

Radioactive background reduction in the Milano neutrino mass experiment

M. Sisti, C. Arnaboldi, C. Brofferio, O. Cremonesi, E. Fiorini, A. Nucciotti, M. Pavan, G. Pessina, S. Pirro, E. Previtali
Dip. di Fisica dell'Università di Milano-Bicocca and Sez. di Milano dell'INFN, I-20126 Milano, Italy

A. Giuliani

Dip. di Scienze Chimiche, Fisiche e Matematiche dell'Università d'Insubria I-22100 Como, Italy and Sez. di Milano dell'INFN, I-20133 Milano, Italy

B. Margesin and M. Zen

ITC-irst, Microsystems Division, I-38050 Povo (TN), Italy

A neutrino mass experiment studies the end-point of a beta decay spectrum: since the event rate in this region is extremely low the radioactive background must be as low as possible. Moreover in a calorimetric neutrino mass experiment the β source cannot be switched off, therefore the unknown radioactive background below the β spectrum must be minimized to avoid deformations of the spectrum. In this poster we discuss the radioactive background observed in the Milano neutrino mass experiment.

1. Experimental Configurations

Material selection in detector proximities

- Roman Pb with lowest ^{210}Pb content ($A_{210\text{Pb}} \leq 4$ mBq/kg)
- Pb-free solder (Sn/Ag alloy)

RUN 9 (2354 h×mg)

- detectors shielded with 3 mm Roman Pb from above
- two 10 mCi ^{55}Fe sources in fixed positions below the detectors shielded by ≤ 1 cm Cu (top) + ~ 1 mm Pb/0.2 mm Cu (shutter)
- ▶ 12 kBq ^{55}Fe Inner-Bremsstrahlung ($Q_{\text{IB}} = 232$ keV)

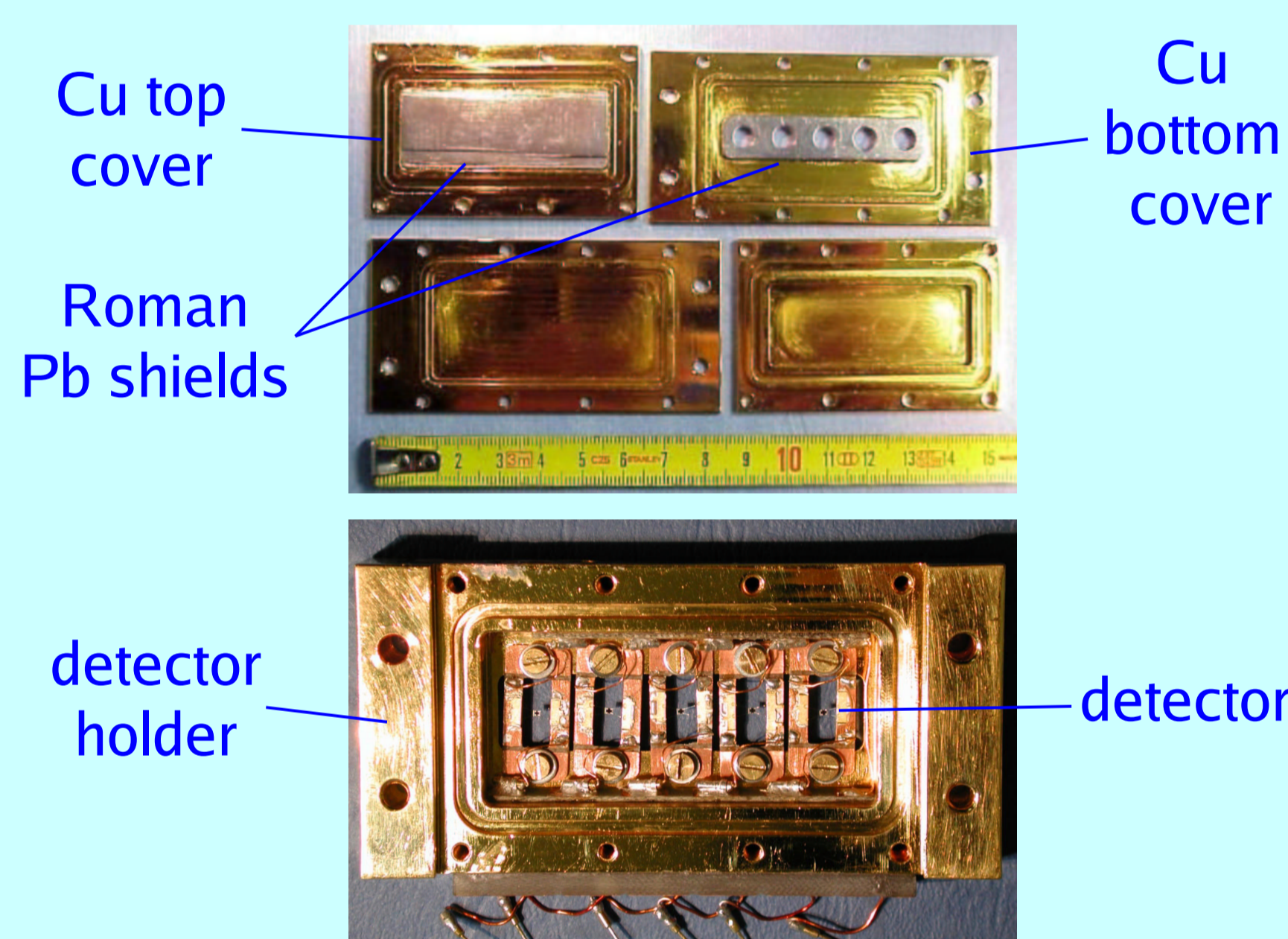
RUN 10 (1538 h×mg)

