GAMMA-400 SCIENTIFIC COLLABORATION

Scientific and Service Data Acquisition System for the GAMMA-400 Apparatus

M.S. Gorbunov, A.M. Galper, S.G. Bobkov, O. Adriani, R.L. Aptekar, I.V. Arkhangelskaja, A.I. Arkhangelskiy, L. Bergström,E.A. Bogomolov, M. Boezio, V. Bonvicini, K.A. Boyarchuk, V.A. Dogiel, Yu.V. Gusakov, B.I. Hnatyk, V.V. Kadilin, V.A. Kaplin, M.D. Kheymits, V. Korepanov, A.A. Leonov, F. Longo, P. Marrocchesi, E. Mocchiutti, A.A. Moiseev, N. Mori, I. Moskalenko, P.Yu. Naumov, M. Pearce, P. Picozza, A.V. Popov, M.F. Runtso, O.V. Serdin, R. Sparvoli, P. Spillantini, S.I. Suchkov, M. Tavani, N.P. Topchiev, A. Vacchi, E. Vannuccini, G.I. Vasilyev, Yu.T. Yurkin, N. Zampa, V.G. Zverev

gorbunov@niisi.msk.ru

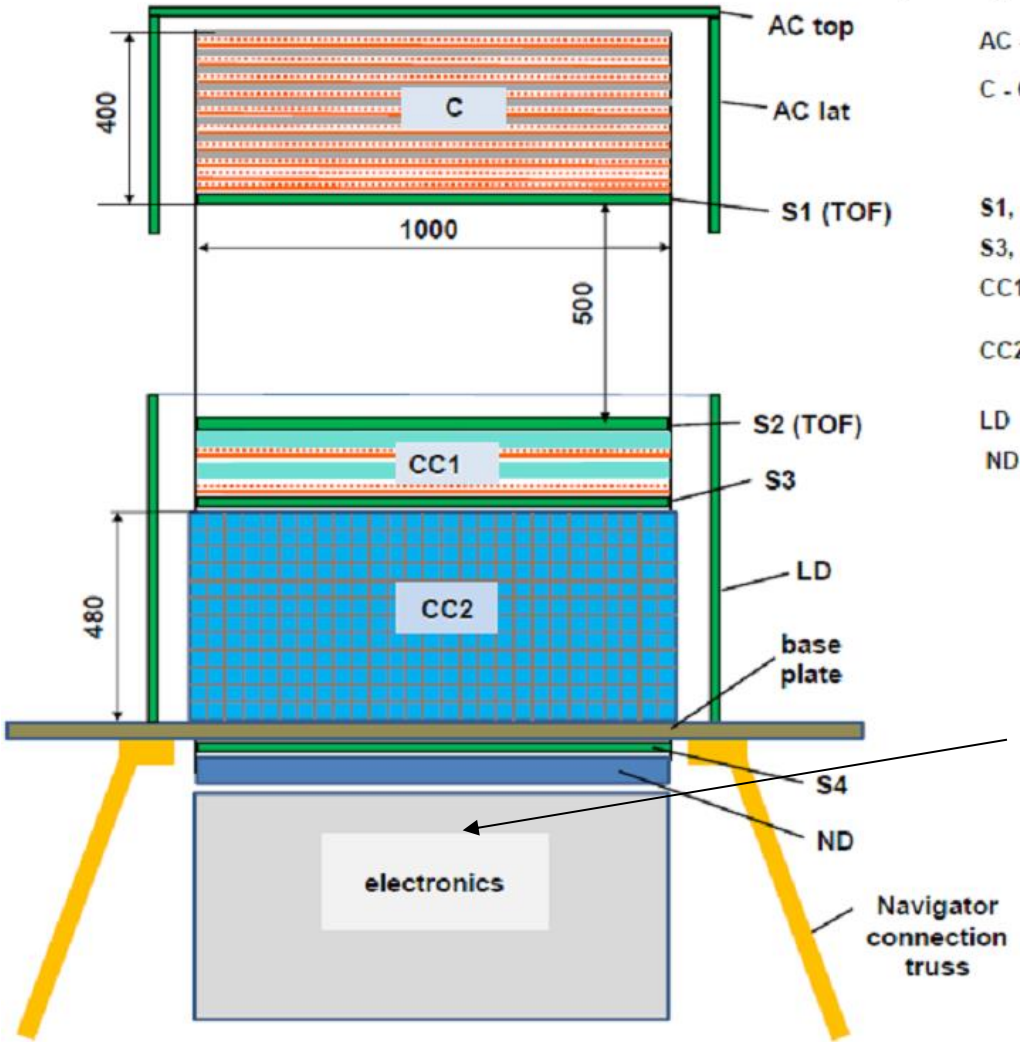
(499) 124-68-52

COSMOS

THE 40TH COSPAR SCIENTIFIC ASSEMBLY

2 - 10 August 2014, Moscow, Russia

Physical diagram of the GAMMA-400 scientific equipment



AC - anticoincidence detectors (AC top , AC lat)

