A tentative review
of
Applications of superconductivity in HEP

F. Gatti
University and INFN of Genova
Two topics:

High Power, High Scale, Large Facility
Cables, Magnets, Cavities, Sup. Acc.

nano-power, micro-scale, room-size facility
Nano-wire, KIDs, bolometers, SSPD, TES
Superconductivity is mandatory in HE Accelerator technology.

- SC magnet technology
- Proton Acc.
- SRF technology
- Electron Acc.

A. Yamamoto

Flavio Gatti, La Biodola, Isola d'Elba, May 2015
ATLAS Approach

Al-stabilizer using Micro-alloying and precipitation

\[ \text{Al}_3\text{Ni precipitated} \]
Contributes as structural component

Pure-Al region
Keep low resistivity

A. Yamamoto

Flavio Gatti, La Biodola, Isola d'Elba, May 2015
Magnet “without coil”

A. Yamamoto

0.2%

0.34%
$\text{Nb}_3\text{Sn}$ points to higher fields

E. Z. Barzi
Towards 17 T dipole

E. Z. Barzi

XRD Analysis
- Superconductive Nb$_3$Sn
- Non superconductive NbSn$_2$
- Niobium oxides are present on the surface

GDOES Analysis
- Sn and Nb overlapping is observed, Nb$_3$Sn phase thickness: $\approx$ 5 $\mu$m
- Oxygen detected close to the surface.
The superconducting detector technologies in this session

• Kinetic Inductance Device (KID)

**CALDER: Cryogenic light detectors for neutrino and dark matter searches**
Speaker: Marco Vignati (ROMA1)

Superconducting Kinetic Inductance Detectors for kilopixel instruments at Radiotelescopes
Speaker:
Dr. Martino Calvo (Institut Néel, CNRS Grenoble)

• SSNPD

Superconducting Nanowires Detecting Single Photons for Integrated Quantum Photonics
Speaker:
Dr. Roberto Leoni
What about TES (transition edge sensors)?
A technology at the edge of maturity.
1K-pixels TES array for EDXS

Courtesy S. Bandler - GSFC-NASA
FWHM = 1.81 ± 0.10 eV
Counts = 7,729

Courtesy S. Bandler - GSFC-NASA
- Best energy resolution detecting 6 keV x-rays (non-dispersive detector)
- Decay time - 200 μs

Courtesy S. Bandler - GSFC-NASA
The most sensitive \( \mu \)wave TES bolometer

BICEP2-Keck-Array

TES-antenna coupled bolometer
In this tech.framework

- HOLMES neutrino mass direct search with TES micro-calorimeter arrays (INFN-ERC)

- CRESST for DM direct search
• LSPE (large scale polarisation explorer) ballon borne CMB Telescope

• ATHENA (ESA-ASI-INAF-Uni Genova) x-Ray observatory that will host the largest TES array working at 50 mK in L2 orbit (See talk of Luciano Gottardi Friday)
4x64 pixels array for $\gamma$-ray

Courtesy J Ullom - NIST Boulder Co
Nuclear spectroscopy: Pu in U enrichment

 Courtesy M. Rabin - LANL
TES vs HPGe

![Graph showing absolute efficiency at 25 cm for different pixel sizes and years.]

- 2006
- 2007
- 2008
- 2010
- 2012

Alternate absorber material: (cryostat thinning + absorber thickness increase)

Mo, Ta, Sn

Courtesy J Ullom - NIST Boulder Co
Alpha spectroscopy

Silicon: ~8-10 keV FWHM

Microcal: 0.75 keV FWHM

TES results from LANL/NIST
RDX is clearly distinguishable from NH$_4$NO$_3$.

(Excellent agreement with F.D. Vila, et al., J Phys. Chem. A, 115, 3243-3250 [2011])
Ultrafast (fs-ps) structural measurements

- isotropic x-ray generation
- 120 um water jet
- focused probe beam
- target chamber wall
- sample under study
- cryostat wall
- 160 TES array

- Lund-Jyväskylä-NIST
Ultrafast (fs-ps) structural measurements

- Lund-Jyväskylä-NIST
Summary

• This session has covered argument of applied superconductivity to fundamental particle and astroparticle physics as well as in other disciplines (nuclear, medical, quantum optics,....)

• The community of “applied superconductivity scientists” is quite large and, in particular, due to the successful achievements of the last decades is continuously growing.

• This the case of superconducting devices like TES, KID, SSPD and others that in less than 20 years from the conceptual schemes or first prototypes are presently reaching the maturity for applications in large scale projects as well in new innovative instruments.

• This continuous growth is confirmed by the large sessions dedicate to these arguments at ASC, LTD, EUCASS, SPW...

