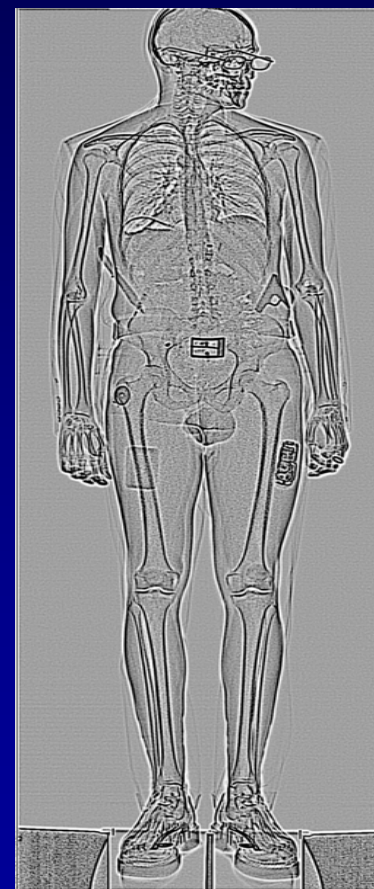
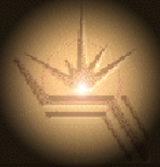


X-ray devices for medical radiography and security

*by Yu. TIKHONOV
Budker INP, Novosibirsk*





During last years the new low dose X-ray devices for medical and security applications have been developed in Budker INP

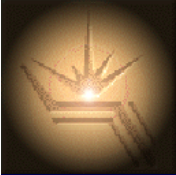
Why we need low (micro) dose technology?

•Medicine:

- situation with tuberculosis and cancer requires the mass inspection of population (at least once per year)
- present fluorography gives very high doses \Rightarrow *risk of cancer!*

•Security:

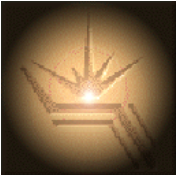
- due to problems with terrorism the detection of dangerous items and weapons hidden on body (and inside the body too) is very important.
- unlike inspecting for metal items, radiographic inspection is the only way to inspect for plastic explosive materials and weapons.
- these devices can be used at airports, customs, prisons, embassies, nuclear power centers, banks etc.



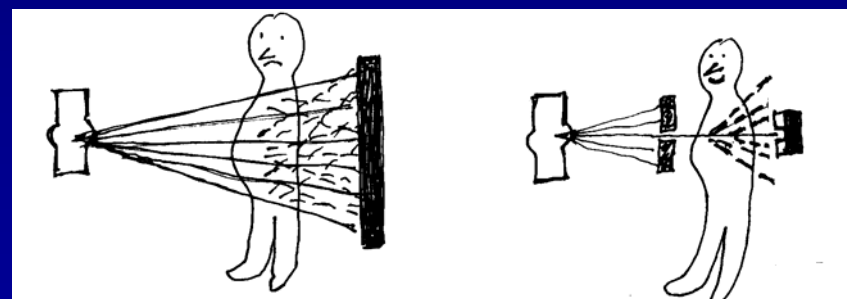
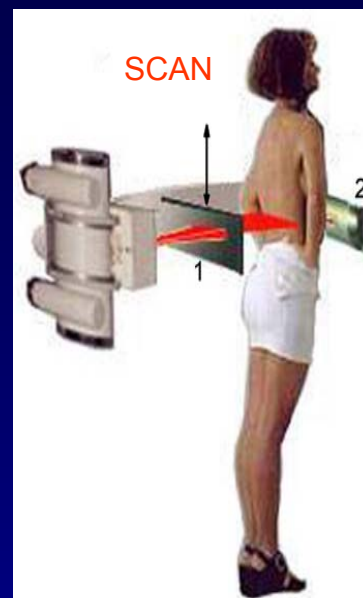
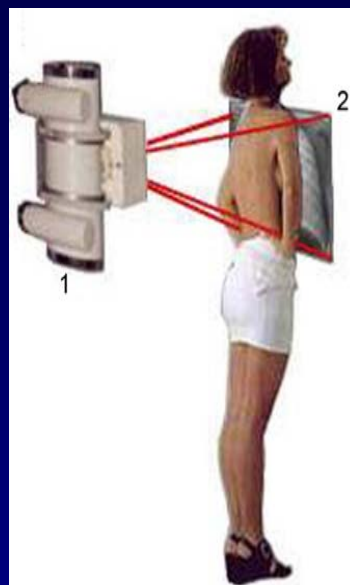
How to obtain low dose?