C - Converter-Tracker - total 1 Xo
8 layers W 0.1 Xo +Si (x,y) (pitch 0.1mm)
2 Si(x,y) no W

S1, S2 - TOF detectors

S3, S4 calorimeter scintillator detectors

CC1 - imaging calorimeter (2Xo)
2 layers: CsI(Tl) 1Xo + Si(x,y) (pitch 0.5 mm)

CC2 - electromagnetic calorimeter
CsI(Tl) 23 Xo 3.6x3.6x3.6 cm^3 - 28x28x12=9408 crystals

LD - 4 lateral calorimeter detectors

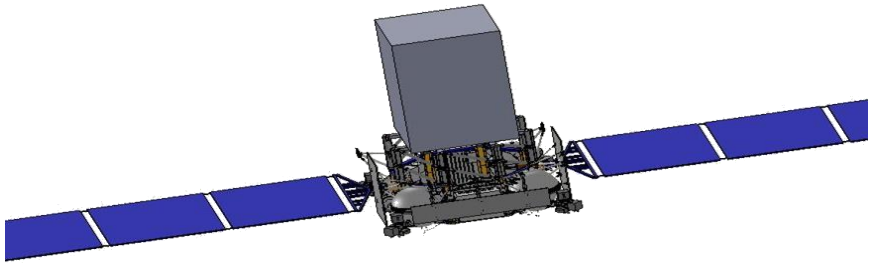
ND - neutron detector

Scientific and Service Data Acquisition System developed by SRISA

Comparison between characteristics of existing and planned gamma-ray telescopes

	space gamma-ray telescopes			ground gamma-ray telescopes		
	Fermi	AMS-2	GAMMA-400	H.E.S.S.-II	MAGIC	CTA
energy range [GeV]	0.02–300	10–1000	0.1–3000	> 30	> 50	> 20
acceptance [m^2 sr]	2.4	0.4	1.2	0.01	0.01	0.1
effective area [m^2]	0.8	0.2	0.6	10^5	10^5	10^6
angular resolution (E_γ > 100 GeV)	0.2	1.0	< 0.02	0.07	0.05	0.06
energy resolution (E_γ > 100 GeV)	10%	3%	1–2%	15%	15%	10%

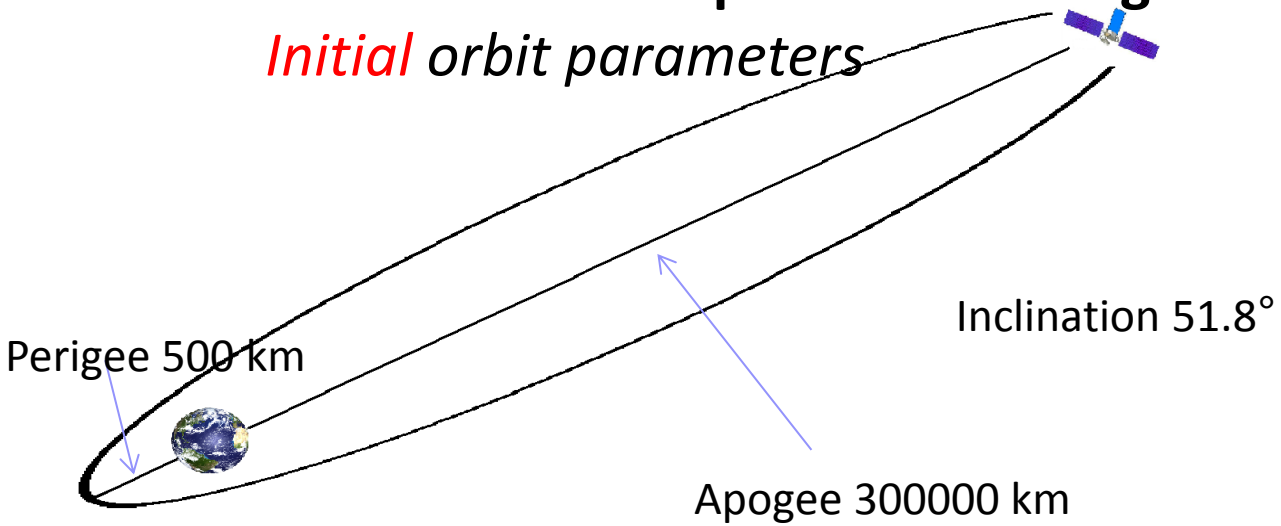
Gamma-400 instrument installed on the ‘Navigator’ spacecraft