• I encourage the organizers of this wonderful conference to continue to host a dedicated session on this field.
Poster Highlights - FDM TES readout

A 16 channel frequency domain modulation readout system with custom superconducting LC filters for the SWIPE instrument of the balloon-borne LSPE experiment

INFN & University Pisa, INFN & University Genova
Cryogenic light detectors for the search of neutrinoless double beta decay

I. Colanoni a,d*, F. Bellini a,b, L. Cardani a,c, N. Casali a,b, M.G. Castellano d, A. Coppolecchia a, C. Cosmelli a,b, A. Cruciani a,b, A. D’Addabbo e, S. Di Domizio f,g, M. Martinez a, C. Tomei b and M. Vignati a,b

a) Physics Department, Sapienza University of Rome, Rome, Italy – b) INFN – Sezione di Roma, Rome, Italy – c) Physics department, Princeton university, Princeton, NJ USA – d) IFN-CNR, Rome, Italy – e) INFN Laboratori Nazionali del Gran Sasso, Assergi (AQ) Italy – f) Physics department, Genova University, Genova, Italy – g) INFN – Sezione di Genova, Genova, Italy

Poster Highlights- KID light Detector
Fabrication and test of a large area spider-web bolometer for CMB polarization experiment.

M. Biasotti, D. Corsini, M. De Gerone, F. Gatti, G. Pizzigoni

1 - Università di Genova Italy; 2 – INFN sez. Genova,
Poster Highlights - Magnets

Feasibility Study of Hybrid Magnetic Cloak for Accelerator Magnets

E. Barzi, D. Turrioni, V. Kashikhin, H. Nguyen, FNAL, Batavia, IL 60510, USA
G. Giunchi, Materials Science Consultant, 20131 Milano, Italy
Poster Highlights - Superconducting coating

Superconductors as accelerators wall coatings in FCC-hh: impedance and compatibility with collective effects issues.

R. Cimino, LNF-INFN, Frascati, Italy and CERN, Geneva, Switzerland.
V. Corato, Enea, Frascati, Italy;
A. Di Gaspare, LNF-INFN, Frascati Italy;
A. Di Trolio and R. Larciprete, CNR-ISC, Roma, and LNF-INFN, Italy
M. Migliorati INFN Roma1 - University "la Sapienza", Rome, Italy;
U. Gambardella, M. R. Masullo and V. G. Vaccaro, INFN-Na, Napoli, Italy.

<table>
<thead>
<tr>
<th>parameter</th>
<th>LHC</th>
<th>HL-LHC</th>
<th>FCC-hh</th>
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<tr>
<td>c.m. energy [TeV]</td>
<td>14</td>
<td>100</td>
<td></td>
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<tr>
<td>dipole magnet field [T]</td>
<td>8.33</td>
<td>16 (20)</td>
<td></td>
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<tr>
<td>circumference [km]</td>
<td>36.7</td>
<td>100 (83)</td>
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<tr>
<td>luminosity [10^{34} cm^{-2} s^{-1}]</td>
<td>1</td>
<td>5</td>
<td>5 (-&gt;207)</td>
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<tr>
<td>bunch spacing [ns]</td>
<td>25</td>
<td>25 (5)</td>
<td></td>
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<tr>
<td>events / bunch crossing</td>
<td>27</td>
<td>135</td>
<td>170 (34)</td>
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<td>bunch population [10^{11}]</td>
<td>1.15</td>
<td>2.2</td>
<td>1 (0.2)</td>
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<tr>
<td>norm. transverse emitt. [μm]</td>
<td>3.75</td>
<td>2.5</td>
<td>2.2 (0.44)</td>
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<td>IP beta-function [m]</td>
<td>0.55</td>
<td>0.15</td>
<td>1.1</td>
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<tr>
<td>IP beam size [μm]</td>
<td>16.7</td>
<td>7.1</td>
<td>6.8 (3)</td>
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<td>synchrotron rad. [W/m aperture]</td>
<td>0.17</td>
<td>0.33</td>
<td>28 (44)</td>
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<td>critical energy [keV]</td>
<td>0.044</td>
<td></td>
<td>4.3 (5.5)</td>
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<td>total syn. rad. power [MW]</td>
<td>0.0072</td>
<td>0.0146</td>
<td>4.8 (5.8)</td>
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<tr>
<td>longitudinal damping time [h]</td>
<td>12.9</td>
<td>0.54 (0.32)</td>
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SEY from Nb_{3}Sn
Kinetic Inductance Detectors for Far-Infrared Spectroscopy

Alyssa Barlis, Univ. of Pennsylvania & NASA Space Technology Research Fellow;
James Aguirre, Univ. of Pennsylvania; Thomas Stevenson, NASA Goddard Space Flight Center

Spectral Line Intensity
Poster Highlights - TES FDM readout neutrino mass exp.
Poster Highlights - Neutrino Mass Exp. with TES

HOLMES is a new experiment to directly measure the neutrino mass with a sensitivity as low as 0.4 eV. HOLMES will perform a calorimetric measurement of the energy released in the electron capture decay of $^{163}$Ho (A. De Rujula and M. Lusignoli, Phys. Lett. B 118 (1982) 429). The calorimetric measurement eliminates systematic uncertainties arising from the use of external beta sources, as in experiments with beta spectrometers. HOLMES will deploy a large array of low temperature microcalorimeters with implanted $^{163}$Ho nuclei.
Poster Highlights - TES for X-ray Space Observatory

Superconducting TES array for large area cryogenic anti-coincidence detector for the ATHENA space mission

Needs for an anticoincidence detector to disentangle fake signals produced by cosmics (protons mostly) and obtain high energy resolution on single elements’ lines

- Fer Kα
- Cluster model simulation (cluster - residual background)
Phonon-Light Detectors for the CRESST Dark Matter search
Anja Tanzke on behalf of the CRESST collaboration

Poster Highlights - TES for DM searches