‘The strong interaction at the frontier of knowledge: fundamental research and applications’

WP 26

Martin SIMON

Stefan Meyer Institute for Subatomic Physics

Austrian Academy of Sciences

STRONG-2020 Kick-off meeting

October 23-25, 2019

JRA8

Advanced ultra-fast solid STate detectors for high precision RAdiation spectroscopy

WP 26

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Stefan Meyer Institute for Subatomic Physics
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STRONG-2020 Kick-off meeting

October 23-25, 2019

Johann (Hannes) Zmeskal
& the Stefan Meyer Institute

Stefan Meyer Institute
for subatomic Physics

- Work Package Leader (WP26, JRA8)
- Exotic Atoms (K^-H, K^-D…)
  - SMI interest in ASTRA
  - STRANEX @ ECT*
  - at SMI also antihydrogen
  - Conference: 14-18 Sept. 2020 in Vienna

EXA2020

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824093.

Advanced ultra-fast solid STate detectors for high precision RAdiation spectroscopy ASTRA

WP 26) members

Organization's legal name	Short name	Activity leader
Austrian Academy of Sciences Stefan Meyer Institute, Austria	OEAW	Johann Zmeskal
Istituto Materiali per Elettronica e Magnetismo CNR, Parma, Italy	CNR	Andrea Zappettini
Jagiellonian University Krakow, Poland	UJ	Pawel Moskal
Laboratori Nazionali di Frascati (LNF) INFN, Italy	INFN	Alessandro Scordo
Politecnico Milano, Dipartimento di Elettronica Italy	POLIMI	Carlo Fiorini
University of Zagreb Croatia	UNIZG	Damir Bosnar

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Advanced ultra-fast solid STate detectors for high precision RAdiation spectroscopy ASTRA

WP 26) objectives

The main objective of the ***ASTRA*** project is to develop beyond state-of-the-art ultra-fast radiation detector systems for high-precision measurements of gamma- and X-ray events in a broad energy range: **few keV to MeV**.

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Advanced ultra-fast solid STate detectors for high precision RAdiation spectroscopy ASTRA

WP 26) objectives

The main objective of the ***ASTRA*** project is to develop beyond state-of-the-art ultra-fast radiation detector systems for high-precision measurements of gamma- and X-ray events in a broad energy range: **few keV to MeV**.

→ cadmium telluride (CdTe) & cadmium zinc telluride (CdZnTe, CZT)

high mass numbers: 48 (30) 52 → high quantum efficiency

large band gap (CdTe~1.44eV, CTZ~1.57eV) → room temperature

but: tune geometries, electronics, read-out, DAQ to application

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Applications of ASTRA

- medical, biology, security
- fundamental physics
  - strong interaction
    - exotic atoms (SMI)

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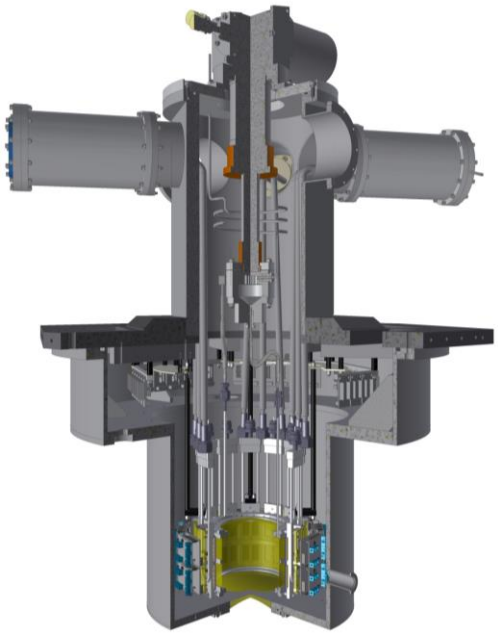
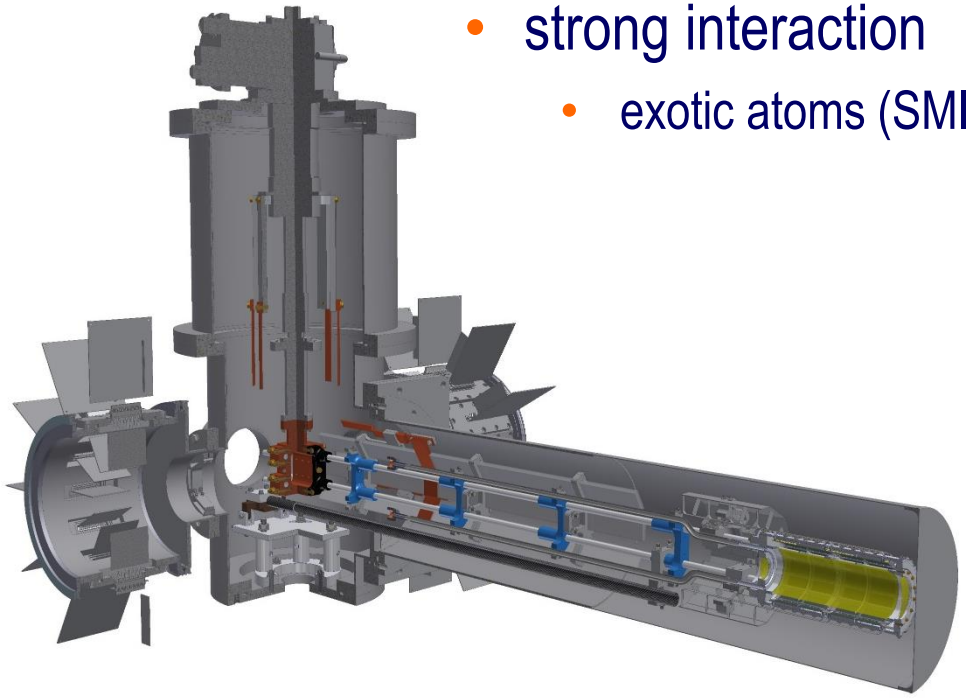
Applications of ASTRA