- Scientific payload 2600 kg
- Power budget 2 kW
- Expected lifetime >7 years

Gamma-400 on spacecraft “Navigator”

Initial orbit parameters



Facts about SRISA

- Was founded in October 1986
- More than 700 scientists
- Located in Moscow
- Technological laboratory for ASIC prototype (Kurchatovsky Institute, Moscow)
- The annual budget is over 50 millions euro

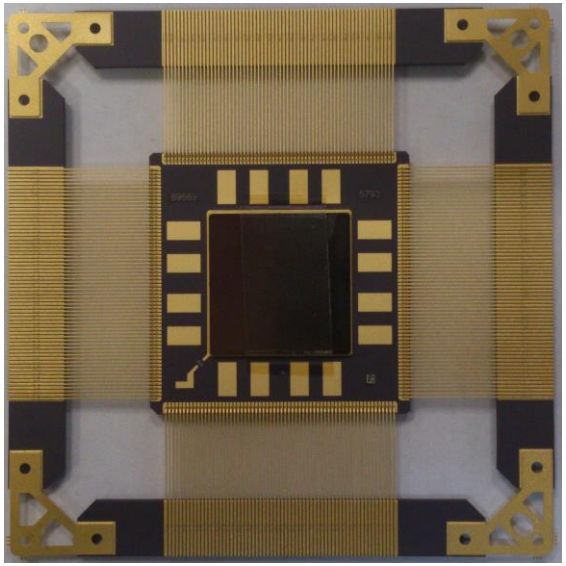
0.25 μm CMOS SOI technology

SRISA Main Activities

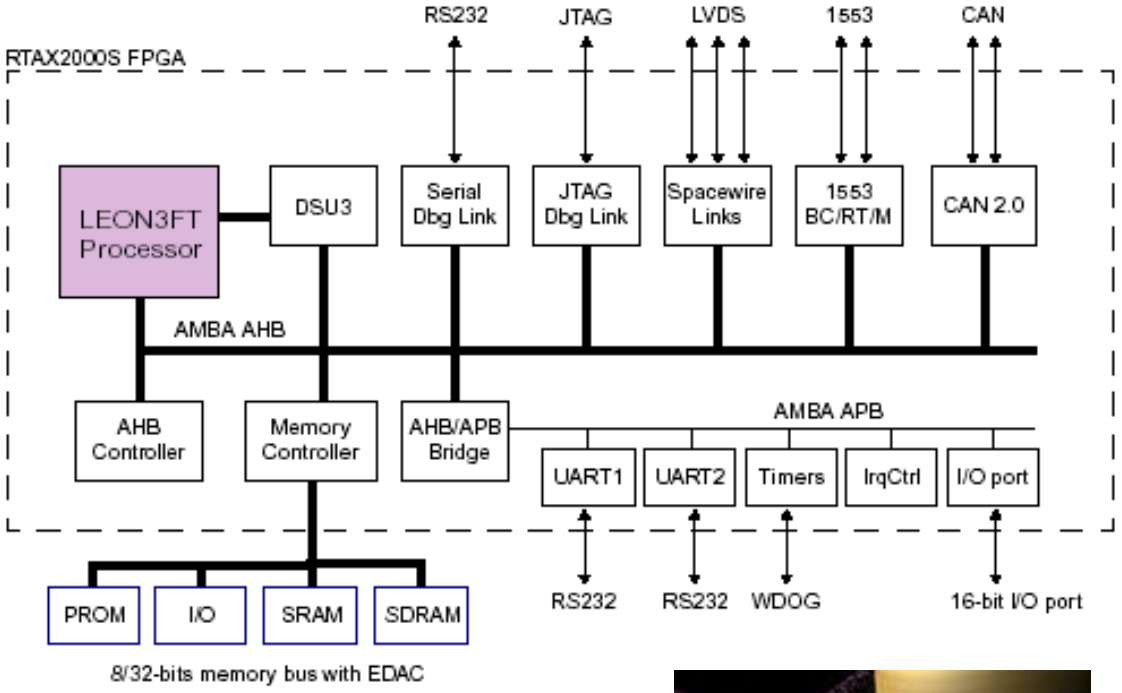
- **Theoretical and applied problems of the programming automation and data security**
- **R&D:**
  - system software: the Real-time Operating System (RTOS), compilers, debuggers, etc.
  - algorithms for building computational models with complex geometry, topology, etc.
  - complex microelectronic designs
  - high performance chips for industry
  - high performance protected chip from cyber attacks
  - **reliable fault-tolerant CPUs and interface circuits for space applications**
- **Oil refinery production efficiency methodic research**
- **Computer science for schools and high schools**