- 5 detectors shielded with Roman Pb (3 mm above, 2 mm below)
- 5 detectors without Pb shield
- without ^{55}Fe sources

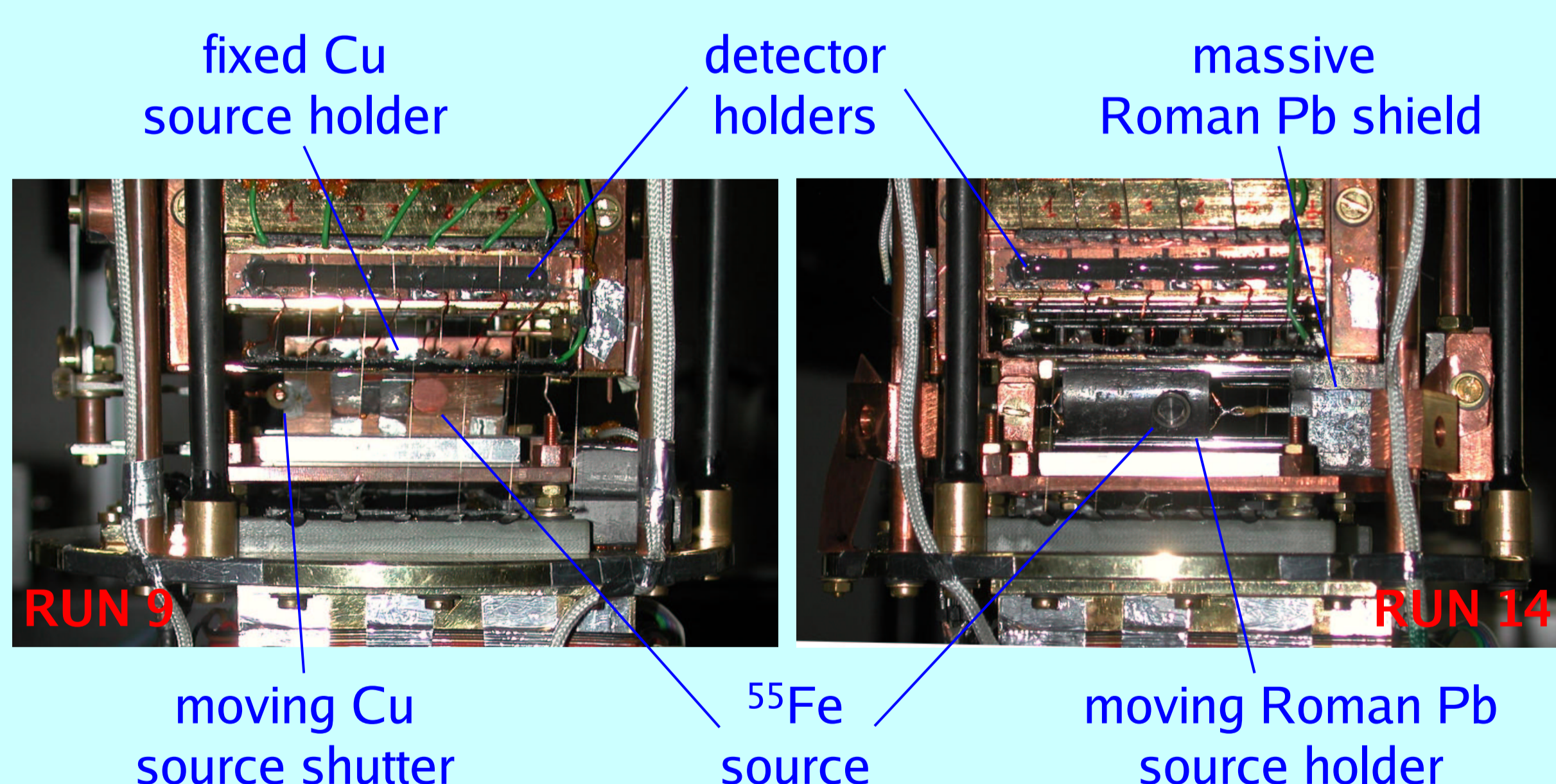
RUN 14 (8751 h×mg)