Kaonic Hydrogen / Deuterium
(Siddharta-2@DAΦNE, E57@J-Parc)

- medical, biology, security
- fundamental physics
  - strong interaction
    - exotic atoms (SMI)





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Applications of ASTRA

Kaonic Hydrogen / Deuterium
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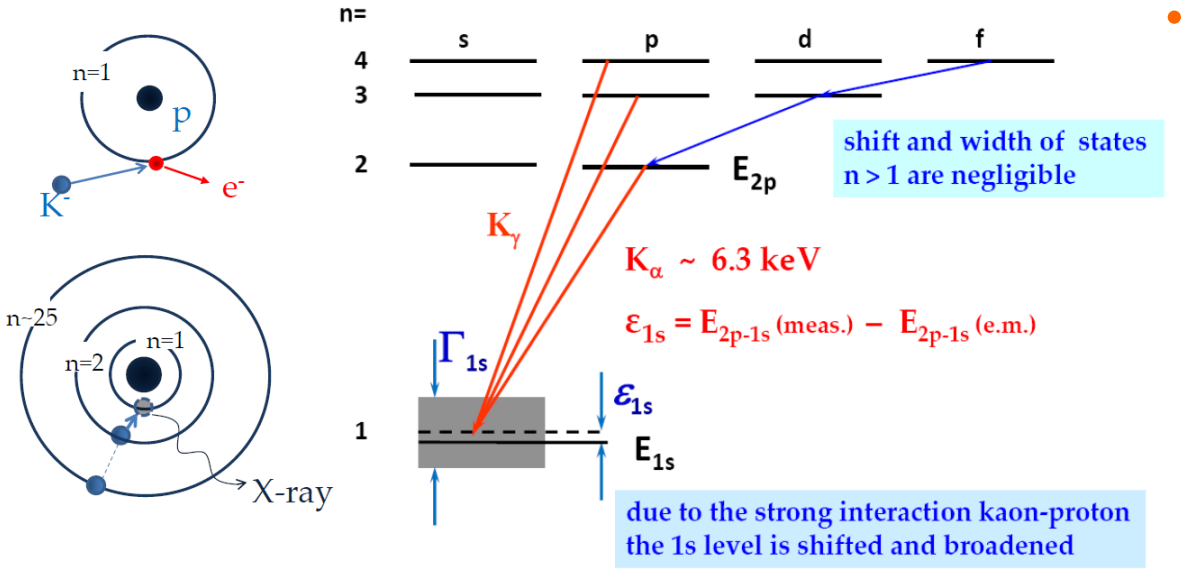
X-ray transitions to the 1s state



- medical, biology, security
- fundamental physics
  - strong interaction
    - exotic atoms (SMI)

K^-H: ~6 keV

K^-He: ~35 keV

p^-He: ~60 keV

$K^-N^{(7+)}$: ~460 keV

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Advanced ultra-fast solid STate detectors for high precision RAdiation spectroscopy ASTRA