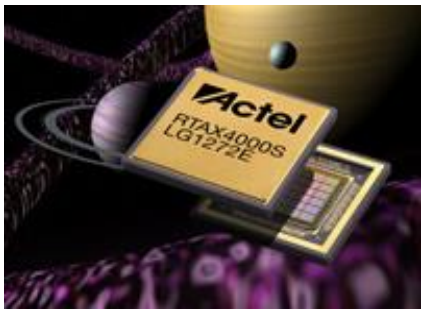
1907VM014 and “Scheme-23” Microprocessors

- SRISA 0.25 µm SOI CMOS (“Mikron” 0.25 µm SOI for “Scheme-23”)
- 100 MHz
- System-on-chip:
  - 2x RS-232
  - GPIO
  - MIL-STD-1553 (ГОСТ Р 52070-2003)
  - SRAM and ROM controller
  - JTAG (IEEE 1149.1)
  - SpaceWire (8 channels for “Scheme-23”)
  - SPI
- Prototype: 1907VM014
- Final: “Scheme-23”
- Production year: 2015 (2017 for “Scheme-23”)



LEON3FT-RTAX

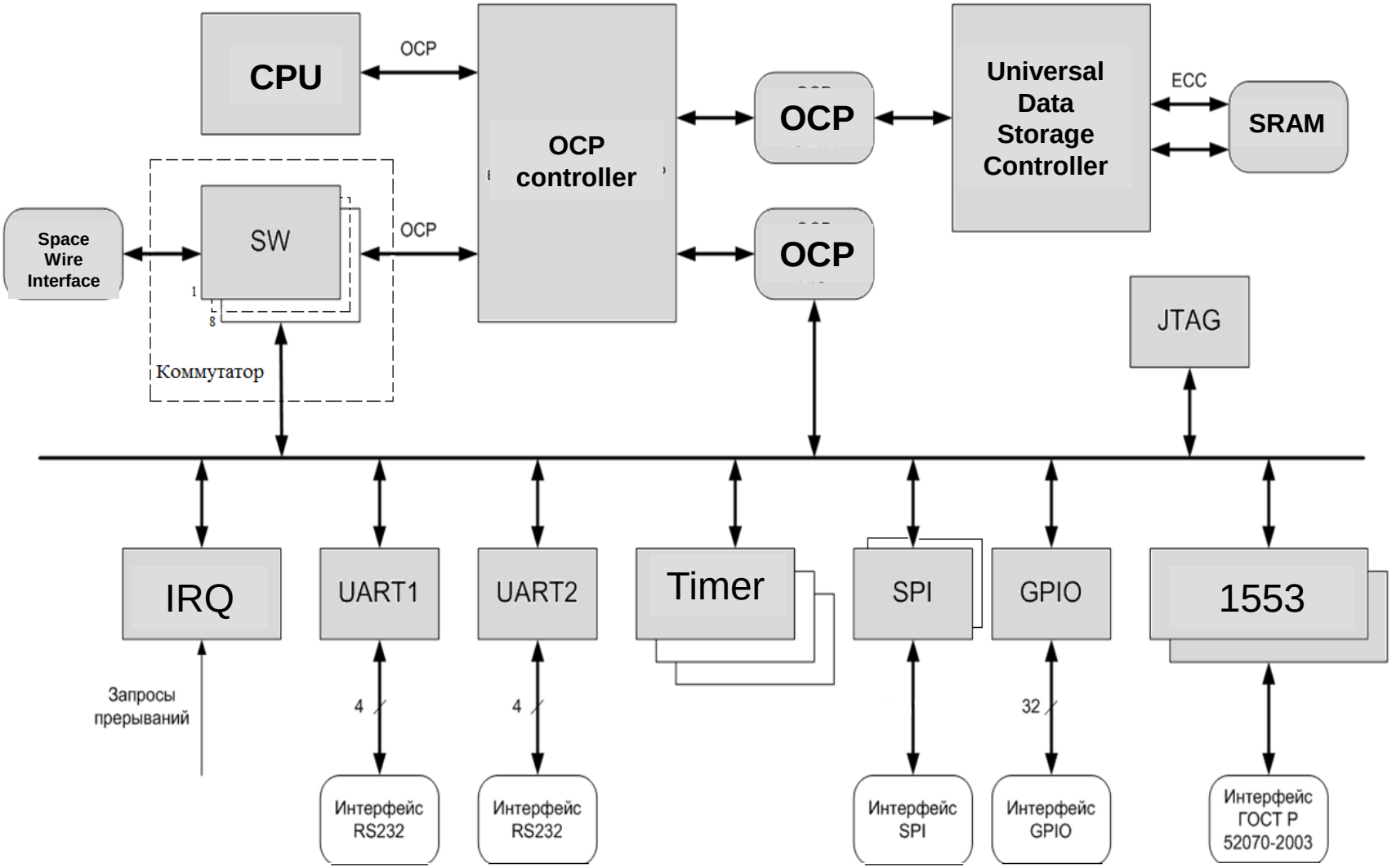




- LEON3FT processor with 2*8 Kbyte cache
- LEON3 Debug Support Unit with JTAG debug interface
- PROM/SRAM controller with EDAC
- Interrupt controller for 15 interrupts
- Timer module with two 32-bit timers and watchdog
- Two UARTs with 16 byte FIFO
- 16-bit I/O port
- Power-down mode