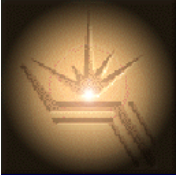
- **Minimization** the scattering radiation (scanning systems!)
- **High efficiency detector**
- **Low noise detector**
- **“Good” X-ray optic**

In this case the dose will be limited only by statistics!



Scanning method vs 2D imaging





Scanning method vs 2D imaging

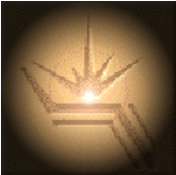
Advantages of scanning method

- the dose ~10 times lower at same contrast (depends on thickness)
- no artefacts
- the image length is not limited (up to 2 m)
- good image quality in hole field
- big dynamic range

Disadvantages

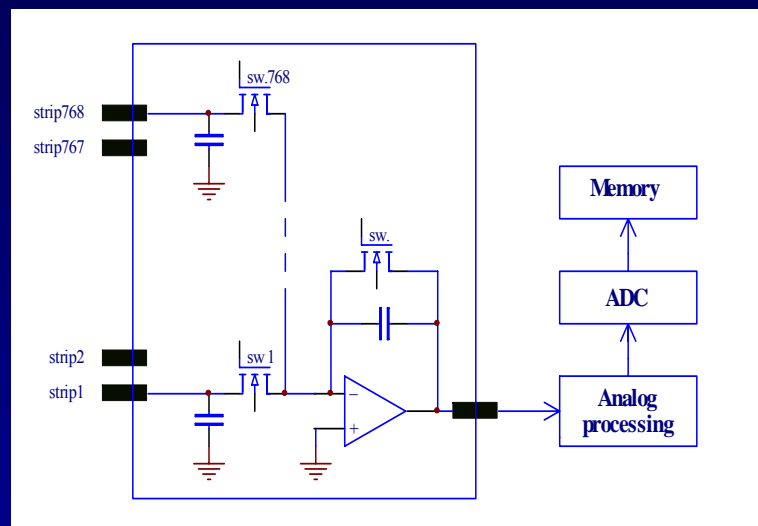
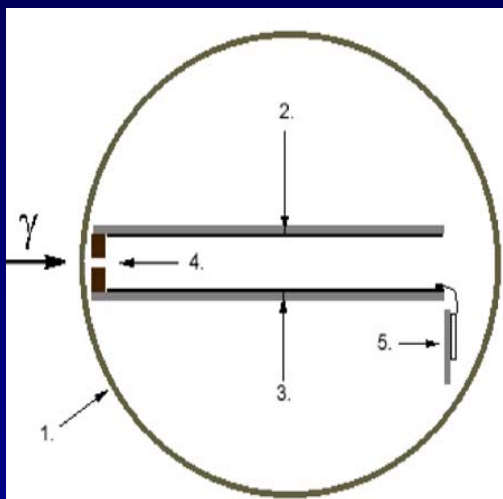
- long scanning time (3-5 s vs 0.01 sec in 2D methods)
- precision mechanics

One remark: it seems in the case of scanning method an image is not sharp due to movements of internals but it is not true! The time for read out of one string is very short (<0.001 s) and image dynamically is very sharp and provide additional information for a doctor.