WP 26) strategy

growth and geometry of crystal: area, thickness

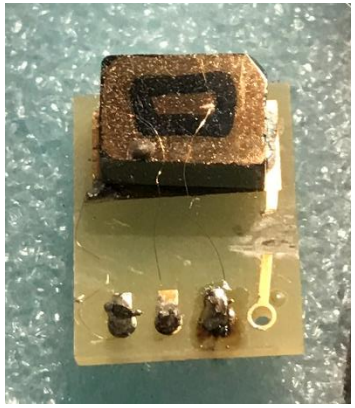
pixel electrodes: spatial resolution & rate vs. efficiency

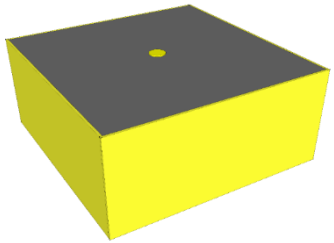
drift electrodes: low capacity, timing

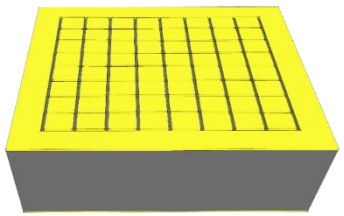
tune read-out: amplifier properties

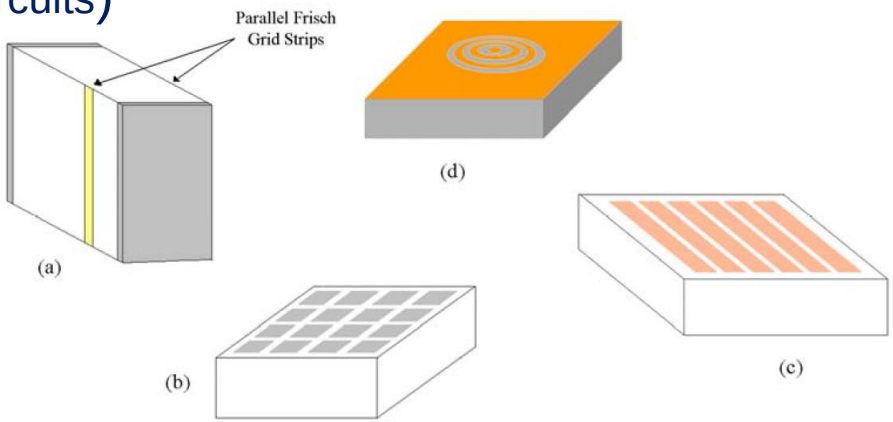
(ASICs: application specific integrated circuits)

DAQ: waveforms









Sensors **2009**, *9*, 3491-3526; doi:10.3390/s90503491

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WP 26) task 1:

Development of CdTe detectors
for an energy range from about 10 – 100 keV

- The goal is to produce crystals with high efficiency and good energy resolution in the energy range 10 - 100 keV. The prototype crystals will have an active area of up to 100 mm^2 and a maximum thickness of 5 mm.

- Various prototypes of CdTe detectors will be realized in order to obtain high energy resolution and low leakage current.

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WP 26) task 1:

- The work will start with the development of high resolution CdTe crystal and mounting boards includes bonding from the crystal to the boards
- CdTe crystals
  mounting boards and bonding
  read-out electronics
  → will be realized at SMI and PoliMi in cooperation with IMEM-CNR.
- DAQ system
  → will be developed at LNF-INFN, Jagiellonian Univ. and Univ. Zagreb.

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WP 26) task 1:

- The produced prototypes will be tested with conventional nuclear sources in order to verify **energy resolution, efficiency, linearity, stability**, and **timing** performances.
  In particular: effects of the detector **temperature** (range from 70-300 K), on linearity and energy resolution will be studied at SMI and LNF

- Finally, the detectors will be tested directly on beam (e.g. DAΦNE), in order to characterize the detector response
  under typical working conditions and
  under the influence of particle exposure, involving all participants.

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WP 26) task 2:

Development of CdZnTe detectors
for an energy range from a few 10 keV to MeV

- The goal is to produce crystals with high efficiency and good energy resolution in the energy range up to MeV. The prototype crystals will have an active area of up to 100 mm^2 and a maximum thickness up to 10 mm.

- Various prototypes of CdZnTe detectors will be realized in order to obtain high energy resolution and low leakage current.

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WP 26) task 2:

- The work will start with the development of high resolution CdTe crystal and mounting boards, which includes bonding from the crystal to the boards, will be realized in cooperation with IMEM-CNR, SMI and PoliMi.
- The read-out electronics will be realized at SMI and PoliMi in cooperation with IMEM-CNR.
- The DAQ system will be developed at LNF-INFN, Jagiellonian Univ. and Univ. Zagreb.

