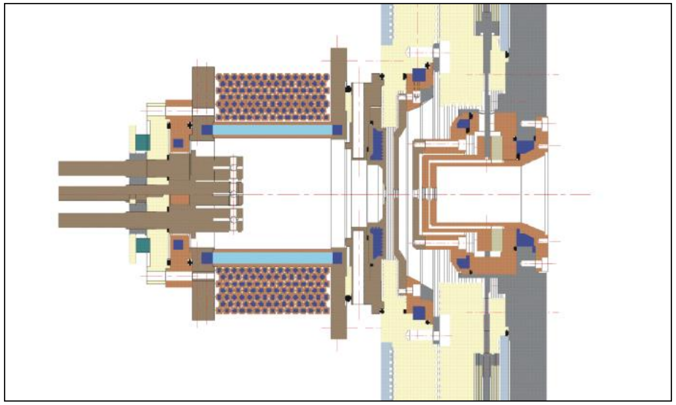


Volk / Schweizer

High Current Ion Source



Test Operation of Ion Source

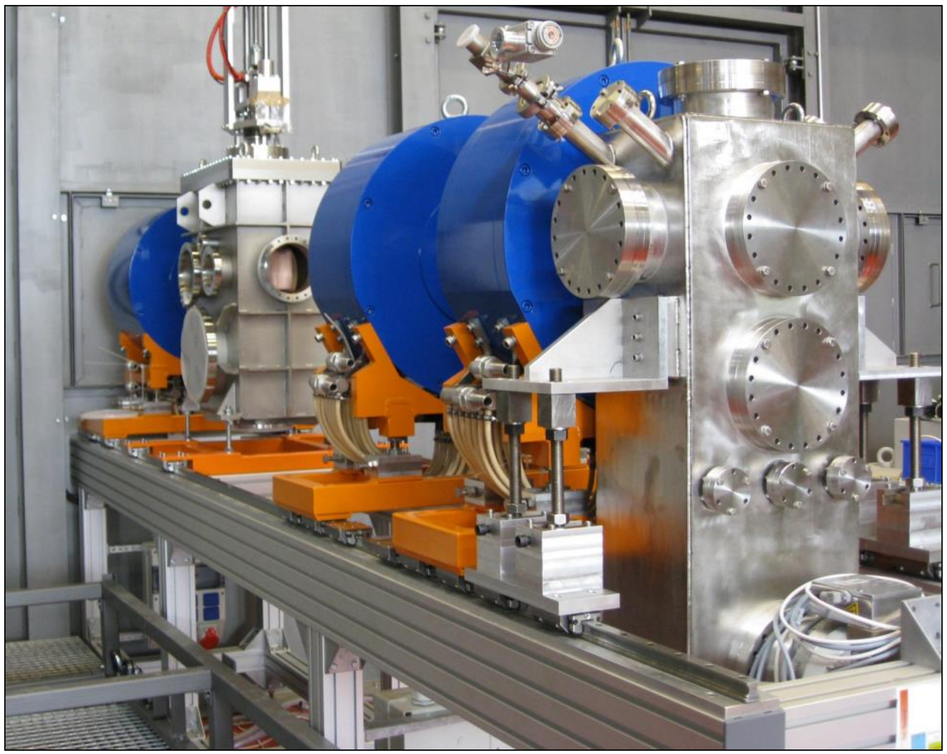


Technical Drawing

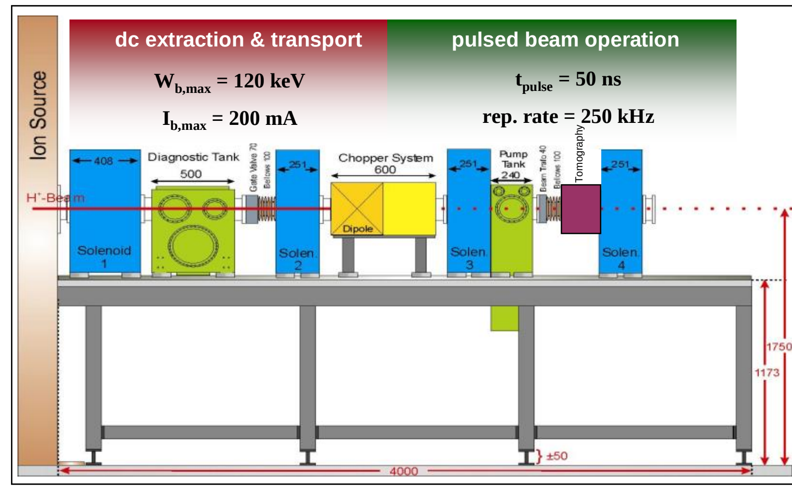
- Volume Type
- Hot Filament Driven Discharge
- Beam Current: 200 mA
- Proton Fraction: 90%
- Low Emittance