High efficiency and low noise detector: *Multichannel Ionization Chamber (MIC)*

Xe, Kr up to 40 bar



MIC schematic diagram:

1 – detector housing;

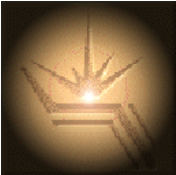
2 – anode plane;

3 – cathode strip plane;

4 – input diaphragm;

5 – readout electronics. (Reticon and Indigo chips are used for readout)

*ϵ -length*pressure*

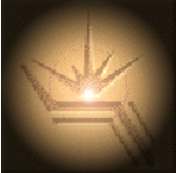


Multichannel Ionization Chambers (MIC)

A few types of MIC's have been developed for different applications

Type	Gas	P, bar	Noise, photons	Strips, mm	#channel	Application	Status
MICm	Xe, Kr	20	3	0.1	2048	Mammogra	Lab test
MIC1024	Xe, Kr	40	3	0.4	1024	Fluorograph	Mass product
MIC1536	Xe, Kr	40	3	0.3	1536	Fluorograph	Lab test
MIC2048	Xe, Kr	40	3	0.2	2048	General diagnostics	Mass product
MIC800	Xe	40	3	1.0	800	Security	Mass product

Efficiency of MIC's: 0.5-0.7



Multichannel Ionization Chambers (MIC)

Advantages of MIC :

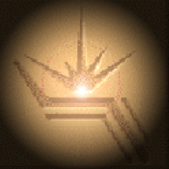
- Low noise
- Large dynamic range
- High radiation resistance
- Fill factor 100%

Disadvantage:

- High pressure

The MIC800 for security (800 mm)





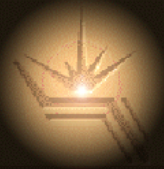
The devices for medical application based on MIC