- http://www.hitechglobal.com/Components/LEON3FT-RTAX.htm

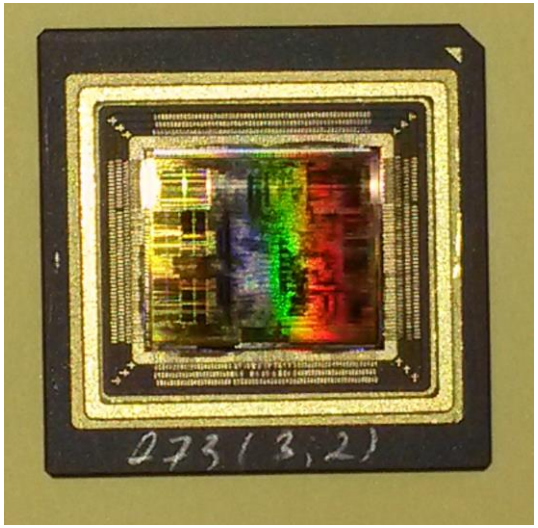
Scheme-23

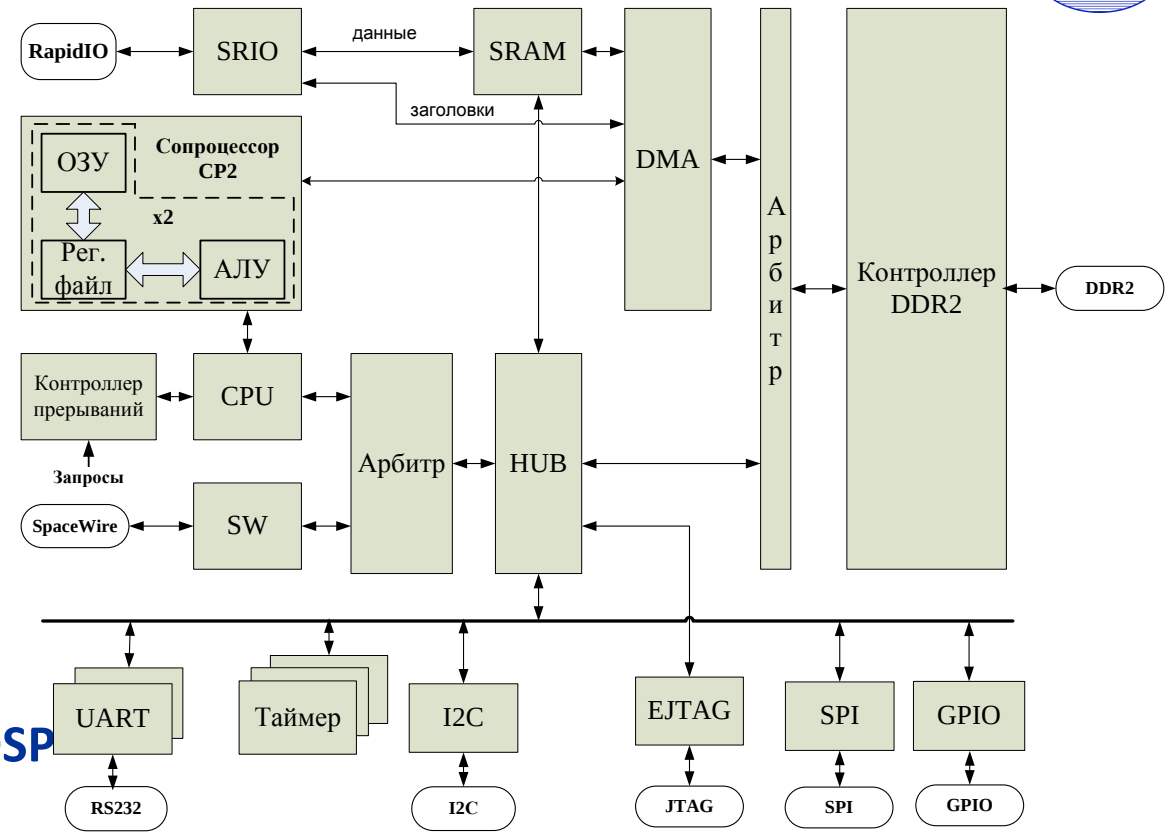

CPU
OCP
OCP controller
OCP
Universal Data Storage Controller
ECC
SRAM
Space Wire Interface
SW
1
8
OCP
OCP
Коммутатор
JTAG
IRQ
UART1
UART2
Timer
SPI
GPIO
1553
Запросы прерываний
4
4
32
Интерфейс RS232
Интерфейс RS232
Интерфейс SPI
Интерфейс GPIO
Интерфейс ГОСТ Р 52070-2003

Single-Event Effects Protection

- Parity bit (1 per byte) for cache memory
- Parity bits for MIL-STD-1553 memory
- DICE-cells in register files with Hamming code protection (13,8) hardware scrubbing
- SECDED for external memory
- Hardware possibility of using SRAM in TMR mode
- MBIST
- Spatial separation of neighboring bits (protection from MBU)
- “guaranteed boot” from ROM
- TID: >200 krad (Si)
- SEL free