- detectors shielded only with Cu
- two 10 mCi ^{55}Fe sources which retracts into a ~ 2 cm thick Roman Pb shield

2. Detector holders



3. ^{55}Fe source in RUN 9 and RUN 14

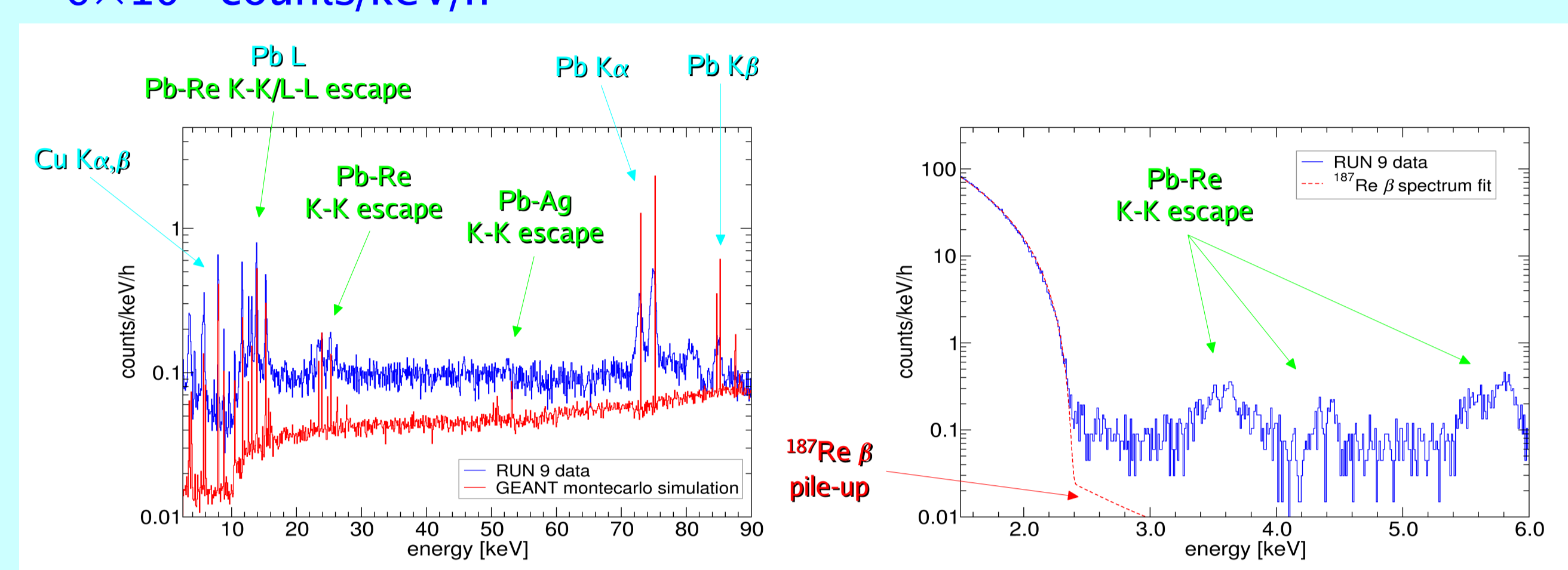


↗ source opens source closes ↘