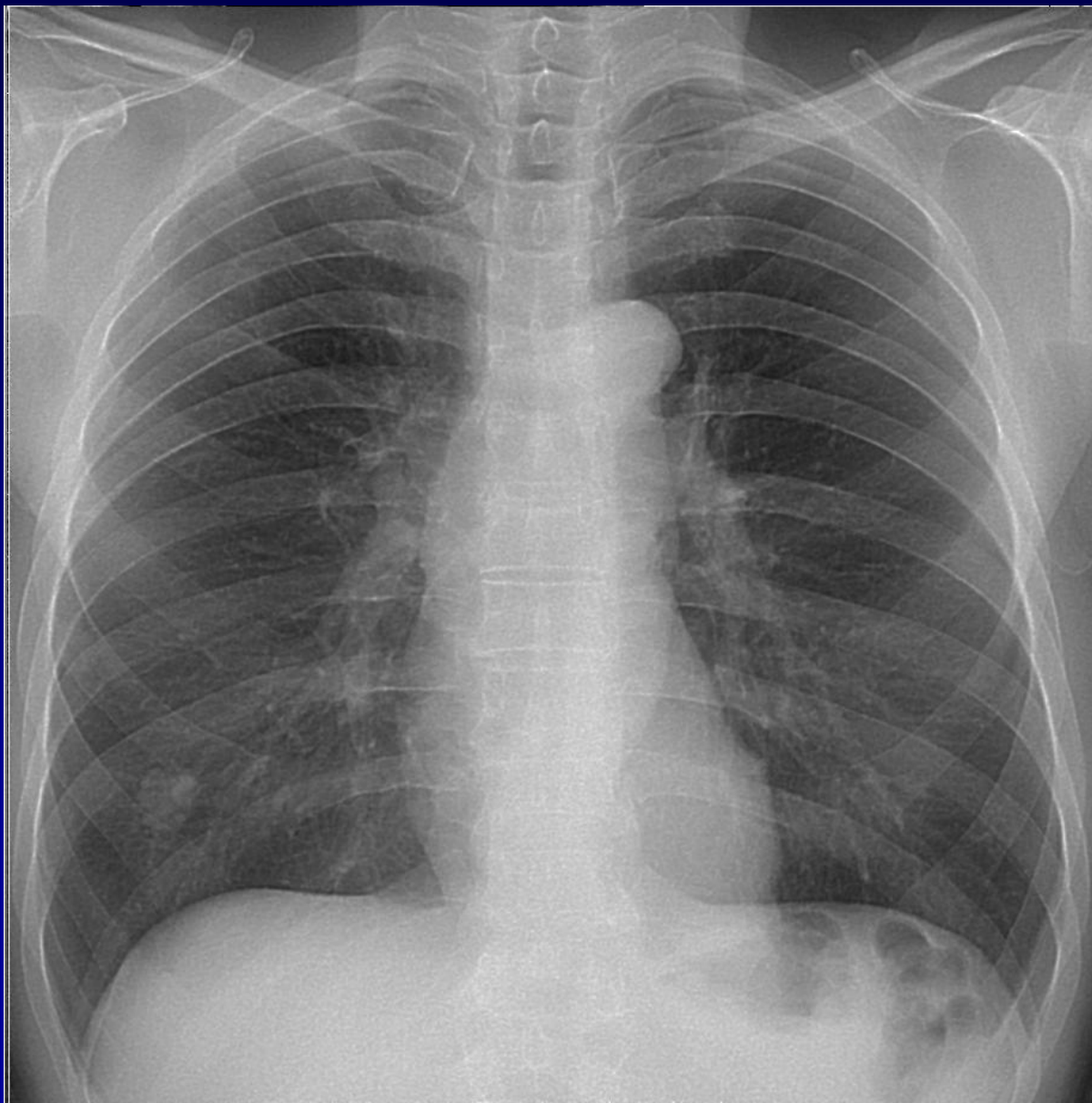
Fluorograph
FMC – NP –O
Russia

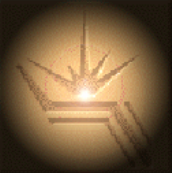


Fluorograph
DRC
South Korea



The example of image obtained with FMC-NP-0

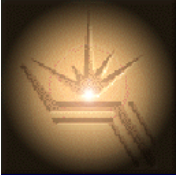




Some parameters of FMC-NP-o (Russia)

Image sizes, <i>mm</i>	410 x 1200
Resolution, <i>pI/mm</i>	2
Contrast sensitivity, % (at dose 100 μ R in detector plane)	0,5
Scan speed, <i>cm/s</i>	10
Dynamic range	1000
Dose for chest image, μ Bv	5
HV on X-ray tube (max), <i>kV</i>	120
Distance: X-ray tube \Rightarrow detector, <i>mm</i>	1300
# images/hour	60

Four companies (2 in Russia, 1 in China and 1 in Korea) produce medical devices based on MIC's detectors by license of BINP .

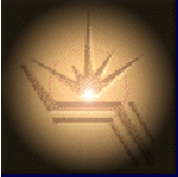


Application for security

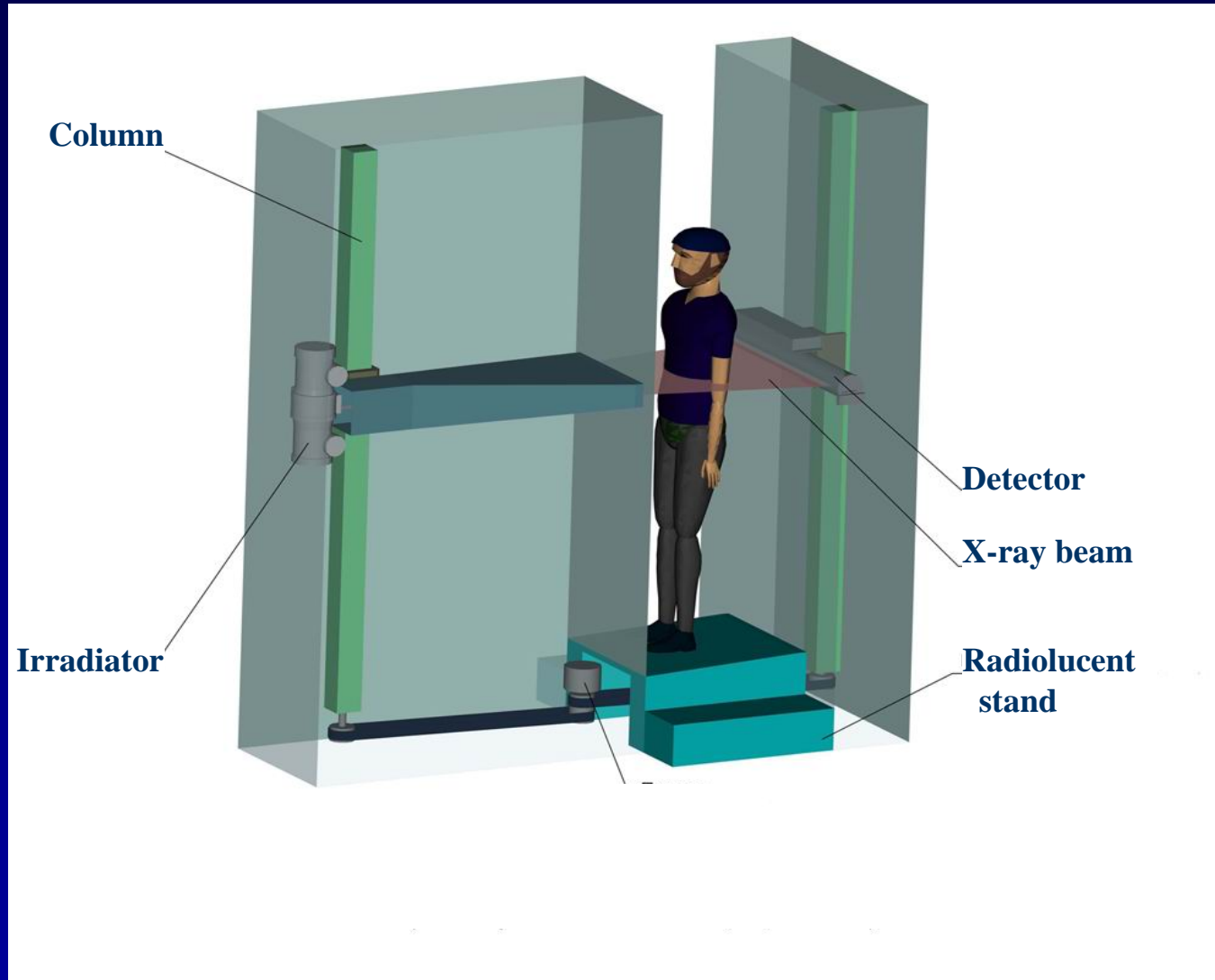
System for Radiographic Control (SRC)