Wiesner / Dinter / Lotz

Low Energy Beam Transport



View of LEBT Section

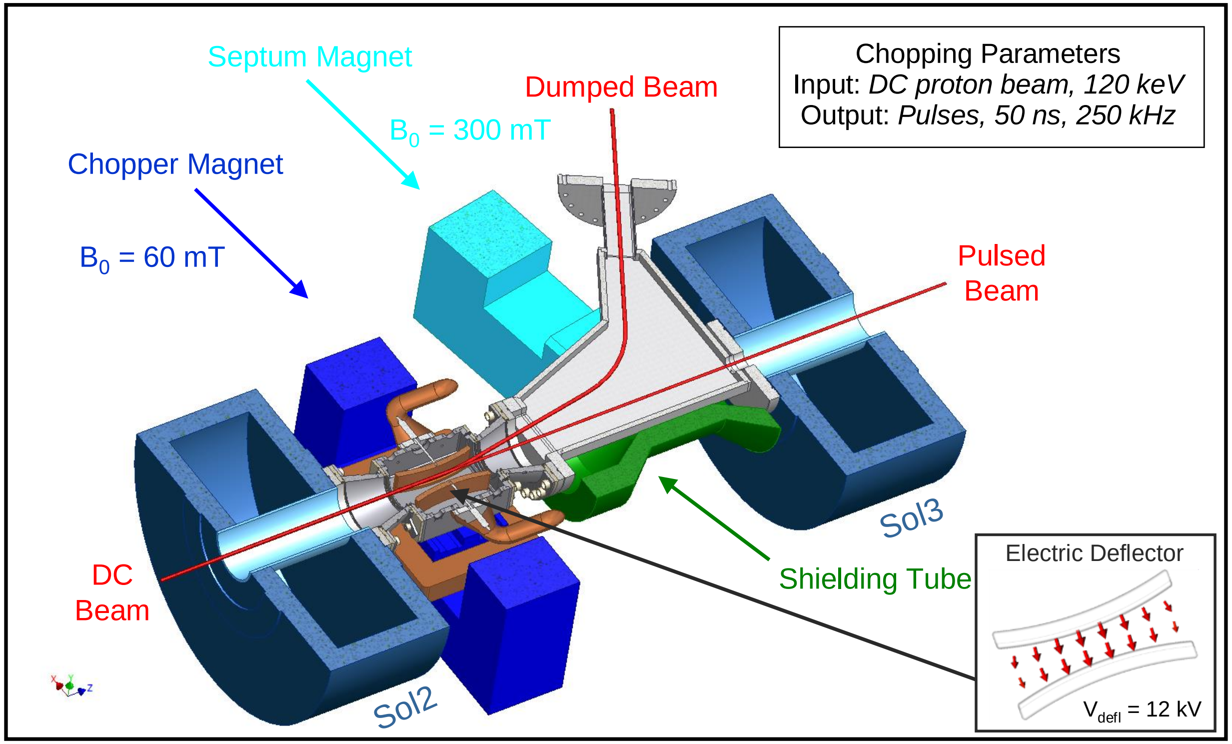


Schematic Drawing

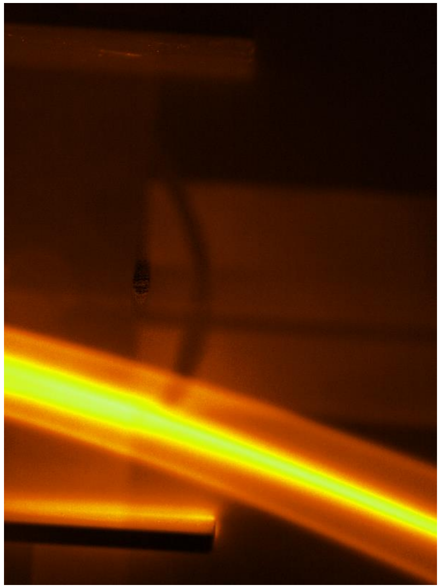
- Beam Energy: 120 keV
- Solenoid Lenses
- Space Charge Compensation
- Optical Non-Invasive Diagnostics