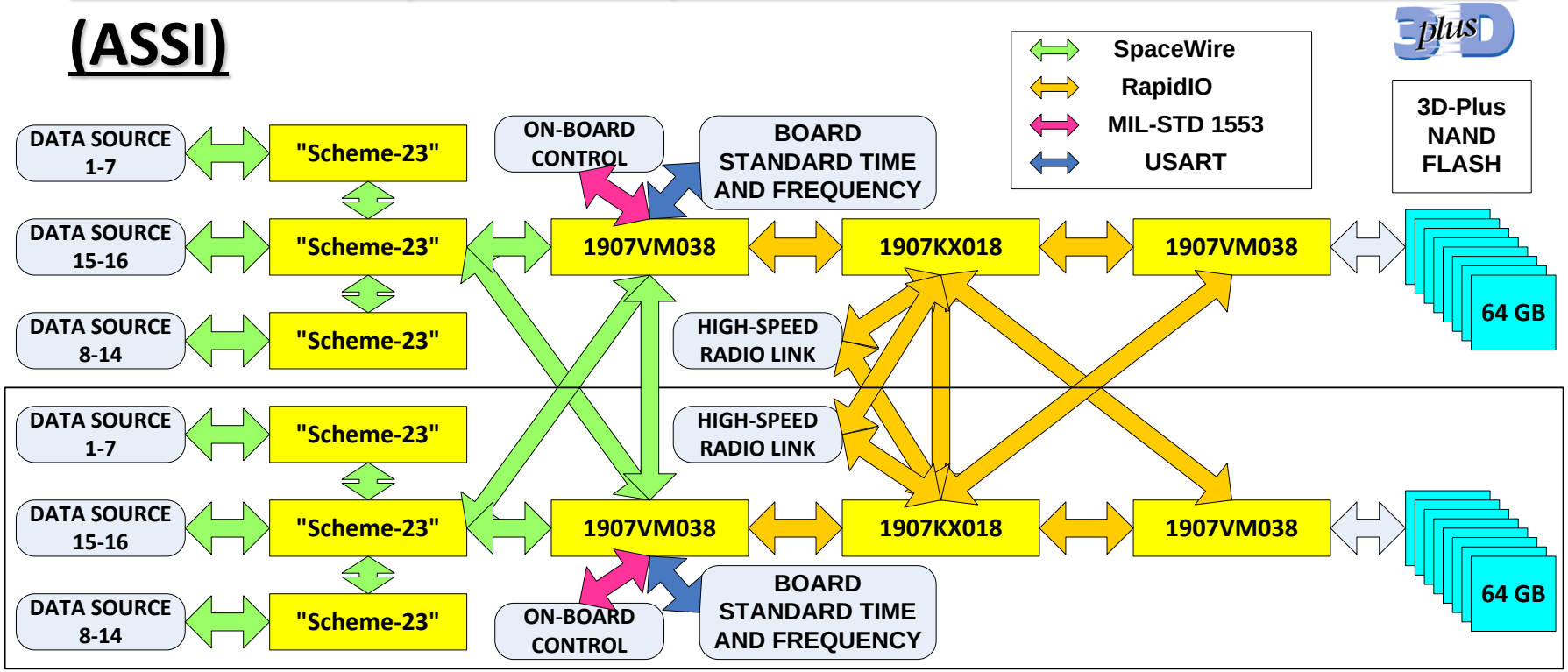
1907BM038





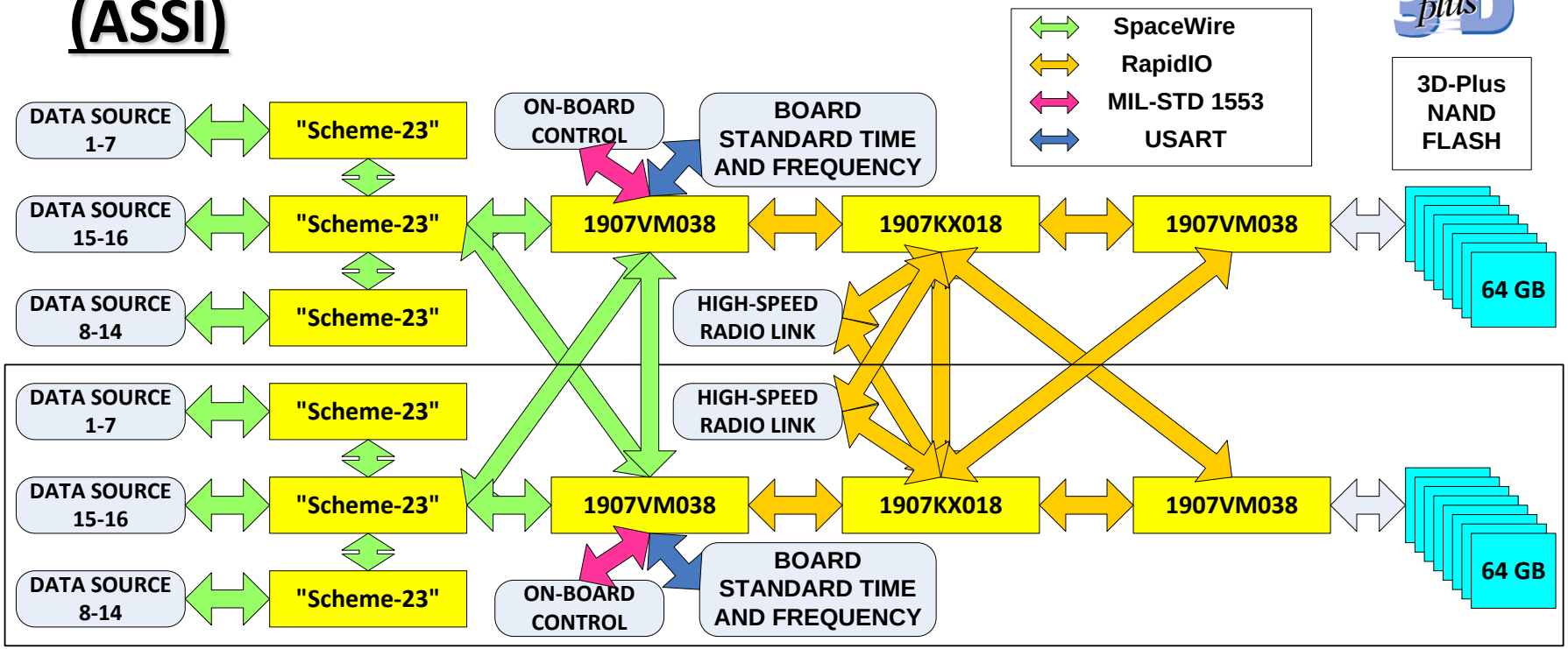
- **System on chip – 128-bit DSP**
  - >2 GFLOPS @ 100 MHz
  - >2 Gbit/s to external memory
- **Architecture:**
  - 32-bit control core
  - 128-bit computational co-processor
  - SPI, DDRII, RS232, RapidIO
- **Production year: 2016**

The data acquisition system for scientific information (ASSI)