see poster U09

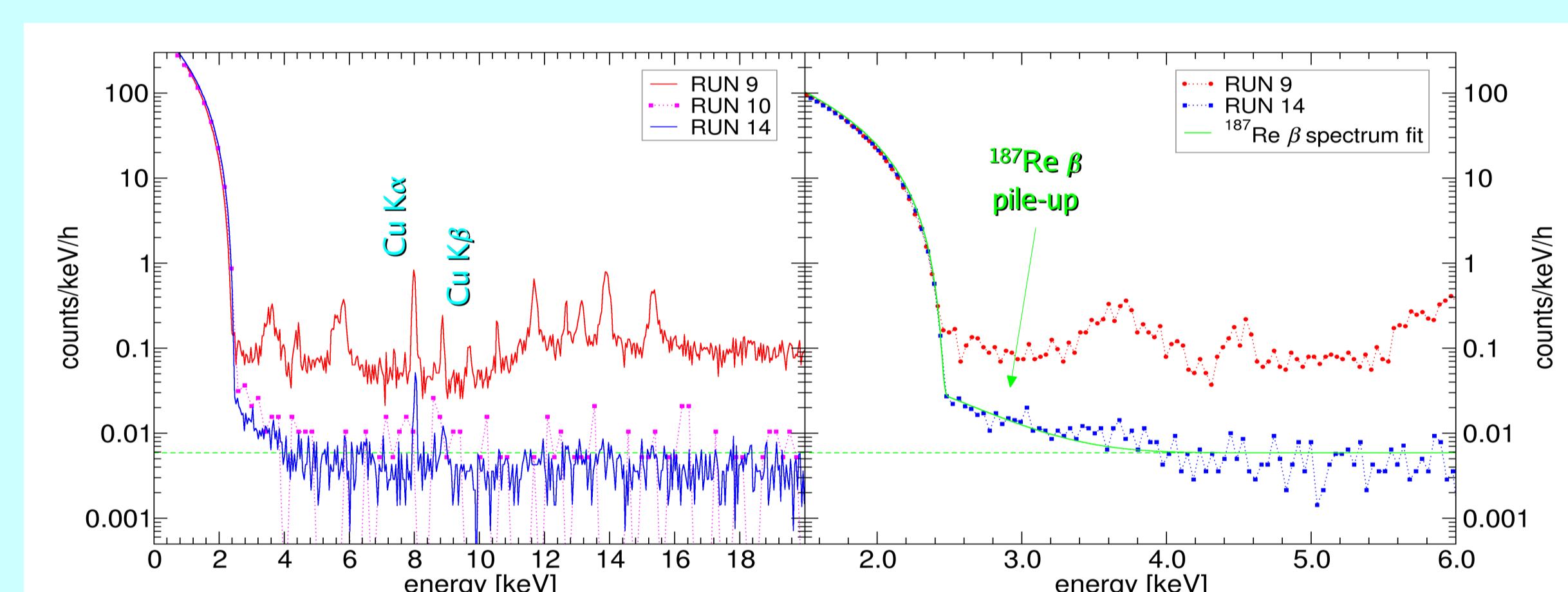
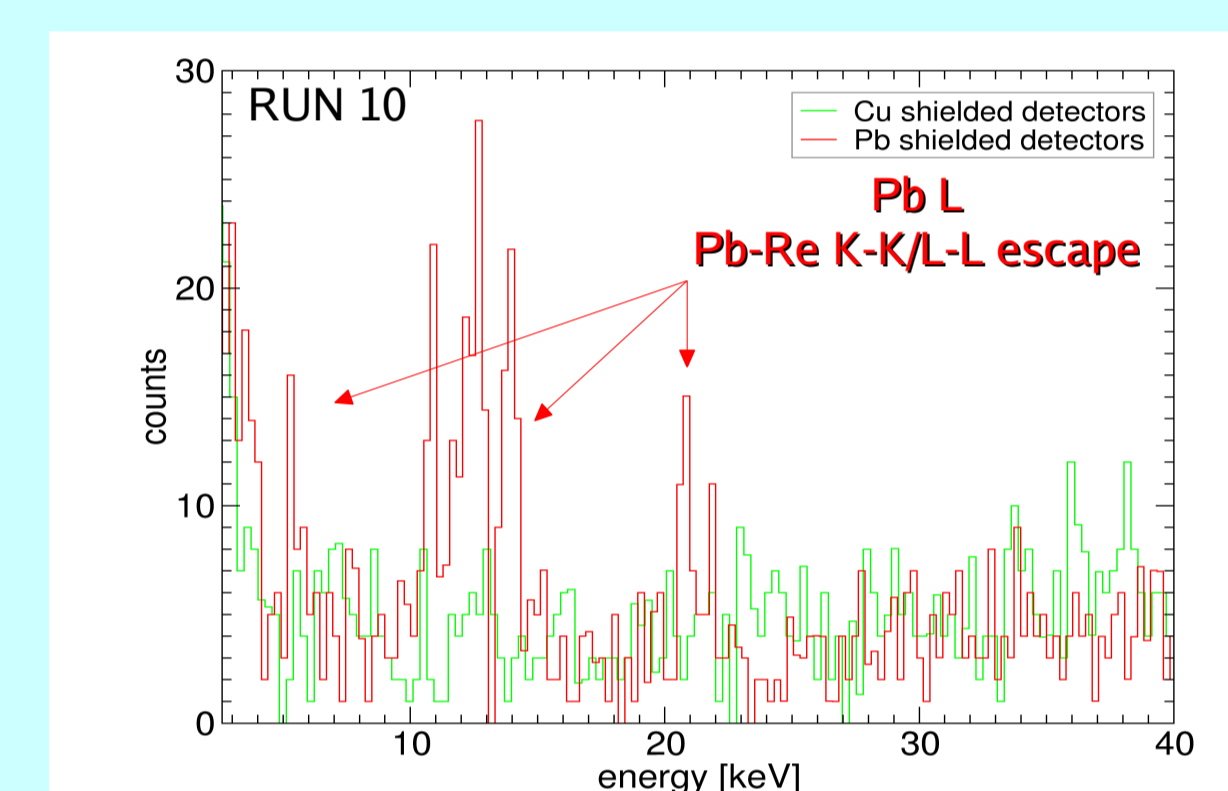
4. RUN 9 results

- high background continuum due to ^{55}Fe Inner-Bremsstrahlung (IB)
 - ▶ IB gammas excite Pb L and K X-rays in Pb shielding close to detectors
 - ▶ X-rays undergo photoelectric absorption in AgReO_4 mainly on K and L Re shells
 - ▷ escaping Re K and L X-rays cause escape peaks at low energies
- $b \approx 6 \times 10^{-2}$ counts/keV/h