Wiesner / Dinter / Noll

E×B Chopper System

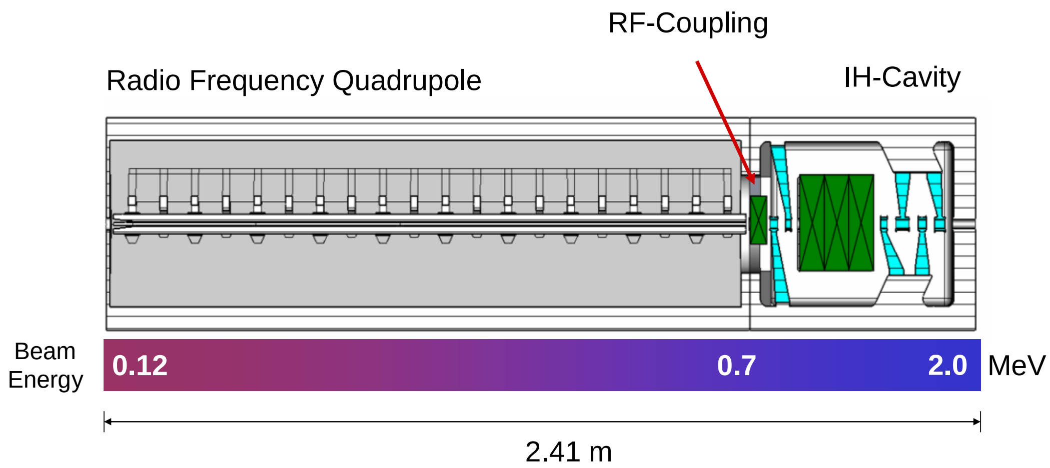


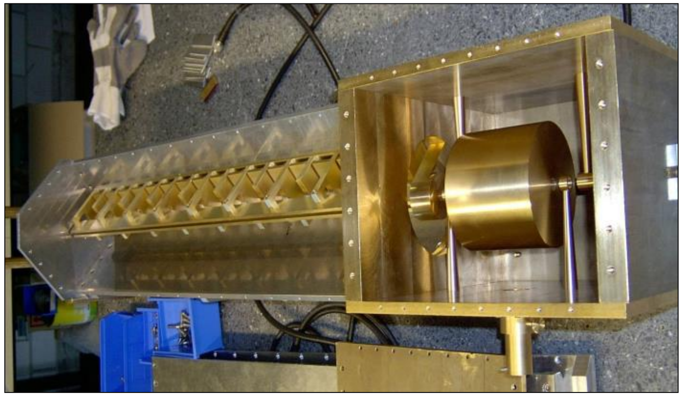
Scheme of E×B Chopper System



CCD Camera Image of Deflected Beam

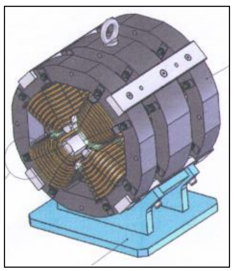
Linac: RFQ-IH-Structure





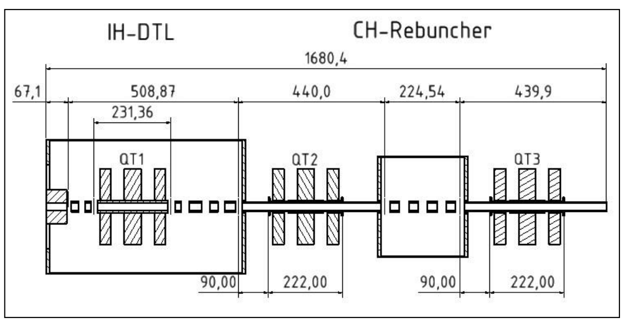
Model for the Study of RF-Coupling in the RFQ-IH Accelerator Stage

Medium Energy Beam Transport

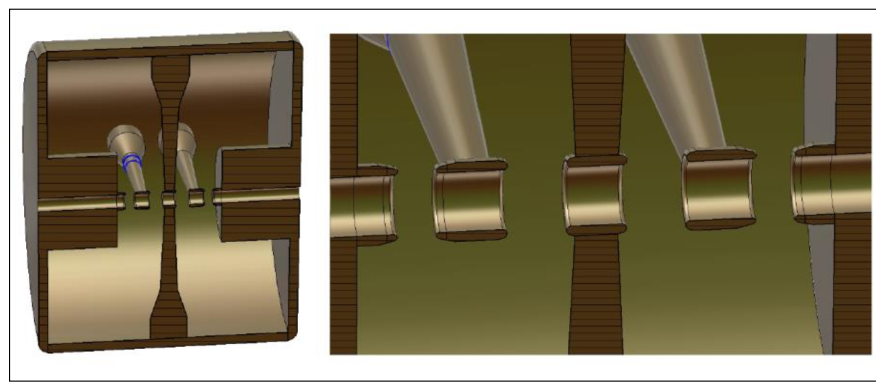


Magnetostatic Quadrupole Triplet for Transverse Focussing

- Beam Energy: 2 MeV ± 0.2 MeV
- 2 External Quadrupole Triplets
- Room Temperature CH - Cavity
- Phase Probe Beam Diagnostics



Layout of the MEBT Section



Cross Sectional View of the CH - Rebuncher Cavity

Chau / Noll / Podlech

Towards Compression Ratio of $\eta = 48$