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JRA8 : Update on progress

ASTRA Kick-Off Meeting

Place:

Istituto Materiali per l'Elettronica e il Magnetismo
Consiglio Nazionale delle Ricerche
Parco Area delle Scienze 37/A 43124 Parma, Italy

Date: September 19, 2019

Time: 10:00 – 16:00

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824093.

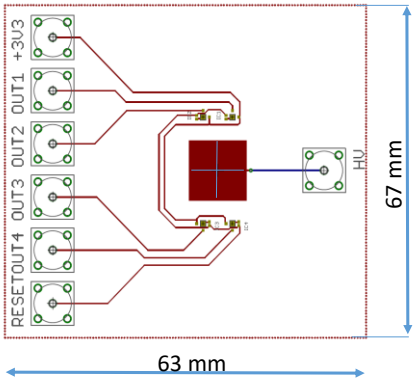
JRA8 : Update on progress

Design and construction of an printed circuit board
SMI in collaboration with IMEM-CNR, PoliMi

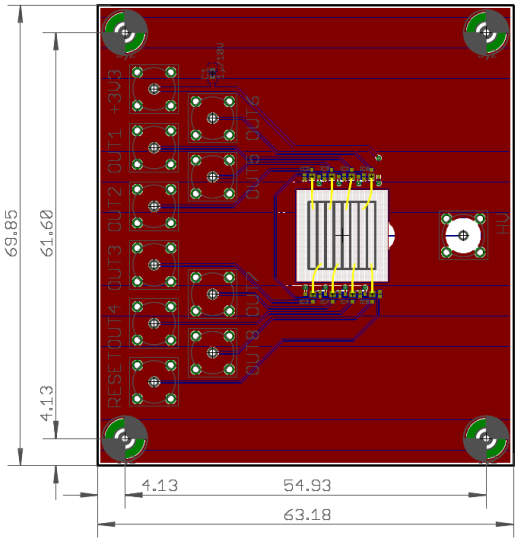
CZT size: 10 x 10 mm^2; thickness 1 – 2 mm
Readout structure: 4 pixels
8 strips

first test phase:
different boards
for mounting
10 x 10 mm^2
CdTe and
CaZnTe crystals

4 pixel with CUBE preamplifiers



8 stripes with CUBE preamplifiers



The boards will also allow to perform cooling tests down to 150 K

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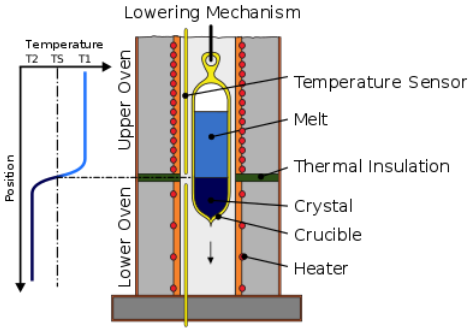
JRA8 : Update on progress

Simulation of detector response, work at IMEM-CNR

- First principle simulation tool to study detector response in different work condition
  (detector geometry, incident photon energy, bias voltage, etc.)

- This tool allows to simulate effects of:
  - Compton scattering
  - Pair production
  - Escape peaks…

Production of CZT crystals (at IMEM-CNR)



- Crystal growth of CZT Ingots (Vertical Bridgman)
- Ingots and Wafer Cut
- Surface Preparation: Lapping and Polishing

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JRA8 : Milestones

- MS56 and MS58 have to be achieved M8 (January 2020)

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS56	CdTe crystal characterized	2 - OEAW	8	Measurements
MS58	CdZnTe crystal characterized	2 - OEAW	8	Measurements

- **Advancement**
  - Development of simulation tools
  - Design of printed circuit boards
  - Production of crystals

- **Expected delivery date**
  - First results December 2019

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JRA8 : Deliverables

- There are no deliverables due for Reporting Period 1 (18 months, June 2019-November 2020)

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D26.1	CdTe detector prototypes with read-out electronics	2 - OEAW	Demonstrator	Public	30
D26.2	Report on the characterization of the final CdTe detector device	30 - INFN	Report	Public	48
D26.3	CdZnTe detector prototypes with read-out electronics	2 - OEAW	Demonstrator	Public	30
D26.4	Report on the characterization of the final CdZnTe detector	30 - INFN	Report	Public	48

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THANK YOU
MERCI

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