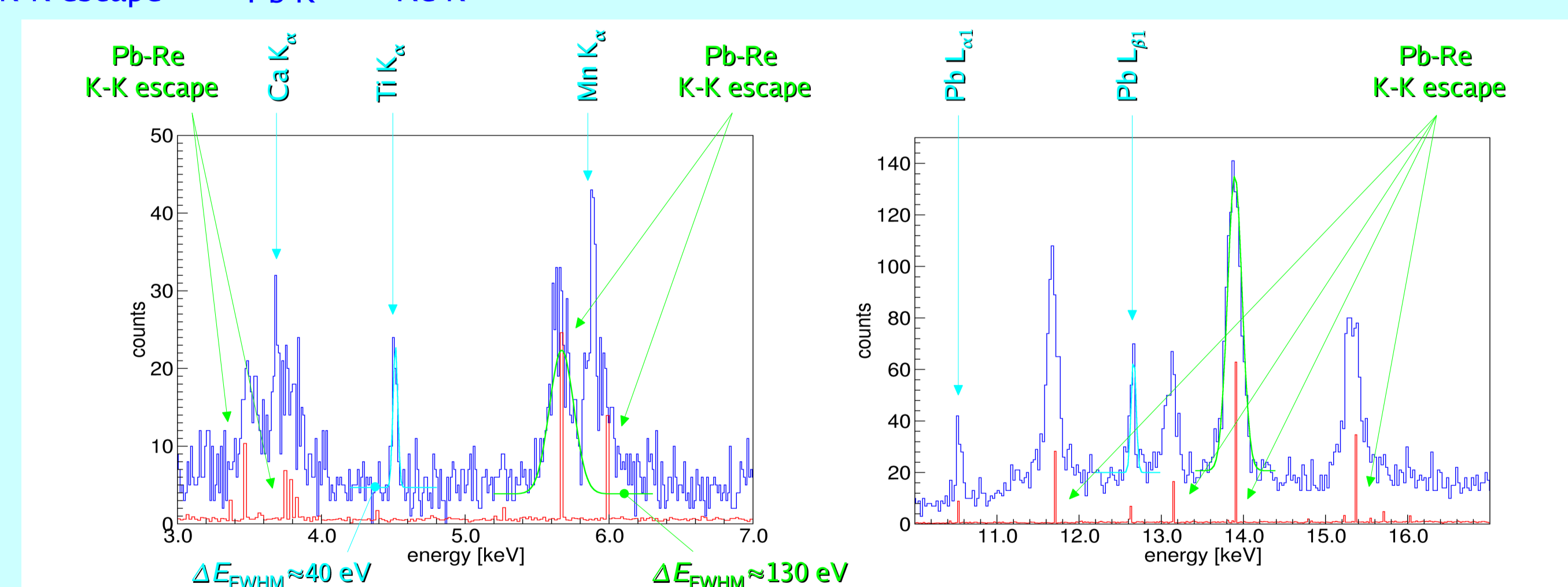
5. RUN 10 and 14 results

- detector Pb shielding increases background
- shielding the ^{55}Fe IB removes most of the background
- RUN 14 source configuration is equivalent to RUN 10 without ^{55}Fe sources
- RUN 14 continuum is constant up to 20 keV and is mainly due by cosmics and environmental radioactivity
 - ▶ $b \approx 7 \times 10^{-3}$ counts/keV/h
 - ▶ signal-to-noise $S/\mathcal{N}(Q_\beta; Q_\beta - 30 \text{ eV}) = \int N_\beta(E) / \sqrt{\int b} \approx 12$



6. Details of the X-ray escape peaks in RUN 9 spectra

- escape peaks are broader than X-ray peaks due to intrinsic Pb and Re X-ray line widths
 - ▶ $\Gamma_{\text{K-K escape}} = \Gamma_{\text{Pb K}} + \Gamma_{\text{Re K}} \approx 60.2 \text{ eV} + 42.1 \text{ eV} = 102 \text{ eV}$



7. Conclusions

- low and constant background is achieved by carefully shielding the ^{55}Fe sources
- detectors must be shielded only with low Z materials
- S/\mathcal{N} should improve increasing detector size m ($S \propto A_\beta \propto m$ and $\mathcal{N} \propto \sqrt{b} \propto \sqrt{m}$)
- background can be further reduced by material selection
- cosmics reduction can be attempted by using an active veto shield just above the detectors (p.e. a Si photodiode)