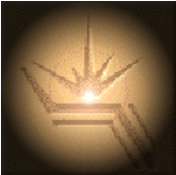
Requirements

- a) possibility of low-contrast objects detection, allowing to observe them inside clothes and inside body also;
- b) ultra-low doses of x-ray irradiation, comparable with background dose;
- c) large image dimensions (more than human height and width);
- d) short period of inspection;
- e) presence of software allowing to analyze an image in a short time;
- f) minimum inconveniences for inspected person;
- g) high output



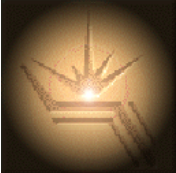
A principal design for SRC





The first SRC sample “Sibscan” (2005)





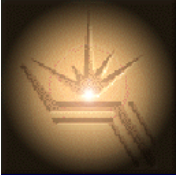
Basic SRC parameters

■ Maximum scanning height	2000 mm
■ Image width	800 mm
■ Channel size (resolution)	1x1 mm
■ Scanning speed	40 cm/s
■ Maximum scanning time	5 s
■ Capacity	3 persons/min
■ Radiation dose per 1 inspection	~0,5 μSv *

**** This dose is equivalent to 5 minutes
of flights cosmic ray background dose!***

The permitted years dose (in many countries) is 1000 μSv
Each passenger can pass SRC inspection many times without any trouble*

*medical inspections are not included!



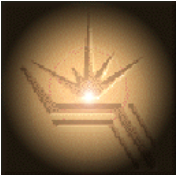
Dose levels (μSv)

1. Medical inspections:

- **Computer tomograph** 10 000
- **Chest inspection, mamography**
- novel devices 30-100
- film X-ray 200

2. Radiation background:

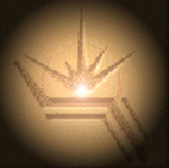
- At 1500 m sea level (per day) 6
 - At 10000 m (per hour) 5
3. **SRC inspection** 0.5