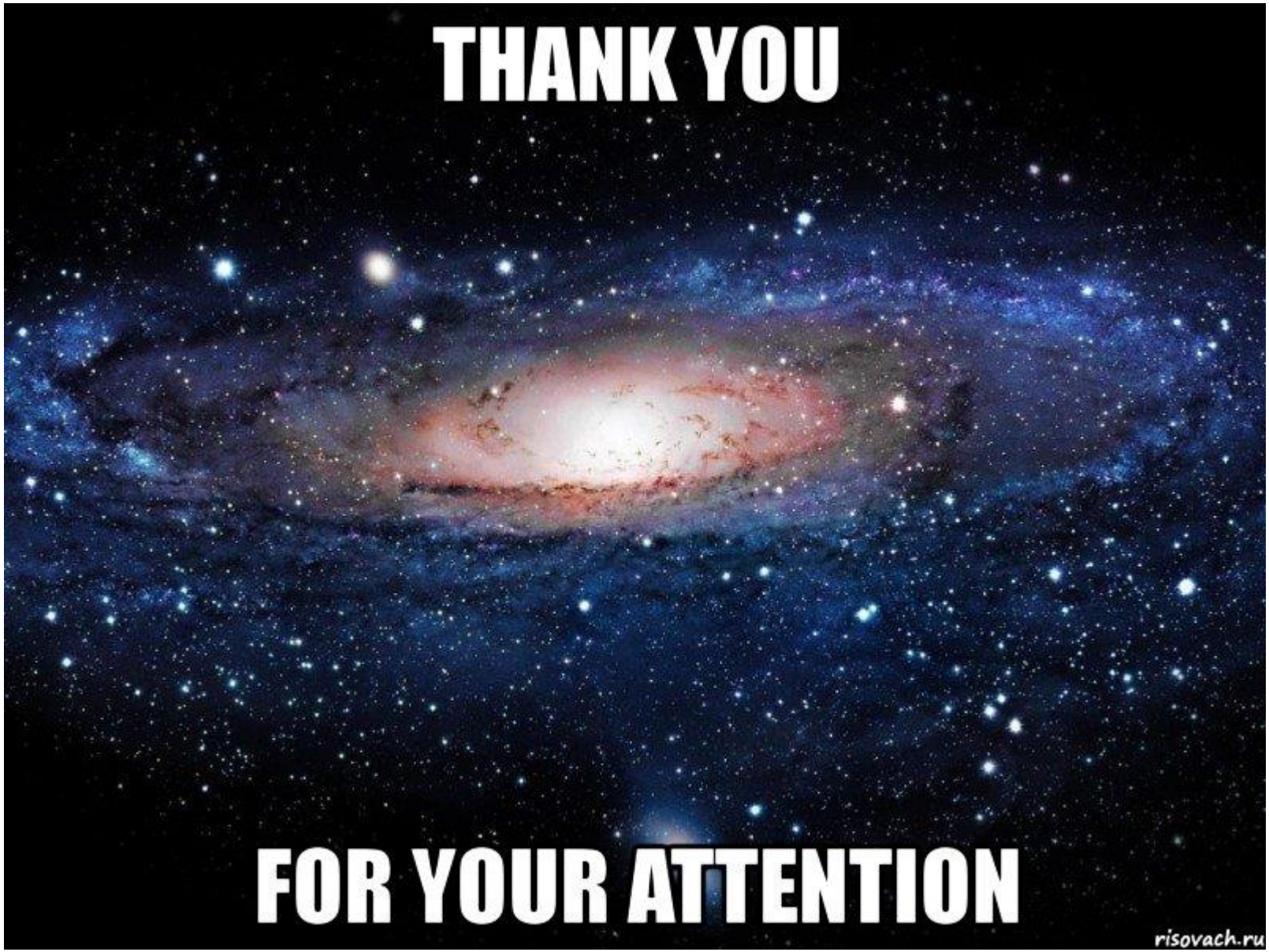


- **Functions: acquisition of the data and the service information and the space flight control**
- **Architecture:**
  - 16 SpaceWire data channels for obtaining the data from detectors
  - command driving channel (CDC) for transmission commands
  - service information and on-board time for detectors
  - mainframe processing unit (CPU) for the primary data collection

The data acquisition system for scientific information (ASSI)



- **Electronic components: Russian and ITAR-free (e.g., 3D Plus)**
- **Total Dose tolerance: >50 krad(Si)**
- **SEL:**
  - Silicon-on-Insulator VLSI
  - Power supply monitors for bulk CMOS VLSI


THANK YOU
FOR YOUR ATTENTION
risovach.ru