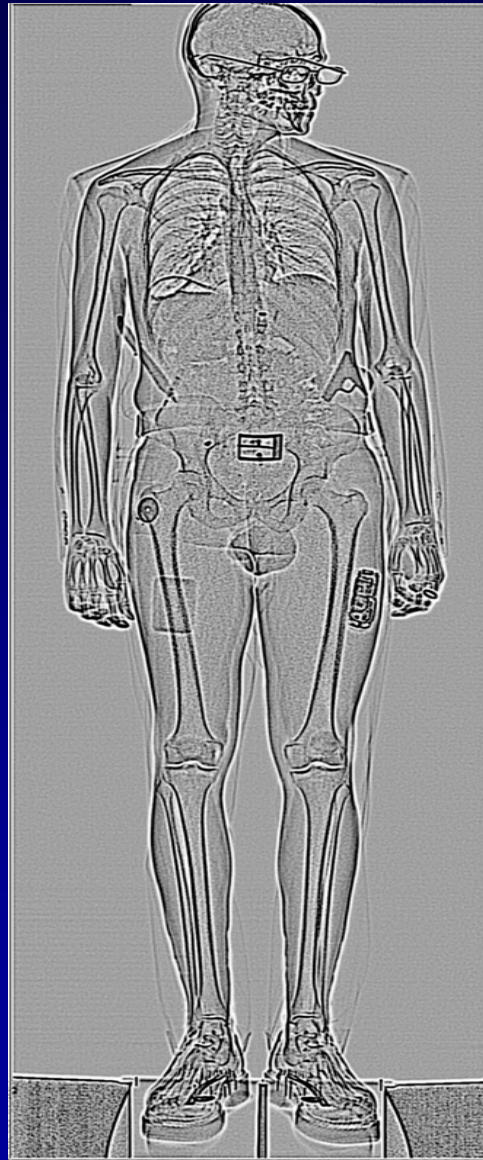
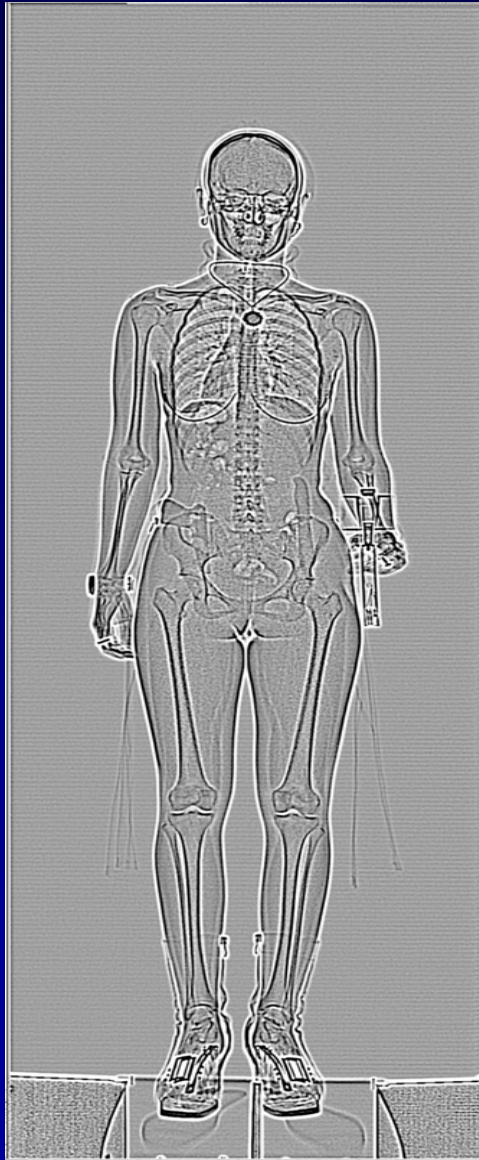
SRC installed in Domodedovo airport in Russia

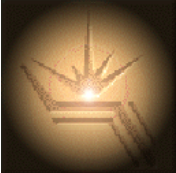


**Up to now 6 SRC devices are in operation in four Russian airports.
Welcome!**



Some “terrorists” found with SRC





Conclusion

- **The set of Multichannel Ionization Chamber's (MIC) have been developed for practical usage in medicine and security**
- **The scanning devices based on MIC's allow to have lowest doses compare to other methods**
- **A few years of operations of the different devices based on MIC's shown good efficiency and reliability**
- **The new developments are in progress:
the goal *-decreasing of the scanning time (electronics+mechanics)***